Precipitation in Antarctica : a comparison between Cloudsat observations and the LMDz General Circulation Model.

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Summary.

APRES3 project (**A**ntarctic **P**recipitation, **R**emote **S**ensing from **S**urface and **S**pace) aims to document and understand current precipitation over the Antarctic ice sheet, knowing that current climate models tend to overestimate the snowfall rate values.

Remote sensing observations using CloudSat radar *[Palerme et al., 2014]* give an estimation of the snowfall of 153 mm/yr whereas current CMIP5 models predict a precipitation rate from 160 up to 300 mm/yr (**fig. 1**).

Methods.

Palerme et al., 2014 proposed a comparison of the snowfall rate between several climate models and CloudSat radar observations to constrain precipitation rate over Antarctica, however precipitation mostly remains unknown. In LMDz simulation, there is a significant over-estimation of the annual mean snowfall rate and a wrong seasonal variability over the high continental plateau.

→ What is the origin of the differences between LMDz model and data ?

We used LMDz simulations in nudged configurations where sea surface temperature and sea ice are prescribed. We compared these simulations to CloudSat radar observations over the whole continent. The satellite blind layer top for observation is fixed at 1,2 km so we selected the same vertical model level to compare the LMDz simulations with data.

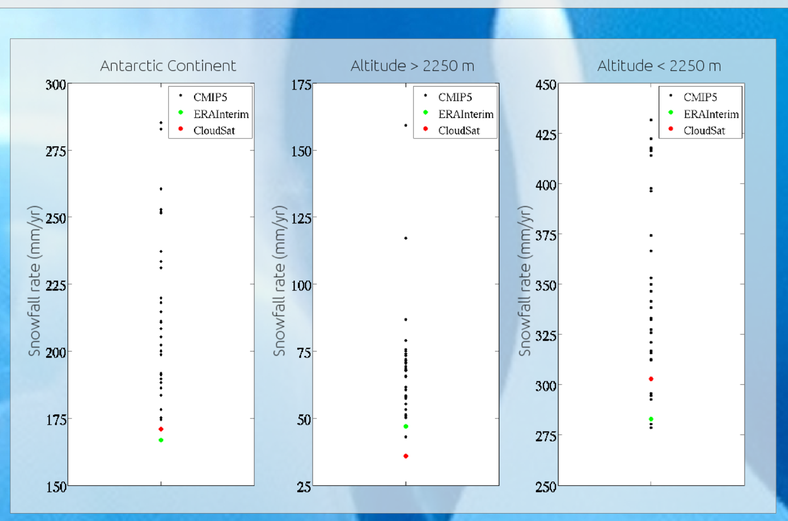


Fig. 1 – Averaged snowfall rates simulated by CMIP models (**black**), ERA-I on the 1999-2008 period (**green**) and CloudSat data on the 2007-2010 period (**red**). All the rates are adjusted to CloudSat observed area (lat < 82°S). *[Palerme et al., 2014; Palerme et al., 2016]*

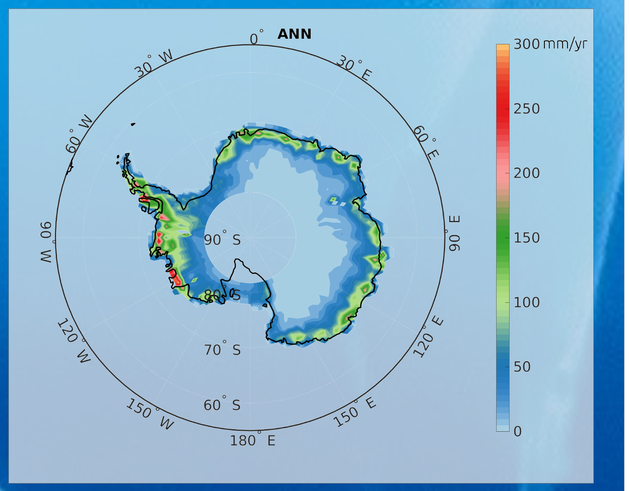
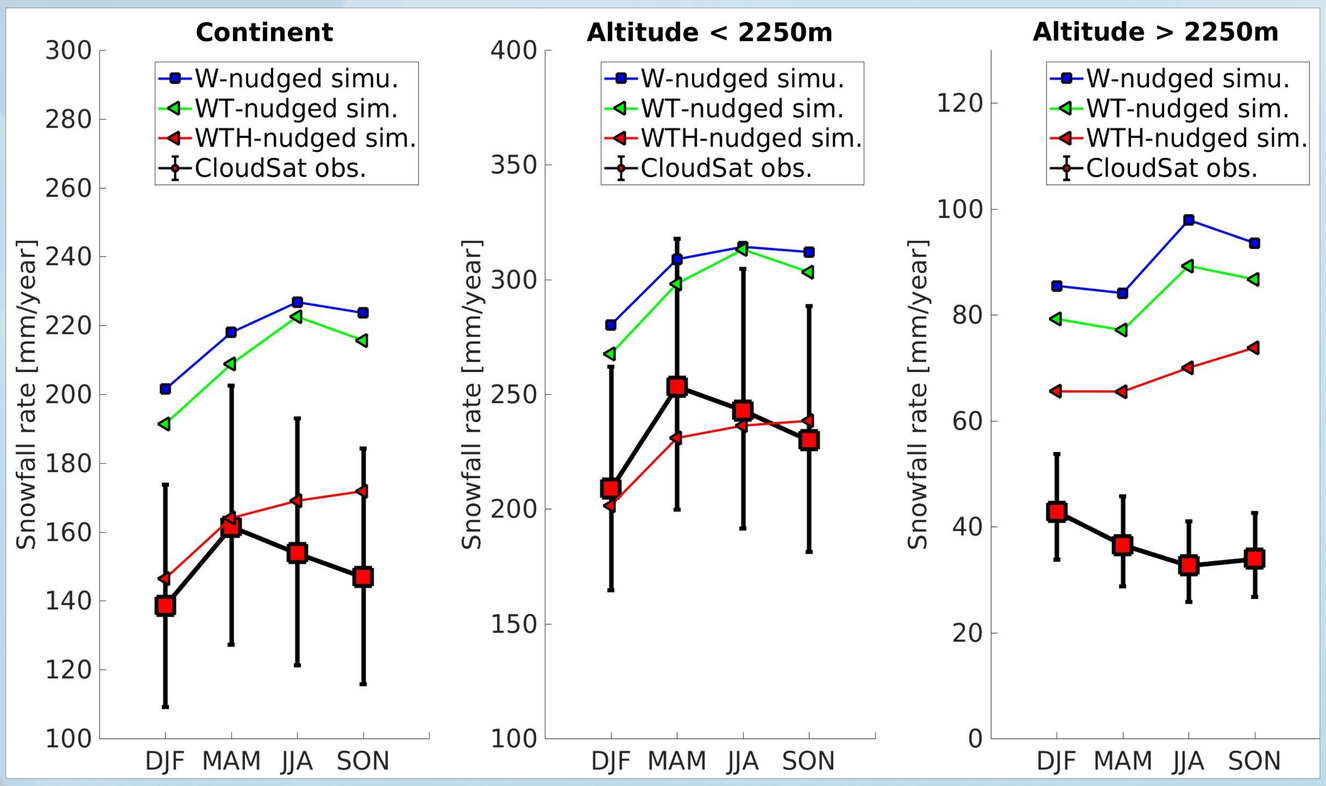


Fig. 2 – Annual snowfall rate obtained by CloudSat radar averaged over the 2007-2010 period. Missing pixels correspond to aberrant values and have been removed. The used grid is 2°x1° degrees.

Results.



Two simulated seasonal evolutions :

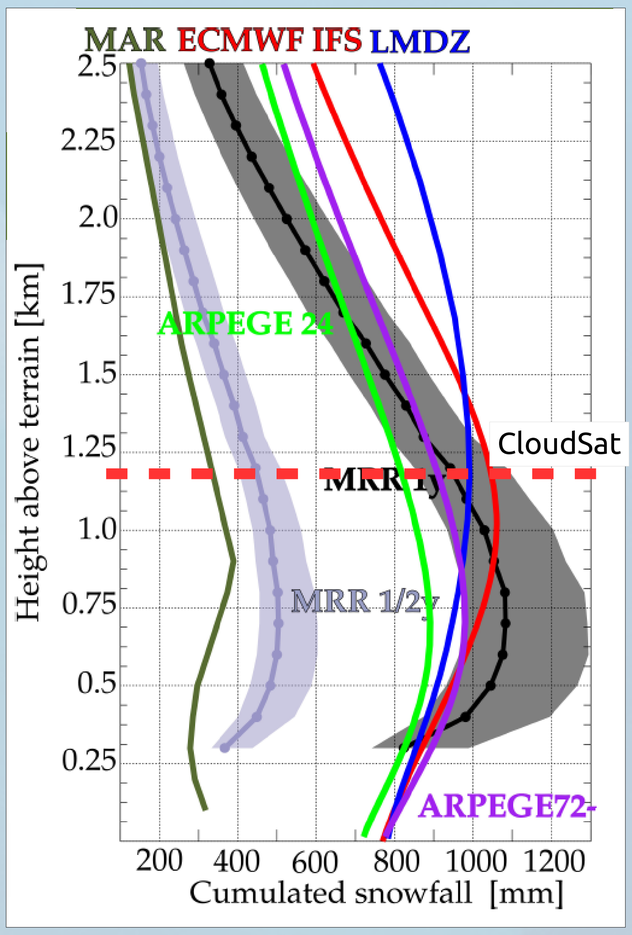
We simulated climate with a 96x71 points grid and observed two regimes with our simulations :

- Nudged dynamics : both Wind (**W**) and Wind-Temperature (**WT**) nudged simulations present an over-estimation of precipitation and a wrong seasonal variability. That over-estimation is explained by a bias of humidity over the Southern Ocean which induces an higher frequency of snowfall events in the model.
- Nudged physics : when the relative humidity is nudged (**WTH**), the bias previously observed is rectified and the agreement with CloudSat observations is very good in annual mean for the coastal area in contrast to the high plateau area.

For every simulation, there is a bad agreement with CloudSat data for seasonal variabilities.

There is also an overestimation of the precipitation over the high plateau area by all simulations. It is probably due to a continuous over-saturation of relative humidity controlling continental snowfall.

Fig. 3 – Comparisons between LMDz simulations with a 96x71 points grid and CloudSat data averaged over the 2007-2010 period..



Discussions.

- As we can observe on **fig. 4**, at our CloudSat studied level, modeled and MRR-observed precipitation rates are in good agreement. To other levels, snowfall rate over Dumont d'Urville station differs from simulations. Taking into account the nearly-perfect correlation between MRR and CloudSat, we expect a similar mismatch at other vertical levels.
- Due to an excessive occurrence of precipitation, the model over-estimate precipitation over the high continental plateau.

Fig. 4 – Cumulative snowfall profile over Dumont d'Urville French station as obtained by in-situ Micro-Rain Radar (black and grey pointed lines) compared with different model ran at different resolutions.
For futher informations : *Grazioli et al., 2017.*

Conclusion and outlooks.

Precipitation in WTH-nudged simulation shows a good agreement and is the nearest seasonal variability to observations but bias remain in the model :

- New nudged simulations studies at different grids to verify the sensitivity of LMDz to the resolution.
- Precipitation analysis at small scale using stretched grid simulation zoomed model and comparison with the full year vertical profile of the snowfall rate at Dumont d'Urville station.
- Multi-vertical levels comparison between CloudSat and LMDz in order to build a 3D structure of precipitation over the whole continent over multiple years.

A 3D comparison between CloudSat and LMDz model would improve our knowledge about precipitation processes over Antarctica.

References & Contacts.

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Palerme et al., 2014. How much snow falls on the Antarctic ice sheet?. *The Cryosphere 8(4), 1577-1587.*
Palerme et al., 2016. Evaluation of current and projected Antarctic precipitation in CMIP5 models. *Clim. Dynam, 1-15.*

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