NEURAL NETWORKS FOR THE SATELLITE RETRIEVAL OF PRECIPITABLE WATER VAPOR OVER LAND

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1. INTRODUCTION

Information about the amount and spatial structure of atmospheric water vapor is critical in a variety of branches, including meteorological weather forecast, climate change studies, and space geodesy applications that require atmospheric correction as the signal propagates through the moist troposphere, such as global positioning system (GPS), satellite altimetry, and synthetic aperture radar interferometry (InSAR).

Conventional instruments used for estimation of vertically integrated water vapor (IPWV) are ground-based radiometers, network of GPS receivers, and satellite radiometers over ocean or land. Nevertheless, in the microwave spectrum, good accuracy from satellite radiometers is achieved only over ocean, because of the low emissivity of open water at those frequencies that makes microwave radiometers very sensitive to changes in the emission of atmospheric water vapor. Accurate estimates over land are inherently difficult because of the high value of the surface emissivity and the large variations compared to the spatial resolution of microwave measurements.

Approaches that have been previously investigated to retrieve water vapor over land have been proposed by Prigent and Rossow [1], Aires et al. [2], and more recently by Deeter [3], providing an rms error of 0.4-0.5 cm (as in [2]) to 0.6 cm (as in [3]).

In this work, a multilayer neural network is proposed to derive IPWV over land from a satellite microwave radiometer. The neural network has been optimized for brightness temperatures measured by the Advanced Microwave Scanning Radiometer - Earth Observing System (AMSR-E) on board the Aqua satellite, coupled with water vapor information provided by European Centre for Medium-Range Weather Forecasts (ECMWF) for the neural-network training.

This work has been developed as a part of the Mitigation of Electromagnetic Transmission errors induced by Atmospheric Water Vapor Effects (METAWAVE) project, a study funded by the European Space Agency. The aim of the project was to develop InSAR corrections for water vapor at local and regional scale. During the project two field experiments have been (carried out in Italy, one around the town of Como, where a local network of GPS receivers was available, and one around the city of Rome, where we have installed a dual-channel ground-based water vapor radiometer, and a local network of GPS operational receivers was present. The processing of the GPS data for Como and Rome were performed by Polytechnic of Milan and Sapienza University of Rome, respectively. For assessing the spaceborne radiometric IPWV estimations, neural network results were compared with the measurements obtained from the in-site instruments.

2. DESIGN OF THE NEURAL NETWORK ALGORITHM

Dealing with this non-linear inverse problem, neural networks have proved to be a very versatile and powerful tool, once the training phase is completed. We have considered the multi-layer perceptron architecture, denoting useful stochastic approximation properties. Our neural network model has been developed using various input combinations and network layer topologies. An independent analysis has been performed over the two regions centered at the field experiment sites in Rome and Como, in Central and Northern Italy, respectively.

For the training dataset of the neural network, we have used as input data brightness temperatures at six frequencies in both polarization from AMSR-E maps collected during the period 2002-2007, mainly on cloudy-free days, while the targets were IPWV values obtained from co-located ECMWF data. For testing purposes, an independent dataset of AMRS-E maps and ECMWF water vapor data was used. As training approach, the early stopping technique [4, 5] was applied. The network topology was constrained to be feedforward, having, besides the input layer, a number of hidden layers with tan-sigmoid transfer function varying from 1 to 3, and an output layer with linear transfer function. As input data, different channel combinations were examined. The use of a priori information as surface temperature and emissivity was investigated, although the use of this data involves the difficulty of obtaining the actual surface temperature and emissivity collocated with the radiometer overpasses. Therefore, estimates of the monthly mean land surface microwave emissivities with a priori information on the atmospheric situation from numerical weather prediction model outputs were used [6].

4. REFERENCES

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