The TOSCA project

Towards an **O**ptimal
-estimation **S**now
Characterization **A**lgorithm

DFG funded project
(German Science Foundation)
2008 - 2011

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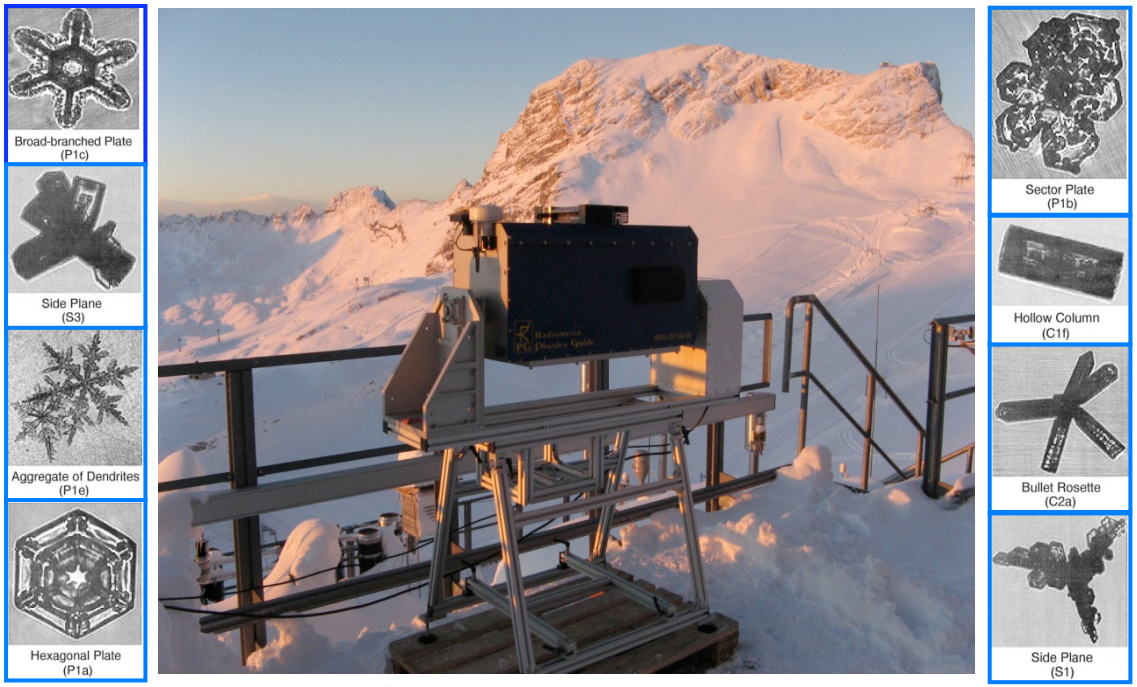
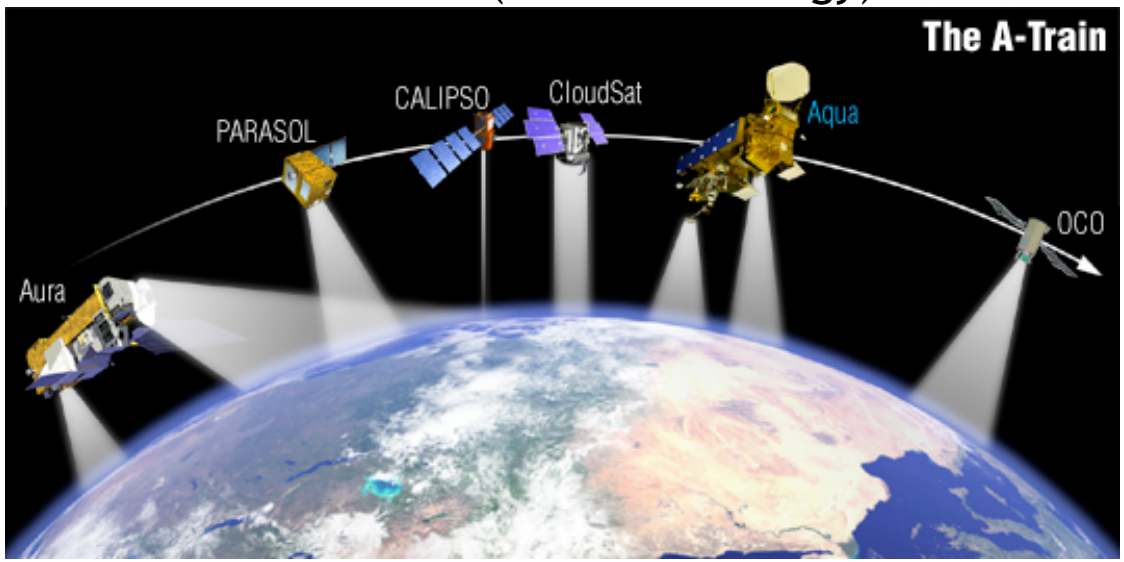


from the ground @ the UFS
(= Environmental Research Station Schneefernerhaus, 2650m MSL)

from space



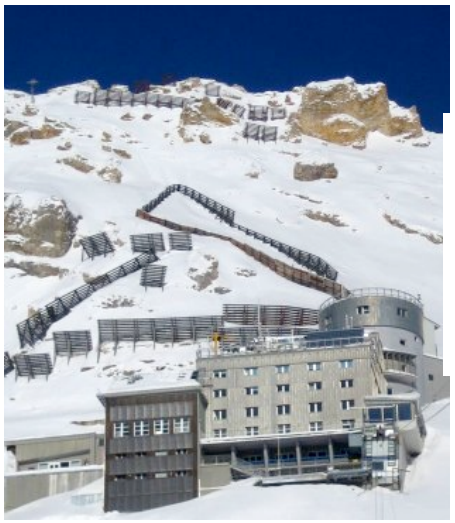
TOSCA: Motivation

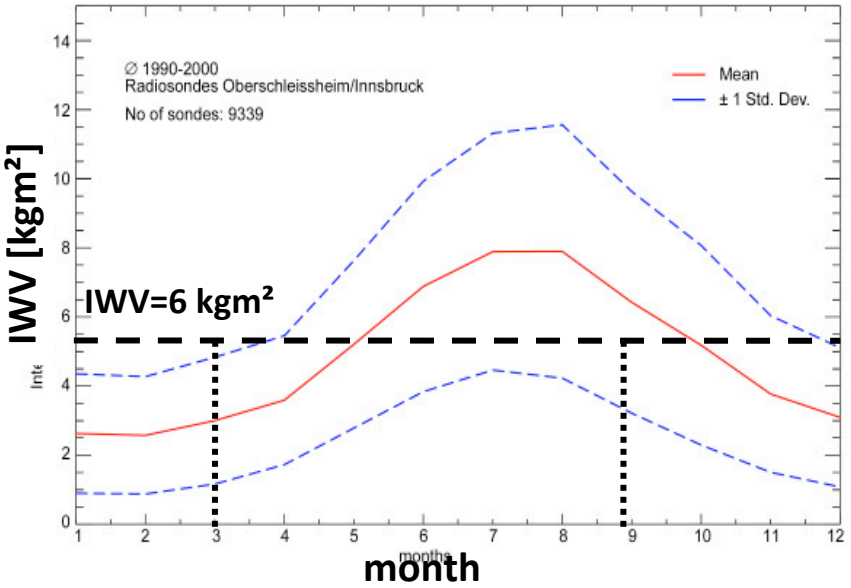
No single instrument is solely capable of describing the microphysical properties of snow!

Integrate a number of state-of-the-art remote sensing instruments
➔ final goal: Develop a modular **optimal-estimation algorithm** and **evaluate the potential for deriving columnar snow microphysics**

… if the retrieval of a certain parameter from the ground is not possible (within a prescribed accuracy), it will probably be difficult to retrieve from space …

Environmental research station „Schneefernerhaus“ (UFS) at the top of Germany





Annual precipitation.:

UFS (2650m): 1991 mm
Munich (511m): 1009 mm

Annual mean temp.:

UFS (2650m): -4.8°C
Munich (511m): 9.2°C

Advantages:

- High frequency of (dry) snow events.
- IWV < 6 kgm² during winter -> good conditions to measure snow scattering signals with passive microwave instruments.
- Very good infrastructure for scientific experiments:
  - cable car, cog railway for heavy instrumentation
  - High speed internet connection for remote access

Integration of atmospheric sensors @ UFS

DPR (RS passive): high accuracy LWP, ice microphysics

2D Video-Disdrometer, PARSIVEL:
In-situ fall speed, particle size, shape

HATPRO (RS passive): T&q profiles, LWP

Integration = physically consistent combination of all employed measurement information

Need knowledge on:

- instrument characteristics (theory, error)
- forward model, i.e. radiative transfer
- inversion methods

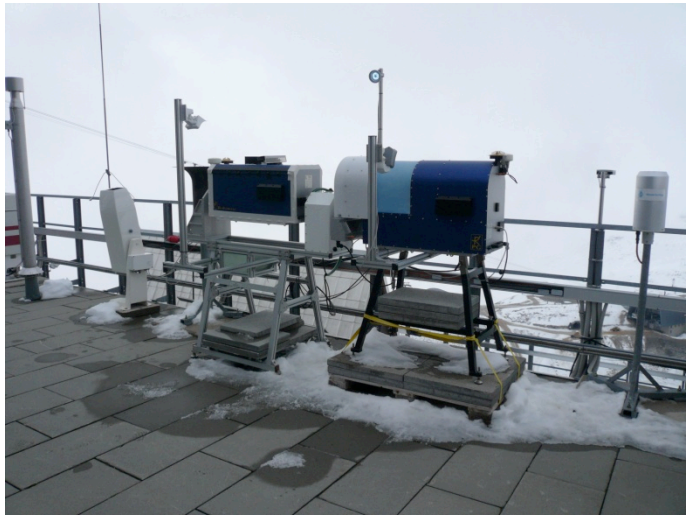
Cloud radar (RS active): cloud boundaries, cloud vertical structure

Ceilometer (RS active): backscatter profile

+ Meteorological Data (DWD)
+ Synop-Data (Zugspitze)
+ Radiosoundings Innsbruck

MicroRainRadar (RS active): Doppler velocity spectrum of precipitation

TOSCA impressions @ UFS

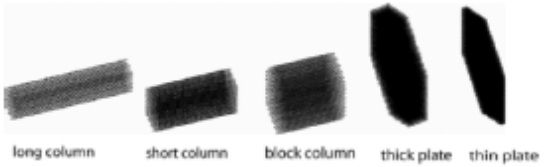


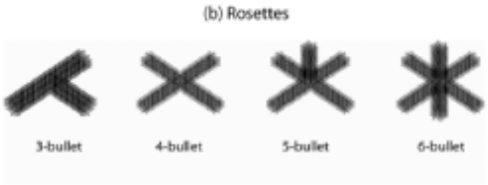
unique ensemble of snow observing instrumentation

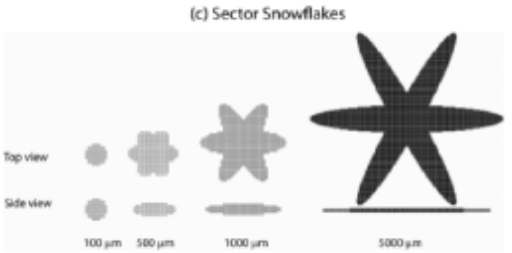
Modelling the shape of snowflakes

Liu, BAMS, 2008

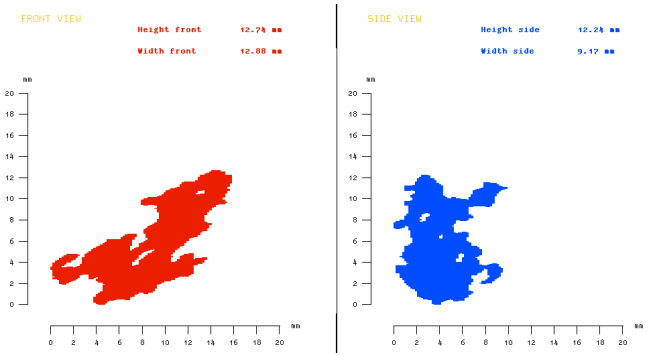
- Recently a lot of single scattering databases have been published (Liu, Hong, …). They assume typpical crystals (stellars, plates, columns, dendrites, …) for their calculations
- **BUT**: Large snowflakes (>1mm) DON‘T look like this!
- Large snowflakes are often „fluffy“ aggregates. That means, <u>we can not find any typical shape</u> for those large snowflakes!
- Many observation (Heymsfield, Muramoto) show that aggregates (snow, ice or biological polymers) have special fractal properties, like specific fractal dimension.
- **One major TOSCA question:** Is it possible to find parameters that characterize the shape and hence the scattering properties of large snowflakes???



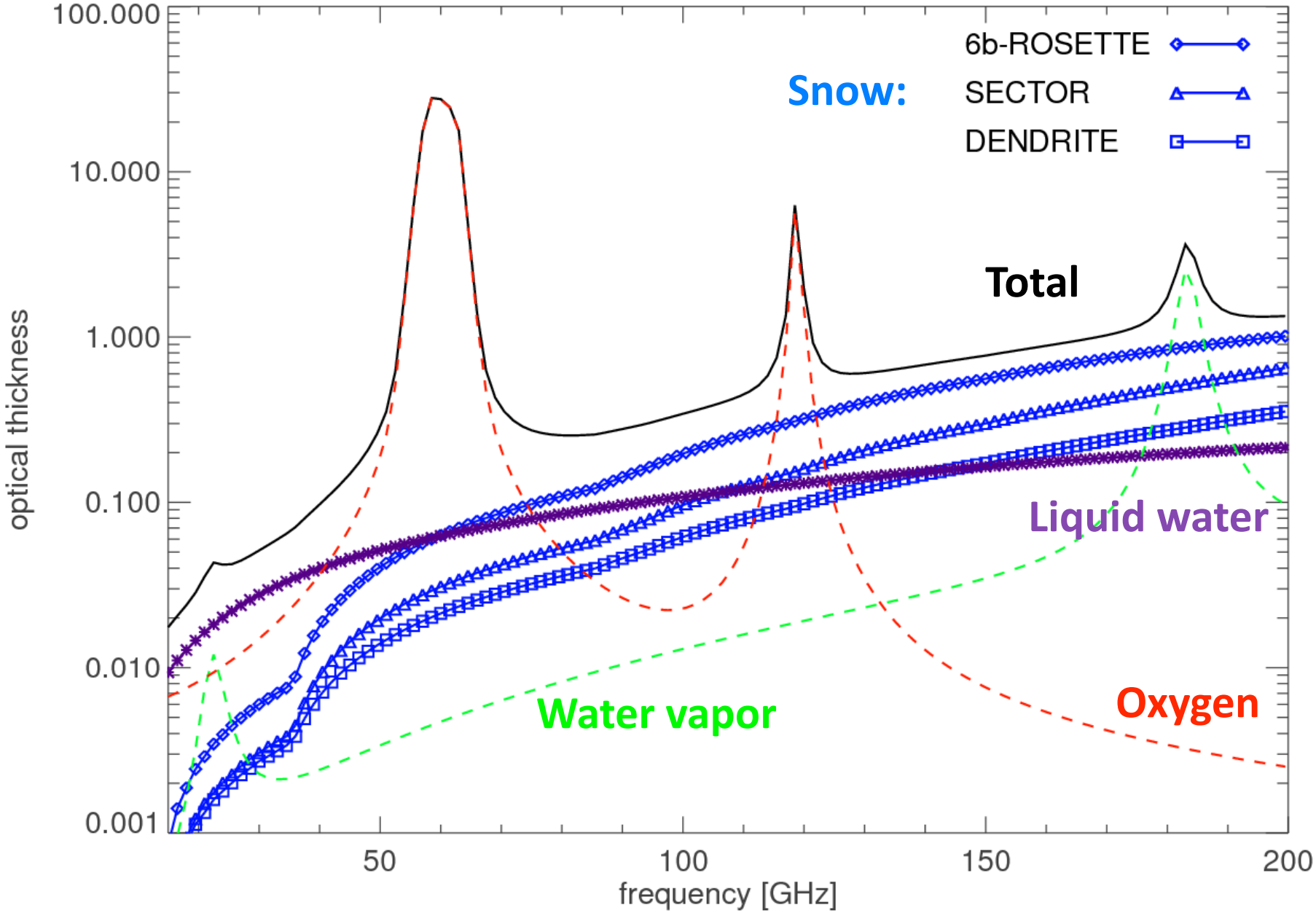




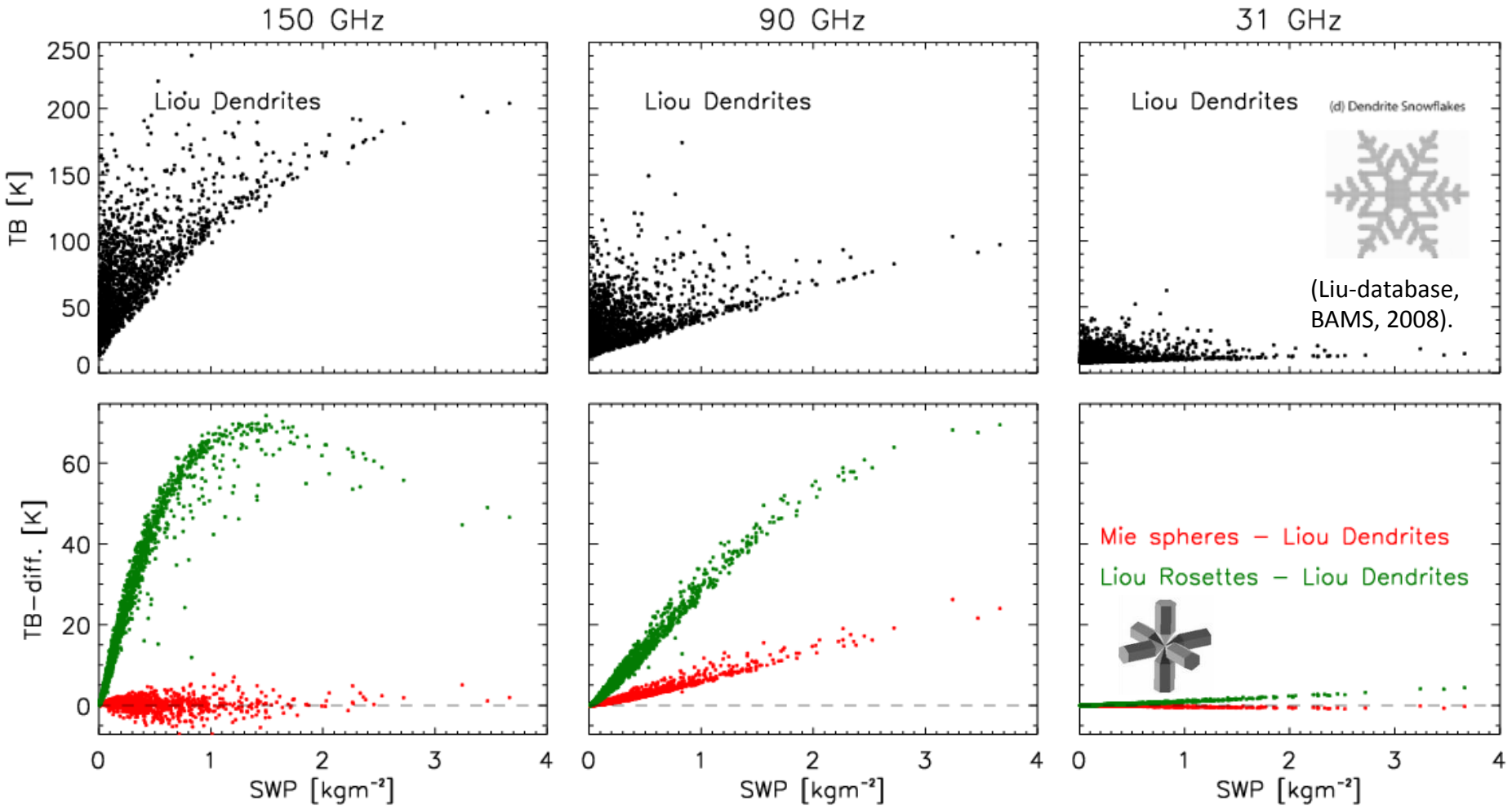
2DVD:



Spectral Sensitivity



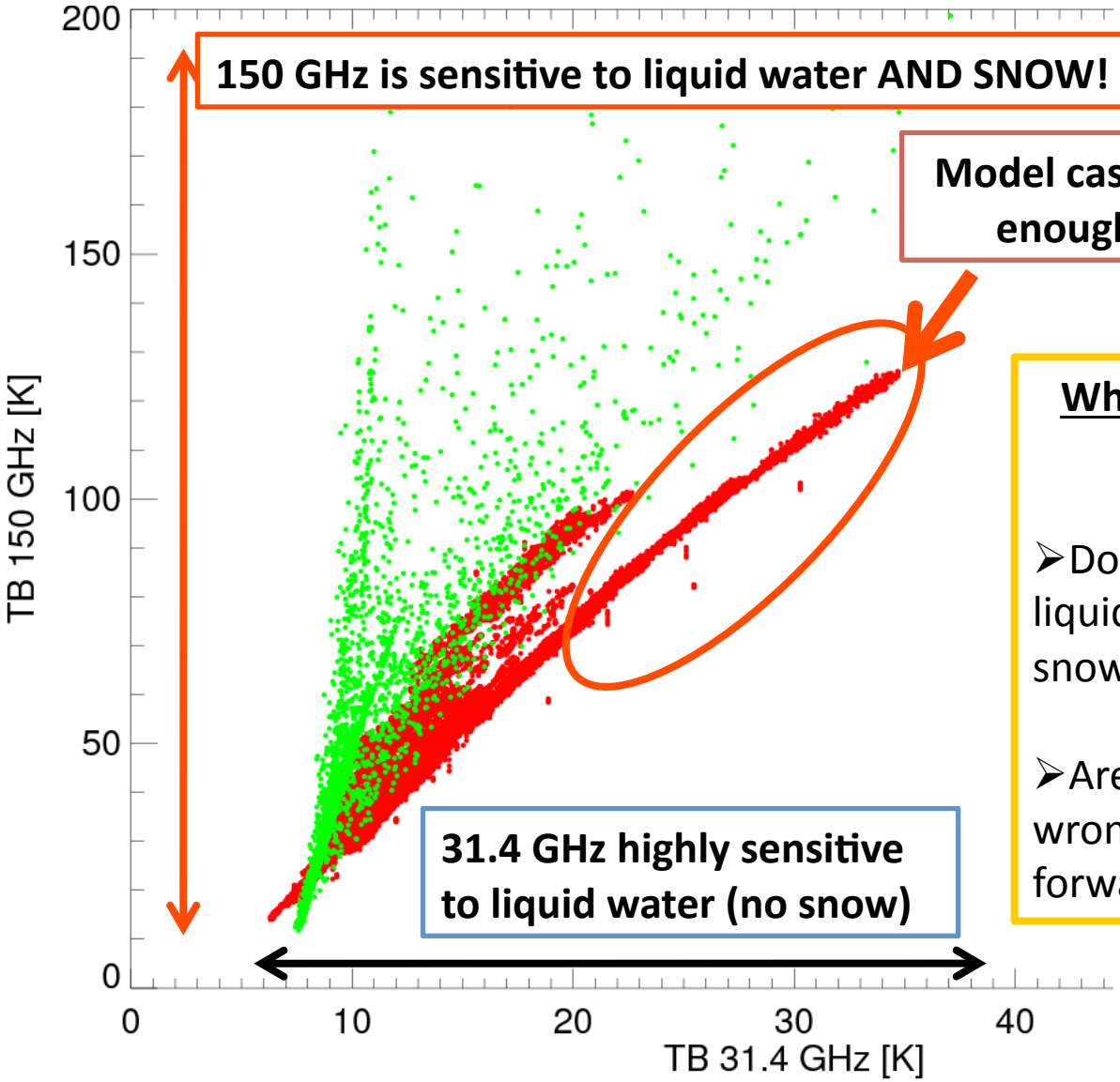
Simulated snow signals in the passive MW:



First sensitivity study: Simulated brightness temperatures (TB) for different snow water paths (SWP) (profiles include cloud ice and graupel)

- 2784 selected snow profiles from **COSMO-DE model output (Oct08-Mar09)**
- TB differences for different snowtypes: Dendrites, 6bullet-rosettes and Mie spheres.

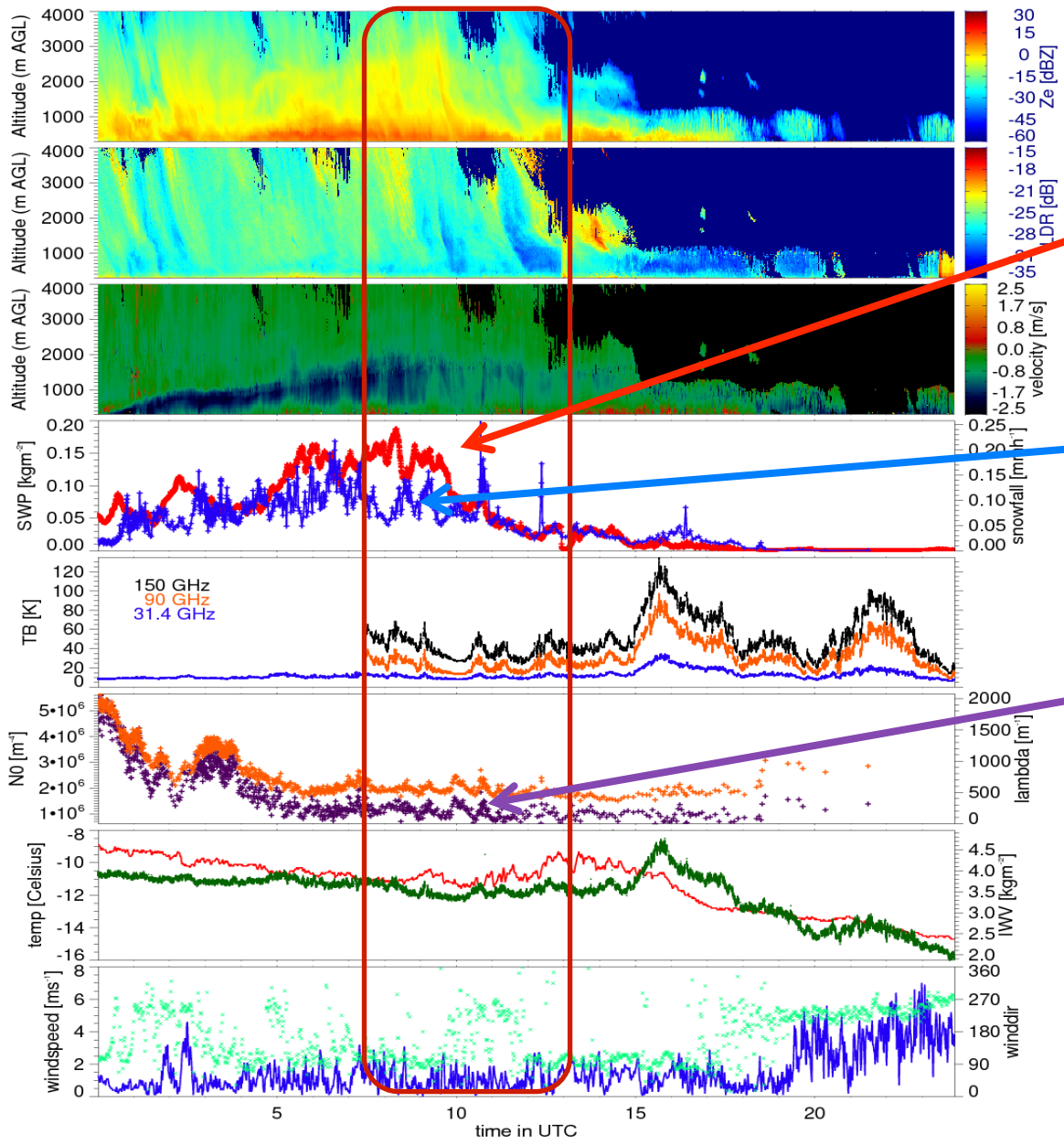
Simulated COSMO-DE variability (2784 profiles) in terms of TBs (green) compared to measured values from the 08. Feb. 2009 (red):



Why are measurements and model statistics so different?

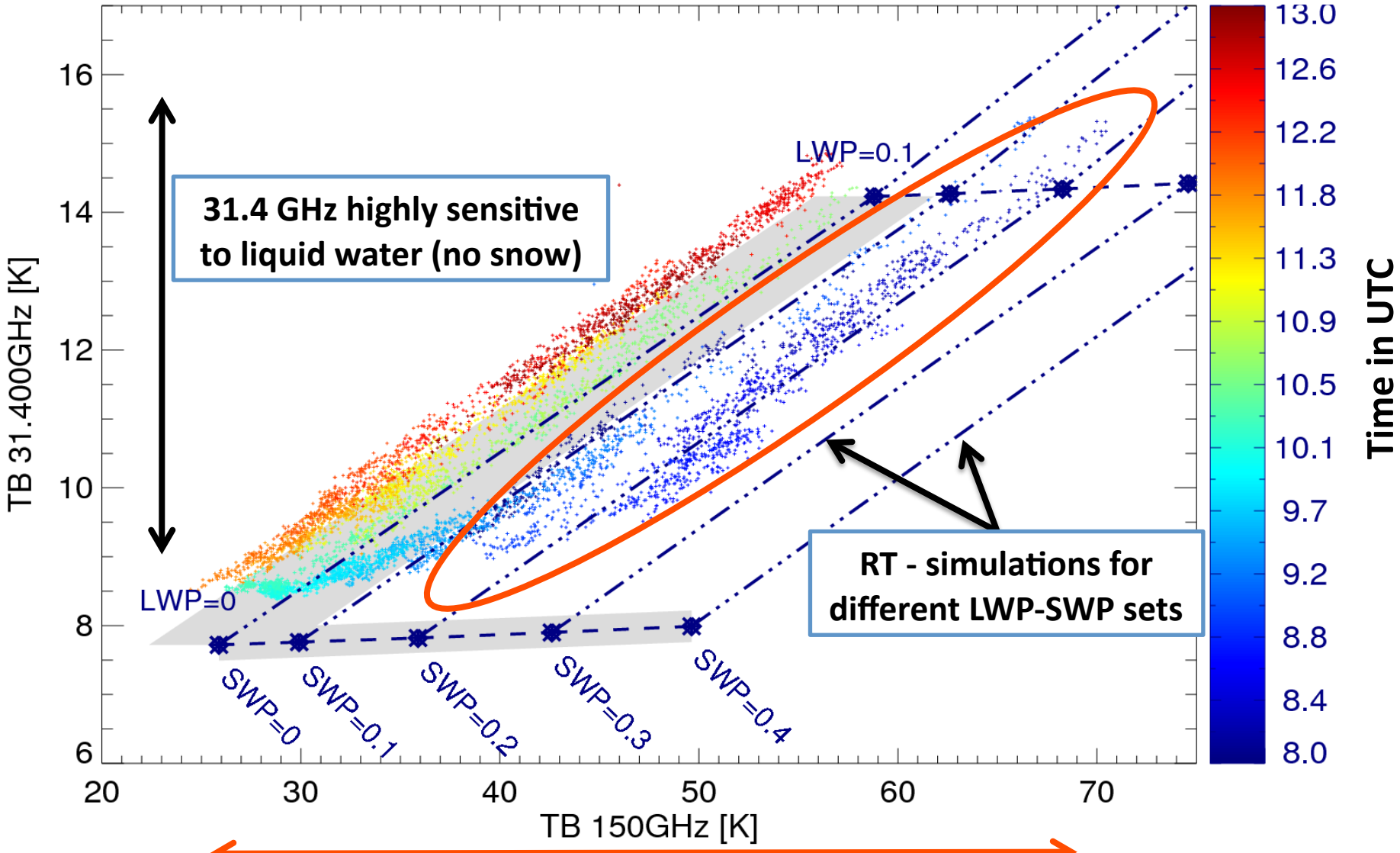
- Does COSMO-DE underestimate liquid cloud water and overestimate snow water?
- Are the snow scattering properties wrong (wrong shape, size distr.) in the forward radiative transfer ?

Overview data plot (08. Feb. 2009):



- Radar derived SWP values up to 0.2 kgm^{-2} . Cloud height ranging from 1-4 km.
- Snowfallrate at ground shows sometimes differences to radar SWP (wind shear effects?)
- 2DVD derived N_0 values ca. one order LOWER compared to Field 2005 – parametrization!

Snow signals in real MWR measurements compared with modelled „selfmade“ cloud and hydrometeor profile:



Thank you for attention!