Leibniz Institute for
Tropospheric Research

Lunds
University

Ten years of aerosol particle concentration measurements in the upper troposphere and lowermost stratosphere by CARIBIC

Markus Hermann, Leipzig

Bengt Martinsson, Lund

Carl Brenninkmeijer (speaker, co-ordinator), Mainz

OUR AEROSOL PARTNERS

AEROCOM 8 Princeton 5-7 October 2009

Leibniz
Association

www.caribic-atmospheric.com

CARIBIC is a flying observatory for detailed measurements

Civil Aircraft for the Regular Investigation of the atmosphere Based on an Instrumented Container

www.caribic-atmospheric.com

MAX-PLANCK-GESELLSCHAFT

Coordinated by the Max Planck Institute for Chemistry in Mainz

CARIBIC essentials

- Regular Lufthansa passenger flights
- One aircraft with special inlet
- One container deployed for 3 days, each month
- Fully automated system
- In situ trace gas species and aerosol properties
- Collection of air and of aerosol samples
- Remote sensing with DOAS system
- Long term
- Near global
- Good performance

PARTNERS

www.caribic-atmospheric.com

CARIBIC has 14 partners in 7 European countries

1. Max Planck Institute for Chemistry, Atmospheric Chemistry Division, Mainz, DE
2. Research Center Karlsruhe, Institute for Meteorology and Climate Research,
3. Leibniz Institute for Tropospheric Research, Leipzig, DE, **AEROSOL**
4. German Air and Space Agency, Atmospheric Physics Division, Wessling, DE
5. University of Heidelberg, Environmental Physics Department, DE
6. Helmholtz GKSS Research Center, Geesthacht, DE
7. University of East Anglia, School of Environmental Sciences, Norwich, GB
8. University of Lund, Nuclear Physics Department, Lund, SE, **AEROSOL**
9. University of Bern, Climate and Environmental Physics, Bern, CH
10. National Center for Scientific Research, LSCE-CEA, Paris, FR
11. Royal Netherlands Institute for Meteorology, de Bilt, NL
12. University of Utrecht, Institute for Marine and Atmospheric Research, Utrecht, NL
13. Institute for Reference Materials and Measurement, Geel, BE
14. Swiss Federal Laboratories for Materials Testing and Research, Zürich, CH

www.caribic-atmospheric.com

THE SYSTEM

www.caribic-atmospheric.com

CARIBIC measurement container

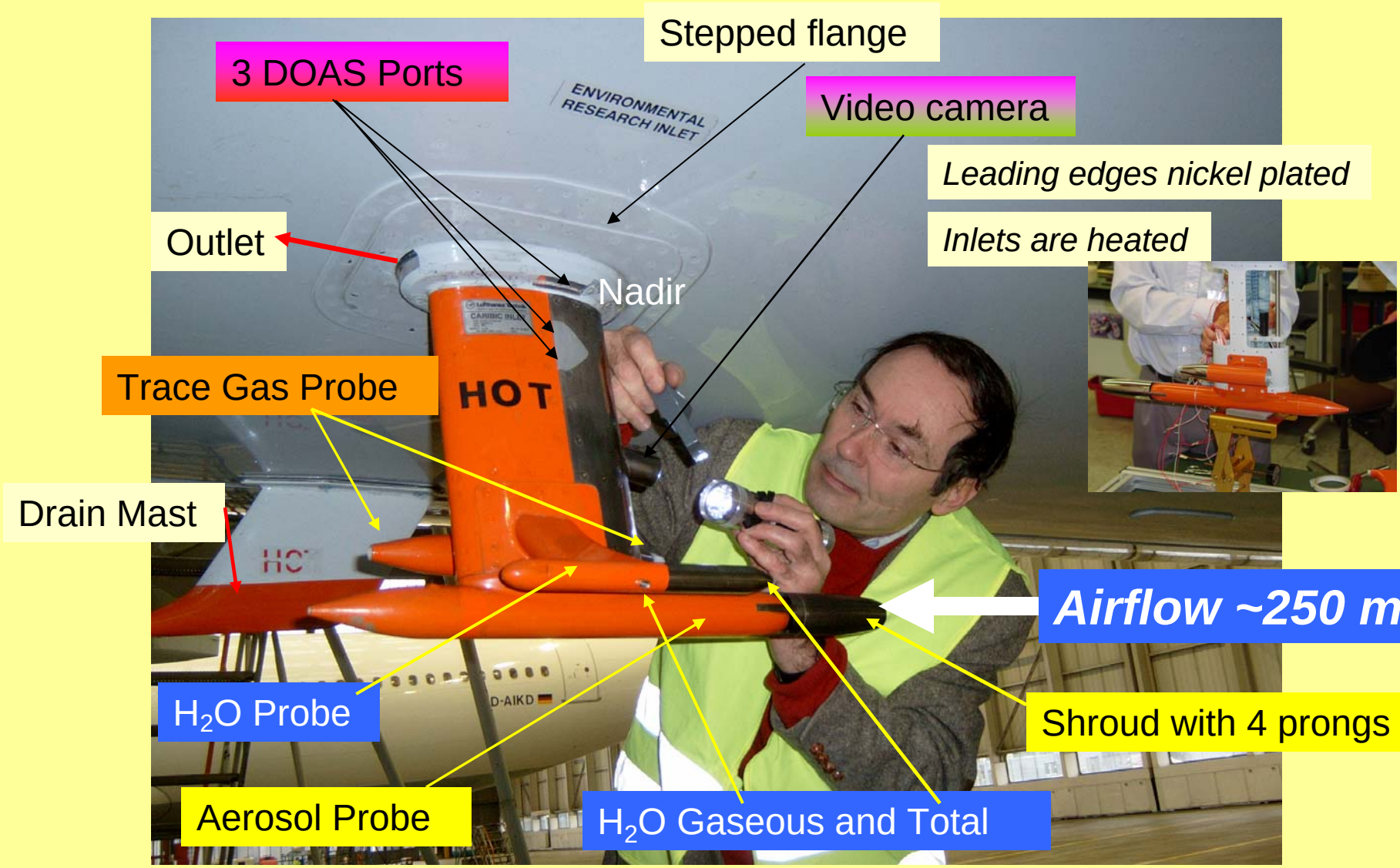
Mass 1,5 ton Deployment monthly

Airbus
A 340-600

D-AIHE

Air inlet system

Permanent part

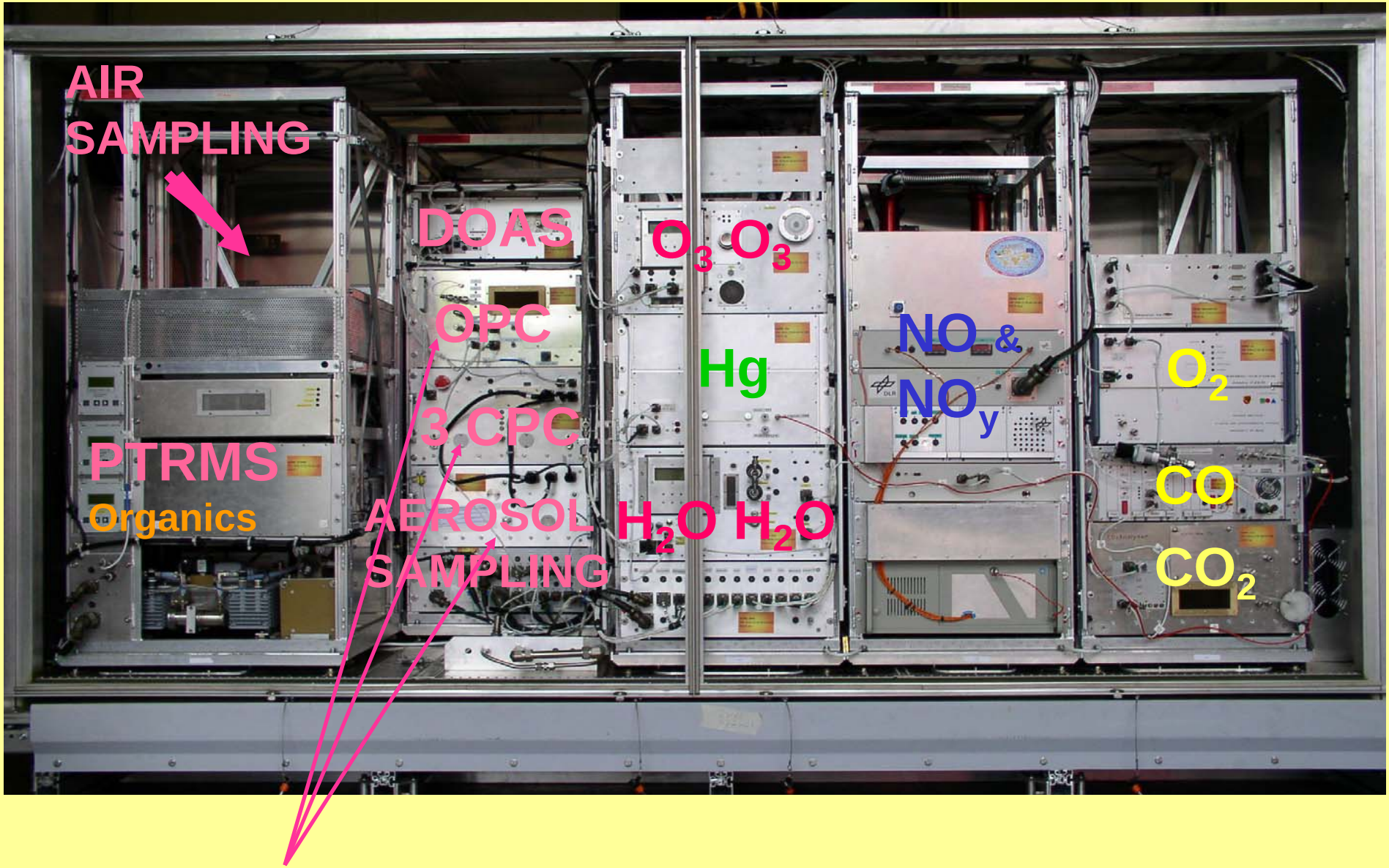


Inspection CARIBIC inlet system of the Lufthansa Airbus A340-600 AIHE „Leverkusen“ during a maintenance check in Frankfurt


ENVIRONMENTAL
RESEARCH INLET
HOT
HOT
NO GRAB

CARIBIC container with equipment. Width 3.2 m. Weight 1.5 ton

The planet's flying laboratory with over 15 experiments

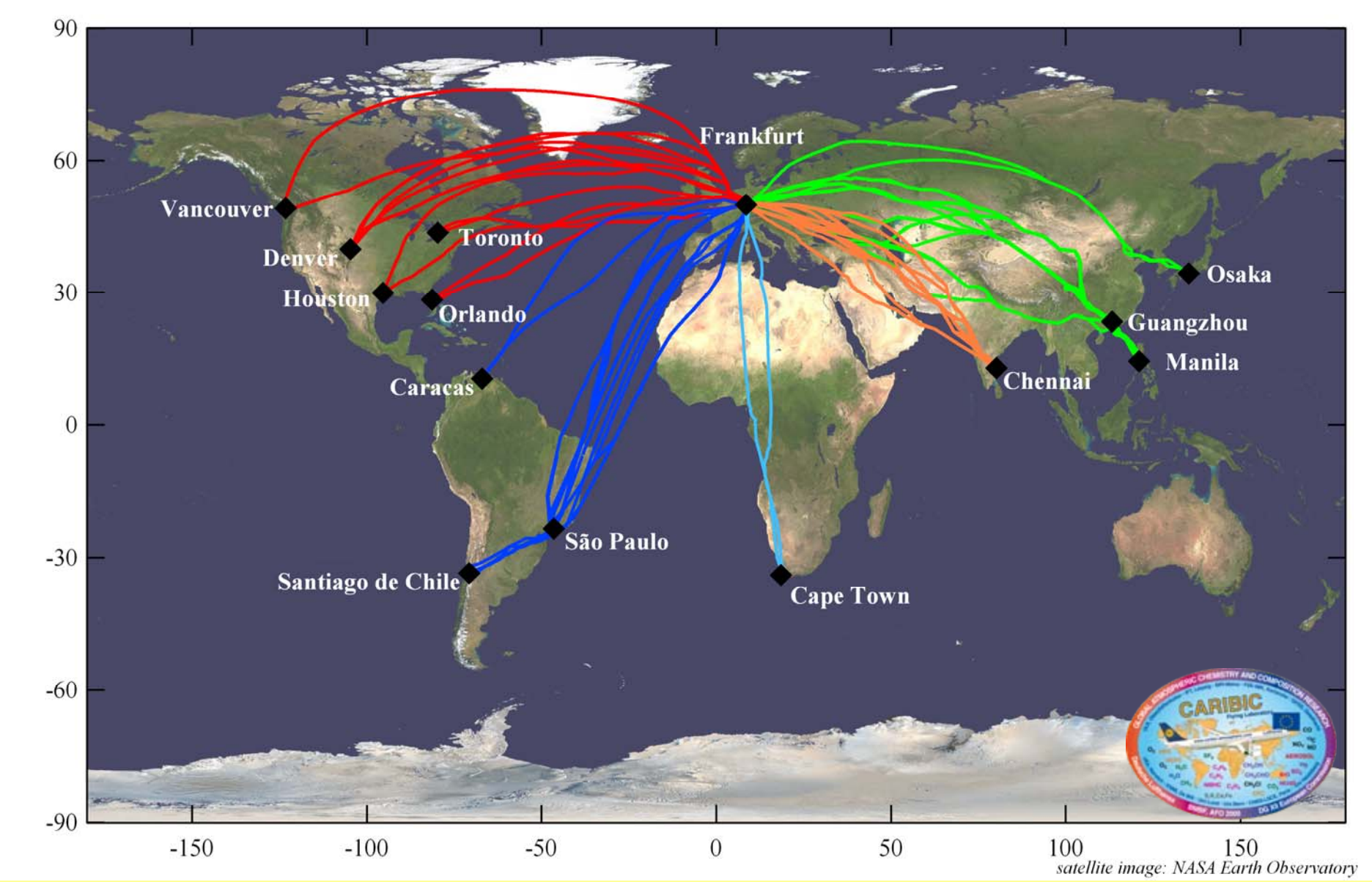


In situ measurement ands collection of particles

- **integral particle number concentration** (particle counter)
  - 4 - 2000 nm diameter (N_4)
    12 - 2000 nm diameter (N_{12})
  - $N_{4\text{-}12} = N_4 - N_{12} \approx$ nucleation mode particles
  - 2 s time resolution
- **elemental composition** (particle sampler)
  - 16 parallel impactors
  - 0.1 µm < diameter < 2.0 µm
  - 1.5 and 10 h time resolution
  - laboratory analysis with *PIXE*, *TEM*, *PESA*
- future: **particle size distribution** (optical particle counter)

Flight Routes

www.caribic-atmospheric.com



CARIBIC Lufthansa flights 2005-2009

Results

Air mass characterization

Kasatochi vulcanic plume

Lifetime of aerosols after cloud contact

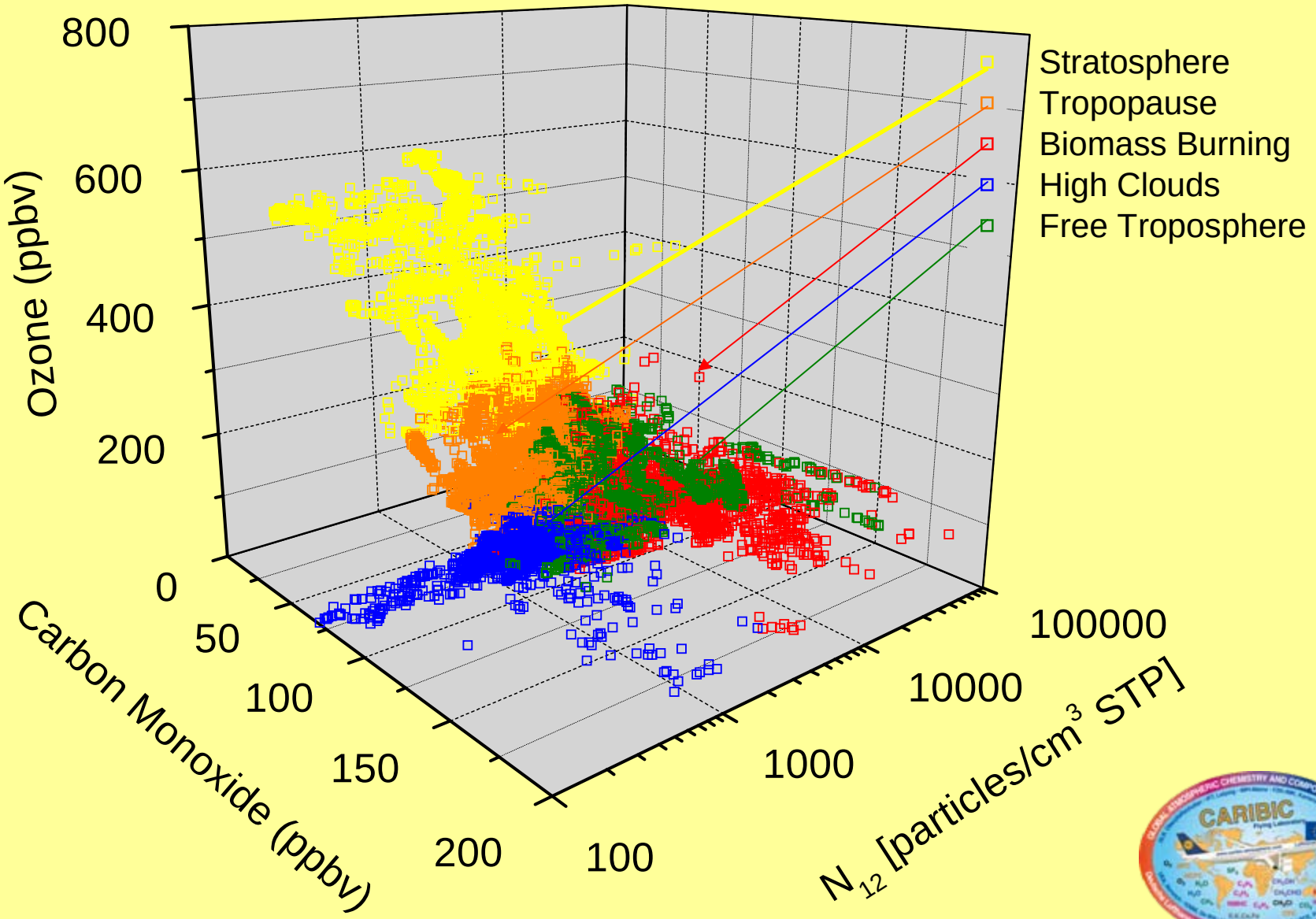
Aerosol sulfate distribution

Aerosol morphology and elemental composition

Aerosol distribution

www.caribic-atmospheric.com

Cluster analysis of air masses



Köppe and Hermann, IfT

Results

Air Mass Characterization

Kasatochi volcanic plume

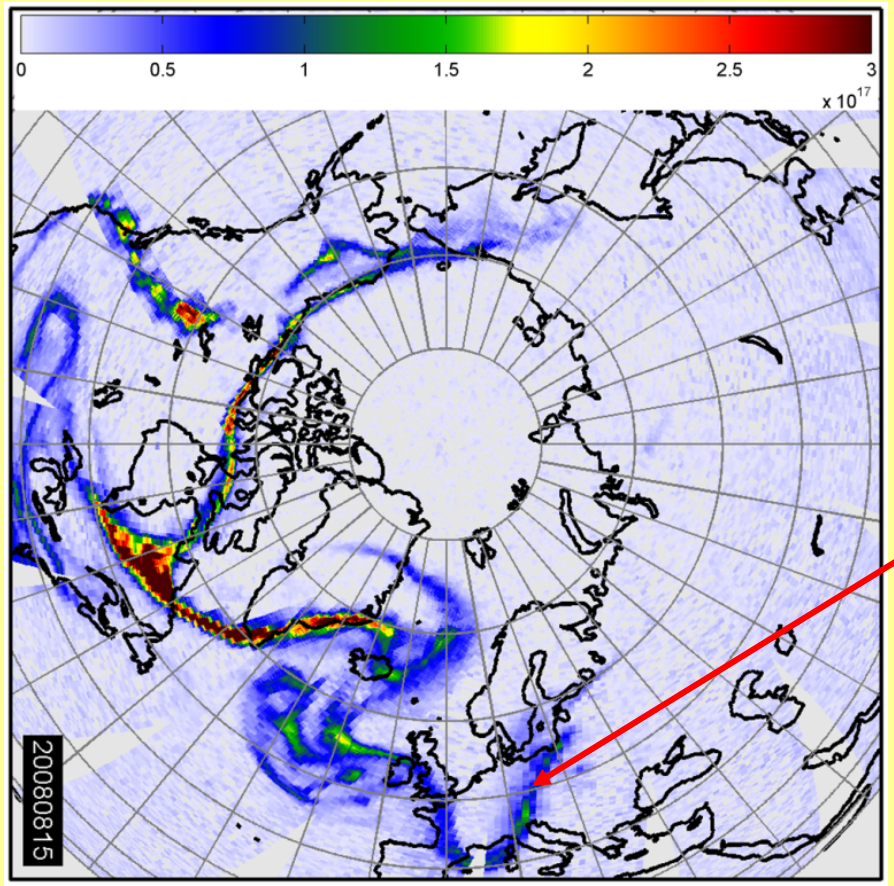
Lifetime of aerosols after cloud contact

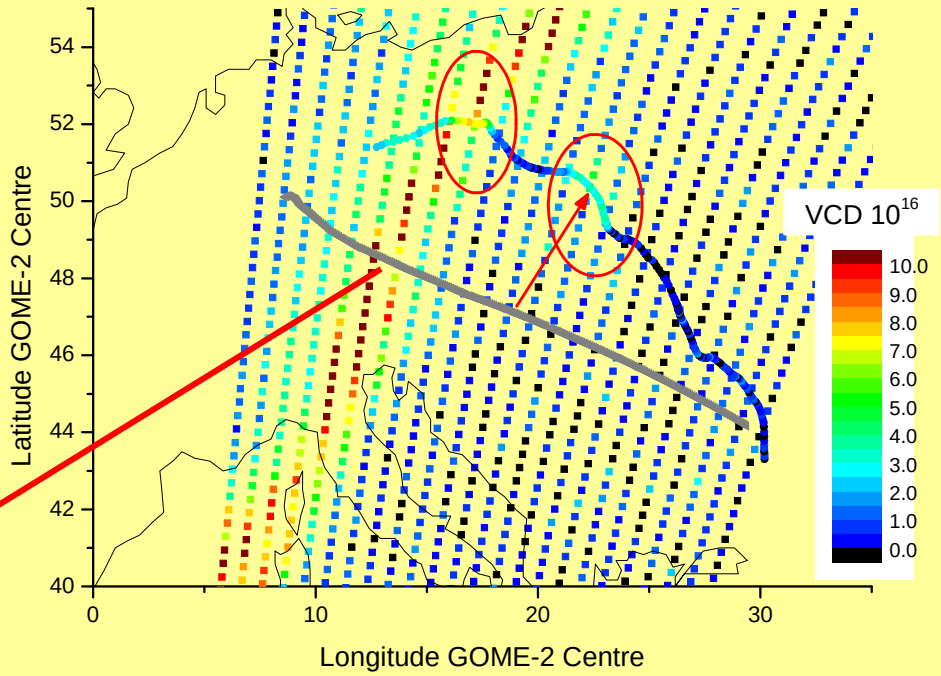
Aerosol sulfate distribution

Aerosol morphology and elemental composition

Aerosol distribution

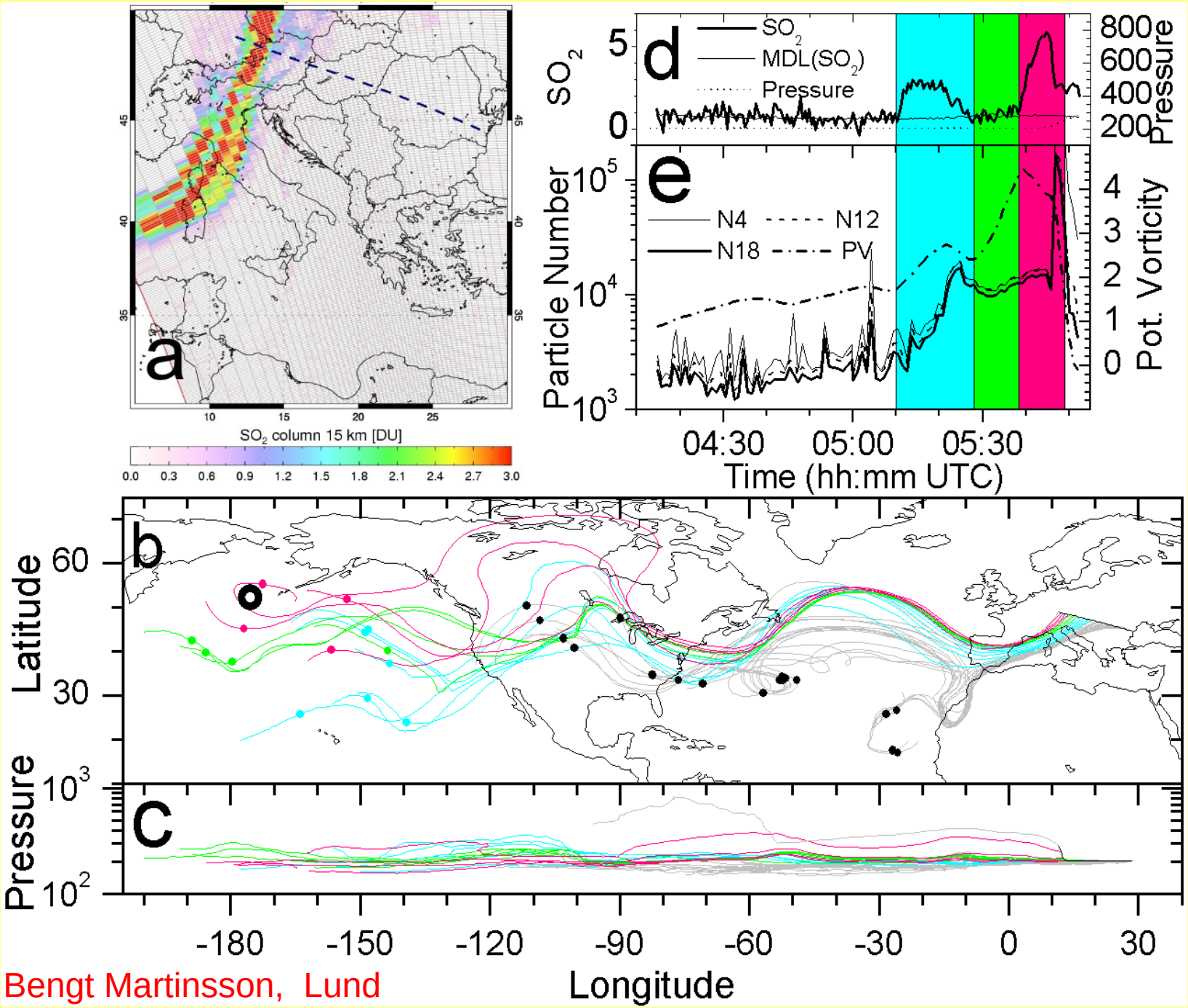
www.caribic-atmospheric.com



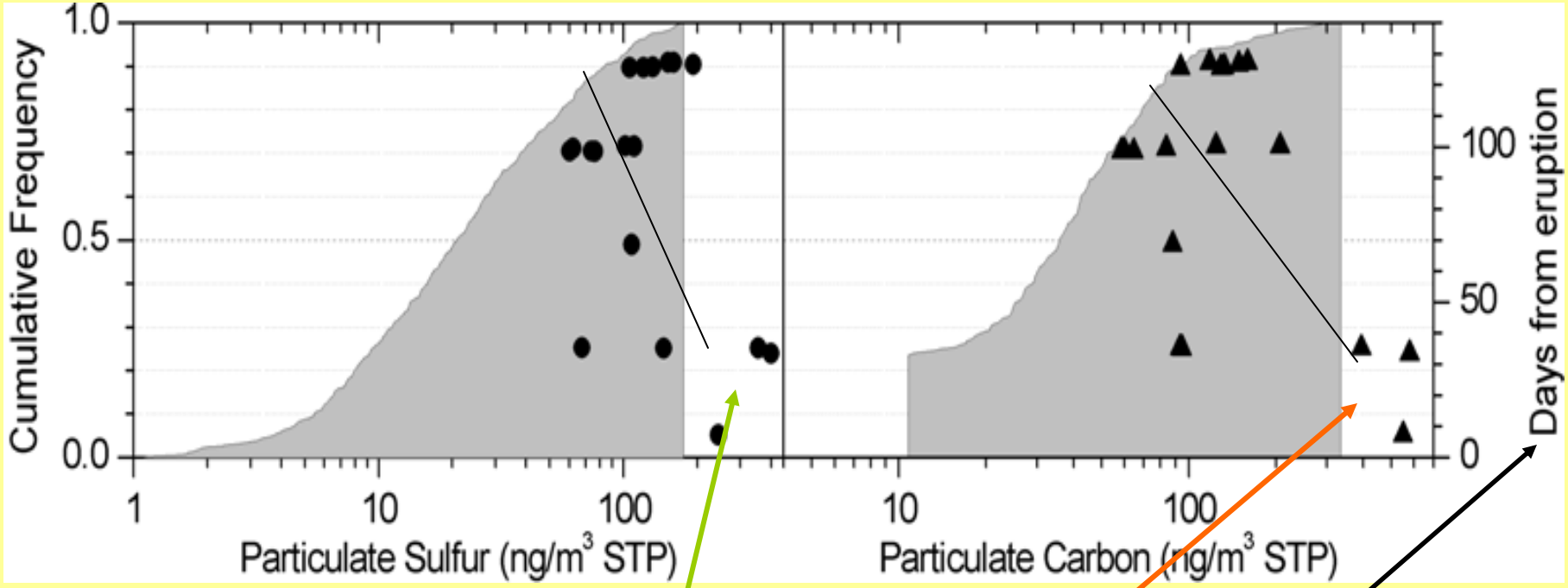


The distribution and dispersion of the Kasatochi SO_2 plume one week after the eruption (15 August 2008), based on GOME-2 VCD retrievals

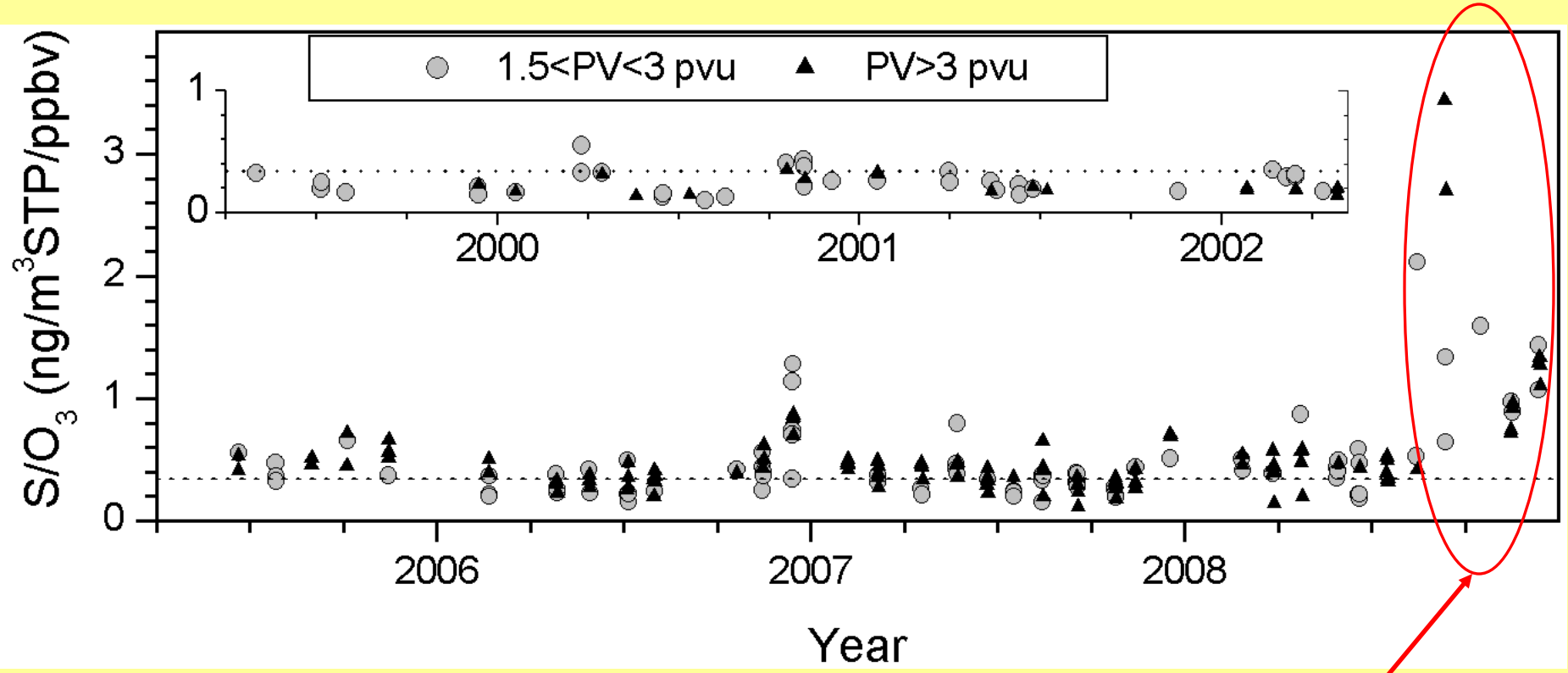
K.-P. Heue, MPI Mainz



Bengt Martinsson, Lund



High Sulfur and Carbon after the eruption



Sulfur to Ozone ratio, it was quiet for 10 years

PV > 3 pvu is considered here as stratospheric air

Kasatochi

Results

Air Mass Characterization

Kasatochi vulcanic plume

Lifetime of aerosols after cloud contact

Aerosol sulfate distribution

Aerosol morphology and elemental composition

Aerosol distribution

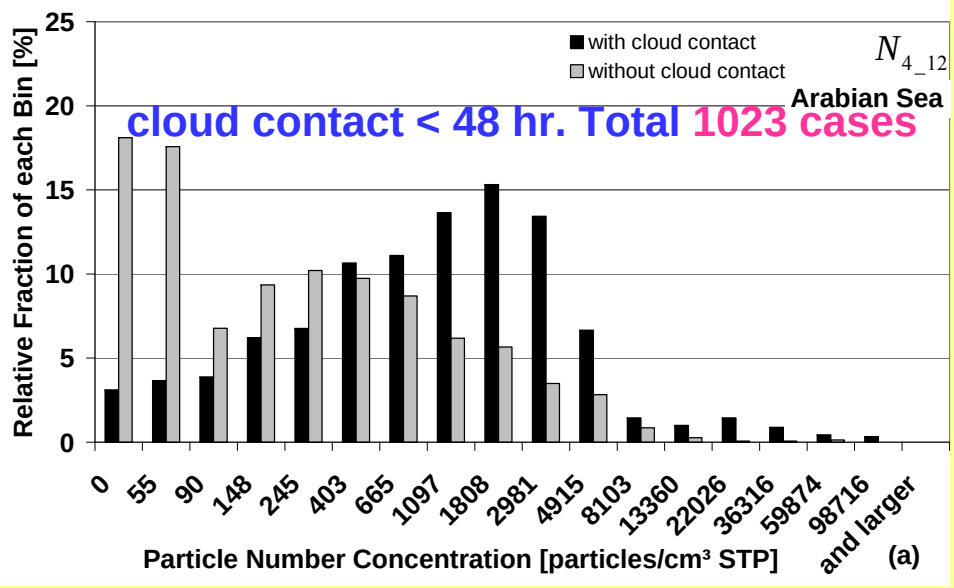
www.caribic-atmospheric.com

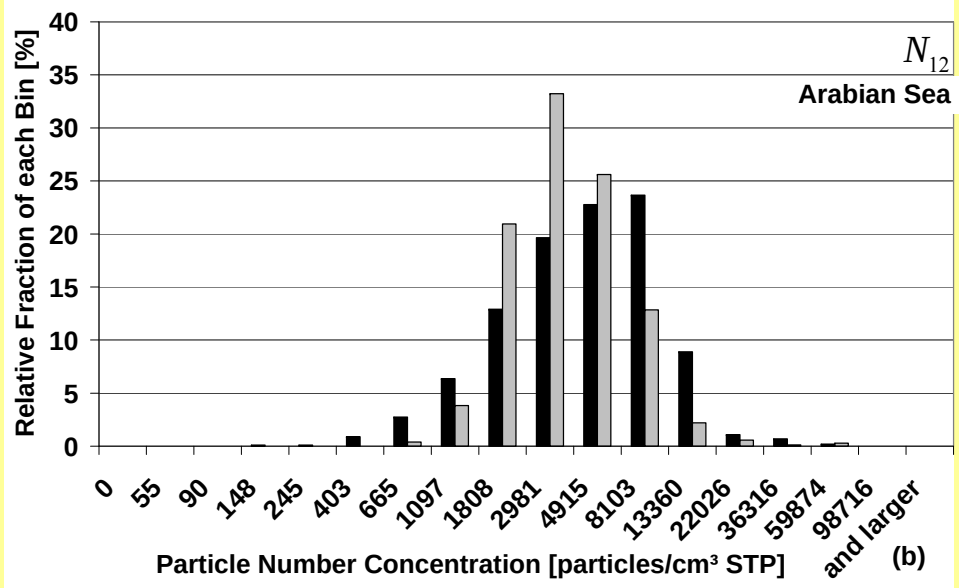
Interception by CARIBIC of air masses, hours to days after “cloud contact“

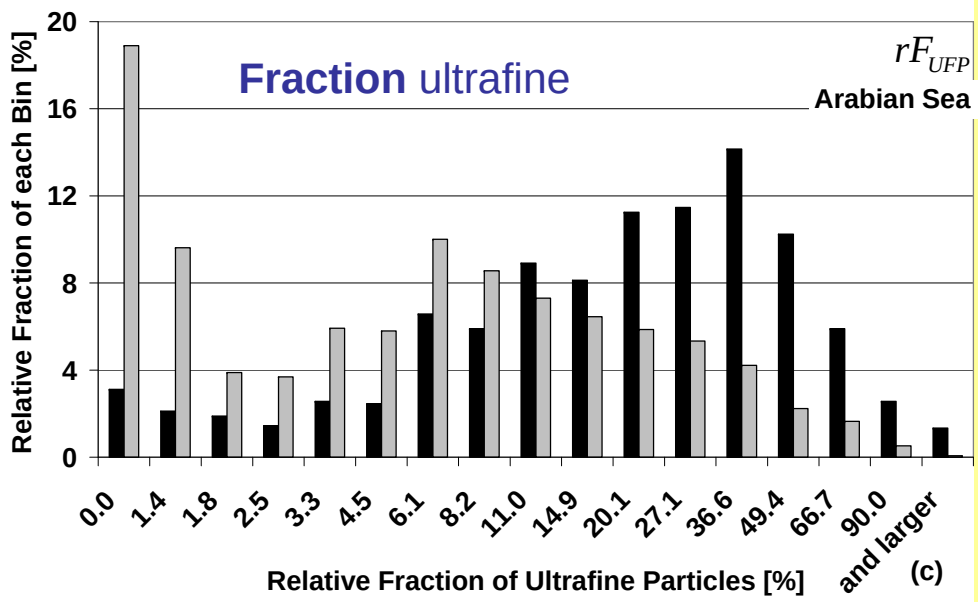
How fast do ultrafine particles disappear after their formation

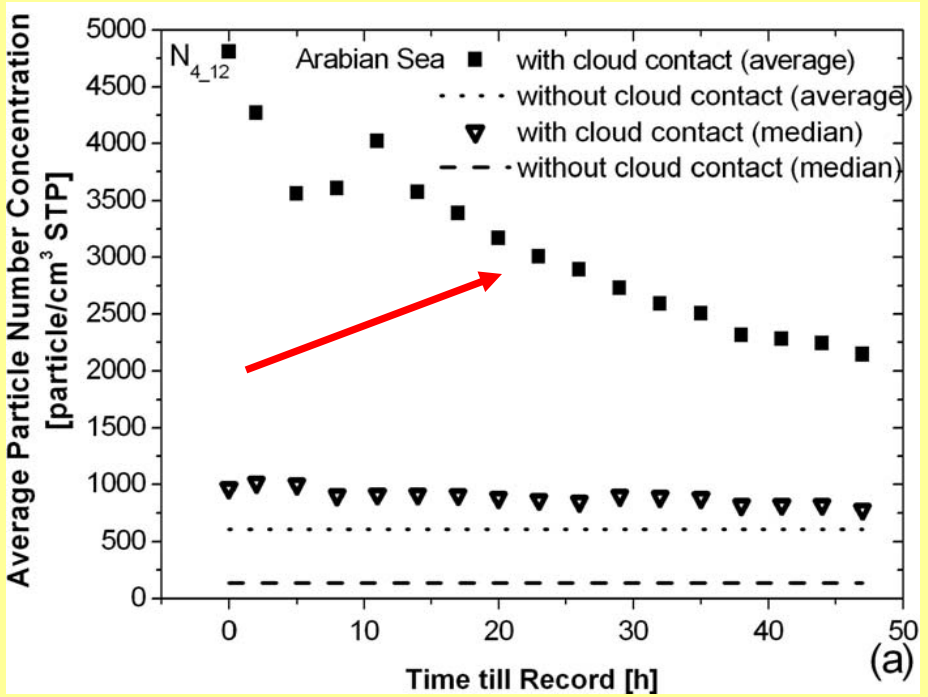
Combine satellite images of clouds with back trajectories and aerosol measurments

Andreas Weigelt and Markus Hermann, IfT









Andreas Weigelt, Markus Hermann et al.

Results

Air Mass Characterization

Kasatochi vulcanic plume

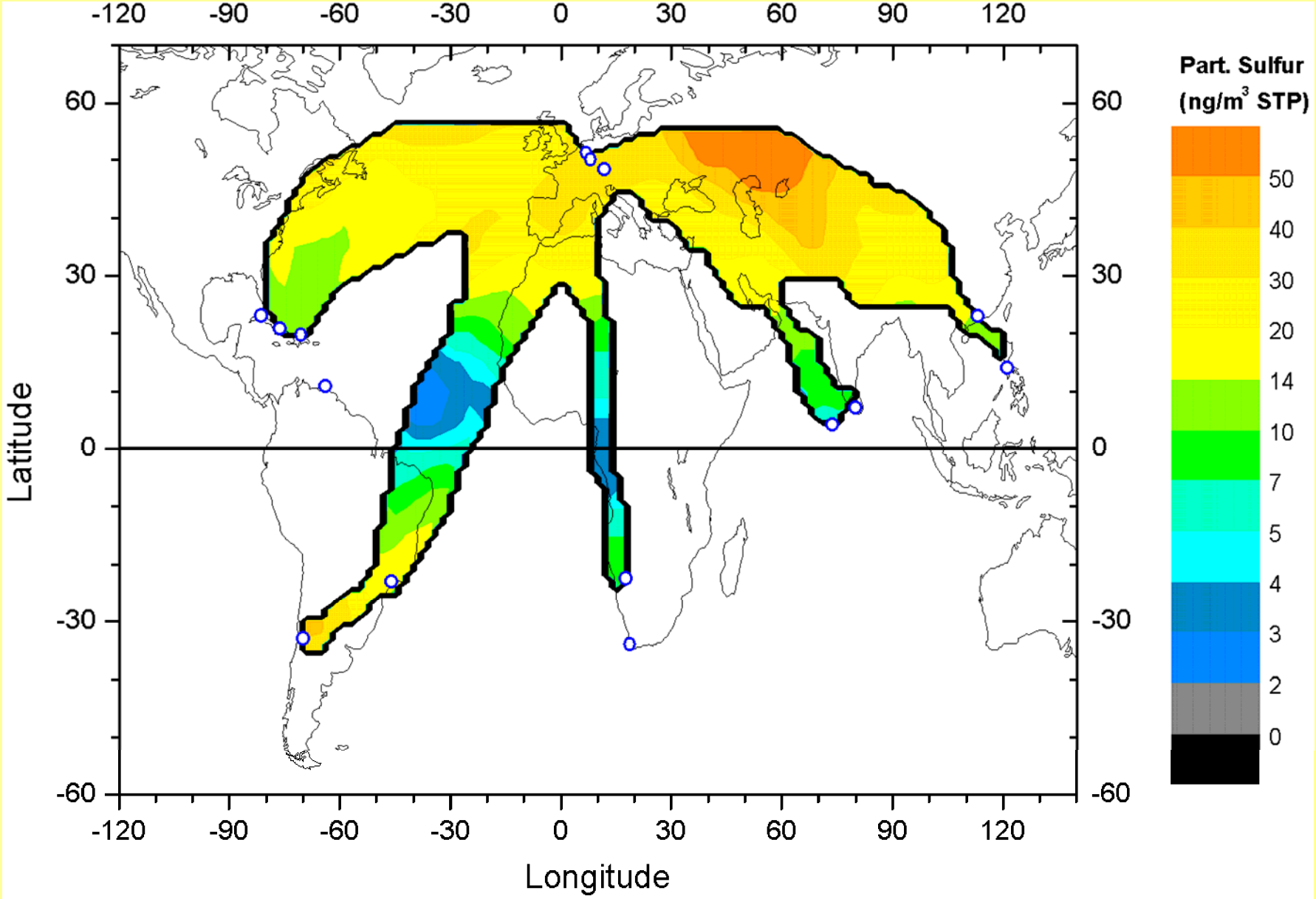
Lifetime of aerosols after cloud contact

Aerosol sulfate distribution

Aerosol morphology and elemental composition

Aerosol distribution

www.caribic-atmospheric.com



Bengt Martinsson, Lund

Results

Air Mass Characterization

Kasatochi vulcanic plume

Lifetime of aerosols after cloud contact

Aerosol sulfate distribution

Aerosol morphology and elemental composition

Aerosol distribution

www.caribic-atmospheric.com

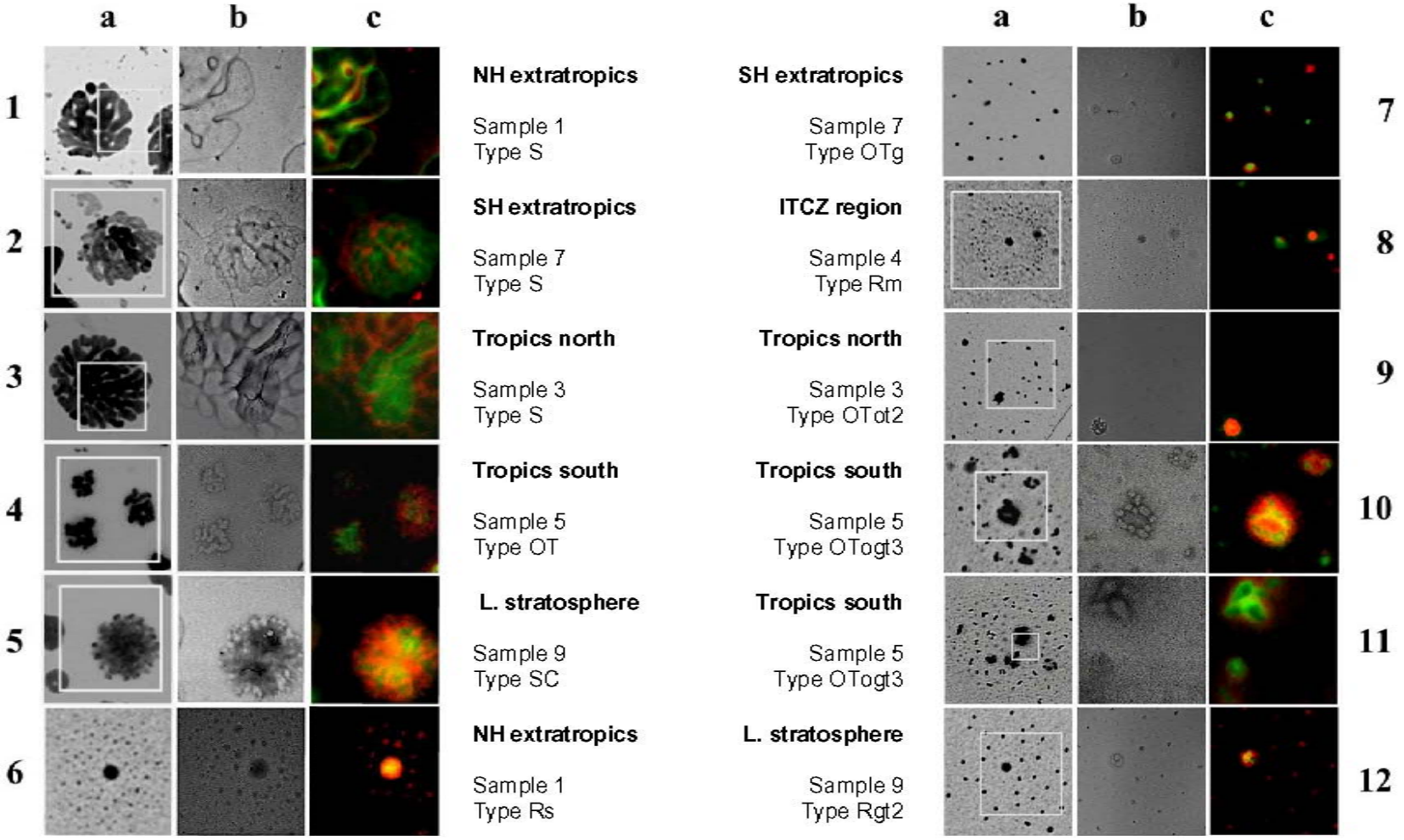


Figure 8. Chemical distribution of individual particles. In column a, particles were imaged by the TEM technique in low magnification. Column b shows the same particles or the same type of particles (images 6 and 7) but taken after EFTEM analysis and with higher magnification. Column c shows EFTEM maps as mixed and colored images of sulfur (green) and carbon (red). Yellow and orange colors indicate mixture of the two elements. The text between the images shows sampling location, sample number and particle type according to the classification of Table 1.

Martinsson, Lund

Results

Air Mass Characterization

Kasatochi vulcanic plume

Lifetime of aerosols after cloud contact

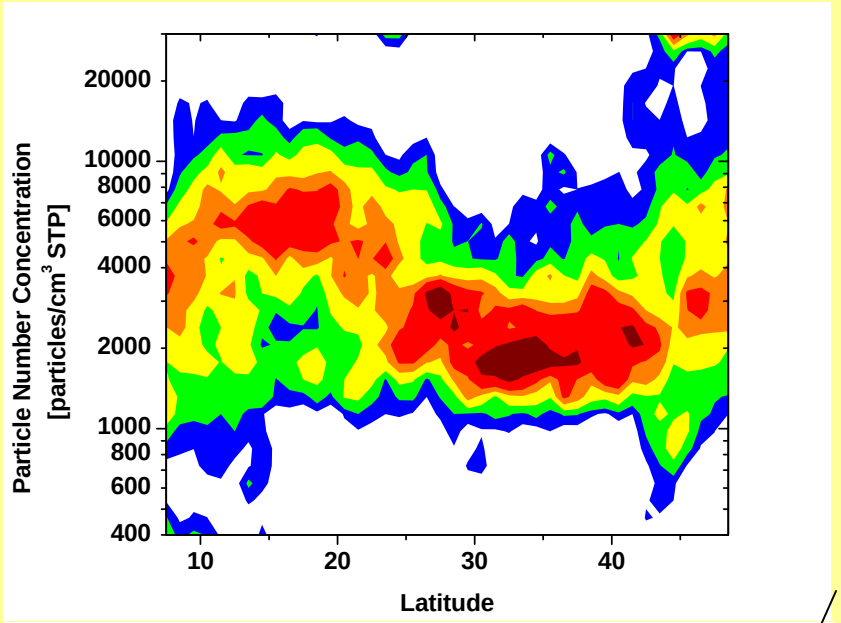
Aerosol sulfate distribution

Aerosol morphology and elemental compositionä

Aerosol distribution

www.caribic-atmospheric.com

Aitken Mode (N_{12}) Particle Number Concentration Boreal Summer

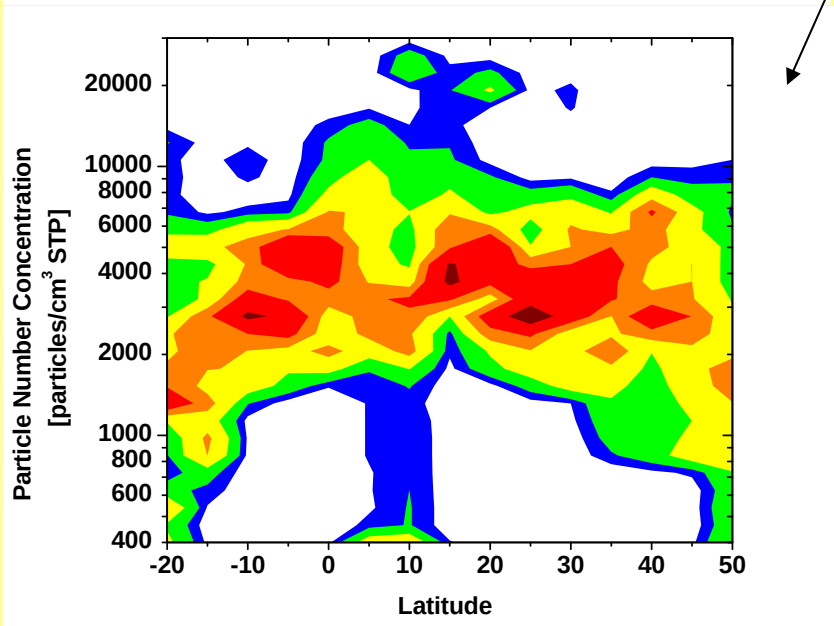


Indian Route

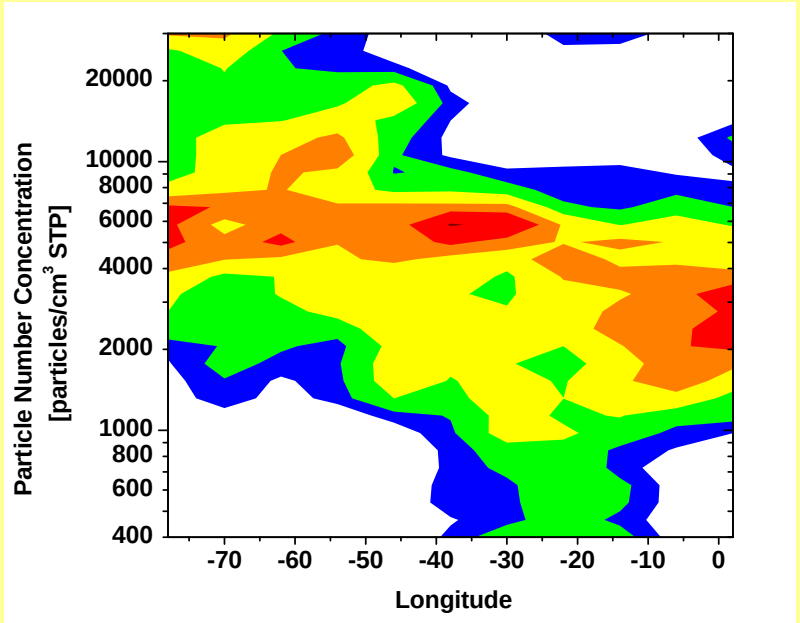
Percentage of data points

16 <	10 < 16
7 < 10	4 < 7
2 < 4	1 < 2

South America Route

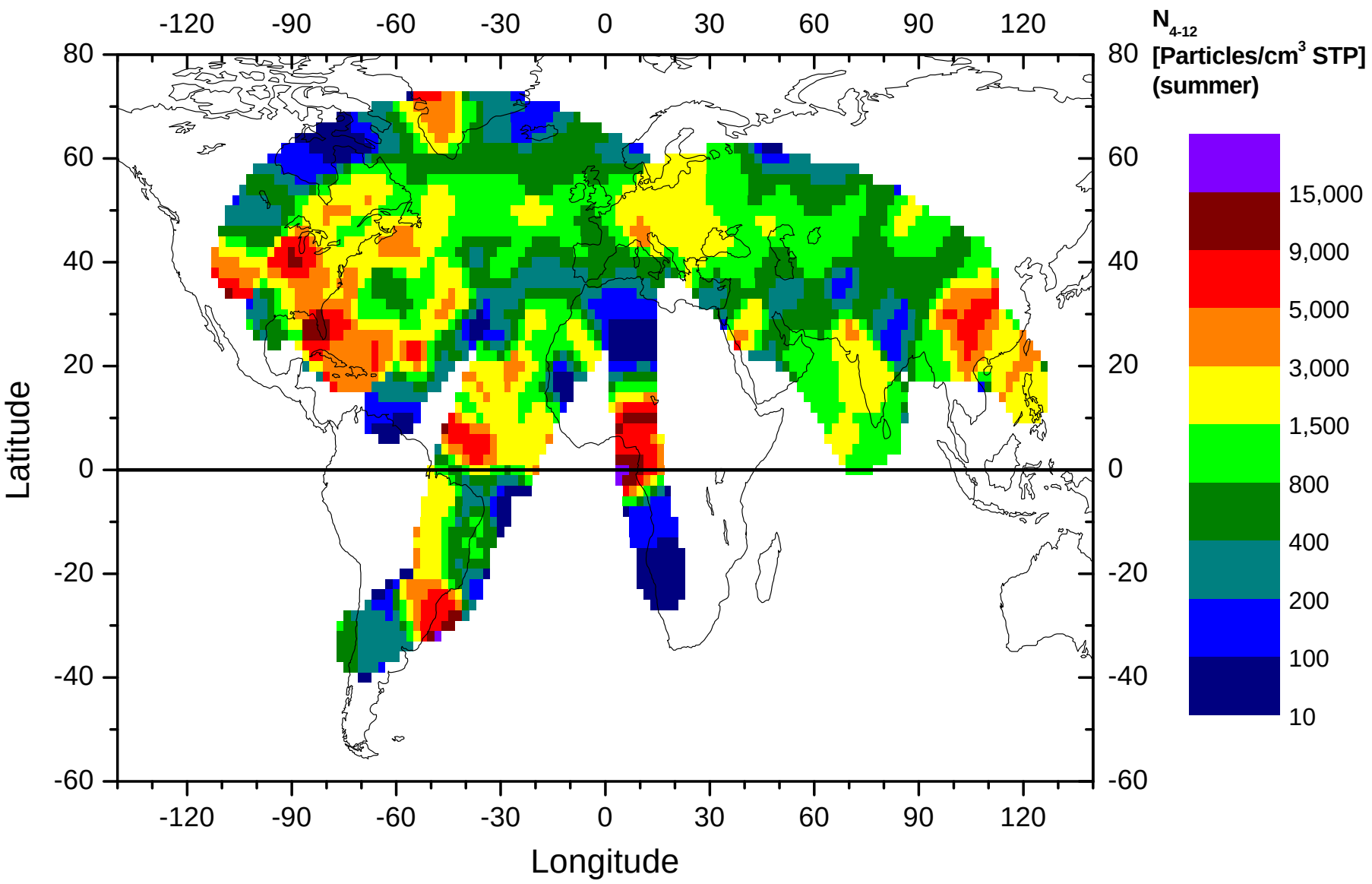


Caribbean Route



Particle Probability Distributions

Nucleation Mode Particles in the UT/LS "Global" Map, Mean Values, Summer



Leibniz Institute for Tropospheric Research

Ohio State University

Up to the next assessment, good luck !!

www.caribic-atmospheric.com