B54A-05

EVALUATION OF SITE AND CONTINENTAL TERRESTRIAL CARBON CYCLE SIMULATIONS WITH NORTH AMERICAN FLUX TOWER OBSERVATIONS

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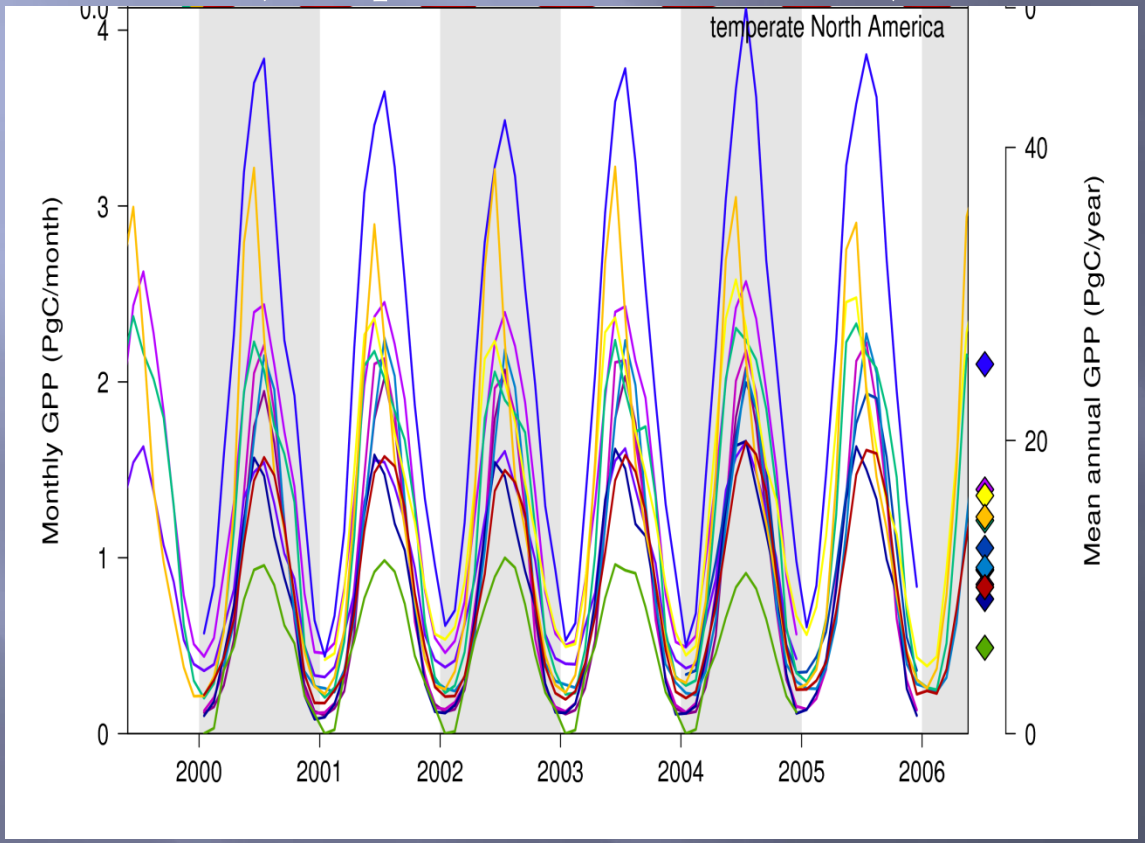
Objectives:

Regional Models
(Temperate North America)

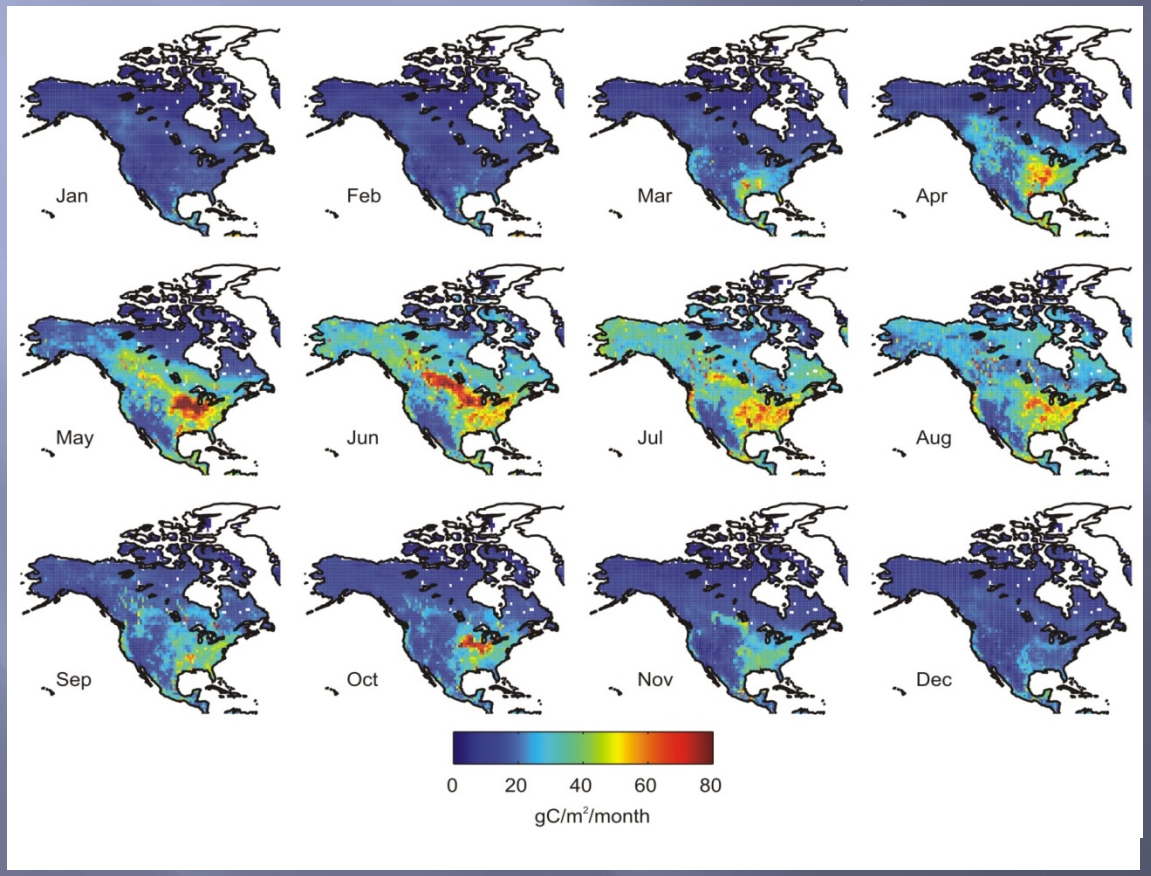


- Use flux towers to evaluate regional models.
  - E.g. What regional models simulate GPP correctly?

Courtesy: NACP Interim Synthesis Workshop, A. Jacobson

Objectives:

Inter-Model Variability
2002 Net Carbon Flux (NEE) by month

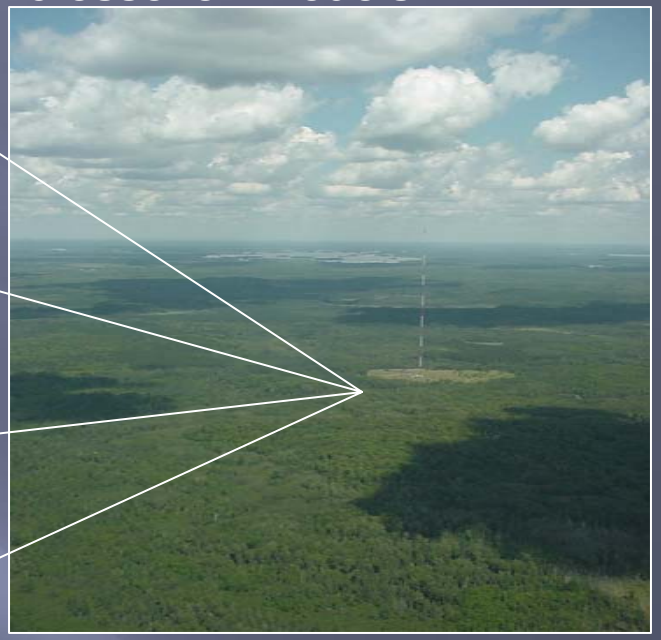


- Use flux towers to evaluate regional models.
  - What regional models simulate GPP correctly?
  - Do regional models have predictive skill for IAV in NEE?
  - Is it helpful to compare regional models to flux tower data?

Courtesy: NACP Interim Synthesis Workshop, D. Huntzinger

Regional vs. Point Model Simulations

scale mismatch - test with 'crossover' models



Site Model Runs and Flux data: order 1x1 km^2 domain

NACP Site Protocol:

1) Gap-Filled Weather Data
2) Soil & Biological Conditions
3) 'Spin-Up' Procedure

Regional Model Runs: order 100X100 km^2 resolution.

NACP Regional Protocol:

1) No common weather, soil, biological or 'spin-up' enforced
2) Native spatial resolution averaged to 1 degree cells
3) Carbon flux 'extracted' from grid cells matching site coordinates

Regional vs. Point Model Simulations

Perfect world: Site and regional model runs match each other and flux tower data.

- unlikely, but worth testing.

Possible causes of discrepancies:

- Lack of model skill.
  - site and regional models perform poorly
- Sites not representative of regions
  - site models do well, regional models poorly
- Regional driver data is poor
  - site models do well, regional models poorly
- Flux tower IAV is not driven by climate
  - site and regional models perform poorly

Lacking to date: Ability to evaluate regional model driver data vs. site level driver data.

Methods

- Regional Models (17)

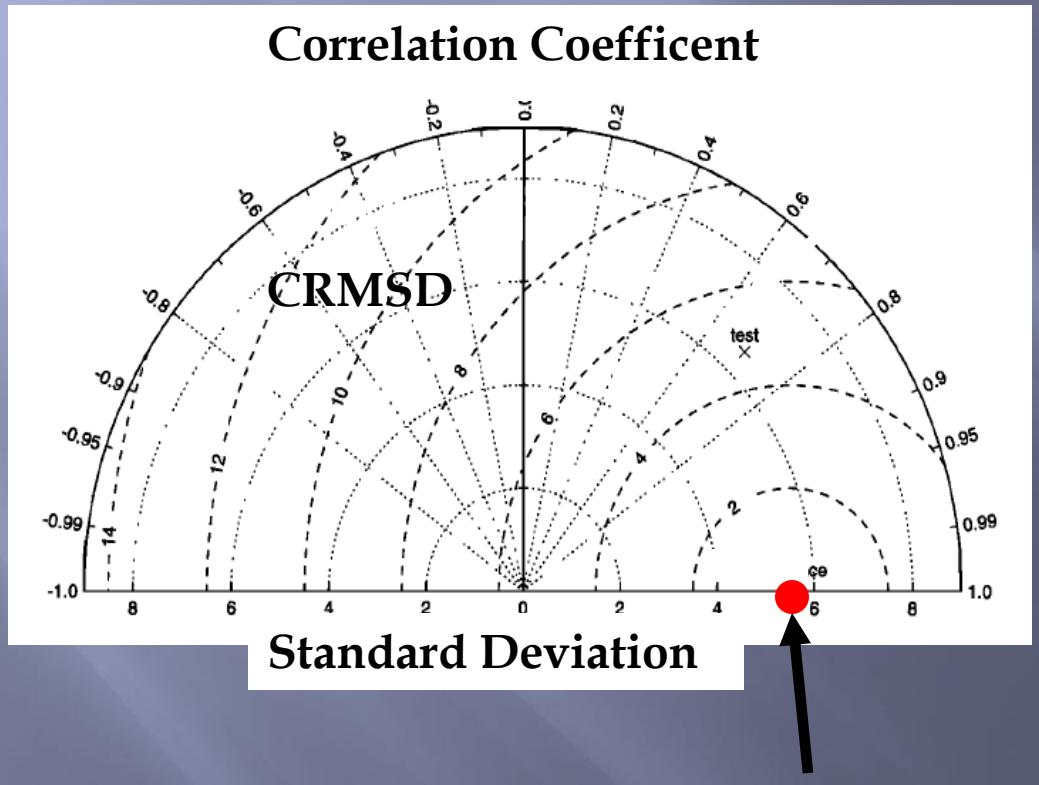
BEPS
CASA-GFEDv2
CASA-Trans
CLM-CASA
CLM-CN
Can-IBIS
DLEM
EC-MOD
ISAM
LPJml
MC1
MOD17
NASA-CASA
ORCHIDEE
SIB3
TEM6
VEGAS2

Denotes "crossover" model

- Crossover Models (site and regional runs) (7)
- Sites (36 Total)
  5 Crops, 4 ENFB
  4 Grass, 6 ENFT
  10 DBF, 7 MISC
- Years 2000-2005 only
- Fluxes: NEE, GPP, Re
- Time step: Annual, Monthly
- Analyses by site and PFT

Methods: Taylor Diagrams

f =model data, *r* = observed data



Variability (Standard Deviation)

$$\sigma = \left[\frac{1}{N} \sum_{n=1}^{N} \left(f_n - \overline{f} \right)^2 \right]^{1/2}$$

Pattern Similarity (R)

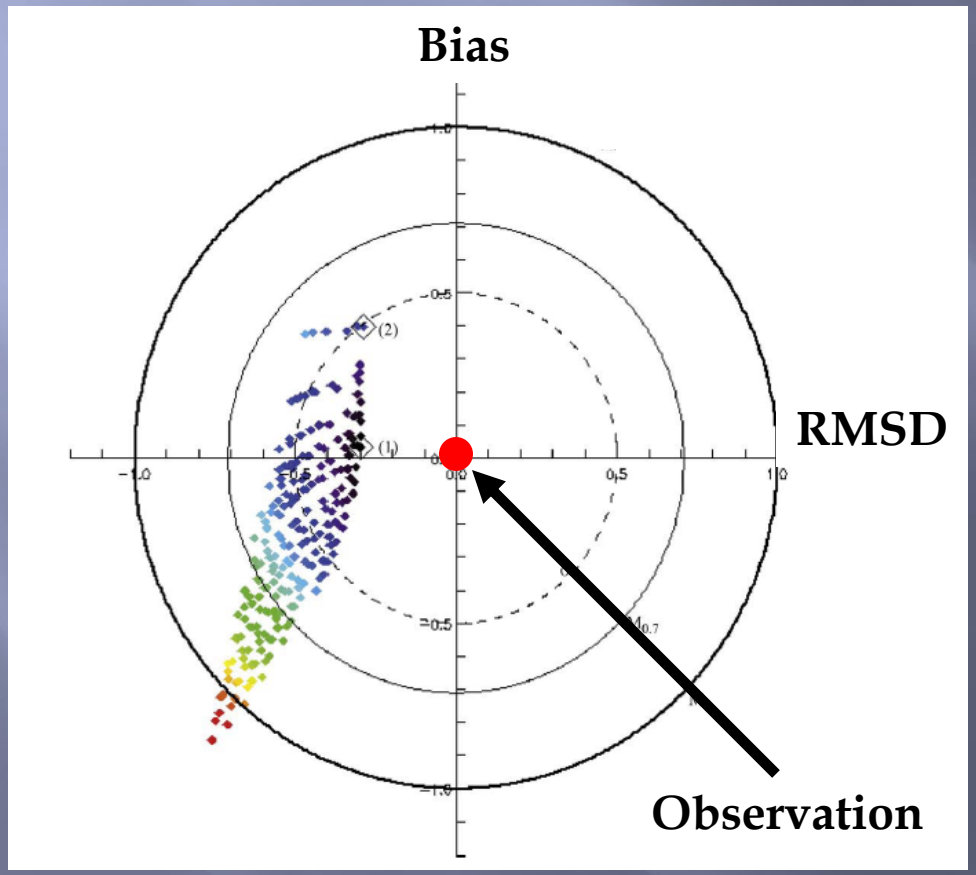
$$R = \frac{\frac{1}{N} \sum_{n=1}^{N} \left(f_n - \overline{f} \right)\left(r_n - \overline{r} \right)}{\sigma_f \sigma_r}$$

Deviation (CRMSD)

$$E' = \left\{ \frac{1}{N} \sum_{n=1}^{N} \left[\left(f_n - \overline{f} \right) - \left(r_n - \overline{r} \right) \right]^2 \right\}^{1/2}$$

Methods –Target Diagram

f =model data, *r* = observed data



$$Bias = \frac{1}{N}\sum(r_n - f_n)$$

$$RMSD = \sqrt{\frac{1}{N}\sum_{n=1}^{N}(r_n - f_n)^2}$$

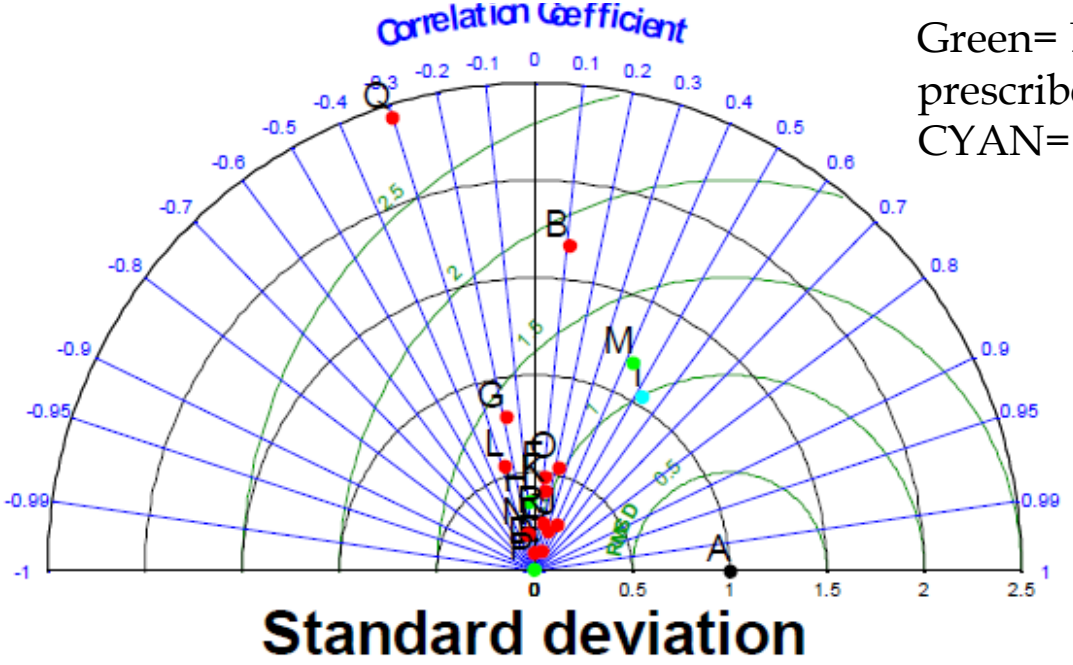
Jolliff et. al (2009)

Results- Annual Fluxes

- IAV for NEE is poorly replicated for all PFTS

A=Observ
B=BEPS
C=CASA GFEDv2
D=CASA-Trans
E=CLM-CASA
F=CLM-CN
G=Can-IBIS
H=DLEM
I=EC-MOD
J=ISAM
K=LPJml
L=MC1
M=MOD17
N=NASA-CASA
O=ORCHIDEE
P=SIB3
Q=TEM6
R=VEGAS2

DBF Annual NEE



Green= LAI prescribed
CYAN= DA

Possible causes: Poor skill modeling IAV, poor driver data, and/or flux towers aren't representative.

Results- Annual Fluxes

- IAV in GPP & Re replicated better than NEE for DBF & ENFT, but not for other PFTs.

A=Observ
B=BEPS
C=CASA GFEDv2
D=CASA-Trans
E=CLM-CASA
F=CLM-CN
G=Can-IBIS
H=DLEM
I=EC-MOD
J=ISAM
K=LPJml
L=MC1
M=MOD17
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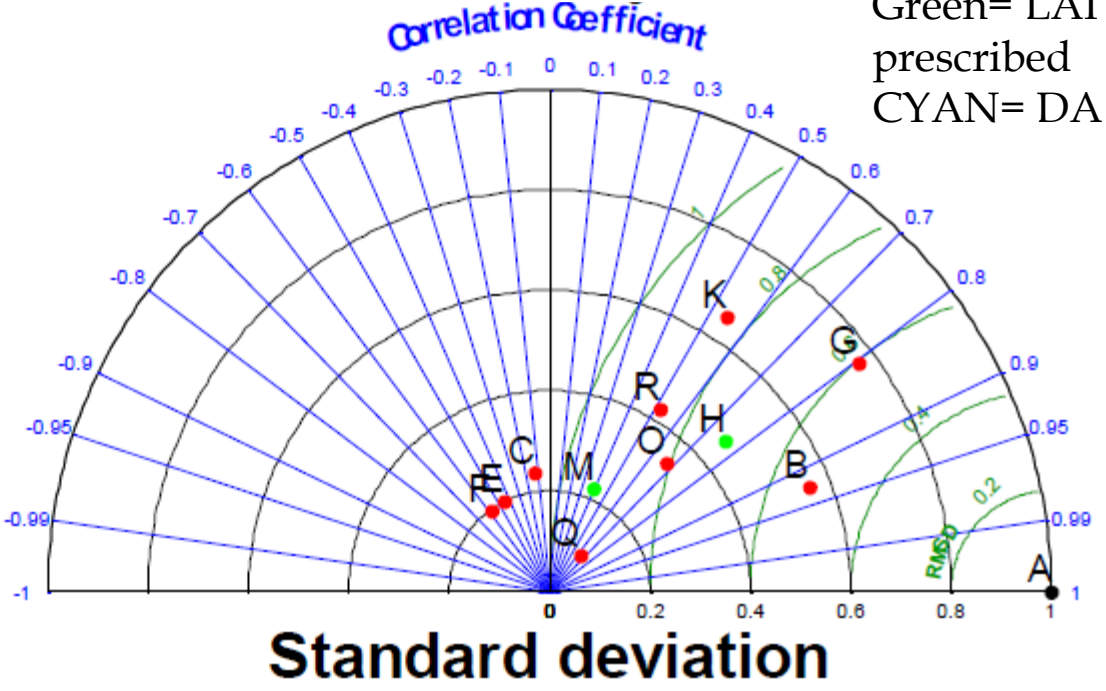
CA-Ca1 (ENFT) annual GPP

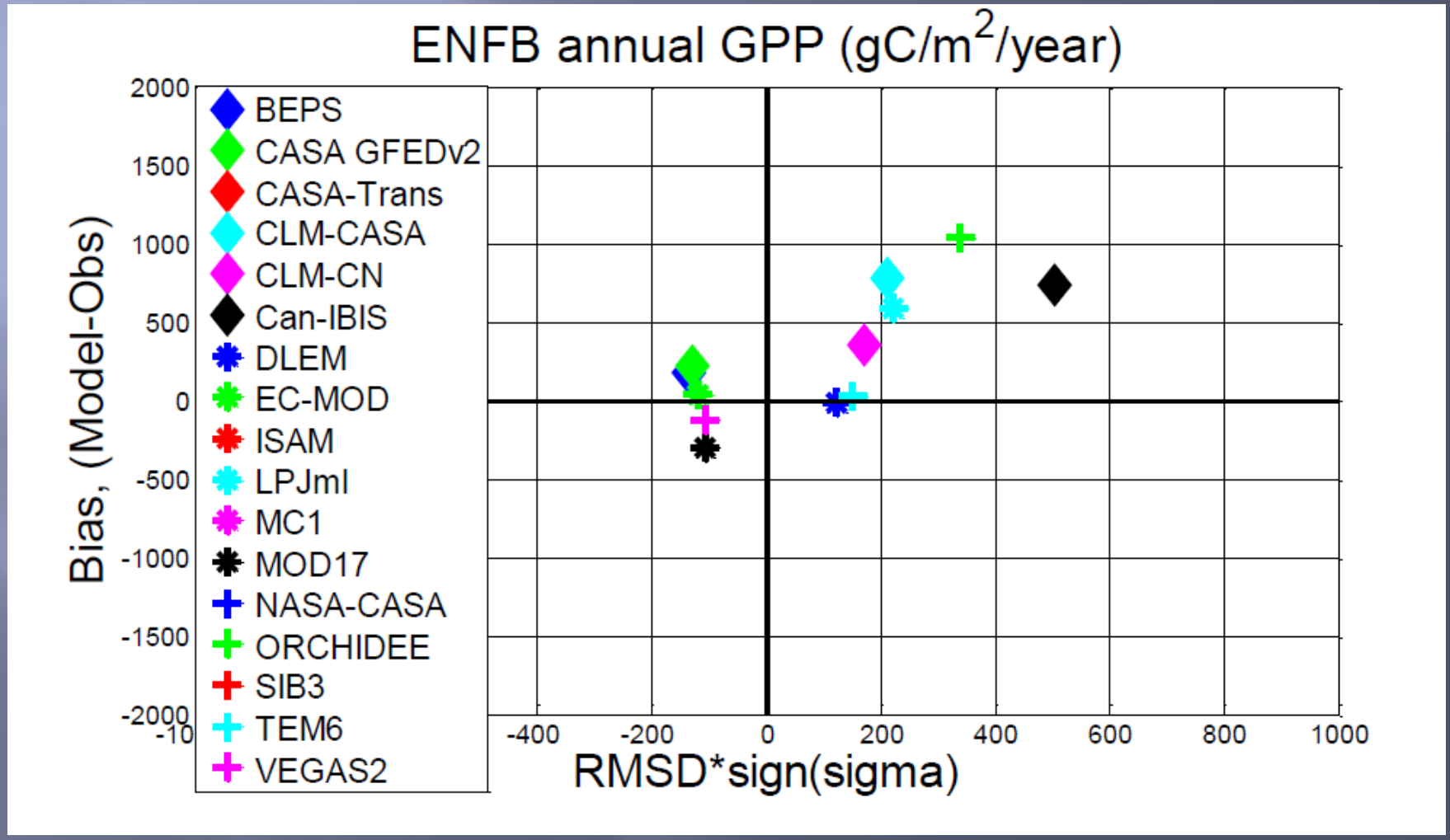
Green= LAI prescribed
CYAN= DA



Cause is not clear. Also true that for monthly fluxes, GPP and Re have higher R

Results- Annual Fluxes

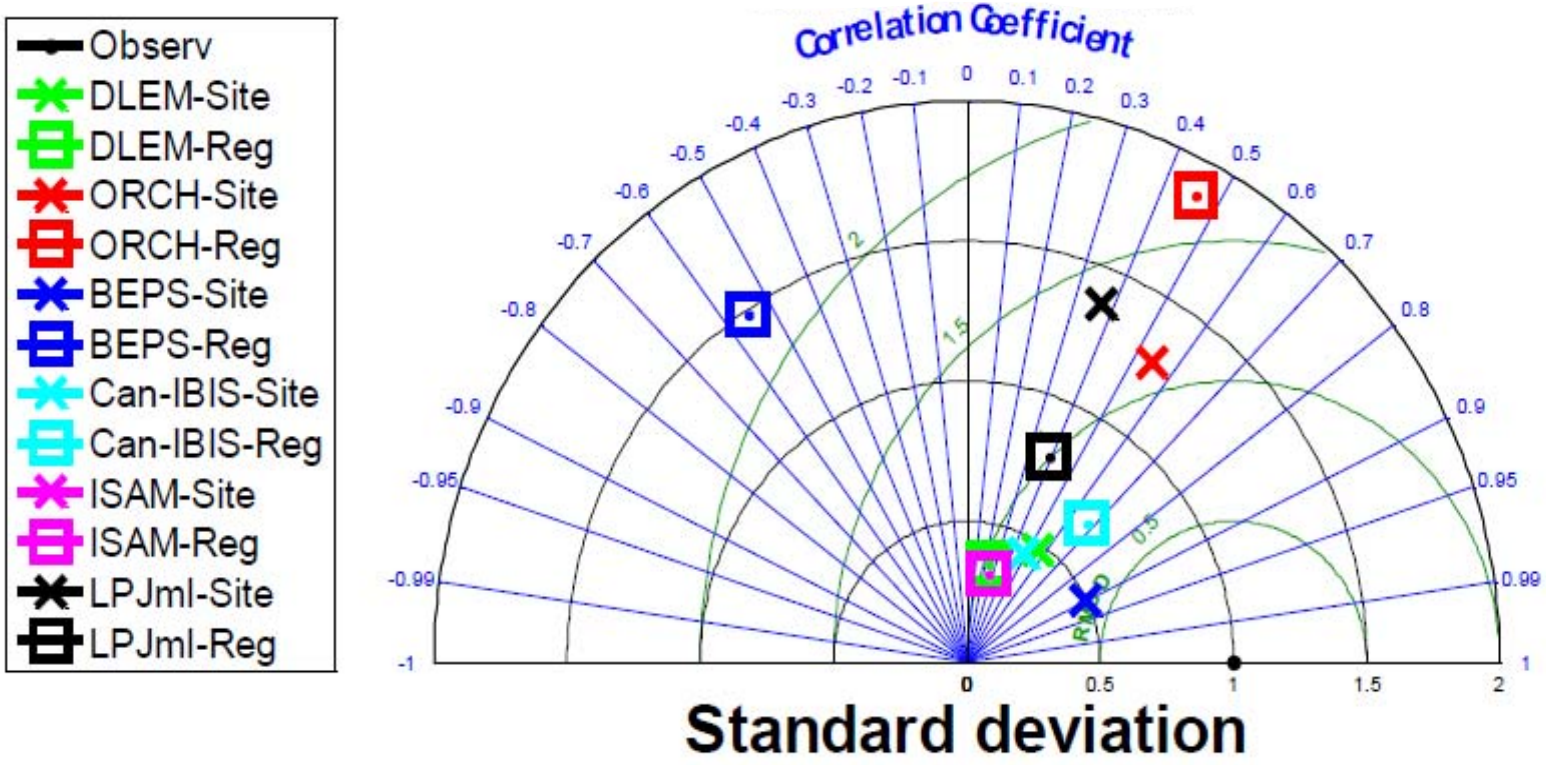
- Models most often over-predicted annual GPP.
- Vegas2 & TEM6 performed the best individually re: GPP bias. LUE models closer to the truth? (see R. Cook's talk)



Results- Crossover Models

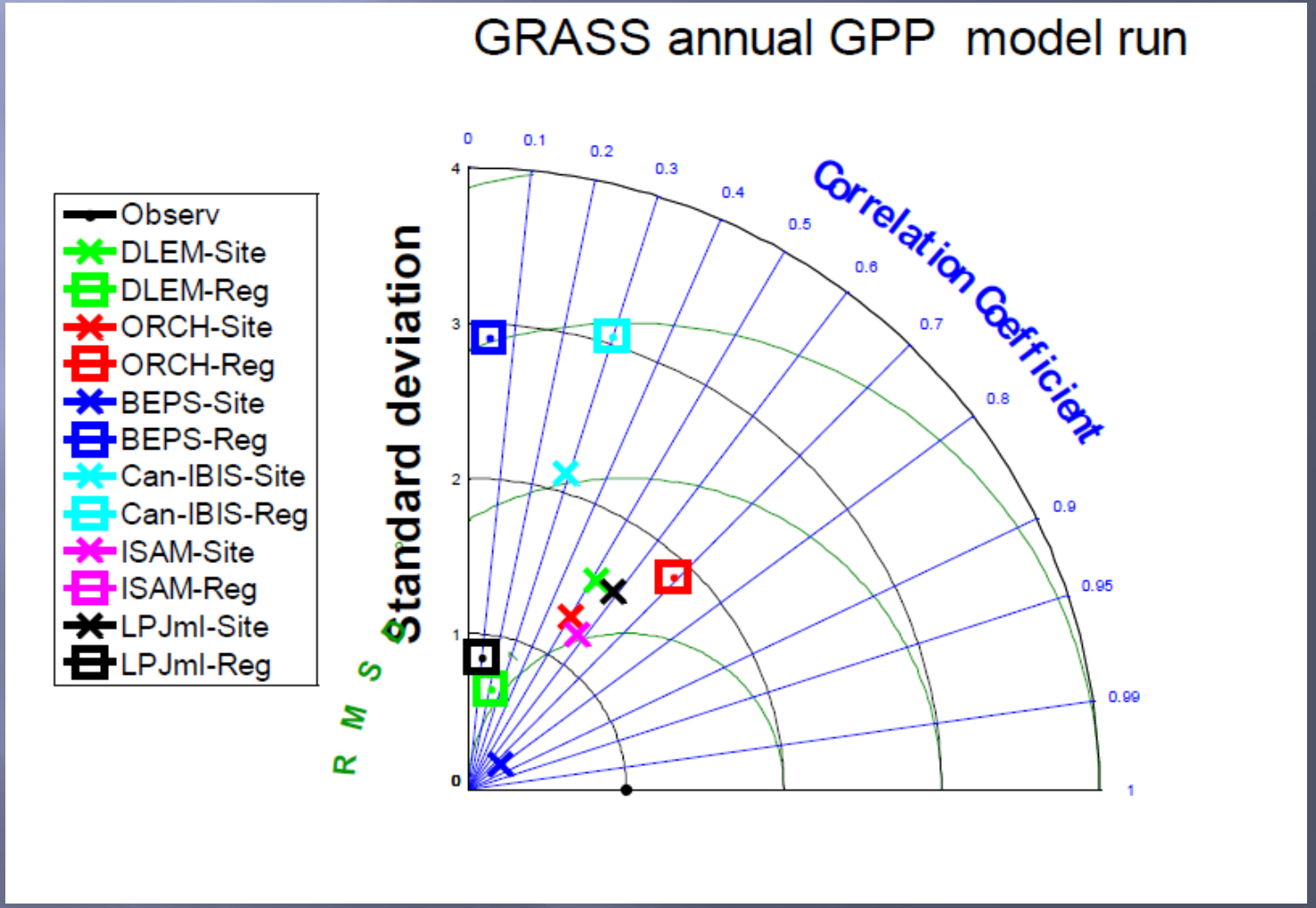
- Site model runs perform similarly to, or slightly better than, regional model runs in term of IAV in NEE
- GRASS - 'slightly better' example

GRASS annual NEE



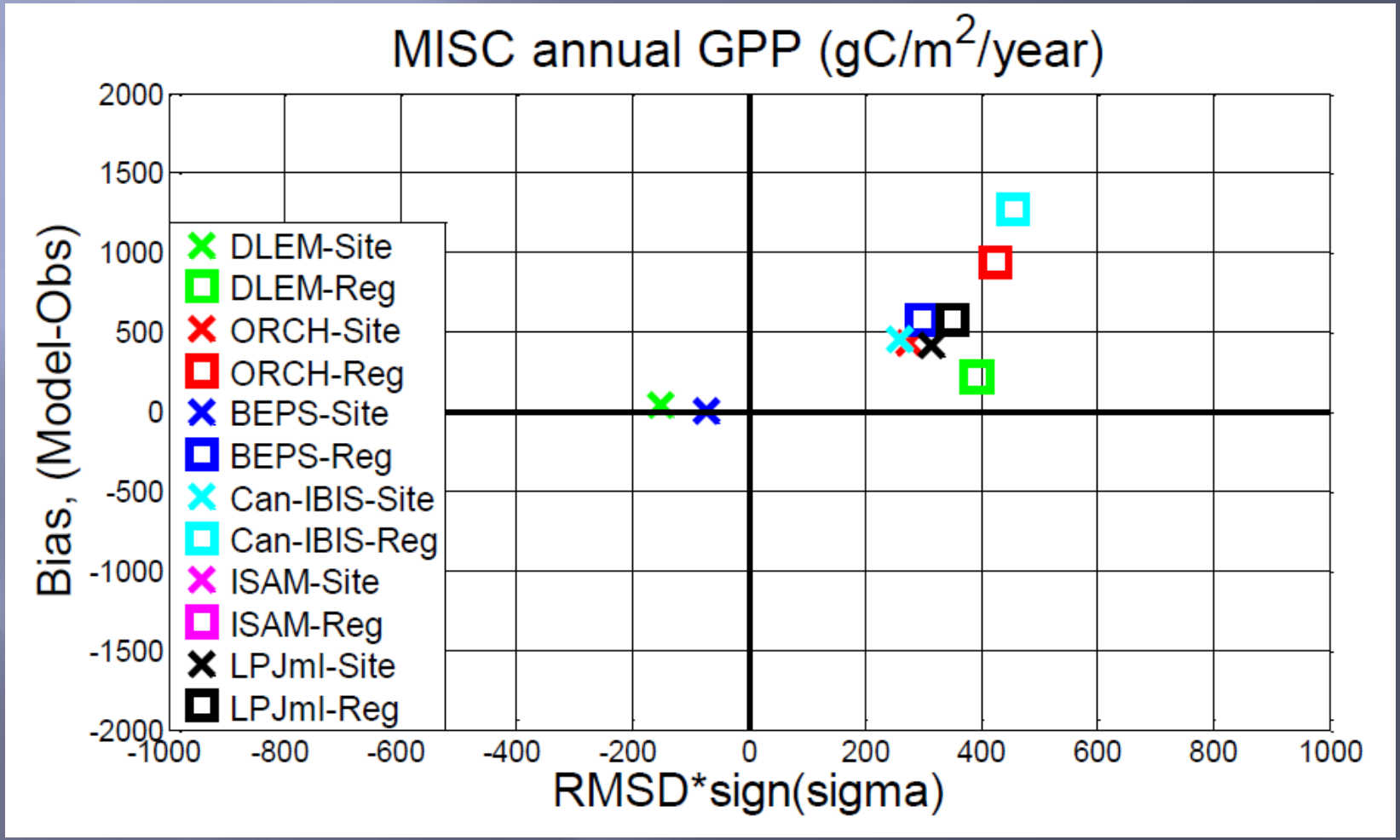
Results- Crossover Models

- Site model runs typically outperform regional model runs for annual GPP & Re - most improvement in variability.
- Regional model runs tend to over-predict IAV in GPP and Re.



Results- Crossover Models

- Site model runs show lower for GPP.
- Degree of improvement varies a lot - driver data?



Results: Model Rankings

Annual NEE Best Performers: MOD17, EC-MOD, CLM-CASA, MC1
Example below - ENFT.

Annual NEE ENFT Statistics (gC/m2/year)							
Absolute Bias		RMSD		R		Sigma Ratio	
14.5	MOD17	2.06E+02	CASA-Trans	7.08E-01	NASACASA	1.00E-01	MOD17
40.6	EC-MOD	2.08E+02	CLM-CASA	6.00E-01	Orchidee	6.19E-01	EC-MOD
61.3	Orchidee	2.23E+02	TEM6	4.38E-01	EC-MOD	6.28E-01	Can-IBIS
103.8	CLM-CASA	2.27E+02	EC-MOD	3.94E-01	ISAM	6.41E-01	BEPS
112.3	CASA-Trans	2.27E+02	MOD17	3.44E-01	BEPS	7.26E-01	MC1
112.5	NASACASA	2.32E+02	CLM-CN	3.08E-01	MOD17	8.13E-01	DLEM
138.0	CLM-CN	2.45E+02	NASACASA	3.07E-01	Can-IBIS	1.23E+00	LPJml
146.3	Can-IBIS	2.45E+02	Orchidee	1.69E-01	CLM-CASA	1.48E+00	TEM6
150.9	Vegas2	2.89E+02	Can-IBIS	-2.36E-02	SIB3	1.49E+00	Orchidee
151.8	BEPS	2.94E+02	ISAM	-8.09E-02	CLM-CN	1.63E+00	Vegas2
163.7	ISAM	2.98E+02	Vegas2	-1.26E-01	DLEM	1.72E+00	CLM-CASA
167.7	DLEM	2.99E+02	SIB3	-1.58E-01	CASA-Trans	1.82E+00	NASACASA
170.7	LPJml	3.04E+02	CASA GFEDv2	-2.61E-01	LPJml	1.92E+00	CASA GFEDv2
173.4	CASA GFEDv2	3.19E+02	DLEM	-2.94E-01	CASA GFEDv2	2.01E+00	ISAM
182.3	SIB3	3.31E+02	LPJml	-3.21E-01	MC1	2.09E+00	CLM-CN
183.1	MC1	3.85E+02	BEPS	-3.51E-01	Vegas2	2.55E+00	CASA-Trans
209.0	TEM6	4.34E+02	MC1	-5.98E-01	TEM6	4.86E+00	SIB3

Results: Model Rankings

Annual GPP Best Performers: Vegas2, DLEM, MOD17, CLM-CN
Example below: DBF.

Annual GPP DBF Statistics (gC/m2/year)							
Absolute Bias		RMSD		R		Sigma Ratio	
6.282	EC-MOD	2.99E+02	CASA GFEDv2	6.29E-01	MOD17	2.03E-02	CLM-CASA
70.86	CASA GFEDv2	3.05E+02	EC-MOD	5.97E-01	Vegas2	6.95E-02	Vegas2
110	CLM-CN	3.16E+02	DLEM	5.71E-01	Can-IBIS	1.23E-01	CLM-CN
123.2	DLEM	3.89E+02	CLM-CN	5.68E-01	CLM-CASA	1.46E-01	CASA GFEDv2
205.3	BEPS	3.92E+02	LPJml	5.66E-01	BEPS	2.12E-01	DLEM
323.1	LPJml	4.02E+02	CLM-CASA	4.69E-01	LPJml	2.81E-01	LPJml
329.2	CLM-CASA	4.06E+02	BEPS	4.42E-01	EC-MOD	2.85E-01	Orchidee
332.8	MOD17	4.14E+02	Vegas2	4.35E-01	Orchidee	2.98E-01	EC-MOD
357.6	Vegas2	4.34E+02	MOD17	4.25E-01	DLEM	3.06E-01	TEM6
436.9	TEM6	4.71E+02	TEM6	3.74E-01	CASA GFEDv2	3.50E-01	MOD17
635.7	Orchidee	6.81E+02	Orchidee	3.39E-01	TEM6	5.27E-01	BEPS
1513	Can-IBIS	1.80E+03	Can-IBIS	2.99E-02	CLM-CN	1.51E+00	Can-IBIS

Conclusions & Future Work

- Regional model runs show very limited skill modeling IAV in NEE.
  - Does not prove that regional models are not able to simulate IAV in NEE.
- Site model runs are similar to regional model runs for IAV in NEE.
  - Not encouraging. If the site model runs can't simulate IAV in NEE, then the regional models also can't either. Are the flux towers capturing large-scale processes?
- Site and regional model runs do moderately well at simulating IAV in GPP for some PFTs.
  - Encouraging evidence of model skill re: IAV. What masks their skill for IAV in NEE?
- Regional model runs significantly over-estimate IAV in GPP.
  - Puzzling. We'd expect the opposite, if anything.
- Flux towers suggest the mid to lower magnitude GPP values predicted by regional models are more realistic.

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References

- Jolliff J.K., J.C. Kindle, I. Shulman et al. 2009: Summary diagrams for coupled hydrodynamic-ecosystem model skill assessment. *Journal of Marine Systems* 76, 64-82.