COST Action ES1404 - Short Term Scientific Mission (STSM)
Scientific report

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ECOST-STSM-ES1404-261015-067935

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Host institution: IFAC-CNR (Italy)

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Snow surface processes through microwave satellite observations

1. Purpose of the visit

The main propose of the visit, it was to strengthen the research collaboration between IFAC and LGGE. Indeed, these two teams are strongly involved in the exploitation of microwave satellite observations to retrieve snow properties.
In recent years, new satellite instruments operated with very low microwave frequency (~1.4 GHz) have been launched such the European Space Agency (ESA) SMOS satellite Earth Explorer 7 mission. Numerous studies have been conducted in the framework of calibration and validation activities. Both IFAC and LGGE are involved in the collection of long in situ measurements timeseries of snow properties and L-band brightness temperature (DOMEX ESA-PNRA campaigns) at Dome C in Antarctica. A new electromagnetic model is also developed at LGGE to relate the satellite data to snow properties. The aims of the STSM are fully in line on what developed in ES1404 COST action and in particular to WG1 and WG2 activities.

2. Work carried out

Our objective is to use L-band satellite observations to explore snow-covered areas in general and ice-sheet in particular because of very low permittivity and high penetration depth. We plan to continue our work at Dome C because snow and microwave measurements are collected near to the Concordia Station and because it is a target for the calibration of SMOS with potential benefit to all worldwide applications, including soil moisture and ocean salinity that are the primary targets of the mission, as well as snow properties. To this end, we have chosen to explore the strong variations observed in March 2015 that are relevant for the quality of the calibration target and to better understand the modification of the snow density in the first layers of the ice sheet and its effect on microwave emission. This STSM had allowed discussing results obtained by both teams about the Dome C study case. Moreover, we have discussed and reviewed a previous common study dealing to the theoretical understanding of SMOS observations on the East Antarctic Plateau, which have been submitted during the last August.

3. Results obtained

We focused our discussion on the study of a significant event observed at Dome C from November 2014 to March 2015 by both the DOMEX ground campaign and the SMOS satellite. Indeed, the brightness temperature at horizontal polarisation shows a continuous increase from November to March followed by a sharp decrease within a few days (about 5 K at 42 degrees of incidence angle – Figure 1 in cyan and black). No such variations have been observed at vertical polarisation, which suggests that this event could be due to near surface changes. When the decrease in brightness temperature of horizontal polarisation occurred, a corresponding increase in snow surface density from 150 kg m^{-3} to 300 kg m^{-3} was measured (Figure 1 in red). This could be related to a storm passing on Dome C, which may have compacted light snow or removed it from the surface uncovering old denser snow layers.
Electromagnetic models (DMRT-ML, WALOMIS) have been used to reproduce this decrease in L-band brightness temperature at horizontal polarisation (Figure 1 in blue and green). For that, in situ measurements have provided snow temperature and density profiles, as well as snow surface density. Simulations of time-series from January to June 2015 are performed changing only the density of the top snow layer. First results show a good agreement between modelled and measured brightness temperatures and confirm the major role of the surface density. However, when snow surface density is low (about less than 200 kg m^{-3}), the model skills are still unsatisfying, suggesting that more investigations are needed. Thus, we have defined a possible approach in order to improve simulations. Instead of only change the surface density in the first layer, we will generate a new surface layer growing with snow accumulation up to the next strong wind event.

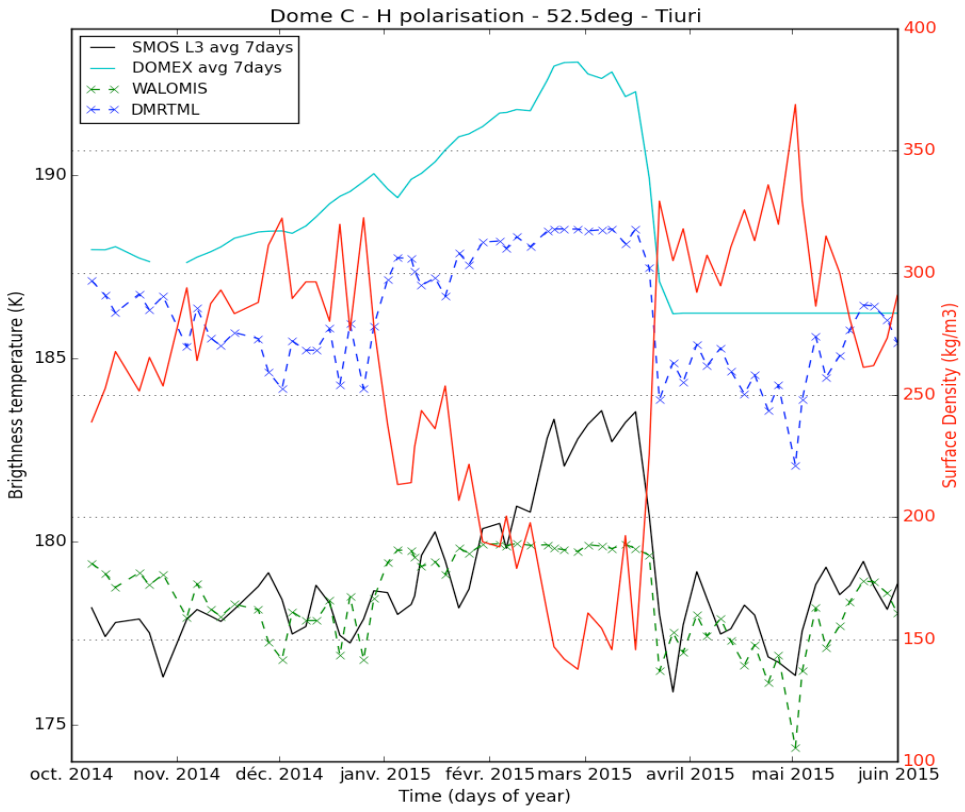

Figure 1: (Right axis) – Brightness temperature (K) at horizontal polarisation from observations (SMOS at 52.5 degrees of incidence angle (black), DOMEX at 42 degrees of incidence angle (cyan)), and simulations (WALOMIS (green) and DMRTML (blue))
(Left axis) – Snow surface density (kg m^{-3}) measured at Dome C (red).

4. Future collaboration with the host institution

This STSM has allowed strengthening the collaboration between IFAC and LGGE. The mission undertaken was very successful. The knowledge shared has been excellent and the visit has opened the possibilities for future common researches to improve the study of snow processes through microwave satellites observations.

5. Future publications/articles

Due to the very short time, no publication directly results from this visit. However, this STSM allows us to work about the revision of an article previously submitted. In the other hand, the very fruitful discussions and the future exchanges could probably result in new commons publications during the next year.

6. Confirmation by the host institution.

See pdf letter attached.

7. Other comments

I would like to thank the COST Action ES1404 to award me this STSM grant as well as, the IFAC-CNR to host me.

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LGGE, Grenoble, France
16 November 2015