Improvement of Indian Summer Monsoon features using Four Dimensional Data Assimilation

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Rational : **Temperature gradient is the fundamental driving force for the monsoon.**
Objective : Examine the impact of assimilation of vertical profile of temperature on the Indian Summer Monsoon simulation in a high resolution atmospheric Model (WRF)

Introduction:

- Indian Summer Monsoon is one of the spectacular features of the global atmospheric general circulation.
- Simulation of ISM by numerical model have been the most challenging task so far.
- The sources of errors in the NWP models can be classified into two categories, one is from imperfection of model in resolving the forcing present in the atmosphere and the other source is from observing the initial true state of the atmosphere.
- The success of a regional model can depend on accuracy of initial state of the atmosphere and time varying lateral boundaries of the model domain [2, 3].
- The accuracy of prediction of rainfall, few days in advance is high when satellite (upper air observations) data have been assimilated to specify initial conditions accurately[1].
- Rakesh et al., [5] showed that, the assimilation of temperature and humidity profiles from AIRS and MODIS significantly improved the rainfall predicted during monsoon period.

Model Setup

Model	Primitive equation, Non – hydrostatic model (WRF V3.2.1)
Domain of integration	40°E – 180°E 30°S – 40°N
Vertical resolution & Horizontal resolution	38 sigma levels 45 Km x 45 Km
Convection scheme	Betts-Miller-Janjic scheme
Microphysics	Lin scheme
Sea Surface Temperature	RGT SST

Initial & Boundary Conditions: NCEP FNL

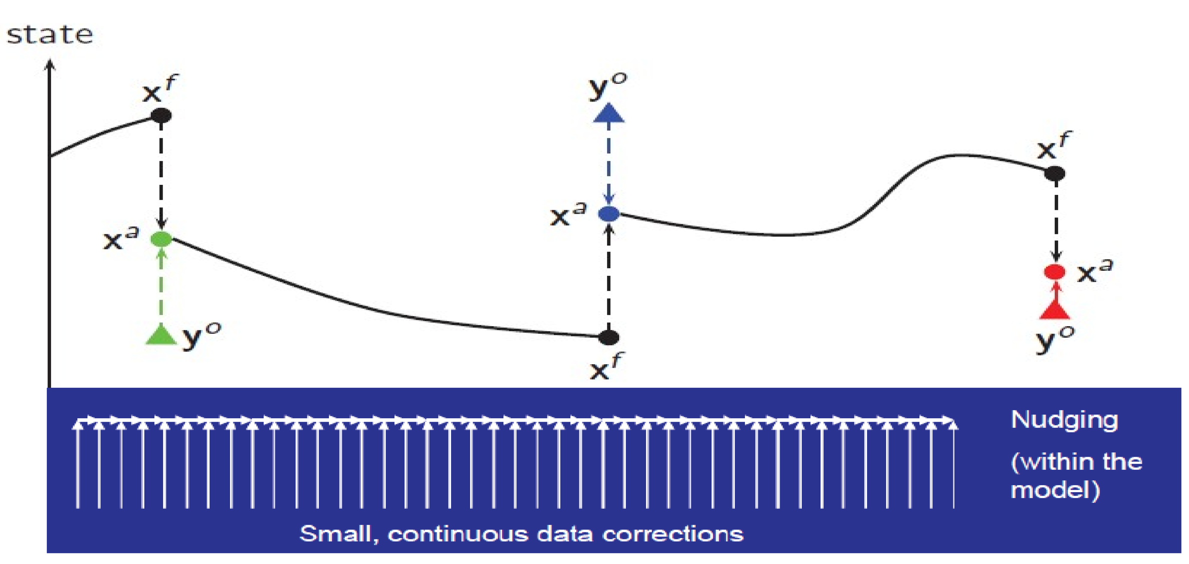
Model integration period :
1 May -31May
1 June-30 Sep 2010

Model verification with ERA-I,CMAP,AIRS

Nudging coefficients for U,V,T / Q / PH → 0.0003

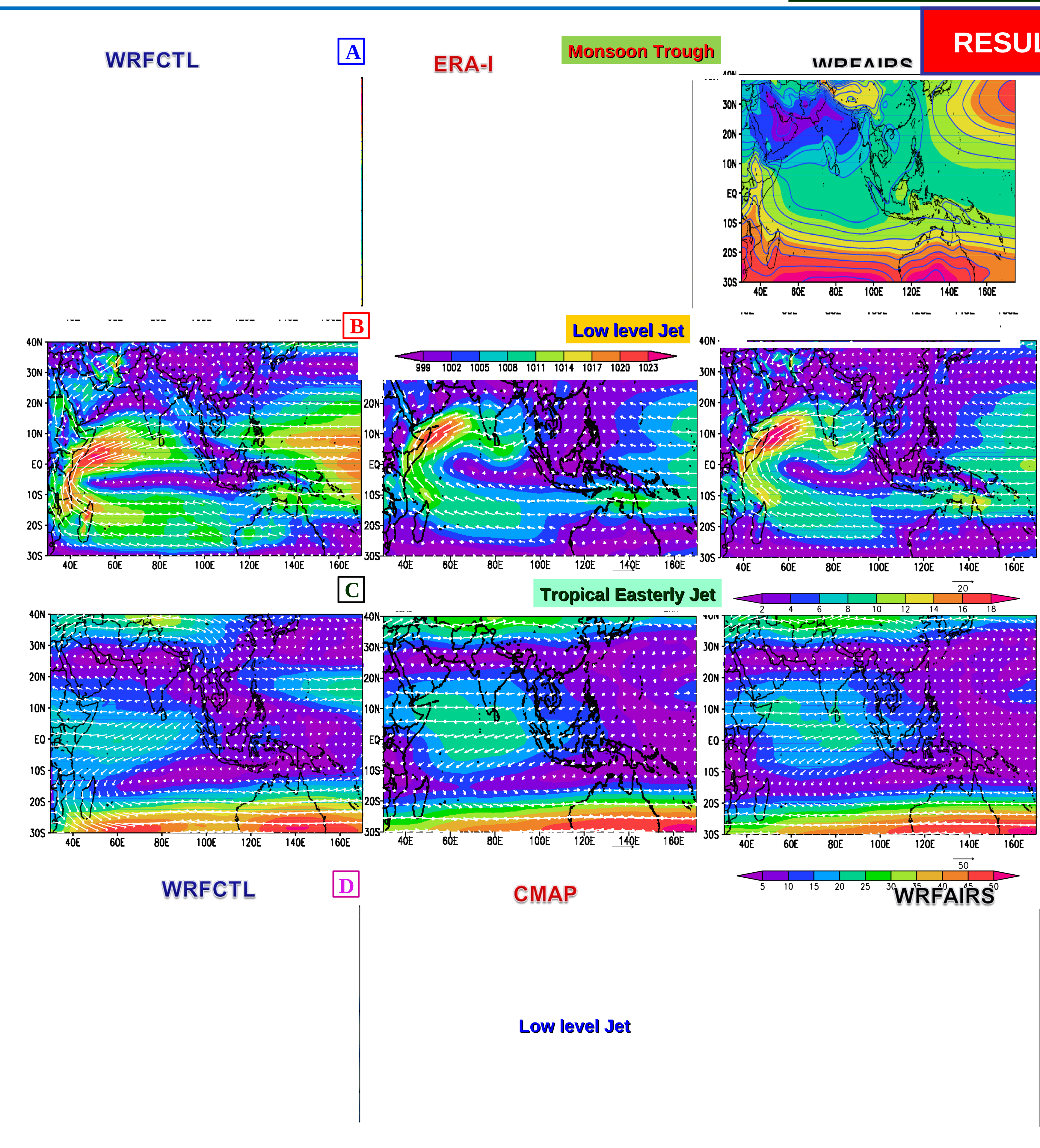
Four Dimensional Data Assimilation Flow

$$\frac{\partial \alpha}{\partial t} = F(\alpha, X, t) + G_\alpha\, W(X,t)\varepsilon(x) p * (\alpha_0 - \alpha)$$

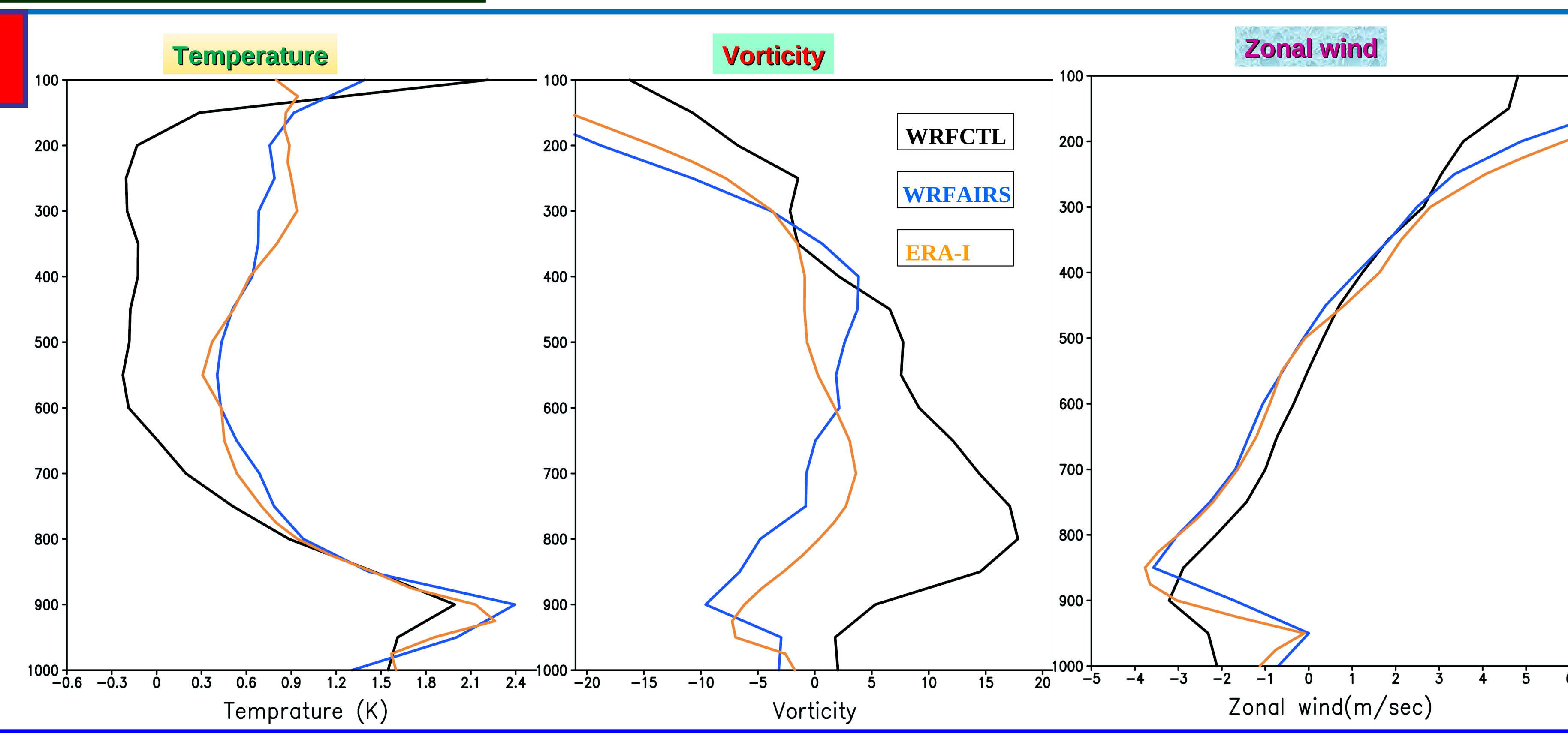


- The model is dynamically initialized with Four Dimensional Data Assimilation (FDDA), is a continuous data assimilation in which the model state is relaxed toward the observed state by augmenting some of the prognostic equations with forcing terms based on the difference between the observed state and the model state.

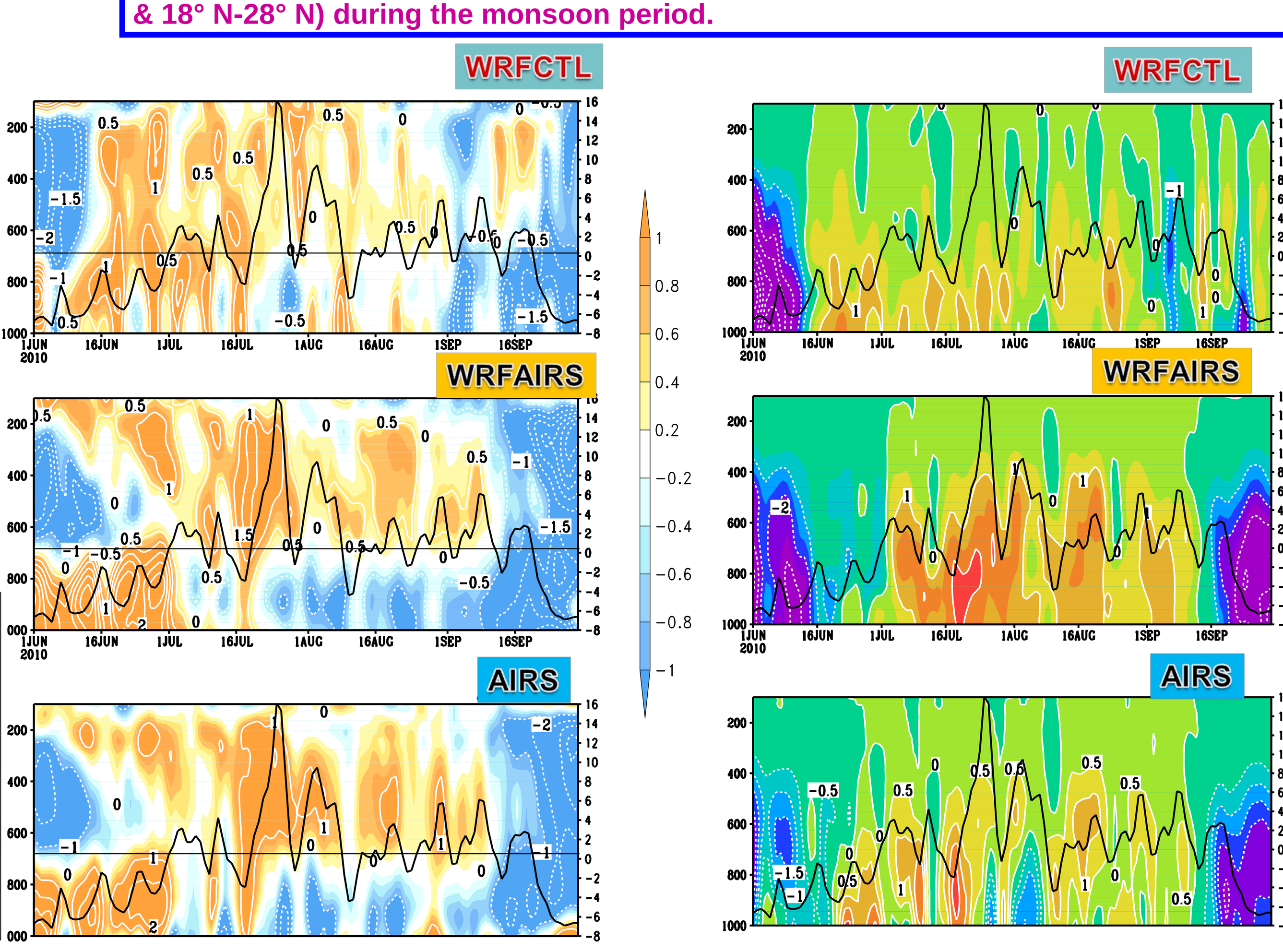
RESULTS



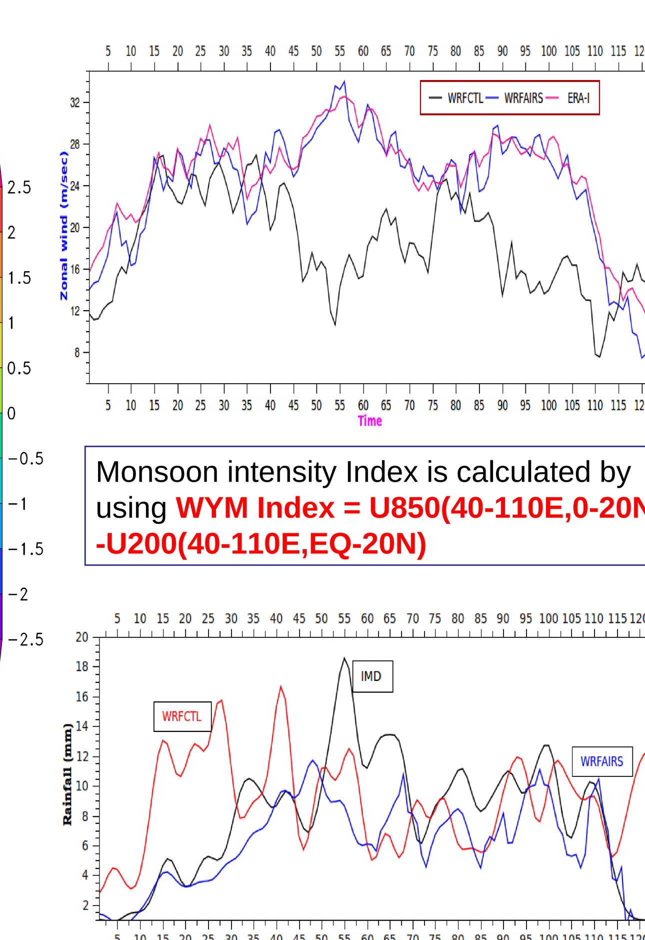
Spatial distribution of (A) Lower level winds (ms^{-1}) ,(B) upper level winds (ms^{-1}), (C) sea level pressure(hPa) and (D) precipitation(mm) during the JJAS-2010.



Vertical structures Temperature (K) relative vorticity (sec^{-1}) and zonal wind(ms^{-1}) and over Central Indian region(CIR) (69°E-88° E & 18° N-28° N) during the monsoon period.



Vertical cross section of temperature and water vapor with superimposed rainfall time series over CIR region from IMD,WRFCTL and AIRS.



Time series of rainfall over CIR region from IMD, WRFCTL and WRFAIRS

SUMMARY

- ✓ Temperature assimilation(WRFAIRS) could improve pressure distribution compared to WRFCTL experiment. It also improved the monsoon trough reasonably well in WRFAIRS experiment than WRFCTL .
- ✓ Monsoon wind circulation (low level and upper level) is well simulated by the assimilation run than WRFCTL in terms of strength as well spatial structure. Hence assimilation of mass fields can significantly impact on the wind fields during the model integration.
- ✓ The mean precipitation during monsoon is as shown in CMAP. In WRFCTL is heavily overestimated the rainfall over western Ghats , head Bay of Bengal and north of Madagascar, whereas in WRFAIRS experiment the mean monsoon rainfall gets recovered in terms of spatial pattern but could not be in magnitude. Interestingly over CIR, it is well simulated than the WRFCTL.
- ✓ Average rainfall over the CIR is captured in phase fairly good in WRFAIRS than WRFCTL experiment.
- ✓ Vertical structure of temperature over the CIR during the monsoon has baroclinic nature and its amplitude modulates with the monsoon activity. This nature is well simulated in WRFAIRS than WRFCTL experiment. Hence the improvement in rainfall simulation may due to improved thermodynamics structures over CIR
- ✓ The mean vertical structures of zonal wind and vorticity over the monsoon trough region is important for understanding the large scale dynamics. These structures are come close to ERA-I in WRFAIRS than WRFCTL.
- ✓ The monsoon circulation index (Zonal wind index) is simulated very well in WRFAIRS experiment than WRFCTL.
- ✓ The temperature associated monsoon elements are very well simulated in temperature assimilation experiment than the WRFCTL run.
- ✓ Future study: The vertical profiles of temperature and humidity from various sources will be assimilated in the model to examine the impact of vertical profiles assimilation on monsoon simulation.

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