KU LEUVEN

Evaluation of a default COSMO-CLM simulation over Antarctica with a focus on accumulation and the surface mass balance

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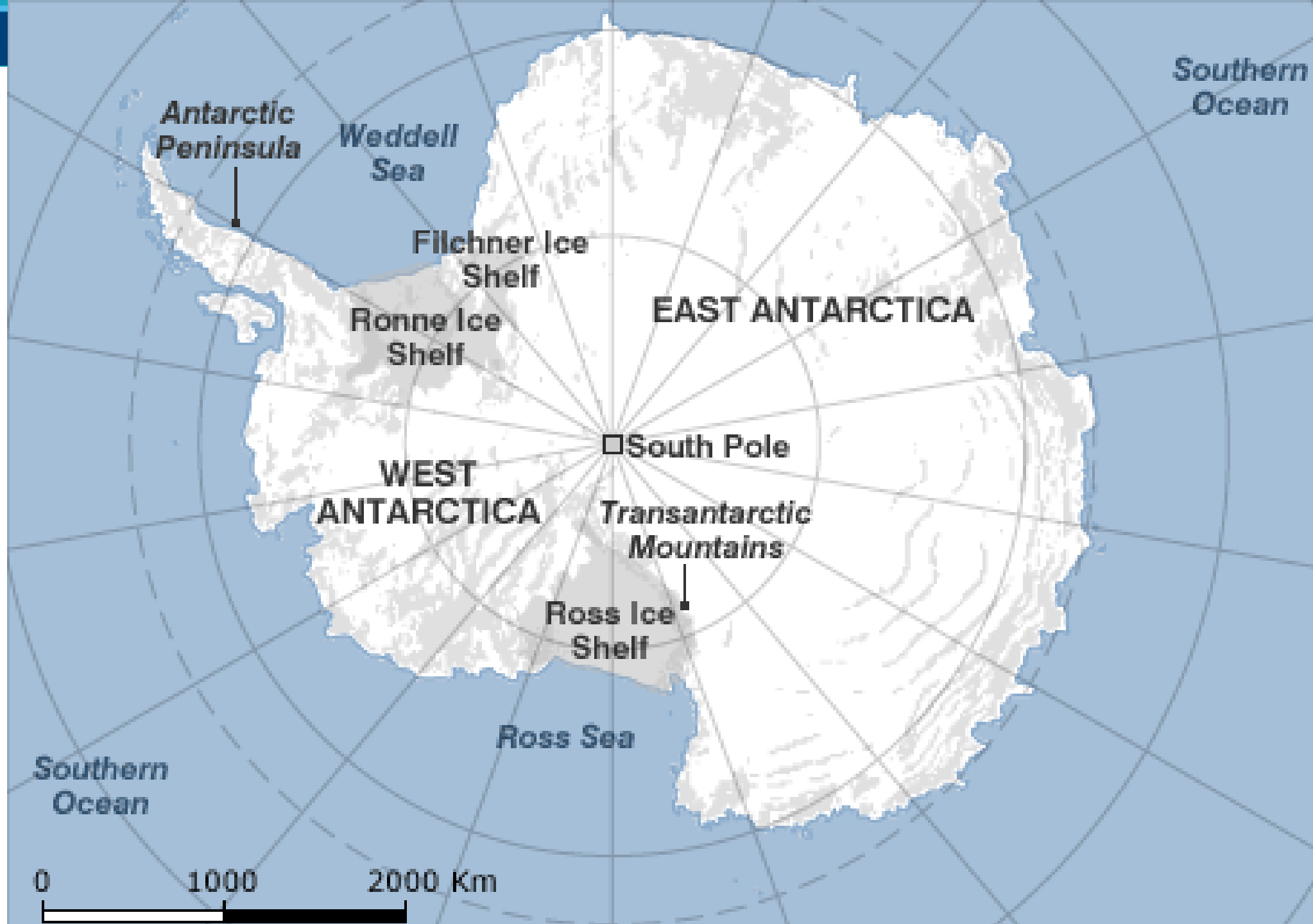


THE AEROCLOUD PROJECT

How do aerosols and clouds affect the East Antarctic climate?

- Antarctic precipitation and clouds representation in climate models remains problematic.
- Precipitation, cloud and aerosol processes are intertwined, only models that correctly represent these processes can give reliable future climate projections.
- Measured boundary layer aerosols should be linked to higher atmospheric levels.

THE AEROCLOUD PROJECT

How do aerosols and clouds affect the East Antarctic climate?

→ Improve the understanding and modeling of precipitation, clouds and their interaction with aerosols in Dronning Maud Land (East Antarctica).

Achieved by using :

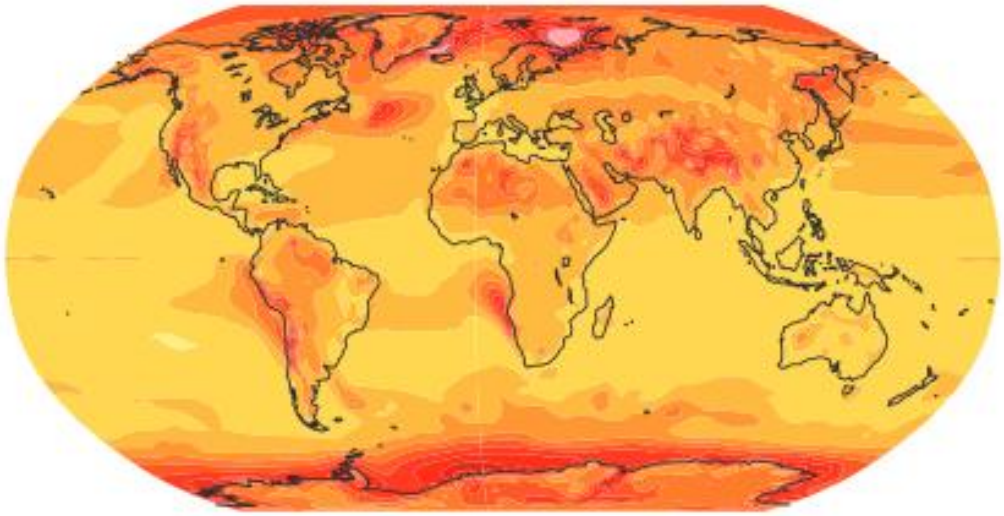
- the observational framework at the Princess Elisabeth station in East Antarctica
- regional climate modeling (COSMO-CCLM²)

The Princess Elisabeth Polar Base, erected on the Utsteinen Ridge (71°57'S - 23°21'E)

INTRODUCTION

- In general, climate models have high biases over Antarctica
- Errors propagate to other regions
- Important to identify the sources of errors
- Current research limited to a few climate models: RACMO, MAR, Polar-WRF
- Little application of COSMO-CLM and COSMO-CLM² over the continent

Mean absolute CMIP5 model ensemble error in annual-mean surface (2 m) air temperature (°C) for the period 1980–2005 with respect to the climatology from ERA-Interim (IPCC AR5 fig 9.2)



→ Use of RCM is preferred in order to identify problems and test adaptations in a specific region

METHODS

- Long-term simulation over the entire continent (extension of the CORDEX-ANT domain) : 0.22° hor. resolution

- Nesting :
  - Dronning maud land
    0.022 ° hor. resolution
  - Roi Baudouin ice shelf
    0.022° hor. resolution

METHODS

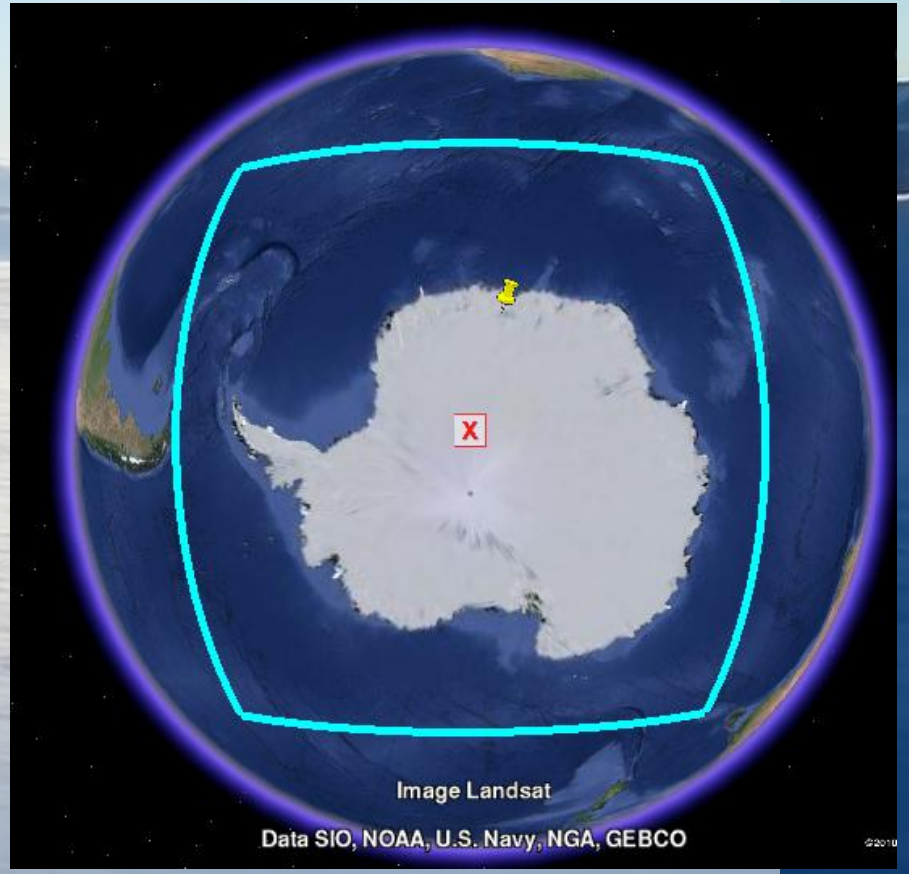
Two simulations over the entire continent (extension of the CORDEX-ANT domain) for the year 2012

COSMO-CLM:

- ERA-Interim
- 3 months spin-up
- COSMO-Terra
- Hor. Resolution 0.22°
- Default settings

COSMO-CLM²

- ERA-Interim
- 3 months spin-up
- coupled to CLM
- Hor. Resolution 0.22°
- Default settings

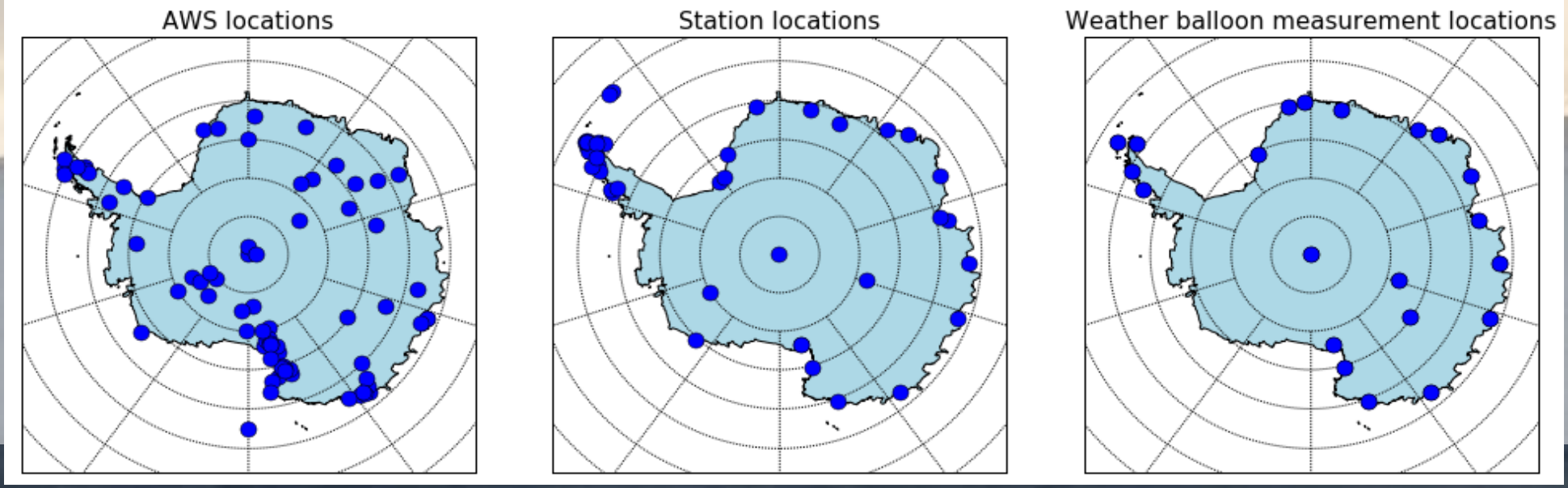


RESULTS:

1) Compare point measurements with nearby pixel in COSMO-CLM(²)

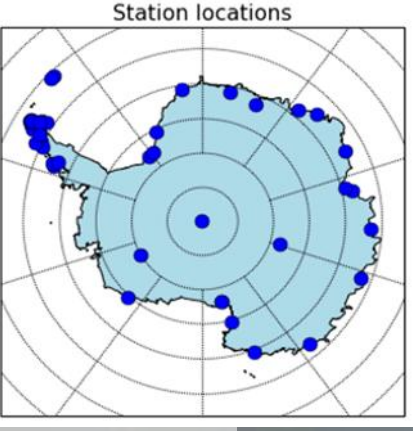
Monthly averages of temperature, pressure and wind speed

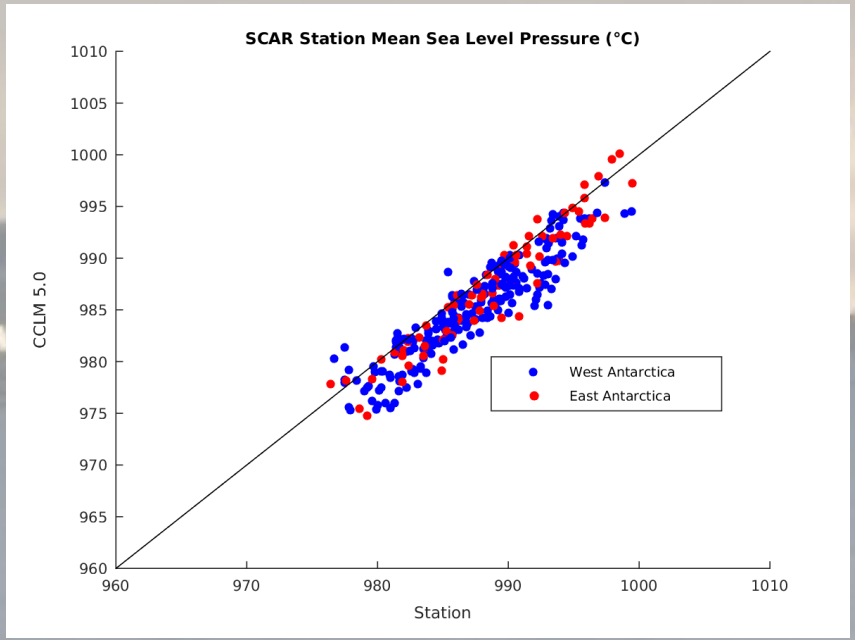
- SCAR READER database (station data, automatic weather stations and weather balloon measurements; Turner et al., 2004)
- Automatic weather stations from IMAU

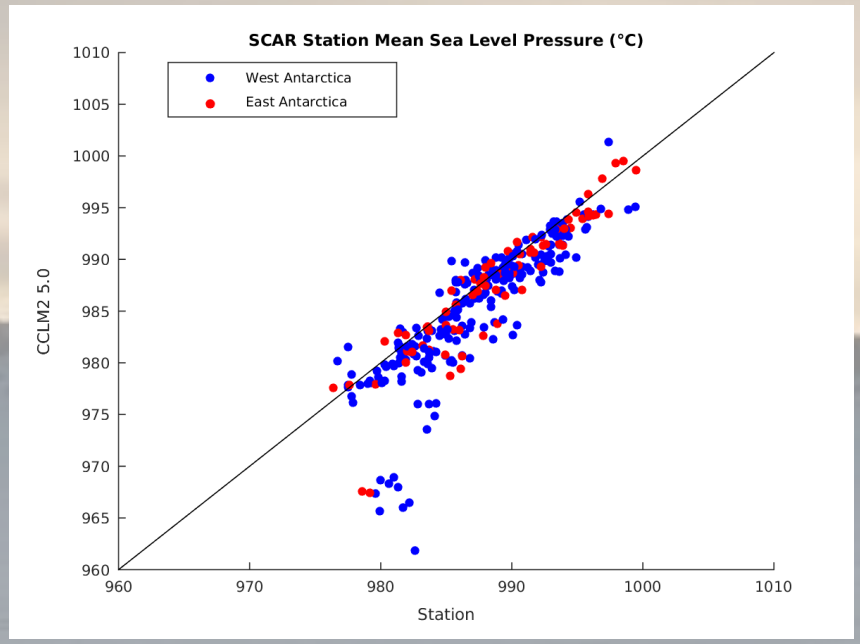


RESULTS

Mean sea level pressure (hPa) :

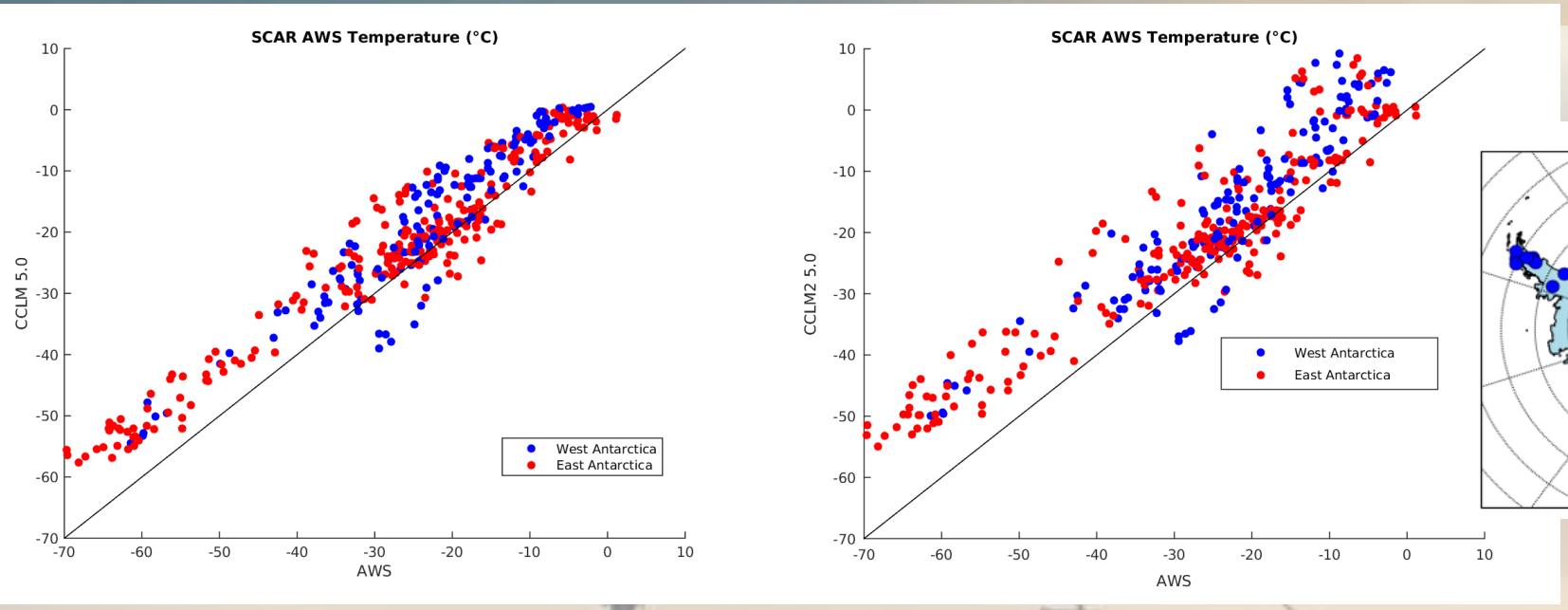


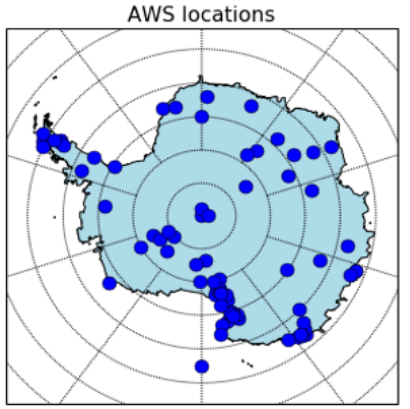


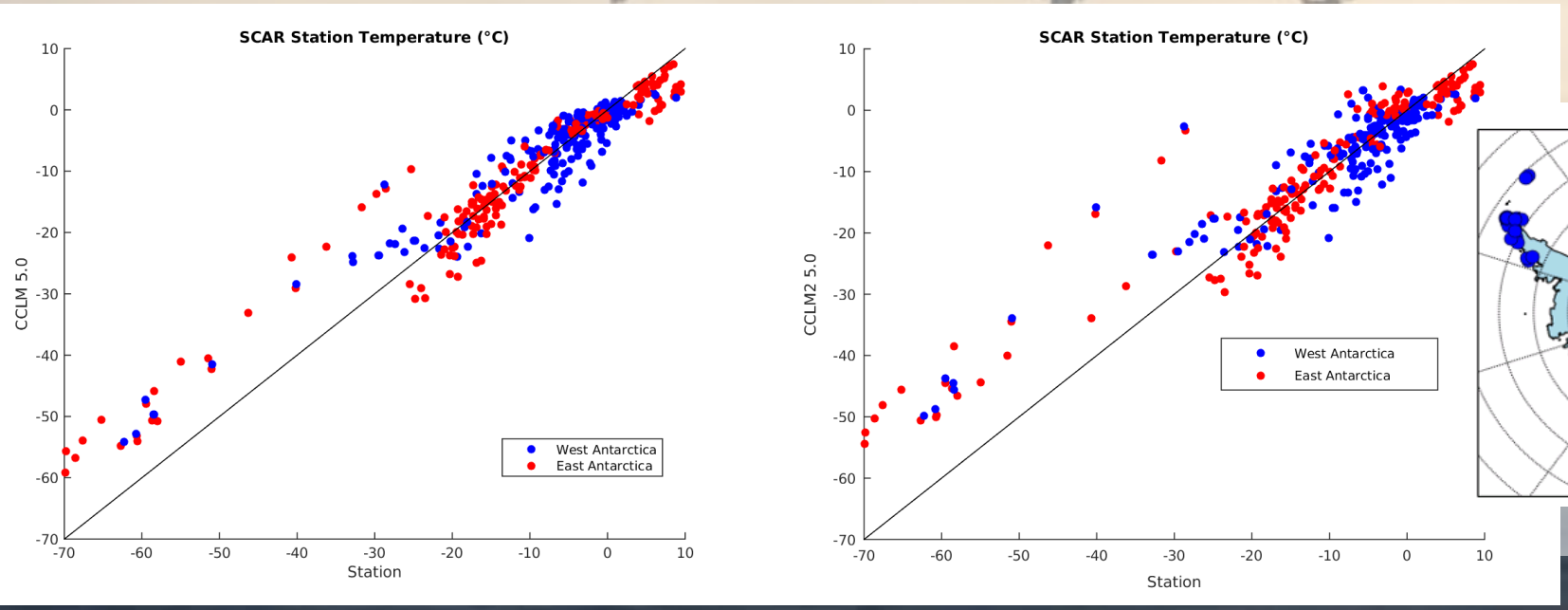


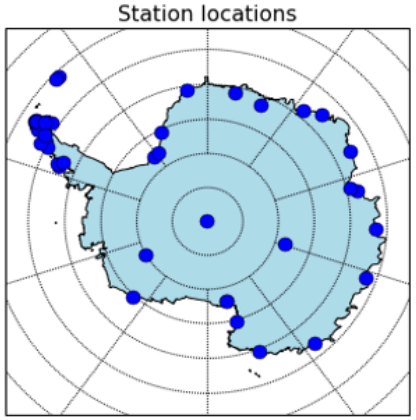
RESULTS

2-meter temperature (ºC)



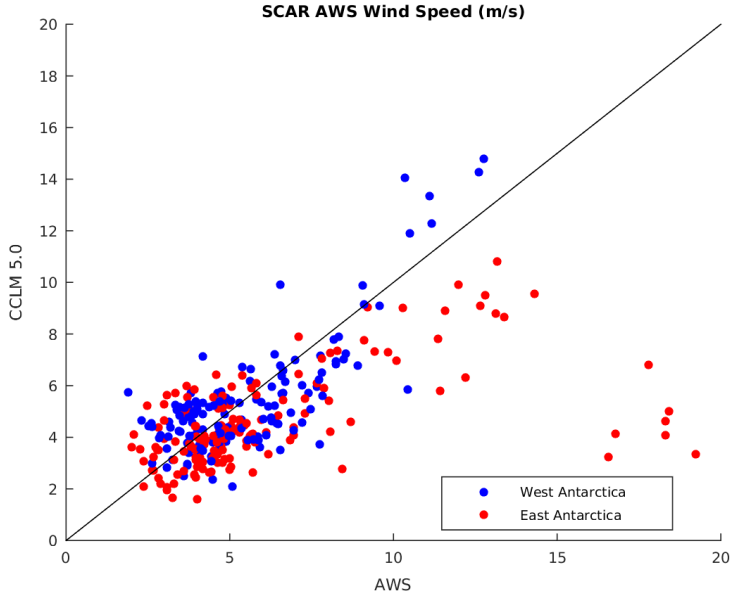


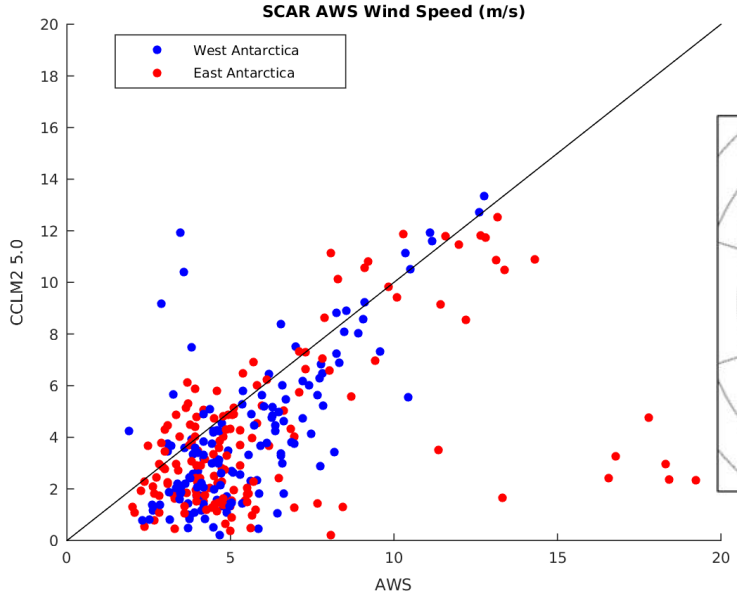


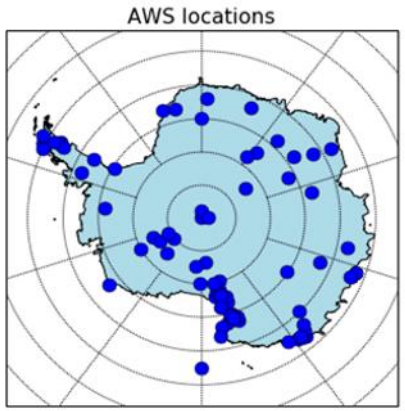


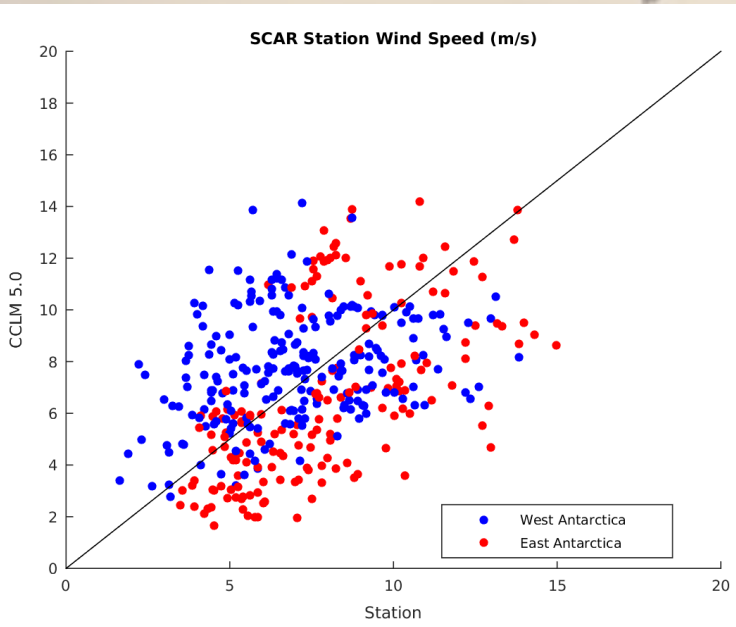
RESULTS

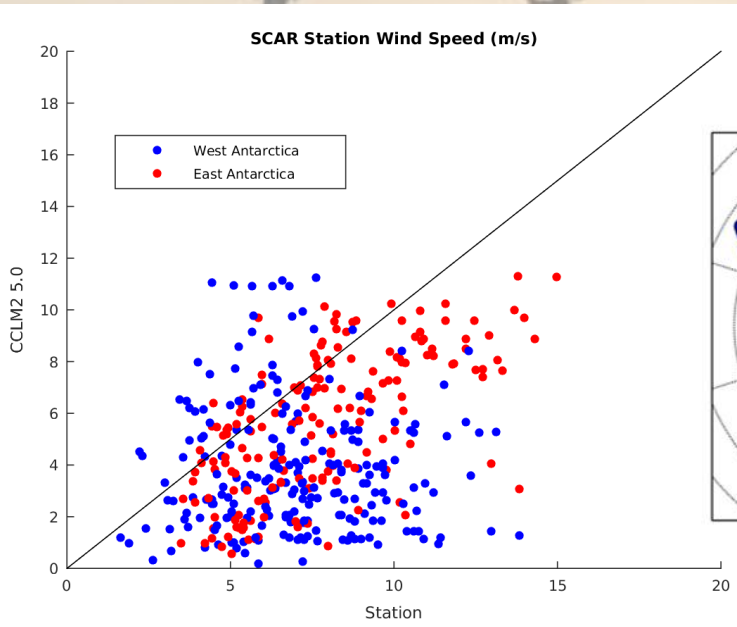
10 meter wind speed (m/s)

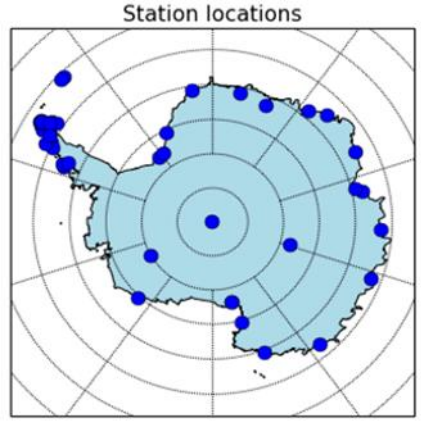






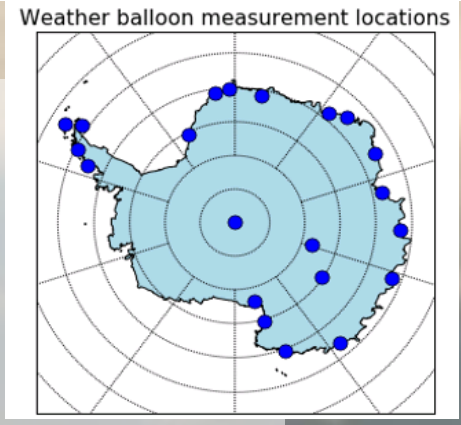


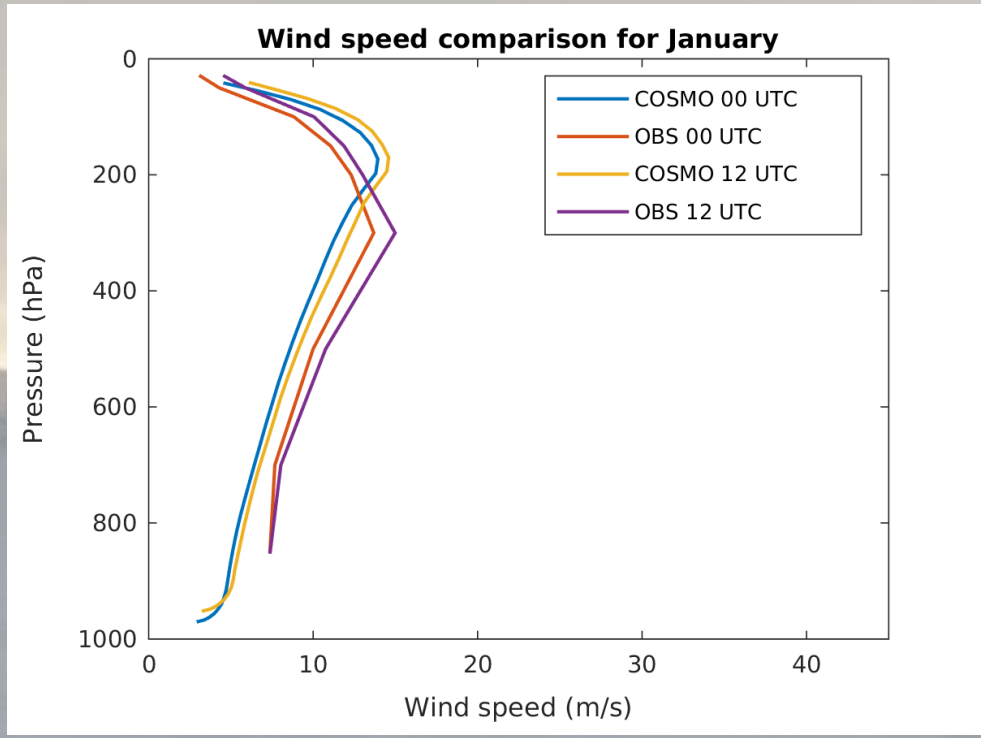


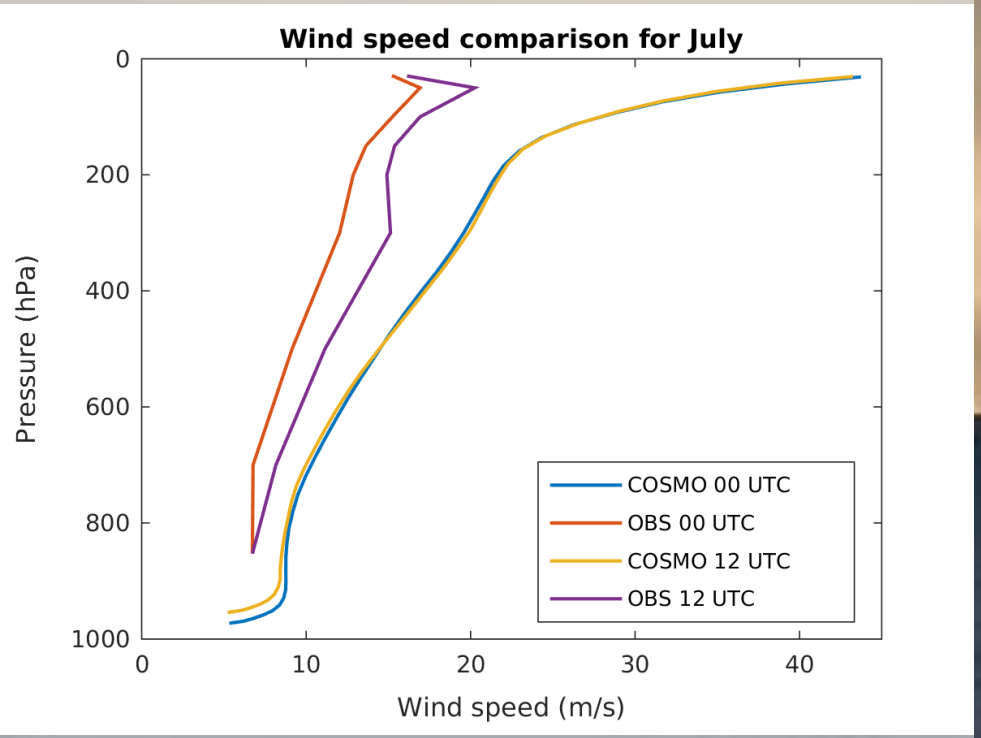


RESULTS

Upper level wind speed (m/s)

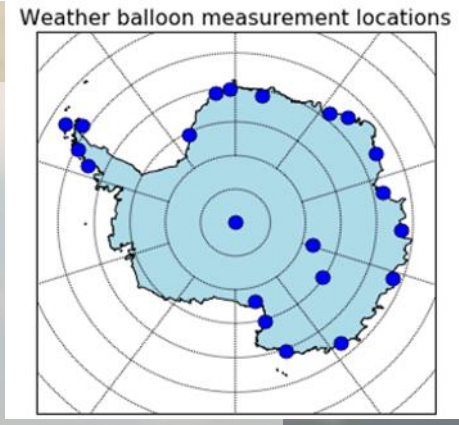


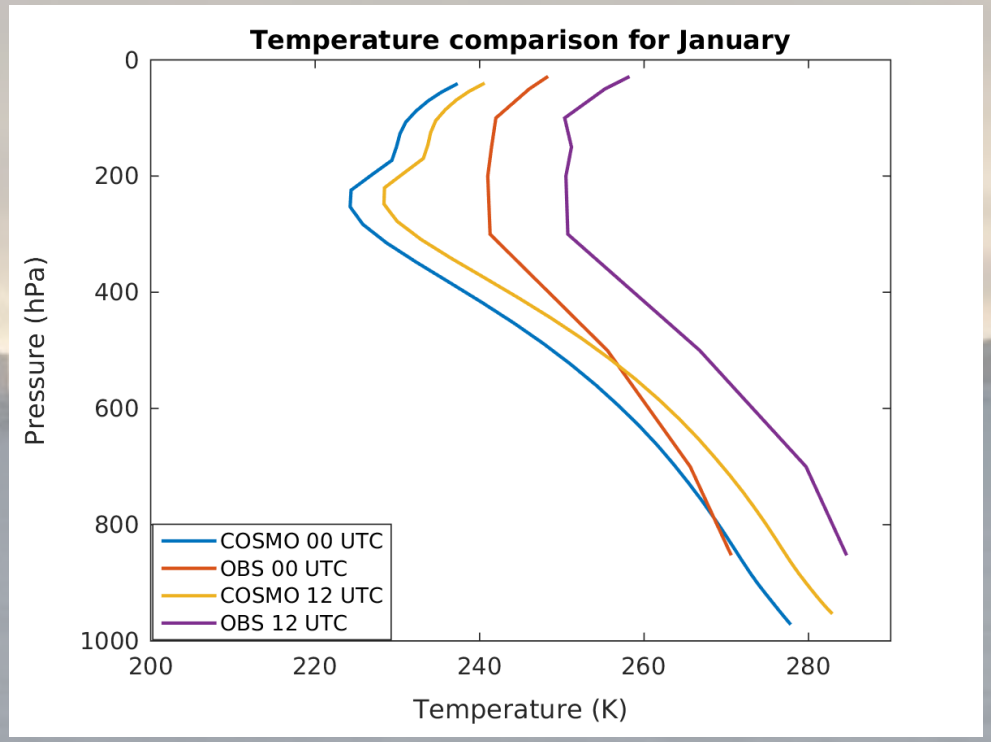


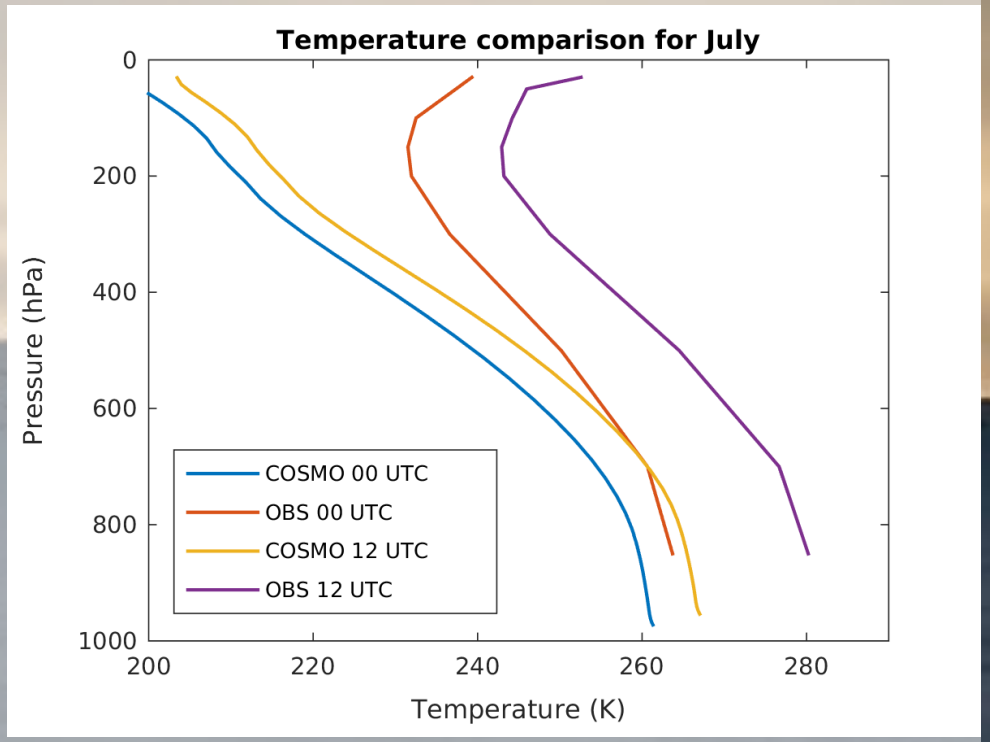


RESULTS

Upper level temperature (K)







RESULTS

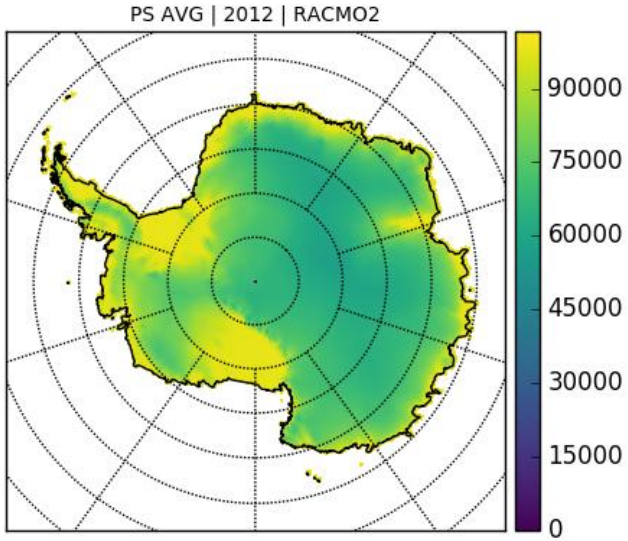
2) Compare COSMO-CLM, COSMO-CLM² and RACMO2

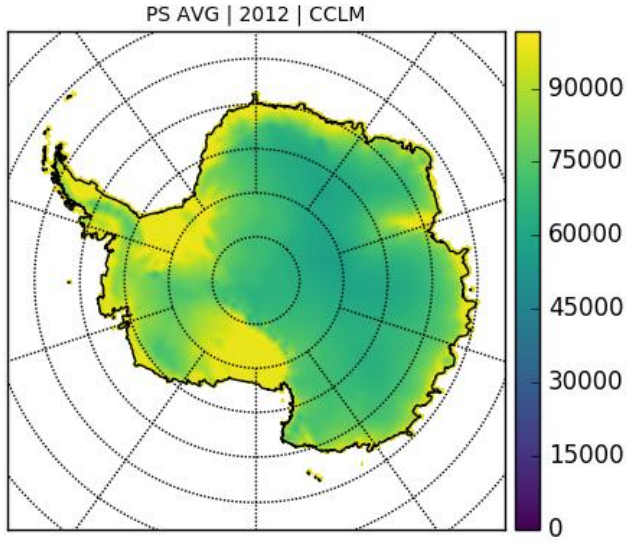
RACMO2 (Regional Atmospheric Climate Model; Van Wessem et al., 2014a)

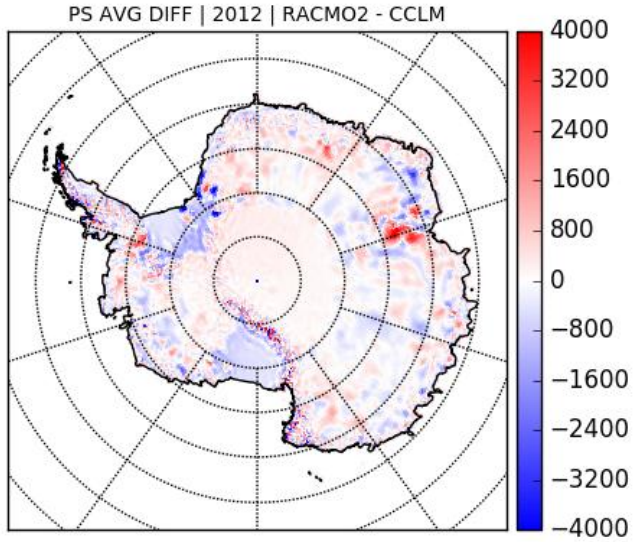
- Extensively evaluated over Antarctica (e.g. Van Lipzig et al., 1998; Sanz Rodrigo et al., 2013)
- Several improvements to model specifications have been executed (e.g. Reijmer et al., 2005; Van Wessem et al., 2014b)
- Long term historical and future simulations available at a horizontal resolution of 27 and 50 km using ERA-Interim as boundary conditions
- The year 2012 was extracted

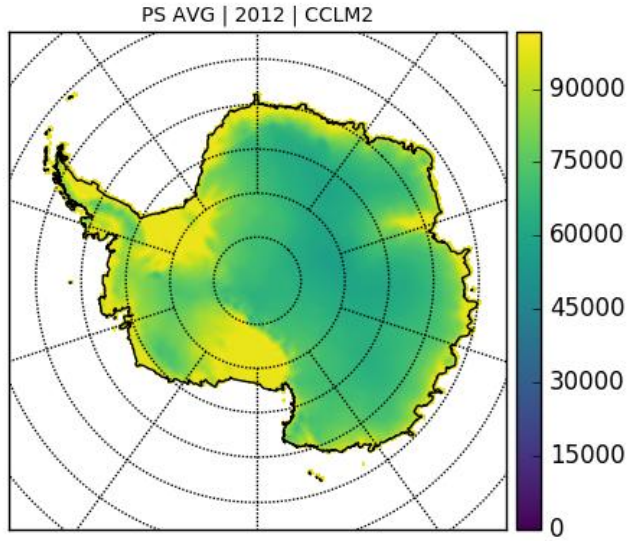
RESULTS

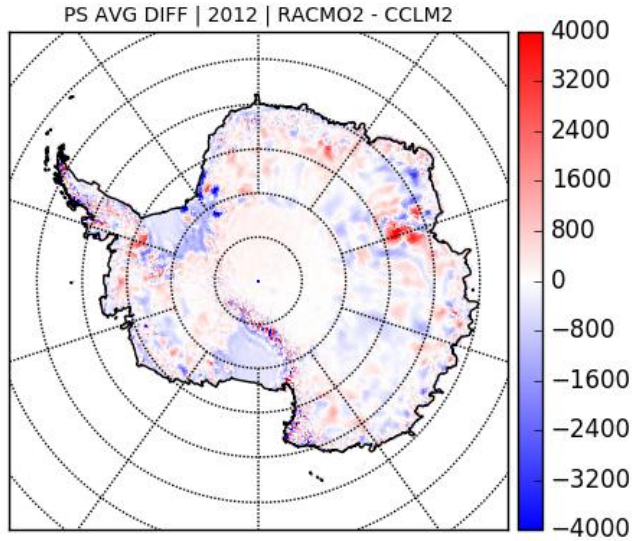
Surface pressure (Pa)





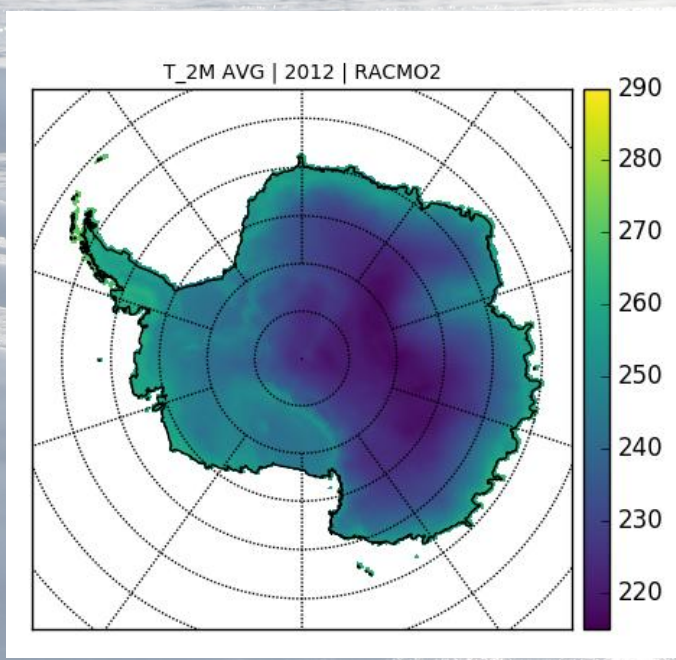


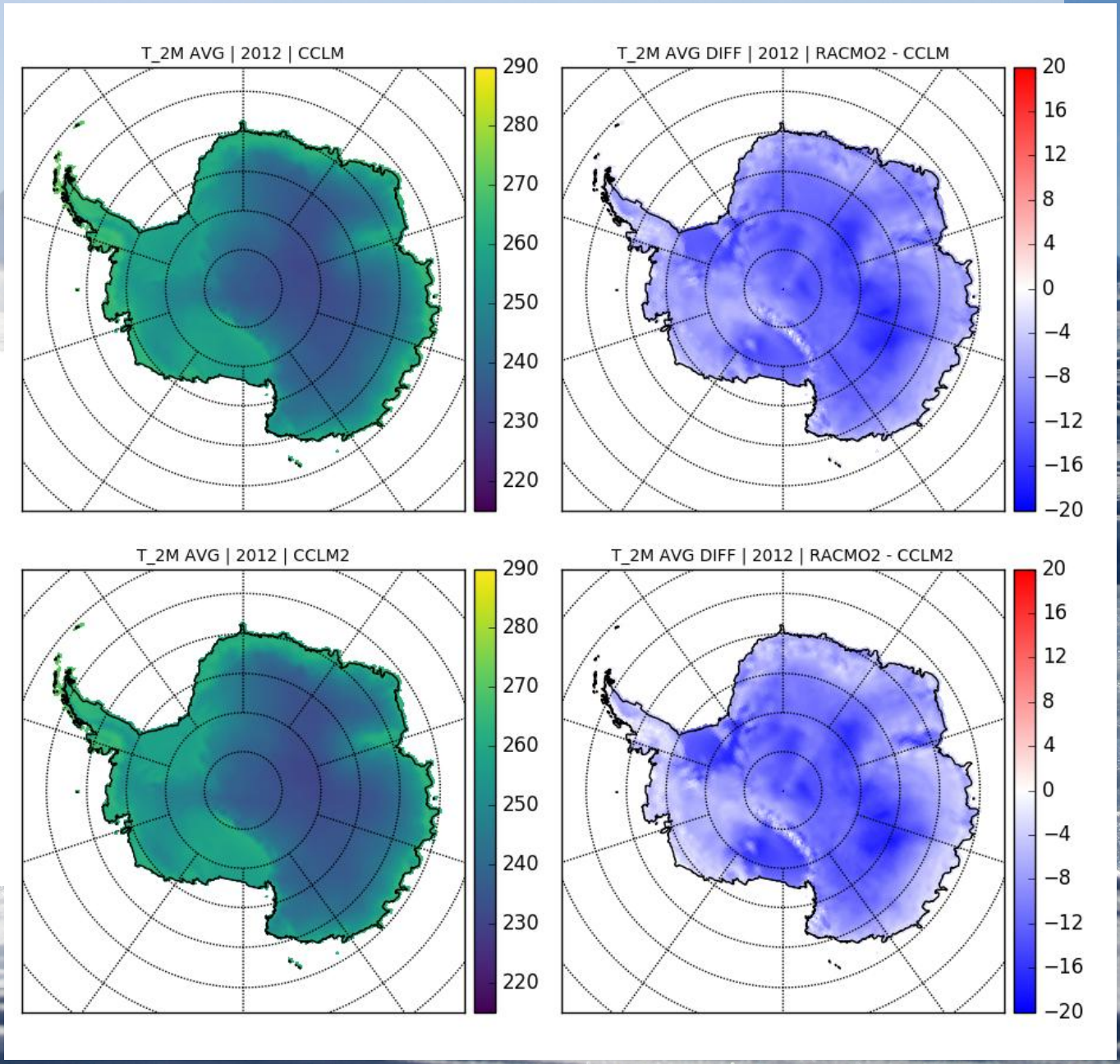




RESULTS

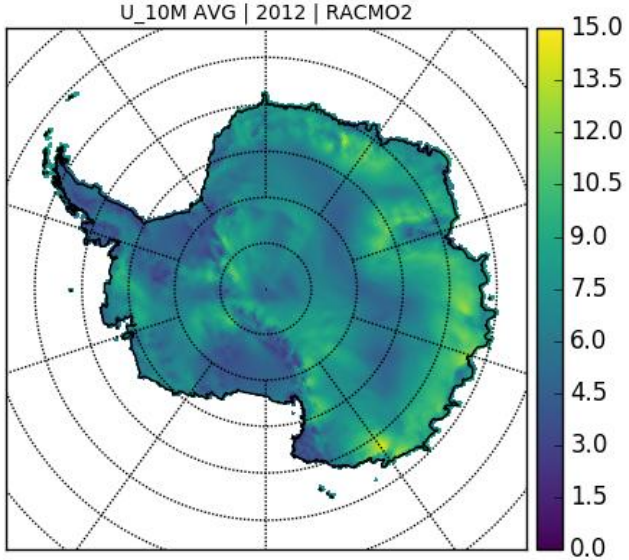
2-meter Temperature (K)

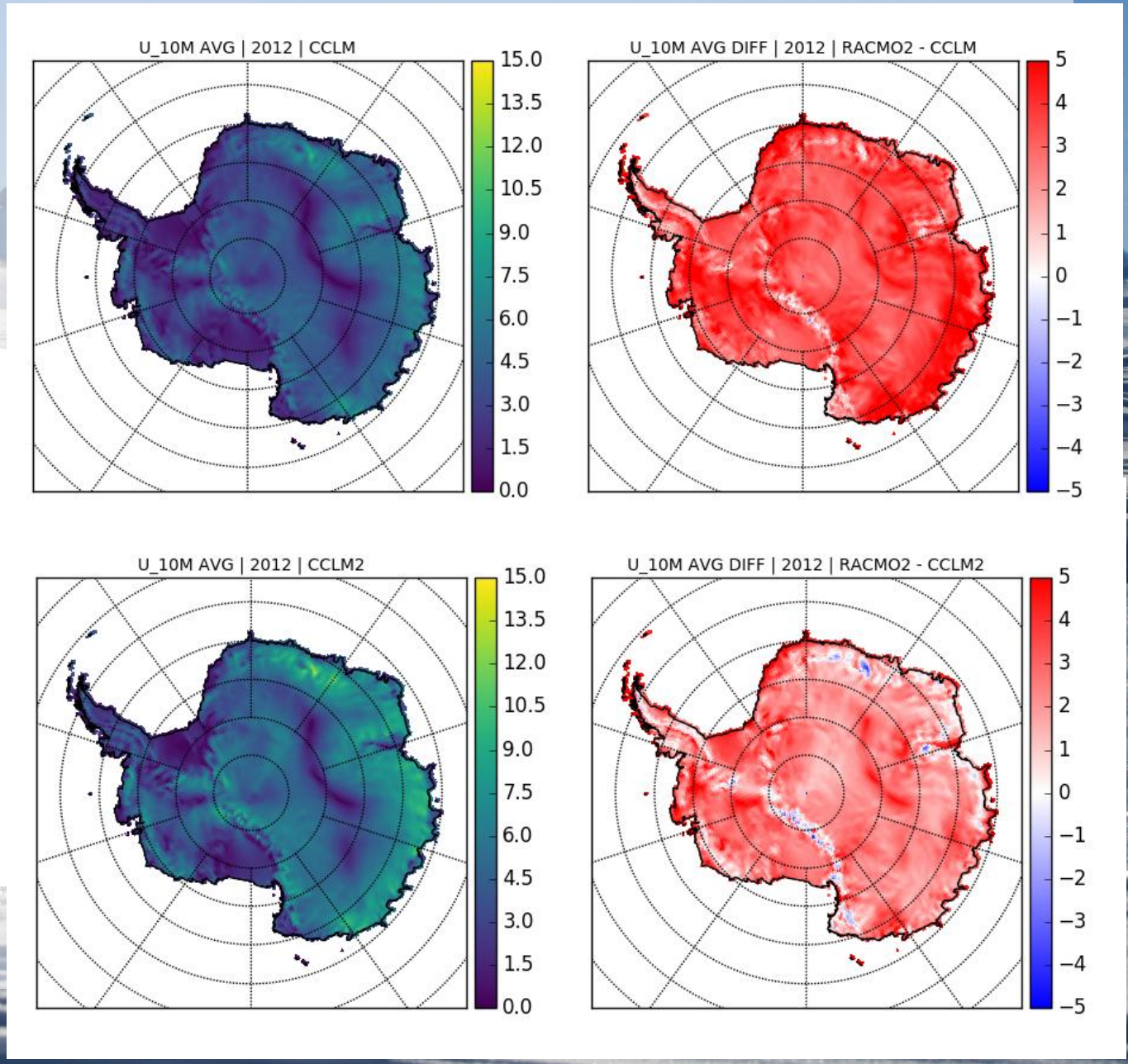




RESULTS

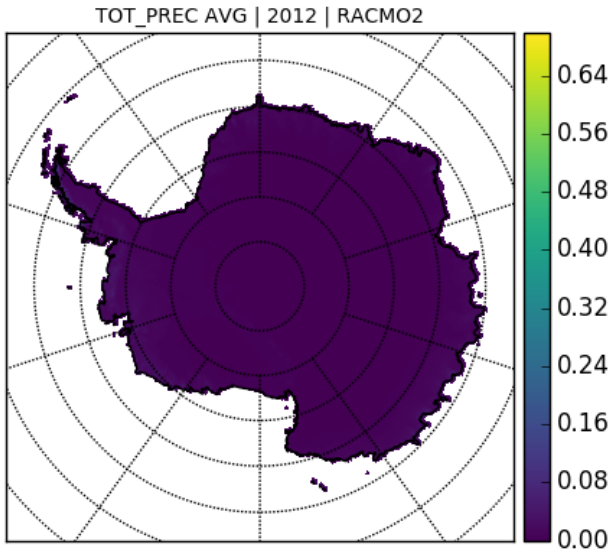
10 meter wind speed (m/s)

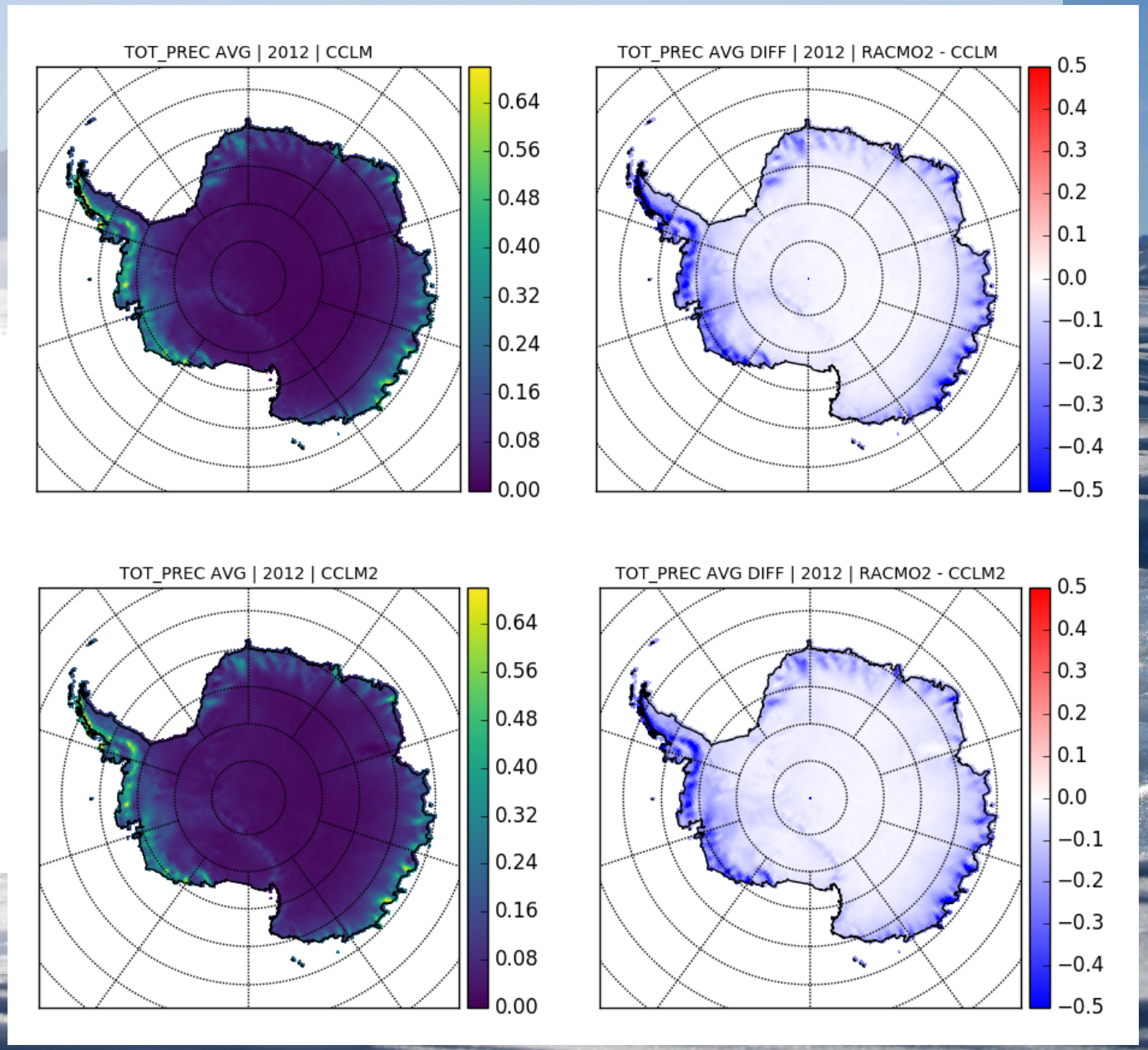




RESULTS

Monthly average precipitation (mm w.e.)



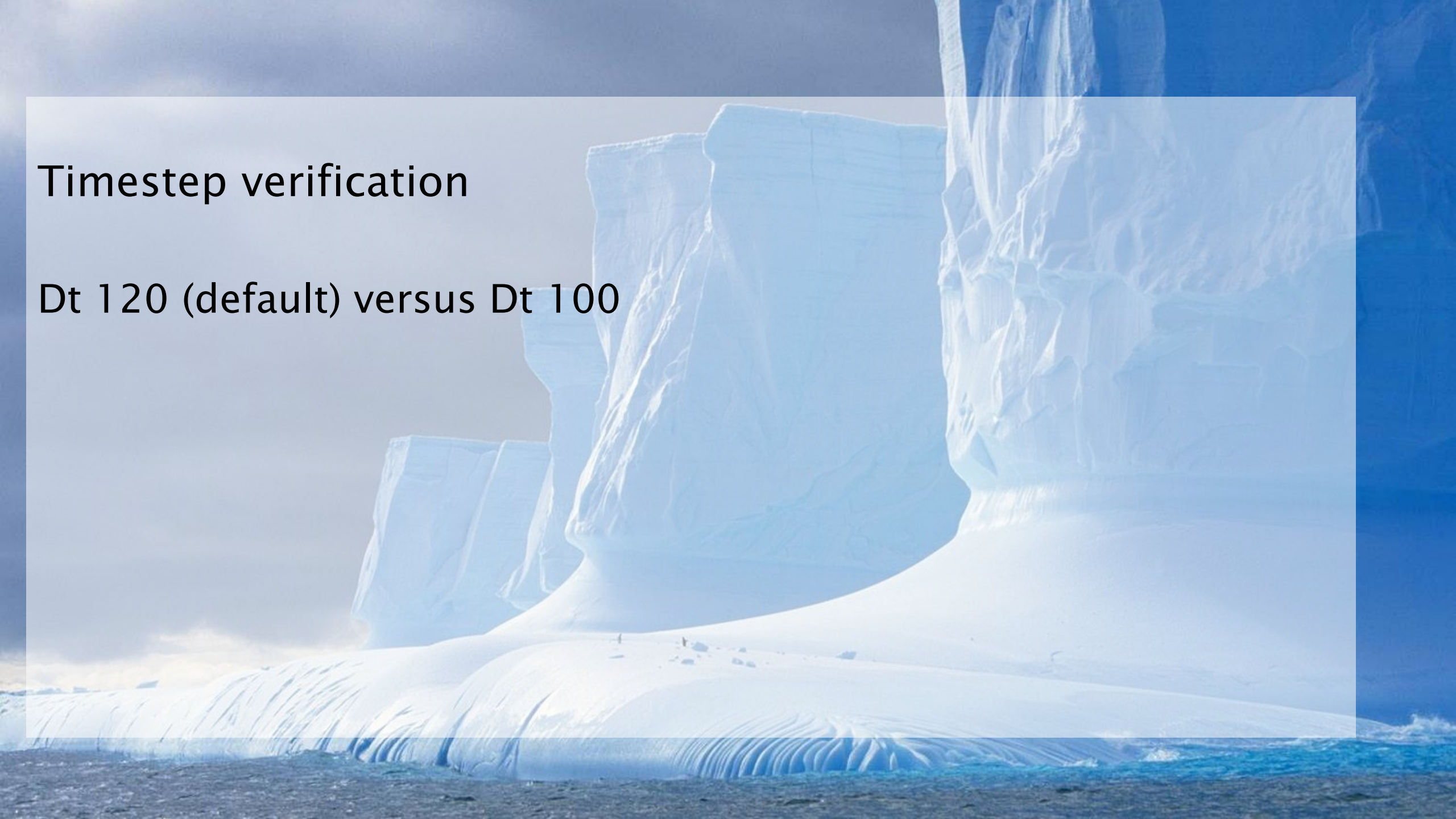


CONCLUSIONS

- Technically possible to run over Antarctica
- CCLM(²) is not yet able to represent the basic climatology of Antarctica
- Ideas for improvements:
  - Vertical resolution in higher troposphere and ozone
  - DEM
  - Albedo
  - Roughness length
  - Other ideas?
- Future work
  - Higher resolution simulations

References

- Reijmer, C. H., van Meijgaard, E., van den Broeke, M. R., 2005. Evaluation of temperature and wind over Antarctica in a Regional Atmospheric Climate Model using 1 year of automatic weather station data and upper air observations, Journal of Geophysical Research 110, D04103.
- Sanz Rodrigo, J., Buchlin, J. M., van Beeck, J., Lenaerts, J. T. M., van den Broeke, M. R., 2013. Evaluation of the antarctic surface wind climate from ERA reanalyses and RACMO2/ANT simulations based on automatic weather stations, Climate Dynamics 40, 353–378.
- Turner, J., Colwell, S. R., Marshall, G. J., Lachlan-Cope, T. A., Carleton, A. M., Jones, P. D., Lagun, V., Reid, P. A., Iagovkina, S., 2004. The SCAR READER project: Toward a high-quality database of mean Antarctic meteorological observations. Journal of Climate 17, 2890–2898.
- Van Lipzig, N.P.M., van Meijgaard, E., Oerlemans, J, 1998. Evaluation of a Regional Atmospheric Model for January 1993, Using In Situ Measurements from the Antarctic, Annals of Glaciology 27, 507–514.
- Van Wessem J.M., C.H. Reijmer, M. Morlighem, J.Mouginot, E.Rignot, B.Medley, I.Joughin, B. Wouters, M.A. Depoorter, J.L. Bamber, J.T.M. Lenaerts, W.J. Van Den Berg, M.R. Van den Broeke and E. Van Meijgaard, 2014a. Improved representation of East Antarctic surface mass balance in a regional atmospheric model, Journal of Glaciology, 60 (222), 761–770.
- Van Wessem, J. M., Reijmer, C. H., Lenaerts, J. T. M., Van De Berg, W. J., Van Den Broeke, M. R., Van Meijgaard, E., 2014b. Updated cloud physics in a regional atmospheric climate model improves the modelled surface energy balance of Antarctica. The Cryosphere 8, 125–135.
- IPCC, 2014: Evaluation of Climate Models. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

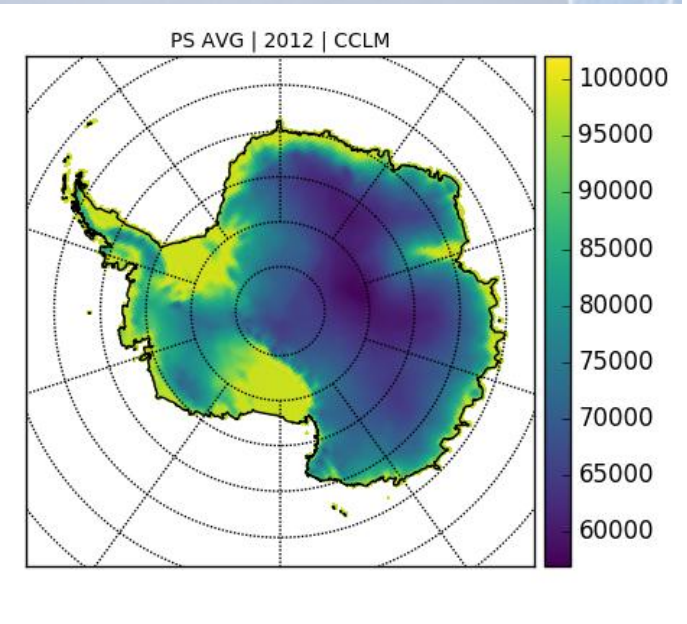


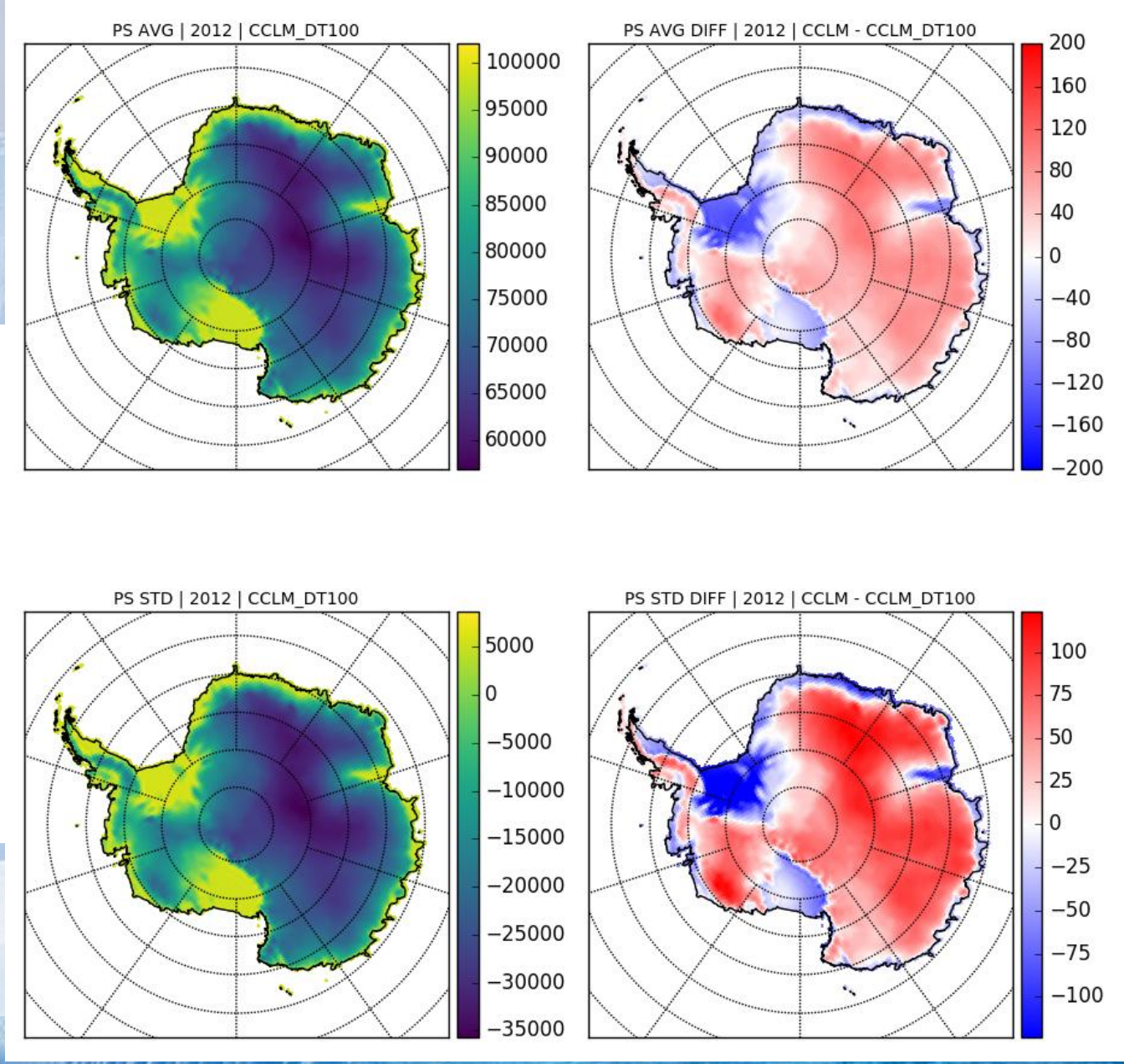
Timestep verification

Dt 120 (default) versus Dt 100

RESULTS

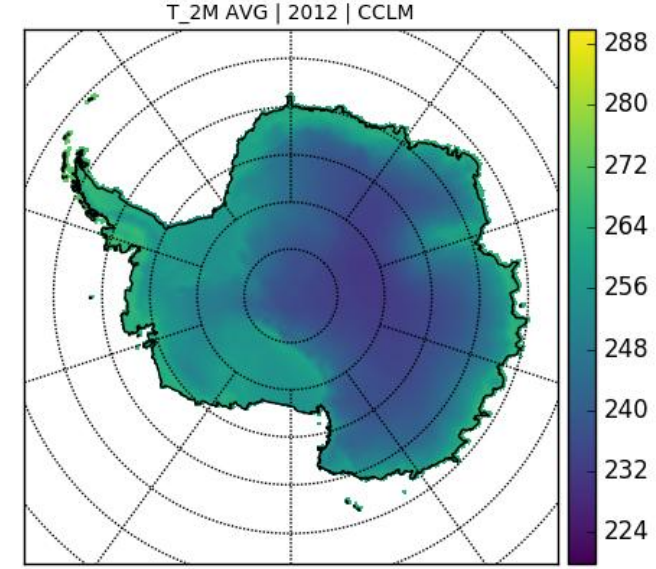
Surface pressure (Pa)

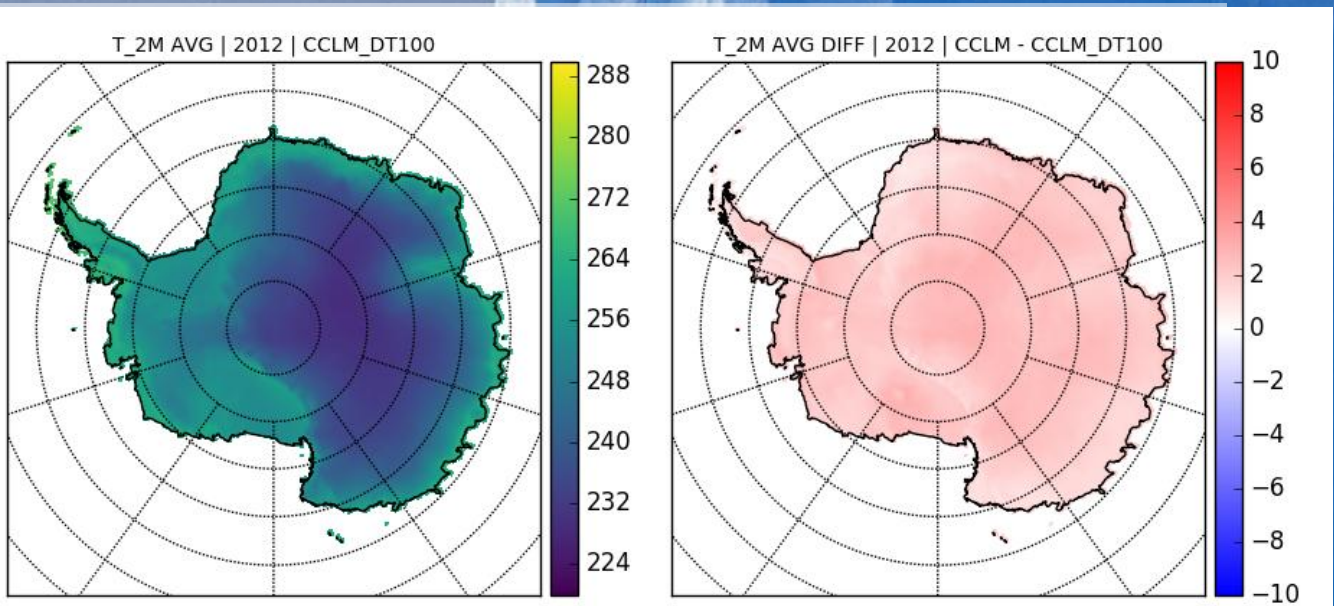


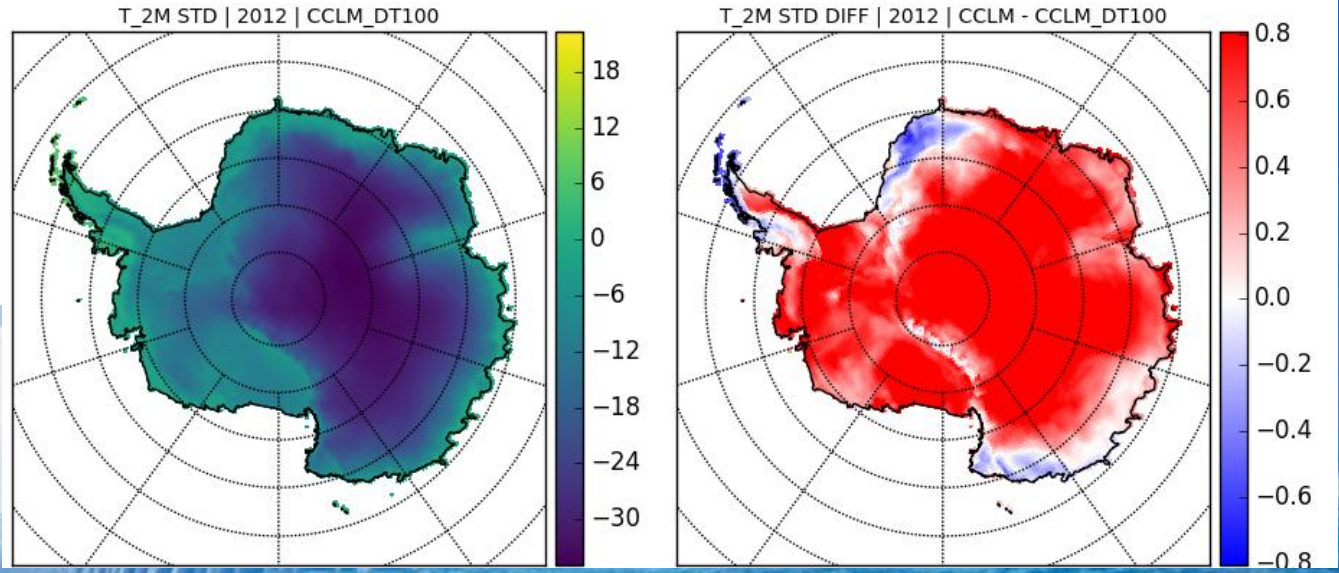


RESULTS

2-meter Temperature (K)

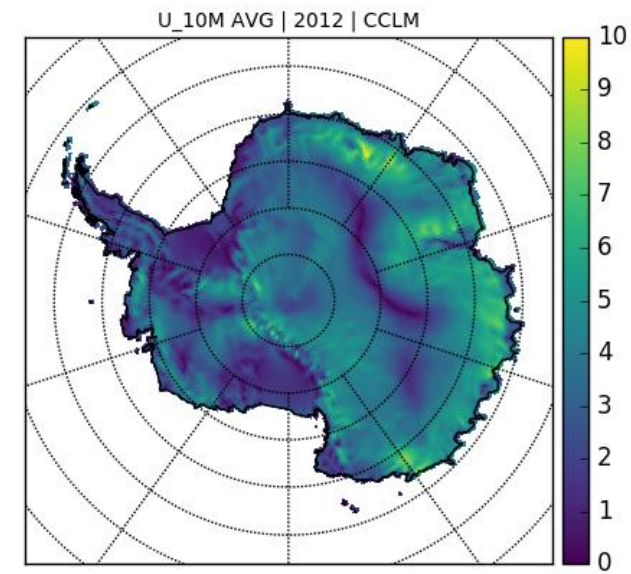


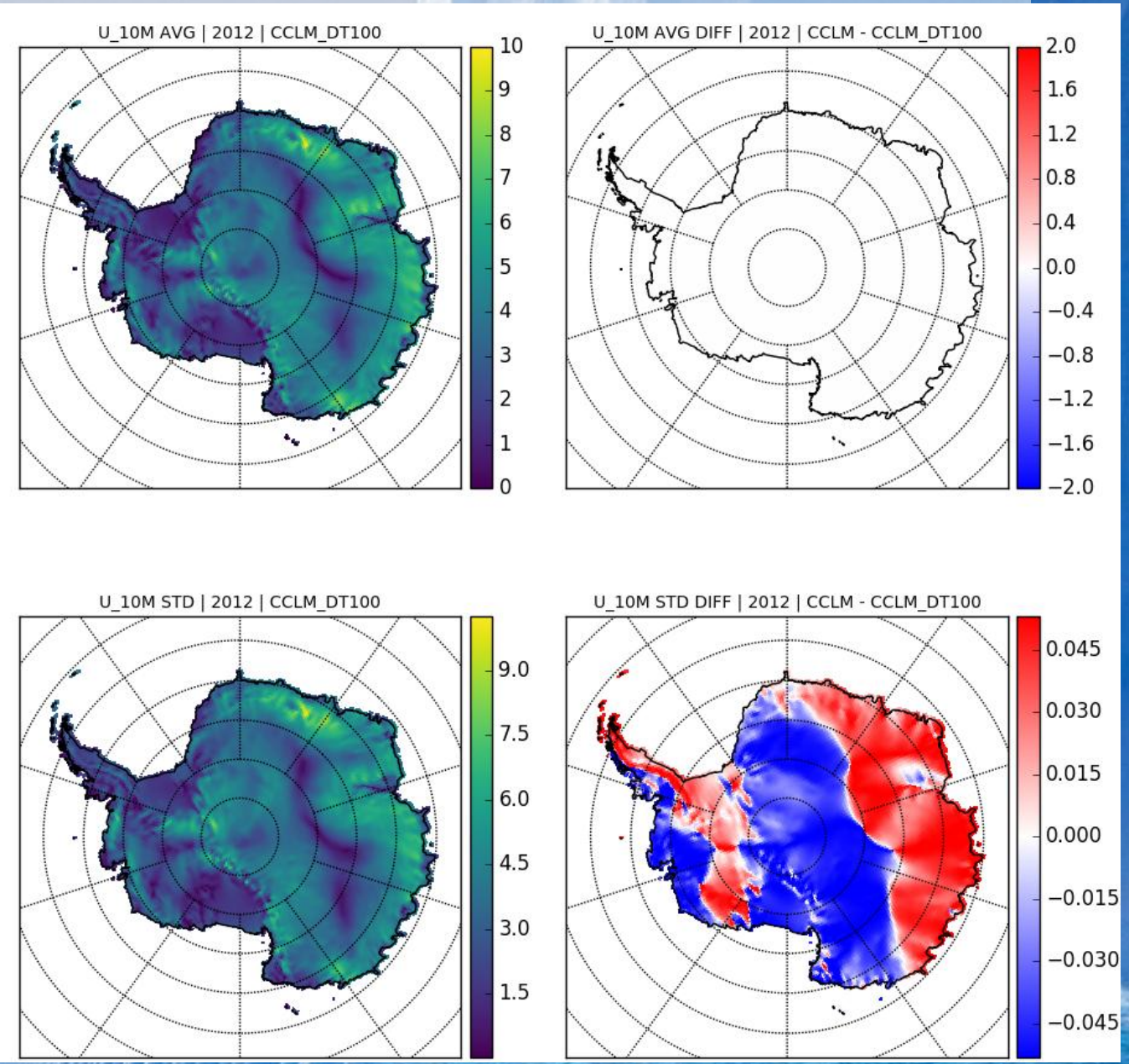




RESULTS

10 meter wind speed (m/s)





RESULTS

Monthly average precipitation (mm w.e.)