An analytical framework to understand flash drought mechanisms

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Introduction

Figures S1-S3 provide a comparison of MBE95 model-simulated ground temperature, mixed layer temperature, and specific humidity standardized anomalies with those from the ERA5 dataset. Figures S4-S6 show the percentiles of all four model states during evolution of the flash drought events shown in Figures 3-5 of the main text respectively. These percentiles were calculated using 30 years of simulated values of all four state variables. Figures S7-S9 show the anomalies of the components of sensitivity of soil moisture with respect winds $g^{S\_u_2}$ and shortwave radiation $g^{S\_RS_n}$ in the drought events shown in Figures 3-5 of the main text respectively. Figure S10 shows the box plots of drought evolution time in each region.
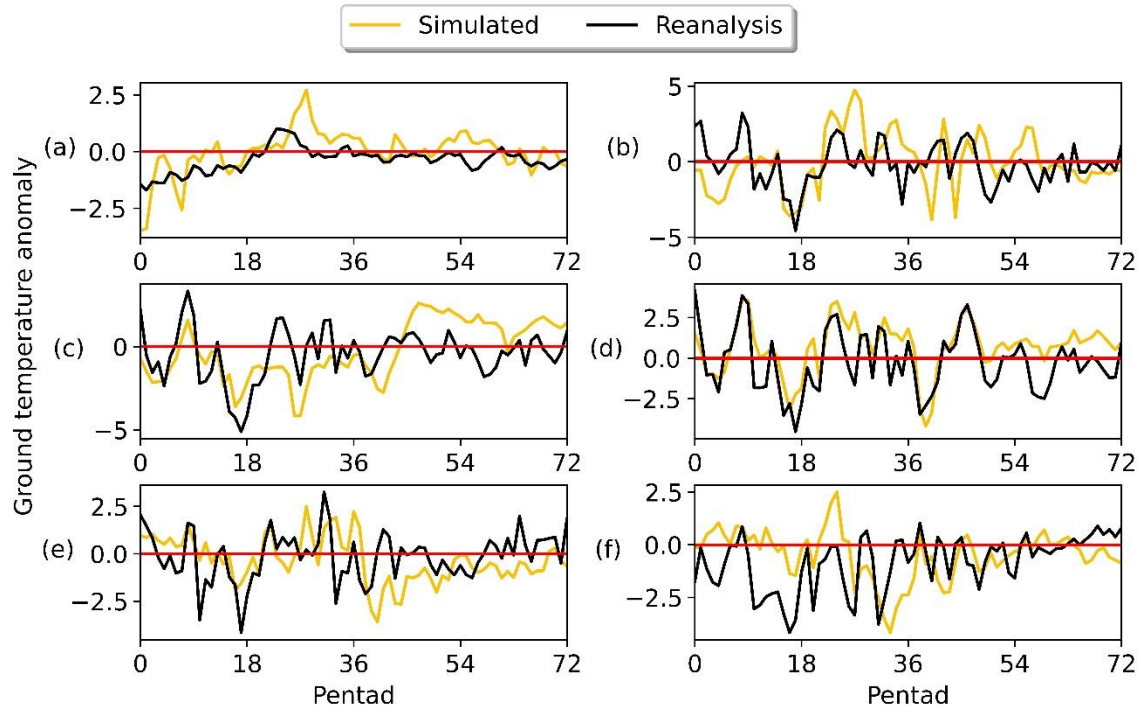
Figure S1: Comparison of pentad-scale model-simulated (yellow) and ERA5 (black) ground temperature anomalies for the representative grids from (a) NE, (b) HR, (c) CNE, (d) SP, (e) WC and (f) NW for the year 1993. The anomalies are calculated as the difference between the value of the state variable and the climatological mean divided by the standard deviation for that pentad. Daily ground temperature was converted to pentad-scale using 5-day moving average, resulting in 73 pentads in a year.
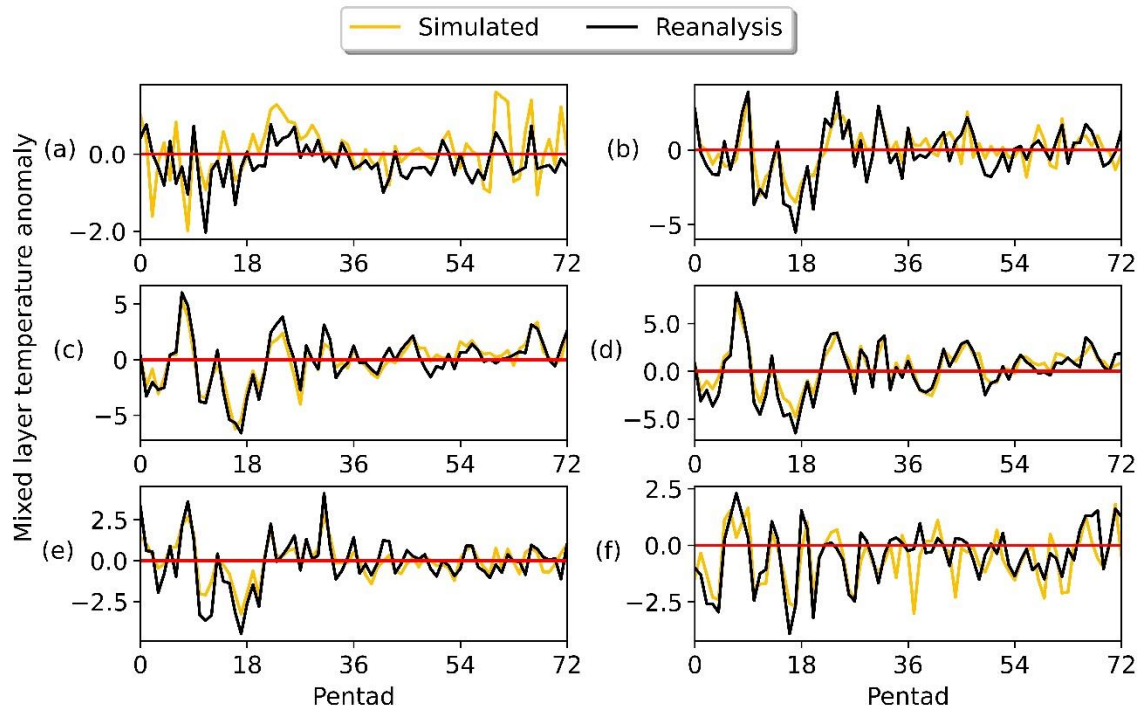
Figure S2: Comparison of pentad-scale model-simulated (yellow) and ERA5 (black) mixed layer temperature anomalies for the representative grids from (a) NE, (b) HR, (c) CNE, (d) SP, (e) WC and (f) NW for the year 1993. The anomalies are calculated as the difference between the value of the state variable and the climatological mean divided by the standard deviation for that pentad. Daily mixed layer temperature was converted to pentad-scale using 5-day moving average, resulting in 73 pentads in a year.
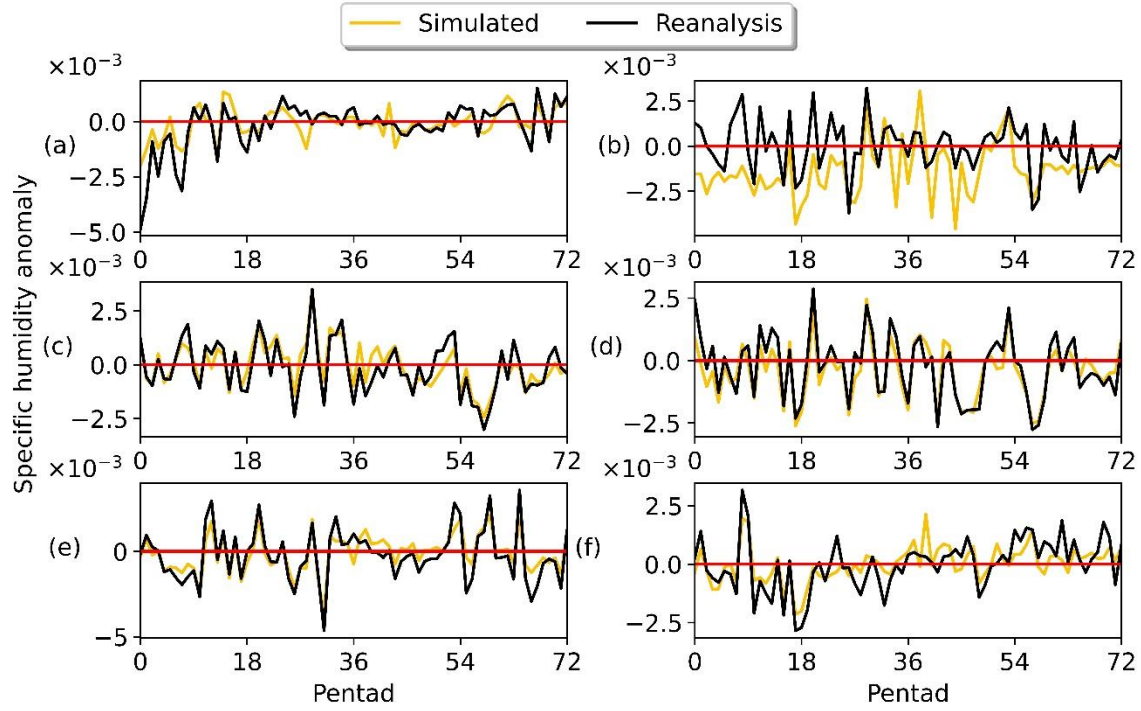
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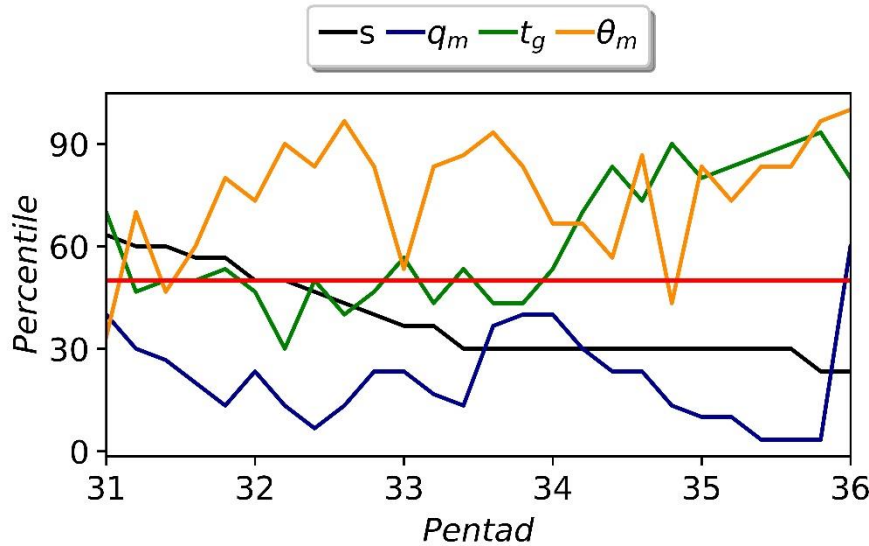

Figure S4: Soil moisture (s), mixed layer humidity (q_m), ground temperature (t_g), mixed layer temperature (θ_m) percentiles for the category 1 flash drought shown in Figure 3 of the main text. The red line represents the 50th percentile values. Percentiles were calculated using 30 years of simulated values of all four state variables.
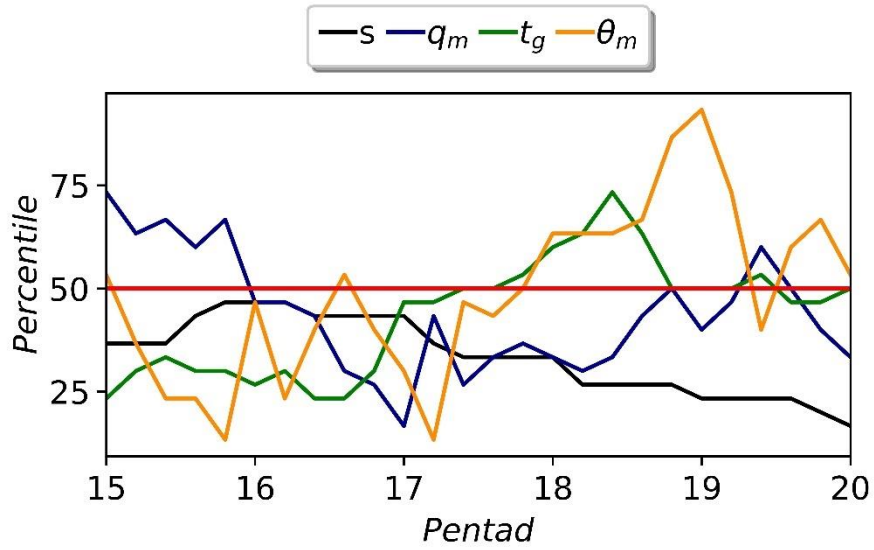
Figure S5: Soil moisture (s), mixed layer humidity (q_m), ground temperature (t_g), mixed layer temperature (θ_m) percentiles for the category 2 flash drought shown in Figure 4 of the main text. The red line represents the 50th percentile values. Percentiles were calculated using 30 years of simulated values of all four state variables.
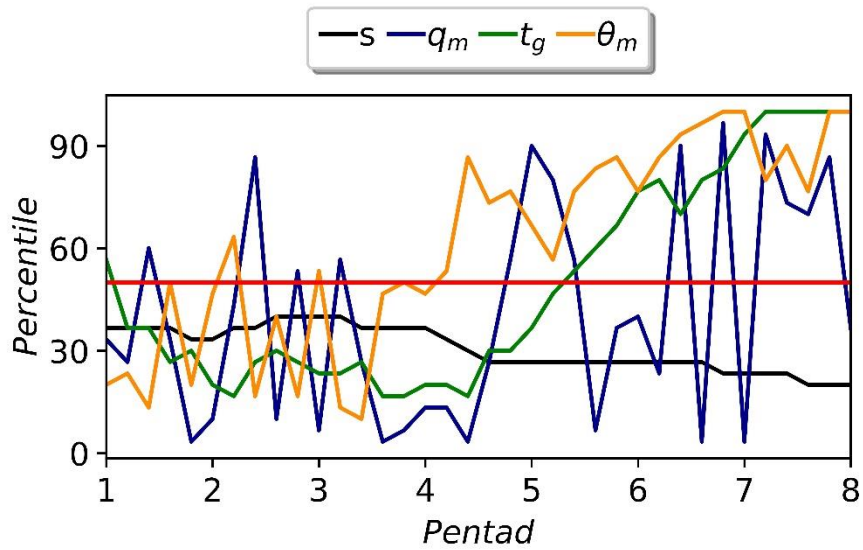

Figure S6: Soil moisture (s), mixed layer humidity (q_m), ground temperature (t_g), mixed layer temperature (θ_m) percentiles for the category 3 flash drought shown in Figure 5 of the main text. The red line represents the 50th percentile values. Percentiles were calculated using 30 years of simulated values of all four state variables.
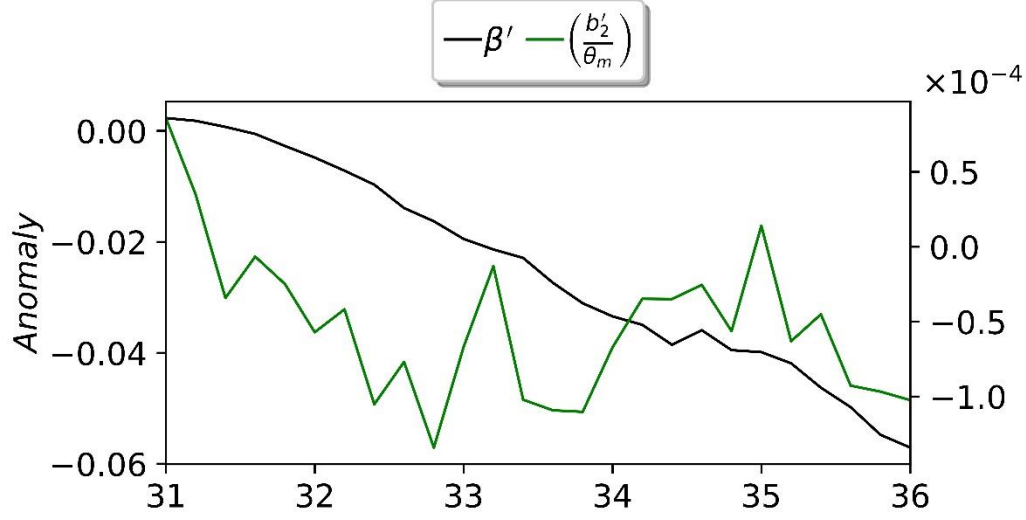
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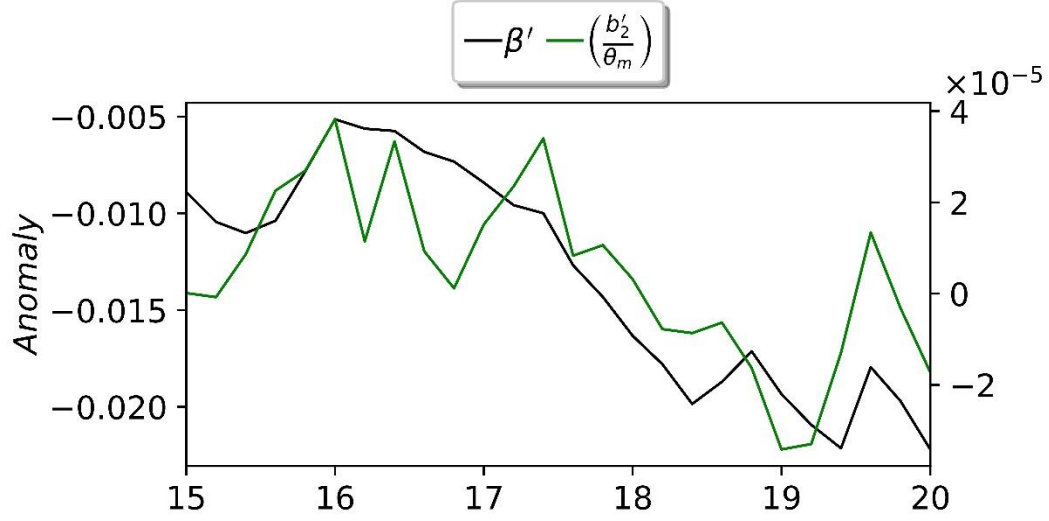

Figure S8: Anomalies of the components of $g^{s\_u_2}$ ((β) on primary Y-axis and $(\frac{b_2}{\theta_m})$ on secondary Y-axis) during the category 2 flash drought shown in Figure 4 of the main text ($\beta = s^c$, and $b_2 = \frac{\gamma}{\Delta+\gamma}$. θ_m is the atmospheric temperature)
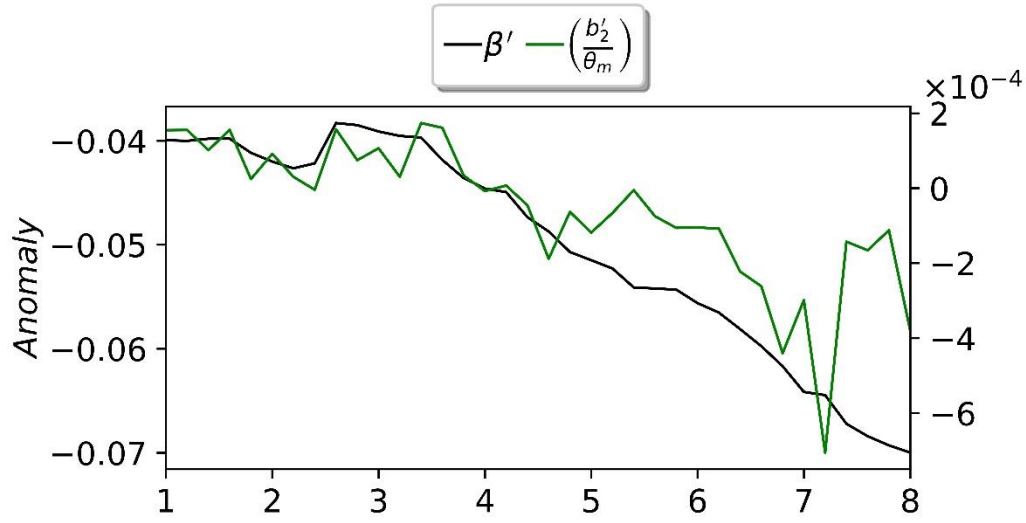
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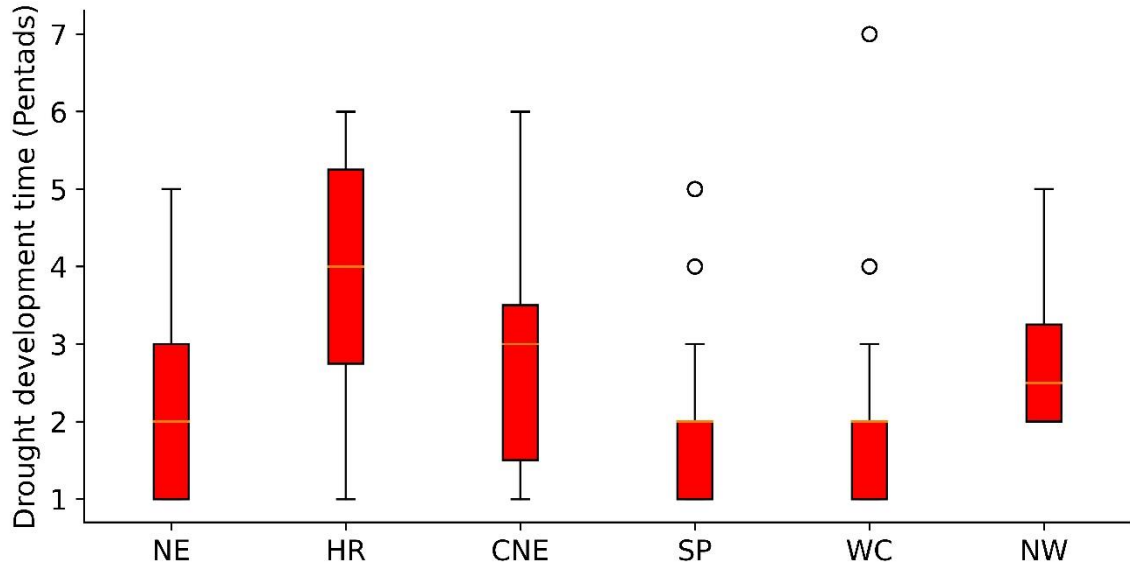

Figure S10: Box plots of flash drought development time in different regions of India. The flash drought development time is the period in pentads in which soil moisture falls from above 40th percentile to below 20th percentile.
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