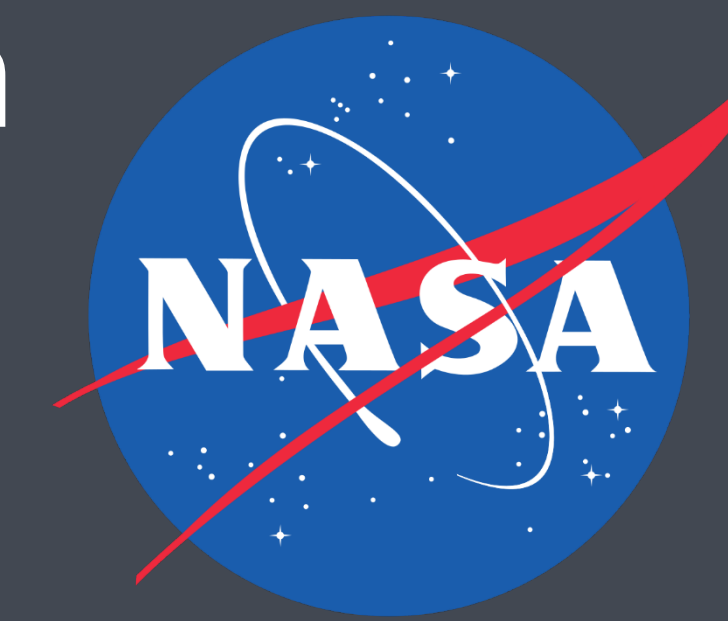


Global Ecosystem Demography Model (ED-global v1.0): Development, Calibration and Evaluation for NASA's Global Ecosystem Dynamics Investigation (GEDI)

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Ecosystem Demography (ED) Model

- Individual-based terrestrial biosphere model characterizing fine-scale plant competition for light, water and nutrient.
- Use Size- and Age-Structured (SAS) partial differential equation system to capture vertical and horizontal heterogeneity in light, water and nutrient availability.
- Closely approximates ensemble behavior of stochastic gap models but is more efficient for large-scale studies of ecosystem dynamics in response to climate change, varying CO₂, land use change and natural disturbance.

Motivation to Develop ED-global

- Global initialization and prediction of carbon sequestration with GEDI data.
- Impacts of land use changes on forest succession and structure.
- Demographic ecosystem response to climate change.

Methods

- Leverage regional versions of ED to global version.
- Spin-up global model to current ecosystem state through two stages.
- Compare estimates of GPP, NBP, LAI, AGB, etc. to a benchmarking package.
- Refine and re-parameterize submodules.

Two-stage spin-up:

- Equilibrium simulation: spin-up 1000 years from bare ground to equilibrium state in carbon pools.
- Transient simulation: continue running for 1166 years (850-2016).

Forcings:

Meteorology from NASA MERRA2 reanalysis; land use change from LUH2; burned area from GFED4; varying CO₂ from NOAA.

Features of ED-global v1.0

- Detailed characterization of vegetation demography.
- Explicit height of plants, potential for direct connection to LiDAR data.
- Characterization of LULCC impacts (e.g., disturbance).
- Plant migration.
- Operates at both local and global scales with flexible spatial resolution.
- Climate variability (e.g., temperature, precipitation and CO₂).
- Evaluated with a full benchmarking package.

GPP Evaluation: ED-global GPP was compared to satellite observations (e.g., SatFlux (Joiner et al 2018) and Sun-Induced Fluorescence (SIF) datasets (Zhang et al 2018)) in terms of spatial and temporal variation.

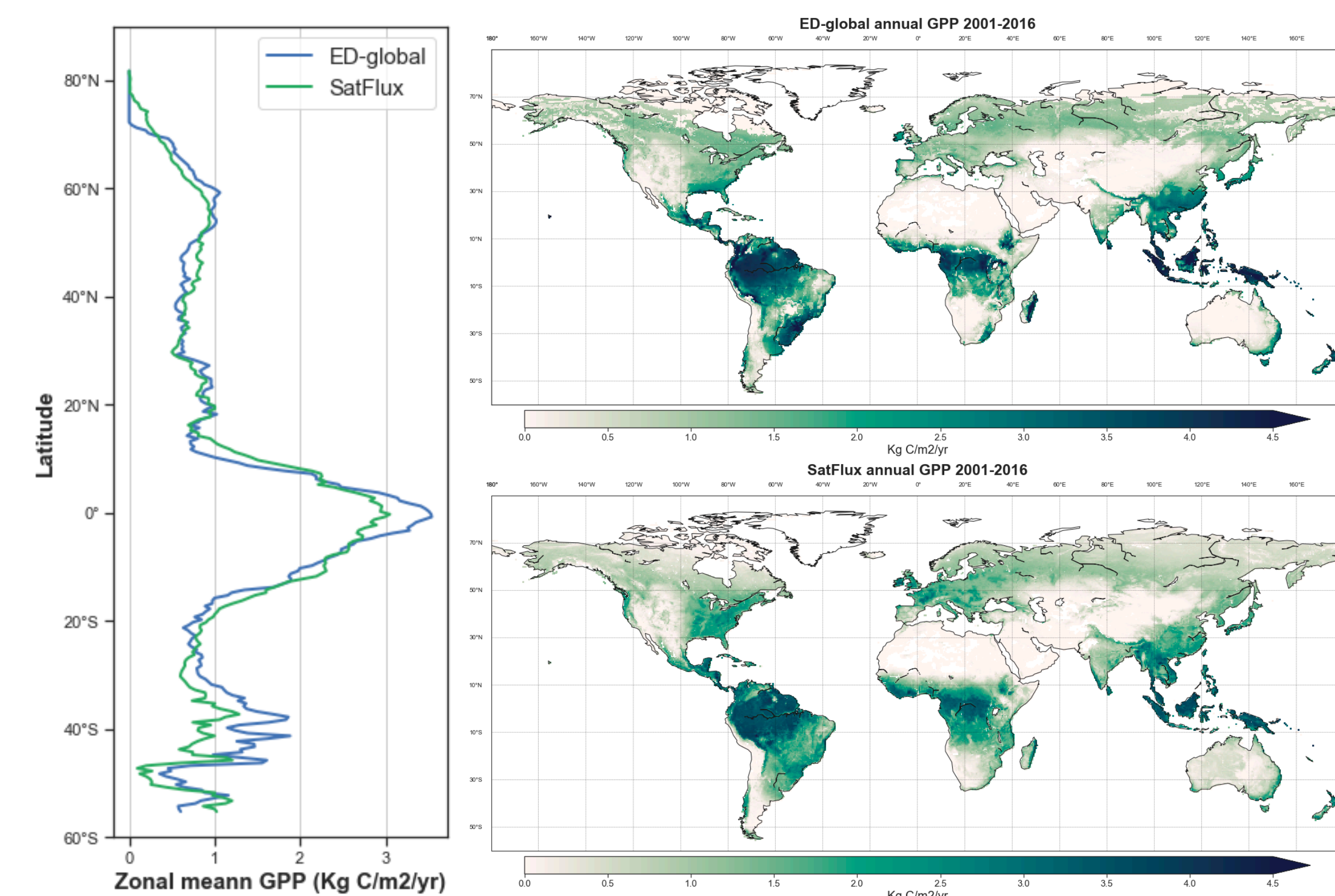
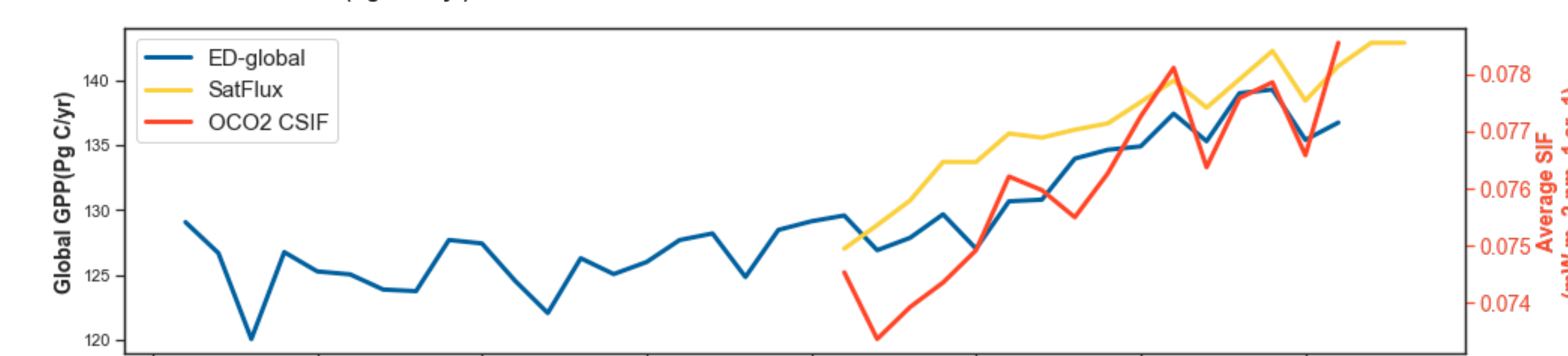
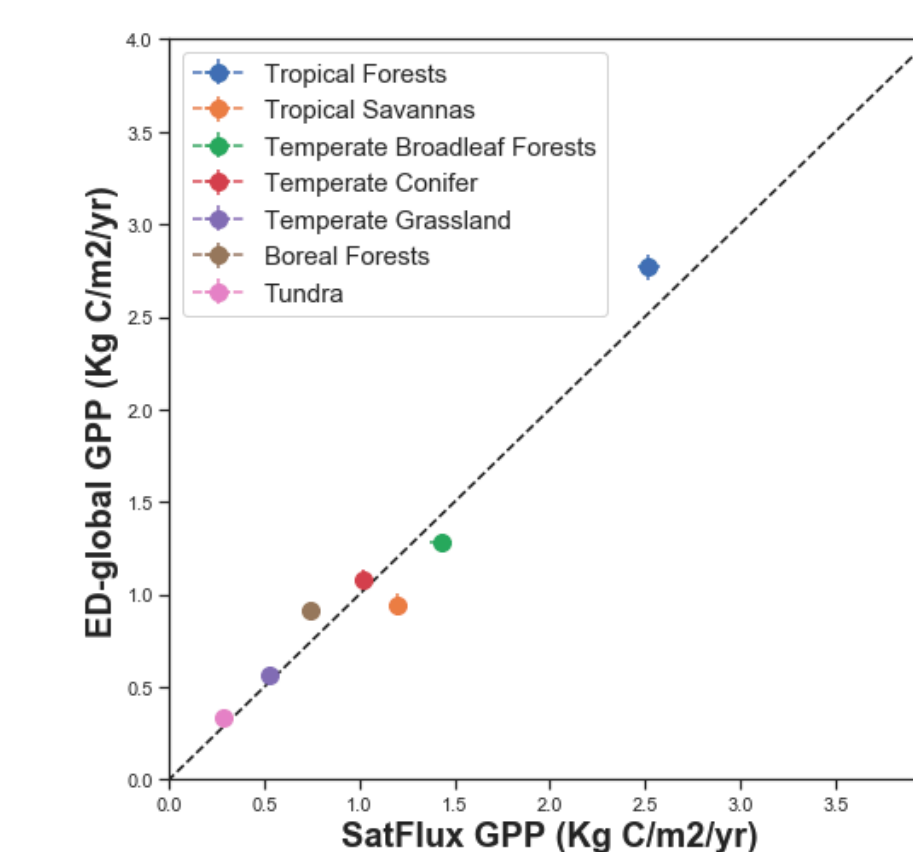


Figure 1 (top). Spatial pattern comparison of 2001-2016 average GPP between ED-global and SatFlux.

Figure 2 (left). Biome-average 2001-2016 GPP comparison between ED-global and SatFlux.

Figure 3 (bottom). Inter-annual variation in global GPP from ED-global and SatFlux and averaged SIF.



LAI Evaluation: satellite LAI product (GEOV2) was used to examine if ED-global could capture temporal trend and variation in LAI.

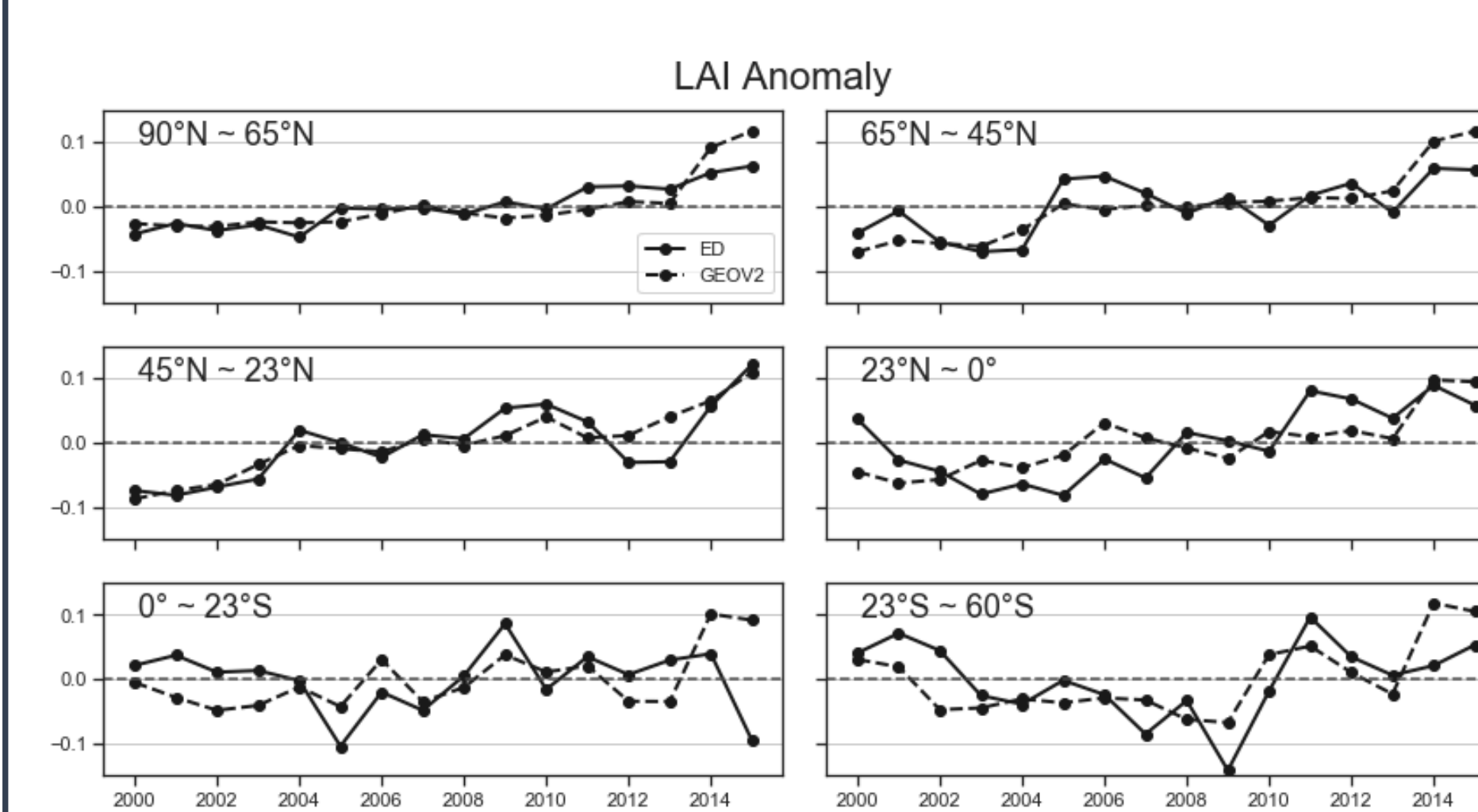
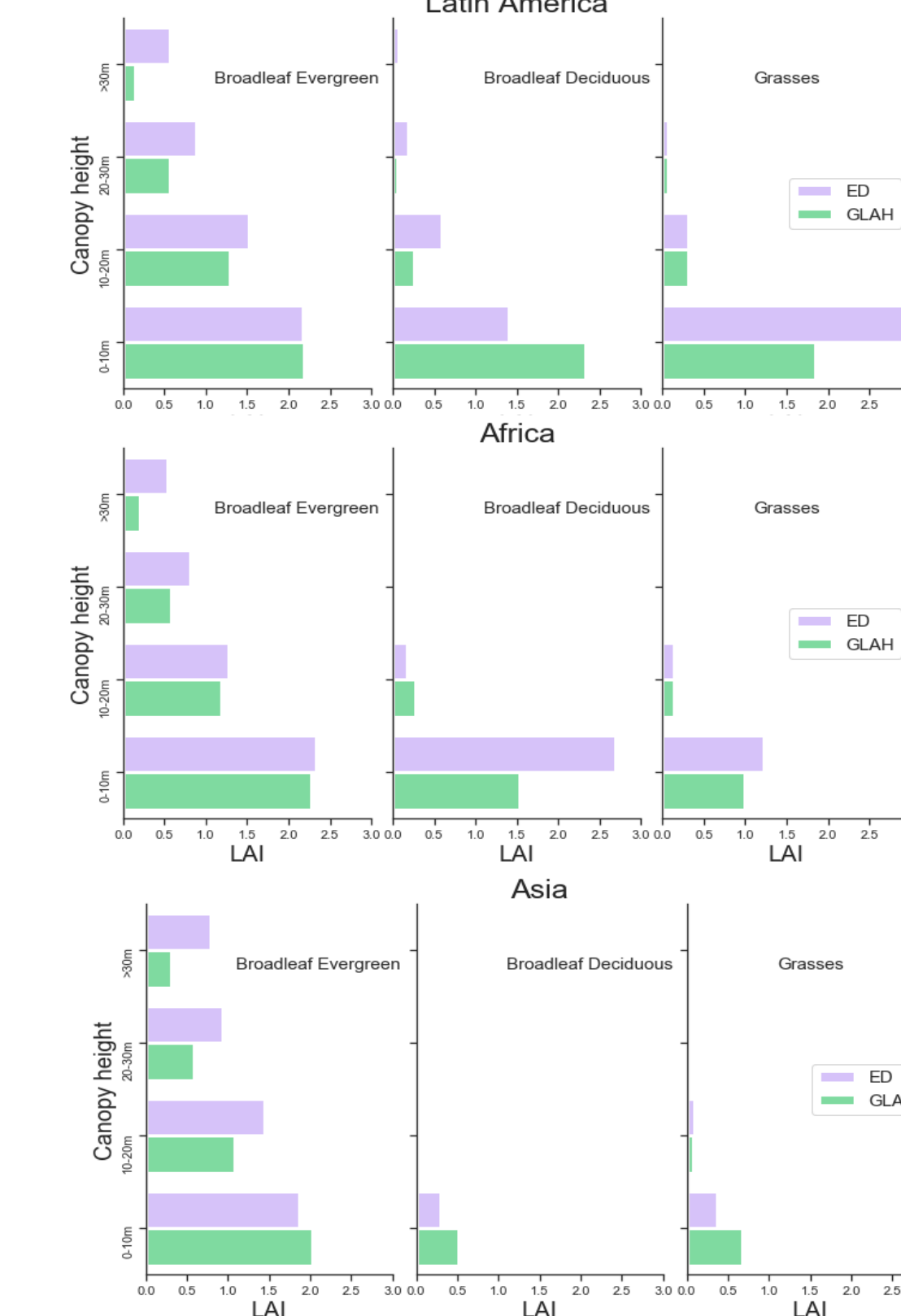


Figure 4 (left). Annual LAI anomaly of ED-global and GEOV2 for different latitudinal bands.

Figure 5 (right). LAI profile comparison between ED-global and LiDAR observations of ICESat-1 (Hao et al 2014) across three PFTs at tropics.

Vertical LAI Evaluation: examine if ED-global reproduce observed LAI profile



NBP Evaluation: TRENDY DGVMs and atmospheric inversions were used to examine if ED-global could reproduce the mean, trend and variation of NBP

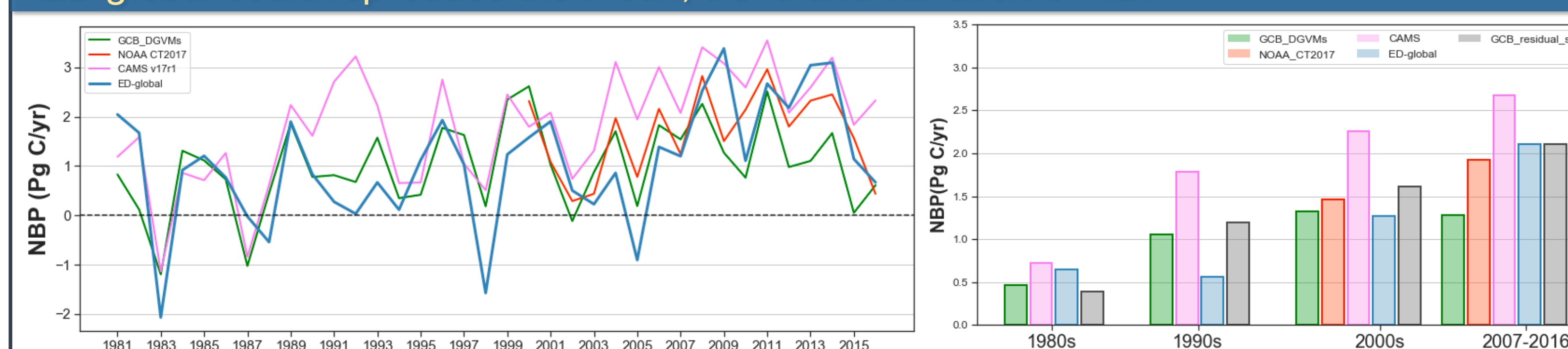


Figure 6 (left). Global NBP time series from ED-global, atmospheric inversions (NOAA CT2017 and CAMS v17r1) and ensemble mean of TRENDY DGVMs.

Figure 7 (right). Comparison of decadal mean of global NBP from ED-global and other approaches.

Biomass Evaluation: spatial pattern of AGB from ED-global and GEOCARBON product.

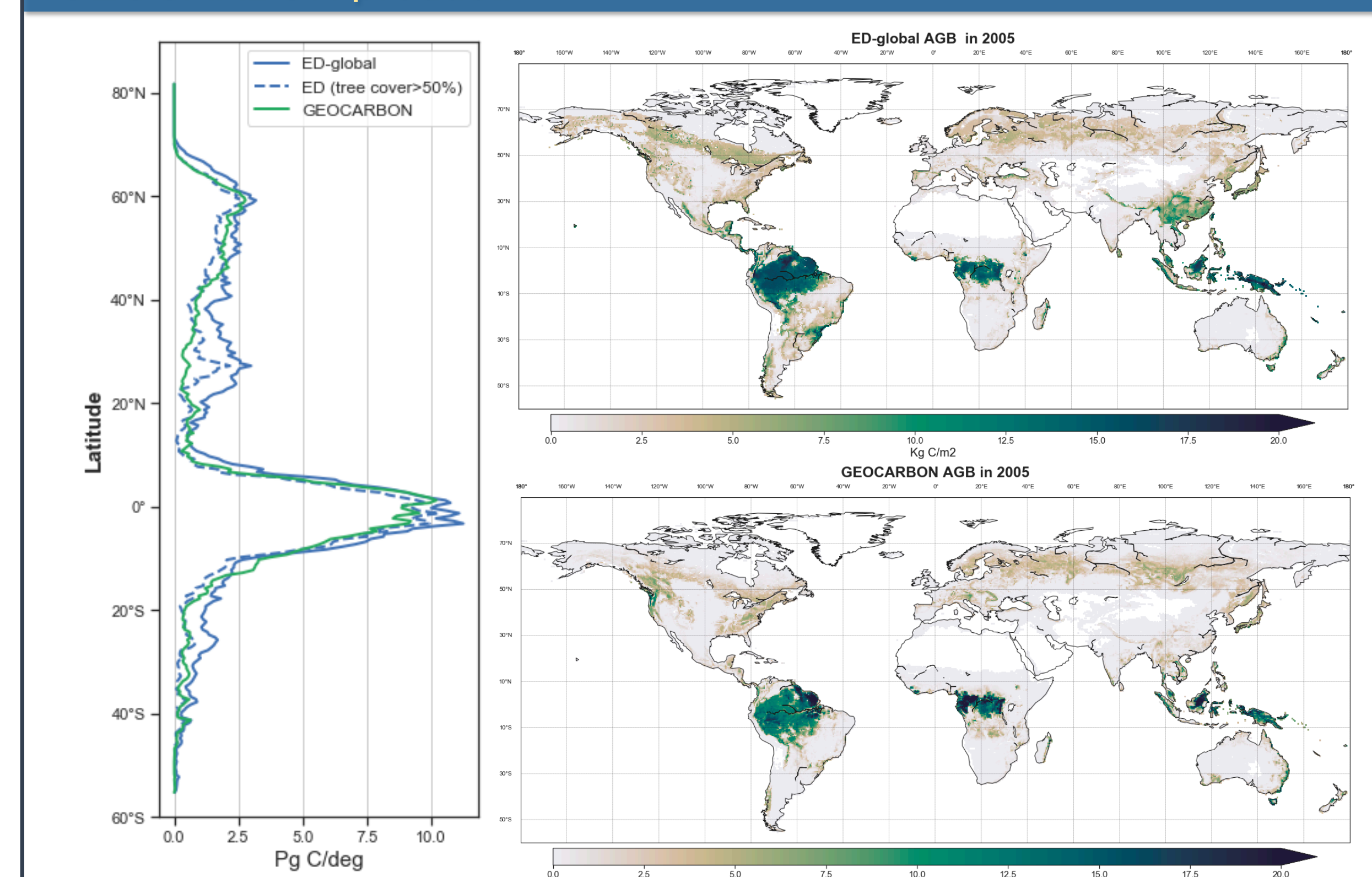


Figure 8. AGB in 2005 from ED-global estimates and satellite-based product from the GEOCARBON project. GEOCARBON AGB only covers forested area.

Next Steps

- Global initialization of ED-global with GEDI collected canopy height datasets.
- Continued refinement of ED-global.
- Incorporate other remote sensing data (e.g., forest change, disturbance)
- Local-global applications: CMS, GEDI and IDS, etc.

Acknowledgement: This work has been funded by NASA's Interdisciplinary Science Program, Carbon Monitoring System.

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