Session CR1.1 : X4.184
Abstrat EGU2016 - 9352

Very high resolution surface mass balance over Greenland modeled by the regional climate model MAR with a downscaling technique

Christoph KITTEL, Charlotte LANG, Cécile AGOSTA, Maxime PRIGNON, Xavier FETTWEIS, and Michel ERPICUM

Laboratory of climatology, University of Liège, Liège, Belgium

Contact : ckittel@student.ulg.ac.be

Université de Liège

Laboratoire de Climatologie et Topoclimatologie

This presentation participates in OSPP

EGU Outstanding Student Poster & PICO Contest

1. Introduction

During the last two decades, the Greenland ice sheet (GIS) has retreated through an increased meltwater run-off in summer leading to a faster sea levels rise. The ice lost occurs in a narrow area, the ablation zone, at the edge of the ice sheet. (Fettweis *et al.*, 2013) Nonetheless, current climate model resolutions appear to be insufficient to resolve correctly ice sheet margins where topography shows more variations. It would be possible to raise resolution of currents models, but it would need a considerable simulation time.

A new version of the land-ice module (**SISVAT**) of the regional climate **MAR** model enables to correct near-surface temperature and humidy from MAR by a gradient based on elevation before forcing SISVAT. With this online downscaling technique, the land-ice module runs at a resolution twice as high as the resolution of the atmosphere module without a significant increase of the simulation time. Furthermore, it presents the advantages to take into account the snow albedo feedback as those modules are fully coupled (Lang, 2015).

2. Methods

Model MAR (v3.6) forced by ERA-Interim (1979-2014) at its boudaries every 6 hours.

- **Simulations**
  1) Sim. 1: MAR at 20km with SISVAT at 10 km (with online downscaling; **Online**)
  2) Sim. 2: MAR at 20km with SISVAT at 20 km (without dowscaling)
- **Interpolation of the 20km results onto the 10km grid** *(fig.1)*
  1) Interpolation by giving the value of the original pixel (20km) to the four sub-pixels (10km) (interpolation by nearest neightbour; **INN**)
  2) Bilinear interpolation (**IB**)
  3) Interpolation with an offline downscaling method based on an elevation gradient (Franco *et al.*, 2012) (**Offline**)
- **Validation and comparison of the results (10km and 20km interpolated results) against observations**
  where MAR values are corrected by an elevation gradient to remove altitude impact

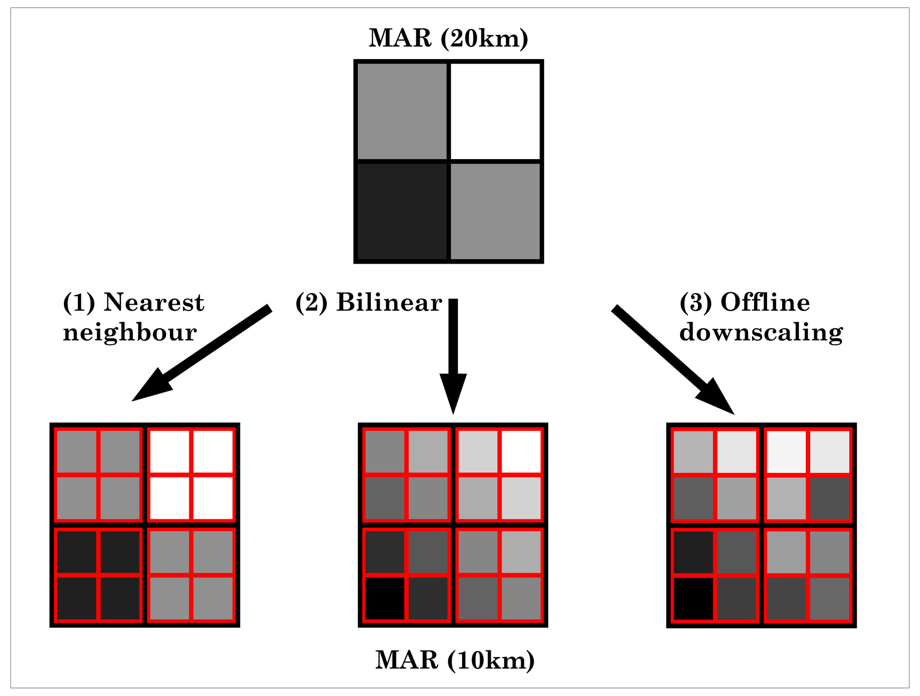

Fig. 1: Differents methods used to interpolate MAR 20km results onto 10km MAR grid, which is the grid of the simulation using the online downscaling technique. (1) Interpolation by giving the value of the original pixel, (2) bilinear interpolation and (3) interpolation with an offline downscaling method (Franco et al., 2012) correcting the variable by a gradient based on the elevation and the difference between 20km elevation and 10km elevation.

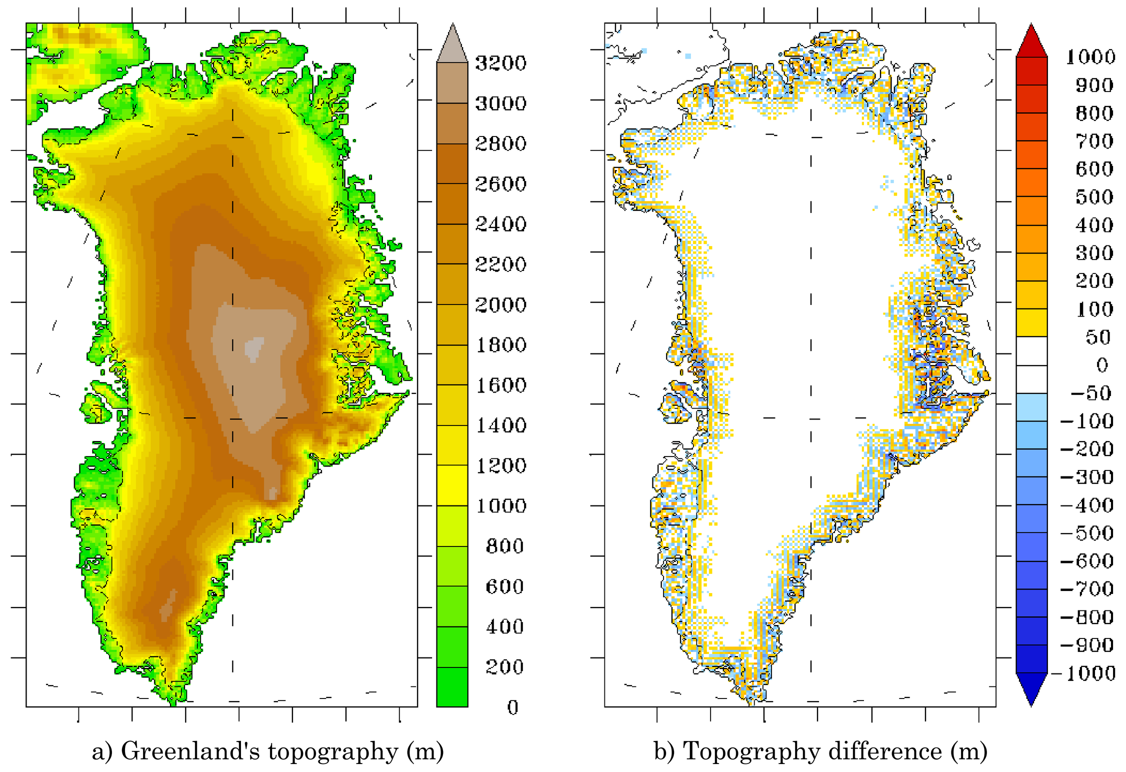

Fig. 2: Greenland's topography at 10km resolution (as used in SISVAT module with the downscaling technique) from Bamber et al. (2013) (a) and difference on the 10km grid interpolated by nearest neighbour between 10km elevation and 20km elevation (b). The dashed line on the GIS represents the common ice mask between all simulations.

3. Results

- **Validation against PROMICE observations**

n=1752	BIAS	CORRELATION	RMSE
Online	0.06	0.93	0.42
Nearest Neighbour	0.06	0.93	0.42
Bilinear	0.02	0.94	0.41
Offline	0.01	0.94	0.41

Observations mean	-0.58	Obs. Standard Dev.	1.14

Tab. 1: Validation of results against accumulation observations (m) from the PROMICE database. MAR values are corrected by a gradient based on elevation and the difference between MAR and observation altitudes in order to remove elevation biases. Online is the simulation with the online downscaling method while nearest neighbour (INN), bilinear (IB) and offline (Franco et al., 2012) are the 20km MAR results interpolated on the 10km grid.

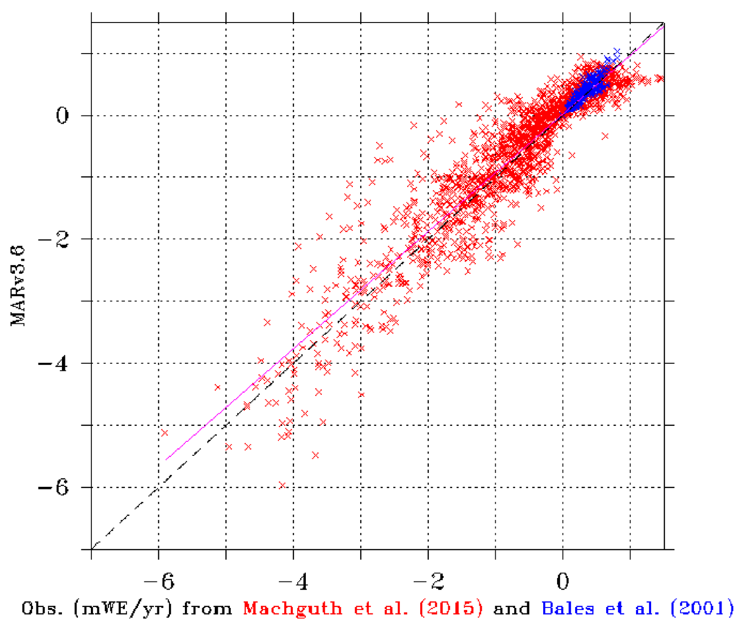

Fig. 3: Observations of yearly accumulation from Machguth et al. (2015, in preparation) and Bales et al. (2001) compared to online downscaled results after removing of elevation biases which shows these MAR results presents an underestimation of the negative accumulation values.

- **Comparison of 10km online downscaled results to 20km interpolated results**

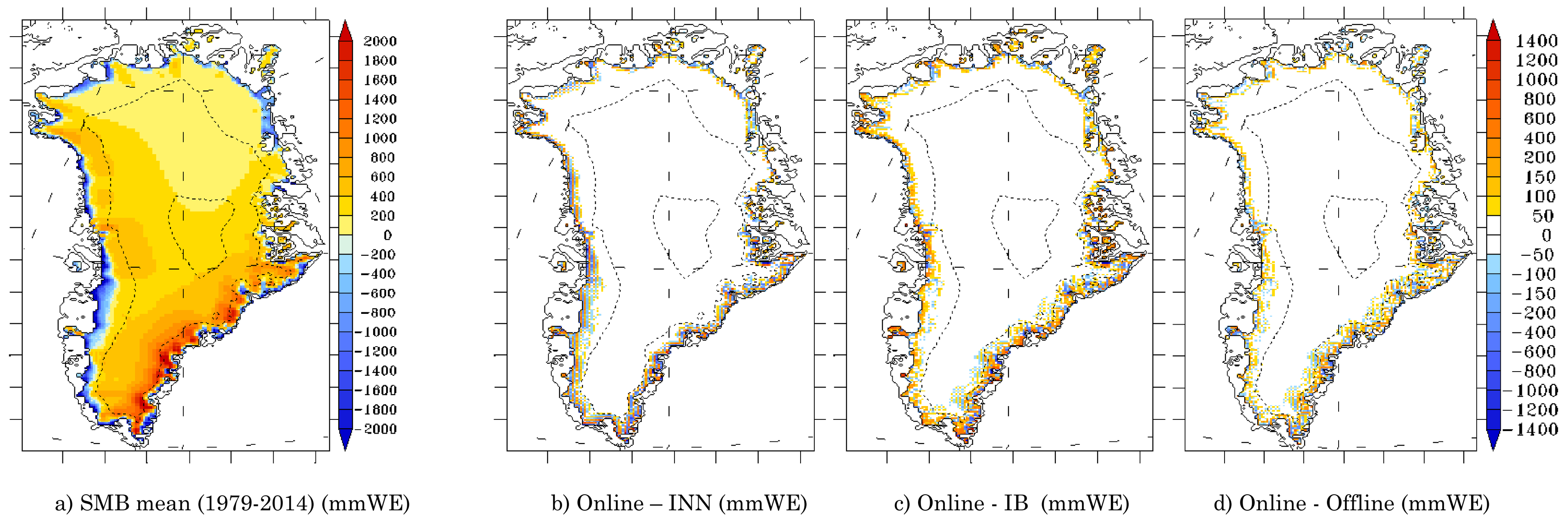

Fig. 4: Surface mass balance mean (1979-2014) simulated by MAR with an online downscaling method (a). Surface mass balance mean biases between reference simulation (Online downscaling) and interpolated 20km results by nearest neighbour (INN) (b), bilinear interpolation (IB) (c) and the interpolation of Franco et al., 2012 (offline).

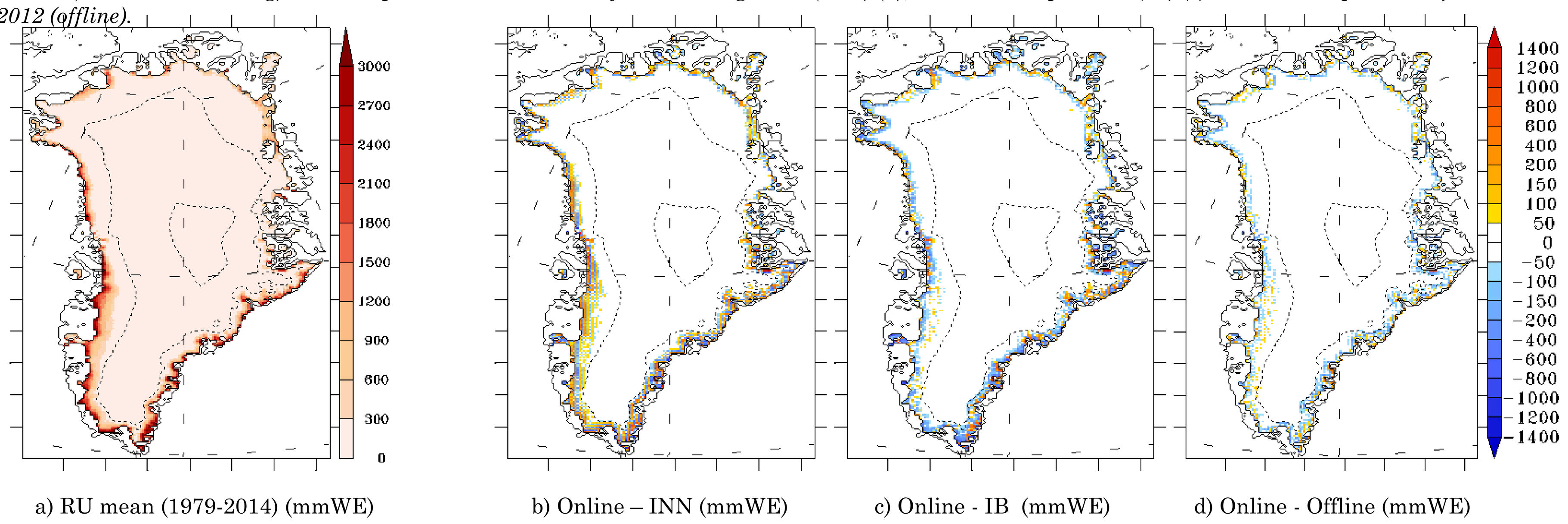

Fig. 5: Run-off mean (1979-2014) simulated by MAR with an online downscaling method (a). Run-off biases between reference simulation (Online downscaling) and interpolated 20km results by nearest neighbour (INN) (b), bilinear interpolation (IB) (c) and the interpolation of Franco et al., 2012 (offline).

[1979-2014]	SMB [Gt/yr]	RU[Gt/yr]
Online	410 ±120	276 ±99
Nearest Neighbour	427 ±112	278 ±99
Bilinear	405 ±114	296 ±102
Offline	420 ±111	288 ±99

Tab. 2: Mean surface mass balance and mean Run-off on the GIS common mask to all simulations.

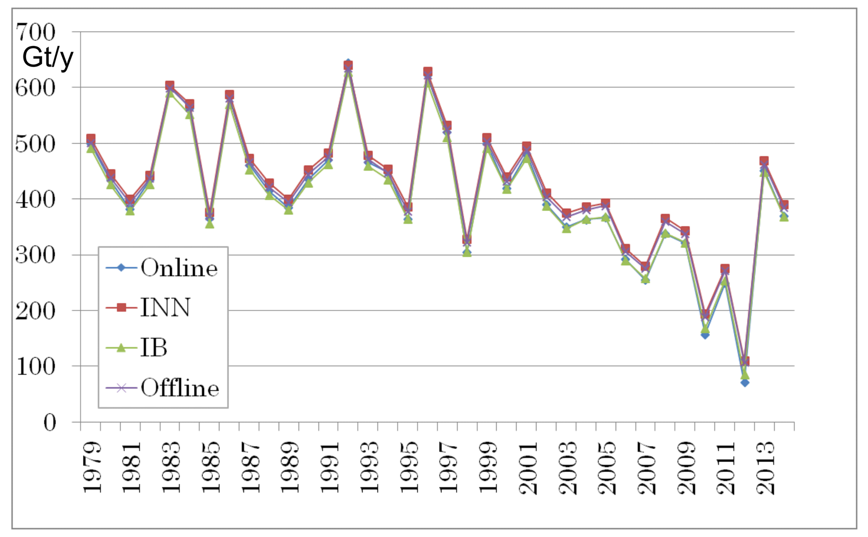

Fig. 6: Surface mass balance variations on the GIS common mask.

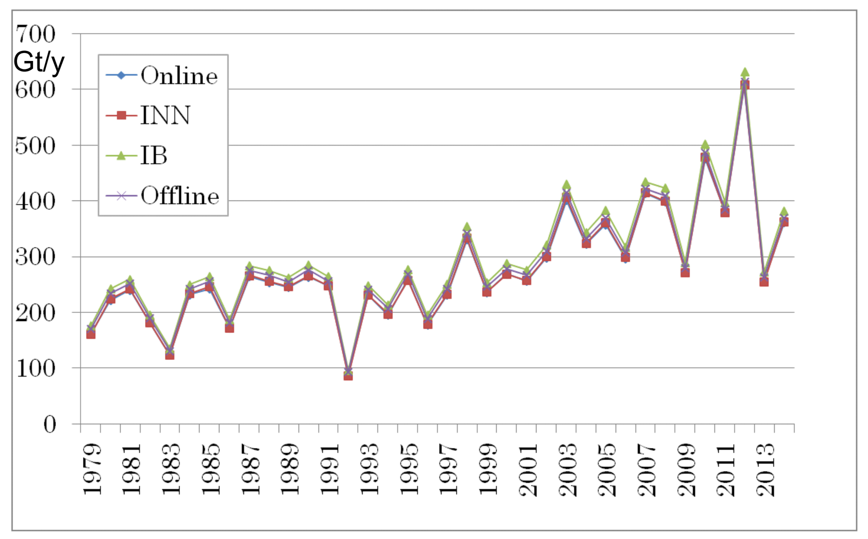

Fig. 7: Run-off variations on the GIS common mask.

- **Results are in good agreements with observations. Nonetheless, fully coupled SISVAT with downscaling and MAR atmospheric does not improve accumulation results when they are corrected to remove height biases between MAR and observations. Otherwise, the higher height corrections in SISVAT 10km versus SISVAT 20km are outside of the common mask where the albedo feedback is potentially stronger.**
- **Results are closed to each others but MAR coupled to SISVAT using an online downscaling method simulates less run-off but a smaller surface mass balance than 20km results interpolated by an offline downscaling method. Corrections of the off-line method are stronger in summer and thus, the run-off is higher during this period.**

4. Conclusion

- The new on-line downscaling method of the MAR model well simulates the GIS surface mass balance in agreement with PROMICE in situ observations.
- But does not improve results by comparison with an offline method when results from a common area to all simulations are corrected to remove altitude biases.
- Perspectives:
  To compare all results to PROMICE observations without corrections.
  To test the on-line downscaling technique at another resolution (MAR at 10km and SISVAT at 5km) to determine if a resolution effect exists.

5. References

- Fettweis, X., Franco, B., Tedesco, M., van Angelen, J. H., Lenaerts, J. T. M., van den Broeke, M. R., and Gallée,H. 2013. Estimating the Greenland ice sheet surface mass balance contribution to future sea level rise using the regional atmospheric climate model MAR, *Cryosphere*, *7*, 469–489, doi:10.5194/tc-7-469-2013
- Lang, C. (2015). *High resolution present and future climate and surface mass balance of Svalbard modelled by the regional climate model MAR*.(Ph. D. thesis) Liège. http://hdl.handle.net/2268/187914
- Franco, B., Fettweis, X., Lang, C.,Erpicum, M. 2012. Impact of spatial resolution on the modelling of the Greenland ice sheet surface mass balance between 1990–2010, using the regional climate model MAR. *Cryosphere*, *6*, 695–711. doi:10.5194/tc-6-695-2012
- Bamber, J. L., Griggs, J. a., Hurkmans, R. T. W. L., Dowdeswell, J. a., Gogineni, S. P., Howat, I., … Steinhage, D. 2013. A new bed elevation dataset for Greenland. *Cryosphere, 7*, 499–510. doi:10.5194/tc-7-499-2013
- Bales, R. C., McConnell J. R., Mosley-Thompson E., Csatho B. (2001). Accumulation of Greenland ice sheet from historical and recent records. *Journal of Geophysical Research, 106* (D24), 33.813-33.825.