

OUTCOME OF RELEVANT WMO MEETINGS

Ionosphere-Atmosphere Coordination Workshop

(Submitted by Terrance Onsager)

Summary and Purpose of Document

An Ionosphere-Atmosphere Coordination Workshop was organized in Boulder, CO, USA, on October 3, 2014 by the CGMS International Radio-Occultation Working Group (IROWG), which is sponsored by WMO. This effort was in response to ICTSW action (Action 4.27). The goals of the workshop were to increase synergy between ionosphere and neutral atmosphere uses of GNSS radio-occultation, to foster scientific interaction between the two communities, to further the dual use of GNSS sensors for atmospheric and ionospheric applications, and to progress on issues related to data formats and future missions.

The discussion highlighted the impact of the ionosphere on the bending angle measurements used for meteorology and climate applications. Currently ionospheric effects are most important for climatology studies, due to the fact that the ionosphere always contributes some amount to the ray bending. A major conclusion of the workshop was that a basic ionospheric parameter derived from radio occultation measurements need to be identified and made available through the WMO Information System.

ACTION PROPOSED

The Inter-Programme Coordination Team is invited to note the activities of the CGMS International Radio-Occultation Working Group (IROWG) Space Weather Sub-group and:

- Support future workshops as requested by the IROWG;
- Consider the ionospheric parameters that could be standardized and made available through the WIS.

DISCUSSION

The Space Weather Sub-group of the Coordination Group for Meteorological Satellites (CGMS) International Radio Occultation Working Group (IROWG) addresses issues of importance to the working activities of the ICTSW. At the 3rd International Radio Occultation Workshop held in September, 2013, the Space Weather Sub-group made a number of recommendations regarding the acquisition of radio occultation data, the use of these data in operational models, and coordination between the space weather and meteorology/climate communities (http://irowg.org/wpcms/wp-content/uploads/2013/11/IROWG-3_Minutes_Summary.pdf).

At the 3rd International Radio Occultation Workshop, the Space Weather Sub-group recommended that an international workshop be held to discuss radio occultation analysis regarding the ionosphere. This workshop was to include space weather experts and scientists to discuss: (i) the removal of ionospheric effects from neutral atmosphere parameters in radio occultation data; (ii) ionospheric data assimilation methods; (iii) ionospheric effects in radio occultation data, such as scintillation; and (iv) extending atmospheric measurements to 40-90 km altitude range to improve characterization of lower-upper atmosphere coupling.

The Space Weather Sub-Group also recommended that missions flying GNSS radio occultation sensors include a complete set of ionospheric measurements and that these data be made available with a latency of less than 30 minutes. It was also recommended that a common format be established for the ionosphere data. Furthermore, it was recommended that this sub-group coordinate its activities with the WMO and that ICTSW members attend future IROWG Space Weather Sub-group meeting.

In response to the recommendations made at the 3rd International Radio Occultation Workshop, the Ionosphere-Atmosphere Coordination Workshop was convened by the IROWG Space Weather Sub-group on 3 October 2014 (see agenda in Appendix). This workshop had four main objectives: 1. increase synergy between ionosphere and neutral atmosphere uses of GNSS; 2. increase scientific interaction between these two communities; 3. further the goal of dual-use of GNSS sensors; and 4. make progress on issues related to data formats and future missions.

As pointed out at the workshop, radio occultation is a good example of a joint activity in the WMO among the meteorology/climate and space weather communities. For example, WIGOS is looking for multiple purposes for its observing networks, and radio occultation is a good test case.

Much of the discussion at the workshop involved the effect the ionosphere can have on the “bending angle” measurements used in meteorology and climate applications. It was emphasized that neglecting the ionosphere can significantly affect climatology results, since its effects are always present. At the current time, ionospheric variability is less important, as it results only in a contribution to the noise in the climatology. Because bending due to the neutral atmosphere decreases exponentially with height, the contribution to bending becomes comparable to the noise level in the signal near and above 60 km. Consequently, the radio occultation signal noise will need to be significantly reduced before the signal paths above 60 km can be effectively used. When this is achieved, the ionospheric contribution to the bending will become important and need to be considered.

For space weather applications it was noted that a basic parameter derived from the radio occultation data needs to be identified and made routinely available through the WMO Information System. This parameter (or parameters) would be the space weather equivalent of the bending angle used in meteorology/climate. Line-of-sight total electron content is likely to be one such parameter, with another parameter related to scintillation also a possibility.



Ionosphere-Atmosphere Coordination Workshop

**UCAR Center Green Campus
3080 Center Green Drive, Building # 1 (CG-1)
Boulder, Colorado U.S.A.
Friday 3 October 2014**

This workshop, convened by the Space Weather Sub-group of the International Radio Occultation Working Group (IROWG), will follow the Eighth FORMOSAT-3/COSMIC Data Users' Workshop hosted by UCAR from 9/30 to 10/2/2014.

Background: The third meeting of the CGMS IROWG recommended that an international workshop be held to discuss aspects of radio-occultation analysis involving the ionosphere. (See Meeting minutes of IROWG-3 IROWG/MM/2013¹, Section 4.4, Recommendation to CGMS #2.) The World Meteorological Organization also recommended addressing ionosphere and neutral atmosphere issues in a synergistic way in order to help optimize the radio-occultation constellation.

Organizers:

- Tony Mannucci, NASA/JPL <Anthony.J.Mannucci@jpl.nasa.gov>
- Jérôme Lafeuille, WMO <JLafeuille@wmo.int>
- Norbert Jakowski, DLR <norbert.jakowski@dlr.de>
- Geoff Crowley, ASTRA <gcrowley@astraspace.net>
- Bill Schreiner, UCAR <schrein@ucar.edu>
- Terrance Onsager, NOAA/SWPC <terry.onsager@noaa.gov>
- Paul Straus, Aerospace Corporation <Paul.R.Straus@aero.org>

Workshop Goals:

- Increase synergy between ionosphere and neutral atmosphere use of GNSS.
- Increase scientific interaction between the two communities.
- Further the goal of dual-use of GNSS sensors: atmosphere and ionosphere.
- Make progress on issues related to data formats and future missions.

Specific Workshop Objectives:

- Increase awareness of ionospheric issues for atmospheric users of GNSS radio occultation.
- Increase use of RO within the ionospheric community, including for input to assimilative models.
- Understand how the ionosphere can bias neutral atmosphere retrievals.
- Extend upper altitude of atmospheric retrievals (to 50 km and above).
- Improve understanding of ionospheric models for the atmospheric community.
- Increase awareness and understanding of atmosphere-ionosphere coupling.
- Understand the use of whole-atmosphere models for the RO community.

¹ http://irowg.org/wp-content/uploads/2013/11/IROWG-3_Minutes_Summary.pdf

Speakers

Tutorial speakers will address topics of interest to atmospheric and ionospheric users of GNSS radio occultation. In addition, there will be scientific talks addressing lower-upper atmosphere coupling and other topics.

Agenda (Friday October 3)

Room CG-1210 (South Auditorium)

Morning Session

9:00-9:10 AM Welcome from Jerome Lafeuille, World Meteorological Organization (remote).

9:10-9:20 AM Workshop Goals.

9:20 AM Tutorial Presentations.

- Radio occultation retrieval processing for ionospheric scientists
William Schreiner, UCAR
- Ionosphere 101, for atmospheric scientists, including ionospheric models as tools for the RO community
Geoff Crowley, ASTRA Associates
- How the ionosphere affects atmospheric retrievals and uses in NWP
Sean Healy, ECMWF

10:50 AM Break

11:20 AM Scientific presentations

1. Nick Pedatella – Lower-upper atmosphere coupling
2. Tomoko Matsuo – Data assimilation in the ionosphere
3. Xinan Yue – Second order ionospheric effects
4. Tae-Kwan Wee – Topics in ionospheric correction

12:20 PM: Lunch Break

Afternoon Session:

1:40 PM : Discussions

General aspects:

Awareness of synergies between neutral and ionized atmospheric analysis, future requirements, e.g. extend retrieval height above 50km.

Methodological aspects:

Retrieval techniques, potential of improving ionospheric corrections, biases, how to handle signal perturbations (scintillations, E-layer), ionospheric data assimilation techniques.

Technical aspects:

Future missions optimizing combined neutral gas *and* ionosphere retrievals, data access and exchange, usefulness of common data formats, use of RO for global scintillation activity measurements.

Scientific aspects:

Coupling processes from below (acoustic, gravity, planetary waves), impact of weather fronts, sudden stratospheric warming events, upper boundary

specification for atmospheric models.

3:30 PM BREAK

4:00 PM Reconvene/Summarize/Action Items

5:00 PM Workshop close

Practical information

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