Determining Fluxes of CO_2 using Mass Constraints

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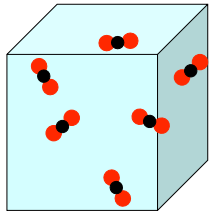
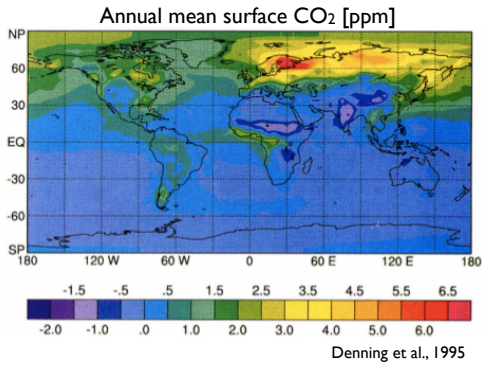
Fluxes from variations in boundary layer CO_2



Mixing ratio
[mol m^{-3}]

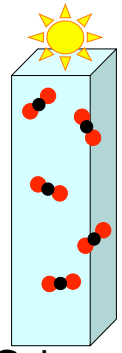
Transport model

Flux
[mol m^{-2} s^{-1}]

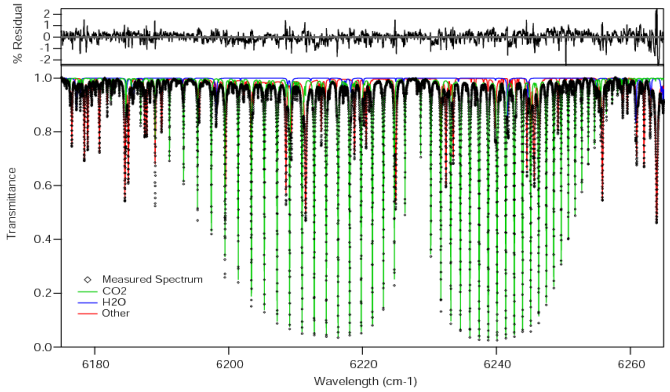


Using variations in boundary layer observations of CO_2 to estimate fluxes tied to vertical mixing.

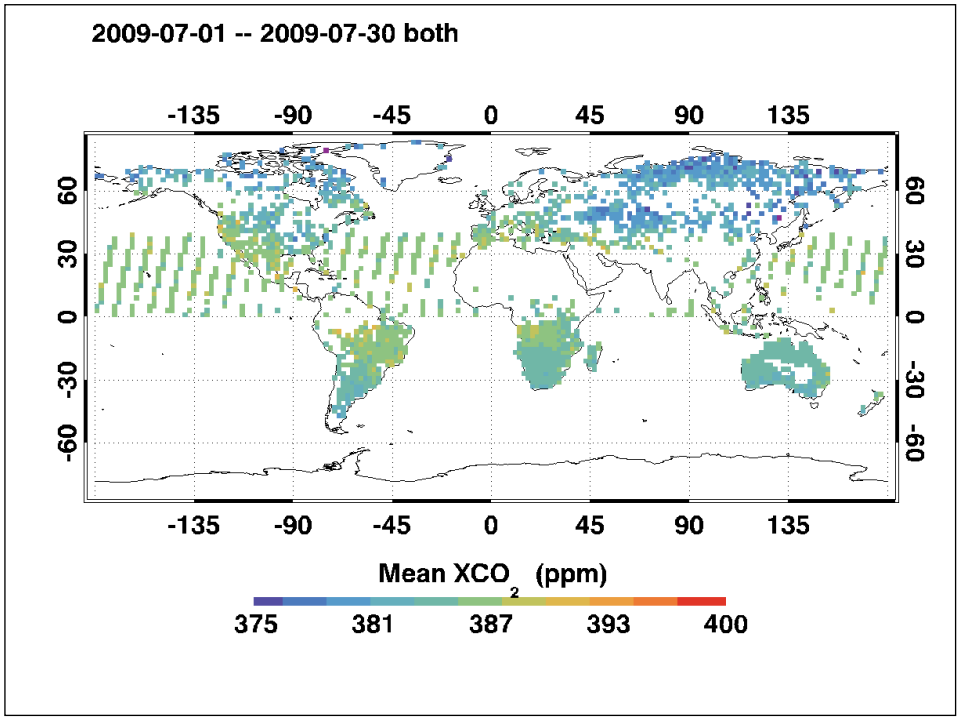
The vertically integrated mixing ratio, $\langle CO_2 \rangle$



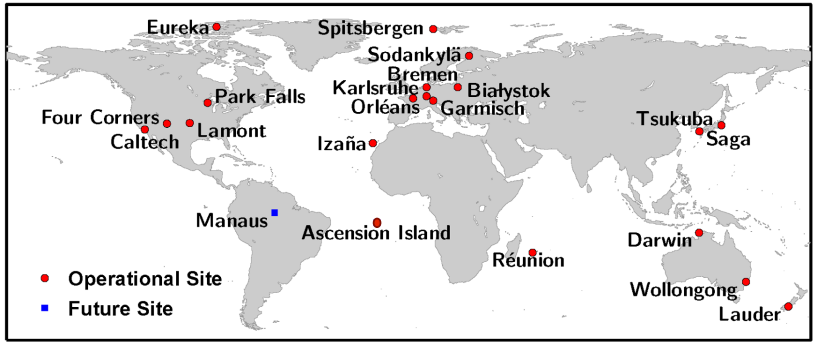
Column
[mol m^{-2}]



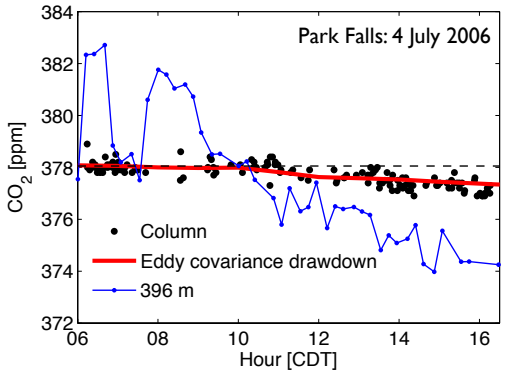
Remote sensing of $\langle CO_2 \rangle$ will improve flux estimates since variations in $\langle CO_2 \rangle$ are directly related to mass fluxes.


2009-07-01 -- 2009-07-30 both
-135
-90
-45
0
45
90
135
60
30
0
-30
-60
Mean XCO2 (ppm)
375
381
387
393
400

Total Carbon Column Observing Network (TCCON)

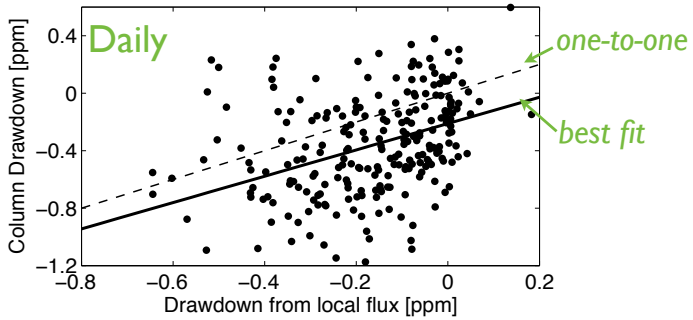


How do <CO_2> and boundary layer CO_2 compare?



<CO_2> and boundary layer CO_2 have different sensitivity to the underlying biospheric fluxes.

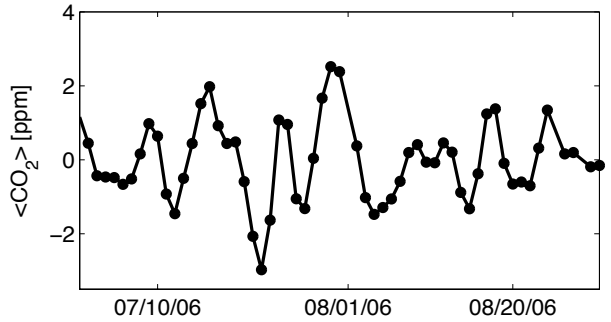
Comparison of column drawdown and local flux at Park Falls



Drawdown in <CO_2> not well predicted by local flux measured on the tower.

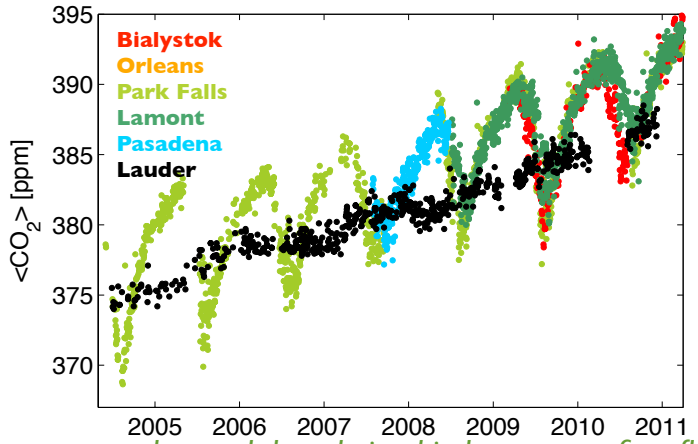
Keppel-Aleks et al., Biogeosciences, 9, 875-891, 2012

Summer daily median <CO_2> at Park Falls



Synoptic scale variations complicate the relationship between <CO_2> and the underlying flux.

TCCON <CO_2> from across the network

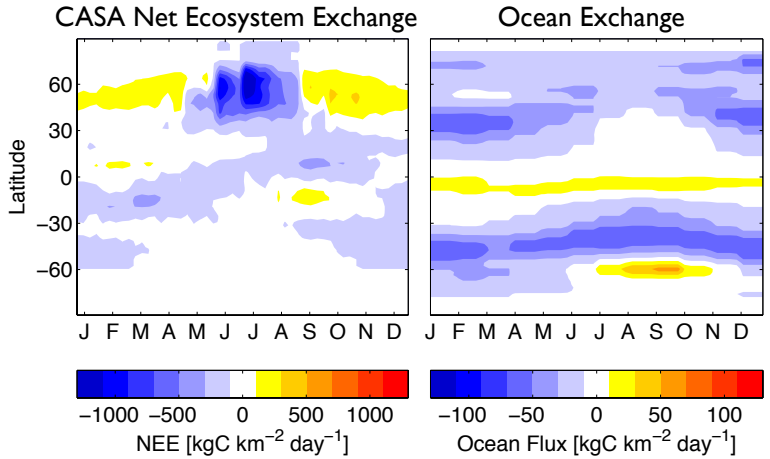


We want to understand the relationship between surface fluxes and <CO_2> variations at seasonal, synoptic, and diurnal timescales.

Simulations

- Use a general circulation model to simulate variations in $\langle CO_2 \rangle$
- Modify underlying fluxes to test the sensitivity of $\langle CO_2 \rangle$ to local and large scale fluxes
- Use these simulations and other available data to understand how best to use $\langle CO_2 \rangle$ data to constrain surface fluxes

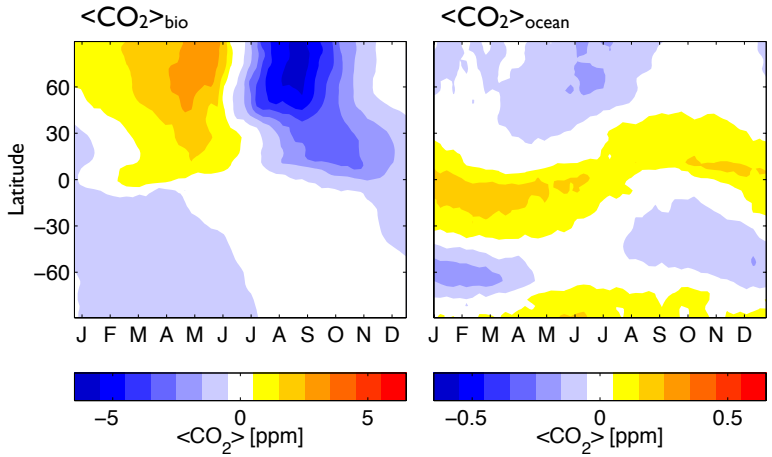
Natural CO_2 fluxes



There is large seasonality in northern hemisphere biospheric fluxes.

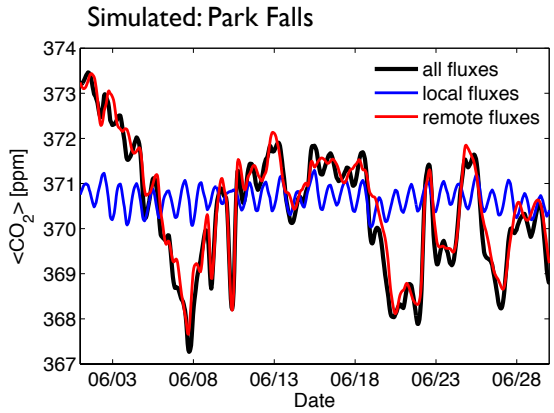
Keppel-Aleks et al., Biogeosciences, 9, 875-891, 2012

Gradients in $\langle CO_2 \rangle$ from natural fluxes



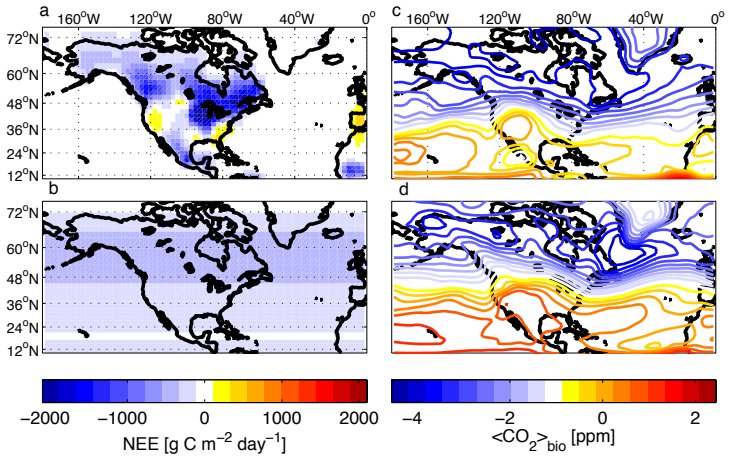
Variations in $\langle CO_2 \rangle$ owe largely to biospheric fluxes.

Effect remote fluxes on variations in $<CO_2>$



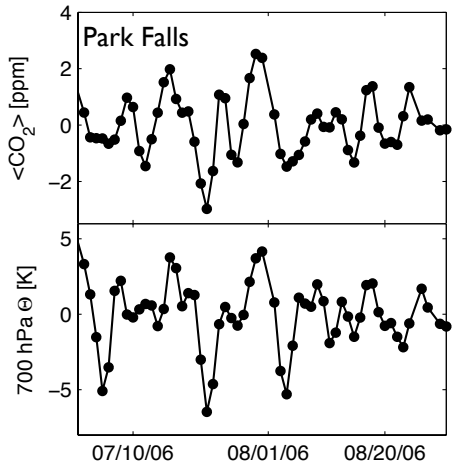
Variations in $<CO_2>$ dominated by large scale fluxes.

Local vs zonally uniform fluxes



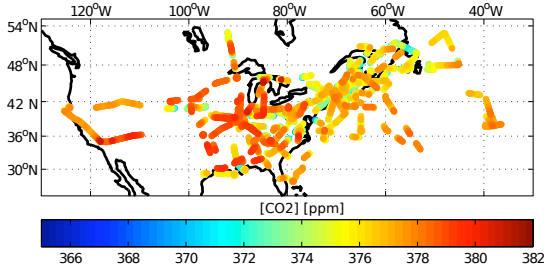
Spatial gradients tied to north-south flux gradient, not local fluxes.

Summer correlation with potential temperature

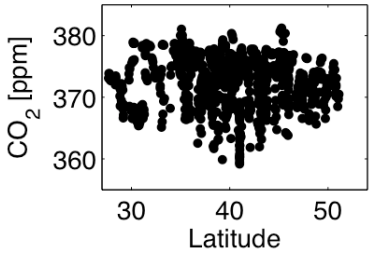


Day-to-day variations in $\langle CO_2 \rangle$ correlate with a dynamical tracer.

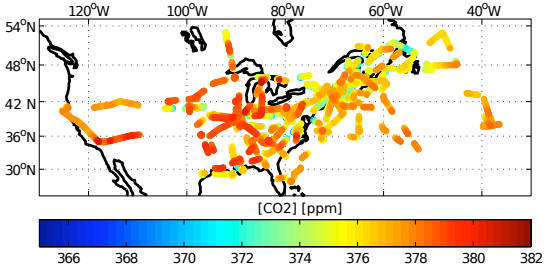
INTEX-NA: July-August 2004



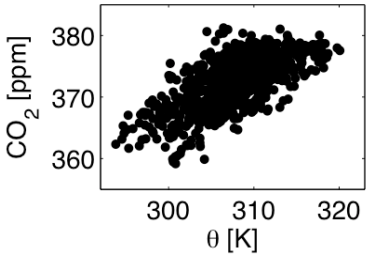
Large-scale observations of tropospheric CO_2 show much variability, only weekly determined by latitude.



INTEX-NA: July-August 2004



Variations in tropospheric CO_2 tied to variations in potential temperature.



Conclusions (?)

- For LEO (GOSAT/OCO-2/etc) I think we can essentially think of I_f and <CO2> as separate products (e.g. I don't see a value in the simultaneous nature of the observations.
- In a GEO application I believe the simultaneity could be useful (e.g. at regional scales, does d<CO2>/dt (over a day, say or over a few days) follow expectation based on I_f (GPP)?).