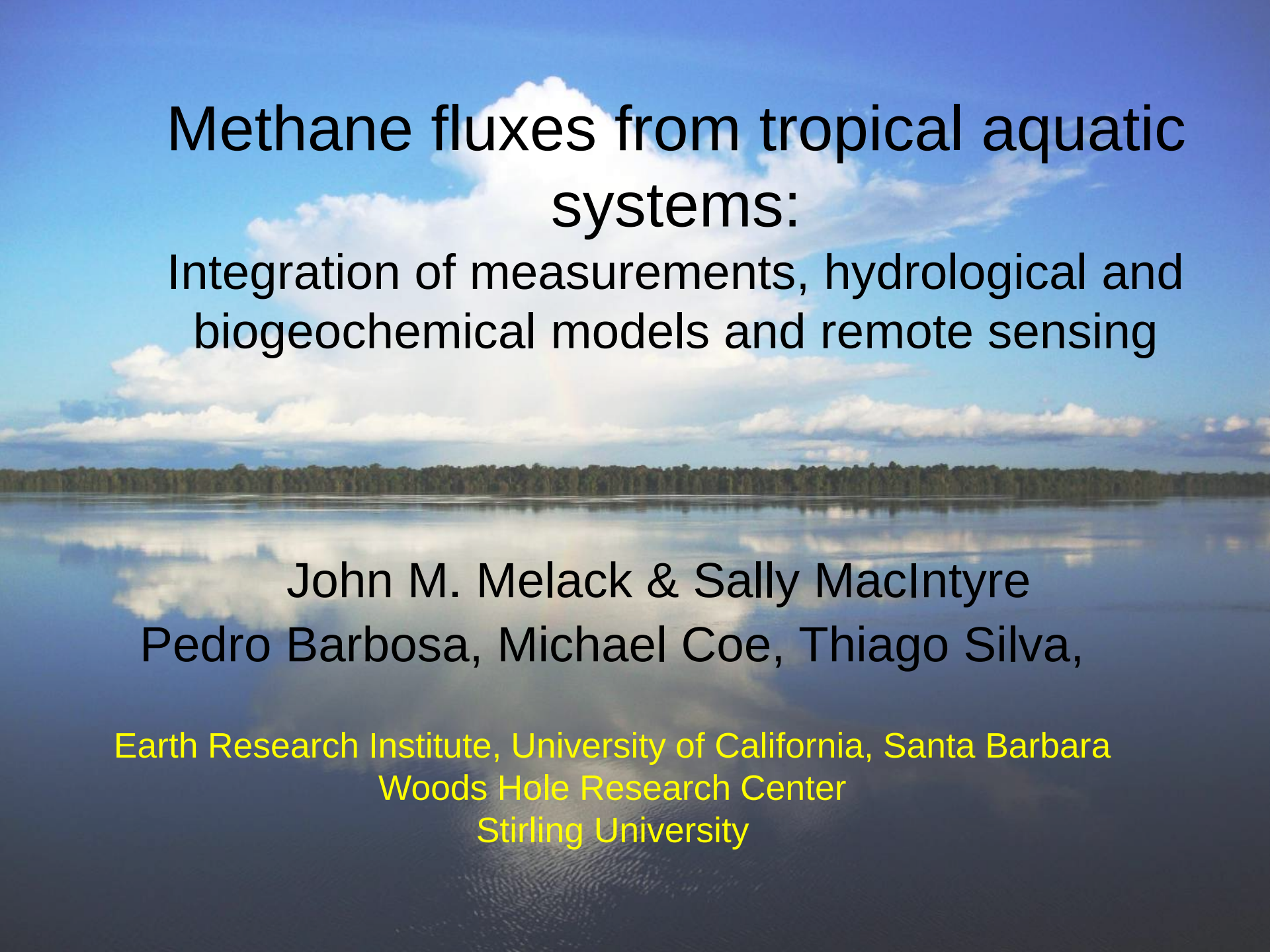


Methane fluxes from tropical aquatic systems:

Integration of measurements, hydrological and biogeochemical models and remote sensing

John M. Melack & Sally MacIntyre

Pedro Barbosa, Michael Coe, Thiago Silva,

Earth Research Institute, University of California, Santa Barbara
Woods Hole Research Center
Stirling University

Methane fluxes from inland waters

Largest natural flux with largest portion from tropics

Floodplain systems (rivers, lakes, wetlands):

- Main tropical aquatic habitat

Uncertainty:

- Large seasonal inundation and habitat variations
- Bubbling important flux
- Physical processes with diel variability
- Biogeochemical processes not well characterized

Approach

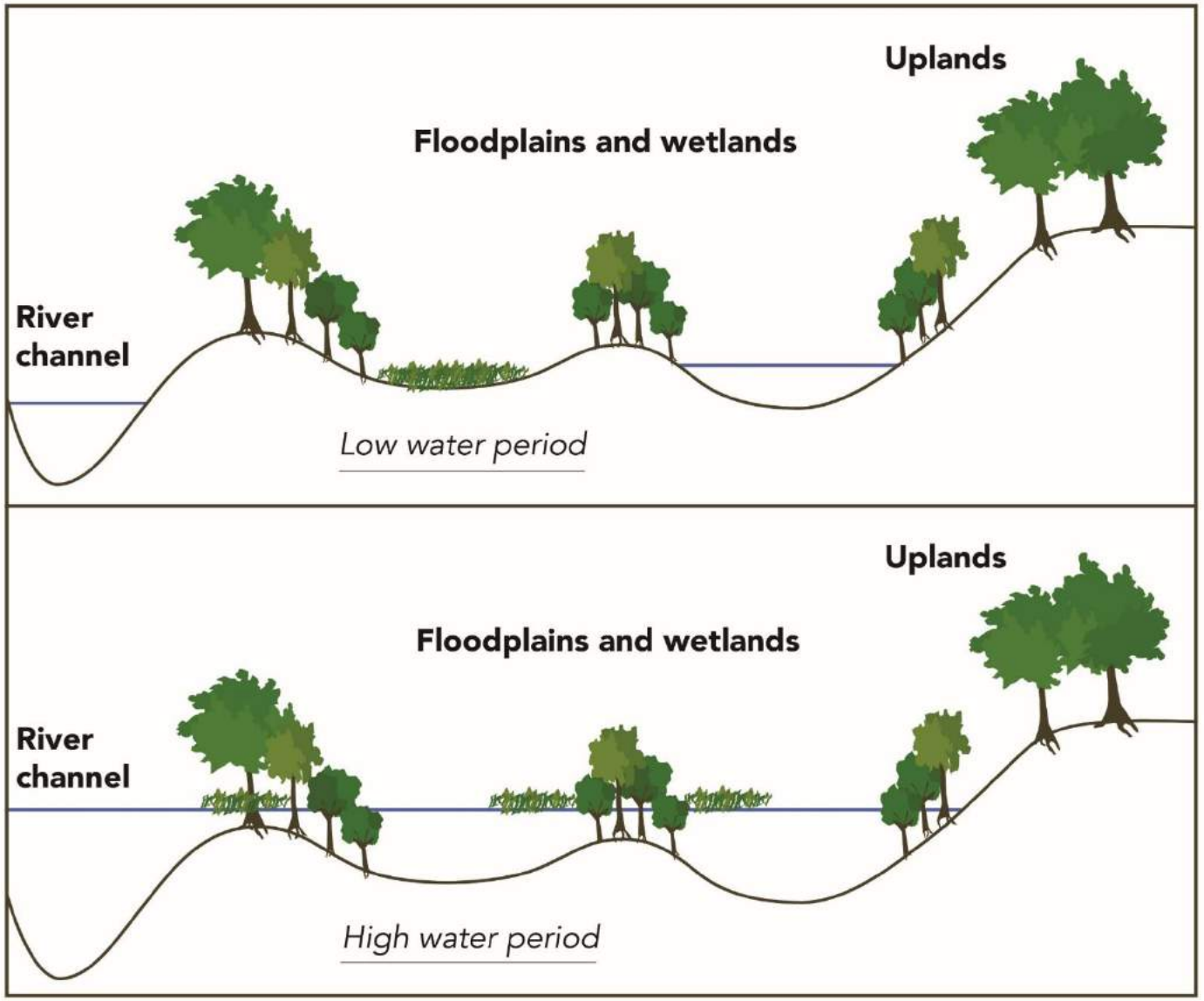
Field measurements of methane fluxes in all habitats and seasons, organic carbon supply and related environmental factors

Intensive measurements of physical processes related to gas exchange and mixing

Modeling of hydrological, hydrodynamic and biogeochemical processes

Remote sensing of inundation and habitat changes

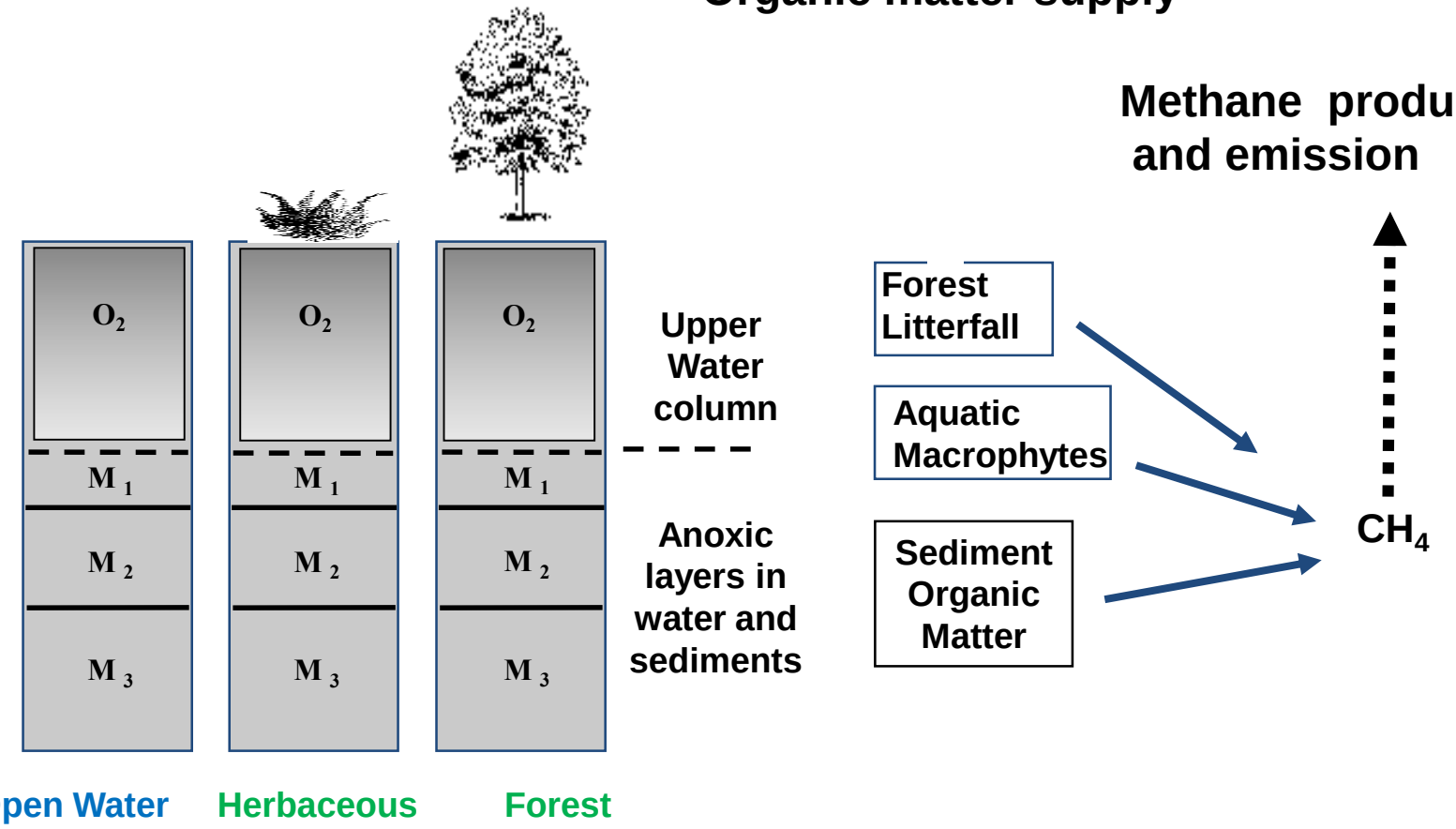
Amazon floodplain system



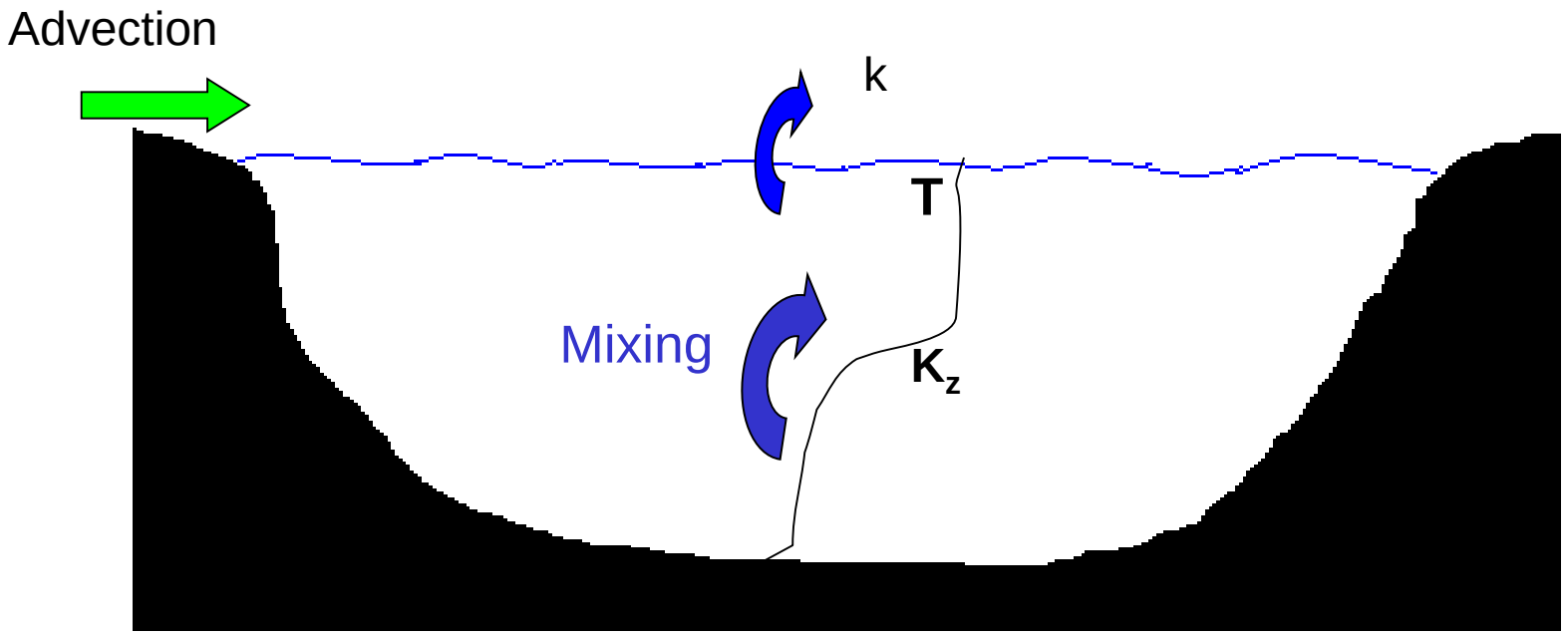
Vegetative cover, water level and inundation extent

Organic matter supply

Methane production and emission



Vertical fluxes and gas exchange

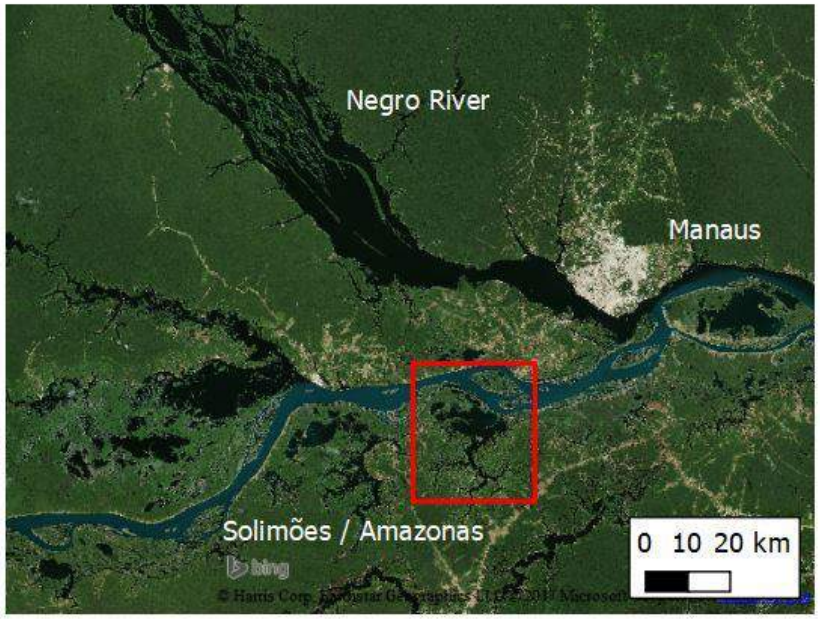


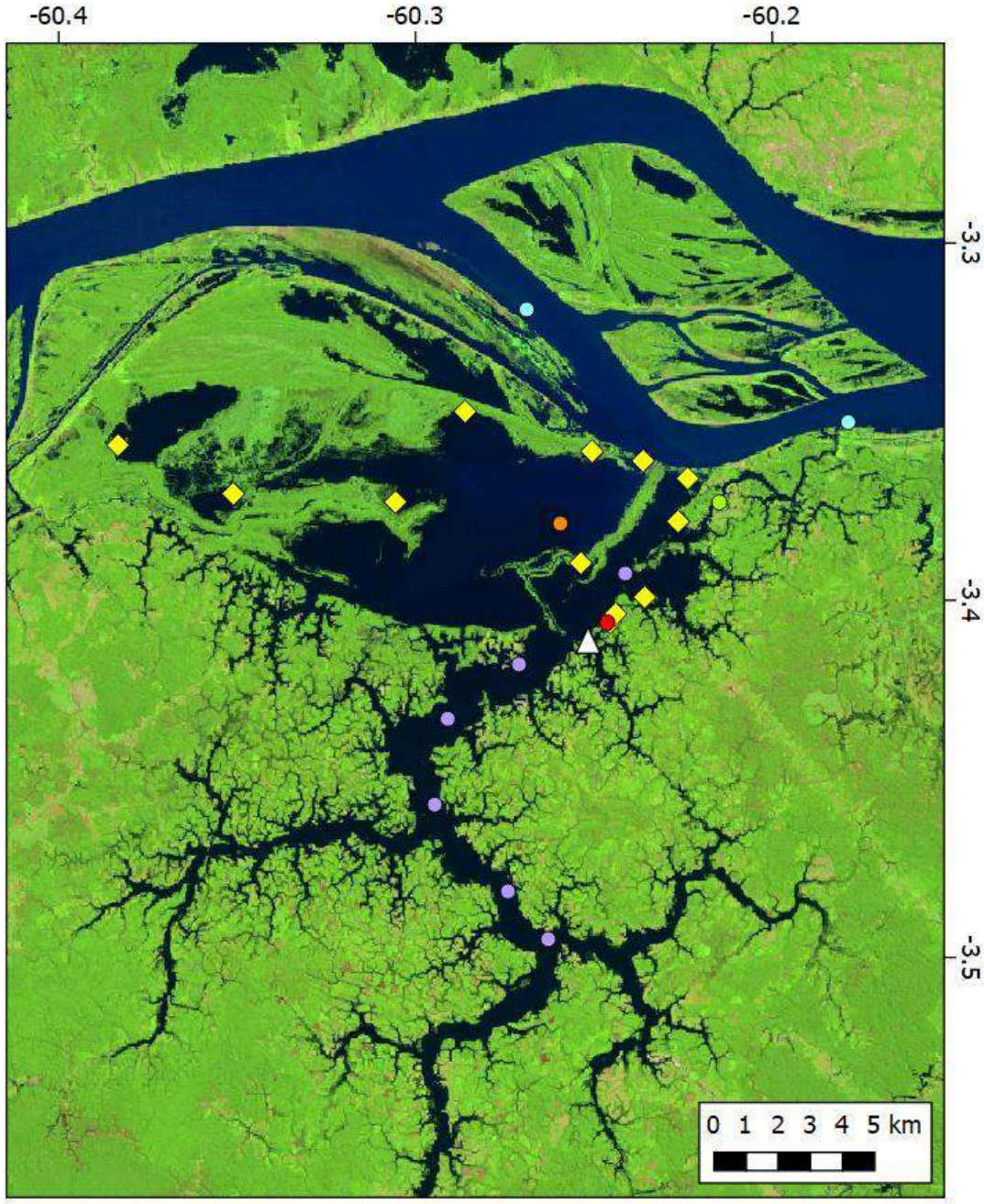
Coefficient of eddy diffusivity, K_z, characterizes turbulence. Flux = K_z (dC/dz)

Gas transfer velocity, k, used to estimate gas fluxes.

Flux = k (C_w – C_{aq})

Lake Janauaca, central Amazon basin





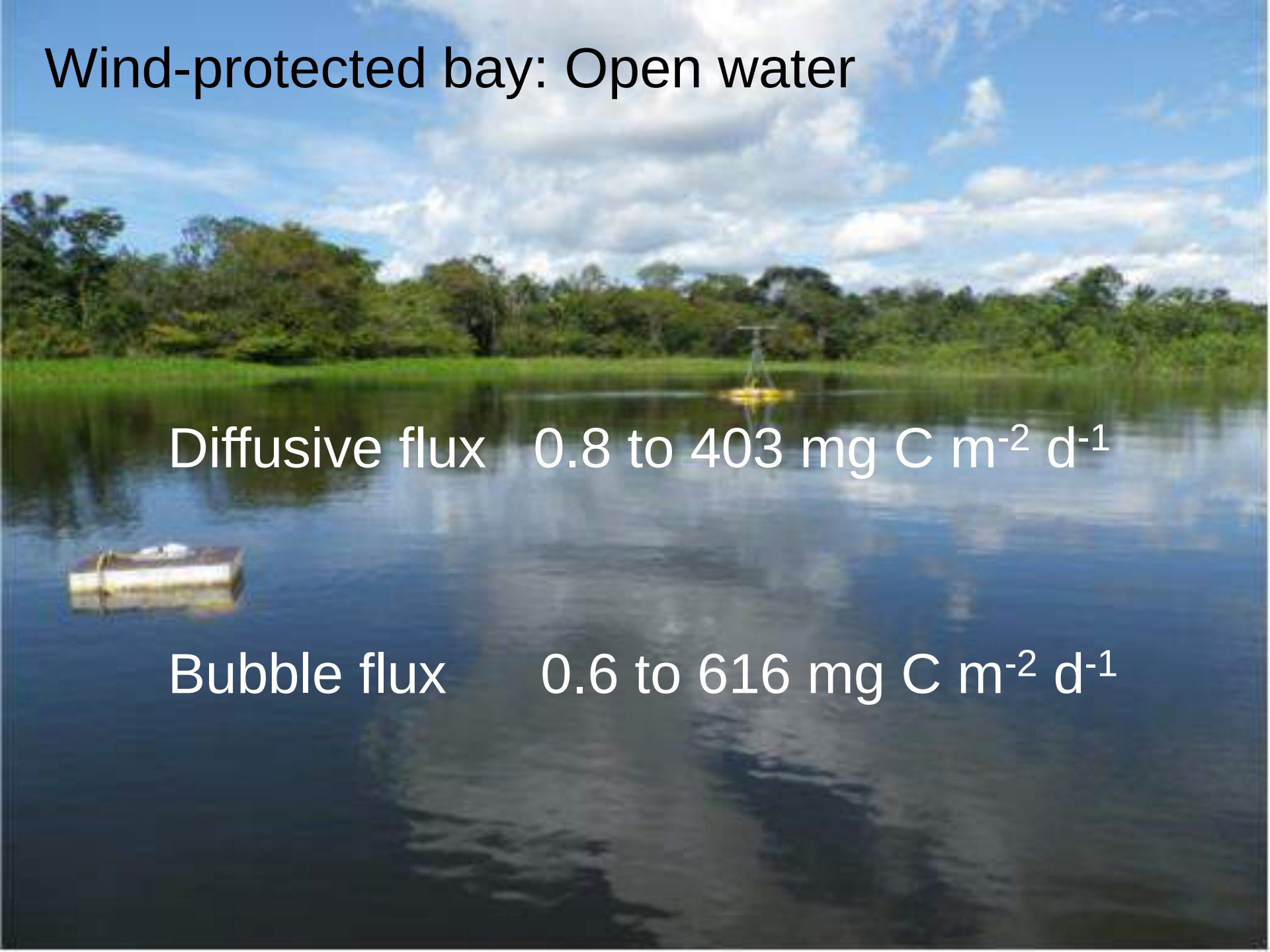
Legend

- Macrophye NPP measurements

Gas Exchange Measurements

- Lake Transect
- Channel
- Solimões
- Wind Exposed
- Wind Protected
- Research Station

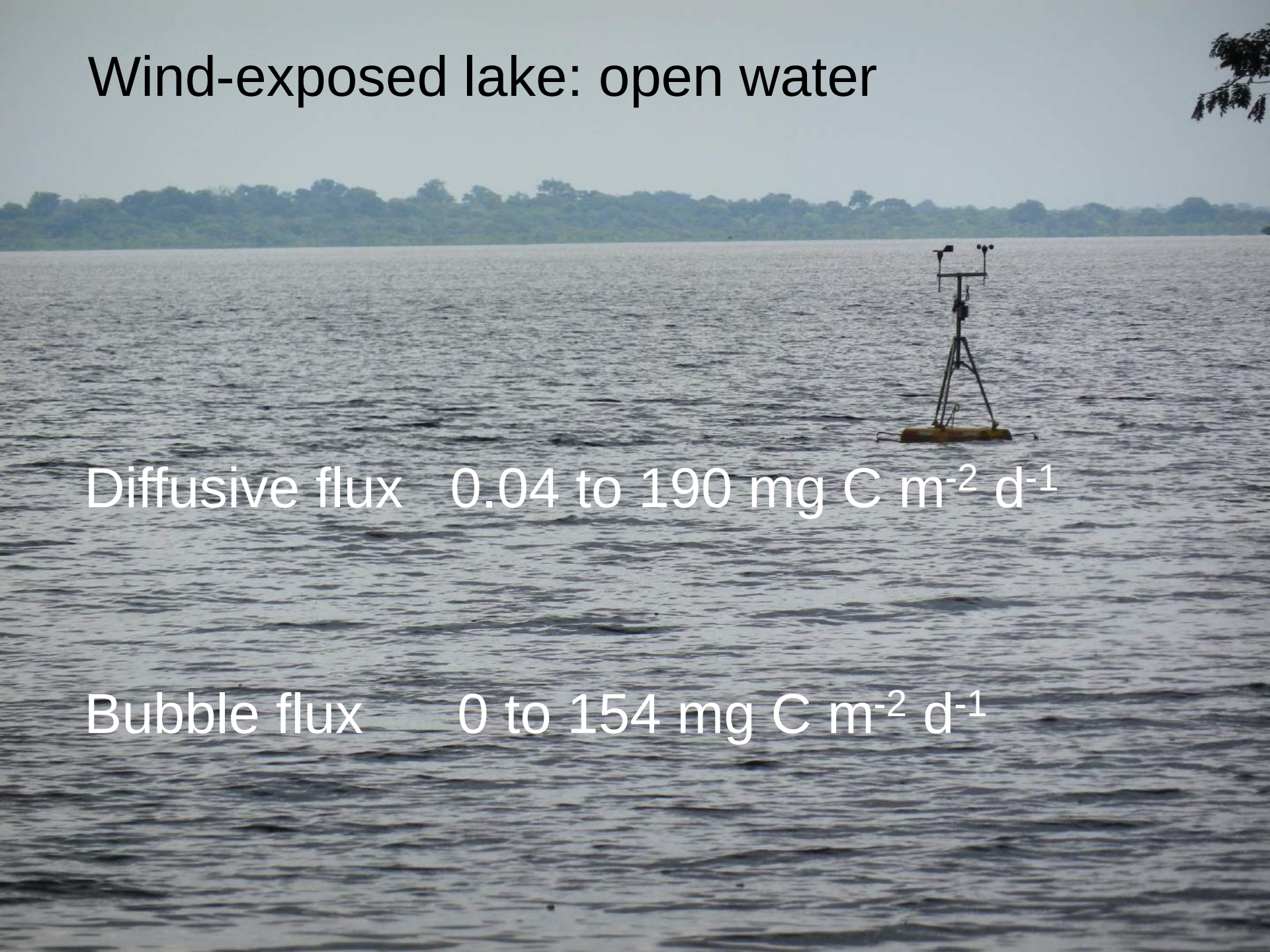
Wind-protected bay: Open water



Diffusive flux 0.8 to 403 mg C m^{-2} d^{-1}

Bubble flux 0.6 to 616 mg C m^{-2} d^{-1}

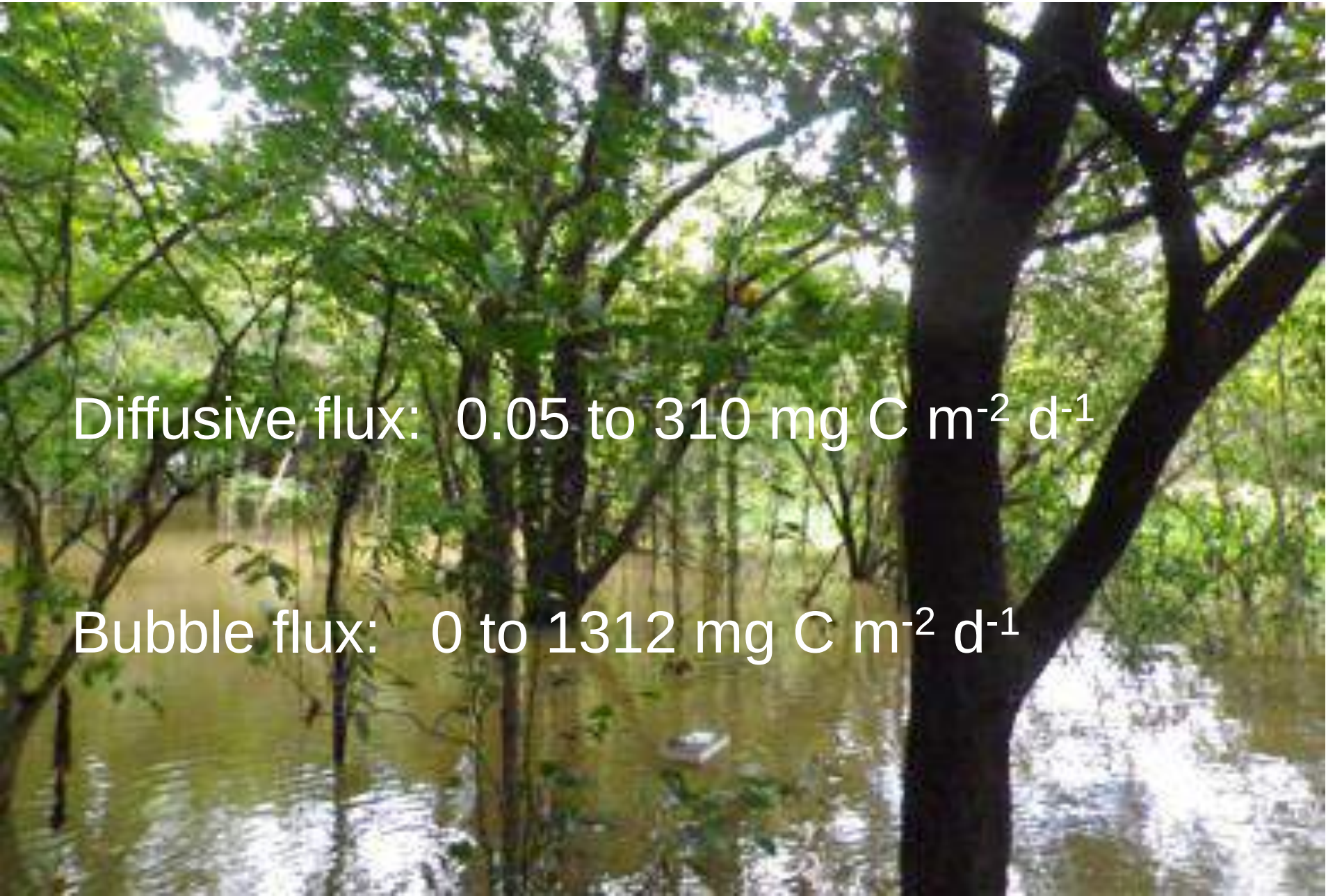
Wind-exposed lake: open water



Diffusive flux 0.04 to 190 mg C m^{-2} d^{-1}

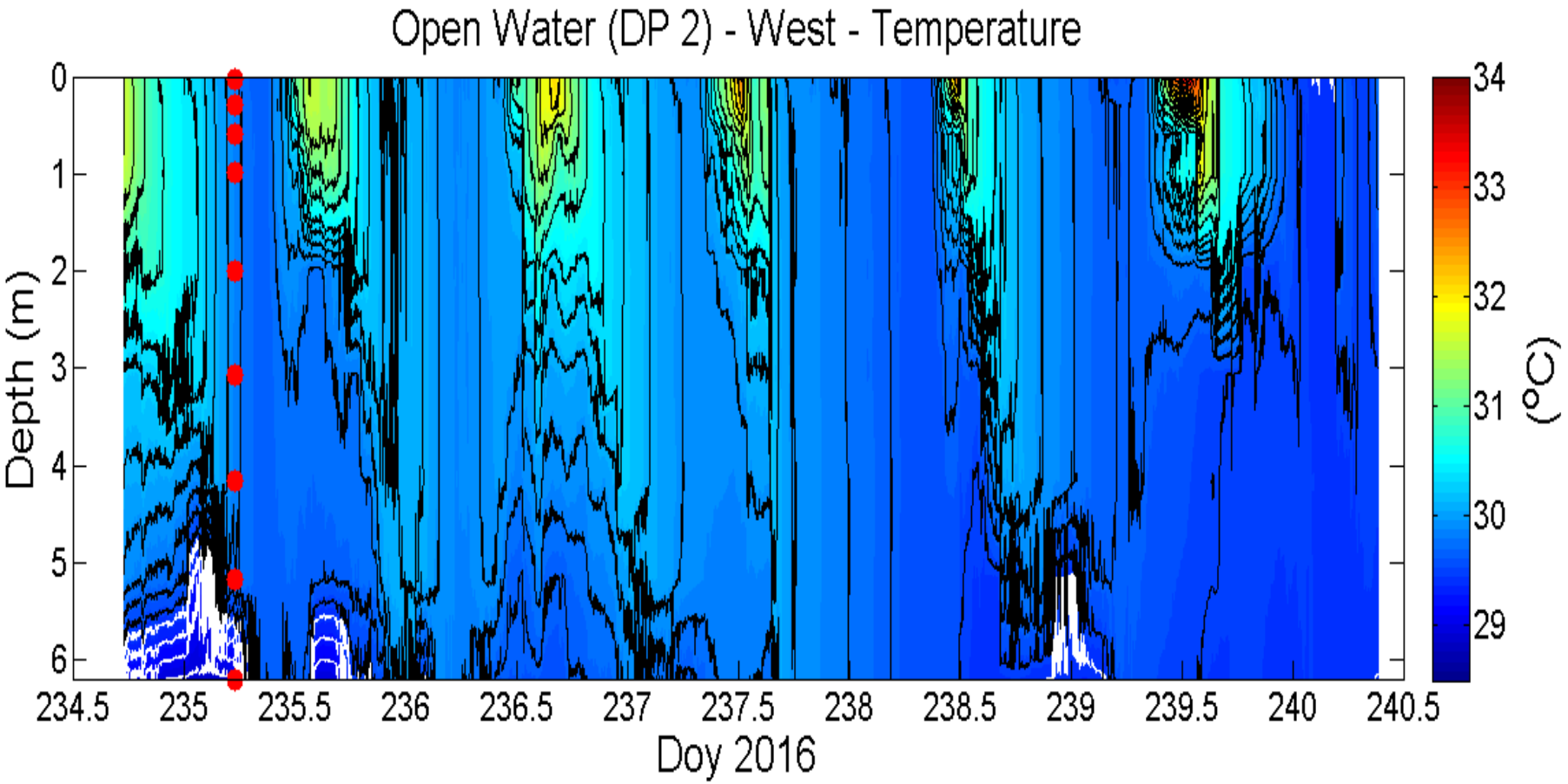
Bubble flux 0 to 154 mg C m^{-2} d^{-1}

Flooded forest



Floating macrophytes

Janauaca open water



Surface renewal model

Gas transfer coefficient can be expressed through the surface renewal model as:

$$K_{600} = c_1 (\varepsilon \nu)^{1/4} Sc^{-1/2}$$

Turbulence at the air-water interface calculated as rate of dissipation of turbulent kinetic energy (ε)

Physical measurements

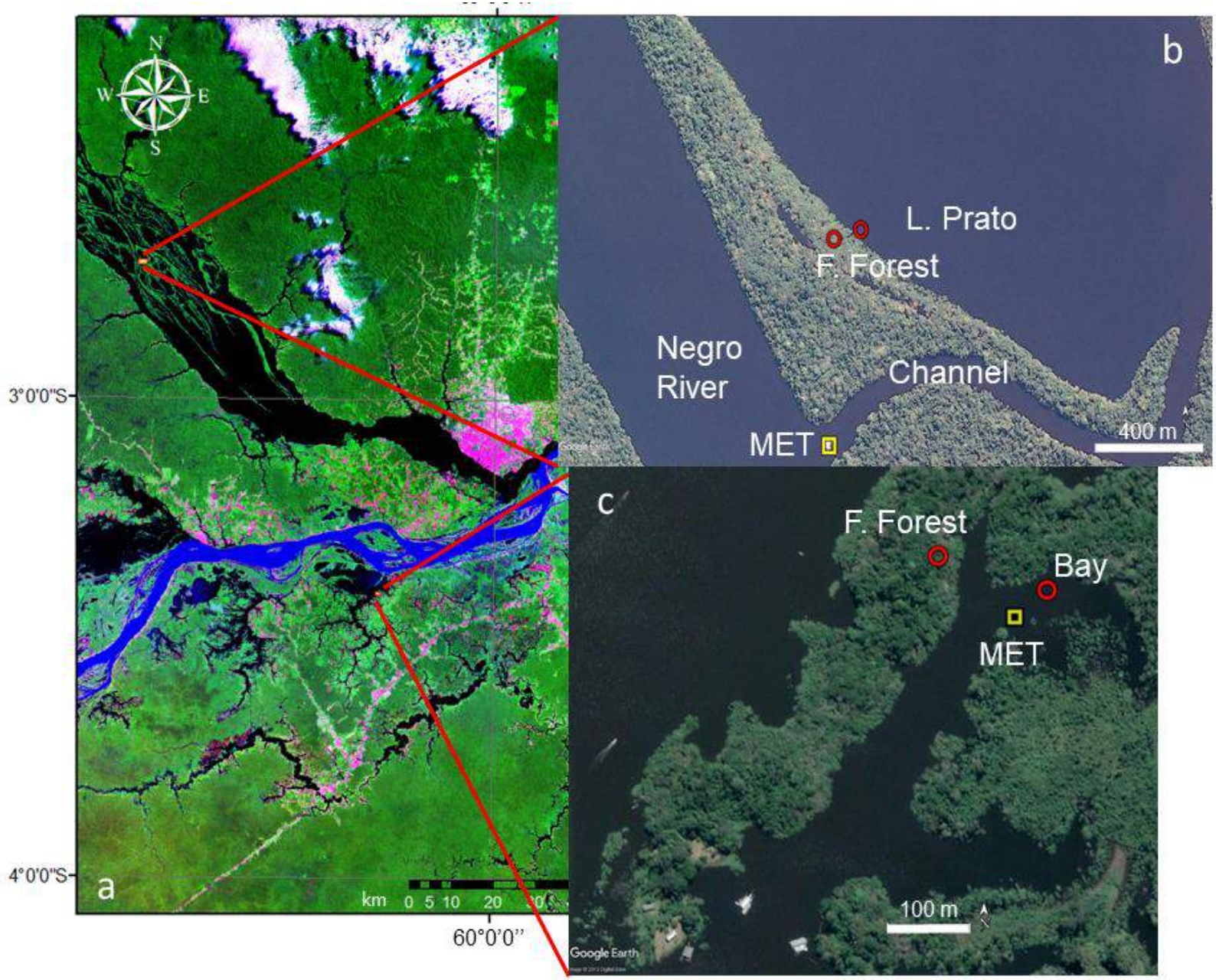
Surface meteorology: wind, humidity, long and short wave radiation, air temperature, rain intensity

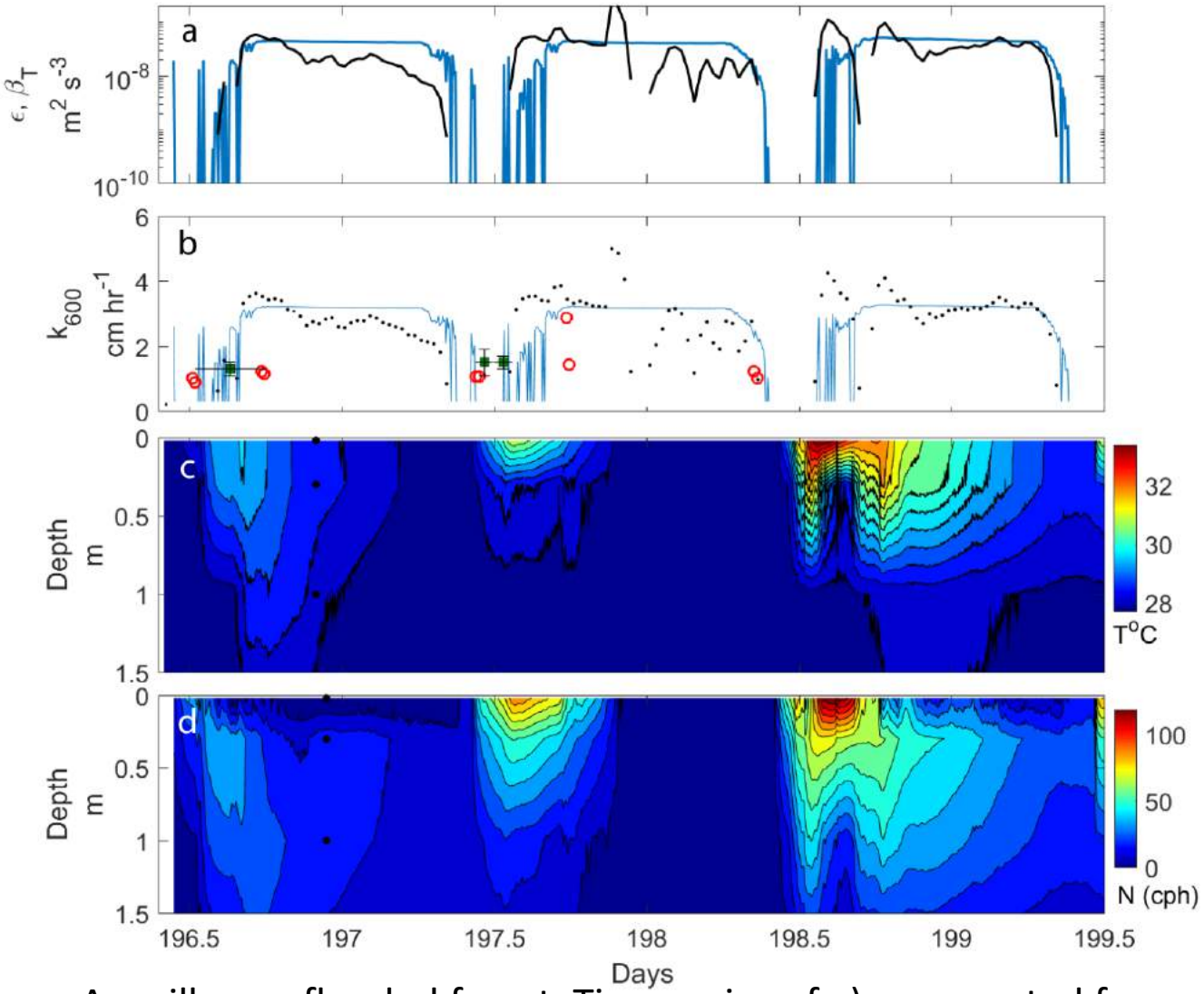
Time-series: temperatures and dissolved oxygen at multiple depths

Water velocities: ADCP and ADV

Turbulence: temperature-gradient microstructure profiler

Methane and carbon dioxide fluxes


N
W
E
S
3°0'0"S
4°0'0"S
60°0'0"
a
km 0 5 10 20
b
L. Prato
F. Forest
Negro
River
Channel
MET
400 m
c
F. Forest
Bay
MET
100 m
Google Earth



Anavilhanas flooded forest. Time series of a) ε computed from the similarity scaling (blue) and β_T (black), b) k_{600} computed from the surface renewal model using computed ε and β_T.

MacIntyre et al. 2019 GRL

Gas exchange coefficient (k) using revised similarity scaling model of ε matches temporal pattern of k determined from microstructure measurements of near-surface turbulence.

Gas exchange coefficients are two to four times higher than calculated with commonly used wind-based equations under low winds.

Diel variations in gas fluxes can be modeled well with time-series of turbulence-based k and dissolved gas concentrations.

Sources of organic carbon?

Floating herbaceous macrophytes

Flooded forest litterfall

Open water phytoplankton

Upland runoff

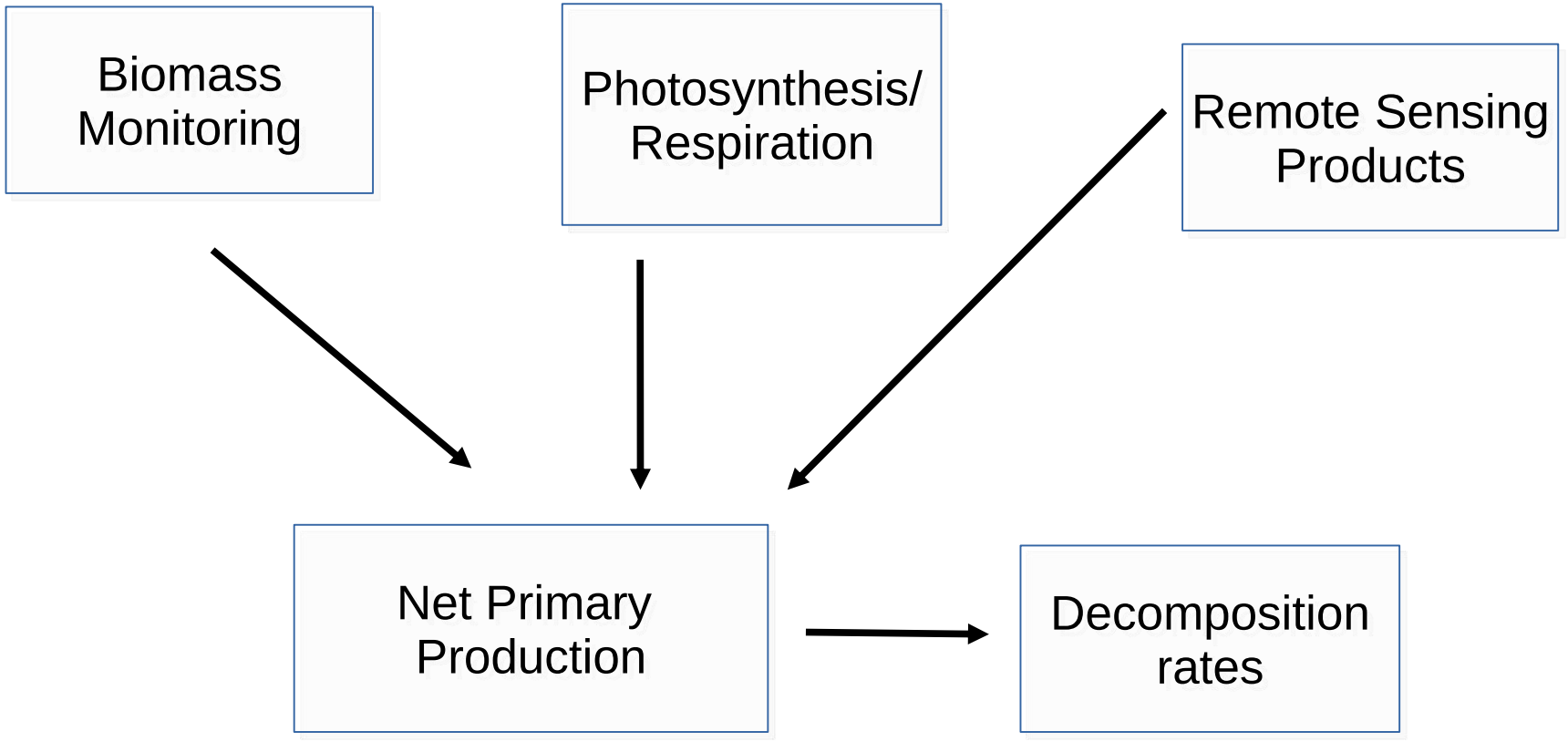
Paspalum repens phenology

Growing season rising water

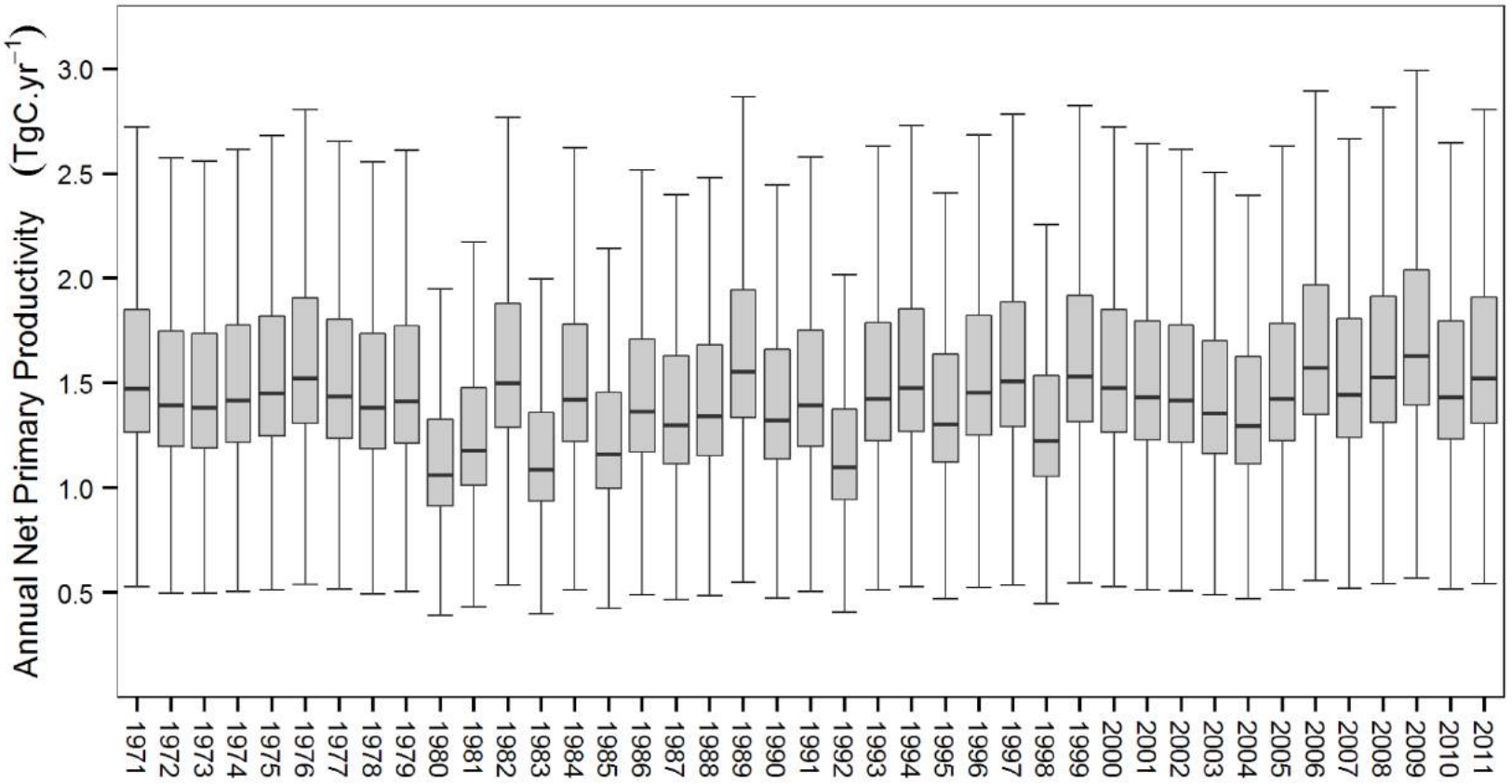
Flowering and seedling, high water

Resprouting, receding waters

Senescent after flowering, high water



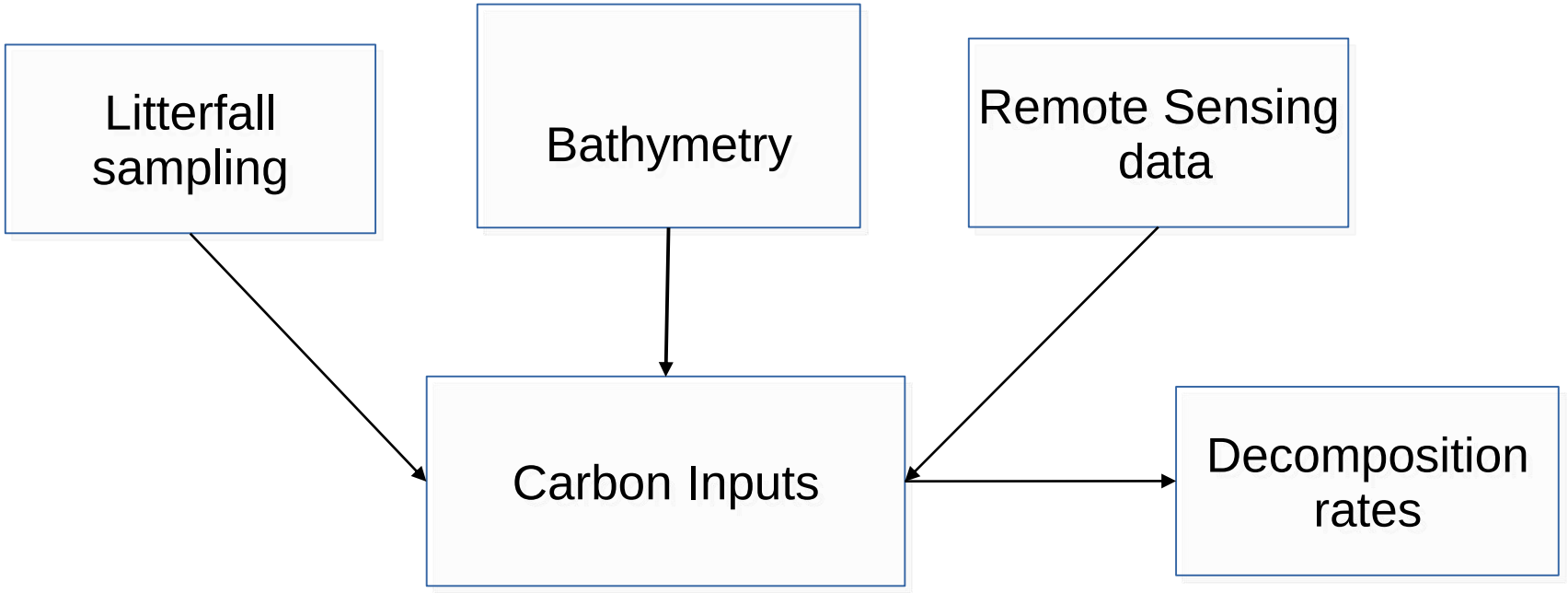
Floating macrophyte productivity

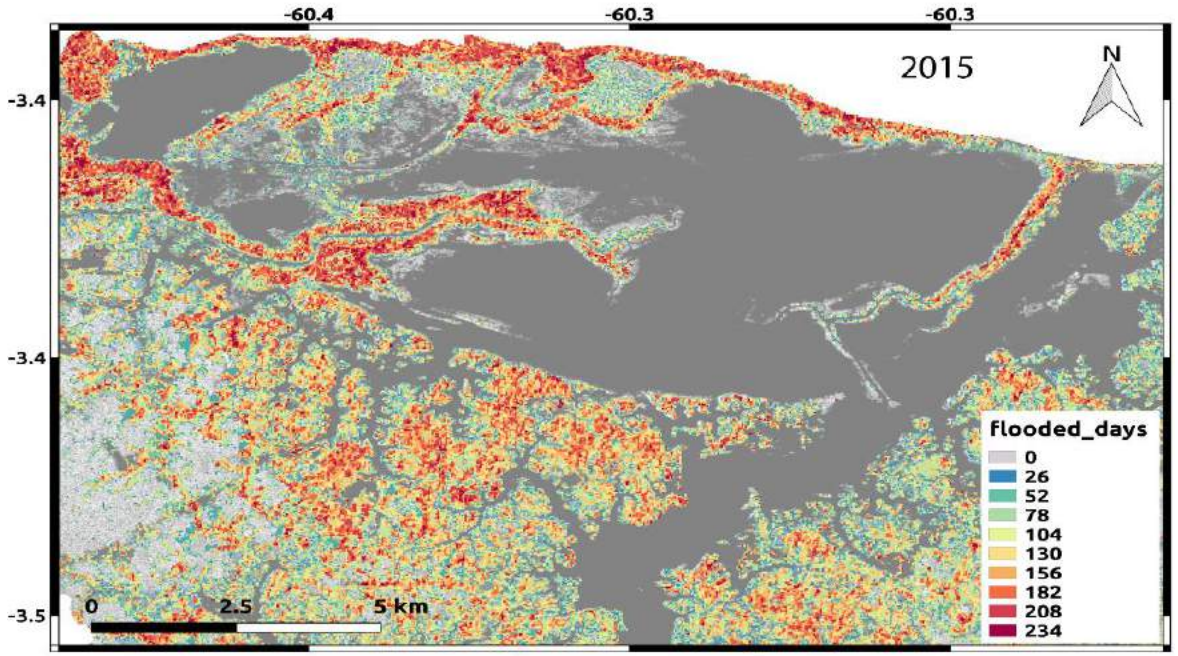


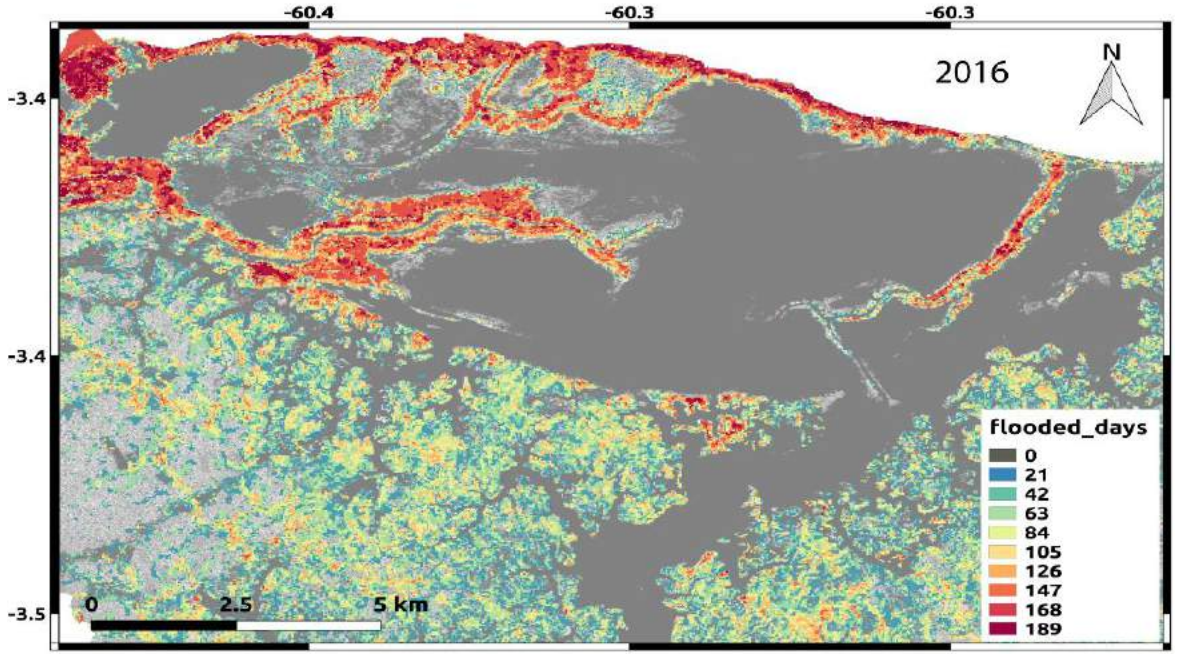
Interannual variability in NPP of up to 50%

Silva et al. 2013 Global Change Biol.

Litterfall


Litterfall sampling
Bathymetry
Remote Sensing data
Carbon Inputs
Decomposition rates



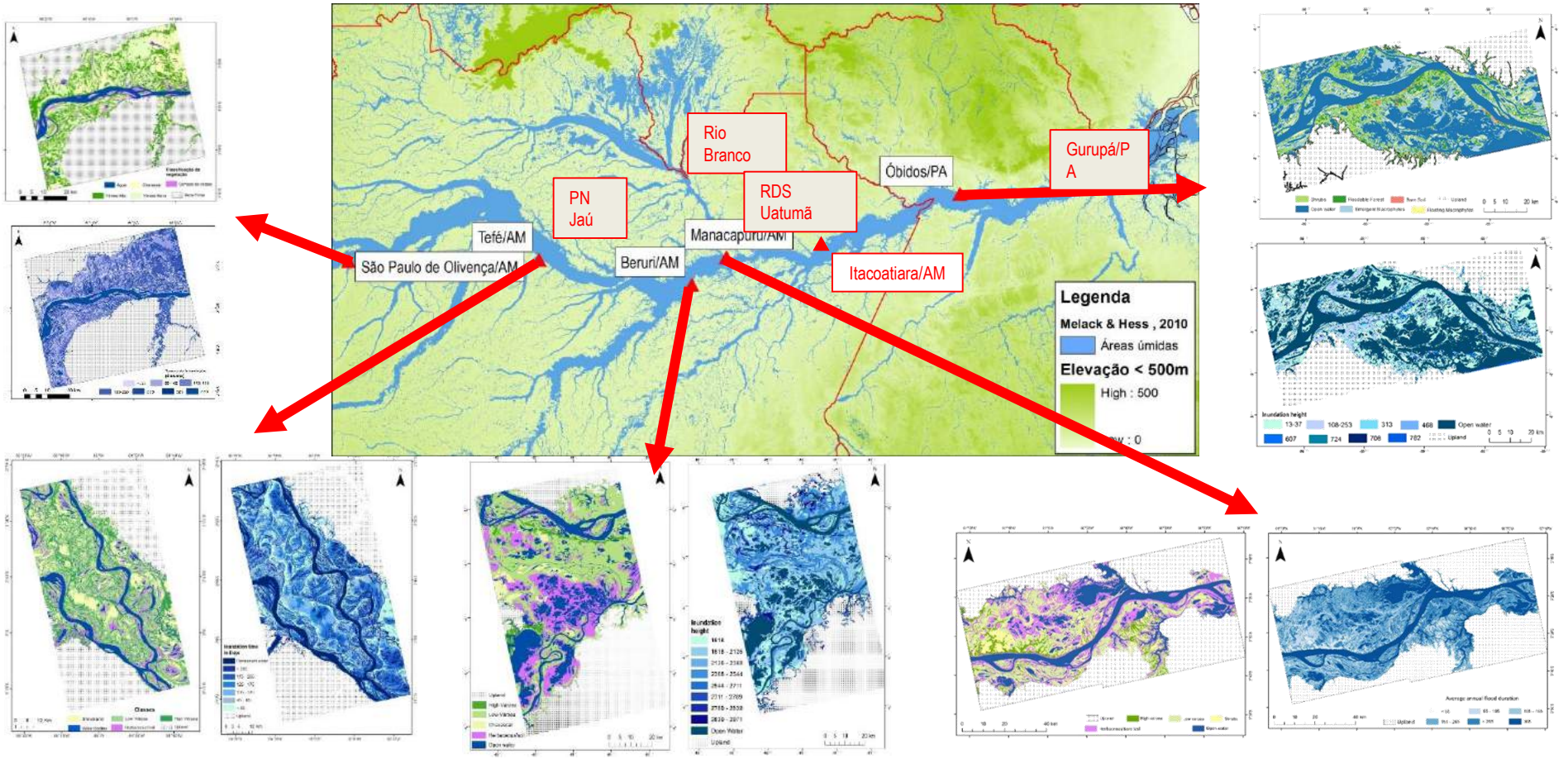


Janauaca

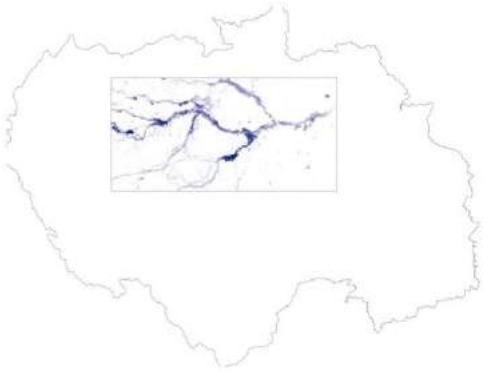
Flooded forests

Inundated periods

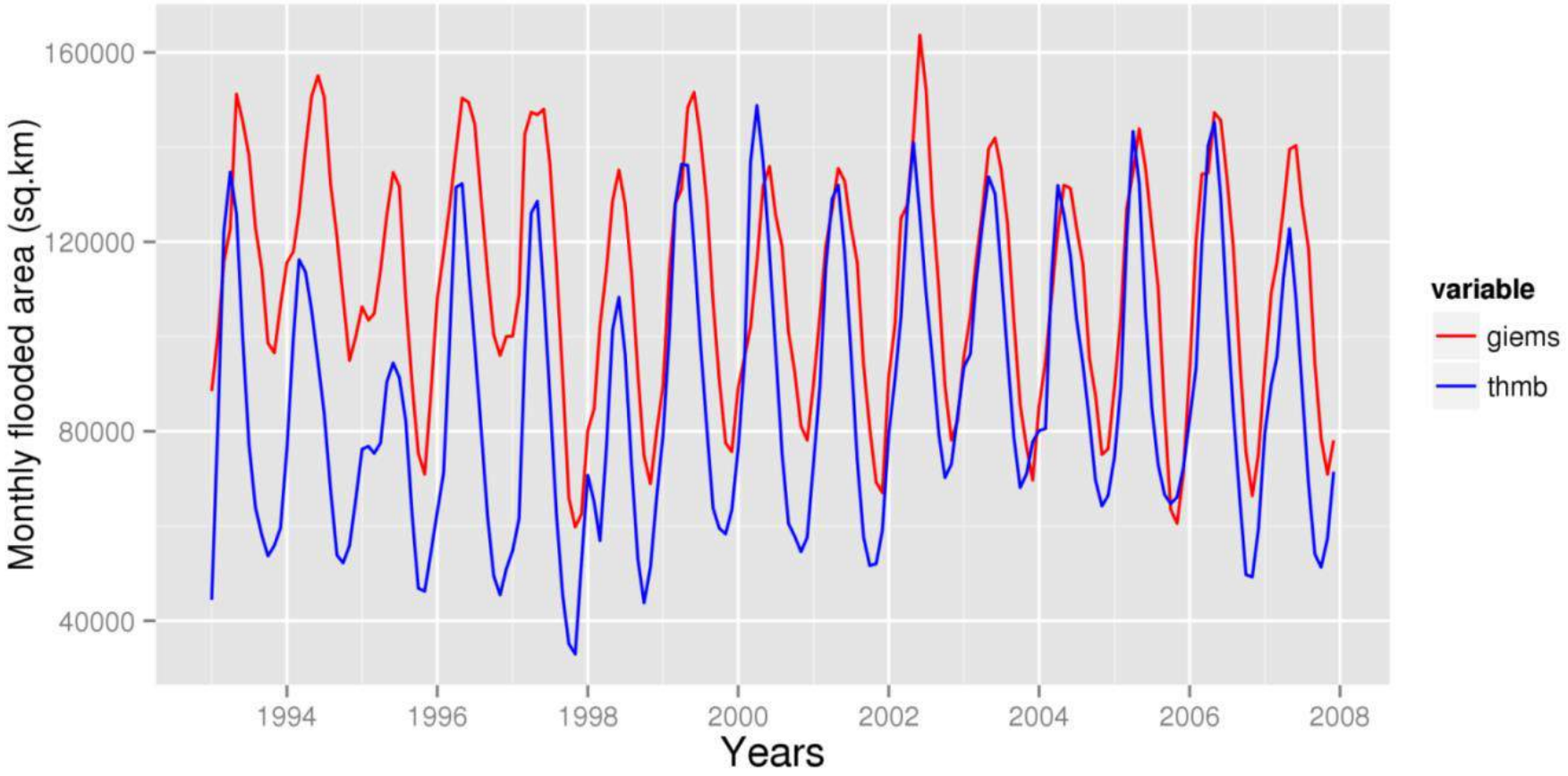
Habitats and inundation

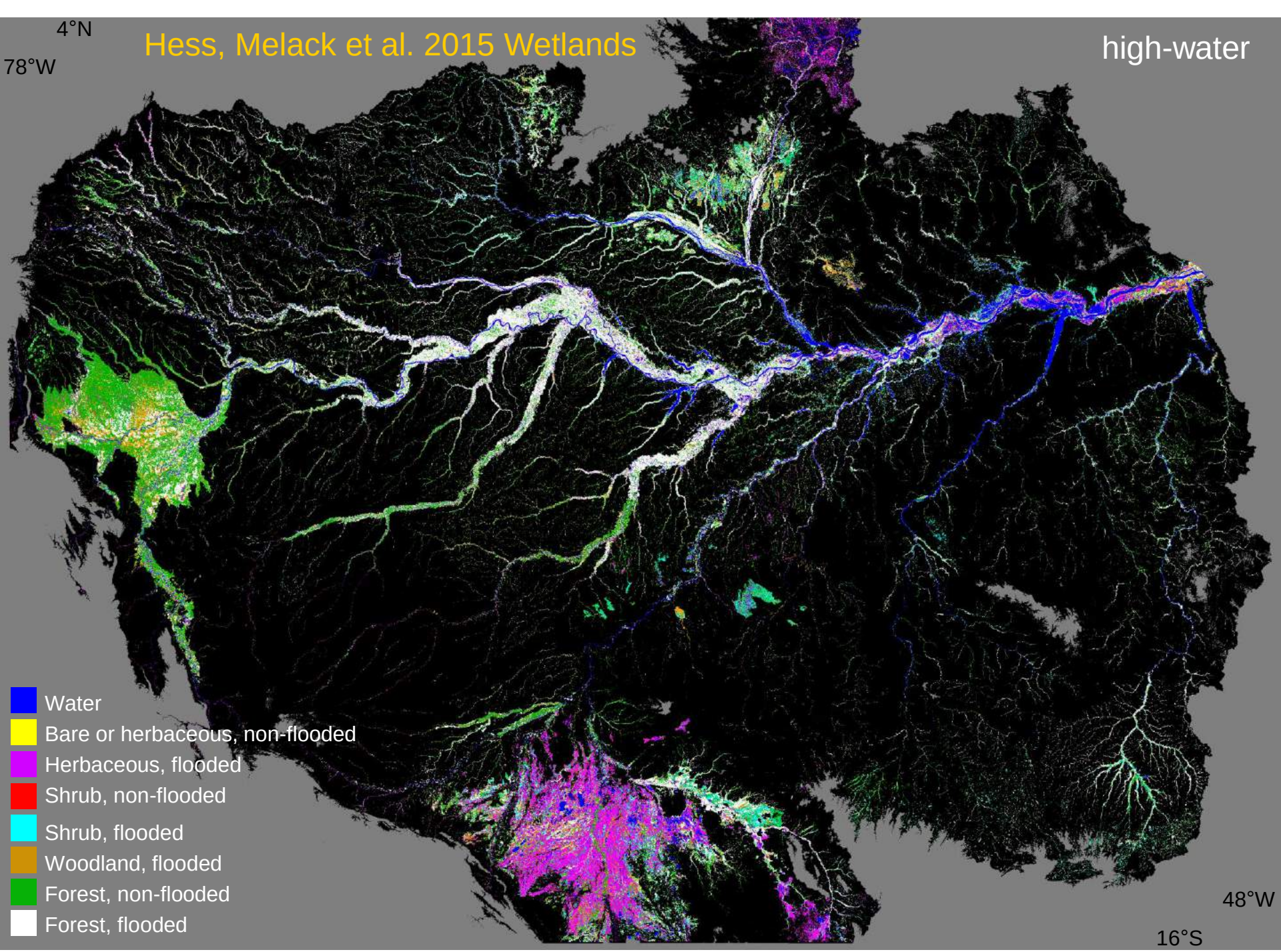


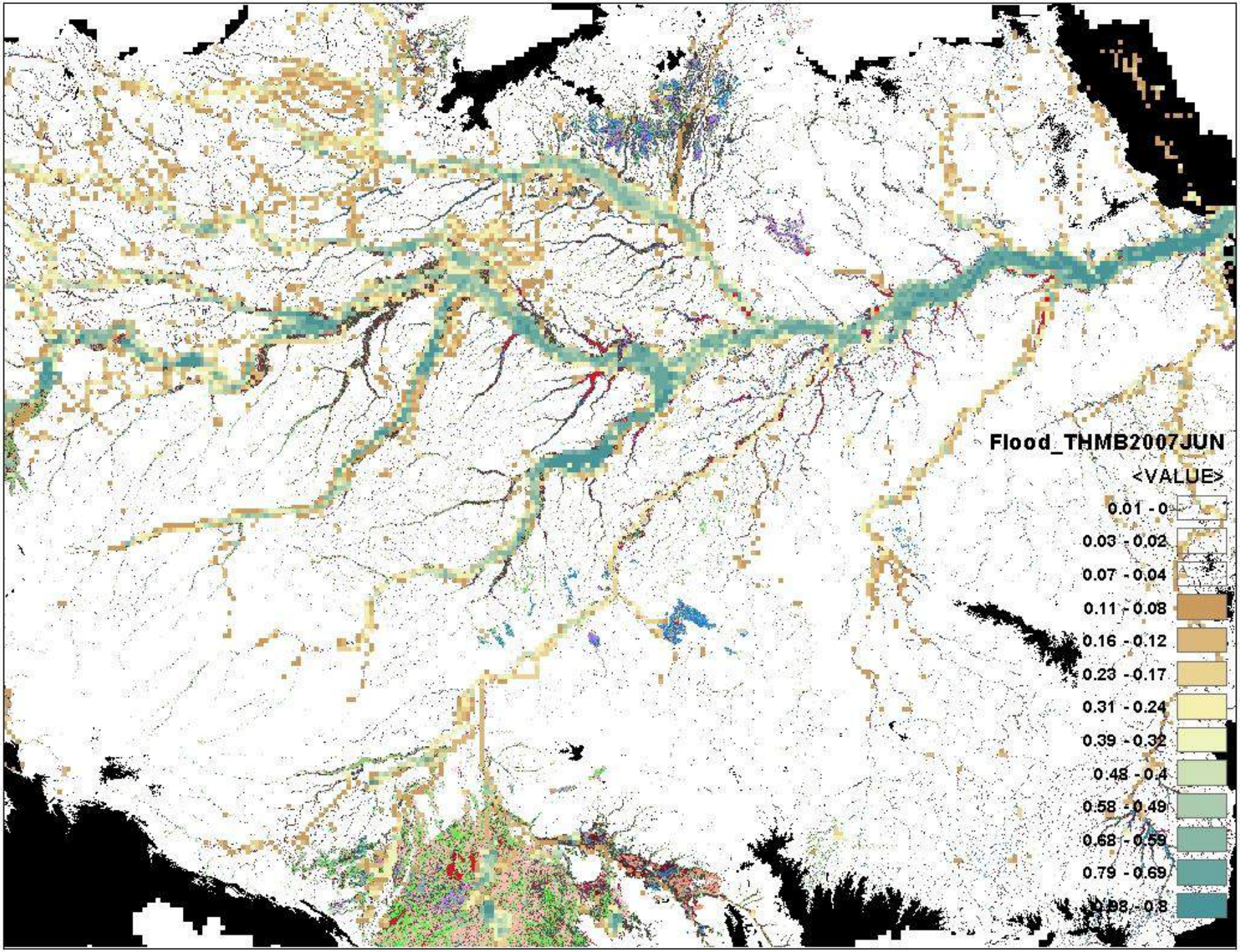
Hydrological modeling with THMB

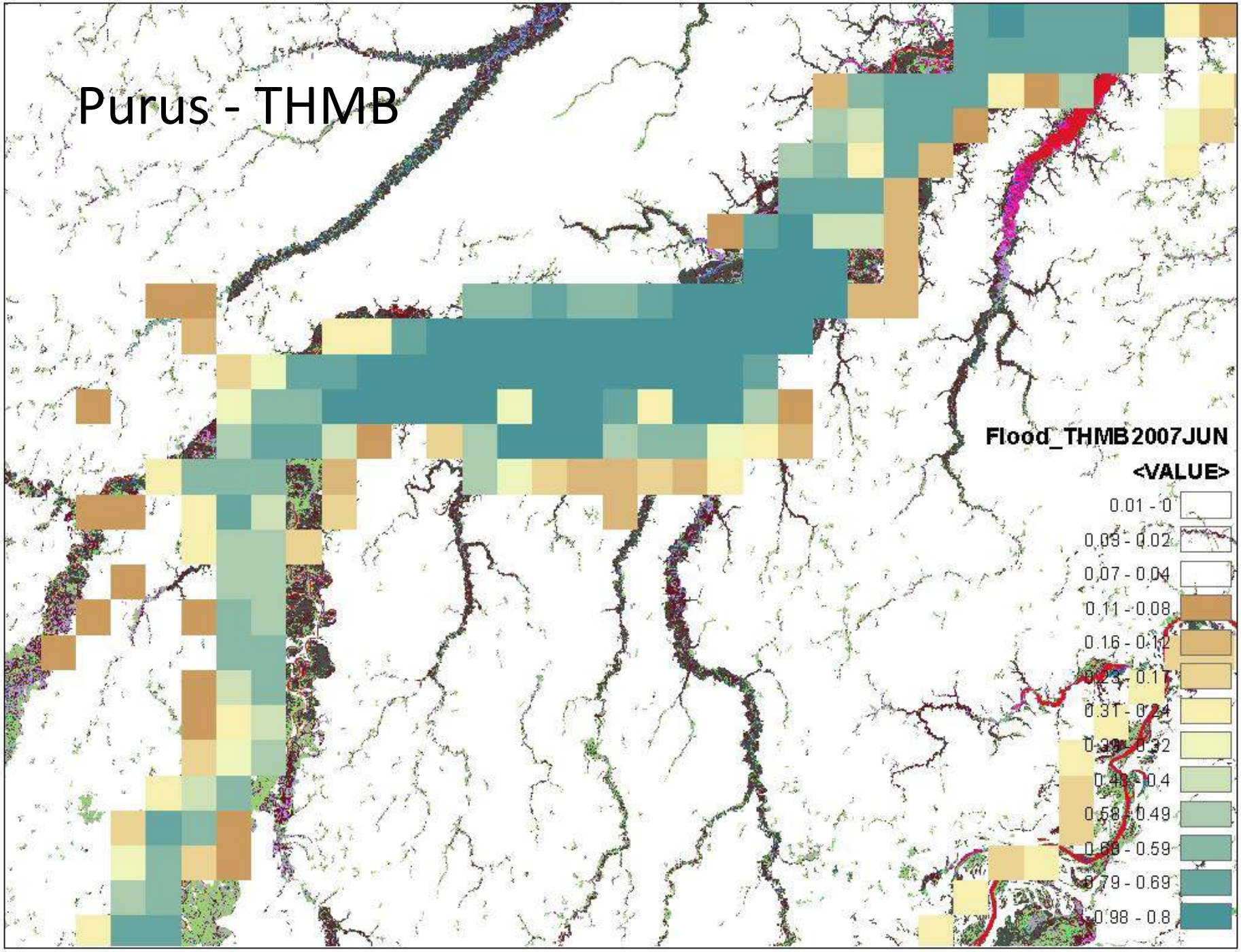


Flooded area simulated and observed




4°N
78°W
Hess, Melack et al. 2015 Wetlands
high-water
Water
Bare or herbaceous, non-flooded
Herbaceous, flooded
Shrub, non-flooded
Shrub, flooded
Woodland, flooded
Forest, non-flooded
Forest, flooded
48°W
16°S


Flood_THMB2007JUN
<VALUE>
0.01 - 0
0.03 - 0.02
0.07 - 0.04
0.11 - 0.08
0.16 - 0.12
0.23 - 0.17
0.31 - 0.24
0.39 - 0.32
0.48 - 0.4
0.58 - 0.49
0.68 - 0.59
0.79 - 0.69
0.98 - 0.8


Purus - THMB
Flood_THMB2007JUN
<VALUE>
0.01 - 0
0.03 - 0.02
0.07 - 0.04
0.11 - 0.08
0.16 - 0.12
0.23 - 0.17
0.31 - 0.24
0.39 - 0.32
0.48 - 0.4
0.58 - 0.49
0.68 - 0.59
0.79 - 0.69
0.98 - 0.8

Next steps

Relate methane fluxes to organic carbon supply

Refine hydrodynamic and hydrological models for floodplains

Combine physical models and biogeochemical processes to methane fluxes


Questions ?
melack@bren.ucsb.edu