IROWG-10 Climate Subgroup

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IROWG-10 meeting minutes:

Climate Subgroup - Members/Visitors

Members: Julia Danzer (WEGC, Austria), Eric DeWeaver (NSF, USA), Ulrich Foelsche (Univ. Graz, Austria), Hans Gleisner (DMI, Denmark), Stephen Leroy (AER, USA), Johannes Nielsen (DMI, Denmark), Marc Schwärz (WEGC, Austria), Endrit Shehaj (MIT, USA), Andrea Steiner (WEGC, Austria), Matthias Stocker (WEGC, Austria), Panagiotis Vergados (JPL, USA), Anna Hall (U. Washington, USA), Paul Staten (IU Bloomington, USA), Sara Vannah (AER, USA), Jun Zhou (UMD, USA), Xin Jing (UMD, USA), Cong Dong (U. Washington, USA), Guojun Gu (UMD, USA), Walid Bannoura (NOAA-NESDIS, USA), Jens Wickert (GFZ, Germany), Kevin Nelson (JPL, USA), Feiqin Xie (TAMUCC, USA), Aodhan Sweeney (U. Washington, USA), Yuying Wang (York University, CANADA), Lauren Hill-Beaton (GSFC, USA), Jihyeok Park (KAIST, Korea)

Visitors:

1. Climate Subgroup – Recommendations to CGMS: (Main Recommendations)

1) **Ensure continuity and long-term availability of climate quality RO measurements with global coverage and full local time coverage through a coordinated and sustained effort. Operational GNSS RO missions for continuous global climate observations need to be established and maintained as a backbone to ensure continuity with at least 20,000 occultations per day. This could be achieved with satellites in sun-synchronous and low inclination orbits with satellites in at least four evenly-spaced orbital planes providing observations with uniform global coverage. Level 0 data need to be freely available for reprocessing.** The community is currently short of 20,000 evenly-distributed occultations per day, but IROWG acknowledges the recommendation of CGMS to achieve this target. For climate studies, the effects of local time-related sampling errors should be examined and minimized. We acknowledge the contributions of commercial data providers, pending validation of their climate data quality, including long-term and full access to the data by independent processing centers. Climate requirements should be taken into consideration when purchasing commercial data.

2) **Acknowledging CGMS recommendation WGIIA50.04 on long-term data access, we recommend that government agencies providing data, whether generated internally or purchased from commercial entities, ensure that all information necessary for independent processing towards climate data products is freely available (following WMO Unified Data Policy Resolution 1, GCOS requirements), including long-term archiving of all measured and acquired data without filtering, sub-selection, and "intentional degradation" (i.e., including the data not passing quality control), starting with level 0 data, and public data access, thus assuring full climate traceability.** This needs to include information on instrument/software updates and full documentation of the processing chains that keep track of any introduced changes/updates (e.g., POD-induced uncertainties). We also recommend that the impact of instrument software updates on climate products be evaluated beforehand. All level 0 data providers should make available phase data, amplitude data, and satellite orbit data in a well-documented format (such as NetCDF).

1. Climate Subgroup – Recommendations to CGMS:

3) **Data providers should ensure two data streams of RO climate data products: one regularly updated data version (interim CDR) and one uniformly reprocessed version (CDR).** The reprocessed version should always cover the full data time period until more recent processing versions are available.

4) **IROWG recommends that processing centers increase efforts on uncertainty estimation and make the methods and results publicly available through peer-reviewed publications**. One method of uncertainty quantification is to produce ensembles of processed observations ("perturbed retrieval ensembles") that include different processing assumptions and initialization information where the SI-traceability chain may be less robust (in accordance with the GCOS-143 Document).

5) **Promote funding of various reprocessing activities of RO climate data records from different independent RO processing centers** along with the principles for reprocessing climate data records of the WCRP Observation and Assimilation Panel (WOAP). Documentation of the historical evolution of processing systems for the provision of climate data records is important. **This should include gridded data together with uncertainty estimates and algorithm descriptions from multiple centers.**

6) We recommend to assess the **uncertainty in the refractivity coefficients that impacts the accuracy and traceability of RO climate time series and trends.** Significant progress was made at JPL in implementing an experiment to measure the refractivity of air, but such experiments currently lack the needed precision by the climate group. Required steps to improve precision have been identified by NASA/JPL, however further financial support is needed. **IROWG is pleased to see these initial laboratory refractivity experiments and encourages CGMs agencies to support this activity.**

7) We acknowledge the **success of the 3G meeting** which brought together the GNSS RO, the GRUAN and the GSICS communities in May 2014 in Geneva and recommend **organizing such meetings periodically by WMO**.

8) We recommend that **operational data providers additionally supply occultation prediction products**, aiding coordinated ground-based collocated measurements.

2. Climate Subgroup – Recommendations within IROWG:

1) **We recommend that IROWG continues to contribute to the development of GNSS RO as a climate monitoring system** by a) assessing the structural uncertainty of RO retrieval data, including differences between processing centers and between different RO instruments and missions, b) supporting the generation of multi-center ensembles of RO climate data records, c) studying the effect of changing spatial coverage with latitude, including characterizing the errors related to incomplete spatial and temporal coverage, and d) clearly communicating the usability and limitations of RO products (e.g., N, T, H2O) to the climate community.

2) **Continue to assess RO water vapor products** in terms of climate quality, information content, and random and systematic uncertainties, including characterization of the stability and inter-center homogeneity, guided by GEWEX and GCOS requirements.

3) **Encourage research into assessing the sources of bending angle uncertainties from different receivers and processing centers (which include SNR, clock noise, ionospheric residuals, calibration techniques etc.) and their impact on the estimates of long-term changes**, which is likely to extend the benchmarking capability of GNSS RO more robustly into the troposphere and higher into the stratosphere.

2. Climate Subgroup – Recommendations within IROWG:

4) **Issues of ionospheric correction and high altitude initialization should be further investigated to optimize the climate utility in the entire stratosphere**.

5) **We recommend that the IROWG community continues to compare RO products with other observations and to foster contributions to IPCC Assessment Reports and other international climate reports**.

6) **Continue participation in the wider scientific community.**

7) **Ensure a complete archive of navigation data bits in a standard format**. We recommend making this information available to the community. We recommend that current providers come up with a common nav bit format.

8) **We recommend to have intercomparison studies of the PBL (refractivity, water vapor pressure, and other direct products), and of the determination methods of the PBL height.**

3. Actions to IROWG-8 From CGMS: