20 & 21 October 2014
Athens, Greece

2nd South-Eastern Europe GEO Workshop on Integrating Earth Observation Data and Services for monitoring the Environment, protecting the citizens and stimulating the regional economic growth

Novel Infrastructure and Data Collection Facility at the Space and Remote Sensing Lab, SAUDI ARABIA

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BEYOND

Greek GEO Office

MARIOLOPOULOS-KANAGINIS FOUNDATION FOR THE ENVIRONMENTAL SCIENCES

European Commission

GEO GROUP ON EARTH OBSERVATIONS

Outline

- King Fahd University of Petroleum & Minerals (KFUPM), Saudi Arabia
- High Performance Computing Center at the KFUPM
- Center for Clean Water and Clean Energy at the KFUPM and the MIT
- The Center for Energy and Geo Processing at the KFUPM and Georgia Tech.
- Dhahran Techno Valley.
- Funding research activities in Saudi Arabia.
- Aerosols in the Arabian Peninsula
- Air quality at the Arabian Peninsula
- Dust storms over the Arabian Peninsula
- Space & Remote Sensing Lab
- 2.4m X-L band EOS-DB reception antenna system
- Particulate matter detectors
- Conclusion

King Fahd University of Petroleum & Minerals (**KFUPM**)

KFUPM is
a public university located at the city of Dhahran, Saudi Arabia with an enrollment of approximately 10,000 students.

The university has state of the art experimental research facilities

Research at the university can be classified into personal, sponsored, and client funded. **KFUPM** researchers serve the nation as professional problem solver in Energy, Water, Pollution, Health, Weather, communications, oil and gas industry.

High Performance Computing Center

- The center for HPC at the KFUPM houses a high-end IBM e1350 e-Server with 128 compute nodes.

- Each compute node is dual processor with each processor being a quad-core totaling a massive 1024-core cluster system.

- The HPC offers a variety of applications and codes that are installed on the cluster.

High Performance Computing Center

- The cluster is unique in its dual-boot capability with Microsoft Windows HPC Server 2008 and Red Hat Enterprise Linux 5 operating systems.
- It has 3 master nodes, one for Red Hat Linux, one for Windows HPC Server 2008 and one for cluster management.
- It has 128 compute nodes. Each compute node of the cluster is dual-processor having two 2.0 GHz x3550 Xeon Quad-core E5405 processors.

Master Nodes

- Number of nodes – 3 nodes
- Processors: Xeon E5405 Quad-Core, 2.0 GHz (Dual-processor)
- Memory: 45 GB RAM on each node.

Computing Nodes

- Number of nodes – 128 nodes
- Processors: x3550 Xeon Quad-Core, 2.0 GHz (Dual-processor).
- Number of cores – 1024 cores
- Memory: 4 GB RAM on each node.

Interconnect

- 10GB Ethernet GBASE-SR.

Operating Systems for Computing nodes (Dual Boot)

- Windows HPC Server 2008 and Red Hat Linux 5.2.

Center for Clean Water and Clean Energy

- Technologies related to the production of fresh water and low-carbon energy are the focus of a research and educational partnership between the MIT and KFUPM.

- The center includes projects on issues such as desalination, solar energy, and advanced manufacturing.

- The eight year collaboration includes more than a dozen large-scale research projects and a number of education and curriculum development projects.

Center research efforts

Technologies for Carbon Capture

Design and manufacturing of solar power systems and desalination systems

Remediation of water from oil and gas production

The Center for Energy and Geo Processing

- The Center for Energy and Geo Processing (CeGP) is a partnership between **Georgia Institute of Technology** and the (**KFUPM**).

- The collaboration focuses on research in the areas of signal processing, seismic data processing, and applying modern signal processing to energy-related data.

- In addition, the Center focuses on education projects that lead to developing curriculum and new learning methodologies.

Dhahran Techno Valley

- To set the stage for the ecosystem innovation and entrepreneurship activities to be effective, KFUPM developed a system and set of processes for advancing the outcomes of the university fundamental and basic research activities.

- KFUPM system for innovation, entrepreneurship and technology enterprising is comprised of: a university sector for Technology Transfer, Innovation and Entrepreneurship (TTIE) and a subsidiary wholly owned by KFUPM known as Dhahran Techno-Valley Company (DTVC).

- The TTIE includes: Innovation Center, Entrepreneurship Institute, Technology Advancement and Prototyping Center and an Industry-Liaison Office.

- DTVC provides the expertise to lead and manage early stage concepts through to commercial products and services.
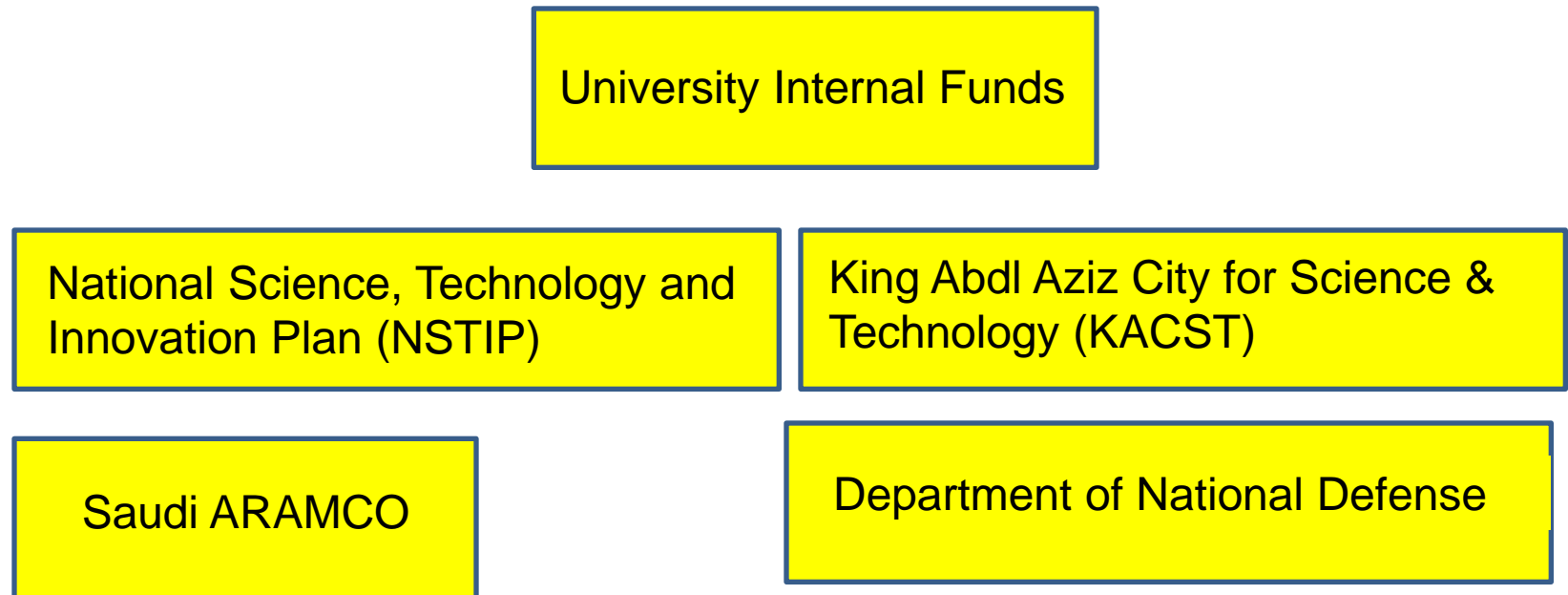
AERONET stations

- Since 1995, the King Abdulaziz City for Science and Technology (KACST) and the National Renewable Energy Laboratory (NREL) have co-operated to establish a network of high quality solar radiation monitoring installations across the Kingdom of Saudi Arabia.

- **Solar Village**: A CIMEL 8 channel sunphotometer for measuring aerosol optical depth at 6 wavelengths and total column water has been deployed at the Solar Village station since February 24, 1999. Near real time and historical data are available at http://www.cimel.fr/photo/sunph_us.htm

- **KAUST:** King Abuallah University for Science & Technology (KAUST), Jeddah, Saudi Arabia

King Fahd University of Petroleum & Minerals (**KFUPM**)

The **KFUPM** is highly reputable institute in Saudi Arabia and at the middle east. Research activities at the KFUPM is funded by governmental funds as:

University Internal Funds

National Science, Technology and Innovation Plan (NSTIP)

King Abdl Aziz City for Science & Technology (KACST)

Saudi ARAMCO

Department of National Defense

Arabian Peninsula

- **Arabian Peninsula (AP)** is located in the SW Asia and connects Asia with Africa.
- It is located in the sub-tropical belt between 12°N - 35°N and 30°W - 60°W.
- The main feature of its climate is arid/semiarid nature.
- Sand storms can occur throughout the year in the AP, but occasionally occur during May - October during hot weather. Storms can last for hours or days and cover small areas in one country or pass across countries in the AP.

- Lack of rainfall and warm temperature during winter months set up conditions for spring sand storms by drying out the soil, producing aerosols and fine particles easily swept by the wind.

Aerosols in the Arabian Peninsula …

- Aerosols play a significant role in changing a climate in the AP by means of modifications of the radiation field.
- They can change the temperature of the surface and between the atmospheric layers.
- Air quality in the AP may be negatively affected by naturally occurring contributions including dust originating from desert regions and by anthropogenic emissions from rapidly growing number of vehicles, excessive construction activities, volatile organic compounds (VOC) released by blooms in coastal waters, and ships travelling in the Arabian Gulf.

Climate at the Arabian Peninsula

1- Saudi Arabia
2- United Arab
3- Emirates
3- Kuwait
4- Qatar
5- Bahrain
6- Oman
7- Yemen

- Information concerning climate in the AP is still limited and not complete.
- Lack of water resources, high summer temperature and the desert environment established one of the harshest climatological conditions on the earth.
- The AP includes a broad climatic spectrum that includes snow in Asir, Saudi Arabia to extreme heat at Rub Al Khali desert.

Aerosols in the Arabian Peninsula …

- Composition, density, and size distribution of the AP aerosol particles temporarily and spatially vary based on natural and anthropogenic events.
- Processes of aerosols production are dominated by:
  - frequently blowing dust storms on the AP,
  - sulfate aerosols created by the growing oil industry,
  - topology near Red Sea Mountains,
  - long-range transport of continental air
- The AP is also surrounded with three major water bodies which affect the sulfur cycle:
  - Arabian Sea,
  - Red Sea
  - Arabian Gulf (AG),.
- Therefore, understanding of aerosol properties at the AP over both land and water environment is important because of the rapid growth of anthropogenic activates.

Air quality at the Arabian Peninsula

- Air quality over the AP have received significant attention during the past 15 years for *unprecedented economic growth, booming in oil and gas industry but studies available are still far from complete*.

- Burning of **Kuwait** oil fields during the 1991 Gulf war resulted in a large environmental impact on the Arabian Gulf Area.

Fig. Black smoke over Kuwait City in April 1991 five weeks after oil fires was set. Credit NASA Earth Observatory. www.earthobservatory.nasa.gov.

Dust storms over the Arabian Peninsula

- The AP is one of the major terrestrial sources of airborne dust.
- It is the home of the Empty Quarter or Rub' al Khali desert that contains half as much sand as the entire Sahara Desert.
- The Rub' al Khali extends over portions of KSA, UAE, Oman, and Yemen.
- The arid environment makes the AP frequently exposed to major dust storms (annually/seasonally).
- Dust storms help the transfer of aerosols, particulates, and pollutants from one part to another across the peninsula.

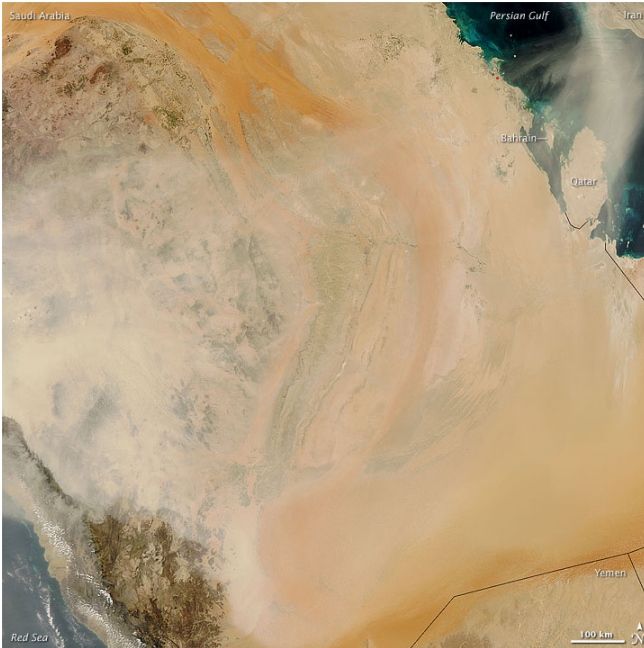# Dust storms over the Arabian Peninsula

Fig. Dust storm blew on March 11, 2009. Credit NASA Earth Observatory.
www.earthobservatory.nasa.gov.

- Major dust storms on the AP blew during Jan – May especially during the spring season.

- As dust storms usually arrive suddenly, citizens should be educated with safety of dust storms especially with those drives on highway.

- Especially young children should avoid the direct exposure of sand storms as sandstorms can carry heavy metals and toxic substances including sulfur, lead, and mercury.

Current Collaborators with the Space & Remote Sensing Lab (**KFUPM**)

On 2013, the Space & Remote Sensing lab was established at the KFUPM to study aerosols and air quality over the Arabian Peninsula.

The Space & Remote Sensing Lab at the KFUPM currently collaborate with researchers from the following institutes:

- King Abdl Aziz City for Science & Technology (KACST), Saudi Arabia
- Jet Propulsion Laboratory (JPL), California Institute of Technology, United States.
- Chapman University, United States

2.4m X-L band EOS-DB reception antenna system

- The antenna will ingest and process:
- MODIS data to level 0 from Terra and Aqua,
- VIRS data from NPP and JPSS1 when satellites are available,
- EPS to level 0 from MetOp,
- NOAA POES satellites,
- CHRPT to level 0 from FY1D.

The antenna will be installed and functioning early 2015.

Particulate matter detectors

The Thermo ScientificTM Model
5030*i* SHARP Synchronized
Hybrid Ambient Real-time
Particulate Monitor. for
continuous PM-10 and PM-
2.5 measurement.

Study of Aerosols' Characteristics and Dynamics over the Kingdom of Saudi Arabia using a Multi Sensor Approach Combined with Ground Observations

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Abstract

This study presents a detailed climatological analysis of the optical and microphysical aerosol properties over four regions of Saudi Arabia using satellite and ground stations data including MODIS/Terra and Aqua, OMI, MISR/Terra, AERONET and CALIPSO for the period April 2003 – January 2013. The study includes cities in the North Western, Western, Eastern provinces of Saudi Arabia and in the Rub' al Khali desert or Empty Quarter. The study discusses

Under preparation

Air Pollution in Arabian Peninsula (Saudi Arabia, United Arab Emirates, Kuwait, Qatar, Bahrain, and Oman): Causes and Effects

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Abstract

Pollution sources over six oil rich countries in the Arabian Peninsula (AP) including Kingdom of
Saudi Arabia (KSA), United Arab Emirates (UAE), Kuwait, Qatar, Bahrain, and Oman have
been reviewed. Unpretending infrastructure activities, overusing governmental subsidized
energy, water desalination, heavy traffic in large cities, and cement plants are found to be the
main reasons for $PM_{2.5}$ and PM_{10} particulate emissions, the emissions of greenhouse gases
(GHG), nitrogen dioxide and sulfur dioxide. On 2010, Qatar recorded the highest CO_2 emission

EGU 2014

Geophysical Research Abstracts
Vol. 16, EGU2014-2104, 2014
EGU General Assembly 2014
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Aerosols and water vapor dynamics over the Kingdom of Saudi Arabia

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The Kingdom of Saudi Arabia contains a vast desert area and the home of some of the largest deserts worldwide. This nature subjects the area to numerous dust storms. This is in addition to local emissions transported from industrial activities. The Arabian Peninsula dust storms have a major impact on air quality and affects dust cycle around the world. The nature of dust also affects air, ground traffics, and human health. Aerosols play a pivotal role in global climate change through their effects on the hydrological cycle and solar energy budget. Recently there have been some trials to study the nature of dust over the kingdom using satellite remote sensing and modeling to investigate the impact of aerosols of natural and anthropogenic origins from both local emissions and long-range transport on the air quality and atmospheric composition, yet a lot more needs to be done. In this study, data obtained from the Moderate Resolution Imaging Spectroradiometer (MODIS) on board of Terra and Aqua satellites are used to analyze aerosols properties over the thirteen provinces of the Kingdom of Saudi Arabia from April 2003 to January 2012. This analysis will help to characterize aerosol and cloud properties, and the seasonal hydrological factors to establish the relative contributions of aerosols derived from different regions to the different Saudi provinces and their impacts on local atmospheric composition and air quality. During this period, we have

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Analysis of Aerosols Climatology over Saudi Provinces Based on Satellites and Ground Stations Data

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Abstract:
The Kingdom of Saudi Arabia is one of the major sources of aerosols in the world, including natural and anthropogenic components. This study presents a detailed climatological analysis of the optical, microphysical aerosol properties and absorption aerosol characteristics over four different regions of the Kingdom of Saudi Arabia using satellite and ground stations data including MODIS/Terra and Aqua, OMI, MISR/Terra, AERONET and CALIPSO for the period April 2003 – January 2013. Analysis shows an increase in the aerosol concentration during March 2009 which could be attributed to a Major dust storm during that time. Comparing the AOD time series over regions 1-3 and region 4 (desert) we observe monthly and annual variability with no recurrence pattern over the years. The results also show minimum precipitation rates during the summer and maximum during the winter over region 3. The Aqua deep blue AOD550 data over region 4 shows a single peak pattern that occurs during the spring season around the dust season. Aeronet observations at 440 nm show maxima of 0.71 in July and a minimum of 0.27 in March from MASDAR and maxima of 0.08 in November and a minimum of 0.05 in August from Solar Village. The non-spherical particles are significantly higher in the spring than the rest of the year based on MISR data. The AOD of non-spherical particles reaches a maximum in June with a value of ~ 0.3517±0.01. The maximum of the spherical fraction AOD occurs in July with a value of ~ 0.4867±0.01.
Acknowledgment

Conclusion

1- Information concerning climate in the AP is still limited and not complete.

2- Unprecedented infrastructure work, economic growth, booming in oil and gas industry are major factors contributing to aerosols and air pollution at the Arabian Peninsula.

3- The Space & Remote Sensing Lab is a new facility established at the King Fahd University of Petroleum & Minerals (KFUPM) to study aerosols, dust and climate at the Arabian Peninsula.