



Particle formation in the troposphere from up to 12 km from CPC observations with the DLR Falcon research aircraft

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in der Helmholtz-Gemeinschaft

Institut für Physik der Atmosphäre

Main question:

Where in the vertical column of the troposphere does particle formation (particles > 4 nm) occur?

Data:

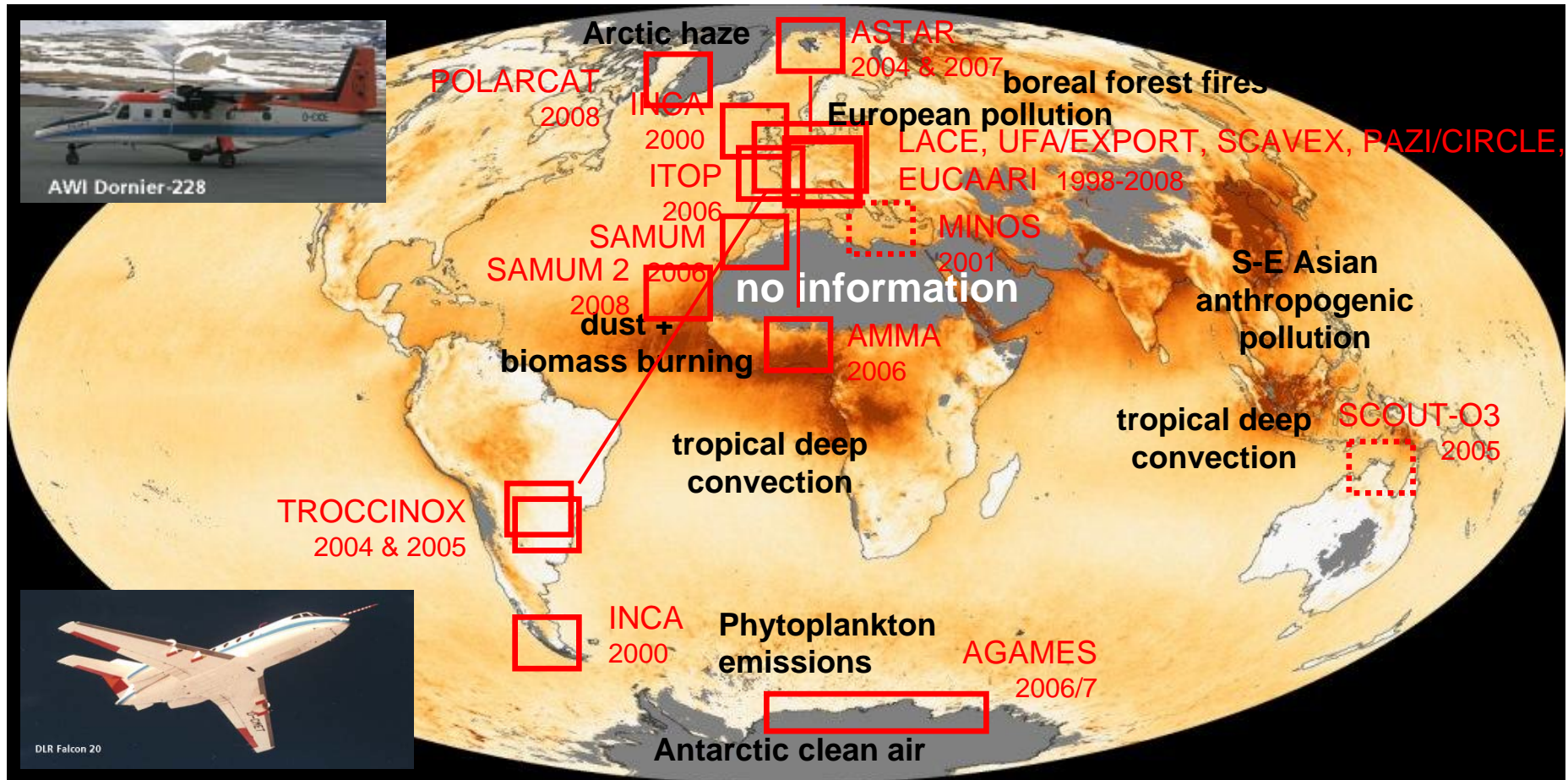
Multi-channel Butanol-CPCs flown on the DLR Falcon aircraft (in polar regions also on AWI Dornier-228)

Information is available (only) from CPCs with cut-off >4 and >10 nm (sometimes >5 and >14 nm)

This presentation:

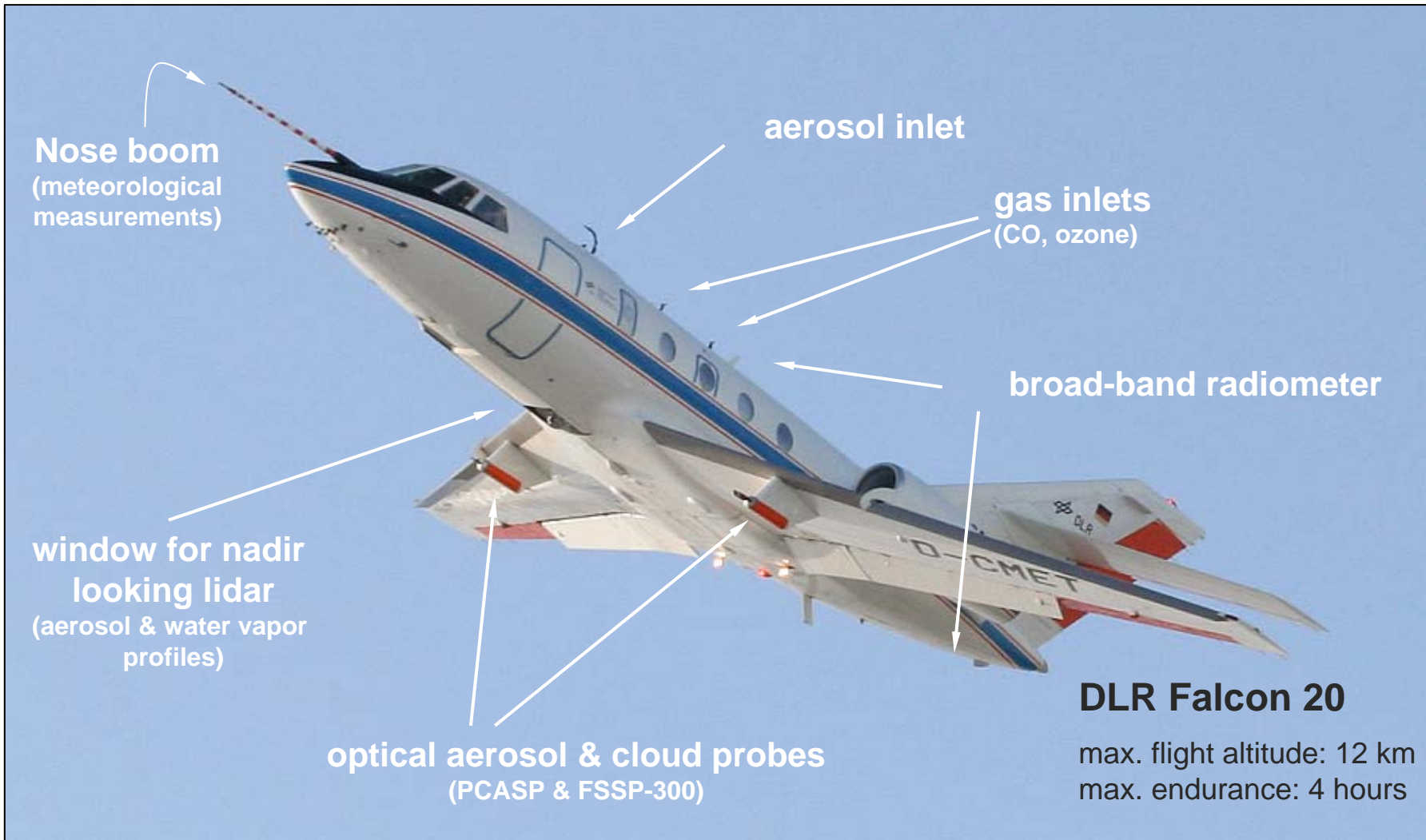
Not much analysis, just a collection of observations made during various field campaigns (campaigns were in general all targeted at other objectives)

Aircraft field experiments with DLR aerosol measurements



2006 annual average of MODIS AOT (@ 550 nm)

<http://climate.gsfc.nasa.gov/viewImage.php?id=199>
Image of the Week - February 18, 2007

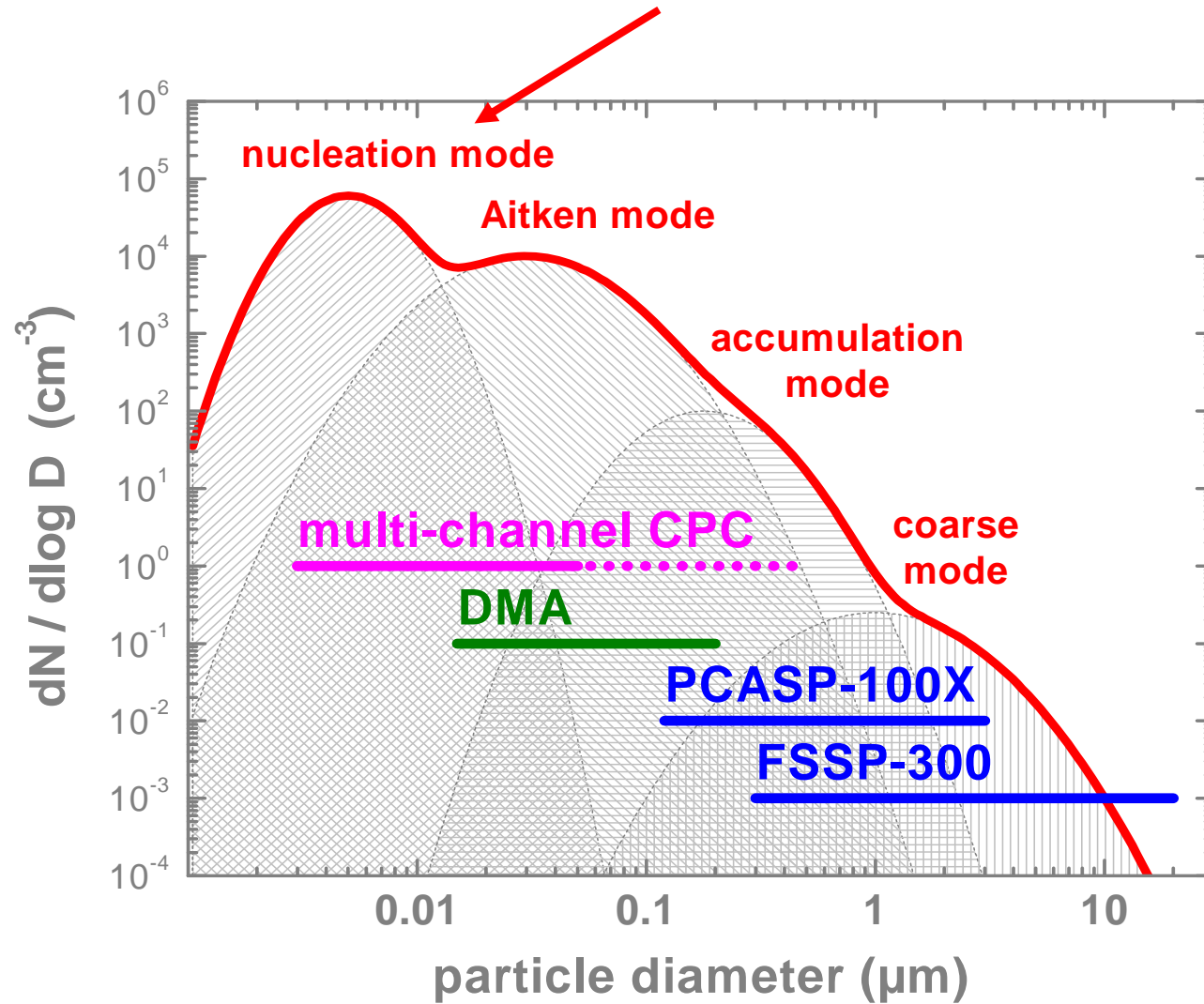




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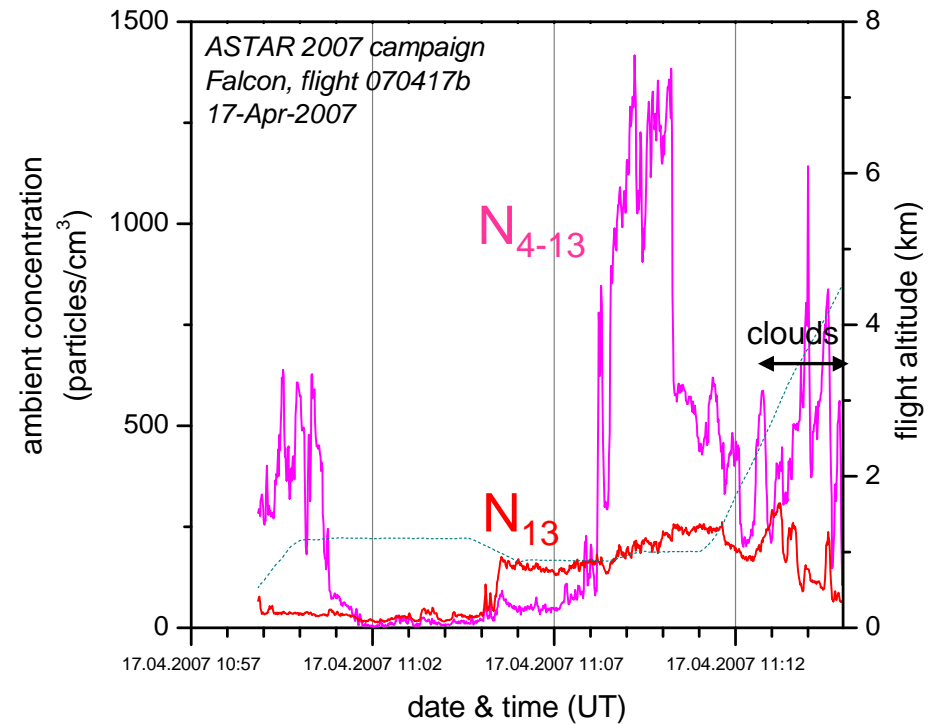
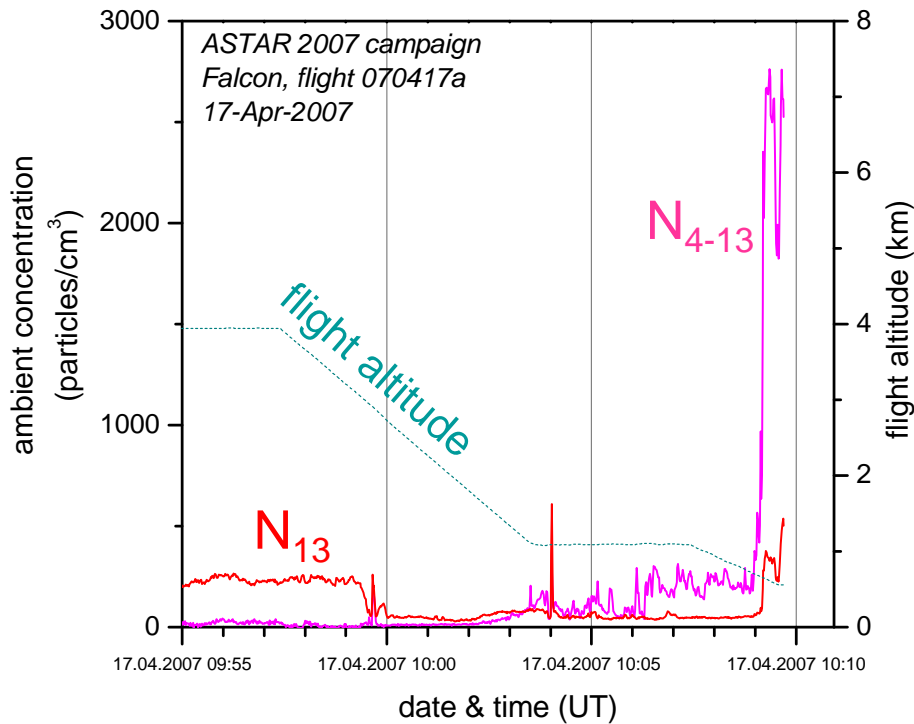
Aerosol instrumentation





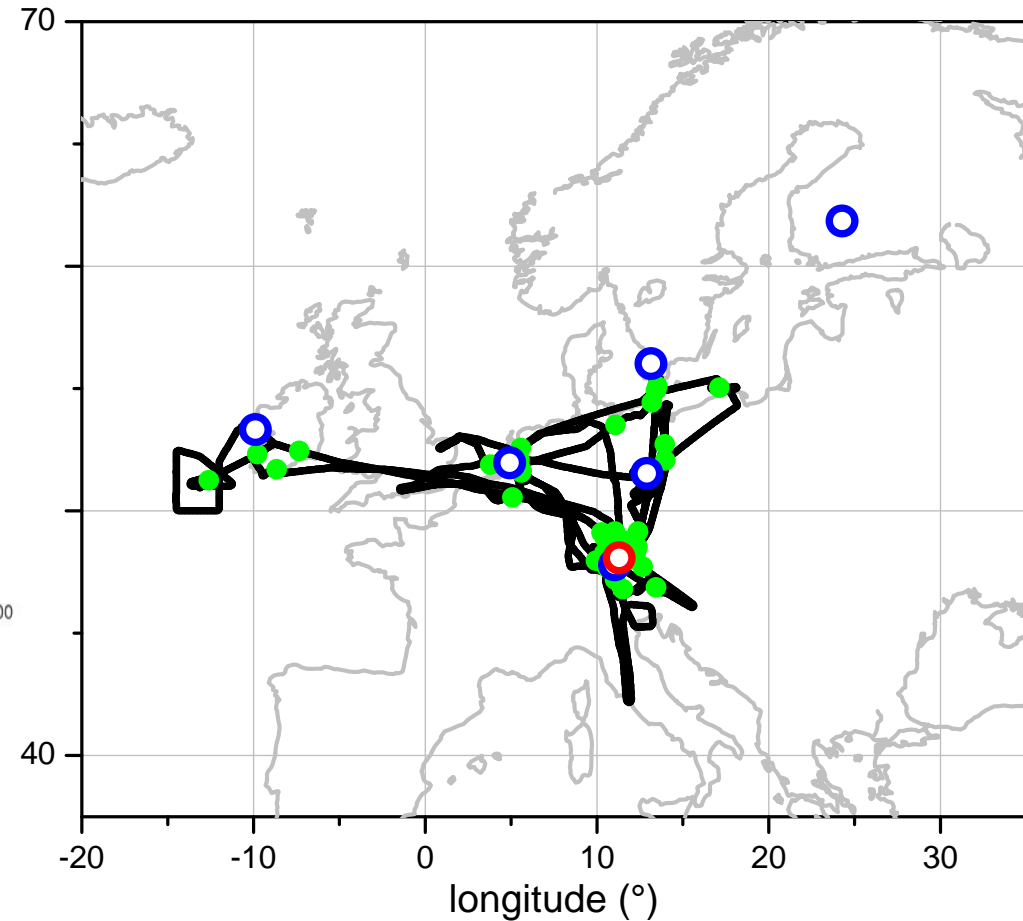
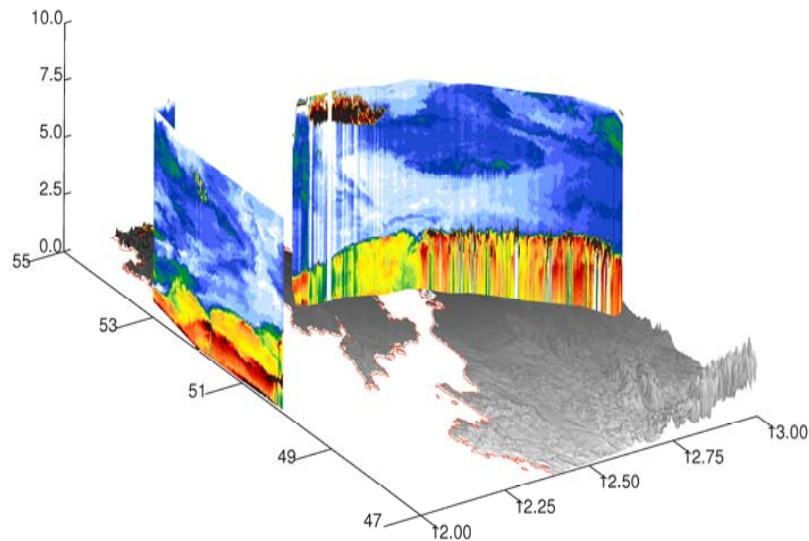
**Falcon measurements over the boreal forest
near Hyytiälä?**

Sorry, no. We only flew once over boreal forest and that was in Sweden (before and after refueling in Kiruna)



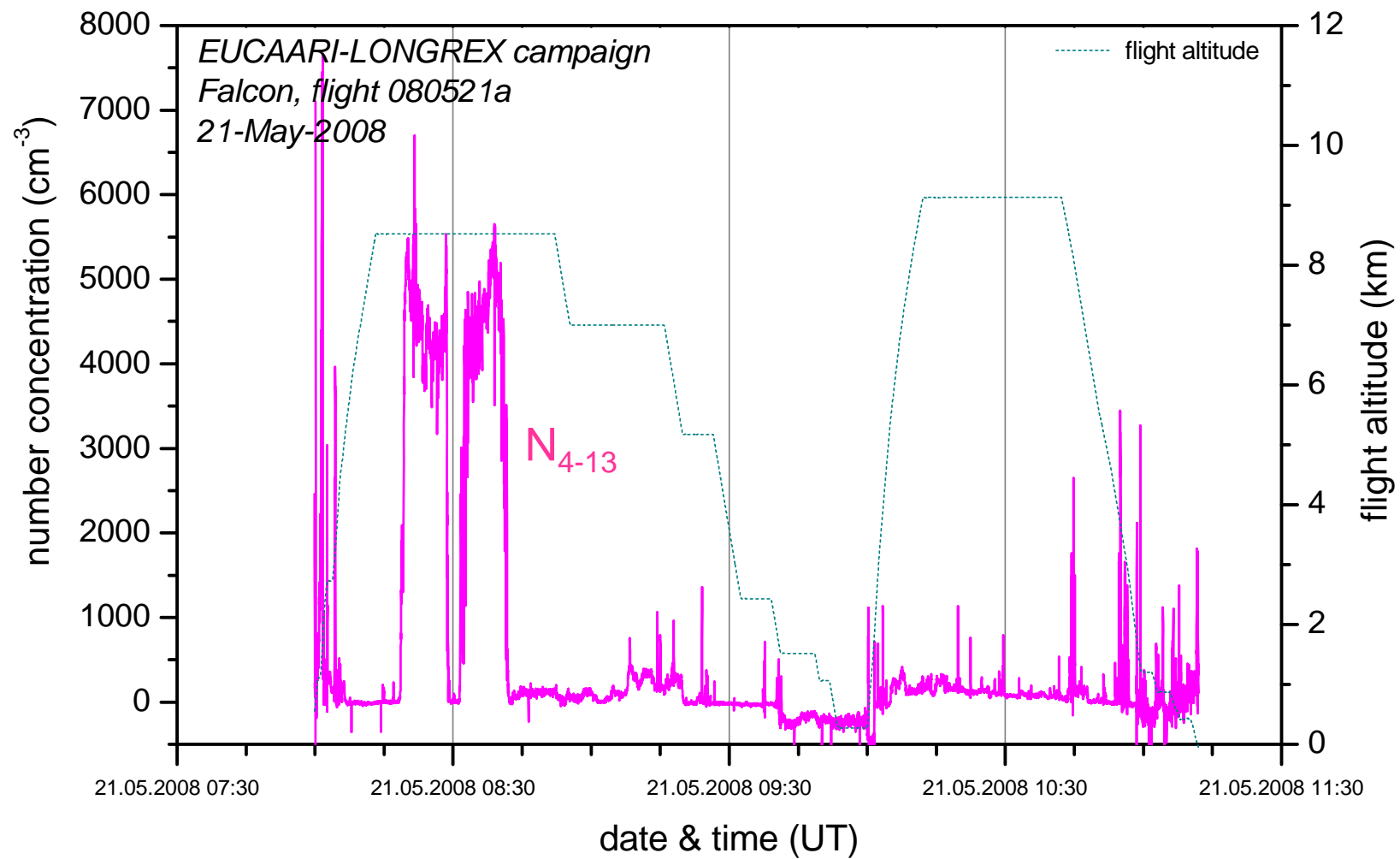
EUCAARI-LONGREX in May 2008

Observations over Central Europe

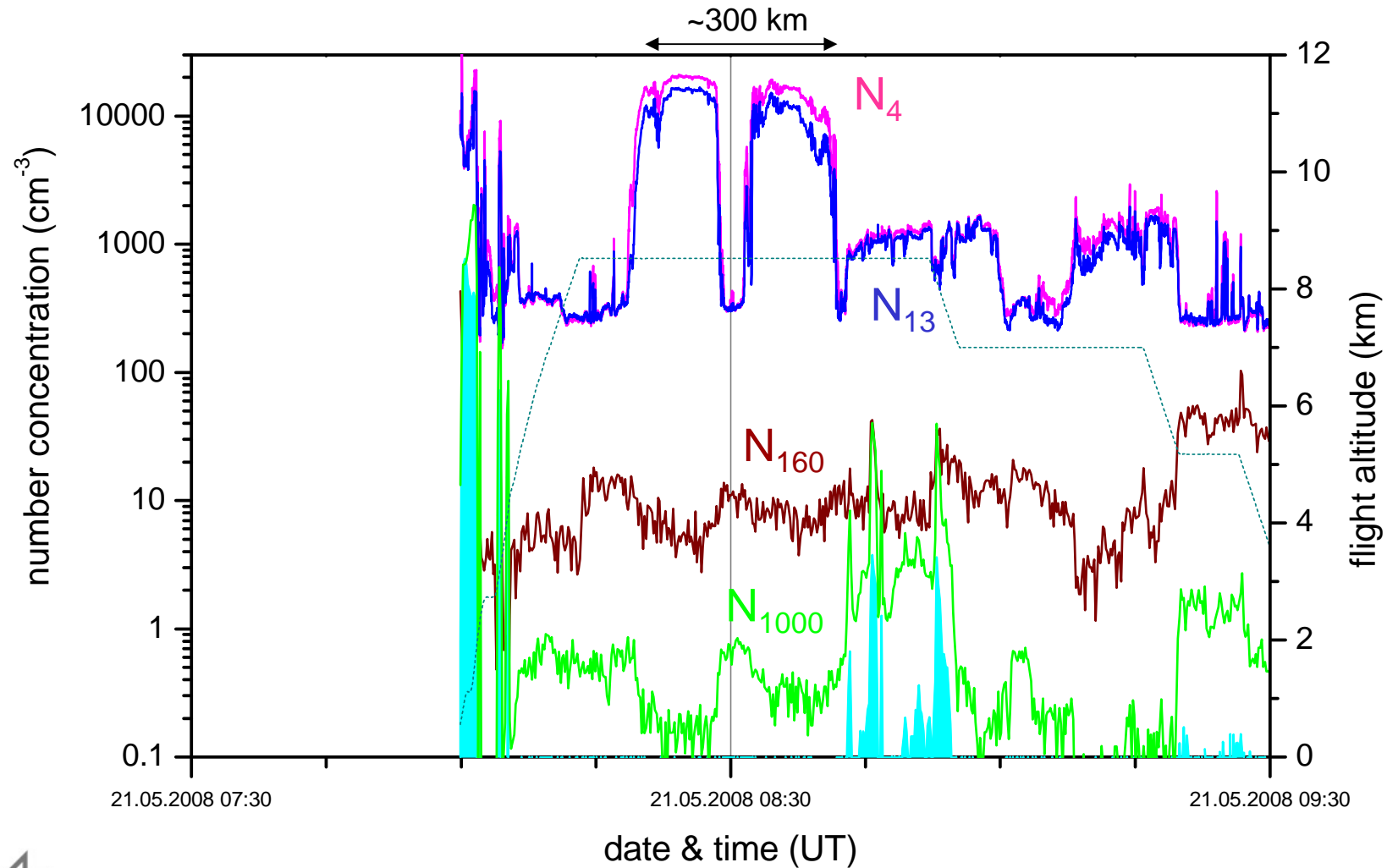


- DLR Falcon flight track
- Location for vertical profiling with Falcon
- EUSAAR ground stations
- Oberpfaffenhofen (operation base)



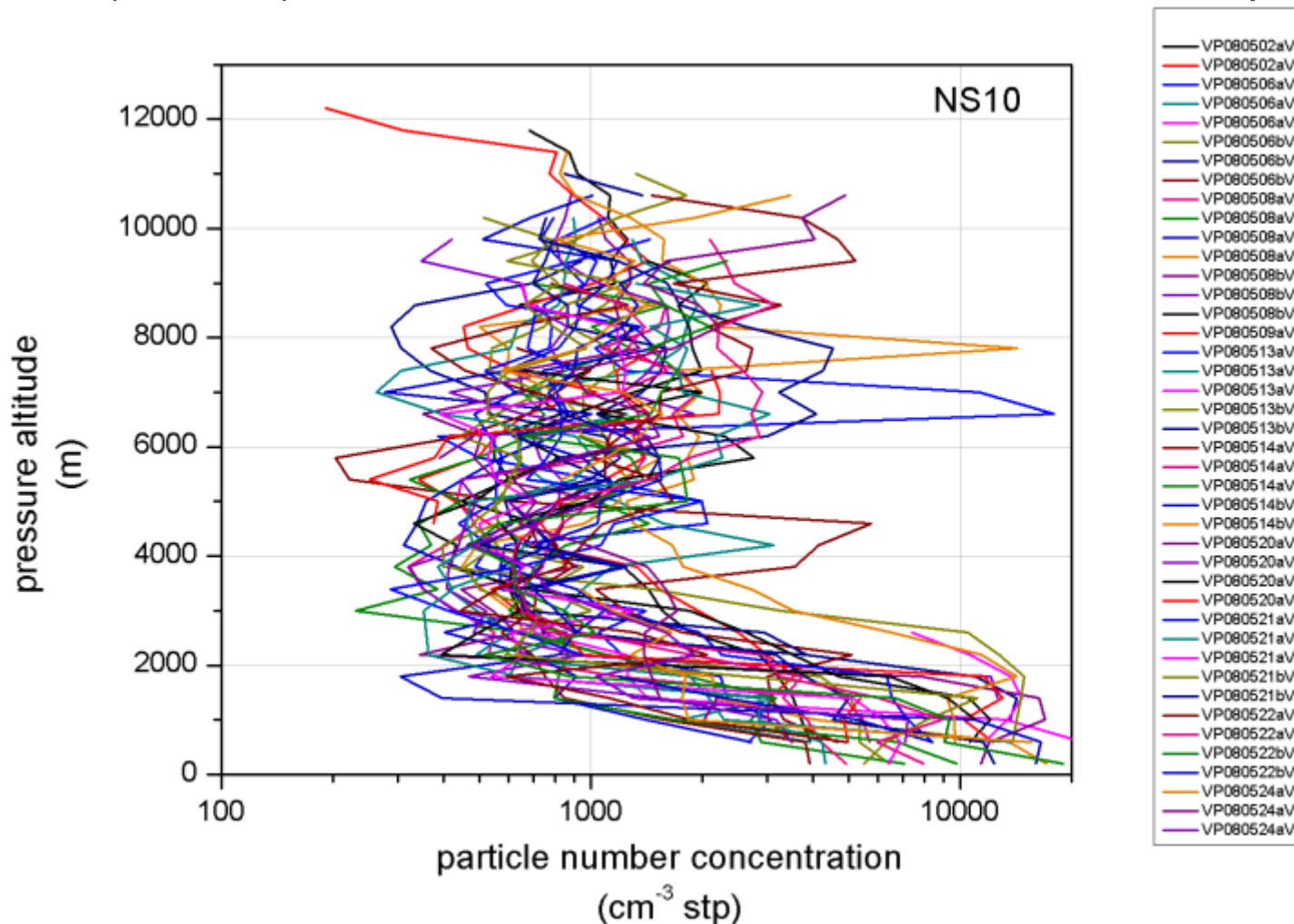


Particle formation event in the upper troposphere over Germany, May 21, 2008

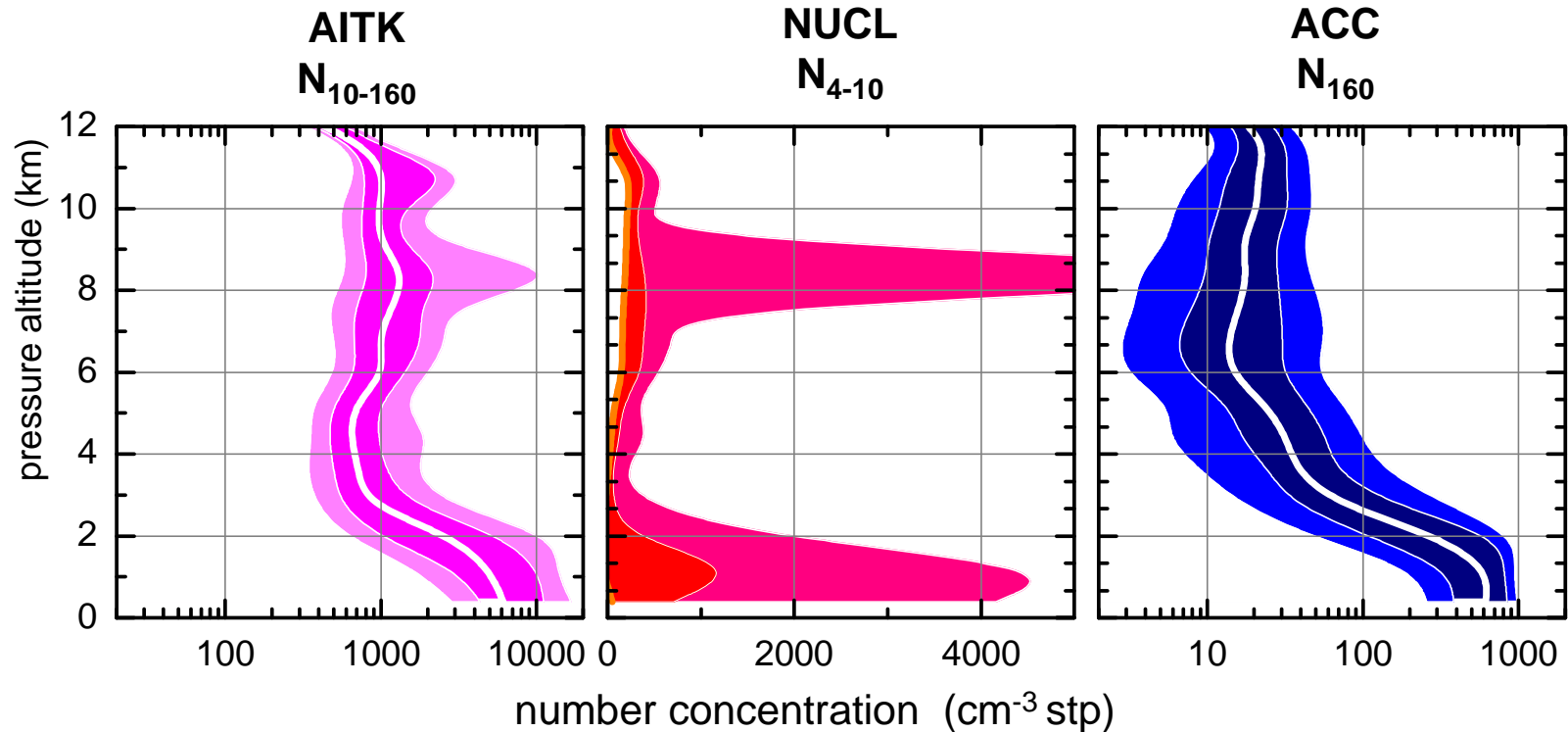


Variability in vertical aerosol distribution over Europe during May 2008

Total CN (>10 nm) number concentration for all Falcon vertical profiles



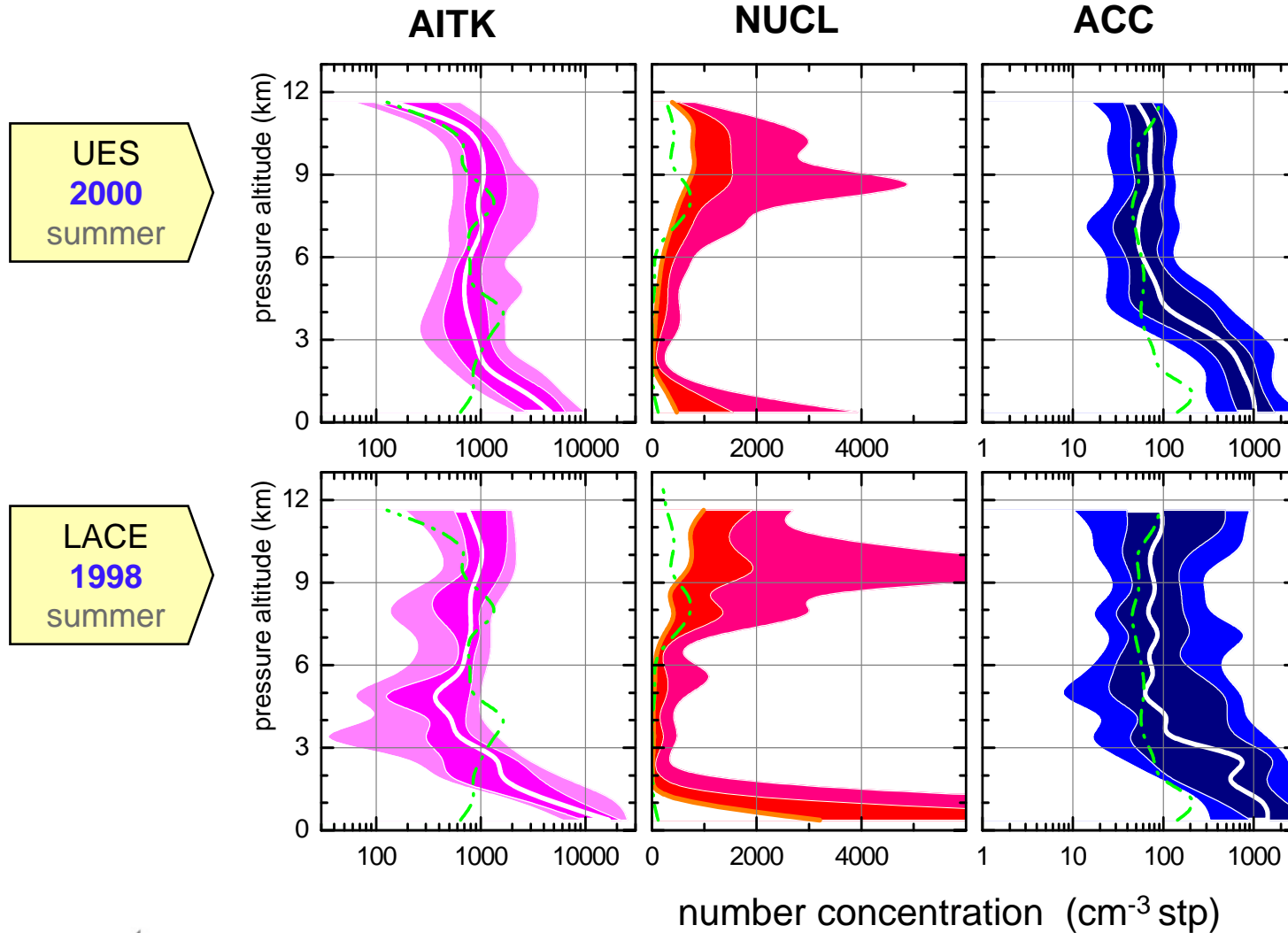
Median number concentration profiles & statistics (EUCAARI-LONGREX)



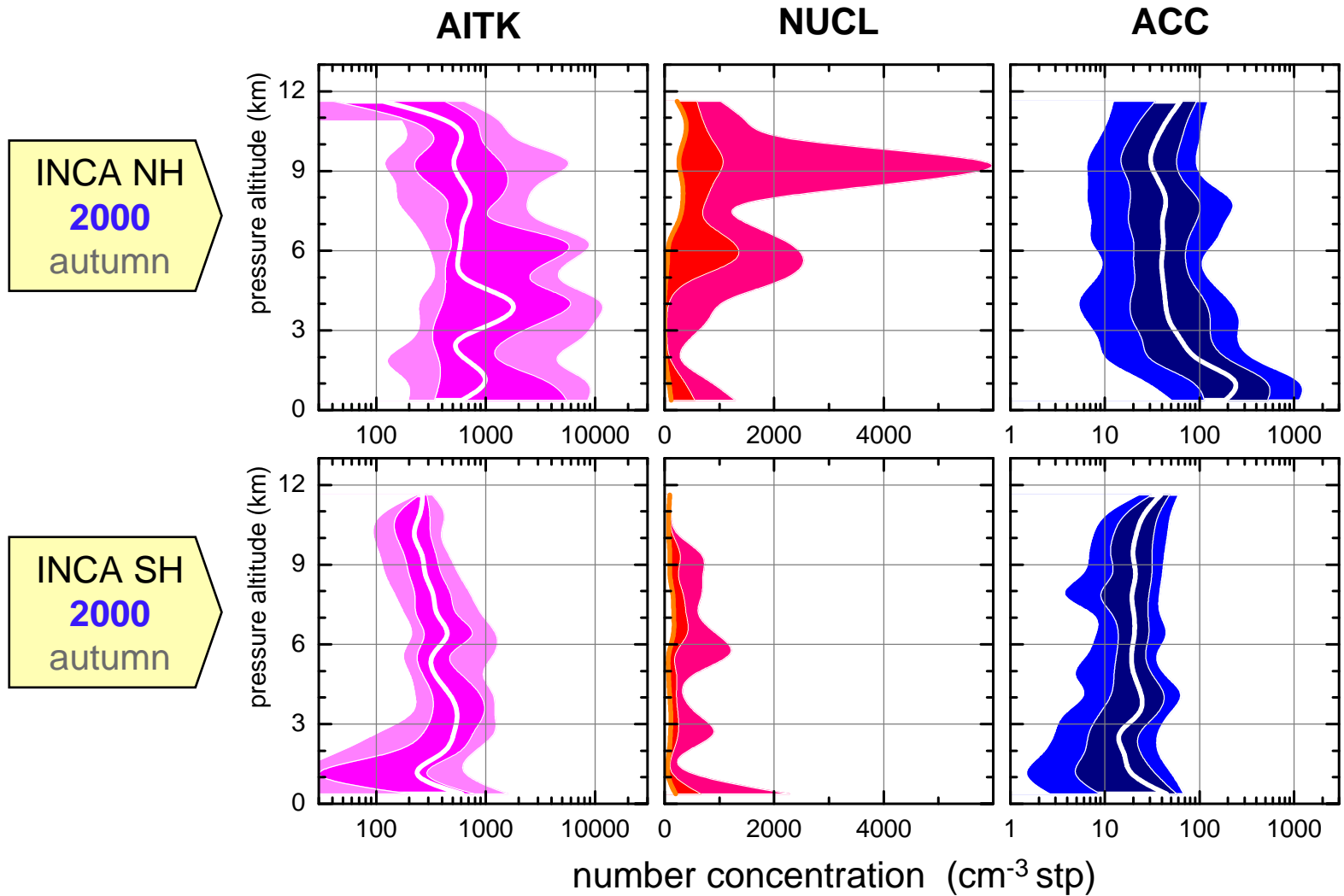
- Profiles: Median, 10-, 25-, 75-, 90-percentiles per 800 m height interval
- Logarithmic concentration scale (except NUCL), concentrations corrected to standard conditions (stp)
- In-cloud data excluded from data set



More mid-latitude aerosol vertical profiles over central Europe



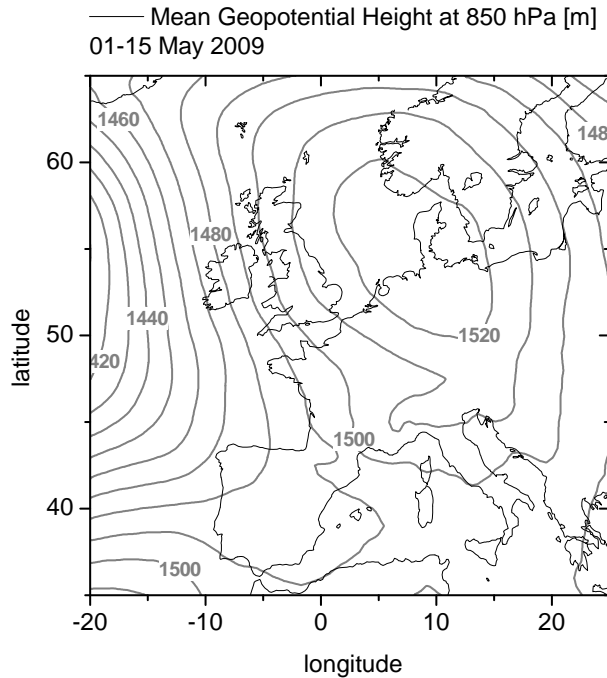
Mid-latitude autumn aerosol vertical profiles: southern & northern hemisphere (rather marine influence)



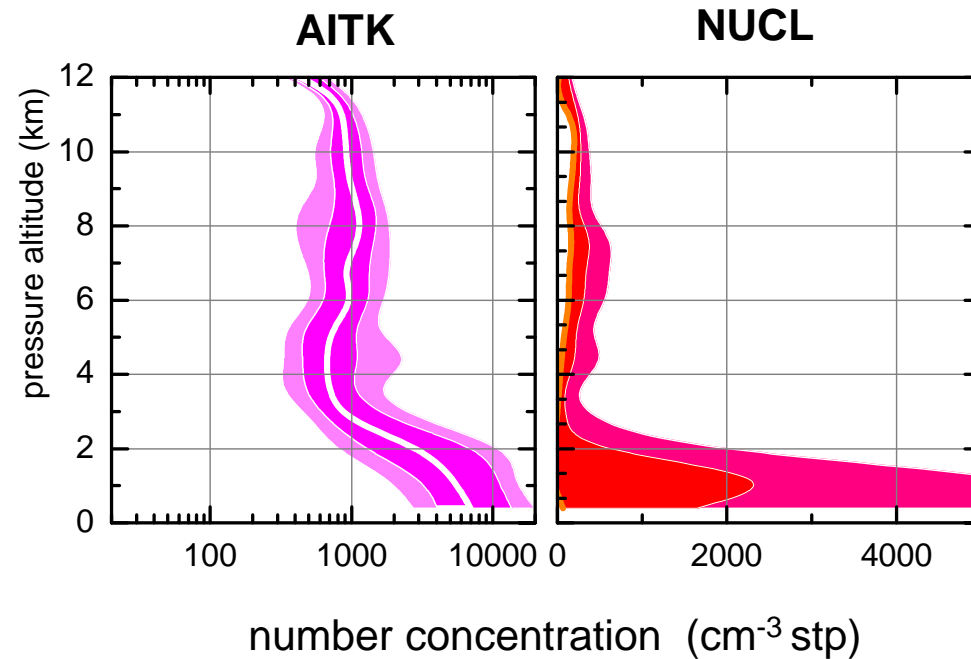
INCA NH
2000
autumn

INCA SH
2000
autumn

When does particle formation NOT occur in the free troposphere?

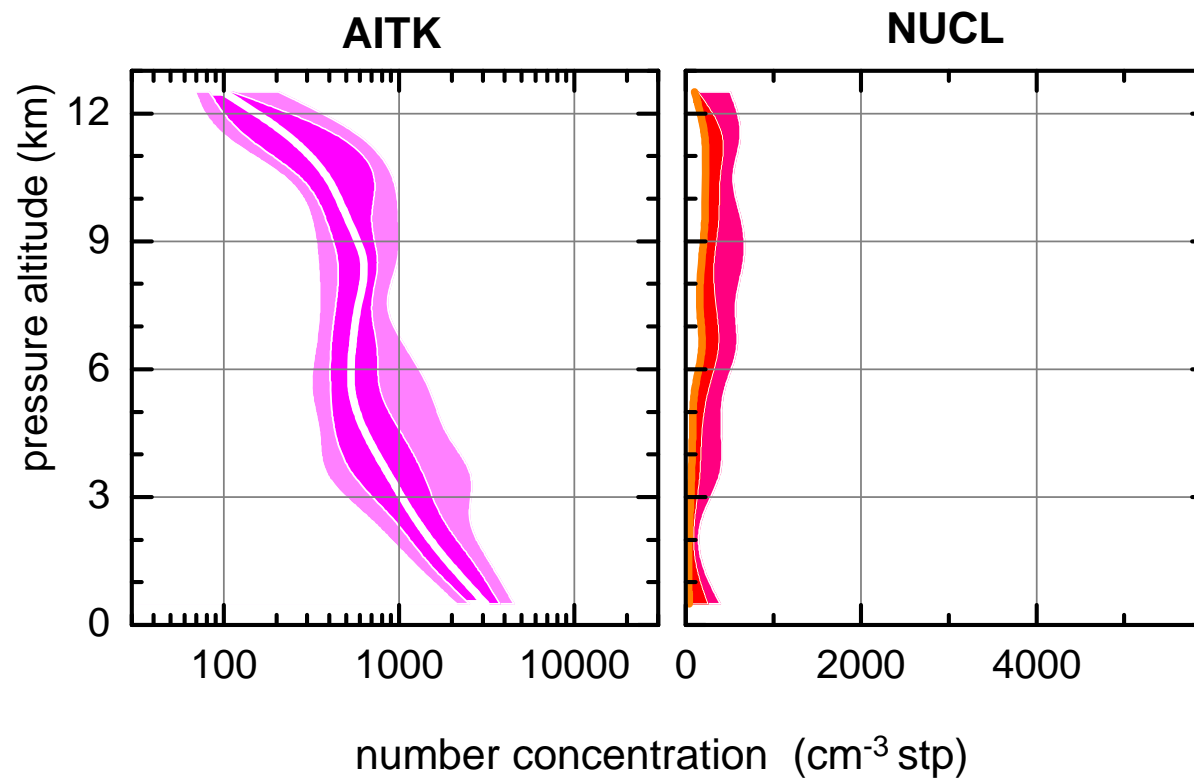


High pressure system in first half of May 2008 → subsidence of air



Large-scale subsidence of air over the Mediterranean in summer

MINOS
east Mediterran.
polluted marine
summer
July/Aug. 2001

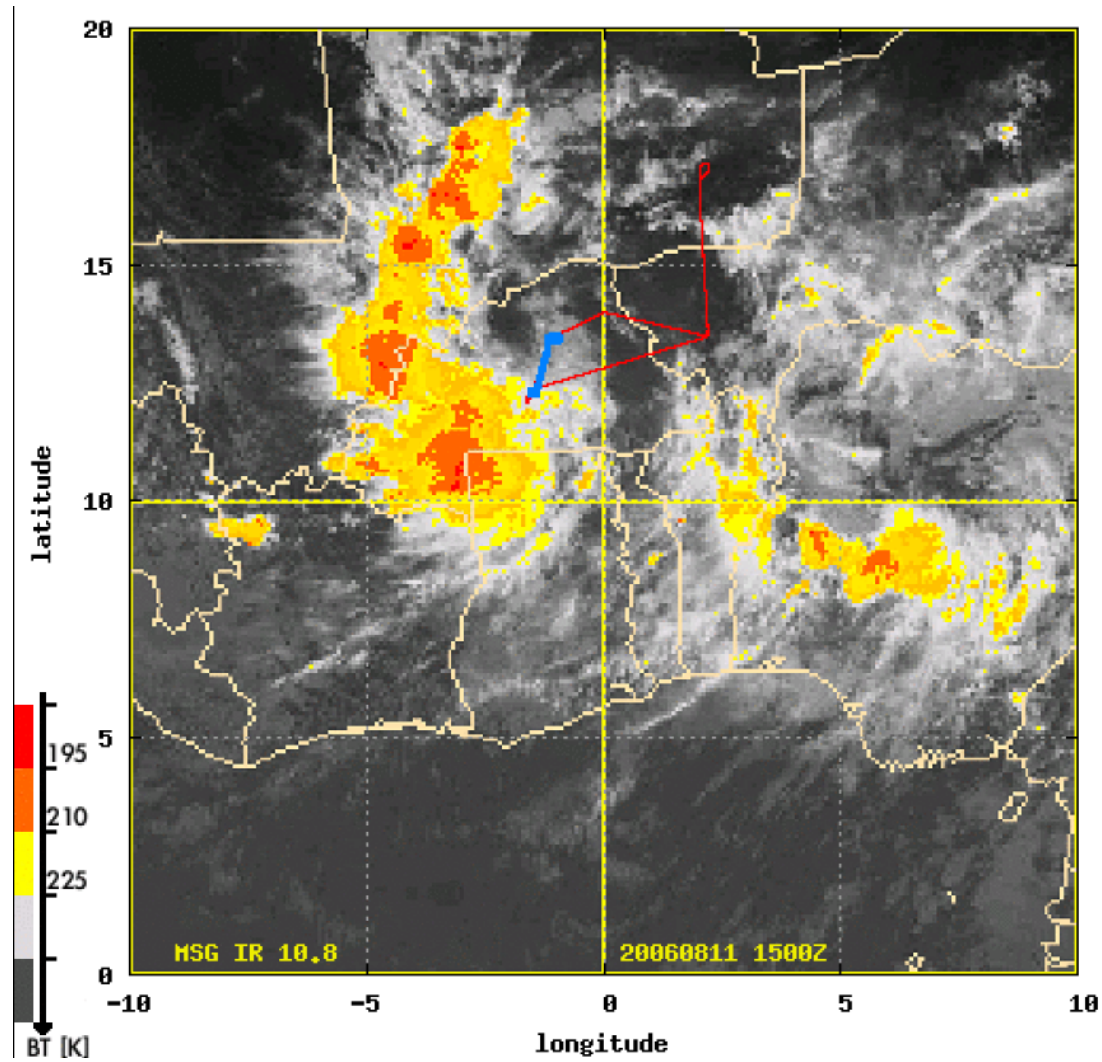


**Observations of particle formation in the tropics
(in the vicinity of deep convection)**

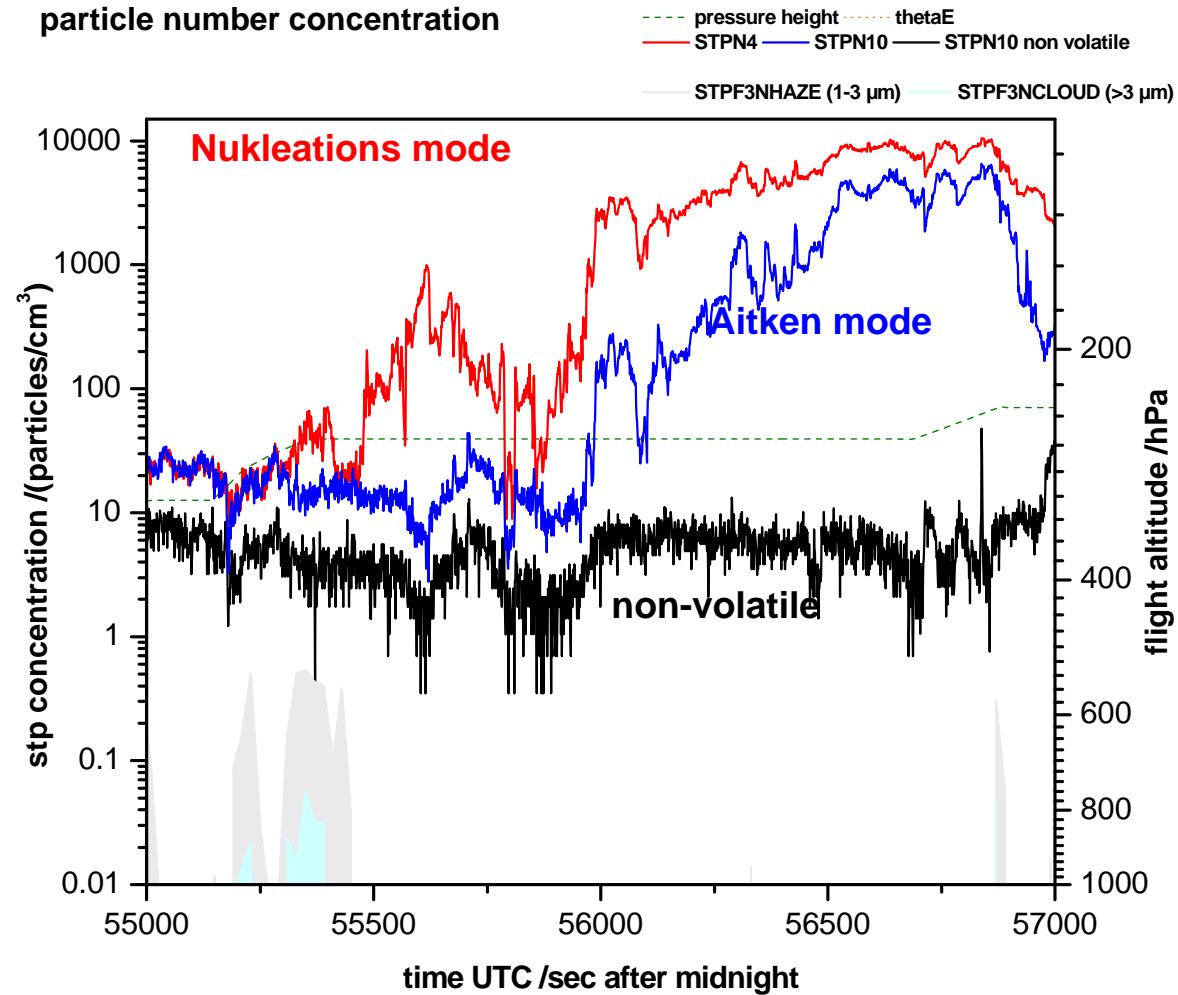


AMMA campaign, West Africa, 11-Aug-2006

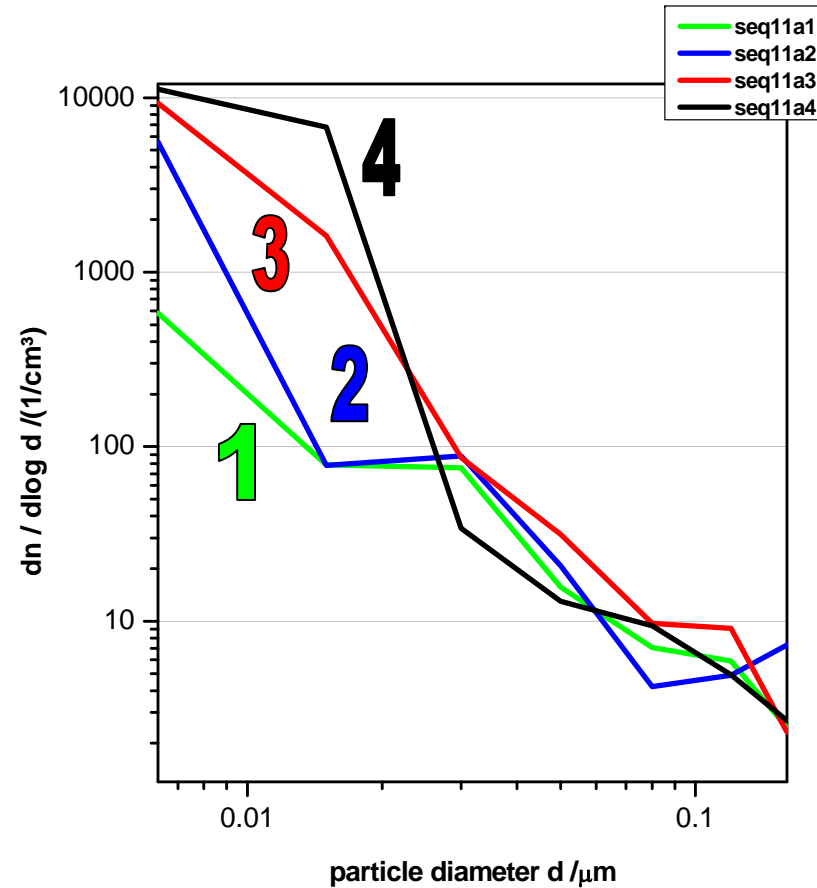
Probing of MCS outflow near Ouagadougou

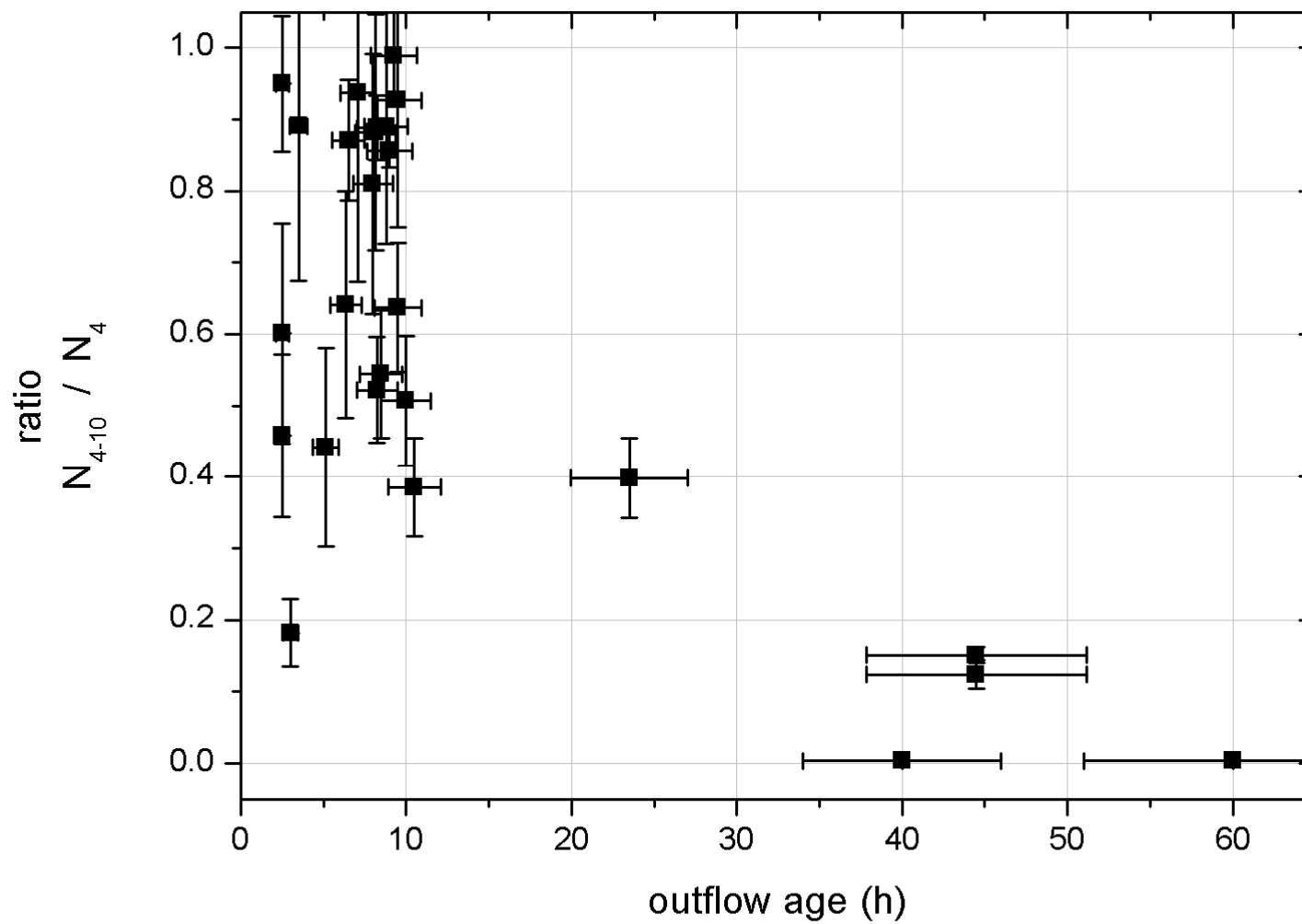


Probing the outflow with increasing outflow age: Wet removal – particle formation – particle growth

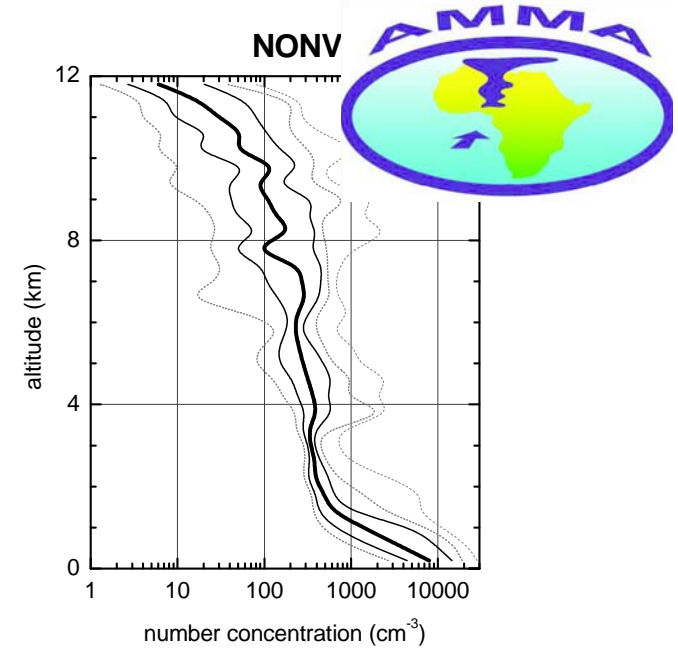
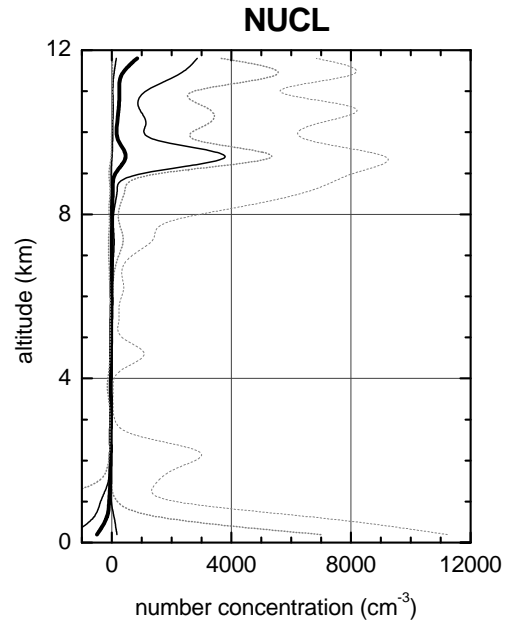
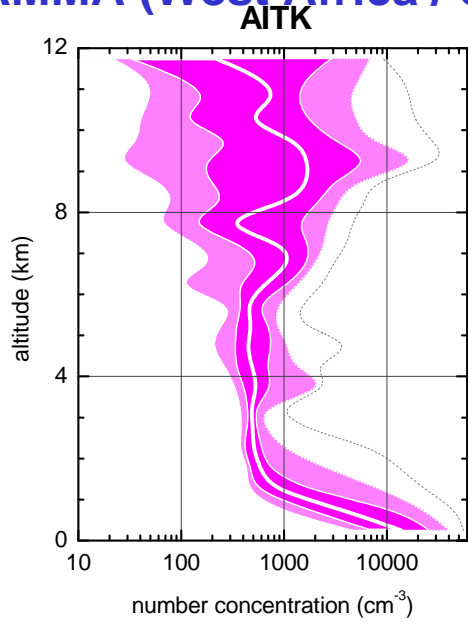


Probing the outflow with increasing outflow age: Wet removal – particle formation – particle growth (Size distributions)

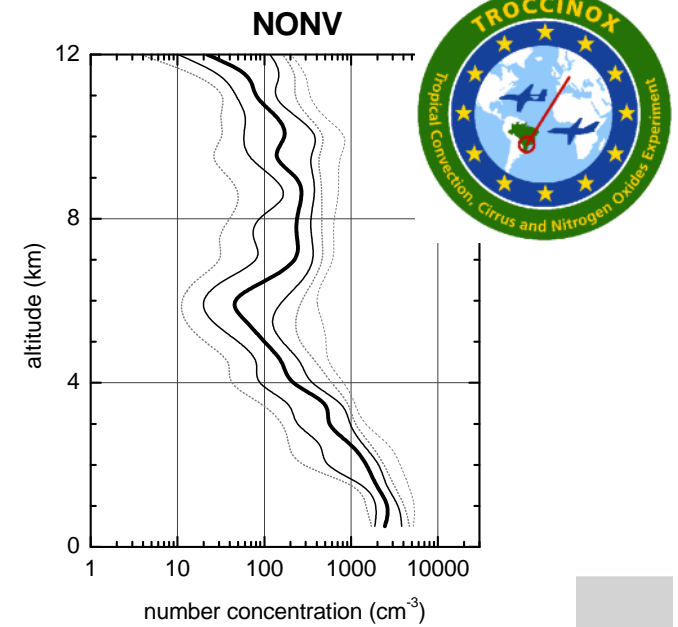
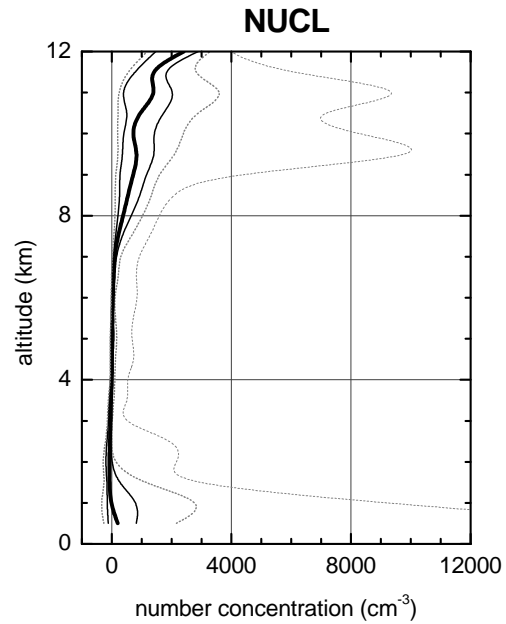
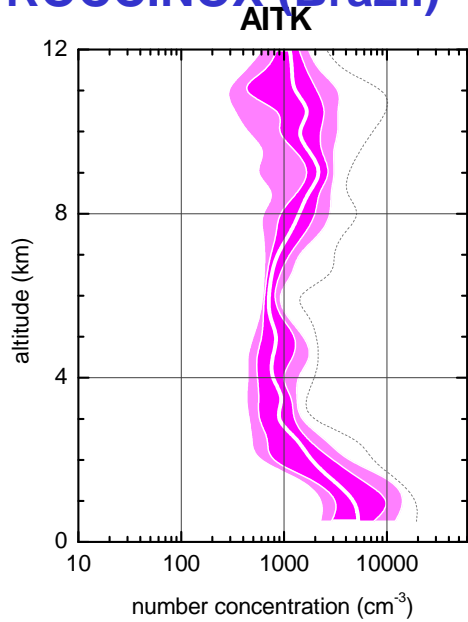




AMMA (West Africa / Sahel)



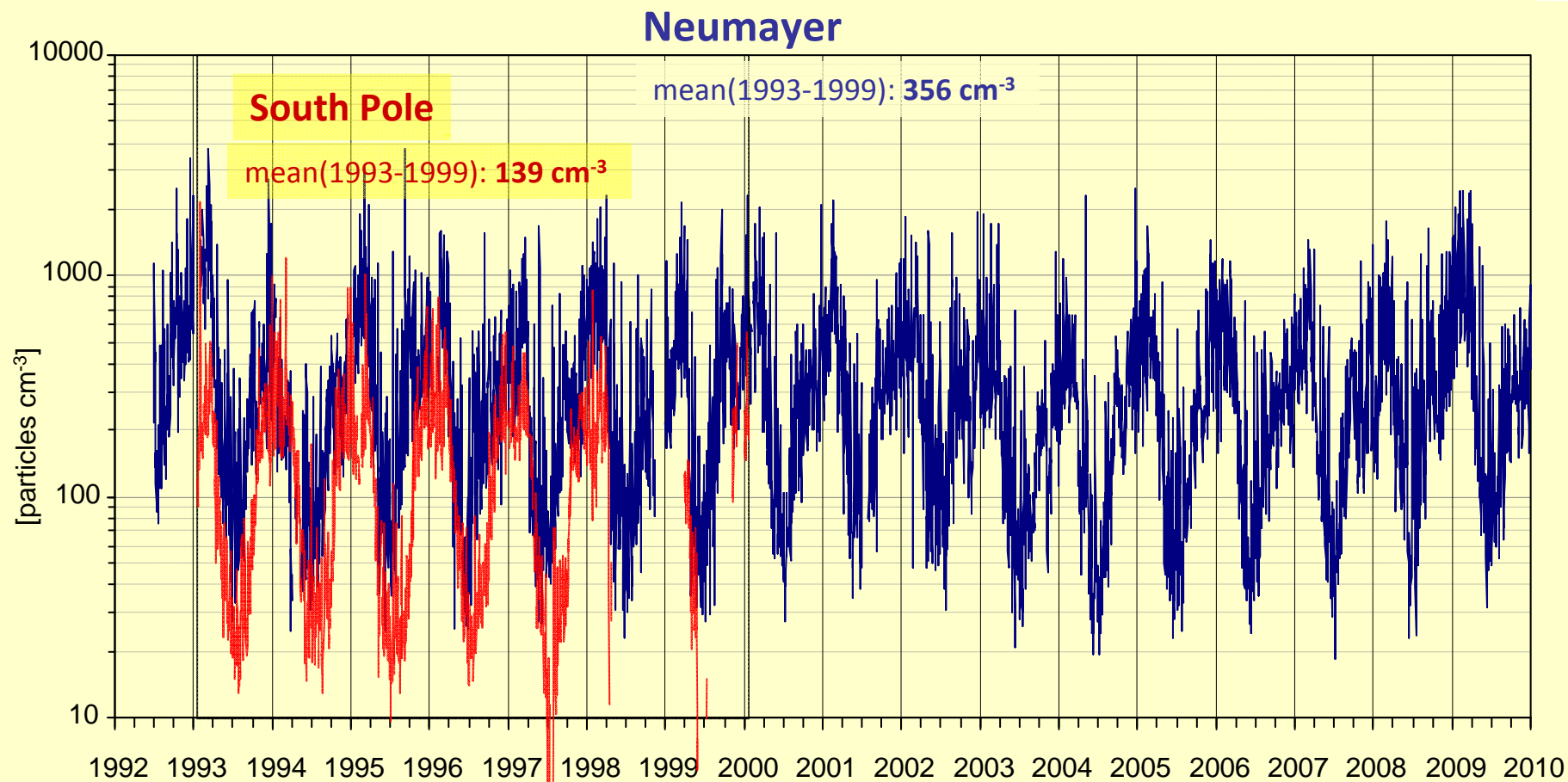
TROCCINOX (Brazil)



Measurements in Antarctica (coastal region)



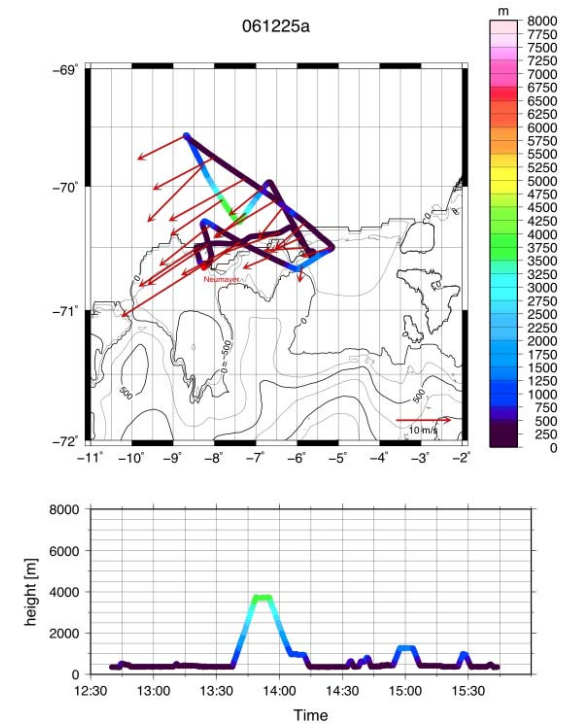
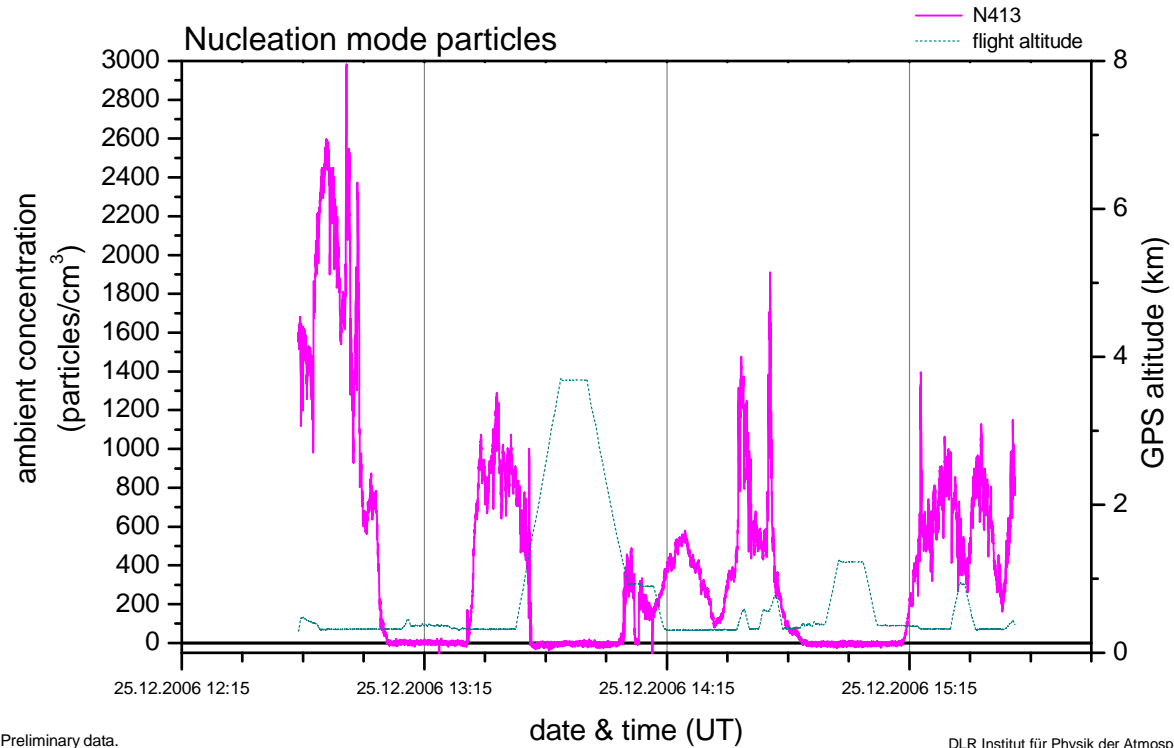
Number concentration of (ultra)fine particles: Seasonal cycle of condensation particles at Neumayer & South Pole



South Pole data: GAW World Data Centre for Aerosols - <http://rea.ei.jrc.it/netshare/wilson/WDCA/>
Neumayer data: R. Weller, AWI

25-Dec-2006 case: particle nucleation at low level

ANTSYO II / AGAMES
 Polar 2, flight 061225a
 25-Dec-2006

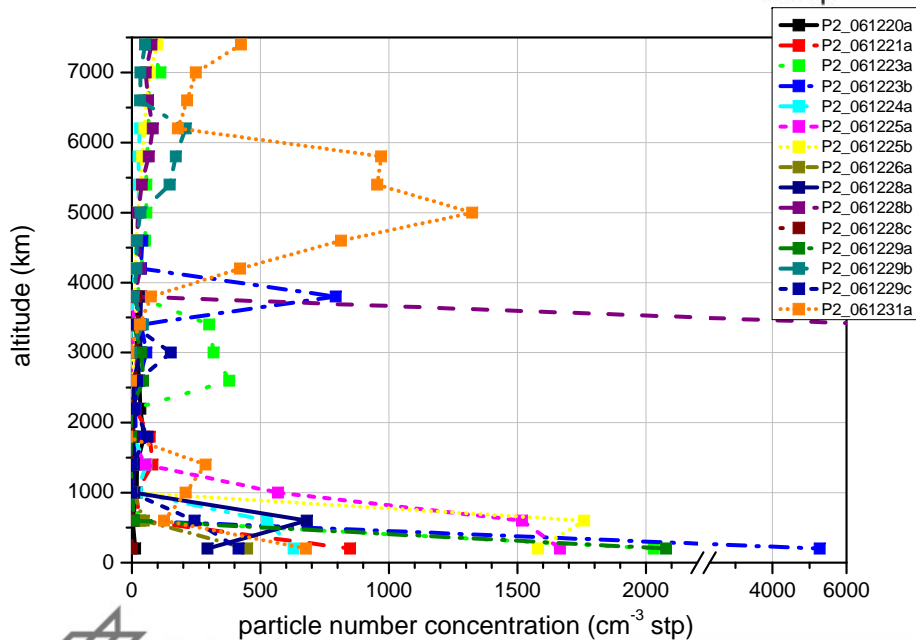
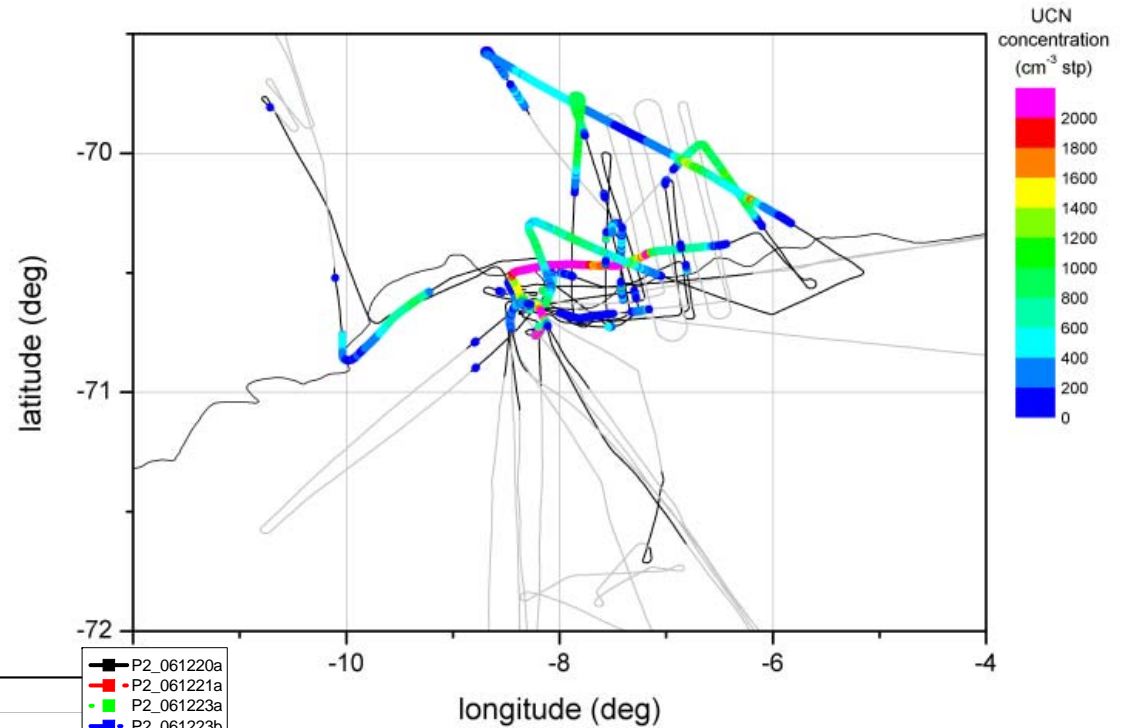


Preliminary data.
 To be used only for quicklook purposes.

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Particle nucleation at Neumayer

... was observed at low level predominantly over water



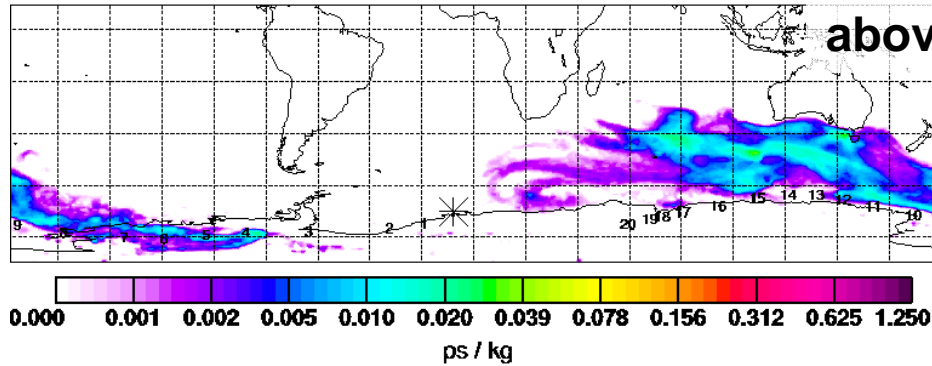
... was observed mostly at low level (below 1.5 km) with only few, but notable, cases of layers in the free troposphere



25-Dec-2006 case: air mass origin

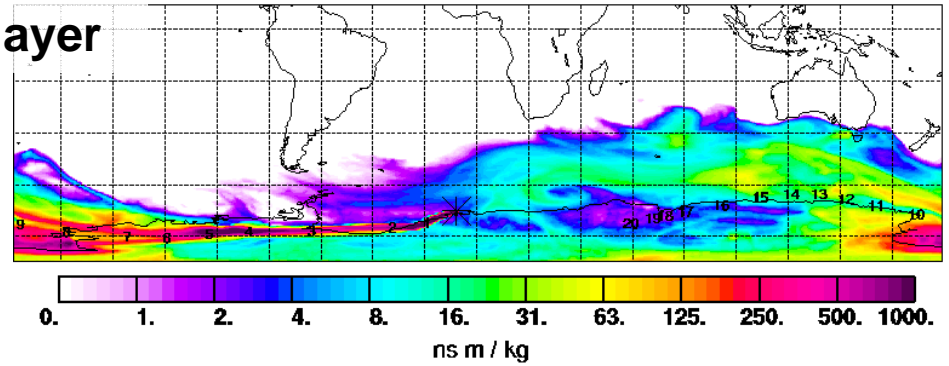
Footprint emission sensitivity in global domain for p2_061225a

Start time of sampling 20061225.135533 End time of sampling 20061225.135551
 Lower release height 658 hPa Upper release height 650 hPa
 Meteorological data used are from ECMWF



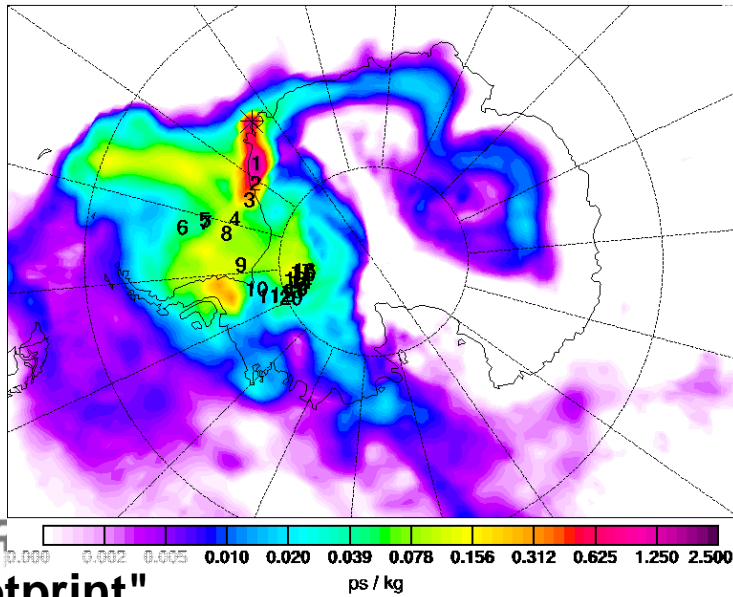
Column-integrated emission sensitivity in global domain for p2_061225a

Start time of sampling 20061225.135533 End time of sampling 20061225.135551
 Lower release height 658 hPa Upper release height 650 hPa
 Meteorological data used are from ECMWF



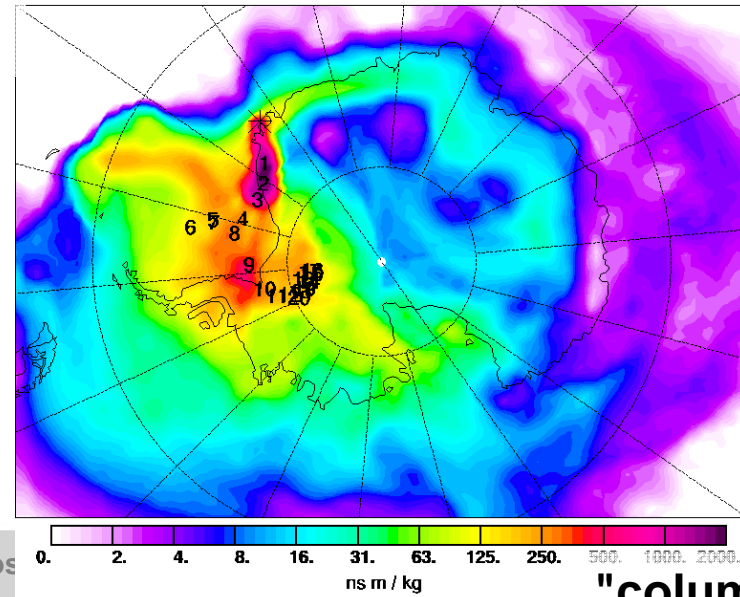
Footprint emission sensitivity in global domain for p2_061225a

Start time of sampling 20061225.131020 End time of sampling 20061225.131248
 Lower release height 969 hPa Upper release height 968 hPa
 Meteorological data used are from ECMWF



Column-integrated emission sensitivity in global domain for p2_061225a

Start time of sampling 20061225.131020 End time of sampling 20061225.131248
 Lower release height 969 hPa Upper release height 968 hPa
 Meteorological data used are from ECMWF



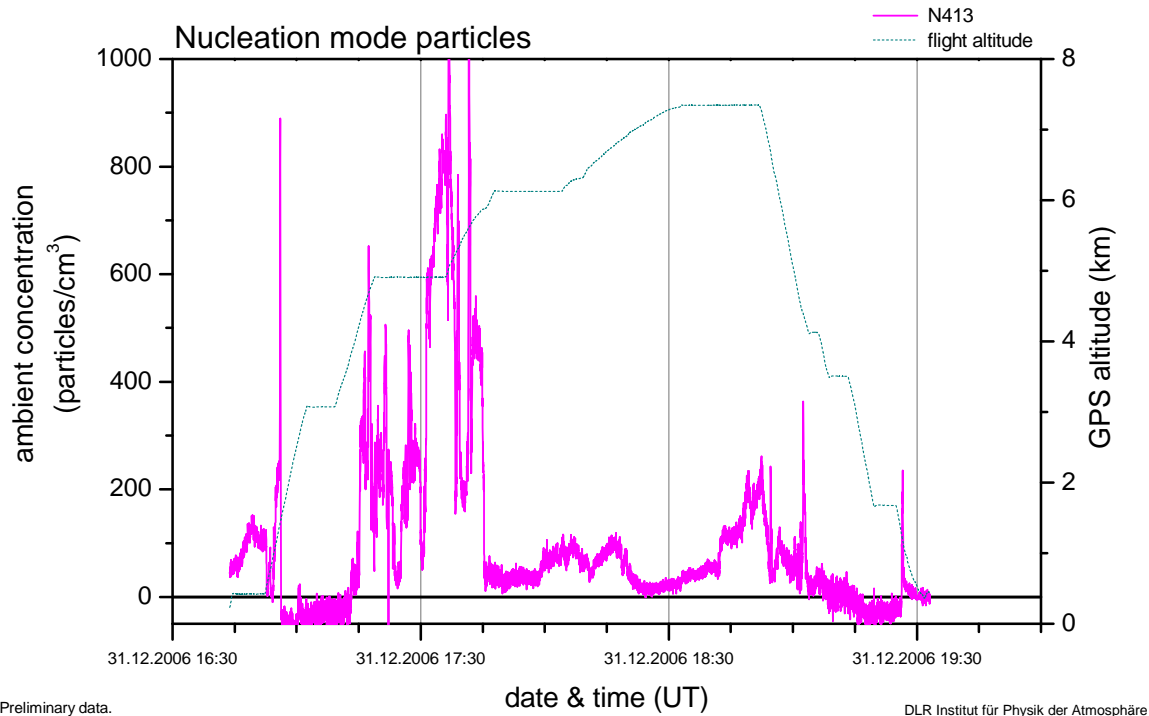
"footprint"

ysik der Atmos

"column"

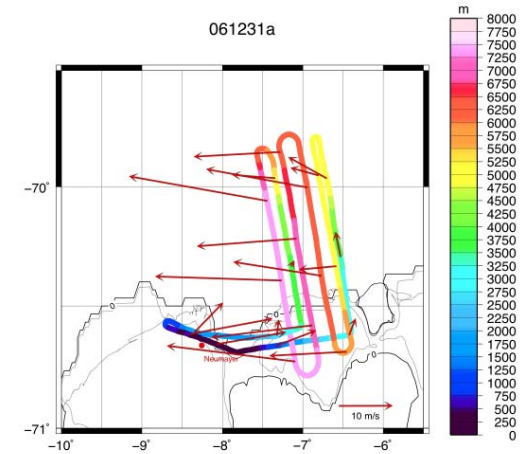
31-Dec case: high altitude particle nucleation

ANTSYO II / AGAMES
Polar 2, flight 061231a
31-Dec-2006

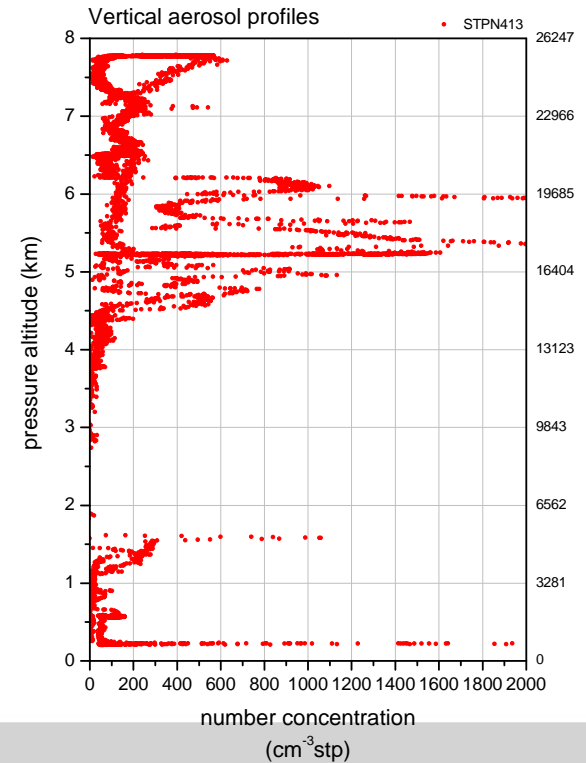


Preliminary data.
To be used only for quicklook purposes.

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ANTSYO II / AGAMES
Polar 2, flight 061231a
31-Dec-2006



Preliminary data.
To be used only for quicklook purposes.

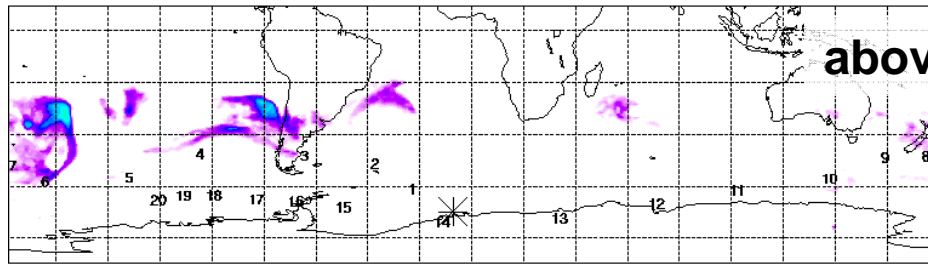
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Footprint emission sensitivity in global domain for p2_061231a

Start time of sampling 20061231.180311 End time of sampling 20061231.180535

31-Dec case: high altitude particle nucleation, air mass origin

Meteorological data used are from ECMWF

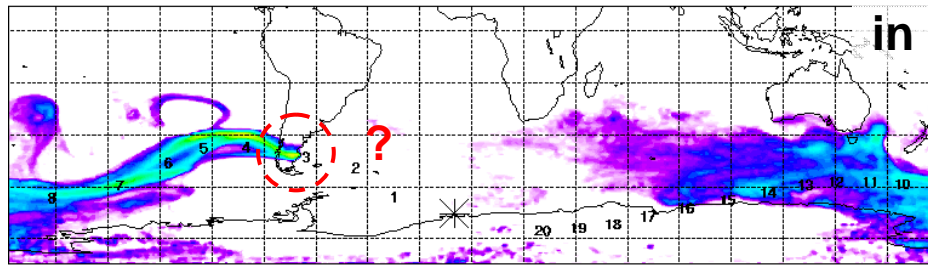


Footprint emission sensitivity in global domain for p2_061231a

Start time of sampling 20061231.173519 End time of sampling 20061231.173642

Lower release height 547 hPa Upper release height 539 hPa

Meteorological data used are from ECMWF

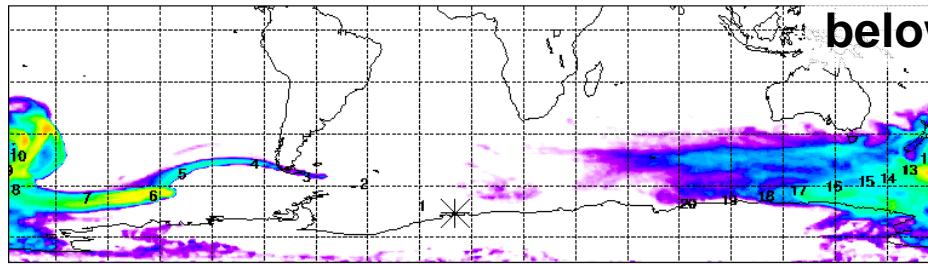


Footprint emission sensitivity in global domain for p2_061231a

Start time of sampling 20061231.170139 End time of sampling 20061231.170208

Lower release height 708 hPa Upper release height 700 hPa

Meteorological data used are from ECMWF



"footprint"

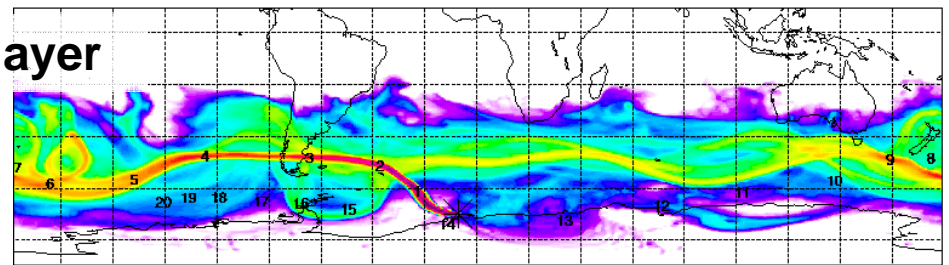
ps / kg

Column-integrated emission sensitivity in global domain for p2_061231a

Start time of sampling 20061231.180311 End time of sampling 20061231.180535

Lower release height 457 hPa Upper release height 457 hPa

Meteorological data used are from ECMWF

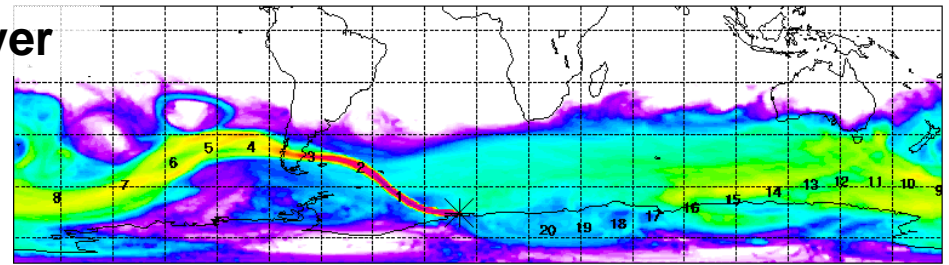


Column-integrated emission sensitivity in global domain for p2_061231a

Start time of sampling 20061231.173519 End time of sampling 20061231.173642

Lower release height 547 hPa Upper release height 539 hPa

Meteorological data used are from ECMWF

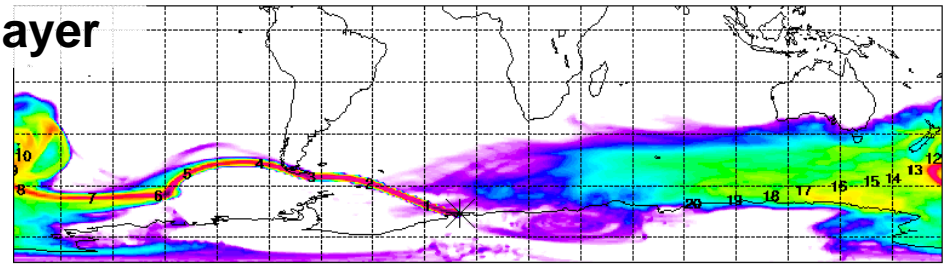


Column-integrated emission sensitivity in global domain for p2_061231a

Start time of sampling 20061231.170139 End time of sampling 20061231.170208

Lower release height 708 hPa Upper release height 700 hPa

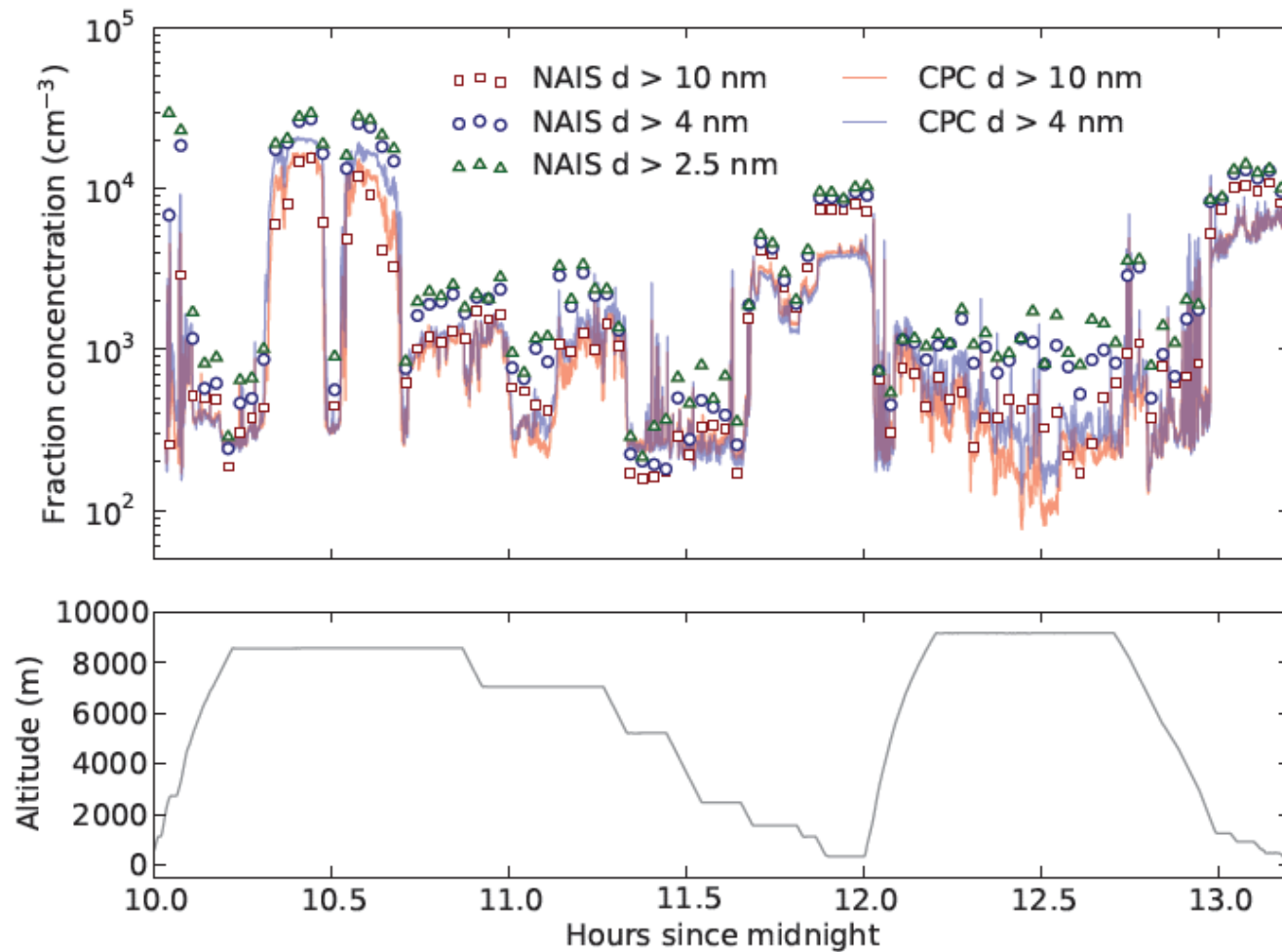
Meteorological data used are from ECMWF



"column"

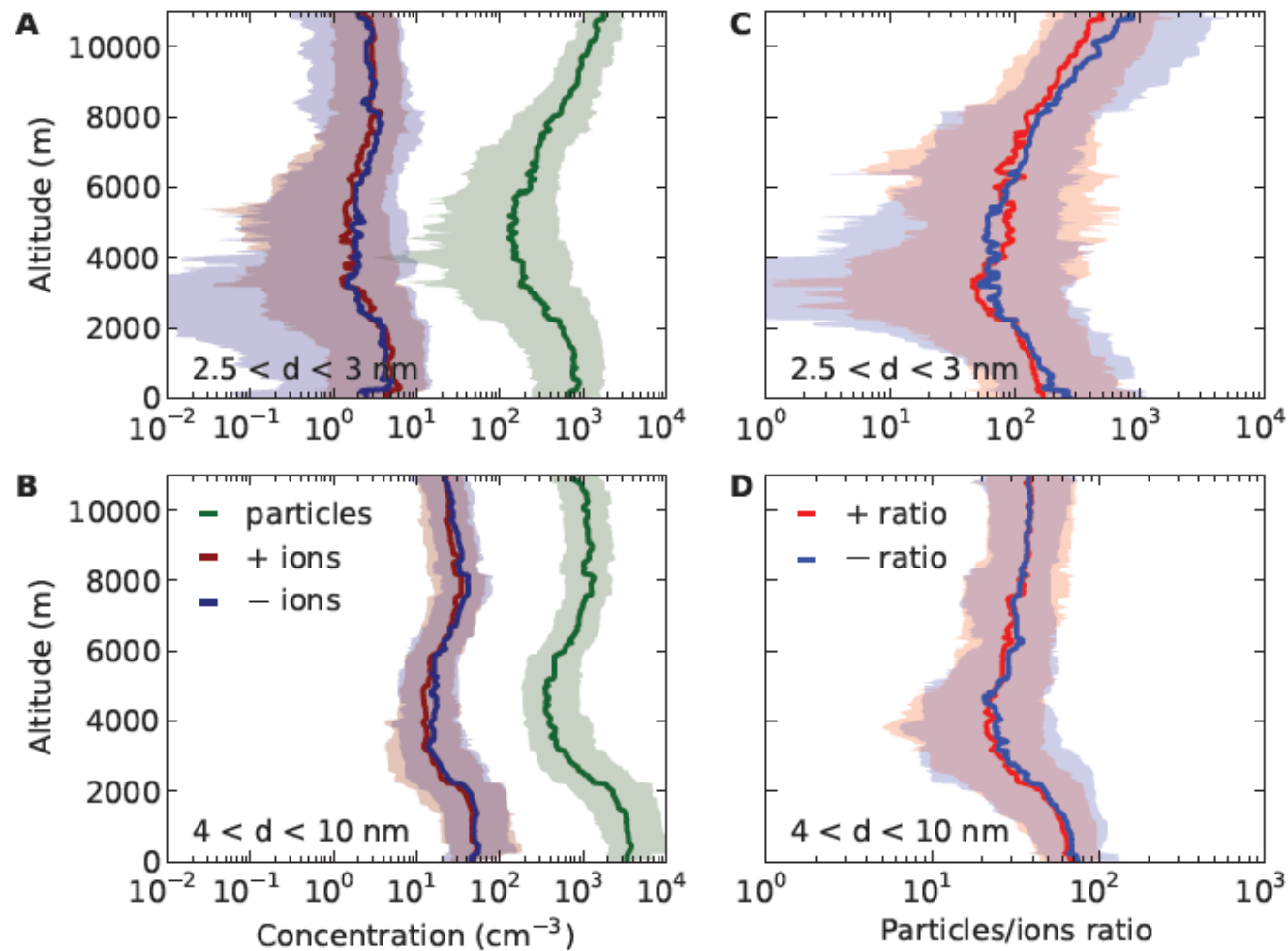
ns m / kg

First airborne observations of sub-3 nm neutral atmospheric particles during EUCAARI-LONGREX with airborne NAIS



Median concentration profiles total and charged clusters and particles + corresponding concentration ratios between total and charged cluster/particles

EUCAARI-LONGREX campaign, May 2008

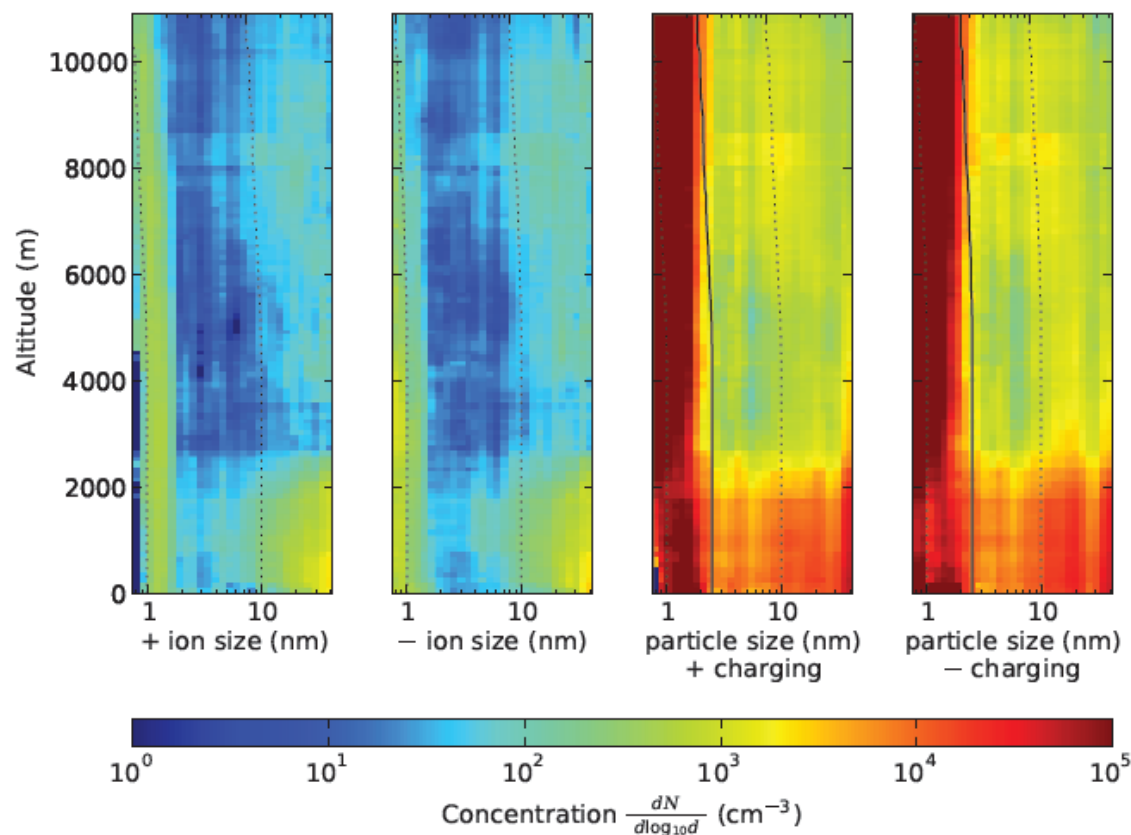


Conclusions of NAIS measurements with DLR Falcon aircraft

- ➔ first-time aircraft deployment of a NAIS instruments on the DLR Falcon during EUCAARI
- ➔ abundant presence of both neutral and charged sub-2 nm clusters at all altitude levels
- ➔ growth of particles into sizes >4 nm does happen only under certain conditions apparently
- ➔ no indication of an enhanced role of ion-induced nucleation toward the tropopause region

Atmospheric sub-3 nm particles at high altitudes

S. Mirme¹, A. Mirme¹, A. Minikin², A. Petzold², U. Hörrak¹, V. -M. Kerminen³, and M. Kulmala⁴



Summary

Particle formation observed from aircraft with CPCs (~4 nm lowest cut-off); during EUCAARI first time deployment of NAIS.

Particle formation events are observed in the troposphere in BL and UT, (almost) never in between. Occurrence is patchy; high variability of number concentrations. Atmospheric dynamics is important.

Aitken mode concentrations profiles in the FT are shaped by particle formation events.

In mid-latitudes UT properties are usually controlled by long-range transport. Particular origin of particle formation events often not clear.

In the tropics particle formation in the UT is connected to deep convective processes (either uplift of precursors or wet removal of pre-existing aerosol or both).

From aircraft measurements alone it is very difficult to arrive at a process understanding, but observations are well suited to test models.

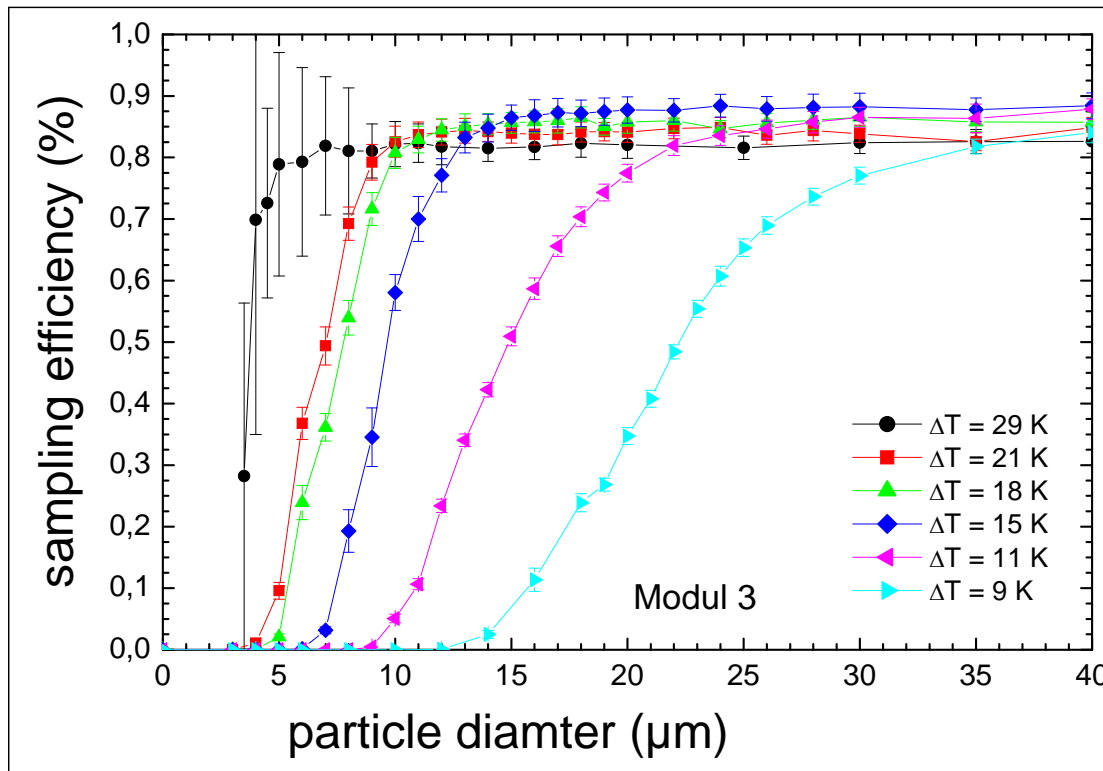
A twin-engine turboprop aircraft is shown from a front-on perspective on a runway at dusk. The aircraft is white with blue and red stripes. Its landing lights are illuminated, casting a bright glow on the runway surface. The background is a dark, overcast sky with a line of trees in the distance. The text "Thank you!" is overlaid in the top right corner.

Thank you!

And thanks to:

A. Petzold, M. Fiebig, T. Hamburger, R. Krejci, H. Rüba & many others

CPC minimal detectable particle size: controlled by Butanol super-saturation (temperature difference between warm & cold part)



Cut-off size (defined by 50 %
sampling efficiency) can be
selected in the range 4...20 nm

Pressure dependence of sampling efficiency of Butanol-based CPC at different temperature settings (= different lower cut-off sizes) at 40 nm

