The effect of latent heat transport by waves on Greenland Surface Mass Balance

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May 5, 2020

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- Here we investigate the effect of heat transport by waves of several length scales on the surface mass balance of the Greenland Ice-sheet.
- The atmospheric waves are split into zonally symmetric circulation, planetary waves and synoptic waves.
- The SMB data is from the Racmo model on a 1 km resolution.

Wave data

- The atmospheric wave data is interpolated from a 0.5 x 0.5° resolution era5 grid to the Racmo grid. This is done on a daily time-resolution.
- The separation of length scales is based on a Fourier series split of the mass flux.
- To achieve a latitude-longitude resolved data set we have only split the meridional and zonal massfluxes into waves, whilst the energy content is not split.
- Hence the wave split, in the meridional direction, may be written as

$$vE(x) = \sum_{n=0}^{\infty} \sum_{l=0}^{L} E^l \left[a_n^l \cos(2\pi n x) + b_n^l \sin(2\pi n x) \right].$$

- A similar expression may be derived for the zonal energy transport.

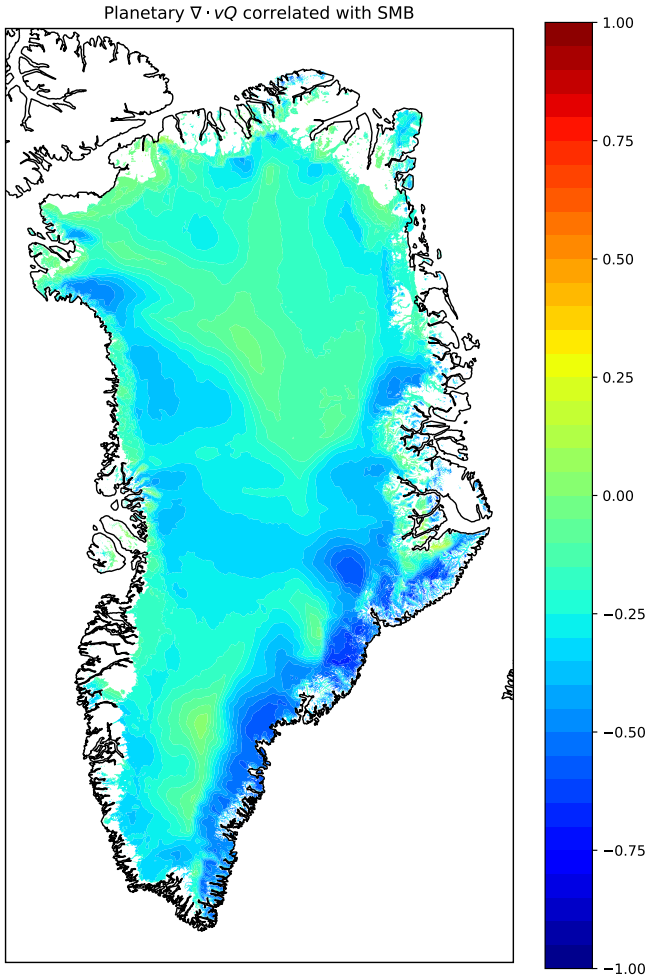
Divergence of transport and correlations with SMB

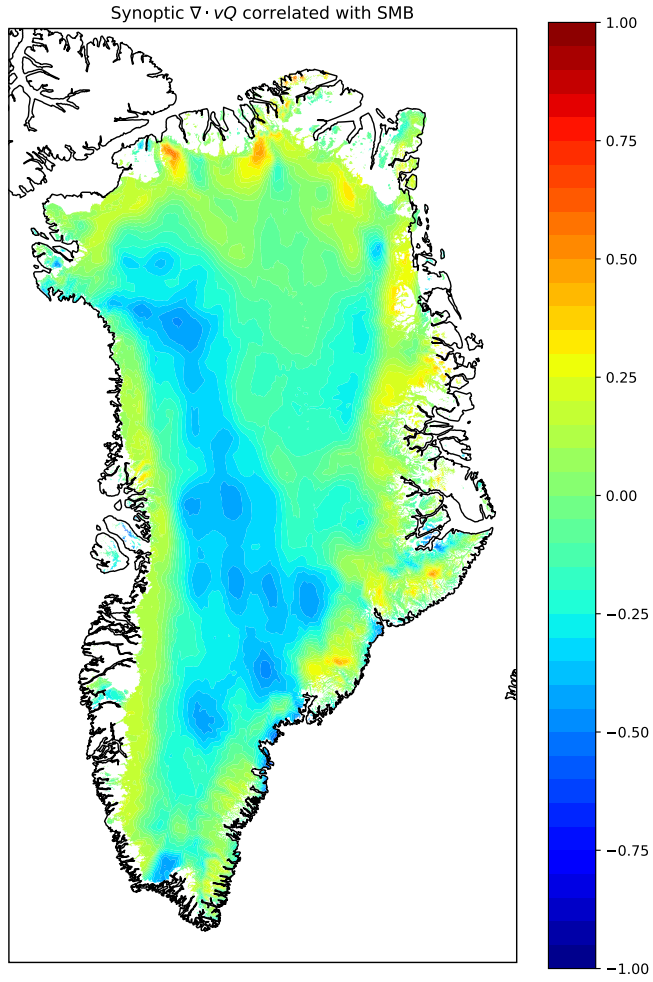
- The energy transport is split into waves based on wavenumber. Wavenumber $n = 0$ corresponds to the symmetric flow, $n = 1$-3 to the planetary waves and $n \geq 4$ to the synoptic waves.
- We compute the divergence of energy transport for each of these length scales

$$\nabla \cdot \boldsymbol{v}E.$$

- The correlation between this divergence and the SMB is computed grid-cell wise.
- A positive correlation indicates that we have melting (negative SMB) when we have convergence (negative divergence) of energy transport in a grid-cell.
- A negative correlation indicates that we have accumulation (positive SMB) when we have convergence (negative divergence) of energy transport in a grid-cell.

2 - Correlations – Latent heat

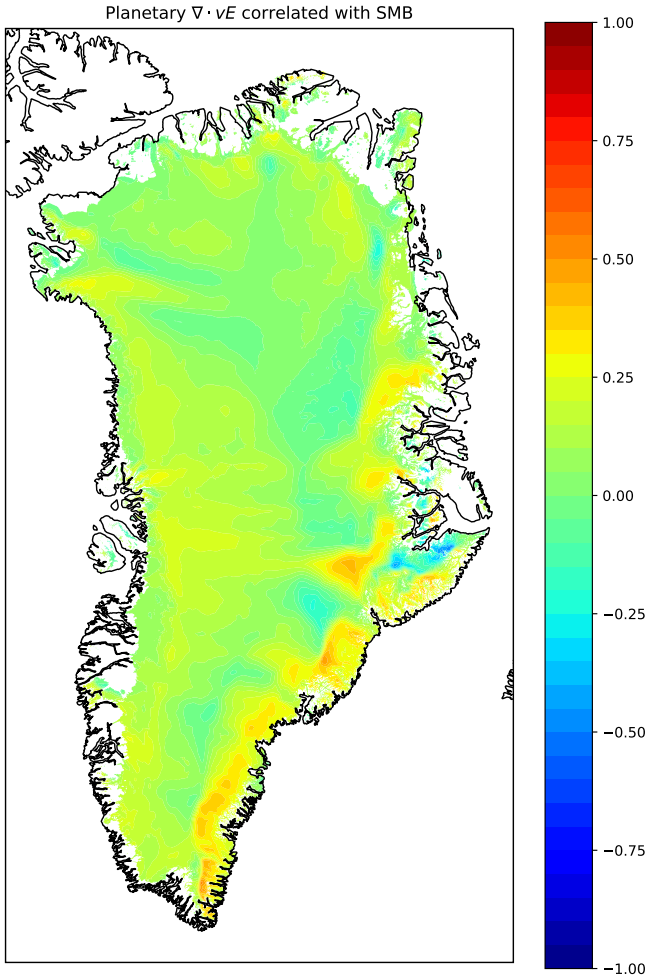


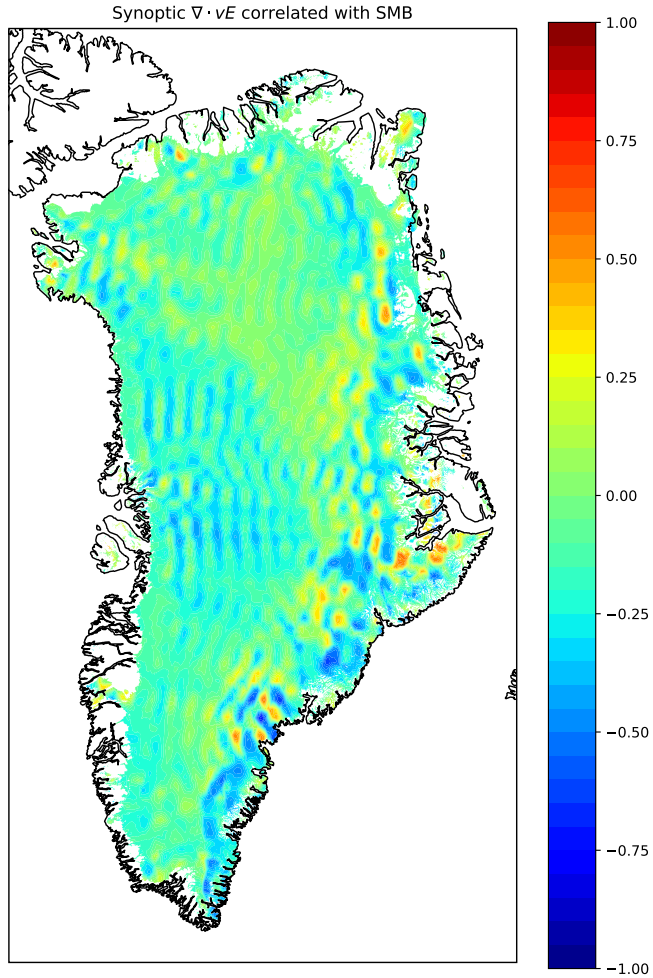


2 - Correlations – Latent heat

- For the planetary waves the main pattern indicates an accumulation of mass in the south-eastern parts of Greenland associated with a convergence of latent heat transport.
- For the other regions the correlations are weak.
- For the synoptic waves the main pattern indicates an mass loss in the case of convergence along the coast-lines. This may be associated with strong synoptic-scale transport with relatively warm cyclones.
- The strongest patterns for the synoptic correlations are along the coastlines, the transport may not reach far over Greenland.
- The symmetric component ($n = 0$, not shown) does not play a significant role. It is very weak at these latitudes.

3 - Correlations – Dry-static energy





3 - Correlations – Dry-static energy

- For the planetary waves the main pattern indicates mass loss in the case of convergence of transport.
- The largest effect is here also at the south-eastern coast of Greenland.
- The synoptic divergence correlations does not show any clear physical patterns, and may rather be influenced on noise in the data.
- Here further investigations are needed.
- For $n = 0$ we have the same case as for latent heat, no clear correlation patterns are present.

4 - Conclusions

Note that this is a preliminary study, and further work is required. However some conclusions we may draw are the following:

- The correlations are not very strong. Ranging from 0.25-0.70 in different regions.
- Planetary waves seem to have the most effect on the south-eastern parts of Greenland.
- Synoptic-scale transport is mostly important when it comes to latent heat.
- The synoptic patterns are strongest along the coastlines.
- $n = 0$ transport does not play a large role at all.
- Planetary scale transport affects the mass balance differently based on whether it is of dry-static energy or latent heat.