An overview of the North American Carbon Program Site-Level Interim Synthesis

NACP Site-Level Synthesis Team*

with special contributions to this talk from:

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Motivation

- An interim synthesis effort for the NACP
- Generate new knowledge of measurement and modeling uncertainty.
- Improve diagnosis, attribution, and prediction efforts.
- Answer basic question:
  - **Are the various measurement and modeling estimates of carbon fluxes consistent with each other - and if not, why**?

Approach

- Constrain and quantify sources of observational and modeling uncertainty.
- Eliminate inconsistencies in model forcing data and modeling protocols.
- Exercise a large number of models across a broad range of sites.
- Community-based evaluation and analysis of multi-model, multi-site results

Scope of effort

- 47 sites and 28 models
- Comprehensive experimental protocol
- Consistent, quality-controlled model driving datasets (meteorology)
- Gap-filled (and unfilled!) fluxes, with consistent uncertainty analysis
- Detailed ancillary and biological data for model evaluation and parameterization
- Analysis across biomes, time scales, processes
- Data and analysis coordinated through Modeling and Synthesis Thematic Data Center (MAST-DC)

Eddy Covariance Tower Sites

Priority	Code	Priority	Code
1	CA-Ca1	1	US-Ne1
1	CA-Gro	1	US-Ne2
1	CA-Let	1	US-Ne3
1	CA-Man	1	US-NR1
1	CA-Mer	1	US-PFa
1	CA-Oas	1	US-Shd
1	CA-Obs	1	US-SO2
1	CA-Ojp	1	US-Syv
1	CA-Qfo	1	US-Ton
1	CA-TP4	1	US-UMB
1	CA-WP1	1	US-Var
1	US-ARM	1	US-WCr
1	US-Atq	2	CA-Ca2
1	US-Brw	2	CA-Ca3
1	US-Dk2	2	CA-SJ1
1	US-Dk3	2	CA-SJ2
1	US-Ha1	2	CA-SJ3
1	US-Ho1	2	CA-TP1
1	US-IB1	2	CA-TP2
1	US-IB2	2	CA-TP3
1	US-Los	2	US-Me3
1	US-Me2	2	US-Me4
1	US-MMS	2	US-Me5
1	US-MOz		

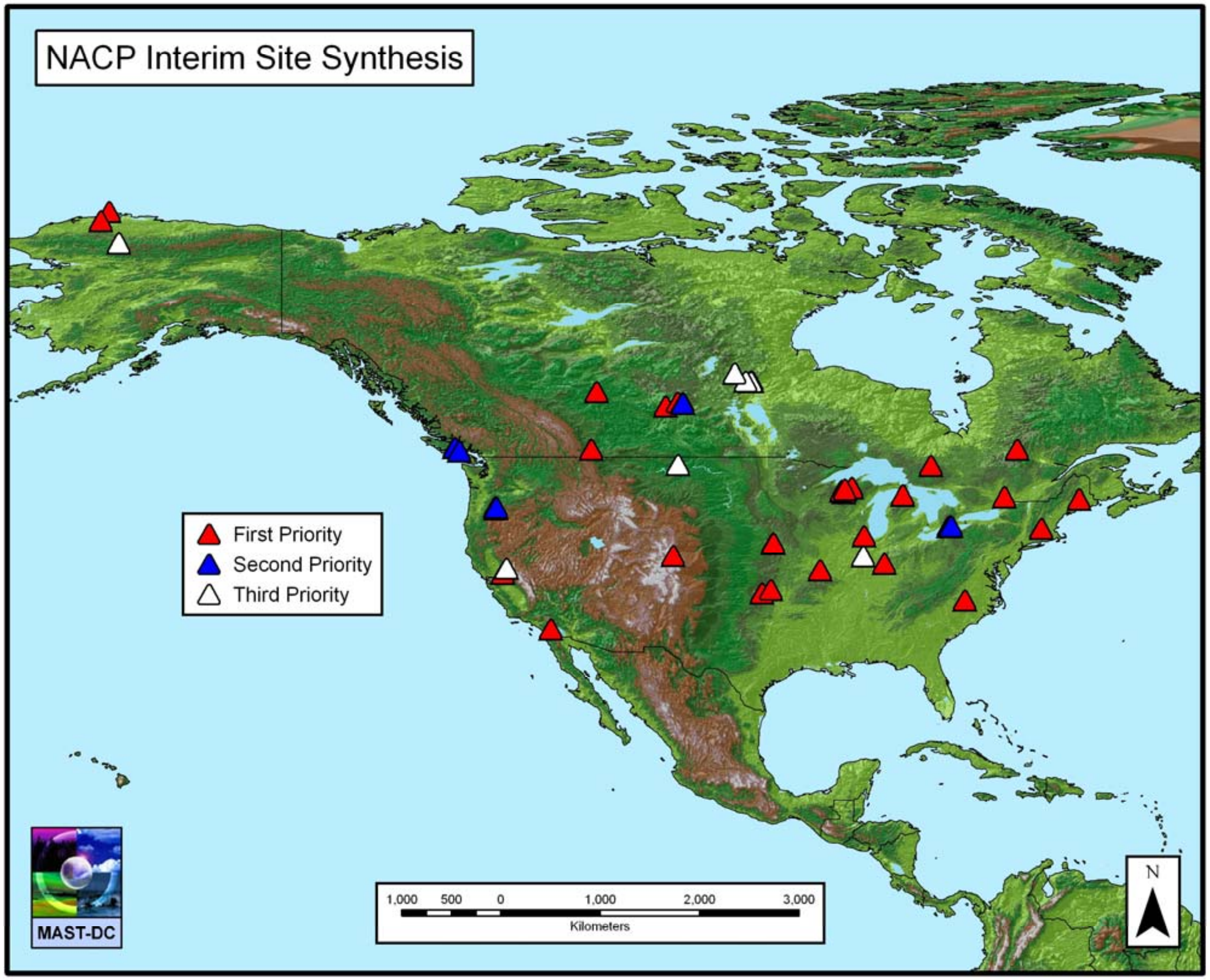


Image credit: MAST-DC

Site Distribution

- Priority 1 (36), Priority 2 (11)
- U.S. (28) and Canada (26)
- By biome
  - Crops (5)
  - Grass (4)
  - Deciduous broadleaf forest (7)
  - Evergreen forest boreal (4)
  - Evergreen forest temperate (6)
  - Mixed forest (3)
  - Shrubs (2)
  - Tundra (2)
  - Wetland (3)

Model Forcing and Ancillary Data

- Gap-filled surface weather data
  - Air temperature
  - Specific humidity
  - Wind speed
  - Precipitation
  - Incident shortwave
  - Incident longwave
  - Surface pressure
  - CO_2 concentration
- Biological / Ecological data
  - Species, age, height
  - LAI, biomass
  - Litter, woody debris
  - AG and BG production
  - Foliar N
  - Phenology
  - Soil C and N
  - Soil texture
  - (and many other variables)

28 Participating models

22 models submitted Results

Agro-IBIS	EPIC
BEPS	GFDL
Biome-BGC	GTEC
Can-IBIS	ISAM
CLASS-CTEM (TRIPLEX-Flux)	ISO-LSM
CLM-CASA'	LoTEC
CLM-CN	LPJml
CN-CLASS	ORCHIDEE
DAYCENT	SiB3
DLEM	SiBCASA
DNDC	SiBcrop
ecosys	SIPNET
ED2	SSiB2
EDCM	TECO

Multiple analyses underway…

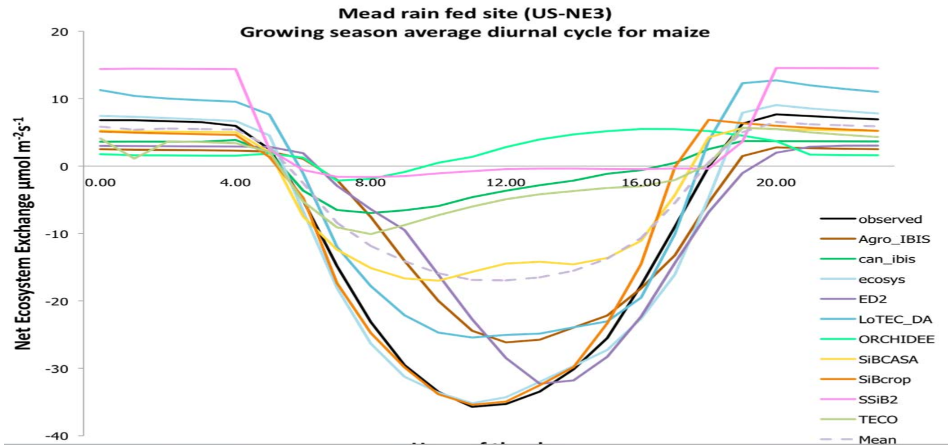
Num	Status	Title	Team
1	Submission	Modeling drought stress	Christopher Schwam, Chris Williams, Kevin Schaefer
2	Writing	Evaluation of continental flux estimates with flux tower measurements	Brett Raczka, Ken Davis
3	Writing	Flux Uncertainty Analysis	Alan Barr, Andrew Richardson, Dave Hollinger
4	Writing	Gap-Filled Weather Uncertainty	Dan Ricciuto
5	Writing	Spectral Analysis	Michael Dietze, Rodrigo Vargas, Andrew Richardson, Paul Stoy
6	Started	Agriculture Sites	Erandi Lokupitiya, Christina Tonitto
7	Started	Disturbance History effect on fluxes	Peter Thornton, Hanqin Tian
8	Started	Forest Ecosystems at diurnal to seasonal time scales	Bill Munger
9	Started	GPP Comparison	Kevin Schaefer, Ben Poulter, David Hollinger, Hans Verbeeck, Alok Sahoo, Brett Raczka, Altaf Arain, Jing Chen, Asko Noormets, Peter Lafleur, Andrew Richardson, Ni Golaz, Rodrigo Vargas
10	Started	Hot Spots in Inter-annual Variability	Guerric Lemaire
11	Started	Intra- and Inter-Model Uncertainties for TECO	Ensheng Weng
12	Started	Isotope analysis	Chun-Ta Lai, Bill Riley, Kevin Schaefer
13	Started	Sensible and Latent Heat fluxes	Alok Sahoo
14	Started	Wetland Sites	Ankur Desai
15	TBD	Age-related Flux changes	Jianfeng Sun
16	TBD	Algorithm Comparison	Dave Hollinger
17	TBD	Biomass Comparison	Leo Liu
18	TBD	Eastern Temperate Forests	Michael Dietze

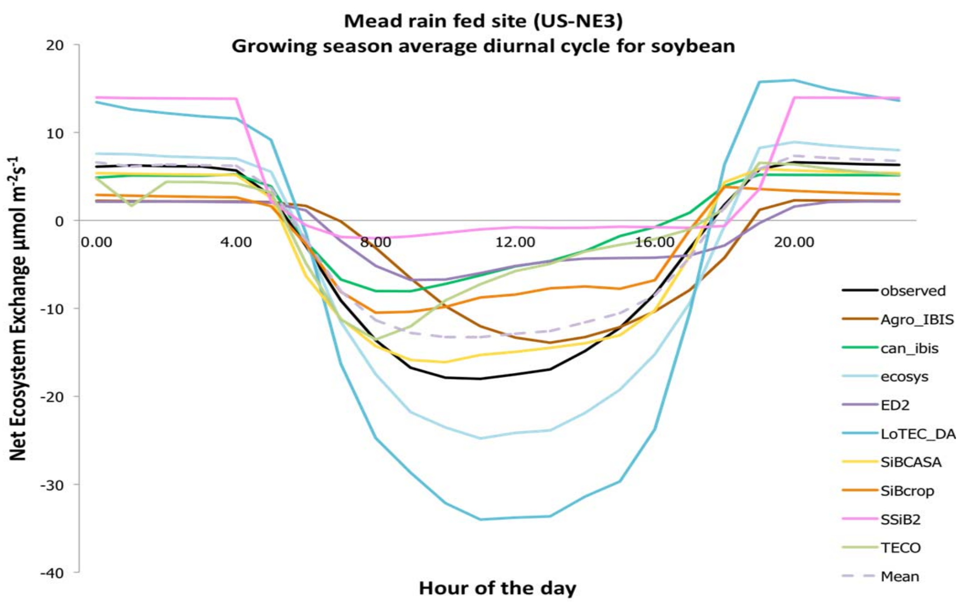
Later in this session…

- Uncertainty in gap-filled meteorological data (D. Riciutto)
- Flux measurement uncertainty (A. Barr)
- Comparison across scales – site to region (B. Raczka)
- Analysis of GPP (K. Schaefer)
- Analysis of NEP and drought effects (C. Schwalm)
- Intra- vs. inter-model uncertainty (E. Weng)

Agricultural site analysis

Lokupitiya, Denning et al.





-16 model submissions

- US-NE1,2,3 (Mead)

- Analyzing NEE, LE, H

- Seasonal and diurnal cycles, R^2, rms values

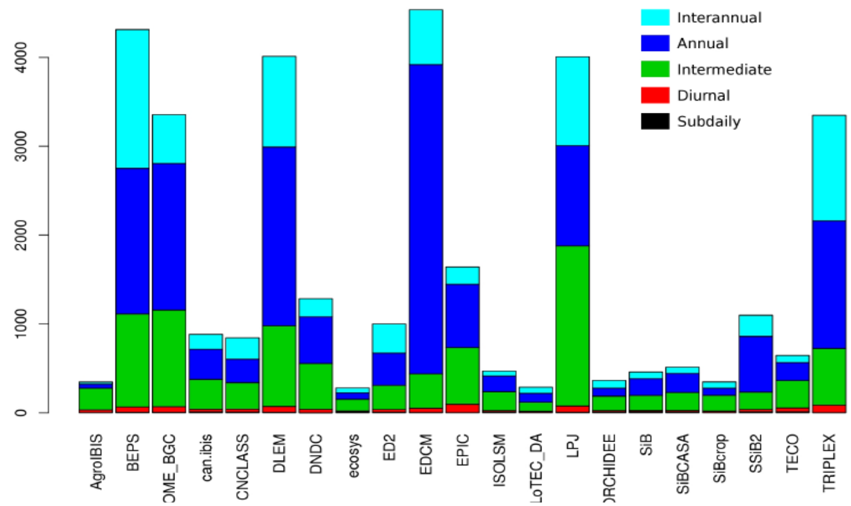
- Key results to date

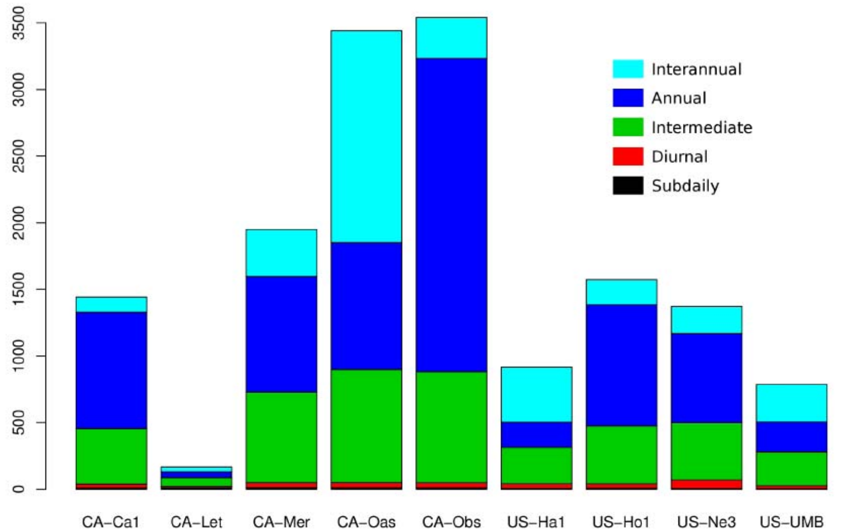
  - most models underestimate corn, none overestimate

  - for soy, closer to mean of models

Spectral analysis

Dietze, Vargas, Richardson, Stoy et al.

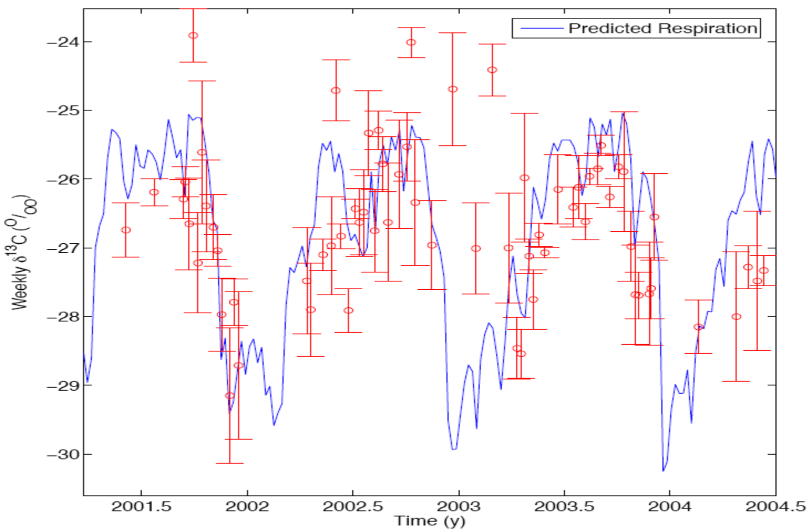


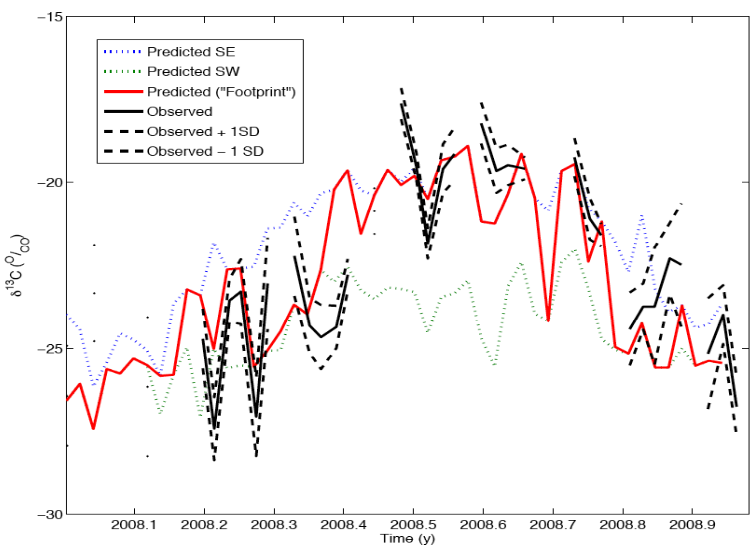


- Wavelet power spectra of model-data residuals
- Flux uncertainty → large long-period spectral uncertainty
  - Results normalized by “null spectra” as test for significance
- Spectral power as function of model, site and timescale
- Wavelet coherence analysis to further estimate significant relationships

Isotope analysis

Riley, Lai et al.





- Motivation
  - $^{13}CO_2$ helps to partition CO_2 flux components (GPP/R, terrestrial/ocean)
  - Seasonality of terrestrial $^{13}CO_2$ exchanges are not well constrained
  - $^{13}CO_2$ model predictions can serve as a constraint on plant physiological predictions (e.g., c_i, g_s)
  - 10 models capable of simulating ^{13}C flux

- Results to date
  - First-cut ISOLSM simulations match US-Wrc seasonality well
  - Good match at very heterogeneous US-ARM when footprint taken into account

Conclusions

- Programmatic Status
  - Progress on multiple analyses (1 submitted, 4 manuscripts in prep, 9 other analyses underway)
  - Building a valuable data and analysis resource
  - Finding (and fixing!) data and model quality issues
- Science
  - We understand measurement uncertainty better than model uncertainty

Conclusions (cont'd)

- Multi-model ensemble is a useful way to analyze the structural model uncertainty
- Next steps:
  - Publish results of steady-state experiments
  - Introduce disturbance history
  - Characterize model uncertainties
    - Forcing
    - Parameterization
    - Process representation

Acknowledgements

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