



Radio Occultation Modeling Experiment (ROMEX)

Presented to CGMS-51 WGII session, agenda item 3

IROWG Co-Chairs: Hui Shao (JCSDA), Ulrich Foelsche (University of Graz)
Rapporteur: Tony Mannucci (NASA/JPL)

With contributions from Richard Anthes (UCAR), Benjamin Ruston (JCSDA),
Christian Marquardt (EUMETSAT) and the ROMEX team

Executive summary

The International Radio Occultation Working Group (IROWG) community has recently proposed a collaborative effort to explore the impact of RO observations:

Radio Occultation Modeling Experiment (ROMEX)

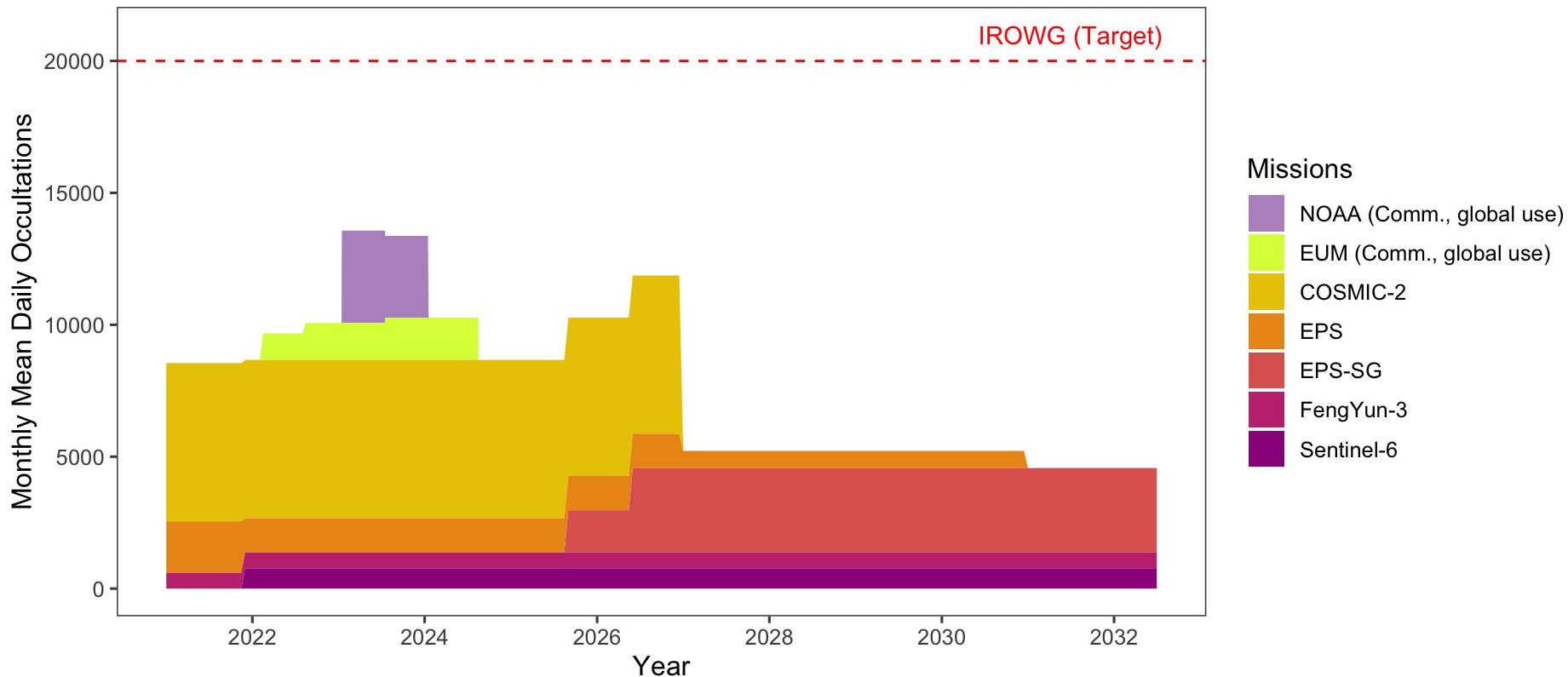
ROMEX seeks to quantify the benefit of increasing the quantity of RO observations using additional observations which were not available to weather centers for their real time operational systems. The IROWG community has gained approval from their respective institutions to perform data assimilation experiments with the additional RO measurements over the designated time period.

The effort concept, was first introduced Dr. Richard Anthes in May 2022, in response to questions from by NOAA for input on future RO needs. The resulted discussion led to a proposal for ROMEX, which was endorsed by the IROWG in September, 2022 (IROWG-9).

The experiment results will provide guidance to the CGMS partners to answer pressing technical and programmatic questions facing the numerical weather prediction (NWP) community. This will help inform near- and long-term strategies for RO missions and acquisitions by all CGMS partners.

Present and future RO

Monthly Mean Daily RO Numbers (NRT)
 (as available today or from mission requirements)



EUMETSAT (April 2023) (Christian Marquardt)

OSSE Studies show positive impacts with increasing RO numbers. No Saturation at 100K+

4404

Harnisch et al. 2013

MONTHLY WEATHER REVIEW

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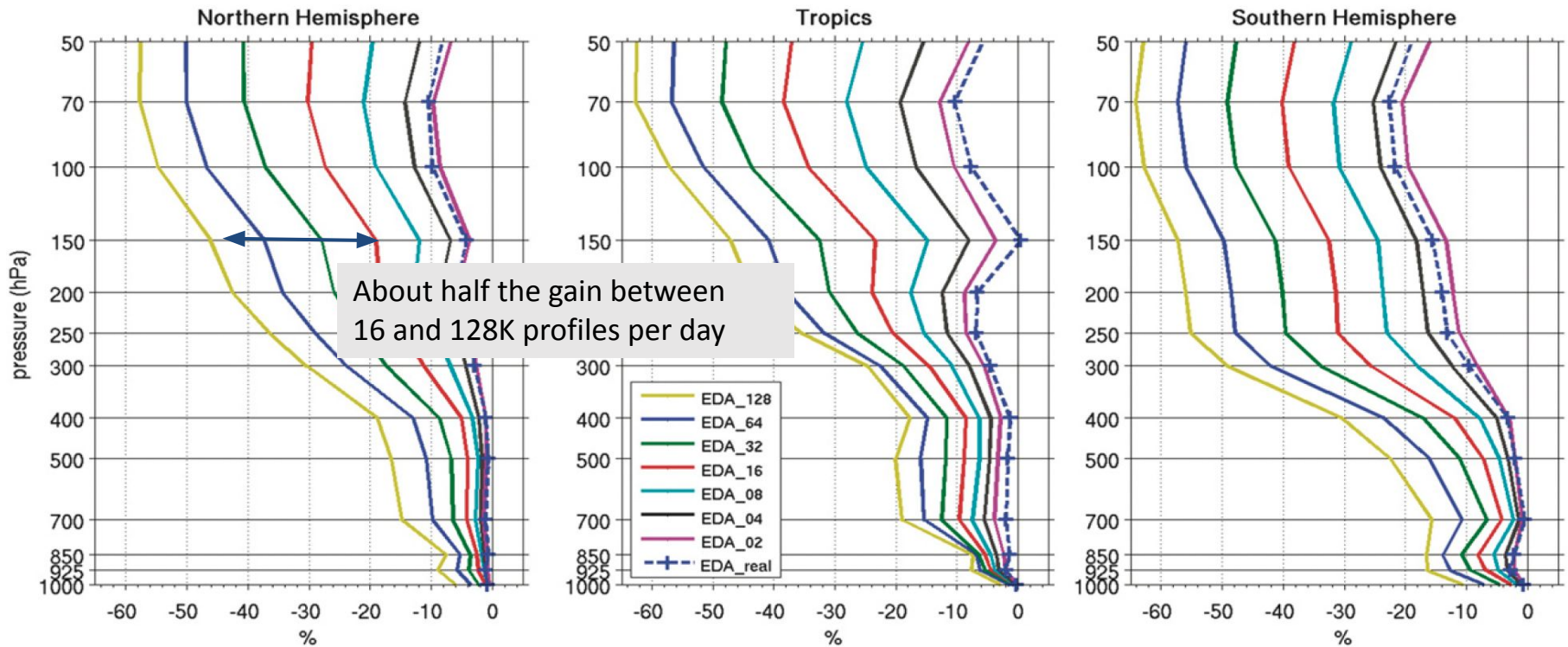


FIG. 4. Normalized difference of EDA spread (%) for temperature at analysis time averaged over the (left) Northern Hemisphere, (middle) tropics, and (right) Southern Hemisphere. Results are for the period 8 Jul–15 Aug 2008.

Harnisch et al. (2013) results confirmed by Privé et al. 2022

Questions from/for the RO community

1) Data Quantity

How many RO profiles per day are needed?

Using the supplemental ROMEX data, is there a fall-off or asymptote in the cost-benefit curve? With roughly 30 thousand profiles per day being collected today, the experiment can measure improvements up to that daily volume.

2) Geographic / Temporal Sampling

How should RO observations be distributed around the globe and in local time?

Should the tropics or other specific latitude regions receive relatively more focus? How important is local-time sampling to NWP and climate applications?

3) Data Quality

Are there systematic differences in the GNSS-RO sources and their processing algorithms?

What is the value of higher SNR? How to best exploit the various quality aspects, such as penetration depth? How can ROMEX help quantify the impact of the quality aspects to help CGMS partners form data requirements?

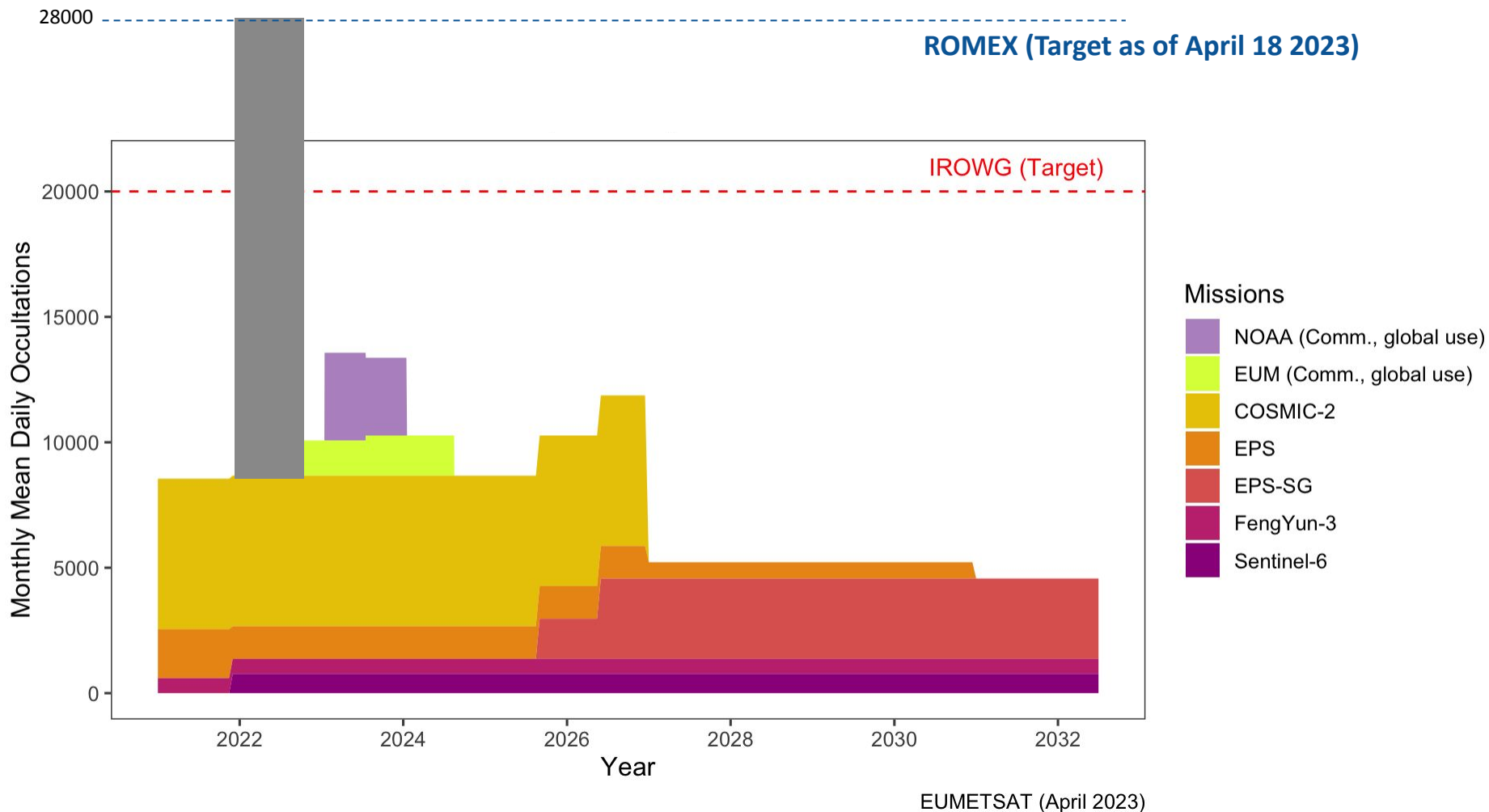
4) Make vs. Buy

How much can CGMS partners rely on commercial services to provide operational data?

Issues include total cost per observation, restrictions on data, robustness of system and long-term stability, level of transparency, and value of additional capabilities (e.g., space weather data and neutral atmosphere observations combined).

The RO Modeling Experiment seeks to: Answer some of the more pressing technical and programmatic questions. Help inform the near- and long-term strategies for RO missions and acquisitions by CGMS partners.

Quantify the benefit of increasing the quantity of RO observations



ROMEX Timetable

Timeline (dates will be assigned once confirmed)	ROMEX Task
29 November 2022	Kick-off meeting: introduction to ROMEX. Sign up sheet for ROMEX participants
19-20 December 2022	Meeting. Set up subgroup discussions: Processing and Experiment Design
22-23 February 2023	Meeting. Status update
January - May, 2023	Data agreement and license document. Meetings with individual data providers
February - May 2023	Data collection and assemble
April 2023	ROMEX white paper
May 2023	Meeting. Status update. Experimental Design
June 2023	Providing testing data (EUMETSAT)
August 2023	Meeting. Initial data assessment
October 2023	Meeting. open table discussion
December 2023	Meeting. Intermediate report
March 2024	Mid-term meeting/workshop (TBD) (Q3)
May 2024	Meeting. open table discussion
July 2024	Meeting. open table discussion (prepare for report for IROWG-10)
September 2024	IROWG-10, ROMEX-1 report

Participating organizations at present:
EUMETSAT, NOAA, NSF, NASA,
JCSDA, NESDIS, NCEP, UCAR COSMIC,
NRL, Wegener Center, ECMWF, UK
Met Office, Meteo France, DWD,
JMA, CMA, KMA, BoM, Canada
(ECCC), DMI, Yunyao, GeoOptics,
PlanetIQ

ROMEX coordination team:
Rick Anthes (UCAR)
Hui Shao (JCSDA, IROWG co-chair)
Ben Ruston (JCSDA)
Christian Marquart (EUMETSAT)

Radio Occultation Modeling Experiment (ROMEX) Framework

(Updated 22 February 2023 from original by Martin McHigh by Hui Shao, Richard Anthes, Ben Ruston and Christian Marquardt)

Overview and Purpose

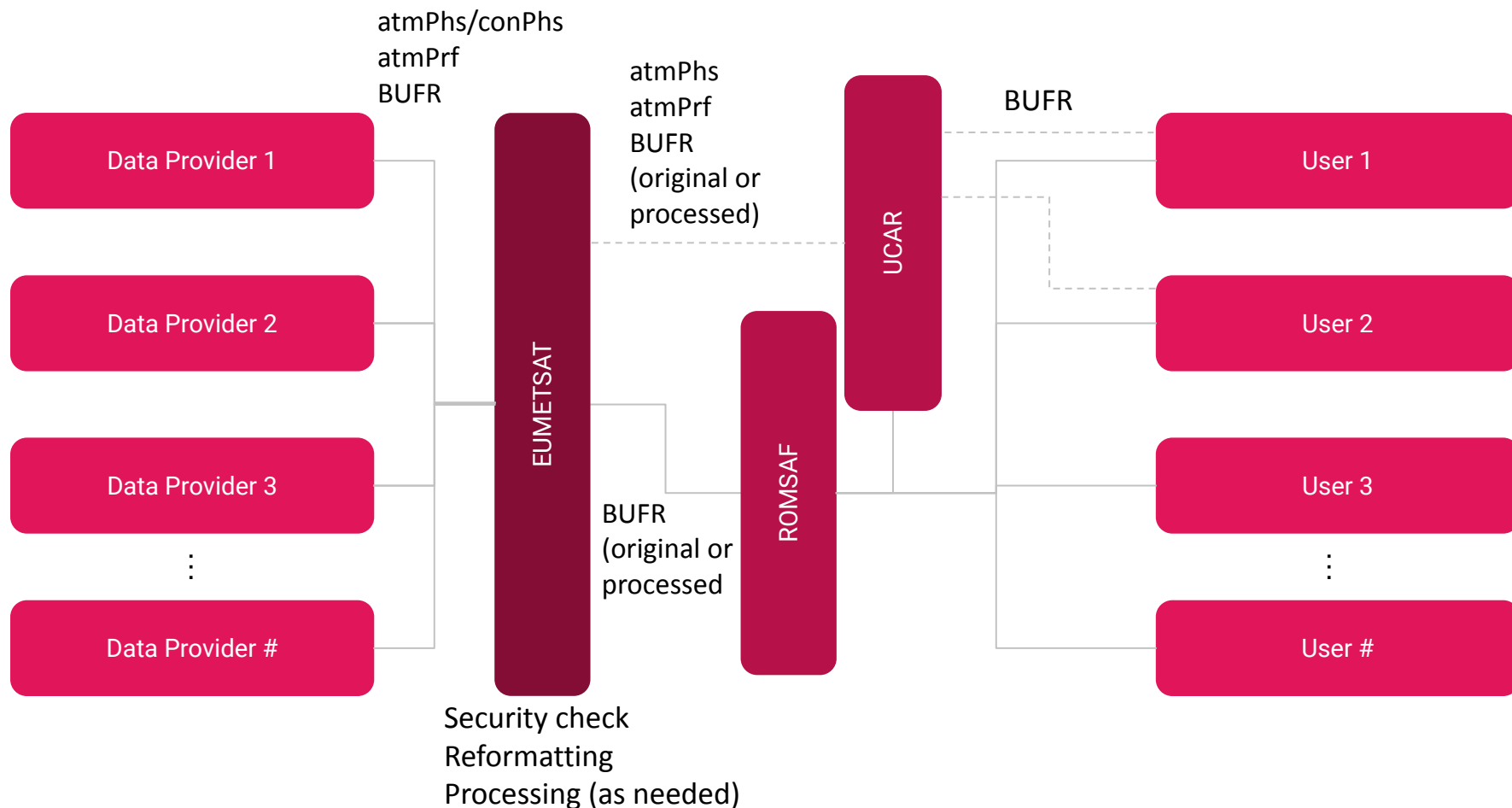
The international Radio Occultation (RO) community has recently and collectively proposed to undertake a collaborative effort to explore the impact of RO observations obtained and shared by the community. This effort, first put forth by Dr. Richard Anthes in May 2022, has been dubbed the Radio Occultation Modeling Experiment (ROMEX). The experiment seeks to answer some of the more pressing technical and programmatic questions facing the community and help inform the near- and long-term strategies for RO missions and acquisitions by NOAA, EUMETSAT, and other international partners. Most important among these questions is to quantify the benefit of increasing the quantity of RO observations. These will be addressed by performing data assimilation experiments with real measurements. The purpose of this framework document is to describe the tasks and efforts needed to conduct the experiment and outline a proposed plan, schedule, and responsibilities for successfully executing the project.

Background and Motivation

Historically RO has played an important role in atmospheric and environmental remote sensing. The direct application of RO observations to weather prediction began with the GPS/MET mission in 1995. In the decades that followed, there have been a plethora of dedicated RO

White paper is under review and will be made available at www.irowg.org

ROMEX Data Flow



EUMETSAT ROMSAF will distribute the final ROMEX data where the data collection and distribution are subject to ROMEX data terms and conditions signed by data providers, processing centers and users

Experiment Design

Testing period: ROMEX-1: Sep-Nov, 2022

Control: Best align with operational configurations. All other observing systems at normal usage levels and methodology.

- GNSS-RO remove (GNOS; NOAA or EUMETSAT commercially purchased data)

ROMEX: same as above.

- GNSS-RO add all available ROMEX data

Impact and Verification

Forecasts statistics bias and RMS statistics for air temperature, moisture, and wind at a series of standard pressure levels. These forecasts will range from 5-10 days.

Accumulated bias and RMS statistics on the observation fits particularly to radiosonde, and microwave and infrared sounders.

Additional diagnostics are encouraged. Analysis of ensemble spread and forecast sensitivity to observation to be included.

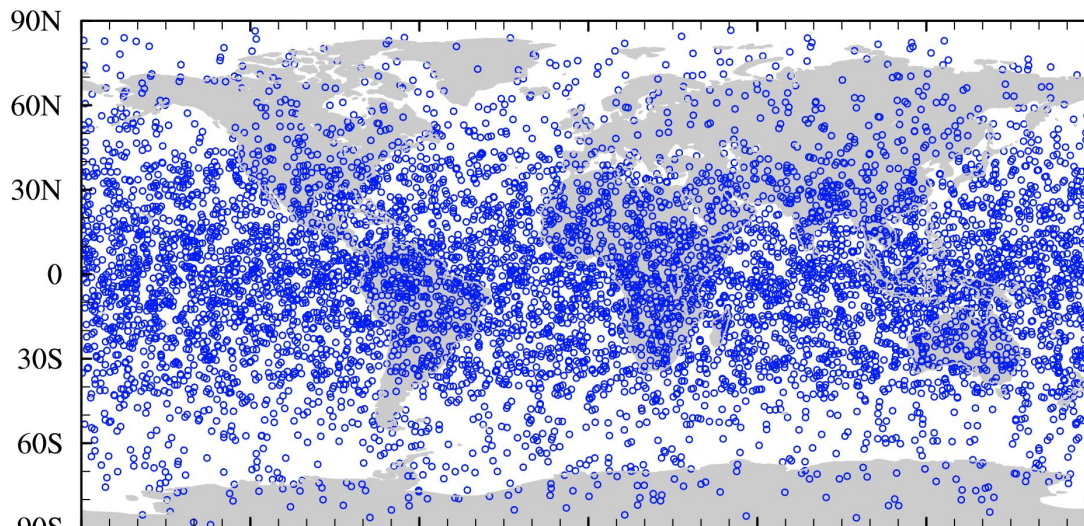
ROMEX Data Volume (estimated)

Mission	RO/day	Control
GRAS	1,200	y
COSMIC-2	6,000	y
US DO Order	5,500	n
EU Spire	1,400	n
GNOS	2,000	n
PlanetiQ	3,300	n
Yunyao	7,000	n
Binhu	100	n
KOMPSAT-5	300	y
PAZ	200	y
TerraSAR-X	100	y
TanDEM-X	100	y
Sentinel-6	800	y
Sum control	8700	y
ROMEX supplemental	19300	n
Sum ROMEX	28000	n

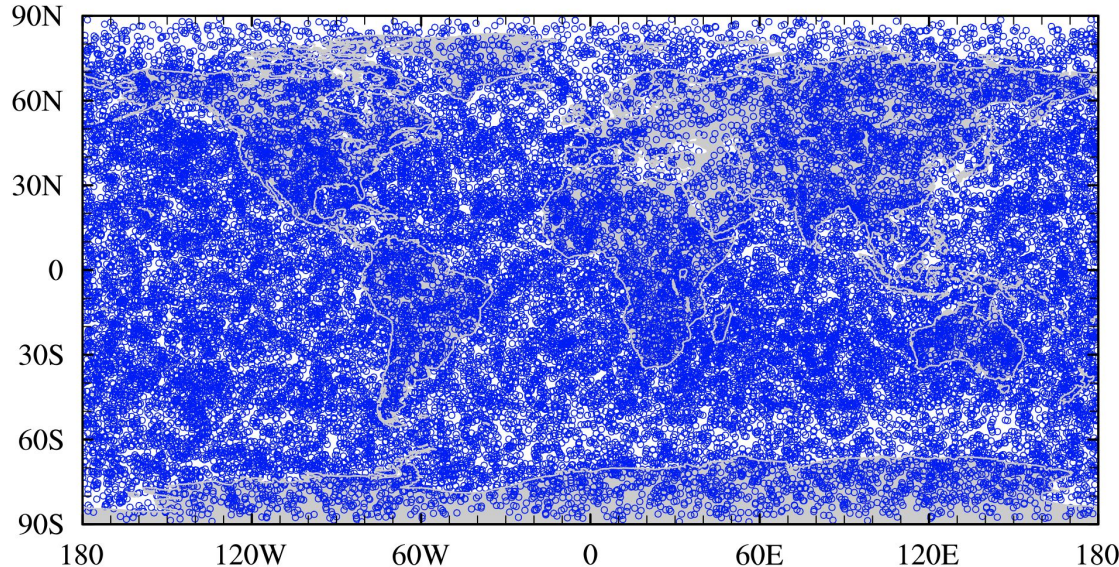
After IROWG-9 there have been 4 meetings, 2 each of the ROMEX data and experiment subgroups (Dec2022 and Feb2023) to define the data usage and a common set of overlapping experiments.

24 hour RO distributions (estimated) for ROMEX experiments

Control
(~7k profiles)



ROMEX
(~30K profiles)



Summary

The international Radio Occultation (RO) community has recently and collectively undertaken a collaborative effort to explore the impact of RO observations obtained and shared by the community through the RO Modeling Experiment (ROMEX)

The experiment will help answer some of the more pressing technical and programmatic questions facing the numerical weather prediction (NWP) community and help inform the near- and long-term strategies for RO missions and acquisitions by NOAA, EUMETSAT, and other international partners

The ROMEX committee has been formed since November, 2022 and make progress in the ROMEX procedures related to workflow, data collection, processing and dissemination, as well as initial experimental design.

The initial data distribution within the ROMEX is expected to be in June-July, 2023, followed by data quality assessment and NWP experiments in following months. Intermediate and final reports are expected to be presented in the upcoming CGMS/WGII meetings and at IROWG-10, 2024

Discussion will take place for following up actions based on the feedback received from ROMEX