Moisture extremes and internal lags as controls on photosynthesis anomalies in temperate forests

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What is a climate extreme?

• A spike or pulse?
• A standardized anomaly?
• Variability around a steady forcing change?
• A forcing that develops an unusual response in a particular system?
What is the biogeochemical response?

Forcing

[Graphs and diagrams showing different forcing responses]
What drives this response?

- Terrestrial ecosystems carbon assimilation and decomposition respond to:
  - Temperature
  - Light quantity and quality
  - Moisture availability
  - Nutrients (Nitrogen, CO$_2$, Phosphorous)
  - Disturbance (Fire, insects, hurricanes, …)
  - Land use (Logging, draining wetlands, …)
  - Competition, adaptation, evolution
Coated With Algae

The satellite images show Lake Erie at two different times in 2011, when the lake suffered the worst algae bloom in decades. The first image shows the lake before the bloom started; the second shows the bloom at its greatest extent, covering much of the lake's western basin.
Spatial stand heterogeneity

Phenotypical phenology variation

Carbohydrate storage

Cross-shading

Self-shading

Leaf age

Pest/pathogen damage

Micrometeorological variation

Nutrient competition

Moisture competition

Soil nutrient/moisture retention
A very tall tower!
Problem 1

• The same climate forcing does not produce the same response across ecosystems – even when they’re right next to each other!
Problem 2

- NEE is a combination of ecosystem carbon cycle processes
- Partitioning into GPP and Reco relies on environmental drivers – making causal analysis circular!
- Use simple data-based metric to assess net “drawdown” from night to day
- Average across time and standardize the anomalies
Problem 3

- Every flux tower based correlation is significant when you have thousands to tens of thousands of datapoints
  - Effect sizes may be small, though
- Account for autocorrelation using “reduced degrees of freedom” metric!

Bretherton et al., 1999, J Clim
The graph shows the relationship between the degree of freedom (DOF) in days and the averaging period in days. The line indicates that as the averaging period increases, the DOF decreases significantly. The data point at the top of the graph is labeled "n=5490."
Important points 1

- Highly significant autocorrelations at daily to seasonal scales up to one month lag imply a strong biological feedback that can damp response to extremes
- Weak negative autocorrelations at multi-year scales also highlight slow press processes and oscillations
- Remotely sensed anomalies have little correlation to carbon flux even though mean seasonal variation correlates highly
Important points 2

- Moisture extremes impact to regional carbon sequestration display significant seasonal lags and primarily influence monthly to seasonal uptake.
- Positive correlations imply mesic forest is in-fact moisture limited, but not in the usual sense.
What about 2012?

U.S. Drought Monitor
October 9, 2012
Valid 7 a.m. EDT

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

http://droughtmonitor.unl.edu/

Released Thursday, October 11, 2012
Author: Matthew Rosencrans, NOAA/NWS/NCEP/CPC
Important points 3

• Warm, dry conditions more likely promoted a longer growing season through phenology than reduced uptake by stomatal closure

• Biotic disturbances and their frequency/extremes may be more important than climate extremes in many places
Thanks!

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