VII Conclusions and future research lines

The purpose of this ph D. thesis is to contribute to determine of the sea surface emissivity at L-band, with application to the ESA's SMOS mission, and eventually, to the NASA's AQUARIUS mission as well. One of the goals of these missions is the retrieval of the ocean salinity, which knowledge is essential to improve the climate numerical models predictions. The brightness temperature (T_B) depends basically on the complex permittivity of the surface observed, and in the case of the sea water T_B is a function of the salinity concentration. However, depending on the sea state conditions (mainly driven by the wind), the ocean emission is modified by other parameters such as: the foam, swell, fetch, etc.

This Ph. D. thesis is divided in three parts. The first one is devoted to describe the development of the LAURA instrument explained in the Chapter II. A description of the receiver, the positioning system, the thermal control unit, and the control program is given. The second part of the thesis consists of the measurement field experiments (Chapters III and V). A total of three field experiments were carried out. During the WInd and Salinity Experiment (WISE 2000 and 2001), LAURA was mounted at the 32 m deck of the Casablanca oil rig to measure T_B. A whole set of instruments were installed to measure the ground-truth data. Chapter III basically deals with the instruments deployment and recovery, measurements strategy, and the problems encountered. The Foam, Rain, Oil, and GPS reflectometry (FROG) was carried out during Spring of 2003 at the IRTA facilities (Delte del Ebre) to take measurements of the water surface, trying to analyze the impact of different effects isolated. In V Chapter, a description of the instruments deployment and recovery and the measure strategy is made. Finally, Chapters IV and VI present the radiometric results of these field experiments.

The following conclusions can be derived from the data analysis from the field experiments:

- A sensitivity to wind speed extrapolated at nadir of ~0.23 K/(m/s), or ~0.25 K/(m/s) when the atmospheric instability or only the measurements corresponding to U_{10} > 2 m/s are accounted for.
  - ♦ An increase at *H*-polarization up to ~0.5 K/(m/s) at 65°.
  - ♦ A decrease at *V*-polarization down to ~-0.2 K/(m/s) at 65°, with a zero-crossing around 55°-60°.
  - ♦ These results are in agreement with the SSA method using Durden and Vesecky and Elfouhaily et al. sea spectra times 2. It is very likely that the computed wind speed sensitivities below 2 m/s are erroneous.
- A modulation of the instantaneous brightness temperatures due to *wave slopes* and *foam*. The standard deviation of this modulation increases with wind speed at a rate of ~0.1-0.15 K/(m/s), depending on polarization, and very weakly on incidence angle.

- A small azimuth modulation ~0.2-0.3 K for low-to-moderate wind speeds, in reasonable agreement with numerical models. On November 10th, 2001, peak-to-peak modulations of 4-5 Kelvin where measured, and explanation has been found for it.
- Impact of the presence of sea foam in L-band brightness temperature is estimated to be ~0.18 K at wind speeds of 20 m/s at nadir. However for the same conditions, the sea foam coverage exhibits a high variability. Hence, dedicated campaigns (FROG field experiment, Chapter VI) to determine the foam emissivity were considered necessary.

On the other hand, the analysis of FROG field experiment data let us obtain the following conclusions:

- Foam contributes to the brightness temperature increase at L-band.
- The foam-induced T_B increases at vertical polarization and decreases at horizontal polarization with increasing the incidence angle (θ = 25° to 50°).
- Foam formations are thicker for higher salinity concentrations than for fresh water. Hence, the T_B increases for salty water.
- The parameter needed in the two-layer theoretical model, were measured: the foam layer thickness, the radii bubbles distribution, the air-water fraction beneath the foam layer and the water bubble content, and the sticky factor estimated comparing the measures and the theoretical model. Measurements are in agreement with the Reul and Chapron theoretical model [25], at H- polarization, although are underestimated at V-polarization.
- At L-band the rainfall contribution to T_B is clearly smaller than the foam contribution and negligible for all practical purposes except for: the formation of fresh water layer, and the dumping of the large waves.
- The impact of a 47μm oil slick (1 liter in 21 m^2) over flat water is negligible. Although in the open sea it decreases the slope variance for the same wind speed.

The FROG experimental results show a T_B increasing at H- and V- polarization due to this parameter. A brightness decrease at H- polarization with the increasing of θ is produced, at the same manner than the theoretical model, computed with the Small Slope Approximation (SSA) method.

Further field experiments could be taken into account based on:

- The generation of a realistic swell and foam and study their effects in the induced T_B, and
- The study the waves slope statistics to compare them to the theoretical models.