GALION: The GAW Aerosol Lidar Observation Network.

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- **Motivation**
- **Examples**
- **Lidar methods**
- **Networking**
- **Status**

Why Aerosol Research?

Aerosols have important effects on human life:

- **Aerosols can be toxic, by composition or by structure (size or shape).**
  Many aerosol-induced diseases have been identified.
- **Aerosols deteriorate visibility.**
  Haze and fog occurence depends on aerosols.
- **Ecosystems are affected by significant mass transport.**
  Eutrophication of lakes and seas.
- **Aerosols influence atmospheric chemistry by providing reactive surfaces.**
  Stratospheric ozone depletion, summer smog.
- **Aerosols affect the radiation budget and hence temperature distribution within the atmosphere and on the ground, including change in spectral distribution.**
  The details depend strongly on type and vertical distribution.
- **IPCC has identified the effect of aerosols on climate as one of the most uncertain contributions:**
  Climate is affected directly by scattering and absorption
  Climate is affected indirectly by changing cloud formation and properties
- **Aerosols disturb satellite imagery.**
  Aerosol interference often deteriorates or prohibits the retrieval of surface properties from space.

Why lidar observation network?

Why measurements?

Aerosols are very difficult to handle in models:

- **Aerosols are produced by many different processes, some sources are localized, others are distributed over large volumes.**
- **Aerosols interact dynamically in a nonlinear way (nucleation, condensation, coagulation, deposition).**
- **Aerosols can be transported over large distances.**

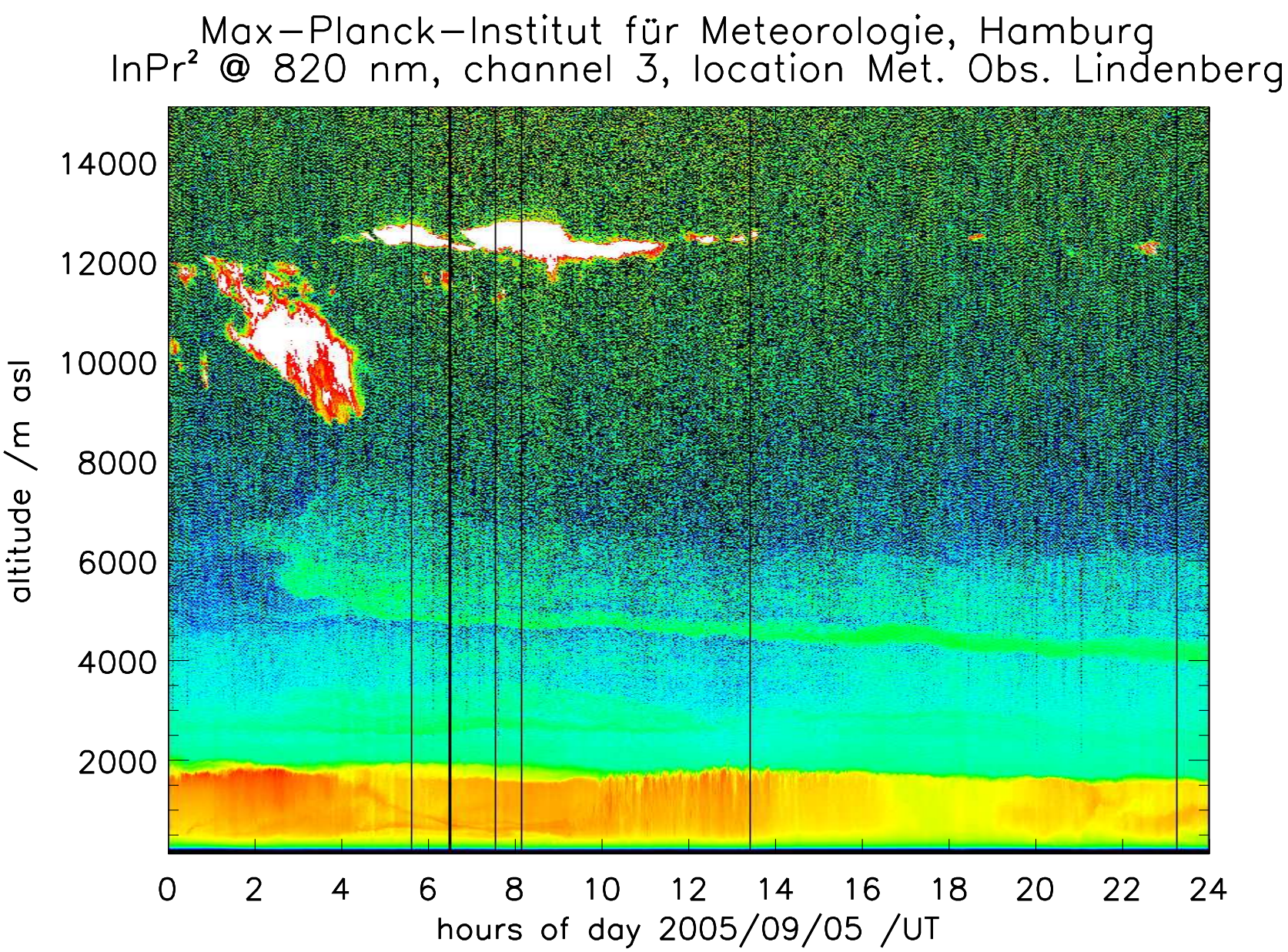
Measurements are needed to assess and improve understanding of aerosol processes and their treatment in models!

Why lidar?

- **Transport, and in particular long-range transport, occurs at elevated layers!**
- **The exact altitude of any aerosol layer is required to trace it back to the source.**
- **Lidar provides excellent information about the vertical structure of aerosol layers.**
- **Advanced lidar methods provide very good information about aerosol optical properties (extinction, backscatter, optical depth).**
- **Advanced lidar plus advanced retrieval methods provide important information about microphysical properties of aerosols.**

Why 4-D?

- **Aerosol distribution is highly variable in space and time.**
- **Long range transport of aerosols and precursors makes the system non-localised.**
- **Global or at least hemispheric coverage is needed for the assessment of source-receptor relations, climate impact studies, or comparative statistics.**


Max–Planck–Institut für Meteorologie, Hamburg
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altitude /m asl
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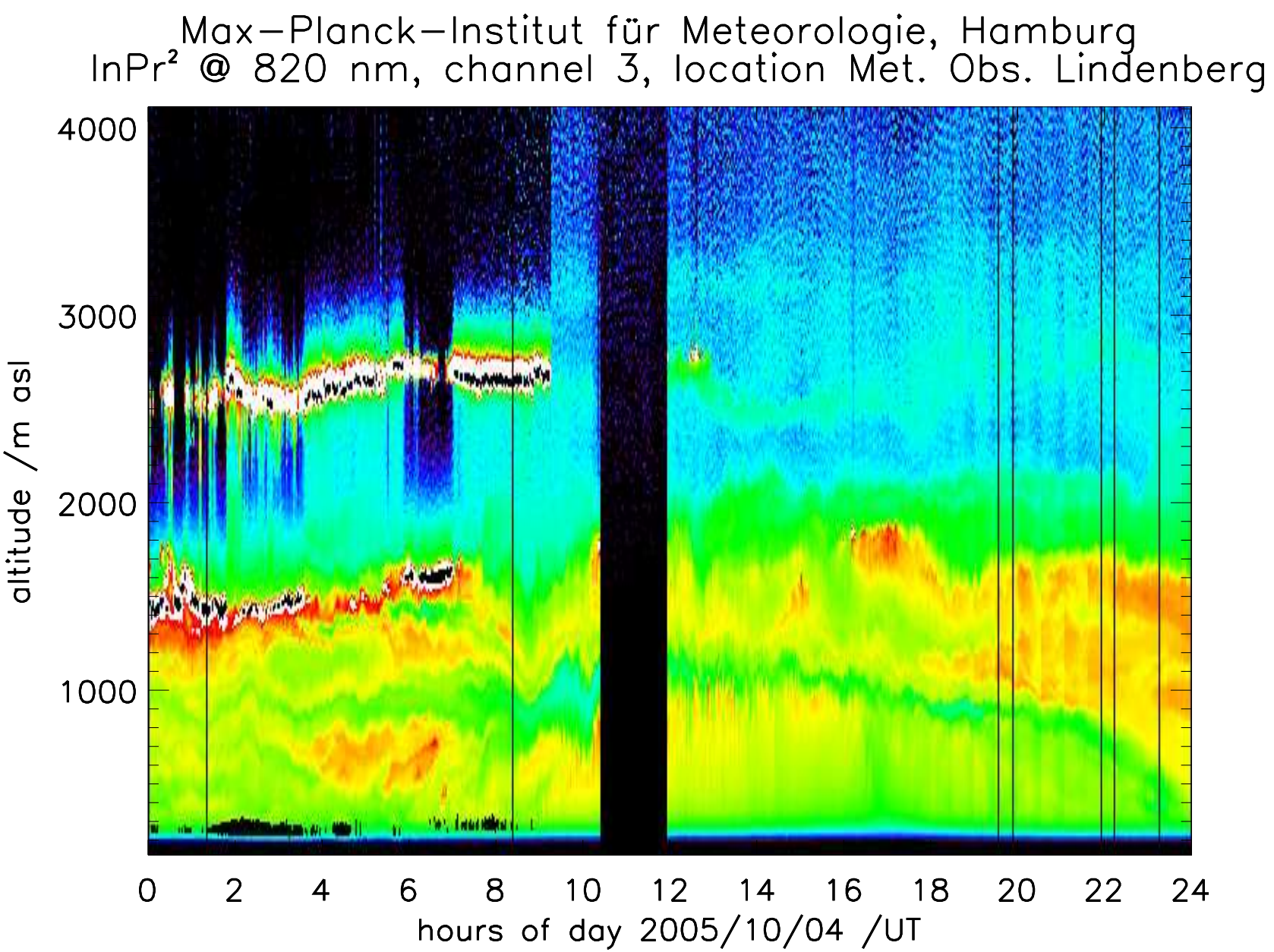
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altitude /m asl
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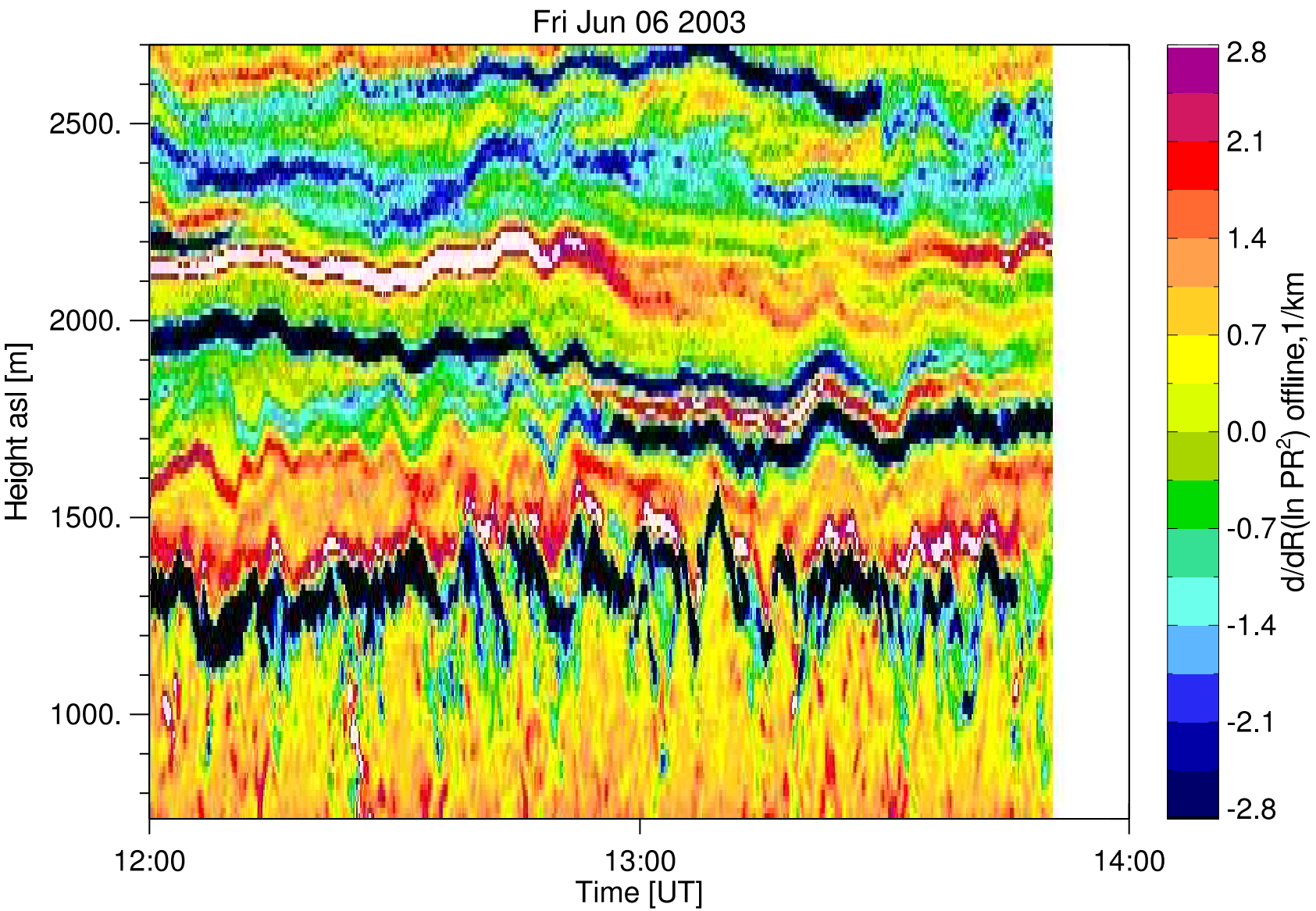
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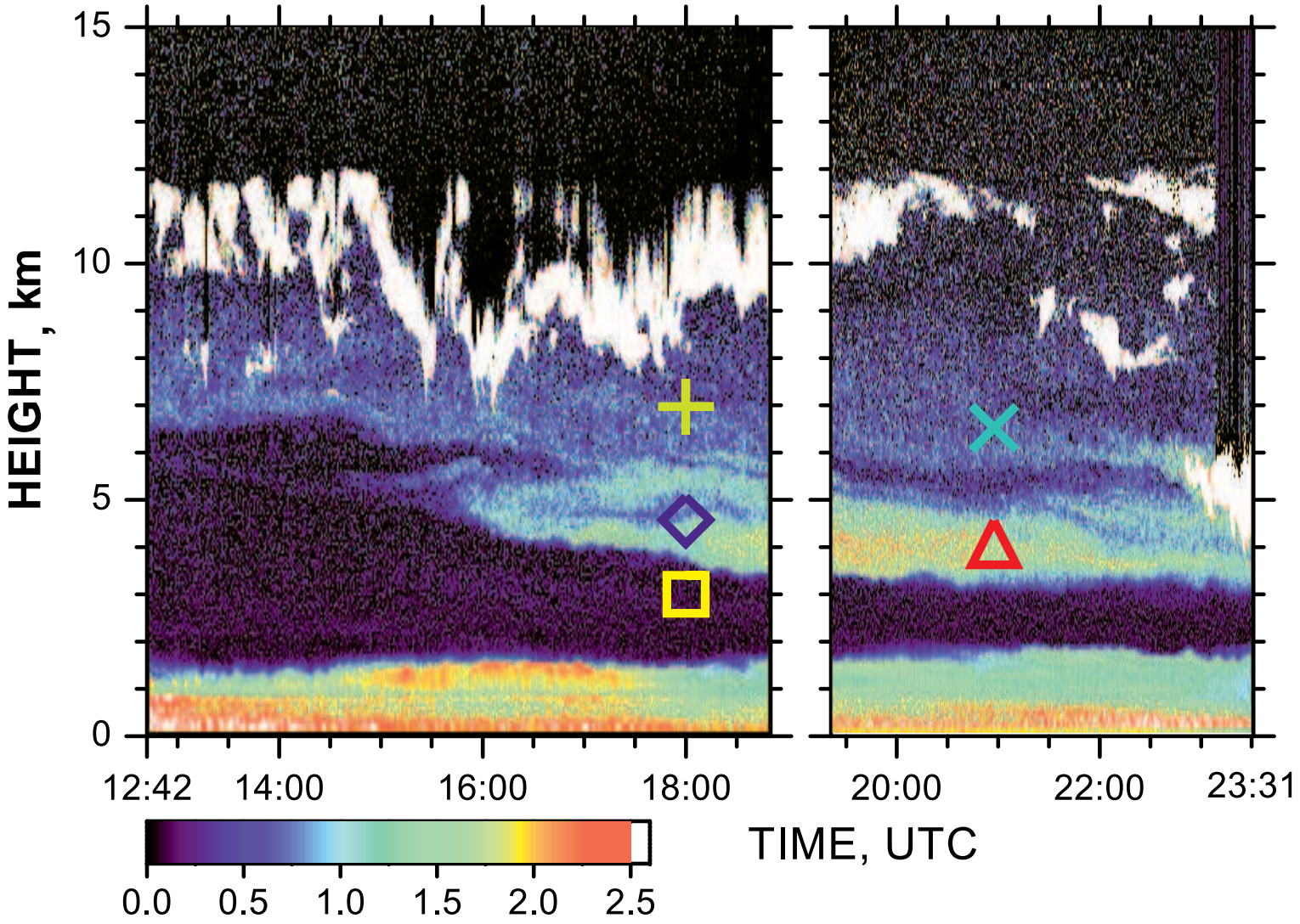
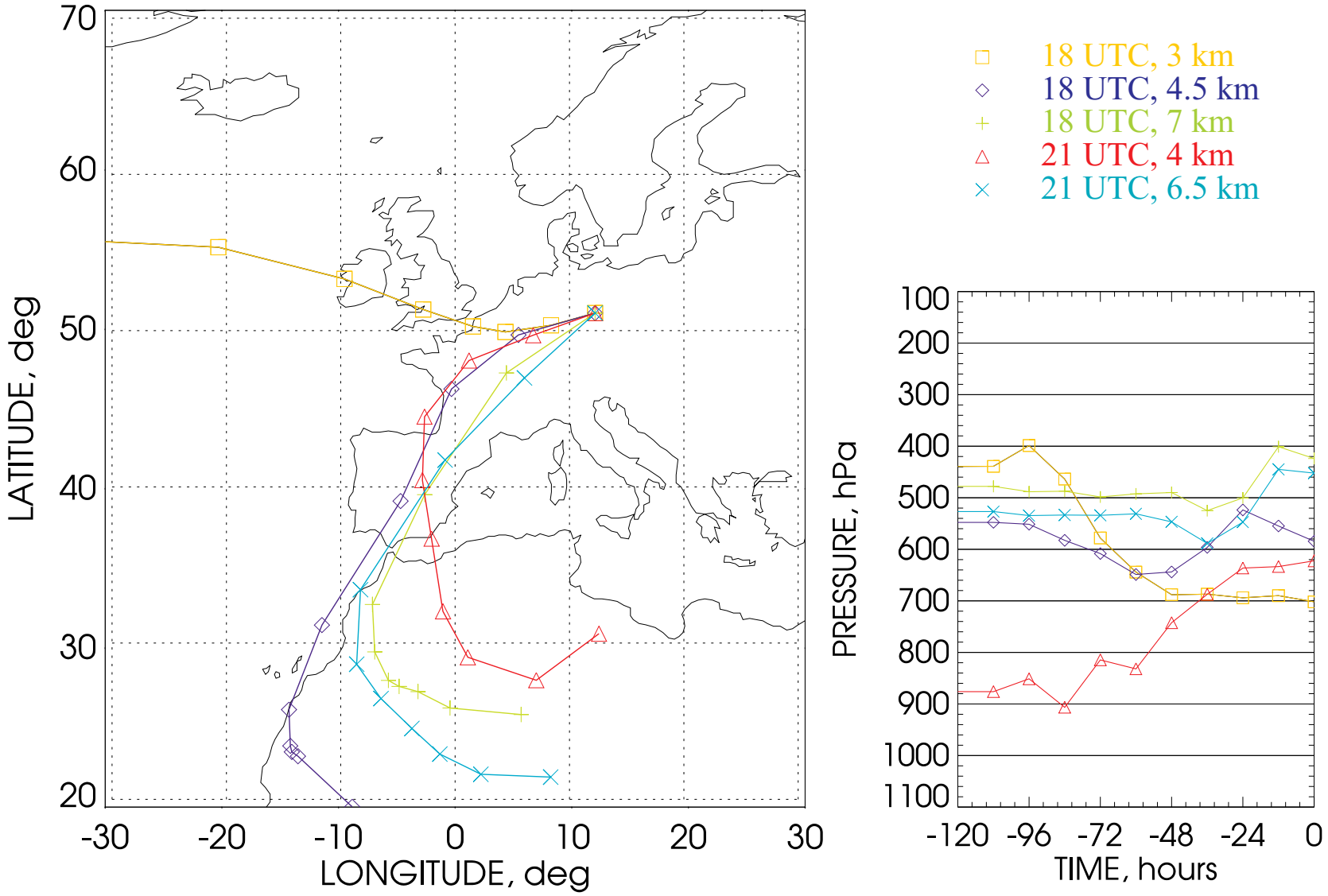
d/dR(ln PR²) offline,1/km



Courtesy I. Mattis, IfT Leipzig



Courtesy I. Mattis, IfT Leipzig

Spatial distribution

- **Backscatter lidar can retrieve the spatial distribution of aerosols**
  - **– with high sensitivity and resolution**
  - **– on temporal scales from turbulence to climatology**
  - **– on vertical scales from turbulence to tropospheric coverage**
  - **– unattended and automated**
  - **– from various platforms, ground-based to spaceborne**
- **Layer structure and precise height information helps to trace aerosol plumes back to their origin.**
- **Lidar measurements cover the 2 dimensions generally neglected in satellite retrievals from passive sensors: vertical and time!**

Methods

Quantitative retrieval of aerosol parameters from lidar measurements.

Lidar equation: $P \cdot R^2 = c(\beta_p + \beta_m) e^{-2\int_0^R (\alpha_p + \alpha_m) dr}$

Backscatter lidar: $\frac{d}{dR} ln(P \cdot R^2) = \frac{d}{dR} ln\, \beta - 2\alpha$ **Is NOT quantitative!**

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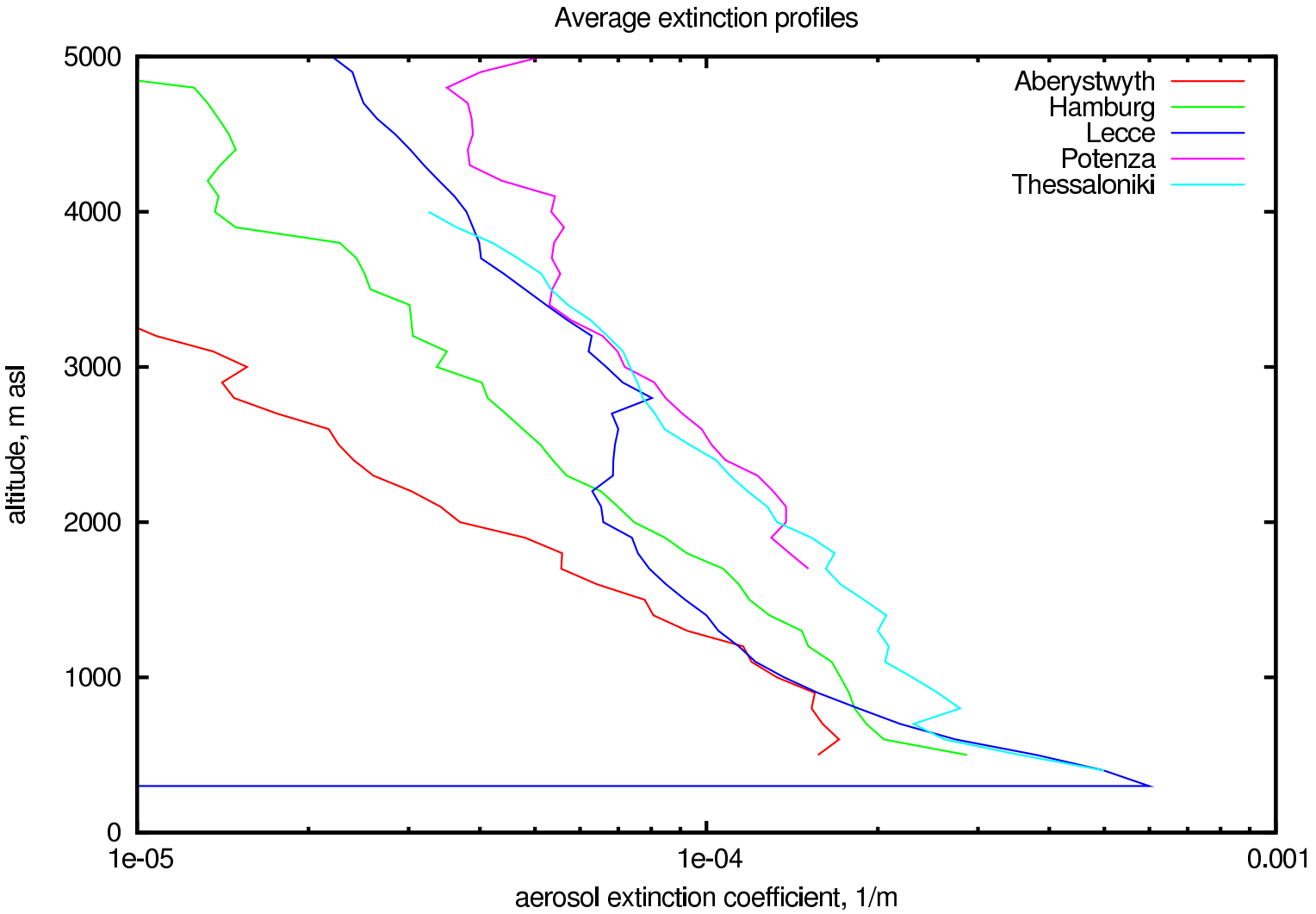
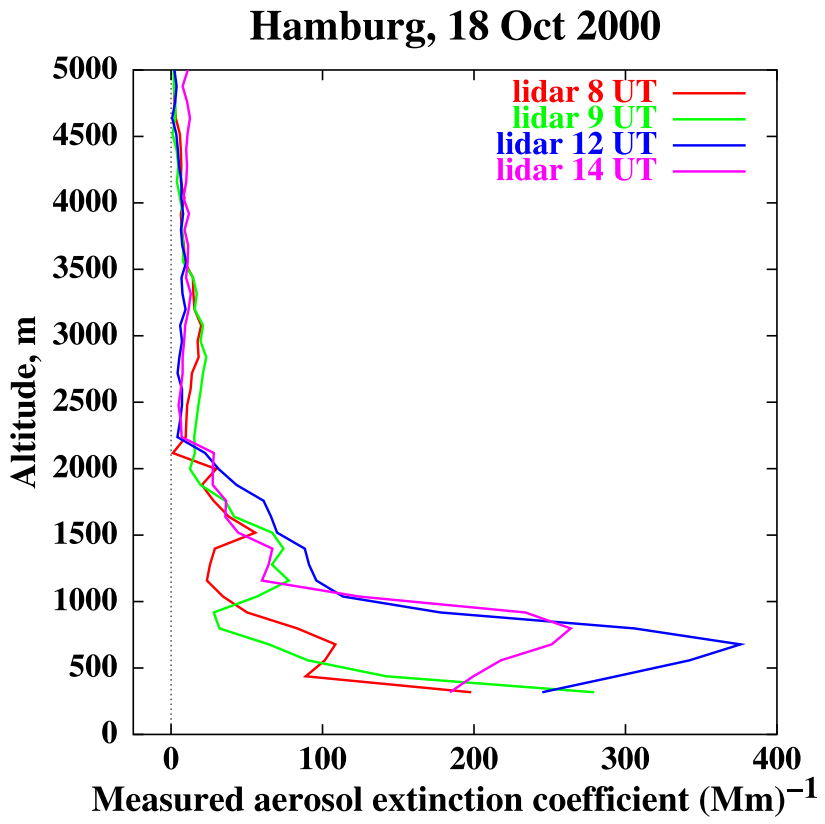
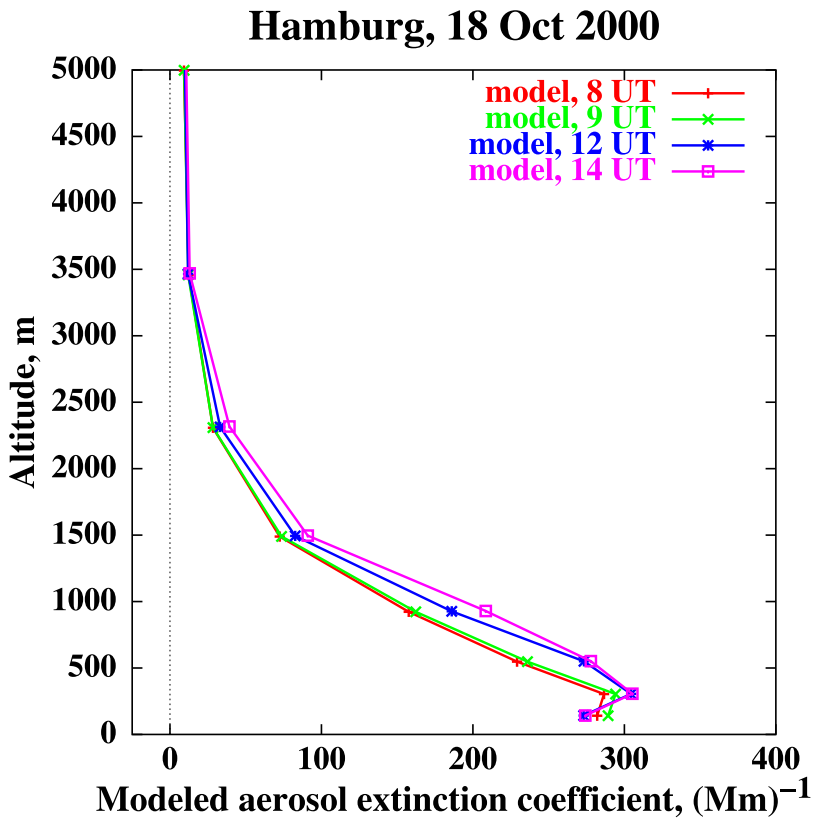
Polarisation allows to distinguish spherical from nonspherical particles!


Average extinction profiles
5000
4000
3000
2000
1000
0
altitude, m asl
1e-05
1e-04
0.001
aerosol extinction coefficient, 1/m
Aberystwyth
Hamburg
Lecce
Potenza
Thessaloniki

Diurnal cycle





Summary

Ground-based lidar can retrieve

- **vertical distribution of aerosols from backscatter lidar on all relevant scales in 4-D**
- **Optical properties from Raman or HSR lidar**
- **Microphysical parameters from multi-wavelengths systems plus advanced retrieval methods.**

Long-term automated operation

- **achieved for backscatter lidar**
- **at few sites for Raman lidar**
- **systems for day+night microphysical retrieval under development**

Quantitative methods permit network operation:

- **to study large scale processes, e.g., long range transport**
- **to establish aerosol climatology on continental (global?) scale, covering 4 dimensions**
- **to provide excellent ground truth**
- **to provide key information for improved interpretation of satellite measurements**
- **to provide key information for model validation**

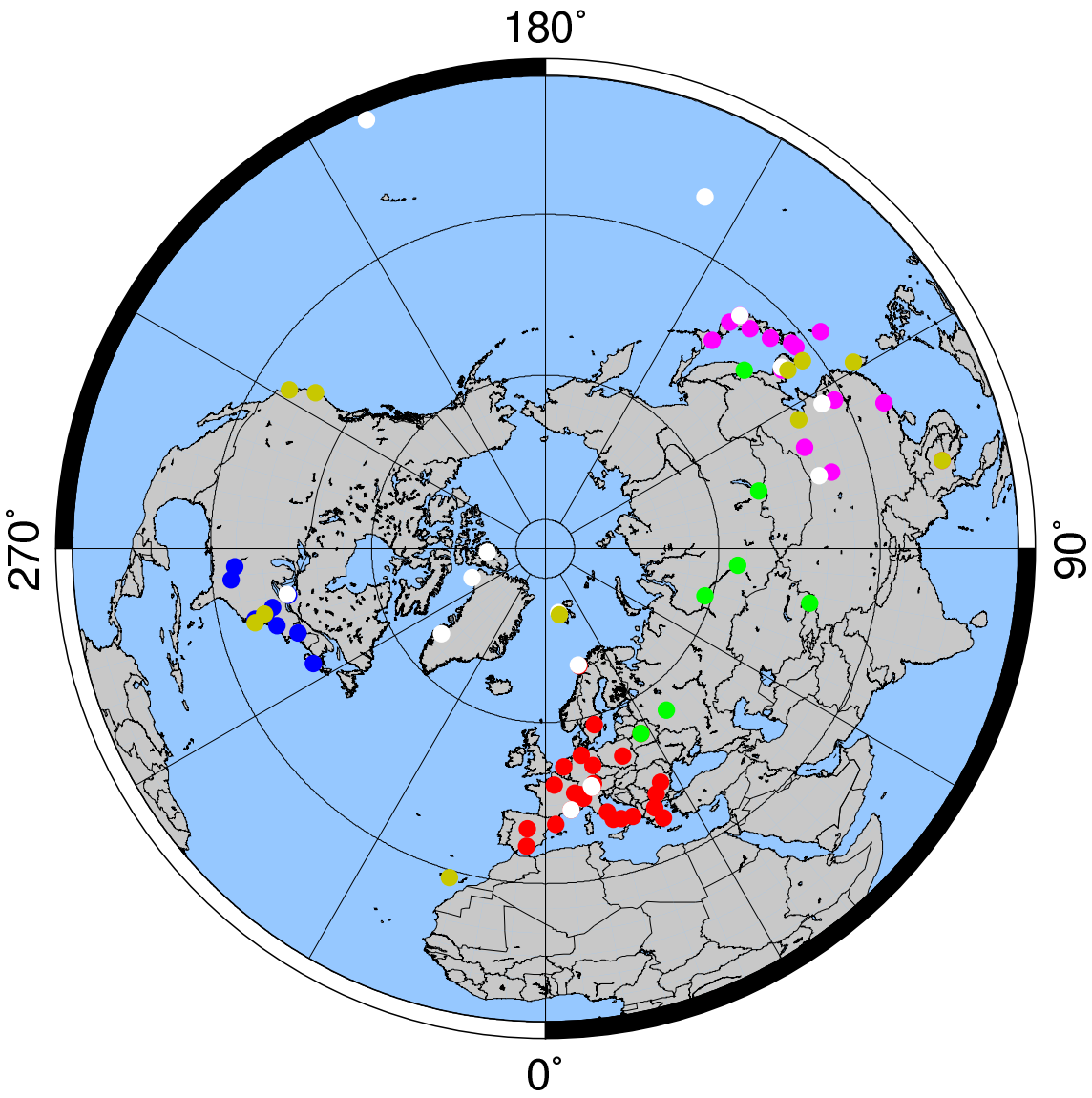
GALION organisation

GALION is organised as a network of aerosol lidar networks, to be amended by selected stations, with commitment to long-term operation. Participating networks are:

- **ALINE, Latin America**
- **AD-Net, East Asia**
- **CIS-LINET, Commonwealth of Independent States**
- **EARLINET, Europe**
- **NDACC, Global Stratosphere**
- **REALM, Eastern North America**
- **MPLNET, Global, Micropulse Lidar**

Tasks for coordination:

- **Harmonise operational scheme**
- **Harmonise data products and name conventions**
- **Provide homogeneous documentation for systems and data**
- **Establish common access point for data**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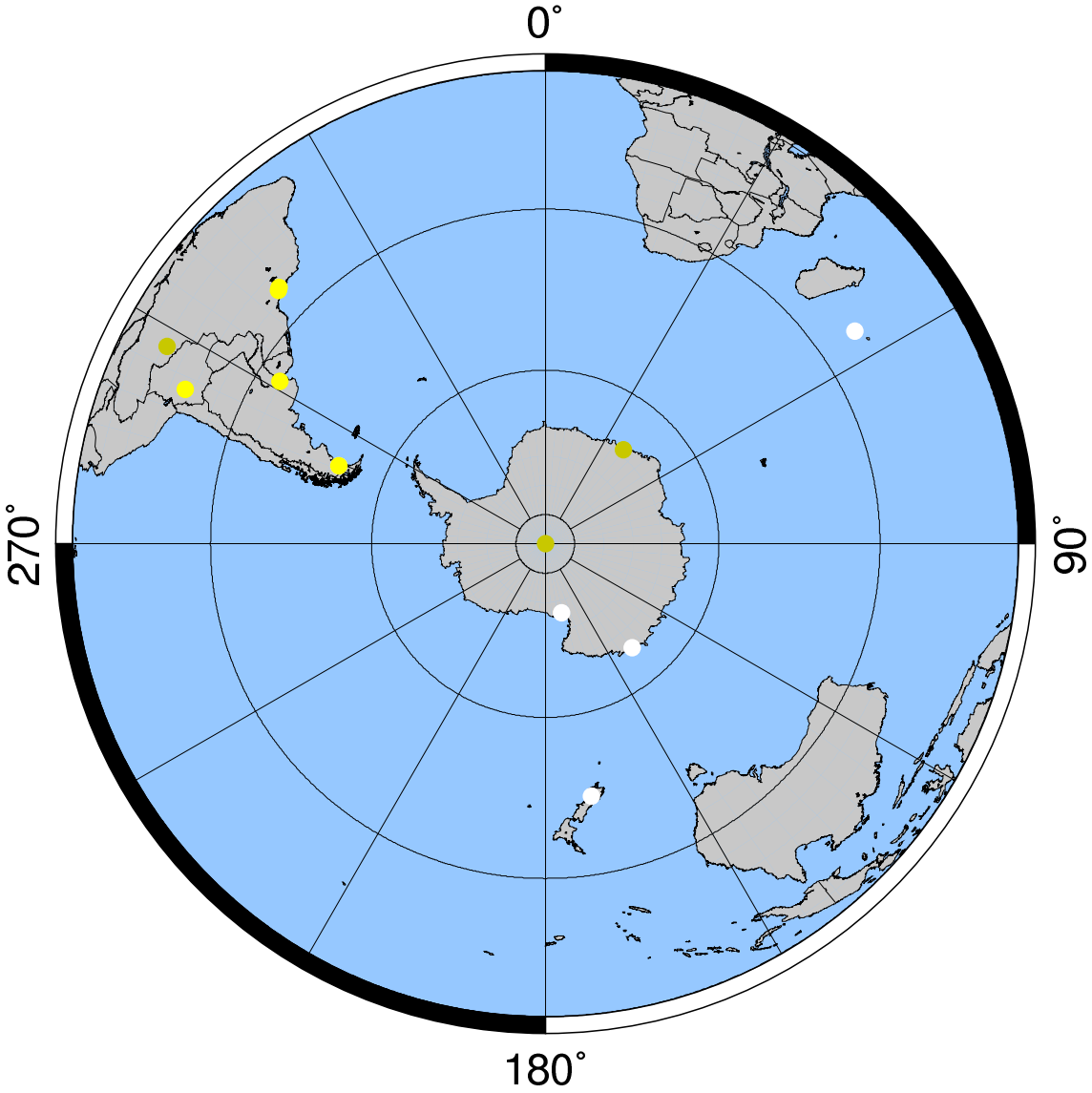
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Organisation

Initial scheme of operation:

- **Routine measurements at fixed dates, 3 per week (on 2 days)**
- **Special measurements on alert (e.g., desert dust outbreaks, biomass burning plumes, volcano eruptions)**
- **Aerosol and cloud layer identification and characterisation**
- **Compilation of aerosol profile data, extinction and backscatter**

Two subnets:

- **Small number of advanced stations**
  - **independent extinction measurements, 2 or more wavelengths**
  - **backscatter measurements at 3 or more wavelengths**
  - **depolarisation measurements**
  - **characterisation of aerosol microphysical properties**
- **Large network with backscatter lidar**
  - **layer identification**
  - **aerosol backscatter at single wavelength**
  - **extinction estimates**

GALION vs. CALIPSO

Why not leave aerosol profiling to spaceborne lidar?

GALION advantages:

- **temporal coverage and resolution (e.g., diurnal cycle!)**
- **advanced observation methods: multiple wavelengths, Raman**
- **can support satellite lidar evaluation by providing**
  - **extinction/backscatter ratio**
  - **Ångström coefficients**
- **observations below clouds**
- **calibration capabilities**
- **long term stability**
- **reference between different satellite systems**

GALION and spaceborne lidars are complementing, not excluding!

Status

- **WMO/GAW experts meeting held in Hamburg, March 27-29, 2007**
- **Cooperation between networks resolved**
- **Main scheme of operation resolved**
- **White Paper in preparation (to be submitted to WMO/GAW)**
- **Endorsed by WMO/GAW SAG Aerosol**

GALION exists!

For data over Europe consider EARLINET!