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RESEARCH REPORT

Data Pre-Processing for NCMRWF Unified Model (NCUM): Version 2

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10	**Abstract**	**Under Monsoon Mission, NCMRWF has proposed to adopt UK Met Office's Unified model (UM) for seamless prediction and the same has been implemented at the centre, which is now referred to as NCMRWF Unified Model (NCUM). NCUM has all the components of the UM system except the data pre-processing package, Met Office Data Base (MetDB). In the absence of MetDB database at NCMRWF, in-house data pre-processing tools were developed to convert the existing T574L64 data assimilation system data dump output- "BUFR" data, to the NCUM required data format - "Obstore" (Prasad, 2012). The structure of the obstore file of each observation type is defined by the list of observational elements in that type. The elements of each observation type is defined by Met Office and listed in a fixed file and this file is updated from time to time depending on requirement. Routine comparison of NCMRWF and UK Met Office obstore data showed that there are prominent changes in some of the obstore types, especially satwnd, scatwnd and sonde obstores. Further, recently NCUM started generating Real Time Monitoring (RTM) outputs of different types of obstores on an operational basis. RTM statistics gave lot of insight into the data arrangement requirements of OPS. These developments necessitated changes in the NCMRWF obstore file creation and this report give an account of these changes.**
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1. Introduction

Under Monsoon Mission, NCMRWF has proposed to adopt UK Met Office's Unified model (UM) for seamless prediction and the same has been implemented at the centre, which is now referred to as NCMRWF Unified Model (NCUM). NCUM has all the components of the UM system except the data pre-processing package, Met Office Data Base (MetDB). At UK Met Office, Observational Processing System (OPS), normally extracts the time windowed observational data sets from its own data base, MetDB into an intermediate file called 'Obstore' for its further use. The "obstore" file has a unique structure and has many header records which provide all information necessary to the read file including its metadata.

NCMRWF has an operational Global Data Assimilation and Forecast System (GDAF) system - based on GFS (T574L64) of NCEP, USA. It has a data pre-processing system for decoding meteorological and oceanographic data received through received through Global Telecommunication System (GTS) and from other sources. After decoding these datasets are archived in a special file structure called "TANK" file in NCEP's 'BUFR' format. These files are accessed from time-to-time for extracting observations for a required time window and dumping them into different category of files based on observation types (eg., dpsfc (surface), Adpupa (upper air), Satwnd (satellite winds), etc.). Figure 1 shows the different types global observations received at NCMRWF through GTS and Internet (ftp) in near-real time for assimilating into the global models.

In the absence of MetDB database at NCMRWF, in-house data pre-processing tools were developed to convert the GDAF dump output BUFR data to the required "Obstore" format (Prasad, 2012). This was the first of its kind attempt to convert NCEP dump BUFR data to obstore format. Since 2012, the obstore data created at NCMRWF is used to run NCUM routinely. Different types of obstore data created includes, Surface, Upper air (Sonde), Aircraft, Satwind, Scatwinds, Satellite radiances (Satrad) and GPS Radio Occultation (GPSRO). In house observation monitoring packages were developed to monitor the obstore data created at NCMRWF and compare with those received from UK Met office. Regular comparison of NCMRWF obstores and UKMO obstores show that even though the quantity of data received at NCMRWF is comparatively less for some type of observations, there is a good global coverage in the NCMRWF obstores. Figure 2 describes theprocedure adopted to convert GDAF dump data to NCUM obstores.

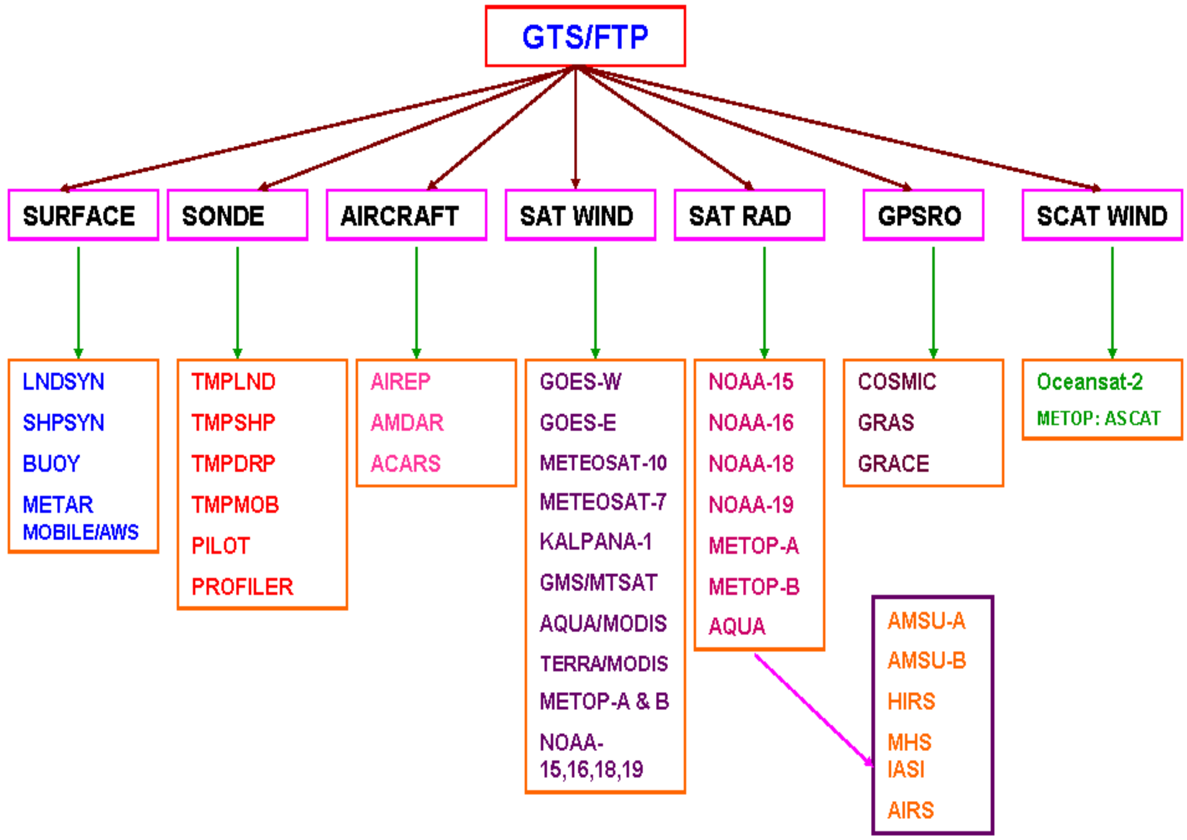

Figure 1: Near-real time global observations received at NCMRWF through GTS and Internet (ftp).

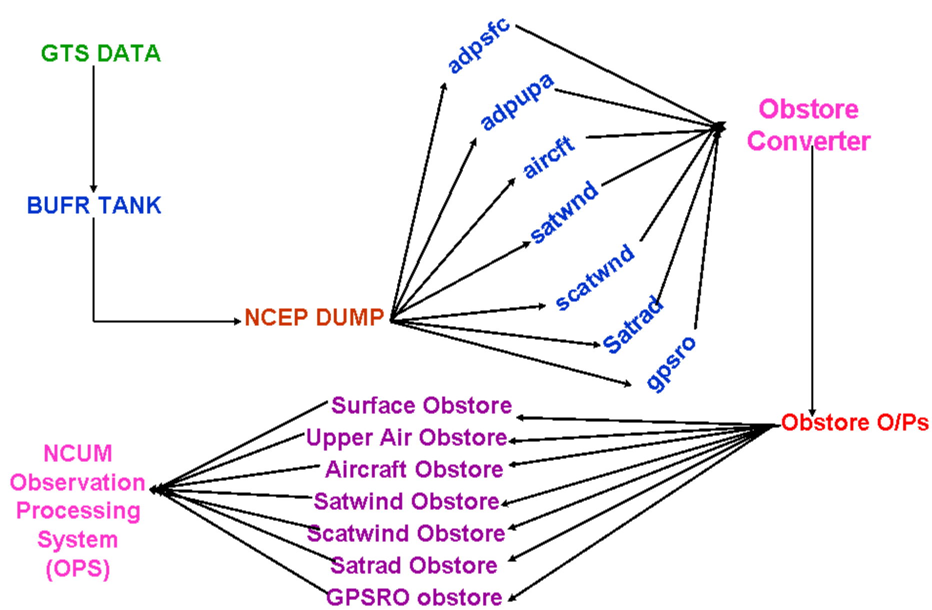

Figure 2: Procedure to convert NCEP dump data to NCUM obstores.

Motivation

The structure of the obstore file of each observation type is defined by the list of observational elements in that type. The elements of each observation type is defined by Met Office and listed in a fixed file and this file is updated from time to time depending on requirement. Routine comparison of NCMRWF and UK Met Office obstore data showed that there are prominent changes in some of the obstore types, especially satwnd, scatwnd and sonde obstores. The main differences are

1) Some of the satwnd sub-types were not being produced correctly in NCMRWF satwnd obstore.
2) In the scatwnd obstore, windsat and the Indian satellite Oceansat-2 scatterometer data were not getting packed.

Further, it was also found that Radiosonde and Pilot reports are to be packed in ascending order of height and while GDAF data dumps data are not packed in ascending/descending order but in mixed manner based on vertical significance code. In order to overcome the above limitations in the NCMRWF obstore data, a second version of obstore packing module was developed by modifying the existing package and including some additional modules.

NCUM generates Real Time Monitoring (RTM) outputs of different types of obstores on an operational basis. RTM statistics gave lot of insight into the data arrangement requirements of OPS. RTM of a particular observation type gives an insight into number of observations processed, the percentage of surplus amount of observations, percentage of observations which failed quality check, percentage of observations used, and the Observation–Background (o-b) statics (Mean and Root Mean Square Error (RMS) values of all observations. RTM output for NCMRWF Sonde obstore showed high o–b statistics (Mean and RMS) values. Thus the RTM feedback provided an indication of the some drawbacks in the Sonde obstore packing at NCMRWF. Although all the satellite winds were packed in NCMRWF satwnd obstore, RTM outputs does not show all the types. This in turn forced us to do a detailed analysis of Observation Processing System (OPS) outputs like varobs and var_cx files.

Current status

Some of the satellite winds sub-types (viz., IR, WV, VI, etc.) from GOES-E and W, JMA, MSG, ESA and MODIS were not going into OPS at NCMRWF mainly because they were changes in the packing of satwnd obstore. In the present version, modules are modified/added to include almost all (as far as possible) satellite wind sub-types from different satellite platforms. The main changes made to incorporate satellite wind sub-types in the NCMRWF obstore is described in Section 2. NCMRWF routinely receives scatterometer winds, viz., ASCAT (Metop satellite) through NOAA/NESDIS, OSCAT (Oceansat-2) from ISRO and KNMI and Windsat (Coriolis Satellite) through NOAA/NESDIS. Currently in the NCUM only ASCAT winds are assimilated routinely. The scatwnd obstore creation packages are modified to include both OSCAT and Windsat winds. This is the first time that Indian satellite data (OSCAT) is going into the NCUM assimilation system. The changes made in the obstore creation package to incorporate additional scatterometer winds is described in Section 3.

Some of the sonde observations received through GTS contain mixed reports of Radiosonde (Temp) and Pilot data. Previously in the NCMRWF obstore creation package, these sonde observations were separated and packed both in TEMP (50100) and Pilot (50200), causing a duplication of the same data. This in-turn was giving excess of data and the statistical errors were more for different parameters like geopotential height, temperature, RH, wind, etc.. Obstore creation package is now modified to remove the duplicate reports, and now the number of observations and the statistics are comparable to that of UK Met office system. The detailed description of the changes made to remove the duplicate data in sonde obstore is described in Section 4.

2. Satellite winds

Main satellite wind types packed in NCMRWF satwind obstore are ESA (22200), MODIS (22600), GOES BUFR (22500), JMA WINDS (23500), and MSG WINDS (23600). Each type is further divided into sub-types. ESA has three sub-types (22201, 22202, and 22203) in different spectral channels like Infra-Red (IR), Visible (VI) and Water Vapor (WV). GOES BUFR has seven different sub-types (22501, 22502,22503,22505,22511 and 22515) in different spectral channels like IR, VI, WV, Clear Sky Water Vapor (CSWV), etc, JMA Winds has six different sub-types in different spectral ranges (23501, 23502, 23503, 23505, 23507 and 23511). There are eleven sub-categories for MSG winds (23611, 23612, 23613, 23614, 23621, 23622, 23623, 23631, 23632, 23651, and 23652). MODIS is six different sub types (22601, 22603, 22604, 22605, 22611 and 22615). Other types of satellite winds included in the satwnd obstore are detailed in OPS technical documentation paper (OTDP6). Similar to UK Met Office, winds from GOES-E, GOES-W, NOAA series satellites and Metop satellites are grouped together into GOES BUFR obstore at NCMRWF. The polar satellite winds (MODIS, NOAA series and Metop) are grouped together in MODIS (22600) type. Figure 3 shows the tree diagram of NCUM satwnd obstore and its different sub-types.

When all the satwnd types are allowed to pass through Observation Processing System (OPS) without any Quality Control (QC) checks, all the sub-types in Figure 3 are dumped in the OPS outputs (viz., varobs and var_cx files), with some of the sub-types having high Probability Gaussian Error (PGE) values. After applying the QC checks, mainly 22501, 22503 (GOES sub-types), 23501, 23502, 23503 (JMA sub-types), 23613, 23632 (MSG sub-types), and 22201 (ESA sub-type) are present in the varobs and var_cx files. Although, the NOAA and Metop polar winds are grouped along with GOES BUFR, varobs output does not show any polar winds in GOES BUFR (22500), but is seen in MODIS (22600) along with Aqua and Terra polar satellite winds. Figures 4 and 5 shows the satwind sub-types in varobs file without QC check and with QC check respectively for a particular day.

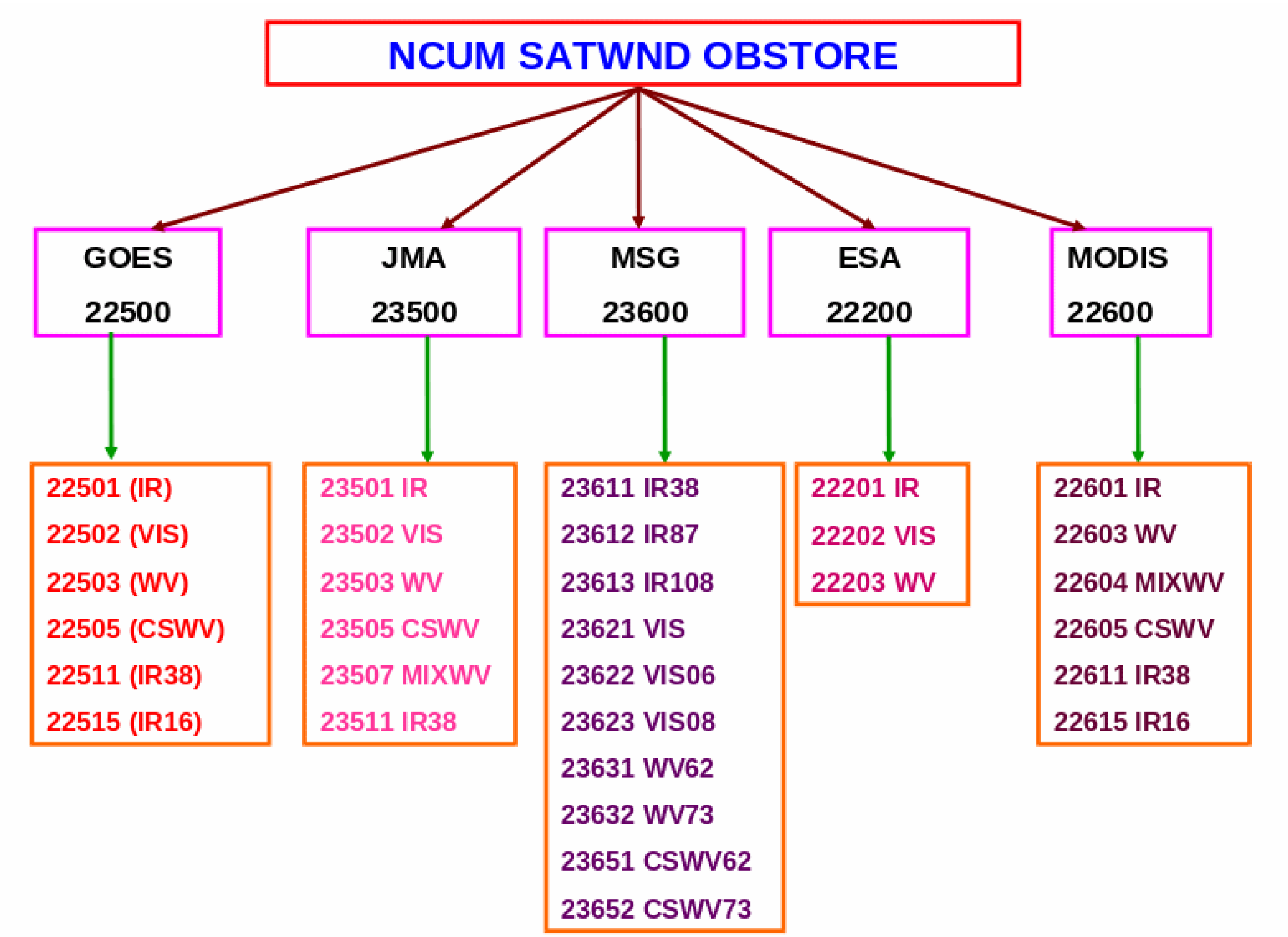

Figure 3: Tree diagram of NCUM satwnd obstore and its sub-types.

From Figure 4, it is clear that the varobs contains all the main NCUM satellite wind types, and it exactly similar to the input satellite winds. It contains 30464, 19134, 80332, 109228, and 42674 numbers of satellite winds respectively in satwnd types 22200 (ESA), 22600 (MODIS), 22500 (GOES), 23500 (JMA) and 23600 (MSG). Figure 5 is similar to Figure 4, but after applying QC. It is noticed from Figure 5 that only about 3%, 1.25%, 2.5%, and 10% of ESA, GOES, JMA, and MSG winds respectively have passed QC checks. Approximately 3% of the total satellite winds are present in the OPS output varobs file. It is confirmed that all the sub-types are packed correctly in the NCUM satwnd obstore file, and whenever the satellite winds passes the entire QC, that wind will be present in the varobs file. The RTM also shows the number of winds present in different sub-types, even though it has not passed the QC checks. Whenever any sub-types passes all the QC checks RTM produces the statistics like mean and RMSE.

3. Scatterometer winds

Different sub-types in the scatteometer wind obstore are ASCAT (24300), OSCAT (20300) and Windsat (24800). The current NCMRWF scatwind obstore does not have OSCAT and Windsat. Header files were extracted from UK Met Office's latest scatwind obstore files, and using the corresponding element files OSCAT and Windsat winds were packed along with the existing NCMRWF scatwind obstore. Windsat is an existing sub-type in the scatwind obstore, and thus this data will normally go into the OPS system without changing the station-list file. As OSCAT is a new sub-type scatterometer wind, the station-list file has to be modified to include the satellite identifier and error values. OSCAT is treated similar to QuickSCAT (SEAWINDS type). Figures 6 and 7 respectively shows the scatterometer winds coverage in the current operational scatwnd obstore (NCUM-O) and the newly developed scatwnd obstore (NCUM-E).

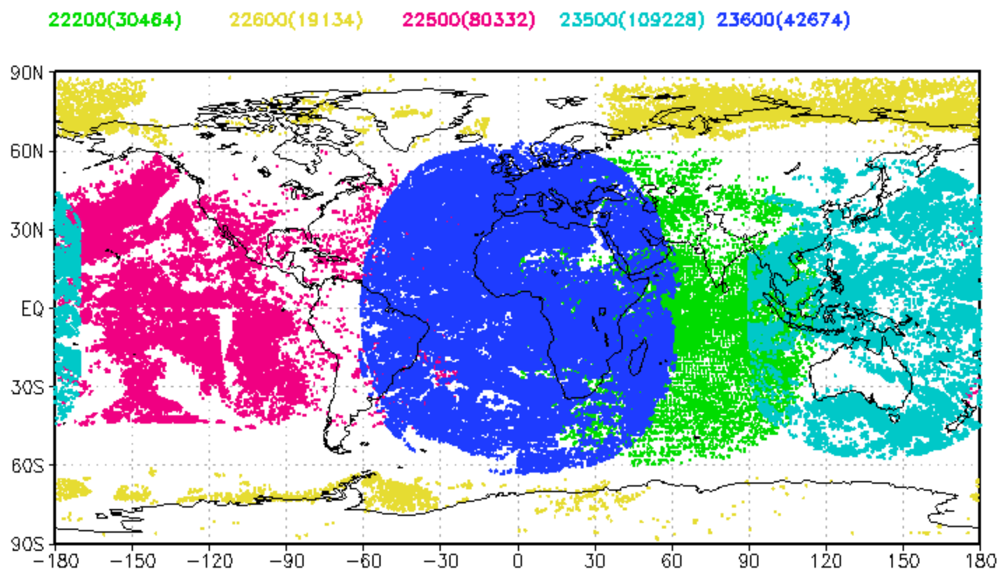

Figure 4: OPS processed satellite winds, when allowed all the winds (without QC).

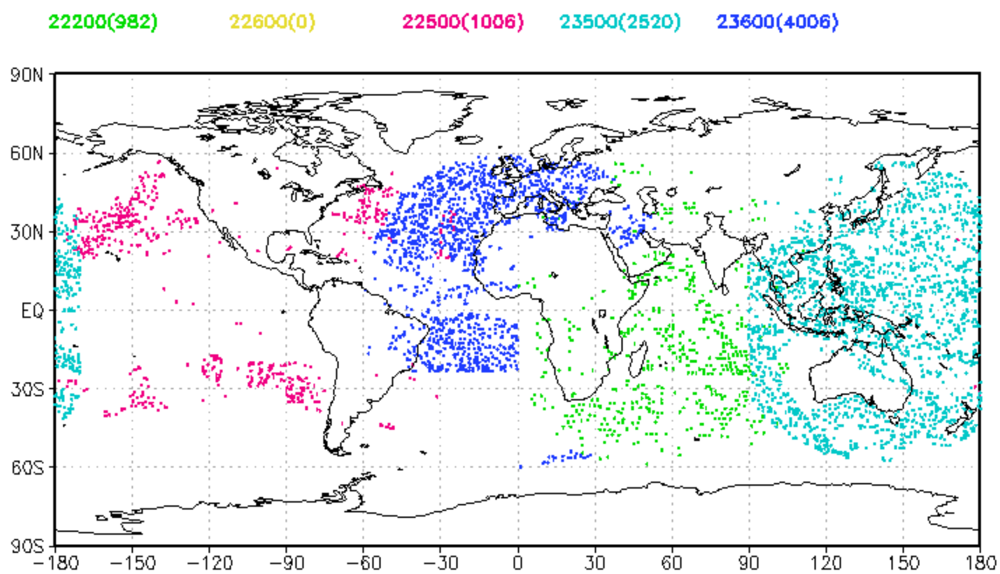

Figure 5: OPS processed satellite winds after applying QC.

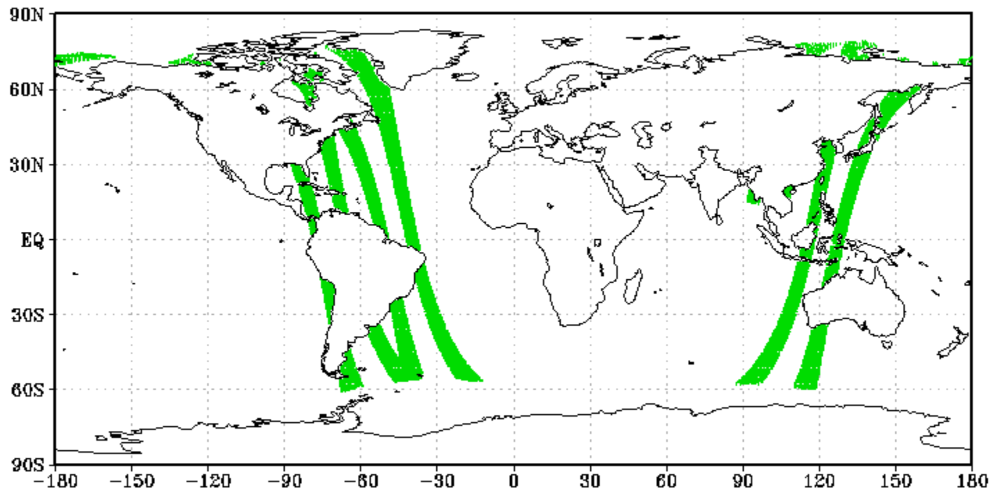

Figure 6: Scatterometer wind coverage in scatwnd obstore (Operational)

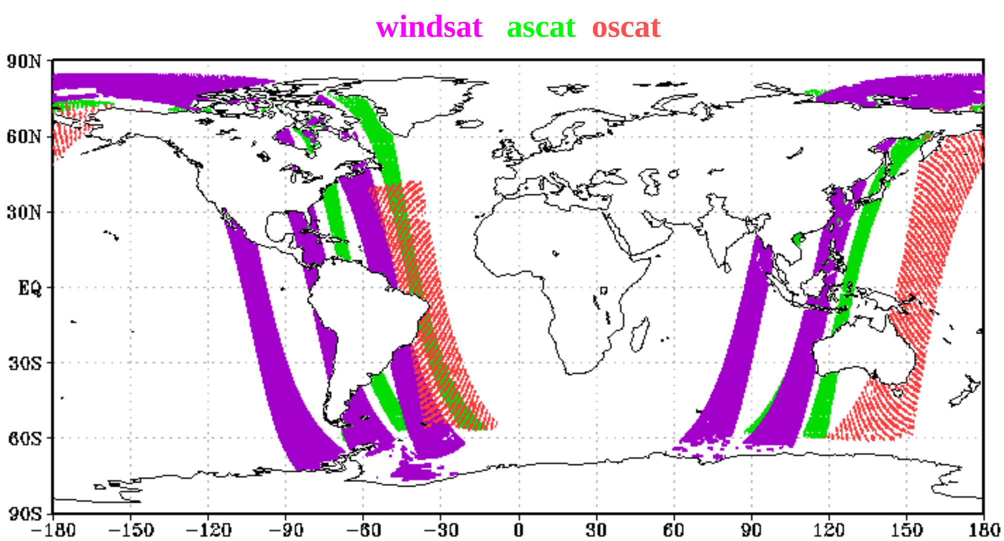

Figure 7: Scatterometer wind coverage in scatwnd obstore (Experiment)

The OPS successfully accepted the newly created scatwind obstore and created outputs (varobs and var-cx files) required for the Variational Assimilation System. The varobs files from NCUM-O and NCUM-E were compared to ensure that OSCAT and Windsat data also has been accepted along with ASCAT. Table 1 shows the scatterometer sub-types present in the NCUM-O and NCUM-E varobs and the respective statistics for u and v winds at 10 m level.

4. Sonde

RTM outputs revealed lot of differences in NCMRWF and UK Met Office sonde obstore, mainly in the o-b statistics of all observations and percentage use of observations. Version-1 of NCMRWF Sonde obstore was packed in such a way that the height/pressure level was not arranged ascending/descending order. It was noticed that, though there were 200 levels (according to the element file) in the profile, after following the ascending/descending order for height/pressure, the OPS stops processing the rest of the profile, when there is a discontinuity in the profile, even if high level height/pressure were present in the profile after the discontinuity. Thorough checking of varobs and var_cx outputs from the OPS provided an insight into the order of the height/pressure that has to be followed to incorporate the full profile in the OPS. Subroutines for sorting height/pressure were developed, and tested. This ensured that the full profile is accepted by the OPS. Even after sorting height/pressure, the o-b error statistics for all observation was not changed.

The Sonde reports coming through GTS contain reports of wind field, temperature field or both fields at various levels of atmosphere along with level pressure, or level geo-potential height or both. It is noticed that some of the Sonde reports, contains only wind and geopotential height field and these reports are treated as pilot reports in this version of obstore packing and packed accordingly.

The RTM output of newly packed sonde obstore showed the error statistics are comparable to that of UK Met Office Sonde obstore. Table 2 shows the comparison of different parameters at different levels in the NCUM-O, UK Met Office (UKMO) and NCUM-E RTM outputs.

Table 1: Statistics of scatterometer winds in NCUM-O and NCUM-E varobs

Observing System/Area	Variable	System	No. Processed	Percentage quality control info			Used obs o-b stats		All obs o-b stats	
				Surplus	QC fail	Used	Mean	Rms	Mean	Rms
OSCAT Global	10m u	NCUM-O	-------	-------	------	-------	--------	---------	-------	-------
		NCUM-E	15508	70.9	19.4	9.7	0.156	1.398	0.007	1.571
OSCAT Global	10m v	NCUM-O	-------	-------	------	-------	--------	---------	-------	-------
		NCUM-E	15508	70.9	19.4	9.7	-0.029	1.395	0.040	1.587
ASCAT Global	10m u	NCUM-O	11747	74.0	16.2	9.8	-0.104	1.380	-0.128	1.458
		NCUM-E	11747	74.0	16.2	9.8	-0.104	1.380	-0.128	1.458
ASCAT Global	10m v	NCUM-O	11747	74.0	16.2	9.8	0.178	1.737	0.225	1.798
		NCUM-E	11747	74.0	16.2	9.8	0.178	1.737	0.225	1.798
WINDSAT Global	10m u	NCUM-O	-------	-------	------	-------	--------	---------	-------	-------
		NCUM-E	20097	68.1	0.0	0.1	0.302	1.067	0.473	1.680
WINDSAT Global	10m v	NCUM-O	-------	-------	------	-------	--------	---------	-------	-------
		NCUM-E	20097	68.1	0.0	0.1	0.320	0.990	-0.049	1.764

Table 2: Comparison of RTM outputs of different parameters at different levels from NCUM-O, UKMO, and NCUM-E RTM outputs.

Observing System/Area	Variable	System	No. Processed	Percentage quality control info			Used obs o-b stats		All obs o-b stats	
				Surplus	QC fail	Used	Mean	Rms	Mean	Rms
TEMP Global 50 hPa	Height	NCUM-O	523	0.0	11.1	88.5	-18.306	35.421	-17.339	40.640
		UKMO	485	1.0	0.4	98.4	-14.921	32.560	-13.798	35.223
		NCUM-E	533	0.4	0.6	98.5	-17.644	35.673	-16.864	40.762
TEMP Global 100 hPa	Height	NCUM-O	457	0.0	16.8	81.8	-3.493	27.705	-20.730	86.644
		UKMO	560	0.9	0.7	98.2	-5.546	25.614	-4.724	29.389
		NCUM-E	443	0.4	0.7	98.4	-3.758	26.380	-2.442	36.851
TEMP Global 250 hPa	Height	NCUM-O	578	0.0	12.1	86.9	0.422	17.978	-5.558	62.820
		UKMO	577	0.9	0.9	98.1	-0.081	17.347	0.091	24.217
		NCUM-E	591	0.2	0.7	98.0	0.525	17.559	0.319	23.217
TEMP Global 500 hPa	Height	NCUM-O	587	0.0	12.1	86.9	0.503	12.087	-5.864	42.636
		UKMO	582	0.9	0.9	98.1	0.420	11.415	0.130	14.970
		NCUM-E	598	0.5	0.8	97.8	0.657	11.715	-0.029	15.570
TEMP Global 700 hPa	Height	NCUM-O	593	0.0	12.6	86.2	0.132	8.725	-2.801	21.446
		UKMO	589	0.8	0.7	97.8	0.211	8.004	-0.112	11.046

		NCUM-E	592	0.5	1.2	97.5	0.284	8.327	-0.466	12.968
TEMP Global 850 hPa	Height	NCUM-O	579	0.0	13.0	84.6	-0.312	8.042	-5.156	32.902
		UKMO	587	0.9	2.2	95.2	0.144	6.959	-2.059	20.000
		NCUM-E	584	0.5	2.7	96.1	0.103	7.325	-3.190	25.470
TEMP Global 50 hPa	Temperature	NCUM-O	538	0.0	15.6	78.4	-0.477	1.296	-10.547	32.866
		UKMO	483	0.8	0.0	95.2	-0.589	1.388	-0.582	1.385
		NCUM-E	538	0.5	0.0	93.7	-0.561	1.355	-0.561	1.356
TEMP Global 100 hPa	Temperature	NCUM-O	584	0.0	37.8	56.5	-0.360	1.373	-29.946	48.385
		UKMO	562	0.9	0.0	95.4	-0.382	1.385	-0.382	1.383
		NCUM-E	583	0.4	0.0	93.8	-0.308	1.370	-0.308	1.368
TEMP Global 250 hPa	Temperature	NCUM-O	604	0.0	16.7	77.2	-0.079	0.922	-12.678	38.351
		UKMO	579	0.9	0.2	95.0	-0.124	0.928	-0.108	1.017
		NCUM-E	603	0.5	0.2	93.2	-0.082	0.914	-0.060	1.044
TEMP Global 500 hPa	Temperature	NCUM-O	610	0.0	15.9	76.2	0.063	0.899	-13.685	42.871
		UKMO	583	0.9	0.0	93.3	0.023	0.940	0.028	0.938
		NCUM-E	609	0.5	0.2	91.6	0.052	0.898	0.047	0.937
TEMP Global 700 hPa	Temperature	NCUM-O	611	0.0	15.9	76.1	-0.126	1.028	-14.461	44.764
		UKMO	589	0.8	0.0	92.9	-0.149	1.095	-0.148	1.091
		NCUM-E	610	0.5	0.2	91.5	-0.108	1.044	-0.122	1.082
TEMP Global 850 hPa	Temperature	NCUM-O	600	0.0	16.0	70.7	0.185	1.287	-14.913	46.138
		UKMO	587	0.9	0.0	87.1	0.105	1.347	0.099	1.348
		NCUM-E	599	0.5	0.0	86.3	0.143	1.345	0.139	1.347
TEMP Global 50 hPa	Relative humidity	NCUM-O	354	0.0	43.5	43.2	2.333	6.672	16.537	29.470
		UKMO	299	0.7	21.7	63.2	1.488	5.737	11.547	22.952
		NCUM-E	355	0.5	30.4	56.3	1.729	5.971	16.982	29.506
TEMP Global 100 hPa	Relative humidity	NCUM-O	387	0.0	66.1	25.8	3.330	9.760	8.319	37.014
		UKMO	387	0.8	37.0	54.8	0.136	12.074	19.987	37.554
		NCUM-E	387	0.3	34.9	56.8	0.537	11.299	18.946	36.251
TEMP Global 250 hPa	Relative humidity	NCUM-O	545	0.0	29.2	66.4	-2.949	19.796	-2.449	31.647
		UKMO	526	0.6	18.3	76.8	-3.024	17.786	3.946	28.203
		NCUM-E	544	0.2	17.3	78.1	-3.186	18.310	2.475	27.405
TEMP Global 500 hPa	Relative humidity	NCUM-O	608	0.0	24.3	73.8	1.329	18.013	-2.811	25.478
		UKMO	582	0.9	8.8	89.2	0.497	17.482	1.576	19.817
		NCUM-E	607	0.5	9.6	88.1	0.964	17.471	1.809	19.737
TEMP Global 700 hPa	Relative humidity	NCUM-O	608	0.0	22.9	74.7	1.663	17.205	-3.140	24.762
		UKMO	587	0.9	7.0	90.3	1.508	16.772	1.842	17.641
		NCUM-E	607	0.5	7.2	89.8	1.505	17.424	1.707	17.868
TEMP Global	Relative	NCUM-O	598	0.0	27.4	69.6	-1.060	14.863	-6.066	26.528

850 hPa	humidity	UKMO	585	0.9	12.0	85.3	-0.270	15.074	-0.200	14.936
		NCUM-E	597	0.5	11.7	84.8	-0.149	15.104	-0.267	15.302
TEMP Global 50 hPa	Wind	NCUM-O	532	0.0	12.0	81.0	0.627	2.567	0.812	4.168
		UKMO	475	0.2	0.0	94.7	0.822	2.662	0.828	2.664
		NCUM-E	525	0.0	0.4	93.0	0.710	2.555	0.839	4.167
TEMP Global 100 hPa	Wind	NCUM-O	589	0.0	29.5	64.7	-0.852	3.279	-2.236	5.117
		UKMO	556	0.2	0.0	95.9	0.382	3.059	0.377	3.058
		NCUM-E	580	0.5	20.7	73.8	-1.283	3.728	-3.000	6.105
TEMP Global 250 hPa	Wind	NCUM-O	607	0.0	12.5	84.0	0.687	3.152	0.300	4.213
		UKMO	570	0.2	0.2	98.1	0.706	3.028	0.773	3.525
		NCUM-E	594	0.2	1.7	95.3	0.729	3.139	0.392	4.096
TEMP Global 500 hPa	Wind	NCUM-O	613	0.0	12.1	83.7	0.380	2.679	0.248	2.874
		UKMO	578	0.2	0.3	96.9	0.541	2.571	0.577	5.668
		NCUM-E	606	0.2	1.0	94.6	0.425	2.609	0.337	2.772
TEMP Global 700 hPa	Wind	NCUM-O	613	0.0	11.4	82.1	0.303	2.493	0.244	2.541
		UKMO	579	0.2	0.2	94.6	0.438	2.397	0.449	2.412
		NCUM-E	635	0.2	0.6	88.2	0.316	2.426	0.283	2.507
TEMP Global 850 hPa	Wind	NCUM-O	604	0.0	10.9	81.3	0.103	2.393	0.029	2.482
		UKMO	578	0.2	0.0	93.8	0.290	2.395	0.294	2.395
		NCUM-E	664	0.2	0.3	82.8	0.055	2.427	0.025	2.456
PILOT Global 100 hPa	Wind	NCUM-O	1	0.0	0.0	0.0	-	-	-	-
		UKMO	126	87.3	0.0	9.5	0.575	2.970	0.160	4.056
		NCUM-E	108	89.8	0.0	2.8	1.501	4.241	0.305	3.578
PILOT Global 250 hPa	Wind	NCUM-O	1	0.0	0.0	0.0	-	-	-	-
		UKMO	138	87.7	0.7	9.4	0.567	2.219	0.648	3.395
		NCUM-E	84	89.30	0.0	2.4	0.006	1.272	0.535	3.614
PILOT Global 500 hPa	Wind	NCUM-O	8	50.0	0.0	0.0	-	-	-1.847	4.353
		UKMO	204	88.2	0.5	10.8	0.189	2.926	0.256	2.468
		NCUM-E	101	88.1	0.0	1.0	-2.702	2.702	0.174	2.637
PILOT Global 700 hPa	Wind	NCUM-O	42	7.1	0.0	0.0	-	-	0.009	0.948
		UKMO	215	74.9	0.0	20.5	0.644	3.826	0.374	3.182
		NCUM-E	127	74.0	0.0	2.4	0.235	1.328	0.477	2.926
PILOT Global 850 hPa	Wind	NCUM-O	80	5.0	0.0	1.2	-3.129	3.129	-1.599	3.750
		UKMO	280	67.5	0.0	24.6	-0.053	2.883	0.772	9.499
		NCUM-E	161	62.1	0.0	1.9	0.347	2.142	0.115	2.683
WINPRO Global 100 hPa	Wind	NCUM-O	16	0.0	0.0	12.5	2.879	3.185	2.879	3.185
		UKMO	13	0.0	0.0	38.5	0.127	1.751	0.127	1.751
		NCUM-E	16	0.0	0.0	12.5	2.879	3.185	2.879	3.185

WINPRO Global 250 hPa	Wind	NCUM-O	69	27.5	8.7	37.7	0.687	2.280	0.887	2.283
		UKMO	324	5.9	0.0	8.3	0.992	2.364	0.887	2.118
		NCUM-E	69	27.5	8.7	37.7	0.687	2.280	0.887	2.283
WINPRO Global 500 hPa	Wind	NCUM-O	165	46.1	9.1	38.2	0.440	2.410	0.685	1.984
		UKMO	927	31.0	0.6	14.7	0.564	2.541	1.023	6.361
		NCUM-E	165	46.1	9.1	38.2	0.440	2.410	0.685	1.984
WINPRO Global 700 hPa	Wind	NCUM-O	303	51.5	9.2	20.8	0.459	2.445	1.207	2.897
		UKMO	1768	28.2	0.2	13.1	1.245	3.074	1.099	2.993
		NCUM-E	303	51.5	9.2	20.8	0.459	2.445	1.207	2.897
WINPRO Global 850 hPa	Wind	NCUM-O	397	51.9	6.5	17.6	0.636	2.247	0.549	2.166
		UKMO	2662	23.1	0.3	8.9	1.187	3.367	1.113	3.510
		NCUM-E	397	51.9	6.5	17.6	0.636	2.247	0.549	2.166

5 Goes Clear Sky Brightness Temperature (GCSBT)

Clear sky brightness temperature (CSBT) from the imagers onboard GOES satellites (GOES-E and GOES-W) are assimilated in NCUM. Both GOES-E (12) and GOES-W (13) were going into the NCUM OPS, until GOES-E (12) has been changed to GOES-15. The radiance calling subroutines in OPS codes are changed to incorporate GOES-15 (Satellite id: 259) and different channels (3, 4, and 6) similar to GOES-13. The modified OPS codes are compiled successfully and established that GOES-15 BT have been accepted in OPS along with GOES-13.

Thinning control in GOESClear ops satrad processes are done in two steps. In the first thinning (Thin Call 1), thinning has been done in a box size of 2 km within a time interval of 1 hour, whereas in the second call, the time inverval is same, but the box size has set to 120 km. Thinning scores are set for different atmospheric conditions (clear, cloudy, rain, etc,.) and surface type (sea, land, ice, etc,.), and clear sky radiances over sea and land are accepted in the OPS. Table 3 gives a glimpse of number of observations passed the QC after thinning for a particular assimilation cycle of a particular day. Out of 84777 (42385 (GOES-13) and 42392 (GOES-15)), 1271 observations passed the QC after thinning, almost 1.5% of the total observations are packed for 4Dvar assimilation. Varobs and Var_cx files for GOES Clear are created successfully.

Table 3: NCUM GOESClear observation statistics (particular assimilation cycle of a particular day)

GOES-13				GOES-15				Total no. of observations Accepted (G-13 &G-15)	
Total no. of obs	Accepted over Sea	Accepted over Land	Total no. of obs. accepted	Total no. of obs	Accepted over Sea	Accepted over Land	Total no. of obs accepted		
42385	405	142	547	42392	695	29	724	1271	1100 (Sea)
									171 (Land)

6 Spinning Enhanced Visible and Infra-Red Imager (SEVIRI) CSBT

NCUM OPS codes and the related namelist and bias files are modified to incorporate Spinning Enhanced and Visible and Infra-Red Imager (SEVIRI) onboard Meteosat Second Genration (MSG) satellites (Meteosat-10, WMO id: 57). Currently NCMRWF is not having SEVIRI data, and the modified OPS codes are tested using SEVIRIClear obstore data downloading from UKMO. The OPS experiment to incorporate SEVIRIClear obstore ran successfully and ensured that both varobs and var_cx files required to run variational assimiation system are created.

Similar to GCSBT, thinning has been been performed for SEVIRIClear BT as well. Out of 12 channels, 5,6,7,9 10, and 11 are checked for thinning. Thinning processes for SEVIRIClear satrad are similar to that of GOESClear satrad. Two steps of thinning within a box size of 2km and 120 km respectively within a spatial resolution of 1 hour. Thinning scores are set to different atmospheric conditions and clear sky BT over sea and land are assimilated after QC. Table 4 is similar to Table 3, but for SEVIRIClear satrad observations on a particular assimilation cycle of a particular day. Out of 166763 total observations, 7928 passed all the thinning QC (2789 over Sea and 5139 over land) and present in the varobs and var_cx files for 4D-Var. Approximately 5 % of the SEVIClear BT passed QC and available for 4D variational assimilation.

Table 4: NCUM SEVIRIClear observation statistics (particular assimilation cycle of a particular day)

SEVIRIClear (Meteosat-10)			
Total no. of obs	Accepted over Sea	Accepted over Land	Total no. of obs. accepted
166763	2789	5139	7928

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6 Conclusions :

(1) NCUM satwnd obstore is updated to incorporate satellite winds from different sub-types, and established that NCUM obstore creating package includes all the spectral channels from different satellites.

(2) OSCAT and Windsat scatterometer winds are incorporated in the NCUM scatwind obstore along with ASCAT winds. This is the first time that Indian satellite data (OSCAT) is going into the NCUM

(3) Sonde obstores are also modified to reduce the o-b statistics in different parameters. Presently, RTM statistics from NCUM sonde obstore are comparable with that of UK Met Office.

(4) Incorporated CSBT from the new satellites GOES-15 (GOESClear) and Meteosat-10 (SEVIRIClear).

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