Experimental studies on long-range transport of aerosols in the troposphere

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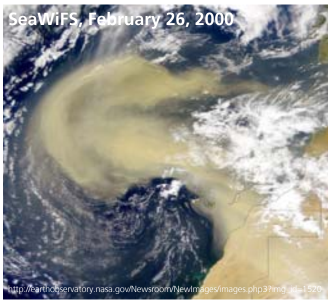
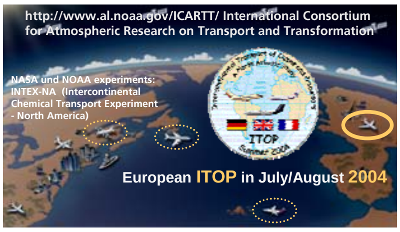
DLR



Motivation

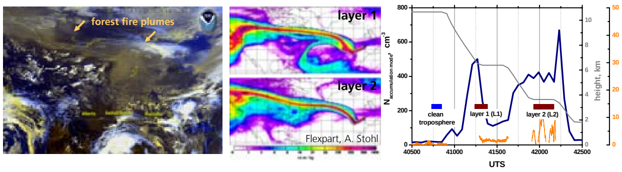
- long-range transport is one of the most important factors controlling the spatial and temporal variability of the aerosol concentration
- although a large fraction of aerosols remains in the planetary boundary layer, particularly desert dust plumes and biomass burning plumes may be lifted into the free troposphere and transported over long distances, even between continents
- during long-range transport from the source region to the far field, the microphysical, optical and radiative properties of aerosols are modified
- information on the effects of transformation and mixing processes during long-range transport is urgently needed:
  1.) for the quantification of the radiative forcing due to aerosols
  2.) for the assessment of heterogeneous processes
  3.) for the validation of aerosol products from space-borne sensors such as aerosol optical thickness
- in contrast to passive space-borne sensors, which only provide column-integrated information on the aerosol optical thickness, airborne in-situ measurements allow probing of the vertical distribution of tropospheric aerosols
- two major field experiments (the European ITOP and the German SAMUM project) deliver airborne in-situ data to study the transformation effects of long-range transport on biomass burning and desert dust aerosols, which are discussed here

ITOP: Intercontinental Transport of Ozone and Precursors

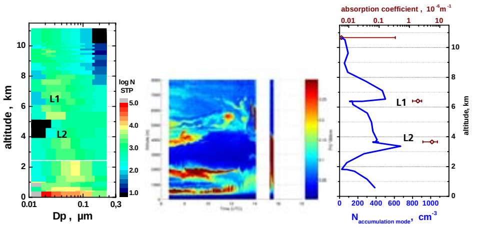


The Falcon 20 research aircraft, operating from an airport north of Paris, was equipped with extensive in-situ aerosol and trace gas instrumentation. Additionally, a ground-based aerosol lidar at Palaiseau south of Paris monitored the vertical structure of the atmosphere.

Case study : Transformation of aerosol properties during mixing processes

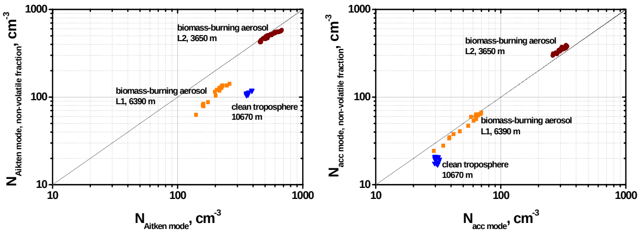


During ITOP, biomass burning plumes from Canada and Alaska were transported across the Northern Atlantic very frequently. On 22 July 2004, various biomass burning layers were investigated, two of which are presented here.



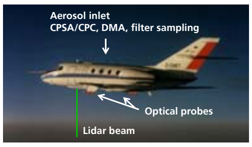
Right panel: strong absorption signal in the visible spectral range and enhanced accumulation mode inside these layers.

Left and mid panel: vertical profiles of aerosol size distribution (left) and lidar over Paris (mid): no small particles inside the strong biomass burning layer between 4 and 5 km altitude, only few small particles inside the weak biomass burning layer between 6 and 8 km altitude.

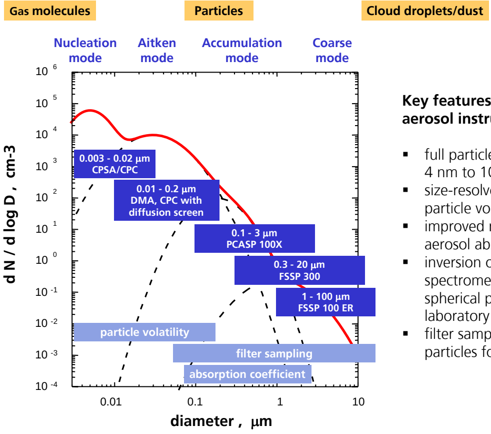


Volatility analyses of Aitken (left panel) and accumulation mode particles (right panel) indicate that the mixing process takes part in the Aitken mode. It turned out that the accumulation mode aerosol inside these biomass burning plumes was completely internally mixed with non-volatile cores, while in the undisturbed background aerosol a considerable fraction of entirely volatile particles was found even in the accumulation mode.

Instrumentation



The German Falcon 20 research aircraft is equipped with a number of in-situ instruments for the extensive measurement of aerosol particles.

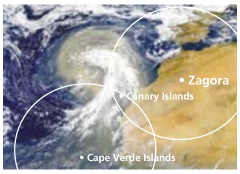


Key features of the DLR aerosol instrumentation

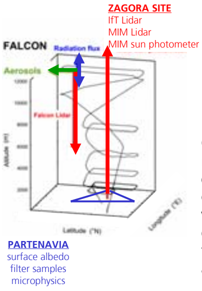
- full particle size spectrum from 4 nm to 100 µm
- size-resolved measurement of particle volatility
- improved measurement of the aerosol absorption coefficient
- inversion of optical particle spectrometer data for non-spherical particles using virtual laboratory tools
- filter sampling of < 4 µm particles for chemical analyses

SAMUM: Saharan Mineral Dust Experiment

A first SAMUM field experiment will take place in Morocco in May 2006.



Studies on transformation of microphysical and optical dust properties during long-range transport and mixing with biomass burning aerosols



Clear-column radiative closure for desert dust aerosol over a source region with respect to aerosol extinction from lidar and from particle size, shape and composition.

Conclusion and Outlook

For the analysis of the transformation processes of the microphysical, optical and radiative properties of aerosols during long-range transport a number of analysis tools have been developed and applied to biomass burning aerosols (ITOP).

These analysis tools will be further developed for the analysis of the transformation processes on desert dust aerosols during long-range transport (SAMUM).

References

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