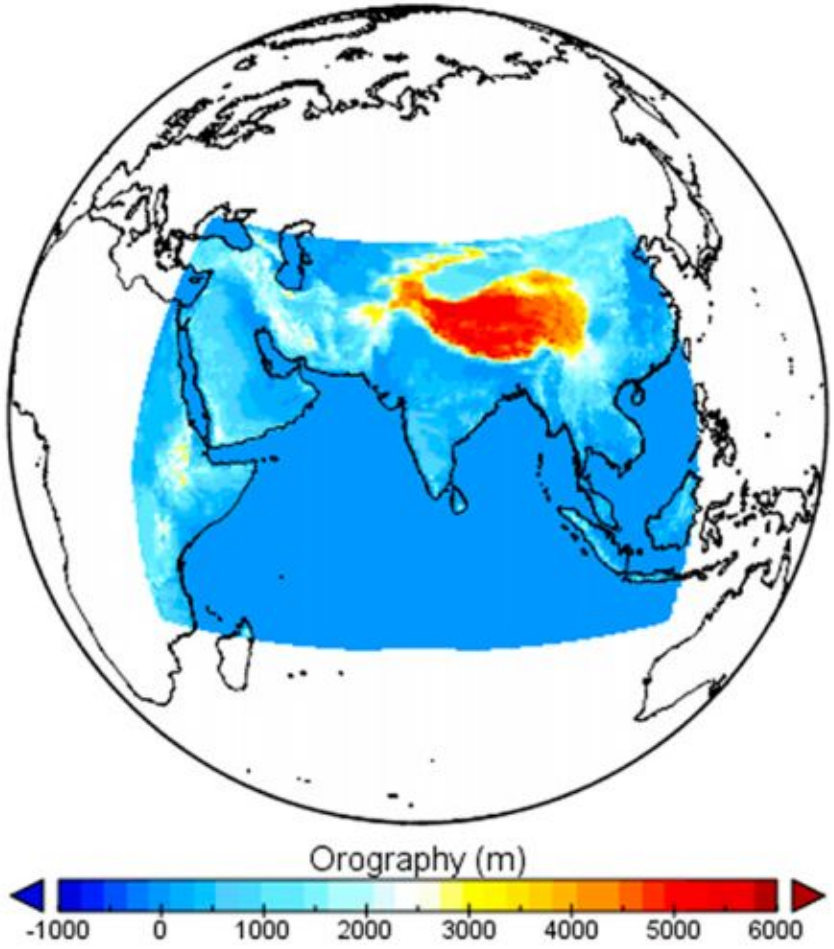
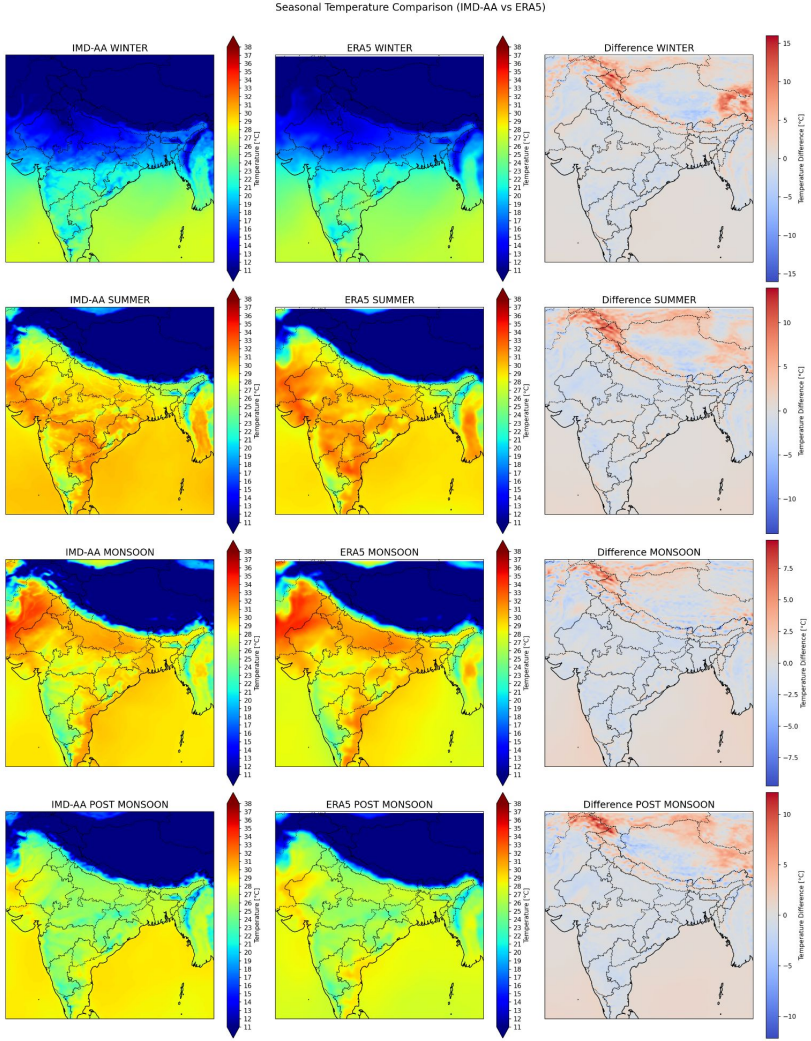
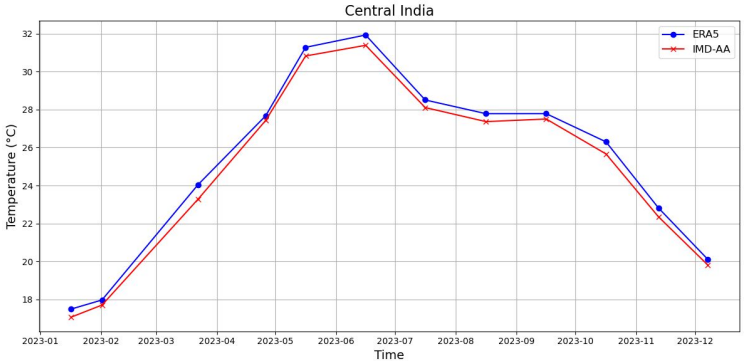
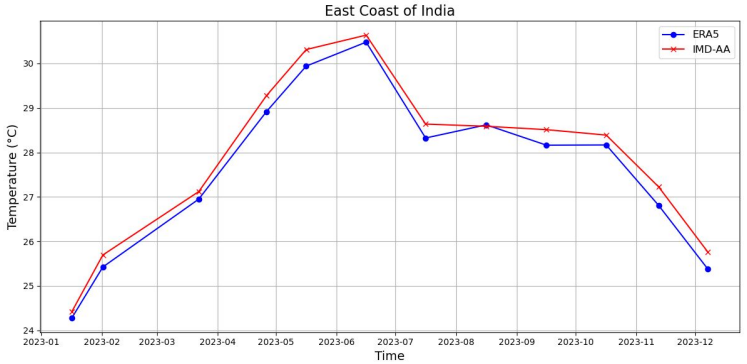
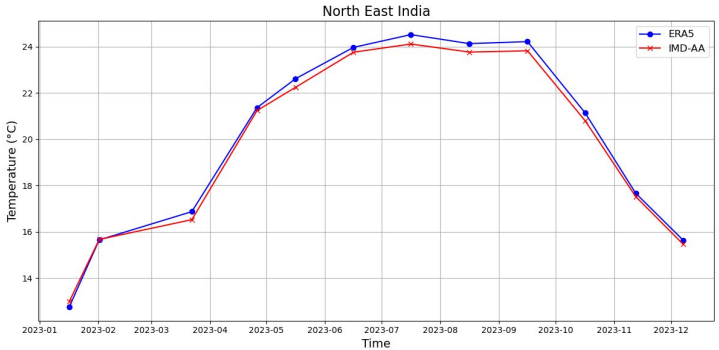


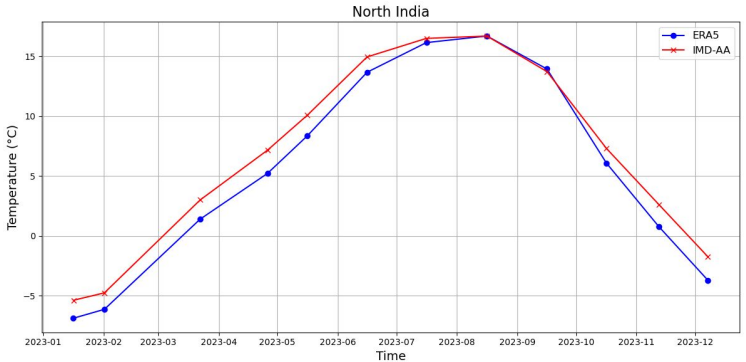
FIG. 1. IMDAA domain with model topography.

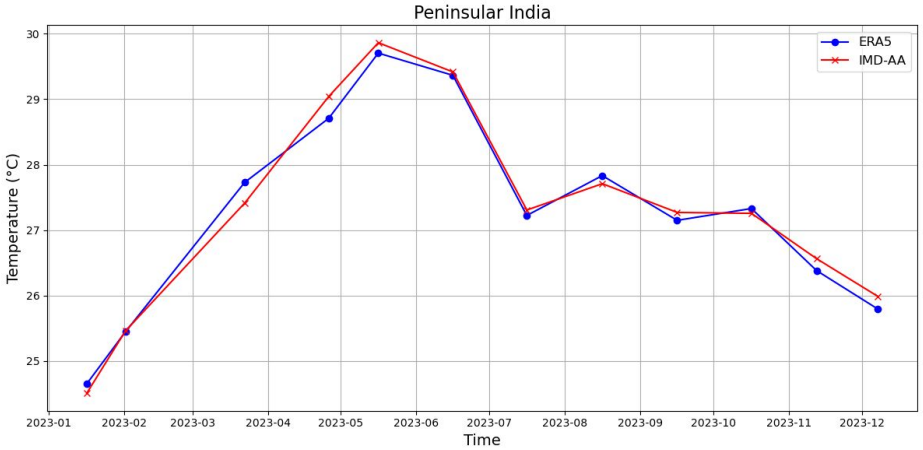

Seasonal Temperature Comparison (IMD-AA vs ERA5)
IMD-AA WINTER
ERA5 WINTER
Difference WINTER
IMD-AA SUMMER
ERA5 SUMMER
Difference SUMMER
IMD-AA MONSOON
ERA5 MONSOON
Difference MONSOON
IMD-AA POST MONSOON
ERA5 POST MONSOON
Difference POST MONSOON
Temperature [°C]
Temperature Difference [°C]

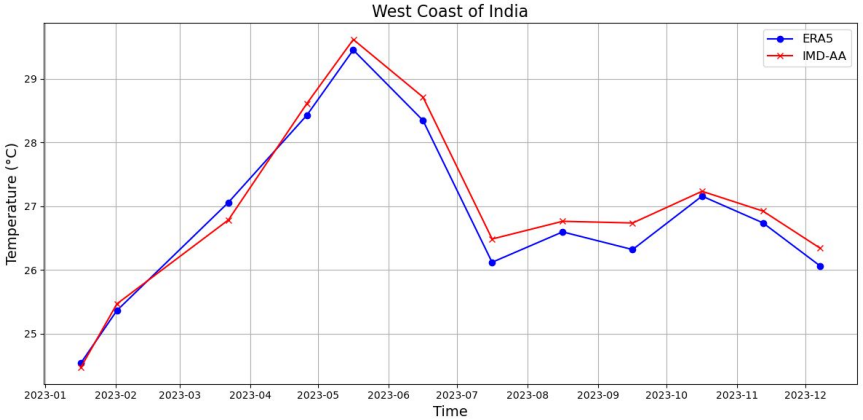

Central India
ERA5
IMD-AA
Temperature (°C)
Time

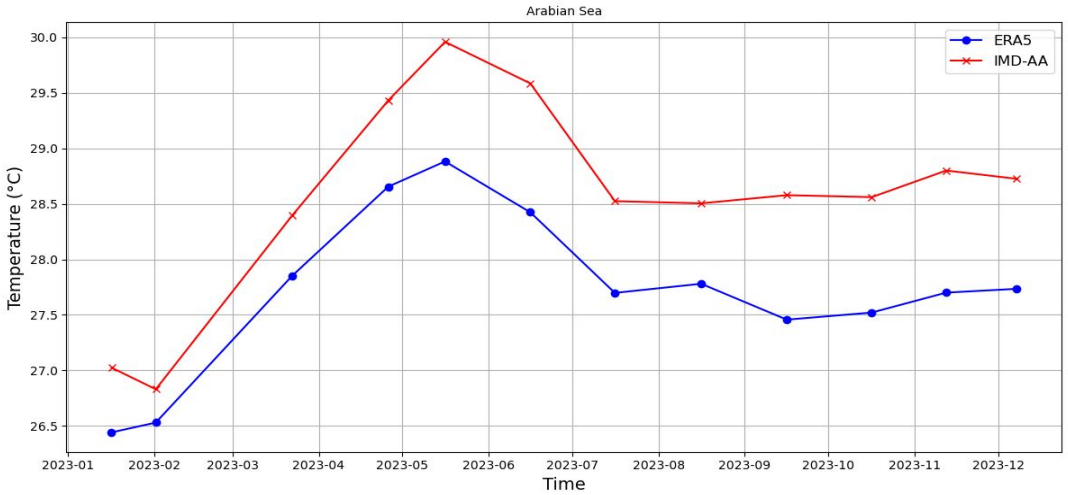

East Coast of India
ERA5
IMD-AA
Temperature (°C)
Time

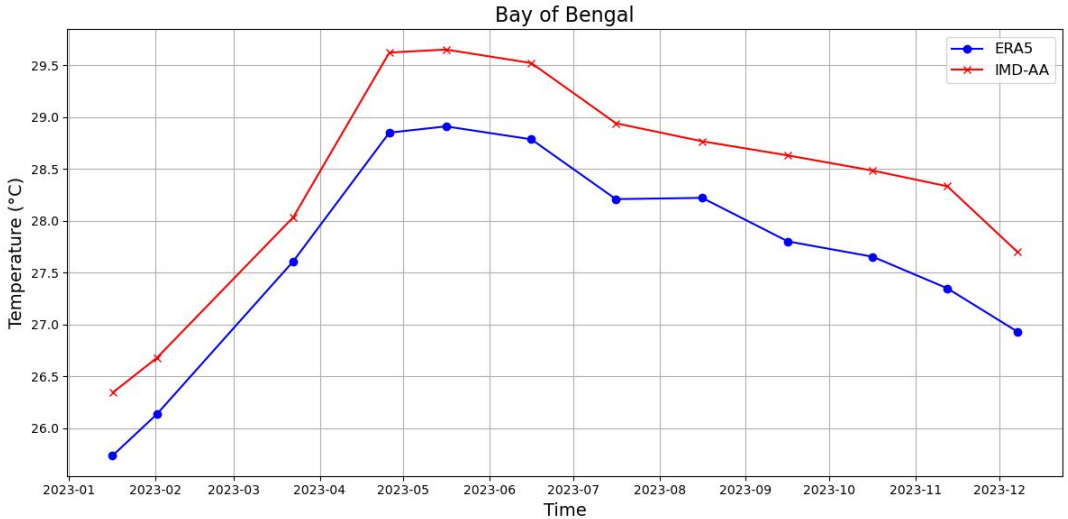

North East India
ERA5
IMD-AA
Temperature (°C)
Time

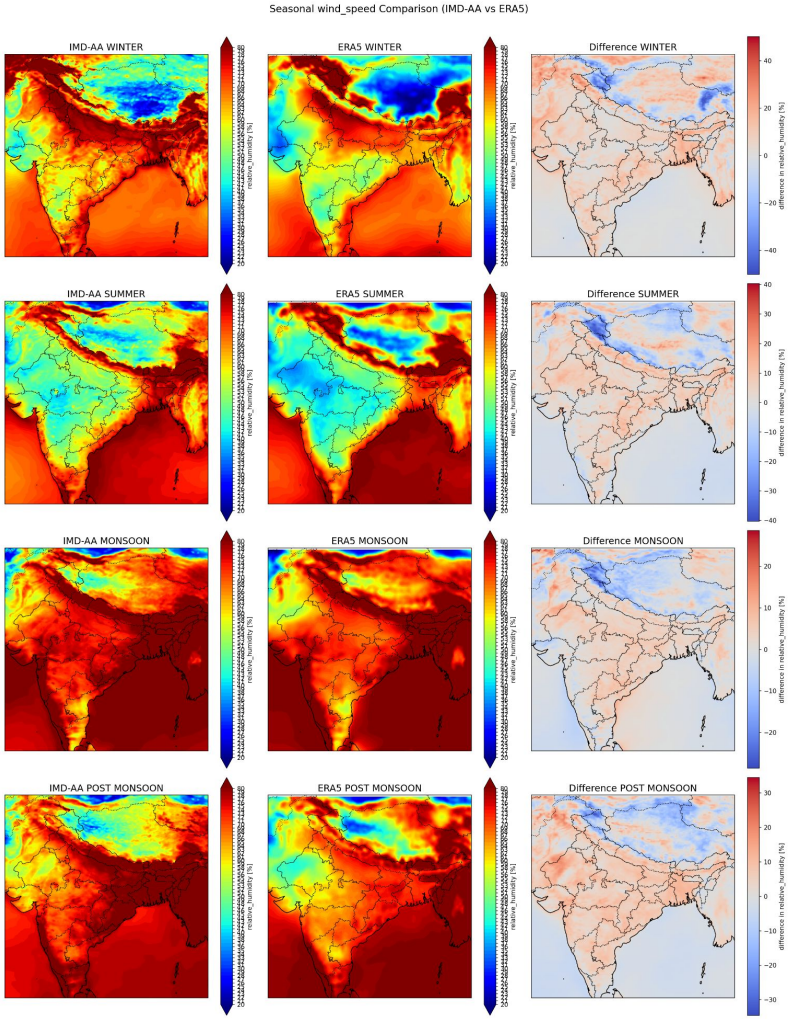

North India
ERA5
IMD-AA
Temperature (°C)
Time

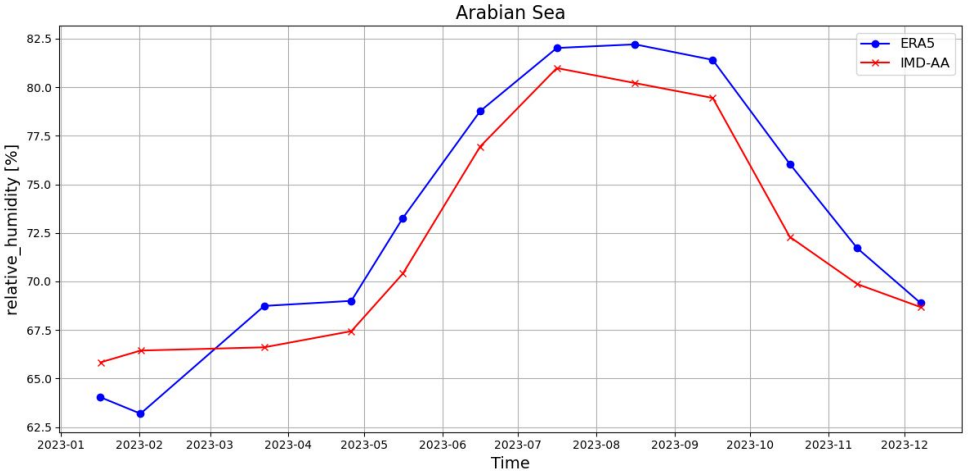

Peninsular India
ERA5
IMD-AA
Temperature (°C)
Time
30
29
28
27
26
25
2023-01
2023-02
2023-03
2023-04
2023-05
2023-06
2023-07
2023-08
2023-09
2023-10
2023-11
2023-12

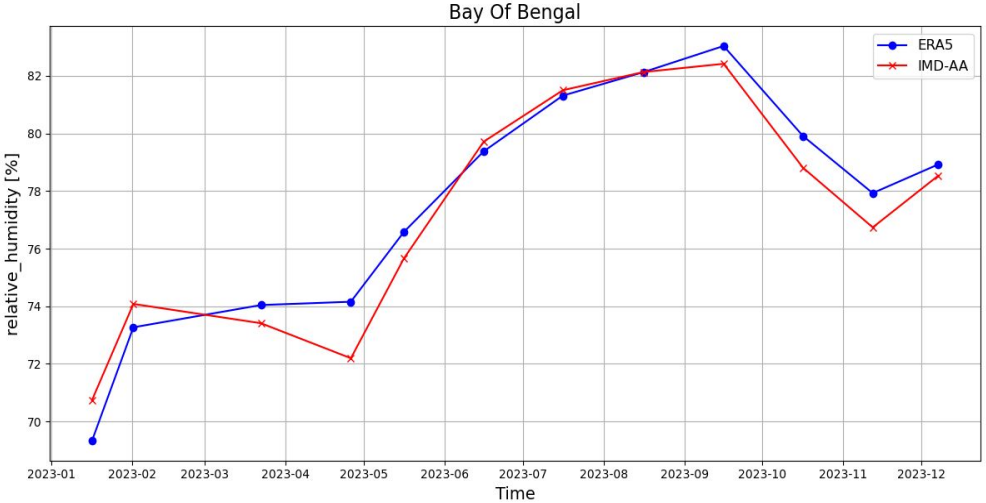

West Coast of India
ERA5
IMD-AA
Temperature (°C)
Time
29
28
27
26
25
2023-01
2023-02
2023-03
2023-04
2023-05
2023-06
2023-07
2023-08
2023-09
2023-10
2023-11
2023-12

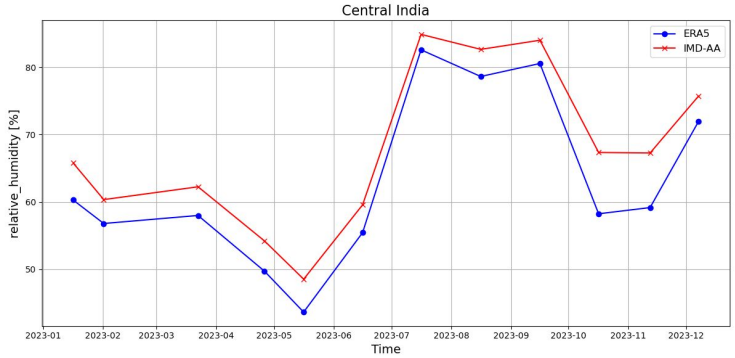

Arabian Sea
ERA5
IMD-AA
Temperature (°C)
30.0
29.5
29.0
28.5
28.0
27.5
27.0
26.5
2023-01
2023-02
2023-03
2023-04
2023-05
2023-06
2023-07
2023-08
2023-09
2023-10
2023-11
2023-12
Time

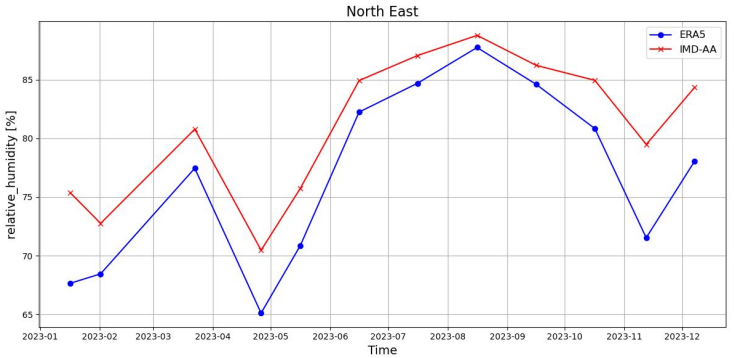

Bay of Bengal
ERA5
IMD-AA
Temperature (°C)
29.5
29.0
28.5
28.0
27.5
27.0
26.5
26.0
2023-01
2023-02
2023-03
2023-04
2023-05
2023-06
2023-07
2023-08
2023-09
2023-10
2023-11
2023-12
Time

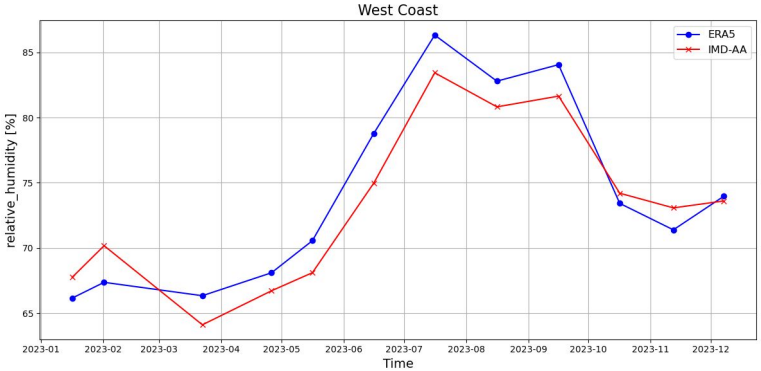

Seasonal wind_speed Comparison (IMD-AA vs ERA5)
IMD-AA WINTER
ERA5 WINTER
Difference WINTER
IMD-AA SUMMER
ERA5 SUMMER
Difference SUMMER
IMD-AA MONSOON
ERA5 MONSOON
Difference MONSOON
IMD-AA POST MONSOON
ERA5 POST MONSOON
Difference POST MONSOON
relative_humidity (%)
difference in relative_humidity (%)

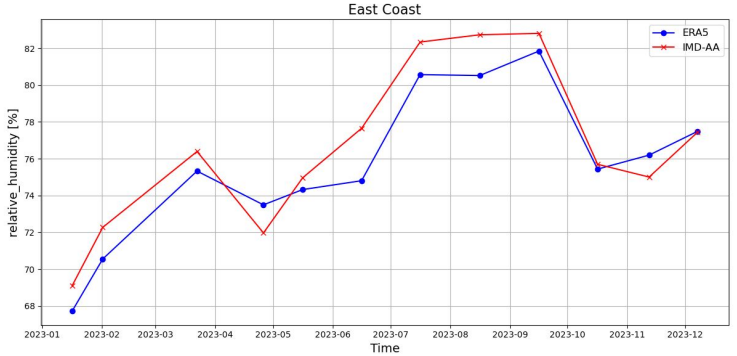

Arabian Sea
ERA5
IMD-AA
relative_humidity [%]
82.5
80.0
77.5
75.0
72.5
70.0
67.5
65.0
62.5
2023-01
2023-02
2023-03
2023-04
2023-05
2023-06
2023-07
2023-08
2023-09
2023-10
2023-11
2023-12
Time

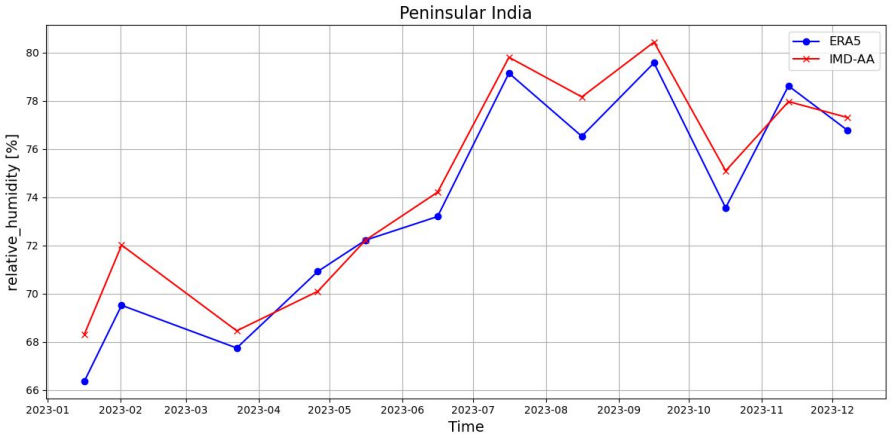

Bay Of Bengal
ERA5
IMD-AA
relative_humidity [%]
82
80
78
76
74
72
70
2023-01
2023-02
2023-03
2023-04
2023-05
2023-06
2023-07
2023-08
2023-09
2023-10
2023-11
2023-12
Time

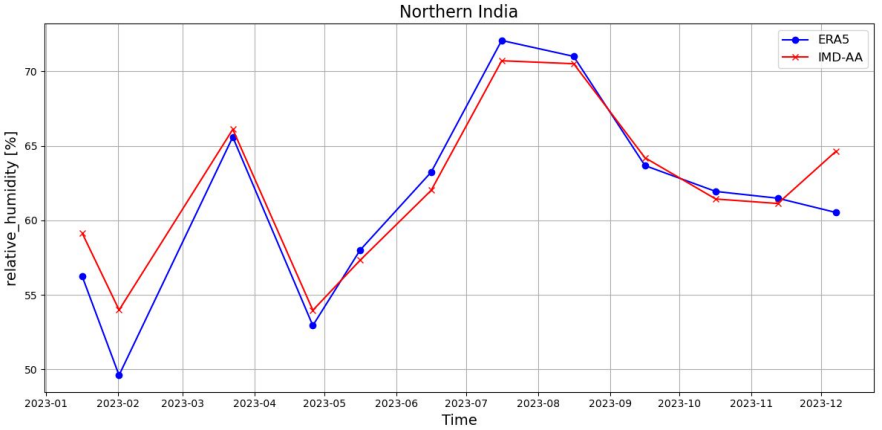

Central India
ERA5
IMD-AA
relative_humidity [%]
Time

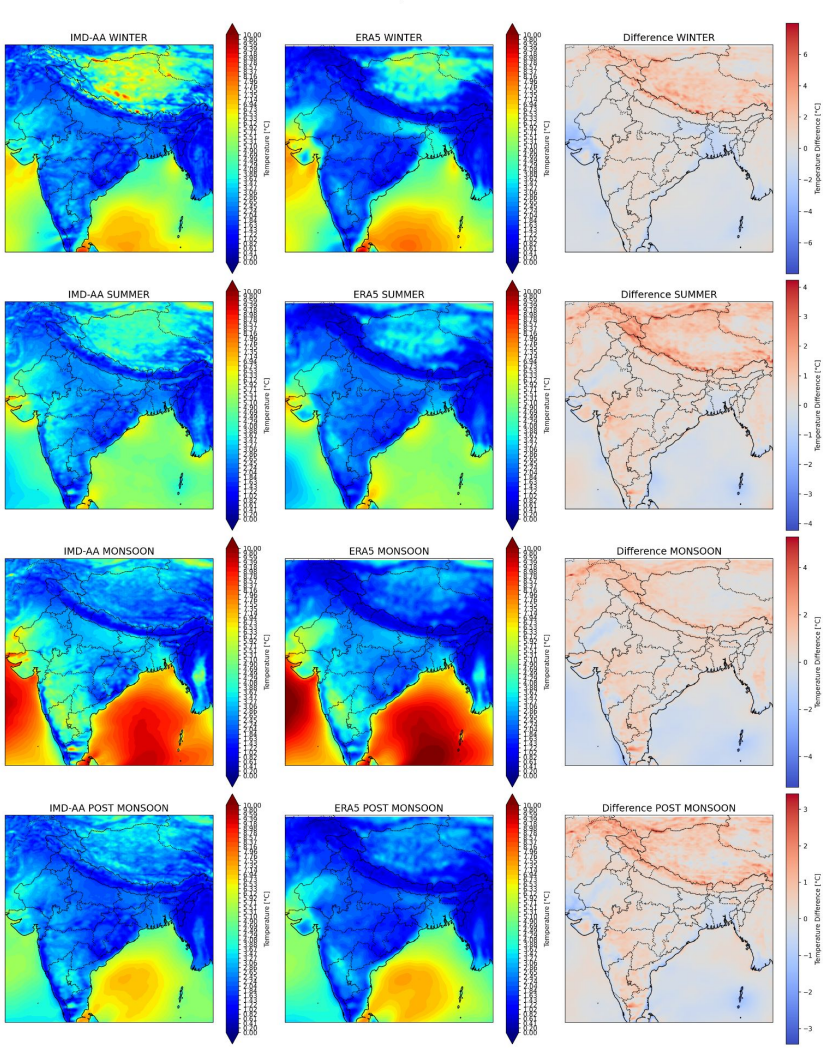

North East
ERA5
IMD-AA
relative_humidity [%]
Time

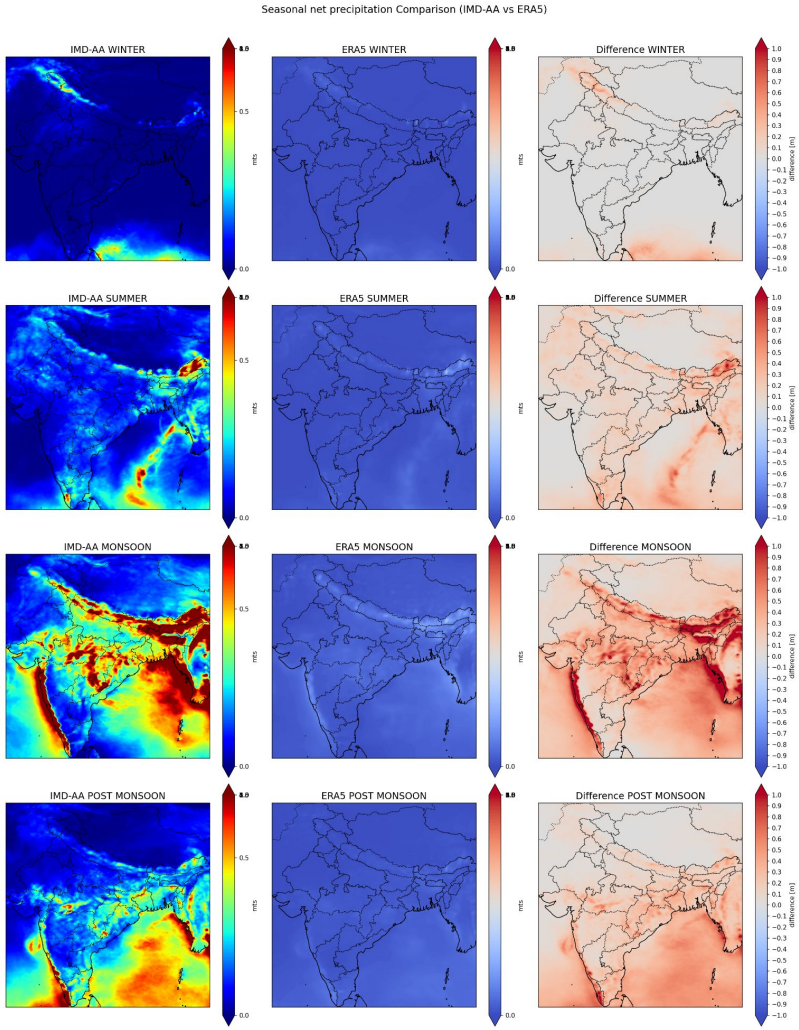

West Coast
ERA5
IMD-AA
relative_humidity [%]
Time


East Coast
ERA5
IMD-AA
relative_humidity [%]
Time


Peninsular India
ERA5
IMD-AA
relative_humidity [%]
Time
66
68
70
72
74
76
78
80
2023-01
2023-02
2023-03
2023-04
2023-05
2023-06
2023-07
2023-08
2023-09
2023-10
2023-11
2023-12


Northern India
ERA5
IMD-AA
relative_humidity [%]
Time
50
55
60
65
70
2023-01
2023-02
2023-03
2023-04
2023-05
2023-06
2023-07
2023-08
2023-09
2023-10
2023-11
2023-12


Seasonal wind Comparison (IMD-AA vs ERA5)
IMD-AA WINTER
ERA5 WINTER
Difference WINTER
IMD-AA SUMMER
ERA5 SUMMER
Difference SUMMER
IMD-AA MONSOON
ERA5 MONSOON
Difference MONSOON
IMD-AA POST MONSOON
ERA5 POST MONSOON
Difference POST MONSOON
Temperature [°C]
Temperature Difference [°C]


Seasonal net precipitation Comparison (IMD-AA vs ERA5)
IMD-AA WINTER
ERA5 WINTER
Difference WINTER
IMD-AA SUMMER
ERA5 SUMMER
Difference SUMMER
IMD-AA MONSOON
ERA5 MONSOON
Difference MONSOON
IMD-AA POST MONSOON
ERA5 POST MONSOON
Difference POST MONSOON
mts
difference (m)

```
    -1 :       Date     Time   Level Gridsize    Miss :     Minimum        Mean     Maximum : Parameter name
     1 : 2023-01-17 03:00:00       0    58564       0 :      0.0000  2.9617e-05  0.00077012 : tp
     2 : 2023-05-09 21:00:00       0    58564       0 :  1.2522e-06  0.00010428   0.0020136 : tp
     3 : 2023-07-16 17:00:00       0    58564       0 :      0.0000  0.00028538   0.0021325 : tp
     4 : 2023-10-13 02:00:00       0    58564       0 :      0.0000  0.00017798  0.00090285 : tp
     5 : 2023-12-03 12:00:00       0    58564       0 :      0.0000  0.00019319   0.0030404 : tp
cdo    infon: Processed 292820 values from 1 variable over 5 timesteps [0.00s 45MB].
```

```
    -1 :       Date     Time   Level Gridsize    Miss :     Minimum        Mean     Maximum : Parameter name
     1 : 2023-01-17 03:30:00       0    58564       0 :      0.0000    0.029350     0.69568 : APCP_sfc
     2 : 2023-05-09 21:00:00       0    58564       0 :   0.0013629     0.12469      1.0664 : APCP_sfc
     3 : 2023-07-16 17:30:00       0    58564       0 :   0.0010957     0.33391      3.5944 : APCP_sfc
     4 : 2023-10-13 02:30:00       0    58564       0 :  0.00029356     0.21560      1.2721 : APCP_sfc
     5 : 2023-12-03 12:00:00       0    58564       0 :      0.0000     0.21094      7.4090 : APCP_sfc
cdo    infon: Processed 292820 values from 1 variable over 5 timesteps [0.04s 48MB].
```

```
    -1 :       Date     Time    Level Gridsize    Miss :     Minimum        Mean     Maximum : Parameter name
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     2 : 2023-02-14 23:00:00        0   376251    7251 :      0.0000  0.00010207   0.0012860 : tp
     3 : 2023-03-16 11:00:00        0   376251    7251 :      0.0000  9.7995e-05   0.0016579 : tp
     4 : 2023-04-15 23:00:00        0   376251    7251 :      0.0000  0.00010423   0.0016341 : tp
     5 : 2023-05-16 11:00:00        0   376251    7251 :      0.0000  0.00012274   0.0020123 : tp
     6 : 2023-06-15 23:00:00        0   376251    7251 :      0.0000  0.00014359   0.0018996 : tp
     7 : 2023-07-16 11:00:00        0   376251    7251 :      0.0000  0.00016760   0.0033146 : tp
     8 : 2023-08-16 11:00:00        0   376251    7251 :      0.0000  0.00013732   0.0031005 : tp
     9 : 2023-09-15 23:00:00        0   376251    7251 :      0.0000  0.00014779   0.0029340 : tp
    10 : 2023-10-16 11:00:00        0   376251    7251 :      0.0000  0.00012025   0.0019021 : tp
    11 : 2023-11-15 23:00:00        0   376251    7251 :      0.0000  0.00014099   0.0020148 : tp
    12 : 2023-12-16 11:00:00        0   376251    7251 :      0.0000  0.00013382   0.0022578 : tp
cdo    infon: Processed 4515012 values from 1 variable over 12 timesteps [0.02s 47MB].
```

```
    -1 :       Date     Time    Level Gridsize    Miss :     Minimum        Mean     Maximum : Parameter name
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     2 : 2023-02-01 12:00:00        0   376251       1 :      0.0000     0.15804      8.6144 : APCP_sfc
     3 : 2023-03-22 12:30:00        0   376251       1 :      0.0000     0.15232      3.2703 : APCP_sfc
     4 : 2023-04-26 00:00:00        0   376251       1 :      0.0000     0.16063      1.9663 : APCP_sfc
     5 : 2023-05-16 08:30:00        0   376251       1 :      0.0000     0.14548      2.0930 : APCP_sfc
     6 : 2023-06-15 23:30:00        0   376251       1 :      0.0000     0.17180      4.0387 : APCP_sfc
     7 : 2023-07-16 08:30:00        0   376251       1 :      0.0000     0.19550      7.8965 : APCP_sfc
     8 : 2023-08-16 08:30:00        0   376251       1 :      0.0000     0.15694      5.4536 : APCP_sfc
     9 : 2023-09-16 03:00:00        0   376251       1 :      0.0000     0.16700      4.1559 : APCP_sfc
    10 : 2023-10-16 14:00:00        0   376251       1 :      0.0000     0.13650      4.2546 : APCP_sfc
    11 : 2023-11-12 08:30:00        0   376251       1 :      0.0000     0.15536      2.1627 : APCP_sfc
    12 : 2023-12-03 12:00:00        0   376251       1 :      0.0000     0.17023      7.4090 : APCP_sfc
cdo    infon: Processed 4515012 values from 1 variable over 12 timesteps [0.03s 65MB].
```
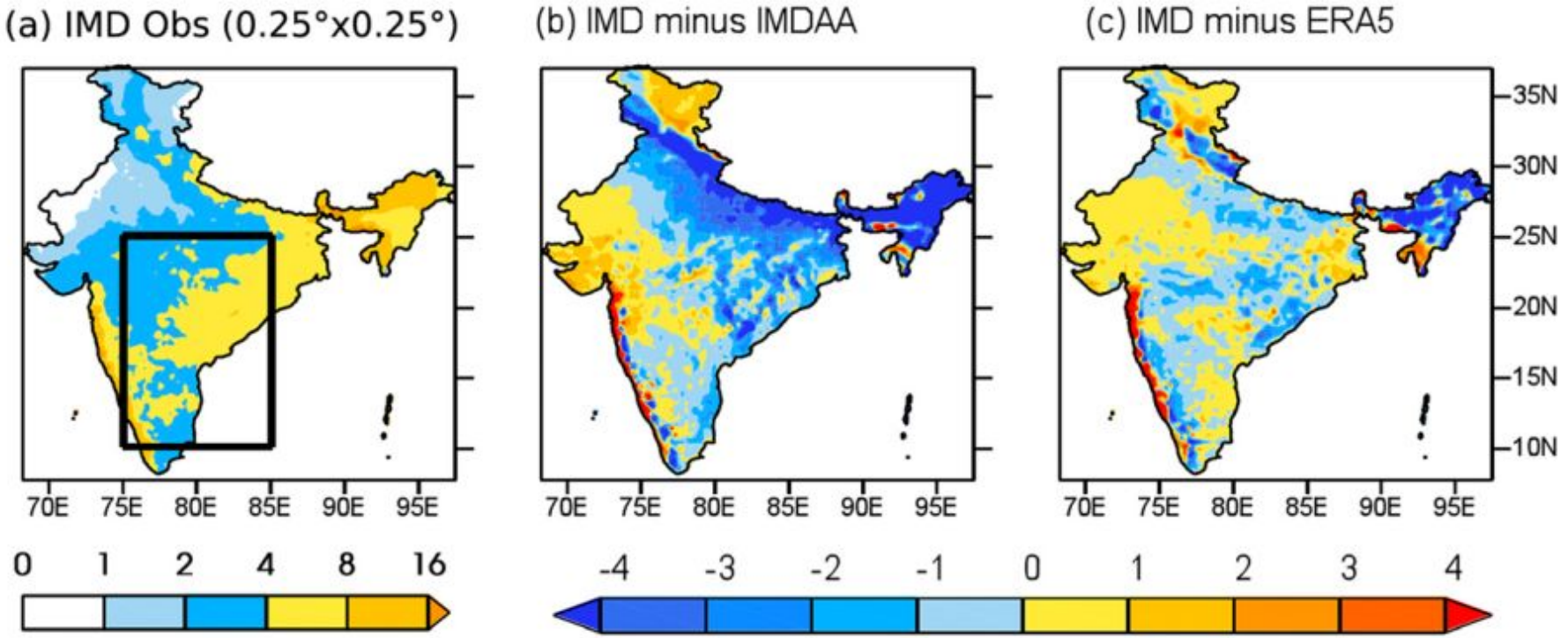
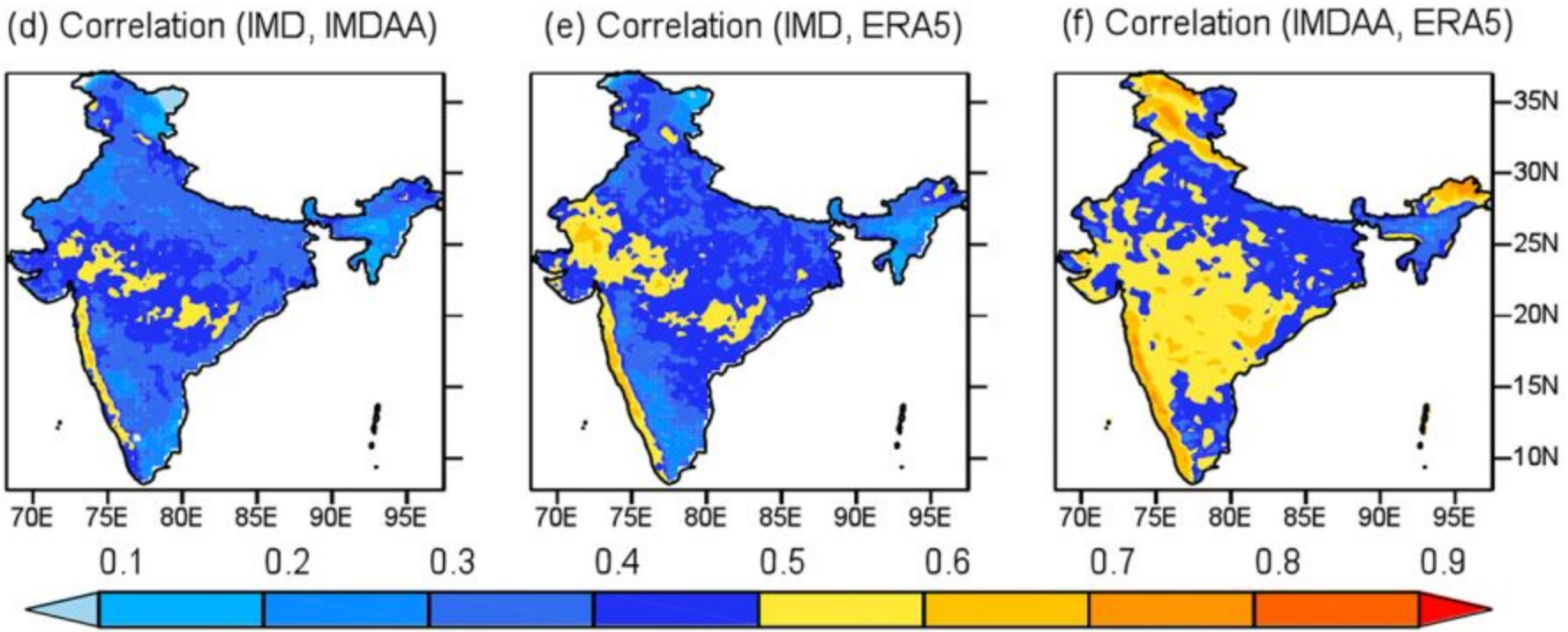

Daily Precipitation (mm) 1979-2018 JJAS Mean, Difference, Correlation




(d) Correlation (IMD, IMDAA)
(e) Correlation (IMD, ERA5)
(f) Correlation (IMDAA, ERA5)
35N
30N
25N
20N
15N
10N
70E
75E
80E
85E
90E
95E
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9

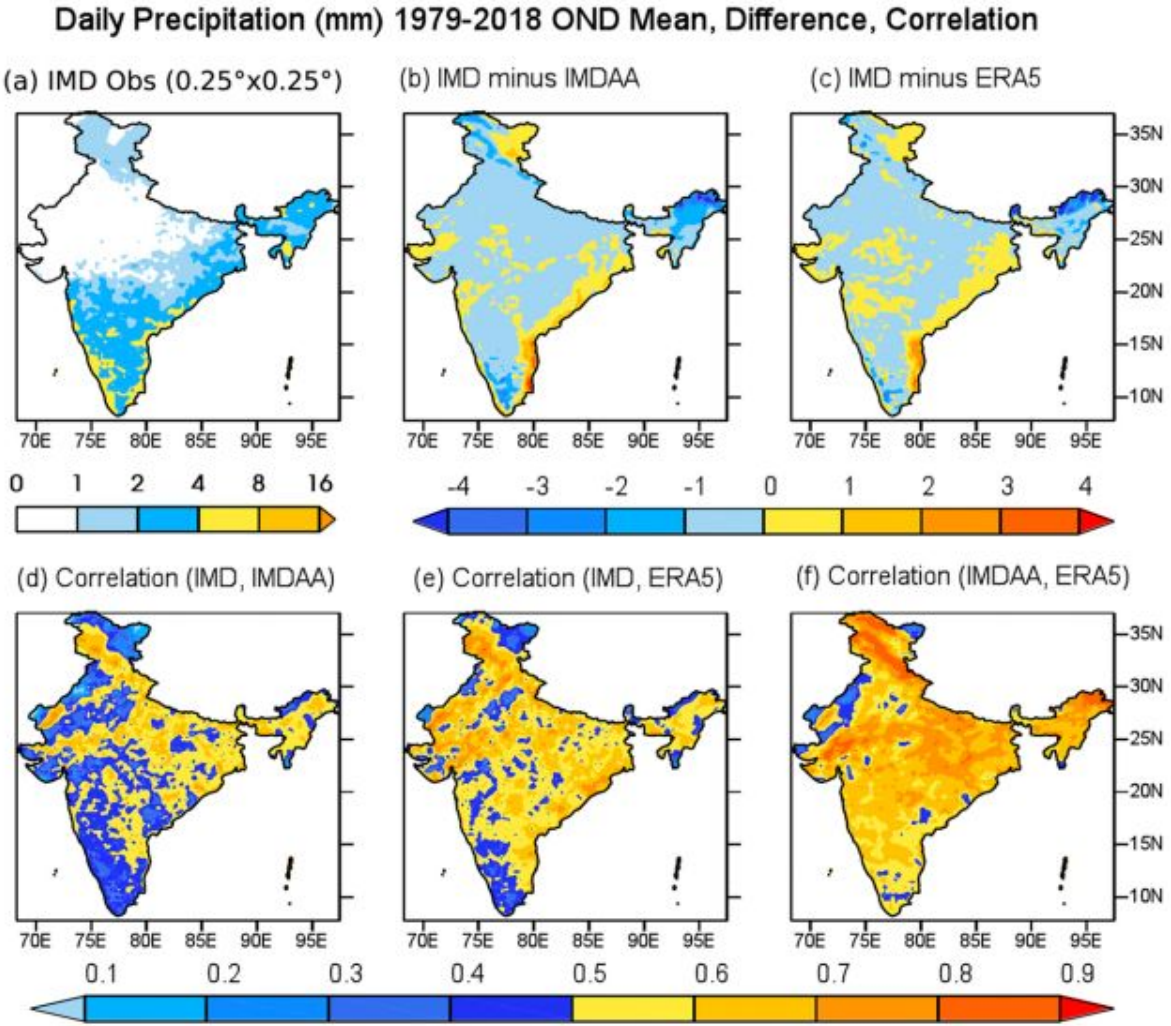
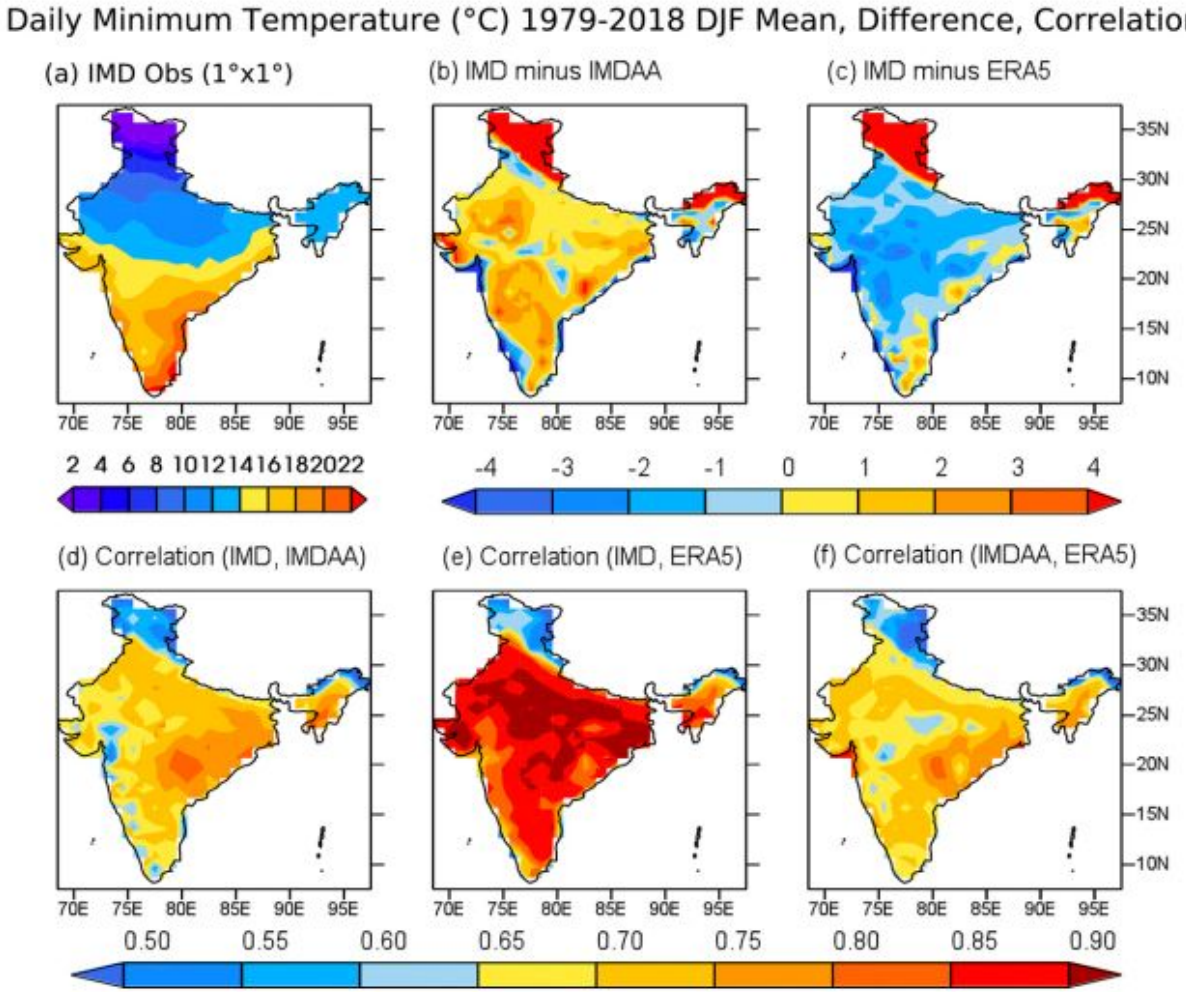


FIG. 16. As in Fig. 14, but for the northeast monsoon season (October–December).


Daily Minimum Temperature (°C) 1979-2018 DJF Mean, Difference, Correlation
(a) IMD Obs (1°x1°)
(b) IMD minus IMDAA
(c) IMD minus ERA5
2 4 6 8 10 12 14 16 18 20 22
-4 -3 -2 -1 0 1 2 3 4
(d) Correlation (IMD, IMDAA)
(e) Correlation (IMD, ERA5)
(f) Correlation (IMDAA, ERA5)
0.50 0.55 0.60 0.65 0.70 0.75 0.80 0.85 0.90
70E 75E 80E 85E 90E 95E
35N 30N 25N 20N 15N 10N

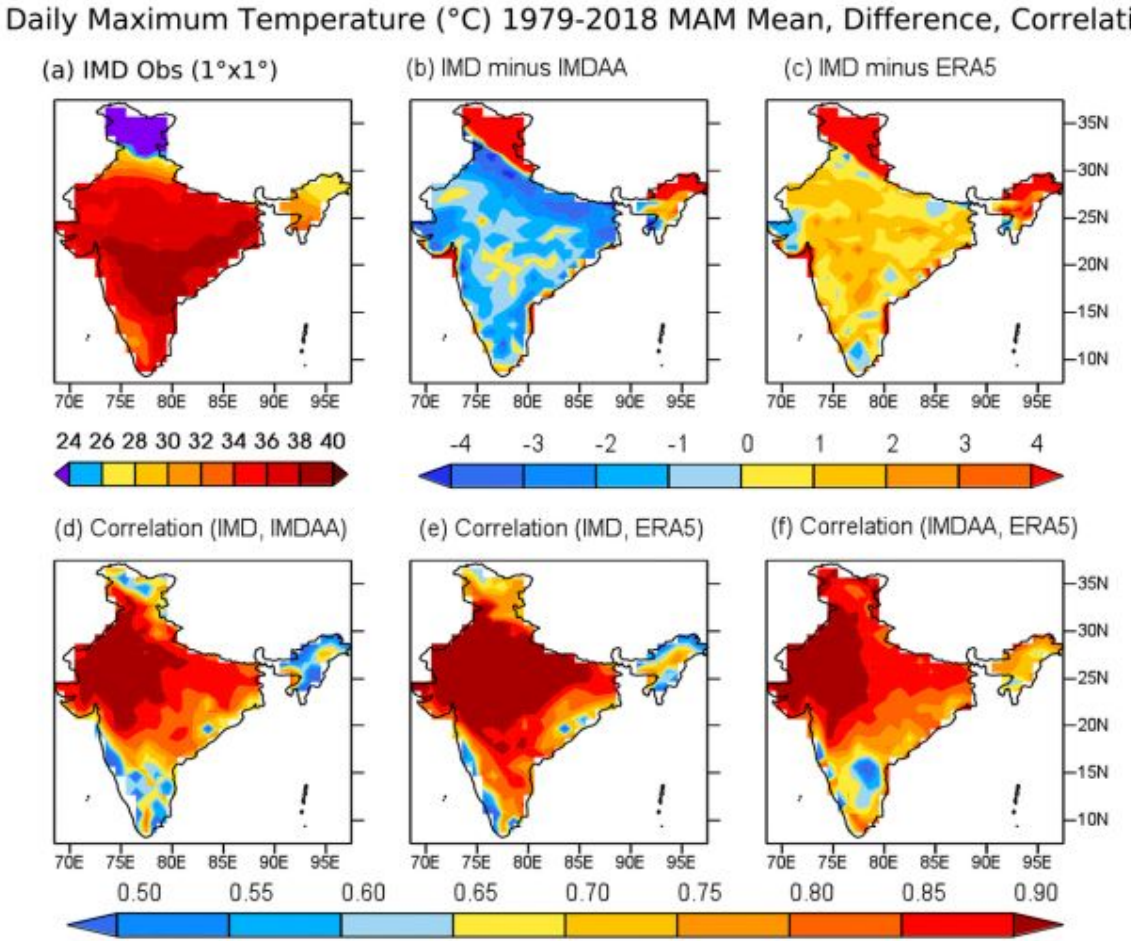


FIG. 18. As in Fig. 17, but for the maximum temperature (°C) from March to May for years 1979–2018.

IMDAA: High-Resolution Satellite-Era Reanalysis for the Indian Monsoon Region

S. Indira Rani,[a] T. Arulalan,[a] John P. George,[a] E. N. Rajagopal,[a] Richard Renshaw,[b] Adam Maycock,[b] Dale M. Barker,[b] and M. Rajeevan[c]

[a] *National Centre for Medium Range Weather Forecasting, Ministry of Earth Sciences, Noida, Uttar Pradesh, India*
[b] *Met Office, Exeter, United Kingdom*
[c] *Ministry of Earth Sciences, New Delhi, India*

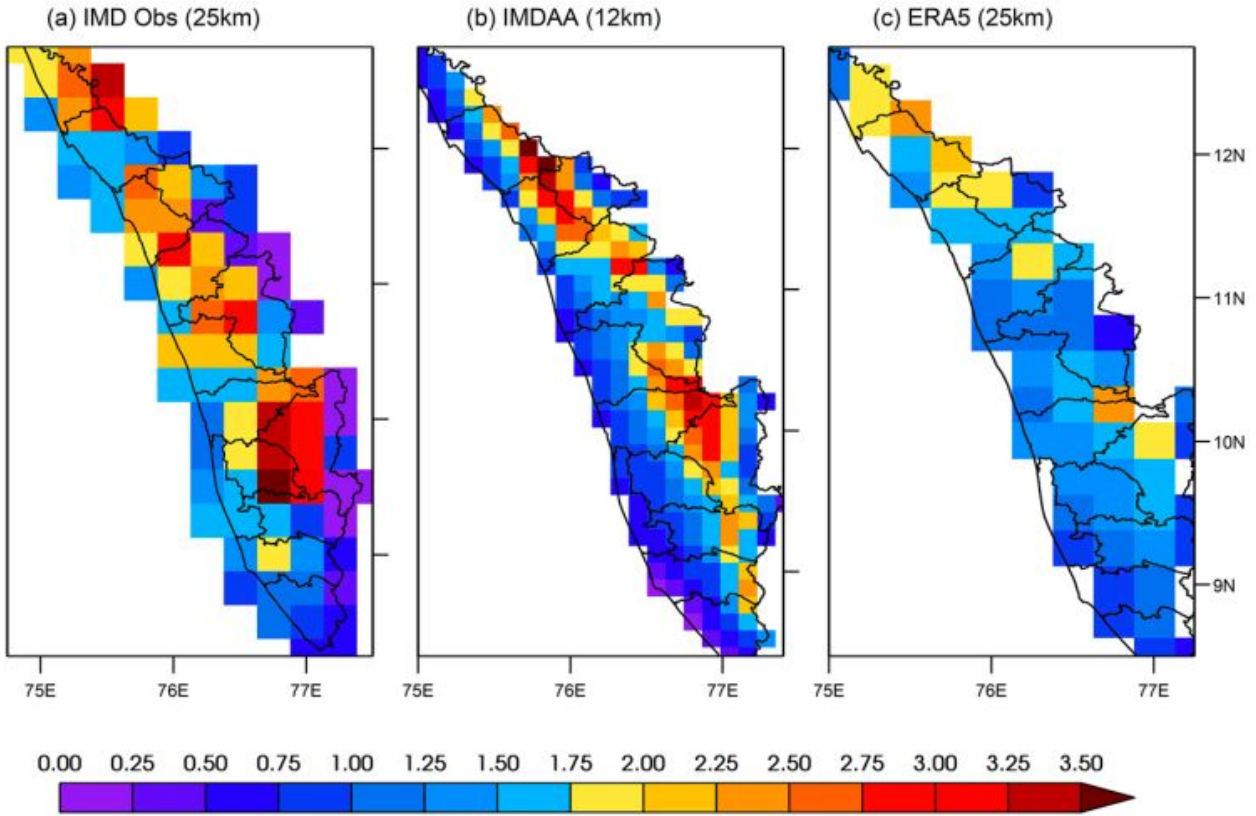


FIG. 21. Hourly averaged (6–18 Aug 2018) rainfall (mm) over Kerala (a) IMD gridded observations (b) IMDAA and (c) ERA5.

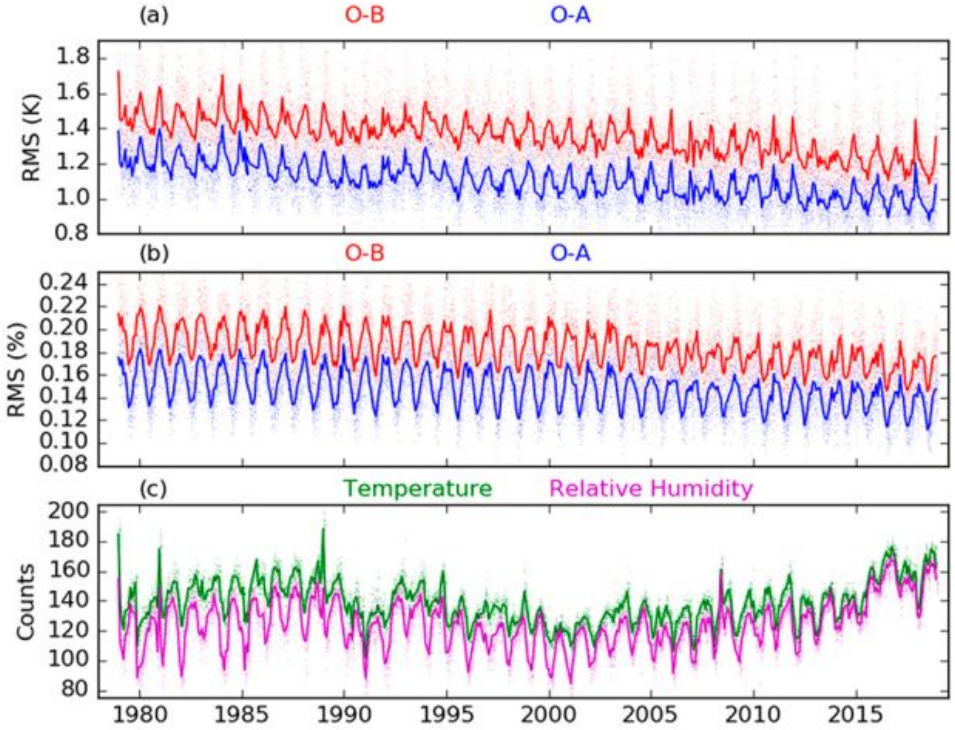


FIG. 9. Time series of the monthly mean of daily average RMS departures of 500-hPa sonde (a) temperature (K), (b) relative humidity (%), and (c) counts of observations assimilated in IMDAA during the 0000 UTC cycle. IMDAA background departures are shown in red and analysis departures are in blue. Green and purple curves represent the monthly mean count of 500-hPa sonde temperature and relative humidity observations assimilated in the IMDAA system. The lightly shaded dots in each curve represent the corresponding daily values. Mean RMS departures of sonde observations at 500 hPa show that the mean values of the *O-B* and *O-A* time series differ significantly ($p < 0.05$).

Comparison of Indian monsoon rainfall from IMDAA and ERA5 with observations shows that spatial distribution of rainfall from IMDAA broadly matches with observations over most parts of India. However, in general, IMDAA shows more rainfall during the southwest and northeast monsoons than observations and ERA5. Compared to the observations, IMDAA produces a slightly cooler winter and hotter summer, and the reverse in the ERA5; however, ERA5 matches better with maximum and minimum observed temperatures.

Two extreme years of Indian summer monsoon in the first de-

rainfall from IMDAA broadly matches with observations over most parts of India. However, in general, IMDAA shows more rainfall during the southwest and northeast monsoons than observations and ERA5. Compared to the observations, IMDAA produces a slightly cooler winter and hotter summer, and the reverse in the ERA5; however, ERA5 matches better with maximum and minimum observed temperatures.

Two extreme years of Indian summer monsoon in the first decade of the twenty-first century were examined to assess the capability of IMDAA in capturing the intraseasonal and interannual

however, the lack of high-resolution observations limits the verification of many of the IMDAA features.

Acknowledgments. The authors gratefully acknowledge the financial support given by the Ministry of Earth Sciences, Government of India (Grant /Project MM/SERP/Met Office_