Radar remote sensing of Antarctic precipitation

A. Berne[1]
J. Grazioli[1,2], J. Gehring[1], J.-B. Madeleine[3], H. Gallé[4], R. Forbes[5], C. Genthon[4], G. Krinner[4], C. Duran[4], N. Souveirijn[6] and N. van Lipzig[6]

[1]EPFL-LTE, Lausanne, Switzerland
[2]Meteo-Swiss, Locarno-Monti, Switzerland
[3] (a) LMD/IPSL, Sorbonne Univ., UPMC Univ Paris 06. (b) PSL Research Univ., École Normale Supérieure, Univ. Paris-Saclay
[4]Grenoble Alpes University, France
[5]ECMWF, UK
[6]KU Leuven, Belgium

Workshop on Falling and Blowing Snow - 18 June 2018

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

L G G E
Laboratoire de Glaciologie et Géophysique de l'Environnement

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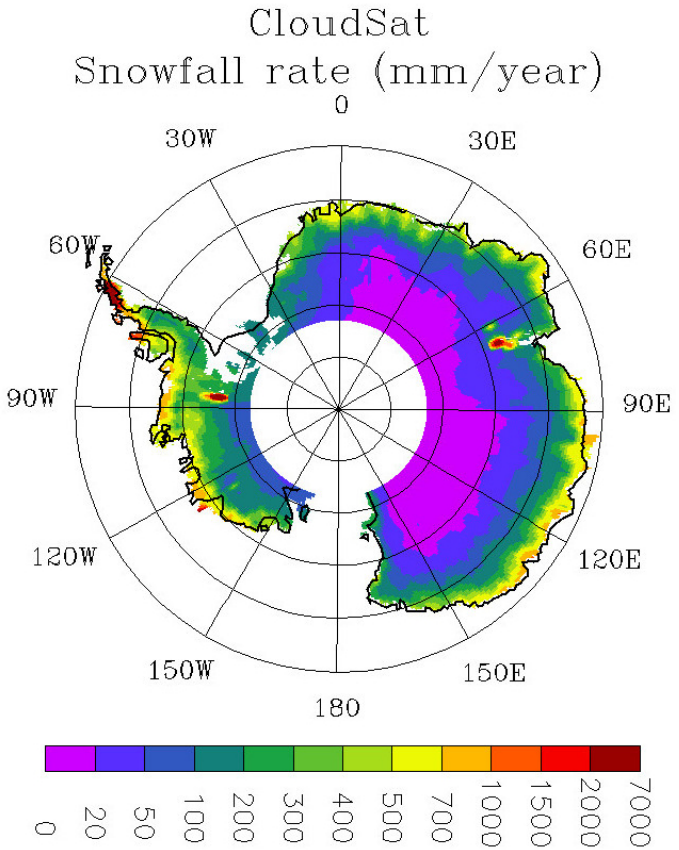
ECMWF

LMD

Precipitation in Antarctica

Extreme environment →
precip. poorly measured/documented

- Inner continent = desert
  → precip very light + very low temp.
- Coastal areas = windy
  → mix of snow and blowing snow.



Palerme et al, 2014

- Precipitation = only positive term in (large-scale) surface mass balance.
- **Need for model-free**, ground-based reference precipitation data

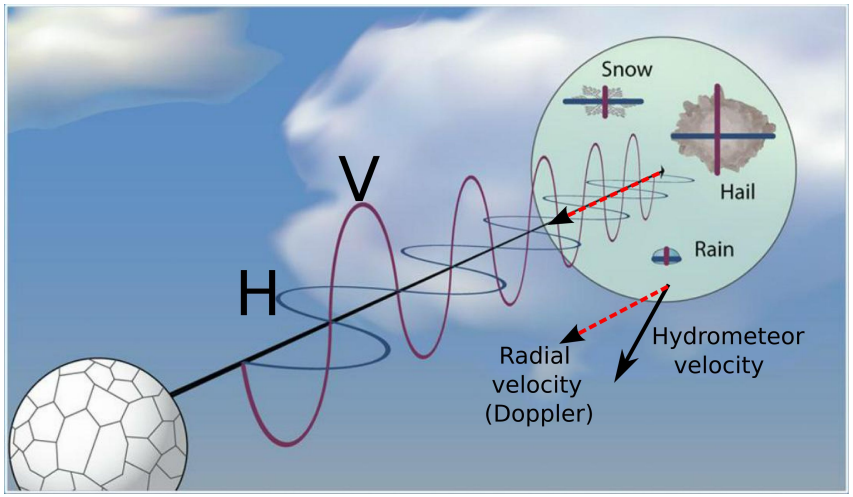
Weather radar

Conventional radar

- Measure amplitude of the signal backscattered by hydrometeors (raindrops, snowflakes, ice crystals).
- Indirect measurement of precipitation characteristics.
- Importance of micro-structure (size, shape, fall speed of indiv. particles).

Polarimetric radar

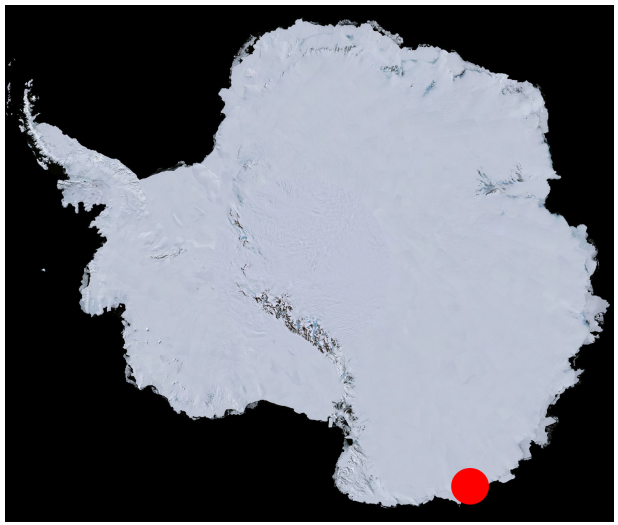
- Dual-pol radar: type and shape of hydrometeors.
- Doppler radar: radial velocity.
- Operational technology.

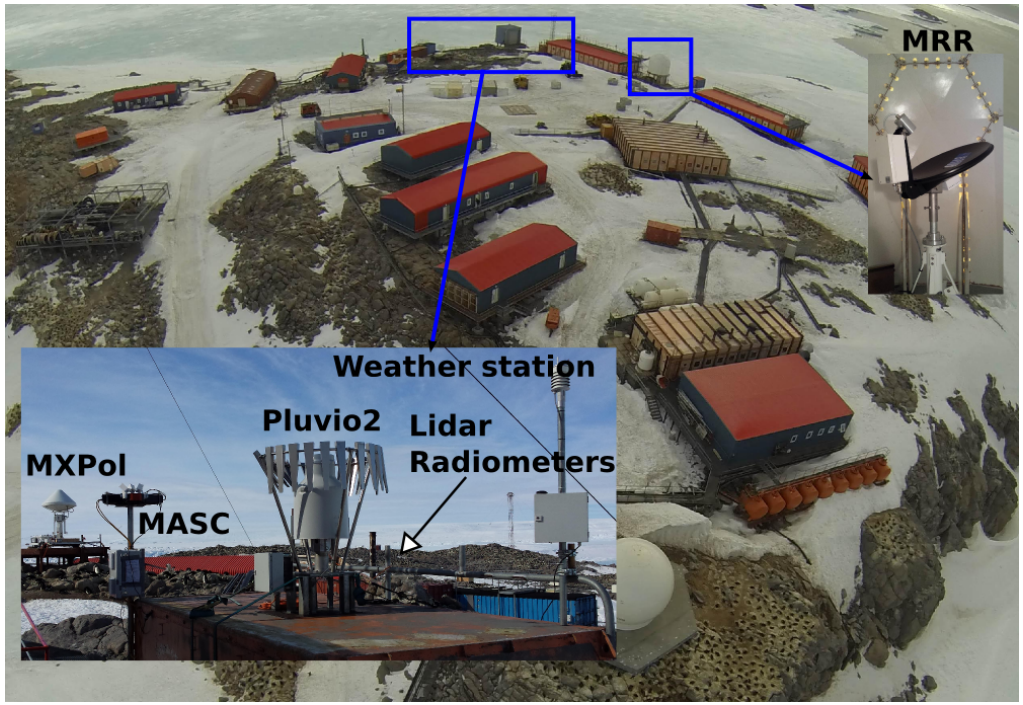


Source: U. Oklahoma

Precipitation measurements: APRES3

APRES3 = **A**ntarctic **P**recipitation: **R**emote **S**ensing from **S**urface and **S**pace





Dumont d'Urville

- Summers 2015/2016, 2016/2017 heavily instrumented
- 2015 - . . . Long term monitoring

Instruments

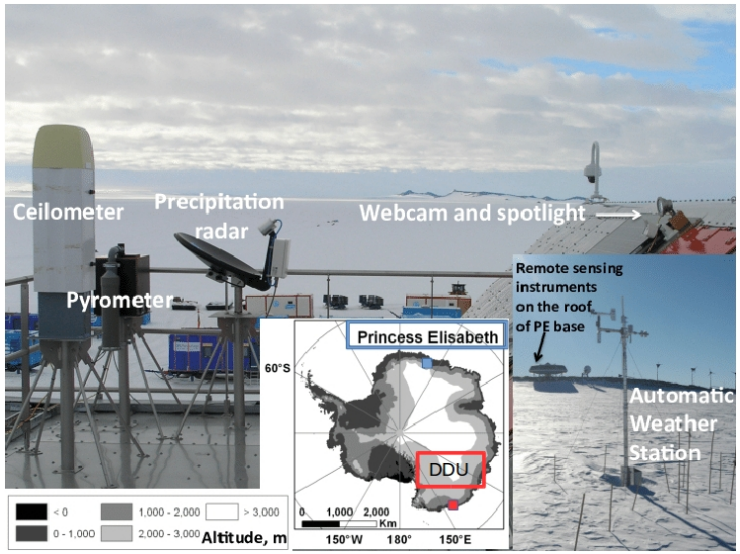
- Scanning radar, MASC, Pluvio^2 **rich info, heavy maintenance**
- MRR (2015-) and lidar (2016-)

MRR data

Multi-year/season analysis of MRR data sets collected at two different locations in East antarctica.

Dumont d'Urville station (41 masl)

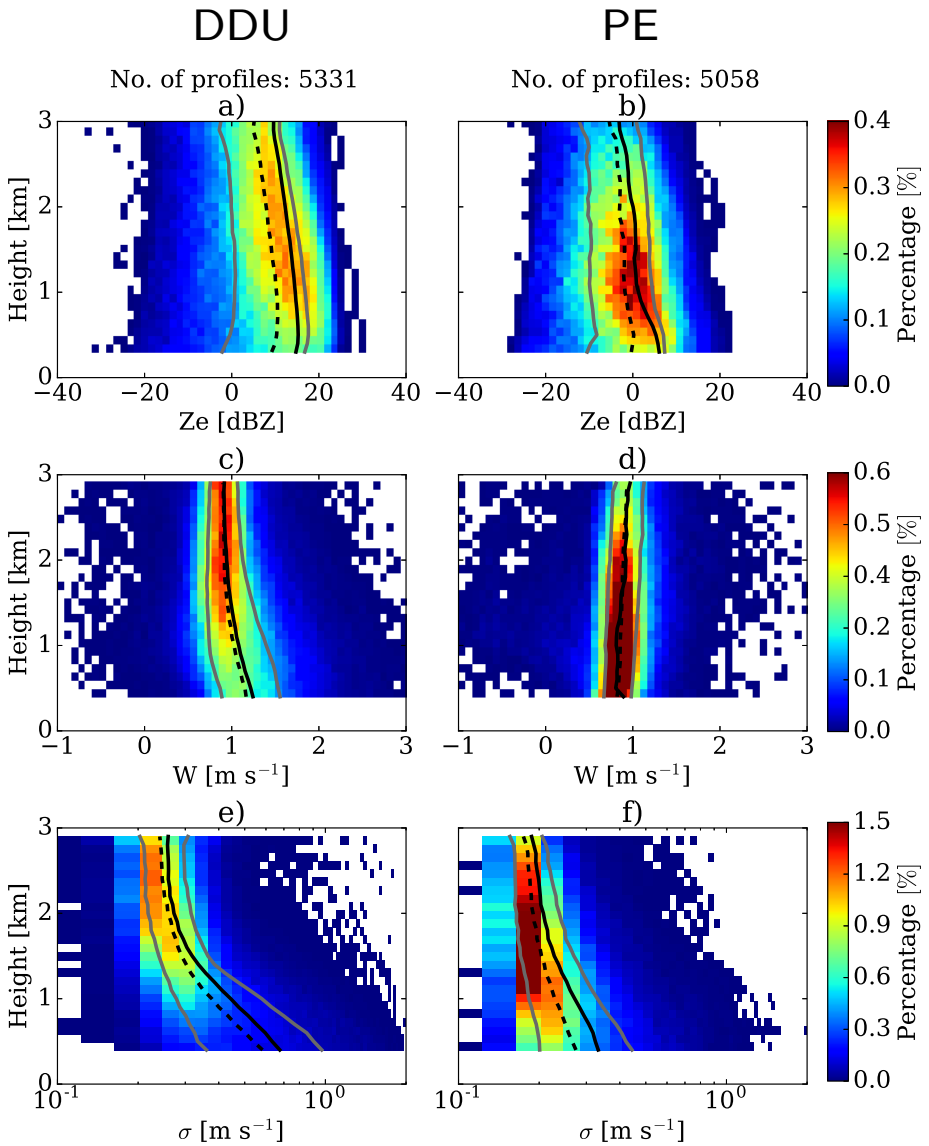
Princess Elizabeth station (1382 masl)



Radar reflectivity Z_e, vertical vel. W and spectral width σ collected since Nov 2015.

Same data collected since 2010, mostly in summer and autumn.

Overall statistics ($\Delta t = 1$h)



- Z_e at DDU $>$ PE.
- Vertical velocity in lowest 1 km at DDU $>$ PE.
- Spectral width (turbulence, diff. crystal types) in lowest 1 km DDU $>$ PE.

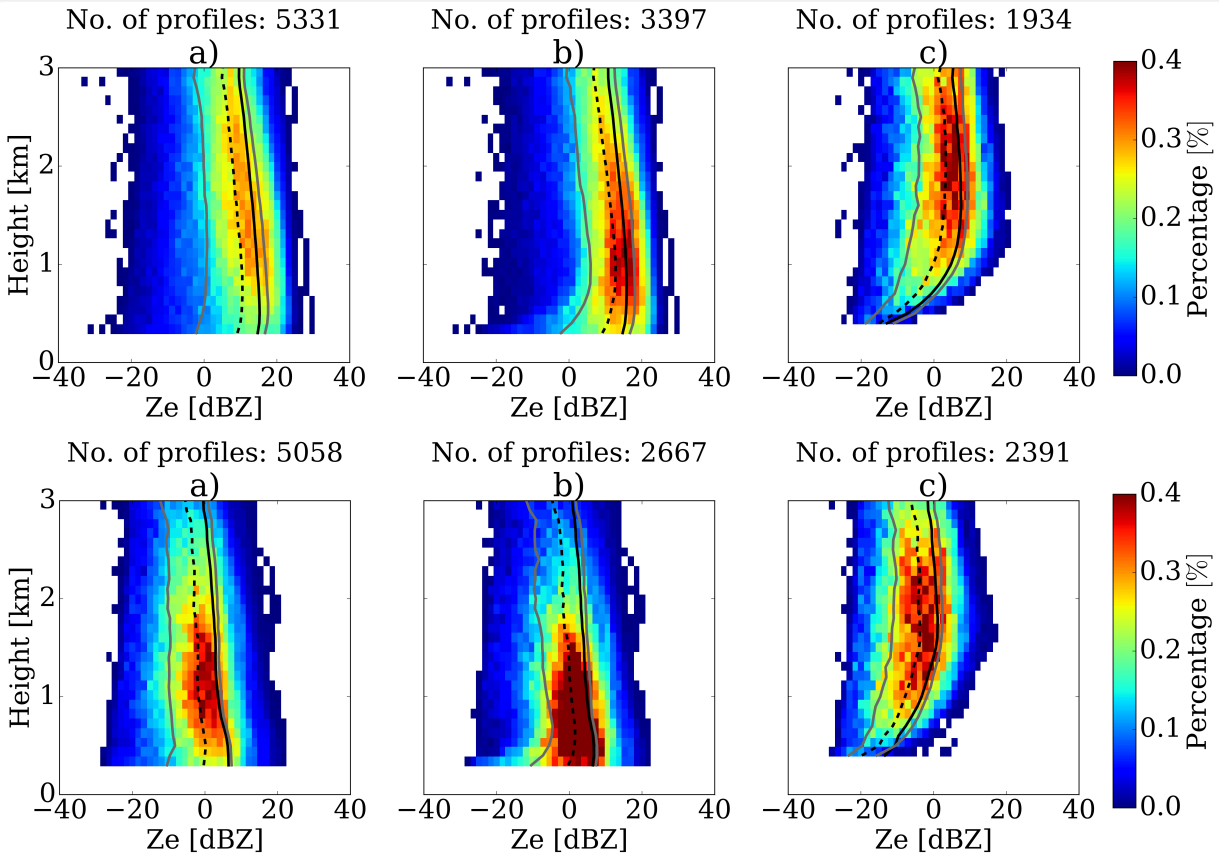
- Difference in altitude and distance to coast $\rightarrow$ warmer and more humid conditions at DDU/PE.
- Different dominant microphysical processes (e.g. agrregation/riming more frequent at DDU).

Surface precipitation vs virga

Virga correspond to profiles with no signal at lowest level (300 m agl).

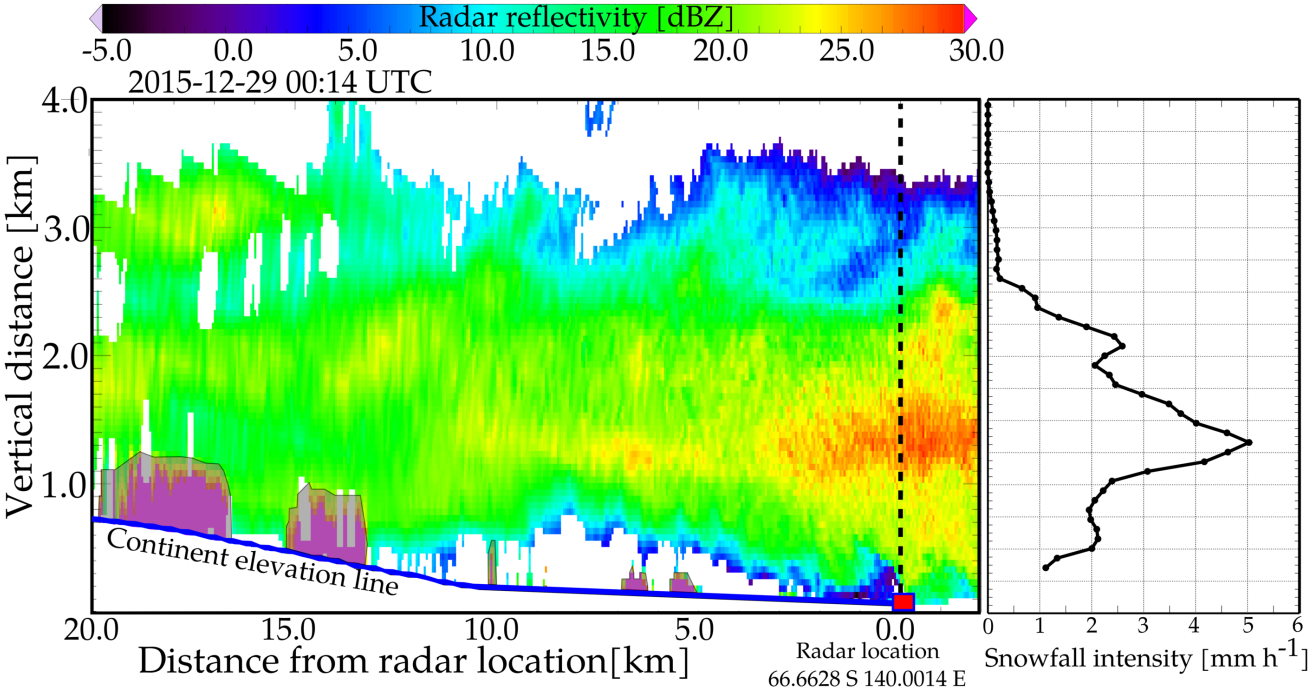
DDU

PE



- Virga are frequent (36% at DDU, 47% at PE).
- Virga have a different vertical structure than surface precipitation.

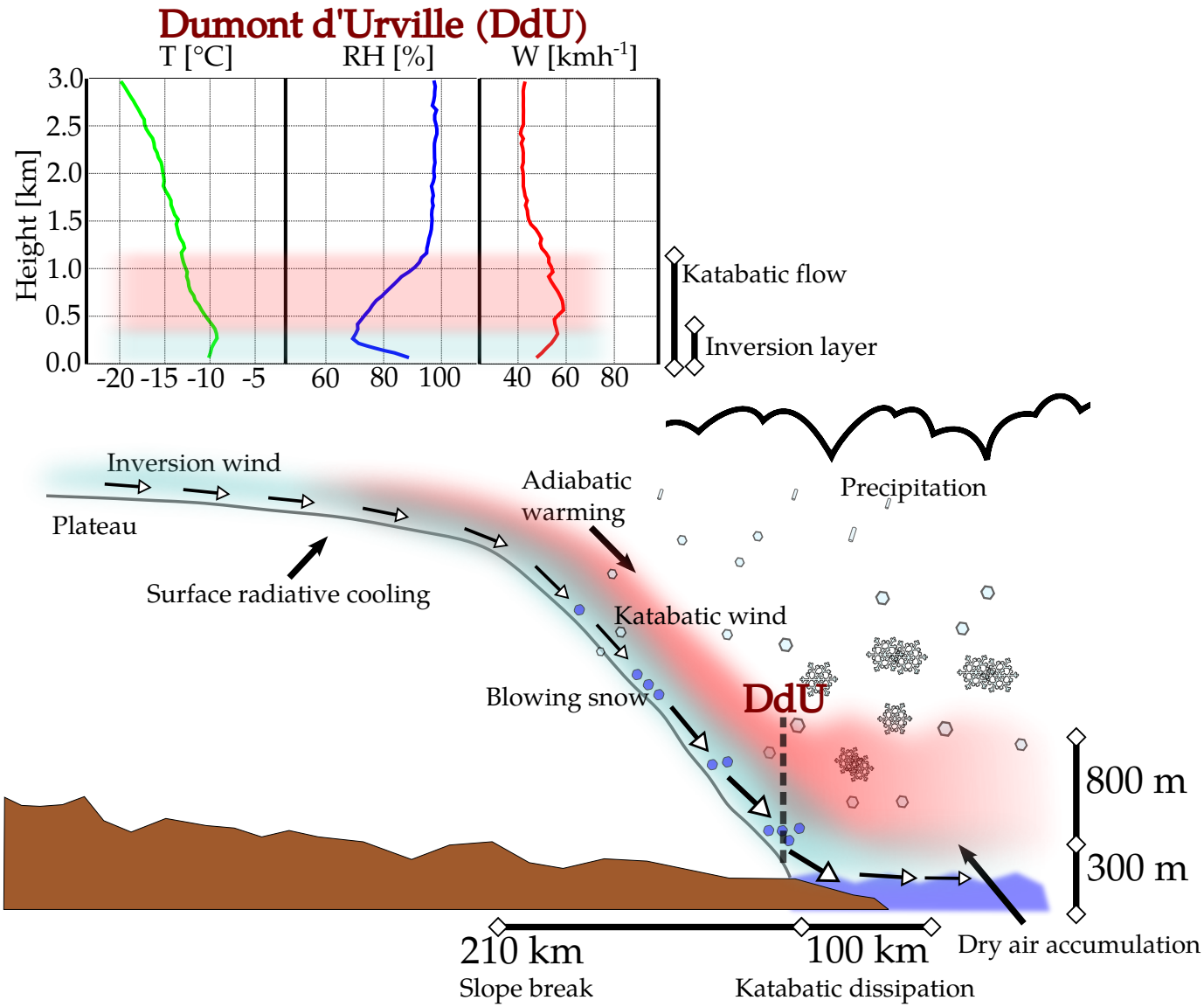
Typical observed precip. vertical cross section



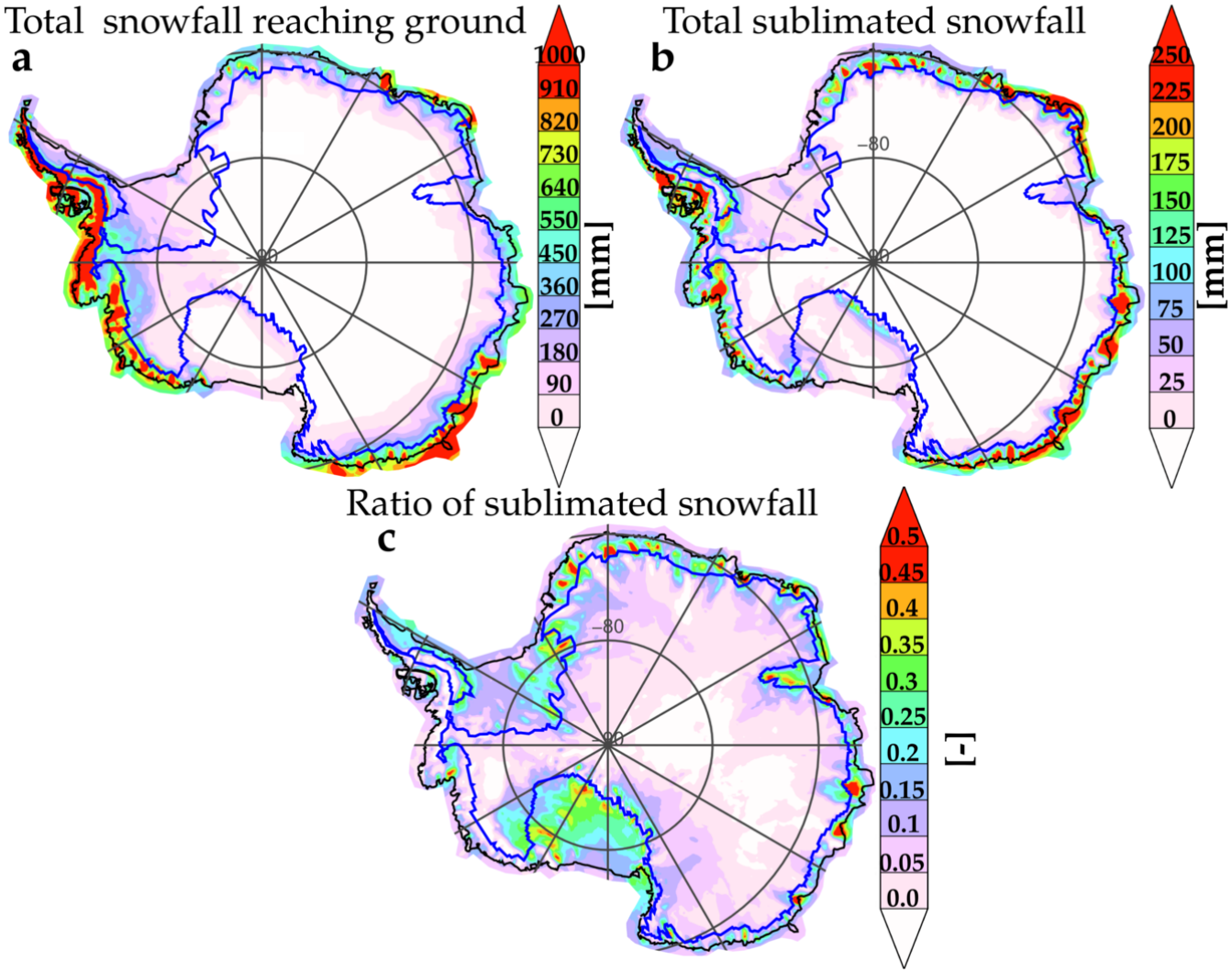
RHI towards the inner continent

- Snowfall intensity decreasing near ground.
- Virga often observed.
- Phenomenon driven by dry katabatic winds?

Katabatic winds and snowfall sublimation



Large scale effects (Nov 2016 - Nov 2017)



East Antarctic "margins" ($<$ 1000 masl): sublimation $\sim$ 35% of potential amount!

Perspectives

Summary

- Antarctic precip. poorly documented but crucial for ice mass balance.
- APRES3: unprecedented collection of Antarctic precipitation data.
- Radar provides key information to characterize precipitation in Antarctica.
- Katabatic winds strongly sublimate snowfall.

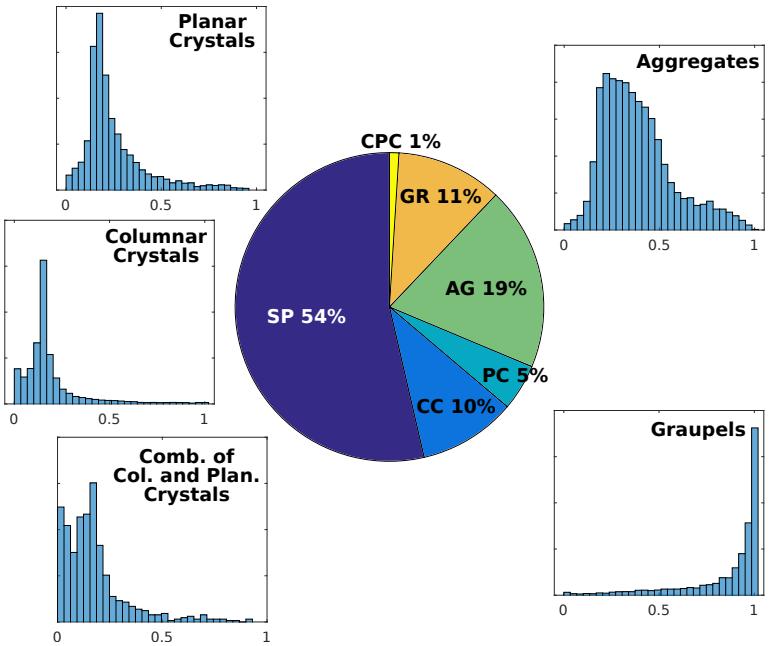
Perspectives

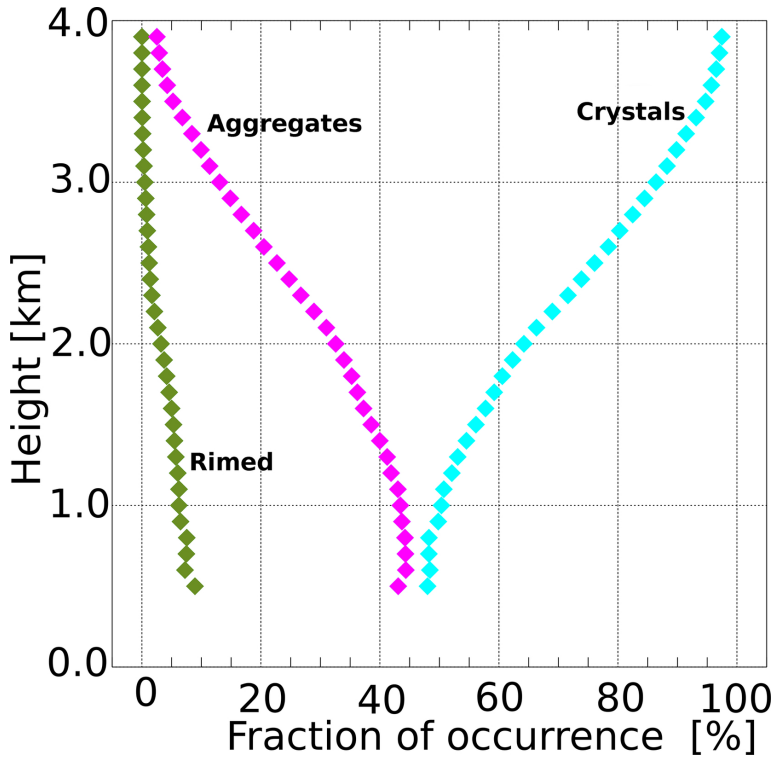
- More data are needed from the different regions of Antarctica.
- Adaptation of existing intruments and development of new ones for extreme conditions.
- Synergy of sensors (in-situ, radar, lidar) and models (regional, climate) is important.
- Coordinated effort from our community!

Thank you for your attention!

Credits: A. Teisseire, IPEV-DDU

Riming in Antarctic snowfall

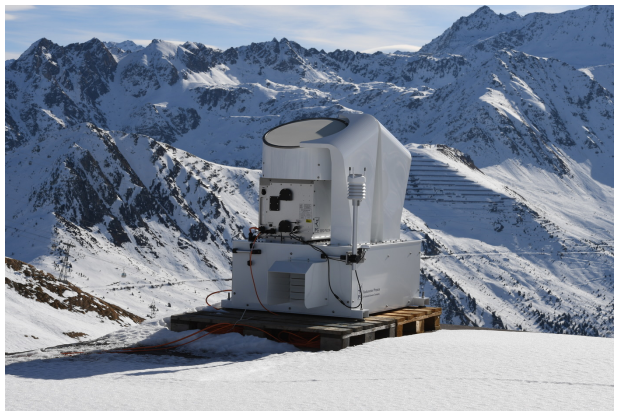


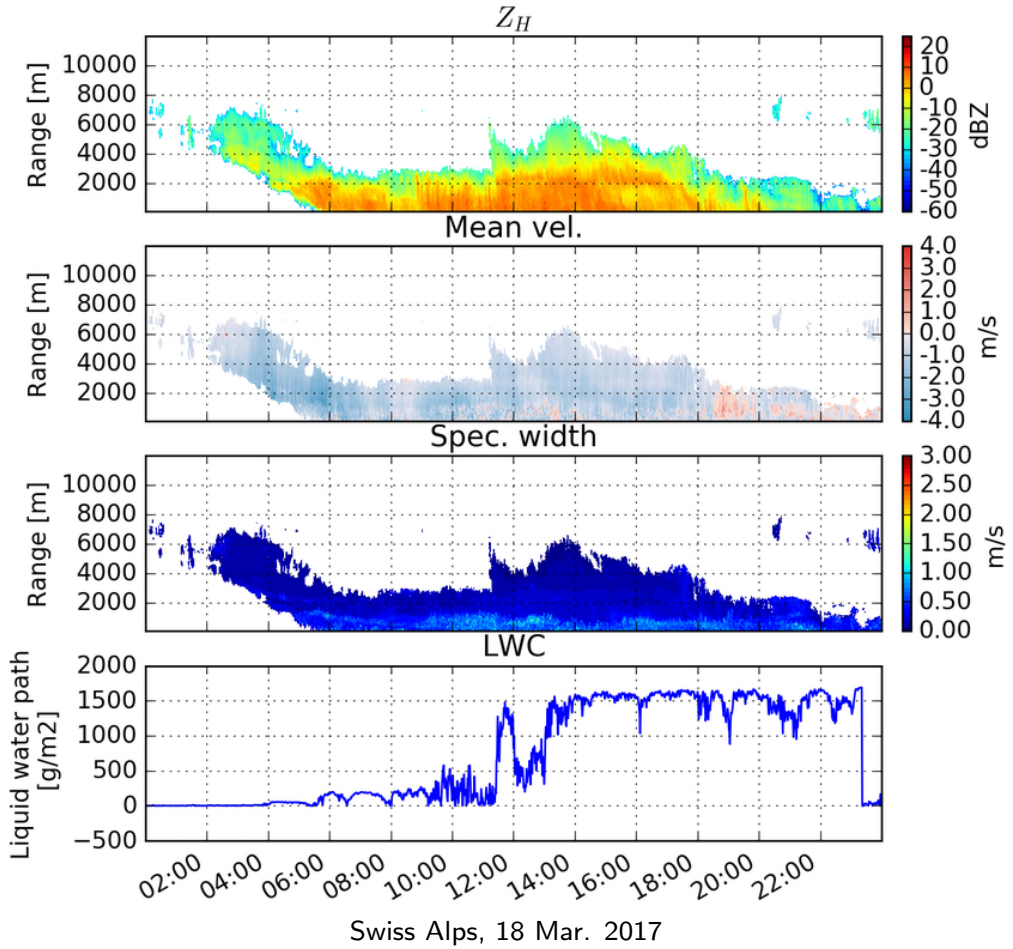


- Characterize riming in Antarctic precipitation (intensity, occurrence...).
- Generating mechanisms of SLW droplets (local/synoptic).

Cloud/precipitation over the plateau

- Very low temperature, humidity and precip.
- Very limited observations of the vertical column.

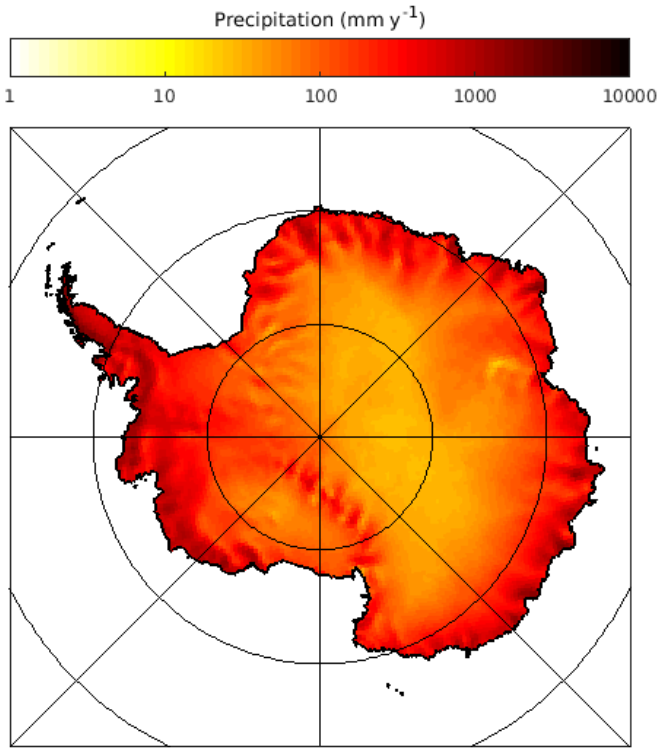


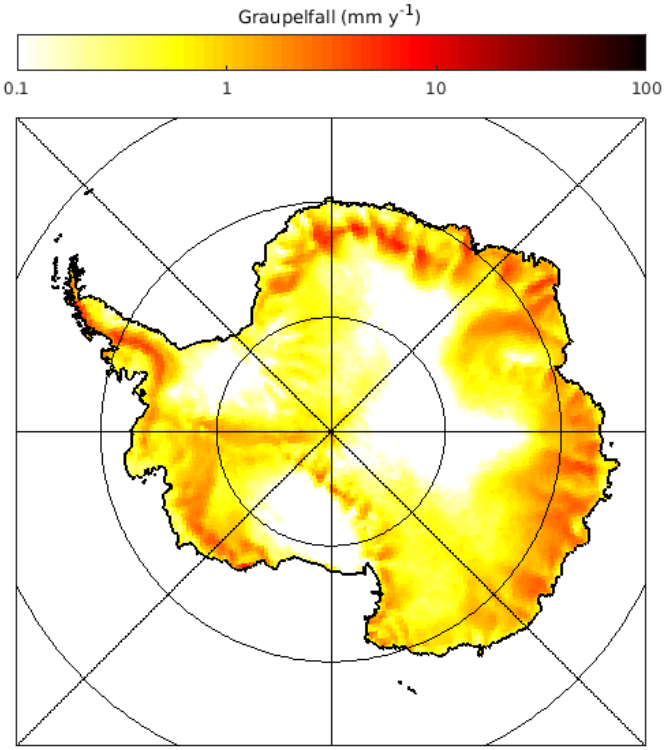


Swiss Alps, 18 Mar. 2017

- Characterize cloud and precipitation over the plateau.
- Reference data set to evaluate atmospheric model and satellite products.

Numerical weather simulation





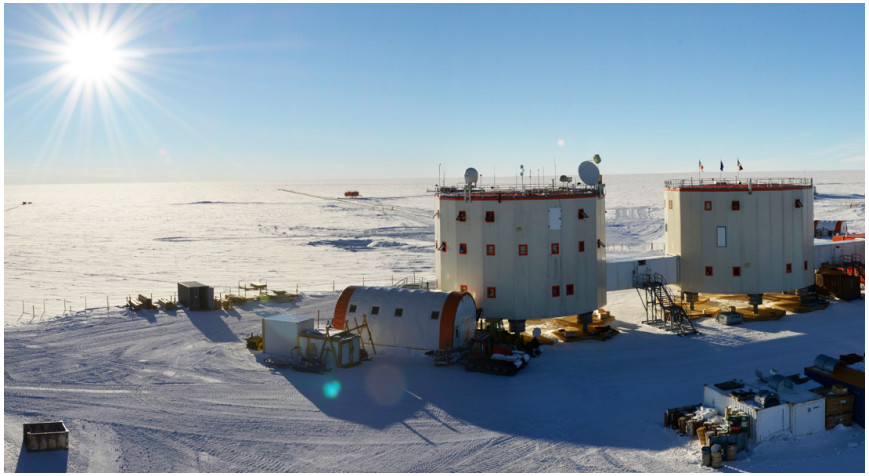
Polar WRF, 36 km resolution

- Evaluation of Antarctic clouds/precip from NWP/climate models and re-analyses.
- Complementarity obs/model to better understand precipitation dynamics, microphysics and variability.

Up-coming campaigns

Davis (AAD): Nov 2018 - Feb 2019

Concordia (IPEV): Nov 2018 - Feb 2019



Princess Elizabeth (IPF): Nov 2019 - Feb 2020