SPATIAL AND TEMPORAL MONITORING OF THE
EAST-ANTARCTIC PLATEAU USING PASSIVE MICROWAVE DATA

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1. INTRODUCTION

Antarctica is one of the most interesting and challenging natural laboratories on Earth, and plays a fundamental role in atmospheric and ocean circulation. Snow cover, which is a key component in the global hydrological cycle, strongly influences the overlying atmosphere and hence polar and global climate. The monitoring of glacial environments requires knowledge of the interaction between snow structure and reflectance properties, and this can be achieved by analyzing a large data set of ground measurements, including spectral, snow and climatic data. Moreover, due to the difficulties related to the extreme environmental conditions, satellite sensors are the most suitable tools for observing the temporal and spatial variations in the extensive snow-covered areas of Antarctica.

Several studies of Antarctica using satellite-borne microwave radiometers have been performed since the launching of the Scanning Microwave Spectrometer (SCAMS) and have continued with the Scanning Multifrequency Microwave Radiometers (SMMR), the Special Sensor Microwave Imager radiometer (SSM/I), the Advanced Microwave Scanning Radiometer (AMSR-E) and Windsat sensor. These studies have focused on analyzing spatial and temporal variations of microwave signatures on a continental scale and on relating them to both topographical and morphological structures of the ice sheet surface, as well as to how they change over time. Others papers pointed out the azimuthal dependency of the brightness temperature, especially at the higher frequencies, over some area of the continent.

In recent years, the need to investigate microwave emission of Antarctic ice sheet is also motivated by the growing interest of the remote sensing community in using the East-Antarctic plateau, where the Italian-French station of Concordia is located, for calibrating and validating data from satellite-borne microwave and optical radiometers. The reason of this interest lies in the size, structure, spatial homogeneity and thermal stability of this area. The roughness is limited with respect to other Antarctic area and the temperature of the firm below 10 m remains constant during the years. This is particularly interesting for low-frequency microwave radiometers since, due to the low extinction of dry snow, the upper ice sheet layer is almost transparent and the brightness temperature variability is therefore extremely small. Moreover the station, which operates all year round, guarantees the availability of ancillary data, such as atmospheric parameters and snow temperature at different depths, which are necessary for the analysis and the interpretation of microwave data.

2. THE EXPERIMENT

In a previous paper [1], AMSR-E data collected in an area of around 60x 90 Km centered at the Italian-French base of Concordia, which is located at Dome-C in the East Antarctic Plateau, were compared to air and snow temperature measured at different depths down to 10 m. This paper showed that microwave emission at 19 GHz and 37 GHz is closely related to the seasonal variation in the surface layer temperature (the upper 2 m), and suggested a simple method for retrieving the snow temperature at different depths from microwave measurements. The paper also demonstrated that, using an Artificial Neural Network (ANN) appropriately trained, it is possible to retrieve snow temperature from 200 cm to 1000 cm.

These results are confirmed in the present paper where the method is validated using temperature and microwave data collected from 2005 to 2007. Moreover, from the analysis of air and snow temperature data measured in the first 2 meters, it was observed that during the spring and summer periods, the temporal trend was rather uniform (i.e. the temperature decreased in spring and was almost constant in summer), whereas some anomalies occasionally occurred for short time periods (around 7-10 days). In these cases temperature rapidly increased of around 10 K and successively rapidly decreased. These events were also recorded by microwave brightness temperature at 19 and 37 GHz.
With the purpose of investigating on these anomalies AMSR-E data were analyzed over a large portion of the East-Antarctica Plateau (from 90° to 180° of longitude and from -65° to -90° of latitude). In particular, brightness temperature maps at 19 and 37 GHz, were realized from some of these periods. From the analysis of these images it can be noted that, for all the considered cases, the temperature variation occurred over the whole Dome-C area without any preferential spatial direction. This fact can be interpreted as caused by a circulation of warm air from the atmosphere to the top of the plateau (which corresponds to Dome-C).

From the spatial analysis of the whole investigated area some interesting features, which presented different microwave brightens temperature spectral signature, were also observed. For example an area, located near to the base, exhibited a very stable spatial and temporal brightness temperature value at 6.8 GHz. These areas are the most appropriate for using as extended calibrators for space-borne radiometers, and confirmed that the plateau can be useful for calibrating low-frequency missions, such as the ESA - SMOS and the NASA Aquarius. Other portions of the plateau (e.g. the area located from 105° to 110° of longitude and from -73° to -76° of latitude) show a great variability and an azimuthally variation of the brightness temperature at 6.8 GHz that disappears when the frequency increases. Although the physical reasons of this effect should be better interpreted, from microwave observations we can conclude that the anisotropy appeared in the deep layers and then was caused by particular events occurred in some years (e.g. strong winds in a preferred direction) or by the snow stratification.

Although these results need further confirmations, we can state that such kind of analyses can bring significant contributions in the understanding of the physical phenomena that regulate the snow deposition and air circulation of the plateau.

3. REFERENCES