Using MODIS land surface temperatures and the Crocus snow model to understand the warm bias of ERA-Interim reanalysis at the surface in Antarctica

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  - ERA-Interim and Crocus surface temperature analysis
- Conclusions

Introduction

Use of remote-sensed surface temperature to evaluate the quality of reanalysis and snow model outputs in Antarctica.

- Limited use of satellite observations for the evaluation of surface temperature simulations

- Ts can be estimated from satellite observations under clear-sky conditions using the thermal emission of the surface in the infrared

- Ts is more appropriate than T2m for investigating the energy budget of a snow-covered surface :
    - Ts : function of the surface energy budget
    - T2m : diagnosis from the surface temperature and the air temperature at the lowest atmospheric vertical level
    - Large temperature gradients near the surface

Data and method

OBSERVATIONS :

MODIS surface temperatures

Clear-sky satellite observations

Hourly data; period : 2000-2011; Resolution ~1km

In situ observations

7 stations : Dome C, South Pole, Syowa, Kohnen, Plateau Station B, Pole of Inaccessibility and Princess Elisabeth.

MODELS :

ERA-Interim surface temperatures

ERA-i Ts is derived from the energy balance equation during the forecast step of IFS (Integrated Forecast Model)

3-hourly data; period: 2000-2011; Resolution : 80 km

Crocus snow model simulations

SURFEX/Crocus

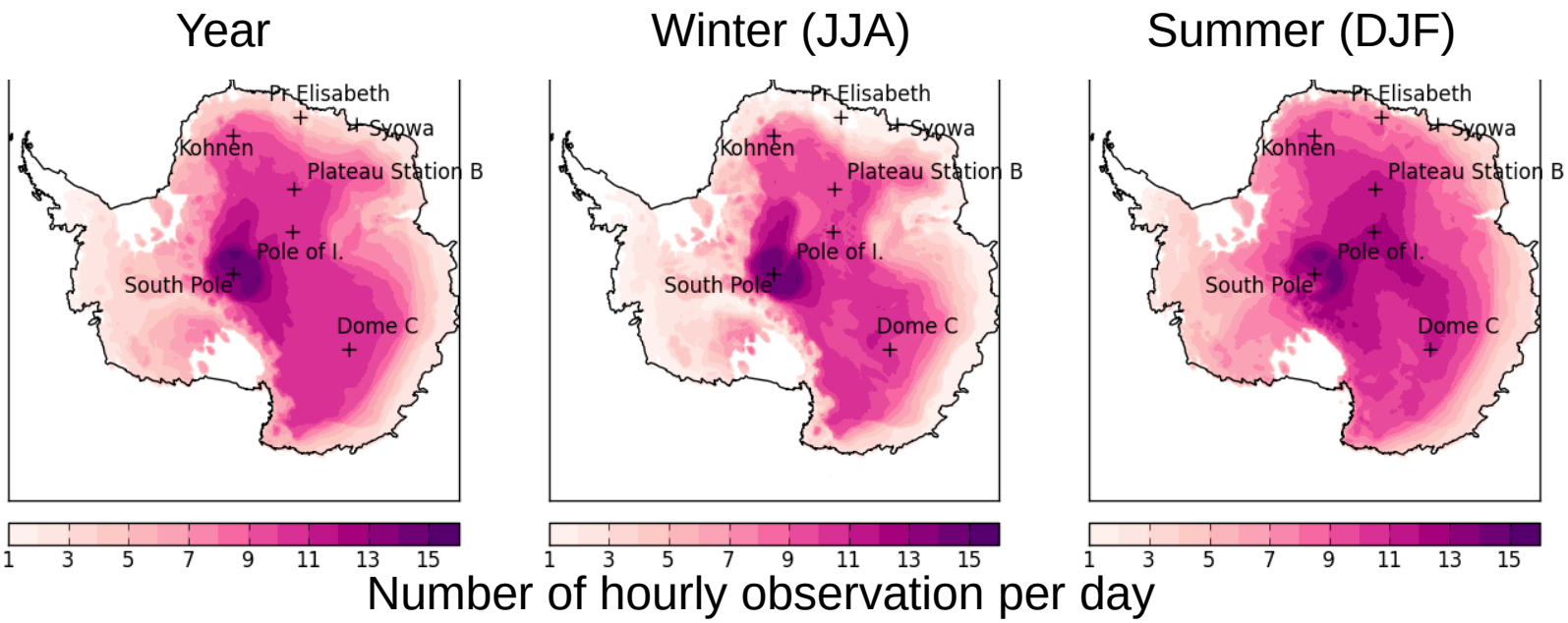
ERA-Interim forcing data : T2m, HR2m, U10m, precipitation rate, LWdown, SWdown, Ps, extracted at 0.5° resolution 3H time step. Bilinear interpolation onto 25 km stereo grid

Hourly data; period: 2000-2011; Resolution ~ 25km

MODIS Ts and ERA-i Ts are projected onto a 25-km grid

MODIS Ts evaluation (1/2)

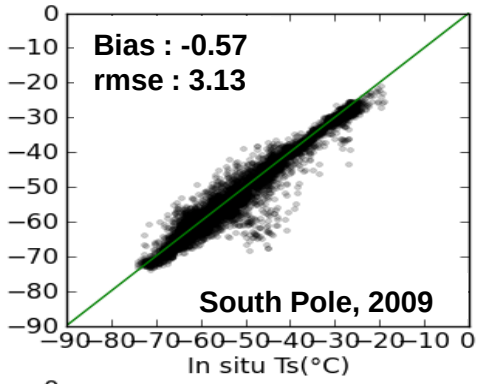
- Availability
  - Revisit time of MODIS
  - Cloudiness (West antarctica, coastal regions)

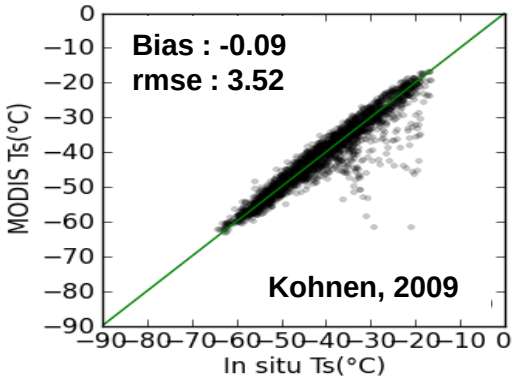


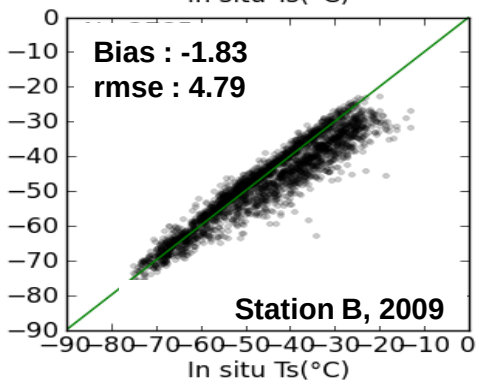
→On average, 14 hourly Ts per day available around South Pole and more than 9 over the Antarctic Plateau.

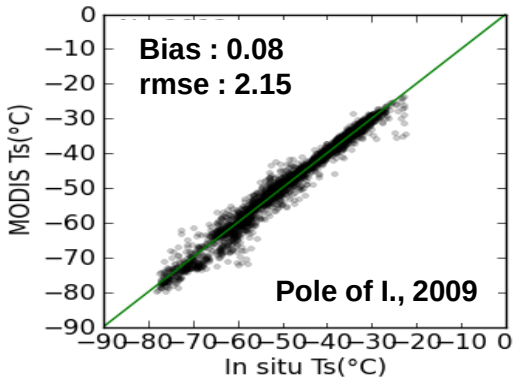
MODIS Ts evaluation (2/2)

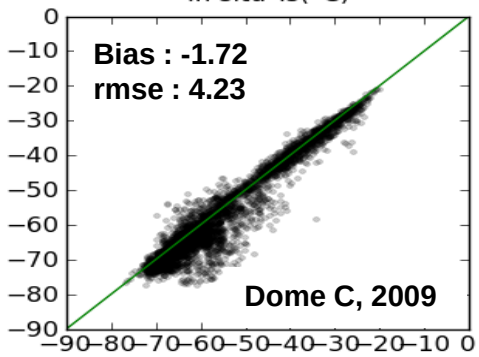
- Comparisons with in situ observations

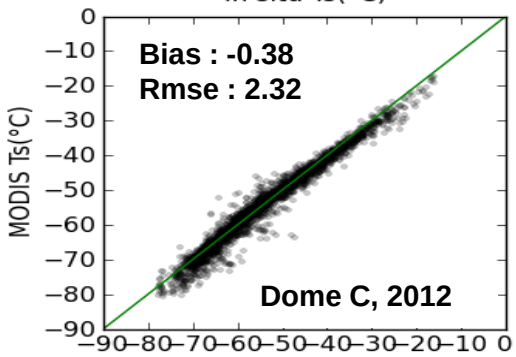












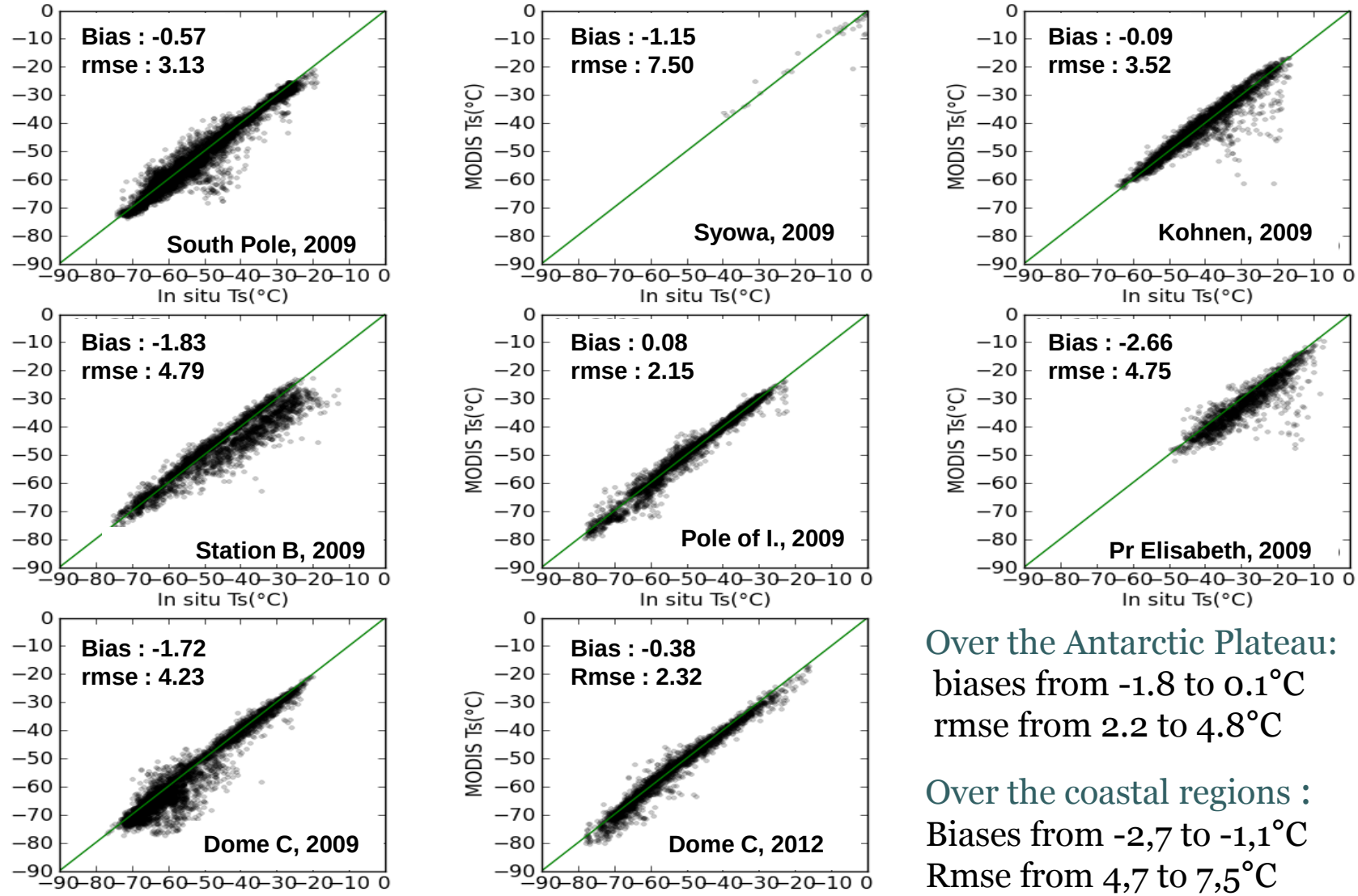
MODIS Ts

In situ Ts

Over the Antarctic Plateau:
biases from -1.8 to 0.1°C
rmse from 2.2 to 4.8°C

MODIS Ts evaluation (2/2)

- Comparisons with in situ observations

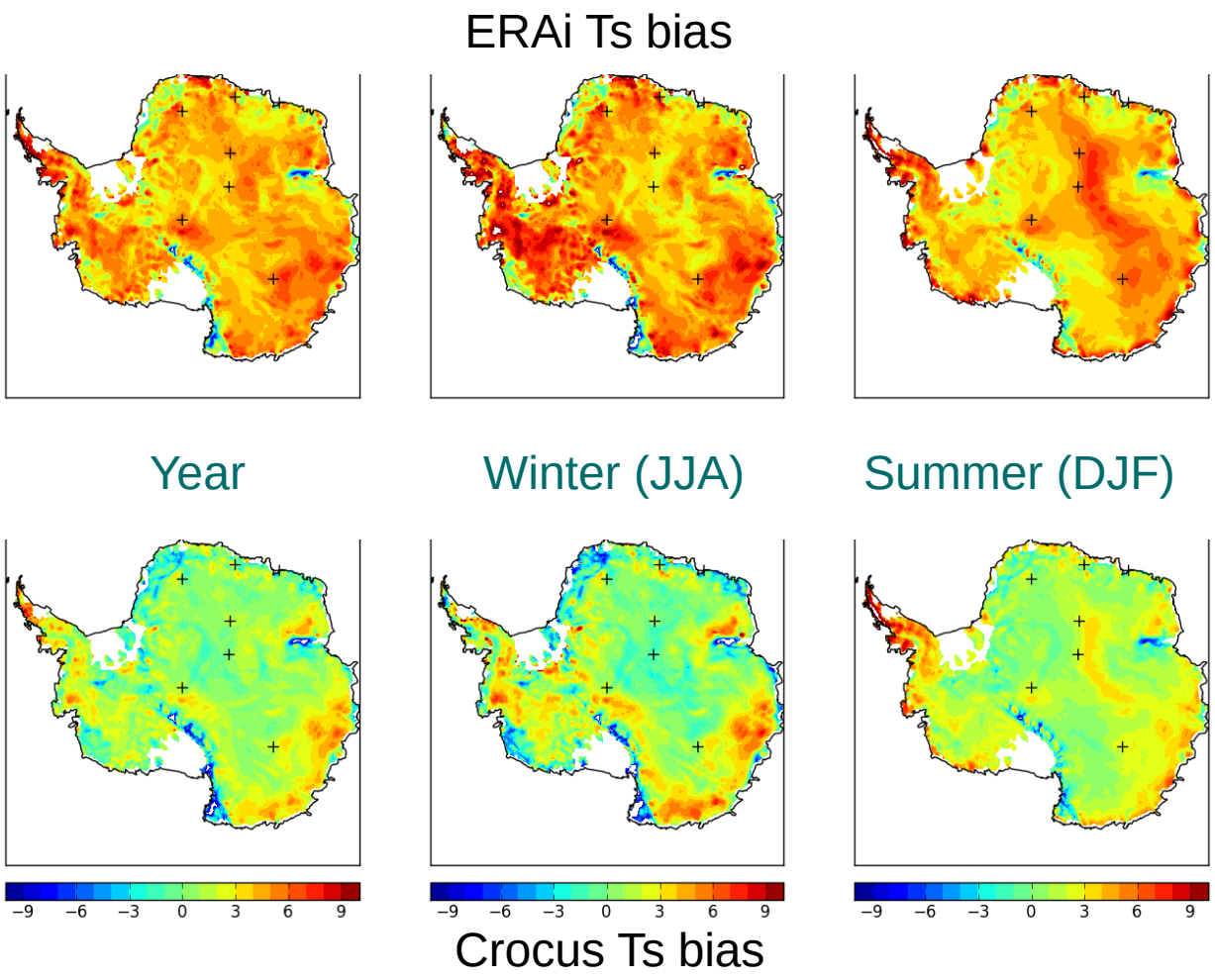


Over the Antarctic Plateau:
biases from -1.8 to 0.1°C
rmse from 2.2 to 4.8°C

Over the coastal regions :
Biases from -2,7 to -1,1°C
Rmse from 4,7 to 7,5°C

ERA-Interim Ts and Crocus Ts analysis (1/4)

- Biases between ERA-i Ts/Crocus Ts and MODIS Ts



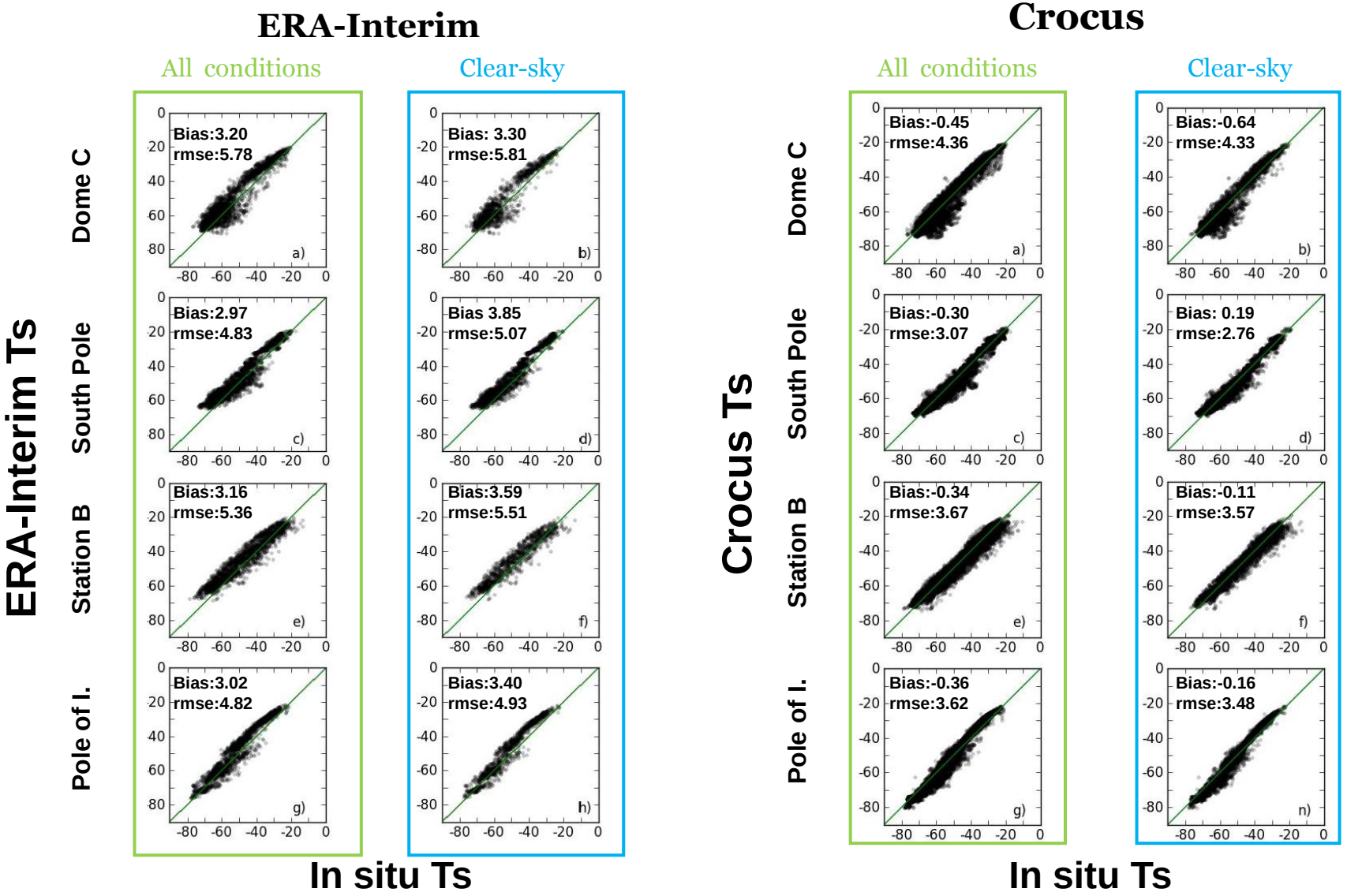
•ERA-Interim warm bias:
+3 to +6°C (Plateau)

Genthon et al, 2010 :
-underestimated albedo
-attenuation of the nocturnal radiative cooling

•Crocus bias:
-2 to +2°C (Plateau)

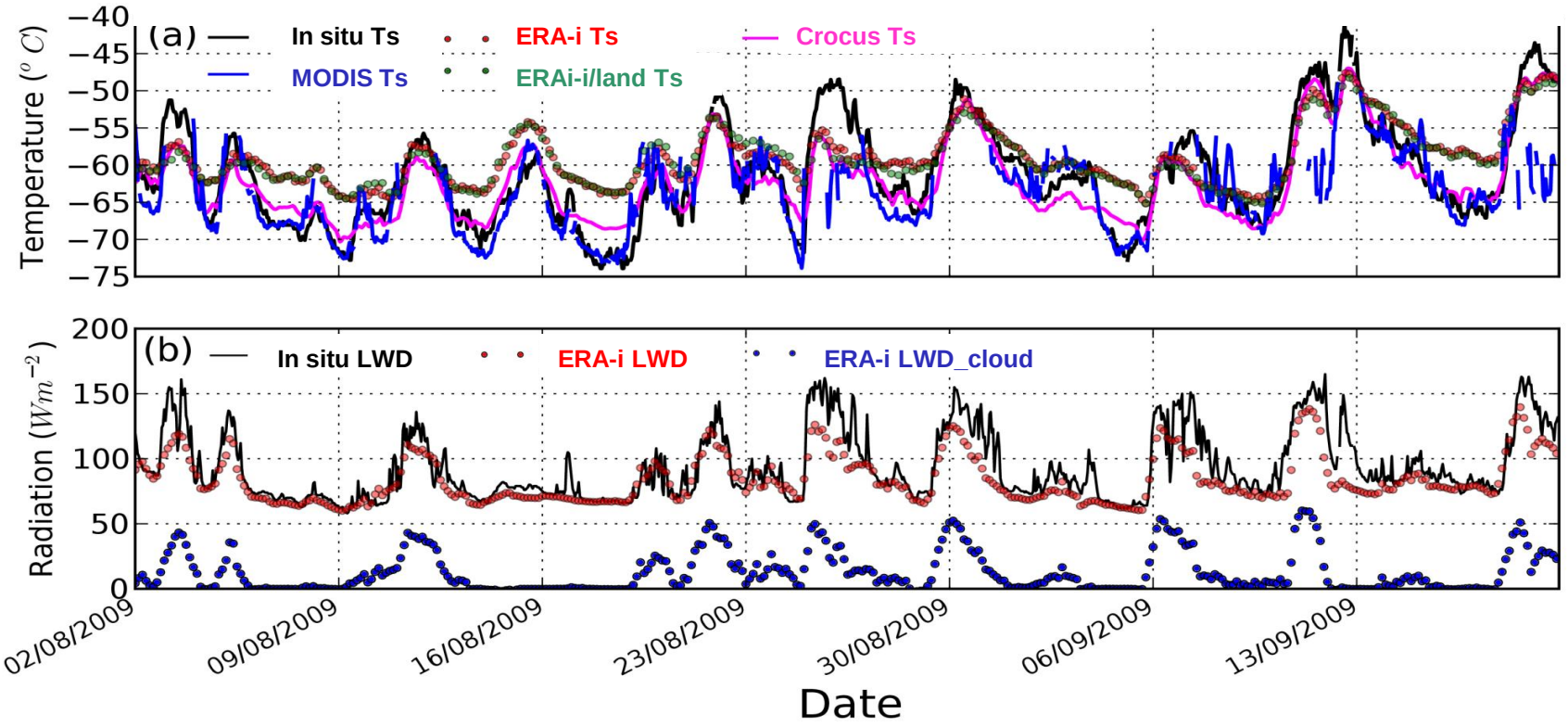
ERA-Interim Ts and Crocus Ts analysis (2/4)

- Comparison with in situ observations



ERA-Interim Ts and Crocus Ts analysis (3/4)

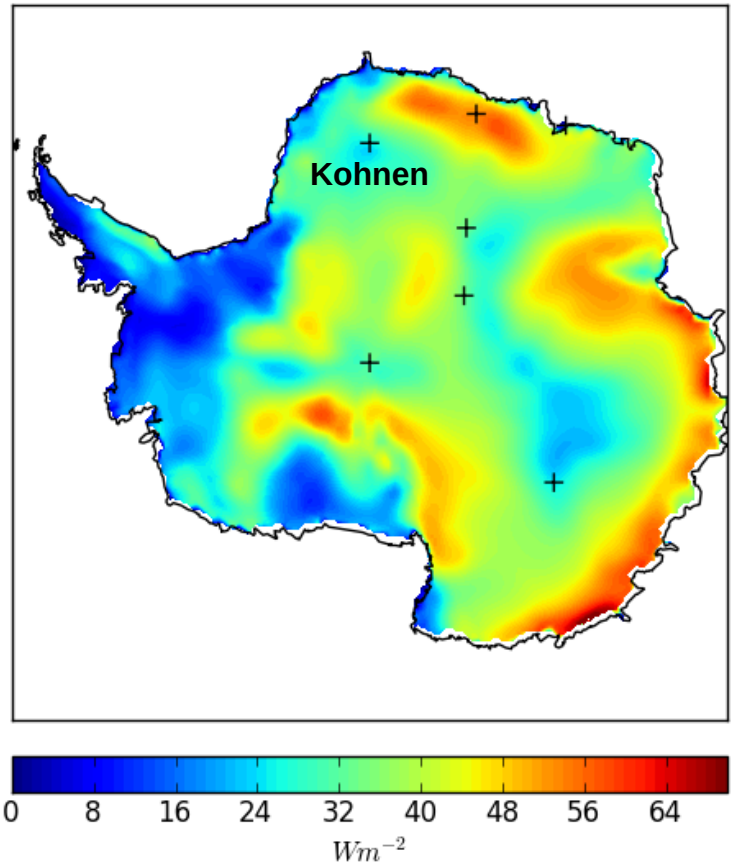
- Comparison between different Ts observations at South Pole



ERA-i warm bias during low LWdown → surface radiative cooling, stable atmospheric conditions
Same parameterization of the surface exchange between **ERA-i** (IFS) and **ERA-i/land** (HTESSEL)
Different parameterization of the surface exchange between **ERA-i** (IFS) and **Crocus** (SURFEX)

ERA-Interim Ts and Crocus Ts analysis (4/4)

- Averaged ERA-i sensible heat fluxes (August 2009)



• ERA-i overestimation:
Over the plateau, Hs > 20 W/m2

Reijmer and Oerlemans, 2002 :
Hs ~ 12 W/m2 in August (Kohnen)

ERA-i Hs ~ 25 W/m2 in August 2009 (Kohnen)

ERA-i warm bias:
Overestimation of the surface turbulent sensible heat fluxes in very stable conditions.

Conclusions

Great potential of MODIS in the Ts on the Antarctic Plateau under clear-sky conditions (availability, quality).

MODIS Ts : well suited for evaluating the Ts simulated by various types of models in Antarctica.

ERA-Interim warm bias on the Antarctic Plateau : +3 to +6°C

Overestimation of the surface turbulent sensible heat fluxes in very stable conditions.

Low Crocus Ts bias : -2 to +2°C

Limitation of the maximum Richardson number in SURFEX/Crocus

Changes in the turbulent flux parameterization strongly impact surface temperature

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Thanks for your attention