Results obtained in simulation over snow surface (WP3)

Final meeting - ESTEC – Februart 2020

WP 3.1 Objectives

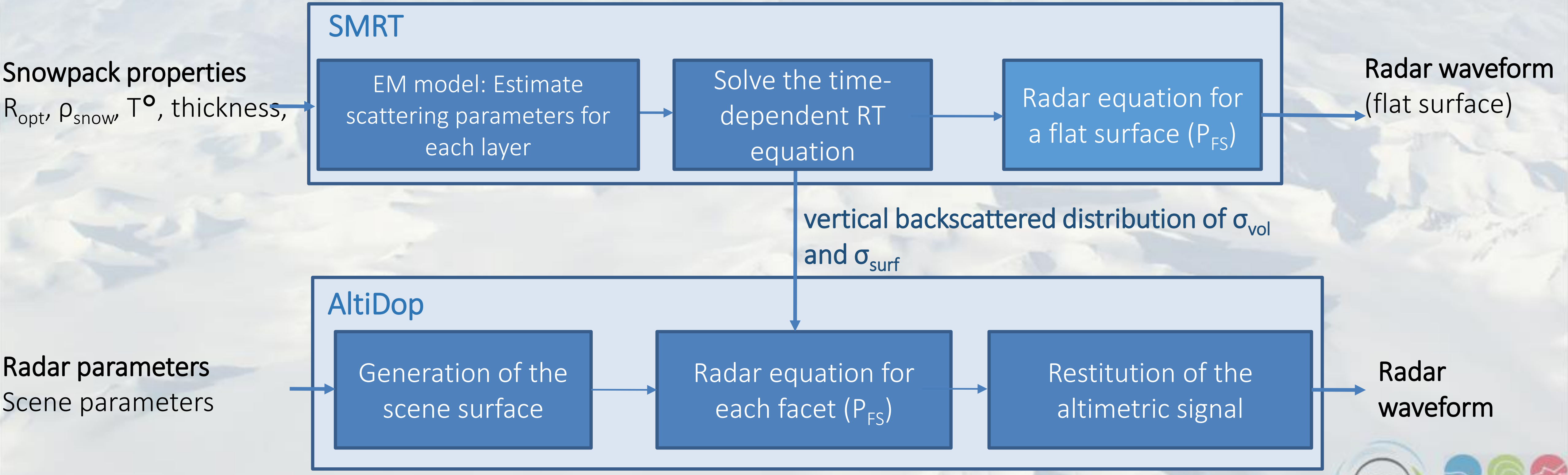
To adapt a snow radiative transfer model (SMRT) and integrate it in the CLS altimeter simulation tool

1) Adapt SMRT to provide not only the total backscatter from the surface but also the time travel of the individual echo required by the simulator to re-construct the radar waveform

2) Definition of two study cases with different snow parameters

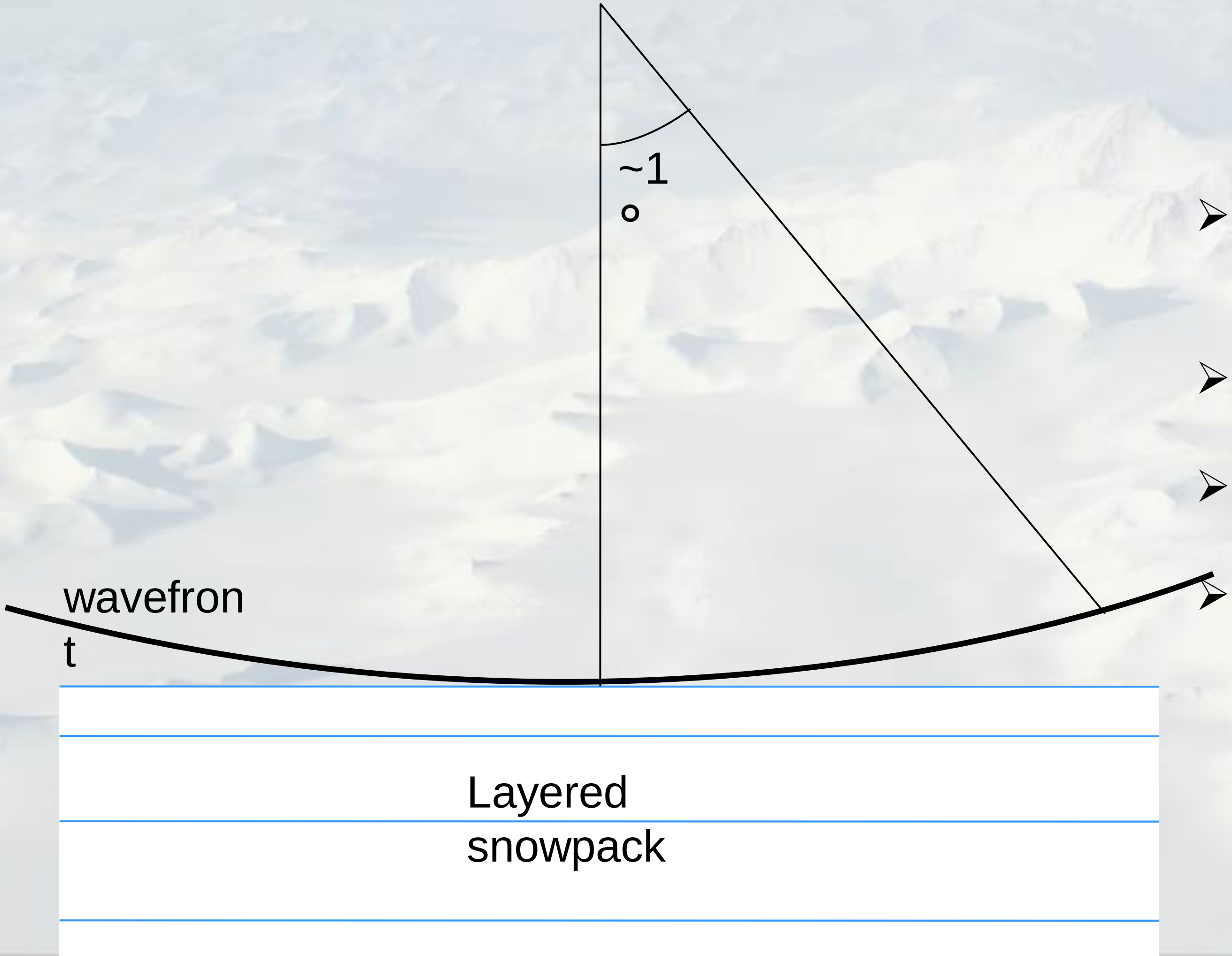
Coupling of a snow model with an altimetric model

1) Simulate **the vertical profile of backscatter and propagation speed** with a Snow Radiative Transfer (SMRT) model
2) Integrate, **horizontally,** over **the footprint** and build the total waveform with AltiDop (or an analytical equation in SMRT for simple cases)



IGE activities since last meeting

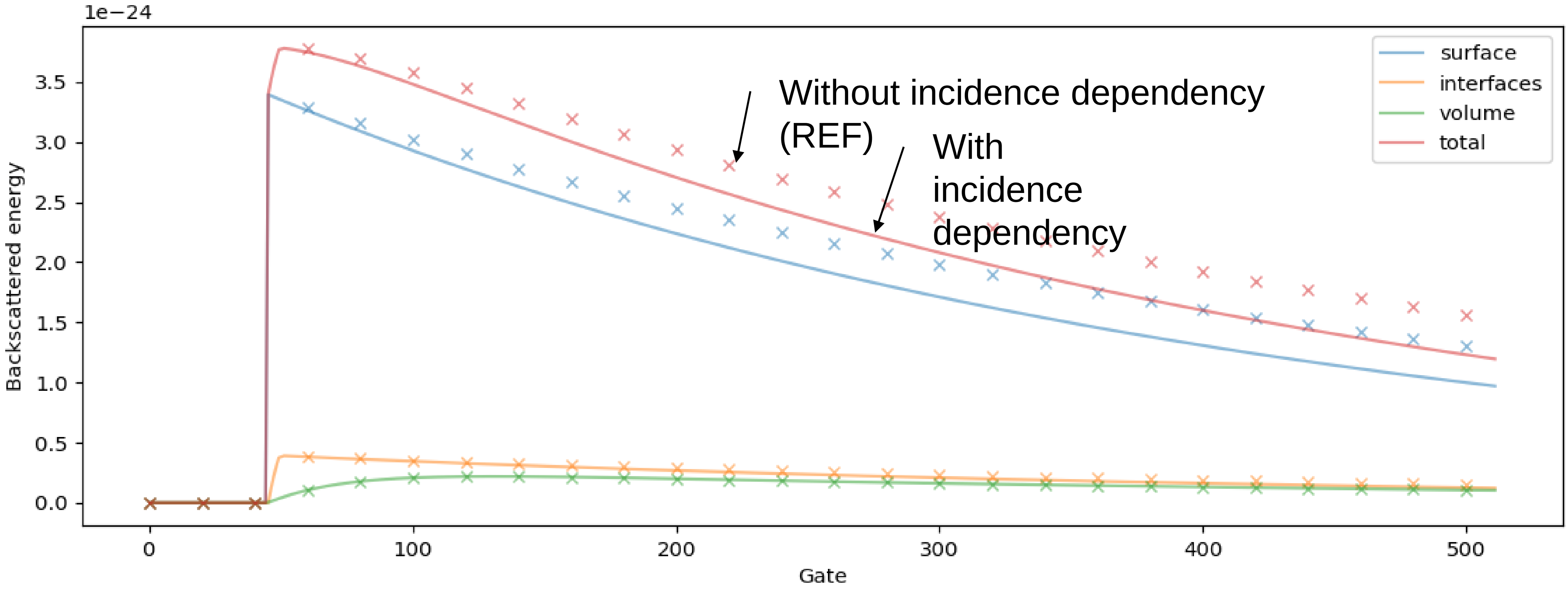
- Consolidation of SMRT (bugs, formatting, documentation)
- Reference snowpack and sensitivity study (see below)
- Added angular dependence for the surface and the interfaces



- Snow surfaces (and inter-layer interfaces) are relatively smooth from an EM point of view
- → strong sensitivity to the incidence angle near nadir
- Volume scattering is isotropic
- → very weak sensitivity to the angle

IGE activities since last meeting

- Significant change and increase of code complexity
- Simulation time is increased: 20 ms vs 15 ms
- Results: tiny effect, visible only for “extreme” configurations:
- - Very smooth surfaces (mean square slope: 10^{-3}) or very low frequency
- - Wide antenna aperture: 3° HWB
- - High #gates



IGE activities since last meeting

- ➢ Sensitivity analysis:
- ➢ first step is to build a realistic snowpack

Lacroix et al. 2008 snowpack gave good results (S and Ku band)

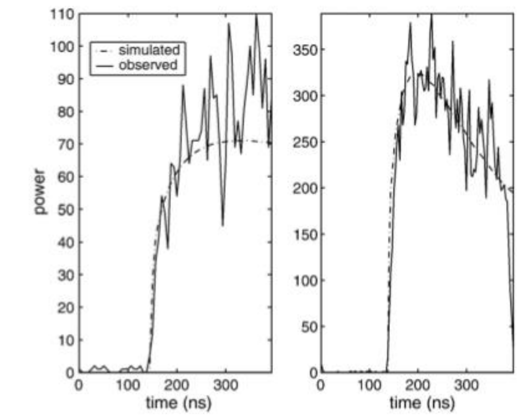


Fig. 12. Waveform observed (solid) and modelled (dashed) over the Vostok lake (lat=104.126°, lon=−76.574) at S (left) and Ku band (right). The parameters found by the inversion are written in the Table 3.

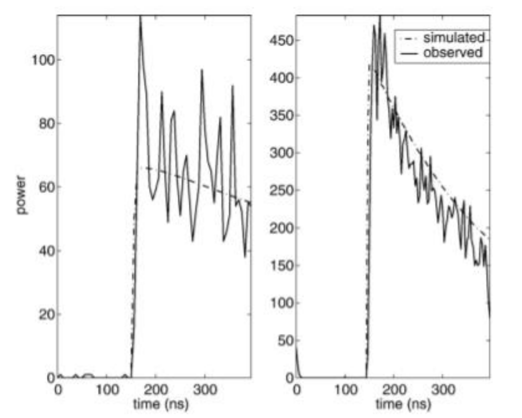


Fig. 13. Waveform observed (solid) and modelled (dashed) on Dronning Maud Land at the position (lat=9.838°, lon=−74.954) at S (left) and Ku band (right). The parameters found by the inversion are written in the Table 3.

<u>But LA08 uses</u>

1) an inadequate snow microstructure representation
2) an inadequate ice absorption formulation
3) inappropriate approximations (and/or few bugs)

+ We want a single layer snowpack to make clear sensitivity analysis

4) rough surface model (IEM) was adapted to S and Ku, we want Ku and Ka.

<u>First strategy</u>: optimize a snowpack with a "modern" SMRT configuration on LA08 results (which were good)

IGE activities since last meeting

Single layer snowpack:

Temperature: 220 K
Diameter: 0.75 mm
Density: 235 kg m^{-3}

Rough surface model: geometrical_optics
Mean square slope: 0.0015

Table 3
Snow parameters inversion at 2 locations (Vos = Vostok, Mau = Dronning Maud Land) based on the fit on individual waveforms represented in the Figs. 12 and 13

Location (lon, lat)	ρ_0 (g cm^{-3})	μ (kg/m^2)	Φ_g (mm)	σ_h (mm)	l (cm)
Vos (104.13, −76.57)	0.24±0.03	80±70	0.9±0.07	3.9±0.3	14±3.6
Mau (9.83, −74.96)	0.34±0.05	422±339	0.8±0.17	4.8±0.5	33.5±4.9

Second strategy: use a realistic density (~320 kg m^{-3}) and adjusting (up) the roughness.

→ see Jeremie's presentation

Lesson learned:

- microstructure choice is extremely important. Major issue to use in-situ data ("grain size measurements").

- For altimetry, roughness is also extremely important. Lack of measurements.