1. More details on the eight ISIMIP2a biome models

The full names of the eight ISIMIP2a models are: CARAIB (CARbon Assimilation In the Biosphere), DLEM (Dynamic Land Ecosystem Model), JULES (The Joint UK Land Environment Simulator), LPJmL (Lund-Postdam-Jena managed Land), LPJ-GUESS (Lund-Postdam-Jena General Ecosystem Simulator), ORICHIDEE (Organizing Carbon and Hydrology In Dynamic Ecosystems), VEGAS (Vegetation Global Atmosphere and Soils), and VISIT (Vegetation Integrative SImulator for Trace gases). In all models, plants are categorized into different plant functional types (PFTs), although some models use smaller number of PFTs (e.g. JULES with 12 PFTs) than others (e.g. CARAIB with 41 PFTs). Across the eight models, the photosynthesis processes are mostly based on Enzyme Kinetic method (Farquhar et al 1980), only VEGAS uses Light Use Efficiency (LUE) approach. However, the specific parameters and assumptions differ from model to model. In each model, GPP is a measure of carbon dioxide uptake by plants per unit time, and land surface area. Other processes such as leaf to canopy up-scaling, phenology, water stress, heat stress, nitrogen addition, carbon-nitrogen interactions, and time steps differ among the eight models.

2. Partitioning of global GPP trend, seasonality and IAV

The regional contribution to global GPP trend $r_j$ was calculated as

$$r_j = \beta_j / \beta_g$$  (1)
where $\beta_j$ is the linear trend (slope from linear regression) of the annual GPP series of region $j$, and $\beta_g$ is the global GPP trend.

In order to understand the contribution of each region to the IAV of global GPP, we partitioned the IAV based on the methods from Ahlström et al (2015), but added standard latitude-based area weighting to the algorithm:

\[
 f_j = \frac{\sum_i A_j x_{j,it} |X_t|}{\sum_i |X_t|} \\
 X_t = \sum_j A_j x_{j,it}
\]

where $x_{j,it}$ is the GPP anomaly for region $j$ in year $t$, $A_j$ is the area of region $j$, and $X_t$ is the area-weighted total global GPP anomaly in year $t$. $f_j$ is the average relative area-weighted anomaly $A_j x_{j,it}/X_t$ for region $j$, weighted with the absolute regional area-weighted anomaly $|X_t|$. $f_j$ ranges from -1 to 1. Higher positive $f_j$ indicates IAV in the pixel varies in phase with integral IAV and larger monthly contribution toward IAV of global GPP, while smaller or negative $f_j$ represents the opposite.

Similarly, we calculated the regional contribution to global GPP seasonality with equation 2, in which $x_{j,it}$ is the monthly GPP departure from the annual mean (‘seasonal anomaly’) for region $j$ in month $t$, and $X_t$ is the area-weighted total global seasonal GPP anomaly in month $t$. 
Figure S1. Global and regional GPP from MODIS, MTE and ISIMIP models: (a) mean annual GPP (unit: Pg C yr\(^{-1}\)) for the period of 2000-2010, (b) linear trends of annual GPP (unit: Pg C yr\(^{-2}\)); note the trends were calculated within the covered period of each data source (MODIS: 2000-2010; MTE: 1982-2010; and ISIMIP models: 1971-2010), (c) linear trends of annual GPP (unit: Pg C yr\(^{-2}\)) for 2000-2010 period; and (d) interannual variability of GPP for the 2000-2010 period (unit: Pg C yr\(^{-1}\)).

(a) Global and regional GPP from MODIS, MTE and ISIMIP models: (a) mean annual GPP (unit: Pg C yr\(^{-1}\)) for the period of 2000-2010, (b) linear trends of annual GPP (unit: Pg C yr\(^{-2}\)); note the trends were calculated within the covered period of each data source (MODIS: 2000-2010; MTE: 1982-2010; and ISIMIP models: 1971-2010), (c) linear trends of annual GPP (unit: Pg C yr\(^{-2}\)) for 2000-2010 period; and (d) interannual variability of GPP for the 2000-2010 period (unit: Pg C yr\(^{-1}\)).

(b) Global and regional GPP from MODIS, MTE and ISIMIP models: (a) mean annual GPP (unit: Pg C yr\(^{-1}\)) for the period of 2000-2010, (b) linear trends of annual GPP (unit: Pg C yr\(^{-2}\)); note the trends were calculated within the covered period of each data source (MODIS: 2000-2010; MTE: 1982-2010; and ISIMIP models: 1971-2010), (c) linear trends of annual GPP (unit: Pg C yr\(^{-2}\)) for 2000-2010 period; and (d) interannual variability of GPP for the 2000-2010 period (unit: Pg C yr\(^{-1}\)).

(c) Global and regional GPP from MODIS, MTE and ISIMIP models: (a) mean annual GPP (unit: Pg C yr\(^{-1}\)) for the period of 2000-2010, (b) linear trends of annual GPP (unit: Pg C yr\(^{-2}\)); note the trends were calculated within the covered period of each data source (MODIS: 2000-2010; MTE: 1982-2010; and ISIMIP models: 1971-2010), (c) linear trends of annual GPP (unit: Pg C yr\(^{-2}\)) for 2000-2010 period; and (d) interannual variability of GPP for the 2000-2010 period (unit: Pg C yr\(^{-1}\)).

(d) Global and regional GPP from MODIS, MTE and ISIMIP models: (a) mean annual GPP (unit: Pg C yr\(^{-1}\)) for the period of 2000-2010, (b) linear trends of annual GPP (unit: Pg C yr\(^{-2}\)); note the trends were calculated within the covered period of each data source (MODIS: 2000-2010; MTE: 1982-2010; and ISIMIP models: 1971-2010), (c) linear trends of annual GPP (unit: Pg C yr\(^{-2}\)) for 2000-2010 period; and (d) interannual variability of GPP for the 2000-2010 period (unit: Pg C yr\(^{-1}\)).
Figure S2. Temporal (inter-annual and seasonal scales) correlation coefficients for GPP estimates from models, MODIS, and MTE, at global and regional scales.

(a) Models vs. MODIS Seasonal

| Region | Correlation Coefficient |
|--------|-------------------------|
| BNA    | 0.97                    |
| TNC    | 0.94                    |
| ENSEMBLE | 0.99                |

(b) Models vs. MTE Seasonal

| Region | Correlation Coefficient |
|--------|-------------------------|
| EUA    | 0.95                    |
| TNC    | 0.93                    |
| ENSEMBLE | 0.99                |

(c) Models vs. MODIS IAV

| Region | Correlation Coefficient |
|--------|-------------------------|
| BNA    | 0.89                    |
| TNC    | 0.91                    |
| ENSEMBLE | 0.98                |

(d) Models vs. MTE IAV

| Region | Correlation Coefficient |
|--------|-------------------------|
| EUA    | 0.94                    |
| TNC    | 0.93                    |
| ENSEMBLE | 0.99                |