CryoRad: a spaceborne ultrawideband microwave radiometer for the observation of Cryosphere and the monitoring of permafrost.

Giovanni Macelloni[1], Marco Brogioni[1], Francesco Montomoli[1], Marion Leduc-Leballeur[1], Emanuele Santi[1], Silvio Varchetta[2], Joel Johnson[3], Ken Jezek[3]

[1]Institue of Applied Physics "Nello Carrara" – National Council of Research -Italy
[2]Thales Alenia Space- Italy
[3]ElectroScience Laboratory, The Ohio State University, Columbus, OH

Extended Abstract

Permafrost is in the list of Essential Climate Variables (ECV), which have been defined by the Global Climate Observing System (GCOS) and acknowledged by World Meteorological Organization (WMO) and United Nations Framework Convention on Climate Change (UNFCCC): The World Climate Research Programme (WCRP) Joint Science Committee has identified the permafrost monitoring as a Grand Challenge. Climate changes directly affect the seasonal dynamics of permafrost. Indeed, the constantly rising temperature shrinks permafrost coverage. In turn, permafrost reduction changes arctic land-erosion patterns and contributes to release into the atmosphere of carbon dioxide and methane. These latter are important greenhouse gasses and their release will amplify the atmospheric warming.
Passive microwaves at low frequencies, e.g. L-band, have proven to be sensitive to the soil status and in particular, to the identification of frozen areas which is relevant for permafrost monitoring. Because of the higher penetration depth in the soil and the less influence of the overlying snow and vegetation layers, passive microwave systems at frequencies lower than 1.5 GHz, have been proven to provide a better estimation of permafrost. In recent research Schwank et al. [1-2] and Rautiainen et al. [3] used L-band data to detect the presence of snow and the freezing state in the soil. Recently, Schwank et al. [2] used a modeling approach to suggest that the brightness temperature (Tb) at V polarization measured at around 50° could achieve segregated information on soil-frost states. Other studies suggested that spaceborne sensors at microwave frequencies lower than L-band could be very attractive for significantly improving observations of the permafrost: the higher penetration depth enables indeed the estimation of soil status independent of the snow or vegetation overlaying the soil and the monitoring of freeze/thaw status and soil frost of deeper layers.
Basing on these studies, the monitoring of the permafrost has been included as a main target for the project of a new satellite mission devoted to the cryosphere, along with the other two principal objectives: the estimation of the internal temperature profiles of the ice sheets and the determination of the sea ice thickness. The feasibility study of this mission featuring a multi-channel microwave radiometer in the frequency range 0.5- 2 GHz has been recently proposed to and approved by the Italian Space Agency (ASI). This mission relies on the heritage of the UWBRAD project funded by the NASA-ESTO program aimed at the development of an airborne ultra-wideband software-defined radiometer for the study of the ice sheet temperature profile [4].
The preliminary results on the frozen soils identification and permafrost monitoring will be presented in this work.

Keywords: Permafrost, Space-borne Mission, Microwave Radiometry, Cryosphere.

References

[1]. Schwank, M., M. Stähli, H. Wydler, J. Leuenberger, C. Mätzler, and H. Flühler, Microwave L-band emission of freezing soil, IEEE Trans. Geosci. Remote Sens., vol. 42, no. 6, pp. 1252–1261, Jun. 2004.
[2]. M. Schwank, K. Rautiainen, C. Mätzler, M. Stähli, J. Lemmetyinen, J. Pulliainen, J. Vehviläinen, A. Kontu, J. Ikonen, C. Ménard, M. Drusch, A. Wiesmann, U. Wegmüller, 2014. Model for microwave emission of a snow-covered ground with focus on L band, Remote Sensing of Environment, Volume 154, November 2014, Pages 180-191, ISSN 0034-4257, http://dx.doi.org/10.1016/j.rse.2014.08.029.
[3]. Rautiainen, K., J. Lemmetyinen, J. Pulliainen, J. Vehviläinen, M. Drusch, A. Kontu, J. Kainulainen, J. Seppänen, "L-Band radiometer observations of soil processes at boreal and sub-arctic environments," IEEE Trans. Geosci. Remote Sens., 50(5), 1483-1497, 2012.
[4]. J. T. Johnson Joel, K. C. Jezek, M. Aksoy, A. Bringer, C. Yardim, M. Andrews, C.-C. Chen, D. Belgiovane, V. Leuski, M. Durand, Y. Duan, G. Macelloni, M. Brogioni, S. Tan, T.-L. Wang and L. Tsang, "The Ultra-wideband Software-Defined Radiometer (UWBRAD) for ice sheet internal temperature sensing: Results from recent observations," 2016 IEEE International Geoscience and Remote Sensing Symposium IGARSS), Beijing, 2016, pp. 7085-7087. doi: 10.1109/IGARSS.2016.7730848