2016 AGU | San Francisco | 12 – 16 December 2016

Model Inter-comparison of Gross Primary Productivity and Evapotranspiration in Alaska

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Background

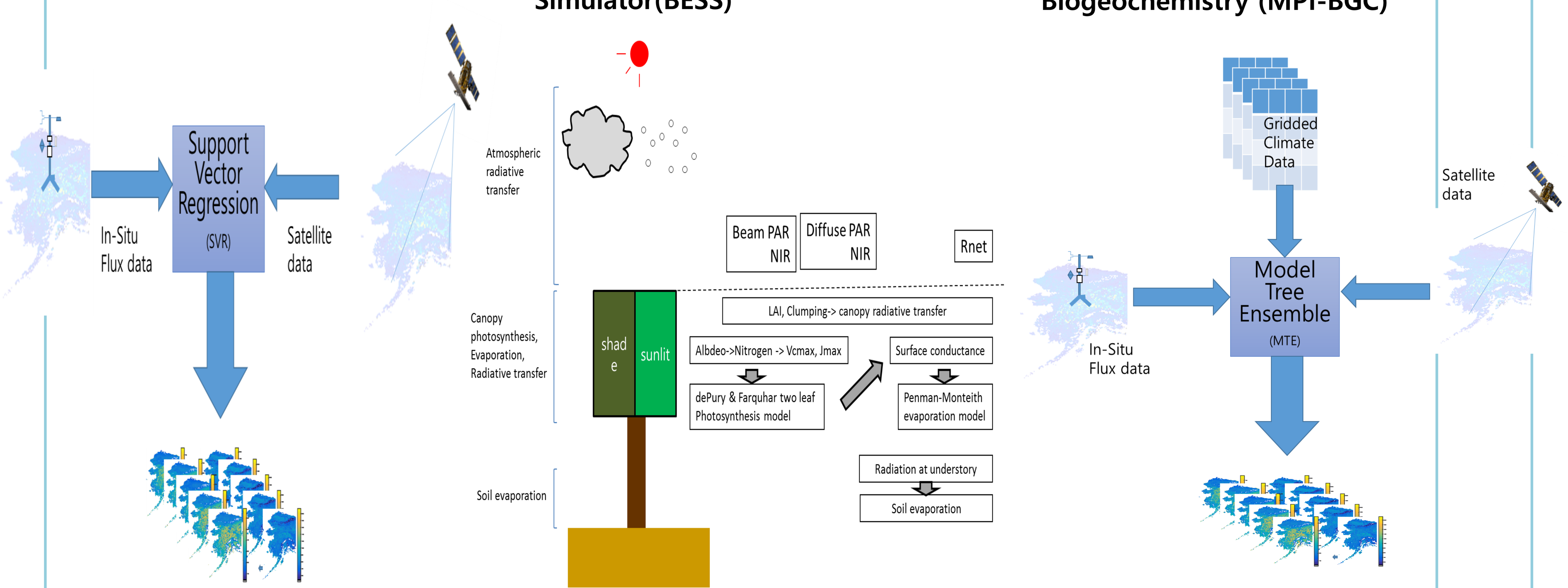
Machine-learning and process-based modeling approaches are two ways to derive regional and global scale gross primary productivity (GPP) and evapotranspiration (ET). Machine-learning approaches upscale in-situ observed fluxes to a large scale with statistical modes, with satellite-derived parameters and other explanatory variables. Process-based models use a series of nonlinear equations to represent land-atmosphere soil system and associated fluxes. In this study, we perform model inter-comparison of gross primary productivity and evapotranspiration products from one process-based model (the Breathing Earth System Simulator) and two independent machine-learning models(Support Vector Regression, and MPI-BGC). The Breathing Earth System Simulator (BESS) is a process-based model that uses MODIS land and atmosphere products to estimate gross primary productivity (GPP) at global scales with 1km resolution. GPP is computed by a carbon-water coupled module, which incorporates a two-leaf longwave radiative transfer model, Farquhar's photosynthesis model and a quadratic Penman-Monteith and energy balance equations. The derived instantaneous estimates of GPP and ET were temporally upscaled to 8-day mean estimated with a simple cosine function. BESS estimated products has been evaluated in agricultural, forest and savanna ecosystems, but not in arctic tundra. The Support Vector Regression (SVR) model, satellite remote sensing data, and disturbance information was combined with 21 eddy covariance towers in Alaska to upscale the estimated carbon and energy balance from 2000 to 2011. The MPI-BGC (Max Planck Institute for Biogeochemistry) is an empirical model using meteorological, satellite and FLUXNET data to estimate global atmosphere-land carbon exchange. The study area is Alaska from 72°N-52°N, and 170°W-140°W, latitude and longitude, respectively. Alaska can be divided into two large regions, the arctic tundra and boreal region.

Objectives

Inter-comparison with 3 independent products, SVR, BESS and MPI-BGC, to characterize the spatiotemporal patterns of GPP and ET by:

- **Quantifying GPP and ET spatiotemporal variation of Alaska**
- **Characterizing inter-annual Variability between the 3 products**

Support Vector Regression | **The Breathing Earth System Simulator(BESS)** | **Max Planck Institute – Biogeochemistry (MPI-BGC)**



Ueyama *et al.,* (2013) | Ryu *et al.,* (2011) | Jung *et al.,* (2011)

Results

Total Mean of GPP and ET from 2000 to 2011

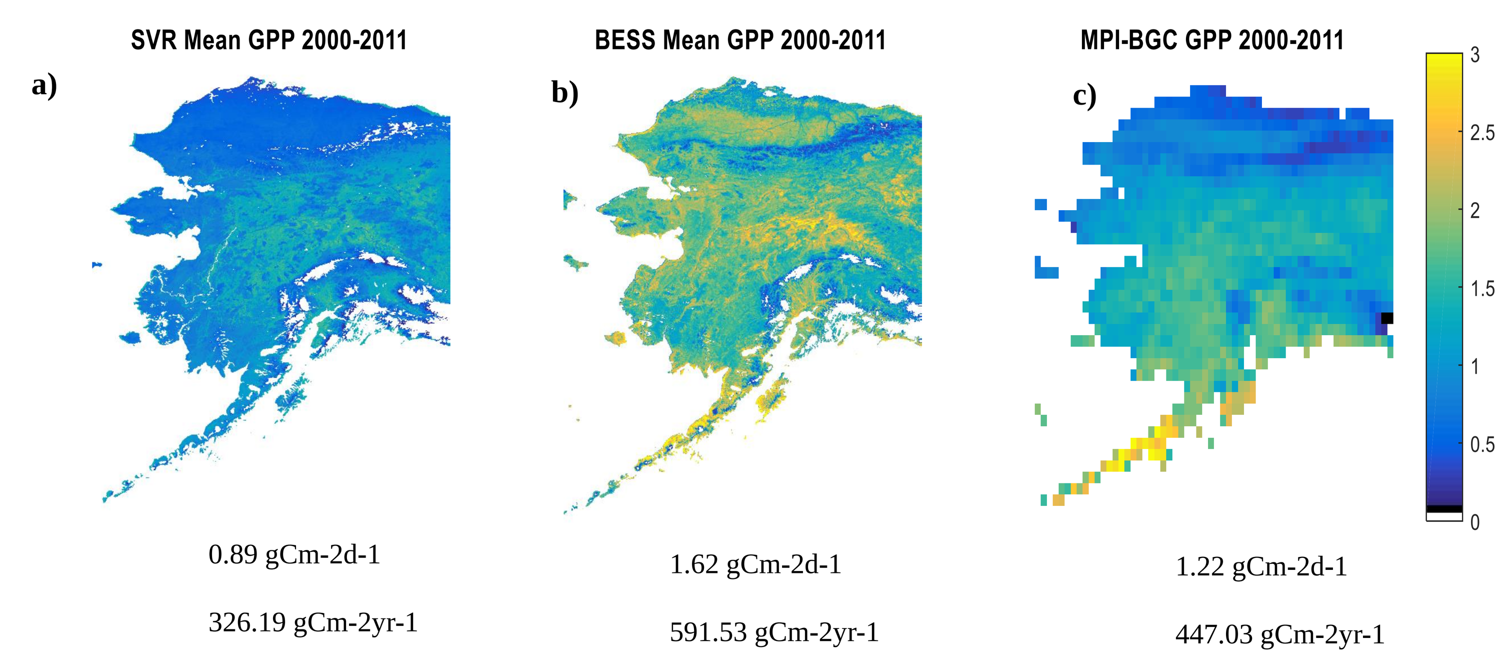


Figure 1. The mean of GPP by a) SVR, b) BESS and c) MPI-BGC from 2001 to 2011

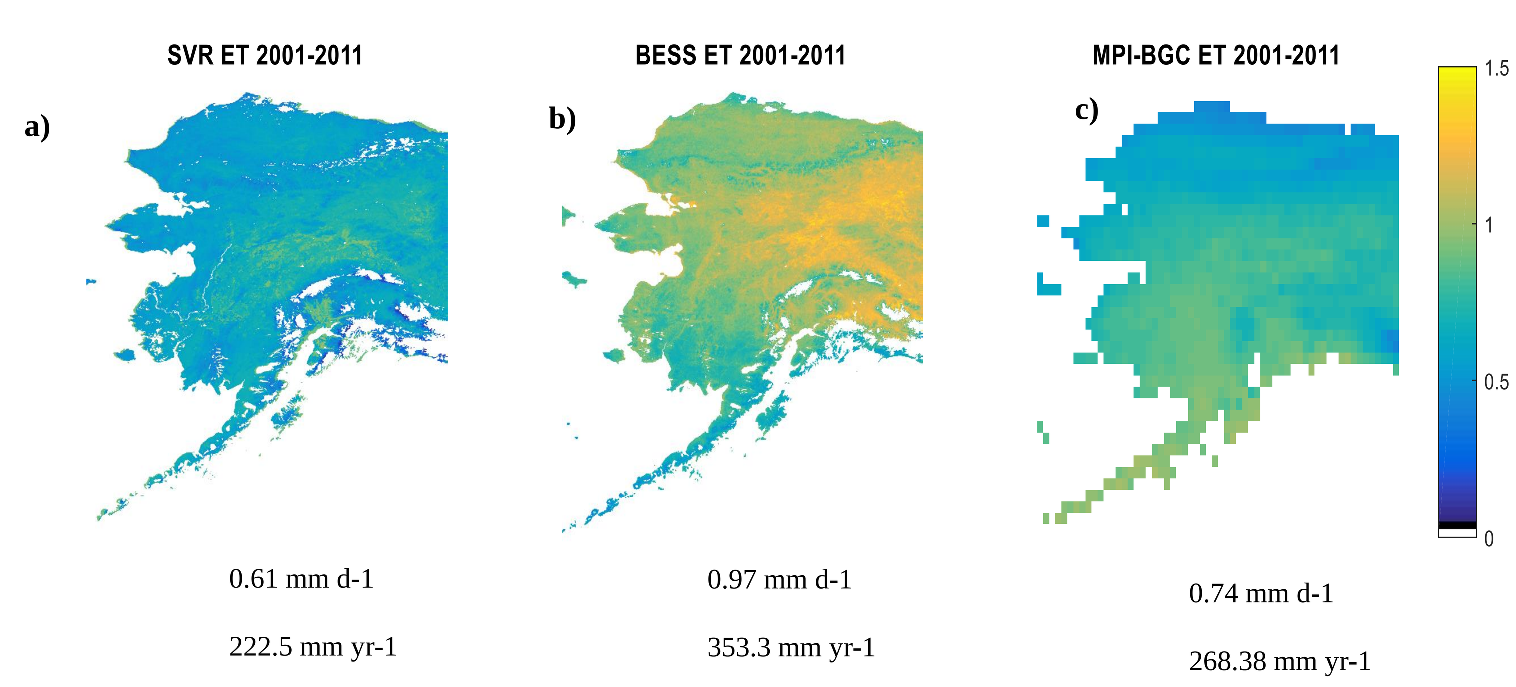


Figure 2. The mean of ET by a) SVR, b) BESS and c) MPI-BGC from 2001 to 2011

Annual Anomalies of GPP and ET

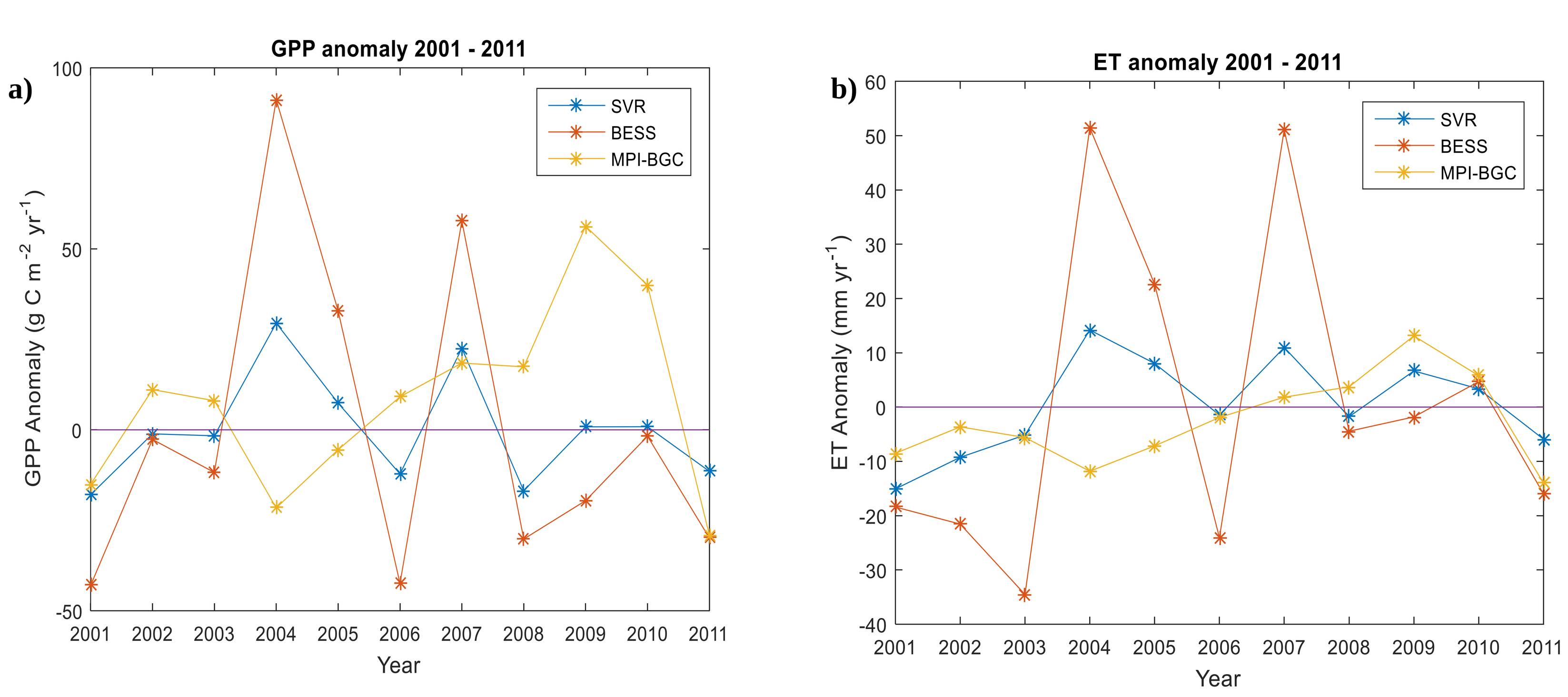


Figure 3. Comparison of annual anomaly of GPP (a) and ET (b) derived from BESS, SVR and MPI-BGC products from 2001 through 2011.

Coefficient of Variance of GPP and ET

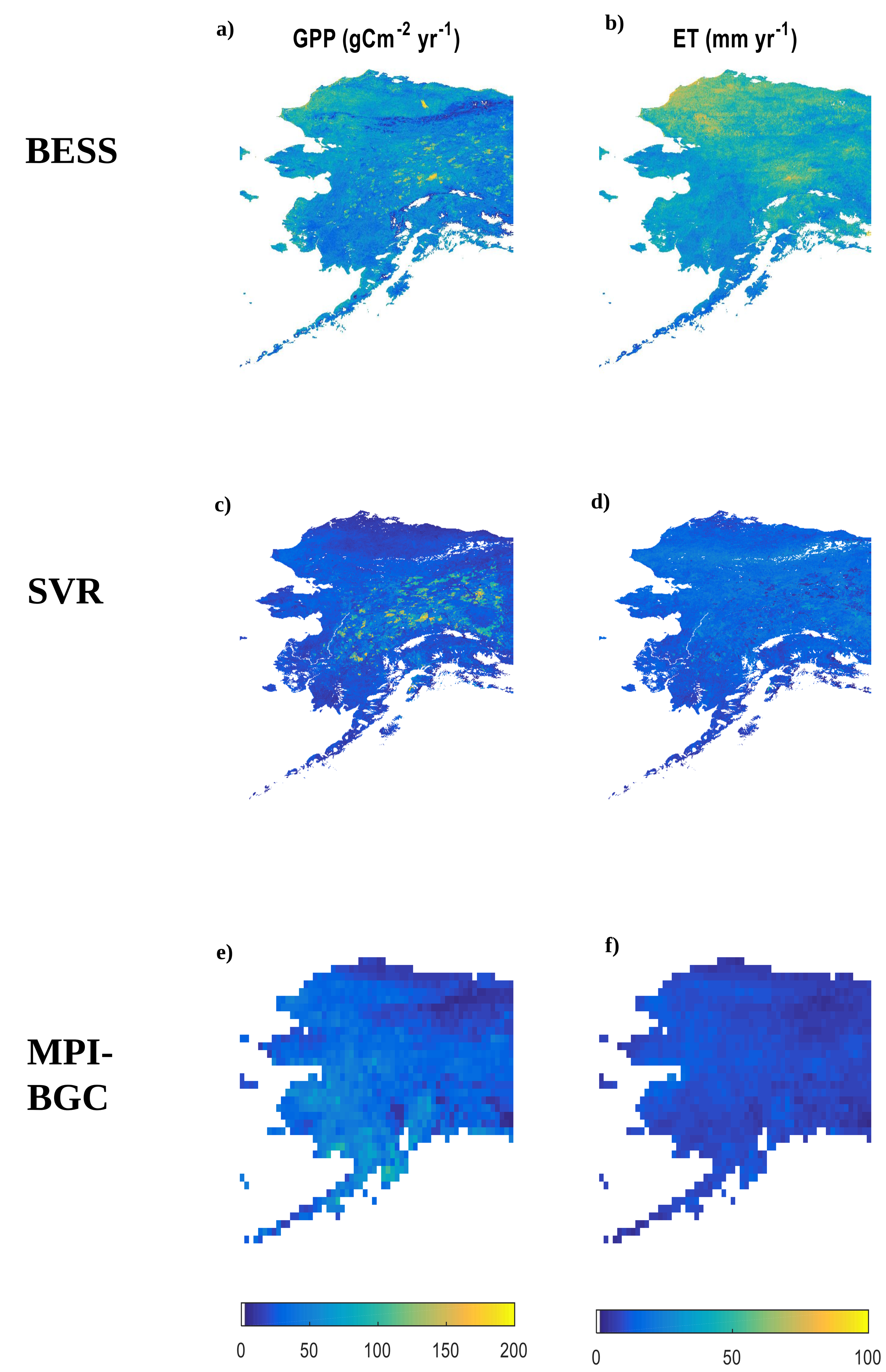


Figure 5. Inter-annual Variation of (a) BESS GPP, (b) BESS ET, (c)MPI-BGC GPP, (d)MPI-BGC ET, (e) SVR GPP, and (f) SVR ET from2001 to 2011. Inter-annual variation is defined as one standard deviation over the time period.

Discussion

This study examines the performance of 3 independent models products of GPP and ET in Alaska from 2001 to 2011. BESS estimates GPP and ET higher than both SVR and MPI-BGC model (Figure1. and Figure 2.). The annual anomaly patterns of GPP and ET show that BESS and SVR had the same pattern with a different magnitude, but MPI-BGC differed. The years 2004 and 2007 were recorded as relatively warm years which BESS and SVR indicated with high anomaly. There was a substantial percentage of bias and error in the evaluation of BESS in arctic tundra from FLUXNET. Many studies have reported high uncertainty in model estimation of GPP in arctic tundra due to the lack of *in-situ* observation data, changing dynamics of permafrost and disturbance regimes (for example, fire).

The inter-annual variation was quantified by standard deviation, indicating that there was high GPP inter-annual variation in the Interior of Alaska compared in the SVR. BESS shows a larger standard deviation in the northern coastal tundra areas and Interior of Alaska. MPI-BGC shows higher inter-annual variation in the south-western region of Alaska. ET estimated by BESS had a relatively higher inter-annual variation in the northern tundra regions and central Alaska compared to SVR and MPI-BGC. Comparison of the three independent model shows high spatial variability in Alaska

Conclusion

Model inter-comparison of gross primary productivity and evapotranspiration with BESS, SVR and MPI-BGC show high variability of model products.

Acknowledgement

We greatly thank Masahito Ueyama for sharing the SVR products.
We would like to acknowledge FLUXNET 2015 and MPI-BGC for providing the open source products.
This study was supported by the National Research Foundation of Korea, which is funded by the Korean Government (MSIP) (NRF-2011-0021063, 0021067) (PN16082, KOPRI).