Microphysics of Antarctic precipitation in climate models : recent advances and challenges

Étienne Vignon[1], Josué Gehring[1], Simon P. Alexander[2], Georgia Sotiropoulou[3], Nikola Besic[4], Nicolas Jullien[1], Noémie Planat[1], Jean-Baptiste Madeleine[5], Franziska Gerber[6,7] and Alexis Berne[1]

1 Environmental Remote Sensing Laboratory (LTE), École Polytechnique Fédérale de Lausanne, Switzerland
2 Australian Antarctic Division, Hobart, Tasmania, Australia
3 Laboratory of Atmospheric Processes and their Impacts (LAPI), École Polytechnique Fédérale de Lausanne, Switzerland
4 Météo France, Toulouse, France
5 Laboratoire de Météorologie Dynamique / Sorbonne Université, Paris, France
6 CRYOS, École Polytechnique Fédérale de Lausanne, Switzerland
7 WSL Institute for Snow and Avalanche Research SLF, Davos, Switzerland

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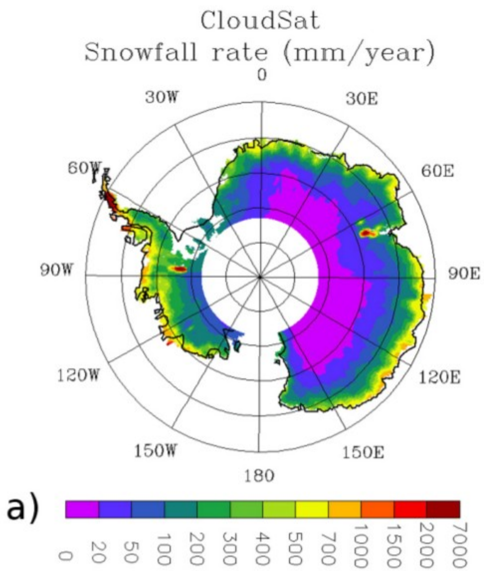
How do we estimate the amount of precipitation that falls over Antarctica ?

Cloudsat

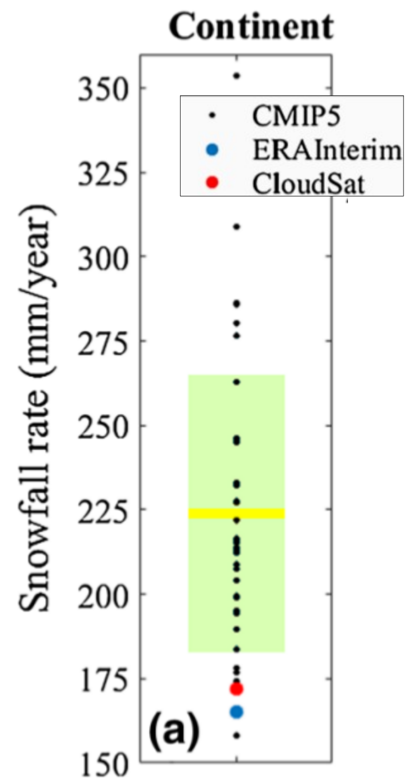


Palerme et al. (2014)

3D structure of precipitation (Lemonnier et al., JGR, 2020) but :

- Based on **arbitrary** reflectivity-snowfall relationship
- Not reliable **below ~ 1200 m**
- No estimation **south of 82°S**

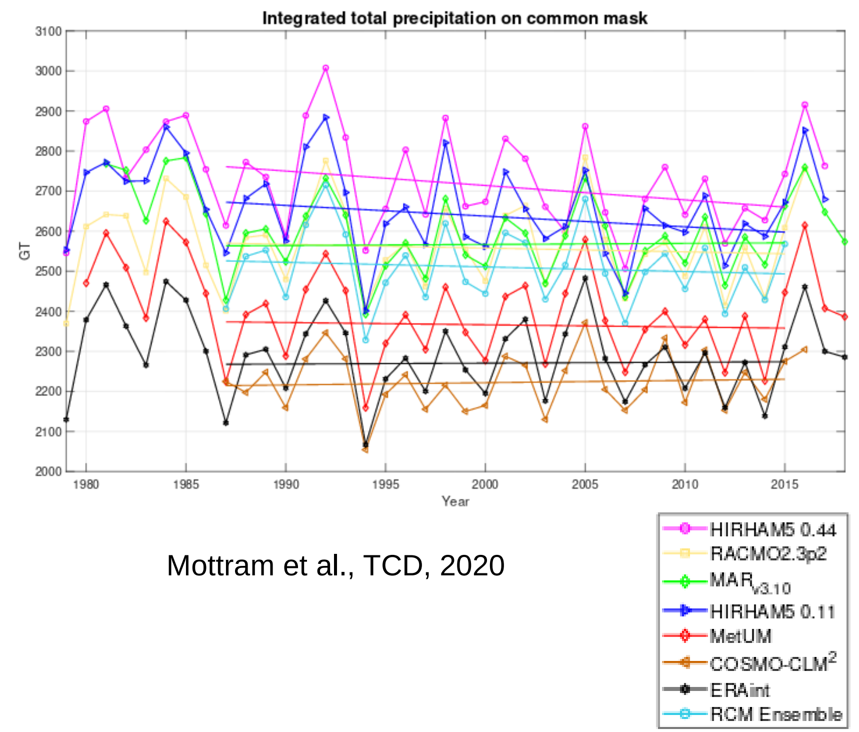
Global Climate Models



Palerme et al. (2017)

- **Large discrepancies**
- Very limited progress from CMIP5 to CMIP6 (Roussel et al., TCD, 2020)

Regional models and reanalyses



Mottram et al., TCD, 2020

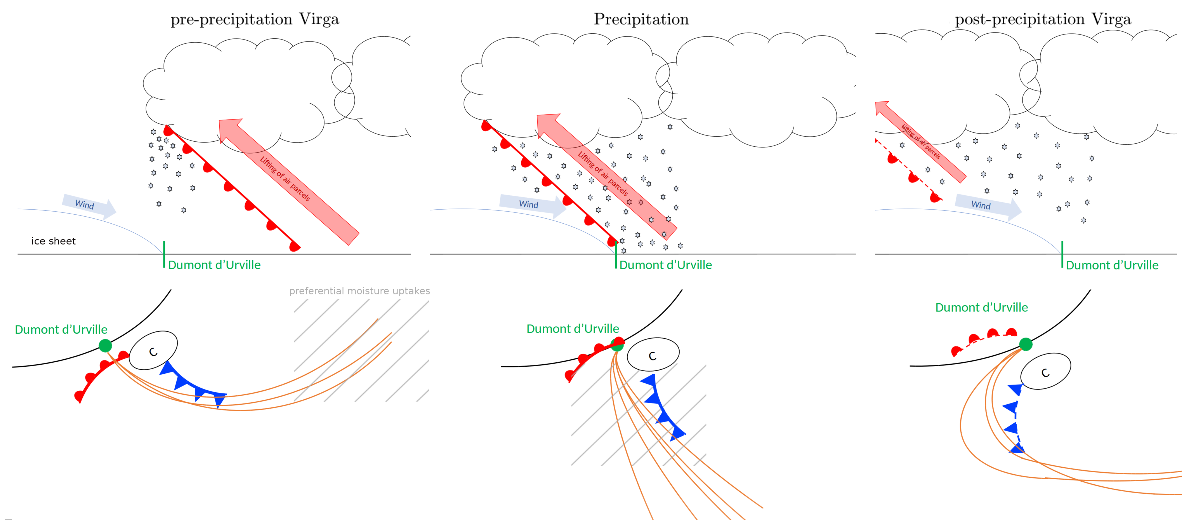
- Significant discrepancies, especially in **coastal regions**

Why models which represent cold precipitation reasonably well in other regions may fail over Antarctica ?

- **Very pristine and cold atmosphere = very specific microphysics**

  → very **low INP concentration** over Southern Ocean (DeMott et al.,2016) and Antarctic coast (O'Shea et al., 2017)
  → frequent **mixed-phase** clouds = **challenges** for atmospheric models
  (Listowski et al., 2017, Listowski et al., 2019, Ricaud et al., 2020)
  → previously underappreciated processes like **secondary ice production**
  (Lachlan-Cope et al., 2017, Young et al, 2019, Sotiropoulou et al, submitted)

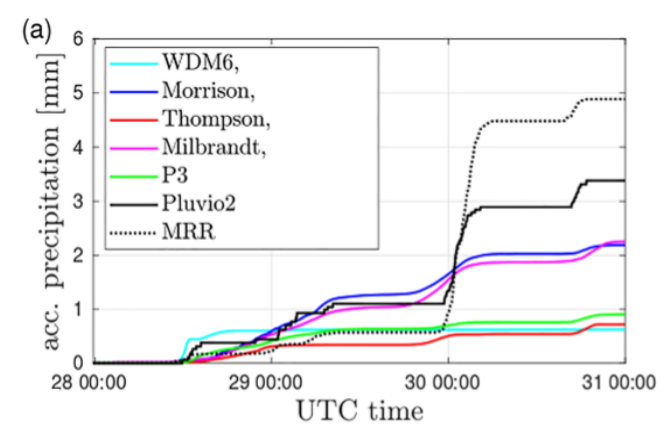
- **Particular dynamical context :**
  Interplay between large scale dynamics, katabatic winds, precipitation sublimation
  (Grazioli et al., 2017,
  Duràn-Alarcòn et al. 2019,
  Jullien et al., TC, 2020)



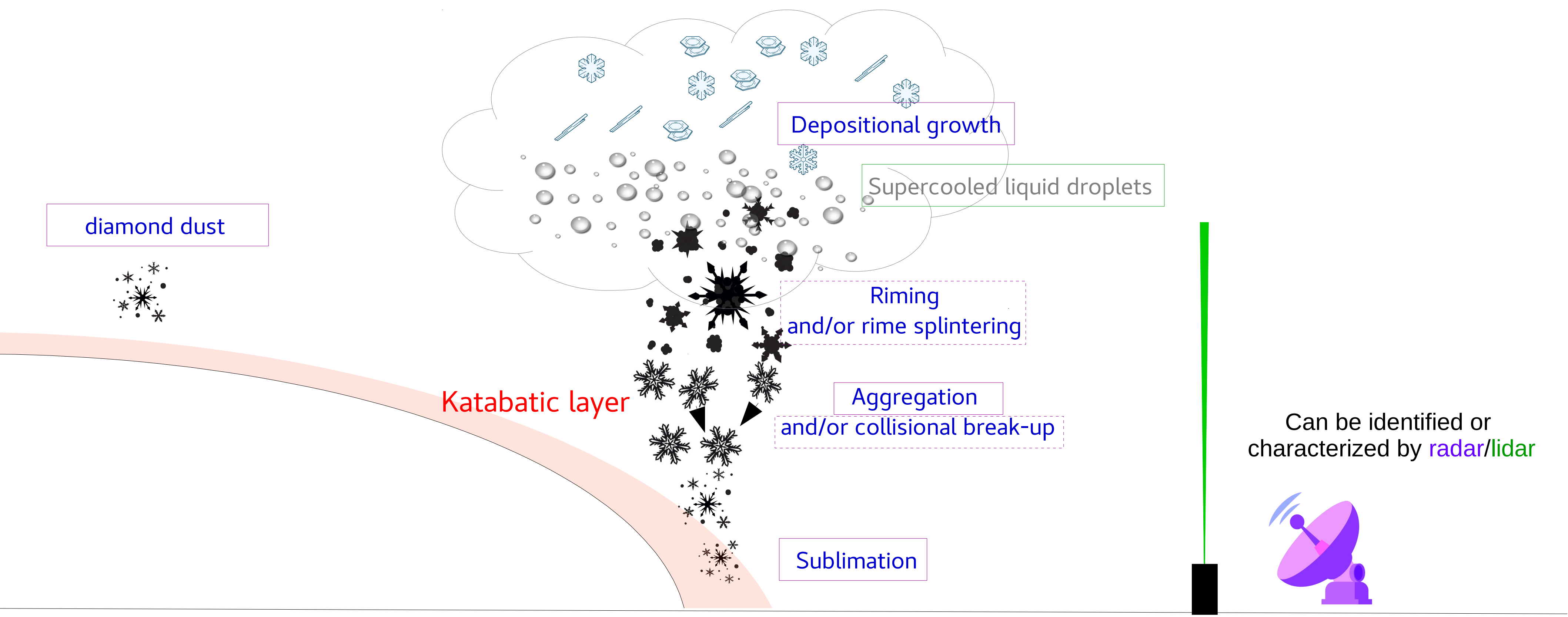
Ability of models to simulate precipitation over Antarctica ?

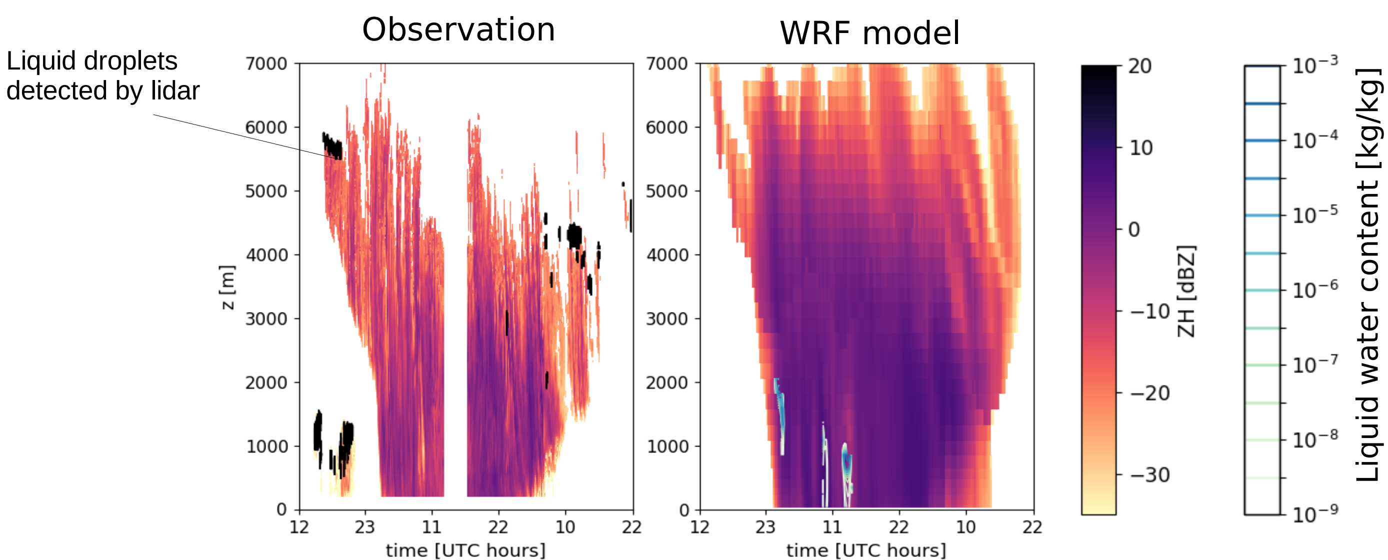
- Comparison with SMB measurement networks (e.g., Agosta et al. 2019) and few comparisons with Cloudsat (Souverijns et al. 2019)

Study at Dumont d'Urville station :
evalution of Polar WRF using radars during two snowfall events
Same model configuration, **several** state-of-the-art microphysical schemes tested → **Strong discrepancies** in surface precipitation amount and vertical structure (Vignon et al. JGR, 2019)



Which microphysical processes are important ?
The potential of remote-sensing for their identification





<u>Example :</u>
Case study of precipitation event and mixed phase clouds off Mawson Land

Time-height plot of radar reflectivity

WRF with its standard microphysical schemes **does not simulate supercooled liquid water**

(Vignon, Alexander et al. in prep)

EPFL

Prospects, what do we need ?

Observations for models

- **Additional data** on the coast, long-term measurements including **winter**
- Measurements over the **Plateau** (diamond dust), in mountainous regions (**orographic** effects)
- Developing observation-based **diagnostics** to **evaluate** microphysical processes in the ‘model space’ (radar simulators not always reliable for the solid phase)

Model evaluation and development

- Further **evaluation** of models at several stations using **remotely-sensed** data.
- Ensure that **main microphysical processes and aerosol properties** are correctly represented
- **Intercomparison** experiment ?
- Developing methodologies to properly **tune** cloud/precipitation schemes (precipitation and radiation considerations)