Overview of SAS land ecosystem-atmosphere flux measurements

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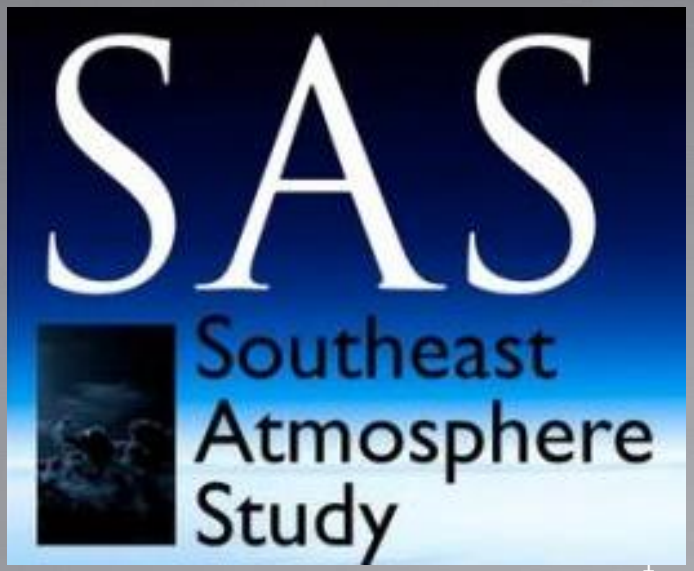

SOAS/NOMADSS/SENEX Science Objective

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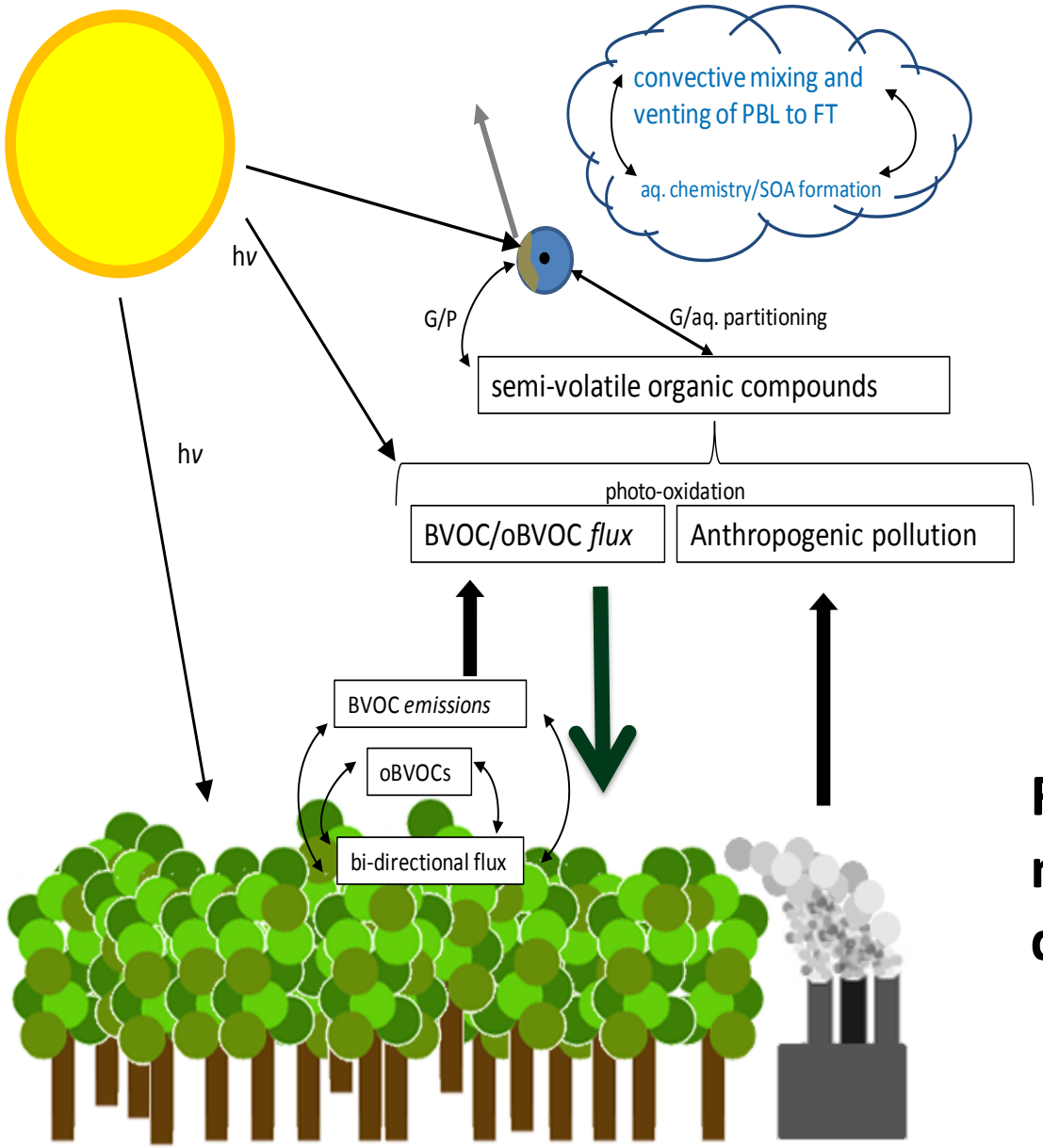

To quantify biogenic emissions and anthropogenic pollution interactions and their affect on atmospheric chemistry and subsequently air quality and climate.

Fluxes go both ways… need to quantify deposition too

Previous regional biogenic VOC studies focused on fluxes or chemistry

Regional studies: SOS (eastern U.S. 1990s), TEXAQS (Texas 2006), LBA (Amazon 1998-2008), OP3 (Borneo 2008), CARES (California 2010), CABERNET (California 2011). Measurements of either regional chemistry or regional fluxes but not both

Local studies: detailed studies of canopy environment, emissions, exchange, chemistry: UMBS USA (PROPHET, CABINEX, etc), Blodgett forest USA (BEARPEX), Manitou Forest USA (BEACHON-ROCS, BEACHON-ROMBAS), Hyytialla Finland (OSOA, HUMPPA, etc), ZF2 Brazil (AMAZE, etc.). Not regional (focused on the surface layer at specific site).

SAS includes fluxes and chemistry

Most BVOC flux studies focus on one scale

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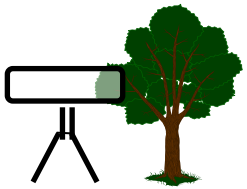
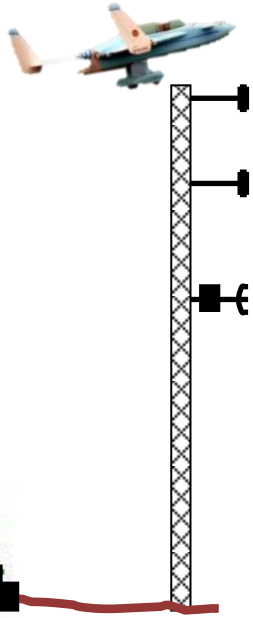
Leaf scale: carbon uptake, enzyme and substrate production

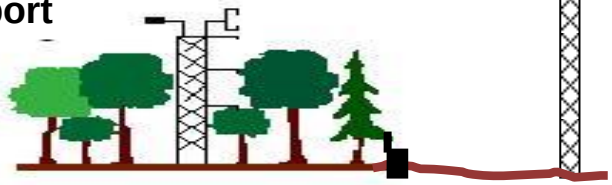


Enclosures



Canopy and boundary layer scale:
Radiative transfer, energy balance, vertical transport

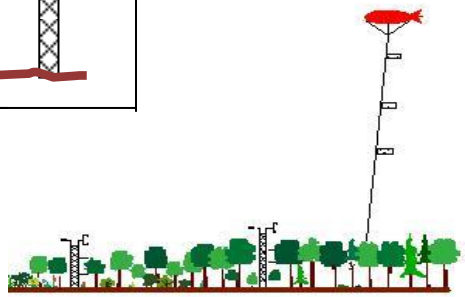
Towers and light aircraft



Landscape scale:

Landcover (LAI, vegetation types), weather patterns

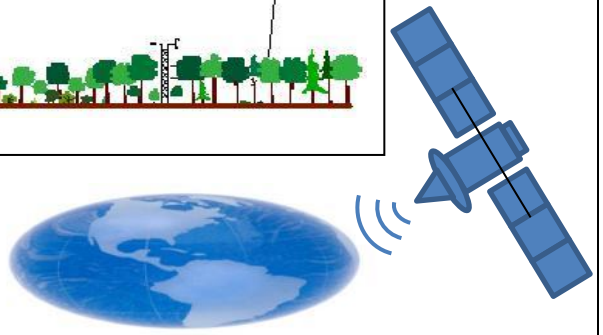
Aircraft and multiple ground sites



Regional to global scale:

Landcover (biomes, vegetation types)

Satellites



SAS flux measurements cover all of the relevant scales

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SAS measurements

- Controlled environment leaf VOC enclosures
- Total VOC reactivity branch enclosures
- Broadleaf and mixed forest VOC flux tower
- Needleaf and mixed forest VOC flux tower
- Stonybrook light aircraft for vertical VOC profiling
- Comprehensive VOC and products at ground sites
- VOC fluxes and concentrations on NSF/NCAR C130 and NOAA P3 research aircraft
- VOC fluxes and concentrations from satellite data

Leaf scale: carbon uptake, enzyme and substrate production

Enclosures

Canopy and boundary layer scale:
Radiative transfer, energy balance, vertical transport

Towers and light aircraft

Landscape scale:

Landcover (LAI, vegetation types), weather patterns

Aircraft and multiple ground sites

Regional to global scale:

Landcover (biomes, vegetation types)

Satellites

Controlled environment leaf cuvette BVOC emission measurements

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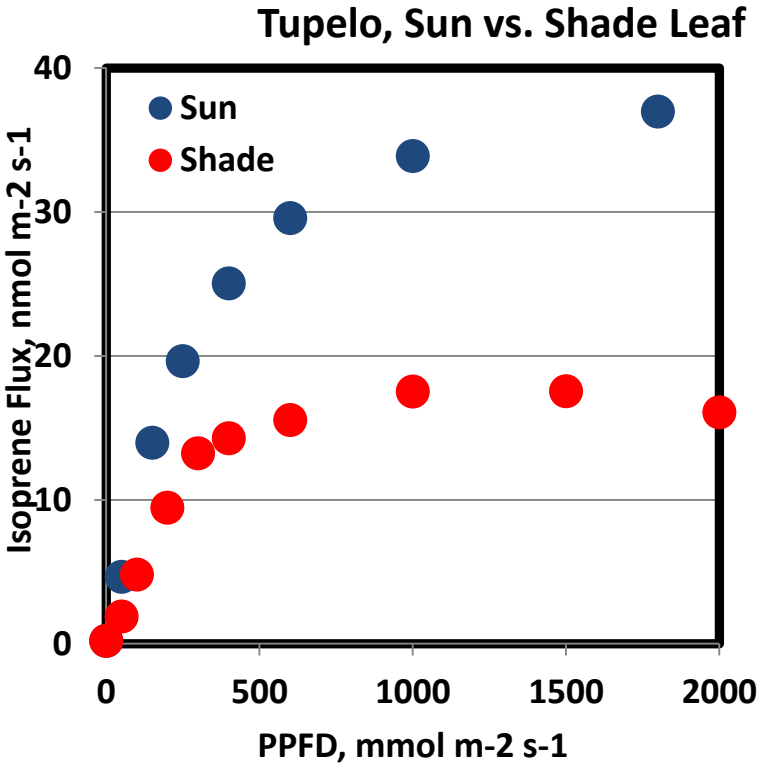
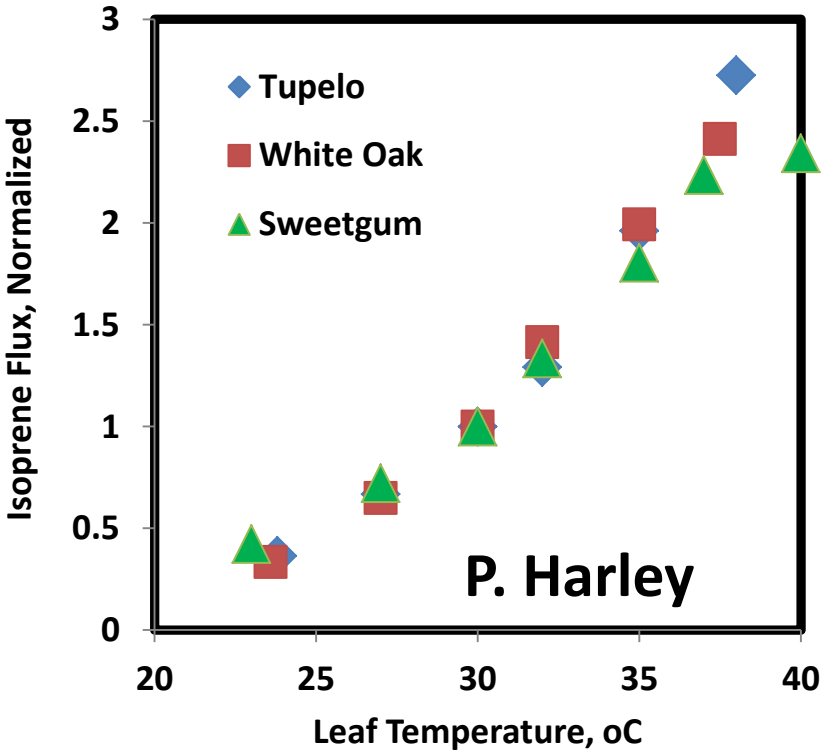
AABC site "cherry-picker" used to access shade and sun leaves of dominant species at different canopy heights

Investigate isoprene substrate, enzyme activity and emissions response to light and temperature throughout the canopy



Photosynthetic Photon Flux Density



Harley (Estonian Univ. Life Sci.)
Guenther (WSU/PNNL)

Branch enclosure measurements of total ozone reactivity of emissions

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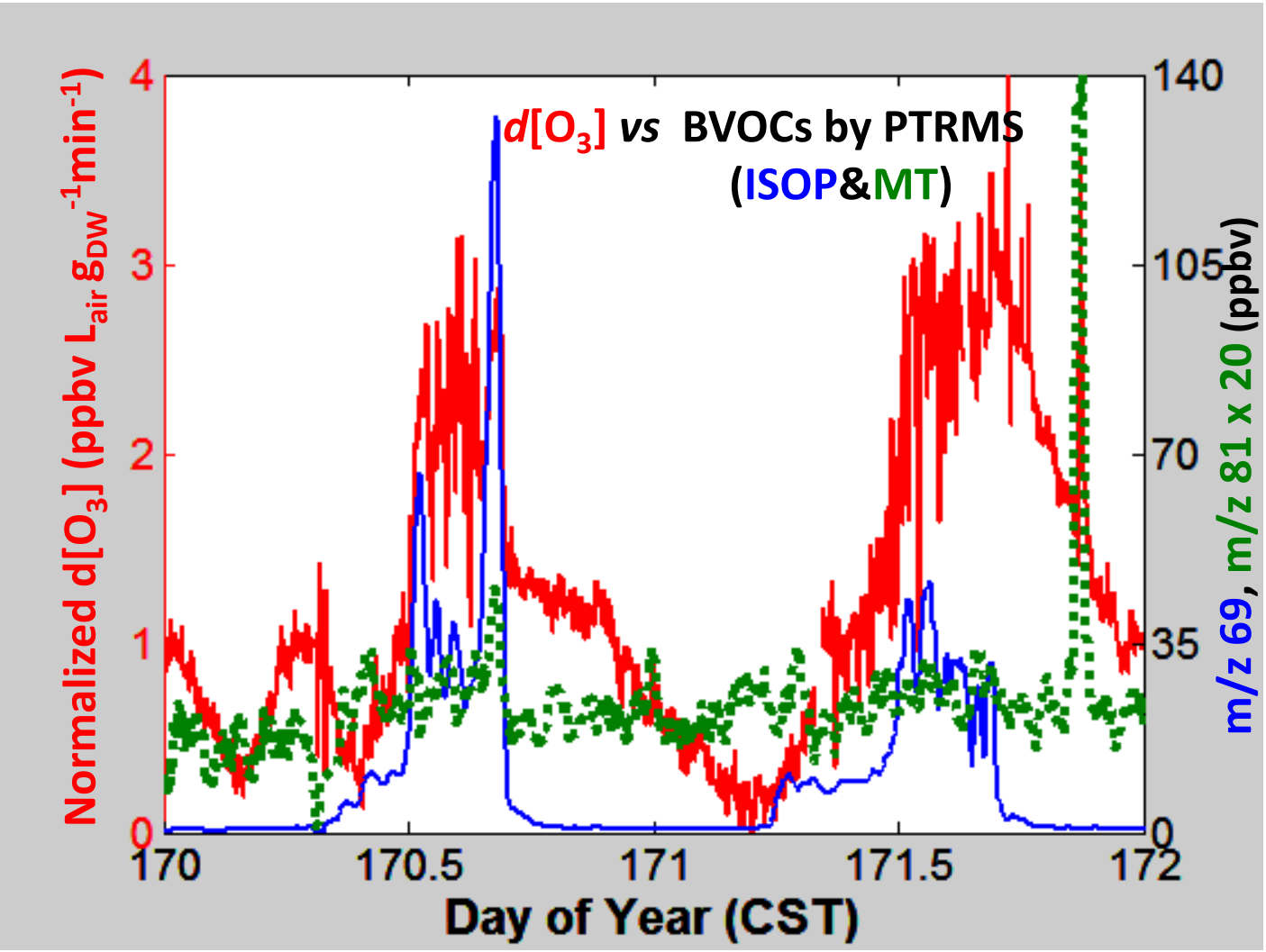
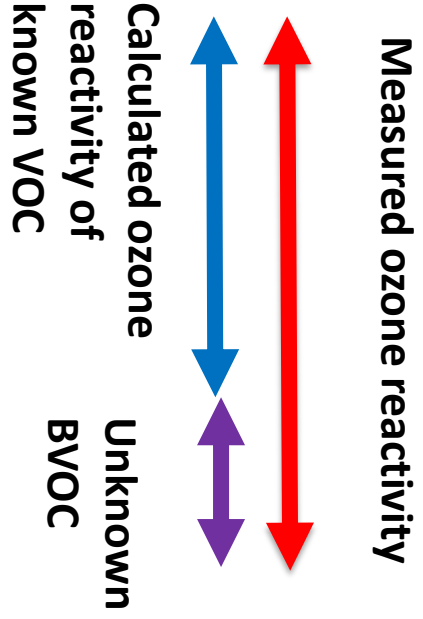
Constrain unknown BVOC with measurements of ozone reactivity





Jeong-Hoo Park (NCAR) Detlev Helmig (U. Colo)

Above canopy fluxes at AABC site: PTR-HRTOFMS eddy covariance measurements of many BVOC and products

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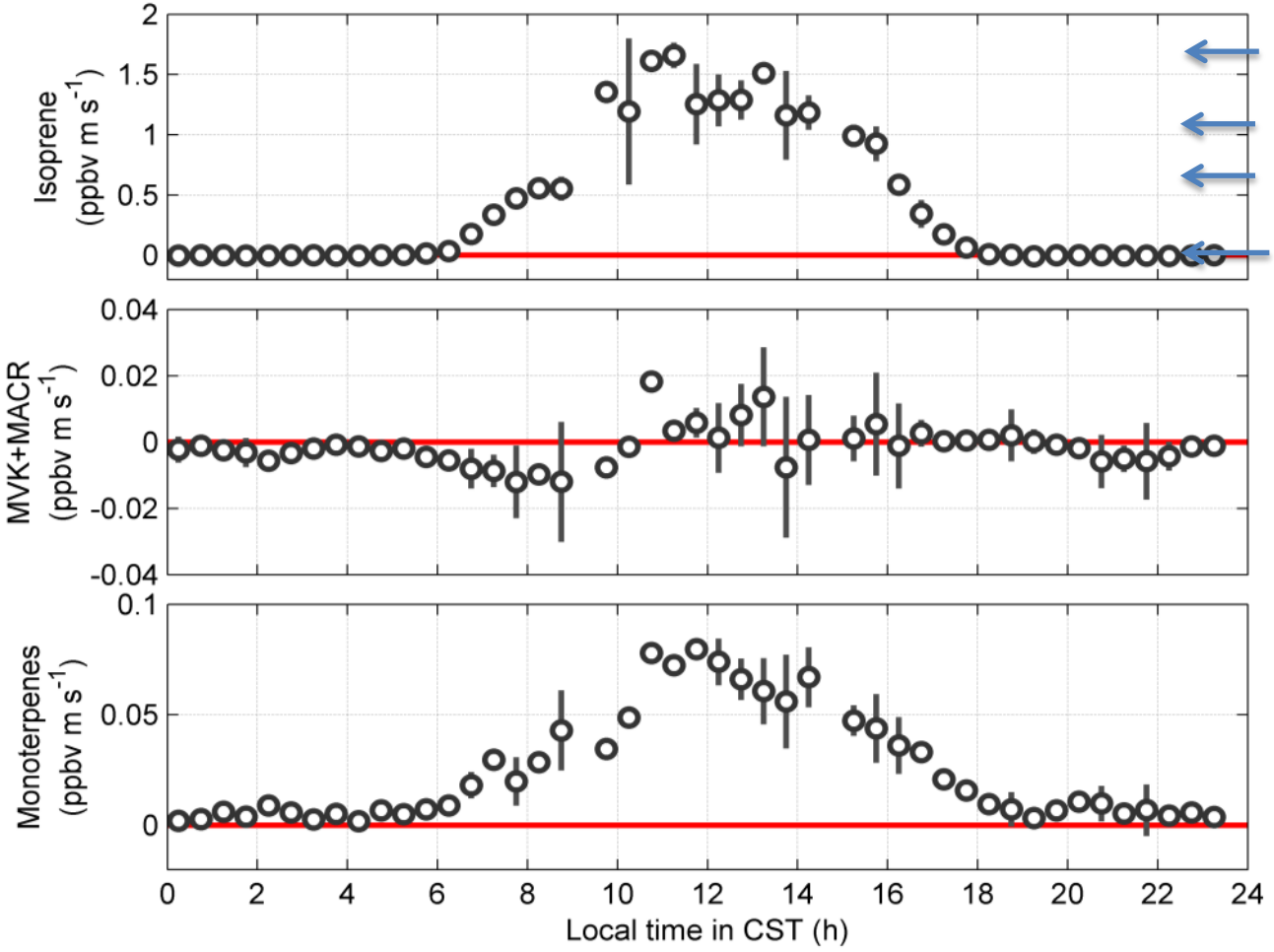
Averaged BVOC flux diurnal variations on sunny days



MEGAN fluxes

- This site
- temperate broadleaf tree
- tropical trees
- temperate needle trees

This is a high isoprene emission site (61% of trees are isoprene emitters)

REA measurements to speciate monoterpene fluxes

26% sweetgum, 21% tupelo, 16% pine, 14% oak, 12% tulip-poplar, 9% baldcypress, 3% hophornbeam

Su and Mak (see poster)
Turnipseed/Guenther

VOC fluxes and comprehensive gas and aerosol measurements at SEARCH site

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<u>Eddy covariance fluxes</u>:

- **PTR/SRI-ToF-MS (UC Berkeley, NCAR/WSU/PNNL)**
- **CIMS (Cal Tech)**

Can also constrain fluxes with the comprehensive concentration measurements of BVOC, oxidation products and biogenic secondary organic aerosol

Canopy layer structure at AABC site
Boundary layer structure at AABC/SEARCH

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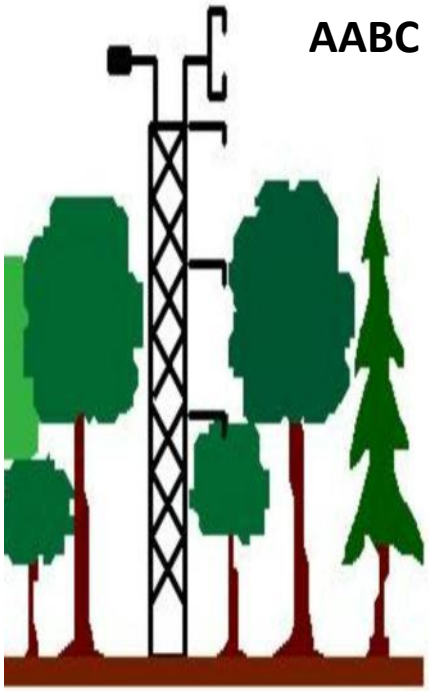
Canopy layer vertical gradients:

BVOC, NOx, O3, CO2, turbulence, temperature, solar radiation, humidity



9 level gradient sampling at AABC site (lowland forest)

2 above canopy: 39m, 45m

2 within overstory canopy: 27m, 33m

4 understory and trunk space: 2m, 9m, 15m, 21m

Surface: 0, -.05 m

Soil temperature, moisture

Boundary layer gradients:

- **BVOC (Long-EZ aircraft)**
- **Winds, turbulence, temperature, humidity, clouds (aircraft, SODAR, RASS, LIDAR, 915 Mhz wind profiler, radiosondes, ceilometer)**

Stonybrook, NCAR-EOL, WSU/PNNL

Boundary layer profiles: Stonybrook LONG-EZ WASP vertical profiler with PTR-TOFMS

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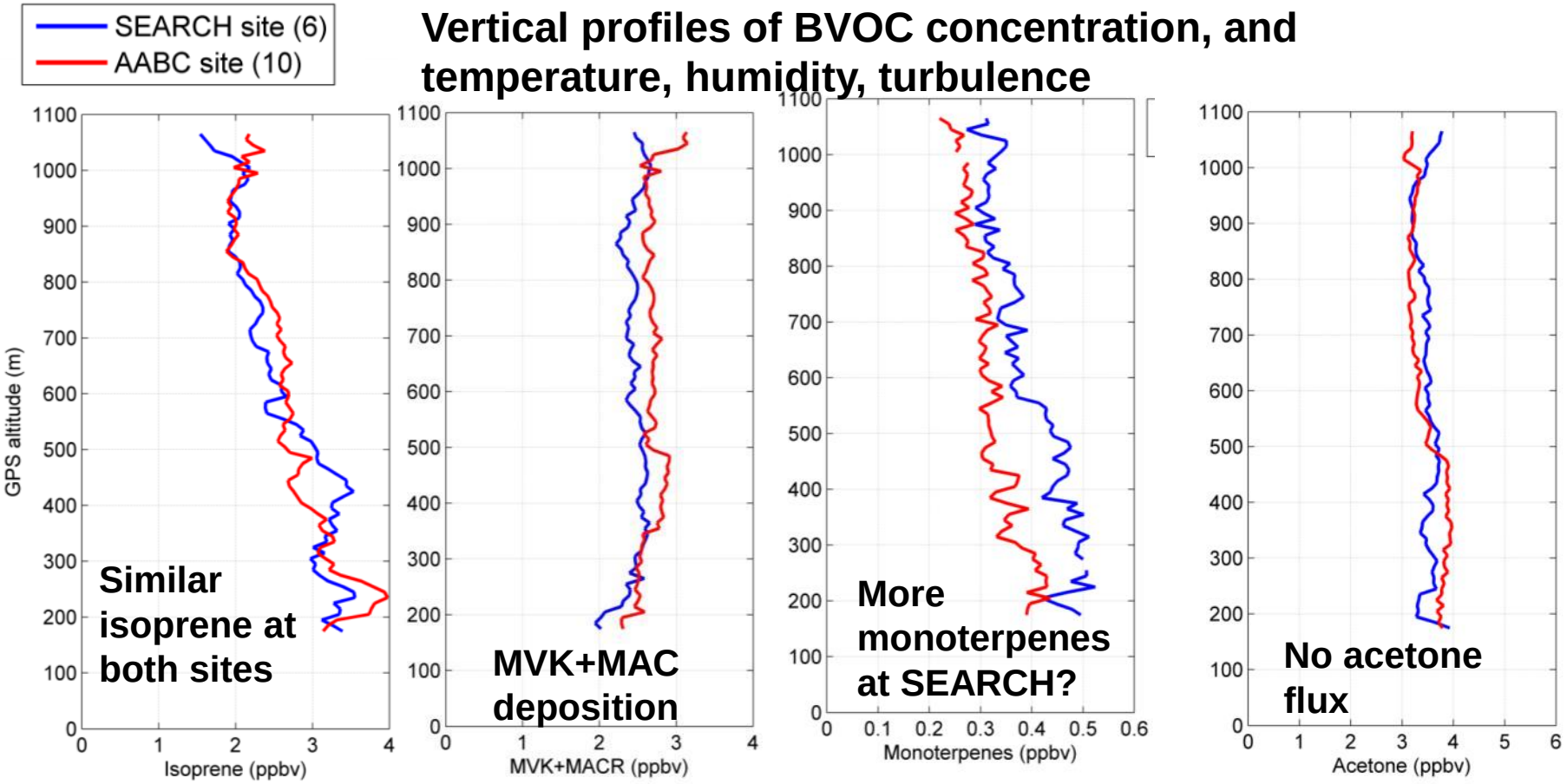
Vertical profiles of BVOC concentration, and temperature, humidity, turbulence



Averaged VOC profiles

Luping Su and John Mak (see poster)

Vertical flux divergence measurements: BVOC lifetime and surface fluxes

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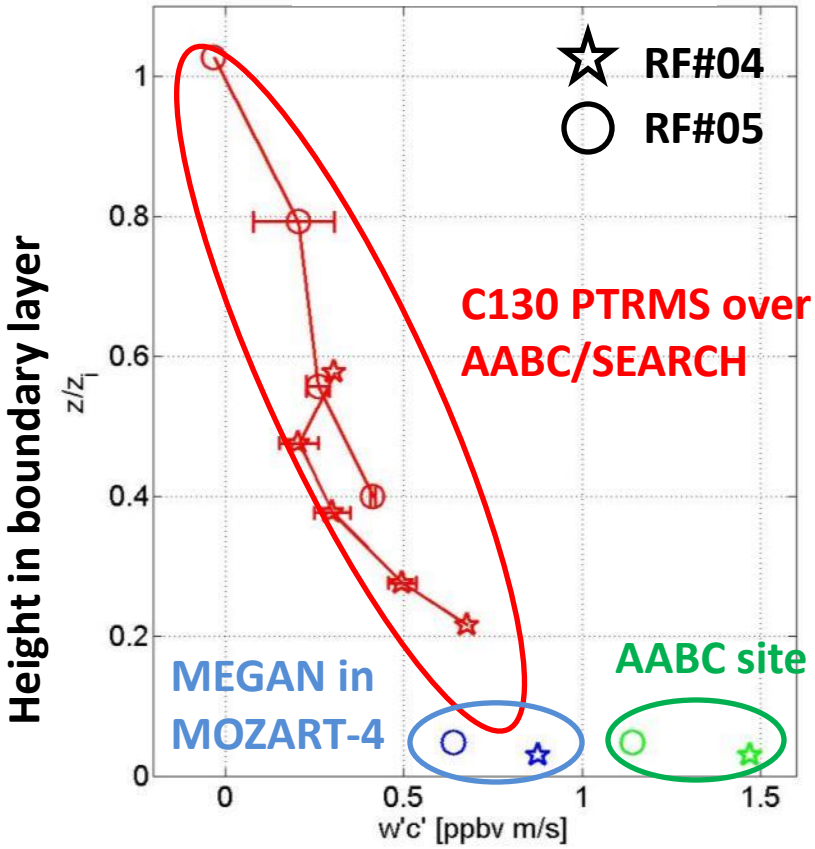
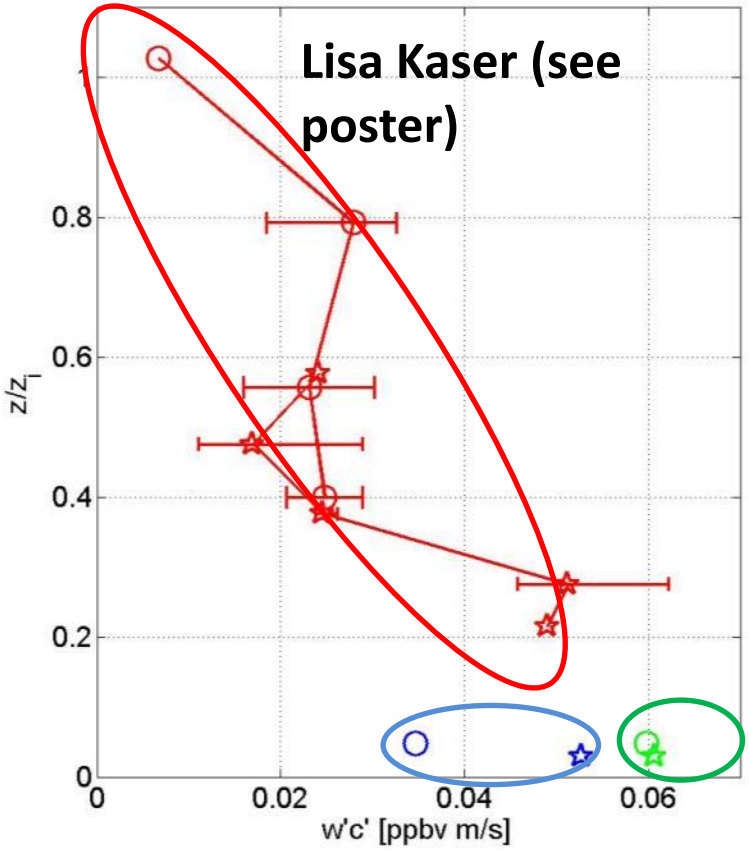
Isoprene Flux



Monoterpene Flux



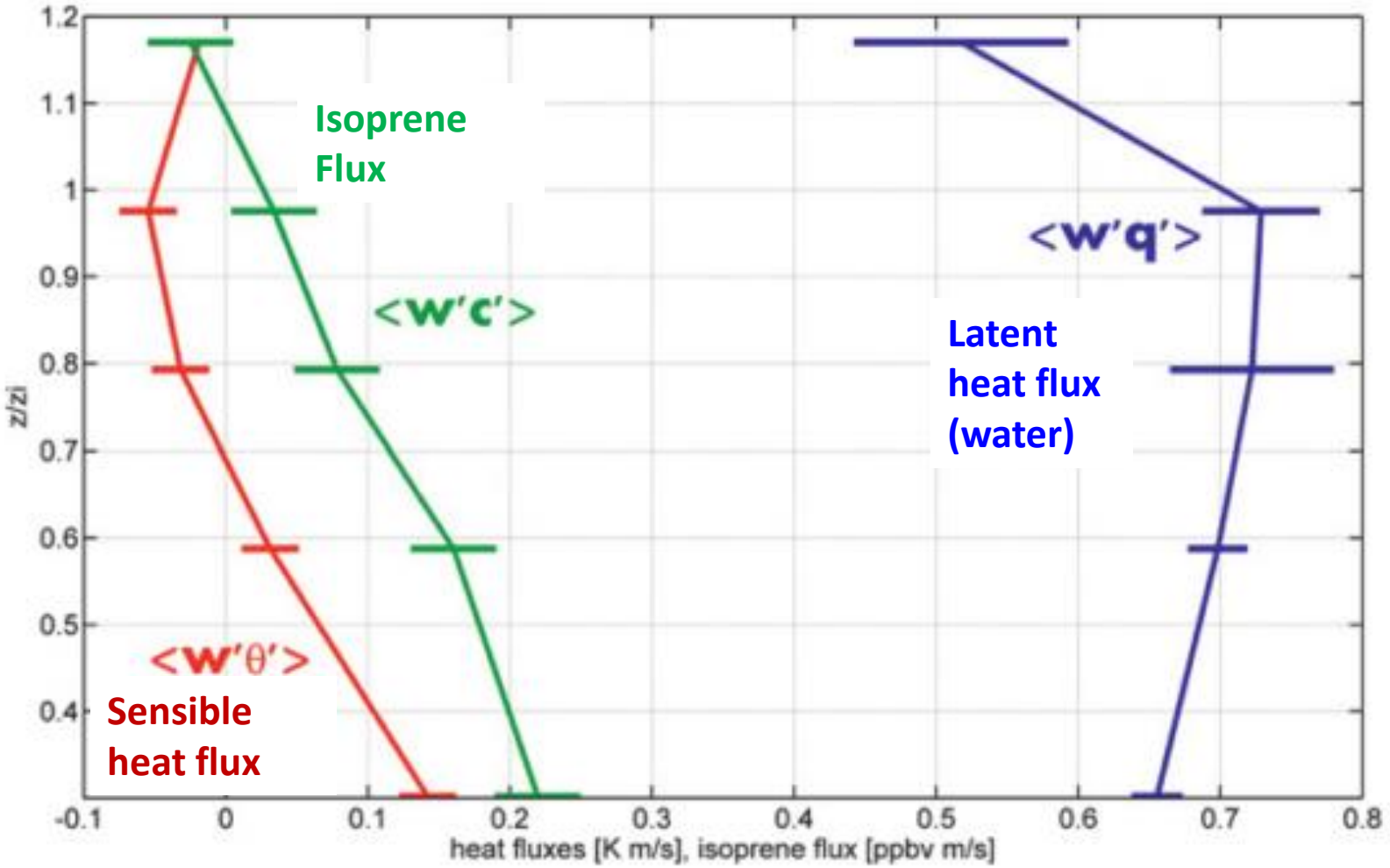
$$\frac{dF}{dz} = \frac{\Delta c}{\tau}$$

OH concentration estimated from τ (BVOC lifetime) and compared with CIMS OH obs.

Monoterpene lifetime compared with on-line GCMS (TOGA) data can identify unknown very reactive MT

C130 eddy covariance flux measurements over AABC and SEARCH site: BVOC, energy & water fluxes

Height relative to boundary layer height



CABERNET 2010
Karl et al. 2013

NOMADDS (NCAR C130) flights in the Boundary layer: BVOC eddy flux data

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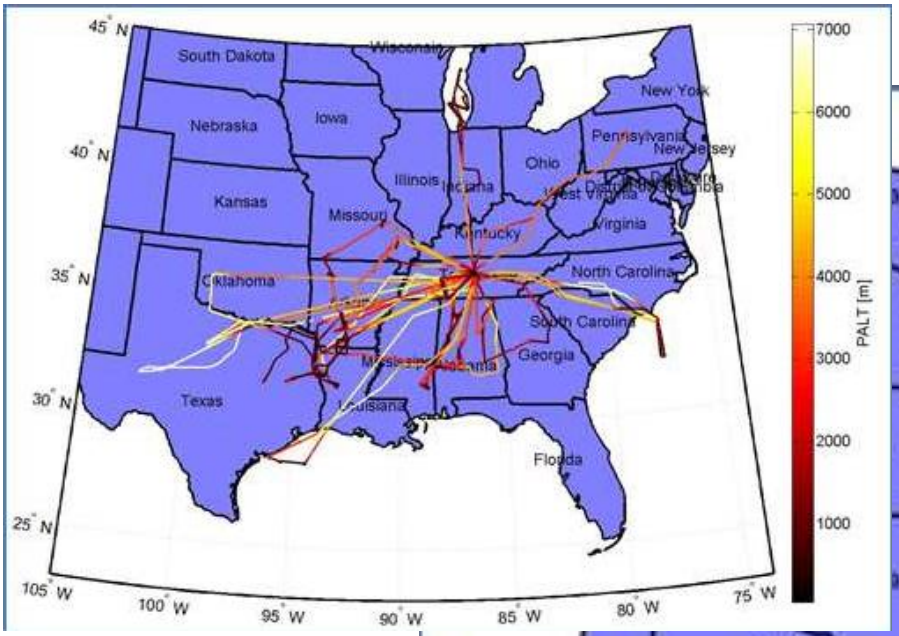
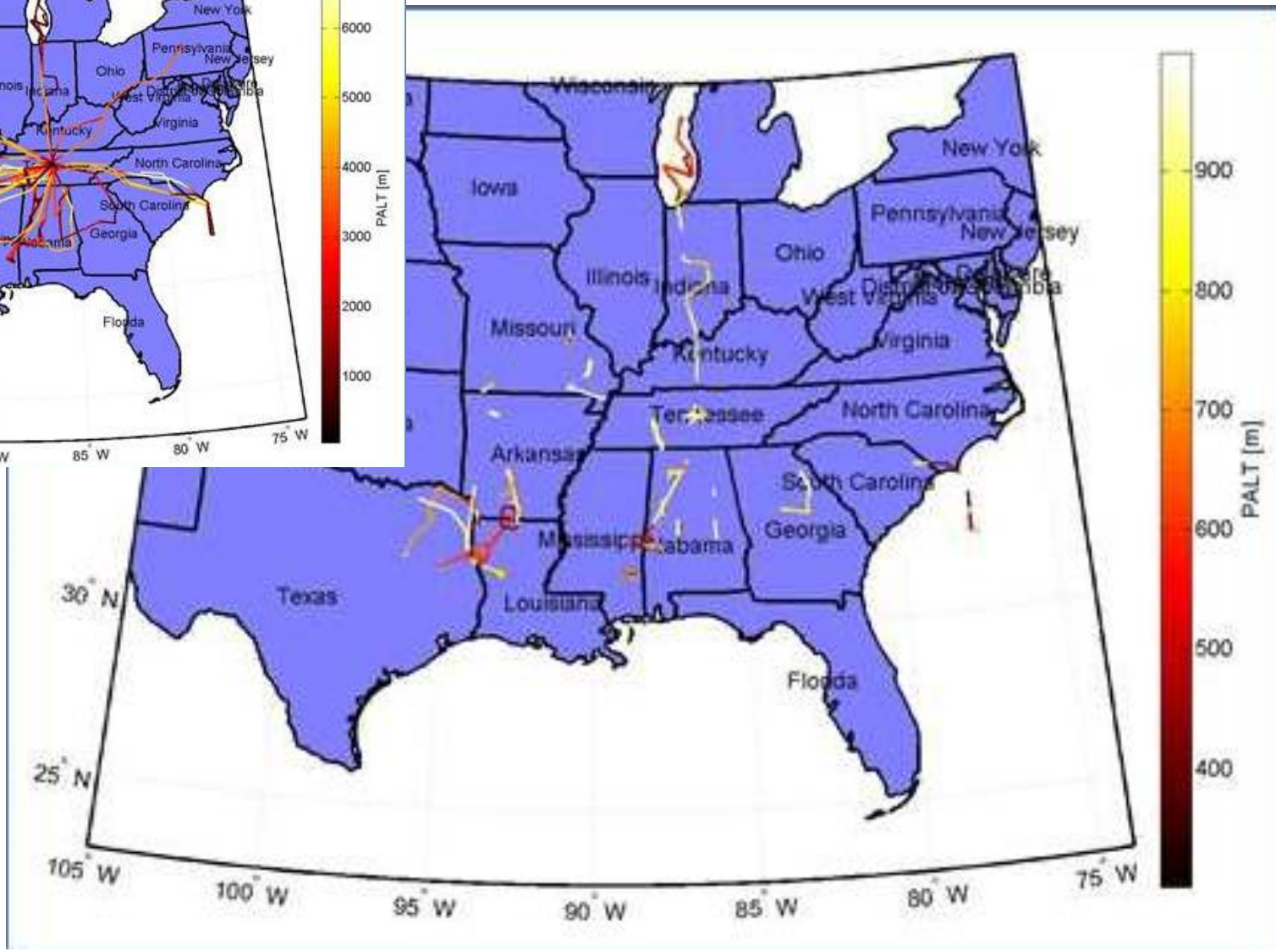
Lisa Kaser (NCAR)





Transects provide BVOC emission estimates for hundreds of locations at ~2km resolution

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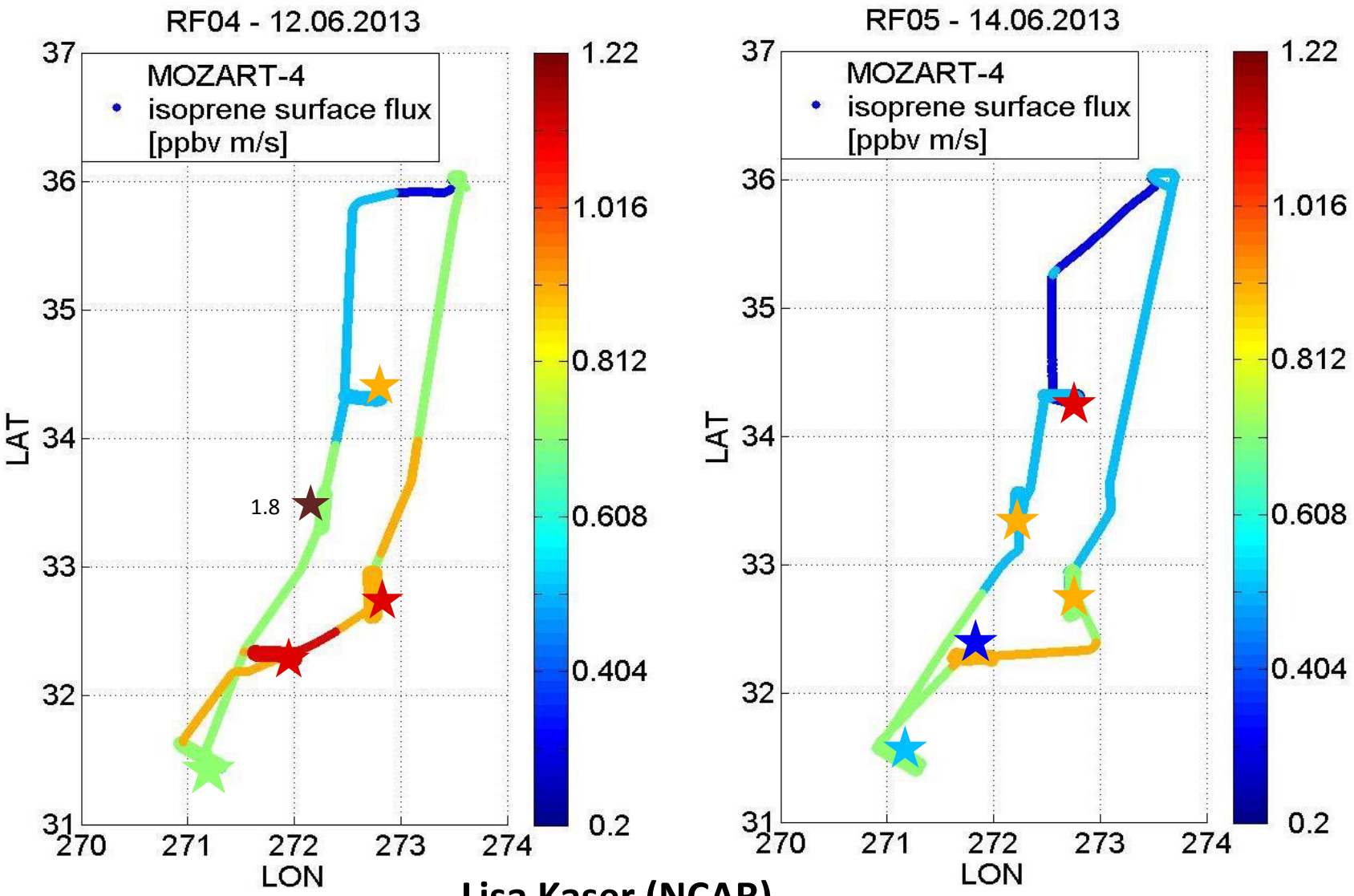

Lisa Kaser (NCAR)

SENEX (NOAA P3) PTRMS data can also constrain BVOC fluxes

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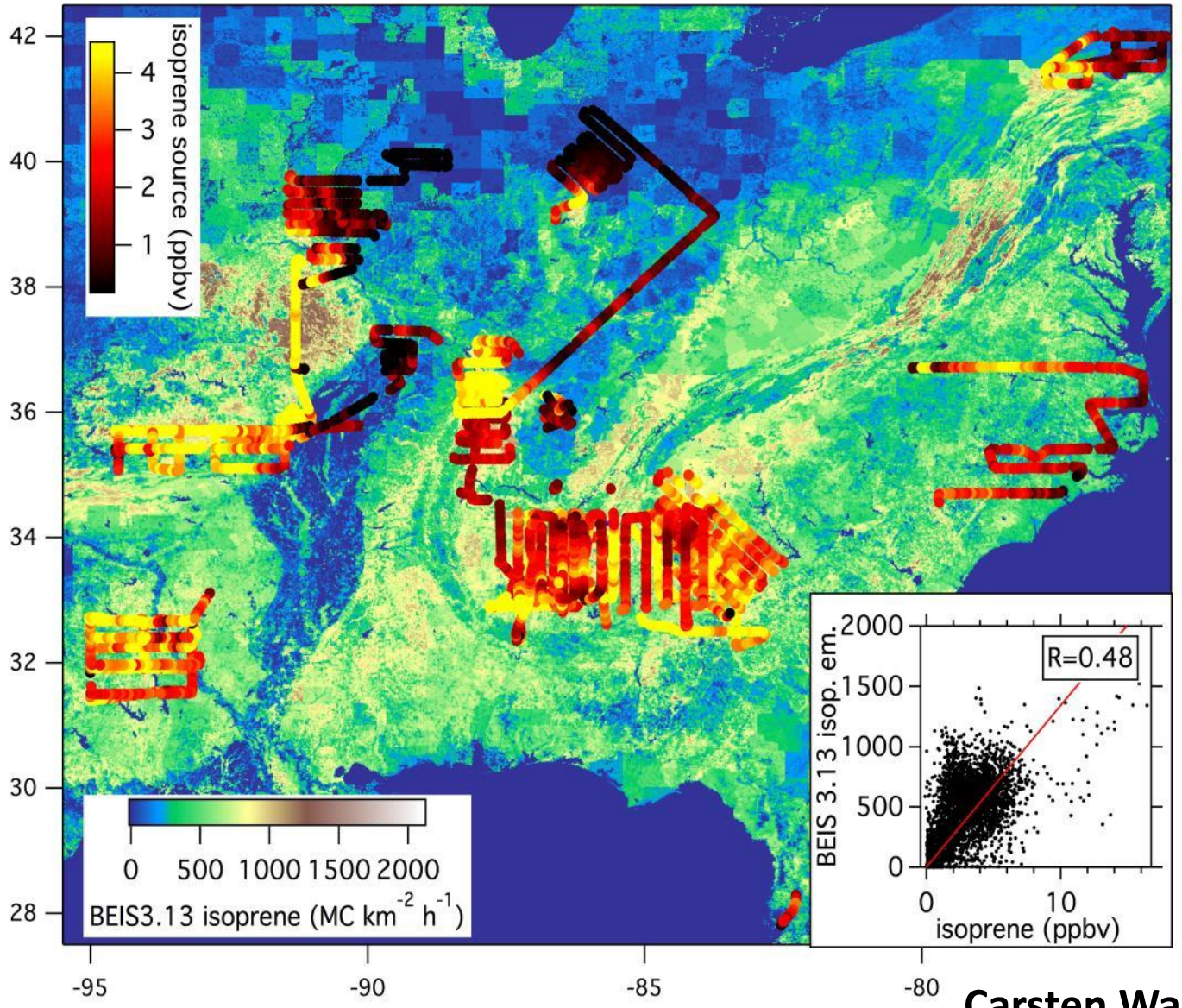

Indirect constraint on BVOC fluxes (inverse modeling)

-Potential direct constraint (variance or disjunct eddy covariance)

-BVOC oxidation and SOA formation

In addition, canister samples target a large range of BVOC with GCMS

Carsten Warneke (CIRES/NOAA)

Next steps: Incorporate SAS and other recent observations into MEGAN 3.0

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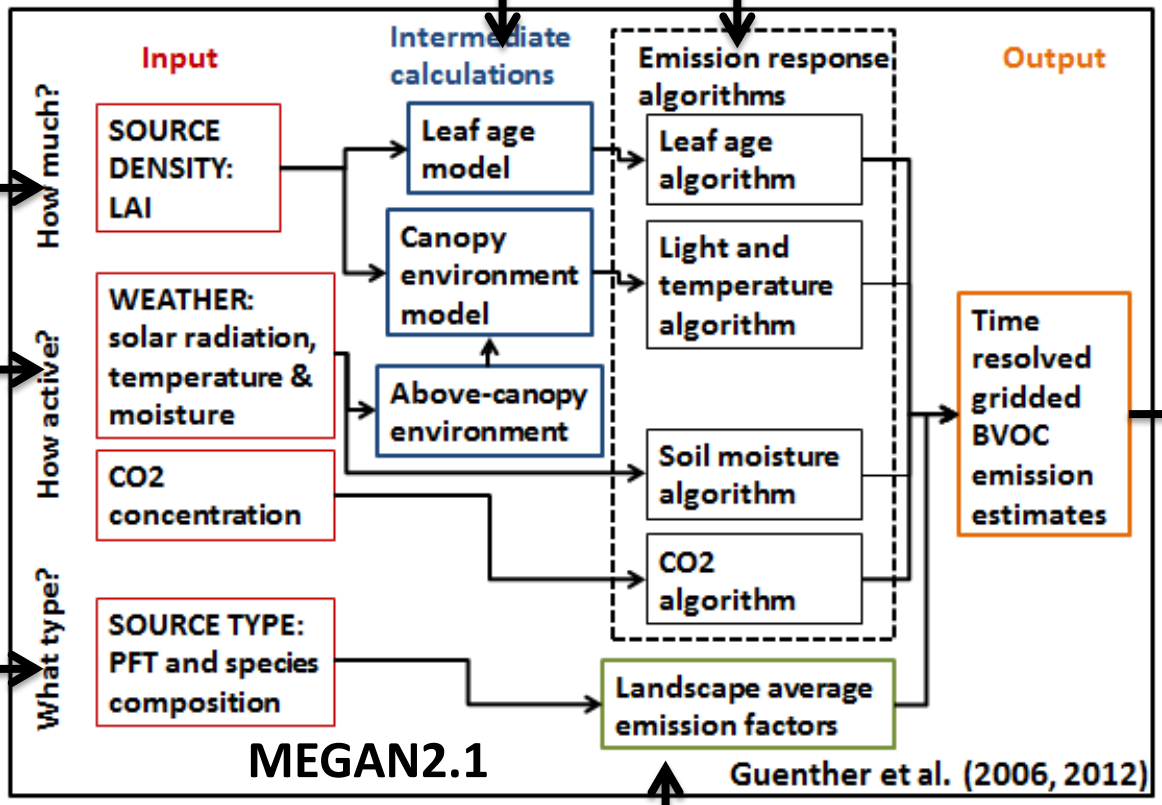
Use enclosure and above canopy flux tower data to improve emission algorithms



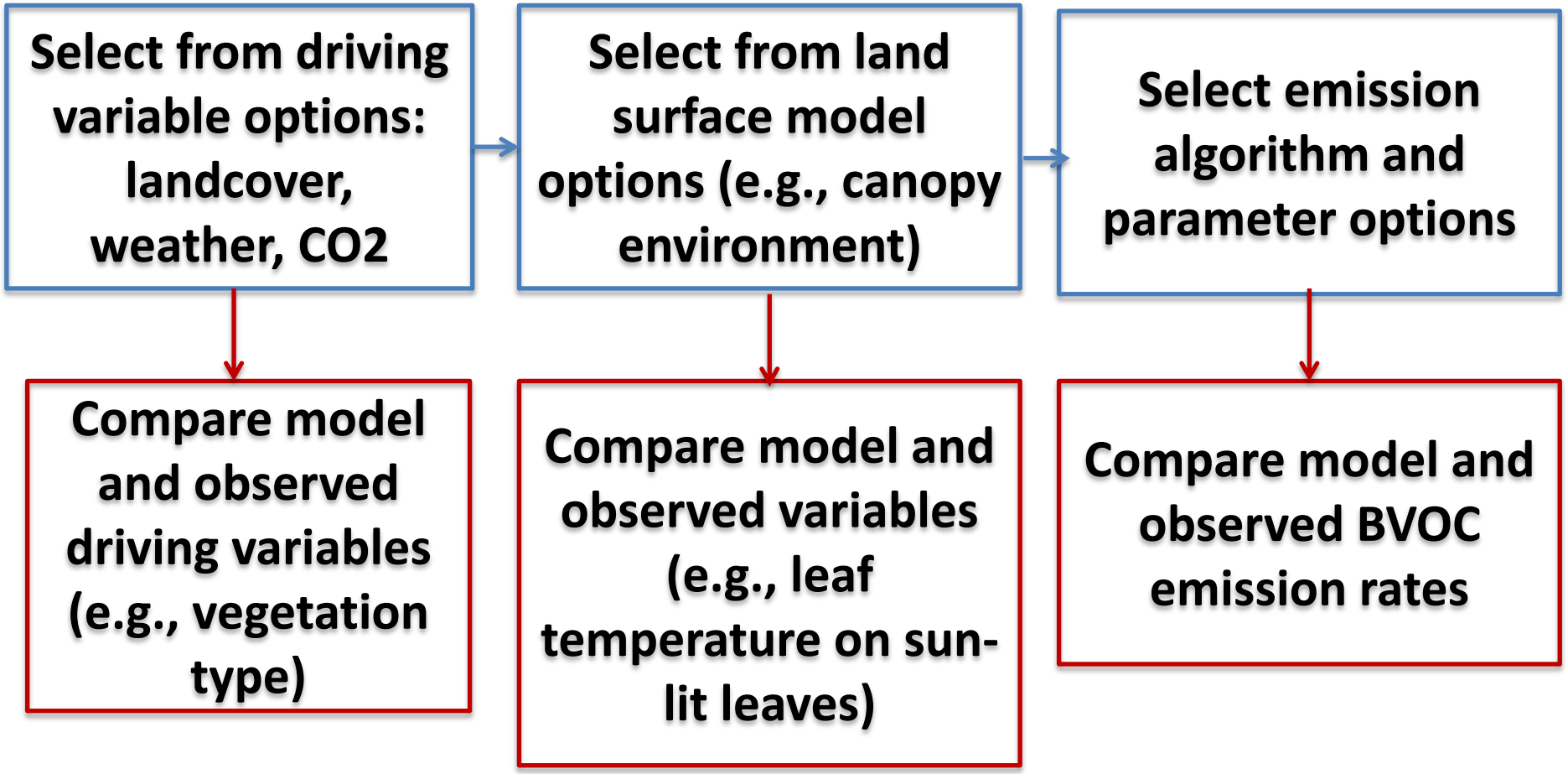
Improve and assess driving variables

Compare with other models (MEGANv2.1, BEIS3.13) and evaluate with aircraft and satellite data

Reconcile enclosure, flux tower, aircraft and satellite measurements and assign landscape level emission factors

Next steps: Community Model Testbed

Include SAS and other observations suitable for comparing and evaluating BVOC emission models and their components



Key Points

- SAS BVOC Emissions data
  - multi-scale
  - can constrain fluxes, dispersion and chemistry
- SAS fluxes include VOC deposition, energy, water fluxes
- SAS observations will be used to
  - Improve emission algorithms (temporal variations)
  - Reconcile/improve emission factors (spatial variations)
- SAS data in a Community Model Testbed
  - Understand differences between models
    - driving variables (landcover, weather)
    - Emission algorithms
    - Emisson factors
  - Evaluate regional emission estimates

Any Questions?

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