Parameterizing Antarctic snowfall in the IPSL Climate Model using radar data.

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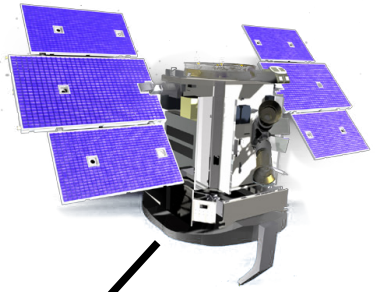
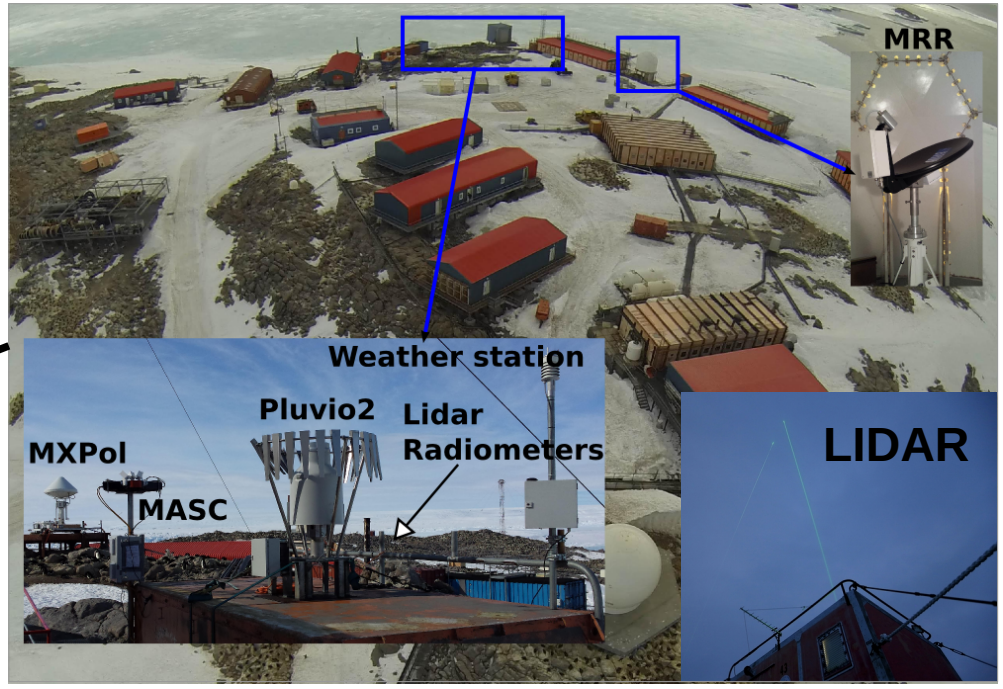
Thinking the contributors C. Listowski, N. Wood, T. L'Ecuyer & C. Palerme

Terre Adélie, a polar climate observatory

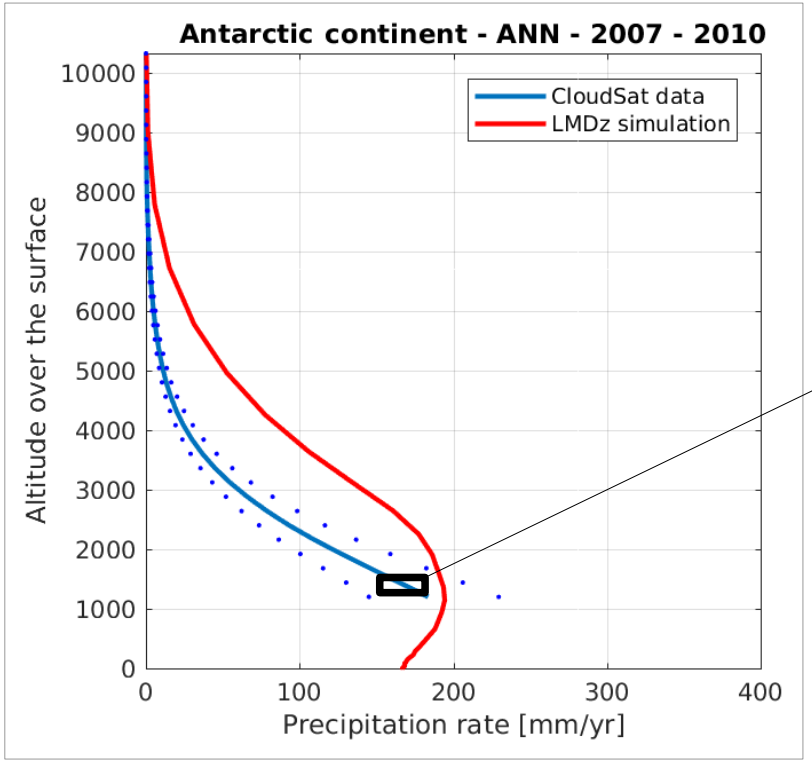
- **APRES3** project : A exciting French-Swiss story about meteorology !

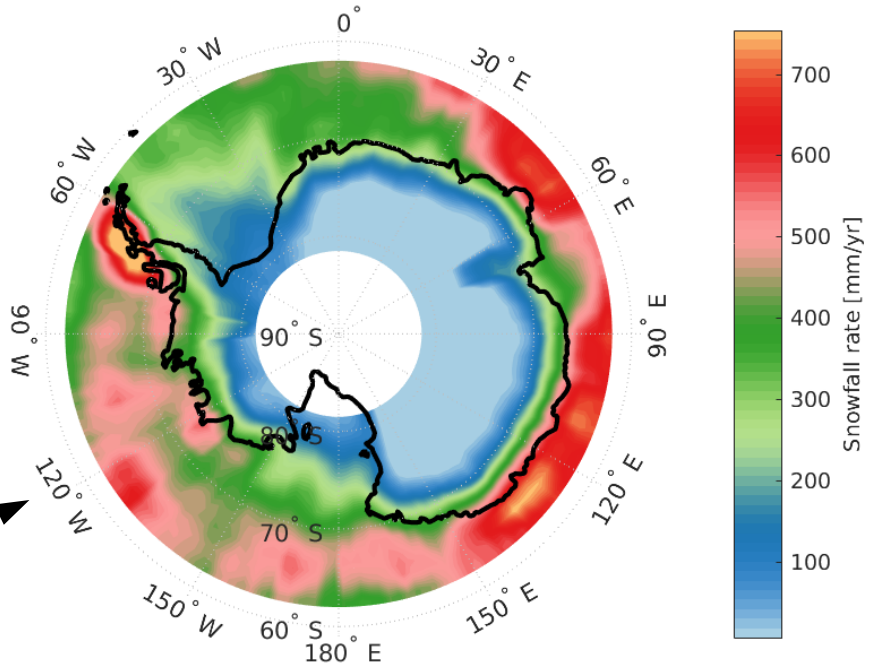




APRES3

Polar comparison of IPSL-CM to CloudSat observations



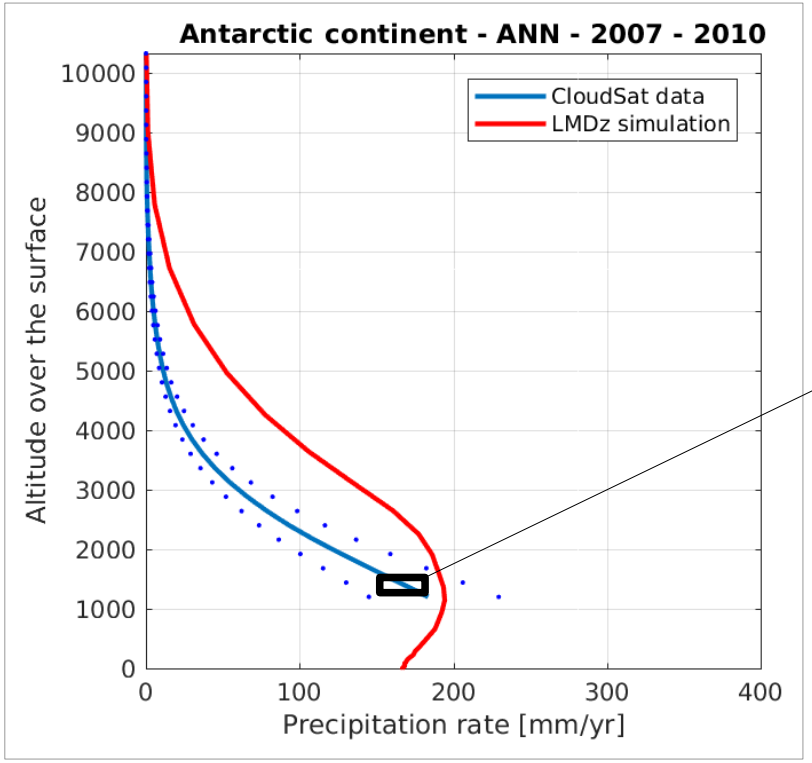


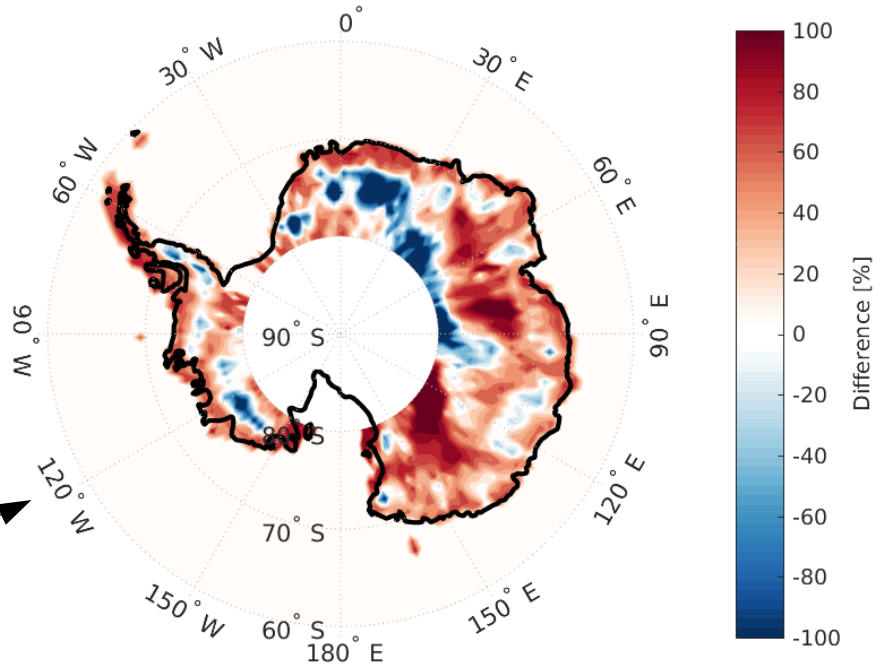
CloudSat precipitation at 1250m, average over the 2007-2010 period *(based on Palerme et al., 2014)*

Comparison of CloudSat to ground radars in East Antarctica - Lemonnier et al., 2018
in preparation

3D CloudSat precipitation dataset - Lemonnier et al., 2018
in preparation

Polar comparison of IPSL-CM to CloudSat observations





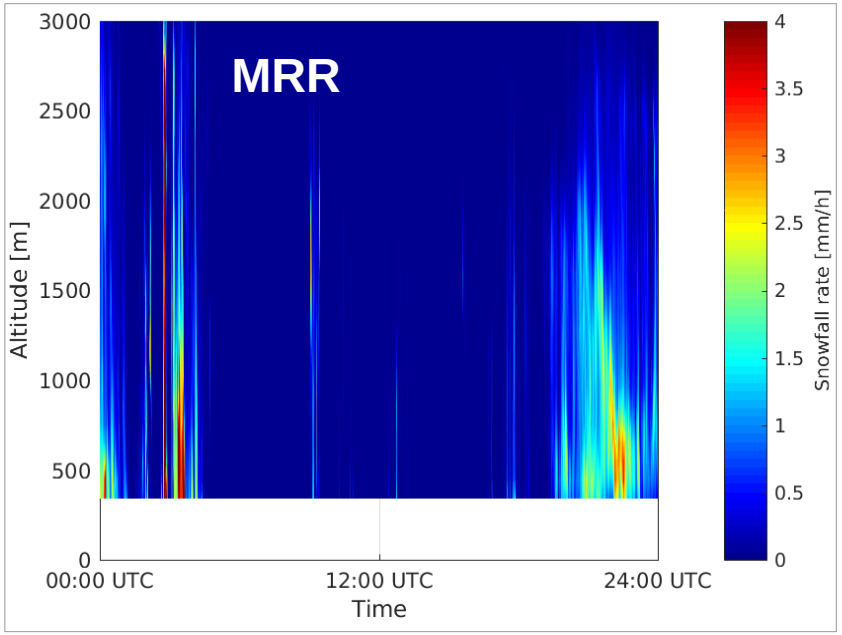
Difference between IPSL-CM and CloudSat precipitation at 1250m

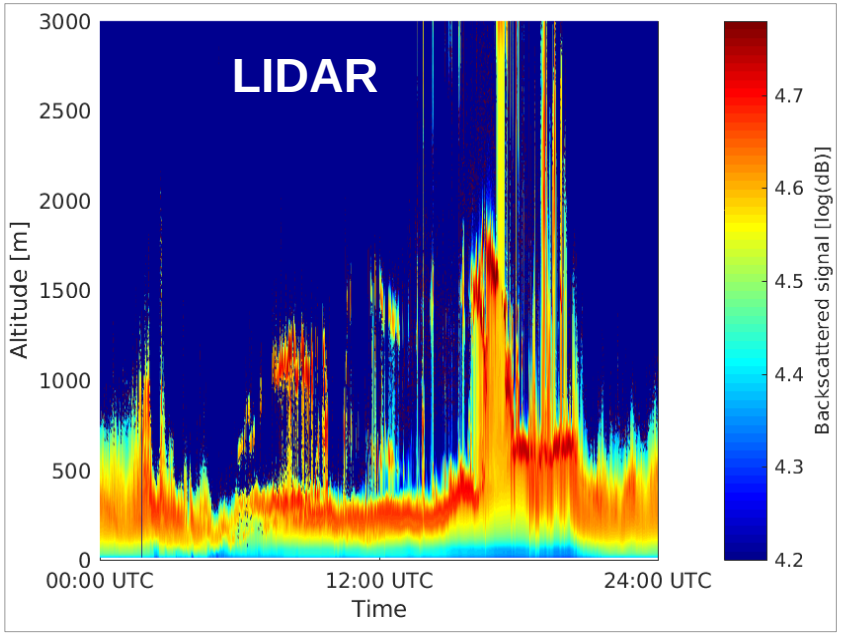
Comparison of CloudSat to ground radars in East Antarctica - Lemonnier et al., 2018
in preparation

3D CloudSat precipitation dataset - Lemonnier et al., 2018
in preparation

Methods : selection of observations

- One-day precipitation case at Dumont d'Urville french station : 23/02/2017.
- Representative event of the Dumont d'Urville climatology.
  - MRR observations for snowfall rate.
  - LIDAR observations for cloud base.





Methods : IPSL-CM

- Nudged simulations – relaxation term toward ERA-I reanalysis with a time constant τ.
  - Validation of U,V (τ=3h), T,Q (τ=12h).
    → Physics of the model well constrained.

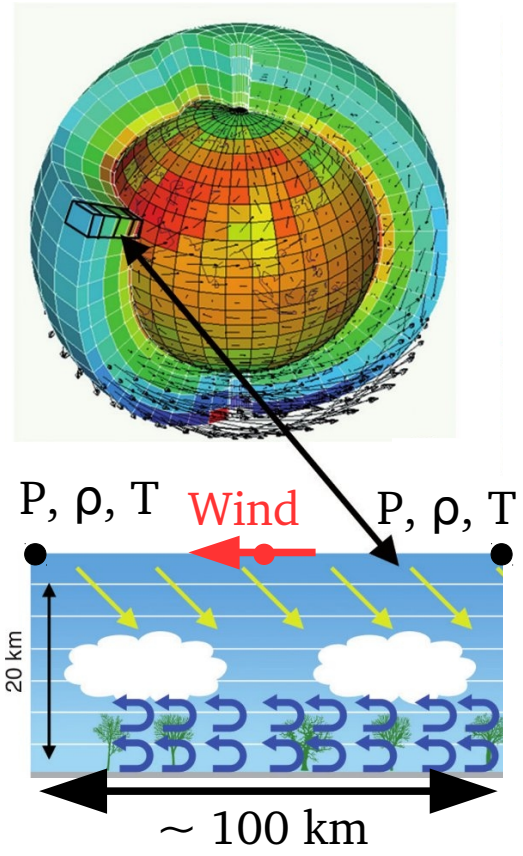
- 64x64 points grid with a zoom over DDU.
- 79 vertical levels.

$$\frac{\partial u}{\partial t} = \frac{\partial u}{\partial t}_{GCM} + \frac{u_{analysis} - u}{\tau}$$

$$\frac{\partial v}{\partial t} = \frac{\partial v}{\partial t}_{GCM} + \frac{v_{analysis} - v}{\tau}$$

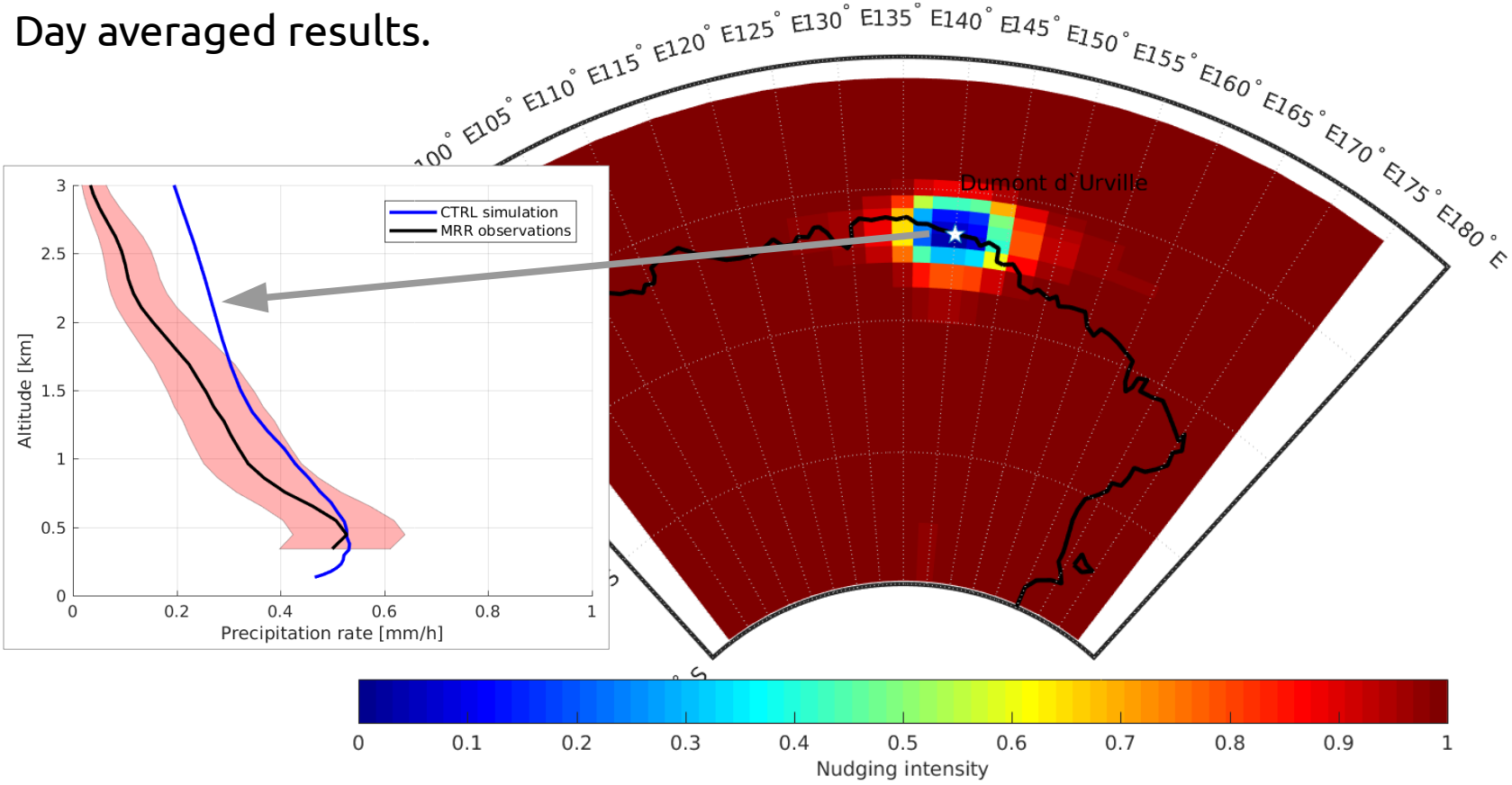
τ Time constant for the relaxation of the model wind toward analyses

Coindreau, 2007



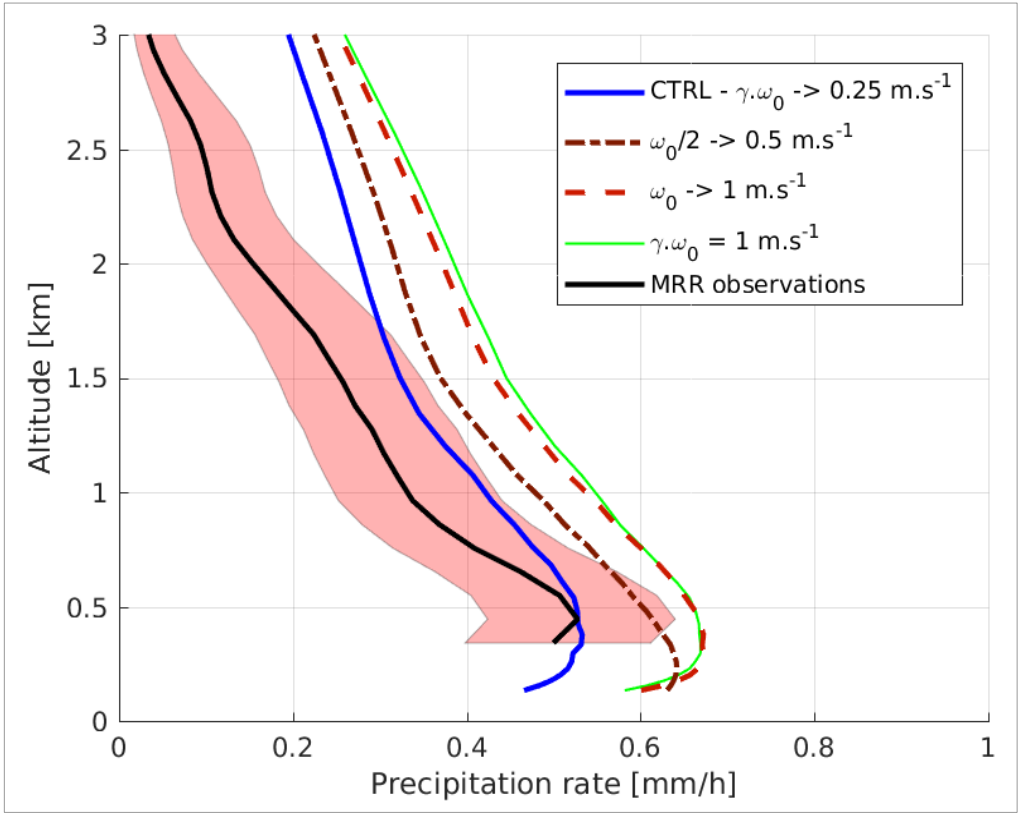
Methods : IPSL-CM

- Zoomed gridbox resolution is 30 km.
- Nudging-free inside the zoom.
- Day averaged results.



Sensitivity to precipitation parameterizations

- Equation for cloud conversion to snow : $\boxed{\frac{dq_{iw}}{dt}} = \frac{1}{\rho}\frac{\partial}{\partial z}(\rho w_{iw} q_{iw})$ → Sink of cloud water
- Sensitivity to $w_{iw} = \gamma_{iw} w_0$
- General impact on the precipitation rate.
- Doesn't affect the shape of the precipitation profile.



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  Sink of cloud water

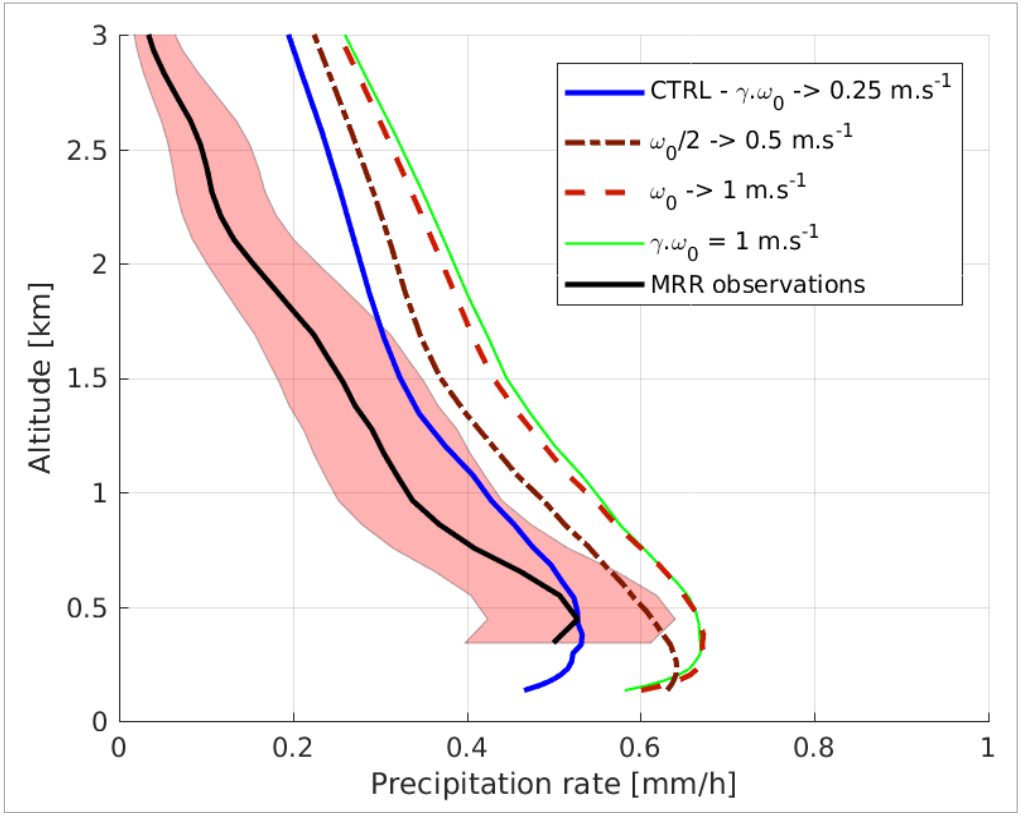
- Sensitivity to $w_{iw} = \gamma_{iw} w_0$

- General impact on the precipitation rate.

- Doesn't affect the shape of the precipitation profile.

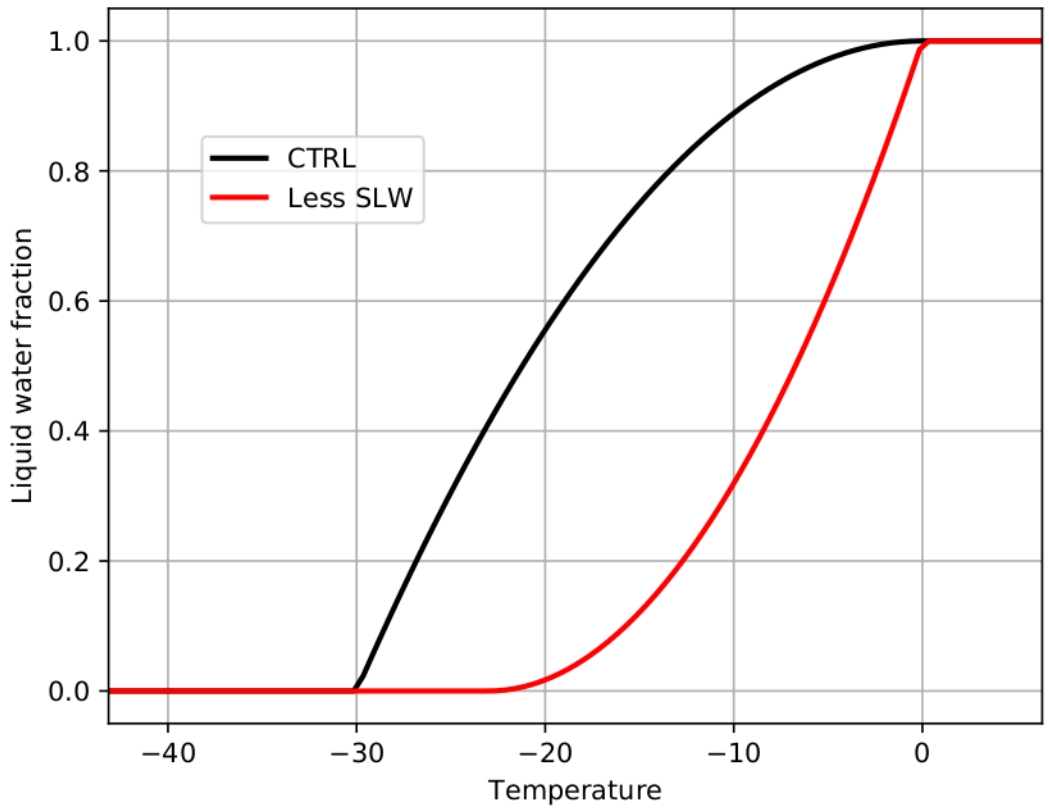
- Same comparison with evaporation coefficient β.
  → Same result.

$$\frac{\partial P}{\partial z} = \beta[1 - q/q_{sat}]\sqrt{P}$$



Sensitivity to cloud liquid fraction

- Cloud liquid fraction is function of Temperature : $clf = (\frac{T - T_{min}}{T_{max} - T_{min}})^n$



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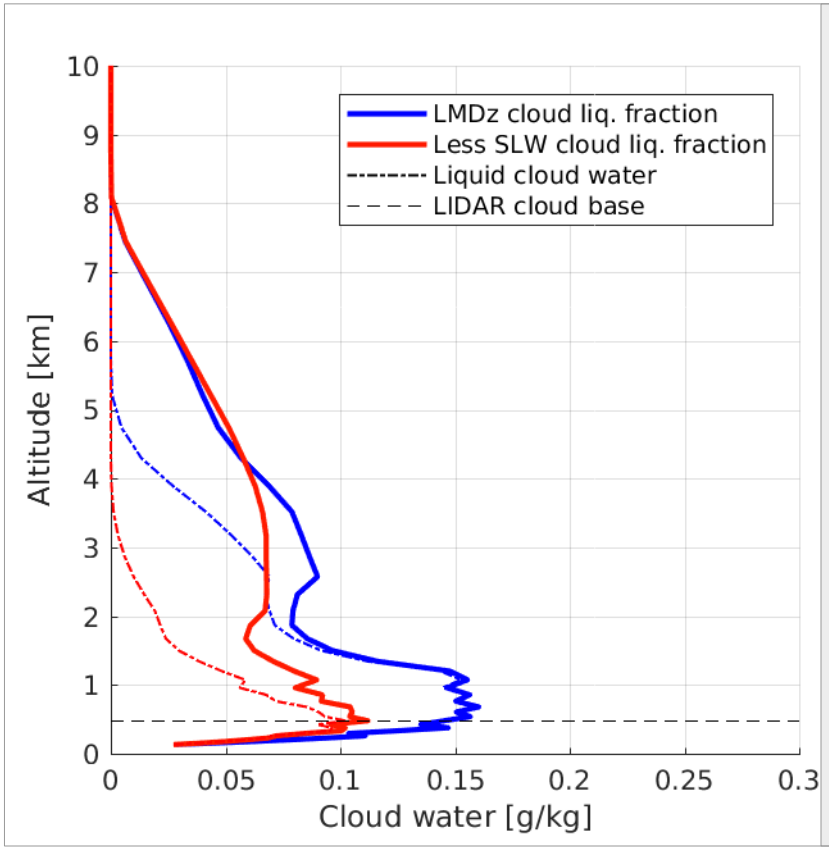

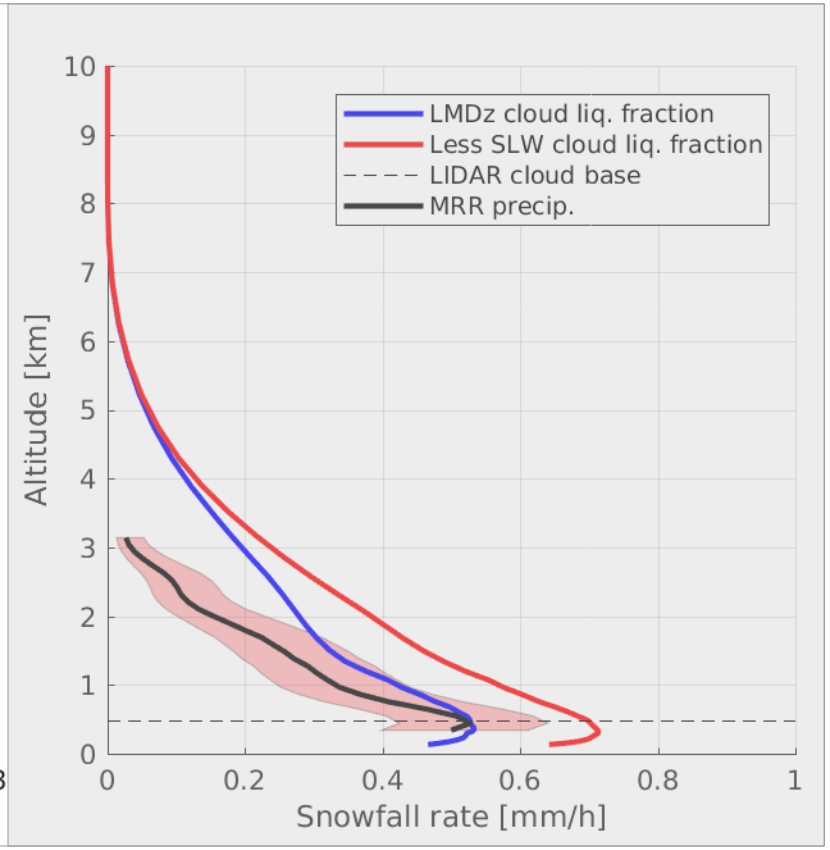

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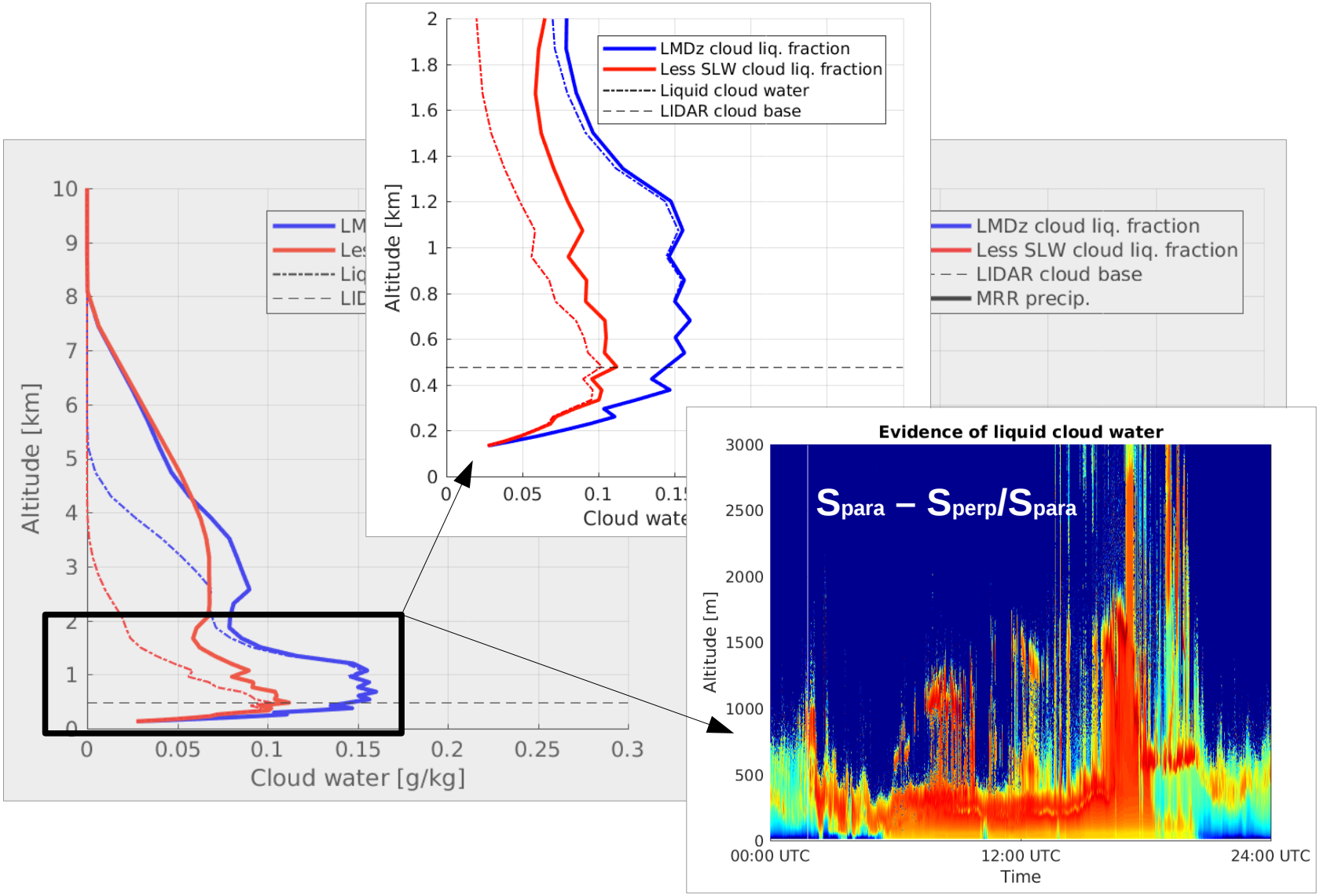

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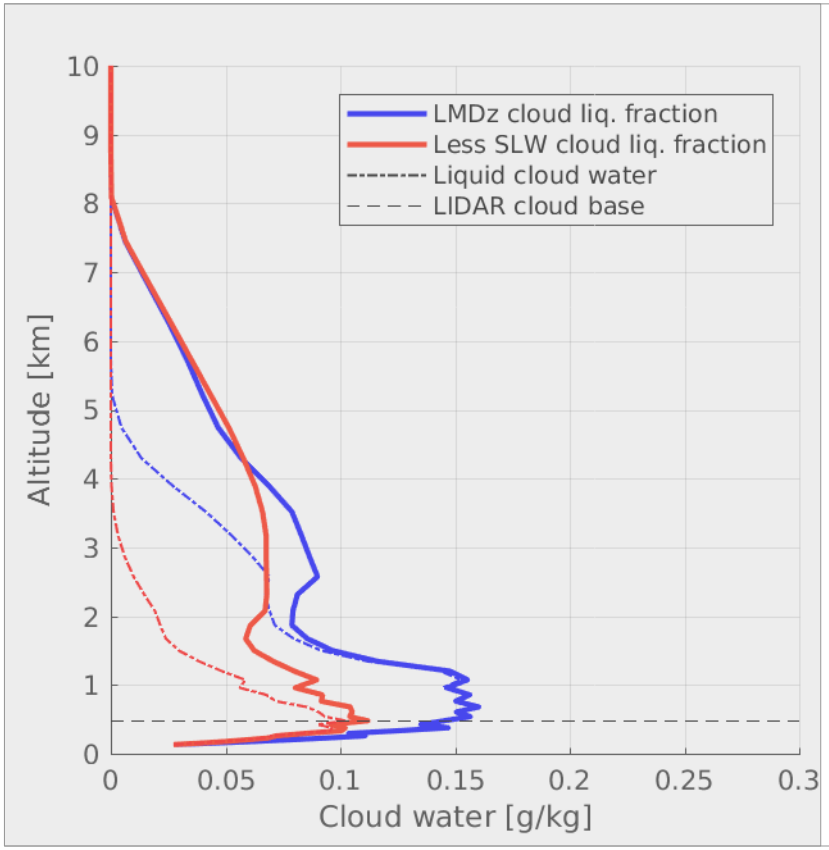
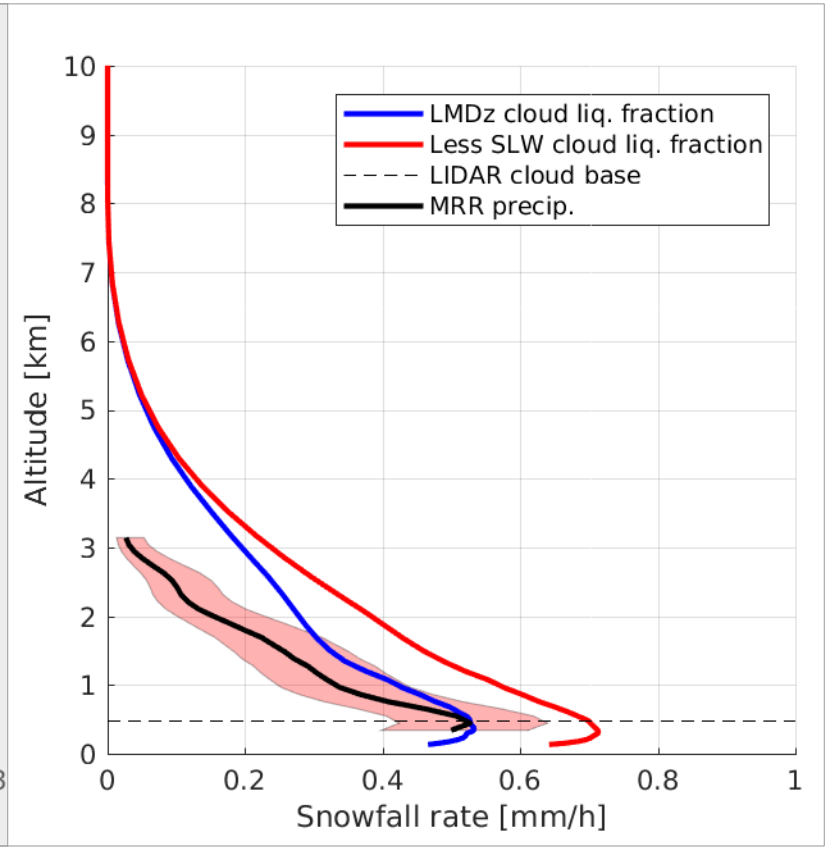




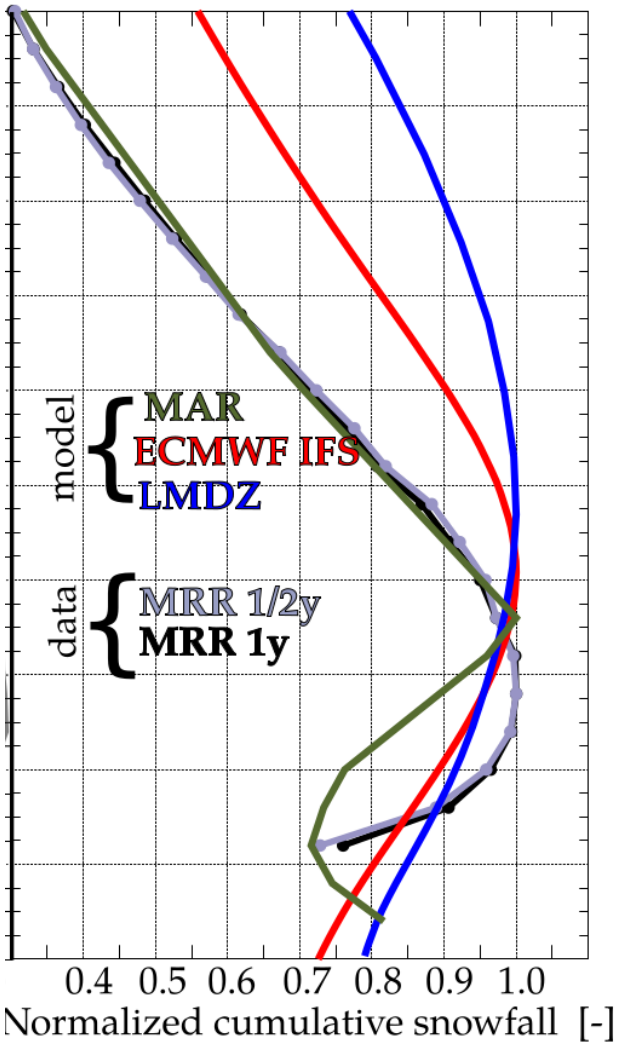
Take-Away messages

- Conversion from clouds to precipitation at a too high altitude …
- … But a quite good agreement towards the surface.

- Current IPSL-CM snowfall parametrizations shift the precipitation profile …
- … But don't affect the shape of the precipitation profile.

Upcoming work

- Comparisons with DAR-DAR products for cloud top altitude and mixed phase.
- Comparisons with complex micro-physical models, or two-moments scheme models.
- Development of new parametrizations for solid precipitation.
  - Prognostic equation for snow.
  - Aggregation of snow.
  - Riming of snow particles.



One full year of MRR measurement – Grazioli et al., 2017

APPENDIX

Sensitivity to precipitation re-evaporation

- The rain is partly evaporated in the grid below : $\frac{\partial P}{\partial z} = \beta[1 - q/q_{sat}]\sqrt{P}$
- Sensitivity to β
- Minor general impact on the amount of precipitation.
- Doesn't affect the shape of the precipitation profile.