WISE 2000: CAN WE MEASURE SALINITY FROM A SATELLITE ?

J. Font[1]*, A. Camps[2], J. Etcheto[3], P. Wursteisen[4], M. Martín-Neira[4], J. Bará[2], I. Corbella[2], N. Duffo[2], L. Enrique[2], F. Torres[2], M. Vall-llosera[2], R. Villarino[2], M. Emelianov[1], C. Gabarró[1], A. Julià[1], J. Boutin[3], A. Weill[3], A. Caselles[5], L. Martínez[5], R. Niclòs[5], E.M. Rubio[5] and M. Moll[6]

[1] Institut de Ciències del Mar, CSIC, Barcelona, Spain - jfont@icm.csic.es
[2] Dep. Teoria del Senyal i Comunicacions, Univ. Politècnica de Catalunya, Barcelona, Spain
[3] LODYC-CETP, Institut Pierre-Simon Laplace, Paris, France,
[4] European Space Agency, ESTEC, Noordwijk, The Netherlands,
[5] Dep. Termologia, Univ. València, Burjassot, Spain,
[6] EMS Sistemas de Monitorización Ambiental S.L., Barcelona, Spain

Abstract

Satellite observation of ocean salinity has not been possible until now due to the challenge of flying a microwave radiometer able to detect sea surface emission variations related to salinity. The European Space Agency SMOS mission is the first attempt to solve this problem. A new radiometric concept and recent improvements in understanding the processes that modify the ocean water emissivity have made it possible. The WISE 2000 campaign has been conducted in the NW Mediterranean to obtain radiometric and in situ data to improve the understanding of the sea state effect on the sea surface L-band microwave emissivity.

Key-words: remote sensing, salinity, instruments and techniques, air-sea interactions

Introduction

Significant progress in terms of weather forecasting, climate monitoring and extreme event forecasting has been made during recent years using sophisticated models fed amongst others by data acquired by operational satellites. However, further significant improvements now depend to a large extend on the availability of global observations of two crucial variables, Soil Moisture (SM) and Sea Surface Salinity (SSS). To date this information is lacking because in situ measurements are far from global, and so far no SM and SSS dedicated, long-term space mission has been attempted.

This situation led to the formulation of the Soil Moisture and Ocean Salinity (SMOS) mission, the European Space Agency's second Earth Explorer Opportunity Mission planned for launch in 2005. The SMOS mission was proposed by a team of scientists from 10 European countries and the United States of America, gathering most of the available expertise in the related fields. The main objective of the SMOS mission is to demonstrate the observation from space of SSS over oceans and SM over land using a common instrument: a microwave L-band two-dimensional interferometric radiometer. It uses a synthetic antenna very thin as compared to an equivalent real one [1].

Material and methods

The dielectric constant for seawater is determined, among other variables, by salinity [2]. In principle it is possible to retrieve SSS from microwave measurements as long as variables influencing the brightness temperature (TB) signal (SST, roughness, foam,) can be accounted for e.g. by the use of different viewing angles, polarisations and frequencies, as well as ancillary data from other sensors and sources. The sensitivity of TB to SSS is maximum at low microwave frequencies and the good conditions for salinity retrieval are found at L-band (1.4 GHz, 21cm wavelength). However, it must be stressed that at this frequency the sensitivity of TB to SSS is low (0.5K per psu for an SST of 20∞C, decreasing to 0.25K per psu for an SST of 0∞), placing demanding requirements on the performance of the instrument [3].

To address new challenges that this mission presents, such as incidence angle variation with pixel, polarization mixing, effect of wind and foam and others, a measurement campaign (WISE 2000: WInd and Salinity Experiment) was sponsored by ESA for autumn 2000. The objective was to perform, for the first time, radiometric measurements of the sea surface from a fixed tower at different azimuth and incidence angles during a long period to allow the occurrence of different environmental (mainly wind and water temperature) conditions. Some airborne campaigns with L-band radiometers had taken place in the US [4], but long-term tower based measurements had never been organised.

Results

An L-band and an IR radiometers, a video, a stereo-camera and four oceanographic and meteorological buoys were installed in and around the oil platform "Casablanca", 40 Km off the coast of Tarragona (NW Mediterranean), where the sea conditions are representative of the Mediterranean open sea with periodic influence of the Ebro river fresh water plume. Events of strong NW and NE winds are not uncommon in the area during autumn.

The experiment was initiated on 14 November 2000, although rough seas did not allow the full deployment of buoys until two weeks later, and some sensors, especially the accelerometers of a wave rider buoy, were damaged and could not be further used. The initially planned duration of one month was extended until 15 January 2001. At present the different data sets are being processed and preliminary results are expected for mid 2001. Although some interferences appeared in different moments and at some look directions, the quality level of the recorded radiometric data appears to be quite good, and consequently the outcome of WISE 2000 is expected to be an important contribution to the SMOS scientific definition studies. These and future measurements will allow a better understanding of the sea state effects on the sea surface emission at L-band, and then improved emissivity models formulation for the development of salinity retrieval algorithms to be used during the SMOS mission.

It is expected that, with these kind of scientific studies and the instrument technological development being carried out by ESA, the observation of salinity from space will be possible in the next future. However, the low radiometric sensitivity to salinity changes, and the expected errors in the measurement, do not allow using single observations for oceanographic applications. It will be necessary to make spatial and temporal averages to reduce noise. The aim of SMOS is to provide salinity data with an accuracy (0.1 psu) adequate for climatic and large scale studies, and with a spatial and temporal resolution similar to the presently available oceanographic atlases and climatological data bases [5]. Of course we are still far away from having a satellite sensor able to be used for mesoscale oceanography in the Mediterranean, but we are in the first step to fill the dramatic gap in salinity observations all over the world oceans.

References

1 – Kerr Y., Font J., Waldteufel P., Camps A., Bará J., Corbella I., Torres F., Duffo N., Vall-llosera M. and Caudal G., 2000. Next generation radiometers: SMOS a dual pol L-band 2D aperture synthesis radiometer. In: IEEE 2000 Aerospace Conference Proceedings, Big Sky MO, March 18-25, IEEE Catalog Number: 00TH8484C ISBN 0-7803-5846-5

2 – Klein L.A. and Swift C.T., 1977. An improved model for the dielectric constant of sea water at microwave frequencies. *IEEE Trans. Ant. Prop.*, 25, 104-111

3 – Lagerloef G.S.E., Swift C.T. and LeVine D.M., 1995. Sea surface salinity: the next remote sensing challenge. Oceanogr., 8, 44-50

4 – Miller J.L., Goodberlet M.A. and Zaitzeff J.B., 1998. Airborne salinity mapper makes debut in coastal zone. *Eos, Trans. AGU,* 79, 173 and 176-177

5 – Levitus S., Burgett R. and Boyer T.P., 1994. World Ocean Atlas 1994 Volume 3: Salinity, NOAA NESDIS 3