

## Report on CGMS-46 to the International Radio Occultation Working Group

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***See “Summary and Next Steps” at the conclusion of this document for key outcomes***

### **1. Introduction**

The 46<sup>th</sup> meeting of the Coordination Group for Meteorological Satellites (CGMS) was held June 3-8, 2018 in Bengaluru (Bangalore), India. Representing IROWG were Tony Mannucci and Uli Foelsche. Both rapporteur and co-chair attended the Working Group II meeting (“Satellite Data and Products”), whereas only the co-chair was present at the Plenary. The scientific working groups, such as IROWG, are expected to participate in Working Group II and Plenary sessions at every CGMS. Presenting at the Plenary session is not expected every year. Plenary sessions are more programmatic in character, with main participation by the agency leads. This year for IROWG there were significant new developments that justified presentation in the Plenary. These developments were updates from the IROWG-6 workshop and the cancellation of the polar orbiting COSMIC-2 constellation (C2B). See the [web site](#).

The attending rapporteur and co-chair thought that the meeting was productive and that effective communication was achieved between IROWG and the CGMS, leading to useful actions and recommendations. However, we acknowledge that C2B cancellation remains a significant issue and there remains considerable ongoing degradation and future risk to the health of the climate observing system due to the scarcity of well-distributed radio occultation (RO) observations, now and in the future.

### **2. Working Group II Participation**

We presented the IROWG working paper to WGII summarizing the IROWG-6 workshop held on September 21-27, 2017 in Estes Park, USA. The four key recommendations for CGMS-46 – endorsed by the IROWG community – were presented. The top recommendation was to ensure that both equatorial and polar components of COSMIC-2 are fully funded and launched. Cancellation of COSMIC-2 polar occurred after the workshop. It was further recommended to target at least 20,000 occultations per day providing good spatial and local time coverage, to be made freely available to the operational and research communities of Numerical Weather Prediction, Climate, and Space Weather. It was clear from our presentation that this recommendation will not be met with existing and planned missions. Given the absence of a polar component to COSMIC-2, it was shown that significant gaps in local time coverage poleward of  $\pm 40^\circ$  latitude will occur with the planned RO missions.

It was recognized that the decision not to pursue COSMIC-2 polar has a significant impact on future data availability. The WGII therefore placed the following recommendation on CGMS members: that they should consider hosting radio occultation payloads on future missions.

A new recommendation on CGMS members was the result of our reporting on an important topic discussed at IROWG-6: RO data obtained from commercial sources. Given the expected heterogeneous sources of RO constellation data, our community has emphasized the importance of long-term archiving of Level0 (raw) data – and all the relevant meta data – from both agency-led missions and commercial data providers. Long-term costs associated with such data provision should be included in mission budgets and for data buys. Researchers need access to these data, and access to information about GNSS-RO

receiver performance and characteristics, for climate reprocessing activities. Access to just the retrieved products is not sufficient for many critical research applications, in particular related to climate.

We noted that there are quality assessment concerns with respect to commercial data as the quality approach is diverse. Subsequently, WGII agreed there is a need to pursue an approach for consistent quality control for RO data in order to enable consistent intercomparison of RO data from different providers and placed an associated Action on IROWG (see below).

We reported the recommendation that international space agencies (in particular NASA, ESA and CNSA, where LEO-LEO and GNSS-RO&-Reflectometry proposals are pending) support mission preparation and implementation projects towards LEO-LEO microwave occultation and GNSS-RO&-Reflectometry demonstration missions. This should include recommending Observation System Simulation Experiments (OSSEs) specifically for such missions.

A science highlight was presented to both Working Group II and the Plenary, based on the work of Adrian Simmons at ECMWF. GNSS-RO is now considered by ECMWF to be an essential measurement for climate reanalyses (e.g., ERA-5, ERA-Interim, JRA-55, MERRA, MERRA-2) as it is an anchor measurement assimilated without bias correction. The consistency of different climate reanalyses in the lower/mid stratosphere has improved significantly since the assimilation of COSMIC data in 2006. The results suggest that the more limited number of observations prior to COSMIC was not sufficient to constrain the mean state of the stratosphere in the reanalyses.

Discussion led to a new action (WGII A46.01) related to spectroscopic measurement resources in support of remote sensing. ISRO was encouraged to update their RO missions list. A new action is that IROWG consider how best to define RO data quality standards. This will be covered below under Action Items.

### **3. Participation at the Plenary Session**

The four main recommendations from IROWG were repeated at the Plenary. The Plenary reinforced recommendations and actions from WG II, including: 1) clarifying data availability (# occultations/day) from future constellations; 2) developing a consistent approach to data quality and impact assessment from heterogeneous data sources; 3) archiving Level0 (raw) data and appropriate metadata for climate reprocessing, noting the similar action from the Global Climate Observing System (GCOS) Implementation Plan (GCOS-200, 2016). This led to a new recommendation to CGMS members related to data archiving.

### **4. Action Items and Recommendations**

Significant new actions and recommendations related to IROWG emerged from the meeting. Three actions levied on IROWG are currently open. The most significant new recommendation from the IROWG perspective is the recommendation adopted by the operational agencies to archive raw RO data (Plenary R46.01). There is a related action on WGIV to consider long-term data preservation (Plenary A46.06). WGIV is "Global data dissemination". Actions and recommendations are documented in CGMS-46\_LOA\_(status\_21\_Sep\_2018).pdf, available at the [CGMS web site](#).

CGMS initiated a new action relevant to IROWG's interest in more precise and accurate refractivity constants for climate monitoring purposes. JPL has started a series of laboratory measurements based on prior recommendations of CGMS and funding by NASA. In coordination with Josep Aparicio (Environment Canada) and Uli Foelsche, this has led to the possibility of parallel work at Env Canada, and an appreciation of the difficulty of funding such work in the long term. This led to WGII action A46.01 for CGMS members

to document their known unfulfilled spectroscopic needs. This should lead to improved coordination and more timely completion of the work at JPL and elsewhere.

The new action on IROWG is to develop principles of data quality assessment and impact for heterogeneous data sources: “IROWG to develop process and principles for RO data quality control to ease intercomparison of data from different providers.” The action is due in 2019 (WGII A46.08).

The OSSE action on IROWG remains open and is now due at CGMS-47: “IROWG to develop a detailed proposal for OSSEs regarding LEO-LEO MW occultation and GNSS-RO&-reflectometry.” (WGII A45.02) . A status report was developed and referenced at the meeting, guiding the discussions (StatusReportLEO-LEO OSSE AI A45.02 V2.pdf). It should be placed on the IROWG web site (irowg.org). More work on this action is advised.

In view of the constellation shortfall, there was a new recommendation on agencies to place RO receivers on their missions (WGII R46.06). It is considered covered by the new CGMS baseline (Sep 2018) and therefore will be closed.

Important action items are still open, including providing science questions for the 7th Impact workshop in 2020 (reference CGMS-45-WMO-WP-02). These questions should be provided to Lars Riishojgaard at Iriishojgaard@wmo.int. This is an opportunity for IROWG to pose questions related to NWP impact that are particularly relevant to RO. (Plenary A45.02).

A space weather-related action remains open: “CGMS agencies with satellites with DB and RO occultation sensors to assess the technical feasibility of a RARS/DBNet RO occultation service in support of the Space Weather community.” (WGI A44.08). However, it was noted that “NOAA has no plans to do implement such a service”. Discussions suggested that moving forward on the action could attract interest in the product. This applies most immediately to the MetOP SG satellites which will offer the service and will provide space weather data.

The following recommendation is still open for IROWG members: “To enhance coordination, ISWGs to discuss with ICWG co-chairs key items for collaboration.” (WGII R44.06).

The recommendation regarding GNSS ICDs led to information regarding Beidou being added. (WGII R43.13). IROWG believes this recommendation is currently being followed.

## **5. Summary and Next Steps**

Significant interaction with IROWG and attention to IROWG concerns occurred at the meeting, but no resolution on the future GNSS constellation was obtained. Although it was not a formal action, IROWG should re-analyze future data scenarios with clearer assumptions for future presentations. It is suggested that EUMETSAT take the lead.

The new recommendation on CGMS agencies to archive Level 0 data is significant if carefully considered. IROWG should monitor the outcome.

Actions levied on IROWG should be addressed as they are due at CGMS-47, in particular clarifying “process and principles” for data assessment, in light of the coming heterogeneous RO constellation. This bears discussion that should begin prior to IROWG-7.

As a group, we need to make progress on the OSSE-related action. This deserves our careful attention.

We look forward to coordination among CMGS members on future spectroscopic needs, which includes updated refractivity constants.