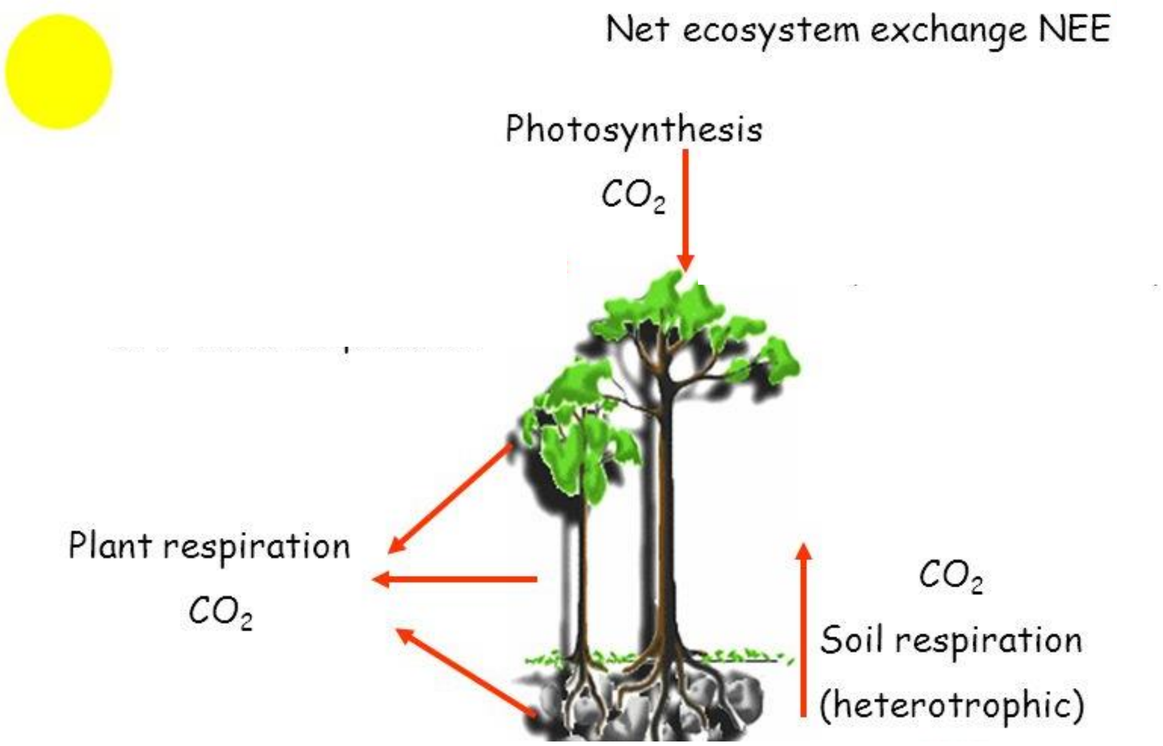
Decipher Climate Clues via Carbon Flux Simulation

Winter Incubator

Qiaoyun Peng, Yue Wang

Mentor: Amanda Tan & Rob Fatland

Overview



- Knowledge of the amount of carbon dioxide (CO_2) flux into and out of the atmosphere is important for understanding climate change.

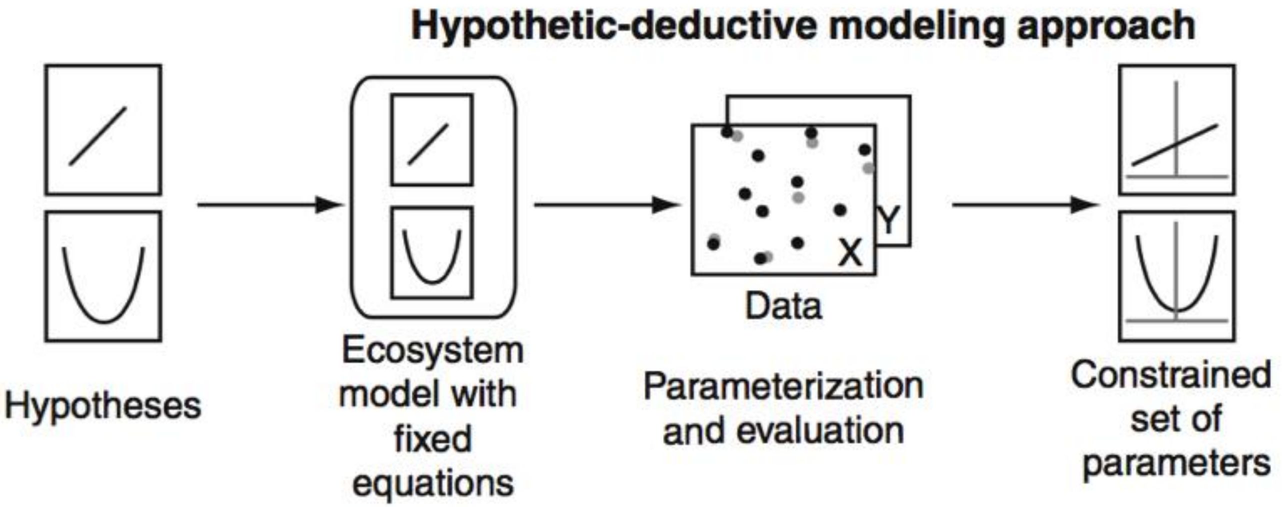
- Mapping and modeling of carbon fluxes in different ecosystems are essential for understanding the contribution of these ecosystems to the global carbon budget.

- This information will be useful for decision making regarding various carbon-related climate change mitigation strategies.

- Study sites (from Fluxnet)

Pre-Incubator

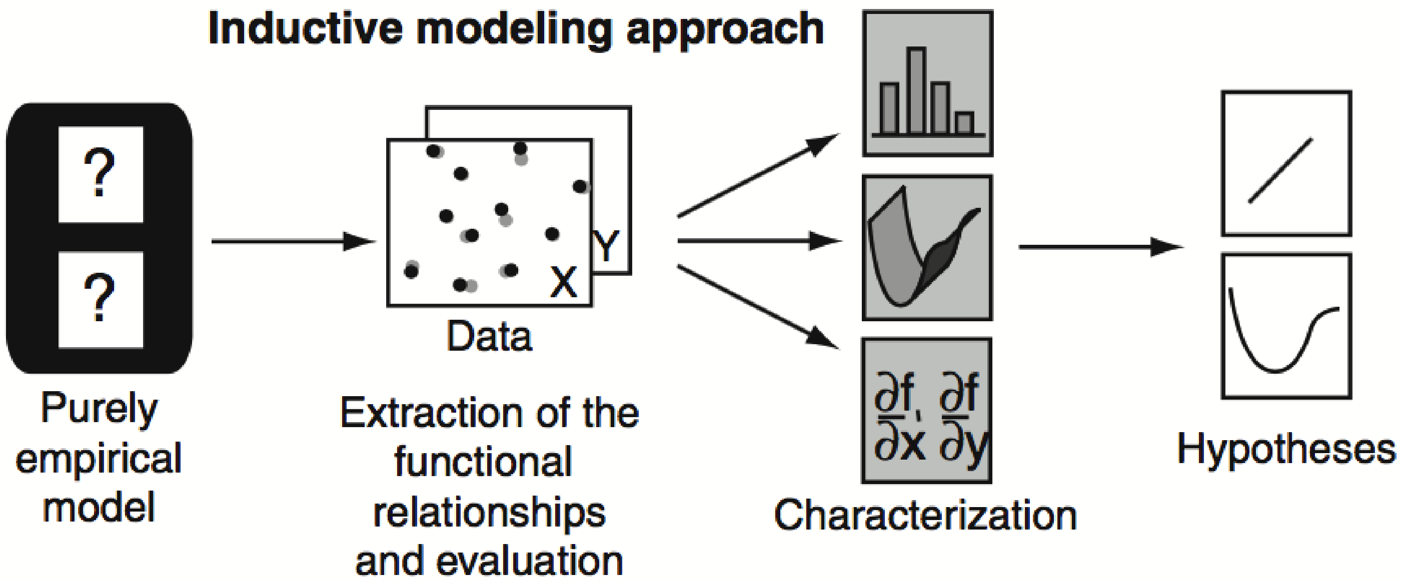
- Large, complex, and multidimensional datasets from which the causalities cannot be obtained just by visual evaluation of the measurements.
- Process-based models: the non-linearity of the relationship between CO_2 flux and other micrometeorological flux parameters (such as energy fluxes) limits the applicability of common carbon flux models to accurately estimate the flux dynamics.



(A.M. MOFFAT et al., Global Change Biology, 2010)

During Incubator

- A fully inductive approach
- A priori assumptions are avoided as much as possible.
- The functional relationships of the carbon fluxes to the climatic controls are inferred solely and directly from the observations.



(A.M. MOFFAT et al., Global Change Biology, 2010)

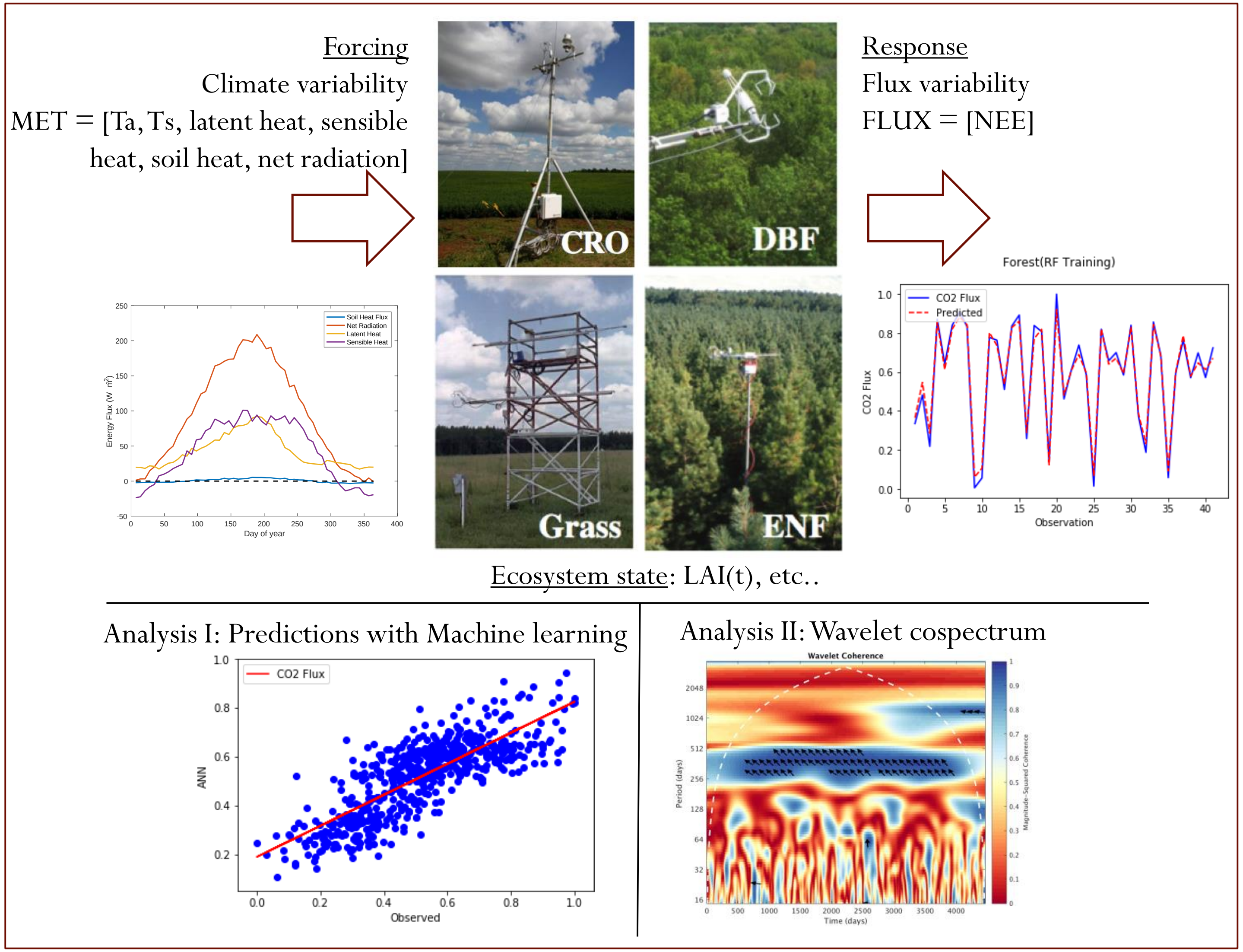
Scientific questions we try to answer:

- Can we model CO_2 fluxes with micrometeorological variables? If so, what statistically meaningful performance could we achieve?

- What's the relative contributions and temporal scale of different drivers?

- How does disturbance (eg. drought, fire…) impact input variables, and further, impact CO_2 flux?

Methods



Goal 1:

Use climate forcing (drivers) to model and predict CO2 flux dynamics in different ecosystems

- **Method 1:**
  ML methods including ANN and random forest
- **Method 2:**
  Wavelet scale decomposition

Goal 2:

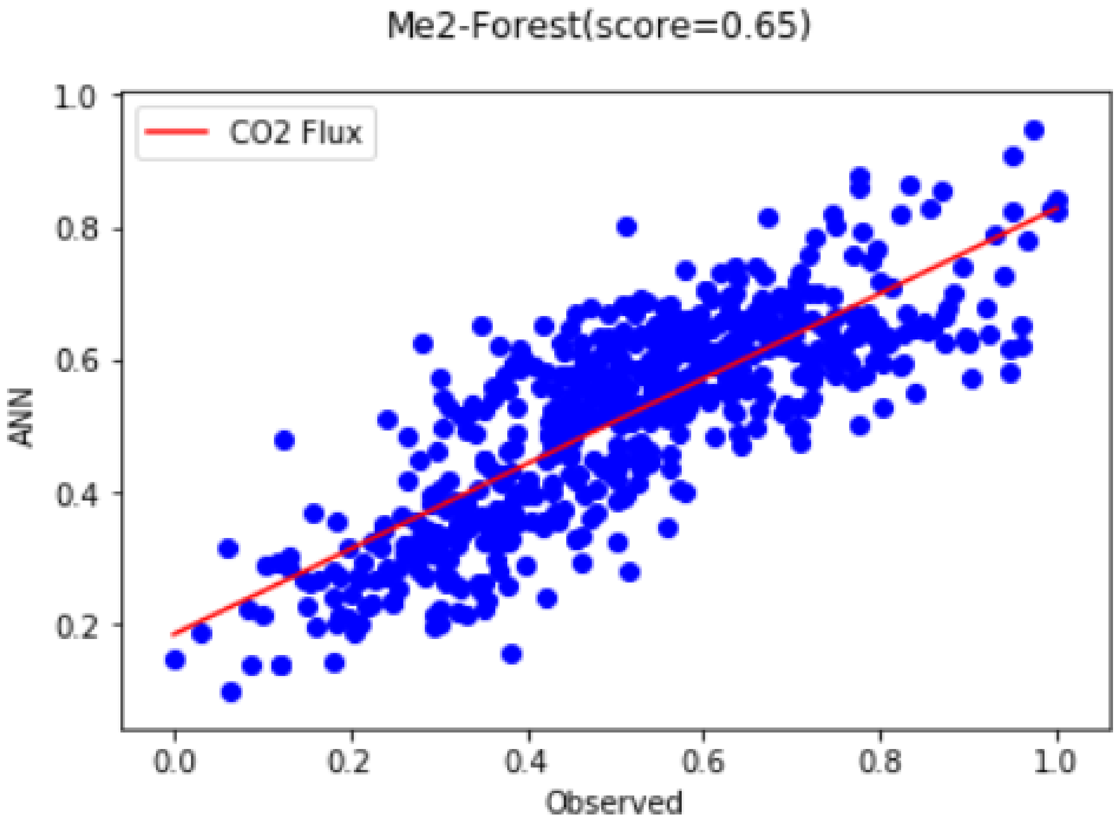
Capture disturbance (eg. drought; fire) effects at the site scale

Method:

Add Leaf Area Index (LAI) as a proxy for disturbance.

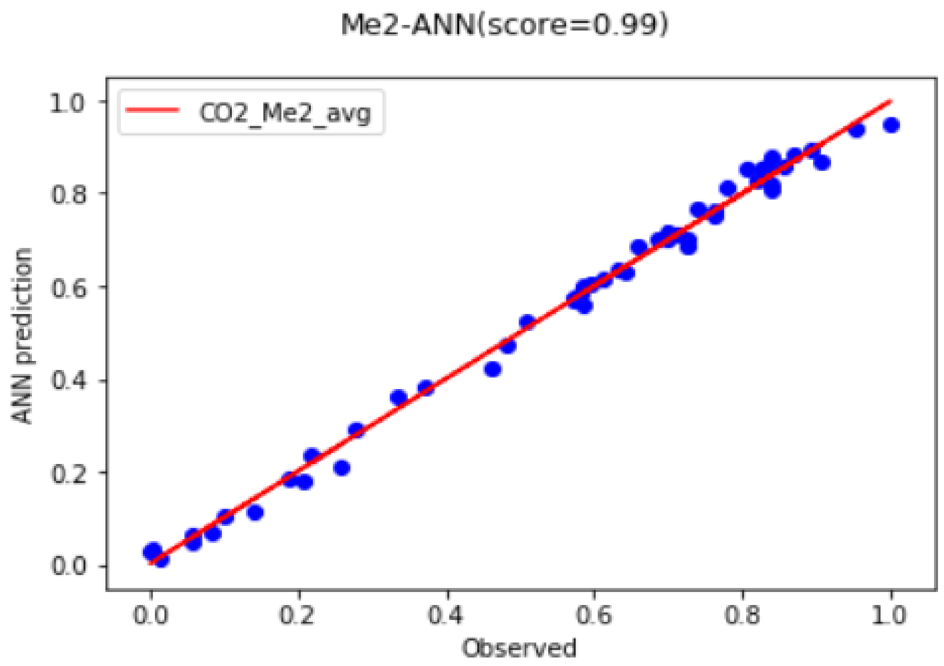
Results

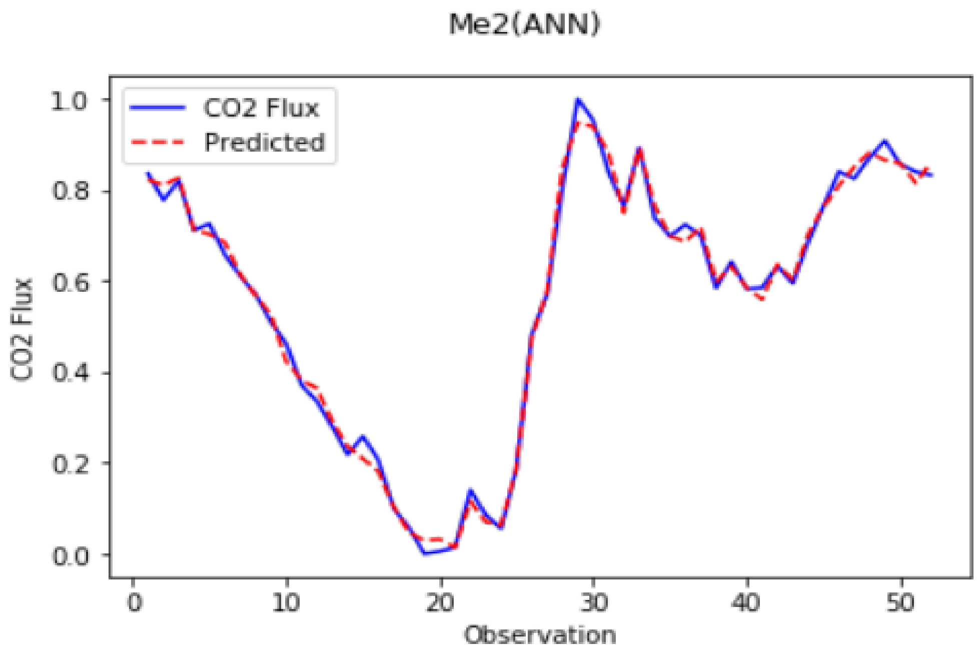
- ANN: training set – forests; testing set – Me2 (weekly data)

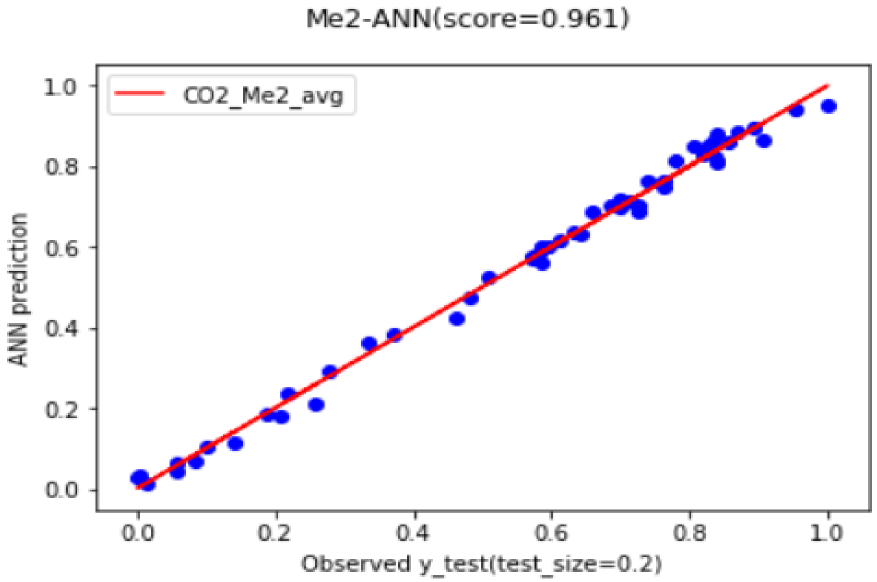


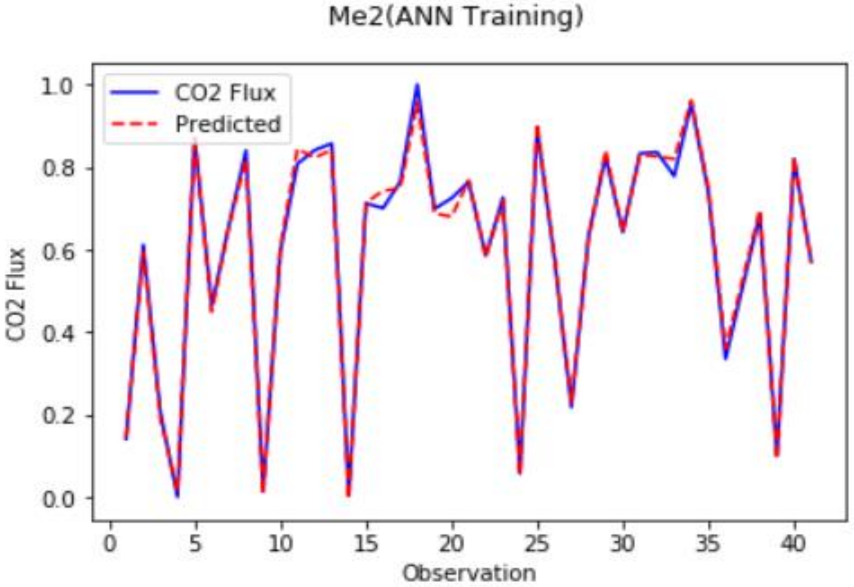
ANN vs. observed CO_2 flux

- ANN: training set – forests; testing set – Me2 (annual average data)

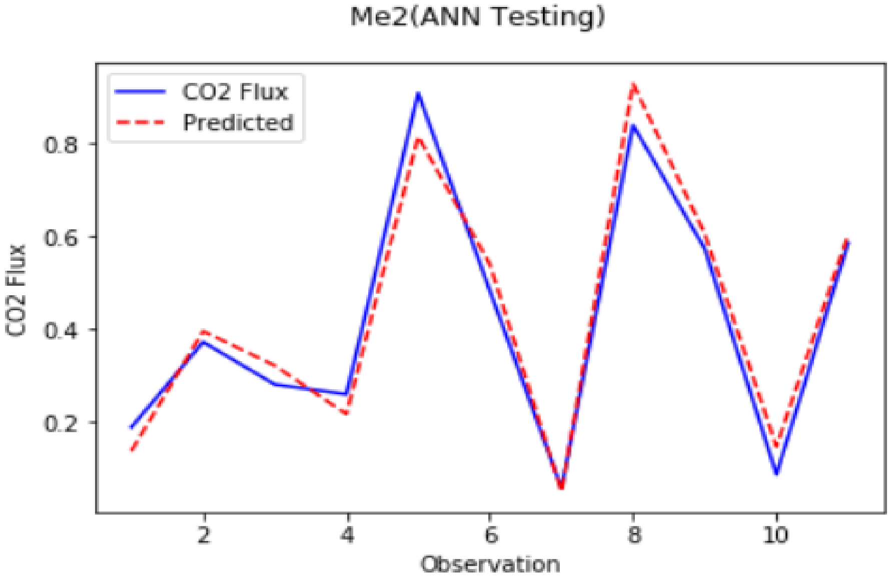






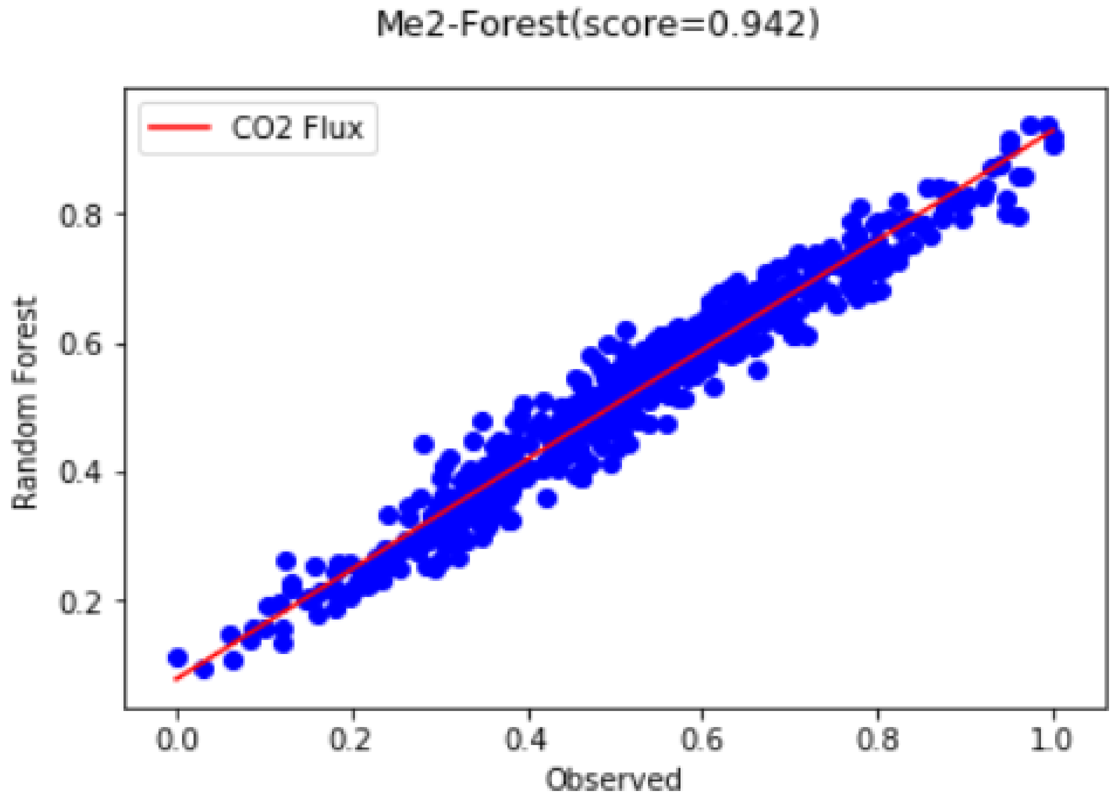


Training set:
80% of the annual dataset

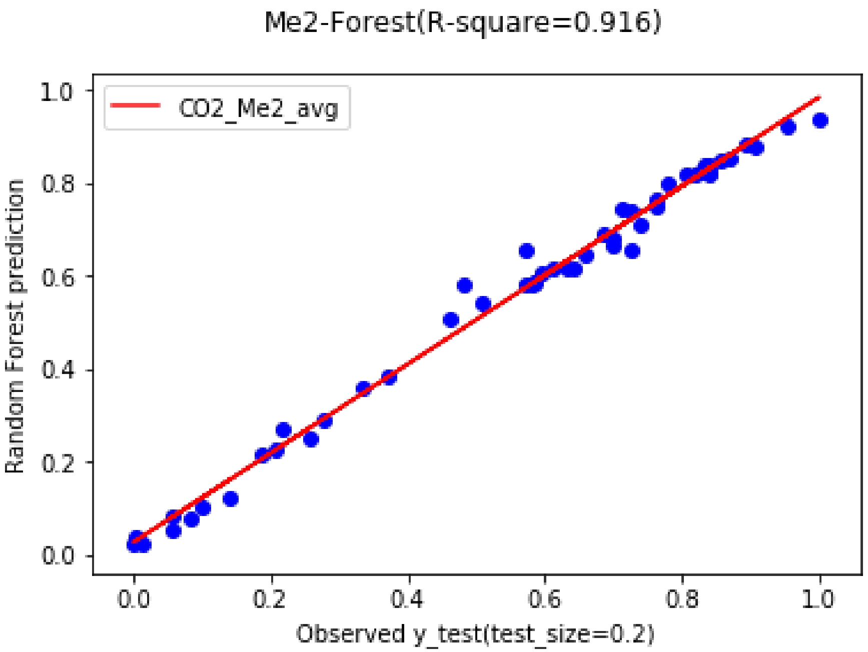


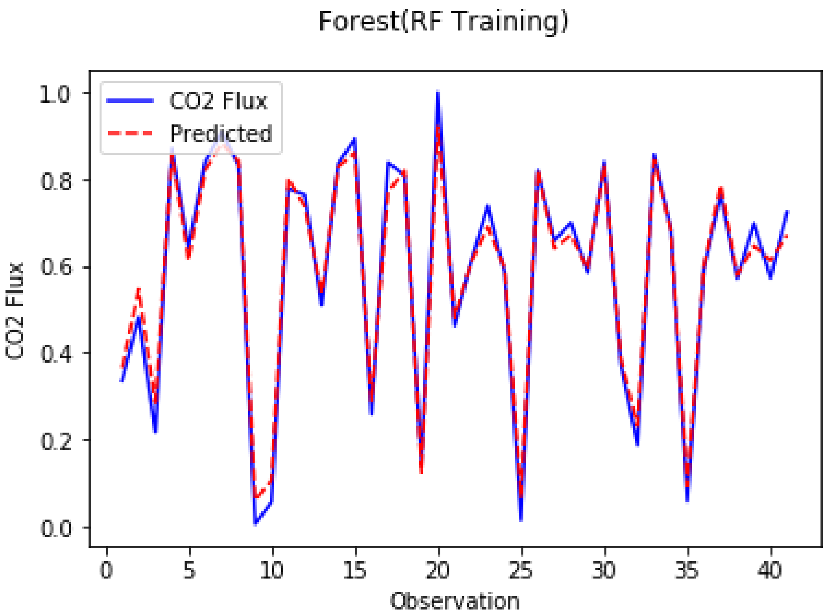
Testing set:
20% of the annual dataset

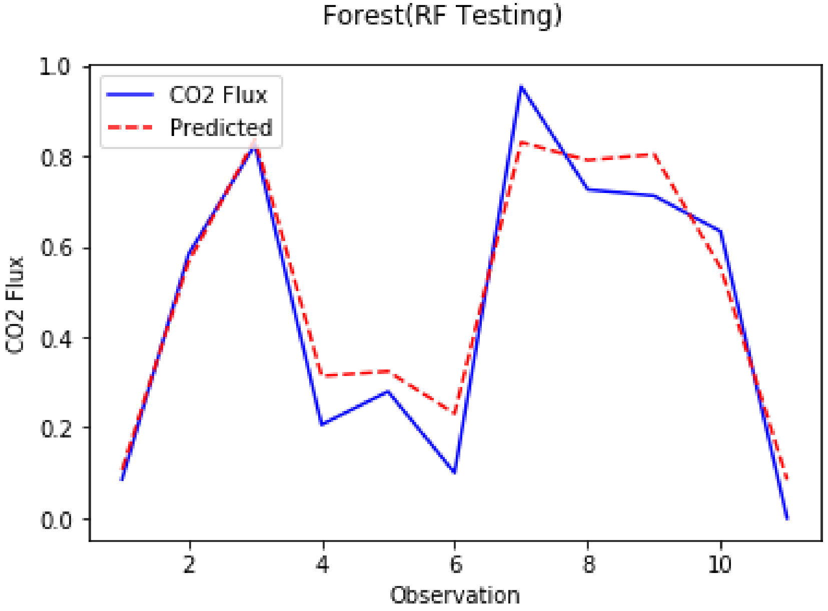
- Random Forest



RF vs. observed CO_2 flux

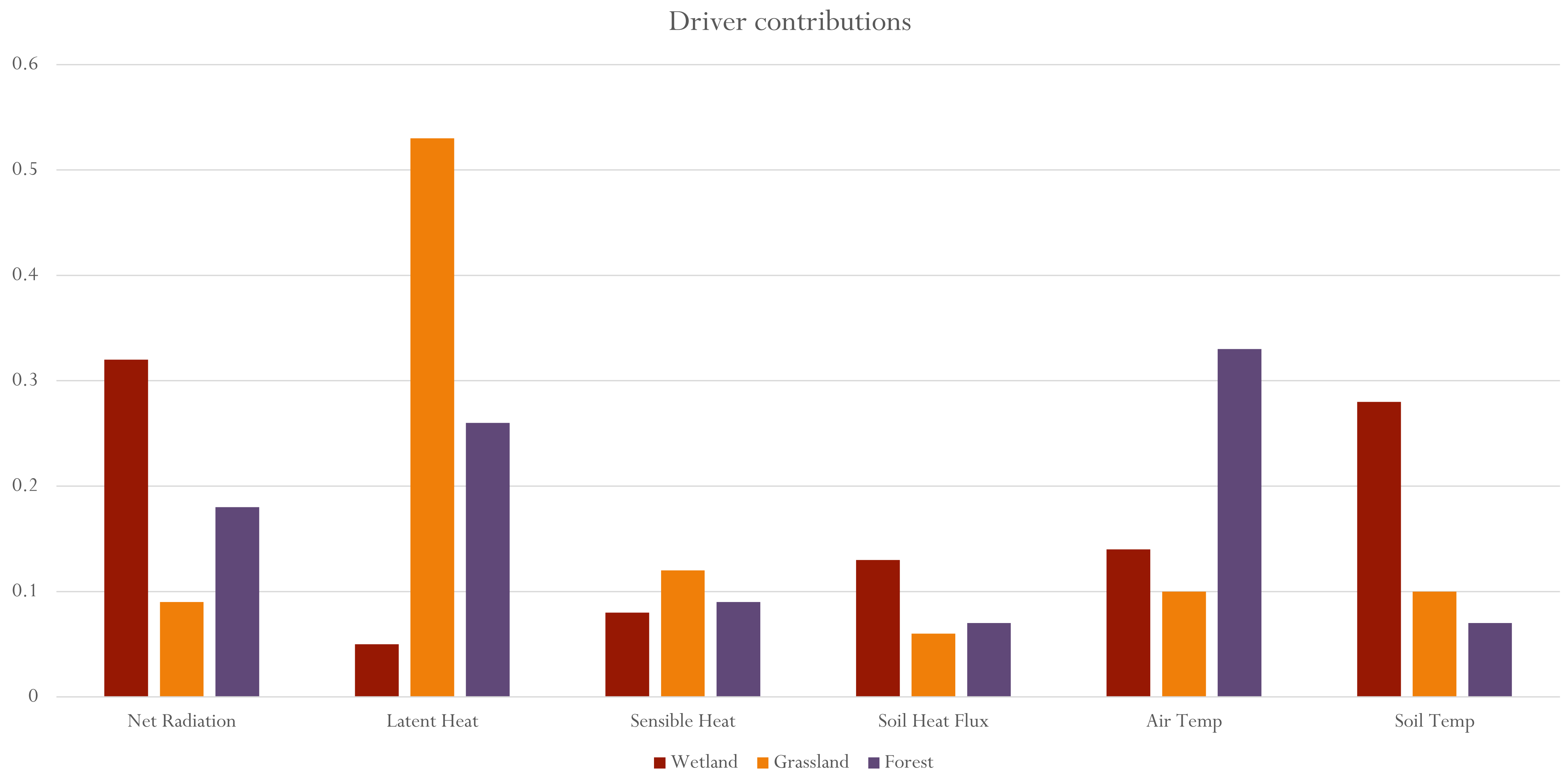




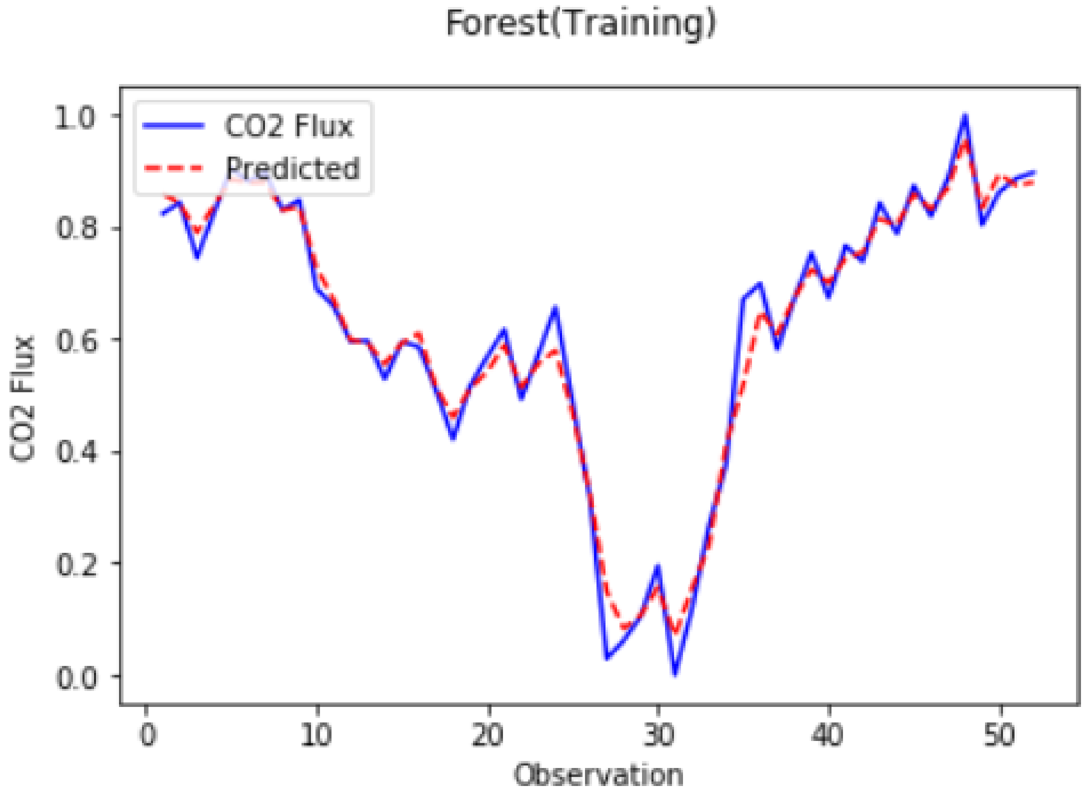


Training set:
80% of the annual dataset

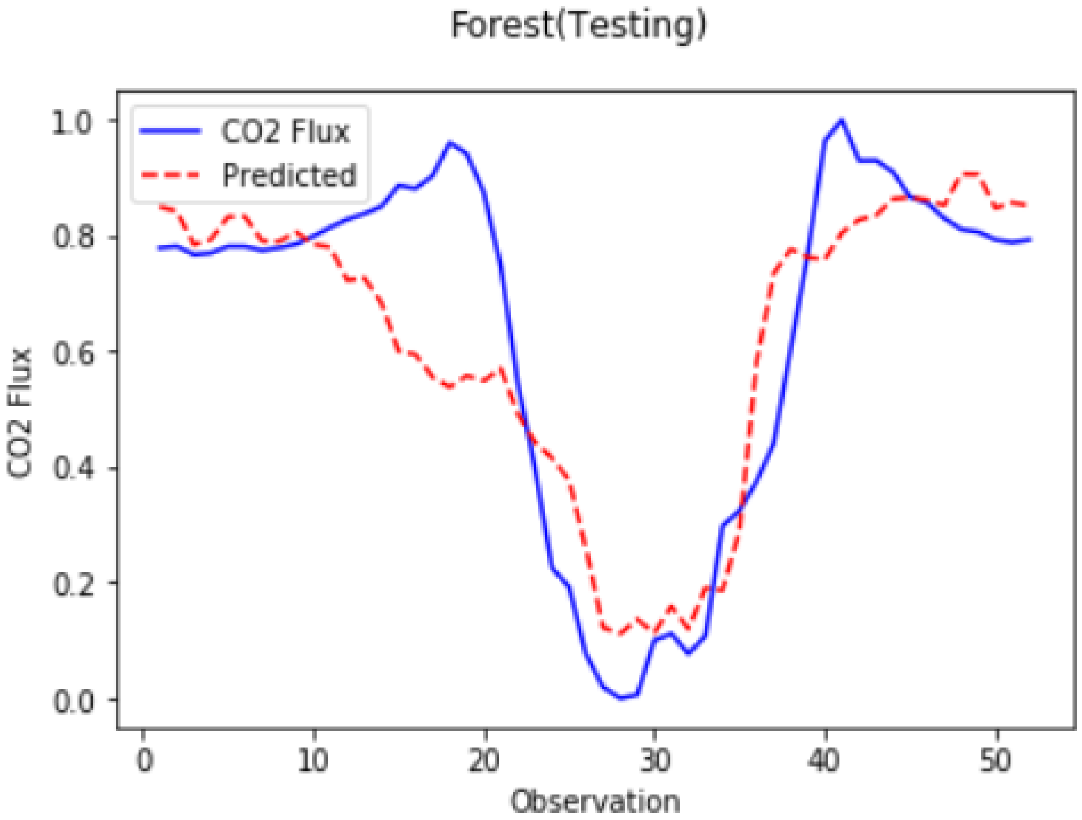
Testing set:
20% of the annual dataset


Driver contributions
0.6
0.5
0.4
0.3
0.2
0.1
0
Net Radiation
Latent Heat
Sensible Heat
Soil Heat Flux
Air Temp
Soil Temp
Wetland
Grassland
Forest

- Random Forest: **Blo vs WCr-Annual**

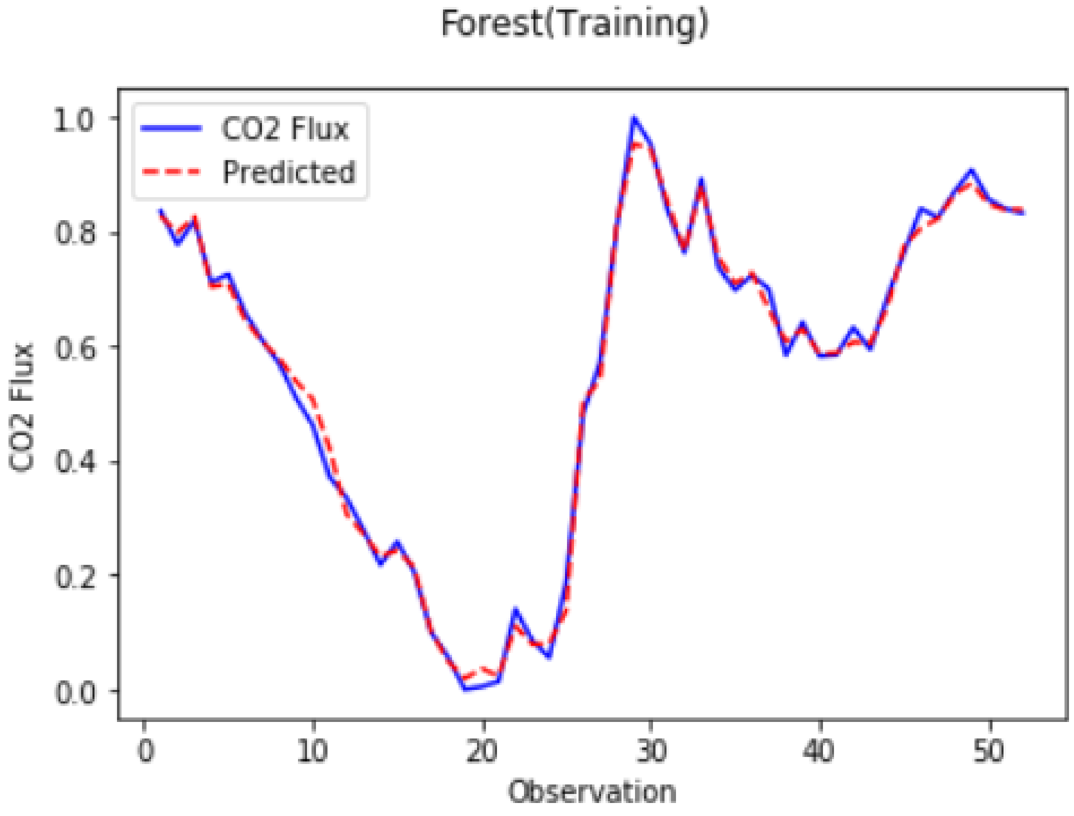


Training set: Blo annual average data

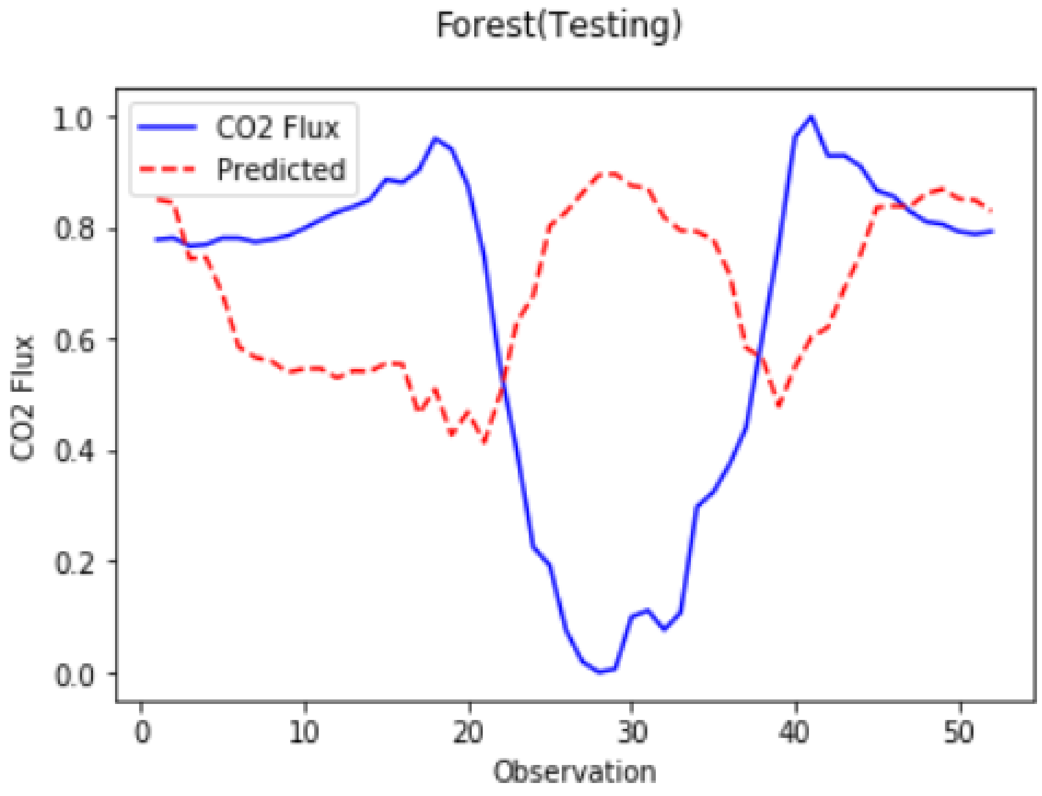


Testing set: WCr annual average data

- Random Forest: **Me2 vs WCr-Annual**

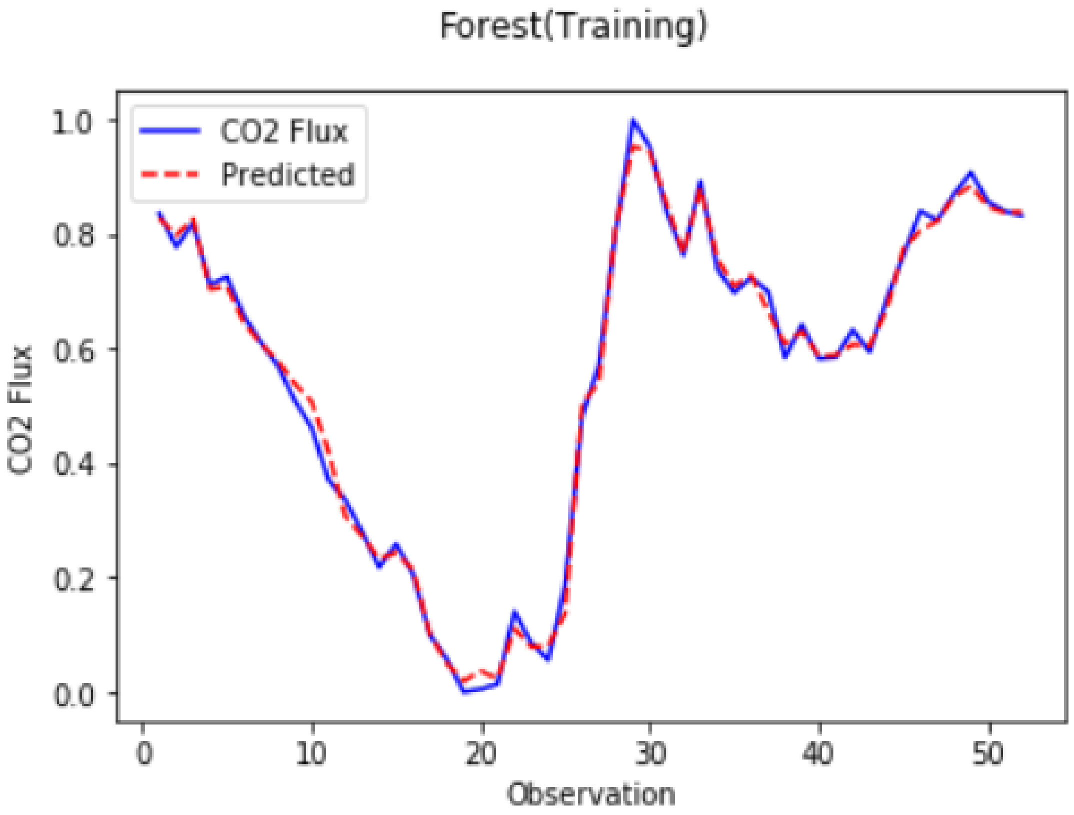


Training set: Me2 annual average data



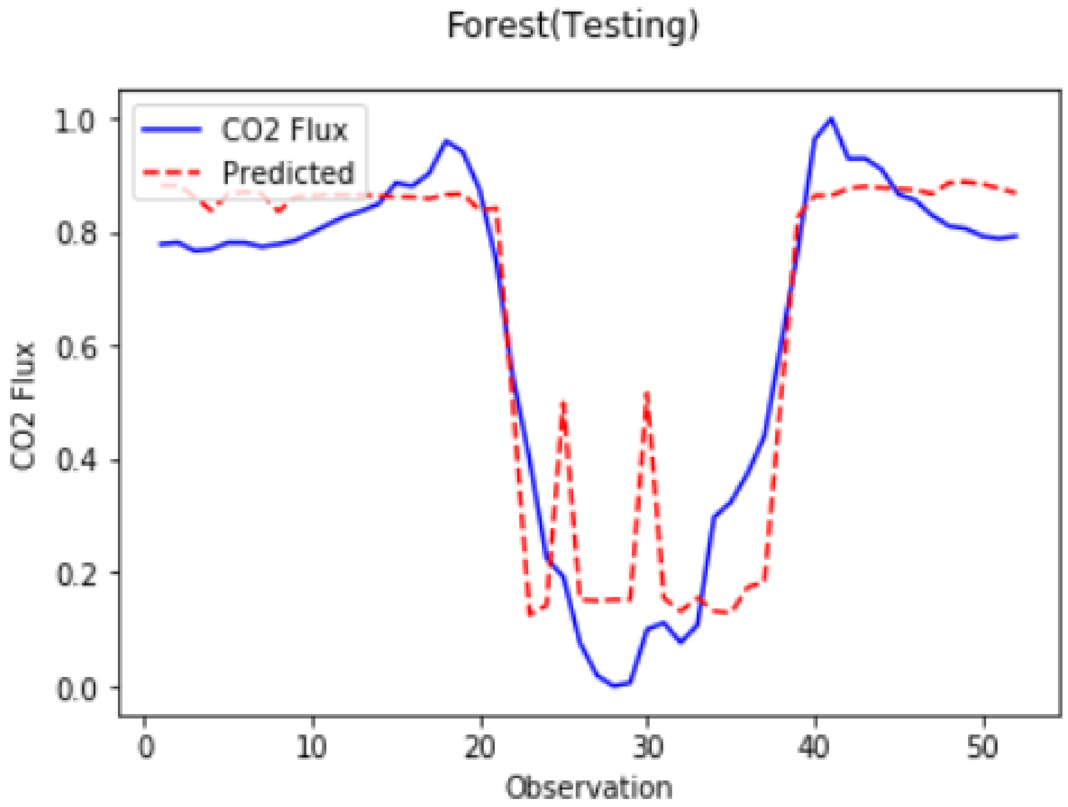
Testing set: WCr annual average data

- Fire influence on CO_2 flux: **Me2 vs WCr-Annual**



RF score = 0.98

Training set: Me2 annual average data with LAI added

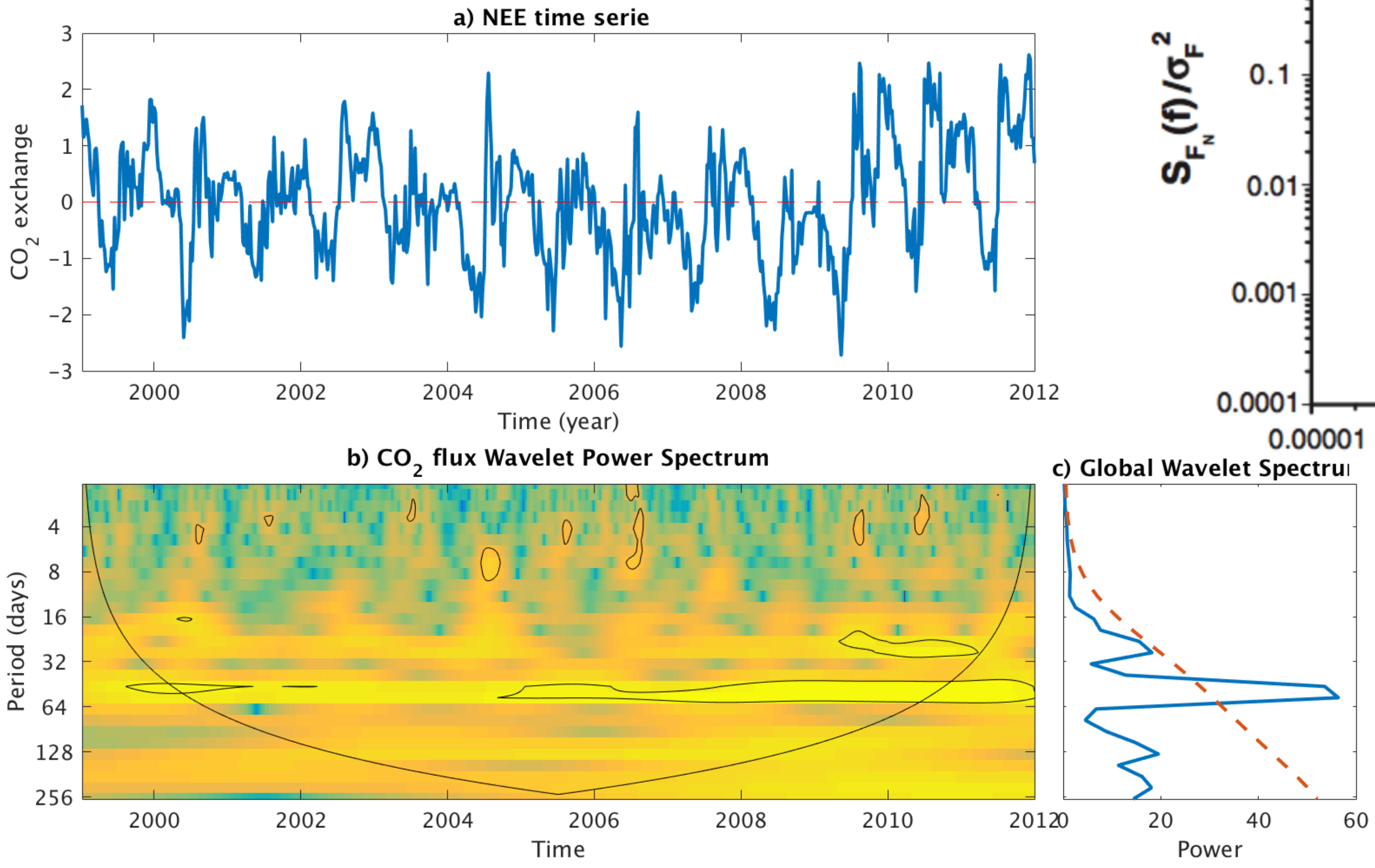


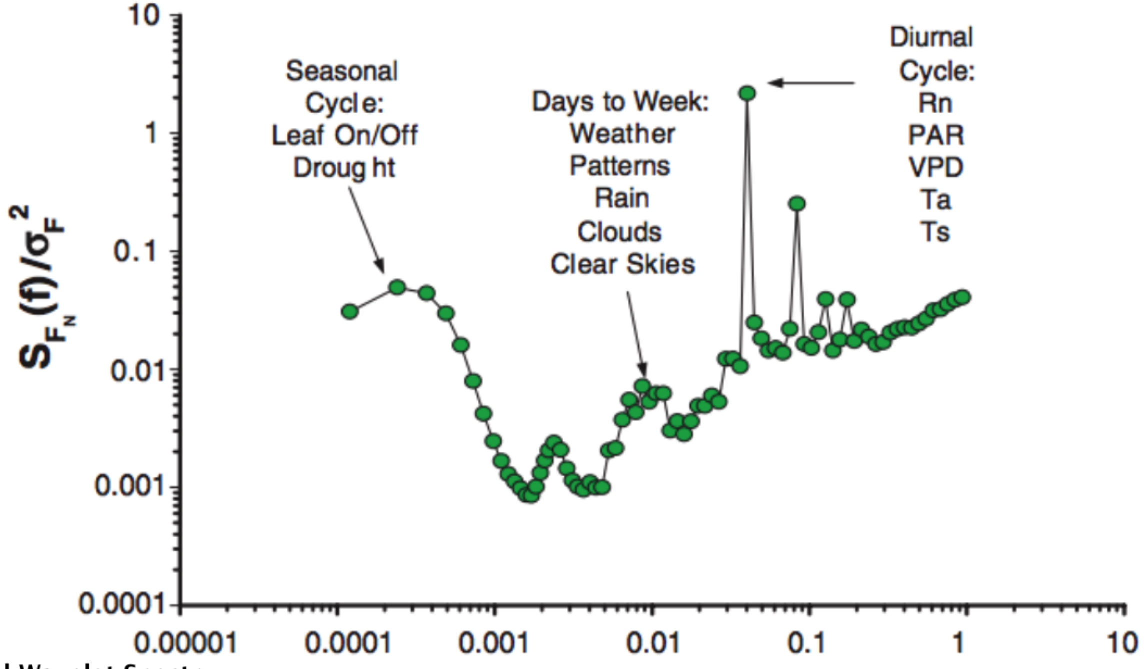
RF score = 0.72

Testing set: WCr annual average data with LAI added

- Wavelet analysis – feature correlation time scales

CO2 flux @ Me2





The magnitude of carbon exchange in different forest stands at various timescales ranging from daily to inter-annual is seriously influenced by local environmental change, such as climate, land use, disturbance and biotic invasions.

Next steps

- Model spatial carbon flux using ANN covering larger areas with remotely sensed meteorological data to provide carbon information at the spatial and timescale of interest.

- The approach is not limited to the net carbon flux, but can be extended to the energy and momentum flux, or other greenhouse gases.

Questions?