CGMS

CGMS-43 IROWG-WP-13
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Prepared by IROWG
Agenda Item: WGII/7
Discussed in
Plenary/F.1.5.1, WGII/7,
WGIII/2.1

OUTCOME AND RECOMMENDATIONS FROM THE IROWG-4

The main recommendations of the fourth IROWG meeting are summarised below - only a short and concise working paper could be provided to CGMS-43 since IROWG-4 and CGMS-43 occur within about one month. The full set of recommendations, relevant at CGMS, at satellite operator, and at IROWG level will be made available at http://www.irowg.org.

For work in the immediate future CGMS-43 is invited to emphasise the following four main IROWG-4 recommendations:

- Ensure that both, **equatorial and polar components of COSMIC-2 are fully funded and launched**; this is required for Numerical Weather Prediction, Climate, and Space Weather;
- IROWG recommends **targeting at least 20,000 occultations/day to be made available to the operational and research communities** of Numerical Weather Prediction, Climate, and Space Weather;
- IROWG recommends that the **RO receiver design includes sufficient software/firmware flexibility to allow changes in the signal processing including processing of new GNSS signals/constellations as they become available; all receiver measurements should cover the ionosphere** as well**;**
- International space/research agencies (e.g., NASA, ESA, CMA, CSA, NSF, NOAA, EUMETSAT and others) to hold an **interagency workshop to define cooperation options for implementing the next steps towards a LEO-LEO research and demonstration mission**.

All given presentations, as well as minutes, this CGMS working paper from IROWG-4 are/will be made available at http://www.irowg.org.

Action/Recommendation proposed: CGMS is invited to take note.

Outcome and Recommendations from the IROWG-4

1 INTRODUCTION

This report summarizes the outcome of the IROWG Workshop No. 4 (IROWG-4) of the International Radio Occultation (RO) Working Group. The workshop was organized by the Bureau of Meteorology (http://www.bom.gov.au/) and the Centre for Australian Weather and Climate Research (http://www.cawcr.gov.au/) in Melbourne, Victoria, Australia; the meeting was held at the Bureau of Meteorology from the 16th to 22nd of April 2015.

IROWG-4 was attended by more than 50 scientists, including representatives from all the major RO processing centres and all major weather prediction centres assimilating RO data. Approximately 50 talks and 4 posters were presented (several presentations and posters were given by attending scientists on behalf of colleagues, because authors could not attend personally). Recommendations were developed in dedicated sub-working groups and presented and agreed upon in a plenary discussion on the last day. Additionally, IROWG-4 was used by several researchers for dedicated specialist/splinter meetings, which are not covered here.

The structure of this report is as follows: Section 2 gives a brief overview of the organization of the workshop and the sub-groups, Section 3 lists the main recommendations which were agreed upon by IROWG, and Section 4 concludes. The report is kept very brief due to the short time interval between IROWG-4 and CGMS-43.

This IROWG document provides the summary in a CGMS working paper format. The full minutes / recommendations / discussions of the sub-working groups within IROWG-4 will be made available at http://www.irowg.org. Presentations are already available at the website.

For reference, an appendix has also been added that gives a brief summary of relevant CGMS actions and recommendations that are impacted by IROWG.

2 IROWG-4 SETUP

IROWG-4 was a full workshop, including presentations, posters and sub-group discussions. The presentations/posters and the sub-group discussions were focussed on specific topics, namely:

- Numerical Weather Prediction (NWP);
- Climate;
- Innovative Occultation Techniques;
- Space Weather.

The possibility of commercial providers of RO data in the near future also led to several dedicated sub-group discussions, the recommendations of which were captured within the main recommendations.

IROWG-4 participants were asked to summarize **relevant activities** within the scope of the sub-group in dedicated sub-group meetings and express recommendations which could either be relevant to CGMS, to the GNSS (Global Navigation Satellite System, e.g. GPS) RO community, to providers of RO data, or within the IROWG. These were discussed in the open plenary.

The participants agreed to highlight four main recommendations for CGMS-43; these were endorsed by all participants. The full set of recommendations per sub-group and further information will be made available in a dedicated IROWG publication, available on our website www.irowg.org.

3 MAIN RECOMMENDATIONS

Many of our IROWG-3 recommendations are carried forward again. We acknowledge the significant progress made for COSMIC-2. The launch of the equatorial component is scheduled for October 2016. However, the polar component of COSMIC-2 has not yet been completely secured, thus risking a substantial gap in RO observations in the middle and high latitudes. To avoid this gap and to increase the substantial positive impact of RO observations on global weather prediction, **we recommend completion of the full COSMIC-2 program**. At this moment, **the completion of the polar component of COSMIC-2 is perceived as the least risky way to obtain global coverage of RO data in the short and medium term**. Updated assimilation studies shown at IROWG-4 again showed the importance of the full COSMIC-2 data.

The possibility of commercial RO data in the near future led to a dedicated discussion on *essential* vs. *additional* data, as defined by WMO Resolution 40. IROWG considers GNSS-RO data as being essential, or basic, data, therefore subject to free and open exchange. According to Res. 40: "Members shall provide on a free and unrestricted basis essential data and products which are necessary for the provision of services in support of the protection of life and property and the well-being of all nations, particularly those basic data and products, as, at a minimum, described in Annex 1 to this resolution, required to describe and forecast accurately weather and climate, and support WMO Programmes." This applies to all providers of essential data.

The following 4 main recommendations have been agreed upon by all participants at IROWG-4, where recommendations 1 and 2 are the top priority recommendations within each of the 3 sub-groups NWP, Climate, and Space Weather:

1. GNSS-RO has become a critical component of the WMO Integrated Global Observing System. It is our judgment, based on the success of COSMIC-1 and other RO missions, that the only well-defined mission able to fill this operational role within the short to medium term is COSMIC-2 (for which full funding is not yet secured). **Both, equatorial and polar components of COSMIC-2 are required for NWP, Climate, and Space Weather**.
2. Recent studies show that substantial increases in NWP accuracy and climate monitoring utility are obtained for increases in the number of RO profiles to at least 20,000/day, and beyond, not approaching saturation at 20,000 per day. **We recommend targeting at least 20,000 occultations/day to be made available to the operational and research communities of NWP, Climate, and Space Weather**. Existing programs (COSMIC-2, assuming both equatorial and polar components, and EUMETSAT's EPS-SG) would provide 10,000-15,000 occultations/day. Further data can be obtained from other missions; this **may include research missions, additional government programs, and commercial sources, provided they follow the WMO Res. 40 open data policy**.

3. Encourage GNSS receiver software flexibility in future RO missions, while ensuring strict change control management. **IROWG recommends that the RO receiver design includes sufficient software/firmware flexibility to allow changes in the signal processing including processing of new GNSS signals/constellations as they become available. In addition, future missions should provide a comprehensive set of ionospheric observations covering the full range of ionospheric altitudes (i.e., both positive and negative elevation angles).**
4. International space/research agencies (e.g., NASA, ESA, CMA, CSA, NSF, NOAA, EUMETSAT and others) to hold an **interagency workshop to define cooperation options for implementing the next steps towards a LEO-LEO research and demonstration mission such as, for example, an airborne demonstration**.

4 CONCLUSIONS

The main recommendations of the fourth IROWG meeting were briefly summarised above - only a short and concise working paper could be provided to CGMS-43 since IROWG-4 and CGMS-43 occur within about one month. The full set of recommendations, relevant at CGMS, at satellite operator, and at IROWG level will be made available at http://www.irowg.org.

For work in the immediate future CGMS-43 is invited to emphasise the following four main IROWG-4 recommendations:

- Ensure that both, **equatorial and polar components of COSMIC-2 are fully funded and launched**; this is required for NWP, Climate, and Space Weather;
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- International space/research agencies (e.g., NASA, ESA, CMA, CSA, NSF, NOAA, EUMETSAT and others) to hold an **interagency workshop to define cooperation options for implementing the next steps towards a LEO-LEO research and demonstration mission**.

All given presentations, as well as minutes, this CGMS working paper from IROWG-4 are/will be made available at http://www.irowg.org.

Acknowledgements

IROWG notes and thanks for financial support to this fourth workshop the following organisations: EUMETSAT, CGMS, and WMO.

Appendix

CGMS Actions/Recommendations relevant to IROWG

- **Plenary 40.06**

Plenary actions open from CGMS-40 and CGMS-41 (at CGMS-42)							
Actionee	**AGN item**	**Action #**	**Description**	**Action feedback/closing document**	**Deadline**	**Status**	**HLPP ref**
WMO	Plen IV.4	40.06	WMO to coordinate impact studies, through the CBS, in order to update and refine its requirements for GNSS radio-occultation (e.g. number of occultations/day, distribution in space)	EUM plans to launch a study in 2014 with results available for the IROWG meeting in Apr 2015 to which CEOS agencies will be invited. Action deferred to CGMS-43. It also contributes to Action 40.23 "CGMS to convene through the IROWG an ad-hoc meeting on the global GNSS-RO constellation, inviting all interested CEOS agencies". (see also actions WGII 40.23, WGIII 41.35 and WGIII 41.37) *EUM plans a WP for CGMS-43.* Matter discussed at the IPET-OSDE-1, April 2014, and CBS-Ext(2014). CBS recommended conducting Observing System Simulation Experiments (OSSEs) in support of satellite system design criteria such as orbit optimization for GPS-RO satellites, or configurations for hypersperspectral IR sounders on geostationary orbit.	(CGMS-41) **New deadline CGMS-43**	**OPEN**	HLPP#1.1.4

Information: Results of EUMETSAT study have been presented to IROWG-4 and to CGMS-43 (EUM-WP-12, Status of EUMETSAT Study on Radio Occultation Saturation with realistic Orbits).

- **WGII 40.23**

WGII actions open from CGMS-40 and -41 (at CGMS-42)							
Actionee	**AGN item**	**Action #**	**Description**	**Action feedback/closing document**	**Deadline**	**Status**	**HLPP ref**
CGMS members	WGII	40.23	CGMS to convene through the IROWG an ad-hoc meeting on the global GNSS-RO constellation, inviting all interested CEOS agencies.	EUM launched a study in 2014 with results available for the IROWG meeting in Apr 2015 to which CEOS agencies have been invited. Action deferred to CGMS-43. See also actions WGIII 41.35 and WGIII 41.37. Study expected to be completed around mid 2015. EUM-WP-xx	(CGMS-41) **New deadline CGMS-43**	**OPEN**	HLPP#1.1.4

Information: Results of EUMETSAT study have been presented to IROWG-4 and to CGMS-43 (EUM-WP-12, Status of EUMETSAT Study on Radio Occultation Saturation with realistic Orbits). Among others, the following CEOS agency were present at IROWG-4: CMA, CSIRO, EUMETSAT, NASA, NOAA.

Suggestion: Closure

- **WGII/4 R 42.02**

CGMS-42 WGII Recommendations							
"Actionee"	AGN item	Rec #	Description	Action feedback/closing document	Deadline	Status	HLPP ref
CGMS ISWGs	WGII/4	R42.02	All ISWGs under CGMS (IPWG, ITWG, IWWG, IROWG, ICWG) to establish a formal interaction with Joint CEOS-CGMS Working Group on Climate.	Nov '14: All ISWGs co-chairs have been added to the WGClimate email list and interactions are ongoing, particularly with the IROWG and ITWG. IPWG position paper provided by Huffman, Wang, Ferraro developed and delivered to J. Bates/CEOS. ICWG has interfaced with CEOS-CGMS JWG. WGII to address the definition of a process for a common approach to interact between all the ISWGs. Possible way forward to designate focal points from each ISWG that follow the JWGClimate deliberations without necessarily attending meetings. IWWG reprocessing of winds, SCOPE-CM ITSC climate sub WG activities?	(CGMS-43)	OPEN	HLPP#5.1

Information: Co-Chairs have been invited to the WGClimate group, one co-chair participated in March 2014 meeting. Requests from WGClimate are forwarded to RO community. H. Gleisner (DMI, ROM SAF) reports SCOPE-CM RO-CLIM (http://irowg.org/projects/ro-clim-under-scope-cm/) activities to WGClimate.

- **WGIII/2.1 R41.14**

CGMS-42 WGIII Recommendations							
"Actionee"	AGN item	Rec #	Description	Action feedback/closing document	Deadline	Status	HLPP ref
CGMS satellite operators	WGIII/2.1 (CGMS-41) WGIII/2.2 (CGMS-42)	R41.14	CGMS Satellite Operators to address the anticipated or potential gaps identified by WG III, in particular: • infrared and microwave sounding on the early morning orbit, • geostationary coverage of Indian Ocean • hyperspectral sounding missing in some geostationary sectors • ocean surface wind by scatterometry • long-term follow-on of radio-occultation constellation, • global precipitation measurement precipitation radar follow-on mission, • long-term Earth Radiation Budget monitoring • limb sounding for high-vertical resolution observations in the stratosphere and mesosphere (of temperature, humidity, wind, aerosol, ozone and other trace gases).	Ref CGMS-41 WGIII R 40.36. Ongoing. Discussed in WGIII at CGMS-41 and -42. CGMS-42-ROSH-WP-02: In order to fill the gaps in Hyperspectral sounding and Long-term Earth Radiation Budget monitoring over the Indian Ocean Roshydromet plans to install the appropriate instruments onboard future Electro-M geostationary satellites. Recommendation amended following WGIII CGMS-42 discussions.	(CGMS-43)	OPEN	HLPP# 1.1

Information: Results of EUMETSAT study (EUM-WP-12, Status of EUMETSAT Study on Radio Occultation Saturation with realistic Orbits).

- **WGIII/2.2 A42.06**

CGMS-42 WGIII actions							
Actionee	AGN item	Action #	Description	Action feedback/closing document	Deadline	Status	HLPP ref
EUM	WGIII/2.2	A42.06	EUMETSAT to review the schedule of its ECMWF radio-occultation study with the aim to deliver advanced results on the specific impact of the high-latitude COSMIC-2 constellation.	Nov '14: Study now at mid-term. First review Oct '14. The full set of scenarios, including the analysis, is expected early 2015, to be presented at the IROWG-4 meeting (Apr '15). The final report should become available in Q3 2015. CGMS-43-EUM-WP-xx	CGMS-43	OPEN	HLPP#1.1.4

Information: Study results have been provided early to support the COSMIC-2 Polar constellation, results have been presented at IRWOG-4; study formally ends Q3 2015.

Suggestion: Closure