Snow extend and snow change mapping with Sentinel-1 using SVM

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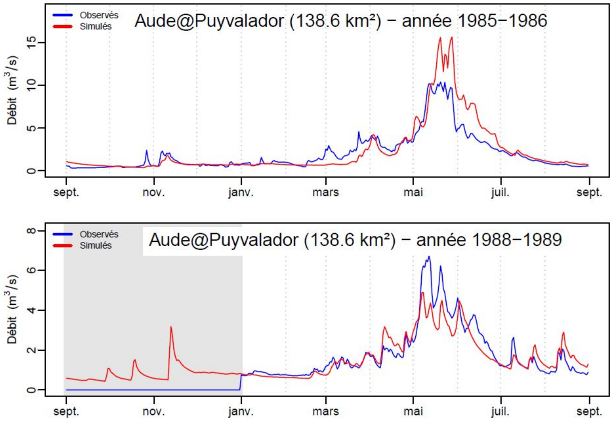
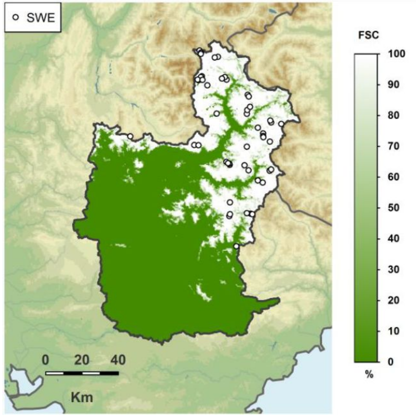
Flow modeling for dam management

Flow modeling impacted by snow



Source : EDF.

MODIS NDSI to assess for snow



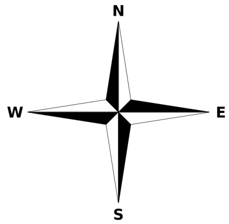
EDF constraint :

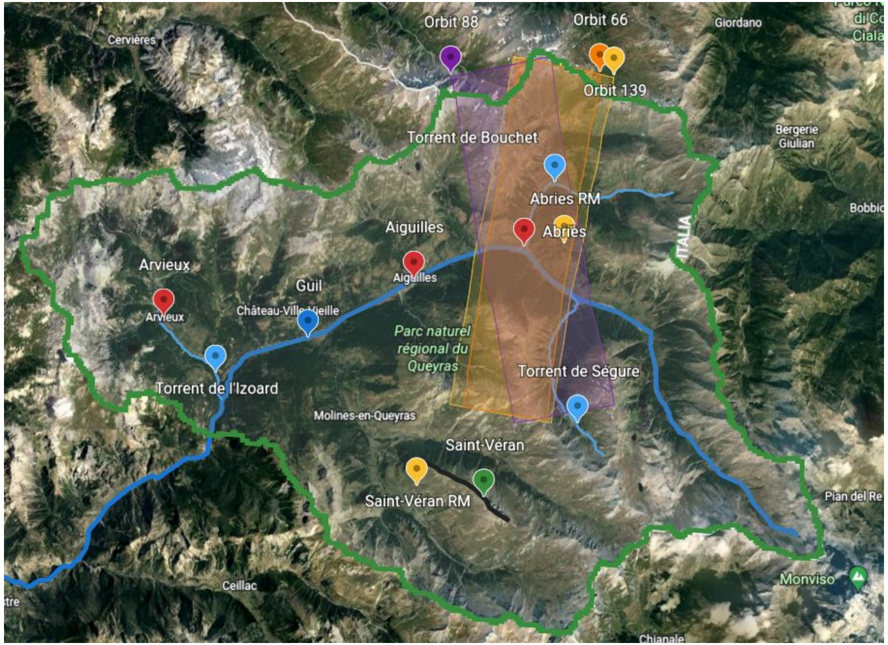
- Spatial resolution : catchment
- Temporal resolution : 1d

Optical imagery is impacted by clouds

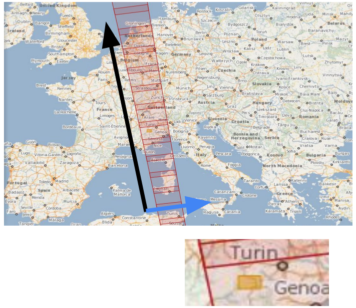
SAR

Guil catchment

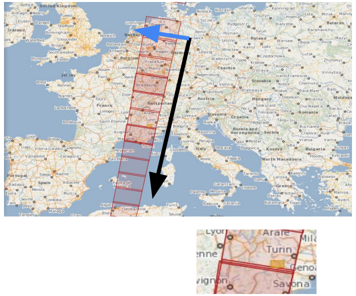




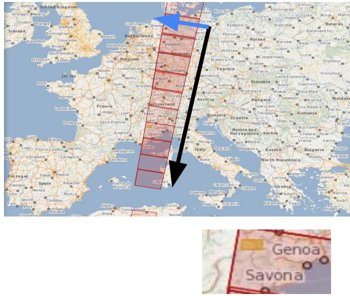
Orbit A88



Orbit D66

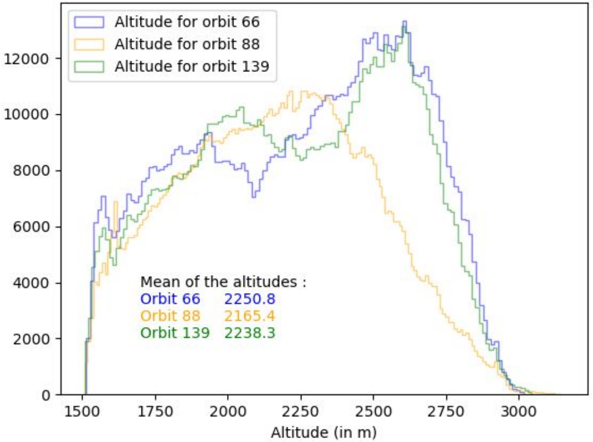


Orbit D139

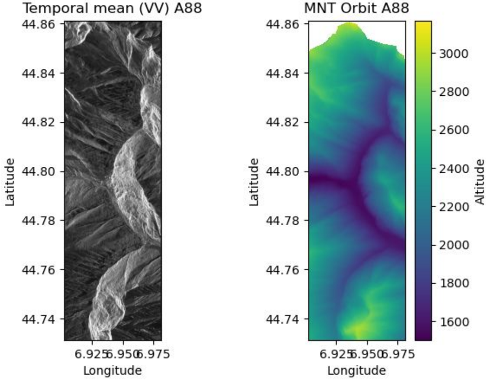


Sentinel 1 orbits

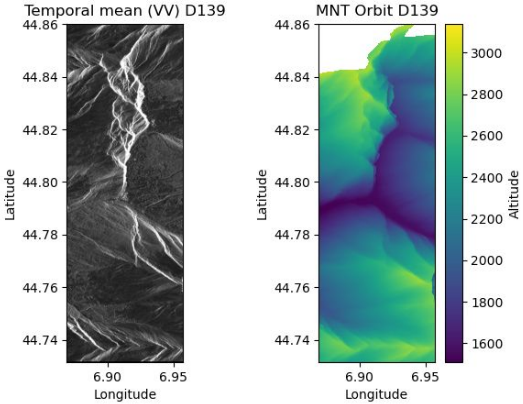
Histogram of the altitudes for each orbit



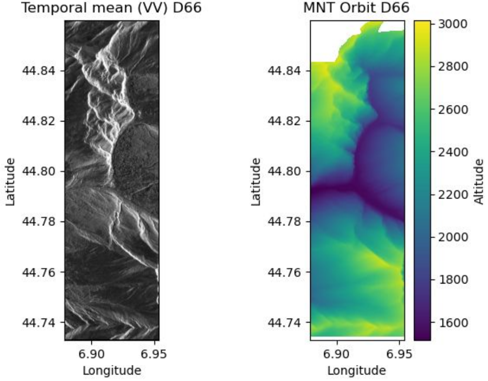
A88



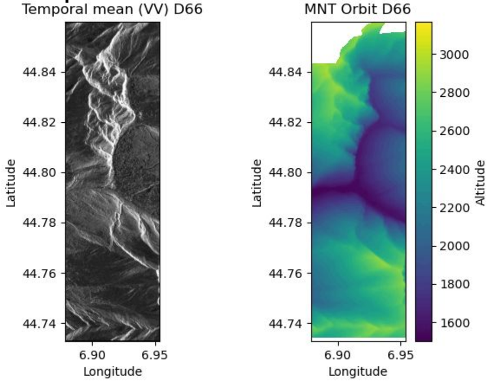
D139



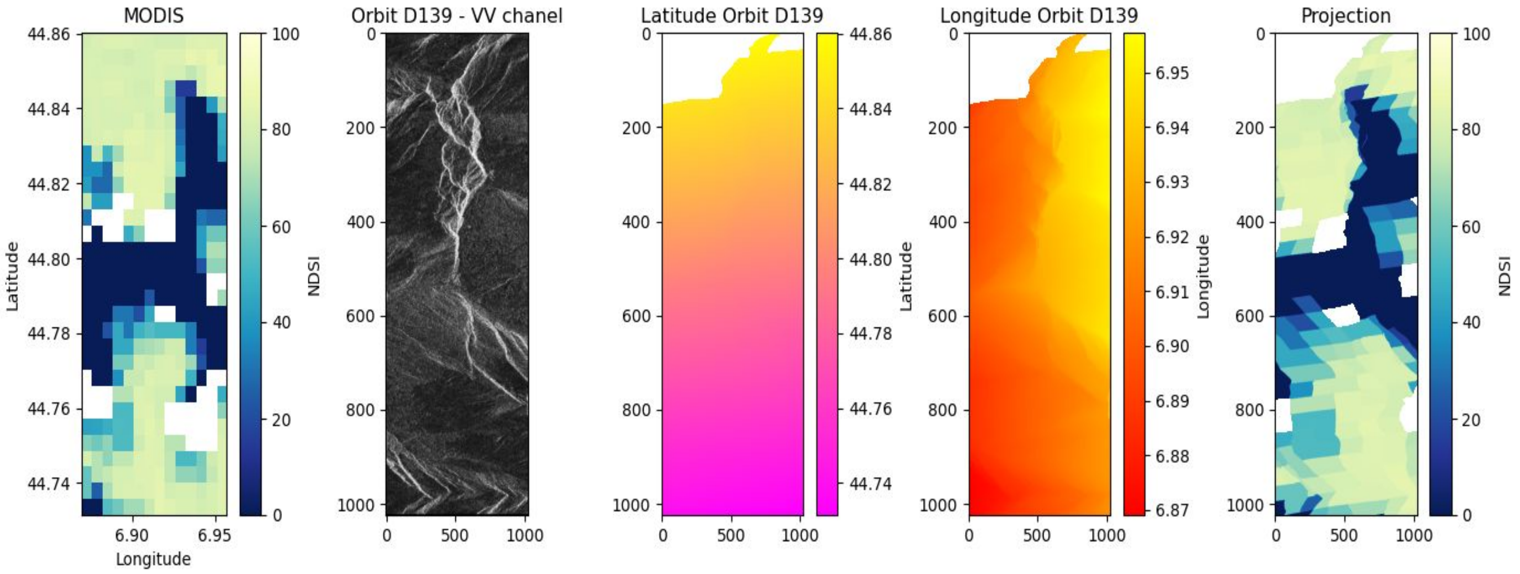
D66



comparaison de D139 et D66



MODIS NDSI projection in Sentinel 1 geometry



Dry vs Wet Snow

Dry snow:
Volumic backscattering
Polarization change

$\sigma^0_{vv} \searrow$

$\sigma^0_{vh} \nearrow$

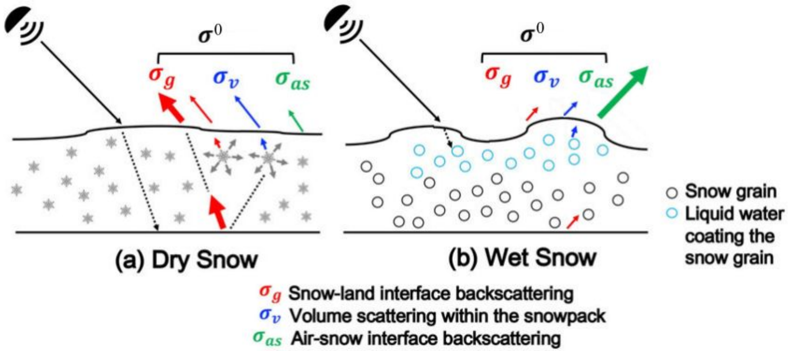


Schéma inspiré de Park et al., 2021

$\sigma^0_{vv} \searrow$

$\sigma^0_{vh} \searrow$

Wet snow:
Drop in backscattering

When snow is detected, the ratio $\sigma^0_{\mathrm{vh}}/\sigma^0_{\mathrm{vv}}$ is linked to snow height:

$$\mathrm{SI}(i,t) = \max\left(0, \left[\mathrm{SI}(i,t-1) + \sigma^0_{\mathrm{vh}}/\sigma^0_{\mathrm{vv}}(i,t) - \sigma^0_{\mathrm{vh}}/\sigma^0_{\mathrm{vv}}(i,t-1)\right]\right)$$

$$\mathrm{SD}(i,t) = \left(\frac{a}{1 - b\mathrm{FC}(i)}\right)\mathrm{SI}(i,t)$$

[Lievens, 2019]

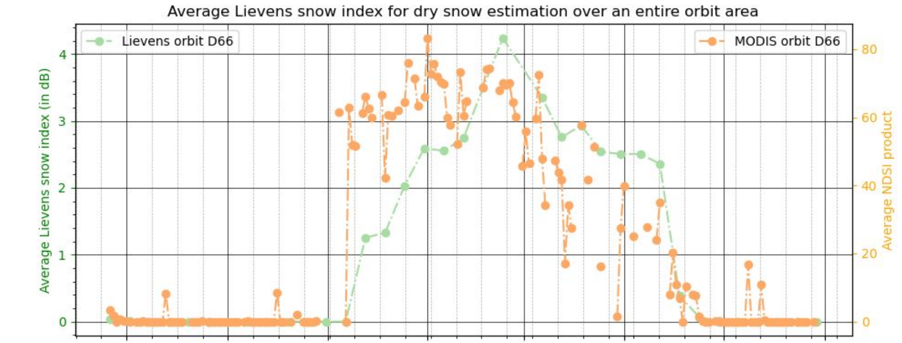
$$R_{vh} = \frac{\sigma^0_{vh}}{\sigma^0_{vh,ref}} \qquad R_{vv} = \frac{\sigma^0_{vv}}{\sigma^0_{vv,ref}}$$

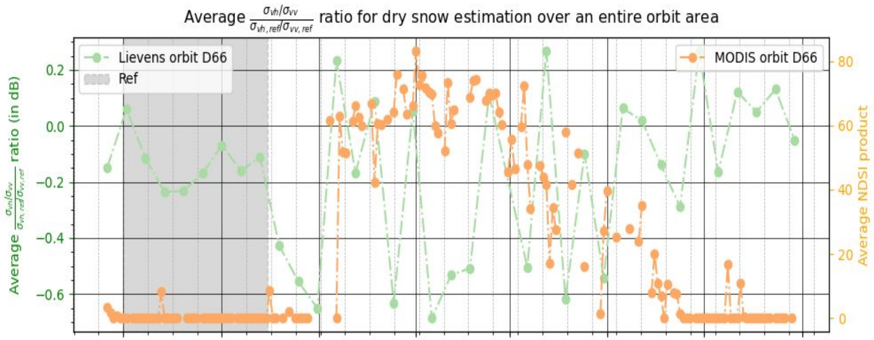
$$R_c = W(\theta)R_{vh} + (1 - W(\theta))R_{vv}$$

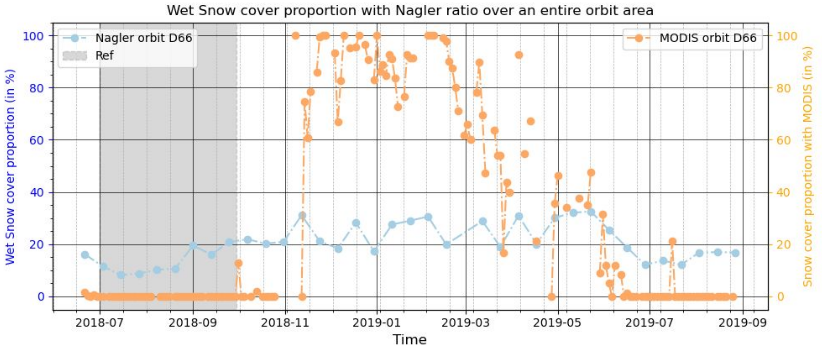
$$R_c < -2dB$$

[Nagler, 2016]

Temporal analyse of snow index







Snow detection SVM results

- Setup
  - Detection snow/no snow
  - Input channels : Rvh, Rvv, Rvh/Rvv
  - 40 000 learning pixels / 10 000 validation pixels : 50% no-snow, 50% snow
  - 4 images per orbit as final test
- Confusion matrices

	Orbit A88	
True no snow	3392	1608
True snow	2815	2885
	Pred no snow	Pred snow

OA: 0.62 F1: 0.58

	Orbit D66	
True no snow	3550	1450
True snow	2985	2015
	Pred no snow	Pred snow

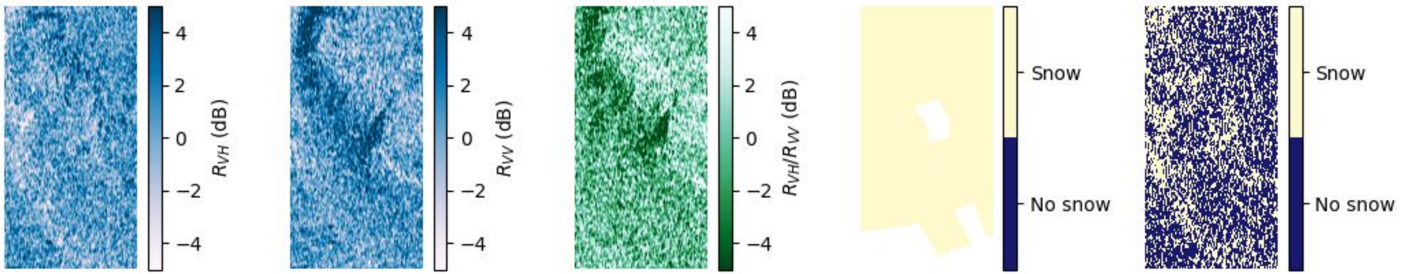
OA: 0.56 F1: 0.55

	Orbit D139	
True no snow	4026	974
True snow	3517	1483
	Pred no snow	Pred snow

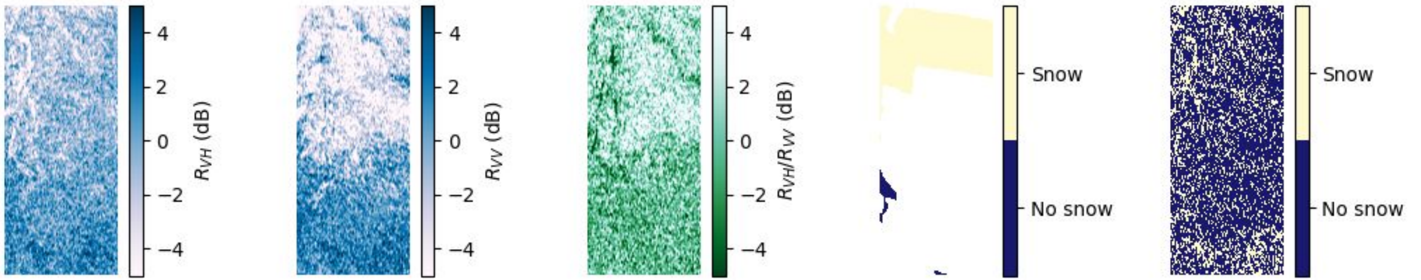
OA: 0.55 F1: 0.52

Image result

A88 - Detection feature close to R_{VH} features



D139 - The Wet Snow features are not detected

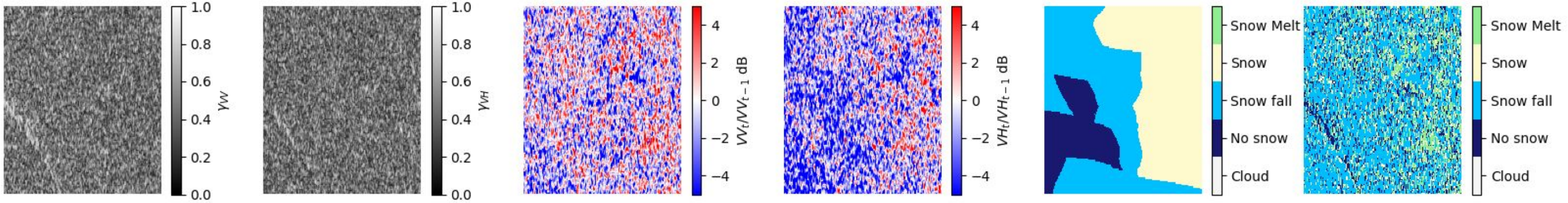


Change detection SMV results

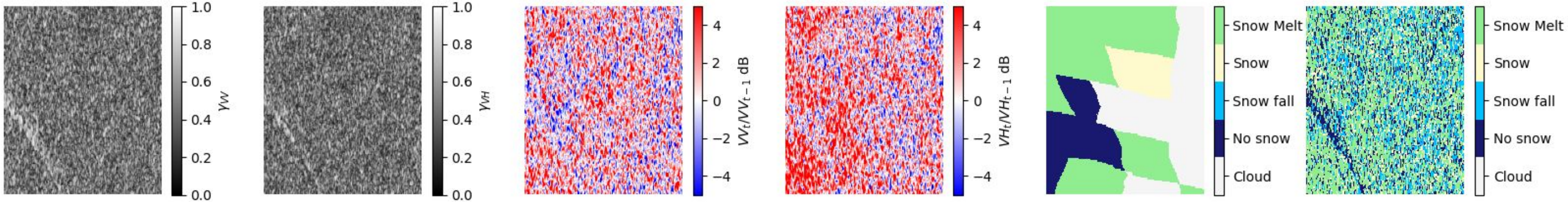
- Setup
  - Classes : no snow, snowfall, snow, snow melt,
  - Input channels : γ_{VV} ,γ_{VH}, VV_t/VV_{t-1}, VH_t/VH_{t-1}
  - 40 000 learning pixels / 10 000 validation pixels : 25% in each classe
  - 4 couple of images per orbit as final test
- Scores :
  - A88 : OA: 0.30, mF1: 0.30
  - D66 : OA: 0.35, mF1: 0.34
  - D139 : OA: 0.35, mF1: 0.35

Results on orbit D66

t: 2019-03-24



t: 2019-04-05



Conclusion

- The link between SAR parameters and NDSI shows :
  - Thresholding is not enough to detect both wet snow and dry snow with SAR
  - SAR alone doesn’t allow to discriminate between snow and vegetation
- Snow cover change detection seems easier than detection snow with SAR and SMV

Future work

- Try with CNN : include the neighbouring
- Use Sentinel-2 for a better optical resolution
- Use longer time series
- Use optical information when available : ie cloud inpainting

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