Université de Liège

Laboratoire de Climatologie
et Topoclimatologie

GEO Sciences

# Impact of the spatial resolution on the Greenland ice sheet surface mass balance modelling using the regional climate model MAR.

**Geosciences Center (ULg)**
**2nd PhD day**
**(14/01/2011)**

**Bruno FRANCO**
Aspirant FRS-FNRS

Promoteurs :
Michel ERPICUM
Xavier FETTWEIS

# Plan

1. Introduction : The Surface Mass Balance (SMB)

2. The MAR model : a regional climate model

3. Impact of the resolution on the SMB modelling

4. Interpolation of the MAR model outputs

5. Conclusion

# 1. Introduction : The Surface Mass Balance (1/2)

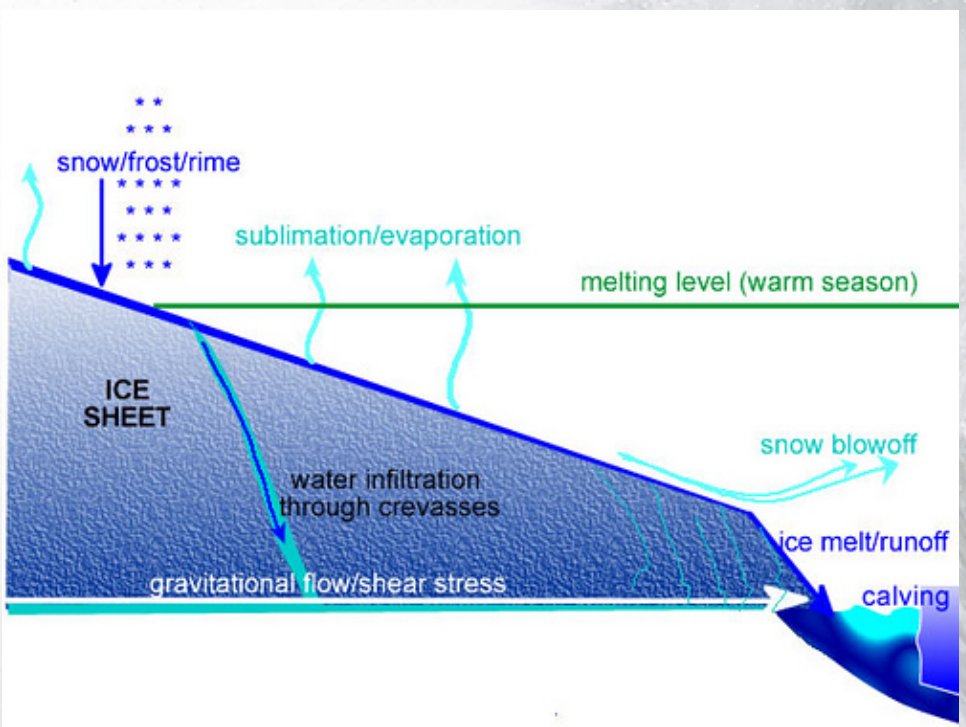
**Ice sheet Mass Balance ≈ Accumulation – Ablation**

**Accumulation process**

**+ snowfall** (solid precipitation)
- evaporation/sublimation

**Ablation process**

- iceberg calving
- basal melting
- flux of drifting snow
- runoff

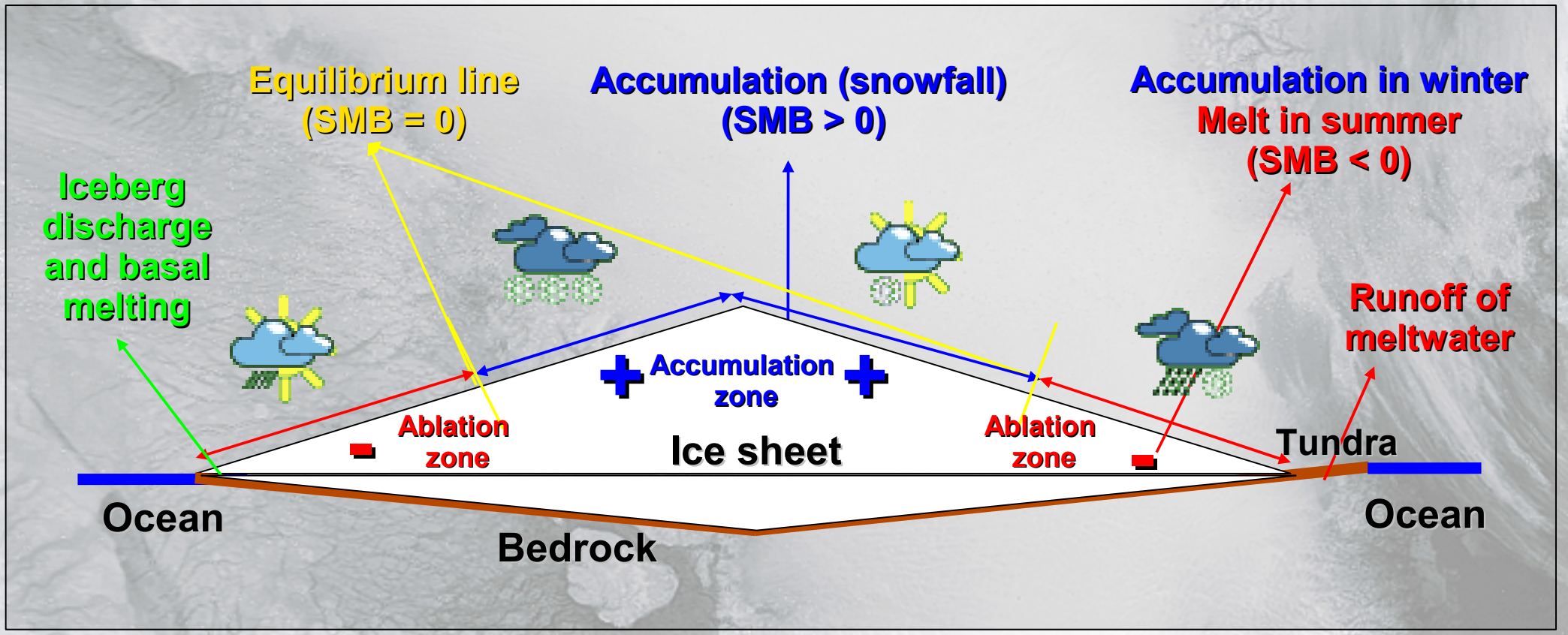



**Runoff** = liquid water production – meltwater retention (meltwater and rainfall)

**Ice shelves not included**

# 1. Introduction : The Surface Mass Balance (2/2)

**Surface Mass Balance ≈ Accumulation – Runoff of meltwater**




Ice dynamic and drifting snow not included in the SMB

# 2. The MAR model : a regional climate model (1/5)

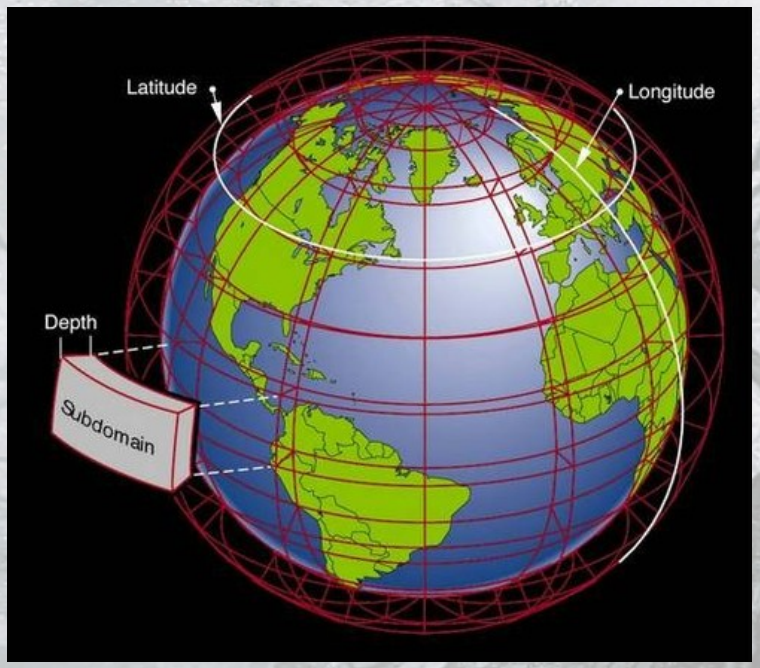
## Regional Climate Model (RCM)

+ Specific integration domain

+ High spatial resolution

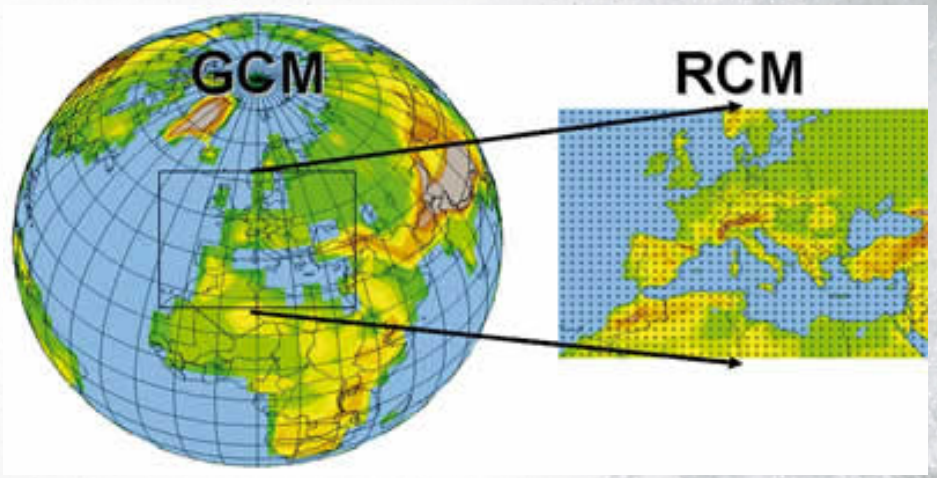
+ Enhanced physical parametrisation

- Forcing fields required




Global Circulation Model

Regional Climate Model




## Forcing fields coming from :

- Global circulation model
- Observations
- Lower-resolution RCM

→ RCM simulations depend on the reliability of the forcing fields

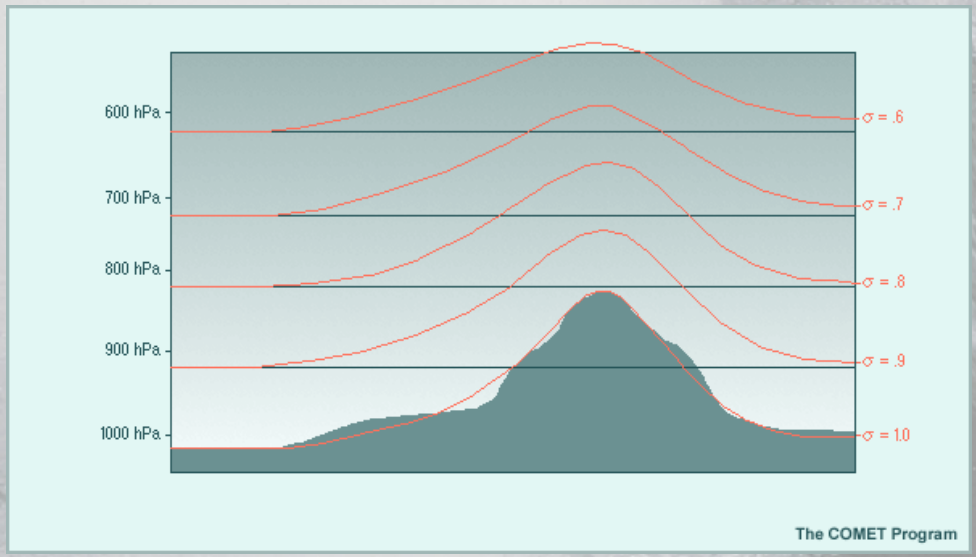
# 2. The MAR model : a regional climate model (2/5)

## MAR (Modèle Atmosphérique Régional)

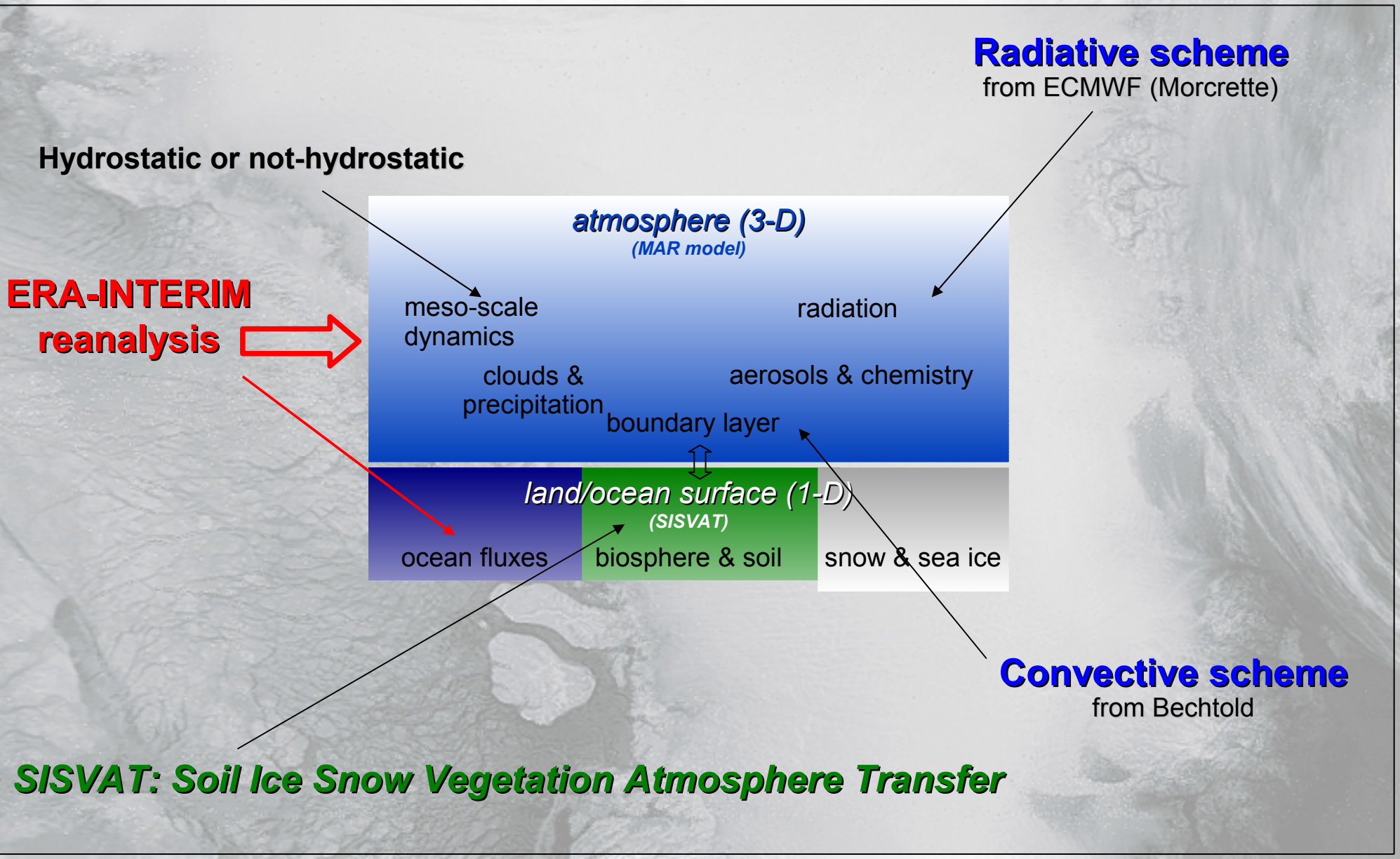
**Implemented by Hubert Gallée (LGGE, Grenoble)**

→ (non-)hydrostatic primitive equation model
→ vertical coordinate is the normalized pressure sigma

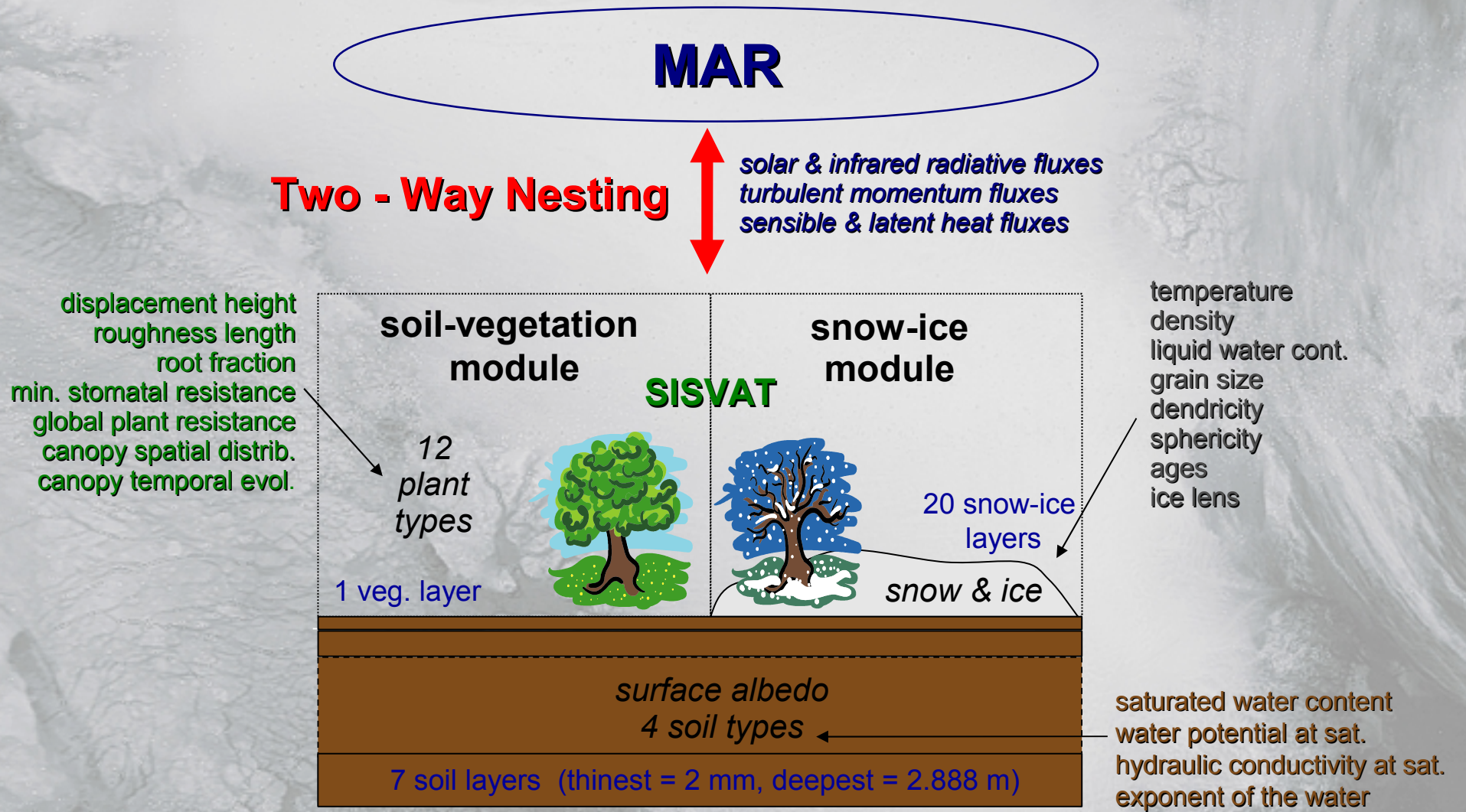
| | | |
|---|---|---|
| **Domain:** | **80 x 140 grid points (2000 x 3500 km)** | |
| **Resolution:** | **25 km** | |
| **Time step:** | **150 s** | |
| **1st atm. level:** | **3 m** | |
| **Vertical levels:** | | |
| | **Atmosphere (MAR)** | **30 levels** |
| | **Snow (SISVAT)** | **20 levels** |
| | **Tundra (SISVAT)** | **7 levels** |
| **Forcing:** | | |
| | **Lateral boundaries** | **Reanalysis 6-h** |
| | **SSTs** | **Reanalysis 6-h** |
| | **Sea ice** | **Reanalysis 6-h** |



# 2. The MAR model : a regional climate model (3/5)



# 2. The MAR model : a regional climate model (4/5)




**Ocean and sea-ice concentration from ECMWF reanalysis**

# 2. The MAR model : a regional climate model (5/5)

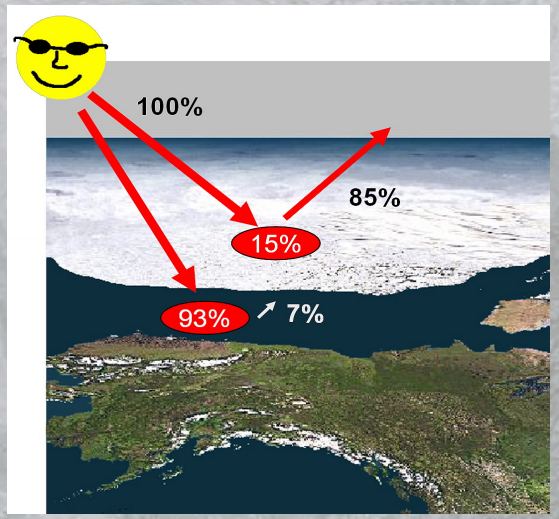
**Atmosphere (3-D)**
**MAR model (25 km)**

6-hourly

Two-Way Nesting

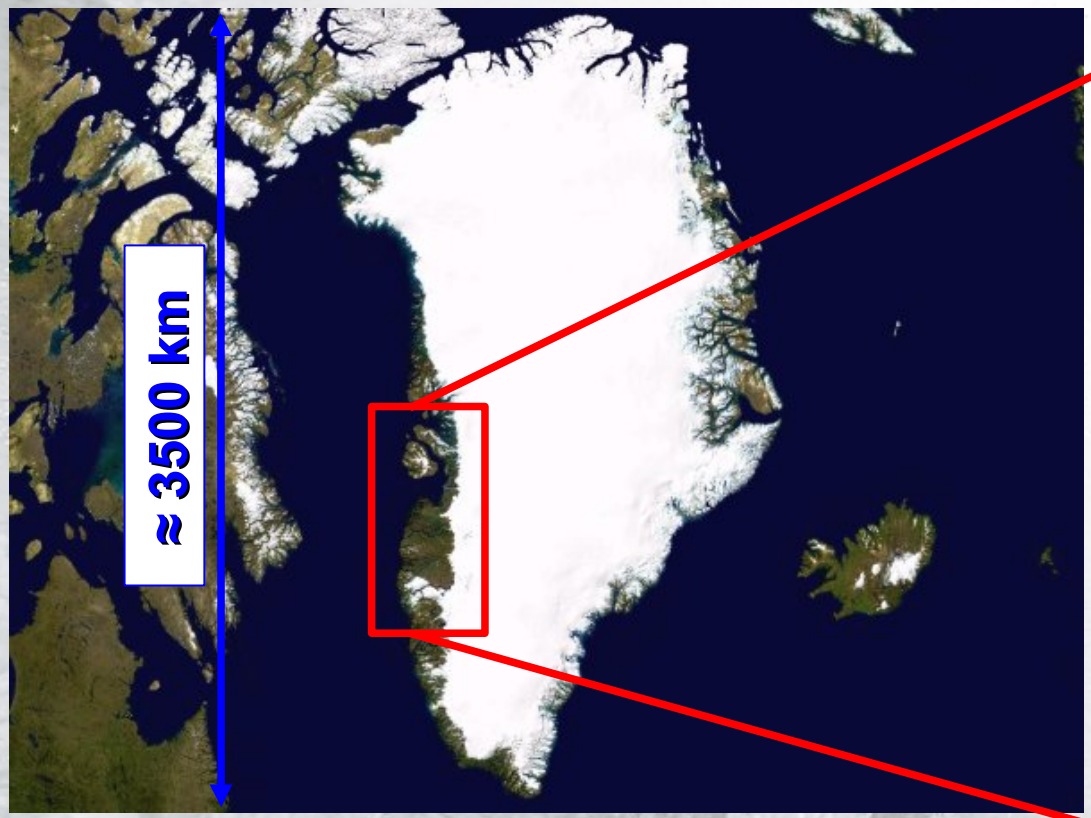
**Forcing fields**
**ERA-INTERIM reanalysis**

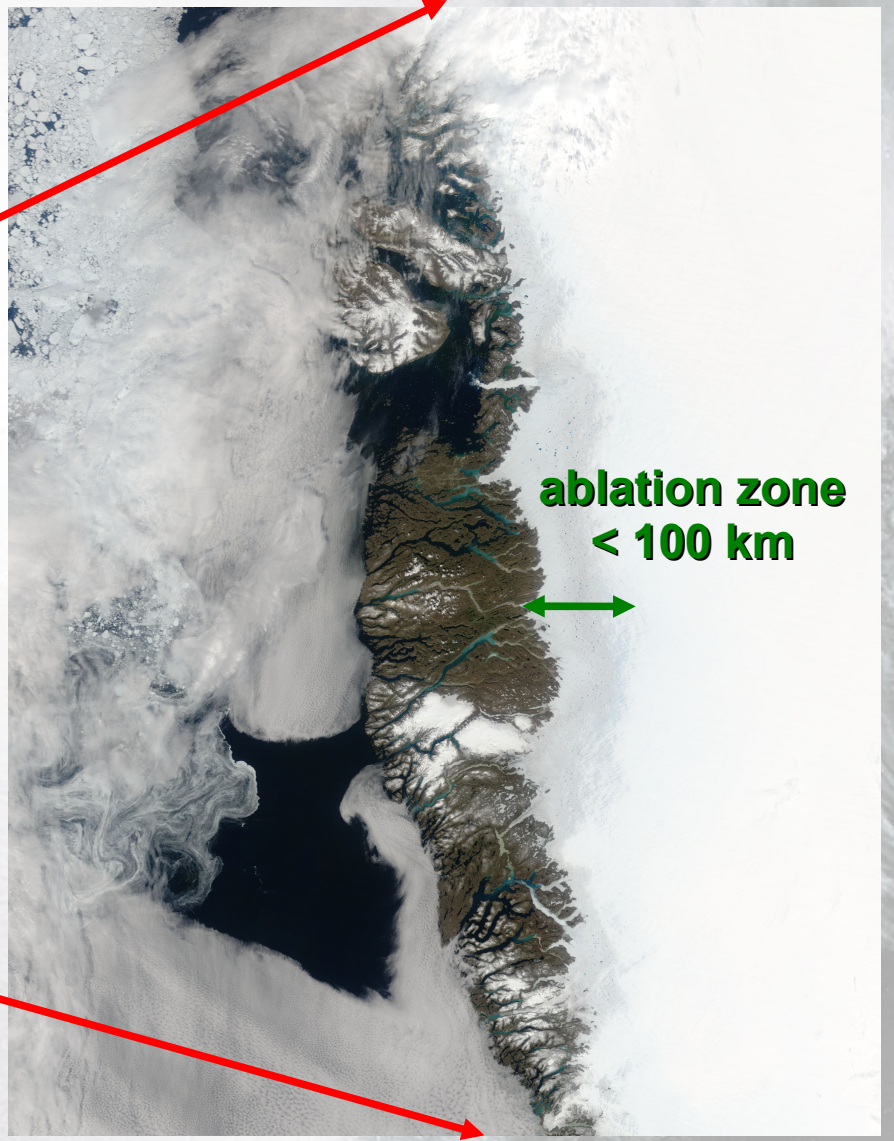
**Surface processes**
**SISVAT module**



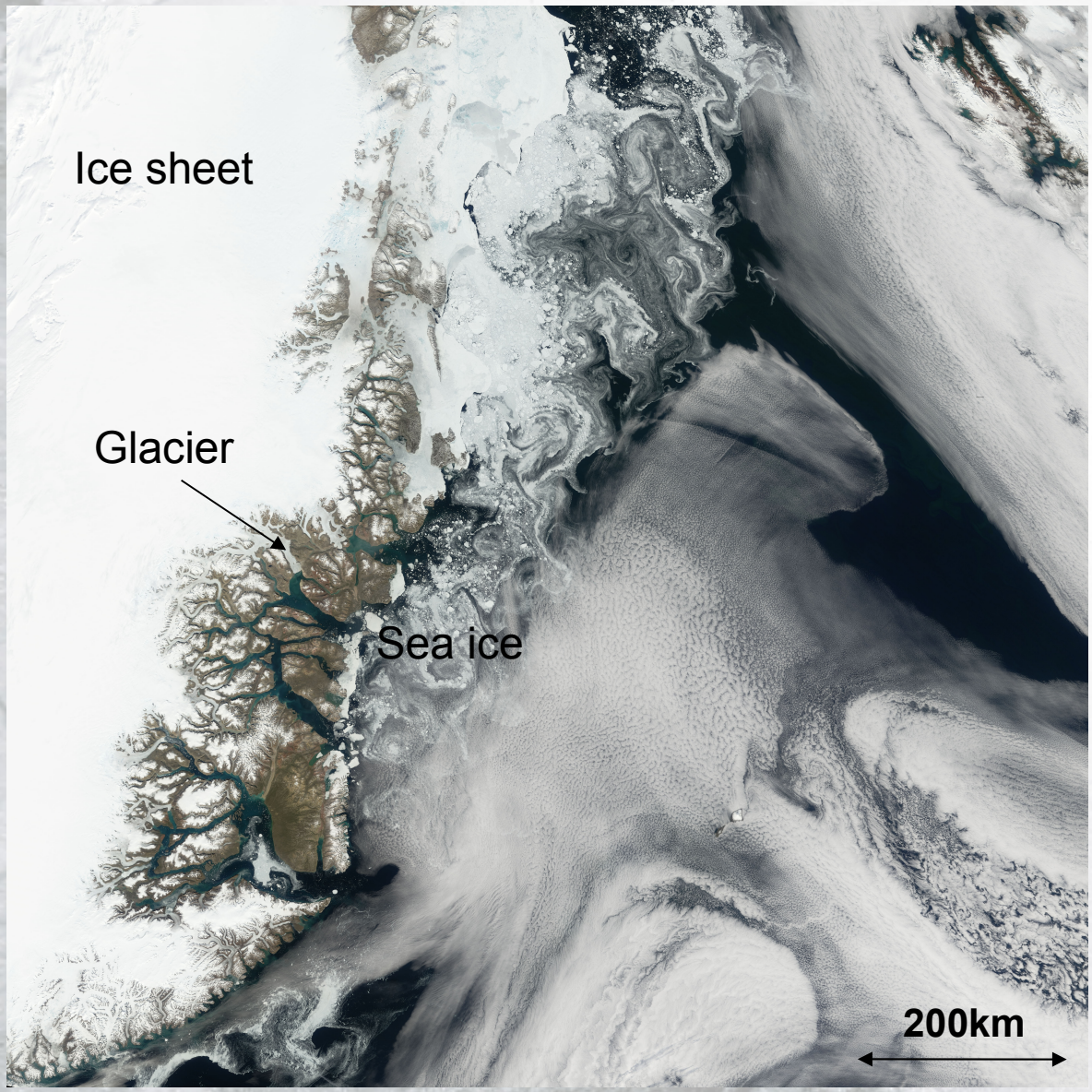
# 3. Impact of the resolution on the SMB modelling (1/7)

**Narrow ablation zone along the ice sheet margins**



# 3. Impact of the resolution on the SMB modelling (2/7)




**Highly rugged topography in the coastal areas**

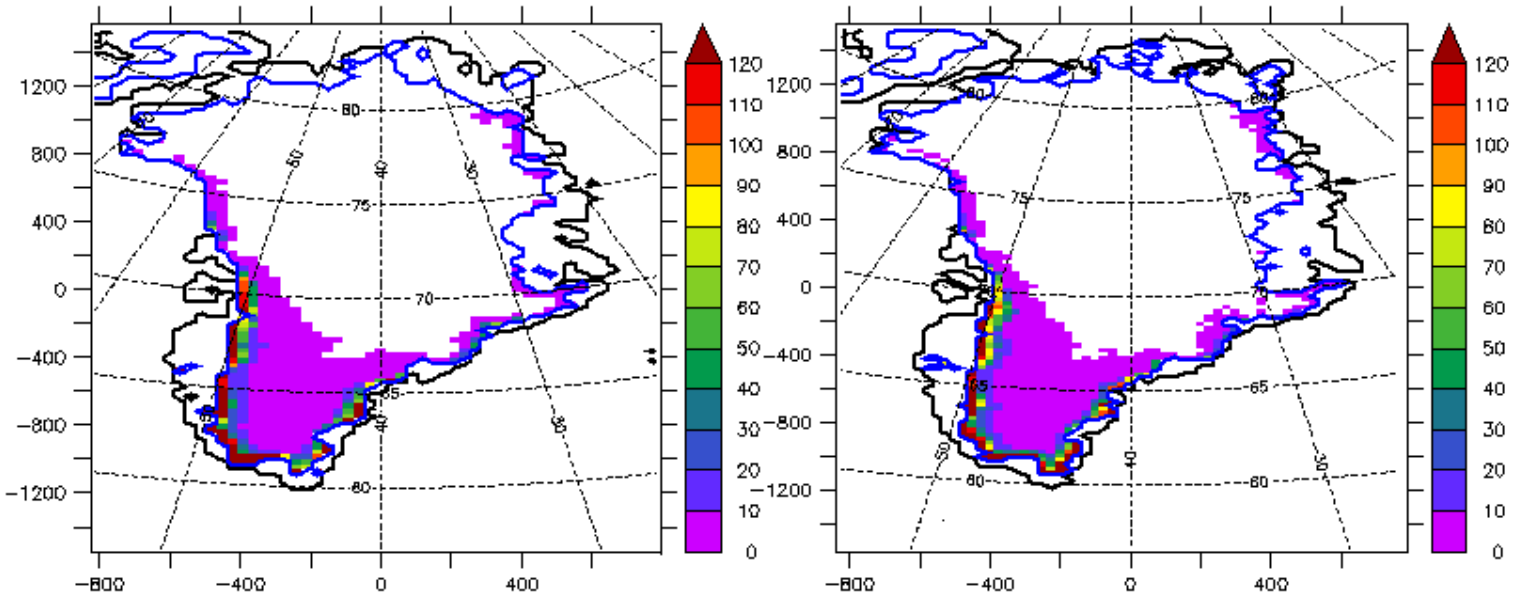
↓

**Heavy precipitation**

↓

**Inputs in the surface mass balance equation**

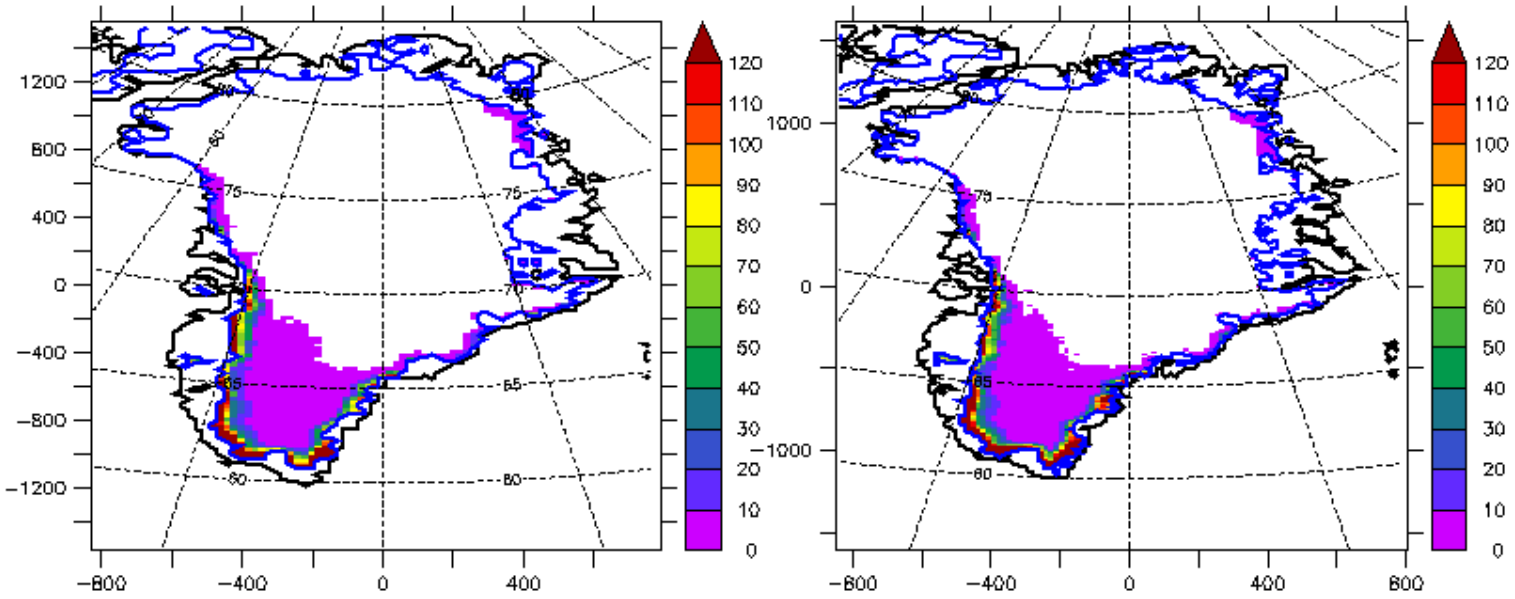
# Meltwater (mmWE) from Sept 1st to Sept 15th 1997




30km resolution




25km resolution

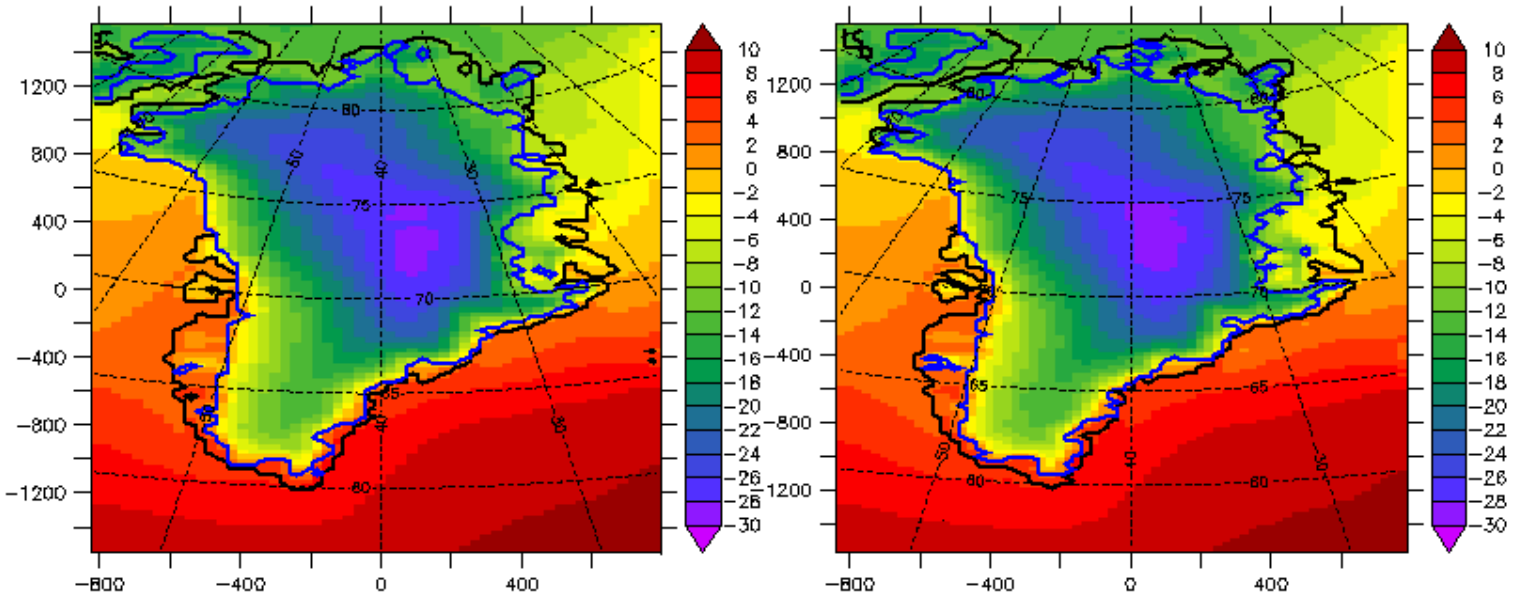



20km resolution



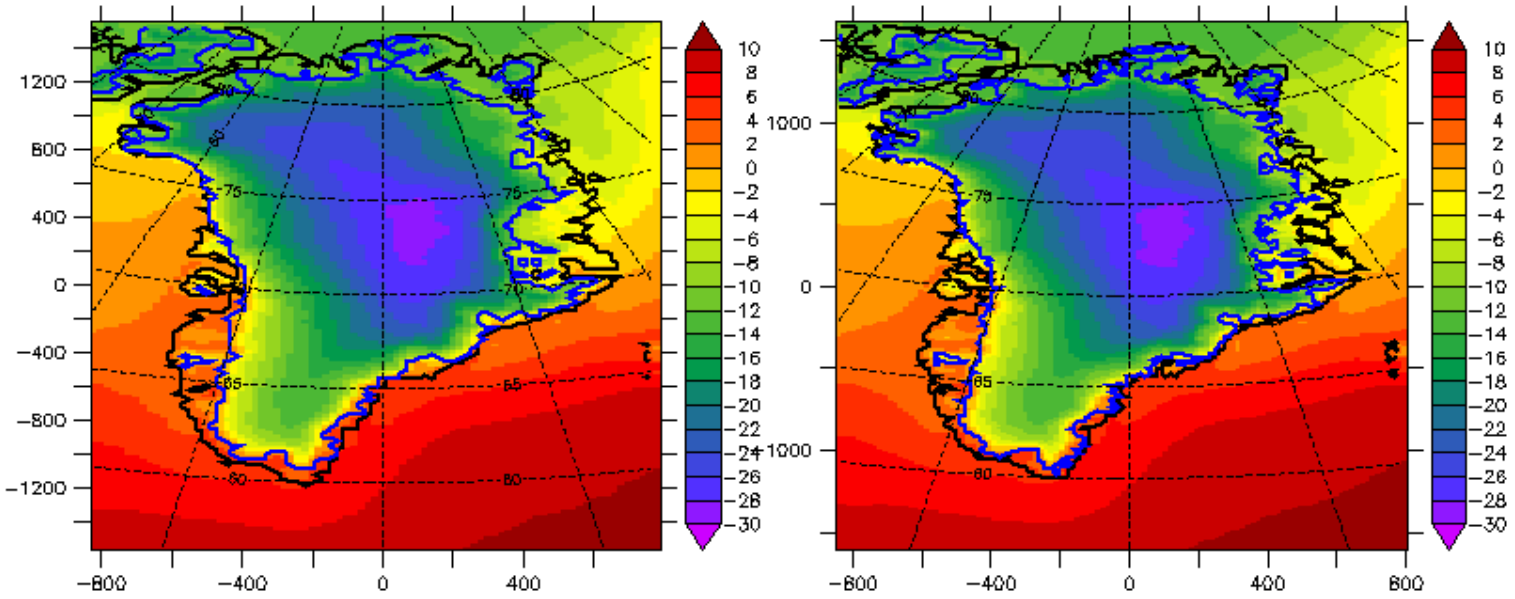

15km resolution

# Mean near-surface temperature (°C) from Sept 1st to Sept 15th 1997



30km resolution

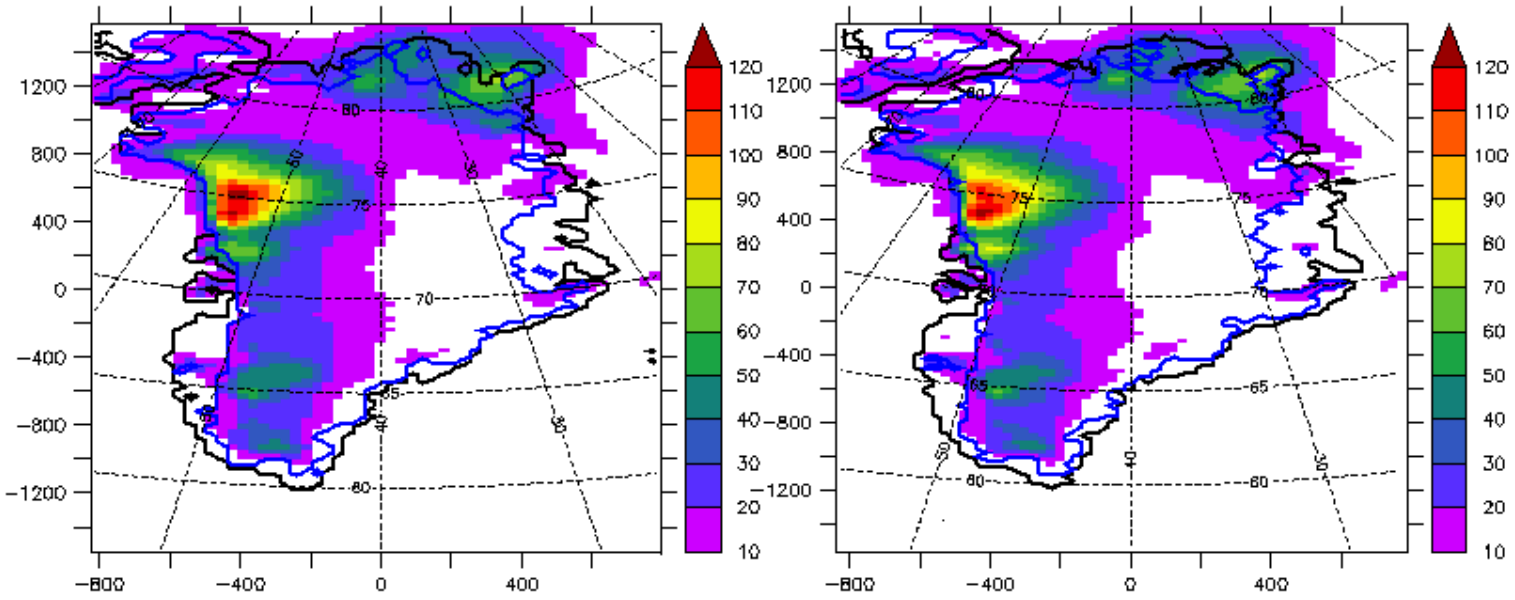
25km resolution



20km resolution

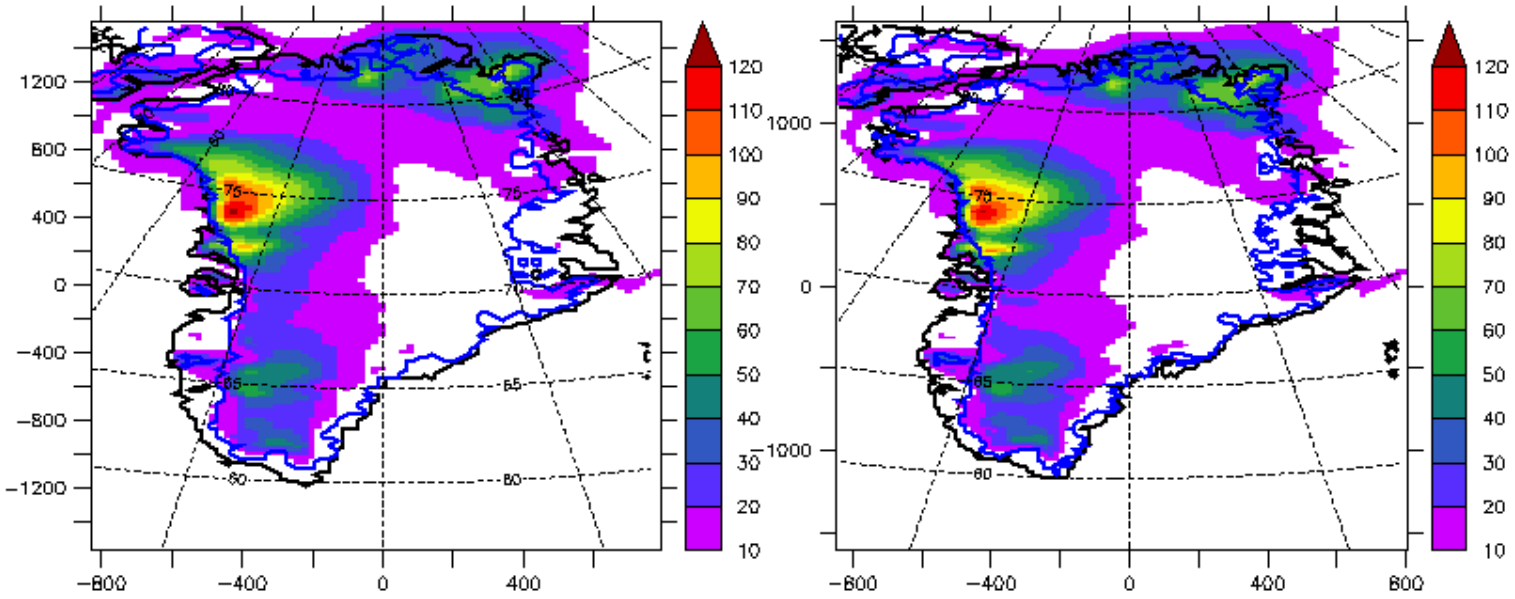
15km resolution

# Snowfall (mmWE) from Sept 1st to Sept 15th 1997



30km resolution

25km resolution



20km resolution

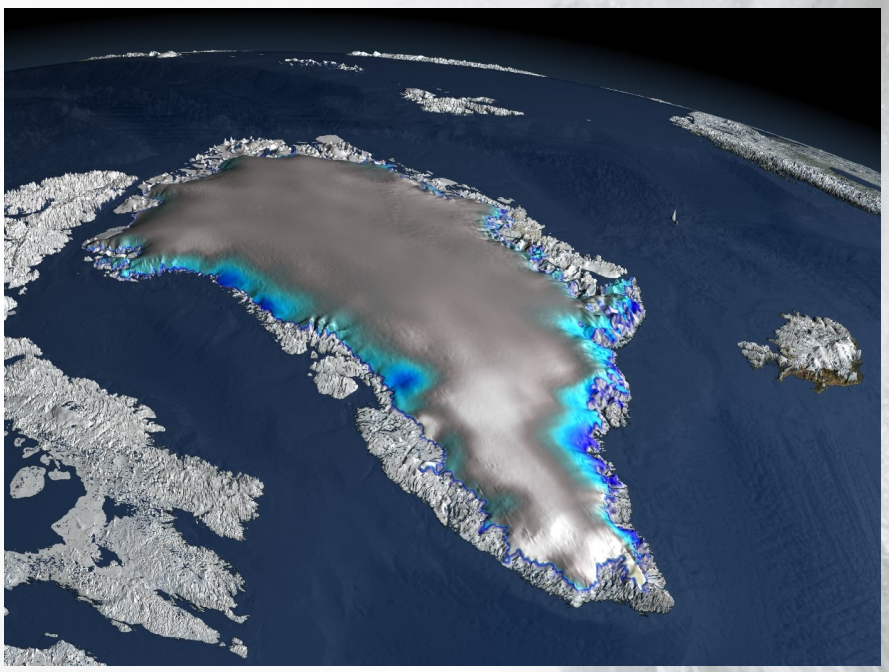
15km resolution

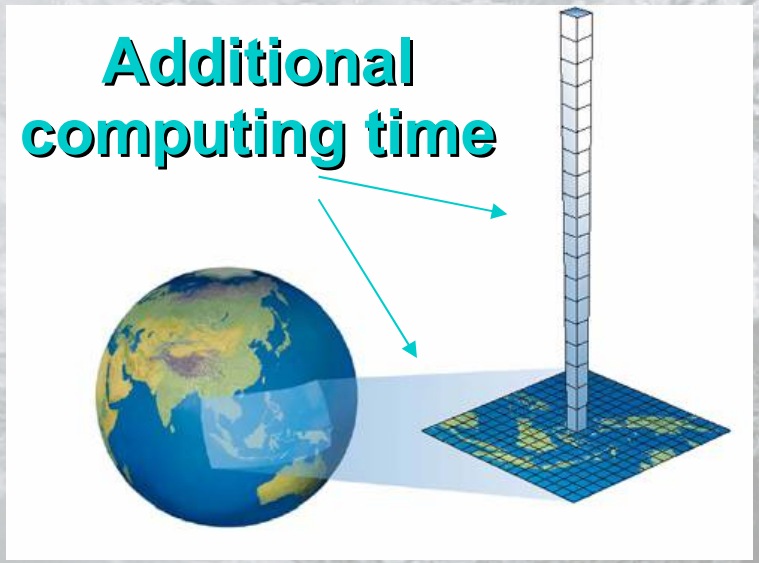
# 3. Impact of the resolution on the SMB modelling (7/7)

RCM outputs are used as forcing fields in ice sheet models for very high resolution simulations

Very high resolution simulations require significant additional computing time for the RCM

**Ice sheet model**





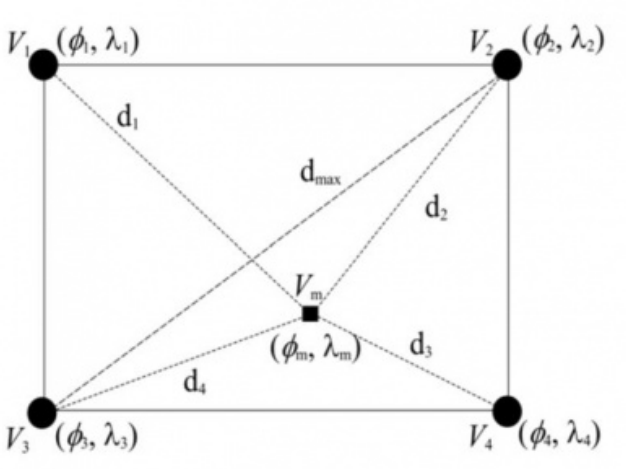

Can interpolated RCM outputs be used as very high resolution forcing fields ?

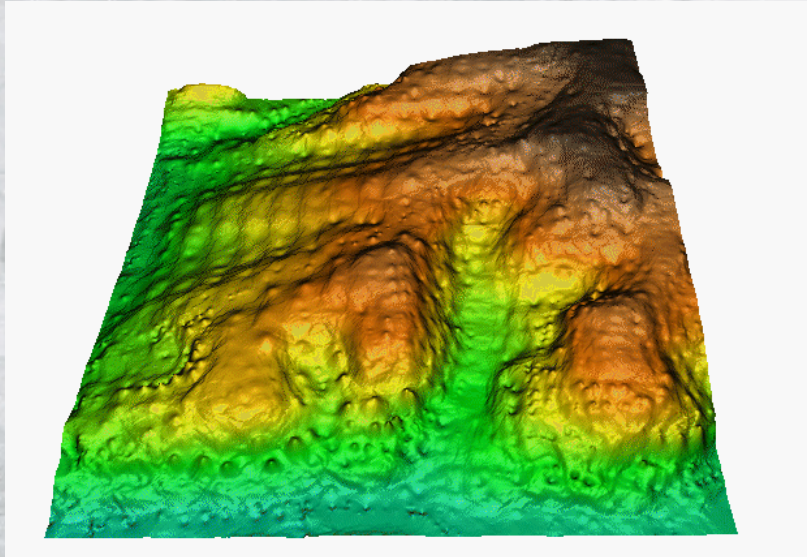
# 4. Interpolation of the MAR model outputs (1/4)

## First test : Inverse Distance Weighted (IDW) interpolation

### Basic equation

$$u(x)=\frac{\sum_{k=0}^{N} w_k(x)u_k}{\sum_{k=0}^{N} w_k(x)} \quad \textit{with} \quad w_k(x)=\frac{1}{d(x,x_k)^p}$$



### Very high resolution

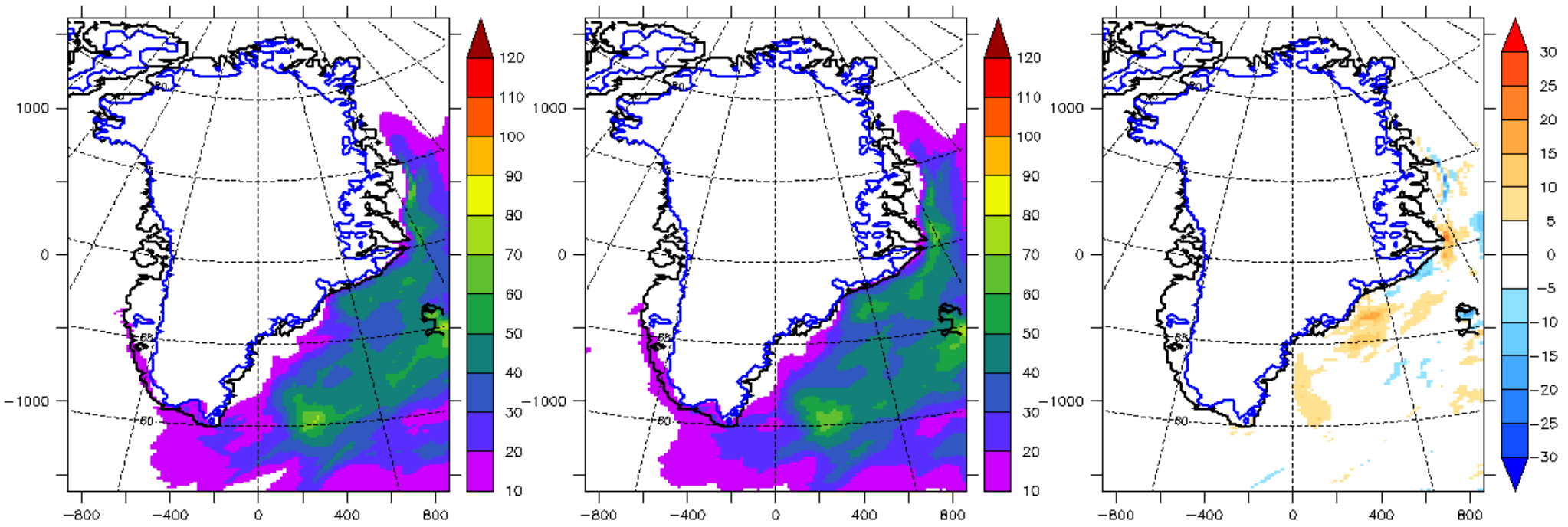
→ highly detailed topography

→ new Greenland ice sheet mask

# 4. Interpolation of the MAR model outputs (2/4)

## IDW interpolation of the 25km-resolution rainfall onto the 15km MAR grid

**From Sept 16th to Sept 30th 2008**




a) Rainfall (mmWE) outputs from simulation at 15km resolution

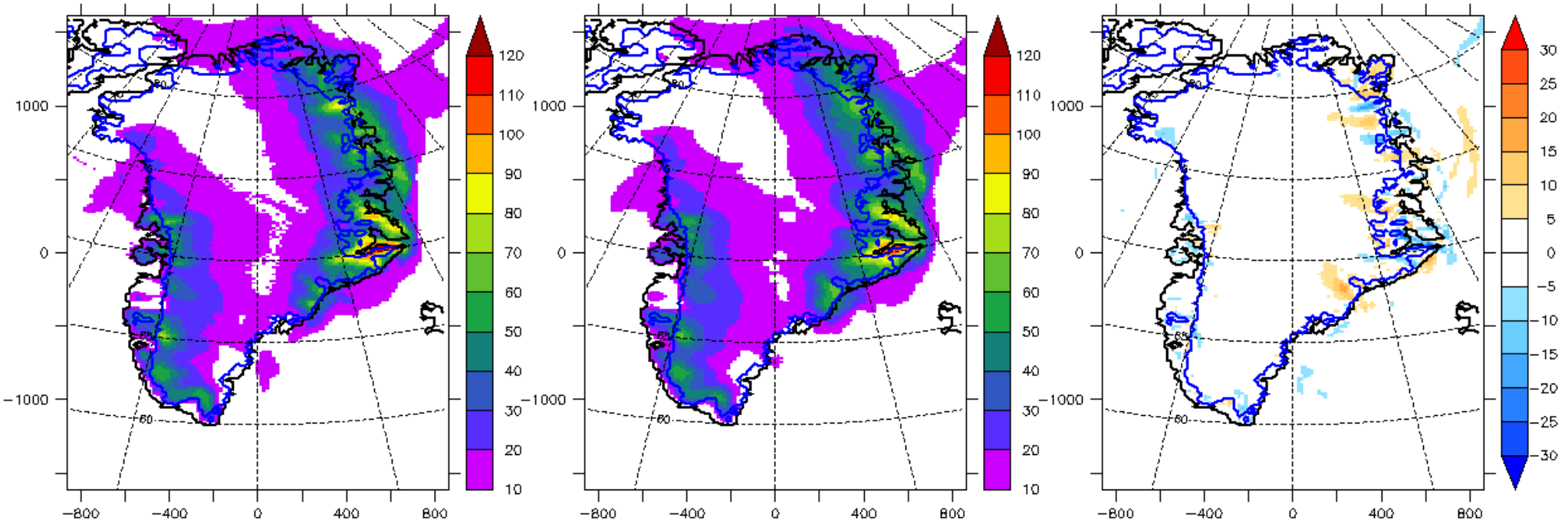
b) 25km rainfall (mmWE) outputs interpolated onto the 15km grid

c) Anomalies (mmWE) between interpolated and simulated rainfall

# 4. Interpolation of the MAR model outputs (3/4)

## IDW interpolation of the 25km-resolution snowfall onto the 15km MAR grid

**From Sept 16th to Sept 30th 2008**




**a) Snowfall (mmWE) outputs from simulation at 15km resolution**

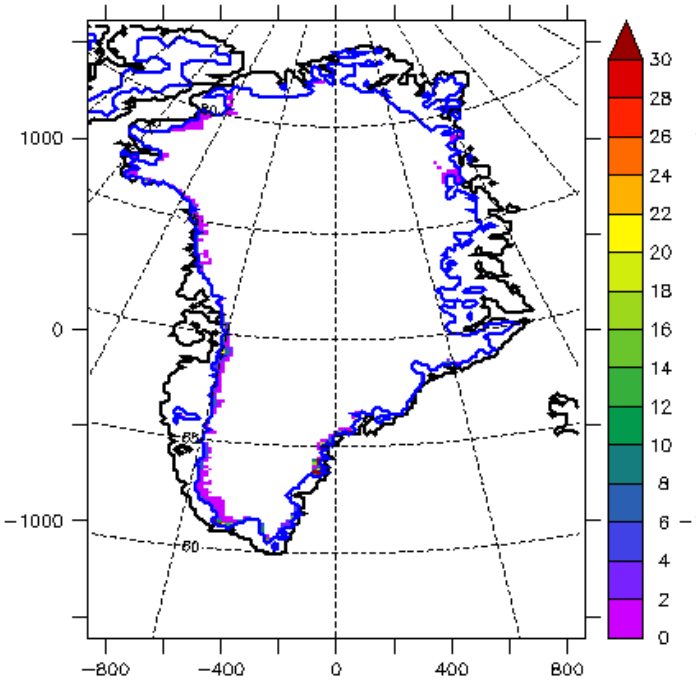
**b) 25km snowfall (mmWE) outputs interpolated onto the 15km grid**

**c) Anomalies (mmWE) between interpolated and simulated snowfall**

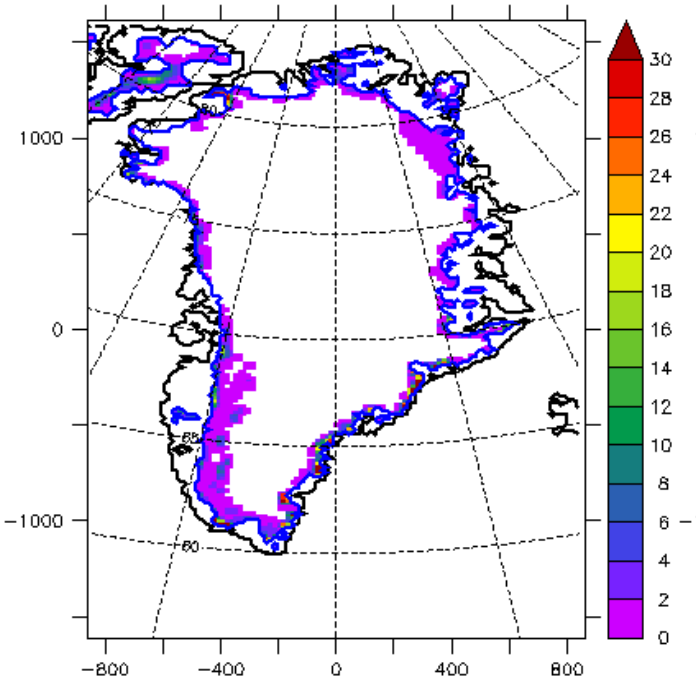
# 4. Interpolation of the MAR model outputs (4/4)

## IDW interpolation of the 25km-resolution runoff onto the 15km MAR grid

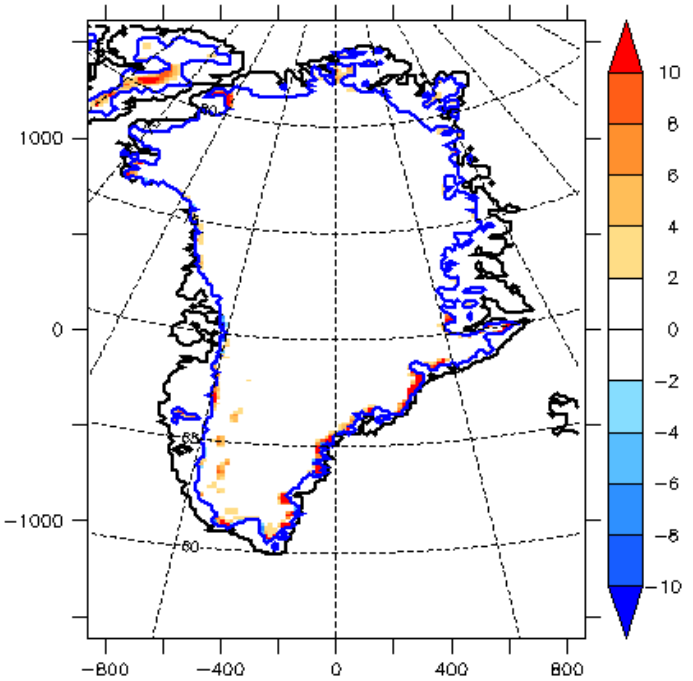
**From Sept 16th to Sept 30th 2008**




a) Runoff (mmWE) outputs from simulation at 15km resolution




b) 25km runoff (mmWE) outputs interpolated onto the 15km grid



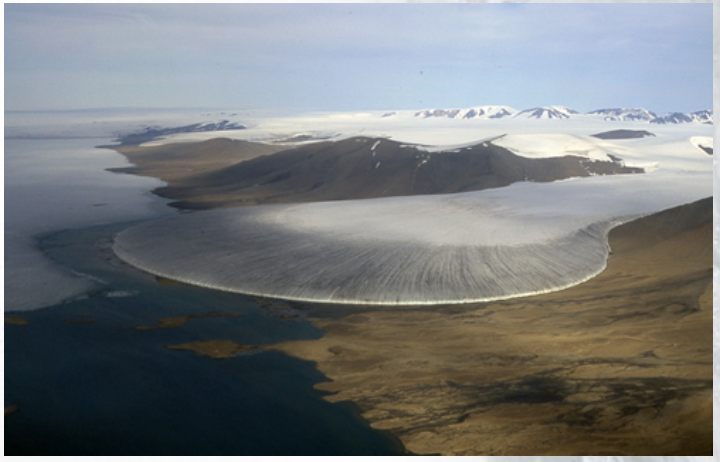

c) Anomalies (mmWE) between interpolated and simulated runoff

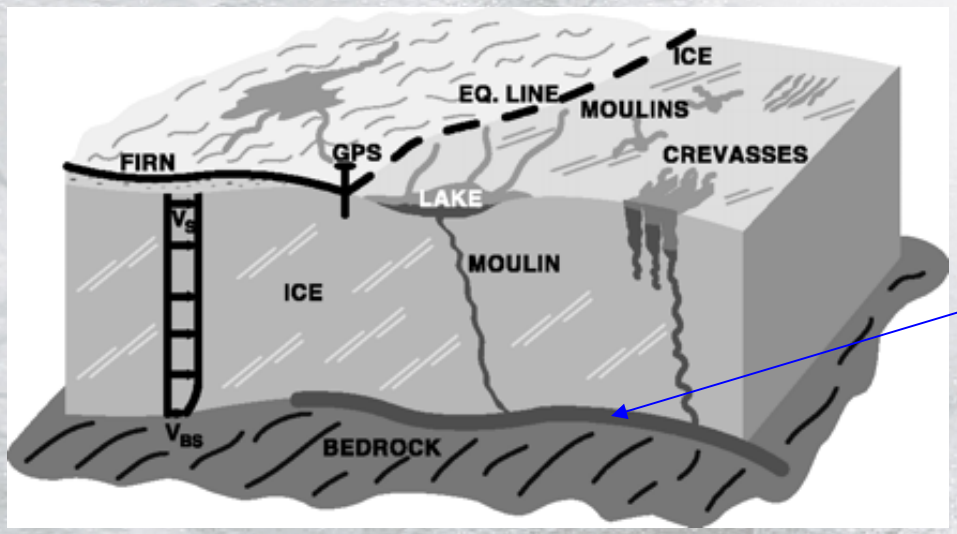
**→ Feedbacks on the runoff ???**

# 5. Conclusion (1/2)

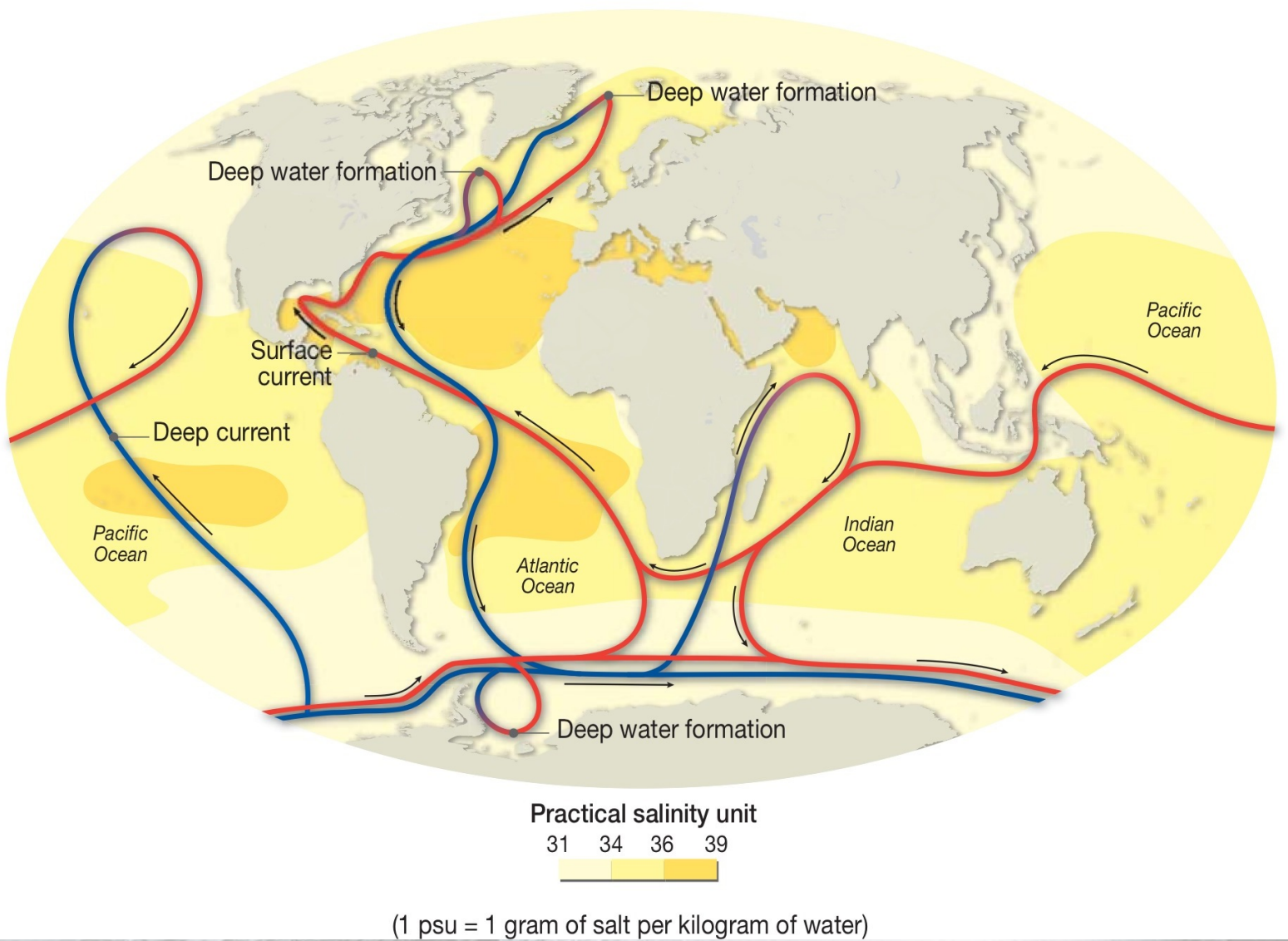
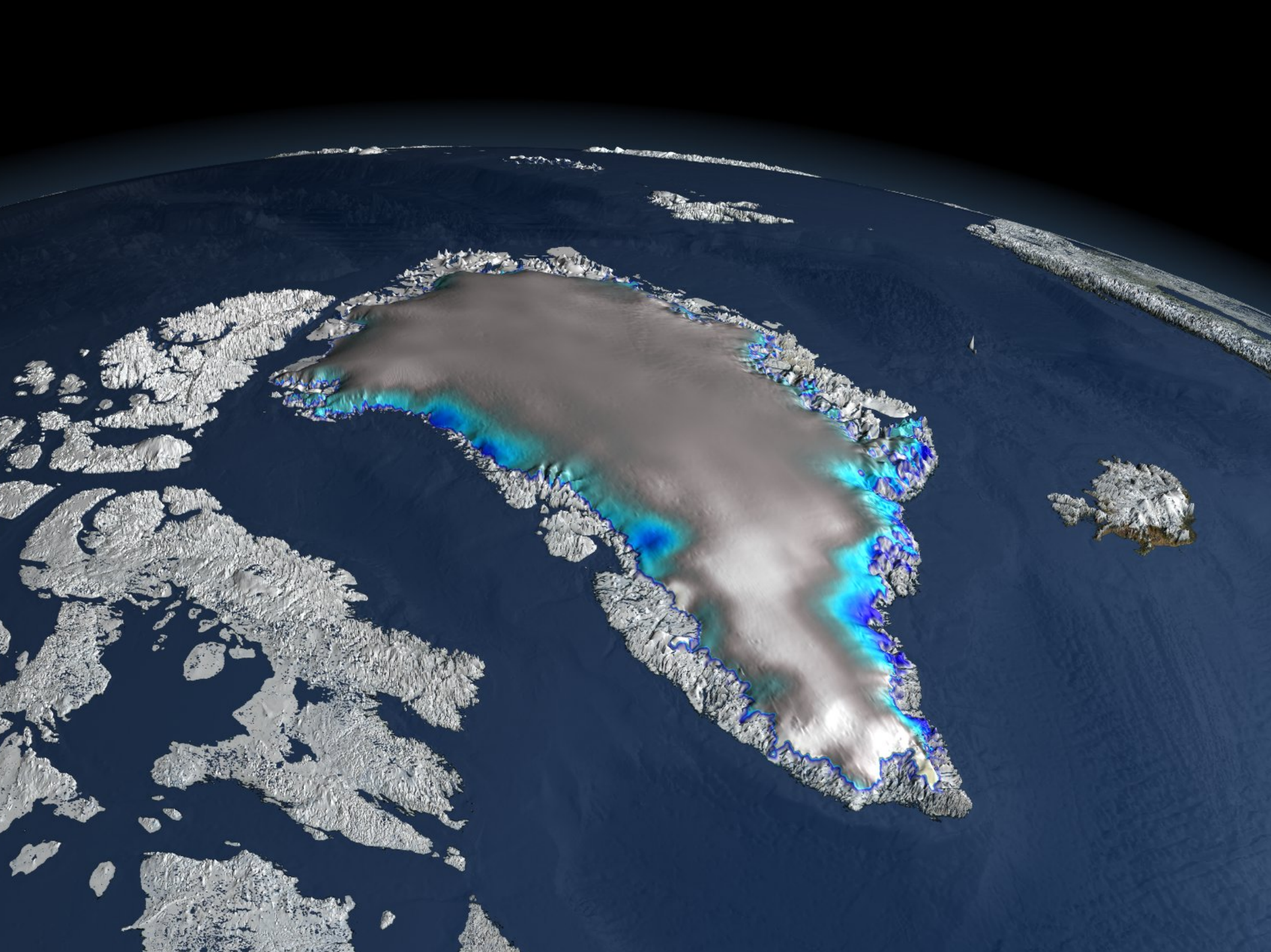
**According to the IPCC projections over the 21st century, the Greenland ice sheet should continue to lose mass**

**Therefore ice sheet models running at very high resolution and forced by reliable outputs from RCM are needed**






**Acceleration of the glacier discharge because the meltwater lubricates the ice sheet/bedrock interface**

# 5. Conclusion (2/2)

## Influences on the global sea-level and the thermohaline circulation