Inland ~~rapid~~ response of Antarctic outlet glaciers with the help of the Envisat radar altimeter

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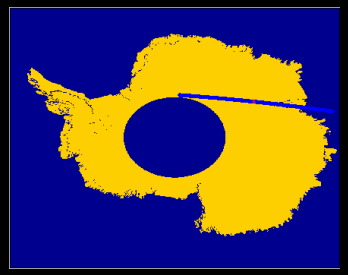
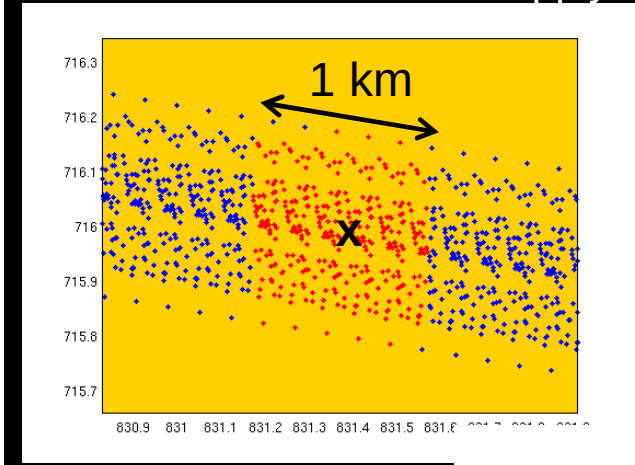
Byrd glacier, SPIRIT

Radar altimetry processing



Distribution of tracks and selection of points within a radius of 1 km to apply corrections.

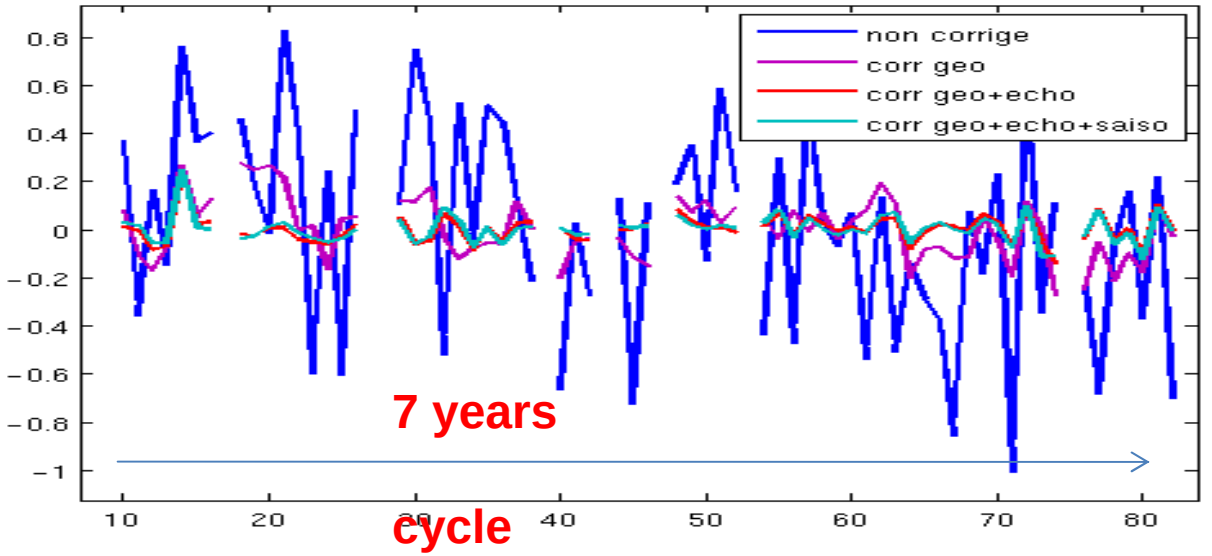


→ 6 points * 65 available tracks
Or around 350 points

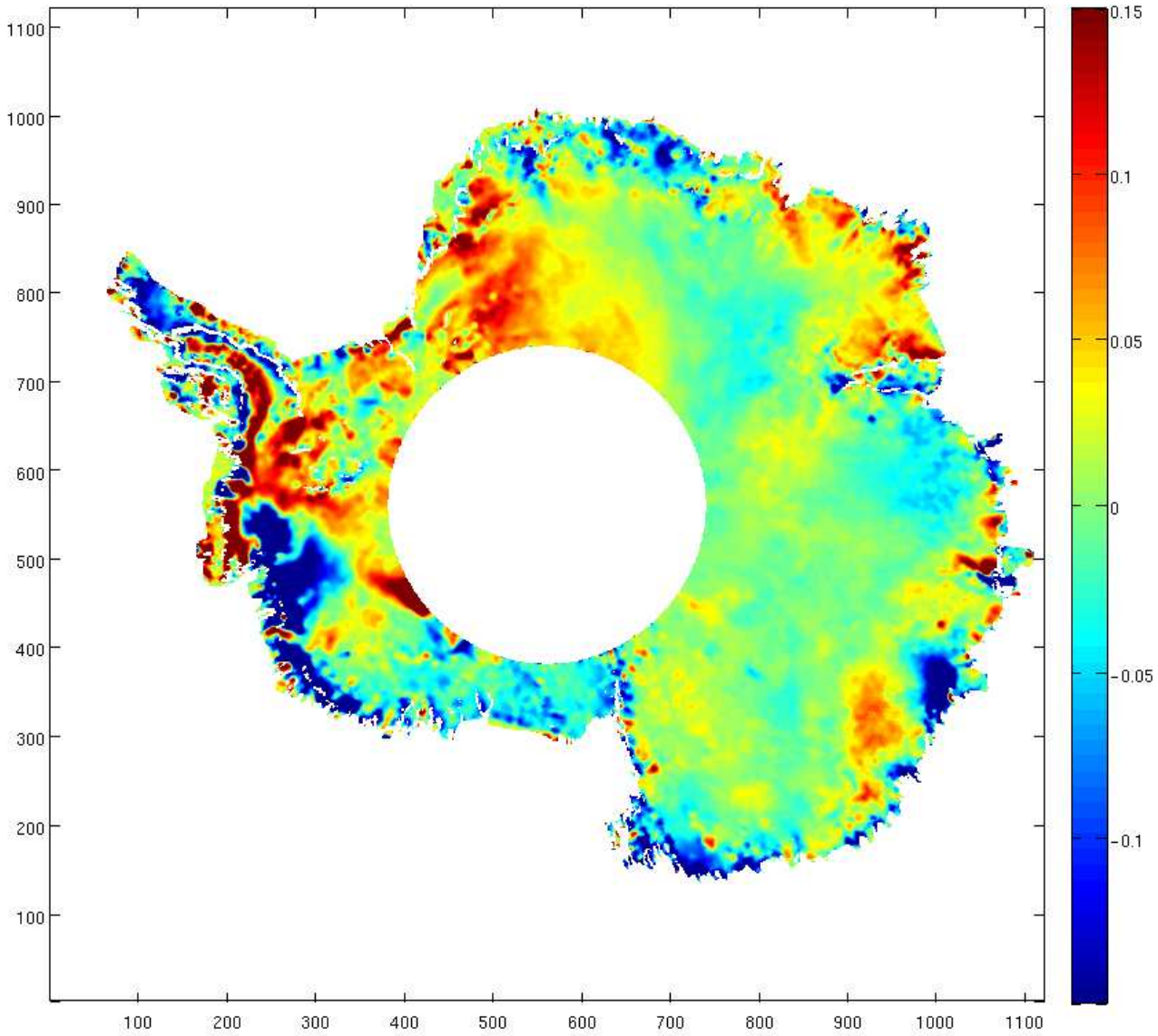
$H = H_0$
$+ fgeo(x,y,x^2,xy,y^2)$ (5)
$+ fecho(waveform\ parameters)$ (3)
$+ fseason(acowt, bsinwt)$ (2)
$+$ linear trend estimation (1)

→ Fit 11 parameters with 350 points
→ dh/dt and px,py for slope correction

$\sigma(H) = 0.38$ m
$\sigma\ (H–hgeo) = 0.11$ m
$\sigma\ (final) = 0.05$ m



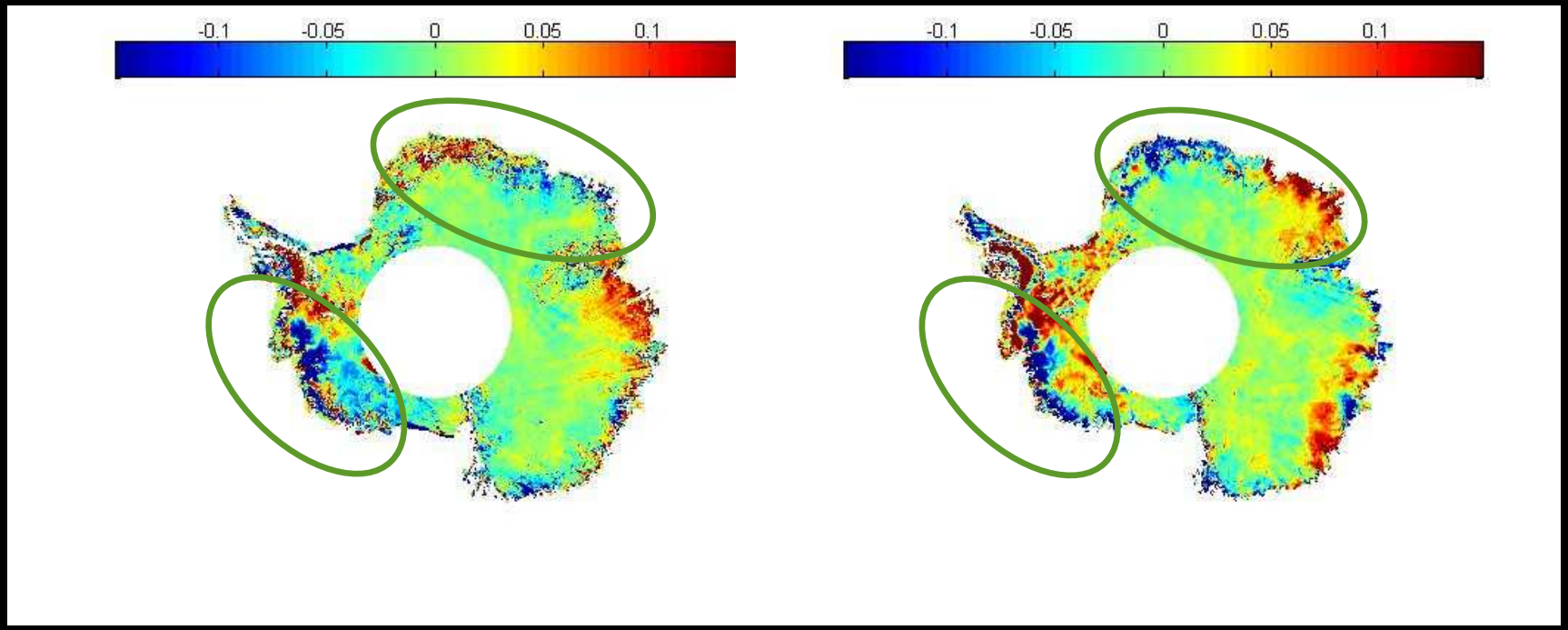
Height variations from Envisat (2002-2010) in m/yr



Antarctica ice sheet height evolution (cm/yr)

ERS 1995-2003

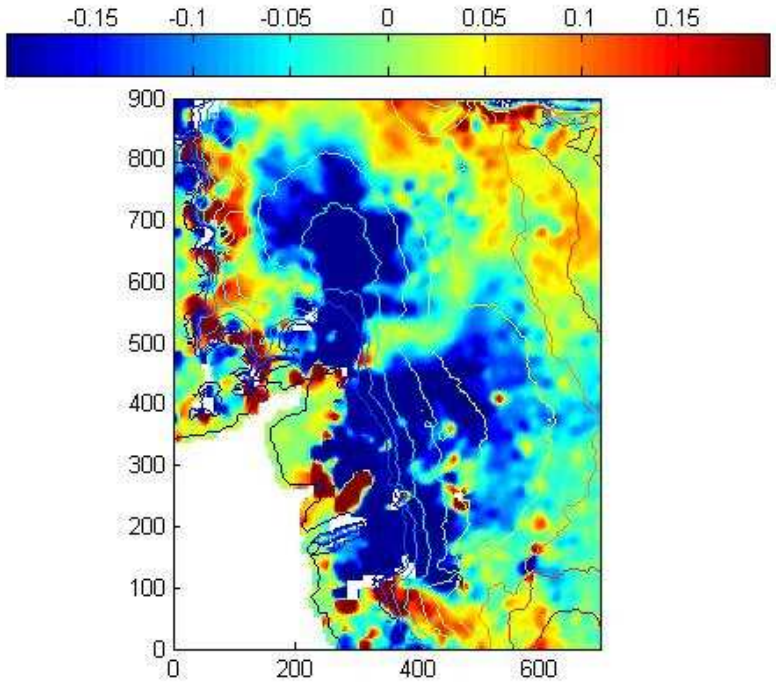
Envisat (2002-2008)



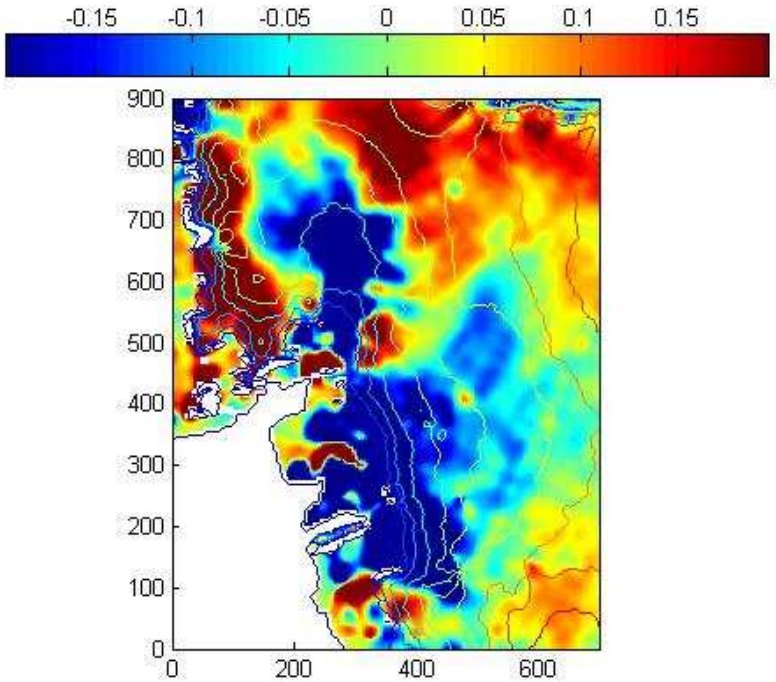
→ Important variability in snow accumulation pattern

Pine Island Glacier- Twaites sector

ERS loss : 58 km³/yr

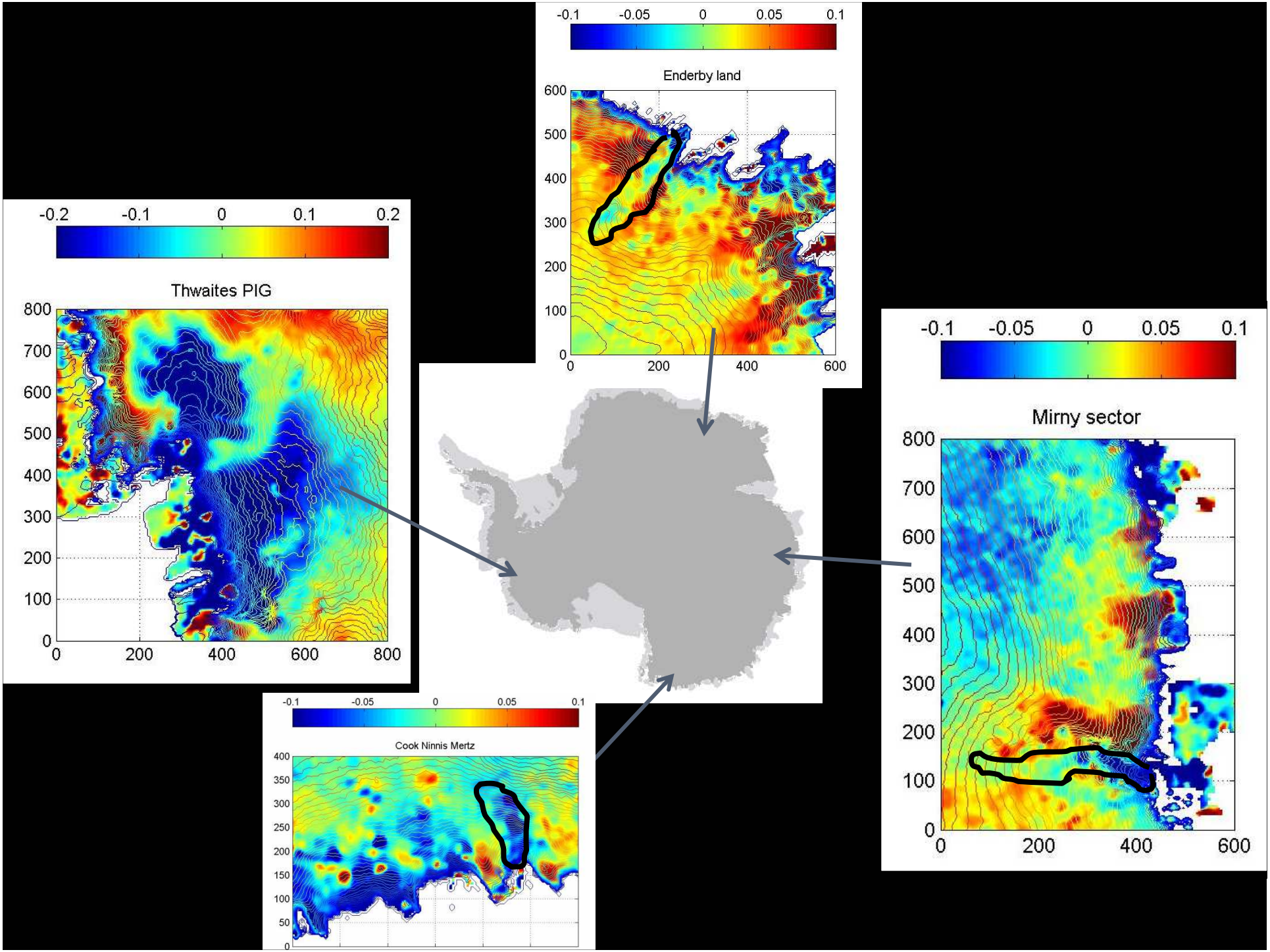


Envisat loss: 53 km³/yr



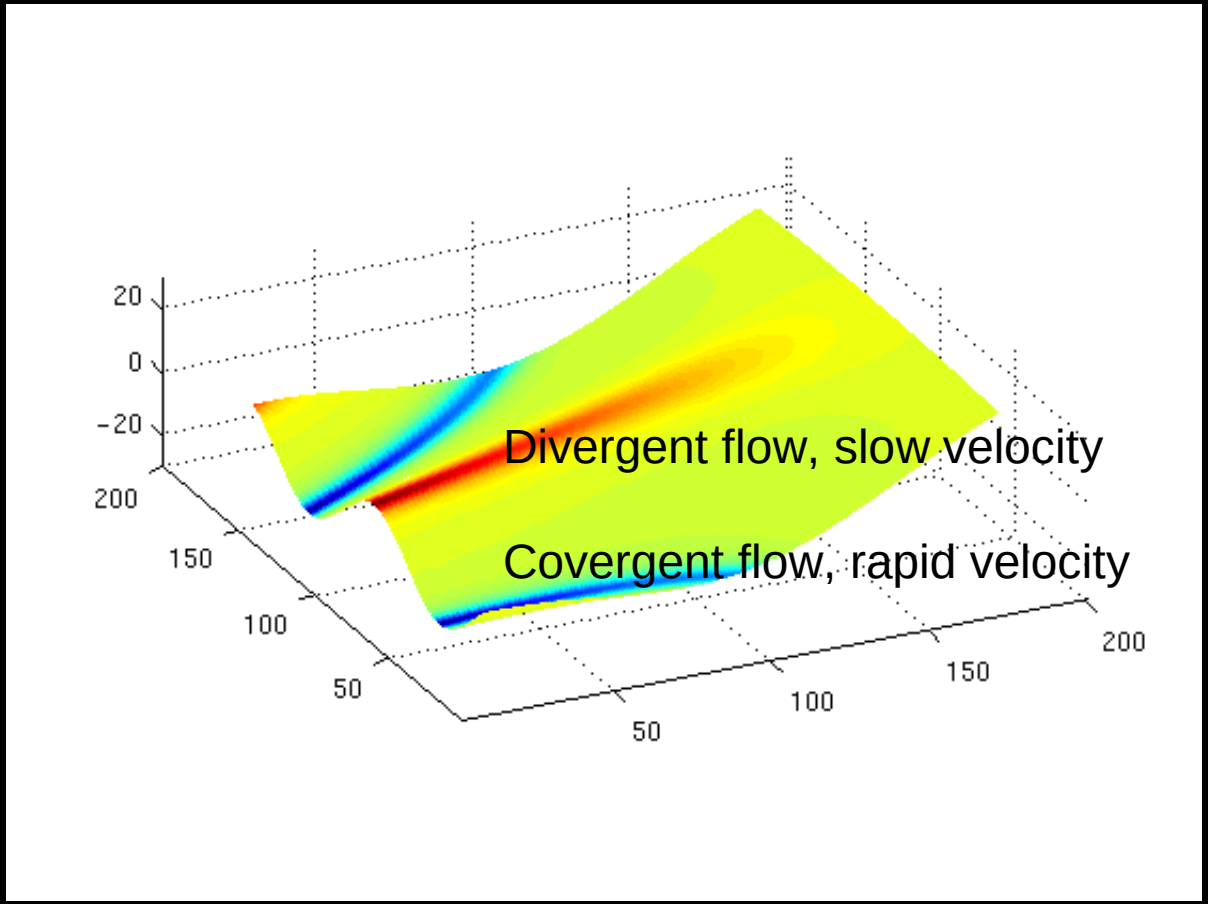
In some places, dynamical signal can easily be detected

The problem is to detect dynamics signal within all superimposed signals


-0.1 -0.05 0 0.05 0.1
Enderby land
0 100 200 300 400 500 600
0 200 400 600
-0.2 -0.1 0 0.1 0.2
Thwaites PIG
0 100 200 300 400 500 600 700 800
0 200 400 600 800
-0.1 -0.05 0 0.05 0.1
Mirny sector
0 100 200 300 400 500 600 700 800
0 200 400 600
-0.1 -0.05 0 0.05 0.1
Cook Ninnis Mertz
0 50 100 150 200 250 300 350 400

Visualisation of the drainage pattern

Ice flow follows the slope direction and is deviated by the surface curvature toward the convergent area.
→ Across-slope curvature is a mean to point out the drainage



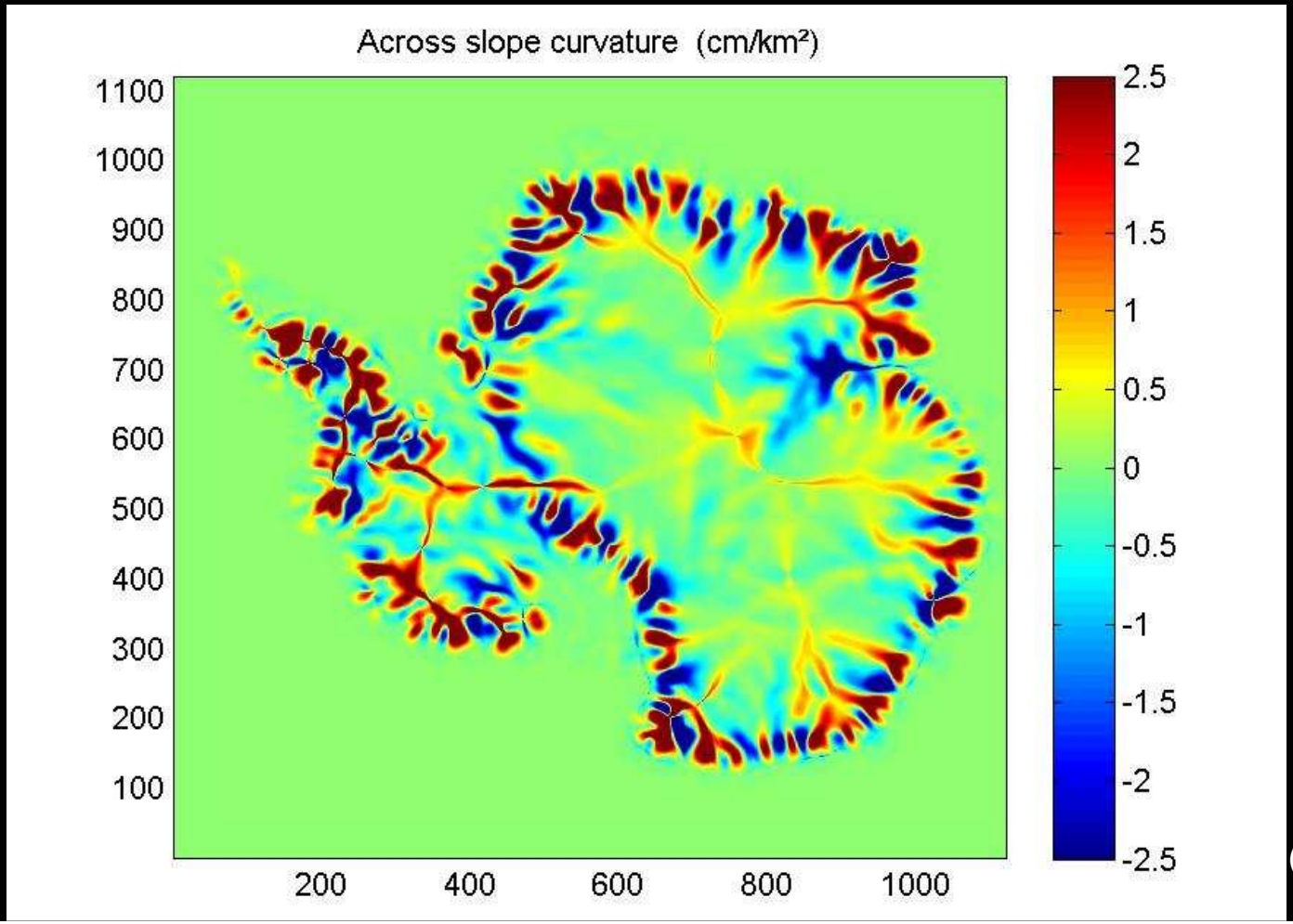
Drainage pattern

→ The across-slope curvature (cy) intervenes in the balance equation

$$d(EU)/dx + cy/p\ EU = b$$

→It corresponds to outlet flow anomalies transmitted from coast to the dome

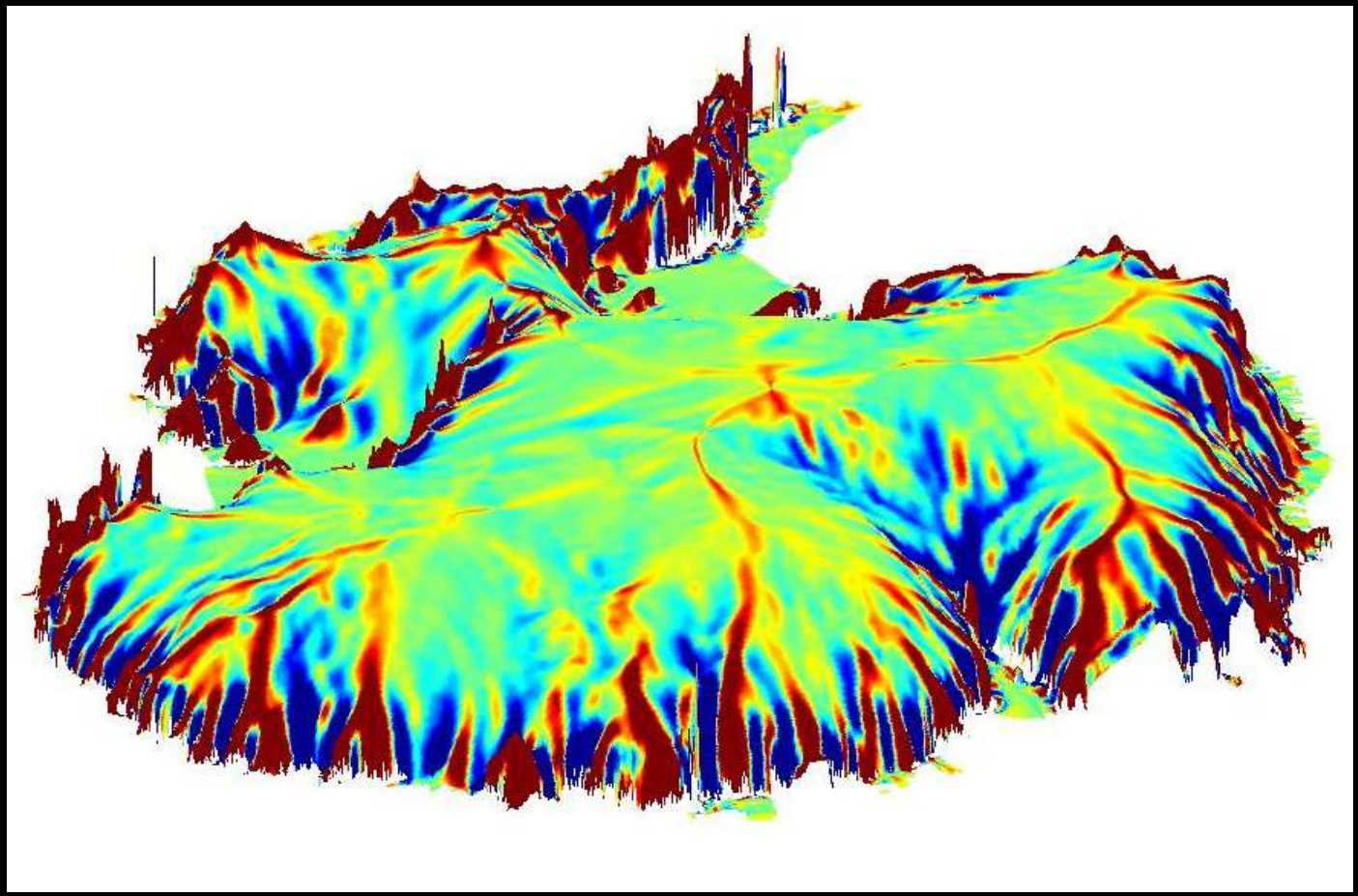
→ It allows to visualize flow pattern



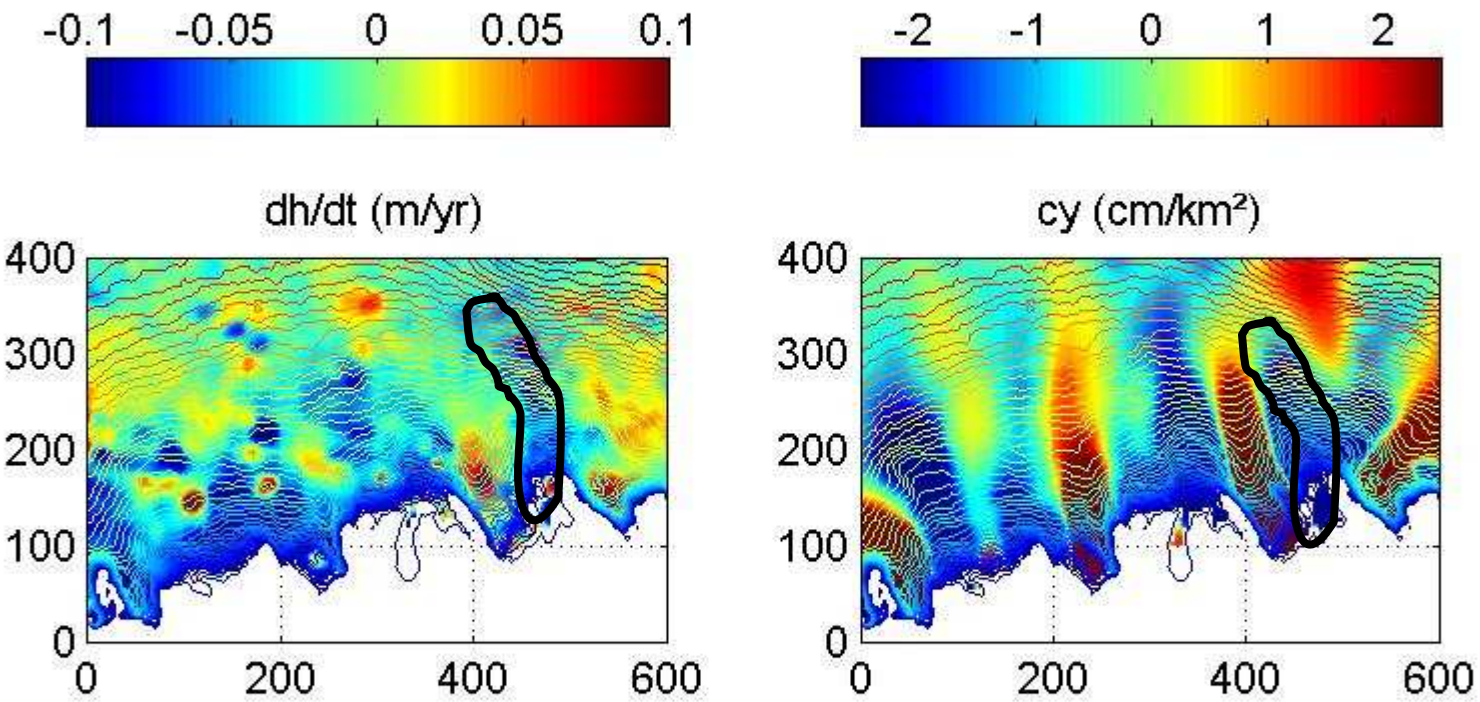
(Remy and Minster, 1997)

3-D visualisation of the drainage pattern

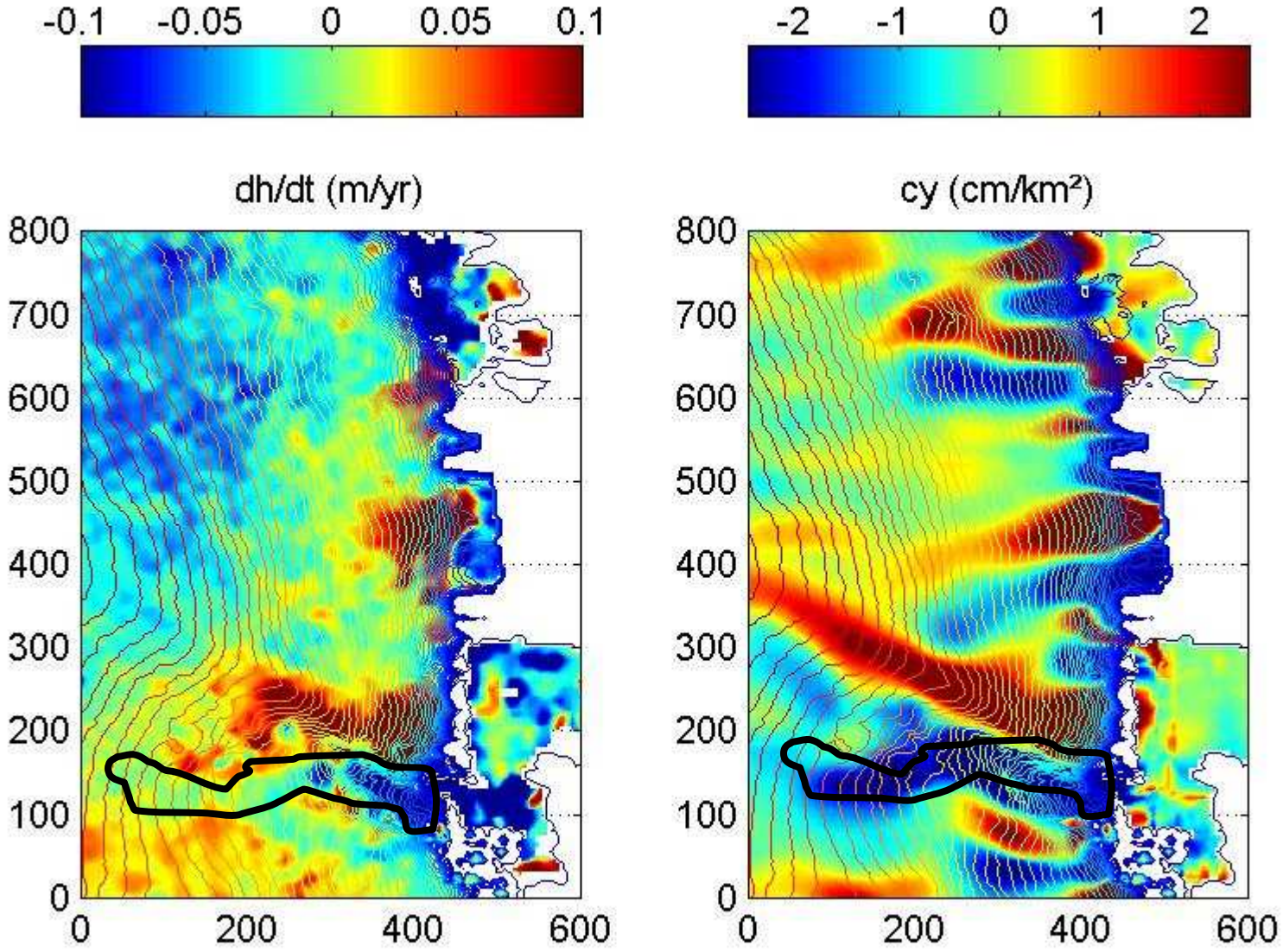
→ At the coast the alternance of divergent (red) or convergent (blue) flow at the 250 km scale is not yet explained



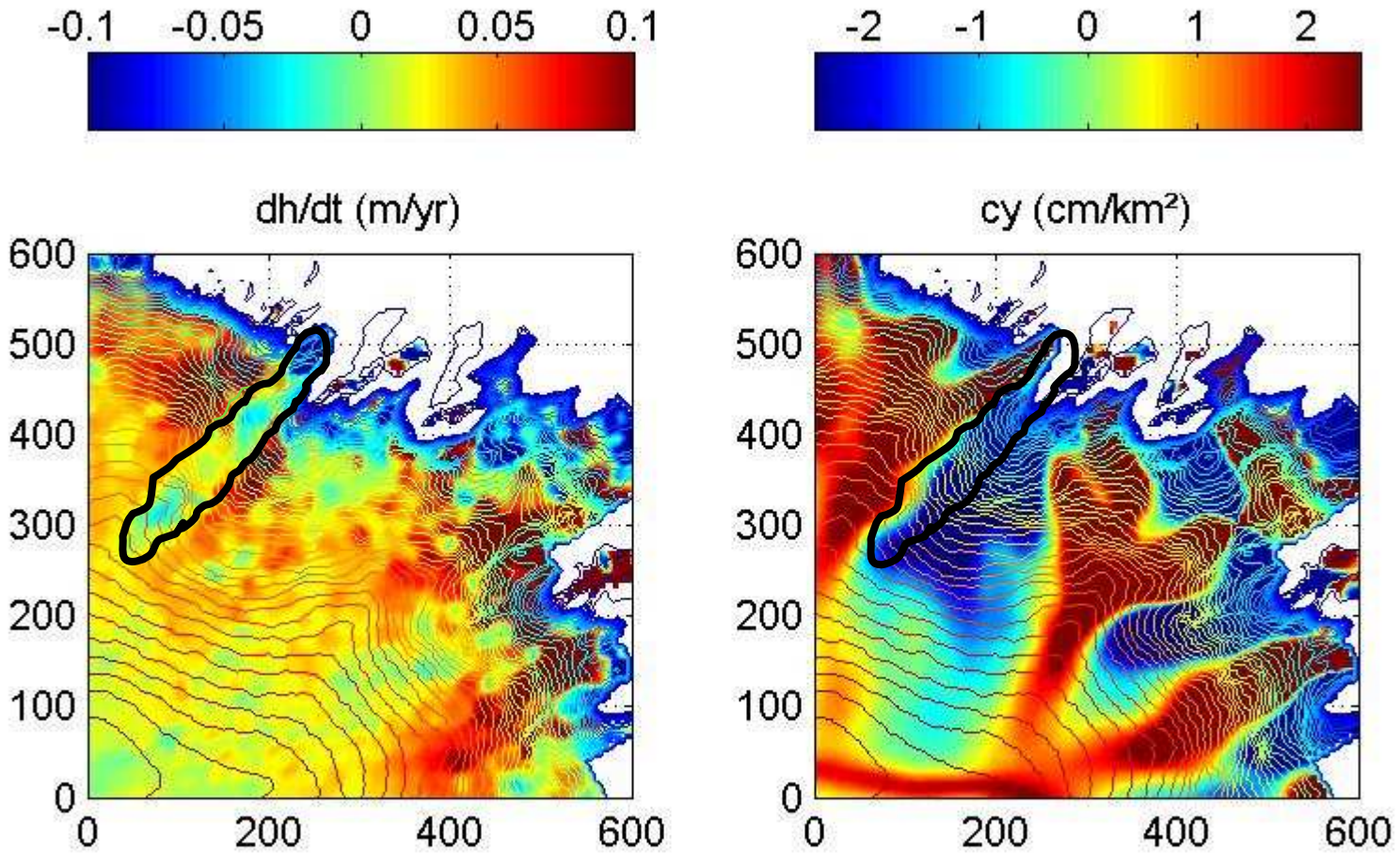
Cook, Ninnis and Mertz sector

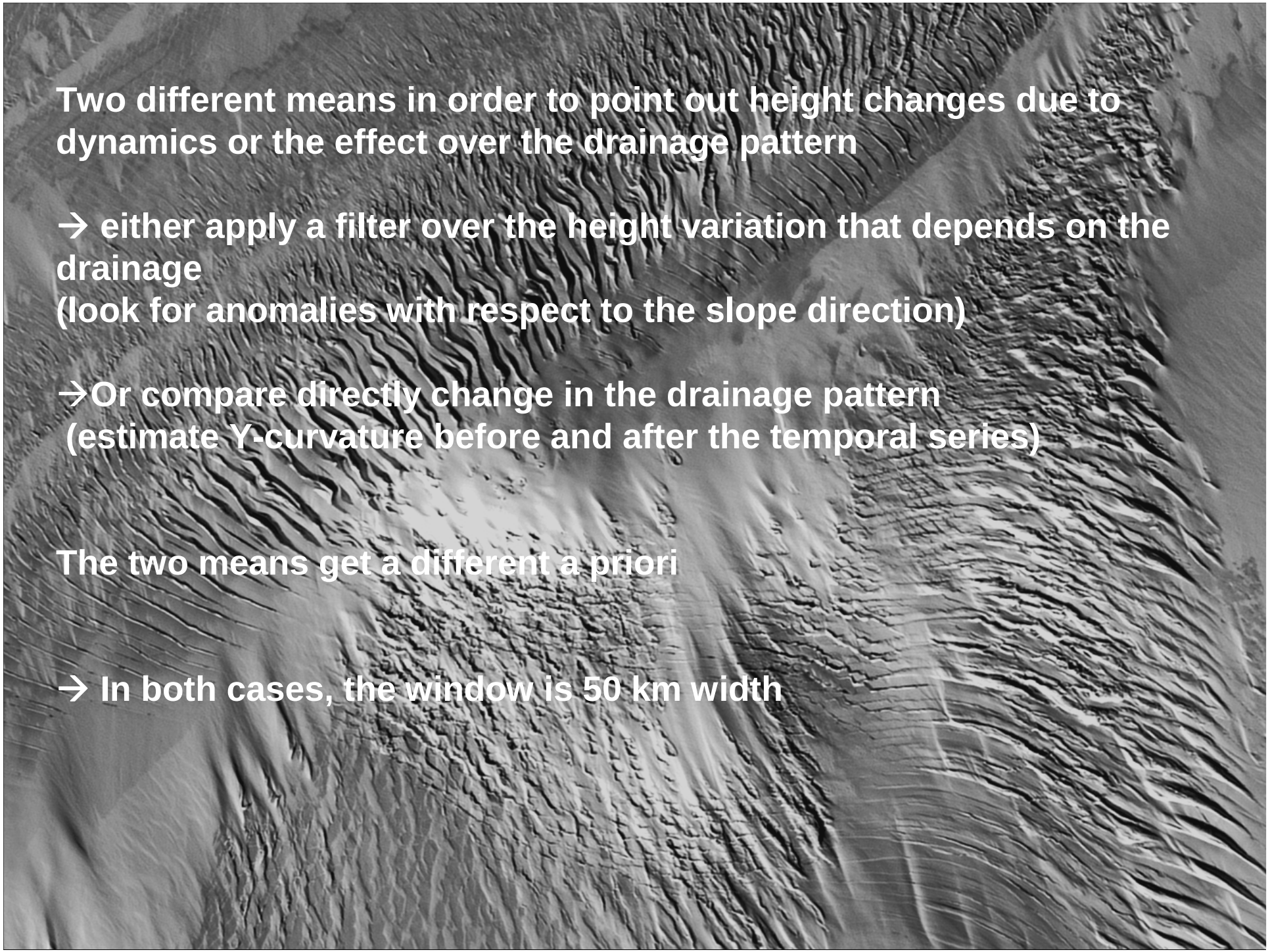


Mirny sector



Enderby sector





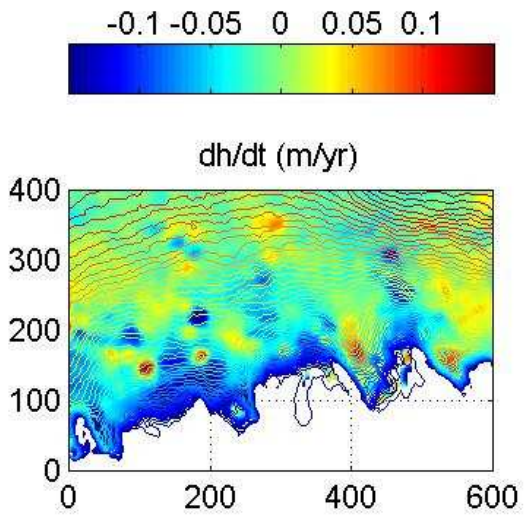
Two different means in order to point out height changes due to dynamics or the effect over the drainage pattern

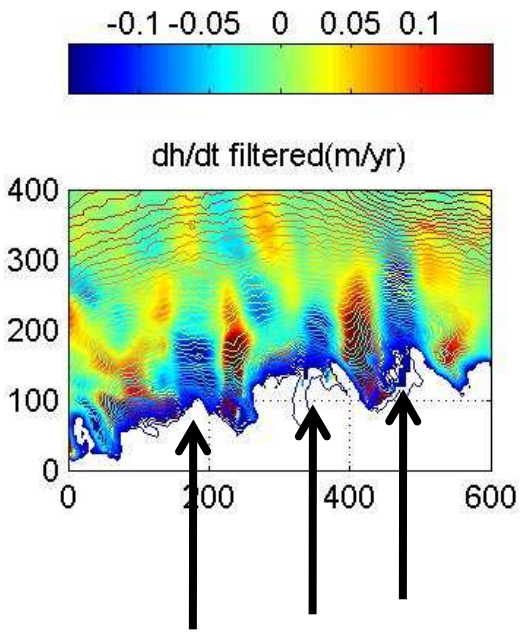
→ either apply a filter over the height variation that depends on the drainage
(look for anomalies with respect to the slope direction)

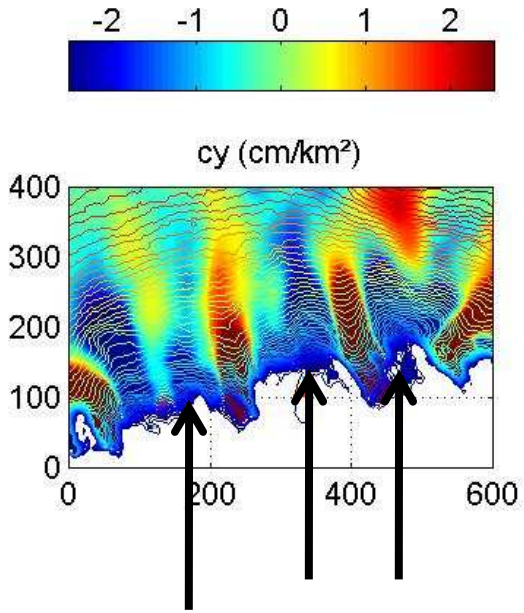
→Or compare directly change in the drainage pattern
(estimate Y-curvature before and after the temporal series)

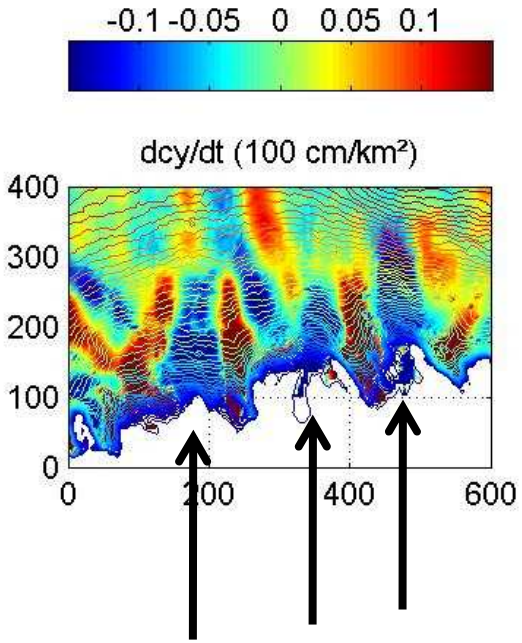
The two means get a different a priori

→ In both cases, the window is 50 km width

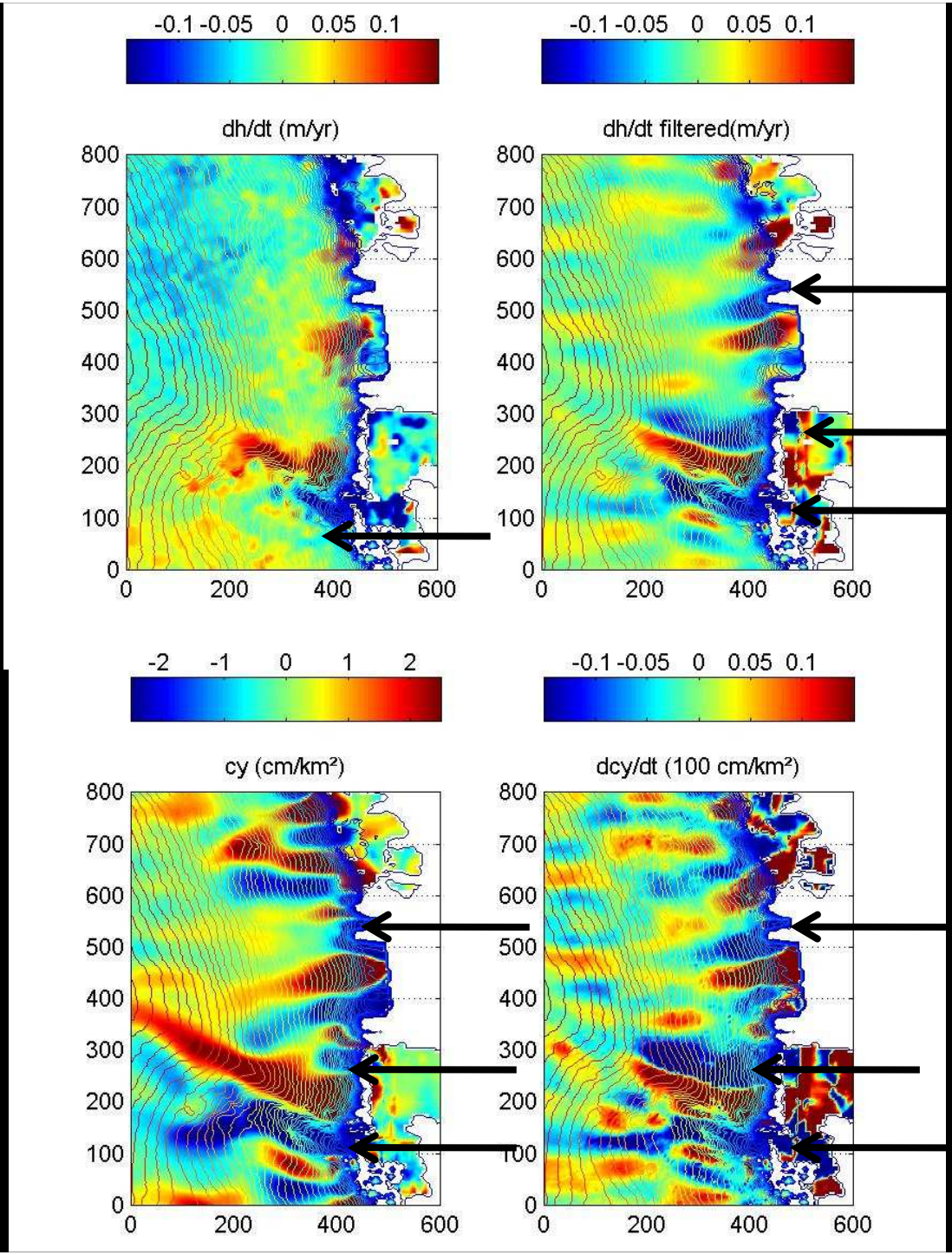






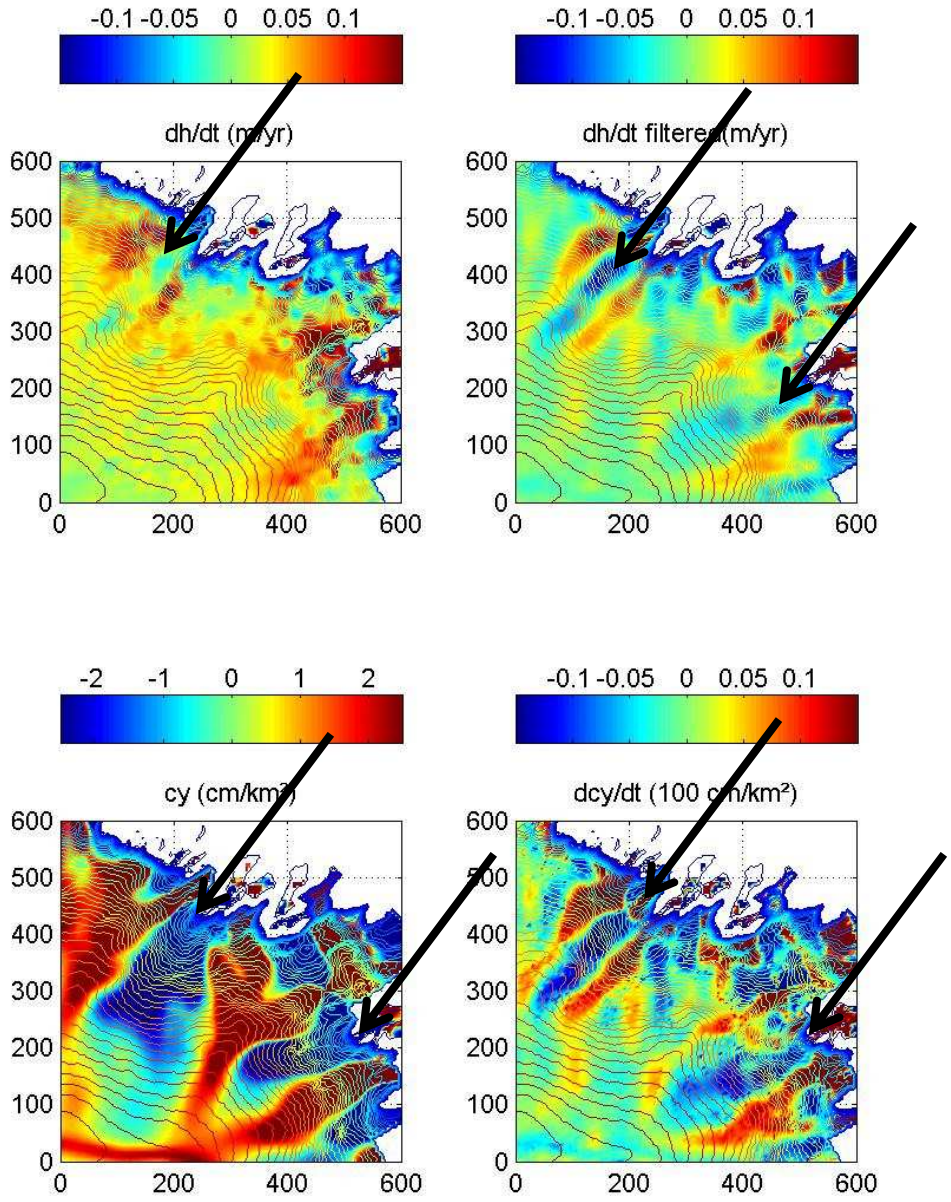


Cook, Ninnis and Mertz sector

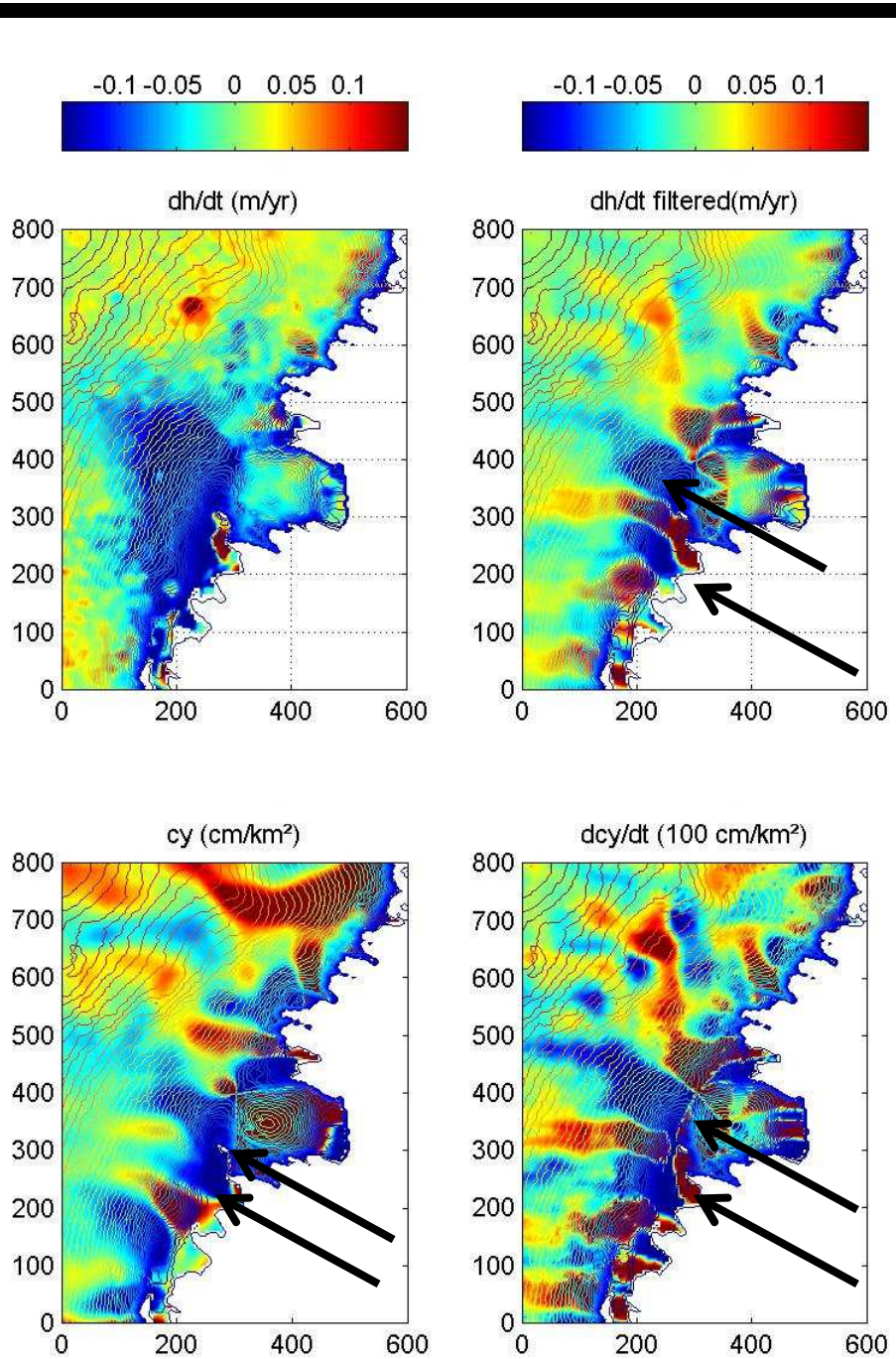


Mirny sector

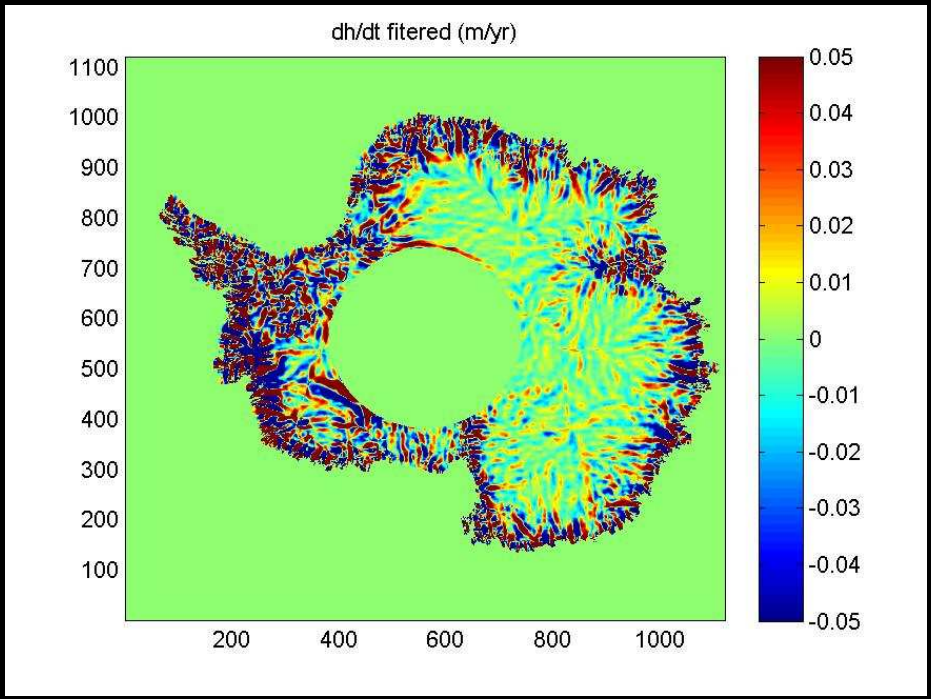
Change is about 1/1000 of the mean value

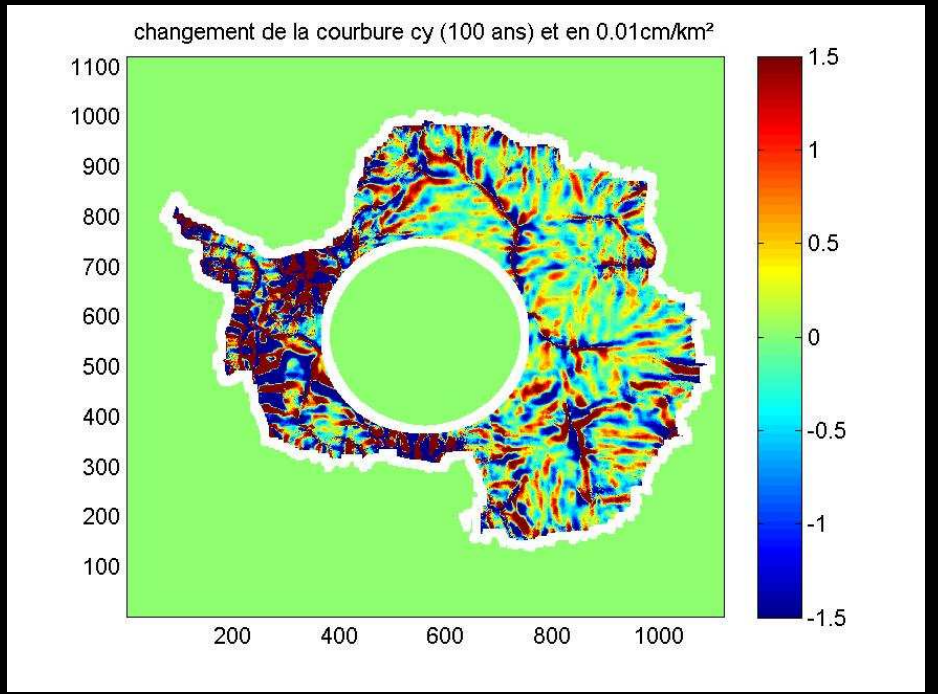


Enderby sector



Totten and law dome sector





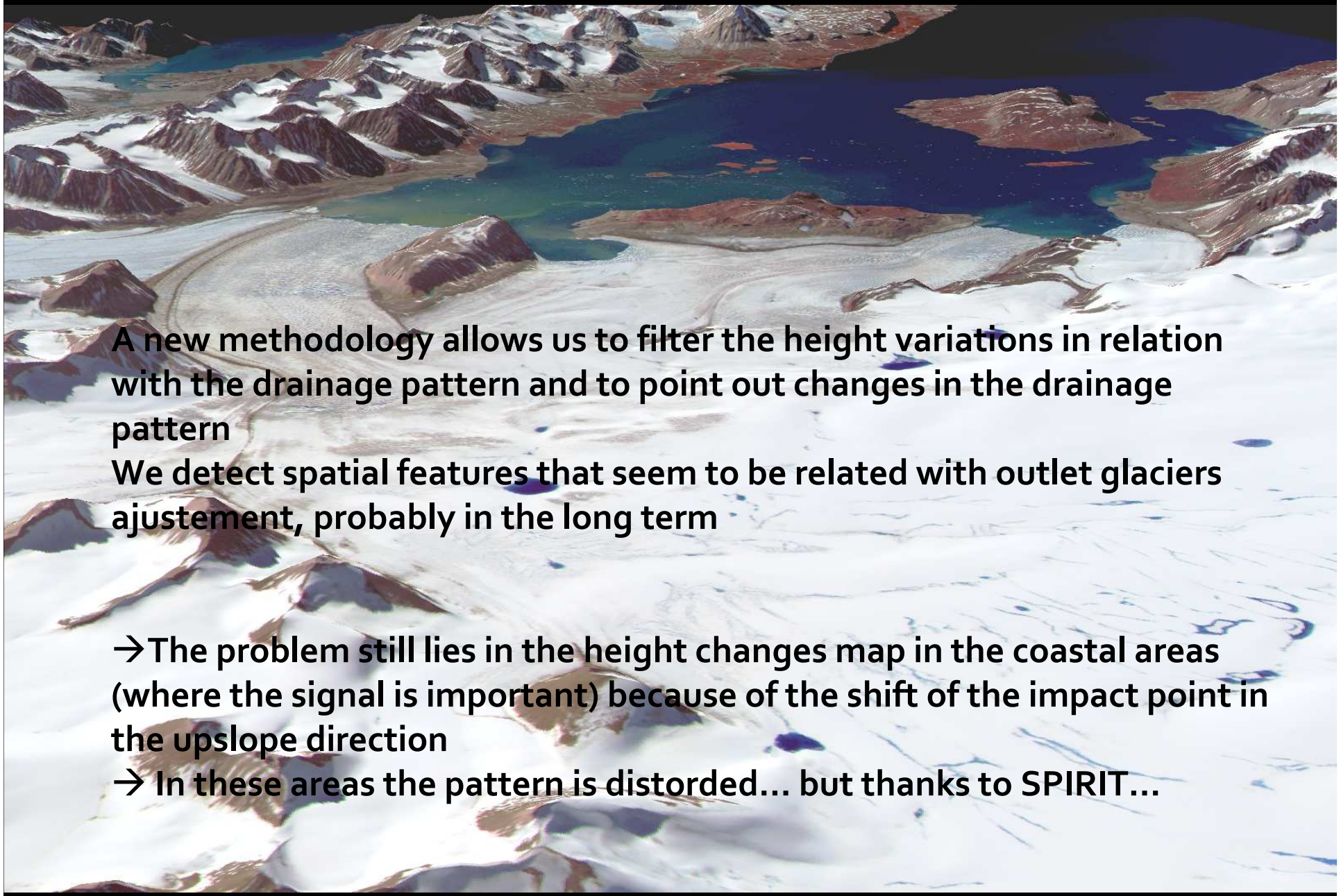
-Observe same kinds of pattern (important signal in PIG, Mertz, Totten, Enderby sectors)

- The features are coherent (each pixel is processed independently)
- The signal is larger near the coast and seems to be propagated from the coast to the interior
- The signal is too much important in the interior to correspond to a response of the ice sheet to an actual perturbation
- The number of areas with change in the drainage pattern is too much important to be a response of the ice sheet to an actual perturbation

-- The drainage change is around 0.5/1000 (100% in 2000 ans → near the relaxation time)

→ Does it correspond to a long term response to climate change ?

CONCLUSION

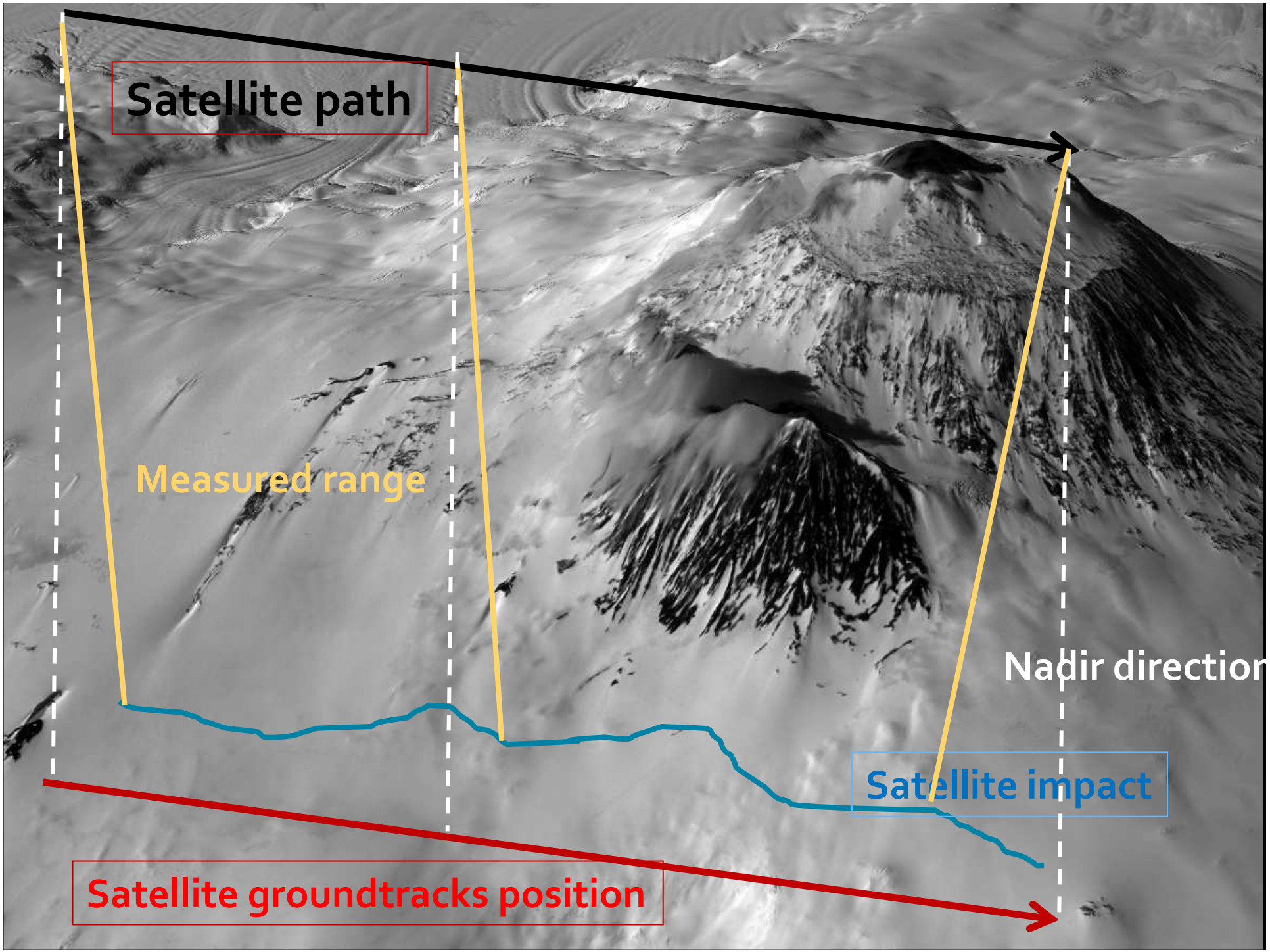


A new methodology allows us to filter the height variations in relation with the drainage pattern and to point out changes in the drainage pattern

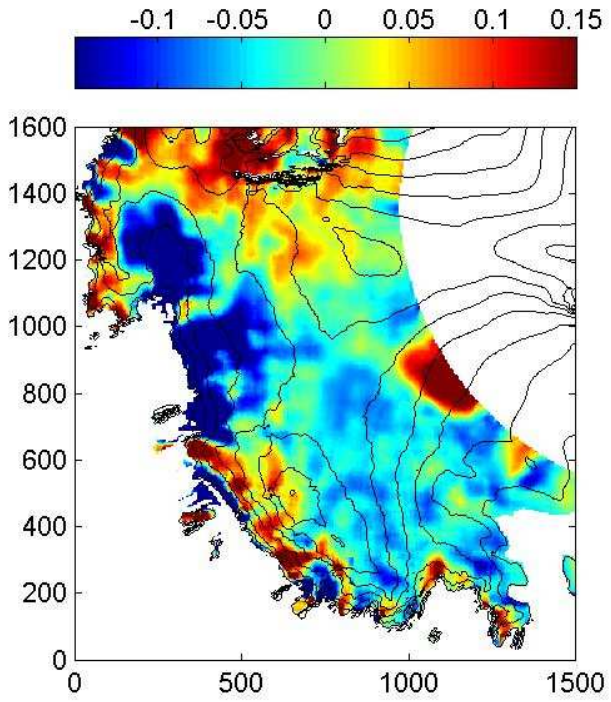
We detect spatial features that seem to be related with outlet glaciers ajustement, probably in the long term

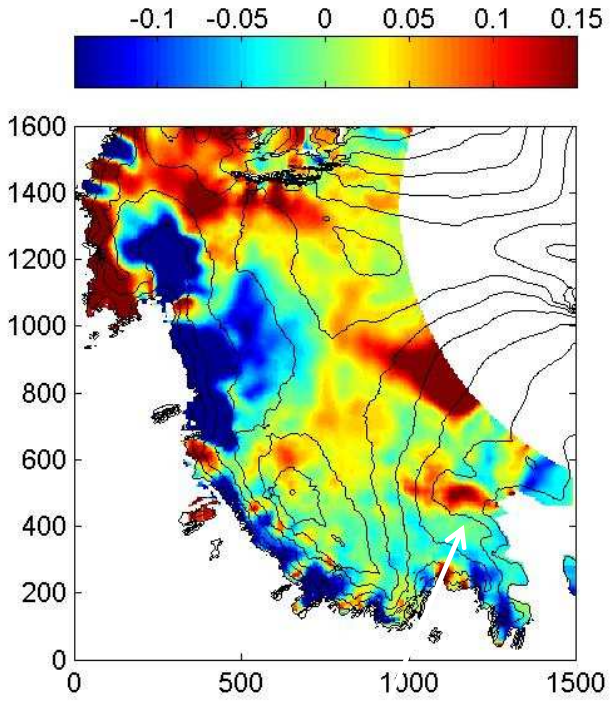
→The problem still lies in the height changes map in the coastal areas (where the signal is important) because of the shift of the impact point in the upslope direction

→ In these areas the pattern is distorded… but thanks to SPIRIT…

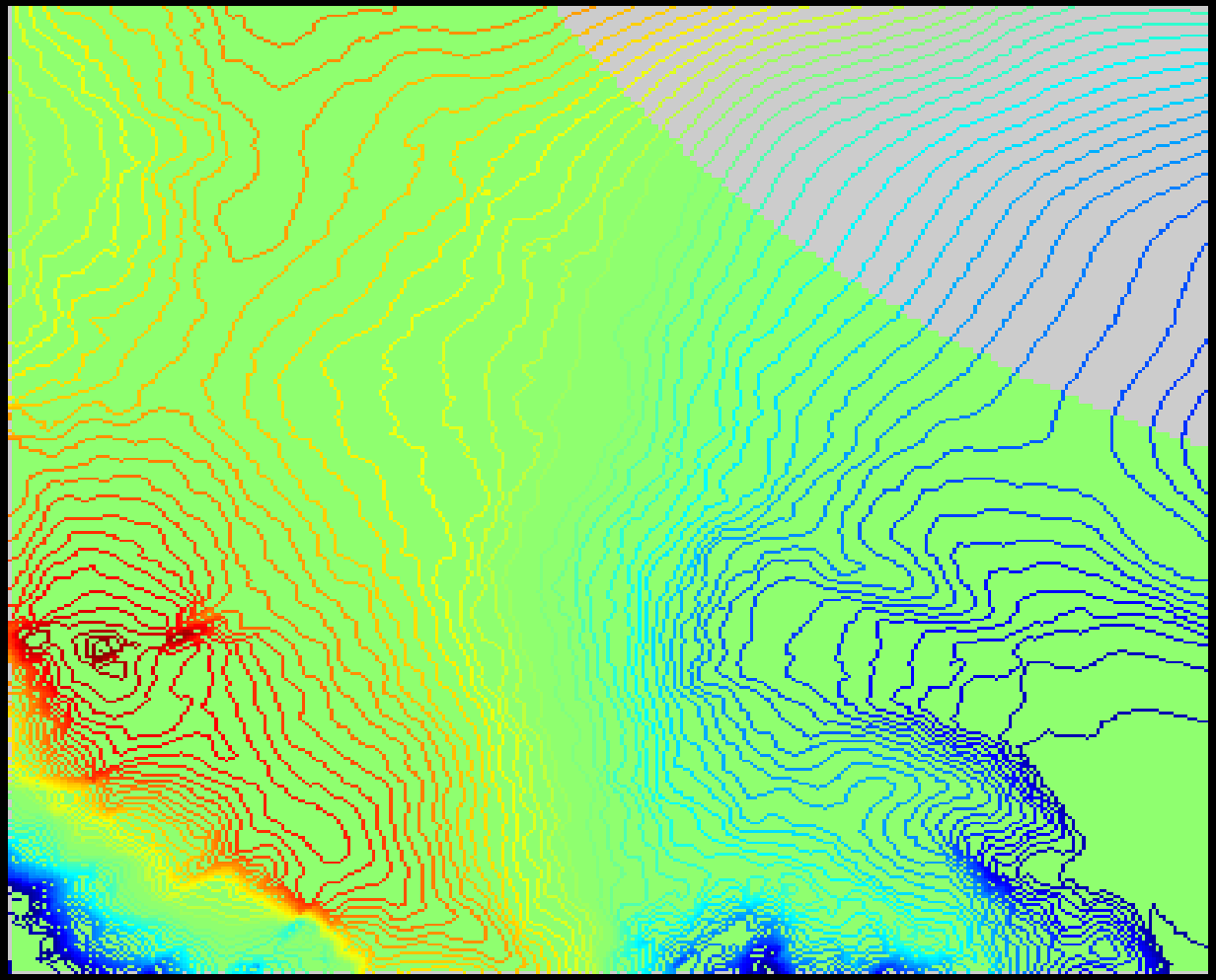

Satellite path
Measured range
Nadir direction
Satellite impact
Satellite groundtracks position

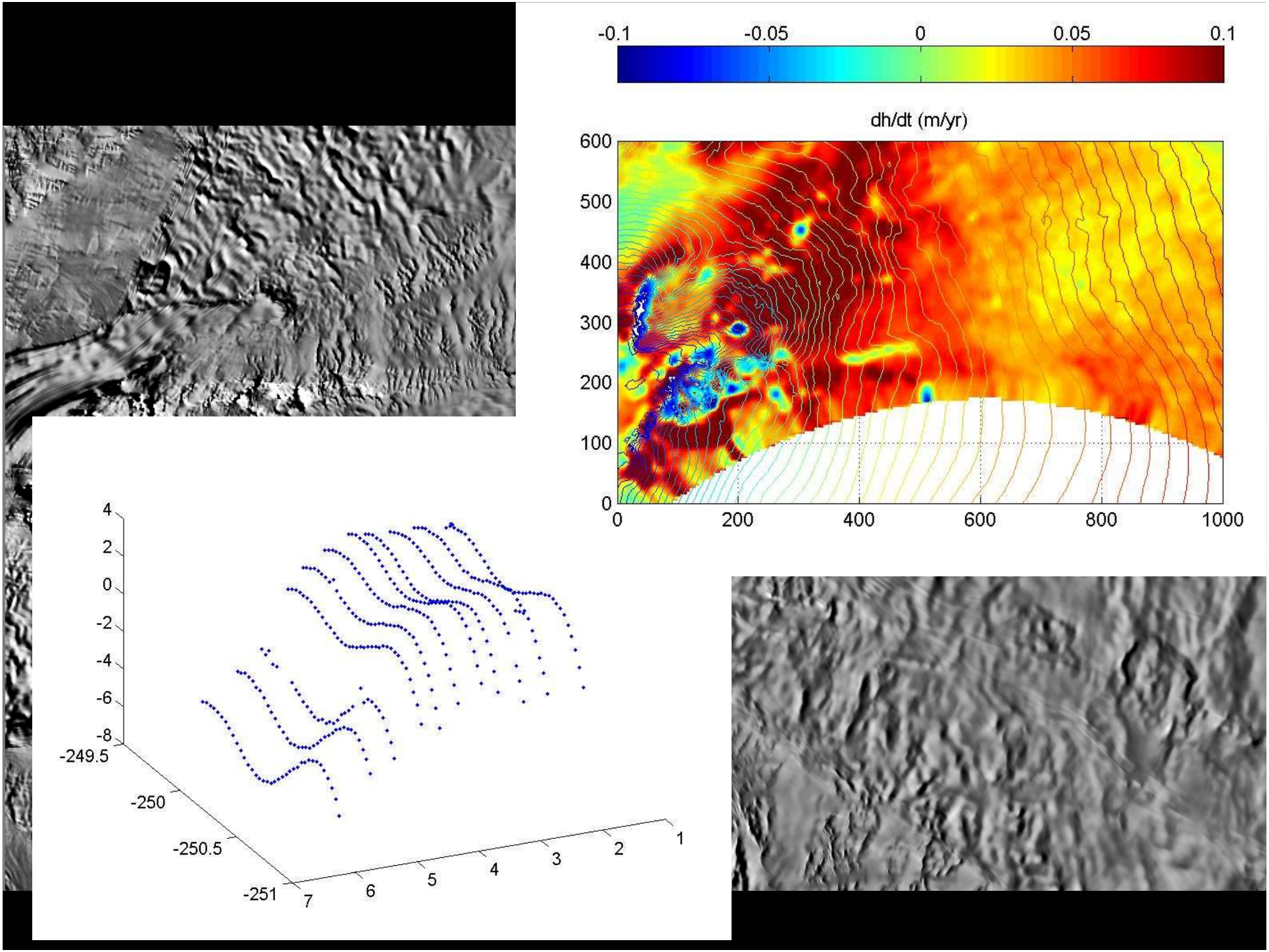
WAIS





Un glacier qui grossit d'un coup…




-0.1
-0.05
0
0.05
0.1
dh/dt (m/yr)
600
500
400
300
200
100
0
0
200
400
600
800
1000
4
2
0
-2
-4
-6
-8
-249.5
-250
-250.5
-251
7
6
5
4
3
2
1