

Conclusions of GNSS-R10 Workshop  
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UPC, Barcelona (Spain)

Conclusions Session Panel:

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Workshop Conclusions:

The workshop took place 21 and 22 of October 2010 at the Polytechnic University of Catalonia (UPC), Barcelona, Spain. It was organized jointly by the Institut d'Estudis Espacials de Catalunya (IEEC), the Spanish Research Council (CSIC) and UPC. It was attended by 58 people from 14 countries.

The program included 6 plenary sessions on Future and Planned Missions, Altimetry Applications, Scatterometry Applications, Land-Cryosphere-Atmosphere Applications, Receivers and Systems, and on Simulators and Simulations.

In addition there were brief poster presentations followed by an exhibit and poster session.

Seen from the last GNSS-R08 workshop, held at ESTEC 24-25 September 2008, the GNSS Reflectometry community seems to have made good progress and looks well consolidated:

- New ground and airborne (aircraft and zeppelin) experiments have been carried out over the main surface types - land, water, ice.
- New algorithms have been tested for various applications, such as altimetry, sea ice, dry snow sounding, wind retrieval, scatterometry, including corrections to L-band radiometry, and soil moisture.
- Several satellite opportunities have been announced, either on board small satellites or on the International Space Station.
- Synergy with existing satellite radio-occultation systems has been being further exploited.
- Receiver and simulator development has made very good progress. Flight-quality receivers are being built that are capable of processing signals from the ~100 GNSS transmitters that will likely be in orbit soon.
- Novel applications of GNSS reflectometry are being attempted, such as soil moisture monitoring, polar ice sheet sounding, and ship detection.

- Announcement of the availability of GNSS-R data sets collected during several experiments in different conditions, provided openly to the GNSS-R community using standard formats:  
[http://www.ice.csic.es/research/gold\\_rtr\\_mining/](http://www.ice.csic.es/research/gold_rtr_mining/)

Out of all these topics, a few deserved special attention and were discussed during the concluding session of the workshop. These are reported below.

#### The interferometric processing technique and its advantages for altimetry applications:

This technique has only recently been demonstrated in the laboratory and in an experiment from a bridge. In general, attendees backed the potential of this concept and recognised the results of its experimental demonstration. The advantage of the technique in terms of its superior altimetry accuracy over the use of clean replicas of open access codes is now well established. The advantage of enabling the use of restricted access signals was also acknowledged. The inter-satellite cross-talk, only studied at a preliminary level, was a subject identified for further analysis.

It was also noted that the price to pay for this technique is a bigger antenna and an associated higher instrument cost. This instrument will not be inexpensive, but it offers altimetry, potentially down to the 5-cm accuracy scientists request over a wide field of view, scatterometry, and other retrievals, a fact that should be taken into account in deciding on future missions such as the In-Orbit Demonstration mission being at the moment at consideration by ESA. Moreover the cost of the instrument on a space mission is not especially critical. The fact that some applications, such as Tsunami warning and hurricane search, cannot be done with other concepts should also be considered.

An interesting proposal of applying this technique not only for reflectometry, but also for radio-occultation measurements was also suggested at the workshop.

#### White paper on GNSS reflectometry:

Back in April 2006 a draft of a White Paper on GNSS Bistatic Ocean Altimetry was being prepared by some members of the GNSS-R community, but it was never finished. During this GNSS-R10 workshop it was thought that this was a good time to continue and to publish it. Steve Lowe (JPL) will take the initiative to send the draft to volunteers who want to add something. Timeline: by IGARSS 2011 in Sendai where there will be a session on GNSS-R.

#### Why is the GNSS-R community not involved in the ocean altimetry group?

At the same time of the GNSS-R10 workshop, a meeting of the ocean altimetry community was taking place in Lisbon, and so, the question above was posed. The meeting in Lisbon focused on the need for long-

term stability of satellite tracks. There was a general consensus that the ocean altimetry community might be very interested in some realistic simulation results of GNSS-R altimetry that could be then presented at that community in their meeting of next year, for example.

The use of continuously-operating GPS networks to retrieve soil moisture, snow depth, and vegetation:

Geodesists, geophysicists, and surveyors have installed over 10,000 high-quality (dual-frequency, carrier phase) GPS receivers around the world. The number of sites will inevitably grow. The operation and maintenance of these sites is supported by state and federal agencies, and the data are freely available on the Internet. Although geodetic receivers/antennas were designed to suppress reflected signals, it has been demonstrated that the signal-to-noise ratio data recorded by these receivers are sensitive to soil moisture, snow depth, and vegetation changes. These ground-based reflection data have a spatial footprint that is intermediate to satellites and in situ sensors. The GNSS-R community has an opportunity to take a leadership role in evaluating these geodetic GPS data for environmental sensing. The soil moisture data, in particular, are valuable for validation of SMOS and SMAP. The snow data are essential for management of water supply and flood control systems. Estimates of vegetation state are required for climate modelling and validation of satellite estimates of land surface conditions. The GNSS-R community should talk to geodesists, who have the networks of sensors, and the hydrologists, who have the requirements.

Measurements with radiometers and GNSS-R on sea-surface roughness:

Several presentations and posters of the workshop were devoted to measurement of sea surface roughness with GNSS-R to be used for correcting the brightness temperature observed by L-band radiometers such as SMOS, Aquarius, or SMAP. This area was identified as of special scientific interest.

Follow-on GNSS-R meetings:

Chris Buck (ESA) is trying to organise a session on GNSS-R within IGARSS-2011, which will take place in Sendai (Japan), 1-5 August.

Beyond that Jim Garrison (Purdue University, US) proposed to use the Microrad approach for the following GNSS-R workshops, that is, to have dedicated workshops every 2 years alternating the venue between US and Europe. He offered his University as venue for GNSS-R12 workshop. He further proposed to include other signals of opportunity.

Workshop Conclusions and Proceedings:

The conclusions of the workshop will be made public through the GRSS Newsletter together with a short summary of the event, including some photos.

The workshop presentations for which the authors gave their authorisation will be made available at the workshop webpage.

The proceedings of the workshop will be in the form of full papers published in a special issue of the Radio Science journal. These papers will have followed the usual peer-review process of this journal.

Furthermore it was proposed to make the GNSS-R '10 an IEEE GRSS conference so that proceedings can be uploaded into IEEEXplore.