High-resolution vertical profiles of X-band polarimetric radar observables during snowfall in the Swiss Alps

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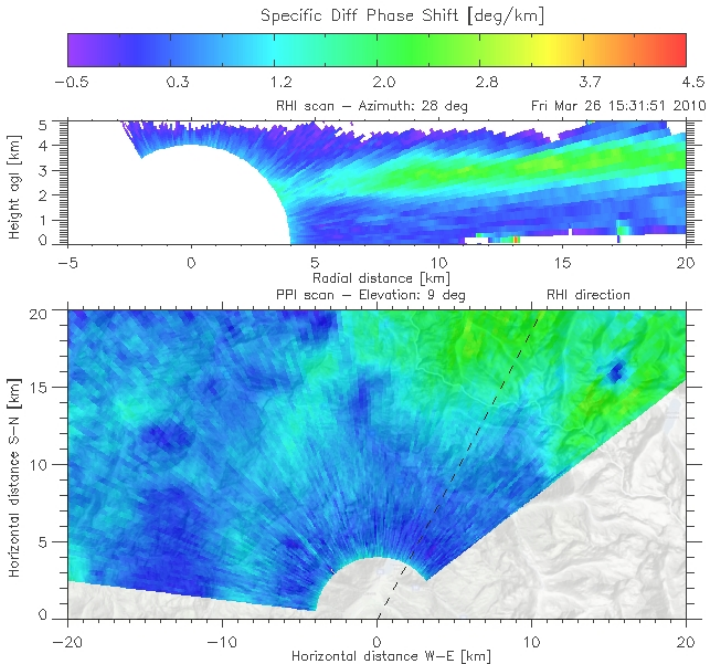
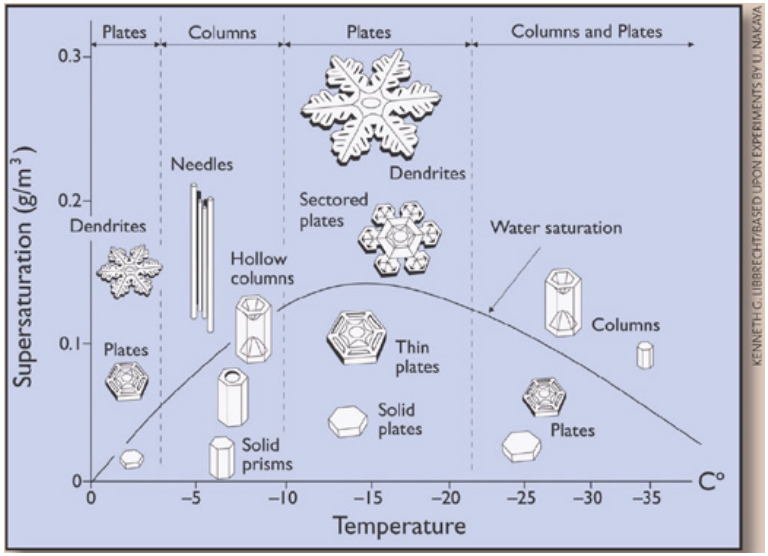


Motivation



Snow crystal habit

- Can snow microphysical processes be observed with an X-band polarimetric radar?
- Can such a radar distinguish different snow particles?

General atmospheric behavior

- Do X-band polarimetric variables exhibit a general behavior with height?
- Can such a behavior be related to atmospheric processes?

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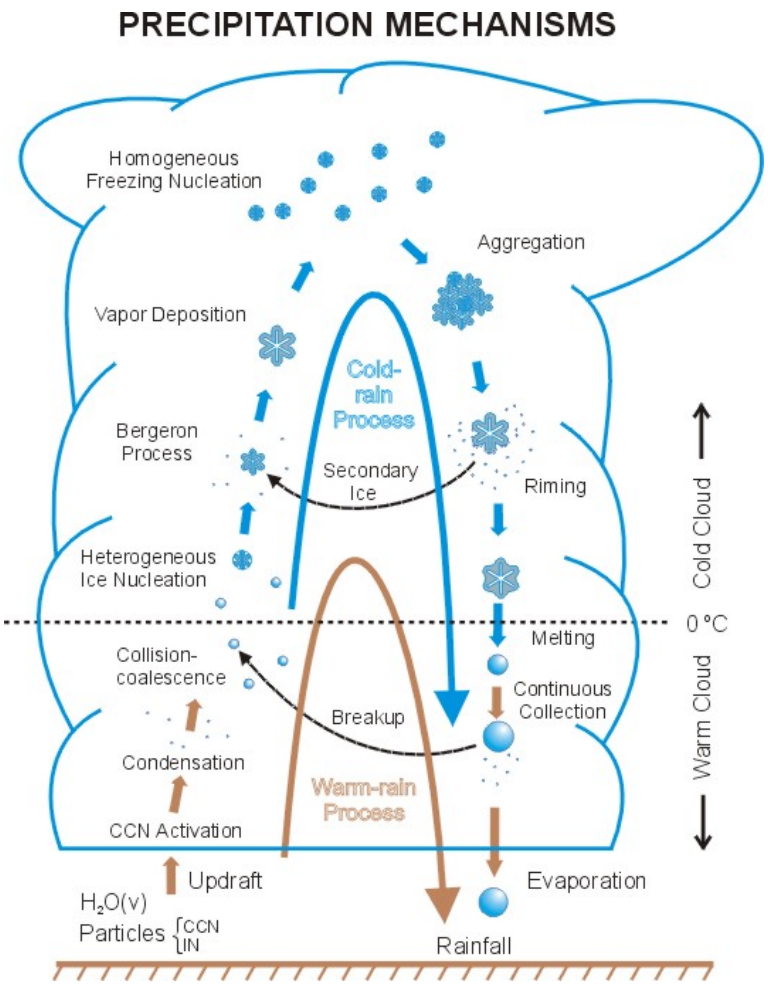

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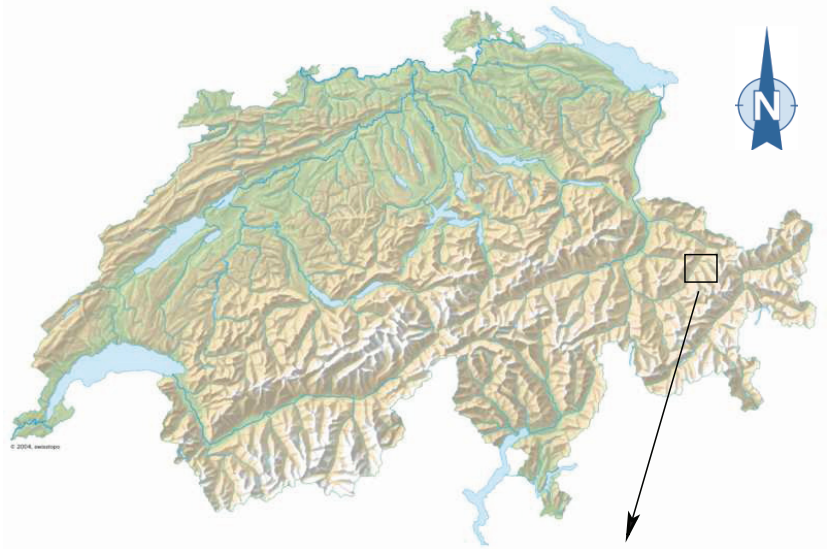
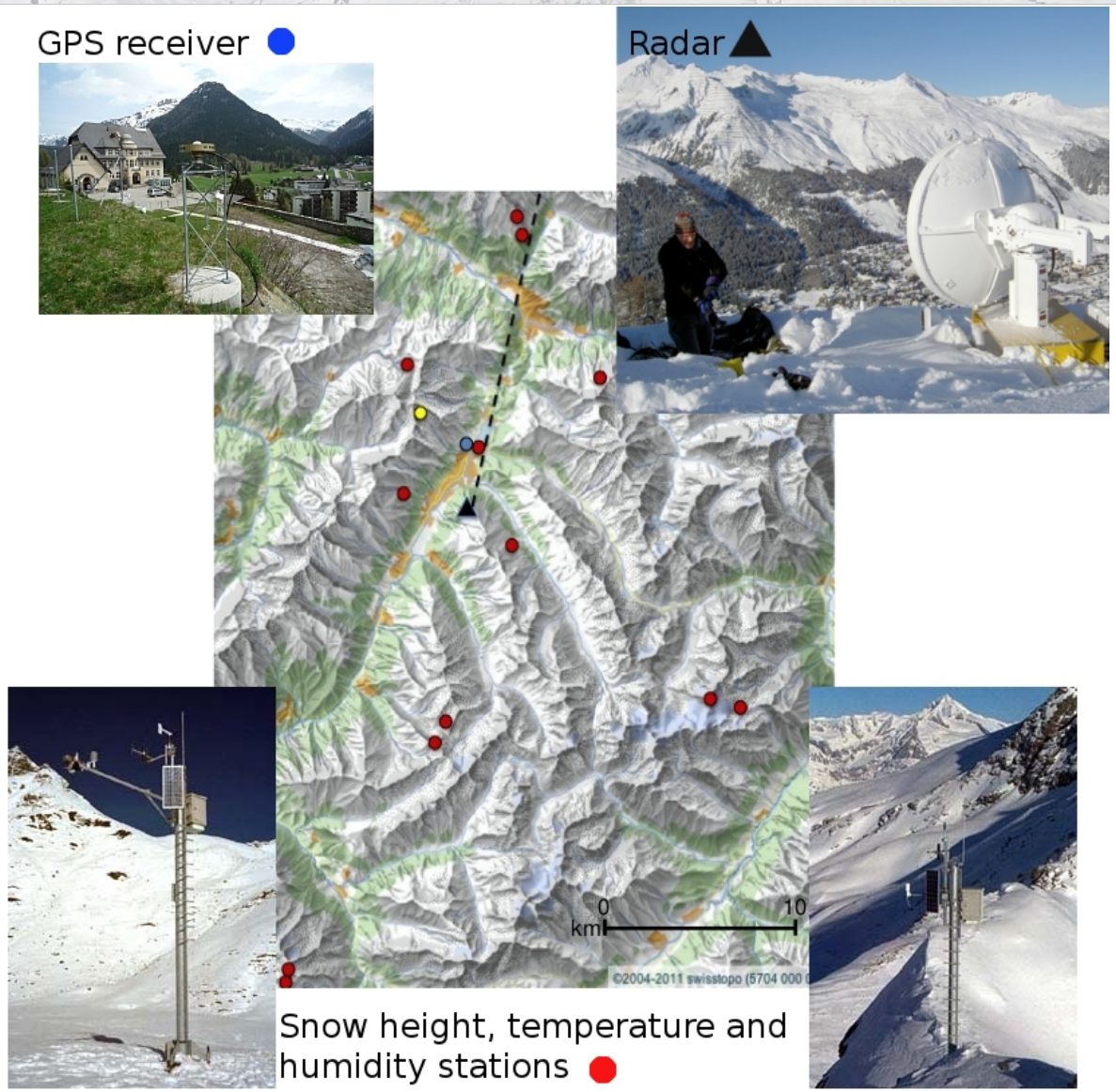
Overview

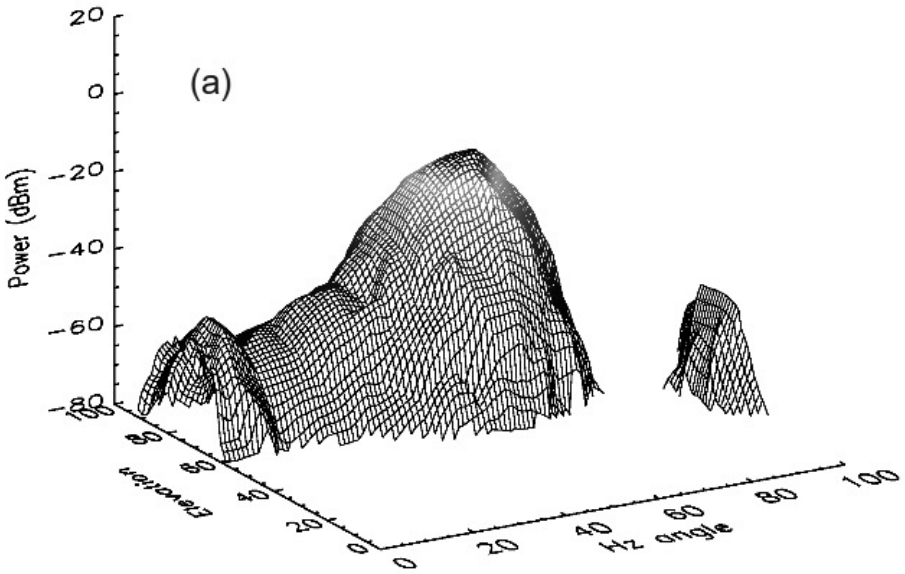


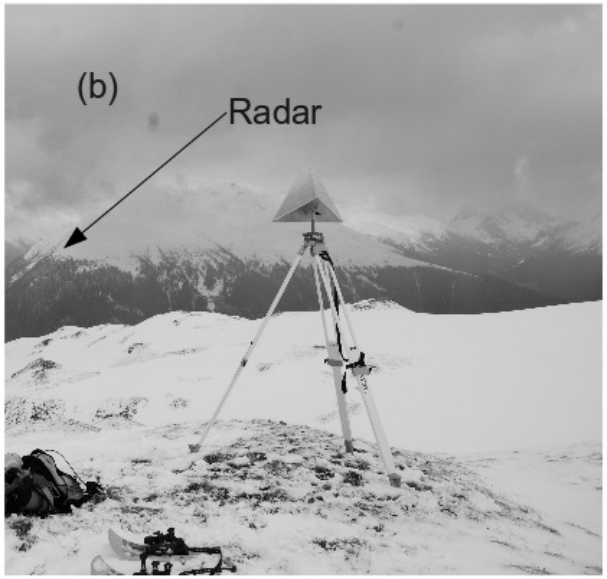
- Radar at 2133 m above sea level.
- Considered period: End of February to end of April 2010.
- Around 110 hours of snowfall collected above the melting layer.
- Contrasting snow events: cold dry snow, aggregates, graupel, dendrites.

Overview


GPS receiver
Radar
0
10
km
©2004-2011 swisstopo (5704 000
Snow height, temperature and
humidity stations

Radar calibration





- Radar constant determined with a corner reflector.
- Radar orientation determined by sun tracking.
- Z_{dr} is calibrated by rotating the antenna at 90° elevation.

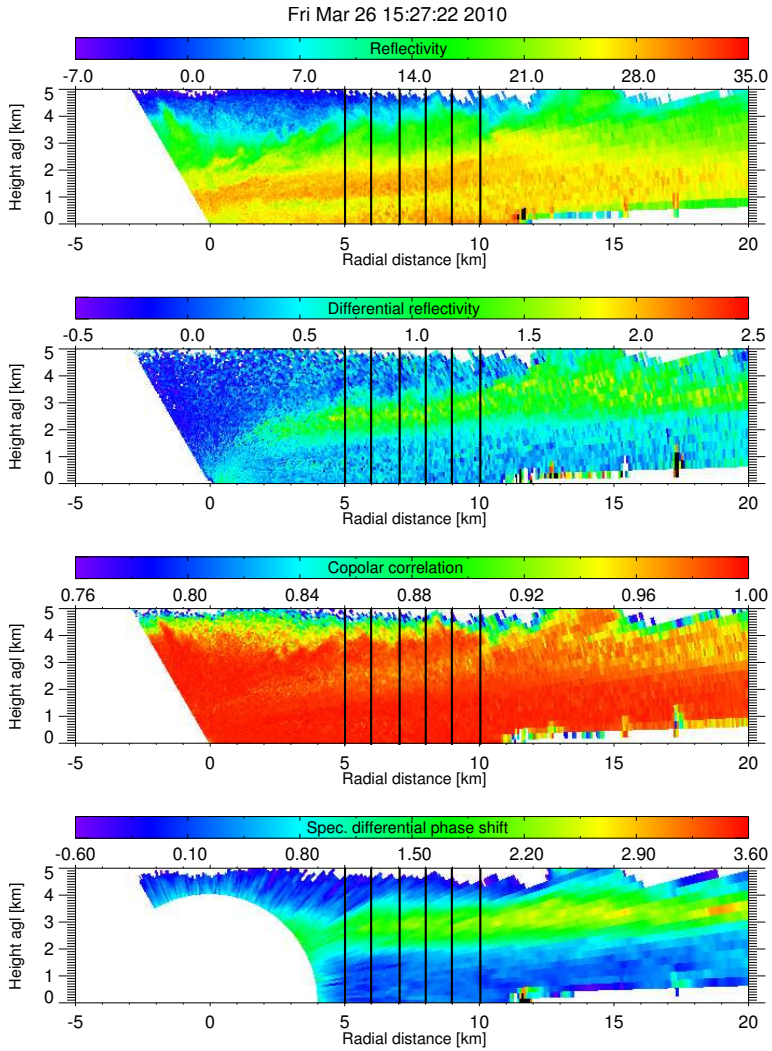
Experimental data (1)

Radar

- RHI scan every 5 min.
- 150 samples per ray at 1° resolution.
- 6 vertical profiles extracted between 5 and 10 km distance from the radar.

Water vapor

- Water vapor path (WVP) inferred from GPS signal.
- WVP separated into three temperature segments by using the humidity and temperature measurements at different height levels.



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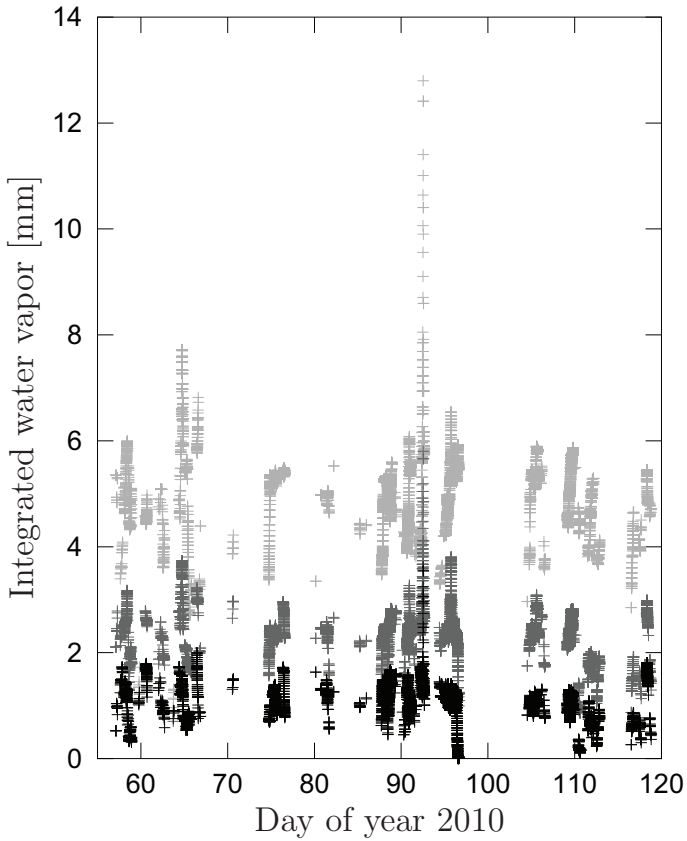
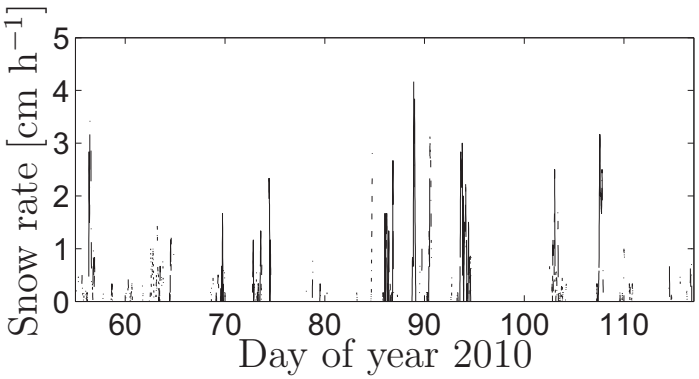


Experimental data (2)

Snow intensity

- Snow accumulation per time inferred from several snow height sensors.



Temperature profile

- Determination of the 0° level by fitting temperature measurements at different height levels.

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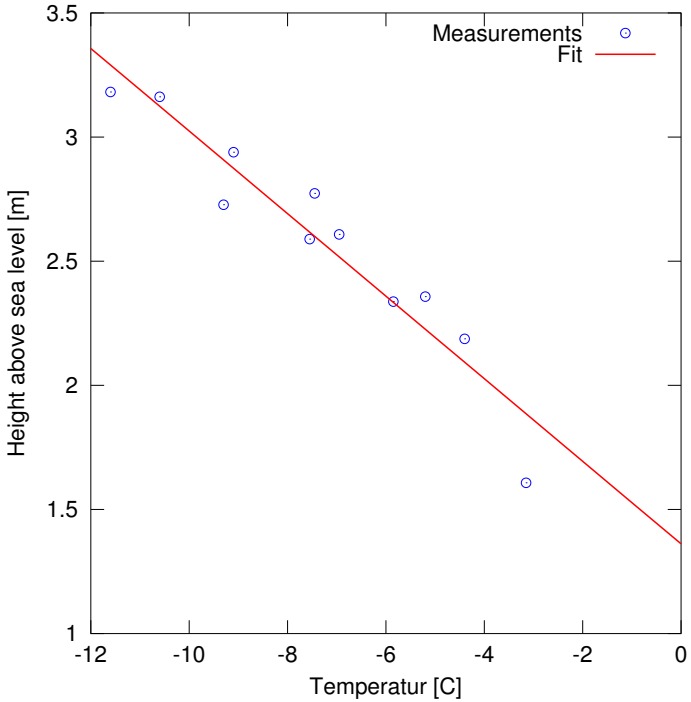
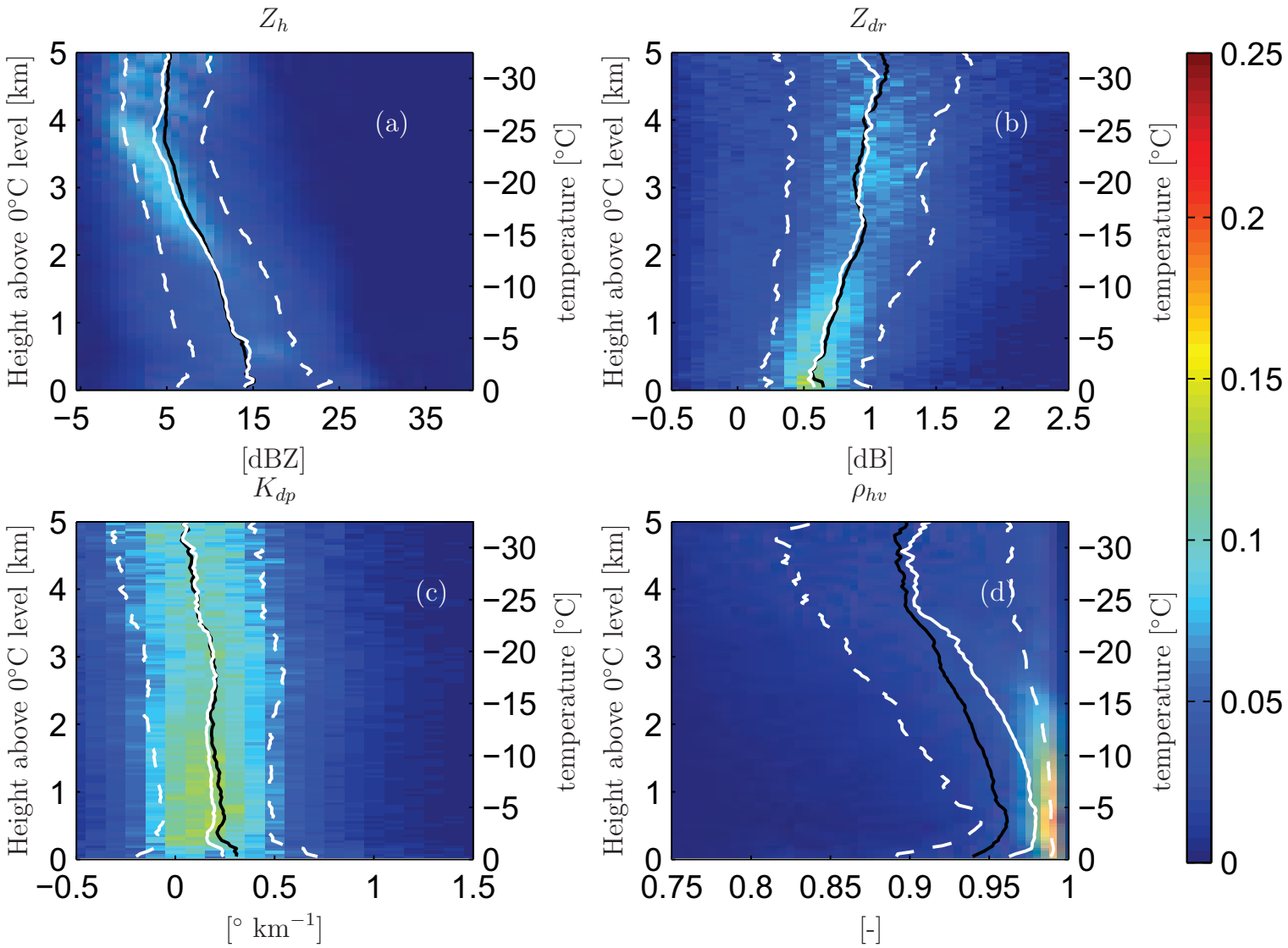


Distribution of polarimetric observables



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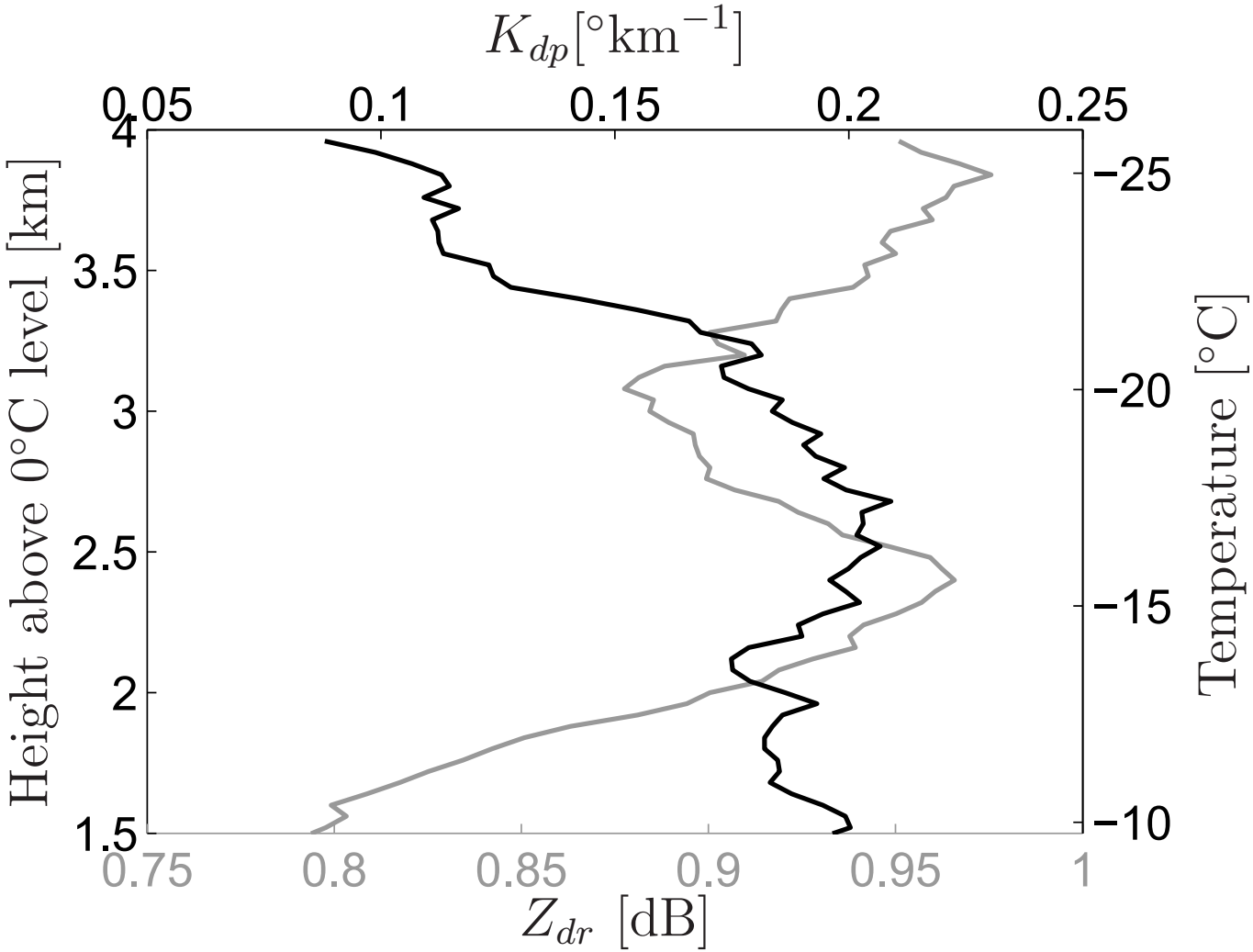
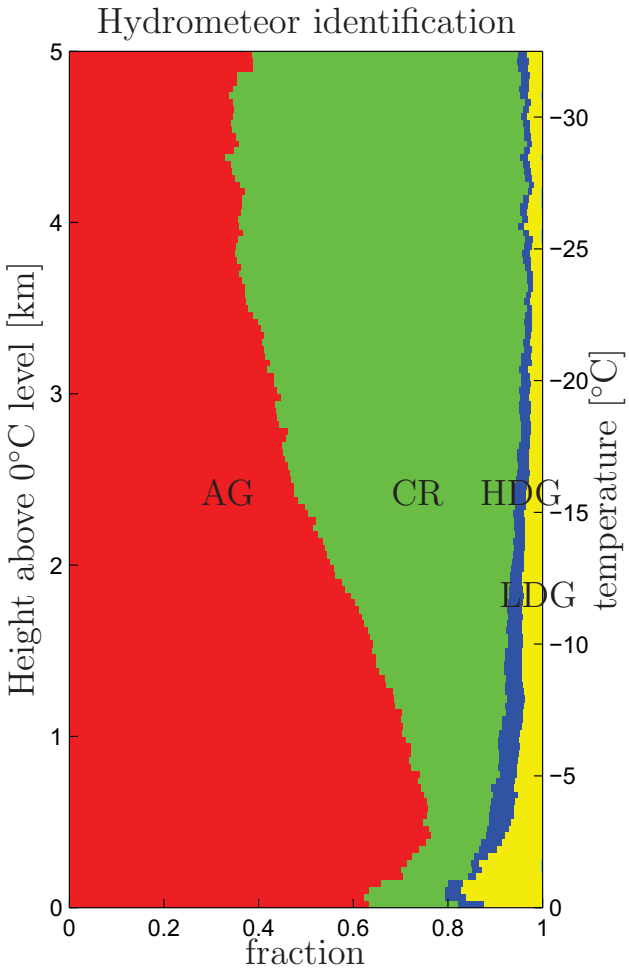


Dendrification signal in Z_{dr} and K_{dp} $\rightarrow$ Kennedy et al., JAMC, 2011.

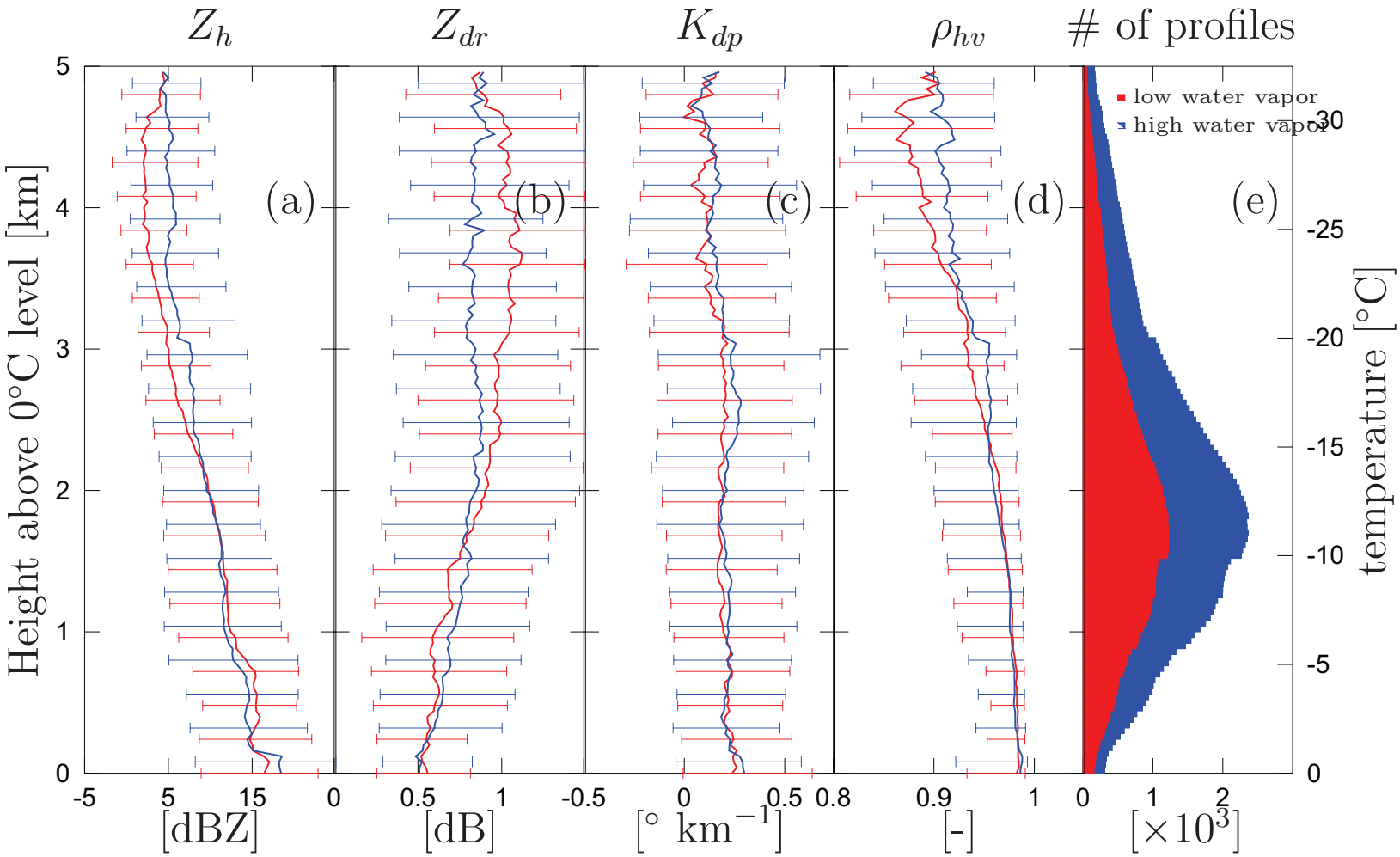
Mean Hydrometeor identification



- Hydrometeor identification with the algorithm of Dolan and Rutledge, JTECH, 2009.
- Increasing abundance of aggregates towards higher temperatures.
- Increasing abundance of graupel towards higher temperatures.

Aggregates, Crystals, High density graupel, Low density graupel

Polarimetric profiles as a function of humidity



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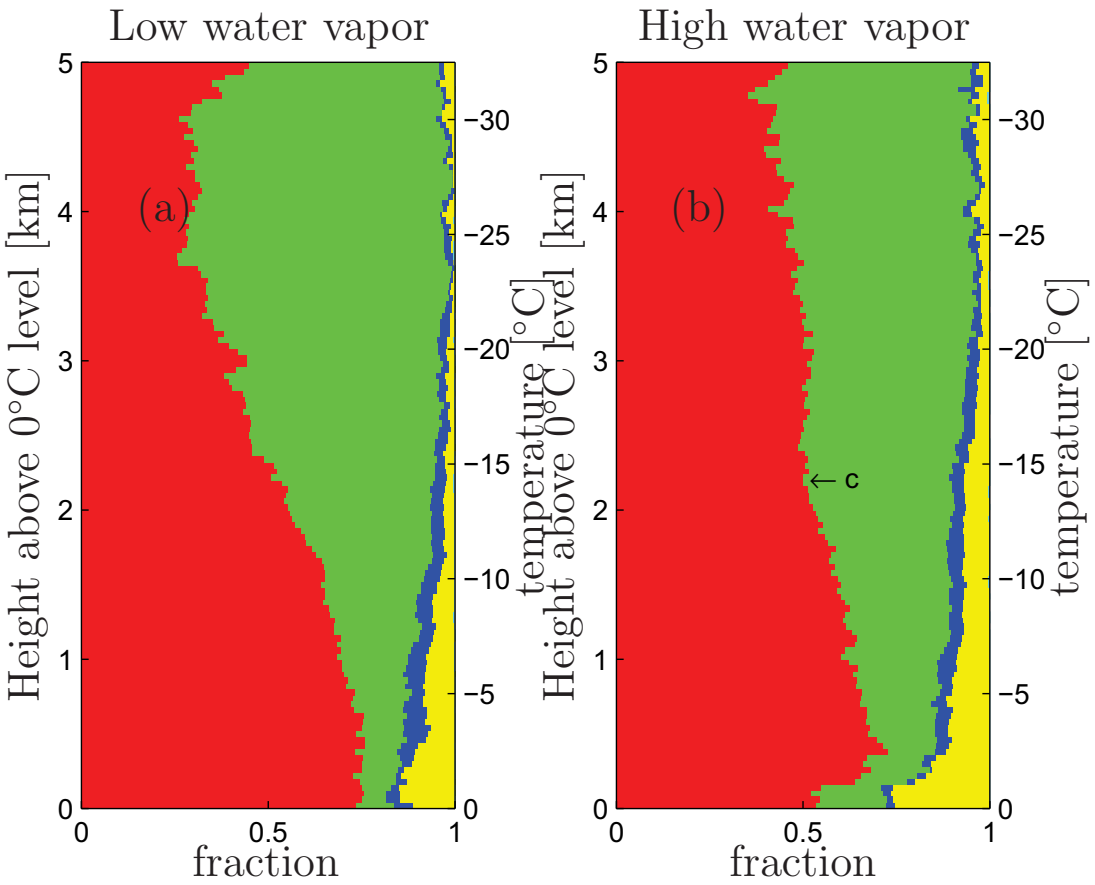
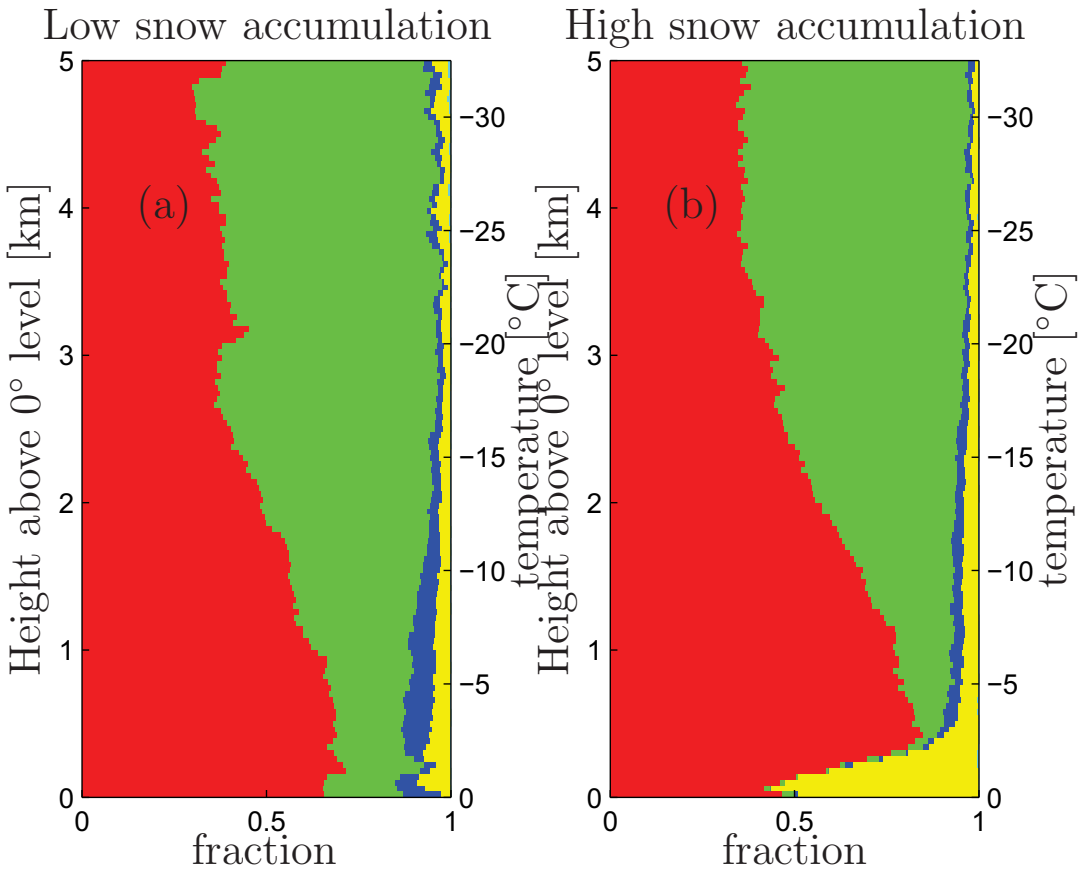


- Signature of dendrification in high water vapor conditions.
- Increased abundance of graupel in high water vapor conditions.
- Increased abundance of crystals in low water vapor conditions.

Aggregates, Crystals, High density graupel, Low density graupel

Hydrometeor identification vs. snowfall rate



- Strongly increased signature of graupel formation for high snowfall rates. → Harimaya and Nakai, JMSJ, 1999; Houze and Medina, JAS, 2005.
- Increased abundance of aggregates for high snowfall rates.

Aggregates, Crystals, High density graupel, Low density graupel

Conclusions and Outlook

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- The average behavior of around 8000 vertical polarimetric profiles measured with an X-band radar above the melting layer has been studied.
- X-band polarimetric profiles as a function of the height above 0°C are related to microphysical processes such as dendrification, aggregation and riming.
- High snowfall rates are coupled to increased riming occurrence.

Outlook

- Are we able to theoretically reproduce and confirm these observations by coupling an electrodynamical model to a snow microphysics model?

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2010-04-01 04:10