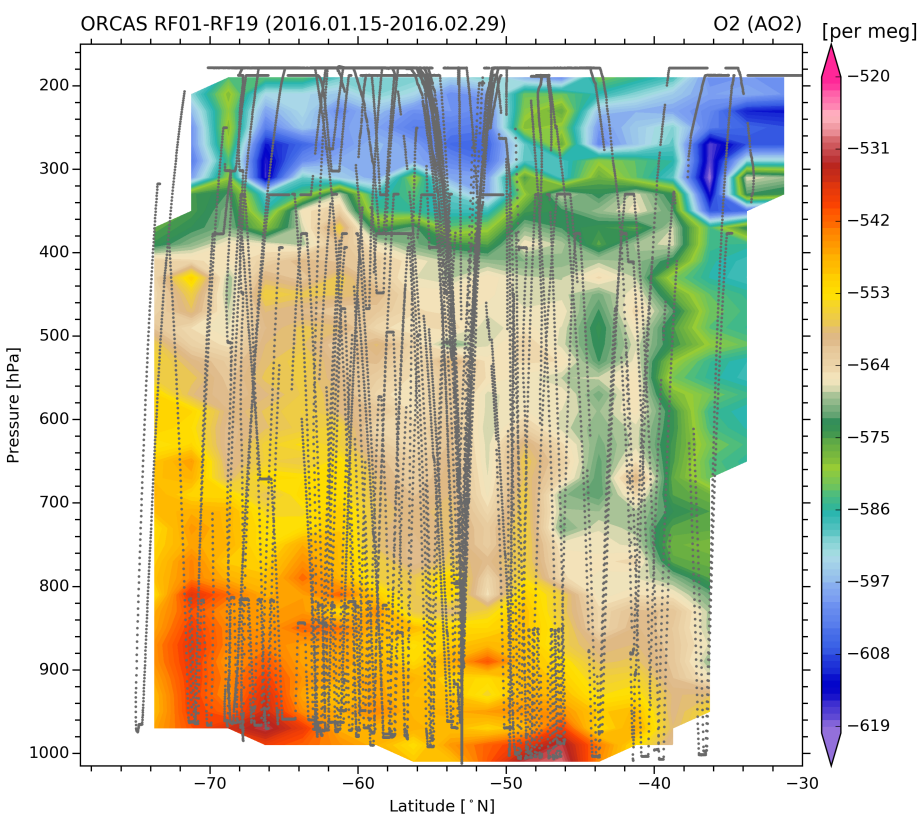
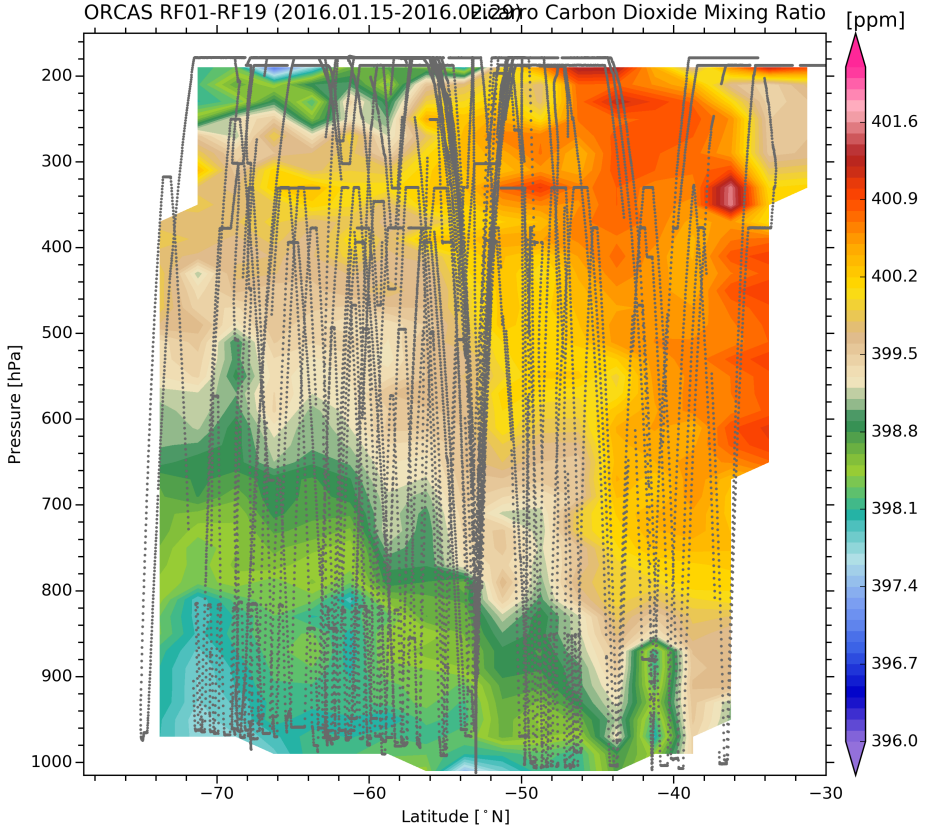
Zonal sections

Oxygen

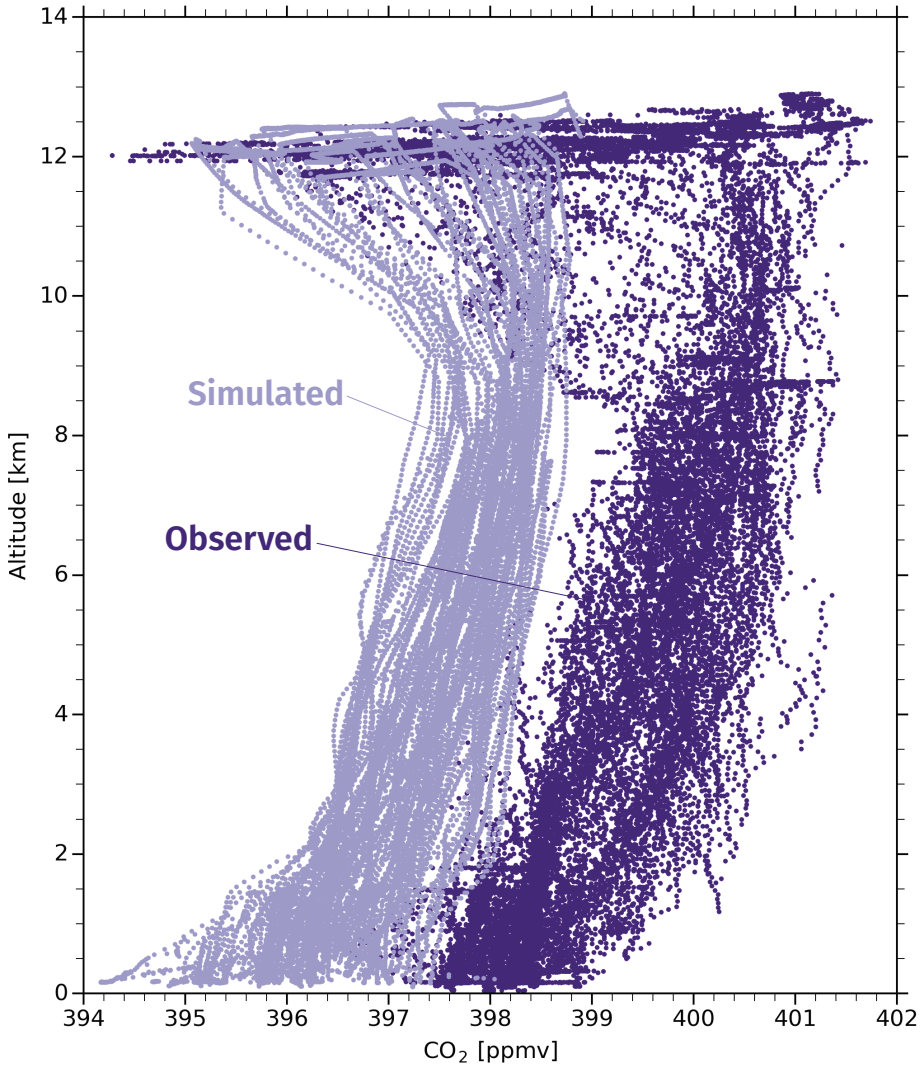


Carbon dioxide

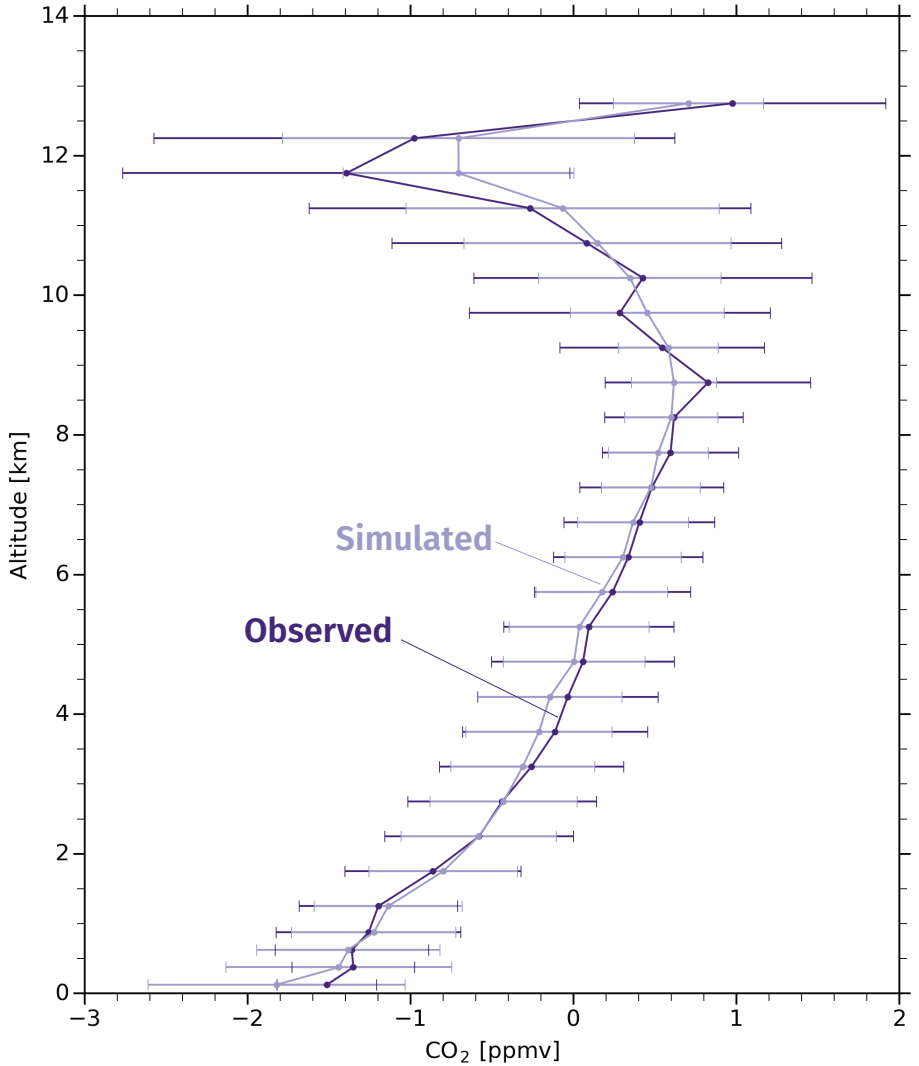


Vertical CO_2 gradient

CO_2 observations and model



CO_2 binned and adjusted



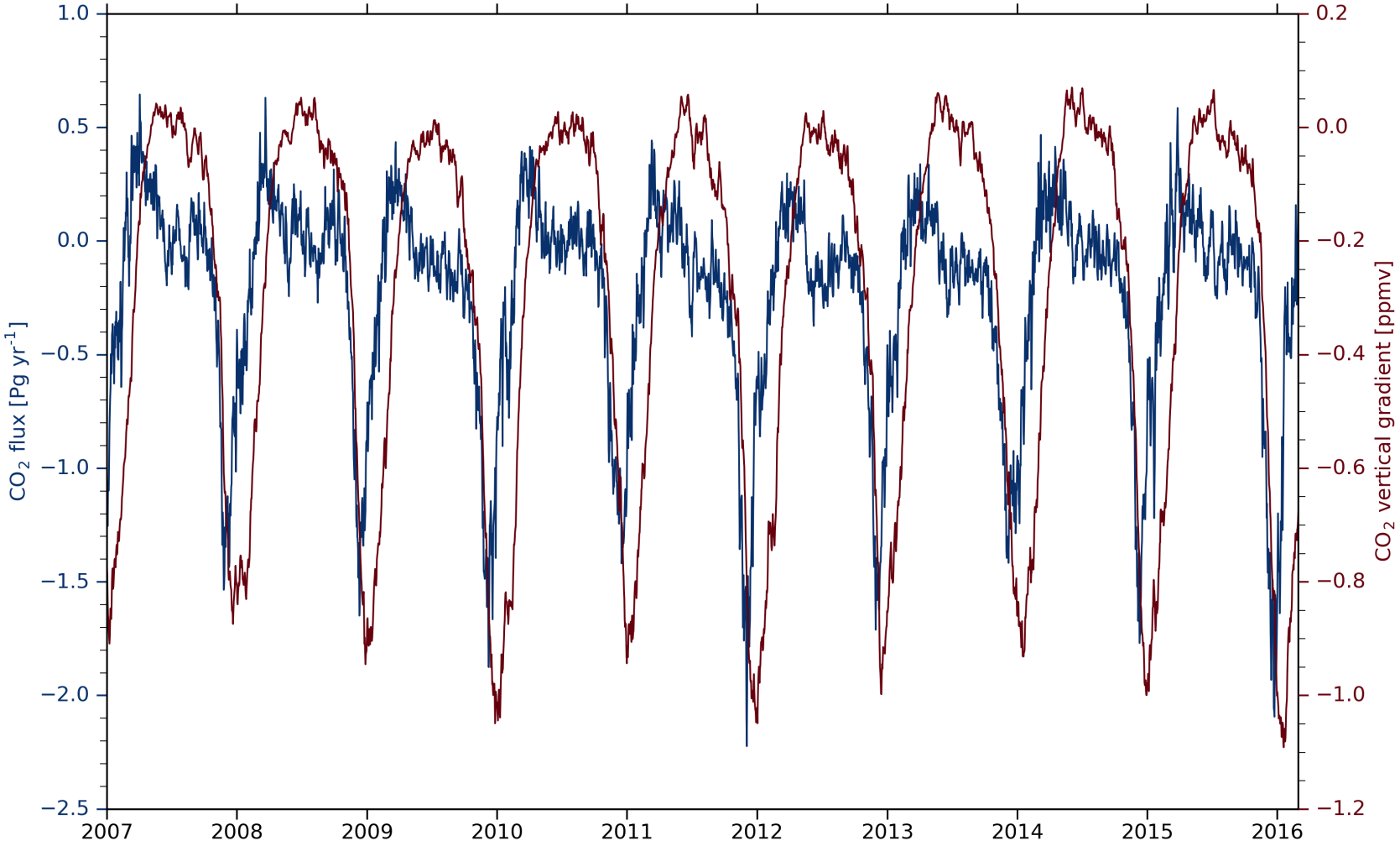
Extracting information from the vertical gradient

Does the observed vertical gradient constrain air-sea CO_2 fluxes?

1. **Spatial representativeness:** do the ORCAS observations provide an accurate estimate of the 'actual' vertical gradient?
2. **Region of influence:** Over what spatiotemporal region does the vertical gradient respond to air-sea fluxes?
3. **Contamination:** How do we account for the influence of fossil fuel, land, and extra-Southern-Ocean CO_2?
4. **Interannual variability:** Was 2015–2016 anomalous?

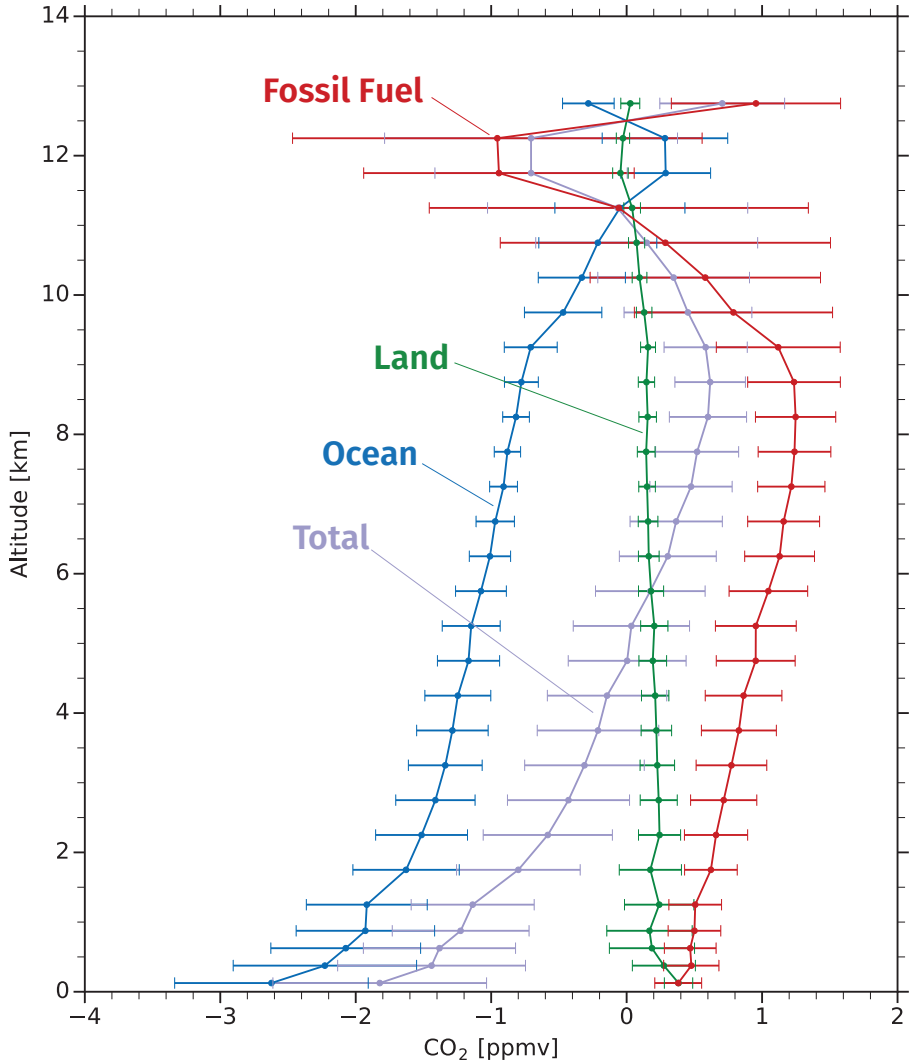
Vertical gradient is tightly related to regional fluxes

Prognostic CO_2 fluxes and vertical gradient



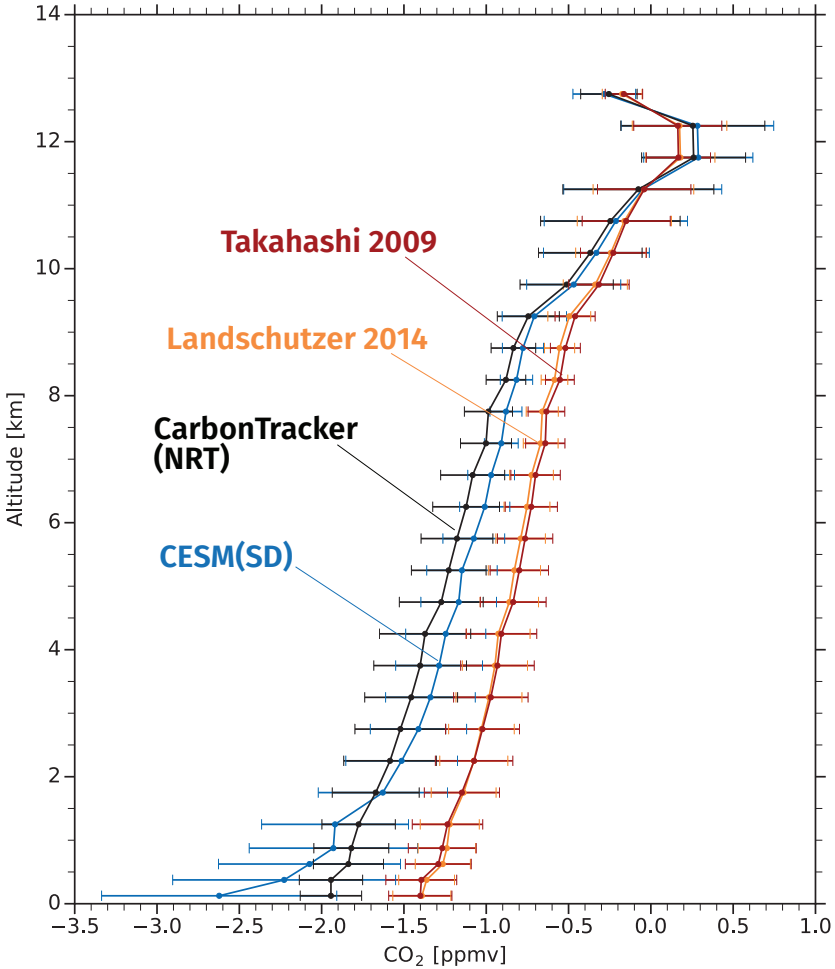
Ocean fluxes dominate vertical CO_2 gradient

CO_2 composition (simulated)

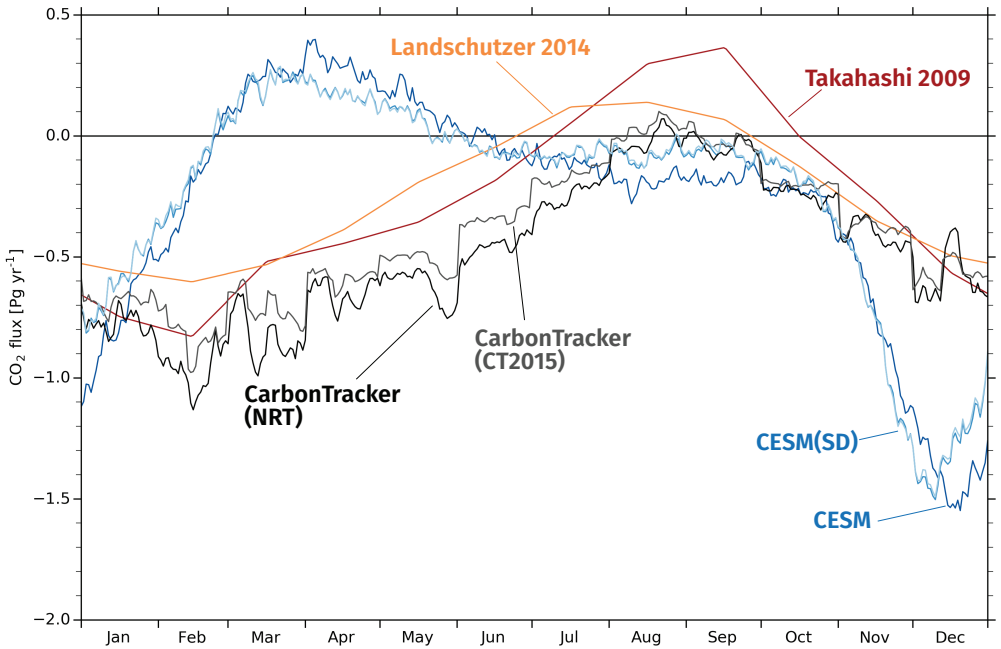


pCO_2-climatology fluxes yield a weak vertical gradient

Ocean-CO_2 fields in CAM(SD)

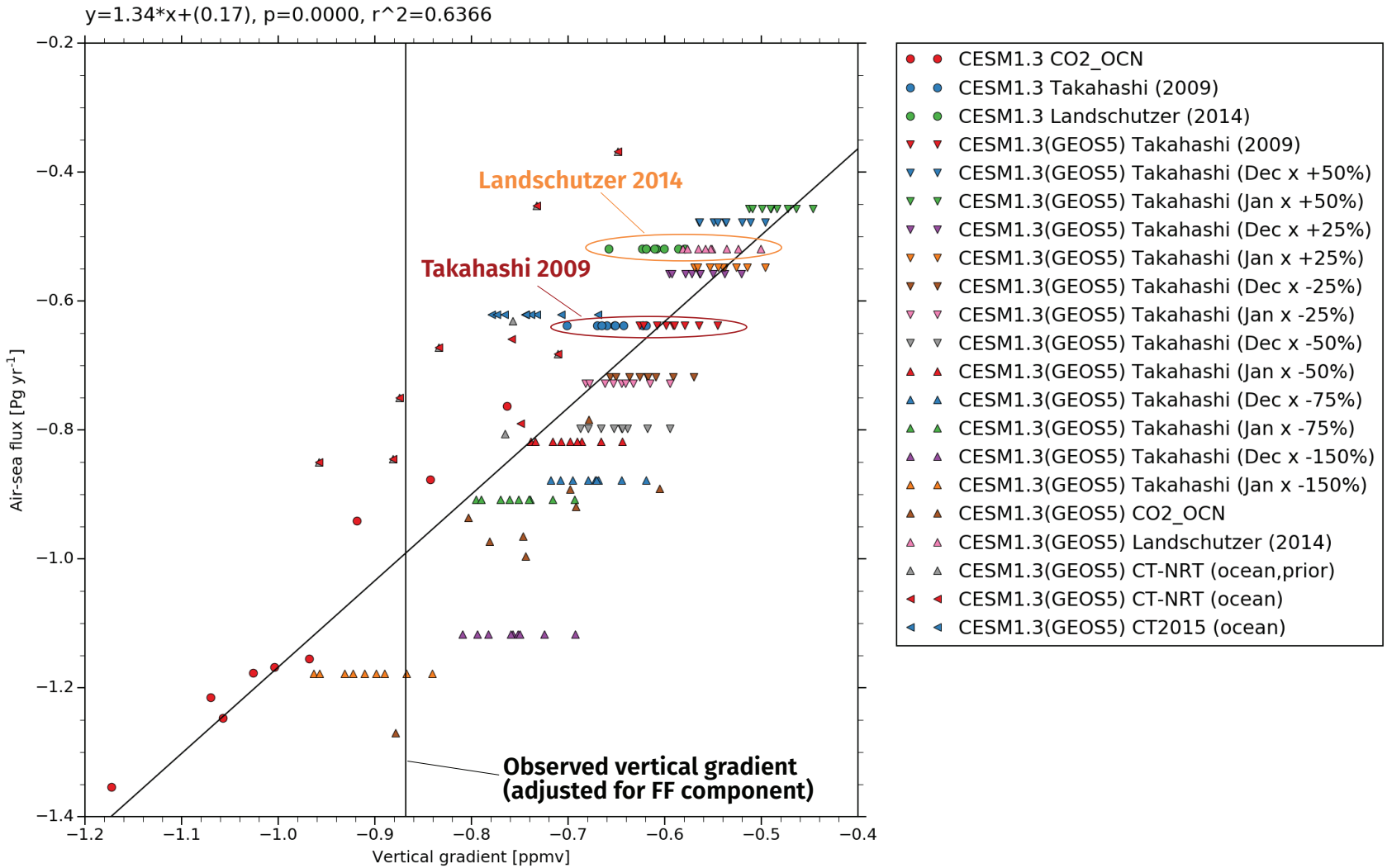


Air-sea CO_2 fluxes



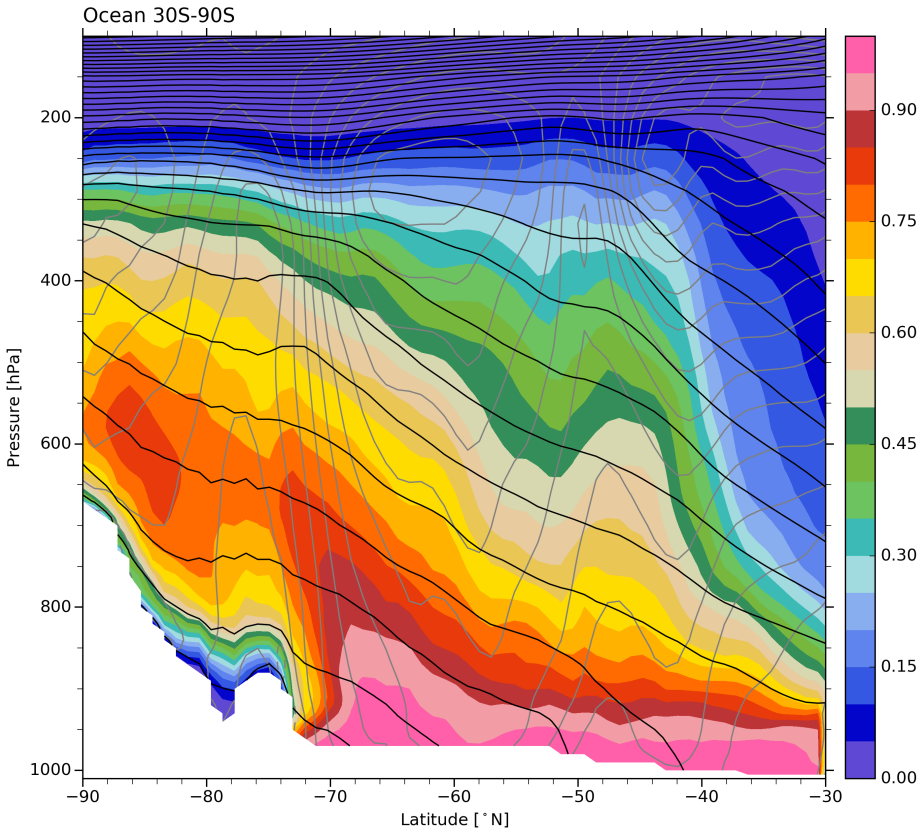
Calibrating an emergent constraint (preliminary)

Dec–Jan flux versus 15 Jan–Feb vertical gradient



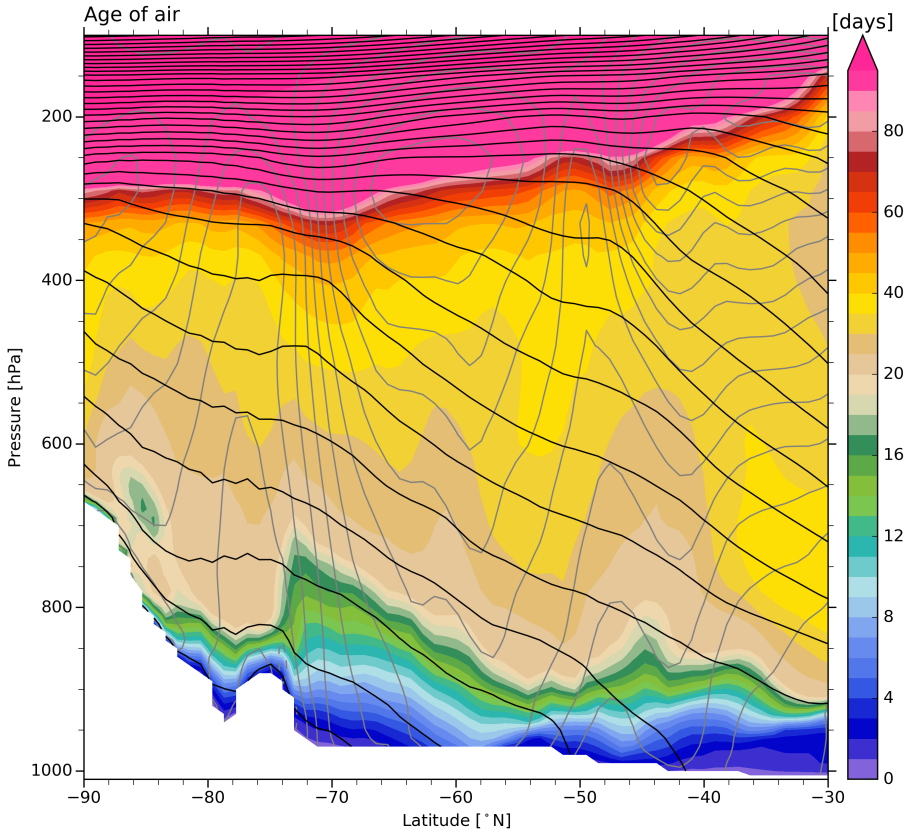
Air mass provenance and age

Southern Ocean air fraction



Zonal velocity (gray; -2.0 : 2.0 : 28.0 m/s)
Potential temperature (black; 275.0 : 5.0 : 445.0 K)

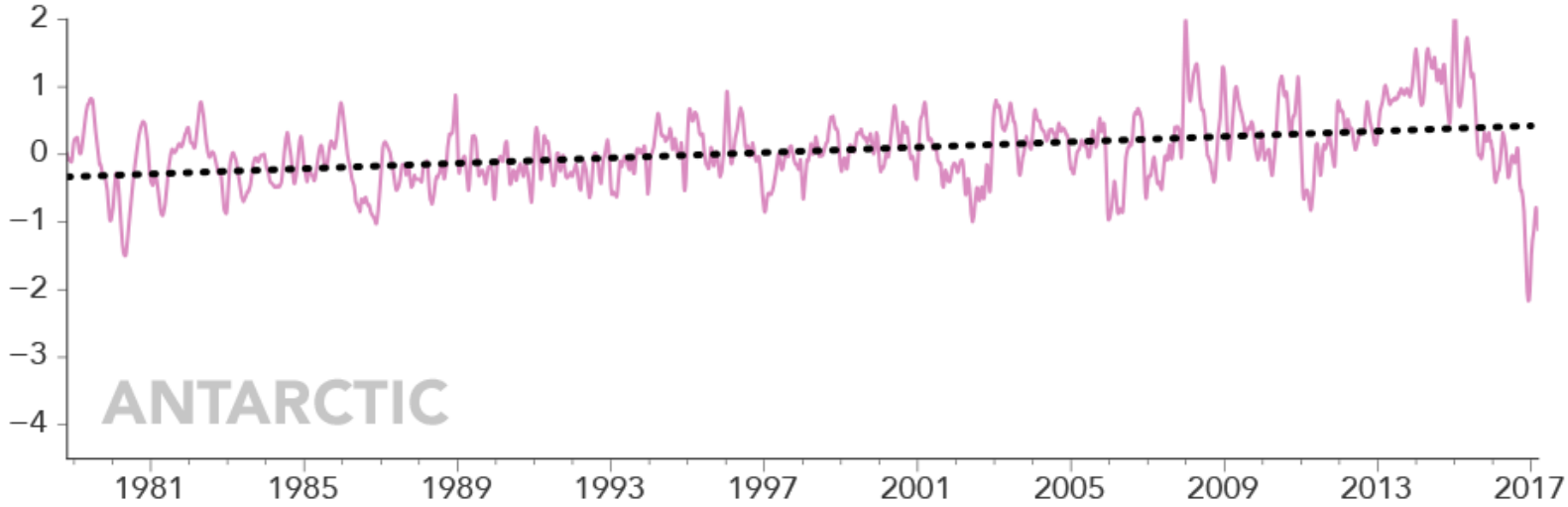
Time since last surface contact



Zonal velocity (gray; -2.0 : 2.0 : 28.0 m/s)
Potential temperature (black; 275.0 : 5.0 : 445.0 K)

Record sea-ice anomalies in 2016–2017

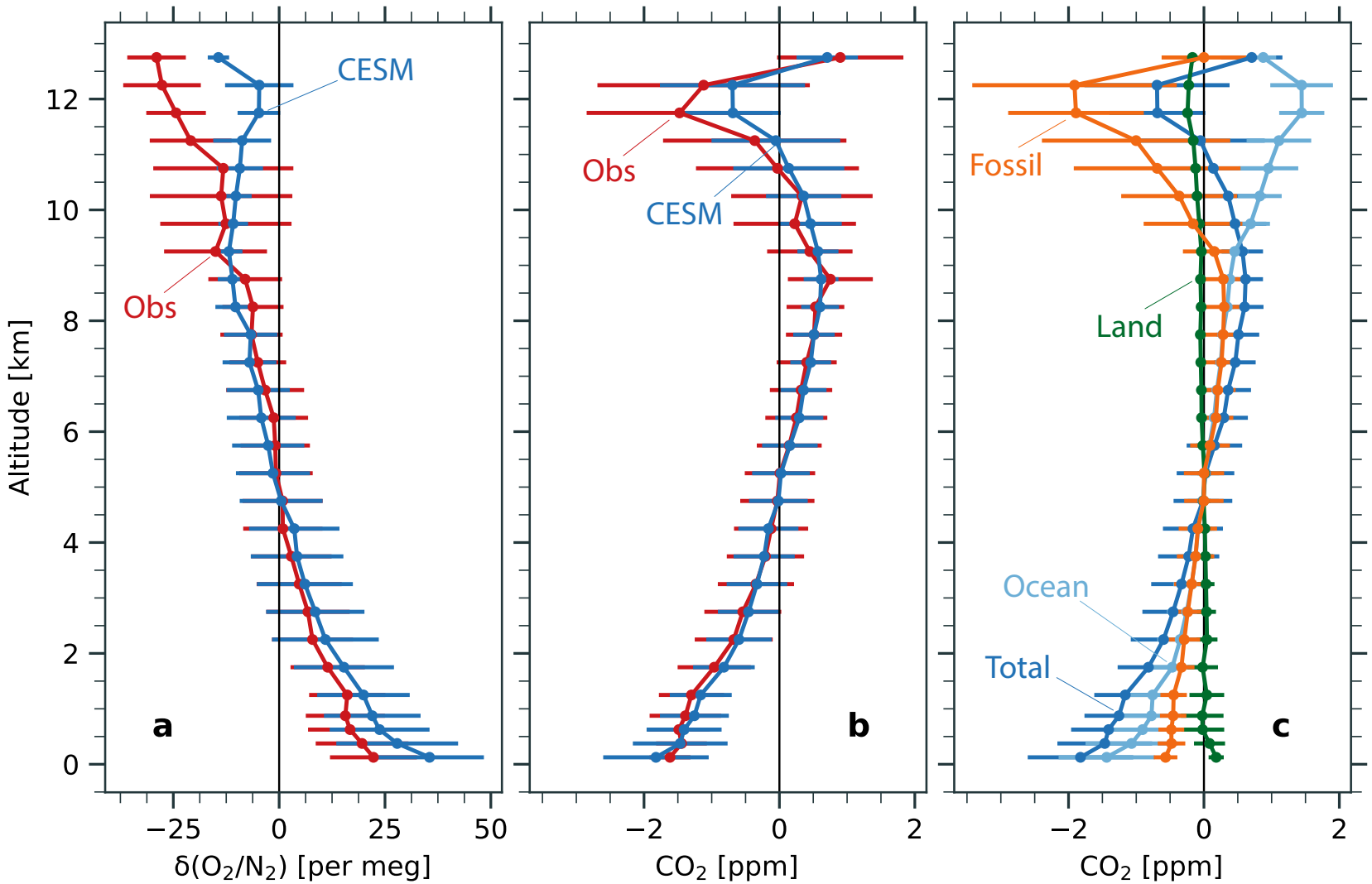
Sea-ice extent anomaly (10^6 km^2)



NASA Earth Observatory

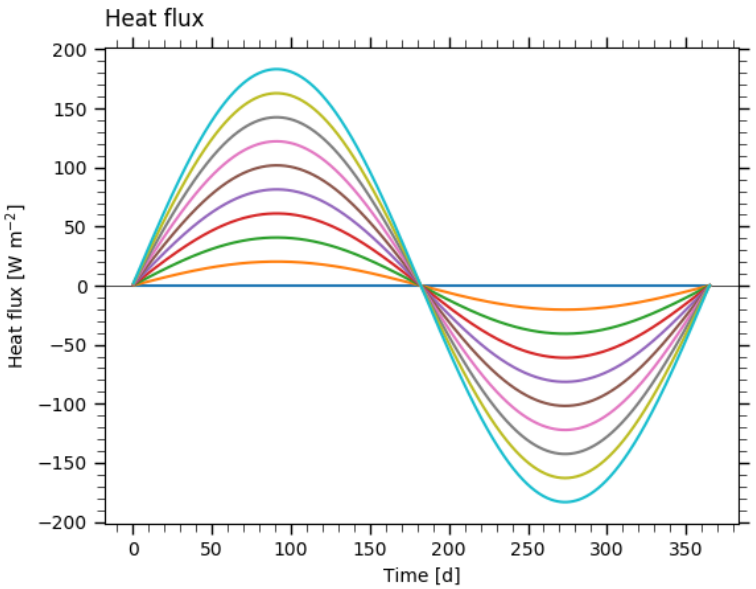
CO_2 simulation just right, but too much O_2

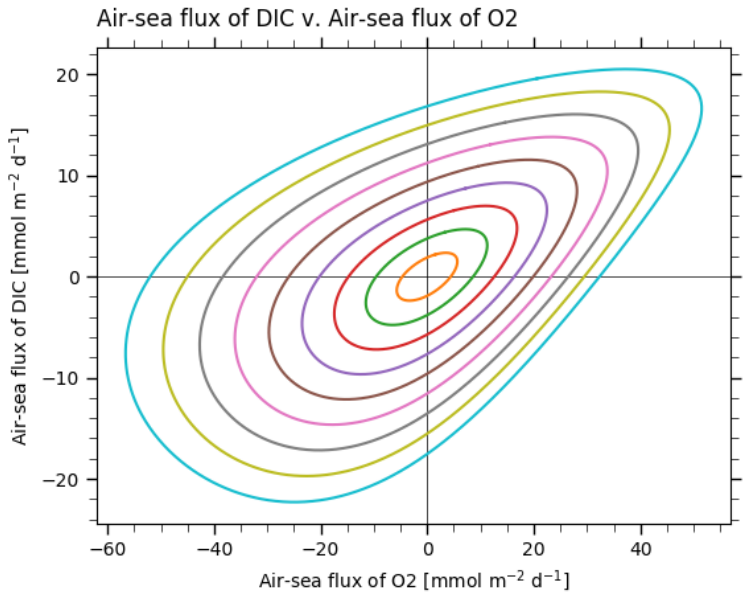
Bin-averaged vertical profiles



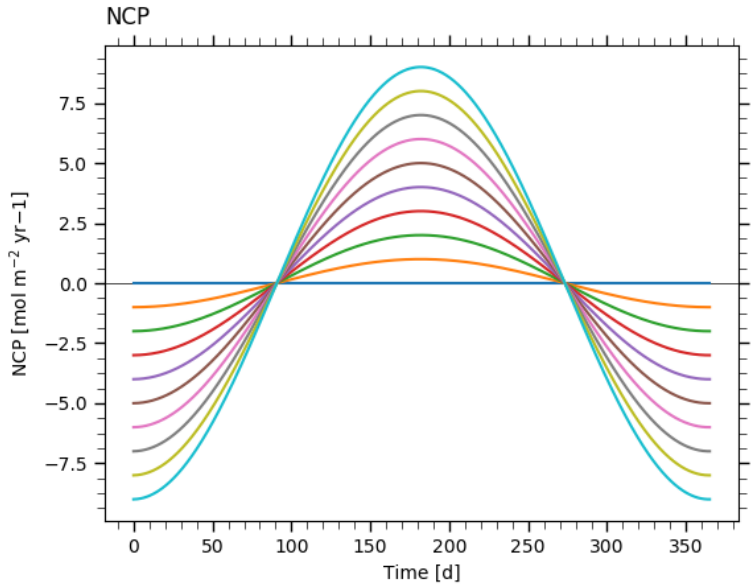
Box model

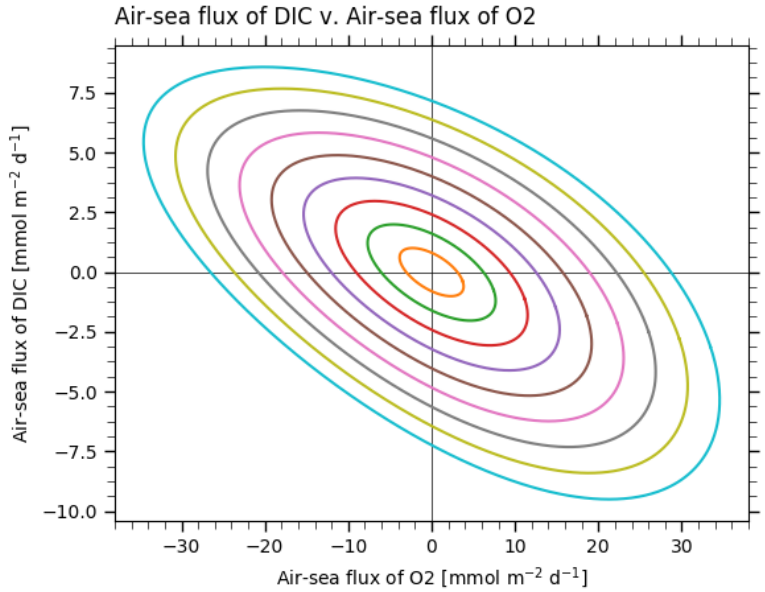
Pure thermal





Pure biological



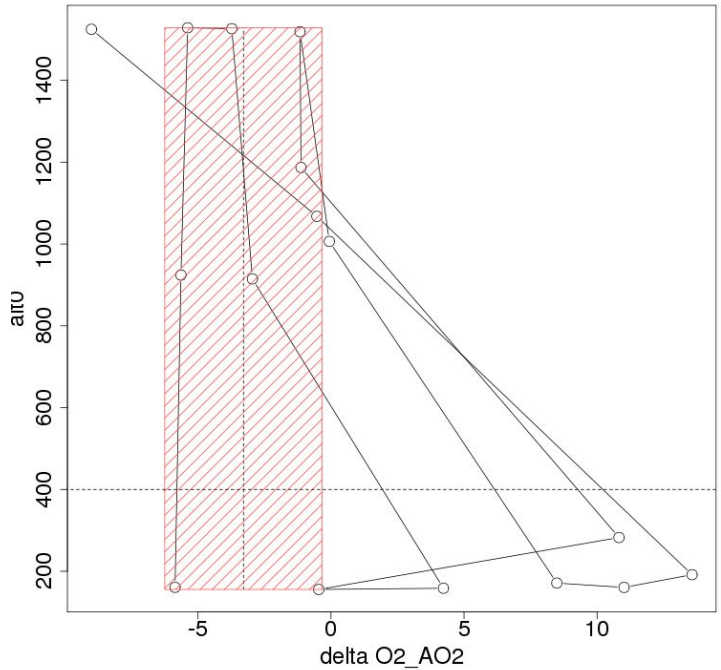


Constraining Southern Ocean air-sea carbon and oxygen fluxes over 100 - 1,000 km using airborne measurements

- Introduction
- Define detection limits for changes in CH4, CO2, and O2
  - Trajectories & Curtains to estimate detection limits
    - Use all gasses in free troposphere (500 m - 2 km)
    - Aggregate statistics of weakly exchanged gas (CH4, ?) in mixed layer
- Define regions of changes significantly different from zero for CO2, O2
  - Photosynthetic (CO2->Ocean, O2->Atmo)
  - Thermal (CO2 and O2 -> same place)
  - Respiratory (CO2-> Atmo, O2-> Ocean)
- Estimate fluxes (for significant changes in composition)
  - Constrain footprint error as related to velocity error
    - Compare observed / reanalysis velocities
- Compare fluxes in significant regions w/ climatology/model

Detection Limits of Lagrangian Sampling

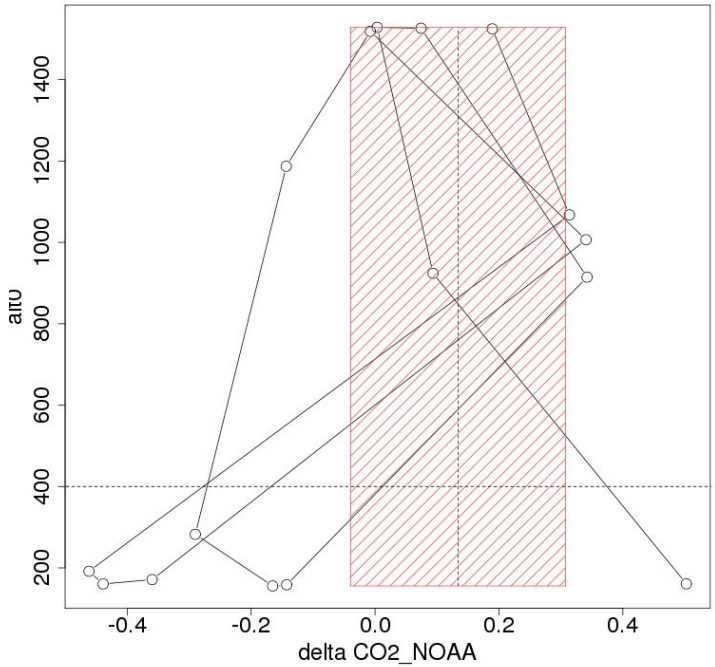
- Detection limits
  - CH4 ~ 0.3 ppb
  - CO2 ~ 0.1 ppm
  - O2 in Drake Passage ~ 1.6 perMeg
  - O2 in Argentine Basin ~ 2.9 perMeg
- Offset (transport error one component)
  - CH4 Offsets
    - Drake Passage -0.7 ppb
    - Argentine Basin 0.03 ppb
  - CO2 Offsets
    - Drake +0.2 ppm
    - Argentine +0.1 ppm
  - O2 Offsets
    - Drake -5.5 perMeg
    - Argentine -3.3 perMeg



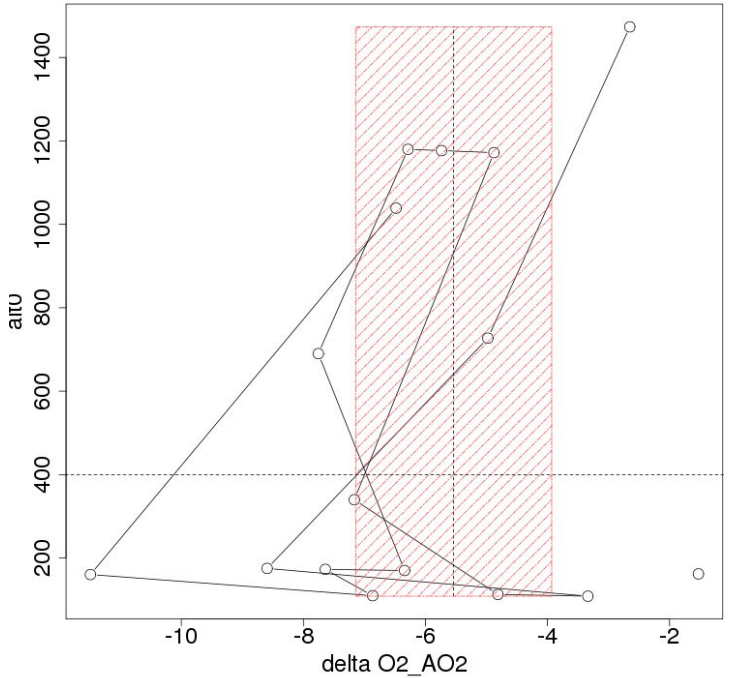
O2 from Argentine Basin
Horizontal dotted line indicates PBL height
Hatched area represents no significant change
Vertical dotted line indicates change in free troposphere

What are observed composition changes?

- Argentine Basin (Photosynthesis)
  - O2 from Ocean (previous slide)
  - CO2 into Ocean (see below)

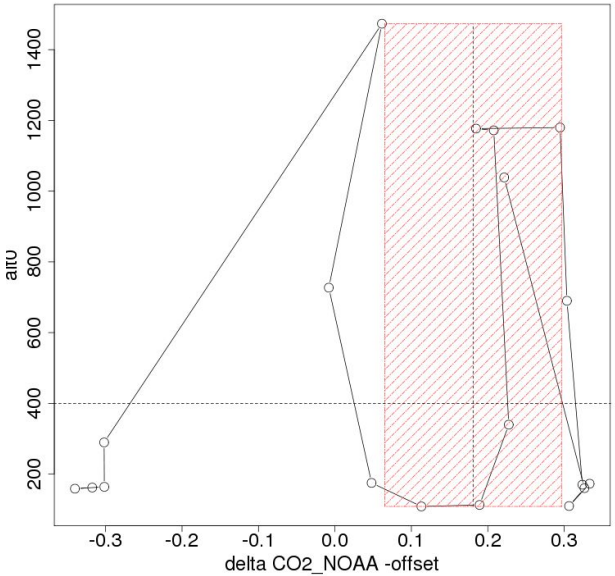


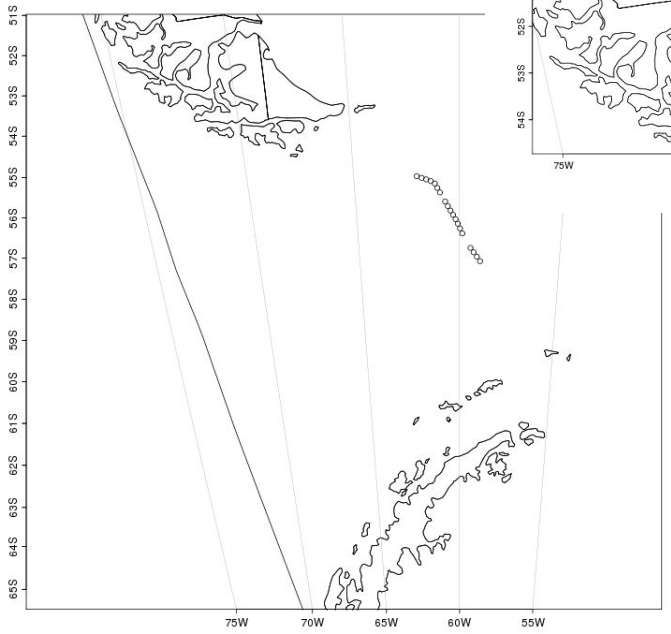
- Drake Passage (Thermal)
  - CO2 into Ocean (not shown)
  - O2 into Ocean (see below)

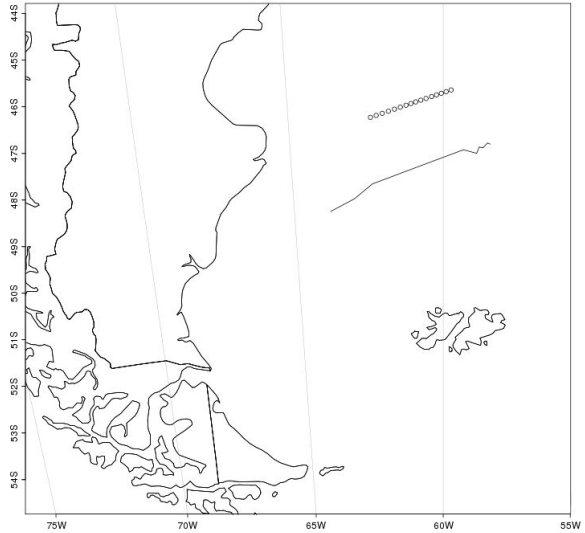


Plan/timeline for completion

- What do we need
  - Journal Suggestions?
- Submit draft ~August







Summertime Atmospheric Boundary Layer Gradients of O_2 and CO_2 over the Southern Ocean

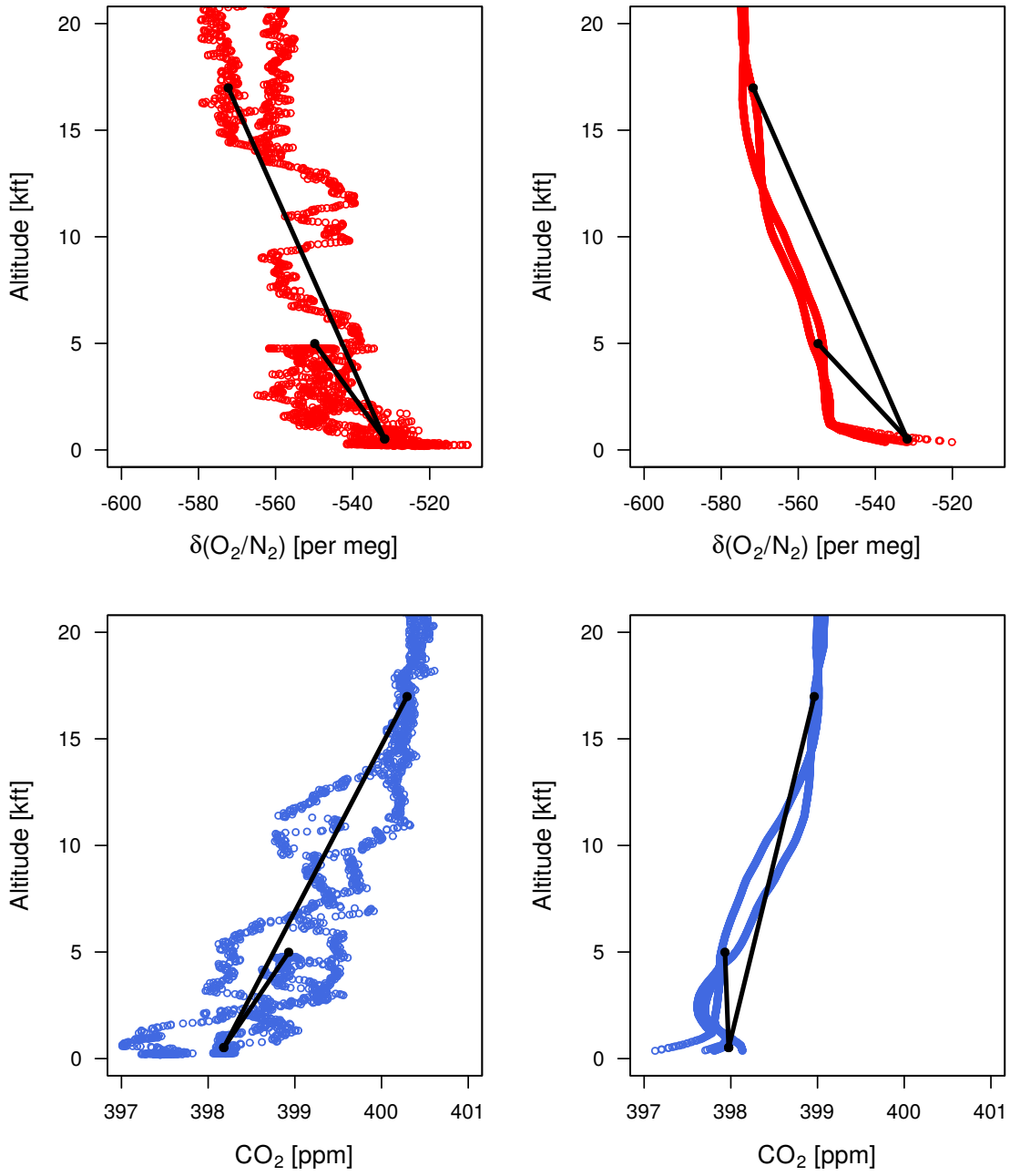
Status Update

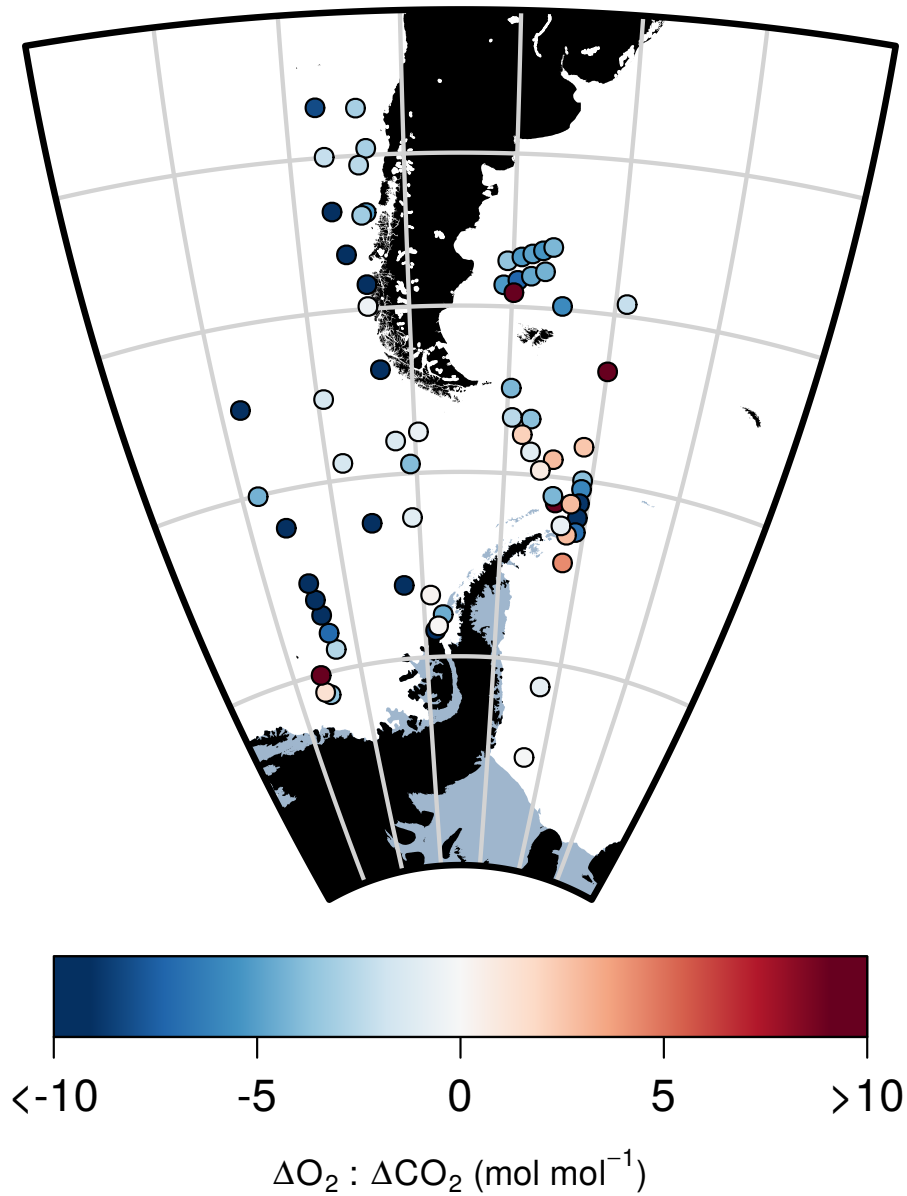
INTRODUCTION
- -Southern Ocean
- -O2:CO2
  - -Fig 1: toy model

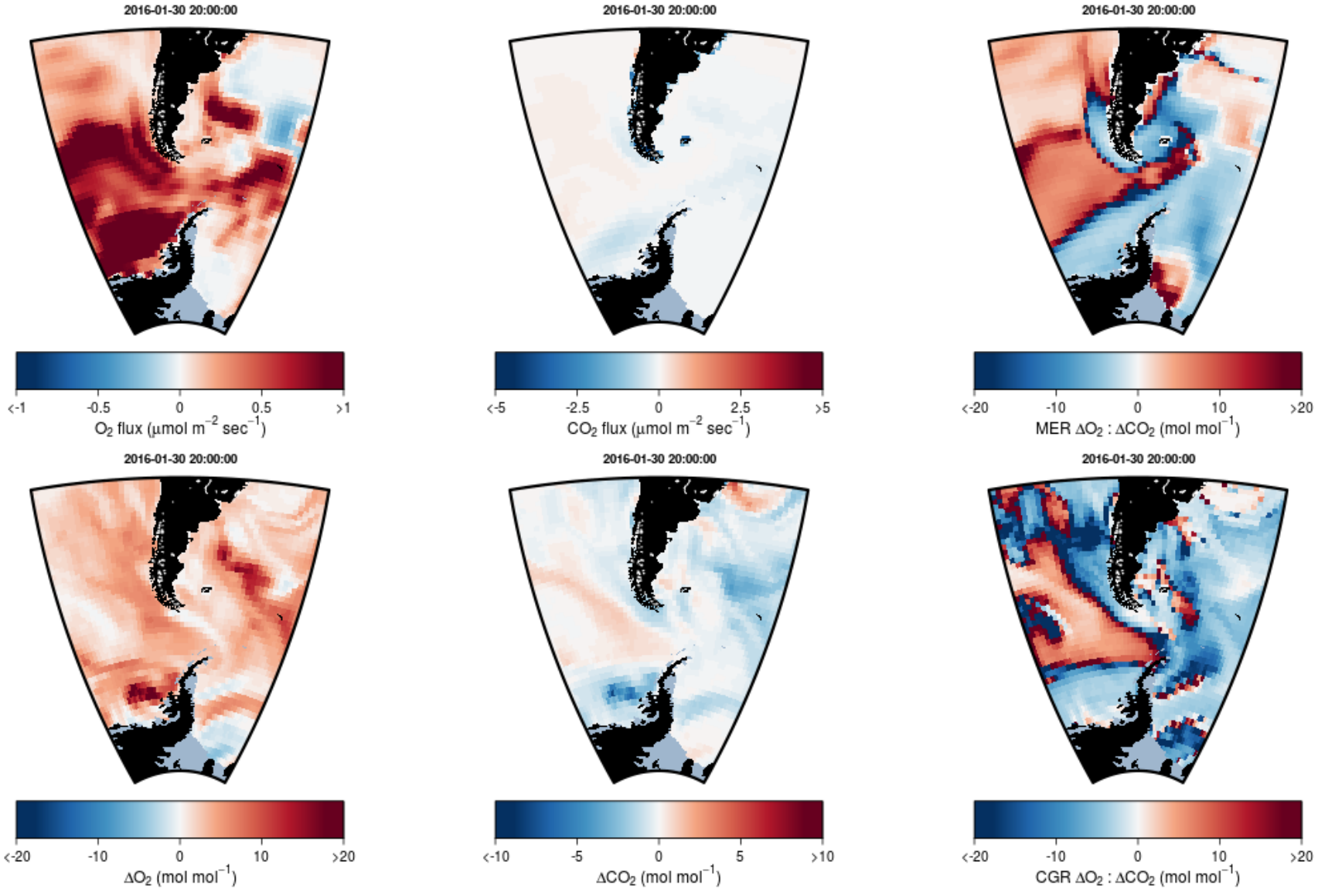
METHODS
- -ORCAS campaign
- -AO2 and Medusa
- -Picarro or CO2.X(?) if using
- -other in situ measurements where necessary (or just cite britt)
- -Flask analysis at SIO
- -Processing of airborne data (AO2 and Medusa & CO2.X if using)
- -Data analysis
- -Other data sources, models (STILT, CESM)

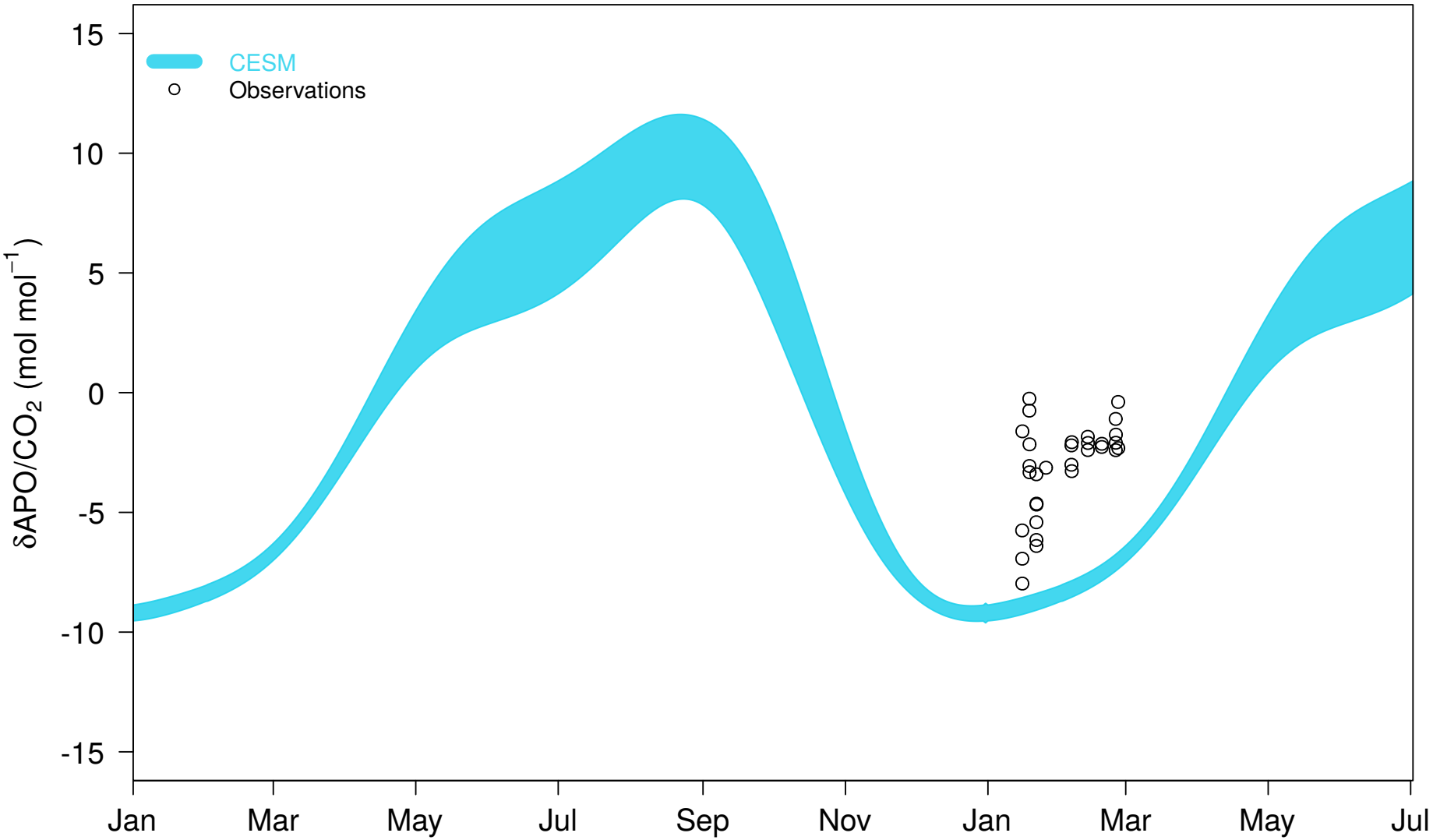
RESULTS/DISCUSSION
- -bl heights and S.O., why models struggle
  - -Fig 2: summary of BL heights in ORCAS, compare two theta profiles?
- -example dip
  - -Fig 3: multi-panel summary
- -justification of ref height selection
  - -Fig 4: multi-panel: histogram, maybe fprint sensitivity by alt,
- -average footprints surface compared to average ref height
  - -Fig 5: multipanel: avg footprints, lat vs alt
- -campaign average, maps of dips and histograms
  - -Fig 6: multi-panel: dip map, hist
- -sampling of N dips in model and obs
  - -Fig 7: multi-panel: sample N dips, converge to campaign average, then model for matching dips and whole domain
- -seasonality of bl gradients and ORs
  - -Fig 8: co2 gradients and o2 gradients w/ model, OR of gradients w/ model
- -fossil fuel gradients vs marine gradients
  - -Fig 9?: multi-panel: tracers and cesm ff gradients

Target journals: JGR Biogeosciences, Biogeosciences, ACP?


Altitude [kft]
δ(O2/N2) [per meg]
CO2 [ppm]
20
15
10
5
0
-600
-580
-560
-540
-520
397
398
399
400
401


<-10
-5
0
5
>10
ΔO2 : ΔCO2 (mol mol−1)


2016-01-30 20:00:00
<-1 -0.5 0 0.5 >1
O2 flux (µmol m-2 sec-1)
2016-01-30 20:00:00
<-5 -2.5 0 2.5 >5
CO2 flux (µmol m-2 sec-1)
2016-01-30 20:00:00
<-20 -10 0 10 >20
MER ΔO2 : ΔCO2 (mol mol-1)
2016-01-30 20:00:00
<-20 -10 0 10 >20
ΔO2 (mol mol-1)
2016-01-30 20:00:00
<-10 -5 0 5 >10
ΔCO2 (mol mol-1)
2016-01-30 20:00:00
<-20 -10 0 10 >20
CGR ΔO2 : ΔCO2 (mol mol-1)



Seasonality of $\delta\mathrm{APO}/\mathrm{CO}_2$ and ${\mathrm{O}_2}^{ocn}/\mathrm{CO}_2$