Characterizing Atmospheric Particulate Matters in Tehran by Use of LiDAR, Atmospheric Models and Satellite Data

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Physics Department Remote Sensing Laboratory (PDRSL)

1-1 Stations
1-2 Objectives

- Monitoring APM in Northwest and central parts of Iran.
- Determining APM’S sources that are affecting the Iran Plateau.
- Studying the APM’S annual behavior.
- Specifying the physical and optical properties of APM as well as their dominant type in this region.
PDRSL

2-3 Methods

- GBM
- AQCC (PM, NO₂)
- HYSPLITE (BT, FT)
- SATELLITE DATA (CALIPSO, MODIS, OMI)
- WYOMING DATA (PT, PRESSURE, RELH, HV)
- NMMB/BSC-Dust Forecast
Lidar and Atmosphere

2-1 Remote Sensing Techniques
EBDL

**lidar equation**

\[ P(R) = K \, G(R) \, \beta(R) \, T(R) \]

\[ \beta(R) = \beta_{aer}(R, \lambda) + \beta_{mol}(R, \lambda) \]

\[ T(R) = \exp\left[ -2 \int_0^R \alpha(r, \lambda)dr \right] \]

\[ \alpha(R, \lambda) = \alpha_{mol, abs}(R, \lambda) + \alpha_{mol, sca}(R, \lambda) + \alpha_{aer, abs}(R, \lambda) + \alpha_{aer, sca}(R, \lambda) \]
\[ P(R) = P_0 \frac{c \tau}{2} \frac{O(R)}{R^2} A \eta \left[ \beta_{aer}(R, \lambda) + \beta_{mol}(R, \lambda) \right] \exp \left[ -2 \int_0^R \left[ \alpha_{aer}(r, \lambda) + \alpha_{mol}(r, \lambda) \right] dr \right] \]

Known quantity: \( \beta_{mol}(R, \lambda), \alpha_{mol}(r, \lambda) \)
Unknown quantity: \( \beta_{aer}(R, \lambda), \alpha_{aer}(r, \lambda) \)
**Lidar and Atmosphere**

### Aerosol Types

**Aerosol Intensive Variables**
- Lidar Ratio
- Depolarization Ratio
- Backscattered color ratio
- Spectral depolarization Ratio

2 Lidar and Atmosphere

1-2 Aerosol Types

4 Case Studies

Tehran

- Population (2015) ~ 12 millions
- Area: 22 km North-South, 35 km East-West
- Elevation: 1,200 to 1,900 m
- Moving Vehicles ~ 3 millions
- Gas consumption: 11.5 MLi/day
4 Case Studies

Unhealthy

Moderate

2.5
2
1.5
1
0.5
0

m/s

0.1
0.2
0.3
Dust Event
29 May 2015
(PM$_{10}$: 133, PM$_{2.5}$: 134, NO$_2$: 56)

Depolarization signals @ 532 nm

Case Studies
Case Studies

MODIS Deep Blue AOD map, May 27, 2015
Case Studies

MODIS Deep Blue AOD map, May 29, 2015
Case Studies

NMMB/BSC-Dust Dust Surface Conc. (μg/m³)
42h forecast for 06UTC 29 May 2015

http://www.bsc.es/projects/earthscience/NMMB-BSC-DUST/
Case Studies

Dust event 19 Jul 2015

(\(\text{PM}_{10}: 185\), \(\text{PM}_{2.5}: 161\), \(\text{NO}_2: 54\))
NOAA HYSPLIT MODEL
Backward trajectories ending at 1600 UTC 19 Jul 15
GDAS Meteorological Data

Job ID: 192740
Job Start: Sun Oct 18 09:10:35 UTC 2015
Source lat.: 35.766900 Ion.: 51.311800 hghts: 1500, 1000, 500 m AGL
Trajectory Direction: Backward
Duration: 72 hrs
Vertical Motion Calculation Method: Model Vertical Velocity
Meteorology: 00002 15 Jul 2015 - GDAS1
NMME/BSC-Dust Dust Surface Conc. (μg/m³)
48h forecast for 12UTC 19 Jul 2015

http://www.bsc.es/projects/earthscience/NMME-BSC-DUST/
5 Conclusion

Sources of the events
Conclusion

Temporal variations of dust and pollution outbreaks

Monthly average values of PM$_{10}$ and PM$_{2.5}$
Oct 2011 to Sept 2015, ref: AQCC
Conclusion

- Iran plateau is located on the Earth dust belt and surrounded by intense dust sources.

- Both dust and anthropogenic particles are contaminating the Tehran atmosphere.

- Most polluted days with anthropogenic aerosols are in winter times due to temperature inversions and low wind speed (< 3m/s).

- Most of the dust events are happening in late spring and summer times.
Gracias