Improvement of Norwegian monitoring infrastructures to meet future observational needs

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We are presenting an overview of the improvements of monitoring infrastructure at 3 Norwegian observatories the recent years. We are also, through a case study of a transport episode into the Arctic, giving an example of how the complementary setup of instruments at the stations can improve our understanding of the climate system.

The Birkenes Observatory (58º23´N, 8º15´E 190 m.asl.) is significant upgraded the recent years, to meet the future needs of climate monitoring of climate gases and understanding of aerosol effects. Currently are the greenhouse gases O_3, CO_2 and CH_4 measured at Birkenes. Advanced measurements of particles are also included in the measurement programme. The aerosol upgrading of the Observatory was partly done in the EU project EUSAAR (ww. eusaar.net) and Birkenes is now recognised as an EMEP/EUSAAR/GAW supersite.

The Zeppelin Observatory (78º54´N, 11º53´E, 474 m.asl.) is owned and operated by the Norwegian Polar Institute. NILU is responsible for the scientific programmes at the station, as part of the largest Arctic research infrastructure:
The Ny-Ålesund international cluster of research stations. Variables measured include greenhouse gases (CH_4, N_2O, O3, halocarbons, halon, SF_6), UV and aerosols/particles.

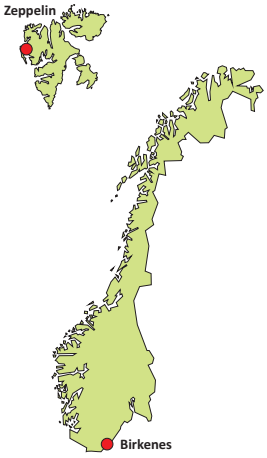
The Troll Observatory in Antarctica (72º1´S, 2º32´E, 1390 m.asl.) has since 2006/2007 gone through a major upgrade. New instruments for monitoring of aerosols, organic and inorganic compounds, ozone and UV have been installed. The physical, optical and chemical properties of the aerosols are studied. This will help us gain knowledge on the particles characteristics and their influence on climate and pollution in the Antarctica. *(Fiebig et. al., 2009).*

Particles (physical and optical)			
Station	**Component**	**Resolution**	**Years**
Birkenes	Aerosol Optical Thickness	1s	1
	Size distribution, 10 nm < D_p < 500 nm	2.5 min	8
	Size distribution, 0.25 µm < D_p < 25 µm	1-2 min	8
	Scattering and backscattering coefficient (450, 550, 700 nm)	1 min	1
	Absorpsjon coefficient (523 nm)	30 min	1
	Particulate matter : PM_{10},$PM_{2.5}$, PM_1	1h /week	10
Ny-Ålesund	Aerosol Optical Thickness	1 min	8
Troll	Aerosol Optical Thickness	1min	3
	Size distribution, 10 nm < D_p < 500 nm	1min	3
	Size distribution, 0.25 µm < D_p < 25 µm	1 min	3
	Scattering and backscattering coefficient (450, 550, 700 nm)	1 min	3
	Absorpsjon coefficient (523 nm)	1 min	3
	Particulate matter : PM_{10}	week	3

Greenhouse gases			
Station	**Component**	**Resolution**	**Years**
Birkenes	CH_4	1 min	1
	CO_2	1 min	1
Ny-Ålesund	CH_4	1 h	10
	Halocarbons	4 h (20 min)	10
	SF_6	4 h (20 min)	10
	N_2O	1h	1
Troll	NMHC	flask	3
	Halocarbons	flask	3

UV and stratospheric ozone			
Station	**Component**	**Resolution**	**Years**
Ny-Ålesund	UV	day	15
	Tot col. O_3 + NO_2	2 x day	19
Troll	UV	min	3
	O_3		

Atmospheric trace gases			
Station	**Component**	**Resolution**	**Years**
Birkenes	O_3,CO,H_2	1h (1min CO)	25
Ny-Ålesund	O_3,CO	1h	21/10
Troll	O_3,CO	1h	3



Particle chemistry, main components (SO_4^{2-}, NO_3^-, NH_4^+, Ca^{2+}, K^+, Mg^{2+}, Na^+, Cl^-)			
	Station	**Resolution**	**Years**
Precipitation	Birkenes	day	37
	Ny-Ålesund	week	29
Air	Birkenes	day	37
	Ny-Ålesund	day	30
	Troll	week	3

Heavy metals, main components (Pb, Cd, V, Cr, Co, Ni, Cu, Zn, As)			
	Station	**Resolution**	**Years**
Precipitation	Birkenes	week	34
Air	Birkenes	week	19
	Ny-Ålesund	week	16

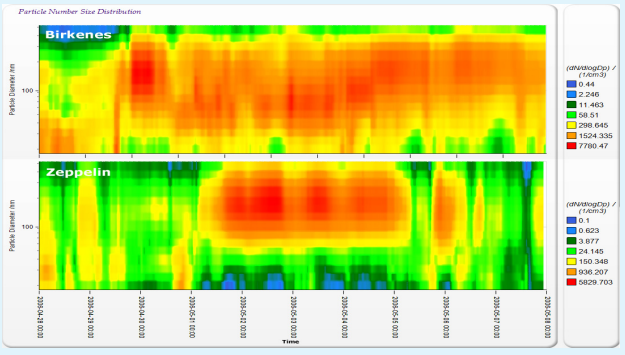
Hg			
	Station	**Resolution**	Years
Precipitation	Birkenes	week	20
Air	Birkenes	week	16
	Ny-Ålesund	hour	6
	Troll	week	3

POPs (α- og γ-HCH, HCB, PCB, PAH, BFH, PFC)				
	Station	**Resolution**	**Years**	**Comment**
Precipitation	Birkenes	week	18	(HCHs, HCB, PCB)
Air	Birkenes	week	18	
	Ny-Ålesund	week	14	Incl. DDT + chlordanes
	Troll	week	3	Incl. chlordanes

Figure to left: Location of Zepplin Observatory on Svalbard and Birknes Observatory on Norway main land.

As a case study for particle measurements at the observatories in Norway we have analysed the well documented episode of long range transport of pollution into the Arctic in April/May 2006. (*Stohl et. al., 2007; Lund Myhre et. al., 2007*). During this episode new records were set for all measured air pollutant species at the Zeppelin Observatory. The episode was also seen at Birkenes, 2-3 days before the main plume arrived at Zeppelin. The episode was caused by transport of polluted air masses from Eastern Europe into the Arctic, a consequence of the unusual warmth in the European Arctic during the spring.

We have studied the size distribution of the particles arriving at both sites during a period of 10 days. We observe an increase in the number of accumulation mode particles and a shift towards larger sizes during the episode. A north/south gradient is also present, the highest aerosol particle concentrations at Birkenes and Zeppelin were found in the 177.8 - 223.9 nm and 223.9 - 281.8 nm intervals, respectively.



Data from the Norwegian observatories are available in the EBAS/EUSAAR and the GAW-WDCA databases. Through the activities carried out at the observatories we contribute to a strengthening of the link between monitoring and research.

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