CRISTAL performance analysis over snow surface: WP3 outcomes summary

Final meeting - ESTEC – February 2020

IGE

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SMRT adaptation to altimetry

What has been achieved:

We have done what we planned !

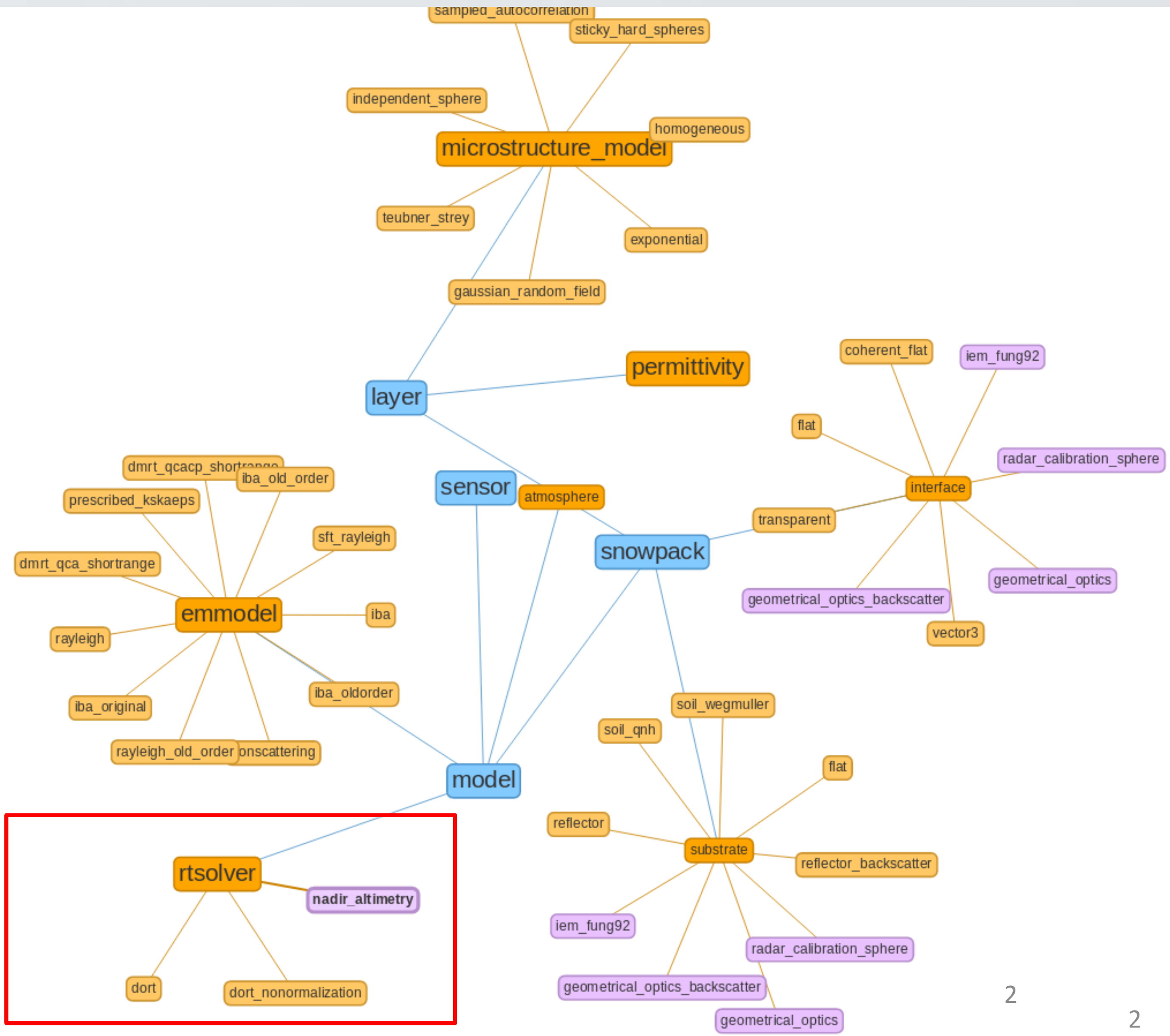
1) develop a new RTE solver to compute time-dependent backscatter

- 1^{st} 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.



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SMRT adaptation to altimetry

What has been achieved:

2) implemented new “rough” surface and interface formulation

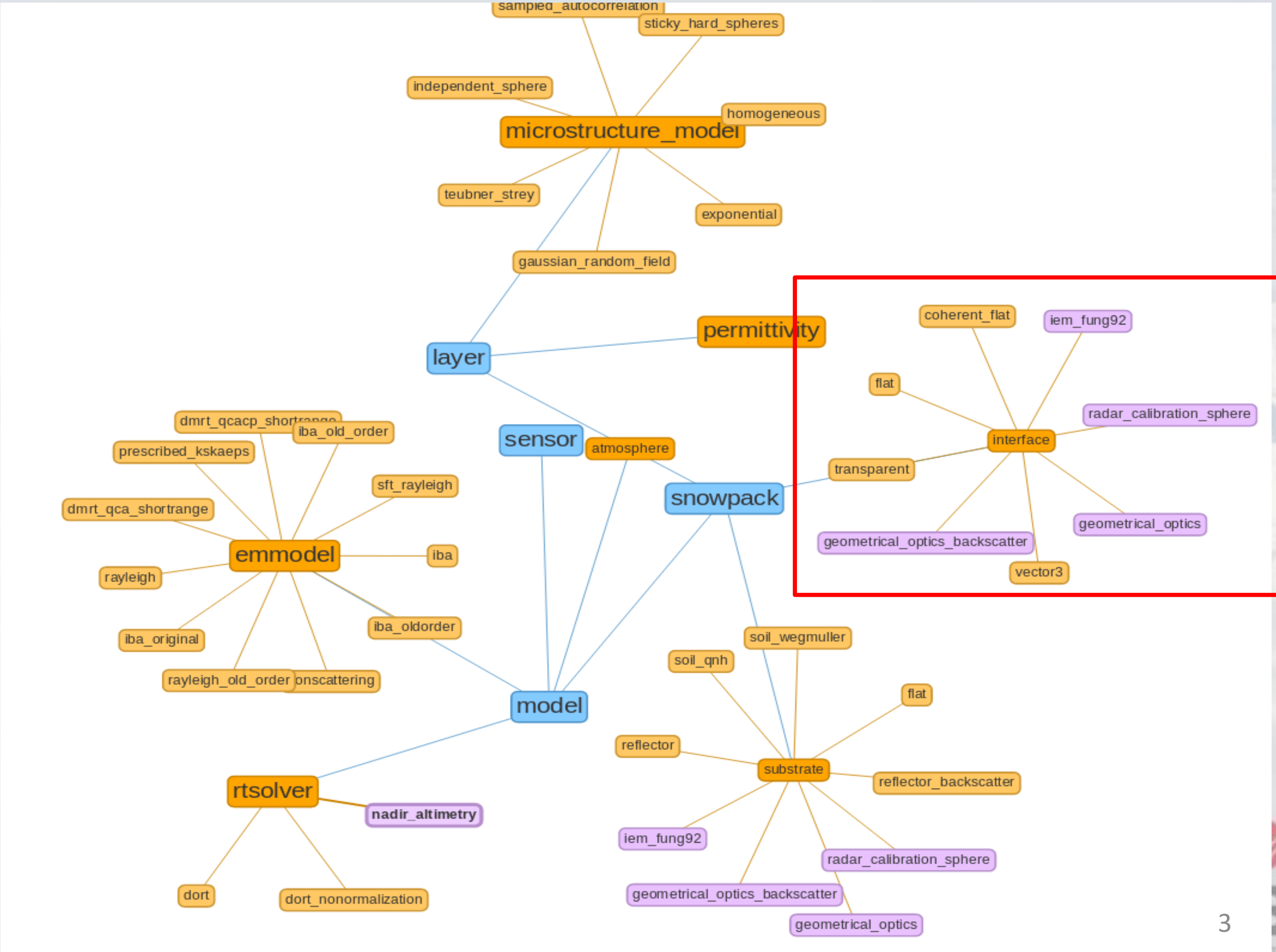
- IEM as in Fung al. 1992 (backscatter only)

- 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**

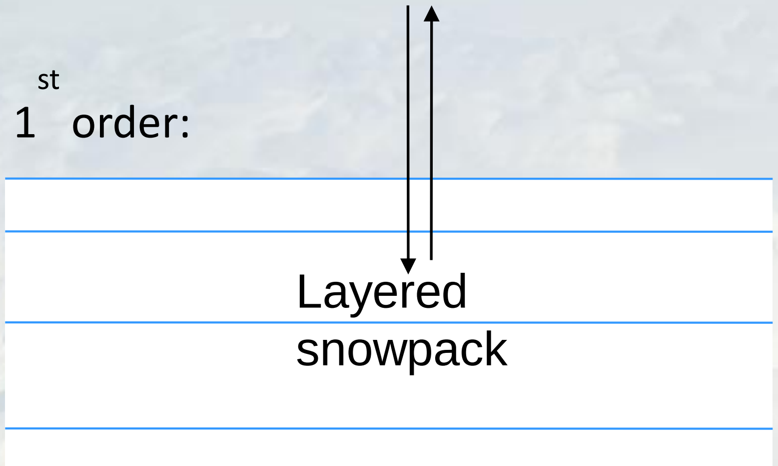
https://github.com/smrt-model/smrt

The altim module will be merged in the next months and pushed to github

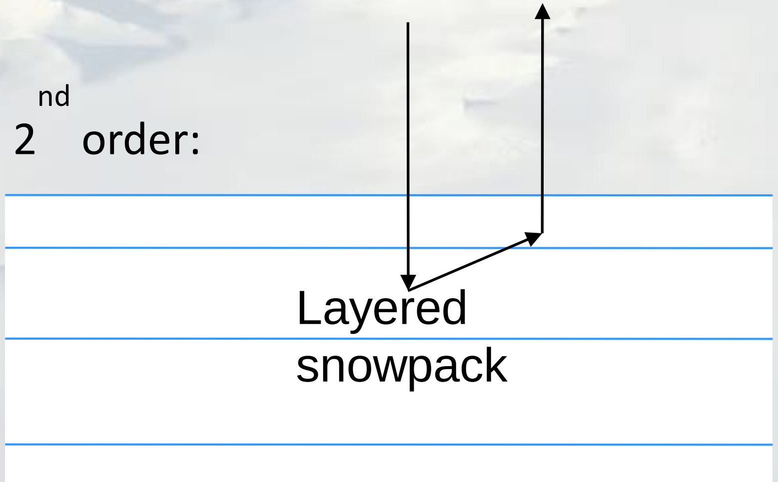
On the higher order interactions

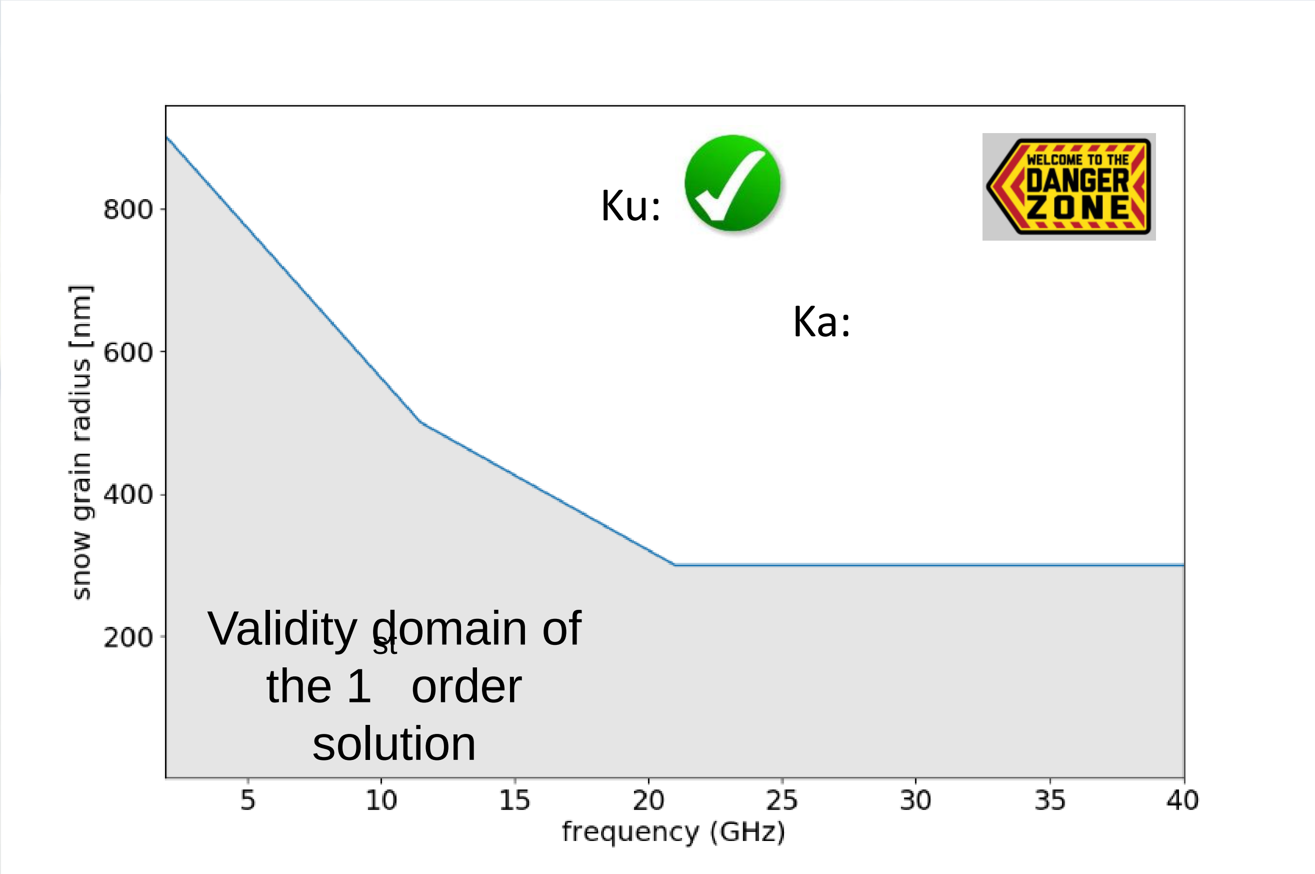
First order interaction is limited to low frequencies / small grains:

1^{st} order:



2^{nd} order:





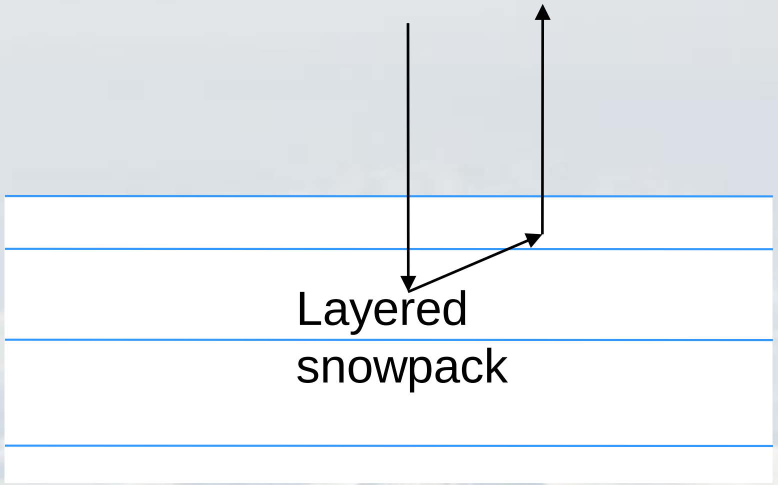
Evaluation by comparison the altimetry solver with the DORT solver

On the higher order interactions

Perspective: implement a 2nd 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



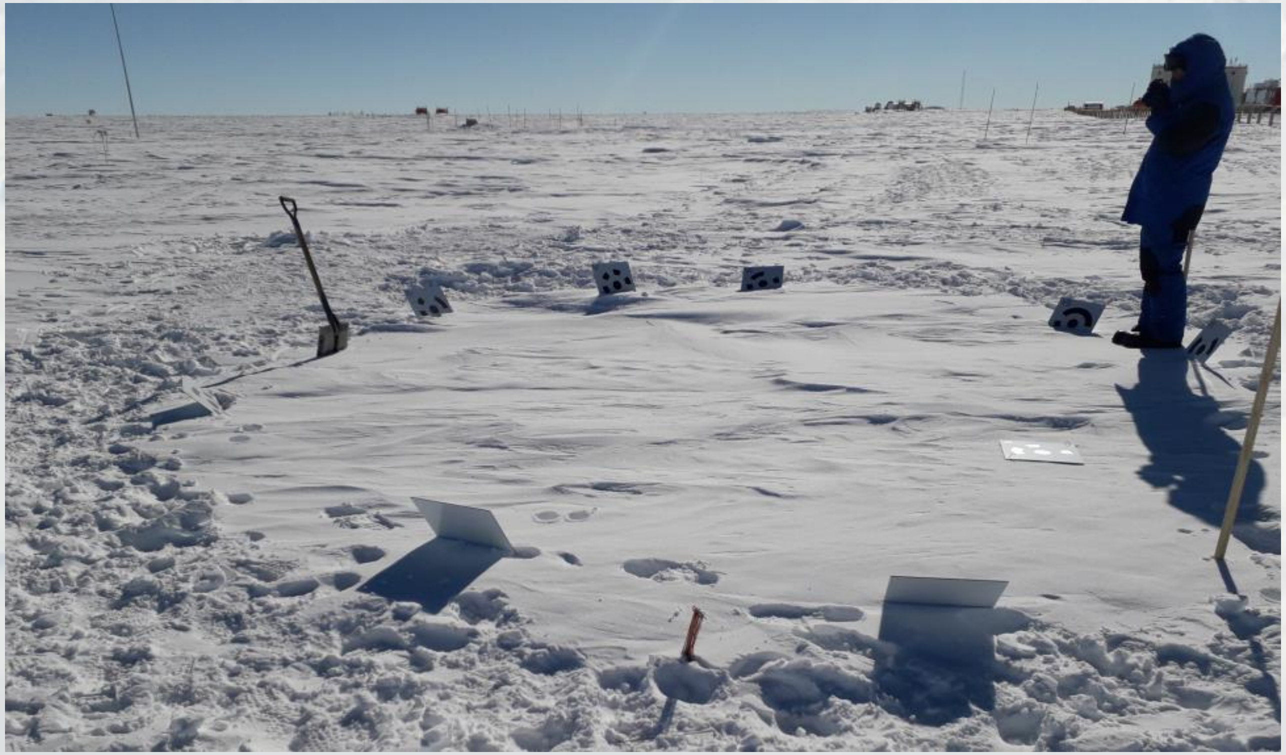
But here:
1st order can still be computed with the iterative method (accurately)
2nd order is small in the Ka band and at lower frequencies

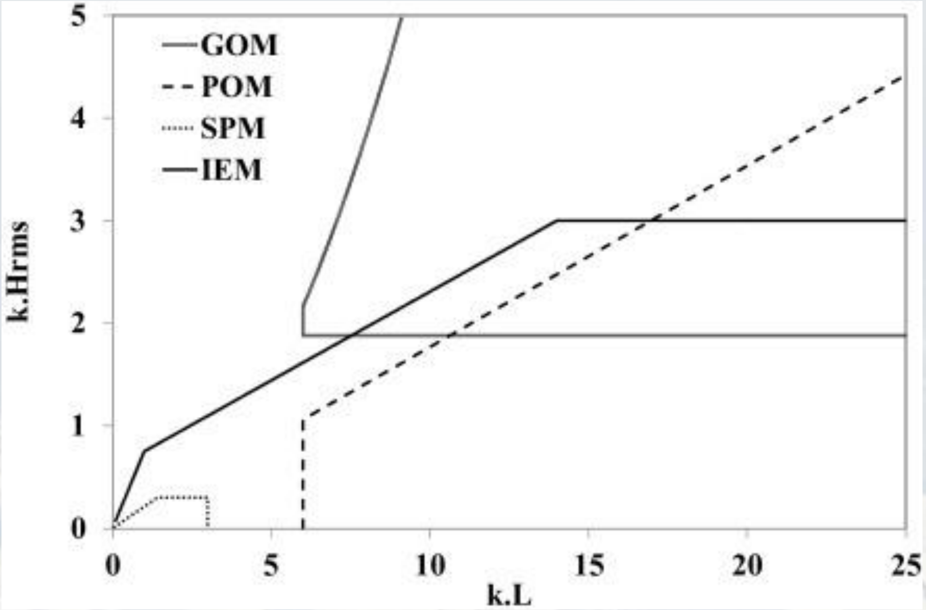
Solution: compute an approximate of the 2nd order with the Monte Carlo technique.

On surface roughness

Which roughness scales count for snow ?

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





→ consequences for the frequency dependence
→ consequences for in-situ data requirement

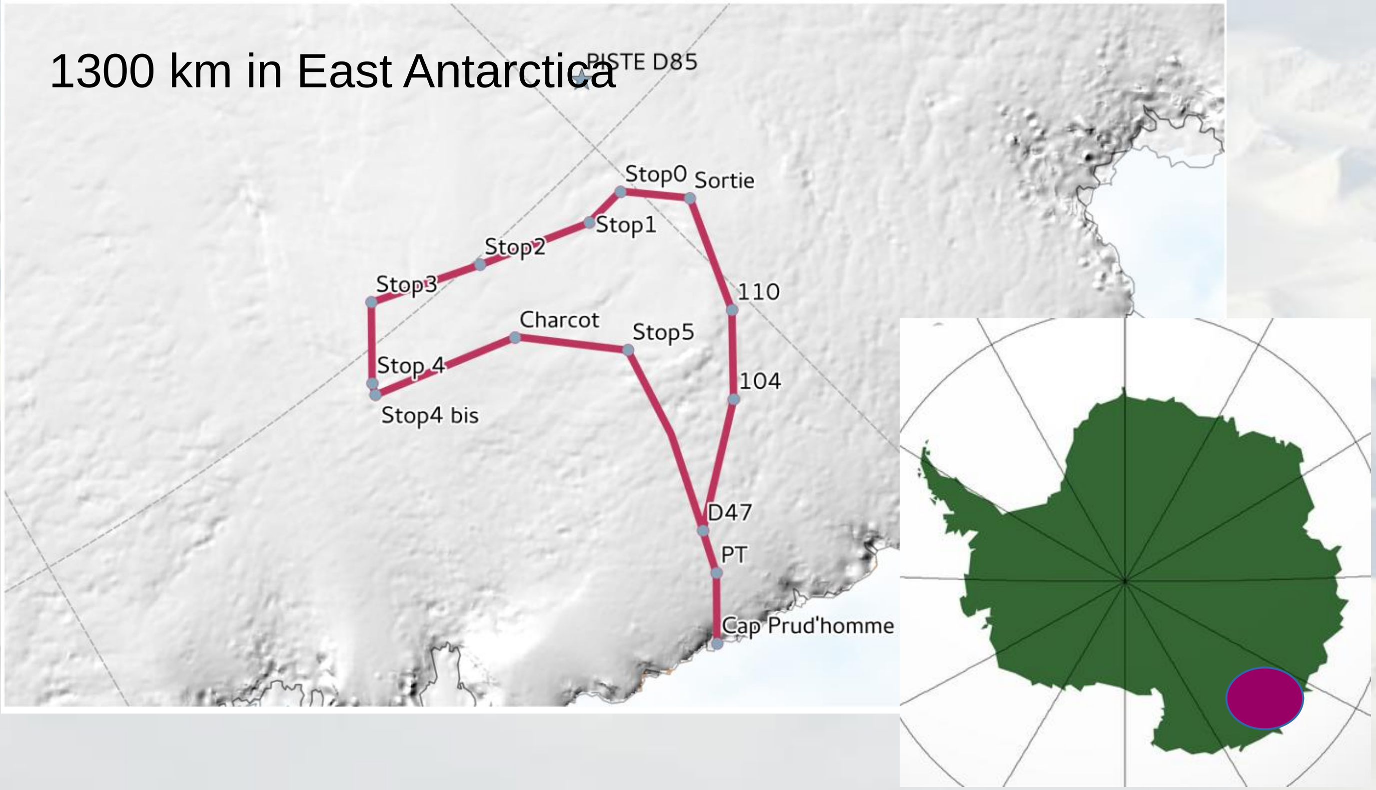
Need to learn more on the roughness of snow surfaces.

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)

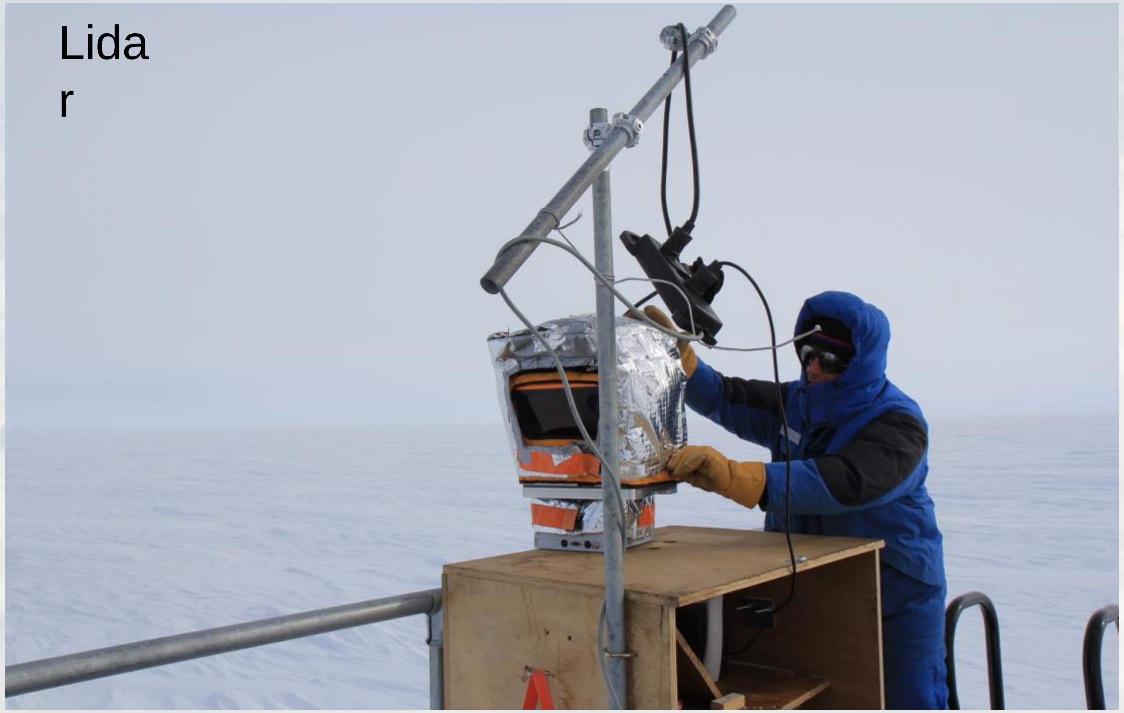
1300 km in East Antarctica

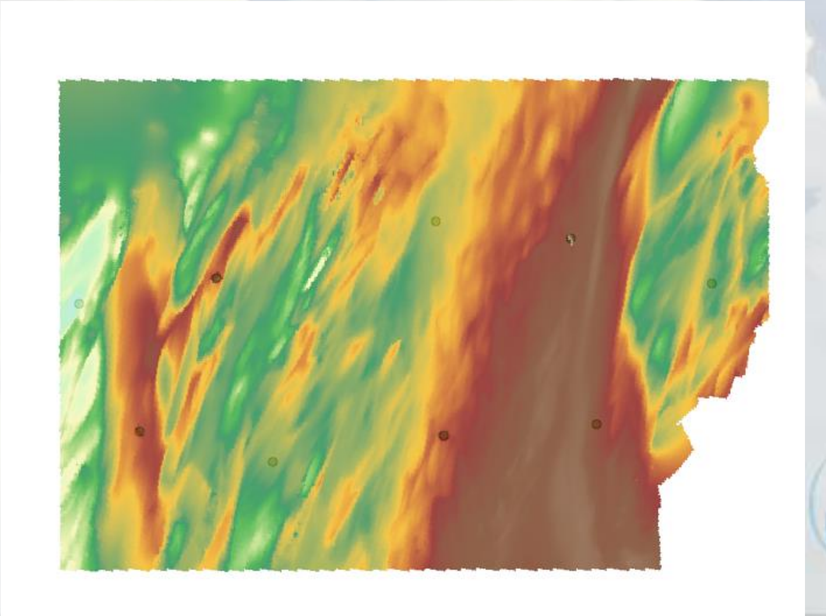


Grain size (SSA), density up to 8m depth

On running SMRT with in-situ data

Surface DEM (centimeter resolution)
→ Meter-scale roughness





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

→ 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, …).
→ 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's model was almost lost.
  - Altimetric code is 1st order as Lacroix 2008.
→ need to develop new components. 2nd 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)