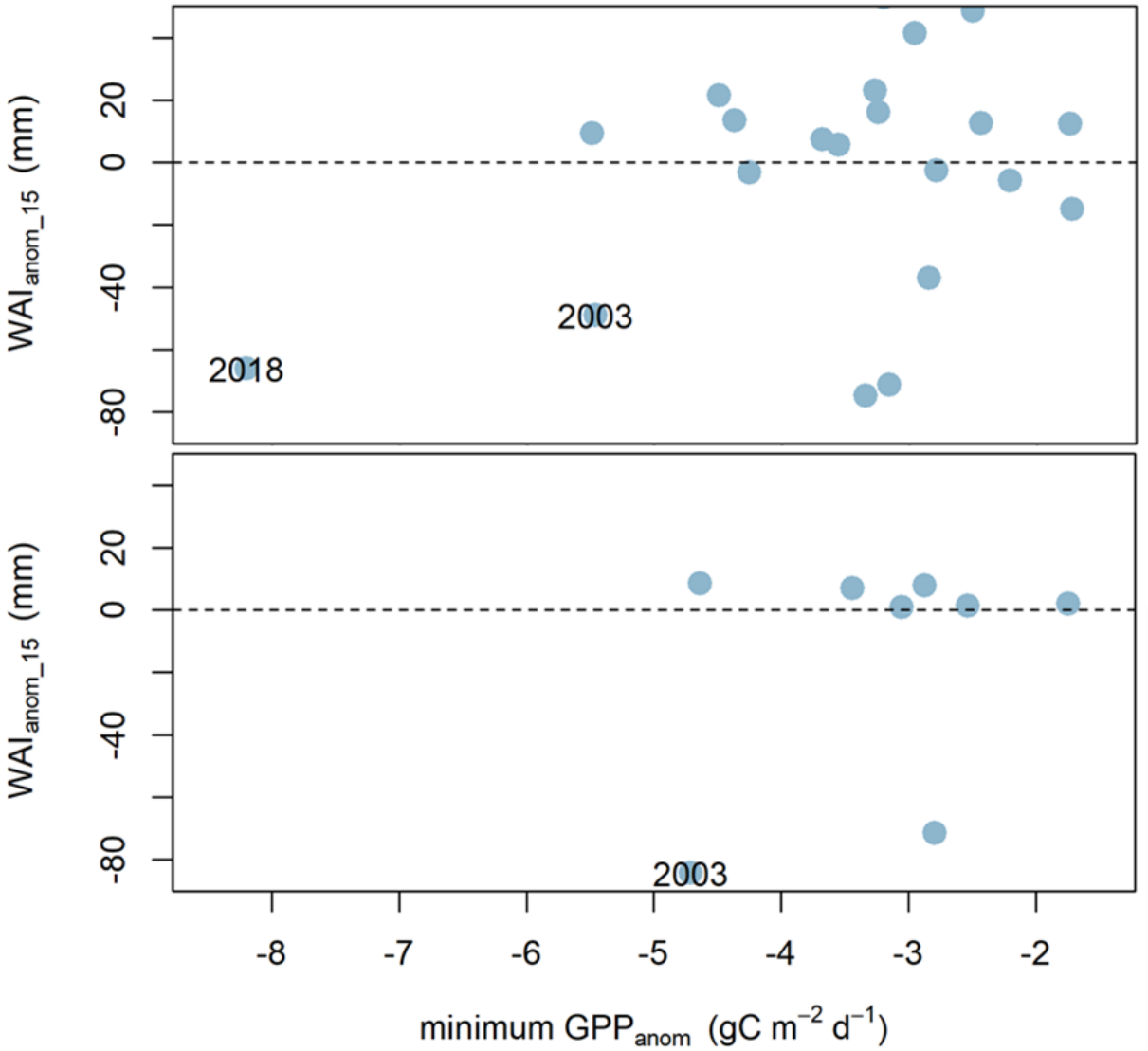


Figure S1. The minimum of GPP anomalies (minimum GPP_{anom}) and WAI anomalies during the day when minimum GPP_{anom} occurs and previous 14 days (mean WAI_{anom_15}) at a) DE-Hai and b) DE-Lnf.

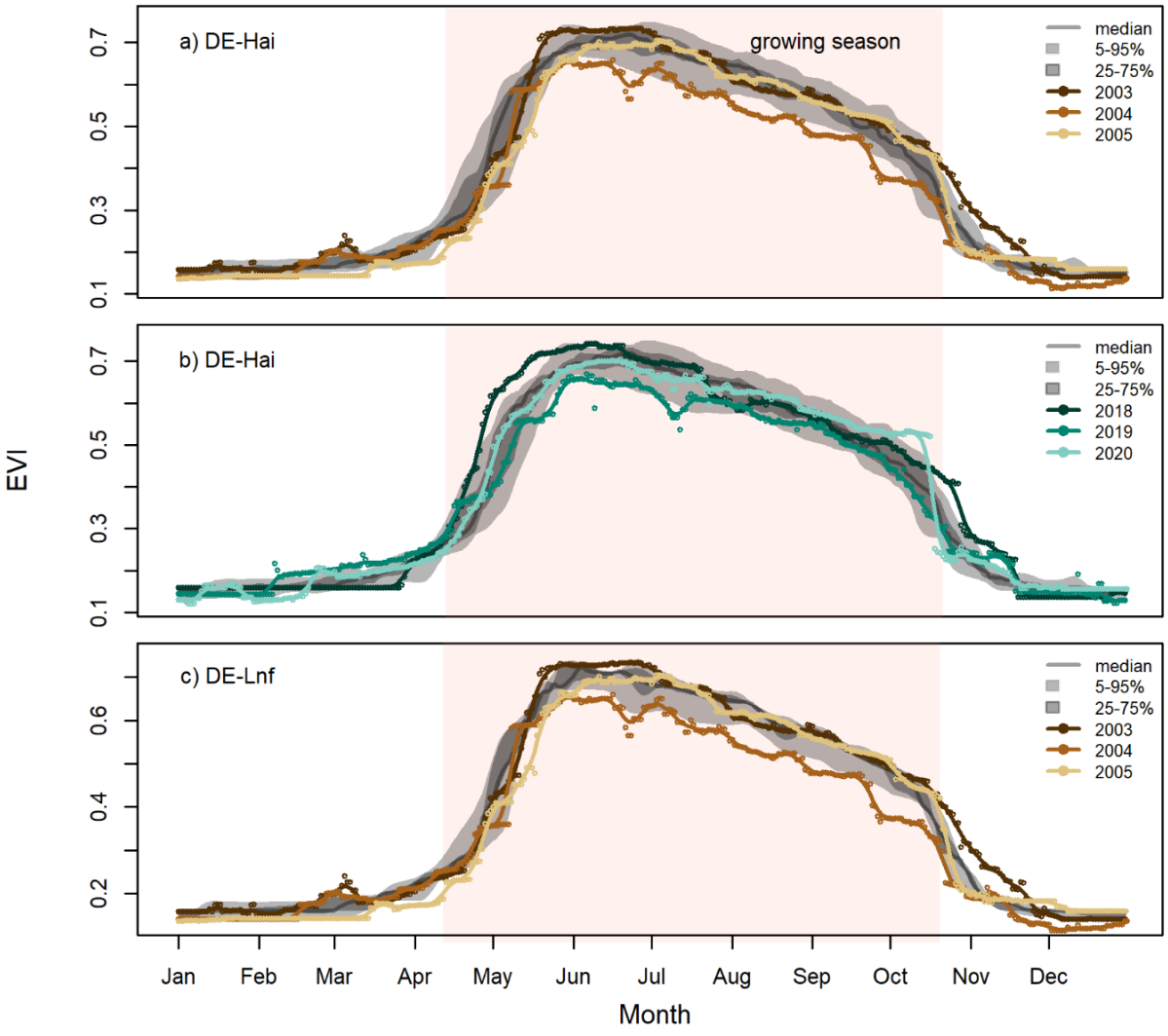
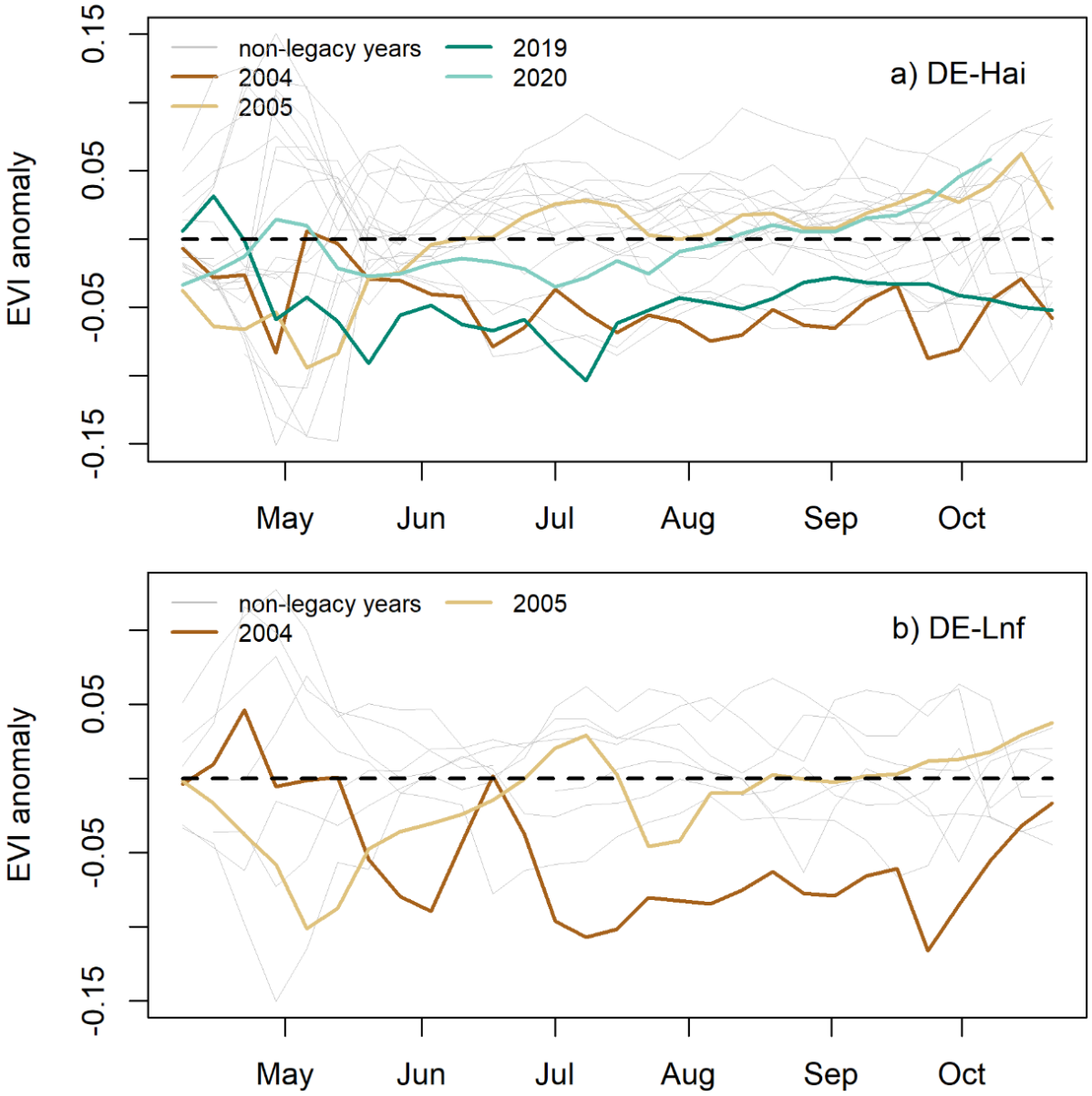


Figure S2. Daily enhanced vegetation index (EVI) in the selected drought and legacy years at a), b) DE-Hai (showing the 2003 and 2018 droughts, respectively) and c) DE-Lnf (showing the 2003 drought). Colored points and lines showed original and smoothed (7-days average) EVI, respectively, in drought and legacy years. The grey lines and shaded areas showed the median, 25th-75th (dark grey), and 5th-95th (light grey) percentiles of EVI, respectively, over non-drought and non-legacy years. The shaded coral areas indicated the average growing seasons of DE-Hai and DE-Lnf.



15 **Figure S3. Enhanced vegetation index (EVI) time series at a) DE-Hai and b) DE-Lnf. Colored lines were EVI anomalies in legacy years (2004, 2005, 2019, and 2020), while grey lines were EVI anomalies in non-legacy years (normal and drought years).**

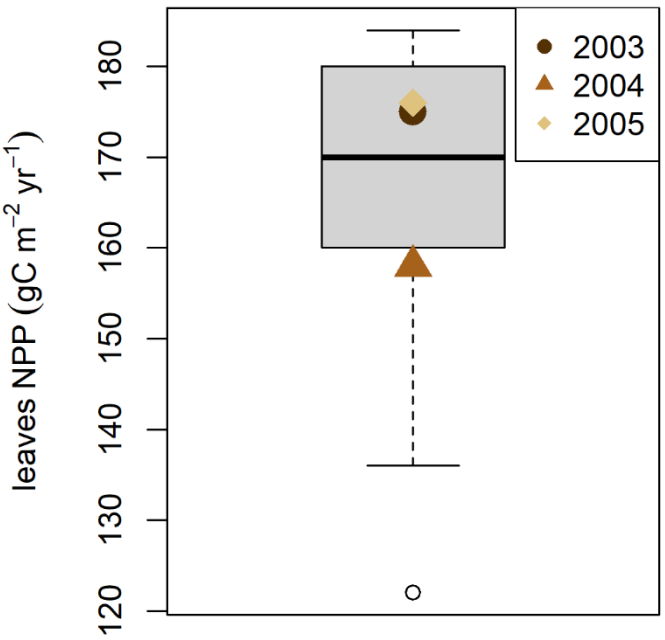


Figure S4. NPP of leaves in the footprint of eddy-covariance tower at DE-Hai. Colored points were leaves NPP in the drought year (2003) and legacy years (2004 and 2005). The boxplot showed NPP of leaves in other years.

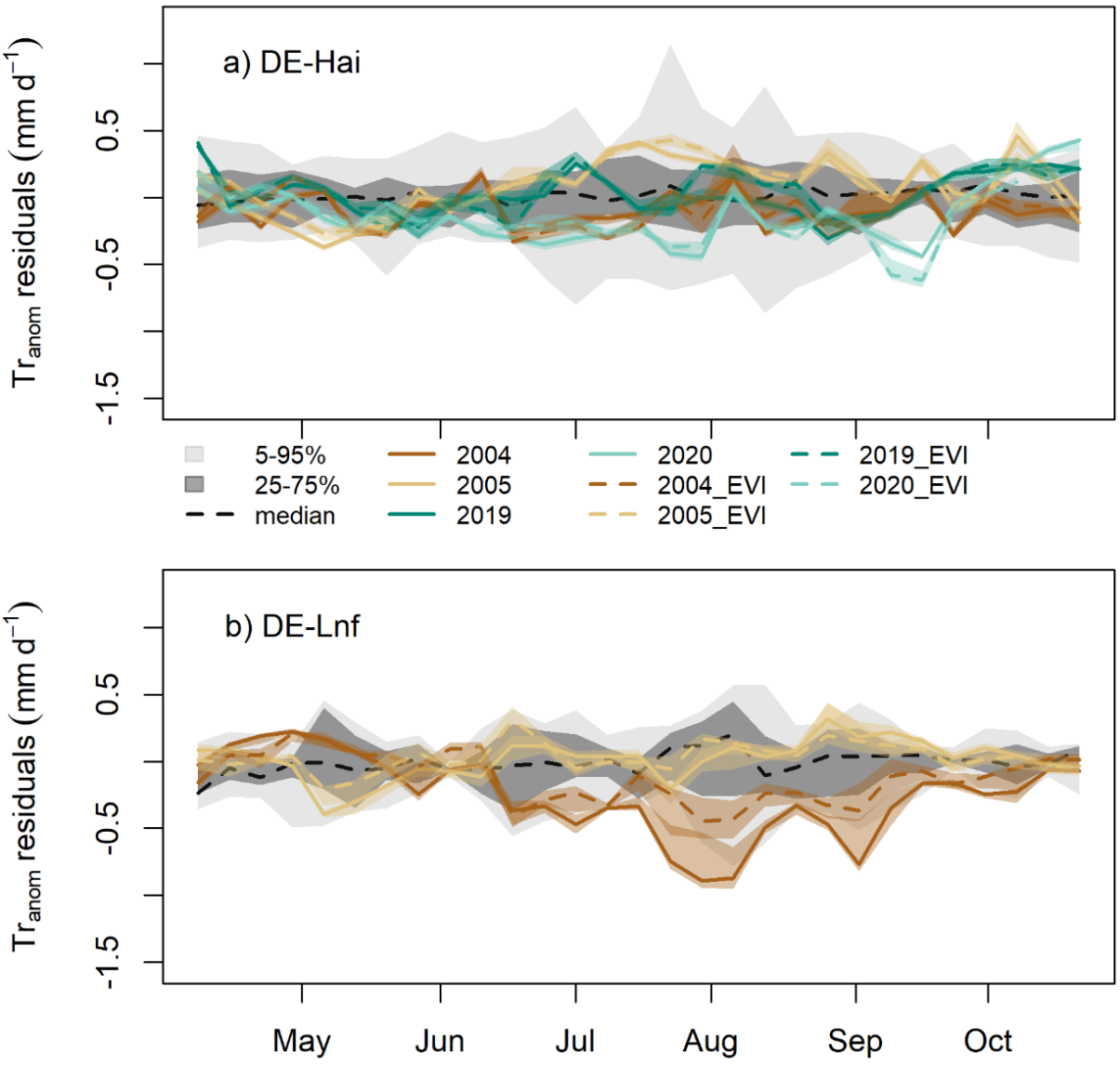


Figure S5. Residuals of transpiration (Tr) anomalies from RF and RF_{EVI} (see Section 3.6) in legacy years at a) DE-Hai and b) DE-Lnf. Residuals of GPP anomalies were characterized by observed minus predicted GPP anomalies (GPP_{anom} residuals). The color lines and bands showed the median and 5^{th}-95^{th} percentile GPP_{anom} residuals of ensemble model runs (see Section 3.4), respectively. The solid and dashed lines showed the residuals based on RF and RF_{EVI}, respectively. The model uncertainties from RF_{EVI} (dark and light grey shaded area, respectively) were characterized by the 25^{th}-75^{th} and 5^{th}-95^{th} quantile ranges of Tr_{anom} residuals in non-legacy years. The black dashed line was the median of Tr_{anom} residuals from RF_{EVI} in non-legacy years. The ticks denoted the start of each month.

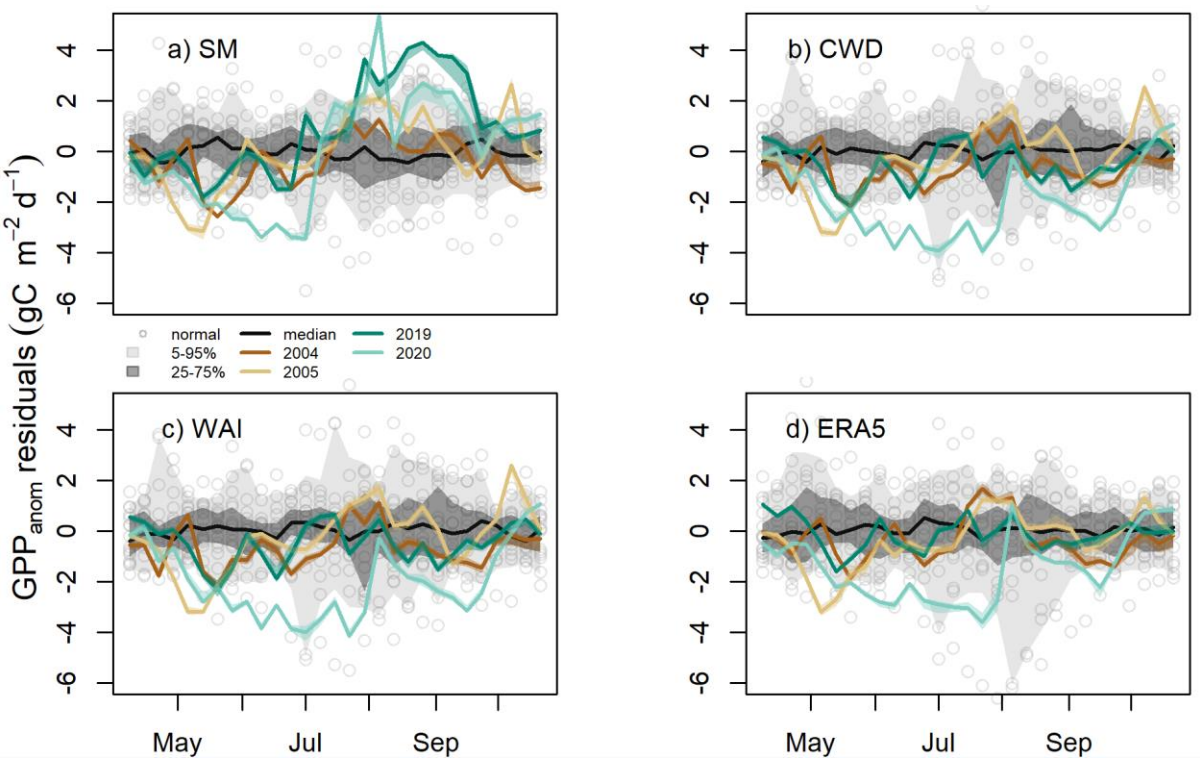


Figure S6. Residuals of GPP anomalies at seasonal scale in legacy years at DE-Hai from a) the model using observed soil moisture (SM), b) the model using cumulative water deficit (CWD), c) the model using estimated water availability index from a bucket model (WAI), and d) the model using soil moisture from ERA5 (ERA5). Legacy effects on GPP was characterized by observed minus predicted GPP anomalies (GPP_{anom} residuals). The model uncertainty (dark and light grey area, respectively) was characterized by the 25%-75% and 5%-95% quantile ranges of GPP_{anom} residuals in non-legacy years. The black line was the median of GPP_{anom} residuals in non-legacy years. CWD was estimated from cumulative differences between observed precipitation and evapotranspiration over dry periods at daily scale.

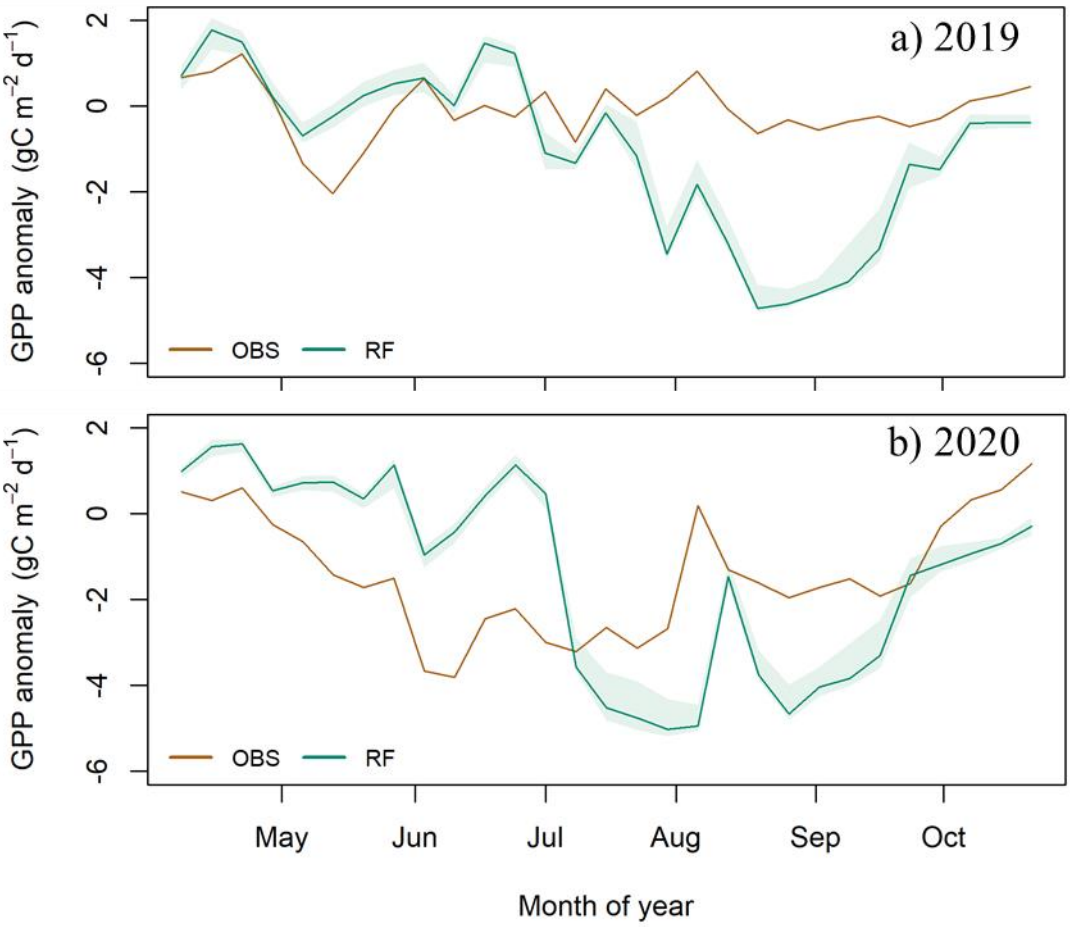


Figure S7. Observed (OBS) and predicted (RF) GPP anomalies in a) 2019 and b) 2020 at DE-Hai. The green area was 5-95% of predicted GPP anomalies from all loops (see Method).

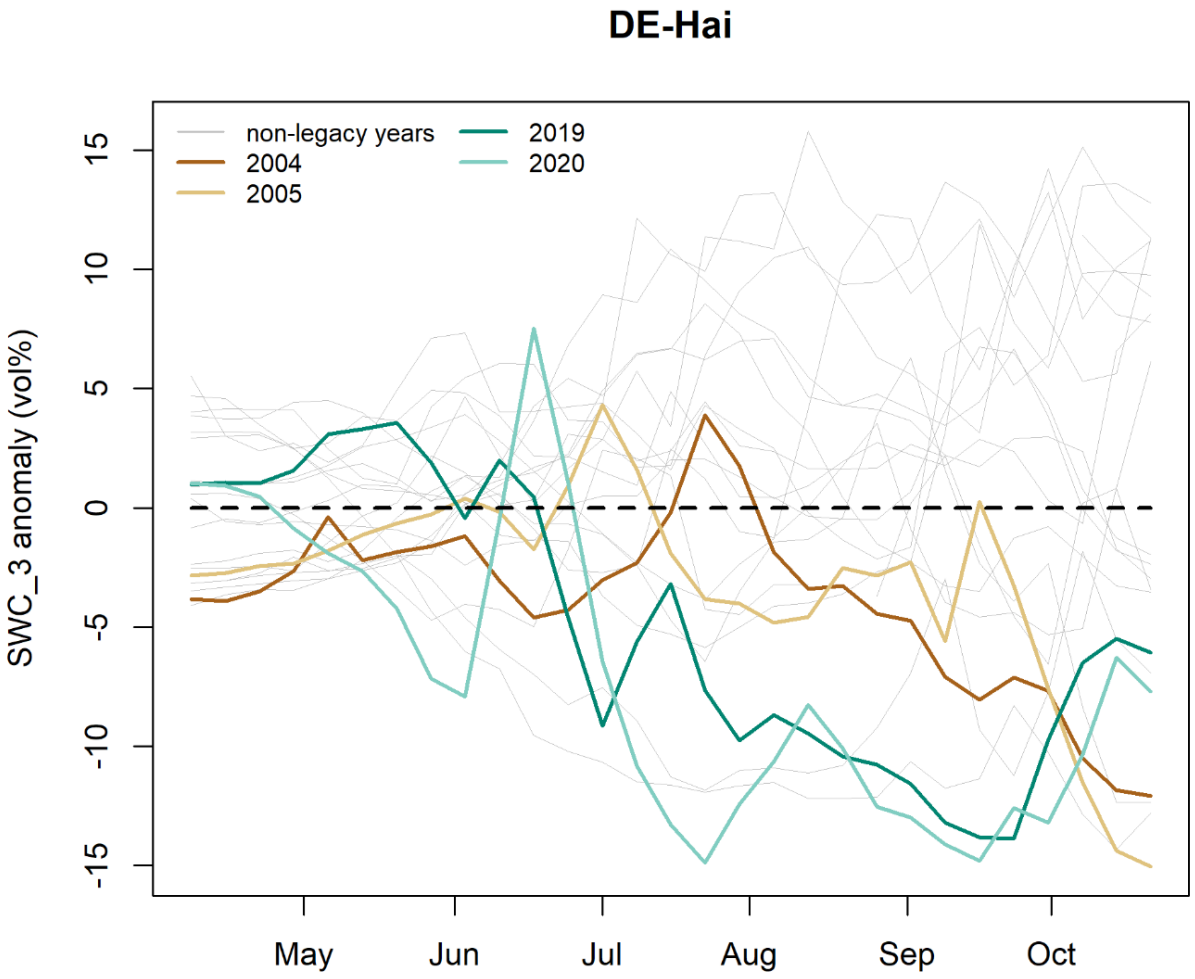


Figure S8. Soil water content at the third layer (30cm) anomalies (SWC_3 anomaly) at DE-Hai. Colored lines were SWC_3 anomalies in legacy years (2004, 2005, 2019, and 2020), while grey lines were SWC_3 anomalies in non-legacy years (normal and drought years).

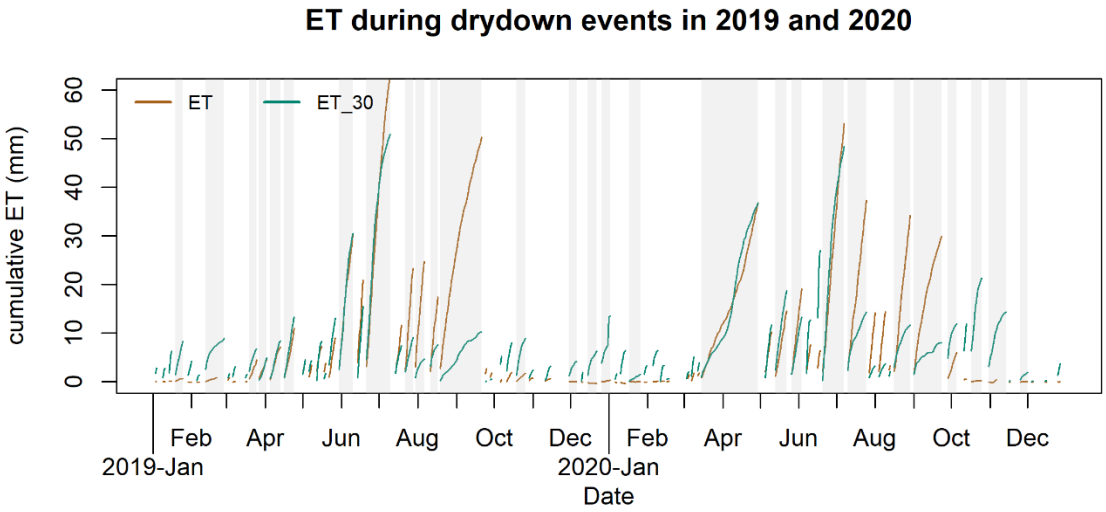


Figure S9. Cumulative evapotranspiration at 0~30cm (ET_30) and at the whole soil (ET) during dry-down periods (grey areas) in 2019 and 2020 at DE-Hai. Dry-down periods were identified as the periods when soil moisture at 0~30cm is continuously decreasing. ET_30 was estimated by summed soil moisture decreases at 0~30cm during dry-down periods. ET was the summed observation from eddy-covariance measurements during dry-down periods.