The frozen sea area: a reference case study for inversion problem

G. Alberti, L. Castaldo, G. Cirillo – CO.RI.S.T.A.
R. Seu – University of Rome
A. Frigeri – University of Perugia
R. Orosei – IFSI Rome

Napoli – 28 April 2010

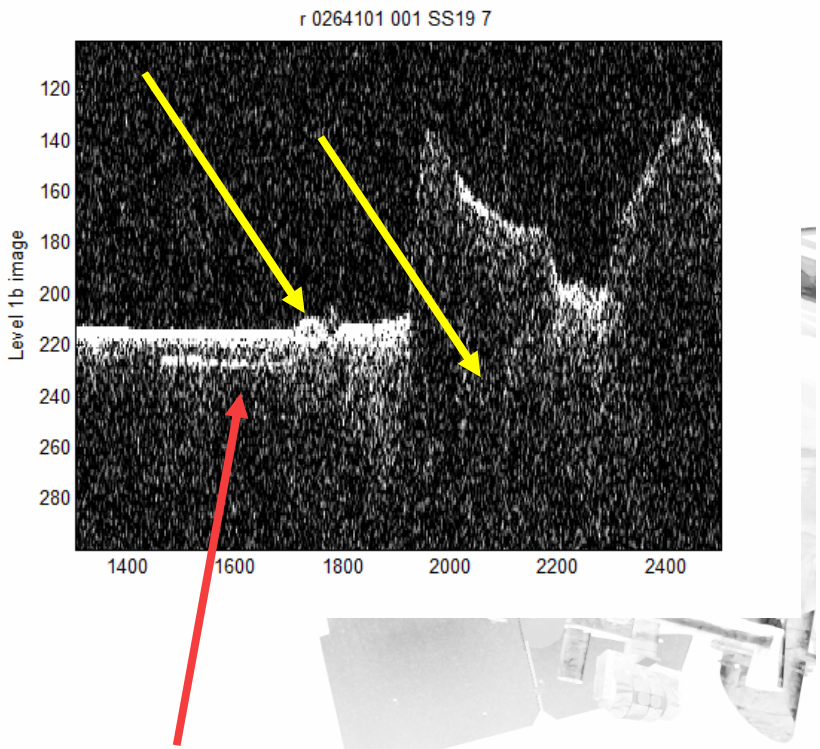
The approach

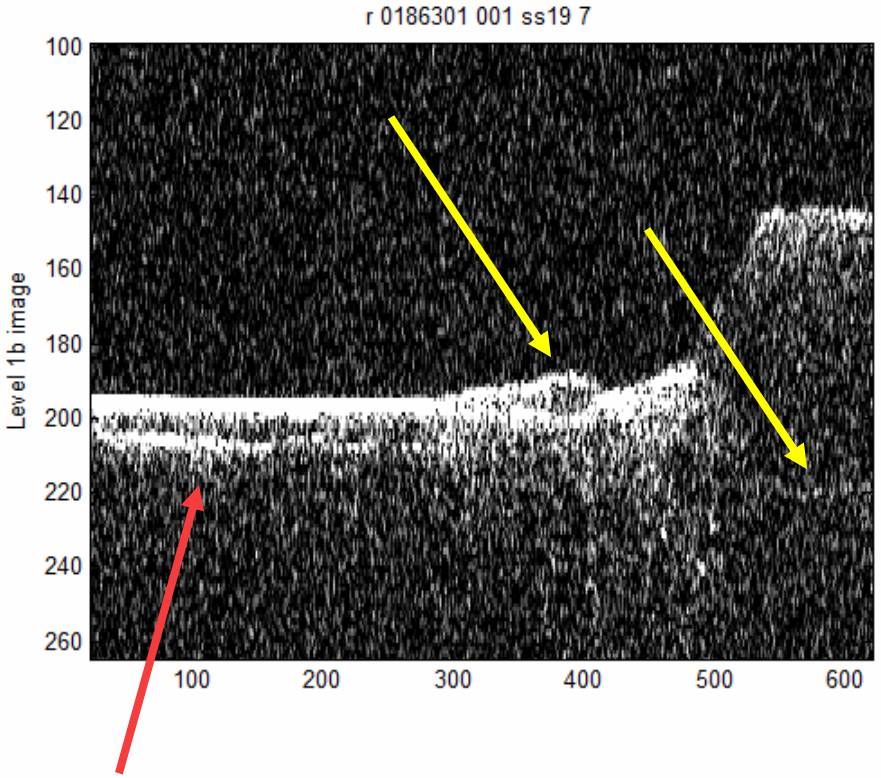
CO.RI.S.T.A. recently faced with the problem of data inversion by using SHARAD data

For a starting point a simple situation has been chosen as reference study case: the frozen sea

The goal is better understand the electromagnetic interaction with surface and sub-surface by using a step-by-step approach, starting from simplified model for layer characterisation and electromagnetic interaction

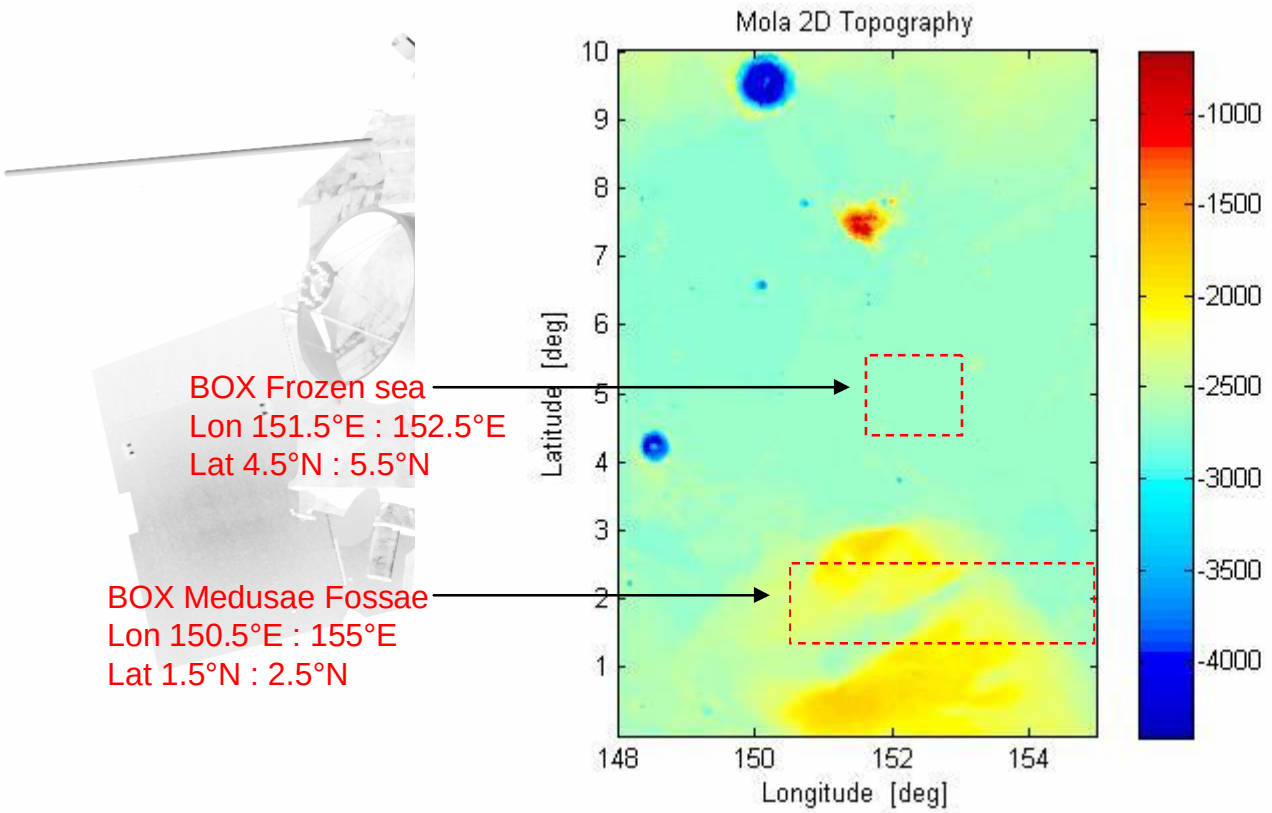
level 1b images





The area

Areas under investigation



BOX Frozen sea
Lon 151.5°E : 152.5°E
Lat 4.5°N : 5.5°N

BOX Medusae Fossae
Lon 150.5°E : 155°E
Lat 1.5°N : 2.5°N

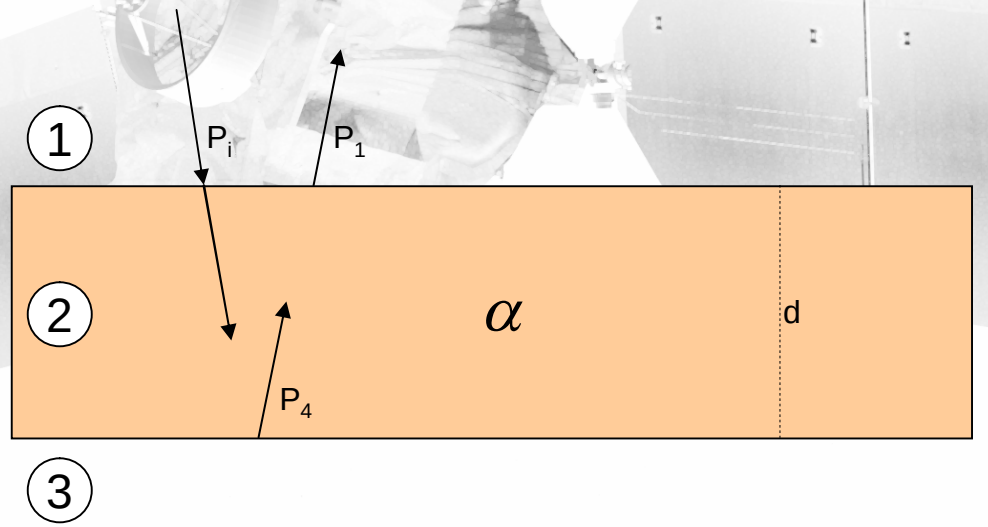
Subsurface investigation

Fresnel equation (only reflection)

Homogeneous low-loss medium

Two medium (two interfaces)

Parallel and flat interfaces



Subsurface investigation

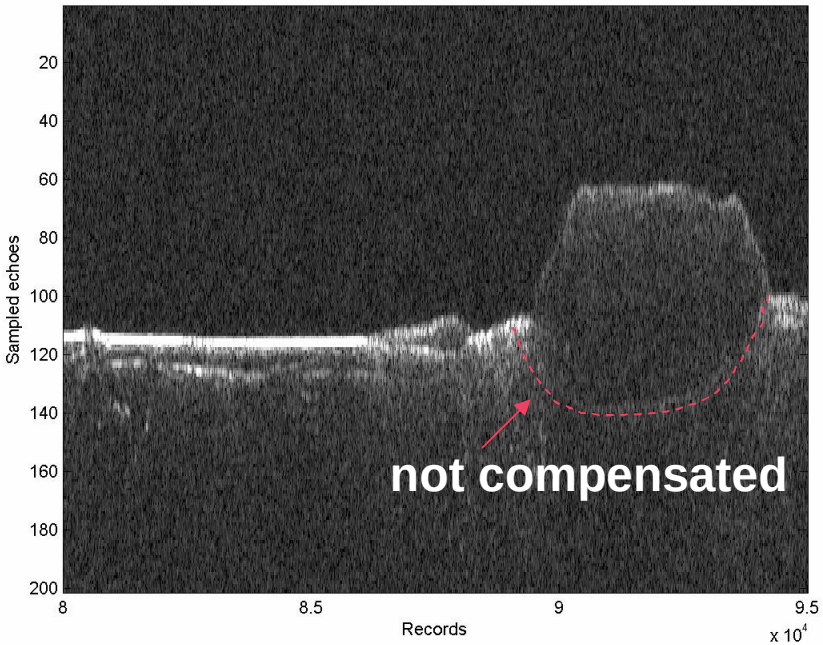
With this hypothesis it is possible to estimate the permittivity of the sub-surface material (medium 3) only from the power ratio of surface and sub-surface, given the permittivity and attenuation of the first one (medium 2)

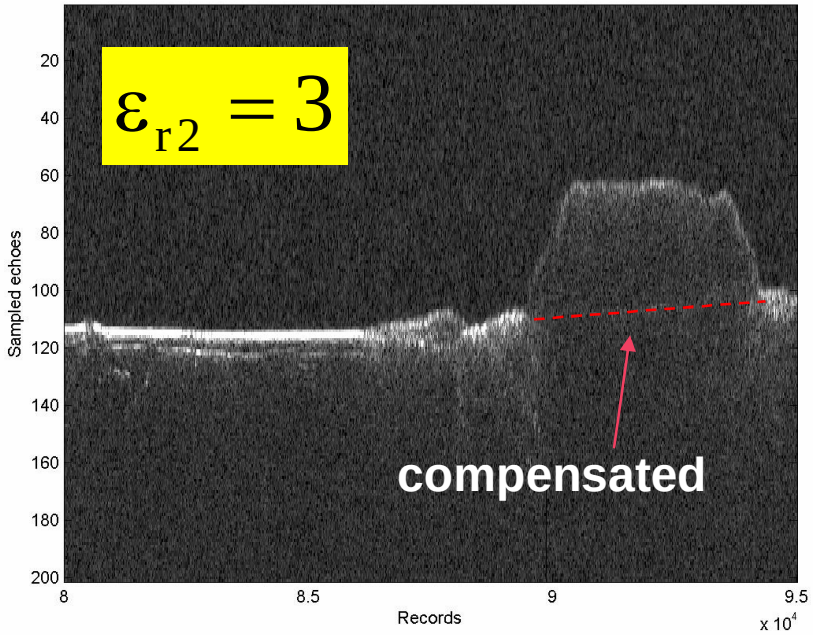
$$\varepsilon_{r3} = \frac{(1-M)^2}{(1+M)^2}\varepsilon_{r2} \qquad M = \mp\sqrt{\frac{P_4}{P_1}}\frac{(1-\varepsilon_{r2})}{4\varepsilon_{r2}}e^{\alpha d}$$

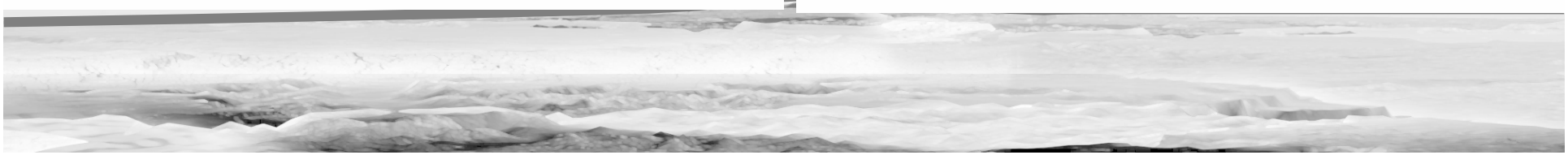
Subsurface investigation

The dielectric constant can be estimated by correcting the signal time delay

r_0589803_001_SS19_700_A



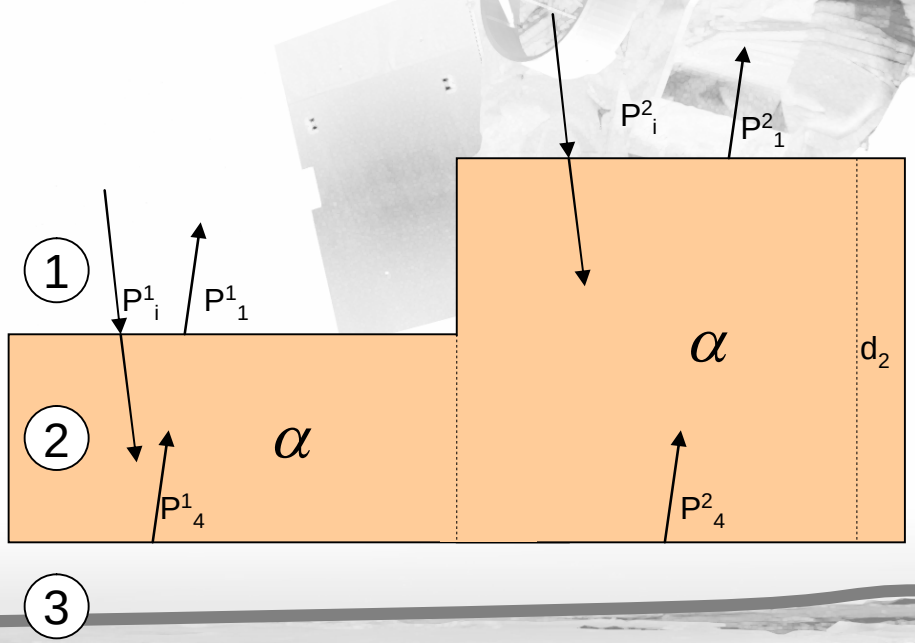




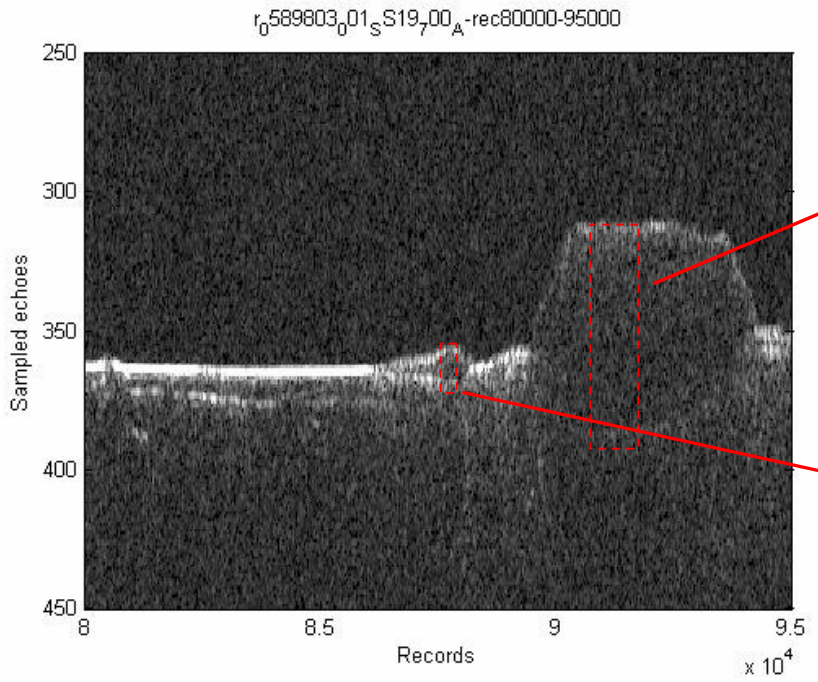
Subsurface investigation

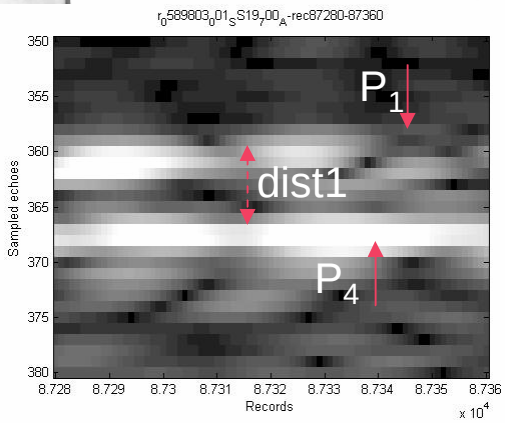
The loss tangent can be estimated by comparing power ratio corresponding to different depths

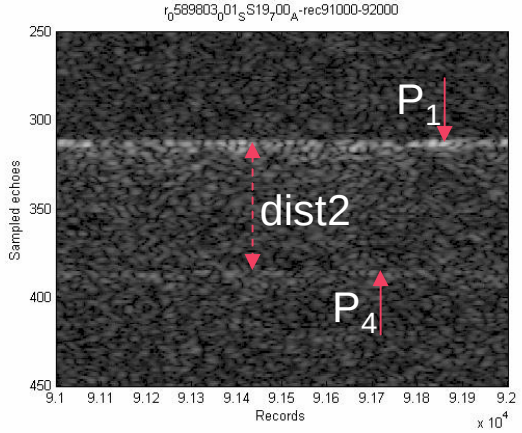
$$\alpha = \frac{1}{2(d_2 - d_1)} \ln\left(\frac{P^2_2}{P^2_4}\frac{P^1_4}{P^1_1}\right)$$



Subsurface investigation







r_0589803_001_SS19_700_A					
dielectric constant	P_4/P_1	dist1	P_4/P_1	dist2	tgd estimated
3	1.69	44.8	0.47	485.8	0.0069388
r_0341902_001_SS19_700_A					
dielectric constant	P_4/P_1	dist1	P_4/P_1	dist2	tgd estimated
3	1.32	61.6	0.41	424.3	0.007668

Subsurface investigation

Then the dielectric constant of the sub-surface can also be estimated (under North-Hill area)

The application of Fresnel equation gives unfeasible values

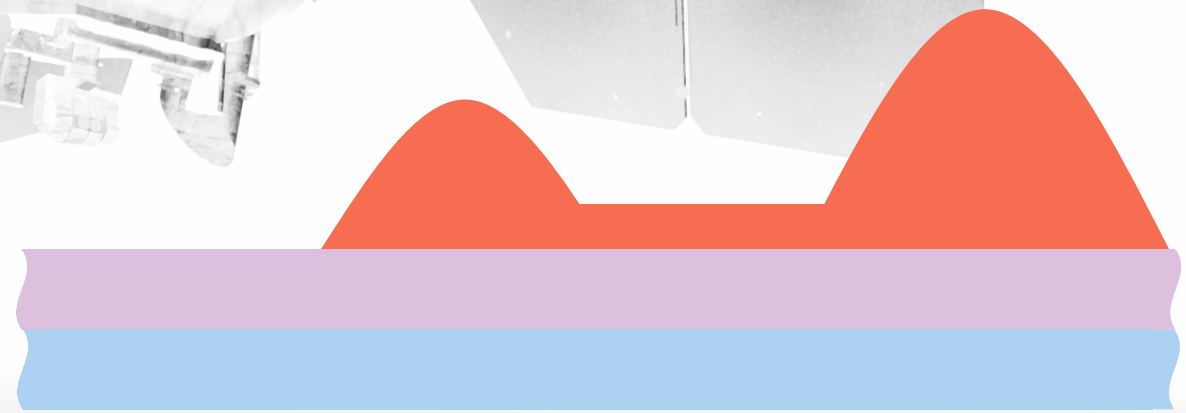
Therefore an additional term should be considered in the surface/sub-surface power ratio

This term takes into account the different scattering behavior of surface and sub-surface

Subsurface investigation

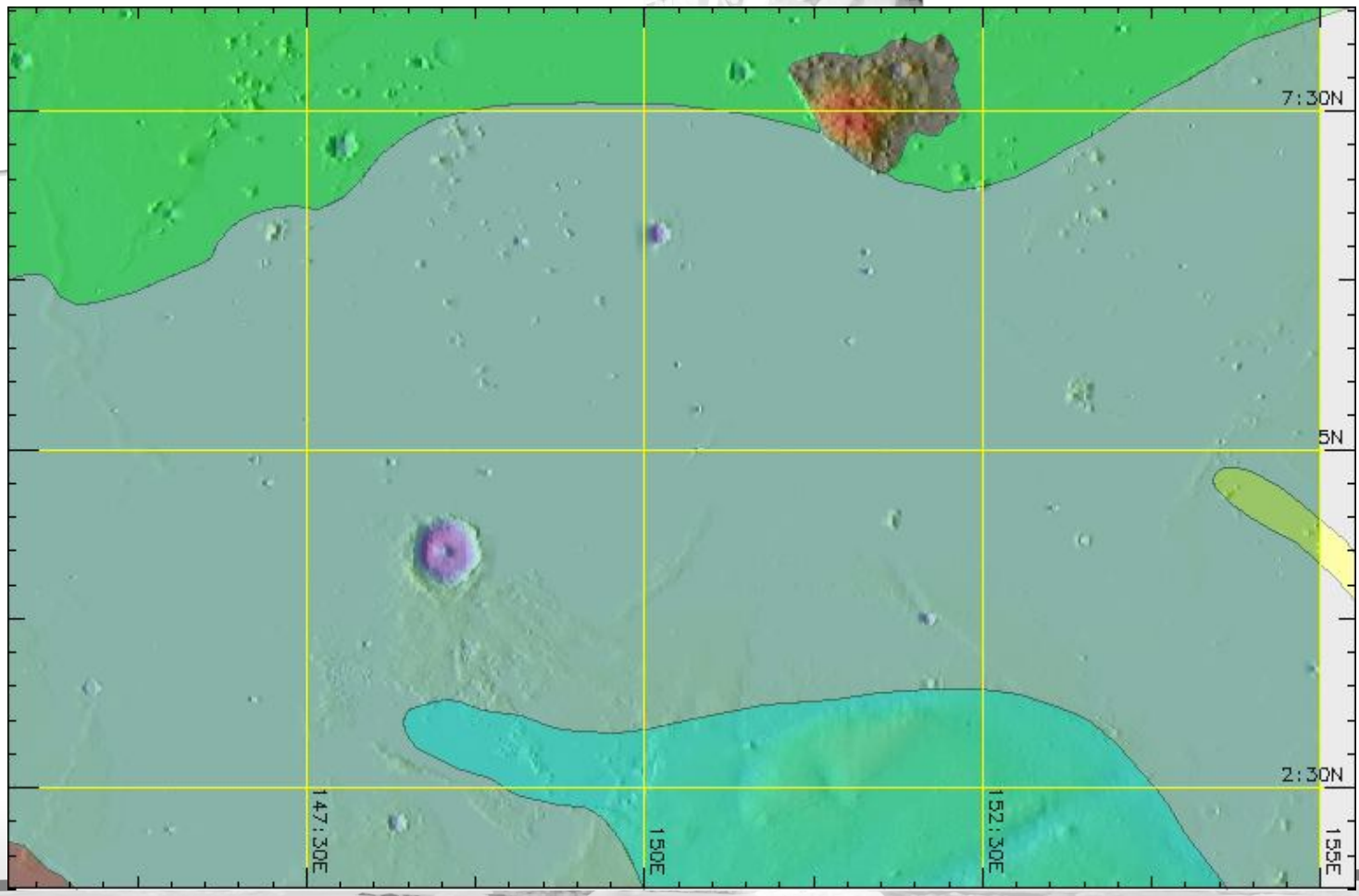
Possible geological interpretation suggests that statistical characteristics of sub-surface under North-Hill can be inferred by analyzing the area just outside it (Frozen Sea)

To this aim simulation tool developed within Level2 activities can be used



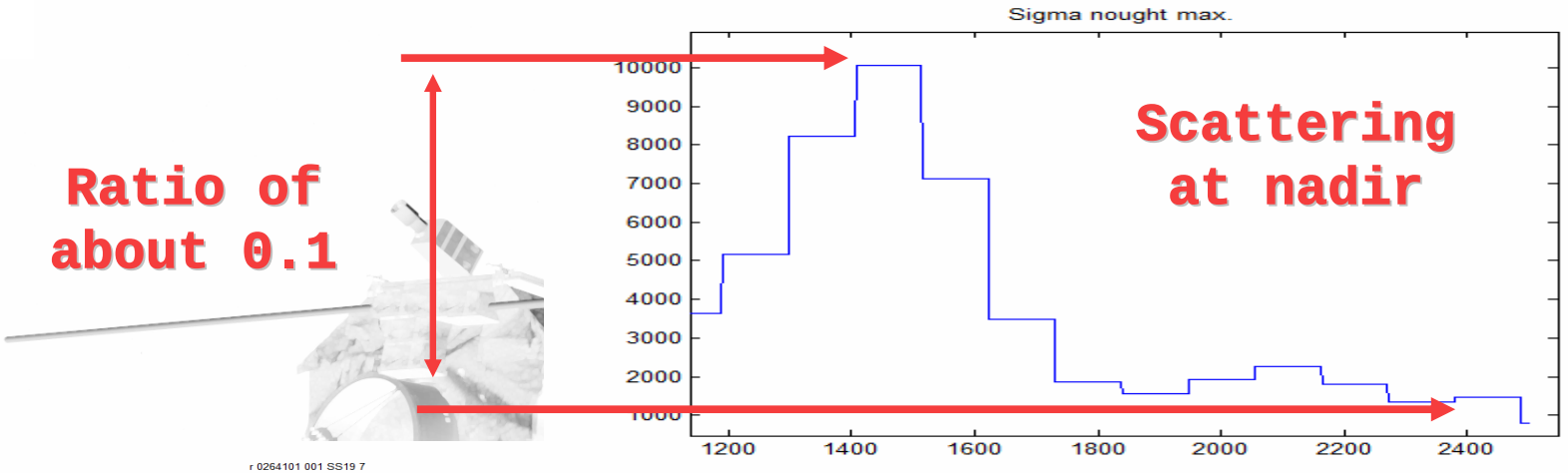
Subsurface investigation

Geologic unit map

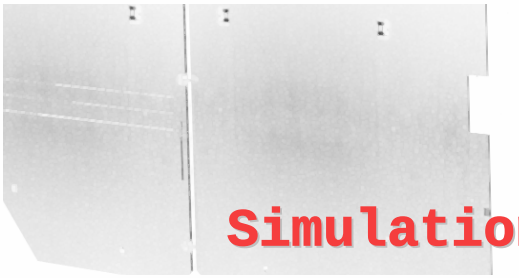


Subsurface investigation

Ratio of about 0.1

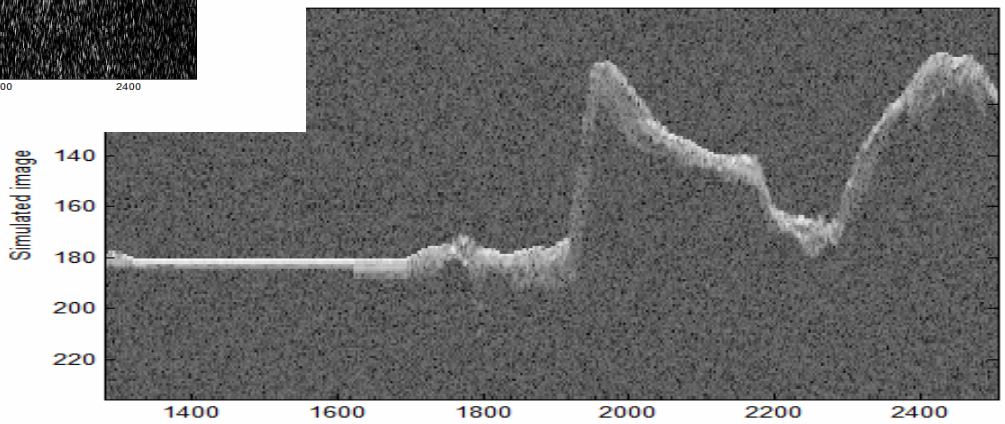


Scattering at nadir



Simulation

r 0264101 001 SS19 7



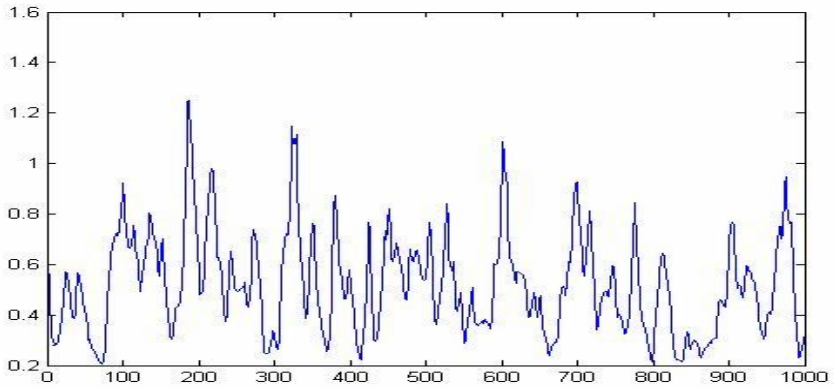
Level 1b

Subsurface investigation

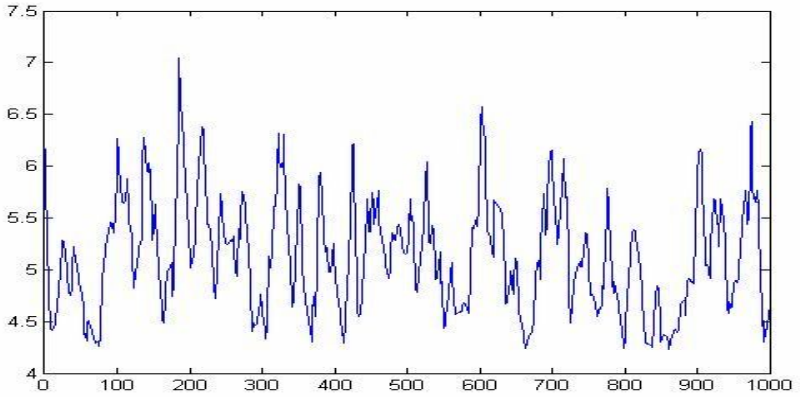
The results under North-Hill

Dielectric constant subsurface North Hill			
Orbit	r_0341902_001_SS19_700_A		
diel cons surf	Rugosity factor	distance[m]	dielectric constant subsurf
3	0.1	424.3122	4.8167
Orbit	r_0589803_001_SS19_700_A		
diel cons surf	Rugosity factor	distance[m]	dielectric constant subsurf
3	0.1	485.8727	5.1287

Power ratio



Dielectric constant

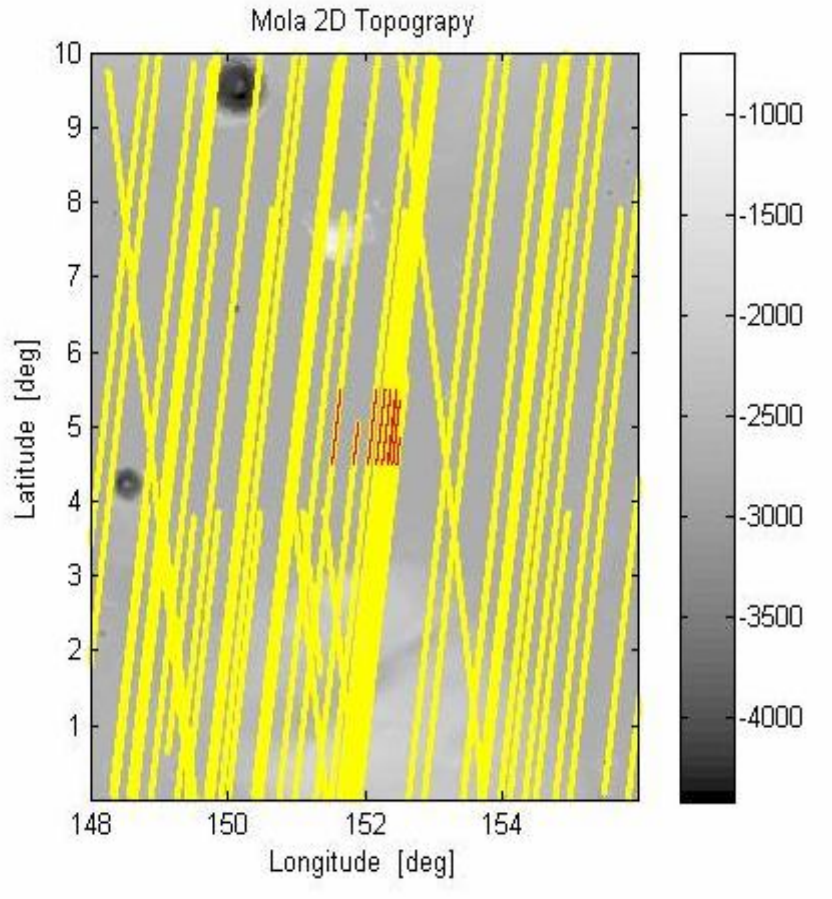


Subsurface investigation

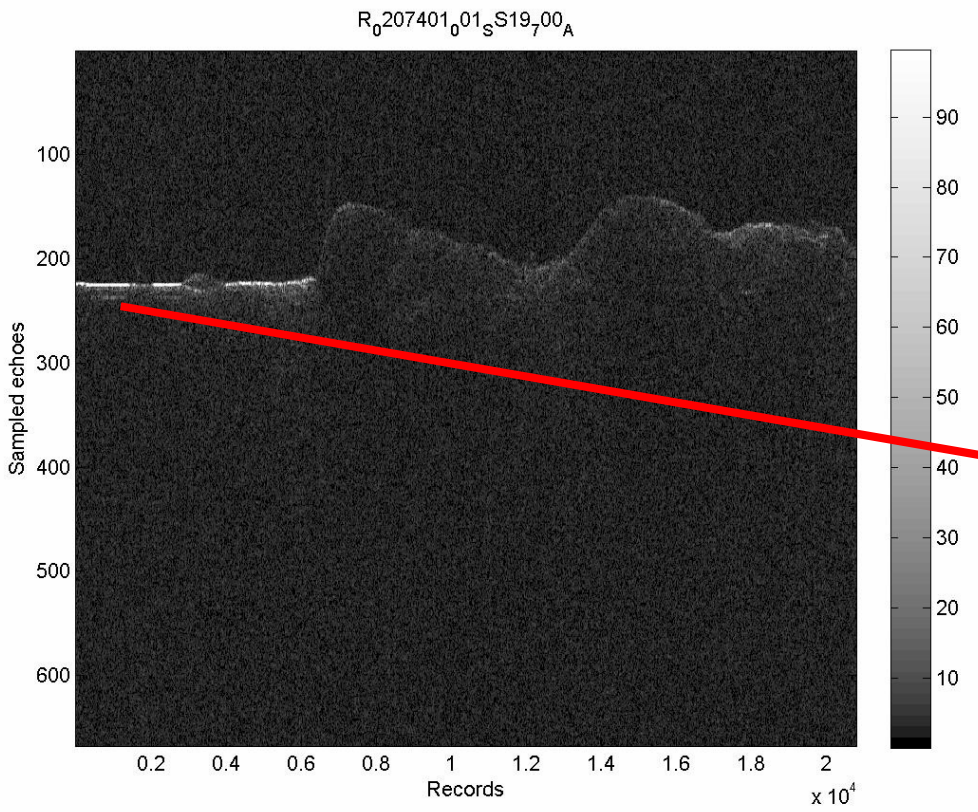
The frozen-sea area is fully covered by SHARAD

Preliminary analysis has been performed with 9 products with near tracks

r_0186301_001_ss19_700
r_0207401_001_SS19_700
r_0264101_001_SS19_700
r_0320802_001_SS19_700
r_0341902_001_SS19_700
r_0363001_001_SS19_700
r_0398601_001_SS19_700
r_0625403_001_SS19_700
r_0661003_001_SS19_700

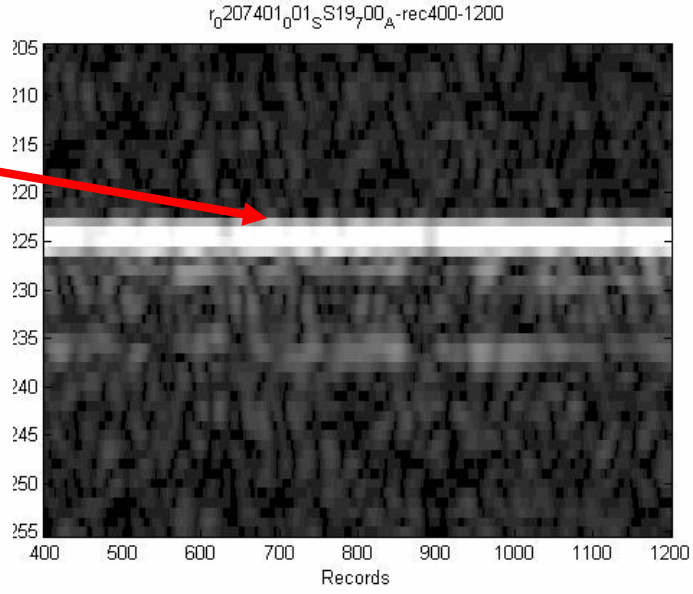


Subsurface investigation



Peaks isolation in defined areas

Record : 400 – 1200



Subsurface investigation

The results under Frozen-sea

Dielectric Constant Subsurface				
Dielectric Constant Surface	tgd=0.007	tgd=0.01	Sublayer Distance[m]	Total records
4.8	11.89	12.26	54.14	
5.1	13.24	13.75	52.52	**13015**

Conclusion

Even the very simple model applied the results are compatible with possible materials and with analogous results already published

Further activities are related to:

- **Inclusion of processor effects in terms of centroid variation and sub-surface defocusing**
- **Estimation of different statistical characteristics of surface/sub-surface from data**
- **Compatibility of estimated values with materials**