Incorporating Biogenic Hydrocarbon Emission Inventories Into Mesoscale Meteorological Models

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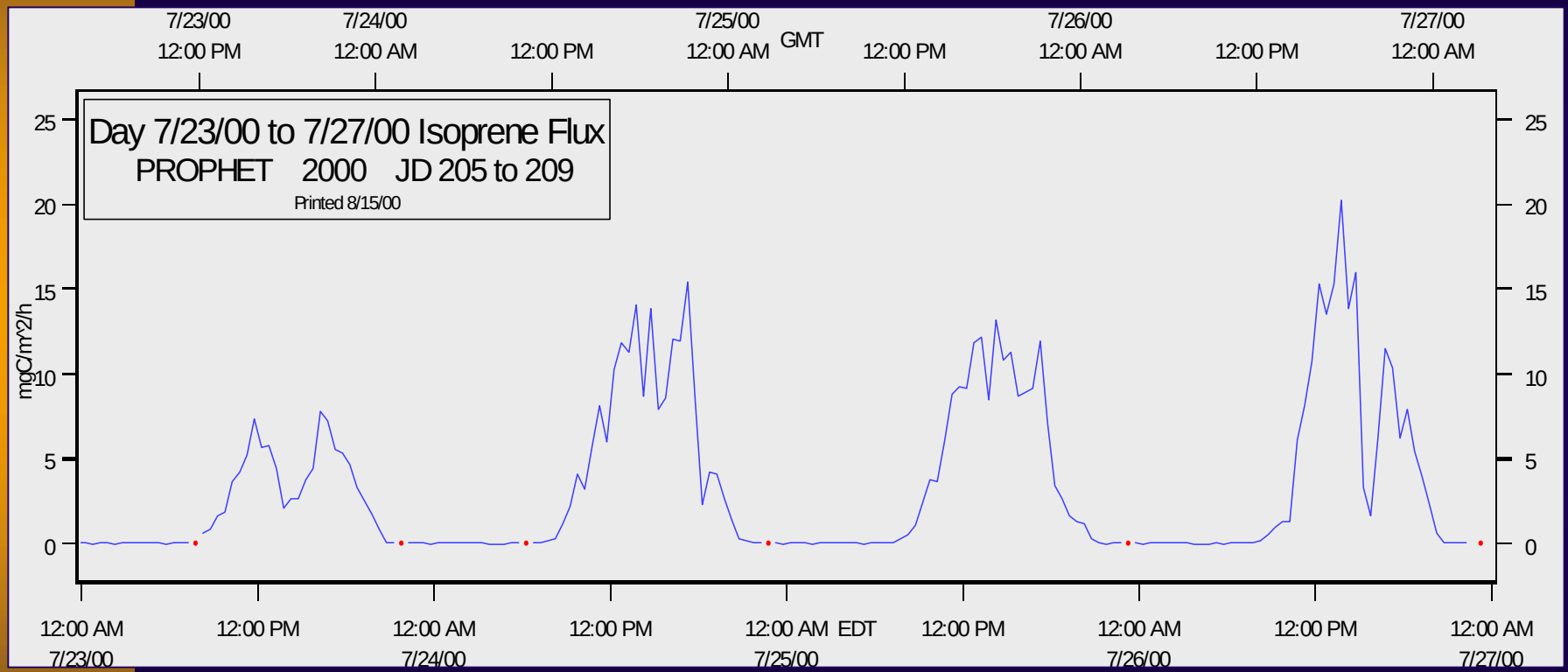
Outline

- Background – importance of biogenic hydrocarbons (BHCs)
- Current approach for modeling BHCs in Mesoscale models
- Observational isoprene flux data
- Results and application of empirical model

Biogenic Volatile Organic Compounds

- Highly reactive in the atmosphere - oxidized quickly by OH, O_3 and NO_3
- Over 90% of Global VOCs are emitted from vegetation (Guenther et al. 1995)
- Contribute significantly to atmospheric chemistry
  - tropospheric O_3 and aerosol formation
  - contributes to the atmospheric oxidative capacity
- Dominant in rural areas (in particular isoprene)

Typical Isoprene Fluxes

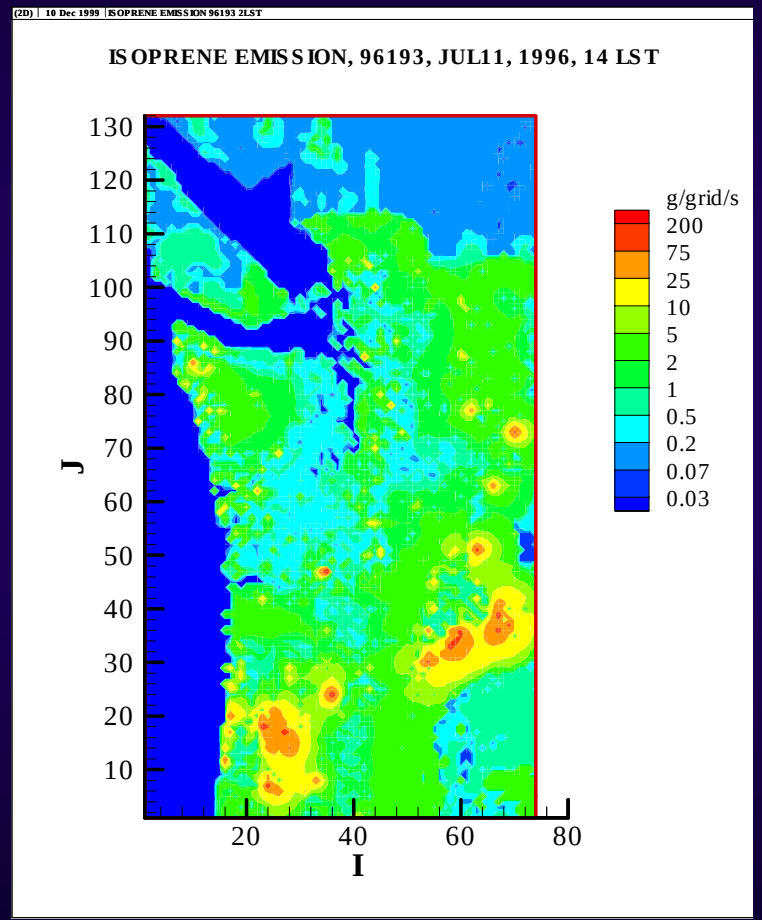


What do we know about isoprene emissions?

- Isoprene fluxes vary with PAR and increase exponentially with temperature
- Isoprene basal emissions vary with position in the canopy (sunlit vs. shaded leaves)
- Short term (minutes to hours) vs. long term (few days) control of emissions are different
- Isoprene is emitted from aspen, oak, poplar at high rates (70 to 100 $\mu g\ g^{-1}\ hr^{-1}$)

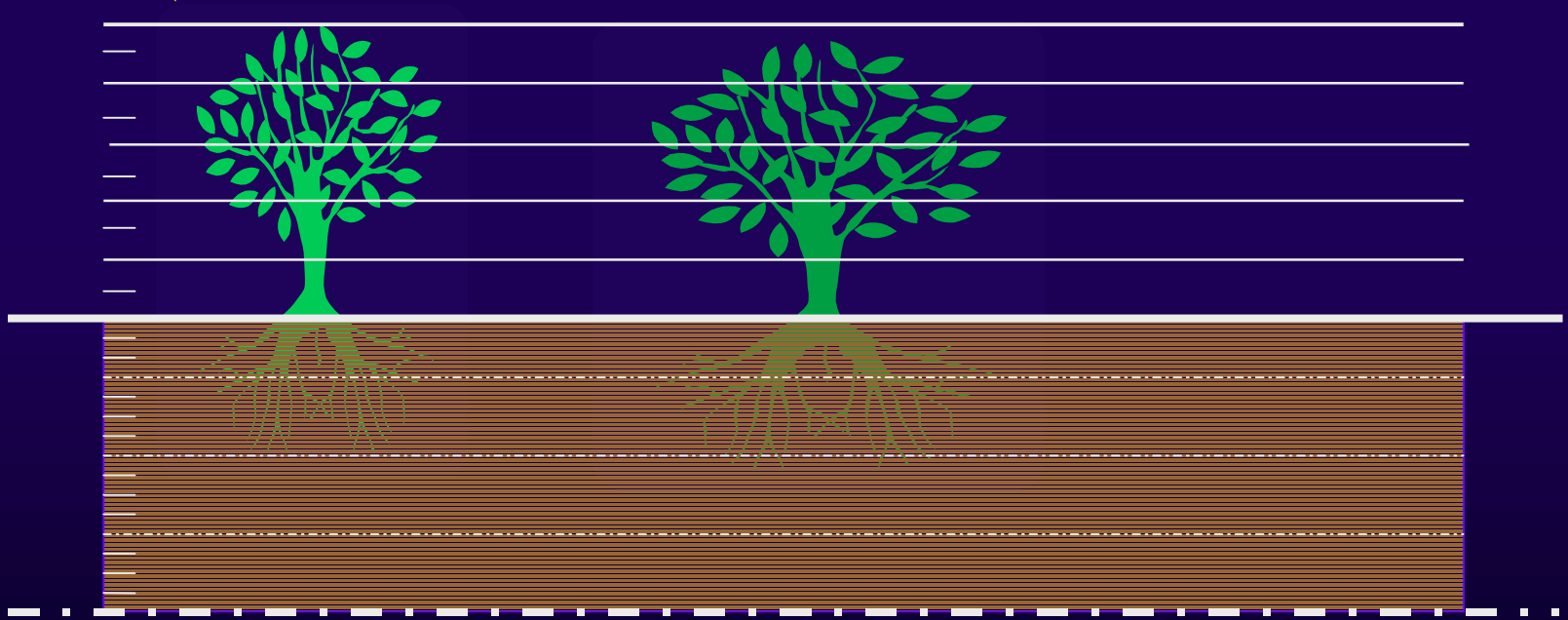
How are biogenic emissions determined?

- Simple canopy models (BEIS2, BEIS3, GLOBEIS)
- More complex canopy models (CANVEG, ACASA)
- Typically not coupled with mesoscale models…but should they be?



Canopy Models

Typical inputs include:
Above canopy solar radiation, temperature, wind speed, and relative humidity



Biogenic Emission Inventory System (BEIS)

- Simple scaling profiles for T, PAR, RH and wind through the canopy
- Leaf energy budget solved for each layer (T_{leaf})
- Guenther isoprene emission algorithms for light and temperature correction terms (C_L, C_T), and adjustment of basal emission rate (C_B)

$$F(T, PAR) = F_s \sum_{i=1}^{n} C_{Bi} C_{Li} C_{Ti}$$

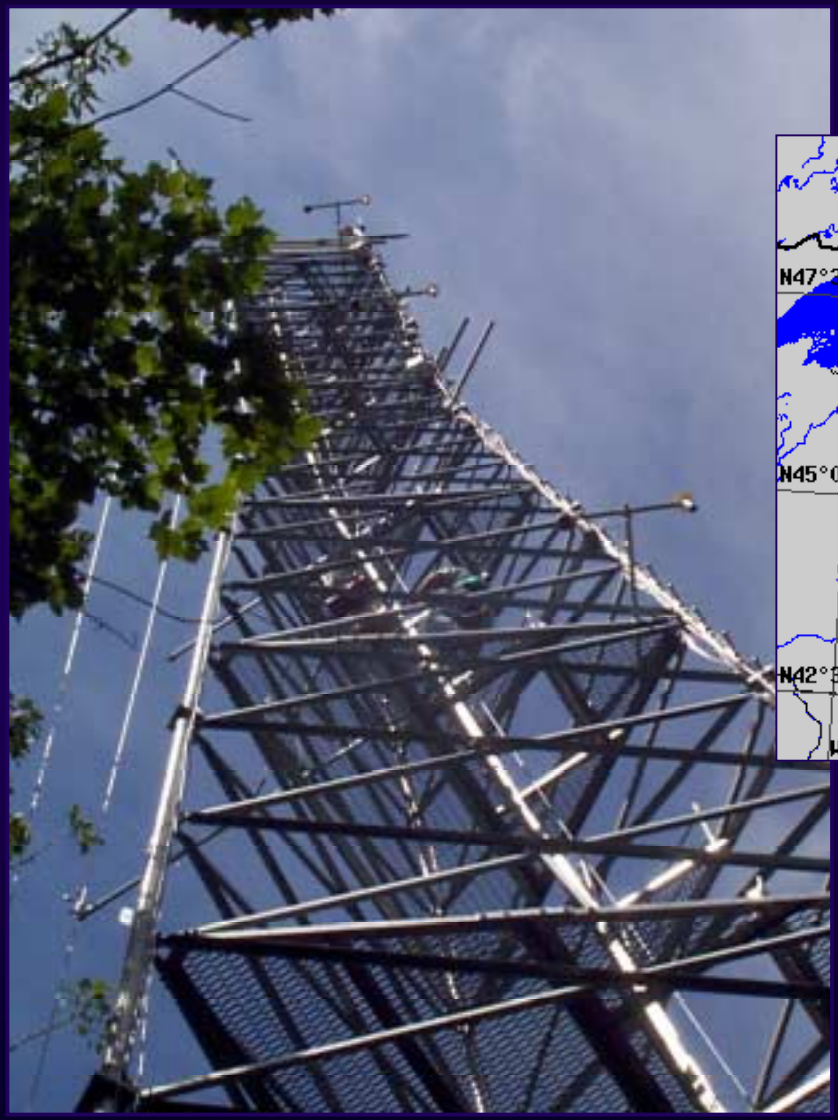
Our shortcomings with predicting Emissions

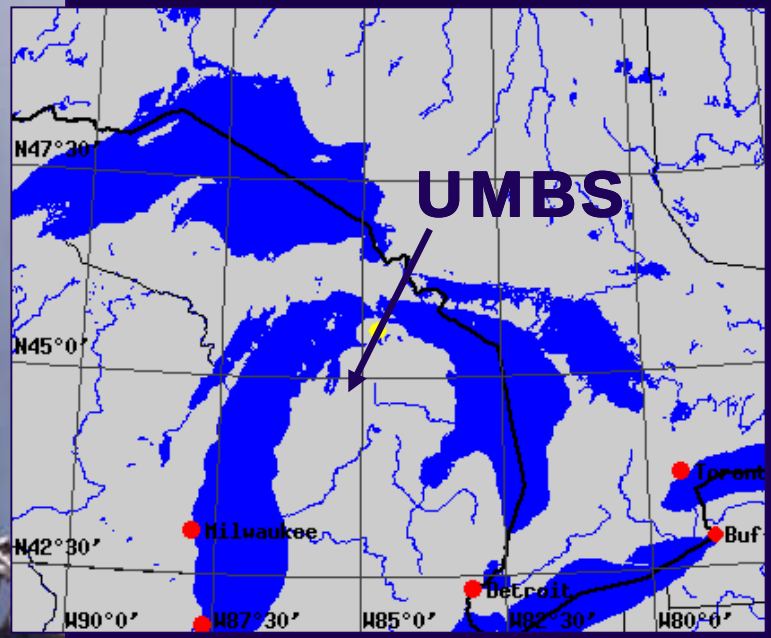
- Hourly and daily variability cannot be explained with simple temperature and light parameters
- Our understanding of the physiological controls is still limited
- Uncertainty with the biogenic inventories are typically within a factor of two

Alternative parameter for estimating emissions

- Surface Energy flux (in particular the sensible heat flux)
  - Canopy scale surrogate for the canopy integrated leaf level temperature and light
  - Available with land surface models and regional models such as MM5
- The correlation is also useful as a tool for verifying canopy models

Observational Data





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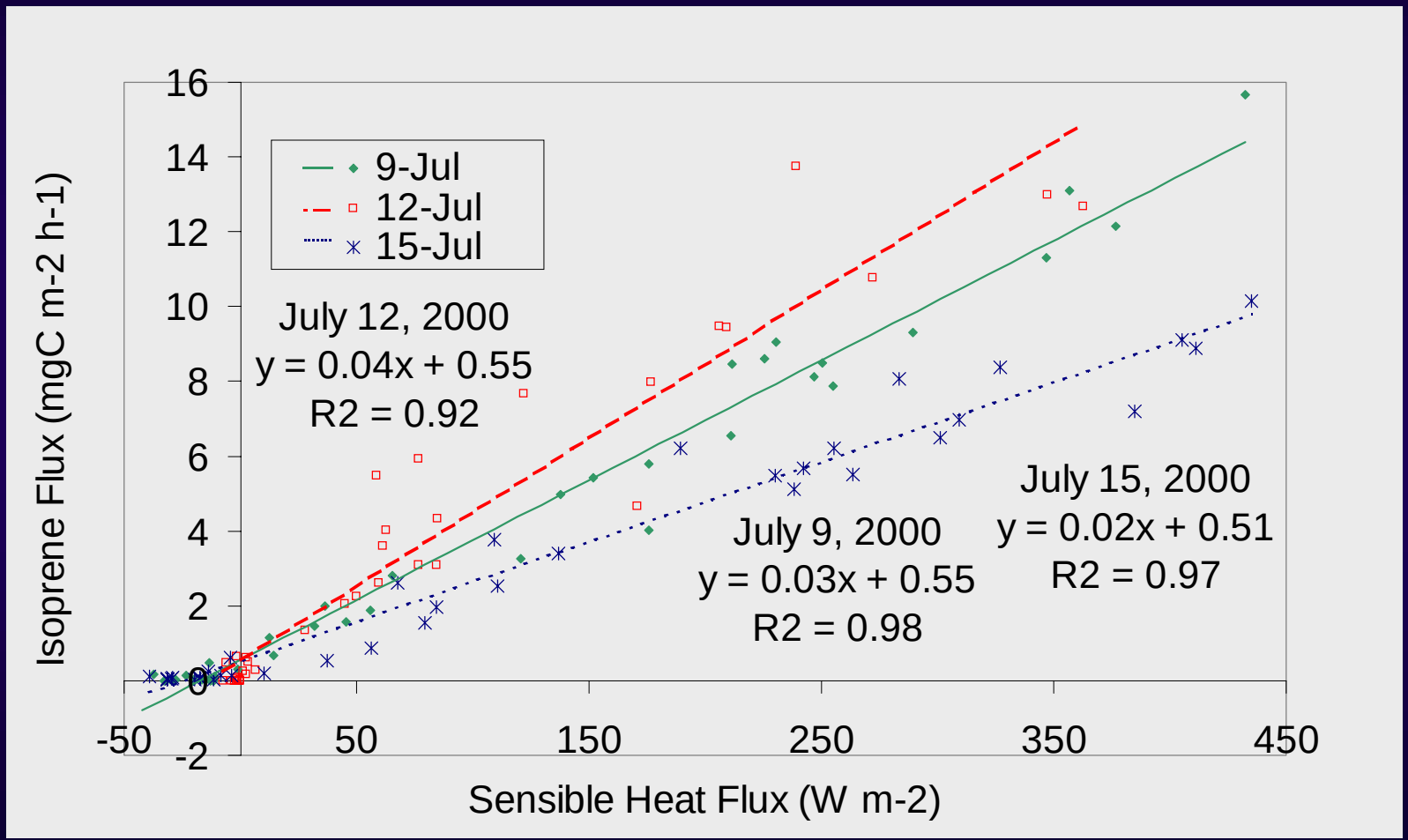
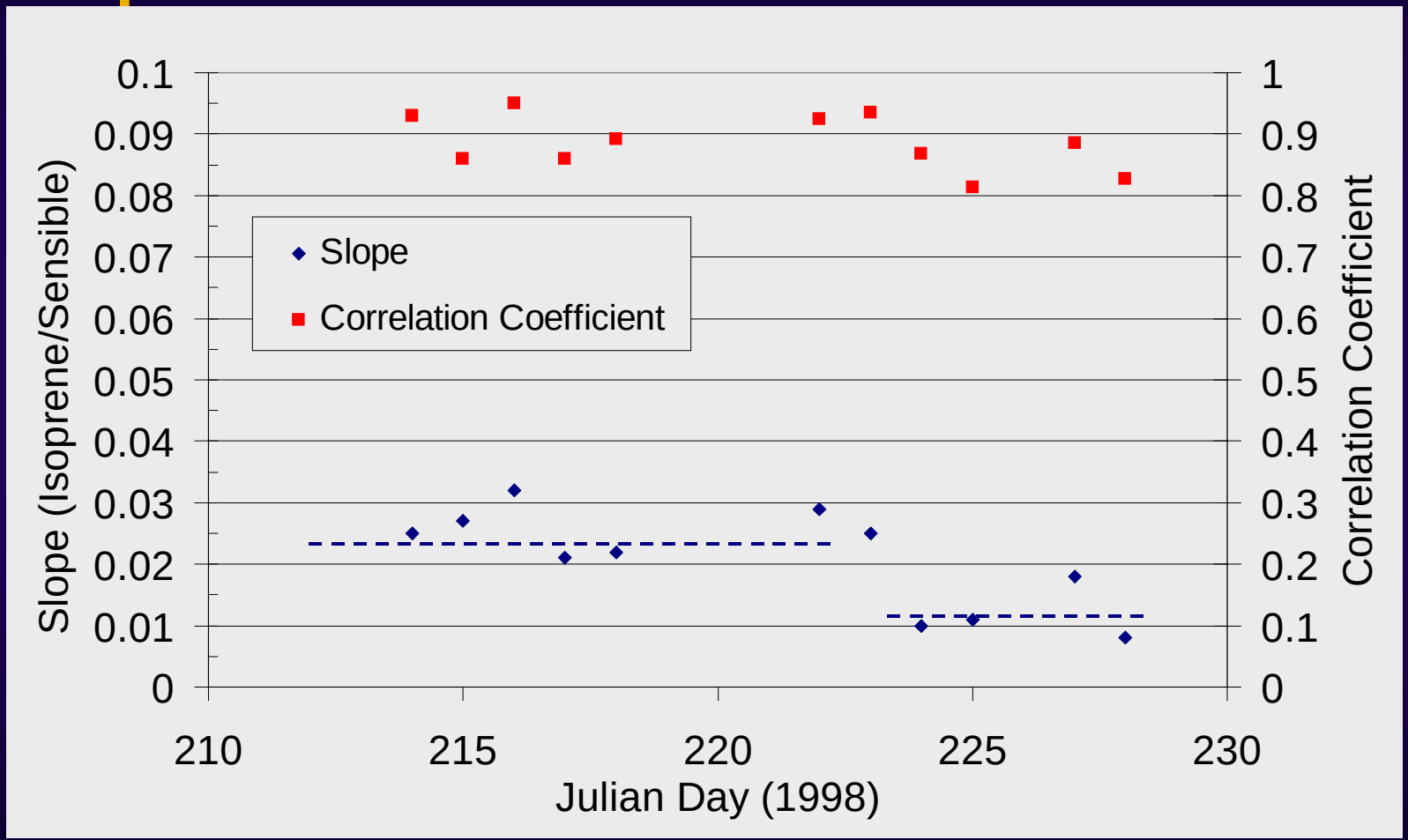
Isoprene Flux Measurements

- Eddy Covariance Flux Measurements $F = \overline{w'C'}$
  - 31 m level AmeriFlux tower
  - Isoprene fluxes with Fast Isoprene Analyzer (FIS)
  - CO_2/H_2O fluxes with open path infrared gas analyzer (IRGA)
  - Sensible heat fluxes with sonic anemometer
  - 30 min. average fluxes, continuous operation from mid-May through October
  - peripheral information from AmeriFlux and Prophet towers (PAR, T, net radiation, humidity, biomass survey, LAI profile)

Linear regression between isoprene flux and sensible heat flux



Slope and correlation coefficients for the daily linear regression between isoprene flux and sensible heat flux



Multiple regression analysis

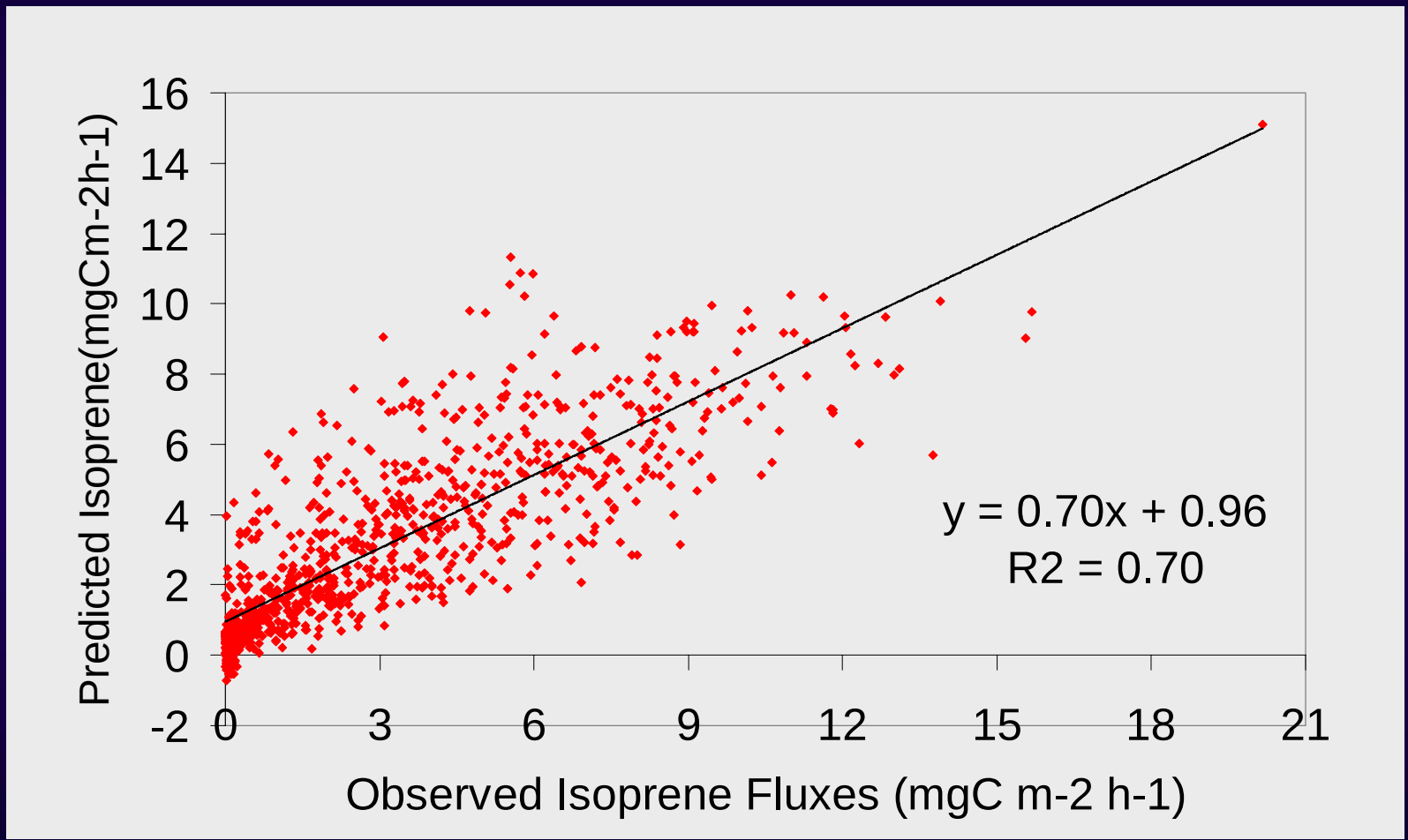
- Observed isoprene fluxes vs. other parameters
- A simple regression was favored using heat flux and maximum daily heat flux

$$[\text{isop. flux}] = 0.67 + .02\ H - 4.1 \times 10^{-5}\ \text{Max H}$$

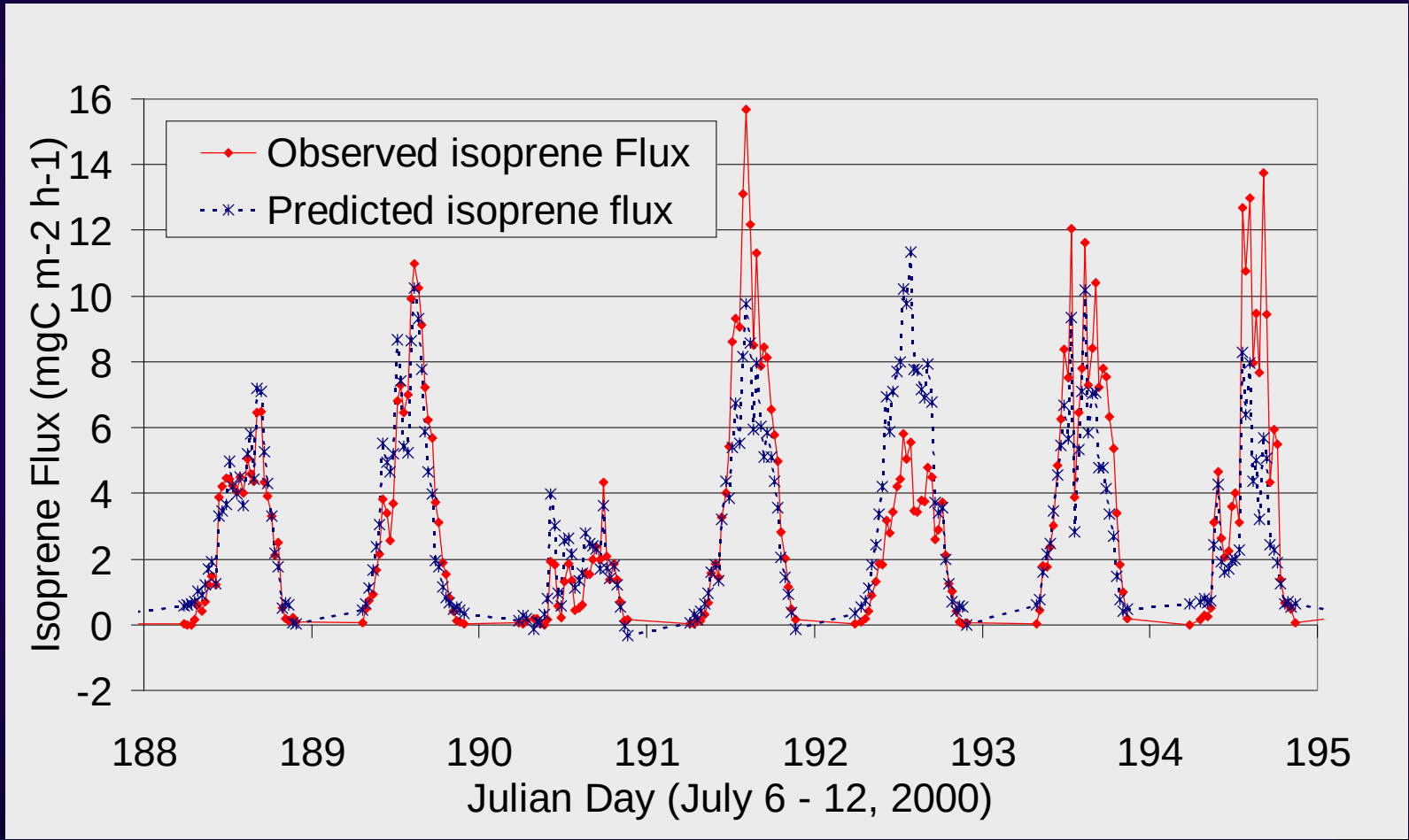
where H = sensible heat flux

Max H = maximum daily heat flux

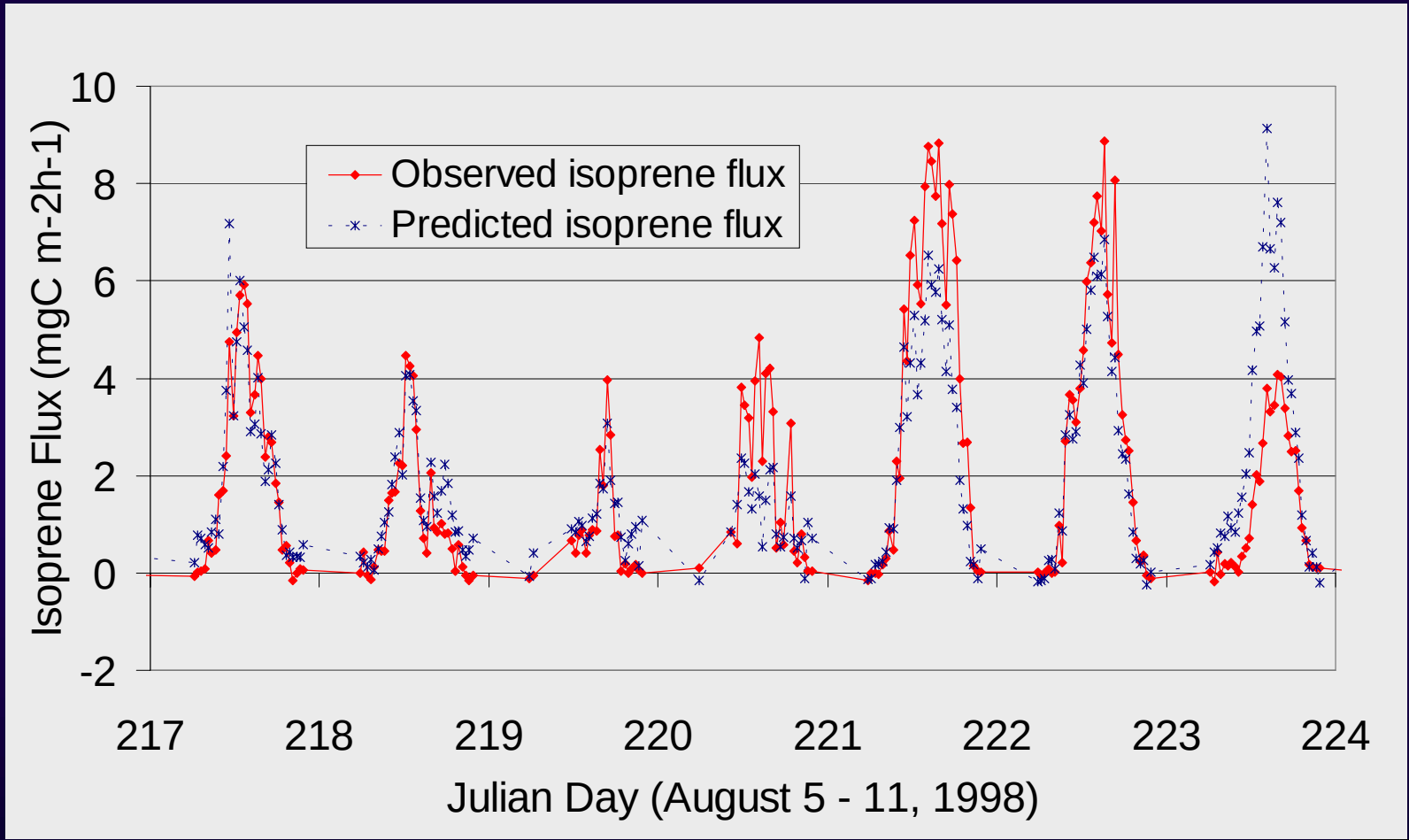
Predicted isoprene flux vs. observed isoprene flux for the 2000 northern MI data



Daily predicted and observed isoprene fluxes for the 2000 northern MI data



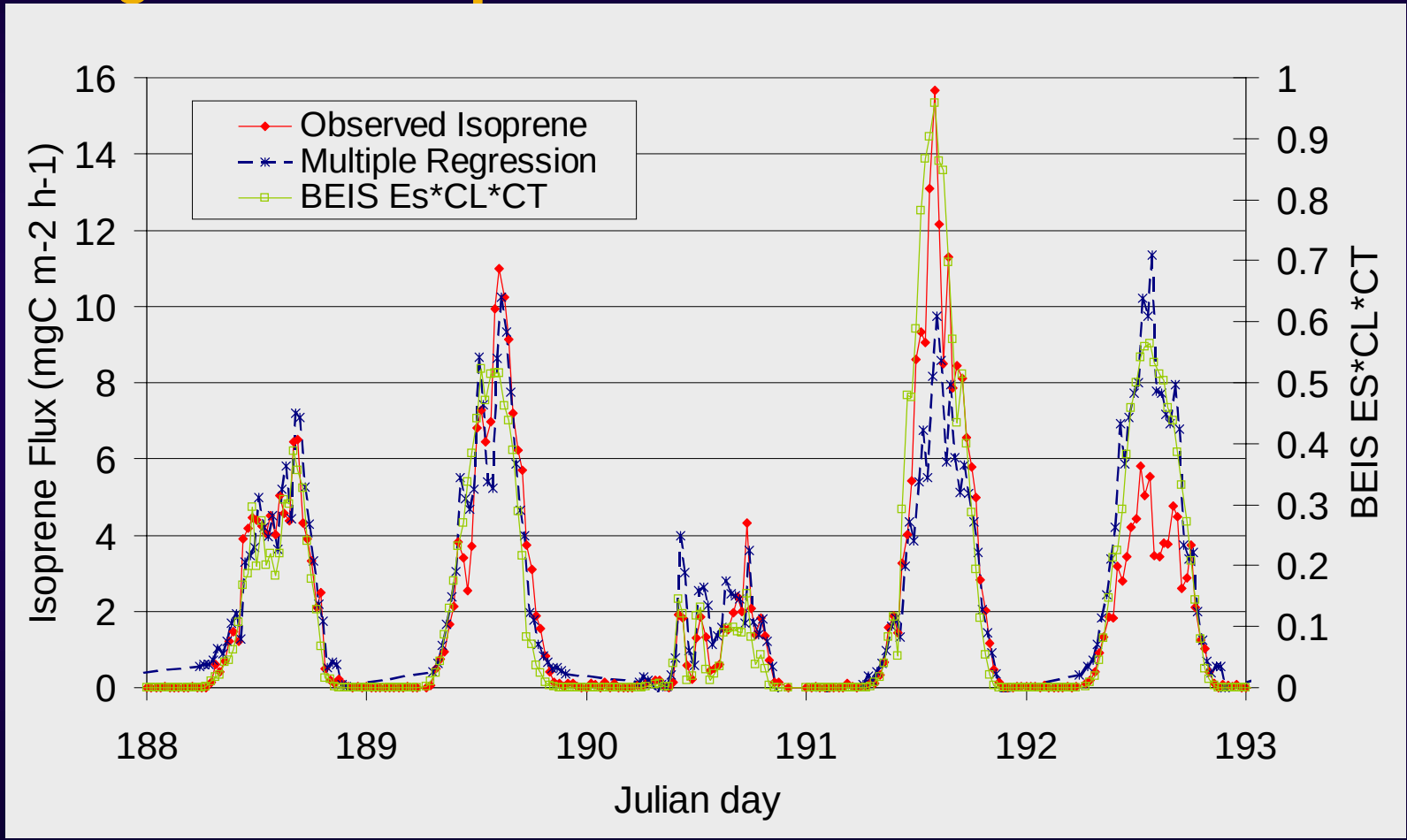
Daily predicted and observed isoprene fluxes for the 1998 northern MI data



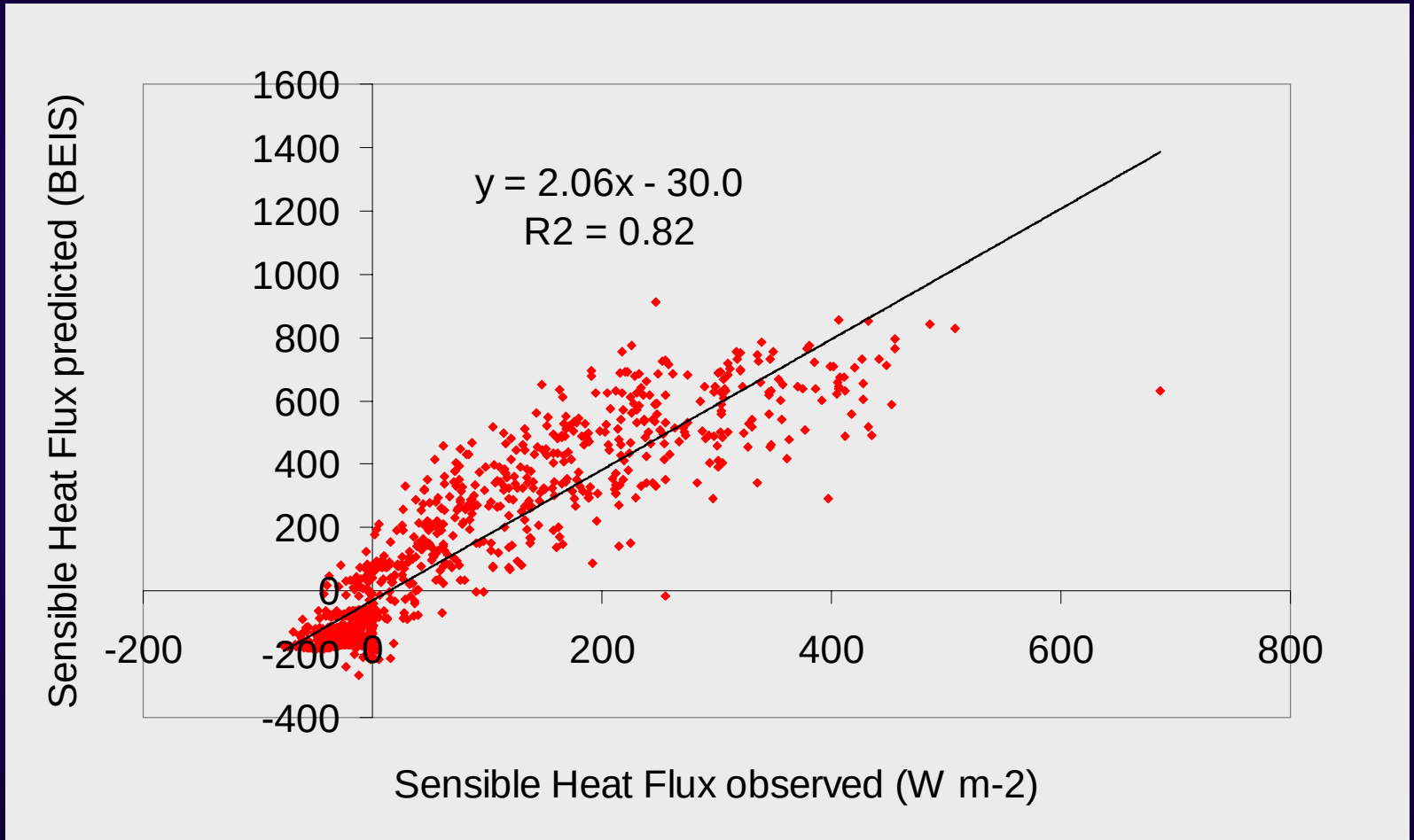
Comparison with BEIS

- The multiple regression results estimate isoprene emissions with good temporal correlation, however, long term (day-to-day) changes in emissions are not captured
- Predictions are on par with BEIS, however, is BEIS predicting isoprene emissions correctly for the right reasons?

Daily observed isoprene fluxes compared to predicted fluxes based on the multiple regression equation and BEIS



BEIS predicted sensible heat flux vs. observed heat flux for 2000



Conclusions

- These correlations and predicted isoprene fluxes still do not explain the physiological control mechanism for isoprene emissions
- The regression equation presented provides a diagnostic tool for testing canopy models
- Could be a useful surrogate for modeling isoprene emissions in current mesoscale meteorological models

Acknowledgements

- Funding provided by the U.S. EPA for part of this research under PROPHET (Program for Research on Oxidants: Photochemistry, Emissions, and Transport)
- Support also provided by the National Science Foundation, Integrated Graduate Education Research Training (IGERT) program
- Special thanks to the UMBS AmeriFlux team, Alex Guenther and Alan Hills