Accumulation over the Greenland Ice Sheet as represented in reanalysis data

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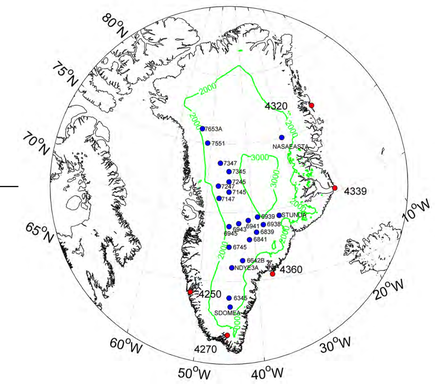
1. Introduction

- **Accumulation** is the main source of input to the **Greenland Ice Sheet** (GrIS), and it has significant impact on the **surface mass balance**, which is crucial to understand the response of the GrIS to climate change.
- **Direct measurement** of **accumulation has temporal and spacial limitations**.
- Precipitation and evaporation from **reanalysis data** have been used to estimate accumulation over the GrIS.
- How well the reanalysis data represent the accumulation of the GrIS has led to interest in the intercomparison and validation of output from different reanalysis data.

2. Data

- The gridded precipitation and evaporation data used in this research are reanalysis products derived from ECMWF, NCEP/NCAR and NCEP-DOE.

Dataset	Resolution	Source
ERA-40	T159 (～125km)	http://data.ecmwf.int/data/
ERA-interim	T255 (～80km)	
NCEP-1	T62 (～210km)	http://www.esrl.noaa.gov
NCEP-2	T62 (～210km)	



- In situ measurements used to validate the reanalysis data was obtained from the Program for Arctic Regional Climate Assessment (PARCA) ice cores drilled in 1997/98 (Source: http://nsidc.org/data/parca/) and Danish Meteorological Institute (DMI) synoptic station (Source: http://www.dmi.dk/dmi/index/). Location of the coastal DMI synoptic stations and the PARCA ice core sites are shown in the above figure. Also shown the 2000 m and 3000 m elevation contours in meters as reference.

3. Results

- Annual precipitation, evaporation and calculated accumulation from reanalysis model outputs have been investigated for the GrIS, based on the common period of 1989–2001.
- ERA-40 and ERA-interim have better spatial distributions of **precipitation** than NCEP-1 and NCEP-2, particularly in their depiction of the moderate precipitation (more than 400 mm yr^{-1}) region along the western flank of Greenland. Concerning temporal variability, ERA-interim shows the best correlation with observations at five synoptic stations, but it still overestimates precipitation over the GrIS, particularly along the coastal region.
- **Evaporation** from ERA-40 and ERA-interim has more a reasonable spatial distribution than that from NCEP-1 and NCEP-2.

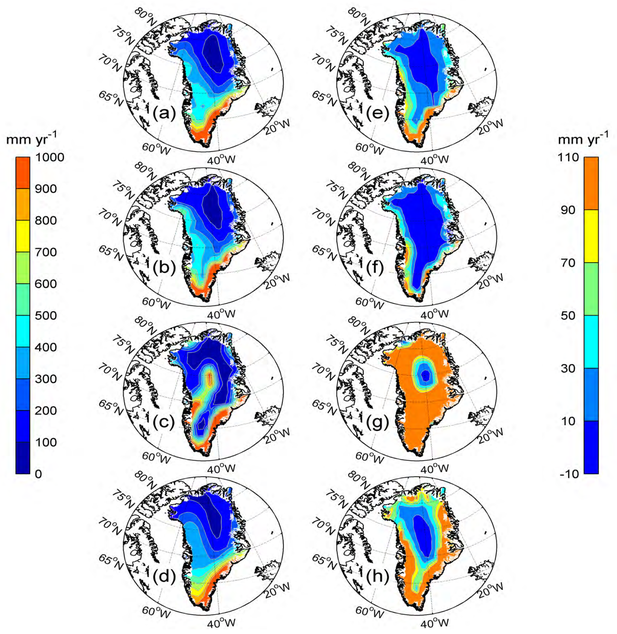


Figure 1. Left: mean annual precipitation over the GrIS from (a) ERA-40, (b) ERA-Interim, (c) NCEP-1, and (d) NCEP-2; Right: mean annual evaporation over the GrIS from (e) ERA-40, (f) ERA-Interim, (g) NCEP-1, and (h) NCEP-2.

- **Accumulation** calculated from ERA-interim shows the closest spatial distribution to the observation-based accumulation, but it still overestimates accumulation along the southeastern coastal regions.
- Concerning **temporal variations**, ERA-Interim showed the best correlation with precipitation observations at five synoptic stations, and the best correlation with in situ measurements of accumulation at nine ice core sites (See Table 1,2 in Chen et al, 2011). Because the reanalysis model grid and surface site are clearly not spatially equivalent, this may bring inherent mismatches.
- **Further analysis** by using ERA-interim reanalysis data **indicated** that the estimated accumulation over the GrIS is increasing in autumn & winter, but decreasing in spring & summer during the period of 1979-2010.

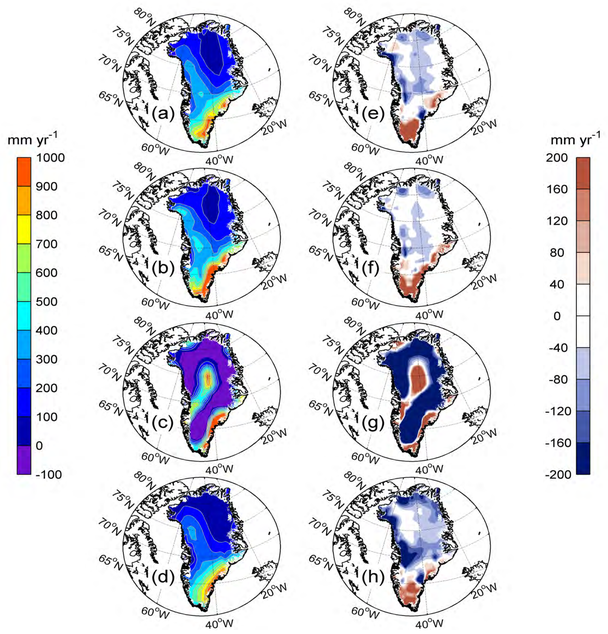


Figure 2. Left: mean annual accumulation over the GrIS calculated from (a) ERA-40, (b) ER Interim, (c) NCEP-1, and (d) NCEP-2 outputs; Right: difference between accumulation map fr Bales et al. (2009) and mean annual accumulation calculated from (e) ERA-40, (f) ERA-Interim NCEP-1, and (h) NCEP-2 outputs.

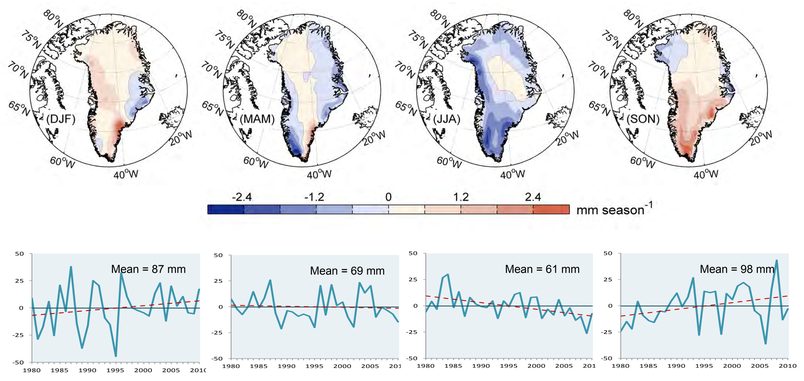


Figure 3. Left: Linear trend in mm season^{-1} of accumulation over the GrIS calculated from ERA-Interim for the period of 1980-2010. Right: Time series of accumulation anomalies in different seasons. Red dashed lines show the corresponding linear trend.

Table 1. Annual mean precipitation, evaporation and accmulation over the GrIS, units: mm yr^{-1}.

Dataset	Precipitation	Evaporation	Accumulation
ERA-40	365	38	291
ERA-interim	363	18	319
NCEP-1	376	199	152
NCEP-2	342	81	246
Ohmura et al. (1999)	340	35	297
Bales et al. (2009)	—	—	300

4. Conclusion

- The results in this research give useful information about the reliability of the reanalysis data in Greenland area.
- To different extent, both ERA-Interim and NCEP-2 are improvements over ERA-40 and NCEP-1, respectively.
- ERA-Interim shows the best accumulation spatial distribution and temporal variation when compared with in situ measurements.
- The decreasing trend of accumulation in spring and summer time can partly contribute to the increasing mass loss of the GrIS recently. When the accumulation is below average, it helped to maintain low albedo through the melting season. Warm conditions, with the positive albedo feedback mechanism, became a major contributor to the increasing surface mass loss since 1979.

5. Reference

Chen, L. L. et al, 2011: Adv. Atmos. Sci., 28(5), doi: 10.1007/s00376-010-0150-9.

http://www.nersc.no/news/paper-accumulation-over-greenland-ice-sheet-represented-reanalysis-data-published.

6. Acknowledgments

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