Atmospheric rivers and anomalous snow accumulation in East Antarctica: case study using regional climate model COSMO-CLM

Irina Gorodetskaya[1*], Niels Souverijns[1], Andrew Ferrone[2], Kristina Trusilova[3] and Nicole van Lipzig[1]

[1]Katholieke Universiteit Leuven, Dept Earth & Env Sci, Belgium;
[2]Luxembourg Institute of Science and Technology, Env Research and Innovation Dept., Luxembourg
[3]Deutscher Wetterdienst, Dept of Climate and Env Consultancy, Germany

*Contact: Irina.Gorodetskaya@ees.kuleuven.be

Introduction

A few strong snowfall events over Dronning Maud Land (DML) in 2009 and 2011 have been responsible for an **anomalously high mass load over the East Antarctica** counterbalancing the negative total mass trend over the Antarctic ice sheet (Boening et al. 2012, King et al. 2012).

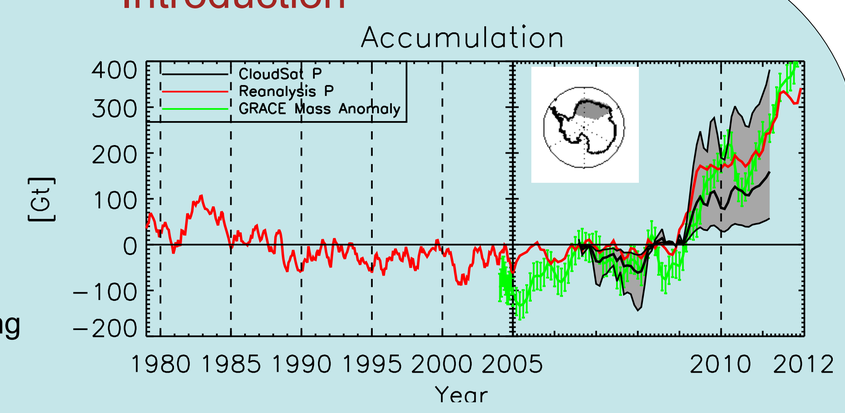

Figure 1 (Boening et al 2012): GRACE mass average over 30W-60E, 65S-80S; Integrated net precipitation (ERA-Interim); CloudSat accumulated snowfall

Using the data from Princess Elisabeth observatory, these extreme snowfalls have been attributed to the atmospheric rivers reaching DML (Fig. 2a). One of these AR cases is shown in Fig. 2b – a narrow long band of enhanced integrated water vapor and strong meridional moisture transport reaching DML coast on 15 February 2011.

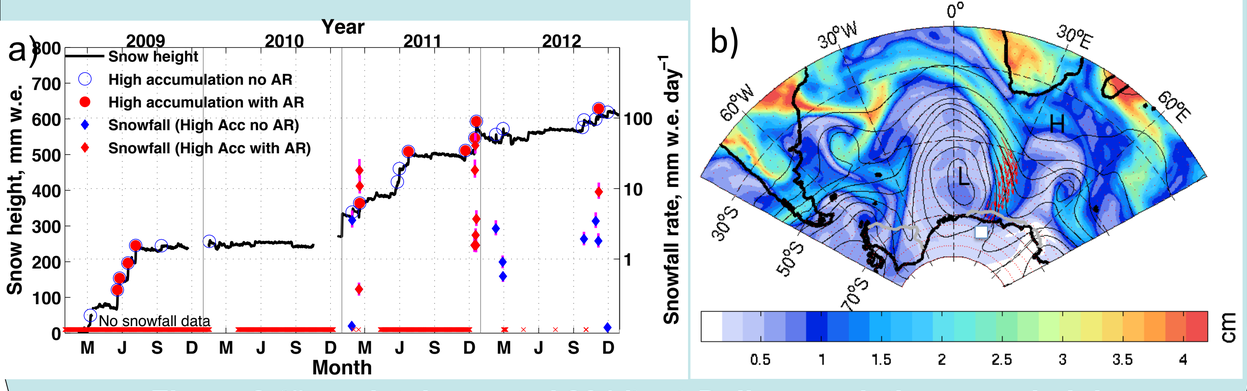

***Figure 2 (Gorodetskaya et al 2014): a) Daily cumulative snow height change and MRR-based snowfall rates measured at PE, b) integrated water vapor* (colors) and total integrated moisture transport (red arrows) showing the AR influencing DML on 15 Feb 2011.**

Methodology

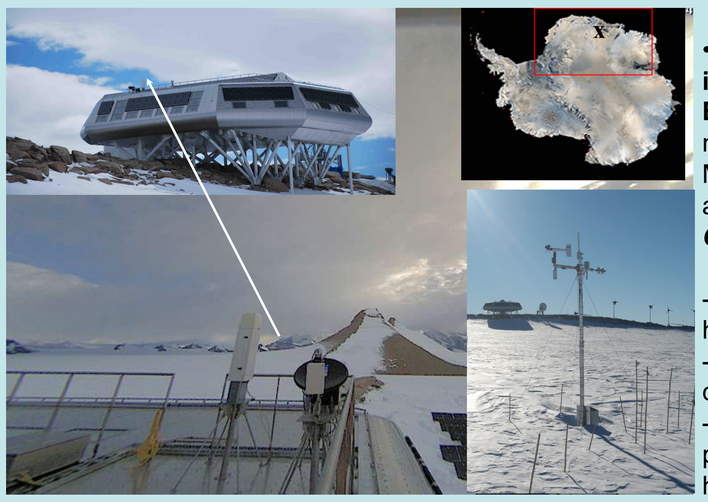

Figure 3: Remote sensing instruments and Automatic Weather station at Princess Elisabeth base

I. DATA:

- The **cloud/precipitation remote sensing instruments** are located on the roof of **Princess Elisabeth (PE) base**, north of Sør Rondane mountains, in the escarpment zone of Dronning Maud Land, East Antarctica (72ºS, 23ºE, 1.4km asl) (http://ees.kuleuven.be/hydrant ***Gorodetskaya et al 2015***):

- **910nm ceilometer**=> vertical backscatter, cloud height and ice/liquid distinction.
- **Infra-red pyrometer** (8-13 μm) => effective cloud base temperature
- **Micro-Rain Radar** (MRR, 24GHz vertically pointing radar; 100m vertical resolution, max 3km height) => vertical profiles of Ze, Doppler velocity and spectral width (***Maahn et al 2012***)
- **Automatic Weather Station** (AWS) 300 m east of PE base provides hourly meteorology, radiative fluxes and snow accumulation (***Gorodetskaya et al. 2013; Thiery et al 2012***).

II. MODEL: Regional climate model CCLM 5.0 (COSMO model in climate mode)

Domain: Dronning Maud Land and adjacent Southern Ocean
Horiz. Res: 0.44º (~50 km); domain size: 100x100 grid points
Run length: one month (February 2011)
Forcing: ERA-Interim (ECMWF IFS model-reanalysis)

- Runge-Kutta dynamical core (more stable integrations in mountainous terrain with steeper slopes)
- Grid-scale precipitation scheme computes the effects of precipitation formation on temperature and the prognostic moisture variables in the atmosphere (water vapour, cloud water, optionally cloud ice, rain, snow and graupel) as well as the precipitation fluxes of grid-scale rain and snow at the ground (lgsp = .TRUE)
- Cloud microphysics: a two-category ice scheme (5 water categories qv, qc, qr, qs, qi); snow = rimed aggregates of ice crystals; cloud ice = small hexagonal plates (itype_gscp = 3; hydci_pp)
- Tiedtke convection parameterization
- TERRA soil/snow scheme
- New thermodynamic sea ice scheme => low-level clouds and surface fluxes

Cloud and precipitation evolution observed at PE before and during the AR event

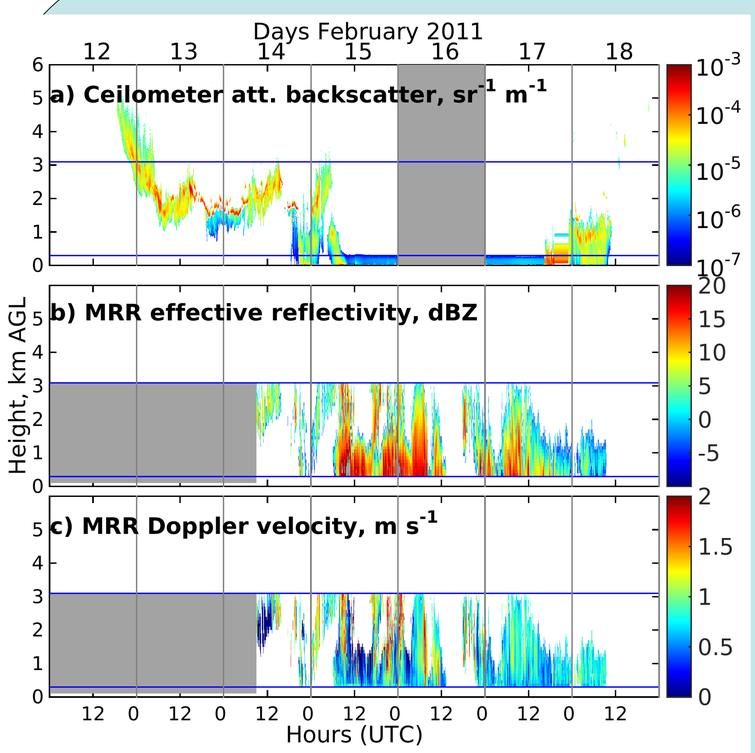

Figure 4: Cloud and precipitation measurements at PE during 12-18 Feb 2011

Comparing modeled and observed precipitation:

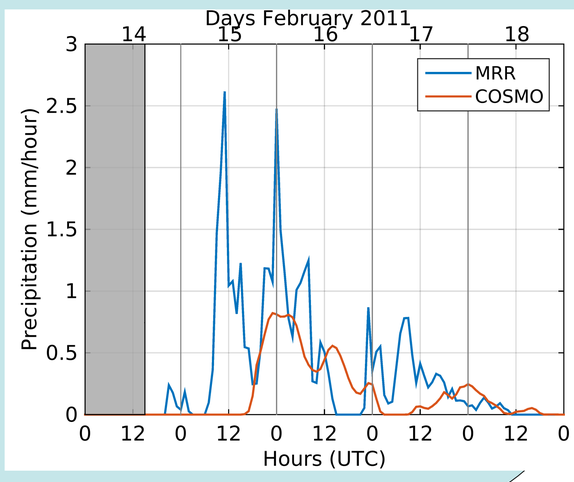

Figure 5: Snowfall rates derived from MRR at PE* and simulated by CCLM (nearest to PE gridbox).

*Snowfall rate is calculated using nine Z-S relationships for dry snow from Kulie&Bennartz 2009 and Matrosov 2007, see Gorodetskaya et al 2015)

CCLM-simulated spatial distribution of humidity, cloud fraction and precipitation

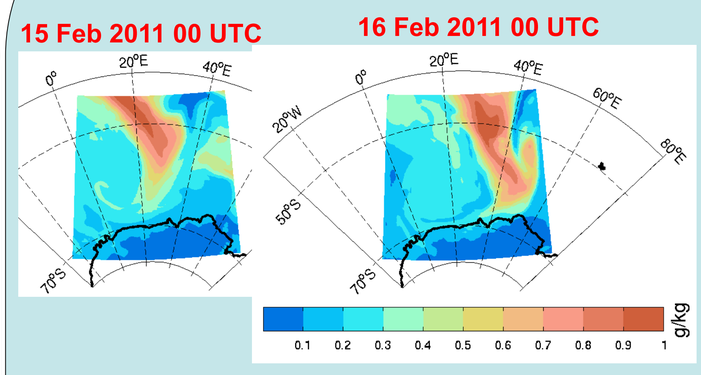

Figure 6 : Specific humidity at 850 hPa level.

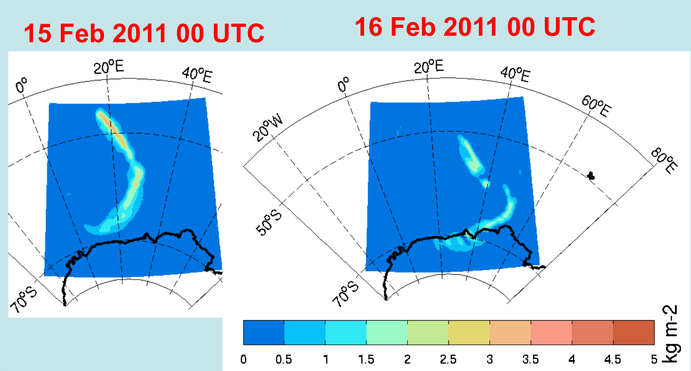

Figure 8 : Total precipitation amount

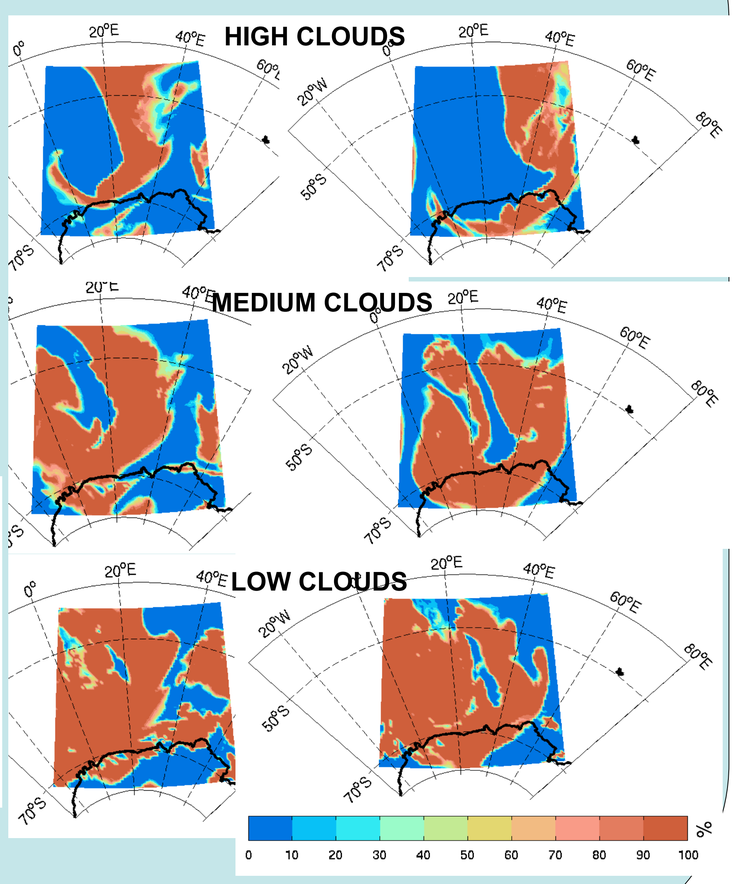

Figure 7: Cloud area fraction.

Conclusions

- We presented an exercise performed with the latest version of CCLM (v5.0) to test its ability to simulate an extreme precipitation event in the East Antarctic escarpment zone
- The exercise is based on the default CCLM5 configurations and coarse horizontal resolution (50 km)
- Observations at PE station show intensive snowfall following the atmospheric river arriving to Dronning Maud Land at PE meridian on 15 Feb 2011
- CCLM snowfall rate is underestimated and the intensity peaks are delayed by ~12 hours compared to the MRR-derived data at PE
- CCLM humidity fields are not completely independent of the ERA-Interim data used as the forcing (short run!)

References

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