LINKING NEON DATA AND BIOGEOCHEMICAL MODELS

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Data are key

- This uncertainty stems from
  - i. Structural uncertainty
  - ii. Parameter uncertainty
  - iii. Initial conditions uncertainty
  - iv. Boundary conditions uncertainty

Friedlingstein et al., 2006
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Arora et al., 2013
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**ESM Historical Ocean and Land Carbon Accumulation**

**a)**
- Observations
- BCC-CSM1.1
- BCC-CSM1.1-M
- BNU-ESM (units corrected)
- CanESM2 (x3) (units corrected)
- CESM1-BGC
- FGOALS-s2.0
- GFDL-ESM2G
- GFDL-ESM2M
- HadGEM2-ES
- INM-CM4
- IPSL-CM5A-LR
- MIROC-ESM
- MPI-ESM-LR (x3)
- MRI-ESM1 (units corrected)
- NorESM1-ME

**b)**
- Ocean C Accumulation (Pg C)
- Land C Accumulation (Pg C)

Hoffman et al, 2013
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Todd-Brown et al, 2013

Fig. 2. Global soil carbon (top), net primary production (middle), and soil carbon turnover times (bottom) for observations and ESMs. Turnover times were calculated as HWSD carbon divided by MODIS NPP for the observations, and simulated global soil carbon divided by simulated global NPP for the ESMs. The gray hashed area on the top panel represents the 95% confidence interval for global soil carbon in the HWSD based on a qualitative uncertainty analysis (see text). The hashed area on the middle panel represents ±2 standard deviations around the mean global NPP estimate from Ito (2011) based on empirical models. The hashed area on the bottom panel indicates the range of turnover times for global soil carbon found in the literature (Amundson, 2001; Raich and Schlesinger, 1992). For soil carbon and NPP, each global estimate is separated into individual biome components according to the legend shown in the top panel.

Variation in global soil carbon stocks simulated by ESMs could be driven by variation in modeled NPP, and we found that global terrestrial NPP varied by a factor of 2.6 across the models (Fig. 2). CCSM4, BCC-CSM1.1, CanESM2, INM-CM4, GISS-E2, and MIROC-ESM all predicted global NPP values within 2 standard deviations of the Ito (2011) estimate of 54 Pg C yr\(^{-1}\), ranging from 46 to 73 Pg C yr\(^{-1}\), whereas the remaining 5 models fell outside this range. NPP from MODIS was similar to Ito (2011) at 52 Pg C yr\(^{-1}\). At high northern latitudes, NPP estimates from the ESMs were more variable (1.7 to 10.1 Pg C yr\(^{-1}\)), compared to a MODIS estimate of 4.7 Pg C yr\(^{-1}\) (Fig. S6 in Supplement).

Turnover times for global soil carbon from the ESMs varied by a factor of 3.6, between 10.8 and 39.3 yr, using global Biogeosciences, 10, 1717–1736, 2013 www.biogeosciences.net/10/1717/2013/
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- Need to find (new) ways to use (new) observations to:
  - Evaluate
  - Benchmark
  - Constrain
  - Assimilate

Jones et al., 2013
• Collect and openly distribute data on the drivers of and responses to ecological change
• Continental scope and 30-year time horizon
• Standardized methods of data collection, high investment in QA/QC, and calibration
Biogeochemistry Observations

- Many relevant observations; Some standard, some less common
  - Eddy covariance fluxes of energy, water and carbon
  - Profiles of soil temperature and moisture, and soil respiration
  - NPP, litterfall and fine root turnover from minirhizotrons
  - NO$_y$ and Ozone deposition
  - Profiles of CO$_2$ and H$_2$O vapor isotopes
  - Soil microbial biomass, diversity & functional composition
  - Lidar and hyperspectral derived biomass, leaf area and canopy chemistry at <1m resolution over 100s km$^2$
NEON in CLM-space
Direct comparison
Functional responses

1. The image contains several scatter plots depicting the relationship between various environmental variables. The plots show data from the National Ecological Observatory Network (NEON) across various sites in the USA over 30 years.

2. A very rich source of data will come from the National Ecological Observatory Network (NEON), a continental-scale facility under the auspices of the National Science Foundation.

3. Observations from NEON will be instrumental in understanding soil carbon dynamics in Earth System Models.

4. Correct simulation of soil carbon dynamics in Earth System Models is crucial for understanding the carbon-cycle climate and concentration feedbacks.

5. To illustrate the potential utility of these data in constraining models, we show the range of Community Land Model (CLM4.5-BGC) output at NEON sites.

6. Functional responses are beneficial as direct comparison of model output and observations is often confounded by mismatches in spatial scale and climate drivers.

7. Comparing modeled functional responses against data at a NEMO network. Here we have been using observations from the NEON and just as unobserved model data assimilation developed and maintained at the National Center for Atmospheric Research.

8. At single site locations we are testing our ability to assimilate real NEON data, and understand functional responses. But in this case the known short-term response between observations and model output, and usually is beneficial for detecting model error.

9. Using monthly values of monthly soil resp, and functional responses for some time to understand model error covariance at a point. This updating occurs every 0.5 hours. We then investigate the impacts of assimilating NEON data over a three-month period.

10. The uncertainty in LAI reflects the actually uncertainty in the LAI spread in 80 members, 1 July 2005 to 31 July 2005.

11. Comparing modeled functional responses against data at a NEMO network. Here we have been using observations from the NEON and just as unobserved model data assimilation developed and maintained at the National Center for Atmospheric Research.
Data Assimilation Research Testbed (DART)

- DART is a community facility for ensemble DA
- Uses a variety of flavors of filters
  - Ensemble Adjustment Kalman Filter
- Many enhancements to basic filtering algorithms
  - Adaptive inflation
  - Localization
- Uses new multi-instance capability within CESM
Ameriflux and MODIS LAI observations
Ameriflux and MODIS LAI observations
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Ameriflux and MODIS LAI observations
Current Directions

• CLM-DART development
  – Investigating improved methodology for using flux tower observations in this framework
  – Adding plant functional types to observation meta-data
  – Adding additional, site specific observation types

• Upscaling NEON observations – PDF of fluxes and assessing representativeness error

• Optimizing NEON data delivery for model evaluation – please let me know if you have ideas