# The Utility of Continuous Atmospheric Measurements for Identifying Biospheric $CO_2$ Flux Variability


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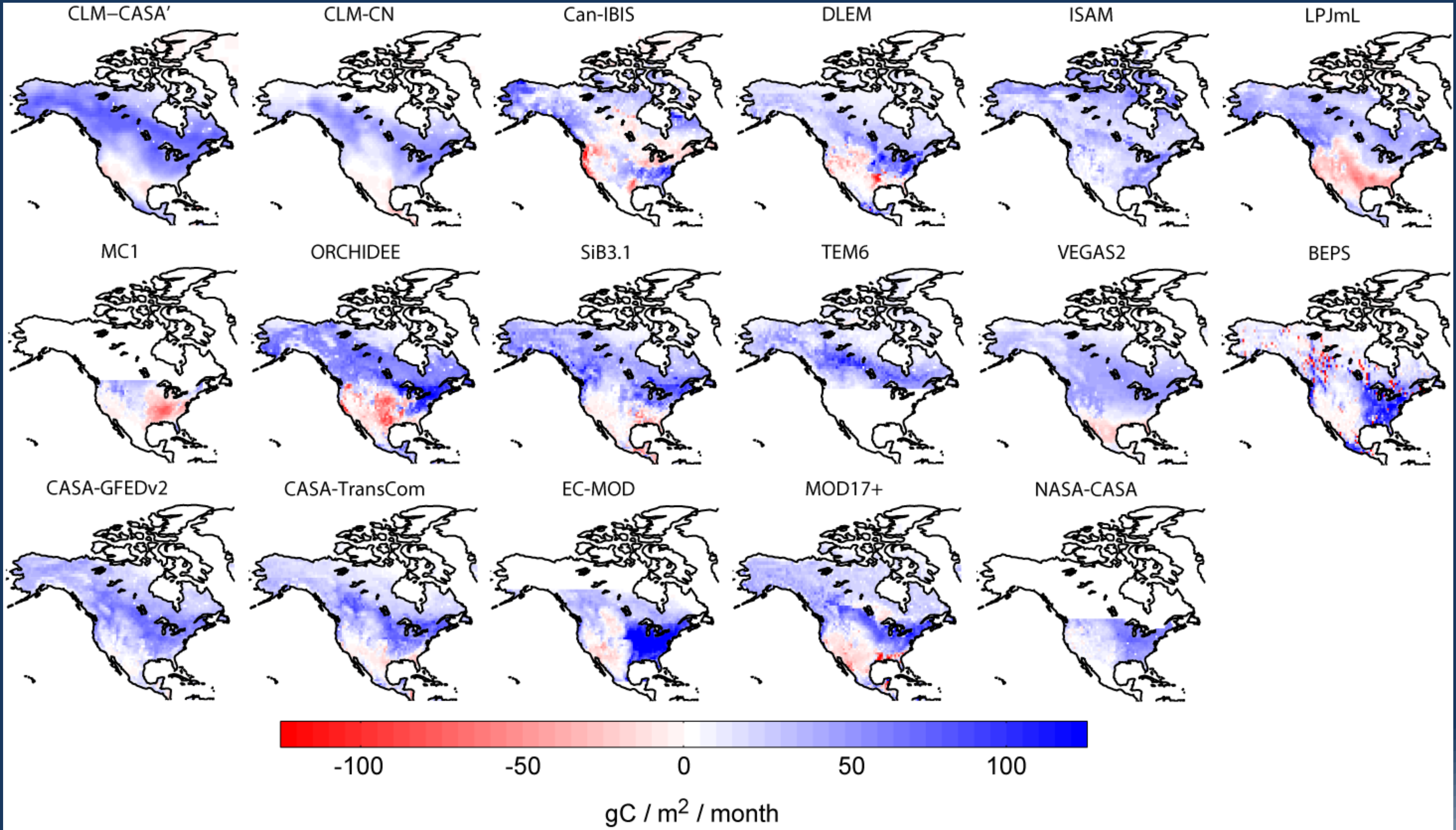
# Long-Term Mean (2000-2005) Summer (June, July, August) Net Ecosystem Productivity




Huntzinger et al. (in prep), 2011
Poster B31D-0337

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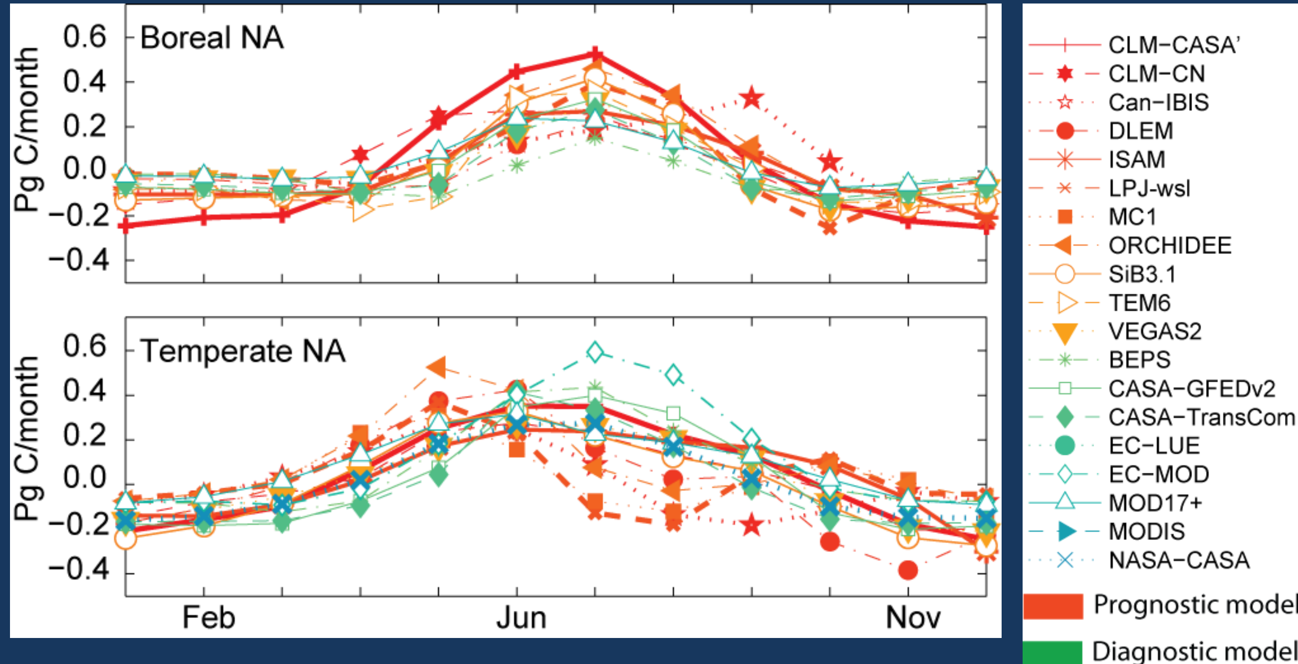
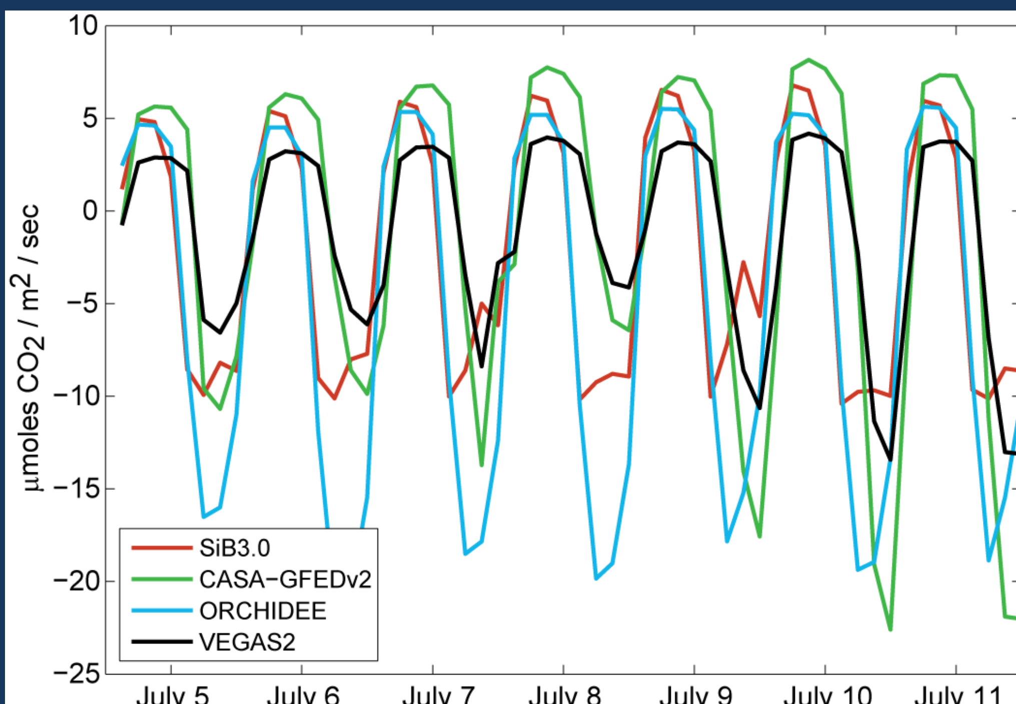
# Seasonal Cycle of NEP




# Diurnal Cycle of NEE at WLEF

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# Which Model is "Better"?

- Is one model better than another?
  - Compare models to data / observations
- Can atmospheric observations be used as a data constraint?
  - Are the fluxes predicted by a given model compatible with the atmospheric observations?

Depends on whether the atmospheric data can detect differences among competing flux distributions.

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# Objective

Determine how much information atmospheric $CO_2$ observations can provide in either:

(1) Evaluating pre-existing sets of surface flux estimates (e.g., from TBMs) across North America.

(2) Estimating surface flux distributions at regional scales (e.g., from inversions).

# Objective

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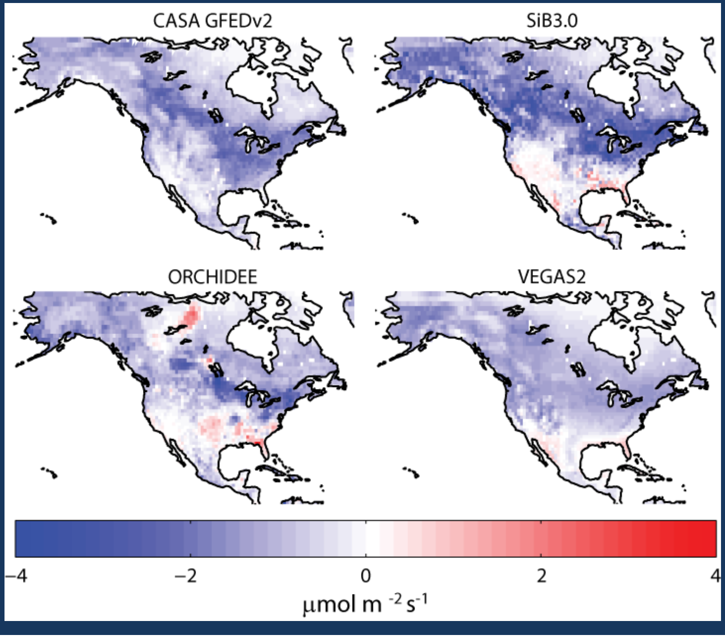
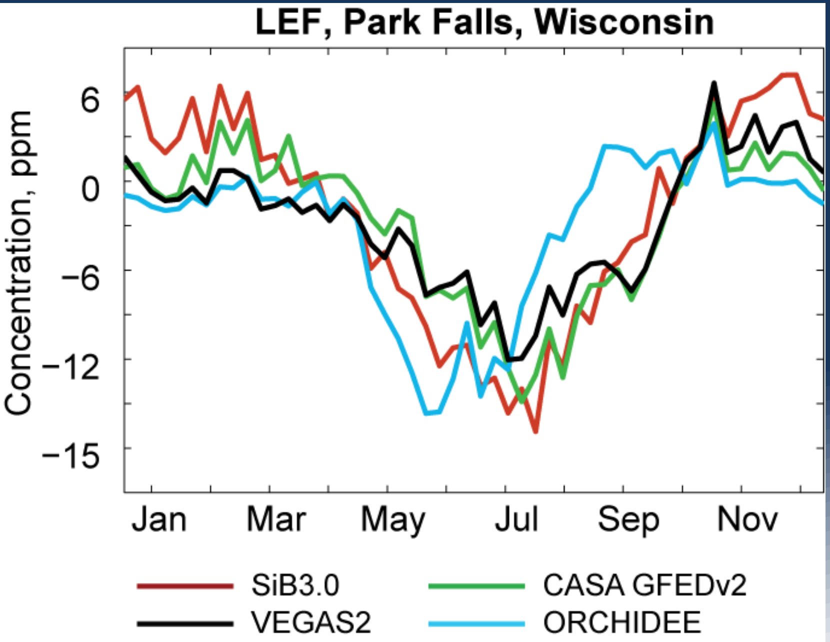
# Approach

- NEE estimates of 4 terrestrial biospheric models (TBMs) are used to represent plausible scenarios of surface flux distributions.
- TBMs coupled with the atmospheric transport model, WRF-STLT.
- Resulting atmospheric signals are compared at 9 towers in the continuous observation network (2004).

Mean 2004 summer (June, July, August) net ecosystem exchange (NEE)



# How different do signals have to be?

- Mean squared difference (MSD) is use to quantify the differences among pairs of synthetic observation signals from different TBMs.

The differences between the synthetic signals are compared within the context of expected or estimated model-data mismatch error ($\sigma^2_R$).

| Tower Name | Location | Height (m) | Tower Type | $\sigma^2_R$ ($ppm^2$) |
|---|---|---|---|---|
| LEF | Park Falls, WI | 396 | Tall | 8.8 |
| WKT | Moody, TX | 457 | Tall | 5.9 |
| SBL | Sable Island, Nova Scotia | 25 | Marine boundary | 4.7 |
| BRW | Barrow, AK | 10 | Marine boundary | 1.7 |
| ARM | Norman, OK | 60 | Short | 11.7 |
| HFO | Petersham, MA | 30 | Short | 38.6 |
| AMT | Argyle, ME | 107 | Short | 19.6 |
| FRD | Fraserdale, Ontario | 40 | Short | 7.9 |
| CDL | Candle Lake, Saskatchewan | 30 | Short | 4.0 |

**Aggregation, representation, and transport model error**

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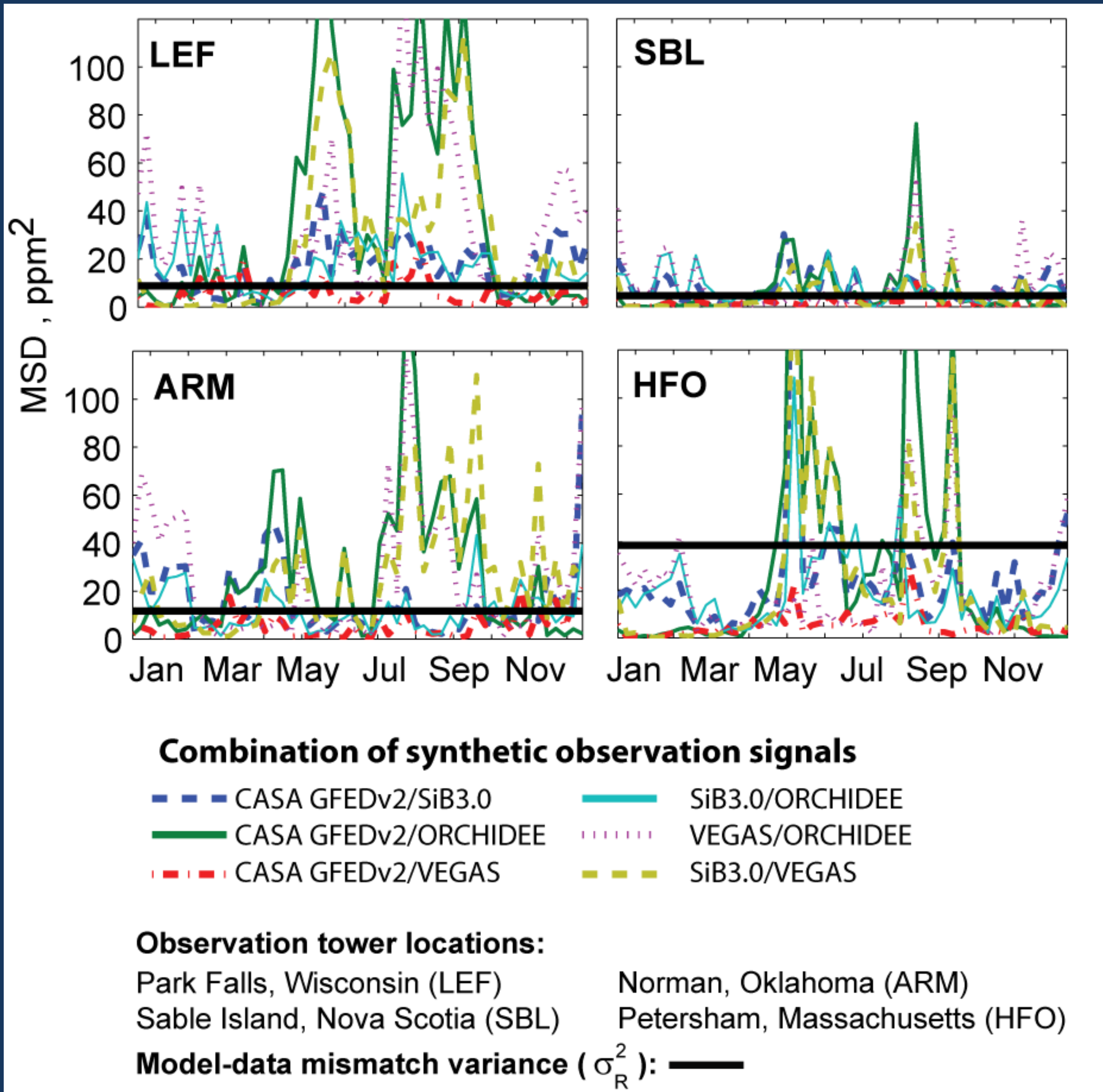
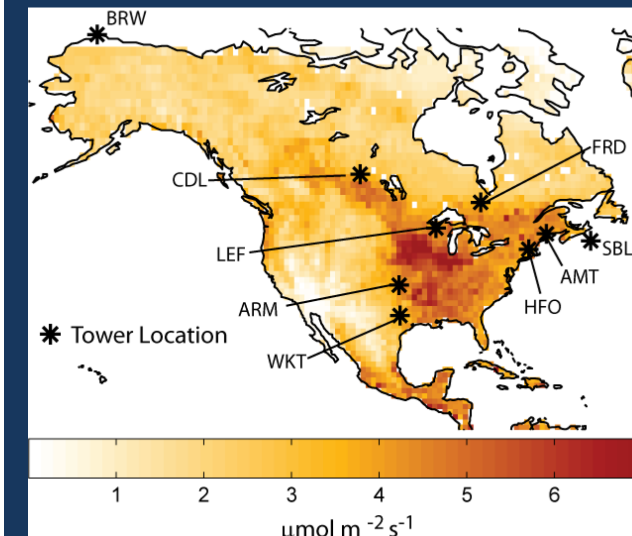
Compare differences in synthetic signals with estimated model-data mismatch variance at the tower.

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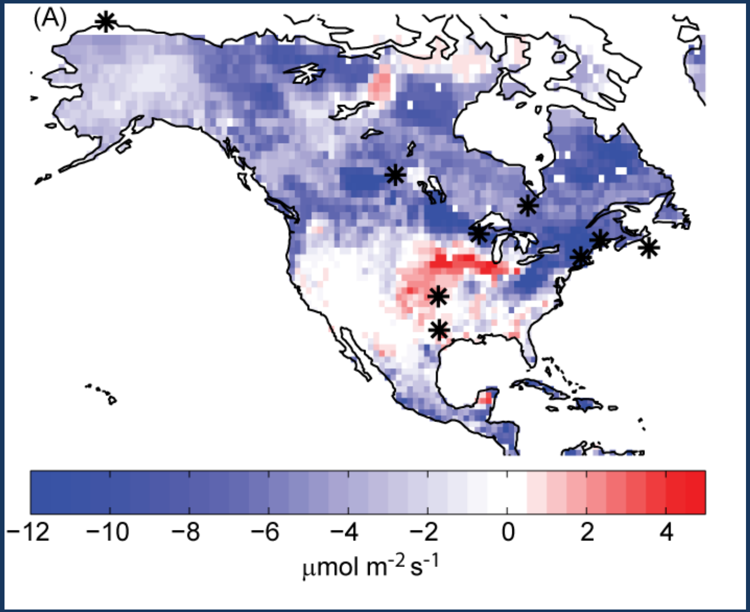
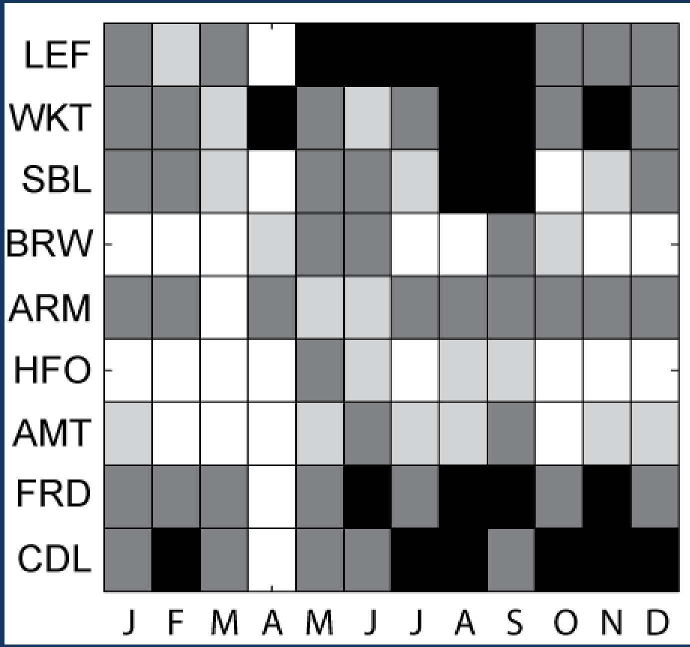
# Overall combined influence of differences in both the spatial distribution and magnitude of fluxes:

| Large-Scale Spatial | Seasonal Cycle | Fine-Scale Spatial | Diurnal Cycle |
|---|---|---|---|
| √ | √ | √ | √ |




- 4 TBMs generate statistically different 3-hourly $CO_2$ time series during most months of the year.
- Differences are less detectable at towers with a higher model-data mismatch variance.
- Measurements can detect overall differences in $CO_2$ concentrations resulting from competing flux distributions

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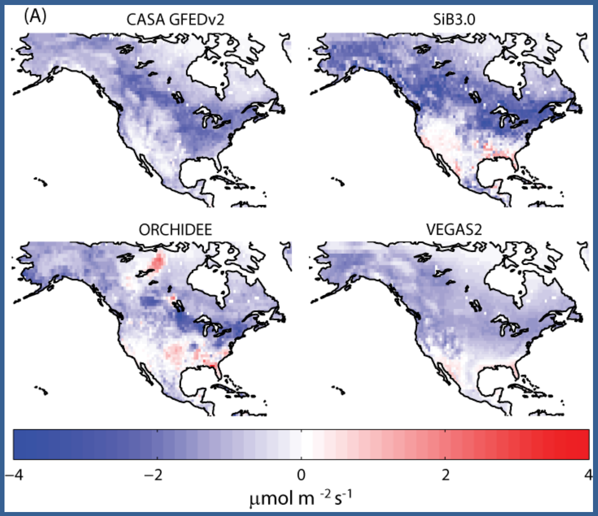
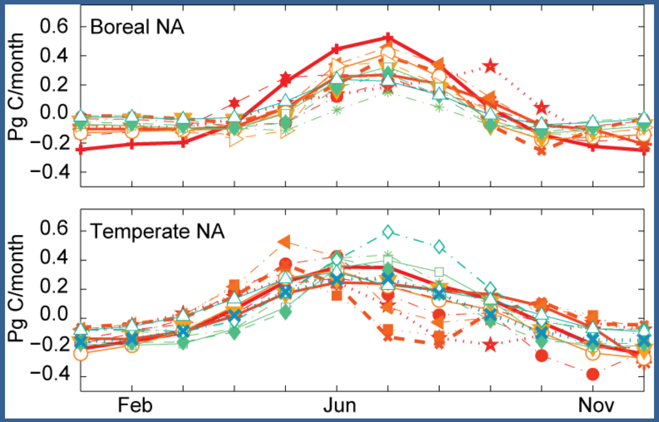
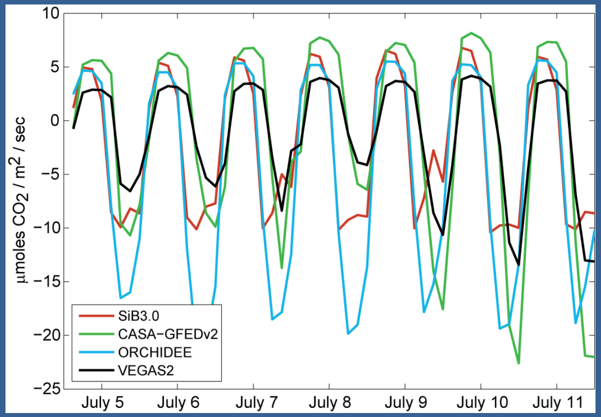
# At what scale (spatial & temporal) is atmospheric data most informative?

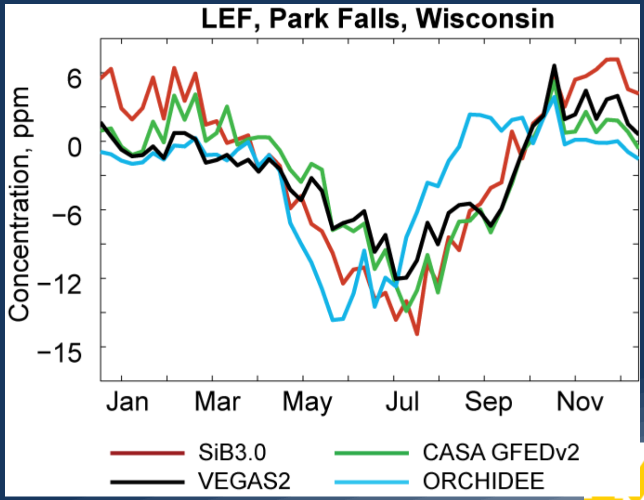
How does the spatial and temporal variability in surface flux




translate into the variability observed in synthetic $CO_2$ concentrations?

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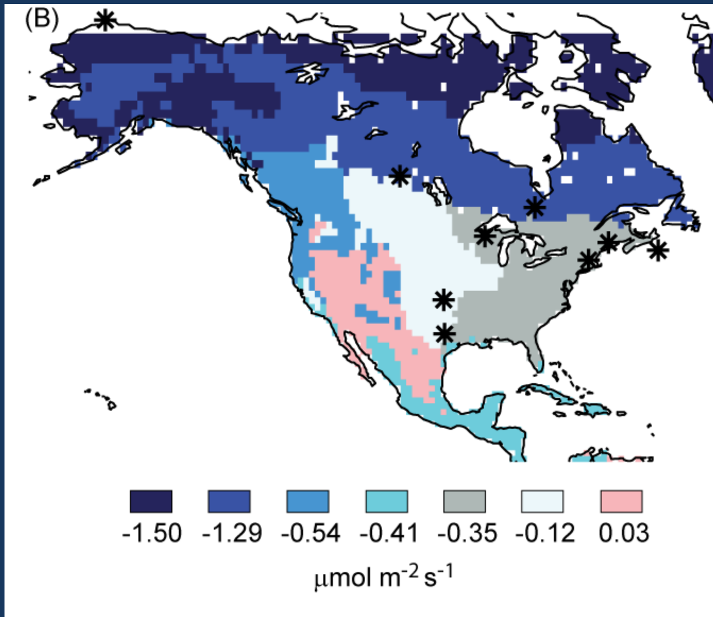


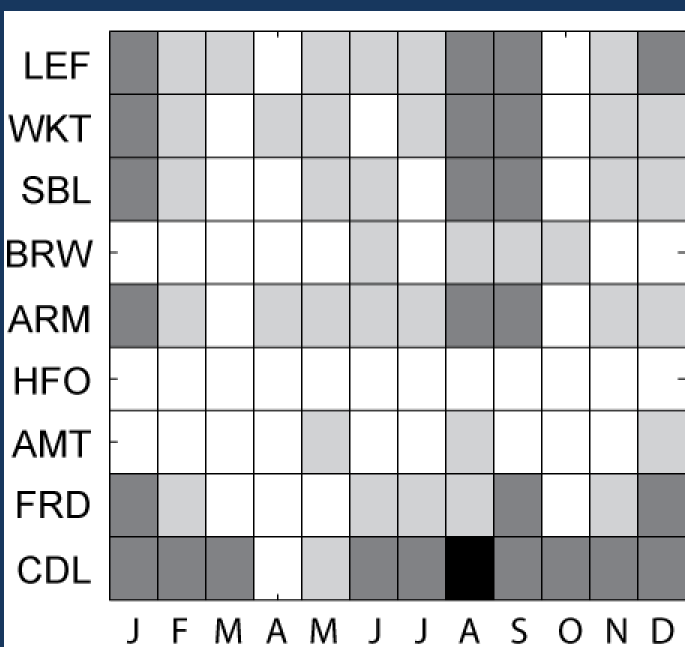


## Remove sub-ecoregion scale variability

Isolate the influence of differences in regional flux magnitude on the generated $CO_2$ signals.

| Large-Scale Spatial | Seasonal Cycle | Fine-Scale Spatial | Diurnal Cycle |
|---|---|---|---|
| √ | √ | | |

Overall, the towers are able to detect differences in flux magnitude over large regions.

Encouraging for TBM evaluation

Observations can be used to discriminate among large-scale fluxes as predicted by different TBMs.

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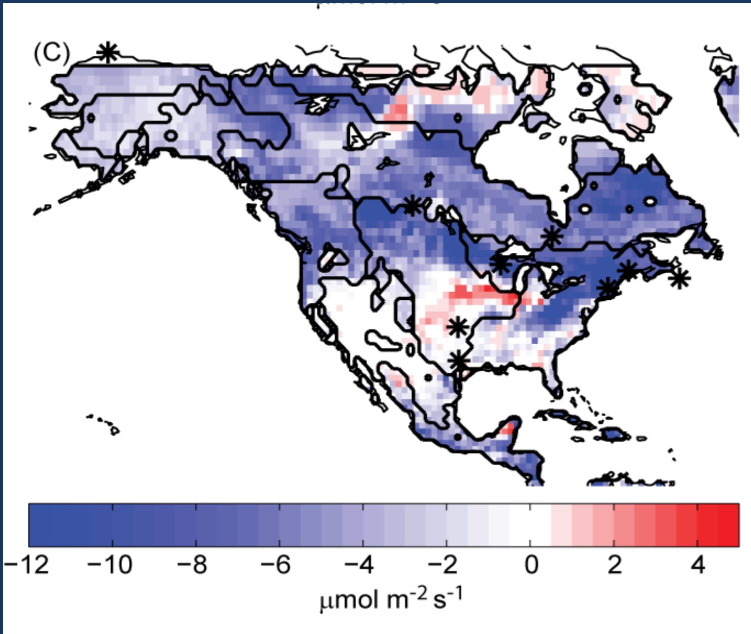
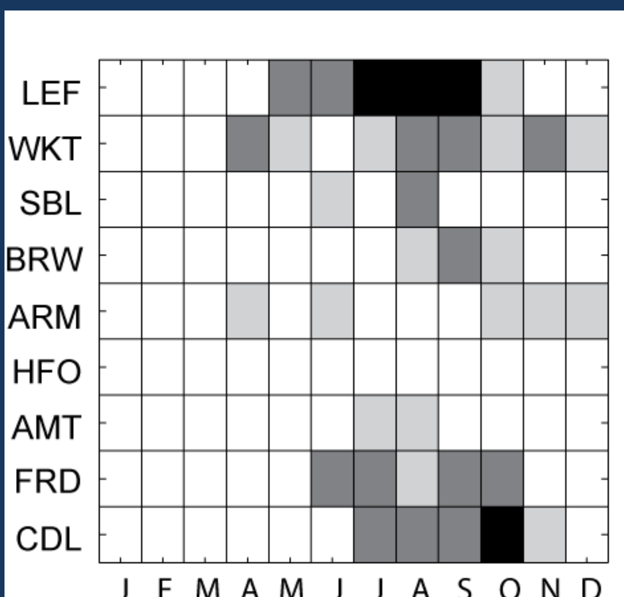



# Normalized net ecoregion scale flux

Examine how the distribution of fluxes within ecoregions influences $CO_2$ concentrations

| Large-Scale Spatial | Seasonal Cycle | Fine-Scale Spatial | Diurnal Cycle |
|---|---|---|---|
| | | √ | √ |




Atmospheric measurements detect fine-scale (spatial, temporal) flux differences during the growing season.

What is the relative importance of spatial distribution of fluxes compared to differences in their diurnal cycle (e.g., timing, strength)?

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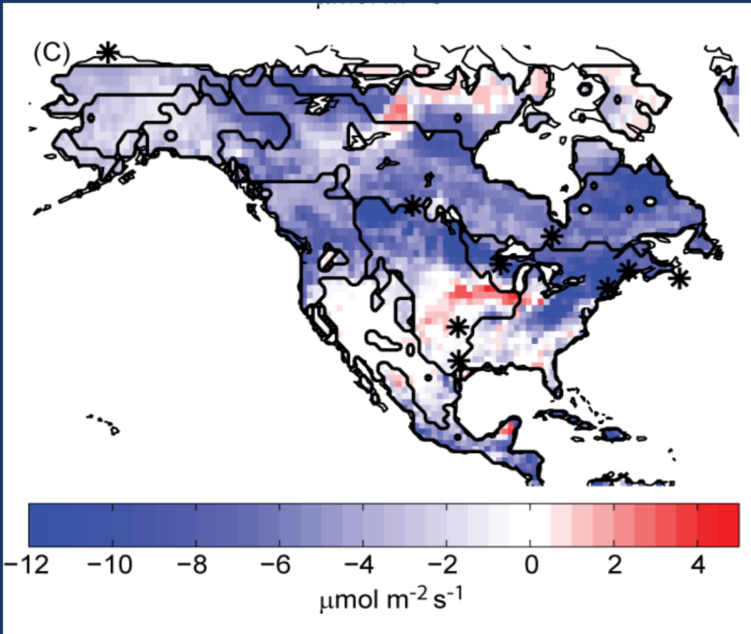


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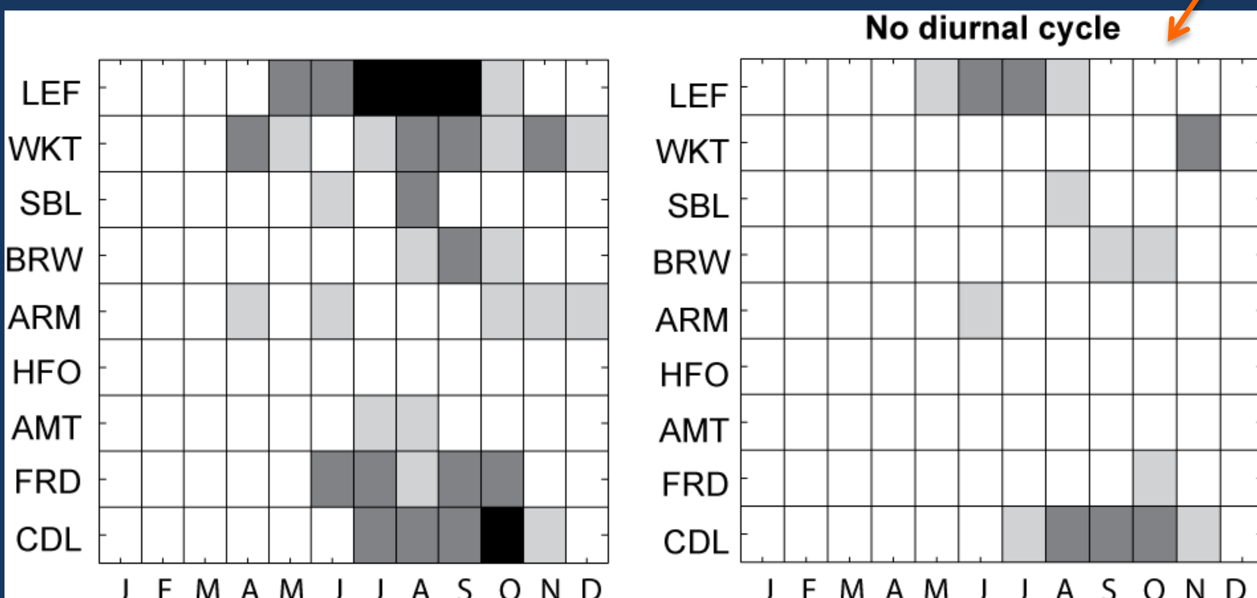
| | | √ | |

Remove diurnal cycle




Differences in signals primarily driven by differences in diurnal cycle of fluxes between the TBMs

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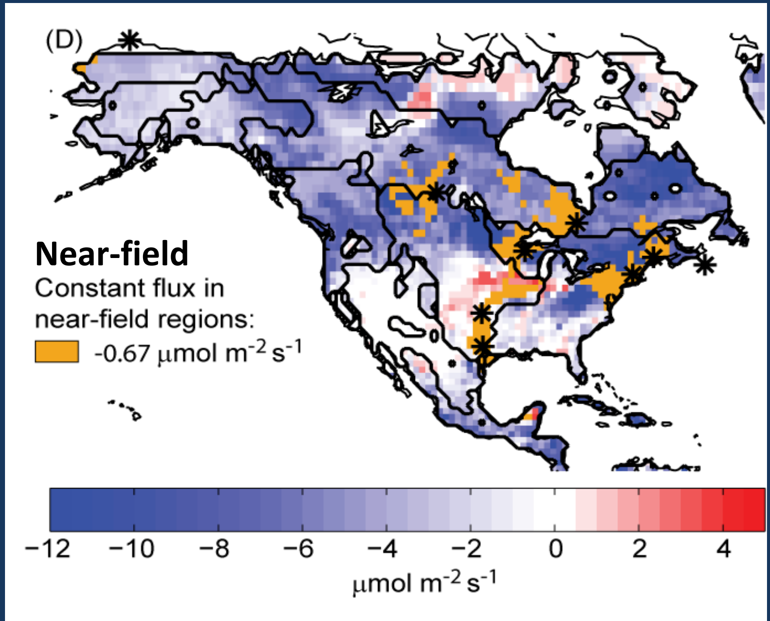
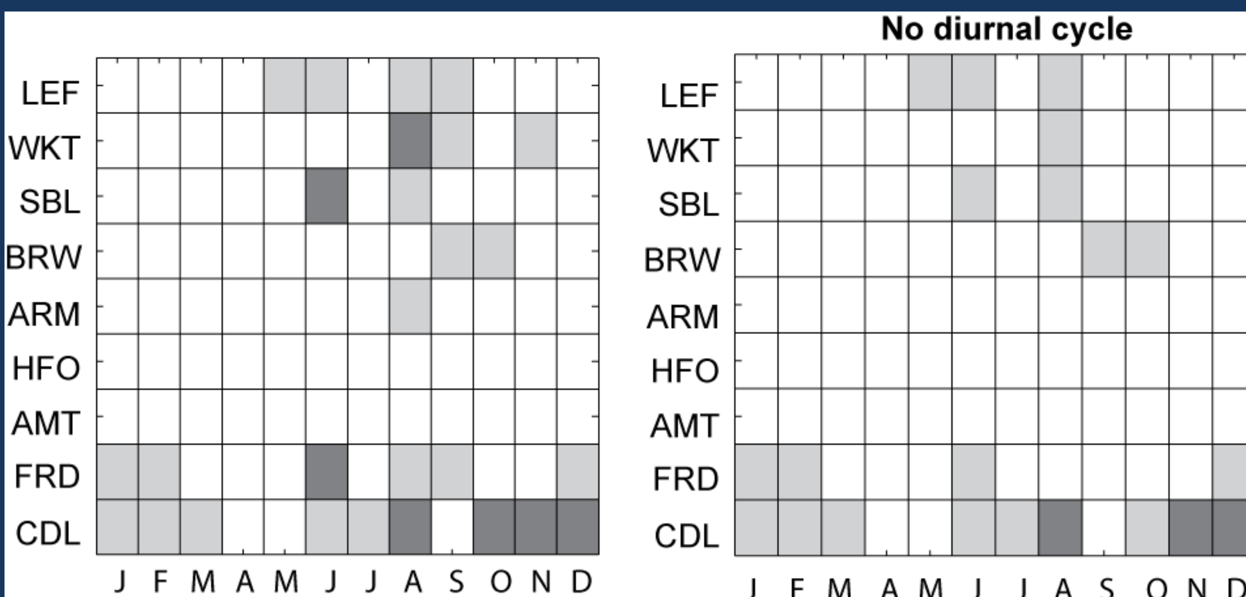



# Isolating influence of far-field fluxes

Assess the impact of the fine-scale variability beyond the near-field of the towers

| Large-Scale Spatial | Seasonal Cycle | Fine-Scale Spatial | Diurnal Cycle |
|---|---|---|---|
| | | √ | √ |

**Only in far-field**



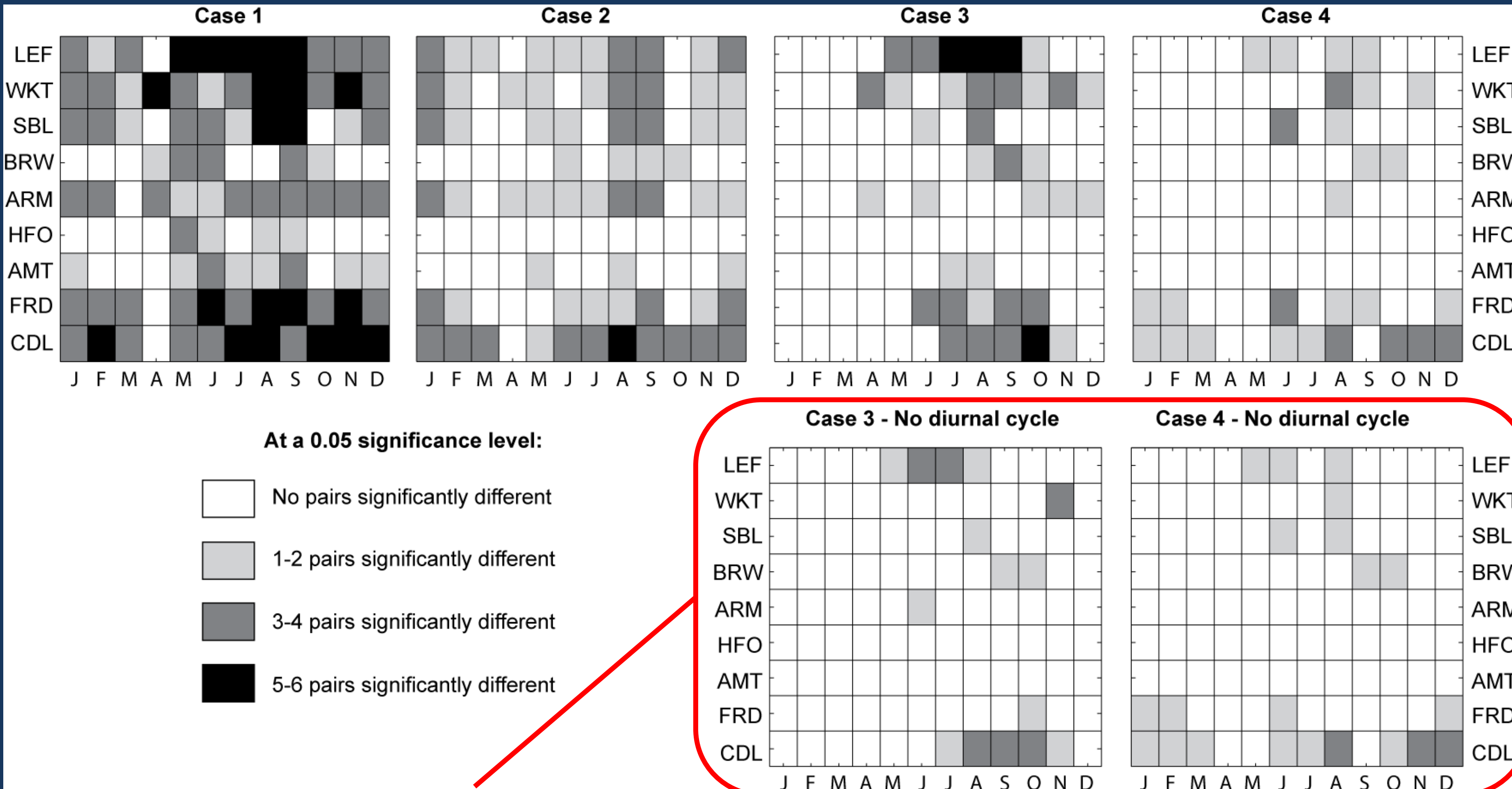

When remove diurnal cycle results, are largely unchanged.

Both large and small scale variability

Large scale variability only

Small scale variability only

Small scale variability in far-field




**Diurnal cycle removed**

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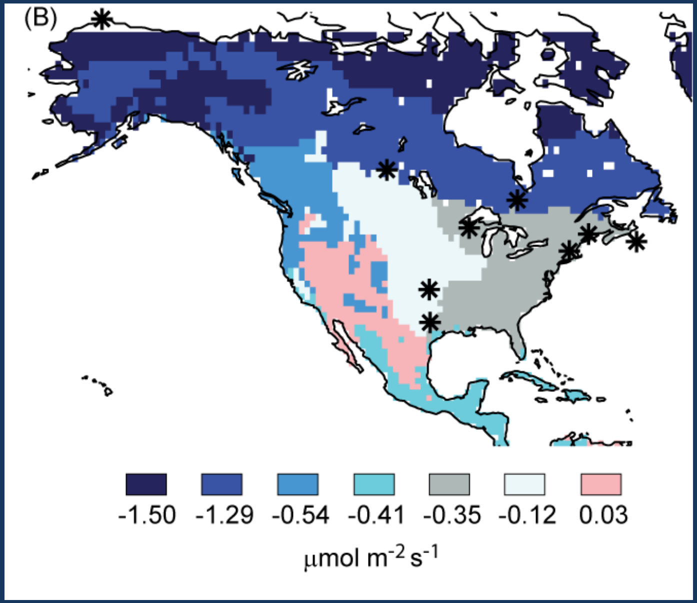
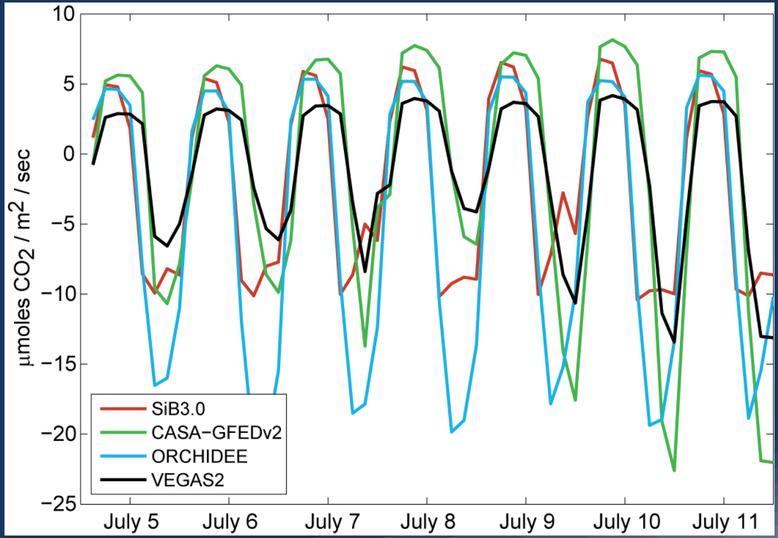
# Conclusions

Atmosphere data can detect large scale differences in flux magnitude among competing TBMs.

Atmospheric signal is very sensitive to slight differences in the diurnal cycle of fluxes represented by the models.

- Important for both in inversions and process-oriented TBMs.

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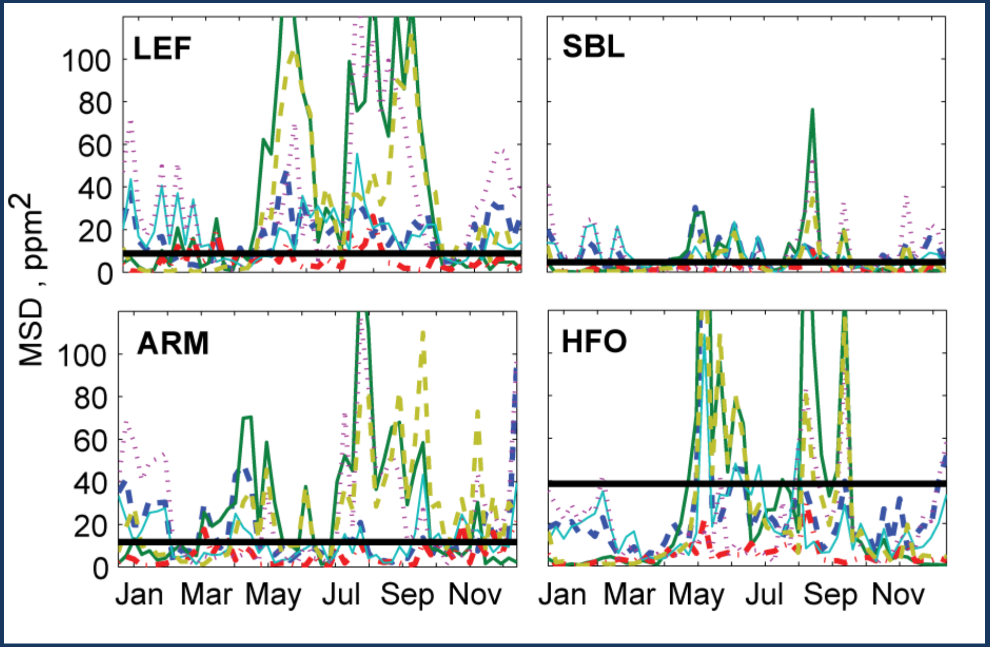
# Conclusions

Magnitude of the model-data mismatch error or variance has a large impact on results.

As we improve atmospheric transport modeling (i.e., reduce uncertainties), we will be able to detect more differences among competing TBMs.

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