Reconstruction of the 1979-2005 Greenland ice sheet surface mass balance using the regional climate model MAR

by

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1. Mass balance
2. MAR model
3. Results
4. Conclusion
1. Definition: Mass balance

**Surface Mass Balance** \( \approx \) accumulation – runoff of the melt water

**Ice sheet Mass Balance** \( \approx \) accumulation – runoff – iceberg calving

- **Equilibrium ligne** \( (SMB = 0) \)
- **Accumulation (snowfall)** \( (SMB > 0) \)
- **Accumulation in winter and melt in summer** \( (SMB < 0) \)
- **Runoff of the melt water**
- **Iceberg discharge and basal melting**

**A warmer climate suggests more snowfall in winter and more melt in summer!**

**What will be dominant in the future?**
2. MAR model

Coupled with a snow model but not with an ice sheet model!
3. 1979-2005 SMB (1/5)

**SMB ≈ Snowfall - Runoff**

- **SMB**: $-3.9$ km$^3$/yr
- **Snowfall**: $+1.6$ km$^3$/yr
- **Runoff**: $+6.2$ km$^3$/yr

Significance = 86%

Significance = 78%

Significance = 97%

Water vapour fluxes: $+0.4$ km$^3$/yr
Rainfall: $+0.3$ km$^3$/yr

~ 1.0 mm/yr in mean sea level rise

~ 1.7 mm/yr in mean sea level rise but underestimated by MAR
3. 1979-2005 SMB (2/5)

Snowfall

Available melt water

Part of snowfall becomes rainfall

Higher snowfall

The melt increases everywhere!

Yearly mean (mm)

Trend (mm yr⁻¹)

Yearly mean (mm)

Trend (mm yr⁻¹)
3. 1979-2005 SMB (3/5)

Surface mass balance

Decrease in the ablation zone

Increase in the accumulation zone

Yearly mean (mm)

Trend (mm yr⁻¹)

Accumulation zone

Equilibrium line

Ablation zone

Increase in the accumulation zone
Why does the runoff increase since 1979?

Temperature: +0.09°C yr⁻¹

Significance = 99%

Rainfall

Significance = 93%

5% of the runoff increase.

Trend of summer 3m-temperature (°C yr⁻¹)
3. 1979-2005 SMB (5/5)

Surface energy balance

- Infrared
  - Significance = 98%
  - No trend

- Solar
  - Significance = 95%
  - No trend

+ no change for both sensible and latent heat fluxes

External forcings: CO₂

Not explained by the natural variability (NAO, ...)

El Chicon
Mount Pinatubo eruption

Infrared trend (W/m² yr⁻¹)
Solar net trend (W/m² yr⁻¹)
5. Conclusion (1/2)

These results suggest:
- an acceleration of surface melt is larger than the heavier snowfall
- a SMB decreasing.

These change are likely due to the human activities.

Remark:
Acceleration of the glacier discharge because likely the melt water lubricates the ice/bedrock interface.
If the Greenland ice sheet melts completely ...

Belgium: 3700 km² below sea level.
Thanks for your attention!

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