Increase in water vapour over India and Indian Ocean during the period 2003–2020: Implications for amplified regional warming

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Overview

The increase in greenhouse gases (GHGs) caused by anthropogenic activities leads to rise in regional and global temperatures. Water vapour, the most abundant GHG, has a significant positive feedback effect on Earth's climate system and global warming. Unlike other greenhouse gases, which are controlled by emissions, atmospheric water vapour is influenced by the surface temperature. Rising water vapour amount in the atmosphere is great concern for the climate change and global warming point of view due to its capacity to enhance the temperature caused by the anthropogenically emitted GHGs. Therefore, this study examines the impact of rising surface temperature, sea surface temperature, evaporation (ocean), and evapotranspiration (land) on water vapour rises and focuses on the recent changes in atmospheric water vapour over India and the Indian Ocean as assessed by the ground based radiosonde, satellite and reanalysis data for the period of 2003-2020.

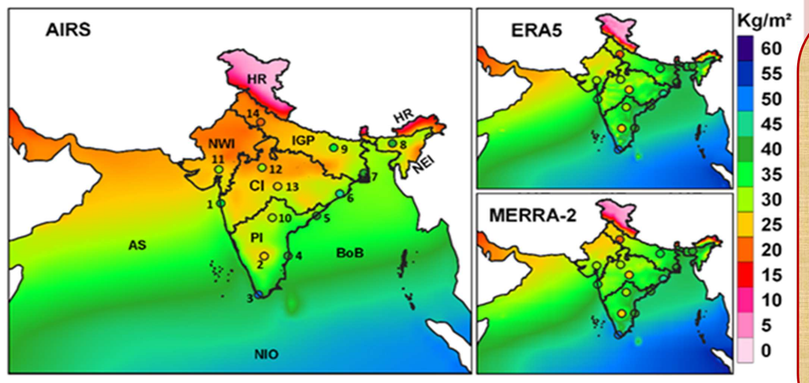
Data and Methodology

•Radiosonde, AIRS (1°) and ERA5 (0.25°) datasets are used for the period 2003-2020 to examine the recent changes in water vapour over India and Indian Ocean.

•Data for the sources and drivers such as sea surface temperature, surface air temperature, evaporation and evapotranspiration are assessed from ERA5 and GLDAS for the same period.

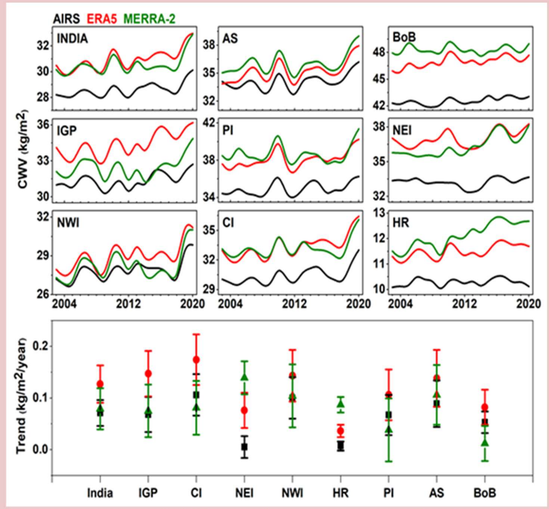
•Assessment of spatial and temporal changes in water vapour, and its associated sources and drivers is carried out over the different regions in India and Indian ocean.

Results and Discussion



The annual averaged column water vapour over India and Indian Ocean from 2003 to 2020 derived from radiosonde (circle) AIRS, ERA5 and MERRA-2.

- The annual mean tropospheric CWV varies in the range of 0–60 kg/m^2, depending on regions.
- Relatively larger CWV values are found over the oceans, particularly in the northeastern Indian Ocean, about 50–60 kg/m^2.



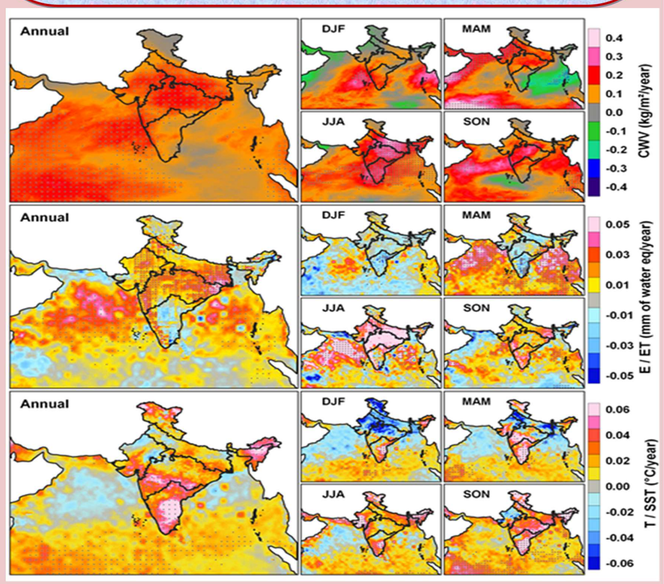
Interannual variability and average trends of column water vapour over India and Indian Ocean regions. estimated from AIRS, ERA5 and MERRA-2 data for the period 2003–2020.

High positive trends are observed in CI and IGP regions over the land, and the western Indian Ocean, about 0.2 kg/m^2/yr.

Significant positive trends in water vapour is observed in summer in most regions, and are about 0.2–0.4 kg/m^2/yr with highest value in lower IGP, eastern CI and south India.

The high ET trends in IGP and CI match with those of CWV trends there.

- The annual averaged CWV shows a gradual and consistent increase in water vapour in all regions, except the AIRS measurements in HR and NEI.
- Among the oceanic regions, all three datasets show very small variability over BoB than that in AS.
- Distinct peaks in CWV are observed in 2009, 2015–16, 2018–19, which are connected to the El Niño and higher temperature with dry conditions in India.



The trends in column water vapour (top panel), evaporation (E, over ocean)/Evapotranspiration (ET, land) and surface air temperature (T, land)/SST (ocean) from 2003 to 2020. The hatch areas represent the statistically significant trends at 95% CI.

Conclusions

- As water vapour is one of the most abundant GHGs, its increase over India and the Indian Ocean would increase temperature through radiative effects. Due to the positive feedback mechanism, rise in temperature would also increase evaporation.
- Increasing water vapour in Indian Ocean would also influence the large-scale atmospheric circulation pattern, a key driver of ocean interannual variability.