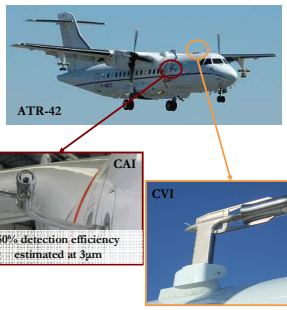
Airborne in-situ measurements of physical and chemical aerosol properties during EUCAARI/IMPACT (May 2008)

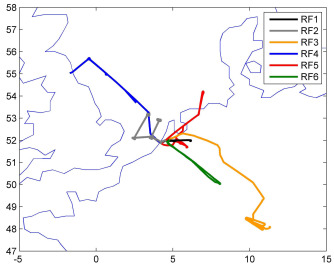
Suzanne CRUMEYROLLE[1], A. SCHWARZENBOECK [2], L. GOMES [1], H.E. MANNINEN[3], R.WEIGEL[1,4], J.-M. PICHON[1], K. SELLEGRI[1], P. LAJ[5]
LaMP, 24 rue des Landais, 63177 Aubiere Cedex (France) [1], Météo-France, CNRM/GMEI, 42 avenue Coriolis 31057 Toulouse Cedex (France) [2], Department of Physics, University of Helsinki, P.O. Box 64, 00014 Helsinki, Finland[3], Institute for Physics of the Atmosphere, University of Mainz, Germany [4], Laboratoire de Glaciologie et Geophysique de l'Environnement, University of Grenoble, France [5],
contact address: suzanne.crumeyrolle@cnrm.meteo.fr

INTRODUCTION



EUCAARI had several aircraft platforms (BAe-146, Falcon and ATR-42, pictured on the left) involved in subprojects LONGREX and IMPACT. LONGREX did long-range studies of aerosol aging, concentrations and composition in Europe. **IMPACT** was mostly concerned with cloud-aerosol-radiation interactions near Cabauw site in Netherlands.

On board the ATR-42, measurements involved particle sizing and counting as well as chemical analysis : by scanning mobility particle spectrometers **SMPS** (20 < Dp < 300nm), optical particle counters **OPC** (GRIMM model 1.108, 0.3 < Dp < 2µm), different condensation particle counters **CPC** (Dp>3nm, Dp> 10nm), and the aerosol mass spectrometer **AMS**. Particles were introduced into the system through an isokinetic aerosol inlet (**CAI**). During cloudy conditions, cloud residual and interstitial particles were analysed using a counterflow virtual impactor **CVI** and an interstitial aerosol inlet, respectively.



During May 2008 the French ATR-42 research aircraft operated by SAFIRE (Service des Avions Français Instrumenté pour la Recherche en Environnement) has performed **22 research flights**. These 22 flights are grouped within 6 different kinds of Research Flights (RF, Figure 1).

The 9 flights corresponding to type RF1 show flight patterns which were centered at and around the surface measurement site of CESAR supersite (located 35 km east of Rotterdam). The objectives of these flights have been to characterize origin and regional context of the air masses sampled at Cabauw, thus correlating aircraft characterization of the vertical structure of the atmosphere above Cabauw with the groundbased measurements at the super site.

NEW PARTICLES FORMATION EVENTS

New Particle Formation (NPF) events were observed with the ATR-42 during 11 (/22) flights (Table1) and simultaneously with NAIS and SMPS, at the CESAR supersite in Cabauw. Only 7 events have horizontal and vertical extension large enough to be fully exploited in this study.

All these events were observed at different moments of the day and thus different stage of development, between 10:00 and 16:00 UTC, and at different locations, over the sea as well as over the continent showing that in the Netherlands these conditions are not decisive. An extended air mass backtrajectory analysis (not shown here) highlights that the major part of air masses that have been observed during the campaign are coming from the North Sea and Scandinavia.

During the numerous ascents and descents of the ATR-42, also the vertical extension of the NPF events could be confined to not exceed the top of the planetary boundary layer. No NPF event could be detected in the free troposphere. These results have already been observed for boreal nucleation events (Laaksonen et al., 2008; O'Dowd et al. 2009).

Table 1 : Overview of ATR-42 flights performed during a new particles formation (NPF) events observed at the ground site of Cabauw and with the ATR-42 : day, Flight number, Flight plans, averaged Boundary Layer height, NPF event upper and lower limit and NPF horizontal extension.

Day	Flight number	Flight plan	BL height (m)	NPF event upper limit (m)	NPF event lower limit (m)	NPF Horizontal extension (km)
05/05/2008	43	RF 2	1400	1250 (over the continent) 300 (over the sea)	----	> 100
06/05/2008	44	RF 2	----	----	----	----
08/05/2008	45	RF 2	1800	1800	----	> 100
11/05/2008	48	RF 2	1500	1450	----	> 160
14/05/2008	50	RF 1	1700	1650	----	> 70
18/05/2008	53	RF 5	1900	~1100	----	> 150
18/05/2008	54	RF 5	2100	2100	600	> 150
19/05/2008	55	RF 1	----	----	----	----
20/05/2008	56	RF 1	----	----	----	----
28/05/2008	61	RF 1	1400	1400	----	~ 100
29/05/2008	62	RF 1	----	----	----	----

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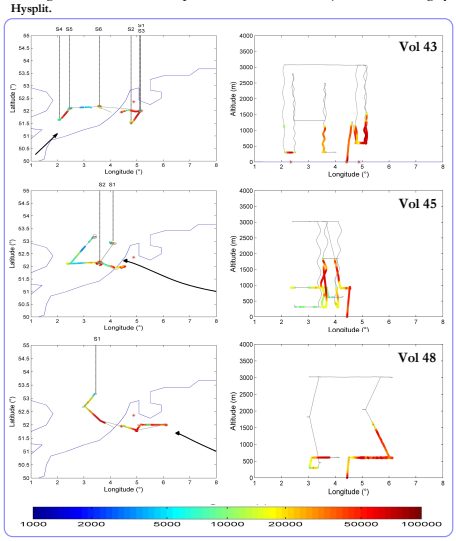
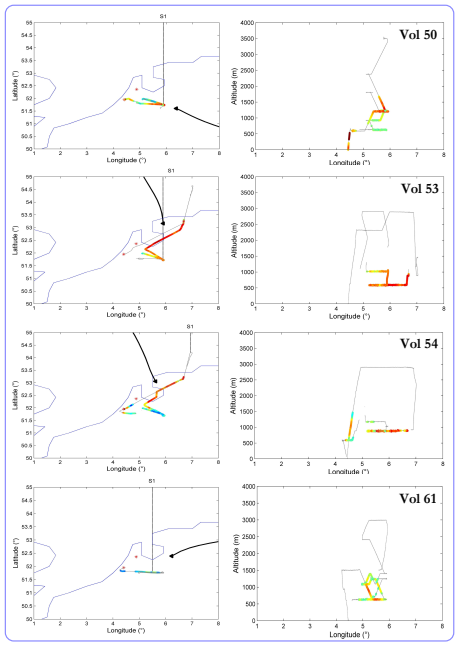
Horizontal (left) and vertical (right) cross sections showing nucleation mode aerosol concentrations within the size range of 3-10 nm along the ATR-42 aircraft trajectories for the seven flights 43 (a and b) on 05 May , 45 (c and d) on 08 May, 48 (e and f) on 11 May, 50 (g and h) on 14 May, 53 (i and j) on 18 May A.M., 54 (k and l) on 18 May P.M. and 61 (m and n) on 28 May 2008. The ATR-42 soundings are locating with black lines in all figures. The black arrows represent the air mass back-trajectories calculating by Hysplit.





MEAN PHYSICAL AND CHEMICAL PROPERTIES OF AEROSOL PARTICLES

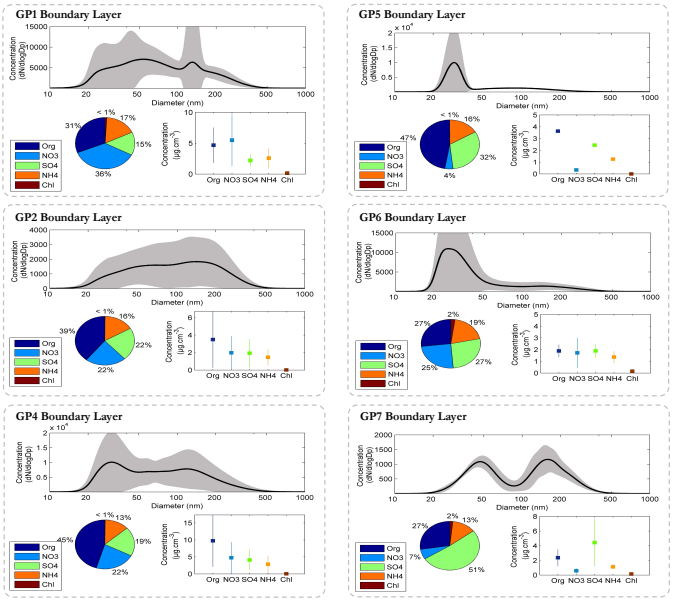
For all the ATR-42 flights performed during EUCAARI (21 research flights), air mass back trajectories have been calculated from HYSPLIT (Draxler et al., 2003) and FLEXPART (Stohl et al., 1998) along the ATR flight trajectories. Using the back-trajectory analysis and the aerosol physical properties, **five** air mass groups have been identified. The air mass group details are given in Table 2. Both atmospherical layers (Boundary Layer and Free Troposphere) are distinguished with temperature and humidity profile. For each air mass group and for both layers, physical and chemical properties of aerosol are averaged and are shown in Figure on the right.

Two air mass groups (GP3, GP7) have been separated from others because of evidence of singular events or atmospherical processes which change fully the particle properties.

One can see, in the Boundary Layer, that the mean diameter of particles mode is closed whatever the air mass group. But the mean concentration and the main component seem to be strongly related to air masses origins.

Table 1 : Overview of air mass groups calculated from FLEXPART and observed with the ATR-42 : origins, and localisation. Then, averaged physical and chemical properties, respectively measured by the SMPS and the AMS are given.

	Air mass groups	GP1	GP2	GP3	GP4	GP5	GP6	GP7
	Origins or particularities	Groenland	Norway	Eastern Europe. MODIS evidence of Biomass Burning events.	South-West of Europe	South-East of Europe	Siberia	Cloud processed air masses
	Boundary Layer	x	x		x	x	x	x
	Free Troposphere	x	x	x	x	x	x	
Physical properties	Mean diameter of particle modes	45 / 108 / 190 37 / 77 / 194	44 / 103 / 191 43 / 120 / 185	--- 44 / 96 / 143	53 / 92 / 153 43 / 90 / 198	34 / 91 40 / 105 / 213	32 / 92 / 158 61 / 125 / 226	46 / 150 ---
Physical properties	Mean particle concentration	6000 500	8000 1700	--- 400	8000 1300	2500 1500	4000 800	800 ---
Chemical properties	Main componant	NO_3 Organics	Organics Organics	--- SO_4	Organics SO_4	Organics Organics	Org/ NO_3 / SO_4 Organics	SO_4 ---
Chemical properties	Mass concentration ($\mu g/cm^{-3}$)	5.48 1	7.9 3.5	--- 1	9.7 1.6	3.6 2.3	1.8 3.3	4.4 ---



CONCLUSIONS AND BIBLIOGRAPHY

New particle Formation Events :

Seven cases of new particle formation (NPF) events have been observed on board the ATR-42 during EUCAARI.

- ✓ At **different moments** of the daytime between 10:00 and 16:00 UTC (different stage of development)
- ✓ At **different locations** : over the sea as well as over the continent
- ✓ The particle **concentration** in the size range 3-10 nm is highly **variable** ($5000cm^{-3}<C<75000\ cm^{-3}$)
- ✓ The **horizontal extension** of NPF event is higher than **70km**
- ✓ The **vertical extension** of the NPF events are limited to the top of the **planetary boundary layer**

Mean physical and chemical properties of aerosol particles :

Seven air mass groups have been identified with back-trajectory analysis and sampled with the ATR-42 during EUCAARI. No clear signature of the air mass origin can be detected on the size distribution. However, the particle concentration and the chemical composition evolution seems to be related to the air mass group.

- ✓ Poluted cases : GP1, GP2 and GP4 ➔ Source of Organics and Nitrates
- ✓ Cloud processed air masses ➔ Coating of SO_4 ?

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O'Dowd, C. D., Yoon, Y. J., Junkermann, et al. Airborne measurements of nucleation mode particles II: boreal forest nucleation events, Atmos. Chem. Phys., 9, 937-944, 2009.