IROWG specific topics for coordination with the CGMS

Presented to CGMS-54 Working Group II session, agenda item 10.1

Co-Chairs: Ulrich Foelsche (University of Graz)
Hui Shao (Joint Center for Satellite Data Assimilation, UCAR; transitioning to Naval Research Laboratory)
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With contributions from the IROWG members

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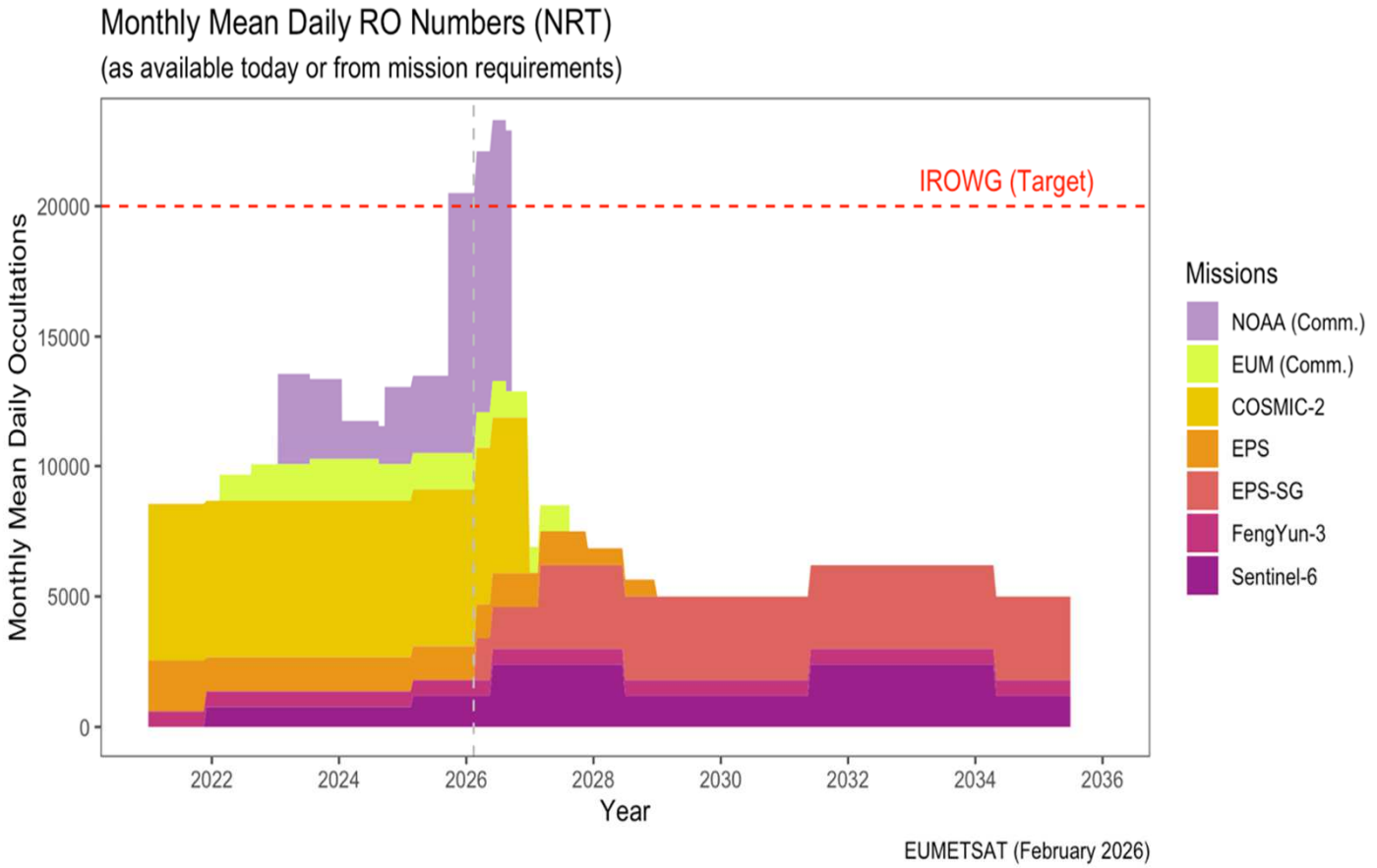
Executive summary of the WP

In this WP we will cover:

- Update on numbers of radio occultations (RO)
- Comments on the 8th CGMS risk assessment workshop
- ROMEX and its follow-up
- Updates to the HLPP
- The planned IROWG-11 workshop in September 2026

Update on numbers of radio occultations (RO)



- This update reflects recent NOAA data purchase 10000 profiles/day (Sept. 2025-2026)
- Final delivery order of RO Data Buy 2 (Sept. 2026-2027) is not reflected in this figure
- Note that COSMIC-2 is past end of life and is degrading more slowly than reflected in the figure
- Meeting “uniform global and local time coverage” remains a goal
- COSMIC-2 profiles are limited to latitudes between ± 40°

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Credit: Christian Marquardt (EUMETSAT)

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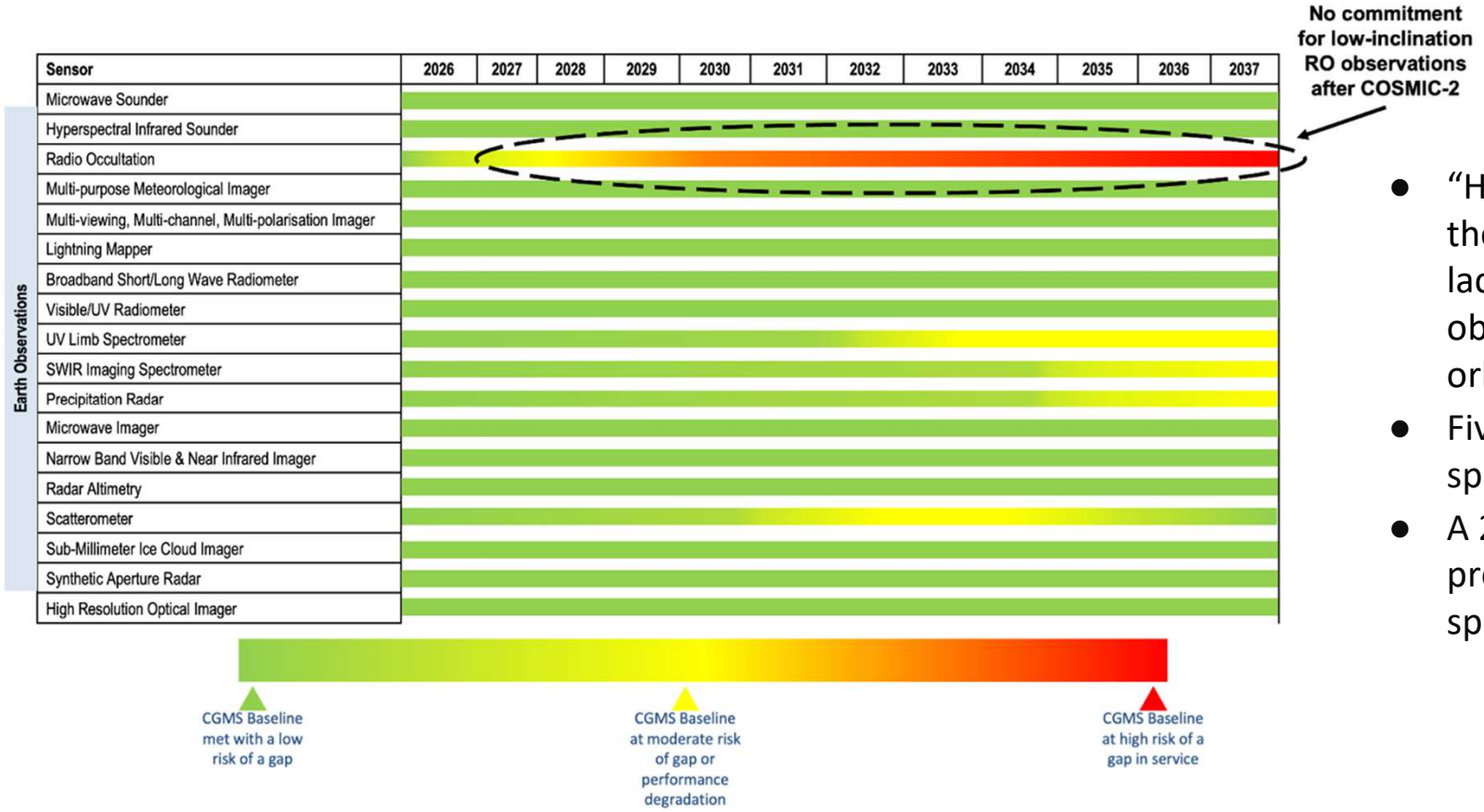
Comments on the 8th CGMS risk assessment workshop (1)



- "High risk of a gap in service" in the later part of the 2020s due to lack of commitment for RO observations from low inclination orbits.
- Five of the original six COSMIC-2 spacecraft are still operating.
- A 2023 reliability analysis predicted a 50% probability of one spacecraft failure every 2 years.

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From the 8th CGMS Risk Assessment workshop held 3-5 February 2026.

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Addressing the RO Continuity Risk

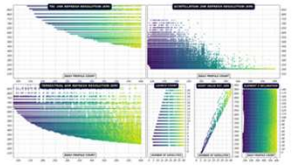
- As presented at the American Meteorological Meeting in Houston (January 2026) the NOAA/NESDIS goal for RO is a hybrid architecture consisting of commercial data and international partnerships.
- The “best value” to meet all weather and space weather constraints is by combining low-inclination orbits (below 40°) with polar sun-synchronous orbit components.
- Scientific considerations if acquiring a majority of data through purchase:
  - Availability of documentation describing level-0 data and the receiver algorithms used to produce it
  - Potential for pre-screening data before delivery to the customer that might inadvertently remove valid atmospheric profiles
  - Limited availability of state-of-the-art data products due to pricing considerations
  - Long-term archival risks associated with RO observations distributed across multiple commercial vendors, potentially impacting the continuity of long-term data records

Addressing the RO Continuity Risk (cont)

(NOAA, AMS 2026)

Architecture Performance Methodology & Results

The RO AoA developed a simulation to evaluate the performance of space architecture designs against NOAA objectives



Over 1.4 million solutions were repeatedly modeled and remodeled and assessed in a multi-objective trade space.

	Model System								Output Performance			
	HIGH-INCLINATION SEGMENT			LOW-INCLINATION SEGMENT			TOTAL SYSTEM		REFRESH RESOLUTION (KM) & DAILY COUNT PERFORMANCE			
Case	SATELLITES	LAUNCHES	INCLINATION	SATELLITES	LAUNCHES	INCLINATION	SATELLITES	LAUNCHES	NEUT. ATM.	TEC	Scintillation	Count
1	9	3	SSO				9	3	515	2040	305	15,000
2	6	3	SSO	2	1	45	8	4	550	1285	315	13,000
3	9	6	SSO				9	6	530	1050	280	15,000
4	6	3	SSO	3	1	0-31	9	4	500	990	205	14,000
5	6	3	SSO	6	1	36-45	12	4	440	770	205	18,500
6	3	3	SSO	6	1	20-36	9	4	500	990	205	13,500

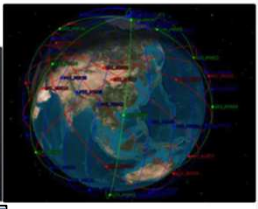
Does not meet constraints/continuity

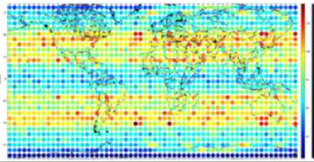
80,000 profiles/day available from Yunyao and TianMu as of July 2025

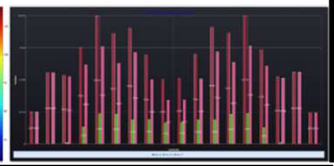
Yunyao Aerospace Constellation | Complete Constellation Plan

- By the end of 2025, a meteorological constellation of 90 satellites in orbit will be completed.
- Effectively enhancing China's meteorological observation capabilities through rapid networking of low orbit meteorological satellites.
- More than 150000 atmospheric occultation profiles and over 60000 ionospheric profiles can be obtained every day.
- Global-scale data with a spatial resolution of 200 km x 200 km and time resolution of 12~20min.





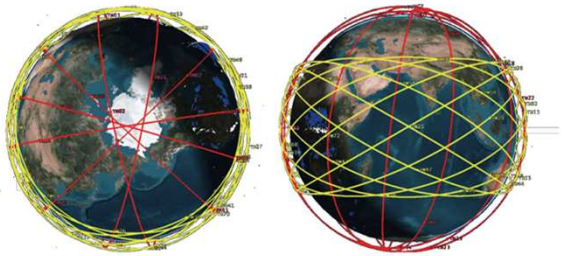




(CMA, CGMS-52 WGII, 2024)

TianMu-1 meteorological constellation

By 2025, the constellation construction will be completed, which can provide **80000 atmospheric profiles/day**, enabling global coverage of the sea surface within 3 hours and providing 3D atmospheric detection data with a grid resolution of 200 kilometers within 6 hours.



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CMA, version 1.0, Apr 22, 2024

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"IROWG strongly supports an open data policy towards the purchase of commercial RO data and recommends that all agencies follow this model. IROWG stresses the importance of free and unrestricted access to essential RO data including archived raw or low-level (level 0) data" (CGMS-52)

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ROMEX and its follow-up

- Endorsed at IROWG-9 (2022), ROMEX provides CGMS and partners with actionable RO observation number recommendations for NWP (ROMEX-NWP)
- Recommendations are uniquely based on real observations from both baseline and commercial RO missions
- Findings have informed HLPP updates and led to NWP configuration changes at several centers
- After two dedicated workshops and an IROWG meeting, the ROMEX common experiment period is now concluding
- Major NWP centers and research institutions contributed through a coordinated verification exchange
- Consolidated multi-center scorecards (by hemisphere, variable, and level) show overwhelming positive impact from RO assimilation increased RO number, up to ~35K profiles/day

Scorecard of 24-h forecast standard deviations from ROMEX (~35K RO profiles/day) versus CONTROL (~8K/day) verified against radiosondes and averaged over three months:

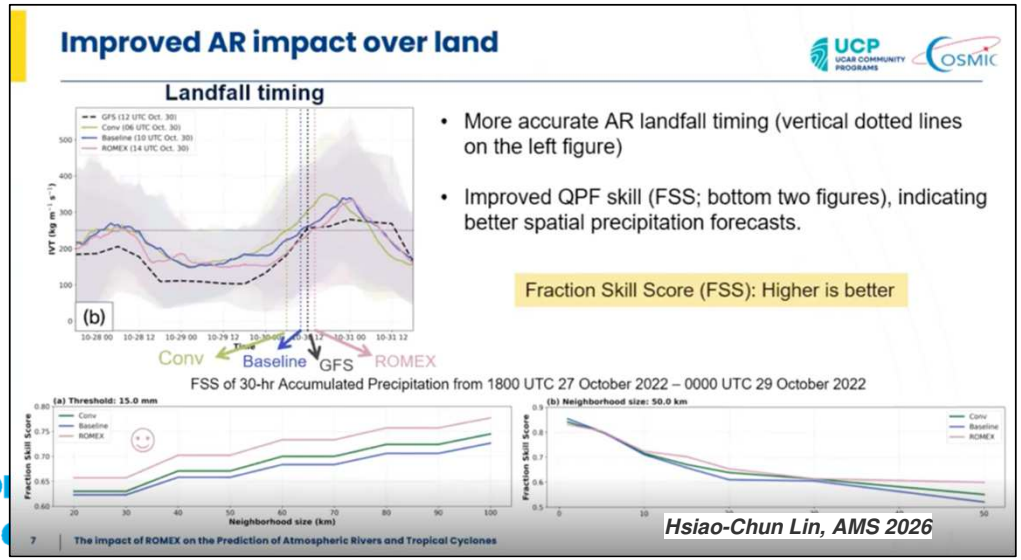
- Northern Hemisphere, Southern Hemisphere, and tropics
- Geopotential height, temperature, humidity, and wind at 100–850 hPa
- Met Office, KMA, Météo-France, ECMWF, and NCEP

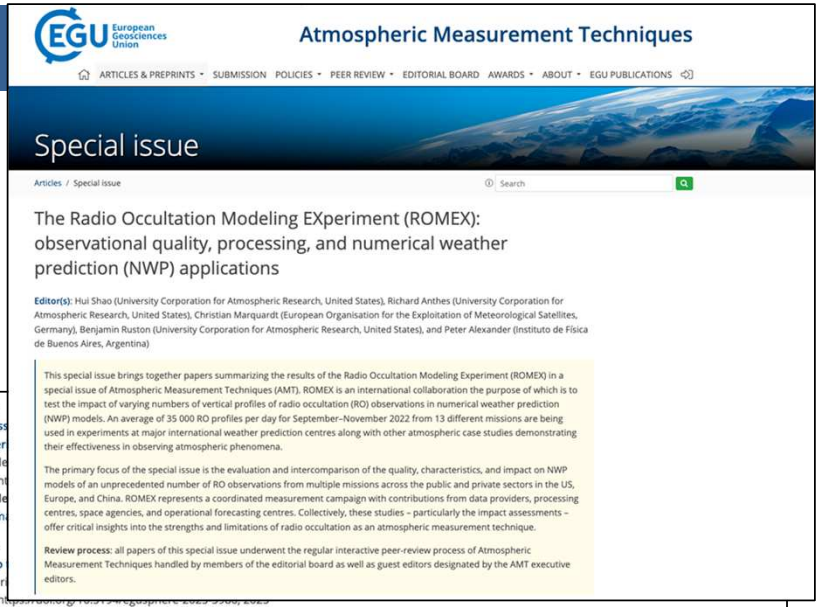
Region	Variable	Met_Office	KMA	METEO-FRANCE	DWD	ECMWF	NCEP
nhem	z100hpa	0.94447287	0.50803214	0.29296875	2.12030432	2.02268274	0.56580182
	z250hpa	0.58152535	0.54455517	-0.1269841	1.66710756	1.27267961	0.14304073
	z500hpa	0.74321451	0.36435586	0.94339623	1.31292613	1.41149994	0.66074003
	z700hpa	0.64750538	0.30465359	1.63043478	1.08140627	0.95898912	1.10282968
	z850hpa	0.53238084	0.4970877	1.51515152	0.34038112	0.58564926	1.44061875
	t100hpa	0.52051451	0.98063278	0.91743119	1.45683043	1.06167271	2.21153138
	t250hpa	0.31379397	2.1038022	1.02040816	2.02580917	0.97978872	0.98259942
	t500hpa	0.14121947	0.80955087		0.59230235	0.47403574	0.3736041
	t700hpa	0.12368309	0.39442439		0.47002565	0.33152303	0.02569515
	t850hpa	0.06336905	0.41772044		0.24986849	0.00902181	-0.1172687
	r100hpa	0.17636884	1.9352803		0.18790265		0.18801262
	r250hpa	-0.2288306	-0.3136436		0.89499172	0.27353373	0.16108571
	r500hpa	0.2426644	0.80869211	-0.0564016	0.72022161	0.60137784	0.4830167
	r700hpa	0.75367876	0.44121838	0.49352252	1.47882736	0.51461468	0.82990419
	r850hpa	0.19883565	0.53642109	0.34340659	0.68751386	0.0483009	0.20989121
	w100hpa	0.28249738	0.86646051	0.81300813	1.06603543	1.2274075	1.74684387
	w250hpa	-1.2783273	0.38718945		0.79482986	1.0041561	0.19444818
	w500hpa	-0.5002794	0.52085768	0.39525692	0.53414297	0.02241154	0.73834533
	w700hpa	0.40074163	0.30000029	0.41841004	0.54044221	0.35450626	0.9732341
	w850hpa	0.26903661	0.2580161		0.51078511	0.28742755	0.67280703
shem	z100hpa	5.73223974	-2.0415201	9.27449514	1.05207789	5.51451585	1.76140127
	z250hpa	3.56502639	1.66897668	2.92445167	0.68893231	3.93236533	1.64999402
	z500hpa	1.31992134	2.30522379	3.85786802	1.1402252	4.09853815	1.16543672
	z700hpa	2.32714185	-0.6630691	4.1567696	1.1058581	4.21338994	1.82232899
	z850hpa	2.20478623	-1.0321983	2.12014134	1.27543119	0.632206	1.03750797
	t100hpa	0.63929635	-0.2362168	1.75438596	1.79806595	0.67525573	2.02154935
	t250hpa	0.14366743	3.15042328		1.36142559	1.20585353	1.35509453
	t500hpa	1.0438662	1.47714145	1.25	1.39762404	1.73771556	2.87080648
	t700hpa	0.75576872	1.72954966	1	-0.5139537	0.49082717	-0.4373007
	t850hpa	-0.3989703	-1.4082701		-0.6910596	-0.2486562	-0.1514421
	r100hpa	-6.8997943	1.17136731		0.66559096		1.76568371
	r250hpa	-1.0937307	0.1231644		1.17706895	0.19506253	0.16139619
	r500hpa	-0.2017853	1.01157252	0.05521811	0.88605352	-2.2154552	0.10564648
	r700hpa	0.09133954	1.28172218	-0.5941771	0.35510081	-1.4821547	1.83115659
	r850hpa	0.40880958	0.433205	0.91324201	1.83235608	-0.4255492	-0.7162439
	w100hpa	0.80598576	0.33201731	1.06761566	1.58291457	0.57530591	2.68391443
	w250hpa	-0.1815993	1.04268431	0.58479532	1.76024256	1.55387594	2.06365112
	w500hpa	1.82917436	1.24952883	-0.3584229	1.12449745	0.41598991	1.60252851
	w700hpa	-0.0586376	0.36050992	0.37174721	0.69395524	1.37510135	0.99451668
	w850hpa	-0.3433326	-0.1653819	-0.3448276	1.37064385	0.03733258	-0.0668611
tropics	z100hpa	0.20988709	0.08188718	-0.4313444	0.04571878	0.63512828	-0.495709
	z250hpa	0.23536985	-0.1918493	-0.5876592	0.28320181	0.98919612	-0.4395182
	z500hpa	-0.1526506	-0.0181595	-0.7675439	1.58631415	0.44153618	-0.7378585
	z700hpa	0.11607797	-0.4954134	0.12562814	2.58882711	0.29933865	-0.1447429
	z850hpa	0.28697524	-0.5590014		1.74980056	0.31888204	0.01758045
	t100hpa	1.02319017	0.80672155	0.64935065	0.75664445	1.02236469	1.07946289
	t250hpa	0.65601303	-0.2423482		0.17350185	1.31963652	1.23469774
	t500hpa	0.85947566	0.00963837		-0.6475838	0.06444418	0.18964254
	t700hpa	-0.1441776	0.49556217		-0.4730242	0.61183604	-0.5233163
	t850hpa	0.38453894	-0.9201642	1.2345679	-0.175068	-0.0955158	1.10387135
	r100hpa	-0.9186995	0.51305276		0.07399397		0.27143032
	r250hpa	0.44613882	0.0858783		0.01030078	-0.0320912	0.72304087
	r500hpa	0.62337513	0.09406383	-1.2674271	0.44533919	0.63909097	0.15150895
	r700hpa	0.35402394	-0.0336692	0.9180791	1.2541749	0.72097031	1.05977339
	r850hpa	0.67369091	0.33493897	0.91059603	0.63587684	0.43222614	0.34283857
	w100hpa	1.11848748	1.07740101	0.85714286	0.71532172	0.86919131	1.94726605
	w250hpa	0.00213178	-0.4126985	1.00334448	0.73020116	-0.5647444	2.05543636
	w500hpa	0.24489991	0.62128622		0.4132501	0.88774759	0.42505932
	w700hpa	0.23024784	-0.0546438		-0.0162047	0.87903245	-0.0850195
	w850hpa	0.56506967	-0.4764394	0.44444444	-0.0985165	-0.227831	0.15129292

GREEN denotes improvement; **RED** denotes degradation, due to increased RO data assimilation at each NWP center.

ROMEX and its follow-up (cont)

- Dataset remains available to users under agreement; related and individual research continues, especially for model bias studies and regional applications (tropical cyclones, atmospheric rivers, etc)
- Synthesis of ROMEX results under development; AMT special issue in progress
- IROWG-11 will review ROMEX status and discuss follow-on activities
- Recommendations for the next phase of ROMEX expected from IROWG-11
- Extension to space weather applications (ROMEX-SW) under consideration





05 Mar 2026
How Does Ass
ROMEX Exper
William J. Mille
EGUsphere, ht
Preprint unde
Short summa

10 Dec 2025
An update to
Josep M. Apari
EGUsphere, h
Preprint under review for AMT (discussion: final response, 4 comments)
Short summary

25 Nov 2025
Processing Multiple GNSS RO Data Using FSI and ROPP: Results from the ROMEX
Yong Chen, Xinjia Zhou, Xin Jing, Shu-Peng Ho, Xi Shao, and Tung-Chang Liu
EGUsphere, https://doi.org/10.5194/egusphere-2025-5763, 2025
Revised manuscript under review for AMT (discussion: final response, 8 comments)
Short summary

24 Nov 2025
Evaluation of biases and uncertainties in ROMEX radio occultation observations
Richard Anthes, Jeremiah Sjoberg, Jon Starr, and Zhen Zeng
Atmos. Meas. Tech., 18, 6997–7019, https://doi.org/10.5194/amt-18-6997-2025, 2025
Short summary

04 Nov 2025
Impact Study of Increased Radio Occultation Observations during the ROMEX Period Using JEDI and the GFS Atmospheric Model
Hailing Zhang, Hui Shao, Benjamin Ruston, and John J. Braun
Atmos. Meas. Tech., 18, 6167–6184, https://doi.org/10.5194/amt-18-6167-2025, 2025
Short summary

03 Sep 2025
Experiments with large number of GNSS-RO observations through the ROMEX collaboration in the Met Office NWP system
Neill Edward Bowler and Owen Lewis
EGUsphere, https://doi.org/10.5194/egusphere-2025-4194, 2025
Revised manuscript accepted for AMT (discussion: final response, 12 comments)
Short summary

Updates to the HLPP

HLPP Task 1.1.4: *Ensure continuity of Radio Occultation observations with required quantity, geographical coverage and temporal sampling for numerical weather prediction and for ionospheric monitoring.*

- Risk posed by loss of functioning COSMIC-2 satellites over time (mission past end-of-life)
- If the risk is addressed with majority-commercial data, geographical and local time coverage should be characterized on an ongoing basis

HLPP Task 1.2.6: *Advance the atmospheric radio occultation constellation, with the long-term goal of providing 20000 occultations per day with uniform **global** and local time coverage on a sustained basis.*

- IROWG continues to endorse the long-term goal of 20000 occultations per day
- With recent data purchase, this goal is currently being met
- Without a low-inclination orbit component, even with recent data purchase, the goal is *not met* due to lack of necessary coverage

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IROWG INTERNATIONAL RADIO OCCULTATION WORKING GROUP

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IROWG-11 Meeting Organization

- September 10 – 16, 2026, Seggau Castle, Austria, together with OPAC-8
- Hosted by the University of Graz
- The website for the workshop will be: https://opacirowg2026.uni-graz.at/en/
- Full workshop, including presentations, posters, plenary sessions, sub-group discussions, and social activities
- Four working subgroup meetings: Numerical Weather Prediction (NWP); Climate; Innovation; Space Weather
- Feature special ROMEX sessions
- Outcome: CGMS recommendations, internal action items, a summary of relevant activities, and meeting minutes



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Backup