Impact of particulate matter sources on air quality of Beijing, China

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- Challenges
- Scientific questions
- Process studies
- Conclusions, outlook

Scientific questions for air quality in Beijing

Aeolian mineral dust originated from West and Northwest during storm events – can carry pollutants and nutrients

Emission reduction measures to improve air quality during the Olympic Summer Games in 2008: cut down coarse particles mainly, still frequent air pollution events

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Air quality **process studies** in Beijing

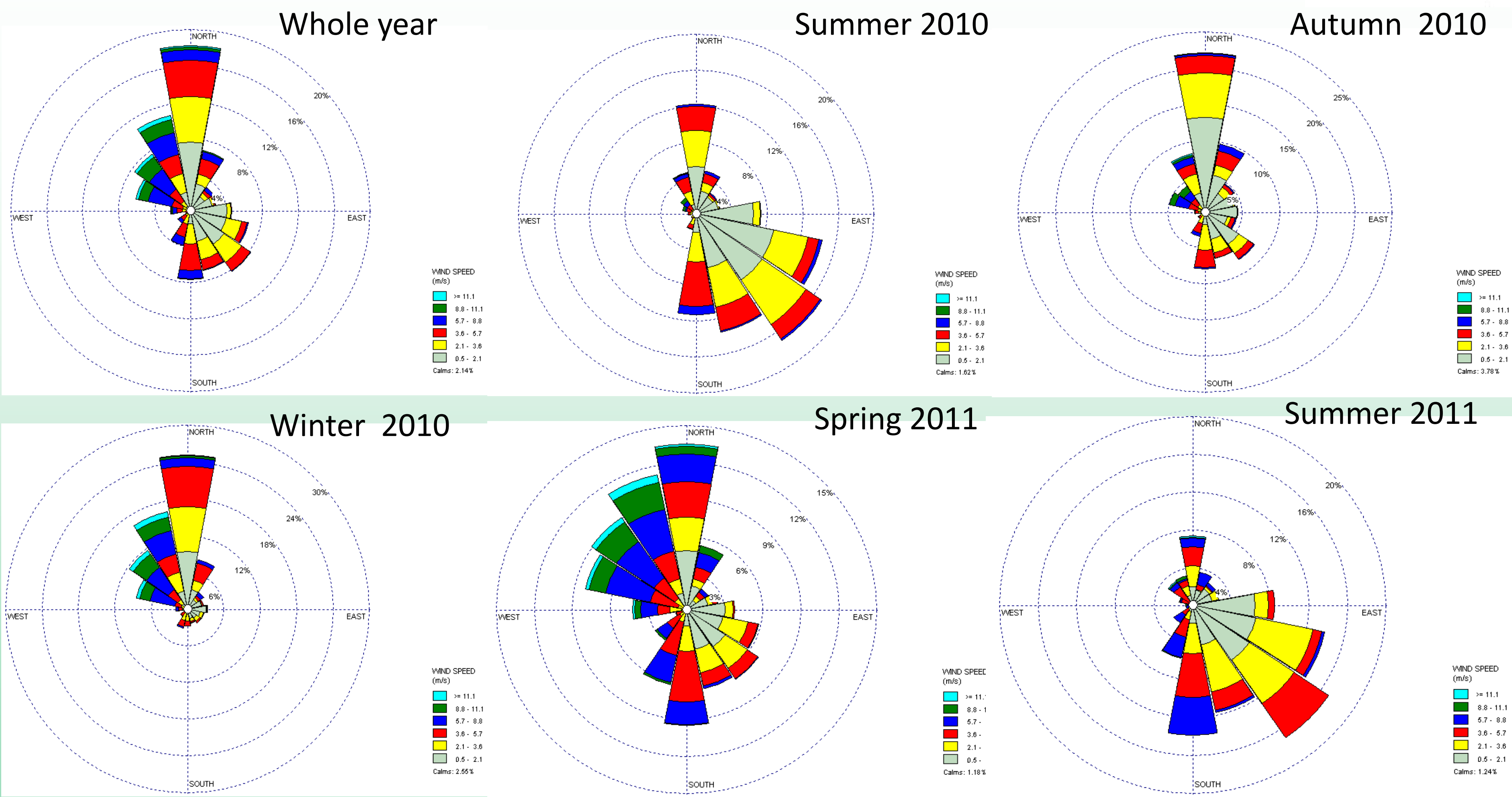
Daily $PM_{2.5}$ filter sampling by 2 HVS DHA80 06/10 – 06/11 at CUGB, since 04/13 at IAP by KIT/IMK-IFU

Main and trace elements analyzed by PEDXRF (Polarized energy dispersive X-ray fluorescence) from KIT/IMG

10 - 20 m distance to $PM_{2.5}$ weekly MVS and LVS by KIT/IMG and passive sampling by DWD

Meteorological, MLH data: ZBAA, IAP, KIT/IMK-IFU

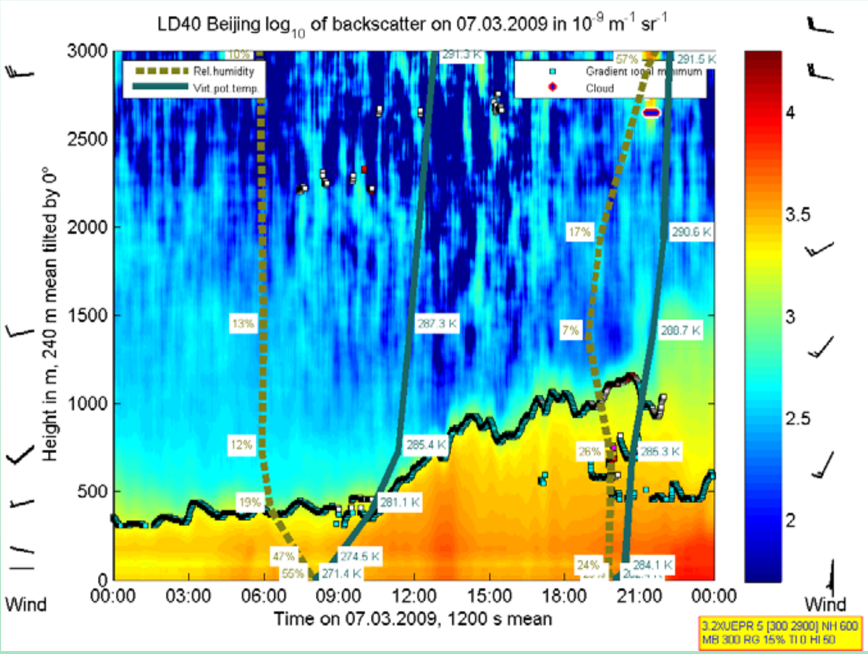
Wind influences in Beijing



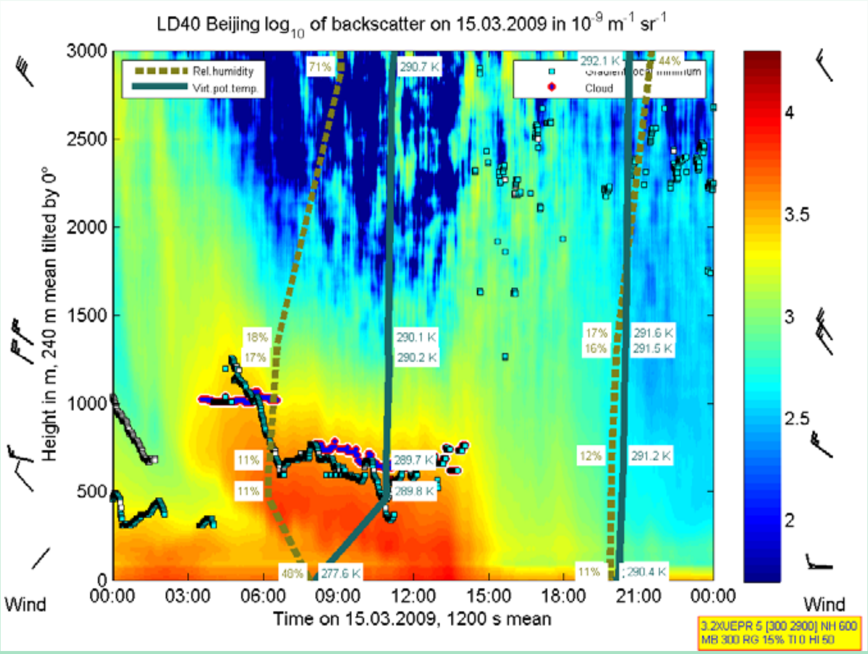
Spring: industrial areas; **Summer:** similar, precipitation, large MLH; **Autumn:** low wind speeds; **Winter:** higher wind speeds

Evaluations in Beijing

Higher particulate loads during winds from South-West



Desert dust clouds, winds from West, dry air



MLH > 1000 m: often multiple layering, < 1000 m: often one layer

High $PM_{2.5}$ load (40 – 140 µg/m^3): MLH much lower than 1000 m

Mixing layer height - air quality

Beijing:

Influence of MLH upon element mass concentrations

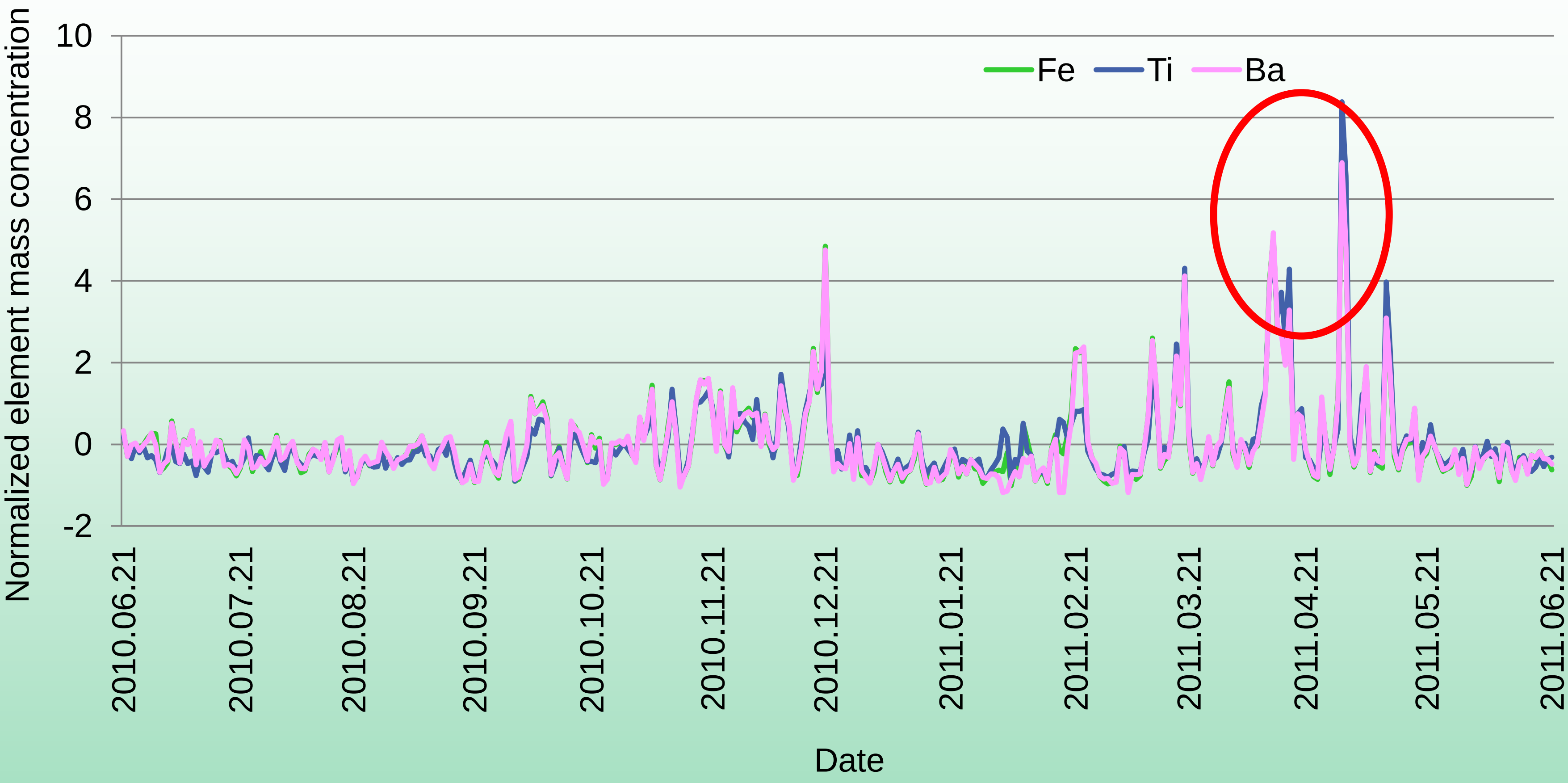
If the origin of the elements is

- the soil this source dominates the concentrations (Al, K and Ca no MLH influence),
- the traffic and industry the air transport dominates (no MLH influence in higher altitudes) and
- a widespread area source the MLH dominates (Cu, Zn)

Haze days: high relative humidity/ low wind speed / low mixing layer height

Dust days: high wind speed

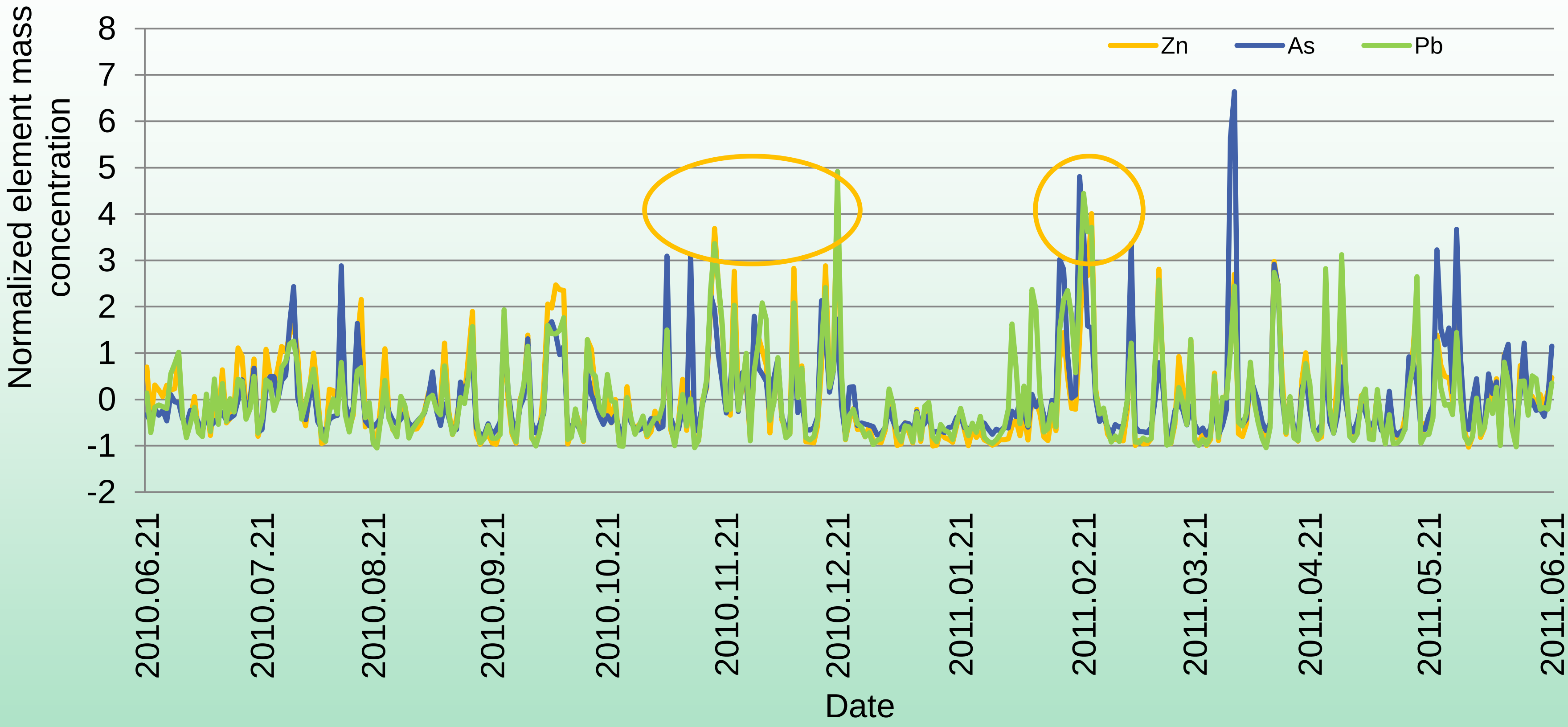
Variation of Fe, Ti and Ba in Beijing



Highest in April because of dust storm (originated from Gobi desert) and re-suspended road dust

Dust events: different natural sources

Variation of Zn, As and Pb in Beijing



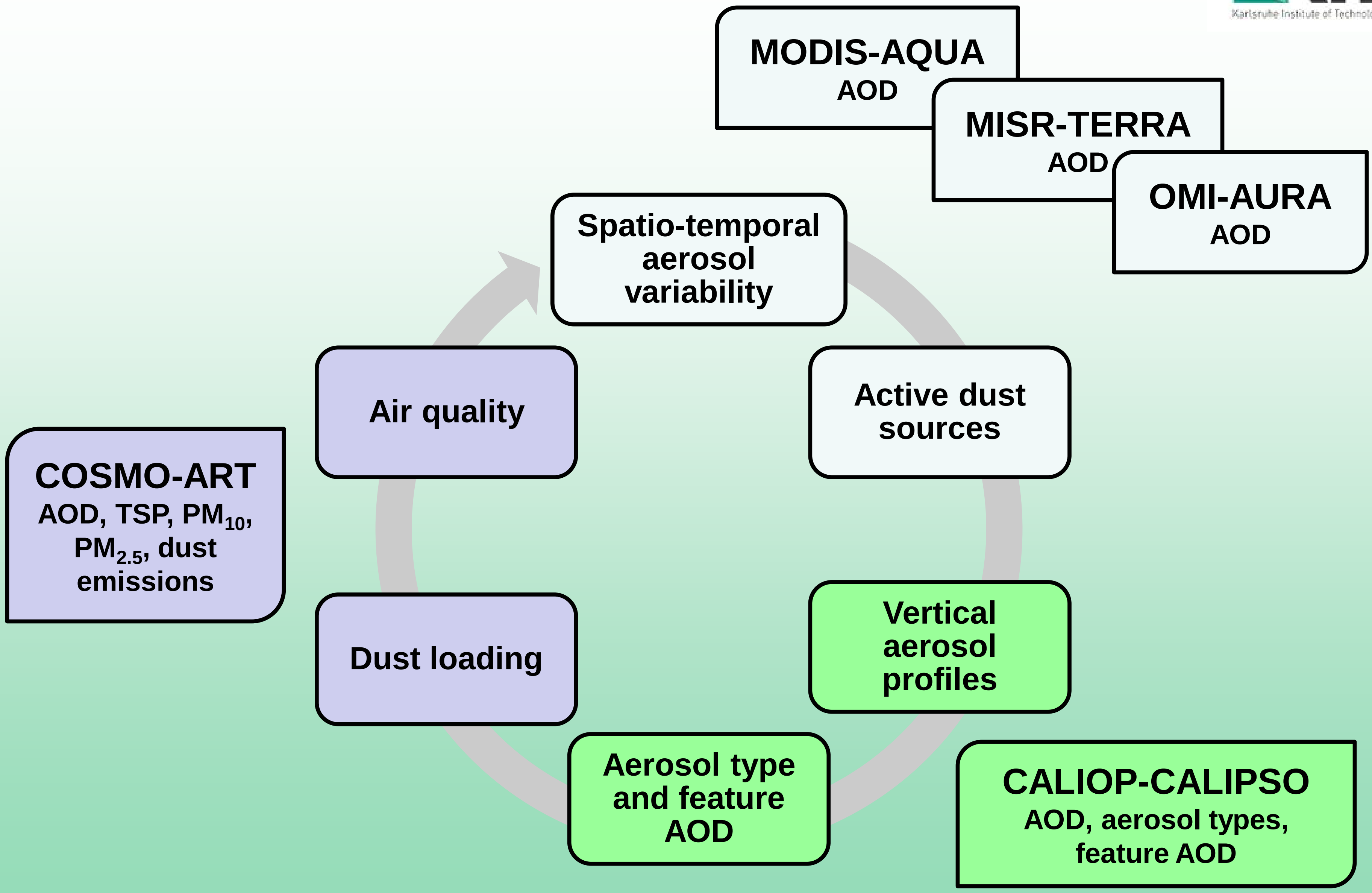
Fossil fuel combustion (oil and coal combustion) and waste incineration, lowest in January - Spring Festival holidays

Haze days: highest PM mass concentration from anthropogenic activities, air pollution event during all seasons

Discussion

- Wind conditions influence urban air quality -> contribution of surrounding emissions: e.g. source apportionment of $PM_{2.5}$
- MLH influenced by future climate change – quality of living in cities
- Only holistic and multidisciplinary approaches provide a deeper understanding -> measurements and modeling

Methodological approach

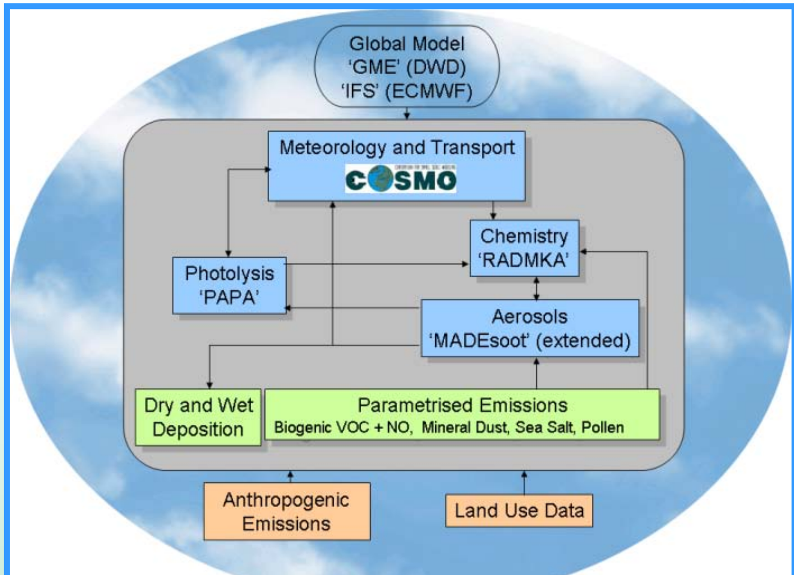


COSMO-ART

Aim: Investigation of impact of gases and aerosols on air quality (continental to local scales)

Gases & Aerosols: 80 gas species, 5 anthropogenic aerosol modes**,** **mineral dust**, sea salt, pollen

Feedbacks: meteorology, aerosols, gas phase, dynamics, clouds



(Vogel *et al*., 2009, ACP; Stanelle *et al*., 2010, ACP)

COSMO-ART
(Consortium for Meso-scale Modeling – Aerosols and Reactive Trace Gases)

Mineral dust:

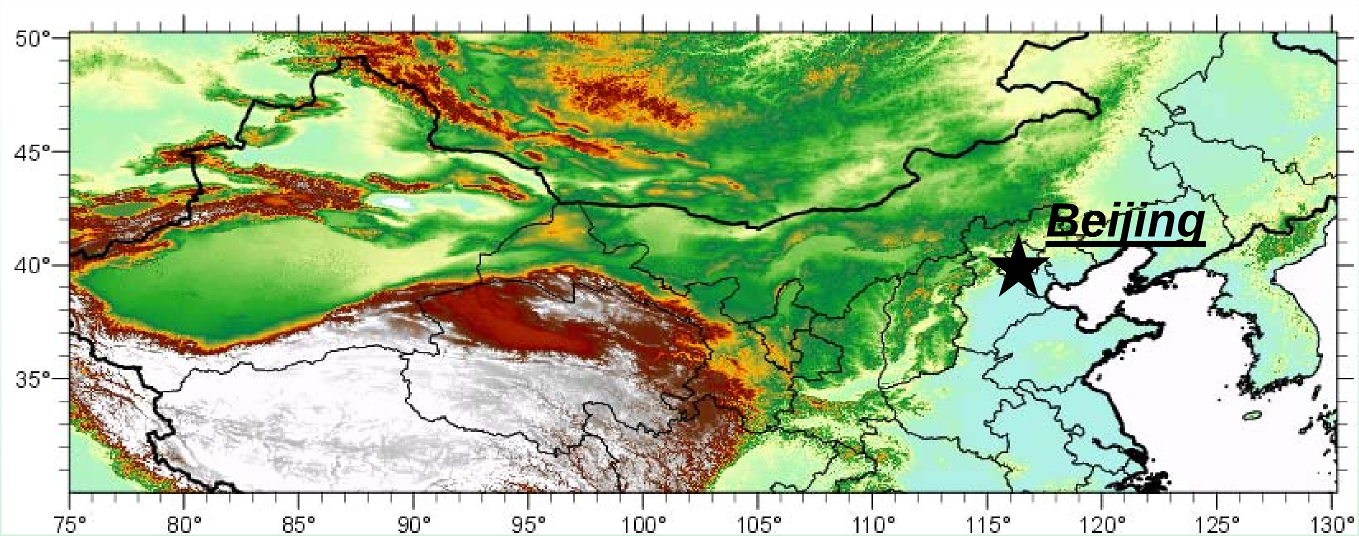
- 3 initial dust modes, dust emissions, TSP, PM_{10}, $PM_{2.5}$, AOD
- Dust emissions: surface properties, friction velocity, soil moisture
- AOD: calculated online as function of extinction coefficients, single scattering albedo derived a priori according to dust size and number concentrations using Mie theory

Data overview

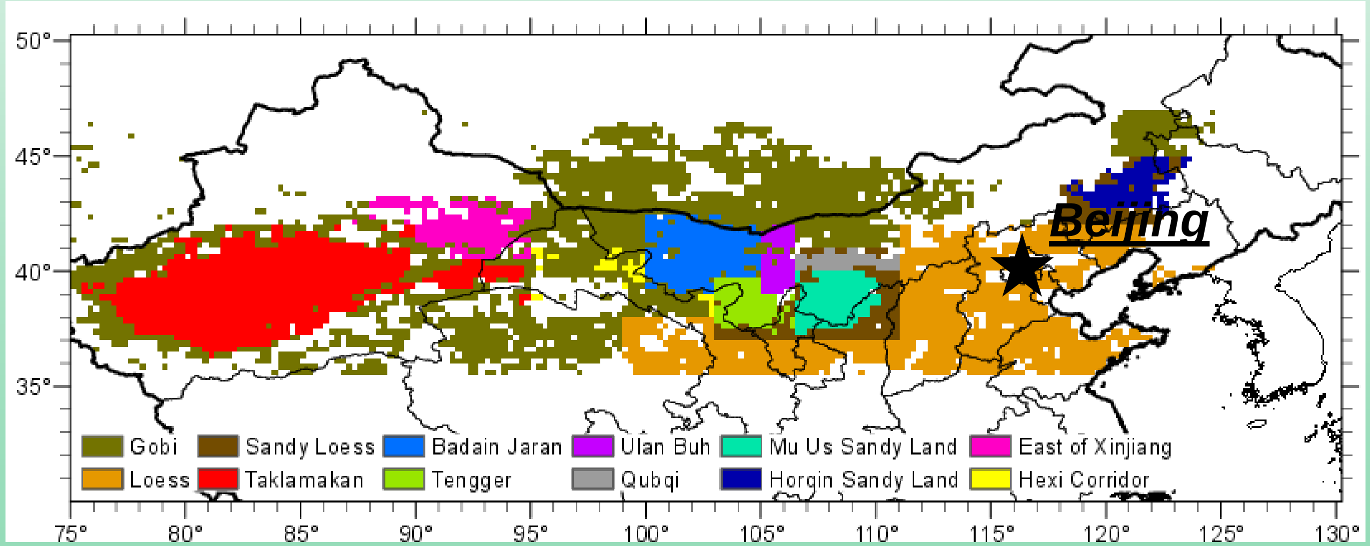
	Parameters and product	AOD wavelength	horizontal resolution	vertical resolution
MODIS	Deep Blue AOD Collection 5.1, Level 2	550 nm	10 x 10 km	-
OMI	Near-UV AOD OMAERUVd, Level 3	500 nm	1 x 1°	-
MISR	Green band AOD MIL2ASAE, Collection 11, Level 2	555 nm	0.15 x 0.15°	-
CALIOP	AOD, aerosol types Level 2, data version 3.01	532 nm, 1064 nm	5 x 5 km	333 m
COSMO-ART	AOD, TSP, PM_{10}, $PM_{2.5}$ without anthropogenic emissions	555 nm	28 x 28 km	Varying terrain following layers

Study area and dust source regions

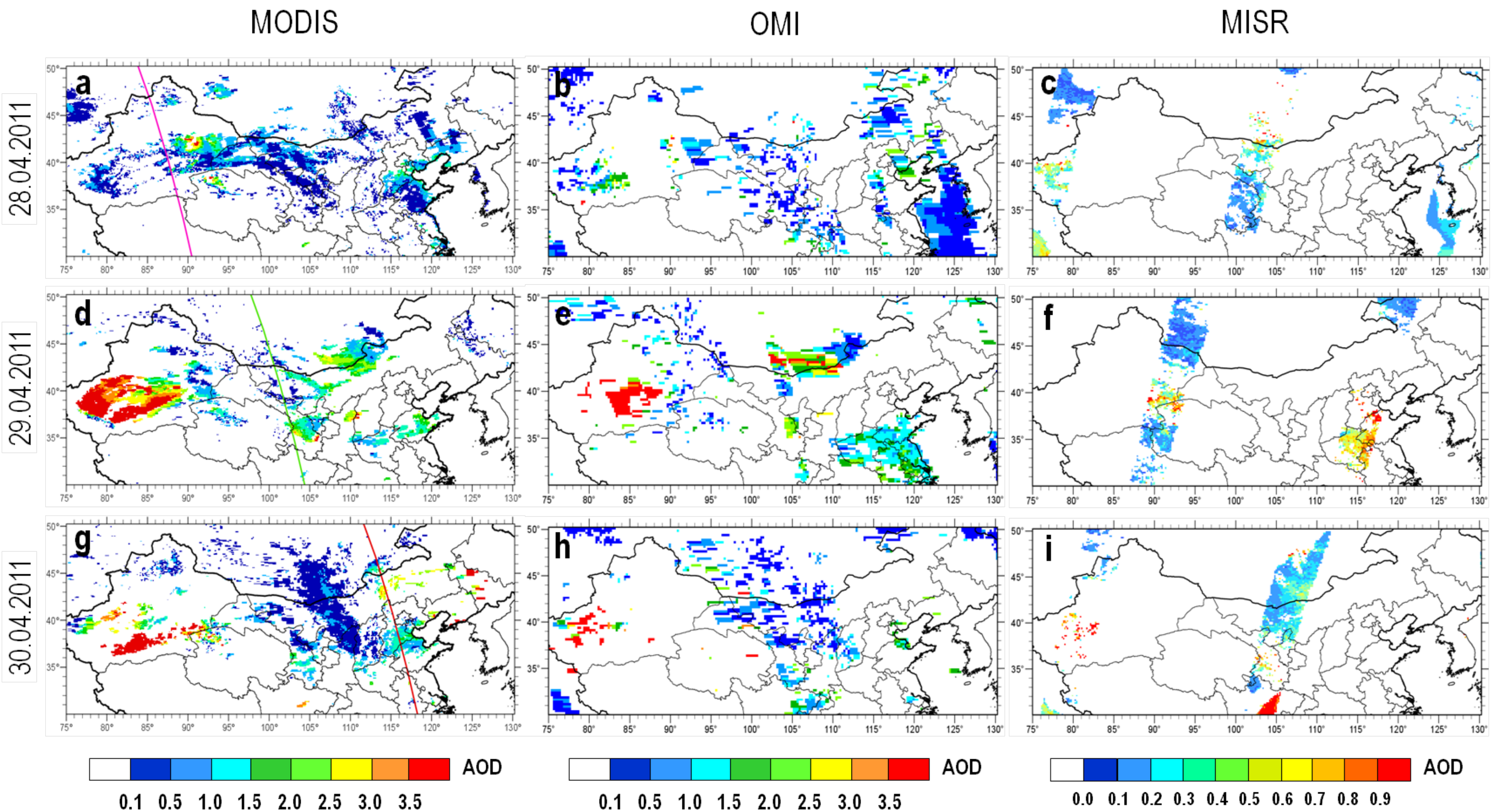
Model domain



Desert areas in Northern China



Spatio-temporal variability of AOD by passive sensors



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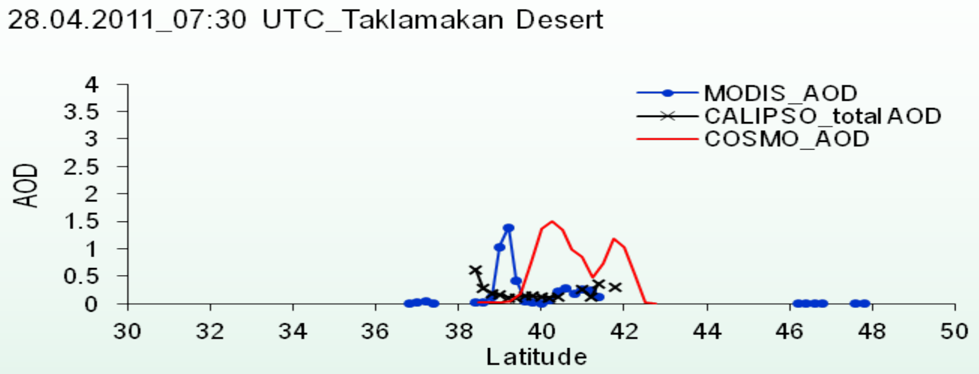
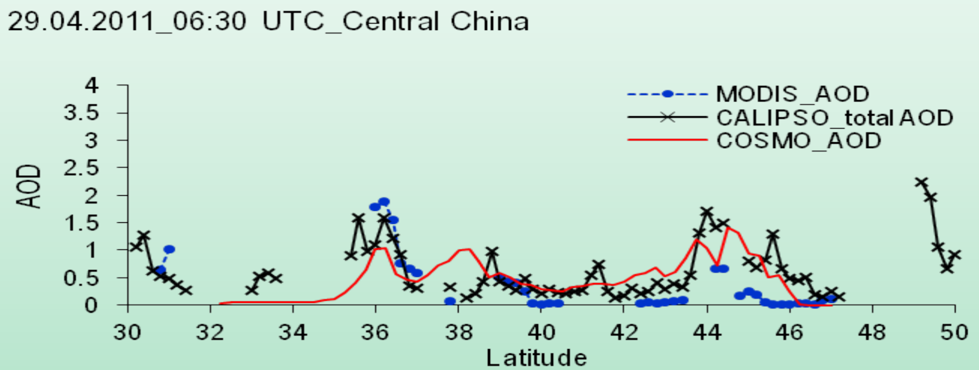
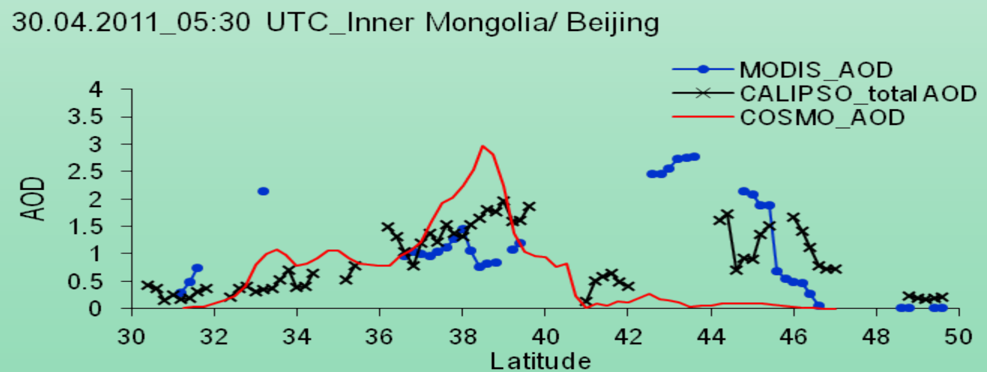
Satellite information for air quality modeling - AOD

Comparison of measured AOD by MODIS and CALIPSO and simulated AOD by COSMO-ART for **model validation**



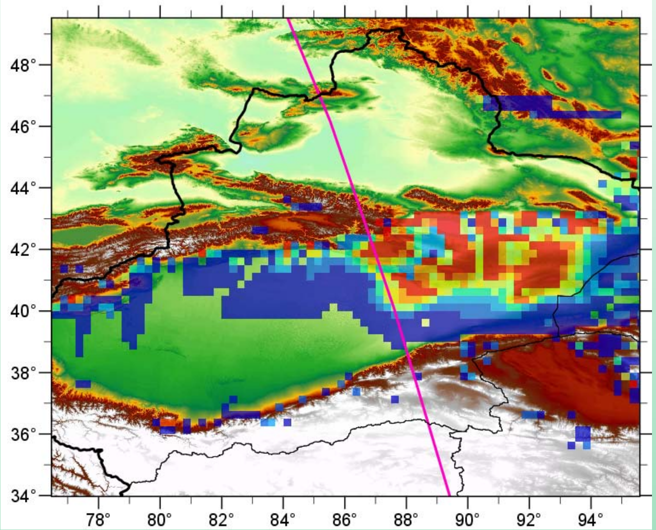




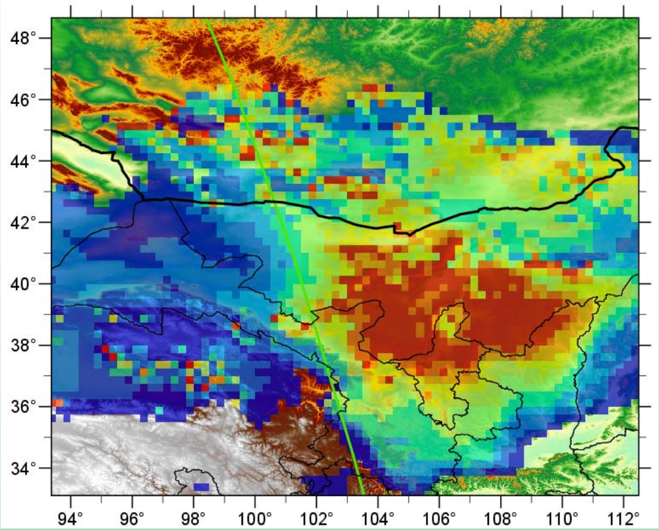
Impact of mineral dust on air quality – $PM_{2.5}$

Simulation of local $PM_{2.5}$ mass concentrations

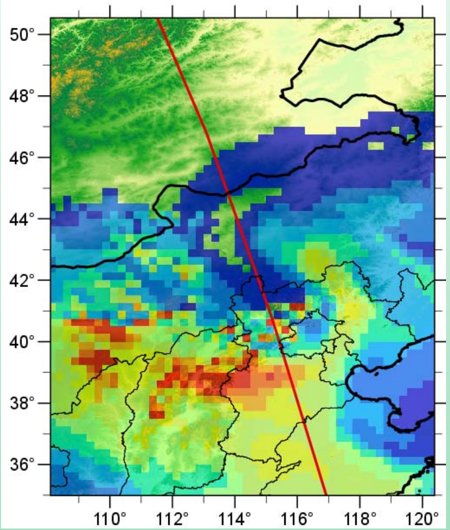
28/04/2011, 07:30 UTC
Taklamakan Desert

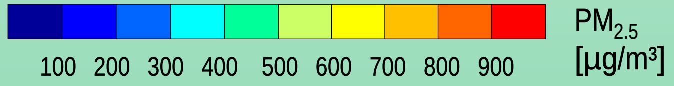


29/04/2011, 06:30 UTC
Central China



30/04/2011, 05:30 UTC
Beijing & Inner Mongolia





Conclusions

- Dust is present over most of the desert areas
  → main <u>source regions</u> Kumtaq, Taklamakan, Gobi
- Most mineral dust is located near the ground → <u>air quality</u>
- Good accordance aerosol by satellites and simulated dust
  → Space lidar and passive sensors - aerosol model validation
- We have to investigate
  - Traffic emissions and its development (e.g. UFP, BC)
  - Feedback mechanisms climate change & air quality
  - Consequences to human health: $PM_{2.5}$, PSD -> UFP
- Study future developments and recommendations relevant for decision makers and stakeholders to improve air quality and to limit climate change impacts

Acknowledgements

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Thank you very much for your attention

Impact of mineral dust on air quality – AOD

Comparison of CALIPSO features and feature AOD and simulated COSMO-ART AOD