OCEAN MONITORING USING GNSS-R TECHNIQUES AND MICRO-WAVE RADIOMETRY: THE PAU INSTRUMENT CONCEPT

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Lack of frequent and global observations from space is currently a limiting factor in many Earth Observation (EO) missions. For example, the Indian Ocean tsunami on 26 December 2004 was detected by radar altimeters but, since tsunami signals are quite weak in open ocean and the satellite must fly over it simultaneously, the probability of detection is very low [http://earth.esa.int/brat/html/appli/geodesy/tsunami_en.html]. Future missions have to provide better spatial and temporal coverage to allow the study of mesoscale variations and other phenomena. Two potential techniques that today have been proposed are [http://earth.esa.int/brat/html/alti/future/welcome_en.html]:

1) the use of satellite constellations, and
2) the use of Global Navigation Satellite Signals (GNSS) as signals of opportunity (no transmitter required).

GNSS-R can also be used to perform the sea state correction required in sea surface salinity retrievals by means of L-band microwave radiometry (TB). At present, two space-borne missions are currently planned to be launched in the near future with this purpose:

1) ESA's SMOS mission, using a Y-shaped synthetic aperture radiometer, launch date July 16th, 2009, and
2) NASA-CONAE AQUARIUS/SAC-D mission, using a tree beam push-broom radiometer.

In the SMOS mission, the multi-angle observation capabilities allow to simultaneously retrieve not only the surface salinity, but also the surface temperature and an "effective" wind speed that minimizes these errors. In AQUARIUS an L-band scatterometer measuring the radar backscatter (σ_0) will be used to perform the necessary sea state corrections. However, none of these approaches are fully satisfactory, since the effective wind speed captures some sea surface roughness effects, at the expense of introducing another variable to be retrieved, and on the other hand the plots (T_B-σ_0) present a large scattering.
In 2003, the PAU project was proposed to the European Science Foundation to test the feasibility of the use of GNSS signals of opportunity reflected over the sea surface to make sea state measurements and perform the correction of the L-band brightness temperature [http://www.esf.org/activities/euryi/awards/2004.html]. The concept is simple: when the electromagnetic wave is scattered over the sea surface, the scattered signal comes from the specular reflection point, determined by the shortest distance between the transmitting GPS satellite and the receiver, but when the sea is roughed, the scattered signals come from a wider region that enlarges with increasing sea state, in a similar manner as the Sun reflecting over the sea. We have proposed to measure the so-called Doppler-Delay Maps (DDMs) to provide a measurement of the width of the area over which the GNSS signals are scattered and infer form it the geophysical variables without need of any intermediate model, either numerical to compute the scattering or for the sea surface spectrum.
Under the EURYI-2004 grant a number of PAU prototypes have been developed (real and synthetic aperture versions of it, with just one receiver for ground tests and a lighter version for R/C aircraft operations). During May-June 2008 one of them was deployed in the North-West coast of the Gran Canaria island ([http://www.grancanariavirtual.com/miradorelbalcon.php]) and gathered for the first time ever L-band radiometric and GNSS-R data, together with oceanographic data (sea surface temperature + sea surface directional spectrum buoys). The field experiment will be repeated during the same period of time in 2009 with an improved version of the instrument. Now, we start understanding the relationship between the sea state and the GNSSR observables (DDMs) and the changes in the brightness temperature, but still there is a long way until meaningful physical quantities that can be successfully extracted from satellite data to be used by the oceanographic communities.
The limited GNSS-R data gathered by the UK-DMC satellite and publicly available shows the potential of this technique, and supported the proposal of a PAU secondary payload in SeoSat/INGENIO (Spanish Earth Observation Satellite). This proposal went through phase A, but did not succeed to enter into phase B due to the accommodation issues with the primary payload raised after a configuration change. Simplified, lighter and less power consuming payloads are currently under study to be ready for future launches of opportunity.
This paper will present:
•The Physics of the L-band radiometric and GNSS reflectometric observations over the ocean,
•The ground-based measurements and their interpretation, and
•The proposed satellite payloads to gather these type observations and how they can help future SMOS follow-on missions.

POTENTIAL USE OF MICROWAVE SATELLITE MEASUREMENTS TO RECONSTRUCT THE THREE-DIMENSIONAL DYNAMICS OF THE OCEANIC UPPER LAYERS

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Keywords – Ocean Dynamics, Surface Quasi-Geostrophy, Sea Surface Height, Sea Surface Temeprature, Microwave Remote Sensing

We examine the emerging potential offered by satellite microwave measurements to derive the three-dimensional dynamics of the upper ocean. The proposed approach exploits the properties of a theoretical framework based on Surface Quasi-Geostrophic (SQG) equations. Within this framework, Sea Surface Heights (SSH) and Sea Surface Temperatures (SST) are closely related. This provides a way to combine SSH and SST measurements and allows to recover surface currents from a single SST image. On the other side, this framework allows to reconstruct subsurface fields, such as horizontal velocities and density anomaly, in the upper 500m of the ocean from SSH and/or SST measurements. Furthermore, within this framework vertical velocities can also be diagnosed from a single SST and/or SSH snapshot. To demonstrate the feasibility of this approach, first, we have explored the ability to reconstruct the three-dimensional dynamics of the oceanic upper layers using numerical simulation. Then, these results have been applied to existing altimetric measurements and microwave SST data from AMSR-E instrument. Our results confirm the validity of this framework and unveil some limitations in the existing microwave measurements that should be improved in future missions.