Climate sensitivity of global seasonal forests inferred from remote sensing versus dendrochronology*

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Abstract

Dendroclimatology research offers insights on how trees respond to climate anomalies and climate trends through historical analysis. However, tree ring databases cannot be easily updated with recent observations. Here, we test if a remotely sensed area under the curve metric from the Enhanced Vegetation Index (EVI) can serve as tree ring equivalent to study growth–climate relationships. The results show that EVI-inferred vegetation sensitivity to climate broadly mirrors forest growth limitations inferred from tree ring analysis. A univariate drought sensitivity index correlates between r=0.35 (individual trees vs. single grid cells) and 0.52 (ecoregion averages). A cluster-based multivariate response function analysis shows misclassification error rates between 0.36 and 0.55% depending on how narrow the required match in multiple variables is defined. While there are apparent differences in response functions derived from tree rings versus EVI, the discrepancies arise primarily from how trees partition photosynthate into current and next year's growth, and the differences do not affect inferences on climatic growth limitations. We conclude that dendroclimatology methods applied to remotely sensed time series of EVI data can provide global, regional, and local characterization of climatic limiting factors of forest ecosystems with global coverage, spatial resolution, and timeliness that could not be obtained from dendrochronology research alone.

Keywords: Dendroclimatology, enhanced vegetation index, limiting climate factors, climatic vulnerabilities, forest ecosystems.

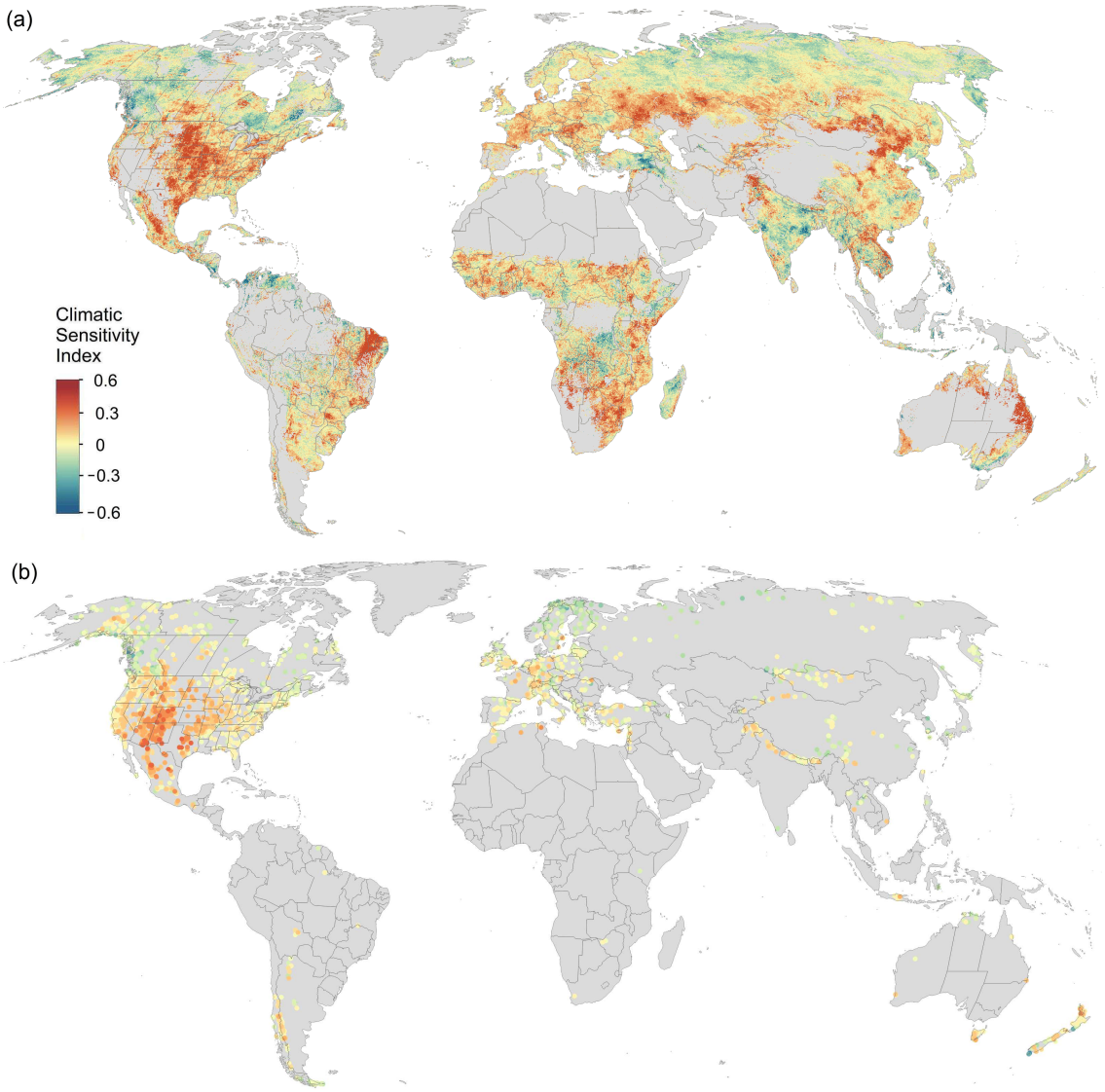

Figure 1. Forest sensitivity to drought, measured as average monthly precipitation correlations minus average monthly temperature correlations, for (a) remotely sensed EVI area under the curve for 250m grid cells classified as forests, aggregated to 5 km cells and (b) tree ring chronology locations. Red indicates drought limited regions while blue areas indicate cold or cloud/light limited environments.

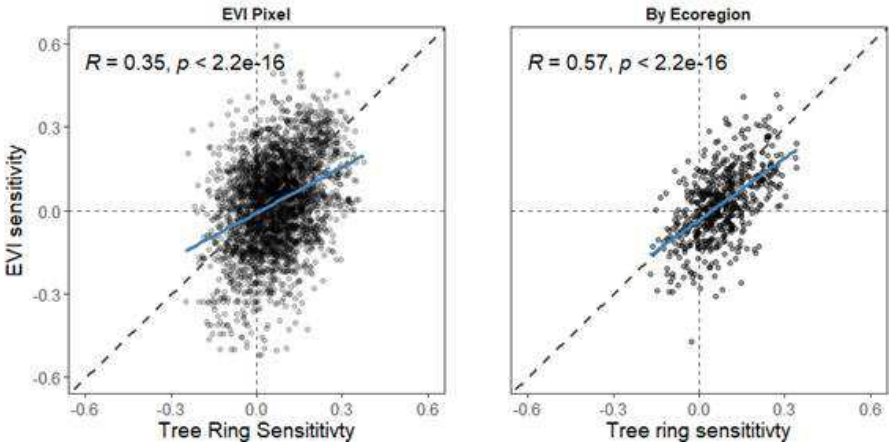

Figure 2. Comparison of forest drought sensitivity inferred from tree ring chronologies versus remotely sensed EVI area under the curve, for (a) the EVI grid cell that contains the tree ring sample location, and (b) sensitivity estimates from EVI grid cells and tree rings averaged by ecoregion.

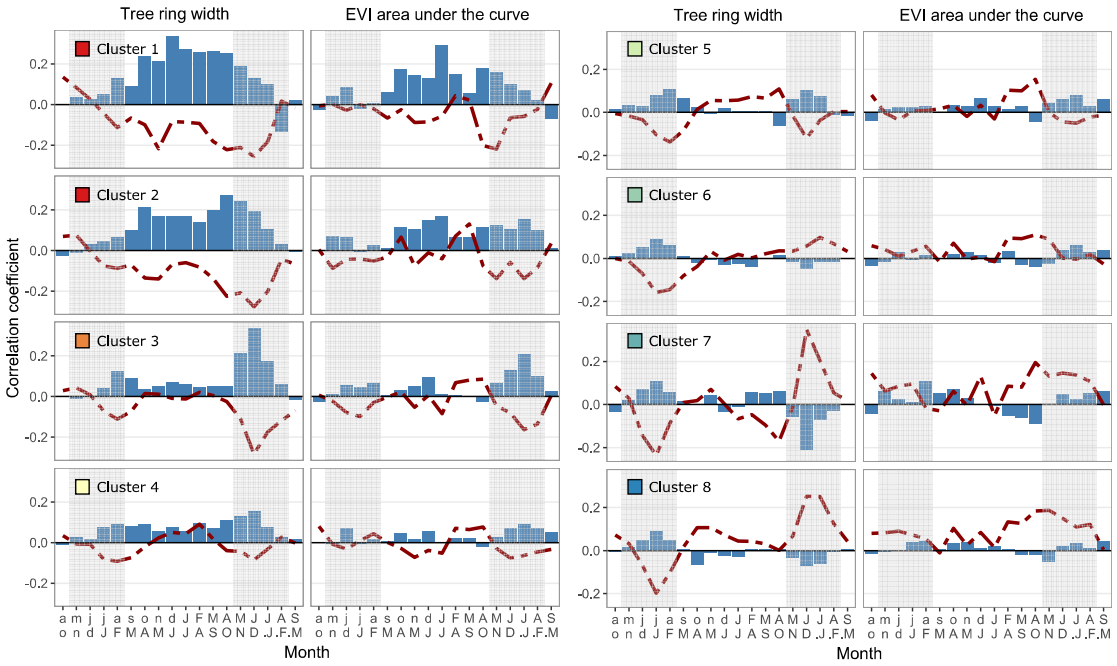

Figure 3. Comparison of tree-ring versus EVI-based monthly temperature (red line) and precipitation (blue bars) limitations for 18 months prior the end of the current growing season. The values are averages for chronology sites, and corresponding EVI grid cells that contain the tree ring sample locations. Typical growing season periods are highlighted in gray, and months in the top and bottom row are for the northern and southern hemisphere, respectively.

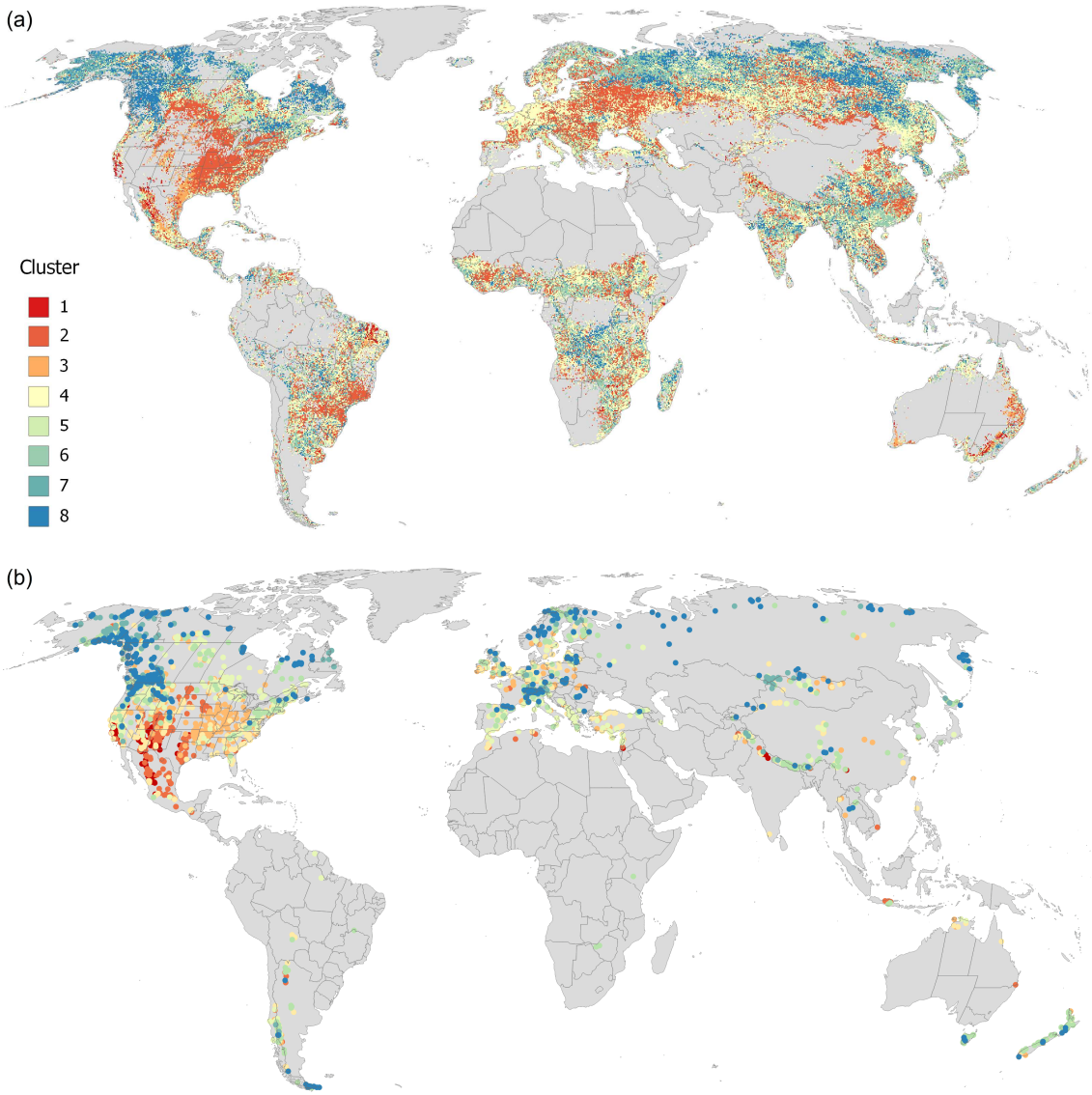

Figure 4. Cluster membership of (a) EVI grid cells and (b) tree ring chronologies, representing multivariate climatic limitations as shown in Fig. 3.