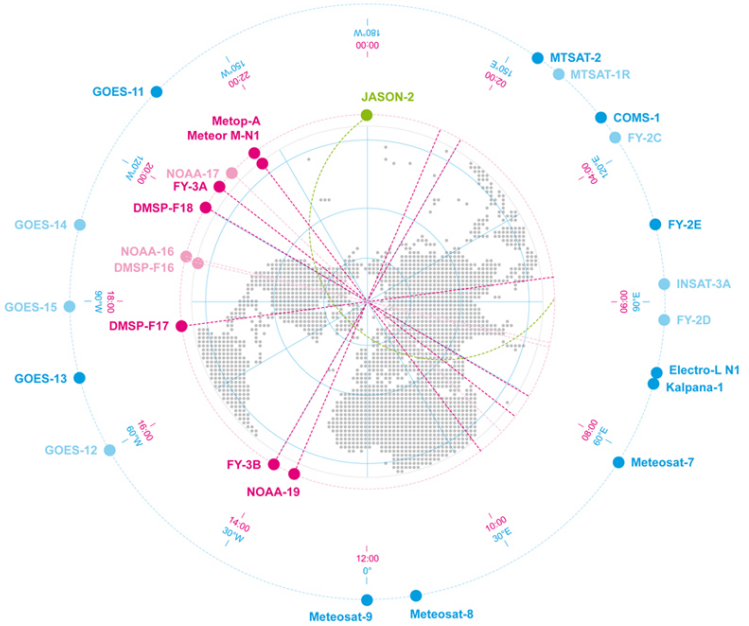


IROWG-4 General Information and Sub-WG Introduction

Co-Chairs: Axel von Engeln (EUMETSAT), Dave Ector (UCAR)
Rapporteur: Tony Mannucci (NASA/JPL)
with input from RUAG, H. Gleisner (ROM SAF/DMI)

Coordination Group for Meteorological Satellites

IROWG INTERNATIONAL RADIO OCCULTATION WORKING GROUP

CGMS

Overview

- CGMS / IROWG Open Points
- Scope-CM RO-CLIM Update
- 3G Meeting Outcome
- WGClimate
- L5 Interference
- BUFR Entries
- Laboratory Measurements
- CGMS High Level Priority Plan
- Bibliometric Analysis
- Sub-Working Group Information

IROWG-3 CGMS-42 Recommendations

- Develop a detailed **GNSS-RO Continuity Plan**, outlining how we move towards a fully operational GNSS RO constellation providing **at least 10,000 observations per day**.
- Take steps to ensure **the continuity of RO measurements**, especially after COSMIC-1. **Operational GNSS RO missions are not only important for weather forecasting, but also for continuous global climate observation**.
- To ensure wherever possible a timely **update of receiver firmware** in order to maximise the receiver performance, e.g. for the Oceansat-2/ROSA instrument to allow L2 tracking, or for the GRAS instrument to extend the altitude range to 120 km.
- **Avoid an observation gap at mid- and high latitudes** by funding/launching the FORMOSAT-7/COSMIC-2 Polar mission.
- International space agencies (e.g., NASA, ESA, NSF, NOAA, EUMETSAT and others) to hold an **interagency workshop to define cooperation options for implementing an airborne demonstration and a LEO-LEO research and demonstration mission**.

IROWG-3 Documents

To CGMS-42:

- Report from the 3rd International Radio Occultation Workshop, CGMS-42 IROWG-WP-01

General:

- IROWG-3 Minutes: Full Minutes/Summary of the workshop
- Critical Impact of the potential Delay or Descoping of the COSMIC-2/FORMOSAT-7 Programme, IROWG/DOC/2013/01
- Status of the Global Observing System for Radio Occultation (Update 2013), IROWG/DOC/2013/02

All available at http://www.irowg.org

CGMS-42 RO Open Actions

CGMS-42 recommendation - WG II						
Actionee	Rec	#	Description	Deadline	Status	HLPP ref
CGMS ISWGs	WG II/4	R42.02	All ISWGs under CGMS (IPWG, ITWG, IWWG, IROWG) to establish a formal interaction with Joint CEOS-CGMS Working Group on Climate.	CGMS-43	OPEN	HLPP# 5.1

Co-Chairs have been invited to the WGClimate group, AvE participated in one meeting and has asked RO community whether they can provide support to WGClimate. H. Gleisner also reports SCOPE-CM activities to WGClimate.

Suggest to address within Climate Sub-Group

CGMS-42 RO Open Actions

CGMS-42 actions - WG III						
Actionee	Action	#	Description	Deadline	Status	HLPP ref
EUM	WG III/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.	CGMS-43	OPEN	HLPP# 1.1.4

Action on EUMETSAT; has been partly address by providing early results at various workshops, meetings (e.g. A. Thorpe's talk at Eighth FORMOSAT-3/COSMIC Data Users' Workshop 2014), and by providing a Working Paper/Presentation for CGMS-43.

CGMS-42 RO Info

Actions and Recommendations from CGMS-42, for Info only.

CGMS-42 actions - WG II						
Actionee	Action	#	Description	Deadline	Status	HLPP ref
CMA	WG II/7	A42.04	CMA is invited to present a paper to CGMS-43 on prospects of RO measurements with future FY-3 satellites.	CGMS-43	OPEN	HLPP# 1.1.4

CGMS-42 RO Info

CGMS-42 recommendations - WG III						
Actionee	Rec	#	Description	Deadline	Status	HLPP ref
CGMS satellite operators	(WG III/2.1 CGMS-41) WG III/2.2	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).	(CGMS-43)	OPEN	HLPP#1.1

CGMS-40 Open Points

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) Matter discussed at the IPET-OSDE-1, April 2014, outcome?	(CGMS-41) **New deadline CGMS-43**	**OPEN**
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 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. Feb 2014: Ongoing interaction with CEOS, the impact study results might be reported at CEOS plenary Oct 2014. The study is scheduled to run to mid 2015. IROWG-4 is tentatively planned for spring or autumn 2015. See also actions WGIII 41.35 and WGIII 41.37.	(CGMS-41) **New deadline CGMS-43**	**OPEN**

Action WMO/EUMETSAT; IROWG part to be closed at this workshop by (1) CEOS agencies invited to IROWG-4; (2) S. Healy's IROWG-4 talk on the EUMETSAT study.

Open: Other Impact studies / Reporting Saturation Study

CGMS-40 Open Issues

6	CGMS members [IROWG]	WGIII R	40.41	CGMS, via the IROWG, to support the development and use of GNSS radio-occultation for ionospheric monitoring.	IROWG-3 space weather sub-group meeting will discuss further steps in Sept 2013.	CGMS-41	CLOSED

Closed Action on IROWG; suggested to provide summary information to CGMS-43 of the ionospheric workshop in October 2014 that happened after the Eighth FORMOSAT-3/COSMIC Data Users' Workshop 2014 meeting.

SCOPE-CM Proposal "RO-CLIM"

Radio occultation based gridded climate data sets - RO-CLIM

- Formalizing the *ROTrends* collaboration as a SCOPE-CM project
- Project lead: Hans Gleisner, DMI/ROM SAF
- Participants: DMI, WEGC/UGraz, UCAR, JPL/NASA, GFZ, EUMETSAT, Met Office, ECMWF, SS&E (Kursinski)
- 5-year project (2014-2018) aiming at:
  - Increase maturity of *ROTrends* CHAMP data set (assessment of high-altitude initialization, validation against other RO missions, improve error characterization, and making data publically available);
  - Development of higher-resolution RO climate data sets;
  - Build capacity for climate-model usage of RO data (e.g., *obs4MIPs*)
- Annual update of project plan and progress report. Hans Gleisner reporting at the annual SCOPE-CM Executive Panel meeting (23-24 March 2015).

3G Workshops: Background (1)

GRUAN-GSICS-GNSSRO WIGOS Workshop on Upper-Air Observing System Integration and Application

Report

1. INTRODUCTION

1.1 PURPOSE

The workshop was held from 6 to 8 May 2014 at the World Meteorological Organization (WMO) headquarters in Geneva, Switzerland, comprising 20 participants, with the purpose of exploring how the benefits of high-quality observations of the upper atmosphere using ground-based upper-air soundings from the GCOS Reference Upper-Air Network (GRUAN), satellite-based infrared measurements (intercalibrated within the Global Space-based Inter-Calibration System (GSICS)), and Global Navigation Satellite Systems for Radio Occultation (GNSS-RO)-based refractive index measurements, can be fully realized, for weather and climate applications.

Copy from WMO Report,
available at http://www.wmo.int/pages/prog/www/WIGOS-WIS/reports/3G-WIGOS-WS2014.pdf

3G Workshops: Background (2)

1.2 WORKSHOP GOALS

1. Identify measures to better connect the GRUAN with the satellite community

   The idea for the workshop had its origins in the GRUAN community, which recognizes the need for better coordination and collaboration with the meteorological satellite community; in response, GSICS groups have discussed GRUAN matters and emphasized (i) that GRUAN may benefit from the highly stable reference IR sounders used in GSICS, and (ii) that GRUAN could be particularly valuable as a reference anchor for satellite instruments operating in the microwave range (MW) where an on-orbit reference is not available.

2. Compare methods of estimating measurement uncertainty (including systematic errors), calibration/validation and collocation

   Data from all "3G"s have associated uncertainties, which are relevant in the calibration and validation of other instruments; the uncertainty that accrues due to collocation mismatch of measurements in space and time is a particularly important aspect of caibration/validation and joint data exploitation in general.

3. Provide guidance on how the various upper-air observing systems and datasets can better serve meteorological and climate applications

   More integrated data utilization from all "3G"s is important to improve their relevance to weather and climate user communities, and to demonstrate the added value of synergetic use.

4. Develop recommendations for future observing system design

   The workshop discussed integration and application of the "3G"s in the context of the wider global upper-air observing system.

Copy from WMO Report,
available at http://www.wmo.int/pages/prog/www/WIGOS-WIS/reports/3G-WIGOS-WS2014.pdf

3G Workshops: Actions (1)

ACTION 3G-1: Explore with climate modelling community (obs4MIPs managers, e.g. Robert Ferraro) their interest in a RO-based or combined "2/3G" dataset.
Who: T. Mannucci,
By when: 31 Aug 2014

ACTION 3G-2: Look into tropopause and planetary boundary layer comparisons between GRUAN and GNSS-RO datasets. Bring up this idea at the upcoming ROM SAF (GNSS-RO) workshop and report back on interest, and potential participants, with timeline.
Who: S. Healy
By when: 30 Jun 2014

RECOMMENDATION 3G-3: Investigate the value of GRUAN and GNSS-RO profiles for studying uncertainties of radiative transfer models and spectroscopic databases. Consider working with the ITWG and CEOS WGCV (K. Thome) as appropriate.
Potential contributors: X. Calbet, M. Matricardi, G. Kirchengast, J. Fischer, N. Jacquinet

ACTION 3G-4: GRUAN and GNSSRO should engage with the GSICS Microwave sub-group to define an activity on inter-comparison of MW instruments especially in areas with no SNOs to test for latitude and day /night dependencies
Who: T. Hewison, J. Dykema, T. Reale
By when: 31 Dec 2014

3G Workshops: Actions (2)

ACTION 3G-7: Investigate ability to predict probability of RO observations days to weeks in advance to inform targeted dedicated launches in support of polar orbiter characterisation by radiosondes at GRUAN sites. Report results to T. Reale.
Who: A. von Engeln and G. Kirchengast
By when: 30 Sep 2014

ACTION 3G-8: Investigate feasibility of generating database of collocations between GRAS and sounders on Metop - perhaps through Visiting Scientist.
Who: A. von Engeln
By when: 30 Sep 2014

ACTION 3G-13: Explore possibility to have a cross-representation of each of the "G"s in the coordination mechanisms of the other "2G"s
Who: Meeting chairs (P. Thorne, T. Hewison, T. Mannucci)
By when: 31 Aug 2014

ACTION G-3: Raise awareness within the GNSS-RO community to make uncertainty calculations publicly reviewable, including identifying where background information comes into processing, where traceability chain may be broken.
Who: G. Kirchengast, A. von Engeln
By when: 30 April 2015

3G Workshops: First Results

- Action 3G-7: Accurate prediction possible over a month for e.g. GRAS, but GPS satellites might undergo manoeuvres — Closed
- Action 3G-1: obs4MIPS -> **Sub-Group/ROTrends** Input — Closed

  BAMS publication on obs4MIPs; recently obs4MIPs opened up to accept a broader set of data; they show no particular interest in a combined dataset, probably since required accuracies are not that high; well-characterized individual datasets suffice; however obs4MIPs would require long-term datasets, where combination of datasets could be helpful?
- Action 3G-8: VS discussed with ROM SAF — Ongoing
- Action 3G-13: Greg Bodeker here (Thanks!) — Ongoing
- Action 3G-3: RO for RTM uncertainties — Ongoing
- Action 3G-4: GRUAN/GNSSRO and GSICS — Ongoing
- Action G-3: Uncertainty Calc. -> **Sub-Group** Input — Open
- Action 3G-2: RO-GRUAN tropopause, PBL comparison -> **Sub-Group/ROTrends** Input — Open

WGClimate

- CEOS-CGMS Working Group on Climate (WGClimate)
- General background available here
- IROWG co-chair attended the 4th of WGClimate, in March 2014. General RO presentation was given.
- RO-CLIM Project Leader (H. Gleisner) provided summary of RO-CLIM to WGClimate group report
- Information on ECV gap analysis work of WGClimate send around

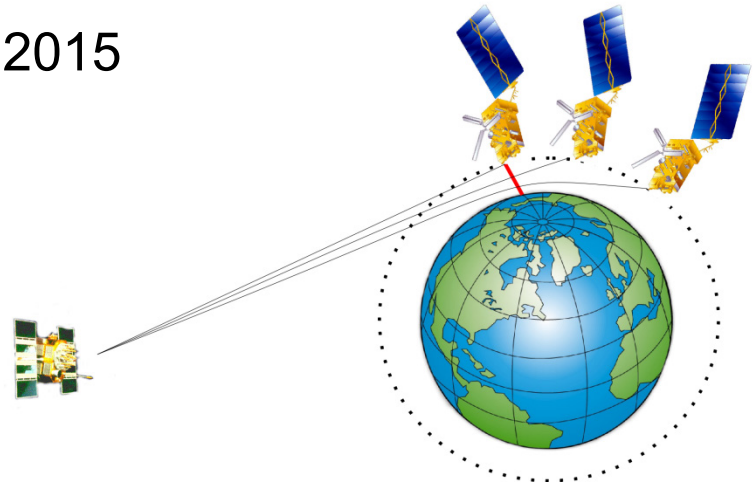
L5 Interference

RUAG provided the following presentation within it's EPS-SG RO work.

DME/TACAN L5 Interference with Radio Occultation Measurements

IROWG - 4

Melbourne, April 2015

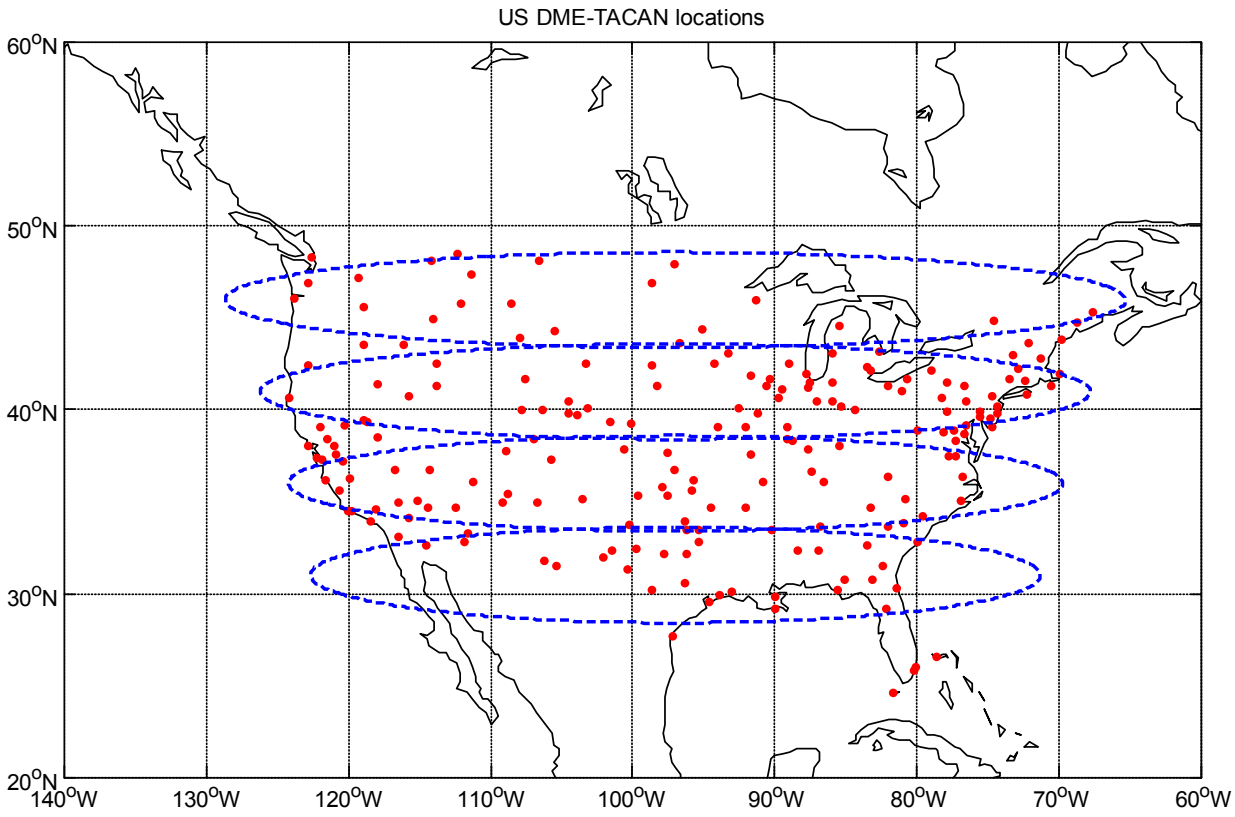


Magnus Bonnedal

Together ahead. RUAG

DME/TACAN Stations in US

- 200 Tx stations in US within f_{L5} ±10 MHz
- Blue lines show approximate MetOp-SG RO antenna coverage at three instances (-3 dB link budget)
- Longitudinal coverage limited by RO antenna
- Latitude coverage limited by DME/TACAN antennas
- Up to 75 Tx stations within the 3 dB beam



Approximations:

- Projection effects will make the coverage banana shaped, but size is right.
- 90^0 LEO orbit inclination assumed

Together ahead. RUAG

DME/TACAN Transmit Properties

Parameter	DME	TACAN
Tx frequency band	1 151 MHz – 1 213 MHz	
Pulse width	3.5 µs	3.5 µs
Pulse pair interval	12 µs	12 and 18 µs
Pulse pair rate	2 700 pulse pairs/s	~0.37 ms repetition time
Duty cycle	4%	4%
Tx power (peak)	100 W or1 000 W	3.5 kW peak, sinusoidal variation, average 3dB lower
Tx antenna gain	9.5 dBi	9.5 dBi
Tx antenna elevation beamwidth	6 deg	6 deg
Tx antenna elevation pointing	4 deg	
Number of Tx in US within f_{L5} ±10 MHz	200 (DME + TACAN)	

Worst case scenario:

- we assume that all ground stations work on max power and capacity (pulse density, i.e. traffic intensity)
- we assume many TACAN (high power) stations. We lack information on the number of TACAN and DME stations respectively

Peak Power Received from a Single DME/TACAN Station

#	Parameter			Link budget
1	Frequency	[Hz]	1.18E+09	
2	Wavelength	[m]	0.255	
3	Distance	[m]	2.69E+06	
4	FreeSpaceAtt	[dB]		-162.5
5	Tx antenna Gain	[dBi]		9.5
6	Rx antenna average gain	[dB]		9.0
7	Tx transmit Power	[W] [dBm]	2 000	63.0
8	Received max power	[dBm]		-81.0
9	Nominal noise in 20 MHz	[dBm]		-98.0

Assumptions:

- LEO in MetOp-SG orbit 820 km altitude
- The -3 dB level is calculated

Implications for the RO Instrument

- The interference power is some 17 dB above the noise floor
- The front end is OK – no saturation or compression
- The ADC will suffer compression and reduced signal gain
- ADC compression will act a bit like pulse blanking, the ADC gain will decrease drastically during the pulse

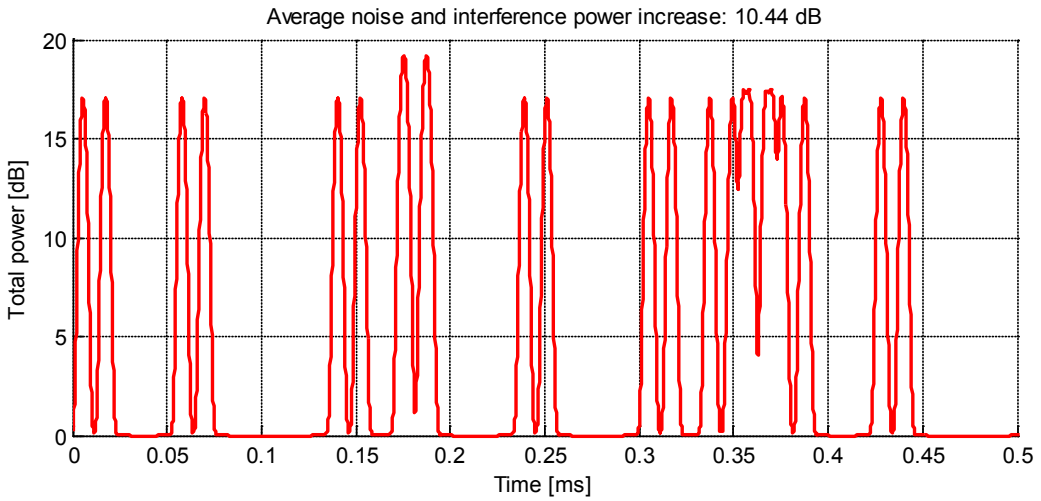
Simulation With 10 Transmitters

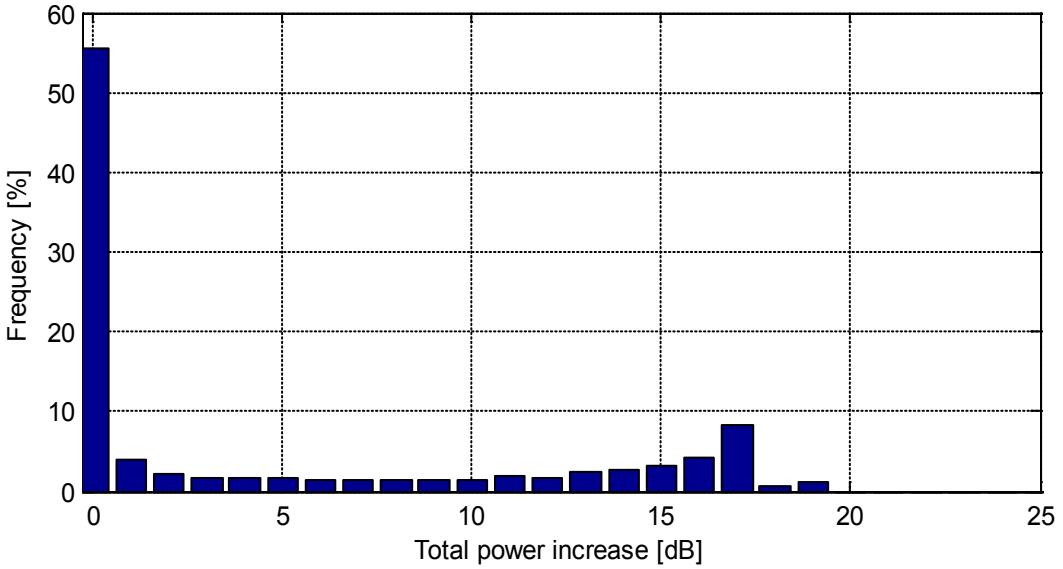
Assumptions:

- 10 transmitters (Tx) @2kW within field of view
- Each Tx transmits 2700 pulse pairs / sec.
- Random start time of pulse train

Result:

- 50% of time low interference
- ADC compression gives ~6 dB SNR loss (3 dB in theory)
- RO performance degraded
- Power is given relative to nominal noise floor





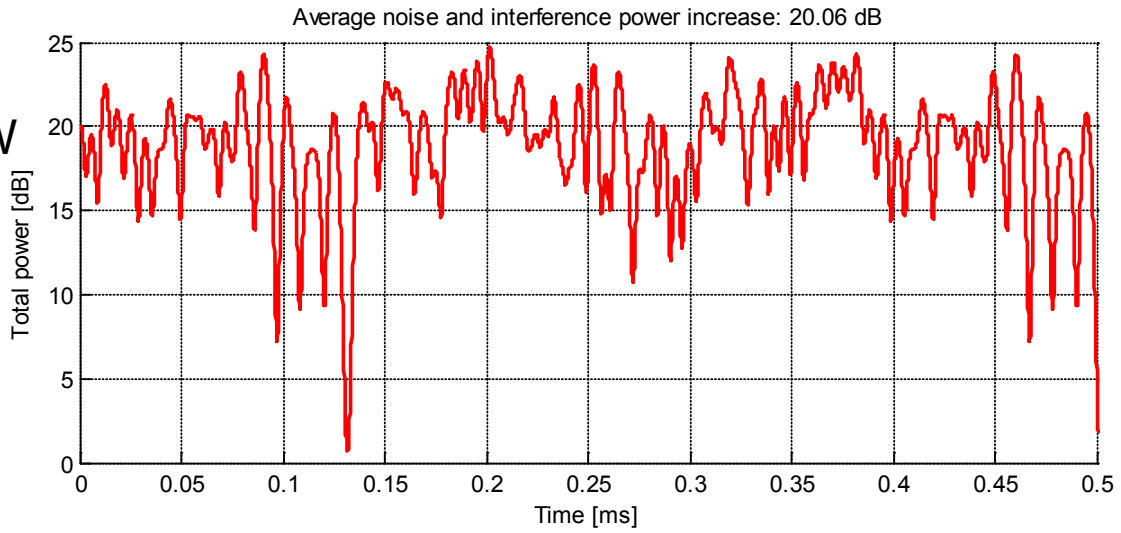
Simulation With 100 Transmitters

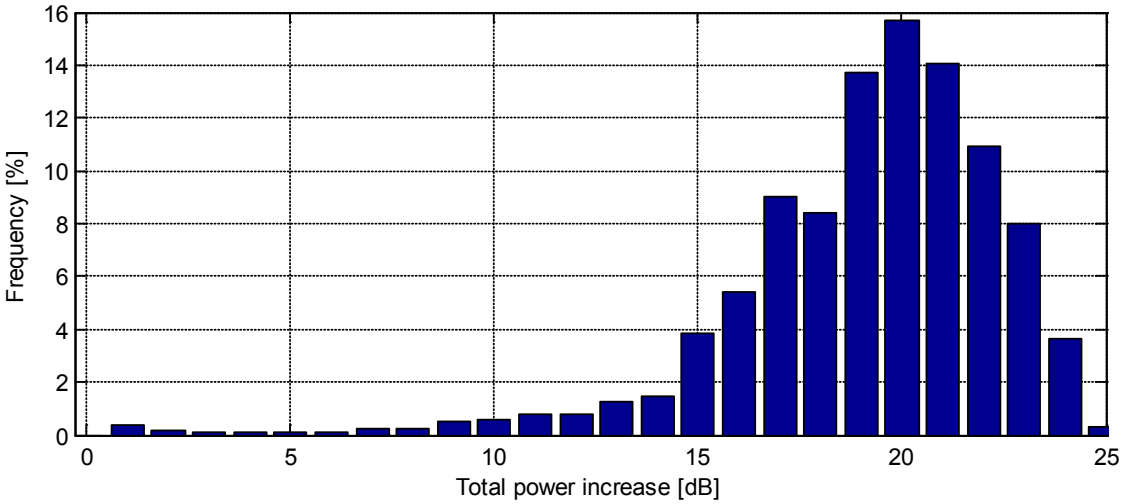
Assumptions:

- 100 transmitters (Tx) @2kW within field of view
- Each Tx transmits 2700 pulse pairs / sec.
- Random start time of pulse train

Result:

- Constant high interference
- ADC compression gives ~20 dB SNR loss
- Unacceptable to RO
- Power is given relative to nominal noise floor





Conclusions

Simulation assumption:

- Extreme worst case scenarios have been simulated:
  - Peak power (DME Tx considerably lower power than TACAN)
  - Max capacity in terms of Tx pulse rate (depends on air traffic density)
- No information on realistic (typical) traffic intensity has been obtained
- Other publication show some 10 dB lower levels (power assumptions?)

Simulation results:

- Over US (and Europe and far east Asia) the interference could increase the noise by some 15-20 dB in the L5 band
- With close to 100 Tx stations in view (at peak Tx power) the RO receiver will be nearly constantly saturated
- The foreseen 20 dB SNR loss is unacceptable to RO performance

Potential mitigations in the receiver:

- AGC function could be adapted not to react on the interferers (works only for relatively sparse Tx pulses)
- Narrowing the filtering of the L5 band. Signal loss can be traded against discriminating Tx frequency band. Interference from transmitters within the filter bandwidth cannot be mitigated.

BUFR Entries

- Several points already discussed. NPW sub-group to follow up?

REF Laboratory Measurements

Summarize what we actually expect from new lab measurements or from a metrologist assessments of the currently available information in a short technical note, starting from J. Aparicio's email/presentation. Summary to be provided to NASA/ESA points of contact.

Suggest Josep to take the lead here.

CGMS High Level Priority Plan (1)

CGMS has released a High Level Priority Plan and asks ISWG to provide feedback. In particular they would like the IROWG to:

- Assess the achievement of the targets in the High Level Priority Plan, that are related to the work of IROWG
- Assess the continued relevance of the HLPP to guide the work of CGMS on issues related to the remit of IROWG
- Propose accordingly necessary amendments to the HLPP, both regarding new targets and targets that should be considered achieved

CGMS High Level Priority Plan (2)

In this context it should be noted that:

- The HLPP has an agreed 'horizon' of 3 - 5 years.
- Proposed actions and recommendations to CGMS should be traceable onto items in the HLPP, but the HLPP should not be a list of short-term actions. Therefore we do not expect annual updates per se to the HLPP.
- There should however be incremental adjustments if required. This can be inclusion of novel items arising from your working group discussions and proposed removal of targets once achieved or obsolete.
- Concrete actions and recommendations are what drives and moves forward CGMS. Therefore it is very important that actions / recommendations are raised by your working group to the CGMS plenary through the plenary WG II, encouraging Heads of Delegations to CGMS to take ownership of actions/recommendations and provide vital agency support.

CGMS High Level Priority Plan (3)

Links to relevant documents:

CGMS High Level Priority Plan
CGMS-42 Actions and Recommendations

Which sub-Working Group could follow this up?

Bibliometric Analysis

At the June 2014 ROM SAF workshop, two recommendations related to a bibliometric analysis were expressed:

- CLIM17: Provide literature data base that lists RO publications by theme
- CLIM18: Evaluate literature with respect to study focuses (bibliometric analysis)

Initial assessment performed at EUMETSAT by R. Weitzel (librarian), A. von Engeln. Draft report to be provided through IROWG Mailing list. Includes access to a data base with all RO publications from 1990 to 2014.

Bibliometric Analysis - Authors

AUTHOR	SCOPUS	WOS
WICKERT J	100	114
KUO YH	82	84
SCHMIDT T	71	76
KIRCHENGAST G	49	68
LIOU YA	44	47
BEYERLE G	37	44
TSUDA T	40	41
ROCKEN C	38	39
JAKOWSKI N	35	39
PAVELYEV AG	32	37
SOKOLOVSKIY S	43	33
FOELSCHE U	32	37
AO CO	31	35
REIGBER C	29	33
HEISE S	32	33
HUANG CY	28	33
STEINER AK	26	33
GORBUNOV ME	26	32
MANNUCCI AJ	29	31
HAJJ GA	28	30
KURSINSKI ER	24	30

IROWG-2 Open Actions

Action IROWG2-01: On IROWG co-chairs to contact the ITWG and survey the common interests between the groups.
Action IROWG2-02: Josep Aparicio will undertake a review to estimate both the total number of radio occultation measurements and the number of operational measurements available per day, based upon the current timeline of GNSS. This will allow us to foresee problems in data coverage in the coming years. An example is the data gap between COSMIC-1 and COSMIC-2; as there is a distinct possibility of no COSMIC-1 data by 2014.
Action IROWG2-05: On IROWG co-chairs and B. Ho, A. Steiner: Provide the following ROTrends information on the IROWG homepage: (a) Links to processing descriptions of all data providers; (b) Published ROTrends intercomparison papers; (c) ROTrends PPC and MMC datasets (including sampling errors of the latter).

IROWG-3 Open Actions

Action IROWG3-01: NWP sub-group will compile a table of current Metop-B standard latencies (50 and 90% latencies, after processing, ready for delivery). Future operational missions should take that table as standard requirement (incl. COSMIC-2).
Action IROWG3-02: IROWG co-chairs to check progress towards updated laboratory measurements of the refractivity coefficients.
Action IROWG3-03: J. Y. Liu and Tony Mannucci will each provide a report on the activities at CEDAR that were initiated by Gary Bust and Geoff Crowley as part of Action IROWG2-08. J. Y. Liu will report RO related activities at the IRI conference in Olsztyn, Poland (June 2013). Due: IROWG-4.
Action IROWG3-04: Obtain information regarding access to COSMIC-2 data downlinks globally to decrease data latency (objective is 30 minutes or less). Tony Mannucci will contact Paul Straus of Aerospace Corp to obtain information from the USAF. J. Y. Liu will contact NSPO to obtain information from that organization. Due: IROWG-4.
Action IROWG3-05: Sun Yue-Qiang of the Space Weather Sub-group will provide information on the planned use of FY-3C ionospheric data, including its use in space weather models. Due: IROWG-4.
Action IROWG3-06: All IROWG members to check and to provide feedback on the information given in the WMO Observing Systems Capability Analysis and Review Tool OSCAR: http://www.wmo-sat.info/oscar/. Due: ongoing.

IROWG-4 Sub-Working Groups

Suggested Sub-Working Groups

(1) Numerical Weather Prediction

(2) Climate

(3) Payload Technology and Innovative Occultation Techniques

(4) Space Weather

(5) Others?

Each Sub-WG selects a chair / Rapporteur.

Guidance to Working Groups

IROWG WG can express:

- recommendations to CGMS
  - achievable within 1-2 years and relevant at CGMS level
  - understandable also to the laymen
- recommendations to satellite operators, data providers
  - follow similar guidelines as to CGMS, however can be more specific
- recommendations / actions within IROWG / sub-group
  - actions need to be agreed with Actionee

All recommendations should be prioritized, i.e. most relevant ones first. These ones might be accompanied by further background info. Please keep a participants list. On the last day, sub-working group Rapporteur presents recommendation, and we decide which are the most important 3-5 ones for IROWG from all the sub-working group ones. Minutes are drafted over here and then finalized by email between IROWG co-chairs and sub-working group leads.

Specific Points (1)

- All:
  - should we provide for each CGMS meeting a short report on relevant RO info?
  - should we start some discussions on commercial data?
  - please have a look at / provide feedback on the CGMS High Level Priority Plan
  - please keep track of actions/recommendations in your sub-working group from IROWG-2/3 and shortly summarize/close them in draft minutes (full minutes at http://www.irowg.org)
  - Suggest to use the full minutes IROWG-3 Word document as a template to fill in sub-group updates. Word document available at: http://www.irowg.org/documents/)
  - GNSS-Service provider: currently have operational one (EUMETSAT GSN), best-effort one (IGS), and building further up for COSMIC-2. Should we aim for an "ECMWF" like service form one provider here and document those requirements?
- NWP:
  - Impact studies performed / information available
  - NWP project page at IROWG website

Specific Points (2)

- Climate:
  - interaction with WGClimate
  - SCOPE-CM RO-CLIM and ROTrends working arrangements
- Research to Operations or NWP:
  - Megha Tropique / Kompsat-5 / PAZ data availability?
- Space Weather:
  - What is follow-up to the iono-atmo coordination meeting?

Specific Points (3)

- Please use the IROWG-3 Word document as template within your working group, available at http://www.irowg.org/workshops/irowg-4/
- This presentation in PowerPoint is also available at http://www.irowg.org/workshops/irowg-4/

Working groups (Sean Healy)

- **I have not looked at the new version of COSMIC data**. I would appreciate the NWP sub-group group to give a view on:
  - NWP impact
  - if the change should be made, do we need more time, ….
- Status of COSMIC-2 Polar.
- Recommend New Project to CGMS: to compare EDA approach with OSSE approach?
- I'm still unsure whether we need refractivity measurements.
- Space weather/NWP: Convergence of observation operators. 2D neutral bending angle operators and slant TEC operator have many similarities. Opportunities to work together.

Possible topics for the NWP Subgroup

Current/future missions:

1) Support for COSMIC-2 (polar).
2) Support for GNOS on FY-3{C,D,E,F,G}. This series runs from 2013-2027. Quality looks promising.
3) GRAS – provision of wave optics data.
4) Other missions, e.g. KOMPSAT-5.

Emphasis on:

1) Space weather.
2) Tropospheric humidity information.

Data processing:

Vertically correlated bending angle errors:

These are increased in the recent UCAR dataset (priv. comm. Harald Anlauf), and the reprocessed GRAS data (priv. comm. Sean Healy), *despite reduced standard deviations* in both cases.

Bending angles are attractive for assimilation because the error correlations are significantly smaller than for refractivity, so we can treat the observations independently and implement, for example, tangent point drift.

Some caution is probably required here, even if initial assimilation experiments look promising.

BUFR (thanks to Harald Anlauf and Dave Offiler for input):

The BUFR template for RO is generic, and this has led to different interpretations by the processing centres. Should the community agree on stricter guidelines (UW5-NWP16)? E.g.

- Standard set of vertical levels?
- Fixed definition of azimuth, occultation point, time of positions/velocities, etc.

Should we recommend the following to be a requirement?:

- L1/L2 bending angles

Also we should start looking ahead to possible direct use of:

- Ionospheric parameters
- Excess phase

Most of this can be covered by specifying requirements in the ROM SAF BUFR document or clarifying ‘notes’ in the WMO tables, but the last two will probably require an **additional** BUFR template for the new RO-specific element descriptors.

ROM SAF Input (1)

Ideas for IROWG working group discussions

- 1. BUFR files: Recommendation UW5-NWP16 is related to setting up an IROWG working group related to unifying the contents of BUFR files.

- 2. Interim data sets: We have recommendations (from UW5, IROWG) for reprocessing. We have also discussed that we could generate "Interim" datasets, i.e., to extent a given reprocesed dataset with data generated with the same version of the code (even though the offline code could have evolved). Should this be discussed at IROWG-4?

- 3. Climate quality water vapour: There is the recommendation from IROWG-3 on “systematically investigating the feasibility of an RO climate-quality water vapour product.” Should this recommendation be carried forward by IROWG-4?

ROM SAF Input (2)

- 4. Reflections: Should IROWG discuss recommendations to investigating and/or producing reflections products, i.e., 1) flagging of occultations, 2) BA parts for the reflected parts?
- 5. Radiosonde collocations: For each occultation CDAAC generates a file with the closest radiosonde profile. Should IROWG recommend that we do something similar?
- 6. PAZ: Should IROWG recommend that investigations related to polarimetric products are investigated in the RO community and/or ROM SAF?
- 7. Ionosphere products: Should IROWG discuss recommendations for which ionosphere products to be produced by EUMETSAT and the ROM SAF?

References: 5th ROM SAF User Workshop: Applications of GPS radio occultation measurements, http://www.romsaf.org/ROMSAF_WS_2014.php; Report: http://www.romsaf.org/general-documents/rsr/rsr_21.pdf

- IROWG: http://www.irowg.org/workshops/irowg-3/

Sub-Working Groups

(1) Numerical Weather Prediction (Lidia)
(2) Climate (Uli)
(3) Payload Technology and Innovative Occultation Techniques
(4) Space Weather (Tony)
(5) Commercial (Rick)

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