Improving NASA GEOS atmospheric CO_2 simulations by calibrating CASA surface fluxes with an empirical sink

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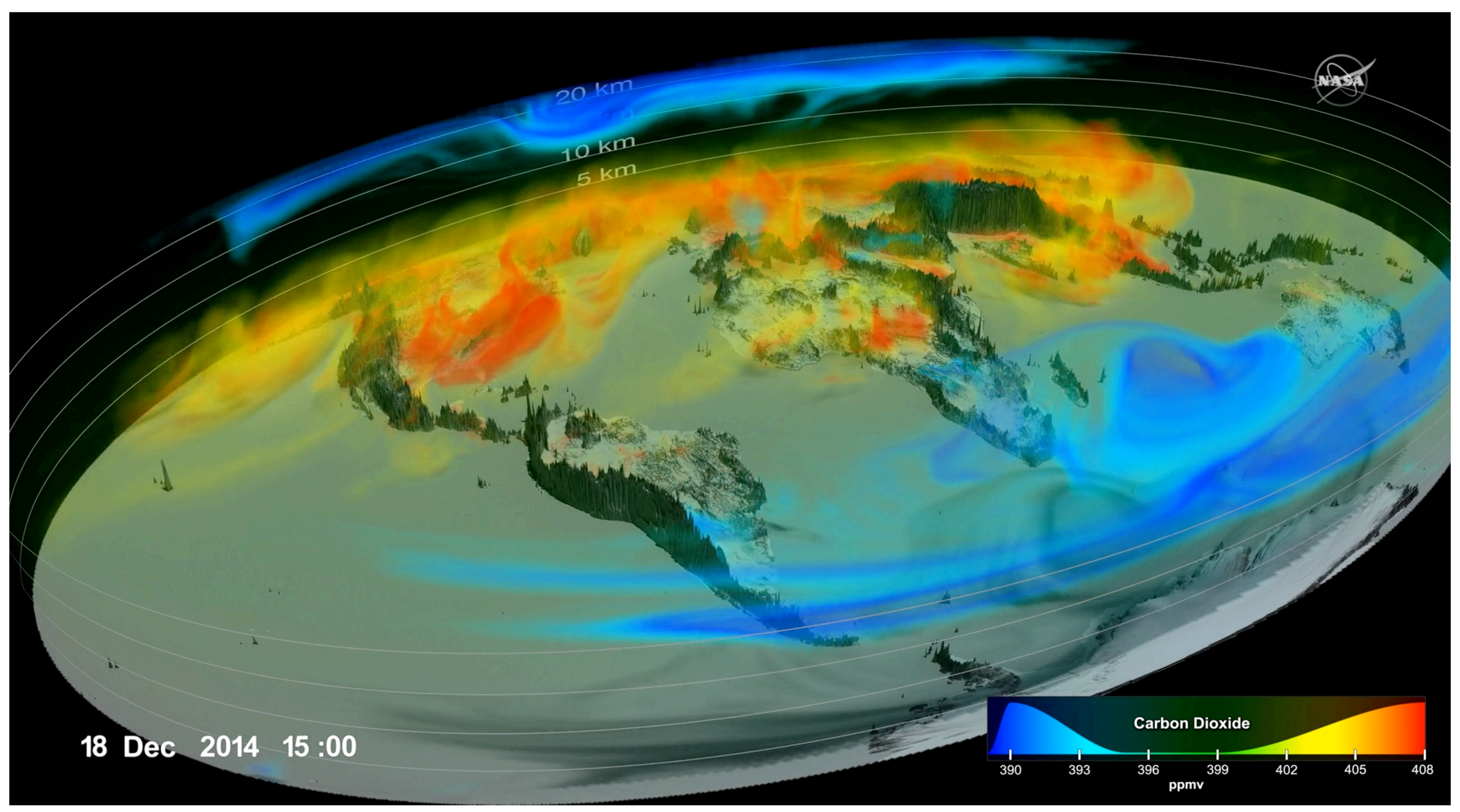
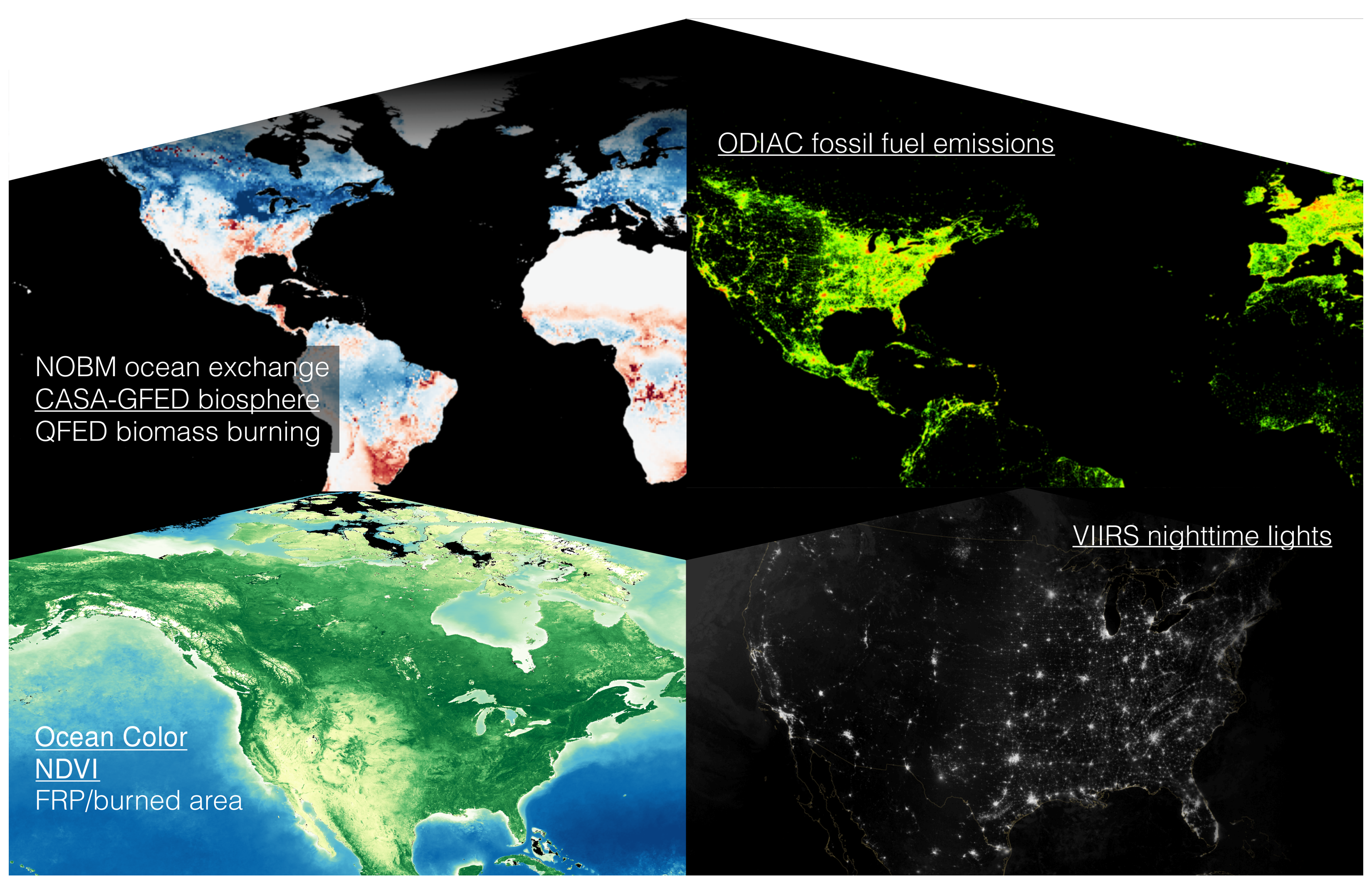
Data-driven CO_2 surface fluxes (bottom) are fed into the NASA GEOS model, which transports their signal through the atmosphere (middle).

When applying the empirical sink presented here, GEOS simulations have comparable skill to flux inversion systems and can be produced in real time at high resolution.





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Base surface fluxes (CQOT)

CASA-GFED terrestrial net ecosystem exchange (NEE) & biofuels, **QFED** biomass burning, **ODIAC** fossil fuels, and a year-specific version of **Takahashi** ocean exchange. Satellite drivers of these fluxes include AVHRR & MODIS NDVI, MODIS FRP, and VIIRS nighttime lights (see left sidebar).

However, **the base fluxes underpredict the global growth rate and seasonal cycle amplitude** (Figs 1 & 2).

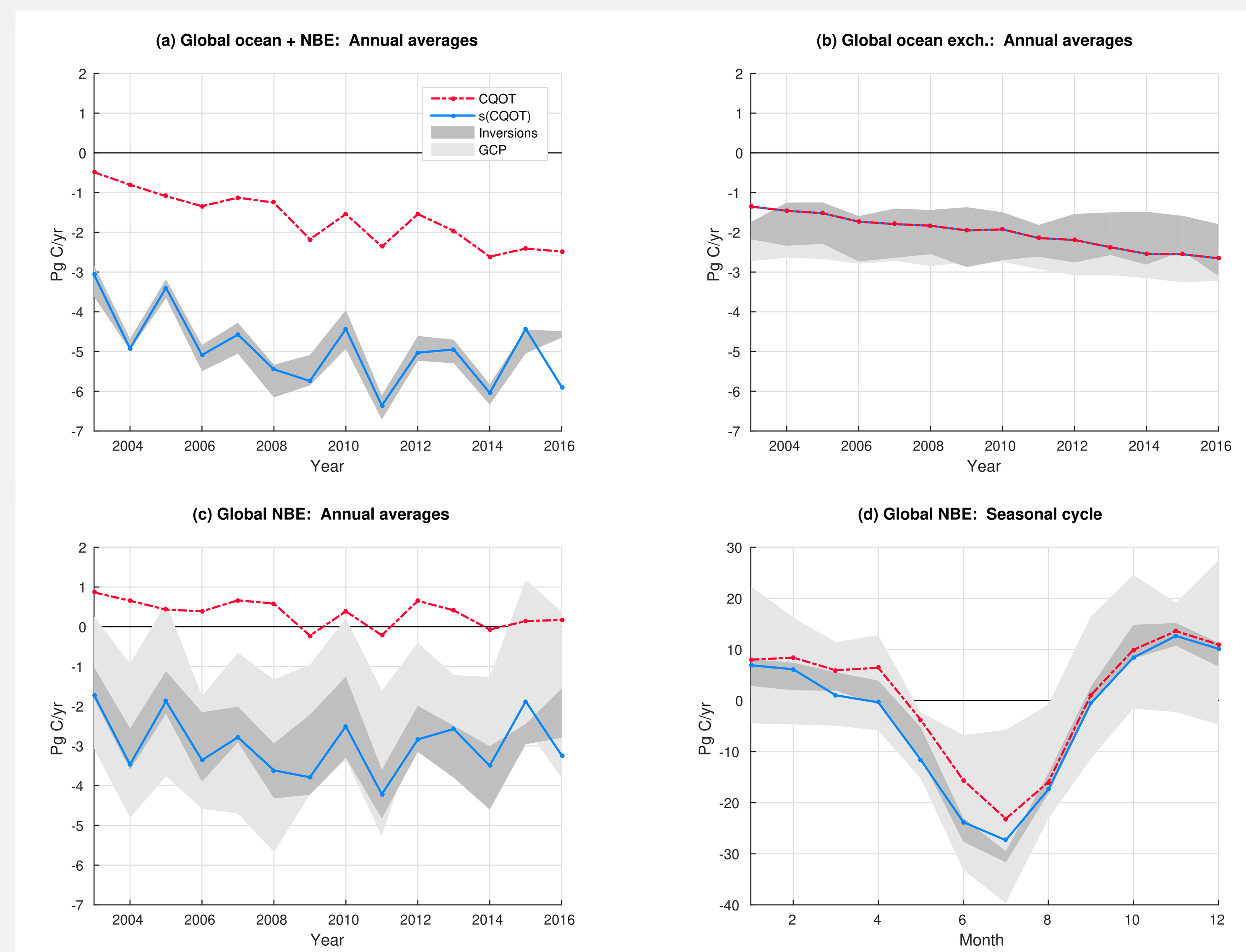

Fig 1. Global total ocean and NBE (NEE + fire) fluxes from the fluxes excluding (CQOT; dash-dot red) and including (sCQOT; solid blue) the empirical sink compared to the ranges of the inversion ensemble (dark grey) and TRENDY model ensemble (light grey).

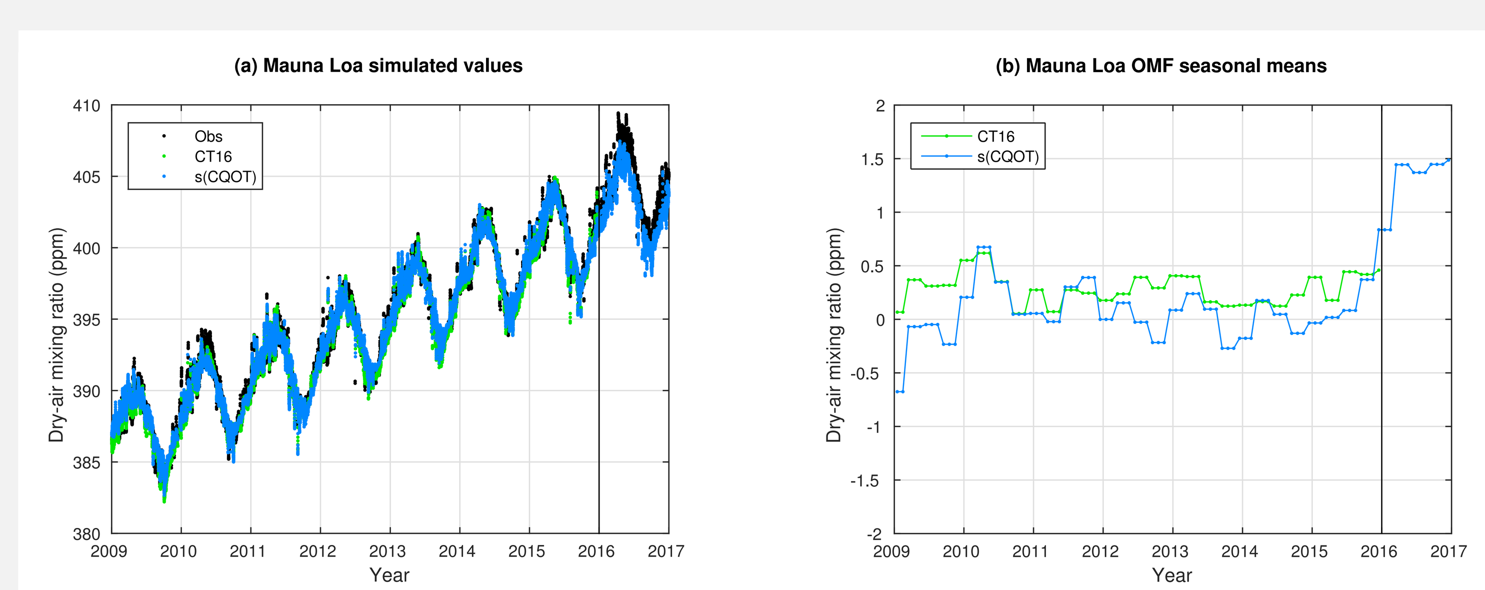

Fig 3. (Left) Simulations using CT16 fluxes (green) and sCQOT fluxes (blue) in the GEOS model and observations (black) at Mauna Loa. (Right) 3-month means of the obs. minus model differences (right). The black line at 2016 indicates the switch from reanalysis (R) to near real time (NRT) modes.

Empirical sink (sCQOT)

A "poor man's inversion" (*Chevallier et al.*, 2009; *Agustí-Panareda et al.*, 2016; *Keppel-Aleks et al.*, 2012) — adjusts the global growth rate and seasonal cycle amplitude of NEE toward observed values.

Our approach decreases monthly heterotrophic respiration proportionally to the temperature increase from the previous month.

The adjustment draws the sCQOT fluxes in line with flux inversion products (Figs 1 & 2). When transported through the NASA GEOS model, the fluxes reproduce in situ measurements with comparable skill to CarbonTracker 2016 (CT16) fluxes (Figs 3 for an example at Mauna Loa).

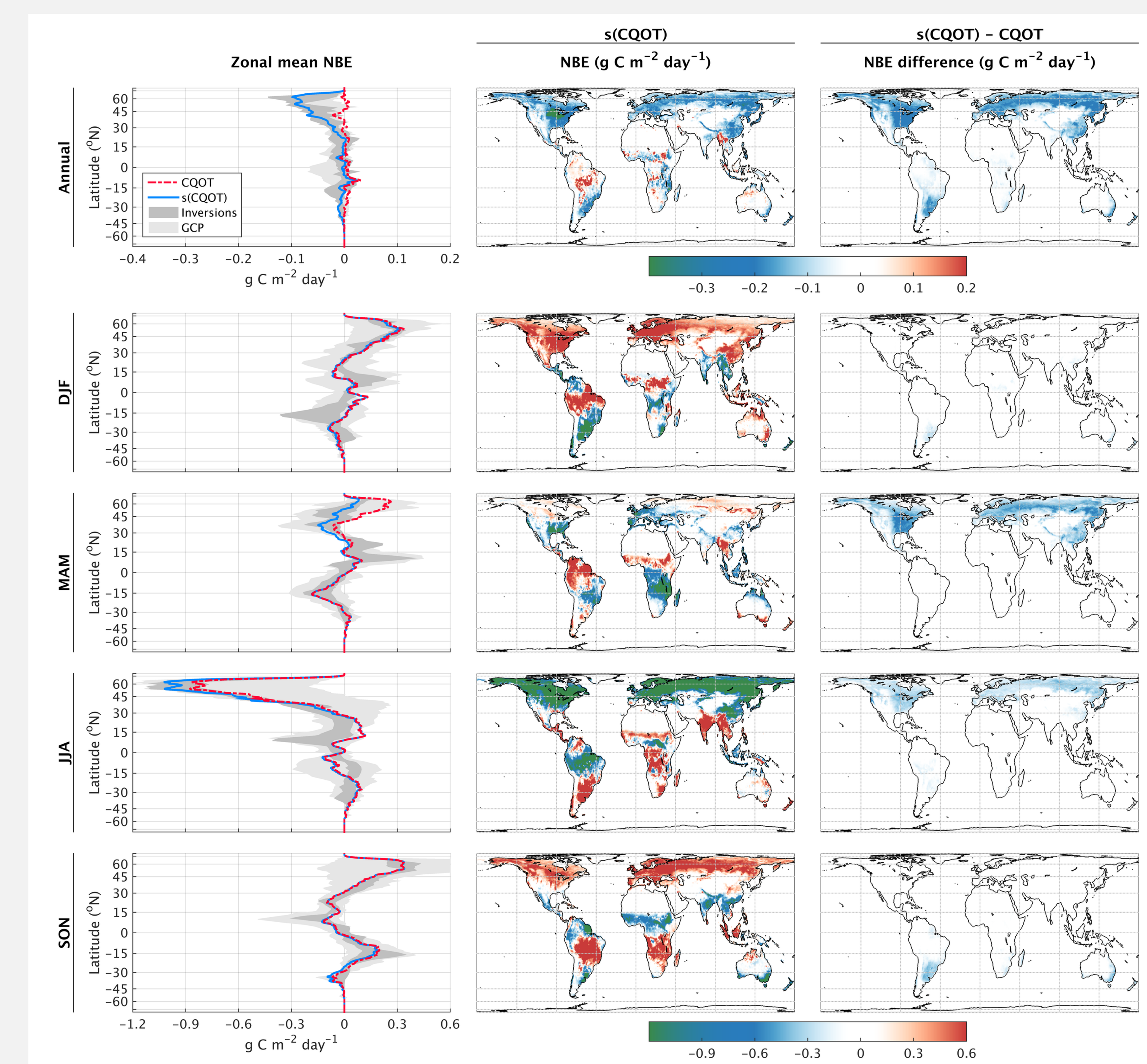

Fig 2. Climatologies (2003—2016) of NBE from the fluxes excluding (CQOT) and including (sCQOT) the empirical sink. The first row represents annual averages and each subsequent row represents averages over different seasons. The left column depicts zonal mean NBE from the CQOT fluxes (dash-dot red) and sCQOT fluxes (solid blue) and the ranges of the inversion ensemble (dark grey) and the TRENDY model ensemble (light grey); the middle column depicts the sCQOT fluxes; and the right column the size of the empirical sink, i.e., the difference between the sCQOT and CQOT fluxes. Note that the scale of the annual average plots is three times smaller than that of the seasonal average plots.

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