TROPOSPHERIC FLUXES OF OCS: MEASUREMENTS FROM THE OCEANS TO THE TERRESTRIAL BIOSPHERE

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Atmospheric OCS

300 – 550 pptv OCS in troposphere
<100 – 200 pptv OCS in stratosphere:
150 – 200 ppt at 12-20 km; 20-50 ppt at 30 km

Most abundant S compound

Stable trop conc. =
balanced sources and sinks?

Lifetime 5 – 35 years

Major source of S to strat in volcanically quiescent periods *[Bruhl et al, 2012]*

Stratospheric mixing ratio decreases with altitude

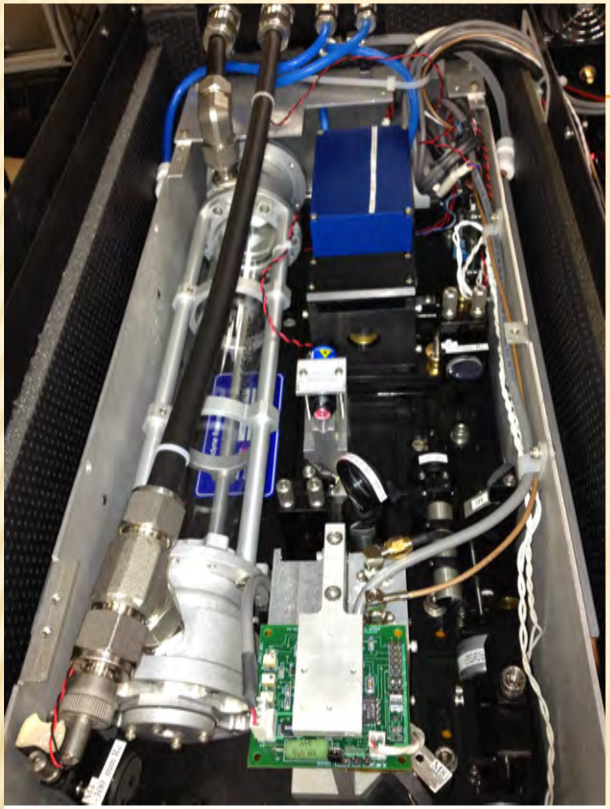
OCS ->[hv] CO + S

S ->[O_2] SO_2

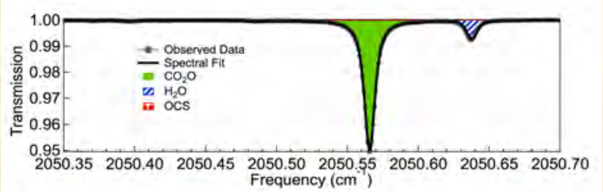
GC-MS analysis of flasks (HIPPO, SEAC4RS, ATTREX, etc.)
Montzka (NOAA), Atlas (Miami), Blake (Irvine)
CIMS (ice cores) Saltzman (Irvine)
Balloon spectrometers
Laser Absorption Spectrometers: Aerodyne Research Inc.

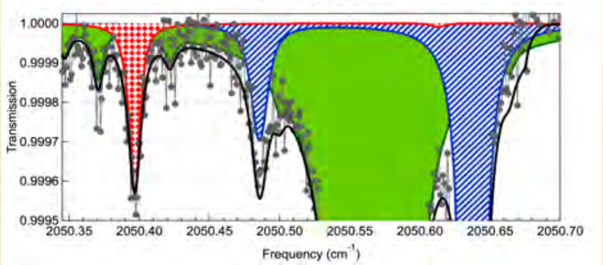
Quantum Cascade Laser Spectrometer

mid-IR Absorption



Nelson et al., 2010; Stimler et al., 2011; Commane et al., 2013



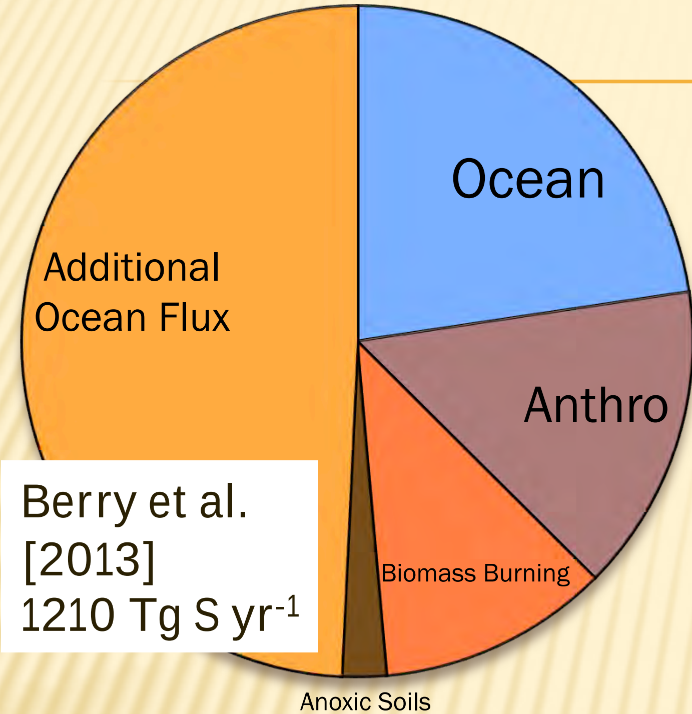


Single detector system
500mL Multipass cell volume
76 cm pathlength ; Reference Cell

Absorption Peaks @ -17^{o} C

OCS: 2050.397 cm^{-1}
H_2O: 2050.566 cm^{-1}
CO_2: 2050.638 cm^{-1}

Tropospheric OCS Sources and Sinks



Sources:

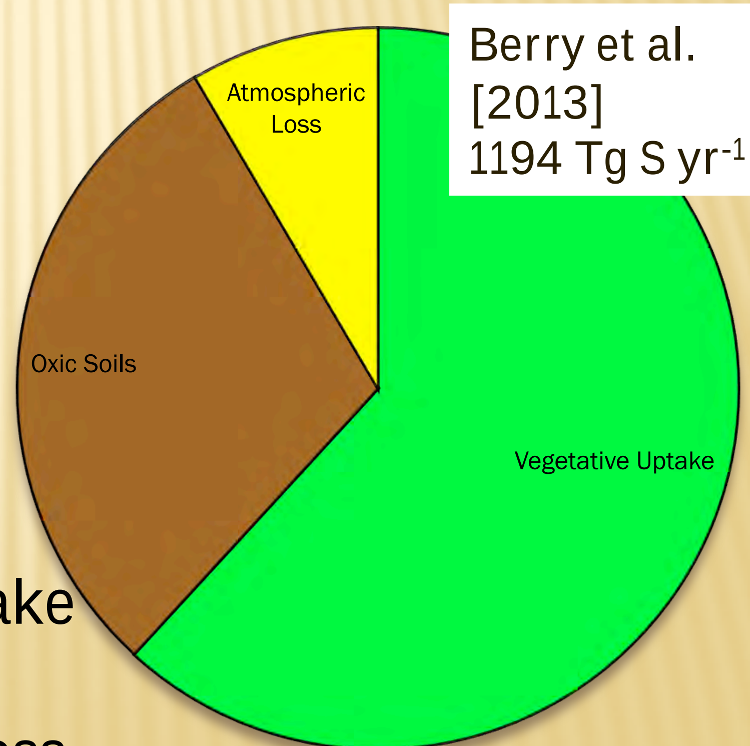
Ocean: *Direct / Indirect*

(High latitude max in summer)

Anthropogenic

Biomass Burning

Anoxic Soils



Balanced Budget:
For right reasons?

Sinks:

Vegetative Uptake

Oxic Soils

Atmospheric Loss

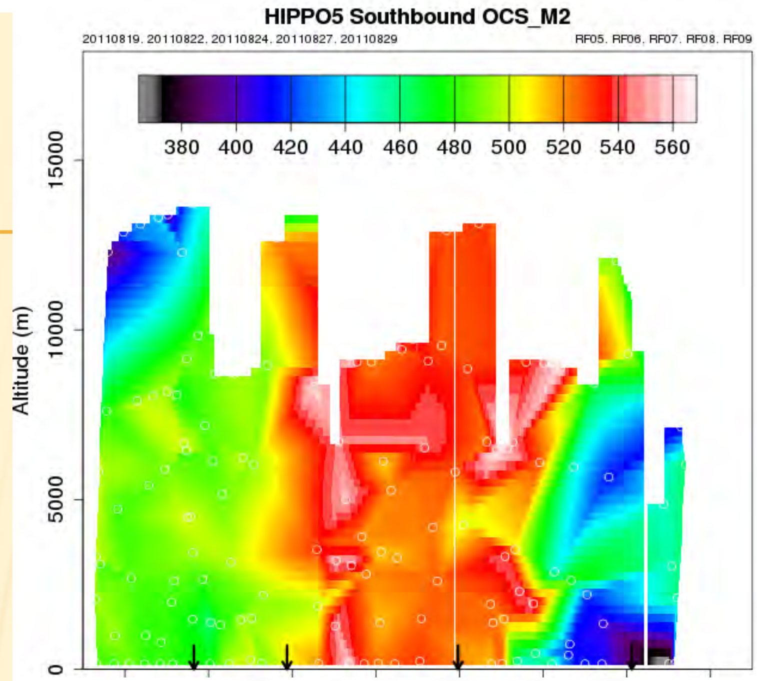
HIPPO 2011

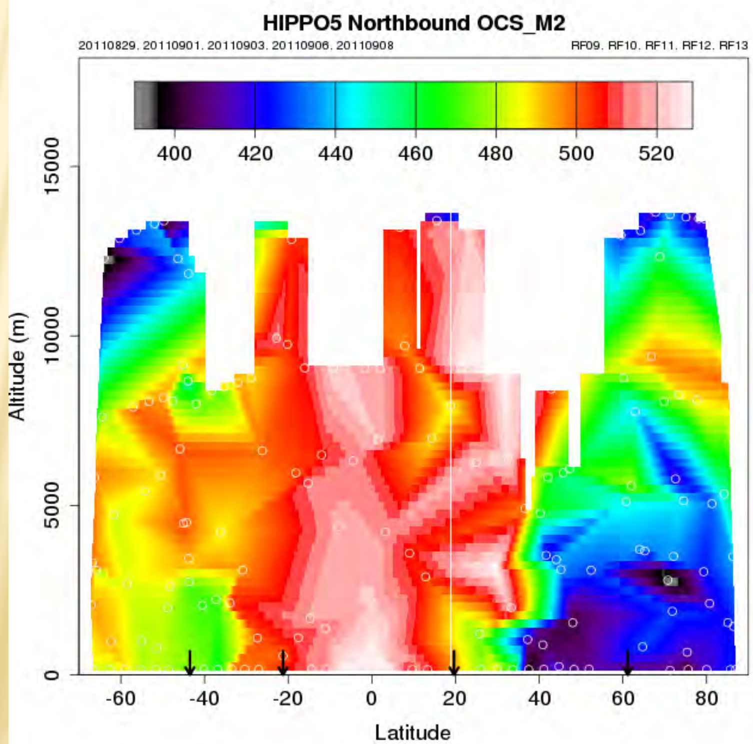
GV aircraft

Flask sample followed by GC-MS

Analysis by
Steve Montzka, NOAA
Elliot Atlas, RSMAS Miami

Transect of Pacific
Wofsy et al 2011





August

Northern mid-latitude depletion

Tropical mid-troposphere enhancement

September

Northern mid-latitude depletion recovery

Tropical mid-troposphere enhancement

*Note change of scale

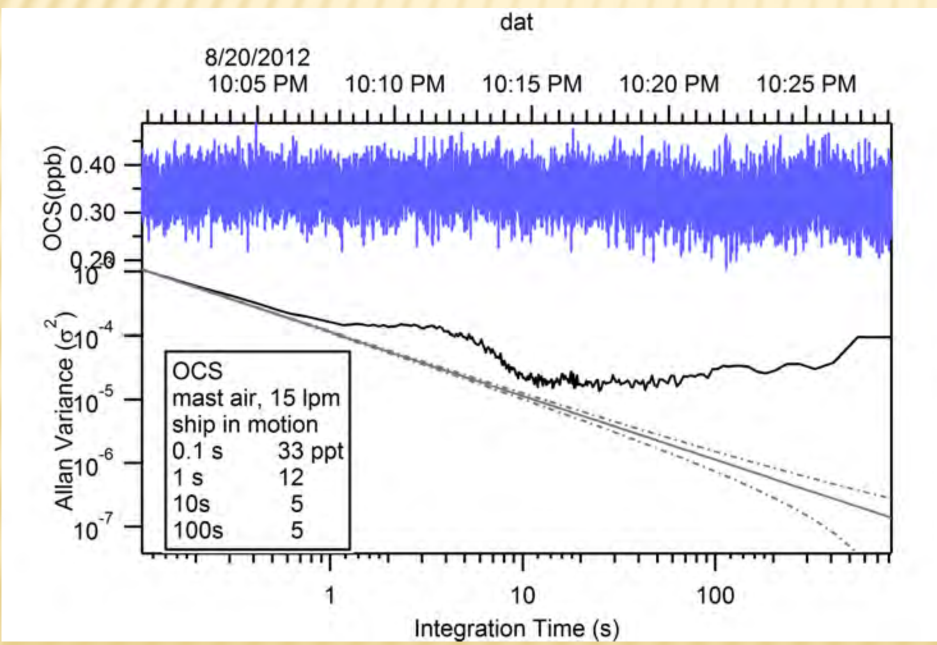
Large uncertainty from flask samples

Fast response instrument – better resolution

Eddy Covariance fluxes of OCS, CO_2 and H_2O on Ron Brown - Bermuda to Boston

Motion corrected sonic winds coupled with fast (10Hz) measurements

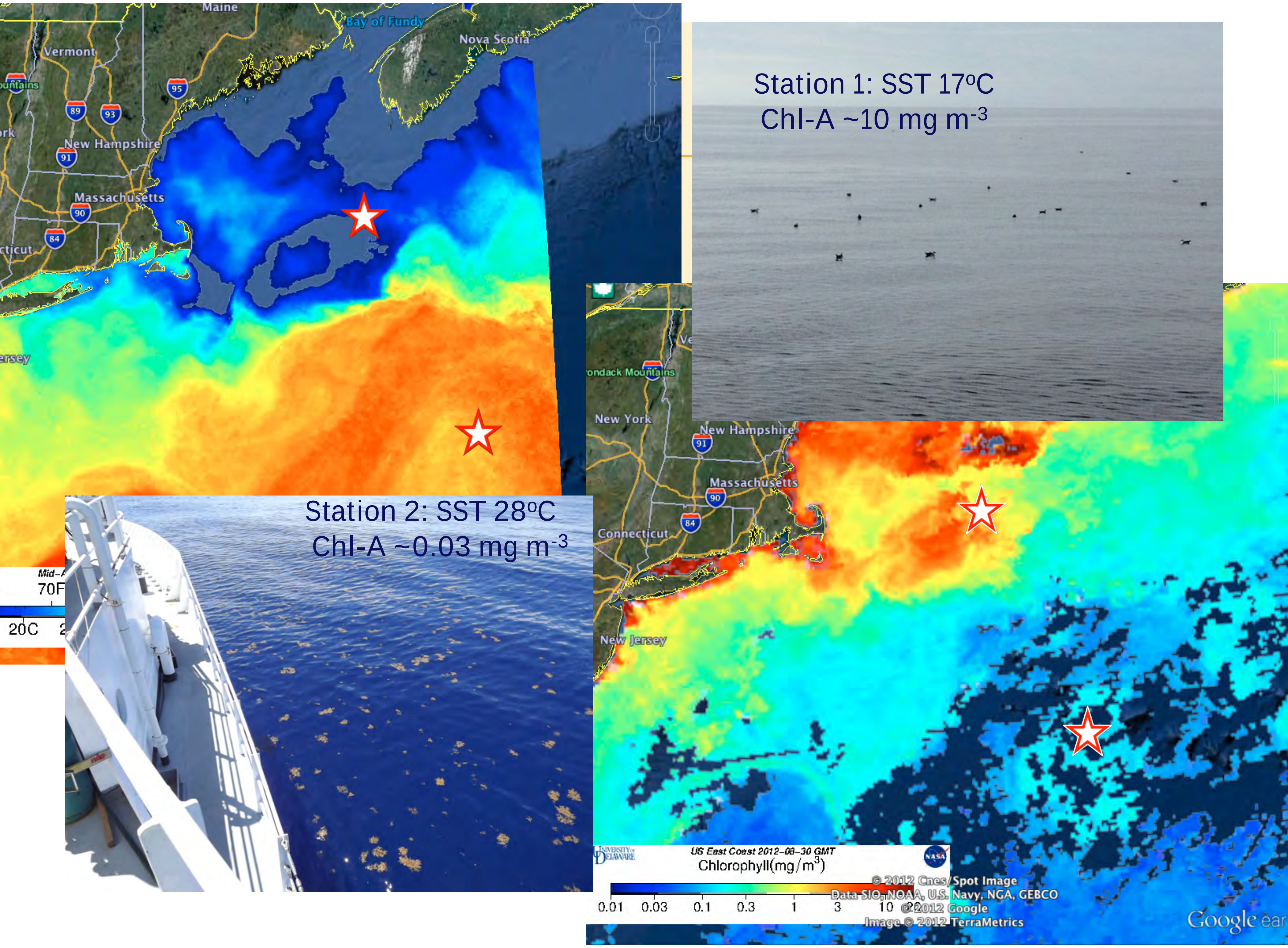
Response Time 0.6s
Lag time 4s



Improved to <2pptv @ 1Hz with reduced flow

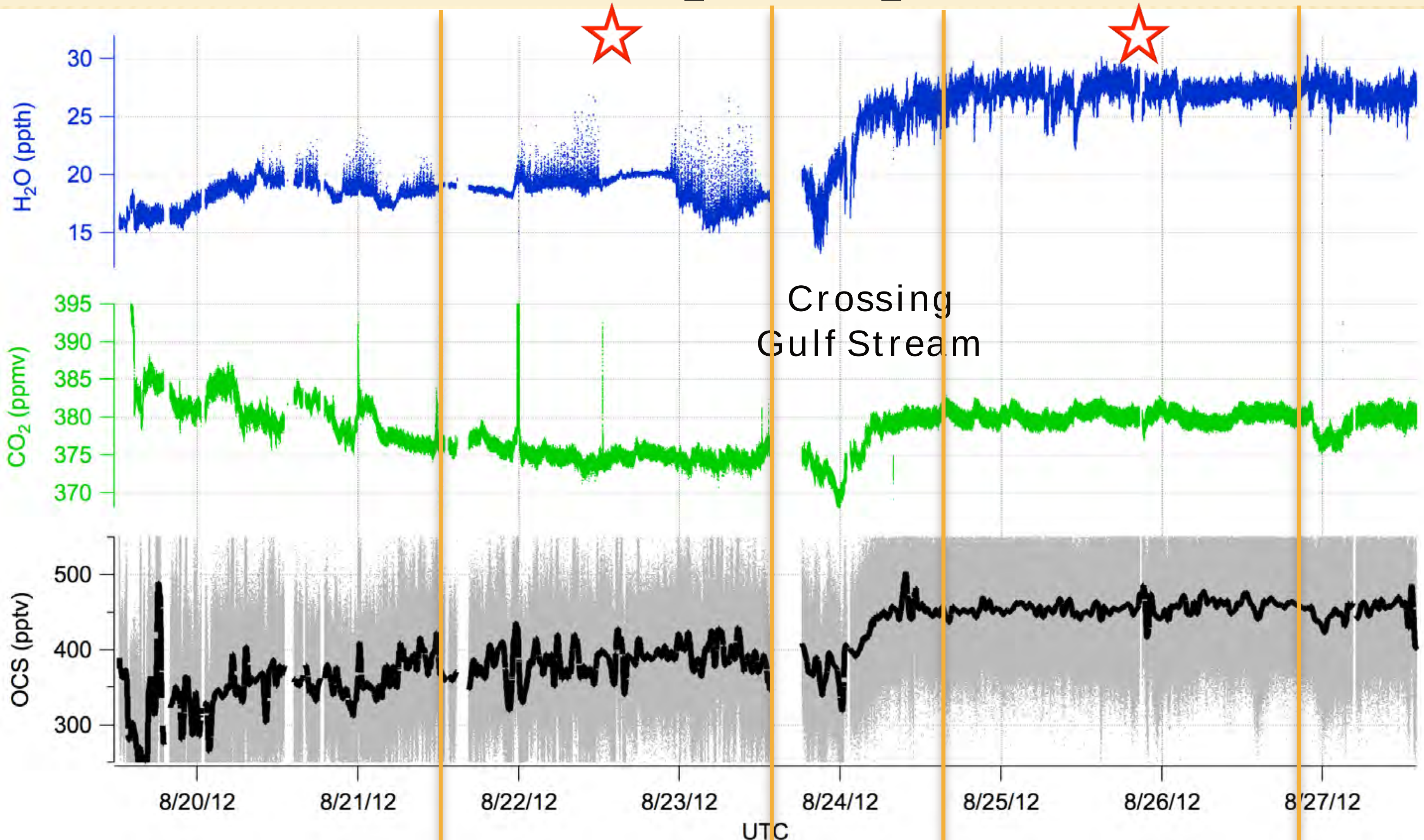
Ludovic Bariteau, Chris Fairall, Sergio Pezoa – NOAA ESRL

Mike Agnese, Scott Herndon, Ryan McGovern, Barry McManus, David Nelson, Mark Zahniser – Aerodyne Research Inc.



Station 1: SST 17ºC
Chl-A ~10 mg m-3
Station 2: SST 28ºC
Chl-A ~0.03 mg m-3
Maine
Bay of Fundy
Nova Scotia
Vermont
New Hampshire
Massachusetts
New York
Connecticut
New Jersey
Mid-A
70F
20C
US East Coast 2012-08-30 GMT
Chlorophyll(mg/m3)
0.01
0.03
0.1
0.3
1
3
10
© 2012 Cnes/Spot Image
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2012 Google
Image © 2012 TerraMetrics

WACS: H_2O, CO_2, OCS



100 pptv more OCS
over open ocean vs coast

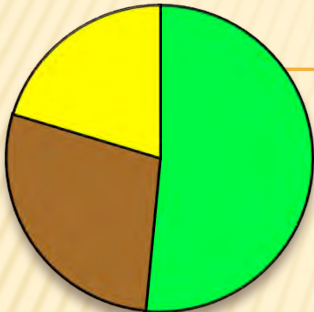
10 Hz data.

Tropospheric OCS Sinks

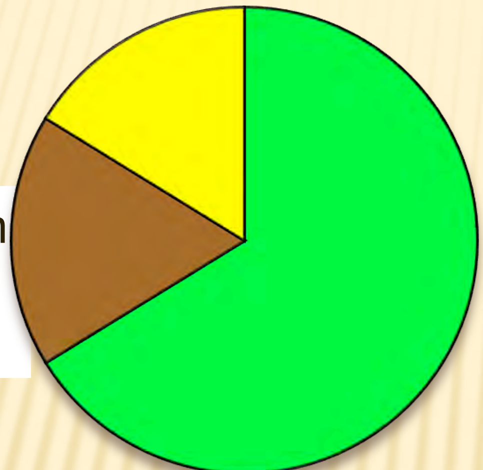
Vegetative Uptake:

Few ecosystem scale flux

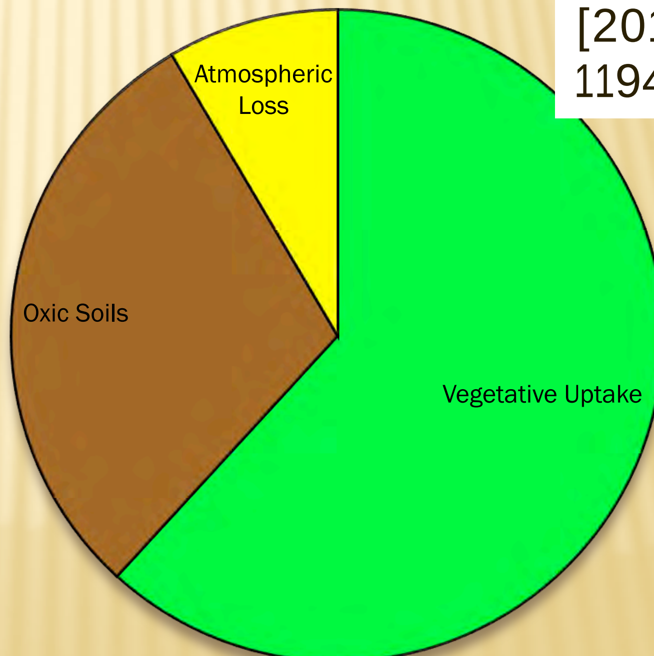
Estimated from leaf scale studies and lab expts.



Kettle et al. [2002]
462 TgS yr^{-1}



Suntharalingam et al. [2007]
740 Tg S yr^{-1}

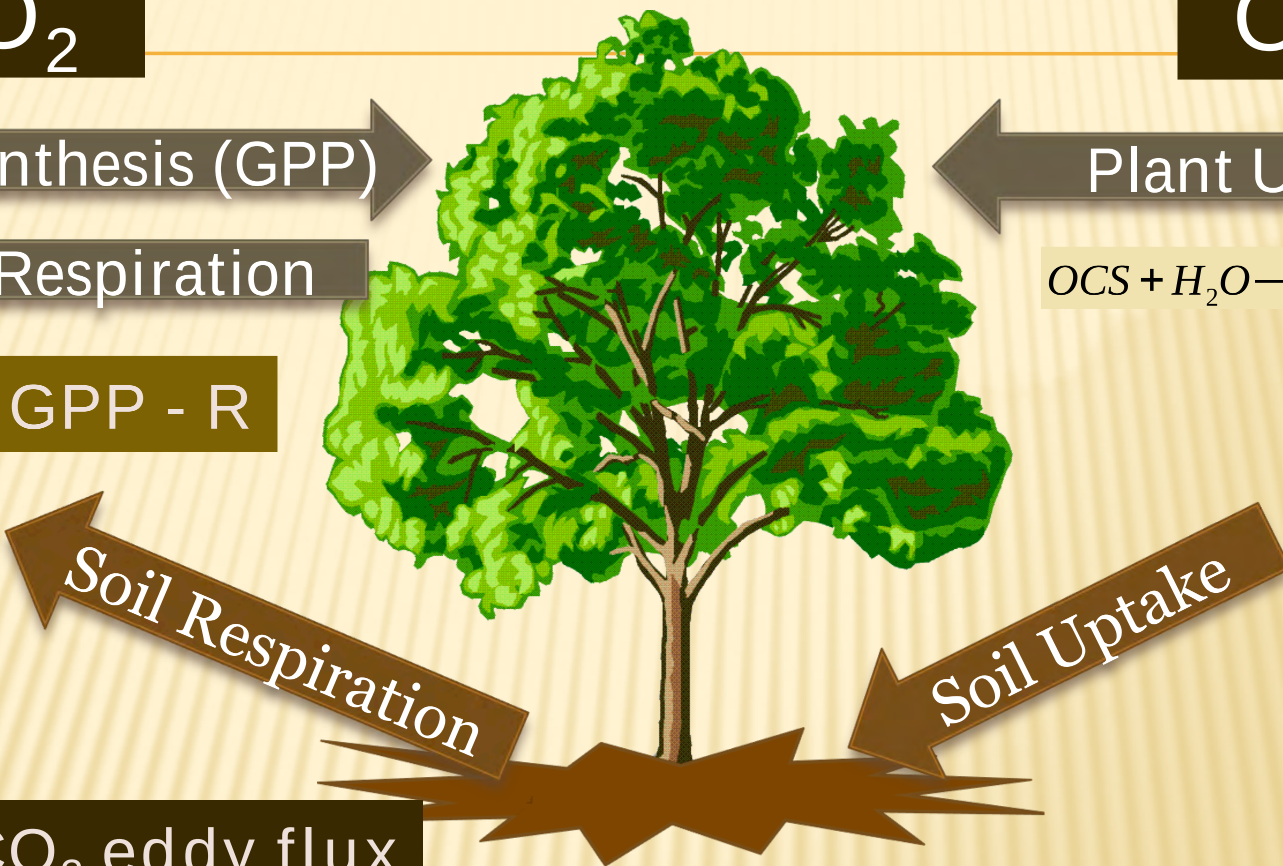


Berry et al. [2013]
1194 Tg S yr^{-1}

OCS Sink: Terrestrial Uptake

CO_2	OCS
Photosynthesis (GPP)	Plant Uptake
Plant Respiration	$OCS + H_2O \xrightarrow{CA} H_2S + CO_2$

NEE = GPP - R

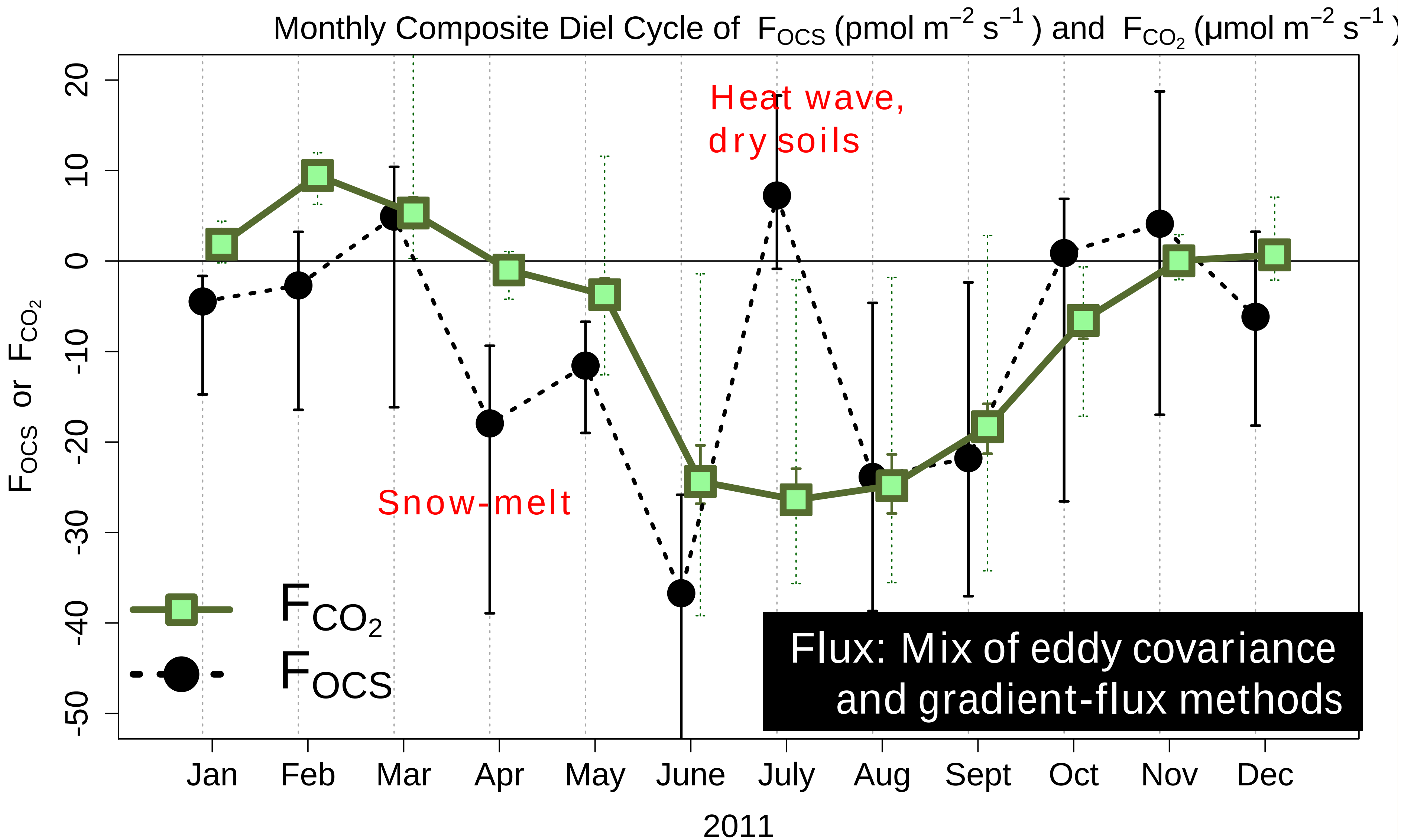


NEE: CO_2 eddy flux

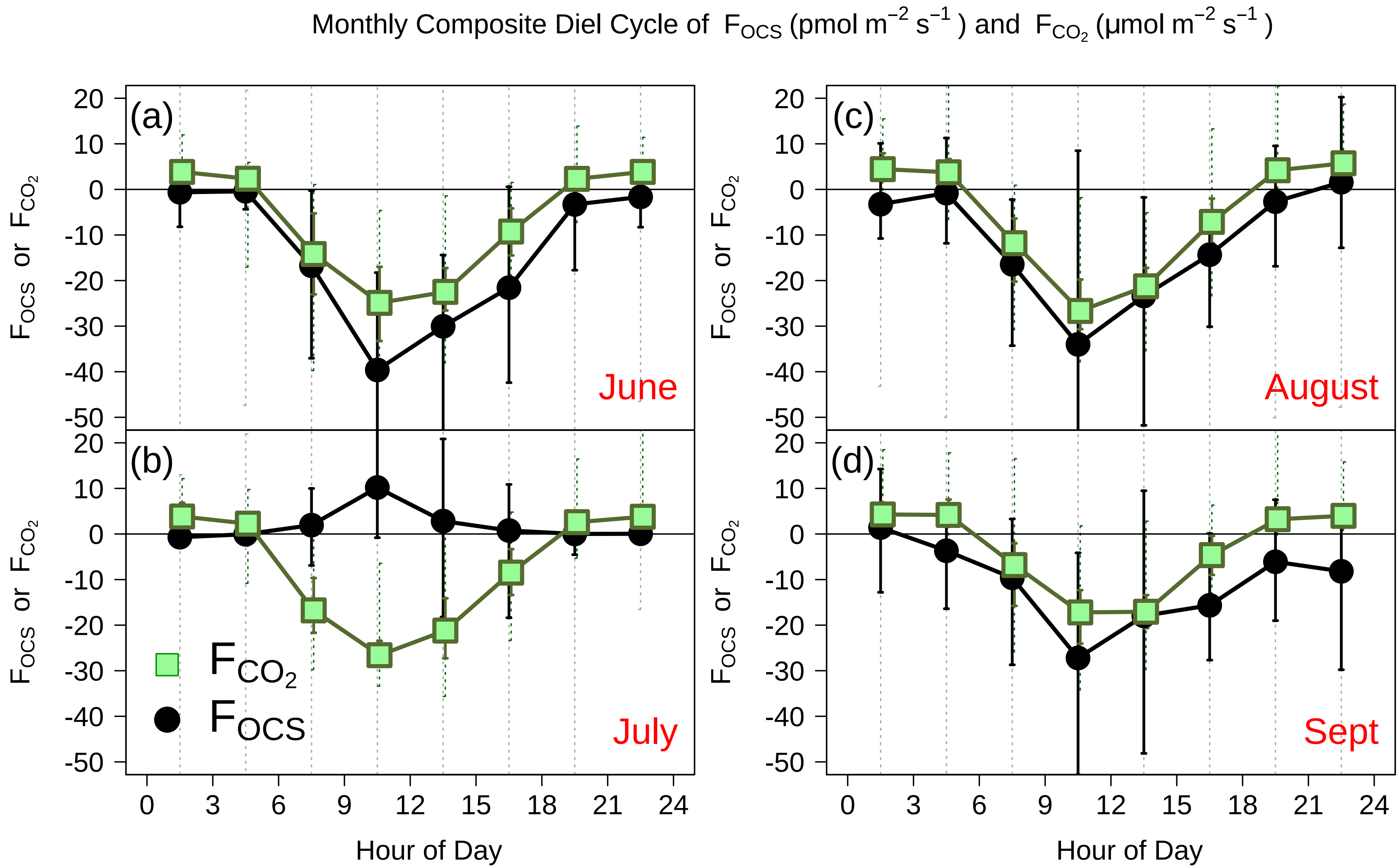
Daytime R ≈ night R(T)
GPP: NOT measured
GPP ≈ NEE - R

No dependence of OCS uptake on $[CO_2]$

Seasonal OCS Flux: Harvard Forest, MA
Mid-Latitude Mixed Forest



Summer Diel OCS Flux



Results of Fast OCS measurements

Terrestrial Sink:

Bidirectional OCS flux from canopy – hot and dry

Diurnal profile: Stomatal opening?

Species dependent uptake rate – conifers less

Warm soils in Sept

– Soil/incompletely closed stomata uptake

Oceanic OCS Source:

OCS higher over open ocean

Opposite to Kettle 2002 Budget

Agrees with HIPPO observations and Berry *et al* 2013

Thanks!

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SEAC4RS, Sept 2013
CO2, CH4, CO
Cavity ring down
Picarro

Daube, Pittman, Commane, McKain, Samra, Santoni, Wofsy

ATTREX, Spring 2014
Global Hawk