Role of planetary waves on Northern hemisphere ice sheets during the last glacial cycle

P. Beghin[1], S. Charbit [1], C. Dumas[1], M. Kageyama[1], D.M. Roche[1], C. Ritz[2]

[1]*Laboratoire des Sciences de Climat et de l'Environnement* [2]*Laboratoire de Glaciologie et Géophysique de l'Environnement*

contact : pauline.beghin@lsce.ipsl.fr – CE Saclay, Orme des Merisiers 91191 Gif–sur–Yvette Cedex – France – +33(0)1 69 08 31 97

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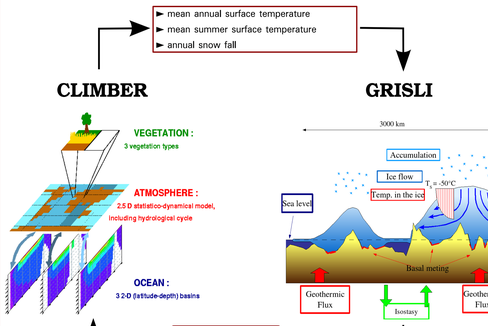
1 – QUESTIONS

- **How planetary waves alter the construction of ice sheets during the last glaciation ?**
- **Do they play any role in the way how one ice sheet construction alters the other ice sheet growth ?**

2 – MODELS DESCRIPTIONS



Ablation = Positive Degree Day method (Reeh, 1991)

$$PDD = \frac{1}{\sigma_{pdd}\sqrt{2\pi}} \int dt \int dT \exp \frac{-\left[T - T_a(t)\right]^2}{2\sigma_{pdd}^2}$$

where σ_{pdd} = daily and monthly standard deviation temperature :

$\sigma_{pdd} = \sigma_0 + \alpha z_S$

with one σ_0 for each region :

- σ_0^{LIS} – laurentide
- σ_0^{FIS} – fennoscandie
- σ_0^{GIS} – Greenland
- σ_0^{SA} – Siberia and Alaska
- σ_0^{R} – rest of the grid

→ **smaller σ_0 = less ablation**

3 – EXPERIMENTAL SET–UP

Four stationary waves parameterizations tested :

1. $p_0'=0$ — **No waves**
2. $p_0'=p_0'(T_0')$ — **Thermal forcing**
3. $p_0'=p_0'(z_s,\Delta T_{E/P})$ — **Orographic forcing**
4. $p_0'=p_0'(T_0')+p_0'(z_s,\Delta T_{E/P})$ — **Oro. + therm. forcing**

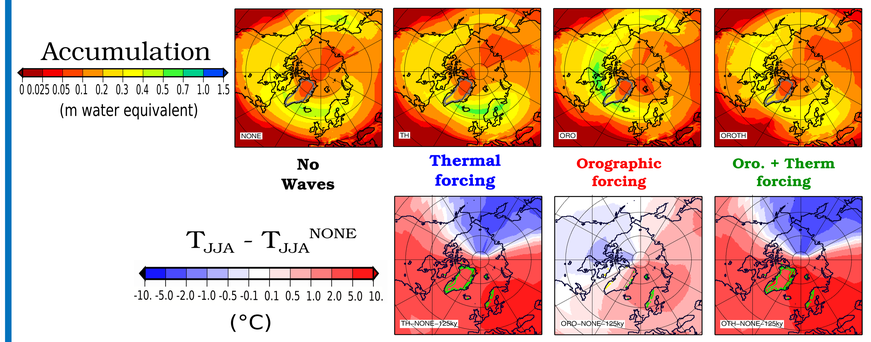
p_0' = azonal sea-level pressure, $\Delta T_{E/P}$ = equator-pole temperature gradient

For each parameterization of waves, three experiments with different couples σ_0^{LIS}– σ_0^{FIS} have been carried out :

- σ_0^{LIS} = 3.25 σ_0^{FIS} = 0.50 **reference case**
- σ_0^{LIS} = 3.25 σ_0^{FIS} = 0.25 → **less ablation on FIS** → **larger Fennoscandia → effect on Laurentide ?**
- σ_0^{LIS} = 3.00 – σ_0^{FIS} = 0.50 → **less ablation on LIS** → **larger Laurentide → effect on Fennoscandia ?**

4 – RESULTS

a. Situation at –125 kyrs for the four different parameterizations of waves



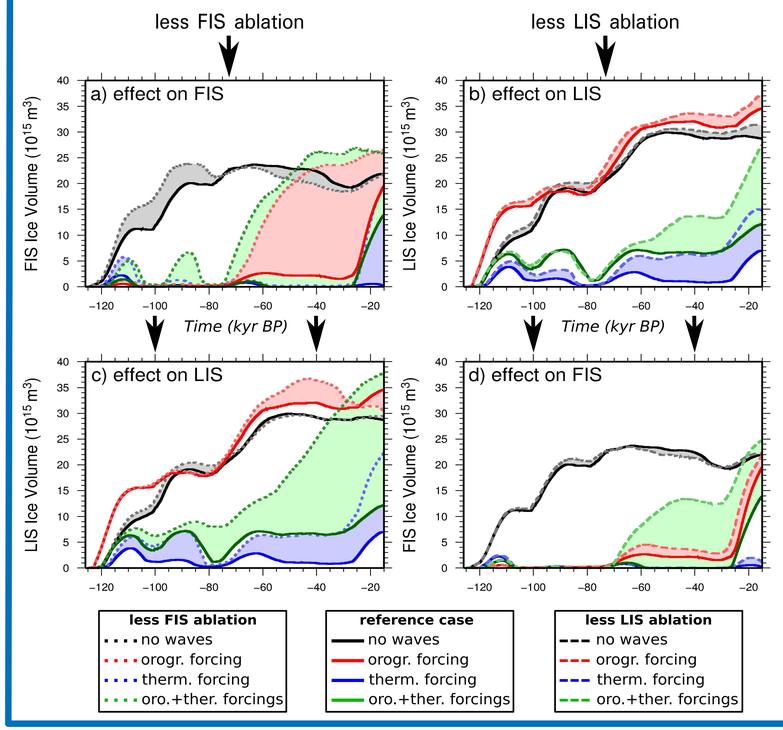
- Accumulation and summer surface temperature patterns depend on waves forcing, influencing ablation

=> Planetary waves can favor (or not) ice sheet formation depending on the forcing that we take into account

=> the sensitivity of a change in ablation calculation will not be the same depending on these forcings.

Example : If we decrease FIS ablation consequences are larger with thermal forcing (accumulation and warm summer temperature over Scandinavia) than with orographic forcing (less accumulation).

b. Evolution of ice volume over the two northern ice sheets during the last glacial cycle for each experiment



- Response to insolation variations : five periods of insolation decrease : **-126 kyr**, -105 kyr, **-85 kyr,** -60 kyr and **-30 kyr**.

-126 kyr until -110 kyr:
Differences at the onset on glaciation can be explained by accumulation and summer temperatures patterns.

-80 kyr until -40 kyr:

1. **the relationship between ice sheet is different depending on planetary waves**

less LIS ablation → larger LIS → same FIS with only thermal forcing *(fig.c blue)*
(fig (b), green and blue curves) → larger FIS with the two forcings *(fig.c green)*

2. **Importance of the glaciation history**

less FIS ablation → smaller FIS *(fig.a greys curves)*

-30 kyr until -15 kyr:
The response is larger when one of the two ice sheets is small *(red curves fig.a and c)*

5 – CONCLUSIONS

Planetary waves influence :

- **the growth of the ice sheets and the dynamics of the cycle through accumulation and summer temperatures patterns → depending on planetary waves forcing**
- **the way how the growth of a given ice sheet alters the construction of the second one → In our experiments, the orographic forcing is crucial in this relationship**