High natural aerosol loadings over boreal forest

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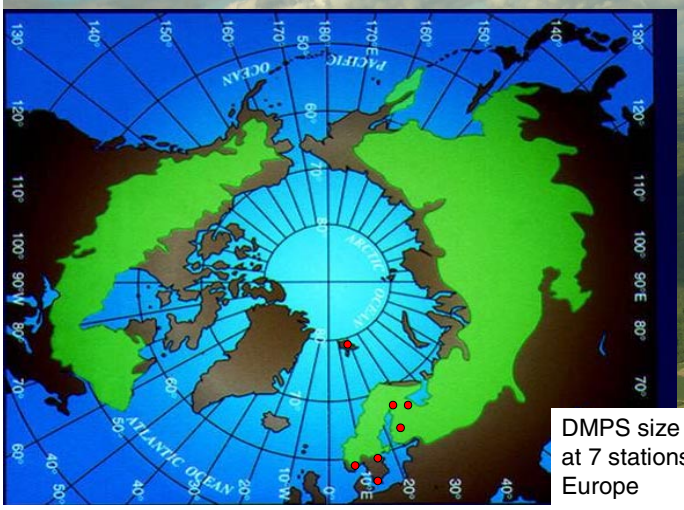
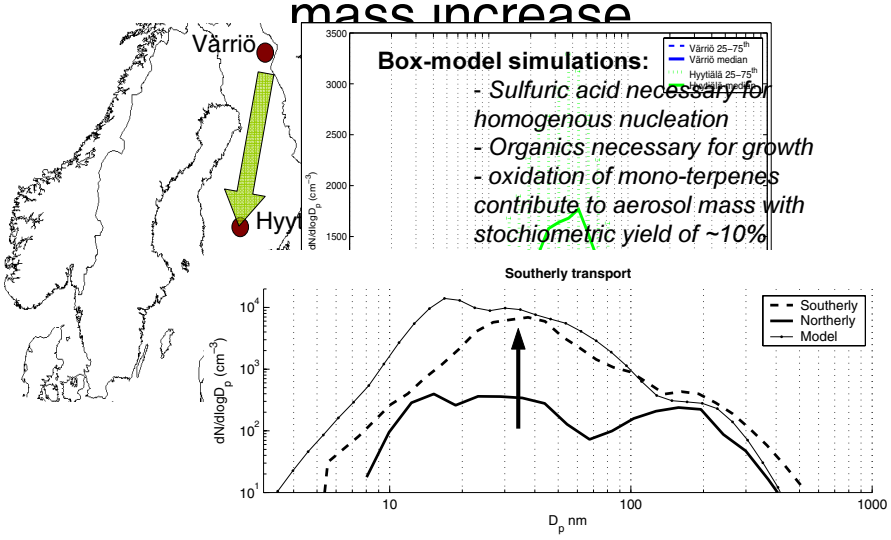
The boreal region



DMPS size distributions at 7 stations in northern Europe

Previous findings

Southerly transport: number and mass increase

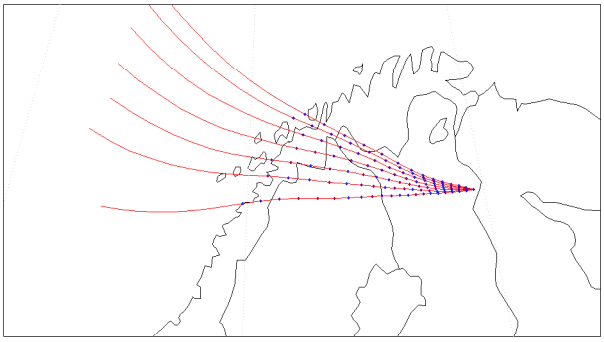


Statistical approach to see if what controls the particle size distribution

- Huge amount of data from three stations
  - Hyytiälä 1999-2004
  - Värriö 1999-2004
  - Pallas 1999-2004
- Huge amount of trajectories
  - 1h resolution back-trajectories (120h) for all three stations each hour through measurement period

Conceptual approach

- Trajectories will spend different time over land before reaching any station dependning on wind speed and transport path.

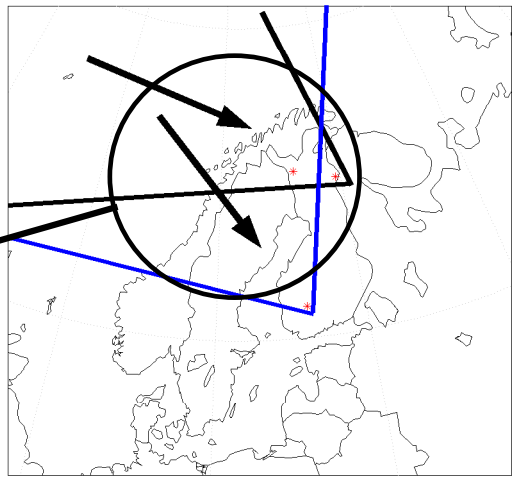


Each trajectory will spend a certain time over land, and thus over the sources

Natural sources??

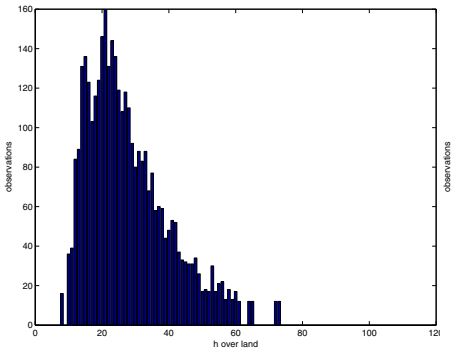
- Cleanest possible sectors selected (W-N)
- Trajectories describing transport within sectors more than 90% of the time selected

Non-zero,
but very low
population density
=
Small anthropogenic contributions



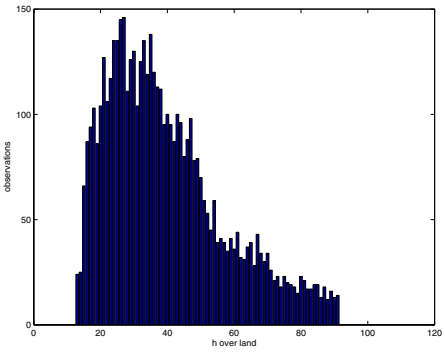
Distribution of trajectories

Värriö and Pallas



~4500 observations

Hyytiälä



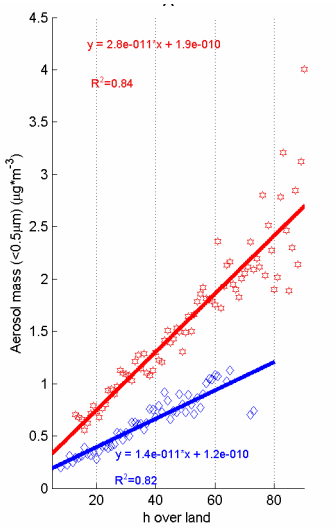
~5200 observations

Supporting data

- Each trajectory connected to hourly average size distribution at each receptor station
- In total, the approach result in 9700 transport cases connected to a size distribution and time spent over land

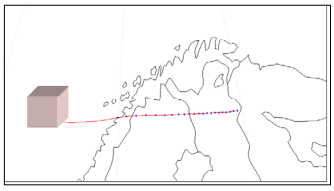
Any attempt to derive source strength of aerosols over land should first focus on the aerosol mass

- **Average of observations per hourly increment of time over land:**
  - ***0.028 µg*m^{-3}*h^{-1} Hyytiälä***
  - ***0.014 µg*m^{-3}*h^{-1} Värriö & Pallas***
- **Twice the mass increase at Hyyiälä**



Terpene emissions

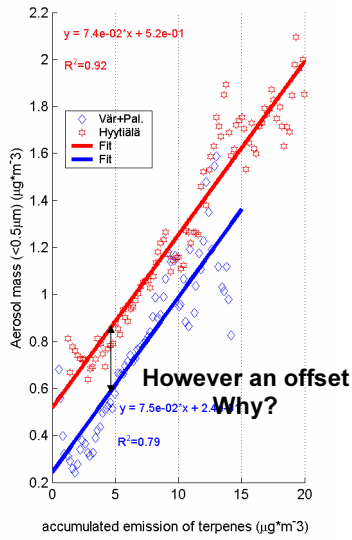
- Latitude dependent biomass density of spruce and pine over Finland (Laurila and Lindfors, 1999)
- Temperature dependent bulk emissions of mono-terpenes (Steinbrecher et al., 1999)
- Emissions of terpenes confined within lowermost 1 km of troposphere
- *Accumulated emission* along each trajectory during transport



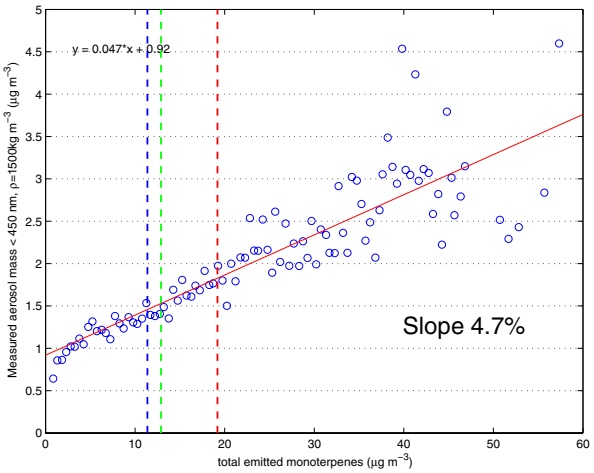
Mass evolution and emitted terpenes

- Better agreement between northerly and southerly stations using emitted terpenes as variable
  - **0.074 *µg*m^{-3}*µg$_{terp}^{-1}$ *m^{-3} Hyytiälä***
  - **0.075 *µg*m^{-3}*µg$_{terp}^{-1}$ *m^{-3} Vär. & Pal.***
- Assuming that lifetimes of terpenes are short (e.g. Hakola et al., 2003) → fraction of reacted terpenes found in the particle phase: an indirect measure of the **yield**

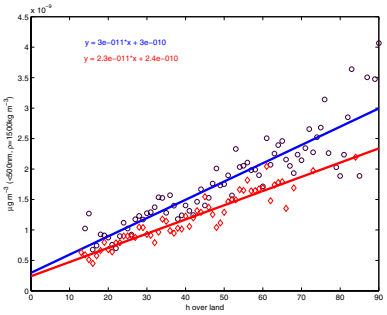
However: only "apparent yield" since we omit sinks and possibly other sources of aerosol mass



Repeated analysis with calculated mixing layer height

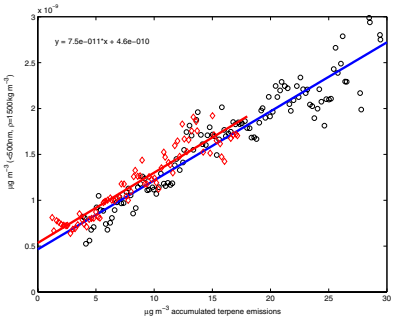


Further testing: Summer versus Spring & Autumn



Mass increase versus time over land: summer and spring and autumn

Deviating slopes!



Mass increase versus terpene emission: summer and spring and autumn

Identical slopes!

i.e. The fractional contribtuion of oxidation products to aerosol mass equally high during all three seasons. Equvalent behaviour for Pallas and Värriö.

Conclusions

- The boreal forest act to establish rapidly a typical number concentration of approximately 1000-2000 cm^{-3}
- The condensation growth is shown to be proportional to the natural emissions of mono-terpenes (or equivalent substances) giving an size distribution dominated by 50-100 nm particles (the climatically interesting size range for light scattering and as CCN)
- These findings facilitate calculations of the total climate forcing by anthropogenic particles