A global function of climatic aridity accounts for soil moisture stress on carbon assimilation

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Supplementary Information

This Supplementary Information contains the following tables and figures:

Supplementary Table 1. Characteristics of the flux tower sites used in the analysis, giving the unique code for each site (Site ID), latitude, longitude, elevation, calculated aridity index (AI), climate classification, vegetation classification, sampling years (recording period) and reference. The climate type follows Köppen system, where Aw is tropical savanna, Am is tropical monsoon, BSk is cold semi-arid or steppe, BSh is hot semi-arid or steppe, BWh is hot arid desert, Csa is temperate with dry hot summer, Cfa is temperate with no dry season and hot summer, Cfb is temperate with no dry season and warm summer, Cwa is temperate with dry winter and hot summer, Dfc is continental with no dry season and cold summer, Dwb is continental with dry winter and warm summer, Dfb is continental with no dry season and warm summer, and ET is polar tundra. The ecosystem type is based on the International Geosphere–Biosphere Programme (IGBP) definition, where ENF is evergreen needleleaf forest, DBF is deciduous broadleaf forest, EBF is evergreen broadleaf forest, MF is mixed forest, WSA is woody savanna, SAV is savanna, CSH is closed shrubland, OSH is open shrubland, and GRA is grassland.

Supplementary Figure 1: Box-plot showing the range of intercept values obtained across all the flux tower sites, grouped by aridity class. The black line is the median value, the box is the interquartile range and the whiskers show the range, with outliers shown as asterisks. The median value is not significantly different from zero.

Supplementary Figure 2: Values of the fitted maximum $\beta(\theta)$ ratio (the ratio of actual flux-derived to modelled well-watered gross primary production) and the critical threshold value of soil moisture for all 67 sites used in the analysis, where the intercept is assumed to be zero. The $\beta(\theta)$ ratio and the soil water content (swc) are both unitless. Note that the scale above 1 has been compressed for visualization purposes.

Supplementary Figure 3: Values of the fitted maximum $\beta(\theta)$ ratio (the ratio of actual flux-derived to modelled well-watered gross primary production) and the critical threshold value of soil moisture for all 67 sites used in the analysis, where the intercept is assumed to be zero (green line) or not fixed (red line). The $\beta(\theta)$ ratio and the soil water content (swc) are both unitless. Note that the scale above 1 has been compressed for visualization purposes.
Supplementary Figure 4: The fitted non-linear regression model of the maximum level (top) and the critical threshold (bottom) of the $\beta(\theta)$ ratio (the ratio of observed to predicted gross primary production) against the aridity index, where the sites are classified according to vegetation type and precipitation phase.

Supplementary Figure 5: The fitted non-linear regression model of the maximum level (top) and the critical threshold (bottom) of the $\beta(\theta)$ ratio (the ratio of observed to predicted gross primary production) against the aridity index, where the sites are classified according to vegetation type and precipitation concentration.

Supplementary Figure 6: The impact of the application of the new soil moisture stress function on simulated gross primary production ($\text{GPP}_{\text{new}}$) at flux tower sites classified as arid (aridity index, AI $>5$). The new model is compared to the simulated level of GPP under well-watered conditions ($\text{GPP}_{\text{ww}}$) and to flux-derived values ($\text{GPP}_{\text{obs}}$).

Supplementary Figure 7: The impact of the application of the new soil moisture stress function on simulated gross primary production ($\text{GPP}_{\text{new}}$) at flux tower sites classified as semi-arid (aridity index, AI between 2 and 5). The new model is compared to the simulated level of GPP under well-watered conditions ($\text{GPP}_{\text{ww}}$) and to flux-derived values ($\text{GPP}_{\text{obs}}$).

Supplementary Figure 8: The impact of the application of the new soil moisture stress function on simulated gross primary production ($\text{GPP}_{\text{new}}$) at flux tower sites classified as humid (aridity index, AI $<2$). The new model is compared to the simulated level of GPP under well-watered conditions ($\text{GPP}_{\text{ww}}$) and to flux-derived values ($\text{GPP}_{\text{obs}}$).

Supplementary Figure 9: Comparison of simulated gross primary production including the new soil-moisture stress function ($\text{GPP}_{\text{new}}$) and the original stress function ($\text{GPP}_{\text{v1.0}}$) from Stocker et al. (2020) against flux-derived values ($\text{GPP}_{\text{obs}}$) at flux tower sites classified as arid (aridity index, AI $>5$).

Supplementary Figure 10: Comparison of simulated gross primary production including the new soil-moisture stress function ($\text{GPP}_{\text{new}}$) and the original stress function ($\text{GPP}_{\text{v1.0}}$) from Stocker et al. (2020) against flux-derived values ($\text{GPP}_{\text{obs}}$) at flux tower sites classified as semi-arid (aridity index, AI = between 2 and 5).

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<table>
<thead>
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<th>Site ID</th>
<th>Latitude (°)</th>
<th>Longitude (°)</th>
<th>Elevation (m)</th>
<th>AI</th>
<th>Climate</th>
<th>IGBP</th>
<th>Recording period</th>
<th>Reference</th>
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References for Table 1


Kurbatova, J., Li, C., Varlagin, A., Xiao, X., and Vygodskaya, N.: Modeling carbon dynamics in two adjacent spruce forests with different soil conditions in Russia, Biogeosci., 5, 969–980, 2008.


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Figure 8 (continued)
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Figure 11 (continued)