Satellite Era Retrospective Analysis over the Indian Region: IMDAA

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Why do we need Regional Reanalysis?

Uniqueness of reanalysis datasets is their completeness and consistency.

These gridded datasets of multiple parameters are normally available without any gap in space and time.

Many studies indicated that global reanalyses with resolutions greater than 50 km cannot represent sub-grid scale variations in meteorology over heterogeneous terrain (Mesinger et al., 2006; Randall et al., 2007).

The cost in computing time of long-period reanalyses makes high-resolution runs expensive, and so resolutions tend not to be suited for studying mesoscale weather systems.

High resolution regional analyses are better able to represent these features (Dickinson et al., 1989; Fowler et al., 2007; Evans and McCabe, 2013).

Indian Monsoon Data Assimilation and Analysis (IMDAA)

- Forty years reanalysis over the Indian Monsoon Region, covering the satellite era from 1979 to 2018.

- Funded by National Monsoon Mission (NMM) project of Ministry of Earth Sciences (MoES), Government of India

- Collaborative project among National Centre for medium Range Weather Forecasting (NCMRWF), UK Met Office and India Meteorological Department (IMD)

- Highest resolution regional reanalysis over the region (12 km)

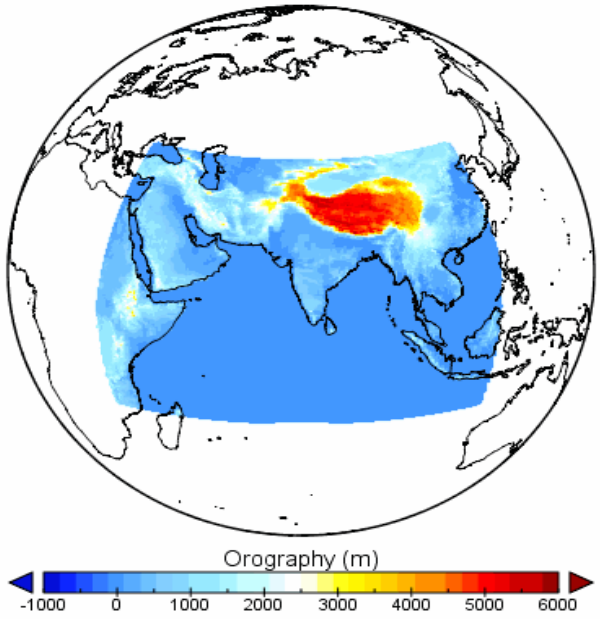
- 4D-Var data assimilation method and the advanced Unified Model (UM) atmospheric model

- Considerable growth and improvement in atmospheric observing systems during the period of this reanalysis, particularly in space-borne observations.

- Enormous efforts were made to gather both conventional and satellite observations from different sources.

- Reanalysis products will be released soon through the NCMRWF web portal in user friendly formats to the research community.

Domain



Horizontal domain of IMDAA spans from 30º E to 120º E, and 15º S to 45º N

Grid spacing of 0.11°× 0.11° and 800 × 576 points in the horizontal.

Heterogeneous domain covering ocean, mountains, plains, deserts, etc.

- **Unified Model with ~12 km horizontal resolution and 64 levels in the vertical up to 40 km**
- **4D-VAR assimilation with resolution ~24 km**
- **EKF based Soil Moisture analysis**
- **3D-VAR based Land Data Assimilation System**
- **Sea Surface Temperature (SST) analysis from the "Hadley Centre Ice and Sea Surface Temperature data set version 2" (HadISST2) up to 2010.**
- **"Operational Sea Surface Temperature and Sea Ice Analysis" (OSTIA) from 2010-2018**
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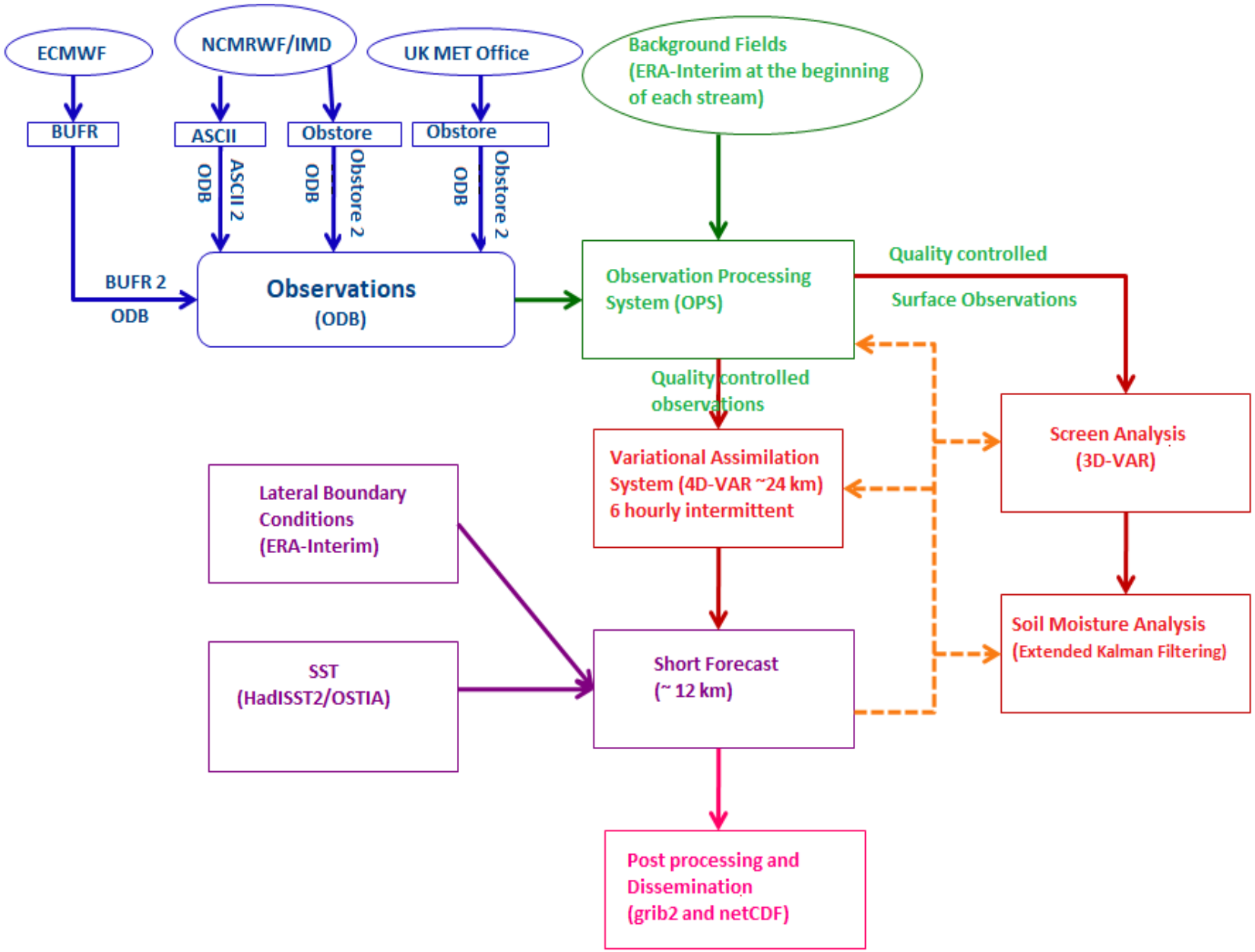
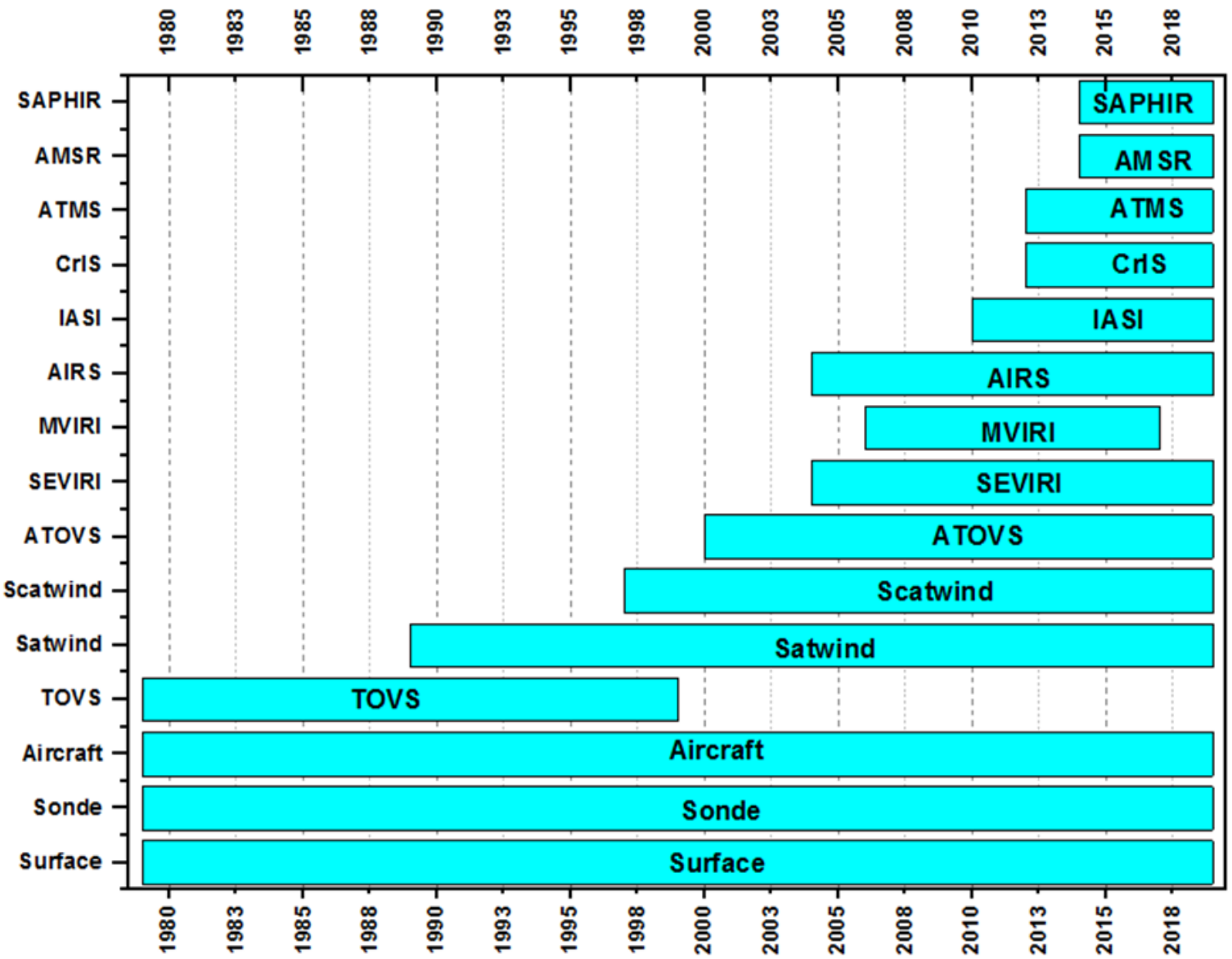
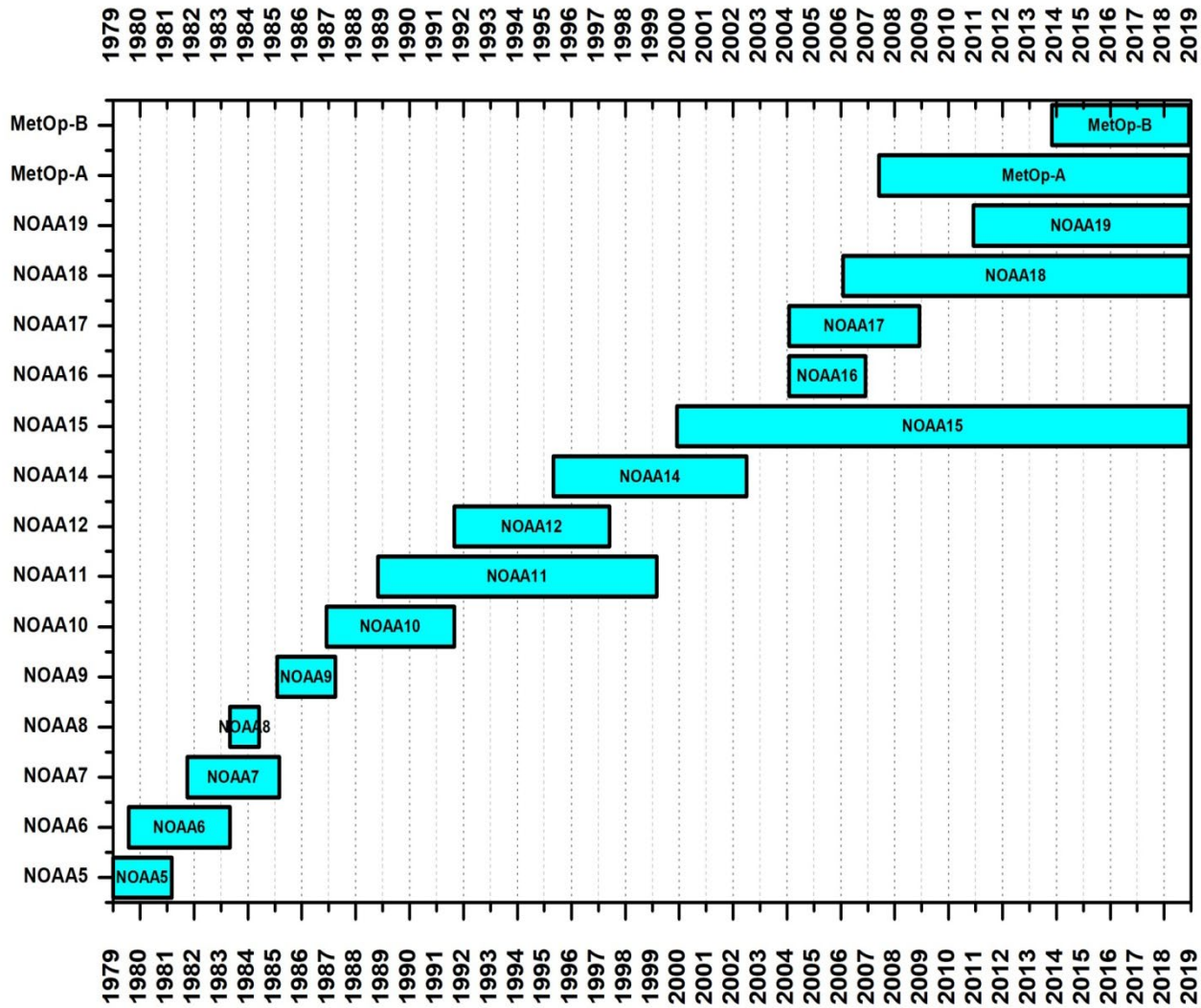
IMDAA Work Flow



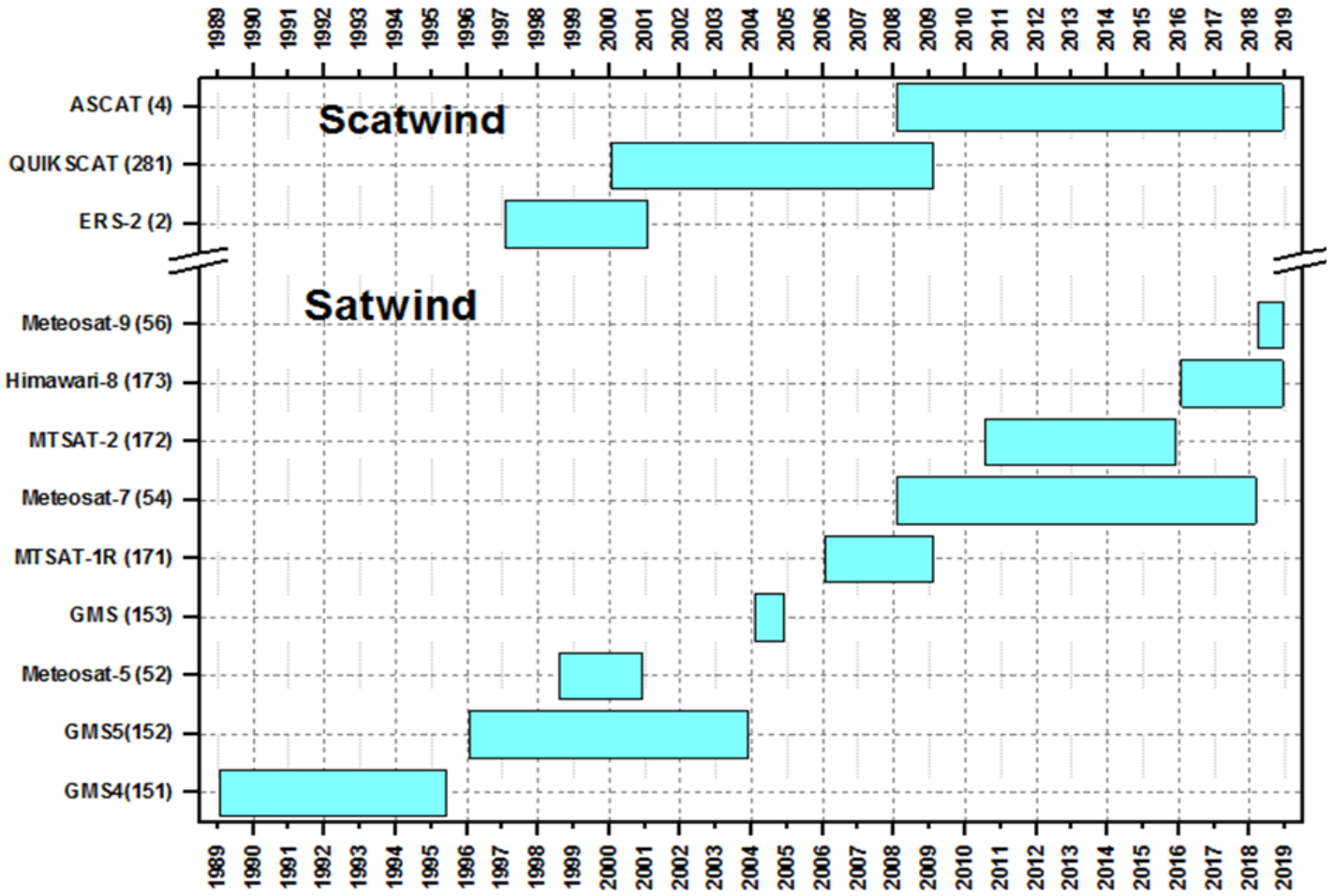
Observations used in IMDAA



Timeline of legacy observations TOVS and ATOVS used in IMDAA



Timeline of Satellite winds used in IMDAA

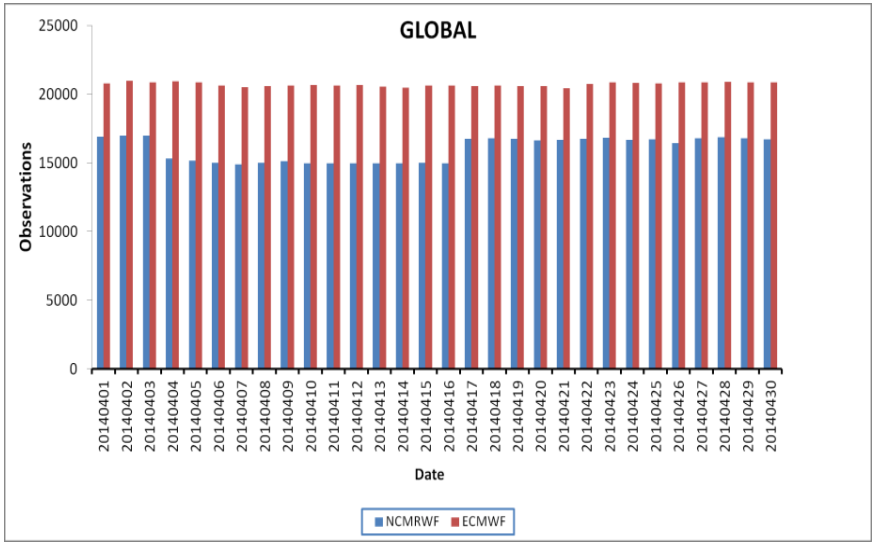


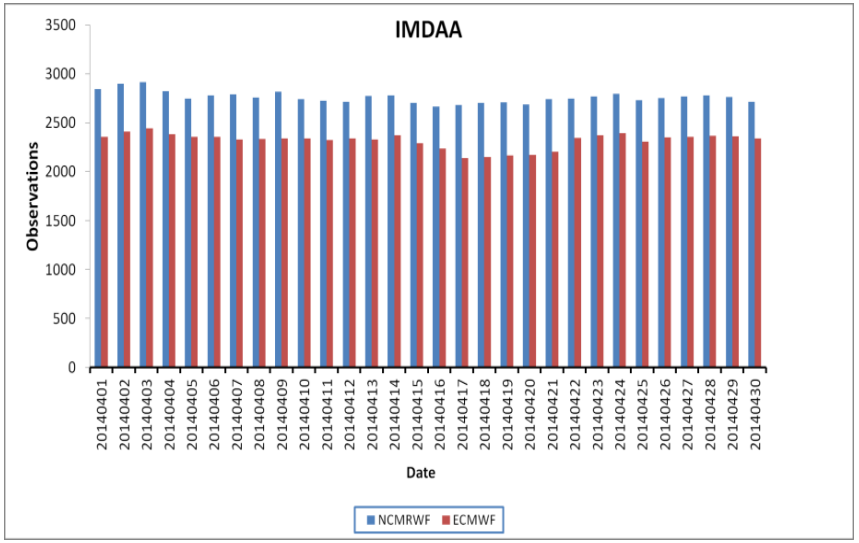
Retrieval of historical observations from IMD/NCMRWF database

Basic meteorological database for IMDAA reanalysis is the European Centre for Medium Range Weather Forecasting (ECMWF) archived meteorological observations.

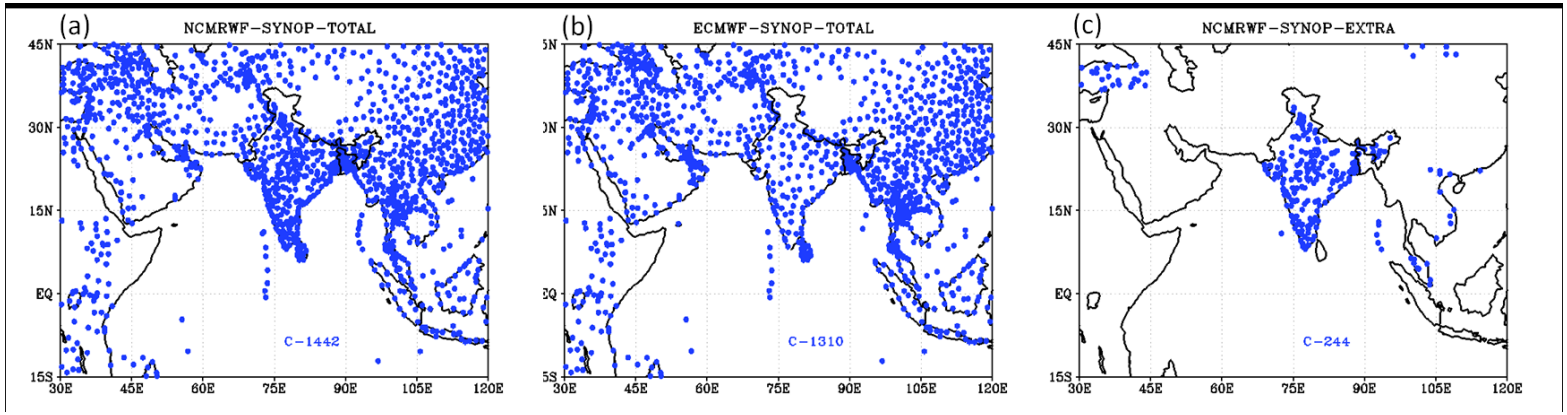
In addition the Indian archives of surface and upper air observations over Indian region are also used.

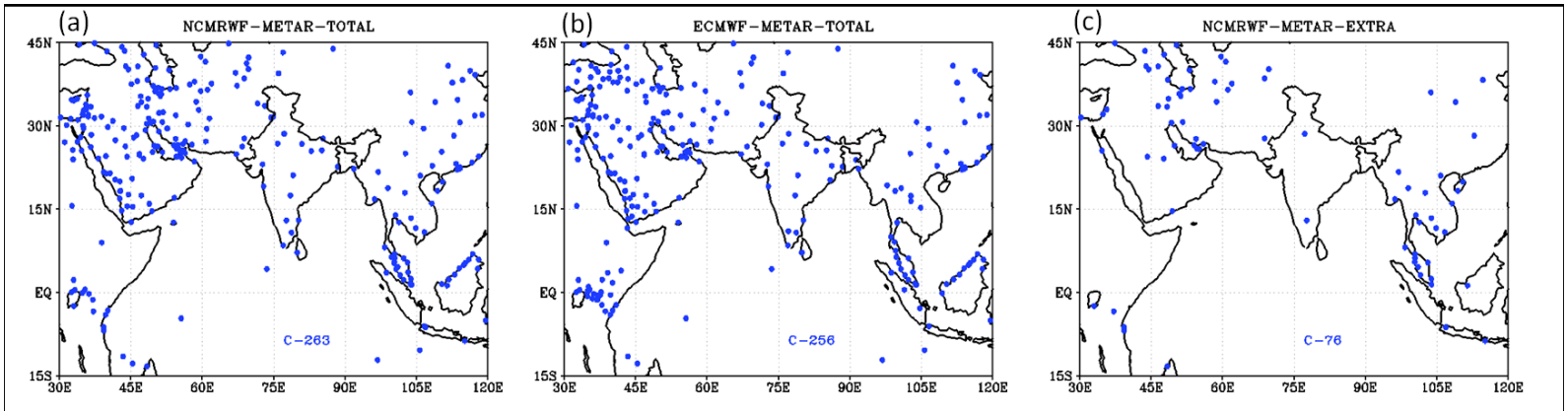
SYNOP Observations

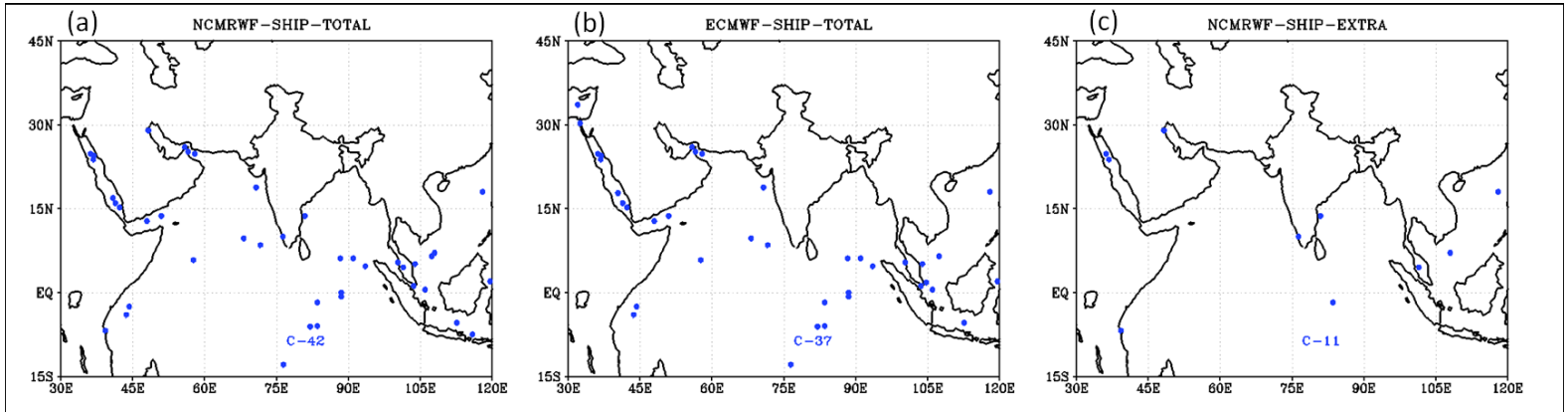




Additional Surface Observations in IMD/NCMRWF database

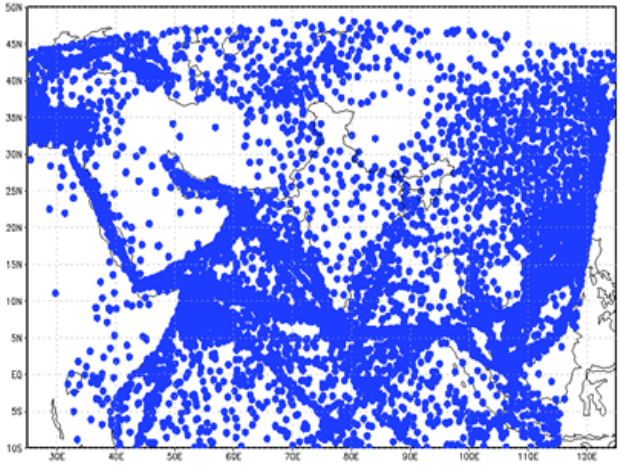




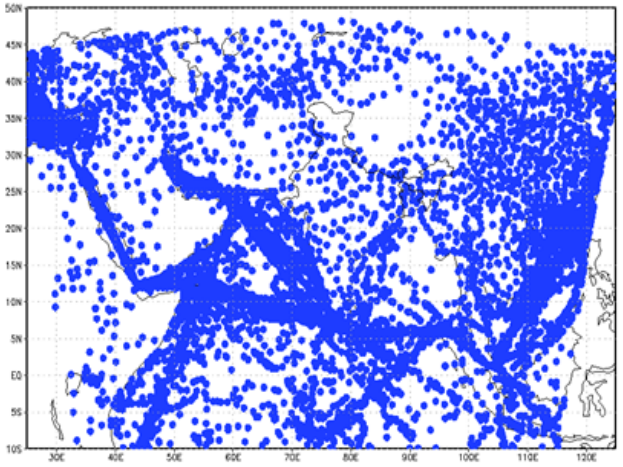


Coverage plots of surface observations assimilated in the IMDAA system during June, July, August, September

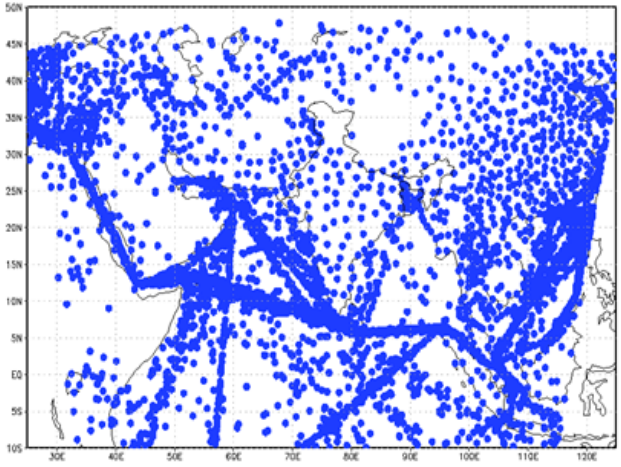
(a) 1984



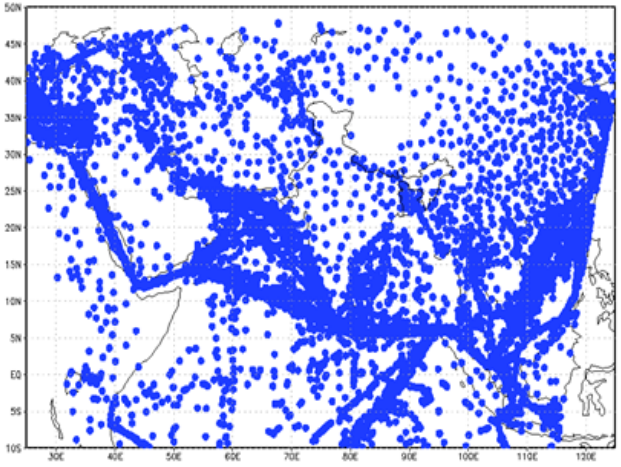
(b) 1994



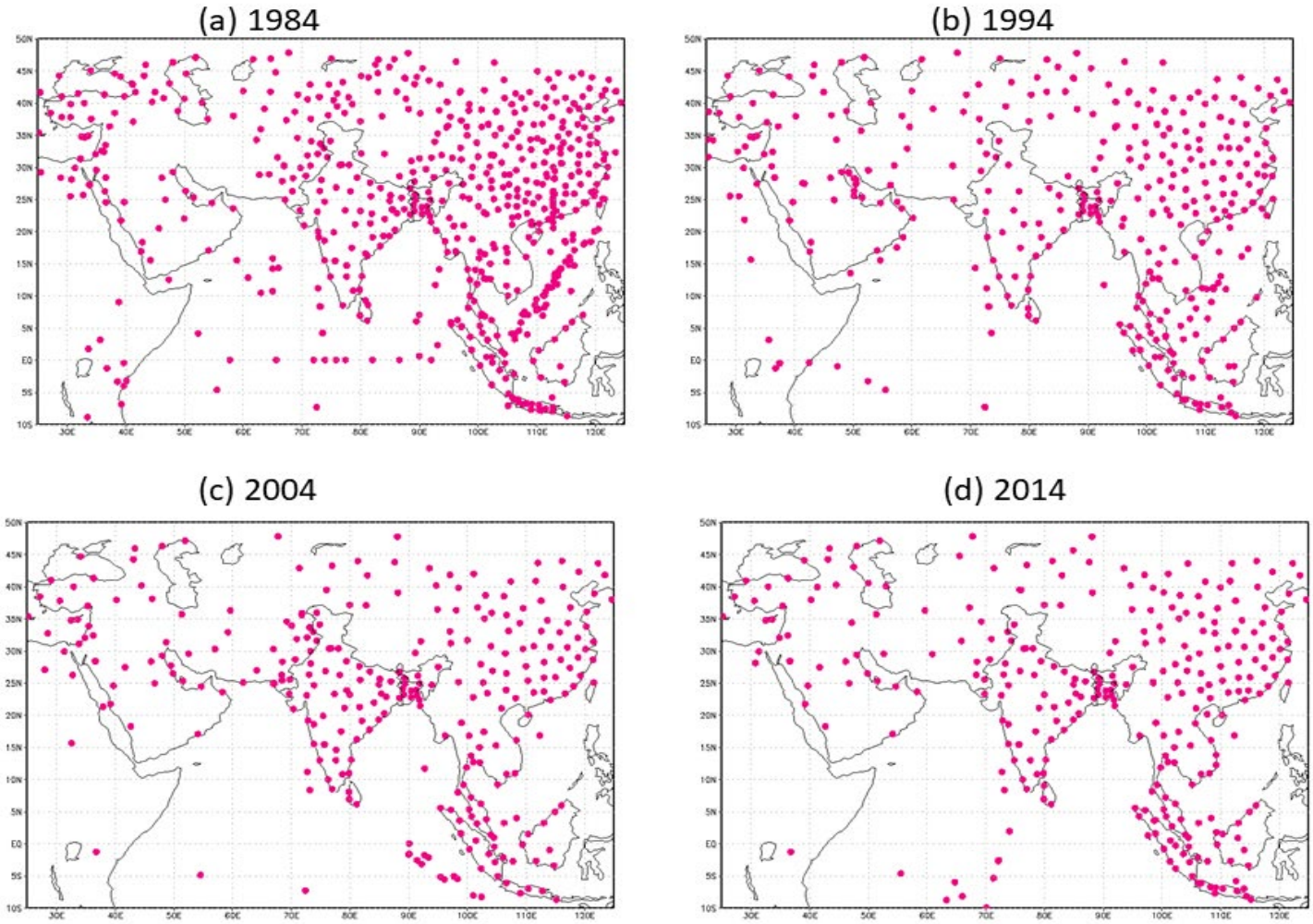
(c) 2004



(d) 2014

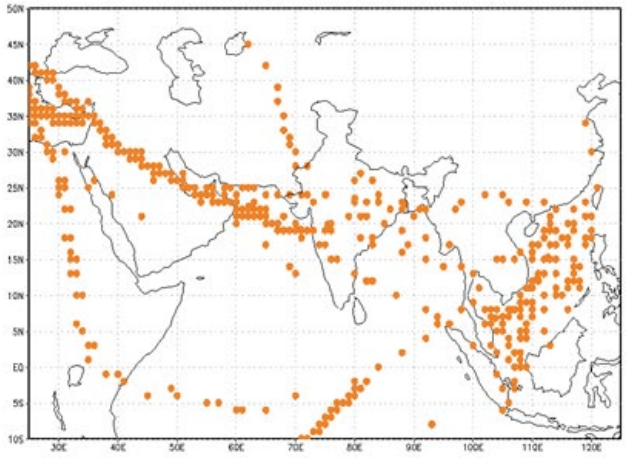


Coverage plots of upper air (TEMP and PILOT balloon) observations assimilated in the IMDAA system during June, July, August, September

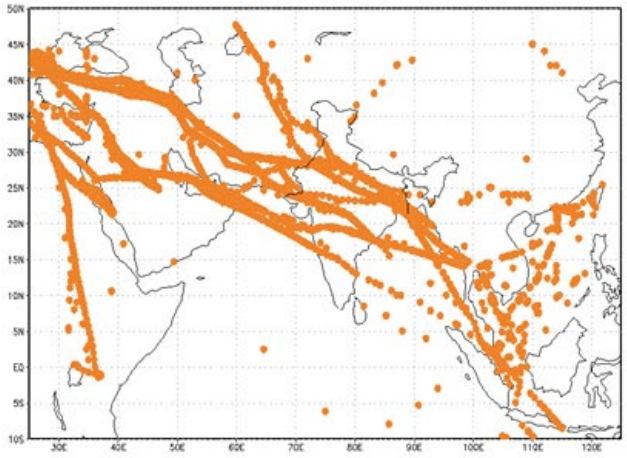


Coverage plots of aircraft (AIREP and AMDAR) observations assimilated in the IMDAA system during June, July, August, September

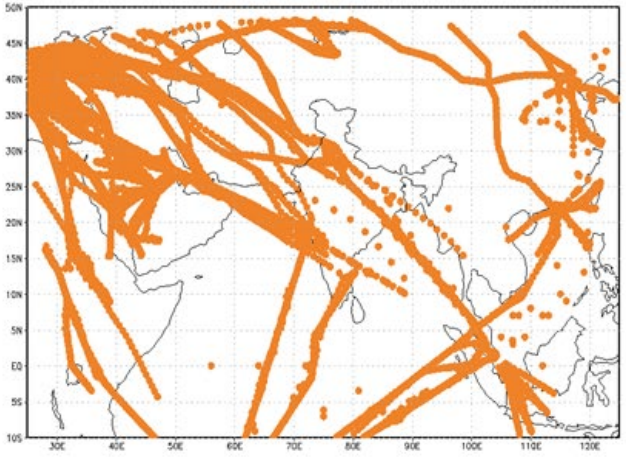
(a) 1984



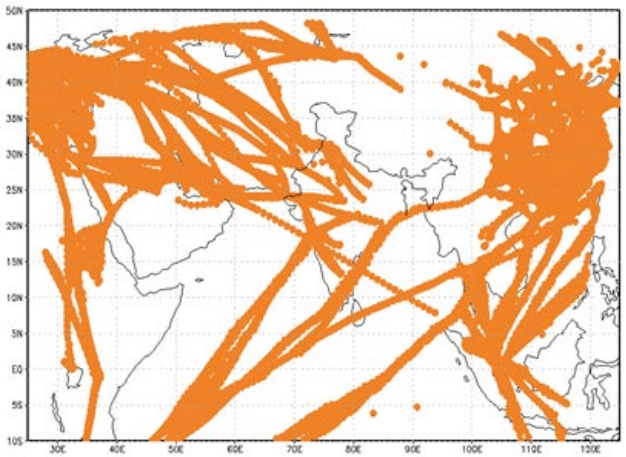
(b) 1994



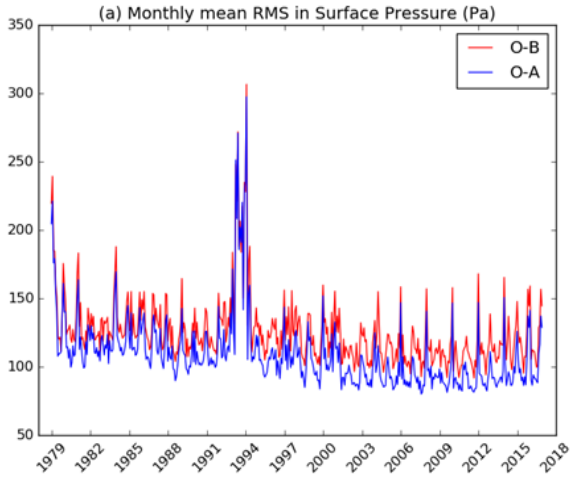
(c) 2004

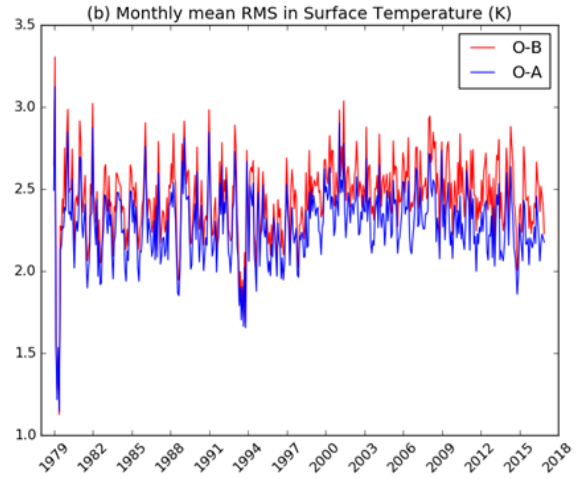


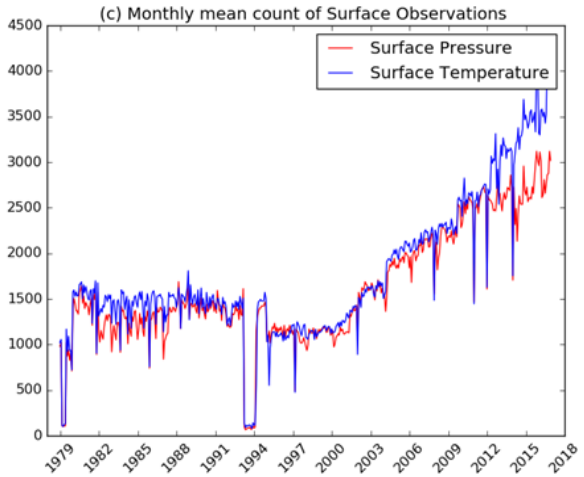
(d) 2014



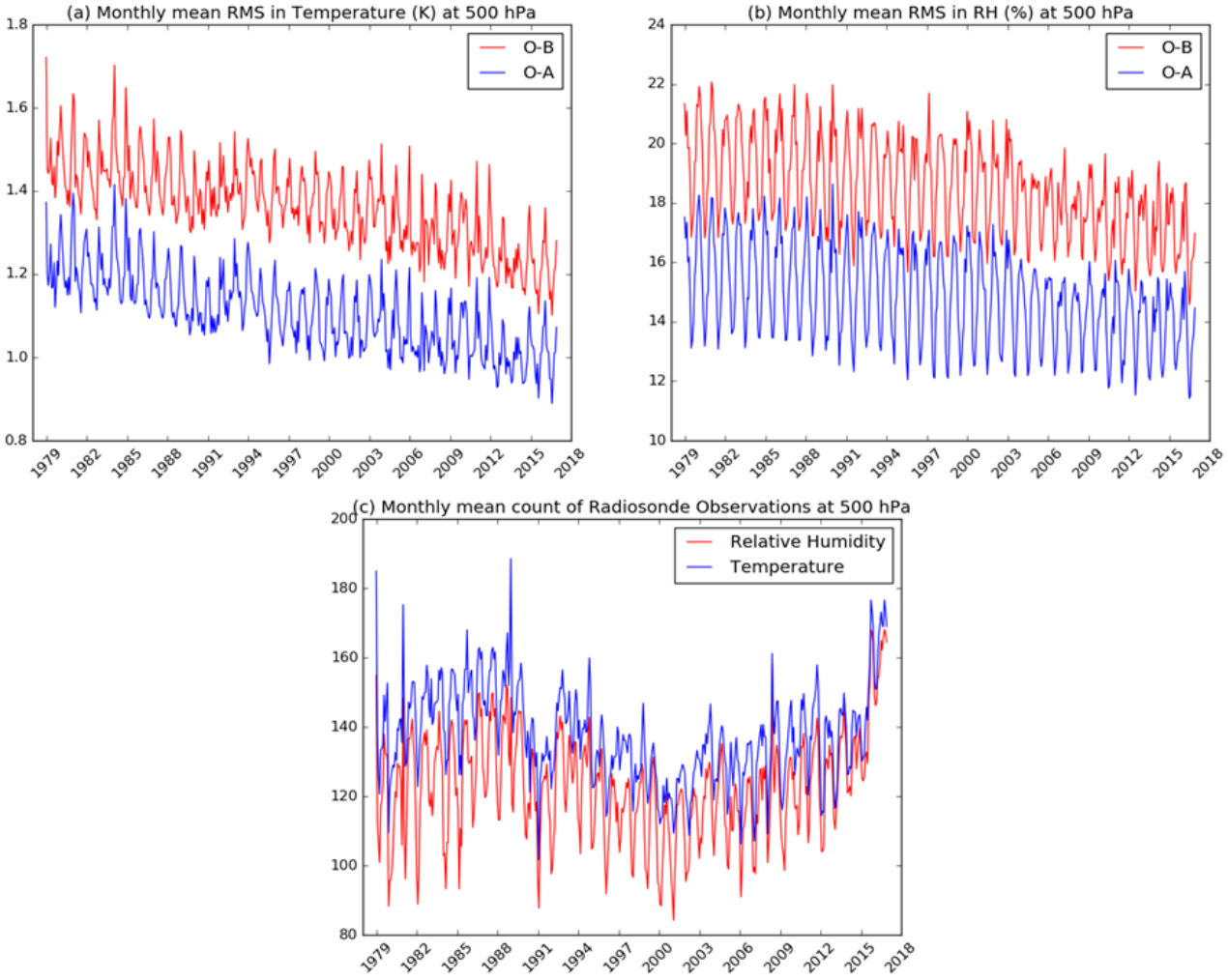
Monthly mean Root Mean square errors in O-B (red curve) and O-A (blue curve) of surface parameters, (a) Surface Pressure (Pa), (b) Surface Temperature (K) and (c) monthly mean count of surface pressure observations (red curve) and surface temperature observations (blue curve) assimilated in the IMDAA system from 1979 to 2016.



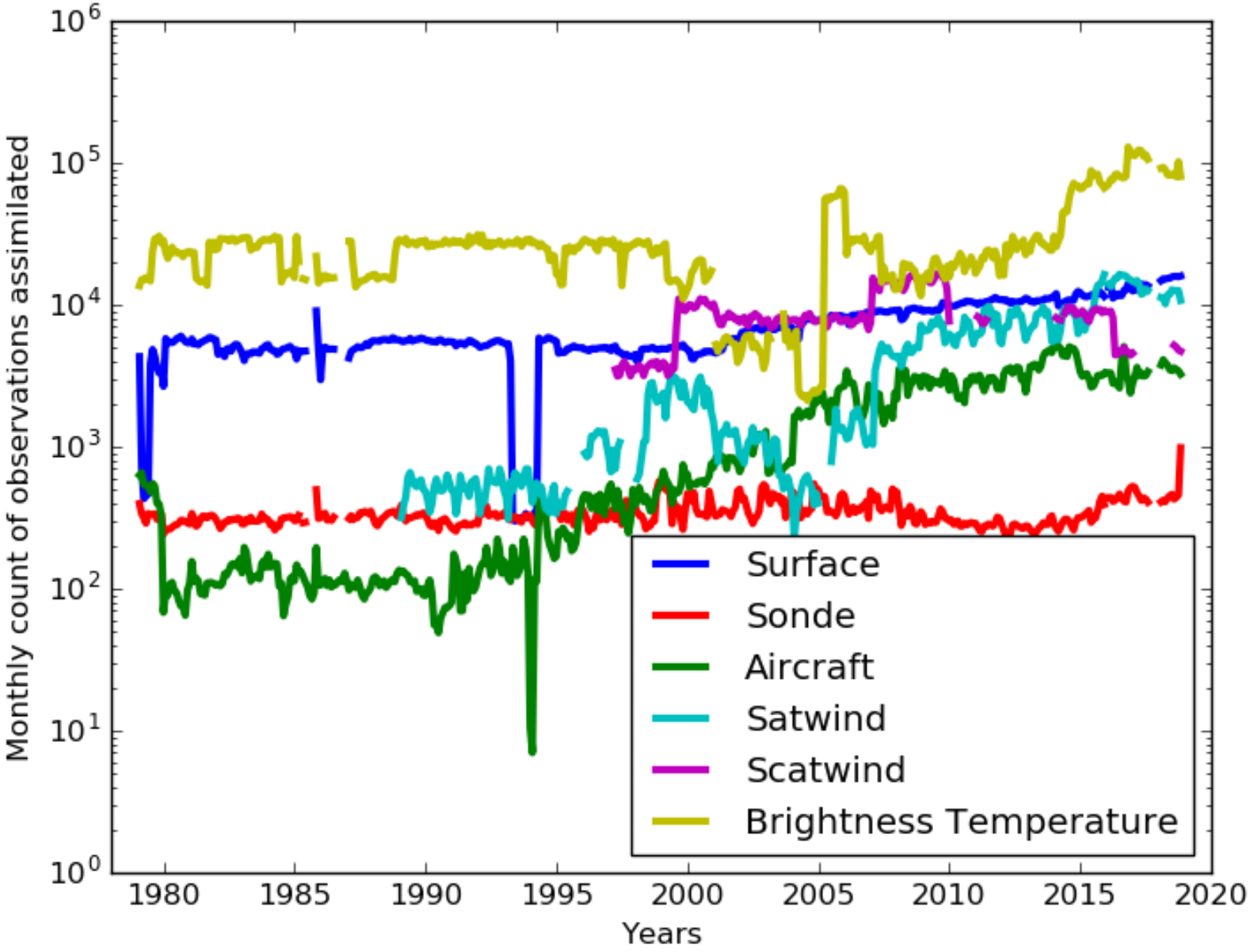




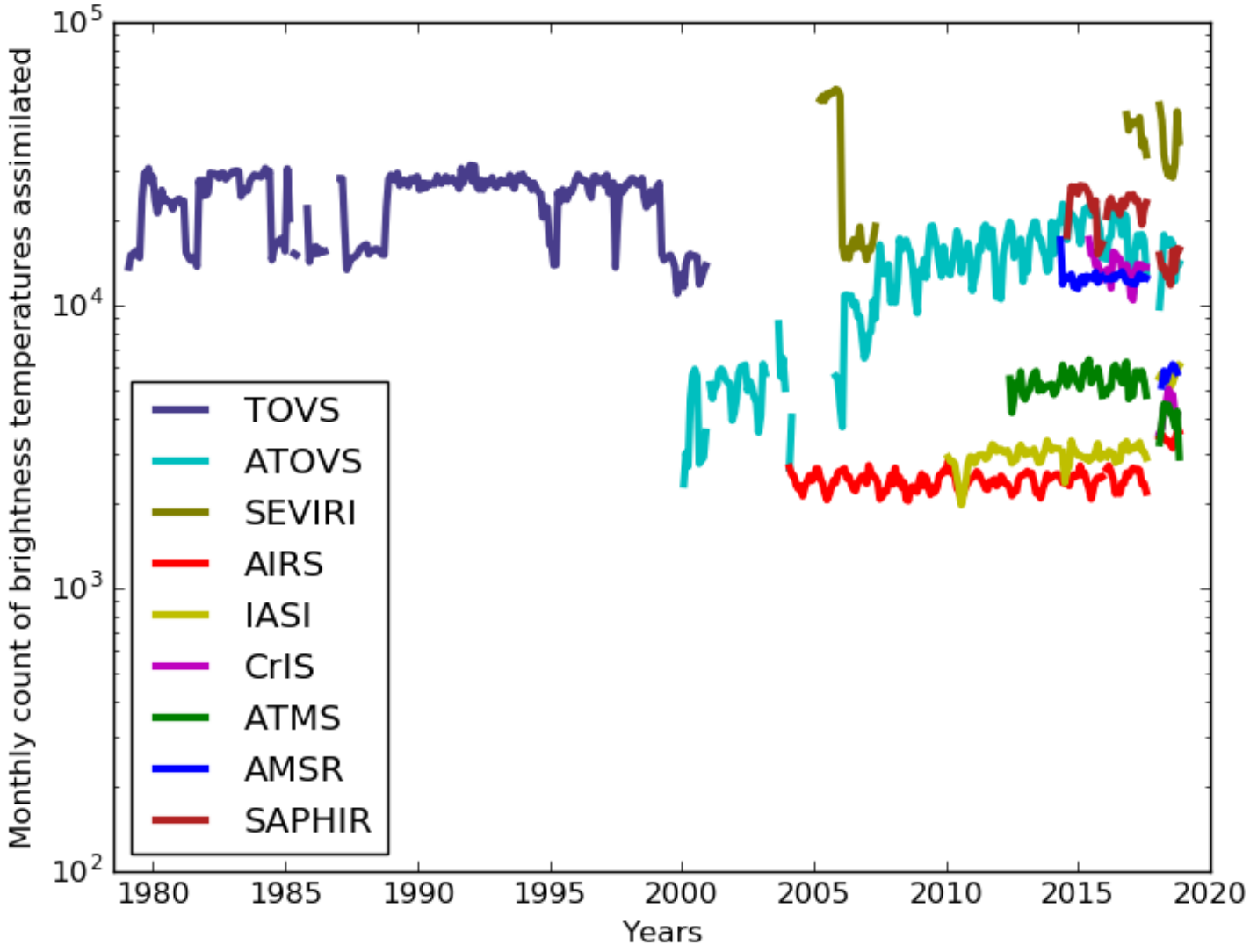
Monthly mean Root Mean square errors in O-B (red curve) and O-A (blue curve) of TEMP observations at 500 hPa, (a) Relative Humidity (x10^{-3}), (b) Temperature (K), and (c) monthly mean count of TEMP 500 hPa RH observations (red curve) and TEMP 500 hPa temperature observations (blue curve) assimilated in the IMDAA system from 1979 to 2016.



Quality observations assimilated in IMDAA

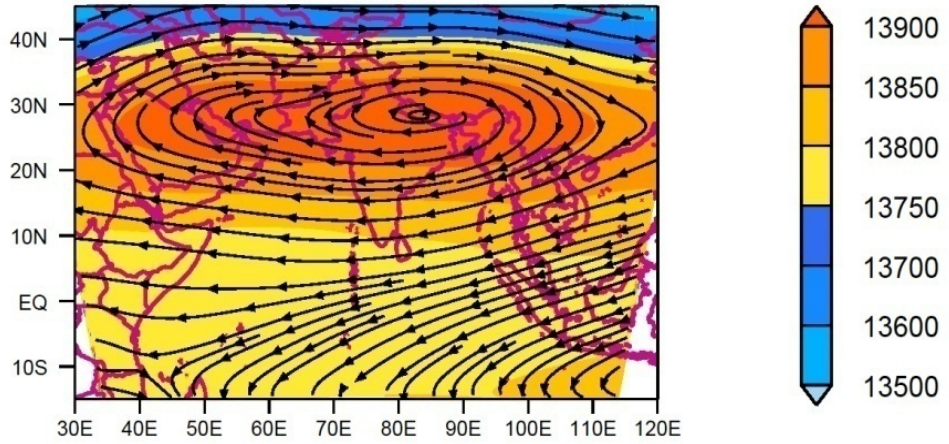


Satellite observations assimilated in IMDAA



Indian Monsoon Salient Features seen from IMDAA

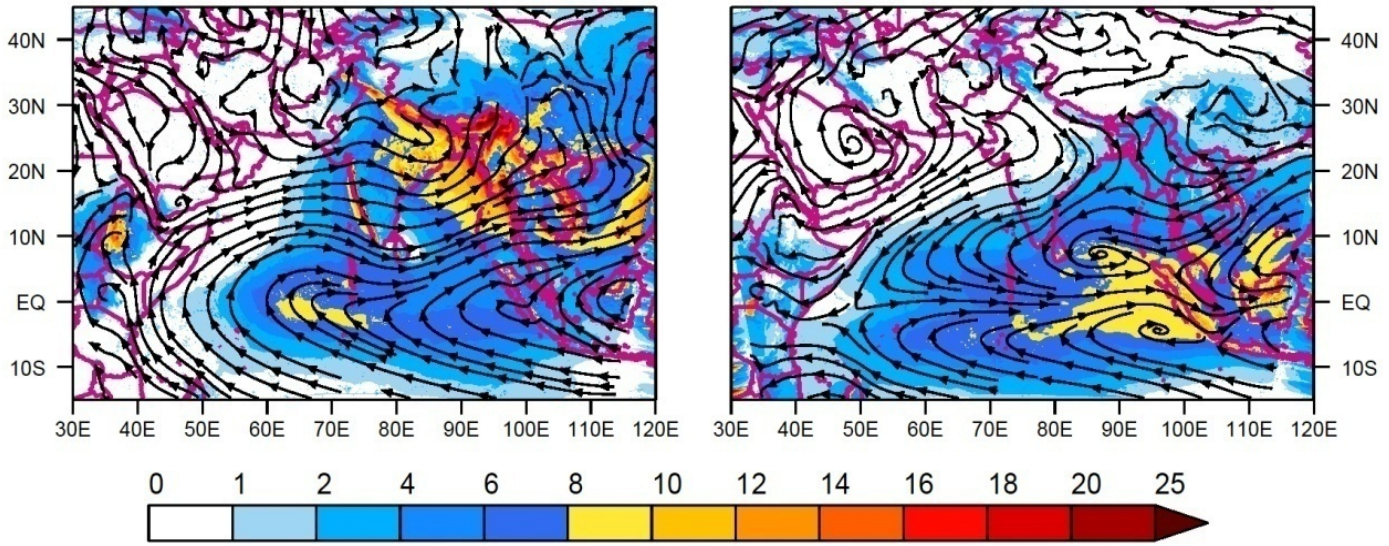
(a) IMDAA - Geopotential Height (m) and Winds at 150 hPa 1979-2016 JJAS



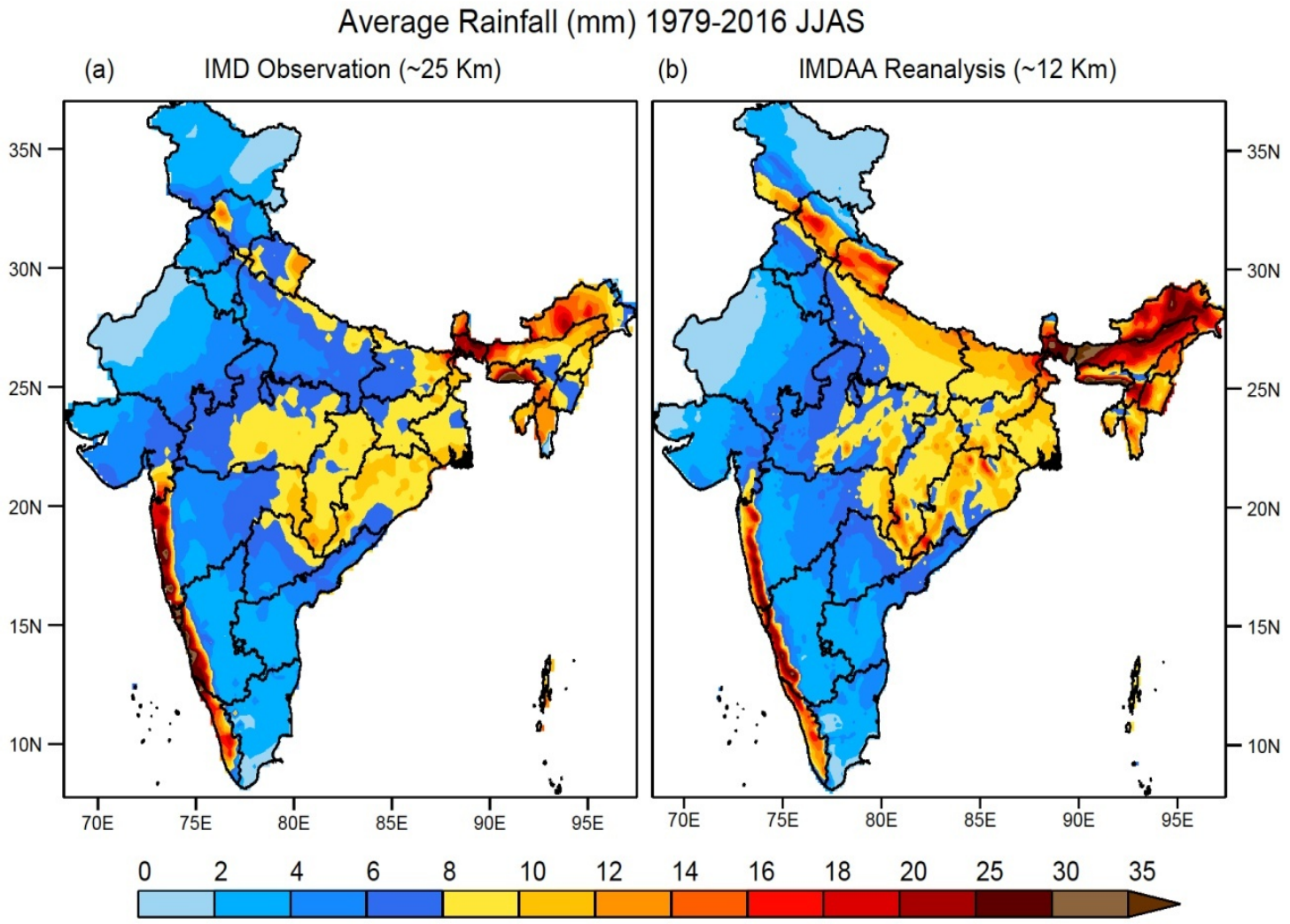
IMDAA - Rainfall (mm) and Winds at 850 hPa 1979-2016

(b) JJAS

(c) OND

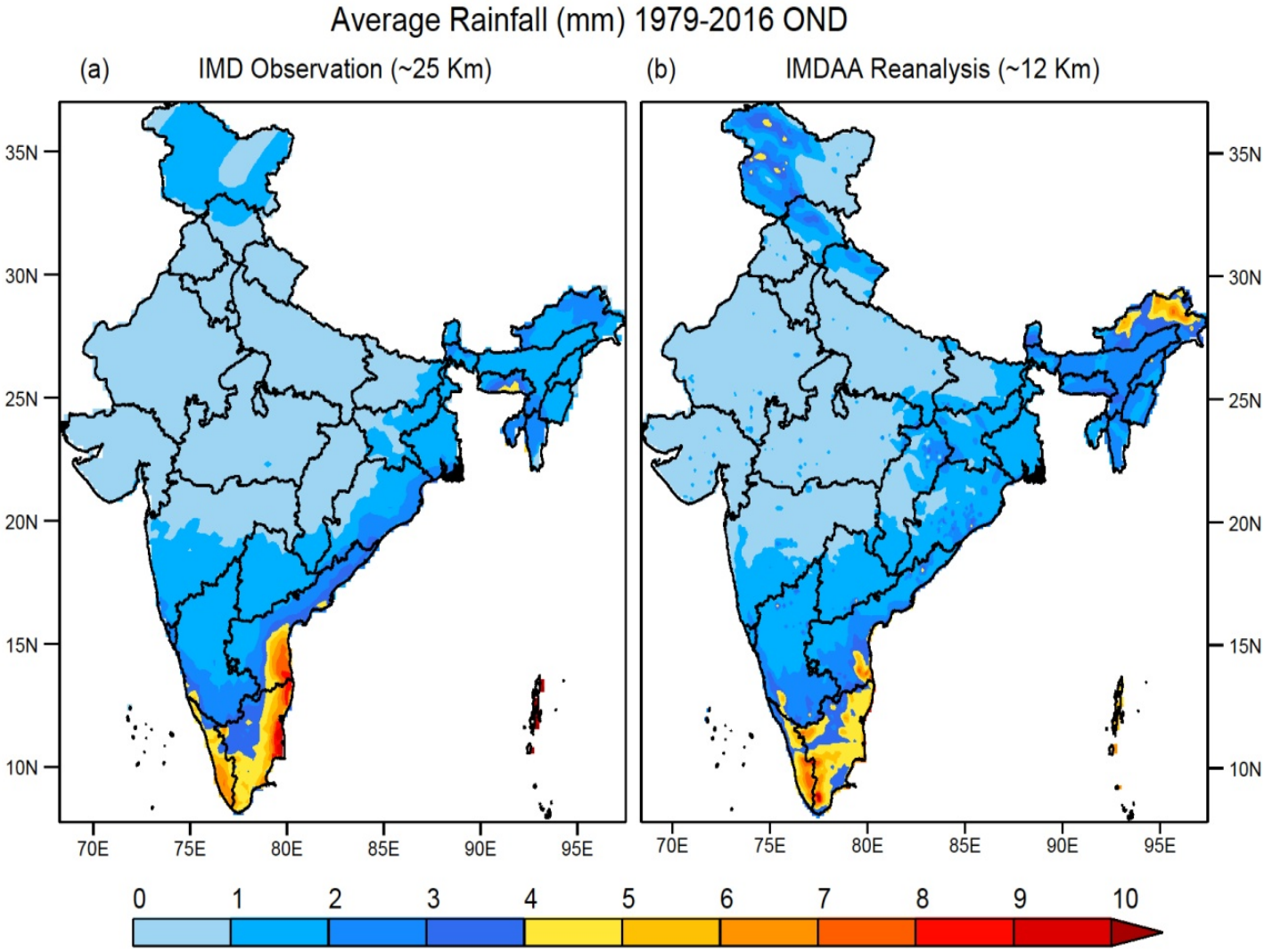


Comparison of IMDAA average rainfall with IMD gridded observations (JJAS)



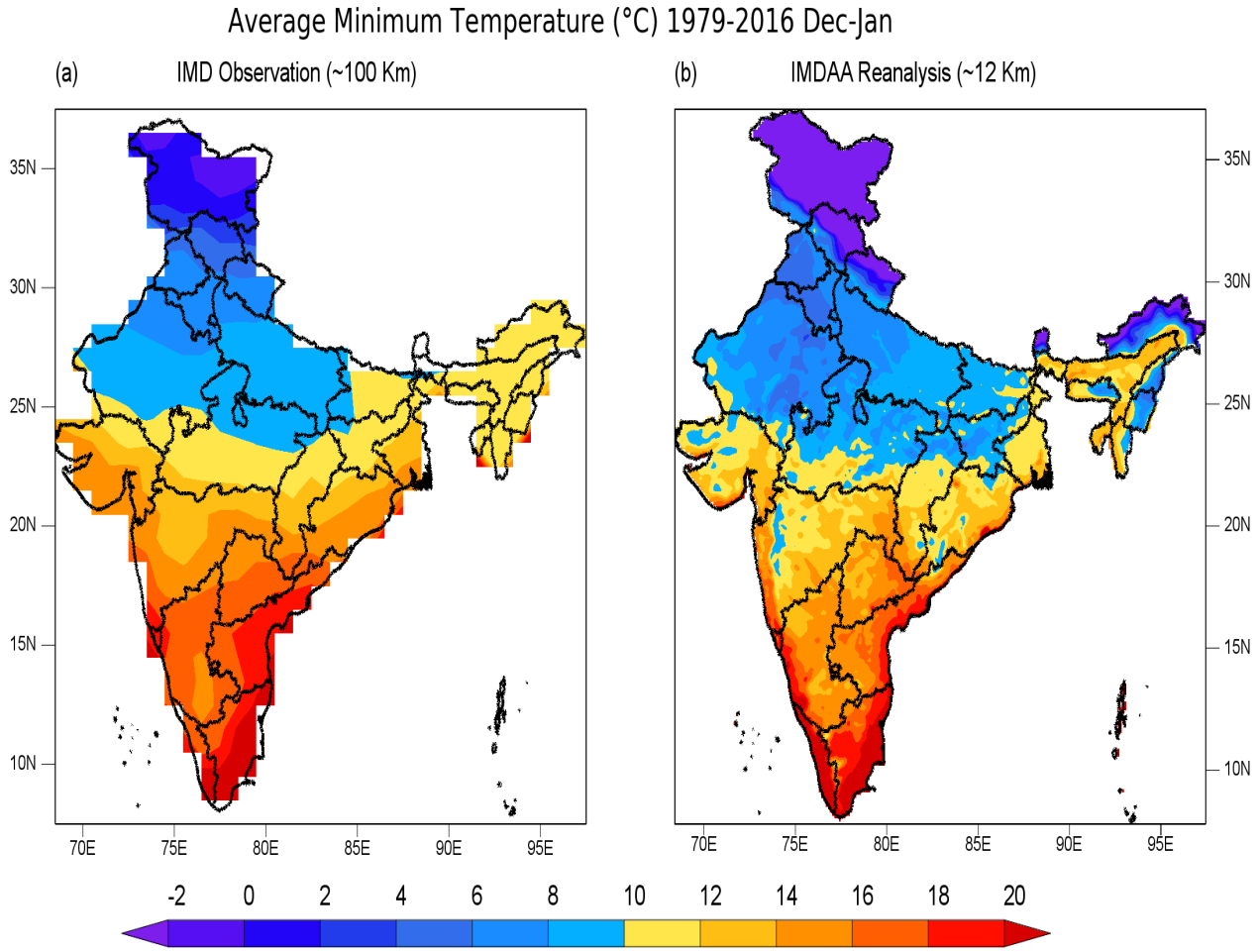
http://www.imdpune.gov.in/Clim_Pred_LRF_New/Grided_Data_Download.html#

Comparison of IMDAA average rainfall with IMD gridded observations (OND)



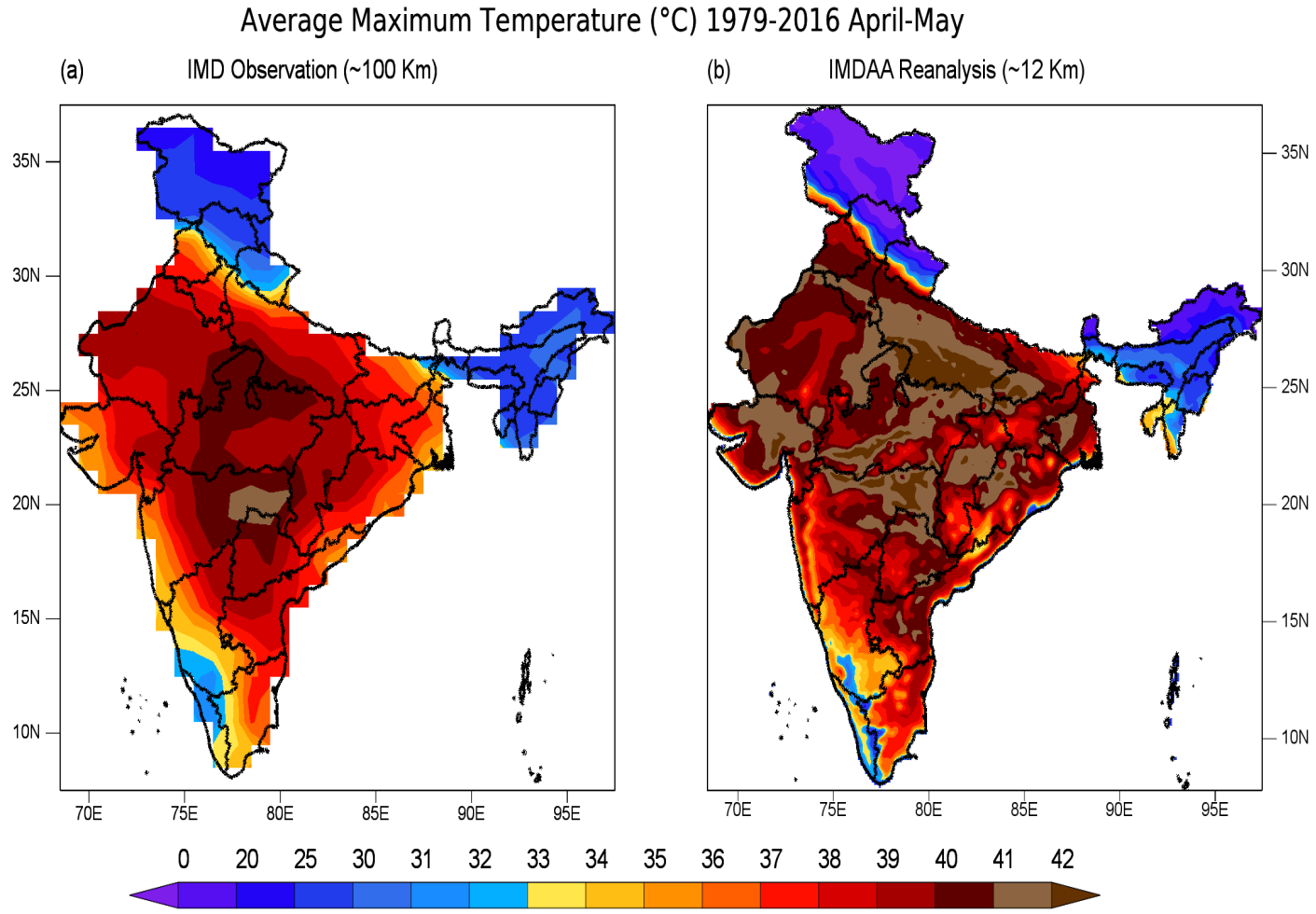
http://www.imdpune.gov.in/Clim_Pred_LRF_New/Grided_Data_Download.html#

Comparison of IMDAA average minimum temperature with IMD gridded observations (Dec and Jan)



http://www.imdpune.gov.in/Clim_Pred_LRF_New/Grided_Data_Download.html#

Comparison of IMDAA average maximum temperature with IMD gridded observations (April-May)



http://www.imdpune.gov.in/Clim_Pred_LRF_New/Grided_Data_Download.html#

Summary

The satellite-era, highest resolution (currently available), long term (40 years, 1979-2018) regional reanalysis over the Indian Monsoon region was prepared jointly by NCMRWF, UK Met Office and IMD.

Observations from the archives of ECMWF, NCMRWF, UK Met Office and IMD were used in IMDAA.

One of the uniqueness of IMDAA is the assimilation of additional surface observations from NCMRWF/IMD archive and SAPHIR radiances

Advanced Data assimilation techniques, atmospheric model and variational bias correction for satellite radiances

Differences in background and analysis fields from the observations are well within acceptable limits. The decreasing trend of "O-A" compared to "O-B" shows the robustness of the assimilation system.

Verification of important weather elements in IMDAA during major seasons over India with respect to independent observational data sets shows very good agreement.

IMDAA outputs will be released in user friendly formats (grib2 and NetCDF) to the research community very soon.

IMDAA offers one of the finest quality high resolution reanalysis data set for the Indian monsoon region for improved research on weather and climate.

Acknowledgements

Financial support given by the Ministry of Earth Sciences, Government of India to conduct this research under National Monsoon Mission.

ECMWF for making available the ERA-Interim reanalysis, and also their archive of global observations collated for reanalysis.

IMD for providing the gridded observations for validation.

We take this opportunity to thank one and all who are directly or indirectly involved in this project.

ITWG for the financial support to participate ITSC-22


National Centre for Medium Range Weather Forecasting (NCMRWF) Noida, India
NCMRWF

THANKS