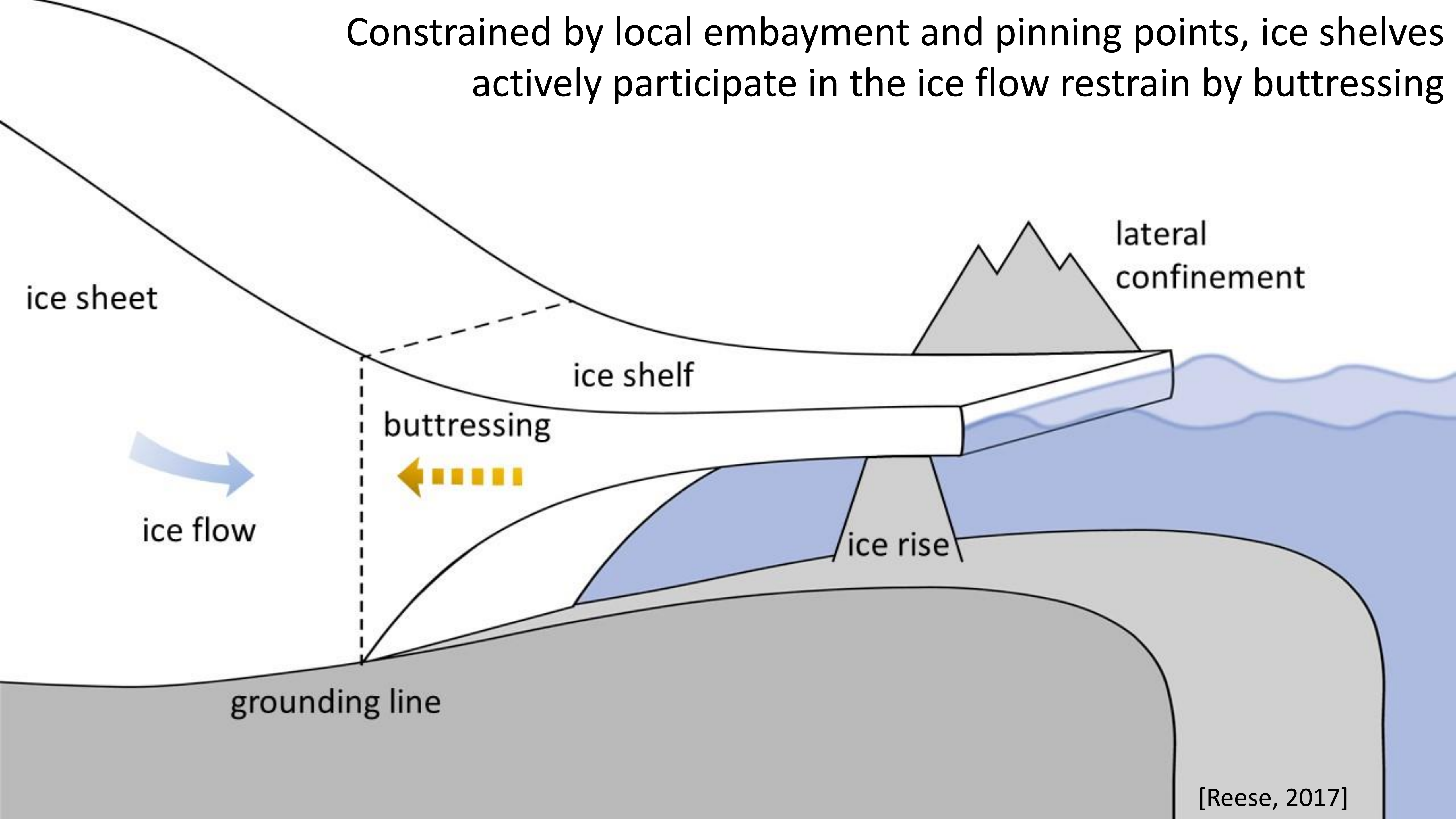
Quentin GLAUDE
Ph.D Student

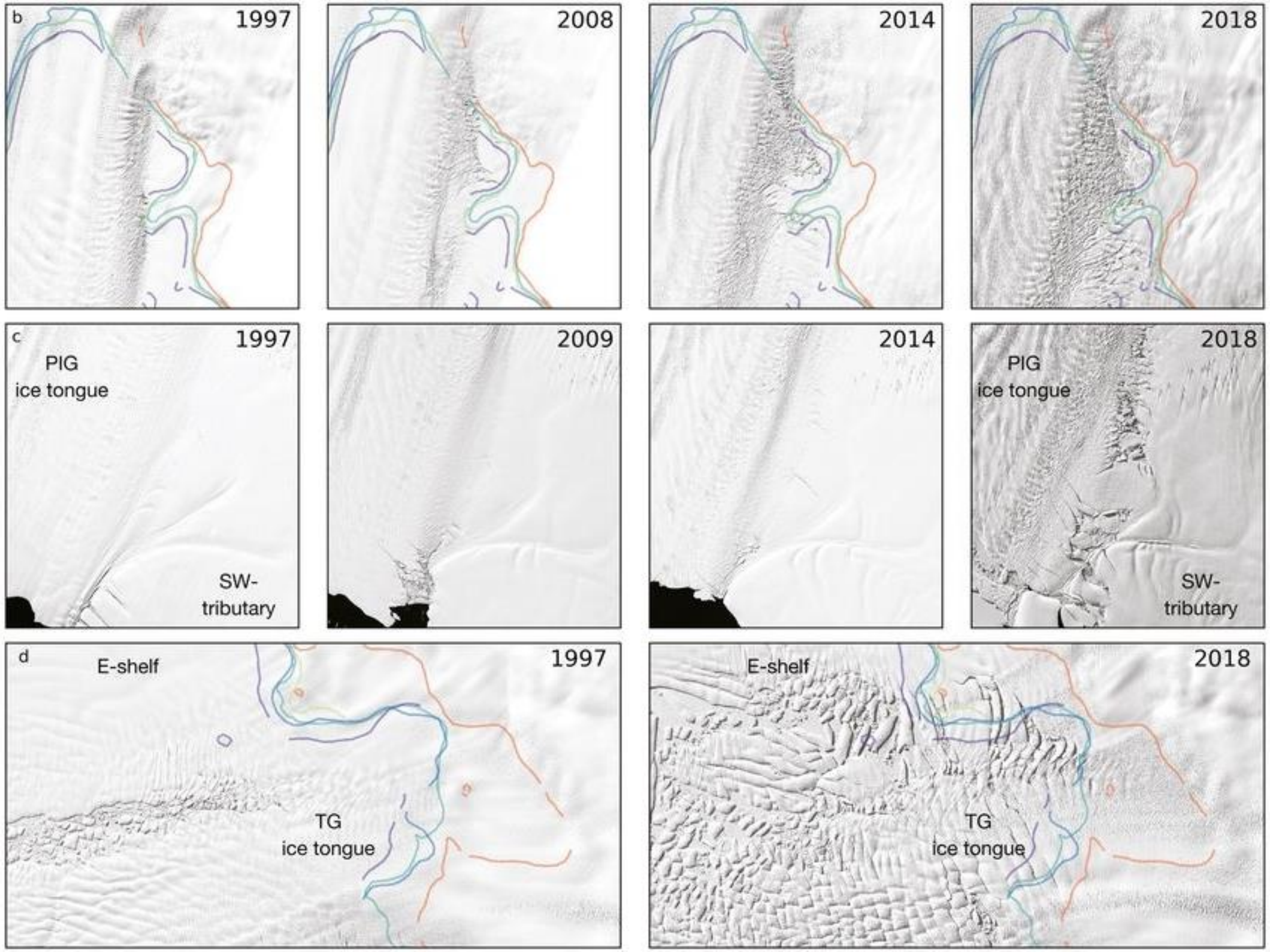
Automation of Ice Fractures and Calving Events Monitoring Using Medical Imaging Ridge Detection Algorithms

Sharing is encouraged

Constrained by local embayment and pinning points, ice shelves actively participate in the ice flow restrain by buttressing



Damage structures are participating in the destabilization of ice shelves and remote sensing can observe it



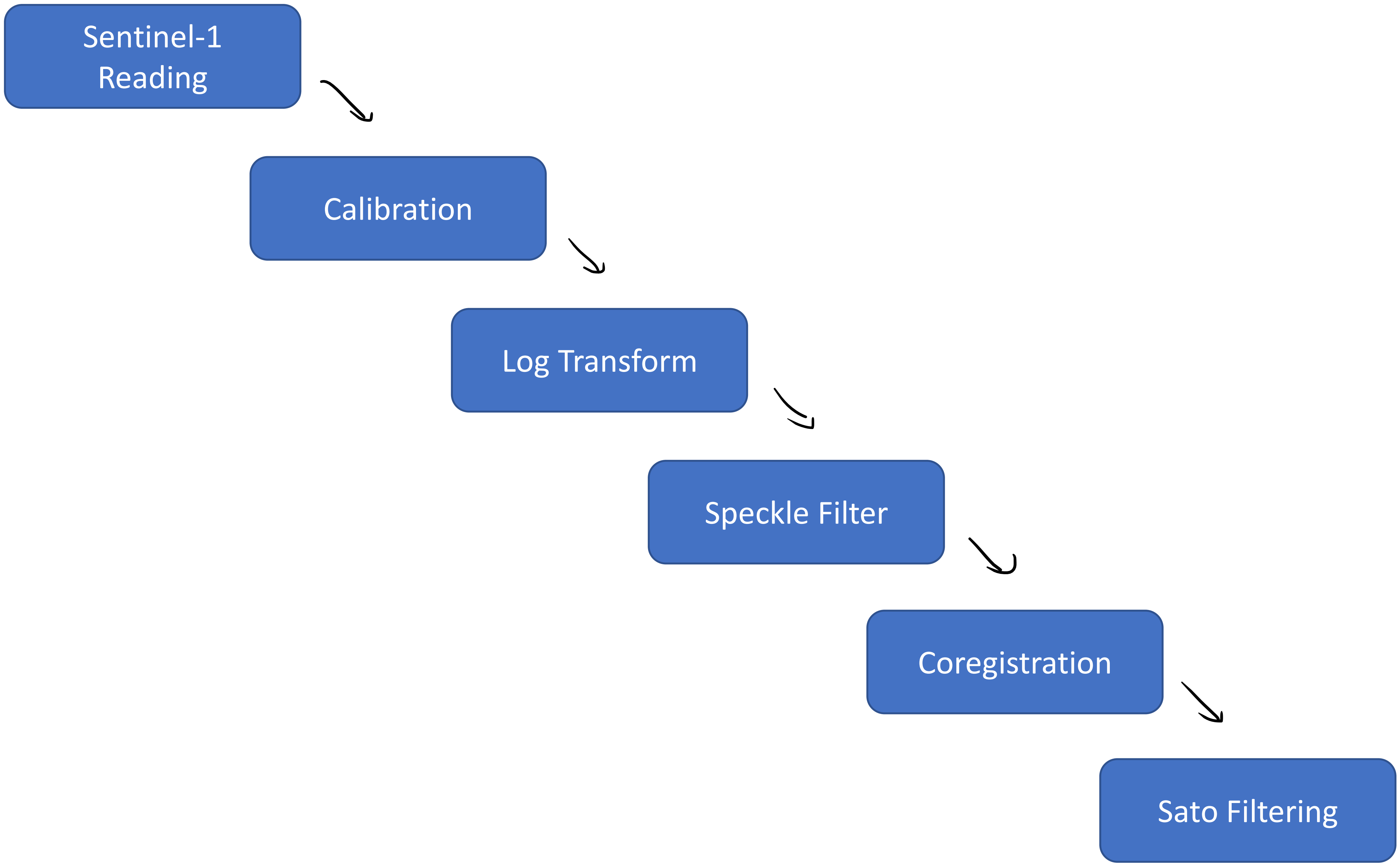
[Lhermitte, 2020]

Nevertheless, damaged structures are still observed by visual inspection, while edge detection techniques are common in medical imaging

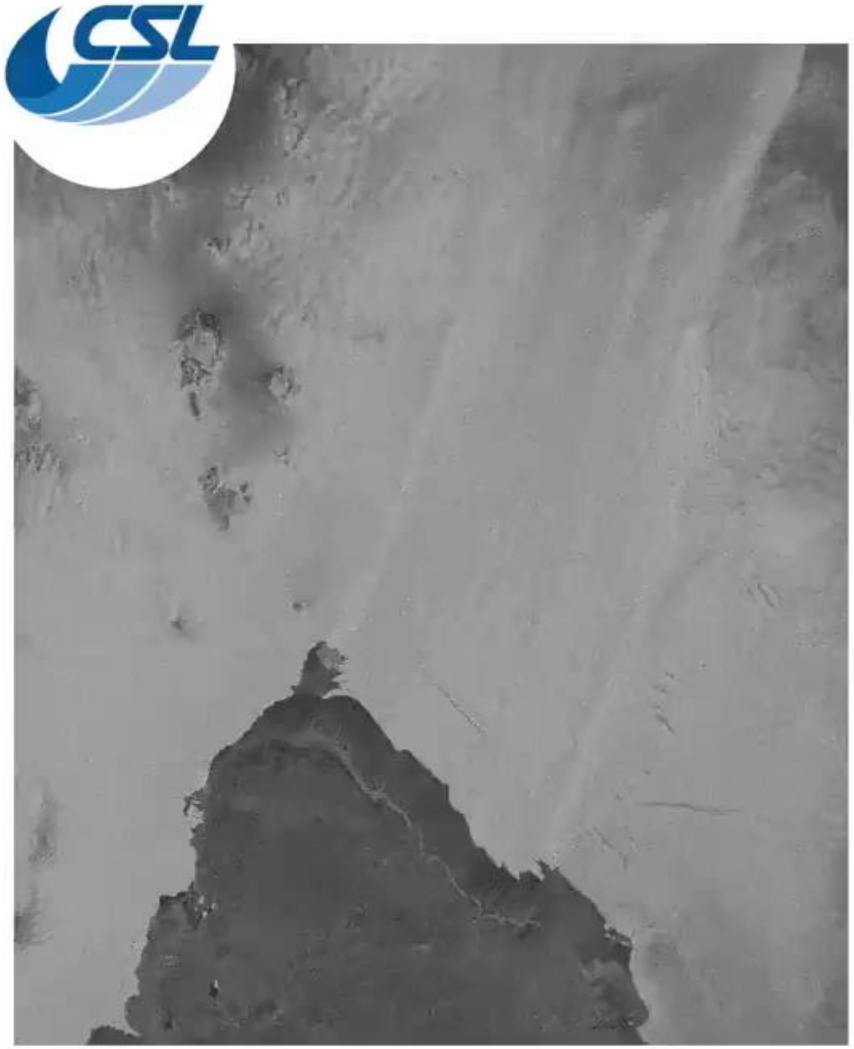
The idea of Sato Filter is to extract locally the eigenvectors/ eigenvalues of the Hessian Matrix and compute for each pixel the probability to belong to an edge

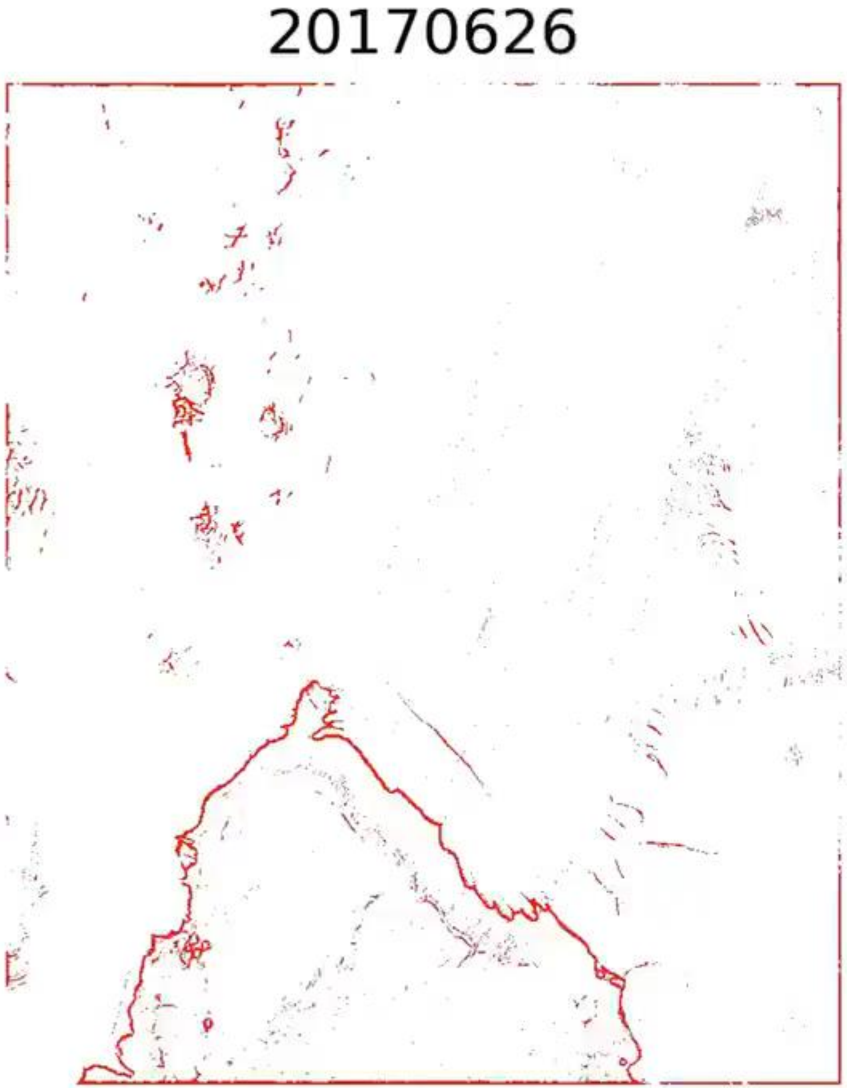
$$H(f) = \begin{bmatrix} \frac{\partial^2 f}{\partial x_1^2} & \frac{\partial^2 f}{\partial x_1 \partial x_2} & \cdots & \frac{\partial^2 f}{\partial x_1 \partial x_n} \\ \frac{\partial^2 f}{\partial x_2 \partial x_1} & \frac{\partial^2 f}{\partial x_2^2} & \cdots & \frac{\partial^2 f}{\partial x_2 \partial x_n} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{\partial^2 f}{\partial x_n \partial x_1} & \frac{\partial^2 f}{\partial x_n \partial x_2} & \cdots & \frac{\partial^2 f}{\partial x_n^2} \end{bmatrix}$$

$\rightarrow$ λ_1, e_1 ; λ_2, e_2 $\rightarrow$ P(edge | pixel)

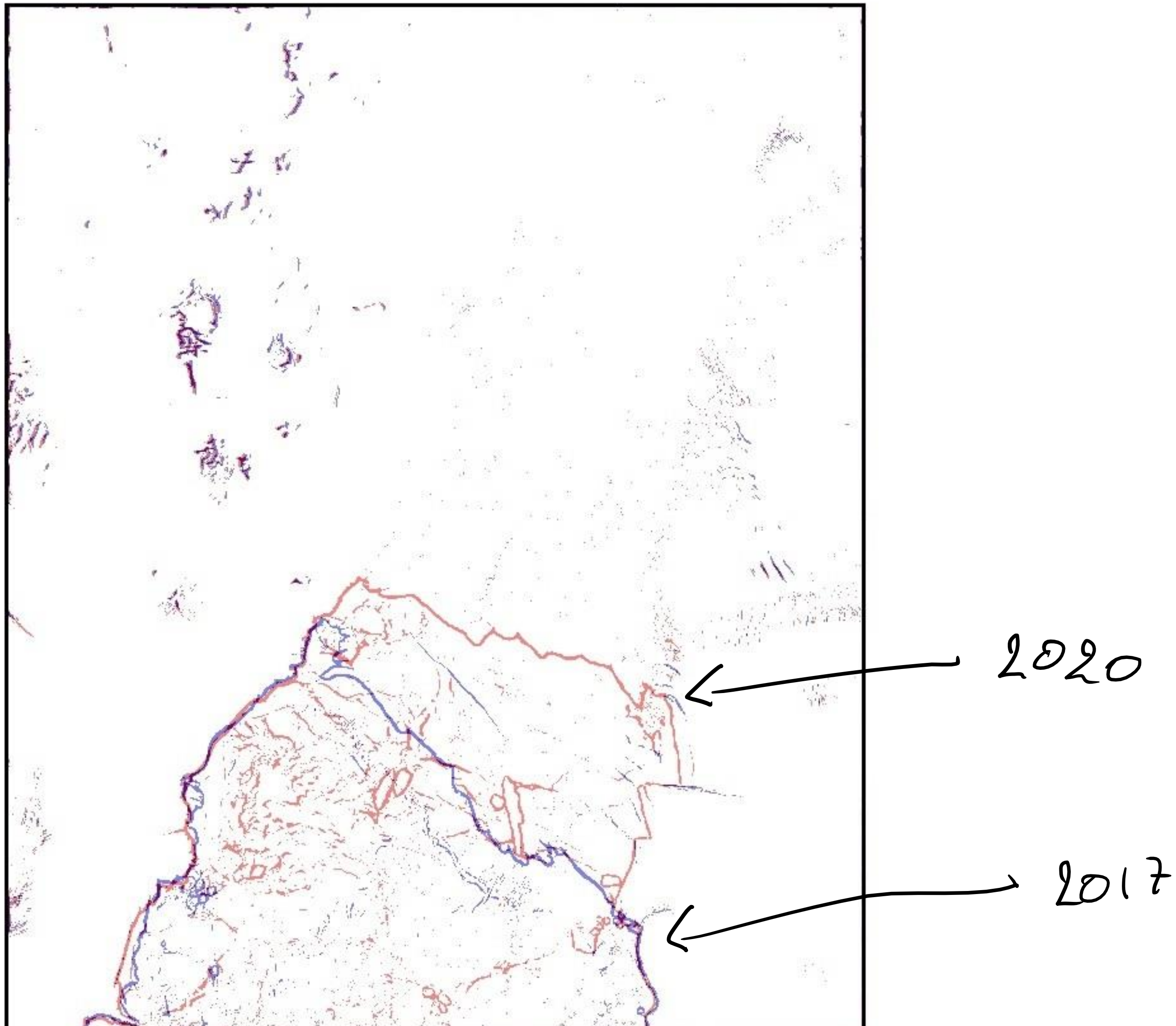

Sentinel-1 Reading
Calibration
Log Transform
Speckle Filter
Coregistration
Sato Filtering

Using 200 SAR images over more than 3 years, we developed an automatic crack propagation and front location monitoring

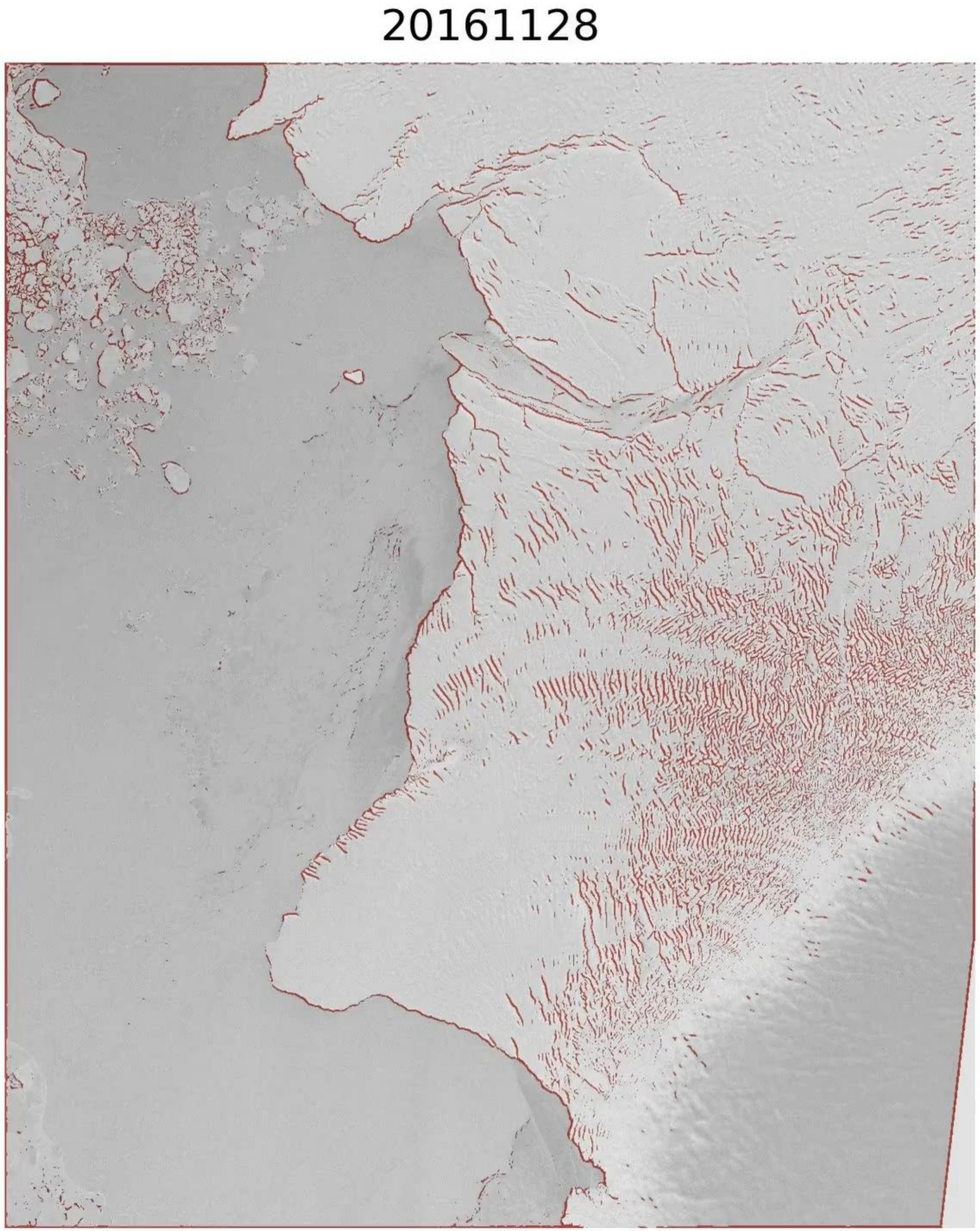




Comparison between June 2017 (blue) and June 2020 (red). We observe that the calving front retreated by overall 20 kilometers



Same experiment was conducted over the Brunt Ice Shelf, where break up events can be predicted



Additional work is needed, and your comments are welcome in this regard. Thanks for attending this session!

Q. Glaude

Side note: because of speckle noise, we apply the hessian matrix on a gaussian filter signals, using the convolution theorem

$$H(f) = \begin{bmatrix} \frac{\partial^2 f}{\partial x_1^2} & \frac{\partial^2 f}{\partial x_1 \partial x_2} & \cdots & \frac{\partial^2 f}{\partial x_1 \partial x_n} \\ \frac{\partial^2 f}{\partial x_2 \partial x_1} & \frac{\partial^2 f}{\partial x_2^2} & \cdots & \frac{\partial^2 f}{\partial x_2 \partial x_n} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{\partial^2 f}{\partial x_n \partial x_1} & \frac{\partial^2 f}{\partial x_n \partial x_2} & \cdots & \frac{\partial^2 f}{\partial x_n^2} \end{bmatrix}$$

$$\frac{\partial^2 (f * g)}{\partial^2 x_1^2} = \frac{\partial^2 g}{\partial^2 x_1^2}$$