

Exploring the Complex Couplings between Environmental Drivers and Greenhouse Gas Exchange in Restored Delta Wetlands

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Wetland restoration

- Wetlands are important ecosystems to the global carbon cycle.
- Wetland restoration for carbon sequestration
 - California Cap and Trade
- Modeling Required!
- Wetlands are complex
 - site differences
 - management
 - meteorology

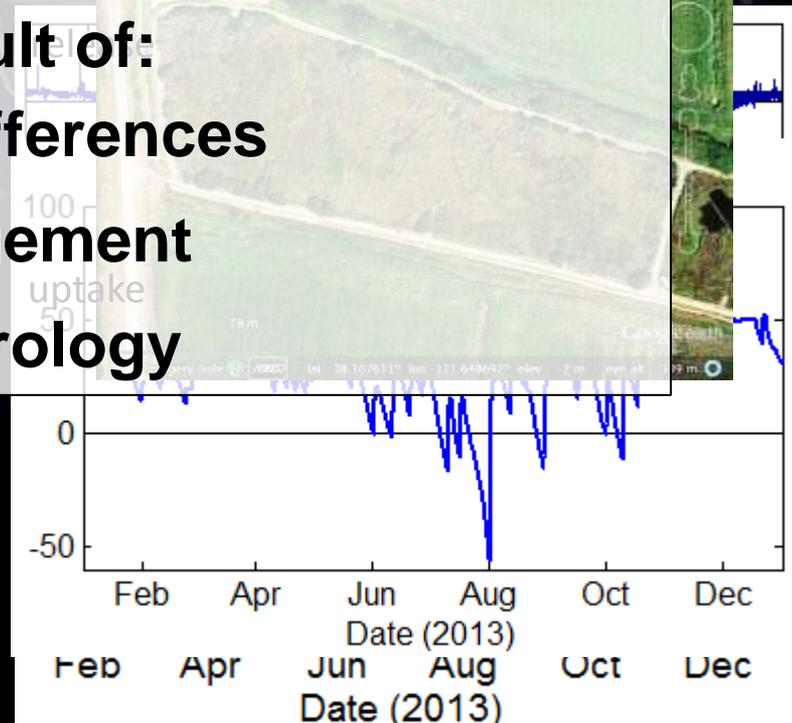
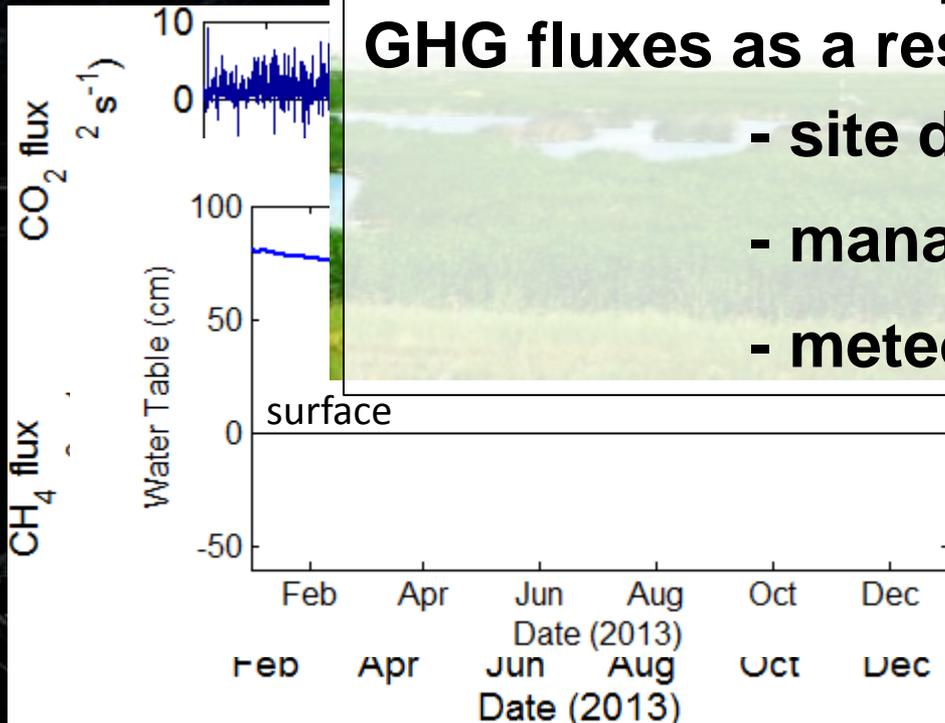


Restored wetlands in the CA Delta



We want to tease apart the differences in GHG fluxes as a result of:

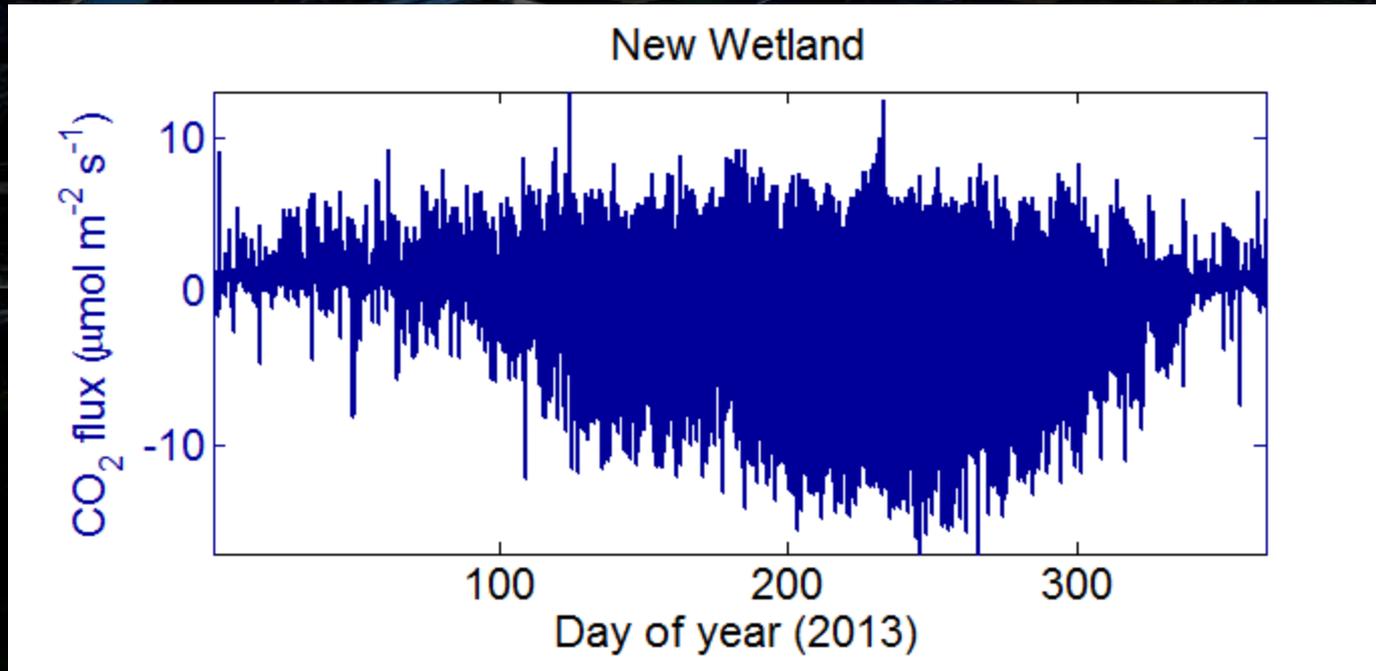
- site differences
- management
- meteorology



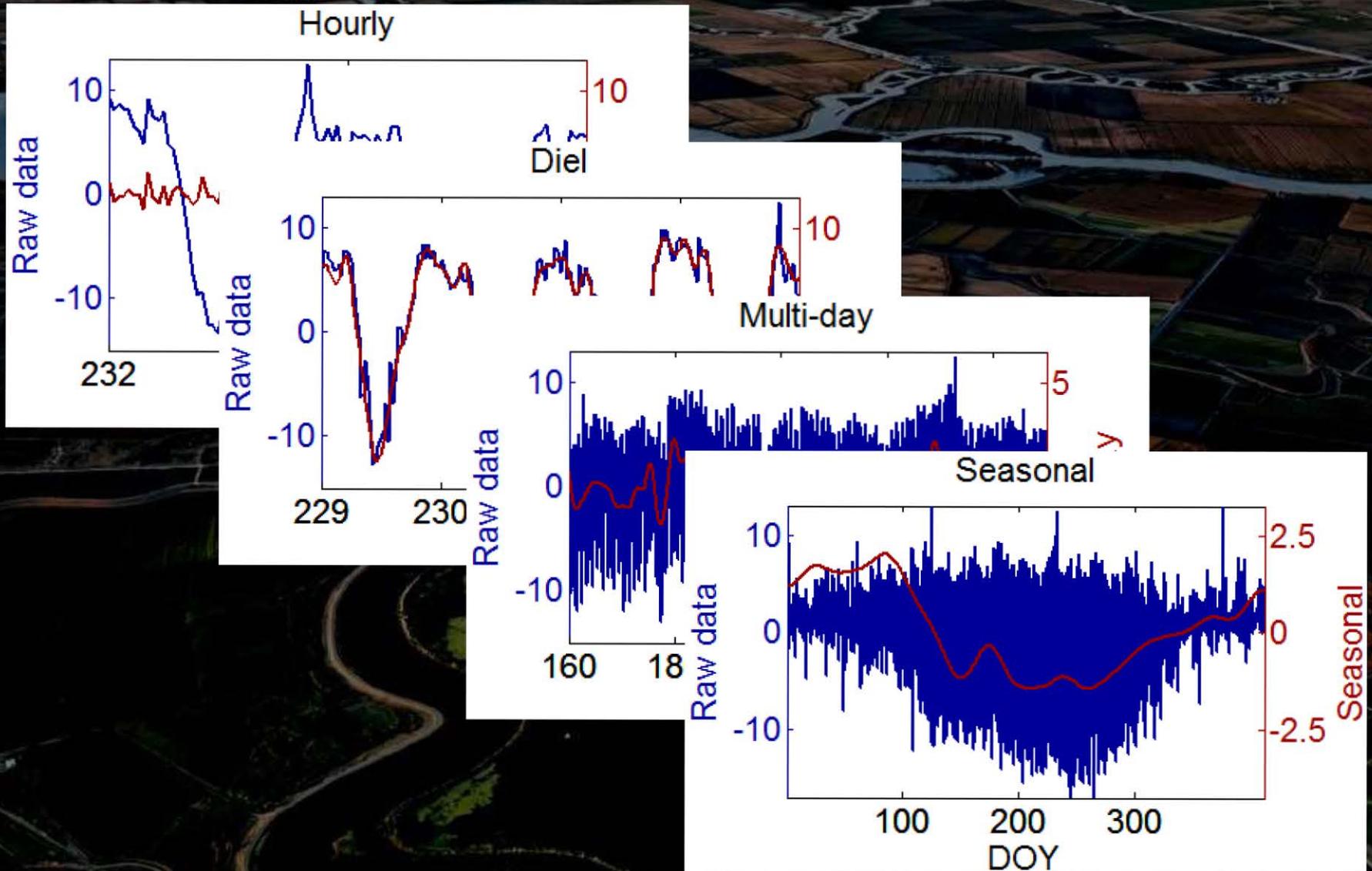
Fluxes measured by eddy covariance

Wavelets as tools to partition variability

- Time series of GHG flux is the superposition of variation (i.e. processes) at multiple time scales.



Patterns observed at different scales



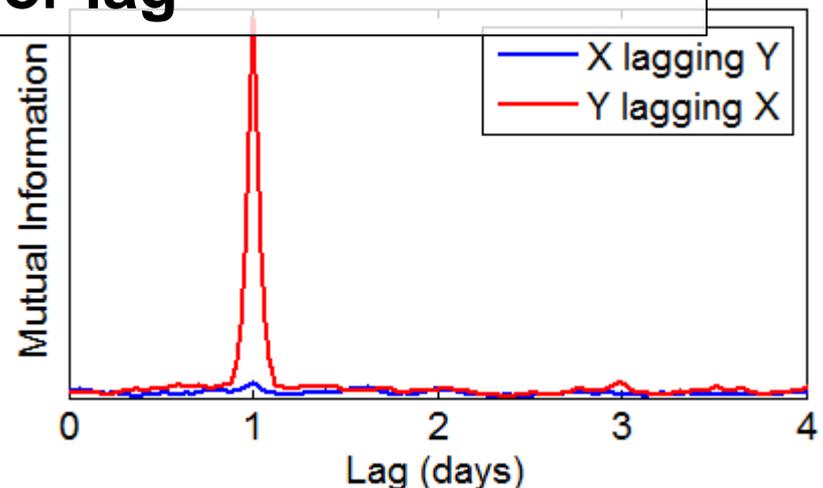
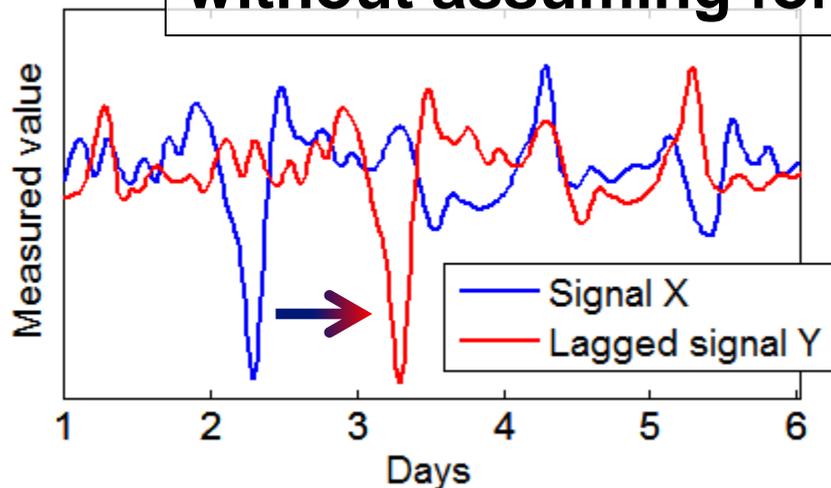
Information theory identifies complex relationships

- Ecosystem couplings are often non-linear and can be asynchronous in time.
- Mutual Information (I) describes the tendency for certain states of two variables (x & y) to coexist.

- Wavelets isolate scales of variability in CO₂ and CH₄ flux

- Mutual information identifies relationships without assuming form or lag

$$I_{xy}(\tau) = \sum p(x_{t-\tau}, y_t) \cdot \log_2 \frac{p(x_{t-\tau}, y_t)}{p(x) \cdot p(y)}; \tau = \text{lag}$$



Results

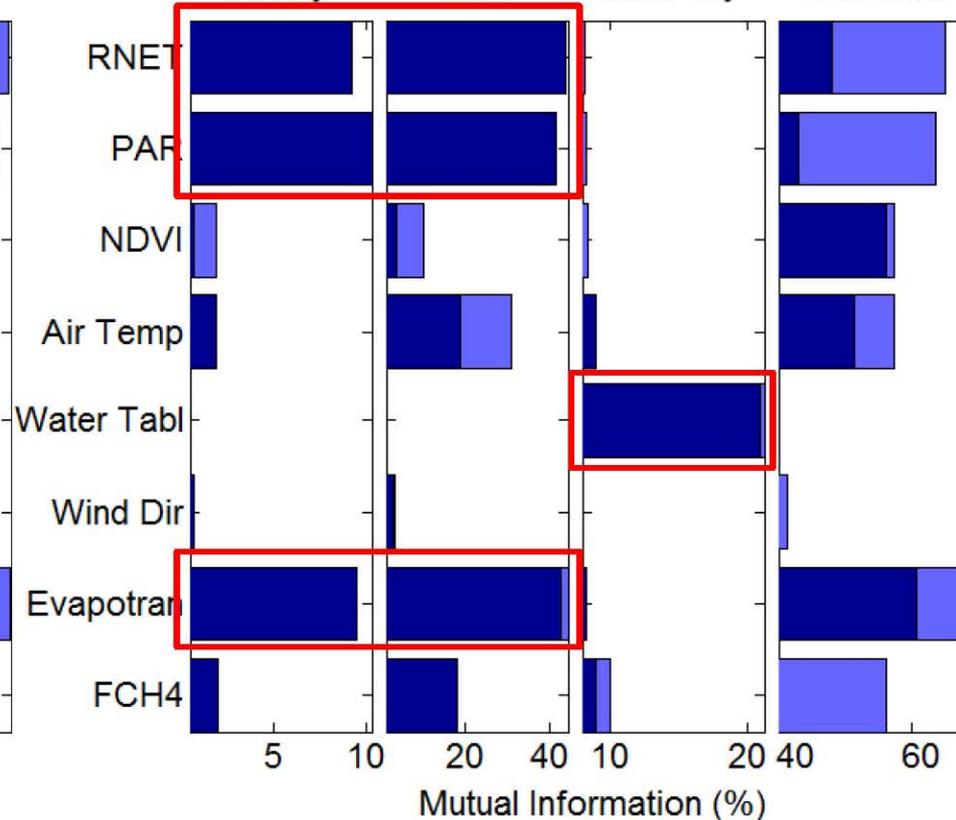
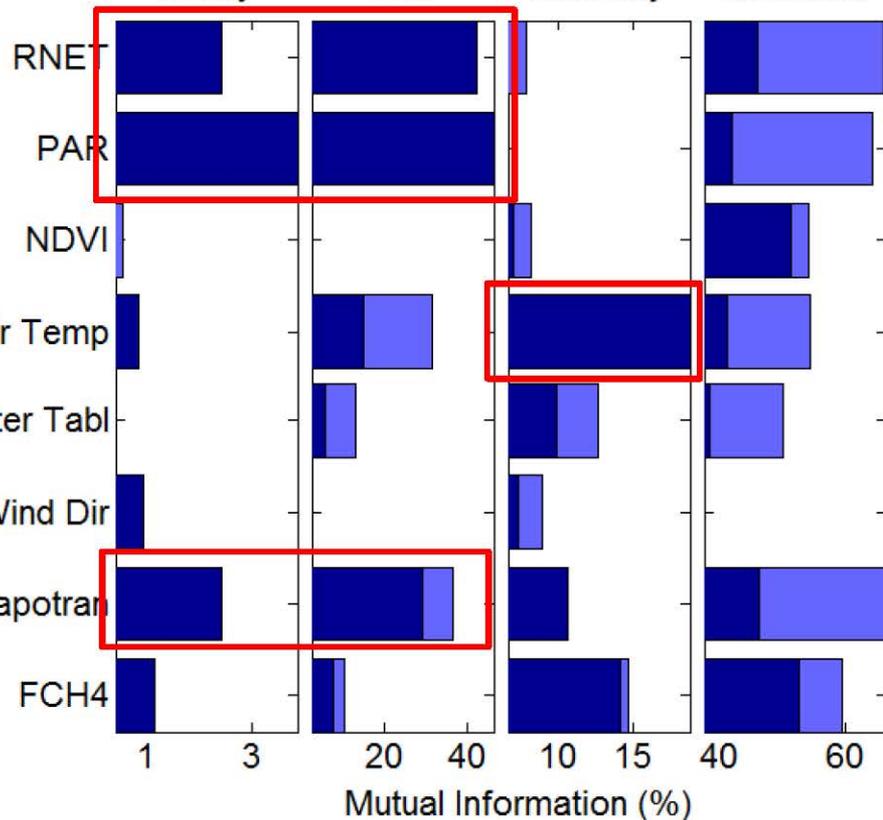
New Wetland FCO₂

Old Wetland FCO₂

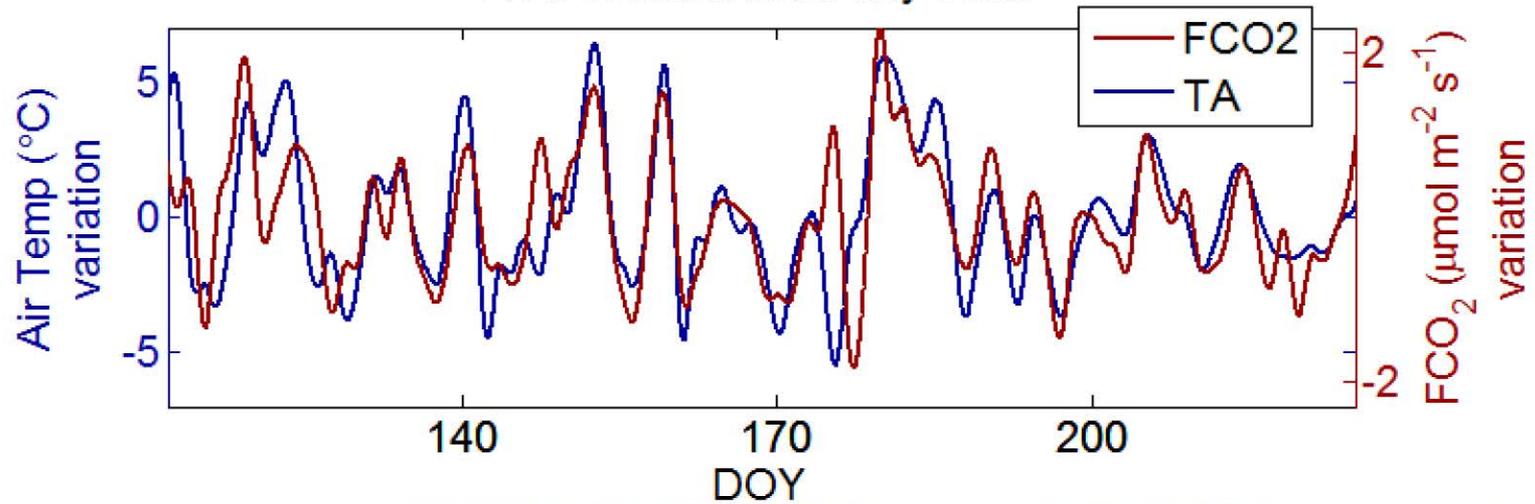


Hourly Diel Multi-day Seasonal

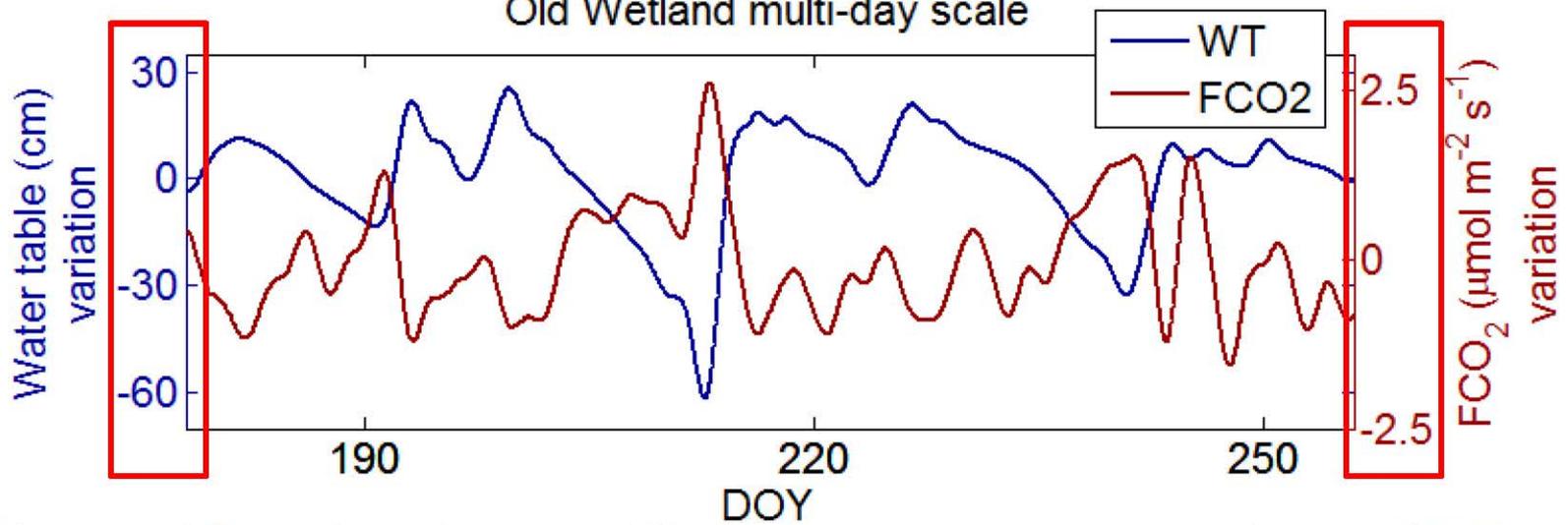
Hourly Diel Multi-day Seasonal



New Wetland multi-day scale



Old Wetland multi-day scale



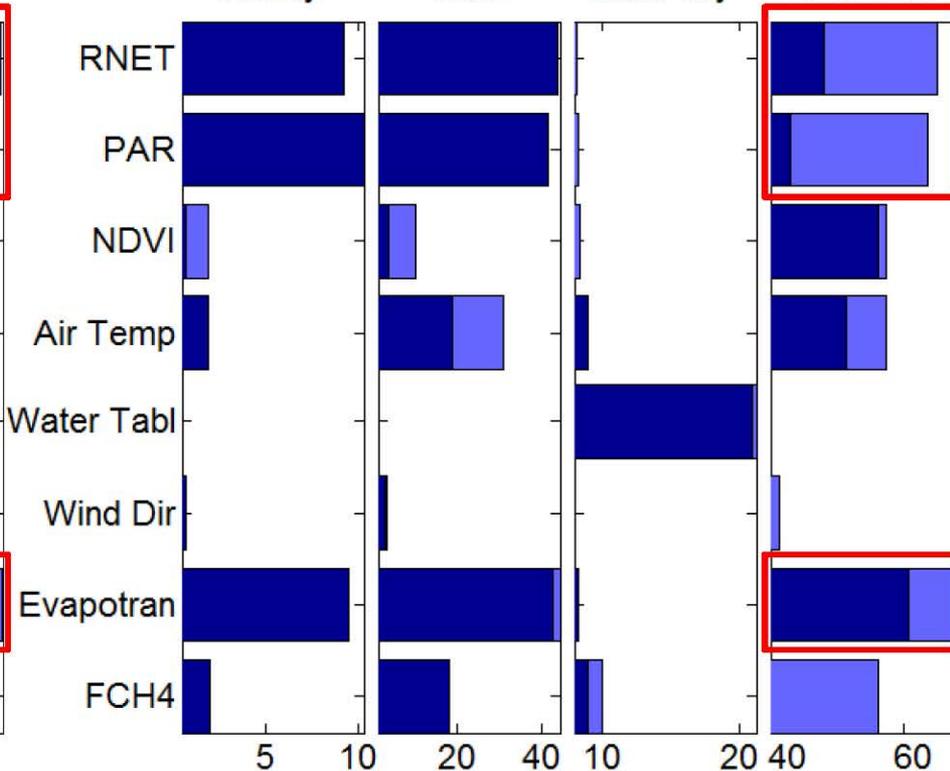
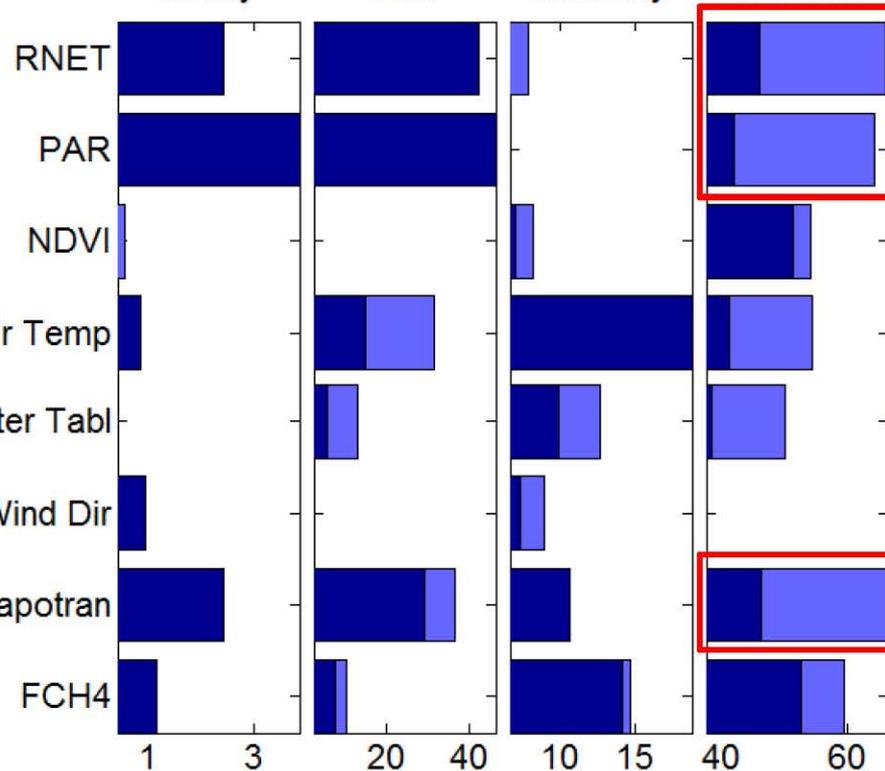
New Wetland FCO₂

Old Wetland FCO₂



Hourly Diel Multi-day Seasonal

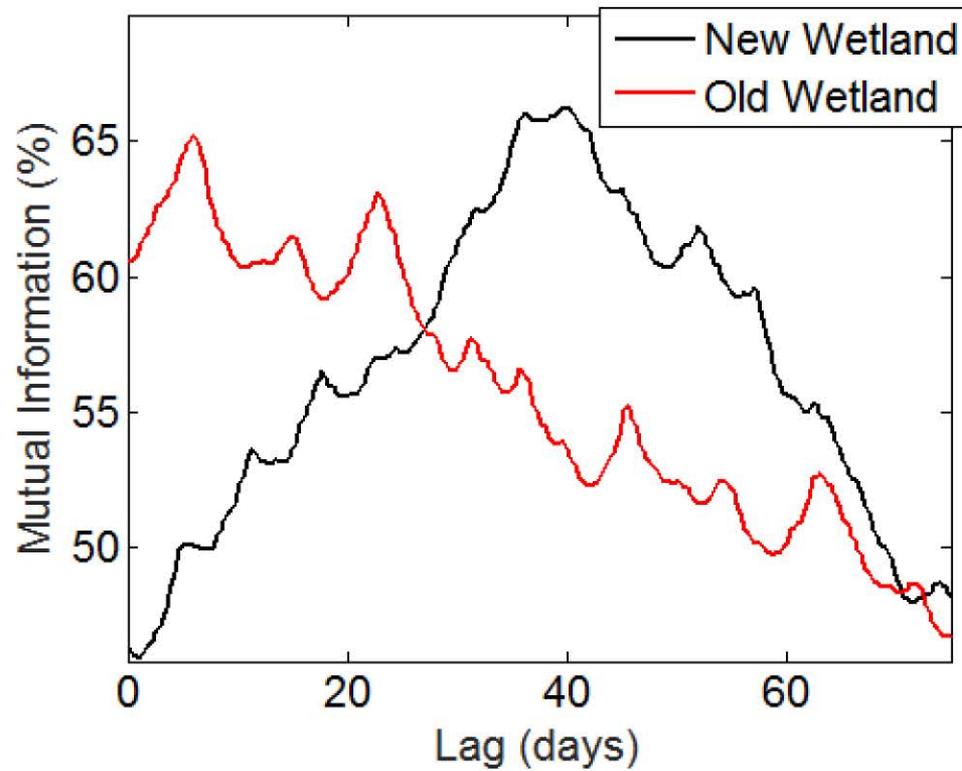
Hourly Diel Multi-day Seasonal



Mutual Information (%)

Mutual Information (%)

FCO₂ lagging Evapotranspiration
Seasonal scale



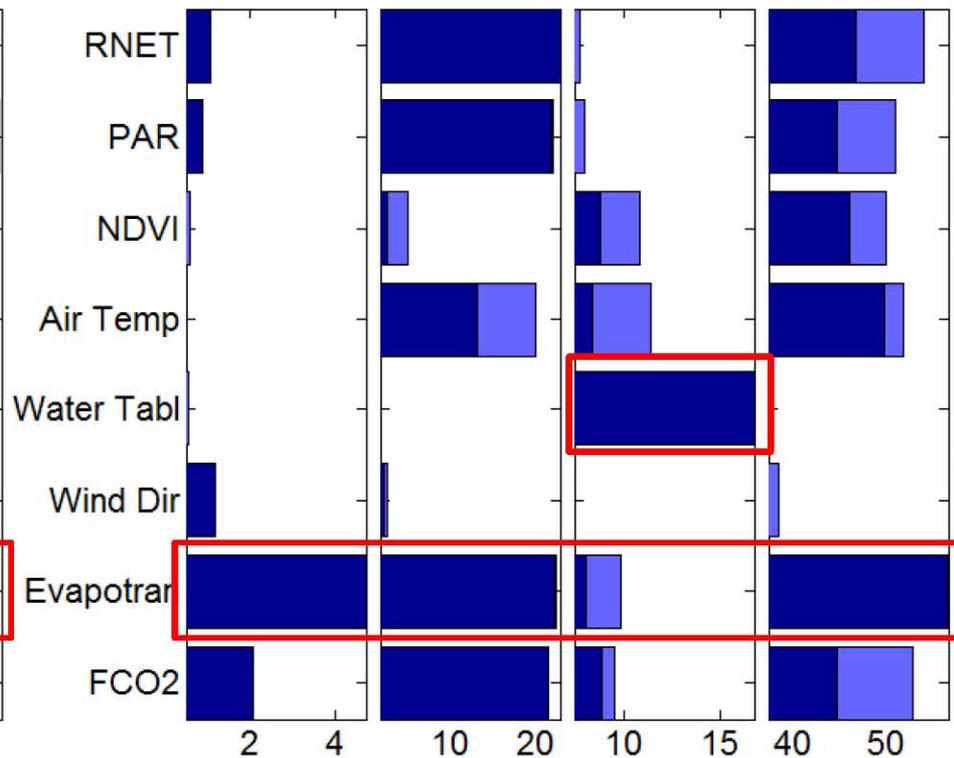
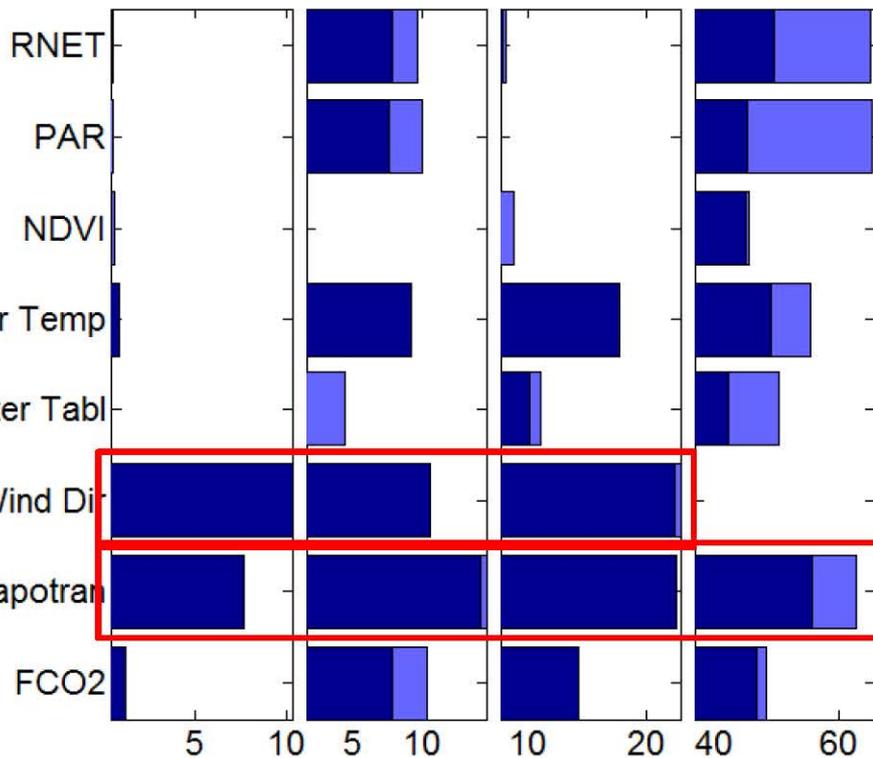
New Wetland FCH₄

Old Wetland FCH₄



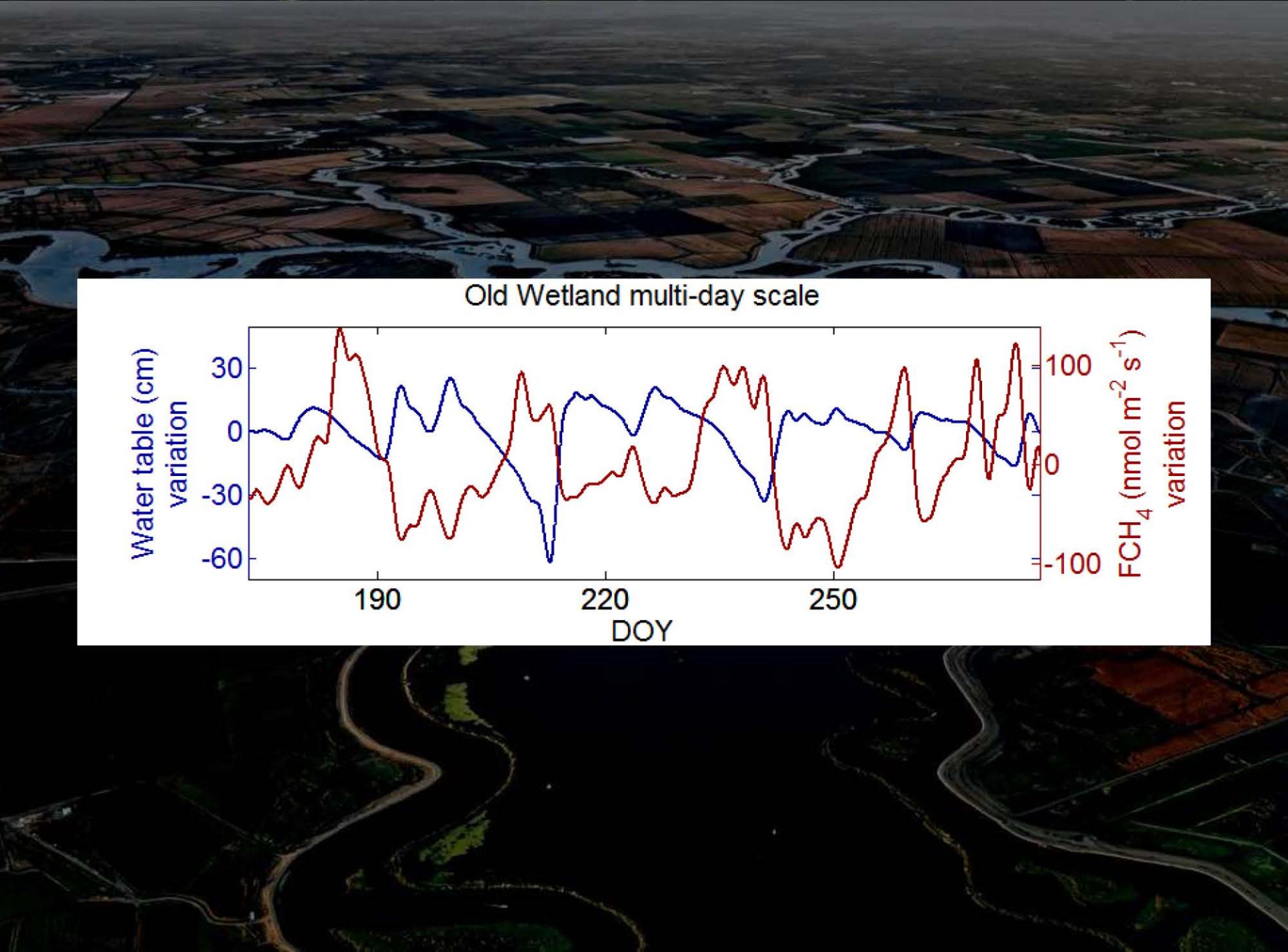
Hourly Diel Multi-day Seasonal

Hourly Diel Multi-day Seasonal

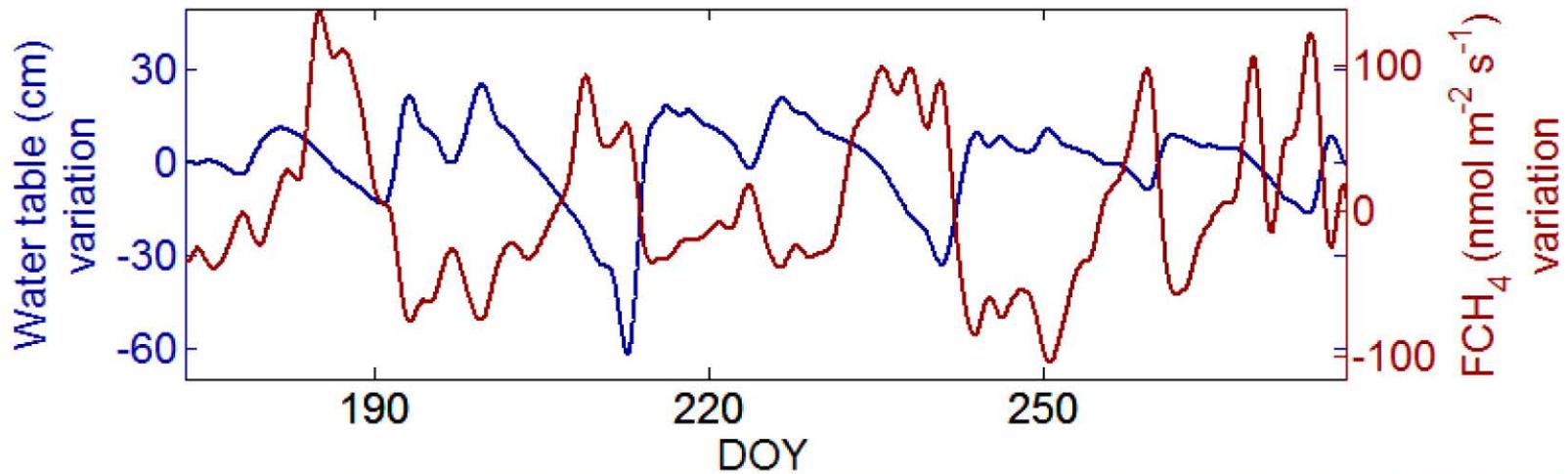


Mutual Information (%)

Mutual Information (%)



Old Wetland multi-day scale



Conclusions

- The combination of wavelets and information theory help us tease apart the processes influencing fluxes of CO_2 and CH_4 .
- Examining the dominant couplings across time scales separated the effects of management & site architecture from meteorology.
 - Water table management has effects on both CO_2 flux and CH_4 flux.
 - Phenology lags evapotranspiration at the seasonal scale in a wetland with a mix of veg & open water
 - CH_4 flux is strongly linked to evapotranspiration (and spatial variation) at multiple time scales
- Teasing out these effects enables us to better manage and model wetland ecosystems



Thank you

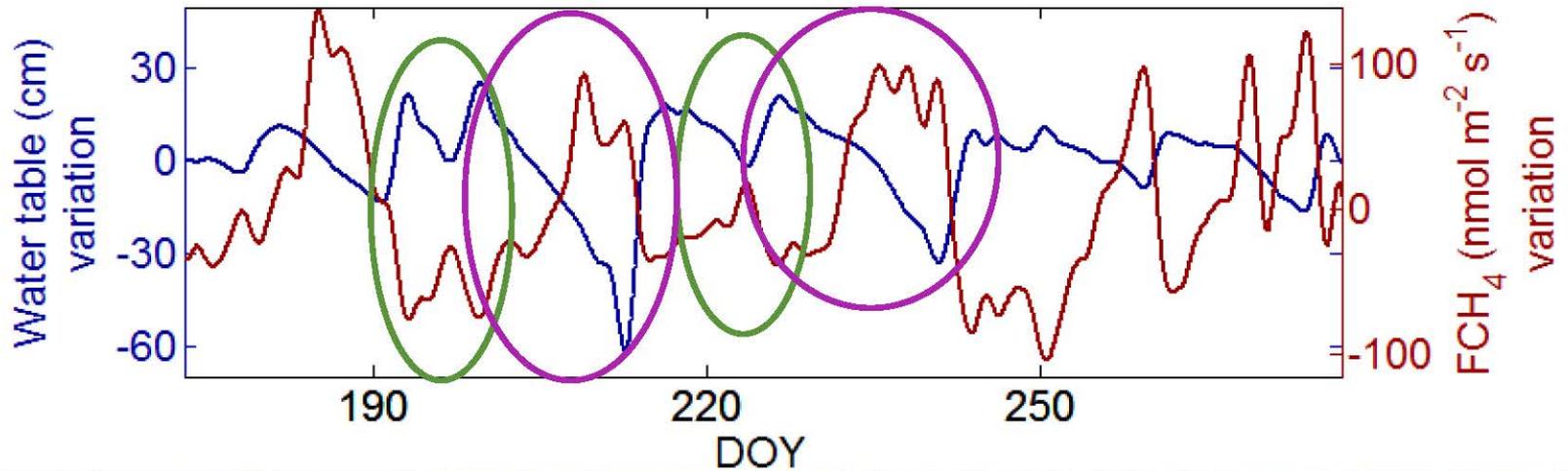
Funding provided by:

The California Department of Water Resources

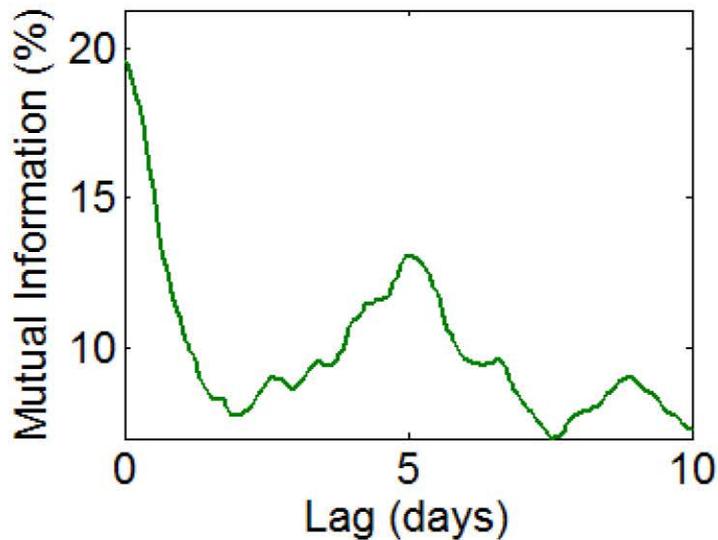
NSF Atmospheric Sciences Grant

USDA Agriculture and Food Research Initiative

Old Wetland multi-day scale



FCH₄ lagging Water Table
Timescale: 3-21 days



FCH₄ lagging Water Table
Timescale: 22-43 days

