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Aerosol studies in Pallas

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Climate Change

Aerosol research team in FMI:

- Heikki Lihavainen, Mika Komppula, Antti Hyvärinen,

  Niku Kivekäs, Veijo Aaltonen, Eija Asmi, Yrjö Viisanen …

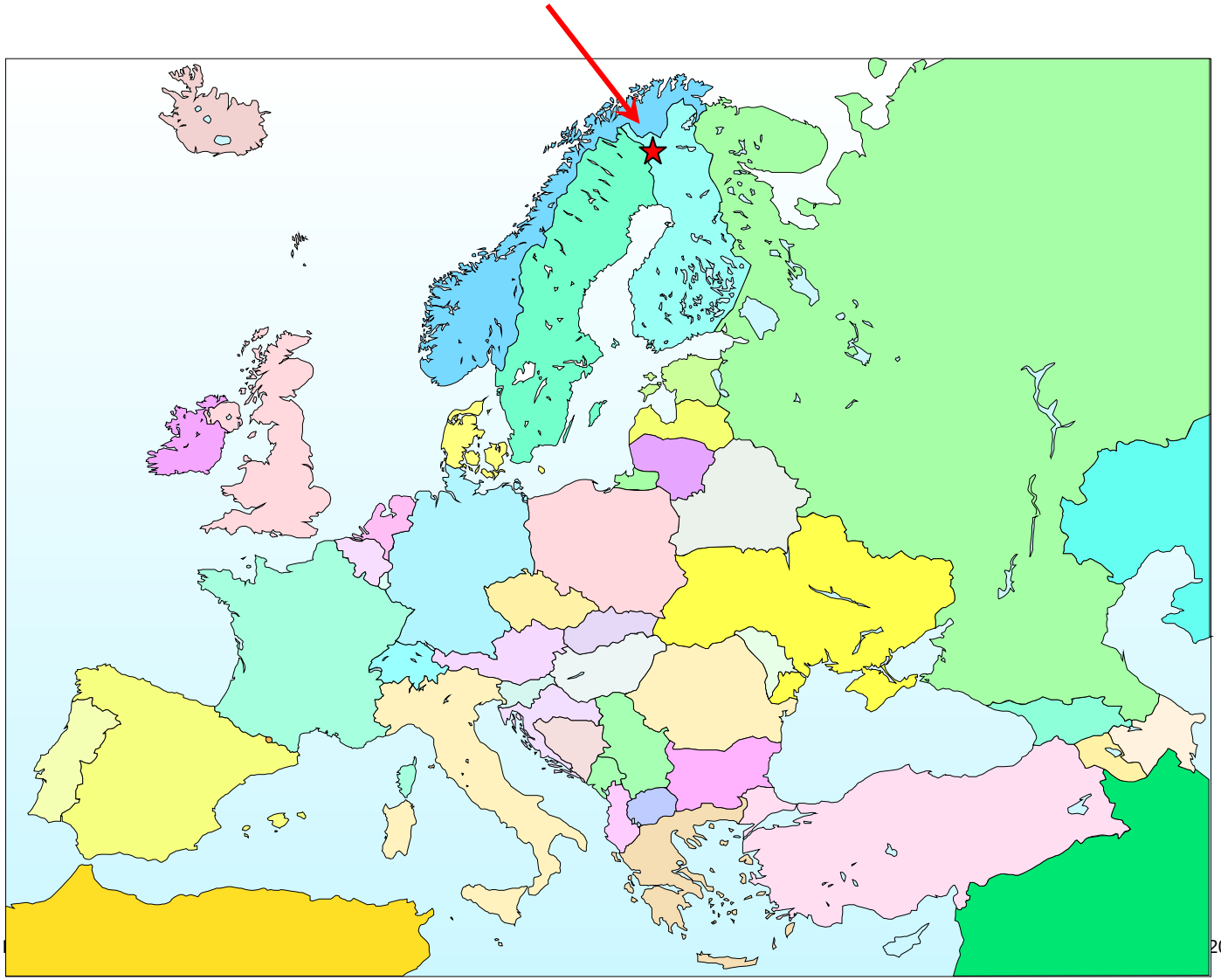
Co-operation:

- Finnish Forest Research Institute
- University of Helsinki
- University of Stockholm
- Paul Scherrer Institute…

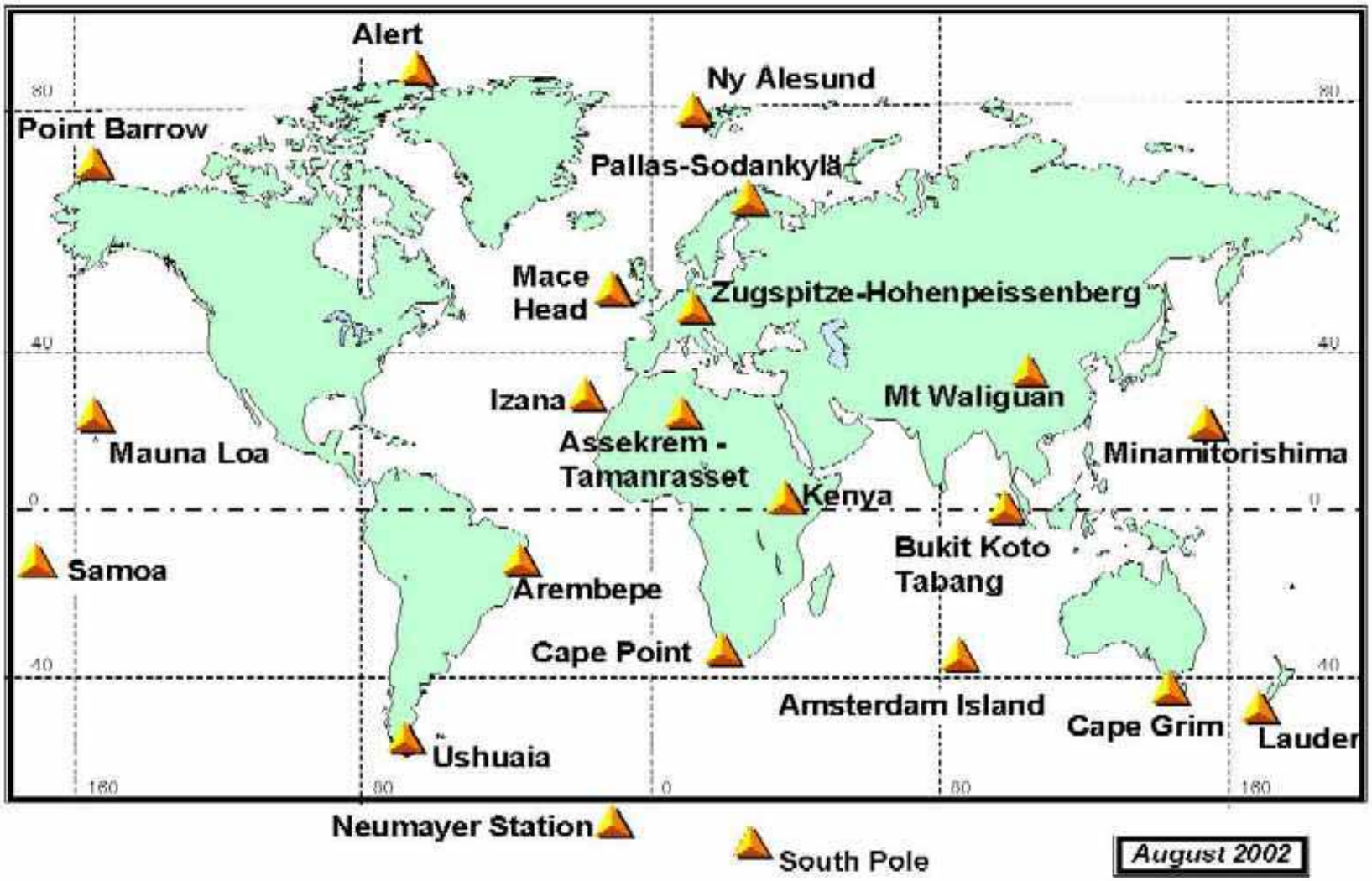
Contents

- Site description
- Atmospheric aerosol formation in Pallas
- Aerosol-cloud interaction studies
- Connection between aerosol formation and clouds
- Aerosol scattering properties
- Conclusions

Location of the Pallas station

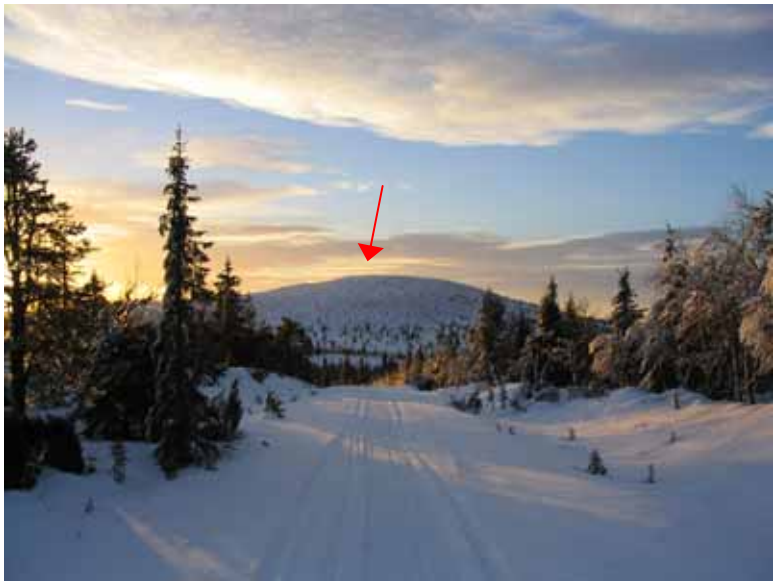


WORLD METEOROLOGICAL ORGANIZATION
GLOBAL ATMOSPHERE WATCH GLOBAL NETWORK



Sammaltunturi station (560 m asl, 67°58'N, 24°07'E)

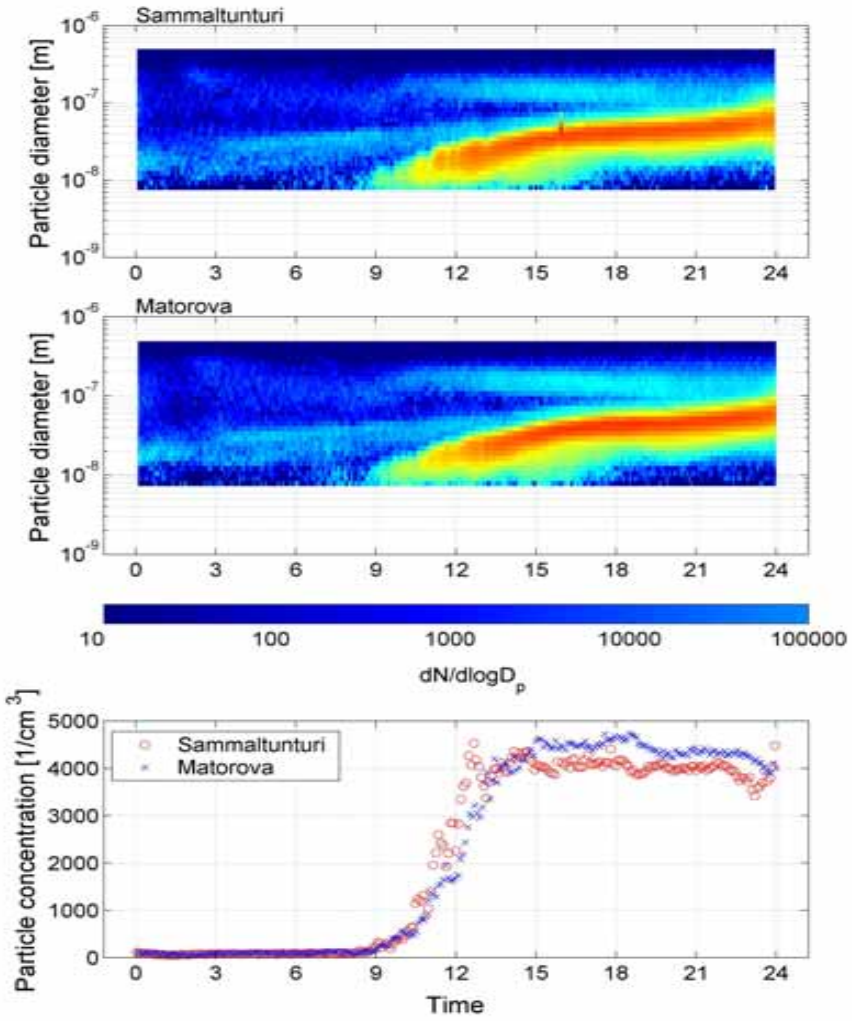
- the main station, located on the top of a hill
- 100 m above the tree line
- inside a cloud a few percent of time

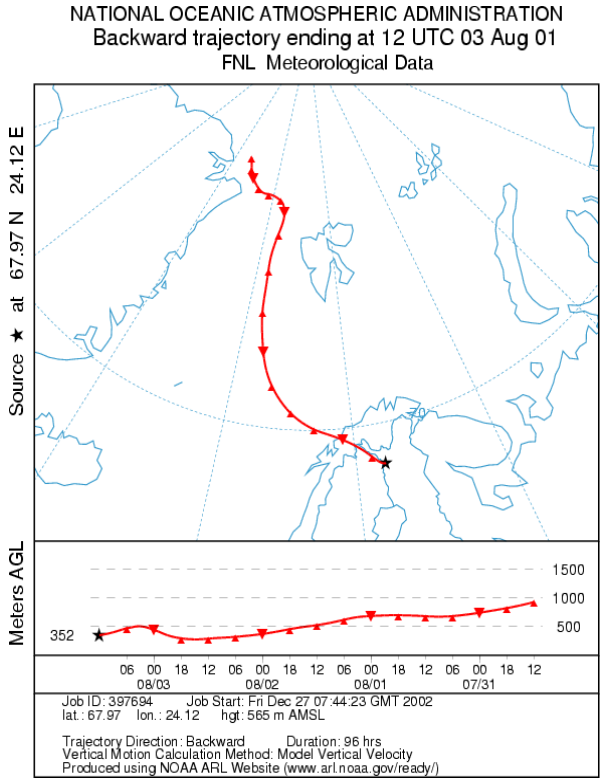


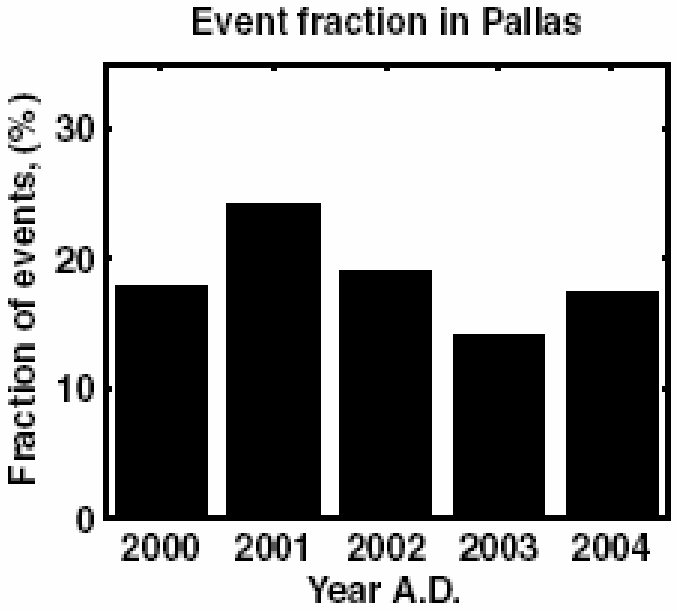
Matorova station (340 m asl, 68º00'N, 24º14'E)

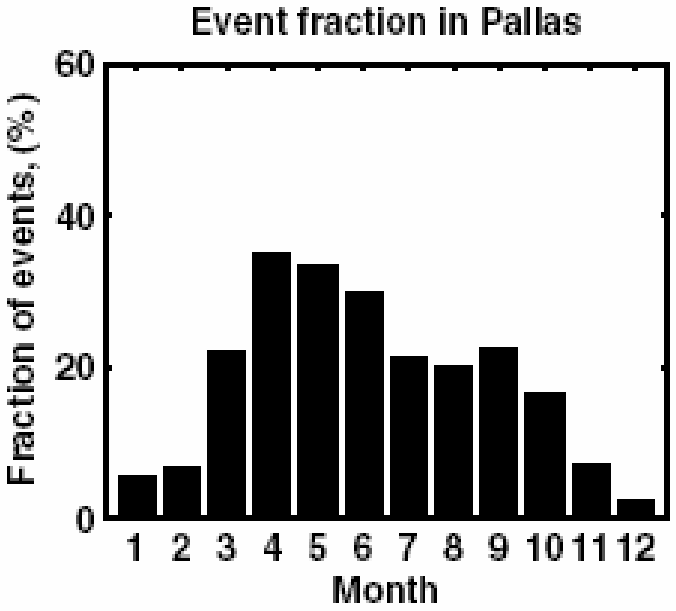
- in the middle of about 100×100-m forest clearing
- six kilometers away from the "in-cloud station"
- practically never inside a cloud

Atmospheric aerosol formation in Pallas







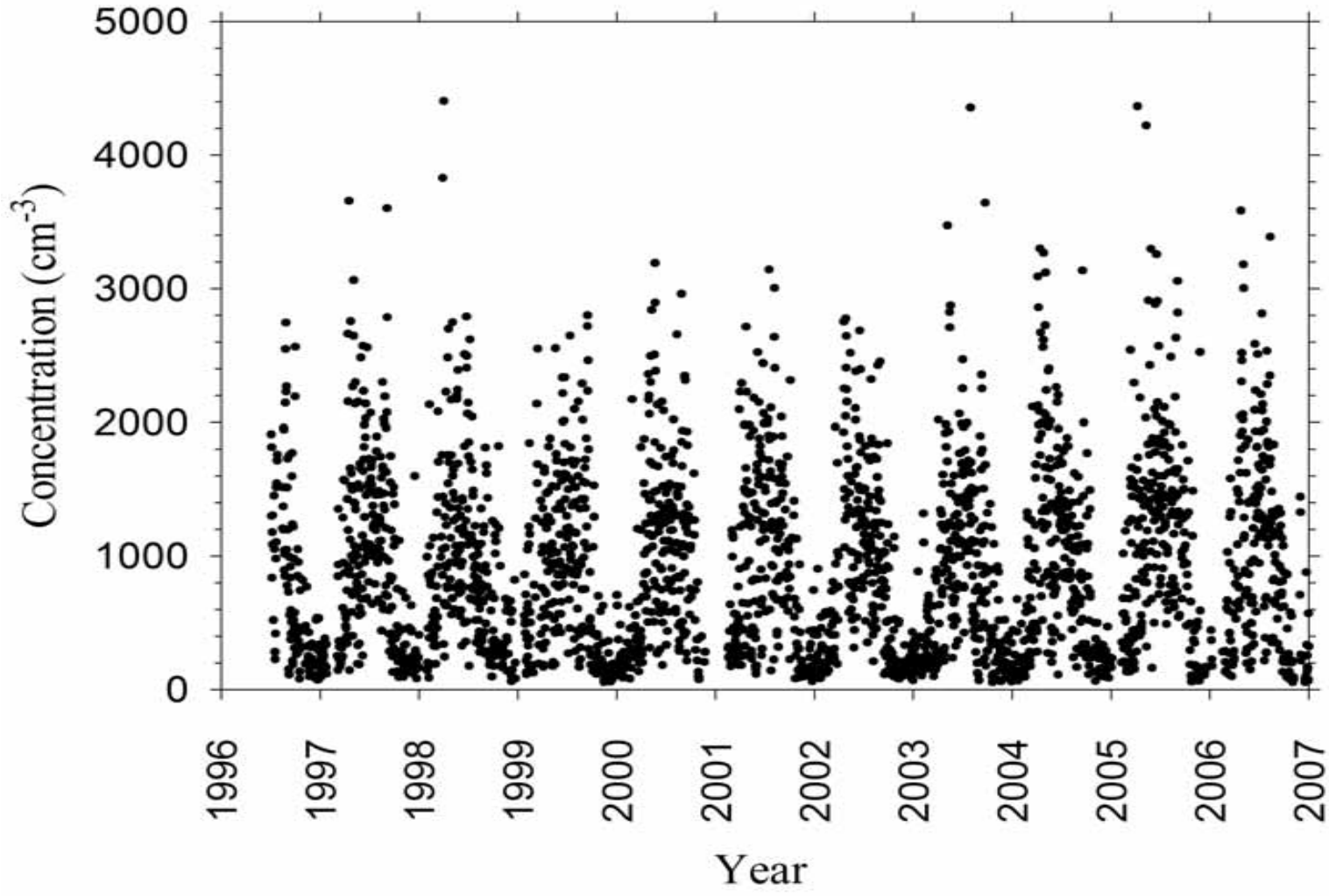


Tellus (2007), 59B, 350–361

Aerosol size distribution measurements at four Nordic field stations: identification, analysis and trajectory analysis of new particle formation bursts

By MIIKKA DAL MASO[1]*, LARISA SOGACHEVA[1], PASI P. AALTO[1], ILONA RIIPINEN[1], MIKA KOMPPULA[2], PETER TUNVED[2], LAURA KORHONEN[1], VILLE SUUR-USKI[1], ANNE HIRSIKKO[1], THEO KURTÉN[1], VELI-MATTI KERMINEN[2], HEIKKI LIHAVAINEN[2], YRJÖ VIISANEN[2], HANS-CHRISTEN HANSSON[3] and MARKKU KULMALA[1], [1]*Department of*

Daily-average total particle number concentrations in Pallas



Analysis:

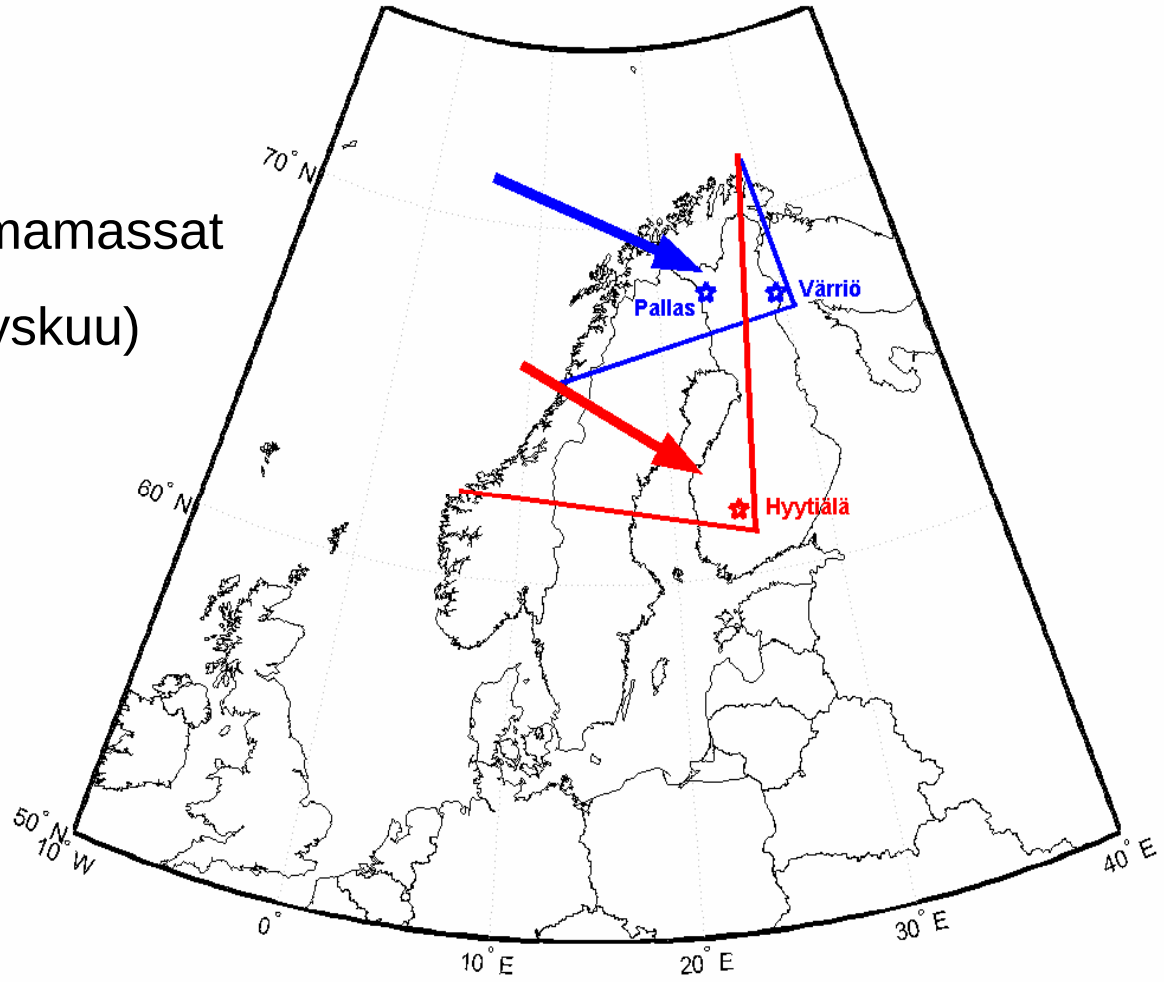
– valitaan ”puhtaat” ilmamassat

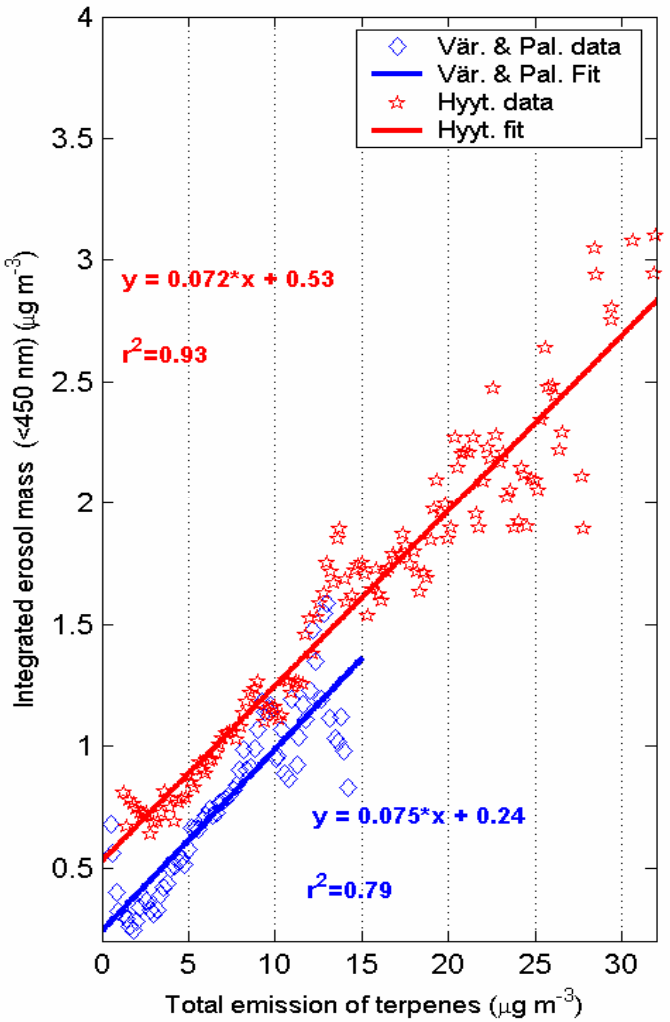
– kesäkausi (huhti-syyskuu)

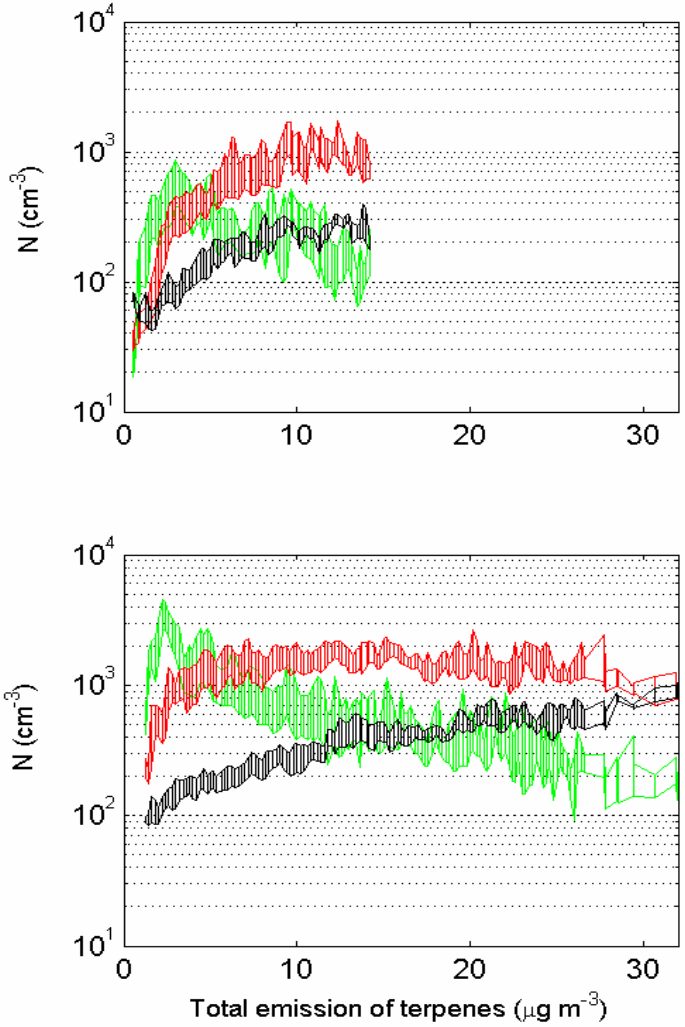
– aemat:

Pallas + Värriö

Hyytiälä




Vär. & Pal. data
Vär. & Pal. Fit
Hyyt. data
Hyyt. fit
y = 0.072*x + 0.53
r2=0.93
y = 0.075*x + 0.24
r2=0.79
Integrated erosol mass (<450 nm) (μg m-3)
Total emission of terpenes (μg m-3)


N (cm-3)
Total emission of terpenes (μg m-3)

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High Natural Aerosol Loading over Boreal Forests

P. Tunved,[1*] H.-C. Hansson,[1] V.-M. Kerminen,[2] J. Ström,[1] M. Dal Maso,[3] H. Lihavainen,[2] Y. Viisanen,[2] P. P. Aalto,[3] M. Komppula,[2] M. Kulmala[3]

Aerosols play a key role in the radiation balance of the atmosphere. Here, we present evidence that the European boreal region is a substantial source of both aerosol mass and aerosol number. The investigation supplies a straightforward relation between emissions of monoterpenes and gas-to-particle formation over regions substantially lacking in anthropogenic aerosol sources. Our results show that the forest provides an aerosol population of 1000 to 2000 particles of climatically active sizes per cubic centimeter during the late spring to early fall period. This has important implications for radiation budget estimates and relevancy for the evaluation of feedback loops believed to determine our future climate.

- Northern European boreal forest are able to maintain a ”natural” background aerosol particle population over a large fraction of year (5-6 months)

- The background particle number concentration is substantial, about 1000-2000 particles/cc

- The background is much larger than that observed in remote marine areas or in Amazonian forest

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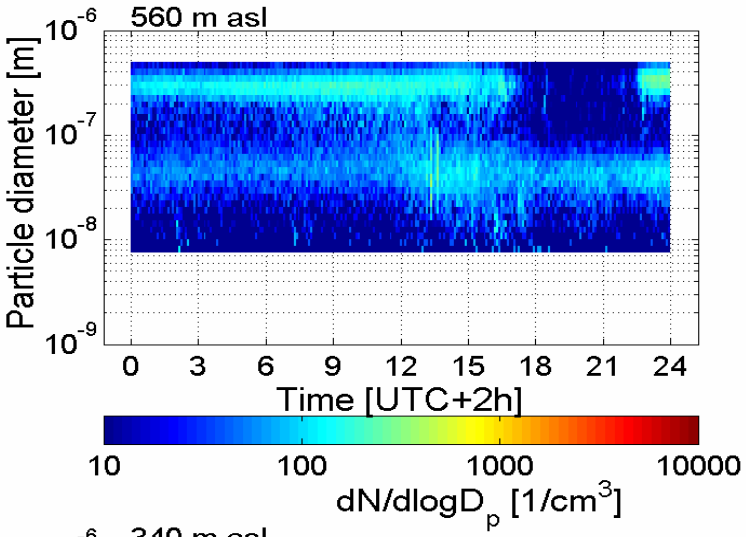
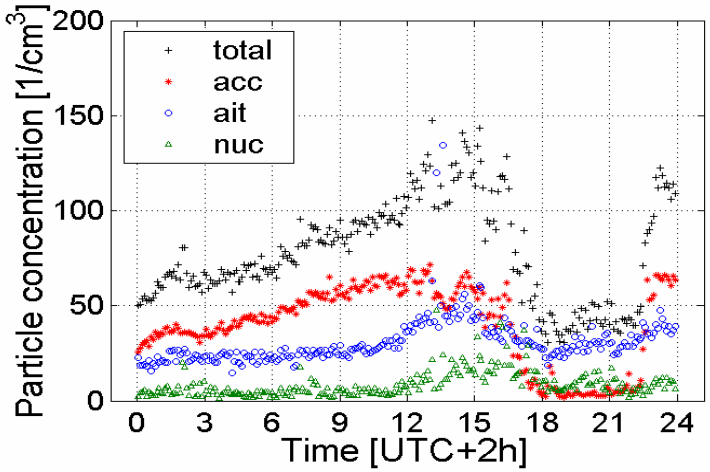
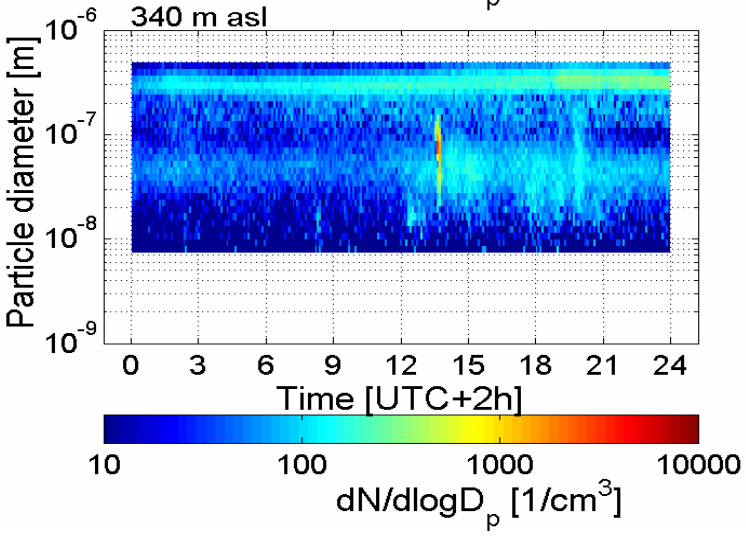
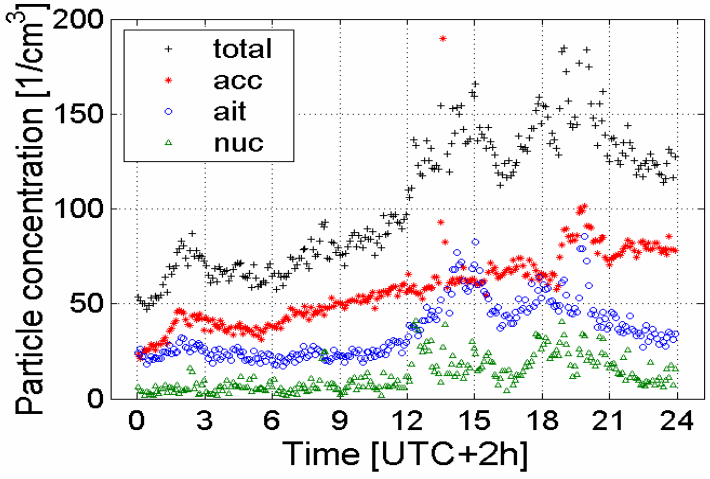
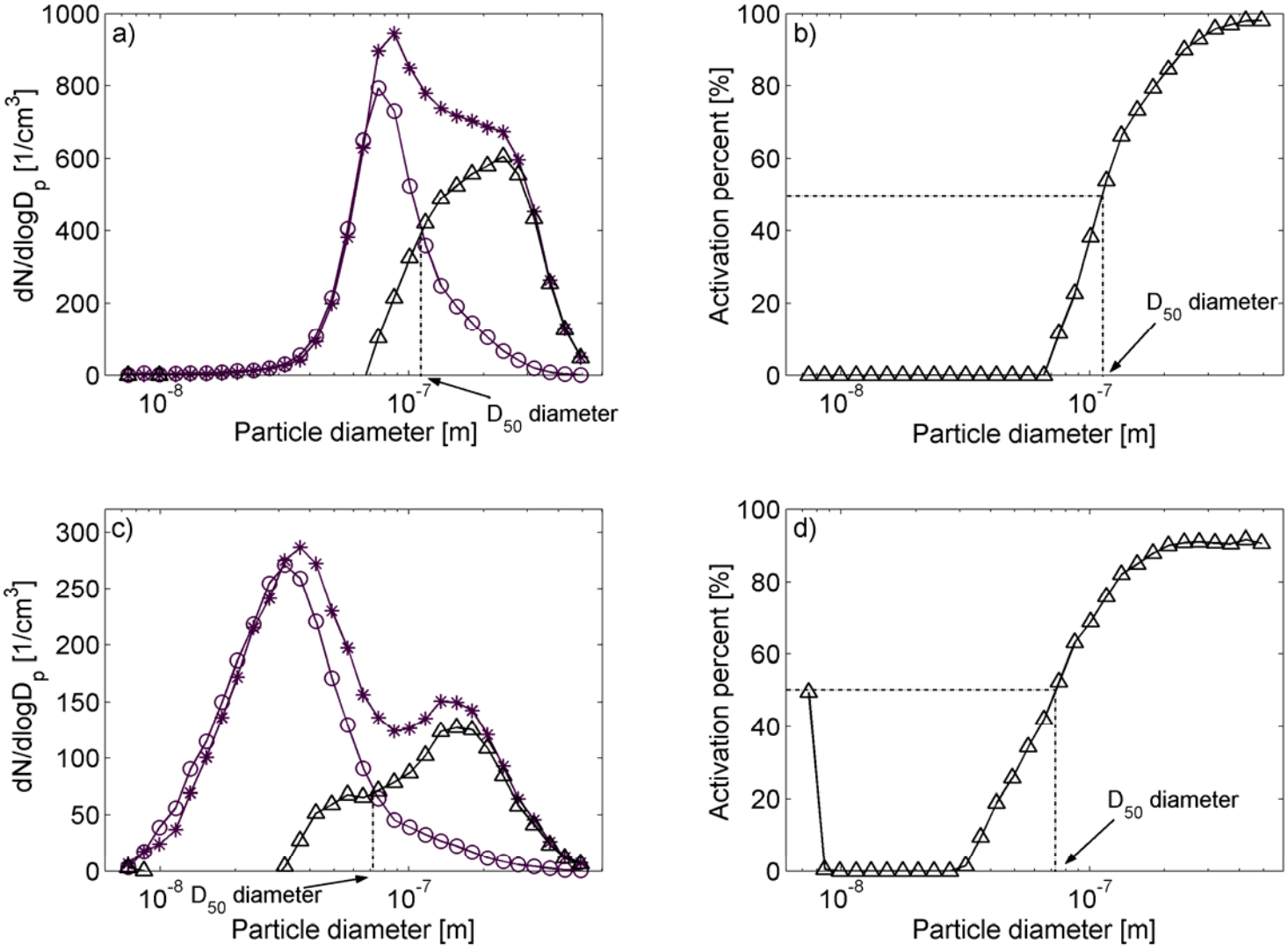
Aerosol-cloud interaction studies in Pallas



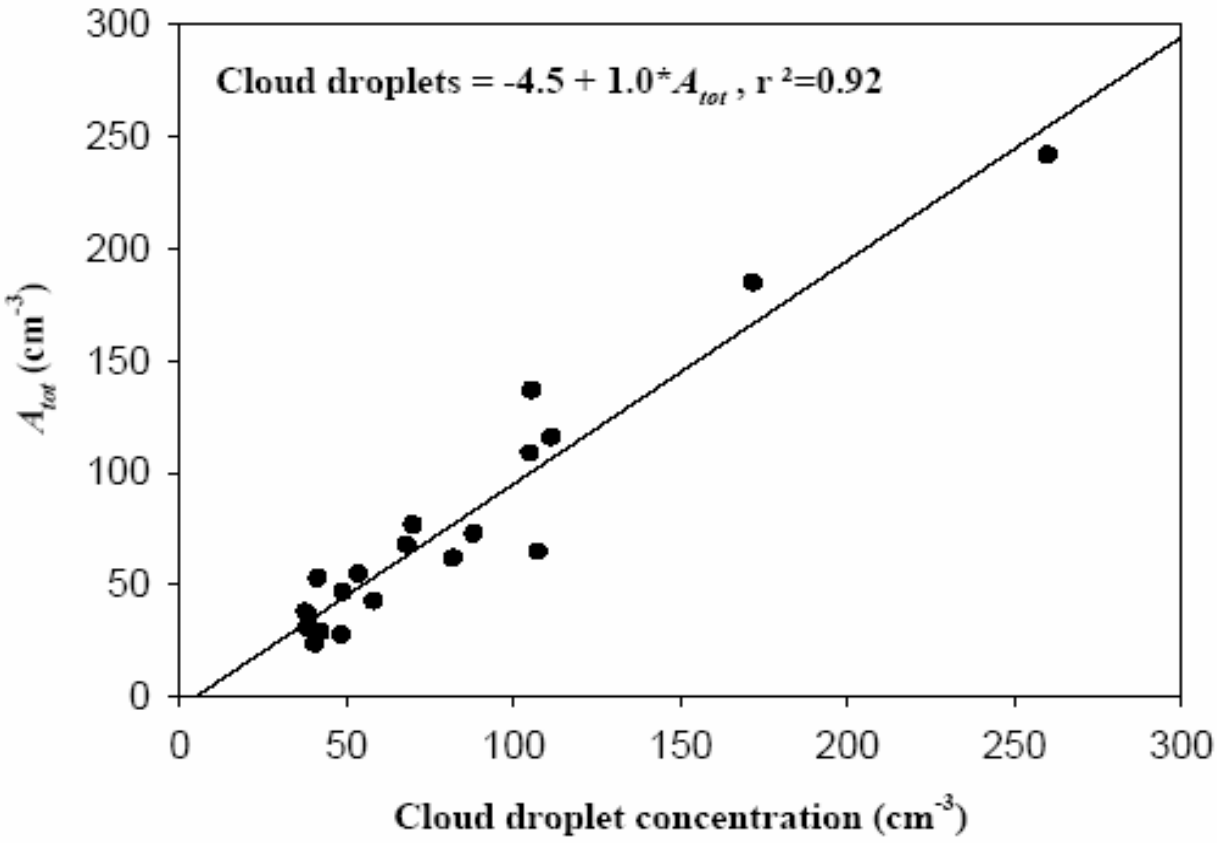







a)
dN/dlogD_p [1/cm^3]
Particle diameter [m]
D_50 diameter
b)
Activation percent [%]
Particle diameter [m]
D_50 diameter
c)
dN/dlogD_p [1/cm^3]
Particle diameter [m]
D_50 diameter
d)
Activation percent [%]
Particle diameter [m]
D_50 diameter

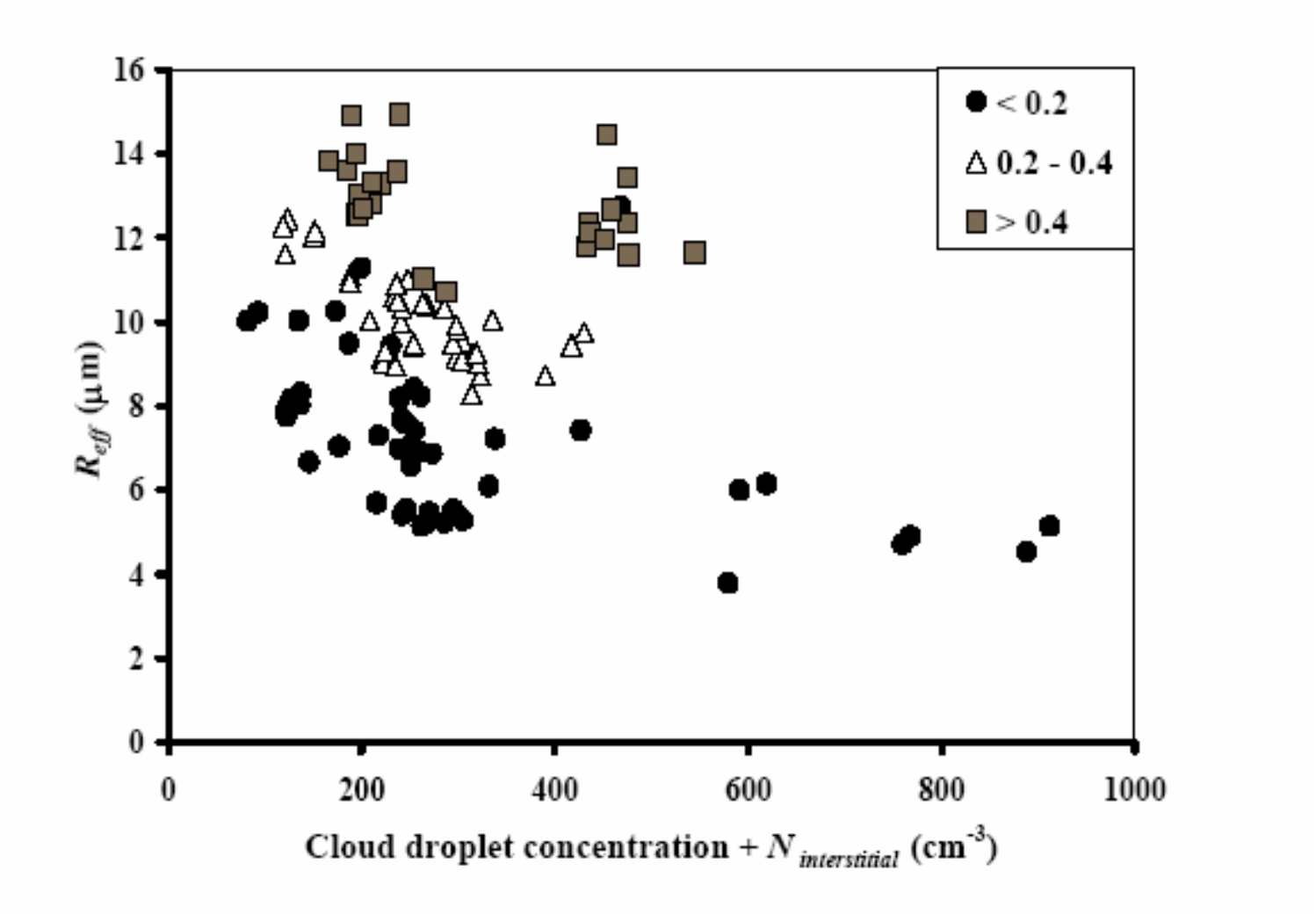
Comparison between ”calculated” and directly measured cloud droplet number concentrations



General character of clouds based on >40 cloud events, classified by the degree of pollution (particle number):

Total particle number concentration (cm^{-3})	**Cloud droplet number concentration (cm^{-3})**	**Activated fraction of particles (%)**	**"Effective" activation diameter (nm)**
<150	**66**	**60**	**71**
150-300	**97**	**49**	**78**
300-600	**181**	**41**	**85**
>600	**290**	**34**	**87**
Average	**154**	**47**	**80**

Komppula M., Lihavainen H., Kerminen V.-M., Kulmala M. and Viisanen Y. (2005) *J. Geophys. Res.* **110**, D06204, doi:10.1029/2004JD005200.

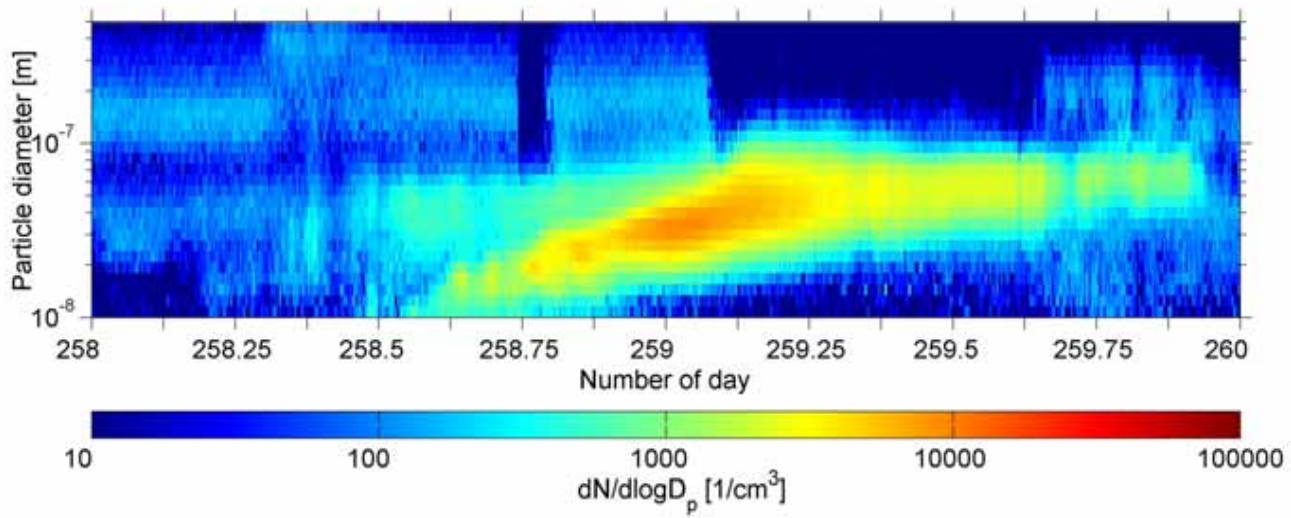

16
14
12
10
8
6
4
2
0
R_{eff} (µm)
0
200
400
600
800
1000
Cloud droplet concentration + $N_{interstitial}$ (cm^{-3})
< 0.2
0.2 - 0.4
> 0.4

Enhanced aerosol particle concentrations in Pallas…

– increase the cloud droplet number concentrations and by that way the cloud albedo (first indirect effect)

– decrease the cloud droplet effective radius and by that way is likely to alter the rain forming potential of clouds (second indirect effect)

Connection between aerosol formation and clouds



GEOPHYSICAL RESEARCH LETTERS, VOL. 32, L14803, doi:10.1029/2005GL023130, 2005

Direct observational evidence linking atmospheric aerosol formation and cloud droplet activation

Veli-Matti Kerminen,[1] Heikki Lihavainen,[1] Mika Komppula,[1] Yrjö Viisanen,[1] and Markku Kulmala[2]

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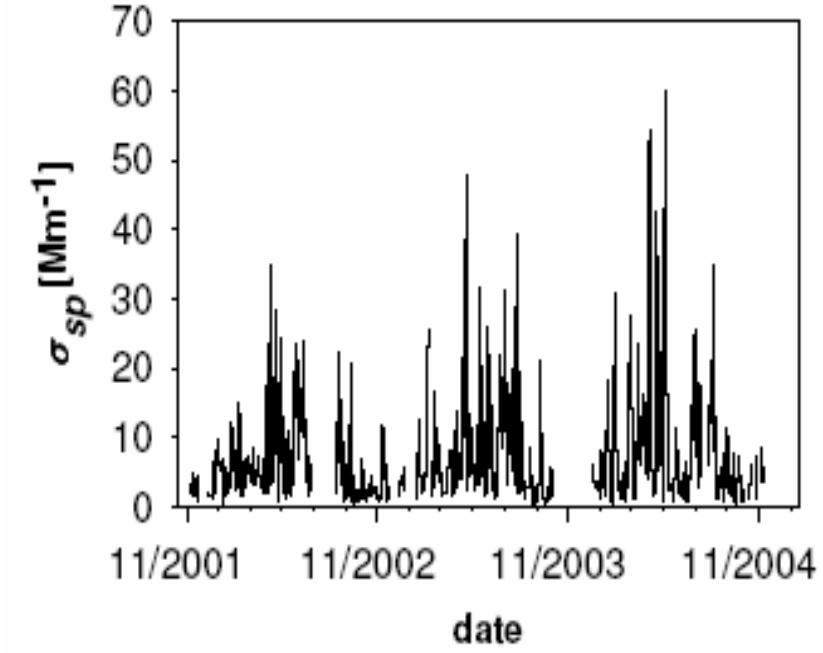
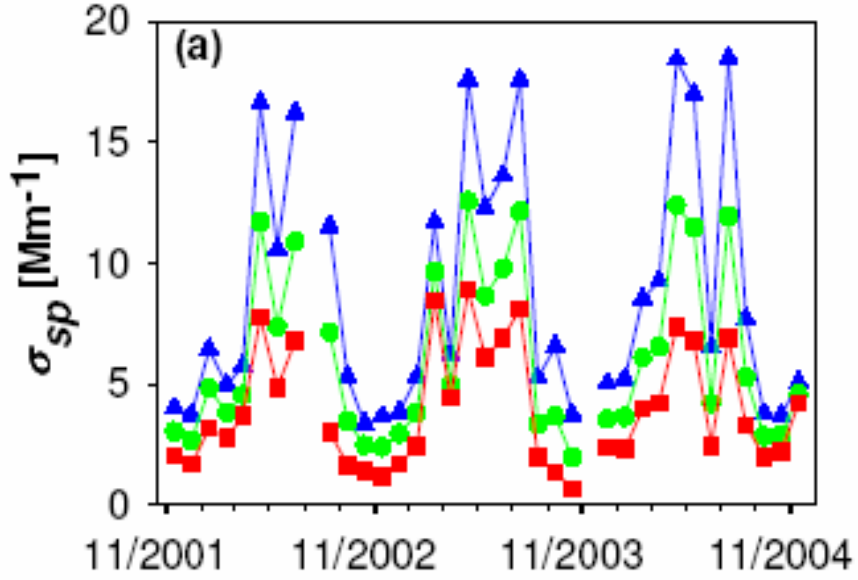
Aerosol scattering coefficient in Pallas

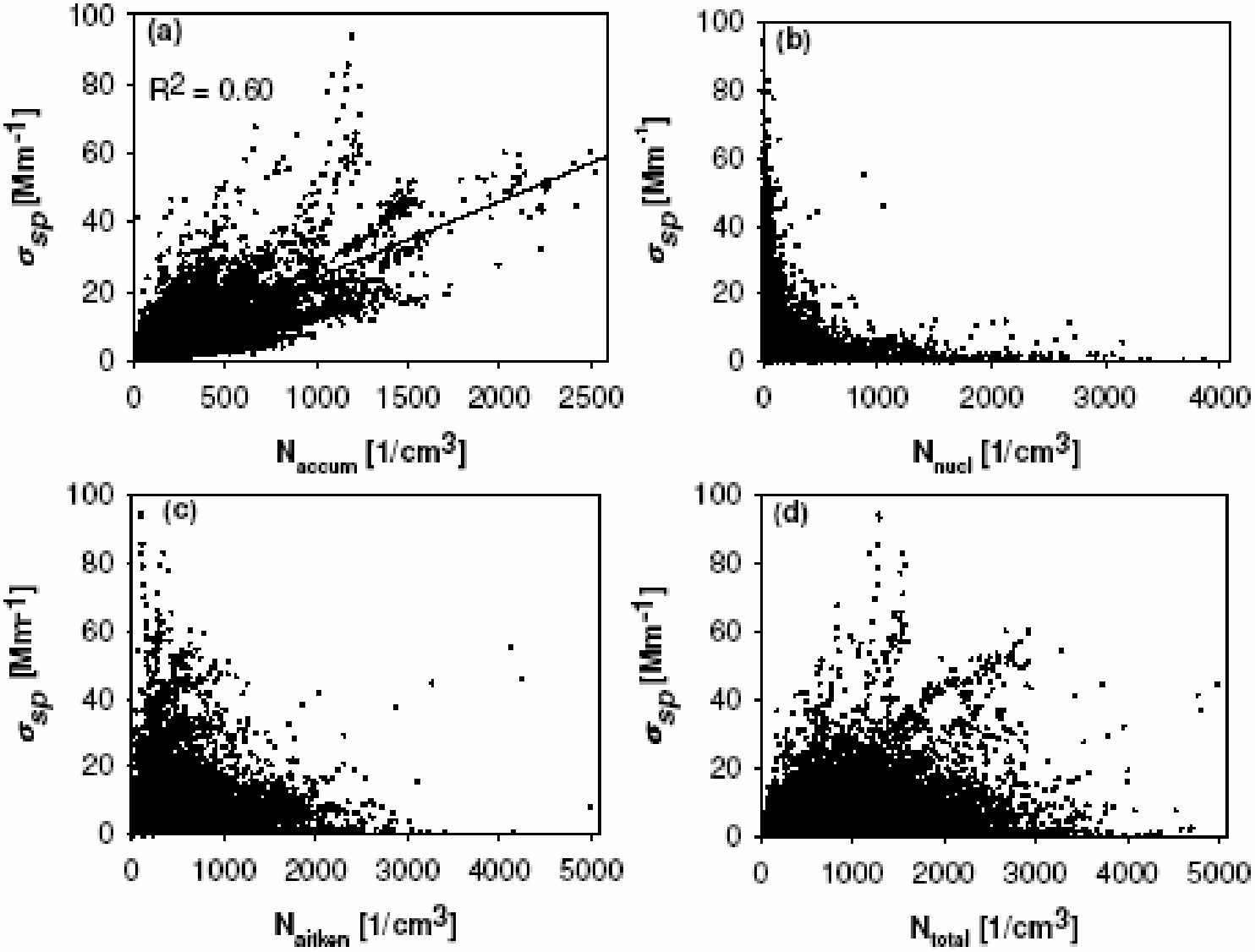


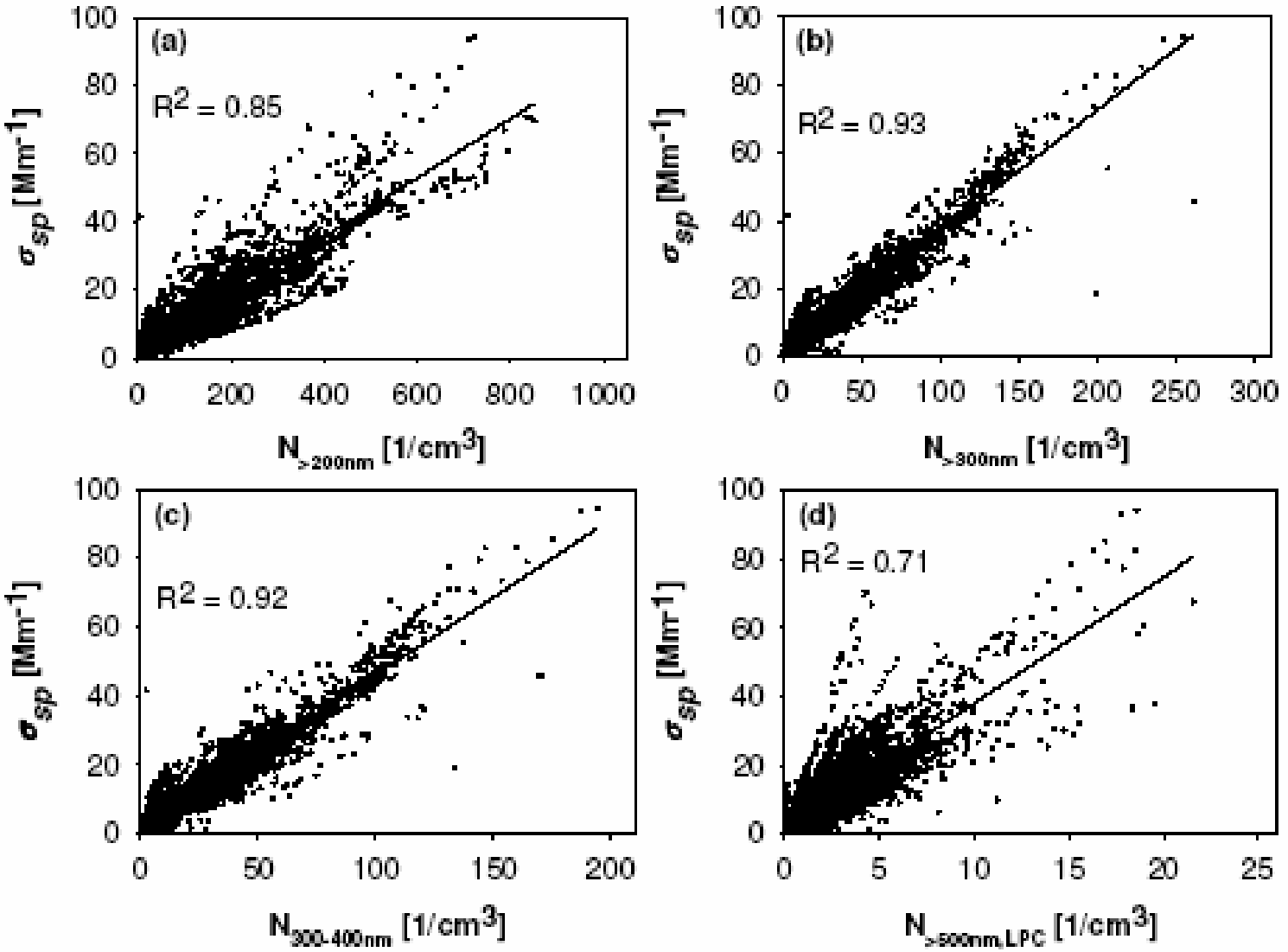


Measurements of optical properties of atmospheric aerosols in Northern Finland

Atmos. Chem. Phys., 6, 1155–1164, 2006
www.atmos-chem-phys.net/6/1155/2006/

V. Aaltonen[1], H. Lihavainen[1], V.-M. Kerminen[1], M. Komppula[1], J. Hatakka[1], K. Eneroth[2], M. Kulmala[3], and Y. Viisanen[1]


(a)
R2 = 0.60
σsp [Mm-1]
Naccum [1/cm3]
(b)
Nnucl [1/cm3]
(c)
Naitken [1/cm3]
(d)
Ntotal [1/cm3]


(a)
R2 = 0.85
σsp [Mm-1]
N>200nm [1/cm3]
(b)
R2 = 0.93
σsp [Mm-1]
N>300nm [1/cm3]
(c)
R2 = 0.92
σsp [Mm-1]
N300-400nm [1/cm3]
(d)
R2 = 0.71
σsp [Mm-1]
N>500nm,LPC [1/cm3]

Conclusions (1)

- Continuous aerosol measurements (>5 years) in Pallas and two other stations in Finland and Sweden have demonstrated that the boreal forest in Northern Europe maintains a substantial background aerosol population (1000-2000 particles/cc) during a large part of the year

Conclusions (2)

- Measurements in Pallas show further that particles formed in the atmosphere contribute to the cloud droplet population, indicating a connection between atmospheric aerosol formation and cloud properties

Conclusions (3)

- Aerosol scattering in Pallas is highest in air masses affected by distant anthropogenic sources, when relatively large (>200 nm in diameter) and aged aerosol particles are transported to the site

Conclusions (4)

- While aerosol scattering and absorption properties (direct effects) are affected mostly by anthropogenic sources in Pallas, aerosol-cloud interactions (indirect effects) are affected also by natural aerosols, especially by boreal forests