A Long-term Hindcast simulation with COSMO-CLM^2 over Antarctica

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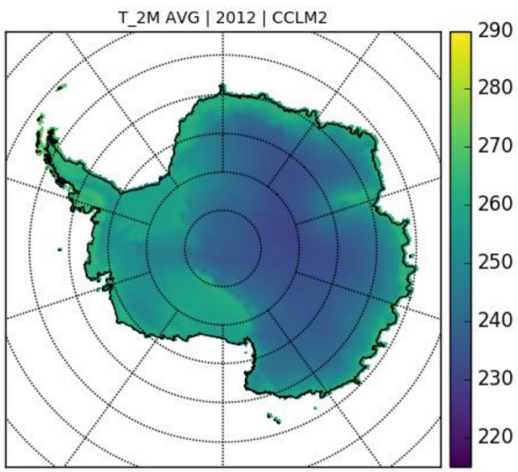
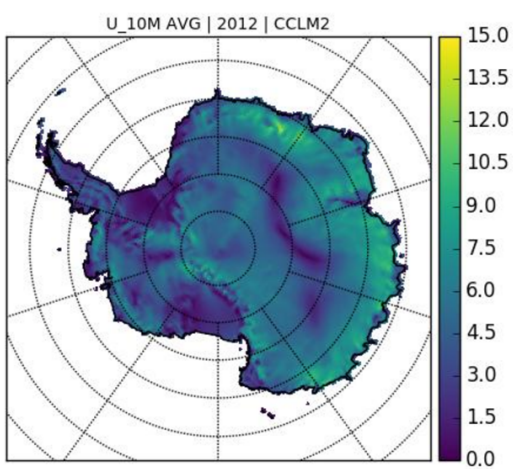
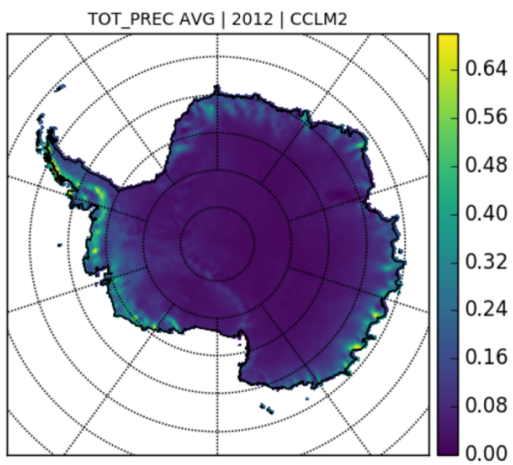
Where were we?

Figure: COSMO-CLM^2 v1 : 2 m temperature (K) - 10 m wind speed (m/s) - tot prec (mm)

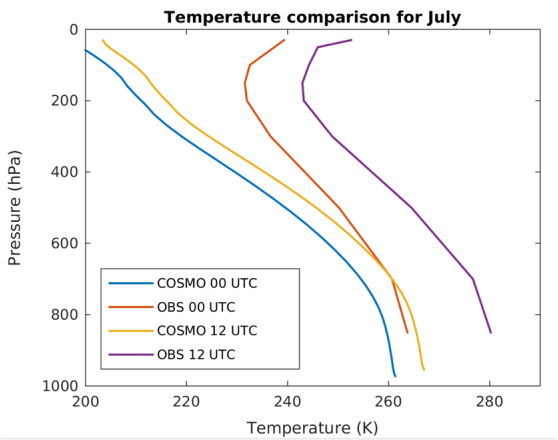


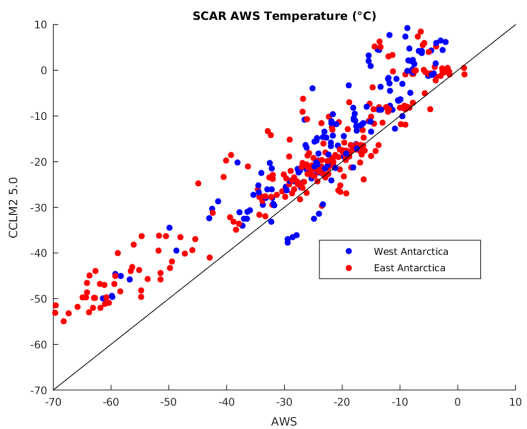


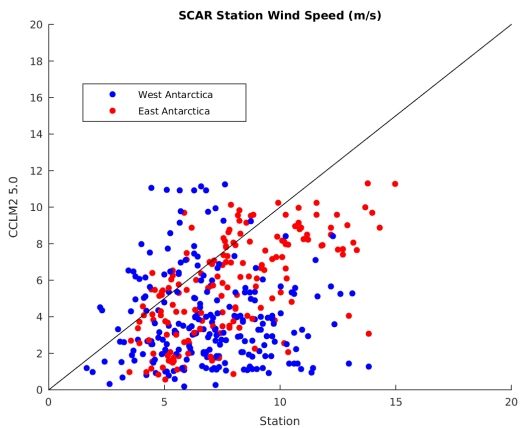


But COSMO was off

Figure: COSMO-CLM^2 v1 vs observations: upper air temperature (K) - 2m temperature (K) - 10 m wind speed (m/s)





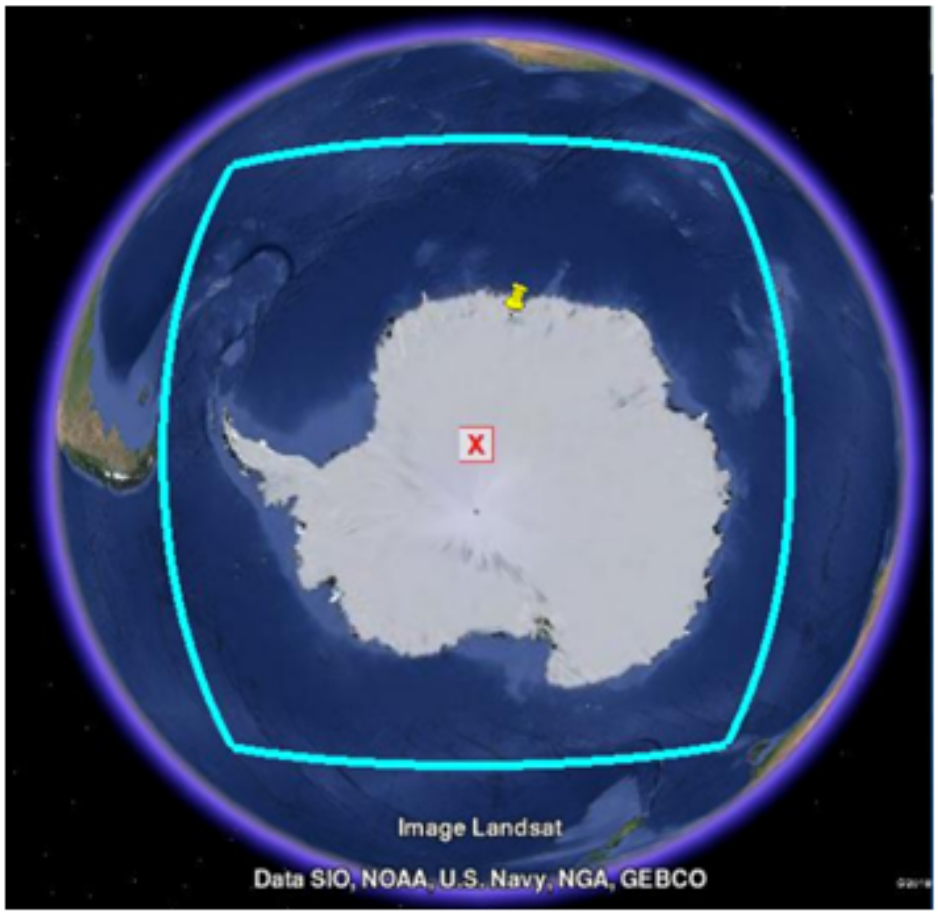


Adaptations are needed

COSMO-CLM^2

- boundary conditions : Era-Interim
- horizontal resolution : 0.22 degrees
- cordex domain
- 30 years run
- coupled to the Community Land Model 4.5

Figure: Cordex domain

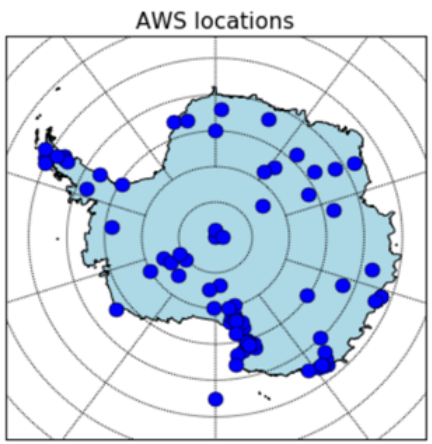


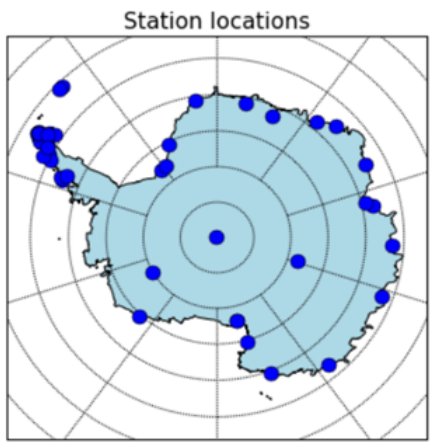
Validation against

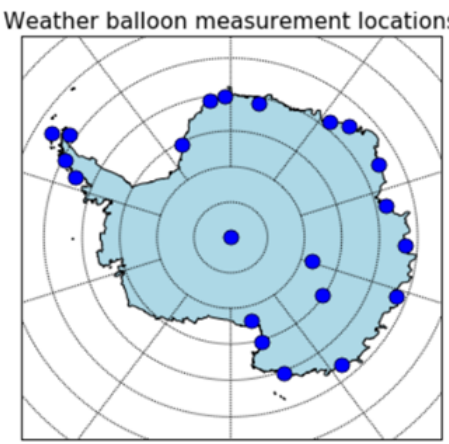
observations

- Automatic Weather Stations
- station measurements
- balloon measurements (Turner et al., 2004)

... but scarce !







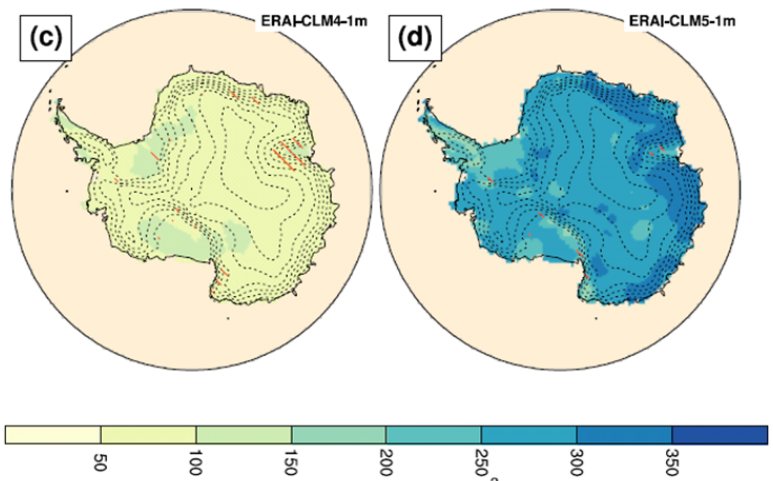
Racmo 2.0 (van Wessem et al., 2014)

... but also a model !

Coupling to CLM

- Community Land Model (CLM) 4.5
- adaptations backported from CLM 5.0 (van Kampenhout et al., *in review*)
  - snow pack bug
  - wind compaction of snow implemented
  - radiation bug
- roughness length adapted to 10^{-5} (Smeets and van den Broeke, 2008)

Figure: Annual mean density in the uppermost snow model layer (1979-1998) for CLM4.5 and CLM5.0



Changes to COSMO

- wrong position of the tropopause → spectral nudging (van de Berg and Medley, 2016)
- surface temperature bias → stability parameters (Cerenzia et al., 2014)
  - reduction of minimal diffusion coefficients for heat
  - reduction of minimal diffusion coefficients for momentum
- precipitation bias → two-moment scheme (Seifert and Beheng, 2008)
  - adaptations to homogeneous and heterogeneous nucleation (Köhler and Seifert 2015)
  - autoconversion threshold lowered (Ghosh and Jonas, 1998)
  - deposition coefficient lowered (Gierens et al., 2003)

Upper air bias

January 2012

Figure: COSMO before spectral nudging, temperature January 2012

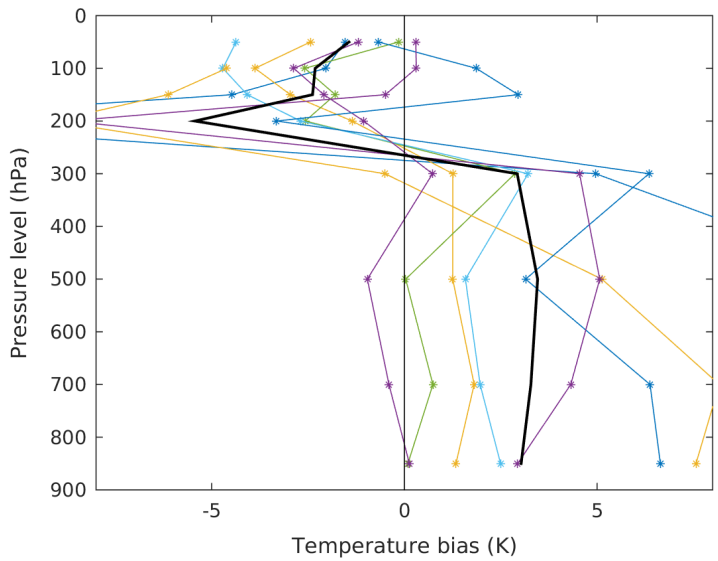
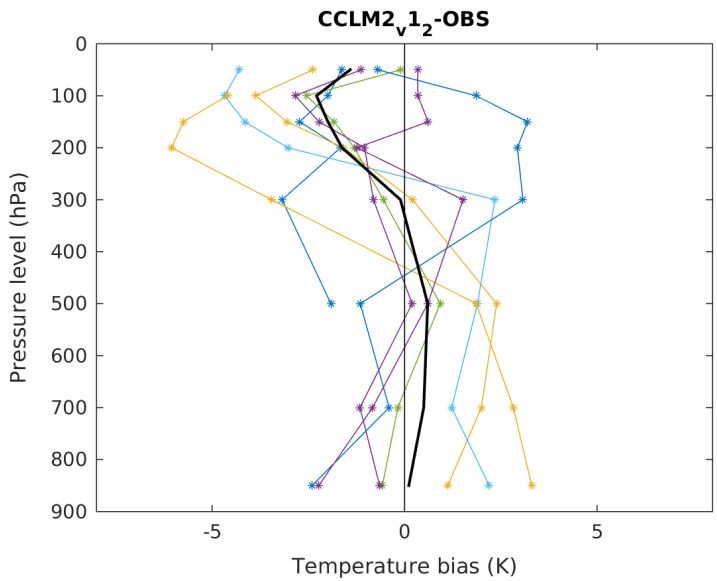


Figure: COSMO after spectral nudging, temperature January 2012

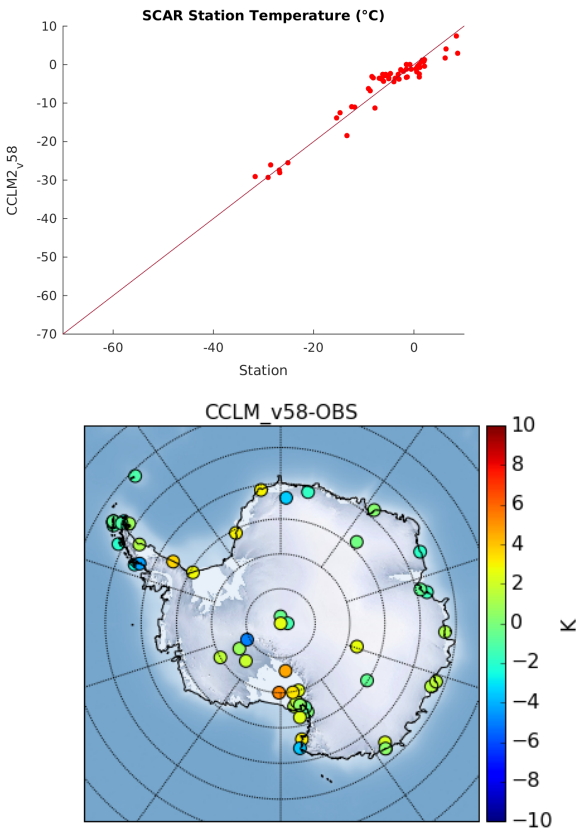


$\rightarrow$ reduction of the upper air bias, but also high impact on the lower atmospheric levels.

Surface temperature bias

T 2M January 2012

Figure: COSMO versus observations



Surface temperature bias

T 2M January 2012

Figure: COSMO versus observations

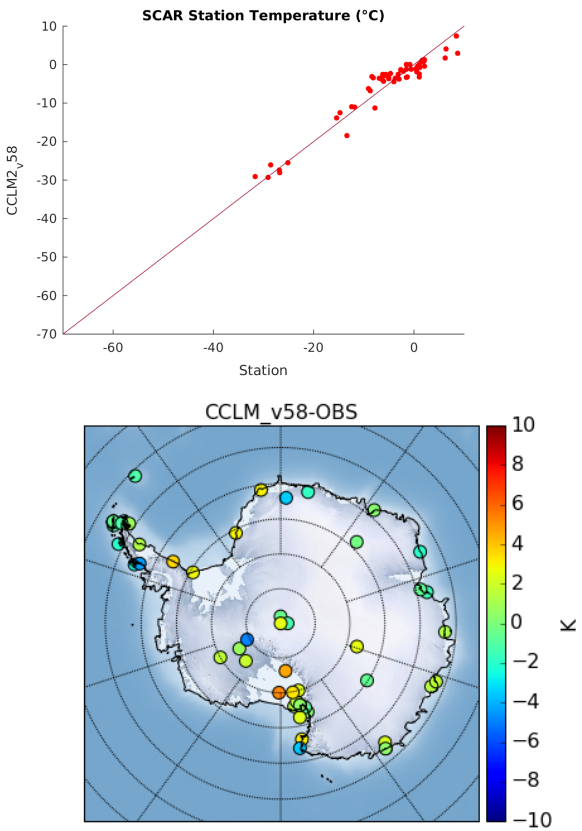
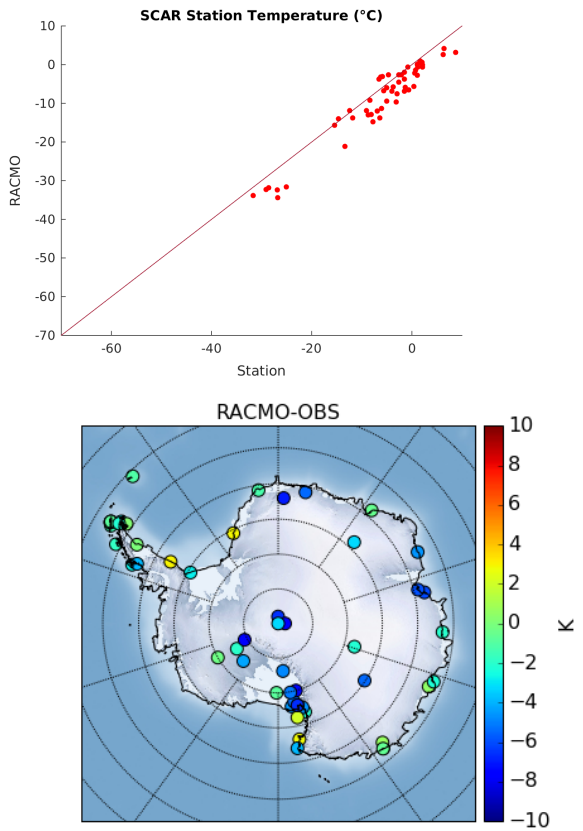
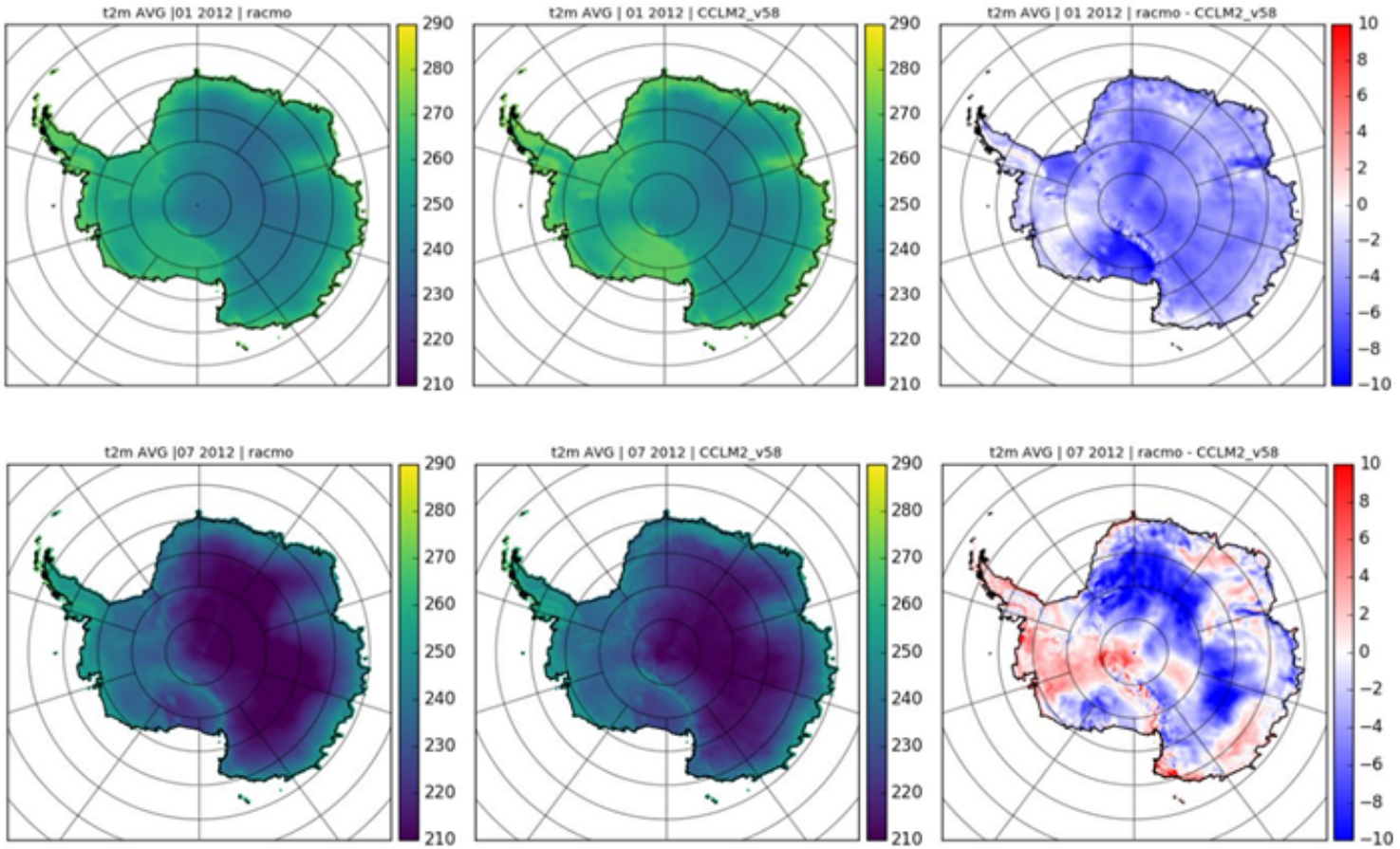


Figure: RACMO versus observations



Surface temperature bias

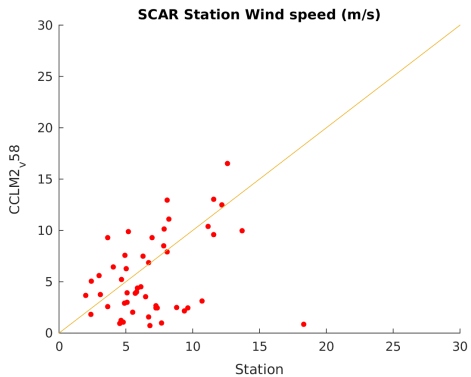
Figure: RACMO versus COSMO (up : January 2012, down : July 2012)

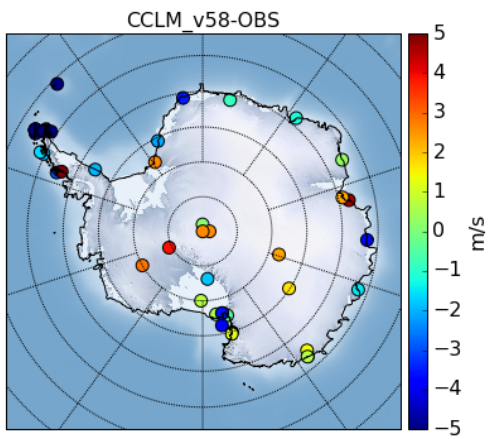


10m wind speed bias

10 M wind speed, July 2012

Figure: COSMO versus observations





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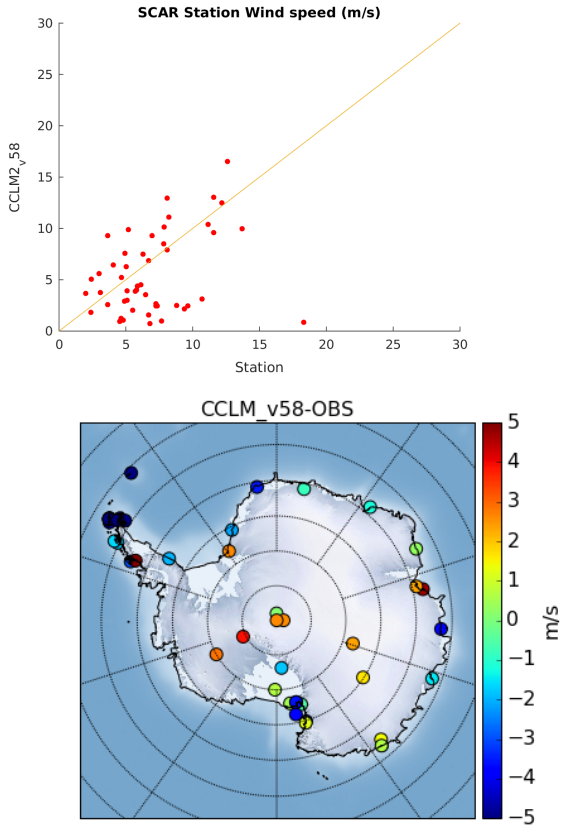

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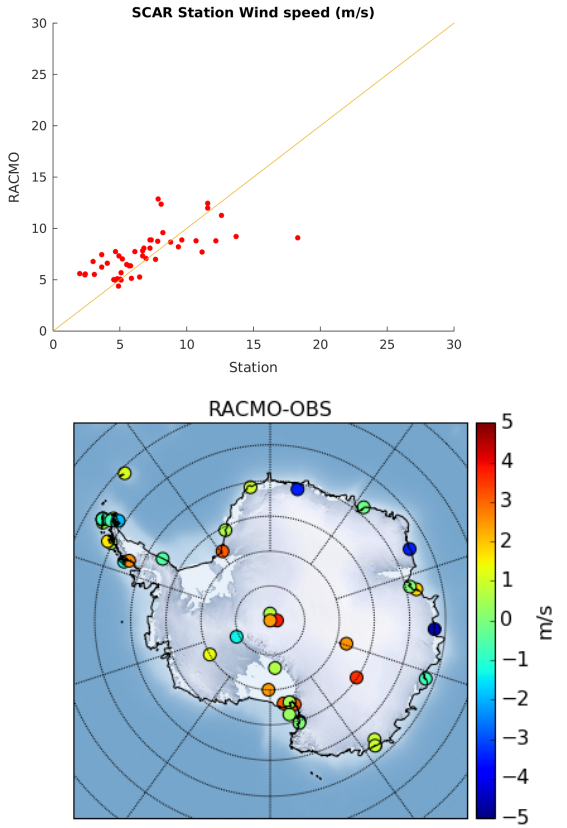
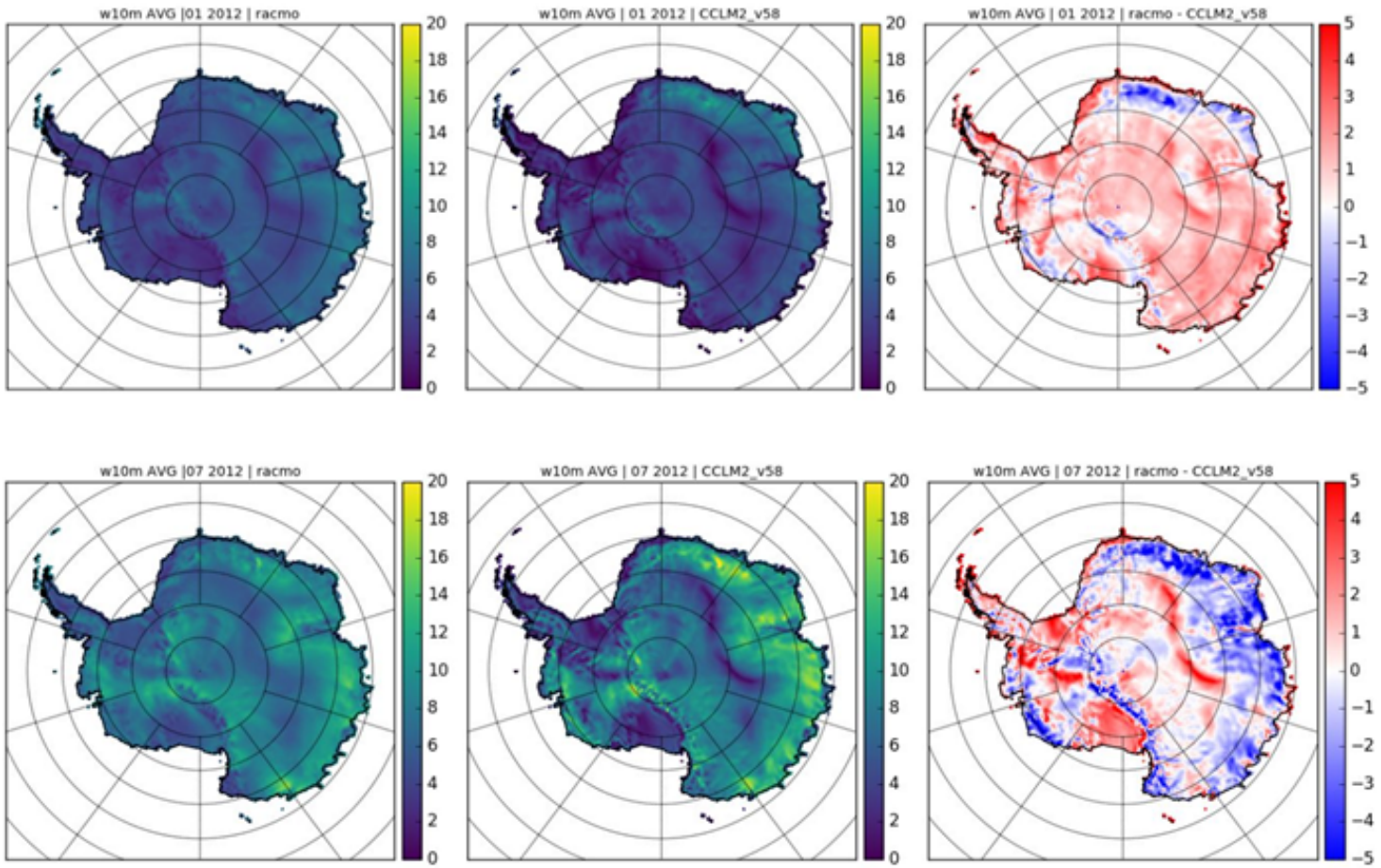


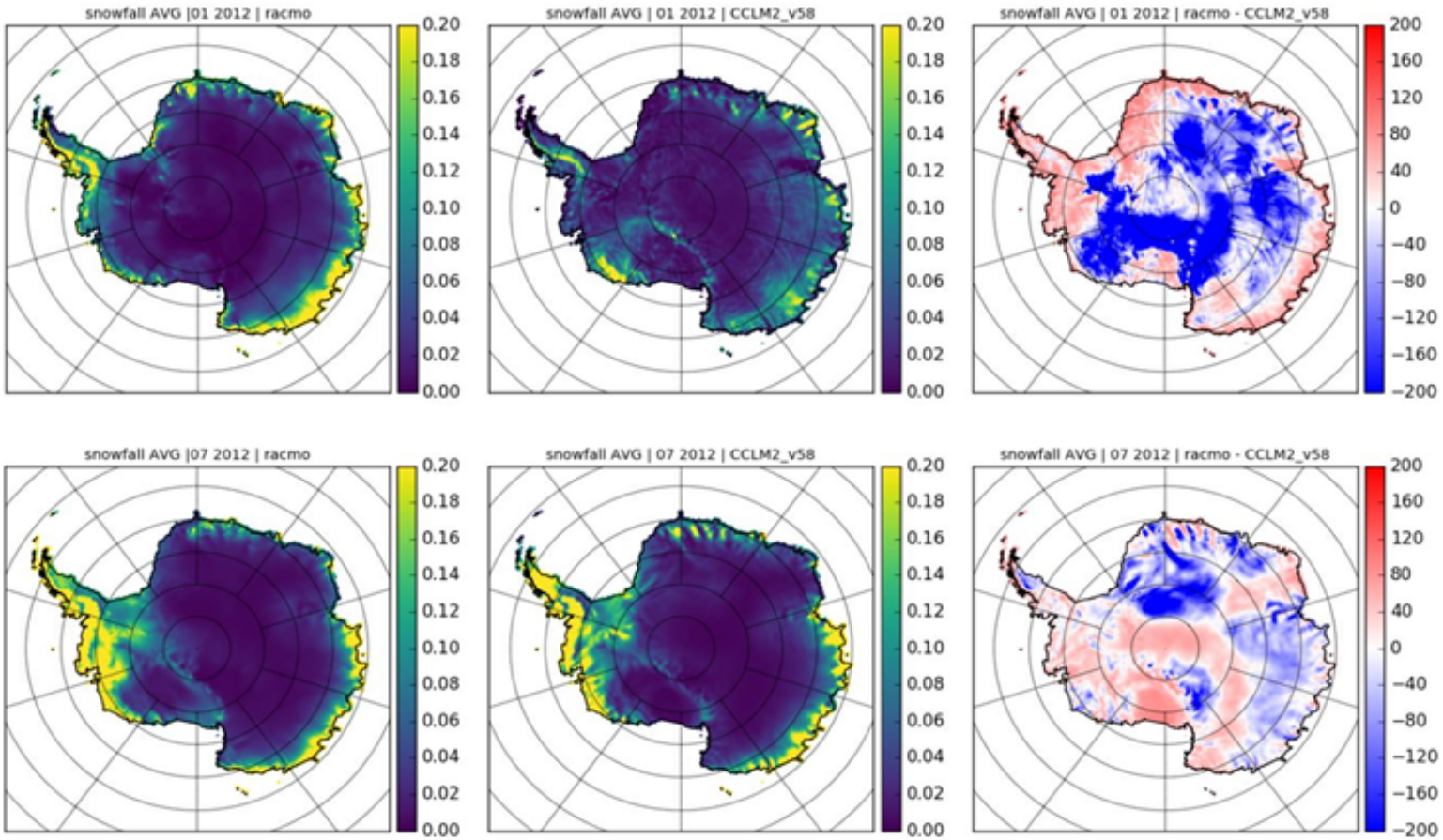
10m wind speed bias

Figure: RACMO versus COSMO (up : January 2012, down : July 2012)



Precipitation bias

Figure: RACMO versus COSMO (up: January 2012, down : July 2012)



Conclusion and future work

- COSMO has been adapted adequately to represent the Antarctic climate
- 30 years run (1983-2017) , contribution to the CORDEX effort - ongoing
- future work
  - nesting over smaller domain, at higher resolution (2.8 km)
  - clouds and aerosols interactions
  - blowing snow scheme

The project website

www.aerocloud.be

References

- Cerenzia, I., Tampieri, F. and Tesini, M.S.: Diagnosis of Turbulence Scheme in Stable Atmospheric Conditions and Sensitivity Tests.COSMO Newsletter 14, 2014.
- Ghosh, S., and Jonas, P.R.: On the application of the classic Kessler and Berry schemes in Large Eddy Simulation models with a particular emphasis on cloud autoconversion, the onset time of precipitation and droplet evaporation. Annales Geophysicae, 16, 5, 628-637, 1998.
- Gierens, K.M., Monier, M., and Gayet, J.F.: The deposition coefficient and its role for cirrus clouds, Journal of Geophysical Research, 108, D2,2003. doi:10,1029/2001JD001558
- Köhler, C.G., and Seifert, A.: Identifying sensitivities for cirrus modelling using a two-moment two-model bulk microphysics scheme, Tellus B: Chemical and Physical Meteorology, 67,1, 24494, 2015. doi:10.3402/tellusb.v67.24494
- Seifert, A., Beheng, K.D.: A two-moment cloud microphysics parameterization for mixed-phase clouds. Part 1: Model description, Meteorology and Atmospheric Physics, 92, 1-2, 45–66, 2008.
- Smeets, C.J.P.P., and van den Broeke, M.R.:Temporal and Spatial Variations of the Aerodynamic Roughness Length in the Ablation Zone of the Greenland Ice Sheet, Boundary-Layer Meteorology, 128, 3, 315-338, 2008.
- Turner, J., Colwell, S.R., Marshall, G.J., Lachlan-Cope, C.A., Carleton, A.M., Jones, P.D., Lagun, V., Reid, P.A., and Iagovkina, S., The SCAR Reader Project: Toward a High-Quality Database of Mean Antarctic Meteorological Observations, Journal of Climate, 17, 2890–2898, 2003. doi:10.1175/1520-0442(2004)017.
- van de Berg, W. and Medley, B: Brief Communication: Upper-air relaxation in RACMO2 significantly improves modelled inter annual surface mass balance in Antarctica, *The Cryosphere*, 10, 459–463, 2016. doi: 10.5194/tc-10-459-2016
- van Kampenhout, L., Lenaerts, J.T.M., Sacks, B., Lawrence, D., Lipscomb, B., Slater, A.and van den Broeke, M.R. Improving the representation of polar snow and firn in the Community Earth System Model, JAMES, in review.
- van Wessem, J.M., Reijmer, C.H., Morlighem, M., Mouginot, J., Rignot, E., Medley, B., Joughin, I., Wouters, B., Depoorter, M.A., Bamber, J.L., Lenaerts, J.T.M., Van De Berg, M.J., Van Den Broeke, M.R., and Van Meijgaard, E: Improved representation of East Antarctic surface mass balance in a regional atmospheric climate model, Journal of Glaciology, 60, 222, 761–770, 2014. doi: 10.3189/2014JoG14J051.