MAUSAM, **61**, 2 (April 2010), 213-220

551.509.313

Impact of AMDAR observations from Lufthansa aircraft on Global Analysis - Forecast System

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(*Received 13 March 2009, Modified 24 September 2009*)

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सार – 14 मई 2008 से दो सप्ताहों की अवधि के लिए विशेष व्यवस्था के अन्तर्गत भारत मौसम विज्ञान विभाग (आई. एम. डी.) और राष्ट्रीय मध्यम अवधि मौसम पूर्वानुमान केन्द्र (एन. सी. एम. आर. डब्ल्यू. एफ.) को बी. यू. एफ. आर. फार्मेट (आई. यू. ए. डी. ओ. आई. ई. जी. जी. आर. हैडर और आई. यू. ए. एच. ओ. आई. ई. जी. आर. आर. सहित) में लुफ्थांसा और लुफ्थांसा कार्गो वायुयानों से प्राप्त किए गए ए. एम. डी. ए. आर. प्रेक्षण उपलब्ध कराए गए। इनसे प्राप्त आँकड़ों को 14 से 31 मई 2008 तक की अवधि के लिए, एन. सी. एम. आर. डब्ल्यू. एफ., (राष्ट्रीय मध्यम अवधि मौसम पूर्वानुमान केन्द्र) निदर्श में सम्मिलित किया गया ताकि एन. डब्ल्यू. पी. पर इनके प्रभावों का निर्धारण किया जा सके। इन प्रेक्षणों के उपयोग से एन. डब्ल्यू. पी. प्रणाली पर कुछ सकारात्मक प्रभाव पड़ा है।

ABSTRACT. AMDAR observations from Lufthansa and Lufthansa cargo aircrafts in BUFR format (with header IUADOI EGGR and IUAHOI EGRR) were made available to India Meteorological Department (IMD) and in turn to National Centre for Medium Range Weather Forecasting (NCMRWF) under special arrangement for a period of two weeks w.e.f. 14th May 2008. These data have been assimilated at NCMRWF (National Centre for Medium Range Weather Forecasting) model for the period 14th - 31st May, 2008 to assess its impact on NWP. Use of these observations gave some positive impact on NWP systems.

Key words − AMDAR, Global data assimilation system, Numerical weather prediction, T80L18.

1. Introduction

Aircraft Meteorological Data Relay (AMDAR) is a program initiated by World Meteorological Organization. In 2001 the AMDAR program completed its second year of operations. AMDAR is used to collect meteorological data worldwide by using commercial aircraft. Data are collected by the aircraft navigation systems and the onboard standard temperature and static pressure probes. The data are then preprocessed before linking them down to the ground either *via* VHF communication (ACARS – Aircraft Communication Addressing and Reporting System) or *via* satellite link ASDAR (Aircraft to Satellite Data Relay). These reports are being routinely transmitted through GTS (Global Tele-communication System) and are available at NCMRWF. Over past few years the AMDAR and ACARS data coverage and number have increased significantly (WMO 1996). The use of AMDAR and ACARS data has been extended in ECMWF's (European Centre for Medium Range Weather Forecasting) operational 4DVAR data assimilation system. A data-denial impact study made in ECMWF (Cardinali *et al*., 2003) using 4DVAR shows a substantial positive impact of the profiling aircraft data on the analysis and forecast accuracy.

But there exist some difficulties in getting these reports over Indian skies at Regional Telecommunication Hub, New Delhi. Under some special arrangement AMDAR observations from Lufthansa and Lufthansa cargo aircrafts in BUFR format (with header IUAD01 EGGR and IUAH01 EGRR) were made available to IMD and in turn to NCMRWF for a period of two weeks w.e.f. 14th May 2008. These data have been assimilated at NCMRWF global model to assess its impact on NWP. Fig. 2(a) depicts the coverage of the aircraft observations received at ECMWF on a typical day at 0000 UTC of 26th May 2008. It comprise of AIREP, AMDAR and ACARS. Figs. 2(b&c) presents the coverage of aircraft observations received at NCMRWF, with and without the above mentioned new AMDAR observations from Lufthansa aircraft. Fig. 2(a) shows that ECMWF receives a good number of AMDAR observations over Eastern Europe and middle-east Asia (within the box). Most of these

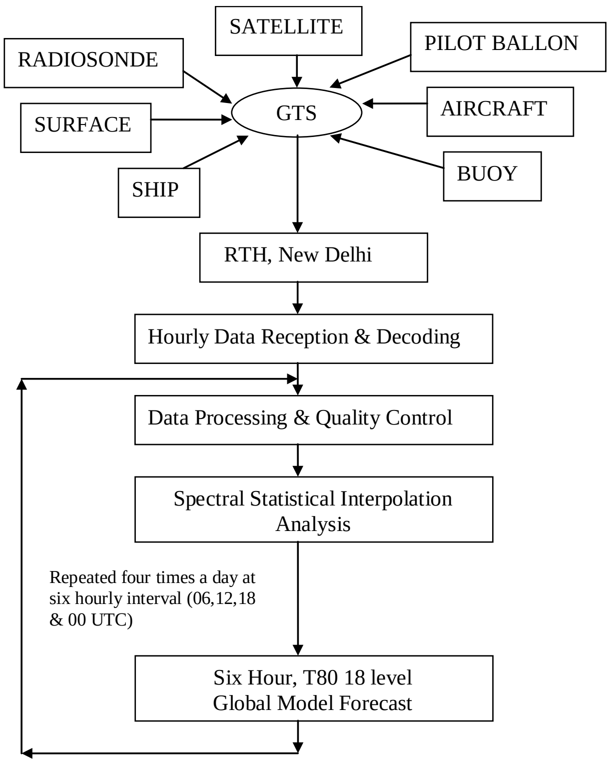
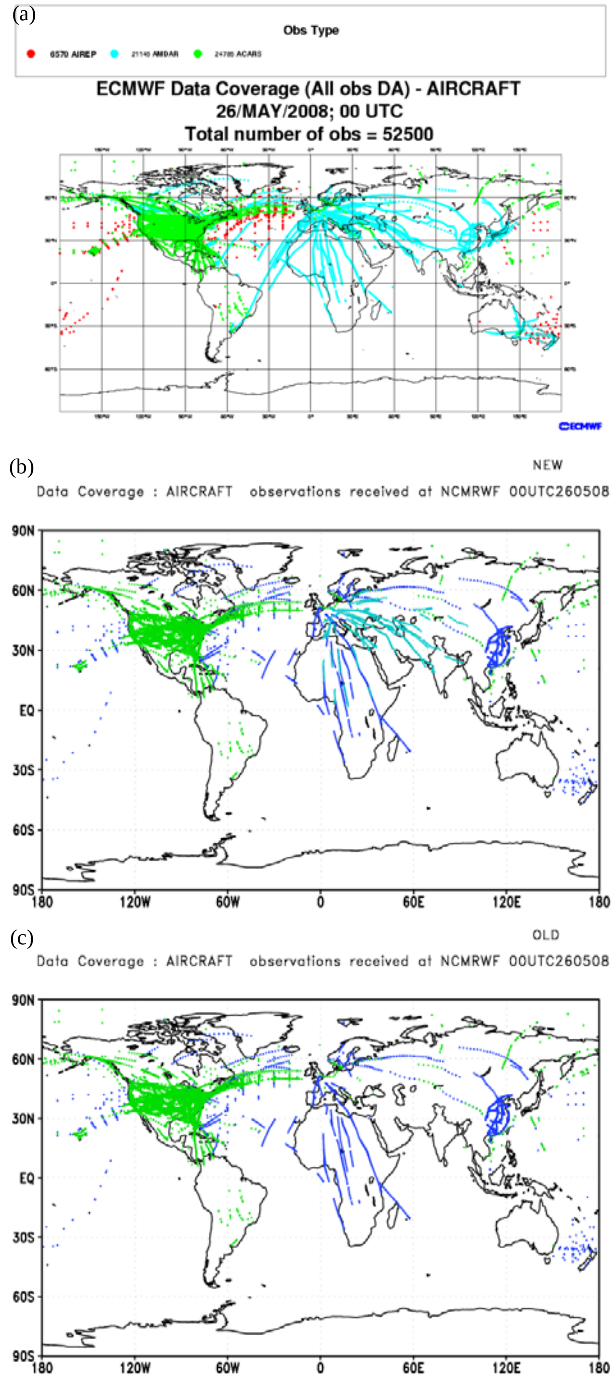


Fig. 1. Global data assimilation system at NCMRWF



Figs. 2(a-c). Coverage of aircraft observations received at ECMWF & NCMRWF on 0000 UTC 26 May 2008 (±3 hrs). (a) ECMWF Data coverage, (b) Data coverage of new aircraft observations received at NCMRWF and (c) Data coverage of old aircraft observations received at NCMRWF

observations are from Lufthansa aircraft. These observations were made available to IMD/NCMRWF under the special agreement [Fig. 2(b)]. NCMRWF did not receive any other aircraft observations over the Indian region apart from Lufthansa aircraft [Fig. 2(c)]. However, on some days Lufthansa aircraft also reported few observations over Africa and Indian Ocean regions. Fig. 3 depicts the daily reception statistics of Lufthansa AMDAR observations at NCMRWF during 14^{th} -31^{st} May 2008. From the figure it is seen that maximum number of observations are received on 1200 UTC cycle (±3 hrs), followed by 0600 UTC, 1800 UTC and 0000 UTC cycles.

Coverage of Lufthansa observations received at NCMRWF for 0000 UTC of 18^{th} May 2008 (±3 hrs) has been depicted in Fig. 4. The observations are mainly over Europe. Observations over India are from three flight tracks, two originating from Chennai and another from Delhi. Observations are also reported from few flight tracks over Africa.

2. Global Data Assimilation System (GDAS)

In NCMRWF global data assimilation and forecast system is in operational since 1^{st} June, 1994. It was initiated to provide medium range weather forecast for agro-meteorological advisory services over India. GDAS in NCMRWF is an intermittent six hourly assimilation system. Its main components consists of data processing

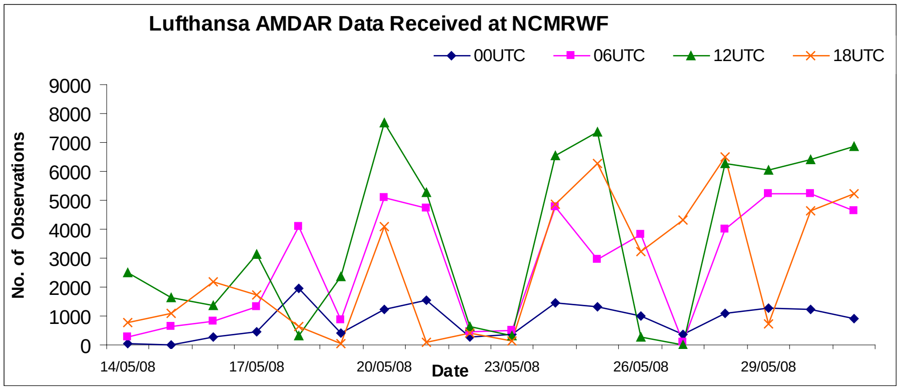


Fig. 3. Daily variation of Lufthansa AMDAR observations

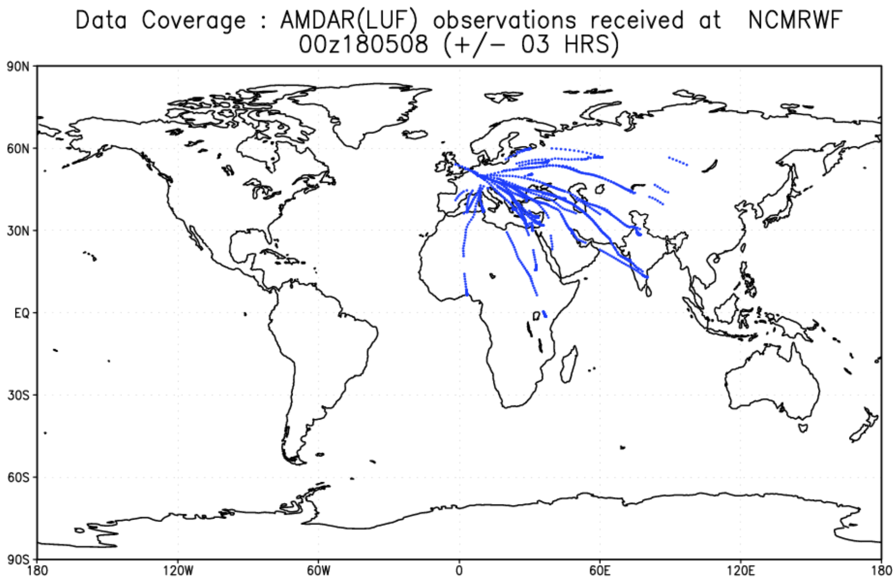
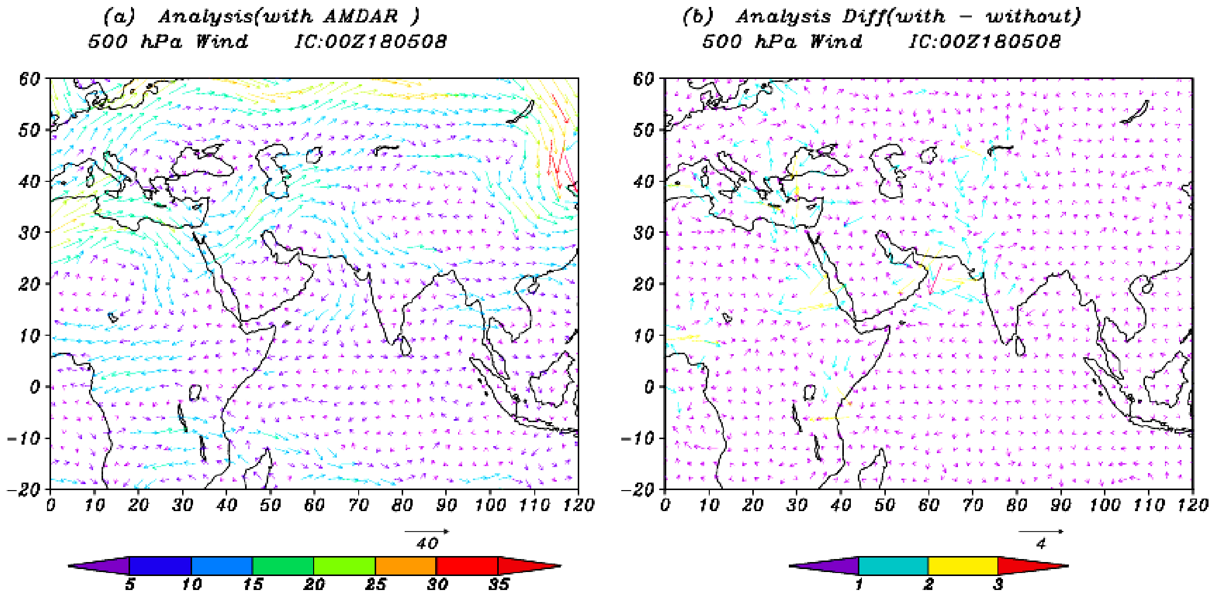


Fig. 4. Coverage of Lufthansa AMDAR observations received at NCMRWF at 0000 UTC on 18 May 2008 (±3 hrs)

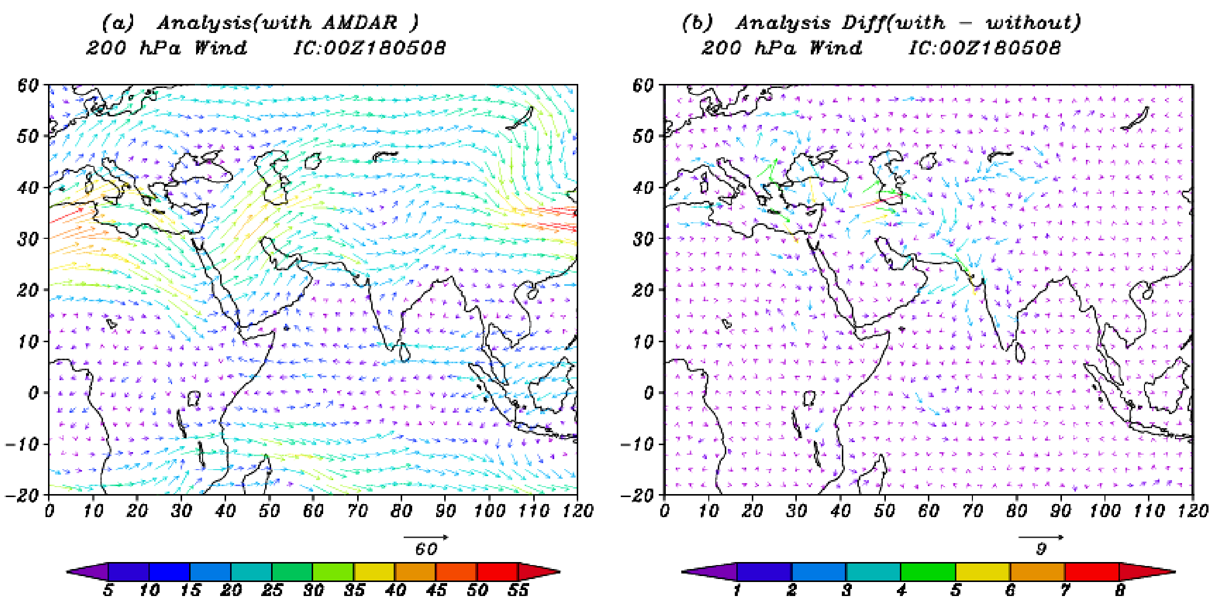
and quality control, analysis scheme and forecast model. Fig. 1 gives a pictorial representation of Global Data Assimilation System at NCMRWF. Details of the GDAS in NCMRWF are described in Das Gupta *et al*., (2002).

3. Experiment

The AMDAR observations received were used in NCMRWF's Global Data Assimilation System using Spectral Statistical Interpolation (SSI) Analysis scheme for the period 14th - 31st May, 2008 alongwith other operationally archived observational data sets to assess the impact of these AMDAR observations on NWP. Details of SSI analysis scheme are described in Parrish *et al*., (1992). The global model used was T80L18 (Triangular Truncation at wave number 80 with 18 vertical levels). The results so obtained were compared with the operational T80L18 outputs without the new AMDAR observations. During this period, northwest India received good amount of rainfall, specially 21st - 24th May 2008, due to the passage of mid-latitude westerly troughs. Since the observations are mainly over Eastern Europe and Afghanistan-Pakistan region an attempt was made to see the impact of these observations on the analyses and predictions of westerly trough and associated rainfall activity.



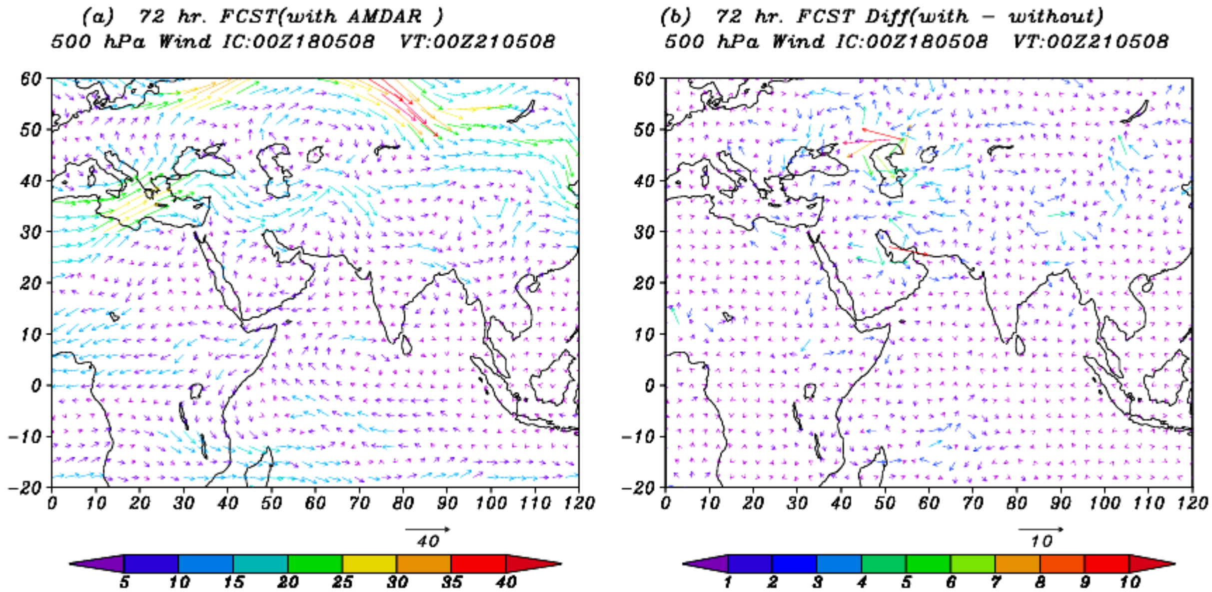
Figs. 5(a&b). (a) Wind analysis (with AMDAR) and (b) Analysis difference (with AMDAR – without AMDAR) at 500 hPa at 0000 UTC on 18 May 2008



Figs. 6(a&b). (a) Wind analysis (with AMDAR) and (b) Analysis difference (with AMDAR – without AMDAR) at 200 hPa at 0000 UTC on 18 May 2008

4. Model description

The global spectral model T80L18 (Triangular Truncation at wave number 80 with 18 vertical levels) (originally adapted from NCEP, USA) has been used here. This model is used for operational medium range weather forecasting purpose at National Centre for Medium Range Weather Forecasting (NCMRWF). Details of the model may be found at Kanamitsu *et al.*, (1991). Further improvements to the model are described in John and

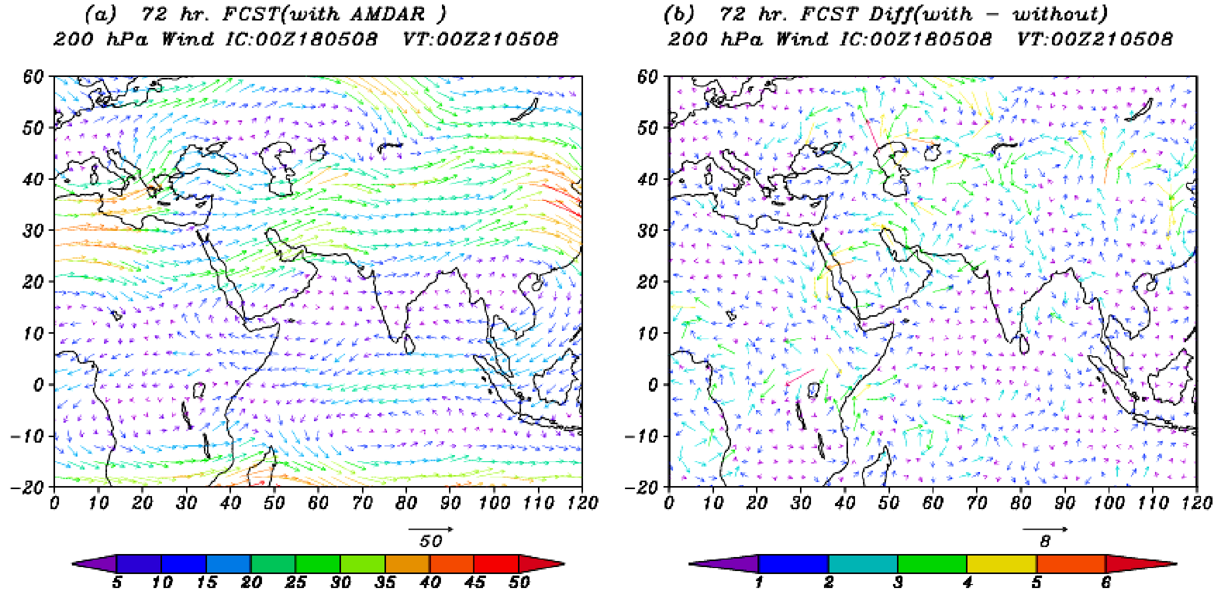


Figs. 7(a&b). (a) 72 hr predicted wind (with AMDAR) & (b) 72 hr prediction difference (with AMDAR – without AMDAR) at 500 hPa at 0000 UTC on 21 May 2008

TABLE 1

Description of the NCMRWF Global Spectral Model

Model elements	Components	Specifications
Grid	Horizontal	Global Spectral-T80 (256 × 128)
	Vertical	18 Sigma Layers (.995, .981, .96, .92, .856, .777, .688, .594, .497, .425, .375, .325, .275, .225, .175, .124, .074, .021)
	Topography	Mean
	Prognostic variables	Relative vorticity, Divergence, Virtual temperature, Log of surface pressure, Water vapour mixing ratio
Dynamics	Horizontal transform	Orszag’s technique
	Vertical differencing	Arakawa’s energy conserving scheme
	Time differencing	Semi-implicit, 900 sec
	Time filtering	Robert’s method
	Horizontal diffusion	Second order over quasi-press. Surface, scale selective
Physics	Surface fluxes	Monin-Obukhov similarity theory
	Turbulent diffusion	K- theory
	Radiation	SW- Lacis & Hansen; LW- Fels & Schwarzkopf
	Deep convection	Kuo scheme modified
	Shallow convection	Tiedtke’s scheme
	Largescale condensation	Manabe’s scheme
	Clouds	Slingo’s scheme
	Rain evaporation	Kessler’s scheme
	Land surface process	Pan’s (3-Layer soil temperature, Bucket hydrology for soil moisture)
	Air-sea interaction	Roughness length (Charnock), SST, SH & LH (Bulk form.)



Figs. 8(a&b). (a) 120 hr Predicted wind (with AMDAR) & (b) 120 hr prediction difference (with AMDAR – without AMDAR) at 200 hPa at 0000 UTC on 21 May 2008

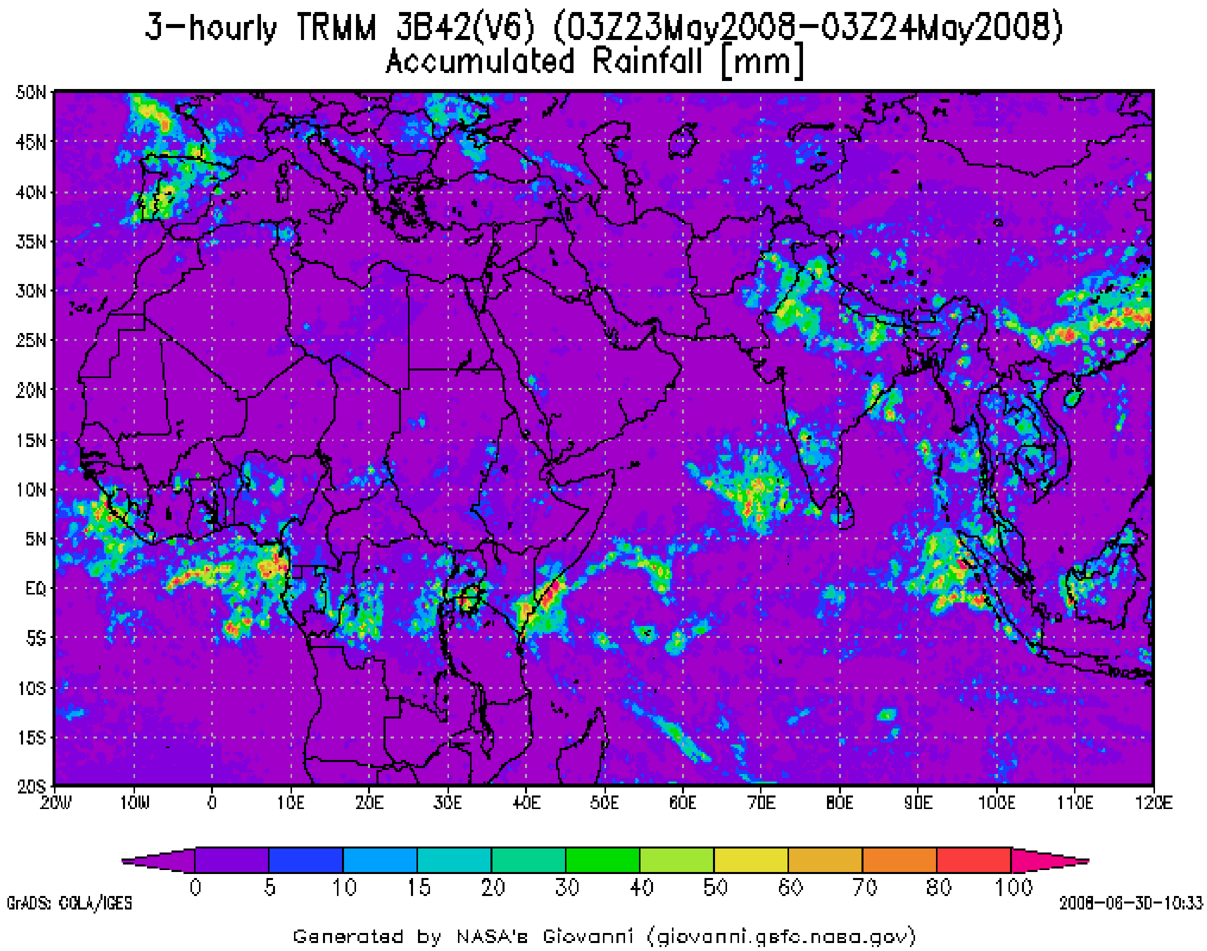
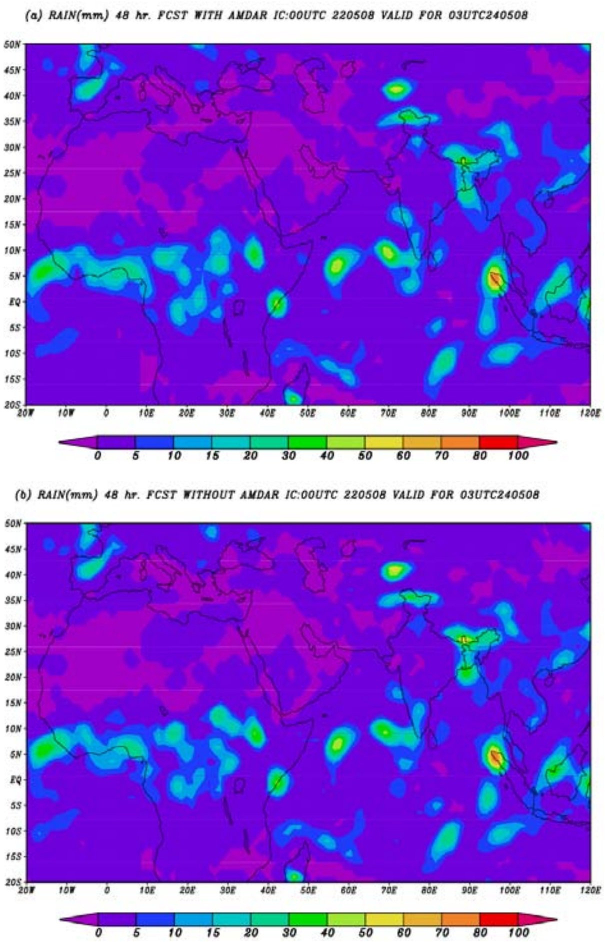


Fig. 9. TRMM 3B42 (V6) 24 hourly accumulated rainfall (in mm) for 0300 UTC 23rd May – 0300 UTC 24th May, 2008



Figs. 10(a&b). 24 Hourly accumulated rainfall in 48 hr prediction IC : 0000 UTC 22 May 2008 VT : 0300 UTC 24 May 2008 (a) with AMDAR Observations (b) without AMDAR Observations

Begum (1997), Basu *et al*., (2002) and Kar *et al.*, (2002). Table 1 presents a summary of the model.

5. Results and discussions

Figs. 5 and 6 represents the analyzed flow at 500 and 200 hPa pressure levels, respectively, with new AMDAR observations and the difference between the analyses with and without these observations on 0000 UTC 18th May 2008. Two mid-latitude westerly troughs are seen along 40° E and 75° E at 500 and 200 hPa with a ridge in between at 60° E.

The difference plot Fig. 5(b) shows that at 500 hPa both the troughs have slightly intensified (1-2m/s) in the analysis after the assimilation of Lufthansa AMDAR observations. The difference plot has shown cyclonic circulation over the trough region. Whereas at 200 hPa the ridge along 60° E got intensified after the assimilation of AMDAR observations. The difference plot shows anti-cyclonic circulation along 60° E.

Figs. 7(a&b) & Figs. 8(a&b) depict 72 hr prediction based on 0000 UTC of 18 May 2008 initial condition valid for 0000 UTC of 21 May 2008. Both the troughs seen in the analyses have moved westerly and weakened in 72 hr prediction. However the predicted trough over Caspian Sea at 500hPa has strengthened with the use of AMDAR observations compared to that without AMDAR observations. Impact of these observations on 72 hr prediction at 200 hPa is seen over the whole band of mid-latitude westerlies and also over Africa and adjoining Indian Ocean.

Fig. 9 depicts 24 hourly accumulated rainfall (mm) for the period 0300 UTC of 23rd May – 0300 UTC of 24th May, 2008 as captured by TRMM 3B42V6. On the same day, 50-60 mm rainfall was observed over northwest India (Punjab, Haryana, H.P.). It is seen from [Figs. 10(a&b)] that though the impact of AMDAR observations on rainfall prediction is marginal but it is positive as the rainfall predicted over northwest India with AMDAR observations is slightly more (15-20 mm) compared to that without AMDAR observation (5-10 mm).

Statistical results such as root mean square error of analysis compared against observations, etc. have also shown marginal improvement after assimilation of Lufthansa AMDAR observations.

6. Conclusion

These observations are found to have some positive impact on NWP systems. It is worthy to mention here that the impact of observations on analyses and subsequent prediction of weather system depends on the situation. However the regular reception of these observations may prove to be beneficial for NWP. It will be worthwhile to explore the possibility of receiving AMDAR observations from other aircrafts on regular basis.

Acknowledgements

We gratefully acknowledge WMO and India Meteorological Department for providing us with the Lufthansa aircraft AMDAR data. We specially thank Dr. (AVM) Ajit Tyagi, D.G., I.M.D. for making the data available to us. We thank Dr. A. K. Bohra (Head, NCMRWF) for providing the necessary facilities to carry out this research work and for his encouragement and support. The first author gratefully acknowledges Council of Scientific and Industrial Research (CSIR) for providing the research fellowship.

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