Supplementary Information
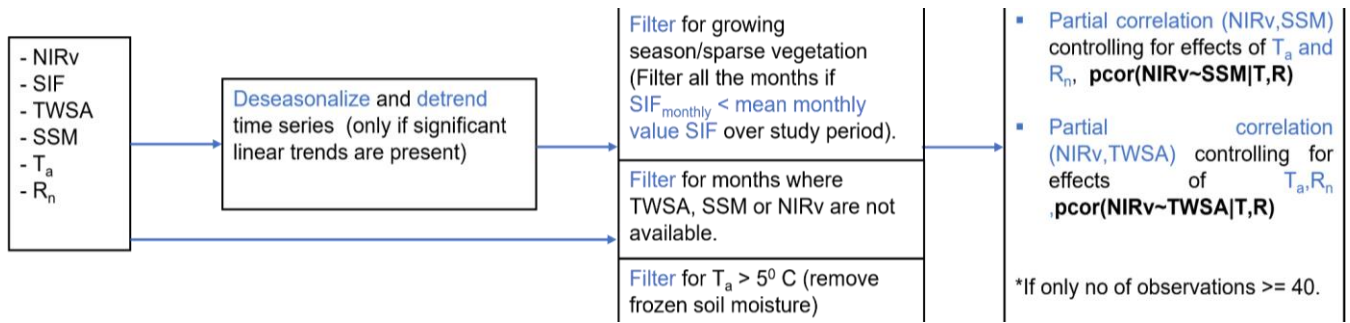
Figure S1: Flowchart of overall data processing and methodology. The input datasets are Terrestrial Water Storage (TWS) Anomalies, Surface Soil Moisture (SSM), Near Infrared Reflectance of Vegetation (NIRv), air temperature (T_a) and Radiation (R_n).
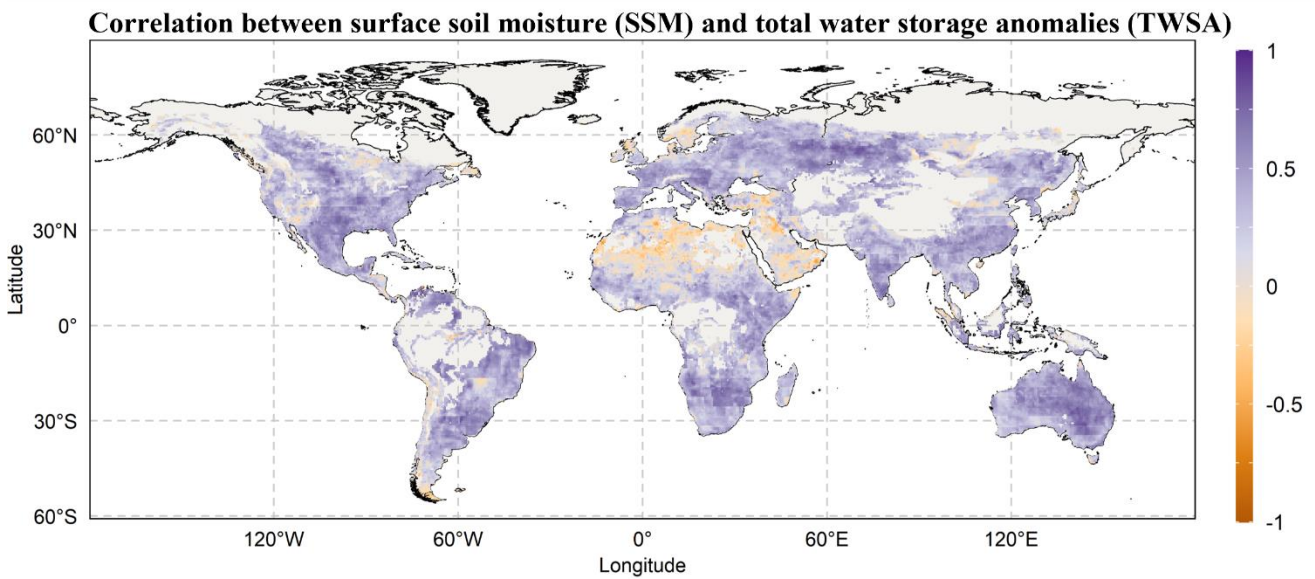
Figure S2: Correlation between surface soil moisture (SSM) from ESA-CCI and total water storage (TWS) from GRACE in growing season months. The purple colour indicates that the correlation is positive while the red colour indicates a negative correlation between SSM and TWS. The non-growing season months are filtered out using the same filtering criteria as described in the methodology.
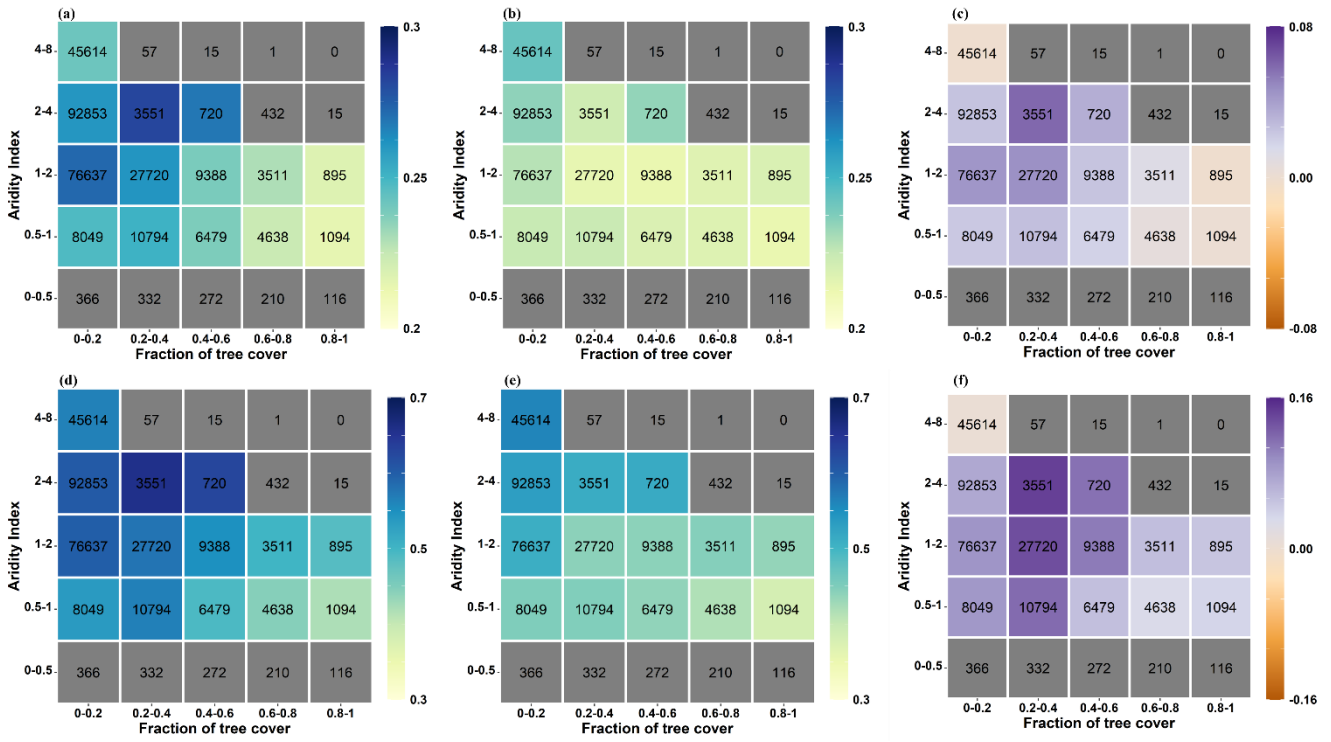
Figure S3: Heatmaps in the upper part indicate the value corresponding to the 10th percentile of the partial correlation between NIRv and (a) SSM, (b) TWS, and (c) the difference between (a) and (b) while heatmaps in the lower part indicate the value corresponding to the 90th percentile of the partial correlation of NIRv with (d) SSM, (e) TWS and (c) difference between (d) and (e). for growing season months only. All the grid cells have a significant partial correlation in growing season months (p < 0.05) and positive partial correlation, [pcor(NIRv~SSM) and pcor(NIRv~TWS) >= 0] during both growing season months and dry months are included for producing heatmaps. The number in each box represents the total number of grid cells for each aridity-tree cover class while the aridity-tree cover classes having less than 500 grid cells have been masked out in grey.
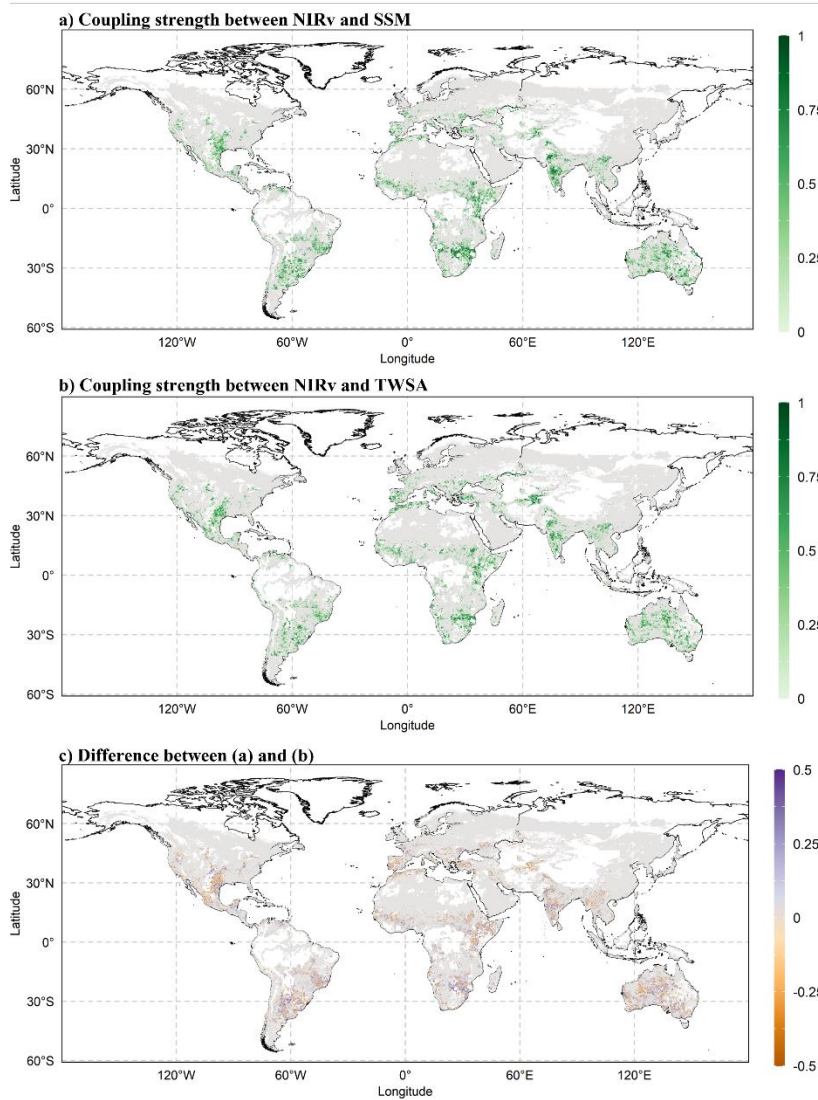
Figure S4: Partial correlation of NIRv with (a) surface soil moisture (SSM), pcor (NIRv~SSM) (b) total water storage anomalies (TWS), pcor (NIRv~TWS), and (c) difference between (a) and (b) in dry months. In this analysis, the identification of dry months was based on selecting those months corresponding to the lowest 10th percentile of surface soil moisture, while also considering only grid cells, where over 100 monthly observations were available after filtering. Furthermore, only grid cells having significant partial correlation (p < 0.05) during growing season months were considered for dry months analysis. Additionally, all the grid cells having a negative partial correlation between NIRv and SSM or NIRv and TWS have been filtered out in this map.
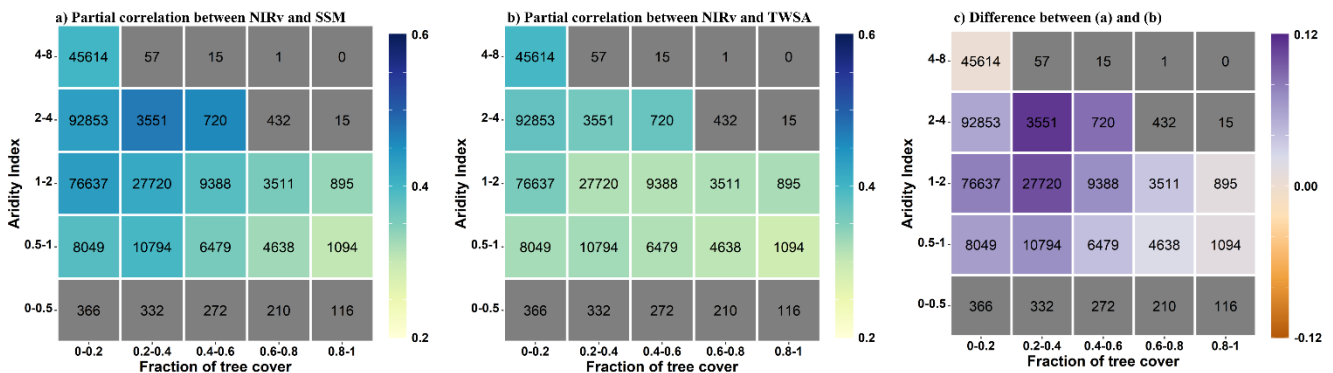
Figure S5: Similar to Figure 2, but only considering the grids cells that are considered in the dry months.
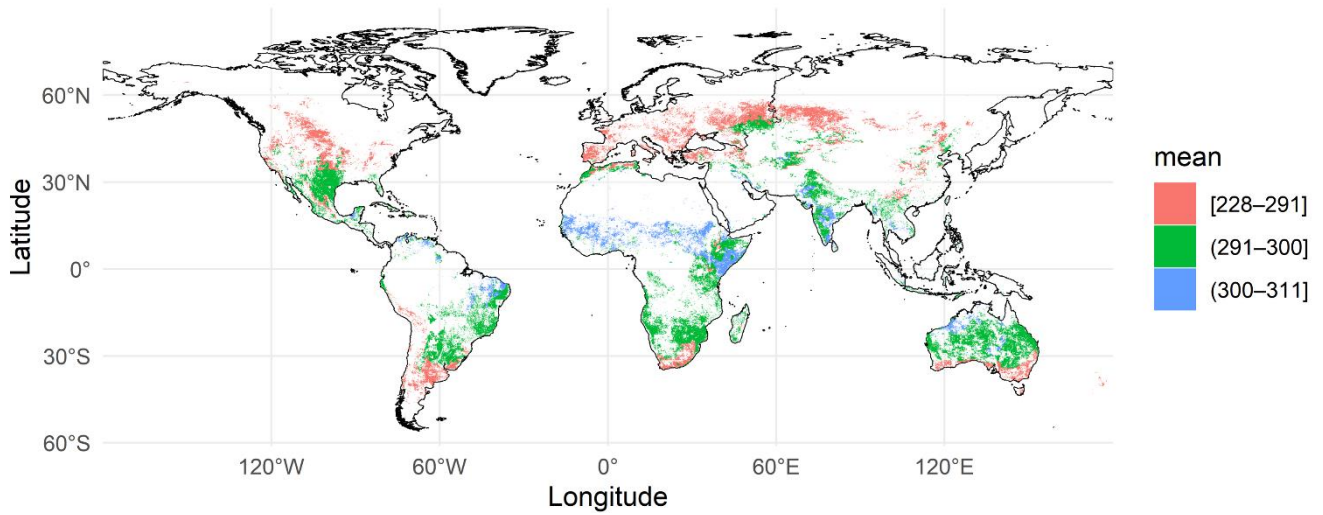
Figure S6: Mean air temperature (T$_a$) (K) in during growing season of grid cells considered for attribution analysis.
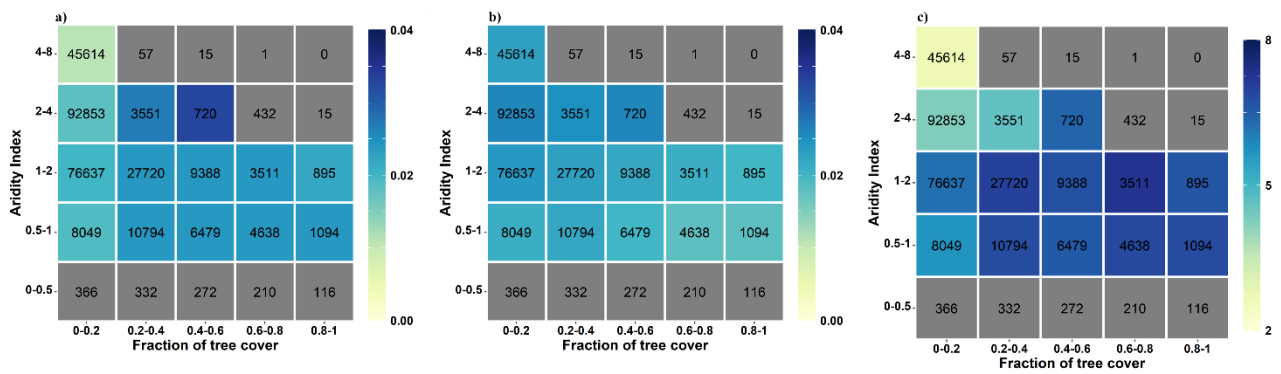
Figure S7: Standard deviation of anomalies of (a) NIRv (b) SSM and (c) TWS across varying aridity class and tree cover fraction classes for growing season months only.
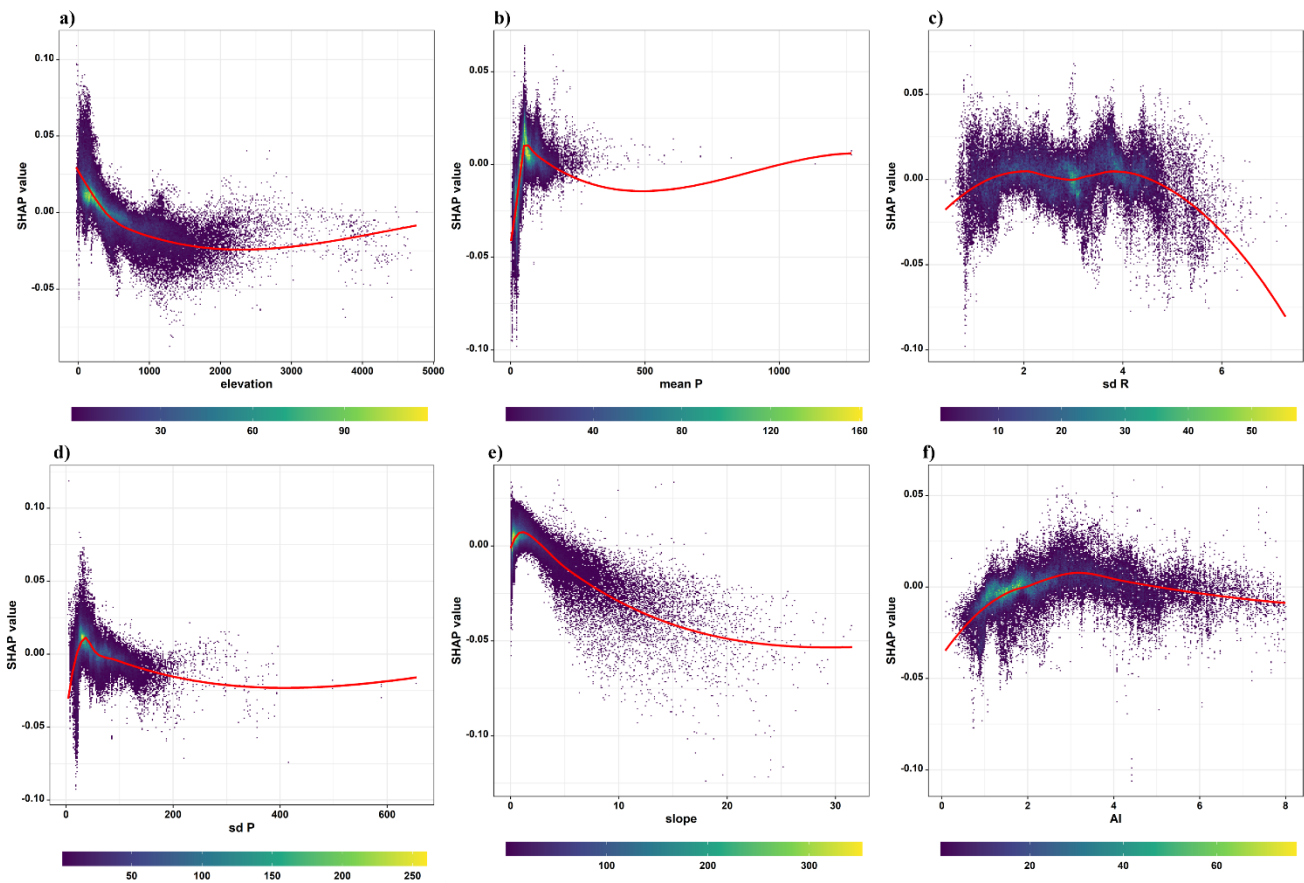
Figure S8: SHAP dependence plot (SHAP value vs value of predictor) for the predictors, (a) elevation, (b) mean P, (c) sd Rn, (d) sd P, (e) slope, and (f) aridity index. These predictors rank 4th to 9th in the SHAP importance plot out of 13 predictors in SHAP analysis.
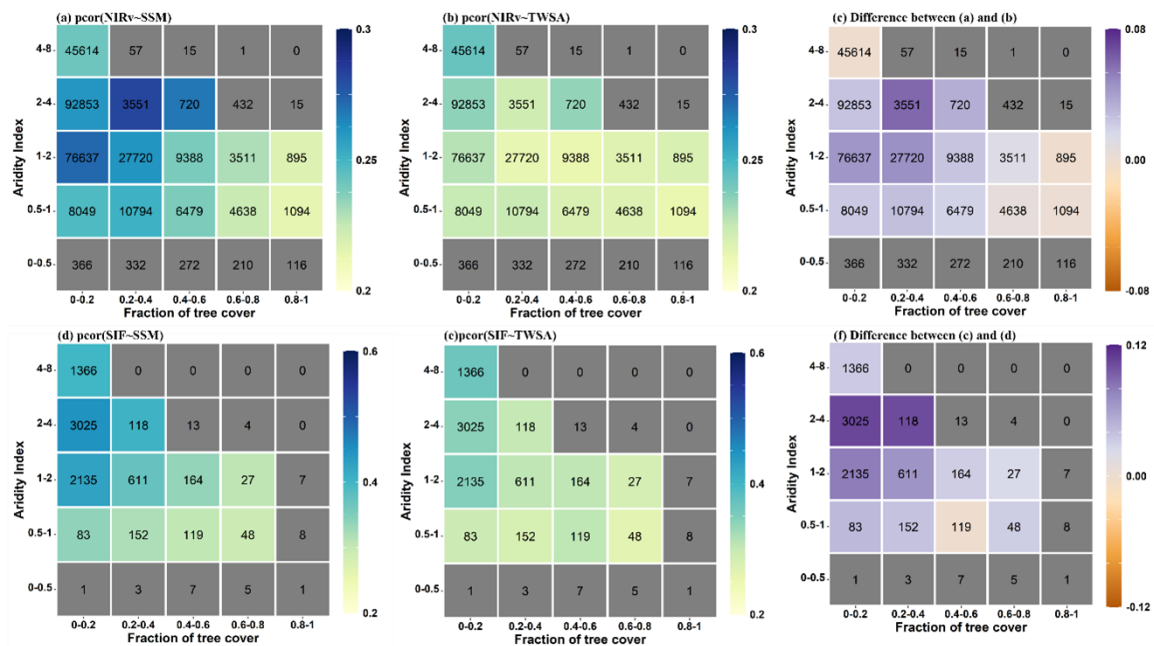
Figure S9: Comparison of partial correlation of NIRv (upper portion) with (a) SSM, (b) TWS, (c) diff (a) and (b), the partial correlation of SIF (lower portion) with (d) SSM, (e) TWS and (f) diff (d) and (e). Note that the partial correlation of NIRv with SSM and TWS is done at 0.05 degrees while that of SIF with SSM and TWS is done at 0.5 degrees.
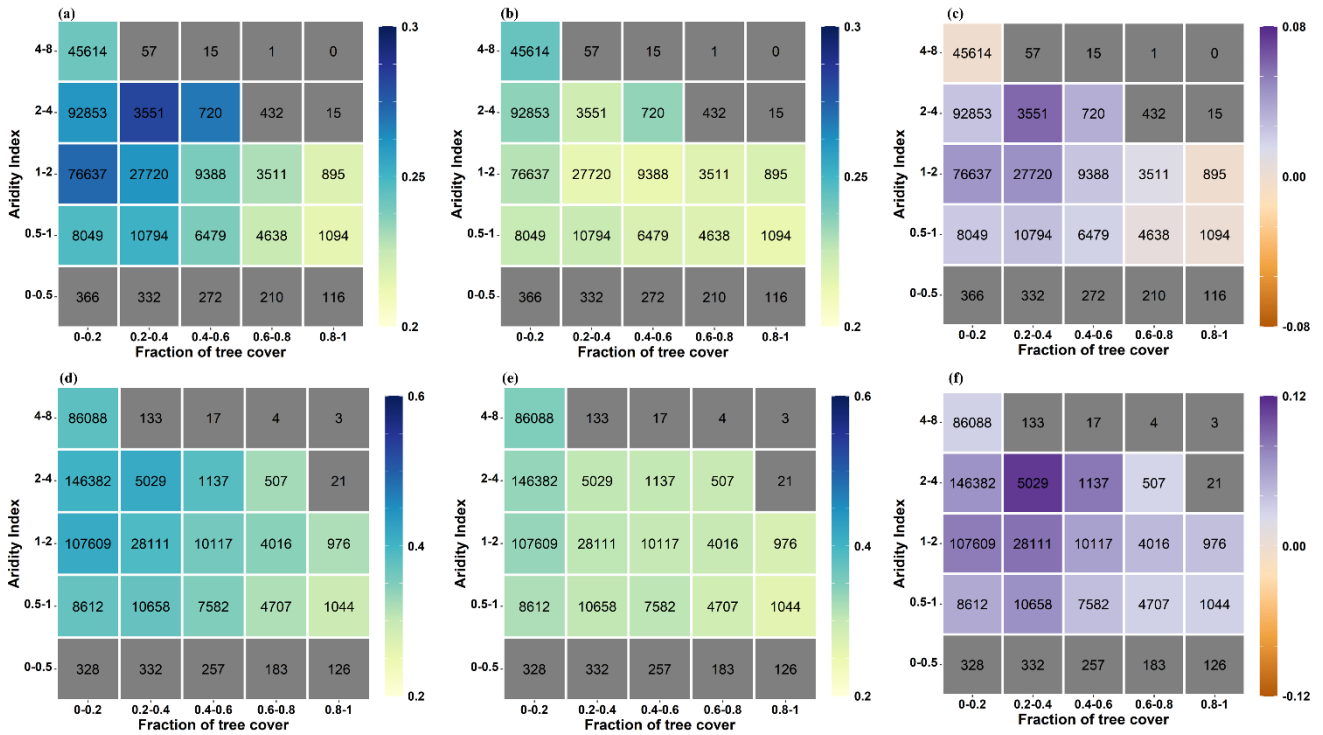
Figure S10: Comparison of partial correlation of NIRv (upper portion) with (a) SSM, (b) TWS, (c) diff (a) and (b) without controlling for the effect of SSM in TWS and the partial correlation of NIRv (lower portion) with (d) SSM, (e) TWS and (f) diff (d) and (e) after controlling for the effect of SSM in TWS. For both analyses, only grid cells having a significant (p < 0.05) and positive (pcor > 0) partial correlation between both pcor(NIRv~SSM) and pcor(NIRv~TWS) are considered. Since the significance of the partial correlation changes with an additional control variable (SSM in TWS), the number of grid cells in the upper and lower portions, represented by the number in boxes, are different.