Preparation of a Science Plan for the Radio Occultation Instrument on EPS-SG/MetOp-SG

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Outline of the talk

- MetOp-SG introduction and the RO instrument
- Background or RO SAG and purpose of the science plan
- Document approach for the science plan
- Outline of the science plan
- Studies and YOUR potential input and contribution
- Questions

EPS / MetOp-SG introduction

- **EUMETSAT Polar System (EPS) / Meteorological Operational Second Generation (MetOp-SG)** is a collaborative programme between **ESA** and **EUMETSAT**
- **EPS-SG / MetOp-SG** is a follow-on system to the first generation series of **MetOp** satellites (**MetOp-A** and **MetOp-B** satellites were launched on 19 October 2006 and 17 September 2012; **MetOp-C** launch in 2018), which currently provide operational meteorological observations from polar LEO orbit
- The follow-on system is essential to avoid possible data gaps and to maintain Europe's role in such systems.
- **ESA** is responsible for the development of the prototype satellites and, on behalf of **EUMETSAT**, for the procurement of the recurrent satellites.
- **EUMETSAT** is responsible for overall end-users requirements, procurement of the launchers and LEOP services, development of the ground segment , and also performs the operations of the satellites and ground segment.

EPS / MetOp-SG payload

Ten different instruments across two satellites; RO is the only instrument on both

Satellite	Instruments	Instrument Provider
Sat-A	METimage	DLR via EUMETSAT
	IASI-NG	CNES via EUMETSAT
	MWS	ESA – MetOp-SG
	RO	ESA – MetOp-SG
	3MI	ESA – MetOp-SG
	Sentinel-5	ESA – GMES
Sat-B	SCA	ESA – MetOp-SG
	MWI	ESA – MetOp-SG
	RO	ESA – MetOp-SG
	ICI	ESA – MetOp-SG
	Argos-4	CNES via EUMETSAT

EPS / MetOp-SG payloads

Instrument	Heritage	Spectral Bands/Channels & Performance
METimage	AVHRR	20 spectral channels: 0.443 – 13.345 µm; spatial sampling 500 m; few solar channels sampled at 250 m.
IASI-NG	IASI	spectral range: 645 – 2760 cm-1; spectral resolution and radiometric accuracy with factor 2 improvement wrt IASI; pixel size 12 km, spatial sampling 25 km, swath 98° (same as IASI).
MWS	AMSU-A,MHS	24 channels: 23.9 – 229 GHz; spatial resolution: 17 – 40 km.
SCA	ASCAT	5.3 GHz radar, 6 fixed fan shaped beams; mid-beam dual polarised; spatial resolution 25 km; dynamic range 4 – 40 m/s.
RO	**GRAS**	**GPS & Galileo signals tracked (Glonass & Compass options); 1575 MHz, 1176 MHz frequencies; bending angle accuracy < 0.5 µrad; >1100 occultations / day (per instrument).**
Sentinel-5	GOME-2	5 spectrometers: 0.27 – 2.385 µm; spatial sampling of 7.5 km.
MWI	(SSM/I, MADRAS)	26 channels at 18 different frequencies: 18.7 – 183 GHz; spatial resolution: 10 - 50 km.
ICI	-	13 channels at 11 different frequencies: 183 – 664 GHz; spatial resolution: 15 km.
3MI	(POLDER)	12 spectral channels, 9 of which provide polarised components: 0.410 – 2.13 µm; spatial resolution: 4 km.
Argos-4	A-DCS	400 MHz transponder.

Key RO requirements

Requirement	RO on MetOp-SG	GRAS on MetOp
Bending Angle Accuracy	0.5 μrad @ 35km	0.5 μrad @ 35km
Number of observations per satellite	~ 1100 occ/day (GPS+Galileo) ~ 2200 occ/day (as above + GLONASS, Compass)	~ 500 occ/day
GNSS constellations	GPS, Galileo, GLONASS, Compass	GPS only
Closed Loop	Yes, @ L1 and L5, up to 250Hz	Yes, @ L1 and L2, 50Hz
Open Loop for low altitudes tracking	Simultaneous Open Loop @ L1 and L5, Doppler Model and Range Model, 250Hz	Open Loop @ L1, Doppler Model, 1KHz
Use of Pilot Signals	Yes, better performance for closed loop	No
Minimum SLTA	-300 km	-250 km
Maximum SLTA	+80km atmosphere, 500km ionosphere	+80 km atmosphere
Autonomous Start-Up	Yes, for GPS and Galileo	No, Almanac needed
Reliability	0.84 @ 7.5 years	0.8 @ 5 years

RO SAG (1)
Background and Purpose

RO SAG is the Radio Occultation Science Advisory Group, providing external advice and recommendations to ESA/EUMETSAT. Terms of Reference includes:

- Provide a **science plan** to detail the scientific work which is needed in preparation of the RO instrument, especially also of the EPS-SG ground segment; update this plan when necessary
- Assist ESA and EUMETSAT in the selection of the **most suitable methods** to be applied for the EPS-SG ground segment, covering both the **central processing at EUMETSAT and the de-centralised processing** in the network of the EUMETSAT Satellite Application Facilities
- **Advise** ESA and EUMETSAT **on requirements and methods for instrument calibration and post-launch validation** activities
- **Advise on** the **scientific requirements of the RO system and instrument**, taking into account constraints which are imposed by the status of design/development of the overall EPS-SG system and of the RO instrument development

RO SAG (2)
Background and Purpose

- **Review the progress and the results of scientific projects** initiated in support of the RO; provide recommendations to ESA and EUMETSAT on the direction and focus of further work to be pursued within these projects
- **Review the progress of the RO project by supporting technical reviews** and advise on implications of non-conformances for mission and scientific objectives
- **Provide recommendations for scientific studies** which are needed to support the RO project, in order to fulfil the requirements in the science plan and by assisting in preparation of work statements and by reviewing results of initiated studies
- **Participate in the coordination of the RO SAG activities** with external science and user groups
- **Contribute to the production of scientific reports and publications** in the framework of the RO SAG activities.

Science Plan – Background & purpose

- Details the **scientific work** needed to meet the **RO mission objectives**
- Provides a **framework** for required **scientific research** and **development activities**
- Follows the EPS Science Plan from the GRAS SAG for the EPS programme
- **Reviews on-going activities** in the areas of:
    a. retrievals, software and databases
    b. Identifying gaps that might exist in the proposed product processing, product format, archiving, dissemination, reprocessing
    c. the level of compliance with the user needs
- **Advises** on needs fo**r additional studies and development**

Document approach for science plan

- Written and compiled by the RO SAG
- Aimed at providing an independent advisory framework and a focus for the establishment of scientific research and development priorities
- Timeline:
  - First draft structure/template prepared in **January 2015**
  - RO SAG to make a first iteration of content by **May 2015**
  - First complete draft ready by **July 2015**
  - First complete and mature version by **October 2015**

Outline/structure of the science plan

Section title	Contents
Introduction	Purpose, scope, app/ref documents and ownership, heritage
Mission objectives	Inc. operational (NRT to climate scales) and research
The RO instrument	Measurement concept, principles, performances, including innovations with respect to heritage instruments (provided by EUMETSAT)
Status and outlook of RO applications	Including bending angle, refractivity, temperature and humidity retrievals, ionospheric products retrievals; results/improvement for NWP both at a Global and Regional level.
RO data processing and products	Including in the discussion of Level 1a, Level 1b products.
Instrument and RO performance monitoring	Short and long term monitoring and product validation (provided by EUMETSAT)
Outreach needs	Reaching out to the operational and scientific expert and user communities, mechanisms for innovative research
RO research and development needs	Including a discussion on priorities in the development of: - Processing packages/algorithms - Studies to be performed - Data support networks, e.g. in situ, GNSS orbits/clocks/navbits

Studies and YOUR potential input and contribution

- Capitalizing on your sound past knowledge in using RO data for research and operational applications
- Potential additional topics and research and development needs should be included in the science plan
  - POD and impact new GNSS Signals
  - Climate use of RO data
  - …
  - …
  - Your topic

Already identified

- Do you have any input/advice for ESA/EUMETSAT and the RO SAG for the science plan?


Questions and Discussion?

Backup slide

Current RO SAG members

SAG Member Name	Affiliation	Invited by
Biagio Forte	University of Bath	EUMETSAT
Andre Hauschild	DLR	EUMETSAT
Sean Healy	ECMWF	EUMETSAT
Jose van den IJssel	TU Delft	ESA
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