Pollution transported to the Arctic during the POLARCAT-France spring and summer campaigns: source regions and aerosol properties

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1. CONTEXT

Polar regions are known to be more strongly impacted by global warming than other regions (IPCC, 2007). Previous studies on climate related processes in the Arctic atmosphere were mostly based on surface observations and many advances in measurement techniques were done since the previous airborne campaigns.

- 4th International Polar Year
- POLARCAT project lauched to study long-range transport of short-lived pollutant (particulates and gases) to the Arctic.
- 12 flights out of Kiruna, Sweden, April 2008.
- 12 flights out of Kangerlussuaq, Greenland, July 2008.

2. INSTRUMENTATION

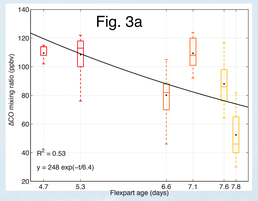
Physical properties:
- Scanning Mobility Particle Sizer (SMPS)
- Optical Particle Counter (OPC Grimm,TSI and PCASP 100-X, DMT)
- Condensation Particle Counter (CPC 3010 & 3025, TSI)

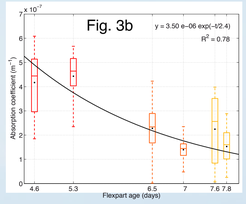
Chemical properties:
- Aerodyne time of flight aerosol mass spectrometer (C-ToF-AMS, MPI, Mainz)
- 2 stage cascade impactor (sub and super-micronic) + a posteriori spectroscopy and microscopy analyses (FSO, Kanazawa)
- Gas phase: CO and O_3 measurements (Mozart, LATMOS, Paris)

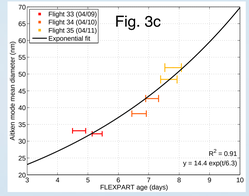
Optical properties:
- 1λ Particle Soot Absorption Photometer (PSAP, TSI)
- 3λ Nephelometer (TSI)
- Aerosol Lidar (LNG, LATMOS, Paris)

3. SPRING CAMPAIGN

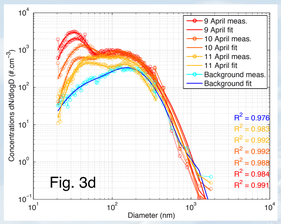
A. European anthropogenic plume sample 3 consecutive days

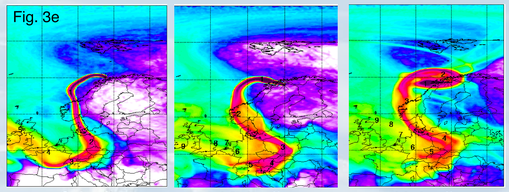




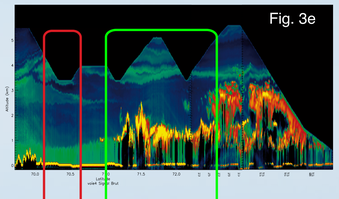


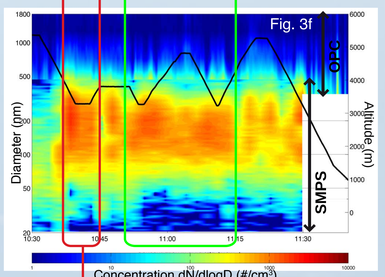
- Air mass origins along the flight tracks were determined from the analysis with the Lagrangian dispersion model FLEXPART [1] (Fig. 3e).
- Anthropogenic air mass from Central Europe sampled 3 consecutive days (9, 10 and 11 April).
- Air mass ageing characterisation by exponential decrease of both CO mixing ratio and light absorption coefficient (i.e., BC concentrations). see Fig. 3a and 3b.
- Aerosol size distributions measured and log-normally fitted in Fig. 3d.
- Increase of the Aitken mode mean diameter and decrease of its concentration evident (Fig. 3c)



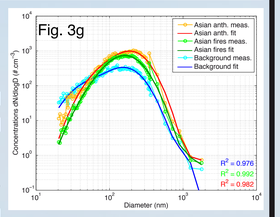


B. Asian anthropogenic and fire plumes

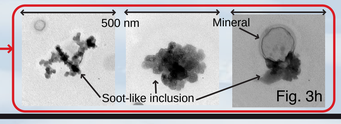




- Asian pollution air mass encountered.
- Lidar backscattering signal enhanced between 3 and 4 km above sea level (Figure 3e).
- The aircraft passed through the polluted layer where aerosol size distribution measurements reveal enhanced concentrations and variations in the mean diameter of the accumulation mode (Fig. 3f and 3g).
- Anthropogenic origin for the first part of the layer (boarded in red in Fig. 3e) while the second part (boarded in green), originated from biomass burning (found from optical properties studied by De Villiers et al. (2010,[2]).
- Microscopy images and spectroscopy analyses of in-situ submicron aerosol samples collected during the flight (for the anthropogenic origin, Fig. 3h and 3i).

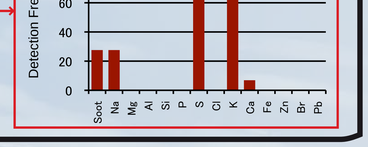


Microscopy



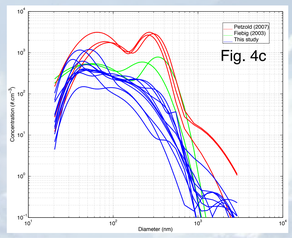
Spectroscopy

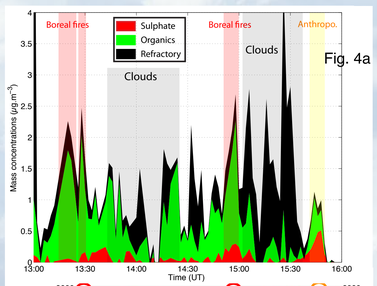
TEM-EDX of individual submicron pollution particles

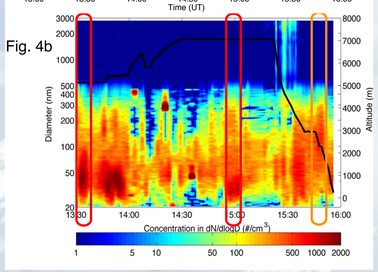


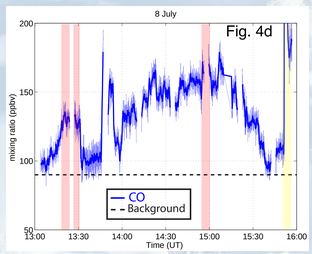
4. SUMMER CAMPAIGN

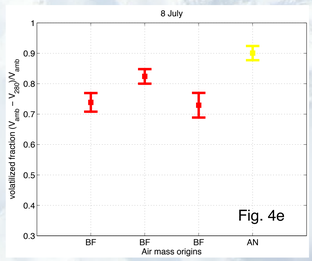
- North American boreal forest fires (BFF) particles transported to Greenland sampled.
- Sulphate and organic mass concentration evolutions (Fig. 4a, red and green, respectively) measured by the AMS as well as the refractory mass (in black).
- Temporal evolution of aerosol size distributions (Fig. 4b).
- Mean aerosol size distributions related to BFF (from 3 POLARCAT flights) are compared to previous measurements of BFF performed by Petzold et al. (2007,[3]) and Fiebig et al. (2003,[4]) in Fig. 4c.
- Findings in correlation with Schmale et al. (2011,[5]).



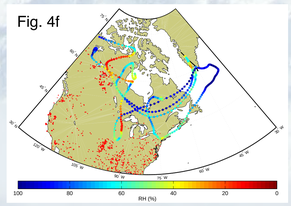


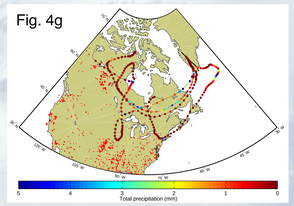






- Selected flight periods are related to enhanced CO mixing ratio (Fig. 4d) and higher values of the light absorption coefficient.
- Elevated values of the volatilized volume fraction (Fig. 4e) are found (0.78 for this flight), thus indicating that a large part of particles were coated.
- The accumulation mode measured during the POLARCAT-summer campaign is less pronounced than observed during the other studies (Fig. 4c). This difference can be explained by wet scavenging occuring along the transport pathway of pollution particles from the source regions to Greenland. Fig. 4f and 4g are presenting ECMWF relative humidity (%) and total precipitation (mm) along the Hysplit back-trajectories.





5. SUMMARY

SPRING

- Ageing of an European anthropogenic air mass is related to the increase of the mean diameter (from 33 to 51 nm) of the Aitken mode, while its concentration decreased from 860 to 165 particles/cm^3. The air mass evolution is also seen in the decrease of the CO mixing ratio and of the light absorption coefficient (related to black carbon concentration). Since aerosol volatility is constant during the 3 days, the Aitken mode growth is mainly due to particle coagulation.
- Asian plumes contain very low concentration of Aitken mode particles while accumulation mode particles (and to a lower extent coarse mode) were enhanced. TEM-EDX analyses gave qualitative informations on the origin of pollution particles. Soot is present in more than 20% of the analysed particles.

SUMMER

- North American boreal forest fire particles transported to the Arctic were studied. Enhancement in CO mixing ratio, and sulphate and organics mass concentration were coupled to these air masses. Absorbing particles were mostly found in the Aitken mode while coated particles composed the accumulation mode.
- The concentration of the accumulation mode particles was very low compared to previous studies. The difference is explained by potential wet scavenging occuring on the pathway of the air masses from the source regions to Greenland.

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