(Preliminary analysis of) Diurnal cycles in land carbon fluxes and imprint on atmospheric CO$_2$

Gretchen Keppel-Aleks
gkeppela@umich.edu
University of Michigan

Thank you to: Dave Lawrence, Cecile Hannay, Keith Lindsay, Anthony Torres
Why evaluate the diurnal cycle?

Seasonal cycle in carbon fluxes is tied to strong seasonal forcings (temperature, radiation)

Evaluating fluxes over a range of timescales yields greater confidence that sensitivities and mechanisms are faithfully represented in land models
Diurnal cycle in May solar radiation at Park Falls, Wisconsin
Seasonal cycle of NEE at Park Falls, Wisconsin

Flux [\(\mu\text{mol m}^{-2}\text{s}^{-1}\)]

Ameriflux
CESM2.0

Month
Seasonal cycle of NEE at Park Falls, Wisconsin

Ameriflux
CESM2.0

May
Seasonal cycle of NEE at Park Falls, Wisconsin

Ameriflux
CESM2.0
Seasonal cycle of NEE at Park Falls, Wisconsin

Ameriflux
CESM2.0

July
Seasonal cycle of NEE at Park Falls, Wisconsin

Ameriflux
CESM2.0

August
Seasonal cycle of NEE at Park Falls, Wisconsin

Flux [$\mu$ mol m$^{-2}$ s$^{-1}$]

Month

NEE [umol m$^{-2}$ s$^{-1}$]

Hour

September

Ameriflux
CESM2.0
Seasonal cycle of NEE at Park Falls, Wisconsin

Ameriflux
CESM2.0

February
NEE at Southern Great Plains

Flux [$\mu$ mol m$^{-2}$ s$^{-1}$]

Month

NEE [umol m$^{-2}$ s$^{-1}$]

March

Hour

-15 -10 -5 0 5 10 15 20

March
NEE at Southern Great Plains

Flux [µmol m$^{-2}$ s$^{-1}$]

Month

J F M A M J J A S O N D

Flux [µmol m$^{-2}$ s$^{-1}$]

Hour

May
NEE at Southern Great Plains

![Graph showing NEE flux and month distribution]

Flux $[\mu \text{mol m}^{-2} \text{s}^{-1}]$

Month

J F M A M JJA S O N D

October

Hour

0 5 10 15 20

NEE $[\text{umol m}^{-2} \text{s}^{-1}]$
Evaluating CESM against flux towers may not be representative due to heterogeneity
Diurnal Rectifier at Park Falls, Wisconsin

(CO₂ reported relative to South Pole)
The vertically integrated mixing ratio, $X_{CO_2}$

Variations in $X_{CO_2}$ are directly related to mass fluxes.

$X_{CO_2} = [O_2] \frac{\text{Column CO}_2}{\text{Column O}_2}$

Crisp et al., 2005; Washenfelder et al., 2006; Keppel-Aleks et al., 2012
Synoptic activity complicates column drawdown and local flux at Park Falls

\[ \Delta X_{CO2} [ppm] \]

\[ \sum \text{Eddy covariance flux [ppm]} \]

one-to-one

slope: 0.9

Keppel-Aleks et al., 2012
CESM1 performed favorably relative to empirical terrestrial ecosystem models for diurnal drawdown at Manaus.
Seasonal variations in column CO$_2$

Total column CO$_2$ suggests that CESM northern hemisphere NEP is small during the growing season by 50%.

Keppel-Aleks et al., 2013
Column mean annual cycle at Park Falls, Wisconsin

![Graph showing CO₂ concentrations with TCCON and CESM 2.0 data.]

- **TCCON**: 8.7 ppm
- **CESM 2.0**: 7.3 ppm
- **CESM1.0**: 3.7 ppm
Mean annual cycle at Southern Great Plains

- TCCON: 6.5 ppm
- CESM 2.0: 4.9 ppm
- CESM1.0: 2.5 ppm
CESM1 performed favorably relative to empirical terrestrial ecosystem models for diurnal drawdown at Manaus.
Diurnal column drawdown at Park Falls, Wisconsin

Diurnal variations are underestimated, but interpretation requires understanding of spatial gradients and links to Ameriflux results.
Mean annual cycle in CO$_2$ is underestimated by 15-25% in CESM2, in contrast to $>60^\circ$ in CESM1.

Comparisons at
—smaller spatial scales (annual cycle of NEE)
—shorter time scale (diurnal fluxes & CO$_2$)
provide opportunities to understand the skill of the mechanisms in CLM.
Postdoctoral Positions at University of Michigan

NASA-funded project to understand the role of soil moisture in controlling carbon and energy fluxes
— CLM5
— SMAP (Soil Moisture Active Passive) satellite
— SIF (solar-induced fluorescence) from satellites

NASA-funded project to understand the amplification of the CO$_2$ mean annual cycle
— CESM
— CO$_2$ from flasks, aircraft, TCCON
— GEOS-Chem atmospheric transport model

Please contact: gkeppela@umich.edu