SURFACE SALINITY MEASURED BY AN AIRBORNE MICROWAVE RADIOMETER IN THE NW MEDITERRANEAN

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Abstract

SMOS (Soil Moisture and Ocean Salinity) is a satellite mission of the European Space Agency (ESA) to be launched in 2007. One of its goals is the generation of global Sea Surface Salinity (SSS) maps. SMOS will carry an L-band (1.4 GHz) interferometric radiometer with full polarimetric capability. The airborne EuroSTARRS campaign was sponsored by ESA in 2001 to provide land and ocean data for the scientific studies supporting the SMOS mission, in particular to acquire 'SMOS like' data to advance in the knowledge of passive microwave multi-incidence observations for various surfaces. Some results of the campaign in the NW Mediterranean are presented and discussed here.

Keywords: Microwave radiometry, SMOS, Surface salinity

The EuroSTARRS campaign took place in November 2001 over land and ocean sites in France and Spain (1). The STARRS (Salinity Temperature and Roughness Remote Sensing) instrument (2) from the US Naval Research Laboratory was flown onboard a DLR (Germany) plane. It is a pushbroom L-band (1400-1426 MHz) V-polarisation radiometer that measures simultaneously brightness temperature (Tb) in six crosstrack beams at different angles and builds a 2-D image as the aircraft moves along track.

On November 21st the plane overflown the Casablanca oil platform, near the shelf break 40 km off the Ebro river delta, in the NW Mediterranean. Simultaneously the R.V. García del Cid was measuring surface salinity and temperature following the flight line, plus some vertical T and S profiles in the area (3). At the same time another ESA campaign (WISE 2001) was taking place from that platform, with a fully polarimetric L-band radiometer measuring Tb at different incidence angles during one month, and several meteorological and oceanographic moored buoys recording surface data around the platform (4).

The objective of this work is to demonstrate that it is possible to retrieve salinity from the radiometer measurements in the Mediterranean, and to validate empirical and theoretical sea surface emissivity models needed for the inversion of Tb into salinity. In the past years, improved methods have been developed to model the polarimetric emission of the sea surface for different SSS, SST and surface roughness. However, these models have been developed or tuned at higher frequencies than L-band, typically 19 and 37 GHz. Using data acquired during WISE a new semi-empirical model was derived by fitting the sensitivity of Tb to wind speed at different angles. In (5) some of these models are presented and used to retrieve SSS from data acquired during WISE.

The algorithm used to obtain salinity from Tb is the Levenberg-Marquardt recurrent least square fit. It has been chosen for its easy implementation and computational efficiency. Tb is computed setting an initial guess for SSS into the direct emissivity model, and the resulting value is compared with the Tb measured by the radiometer. Then an increment (DSSS) is added to the initial salinity, the new Tb is computed and compared again to measurement. This recursive process is stopped when the difference between measured and computed Tb is smaller than a specified threshold.

In situ SSS measured during EuroSTARRS was quite constant, its variability being below the sensitivity of the radiometer. The wind speed was very low during the flight and an average value of 3.67 m/s has been used in the computation. SST was measured by additional infrared channels in STARRS. As the radiometric data were significantly noisy, an average of the 800 Tb measurements recorded during a straight flight in very similar atmospheric conditions have been used in the retrieval.

Six different emissivity models have been tested, and retrieval results compared with Casablanca in situ measurements. Semi-empirical models provide better results than theoretical models, and the best performances are obtained when using models derived from WISE data. It has to be stressed that the latter correspond to similar environmental and hydrographic conditions than during EuroSTARRS, but were acquired by a radiometer of different technology and situated much closer to the sea surface (4).

Table 1 presents the errors on the retrieved salinity using 3 different semi-empirical models, all of them derived from WISE campaign data: the first one is dependent on wind speed (WS), the second dependent on significant wave height (SWH), and the third dependent on both parameters. Results show that the best option is the joint dependence on WS and SWH, since this model, in opposition to the others, includes the effect on surface roughness of swell and not fully developed wind seas.

Table 1. Comparison of different semi-empirical models. ΔSSS = |SSS_measured - SSS_retrieved|

MODEL	ΔSSS
Wind speed dependence	0.086 psu
Wave height dependence	0.346 psu
Wind and wave height dependence	0.022 psu

An open question for the SMOS mission, is how these auxiliary parameters (WS and SWH), necessary for the SSS retrieval, will be obtained all over the world oceans. Table 2 shows the errors on the retrieved salinity in the EuroSTARRS case produced by errors on the wind speed measurements using the semi-empirical model dependent only on WS. Additionally to *in situ* data two different sources for wind speed information have been analysed: QuikSCAT satellite scatterometer and ARPEGE (MétéoFrance) atmospheric model. Both have similar spatial resolutions, but the temporal resolution is much higher for the model (6h) than for the satellite (3 days).

Table 2. Errors in retrieved salinity when using different sources for wind speed.

WS SOURCE	ΔSSS
Wind speed in situ measurement	0.086 psu
Wind speed QuikSCAT	0.655 psu
Wind speed from ARPEGE model	0.332 psu

It appears that small errors on WS (nominal error for the model is 2m/s) produce large errors on the retrieved salinity. The better results with ARPEGE output than with QuikSCAT measurements is probably related to the different temporal resolution.

References

1 - Berger M., Camps A., Font J., Kerr Y., Miller J.L., Johannessen J., Boutin J., Drinkwater M.R., Skou N., Floury N., Rast M., Rebhan H., Attema E., 2002. Measuring ocean salinity with ESA's SMOS mission – Advancing the science. *ESA Bull-Eur Space*, 111: 113-121

2 - Miller J.L., and Goodberlet M., 2003. Development and application of STARRS – a next generation airborne salinity imager. *Intl. J. Remote Sensing*, accepted.

3 - Emelianov M., Font J., Julià A., Gabarró C., LLoret M. and Solé J., 2003. Sea surface fiels at Casablanca site (NW Mediterranean) during the EuroSTARRS campaign. Proceedings of the WISE/LOSAC/EuroSTARRS Campaigns Workshop, ESA SP-525: 73-80

4 - Camps A. , Font J., Vall-llossera M., Gabarró C., Villarino R., Enrique L., Miranda J., Corbella I., Duffo N., Torres F., Blanch S., Arenas J., Julià A., Etcheto J., Caselles V., Weill A., Boutin J., Contardo S., Niclòs R., Rivas R., Reising S.C., Wursteisen P., Berger M. and Martín-Neira M., 2003. The WISE 2000 and 2001 campaigns in support of the SMOS mission: Sea surface L-band brightness temperature observations and their application to multi-angular salinity retrieval. *IEEE Trans. Geosci. Remote Sensing*, in press

5 - Gabarró C., Vall-llossera M., Font, J. and Camps, A., 2003. Determination of sea surface salinity and wind speed by L-band microwave radiometry from a fixed platform. *Intl. J. Remote Sensing*, 24, in press.