CRISTAL performance analysis over snow surface: WP3 outcomes summary

Final meeting - ESTEC – February 2020



SMRT adaptation to altimetry

What has been achieved:

We have done what we planned !

- 1) develop a new RTE solver to compute timedependent backscatter
- st
- 1 order iterative solution
- computationally efficient
- extensive internal validation (energy conservation, ...)
- extensive validation against Lacroix et al. 2008.
 Bonus: assessed Lacroix's approximations and found a few bugs.



SMRT adaptation to altimetry

What has been achieved:

2) implemented new "rough" surface and interface formulation

- IEM as in Fung al. 1992 (backscatter only)
- Geometrical optics (backscatter only)
- Geometrical optics (bi-directional scattering)

Cover a wide range of roughness / wavelength

Perspective: Small Perturbation Method or Small Slope Approximation



SMRT adaptation to altimetry

SMRT has grown:

 Line of Code

 May 2019:
 4922

 Today:
 7086

https://github.com/smrt-model/smrt



GitHub



On the higher order interactions

First order interaction is limited to low frequencies / small grains:



On the higher order interactions

Perspective: implement a 2 order model in SMRT.

Solution: Monte Carlo technique

- explicitly compute the trajectory of the wave/photons
- relatively easy to implement
- computationally intensive / very slow convergence

But here:

- 1_{nd}order can still be computed with the iterative method (accurately)
- 2 order is small in the Ka band and at lower frequencies

Solution: compute an approximate of the 2^{nd} order with the Monte Carlo technique.





On surface roughness

Which roughness scales count for snow ?

Centimeter scale

Metric scale

- (IEM domain) (GO domain)
- Topographic scale (AltiDop domain)





 \rightarrow consequences for the frequency dependence \rightarrow consequences for in-situ data requirement

Need to learn more on the roughness of snow surfaces.

On running SMRT with in-situ data

SMRT has been used with a "synthetic" snowpack representative of the ice-sheet SMRT can run on the ice-sheets, seasonal snow, sea-ice, frozen lakes, ...

Our short-term plan: use ASUMA traverse data (2016)



Grain size (SSA), density up to 8m depth

On running SMRT with in-situ data

Surface DEM (centimeter resolution) → Meter-scale roughness

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On running SMRT with in-situ data

Even with such comprehensive dataset:

- the choice of the microstructure remains an issue / related to snow grain size measurements.

- 1 snow core for a kilometer wide pixel

In brief, several parameters are unknown or inaccurate.

Our plan for the coming months:

- SMRT simulations with ASUMA in-situ data → altimetry and passive modes
- comparison with Ku and Ka band altimetric data + 10, 19, 37 GHz passive microwave
- \rightarrow Publication.



Conclusion

- we now have a passive / radar / altimetric microwave radiative transfer model using **consistent physics, coding interface,** working consistently **across a few media** (ice-sheet, sea-ice, ...).

 \rightarrow excellent for synergistic use of multi-sensor data; learning investment, ...

SMRT is a repository of many existing legacy formulations, equations or models, but little new developments

 + Lacroix et al. 2008'st model was almost lost.
 - Altimetric code is 1^d order as Lacroix 2008.
 → need to develop new components. 2 order RT, microstructure, ...

Even when available, using in-situ data to run SMRT is a big challenge. Both technical and fundamental issues.
 → provide ready-to-use dataset (sugg. by M.J Brodzik, NSIDC)

