REGIONAL ORGANIZATION
FOR THE PROTECTION OF
THE MARINE ENVIRONMENT
KUWAIT

الإمارات العربية المتحدة
وزارة البيئة والمياه

Scientific Committee Meeting on Monitoring and Assessment of Sand and Dust Storms in ROPME Sea Area

Dubai, UAE, 26-28 September 2016

REPORT OF THE MEETING

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INTRODUCTION

In accordance with Decision CM 16/7 of the Council-16 and the recommendation of the Technical Workshop on SDS held in Dubai, UAE during 11-12 October 2015, the Scientific Committee Meeting on Monitoring and Assessment of Sand and Dust Storms in ROPME Sea Area was convened in Dubai, UAE from 26 to 28 September 2016. The Meeting was organized in cooperation with NFP-UAE, JICA, GEOMAR (Germany) and the University of Birmingham (UK). The objective of the Meeting was to prepare the scientific programme and a work plan for the assessment of SDS impacts in the RSA and to deliberate and finalize the scientific programme for a “Pilot Study” and a “Baseline Assessment”.

ATTENDANCE

The Meeting was attended by designated senior experts from ROPME Member States, international consultants, experts from JICA and Professional Staff of ROPME Secretariat. The list of participants is attached as Annex I to this Report.

AGENDA ITEM 2: OPENING OF THE MEETING

1.1 The Meeting was opened at 9:00 am on Monday, 26 September 2016 with a welcome statement by the representative of the Ministry of Climate Change and Environment (MOCCAE), UAE, Mr. Salim Akram. In his statement, he warmly welcomed the participants to Dubai and wished them a very successful Meeting. He also appreciated the efforts of ROPME Secretariat towards the implementation of the Council Decision 16/7 and recommendations of the Technical Workshop of October 2015. He highlighted the need to better understand the extent of impacts of SDS on the marine environment of the RSA, a subject which has never been studied in the Region. The statement (in Arabic) is attached as Annex VII to this Report.

1.2 On behalf of ROPME, Dr. Hassan Mohammadi, ROPME Coordinator, welcomed the participants and conveyed the warm greetings and well wishing of H.E. Dr. Abdul Rahman Al-Awadi, Executive Secretary of ROPME**.** He commented that desertification and land use change is a major environmental challenge in the Middle East, with increasing impacts on the ROPME Sea Area ecosystems through enhanced dust inputs. The proposed pilot study should be immediately followed by a baseline assessment. However, since dust inputs are strongest in northern part of RSA, the Pilot Study should focus on this area, but could have wider coverage to represent the Region.

AGENDA ITEM 3: ORGANIZATION OF THE WORK

2.1 Election of Chairman and Rapporteur

The Meeting unanimously elected Mr. Salim Akram as Chairman and Dr. Zongbo Shi as Rapporteur of the Meeting.

2.2 Introduction of Participants

The participants introduced themselves to the Meeting by name, agency and area of expertise.

AGENDA ITEM 4: ADOPTION OF THE AGENDA

3.1 The Meeting discussed and adopted the Provisional Agenda, which is attached as Annex II to this Report.

AGENDA ITEM 5: **EXPERIENCE FROM OUTSIDE THE REGION (JAPANESE CASE STUDY) BY DR. MASAO MIKAMI, JMBS, JAPAN**

5.1 Dr. Mikami of Japan Meteorological Business Support Center (JMBS) presented a case study for the assessment of SDS impact on the marine environment in Japan entitled "*Monitoring and Modeling of Dust Storm and its Impact to the Ocean".* He showed that the Characteristics of Asian dust is complex due to the complex ground surface condition and topography. And that the snow cover and seasonal change of vegetation will affect the outbreak of dust storm in the North-eastern Asia.

In order to monitor the wind erosion process in the region, the author has conducted field campaigns in cooperation with China and Mongolia. And, based on the observational information, a new dust emission scheme has been incorporated into the new global dust model, MASINGAR, which is now used for operational dust forecast information by JMA.

In the presentation, international cooperation through WMO and TEMM was also introduced and comments were made on dust impact on the atmospheric environment and the ocean ecosystem.

AGENDA ITEM 6 : CURRENT MONITORING AND RESEARCH ACTIVITIES IN THE REGION

6.1 Dust Fallout Properties Within Dust Storms Frequent Paths in the ROPME Sea Area By Dr. Ali Aldousari, KISR, Kuwait.

Dr Ali M. Al-Dousari presented the major dust storm trajectories in the world with a particular focus in paths that fall into ROPME Sea Area. The amount of dust, in addition to particles distributions and statistical parameters within these trajectories were also discussed for comparison between the trajectories. Maps were presented for fallen dust amounts, physical and chemical properties in Kuwait. The dust properties that were mentioned in the presentation are:

- The amount of fallen dust monthly and annually for 2 years
- The particle size and statistical parameters
- The mineralogy of fallen dust
- The major and trace elements

- The pollen amount and type distribution
- The Total Petroleum Hydrocarbon in the dust
- The BET-surface area of dust parts
- The organic matter
- The acidity (pH)

The presentation also had estimated the amount of dust that fallen into ROPME Sea Area in 2006 and 2011. The presentation emphasizes on the adaptation methods that were applied in Kuwait, mainly using native plants, to prevent re-suspension (re-movement) of dust particles after first deposition. Therefore, it was highly recommended to use native plants within source areas of dust.

6.2 Effect of Mineral Dust on Ocean Productivity and Biogeochemistry of the Northern ROPME Sea Area. By Dr. Turki Al-Said, KISR, Kuwait

Dr.Turki started his presentation explaining that Kuwait is subjected to severe dust and sand storms. Aeolian dust is an important source of iron to marine photosynthetic organisms. The deposition of atmospheric dust is the primary process supplying trace metals such as Al, Mn and Fe to the surface ocean. Few studies have been conducted to understand the effect of dust on the biological activity in Kuwait's waters. Incubation experiment which involve spiking of aeolian dust rich in essential micronutrients (Co, Cu, Fe, Ni, Zn, Mn) increase phytoplankton growth reaching red tide proportions. Dust impact is a major ecological force in the formation of algal blooms and detailed study on effect of dust on the biological abundances and associated processes in Kuwait waters is urgently needed.

Dr. Turki presented the results of a recent completed project showing that concentrations of metals (Fe, Cu and Zn) were comparable with other coastal regions and much lower than previously reported data.

He presented the objective of the new anticipated project of KISR with the National Institute of Oceanography, India (NIO) which aims to assess the sources and effect of mineral dust fluxes on ocean biogeochemical processes in the northern RSA through: (a) estimation of the atmospheric deposition of mineral dust, identification of sources, and its soluble fraction (inorganic leachable ions and nutrients); (b) evaluation of effects of mineral dust fluxes on ocean biology and chemistry; and (c) providing a database of mineralogy, geochemical and isotopic characteristics of mineral dust and the soluble component of mineral dust for future reference.

Thus, the study will help to understand carbon sequestration via the chemical and biological pathways. Incubation experiments will be carried out by applying dust particles collected from different locations in Kuwait to phytoplankton assemblages. During the project, seawater samples will be collected for chemical and biological analysis to understand the impact of the dust on primary production and its possible role in carbon sequestration. Routine measurements will include monthly sampling of fundamental biogeochemical parameters such as dissolved oxygen, pH, nutrients and chlorophyll-a. Seasonal measurements will be carried out for dissolved organic carbon and alkalinity to understand the impact on the carbonate system. Project tasks were identified and each task activities including analysis and measurements were described. Dr Turki emphasized that the anticipated project will provide valuable data. Available instruments to be utilized during the future work were also cited.

6.3 MASDAR, UAE (earth.masdar.ac.uae)

In a short intervention by the representative of MASDER in the meeting, he expressed the willingness to participate in the programme through making available to the programme the information and data in the following activities:

- Satellite observation for chl.
- Ocean modelling of currents.
- Wolfgang atmospheric modelling.
- Tricho blooms in the UAE region in periods with T 24-28 C.

AGENDA ITEM 7: STATUS OF EXISTING CAPACITY FOR SAND AND DUST STORMS MONITORING IN THE RSA (PROF. ERIC ACHTERBERG)

The programme of the first day of the meeting ended by two presentations of Prof. Achterberg. In the first presentation he briefed the participants with the aim, objectives and expected outcomes of the proposed pilot project, baseline study and long-term programme for monitoring and assessment of impacts of dust on the RSA.

In his second presentation, Prof. Achterberg presented details of the outcomes of the circulated questionnaire which aims to establish the monitoring and research capacity on dust and ocean biogeochemistry within the ROPME Member States.

Annex III includes an evaluation report on the received responses from Member States from which the following points can be highlighted:

- Five countries (Bahrain, Iraq, I.R. Iran, Kuwait and UAE) have sent details on existing atmospheric and seawater column sampling and analysis
- Amount of monitoring undertaken is extensive and very useful to the planned SDS monitoring programme
- Substantial amount of particulate matter and gas monitoring using direct light attenuation sensors or gas sensors
- Particulate aerosol sampling for dry deposition undertaken at a good number of sampling sites in the region
- Satellite observations and ground based remote sensing activities is undertaken in a number of countries
- Limited amount of aerosol modelling is undertaken. It will be important to engage the modellers in the planned dust programme
- Good amount of water sampling undertaken. Sampling for nutrients is common with some metal analyses
- Water sampling stations are well distributed around the region which is very useful to the monitoring programme
- Substantial amount of air quality data available from member states

Prof. Achterberg concluded that the outcomes of this questionnaire is of great importance and provides excellent information which will be used to develop a coherent and inclusive scientific programme for the proposed regional study.

AGENDA ITEM 8: ELEMENTS OF THE MONITORING PROGRAMME OF FALLEN DUST IMPACTS ON THE MARINE ENVIRONMENT OF THE ROPME SEA AREA

Prof. Achterberg briefly explained the aims and objectives of the research programme and recommended that the programme should be implemented in three phases

- Phase I: Pilot study
- Phase II: Baseline
- Phase II: Long-term programme

Coordinator of ROPME, Dr. Mohammadi, then suggested that the pilot study represent the RSA and include UAE, Kuwait, Iraq and Iran. It is possible that one more country can join the pilot study, e.g., Qatar, Bahrain, or Saudi Arabia. However, the training and capacity development during the pilot study phase will be provided for all countries. He also commented that future programmes (baseline and long-term) should extend to the wider areas including the Sea of Oman.

After some debate on the approaches to be adopted in the discussions, the committee members agreed to go through the concept paper (Annex IV) point by point, including research aim/objectives and the research programme. This will lead to a final agreement on the details of the Scientific Programme.

8.1 Overall aim:

The committee members debated and agreed that the overall aim of the pilot study is to provide initial data for developing a one year baseline monitoring programme (BAISDS-2019), and the specific objectives should include:

- Setting up capacity to undertake aerosol sampling with high and low volume aerosol collectors
- Collecting aerosol and seawater samples (using clean techniques) at 3 to 5 stations over a period of 2 months
- Measuring total and soluble elements and compounds in the collected aerosol samples
- Measurements of trace elements, nutrients, organic compounds, carbonate chemistry, chlorophyll a and indicators of ecosystem structure in the collected water samples
- Determining the biological impact of aerosols in selected samples
- Identifying potential sources and transport pathways of mineral and anthropogenic aerosols in the region
- Identifying gaps and needs of baseline monitoring programme

8.2 Target elements, compounds and biological impact assays

The committee agreed that the target elements, compounds, and biological impact assays should include:

- Essential elements for microorganisms (e.g., Fe, Co, N, P, Si)
- Toxic elements (Cu, Pb, PAHs) and elements that may be involved in nuisance bloom development (N, P)
- Mineralogy using X-ray Diffraction
- Quantitative source apportionment of PM/soluble and total trace elements

- atmospheric modelling of trace element and nutrient deposition, constrained by remote sensing of total aerosol deposition rates in combination with ground measurements
- Water sampling: chemistry and biology including carbonate chemistry linking inputs from atmosphere, river and sediment
- Enhance and validate a local physical biogeochemical ocean model with improved aerosol supply fluxes and biological impact quantifications
- Data on criteria anthropogenic gases, such as ozone, SO2, NOx and PM are to be collected to identify origin of collected air masses
- LIDAR observations (at least one operational in Kuwait) will be performed to support atmospheric modelling. Multispectral (UV to PIR) atmospheric aerosol optical depth (AOD) will be performed using manual photometers in the frame of the Maritime Aerosol Network (MAN) components of AERONET

Elements, compounds, gases and physical measurements	**Matrix**
Na, Mg, Al, K, Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ag, Cd, Sn, Hg, Pb, U, P, OC/EC, PAHs, molecular tracers	Collected aerosols (total fraction)
Na, Mg, Al, K, Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ag, Cd, Sn, Hg, Pb, U, chlorite, sulphate, ammonium, nitrate, phosphate, silicic acid, sulphate, DOC	Water soluble aerosol fraction
Al, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ag, Cd, Hg, Pb, U, ammonium, nitrate, phosphate, silicic acid, DOC, dissolved inorganic carbon and total alkalinity	Surface seawater samples
Ozone, VOCs, NOx and SO_2 at selected stations	Gas phase
Aerosol optical depth (AOD, using manual photometer)	Atmosphere
XRD-EM mineral analysis	Particulate aerosol samples

The committee recommended that standardized methodology in sampling and analysis of aerosol and water should be developed, and training should be provided to the regional partners from different participating countries. ROPME has recognized that it is important to train capacity in other labs in the region and an intercomparison exercise should be carried out when samples are collected at one place and shared and analyzed by different labs. It was agreed that both particulate matter (dust) and seawater reference materials need to be purchased (after notifying ROPME) for an anonymous proficiency test exercise for the pilot study.

The committee recommended that national agencies in the region are to submit critical gas and particulate matter monitoring data for the research programme.

Some committee members mentioned to include both soluble and particle phase in seawater, sediment release of nutrients and metals, coral reefs and seagrass, persistent organic matter and organic mercury and tin within the programme. The committee debated on these issues and agreed that all the above aspects are important but they are out of scope of this particular study. However, we should explore the possibility to collaborate with other ongoing programmes and consider using case studies on the above aspects, e.g., carry out sampling at one site during the programme. Dr. Hassan Awad then suggested that during the pilot project, we need to test as many analytes as possible in order to select some for future analysis in the baseline assessment on basis of the pilot study. The Chairperson and Dr. Mohammadi recommended that radio-isotopes should also be measured but we need to find out how much materials are needed for radio-isotope analysis at MESL/IAEA of Monaco.

Further discussions focused on the biological impact of dust. It was recommended that seawater should be taken at 50 m depth and the following parameters to be measured:

- Chlorophyll a
- Photosynthetic efficiency (stressed by pollution or nutrient limitation)
- Microbial composition (HPLC analysis, genomic analysis)

In addition, dust microcosm experiments should be carried out on a routine analysis. It was decided that Dr.Turki Al-said from KISR to send the list of instruments needed for seawater analysis using the standard procedure to ROPME and the consultants, and Prof. Achterberg to send the recommended procedure for the biological impact assessment to ROPME. However, the committee recognized that this is too complicated for the pilot study but should be included in the baseline measurements.

8.3 Criteria and selection of suitable sampling sites

The committee agreed on the criteria and selection of suitable sampling sites

- Cost and effective
- Should consider wind patterns, representative locations, and anthropogenic activities
- Selection of sites: should change "conducted" to "studied" when talking about air back trajectories and air quality prediction
- Existing ROPME reference sites are to be carefully considered to benefit from historical data
- Existing and planned regional initiatives

Baseline sampling sites (after pilot):

- Include a number of stations: e.g, 8 stations and including the Sea of Oman
- Offshore sampling: using available ships (cruises) in coming years; samplers on oil/gas platform, including rigs; possible to have two stations over the RSA
- Qatar: potential to have sampling station available already but may not be available to do all analyses as planned in the programme (need more training/equipment). Therefore, Qatar will not be able to make all the analyses as in the programme; but can provide air quality data

8.4 Sampling protocols and sample types

The committee agreed on the following standard sampling protocols such as those proposed by GEOTRAES

- Aerosol, one high volume with quartz filter and one low volume using PTFE filter; all partners should use the same brand of samplers if possible; suggested to use as feasible the automatic samplers (up to 15 samples per time) to reduce workload. The committee suggested that one type of equipment to be used for all sites (e.g., Digitel and Partisol for aerosol sampling) and all should be calibrated before the campaign.

- Water column: water samples should be collected at sites close to aerosol samples. Surface water: 20 cm to 1m depth; water samples should be taken on monthly basis, and AOD and aerosol samples on a daily basis.
- nutrient analysis should be using certified reference material KANSO
- Trace metal sampling of seawaters: for this project it is suggested to sample using clean hose and pump for sampling shallow waters.
- Trace metal analysis: isotope dilution ICPMS with Seafast sample preparation system; other appropriate techniques considered as well
- Need to train the sampling and analysis methods that are easy to handle and clean; should be part of the training process.

The possibility of implementing the sampling protocol in each country was widely discussed and the following points were raised:

- **Iraq**: has TSP/PM10/PM2.5 samplers; water samples by hand; no equipment for depth water; analysis for part of the parameters
- **Kuwait**: TSP samplers under purchase; able to do a good number of the analyses; pump and CTD for water sampling; can share sample for pilot study
- **UAE**: 41 onshore or offshore air quality monitoring stations (SO2/NOx, PM10) with five stations for PM2.5 and dust fall collector; chemical analysis of dust fall; CDT… ranges of approaches
- **Qatar:** PM2.5/PM10 raw data, no TSP
- **Bahrain**: willing to participate; but no TSP samplers
- **Saudi Arabia**: water hand sampling; unclear
- **Iran**: no one was present in the meeting
- **Oman**: no one was present in the meeting

Biological impact of aerosols (microorganism community)

- Culture experiments
- Microcosms on cruises
- Possible mesocosm experiment
- Indicators via Bioassays: simple approach on same species
- KISR: culture lab of specific species and able to run on the real water samples (plan to do on real water samples with phytoplankton in this pilot study)
- ROPME Coordinator questioned how could we extrapolate the data to RSA and also need to consider differences in species at different seasons

After the discussion of the above elements, it was recommended that the Scientific Committee to prepare Standard Operating Procedures (SOP) for the full range of activities as part of the sampling and analysis activities.

8.5 Sampling frequency

- Pilot study: 2 months in 2017, Training, purchase of instrumentations, and actual sampling to start in mid-2017 (dusty season, April-June)
- Baseline 2018: full year, to cover the dust and non-dust seasons

8.6 Samples banking

It was agreed that ROPME shall archive the samples under the required condition. Sub-samples will be sent and analysed in ROPME designated labs.

8.7 Data management and reporting

The committee agreed that data should be archived in ROPME and GEOMAR data library and made available to all partners, pending data agreement; ROPME will lead on data validation (part of training and capacity building). Data will be organized into technical reports.

8.8 Training needs

A series of training activities was proposed, all to be conducted in the ROPME region:

- Sampling, preservation and analysis: training in the region (4 days before the start of the Pilot Study)
- Aerosol and water analysis for organic compounds (4 days during or just after the Pilot Study)
- Aerosol and water analysis for inorganic compounds (4 days during or just after the Pilot Study)
- 4 day training workshop in a regional institute (after the Pilot Study) on data modelling and management (different atmospheric and oceanographic biogeochemical models)

Dr. Awad emphasized the need to do the proficiency tests in order:

- To find the gaps and training needs
- To find out who and which lab can do the proposed analyses

8.9 Linkages with other ROPME activities

It was recommended that linkage/harmonisation should be established for the baseline 2018 with the following activities:

- Oceanographic cruises; set up a scientific programme for the planned upcoming cruises
- ROPME Mussel Watch programme; every three years (25 sites for sampling oysters); harmonise the time of sampling for dust and oysters; could potentially see the impact of dust which represent added value
- Survey of radionuclides in sediment and biota

Dr. Mohammadi added that ROPME satellite images receiving station can help in the programme and produced data can be stored in the ROPME integrated information system (RIIS). In this regard, access protocol to be developed, for the time being, access is limited but can be arranged if Member States want to do some work on the specific areas.

Dr. Awad Hassan insisted on the importance that all relevant regional and national activities should be integrated to have a more representative regional picture; linkage of science, social and economic benefits.

Mr. Salim, UAE representative highlighted that it is a need to link the programme to other activities in national institutions (Department of Transport , research centres, regulators,…..). He added that voluntary sharing of responsibilities in the aerosol dust sampling programme is one important step.

Some participants urged ROPME should explore the possibility of integration with regional and international programmes of UNEP.

Some members of the committee proposed to include in the programme the study of mineral dust impacts on rain events on the Indian sub-continent, and the effects of west Asian pollution aerosols on the health of the RSA.

KISR representatives expressed strong willingness to contribute in the programme. KISR will also order dust samplers. They advised other Member States to order the samplers themselves as well; this is capital investment so should be purchased by member states.

AGENDA ITEM 9: IMPLEMENTATION PLAN AND TIME- FRAME

Dr. Awad proposed the Time Plan for the implementation of the three phases of the Programme. The proposal was discussed and the Committee Members agreed on the following Time Plan:

1) Mid-Oct: send the updated questionnaire to members states including the type of dust collectors (type and specification of the samplers and whether the members states have the samplers)
2) Mid-Nov 2016: to obtain the questionnaires of three countries which have not yet been able to submit, with additional information from other member states
3) End of Nov 2016: The completed questionnaires will be sent to consultants; the questionnaire report will be updated; consultants will list the existing laboratories in the region to be invited to participate in the pilot study
    a. Consultants and ROPME to contact respective labs; Consultants recommend what to analyse, budget and timeframe and then Member States will respond and then we can finalize
    b. We know what countries can do sampling
    c. We need to find out what countries and labs can do the analysis
4) End of 2016: circulate the list of labs that are willing to participate in the sampling and analysis for the pilot study
5) Jan 2017: Reference samples to be sent to the willing labs for proficiency tests by the consultants
    a. Contact participating labs in member states whether the samplers can be purchased and funding available? Order placed? When they will be delivered and ready for use?
6) Jan to Feb 2017: sample analysis by participating laboratories in the region
7) Mid-march 2017: Data to be sent to ROPME and Consultants
8) End of March 2017: Consultants will identify the gaps and training needs
9) April 2017: Dust and water sampling training (2 persons from each Member State)
10) Sep to Oct 2017: Pilot study sampling period
11) May 2018: Completion of sample analyses and reporting for pilot study data to consultants: six months after the sampling
12) June 2018: meeting in the region to discuss the outcome of the pilot study; we expect that *participants from pilot study will present* their results

13) Aug 2018: Reports of the pilot study to the ROPME Council (one for decision makers and one scientific report)
14) Jan-Dec 2019: baseline (abbreviation to change to 2019)
    a. Mid report for the baseline in 2019
15) June 2020: completion of analyses of samples and reporting for baseline study 2018

AGENDA ITEM 10: DISTRIBUTION OF TASKS AND ORGANISATION OF WORK

According to the above accorded implementation plan by the Committee Members, the following points were deeply discussed and agreed on:

- Questionnaire has to be updated with additional section for the used types of aerosols collectors and frequency of sampling and re-circulated for completion and updating.

- It is necessary to unify the type of used aerosols collectors among the participating countries in the programme. Consultants will look for and propose a model of suitable collector.

  Dr. Mohammadi mentioned that Member States are to purchase their own samplers as their own property

- Towards widening the participation of Member States in the programme, ROPME Secretariat will circulate a call for participation among national institutions for conducting the analyses

- ROPME will organise a Proficiency Test among the willing laboratories for the selection of competent laboratories to participate in the analyses

- Certified reference materials to be used for training, Proficiency Test and analyses of samples during the whole programme.

- ROPME has to share all data/reports; anyone engaged in the study will be acknowledged in relevant reports/publication; all participants should have access to relevant information within the programme

Dr. Awad mentioned that if there are countries, for some reasons cannot participate in the pilot phase of the programme, ROPME Secretariat will make every efforts to ensure their participation in the baseline study.

AGENDA ITEM 11: OTHER MATTERS

No other matter was raised.

AGENDA ITEM 12: CONCLUSIONS AND RECOMMENDATIONS

The Meeting of the Scientific Committee adopted the following recommendations:

1. Implementation of the work plan of the programme within the agreed time frame

2. Consultants to update the questionnaire including types of used collectors and frequency of sampling

3. Circulation of the updated questionnaire for compiling and updating by all Member States

4. Unifying the aerosols collectors be used during the whole programme. States should purchase their own collectors as their own property

5. Scientific Committee will prepare Standard Operating Procedures (SOP) for the full range of activities as part of the sampling and analysis activities

6. Representatives of Kuwait to send to ROPME Secretariat the list of instruments needed for seawater analysis using the standard procedure and the consultants to send the recommended procedure for the biological impact assessment.

7. ROPME Secretariat to organize a Proficiency Test (PT) among the willing national laboratory in the region for participation in the analyses of collected samples. Consultants will provide the necessary Reference Materials for the Test. The PT be carried out during the baseline or later experiments

8. Consultants to update the Concept Paper highlighting the potential of Climate Change on Sand-dust Storms and its impacts on the marine environment in RSA

9. ROPME to establish a module in the ROPME Integrated Information System (RIIS) for uploading activities and data relevant to the whole programme for sharing within the region and world-wide in future.

AGENDA ITEM 13: CLOSURE OF THE MEETING

Dr. Hassan, Coordinator of ROPME concluded the meeting after the exchange of courtesies at 17:00 hours on Wednesday, 28 September 2016.

ANNEX I

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LIST OF PARTICIPANTS

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ANNEX II

PROVISIONAL AGENDA

UNITED ARAB EMIRATES
MINISTRY OF CLIMATE CHANGE
& ENVIRONMENT

الإمارات العربية المتحدة
وزارة التغير المناخي
والبيئة

Scientific Committee Meeting on Monitoring and Assessment of Sand and Dust Storms in ROPME Sea Area

Dubai, UAE, 26-28 September 2016

PROVISIONAL AGENDA

1) **Registration**

2) **Opening of the Meeting**

3) **Organization of the Work:**
   - Statement of Ministry of Climate Change and Environment
   - Statement of ROPME

4) **Adoption of the Agenda**

5) **Experience from Outside the Region (Japanese Case Study)**

6) **Current Monitoring and Research Activities in the Region**

7) **Status of Existing Capacity for Sand and Dust Storms Monitoring in the RSA**

8) **Elements of the Monitoring Programme of Fallen Dust Impacts on the Marine Environment of the ROPME Sea Area**
   - Overall and Specific Objectives
   - Coverage Area (Sub regional / Regional)
   - Scientific Programme design (duration, sampling sites and frequency, analytes….etc.)
   - Needed training

9) **Implementation Plan and Time- Frame**

10) **Distribution of Tasks and Organisation of Work**

11) **Other Matters**

12) **Conclusions and Recommendations**

13) **Closure of the Meeting**

ANNEX III

QUESTIONNAIRE EVALUATION REPORT

Scientific Programme for Baseline Assessment and Long-term Monitoring of Impacts of Sand and Dust Storms on the Marine Environment in the ROPME Sea Area

The ROPME technical workshop in Dubai on 11-12 October 2015 agreed on conducting a long-term monitoring programme to assess the effects of dust and sand storms on the marine environment in the ROPME region. The first step of this process is to undertake an evaluation of existing capabilities in the region, and the second step is to undertake a pilot study. Subsequently, a baseline study of a full year and long-term monitoring programme can be undertaken.

This document reports on the evaluation of the existing capacity in the region, and provides an outline plan for the pilot study.

Existing capacity

The return on the evaluation form send out by us in late 2015 was excellent. We received returns from 5 countries (Iraq, Iran, Kuwait, UEA, Bahrain) with details on existing atmospheric and water column sampling and analysis. The amount of monitoring undertaken is extensive and very useful to our proposed scientific programme. We have summarized the finding, and this is provided in appendix 1.

There is a significant amount of particulate matter and gas sampling undertaken at a good number of sampling sites in the region. Furthermore, a number of countries have substantial satellite observation and ground based remote sensing activities. A limited amount of aerosol modelling is undertaken; it will be important to engage the modellers in our programme.

There is a good amount of water sampling undertaken, and in particular sampling for nutrients is common. The sampling stations are well distributed around the region. This is all very useful to our scientific programme.

There is a substantial amount of air quality data available from member states, which should be mined for analysis of the spatial distribution of air pollutants and dust as well as providing information on the sources of PM.

Overall, the return on the evaluations were of great importance and provide us with excellent information to design the pilot study, baseline study and long-term monitoring programme.

The scheduled meeting in August 2016 will allow us to make decisions on where to site the samplers for the pilkot and baseline study, with the aid of the information from the evaluation.

ROPME Pilot Project design

A number of important questions need to be addressed in order to improve our understanding of the effects of dust and sand storms on the marine environment in the ROPME area:

- What are the supplies of nutrients, trace elements and organic contaminants to the RSA by total and soluble aerosol deposition?
- What are the contributions of anthropogenic and natural sources to aerosol loadings in the RSA?
- What are the chemical and biological impacts of aerosol inputs to the waters of the RSA?
- How can future decisions be made on reduction of anthropogenic aerosol emissions in the ROPME region to mitigate their impact on RSA ecosystems?

These questions require us to understand and assess the impact of aerosol inputs to the RSA upon agreed baseline parameters.

The first step in the process of obtaining baseline parameters and undertaking a long term monitoringprogramme, will be the setting up of a pilot study of a limited scope and duration.

The Pilot Study will form a limited study involving 3 to 5 sampling sites in different parts of the RSA. The Pilot Study will ensure that the overall programme gets underway swiftly, and will also allowidentification of gaps and needs for the follow up larger programmes.

The pilot study is thus the predecessor of the Baseline Assessment. The "Baseline Assessment of Impact of Sand and Dust Storms (BAISDS) in the ROPME Sea Area" is a collective task of assessing Aerosol inputs and their biological impact for a full year in 2018-2019, to be used in references, comparisons and decision making. The BAISDS-2018 is expected to become a reference status to mineral dust and other aerosols for future times to come.The Long-term monitoring programme will follow the baseline assessment andprovide a temporal perspective to regional dust and anthropogenic aerosol concentration changes, and subsequent impacts on the health of the RSA.

Basic approach for the development of Pilot Study and BAISDS-2018

In developing the Pilot study and BAISDS-2018, complete harmonization of related initiatives and sharing of responsibilities will occur. The major milestones to be achieved are:

- Meeting of a Scientific Group to finalize the details of Scientific Programme of Pilot Study and BAISDS-2018.This meeting will identify sampling sites and institutes responsible for sampling
- Practical activity of developing the Pilot Study and BAISDS-2018 by way of completing sampling, analyses, interpretation and reporting

- Development of Regional capacity to contribute to and continue the efforts over a long time period by way of strengthening expertise and designating Regional Reference Laboratories

The overall aim of this small Pilot scale study is to provide initial data for developing a one year monitoring programme of BAISDS-2018.

Objectives of Pilot Study

- Set-up capacity to undertake aerosol sampling with high volume aerosol collectors, purchase aerosol collectors and sampling equipment for water column sampling
- Train staff in aerosol collection and water sampling
- Collection of aerosols and seawater samples over a 2 months period in the year 2017 at 3-5 locations in the ROPME Sea Area
- Identification of gaps and needs for larger monitoring programme
- Measurement of total and soluble elements and compounds in the collected aerosol samples at GEOMAR, Germany
- Measurement of trace elements, nutrients, organic compounds, carbonate chemistry, chlorophyll a and indicators of ecosystem structure in the collected water samples at GEOMAR, Germany
- Determination of the biological impact of aerosols in selected samples at GEOMAR, Germany
- Identification of the potential sources and transport pathways of mineral and anthropogenic aerosols in the Region at Birmingham

Expected outcome from Pilot Study

- Small and limited dataset on aerosol deposition and impacts on surface water biogeochemistry and biology for parts of the RSA
- Substantial and high quality dataset
- Gaps and Risks assessment for BAISDS-2018
- Actions plan to deal with gaps and risks for BAISDS-2018 implementation

Requirements to undertake Pilot Study

- High volume aerosol collectors for 3-5 sampling sites (2 collectors at each site)
- Funds for consumables and transport of samples to GEOMAR

- Researcher and technician at GEOMAR to prepare pilot study, train collectors, undertake sample analyses and reporting
- Researcher at Birmingham to undertake data analysis on existing and pilot study data

Indicative Programme Time-frame

- Meeting of the Ad-hoc Committee to finalize a detailed Scientific Programme with the identification of sampling team, players and Protocol of sampling – August 2016
- Designation of responsible Laboratories for conducting Aeolian mineral dust and seawater pilot study sampling – August 2016
- 1 week Training on sampling and sample preparations: January 2017
- Start of sampling for pilot study: June 2017 for a period of 2 months
- Completion of sample analyses of samples and reporting for pilot study: January 2018
- Start of BAISDS-2018: June 2018 for a 12 months period
- Completion of analyses of samples and reporting for BAISDS-2018: June 2019

Appendix 1

ROPME Evaluation outcomes

Iraq, Basra Environmental
Mr. Ahmed Hanoon

Section 1: Dust monitoring, analysis, and modelling

Section 1.1: Dust, air quality, and meteorology monitoring stations

A range of PM_{10} and $PM_{2.5}$samplers are available, and placed in the south of the country and also Bagdad. Optical and beta-attenuation measurements are also available. These are all very useful to our ROPME programme.

In addition, SO_2, O_3, NO_x-NO_2, CO, VOC data are available.

Section 1.2: Chemical and mineralogical analysis of airborne dust or dustfall

Elemental data is available for particulate matter and dust fall since 2006 for the Basra region, which is very useful.

Section 1.3: Ground-based remote sensing observations

No detail provided.

Section 1.4: Satellite observations

No detail provided.

Section 1.5: Analytical capacity of airborne dust and dust fall

Trace metals using AAS

Section 1.6: Modelling capacity of airborne dust and dust fall

none

Section 1.7: Additional Information

Section 2: Ocean biogeochemical and biological parameter monitoring, analysis, and modelling

Section 2.1: Ocean nutrient, trace metal and biological monitoring

Measurements of pH, temperature, phosphate, nitrate, chla and trace metals are made in the sea waters near Basra.

Section 2.2: Analytical capacity of marine biogeochemical variables

Spectrophotometer for nutrients and AAS for trace metals.Microscope with camera for phytoplankton.

Section 2.3: Remote sensing

No detail provided

Section 2.4: Modelling capacity of ocean biogeochemistry

No detail provided

Section 2.6 Additional information

No detail provided

Iran, Department of Environment
Dr Shina Ansari

<u>Section 1</u>: <u>Dust monitoring, analysis, and modelling</u>

Section 1.1: Dust, air quality, and meteorology monitoring stations

A range of PM_{10} and $PM_{2.5}$samplers are available, and placed around the country with also units along the coast, but it is difficult to assess what the locations are. There are optical, beta-attenuation, TEOM and filter systems available for online PM mass monitoring. This is all very useful to our ROPME programme.

In addition, SO_2, O_3, NO_x-NO_2, CO, VOC data is available

Section 1.2: Chemical and mineralogical analysis of airborne dust or dustfall

Elemental data and organic is available for particulate matter and dust fall, which is very useful.

Used analytical methods include GC-MS, IC, ICP-MS, ICP-OES, AAS, XRD, SEM, XRF, ToT,

Section 1.3: Ground-based remote sensing observations

Handheld and automatic sunphotometer measurements

Lidar observations and ceilometer (vertical backscattering) measurements

Section 1.4: Satellite observations

A whole range of satellite observations are used for collection of atmospheric and oceanographic products

Section 1.5: Analytical capacity of airborne dust and dust fall

A full suite of analytical techniques are available to measure trace metals, organic compounds, nutrients, particle characteristics.

Section 1.6: Modelling capacity of airborne dust and dust fall

Model	Center
BSC-DREAM8b	**BSC-CNS**
MACC-ECMWF	**ECMWF**
NGAC	**NCEP**
NMMB/BSCDust	**BSC-CNS**
Others: hysplit, aeromod, pmf, cmb, cmaq, wrf	

A range of models are used in Iraq. It is not clear at what institute the models are run, and who runs them.

Iran Meteorological Research Centre (ASMERC) is running aerosol/dust models, in particular the CasHKIand WRF-Chemmodels.

Section 1.7: Additional Information

Section 2: Ocean biogeochemical and biological parameter monitoring, analysis, and modelling

Section 2.1: Ocean nutrient, trace metal and biological monitoring

Measurements of pH, temperature, salinity, phosphate and trace metals are made in the sea waters off Khuzestan and Hormozgan, since 2013, and also in river waters and marshes.

Section 2.2: Analytical capacity of marine biogeochemical variables

Spectrophotometer for nutrients and ICPMS, ICPOES and AAS for trace metals.Microscope and PCR for phytoplankton and zooplankton.Also particle characteristics using XRF.

Section 2.3: Remote sensing

Not reported

Section 2.4: Modelling capacity of ocean biogeochemistry

ASMERC runs WRF-chem model for dust

Section 2.6 Additional information

none

United Arab Emirates, National Centre of Meteorology and Seismology (NCMS)
Majed Nasser Al Shekaili

Section 1: Dust monitoring, analysis, and modelling

Section 1.1: Dust, air quality, and meteorology monitoring stations

Air quality monitoring at Al Jeer –RAK,Al Burairat–RAK,Al Qasimiyah–RAK, Ghalilah–RAK, Al Humaidiyah–Ajman, Mushririf–Ajman, Hamriyah FZ-Sharjah, Kalba- Sharjah stations

PM_{10}beta-attenuation and SO_2, NO_x-NO_2, CO monitors are operational. This is useful to our ROPME programme.

Kuwait, KISR
Dr. T Al-Said and Dr. A Dousari

Section 1: Dust monitoring, analysis, and modelling

Section 1.1: Dust, air quality, and meteorology monitoring stations

TSP (gravimetric) and PM_{10} (gravimetric) and PM_{10} beta attenuation systems are operational at various sites since 2010. It seems that TEOM data are also available.

Section 1.2: Chemical and mineralogical analysis of airborne dust or dustfall

SEM, ICP-MS, Radionuclide, Pollen, Particle Size and amount fallen dust, and TPH are determined on dustfall for the period 2009-2011.

In addition, SO_2, NO_x-NO_2, O_3, CO data is available, so do meteorological data.

All these are at a range of sites.

Section 1.3: Ground-based remote sensing observations

No detail reported

Section 1.4: Satellite observations

MODIS Aqua Terra work is undertaken for 2009-2011

Section 1.5: Analytical capacity of airborne dust and dust fall

No detail provided but SEM, ICP-MS, Radionuclide, Pollen, Particle Size

Section 1.6: Modelling capacity of airborne dust and dust fall

Section 1.7: Additional Information

Section 2: Ocean biogeochemical and biological parameter monitoring, analysis, and modelling

Section 2.1: Ocean nutrient, trace metal and biological monitoring

Measurements of pH, temperature, salinity, nitrate, silicate, phosphate and metals are made in the sea waters off Kuwait.

Section 2.2: Analytical capacity of marine biogeochemical variables

CTD, Colorimetric techniques for nutrients, GFAAS, CSV, FeFIA for metals.Fluorimeter for chlorophyll, microscopy for phytoplankton and zooplankton.

Section 2.3: Remote sensing

Section 2.4: Modelling capacity of ocean biogeochemistry

Section 2.6 Additional information

none

Bahrain, Supreme Council for Environment (SCE)

Ms. Sara YousifTaqi
Eng. Hassan Abdulla AlMarzooq

Section 1: Dust monitoring, analysis, and modelling

Section 1.1: Dust, air quality, and meteorology monitoring stations

PM_{10} beta attenuation system operational at site in period 20061-2012.

In addition, SO_2, NO_x-NO_2, CO, VOC, and meteorological data data are available at Bahrain Fort, Tubli, Hidd, Ma'ameer and Askar Stations

Section 1.2: Chemical and mineralogical analysis of airborne dust or dustfall

No detail reported

Section 1.3: Ground-based remote sensing observations

No detail reported

Section 1.4: Satellite observations

No detail reported

Section 1.5: Analytical capacity of airborne dust and dust fall

No detail provided

Section 1.6: Modelling capacity of airborne dust and dust fall

No detail reported

Section 1.7: Additional Information

No detail reported

Section 2: Ocean biogeochemical and biological parameter monitoring, analysis, and modelling

Section 2.1: Ocean nutrient, trace metal and biological monitoring

Measurements of pH, temperature, salinity, nitrate, phosphate and chlorophyll are made in the sea waters off Bahrain since 2007, in particular at Qassar Noon, Mashtan, Jabbari, FashtTighalib, Ghumais, Askar, Msoor, Petroleum refinery, Al Gaha, Suhain, Fa#ash, Al Gazara, Dam, Qita'at>Jaradah, Marina club, Al JarimKhorfasht, Murwada, Bartafi, Qassar, Umm Al na'assan, JaziratYa#suf, Al Jasara, Shtaya, Abu Ithama, Najwat Abu Ithama, BpOmana, and Al Jarim West.

Section 2.2: Analytical capacity of marine biogeochemical variables

CTD, Colorimetric techniques for nutrients, GFAAS, CSV, FeFIA for metals.Fluorimeter for chlorophyll, microscopy for phytoplankton and zooplankton.

Section 2.3: Remote sensing

No detail reported

Section 2.4: Modelling capacity of ocean biogeochemistry

No detail reported

Section 2.6 Additional information

No detail reported

ANNEX IV

CONCEPT PAPER

BASELINE ASSESSMENT AND MONITORING OF IMPACTS OF DUST ON THE MARINE ENVIRONMENT OF THE ROPME SEA AREA

DRAFT

Concept Paper

Baseline Assessment and Monitoring of Impacts of Dust on the Marine Environment of the ROPME Sea Area

Introduction

Background

Decision CM16/7 of the ROPME Ministerial Council directed that in view of the high significance of the matter, information on the impact of sand and dust storms on the marine environment in the ROPME Sea Area (RSA) be obtained. It mandated that a Concept Paper be prepared to elaborate the issues of the impact of sand and dust storms on the health of the ocean in the RSA, to be followed immediately by a pilot scale project and subsequently by a baseline assessment and long-term monitoring programme. Pursuing these Decisions, a Regional Meeting for the Review of the Concept Paper Elaborating the Issues of Sand and Dust Storms and their impact on Ocean Health in the RSA is conducted during 11-12 October 2015. This forum provides an opportunity to review the general aspects relevant to mineral dust production, transport and deposition in the ocean and consequent biogeochemical and physical impacts in the Region, consider the capacities and resources of the Member States and prioritize the areas of future activities of high significance to RSA. The Meeting will develop a small scale pilot study which will cover part of the region and will allow the identification of gaps and needs that are required to be addressed for a successful implementation of the subsequent larger scale programme. The Meeting will also develop the rationale for the baseline assessment and long-term monitoring “to generate the first synoptic data on sand and dust storms and their impacts on the marine environment in the RSA, collate existing data, assess and mobilise the core expertise of the Member States on the subject and prepare technical capacity grounds for a comprehensive Regional monitoring programme and Regional network of facilities”. The present Draft Concept Paper is prepared in this context and is submitted to the First Meeting of the Regional Scientific Group to deliberate upon and finalize.

Need for Baseline Assessment and Long-term Monitoring Programme

Millions of tons of dust, usually from arid and semi-arid areas, are emitted annually to the atmospheric boundary layer (Shi et al., 2012). The large quantities of dust result in severe air pollution, reduced visibility, adverse human health effects and impaired soil fertility. Importantly, mineral dust is a dominant atmospheric aerosol on a global scale and plays an important role in the Earth’s climate system. Mineral dust directly affects the climate by reflecting solar radiation and absorbing solar and terrestrial radiation, and indirectly by influencing cloud properties. The radiative effects therefore have important implications for global climate, but form an important uncertainty in climate model predictions (Patey et al., 2015). Dust can indirectly affect the climate by stimulating primary productivity and di-nitrogen fixation in the surface ocean through addition of nutrients such as iron and phosphorus (Zender et al., 2003). For example, variations in iron supply to the Southern Ocean associated with mineral dust are considered to influence atmospheric CO_2 levels on geological timescales through iron fertilisation of primary productivity (Martin, 1991).

The African and Asian low-latitude deserts are the major global sources of dust (Zender et al., 2003). The dust belt includes the Sahara and Sahel, arid and semi-arid regions in Arabia and Central Asia, and the Taklamakan and Gobi deserts in East Asia. The Arabian Plateau and the Tigris-Euphrates Basin in the Middle East are areas of active wind erosion. The most important dust sources in the region include the Tigris-Euphrates River alluvial plain in Iraq and Kuwait, the low-lying flat lands in the east of the Arabian peninsula along the Gulf, and the Ad Dahna and the Rubal Khali deserts (Ginoux et al., 2001). The alluvial plains have the highest frequency of dust storms in the Middle East (Ito, 2013), and the fine sediments from the Tigris and Euphrate rivers allow long distance dust transport. Another dust source area is along the Oman coast, with a low frequency of dust storms (Ito, 2013).

Dust emission estimates for the Middle East range from 221 to 496 Tg y^{-1} (Ginoux et al., 2001; Tanaka and Chiba, 2006; Zender et al., 2003) representing between ca. 12 to 28% of global dust emissions. In recent years dust activities have intensified in the region, and this has been attributed to anthropogenic activities such as damming of the Tigris and Euphrates rivers, retreat of Caspian and Aral Seas, land use changes and land degradation (Al-Awadhi et al., 2014; Ginoux et al., 2012). Enhanced atmospheric dust loadings occur throughout the year in the region, but decrease in winter months. A typical annual cycle shows increases in dust loadings in March and April, a maximum in June and July and a decrease in September (Ginoux et al., 2001).

The RSA receives one of the largest aerosol loadings of any of the world's ocean regions due to its proximity to the Middle Eastern deserts and prevailing wind patterns. The situation in the RSA is comparable to the tropical and subtropical North Atlantic Ocean, which is subjected to large dust inputs from North African deserts (Patey et al., 2015). Dust and anthropogenic aerosols form an important source of nutrients (nitrogen, phosphorus and silicon) and biologically important (e.g. iron, zinc) and toxic (e.g. copper) trace elements to the global surface ocean (Baker et al., 2007; Duce and Tindale, 1991; Jickells et al., 2005), and therefore have an important influence on marine biogeochemical processes and ecosystems. It has been reported that transport of dust from the Sahara and Sahel regions of northern Africa results in increased dissolved Fe concentrations in the North Atlantic Ocean (Measures et al., 2008; Rijkenberg et al., 2008; Rijkenberg et al., 2012; Sarthou et al., 2007; Ussher et al., 2013), which influences di-nitrogen fixation (Mills et al., 2004; Moore et al., 2009; Rijkenberg et al., 2011; Schlosser et al., 2014) and the structure and functioning of microbial communities (Hill et al., 2010). Aerosol inputs into the Northern Red Sea have been reported to have detrimental effects on phytoplankton communities, which has been attributed to enhanced dust-derived copper inputs (Paytan et al., 2009). However, very little is known about aerosol inputs to the RSA and their impacts of ocean chemistry and biology.

Recent studies have shown that anthropogenic emissions have become an important contributor to aerosol deposition to the oceans (Duce et al., 2008; Fomba et al., 2013; Patey et al., 2015). Studies in the tropical North Atlantic Ocean have shown that pollutant aerosols originating from west Africa, Europe and North America become mixed with Saharan and Sahelian mineral dust (Fomba et al., 2013; Patey et al., 2015). The anthropogenic aerosols are derived from agriculture, biomass burning, fossil fuel burning in power plants, domestic heating, automobiles and ships (Ito, 2013; Ito and Shi, 2015; Luo et al., 2008; Mahowald et al., 2009; Myriokefalitakis et al., 2015), and industrial processes including smelting and petrochemical activities. Anthropogenic aerosol particles are typically smaller than mineral dust, and hence can be transported further afield. In addition, a higher proportion of the elements and compounds associated with anthropogenic aerosols dissolve upon deposition in the surface ocean, compared with mineral dust. The following compounds are enriched in anthropogenic aerosols: V, Ni, Cu, Cr, Zn, Cd, Hg, Pb, N, sulphate, organic carbon and black carbon, polyaromatic hydrocarbons (PAHs).

Furthermore, acidic gases emitted from fossil fuel combustion can also interact with mineral dust, leading to dust acidification. This will help to convert insoluble nutrients such as iron and phosphorus into bioavailable forms (Ito, 2013; Ito and Shi, 2015; Myriokefalitakis et al., 2015; Nenes et al., 2011; Shi et al., 2012). The net effect would be an increase in the delivery of bioavailable nutrients and trace elements to the ocean (Ito and Shi, 2015).

The ROPME region has seen pronounced population growth and industrialisation over the last decades (ROPME, 2013), resulting in enhanced environmental pressures on the RSA. Pressures identified by ROPME include oil pollution, radioactive discharges, discharges of household and industrial sewage which provide enhanced metal, nutrient and organic matter loadings, and environmental degradation of coastal zones and overexploitation of living marine resources (ROPME, 2013). The increased frequency of nuisance phytoplankton blooms (red tides) has been considered a major threat to human health and marine ecosystem services in the RSA (ROPME, 2013).

The impacts of mineral dust deposition to the RSA has however not yet been considered, despite reported increased dust activity over recent years (Solmon et al., 2015) and likely a higher contribution to the dust loading of anthropogenic aerosols (both from fossil fuel combustion and anthropogenic dust emission) from increased urbanisation and industrialisation. Anthropogenic aerosols will likely also be transported to the RSA from outside the ROPME region; in particular atmospheric pollution from Pakistan and India will be delivered during the NE monsoon period. The anthropogenic and biomass burning aerosols from the Indian subcontinent can be observed during the NE monsoon period over the North Indian Ocean (December to May), including the Sea of Oman (Myriokefalitakis et al., 2015); the impacts on the health of the ocean are unknown. Furthermore, the RSA is an important shipping region, with annually nearly 50,000 vessels passing through the Strait of Hormuz. Ship´s emissions contain elevated levels of toxic trace elements and compounds (Cr, V, Ni, PAHs, S) which tend to be highly soluble (Ito, 2013; Schroth et al., 2009) and are therefore likely to make a significant but unknown contribution to aerosol inputs in the RSA.

The importance of mineral dust and other aerosols as a source of trace elements, nutrients and other compounds to the ocean has stimulated research into its production, transport, deposition and subsequent dissolution in surface waters. Over the last two decades, satellite measurements have proved indispensable in the evaluation of dust sources and the provision of transport pathways. While they provide unparalleled spatial and temporal coverage of dust transport, it is however hard to extract quantitative information on aerosol concentration, composition and its dissolution in seawater from satellite observations. In-situ aerosol measurements and dust dissolution studies are therefore essential to obtain accurate data (Mahowald et al., 2005). Due to the sporadic nature of dust transport, long-term measurements of aerosols, such as those made at Bermuda, Miami and in the

Canary Islands (Gelado-Caballero et al., 2012; Prospero and Lamb, 2003; Trapp et al., 2010) and Cape Verde (Patey et al., 2015) are essential in order to build up a picture of dust fluxes and composition. Analyses of the total quantity of elements and compounds in aerosols provide information on the total fluxes to the surface ocean. Dissolution experiments with collected aerosols provides data on the fraction of elements and compounds released upon entry of aerosols in seawater (Buck et al., 2006), which is directly relevant to assess biological impacts. Collected aerosols can also be used to assess their effects on surface water microbial communities through short term bottle incubation experiments involving aerosol additions to microbial populations (Hill et al., 2010; Mills et al., 2005; Paytan et al., 2009).

In situ oceanographic observations of the impacts of aerosol deposition on biogeochemical processes and ecosystem functioning and structure in the surface ocean are of great value. A multitude of studies have provided important information about aerosol impacts on surface ocean chemistry, di-nitrogen fixation, heterotrophy and community structure (Achterberg et al., 2013; Guieu et al., 2014; Moore et al., 2009; Schlosser et al., 2014).

The chemical composition and mineralogy of transported dust can be used to identify the original source of the dust (Patey et al., 2015). This will be important for tracing anthropogenic atmospheric pollution sources in view of potential targeted emission reduction legislation. Recent research indicated the importance of dust composition and mineralogy for trace metal solubility (Aguilar-Islas et al., 2010; Sholkovitz et al., 2012), which highlights the need to link aerosol samples to specific sources.

In the light of all these, a number of important questions arise:

- What are the supplies of nutrients, trace elements and organic contaminants to the RSA by total and soluble aerosol deposition?
- What are the contributions of anthropogenic and natural sources to aerosol loadings in the RSA?
- What are the chemical and biological impacts of aerosol inputs to the waters of the RSA?
- How can future decisions be made on reduction of anthropogenic aerosol emissions in the ROPME region to mitigate their impact on RSA ecosystems?

These questions require us to understand and assess the impact of aerosol inputs to the RSA upon agreed baseline parameters.

Definitions and mechanism

Generic definition of Pilot Study, Baseline Assessment and Long-term monitoring programme

The Pilot Study will form a limited study involving up to 3 sampling sites in different parts of the RSA. The Pilot Study will ensure that the overall programme gets underway swiftly, and will also allow identification of gaps and needs for the follow up larger programmes.

The Baseline Assessment will be described in detail in the course of this documentation. However, a generic definition is to be established at the start, in order to delineate the scope of the work and focus the efforts within a framework of feasibility. The generic definition is as follows:

The "Baseline Assessment of Impact of Sand and Dust Storms (BAISDS) in the ROPME Sea Area" is a collective task of assessing Aerosol inputs and their biological impact for a full year in 2017-2018, to be used in references, comparisons and decision making.

The BAISDS-2017 is expected to become a reference status to mineral dust and other aerosols for future times to come.

The Long-term monitoring programme will provide a temporal perspective to regional dust and anthropogenic aerosol concentration changes, and subsequent impacts on the health of the RSA.

Basic approach for the development of Pilot Study and BAISDS-2017, and subsequent Long-term monitoring Programme

In developing the Pilot study and BAISDS-2017, complete harmonization of related initiatives and sharing of responsibilities will occur. The major milestones to be achieved are:

- Meeting of a Scientific Group to finalize the details of Scientific Programme of Pilot Study and BAISDS-2017
- Practical activity of developing the Pilot Study and BAISDS-2017 by way of completing sampling, analyses, interpretation and reporting
- Development of Regional capacity to contribute to and continue the efforts over a long time period by way of strengthening expertise and designating Regional Reference Laboratories

While this is the broader picture, the details will emerge further on in this document.

Objectives and outcomes

The overall aim of this small Pilot scale study is to provide initial data for developing a one year monitoring programme of BAISDS-2017.

Objectives of Pilot Study

- Set-up capacity to undertake aerosol sampling with high volume aerosol collectors
- Collection of aerosols and seawater samples over a 2 months period in the year 2016 at 3 locations in the ROPME Sea Area
- Identification of gaps and needs for larger monitoring programme
- Measurement of total and soluble elements and compounds in the collected aerosol samples
- Measurement of trace elements, nutrients, organic compounds, carbonate chemistry, chlorophyll a and indicators of ecosystem structure in the collected water samples
- Determination of the biological impact of aerosols in selected samples
- Identification of the potential sources and transport pathways of mineral and anthropogenic aerosols in the Region

Objectives of Study of Dust Inputs to RSA during 4 seasonal Cruises in 2016

- Contribute to the 2016 cruise programme through aerosol collection and surface water analysis for assessment of impacts of aerosols on RSA
- Undertake aerosol sampling on cruises using high volume aerosol samplers
- Measurement of total and soluble elements and compounds in the collected aerosol samples
- Determination of the biological impact of aerosols in selected samples
- Identification of the sources and transport pathways of aerosols collected on cruises

Objectives of BAISDS-2017

The overall aim is to provide essential baseline data for developing an international flagship monitoring programme of aerosol impact on the RSA

- Collection of aerosols over a full seasonal cycle in the year 2017 at locations in the ROPME Sea Area
- Measurement of total and soluble elements and compounds in the collected aerosol samples

- Collection of surface water samples over a full seasonal cycle in the year 2017 at locations in the ROPME Sea Area for chemical and biological measurements
- Determination of the biological impact of aerosols over a full seasonal cycle in 2017-2018 in the ROPME Sea Area
- Determination of the impact of aerosols on the water column carbonate system (ocean acidification) over a full seasonal cycle in 2017-2018 in the ROPME Sea Area
- Quantification of the sources and fluxes of mineral and anthropogenic aerosols in the Region
- Determination of the main processes regulating the distribution, transport and the deposition of mineral and anthropogenic aerosols in the RSA
- Chemical transport modelling to integrate the mineral and anthropogenic aerosol data from observations with information on dispersion, transport and biological uptake processes
- Modelling of trace element and nutrient deposition, constrained by remote sensing of total aerosol deposition rates in combination with ground measurements
- Further development of local physical-biogeochemical model with improved aerosol supply fluxes and biological impact quantification
- Use outcomes of the monitoring programme to assess impact of aerosol deposition on health of the RSA and lobby regional governments to reduce anthropogenic atmospheric emissions in the region
- Promotion and strengthening of the capabilities and readiness of the Member States in the domain aerosol mineral dust monitoring and establishment of biological effects
- Archival and integration of relevant atmospheric and oceanographic information to the BAISDS-2017
- Establishment of Regional and international collaborations on the platform of BAISDS-2017 as a networked capacity for future endeavors
- Designation of Regional Reference Laboratories for the continuation of work emanating from the BAISDS-2017
- Establishment of a regular long-term Regional Monitoring Programme including the networking of National Monitoring Programmes on aerosols

Objectives of Long-term monitoring programme

The overall aim is to provide long-term trends on aerosol deposition and the impacts on the health of the RSA

- Quantification of temporal and spatial distribution of deposition fluxes of soluble and total trace elements, atmospheric nutrients and organic pollutants to the ROPME Sea Area from both natural and anthropogenic sources

- Quantification of temporal and spatial impacts of aerosol deposition on water column biogeochemistry, carbonate chemistry (ocean acidification) and ecosystems
- Quantification of anthropogenic sources (dust and fossil fuel combustion aerosol) to the aerosol deposition fluxes
- Refinement of the chemical transport model with the outcomes of the monitoring programme
- Assessment of temporal changes in aerosol deposition and biogeochemical and ecosystem impacts in the RSA
- Development and refinement of RSA biogeochemical model
- Development of effective atmospheric pollutant emission control measures in the region
- Assessment of the effectiveness of atmospheric pollutant emissions in the RSA and benefits to RSA

Expected outcome from Pilot Study

- Small and limited dataset on aerosol deposition and impacts on surface water biogeochemistry and biology for parts of the RSA
- Substantial and high quality dataset from collaborative 2016 cruise campaigns in RSA region
- Gaps and Risks assessment for BAISDS-2017
- Action plan to deal with gaps and risks for BAISDS-2017 implementation

Expected outcome from the BAISDS-2017

- Establishment of a comprehensive geospatial database of previous relevant studies in the Region and experiences gained elsewhere on aerosol impacts, with provision for updating of data from the monitoring stations and networking with other data facilities

- Establishment of a joint information center with dedicated website for collection of required international standards, international guidelines, standard software, data analysis models, standards concerning aerosols as related to marine biogeochemical and ecosystem impacts and decision support tools

- Designation of Regional aerosol dust monitoring facilities and measurement laboratories, and including a cross calibration exercise to guarantee harmonization of the measurements made by each laboratory (capacity building)

- Development of a Regional Monitoring programme for Aeolian mineral dust and its impacts on the ocean through the participation of Member States, including designated stations and standardized operating procedures and equipment

- Establishment/suitable upgrading of aerosol dust analysis stations in the ROPME Sea Area. These stations serve both as a network for Aeolian mineral dust concentration information as well as Aerosol Monitoring System through standardized methodology

- Provision of scientist exchange programme and Regional seminars/ workshops on studies dedicated to marine environment and Aeolian mineral dust and their impacts on ocean health

- Establishment of aerosol dust monitoring and analysis stations, biological impact assessment activities for dust deposition to the ocean, training and collaboration programmes by the Member States

The above outcomes can be targeted in a phased manner on completion of the BAISDS-2017 and presentation of results to the Member States by the Regional Scientific Group.

Expected outcome from Long-term Study

- High quality temporal and spatial data set of Aeolian mineral dust measurements, with their impact on the ocean in the RSA
- Data for policy makers and scientists to establish impacts of Aeolian mineral dust inputs on health of the ocean, including nuisance algal blooms
- Data and evaluation tools for regional policy makers to undertake emission reduction measures with respect to atmospheric pollution
- Strengthened long-term scientific collaborations in the ROPME region

Technical description

Elements of BAISDS-2017

Following are the elements of the technical programme to develop BAISDS-2017, each of which is described in detail below:

1. Geographic coverage
2. Prioritization of monitoring and research issues
3. Target elements and compounds
4. Criteria and selection of suitable sampling sites
5. Sampling Protocol and sample types
6. Sampling Frequency

7. Sampling management
8. Database design and operation
9. Sample analyses issues and Identification of responsible laboratories
10. Inter-calibration and QA/QC procedures
11. Data Management and Reporting
12. Training needs
13. Linkage with other ROPME Activities
14. Integration with other National and Regional Programmes
15. Programme Time-frame

Description of the elements of the technical programme of BAISDS-2017

1. **Geographic coverage**

   BAISDS-2017 is envisaged to cover the ROPME Sea Area. Aerosol sources from both the Middle East and India and Pakistan are expected to be transported to the RSA, and consequently sampling stations will need to be situated at various strategic sites in the ROPME region

2. **Prioritization of monitoring and research issues**

   The basic research issue linked to the BAISDS-2017 is:

   - Background survey

3. **Target elements, compounds, and biological impact assays**

   The priority set of target elements and compounds to be analyzed in collected aerosol samples in BAISDS-2017 are listed below. The elements include essential elements for microbial organisms (e.g. Fe, Co, N, P), but also toxic elements and compounds (Cu, PAHs) and elements that may be involved in nuisance bloom development (N, P). We will also determine the impacts of dust inputs on water column carbonate chemistry, in order to assess ocean acidification effects. On selected samples, we will determine mineralogy using XRD and electron microscope (EM) techniques, in order to contribute to the determination of the source of the aerosol. A comprehensive quantitative source apportionment of airborne particles and soluble trace elements and nutrients therein will be carried out using receptor models. We will undertake atmospheric modelling of trace element and nutrient deposition, constrained by remote sensing of total aerosol deposition rates in combination with ground measurements

   We will undertake water sampling to assess the impact of aerosol inputs on chemistry (including ocean acidification) and biology. We will further develop a local physical-biogeochemical model with improved aerosol supply fluxes and biological impact quantification. Typical anthropogenic gases, such as ozone, NOx and SO_2 are to be determined at selected stations to identify origin of the collected air masses. Multispectral (UV to PIR) atmospheric aerosol optical depth (AOD) will be performed using manual photometers in the frame of the Maritime Aerosol Network (MAN) component of AERONET. Data will be provided to the AEROSOL/MAN data base of aerosol measurements over marine areas (http://aeronet.gsfc.nasa.gov/new_web/maritime_aerosol_network.html).

Elements, compounds, gases and physical measurements	**Matrix**
Na, Mg, Al, K, Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ag, Cd, Sn, Hg, Pb, U, P, OC/EC, PAHs, molecular tracers	Collected aerosols (total fraction)
Na, Mg, Al, K, Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ag, Cd, Sn, Hg, Pb, U, Cl^-, sulphate, ammonium, nitrate, phosphate, silicic acid, sulphate, DOC	Water soluble aerosol fraction
Al, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ag, Cd, Hg, Pb, U, ammonium, nitrate, phosphate, silicic acid, DOC, dissolved inorganic carbon and total alkalinity	Seawater samples
Ozone, VOCs, NOx and SO_2 at selected stations	Gas phase

Aerosol optical depth (AOD, using manual photometer)	Atmosphere
XRD-EM mineral analysis	Particulate aerosol samples

Biological Impact	**Matrix**
Effects of dust deposition on surface water ecosystems (chlorophyll a , photosynthetic efficiency and microbial composition of waters)	Surface seawaters
Dust additions from selected samples to phytoplankton cultures	Seawater phytoplankton culture

4. Criteria and selection of suitable sampling sites

Criteria are required to select the optimum sampling sites, for which the following aspects are to be considered:

- Sampling must be cost and effort effective
- Process of selection of sampling sites should consider the wind patterns of the Region and represent locations of importance for the various air masses reaching the RSA, and anthropogenic activities (industry, urban areas, shipping). Air mass trajectory modeling experiments and regional air quality data analysis will be conducted to aid with site selection.
- Existing ROPME Reference sites are to be carefully considered in order to benefit from historical data
- Existing and planned Regional initiatives including surveys should be utilized to undertake Aeolian mineral dust sampling at sea in combination with water column sampling to assess impact of dust deposition. This harmonization will optimize sampling effort and provide important added value to the programme

- Adaptive extension of national efforts should be ensured to cover some sites on the coast as well as in the near-shore environment through national activities as contribution to BAISDS-2017

With these criteria, xx sites as explained below are considered as BAISDS-2017 reference stations.

5. Sampling Protocol and sample types

The standard operating procedure of sampling for aerosols will be to collect total suspended particles (TSP) using high volume aerosol collectors, employing W41 (Whatmann 41) filters and also Quartz (Whatmann QMA) filters. Full digestion will be undertaken on the W41 filters for subsequent elemental analyses by inductively coupled plasma mass spectrometry (ICP-MS). The digestion will involve a mixture of HCl, HNO_3 and HF to obtain complete digestion. A rapid deionized water (e.g. MQ water, Millipore) leach will be undertaken on W41 and QMA filters for subsequent elemental analyses by ICP-MS, and anion analyses by ion chromatography and nutrient analyses by autoanalyser. Dissolved organic carbon analyses will be undertaken using high temperature combustion techniques and PAHs using liquid chromatography. Mineralogical composition will be conducted on selected samples through X-Ray Diffraction (XRD)/EM analyses. A punch of QMA will be used for organic carbon (OC) and elemental carbon (EC) using a carbon analyser. Half of the QMA filters will be extracted with organic solvent for molecular marker analysis by GC-MS.

Water column sampling will be undertaken for nutrients with subsequent analysis using an nutrient autoanalyser. Samples will be collected for organic carbon, organic pollutants, microbial community structure and chlorophyll a analysis. In addition samples will be undertaken for trace elements using specialized trace metal clean techniques. Analysis will be undertaken by ICP-MS following preconcentration and matrix removal. Samples will be collected for carbonate chemistry analysis (dissolved inorganic carbon and total alkalinity). Temperature and salinity will be determined on-site using calibrated probes.

Biological impact assessment of aerosols will be conducted by addition of aerosol sample to phytoplankton cultures during short-term (48 h) incubation experiments, and assessment of changes in biomass (chlorophyll a) and physiological health (Fv/Fm) (Hoffmann et al., 2012).

For BAISDS-2017, we will adopt the aerosol sampling and elemental analysis protocol from the International GEOTRACES programme (Morton et al., 2013). For nutrient and organic analyses we will use standard methods. The Scientific Group will prepare clear standard operating procedures for the full range of activities as part of the sampling and analyses activities.

6. Sampling Frequency

The BAISDS-2017 is an exercise of establishing a reference for the year 2017-2018 over a period of 12 months. As such, a full seasonal cycle will be sampled continuously at the various sampling sites. Filters on the high volume pumps will be changed every 2 days. Filters will be frozen to -20C for subsequent analyses. Water samples will be collected every month.
Daily AOD measurements will be undertaken. At selected sites continuous gas measurements will be undertaken.

7. Sampling management

The sampling process management will be a coordinated operation, requiring cooperation and support of the Member States. The schema is as follows:

- ROPME will be BAISDS-2017 Coordinator and will receive guidance from the Scientific Group.
- BAISDS-2017 Coordinator will establish a sampling schedule, provide necessary technical support and prepare a Sampling Protocol in cooperation with the Regional Scientific Group and GEOMAR to be made available to the members of the sampling management team

8. Sample banking

ROPME shall archive the samples in ROPME-Sample Bank (RSB) under required conditions, pending the dispatch of sub-samples to the central laboratory for analyses.

9. Sample analyses issues and identification of responsible laboratories

One laboratory is designated for the analyses of samples, especially since this is a baseline assessment. For the follow-up monitoring however, further laboratories can be selected and involved by conducting proficiency tests. In case of force majeure, it may be decided to split the samples for analyses amongst different laboratories in the Region.

10. Inter-calibration and QA/QC procedures

This will be carried out as per the relevant Guidelines of GEOMAR

11. Data Management and Reporting

All data generated from the BAISDS-2017, both concerning Aeolian mineral dust and the ancillary environmental information, will be secured under ROPME copyright as they are produced. BAISDS-2017 Coordinator, in consultation with the Scientific Group will validate all the data. The validated data will be managed as per the following schema:

- Data will be archived in ROPME and GEOMAR Data Library
- Data will be organized into technical report with necessary interpretations, with the help of expert consultants
- Technical report will be published by ROPME for circulation
- Data will be hosted on ROPME Integrated Information System (RIIS)

12. Training needs

There is a distinct opportunity for capacity development in the Region for both the participation in BAISDS-2017 and to carry out the follow-up activities, such as a regular monitoring programme. As such, the training needs are for:

- Effective sampling , sample preservation and analyses
    - A training course demonstrating the relevant procedures for sampling and aerosol analyses is planned with the cooperation of GEOMAR for National experts expected to participate in BAISDS-2017. This can be treated as an exercise to 'train the trainers', expecting a cascading effect in the Member States. GEOMAR is to provide the training programme along with the needs and requirements for the training course, so as to help in preparations
- Successful sampling and analyses of samples
    - The designated Regional Reference Laboratory will have the responsibility to train the scientists of the Region periodically to carry out the sampling and analyses of aerosols
- Data management
    - ROPME in cooperation with IOC and GEOMAR and on the platform of RIIS will conduct training programmes on general marine data management as applicable to the Region, from time to time

13. Linkage with other ROPME Activities

Effective linkages/harmonization will be established for BAISDS-2017 with the following ROPME activities, as cited earlier:

- Oceanographic cruises
- Preparation of the State of the Marine Environment Report (SOMER)
- RIIS

14. Integration with other National and Regional Programmes

It is expected that the Member States will offer an opportunity to integrate with their existing and planned national programmes of relevance in order to make BAISDS-2017 cost and effort effective. Voluntary sharing of responsibilities in the aerosol dust sampling programme is one important primary step.

Further, ROPME shall explore the possibility of involving Regional and International programmes of UNEP. In particular, a link to UNEP-ROWA will be important in order to link aeolian mineral dust impacts on rain events on the Indian sub-continent, and the effects of west Asian pollution aerosols on the health of the RSA.

15. Indicative Programme Time-frame

- Finalization of Draft Scientific Programme: January 2016
- Meeting of the Ad-hoc Committee to finalize a detailed Scientific Programme with the identification of sampling team, players and Protocol of sampling – March 2016
- Designation of responsible Laboratories for conducting Aeolian mineral dust and seawater pilot study sampling – April 2016
- 2 weeks Training on sampling and sample preparations: May 2016
- Contribution to 2016 ROPME cruise programme
- Start of sampling for pilot study: Nov 2016 for a period of 2 months
- Completion of sample analyses and reporting for pilot study: July 2017
- Start of BAISDS-2017: Nov 2017 for a 12 months period
- Completion of analyses of samples and reporting for BAISDS-2017: November 2019

Conclusion

BAISDS-2017 is an essential and timely exercise. As structured in the descriptions above, it is feasible to conduct it successfully and establish a reference for future use. Cooperation and establishment of a mechanism for sharing the responsibilities by the Member States is the key to success. Once completed, BAISDS-2017 will stand as a key milestone in the collective efforts of monitoring the Region and rendering our ecosystems protected.

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ANNEX V

UPDATED QUESTIONNAIRES ON DUST AND OCEAN BIOGEOCHEMICAL MONITORING AND RESEARCH CAPACITY IN ROPME MEMBER STATES

Questionnaires on dust and ocean biogeochemical monitoring and research capacity in ROPME member states

The aim of this questionnaire is to find out the monitoring and research capacity within ROPME Member States related to research on dust and ocean biogeochemistry. This will be used to develop a coherent and inclusive scientific programme for a Regional study on the “Monitoring and Assessment of Sand and Dust Storms on the Marine Environment in the ROPME Sea Area”.

This questionnaire will be divided into two sections.

Please complete this questionnaire, adding all the information relevant to each question and the national representative of your country

The survey has two sections covering:

Section 1: Dust monitoring, analysis, and modelling

Section 2: Ocean biogeochemical and biological parameter monitoring, analysis, and modelling

Institutional information:

Name of Member State: ____________.

National representative/contact person:

Prof, Dr, Ms, Mrs, Mr:
Position:
Institution:
Postal Address:
Telephone:
Telefax:
E-mail:
http://
Date: Signature:
(Permanent Representative)

Please, return the completed form at your earliest convenience, but not later than 28thNovto thefollowing address:

Dr. Hassan Awad [hbawad@ropme.org] ; [ropme@ropme.org]

Section 1: Dust monitoring, analysis, and modelling

Section 1.1: Dust, air quality, and meteorology monitoring stations

Particulate aerosol or dust samplers (e.g. TSP (total suspended particulate) or PM10) are essential for collection of dust samples Chemical composition analysis of the dust/particulate aerosol samples will then be conducted in a laboratory.

Table 1: TSP samplers; please add rows as necessary

Model	Volume (high, e.g., 1 m^3/min or low, e.g., 16.7 l/min)	Automatic filter change (allowing daily sampling for up to two weeks)? (yes or no)	Frozen storage of samples? (yes or no)

The recommended High Volume Sampler is Digital High Volume Aerosol Sampler DHA-80, which can automatically change filters for up to 16 times (with a preset sample duration), and we recommend frozen storage of collected samples. The recommended low volume sampler is the PM126M sampler from Environment SA, which can automatically change filters for up to 21 times (with a preset sample duration), and we recommend frozen storage for collected samples.

In-situ instruments to monitor airborne dust and other pollutants are currently used by environmental networks, Universities and research institutes. So, it is highly recommended to include information about instruments and networks owned by both and other national entities. Model of instrument in operation, coordinates and height, name of the network, Near Real Time (NRT) data availability to the Met Service (or not) and period of data records should be reported in the Table 2.

Table 2: Air quality monitoring; please add rows as necessary

Method	Model	Lat	Lon	Height	Network/ institution	NRT?	Data available since when
PM10/PM2.5 gravimetric method						**Yes No**	
PM10 Beta-attenuation						**Yes No**	
PM10 Tapered Element Oscillating Microbalance (TEOM)						**Yes**	

PM10 TEOM-FDRS (Filter Dynamics Measurement System)						**Yes**	
PM10 Chemical Speciation (Chemical composition)						**Yes** **No**	
SO2						**Yes** **No**	
O3						**Yes** **No**	
NOx and/or NO2						**Yes** **No**	
CO						**Yes** **No**	
Volatile Organic Compounds (VOCs)						**Yes** **No**	
Meteorological parameters (wind speed, wind direction, humidity, rainfall)							

PLEASE COPY AND FILL IF THERE ARE MULTIPLE STATIONS

Section 1.2: Chemical and mineralogical analysis of airborne dust or dust fall

Chemical and mineralogical analysis of airborne dust or dust fall at Universities and research institutes should be reported in the Table 3.

Table 3: Chemical and mineralogical analysis of particulate matter or dust fall

Parameter	Methods	Lat	Lon	Height	Network/ institution	Scientist in charge; Email address	Data available since when
Particulate matter Chemical Speciation (Chemical composition)							
Dust fall speciation (Chemical composition)							

Section 1.3: Ground-based remote sensing observations

Ground-based remote sensing techniques for aerosol/dust monitoring are normally used by Universities and research institutes. So, it is highly recommended to include information about instruments and networks owned by national external entities. Model of instrument in operation, coordinates and height, name of the network, Near Real Time (NRT) data availability (or not) and period of data records should be reported in the Table 4.

Table 4: Ground-based remote sensing observations; please add rows as necessary

Method	Model	Lat	Lon	Height	Network/ institution	NRT?	Data available since when
sun photometers observations within the international AERONET network based on Cimel instruments						Yes No	
Other automatic Sunphotometers						Yes No	
Hand Sunphotometers						Yes	
Lidars						Yes	
New generation Ceilometers (vertical backscattering)						Yes No	

Section 1.4: Satellite observations

Please, specify the satellite sensor used to monitor/characterized dust and/or aerosols in your country. Please, contact the remote sensing institutes of your country in order to report on national capabilities.

Table 5: Satellite-borne observations; Please, add rows as necessary

Sensor	Product	Quantitative use (images)	Quantitative use (data)	Period since
Seviri/MSG Yes /No		Yes /No Please specify:	Yes No Please specify	
MODIS Aqua/Terra Yes No		Yes /No Please specify:	Yes /No Please specify:	
OMI/Aura Yes No		Yes /No Please specify:	Yes /No Please specify:	
NOAA-nn Yes No		Yes /No Please specify:	Yes /No Please specify:	
Seawifs/EOS-AM Yes No		Yes /No Please specify:	Yes /No Please specify:	
CALIOP/CALIPSO Yes No		Yes /No Please specify:	Yes /No Please specify:	
GOME/ERS2 Yes No		Yes /No Please specify:	Yes /No Please specify:	
IASI Yes No		Yes /No Please specify:	Yes /No Please specify:	

Is there in your country a specialized center for satellite data reception that can be useful for dust storm study? *(yes /no)*

If so please describe and provide contact details of scientist in charge.

Section 1.5: Analytical capacity of airborne dust and dust fall

Analytical capacity of airborne dust or dust fall at Universities and research institutes should be reported in the Table 6.

Table 6: Analytical capacity related to chemical and mineralogical analysis of particulate matter

Parameters	Analytical instruments	Institution	Scientist in charge
Trace metals			
Crustal elements			
Mineralogy			
Aerosol nutrients: nitrate, phosphorus, ammonium			
Molecular markers			
Ionic species			

Section 1.6: Modelling capacity of airborne dust and dust fall

Please, describe in this section the aerosol/dust models you use for dust monitoring and/or dust reanalysis. Please, include modelling capabilities/use of Universities and research institutions of your country.

Table 7: Dust modelling

Model	Center	Do you use this model for dust forecasting? Tick for yes	Do you use these products for case analysis? Tick for yes	Period since	Scientist in charge
BSC-DREAM8b	BSC-CNS				
CHIMERE	LMD				
DREAM-NMMEMACC	SEEVCCC				
GEOS-5	NASA				
LMDzT-INCA	LSCE				
MACC-ECMWF	ECMWF				
MetUM	UK Met office				
NGAC	NCEP				
NAAPS	US Navy				
NMMB/BSCDust	BSC-CNS				
Multi model Dust Products	SDS WAS NAMEE Node				
TMS/BSCDream8b	TSME				
Others					

In case your country has an institution that has developed and/or run a model of aerosol/dust, please include the following information:

Table 8: Main features of your aerosol/dust model

Model	
Institution	
Meteorological Driver	
Geographical Domain	
Emission scheme	
Horizontal Resolution	
Vertical Resolution	
Height first layer	
Radiation interactions	
Transport size Bins	
Data assimilation	
Other features	

Section 1.7: Additional information

Please use this section to add any information which can be useful but not included in the questionnaire. This section can be used to comment the questionnaire itself.

Section 2: Ocean biogeochemical and biological parameter monitoring, analysis, and modelling

Please list in-situ and offline instruments to monitor physical and chemical properties of the ocean in Table 9.

Table 9: Air quality monitoring; please add rows as necessary

Method	Lat	Lon	Height	Network/ institution	Coastal?	NRT?	Data available since when	Scientist in charge; Email
pH					Yes No	Yes No		
Salinity					Yes No	Yes No		
nitrate					Yes No	Yes No		
Temperature					Yes No	Yes No		
phosphate					Yes No	Yes No		
Trace metals					Yes No	Yes No		

PLEASE COPY AND FILL IF THERE ARE MULTIPLE STATIONS, Please provide a map of the monitoring stations, if any

Section 2.2: Ocean nutrient, trace metal and biological monitoring

Ocean water nutrient, trace metal and biological analysis at Universities and research institutes should be reported in the Table 10.

Table 10: Ocean nutrient, trace metal and biological monitoring; please add rows as necessary

Parameter	Methods	Lat	Lon	Height	Network/ institution	Scientist in charge; Email address	Coastal ?	Data available since when
Nutrients							Yes No	
							Yes No	
							Yes No	
							Yes No	
							Yes No	
							Yes No	
Trace metal							Yes No	
							Yes No	
							Yes No	
							Yes No	
							Yes No	
							Yes No	
Chlorophyll							Yes No	

							Yes No	
							Yes No	
							Yes No	
							Yes No	
							Yes No	
Phytoplankton							Yes No	
							Yes No	
							Yes No	
							Yes No	
							Yes No	
							Yes No	
Zooplankton							Yes No	
							Yes No	
							Yes No	
							Yes No	
							Yes No	
							Yes No	

Section 2.3: Remote sensing

Please, specify the satellite sensor used to monitor/characterized marine parameters in your country. Please, contact the remote sensing institutes of your country in order to report on national capabilities.

Table 11: Satellite-borne observations; Please add rows as necessary

Sensor	Product	Quantitative use (images)	Quantitative use (data)	Period since
		Yes /No Please specify:	Yes No Please specify	
		Yes /No Please specify:	Yes /No Please specify:	
		Yes /No Please specify:	Yes /No Please specify:	
		Yes /No Please specify:	Yes /No Please specify:	
		Yes /No Please specify:	Yes /No Please specify:	
		Yes /No Please specify:	Yes /No Please specify:	
		Yes /No Please specify:	Yes /No Please specify:	
		Yes /No Please specify:	Yes /No Please specify:	

Is there in your country a specialized center for satellite data reception that can be useful for ocean study? *(yes /no)*
If so please describe and provide contact details of scientist in charge.

Section 2.4: Analytical capacity of marine biogeochemical parameters

Analytical capacity of marine biogeochemical parameters at Universities and research institutes should be reported in the Table 12.

Table 12: Analytical capacity related to marine biogeochemical parameters

Parameters	Analytical instruments	Institution	Scientist in charge
Trace metals			
Nutrients: nitrate, phosphorus, ammonium			
Chlorophyll			
Phytoplankton			
Zooplankton			

Section 2.5: Modelling capacity of ocean biogeochemistry

Please, describe in this section the ocean models you use for marine biogeochemical cycle analysis. Please, include modelling capabilities/use of Universities and research institutions of your country.

Table 13: Dust modelling

Model	Center	Do you use these products for case analysis? Tick for yes	Period since	Scientist in charge

In case your country has an institution that has developed and/or run a model of aerosol/dust, please include the following information:

Table 14: Main features of your aerosol/dust model

Model	
Institution	
Meteorological Driver	
Geographical Domain	

Horizontal Resolution	
Vertical Resolution	
Transport size Bins	
Data assimilation	
Other features	

Section 2.6: Additional information

Please use this section to add any information which can be useful but not included in the questionnaire. This section can be used to comment the questionnaire itself.

ANNEX VI

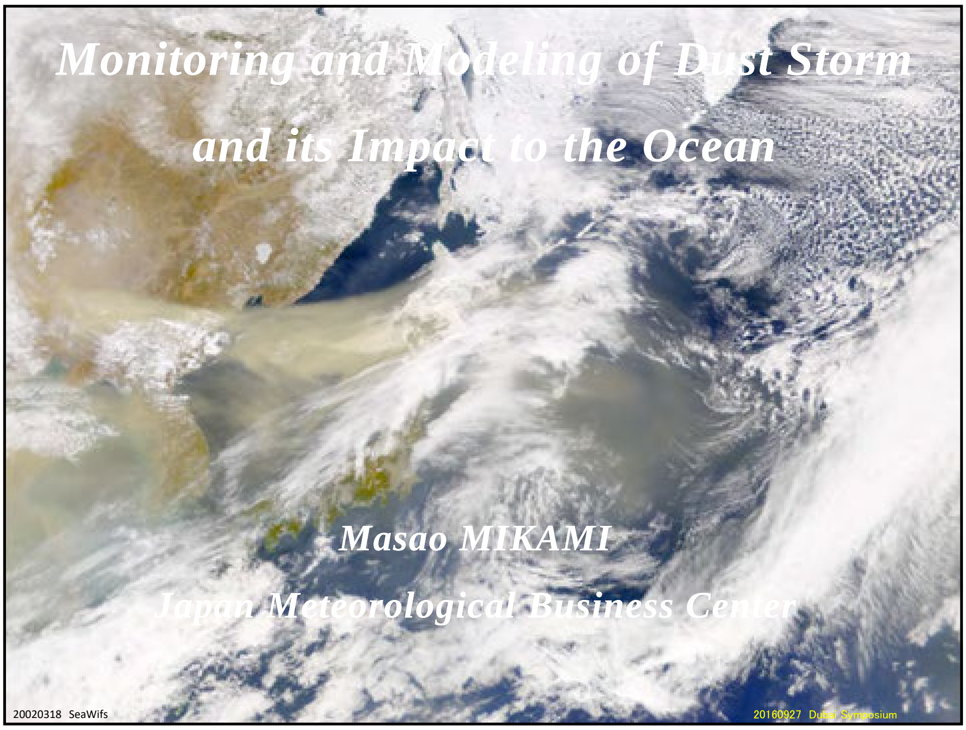
PRESENTATIONS

LIST OF PRESENTATIONS

1	*MONITORING AND MODELING OF DUST STORM AND ITS IMPACT TO THE OCEAN* *DR. MASAO MIKAMI, JAPAN METEOROLOGICAL BUSINESS CENTER*
2	**DUST FALLOUT PROPERTIES WITHIN DUST STORMS FREQUENT PATHS IN THE ROBME SEA AREA** **DR. ALI M. AL-DOUSARI, KUWAIT INSTITUTE FOR SCIENTIFIC RESEARCH (KISR)**
3	**EFFECT OF MINERAL DUST ON OCEAN PRODUCTIVITY AND BIOGEOCHEMISTRY OF THE NORTHERN ROPME SEA AREA.** **KISR, KUWAIT - CSIR NIO, INDIA** **DR. TURKI AL-SAID, OCEANOGRAPHY GROUP/EBMMR/ELSRC** **KUWAIT INSTITUTE FOR SCIENTIFIC RESEARCH (KISR)**
4	**PROPOSED PILOT PROJECT, BASELINE STUDY AND LONG-TERM PROJECT FOR MONITORING AND ASSESSMENT OF** **IMPACTS OF DUST ON THE RSA** **DR. ERIC ACHTERBERG, GEOMAR**
5	**QUESTIONNAIRES ON DUST AND BIOGEOCHEMICAL MONITORING AND RESEARCH CAPACITY IN ROPME MEMBER STATES** **DR. ERIC ACHTERBERG, GEOMAR**
6	**IMPLEMENTATION PLAN FOR THE ASSESSMENT OF IMPACTS OF DUST IN THE MARINE ENVIRONMENT OF THE RSA** **DR. ERIC ACHTERBERG, GEOMAR**

MONITORING AND MODELING OF DUST STORM AND ITS IMPACT TO THE OCEAN

DR. MASAO MIKAMI
JAPAN METEOROLOGICAL BUSINESS CENTER


Monitoring and Modeling of Dust Storm
and its Impact to the Ocean
Masao MIKAMI
Japan Meteorological Business Center
20020318 SeaWifs
20160927 Dust Symposium


Today's Contents
1. Introduction
2. Climatology of Asian Dust
3. Dust Emission Mechanism
4. Field Monitoring
5. Modeling Study
6. Monitoring of Asian Dust and International Cooperation
7. Impact of Dust (Environment, Ocean..)

Personal History

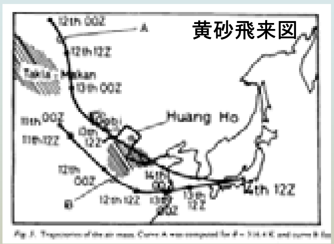
1954	Born in Tokyo
1978	Meteorological College, Japan Met. Agency
1985～	Meteorological Research Inst./JMA
1989～1994	Japan-China Project on Desertification
2000～2005	PI of Japan-China Project ADEC
2005～2008	PI of Japan-Austria Project JADE
2008～2011	PI of Japan-Austria Project JADE2
2012～2015	Chairman of WMO-SDS-WAS Asian Node RSC
2013～2015	Senior Researcher for Research Affairs of MRI

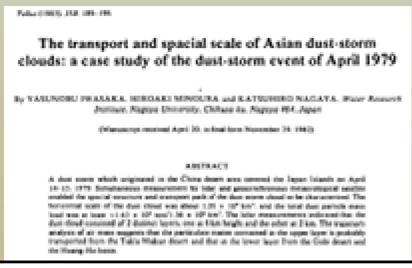
Research Field: Dust Physical Process, Atmospheric Environment

Why DSS research has been carried out in Japan?

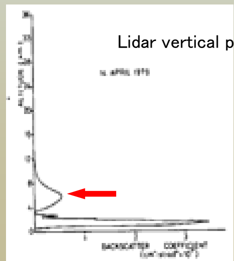
In 1979, Duce et al. found that a lot of dust particles are seen in the background atmosphere sampled in Marshal island in North Pacific Ocean during spring season. They found that these particles were transported from Asian Continent.（Duce et al., *Science*,1980).

Around the same time, Iwasaka et al. (Nagoya Univ.) monitored mineral aerosol layer over Japan using Lidar（Iwasaka et al., *Tellus*, 1983).

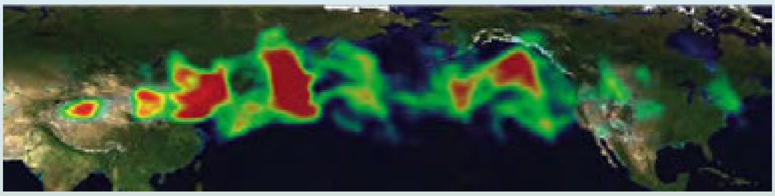



The transport and spacial scale of Asian dust-storm clouds: a case study of the dust-storm event of April 1979

ABSTRACT

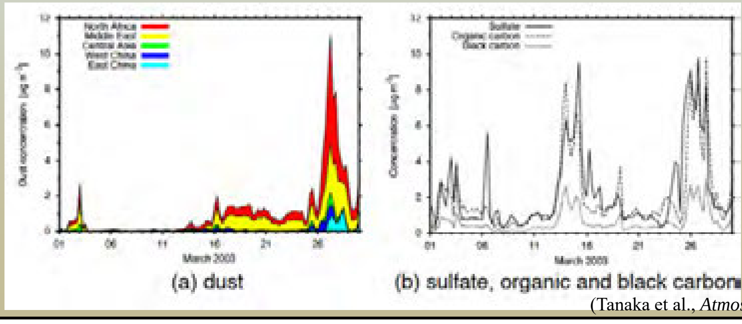


Long-range transport of dust



Transport of Mongolian dust to N. America in April 2001. This image was made by compositing several days of TOMS data. (NASA)

Dust over Kyoto, Japan



(Tanaka et al., *Atmos. Envi.* 2005)

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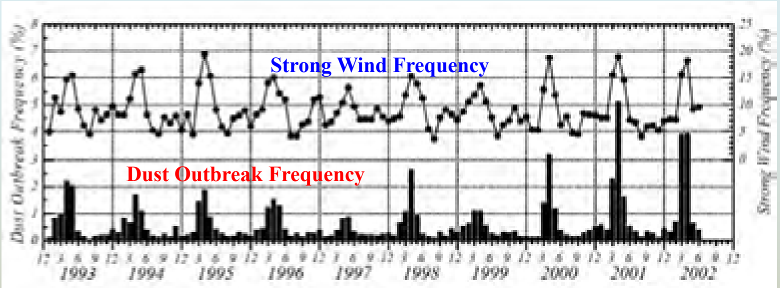
Dust Climate in Northeastern Asia



Annual variations of strong wind and dust outbreak. Black bar shows dust outbreak frequency and line graph shows strong wind frequency

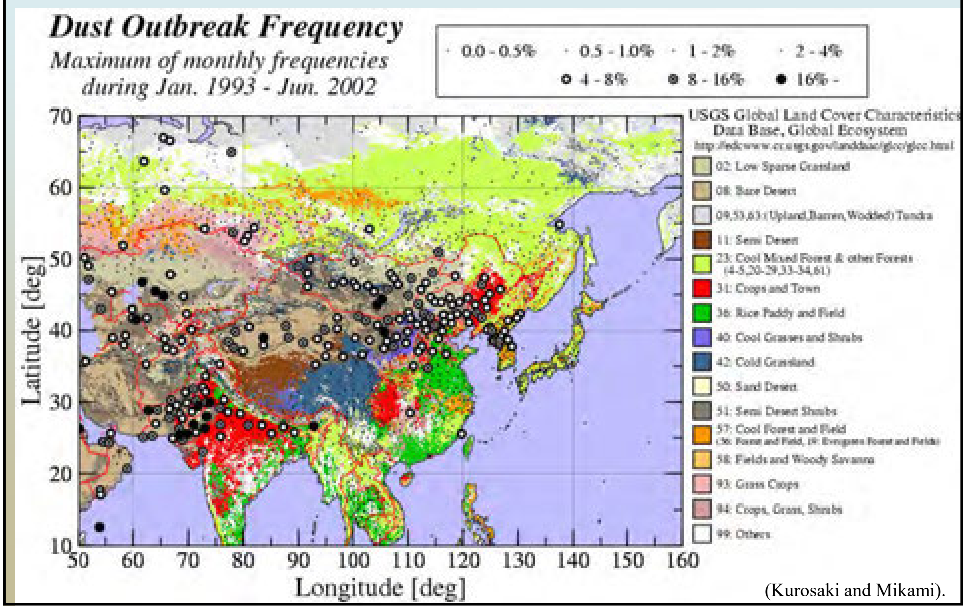
Correlation with strong wind

⬇

Strong wind controls dust outbreak

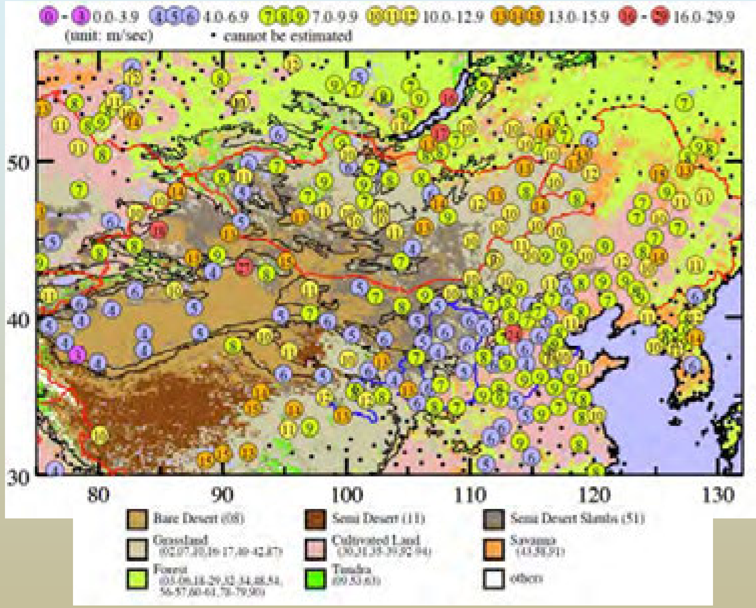
(*Kurosaki and Mikami, GRL, 2003*)

Complex ground cover and topography



(Kurosaki and Mikami).

Distribution map of threshold wind velocity

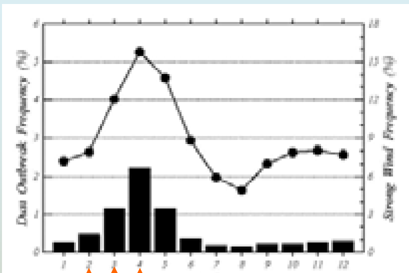


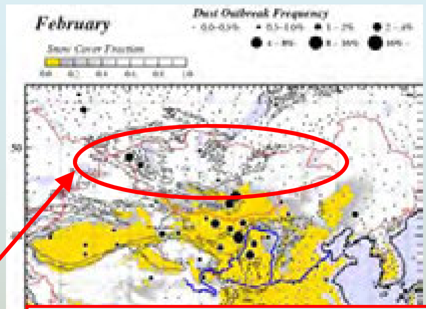
Climate ⇨ ground surface ⇨ dust emission

Kurosaki and Mikami, JGR 2007

Effect of Snow Cover

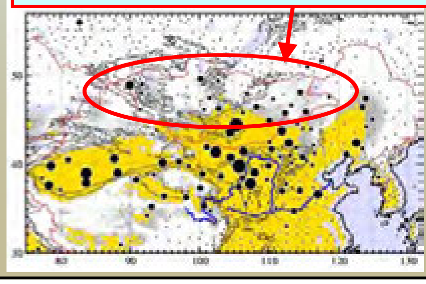
Near Real-Time SSM/I EASE-Grid Daily Global Ice Concentration and Snow Extent

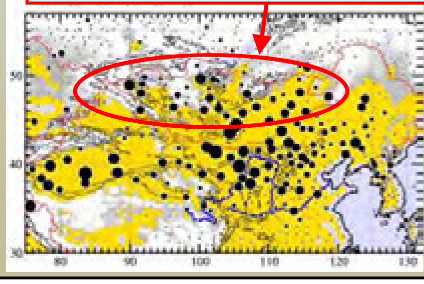




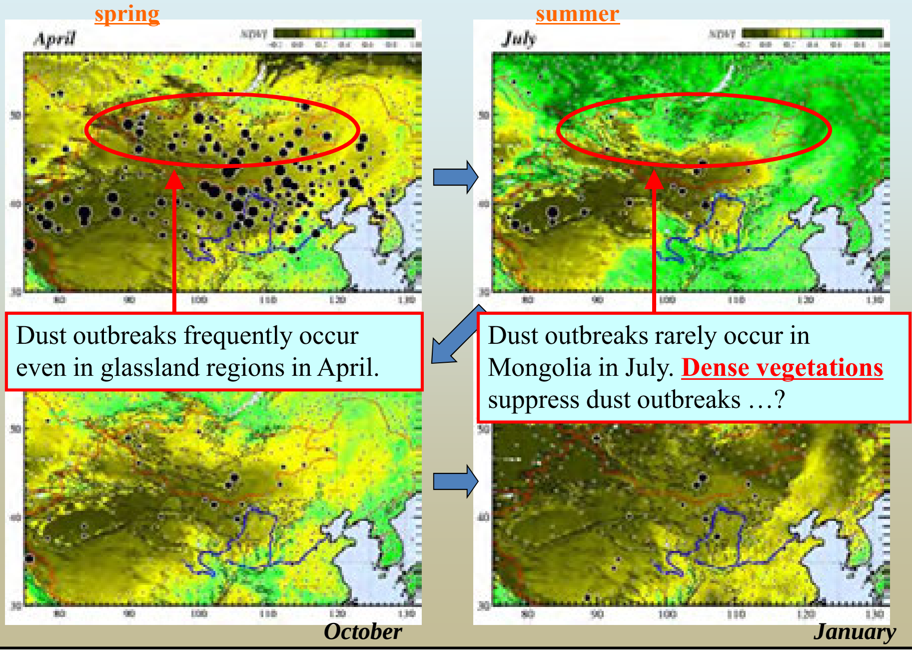
Dust outbreaks rarely occur in Northern and Western Mongolia. These regions are **covered by snow**.

Dust outbreaks frequently occur in Northern and Western Mongolia in April.





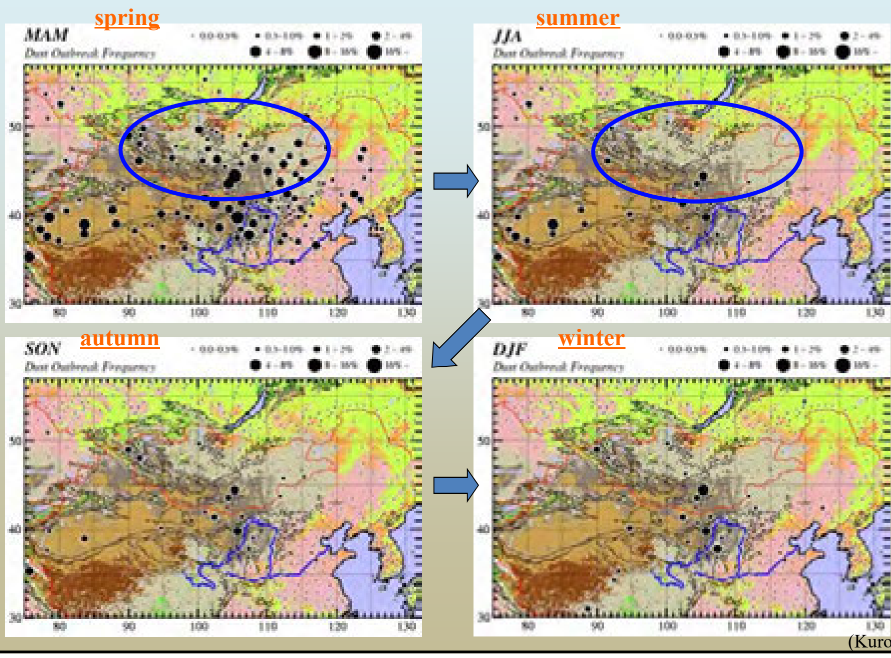
Effect of vegetation



Dust outbreaks frequently occur even in glassland regions in April.

Dust outbreaks rarely occur in Mongolia in July. **Dense vegetations** suppress dust outbreaks …?

Asian Dust ⇒ Seasonal variation



(Kurosaki)

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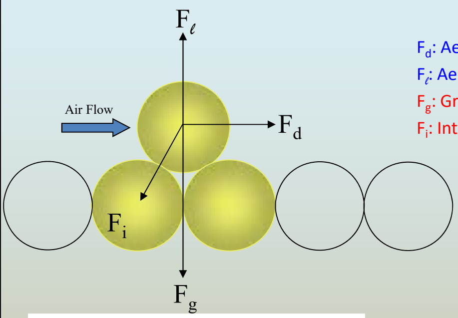
Forces acting on a sand particle on the surface



F_d: Aerodynamic drag
F_ℓ: Aerodynamic lift
} Particle separate force

F_g: Gravity force
F_i: Inter-particle cohesive forces
F_{iv} : van der Waals force
F_{ie} : electrostatic force
F_{ic} : capillary force
F_{ich} : chemical binding force
} Particle binding force

power relation

$$F_d + F_\ell \longleftrightarrow F_g + F_i$$

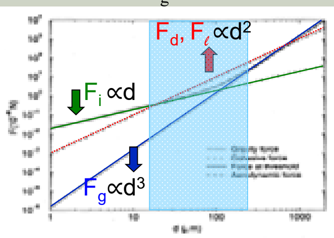
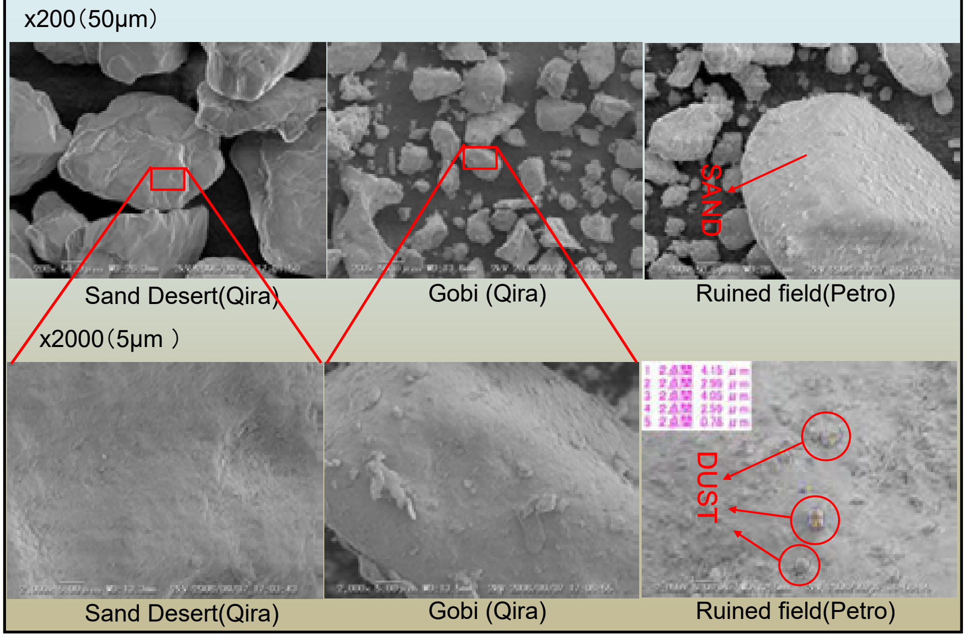


Figure 2. The gravity, cohesive, and aerodynamic forces (at $u_* = 0.4$ m s^{-1}) plotted as functions of particle size. For fine particles the cohesive force dominates over the gravity and aerodynamic forces; for medium-sized particles, the aerodynamic force is the largest, and for large particles the gravity force becomes dominant. See text for more details. (Shao, 1996)

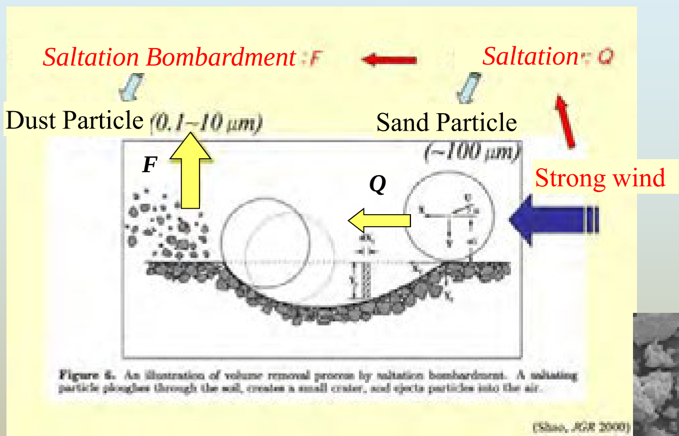
When surface shear stress (friction velocity) exceeded a threshold ($F_d+F_l > F_g+F_i$, blue area), particle start to jump. (20 ~ 300 μm)

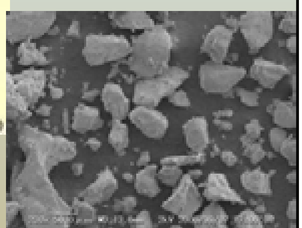
→Threshold friction velocity: u_{*t}

Sand and Dust particles seen by Electron Microscope



Dust emission under strong wind –Saltation Bombardment-





By the collision of sand particle, dust particles are ejected from ground surface
➛ saltation bombardment

where *Q*: Saltation Flux (sand: 70~500μm)

F: Dust Flux (dust: < 20μm)

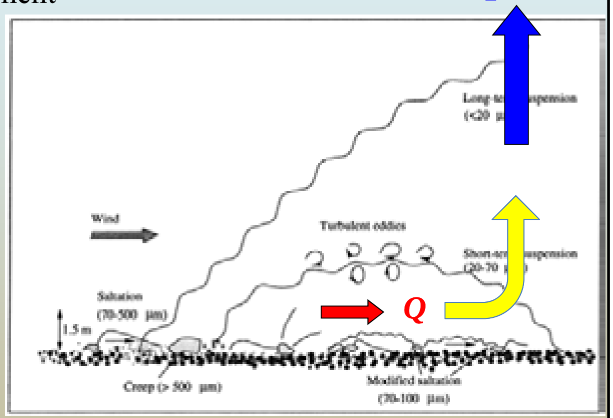
Wind Erosion Process

3-Types of Particle Movement

> creeping (> 600 μm)

> saltation (70-600 μm)

> suspension (< 70 μm)



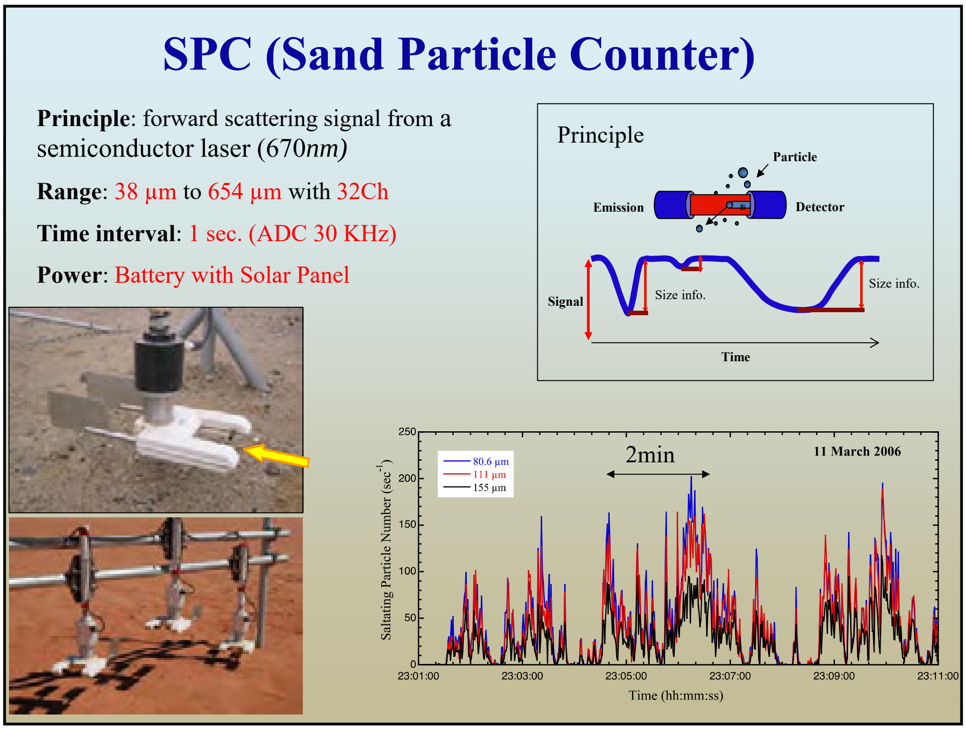
Pye [1987], Shao [2000]

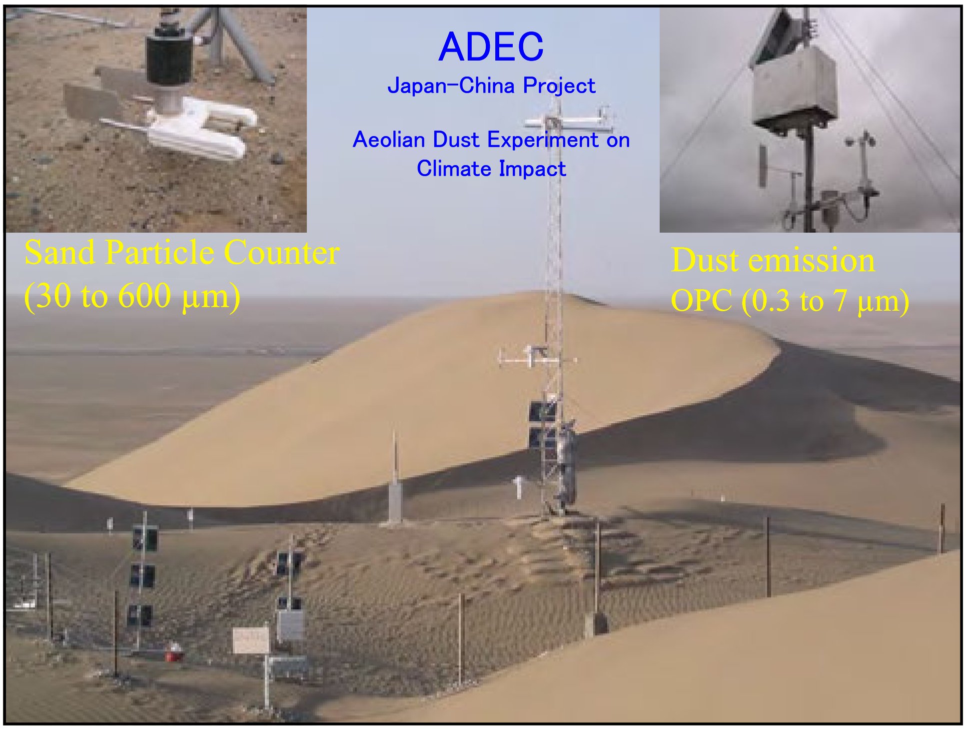
Dust is injected to the atmosphere by the collision of saltating sand particle

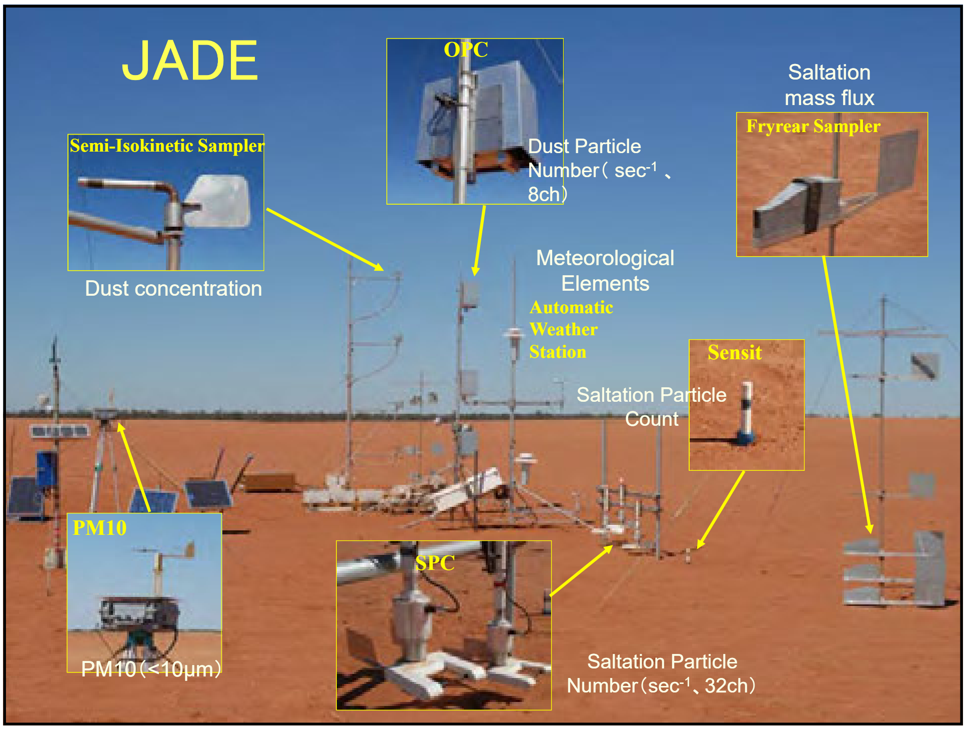
➝ *saltation bombardment*

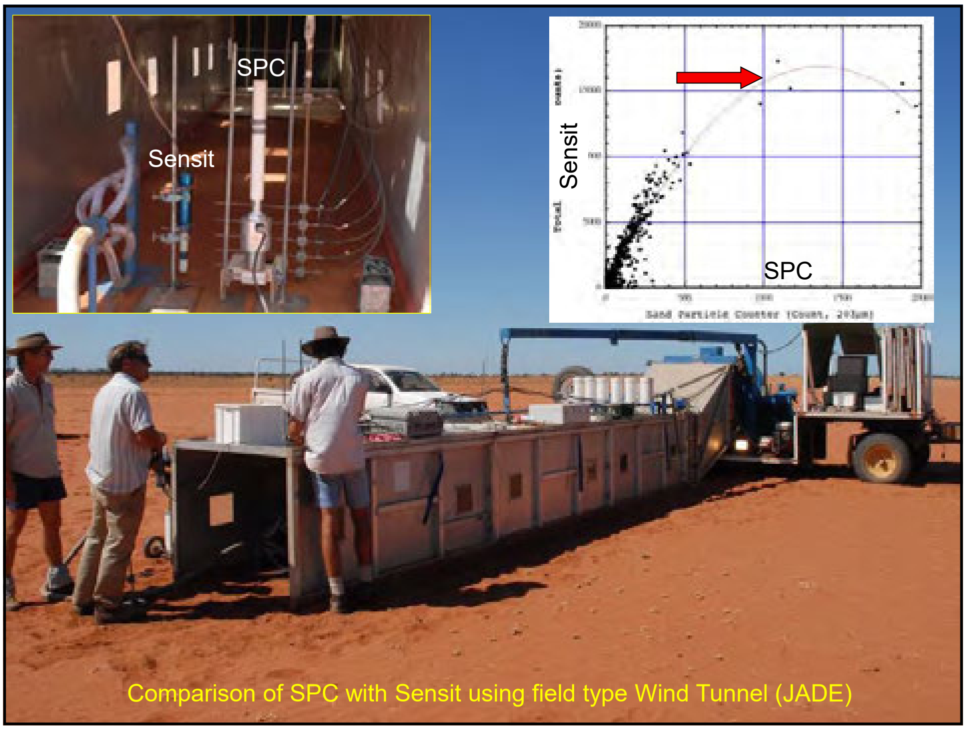
Q: Horizontal flux of sand (70 μm< D_S < 500 μm)

F: Vertical flux of dust (0.1 μm < D_d < 20 μm)

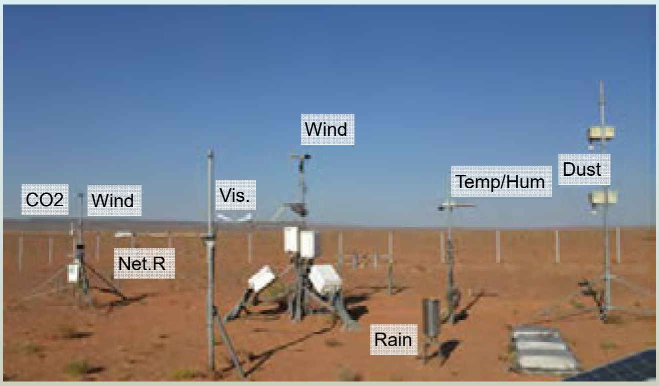

SPC (Sand Particle Counter)
Principle: forward scattering signal from a semiconductor laser (670nm)
Range: 38 µm to 654 µm with 32Ch
Time interval: 1 sec. (ADC 30 KHz)
Power: Battery with Solar Panel
Principle
Particle
Emission
Detector
Signal
Size info.
Size info.
Time
Saltating Particle Number (sec-1)
250
200
150
100
50
0
80.6 µm
111 µm
155 µm
2min
11 March 2006
23:01:00
23:03:00
23:05:00
23:07:00
23:09:00
23:11:00
Time (hh:mm:ss)


ADEC
Japan-China Project
Aeolian Dust Experiment on Climate Impact
Sand Particle Counter (30 to 600 µm)
Dust emission
OPC (0.3 to 7 µm)


JADE
OPC
Dust Particle Number(sec-1 、8ch)
Saltation mass flux
Fryrear Sampler
Semi-Isokinetic Sampler
Dust concentration
Meteorological Elements
Automatic Weather Station
Sensit
Saltation Particle Count
PM10
PM10(<10μm)
SPC
Saltation Particle Number(sec-1、32ch)

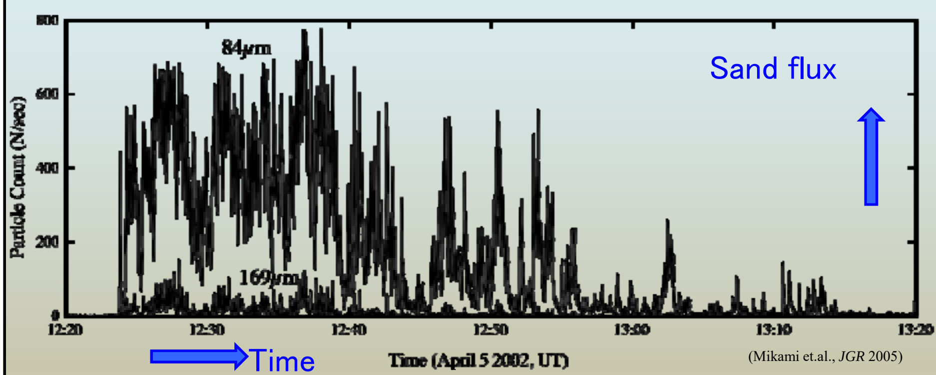

SPC
Sensit
Sensit
SPC
Comparison of SPC with Sensit using field type Wind Tunnel (JADE)

Mongol, Tsogt-Ovoo dust observation



Category	Item	Instrument	Specification	
Meteorology	Wind	Ultra sonic anemometer	180 cm、10 Hz	→ Momentum/Heat Fluxes
	Wind	Cup anemometer	300 cm	
	Air Temp/Hum	Psycrometer	198 cm	
	Rad. Budget	Net radiometer	150 cm SRup, SRdown, IRup, IRdown	→ Net Radiation
	Visibility	Visibility meter	200 cm	
	CO2	Infrared CO2 fluctuation meter	180 cm、10 Hz	→ CO2 Flux
	Precipitation	Tipping bucket rain gauge		
Soil Physics	Soil Temp.	Pt resistance termometer	1, 1, 1,5, 2.5, 5, 10, 15, 20, 30, 50 cm	→ Soil Heat Flux
	Soil Moisture	TDR soil mositure meter	1, 1, 1,5, 2.5, 5, 10, 15, 20, 30, 50 cm	
Sand/Dust	Saltation sand	Pressure sensitive sand counter	Sensit (5.9 cm)	→ Saltation Particle Number
	Dust	Optical particle counter	2 Levels: $PM_{2.5}$・PM_{10}、0.3, 0.6, 0.9,1.4, 2, 3.5, 5.9, >8.4 μms	→ Dust Vertical Flux
Others	Soil crust monitor	Interval digital camera	2 Places	
			*Intensive observation period	

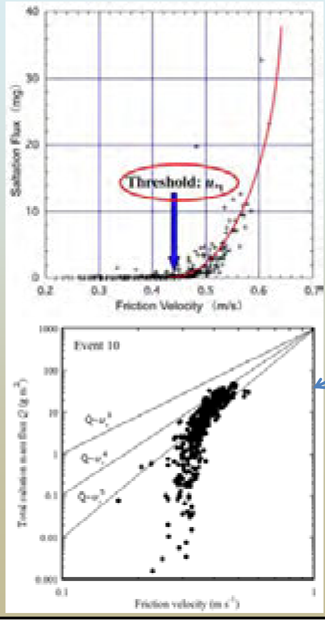
Precise observation of dust storm using SPC



Time sequence of saltating sand particles(84μm, 169μm)

>>SPC proved to be available for the saltation process study

Sand Flux and Friction velocity (Threshold Friction Velocity)



Saltation Flux (Horizontal flux)

$$\tilde{Q}(D) = \frac{c_S(D)\rho u_*^3}{g}\left(1 - \frac{u_{*t}^2(D)}{u_*^2}\right)$$

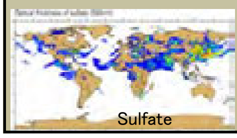
$$where \quad c_S(D) = 0.25 + \frac{v_g(D)}{3u_*}$$

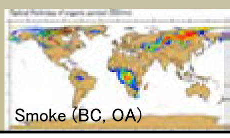
(Tanaka et al., *JMSJ* 2005)

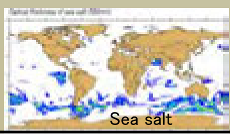
$Q \propto u_*^3 \sim u_*^5$

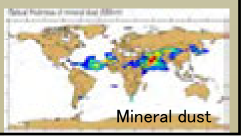
Global dust model：MASINGAR by JMA

- Based on MRI-GCM-CTM（Chemical transport model）
  ＞ T159L40~T318L48 Specter model
- Aerosols: Dust(MD), SOx(AS), Sea solt(SS), Carbon(CB)
- Physics
  ＞Turbulent transport, Cumulus convection
  ＞Wet and dry depositions
- Dust particle: 0.1 ～ 10 μm 10 bins
- Vegetation、soil moisture、snow、land use、texture、soil type
- Emission：saltation bombardment ⟶ vertical dust flux









Saltation bombardment is a key process in wind erosion

Streamwise saltation flux, ***Q*** (Streamwise sand flux)

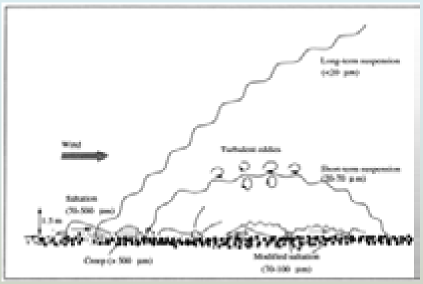
Sand flux of particle size, D_S, at height z, $q(z, D_S)$

$$Q = \iint q(z, D_S)\, dz\, dD$$

Q is commonly expressed as the following form

$$Q = \frac{c_s \rho}{g} u_*^3 f\left(\frac{u_{*t}}{u_*}\right)$$

U_{*t} ; threshold friction velocity



Pye [1987], *Shao* [2000]

MASINGAR uses the following formula

$$\tilde{Q}(D) = \frac{c_S(D)\rho u_*^3}{g}\left(1 - \frac{u_{*t}^2(D)}{u_*^2}\right)$$

$$where \quad c_S(D) = 0.25 + \frac{v_g(D)}{3u_*}$$

$$Q = \int_0^\infty \tilde{Q}(D) p_m(D) dD$$

Streamwise Sand Flux

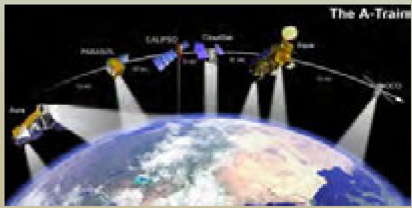
And dust flux (upward direction), ***F***, is expressed as;

$$\tilde{F}(D_S, D_d) = \frac{2}{3}\frac{\rho_p}{\rho_d}\frac{\beta\gamma}{u_{*t}(D_d)^2}\tilde{Q}(D_S)$$

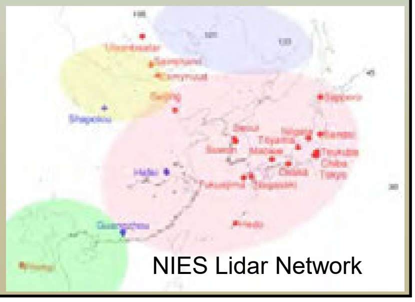
Vertical Dust Flux

Aerosol data assimilation

- *Aerosol observation*:
  Available data are very sparse! Spatio-temporally, both ground-based and satellite data
- *Model simulation*:
  useful, but not real! (it's virtual reality)
- *Data assimilation*:
  It's a fusion of observation and simulation with powerful and highly informative techniques.



CALIOP/CALIPSO



NIES Lidar Network

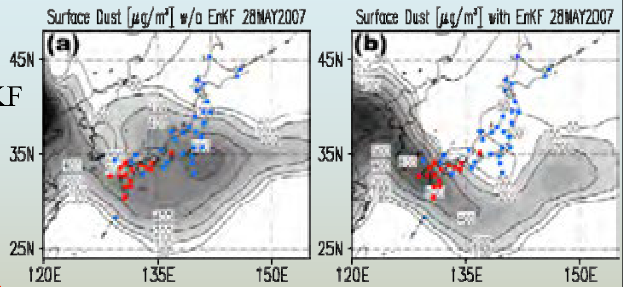
Results (comparison with weather reports)

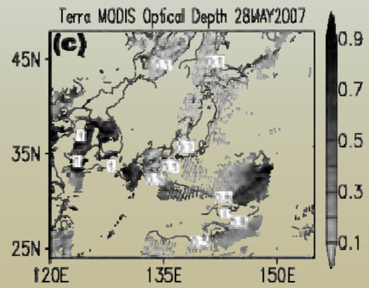
(a) Free model run w/o EnKF

(b) Analysis of 4D-EnKF assimilation.

Red points show weather stations observed dust event. Blue did not.

(c) MODIS OT on 28May07.





Global dust emission and deposition (MASINGAR)

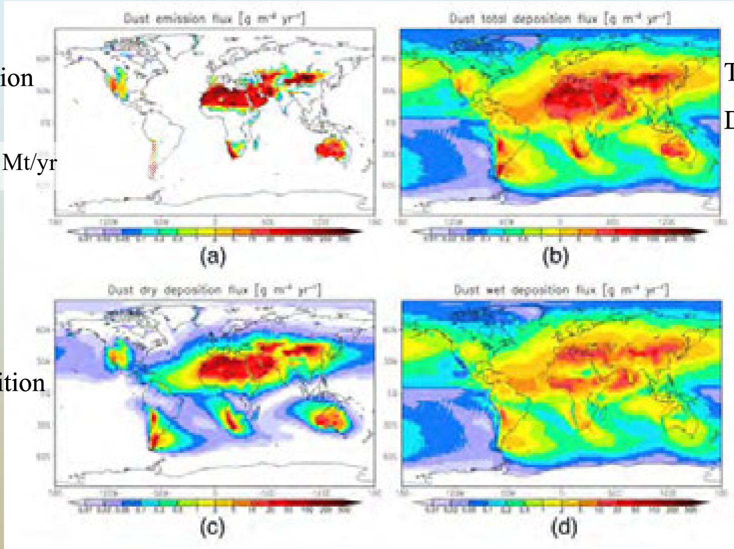
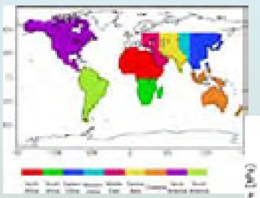
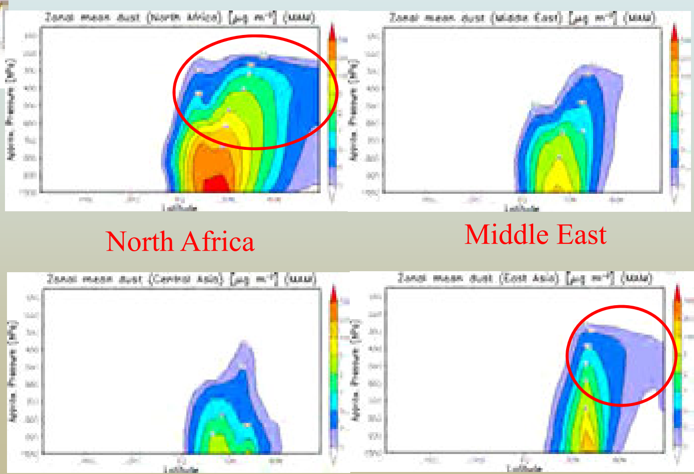


Figure 2. Simulated annual mean dust source and sink fluxes. (a) Emission, (b) total deposition, (c) dry deposition, and (d). wet deposition. Units are in g m^{-2} yr^{-1}. (Tanaka and Chiba, *JMSJ* 2005)

Regional difference of zonal mean dust concentration (MAM)





(Tanaka and Chiba, JMSJ 2005)

WMO-WWRP Sand and Dust Storm Warning Advisory and Assessment System SDS-WAS

Mission

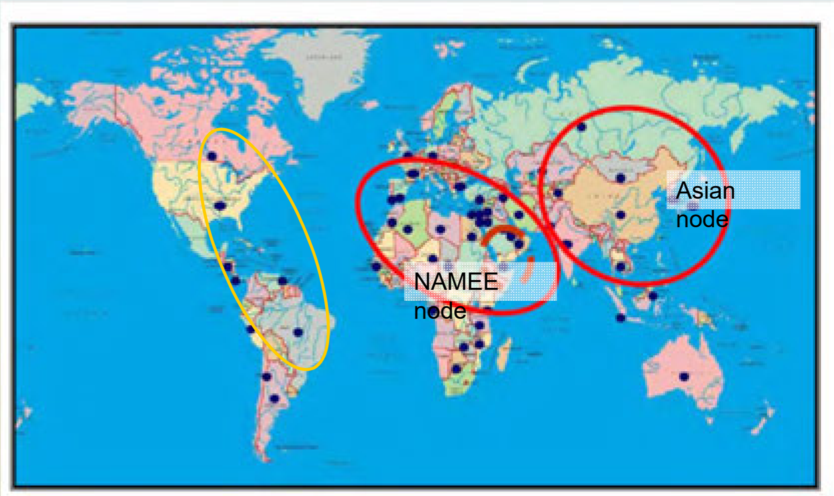
To enhance the ability of countries to deliver timely and quality sand and dust storm forecasts, observations, information and knowledge to users through an international partnership of research and operational communities

History

September 2004, the first meeting was held at CMA Beijing (WMO Experts workshop on SDS).

In 2012, Implementation plan was approved at CBS council.

SDS-WAS Node structure
NAMEE:NA, ME, EUR
Asia: J-K-C-Mo others



The NAMEE Regional Center

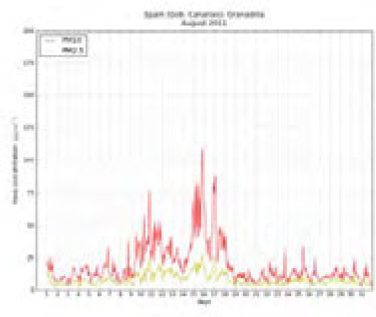
Barcelona Supercomputing Center
Centro Nacional de Supercomputación

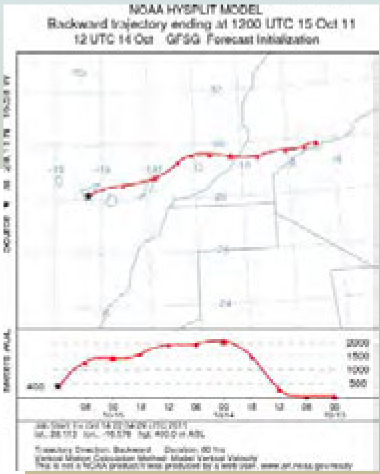
GOBIERNO DE ESPAÑA
MINISTERIO DE MEDIO AMBIENTE Y MEDIO RURAL Y MARINO
AEMet Agencia Estatal de Meteorología

The NAMEE Regional Center is jointly managed by AEMET and the BSC-CNS
It is located in Barcelona, at BSC-CNS premises

In-situ observations (AQ stations)

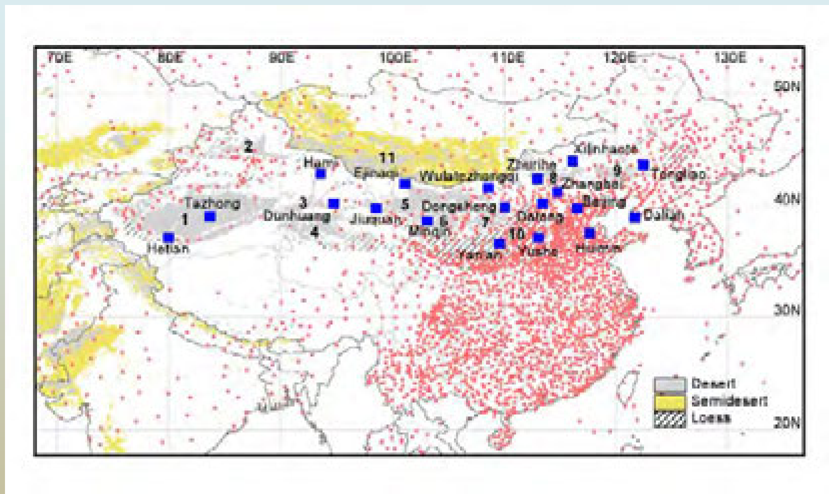
- Rural background stations
- Near-real-time data





Long-term Monitoring for Asian SDS:

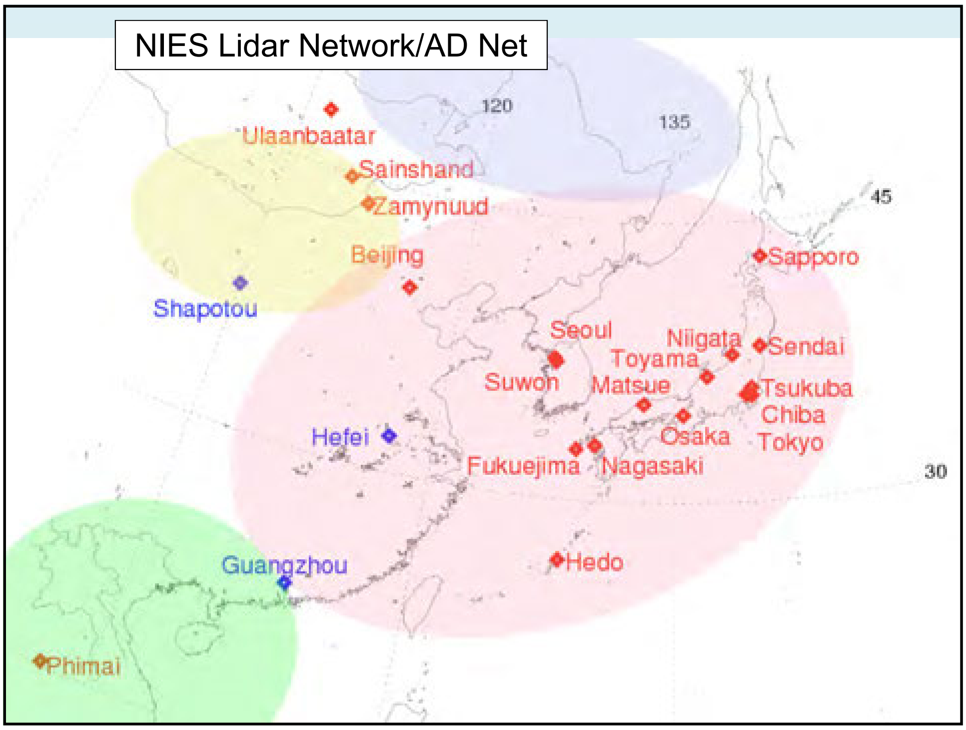
Thousands visibility stations
29 PM10 stations in CMA with 10 Sino-Korea co-operational stations



■ **PM10**
● **Visibility-SDS**

Main SDS source regions: 1, Taklimakan Desert; 2, Gurbantunggut Desert; 3, Kumtag Desert; 4, Qiadam Basin Desert; 5, Badain Juran Desert; 6, Tengger Desert; 7, Mu Us Desert; 8, Onqin Daga sandy land; 9, Horqin sandy land; 10, Loess Plateau; 11, Deserts and semideserts in Mongolia.

NIES Lidar Network/AD Net

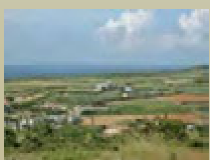


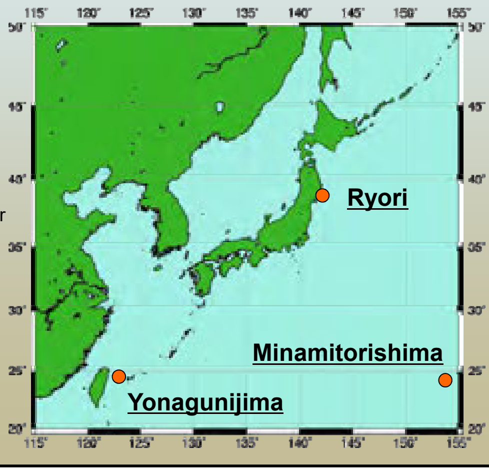
Monitoring of aeolian dust by JMA

a) Surface AOD

- JMA has been conducting AOD measurements using sunphotometers at 3 WMO/GAW stations as part of its environmental monitoring network.

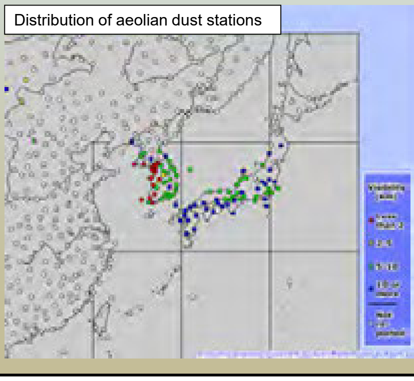
Precision Filter Radiometer (PFR)





b) Visibility and meteorological conditions

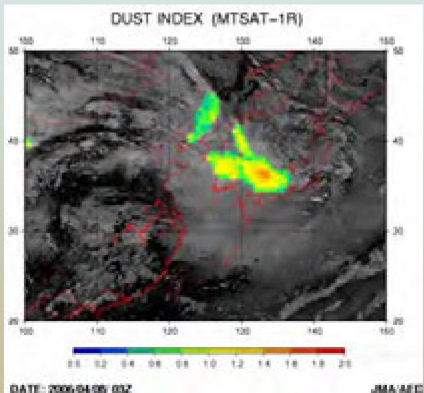
- JMA operates 61 manned observational stations, which observe aeolian dust in terms of the visibility and meteorological conditions.
- On JMA's webpage, the minimum visibility at each station is categorized in different colors.
- When the visibility becomes below 10 km, the station reports aeolian dust in SYNOP messages.



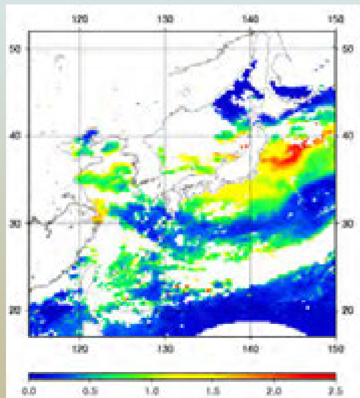
Map of stations observing aeolian dust Kosa or local sand/dust haze during the day

c) Satellite

- **JMA's monitors aeolian dust using satellite products (AOD and aeolian dust index) derived from satellite imagery of MTSAT at Meteorological Satellite Center of JMA.**

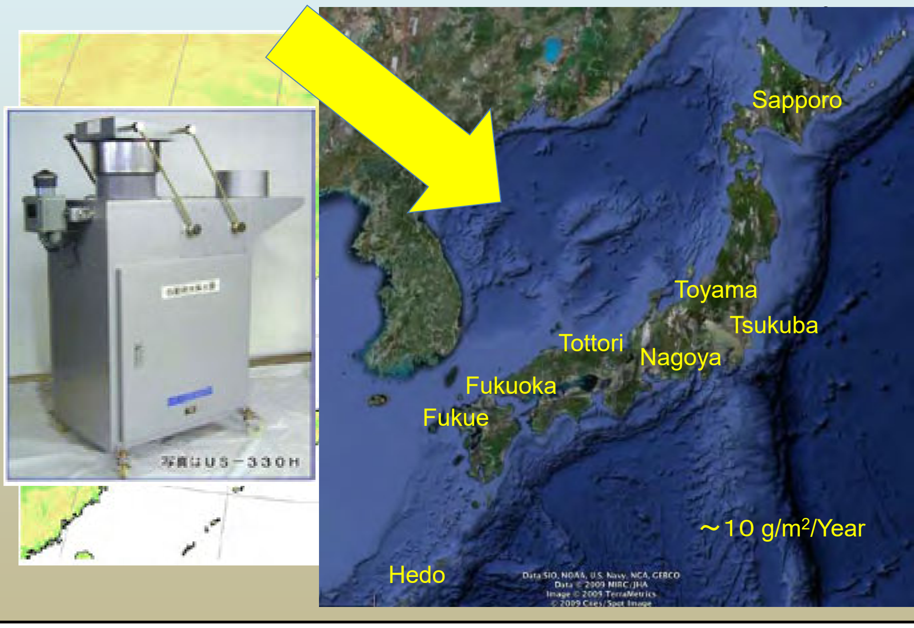


Aeolian dust index derived from infrared differential imagery of MTSAT (03UTC on 8 April 2006)



AOD derived from visible imagery of MTSAT (03 UTC on 18 April 2006)

DRAEMON
(DRY AND WET DEPOSITION MONITORING NETWORK)



TEMM Dust and Sand Storm Program

TEMM DSS:
Based on the understanding of the resent increase of dust and sand storm (DSS) in East Asia, Ministers of the Environmental Ministry of China, Korea and Japan (TEMM) have agreed to promote cooperative measures for establishing dust monitoring network and early warning system since April 2002. For this purpose, TEMM have established two expert working groups, one is for data sharing and improving dust forecast model (WG1) and the other is for countermeasure at dust source regions (WG2).

WG1:
It is planned to share the dust storm monitoring data for selected event and to validate and improving the dust forecast models, MASINGAR, ADAM, C-Force, using these data. Until now, WG1 special issue was published at SOLA. At the 5th meeting in Fukuoka, Japan, in Nov. 2012, it is agreed to share the monitoring data at 2011 dust events for the model development.

WG2:
It is planned to review countermeasure technologies for desertification and to make field inspections at desertification areas in China. In the 5th meeting of WG2 held at Jeju-Island, Korea, on Nov. 2012, it is discussed for the design of the field work at Inner-Mongolia.

Today's Contents

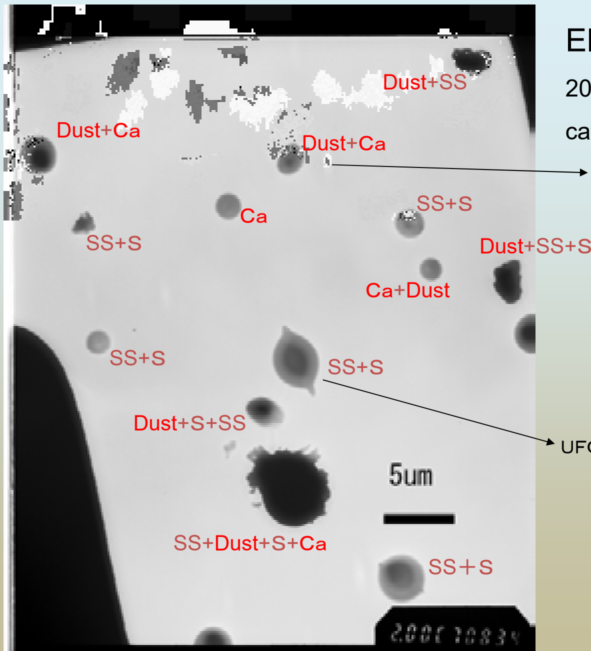
SDS Impacts

- Human Health
  (Asthma, infections, Meningitis in Africa, Valley Fever in the America's)
- Agriculture (negative & positive impacts)
- Marine productivity
- Improved Weather and Seasonal Climate Prediction
- Aviation (air disasters)
- Ground Transportation

Impact on the Atmospheric Environment

- PM2.5 Issue in Beijing
  - On 12 Jan. 2013, Monitoring of PM2.5 in Beijing was 886 $\mu g\ m^{-3}$!
- Internal mixture with anthropogenic particles

写真: CNN



Sample taken at FUKUOKA Univ.
(southwest of Japan)

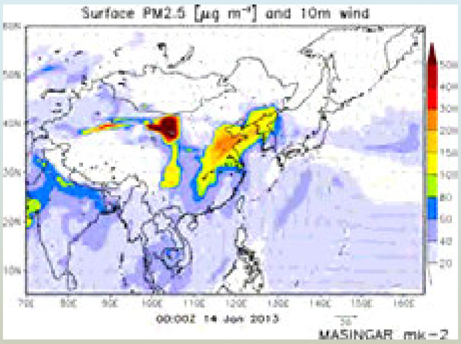
Electron Microscope

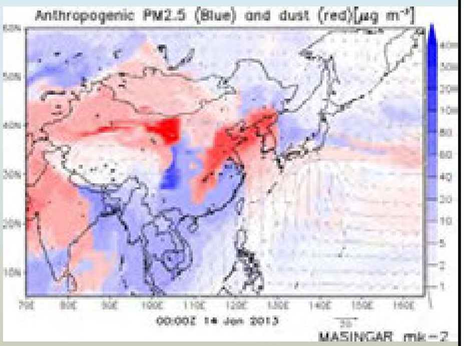
2008/03/17 17:00

carbon, 1.0mm, mag: 2k

Reality is more complex....

Surface concentration of Dust and PM2.5 by Dust Model 14 January 2013

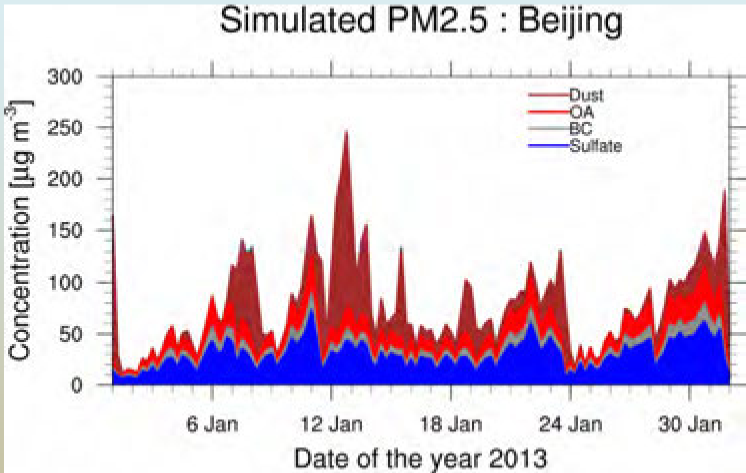




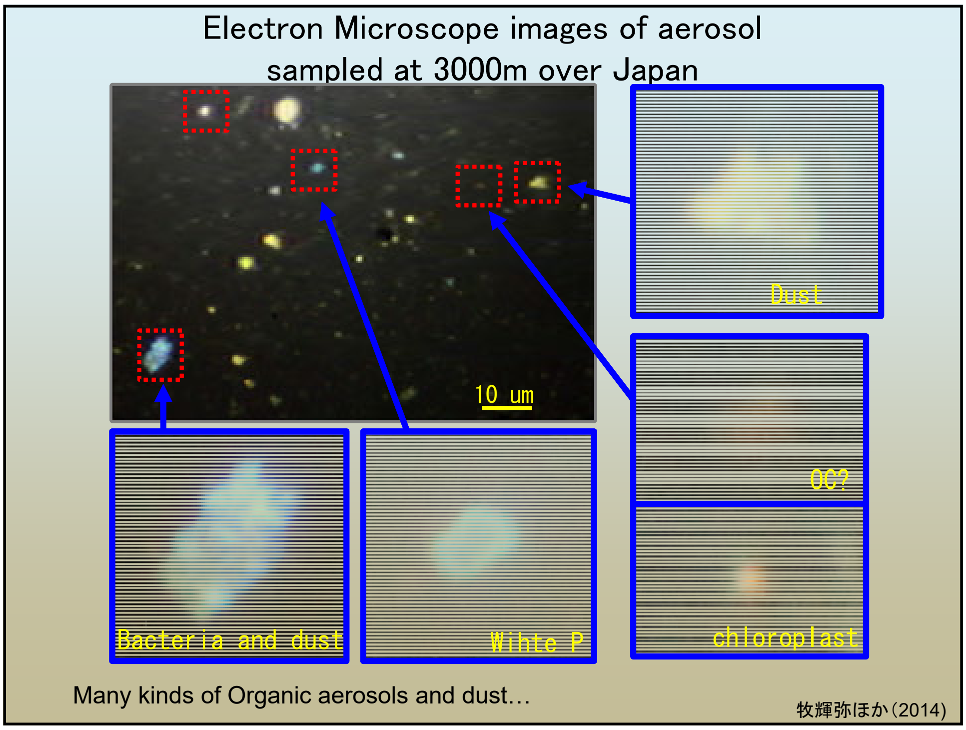
MODIS Image, 14 January 2013: NASA

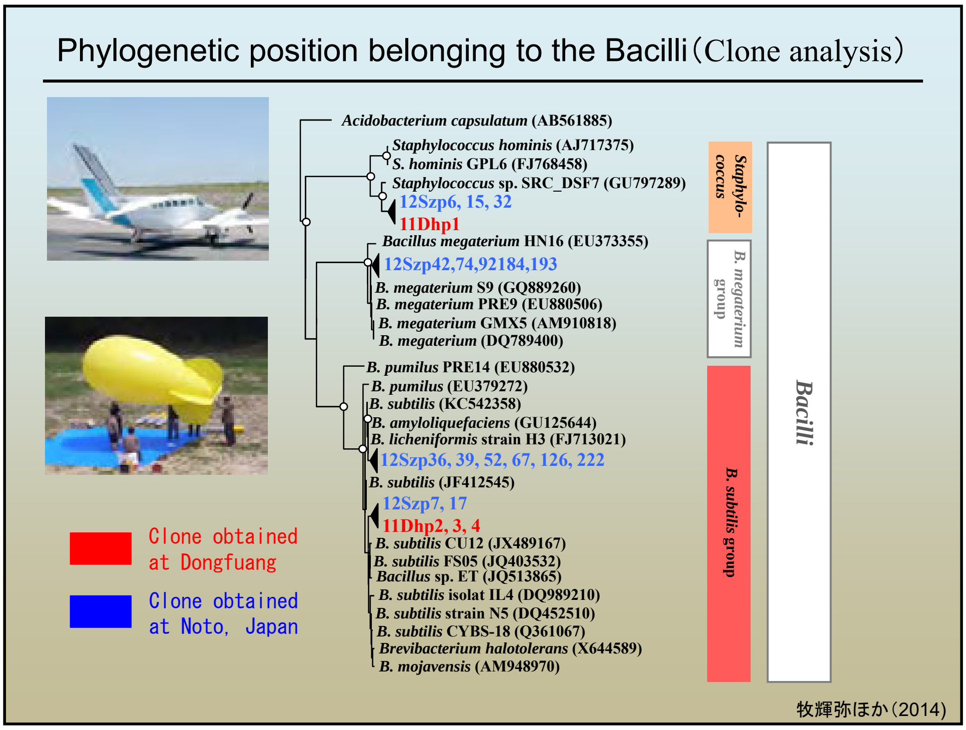
- Blue : Anthropogenic
- Red : Dust
- ⇒Internal mixture

Aerosol Concentration in China by aerosol model



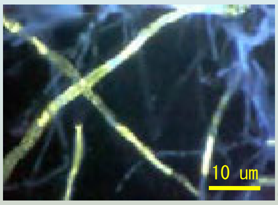
- Jan. 12–13 Event in Beijing, it seems internal mixing dust
- Even latest present dust model underestimate PM2.5 concentration (>500 μ g m^{-3}) compared with the observation.

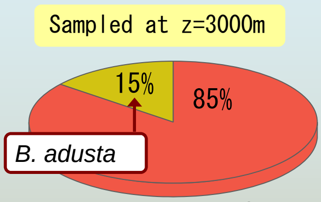

Electron Microscope images of aerosol
sampled at 3000m over Japan
10 um
Dust
OC?
chloroplast
Bacteria and dust
Wihte P
Many kinds of Organic aerosols and dust…
牧輝弥ほか(2014)


Phylogenetic position belonging to the Bacilli（Clone analysis）
Acidobacterium capsulatum (AB561885)
Staphylococcus hominis (AJ717375)
S. hominis GPL6 (FJ768458)
Staphylococcus sp. SRC_DSF7 (GU797289)
12Szp6, 15, 32
11Dhp1
Bacillus megaterium HN16 (EU373355)
12Szp42,74,92184,193
B. megaterium S9 (GQ889260)
B. megaterium PRE9 (EU880506)
B. megaterium GMX5 (AM910818)
B. megaterium (DQ789400)
B. pumilus PRE14 (EU880532)
B. pumilus (EU379272)
B. subtilis (KC542358)
B. amyloliquefaciens (GU125644)
B. licheniformis strain H3 (FJ713021)
12Szp36, 39, 52, 67, 126, 222
B. subtilis (JF412545)
12Szp7, 17
11Dhp2, 3, 4
B. subtilis CU12 (JX489167)
B. subtilis FS05 (JQ403532)
Bacillus sp. ET (JQ513865)
B. subtilis isolat IL4 (DQ989210)
B. subtilis strain N5 (DQ452510)
B. subtilis CYBS-18 (Q361067)
Brevibacterium halotolerans (X644589)
B. mojavensis (AM948970)
Staphylo-coccus
B. megaterium group
B. subtilis group
Bacilli
Clone obtained at Dongfuang
Clone obtained at Noto, Japan
牧輝弥ほか(2014)

The effect of fungi in the atmosphere

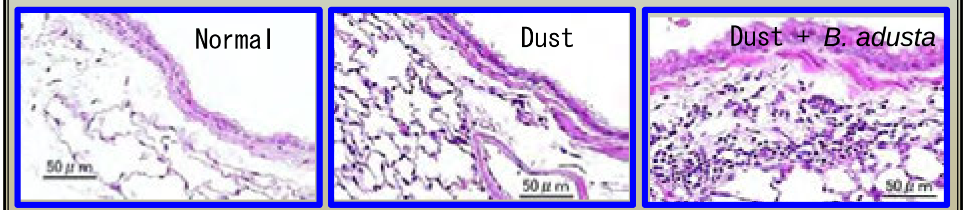
Bjerkandera adusta





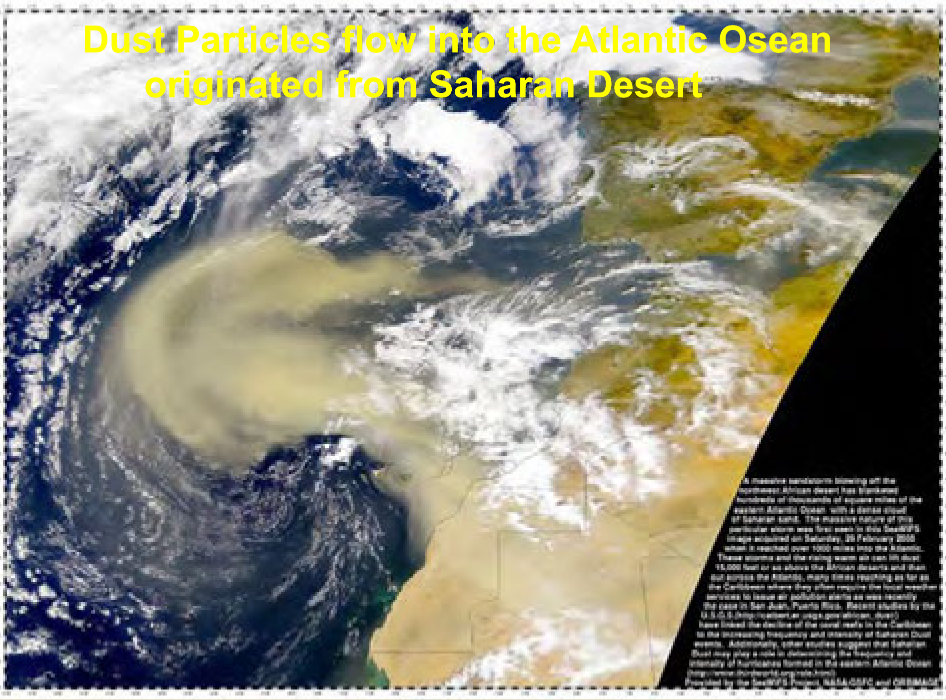
Clonal analysis targetted 18S rDNA

Exacerbation of allergy (Airway epithelial cell)



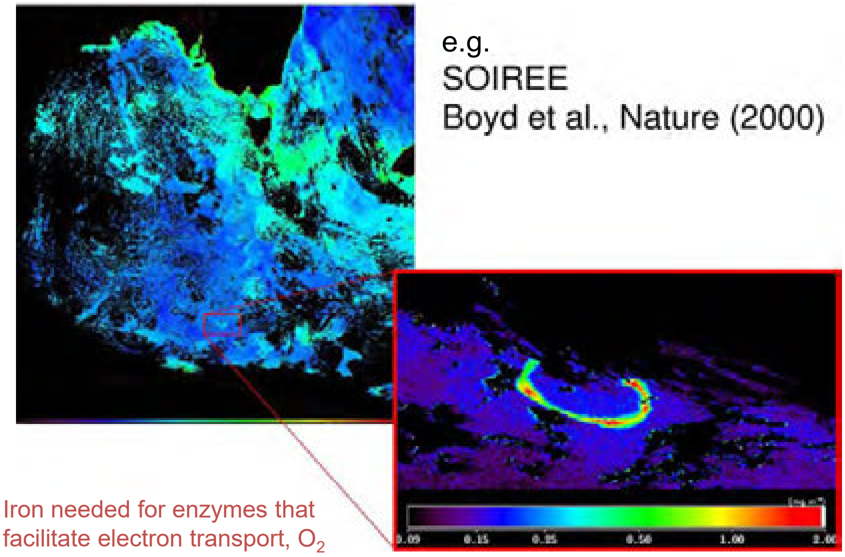
B. Liu, T. Ichinose, M. He, F. Kobayashi, T. Maki, S. Yoshida, Y. Yoshida, K. Arashidani, M. Nishikawa, H. Takano, G. Sun, T. Shibamoto,. Allergy, Asthma & Clinical Immunology. 2014. in press

牧輝弥ほか(2014)



In situ Fertilization experiments: Is iron limiting?

e.g.
SOIREE
Boyd et al., Nature (2000)



Iron needed for enzymes that facilitate electron transport, O_2 transport and other important functions.

Saharan dust, rich in Nitrogen, Iron and Phosphorus, helps to fertilize the huge plankton blooms that occur in the tropical eastern Atlantic.

MODIS satellite true colour image of dust storm over tropical North Atlantic Ocean, March 2004.

Threshold Friction Velocity u_{*t} *is expressed as;*

$$u_{*t}\,(d_s;\lambda,\theta,sc,cr,\ \ldots)=u_{*t}\,(d_s)\ f_{\lambda}(\lambda)\ f_w(\theta)\ f_{sc}(sc)\ f_{cr}(cr)\ \ldots$$

roughness moisture salinity crust

$u_{*t}\,(d_s)$: threshold friction velocity for sand particles of size d_s
f : correction functions
λ : surface roughness element
θ : volumetric water content
sc : salt content
cr : surface crustiness

Shao [2000]

Vertical Dust Flux F *is expressed as;*

$$\tilde{F}(d_i,d_s)=c_Y\left[(1-\gamma)+\gamma\frac{p_m(d_i)}{p_f(d_i)}\right]\frac{Qg}{u_*^2 m}\left(\rho_b\eta_{fi}\Omega+\eta_{ci}m\right)$$

Saltation flux

Soil texture
(= PSDs of parent soil)
→(fraction of
airborne particles to
fully dispersed particles)

Saltation bombardment
(= crust binding force)
(= soil plastic pressure)
(= volume removal)

Aggregates disintegration
(= soil texture)
(= fraction of aggregated dust)

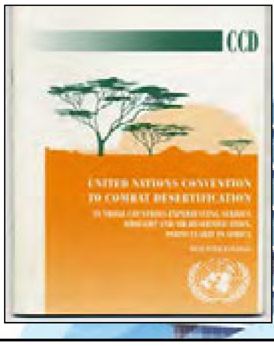
Shao [2001]

DUST FALLOUT PROPERTIES WITHIN DUST STORMS FREQUENT PATHS IN THE ROBME SEA AREA

DR. ALI M. AL-DOUSARI
KUWAIT INSTITUTE FOR SCIENTIFIC RESEARCH (KISR)

Dust fallout properties within dust storms frequent paths in the ROPME Sea Area

Ali M. Al-Dousari



26-Sept-2016

Previous studies

The following projects have a direct or indirect relation to the proposed project:

•EES-12: Mineralogy, granulometery and distribution pattern of dust fallout in Kuwait (completed 1980).

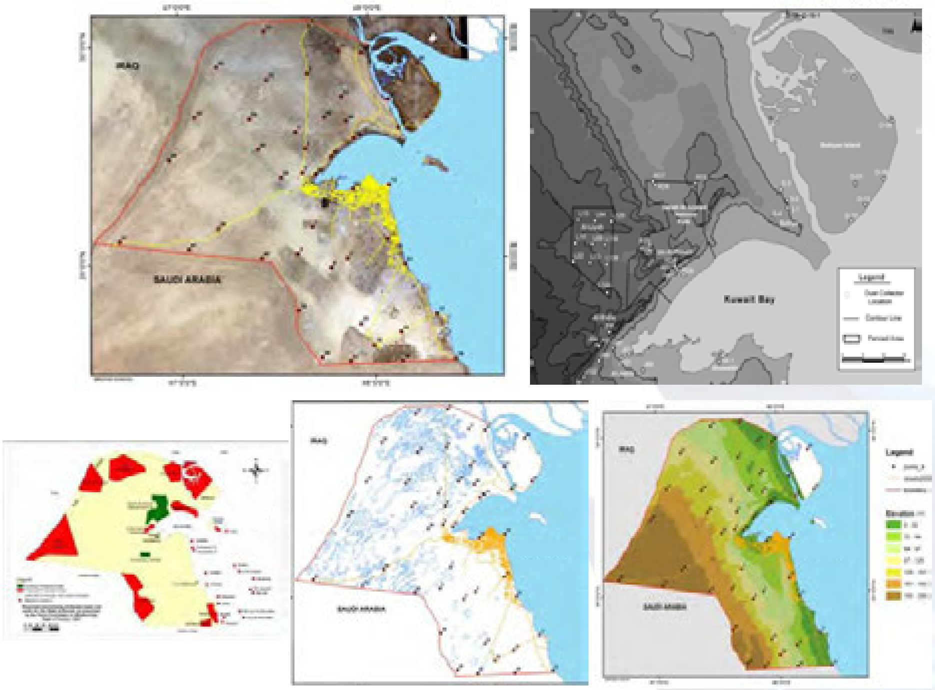
•EES-27: Study of sand and dust storm sediment - Phase II (completed 1984).

•EES-66: Dust fallout in the northern part of ROPME sea area (completed 1986).

•EC019C: Field environmental measurements in Bubiyan Island monitoring climatic conditions and movement of aeolian sediments (sand & dust) (completed 2005).

•EC041K: Dust fallout monitoring and analysis in Jahra City and surroundings (completed 2007)

•EC063C: Monitoring and Assessment of Dust Fallout and Associated Pollens with in the State of Kuwait.(Completed 2011)



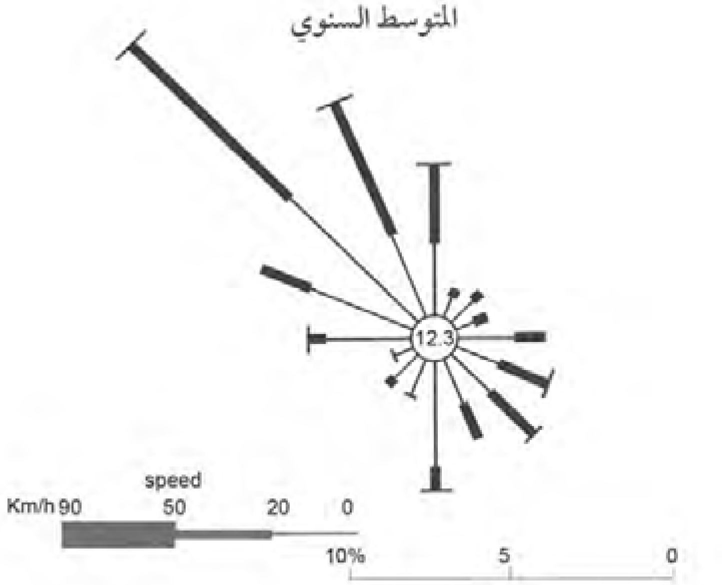
Mean Number of Days and Hours of Dust Phenomena at Kuwait International Airport (Safar, 1985) (1954-1984)

Month	Dust/Sand Storms		Raising dust		Suspended dust		Haze	
	Days	Hours	Days	Hours	Days	Hours	Days	Hours
January	1.1	4.2	3.7	22.0	3.1	15.4	7.7	47.5
February	1.3	4.7	4.3	35.2	4.4	21.7	7.5	51.2
March	2.1	7.2	6.1	45.7	4.7	38.0	7.6	76.0
April	3.2	11.2	6.1	43.9	5.2	43.8	7.4	81.1
May	4.2	12.7	6.7	51.8	6.2	52.0	7.5	106.3
June	4.8	31.7	10.3	108.3	4.7	56.3	6.4	93.3
July	4.4	31.3	8.4	92.7	5.7	55.1	7.3	94.4
August	2.3	11.2	8.3	75.6	5.2	38.9	8.9	97.4
September	0.6	2.5	5.1	31.4	6.0	25.7	11.3	96.2
October	1.5	4.8	3.6	22.9	5.7	26.2	10.7	79.7
November	0.4	0.9	2.9	14.8	4.0	18.1	10.3	56.0
December	1.1	5.3	3.4	18.3	3.2	14.4	8.8	51.0
Annual Total	27.0	127.7	68.9	562.6	58.1	405.6	101.4	930.1

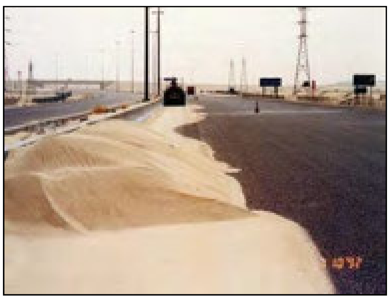
The average number for dust storm days in the RSA (Source: Al-Kulaib, 1990 after modification).
*** Kuwait data from this study from July 2000 to March 2010.**

Station	No. of years	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annually Average
Kuwait*	11	0.9	1.2	1.1	3.3	3.7	4.4	4.5	1.9	0.6	1.4	0.3	1.1	21
Bahrain	33	0.1	0.3	0.5	0.6	0.5	1.4	1.5	0.2	0.3	0.0	0.1	0.1	5.6
Doha	15	0.4	0.5	0.7	0.7	0.4	1.7	1.4	0.4	0.4	0.3	0.4	0.1	7.6
Abu Dhabi	6	0.4	0.3	0.6	0.1	0.4	0.4	0.7	0.0	0.0	0.0	0.2	0.7	3.9

المتوسط السنوي

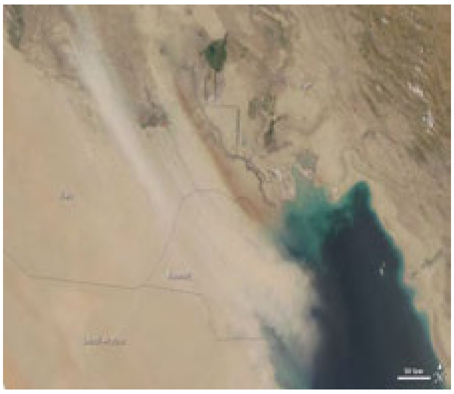


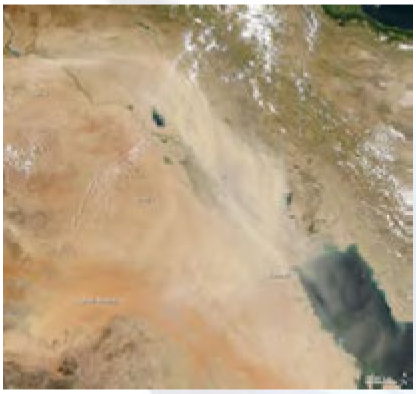
Human Effect

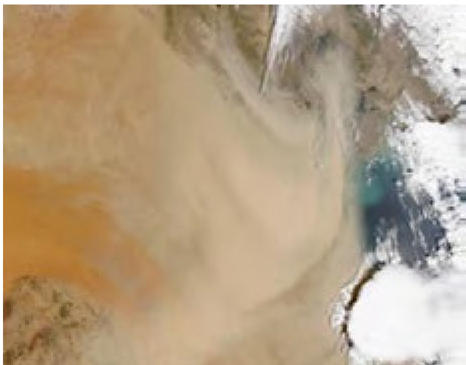


August 15, 2009. Moderate Resolution Imaging Spectroradiometer (MODIS) detected fires

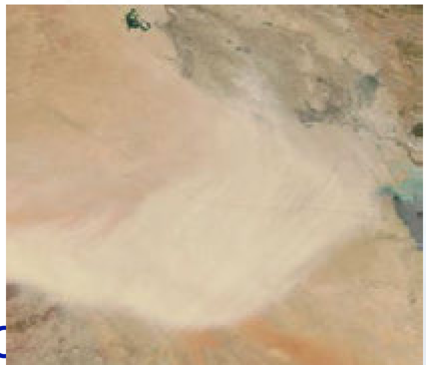
7 June 2010 -Aqua satellite.







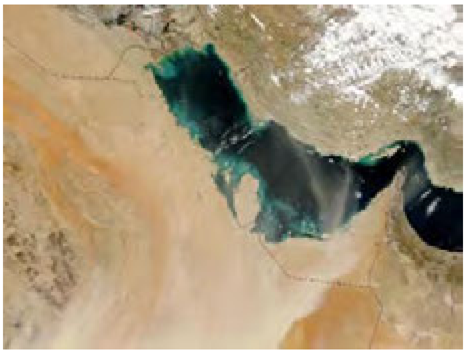
April 16, 2003, the Moderate Resolution Imaging Spectroradiometer (MODIS)



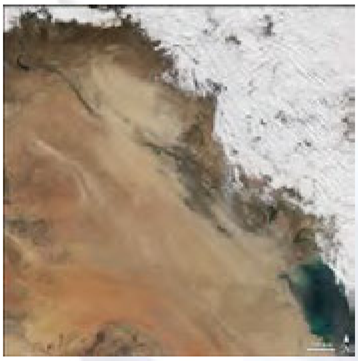
Moderate Resolution Imaging Spectroradiometer (MODIS) on June 6 June ,2005.

Dust storm Images

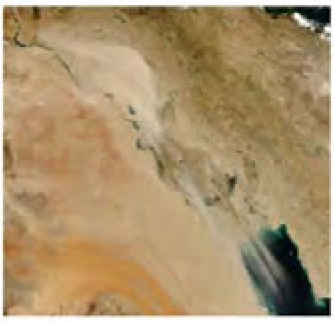
NASA captures Aqua satellite, the image a massive dust storm in Saudi Arabia on March 26th 2011 .

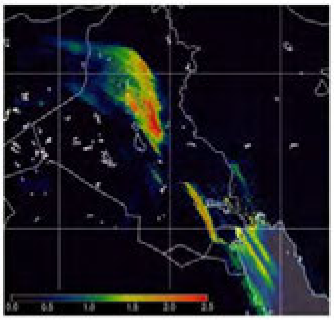


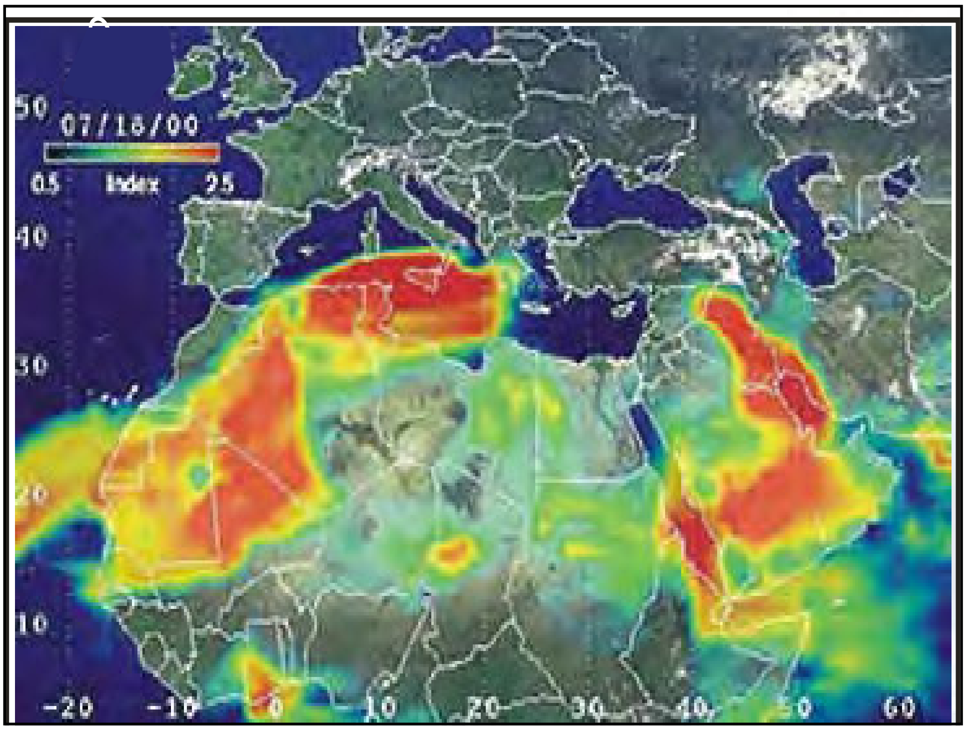
The Moderate Resolution Imaging Spectroradiometer (MODIS) flying onboard the Aqua satellite 21 Jan 2006



MODIS aerosols distribution map August 7, 2005



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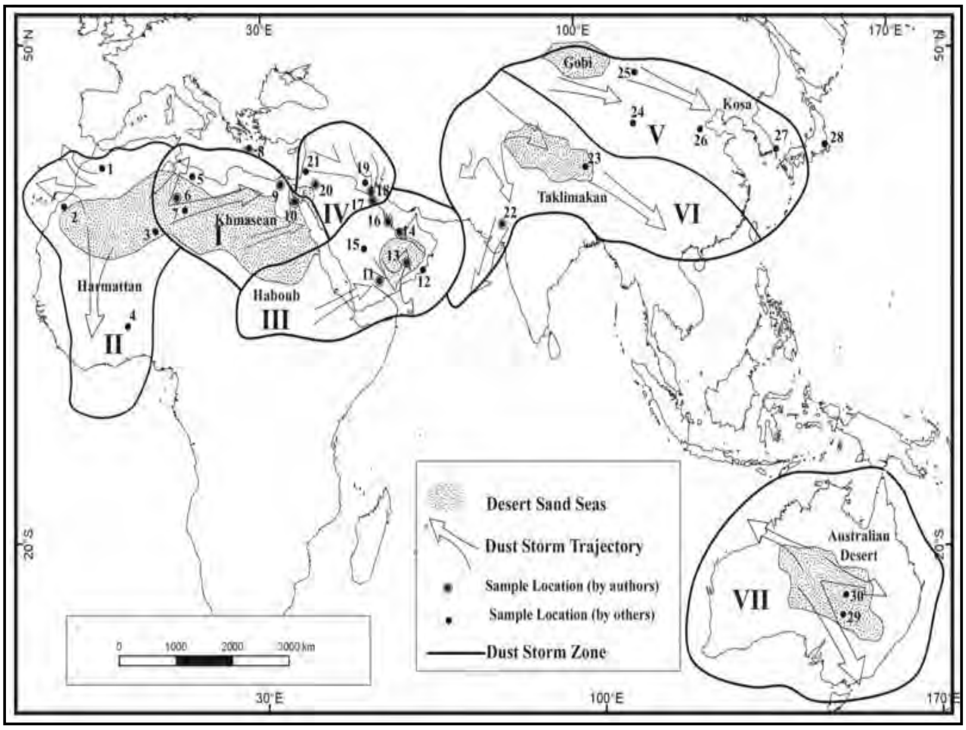
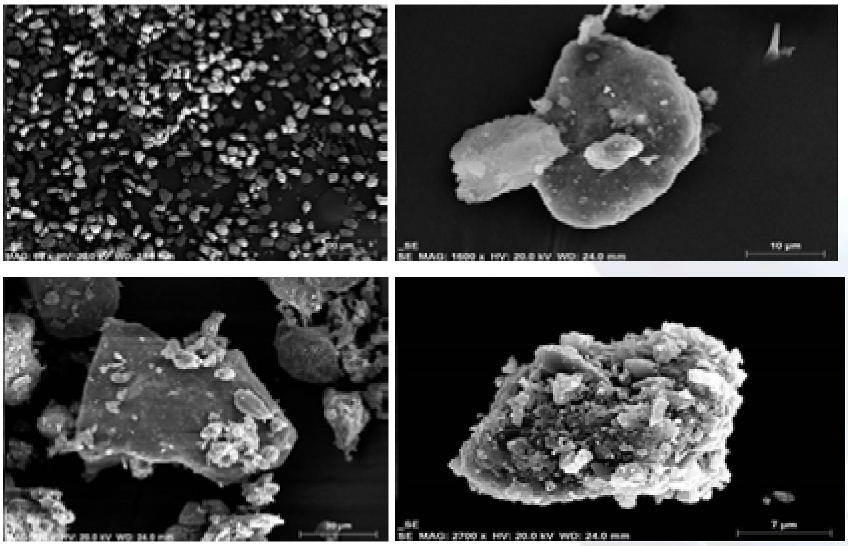
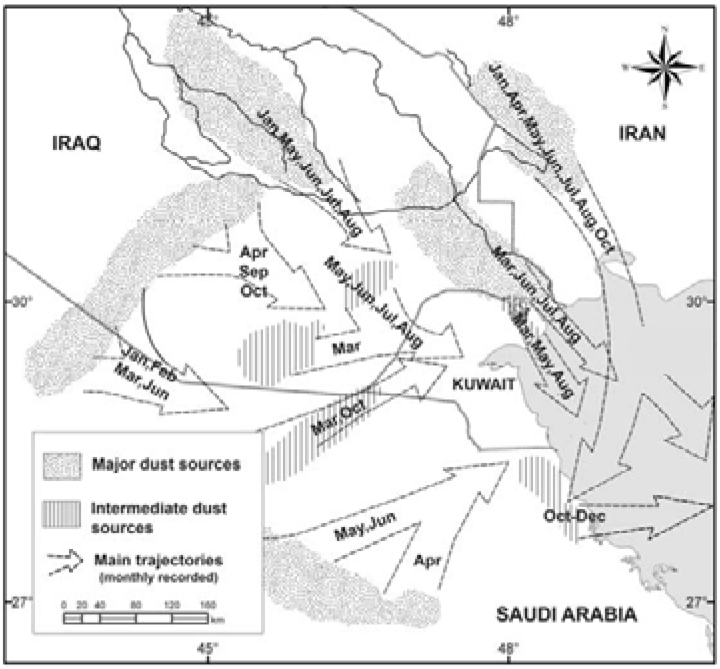

Gobi
Kosa
Taklimakan
Khmasean
Harmattan
Haboub
Australian Desert
I
II
III
IV
V
VI
VII
Desert Sand Seas
Dust Storm Trajectory
Sample Location (by authors)
Sample Location (by others)
Dust Storm Zone
0 1000 2000 3000 km

Smooth dust particles within West Rub Al-Khali with dominancy of very coarse silt (a), sub-angular quartz grain with some adhering carbonates particles (b), and 30 μm carbonate particles from Bubiyan with huge number of adhering gypsum and bassanite particles (c &d).



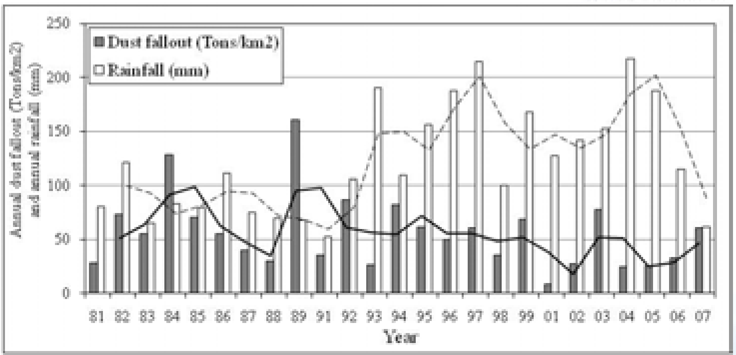


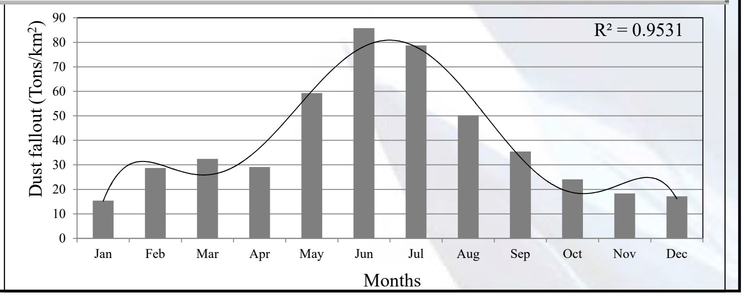
Amount of fallen dust (monthly and annual)

Zone-Location	Political region	Reference	Tons.Km^{-2}.mo^{-1}	Tons.km^{-2}.yr^{1}
Zone I: The western and southern Sahara Desert				
A long Niger River	Mali	McTainsh et al,. 1997	75-858	913-10446
Northern Diarnena	Chad	Maley, 1982	11.83	142
Kano	Nigeria	McTainsh et al,. 1982	11.4-15.1	137-181
Southern Chad	Chad	Maley, 1982	9.08	109
Nouadhibou	Mauritania	Rott, 2001	6.54	80
Smara	Western Sahara	Rott, 2001	9.12	111
Agadir	Morocco	Rott, 2001	9.39	114
Sidi Ifni	Morocco	Rott, 2001	11.88	145
Tan Tan	Morocco	Rott, 2001	14.37	175
Dakhla	Mauritania	Rott, 2001	15.72	191
Boujdour	Western Sahara	Khiri et al, 2004	17.97	219
Zone II: The eastern Sahara Desert				
Libya	Libya	O'Hara et al., 2006	13	155
Negev Desert	Palestine	Singer et al., 2003	4.8-18.1	57-217
Crete	Greece	Pye, 1992	0.83-8.33	10-100
Zone III: Sudan-Ethiopia and southern Arabia				
Fahal	Oman	Badawy et al., 1992	7.4	89
Riyadh	Saudi Arabia	Modaihsh, 1997	32.67	392
Zone IV: Northern Arabia				
Dead Sea	Palestine	Singer et al., 2003	3.71	45
Khur Al-Zubir	Iraq	Khalaf et al., 1980	6.9	75.92
Um Qasr	Iraq	Gharib et al., 1987	17.59	193.47
Kuwait	Kuwait	Present study	22.5	270
Zones V and VI: Gobi and Taklimakan deserts				
Xilingele	Mongolia	Hoffmann et al., 2008	24	292
Shapotou	China	Li et al., 2004	31	372
Tokyo	Japan	MOE, 1993	0.29	3.5
Zone VII: Australia Desert				
Adelaide	Australia	Tiller et al., 1987	0.42-0.83	5-10
Namoi valley	Australia	Cattle et al., 2002	1.4-4.85	16.9-58.2

المصدر بتصرف: 1-الهيئة العامة للبيئة (الغبار المتساقط بالشويخ) 2-مطار الكويت الأرصاد الجوية

KISR





KISR

Trajectory zone	Particle size percentages							Reference
	Sand	V.C.Silt	C.Silt	M.Silt	F.Silt	V.F.Silt	Clay	
Zone I: The western and southern Sahara Desert								
Tripoli-Libya	20	12	17	19	17	8	8	O'Hara et al., 2006
Biougra-Morocco	12	28	22	16	8	8	6	Khiri et al.,2004
Cartagena-Colombia	10	4	18	22	18	12	16	Present study
Arizona-USA	9	26	30	13	8	4	10	Pewe et al.,1981
Average	13	18	22	18	13	8	10	
Zone II: Eastern Sahara Desert								
Tripoli-Libya	20	12	17	19	17	8	8	O'Hara et al., 2006
Cairo-Egypt	10	15	37	21	10	4	3	Present study
Average	15	14	27	20	14	6	6	
Zone III: Sudan-Ethiopia and southern Arabia								
Wadi Dawasir	40	8	21	15	11	2	4	Present study
Ain	97	0	1	1	1	1	0	Present study
Dubai	17	3	14	24	23	10	8	Present study
Average	51	4	12	13	12	4	4	
Zone IV: Northern Arabia								
Amman-Jordan	30	11	30	17	8	2	2	Present study
Um Qasr-Iraq	3	12	20	25	15	5	20	Khalaf et al., 1980
Kuwait	37	22	18	14	7	2	0	Present study
Manamah-Bahrain	12	10	20	11	13	5	28	Present study
Average	21	14	22	17	11	4	13	
Zone V and VI: Gobi and Taklimakan deserts								
Taklimakan-China	70	24	2	1	2	1	0	Nishikawa et al.,2000
Ejin-China	35	18	10	8	5	2	22	Wang et al., 2005
Siberia-Russia	11	31	28	11	7	4	8	Pewe,1981
Average	39	24	13	7	5	2	10	
Zone VII: Australian Desert								
Bald Hill-Australia	9	3	5	5	4	3	70	Cattle et al., 2002
Average	26	14	18	14	10	5	13	
Max	97	31	37	25	23	12	70	
Min	3	0	1	1	1	1	0	

Grain size % of Fallen dust from upwind to downwind

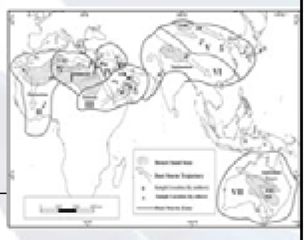
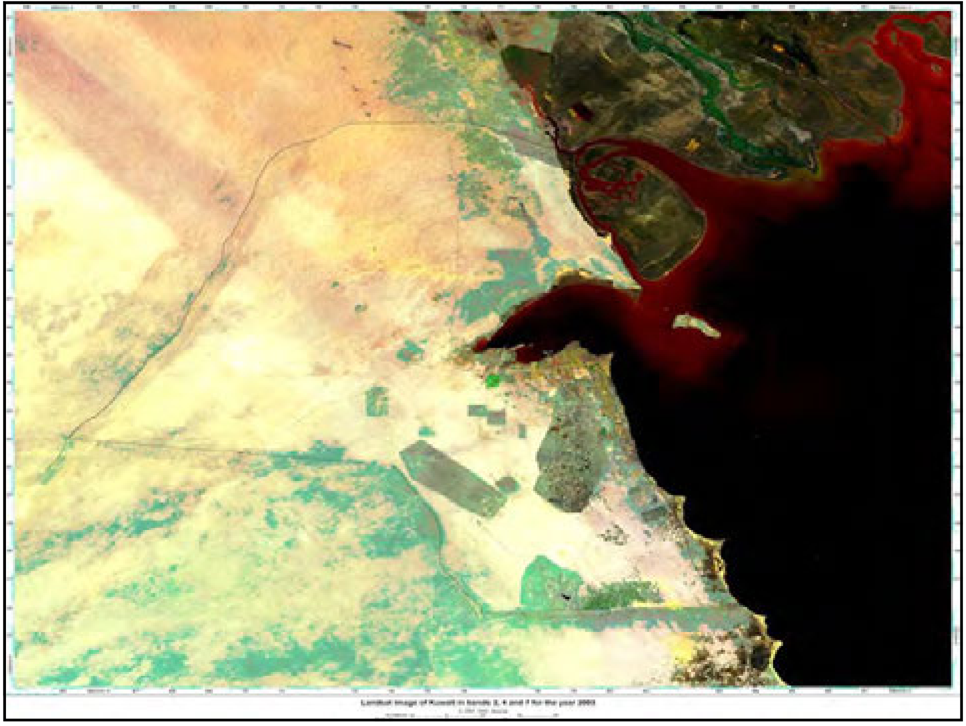


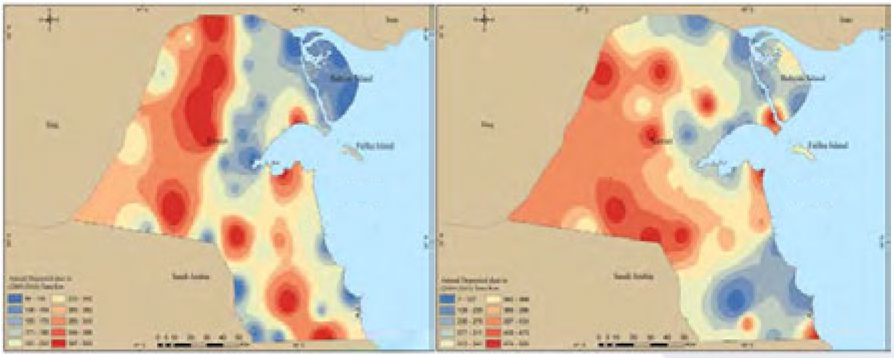
Table. The amount in m^3 and cost in USD of sand removal from civil and military facilities

Settlements	Total Sand Removed (m^3)	Total Cost (USD)	Cost for removal for m^3 (USD)	Total Amount of Sand Removal (m^3)	Total Cost of Sand Removal (USD)	Cost for sand removal for m^3 (USD)
	1993			2013		
Kuwait Oil facilities	283,545	717,811	2.53	347,310	993,862	2.87
Main Highways	779,855	913,272	1.17	2,651,431	2,141,757	0.81
Power stations	42,500	121,618	2.86	160,600	955,452	5.95
Military Base	650,700	357,700	0.55	1,320	78,694	59.61
Average	439,150	527,600	1.78	790,165.13	1,042,441	5.33
Total	1,756,600	2,110,401		3,160,660.52	4,169,766	

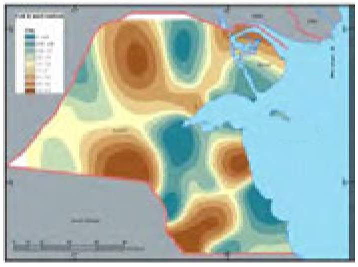
Table. The costs of sand removal in Kuwait comparing to surrounding regions.

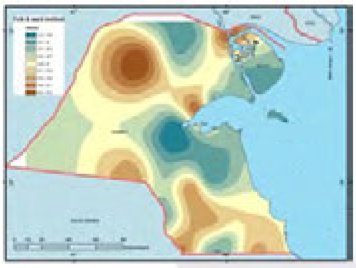
Area	Reference	Year	Sand removal cost of m^3 (USD)
Kuwait	Present study	1993	1.78
Kuwait	Present study	2013	5.33
Hofouf-Saudi	Alghamdi and Al-Kahtani, 2005	2004	0.50
Riyadh-Saudi	Al-Hareeq, 2012	2007	3.73
Riyadh-Saudi	Al-Hareeq, 2012	2012	0.80
Bushra-Syria	Alobaid, 2000	1996	0.09
Sistan-Iran	Pahlavanravi et al., 2012	2000	2.00
Sistan-Iran	Pahlavanravie et al., 2012	2004	0.50





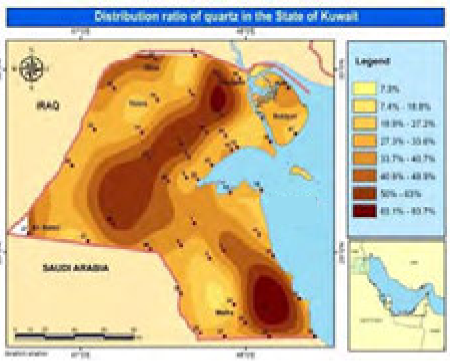
Annual dust comparison between (2009/2010) and (2010/2011)

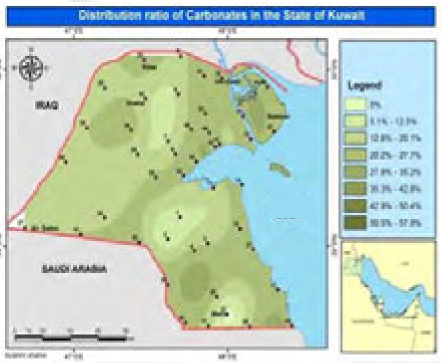


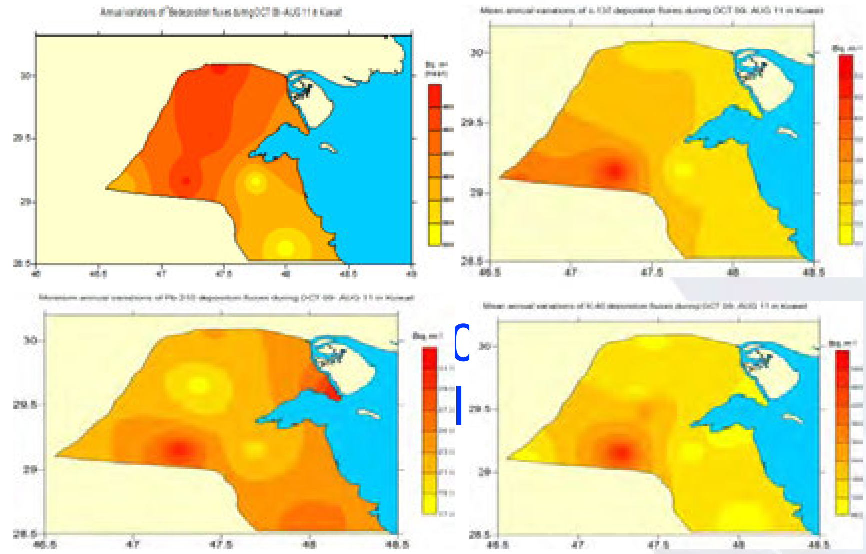


Clay % and mean particle size

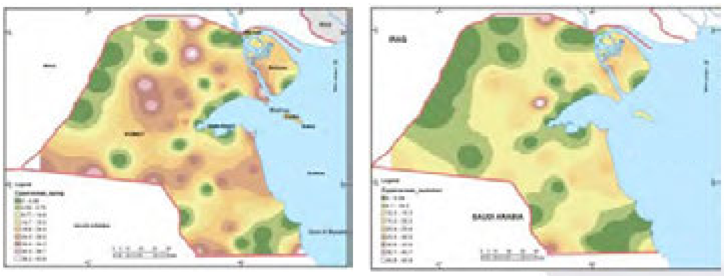
Mineralogy (Quartz and Carbonates %)





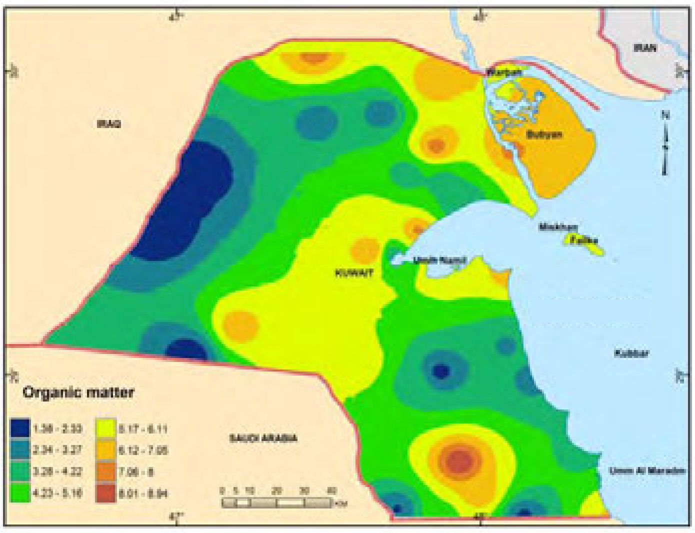


KISR
Kuwait Institute for Scientific Research

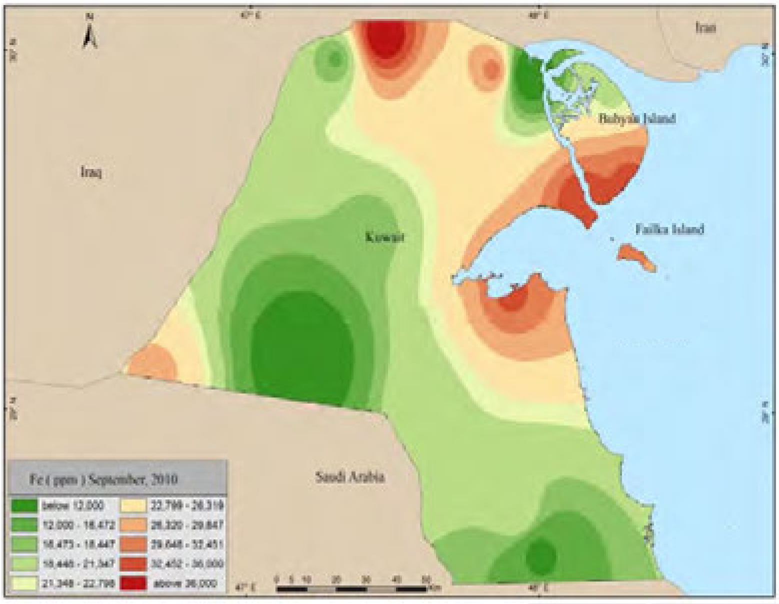


Cyperaceae pollen
Winter and summer

Organic Matter % in dust



Iron (Fe) in ppm



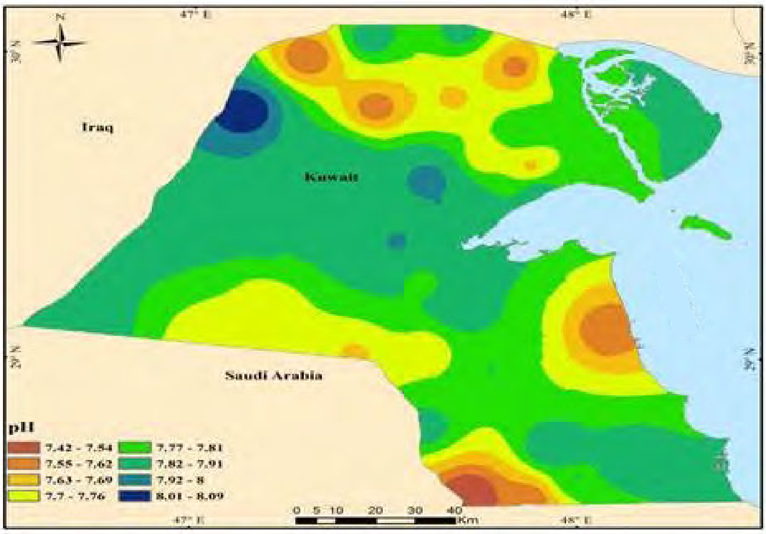
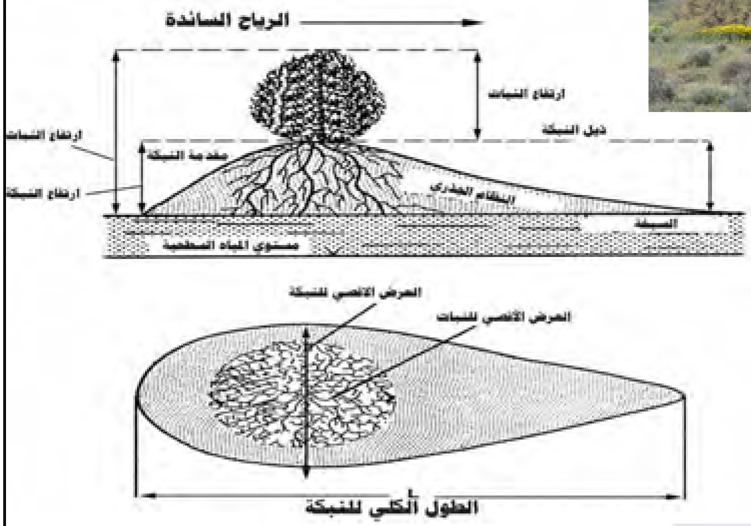
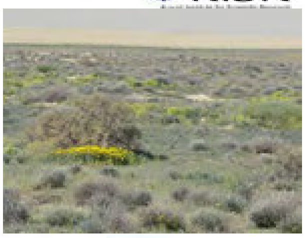
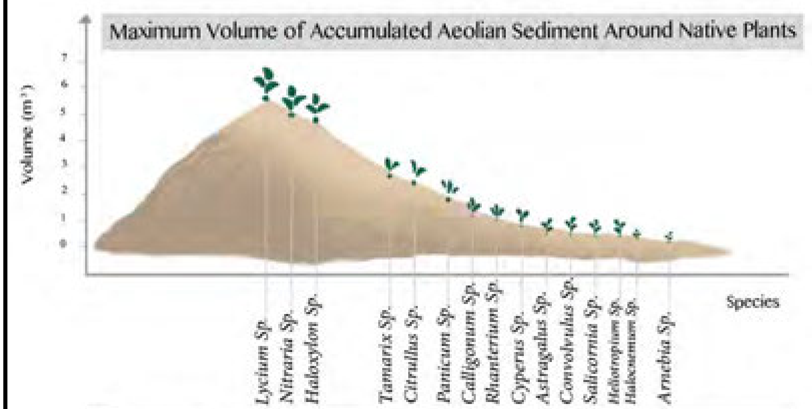


Table. The correlations between dust deposition and fallout

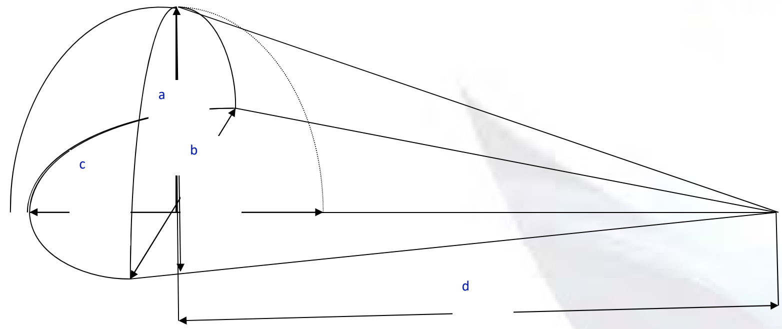
	Dust Deposition	*Be-7*	*Cs-137*	*Pb-210*	*K-40*
Dust Deposition	1				
Be-7	0.33	1			
Cs-137	0.82	0.47	1		
Pb-210	0.69	0.83	0.78	1	
K-40	0.98	0.34	0.84	0.71	1





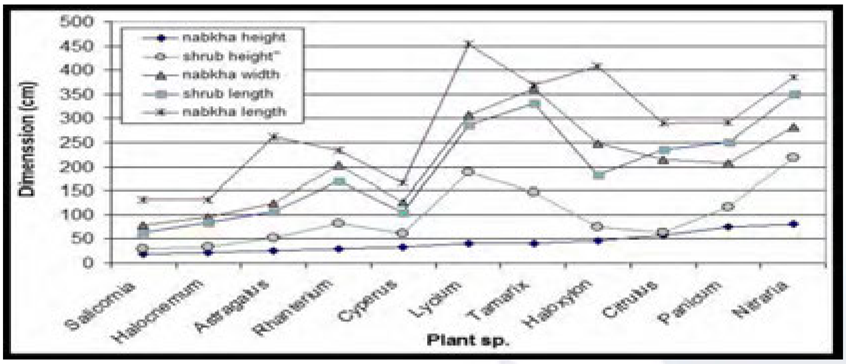


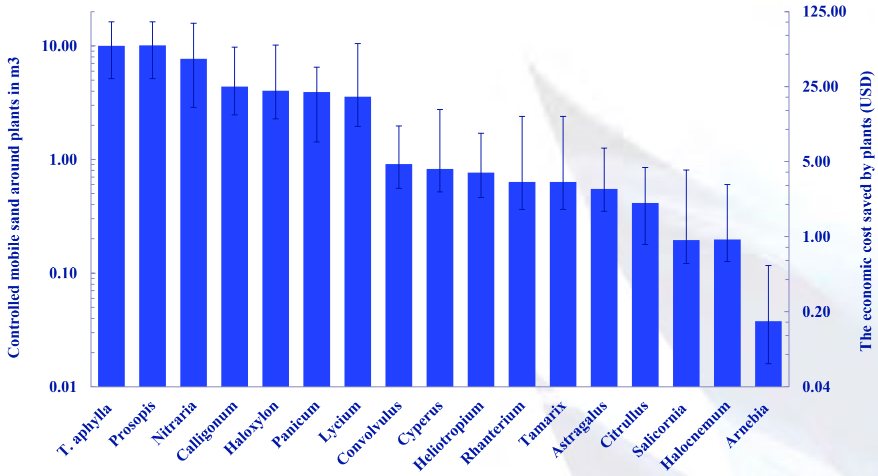
	Lycium Sp.	Nitraria Sp.	Haloxylon Sp.	Tamarix Sp.	Citrullus Sp.	Panicum Sp.	Calligonum Sp.	Rhanterium Sp.	Cyperus Sp.	Astragalus Sp.	Convolvulus Sp.	Salicornia Sp.	Heliotropium Sp.	Halocnemum Sp.	Arnebia Sp.
Minimum (m^3)	0.14	0.67	0.08	0.24	0.05	0.33	0.04	0.03	0.01	0.01	0.002	0.010	0.010	0.010	0.001
Average (m^3)	1.18	1.99	1.26	1.05	0.64	0.95	0.30	0.19	0.19	0.19	0.090	0.060	0.100	0.060	0.004
St. Deviation	1.30	1.33	1.21	0.59	0.45	0.46	0.35	0.24	0.21	0.13	0.120	0.090	0.080	0.050	0.002



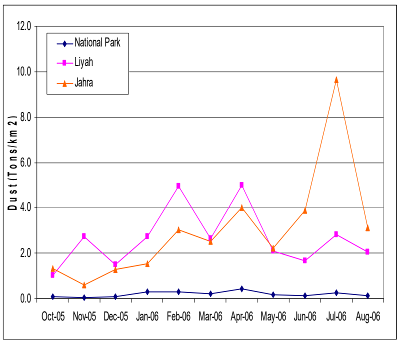
Total Volume of nabkha is given as = $V_E + V_P = \frac{\pi.a_1.b_1.c_1}{12} + \frac{\alpha.d^5.\tan\theta}{5}$

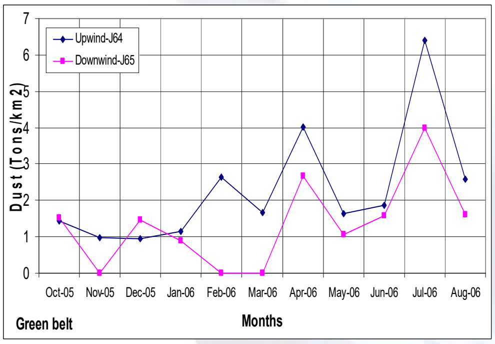
Morphology of plants and sand trapped (nabkha)





Adaptation with dust





Summary & conclusion

•Any disaster within the terrestrial environment is a benefit to the marine environment
•There are 120 ton/km2 fall in RS, that is about 30 million tons fall into the ROPME Sea Area in 2006,i.e about 4886 ton/km3.
•The amount of fallen dust increased up to 339 ton/km2 are about 81 million tons fall into the ROPME Sea Area in 2010/2011,i.e about 13,803 ton/km3.

ENVIRONMENTAL AND ECONOMIC IMPORTANCE OF NATIVE PLANTS AND GREEN BELTS IN DEGRADED LANDS

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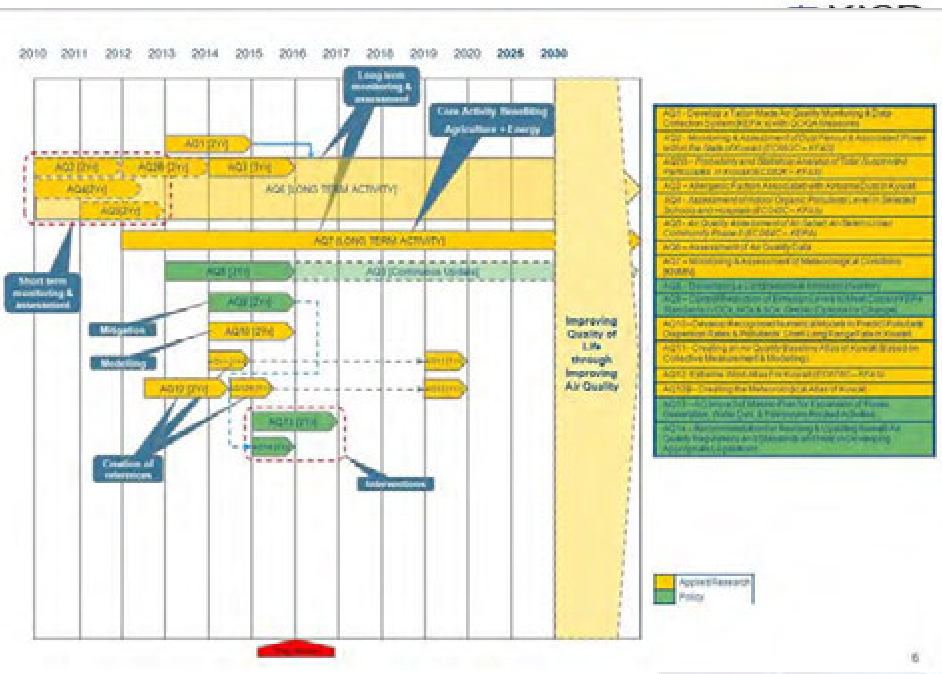
ABSTRACT

The removal costs of cubic meter for encroached sand and dust around main infrastructures (highways, oil wells and gathering centers, power stations and air basis) in Kuwait increased from 1.78 USD in 1993 to 5.33 USD in 2013 representing the highest cost in the region. Correspondingly, morphological and chemical properties of nabkha deposits around 15 dominant species of native plants were determined, where after, the saving cost by each plant was also calculated in equivalent to the cubic meter removal cost. Approximately 1,640 samples were collected, 800 from nabkhas around perennial plants and 840 from four green belts. The green belts are found effective in improving soil properties and control the shifting sand by 193% compared to upwind. *Nitraria retusa*, *Lycium shawii*, *Haloxylon salicornicum*, and *Calligonum polygonoides* trapped the maximum mobile sand and dust up to 21.9 m^3, 15.5 m^3, 14.5 m^3 and 13.3 m^3 respectively, which makes them the most effective solutions for present and future applications in controlling aeolian processes. Therefore, six vegetated oases were established with about 110,000 of these effective native plants from March 2011 to December 2016 in order to test their tendency in controlling mobile sand and dust. These oases have a positive effect as they captured about 115 tons of aeolian sediments saving 6,112,764 USD as estimated removal cost if these accumulations all around human settlements. They have also contributed in reducing the annual rates for mobile sand and dust by 94% and 64.5% respectively.




THANK YOU

EFFECT OF MINERAL DUST ON OCEAN PRODUCTIVITY AND BIOGEOCHEMISTRY OF THE NORTHERN ROPME SEA AREA.
KISR, KUWAIT - CSIR NIO, INDIA

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KISR

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EFFECT OF MINERAL DUST ON OCEAN PRODUCTIVITY AND BIOGEOCHEMISTRY OF THE NORTHERN ROPME SEA AREA.

KISR, KUWAIT - CSIR NIO, INDIA

TURKI ALSAID
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ROPME Regional meeting
26-28 September 2016

Presentation Outline

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- Introduction
- Background
- Project Description; Overview
- Project objectives
- Technical Outcome
- Schedule
- Project tasks
- Available equipments; in KISR
- Summary

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Introduction

- Kuwait is subjected to severe dust and sand storms.
- Recognition of aeolian dust as an important source of iron to marine photosynthetic organisms.
- The deposition of atmospheric dust is the primary process supplying trace metals such as Al, Mn and Fe to the surface ocean.
- The residence time in surface waters for each of these elements differs according to their chemical speciation and biological utilization (Wuttig et al. 2013).

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Background

- Few studies have been conducted to understand the effect of dust on the biological activity in Kuwait's waters.

- Incubation experiment (Subba Rao et al., 1999,Subba Rao et al., 2003).) spiking eolian dust rich in essential micronutrients (Co, Cr, Cu, Fe, Ni, Zn, Mn, Pb) increased phytoplankton growth reaching red tide proportions

- Subba Rao et al. (2003) and Ismail et al. (2007) concluded that dust impact is a major ecological force in the formation of algal blooms

- However, detailed study on effect of duct on the biological abundances and associated processes in Kuwait waters is urgently needed.

Dust storm over Kuwait and neighboring countries on January 8, 2013.

Stressors

Build up of Salinity

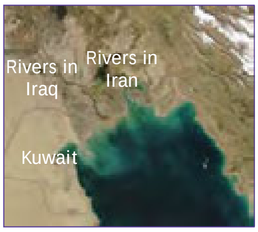
Rising temperature

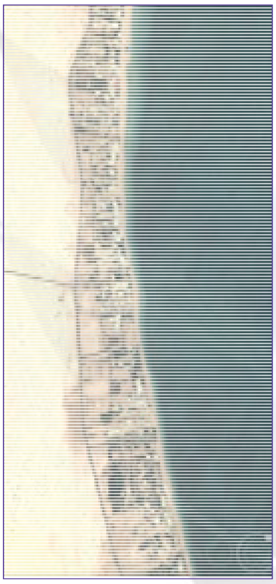
Less freshwater flow

Highly polluted

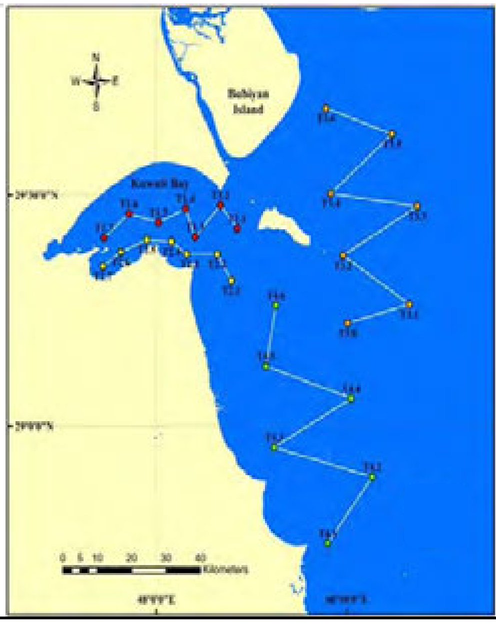
Desalination plants

Annual dust storms
(60-200 x 10^6 tons, 50% of the total dust emissions in to the troposphere)





Completed project; produced new set of data 2015-2016 trace metals, nutrients, physical and chlorophyll a



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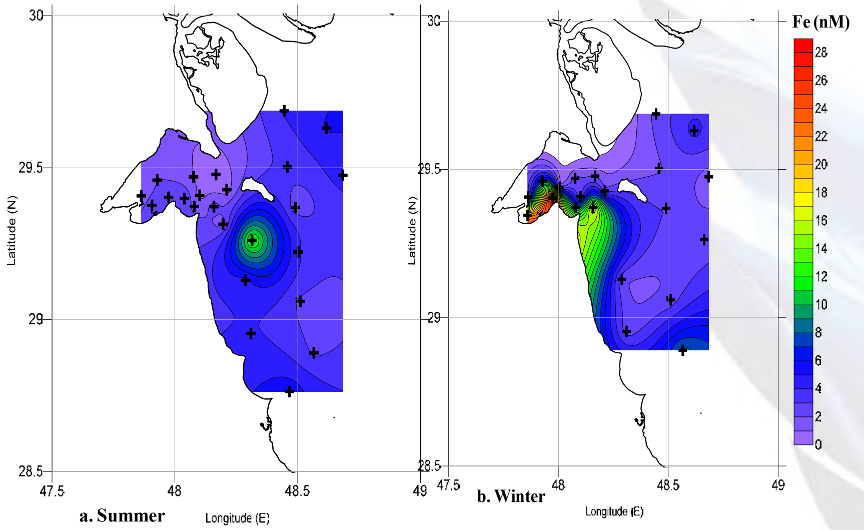
Distribution of dissolved Iron in Kuwait waters.



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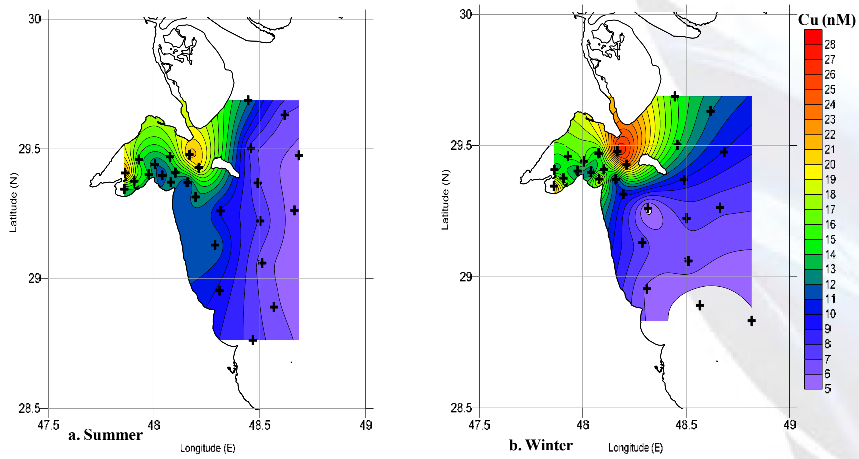
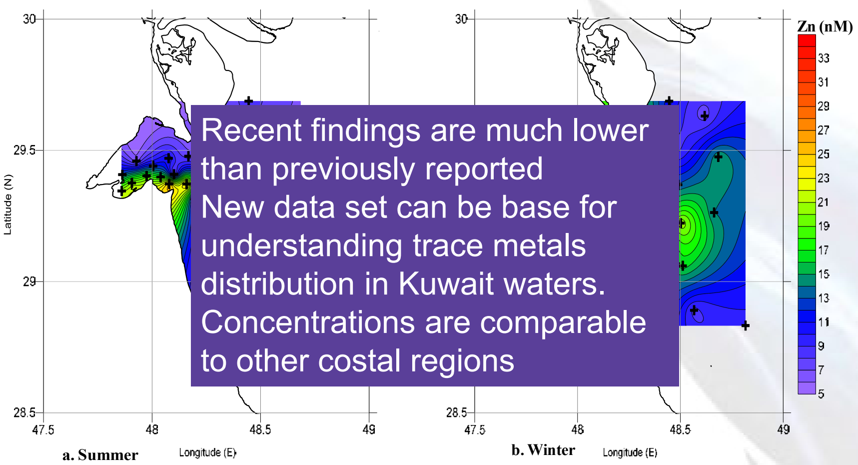
Distribution of dissolved Copper in Kuwait waters.



Distribution of dissolved Zinc in Kuwait waters.



Recent findings are much lower than previously reported
New data set can be base for understanding trace metals distribution in Kuwait waters.
Concentrations are comparable to other costal regions

Project description; overview

- Install dust collectors at Failaka island and KISR campus .
- It is proposed to estimate the total amount of dust being deposited in the Kuwait waters and the fluxes of soluble components through leaching.

Project Description; overview

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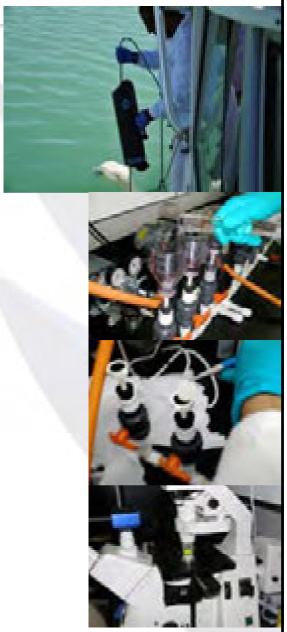
•Seawater samples will be collected for chemical and biological analysis to understand the impact of the dust on primary production and its possible role in carbon sequestration.

•Routine measurements will include monthly sampling of fundamental biogeochemical parameters such as dissolved oxygen, pH, nutrients and chlorophyll *a*.

•Seasonal measurements will be carried out for dissolved organic carbon and alkalinity to understand the impact on the carbonate system.



Project Description; overview

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- Thus studies in the RSA will help to understand carbon dioxide via the chemical and biological pathways.
- Incubation experiments will be carried out by applying dust particles collected from different locations in Kuwait to phytoplankton assemblages.

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Project Objectives

- To assess the sources and effect of mineral dust fluxes on ocean biogeochemical processes in the northern RSA.
  - ✓ (a) To estimate the atmospheric deposition of mineral dust, identification of sources, and its soluble fraction (inorganic leachable ions and nutrients).
  - ✓ (b) effect of mineral dust fluxes on ocean biology and chemistry.

- Provide a database of mineralogy, geochemical and isotopic characteristics of mineral dust and the soluble component of mineral dust for future reference.

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Technical Outcomes

- Advancement of scientific knowledge of oceanographic and biogeochemical processes in the Northern RSA.
  - Understanding the impact of mineral dust on productivity in the RSA and human health.
  - Effective utilization of already available information/data for improving the present understanding.
- To establish detailed database concerning mineralogy, geochemical and isotopic characteristics of mineral dust and the soluble component of mineral dust

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Schedule

The total duration of the project is 24 months (the last 6 months of the project will be for report writing)

	FY1												FY2											
Tasks	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
1																								
2																								
3																								
4																								
5																								
6																								

Task 1. Mobilization
Task 2. Collection of dust particles and seawater samples
Task 3. Chemical and biological sample analysis
Task 4. Incubation experiments
Task 5. Data analysis
Task 6. Report writing

Project tasks

Project tasks

Task 1. Mobilization

Task 2. Collection of dust particles and seawater samples

Task 3. Chemical and biological sample analysis

Task 4. Incubation experiments

Task 5. Data analysis

Task 6. Report writing

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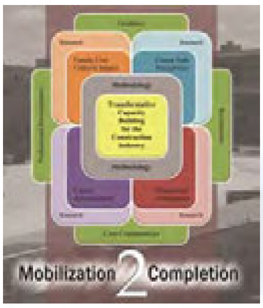
Task 1. Mobilization

- The sampling and analyses plan will be reviewed and finalized.
- Initial test, calibration and standardization on the new instruments will be applied.
- Assessing and preparing sampling locations of the aerosol particles.
- Discussion with the NIO scientists is essential at this stage to verify the high volume sampler's frequency of sampling and all other necessary required analysis.



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Task 2. Collection of dust particles and seawater samples

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- **Base line data**: to the proposed study and assessment of available data.
- **Sources of dust from Remote Sensing of dust from satellite images** (AOD and Angstorm Exponent) from MODIS (twice a day) and Eumesat satellites at daily and even hourly coverage.

- **Meteorological data and instrumentation set up** (AWS) (Failaka Island) **LIDAR procurement and set up** (KISR campus). Understanding the meteorological conditions for formation of dust storms:
  1. Summer shamal
  2. Winter shamal
  3. Local winds

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Task 2. Collection of dust particles and seawater samples

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- **Ground measurement of dust**: High Volume samplers and Dust traps. Continuous observations for one year at two locations. (i) KISR and (ii) Failaka Island.

- **Dust Fluxes:** Amount of dust deposited: Concentration of dust (AOD and AE) and height of dust layer and : LIDAR, CALIPSO (satellite lidar) and atmospheric profiles (Meteorological stations), Comparison of measured dust fluxes with GOCART and other Dust models.

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Task 2. Collection of dust particles and seawater samples

- Seawater sample collection:
  Stations 1-5 during two field campaigns (15 days each).
  - In April (when the frequency of dust storms is high) and
  - In December (when the frequency is low).

- High resolution time-series sampling and measurements: At stations 1, 2 & 5 for 15 days to study changes following a dust event. (every alternate day for T, S, light penetration depth, DO, nutrients and chlorophyll *a)*

Task 2. Collection of dust particles and seawater samples

- Sampling will be conducted in Kuwait's waters on a monthly basis for a period of 12 months.
- Seawater samples will be collected using Niskin samplers
- In-situ measurements (temperature, salinity, pH, turbidity, dissolved oxygen and fluorescence) will be done by using a CTD AAQ-Rinko

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Task 2. Collection of dust particles and seawater samples

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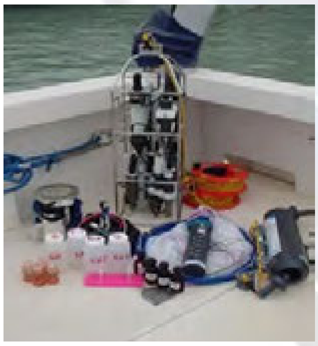
- Sub-sampling will be done for dissolved oxygen (DO), pH, nutrients, dissolved inorganic carbon (DIC), alkalinity (at NIO), suspended particulate organic matter (SPOM), trace metals (Cu, Ni, Co , Zn and Fe), chlorophyll *a*, pigments and phytoplankton
- Atmospheric aerosols (total suspended particles – TSP) will be collected on 47 mm diameter, polypropylene (0.45 µm nominal pore-size, Sterlitech) and polycarbonate filters (0.4 µm pore-size, Nuclepore)



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Task 3. Chemical and Biological Sample Analysis

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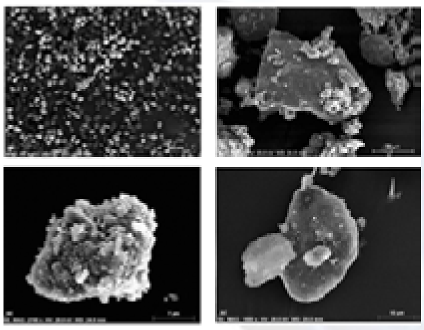
Dust samples will be analyzed for following parameters:

- Mineralogy
- Major Metals
- Trace Metals
- Carbonate content (Coulometer)
- Grain Size
- Organic carbon and if necessary isotopes of Carbon
- Sr and Nd and Pb isotopes



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Task 3. Chemical and Biological Sample Analysis

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Determination of flux of soluble component of dust:

- Leachable ions and Nutrients (Milli Q) using Ion Chromatograph
- Leachable Trace metals. (Milli Q) ICP-MS

Trace metal Fe(III) will be measured using FIA-FeLume; speciation will be done using Ad-CSV.




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Task 3. Chemical and Biological Sample Analysis

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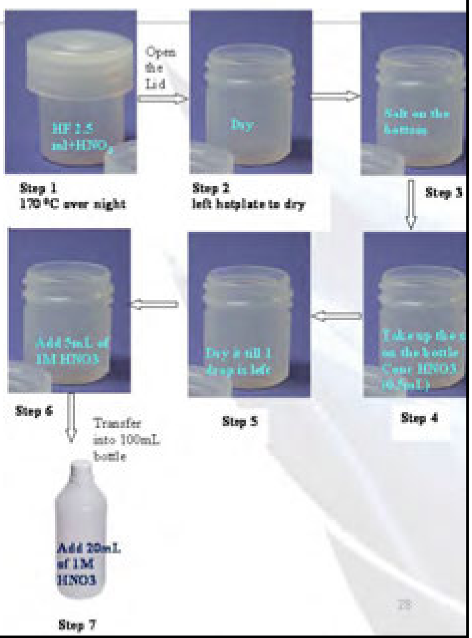
- Dissolved Oxygen Analysis by the classical winkler titration method using DOT-5 instrument.
- pH will be analysed using a pH meter.
- Nutrients (nitrate, nitrite, ammonia, phosphate and silicate) will be analysed using a SKALAR autoanalyser.
- SPOM will be collected by filtering 3-5 litres of seawater.


Task 3. Chemical and Biological Sample Analysis

- ➢Calculation of atmospheric deposition of soluble nutrients and trace metal fluxes and possible impact on ocean biogeochemical processes.
- ➢DIC will be measured using a UIC coulometer connected to VINDTA.
- ➢Alkalinity will be measured by potentiometric titration connected to VINDTA supplied by Marianda systems.

Task 3. Chemical and Biological Sample Analysis

Digestion steps of dust particles proposed to be used during the project.



Task 3. Chemical and Biological Sample Analysis

- POC and nitrogen will be measured seasonally to document the impact on carbon and nitrogen cycling in addition to tracing the source of organic matter.

- Phytoplankton speciation through microscopy and pigment measurement through HPLC

Task 4: Incubation experiments

- Incubation experiments will be conducted seasonally to estimate the amount of nitrogen fixed by marine organisms (e.g. cyanobacteria).

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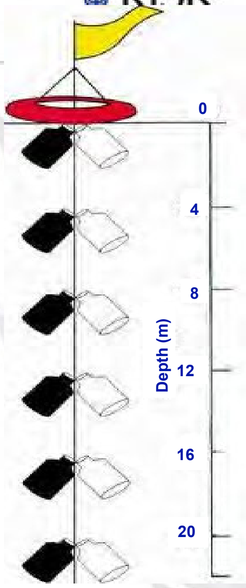
Task 4: Incubation experiments

- Process study will be conducted during low dust season
- Previously collected dust will be used for spiking experiments on a mooring in offshore waters
- For the process study seawater will be collected and spiked with dust. Enhancement of chlorophyll and phytoplankton species will be enumerated.
- All parameters mentioned earlier will be also monitored



Schematics showing the dark and light incubation bottles deployed on a mooring from surface float

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Task 5. Data analysis

- To generate of a new database of mineralogy, geochemical and isotopic characteristics of mineral dust and the soluble component of mineral dust for future reference.
- The new data will be analyzed to improve our understanding of the ecosystem.
- Also descriptive analyses will be conducted from data produced from the incubation culture experiments.

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Task 6. Report writing

- The project leader will be responsible of preparing the progress and final reports.
- Task leaders and the principal investigator will be participating in this task.

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Available Equipments in KISR

- Ad-CSV(797 VA Computrace)
- FIA (FeLume)
- Skalar Auto Analyser
- Flow cytometer
- Inverted Microscope
- Milli-Q water system
- TN/TOC analyzer
- UV- Visible Spectrophotometer
- DOT-5 for Dissolved Oxygen
- Flurometer
- BOD and COD Robotic Analyzer
- ICP-MS/ ICP-OES, XRD, GF-AAS & HPLC

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Available Equipments in KISR

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- AAQ170 RinKo CTD for measurements of water temperature, salinity, depth, dissolved oxygen, chlorophyll-*a* concentration, pH and turbidity
- Niskin samplers (5 litres) and Go-Flow
- Filtration units to filter seawater samples
- Laminar Flow cabinets
- pH meter, Digital balances, Micro pipettes
- UV digestion system
- Digesting hotplate 3000 digestion system (rated 1400 W)
- High volume air sampler (requested)

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Summary & KISR contribution in ROPME Project

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- NIO and KISR project will provide valuable data
- Expected outcome were detailed and clarified
- Incubation experiments objectives were stated
- Available instruments and tasks of the new project were also mentioned.

- Two suggestions for KISR contribution for future collaboration with ROPME:
- ROPME to assist and partially fund the anticipated NIO and KISR project
- Or
- Service project should be initiated from KISR side to cover anticipated ROPME tasks required for the Pilot Study.

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Dust is recognized to be important factor introducing essential metals to the water column and hence induce phytoplankton blooms and enrich the biological activity in surface oceans.

Frequent dust storms recorded for the last decade in Kuwait raise the importance of conducting a detailed research study focusing on the effect of dust particles on the biochemical processes in the RSA.

Dust storm over Kuwait and neighboring countries on January 8, 2013.

Previous studies by KISR established a base line of the dust characteristics in Kuwait, explained in the previous section. Although biological, physical and chemical oceanographic studies has been also conducted in Kuwait waters, no detailed study assessing the effect of dust on the biochemical processes in the RSA has been carried out.

The proposed collaboration between KISR and CSIR-NIO is aimed to address this lacuna. Under this collaboration results of previous studies will be assessed and evaluated as part of the project

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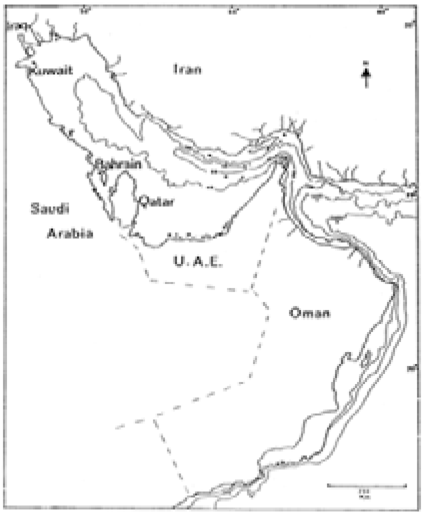
Thank you

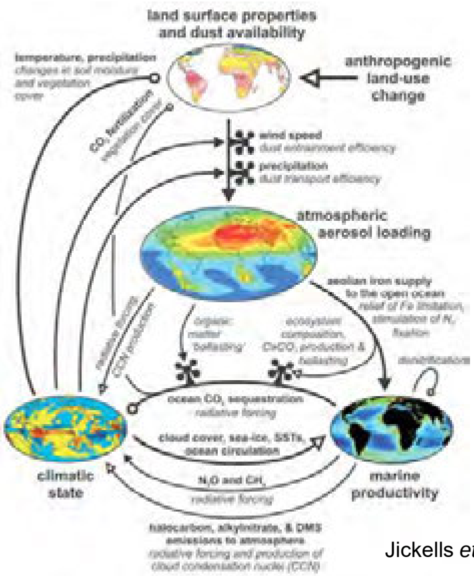
PROPOSED PILOT PROJECT, BASELINE STUDY AND LONG-TERM PROJECT FOR MONITORING AND ASSESSMENT OF IMPACTS OF DUST ON THE RSA

DR. ERIC ACHTERBERG, GEOMAR

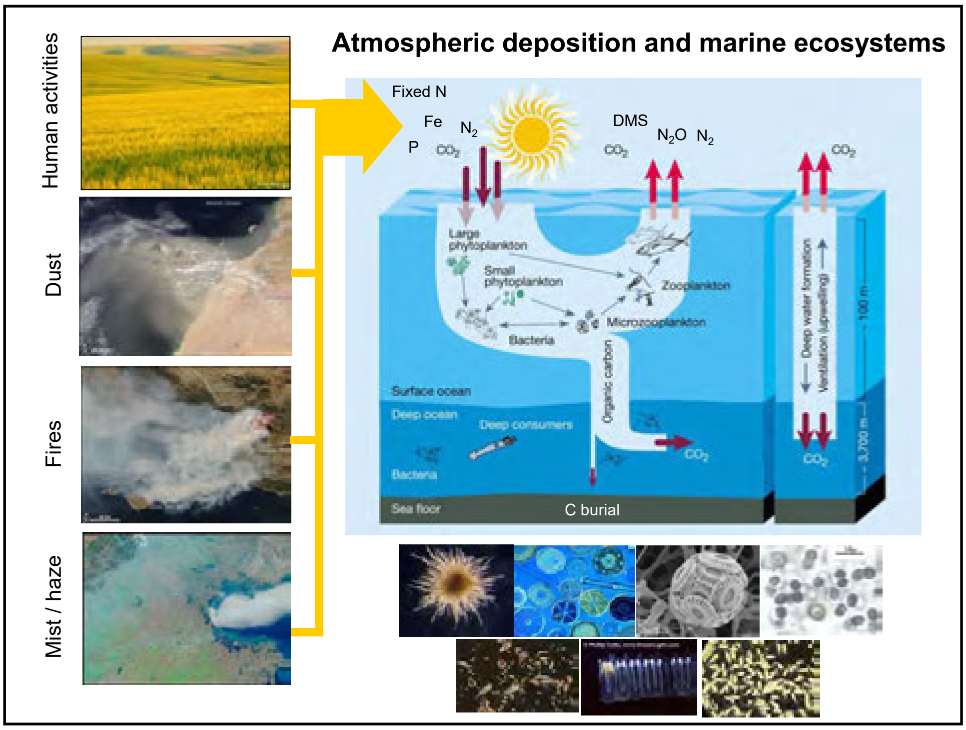
Proposed Pilot Project, Baseline Study and Long-Term Project for Monitoring and Assessment of Impacts of Dust on the RSA



Global dust connections



Jickells *et al*. Science 2005



Proposed Pilot Project, Baseline Study and Long-Term Project for Monitoring and Assessment of Impacts of Dust on the RSA

Important questions :
What are the supplies of nutrients, trace elements and organic contaminants to the RSA by total and soluble aerosol deposition?

What are the contributions of anthropogenic and natural sources to aerosol loadings in the RSA?

What are the chemical and biological impacts of aerosol inputs to the waters of the RSA?

How can future decisions be made on reduction of anthropogenic aerosol emissions in the ROPME region to mitigate their impact on RSA ecosystems?

These questions require us to understand and assess the impact of aerosol inputs to the RSA upon agreed baseline parameters.

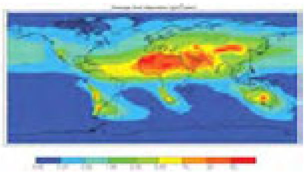
Basic approach for the development of Pilot Study and BAISDS-2018, and subsequent Long-term monitoring Programme

In developing the Pilot study and BAISDS-2018, complete harmonization of related initiatives and sharing of responsibilities should occur. The major milestones to be achieved are:

-Meeting of a Scientific Group to finalize the details of Scientific Programme of Pilot Study and BAISDS-2018

-Practical activity of developing the Pilot Study and BAISDS-2018 by way of completing sampling, analyses, interpretation and reporting

-Development of Regional capacity to contribute to and continue the efforts over a long time period by way of strengthening expertise and designating Regional Reference Laboratories



Aims and Objectives of Monitoring Studies

- **The overall aim of the small Pilot scale study is to provide initial data for developing a one year monitoring programme of BAISDS-2018.**

- **Objectives of Pilot Study**
- Set-up capacity to undertake aerosol sampling with high volume aerosol collectors
- Collection of aerosols and seawater samples over a 2 months period in the year 2017 at 3 to 5 locations in the ROPME Sea Area
- Identification of gaps and needs for larger monitoring programme
- Measurement of total and soluble elements and compounds in the collected aerosol samples
- Measurement of trace elements, nutrients, organic compounds, carbonate chemistry, chlorophyll a and indicators of ecosystem structure in the collected water samples
- Determination of the biological impact of aerosols in selected samples
- Identification of the potential sources and transport pathways of mineral and anthropogenic aerosols in the Region

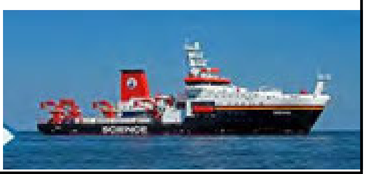
Expected outcomes

- **Expected outcome from Pilot Study**
- Small and limited dataset on aerosol deposition and impacts on surface water biogeochemistry and biology for parts of the RSA
- Substantial and high quality dataset from collaborative 2016 cruise campaigns in RSA region??? Has this occurred???
- Gaps and Risks assessment for BAISDS-2018
- Actions plan to deal with gaps and risks for BAISDS-2018 implementation
-

Aims and Objectives of Monitoring Studies

- **The overall aim of the 2016 cruise studies is to provide detailed aerosol and water column data to support cruise programme**

- **Objectives of Study of Dust Inputs to RSA during 4 seasonal Cruises in 2017**
- Contribute to the 2017 cruise programme through aerosol collection and surface water analysis for assessment of impacts of aerosols on RSA
- Undertake aerosol sampling on cruises using high volume aerosol samplers
- Measurement of total and soluble elements and compounds in the collected aerosol samples
- Determination of the biological impact of aerosols in selected samples
- Identification of the sources and transport pathways of aerosols collected on cruises



Aims and Objectives of Monitoring Studies

- **The overall aim is to provide essential baseline data for developing an international flagship monitoring programme of aerosol impact on the RSA**
- **Objectives of BAISDS-2018**
- Collection of aerosols over a full seasonal cycle in the year 2018 at locations in the ROPME Sea Area
- Measurement of total and soluble elements and compounds in the collected aerosol samples
- Collection of surface water samples over a full seasonal cycle in the year 2018 at locations in the ROPME Sea Area for chemical and biological measurements
- Determination of the biological impact of aerosols over a full seasonal cycle in 2018-2019 in the ROPME Sea Area
- Determination of the impact of aerosols on the water column carbonate system (ocean acidification) over a full seasonal cycle in 2018-2019 in the ROPME Sea Area
- Quantification of the sources and fluxes of mineral and anthropogenic aerosols in the Region
- Determination of the main processes regulating the distribution, transport and the deposition of mineral and anthropogenic aerosols in the RSA
- Chemical transport modelling to integrate the mineral and anthropogenic aerosol data from observations with information on dispersion, transport and biological uptake processes

Aims and Objectives of Monitoring Studies

- **The overall aim is to provide essential baseline data for developing an international flagship monitoring programme of aerosol impact on the RSA**
- **Objectives of BAISDS-2018**

- Modelling of trace element and nutrient deposition, constrained by remote sensing of total aerosol deposition rates in combination with ground measurements
- Further development of local physical-biogeochemical ocean model with improved aerosol supply fluxes and biological impact quantification
- Use outcomes of the monitoring programme to assess impact of aerosol deposition on health of the RSA and lobby regional governments to reduce anthropogenic atmospheric emissions in the region
- Promotion and strengthening of the capabilities and readiness of the Member States in the domain aerosol mineral dust monitoring and establishment of biological effects
- Archival and integration of relevant atmospheric and oceanographic information to the BAISDS-2018
- Establishment of Regional and international collaborations on the platform of BAISDS-2018 as a networked capacity for future endeavors
- Designation of Regional Reference Laboratories for the continuation of work emanating from the BAISDS-2018
- Establishment of a regular long-term Regional Monitoring Programme including the networking of National Monitoring Programmes on aerosols

Expected outcomes

- **Expected outcome from the BAISDS-2018**
- Establishment/suitable upgrading of aerosol dust analysis stations in the ROPME Sea Area. These stations serve both as a network for Aeolian mineral dust concentration information as well as Aerosol Monitoring System through standardized methodology
- Provision of scientist exchange programme and Regional seminars/workshops on studies of the marine environment and Aeolian mineral dust and their impact on ocean health
- Establishment of aerosol dust monitoring and analysis stations, biological impact assessment activities for dust deposition to the ocean, training and collaboration programmes by the Member States
- The above outcomes can be targeted in a phased manner on completion of the BAISDS-2018 and presentation of results to the Member States by the Regional Scientific Group.

Expected outcomes

- **Expected outcome from the BAISDS-2018**
- Establishment of a comprehensive geospatial database of previous relevant studies in the Region and experiences gained elsewhere on aerosol impacts, with provision for updating of data from the monitoring stations and networking with other data facilities
- Establishment of a joint information center with dedicated website for collection of required international standards, international guidelines, standard software, data analysis models, standards concerning aerosols as related to marine biogeochemical and ecosystem impacts and decision support tools
- Designation of Regional aerosol dust monitoring facilities and measurement laboratories, and including a cross calibration exercise to guarantee harmonization of the measurements made by each laboratory (capacity building)
- Development of a Long Term Regional Monitoring programme for Aeolian mineral dust and its impact on the ocean through the participation of Member States, including designated stations and standardized operating procedures and equipment

Aims and Objectives of Monitoring Studies

- **The overall aim is to provide long-term trends on aerosol deposition and the impacts on the health of the RSA**
- **Objectives of Long-term monitoring programme**
- Quantification of temporal and spatial distribution of deposition fluxes of soluble and total trace elements, atmospheric nutrients and organic pollutants to the ROPME sea area from both natural and anthropogenic sources
- Quantification of temporal and spatial impacts of aerosol deposition on water column biogeochemistry, carbonate chemistry (ocean acidification) and ecosystems
- Quantification of anthropogenic sources (dust and fossil fuel combustion aerosol) to the aerosol deposition fluxes
- Refinement of the chemical transport model with the outcomes of the monitoring programme
- Assessment of temporal changes in aerosol deposition and biogeochemical and ecosystem impacts in the RSA
- Development and refinement of RSA biogeochemical ocean model
- Development of effective atmospheric pollutant emission control measures in the region
- Assessment of the effectiveness of atmospheric pollutant emission controls in the RSA and benefits to RSA.

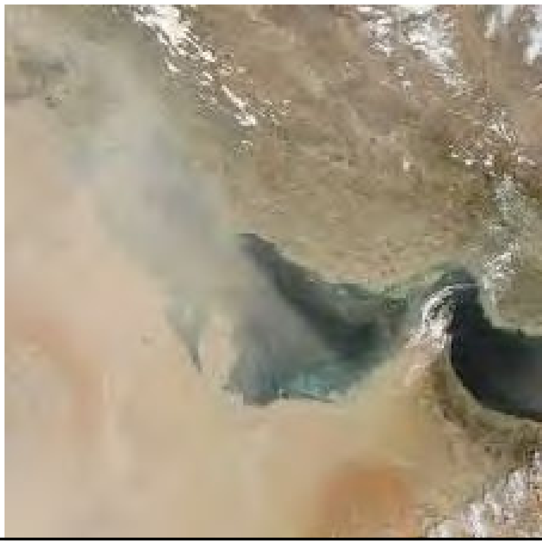
Expected outcomes

- **Expected outcome from Long-term Study**
- High quality temporal and spatial data set of Aeolian mineral dust measurements, with their impact on the ocean in the RSA
- Data for policy makers and scientists to establish impacts of Aeolian mineral dust inputs on health of the ocean, including nuisance algal blooms
- Data and evaluation tools for regional policy makers to undertake emission reduction measures with respect to atmospheric pollution
- Strengthened long-term scientific collaborations in the ROPME region
-

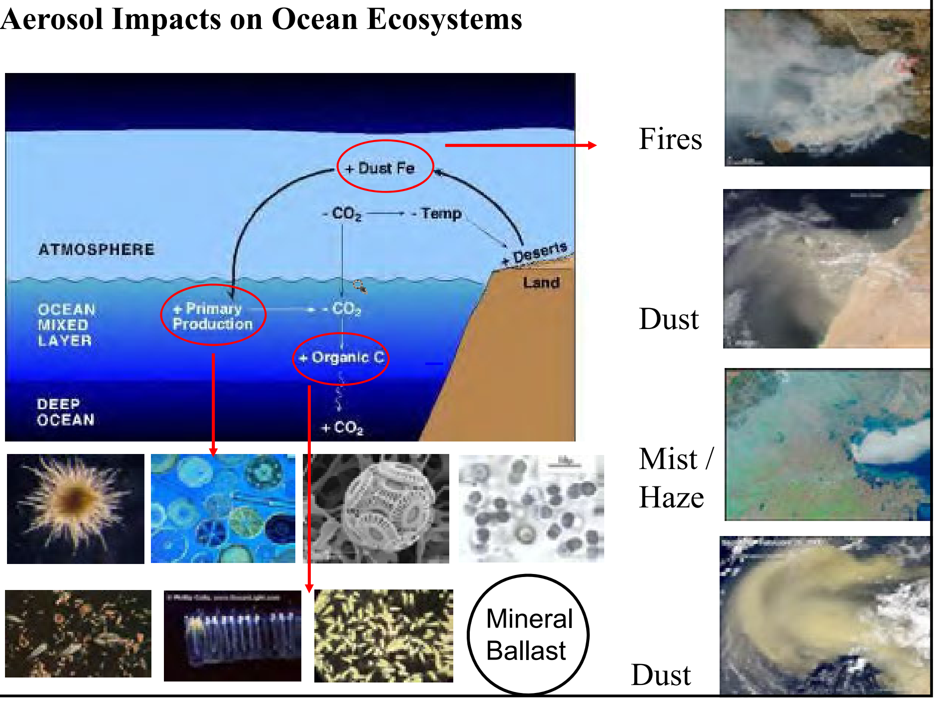
QUESTIONNAIRES ON DUST AND BIOGEOCHEMICAL MONITORING AND RESEARCH CAPACITY IN ROPME MEMBER STATES

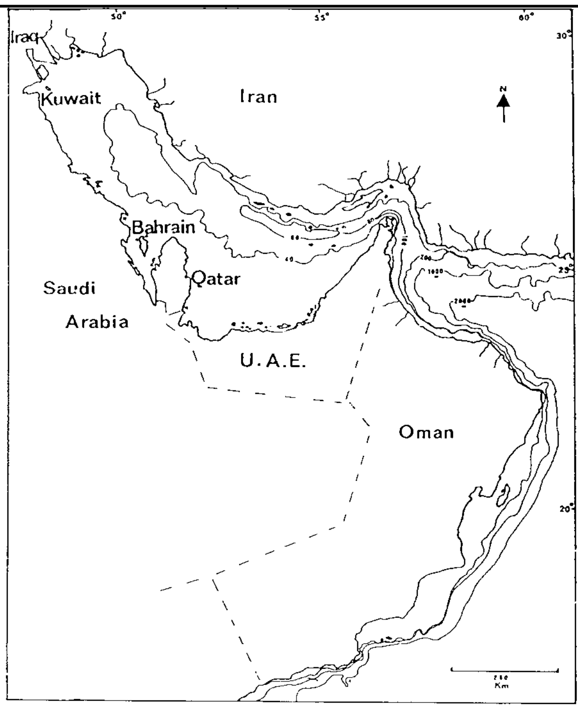
DR. ERIC ACHTERBERG, GEOMAR

Questionnaires on Dust and Biogeochemical Monitoring and Research Capacity in ROPME Member States



Aerosol Impacts on Ocean Ecosystems





Questionnaire on monitoring activities and research capacity for dust and ocean biogeochemical variables in the ROPME member states

The aim of this questionnaire is to establish the monitoring and research capacity within the ROPME member states related to research on dust and ocean biogeochemistry.

The outcomes of this questionnaire will be used to develop a coherent and inclusive scientific programme for a regional study on the "Monitoring and Assessment of Sand and Dust Storms on the Marine Environment in the ROPME Sea Area".

The questionnaire has been prepared by:
Dr. Zongbo Shi (z.shi@bham.ac.uk; University of Birmingham, United Kingdom) and Prof Eric P. Achterberg (eachterberg@geomar.de; GEOMAR, Kiel, Germany)

In case any questions arise during completion of the questionnaire, please do not hesitate to contact us.

The survey has two sections covering:
Section 1: Dust monitoring, analysis, and modelling
Section 2: Ocean biogeochemical and biological parameter monitoring, analysis, and modelling

Institutional information:
Name of member state: ____________.
National representative/contact person:
Prof, Dr, Ms, Mrs, Mr:
Position:
Institution:
Postal Address:
Telephone:
Telefax:
E-mail:
http://
Date: Signature:
(Permanent Representative)

Word file

The return on the evaluation forms sent out by us in late 2015 was excellent.

-We received returns from 5 countries (Iraq, Iran, Kuwait, UEA, and Bahrain) with details on existing atmospheric and water column sampling and analysis.

-Amount of monitoring undertaken is extensive and very useful to our proposed monitoring programme

-Substantial amount of particulate matter and gas monitoring using direct light attenuation sensors or gas sensors

-Particulate aerosol sampling for dry deposition undertaken at a good number of sampling sites in the region

-Satellite observations and ground based remote sensing activities is undertaken in a number of countries

-Limited amount of aerosol modelling is undertaken
→it will be important to engage the modellers in our ROPME Dust programme

-Good amount of water sampling undertaken
→ sampling for nutrients is common with some metal analyses

-Water sampling stations are well distributed around the region
→very useful to our monitoring programme.

-Substantial amount of air quality data available from member states

→ should be mined for analysis of the spatial distribution of air pollutants and dust as well as providing information on the sources of particulate matter

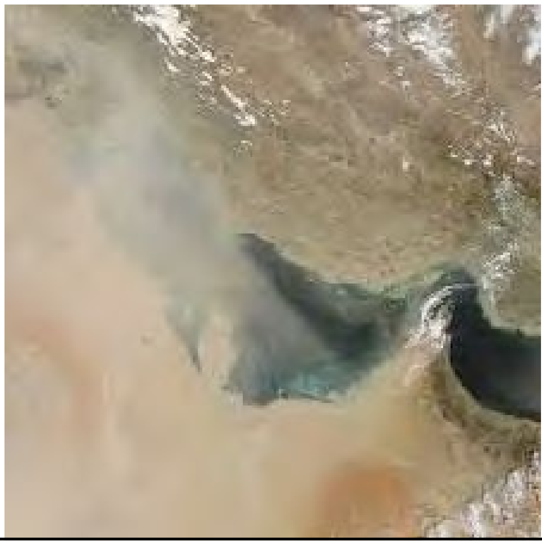
-Overall, the return on the evaluations was of great importance and provides us with excellent information to design the pilot study, baseline study and long-term monitoring programme

-The meeting this week will allow us to make decisions on the locations of the aerosol and water samplers for the pilot and baseline study, with the use of the information from the evaluation

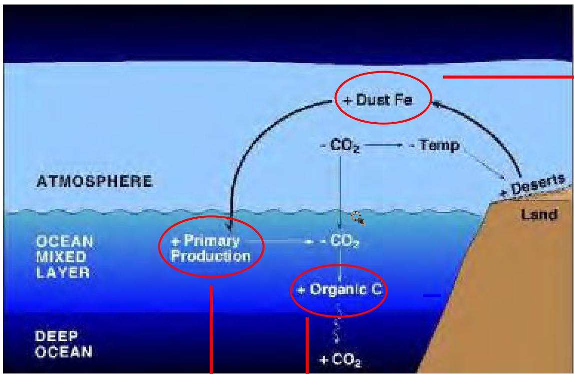
IMPLEMENTATION PLAN FOR THE ASSESSMENT OF IMPACTS OF DUST IN THE MARINE ENVIRONMENT OF THE RSA

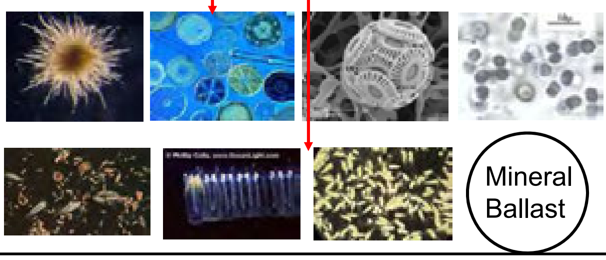
DR. ERIC ACHTERBERG, GEOMAR

Implementation plan for the Assessment of Impacts of Dust in the marine environment of the RSA



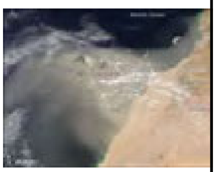
Aerosol Impacts on Ocean Ecosystems





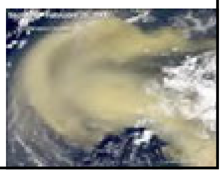
Mineral Ballast

Fires



Dust

Mist / Haze



Dust

Proposed Pilot Project, Baseline Study and Long-Term Project for Monitoring and Assessment of Impacts of Dust on the RSA

Important questions :

What are the supplies of nutrients, trace elements and organic contaminants to the RSA by total and soluble aerosol deposition?

What are the contributions of anthropogenic and natural sources to aerosol loadings in the RSA?

What are the chemical and biological impacts of aerosol inputs to the waters of the RSA?

How can future decisions be made on reduction of anthropogenic aerosol emissions in the ROPME region to mitigate their impact on RSA ecosystems?

These questions require us to understand and assess the impact of aerosol inputs to the RSA upon agreed baseline parameters.

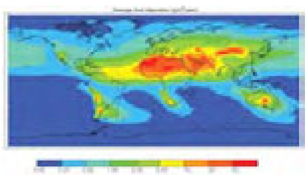
Basic approach for the development of Pilot Study and BAISDS-2018, and subsequent Long-term monitoring Programme

In developing the Pilot study and BAISDS-2018, complete harmonization of related initiatives and sharing of responsibilities should occur. The major milestones to be achieved are:

-Meeting of a Scientific Group to finalize the details of Scientific Programme of Pilot Study and BAISDS-2018

-Practical activity of developing the Pilot Study and BAISDS-2018 by way of completing sampling, analyses, interpretation and reporting

-Development of Regional capacity to contribute to and continue the efforts over a long time period by way of strengthening expertise and designating Regional Reference Laboratories



Aims and Objectives

- **The overall aim of the small Pilot scale study is to provide initial data for developing a one year monitoring programme of BAISDS-2018.**

- **Objectives of Pilot Study**
- Set-up capacity to undertake aerosol sampling with high volume aerosol collectors
- Collection of aerosols and seawater samples over a 2 months period in the year 2017 at 3 to 5 locations in the ROPME Sea Area
- Identification of gaps and needs for larger monitoring programme
- Measurement of total and soluble elements and compounds in the collected aerosol samples
- Measurement of trace elements, nutrients, organic compounds, carbonate chemistry, chlorophyll a and indicators of ecosystem structure in the collected water samples
- Determination of the biological impact of aerosols in selected samples
- Identification of the potential sources and transport pathways of mineral and anthropogenic aerosols in the Region

Expected outcomes

- **Expected outcome from Pilot Study**
- Small and limited dataset on aerosol deposition and impacts on surface water biogeochemistry and biology for parts of the RSA
- Substantial and high quality dataset from collaborative campaigns in RSA region
- Gaps and Risks assessment for BAISDS-2018
- Actions plan to deal with gaps and risks for BAISDS-2018 implementation
-

Aims and Objectives of Monitoring Studies

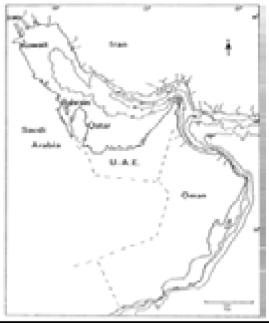
- **The overall aim is to provide essential baseline data for developing an international flagship monitoring programme of aerosol impact on the RSA**
- **Objectives of BAISDS-2018**
- Collection of aerosols over a full seasonal cycle in the year 2018 at locations in the ROPME Sea Area
- Measurement of total and soluble elements and compounds in the collected aerosol samples
- Collection of surface water samples over a full seasonal cycle in the year 2018 at locations in the ROPME Sea Area for chemical and biological measurements
- Determination of the biological impact of aerosols over a full seasonal cycle in 2018-2019 in the ROPME Sea Area
- Determination of the impact of aerosols on the water column carbonate system (ocean acidification) over a full seasonal cycle in 2018-2019 in the ROPME Sea Area
- Quantification of the sources and fluxes of mineral and anthropogenic aerosols in the Region
- Determination of the main processes regulating the distribution, transport and the deposition of mineral and anthropogenic aerosols in the RSA
- Chemical transport modelling to integrate the mineral and anthropogenic aerosol data from observations with information on dispersion, transport and biological uptake

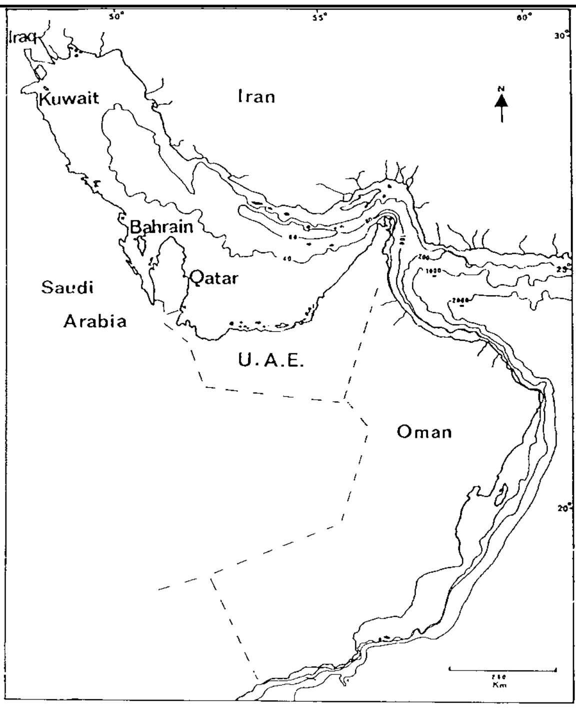
- **The overall aim is to provide essential baseline data for developing an international flagship monitoring programme of aerosol impact on the RSA**
- **Objectives of BAISDS-2018**
- Modelling of trace element and nutrient deposition, constrained by remote sensing of total aerosol deposition rates in combination with ground measurements
- Further development of local physical-biogeochemical ocean model with improved aerosol supply fluxes and biological impact quantification
- Use outcomes of the monitoring programme to assess impact of aerosol deposition on health of the RSA and lobby regional governments to reduce anthropogenic atmospheric emissions in the region
- Promotion and strengthening of the capabilities and readiness of the Member States in the domain aerosol mineral dust monitoring and establishment of biological effects
- Archival and integration of relevant atmospheric and oceanographic information to the BAISDS-2018
- Establishment of Regional and international collaborations on the platform of BAISDS-2018 as a networked capacity for future endeavors
- Designation of Regional Reference Laboratories for the continuation of work emanating from the BAISDS-2018
- Establishment of a regular long-term Regional Monitoring Programme including the networking of National Monitoring Programmes on aerosols

Implementation plan for the Assessment of Impacts of Dust in the marine environment of the RSA

Geographic coverage

The Pilot study will be undertaken at 3-5 sites.
BAISDS-2018 is envisaged to cover the ROPME Sea Area. Aerosol sources from both the Middle East and India and Pakistan are expected to be transported to the RSA, and consequently sampling stations will need to be situated at various strategic sites in the ROPME region





Prioritization of monitoring and research issues

The basic research issue linked to the Pilot study and BAISDS-2018 is:

Background survey

Target elements, compounds, and biological impact assays

The priority set of target elements and compounds aerosol samples :
-Essential elements for microbial organisms (e.g. Fe, Co, N, P, Si)
-Toxic elements and compounds (Cu, PAHs) and elements that may be involved in nuisance bloom development (N, P).

-We will determine mineralogy using XRD and electron microscope (EM) techniques to determine the source of the aerosol.

-We will undertake a quantitative source apportionment of airborne particles and soluble trace elements and nutrients using receptor models.

-We will undertake atmospheric modelling of trace element and nutrient deposition, constrained by remote sensing of total aerosol deposition rates in combination with ground measurements.

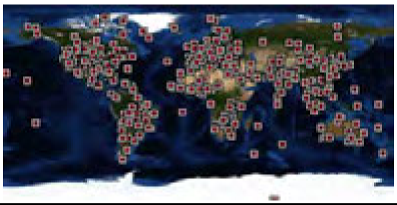
Target elements, compounds, and biological impact assays

We will undertake water sampling to assess the impact of aerosol inputs on chemistry (including carbonate chemistry to assess ocean acidification) and biology.

We will further develop a local physical-biogeochemical ocean model with improved aerosol supply fluxes and biological impact quantification.

Typical anthropogenic gases, such as ozone, NOx and SO_2 are to be determined at selected stations to identify origin of the collected air masses.

LIDAR observations will be performed to support atmospheric modelling. Multispectral (UV to PIR) atmospheric aerosol optical depth (AOD) will be performed using manual photometers in the frame of the Maritime Aerosol Network (MAN) component of AERONET.



Target elements, compounds, and biological impact assays

Elements, compounds, gases and physical measurements	Matrix
Na, Mg, Al, K, Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ag, Cd, Sn, Hg, Pb, U, P, OC/EC, PAHs, molecular tracers	Collected aerosols (total fraction)
Na, Mg, Al, K, Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ag, Cd, Sn, Hg, Pb, U, Cl^-, sulphate, ammonium, nitrate, phosphate, silicic acid, sulphate, DOC	Water soluble aerosol fraction
Al, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ag, Cd, Hg, Pb, U, ammonium, nitrate, phosphate, silicic acid, DOC, dissolved inorganic carbon and total alkalinity	Seawater samples
Ozone, VOCs, NOx and SO_2 at selected stations	Gas phase
Aerosol optical depth (AOD, using manual photometer) & LIDAR	Atmosphere
XRD-EM mineral analysis	Particulate aerosol samples

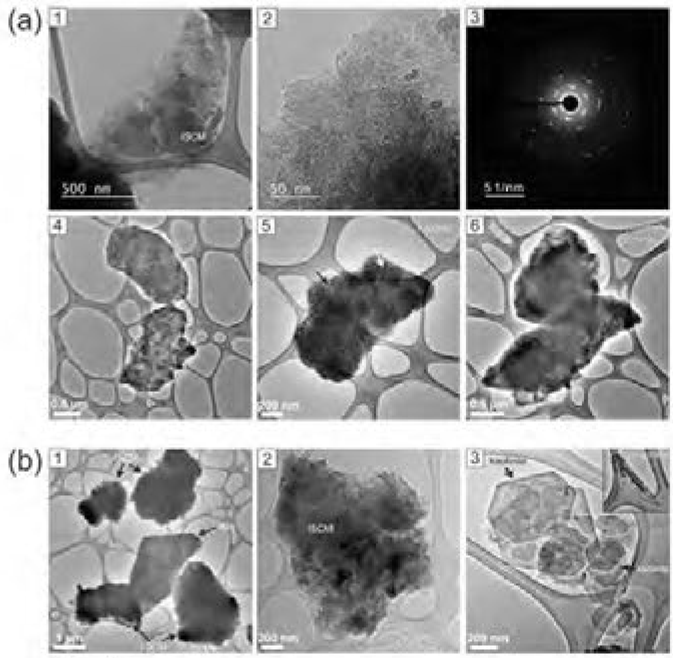
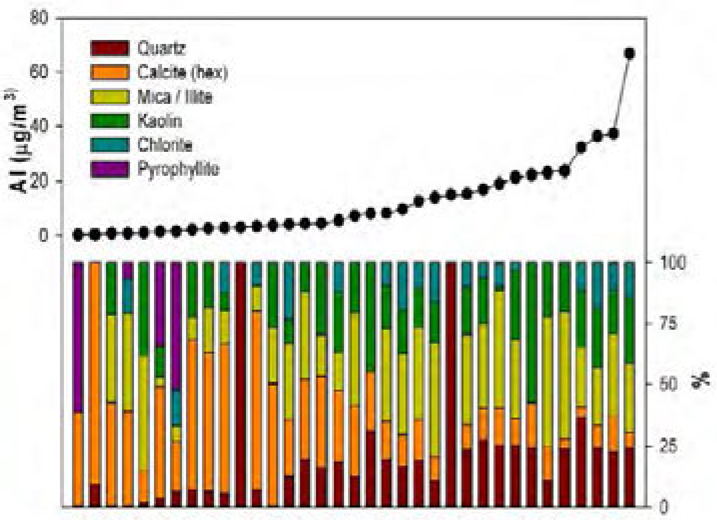

(a)
1
2
3
4
5
6
500 nm
50 nm
5 1/nm
ISCM
(b)
1
2
3
ISCM
200 nm

Fig. 3

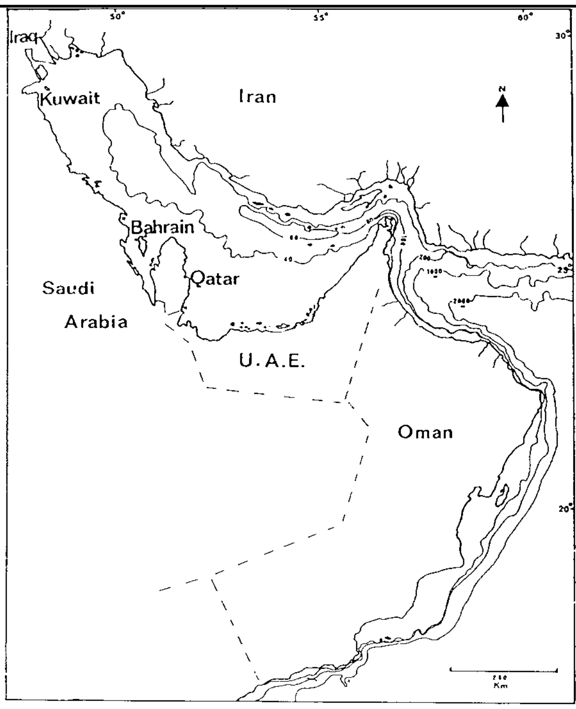

Quartz
Calcite (hex)
Mica / Illite
Kaolin
Chlorite
Pyrophyllite
Al (µg/m³)
80
60
40
20
0
100
75
50
25
0
%

Target elements, compounds, and biological impact assays

Biological Impact	Matrix
Effects of dust deposition on surface water ecosystems (chlorophyll a , photosynthetic efficiency and microbial composition of waters)	Surface seawaters
Dust additions from selected samples to phytoplankton cultures	Seawater phytoplankton culture

Criteria and selection of suitable sampling sites

- **Criteria are required to select the optimum sampling sites, for which the following aspects are to be considered:**
- Sampling must be cost and effort effective
- Process of selection of sampling sites should consider the wind patterns of the Region and represent locations of importance for the various air masses reaching the RSA, and anthropogenic activities (industry, urban areas, shipping). Air mass trajectory modeling experiments and regional air quality data analysis will be conducted to aid with site selection.
- Existing ROPME Reference sites are to be carefully considered to benefit from historical data
- Existing and planned Regional initiatives including surveys should be utilized to undertake Aeolian mineral dust sampling at sea in combination with water column sampling to assess impact of dust deposition. This harmonization will optimize sampling effort and provide important added value to the programme



Sampling Protocol and sample types

- **The standard operating procedure of sampling for aerosols will be:**

Total suspended particle (TSP) collection using high volume aerosol collectors, employing W41 (Whatman 41) filters and also Quartz (Whatman QMA) filters.

- Full digestion will be undertaken on W41 filters for subsequent elemental analyses by ICP-MS The digestion will involve a mixture of HCl, HNO_3 and HF to obtain complete digestion. This approach will be used for selected samples

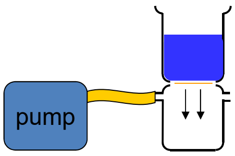
- XRF analyses for total elemental characterization will be undertaken to compliment full digestion and ICP-MS measurements

- A rapid deionized water (e.g. MQ water, Millipore) leach will be undertaken on W41 and QMA filters for subsequent elemental analyses by ICP-MS, and anion analyses by ion chromatography and nutrient analyses by autoanalyser, and DOC analysis, and PAHs using liquid chromatography.

- Mineralogical composition will be conducted on selected samples through X-Ray Diffraction (XRD)/EM analyses. A punch of QMA will be used for organic carbon (OC) and elemental carbon (EC) using a carbon analyser. Half of the QMA filters will be extracted with organic solvent for molecular marker analysis by GC-MS.

Aerosol sampling on Cape Verde

- Low volume aerosol collection system installed at Cape Verde atmospheric observatory (June 2007)

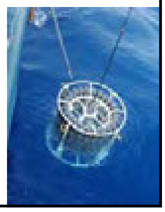


100 ml de-ionised water drawn through filter in ca. 10 s

Sampling Protocol and sample types

- **Water column sampling will be undertaken for**

- Nutrients with subsequent analysis using an nutrient autoanalyser.
- Samples will be collected for organic carbon, organic pollutants, microbial community structure and chlorophyll a analysis.
- Samples will be undertaken for trace elements using specialized trace metal clean techniques. Analysis will be undertaken by ICP-MS following preconcentration and matrix removal.
- Samples will be collected for carbonate chemistry analysis (dissolved inorganic carbon and total alkalinity).
- Temperature and salinity will be determined on-site using calibrated probes.



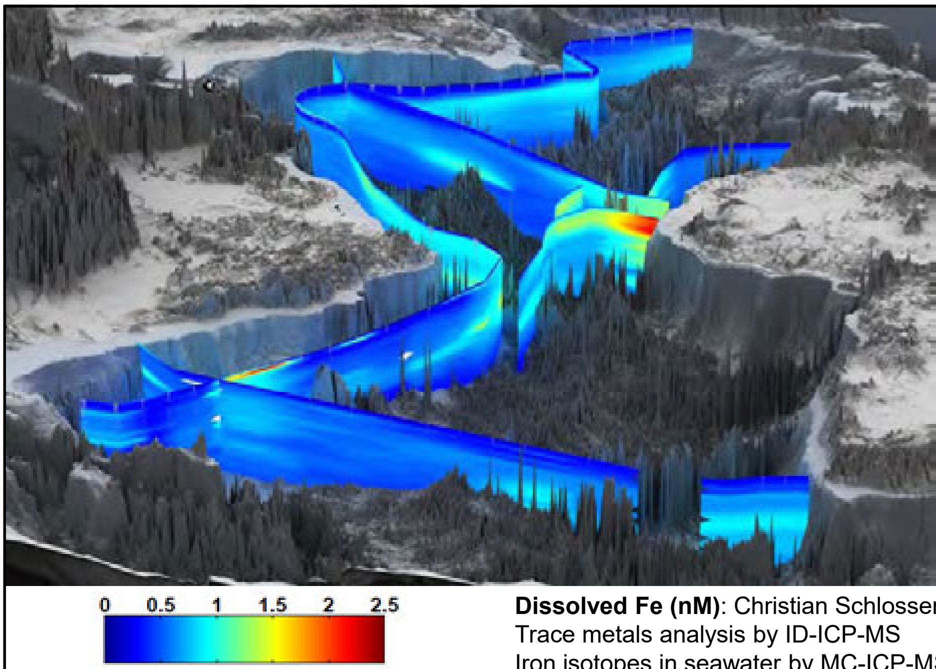
Trace metal sampling of seawaters

- Ti rosette frame with trace metal bottles
- Trace metal clean winch with conducting kevlar rope as CTD wire
- For this project I suggest sampling using clean hose and pump for sampling shallow waters. We will follow GEOTRACES protocols

Laboratory based isotope dilution-inductively coupled plasma-mass spectrometry with Seafast sample prep system

ID-ICP-MS for Ag, Cd, Cu, Fe, Ni, Pb, Zn, Mo, V
ICP-MS for Al, Co and Mn

GEOTRACES



Dissolved Fe (nM): Christian Schlosser
Trace metals analysis by ID-ICP-MS
Iron isotopes in seawater by MC-ICP-MS

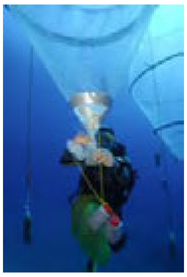
GEOTRACES

Sampling Protocol and sample types

- **Biological impact assessment of aerosols will be undertaken by**
- addition of aerosol sample to phytoplankton cultures during short-term (48 h) incubation experiments, and assessment of changes in biomass (chlorophyll a) and physiological health (Fv/Fm) and community (flow cytometry
- It is possible to undertake larger scale mesocosm experiment

Mesocosm experiments: the DUNE project

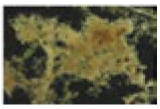
Optical measurements to observe the fate of Saharan dust in seawater



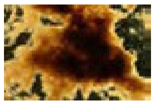
Sediment traps in mesocosms

Optical properties of the sinking particles → size of particles, composition and amount of suspended particles, relative concentration of small to large particles

Control



+ Dust



Increase in the amount of aggregated material and organic matter

Sampling Protocol and sample types; metrology

- For BAISDS-2018 we will adopt the aerosol sampling and elemental analysis protocol from the International GEOTRACES programme (Cutter et al., 2013 and Morton et al., 2013). GEOTRACES reference materials will be used.

- For nutrient and organic analyses we will use standard methods with appropriate certified reference materials (KANSO for nutrients and Hansell for DOC).

- The Scientific Group will prepare clear standard operating procedures for the full range of activities as part of the sampling and analyses activities.

Sampling frequency

- The Pilot study will be run for 2 months in 2017, with continuous sampling
- The BAISDS-2018 is an exercise of establishing a reference for the year 2018-2019 over a period of 12 months.
- BAISDS-2018: A full seasonal cycle will be sampled continuously at the various sampling sites.
- Filters on the high volume pumps will be changed every 2 days. Filters will be frozen to -20C for subsequent analyses.
- Water samples will be collected every month.
- Daily AOD measurements will be undertaken. LIDAR measurements will be undertaken.
- At selected sites continuous gas measurements will be undertaken.

Sampling frequency

- **The sampling process management will be a coordinated operation, requiring cooperation and support of the Member States. The schema is as follows:**
- ROPME will be BAISDS-2018 Coordinator and will receive guidance from the Scientific Group.
- BAISDS-2018 Coordinator will establish a sampling schedule, provide necessary technical support and prepare a Sampling Protocol in cooperation with the Regional Scientific Group and GEOMAR to be made available to the members of the sampling management team

Sample banking

- ROPME shall archive the samples in ROPME-Sample Bank (RSB) under required conditions, pending the dispatch of sub-samples to the central laboratory for analyses.

Sample analysis and responsible laboratories

- One laboratory is designated for the analyses of samples, as this is a baseline assessment. Analysis will additionally conducted in sampling laboratories to built capacity
- For the follow-up monitoring, further laboratories can be selected and involved by conducting proficiency tests.
- In case of force majeure, it may be decided to split the samples for analyses amongst different laboratories in the Region.

Data Management and Reporting

- All data generated from the BAISDS-2018, both concerning Aeolian mineral dust and the ancillary environmental information, will be secured under ROPME copyright as they are produced.
- BAISDS-2018 Coordinator, in consultation with the Scientific Group will validate all the data.

- **The validated data will be managed as per the following schema**:
- Data will be archived in ROPME and GEOMAR Data Library
- Data will be organized into technical report with necessary interpretations, with the help of expert consultants
- Technical report will be published by ROPME for circulation
- Data will be hosted on ROPME Integrated Information System (RIIS)

Training needs

- There is a distinct opportunity for capacity development in the Region for both the participation in BAISDS-2018 and to carry out the follow-up activities. As such, the training needs are for:

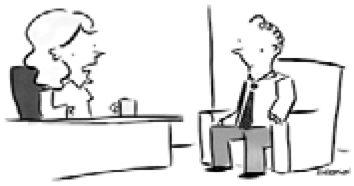
- Effective sampling , sample preservation and analyses
  – A training course demonstrating the relevant procedures for sampling and aerosol analyses is planned with the cooperation of GEOMAR for National experts expected to participate in BAISDS-2018.

  → train the trainers', expecting a cascading effect in the Member States.

  GEOMAR is to provide the training programme along with the needs and requirements for this training course, so as to help in preparations

Training needs

- Successful sampling and analyses of samples
  - The designated Regional Reference Laboratory will have the responsibility to train the scientists of the Region periodically to carry out the sampling and analyses of aerosols
- Data management
- ROPME in cooperation with IOC and GEOMAR and on the platform of RIIS will conduct training programmes on general marine data management as applicable to the Region, from time to time



"OK, I've shown you the ropes, given you the low down, and gotten you up to speed. All that's left is actually training you."

Linkages with other ROPME activities

- Effective linkages/harmonization will be established for BAISDS-2018 with the following ROPME activities:
- Oceanographic cruises
- Preparation of the State of the Marine Environment Report (SOMER)
- RIIS

Integration with other National and Regional Programmes

- It is expected that the Member States will offer an opportunity to integrate with their existing and planned national programmes of relevance in order to make BAISDS-2018 cost and effort effective.
- Voluntary sharing of responsibilities in the aerosol dust sampling programme is one important primary step.
-
- ROPME shall explore the possibility of involving Regional and International programmes of UNEP.
- A link to UNEP-ROWA will be important in order to link aeolian mineral dust impacts on rain events on the Indian sub-continent, and the effects of west Asian pollution aerosols on the health of the RSA.

Indicative Time Plan

- Finalization of Draft Scientific Programme: early 2016
- Meeting of the Ad-hoc Committee to finalize a detailed Scientific Programme with the identification of sampling team, players and Protocol of sampling – September 2016
- Designation of responsible Laboratories for conducting Aeolian mineral dust and seawater pilot study sampling – September 2016
- 4 days Training on sampling and sample preparations: February 2017
- Contribution to ROPME cruise programme
- Start of sampling for pilot study: Nov 2017 for a period of 2 months
- Completion of sample analyses of samples and reporting for pilot study: July 2018
- Start of BAISDS-2017: Nov 2018 for a 12 months period
- Completion of analyses of samples and reporting for BAISDS-2018: January 2020

ANNEX VII

STATEMENT OF THE MINISTRY OF CLIMATE CHANGE AND ENVIRONMENT, UAE

UNITED ARAB EMIRATES
MINISTRY OF ENVIRONMENT & WATER

كلمة ممثل
وزارة البيئة و المياه

الورشة الفنية الإقليمية الاقليمي حول تقييم آثار الغبار و العواصف الرملية على البيئة البحرية لمنطقة بحر روبمي

11 - 12 أكتوبر 2015- دبي

بسم الله الرحمن الرحيم

السيدات و السادة الكرام،،

السلام عليكم و رحمة الله و بركاته،،

يسرني أن أرحب بكم جميعا في بلدكم الثاني الامارات العربية المتحدة في افتتاح الورشة الفنية الإقليمية حول تقييم آثار الغبار و العواصف الرملية على البيئة البحرية لمنطقتنا، كما أغتنم هذه الفرصة لتجديد شكري و تقديري إلى الأخوة في الأمانة العامة للمنظمة الإقليمية لحماية البيئة البحرية لجهودهم و حرصهم الدائم على تنفيذ التوصيات و البرامج و الأنشطة الصادرة عن الاجتماع السادس عشر للمجلس الوزاري للمنظمة، و التي من ضمنها عقد هذه الورشة التي تهدف إلى تقييم آثار الغبار و العواصف الرملية على البيئة البحرية لمنطقة بحر روبمي .

السيدات و السادة الكرام،،

انها لمن المناسبات القليلة التي يتم تناول هذا الموضوع في المنطقة، حيث دائما ما يكون التركيز على مختلف الآثار الأخرى للعواصف الرملية من صحية و اقتصادية و اجتماعية و إعاقة لحركة النقل البري و البحري و هذا رغم ما قد ثبت في مناطق أخرى من العالم أن هذه العواصف الرملية لها الكثير من الآثار الضارة على البيئة البحرية و انتاجيتها و جودة مياهها. كما لم يسبق تقييم هذه الآثار على بيئتنا البحرية رغم تواجد منطقتنا وسط بؤرة العواصف الغبارية و ما تستقبله هذه البيئة من كميات هائلة من الغبار. و تصنف العواصف في المنطقة إلى ثلاث فئات رئيسية الأولى هي الغبار المتطاير حيث تكون الرؤية الأفقية أقل من 11كيلومترا و تستمر وقتا أطول نسبيا يتراوح بين 3 و 4 أيام، الفئة الثانية فهي العاصفة الغبارية حيث تكون الرؤية الأفقية أقل من كيلومتر و لا تدوم أكثر من يومين إلى ثلاثة أيام محملة بكميات كبيرة من الغبار، أما الفئة الثالثة فهي

العاصفة الغبارية الشديدة حيث تكون الرؤية الأفقية أقل من 200 متر، و تدوم ساعات قليلة غالبا و تمطر كميات كبيرة جدا من الغبار و تصحبها عادة رياح موسمية عاتية.

السيدات و السادة الكرام،

من أهم الآثار السلبية للعواصف الغبارية على البيئة البحرية نقلها للملوثات العالقة في الغبار من مواد عضوية وهي مواد ذات قدرة منخفضة على الذوبان في الماء و قدرة عالية على التنقل لمسافات بعيدة على شكل جزئيات غازية و المبيدات الزراعية من أهم هذه الملوثات. و إلى جانب تأثيرها على النظم الإيكولوجية البحرية الحساسة مثل الشعاب المرجانية عبر نقلها للكائنات الدقيقة التي تترسب فوقها مخفضة بذلك توافر أشعة الشمس اللازمة للتحليل الضوئي الذي تقوم به الطحالب الأساسية المرافقة للشعاب يوفر الغبار المتراكم فوق البحر بيئة ملائمة لاستفحال الانتشار الطحلبي الضار

السيدات و السادة الكرام،،

إن الحد من مخاطر العواصف الغبارية و تقييم آثارها على البيئة البحرية هو تحد معاصر للمنطقة يحتاج إلى تكاتف الجهود و تطوير برامج و خطط وطنية و إقليمية للتقييم المستمر لآثارها السلبية و ماهذه الورشة إلا ترجمة لإرادة و وعي إقليمي بأهمية هذا التحدي الذي نطمح أن تكون أولى الخطوات نحو ارساء برنامج رصد و مراقبة اقليمي شامل للبيئة البحرية لمنطقة بحر روبمي

السيدات و السادة الكرام،،

ختاما أود التأكيد على أن هذه الورشة تمثل فرصة هامة لنا جميعا لاستعراض الجوانب العامة المتعلقة بالعواصف الغبارية و آثارها على البيئة البحرية ، كما أتقدم لكم مجددا بالشكر والتقدير على حضوركم، و أتمنى أن تحقق هذه الورشة أهدافها المنشودة من خلال إثراء المناقشات وتبادل الحوار البناء.

وفقنا الله و إياكم، و السلام عليكم و رحمة الله و بركاته.