Regional Climate Downscaling for Middle East, Red Sea, and Arabian Peninsula

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Objectives:

• Addresses important environmental issues in the region

• Provide a scientific bases for environmental policy and decision making

• Assesses Impact on Natural Systems

• Predicts Natural and Anthropogenic Hazards: Dust storms, Extreme Precipitation, Floods

• Air-land interaction, dune motion, dust mobilization

• Aerosol-cloud interaction and precipitation engineering

• Climate impact on the Red Sea physical and biological systems
TOOL #1: Global Fine-Resolution GCM

Surface air temperature and 850 mb wind from 25-km global run
TOOL #2: Regional Non-hydrostatic Model with the same physics
TOOL #3: WRF-Chem

IBM BG/P, 64000 cores
222 TFLOP

Resolution: 5100x4350x35

Time step: 6 s

Run takes about 7 h for 1 day simulation

We used hybrid computational mod on all 64000 cores
Temperature (K) at 500 hPa daily average for day 30

- Standard-NCEP
- GridNudging (SGN)-NCEP
- SpectralNudging (SPN) - NCEP
- ReinitializeGridNudging (RGN) - NCEP
Temperature (K) at 850 hPa daily average for day 30
Genin et al. (1995) found coral death in the Red Sea in the winter following the Pinatubo eruption.

Cooling induced mixing, bringing nutrients which produced an algae bloom, which smothered the coral.

a. Dec. 15, 1994 (normal)
b. April 6, 1992 (after Pinatubo)
Climate: 2m annual temp trend (K/dec)

annual: trends (K/10y) in 2m temp/NCEP: 1983-2009

annual: trends (K/10y) in 2m temp/ECMWF 1983-2002

annual: trends (K/10y) in 2m temp/GFDL 1983-2008

annual: trends (K/10y) in 2m temp/OBS 1983-2009
The Intertropical Convergence Front (ITF) is defined and the interface between Saharan and tropical air masses, here is diagnosed as the latitude of the maximum meridional temperature gradient:

\[ \text{ITF} = \frac{\sum \text{lat} \ (dT/dy)}{\sum (dT/dy)} \]

where \( T \) is temperature at 2m or 850 hPa.
Cloudiness and Solar Radiation Anomaly

**jja total cloudiness (%/10a)**

**jja surf down shortwave flux (W/m^2/10a)**
Trans-boundary pollution transport and urbanization effect on air-quality
Dust Storm Front Affecting the Saudi capital of Riyadh, Saudi Arabia, Tuesday, March 10, 2009
Robotic Sun-photometer
For measuring dust concentration
And ocean color
Solar Roof Top Installation 2MW PV
Water resources

Rainfall and flood prediction

Fog formation

Boundary layer structure

Meteorological extremes
Kaust Flash Flood Risk Assessment

Flood Risk

Kaust Watershed
Current strength:

**Prof. Georgiy Stenchikov:** Atmospheric Modeling, Climate modeling
Dr. Matteo Zampieri, Dr. Rachid Abida, Dr. Stoitchko Kaleederski, Dr. Anthony Lock, Dr. Basit Khan, Dr. Jish Prakash

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Cooperation:

*Internal:*
AMCS on computational studies of atmosphere-land interaction
WDRC on flood simulation

*External:*
Oxford (OCCAM) – on dune motion, joint postdoc
NCAR – Desert Meteorology, Cloud modeling
NASA – Aerosol Observations, Ocean Color Observations
DLR – Aerosol and Boundary Layer Observations
NOAA/GFDL – Climate Modeling
UT Austin – Dust Storms
Princeton University – Boundary layer Modeling
Decadal trend patterns in seasonal cycle amplitude (JJA-DJF).