Snowfall Experiment in Finland in support of GPM GV

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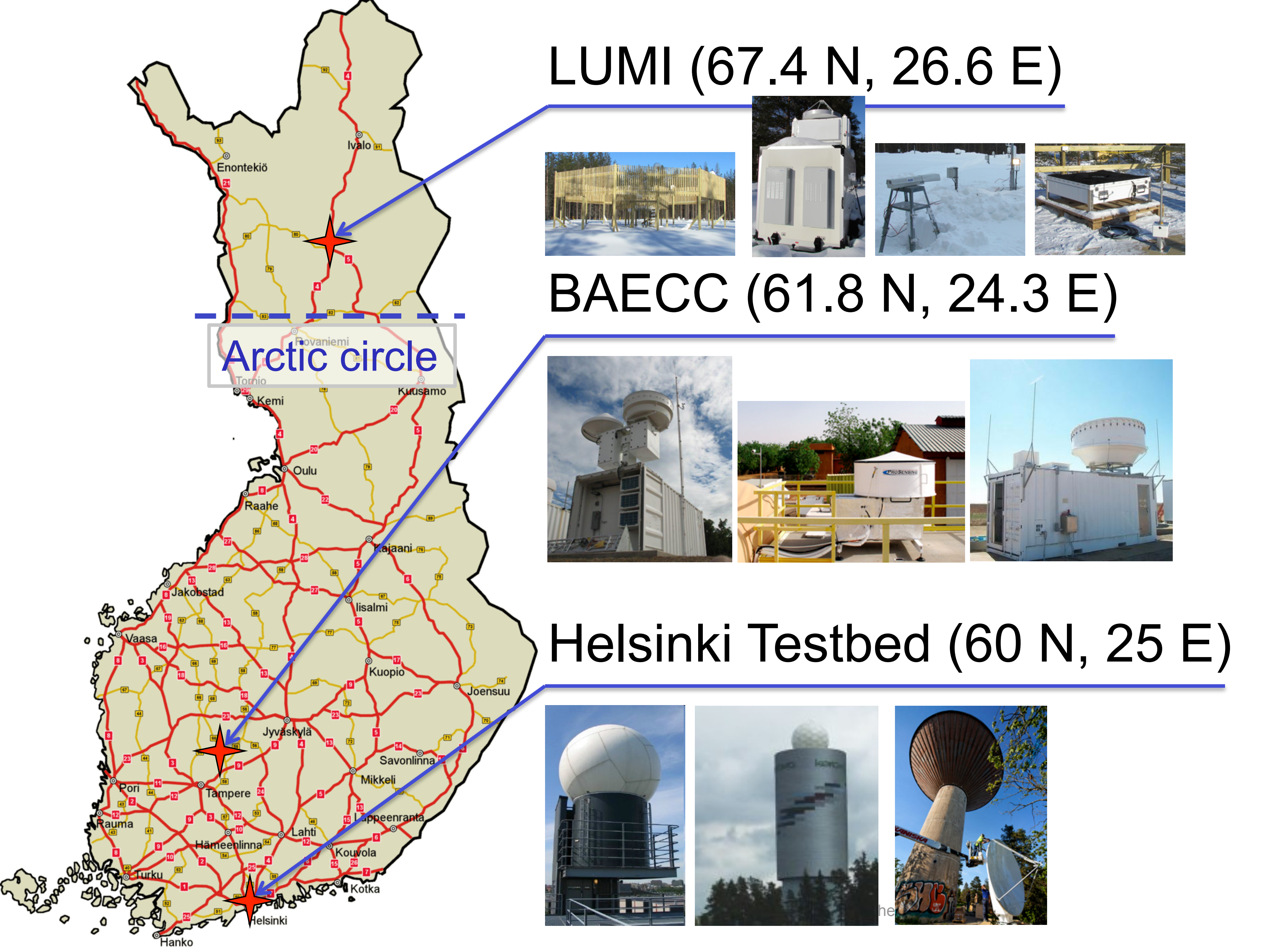

LUMI (67.4 N, 26.6 E)
BAECC (61.8 N, 24.3 E)
Helsinki Testbed (60 N, 25 E)
Arctic circle
Ivalo
Enontekiö
Rovaniemi
Tornio
Kemi
Kuusamo
Oulu
Raahe
Kajaani
Jakobstad
Iisalmi
Vaasa
Kuopio
Joensuu
Jyväskylä
Savonlinna
Mikkeli
Pori
Tampere
Lappeenranta
Rauma
Lahti
Hämeenlinna
Kouvola
Turku
Kotka
Helsinki
Hanko

Biogenic Aerosols -
Effects on Clouds and Climate
(BAECC)





Objective: To verify the effects of secondary aerosol formation on cloud properties with combination of *in-situ* observations and active remote sensing instruments provided by DOE ARM AMF2, and place these observations with in larger context through modeling efforts

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UNIVERSITY OF
EASTERN FINLAND

ARM
CLIMATE RESEARCH FACILITY

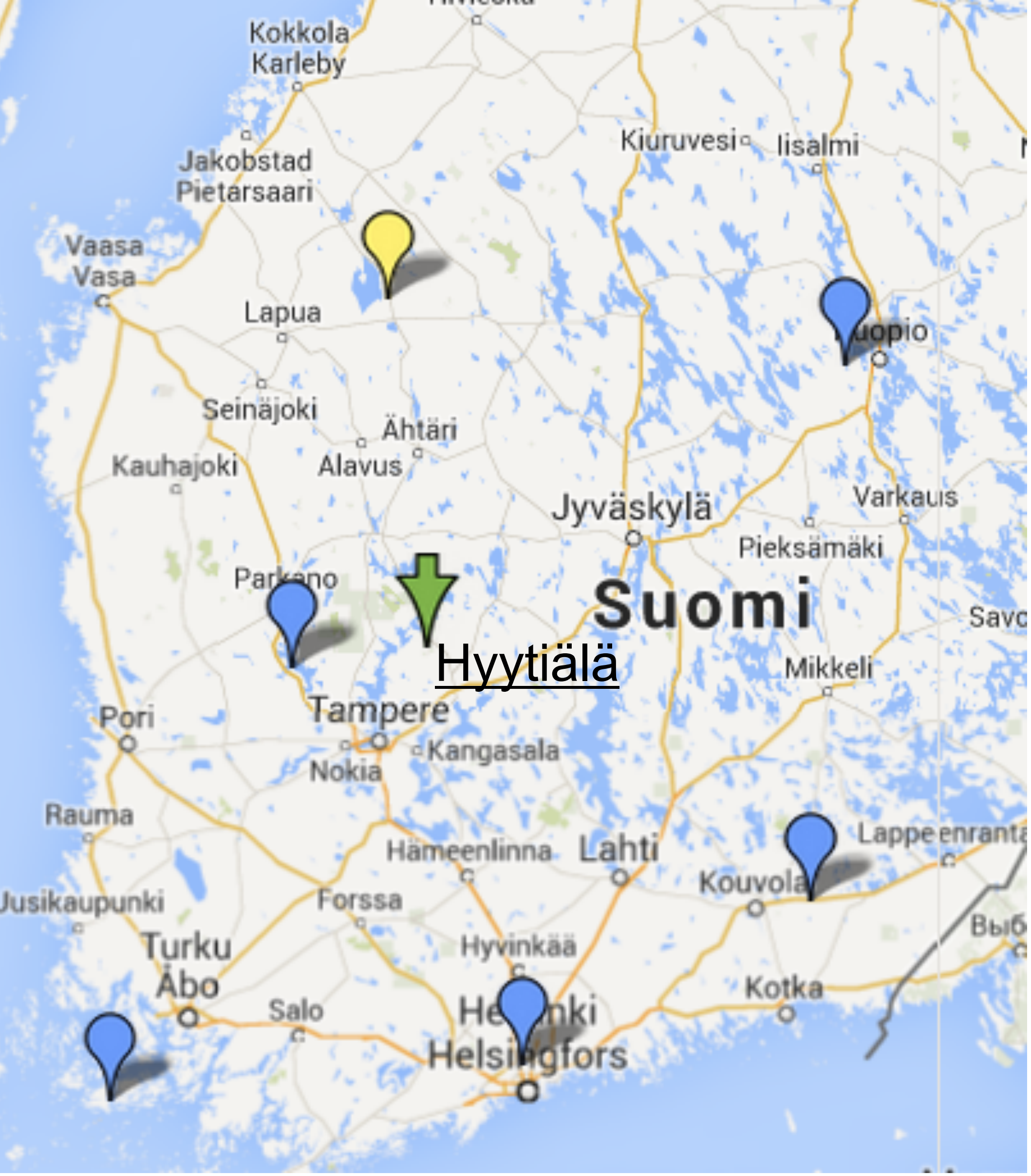
Biogenic Aerosols - Effects on Clouds and Climate: Snowfall Experiment **(BAECC SNEX) Feb 1 – Apr 30, 2014**

This IOP is carried out in coordination with GPM GV program

Objectives

- Snowfall microphysics and connection to multi-frequency and dual-pol radar observations
- Characterization of performance of the surface based snowfall measurement instruments, with the focus on PSD observations

BAECC SNEX



Hyytiälä and FMI weather radars

- GPM GV instrumentation is installed at the University of Helsinki Forestry Field Station (Hyytiälä)
- 250 km north of Helsinki
- 64 km east of the nearest FMI weather radar (IKA)
- ARM AMF2 is deployed in Hyytiälä

Instruments and measurements

Radars & remote sensing

- SACR (X, K_a - bands)
- KAZR (K_a - band)
- MWACR (W –band)
- Windprofiler (L-ban)
- Microwave Radiometers
- Lidars (HSRL, MPL, Doppler)

Precip. sensors

- Particle Image Package (PIP)
- 2 x OTT Pluvio
- 2 x 2DVD
- 2 x Parsivel
- Snow depth
- Hot plate
- Vaisala PWD

Radio sounding every 6 hours

Measurements field


X/ Ka - SACR
MWACR and
Wind profiler

BAECC snowfall setup

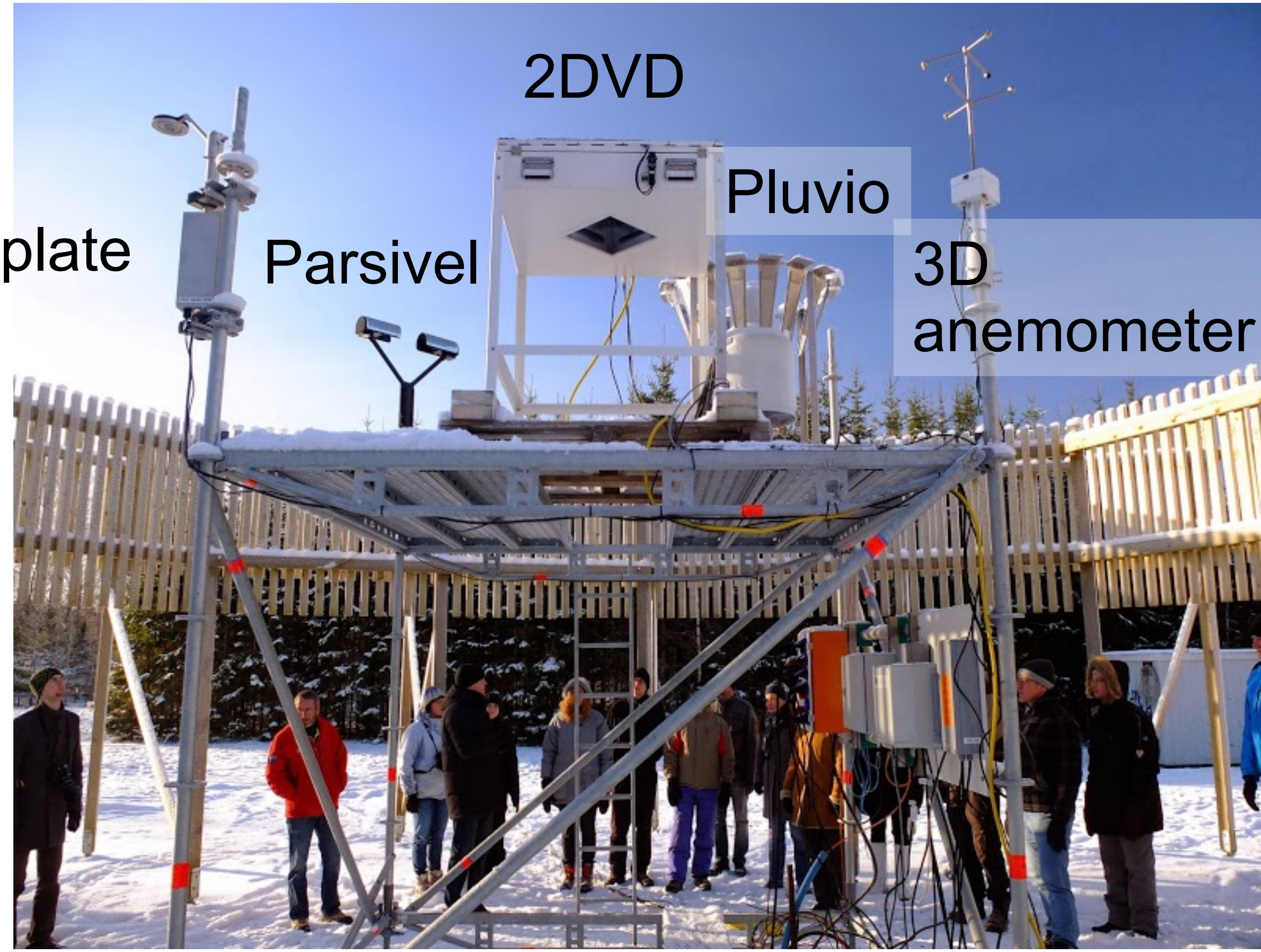
Inside fence: Ott Pluvio2 (200), Hot Plate, OTT Parsivel2, 2D-video, METEK anemometer

Outside: Ott Pluvio2 (400), Ott Parsivel2, NASA PIP, Jenoptik snow depth sensor, MRR, METEK anemometer, 2D-video

Dual fence international reference

Following improved GCPEx design (according to recommendations by Peter Rodriguez, Environment Canada)

Inside of the fence



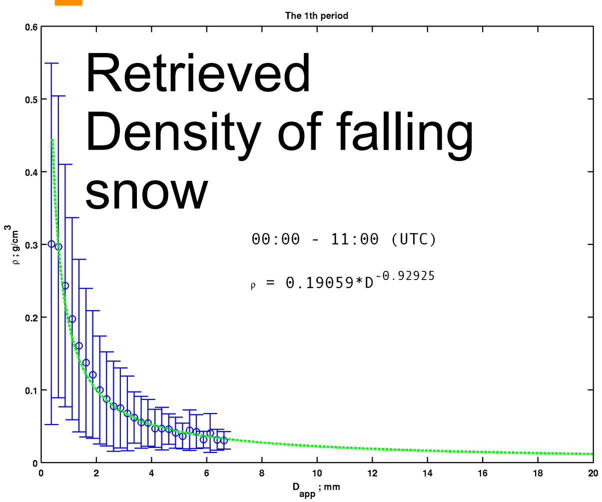
Wind measurements at instrument sampling volume heights were carried out by 3D anemometers inside and outside of the fence

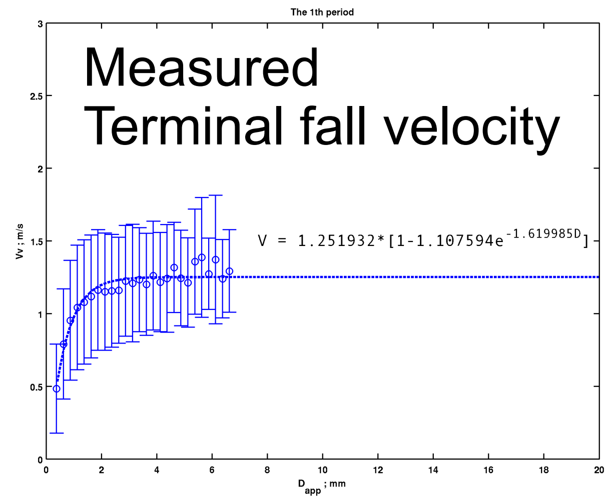
Field instruments

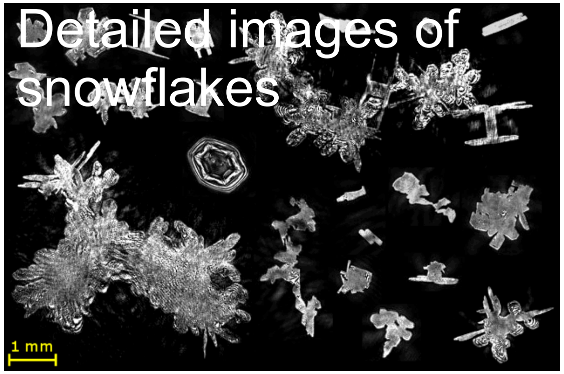
Snow Events - more then 20 snow days

Starting time	Ending Time	Description	Temperature (C)
31 January 22 UTC	1 February 04 UTC	snow	-8.7- (-8.5)
1 February 10 UTC	1 February 16 UTC	snow (riming)	-7.6 - (-3.7)
2 February 14 UTC	2 February 15 UTC	snow/freezing rain	-4.3 - (-4.0)
2 February 16 UTC	2 February 22 UTC	snow	-5.0 -(-4.6)
7 February 22 UTC	8 February 05 UTC	snow/melting snow	-0.8 - 0.8
8 February 16 UTC	9 February 22 UTC	melting snow/rain	0.7 -2
10 February 21 UTC	11 February 05 UTC	snow/early state of melting	0.2-0.6
12 February 04 UTC	12 February 10 UTC	snow (aggregates)	-0.8- 0.14
13 February 00 UTC	13 February 06 UTC	snow/melting snow	0.3-0.6
15 February 21 UTC	16 February 02 UTC	snow (riming)	-1.8 - (-0.9)
18 February 17 UTC	18 February 22 UTC	snow	0.4-0.7
21 February 00 UTC	21 February 06 UTC	snow	-9.5 -(-5.7)
21 February 16 UTC	22 February 08 UTC	snow(riming)/melting snow	-2.4-0.9
22 February 10 UTC	22 February 11 UTC	melting snow/rain	1.4-1.8
22 February 22 UTC	23 February 10 UTC	melting snow/rain	0.9 - 2.9
26 February 12 UTC	27 February 11 UTC	PIP very light snow, larger particles 07 but very few particles	-1.1 - 0.3
28 February 22 UTC	1 March 06 UTC	PIP very light snow, higher velocities 02 but very few particles	-1.1 -(-0.6)
2 March 06 UTC	2 March 15 UTC	melting snow/rimed small particles	-1.8 - 0.4
3 March 02 UTC	3 March 16 UTC	melting snow / aggregation (07, 11 UTC)	-0.2 -0.8
7 March 12 UTC	7 March 18 UTC	light rain	3.1 - 5.1
7 March 22 UTC	8 March 08 UTC	rain/melting snow	0.6 - 2.8
13 March 21 UTC	13 March 22 UTC	rain	4.4 - 4.7
15 March 02 UTC	15 March 08 UTC	snow/ aggregation large particles	-1.2 - (0.1)
15 March 14 UTC	16 March 11 UTC	first melting, in the night snow aggregates, in the morning maybe riming	-3.4 -2.2
18 March 05 UTC	19 March 19 UTC	large aggregates/ riming (maybe 8 UTC and 21 UTC)	-8.5 - (-1.5)
20 March 13 UTC	21 March 00 UTC	snow/riming	-3.9 - (-3.0)
21 March 06 UTC	21 March 15 UTC	rain	4.2-7.6
23 March 11 UTC	23 March 16 UTC	rain/melting snow	2.0-3.7

Precipitation microphysics



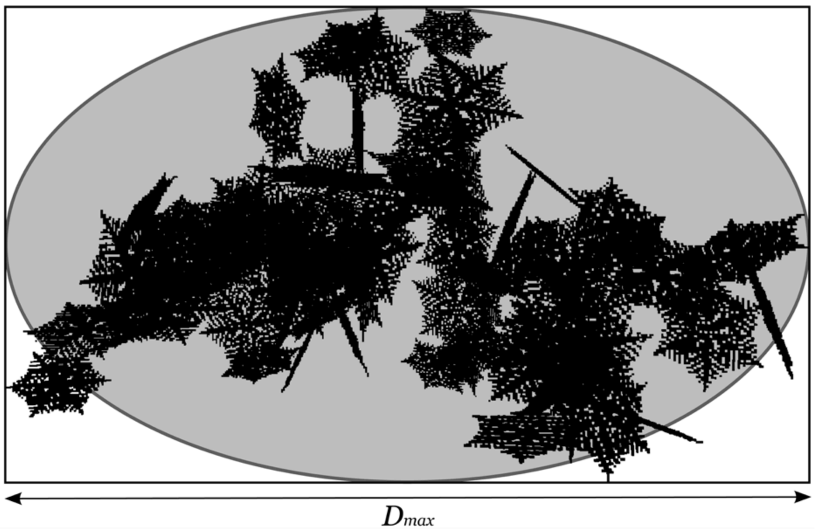


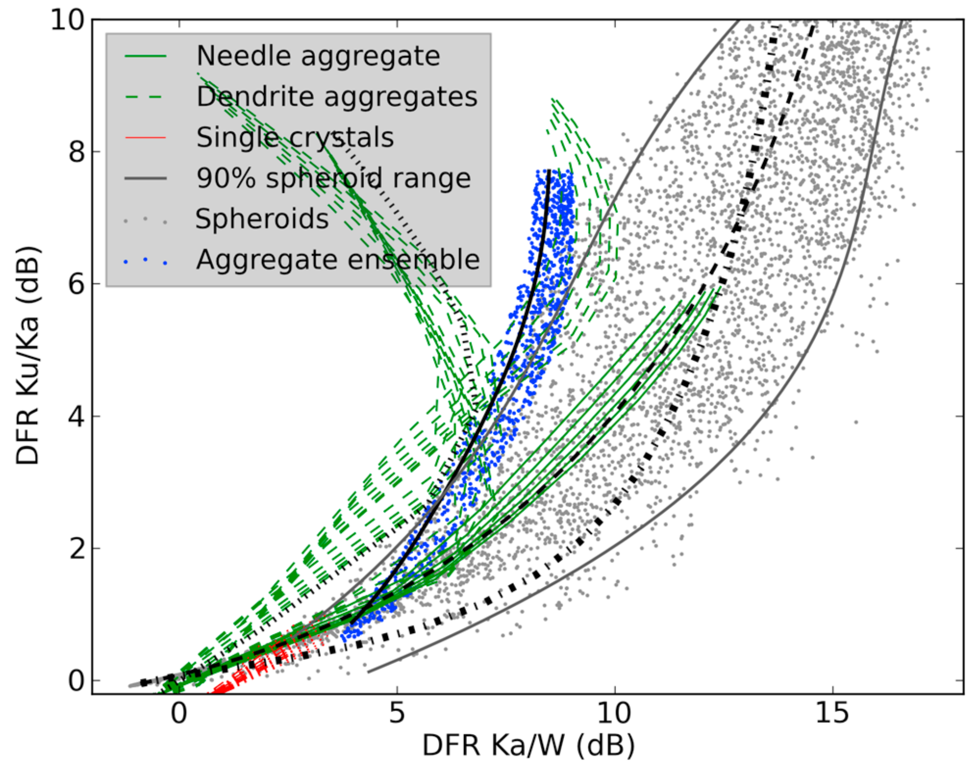


(Holographic camera)

- Preliminary analysis of the 2DVD data was carried out by following Huang et al. (2014)
  - yielding mass (density)-dimensional relations
- New type of automatic snow camera was tested. Prototype holographic camera was deployed by Univ. Of Oulu

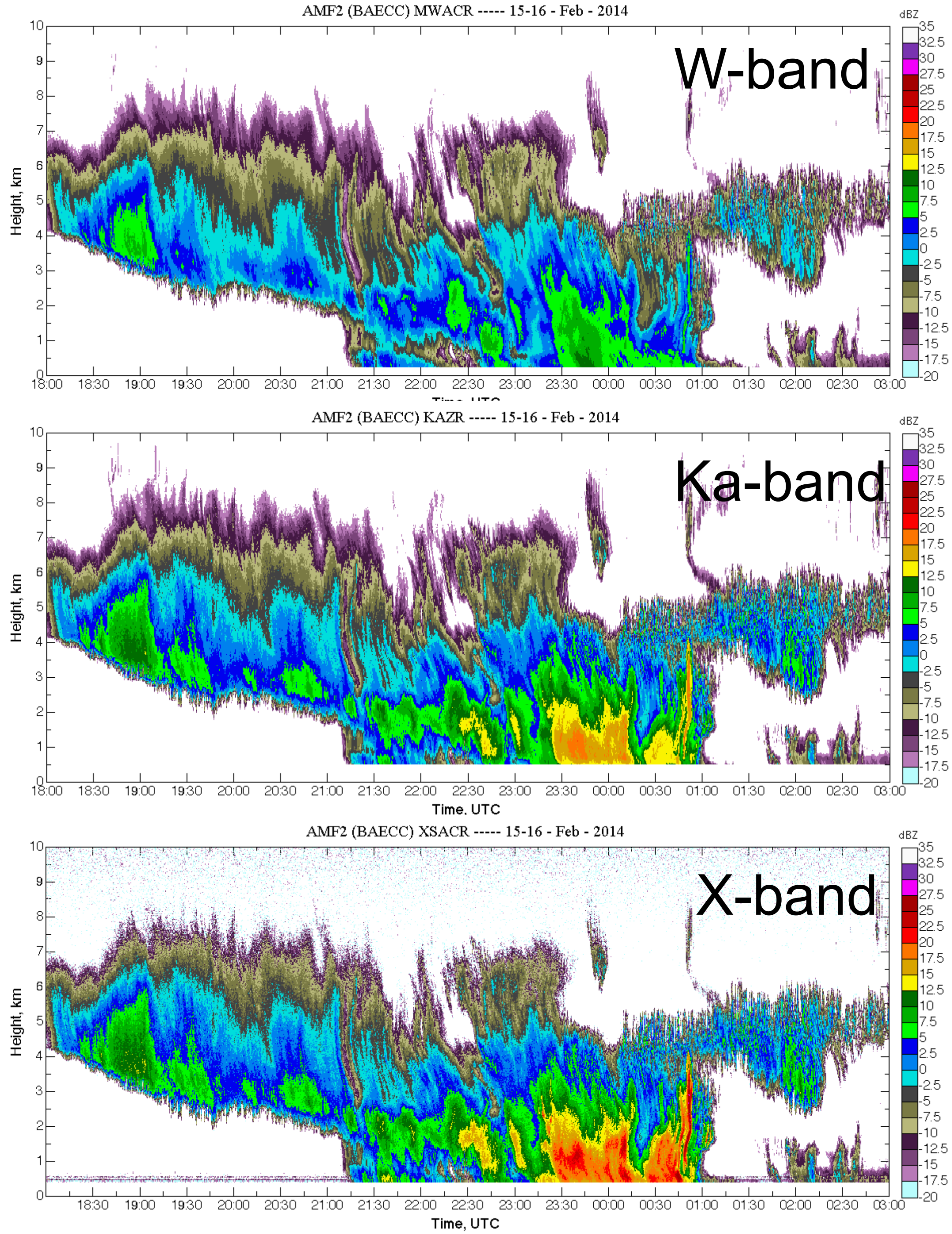
Spheroid vs. complex particles





One of the research topics was to investigate under which conditions ‘spheroid’ model fail.

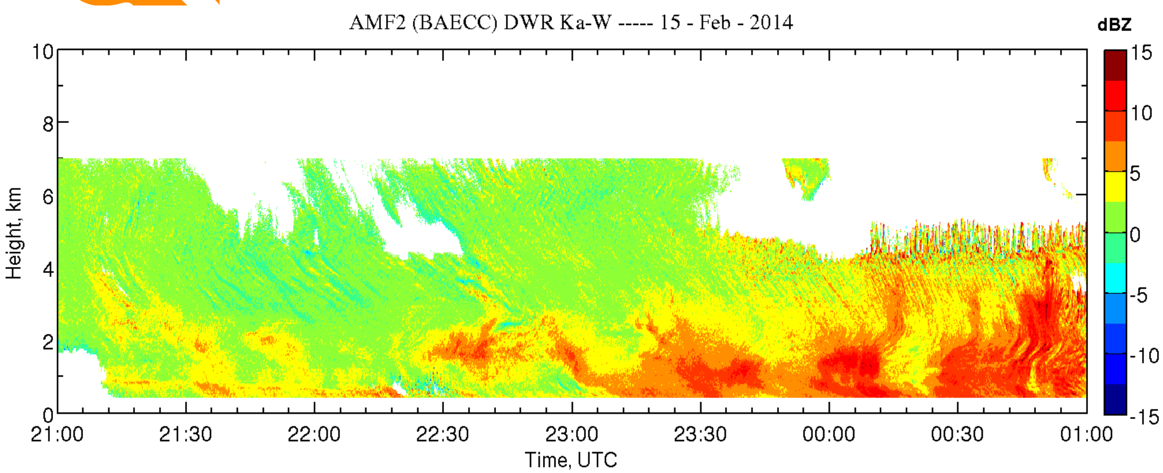
Leinonen et al. (2012) have shown by using triple frequency observations that neither complex or spheroid particle models explain the complete measurement space.

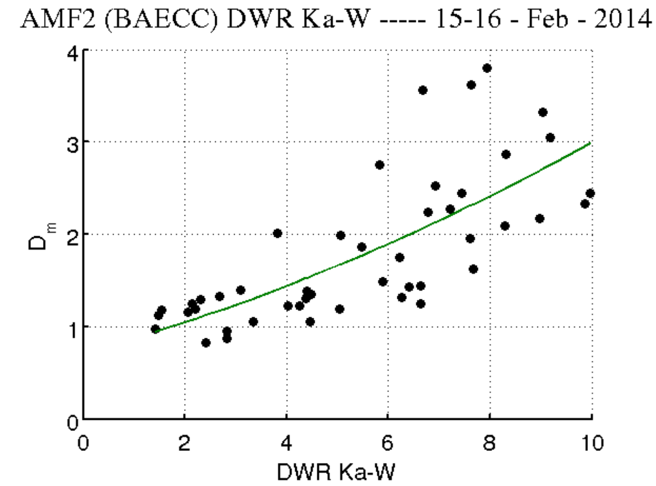


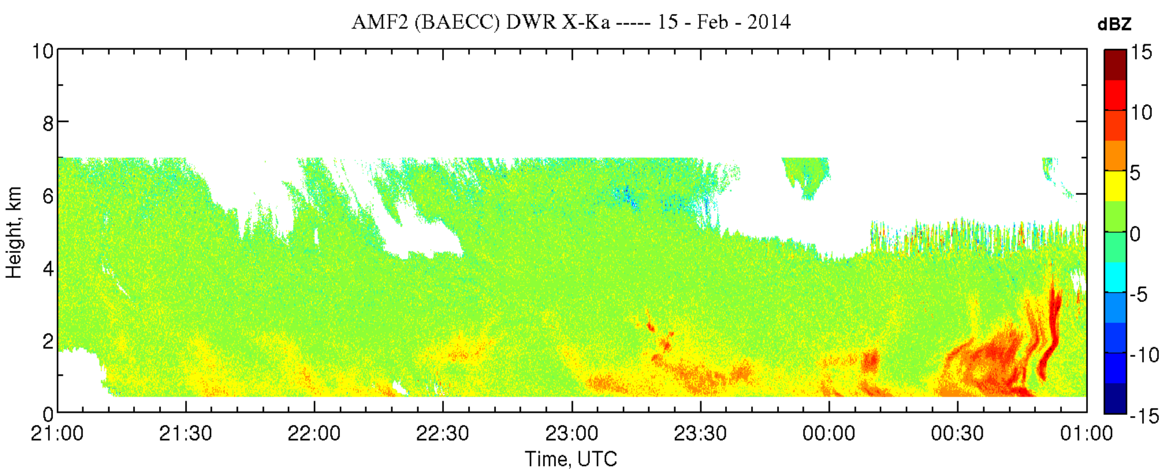
Example of triple - frequency observations on Feb 15-16, 2014

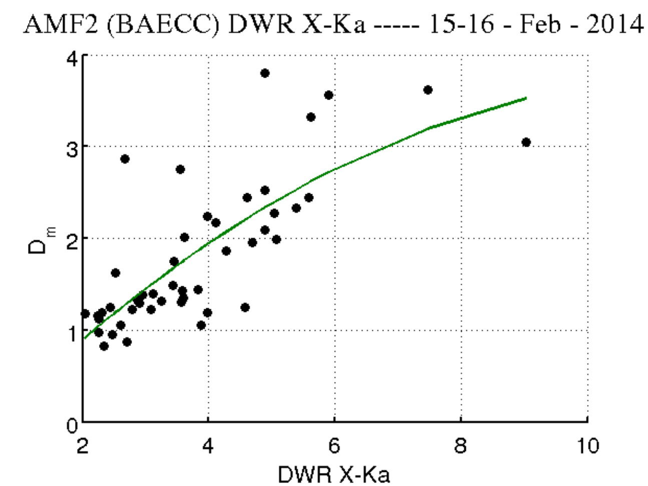
Interpretation of those observations are supported by surface based precipitation measurements

DFR plots for 15-16 February 2014





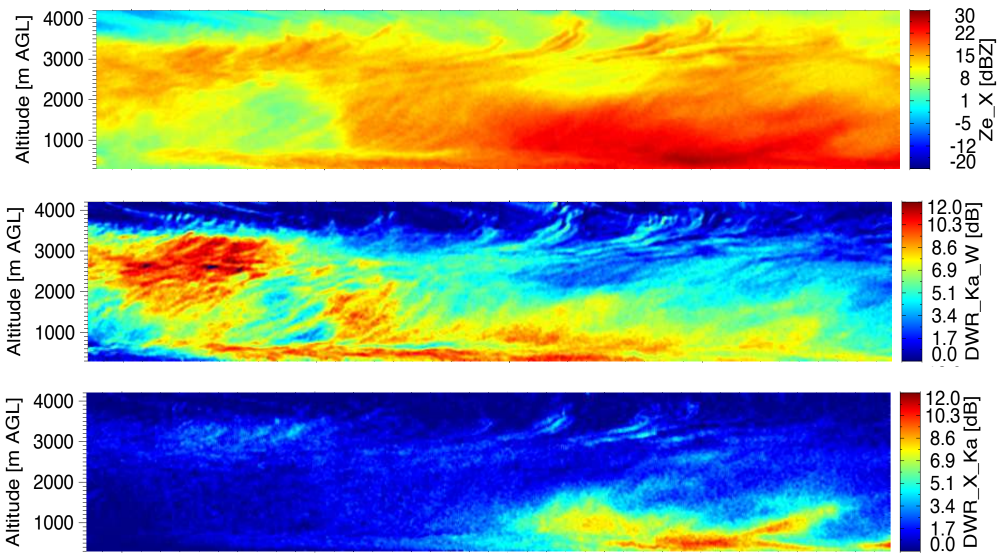


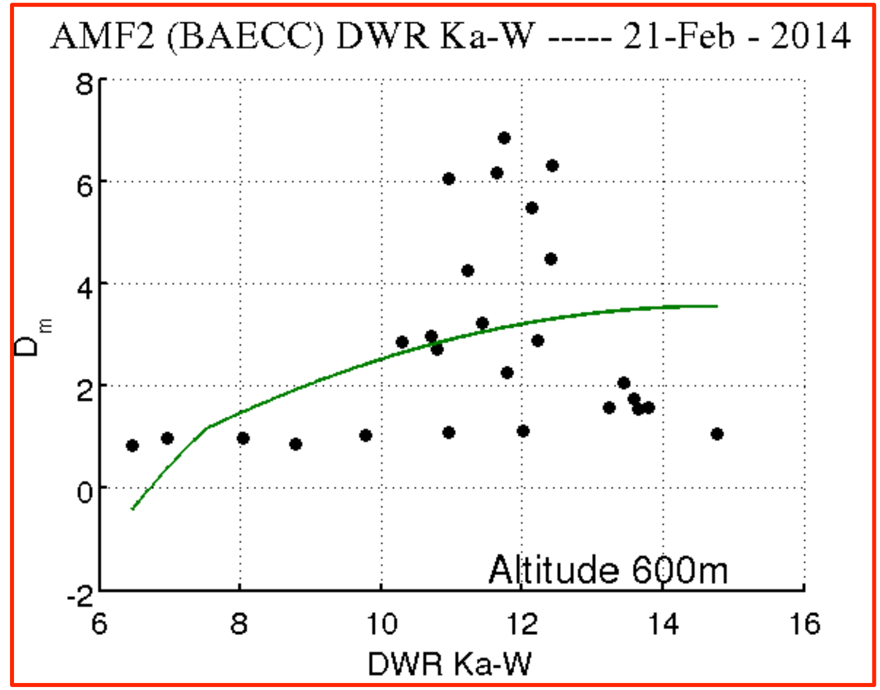


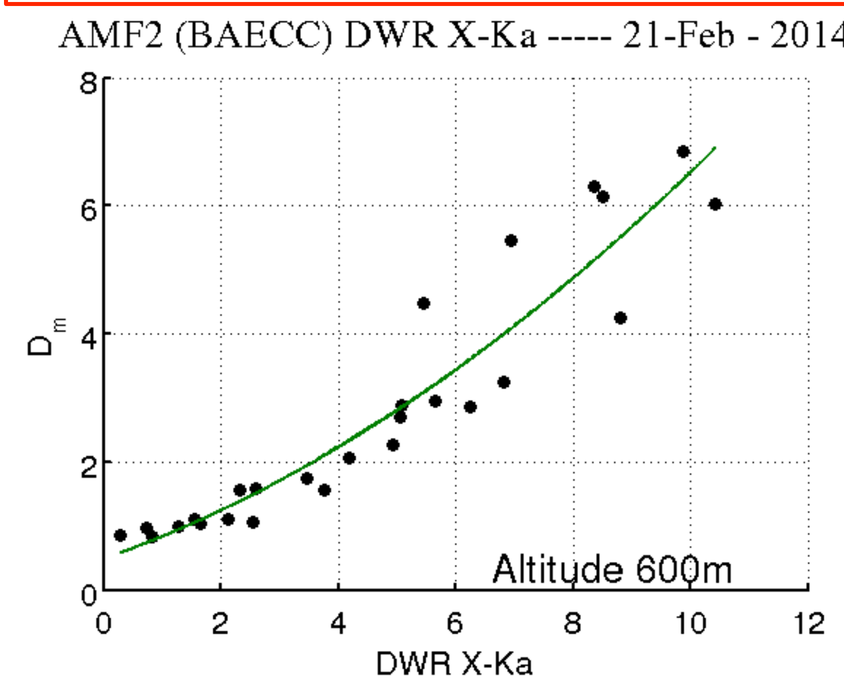
Good correlation between DFR and PIP measured mass weighted mean diameter

February 21, 2014

22.50-23.30







On Feb 21, correlation between DFR Ka/W and D_m disappears. This is due to failure of the 'spheroidal' model.

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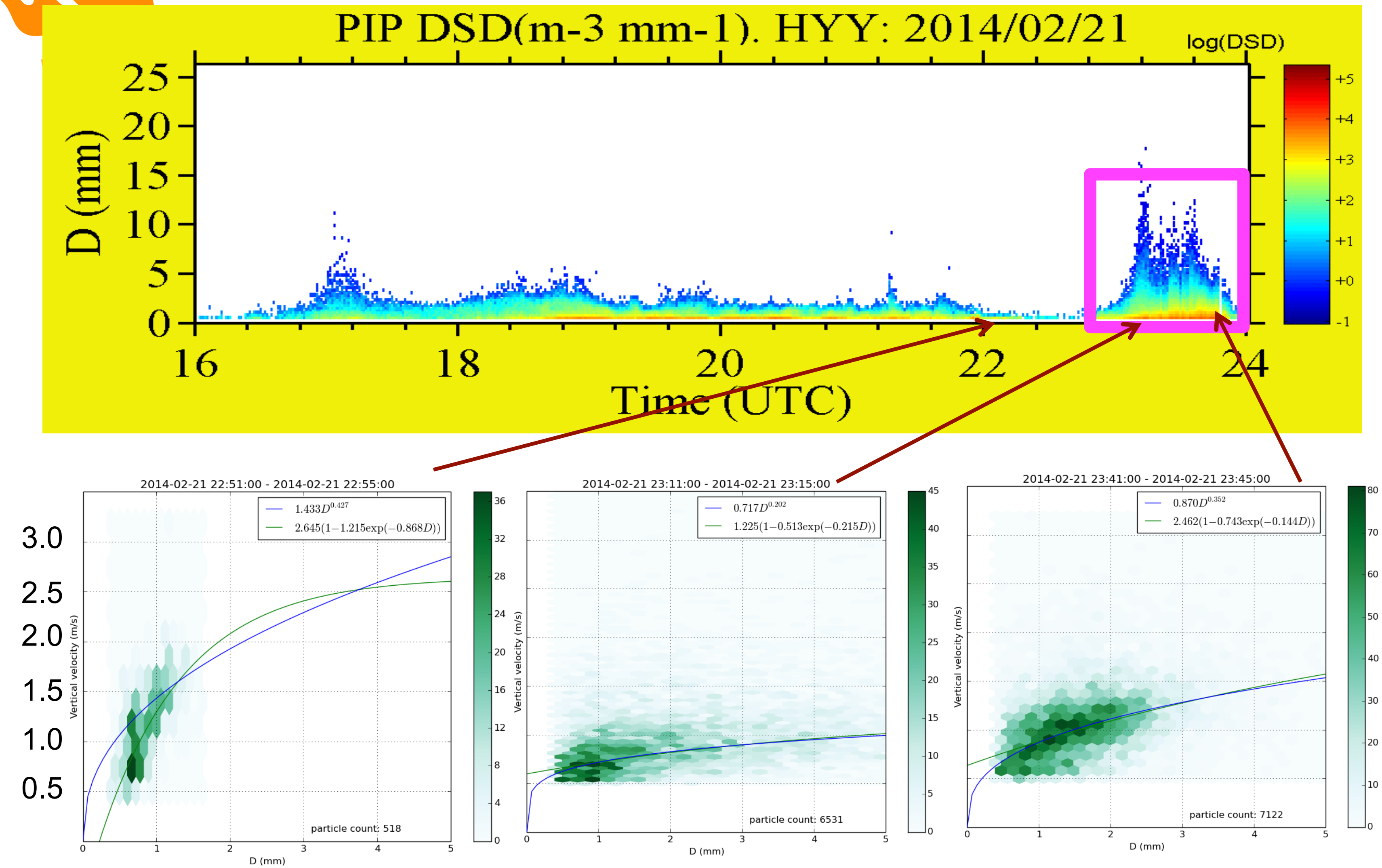
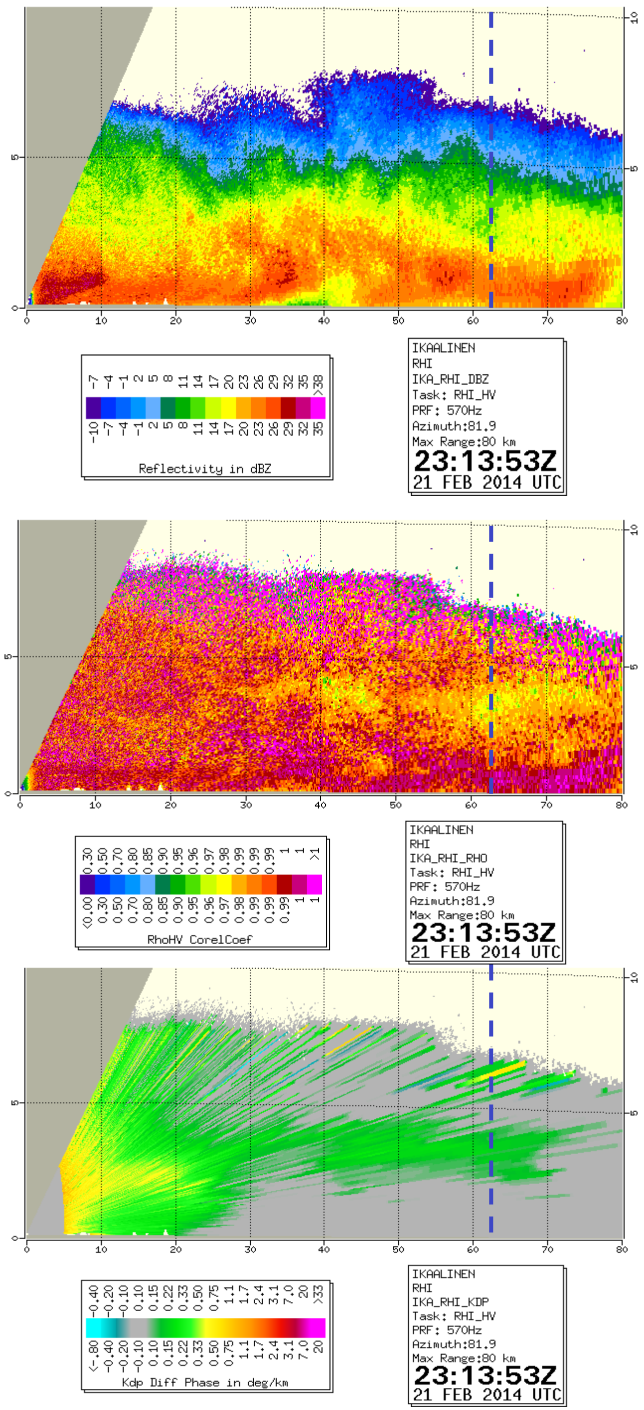
February 21, 2014



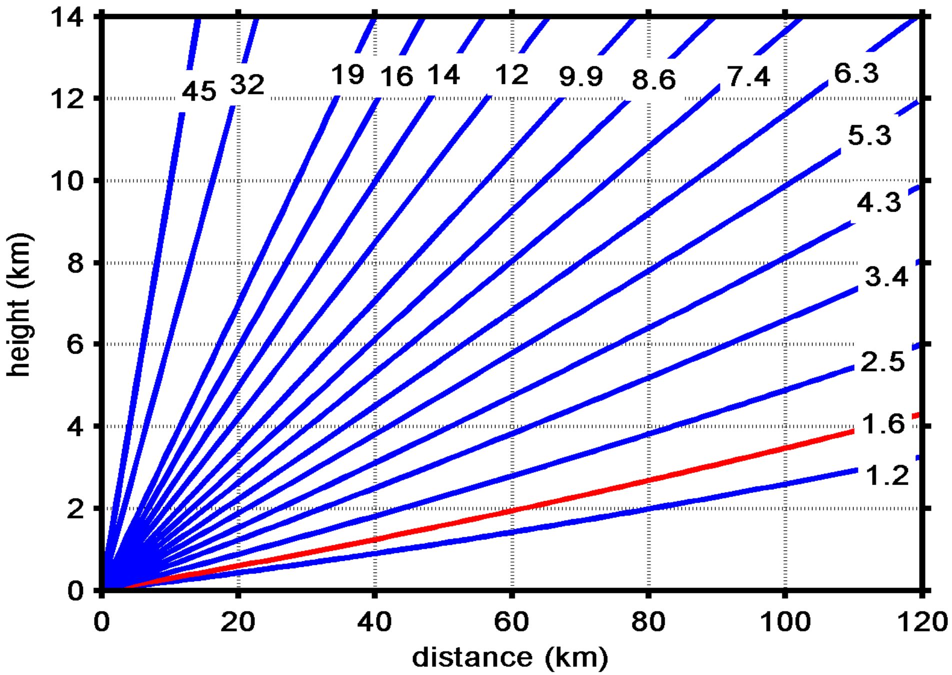
Surface observations indicate transition from rimed particles to aggregates. The DFR-Dm correlation fails in the aggregation part.



Dual-polarization radar measurements (Feb. 21, 2014)

- At the time when DFR W / K_a – D_m correlation failed FMI radar recorded a K_{dp} band above Hyytiälä
- K_{dp} band indicates onset of aggregation (Moisseev et al., 2014, submitted)
- K_{dp} / Z_{dr} bands could show a skill in diagnosing areas where ‘spheroidal’ model fail => could be used for GPM GV

Kumpula radar



- Since the GPM launch we carry out a set of dedicated scans at the time of GPM overpasses
- The volume scan is based Baldini et al recommendations
- Before and after the volume scan RHI observations are performed

- The main challenge is to keep up-to-date radar scan schedule

Summary

- The main Finnish activity in 2013-2014 is the BAECC experiment
- Excellent multi-frequency radar and surface based observations of snowfall were collected
- Failure of the ‘spheroidal’ model is linked to intense aggregation
- Dual-polarization radar observation can be used to diagnose such conditions