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TECHNICAL REPORT

Temporal monitoring of remote sensing observations for the NWP assimilation at NCMRWF

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January 2025

National Centre for Medium Range Weather Forecasting
Ministry of Earth Sciences, Government of India
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10	Abstract	The National Centre for Medium-Range Weather Forecasting (NCMRWF) receives observational data from various sources, including GTS, NOAA, EUMETCast, IMD, ISRO, KMA, JMA, etc for NWP assimilation. NCMRWF monitors this received data daily for each six hourly intermittent assimilation cycle (0000Z, 0600Z, 1200Z, and 1800Z). Temporal monitoring of the reception of each observing system is important for ensuring the consistency of the observations used in the assimilation system and also for identifying the issues in the data dissemination from the providers, network related issues, or issues related to data reception at NCMRWF. Temporal monitoring of almost all conventional observations and some of the remote sensing observations are part of the NCMRWF online monitoring system. The 45-days time-series plots provide valuable insights in to the observed datasets, which includes the information like current day count, average count for the last 45 days and the current day departure percentage from the average. The objective of this report is to prepare the last 45-days data and generate a time-series plots for the satellite observations, which includes Global Navigation Satellite System - Radio Occultation (GNSS-RO), GNSS Integrated Precipitable Water (IPW) or Zenith Tropospheric Delay (ZTD), geostationary satellite radiances, and scatterometer sea surface wind observations.
11	Security classification	Non-Secure
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13	Key Words	Remote sensing; GNSS-RO; Scatterometer; Monitoring.

Contents

सारांश

राष्ट्रीय मध्यम अवधि मौसम पूर्वानुमान केन्द्र (NCMRWF) संख्यात्मक मौसम प्रागुक्ति (NWP) आत्मसात के लिए GTS, NOAA), EUMETCast, IMD, ISRO, KMA, JMA, etc. सहित विभिन्न स्रोतों से अवलोकन संबंधी डेटा प्राप्त करता है। NCMRWF प्रत्येक छह घंटे के आंतरायिक आत्मसात चक्र (0000Z, 0600Z, 1200Z, और 1800Z) के लिए प्रतिदिन इस प्राप्त डेटा की निगरानी करता है। प्रत्येक अवलोकन प्रणाली के रिसेप्शन की अस्थायी निगरानी आत्मसात प्रणाली में उपयोग किए गए अवलोकनों की स्थिरता सुनिश्चित करने और प्रदाताओं से डेटा प्रसार में मुद्दों, नेटवर्क से संबंधित मुद्दों, या NCMRWF में डेटा रिसेप्शन से संबंधित मुद्दों की पहचान करने के लिए महत्वपूर्ण है। लगभग सभी पारंपरिक अवलोकनों और कुछ रिमोट सेंसिंग अवलोकनों की अस्थायी निगरानी NCMRWF ऑनलाइन निगरानी प्रणाली का हिस्सा है। 45-दिनों की समय-श्रृंखला प्लॉट देखे गए डेटासेट में मूल्यवान अंतर्दृष्टि प्रदान करते हैं, जिसमें वर्तमान दिन की गणना, पिछले 45 दिनों की औसत गणना और औसत से वर्तमान दिन के प्रस्थान प्रतिशत जैसी जानकारी शामिल है। इस रिपोर्ट का उद्देश्य पिछले 45 दिनों का डेटा तैयार करना और उपग्रह अवलोकनों के लिए एक समय-श्रृंखला प्लॉट तैयार करना है, जिसमें ग्लोबल नेविगेशन सैटेलाइट सिस्टम - रेडियो ऑकल्टेशन (GNSS-RO), जीएनएसएस इंटीग्रेटेड प्रीसिपिटेबल वॉटर (GNSS-IPW) या जेनिथ ट्रोपोस्फेरिक विलंब (ZTD), भूस्थैतिक उपग्रह विकिरण, और स्कैटरोमीटर समुद्री सतह हवा अवलोकन शामिल हैं।

Abstract

The National Centre for Medium-Range Weather Forecasting (NCMRWF) receives observational data from various sources, including GTS, NOAA, EUMETCast, IMD, ISRO, KMA, JMA, etc for NWP assimilation. NCMRWF monitors this received data daily for each six hourly intermittent assimilation cycle (0000Z, 0600Z, 1200Z, and 1800Z). Temporal monitoring of the reception of each observing system is important for ensuring the consistency of the observations used in the assimilation system and also for identifying the issues in the data dissemination from the providers, network related issues, or issues related to data reception at NCMRWF. Temporal monitoring of almost all conventional observations and some of the remote sensing observations are part of the NCMRWF online monitoring system. The 45-days time-series plots provide

valuable insights in to the observed datasets, which includes the information like current day count, average count for the last 45 days and the current day departure percentage from the average. The objective of this report is to prepare the last 45-days data and generate a time-series plots for the satellite observations, which includes Global Navigation Satellite System - Radio Occultation (GNSS-RO), GNSS Integrated Precipitable Water (IPW) or Zenith Tropospheric Delay (ZTD), geostationary satellite radiances, and scatterometer sea surface wind observations.

Keywords: Remote sensing; GNSS-RO; Scatterometer; Monitoring.

1. Introduction

The National Centre for Medium-Range Weather Forecasting (NCMRWF) receives global atmospheric and oceanic data from different agencies, including the Global Telecommunications System (GTS), National Oceanic and Atmospheric Administration (NOAA), European Organization for the Exploitation of Meteorological Cast (EUMETCast), India Meteorological Department (IMD), Indian Space Research Organization (ISRO), Korea Meteorological Administration (KMA),China Meteorological Administration (CMA), Japan Meteorological Agency (JMA), etc. Conventional observations are primarily received via GTS network of the World Meteorological Organization (WMO), facilitated through the Regional Telecommunication Hub (RTH) at IMD in New Delhi. To access bulk satellite datasets, NCMRWF has established data links with leading global satellite operators such as NOAA, EUMETCast, CMA, KMA, and ISRO (Prasad, 2020). NCMRWF prepares daily observation monitoring report for each six hourly intermittent assimilation cycles (0000Z, 0600Z, 1200Z, and 1800Z) for early and update runs. The early run is with an observation cut off between -3 and +2 hours centred around the assimilation cycle, while the update run observation cut off is ±3 hours centred around the assimilation cycle. NCMRWF observation monitoring reports provide insights into the various types of datasets received, both conventional and remote sensing observations, including spatial plots of the different datasets, vertical pressure level plots from various radiosonde locations, and a time-series analysis of last 45 days of the conventional observations and atmospheric motion vectors (AMVs). The 45-days time-series is crucial for understanding the departure and normal counts of the received observations. While it is monitored for the conventional observations (synop, ship, buoy, aircraft, radiosonde/rowinsonde, and pilot) and AMVs (Saha et al., 2021; Srinivas et al., 2023; Indira Rani et al., 2024; Saha et al., 2024), it does not currently encompass satellite observations data such as Global Navigation Satellite System (GNSS) observations, satellite radiance, and scatterometer sea surface wind observations etc. This

report focuses on the 45 days- time series monitoring of satellite observations, specifically GNSS-Radio Occultation (RO), GNSS-Integrated Precipitable Water (IPW) or Zenith Tropospheric Delay (ZTD), geostationary radiance, and scatterometer sea surface wind observations.

2. Time-series of satellite observations added to NCMRWF monitoring report

The 45-day time series is prepared using data collected over the past 45 days from various sources. For each satellite observation, the data count is extracted daily based on the WMO satellite identifier from the received dataset for each assimilation cycle. The counts of these observations are recorded in a file designated for the first day. This file is then updated daily by removing the oldest entry and appending the latest data to the end. Additionally, the 45-days data file includes crucial information, such as the average values and deviations for the current day.

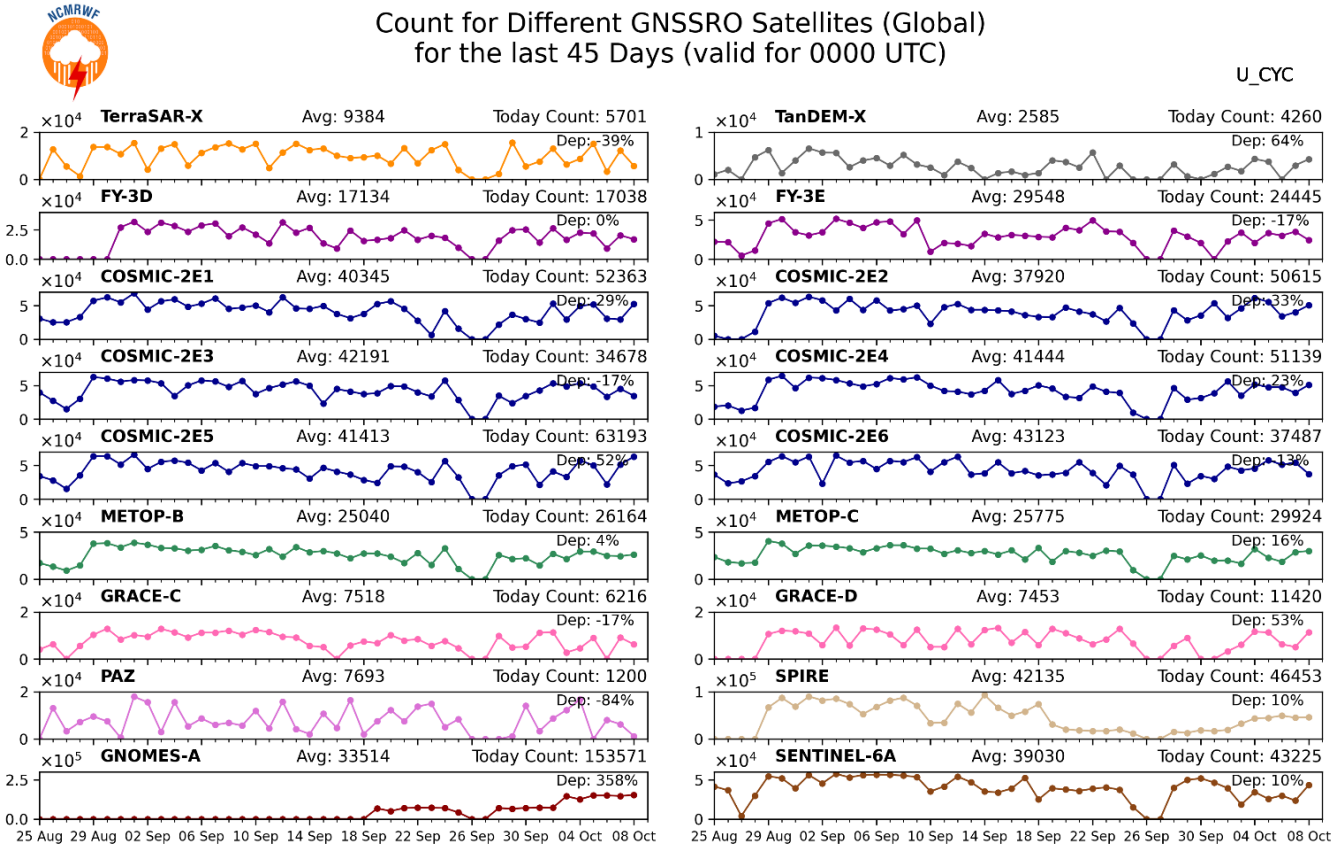

Figure 1: 45-days time-series for data received from 18 satellites with GNSS RO receivers for the period 25th August 2024 to 08th October 2024.

NCMRWF recently added the time series monitoring of GNSS-RO, GNSS-ZTD (IPW), Scatterometer Sea Surface winds and radiances from various geostationary satellites.

Table.1 List of Low Earth Orbit (LEO) satellites with GNSS-RO receiver and the corresponding WMO Satellite identifier

S.No	GNSS RO LEO Satellites	WMO Satellite Identifier
1	TerraSAR-X	42
2	TanDEM-X	43
3	PAZ	44
4	Metop-B	3
5	Metop-C	5
6	GNOMES-A	267
7	Fy-3D	523
8	Fy-3E	524
9	Sentinel-6A	66
10	Cosmic-2 E1	750
11	Cosmic-2 E2	751
12	Cosmic-2 E3	752
13	Cosmic-2 E4	753
14	Cosmic-2 E5	754
15	Cosmic-2 E6	755
16	GRACE-C	803
17	GRACE-D	804
18	Spire	269

GNSS-RO data is mainly received via GTS. NCMRWF started receiving the commercial SPIRE GNSS-RO data from NOAA since November 2022 through the MoU between IMD and NOAA, and later on NCMRWF started receiving the SPIRE data from EumetSat and also through the GTS. The spire GNSS-RO data is currently generating approximately 20,000 occultation profiles

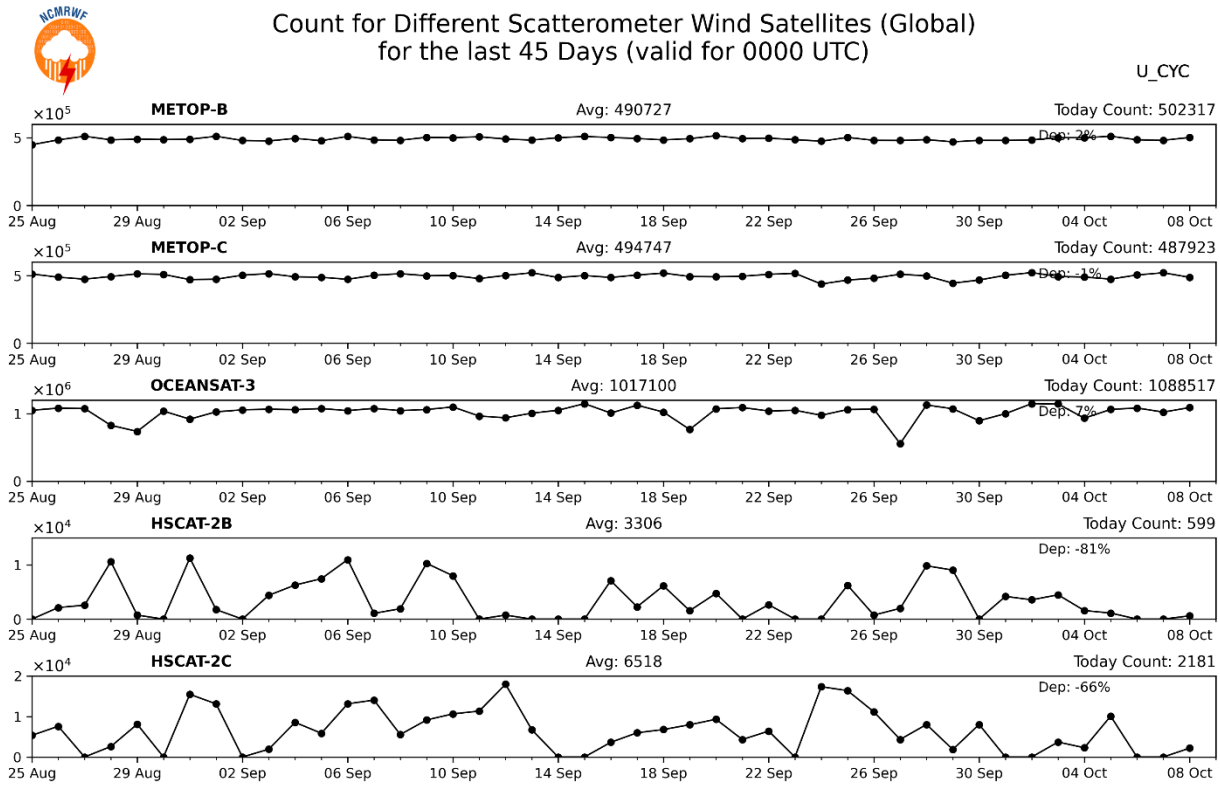

Figure 2: 45 days time-series for scatterometer sea surface winds received at NCMRWF from different satellites (Metop-B, Metop C, Oceansat-3, Hy-2B, Hy-2C) for the period 25th August 2024 to 08th October 2024.

per day. The Spire STRATOS RO antenna-receiver payload tracks GNSS signals from GPS, GLONASS, GALILEO, and the Quasi-Zenith Satellite System (QZSS) (Ho et al., 2023). NCMRWF currently receives GNSS-RO data from almost 18 satellites (Table.1) with GNSS-RO receiver payload. NCMRWF receives sea surface winds from Advanced Scatterometer (ASCAT) onboard MetOp-B and MetOp-C satellites from NOAA and EumetCast, Oceansat-3 sea surface winds from National Remote Sensing Centre (NRSC), ISRO, and the Chinese scatterometer (Hai

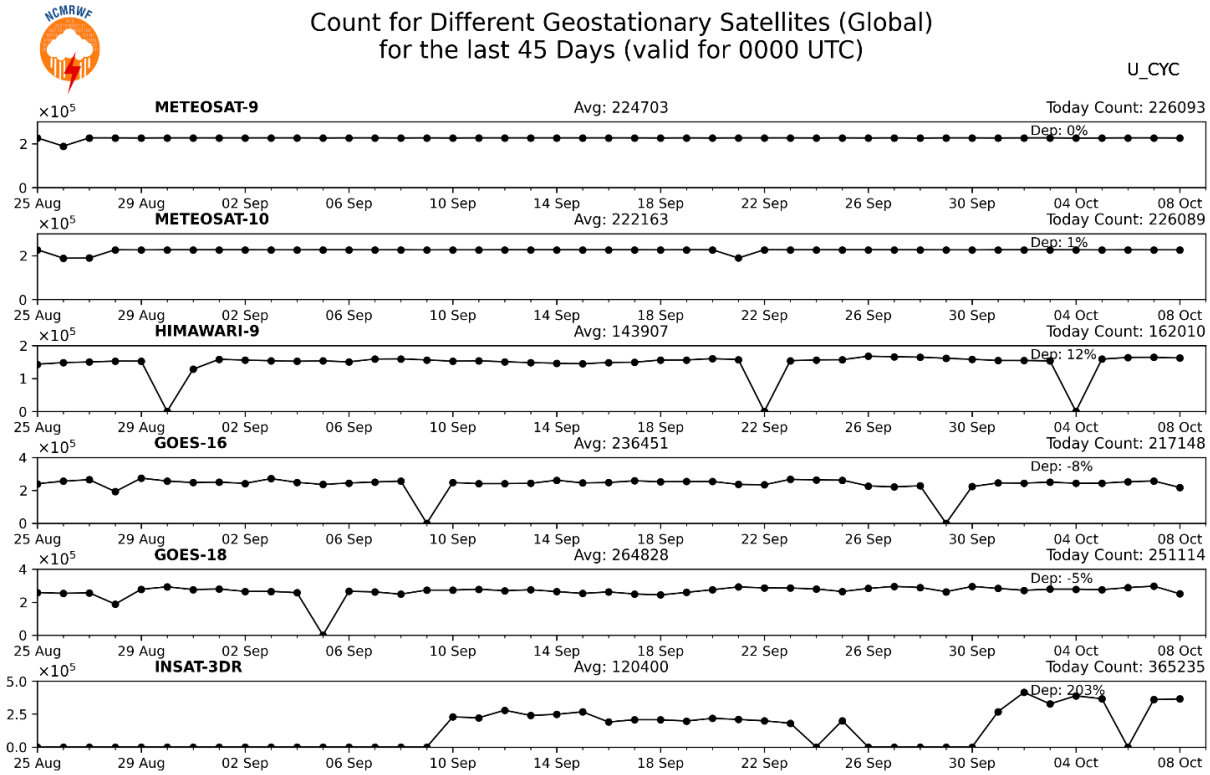

Figure 3: 45-days time-series for geostationary radiances received at NCMRWF from different satellites (Meteosat-9, Meteosat-10, GOES-16, GOES-18, Himawari-9, and INSAT-3DR) for the period 25th August 2024 to 08th October 2024.

Table.2 List of Satellites with the scatterometer payloads and WMO Satellite identifier

S.No	Scatterometer satellites	WMO Satellite Identifier
1	Metop-B	3
2	Metop-C	5
3	Oceansat-3	421
4	HY-2B	503
5	HY-2C	504
6	HY-2D	505

Yang – HY) observations from HY-2B (HSCAT-2B), HY-2C (HSCAT-2C), and HY-2D (HSCAT-2D) from the EumetCast. Table 2 consolidates the lists of satellites from which

NCMRWF receives the scatterometer sea surface winds. Figure.3 presents the 45-days time-series count for the sea surface winds from different satellites.

NCMRWF receives radiances from Geostationary satellites from various sources. NCMRWF is receiving the Meteosat (both prime and IODC) and Himawari imager radiances through the GTS. The GOES (both East and West) satellites radiances are received from NOAA and the INSAT-3DR/3DS data through IMD, Table 3 shows the lists of geostationary satellites from which NCMRWF receives near-real-time radiances and Figure 3 shows the corresponding 45 day time series plot.

Table.3 List of geostationary satellites and WMO Satellite identifier

S.No	Geostationary Satellites	WMO Satellite Identifier
1	Meteosat-9	56
2	Meteosat-10	57
3	GOES-16	270
4	GOES-18	272
5	Himawari-9	174
6	INSAT-3DR	473

In addition to the separate time series monitoring of observations from various satellites, a consolidated time series plot (Figure 4) of each type of observation (GNSS-RO, GNSS-ZTD/IPW, Scatterometer winds, geostationary radiances) are included in the revised NCMRWF observation monitoring report and are available at the HPC.

3. Summary

The 45-days time-series provides crucial information about the observational dataset. NCMRWF currently monitors this time series for conventional observations such as synop, ship, buoy, aircraft, radiosonde/rowinsonde, pilot, and AMVs. There is a need to extend this analysis to satellite observations. This report presents the 45-day time series for the satellite observations, specifically GNSS-RO, GNSS-IPW (ZTD), scatterometer sea surface winds, and geostationary radiances. Future plans include generating similar time series figures for additional satellite observations like multispectral and hyperspectral observations from various polar and inclined orbiting satellites.

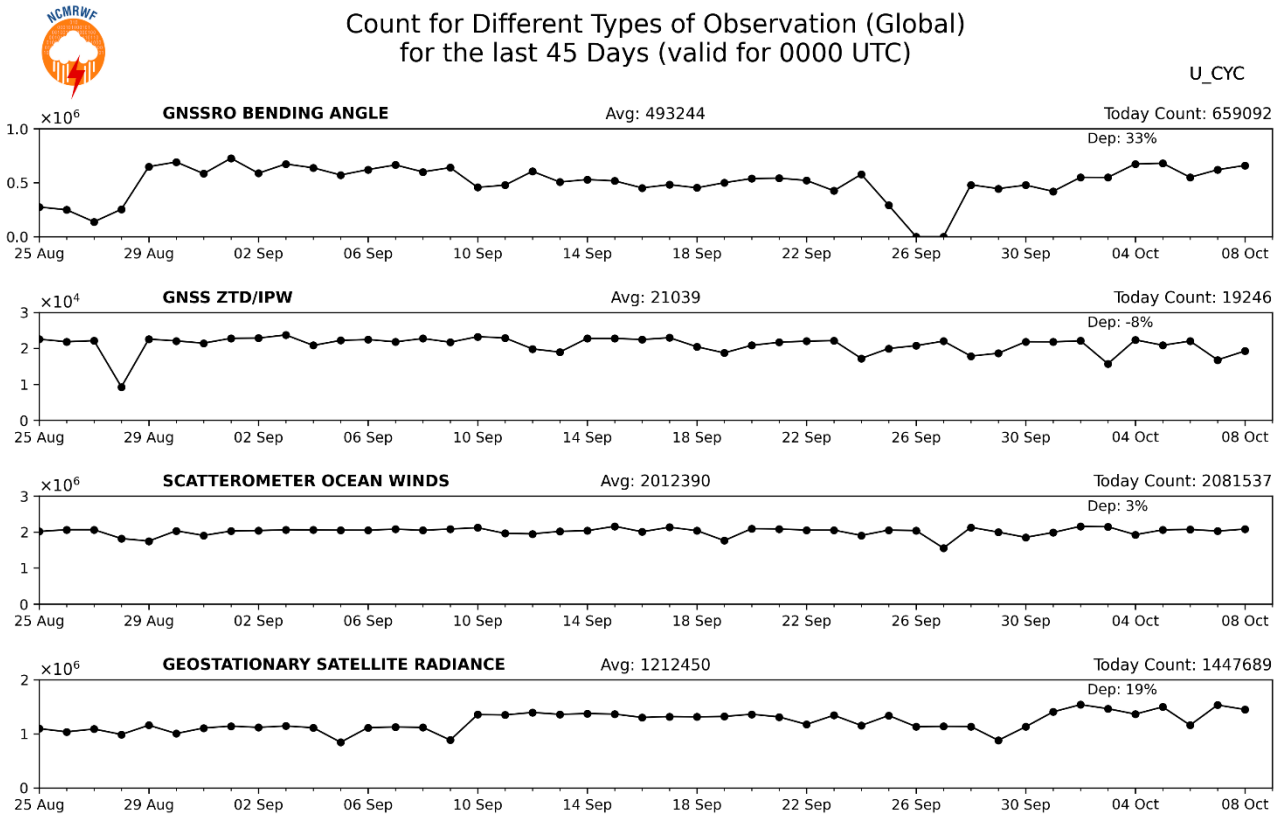

Figure 4: 45-day time-series for total observations of GNSS-RO, GNSS IPW or ZTD, scatterometer sea surface winds, and geostationary radiances received at NCMRWF for the period 25th August 2024 to 08th October 2024.

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Author Contributions

Smrati Purwar: Software, data curation, Visualization, Investigation, Original draft, review and editing.

Indira Rani S.: Supervision, Investigation, review and editing.

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