



*Supplement of*

## **Contrasting drought legacy effects on gross primary productivity in a mixed versus pure beech forest**

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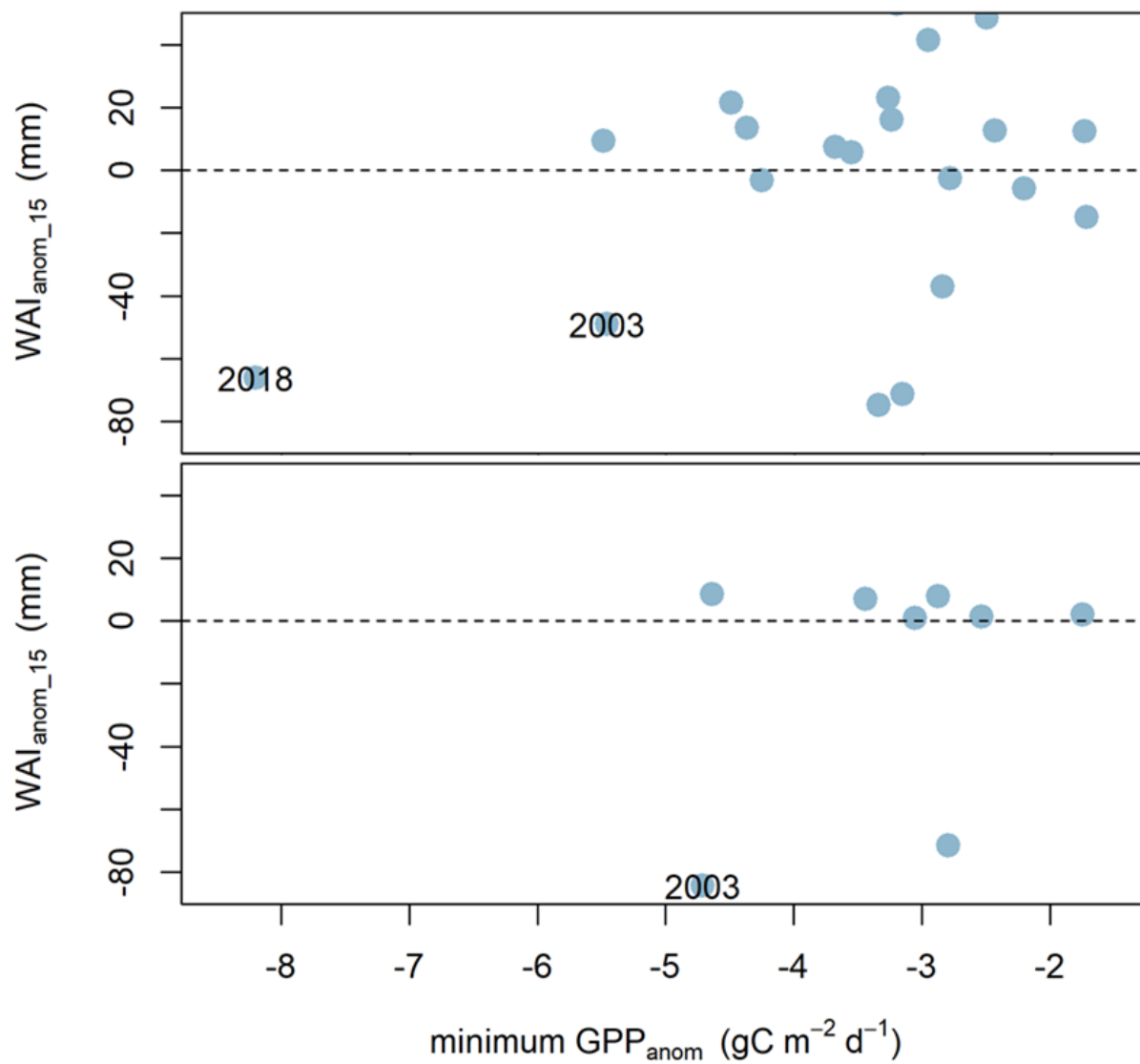
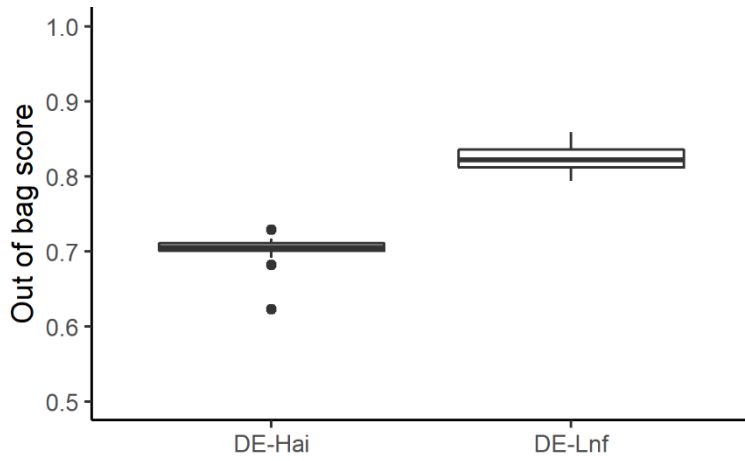
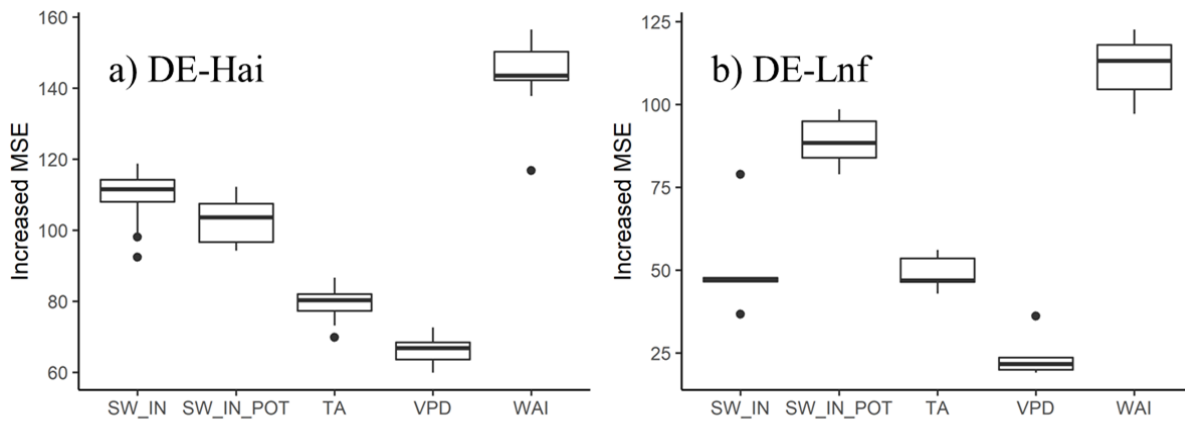


Figure S1. The minimum of GPP anomalies (minimum GPP<sub>anom</sub>) and WAI anomalies during the day when minimum GPP<sub>anom</sub> occurs and previous 14 days (mean WAI<sub>anom\_15</sub>) at a) DE-Hai and b) DE-Lnf.

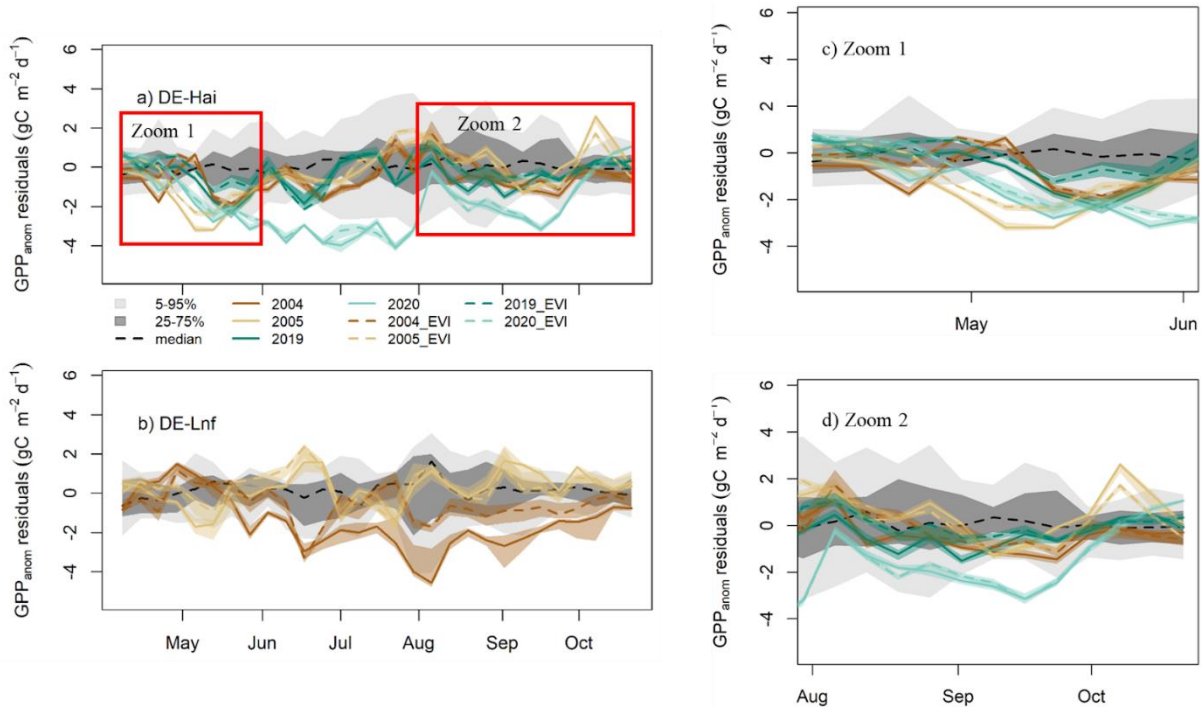


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**Figure S2. Out of bag scores of RF models at DE-Hai and DE-Lnf.** Since using leave-one-year-out strategy (see Section 3.4), each RF model for a resulting time series has its own OOB score.

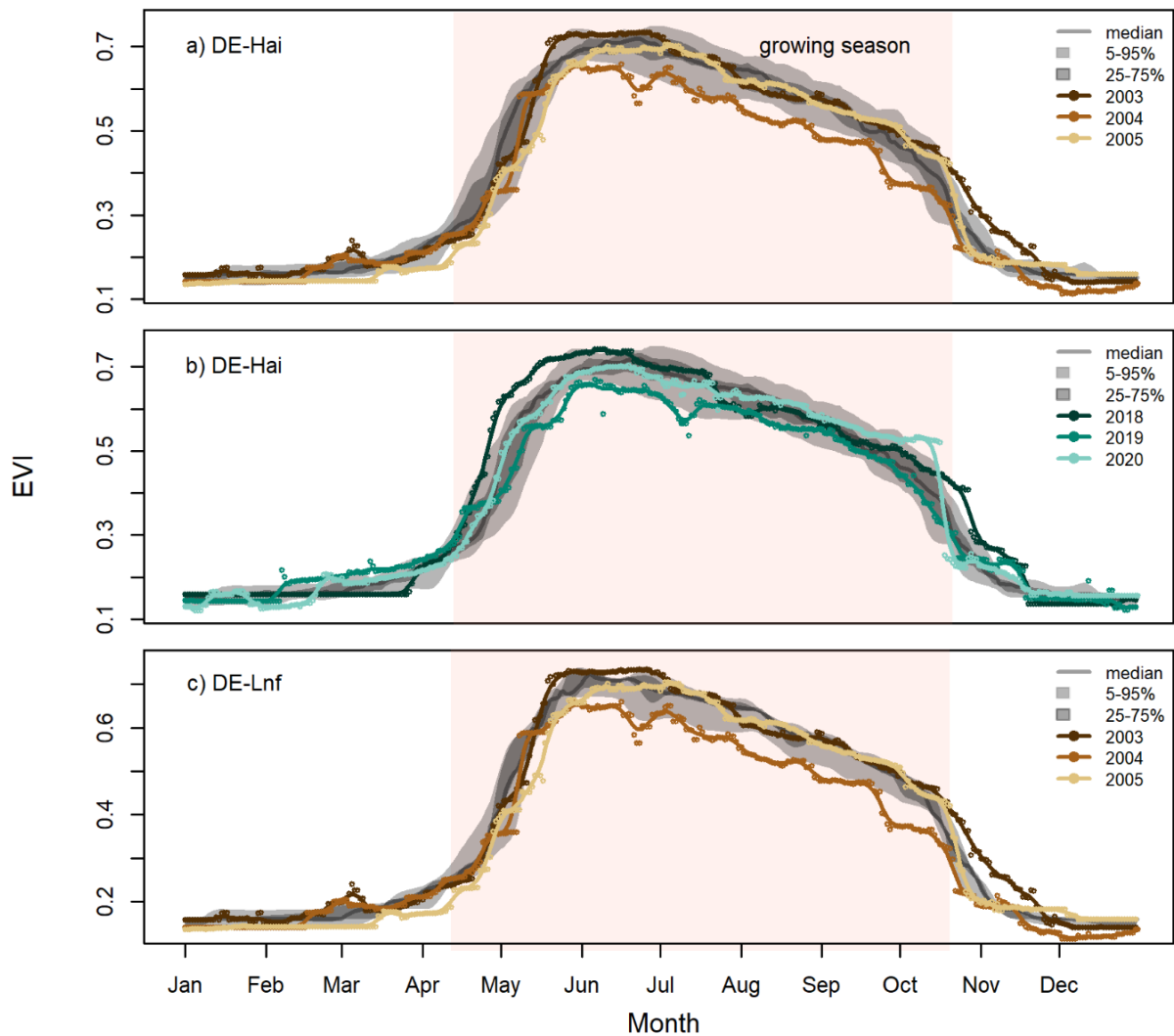


10 **Figure S3. Variable importance, indicated by increased MSE, of RF models at DE-Hai and DE-Lnf.** Since using leave-one-year-out strategy (see Section 3.4), each RF model for a resulting time series has its own variable importance.

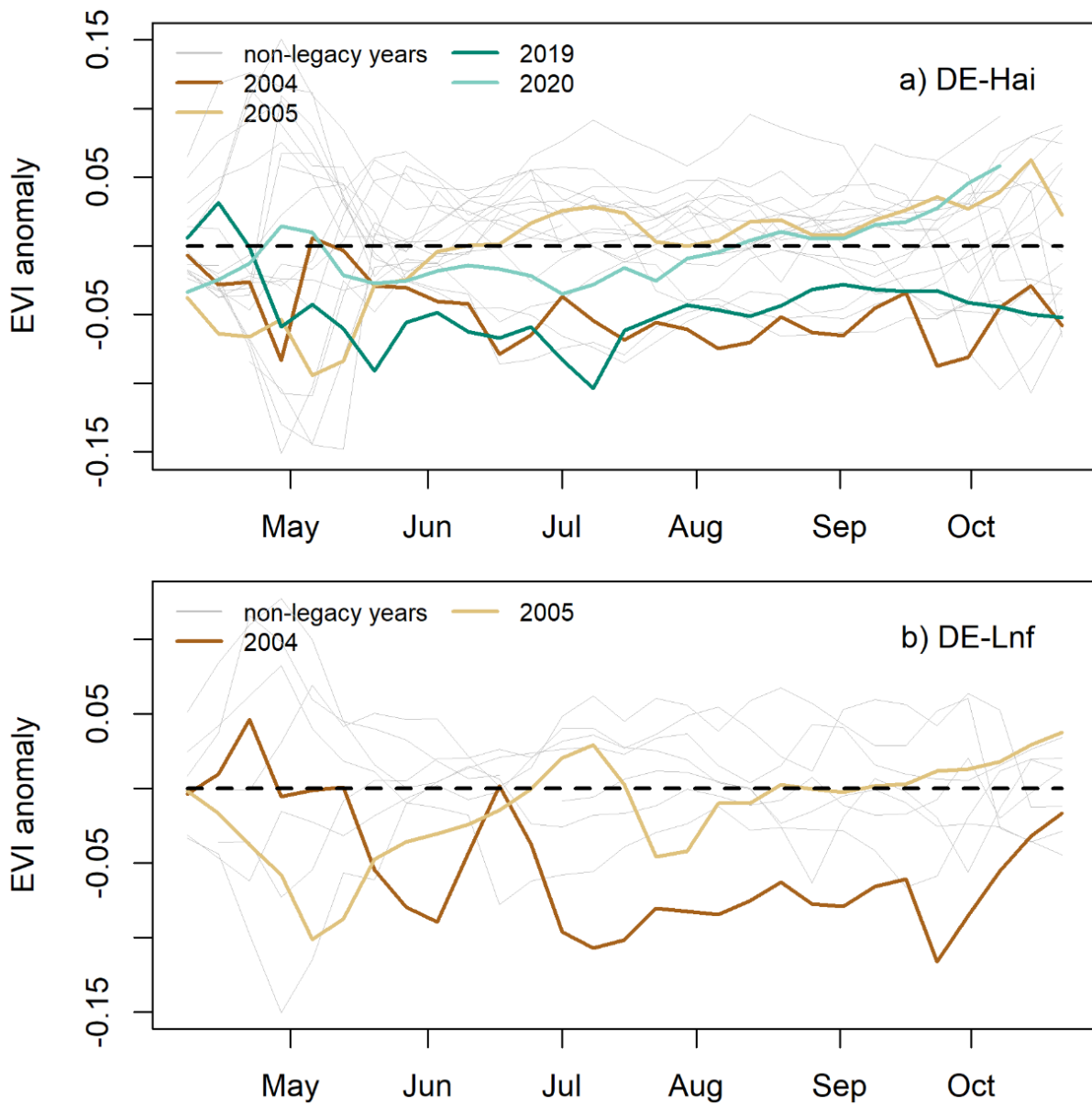


15 **Figure S4. Residuals of GPP anomalies from RF and RF<sub>EVI</sub>** (see Section 3.6) in legacy years at **a) DE-Hai** and **b) DE-Lnf**. Residuals of GPP anomalies are characterized by observed minus predicted GPP anomalies (GPP<sub>anom</sub> residuals). The color lines and bands show the median and 5<sup>th</sup>-95<sup>th</sup> percentile GPP<sub>anom</sub> residuals of ensemble model runs (see Section 3.4), respectively. The solid and dashed lines show the residuals based on RF and RF<sub>EVI</sub>, respectively. The model uncertainties from RF<sub>EVI</sub> (dark and light grey shaded area, respectively) are characterized by the 25<sup>th</sup>-75<sup>th</sup> and 5<sup>th</sup>-95<sup>th</sup> quantile ranges of GPP<sub>anom</sub> residuals in non-legacy years. The black dashed line was the median of GPP<sub>anom</sub> residuals from RF<sub>EVI</sub> in non-legacy years. The ticks denoted the start of each month. Panel c and d show in more detail results in April-June and August-October at DE-Hai, respectively.

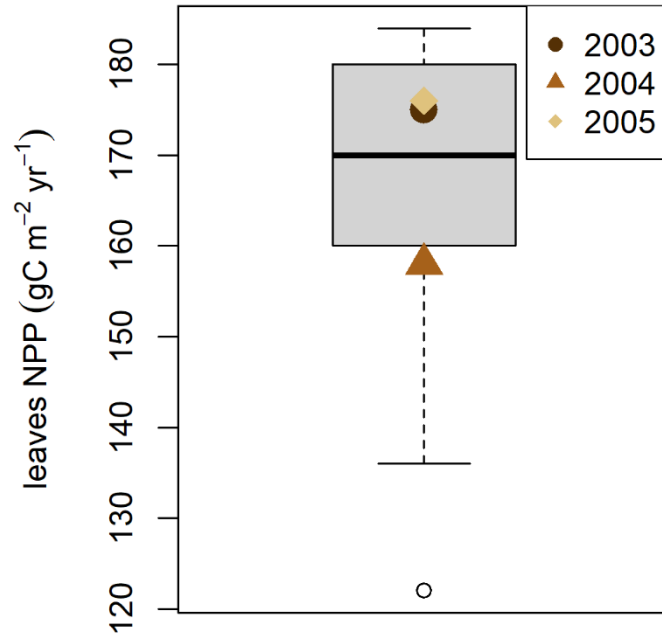
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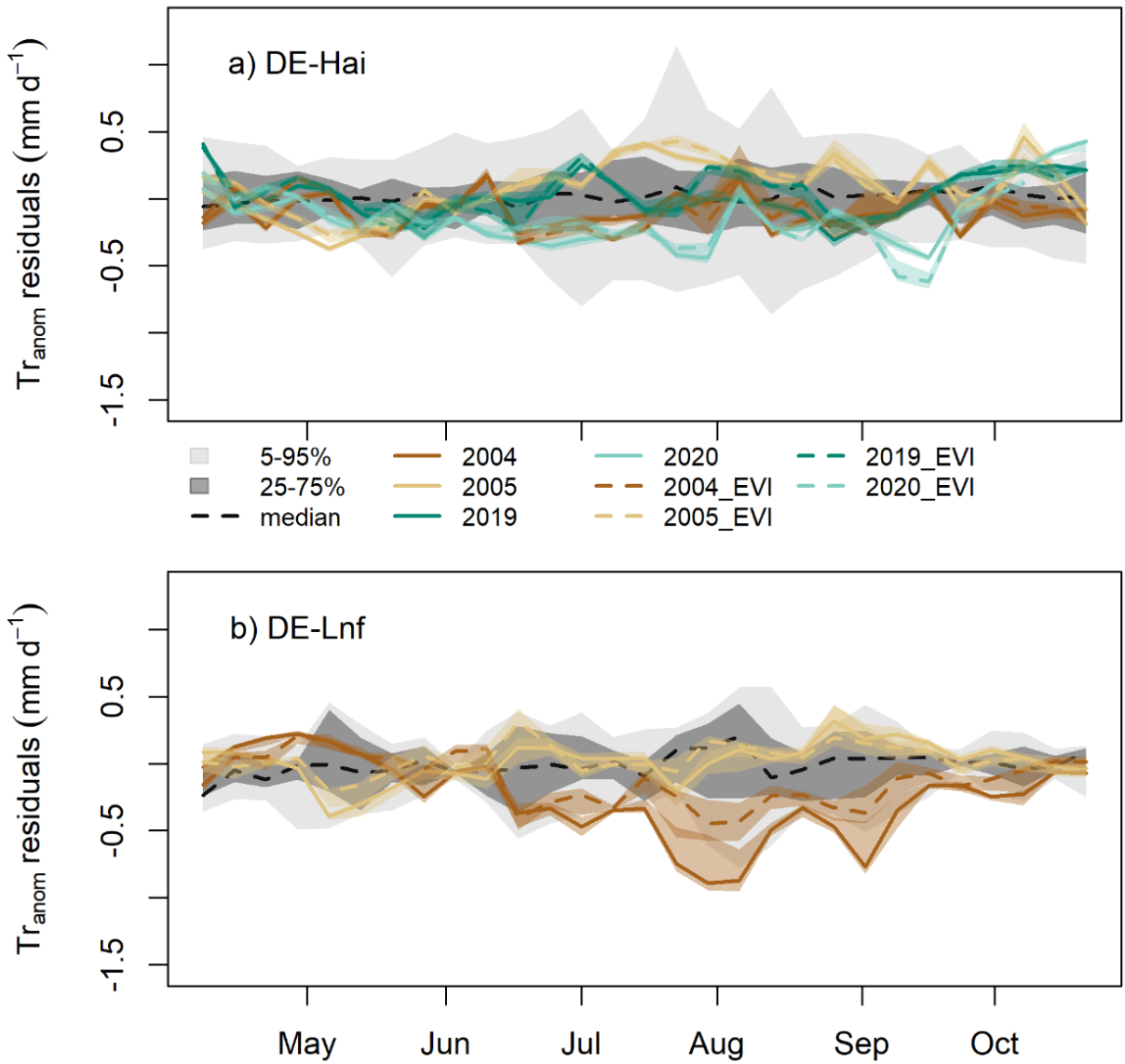
25 **Figure S5. Daily EVI in the selected drought and legacy years at a) DE-Hai 2003, b) DE-Hai 2018 and c) DE-Lnf 2003 showing the droughts and following legacy years, respectively.** Colored points and lines showed original and smoothed (7-days average) EVI, respectively, in drought and legacy years. 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.



30 Figure S6. 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).



35 **Figure S7. 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.**

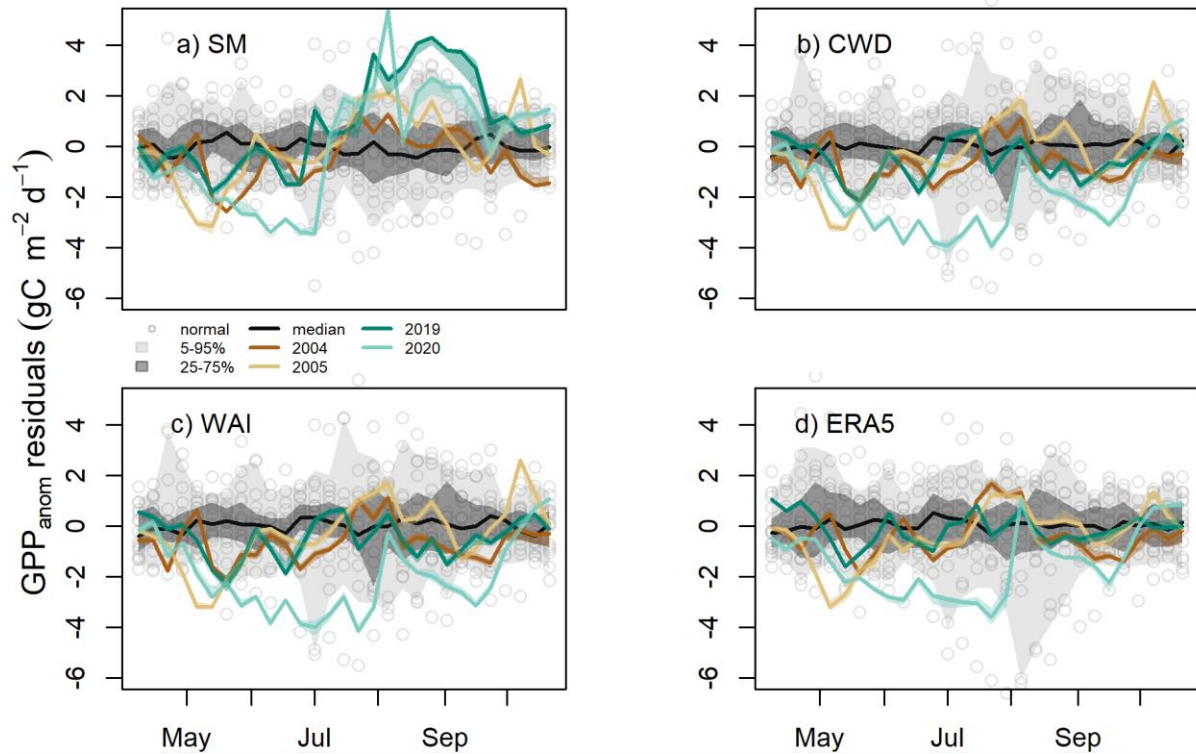


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**Figure S8. Residuals of transpiration ( $Tr$ ) anomalies from RF and  $RF_{EVI}$  (see Section 3.6) in legacy years at a) DE-Hai and b) DE-Lnf.** Residuals of GPP anomalies were characterized by observed minus predicted GPP anomalies ( $GPP_{anom}$  residuals). The color lines and bands showed the median and 5<sup>th</sup>-95<sup>th</sup> 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<sup>th</sup>-75<sup>th</sup> and 5<sup>th</sup>-95<sup>th</sup> 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.

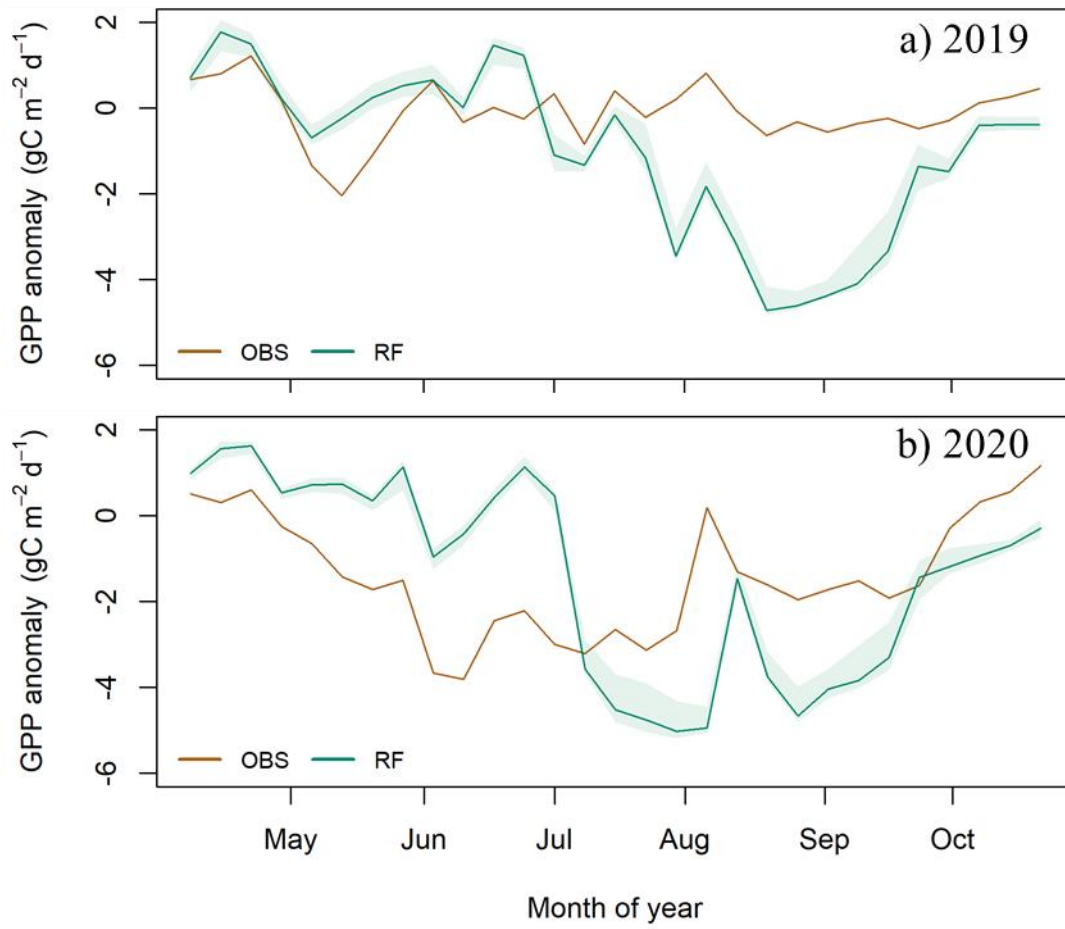
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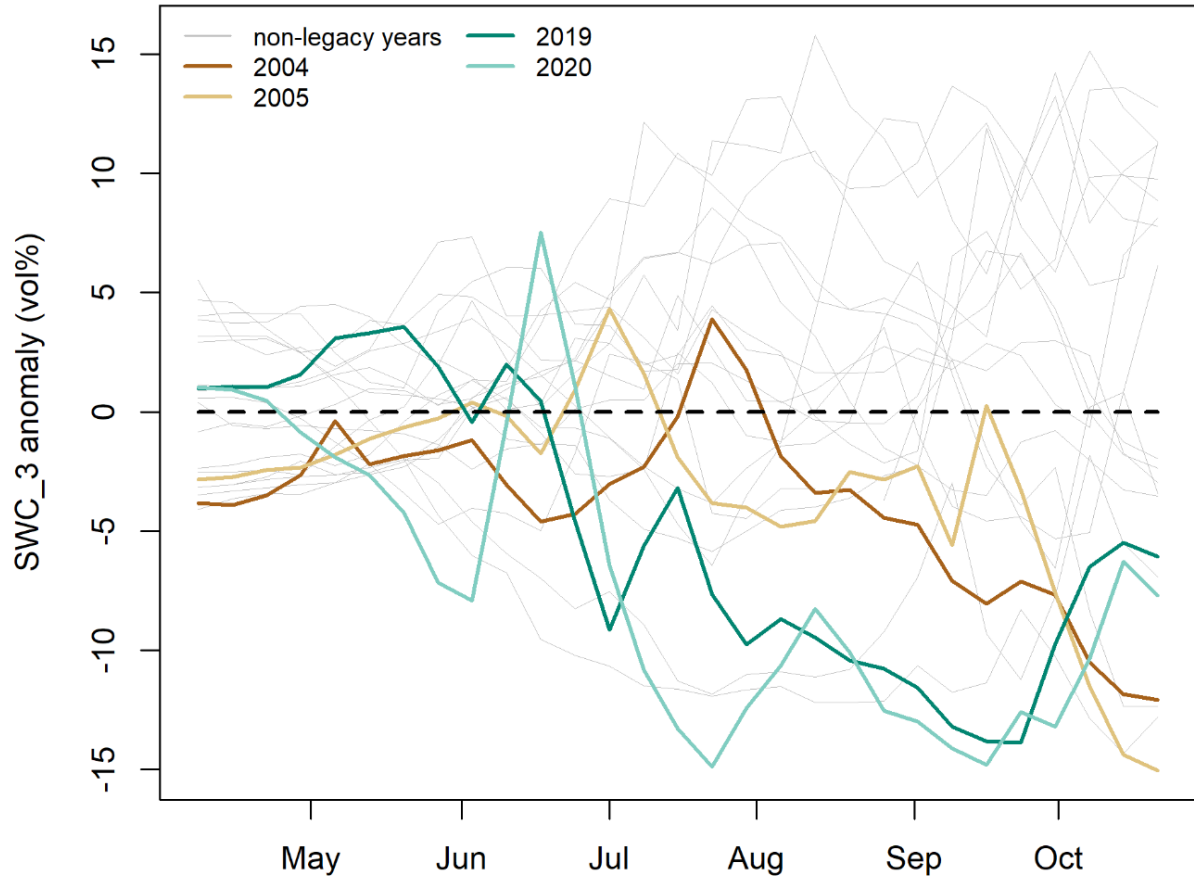
50 **Figure S9. Residuals of GPP anomalies at seasonal scale in legacy years at DE-Hai from a) the model using observed soil moisture (SM), b) the model using cumulative water deficit (CWD), c) the model using estimated water availability index from a bucket model (WAI), and d) the model using soil moisture 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.

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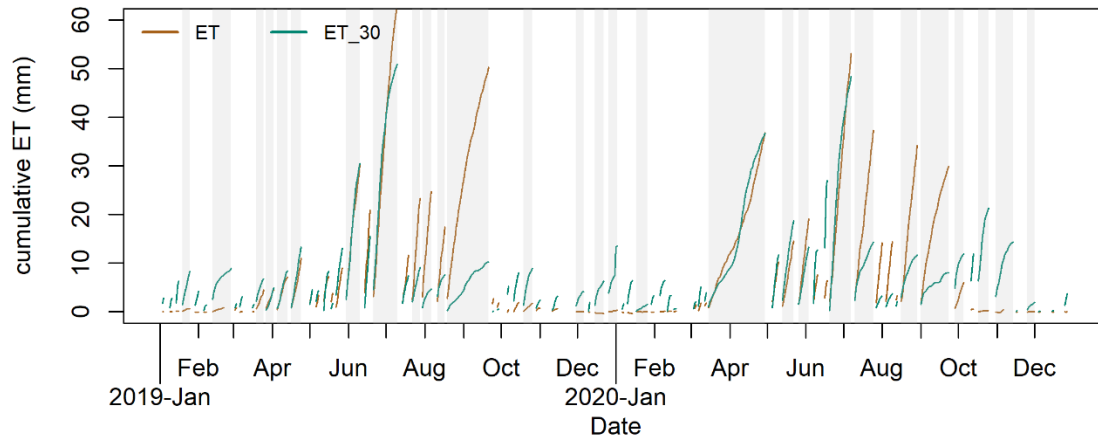
60 **Figure S10. Observed (OBS) and predicted (RF) GPP anomalies in a) 2019 and b) 2020 at DE-Hai.** The green area was 5-95% of predicted GPP anomalies from all loops (see Method).

## DE-Hai



65 **Figure S11. 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).

### ET during drydown events in 2019 and 2020



70 **Figure S12. 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.