PM_{10} and visibility in Tel-Aviv as affected by meteorological conditions and atmospheric circulation types

Ilan Levy and Uri Dayan

Department of Geography
The Hebrew University of Jerusalem

Background

- Visibility impairment: light scattering and absorption of aerosols
- Aerosols concentration:
  - meteorological conditions
  - emission source strength
- PM_{10} and Visibility outcome of:
  - weather pattern circulation
  - air mass history.
- Atmospheric visibility as surrogate for optical air quality (smaller fraction)
- Impacts of aerosol on human health in Tel Aviv (USEPA/Isr. MoE, 2003)

Aim of this study

Examine the dependence of PM_{10} and visual range on:

- Seasonal meteorological conditions
- Synoptic weather patterns
- Sectorial source regions

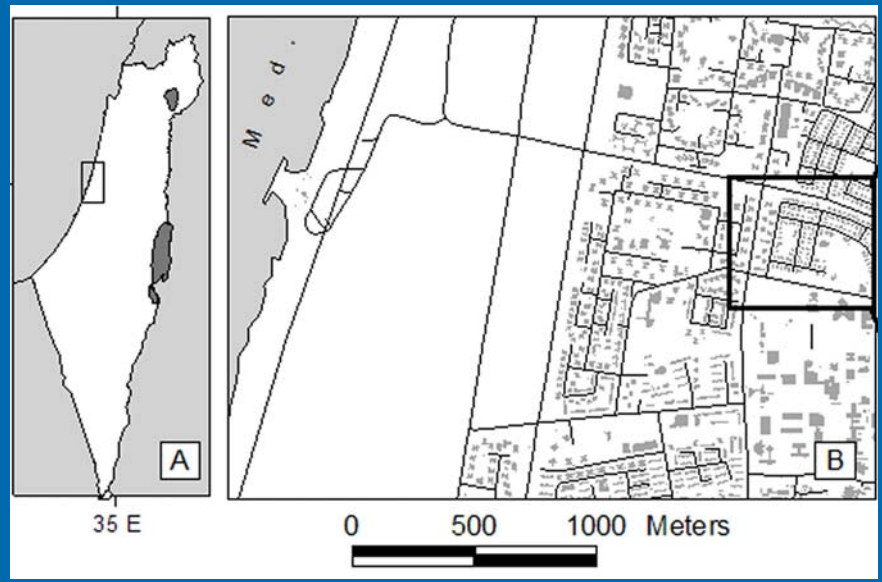
General settings: Tel Aviv Metropolitan Area

- Population: ~1 Million
- Climate: Predominance of STH (High temp. and Solar radiation)
- Aerosol sources: photochemical haze, sea-salt, mineral dust

The sampling site – Yad Avner

- Residential area
- 2.5 km from shoreline
- 250m from paved road
- 16m AGL

⇓



Site represents urban background dust concentrations, minimal local contamination

Confirmation: 3 yrs mean PM_{10} concentrations of night time (55 µgr m^{-3}) and weekends (52 µgr m^{-3}) are very close to all week days (59 µgr m^{-3})

Data & Methodology

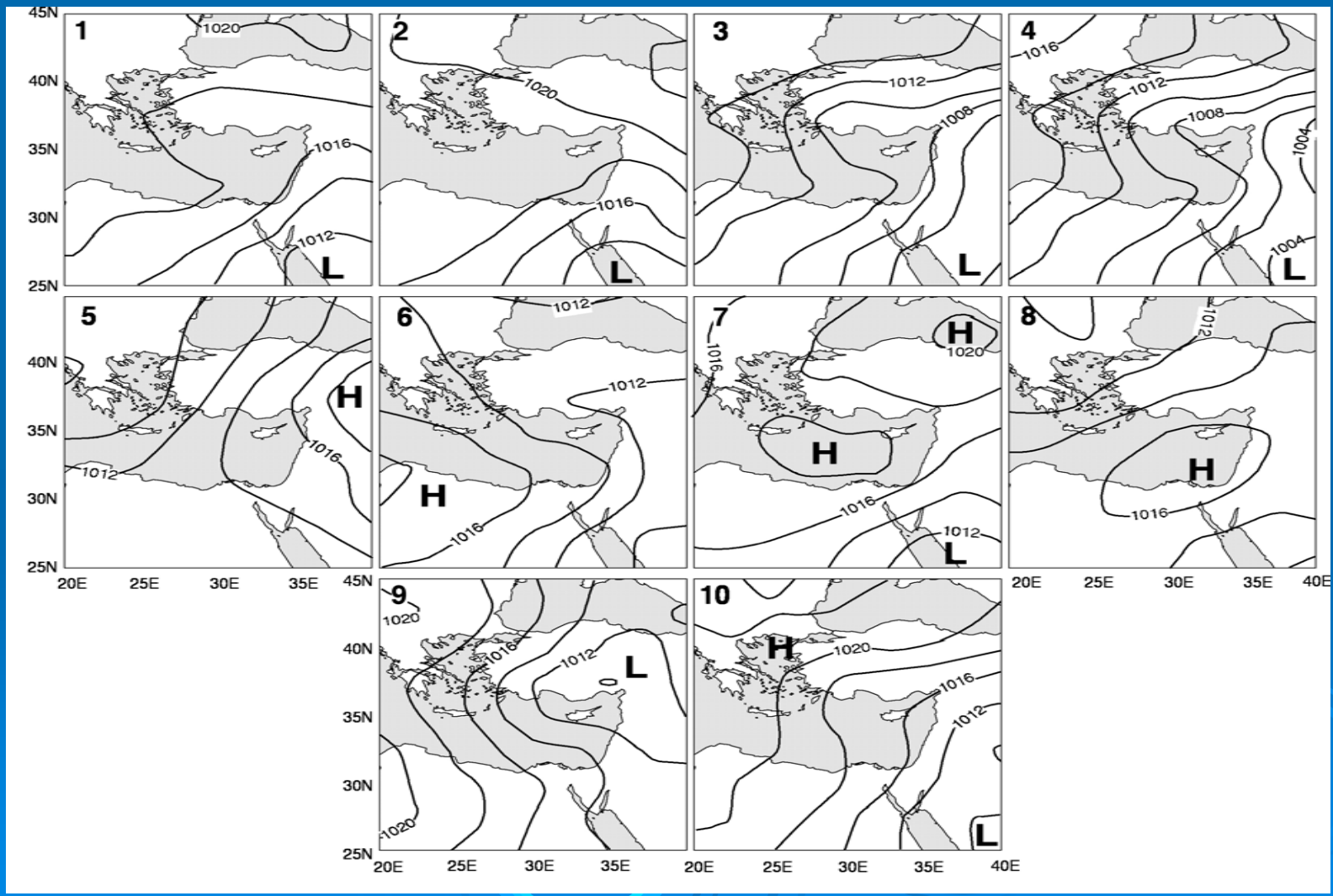
- 3 years (Feb 2000 – Nov 2002)
- 30min avg.: PM_{10}, visual range, meteo. data
- Visual range:
  - Handar 470.
  - Forward scatter visibility sensor.
  - 0.3-60km ± 15% RMSE
- PM_{10}:
  - TEOM 1400a
  - Ambient Particulate Monitor
  - ± 1.5 μg m^{-3} (1hr avg.)

Data & Methodology

- Elimination of natural visibility impairment:
  - 10:00-14:00 LST
  - RH ≤ 80%
  - No precipitation
- Influence of circulation type:
  - Classification of SLP charts
  - 10 most prevalent types used (>20 days)
- History of air mass:
  - Backtrajectory analysis (HYSPLIT, 72h, 200m)

Synoptic classification

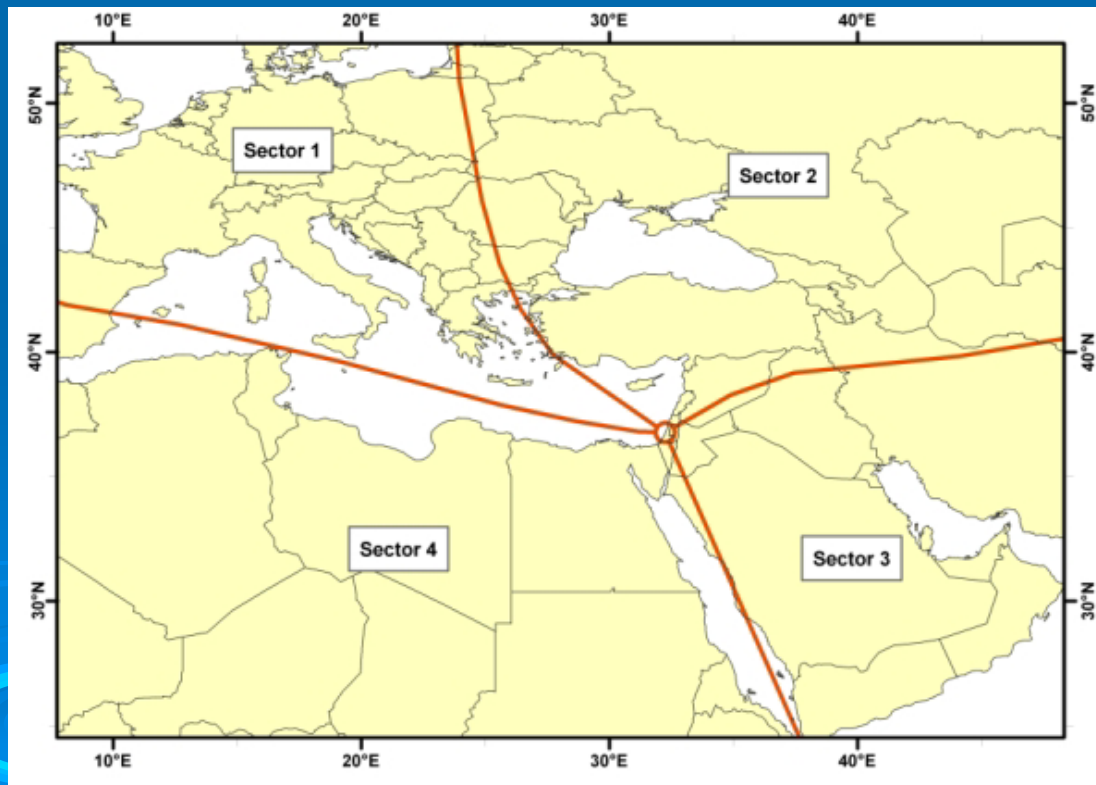
10 most prevalent types used:



Sector partitioning

- PM_{10} and Visual range depend on:
  - Particles accumulated during transport
  - Impact of source region

- 4 source regions:
  - (Dayan, 1986)
  - Statistics for trajectory ensembles confined within each sector



Annual mean mass concentration of PM_{10}

Tel Aviv: Elevated yearly means as compared to other big cities.

High concentrations of mineral dust from surrounding deserts

Site	PM_{10} [μgr m^{-3}] Avg. (Std)	Period
Tel-Aviv, IL (4)	57.0 (60)	2000-2002
Liverpool, UK(1)	25.0 (--)	1994
Basel, CH (2)	22.5 (30)	1998-2001
Bern, CH (2)	35.9 (30)	1998-2001
Lugano, CH (2)	33.0 (33)	1998-2001
Zurich, CH (2)	24.0 (30)	1998-2001
Helsinki, SF (3)	18.7 (30)	1999-2001
Sweden (3)	25.8 (30)	2002

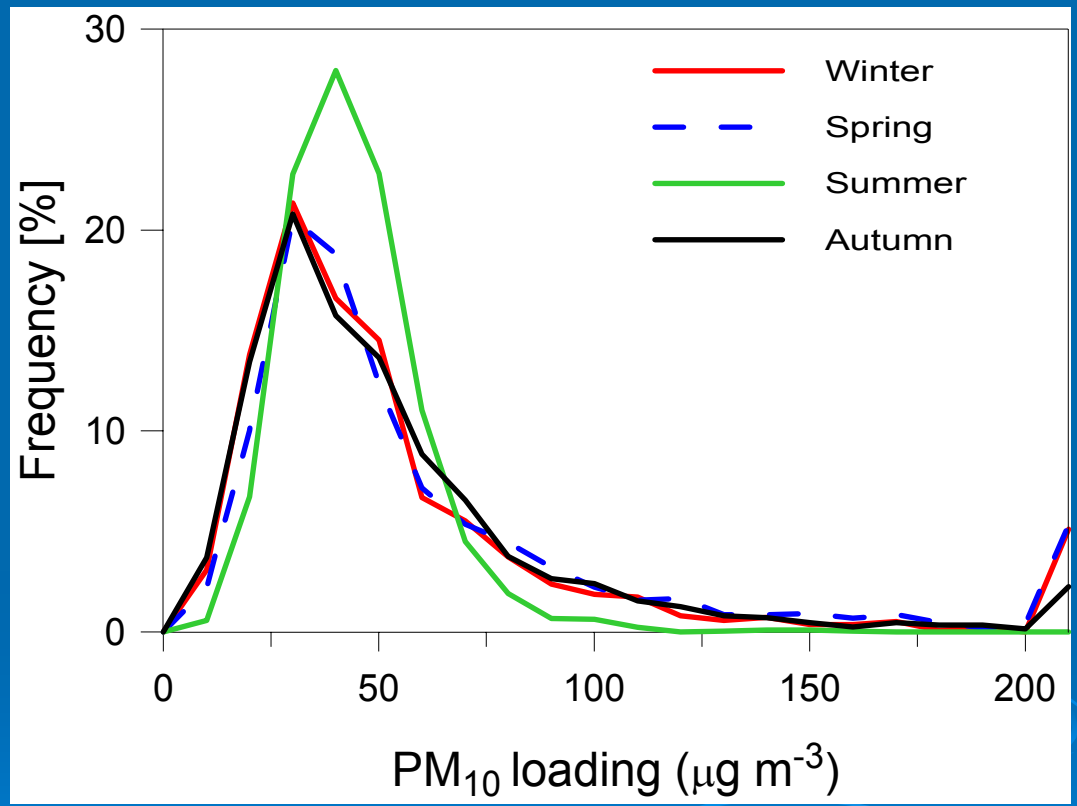
(1)Seinfeld and Pandis, 1998
(2)Gehrig and Bochmann, 2003
(3)Laakso et al., 2003
(4)This study

Seasonal frequency distribution of PM_{10}

Summer season:

- Highest modal (40 μgr m^{-3})
- Smallest variance (IQR 18 μgr m^{-3})

⇓

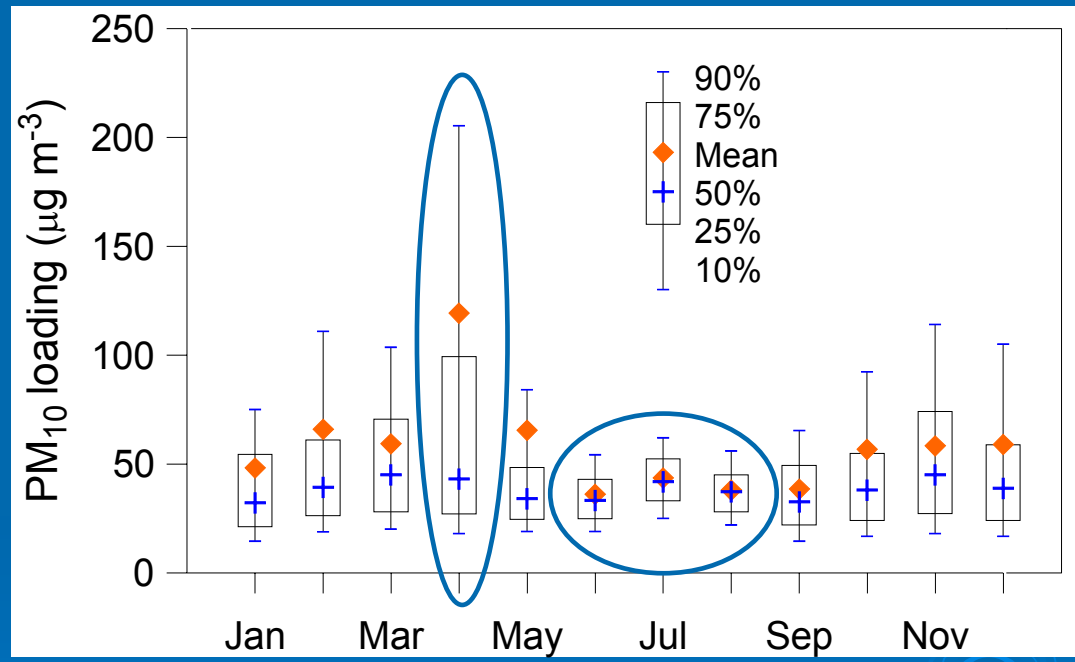


Summer exclusive synoptic pattern:
Persian Trough

Monthly distribution of PM_{10}

- Smallest var. for summer
- Highest mean PM_{10} conc. during April (IQR - 75 µgr m^{-3})

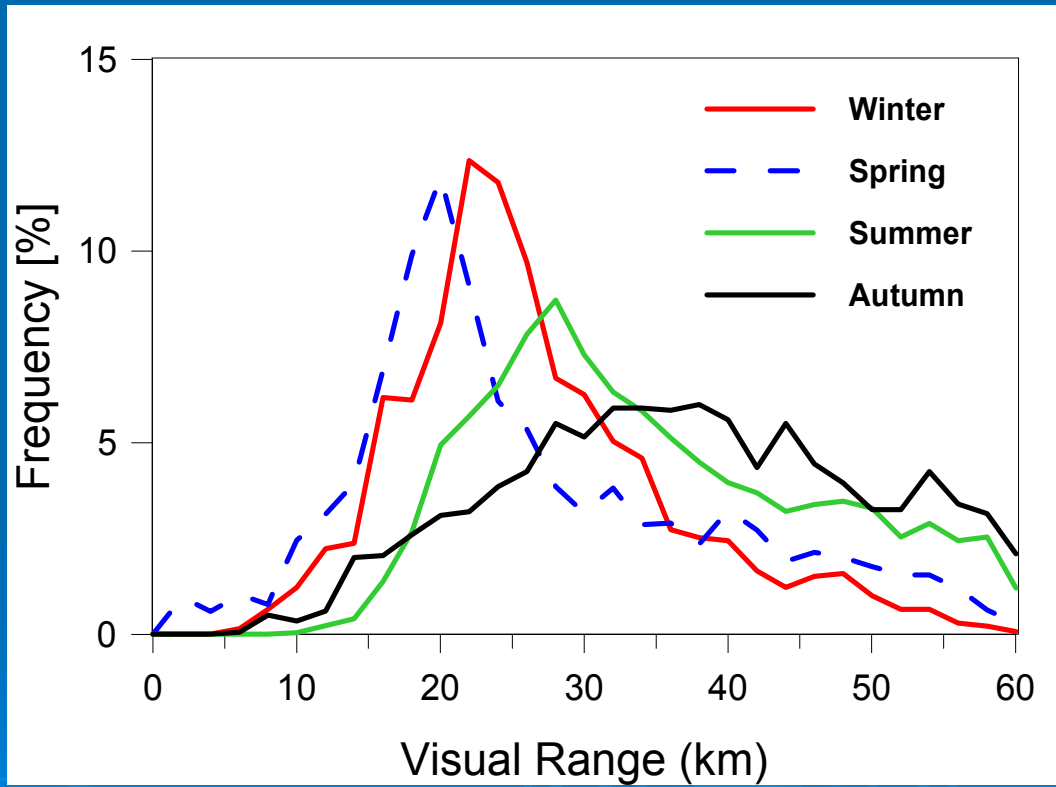
⇓



Pulsative nature of dust outbreaks (Sharav Cyclones)

Seasonal frequency distribution of visual range

- Modal visual range:
  - Spring: 20 km
  - Winter: 22 km
  - Summer: 28 km
  - Autumn: 32-38 km



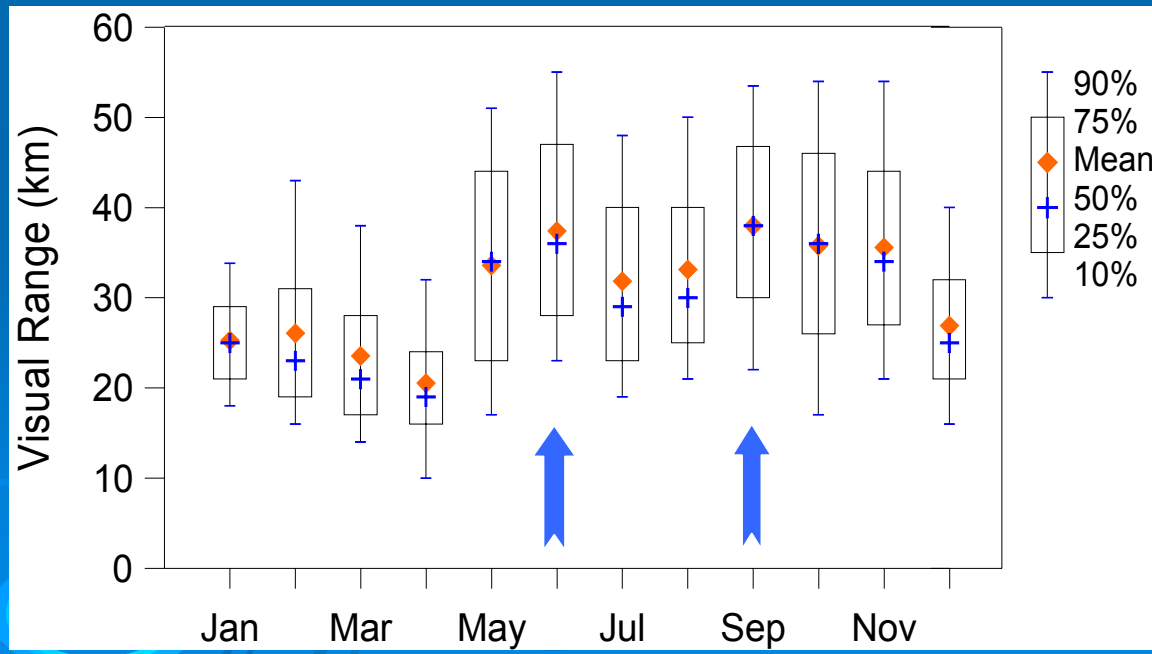
Monthly distribution of visual range

- Maximal mean visual range for edges of summer (June & Sept., 37 km):

  Max. northerly continental wind component

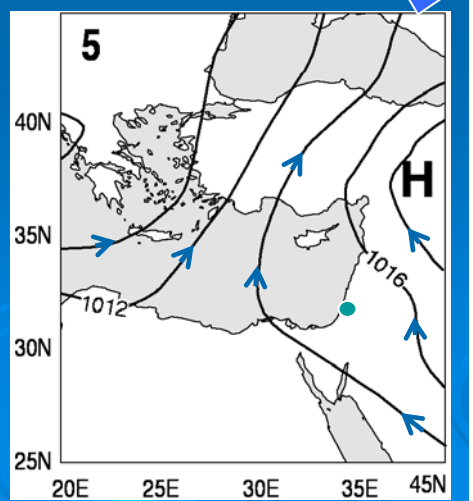
  (LTM: $v_{1000hPa}$ = -2.5 m s^{-1})

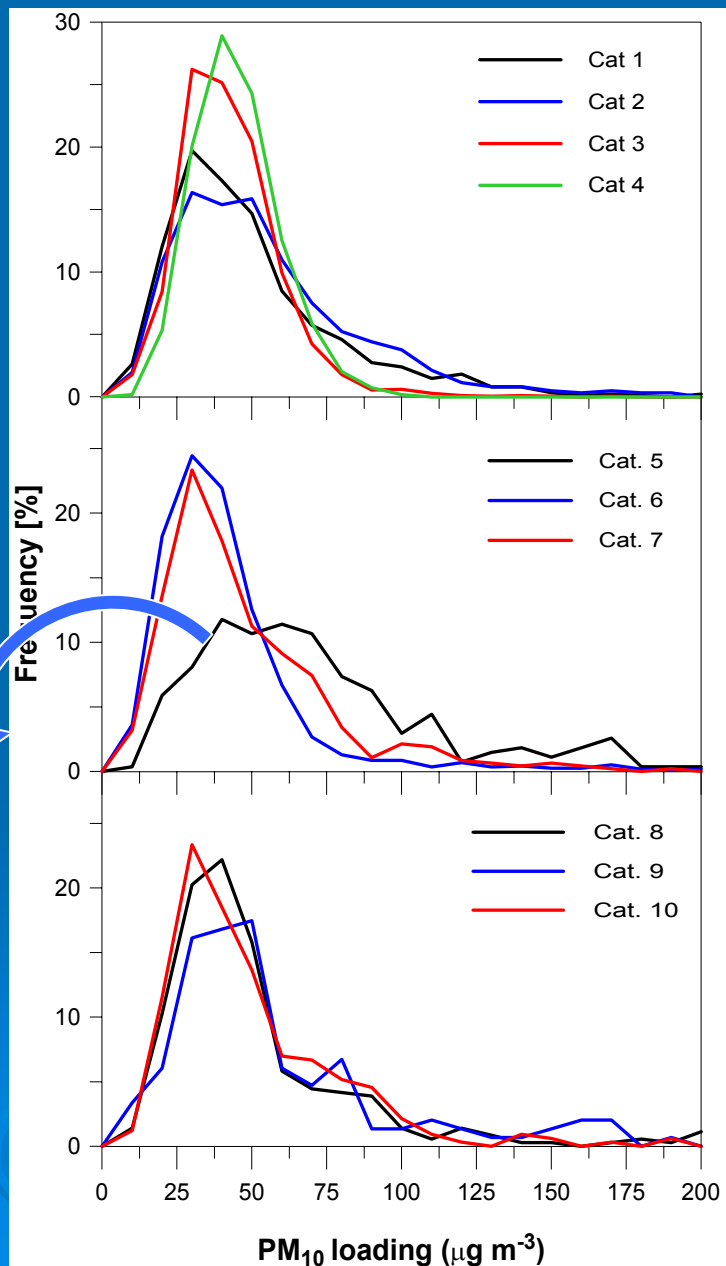
- VR deterioration from Nov. – Apr.



Effects of synoptic conditions on PM_{10}

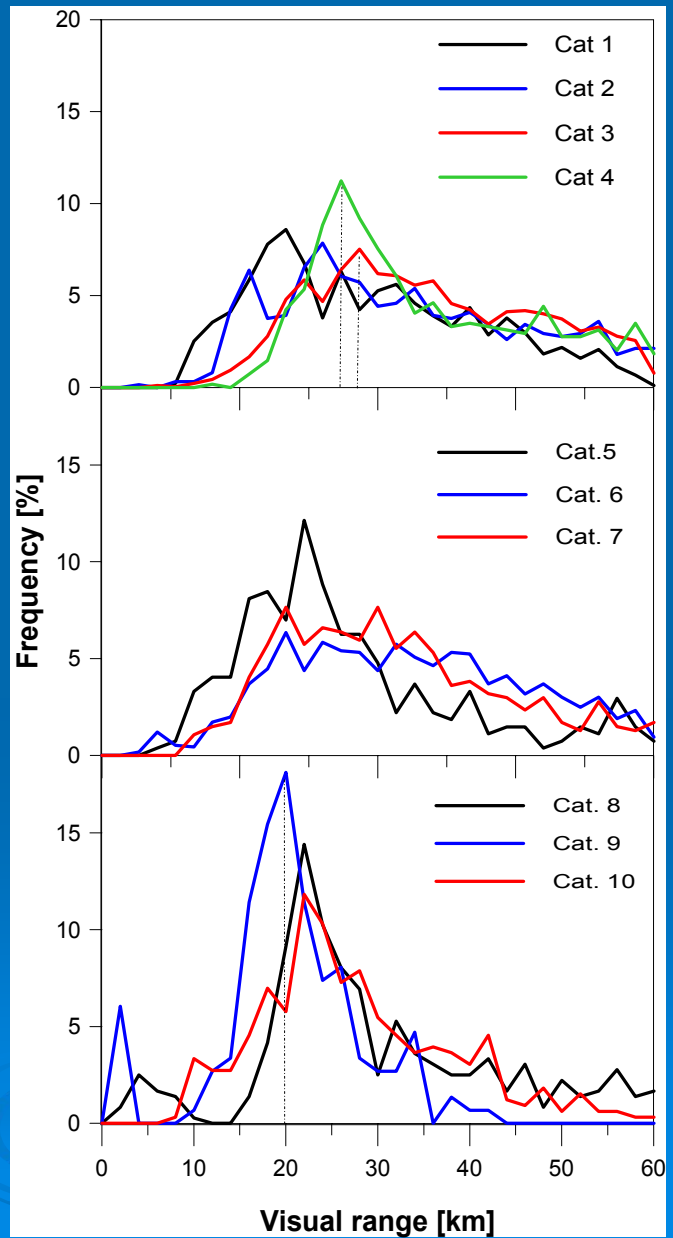
- Log-Normal distrib., skewed to the right – Bigger variation for highest PM_{10} conc.
- Exception: High to East (5) –
  - SE winds,
  - More heterogeneous





Effects of synoptic conditions on Visual Range

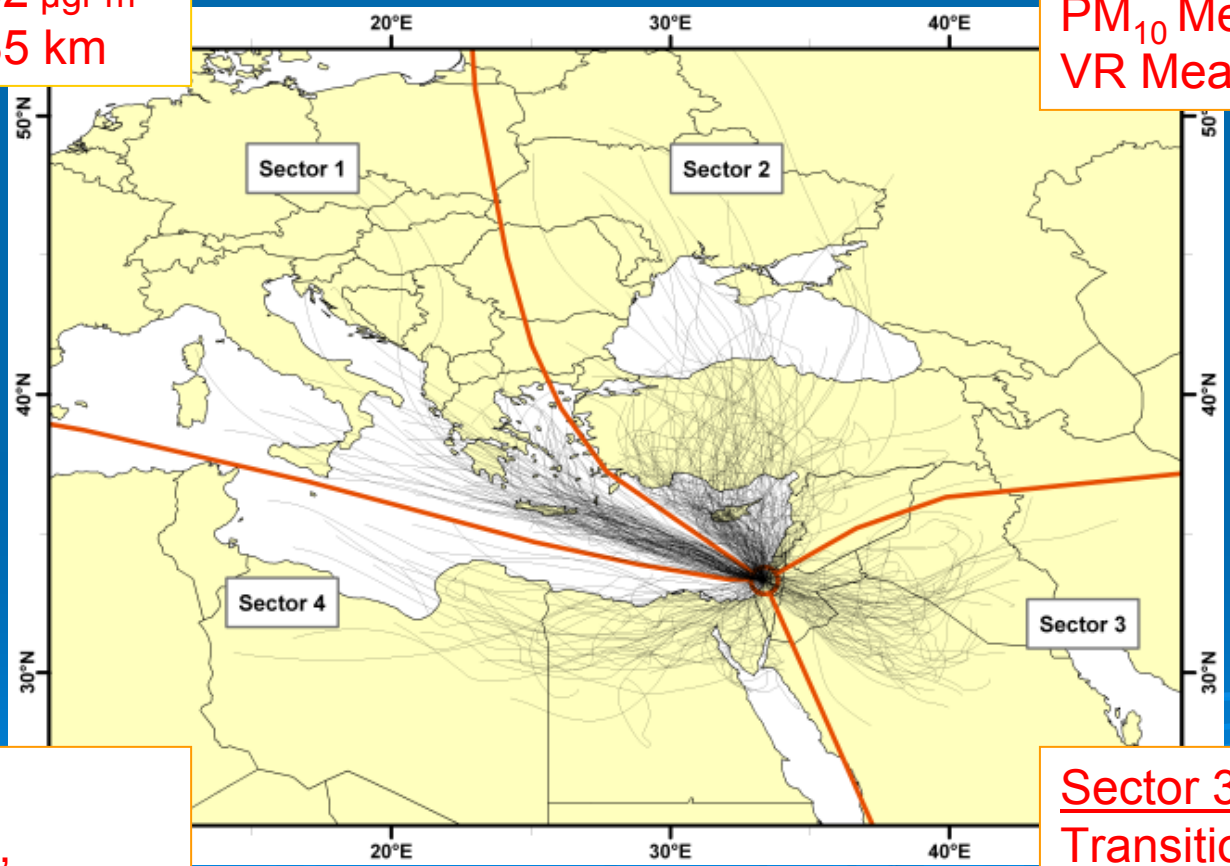
- All: Skewed to the right - a bigger variation for highest VR
- Persian Trough – Summer (3,4):
  - highest modal VR (25-27 km)
- Cold low to the North – Winter (9):
  - lowest modal VR (20 km)
  - Trajectories crossing North Africa



Effect of sector partitioning on PM_{10} and Visual Range

Sector 1:
Mostly Summer,
PM_{10} Median: 32 μgr m^{-3}
VR Mean: 35 km

Sector 2:
Central Europe,
PM_{10} Median: 37 μgr m^{-3}
VR Mean: 34 km



Sector 4:
Desert sources,
PM_{10} Median: 96 μgr m^{-3}
VR Mean: 22 km

Sector 3:
Transitional seasons,
PM_{10} Median: 63 μgr m^{-3}
VR Mean: 26 km

Summary

- Air masses from N. Africa and Arabian Pen. sectors are significantly more dust loaded as compared to Western & Central Europe sectors
- Most air masses reaching the EM arrive from Europe, resulting to high VR (>19km for 90% of the time)
- Sectorial source regions classification predicts better the properties of air masses rather then weather types