Water Vapor Transport to the Upper Troposphere/Lower Stratosphere via Lightning-Intense Deep Convective Systems in the Third Pole Region

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Motivation

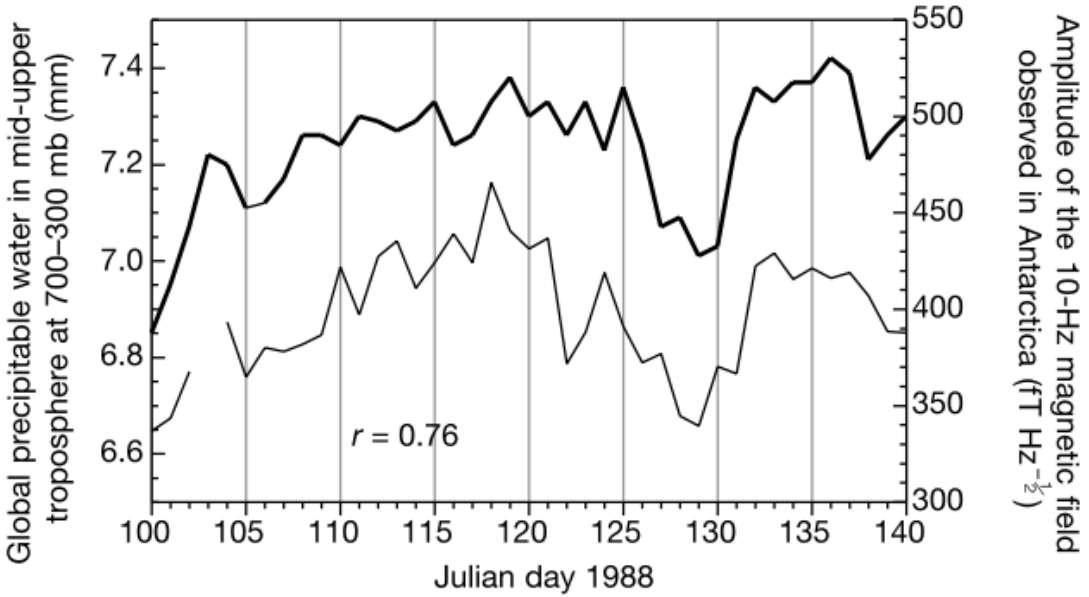


Fig. 1: The daily mean variability of the global NVAP* precipitable water above 700 mbar from 9 April to 19 May 1998 (thick line), together with the 10-Hz magnetic field amplitude measured in Antarctica (thin line)[1]

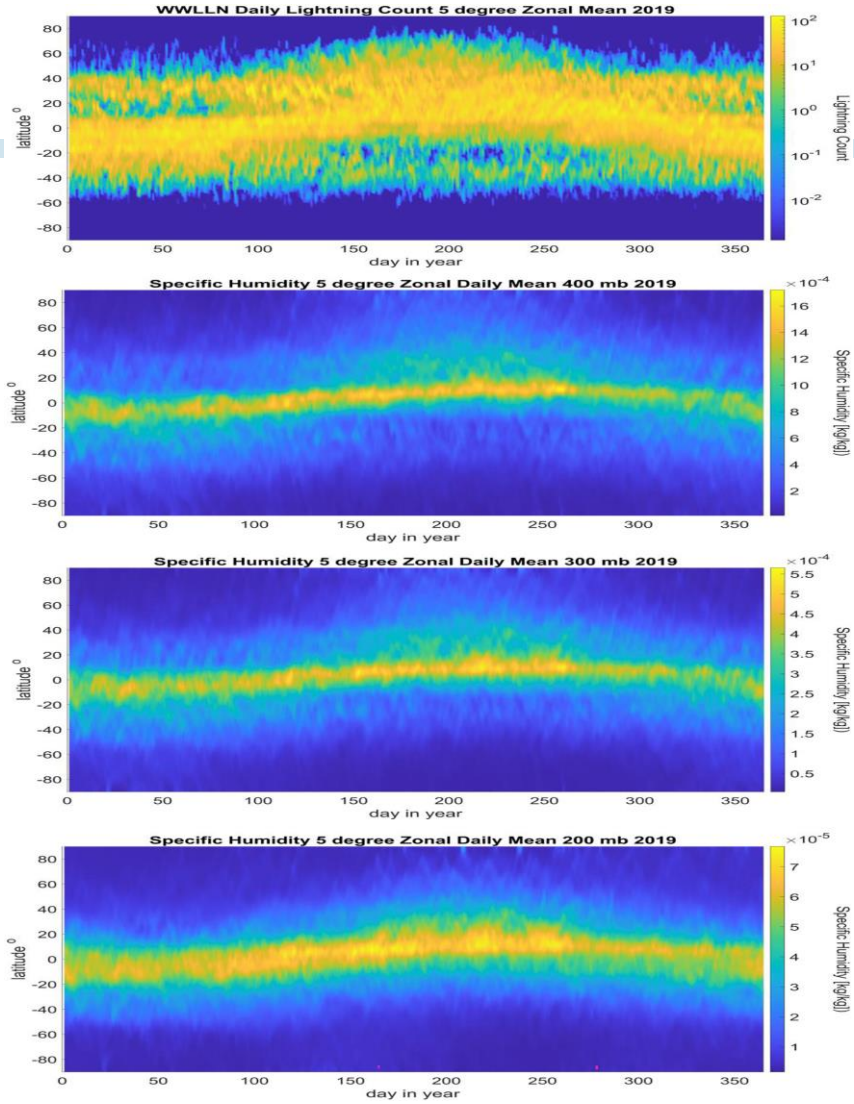


Fig. 2: (a) Latitude-Time plot of daily WWLLN lightning count per 5-degree latitude bin; (b) Latitude-Time plot of daily SH per 5-degree latitude bin for 400 hPa; (c) 300 hPa; and (d) 200 hPa.[2]

[1] C. Price, 2000, Nature
[2] C. Price et al., 2023, JGR Atmosphere

Lightning in the Third Pole Region

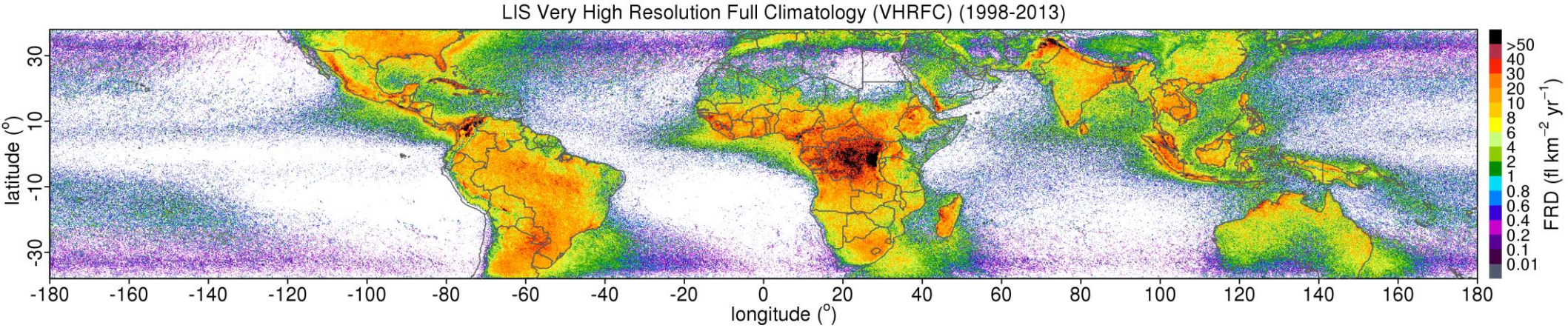


Fig. 3: LIS 0.1 Degree Very High-Resolution Gridded Lightning Full Climatology (VHRFC).[3]

Lightning activity and specific humidity variation at 100 hPa suggest that lightning can serve as an indicator of water vapor exchange from the boundary layer to the UTLS region.

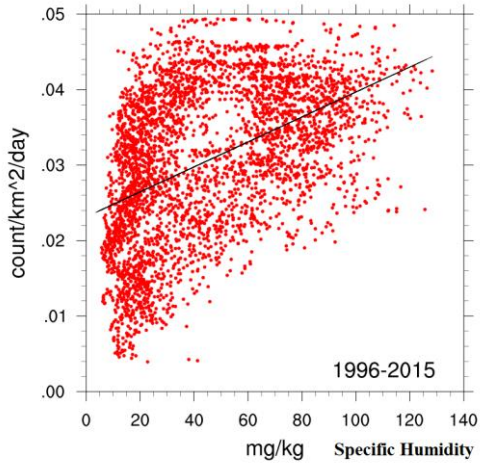
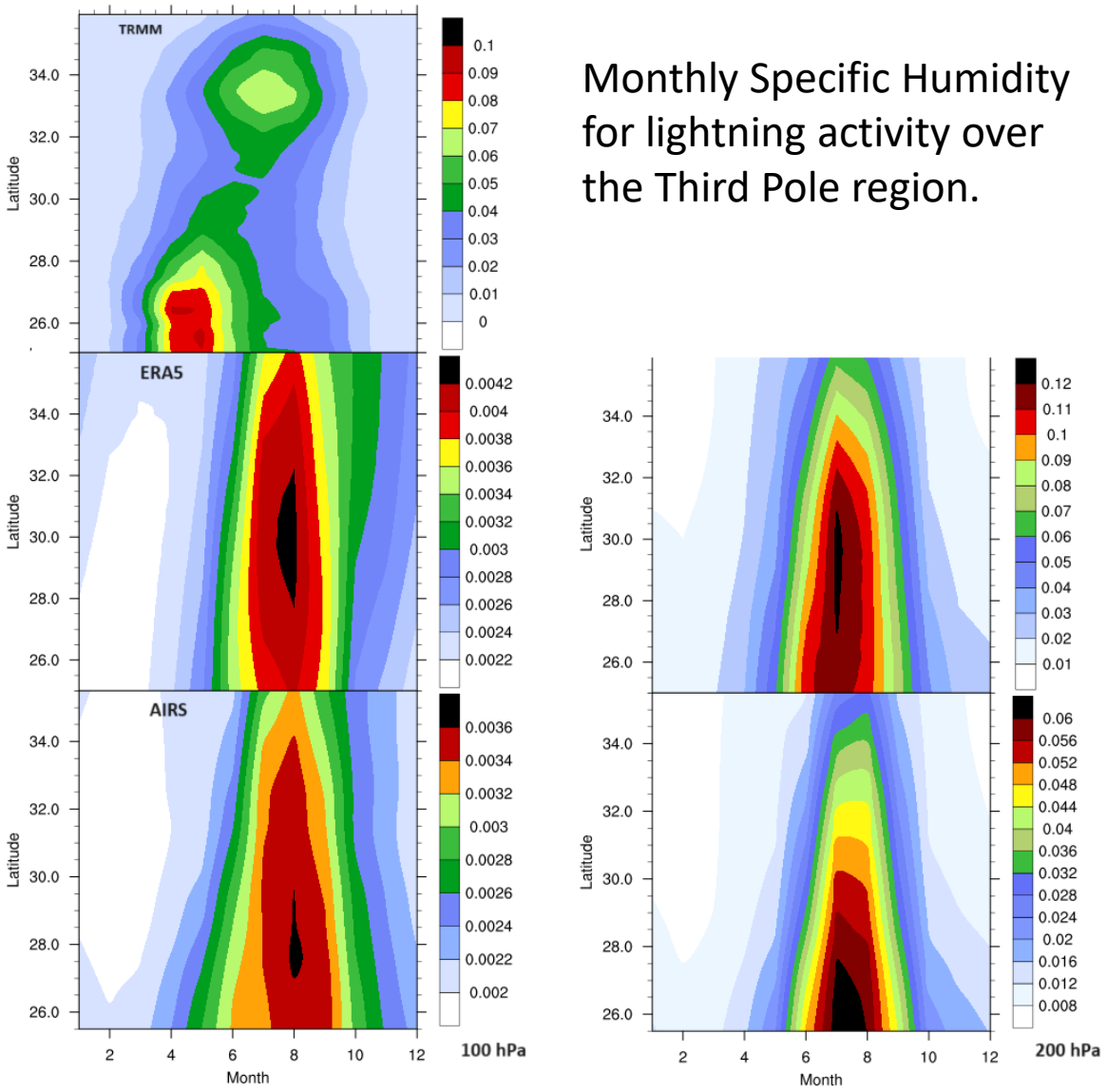
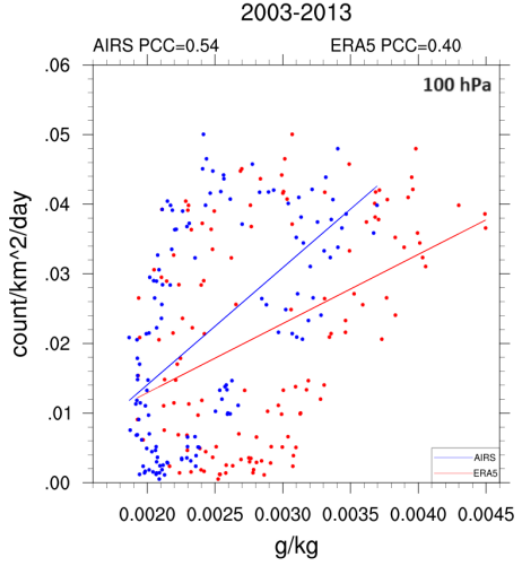


Fig. 4: TRMM daily lightning count vs 100 hPa specific humidity over the Third Pole region. (from 1996 to 2015)

[3]*D Cecil, 2012, Atmospheric Research*

Monthly Specific Humidity for lightning activity over the Third Pole region.





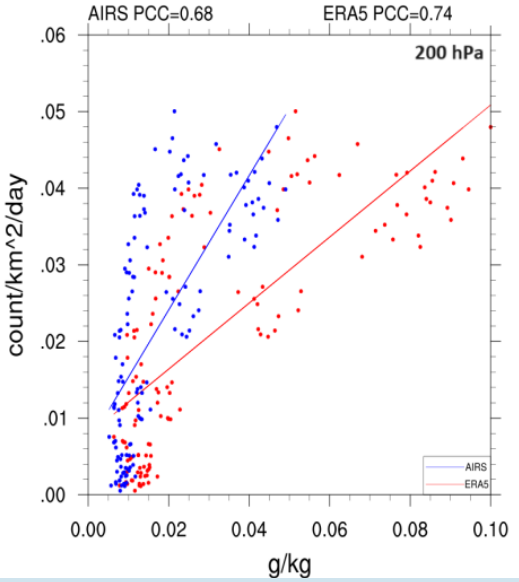


Fig. 5: TRMM monthly lightning over the Third pole region with respect to specific humidity at 100 hPa and 200 hPa from AIRS and ERA5. (from 2003 to 2013)

Lightning in the Third Pole Region

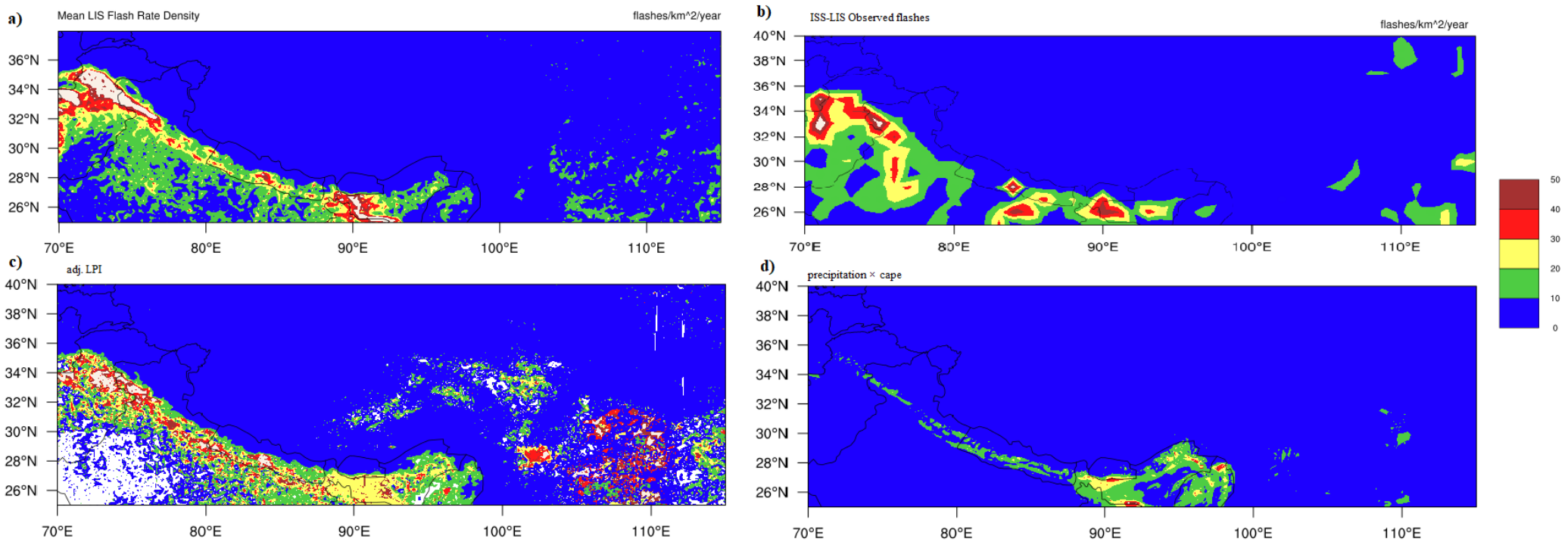


Fig. 6: a)TRMM lightning climatology, b) ISS-LIS observed (gridded to 1-degree) for 2019-2020, LPI simulated from km-scale ICON-CLM, and Precipitation × CAPE from simulation for the same period.[4]

[4]*Singh and Ahrens, 2023, Atmosphere*

Specific Humidity at Upper Troposphere

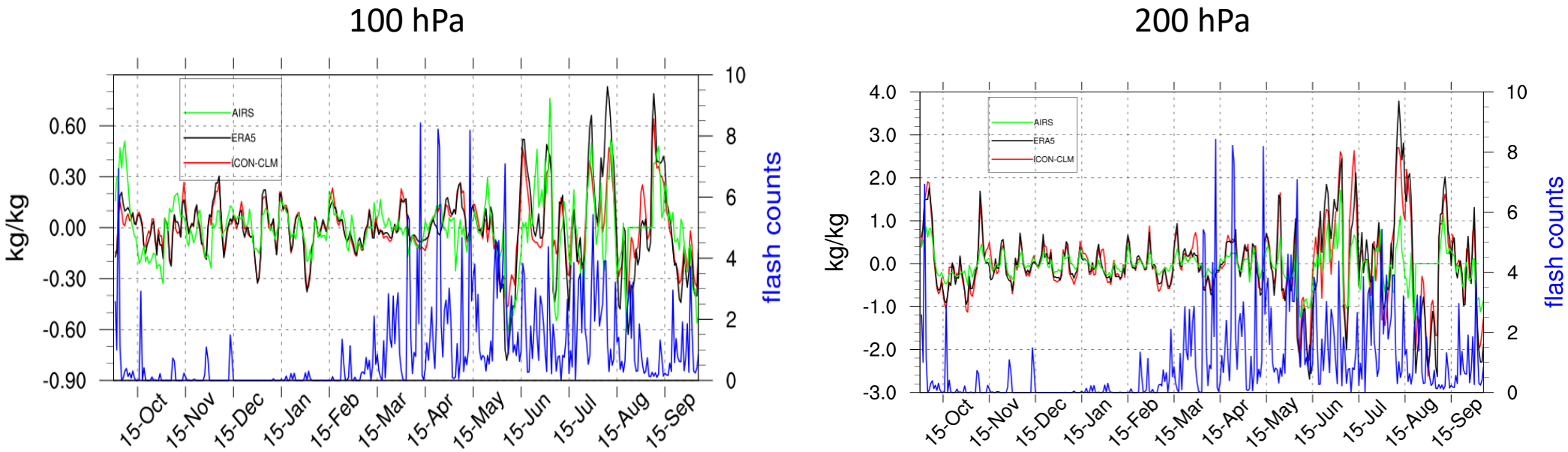


Fig. 7: ISS-LIS observed daily lightning flashes (blue), with specific humidity from AIRS (green), ERA5 (black), and ICON-CLM (red) simulation over the Third Pole region at 100 hPa and 200 hPa for the period of October 2019 to September 2020.

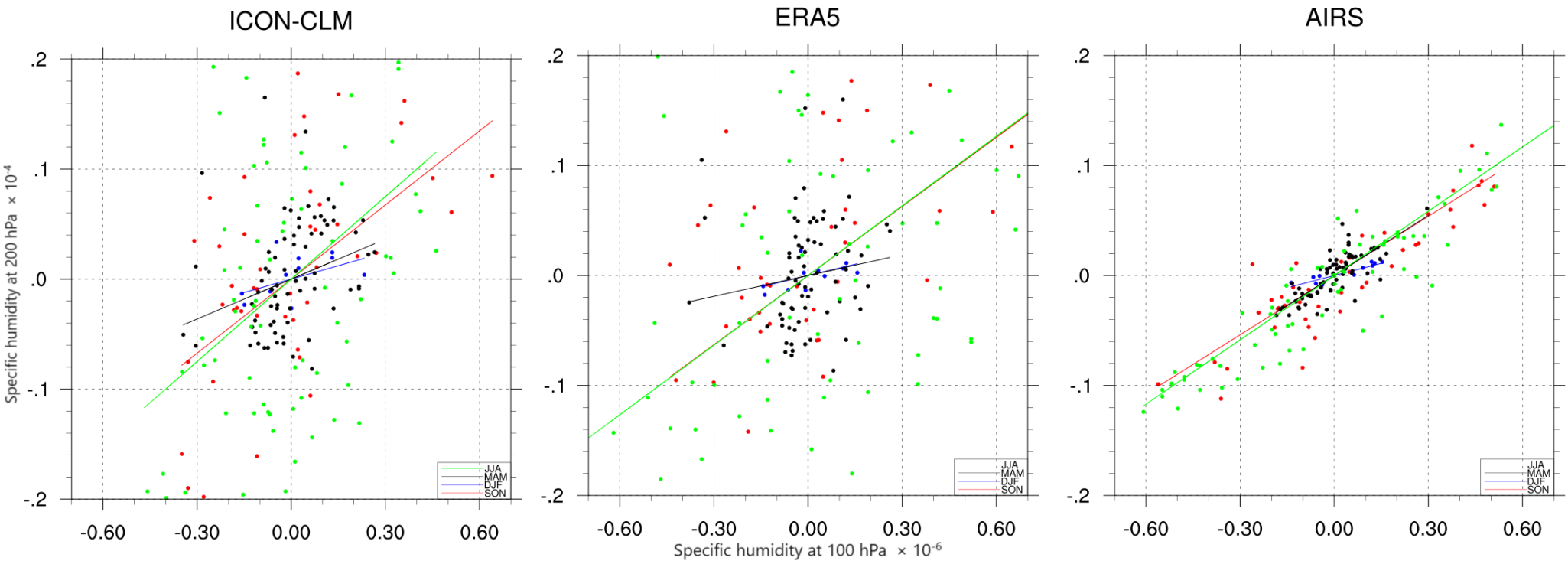


Fig. 8: For all the observed lightning event correlation of specific humidity at 100 hPa and 200 hPa over the domain.

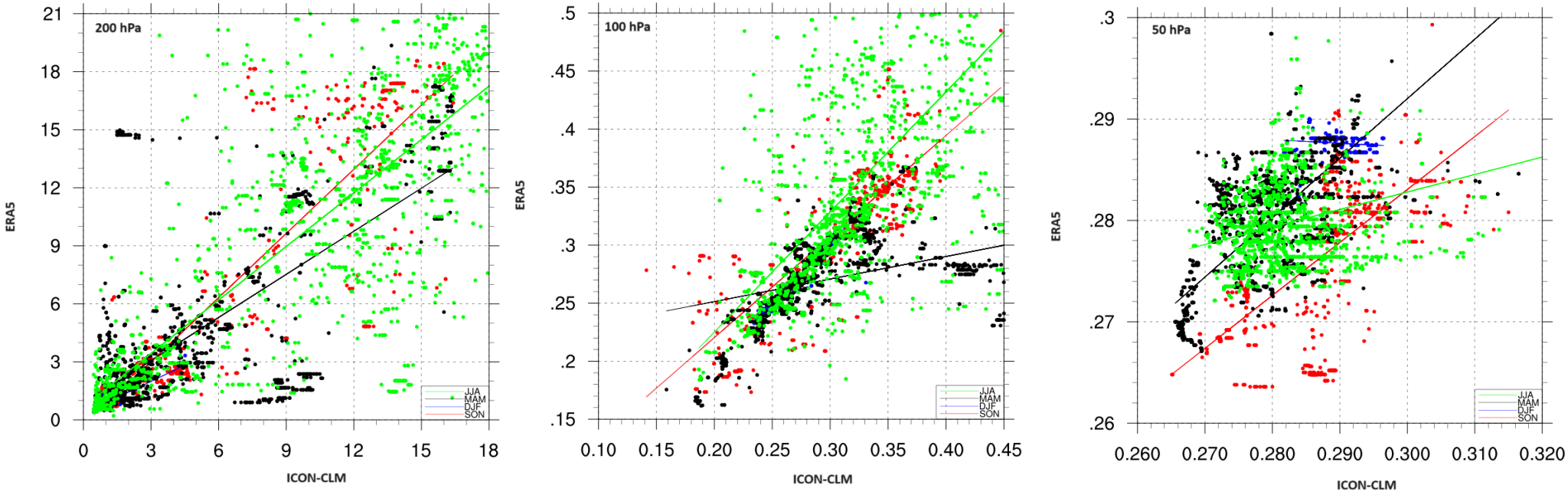


Fig. 9: Correlation of specific humidity at 200 hPa. 100 hPa and 50 hPa over the region of observed and simulated lightning events from ERA5 and ICON-CLM.

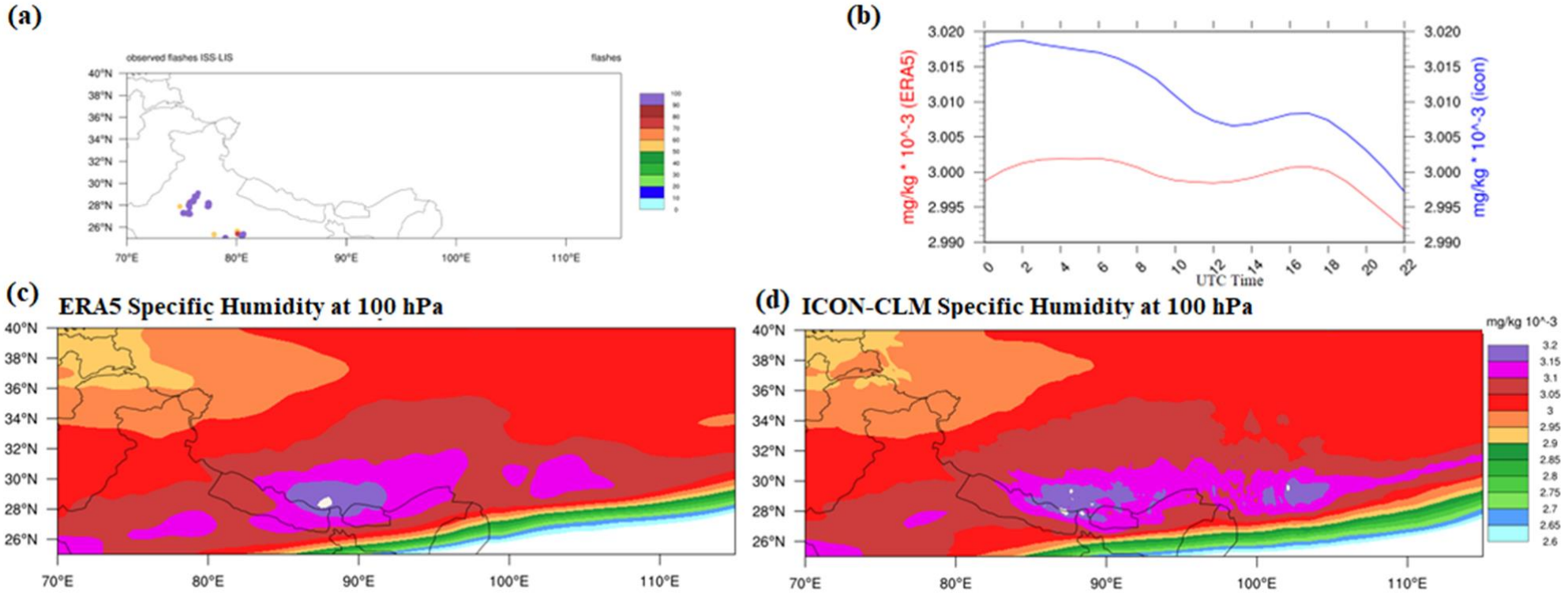


Fig. 10: a) A specific lighting event over the domain, b) 100 hPa specific humidity time-series by ERA5 and ICON-CLM, c) ERA5, and d) ICON-CLM specific humidity at 100 hPa

- ✓ ICON-CLM at km-scale shows quite good agreement with the observe lightning events.
- ✓ ERA5 during monsoon represents moist bias in Upper Troposphere and Lower Stratosphere compare to AIRS and ICON-CLM simulation at km-scale simulation.
- ✓ Deep convective events over the Third Pole region can transport water vapor to Upper Troposphere but needs additional mechanism to reach Lower Stratosphere.

Thanks