

# An Update from the International Radio Occultation Working Group Meeting 2016

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# Overview

International  
RO Working  
Group Meeting

Motivation

Radio  
Occultation

GRUAN and  
the RO  
community

Sub-groups

RO  
uncertainty  
estimation

Summary

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# Motivation

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Summary

- GRUAN-GSICS<sup>1</sup>-GNSS-RO<sup>2</sup>(3G) workshop in Geneva [WMO, 2014]  
goals:
  - better connect GRUAN with satellite community
  - compare methods for uncertainty estimation, cal/val
  - discuss how to better serve climate/meteorological application
  - discuss future observing system design
- RO measurements, as well as GRUAN data products, are known to be of reference quality
- Comparison of entirely independent measurement techniques can reveal biases and uncertainties in measurements/retrieval

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<sup>1</sup>Global Space-based Intercalibration System

<sup>2</sup>Global Navigation Satellite System Radio Occultation

# The Radio Occultation Method

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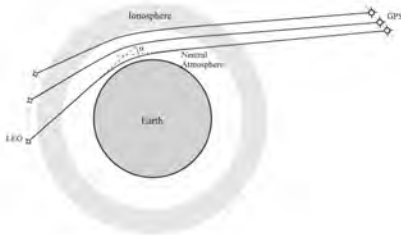
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Summary

- Signal transmitted by GNSS satellite (here GPS) is received by a low-earth orbit (LEO) satellite



Phase shift  $\rightarrow$  bending angle  $\rightarrow$  refractivity  $\rightarrow$  (dry) temperature

Figure credit: [Syndergaard, 1999]

# GRUAN and RO community

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RO and GRUAN data can complement each other!

- RO highest accuracy in upper troposphere/lower stratosphere, GRUAN very valuable also in lower levels
- Comparing GRUAN and RO enables us to study the quality of RO retrievals and GRUAN bias corrections
- In a perfect world the measurements made with different techniques agree within their uncertainties
- RO technique offers the possibility to be SI traceable. A traceable uncertainty estimate on each datum is desirable

# OPAC-IROWG Meeting 2016

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## **OPAC** - Occultations for Probing Atmosphere and Climate **IROWG** - International Radio Occultation Working Group Meeting

- Joined OPAC-6 IROWG-5 meeting was held in Austria in September 2016
- I participated to represent the GRUAN community and gave the presentation  
*'The GCOS Reference Upper-Air Network (GRUAN) and its Relevance to the Radio Occultation Community'*  
[Tradowsky et al., 2016]

# Focus of the OPAC-IROWG Meeting

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Summary

- Occultation methodology
- RO in meteorology, numerical weather prediction
- RO in climate monitoring and research
- RO in ionospheric science
- Future missions

# IROWG Sub-group Meetings

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Summary

- Climate
- Numerical Weather Forecast
- Ionosphere and Space Weather



# Climate Sub-group

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Summary

Members e.g.: Chi Ao, Andrea Steiner, Ben Santer, Johannes Nielsen, myself...

The sub-group was working on recommendations for:

- ① Coordination Group for Meteorological Satellites
  - Ensure long-term availability of data with global coverage, regular reprocessing for RO climate records
- ② Recommendations to satellite operators and data providers
  - Document processing chain, increase effort on uncertainty estimation, gridded data products with uncertainties
- ③ Recommendations within IROWG
  - Develop RO as climate monitoring system (SCOPE-CM<sup>3</sup>), continue participation in wider scientific community

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<sup>3</sup>Sustained and coordinated processing of Environmental Satellite data for Climate Monitoring

# Uncertainty estimation in RO retrievals 1

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Summary

- RO does not offer a direct measurement of essential climate variables
- The phase shift is measured and the bending angle can be calculated
- In the conventional RO retrieval the noisy bending angles are merged with a smooth bending angle profile above approximately 40 km → climatology
- The choice of smoothing algorithm and climatology influences the retrieval at all levels  
→ structural uncertainty

# Uncertainty estimation in RO retrievals 2

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Summary

- Comparison of retrievals from different processing centres used to estimate this structural uncertainty [Ho et al., 2012, Steiner et al., 2013]
- Chris Burrows, Sean Healy, John Eyre and I presented a tangent linear retrieval algorithm which allows to estimate the structural uncertainty in the retrieval directly [Tradowsky et al., 2017]
- The Wegener Center in Graz is working on a Reference Occultation Processing System which includes uncertainty propagation
- Jacob Schwarz et al.: Integrating uncertainty propagation in GNSS radio occultation retrieval: From bending angle to dry-air atmospheric profiles [Schwarz et al., 2017]

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- Valuable to keep an ongoing exchange between RO and GRUAN communities. Thank you Axel, Rob, Joe and others for being here!
- I will present a GRUAN-RO comparison in a separate talk
- I am looking forward to represent GRUAN at the next IROWG meeting during September 2017
- Please keep me up to date about your projects involving GRUAN and RO

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# References II

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*Journal of Applied Meteorology and Climatology*, 56(6):1643–1661.



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WMO INTEGRATED GLOBAL OBSERVING SYSTEM (WIGOS); GRUAN-GSICS-GNSSRO WIGOS Workshop on Upper-Air Observing System Integration and Application.

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# Thank you for your attention!

