

# Numerical simulation of Fog over Indo Gangetic Plains (IGP), India during CAIPEEX 14-15 and WIFEX15-17 field campaigns using WRF/WRF\_Chem models

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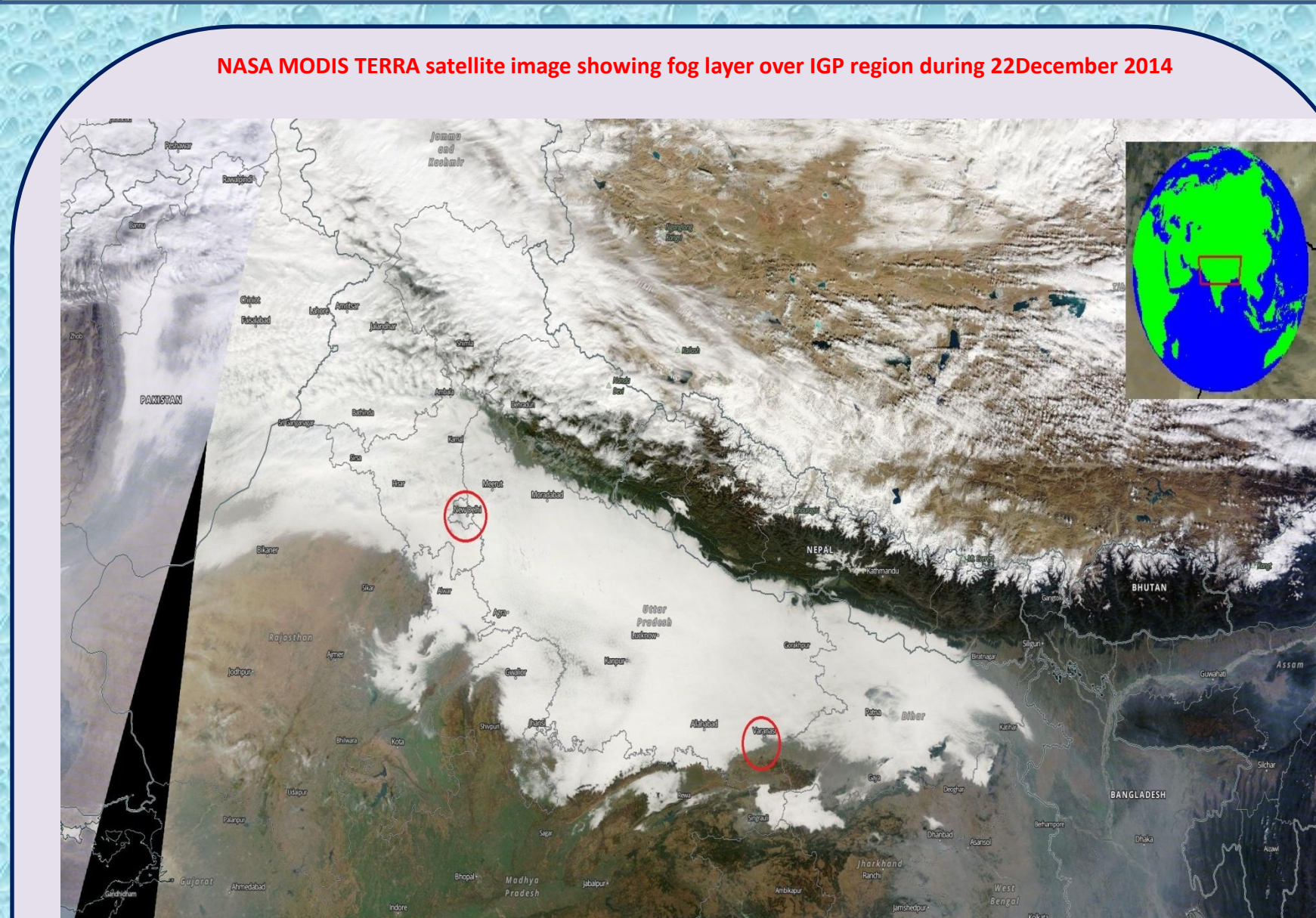
## Background

A series of numerical experiments were carried out with various combinations of physical parameterization schemes to determine the fidelity of the Weather Research and Forecasting (WRF) model (at 2 km resolution) to simulate fog event at Barkachha (in IGP, 25.06N, 82.59E). These simulations with four Planetary Boundary Layer (PBL) combined with five microphysics schemes during Cloud Aerosol Interaction and Precipitation Enhancement Experiment Integrated Ground Observational Campaign 2014-15 (CAIPEEXIGOC) and Winter Fog Experiment (WIFEX2015-16), revealed that the MYNN2.5 PBL scheme with WSM6 microphysics is probably the best combination for simulating Liquid Water Content (LWC) during the fog event. This setup was further used for experimental forecast during WIFEX2016-17 at IGI Airport, New Delhi. During WIFEX16-17 we observed 20 fog events. We ran forecast using WRF with IITM High Resolution GFS (IITM-GFS, 12km) and NCMRWF Unified Model (NCUM, 23 km) Initial & Boundary conditions (IC/BC). Out of 25 (68) dense fog events, WRF with IITM-GFS and NCUM has forecasted 17 and 25 fog events respectively and false alarm rate for IITMHIRESGFS And NCUM is 15(43) and 40(43) respectively. Model derived LWC variations were inter compared with radiometer observations and depth and duration of fog layer at IGI airport has been evaluated. We also carried out a case study with WRF\_Chem to investigate importance of aerosols for visibility forecast during fog event. We found that inclusion of chemistry has improved visibility significantly.

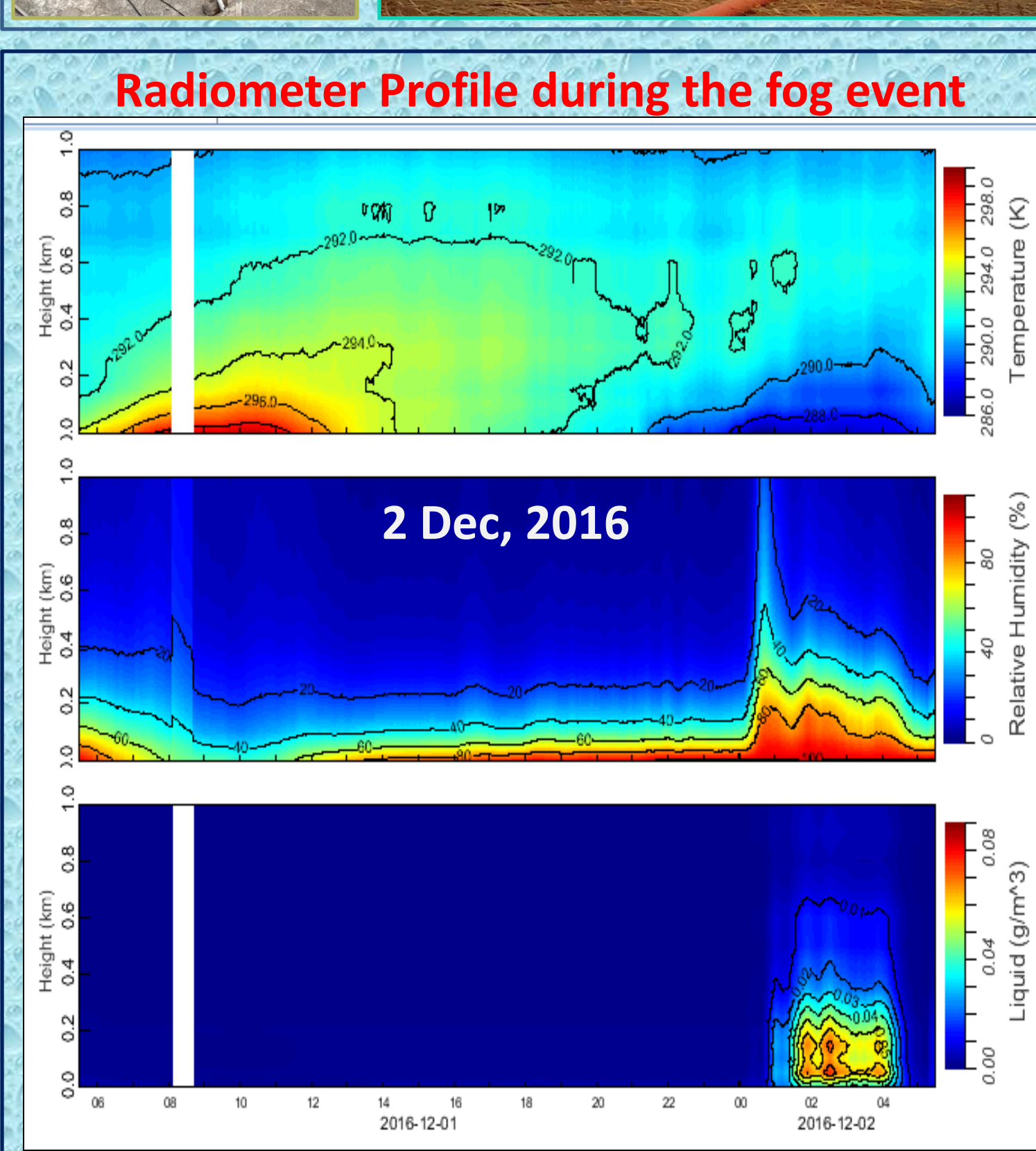
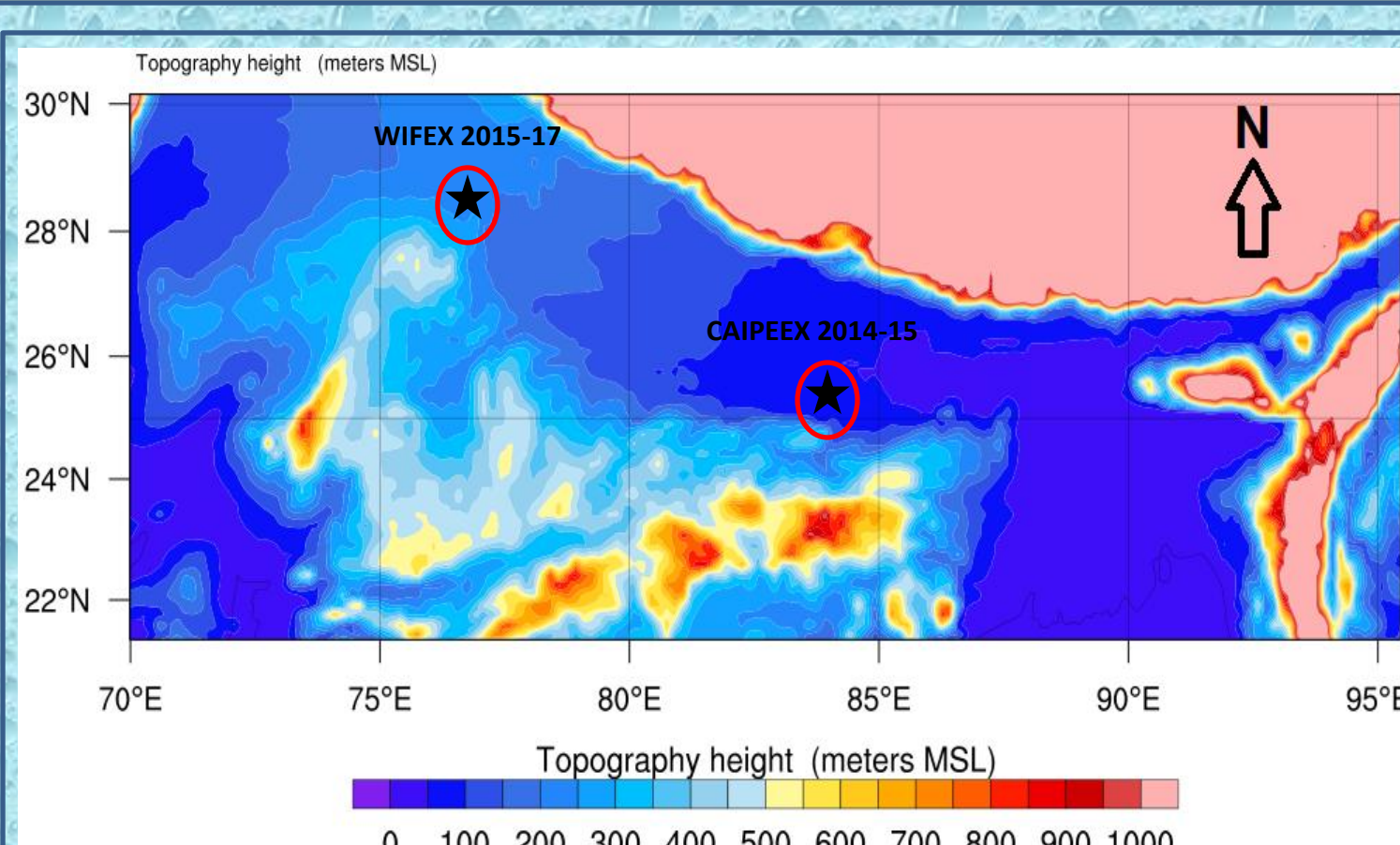
## Data and methodology

- Weather Research and Forecasting (WRF) and WRF\_Chem (3.6.1) with 2km single domain set up.
- 0.25° ERA-Interim reanalysis data from ECMWF, IITM-GFS (~12km) and NCUM (~23km) forecast data during WIFEX2016-17.
- Observed meteorological parameters and fluxes data from 20m tower at Barkachha rural site and IGI Airport New Delhi in IGP region.
- Vertical wind speed and direction from SODAR & Radio sonde data.
- Relative Humidity and LWC profiles from Radio meter at IGI airport during WIFEX 15-17
- Statistical methods such as correlation, RMSE, Standard Deviation analysis technique are used in this study.
- NASA MODIS TERRA/AQUA satellite images have used for identification of fog spacial coverage over IGP.

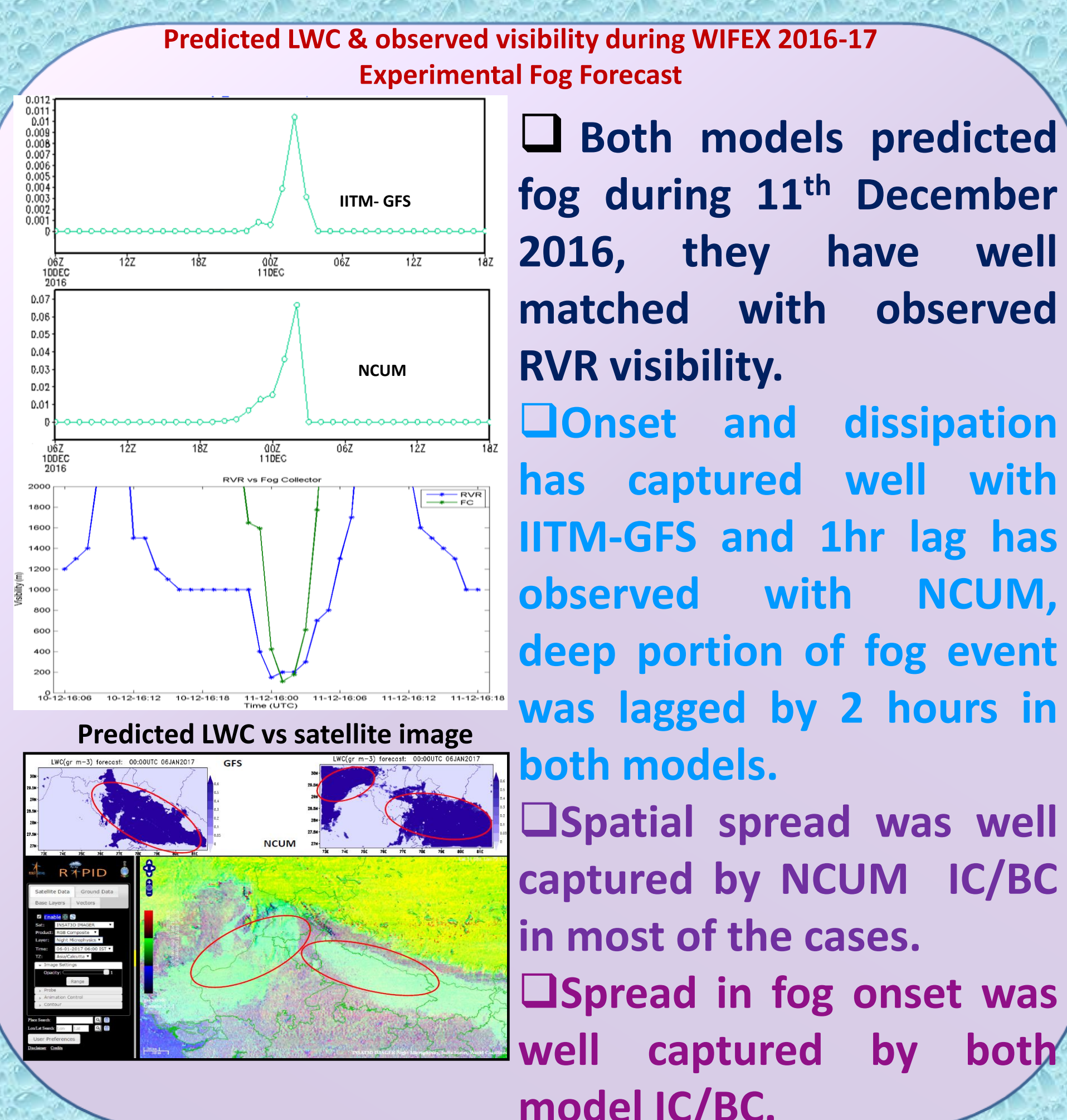
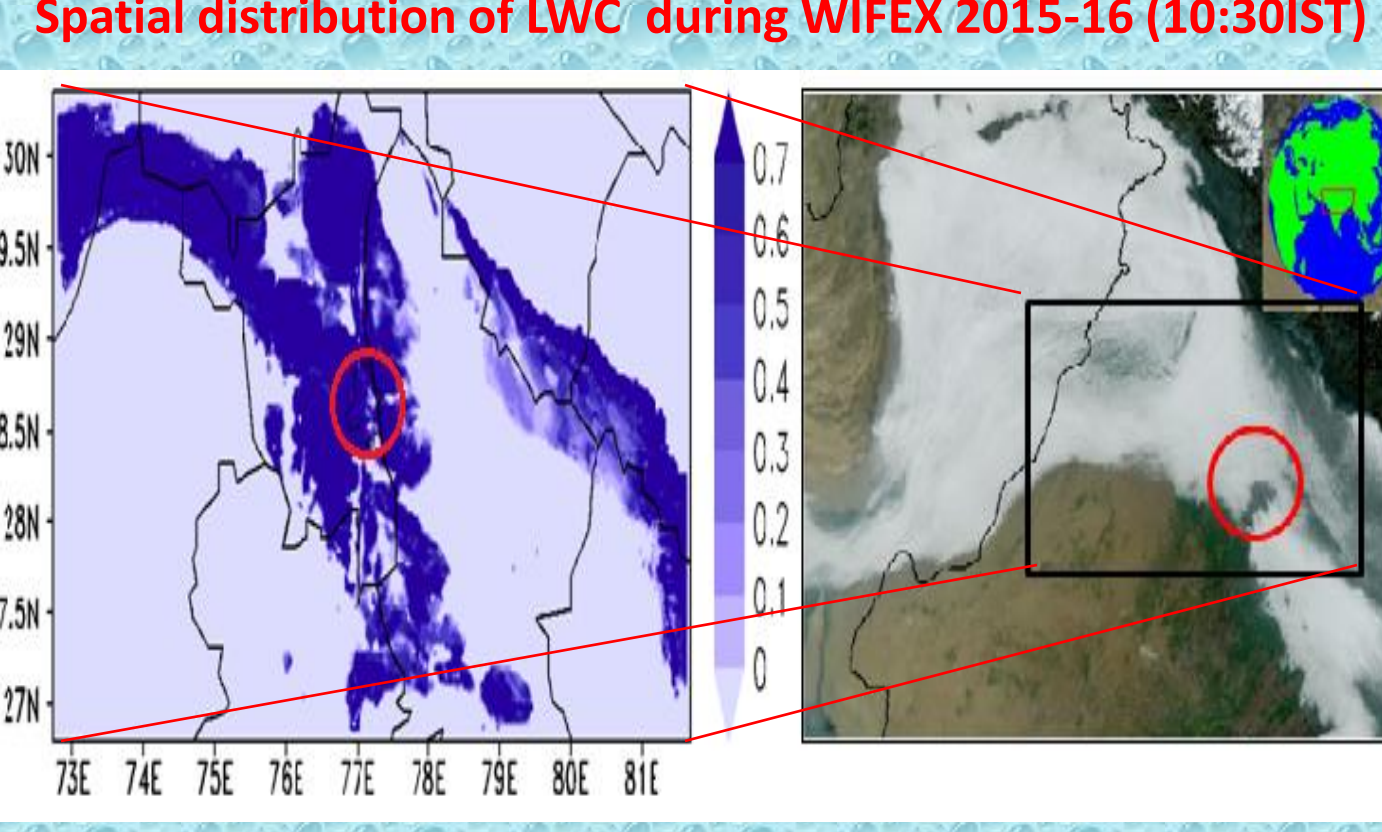
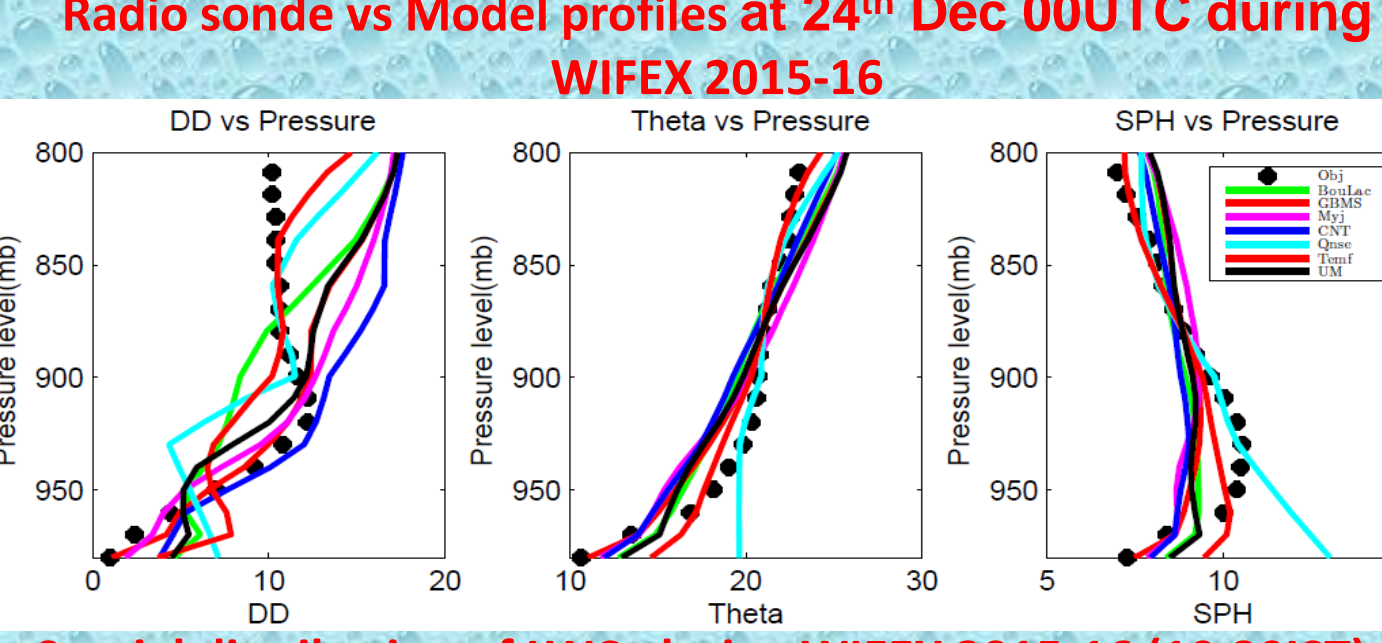
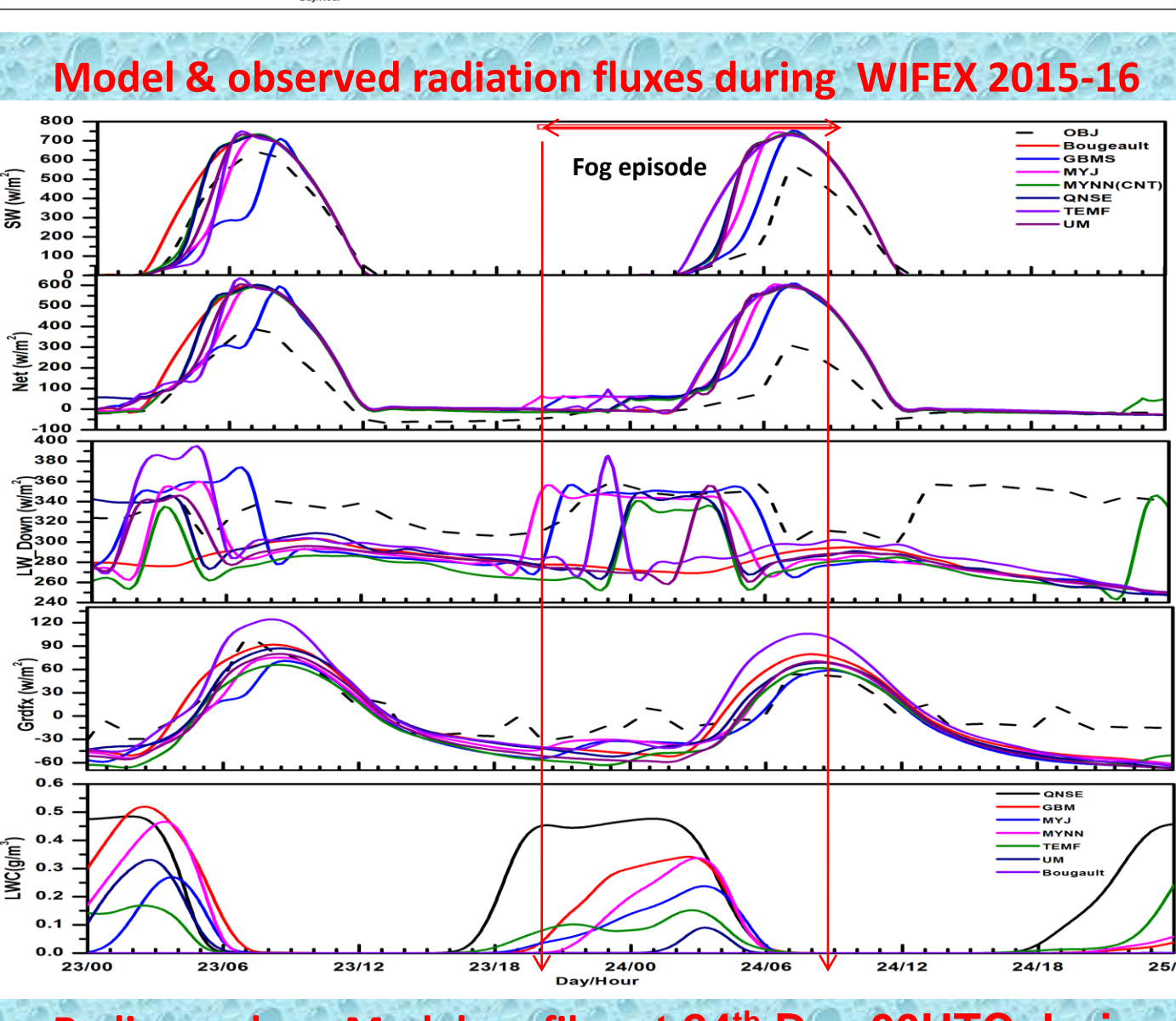
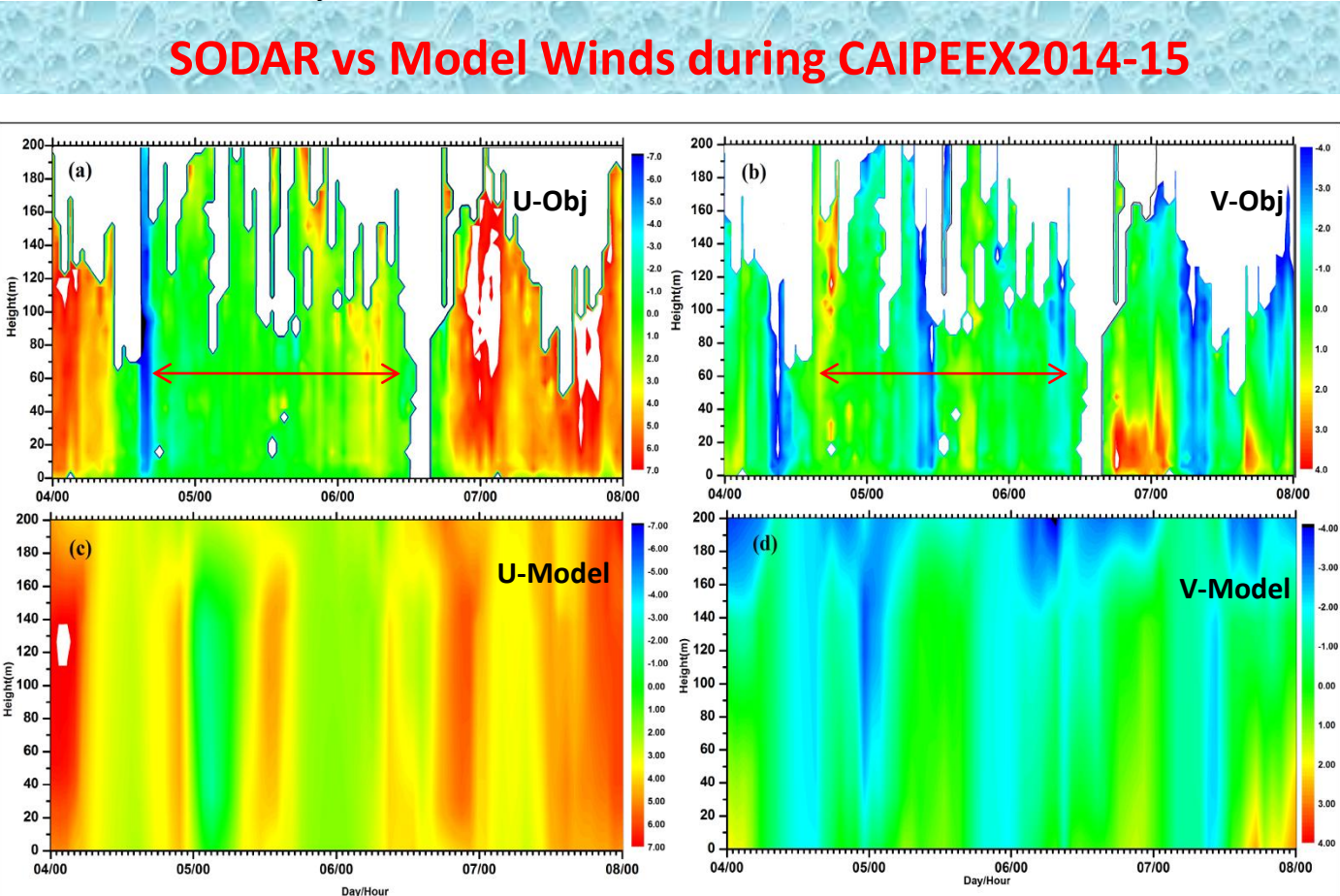
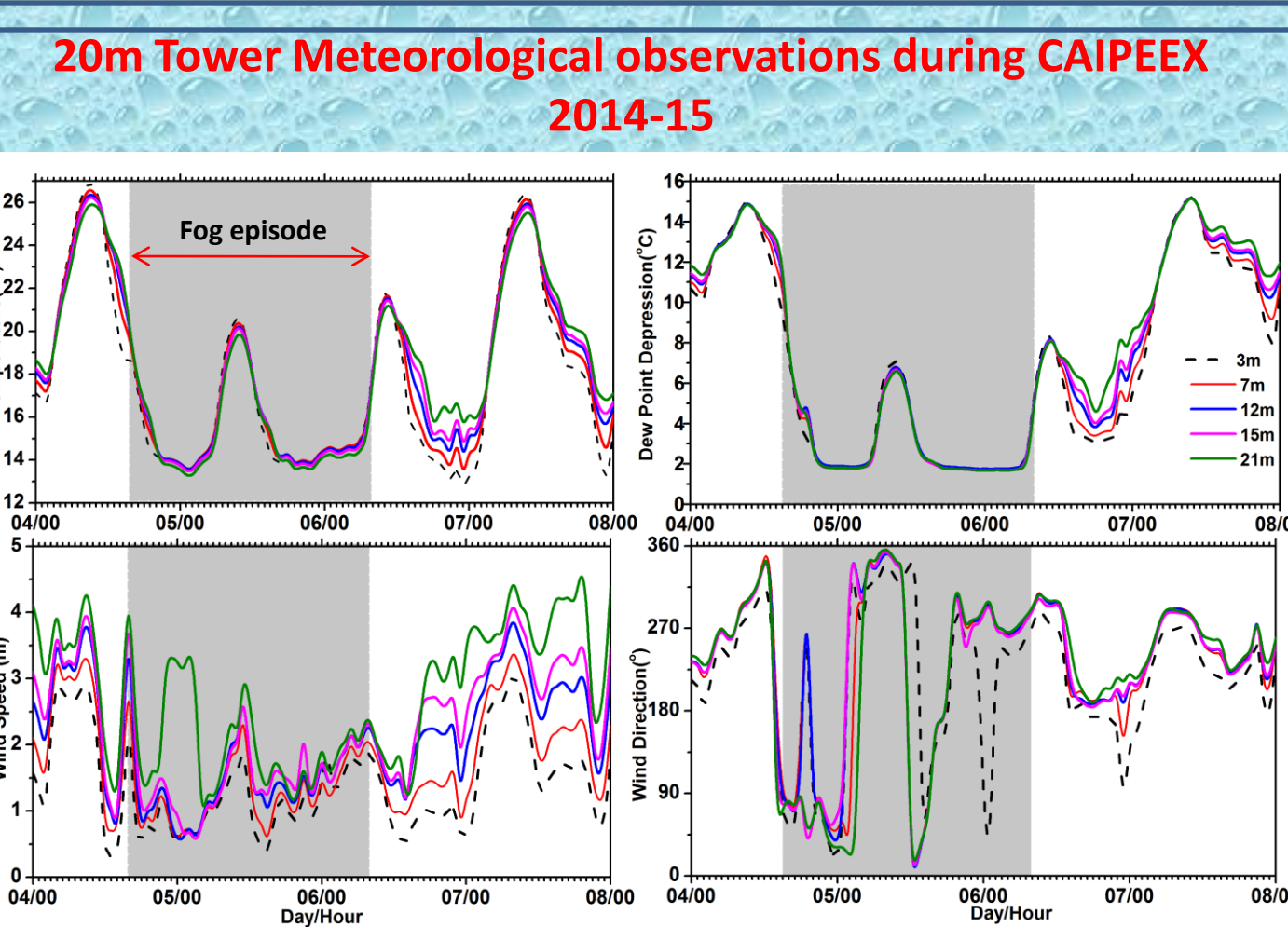
## Results and Discussions



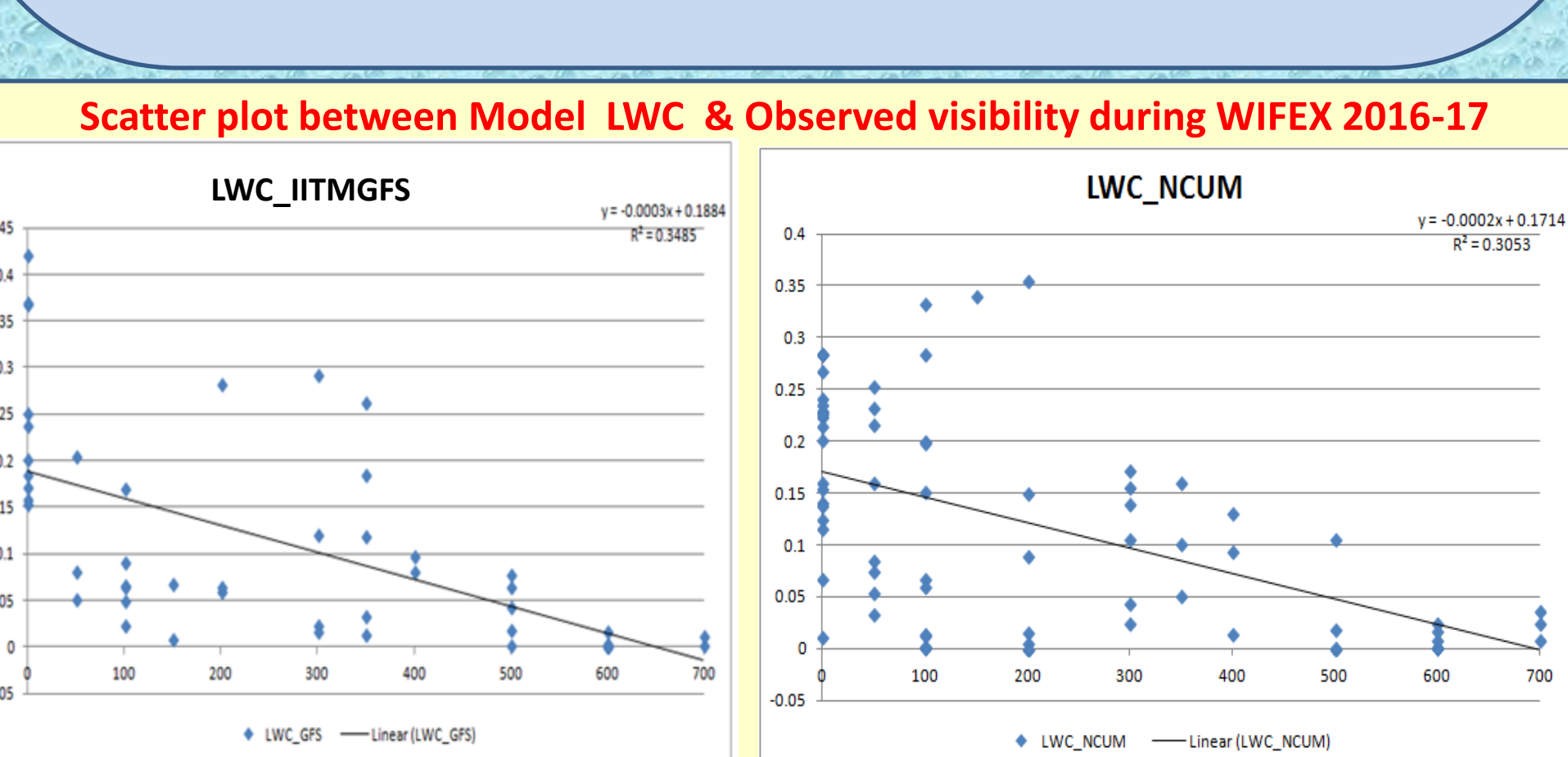
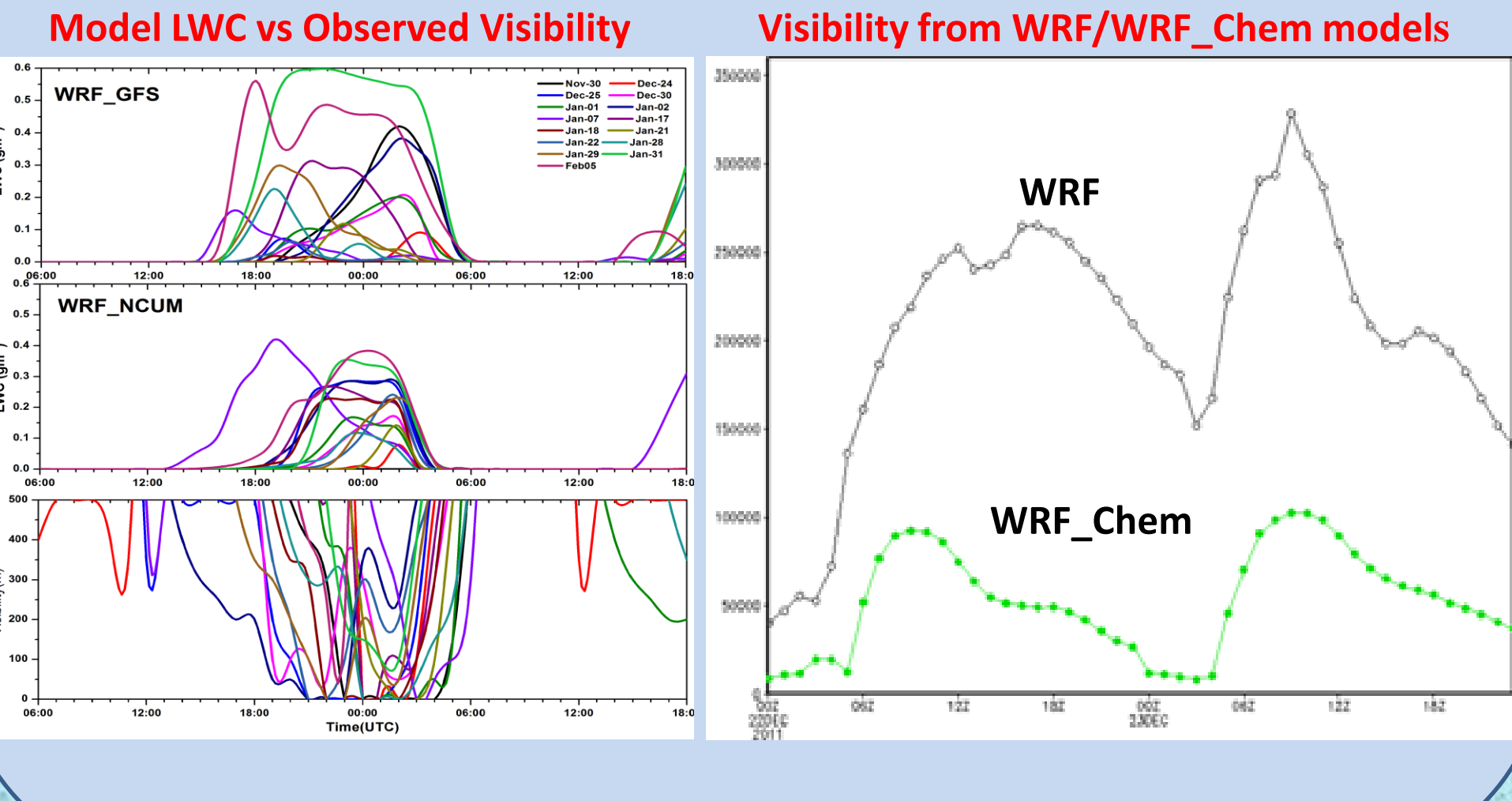
- Fog formation over IGP regions of India has unique feature, where we can see over a large horizontal extent from Pakistan to Bangladesh (>1000 km) and persist up to a week based on associated synoptic meteorological conditions.



- Clear low level inversion in midnight.
- Humidification and development of deep moist layer.
- Triggered fog early morning.
- Vertical dept of fog is about 400 meter.



Model skills scores during WIFEX 2016-17		
Fog Collector	WRF GFS IC/BC 30 <sup>th</sup> Nov 2016 to 06 <sup>th</sup> Feb 2017	WRF NCUM IC/BC 30 <sup>th</sup> Nov 2016 to 06 <sup>th</sup> Feb 2017
Predicted Fog events	17/25 (68 days)	25/25 (68 days)
Failed Fog events	08	Nil
False alarm	15	40



## Summary

- Statistical evaluation results revealed that the MYNN2.5 PBL scheme with WSM6 microphysics is best combination for simulating fog LWC to simulate fog over this observational site.
- Only MYNN2.5 combination with WSM6, WSM3 and Lin microphysics were able to capture the spatial extent of LWC during the fog event.
- Chemistry runs have improved visibility forecast suggesting that aerosols impact on visibility.
- Experimental forecast during WIFEX2016-17 has given some good skills for fog forecast with WRF model with different global model IC/BC.
- WRF with IITM-GFS IC/BC has given good skill score during WIFEX2016-17

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