# ASSIMILATION OF CONVENTIONAL AND SATELLITE WIND OBSERVATIONS IN THE GLOBAL DATA ASSIMILATION SYSTEM AT NCMRWF

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ABSTRACT

For determining the three-dimensional structure of the global circulation of atmospheric fluid it is very important to assimilate wind information from all available sources through out the globe. This paper is aimed at describing efforts made at NCMRWF in assimilating various types of global wind observations, both conventional and satellite, in its operational Global Data Assimilation System (GDAS).

The conventional in-situ observations are very few and mostly confined over land, leaving behind vast amount of data sparse oceanic region. Thus it is very essential to make use of various other global wind observations like, buoy, aircraft and remote sensing data, such as cloud drift winds, scatterometer winds and microwave winds etc. There are some well known uncertainties in the remote sensing data, such as height assignment of cloud motion winds and directional ambiguity of scatterometer winds etc, which are to be addressed before assimilating these wind observations. Apart from conventional winds, satellite winds from INSAT, GMS, GOES and METEOSAT at low resolution, recently we have started utilizing high resolution METEOSAT-5 and ERS-2 winds data in the operational GDAS at NCMRWF. One of the main objectives of this work is to describe the impact of various types of wind data used in the NCMRWF operational analysis/forecasting system. Results on the intercomparison of CMVs from various geostationary satellites is also discussed. Impact of high resolution CMVs from METEOSAT is discussed as a special case study.

## 1. Introduction

Atmospheric data assimilation is the process of determining a consistent four-dimensional atmospheric state using various information like, meteorological observations taken from all over the globe, first guess field from a Numerical Weather Prediction (NWP) model and other physical constraints like mass-wind relationship, various type of statistical information about the observations and the background field used as first guess etc., while analyzing the data. The operational global data assimilation system at NCMRWF makes use of almost all types of both conventional and non-conventional data received on GTS.

## 2. NCMRWF Global Data Assimilation System

The Global data Assimilation System (GDAS) is an important component of the Analysis/Forecast system which basically provides the initial condition to the Numerical Weather Prediction (NWP) model. It consists of mainly three components. (i) Data reception and quality Control (ii) Data Analysis and (iii) the NWP model. The NWP model basically provides the first guess to the analysis scheme. The details of various components are discussed in Rizvi et al. (1997). The analysis scheme used in GDAS is based on the concept of Spectral Statistical Interpolation (SSI) technique developed originally at NCEP, USA (Parrish and Derber, 1992). It is based on the Lorenc (1986) concept of minimizing a cost function J consisting of mainly two parts as follows.

$$J = J_{ges} + J_{obs}$$

The two terms, on the right hand side of J, deal with the fit of analysis with the first guess field and the observations respectively. In order that the analysis should fit best with both the first guess and the observations, J is minimized, using conjugate gradient algorithm (Chandra, 1978) with respect to the analysis variables. Further details about the operational analysis scheme at NCMRWF can be seen in Bansal and Rizvi (1993), Rizvi and Parrish (1995) and Rizvi et al.(1998).

## 3. Global Data Utilization

The meteorological data from various observing platforms from all over the globe is received at Region Telecommunication Hub (RTH), New Delhi through Global Telecommunication System (GTS) and the same is made available to NCMRWF. Keeping in view that these global observations pertain to different types of instruments, both from conventional and non-conventional type, some observations deal with single level and some of them have multi-level information etc., proper processing is required to separate out these highly inhomogeneous set of observations in proper categories. This is very essential because different type of observations have different error characteristics which are to be given due weightage in their analysis. At present, various type of data used in the operational GDAS at NCMRWF are as follows.

### 3.1 Conventional Data

(a) TEMP and TEMP-SHIP: Wind and temperature at all the significant and mandatory pressure levels except humidity field which is up to 300 hPa. Surface temperature, wind, pressure, moisture and elevation from the surface reports are also utilized.

(b) PILOT and PILOT-SHIP: Winds at all the mandatory and significant pressure levels and all the wind reports by height.

(c) SYNOP, SYNOP-SHIP and BUOY: Surface Temperature, wind, pressure, moisture and elevation.

(d) Aircraft reports: Winds and temperature information.

### 3.2 Non-Conventional Data

(a) Cloud motion vectors (CMVs) Both low (> 500 hPa) and high (< 500 hPa) levels wind from INSAT, GMS, GOES and METEOSAT satellites. High resolution CMVs from METEOSAT for a limited region (00 - 150 South and 400 East to 1200 East).
(b) NOAA satellite temperature profiles and total precipitable water content.
(c) Surface wind information from ERS2 satellite.
(d) Synthetic data based on satellite T-number is also used whenever a cyclone is observed in the Arabian sea and Bay of Bengal.

As a special case , high resolution METEOSAT cloud motion vectors are used (25 Oct.-29 Oct., 1999) to study the impact on the Super Cyclone which formed in the Bay of Bengal during this period.

## 4. Results Discussion and Conclusions

In the present study output of operational GDAS for July, 1999 have been compared with the corresponding run for the same period without METEOSAT high resolution CMVs. It is observed that use of high resolution METEOSAT winds make positive impact on the NCMRWF analysis/forecast system. As shown in Fig.1, at 500 hPa., the forecast wind vector RMSE in Tropics (300 S to 300 N) and Indian region (100 S to 400 N, 00 E to 1450 E) are less in the operational run which uses the additional high resolution METEOSAT CMVs. For a special case study, METEOSAT high resolution CMVs data were obtained from EUMETSAT on request to study the impact on the Orissa Super Cyclone, which formed in the Bay of Bengal during October 1999.

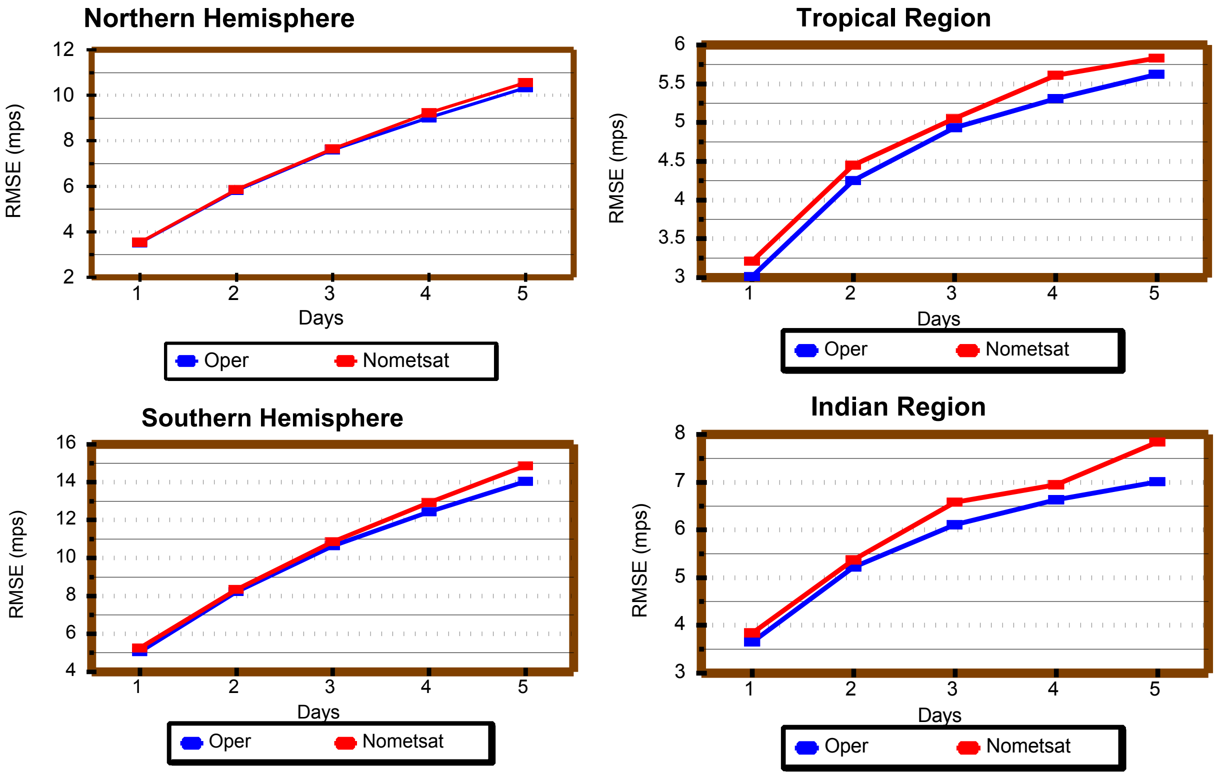


Figure 1. 500hPa forecast Vector Wind RMSE for July, 1999

The use of these winds have shown positive impact on the NCMRWF analysis during the cyclone period. As shown in Fig.2, the analysed position of the cyclone track is in better agreement with the operational cyclone track of India Meteorological Department. The use of these winds have improved 24 and 48 hour forecast. It can be seen in Fig.3, that the 24 and 48 forecast (based on initial condition of 00 UTC of 26th October, 1999) of 850 hPa. wind flow is better defined in the experiment run specially in the NE-sector of the cyclone.

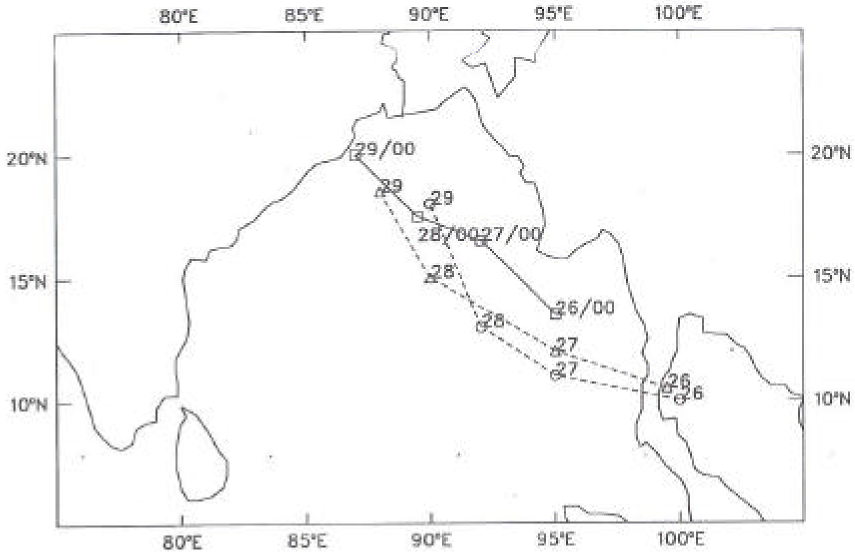


Figure 2. Analysed position of the cyclone track (OPER = circles, EXP = triangles) and observed along with the operational cyclone track of IMD, New Delhi, (OBS = squares).

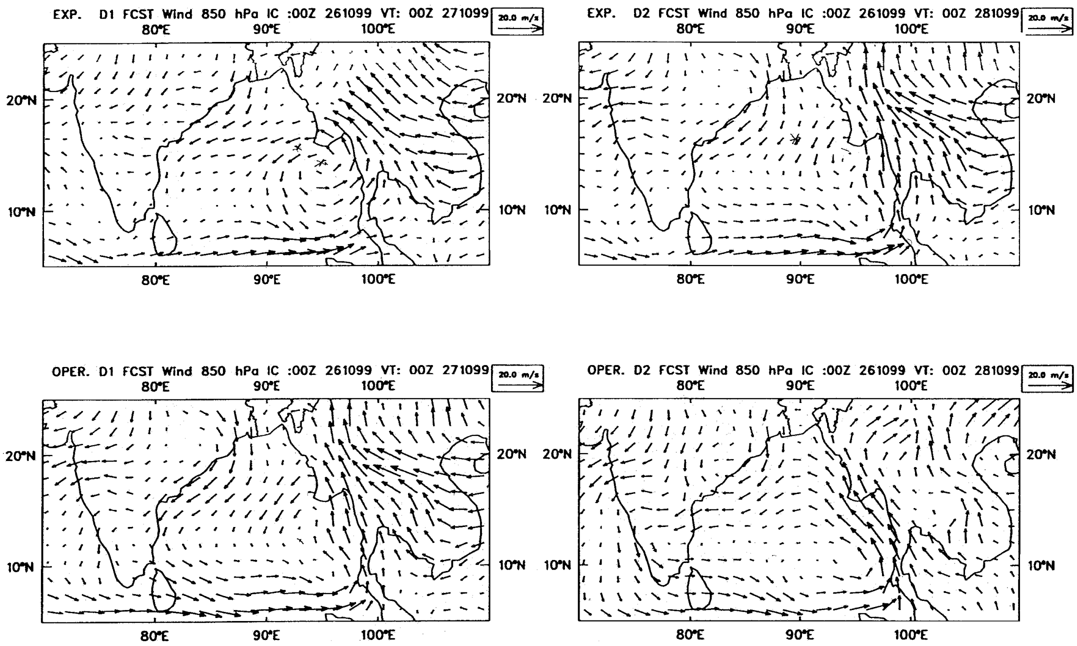


Figure 3. 850 hPa (wind flow), 24 and 48 hour forecast (OPER & EXP) IC : 00 UTC 26 October 1999.

Recently a new CMVs derivation scheme was implemented at IMD, New Delhi for computation of INSAT CMVs. To see its impact on the NCMRWF operational GDAS, 15th Jan. to 15th Feb., 2000 data was used for inter-comparison of the CMVs data from GOES, GMS, INSAT and METEOSAT satellites. GOES rmse was found to be less as compared to other satellites, specially at higher (< 500 hPa.) levels and the same is shown in Fig.4. It has been observed that INSAT CMVs are fitting well with the NCMRWF analysis / forecast system after the implementation of new INSAT CMVs derivation scheme.

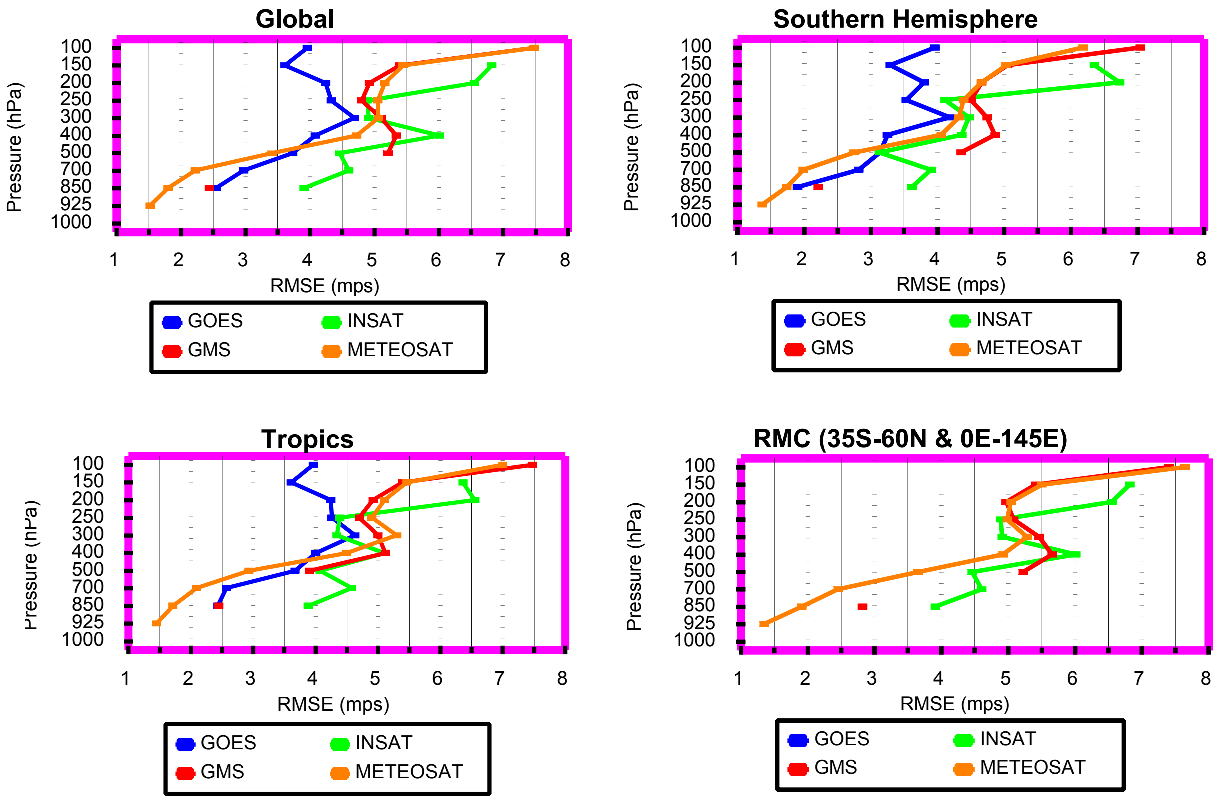


Figure 4. Vector Wind RMSE (Jan - Feb, 2000)

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