Dynamical Pathways to Temperature Variability in South Asia

Hardik Shah[1] and Joy Monteiro[1,2]
[1]Department of Earth and Climate Science, Indian Institute of Science Education and Research Pune, Pune, India
[2]Department of Data Science, Indian Institute of Science Education and Research Pune, Pune, India

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Objective

To identify the physical mechanisms governing near surface temperature variability, and associated large scale dynamical pathways in South Asia.

Background

- Existing heatwave studies have shown that some features like surface drying and upper tropospheric blocks ([1]) are associated with enhanced surface warming.
- The circulation changes translating upper tropospheric forcing to surface temperature response have rarely been studied in South Asia. Further, the methodology for clarifying physical mechanisms is based on composites ([2]), which obscures the rich diversity of pathways that could lead to temperature extremes.

Methodology

- We use the decision tree model to enhance our process-oriented understanding of variability in near surface temperature. We use 2 meter temperature (T2m) anomaly computed from the ERA5 reanalysis dataset. We study the Northwest Indian heatwave hotspot during the premonsoon season in the period 1995-2022.
- We identify the critical variable(s) explaining terciles of T2m anomaly, and recursively build explanatory trees until distinct circulation patterns related to different T2m anomaly regimes become evident.
- All variables have been standardized for modeling. We focus on Mar-Apr results in this poster.

Variable key:
- **DSE*** = Dry Static Energy
- **SW*** = Shortwave radiation fluxes into the surface
- **SHF*** = Sensible Heat fluxes into the surface
*Apostrophe denotes anomalies, e.g., SHF'

References -
[1] Pfahl, S., and H. Wernli, (2012), Quantifying the relevance of atmospheric blocking for co-located temperature extremes in the Northern Hemisphere on (sub-) daily time scales, Geophys. Res. Lett., 39, L12807.
[2] P. Rohini, M. Rajeevan, and A. K. Srivastava, "On the Variability and Increasing Trends of Heat Waves over India," Scientific Reports, vol. 6, p. 26153, Sept. 2016.

Results: Mechanisms driving temperature anomaly

1) T2m'_Lag1 is a significant explainer of T2m'
   - Thus, the process governing T2m' has the **Markov property**
2) Using surface, radiative and advective flux variables other than T2m'_Lag1 in the model indicates the **role of the atmosphere in heating the surface**
   - The variables captured are diagnostic, so we model **daily change in T2m'** instead
3) **Advective fluxes of DSE into 600-900 hPa** is the most important variable driving daily change in T2m'
4) Model for **Reynolds decomposed terms** governing variability of 600-900 hPa **DSE (s)** in Apr

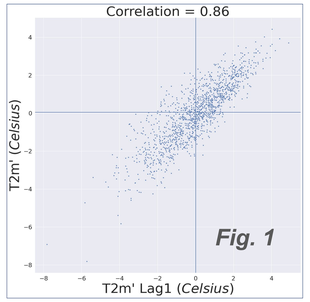

Fig. 1

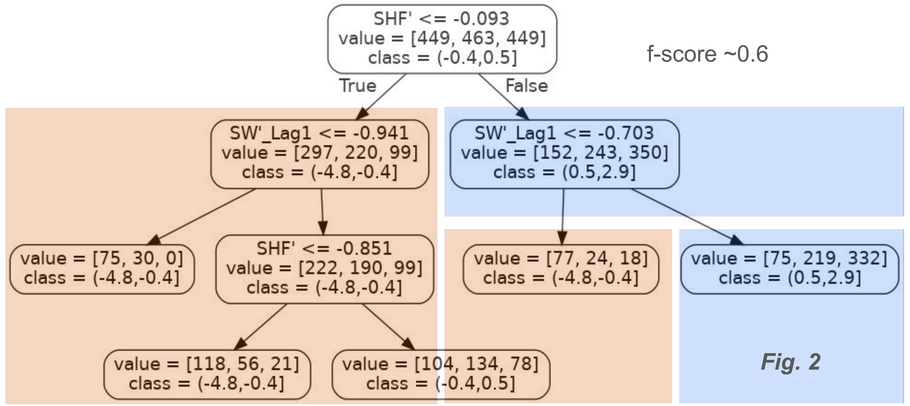

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Fig. 2

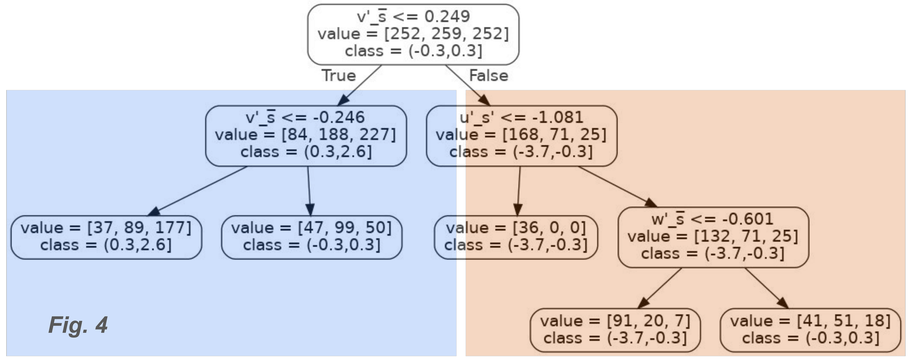
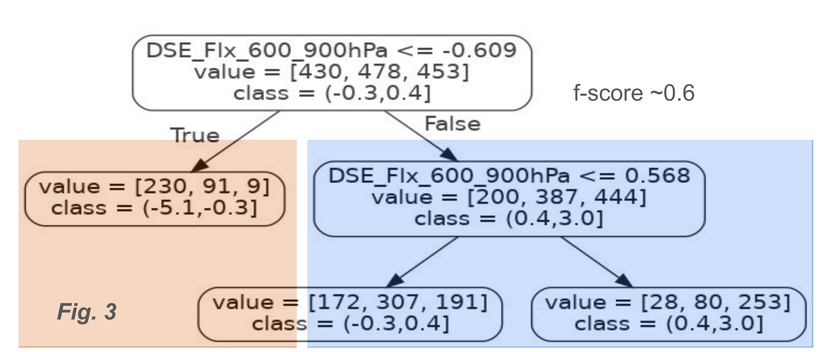


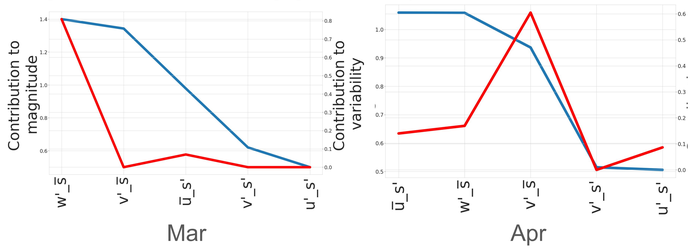
Fig. 4



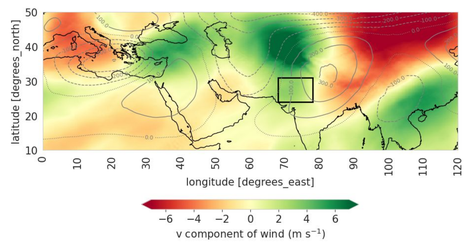
f-score ~0.6
Fig. 3

Results: Role of large scale circulations

Reynolds Decomposition of Advective DSE fluxes in 600-900 hPa: **Magnitude** and **Variability** governed by different terms



300 hPa composite for third branch (negative extreme) above



Next steps

- Large scale dynamical interpretation of difference in drivers of **DSE magnitude vs variability**
- Characterization and drivers of **skewness** of 600-900 hPa DSE fluxes by season
- Importance of **eddy-eddy covariances**, and implication in context of macro turbulence theory
- Proximate mechanism elucidation