Wetland Carbon Dioxide Flux Residuals
An Impact of Hydrology?

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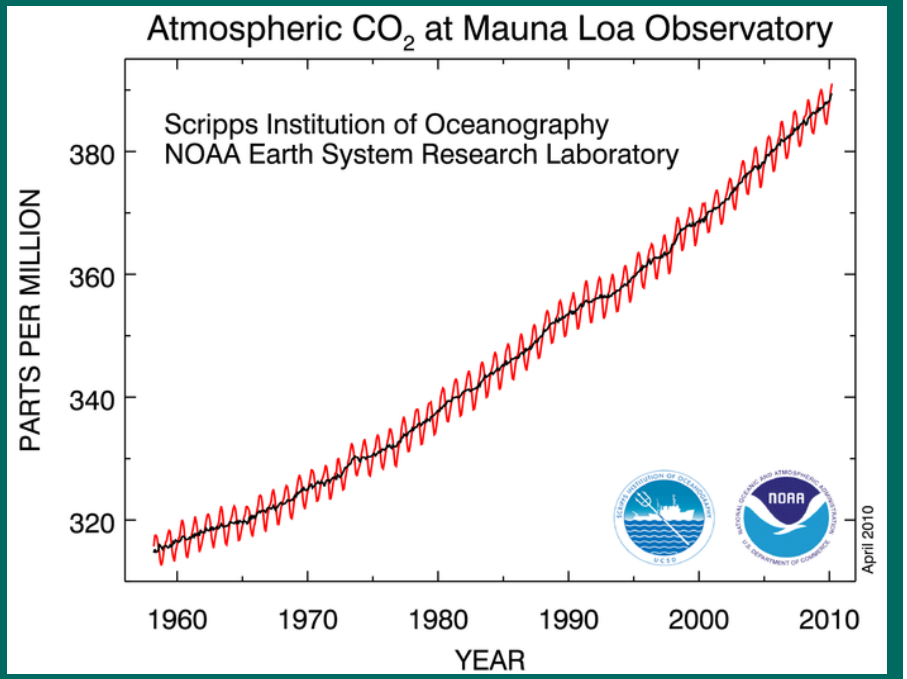
Water table values are compared to model residuals at three wetland sites to see if there is a correlation between wetland hydrology and model error.

Motivation

- Longest record of CO_2 concentration shows a 22% increase in atmospheric CO_2 over the last forty years
- The United Nations Intergovernmental Panel on Climate Change agreed the climate system is warming due to human activities and that CO_2 is the most important anthropogenic greenhouse gas (Meehl et al, 2007)
- Wetlands make up to one third of the world's soil carbon reservoir (Turunen et al. 2002)
- Falling water table heights, which have been predicted to result from the warming climate (Meehl et al, 2007), can cause a release in soil carbon as wetland peat dries up



Wetland Definition

Area where soil is flooded often enough that vegetation with aquatic adaptations lives there under normal conditions

Western Peatland, Lost Creek, and Mer Bleue

Photo from Fluxnet Canada website

- Central Alberta
- Spruce and Larch tree fen
- Betula and Ledum shrubs
- 507.3 mm annual precip.

(Fluxnet Canada)

Photo taken by Ben Sulman

- Northern Wisconsin
- Alder-willow shrub fen
- 771 mm annual precip.

(Ameriflux)

Photo from Trent University

- Southern Quebec
- Raised bog
- Shrubs and sphagnum moss
- 910 mm annual precip.

(Fluxnet Canada)

Carbon Dioxide Exchanges

- Net Ecosystem Exchange (NEE)
  - Net rate of CO_2 coming in (+) or leaving (-) the atmosphere
- Gross Primary Production (GPP)
  - Rate of CO_2 being taken out of the atmosphere for photosynthesis
- Ecosystem Respiration (ER)
  - Rate of CO2 being released to the atmosphere during plant respiration and the decay of organic material by microorganisms

NEE = GPP + ER

(–) (+)

Flux Tower Observations

- Use the eddy covariance method
  - A measure of the covariance between vertical motions and gas concentrations
- Assumptions
  I. Flat terrain
  II. Steady weather conditions
  III. Uniform and expansive vegetation upwind
- Error
  - ~5% error from variation in atmospheric turbulence and vegetation after a year of measurements
  - 5-10% error from instruments used

(Baldocchi, 2008)

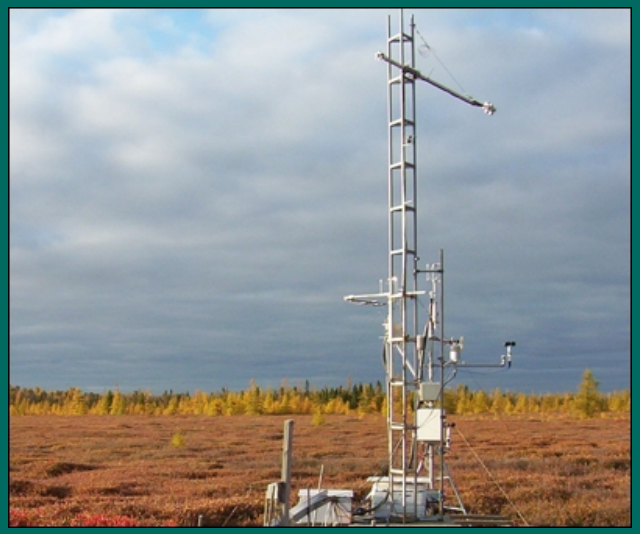
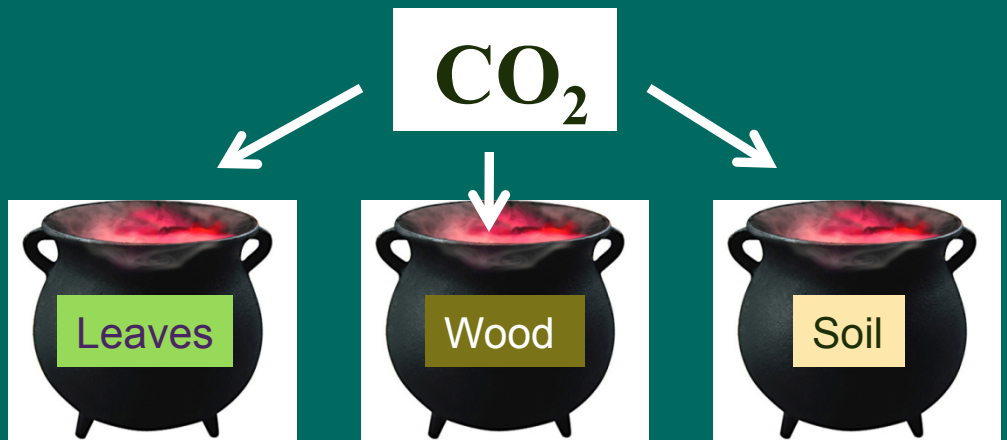


Photo from The Blue Lab at Trent University in Canada

Terrestrial Carbon Cycle Models

- Carbon pools
  - eg. Carbon uptake by soil or leaves
- Vegetation distribution and properties
- Soil layers, distribution and properties
- Meteorological Data
  - eg. Temperature, Humidity, Precipitation
- Calculations for GPP, NEE and ER



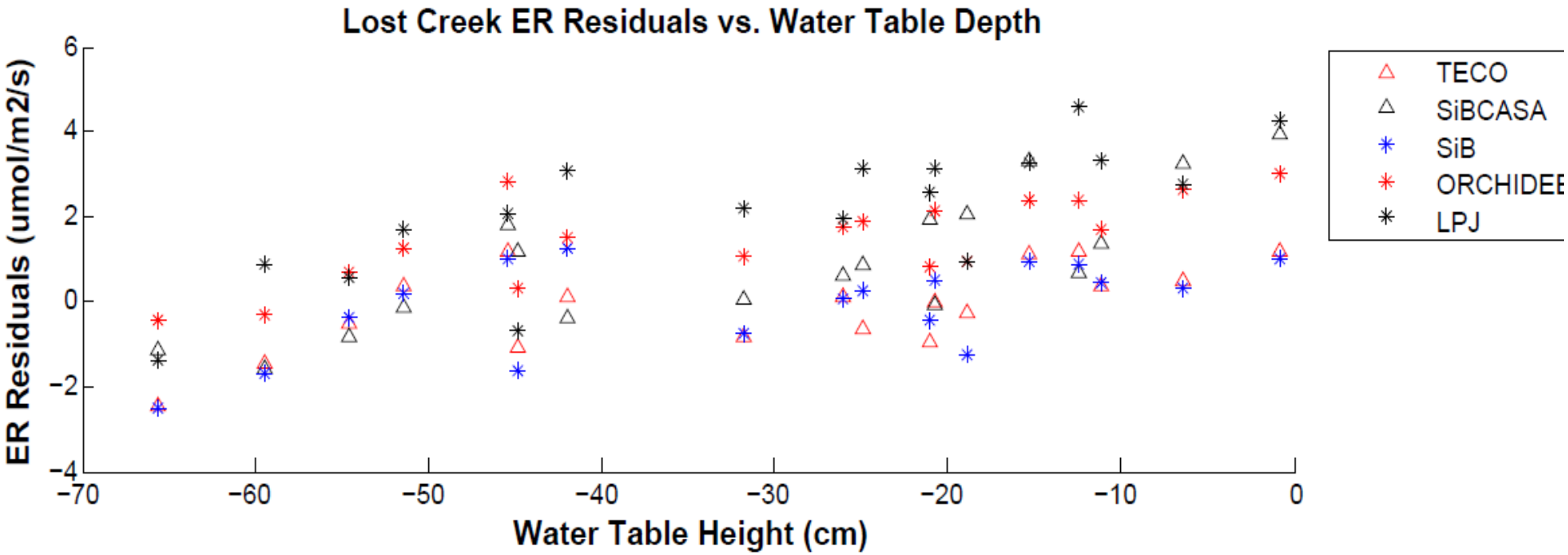
Residuals

- Residual = [Modeled Value] – [Observed Value]
- Positive residuals show overestimates
- Negative residuals show underestimates
- All models will have some error
- Error should not be correlated with any one variable

Residuals, cont'd

- Purpose: to see if model residuals are correlated with water table
- Utilized 5 high-frequency models
- Used only summer months, when water table data is most reliable
- Western Peatland: 4 years of data, 2004-2008
- Mer Bleue: 6 years of data, 2000-2006
- Lost Creek: 6 years of data, 2001-2007

Residuals


Lost Creek ER Residuals vs. Water Table Depth
ER Residuals (umol/m2/s)
6
4
2
0
−2
−4
−70
−60
−50
−40
−30
−20
−10
0
Water Table Height (cm)
TECO
SiBCASA
SiB
ORCHIDEE
LPJ

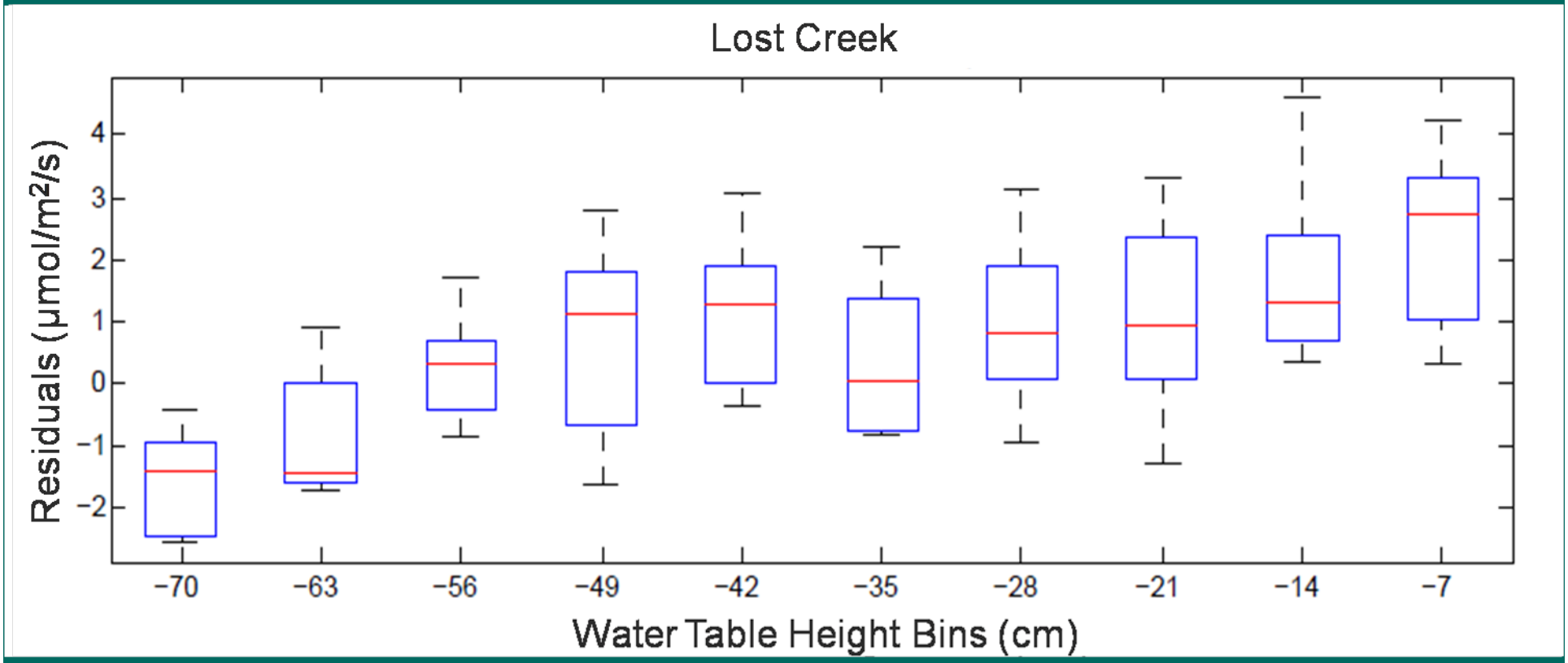
Correlation Coefficients for Scatter Plots

R^2 Values For Each Site and Model

Site	TECO	SiBCASA	SiB	ORCHIDEE	LPJ
LC	0.3846	0.6109	0.3137	0.5280	0.6014
MB	0.7996	0.1537	0.0774	0.1695	0.4445
WP	0.7274	0.5418	0.4361	0.5700	0.6072

Residuals vs. Water Table Height

- **Scatter plot data *bin-averaged***
  - Meaning: water table divided by 10 to make 10 “bins”
  - Corresponding residuals made into box plots



Discussion

- SiBCASA, SiB and ORCHIDEE
  - Model characteristics in common
    - Contain meteorological data for temperature, precipitation, humidity, wind speed and solar radiation
    - Use the enzyme kinetic model to calculate GPP
  - Modeling similar wetlands in a similar way
- TECO and Lost Creek
  - Less correlated with WT at Lost Creek
  - Model most correlated with WT at other two sites
    - Lost Creek has a maximum WT height 15-20cm higher
- Why SiB?
  - Simpler calculations – should be less accurate?
  - No carbon pools
  - Other models have between 5 and 16 carbon pools

(Schaefer et al, 2008; Oakridge National Laboratory Website)

Conclusions

- Positive correlation between summer water table heights and model residuals
- Models perform better when the water table is lower
- Less complex modeling of terrestrial carbon uptake may provide more accurate results in the short term

Acknowledgements and References

- Advising
  - Professor Ankur Desai
  - Ben Sulman
- Flux Tower Measurements and Gap-filled Data
  - AmeriFLUX and Fluxnet Canada
- Metadata for TECO, SiB, ORCHIDEE and LPJ
  - Oakridge National Laboratory

- References

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