About the tide oscillations and icebergs motion recorded at Jakobshavn isbrae during summer 2007 using high resolution digital camera, Icefjord, West Greenland.

Discussion about acceleration of glacier flow in Greenland, lubrication at the ice-rock interface, vertical circulation of melt water (moulins) and lubrication recorded in situ under Argentire glacier (Mt-blanc).

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5 mars 2008

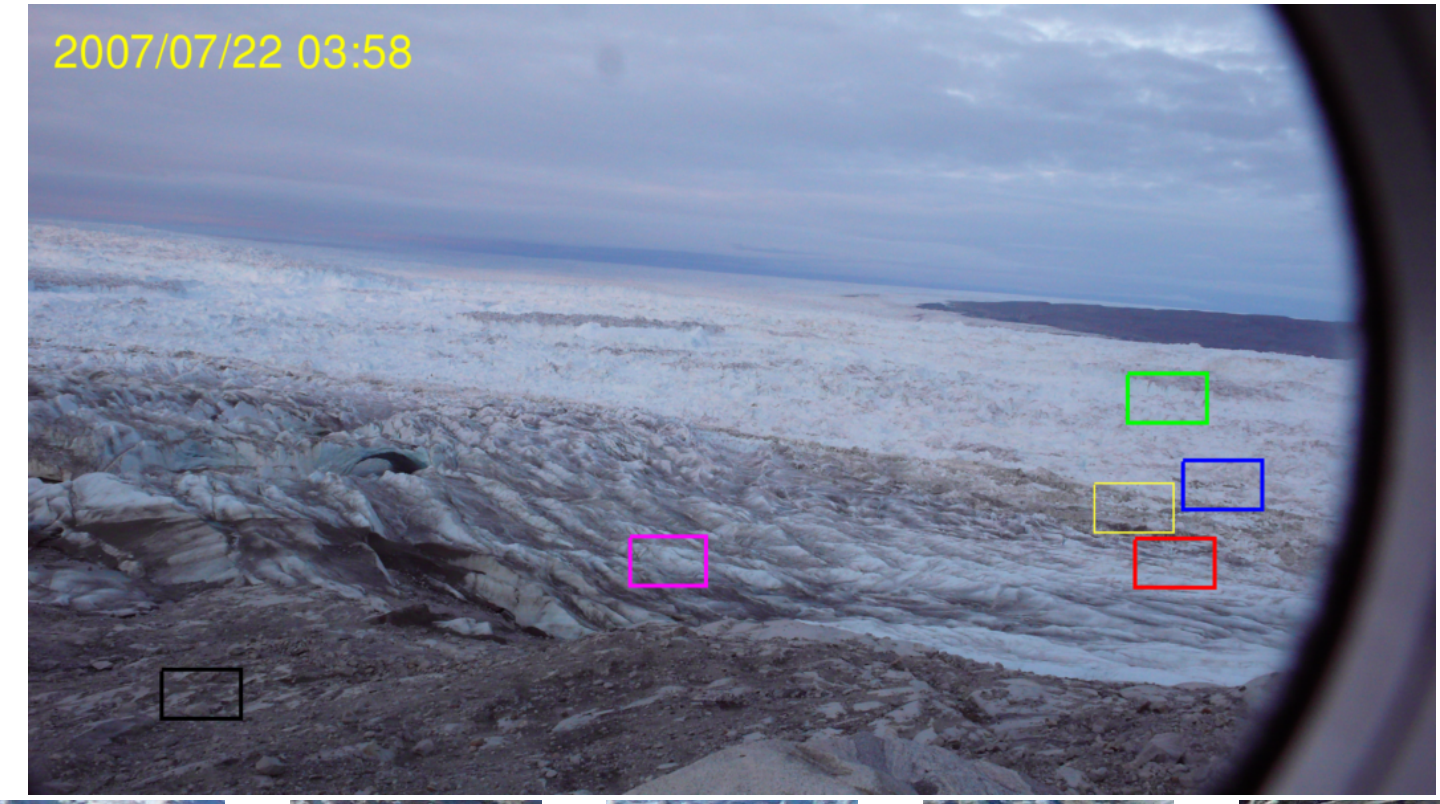
Data acquisition

Automated digital image capture using a custom circuit for triggering a commercial digital camera

- low power consumption of control circuitry ($< 200\ \mu$A) for an autonomy of several years
- camera consumption limits the global autonomy to theoretically $\simeq$1000 frames
- date & time stored in EXIF header for quantitative processing (problem of powering the camera's internal clock)

Two testbeds : a 1 month long continuous sequence shot in Greenland, a 6 month long webcam archive from Chamonix, France.

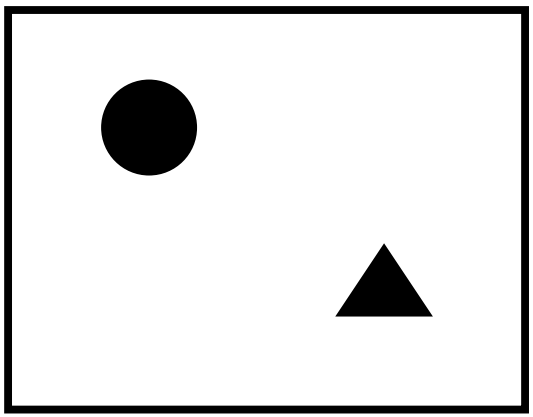
Selected analysis area



blue red green magenta black

Measurement horizon (theory)

- Fixed window : correlation technique only works as long as reference and anlyzed frame look similar.
- Short term difference of successive frames provides poor accuracy (motion $>$ 1 pixel between two frames)
- Shift reference window and connect drift curves



Reference frame (fixed)

+ illumination artifact : apparent "Y motion" with 24 hour period due to sun motion

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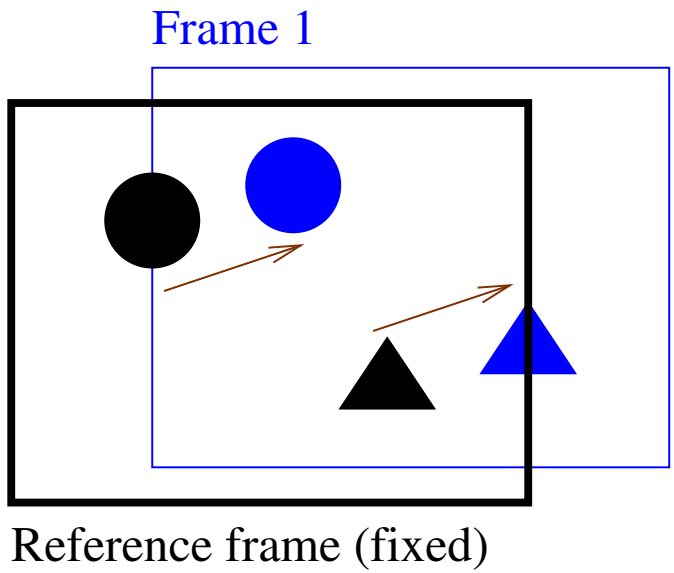

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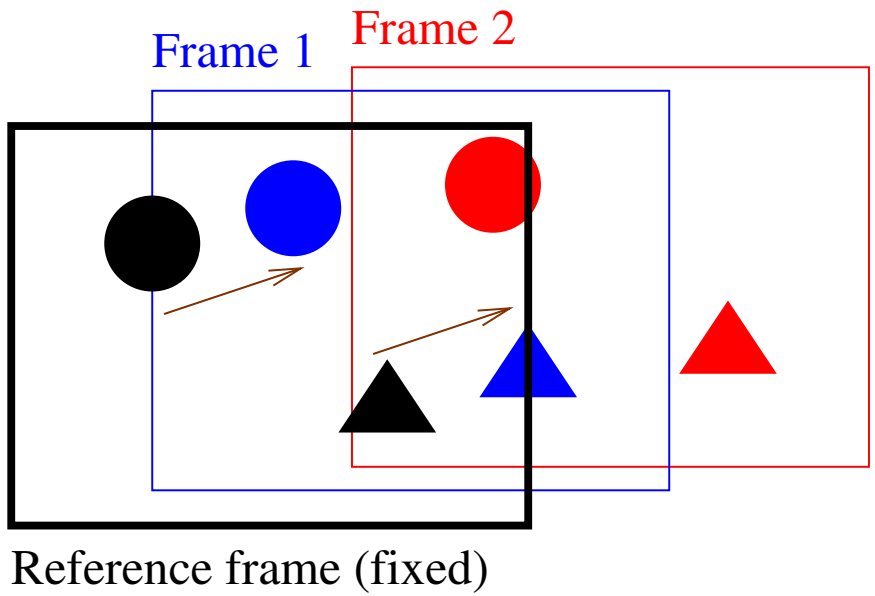

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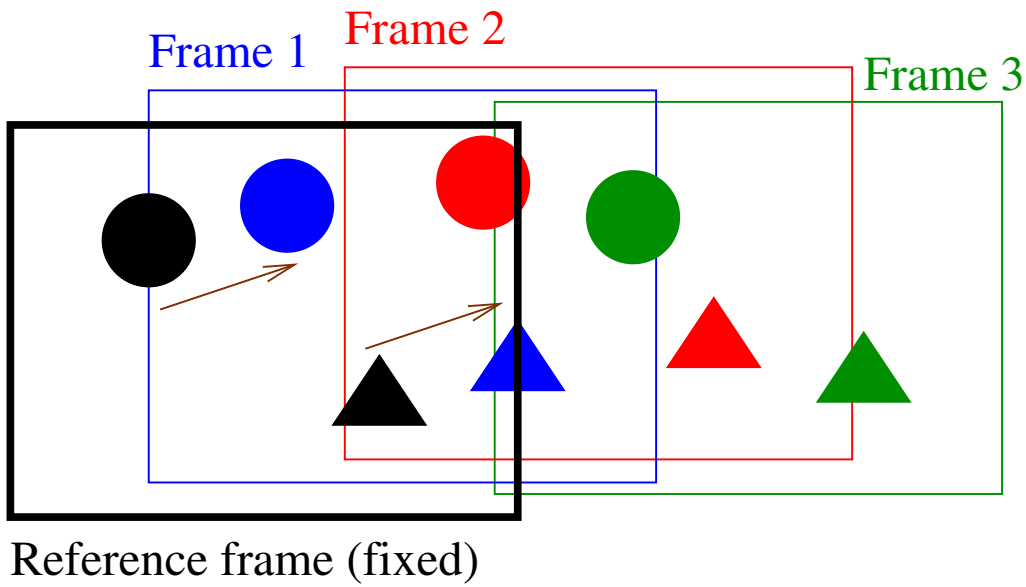

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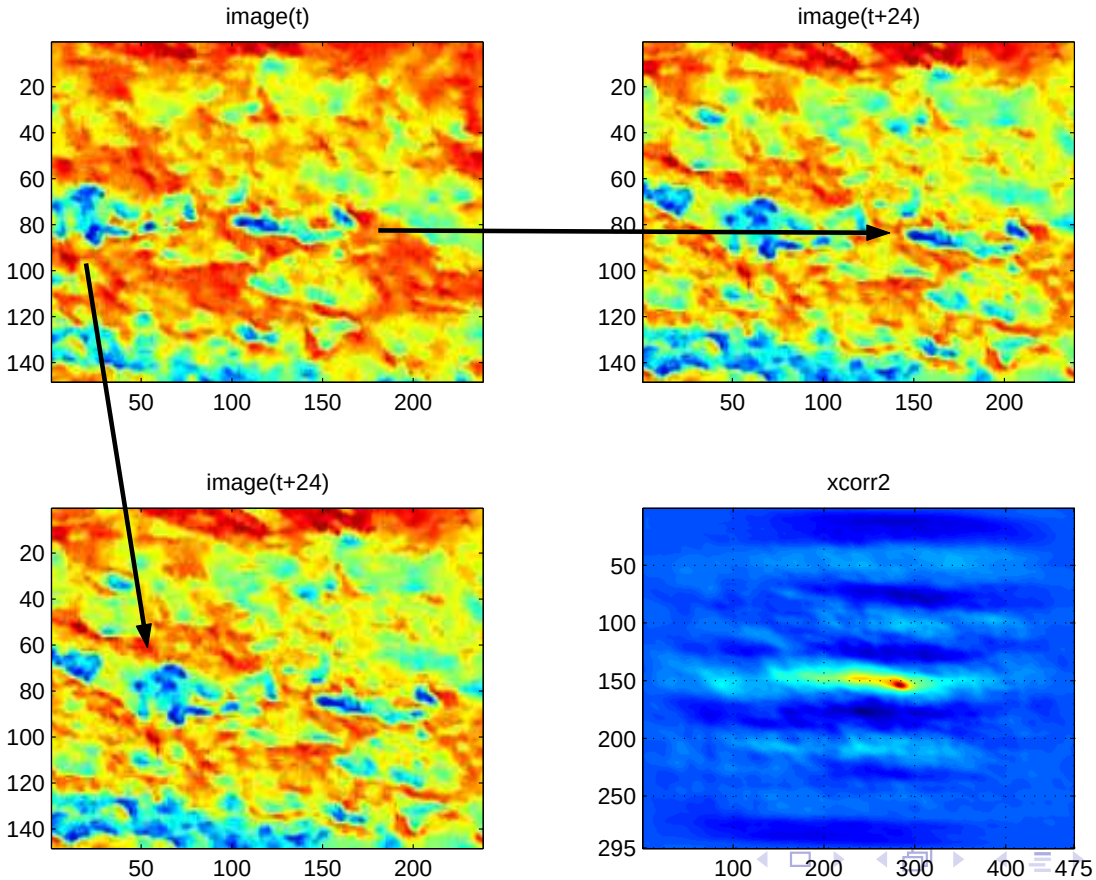
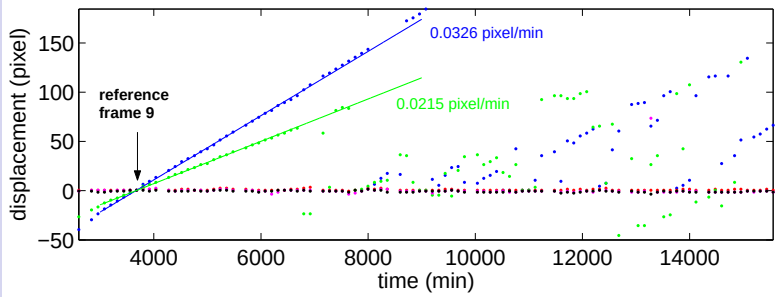
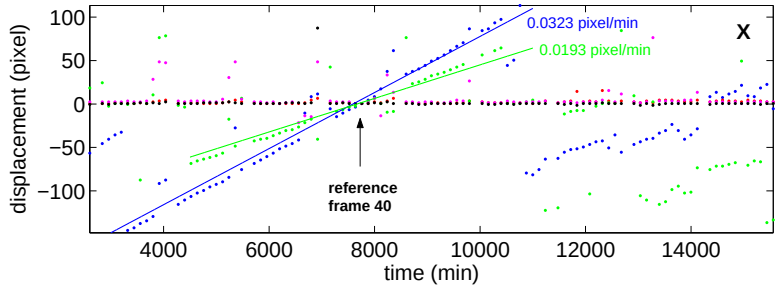
Motion detection (application)

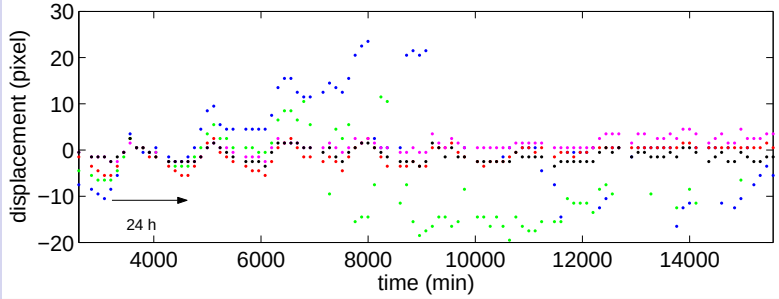
- Basic but robust technique : intercorrelation looks for translation vector for best match of a reference picture and a measurement picture (`xcorr2()` with Matlab)
- We will use an Eulerian descritpion of fluid motion (fixed window, monitor the mass entering and leaving this frame)

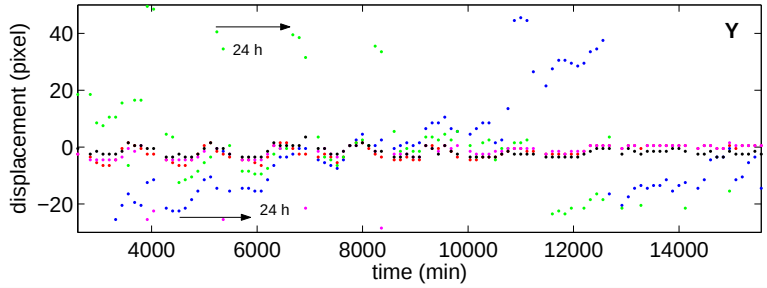


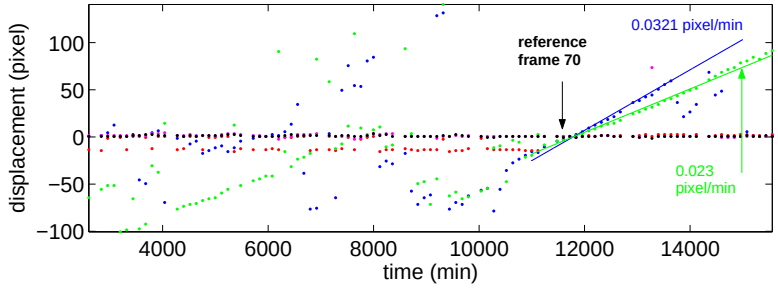
Measurement horizon (results)

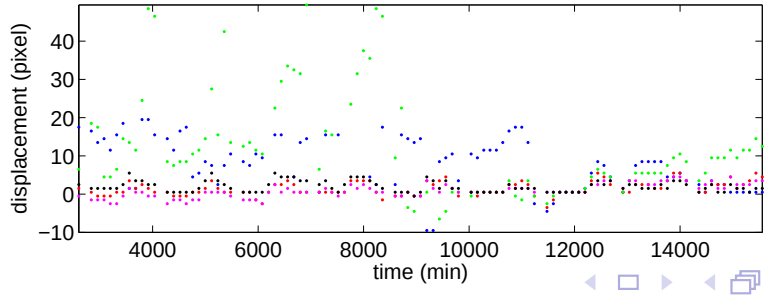






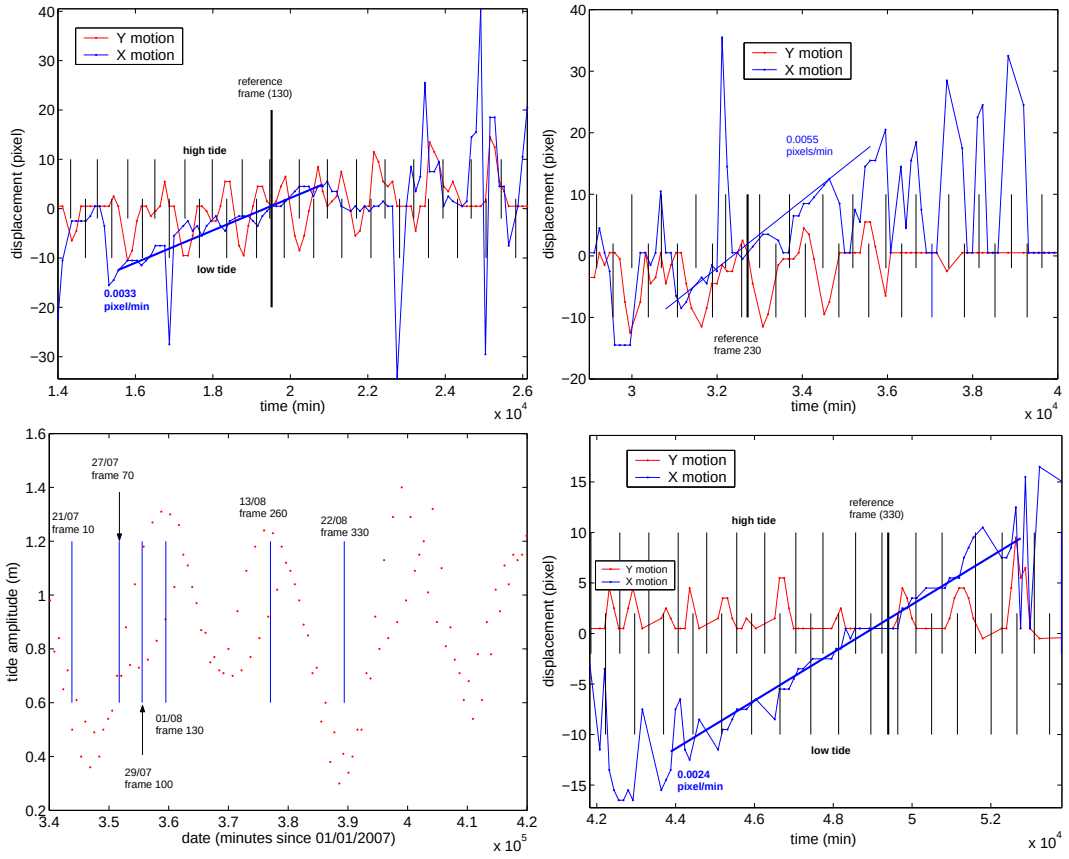






Influence of tide

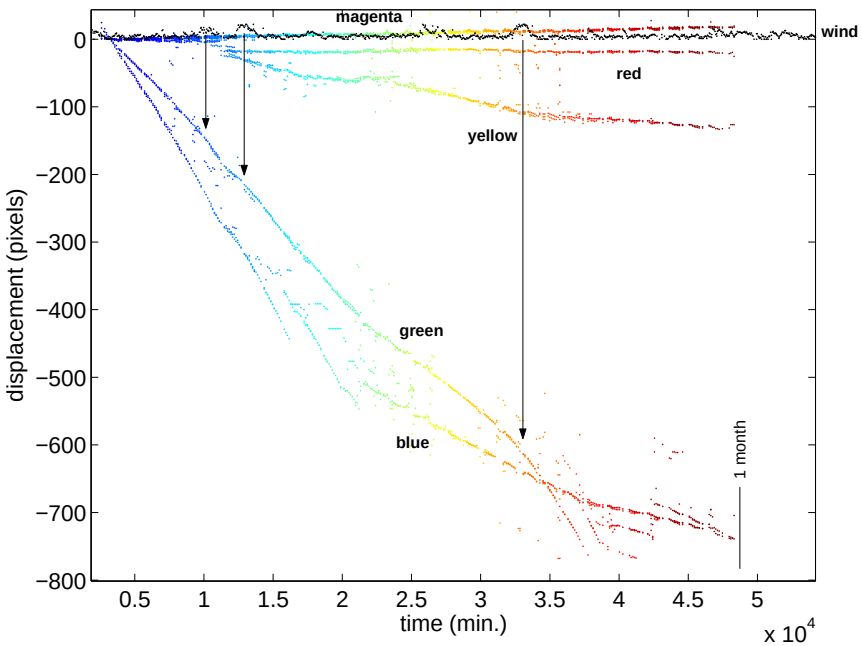
Visually, obvious influence of tide on "vertical" motion of ice

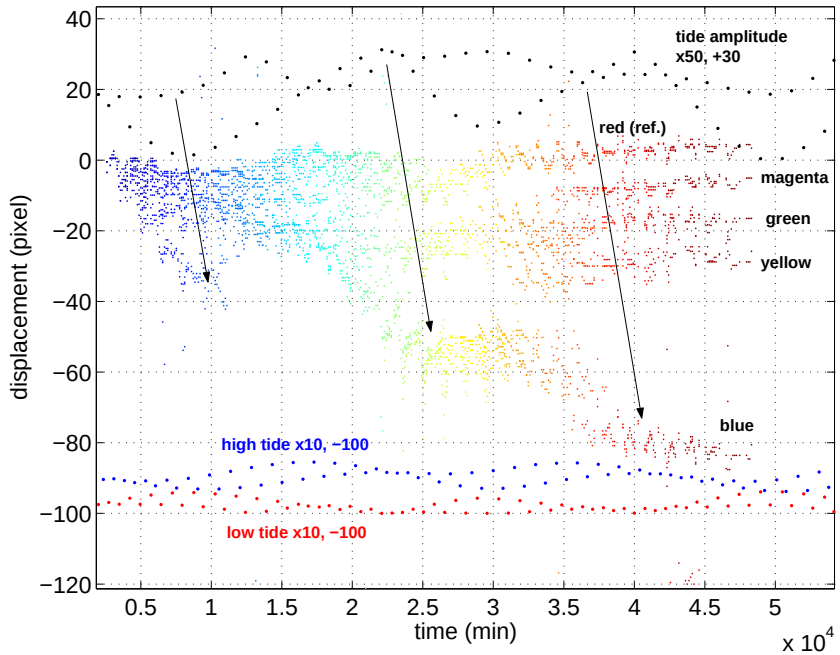


- Two tide amplitude maxima over 1 month record : visible signal synchronous with predicted tide max/min.
- No obvious signal synchronous with tide during amplitude minimum (bot. right)

Influence of wind

No visible influence of wind[1] : the local influence on a given iceberg is not tracked : would require a Lagrangian description of fluid motion (object tracking)





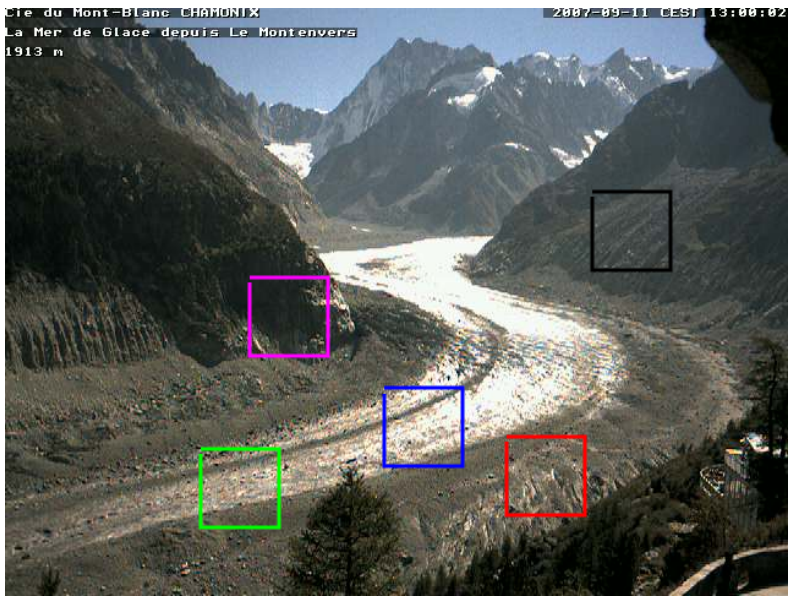
Long term "vertical motions" appears related to tide[2] amplitude (right)

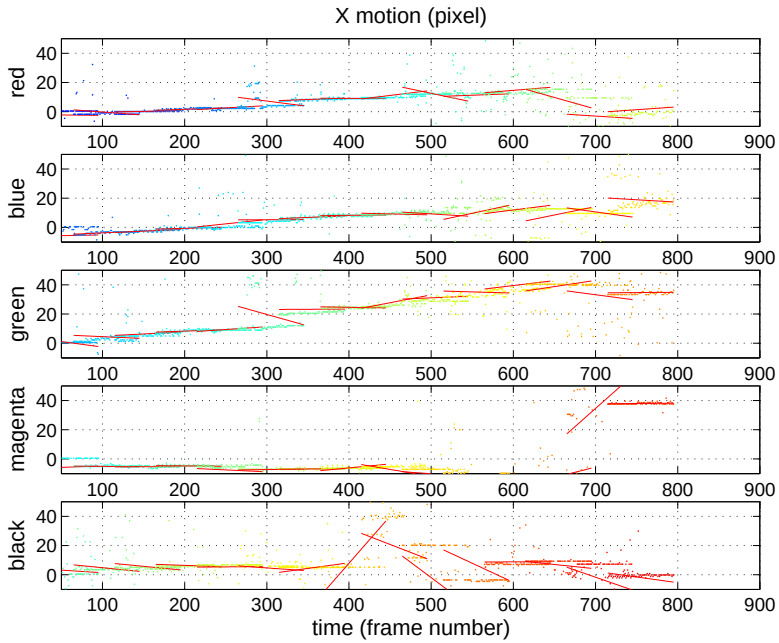
[1] Hourly METAR data collected from http://english.wunderground.com/history/airport/BGJN/

[2] Web interface to xtide at http://tbone.biol.sc.edu/tide/sites_othernorth.html

Influence of picture quality

We have demonstrated the use of high resolution (10 Mpixels), low compression images on a fast moving object.
What about poor quality images of a slow glacier ?



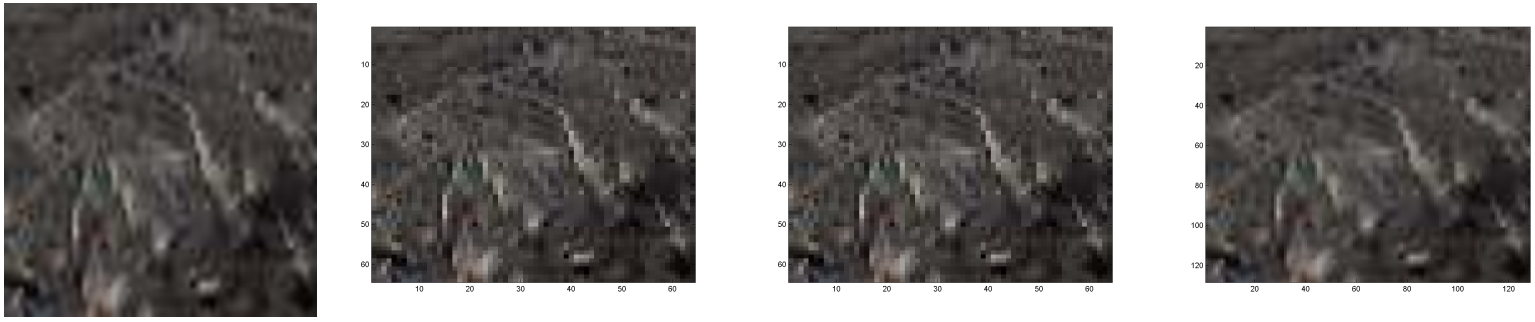


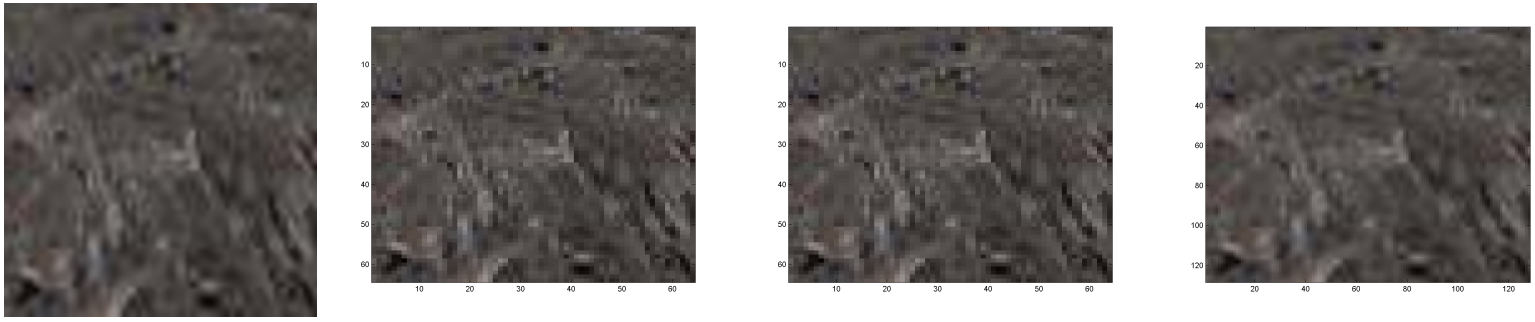
Requires

1. interpolation of the original image to smooth JPEG compression boundaries and improve resolution
2. histogram equalization

Influence of picture quality

Strong JPEG compression ⇒ artifacts





Matlab's `imresize()` bilinear interpolation (weighted average of pixels in the nearest 2-by-2 neighborhood)

Results and improvements

- Some frames[3] with poor weather induce high noise level : would require pre-processing to avoid noise
- Strong effect of shadow $\longrightarrow$ histogram equalization

$\Rightarrow$ reduce influence of noise when connecting successive windows by using linear fit of glacier motion

[3] http://www.compagniedumontblanc.fr/webcam/CMM1MERDEGLACE.jpg

Results and improvements

- The motion is an average over a given part of the picture : the larger the picture, the longer the horizon, but the worse the average
- Connection of analysis periods is not always accurate
- Conversion from pixel to meters requires terrain model + camera characteristics
- Validation using calibrated instruments (GPS)

Yet, digital image processing provides a means of continuous monitoring of ice flow in area where instuments cannot be positioned (icebergs, strong slopes)