WET SNOW PROPERTIES with Active Microwaves (Synthetic Aperture Radar)

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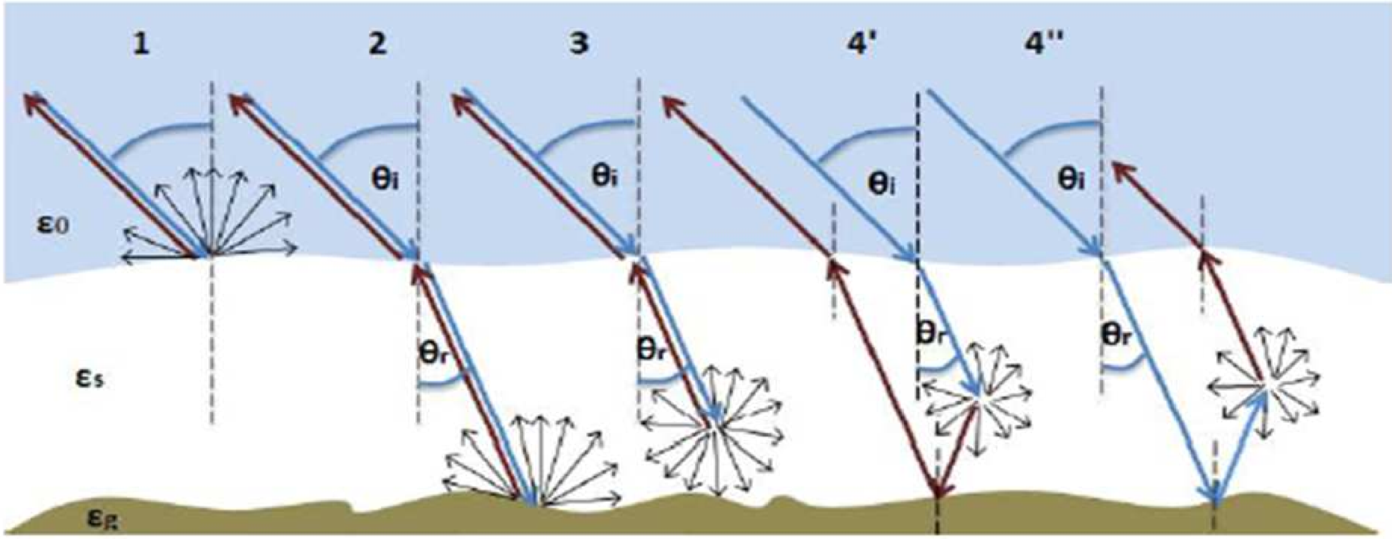
Atelier Neige-OSUG, 30 Avril 2015

1. Snow backscattering mechanism



Backscattering Components:

1. Snow surface
2. Underlying ground
3. Volume

4’. Volume-underlying ground interaction

4’’. Underlying ground-volume interaction

(from Besic et al., 2014)

Wet snow (surface) retrieval	Dry snow (depth) retrieval	Snow volume retrieval	Freqency (GHz/cm)	SAR sensors
X	0	0	**L (1.2/26)**	JERS, ALOS 1&2
X	0 (X QuadPol)	0	**C (5.3/5.6)**	ERS 1&2, ASAR, Radarsat 1&2, Sentinel 1.
X	X	X	**X (9.6/3.1)**	TerraSAR-X, COSMO-SkyMed
X	X	XX	**Ku (17.2/2.5)**	Cryosat-2 (Altimeter)

2. WET Snow Mapping (Intensity mode)

2.1 Threshold-based method using polarized SAR data (Nagler et al., 2000)

– Wet snow detected using change detection against dry snow reference.

* Characteristics

– Not requiring polarimetric data, only co- or cross-polarized mode (HH, VV or HV, VH)

– Binary Segmentation (snow/no-snow) as a mask

– Either a summer (no-snow) or a dry snow scene can be used as reference

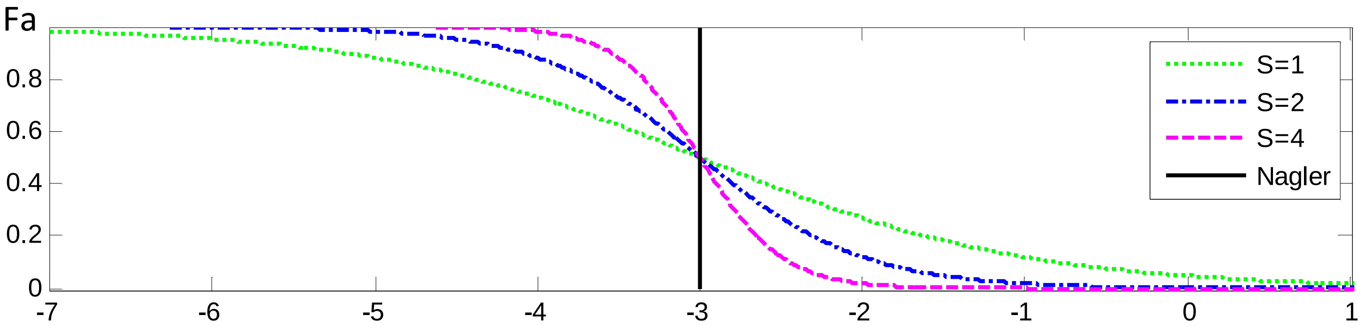
* Principle: Wet snow on the ground → Backscattered signal decreases: $\frac{\sigma^0_{winter}}{\sigma^0_{ref}} \leq -3\ dB$

2.2 Soft threshold (Longépé et al., 2009)

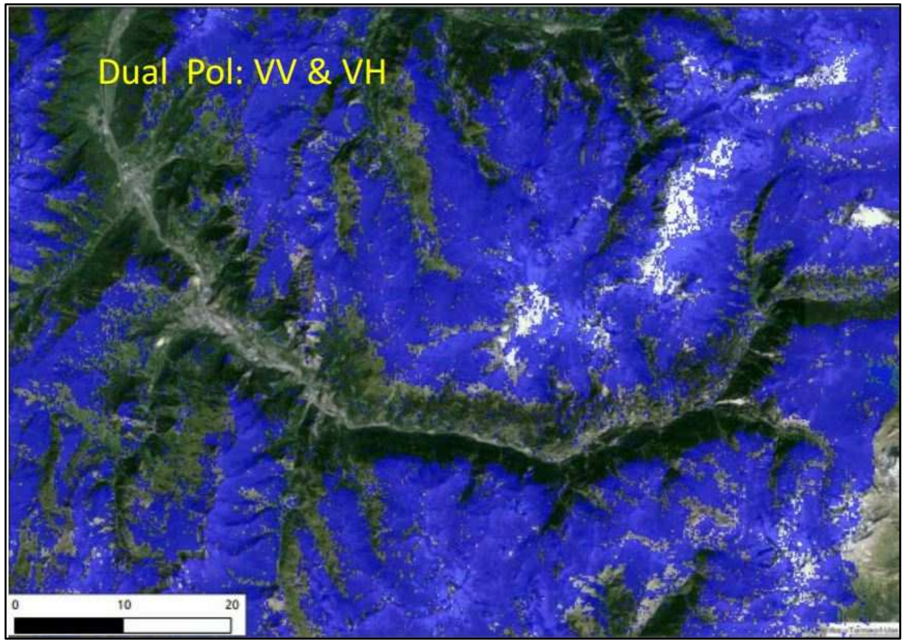
* Characteristics

– Take into account the snow heterogeneity using a steepness factor for the -3 dB threshold as a sygmoidal function:

$$F_a = \left[1 + \exp\left(s.\left(\frac{\sigma^0_{wet}}{\sigma^0_{ref}} + 3\right)\right)\right]^{-1}$$



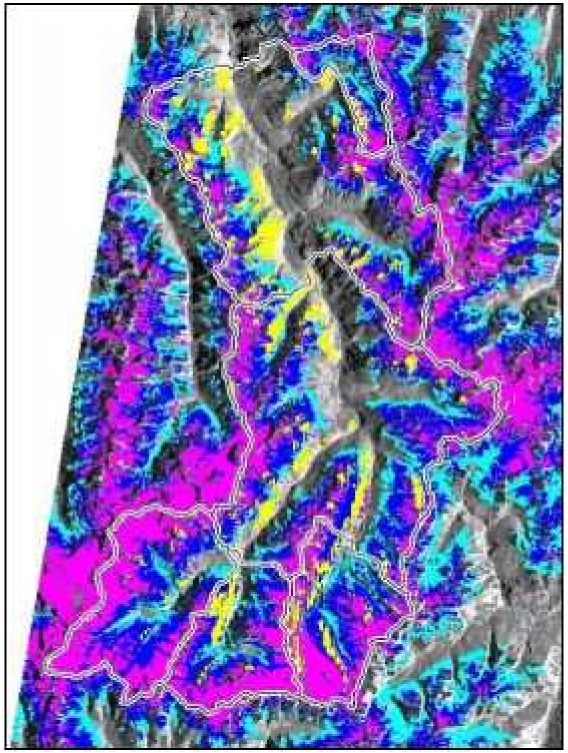
Improvement of the method



Example of wet snow map from Asar-Envisat (C-band) merged with Landsat ETM optical image, 13 April 2008. Maurienne valley, France (*Nagler et al., 2014).*

(Pour IETR-LTHE-Gipsa : Dedieu et al, 2012; Lessard-Fontaine et al, 2012; Besic et al, 2014, 2015).

Temporal evolution



Asar-Envisat mutitemporal wet snow maps over Ötztal valley (Austria), Spring 2004: 04 May (cyan), 08 June (blue), 13 July (magenta). No information (layover) in yellow.
(*Nagler and Rott, 2005).*

3. Liquid Water Content estimation (polarimetry mode)

- PNTS Projects, CNES (French Space Agency) and INSU: #010 (2009-2011), # 14-003 (2014-2015)
- SOAR Projects, Canadian Space Agency and MDA: #1341 (2009-2012), # 5135 (2014-2016)

Radarsat-2 full polarimetric satellite (C-band) for snow properties retrieval : 2009-2015
Gdes Rousses and Oisans massifs (French Alps)

* **Field measurements** (10 sites, 30 images)

LWC : liquide water content is given by = Epsilon - (A*σ -B*σ^2) /C
with A = 1.202, B = 0.983, C = 21.3 (LEAS capacitance probe) **ε** : dielectric constant (c/V m)

Conductivity function : relationship between ε and volumetric water content θ

* **Image polarimetric decomposition**

Cloude-Pottier (1996, 1997),
Yamaguchi (2005), Arii (2011).
Sites window size = 25x25 m

LWC characterization : relationship between ε and SAR phase signal $\vec{E}$

(Dedieu & Besic et al., under preparation for IEEE-GRSL 2015)