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Research Article

SIGNIFICANCE OF SCATTEROMETER WINDS DATA IN WEAK VORTICES DIAGNOSIS IN INDIAN SEAS

R.K. Giri[1], *Satish Prakash[2], Ravindra Kumar[3] and Jagabandhu Panda[4]
[1]India Meteorological Department, Lodi Road, New Delhi-3
[2,3]Department of Physics, Meerut College Meerut-UP-250001
[4]Division of Physics and Applied Physics School of Physical and Mathematical Sciences Nanyang Technological University SPMS-PAP-04-19, 21 Nanyang Link Singapore 637371
**Author for correspondence*

ABSTRACT

The conventional observations over the sea region are limited and insufficient to carry out the studies. The wind field plays an important role in atmospheric flows especially in data sparse regions. To analyse the weak vortices in Indian Ocean QuikSCAT Scatterometer data is very useful, because during the genesis stage the determination of the position and intensity of the vortex is very difficult. In this paper few cases of weak vortices for the year 2004 have been examined subjectively and compared with the centers determined with the help of satellite images and actual track of the system. The results show the agreement fairly well after considering the information from the QuikSCAT winds data. The error deviation is ± 0 -2 $^{\circ}$N /0 - $\pm$ 1 ^{0} E in latitude and longitude respectively. Because the judgment is subjective so inherent human error is also a part of the error deviation said above. Further, recent study with PHET cyclone, (31st May -07 June 2010) using Scatterometer data assimilation from OCEANSAT -2 satellite in Weather Research Forecast (WRF) model shows positive impact on cyclone track forecast.

***Key Words**: Quikscat, Vortices, Assimilation And Sea Surface Temperature (SST), Weather Research Forecast (WRF)*

INTRODUCTION

Scatterometer named SeaWinds was launched onboard the QuikSCAT satellite by the National Aeronautics and Space Administration (NASA)/Jet Propulsion Laboratory (JPL) on 19 June 1999. The width of swath of QuikSCAT/SeaWinds is 1800 km and spatial resolution of 25 km. To assimilate the QuikSCAT data Tahara, Y (2000) has built the quality control system (Fig 1). The gravity-capillary waves provide high-resolution wind vector fields over the sea. Wind speed and wind direction are provided with high quality and uniquely define the mesoscale wind vector field at the sea surface. The all-weather ERS scatterometer observations have proven important for the forecasting of dynamical and severe weather. The swath and antenna of the sea wind scatterometer is shown in the Fig. 2. In this system wind data are thinned on 1 x 1 degree (lat./lon.) grid and used in the data assimilation procedure. Performance wise QuikSCAT data compared with drifting buoys and RMSE was found 1.57 m/sec (K. Satheesan et al, 2007). The space-based scatterometer measurements of wind speed and direction help a wide variety of studies of oceanic processes and improve weather forecast via data assimilation in the operational models (Goswami and Rajagopal, 2003). Liu, 1984 and Wu, 1991, show that the Sea wind vectors depend on the Sea Surface Temperature (SST) and atmospheric density. Kelley et al, 2001, have been found that the sea wind vectors are related to the ocean currents also. Assimilation of QuikSCAT in mesoscale model like MM 5 winds shows positive impact (Rambabu, 2004) for the genesis of cyclone. Presently, QuikSCAT data is not available but from Indian OCEANSAT -2 data is available for research work. OCEANSAT -2 is a joint mission of India and France (ISRO & CNES) for the study of oceanography and meteorology.

MATERIALS AND METHODS

A satellite borne scatterometer obtain the surface wind vectors over the ocean by measuring the radar signal from the sea surface where ripples and bubbles over the ocean surface are in equilibrium with the local wind stress. It is the sea surface roughness, which depends on other factors also like SST, atmospheric density stratification in spite of wind speed and direction. The QuikSCAT swath data mapped to 0.25^0 grid divided into two maps based on ascending and descending passes obtained from the Remote Sensing Systems is used. The data or images used in this study have been taken from the global website: http://manati.orbit.nesdis.noaa.gov/quikscat.

The weak vortices cases information for the year 2004 has been taken from India Meteorological Department, Lodi Road, and New Delhi. The data is qualitatively analysed and the center position of the vortices is compared with the vortices center determined by the satellite images. OCEANSAT -2 for PHET cyclone is taken from the National Remote Sensing Centre (NRSC) Hyderabad.

The backscatter signal from the sea surface is dominated by the so-called Bragg resonant mechanism, when using radar systems such as the scatterometer (*Valenzuela*, 1978) and the SAR (*Hasselmann et al*., 1985). The condition for resonance of the incoming microwaves is: $\lambda_B = \frac{N\lambda}{2\sin\theta}$

Where, λ_B is Bragg wavelength and n is whole number. Braggs scattering will be dominant in the range of 20° > θ > 70°. The scattering cross section of radar beam for n =1 is given below:

$$\sigma^0 = T(\theta)\left[E(2k) + E(-2k)\right]$$

Where, ***k*** is the vector wave number of the radar beam with amplitude $k = \frac{2\pi}{\lambda}$, E is the spectral energy density of the short surface waves, and T is a transfer function describing the electromagnetic interaction with the ocean surface. In this way wind vector s derived with an uncertainty of RMS error of approximately 2.5 m/sec and related to wind at 10 meter height above the ocean surface

DISCUSSIONS

As we know that there is a vast oceanic region where the data can be extracted through remote sensing only. The microwave sensor onboard on the satellite is the suitable medium to get this data. The formation of low-pressure area into the sea or its intensification into depression or cyclonic stage is monitored continuously by judging the intensity, speed and direction through the satellite. The position of the weak vortices in the initial stage is crucial and need sufficient quantity of the data. Because the oceanic region is data sparse, satellite imagery or digital data or microwave sensor data is the only medium along with few drifting or moor buoys observations over the sea. The information retrieved from the QuikSCAT scatterometer is available graphically and digital form also. The graphical data of the ascending and descending pass is used to diagnose qualitatively the initial position of the vortex in the sea. Digital data is utilized in Numerical Weather Prediction (NWP) model assimilation to tune precisely the position and intensity of the vortices or cyclones in the oceanic region. In this paper, 10 cases (Figs: 3-12) of weak vortices for Indian Ocean during the year of 2004 examined qualitatively. The results of the estimated position through quikSCAT scatterometer wind are compared with the conventional satellite based estimation technique of synoptic application unit of India Meteorological Department and found matched reasonable well. The 3D Var assimilation of OCEANSAT -2 scaterometer data in WRF model for the cyclonic storm PHET in Grell-Devenyi (GD) ensemble scheme shows positive impact on cyclone track forecast. The Advanced Scatterometer Data (ASCAT) data from OCEANSAT -2 is 50 x 50 km resolution and its assimilation in WRF generated the output at 27 km resolution. The assimilation of the scatterometer wind data of domain of PHET cyclone filled some gap of data in data sparse region and brings out positive impact on the track of the cyclone. Timely track forecast of cyclone is very

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Table 1: Subjective judgement of position and intensity of weak vortices with the help of satellite imagery and scatterometer winds

Case	Date	Centre Based satellite image/Intensity	Center from Scaterrometer winds	Error Deviation from SAU
1	04 May,2004	10.5°N/74.5°E/T1.0	10.3°N/75.4°E	+0.2°N/+0.1°E
2	11 June,2004	17.5°N/66.6°E/T2.0	17.5°N/68.4°E	+0.0°.N/-1.8°E
3	12 June,2004	16.0°N/87.3°E/T2.0	17.5°N/86.5°E	-1.5°N/+0.8°E
4	2nd July,2004	19.0°N/86.0°E/LLC	18.3°N/86.0°E	+0.7°N/0.0°E
5	14th July,2004	18.5°N/88.0°E/T1.0	18.6°N/87.0°E	-0.1°N/+1.0°E
6	2nd Aug.,2004	19.5°N/88.5°E/T1.0	19.1°N/87.3°E	+0.4°N/+1.2°E
7	2nd Oct.,2004	14.0°N/85.5°E/T1.5	15.0°N/85.0°E	-1.0°N/+0.5°E
8	14th Oct.,2004	18.5°N/90.5°E/T1.0	17.0°N/89.5°E	+1.5°N/+1.0°E
9	3rd Nov.,2004	13.0°N/67.0°E/T1.0	13.5°N/66.5°E	-0.5°N/+0.5°E
10	3rd Dec.,2004	8.2°N/54.0°E/T1.0	8.0°N/54.2°E	+0.2°N/-0.2°E

Table 2: Model Configuration and Experimental Design

Horizontal grid distance	27 km
Integration time step	90s
Number of grid points	131 in both west-east as well as south north directions
Number of met grid levels	27
Number of vertical model eta levels	38
Model top	50 hPa
Microphysics	WSM 3-class simple ice scheme
Radiation scheme (long wave)	RRTM scheme
Radiation scheme (short wave)	Dudhia's short wave radiation
Surface layer physics	Monin-Obukhov scheme
Land-surface physics	Unified Noah land-surface model
Boundary layer physics	Yonsei University (YSU) scheme
Cumulus convection	Grell-Devenyi (GD) ensemble scheme (CONTROL, & OSAT2SF (uses OCEANSAT-2 surface winds for assimilation) experiments)
Dynamic option	Eulerian mass
Time integration	3rd order Runge-Kutta
Diffusion	2nd order diffusion in coordinate surface
Mode of simulation	Non-hydrostatic
Map projection	Mercator
Number of domain	Single
Central point of the domain	Central latitude: 17.50N Central longitude: 61.50E
Initial and boundary conditions	3-dimensional real data (FNL:1^{O}X1^{O})
Simulated hours	78 hours starting from 1800 UTC June 01, 2010

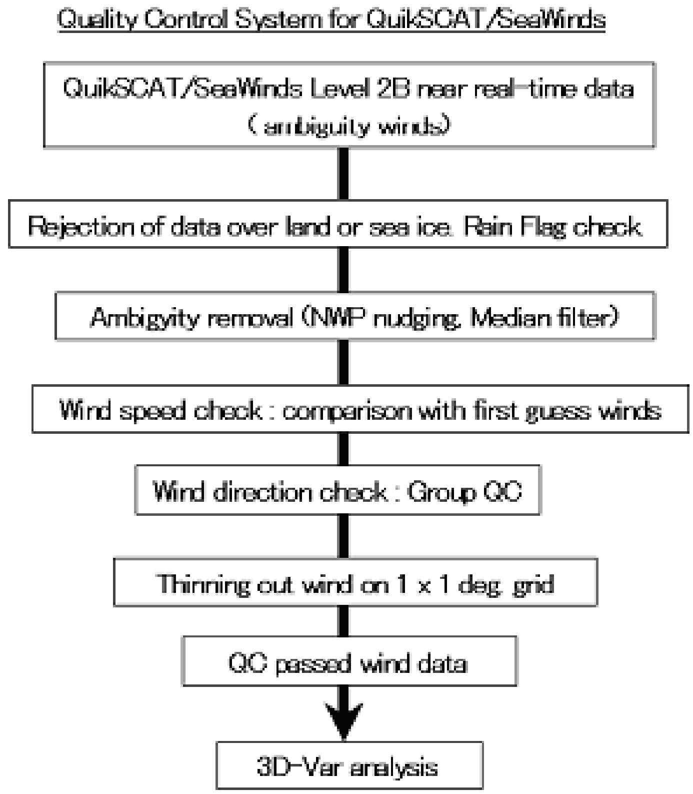

Figure 1: Quality control procedure for QuikSCAT /Seawinds data

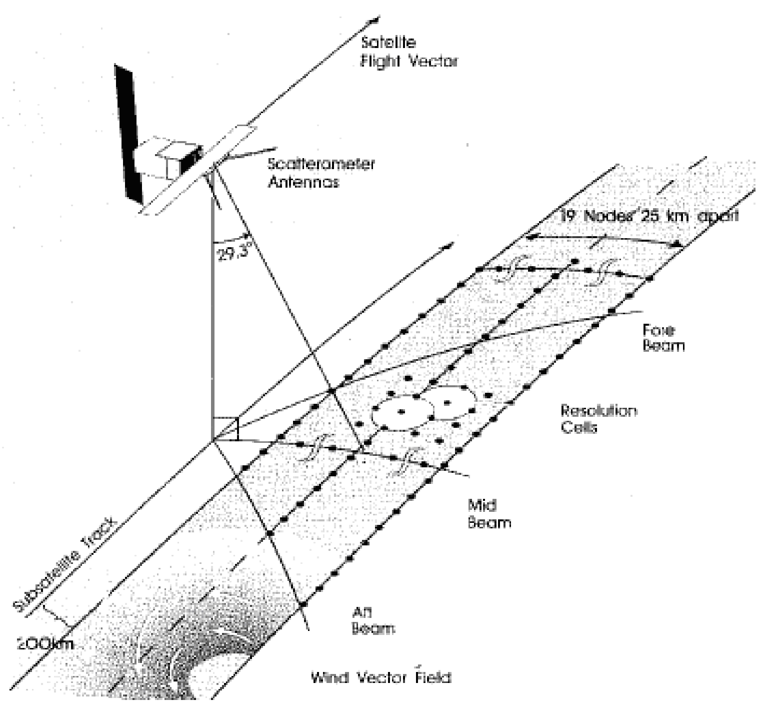

Figure 2: QuikSCAT wind Scatterometer principle

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challenging task and its accurate prediction can save the lives of the people and property. The sea surface wind derived from either QuilSCAT or OCEANSAT -2 data play an important role for both weak as well as strong vortices and cyclones. Table 2 shows the WRF model assimilation details.

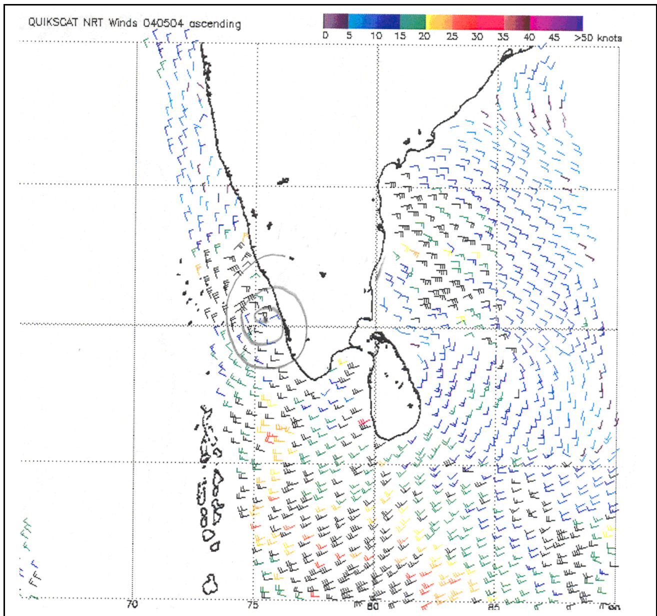

Figure 3: Vortex on May 04, 2004

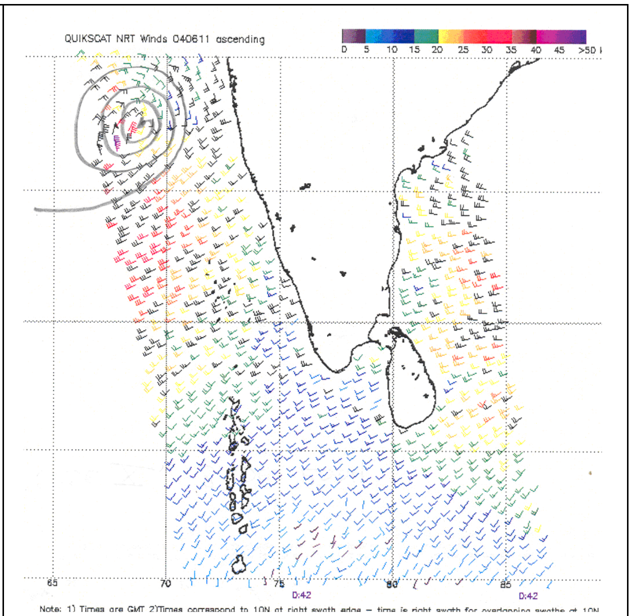

Figure 4: Vortex on June 11, 2004

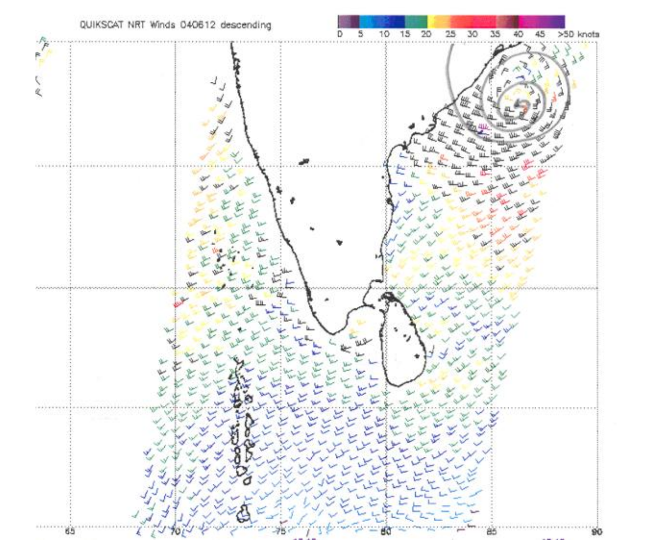

Fig -5 Vortex on June 12, 2004

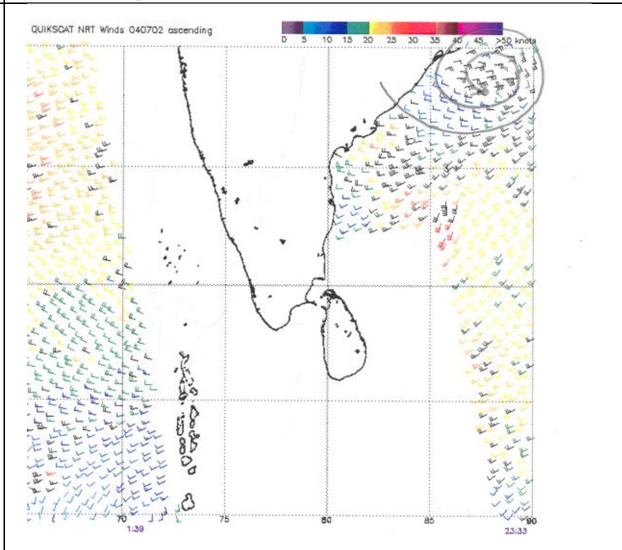

Fig – 6 Vortex on July 02, 2004

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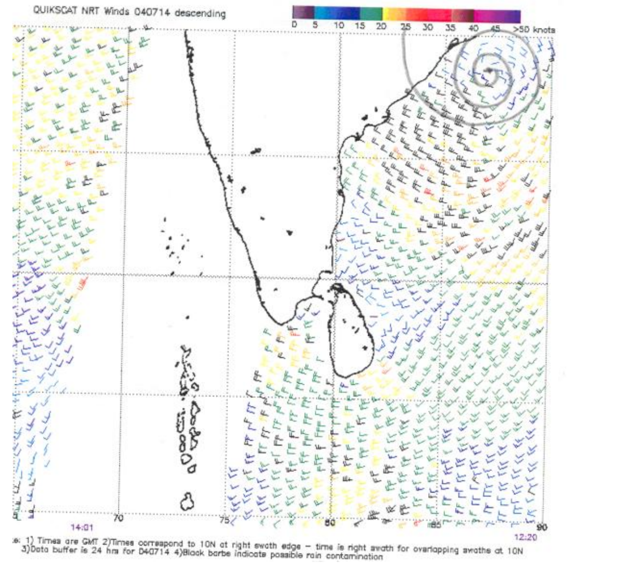

Fig -7 Vortex on July 14, 2004

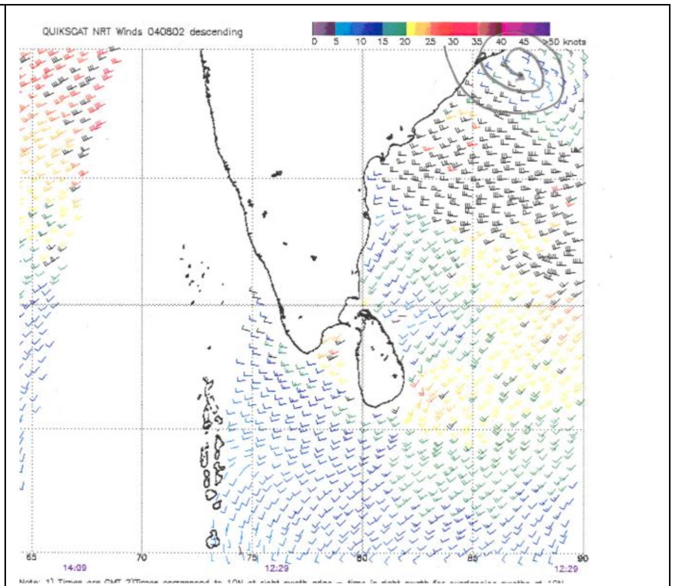

Fig -8 Vortex on August 02, 2004

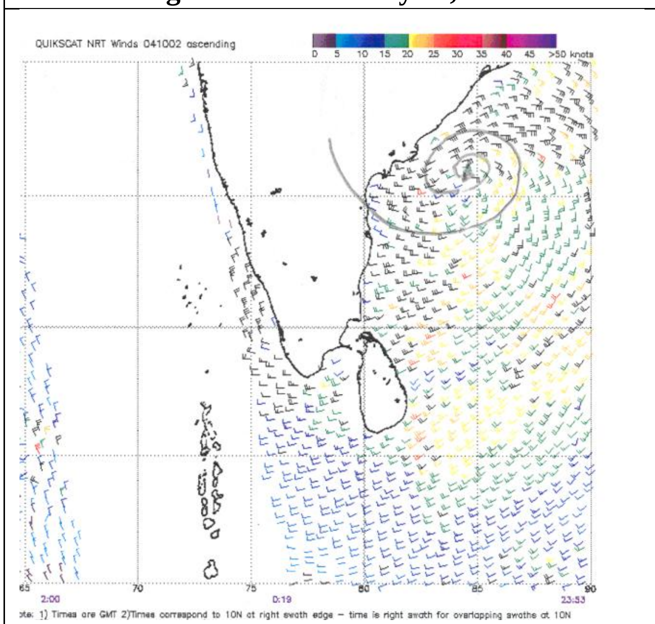

Fig -9 Vortex on October 02, 2004

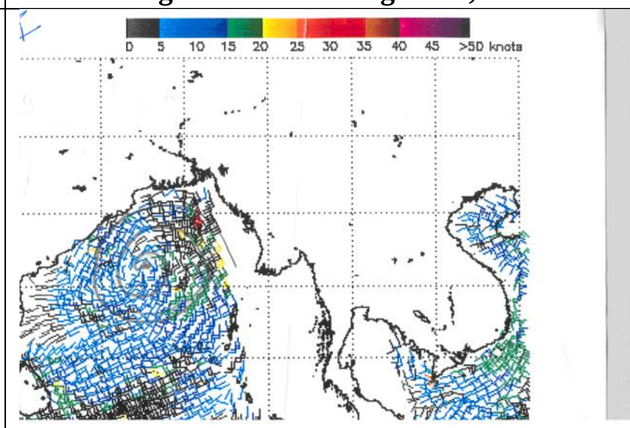

Fig -10 Vortex on October 14, 2004

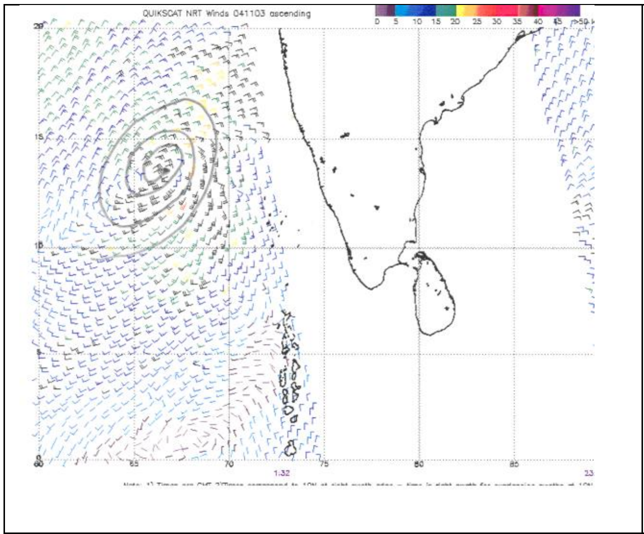

Fig –11 Vortex on November 03, 2004

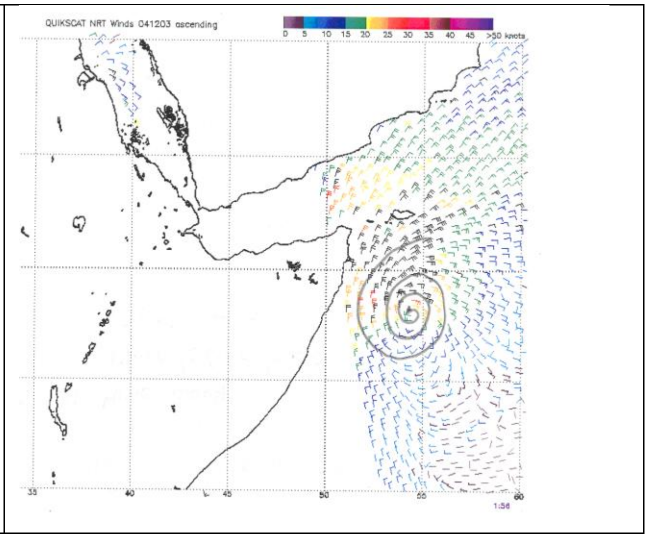

Fig -12 Vortex on December 03, 2004

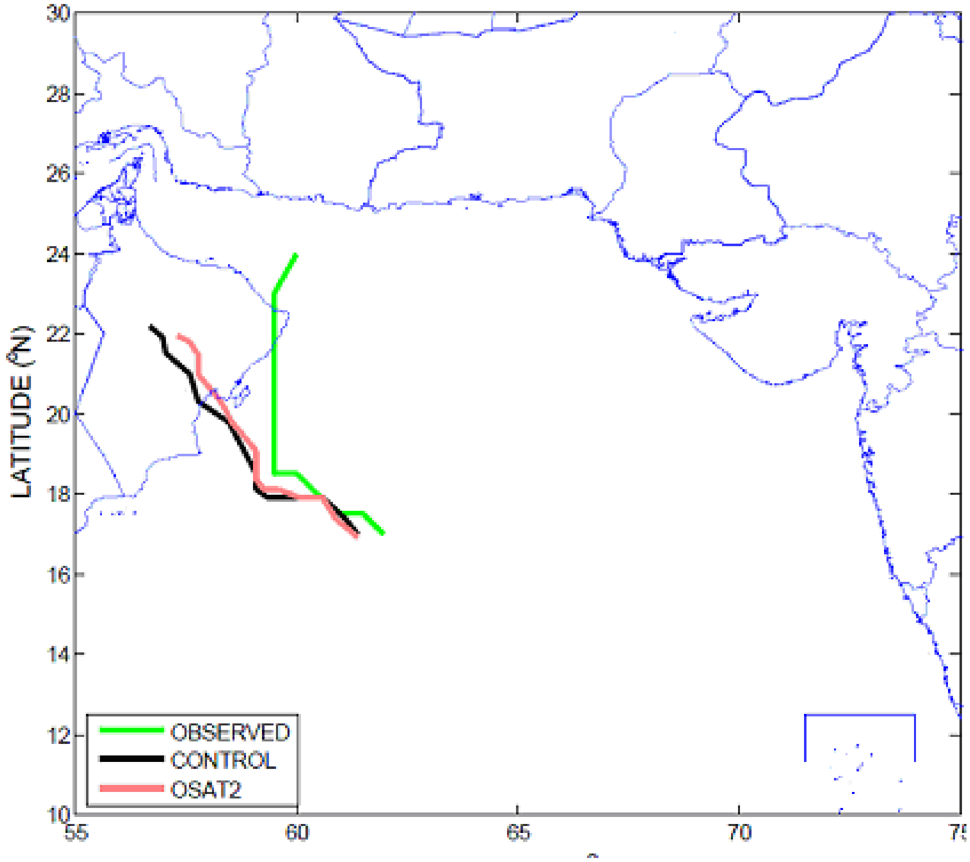

Figure 13: OCEANSAT – data assimilation in WRF model (OSA2 shows improvement in cyclone track forecast as compared with observed track)

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RESULTS

It is evident from the table 1 above that by using the QuikSCAT winds data for the diagnosis of vortex center are considerably improved. This information is very valuable in data spares regions (like Oceans). Weak vortices analysis in Pre-monsoon, Monsoon and Post- Monsoon season, sea winds provide the valuable input in the diagnosis or determining the center in the initial stage. It is very valuable input to the NWP models as various authors shown that it has shown that the initial field with the inclusion of Scatterometer data was nearer to the actual situation. Inclusion of QuikSCAT winds data will improve the 48-hour (Short range forecast). WRF assimilation of OCEANSAT-2 data shows the positive track forecast results for the tropical cyclone PHET (Figure 13).

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