REPORT OF THE 51st PLENARY SESSION OF THE COORDINATION GROUP FOR METEOROLOGICAL SATELLITES

EXTRACT
WORKING GROUP II

DRAFT REPORT available for plenary as an information document (CGMS-51-WGI-WP-09)
If updates are needed, please send these to cgmssec@eumetsat.int

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PARALLEL WORKING GROUP SESSIONS

WGII REPORT

Chair: *J. V. Thomas ISRO*
Acting Co-Chair: *H. Pohjola, WMO*
Rapporteur: *P. Ruti, EUMETSAT / M. Goldberg, NOAA*

1. Opening, objectives and expected outcomes

Morning session chaired by Natalia Donoho (NOAA). The opening session put forward the following expected outcomes:

i) Provide a scientific forum for CGMS agencies to address global issues and challenges with respect to data and products generation from their specific satellite systems
ii) Address areas of mutual interest and advice agencies on topics related to development and use of satellite data and products, and related coordination activities, including on relevant issues for the implementation of the Vision for the WMO Integrated Global Observing System (WIGOS) in 2040
iii) Provide guidance on questions related to satellite data and products to user communities, such as those organized in the WMO Application Areas
iv) Act as CGMS interface, at expert level, to other groups and organisations in areas of satellite data and products, with respect to science and product development, and instrument calibration activities
v) Promote common standards and methodologies in the area of product generation (Level-1 and -2) including calibration;
vi) Address scientific and operational aspects of the satellite data production systems at international level
vii) Exchange and harmonise, where applicable, user requirements for satellite data and products
viii) Address topics from the CGMS High Level Priority Plan within the scope of WGII;
ix) Arrange efficient reporting from the ISWGs and other CGMS-related international initiatives to WGII and CGMS Plenary
x) Ensure a scientific dialogue at CGMS Member agency level on pertinent issues and high priority scientific challenges
xi) Support the work of the ISWGs and provide actions and recommendations for this purpose;
xii) Assess recommendations from the ISWGs and provide guidance to the CGMS Plenary on issues raised
xiii) Support the preparation of selected thematic Plenary session.

WGII endorsed Heikki Pohjola (WMO) as the incoming co-chair after the retirement of Kenneth Holmlund (WMO)

2. CGMS agency reports on highlights and issues in dataset and product generation [150']

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CGMS-51-CMA-WP-04 - CMA agency report on highlights and issues in dataset and products

Executive Summary

- FY Historical satellite data repossessing dataset for 13 satellites and 7 types instruments has been constructed spanning 30 years, including 7 FCDR and 4 TCDR to significantly improved quality of the dataset, and strongly supported the application research of remote sensing data in China.
- FY-3G, the first satellite of China to measure precipitation with the active dual-frequency radars in space, has been successfully launched on April 16, 2023. Four instruments have been turned on and running in good condition, and in-obit testing will be carried out in the following 6 months.
- CMA developed an automated hailstorm likelihood estimation algorithm, demonstrating the potential and advantages of Fengyun satellites in weather nowcasting.

NOAA personnel enquired whether the CMA was developing a Small- or CubeSat programme, and the CMA responded that although nothing had been decided yet operationally speaking, there was an on-going scientific project.

CGMS-51-EUMETSAT-WP-04 - EUMETSAT report on highlights and issues in dataset and product generation

Executive Summary

- MTG-I1 successfully launched on December 13, 2022 at 21:30 CET
    - The Commissioning of MTG-I1 is to be divided into two main parts: Satellite in-orbit verification (done by ESA & Industry) and System commissioning, including end-to-end processor science validation (done by EUMETSAT)
- FCI first full disk acquisition took place on 15 March. 'First image' to be published on 4th May, 2023
- Lightning Imager (LI) full activation is to follow on the week starting 17th April
- Future plans: MTG-S to be launched early 2023, MetOp-SG-A in mid-2024, MetOp-SG-B in mid-2025 and MTG-I2 in mid-to-late 2025
- The operational follow-on to ESA's Aeolus DWL (EPS-Aeolus) and a new MW Sounder constellation of SmallSats (EPS-Sterna) are both in preparatory phases (0-A-B). Full scientific and socio-economic benefits analyses for both programmes are to follow shortly
- EUMETSAT has been paying interest to the development of AI/ML, particularly on the potential to change Nowcasting and NWP
- Next EUM Meteorological Conference to be held on Sept. 11-15th in Malmö, Sweden

CGMS-51-IMD-WP-01 - IMD report on highlights and issues in dataset and product generation

Executive Summary

- Two GEO satellites operated by IMD (INSAT-3DR and INSAT-3D) presented
- IMD reported on MMDRPS – A new Indian data processing system, designed to handle the data from the INSATs. Provides computing resources which enable acquisition, processing, archival and dissemination of complete meteorological data sets
- New products Developed:

    - Storm index, Experimentally-derived detection of storms every 15 minutes by integrating OLR from INSAT and reflectivity from precipitation radar on-board TRMM
    - Climate product, gridded (0.1°) OLR product using GSICS-corrected INSAT-3D, for between 2014-2020. Tests showed broad agreement with other observation with bias of ca. 5-6 W/m^2 over continental India. Testing in the wider Indian ocean region to follow to fill the gap in CDR
- RAPID V2: RAPID scan facility of INSAT-3DR Imager, was demonstrated on tropical cyclones in the Northern Indian Ocean during 2022

CGMS-51-ISRO-WP-03 - ISRO report on highlights and issues in dataset and product generation

Executive Summary

- Presently, 2 satellites INSAT-3D and INSAT-3DR are operational (by IMD) in GEO. Sounder on-board INSAT-3D is not functioned since Sep 2020.
- EOS-06 (Oceansat-3) was successfully launched on 26 Nov, 2022 with K_u-band scatterometer, DualBand Sea Surface Temperature Monitor (SSTM), and a 13-band Ocean Color Monitor (OCM-3).
- In-Orbit Tests (IOT) have recently been completed and CAL/VAL phase is on-going. Data from Scatterometer and OCM-3 to be released to users very soon. SSTM operations have been stopped due to in-orbit anomaly in its scan mechanism.
- EOS-07 (Microsat-2B) was launched on 10 Feb, 2023 in low-inclination orbit with a 6-channel Microwave Humidity Sounder (MHS) on-board.
- ISRO-CNES joint mission SARAL/AltiKa is functioning in 'mispointing' mode and the mission was extended till December 2024, provided the health of the satellite remains satisfactory.
- INSAT-3DS is planned to be launched later this year, 2023, with many improvements to mitigate the issue related to the blackbody calibration and midnight sun-intrusion.
- GISAT-2 is scheduled for launch in March 2024.
- Under GSICS, inter-calibration of IR channels are in demo phase with IASI-B/C and shortly extended to CrIS. Ray-Matching method has been developed for inter-calibration of Vis/SWIR channels using MODIS and 6 years (2016-2021) data has been processed for INSAT-3D/3DR VIS/SWIR channels.

Participants requested clarification on whether the 6-Channel MHS mission EOS-07 was planned to be a SmallSat? ISRO responded affirmatively, stating that the mission should be seen broadly as a demonstrator and, if all were to go well, ISRO may consider to follow-up with a MHS constellation.

CGMS-51-JAXA-WP-01 - JAXA report on highlights and issues in dataset and product generation

Execute Summary

- JAXA's Earth Observation satellite program and data product in operation and to be launched
- Contribution to water cycle and climate studies, disaster mitigation, and various operational applications, including weather forecast, fishery, and agriculture, is a big target of JAXA's Earth observation missions.

- To this purpose, JAXA currently operates six EO satellites/missions in orbit, and will continue those contributions by launching new satellites in near future.
    - The reprocessing during about 20 years for the new version of the GSMaP will be distributed by mid-May.
    - GCOM-C has achieved the 5-year nominal mission phase and been in the post-mission phase since Jan. 2023.
    - JAXA's Mission for Next-generation Precipitation Radar (PMM)
- In terms of the WMO project for monitoring extremes, JAXA contributes to the WMO SWCEM Project by providing GSMaP rainfall product with climate normal.
    - In June 2022, JAXA started to distribute the GSMaP real time data (GSMaP_NOW) to the SWCEM members.
    - JAXA is preparing the release of the reprocessing GSMaP data, as noted the above, and will re-calculate the climate normal again for the WMO project.
- JAXA also reaffirmed their intent to collaborate with various model communities to utilize satellite data in their models to enhance future predictions and contribute to science and society.

EUMETSAT asked JAXA representatives about the anticipated timeline for PMM, given the current planned/proposed synergies between European and American agencies for precipitation missions. JAXA responded the current timeline would fit very well into the European and American plans, as PMM is anticipated to be ready for launch in Spring, 2029.

NOAA staff asked JAXA representative about whether or not JAXA had long-term plans for the continuity of AMSR. JAXA noted that AMSR3 was planned to be on-board the next JAXA EO satellite, planned to be launched in 2024, securing coverage into the 2030s. Longer term plans are currently under discussion within JAXA and amongst the end users of AMSR data, though no plans are as-of-yet forthcoming. NOAA noted the possibility of synergy of a potential next generation AMSR with its own planned GeoXO throughout the 2030s.

CGMS-51-JMA-WP-04 - JMA report on highlights and issues in dataset and product generation

- JMA switched over from its operational Himawari-8 geostationary satellite to its Himawari-9 unit on 13 December 2022, after a period of quality monitoring for the latter's Advanced Himawari Imager (AHI) and parallel dissemination of Himawari-9 (starting on 27 September 2022). The details of this monitoring will be presented in CGMS-51-JMA-WP-03.
- Himawari-8/9 radiometric calibration bias and image-navigation biases
    - Parameters for sensor sensitivity correction for bands 1 to 6 have been updated on annual basis. The last update was implemented for Himawari-8/AHI on 11 July 2022.
    - Calibration monitoring data for the AHI, along with information from health check observation, is available on JMA's calibration monitoring page based on the ray-matching approach commenced to support NOAA20/VIIRS from June 2022 in addition to SNPP/VIIRS.

  - The dataset for input in radiative transfer model-based calibration monitoring was updated from JRA-55 to JRA-3Q in November 2022 in relation to a JMA reanalysis project.
- Himawari-8/9 products
  - Himawari-8/9 products, including Atmospheric Motion Vectors (AMVs), Clear Sky Radiance (CSR), and Highresolution Cloud Analysis Information (HCAI), are generated at JMA/MSC and disseminated via the Global Telecommunication System (GTS) and the JMA Data Dissemination System (JDDS).
  - SST data are provided for JMA's regional SST product, aerosol data are provided for data assimilation in JMA's aerosol prediction model, and CCI and fog detection data are provided for aviation safety.
- Information on Himawari Observation
  - At around 04 UTC on 15 January 2022, a large-scale eruption occurred at the Hunga Tonga-Hunga Ha'apai volcano near Tonga. The Himawari-8 AHI observed the rapid spread of the volcanic fumes emitted and the propagation of the resulting pressure wave. Imagery relating to the event is provided on JMA's website at https://www.data.jma.go.jp/sat_info/himawari/obsimg/image_2022.html (Japanese only).

CGMS-51-JMA-WP-05 - Follow-up report on the project for enhancing utilization of Himawari-8/9 Data - Rapidly Developing Cumulus Area (RDCA) detection [__']

- JMA has provided Convective Cloud Information, including Rapidly Developing Cumulus Area (RDCA) for aviation customers. RDCA is determined using only Himawari-8/9 observation data.
- JMA has cooperated with Malaysia (MET Malaysia), Singapore (MSS), Thailand (TMD) and Vietnam (VNMHA) as part of the ESCAP/WMO Typhoon Committee Project.
- These NMHSs and JMA exchanged letters, and JMA provided them with the source code for RDCA determination.
- Individual NMHSs installed the program on their system and ran it as an initial-test.
- JMA plans to evaluate RDCA determination and tune the program, if necessary.

EUMETSAT asked the JMA if they assimilate lightning data into NWP or nowcasting models. JMA responded that lightning data was not yet operationally assimilated, that so far it has only been used in research or validation purposes

CGMS-51-KMA-WP-02 - KMA report on highlights and issues in dataset and product generation

Executive Summary

- KMA presented their new approaches for users, noting the application of AI/ML technique(s) for weather missions:
  - The Model classifies GK2A fog into 3 types (danger, caution, attention) as a road hazard weather service according to visibility. This provides fog information to drivers through mobile navigation, and increases the use of 'visibility instruments' on highways to improve the accuracy.

    - The technique provides an AI-based 'proxy radar' using GK2A data, every 10 minutes, for a no radar observation area. This is especially useful in the pathway of typhoon and northerly-flowing convective clouds flow into the southern part of Korea.
- KMA noted an extension of scope to climate mission support, including:
    - Monitoring flash drought, due to heat wave over Korean Peninsular with satellite derived SM, EVT, LST, VHI etc. and anomaly of SM and EVT.
    - Providing various composited maps of GHGs at the global, east Asia and Korea-scales by using GOSTAT-1/2, OCO-2/3. This was compared with ground based GAW and TICCON data. It will be fundamental for GHG monitoring at KMA
- Application of Geo-hyperspectral infrared sounder at KMA
    - Retrieve T & q profiles from FY4B and plan for OSSEs using proxy hyperspectral infrared sounder

NOAA asked KMA why the CO_2 measurements on TCCON are so different to in-situ measurements. KMA noted that the comparison of satellite data with observations made at the ground-level can be difficult because ground level CO_2 can be influenced by strong, local sources. This can potentially lead to positive biases when compared to satellite column-based retrievals of XCO2

CGMS-51-NASA-WP-03 - NASA report on highlights and issues in dataset and product generation

Executive Summary

NASA continues to operate a network of eight high performance differential absorption tropospheric ground-based ozone LIDAR instruments that are deployed in locations across the continental US.

- Field Campaign: The Convective Process Experiment in Cabo Verde (CPEX-CV) in summer of 2022. Follow-up to previous CPEX-AW campaign conducted in 2021. The goal was the analysing of the lifecycle and properties of convective systems in the Inter-Tropical Convergence Zone (ITCZ) and assessing the impact of assimilated CPEX data on prediction skill of tropical, Atlantic weather systems. Validation was done against similar observations from space-based platforms
- The Airborne Visible Infrared Imaging Spectrometer (AVIRIS) and the AVIRIS – Next Generation (AVIRIS-NG) instruments flights were conducted in pursuit of a diverse set of science and applied science goals. The instruments provide measurements in the visible through shortwave infrared wavelength range at 10 and 5 nm spectral resolution respectively. The third generation AVRIS, AVIRIS-3 instrument, will begin making measurements in 2023. Compared to AVIRIS-NG, AVIRIS-3 is a more compact instrument with 4x improved throughput and a wider field of view.
- GHG monitoring on-board the ISS: an instrument developed principally to study mineral dust as part of Earth Surface Mineral Dust Source (EMIT) investigation is also sensitive to some GHGs, i.e. CO_2 and CH_4. The instrument is another NASA contribution to climate monitoring. NASA is using EMIT observations for detecting and mapping of carbon point-sources.
- In July 2022, the Modern-Era Retrospective analysis for Research and Applications - 2 (MERRA-2) released the Stratospheric Composition Reanalysis of Aura Microwave Limb Sounder (M2-SCREAM) data product. This stratosphere-focused chemical reanalysis provides assimilated global 3D fields of ozone, water vapor, hydrogen chloride (HCl), nitric acid (HNO_3), and nitrous oxide

(N_2O) mixing ratios. The assimilated fields, from 2004 to present are provided at a 50-km horizontal resolution and at a three-hourly frequency. The product assimilates Microwave Limb Sounder (MLS) profiles of the five constituents alongside total ozone column from the Ozone Monitoring Instrument.

- In September 2022, the National Snow and Ice Data Center (NSIDC) released version 2 of the Sea Ice Concentrations from Nimbus-7 SMMR and DMSP SSM/I-SSMIS Passive Microwave Dataset. The product contains daily and monthly sea ice concentration (fractional area coverage) for the Arctic and Antarctic regions on NSIDC's 25 km polar stereographic grid.

EUMETSAT asked for a status update on the Earth System Observatories, a series of satellite missions which aim to provide key information to guide efforts related to climate change, disaster mitigation, fighting forest fires, and supporting agriculture. NASA responded that the scope of the project is still under discussion between NASA, NOAA and planned international partners

CGMS-51-NOAA-WP-06 - NOAA report on highlights and issues in dataset and product generation

Executive Summary

- In 2022, NOAA/NESDIS launched NOAA-21 (Nov. 10) and GOES-18 (March 1). GOES-18 entered service as GOES West on January 4, 2023. GOES-R Series satellites are planned to operate into the 2030s.
- NOAA and NASA have already begun work on the next-generation geostationary mission called Geostationary Extended Observations (GeoXO). The Department of Commerce formally approved the GeoXO Program on Dec. 14, 2022. GeoXO will continue observations provided by GOES-R and bring new capabilities to address our changing planet and the evolving needs of NOAA's data users.
- Once NOAA-21 is fully commissioned and science products are provisional, notionally a year after launch, NOAA-20 will transition a quarter orbit ahead of S-NPP. NOAA-21 will then become the primary satellite, NOAA-20 will become the backup satellite, and Suomi-NPP will become the tertiary satellite in the JPSS constellation.
- The Near Earth Orbit Network (NEON) Program will supplement and eventually replace NOAA's Joint Polar Satellite System (JPSS). JPSS will continue to operate its series of polar orbiting satellites through the late 2030's. NEON will lay the groundwork for the next generation of LEO satellites long before the final JPSS launch takes place. NEON will continue, improve and extend NESDIS' global observations for weather forecasting, disaster management, and climate monitoring.
- Space weather is one of the largest threats to modern society and is yet the least known. It has the ability to affect national security, such as power grids, GPS, aviation, satellites, and our economic well-being. According to a recent National Research Council report [2009], geomagnetic storm-disabled electric power grids and collateral impacts could result in projected economic and societal costs of up to $2 trillion dollars per extremely large storm, and full recovery could take 4-10 years. NOAA's Space Weather Follow-On (SWFO)-L1 will maintain observational continuity of realtime solar imagery and solar-wind measurements and replace the two legacy missions - DSCOVR and SOHO. The SWFO-L1 observatory will be placed at the first Sun-Earth Lagrange point

(L1) with the goal of providing images and data critical for the operations of the National Weather Service's (NWS) Space Weather Prediction Center (SWPC) alerts and forecasting.

- NOAA is transitioning all its product generation to the Cloud, including reprocessing. NOAA defines its commitments to the user community through the NESDIS Level Requirements, The Product Baseline, and the 5 Year Product Plan.

EUMETSAT and JAXA asked NOAA officials what they considered to be the product baseline for surface products. NOAA replied that they see potential in (both technologically speaking and in the ability to get through congress) flood mapping, wildfire and air quality, the so-called 'big three' environmental issues in the United States at the moment. This means NOAA is paying particular effort to developing products and services around these three areas, on top of the normal workflow

CGMS-51-ROSHYDROMET-WP-03 - ROSHYDROMET report on highlights and issues in dataset and product generation

Executive Summary

- Roshydromet launched a new Geostationary satellite, ELEKTRO-L N4, on 5th February 2023
- Roshydromet combined seamlessly a mosaic of images from VIS and IR data from Arktika-M N1, Elektro-L N2, Elektro-L N3 and Elektro-L N4 satellites as a demonstration
- Developed a new AI cloud masking product. Able to be used for both day- and night-time conditions. Technology uses neural networks and Roshydromet determined an average accuracy of 91%
- New products presented:
    - Cloud parameters including: cloud top temperature and cloud top height.
    - Real-time detection of precipitation zones across Russia using GEO satellite data, combined with NWP forecast products
    - Close to the surface wind speeds and directions in the Arctic region
    - Regional fire monitoring / volcanic eruption product. Able to see and trace ash and smoke plumes
    - New AMV retrievals using Elektro-L N3, verified against radiosonde winds
    - Retrieval of CO_2 total column concentration using hyperspectral IR sounder over Russia. Shows seasonal CO_2 cycle compares well to other records (NOAA-20, OCO-2, GOSAT)

EUMETSAT enquired as to why the CO_2 seasonal cycle is not captured well by other data records. Roshydromet posited that the discrepancy may be due to the fact that other agencies and data-processing centers are adjusting their data records according to TCCON data from satellite observations, whereas Roshydromet use in-situ measurements, taken from tower in Siberia.

CGMS-51-WMO-WP-02 - WMO Data Policy and Satellite Data (core data)

The WMO provided an update of the activities undertaken to establish core satellite data, as per the new WMO Unified Policy for the International Exchange of Earth System Data (Res. 1).

- Approved by members in 2021, the new core data policy replaces the old resolutions for weather, climate and hydrology creating a single, unified policy

- Per the policy, WMO defines both 'core' Data, which must be free and unrestricted and 'recommended' data, which the WMO believes should be exchanged
- The policy covers only member states. It claims no authority over the activities of the private sector
- To date, no data sets have been labelled as 'core' or 'recommended', but features of what the data sets will include has been established in WMO documentation
- WMO recommends that agencies should nominate representatives to decide what data sets should be 'core' or 'recommended', such that a common view can be established by Q4 of 2023, and then endorsed shortly thereafter by the WMO congress

NOAA asked the WMO to clarify whether the intentions for the core data policy should be to restricted to the future, i.e. next-generation data generated by new missions, or if the WMO plans to generate also an archive of data. WMO's current plans are primarily targeting next-generation systems and that any idea to create an archive of historical data which might be considered 'core' by the standards in this policy will come later.

Lars Peter Riishøjgaard made the point that there is a need to respect the space agencies and member states' decision-making sovereignty on policy, to ensure the future of data exchange. Exchange has proven to be crucial for weather, air quality and climate applications, and suspects that exchange of data records (e.g. for climate) will become the norm in the late 2020s, after the core data policy is finalized and implemented.

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3. CGMS International Science Working Groups [120' incl. discussions]

3.1 GSICS EP Specific topics for the attention of CGMS [15']

CGMS-51-GSICS-WP-01 - GSICS Report

Executive Summary

Global Space-based Inter-Calibration System (GSICS) is an international collaborative effort initiated in 2005 by the World Meteorological Organization (WMO) and the Coordination Group for Meteorological Satellites (CGMS) to monitor, improve and harmonize the quality of observations from operational weather and environmental satellites of the Global Observing System (GOS). GSICS aims at ensuring consistent accuracy among space-based observations worldwide for climate monitoring, weather forecasting, and environmental applications.

This year's meeting of the GSICS Research and Data Working Groups (GRWG and GDWG) was hosted in hybrid mode by NOAA at College Park, MD, USA 27 Feb – 3 March 2023.

Relevant current topics includes expanding GSICS to provide inter-calibration for:

1. Space Weather
2. GHG constellation
3. Ocean Surface Vector Winds

and adding commercial providers as members.

3.2 ICWG Specific topics for the attention of CGMS [15']

CGMS-51-ICWG-WP-01 - ICWG activity updates and recommendations

Executive Summary

The ICWG presented the activities and relevant discussion items of the ICWG since the CGMS-50 meeting. It includes:

- An introduction to the CGMS of the new co-chairs of the ICWG (From NOAA and DWD)
- An update of ICWG-3 planning (Feb 2024)
    - A dedicated session on using lightning observations from space is planned
    - Discussion session also planned on combining all datasets from CGMS agencies' GEO satellites into one (the so-called GEO-RING)
- A new report is set to be released by the ICWG, retailing the results of an inter-comparison of cloud properties from GEO and polar-orbiting satellites. This was focused on high impact applications such as AMW, winds, all-sky radiances, and cloud height
- The next in the series of half-day virtual 'tag-ups' (November, 2023), a discussion of the HLPPs and related actions, and an update from the ISCCP-NG TG.

3.3 IPWG Specific topics for the attention of CGMS [15']

CGMS-51-IPWG-WP-02 - IPWG activity updates and recommendations

Executive Summary

- After postponements in 2020 and 2021, the IPWG-10 meeting took place during 13-17 June 2022 at Colorado State University (CSU), US (week of CGMS-50).
- 173 attendees (in-person and online total), 94 presentations, 22 countries represented
- The Baseline Surface Precipitation Network (BSPN) Working Group is drafting a strategy for a uniform quality radar/gauge database, with inputs from QPE experts
- The CubeSat/SmallSat Constellation Working Group is designing a OSSE framework to assess sensor capabilities (channels, resolution, sampling)
- The Multi-satellite precipitation Working Group is soliciting user needs from global product producers, and global product producer needs from the research community
- The Machine Learning Working Group is developing a standard training and independent test data set for individuals to evaluate ML algorithm capabilities in a consistent fashion.
- Planning for IPWG-11 as Tokyo, Japan, in July 2024

NOAA participants commented that precipitation product comparison and validation system NPrecipSe should be considered very useful and a very big achievement. European and Asian agencies and Met Service should consider to create their own versions of this system and, via the IPWG, work to improve further the existing system (only available in the continental United States).

EUMETSAT asked the IPWG if there exists any ideas/plans to propose a Cube- or SmallSat OSSE? The IPWG replied that plans for an OSSE are in fact currently being drafted, with an aim to be finalized at the IPWG in Tokyo, Japan in 2024.

3.4 IROWG Specific topics for the attention of CGMS [30']

CGMS-51-IROWG-WP-01 - ROWG update on recommendations and activities

Executive Summary

- Dr. Sean Healy has stepped back as the IROWG co-chair, being replaced by Dr. Hui Shao from UCAR/Joint Center for Satellite Data Assimilation, who was elected by the IROWG community. The formal handover took place at the IROWG-9 meeting in September 2022 in Leibnitz, Austria.
- The meeting was the first held in-person since the beginning of the Covid-19 pandemic, featuring over than 100 participating scientists and experts from all major RO processing centers, agencies, weather predicting centres, commercial data providers and researchers. This participants were divided into 4 working subgroups: NWP, Climate, Receiver Technologies and Innovative Occultation Techniques, and finally Space weather.
- There were additional dedicated sessions to: BUFR format revisions, level-0 data format definition and future radio occultation operator development.
- Scientific and technical developments coming out of the meeting include the full exploitation of every GNSS satellite constellation, an acknowledgement of the impact of RO-observations from NOAA and EUMETSAT commercial data buys in NWP, developments in the use of GNSS-RO for climate applications and the acknowledgement for the creation of a RO climate data record, and presentations of the results of a GNSS-RO gap analysis, showing there exists a potential danger of a gap in the number of occultations per day, starting in ~2027 when COSMIC-2 is set to reach end-of-life.

Participants noted that the 20,000 occultations/day figure, which had recently been reaffirmed by study, is still not closed to being reached; and agencies are not even meeting the WMO's recommended threshold number of 14,000 occultations/day. This comes before the COSMIC-2 gap referred by IROWG.

A discussion about how to meet these goals followed. NOAA made the point that both it and EUMETSAT have engaged the private sector to deliver occultations, but these were expensive and only on a pilot-basis. Lars Peter Riishøjgaard suggested that agencies should attempt to 'share the burden' in acquisition of occultations, including with commercial data buys from the private sector and that a WMO framework may be helpful in ensuring both fairness and that the data which reach NWP centers are broadly similar so that they are working with the 'same sense of the truth'.

CGMS-51-IROWG-WP-02 - The RO Modeling Experiment (ROMEX)

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.

The IROWG additionally made the point that the orbits of GNSS-RO missions are often not specifically considered which may lead to gaps in coverage, as a big determining factor for which orbit is selected may often just come down to what is available in terms of launch services. They also note that GNSS-RO satellites also have to be designed with certain orbits in mind, using the orientation of the solar panels as an example of this

NOAA suggested that the 'backbone' number of government-owned and operated, GNSS-RO-capable satellites should be decided at both agency level and in collaborative bodies like CGMS

3.5 ITWG Specific topics for the attention of CGMS [15']

CGMS-51-ITWG-WP- - ITWG activity updates and recommendations

Executive Summary

ITWG held the ITSC-23 in Tromso, Norway in March 2023. The event featured 166 participants and reports from agencies, NWP centres and from other CGMS working groups. Event working groups focused on:

- AI/Machine Learning applications
- Small- and CubeSat data assimilation
- GEO Hyperspectral Sounder data assimilation
- 'Earth System Approach'
- Potential sharing of computing resources
- There were also 2 technical sub-groups, dealing with RTTOV / CRTM (radiative transfer models) and Radio-Frequency interference.

The event generated a number of recommendations to be considered by the CGMS, GSICS, space agencies and data providers more broadly.

NOAA participants found it unrealistic for agencies to share computing resources to NWP centers, particularly internationally. A more realistic approach might involve the cost of operations being spread out amongst the various stakeholders, or sharing resources but in the specific context of a OSSE

3.6 IWWG Specific topics for the attention of CGMS [15']

CGMS-51-IWWG-WP-03 - IWWG Report

Executive Summary

The presentation given at GCMS-51 presented the activities and relevant discussion items of the IWWG since the CGMS-50 meeting. It included:

- An introduction to the CGMS of the new co-chairs of the IWWG
- An update of IWW16 planning (May 8-12, 2023)
- An update on the 4th AMV Inter-comparison
- A discussion of the HLPPs and related actions
- An update from the OSW TG

3.7 IESWG The International Earth Surface Working Group [15']

CGMS-51-GUEST-WP-06 - IESWG activity updates including updated ToRs for an IESWG CGMS International Science Working Group for WGII review

Executive Summary

Updated IESWG ToR iterated between the CGMS WG-II, IESWG and ITWG

The IESWG continues to work towards CGMS recognition as there is a need for a group with the unique combination of data assimilation and Earth surface modeling experts to fully exploit existing and future observations.

The International Earth Surface Working Group (IESWG) activities began in 2006 from a sub-group on Remote Sensing and Modelling of Surface Properties (RSMSP) under the International TOVS Working Group. After four successful meetings, the final RSMSP meeting in Grenoble in March 2016 it was decided to incorporate a broader stance towards bridging the modeling gap of the Earth surface-atmosphere interactions and fluxes in energy and water, for the purposes of improvement of NWP and advance coupled reanalyses.

The new International Earth Surface Working Group (IESWG) has convened three international meetings in 2017, 2018 and 2019 followed by 2 online meetings during the COVID-19 pandemic, aiming at gathering overviews of the surface modelling and monitoring progress in 2021, and then hosting the 4th IESWG online meeting in 2022 enlarging further the world-wide participation. In 2023 the 5th IESWG meeting is planned as a hybrid meeting hosted by the Finnish Meteorological Institute in Helsinki, Finland.

International Framework

The IESWG has had a strong connection with the CGMS-ITWG and also has interaction and close contact with the CGMS-IPWG. The IESWG has also coordinated each of the first 3 meetings to align with other specific and related meetings. IESWG-1 with a SMAP Weather Focus Session, IESWG-2 with the 8th EUMETSAT LSA-SAF Workshop, and IESWG-3 in tandem with SnowWATCH-GCW of the WMO. This has helped to raise awareness of the IESWG to a broader community and strengthened the communication with these other activities. IESWG-4 was held virtually in 2022 and again saw broad global participation.

Operational Overarching Goals

The IESWG aims at receive operational strategic element needed by global centers to integrate Earth Observation data (e.g. reduce emissivity uncertainty limiting DA over land/cryosphere, use new observation such GNSS-R, uptake modelling requirements to assimilate successfully) with particular focus at Land-Atmosphere interface with the overall goal to advance coupled data assimilation. The IESWG body functions to coordinate a set of actions and recommendations for current and emerging environmental observations sensitive to the Earth surface. A close connection with CGMS allows for not only advancement on scientific goals, but broader coordination that promotes faster uptake of these observations.

Linked with NOAA Science Advisory Board: A Report on Priorities for Weather Research. NOAA Science Advisory Board Report, 119 pp., 2021 https://sab.noaa.gov/wp-content/uploads/2021/12/PWR-Report_Final_12-9-21.pdf

- NOAA OD-2 Recommendation to maximize data assimilation use of Earth observations over land.
- NOAA OD-4 Recommendation Advance Coupled Earth system

Linked with ECMWF strategy 2021. Publisher. ECMWF. URL, doi.org/10.21957/s21ec694kd and vision statement ("ECMWF will strengthen its leadership position in data assimilation by progressing in coupled assimilation, algorithmic development and integration of approaches"). Reference to:

- WMO WWRP plan (https://library.wmo.int/doc_num.php?explnum_id=10830 "Coupled data assimilation addresses two overarching goals of the World Meteorological Organization (WMO) World Weather Research Programme (WWRP) strategic plan: 1) to improve environmental prediction and 2) develop a seamless predictive capability (Brunet et al. 2015).").
- GCOS plan (https://library.wmo.int/index.php?lvl=notice_display&id=22134#.Y9kfKhPMKhw "Theme C: Improving data quality, availability and utility, including reprocessing and Action C4: New and improved reanalysis products, point 2. Demonstrated benefits of coupled reanalysis.").

Compared to the CEOS Land Product Validation subgroup, IESWG has a different vocation towards operational aspects, such as data assimilation, observation operators and modelling developments that can advance towards coupled land-atmosphere assimilation in numerical weather prediction and climate/environmental reanalyses. The three main topical areas in the IESWG are:

1) Snow ice and cryosphere-atmosphere interaction

2) Vegetation and land-atmosphere fluxes

3) Soil moisture, river-discharge and water cycle

The IESWG participants typically report on Earth surface-atmosphere coupling and data assimilation with particular focus on methodologies, algorithmic and modelling advances that can enhance satellite observations uptake from present missions and prepared for upcoming ones. Operational centres and space agencies have provided support in the past editions of the working group meetings.

4. High Level Topics - New Horizons [60' incl. discussions]

4.1 Satellite early warning for disaster reduction

CGMS-51-GUEST-WP-04 - An African project to show case the relevance of satellite data for early warnings [30']

Executive Summary

Guest speaker, Doug Parker of NCAS, University of Leeds, gave a presentation focused the importance of satellite data for generating early warnings for extreme weather, and the effects of efforts to bring these early warnings to historically underserved communities. This focused on several case studies done in developing African nations.

The socio-economic value of improving weather forecasts in Africa, particularly as extreme weather events become more intense due to climate change, was highlighted by the HIGHWAY project on Lake Victoria, where estimates show that this single project may be responsible for up to 300 lives saved per year.

Parker presented the benefits of and challenges of implementing efficient, accurate Nowcasting systems in African nations. Nowcasting systems would save lives and property, bring economic value to local industries (e.g. agriculture, fishing) and assist greatly with disaster relief.

Attempts to implement nowcasting infrastructures (i.e. radar networks) have largely since the 1980s for a variety of reasons. New techniques and methods may be able to change this: high-resolution satellites, e.g. MTG, making observations in sparsely-observed areas in Africa will improve Nowcasting skill. This can be coupled with new methods to process the data (e.g. AI/ML), better training for regional meteorological services, and ways directly communicate and integrate weather information into the lives of ordinary citizens (e.g. with a mobile application).

Lars Peter Riishøjgaard mentioned that NWP limited in African, due to both high convective activity, which is harder to predict, and a lack of good observations. He notes where observations are less sparse, in Northern or Southern Africa, closer to the coastal regions, weather forecasting systems have higher skill.

Participants also asked whether regional training centres had been engaged in this project. Parker responded that they had and the regional training centres in Pretoria (South Africa) and Nairobi (East Africa) had been integral to the efforts of the project. He did also note that a lack of radar networks had held back training efforts in Africa, as there are fewer products to reference.

4.2 New architectures and miniaturized instruments how will they shape the future LEO system

CGMS-51-GUEST-WP-03 - Prospects for operational implementation of MW hyperspectral measurements [30']

Execute Summary

Guest speaker Christian Kummerow presented the current state of hyper microwave measurement technology, remarking that hyperspectral MW is very close to being in reach of private industry, who may use it to make observations to be provided to agencies and NWP centres, etc.

Some problems still remain with optimization of the technology. Hyperspectral MW remains a highly power intensive method, increasing the overall size of the power source and thus the satellites carrying them. This contributes to a higher cost. Data downlink remains an issue which is not addressed by digital backend architecture.

Some capabilities of hyperspectral MW observations were also noted: improved soundings for NWP, radiofrequency interference (RFI) could be identified and possibly mitigated, and observations can be used in inter-calibrations. These three capabilities were summarized:

1. Soundings improve significantly with hyperspectral capabilities. Even greater advantages when clouds are present but still working on details
2. A fairly simple hyperspectral setup at 23 GHz is very capable of detecting even small RFI signals
3. Hyperspectral capabilities at 183 GHz, when used during coincident overpasses with small radiometers can significantly improve inter-calibration capabilities.

Both NOAA and EUMETSAT highlighted their own investigations into developing hyperspectral MW sounders, NOAA in the context of LEON and EUMETSAT in the context of EPS-Sterna. Both agencies agreed it would be wise to implement the lessons learned from the RFI studies into planned (or future) systems

Ken Holmlund highlighted that the WMO had arranged an information day for commercial vendors of meteorological satellite data. He suggsested that they too, might be interested in implementing Kummerow's results in their own satellite constellations.

4.3 An outlook for the future of wind observations

CGMS-51-IWWG-WP-02 - Overview of current satellite capabilities for wind observations and an outlook for the future [30']

Executive Summary

The IWWG presented the current state-of-the-art and near-future of wind observing systems. This presentation was the follow-up to an action item from GCMS-50, where a review of space-based wind observing systems was requested.

The IWWG stressed that the requirements on global winds, a critical atmospheric parameter, are not currently being met, according to requirements listed on WMO OSCAR, and are unlike to be met in the near-future of planned missions.

Several wind observing techniques were presented, along with their pros and cons:

- AMVs: Good resolution, global coverage and no gaps; but height assignment highly uncertain and only gives information and a single layer in the atmosphere

- Surface winds from Scatterometers: Gives direct measurement of wind at high resolution and is not weather dependent; but only gives products close to the surface
- DWL gives a direct measurements of winds speed at high vertical resolution, gives products in all weather and sky conditions; but is highly complex, has only limited coverage and only measures winds in one direction. Additionally, no more DWL are planned until the 2030s
- 3D winds from IR sounders, which are demonstrative, can be retrieved from current IR sounders and give a continuous vertical profile, works in all-sky situations and has good coverage; but is a passive tracer and possesses correlation errors due to assimilation of L1 into NWP
- Stereo Winds are a demonstrative technology, making observations from imagers. They can accurately assign cloud heights without explicit knowledge of cloud microphysics; but are passive tracers and restricted to a single layer in the atmosphere
- Optical flow methods are a novel technique which give dense wind coverage with excellent temporal resolution; but require a great deal of computing resources to assimilate into NWP

NOAA claimed they have not been investigating any specific missions for 3D winds in the short time, and that NOAA considers its requirements for winds already met.

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5. Review of WGII list of actions [60' incl. discussions]

CGMS-51-WGII-WP-04 - Status on WGII Chairs and rapporteurs

Oral Only

CGMS-51-WGII-WP-05 - WGII ToR

Oral Only

CGMS-51-WGII-WP-06 - Proposal to the International Science Working Group leading team

Oral Only

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6. Climate and greenhouse gas observations [20'] (incl. discussion)

Working papers on climate and greenhouse gas, including CEOS-Climate report (mitigation, adaptation, long-term monitoring)

CGMS-51-WMO-WP-03 - GHG observation strategy - How we should address the WMO initiative [20']

Executive Summary

The WMO created the GHG observation strategy, to support the implementation of the 2015 COP-21 Paris Agreement, which aims to reduce anthropogenic GHG emissions.

- However, natural GHG fluxes (i.e. driven by natural processes) often not taken into account, despite interacting with anthropogenic systems in ways that are not well understood. It is also difficult to account for what the UN refers to as 'negative emissions', such as carbon offsets and credits, as they are often ineffectively monitored and poorly regulated. This may lead to a risk of under/overestimating the impact of carbon-mitigation efforts.
- While 'top-level' global CO_2 budgets are fairly well understood, individual contributions from a number of sources (e.g. land use changes) are not, and neither are the impacts of major carbon sinks. Accounting generally has two approaches: the 'top-down' (direct retrieval of carbon flux) and 'bottom-up' (adding up sources and sinks), each with their own advantages and issues.
- In response, WMO is developing the Global Greenhouse Gas Watch (G3W). This would treat GHG monitoring more operationally and regularly, similar to NWP, and less research-focused ad-hoc reporting common today. The G3W aims to create a system of global, near-real time observations of CO_2 from both satellite and ground-based systems. This would be coupled with GHG model which would output CO_2, CH_4 and N_2O concentrations at a (initially) 100 km grid-resolution, with an aim to bring this down to ~1 km within 10 years

Participants seek clarification on why the initial target is 100 x 100 km grid when technology can already accommodate better resolution than this? Lars Peter Riishøjgaard responds that this resolution had been under discussion in the WMO and the justification is that this is 'somewhat defensible' when trying to build up a picture of global CO_2 (etc.) emissions, while avoiding incentivizing competition with researchers, agencies and companies that aim to do city-scale emissions tracking. This will also avoid contradicting any country's reported emissions which may simply damage collaborative efforts between international partners.

CGMS-51-JWGCLIM-WP-01 - WGClimate status and plans and specific topics for the attention of CGMS [20']

Executive Summary

The CEOS-CGMS Joint Working Group on Climate met in Tokyo for its 18th meeting (WGClimate-18) in February, 2023. The Group focused on developing its 2023 Work Plan, including assessing and prioritizing strategies, initiatives, tasks, and partnering opportunities. For its highest priorities, the Group designated leads, schedules and paths forward. These top priorities included:

1) developing the Space Agency Response to the 2022 GCOS Implementation Plan (IP)

2) updating the Group's Coordinated Action Plan to help close addressable gaps in the GCOS IP Actions

3) releasing an updated version of the Essential Climate Variable (ECV) Inventory

4) restructuring (simplifying) the ECV Inventory and its maintenance processes

5) releasing a merged Gap Analysis Report (v3/4.1) for the Inventory

6) developing the Space Agency Statement for UNFCCC COP-28 and associated contributions for Earth Information Day.

The Group continues to publish online Use Cases for Climate Data Records, and is finalizing a robust taxonomy of definitions and best practices for multi-year time series data sets. The Group's 2023 activities are limited by the number of active representatives, and encourages all agencies to consider opportunities for active participation or other contributions.

EUMETSAT participants praised the progress made by the CEOS-JWG but commented that for many cases, climate data records are not sufficient and there is a need for real-time data sets, too.

CGMS-51-ESA-WP-07 - GHG monitoring evolution - CO2M and the ground segment [20']

Executive Summary

The European contribution (ESA, Copernicus, EUMETSAT) to global GHG monitoring, specifically the upcoming CO2M mission was presented by the European Space Agency. As per the Paris agreement, the CO2M mission will assist in the European target to make a global 5-year 'stocktake' of carbon. It will also measure CH_4 and NO_2.

- The concept allows for both monitoring over a wide area and identifying hotspots, with a variable horizontal resolution of up to 4 km^2. This allows it to give actionable information at the subnational, national or (wider) regional scales. Precision of hotspot retrievals is intended to be 0.7 ppm
- Error sources of CO2M are aerosol and clouds. A data filter allows to filter observations according to Aerosol Optical Depth, but in areas with large amounts of particulates (e.g. large urban areas), x-ray observations allow for the correction of aerosol scattering effects. Cloud contamination will disallow retrieval without a filter
- COM2 is currently preparing for a Critical Design Review (CDR, phase C) in 2023, with an aim for the launch of the first satellite in 2026

EUMETSAT participants asked which elements of the WMO's GHG initiative ESA/the commission believed the CO2M mission could specifically fulfil. ESA responded that although one should not consider CO2M to be the only solution required to meet the WMO's initiative, it will provide them with accurate, reliable, space-based measurements to work with in addition to reports from member states, measurements from ground, air and sea-based networks, etc. WMO may also be able to contribute diplomatically when GHG satellites with high resolution are able to identity large point sources

Heikki Pohjola (WMO) asked if the CO2M constellation is able to reach the OSCAR time resolution requirements (1 h). ESA replied that with the current planned set-up for CO2M, it is unlikely to meet this threshold on its own.

Ken Holmlund commented that while the CO2M has excellent potential, a much bigger constellation of (10+ satellites) would be required, along with commitments from agencies to ensure that this observations will continue to be made over the long term. He also suggested that agencies and

researchers should investigate if it is feasible to retrieve CO_2 at high-time resolution by some other manner of retrieval.

CGMS-51-NASA-WP-05 - NASA climate contributions [20']

Executive Summary

NASA presented their contributions to global GHG monitoring which is made up of several local, regional and global initiatives, making measurements of GHGs and particulates by networks of ground-based instruments, aircraft and satellite observations. Some of the ground networks have now been operating for up to 25 years.

- Airborne measurements are now made by a fleet of NASA aircraft. These observations help form NASA's broader strategy for GHG monitoring, which includes allowing for integration of instruments into their aircraft for scientific studies, planning aircraft routes to retrieve observations from under-sampled locations and a competitive procurement strategy for building novel or improved observations to help drive forward development of the global observing system.

- GHG modeling and analysis activities are spread through the ESD. Global Modeling and Assimilation Office (GMAO) conducts Research and Development of models and assimilation systems (e.g., GEOS, Model-E, NU-WRF) that produce quasi-operational data products that advance our understanding of the Earth and its component systems. The Carbon Cycle and Ecosystem (CCE) Focus Area continues to develop and maintain Carbon Monitoring System Flux (CMS-Flux), which is a global carbon cycle data assimilation system that quantifies the spatial and process drivers of atmospheric CO_2. The Advanced Information Systems Technology (AIST) program supports the developed of Earth System Digital Twin. Finally, the Earth Information System (EIS) is building upon and combining data acquired by NASA's Earth Science fleet and Earth System Models to create Level 5 data products that range retrospective analysis, real-time Earth science data products, seasonal to sub-seasonal forecasts, to decadal predictions. _

- NASA also highlighted their inter-agency and global cooperation initiatives, which they claim is core to their GHG monitoring. These include a number of bilateral deals, including close cooperation with NOAA and NASA participation in international bodies such as the CGMS, CEOS and in the WMO's projects, such as IG3IS.

European and Asian participants were interested in whether NASA would implement AI/ML techniques into their product development in the future. NASA responded that it had 'no good answer' to this question since it was the opinion of NASA at this moment that AI was advancing too quickly and a broader agency assessment would be required first.

EUMETSAT asked how NASA structures investigations into AI/ML. NASA said nothing is official yet as these discussions about AI/ML and what it means for the agency are on-going at the directorate level, and any projects which utilize AI are currently only used in the context of other projects.

CGMS-51-CMA-WP-05 - Operational performance of FY-3E/HIRAS and FY-4B/GIIRS

Executive Summary

- Due to the sunlight on 0530 orbit, the instrument temperature field of FY-3E/HIRAS-II was reset in August 2022, and the parameters for calibration were adjusted to fit the new state of the sounder.
- The spectral calibration with respect to LBLRTM is in range of 5 ppm for three bands respectively, the radiometric calibration with respect to MetOp-B/C IASI is about 0.5 K in LWIR, 0.5 to 1 K in MWIR.
- GIIRS spectral accuracy is less than 5 ppm, radiometric accuracy is less that 1K except in some spectral channels, which are affected by noise.
- The 3rd HIRAS will be launched in the Aug, 2023 onboard FY-3F satellite.
- FY-4C/GIIRS is in the design phase and plan to be launched in 2025.

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7. Selected topics of high priority to members (WPs will be pre-selected)

CGMS-51-CMA-WP-06 - Preliminary XCO2 retrieval results of ACDL on DQ-1

- CMA presented new XCO2 retrievals from the ACDL instrument on-board DQ-1 satellite. The retrieval of useful observations relies on the applying of filters (e.g. FFT, EMD or wavelet) to remove high frequency noise from the signal. Acquisition uses a pulse stacking method to improve the S/N ratio

- Early analyses of the XCO2 retrievals from a test period in June 2022, show the data to have a low mean bias (< 1 ppm) and standard deviation, when compared to 2 test sites in Xianghe (bias: 0.48 ppm stdv: 1.48 ppm) and Sodankylä (bias: 0.8 ppm stdv: 1.99 ppm).

CGMS-51-WMO-WP-11 - Tropical Cyclone community: requirement for LEO satellite missions

Executive Summary

- Satellite data continues to be the primary tool used to estimate storm intensity, position, and structure. Approximately 90% of TCs are observed exclusively with satellite data. Monitoring the position, intensity and structure of a TC is often a key point for subsequent decisions in the warning chain.
- The unique capabilities provided by LEO sensors allow confident operational estimates of the maximum sustained winds, radius of maximum winds, and extent of critical wind thresholds. Despite some improvements to TC monitoring over the last 4 years, significant data gaps remain. Legacy satellite missions are reaching the limits of their age and many satellites now have failed or have failing critical sensing channels. In addition, there are coverage time gaps as most LEO satellites are sun synchronous.
- It is critical to maintain the health and diversity of the LEO constellation to provide the highest quality inputs to the TC warning process.

Heikki Pohjola asked if NOAA had any plans to expand commercial data providers to assist with operations related to tropical cyclones. NOAA admit that such an idea does exist amongst NOAA operators, but no official steps have been taken to move towards, which would require approval and funding – likely through congress. NOAA also noted this would be a novel application of technologies, which comes with risks.

CGMS-51-NOAA-WP-07 - NOAA/NESDIS GeoXO Update

Executive Summary

- GeoXO has passed the USA Department of Commerce Milestone #2 and the program is proceeded with its full constellation.
- The next major decision points are the Mission Definition Review and KDP-B in 2024.
- The GeoXO Imager (GXI) contract was awarded to L3Harris in March 2023
- The GeoXO Sounder award will be announced in September 2023
- The Phase-A studies for the lightning mapper (LMX), ocean color sensor (OCX) and atmospheric composition sensor (ACX) will finish in late 2023.
- Spacecraft contract will be award in 2024.

CGMS-51-NOAA-WP-09 - Geostationary Reprocessing Activities at NOAA/NESDIS

Executive Summary

- NESDIS is supporting several reprocessing activities across all of the GOES series
- Rescuing data from SMS-1 through GOES-7 that was corrupted during tape storage
- Applying EUMETSAT developed QC and reformatting tools to GOES 8-15 GVAR data
- Reprocessing the GOES-R ABI and GLM Records.
- Co-developing with other space agencies an application of the current GEORING of advanced imager (the next generation of the International Satellite Cloud Climatology Project - ISCCP-NG)
- Reprocessing and storage will be done in the Cloud and shared publicly.

CGMS-51-NOAA-WP-11 - NESDIS Wildland Fire Program

Executive Summary

- While existing operational satellite-derived active fire products are frequently used in a variety of operational and research applications, stakeholder engagement has identified critical gaps, such as increasing the response time for the initial attack of fires that have the potential to impact life and property, incomplete situational awareness for wildfire incident management (extended attack), and addressing science and access barriers that limit exploitation of satellites.
- In an effort to address key capability gaps, NESDIS has established a Wildland Fire Program focused on impactful service delivery. NESDIS Wildland Fire Program projects, aimed at addressing critical active fire capability gaps, are underway, with product and service demonstrations expected to begin by June 2023.

- The improved products are generated using the Next Generation Fire System (NGFS), which consists of a sensor agnostic (applicable to geostationary or low earth orbit satellites) active fire algorithm and higher order capabilities, including alerting, incident situational awareness tools that are highly tolerant of cloud cover, and an event-based data model that combines time-resolved satellite fire detections with complementary geospatial data layers.
- The active fire algorithm requirements are driven by the applications needed to achieve the desired user outcomes. For instance, in order to alert first responders to potential new wildfire starts in a timely manner, the following algorithm capabilities are needed: automated hot spot detection that is consistent with human expert interpretation of satellite imagery, tracking of previously detected hot spots, and fusion with supplemental data layers (i.e. fire weather maps, fuel type, etc.) and accurate geolocation. One of the broader implications of NESDIS Wildland Fire Program activities is an assessment of how current L2+ fire product requirements map to impact goals.

Heikki Pohjola asks if a 'false alarm rate' of the fire product(s) has been determined. NOAA say they have yet to determine a false alarm rate, but validation studies and follow-ups are currently underway following a number of verified fire events.

CGMS-51-NOAA-WP-19- Nowcasting: Observational thresholds, objectives, and priorities for U.S. weather services

Executive Summary

Nowcasting is defined as forecasting for weather conditions within the upcoming six hours.

NOAA focused on six nowcasting application areas where satellites play a major role as an observational source: thunderstorms, heavy rain / flooding, dense fog, fire monitoring, offshore winds / sea ice, and winter precipitation.

Surveys were sent to operational meteorologists and the results of those surveys were used to develop initial observation ranges:

- Minimally useful
- Expected (2030)
- Maximum effective

Subject-matter experts subsequently reviewed the observation ranges and the ranges were adjusted for consistency and if necessary for additional considerations beyond those from the operational meteorologists originally surveyed.

In addition, Jordan Gerth (NOAA) noted that input from outside the United States would be helpful to assess global nowcasting requirements, particularly for those that might be able to be met by satellites. Paolo Ruti (EUMETSAT) suggested that the hydrology communities in Europe has worked together to create a number of useful applications of IR and MW when modelling nowcasting events (e.g. flooding)

CGMS-51-WMO-WP-17 - WMO Polar Space Task Group (PSTG)

Execute Summary

The WMO Commission for Observation, Infrastructure and Information Systems (INFCOM) at its second meeting (INFCOM2) requested: "Global Cryosphere Watch Advisory Group (GCW-AG) to prepare, in consultation with the Standing Committee on Earth Observing Systems and Monitoring Networks (SC-ON), terms of reference and a modus operandi for a task team on the coordination of space-based capabilities for advancing benefits of, and access to, space-based cryosphere observations, by evolving those of the Polar Space Task Group, for approval by INFCOM President"

The Terms of Reference (ToR) are developed for the World Meteorological Organization (WMO) Infrastructure Commission (INFCOM) Task Team on the coordination of space-based capabilities for advancing benefits of, and access to, space-based cryosphere observations, evolving those of the Polar Space Task Group (PSTG) developed in 2017 and reflect recent changes in the WMO strategic objectives, in particular embracing a holistic Earth System modelling approach and acknowledging that global Numerical Weather Prediction modelling underpins most WMO application areas.

CGMS-51-NOAA-WP-10- Reprocessing of SNPP VIIRS Aerosol Products and their Applications

Executive Summary

The growth and decline of the economy has a bearing on air quality. The impact of changes in economic activity on air quality, like that witnessed during the lockdowns associated with the COVID-19 pandemic, were documented using tropospheric nitrogen dioxide (NO_2) column amounts observed by satellites.

Nitrogen dioxide and volatile organic compounds are precursors for formation of ozone and fine particulate matter. Air quality is typically quantified (good or bad) based on ozone and fine particulate concentrations.

In this study, we showed that when nitrogen dioxide increases or decreases, aerosol optical depth (AOD) increases or decreases commensurably. Aerosol optical depth decreased by 22% in major cities (37 of the 43 cities studied) around the world during the COVID-19 lockdowns. To achieve similar improvements in the US with targeted emissions reductions, 6 million light duty vehicles will need to be transitioned from gasoline to electricity.

- Changes in economic activity lead to decreased emissions and lead to improved air quality. Can we detect those changes in satellite aerosol optical depth (AOD) data?
- Develop long-term climatology of AOD so data for any given time period going forward is analysis ready.
- Conduct tracer-tracer correlations to attribute aerosols to different emissions sources (fires vs. urban pollution)

Some participants questioned the validity of the 6 million car vehicles claim.

Heikki Pohjola asked how long it would take to achieve this reduction of 6 million vehicles. While no specific estimate was given, NOAA project staff admitted that, looking at the rate of uptake of electrified vehicles today, it would take a very long time to achieve this.

CGMS-51-NOAA-WP-08 - NOAA's Microwave and Hyperspectral IR Workshop Outcomes

Executive Summary

NOAA presented the outcome of two recent sounder-technology workshops

Summary from MW Sounding Workshop:

- Backbone 3-orbit constellation with sensors providing data in the 23 GHz to 183 GHz frequencies
- Sensor Noise: New sensors should aim to achieve lower noise and striping than current sensors.
- Frequencies: 50-60 GHz frequencies have more information content than the 118 GHz for temperature sounding; 183 GHz are important for humidity soundings; 23, 31, 50, 51, and 89 GHz are also used for surface, QA/QC and Cloud clearing in DA, and precipitation.
- Legacy POES: MW sounders on older satellites that are operating beyond their mission life still provide impactful measurements and should be continued as long as technically possible.
- Mission Life: It takes 1-2 years to full test and implement new measurements in to NWP DA. Longer mission life is therefore recommended.
- RFI: Both future backbone and supplemental MW sounder missions should incorporate technology to address frequency interference (RFI).
- Robust calibration strategy is needed for inter-calibration, absolute calibration, and traceable calibration.

Summary from IR Sounding Workshop:

- Higher spatial resolution models move to 1-2 km spatial resolution, and cloud clearing
- NEDT: low noise is necessary, consider together with spectral, and spatial resolution
- Calibrations stability is very important
- On-board processing like IASI for data reduction is acceptable.
- Co-location with MW sounders (and/or imagers) is desirable but not essential
- Frequency: Frequent IR measurements of water vapour for winds (e.g. hourly coverage)
- Low latency (e.g. DBNET) for rapid refresh models that have short cut-off forecast runs
- Atmospheric Chemistry: compliment with SWIR missions dedicated to atmospheric chemistry such as MOPITT, OMPS, SCIAMACHY, GOSAT, OCO-2, TROPOMI, GeoCarb etc.
  - The SW range of the IR sounders in future should be extended to (1.5-2.5 micrometers)
  - Morning and afternoon orbits better capture photochemical processes
  - Fire emissions of CO, O_3, PAN and NH_3. IR sounders tracked these emissions quite well.
  - Atmospheric chemistry

CGMS-51-JMA-WP-03 - Validation of AHI on Himawari-9, in L1 and L2 products

Executive Summary

Operational switchover from Himawari-8 to -9 was conducted on 13 December 2022 following a period of parallel data dissemination from 27 September 2022. Level-1/-2 products quality was evaluated using the Himawari-8/-9 parallel observation data and similar performance results were derived in both Himawari-8/-9 products.

- Himawari-9 Level-1 products performance
  - Image navigation: ~0.3 km
  - Inter-band co-registration: ~60 m
  - Radiometric calibration: < ~5% (B01 to B05) and 5–8% (B06), < ~0.3 K (IR bands)
- Himawari-9 Level-2 products
  - AMV, Cloud properties: Similar characteristics and qualities for H-8 and H-9.
  - CSR: No significant difference in the statistical properties for B08 (6.2 µm) and B10 (7.3 µm) , but O-B for H-9 shows slightly higher temperature for B09 (6.9 µm).
  - SST, Sunshine Duration: Calibration correction conducted.

8. Preparing for the plenary session [60']

Oral only, see end of documents for recommendations

Commented [JS7]: Note: according to the agenda, this session doesn't exist

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9. High Level Topics - New Horizons [30']

9.1 New architectures and miniaturized instruments how will they shape the future LEO system

CGMS-51-NASA-WP-04 - NASA vision for future miniaturized meteorological instruments [20']

Execute Summary

- NASA has a long history of developing novel technologies, and small satellites are no exception. NASA has been building and launching SmallSats (ca. 180 kg in ca. 1 m^3 volume / the size of a kitchen fridge) and, more recently, CubeSats (which NASA defines as up 12 multiples of '1 Unit', where 1 unit = 10 x 10 x 10 cm) mostly as demonstrators.
- NASA has focused recently on integrating Small- and CubeSat technology into its EarthVenture initiative, a competitive selection of low-cost, science driven missions to develop novel technologies and support private investment in space
- On SmallSats specifically, NASA has put in a great deal of effort recently to validate observations made by instruments in SmallSat payloads. Novel missions, such as TEMPEST-D or CYGNSS, have been validated against operational instruments from NOAA and EUMETSAT to ensure 'science quality' observations

Paolo Ruti (EUMETSAT) asked NASA if the push towards miniaturization was driven by user requirements. NASA claims while requirements are important, it is not the only consideration, and requires a constant understanding and reassessment of what is both technologically feasible and scientifically interesting. As a result of this technology-driven approach, NASA runs open calls for ideas and frequently hosts panel discussions in order to decide which ideas to follow through on. The philosophy, NASA said, is "How do we make the development of future technology easier?"

EUMETSAT participants also asked NASA whether they believe that Hyperspectral MW technologies are 'ready' to be used in SmallSats. NASA responded affirmatively, noting that they are currently investing

efforts into hyperspectral MW and that it should be possible to deploy in SmallSats in the near-future

10. CGMS future direction 2022+ project [30']

CGMS-51-CGMS-WP-12 - Status of the CGMS future direction 2022+ project

Executive Summary

Paolo Ruti (EUMETSAT) presented a working paper which gave an overview of the activities undertaken on the CGMS future direction 2022+ project since the CGMS-50 plenary for consideration and feedback by the CGMS-51 working groups (WGs I-IV and the SWCG). The 2nd high-level meeting on 29 March 2023 endorsed the way forward proposed, noting the need for the identification of concrete implementation measures in the next year (up to CGMS-52) and a stronger link as concerns the potential interfaces.

The basis for discussion are the agreed seven strategic themes:

- Socio-economic benefits
- Research to operations (R2O)
- Future observing (hybrid) space infrastructure
- Future information technologies
- Relationship with the private sector
- Climate and Earth system monitoring
- Space situational awareness
- A topic for all: supporting developing countries

JAXA participants noted that on research to operations, researchers and those who work in operations seemingly had a ‘very different philosophy and culture’ when it comes to the management of projects. This, in turn, leads to different working and funding structures, making the establishment of long-term strategic goals difficult to maintain.

EUMETSAT participants agreed with this perspective and believes the value of organizations like the CGMS can therefore be to filter out common practices to avoid redundancy or clashes of culture between either CGMS member agencies, or CGMS agencies and their member states.

NOAA participants noted that many CGMS member agencies have member states with their own met services. These met services, or consortia of met services often have their own research-to-operations initiatives. NOAA stress that the idea of 2022+ project is not to ‘hijack existing structures’ in R2O, but rather to add an additional layer of cooperation to influence how future satellite programmes are made as they move from research projects/demonstrators to operational system.

The WMO ask if the intention is to re-order the CGMS around these topics or if to leave the topics to be tackled by existing structures. The participants agreed that the best approach is to not alter in the existing structure in any fundamental way, but allow these topics to guide the existing structure. Participants did note however, that technology that fundamentally changes aspects of the EO or space industry (with AI/ML held up as a possible example) may result in the need to revisit the working group structure CGMS

structure.

11. Review and updating of the HLPP [20']

CGMS-51-CGMS-WP-XX - Status of implementation of CGMS High Level Priority Plan (2022-2026)

Oral Only, review of HPLL document:

https://www.cgms-info.org/Agendas/GetWpFile.ashx?wid=07bec3de-e931-46dd-b3c1-be9e0a991b4f&aid=21503bc8-0290-46b0-a559-a6e989946998

CGMS-51-CGMS-WP-YY - Revised HLPP 2023-2027 - for recommendation to plenary

12. Future CGMS WGII meetings [10']

CGMS-51-WGII-WP-01 - Decision on dates of WGII inter-sessional activities/meetings in 2023-2024 (CGMS-51 to CGMS-52)

TBD

CGMS-51-WGII-WP-03 - Decision on dates of CGMS-52 WGII plenary session

TBD

13. Any other business [5']

Nothing to report

14. Conclusions, preparation of the WGII report for plenary [15']

Agreement on outcomes, conclusions and preparations of the WGII report to Plenary

Recommendations to Plenary (High Level)

14 recommendations at the High Level were made by the WGII:

Commented [JS8]: Pending finalization!

CGMS-51 Recommendations - WGII			
Actionee	**AGN item**	**Recommendor**	**Description of Recommendation**
CGMS-51 High Level Recommendations - WGII			
		ICWG	Space Agencies are encouraged to participate in the formulation and testing of the ISCCP-NG L1g and testing of L2 Cloud Products. ISCCP-NG is a pilot project from WCRP/GEWEX to make a next generation of the International Cloud Climatology Project (ISCCP). Motivation is to exploit the vast new capabilities of the current and future geostationary imagers.

CGMS-51 Recommendations - WGII			
Actionee	**AGN item**	**Recommendor**	**Description of Recommendation**
		IPWG	IPWG notes that Geostationary IR is not listed as having precipitation capabilities in either the HLPP document nor the CGMS Baseline document. However, the global constellation of GEO-based measurements is fundamental to the global datasets produced by several agencies. Precipitation should be added to the "observables" column in both documents
		IPWG	IPWG solicits support for Baseline Surface Precipitation Networks – Convincing member states to provide one or two years of gridded radar QPE adhering to BSPN guidelines.
		IROWG	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
		IROWG	IROWG recommends operational Global Navigation Satellite System (GNSS) RO missions for continuous global climate observations to be established and maintained to serve as a backbone, ensuring continuity and long-term availability of climate-quality RO data
		IROWG	IROWG continues to support the previous recommendations that GNSS-RO data - with at least 20,000 occultations/day - are globally distributed and provide full sampling of the diurnal cycle. IROWG also recommends further investigation of the value of increased target observation quantities, to provide a sound basis for future statements on the desirable number of observations and insights on satellite mission planning and coordination
		ITSC24-AS-8	Recommendation to space agencies and data providers: to expand the backbone system with 3 additional orbits between the current 1330, 0930, and 0530 local)
		ITSC24-IIFS	The WIGOS Vision 2040 for passive IR and MW sounding with agency commitments beyond the established 3-orbit baseline. Noting recent assessments of expected impact, the WG recommends complementing the 3-orbit CGMS baseline with a further 3-orbit system that features at least MW sounding capabilities, with equator-crossing times between those of the 3-orbit baseline to optimize time-to-coverage of the overall system.
		ITSC24-NWP-5	Recommendation to CGMS and WMO members: When commercial satellite data is purchased, ensure provision to users of the necessary data and meta-data required to make use of the data in applications, as early as possible
		ITSC24-IIFS-10	Recommendation to space agencies involved in reference missions (CLARREO, TRUTHS, LIBRA): To work towards harmonized product definitions to make the use of these products easier for inter-calibration exercises. Constellation of small satellite and new instruments
		IWWG	Encouragement and support from satellite agencies would accelerate the effective use of the OSW within NWP, with potentially large effect on forecast quality of the extending virtual scatterometer constellation
		IWWG	Scatterometer to be assessed the continuity of afternoon orbit and RT assess
		IESWG	IESWG to approve the creation and ToR - The International Earth Surface Working Group aims at enhancing the use of Earth Observation (EO)-data for Biosphere and Cryosphere modelling applications from active/passive remote sensing for the study of processes related to the surface-atmosphere interactions with the aim of advancing data assimilation for application in weather and climate. The scope of the IESWG covers observations from the entire spectrum, ranging from microwave missions (e.g. SMOS, SMAP, GMI, ASCAT) to optical and thermal sensors (e.g. OLCI, …), and also follow-on missions building from this heritage. Observations of both polar orbiting and geostationary satellites are included. The IESWG is monitoring and documenting user requirements for EO data used to characterize the surface and the subsequent surface-atmosphere interaction in numerical models.

Commented [JS9]: Proposal to merge these two

Commented [JS10]: Proposal to "(could we have a general recommendation together with RO)"

Commented [JS11]: Note: ; To be decided

CGMS-51 Recommendations - WGII			
Actionee	**AGN item**	**Recommendor**	**Description of Recommendation**
		WGII	CGMS WG2 recognises the relevance of WMO initiative on operationalizing GHG monitoring (GHG Watch). WMO can play a very important role in coordinating several measurement networks and ensuring NRT availability of diverse observations used in different component of the value chain (remote sensing processors, validation, data assimilation) WMO can also guarantee the proper Research to Operations transition and to become an entry points for decision makers. We encourage WMO to make use of existing coordination mechanisms across satellite agencies to foster their GHG initiative
		WG-Climate	WGClimate capacity and work plan are strongly limited by the number of active representatives in the Group. The Group encourages all agencies to consider support opportunities. Opportunities include active representation, and/or participation in initiatives such as drafting and reviewing Space agency response to GCOS IP, submitting CDRs to ECV inventory updates, submitting CDR use cases, and participating inventory gap analyses.
		WG2 Chairs	Working Group II recognizes the need for advancing space-based observations for cryosphere, polar and high-mountain areas and recommends WMO to ensure the proper mechanism to foster such activities
CGMS-51 Best Practices recommendations - WGII			
		IPWG	To address gap analysis, IPWG (through its Constellation WG) requests CGMS support in developing a benchmark using OSSEs to conduct comprehensive assessments of current capabilities and the value of specific sensors if added/withheld from the current program of record/CGMS baseline. Especially timely given the proliferation of largely sounding-based cubesats and small sats.
		IROWG	IROWG recognizes the importance of space weather applications of RO data. IROWG recommends that RO and non-RO missions that use dual-frequency GNSS receivers for their orbit determination needs should make available to the operational and research communities all necessary low-level (level 0) data and metadata required to produce accurate overhead TEC data from the GNSS receiver
		IROWG	IROWG encourages technology and retrieval developments for improving planetary boundary layer profiling from GNSS-RO and their utilization in NWP data assimilation as well as the further exploitation of RO-derived water vapor
		ITSC24-CWG-3	Recommendation ITSC24-CWG-3 to GSICS: extend calibration and harmonization activities to historic sensors to support climate applications, including CDR / ECV production and reanalysis.
		WMO	Encourage greater coverage from SAR for all TC intensities
		ITSC24-CWG-2	Recommendation to space agencies to note the link between (on the one hand) a tendency to small satellite technology, potentially entailing compromised calibration capabilities and (on the other) the scientific case for independent on-orbit calibration missions, such as CLARREO
		Standing-NWP-2	Recommendation to funding bodies of NWP centres and space agencies: Consider, as part of the cost of satellite programmes, providing computational and personnel resources targeted at operational NWP centres to optimise the public's return on investment from these expensive measurement systems
		IWWG	For improved satellite wind speed calibration, collaboration on WMO level with in-situ experts and with dropsonde providers is recommended in order to better comprehend in -situ measurement data and their accuracy in extreme conditions, which is of large societal relevance
		IWWG	To define an official international operational framework to ensure timely and valuable high-resolution SAR acquisitions of Tropical Cyclones.
		IWWG	IWWG to explore and highlight complementarities and/or potential synergies between various wind observations types
CGMS-51 Internal Working Group Business- WGII			

Commented [JS12]: Note: (does it need more analysis at WG2 level) sharing the data to be considered for high level

Commented [JS13]: Note: (does it need more analysis at WG2 level) – to work on use cases

Commented [JS14]: (this is a general warning - does it need more analysis at WG2 level)

Commented [JS15]: Note: (maybe to be reformulated for high level recommendation)

CGMS-51 Recommendations - WGII			
Actionee	**AGN item**	**Recommendor**	**Description of Recommendation**
		ITSC24-NWP-12	Recommendation to ITWG co-chairs: Organize a discussion topic for future conferences on use of coupled systems in sounder radiance assimilation
		IWWG	The IWWG hopes to find a new host for the email and web servers that are currently hosted by SSEC at the University of Wisconsin – Madison.

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CGMS-51 WGII, 24 April 2023 - Connection details
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India/ISRO:J V Thomas (Guest)
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Kaye, Jack (HQ-DK000)
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Table Formats

CGMS-51 actions - WGII					
Actionee	**AGN item**	**Action**	**Description**	**Deadline**	**Status**

CGMS-51 recommendations - WGII			
Actionee	**AGN item**	**Rec**	**Description**