Campaign: Biogenic Aerosols – Effects on Clouds and Climate
Snowfall Experiment

D. Moisseev[1] , A. von Lerber[2], M. Leskinen[1], V. Chandrasekar[1,2,3] , W. Petersen[4] and E.J. O'Connor[2,5]

[1] University of Helsinki, Helsinki, Finland, dmitri.moisseev@helsinki.fi

[2] Finnish meteorological Institute, Helsinki, Finland

[3] Colorado State University, Ft. Collins, Colorado, USA

[4] NASA GSFC/Wallops Flight Facility, USA

[5]University of Reading, Reading, United Kingdom

Background

Snowfall measurement campaign is organized during mobile facility AMF2 of U.S. Department of Energy deployment in Finland (1. Feb -30. Apr 2014). Focus is on understanding snowfall microphysics by combining multi-instrumental observations of vertical structure of precipitation and comprehensive surface observations. The snowfall experiment is related to a larger collaboration campaign called BAECC, in which the influence of biogenic aerosols emitted by the boreal forest to formation of clouds and precipitation is investigated.

Remote Sensing Instruments

X-, Ka- and W- radar observations are used to characterize cloud and precipitation microphysics. These observations are supplemented by dual-pol C-band weather radar measurements, which will facilitate classification of particle type and the different areas of ice growth mechanisms in the clouds. MRR is used to close the gap in observations near the surface. Radiometers define the column-integrated amounts of water vapor and liquid water. Lidar observations determine the cloud base height and the cloud particle type.

AMF2 KAZR 35 GHz - zenith radar	AMF2 MWR3C 24, 31, 90 GHz - scanning radiometer
AMF2 MWACR 95 GHz – zenith radar	AMF MWR2C 24, 31 GHz- scanning radiometer
AMF2 XSACR 9.7 GHz - scanning radar	AMF2 HSRL lidar
AMF2 KASACR 35 GHz - scanning radar	AMF2 MPL lidar
FMI 5.6 GHz dual-pol weather radar	FMI HALO Photonics Doppler lidar
MRR 24 GHz radar	

Field Instruments

Below in the table are listed the field instruments of the snow experiment. In addition instruments of AMF2 e.g. 2D-video distrometer, and Belfort weighing gauge can be used as comparison. Placing the surface based snowfall measurement instruments inside the double-fence wind protection and outside on the measurement field enables the characterizing their performance as a function of wind speed. The radio sounding are carried out four times a day.

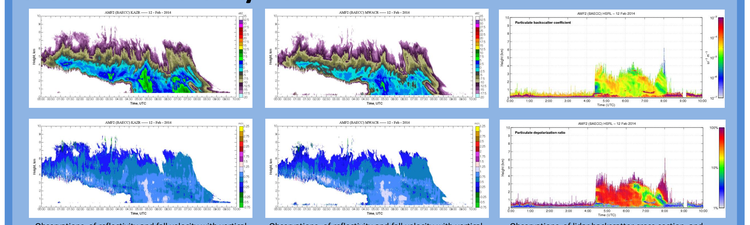
Inside double fence wind protection	Outside wind protection
JOANNEUM 2D-video disdrometer	NASA Particle Imaging Package
METEK 3D-anemometer	GILL 2D-anemometer
OTT Parsivel optical disdrometer	OTT Parsivel optical disdrometer
OTT Pluvio 200 gauge	OTT Pluvio 400 gauge
YES HotPlate gauge	Jenoptik Snow Depth Sensor

Events

Campaign it still ongoing, at the moment around twenty precipitation events are recorded. The main events are listed in the table below. The minimum and maximum temperatures of the event and the mean liquid accumulation of the different gauges and optical disdrometers is marked also to the table. The winter temperatures have been mild this year, thus many of the cases have mixed precipitation.

Start time	End time	Description	Temperature (min- max in C°)	Mean liquid accumulation (mm)
31 January, 22 UTC	1 February, 04 UTC	snow	-8.7 - (-8.5)	8.8
1 February 10 UTC	1 February 16 UTC	snow (riming)	-7.6 – (-3.7)	1.5
2 February 14 UTC	2 February 15 UTC	snow/freezing rain	-4.3 – (-4.0)	0.2
2 February 16 UTC	2 February 22 UTC	snow	-5.0 – (-4.7)	2.0
7 February 22 UTC	8 February 05 UTC	snow/melting snow	-0.8 – (0.8)	4.0
8 February 16 UTC	9 February 22 UTC	melting snow/rain	0.7 – 2.0	1.7
10 February 21 UTC	11 February 05 UTC	snow/early state of melting	0.2 – 0.6	1.7
12 February 04 UTC	**12 February 10 UTC**	**snow (aggregates)**	**-0.8 – 0.1**	**1.2**
13 February 00 UTC	13 February 06 UTC	snow/melting snow	0.3 – 0.6	0.6
15 February 21 UTC	**16 February 02 UTC**	**snow (riming)**	**-1.8 – (-0.9)**	**3.1**
18 February 17 UTC	18 February 22 UTC	snow/melting snow	0.4 – 0.6	0.4
21 February 00 UTC	21 February 06 UTC	snow	-9.5 – (-5.7)	0.4
21 February 16 UTC	22 February 08 UTC	snow(riming)/melting snow	-2.4 – 0.9	9.4
22 February 10 UTC	22 February 11 UTC	melting snow/rain	1.4 – 1.8	0.03
22 February 22 UTC	23 February 10 UTC	melting snow/rain	0.9 - 2.9	2.4

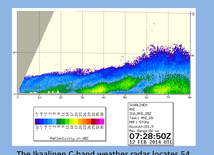
Case 12TH February 2014



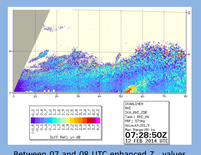
Observations of reflectivity and fall velocity with vertical profiling Ka - radar.

Observations of reflectivity and fall velocity with vertical profiling W - radar.

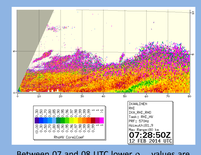
Observations of lidar backscatter cross-section and circular depolarisation with mf2hsrl lidar.



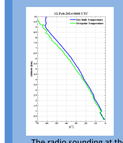
The Ikaalinen C-band weather radar locates 54 km from Hyytiälä.

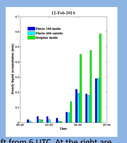


Between 07 and 08 UTC enhanced Z_{dr} values are seen over the Hyytiälä site indicating non-spherical shaped particles .

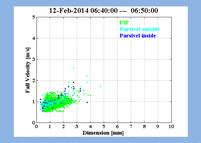


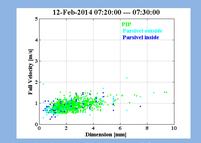
Between 07 and 08 UTC lower ρ_{hv} values are observed which coincide with high Z_{dr} .





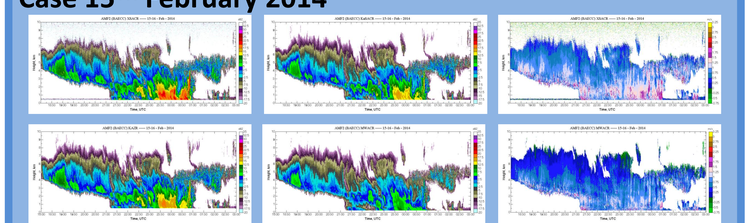
The radio sounding at the left from 6 UTC. At the right are the liquid accumulation of gauges, Pluvio 200 and Hotplate are located inside the wind protection.





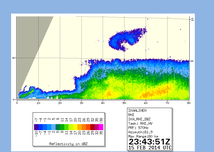
The fall velocities as a function of diameter, with PIP the dimension is equivalent diameter. PIP and the other Parsivel are located outside the wind protection.

Case 15TH February 2014

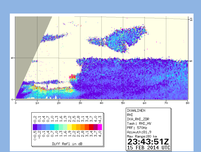


Vertical scans of radar reflectivity factor measured with X-, Ka- and W- frequencies.

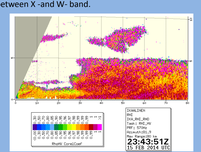
The bands of higher fall speed are observed. In W-band the larger particles are no longer in Rayleigh regime and there are differences in the fall velocity observations between X -and W- band.



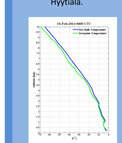
Ikaalinen C-band weather radar RHI towards Hyytiälä.

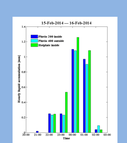


Differential reflectivity Z_{dr} values are low indicating spherical particles.

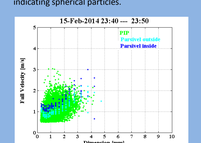


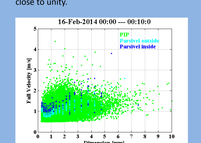
Cross-correlation coefficient ρ_{hv} values are close to unity.





The radio sounding at the left from 00 UTC. At the right are the liquid accumulation of gauges, Pluvio 200 and Hotplate are located inside the wind protection.





The fall velocities as a function of diameter, with PIP the dimension is equivalent diameter. PIP and the other Parsivel are located outside the wind protection. The higher fall velocities compared to 12th February case indicate riming.