



# Studying of atmospheric aerosols in Central Siberia: first results from the “ZOTTO” observatory

A. Panov<sup>1</sup>, J. Heintzenberg<sup>2</sup>, W. Birmili<sup>2</sup>, R. Otto<sup>2</sup>, X. Chi<sup>3</sup>, and M. O. Andreae<sup>3</sup>

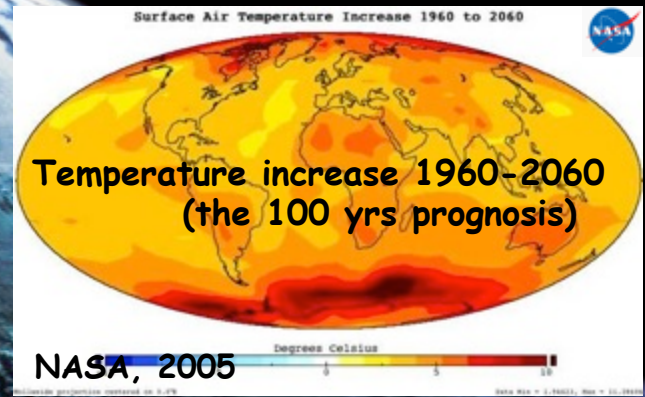
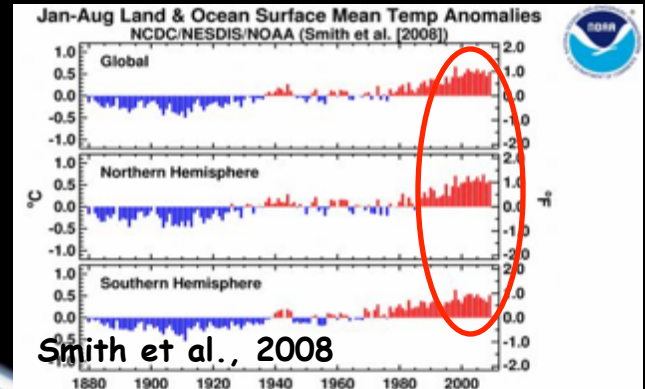
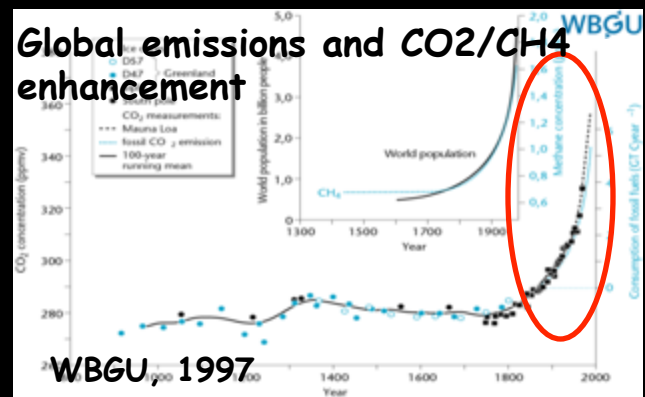
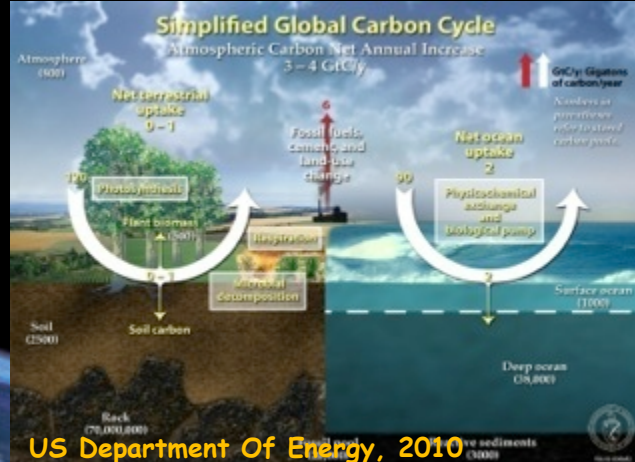
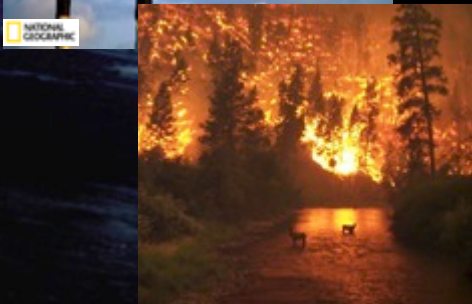
<sup>1</sup>V.N. Sukachev Institute of Forest SB RAS, Krasnoyarsk, Russia

<sup>2</sup>Leibniz Institute for Tropospheric Research, Leipzig, Germany

<sup>3</sup>Max Planck Institute for Chemistry, Mainz, Germany



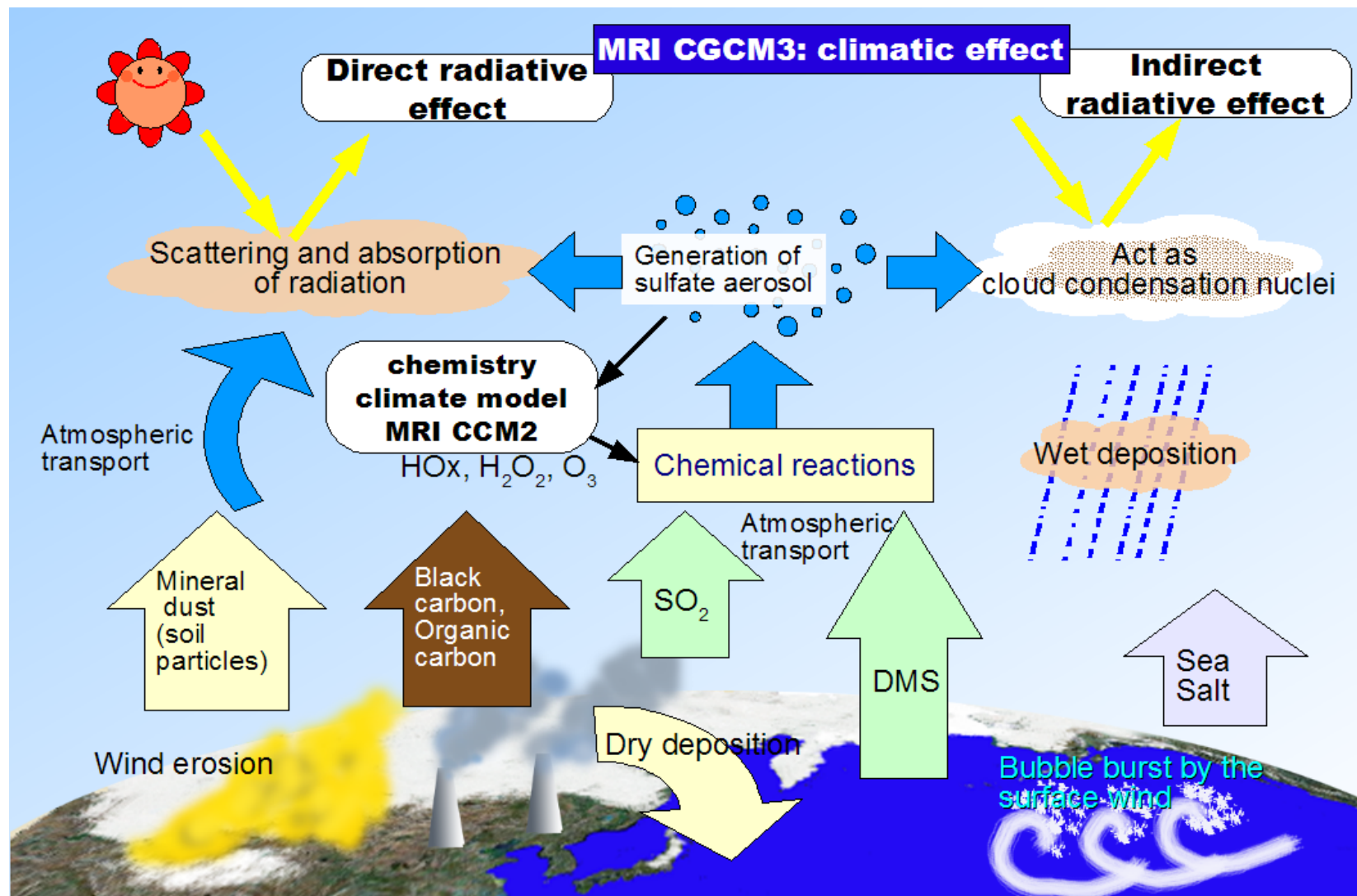
# Global change...



The face of the Earth as we know it - hangs in the balance

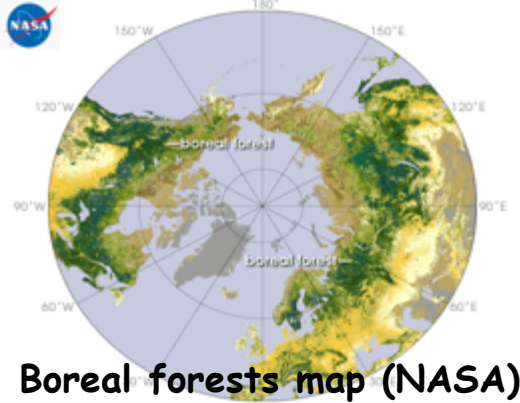


# Aerosols and the global climate



Aerosol model of the Meteorological Research Institute, 2008



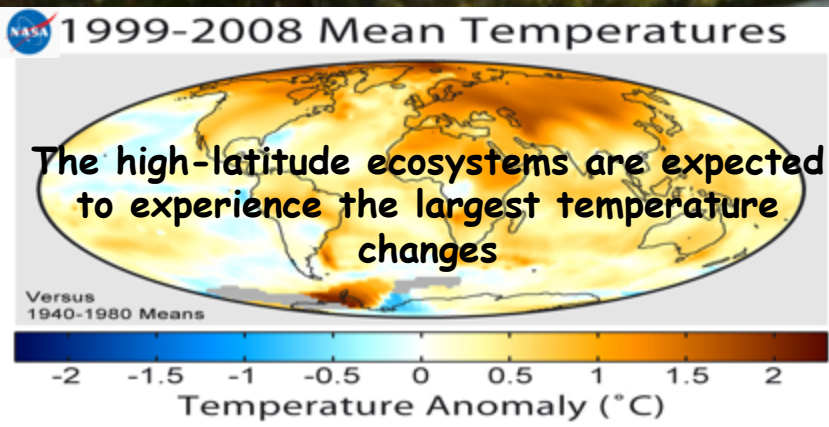
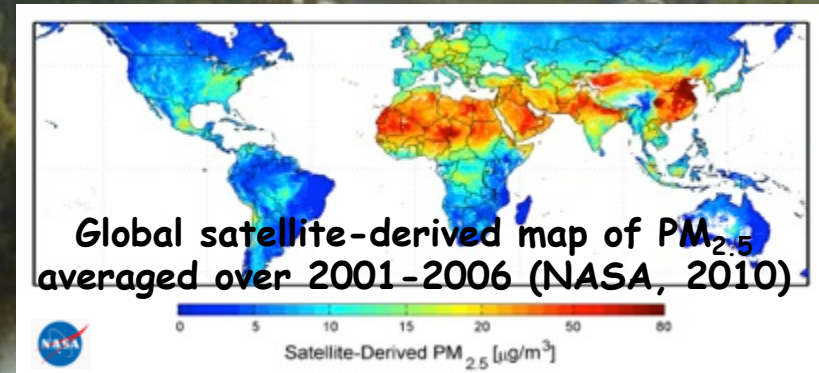
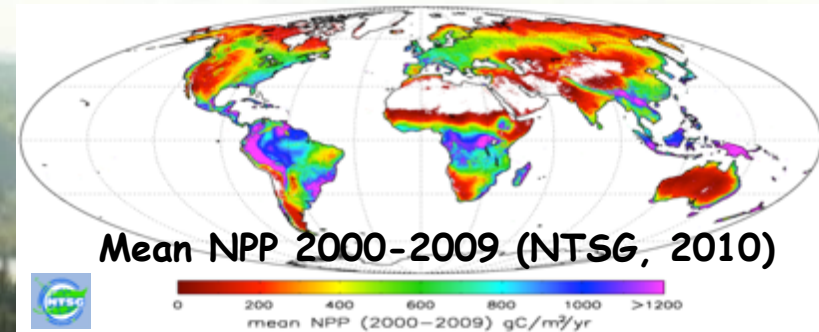


# Boreal forests

The world's largest land biome, and makes up 29% of the world's forest cover with the largest areas located in Russia and Canada.

The Siberian landmass hosts an ecosystem that is globally relevant for the atmospheric budget of carbonaceous greenhouse gases, such as CO<sub>2</sub> and CH<sub>4</sub> (Schulze et al., 1999; Lloyd et al., 2002), but also aerosol particles.

The secondary aerosol over boreal forests is predicted to exert a net cooling effect on global climate (Spracklen et al., 2008).



The high-latitude ecosystems are expected to experience the largest temperature changes

A particular concern is how the vast Siberian ecosystem might change during the ongoing global warming, and which global consequences this will have (IGBP, 2007).

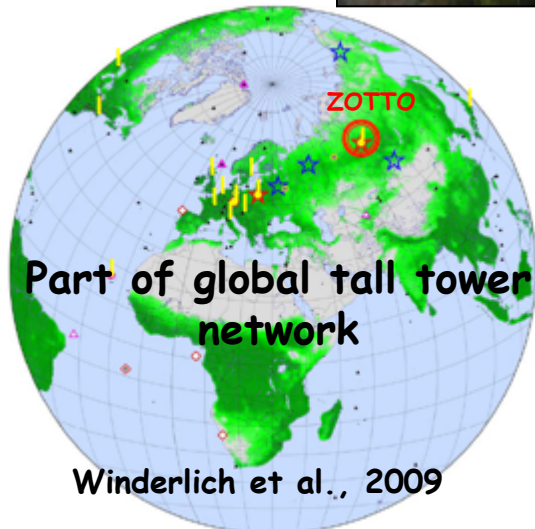
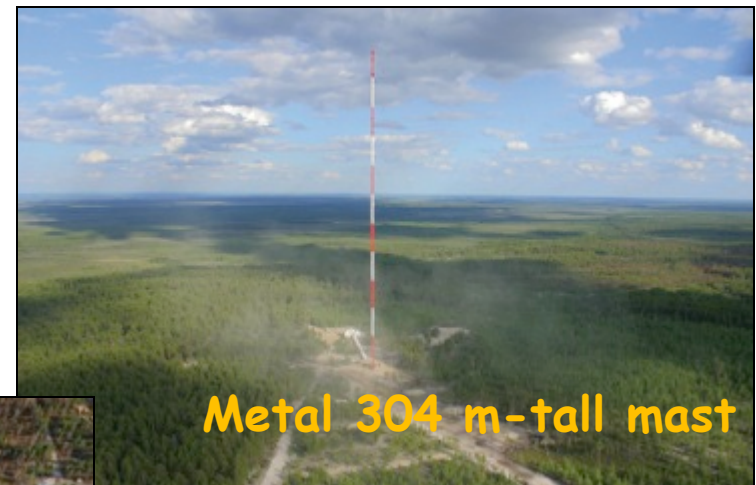
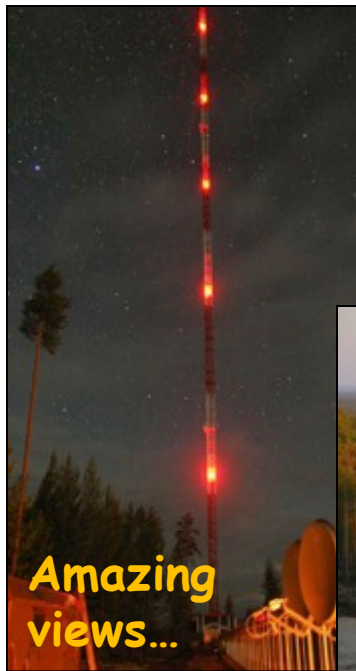




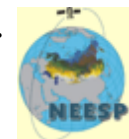
# The Zotino Tall Tower Facility (ZOTTO)



Since 2006, as part of a global cooperative effort in the framework of the ISTC partner project "Biogeochemical Responses to Rapid Climate Changes in Eurasia" the Zotino Tall Tower Facility (ZOTTO; [www.zottoproject.org](http://www.zottoproject.org)), a unique international research platform for large-scale climatic observations, is operational in the middle of Siberia.



ZOTTO is embedded in the Northern Eurasian Earth System Partnership Initiative (NEESPI), an external project of the International Geosphere-Biosphere Program (IGBP).





# ZOTTO site

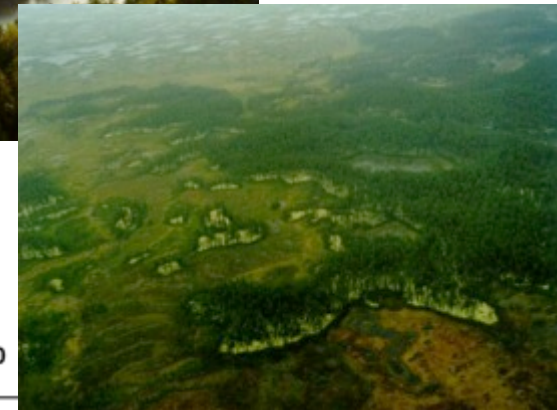
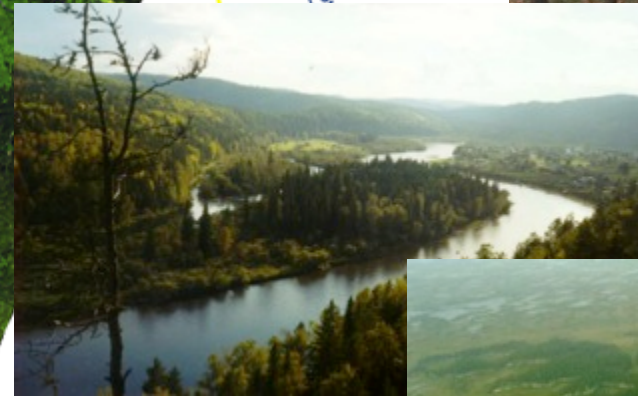
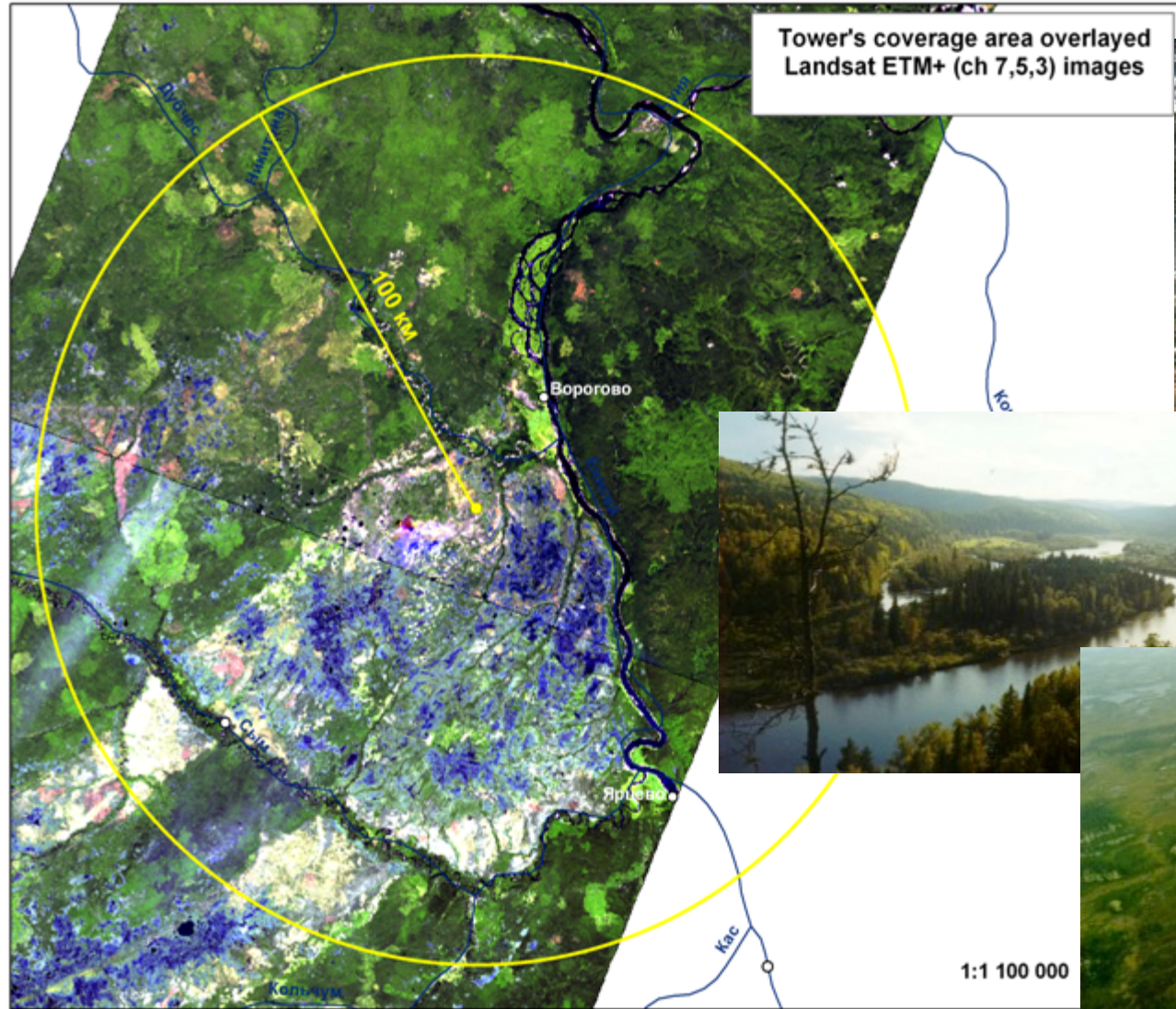


**ZOTTO is located in the center of the Siberian taiga, about 20km west of the Yenisei River and about 600km north of Krasnoyarsk, Krasnoyarsk region, Siberia.**





# ZOTTO footprint area



The ZOTTO footprint area ( $\sim 1000 \text{ km}^2$ ) covers mosaic of light dark and mixed forests and wetlands – the most representative ecosystem types in Central Siberia.

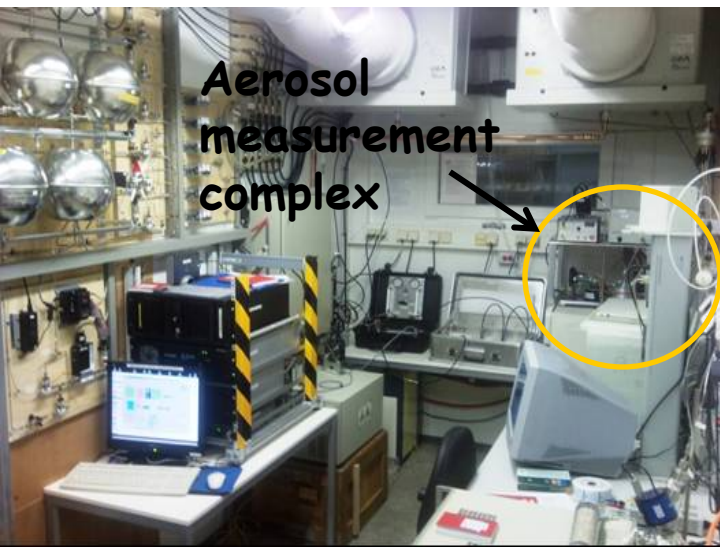


# Instrumental setup and measurements:

Ambient aerosols at ZOTTO are collected through two inlet pipes, one reaching to the top of the tower at 300m above ground, the other one to 50m height.

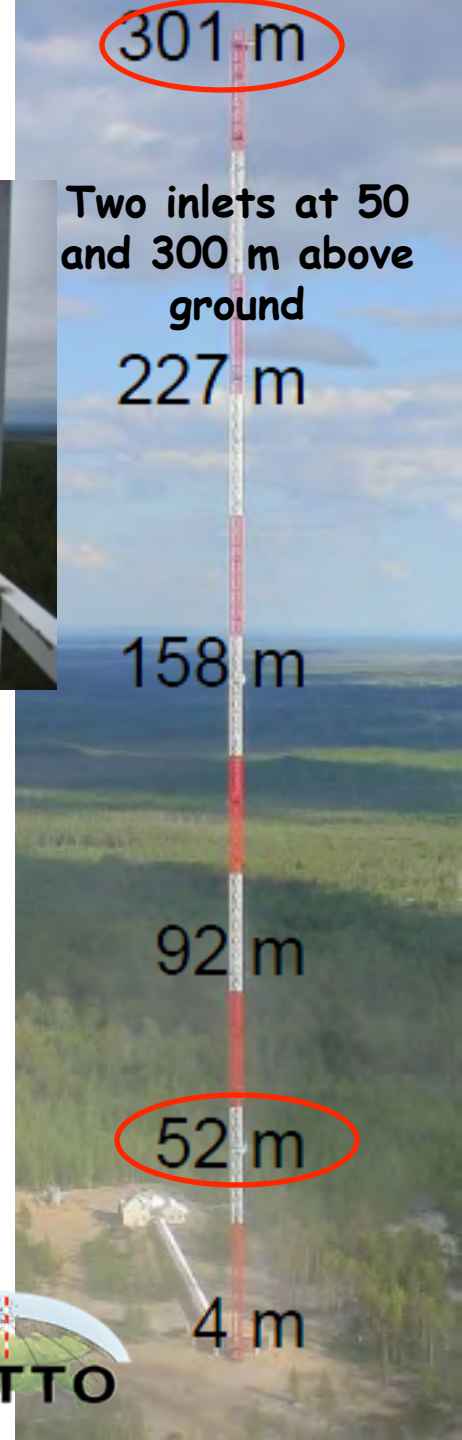
Particle number size distributions in the diameter range 15 - 835 nm have been recorded continuously at ZOTTO since 9/2006 by a Differential Mobility Particle Sizer (DMPS).

A single-wavelength Particle/Soot Absorption Photometer (PSAP, Radiance Research, Seattle, USA) was used for measuring particulate light absorption.



Aerosol measurement complex

The carbon monoxide (CO) mixing ratios in air were measured by UV resonance fluorescence, using a Fast-CO-Monitor (Model AL 5002, Aerolaser GmbH, Germany).



Two inlets at 50 and 300 m above ground

227 m

158 m

92 m

52 m

4 m



# Time series of daily averages for 2006-2010 y.

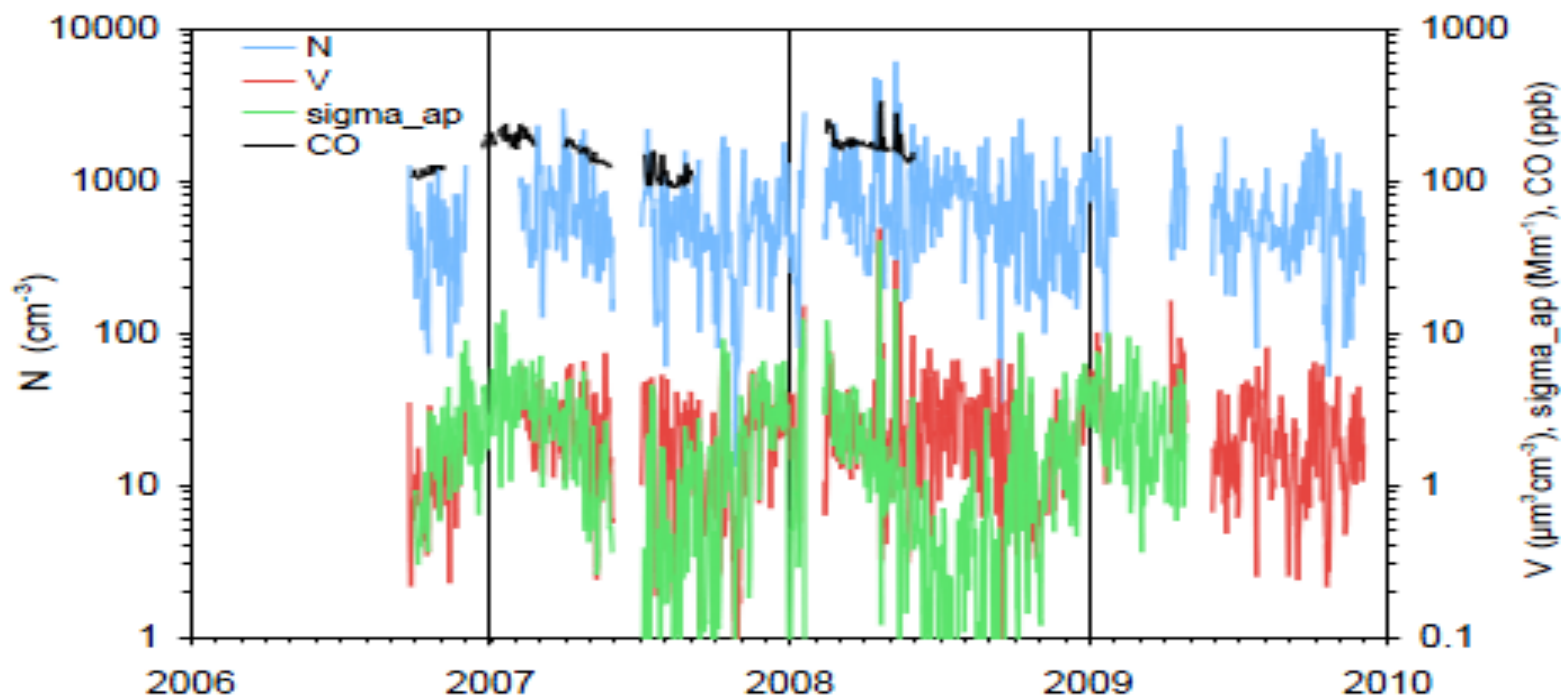


Fig. Daily averages of total number ( $N$ ,  $\text{cm}^{-3}$ ), total volume ( $V$ ,  $\mu\text{m}^3 \text{cm}^{-3}$ ), particulate absorption at 570 nm wavelength ( $\sigma_{\text{ap}}$ ,  $\text{Mm}^{-1}$  (average of the 50m and 300 m) levels), and carbon monoxide ( $\text{CO}$ , ppb) at 300m at ZOTTO.





# Integral aerosol parameters



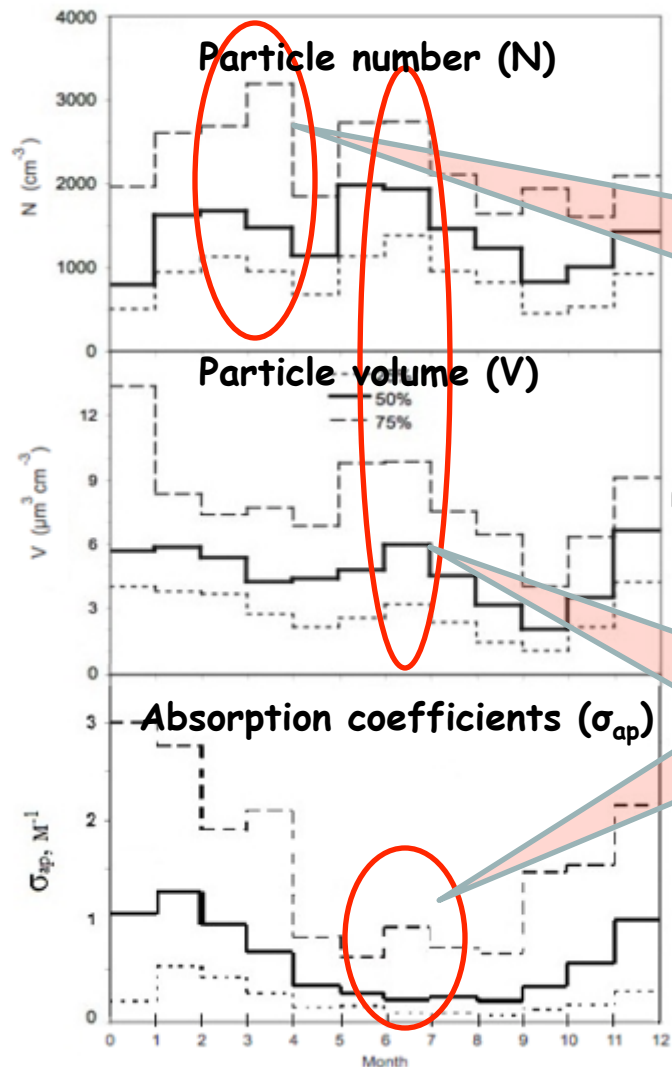
**Table. Aerosol particle number and volume at 50 and 300 m height at ZOTTO**

|                                     |            | Annual |      |        | May - August |      |        | November - February |      |        |
|-------------------------------------|------------|--------|------|--------|--------------|------|--------|---------------------|------|--------|
| Parameter                           | Percentile | 50m    | 300m | 50/300 | 50m          | 300m | 50/300 | 50m                 | 300m | 50/300 |
| N, cm <sup>-3</sup>                 | 25%        | 970    | 750  | 1.3    | 1040         | 890  | 1.2    | 860                 | 630  | 1.4    |
|                                     | 50%        | 1650   | 1290 | 1.3    | 1630         | 1390 | 1.2    | 1490                | 1190 | 1.3    |
|                                     | 75%        | 2650   | 2140 | 1.2    | 2390         | 2110 | 1.2    | 2600                | 2070 | 1.3    |
| V, μm <sup>3</sup> cm <sup>-3</sup> | 25%        | 2.8    | 2.3  | 1.2    | 3.0          | 2.5  | 1.2    | 3.4                 | 2.8  | 1.2    |
|                                     | 50%        | 5.0    | 5.0  | 1.0    | 5.1          | 4.7  | 1.1    | 5.4                 | 4.8  | 1.1    |
|                                     | 75%        | 8.7    | 8.7  | 1.0    | 8.9          | 7.9  | 1.1    | 9.8                 | 8.3  | 1.2    |

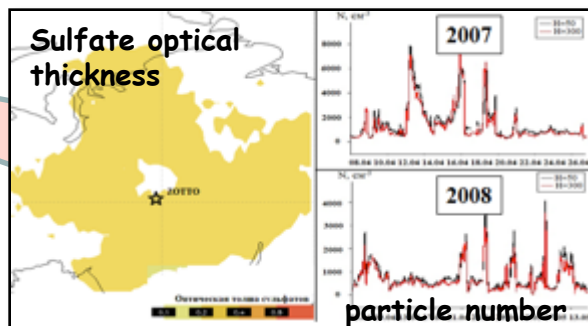
Measurements showed the concentrations are higher at 50m than at 300 m, with their ratio being highest in the number (1.3) and lowest in the volume concentrations (1.1). This suggests the presence of particle number sources near the ground.



# Seasonal cycle of atmospheric aerosols and possible sources

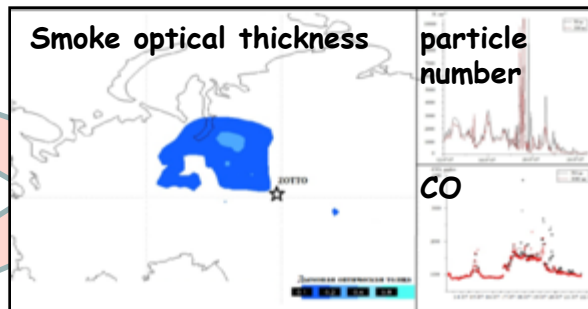


Winter and early spring - high aerosol values due to fossil fuel combustion, regional transport, and temperature stratification.



Suggested arctic haze phenomenon recorded at ZOTTO (April 2007, 2008)

Strong peaks in particle number and a possible annual maximum in April could be associated to the Arctic haze phenomenon.



Fires recorded at ZOTTO in July, 2007

Summer time - secondary particle sources from vegetation and particles from soil erosion.

The biomass burning emissions form particle number and volume peaks and the elevated absorption coefficients in July found.

Autumn - a decrease of particle number and volume found due to the large amount of rainy and foggy days led to air cleaning.

# Seasonal particle size distribution

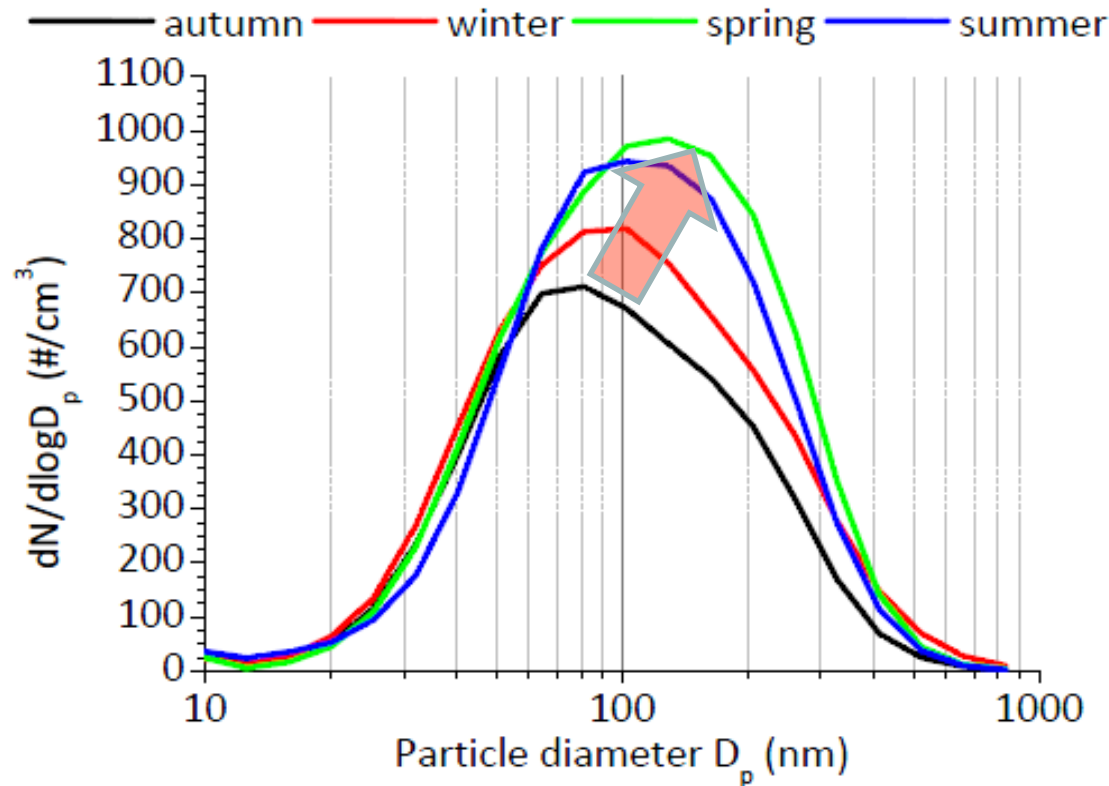
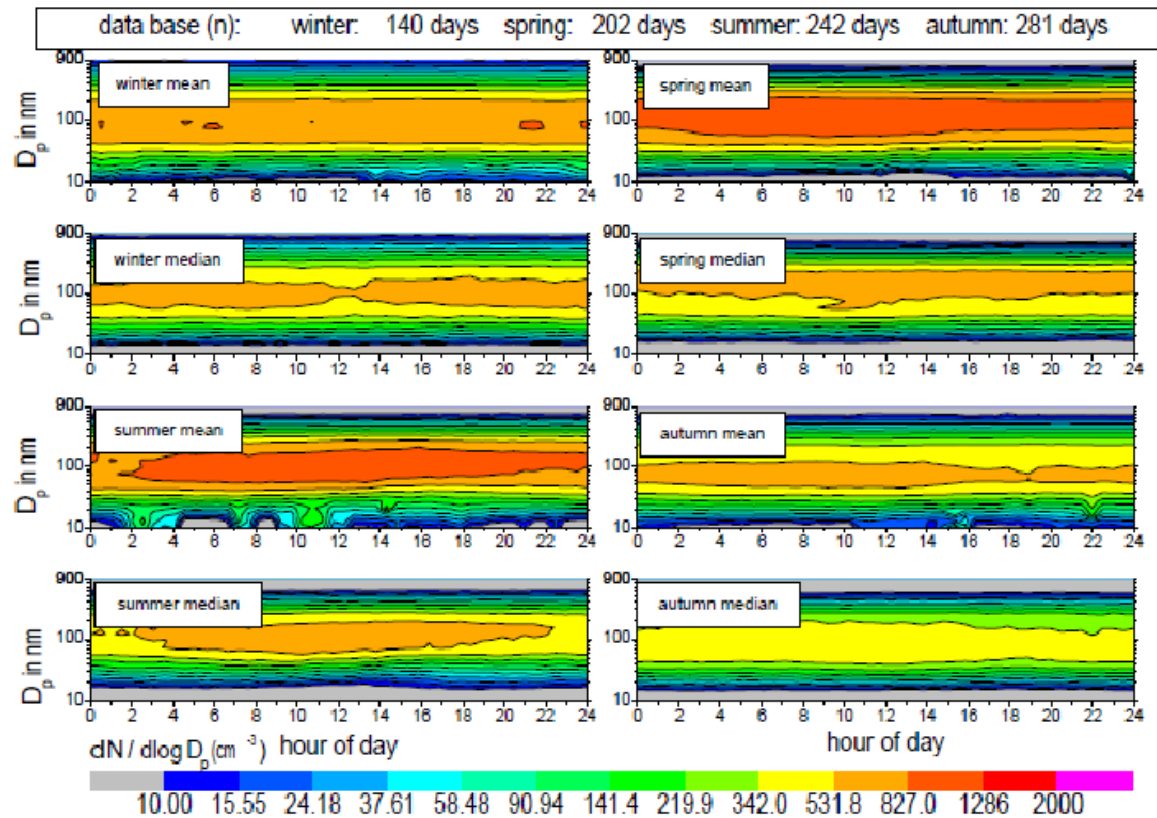


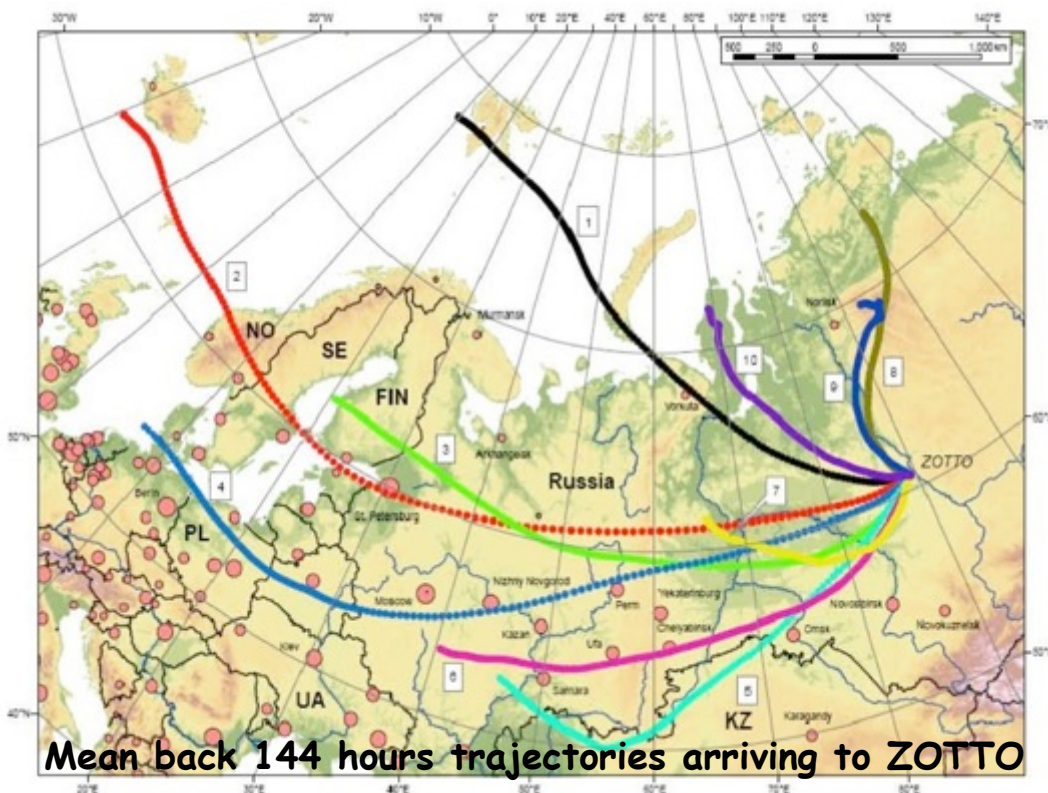
Figure supports the seasonal dependence of the particle number concentrations, showing averaged particle number size distributions for the four seasons on a linear scale. As there is almost no difference in particles <60 nm, the graphs split up for particles >60 nm. With higher total concentrations, the diameter with the highest concentrations is shifting from around 80 nm in autumn up to 120 nm in spring.

# Diurnal particle size distribution



**Fig. Mean and median diurnal particle size distributions**

The plots represent almost no diurnal trend with constant concentrations for every size channel throughout the day. Mean values are higher than the median. Only very low midday peaks occur in summer and autumn in the lowest size channels (mean values).



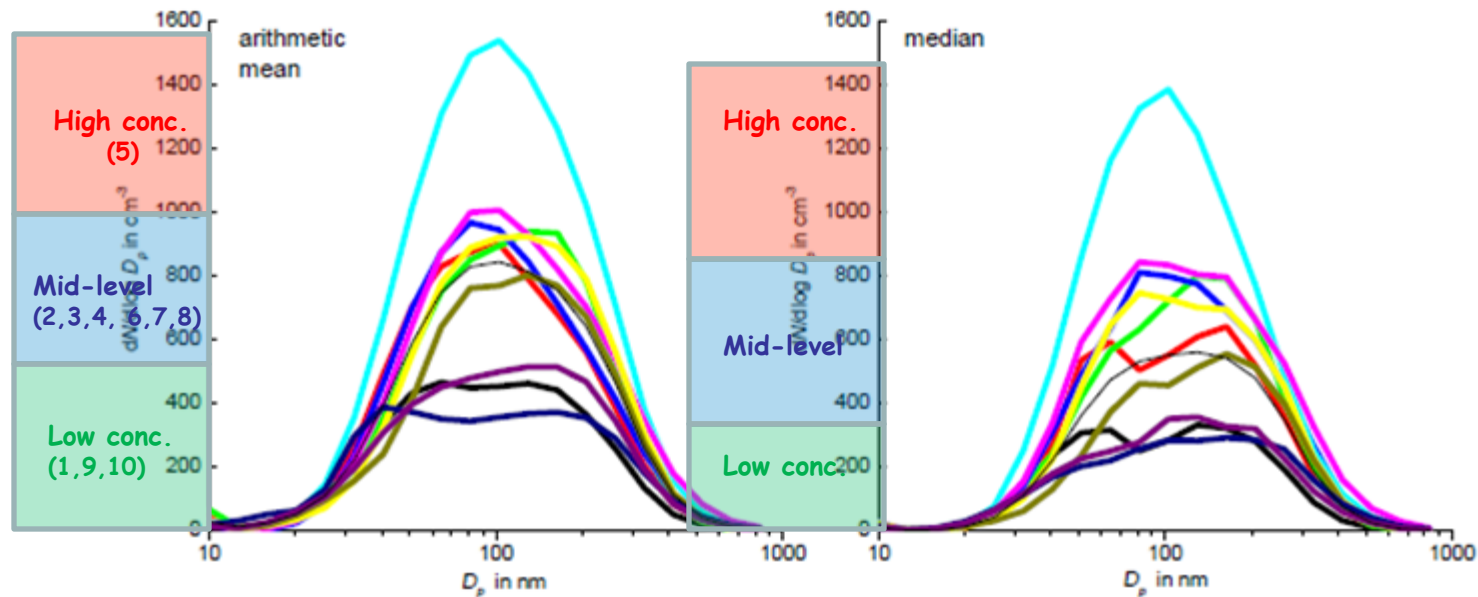
The back trajectories statistical analysis of four-year data record appeared to be an appropriate tool to validate the representativeness of the aerosol measurements at ZOTTO for Western part of Eurasia, but with only limitation at 100° E.

• **Low concentrations ( $400-500 \text{ cm}^{-3}$ ):** Air masses traveling from the Arctic ocean (AO) and coastal areas (Taimyr and Yamal) - clusters 1, 9 and 10.

• **Mid-level concentrations ( $600-800 \text{ cm}^{-3}$ ):** Trajectories originated from western directions and covering the vast area from Northern Atlantic to Central Asia - clusters 2, 3, 4, 6, 7, and for air masses going from AO coastal areas (Taimyr) in summer - cluster 8.

• **High concentrations ( $1200 \text{ cm}^{-3}$ ):** Air masses traveled in summer through the southern regions of the European part of Russia and Kazakhstan (cluster 5) with the large areas covered by croplands.

# Average particle size distributions for clusters



Most number size distributions exhibit a unimodal overall shape with a number concentration maximum around 100 nm. For the lower concentration clusters, a bimodal shape with a more obvious Hoppel minimum (Hoppel et al., 1990) between the Aitken and accumulation modes tends to emerge. Such distributions are indicative of remote background conditions where nucleation, growth by condensation and cloud processing are the dominant processes shaping the number size distribution.

# Conclusions

Average number and volume concentrations tend to be lower than those reported for boreal forest sites at similar latitude in Northern Europe (as reported by Tunved et al., 2005; Dal Maso et al., 2007).

For all integral parameters and all seasons the concentrations are higher at 50m than at 300 m, with their ratio being highest in number and lowest in volume concentrations. This suggests an impact of near-ground sources.

The back trajectories statistical analysis of four-year data record appeared to be a appropriate tool to validate the representativeness of the aerosol measurements at ZOTTO for Western part of Eurasia, but with only limitation at 100° E.

Our cluster analysis of back trajectories yielded ten clusters with basically three levels of particle concentration: Low concentrations (400–500 cm<sup>-3</sup>) in Arctic air masses, medium concentrations (600–800 cm<sup>-3</sup>) in zonally advected air masses from westerly directions, and high concentrations (1200 cm<sup>-3</sup>) in slowly moving air from the southernmost latitudes. Most number size distributions peaked around 100 nm.

# Acknowledgements

**ZOTTO Staff**

**ZOTTO Consortium:**

**V.N. Sukachev Institute of Forest, Krasnoyarsk, Russia**

**Max-Planck-Institute for biogeochemistry, Jena, Germany**

**Max-Planck-Institute for chemistry, Mainz, Germany**

**Leibniz Institute for Tropospheric Research, Leipzig, Germany**

**A.M. Obukhov Institute of Atmosphere Physics, Moscow, Russia**

**Sankt Petersburg State University, Sankt Petersburg, Russia**

**Siberian Federal University, Krasnoyarsk, Russia**

**International Science and Technology Center, Moscow, Russia**

