Radar remote sensing of Antarctic precipitation

A. Berne
J. Grazioli, J. Gehring, J.-B. Madeleine, H. Gallé, R. Forbes, C. Genthon, G. Krinner, C. Duran, N. Souveirijn and N. van Lipzig

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
Precipitation in Antarctica

Extreme environment → precip. poorly measured/documentated
- Inner continent = desert
  → precip very light + very low temp.
- Coastal areas = windy
  → mix of snow and blowing snow.

• 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 = Antarctic Precipitation: Remote Sensing from Surface and Space

Dumont d’Urville
- Summers 2015/2016, 2016/2017 heavily instrumented
- 2015 - ... Long term monitoring

Instruments
- Scanning radar, MASC, Pluvio² 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)

Radar reflectivity $Z_e$, vertical vel. $W$ and spectral width $\sigma$ collected since Nov 2015.

Princess Elizabeth station (1382 masl)

Same data collected since 2010, mostly in summer and autumn.
Overall statistics ($\Delta t = 1h$)

- $Z_e$ 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 → warmer and more humid conditions at DDU/PE.
- Different dominant microphysical processes (e.g. aggregation/riming more frequent at DDU).
Virga correspond to profiles with no signal at lowest level (300 m agl).

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

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

Dumont d'Urville (DdU)

T [°C]  RH [%]  W [kmh⁻¹]

Height [km]

-20 -15 -10  -5  60  80  100  40  60  80

Katabatic flow
Inversion layer

Inversion wind
Plateau
Surface radiative cooling
Adiabatic warming
Precipitation
Blowing snow

210 km
100 km
800 m
300 m

Dry air accumulation
Slope break
Katabatic dissipation

Blowing snow

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East Antarctic “margins” (< 1000 masl): sublimation ∼ 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 instruments 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.

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

Swiss Alps, 18 Mar. 2017

Radar remote sensing of Antarctic precipitation
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