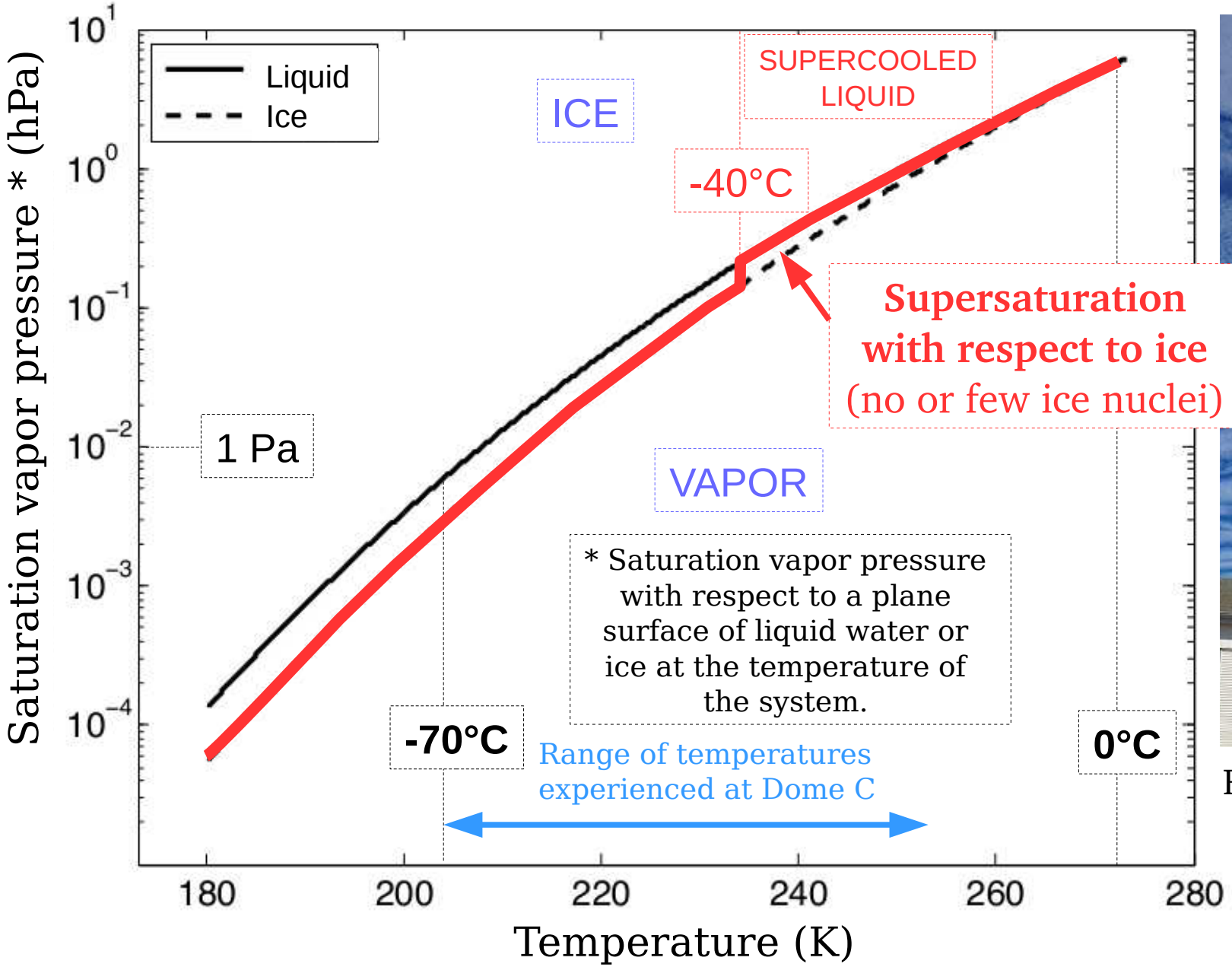
Climate Modeling of Ice Supersaturation and Haze at Dome C, Antarctica

J.-B. Madeleine[1]*, H. Gallée[2], R. Forbes[3], D. Veron[4], C. Genthon[2], F. Hourdin[1], F. Lemonnier[1], L. Piard[2]

* jean-baptiste.madeleine@lmd.jussieu.fr
[1] LMD (Paris, FR), [2] IGE (Grenoble, FR),
[3] ECMWF (Reading, UK), [4] University of Delaware (USA)

With results from the CALVA & APRES3** projects*
** CALibration and VAlidation of climate models and satellite retrievals*
*** Antarctic Precipitation, REmote Sensing from Surface and Space*

Ice supersaturation



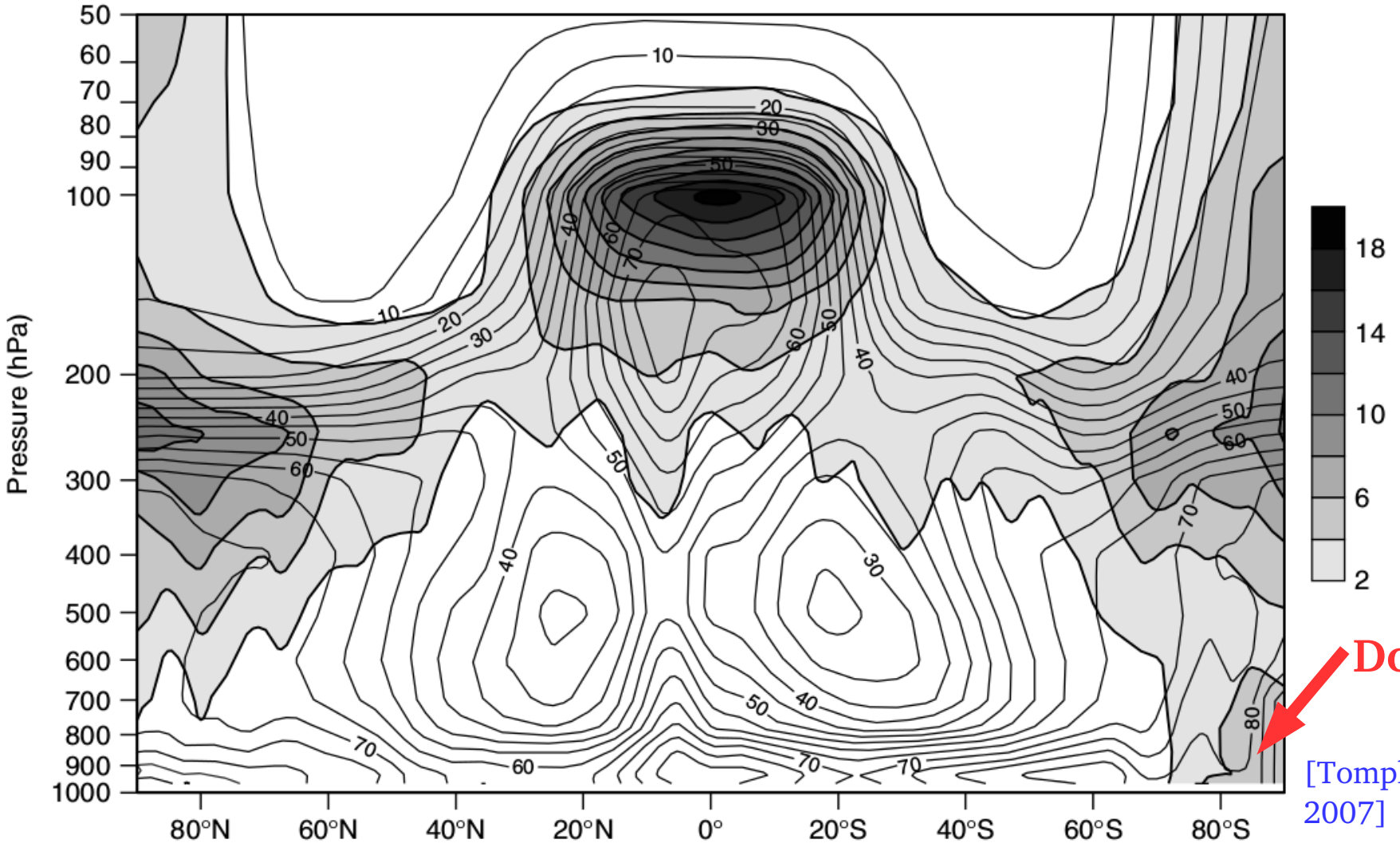
Fallstreak holes over Rhode Island, USA

Supersaturation at global scale

ECMWF results

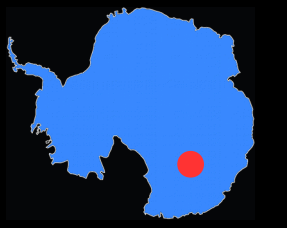
Shaded: difference RH (supersat) – RH (nosupersat)

Contours: RH in control simulation



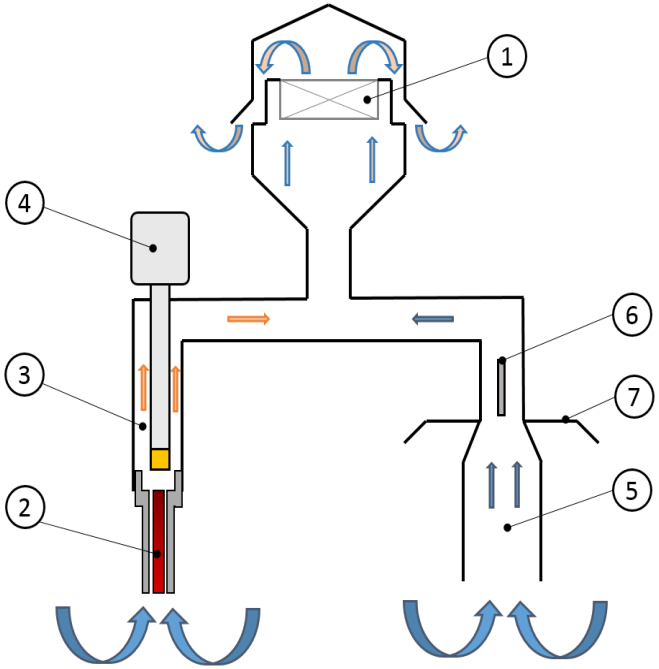
[Tompkins et al, 2007]

Instruments



Modified HMP:

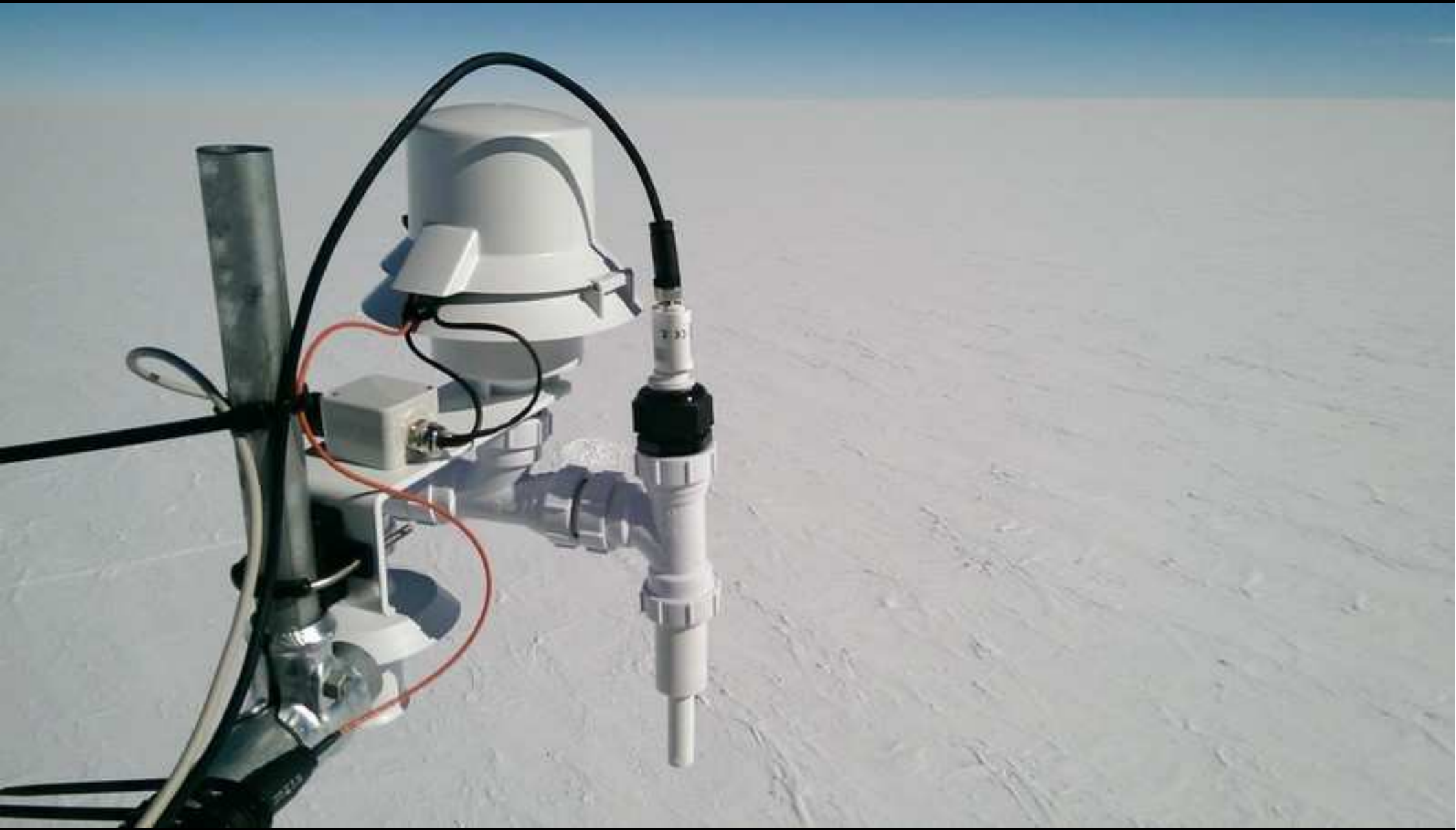
- **1:** Fan
- **2:** Heating tube
- **3:** Heated air
- **4:** HMP155
- (p_{vap} and T°C)
- **5:** Unheated air
- **6:** PT100 (T°C)
- **7:** Shaded inlet



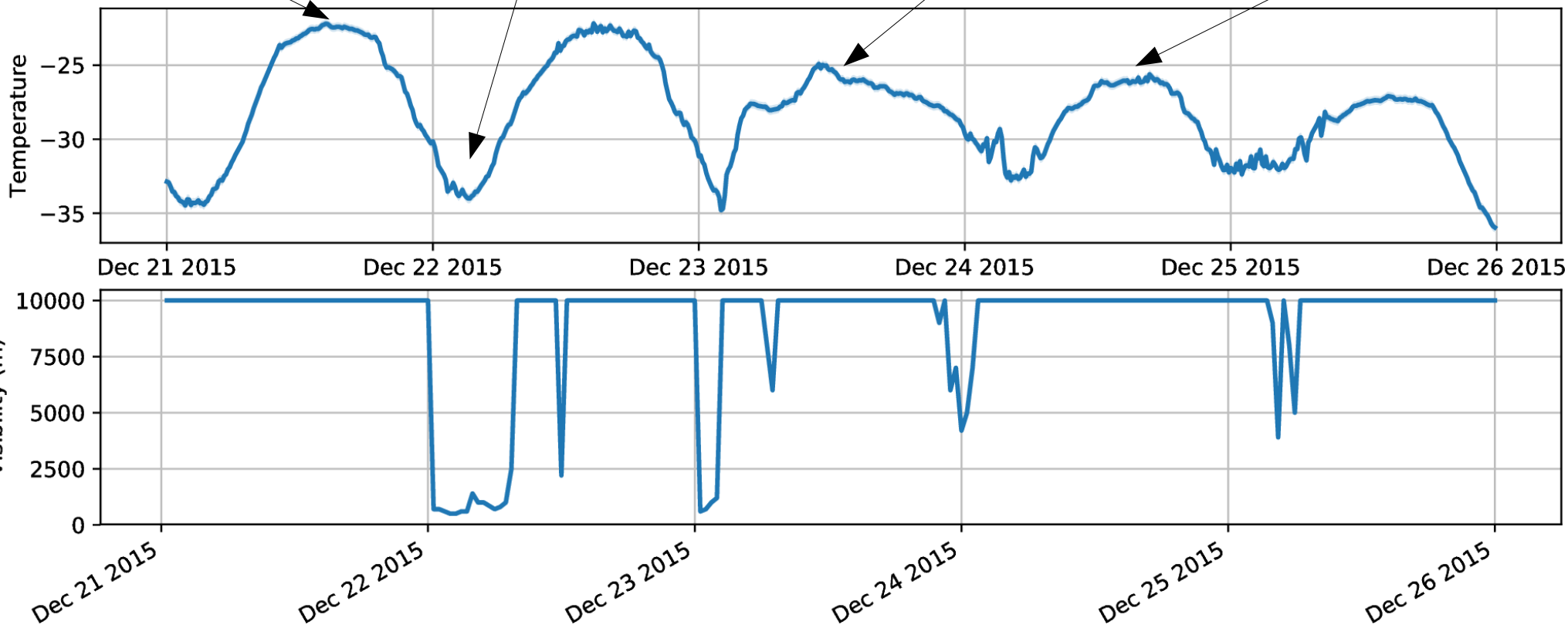
Inexpensive, compact and light, measures down to -80°C.

See Genthon et al. talk on Thursday, 11AM, session AC-1g, room C Sanada I

View from the top of the tower



Selected period – Dome C obs.




Concordia video 2015-12-22 00:22:39


Concordia video 2015-12-22 01:21:01

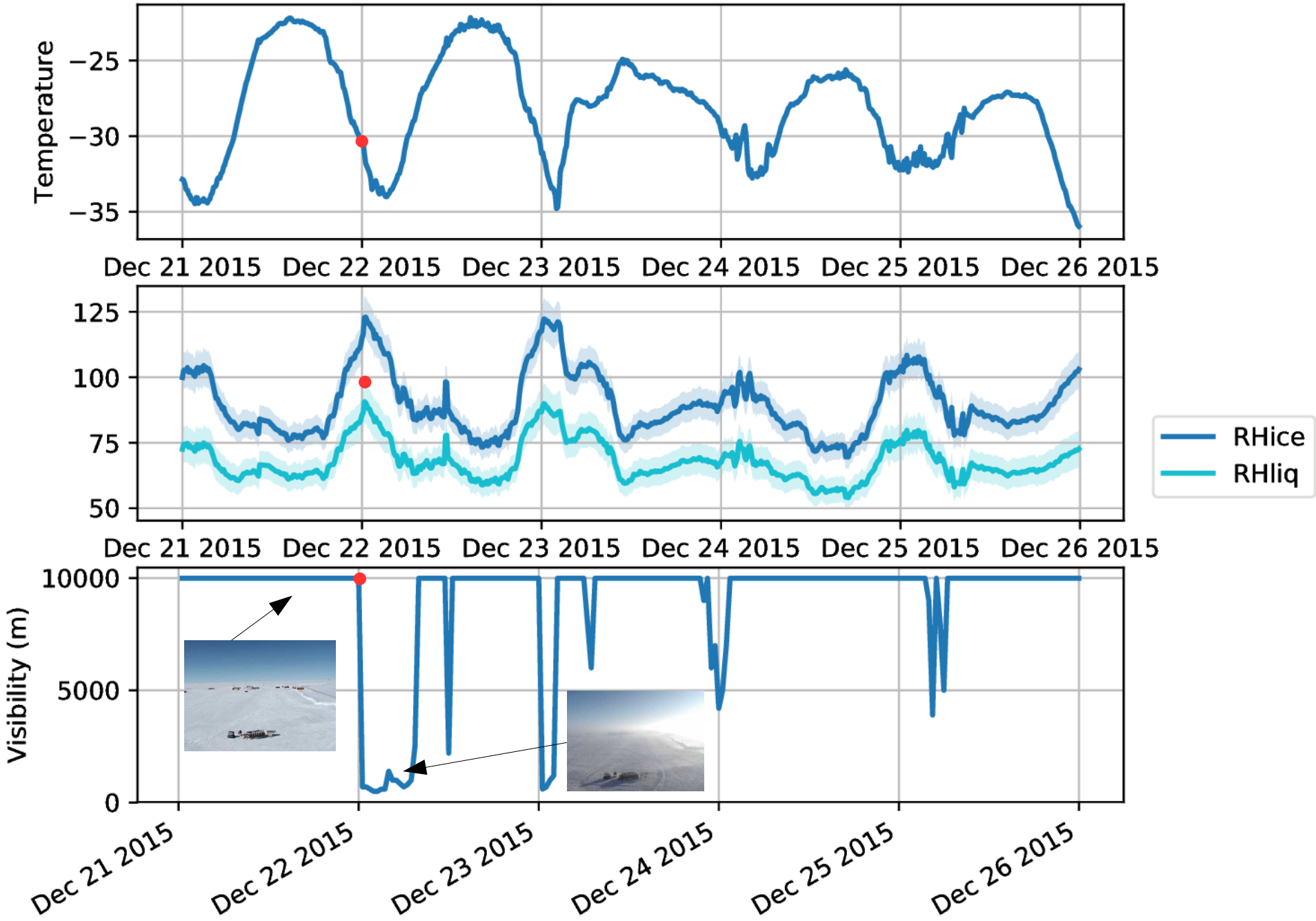

Concordia video 2015-12-22 02:32:58


Concordia video 2015-12-22 03:16:32


Concordia video 2015-12-22 07:41:01

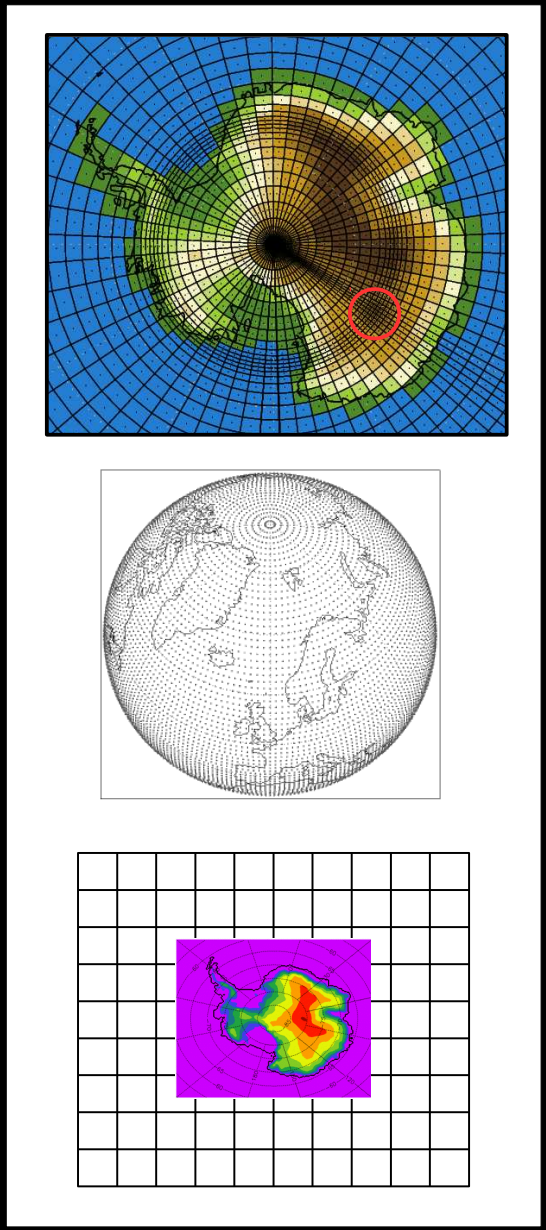

Concordia video 2015-12-22 10:02:44

Ice haze formation

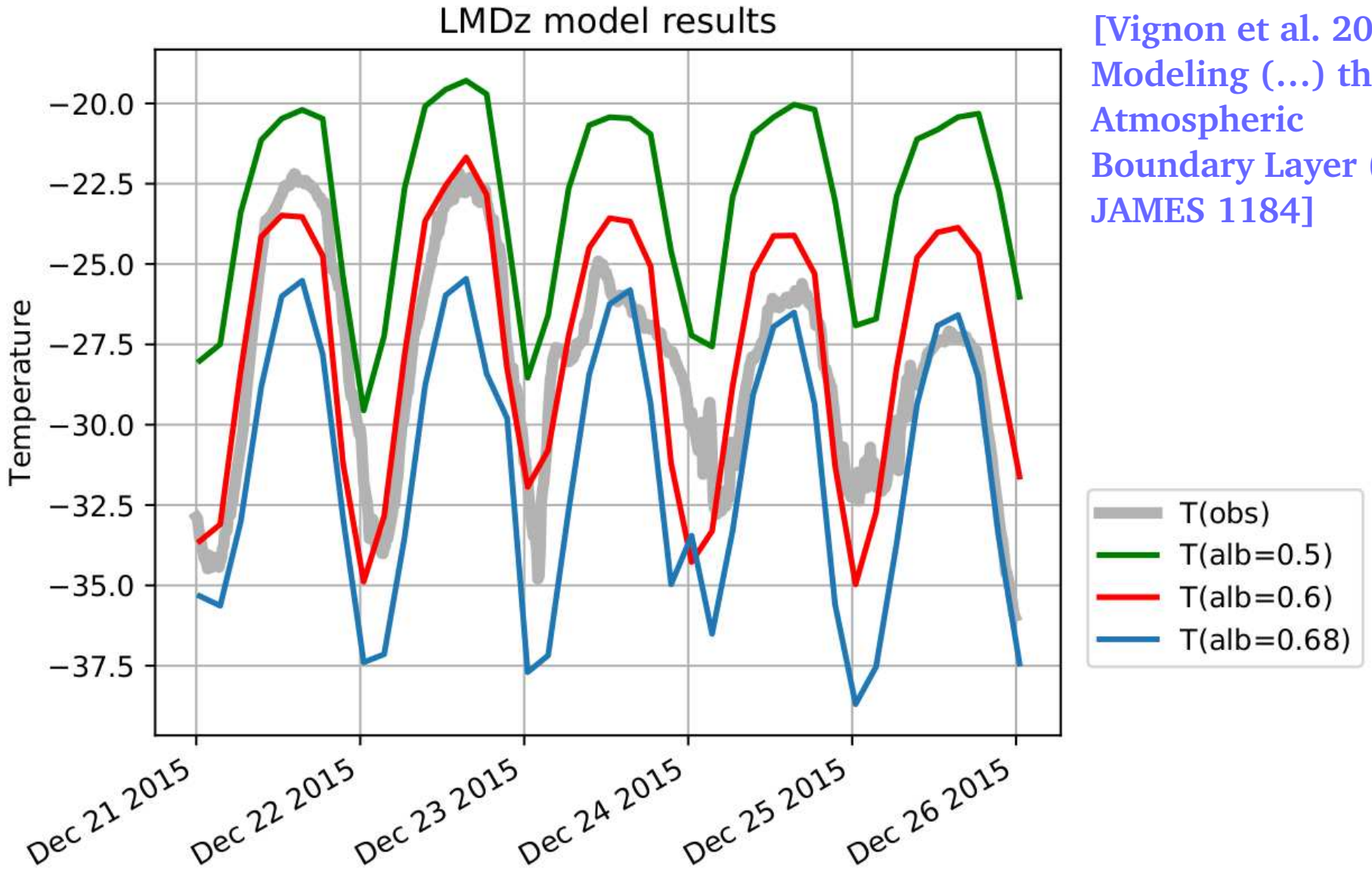


Model intercomparison

- **IPSL-CM** (global, zoom) : no supersaturation → ice condenses when $RH_i = 100\%$ and $\text{Cloud liquid fraction} = \left(\frac{T - T_{min}}{T_{max} - T_{min}}\right)^n$
- **IFS** (global, high resolution) : microphysical scheme → crystal growth by deposition for T > -38°C and homogeneous freezing for T < -38°C
- **MAR** (limited area model) : microphysical scheme and blowing snow, 6 prognostic equations

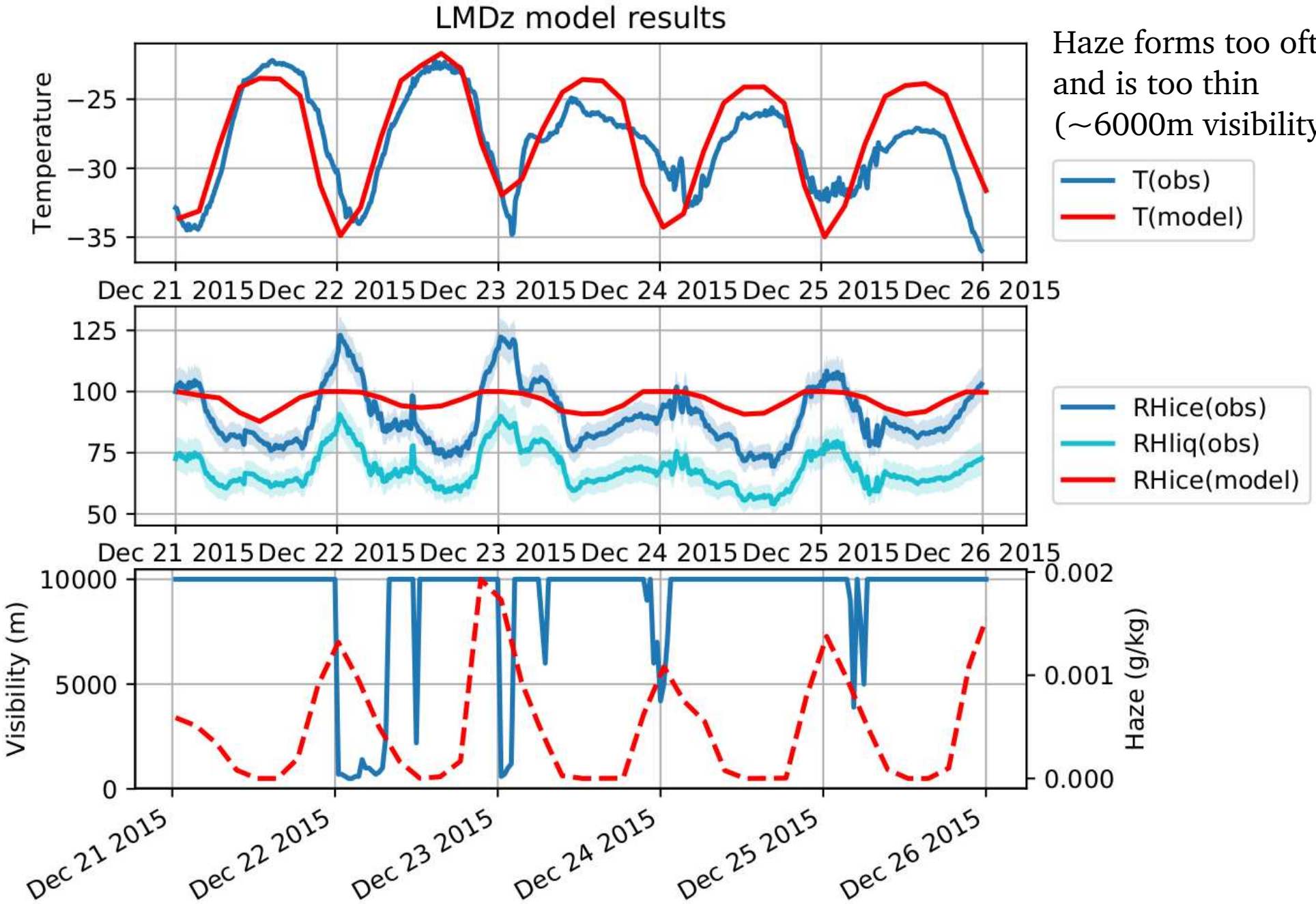


Sensitivity to nIR (1.19 - 4 μm) albedo



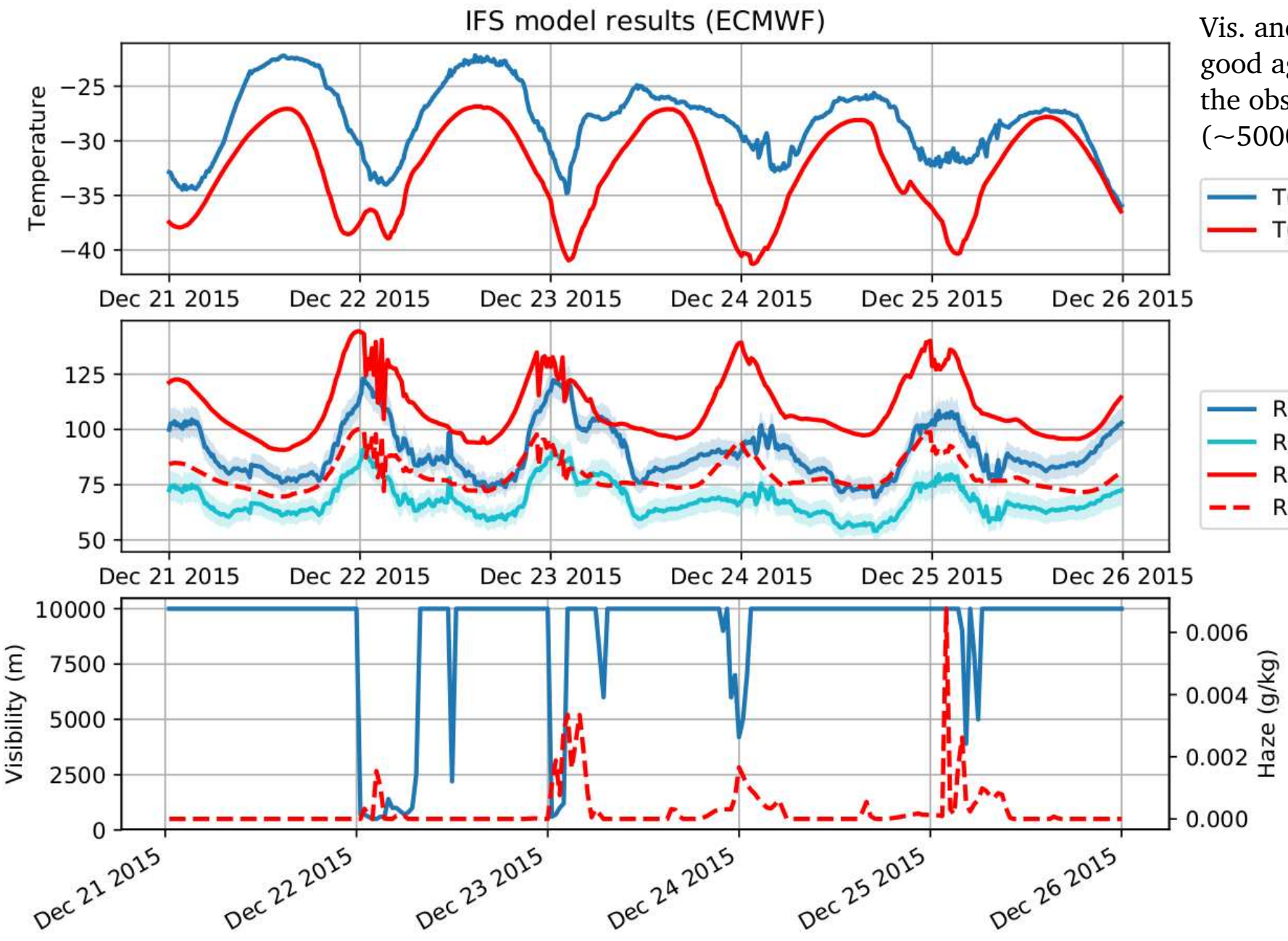
[Vignon et al. 2017, Modeling (…) the Atmospheric Boundary Layer (…) JAMES 1184]

Results without supersaturation



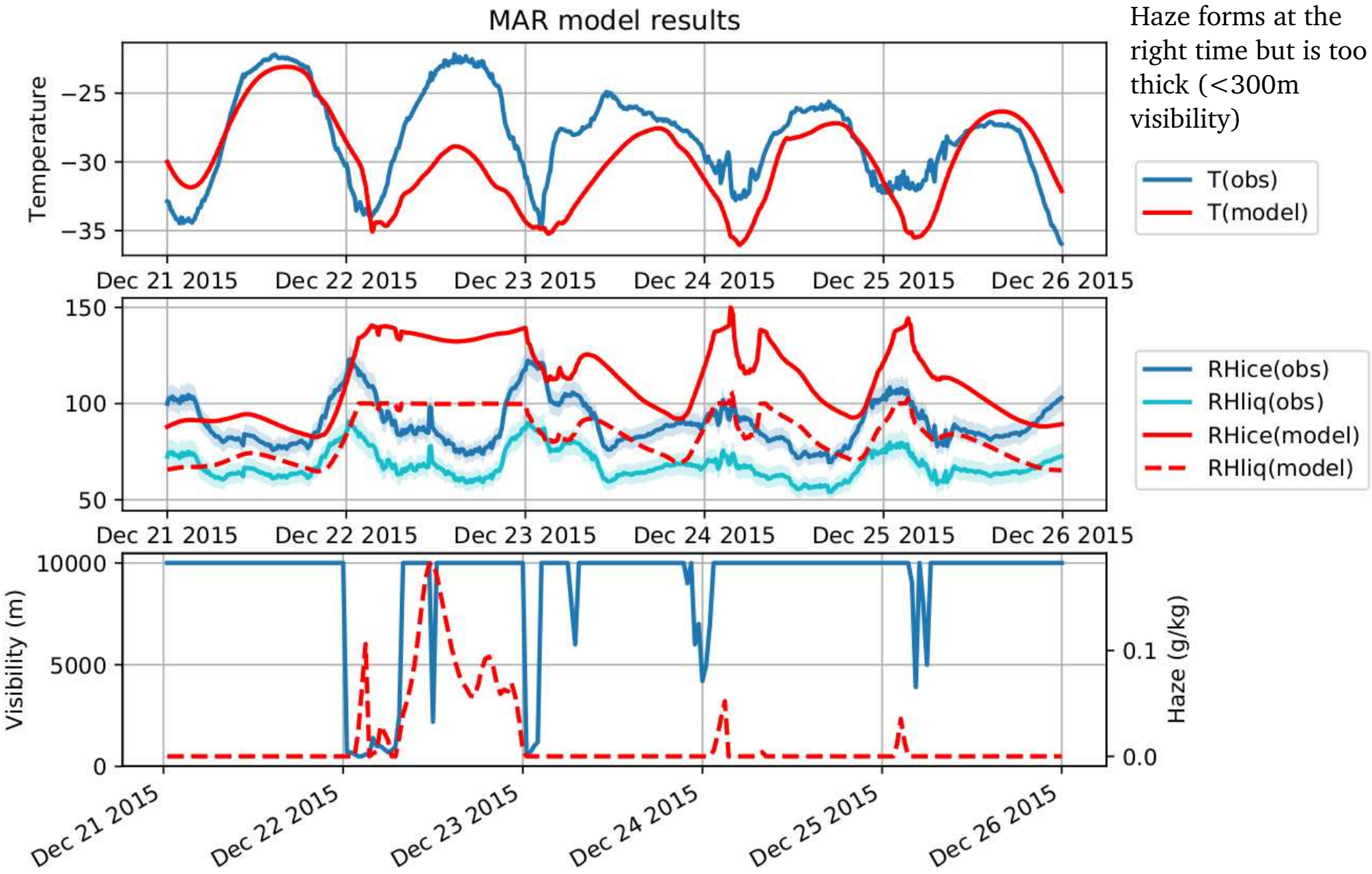
Haze forms too often and is too thin (~6000m visibility)

IFS results (includes supersaturation)



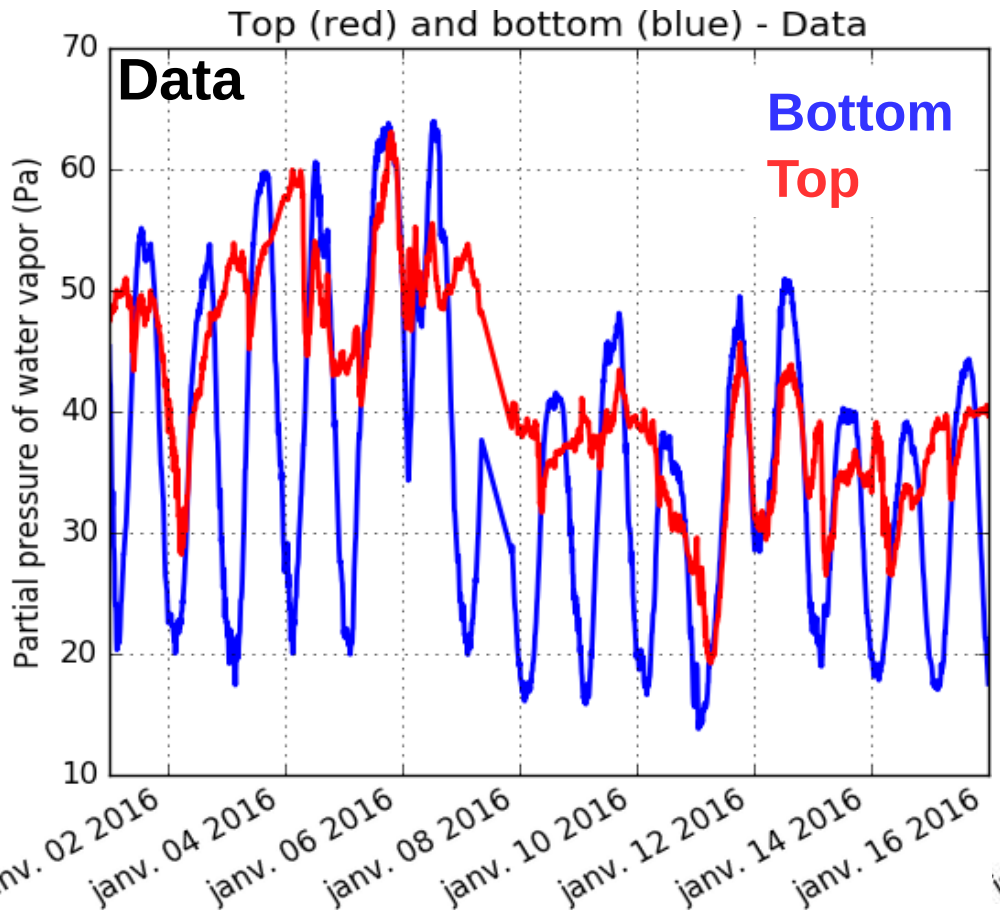
Vis. and timing in good agreement with the observations (~5000m visibility)

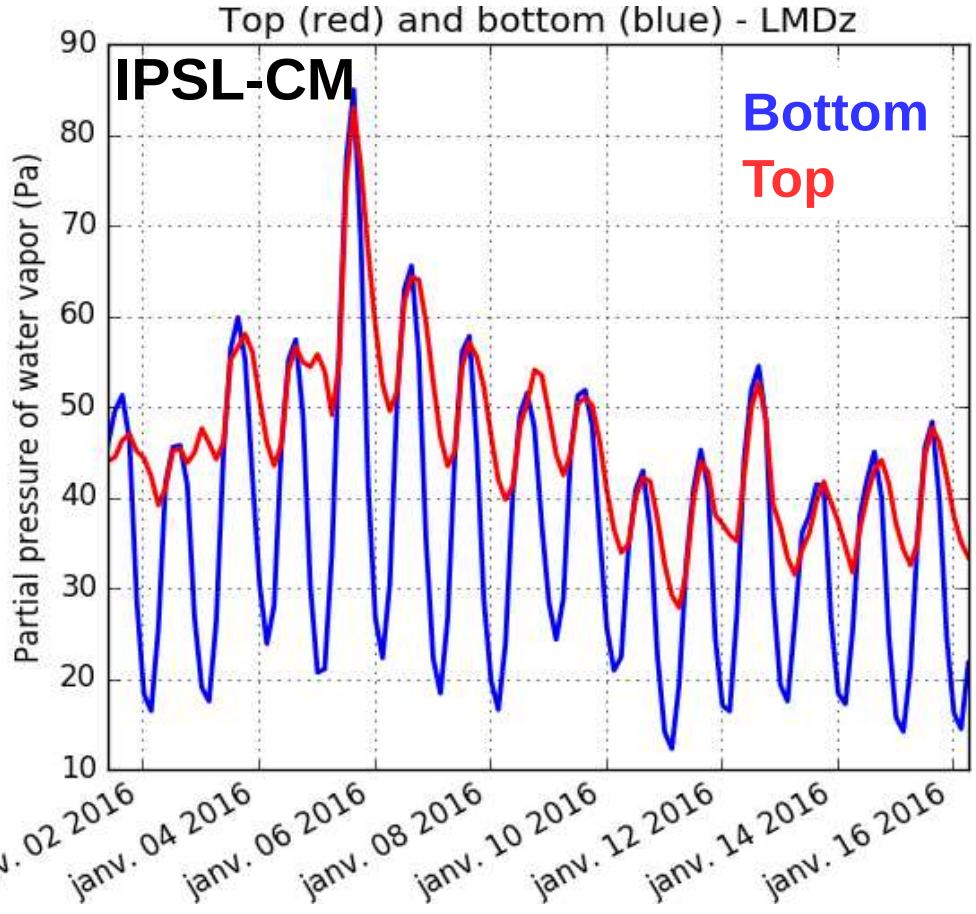
MAR results (40 km resolution)



Haze forms at the right time but is too thick (<300m visibility)

Vapor partial pressure along the mast





→ Turbulent diffusion in the boundary layer can be validated using the multiple hygrometers along the mast (gives access to the water vapor turbulent fluxes)

Conclusions

- Model BL schemes and snow properties need to be tuned to reach a good agreement with the observed temperatures (especially high sensitivity to near-infrared albedo)
- IPSL-CM temperatures are in good agreement with the observations but underestimate haze opacity
- IFS shows good agreement with both the observed humidities and haze opacities despite a cold bias
- MAR overestimates supersaturation and haze opacity → fails to dissipate the haze → cold bias

These microphysical observations at Dome C are very promising
→ **work is underway to further constrain microphysics**
(amount of ice nuclei, microphysical properties of the fog)