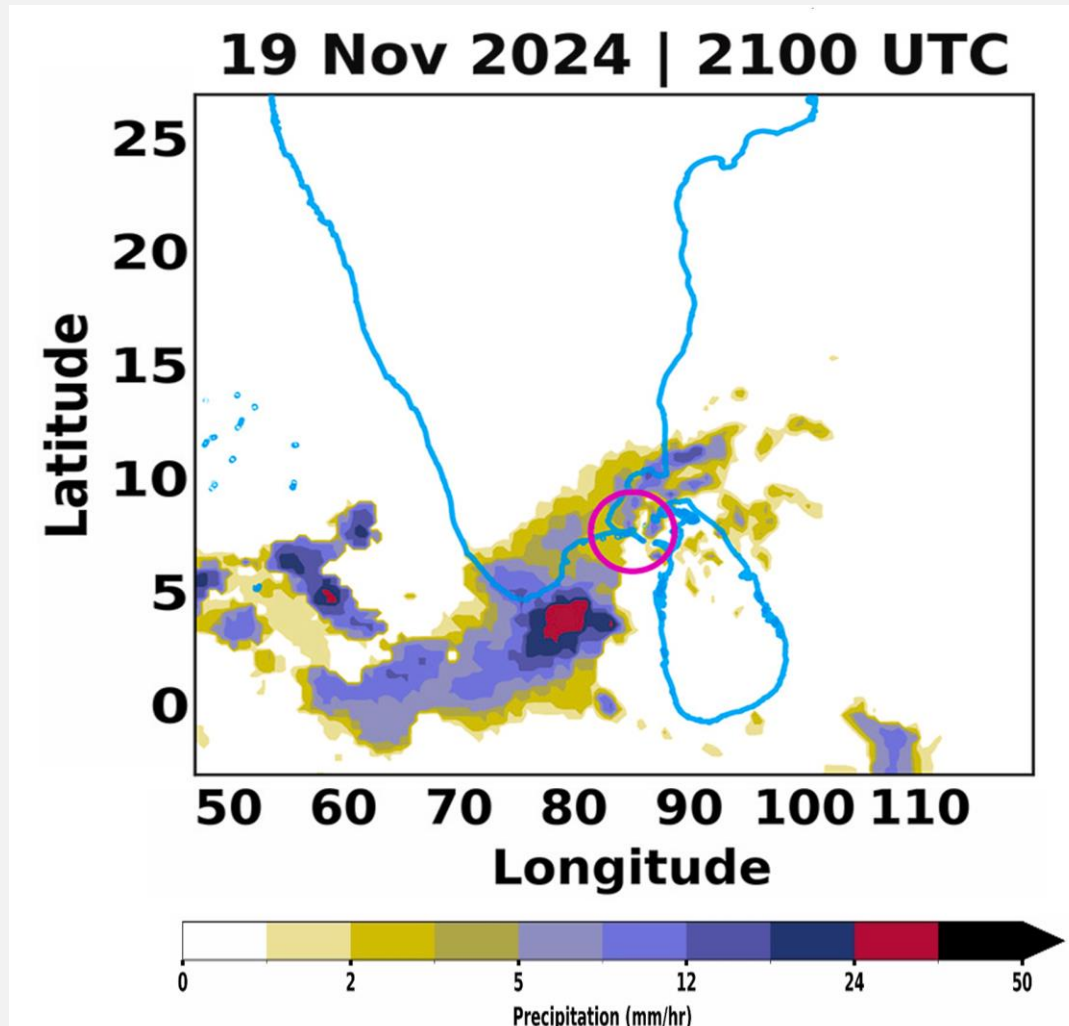


Meenakshi S¹ and S Sridharan¹

1. National Atmospheric Research Laboratory, Gadanki-517112, Tirupati, India

Email: meenakshi@narl.gov.in

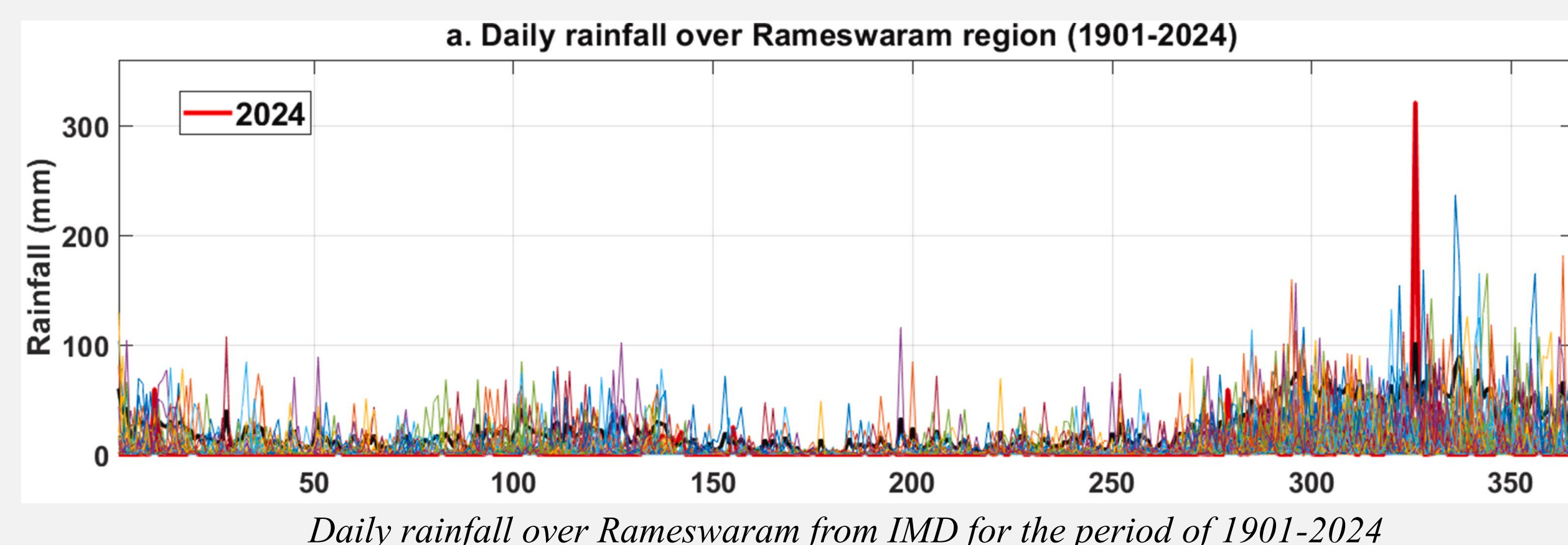
Introduction



On 20-21 November 2024, extreme precipitation- first of its kind to occur in the past 124-year IMD record, resulted in severe flooding over Rameswaram. In this present study, we have investigated the atmospheric conditions which led to this heavy rainfall over Rameswaram, a coastal region in Tamil Nadu on 20 November 2024.

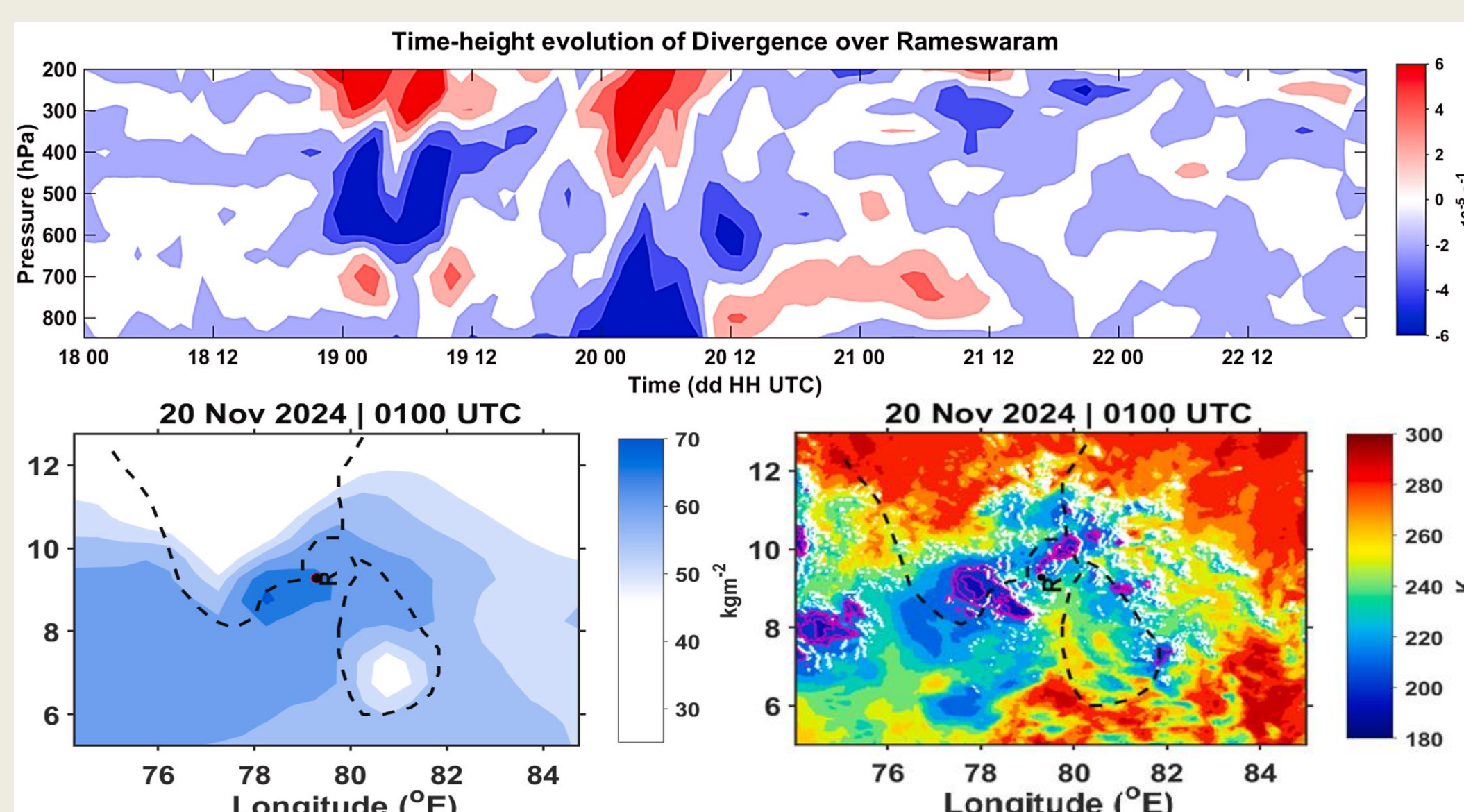
Data and Methodology

IMD rainfall data, ERA5 reanalysis data sets, Brightness temperature, precipitable water and sea surface temperature anomaly from NOAA, NASA-GPM precipitation

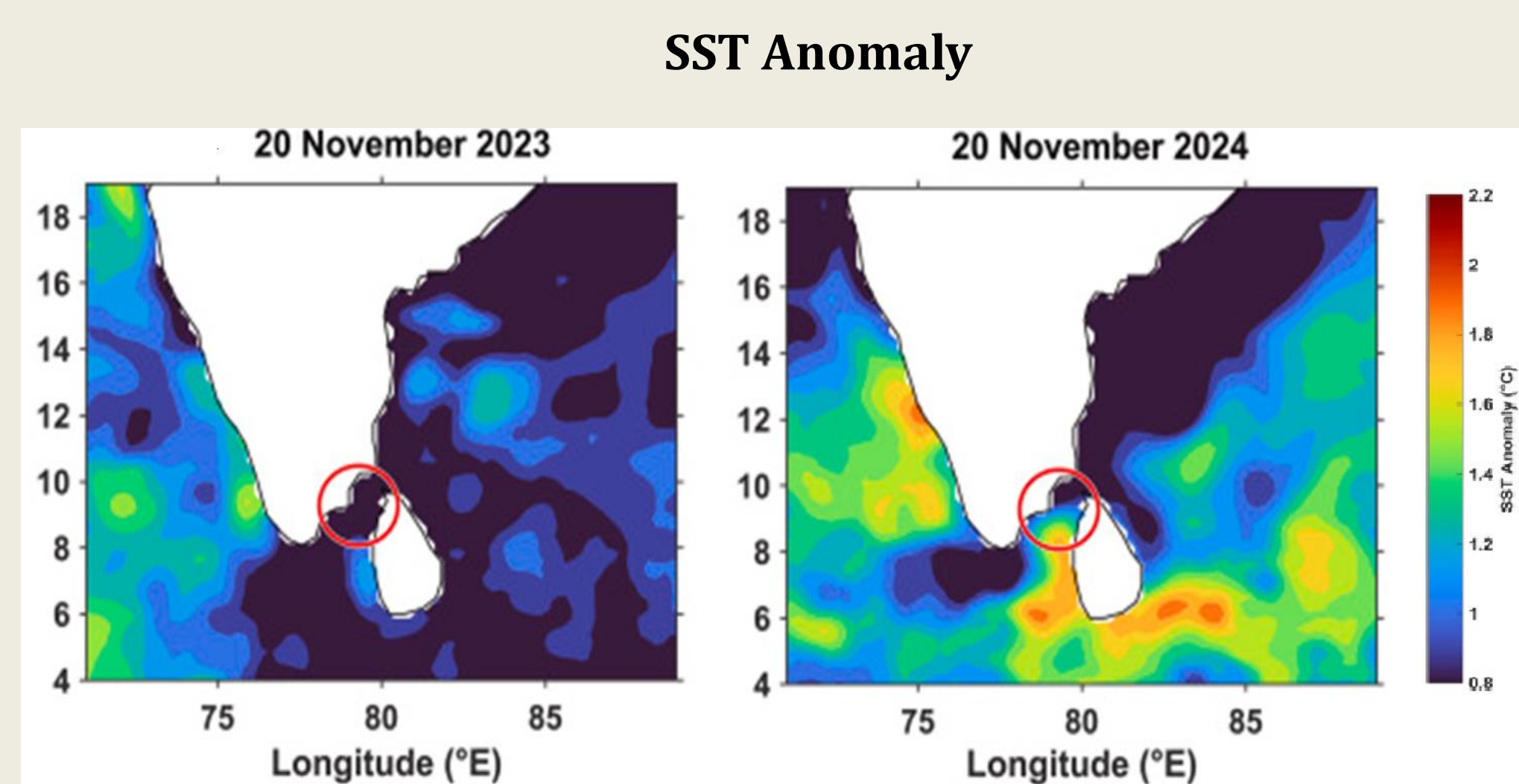


Daily rainfall over Rameswaram from IMD for the period of 1901-2024

Results and Discussions

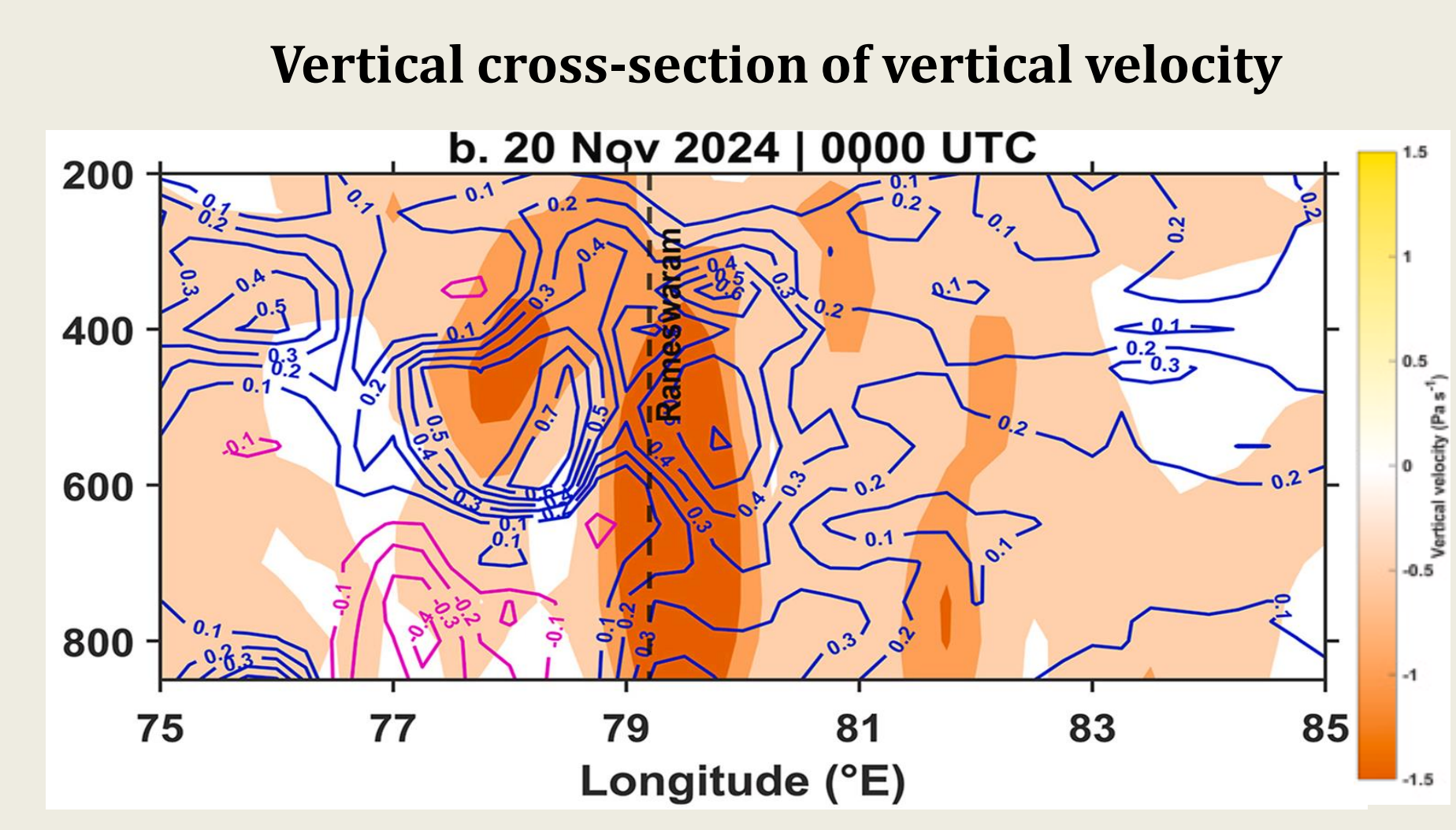


Divergence ($-8 \times 10^{-5} \text{ s}^{-1}$), brightness temp. ($< 210 \text{ K}$) and precipitable water (72 kg m^{-2}) indicate deep convection over Rameswaram



SST anomaly $\approx +1.8^\circ\text{C}$

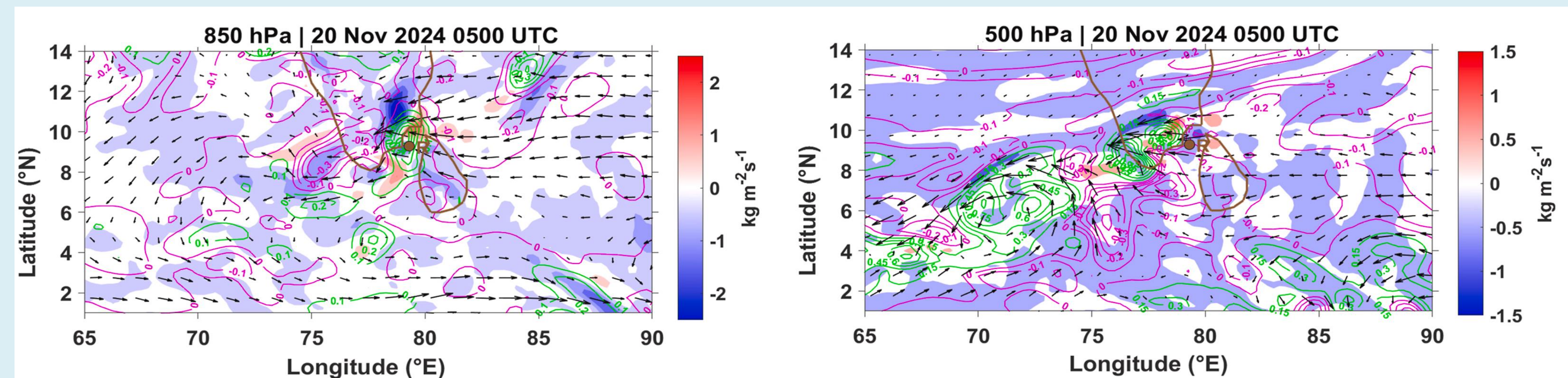
Warmer ocean conditions favored enhanced evaporation and increased atmospheric moisture availability.



Vertical cross-sections of ω overlaid with PV contours (PVU) where magenta and blue lines indicate negative and positive values.

Enhanced ω ($\sim 2 \text{ Pa s}^{-1}$) is found at mid-tropospheric heights (500-400 hPa)

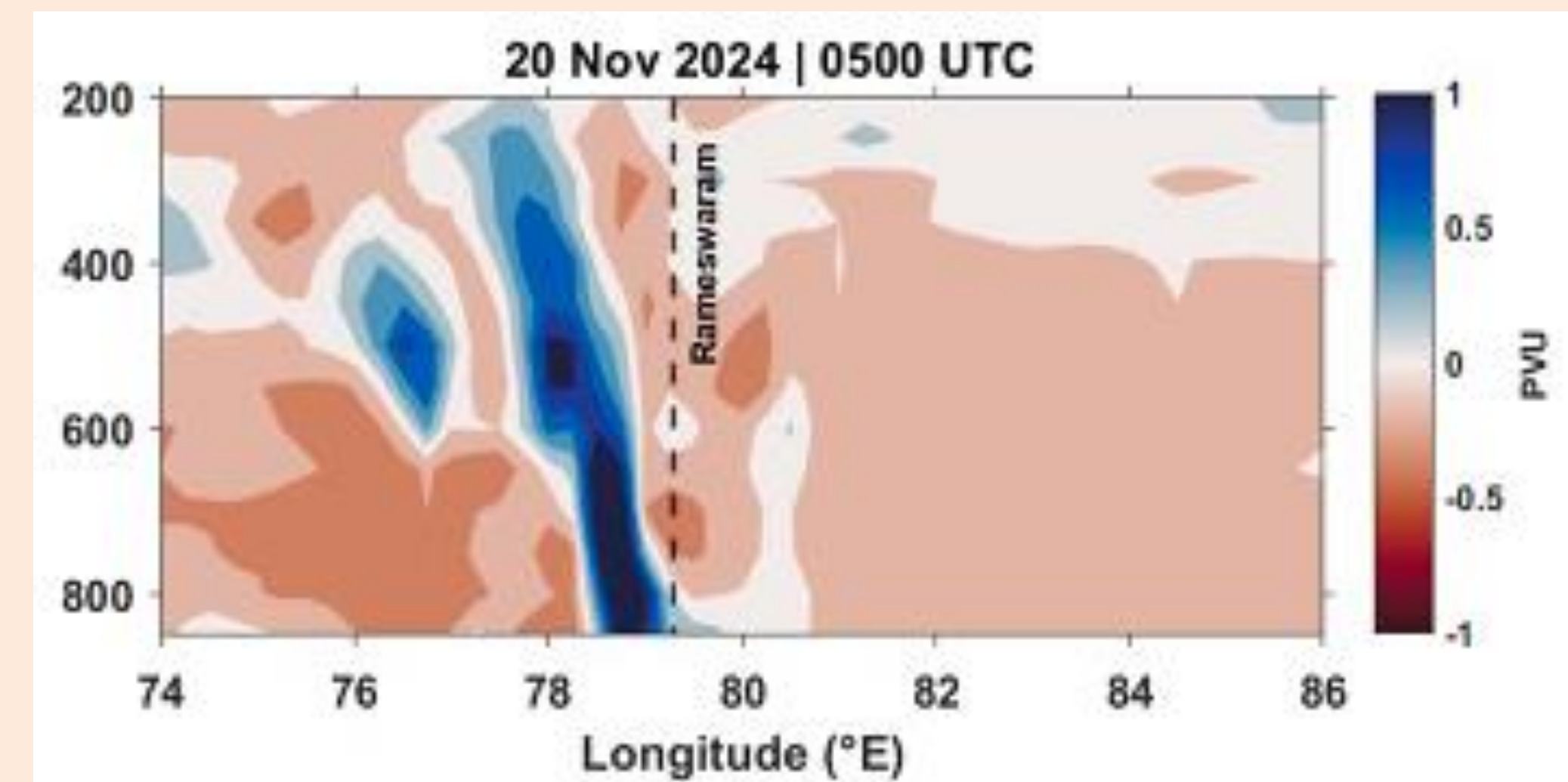
Moisture Flux



Moisture flux divergence overlaid with PV anomaly contours (PVU)

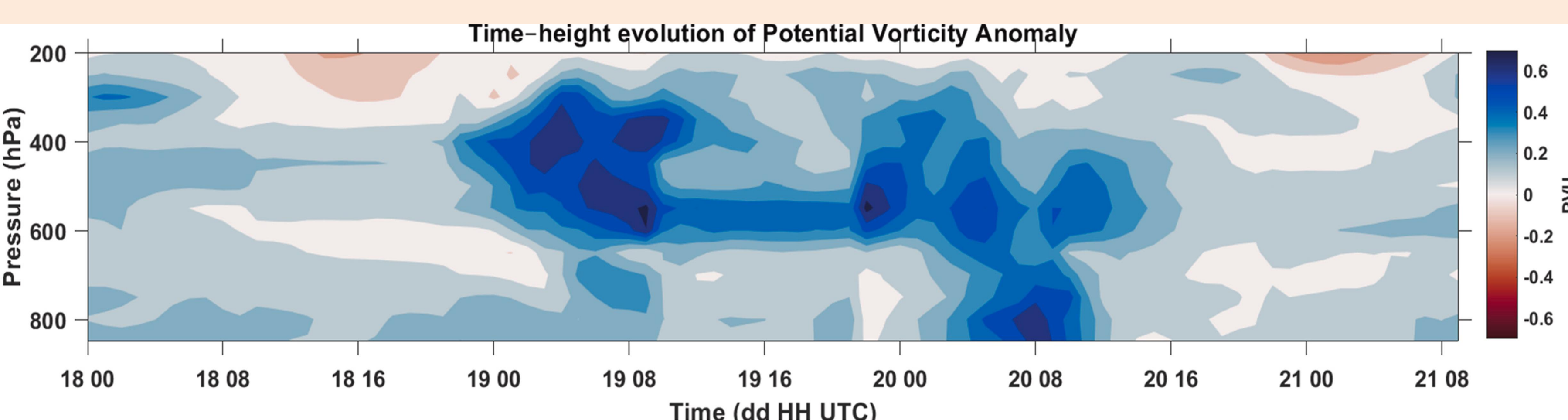
A strong easterly moisture transport, resulting in a large reservoir of moisture over Rameswaram prior to the extreme rainfall.

Potential Vorticity (PV)



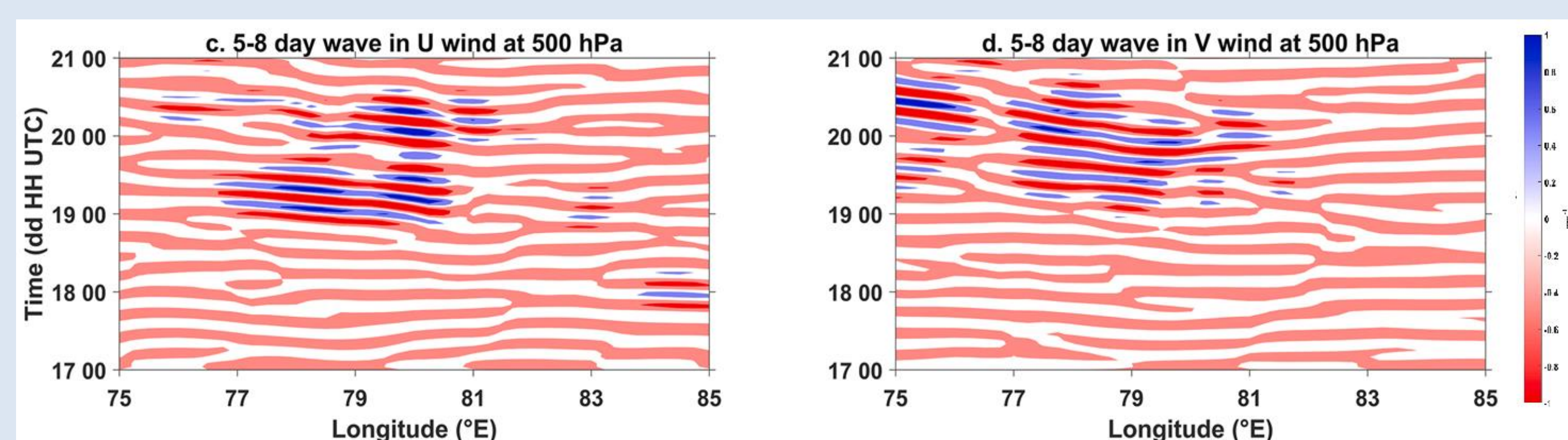
Vertical cross-section of potential vorticity (PV) anomaly

Positive PV tower extending from approximately 850 to 200 hPa, together with horizontal and vertical PV dipoles associated with deep convection and instability.



The evolution of PV anomalies, a PV tower and a mid-level vortex indicates an important dynamical contribution, with the overall evolution suggesting a top-down mechanism.

Wave activity



At both 850 and 500 hPa, there is a westward propagating wave with large amplitudes around 80°E during 19-20 November 2024 which is more prominent in zonal wind than meridional wind at 850 hPa.

Acknowledgments

The authors acknowledge the IMD, ECMWF, NASA, NOAA and NCAR/NCEP for the making the datasets open for the scientific community.

Meenakshi, S., & Sridharan, S. (2026). Governing factors of the unprecedented extreme rainfall over Rameswaram Island. Journal of Atmospheric and Solar-Terrestrial Physics, 106759. [10.1016/j.jastp.2026.106759](https://doi.org/10.1016/j.jastp.2026.106759)

Conclusions

- Record rainfall was preceded by very high moisture over Rameswaram
- Warm Bay of Bengal SST ($+1.8^\circ\text{C}$) and easterly flow supplied the moisture.
- Deep convection was supported by low-level convergence, upper-level divergence and vertical velocity from 850 to 200 hPa.
- A PV tower and mid-level vortex along with the easterly waves, with PV descending from 550 to 800 hPa, indicate top-down dynamics