ORCAS Dry Run Flight Planning Meeting

Boulder, Colorado August 17-19, 2016

ORCAS Motivation:

- The Southern Ocean is a large sink for anthropogenic CO_2 with particular sensitivity to climate change.
- State-of-the-art Earth System Models diverge for seasonal Southern Ocean air-sea CO_2 and O_2 fluxes, and for Southern Ocean climate-carbon feedbacks.
- Atmospheric O_2 provides unique constraints on the biological, thermal, and anthropogenic drivers of Southern Ocean CO_2 exchange.

ORCAS Measurement Objectives:

Large scale

(45-70 S, 0-14 km altitude) atmospheric O_2 and CO_2 distributions, characterizing the size and temporal growth of the zonal atmospheric O_2 plume, and constraining zonal fluxes on monthly to seasonal time scales.

Basin scale

Vertical atmospheric O_2 and CO_2 gradient ratios through the mid-troposphere and spatial distributions to support estimation of flux ratios and magnitudes over full campaign time period and spatial extent.

Regional scale

Pseudo-Lagrangian flights for localized daily flux estimates and O_2 and CO_2 gradient ratios across the top of the ABL.

Plus:

Remote sensing of hyperspectral ocean color over daily flux influence regions and along the Antarctic Peninsula.

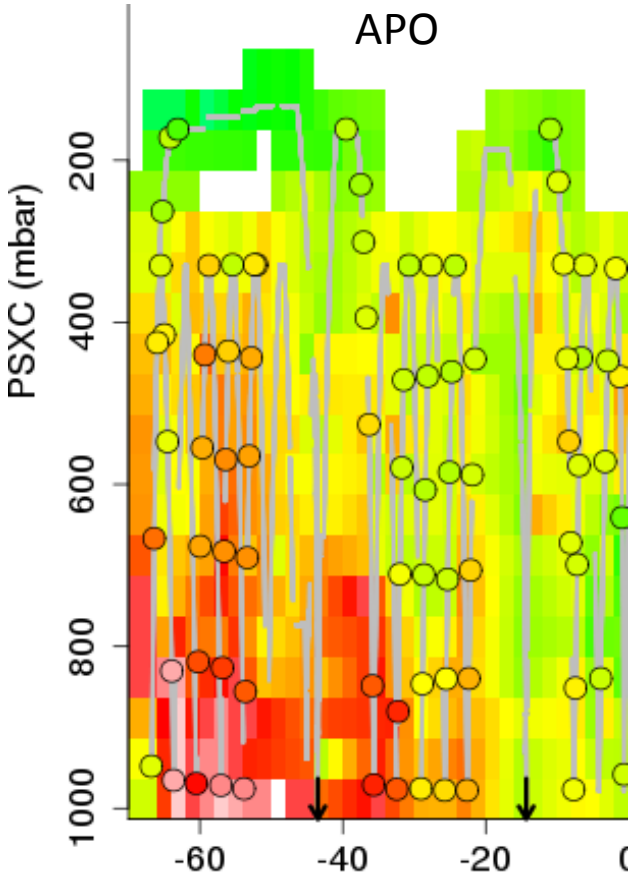
Biogenic reactive gas measurements to quantify emissions of chemically and radiatively important species.

Cloud microphysics measurements to address large discrepancies in climate models

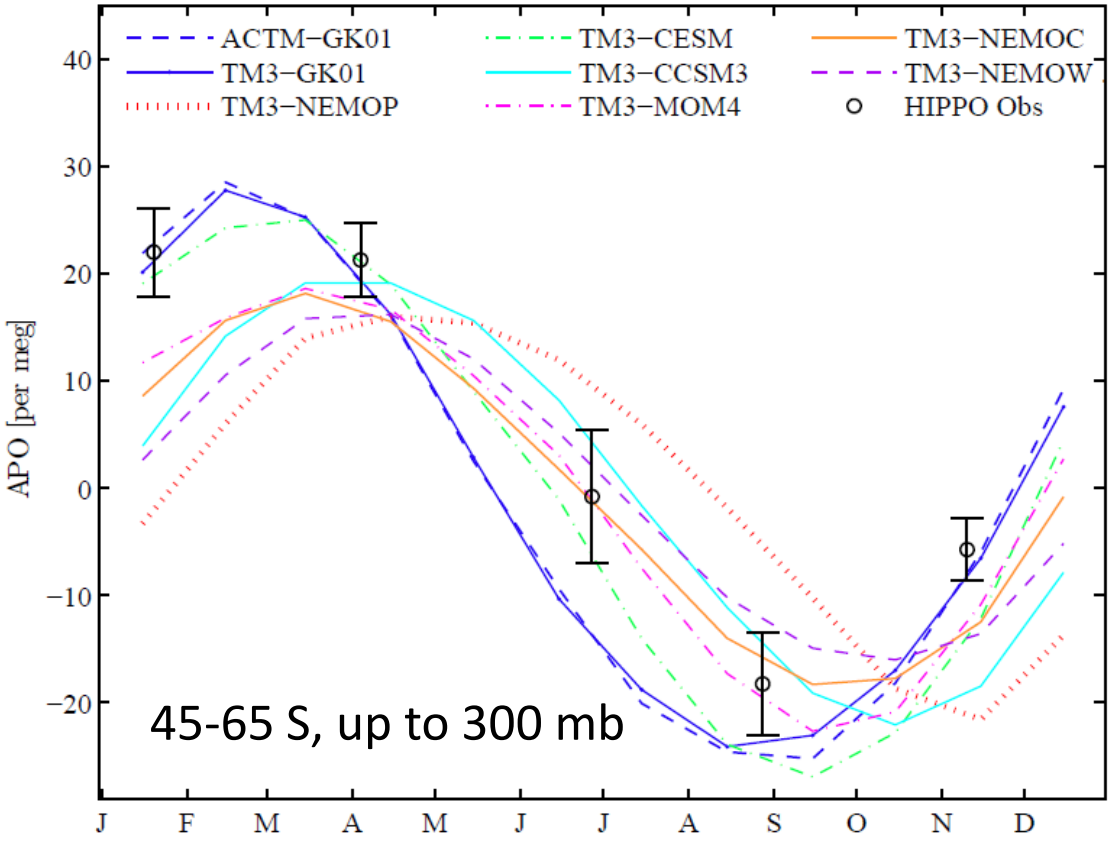
Large scale objectives

- Magnitude
- Evolution
- Latitudinal gradient

HIPPO1 January 2009
APO



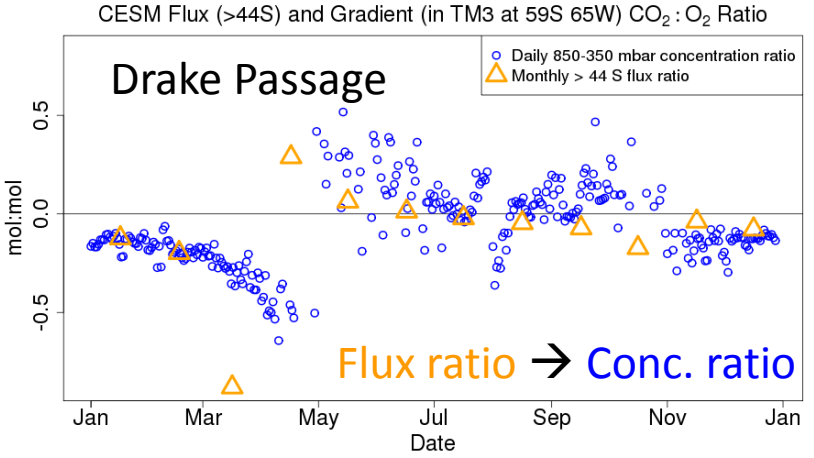
HIPPO Southern Ocean Curtain Averages

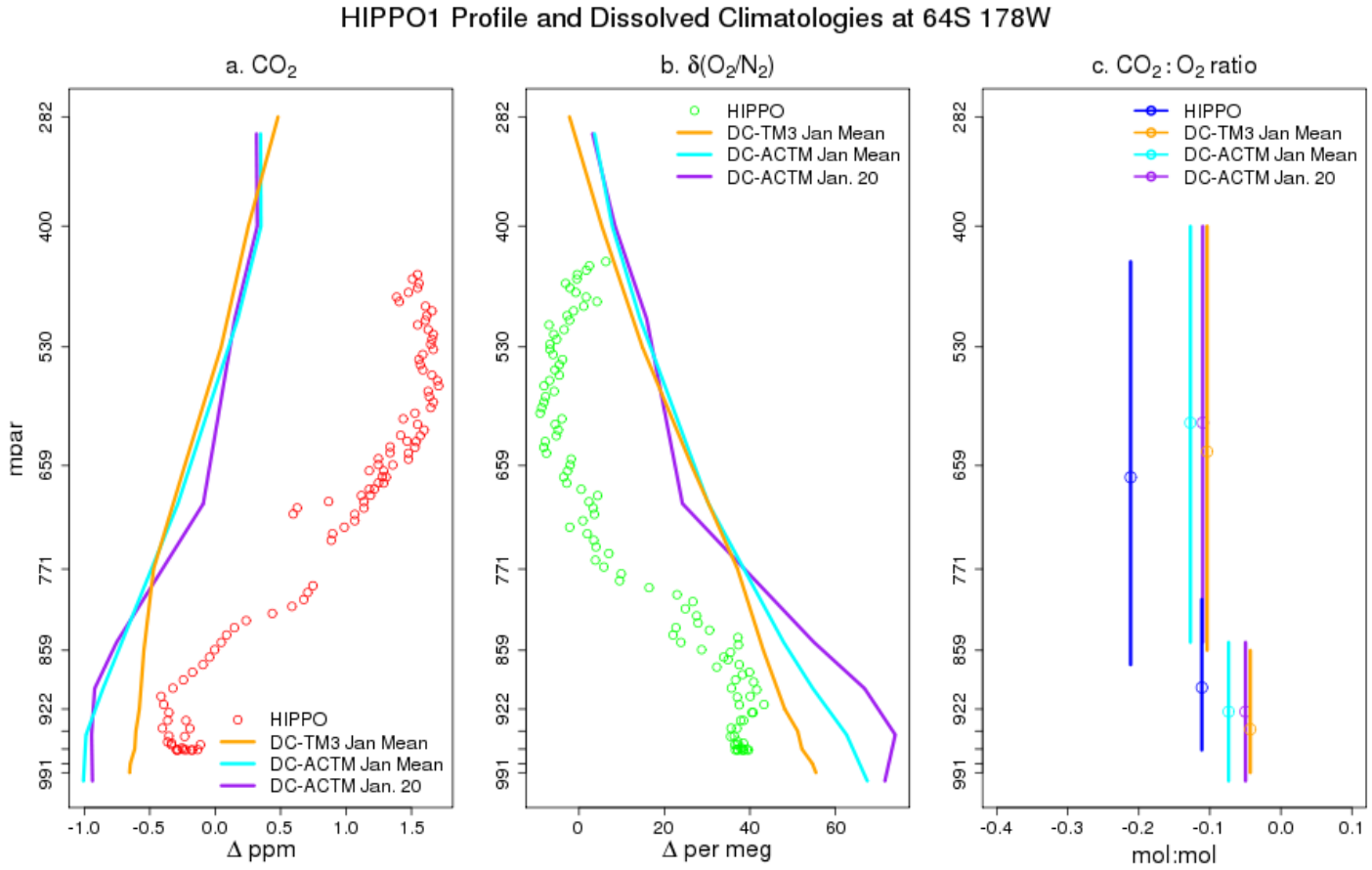


J. Bent, Dissertation, 2014

Ratio objectives

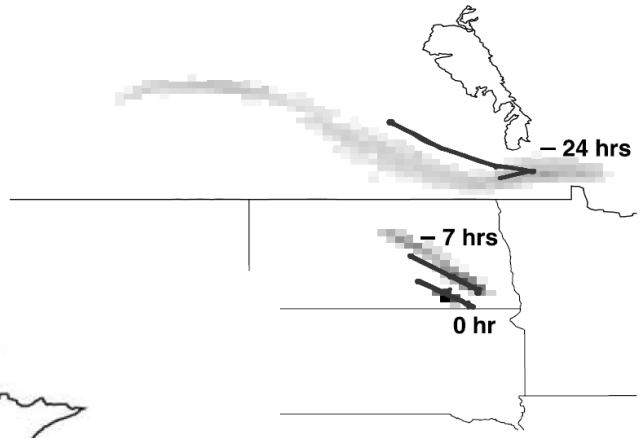
- mid-troposphere
- boundary-layer transition

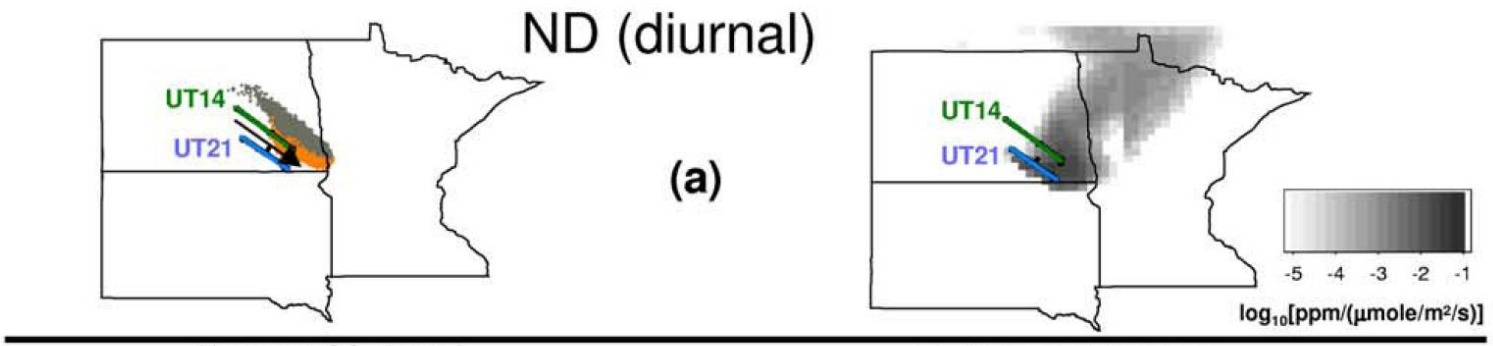


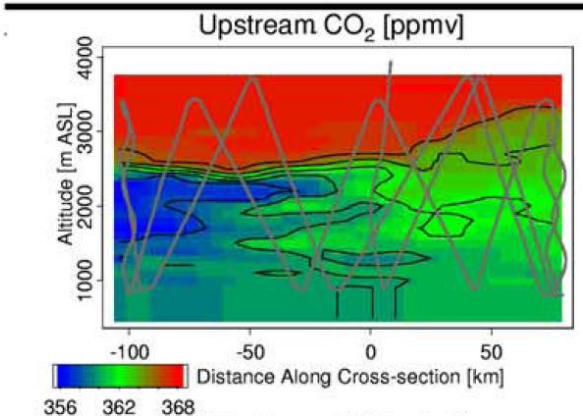


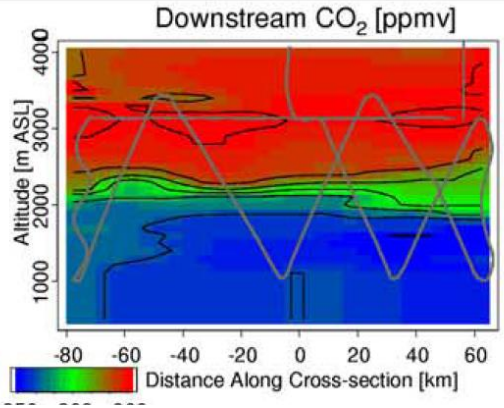
Lagrangian objectives

- 4-30 hour experiments
- entire campaign assimilation









Measuring fluxes of trace gases at regional scales by Lagrangian observations: Application to the CO_2 Budget and Rectification Airborne (COBRA) study

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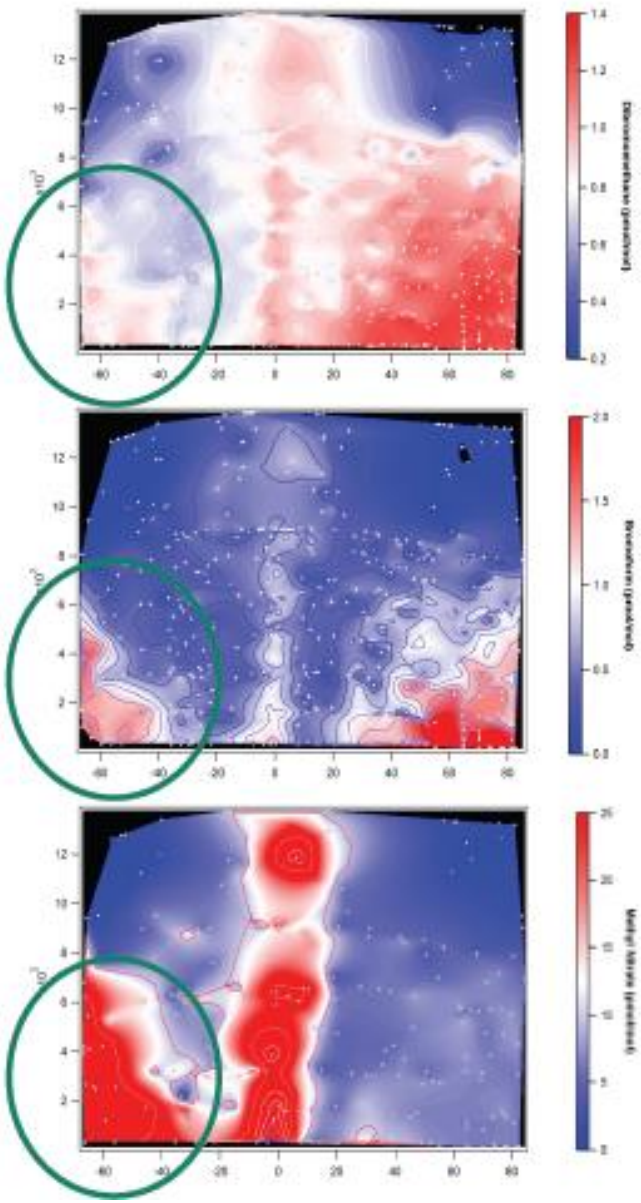
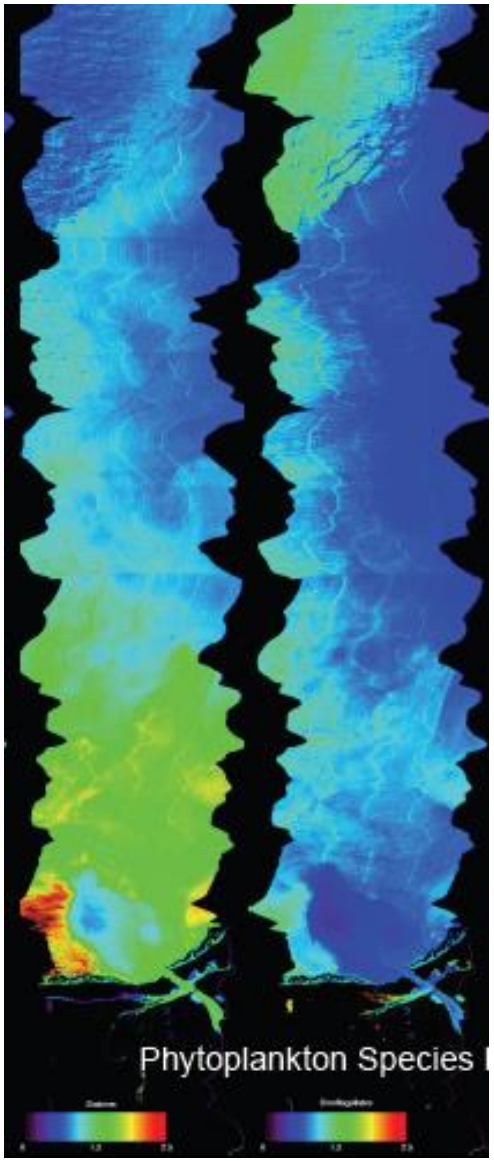
JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 109, D15304, doi:10.1029/2004JD004754, 2004

Reactive gas, remote sensing, and cloud microphysics objectives





- targets of opportunity
- dedicated flights/segments

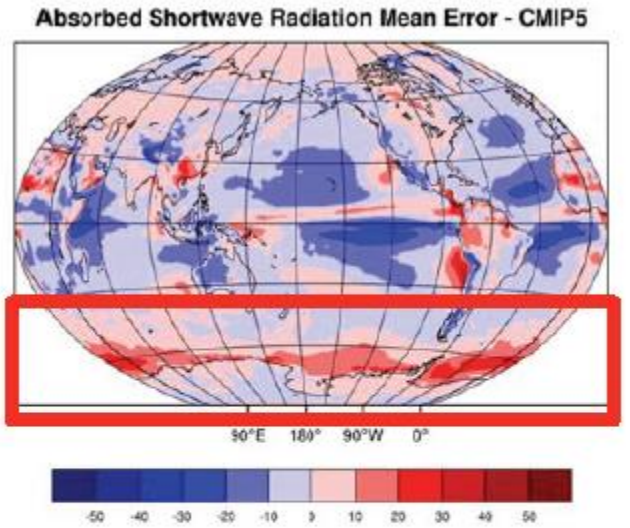


Figure 1: CMIP5 model clouds do not reflect enough sunlight. *Ensemble mean error for CMIP5 models in shortwave radiation absorbed by the Earth System. Positive values indicate too much shortwave radiation absorbed.*

ORCAS Project Overview:

- **Nominal mission plan:**
  - 14-15 × 6-8 hour flights for a total of 98 research flight hours (+ any TF savings)
  - 6 large-scale survey flights, SW and SE flights in weeks 1, 3/4, and 6.
  - 3 pairs of two-day Lagrangian flights, or 2 pairs plus 2 days of intensive BL sampling
  - 1-2 dedicated remote sensing flights
  - 1 dedicated student flight
  - Upload and deployment calendars (PMs)
  - Mission planning calendar (BBS)

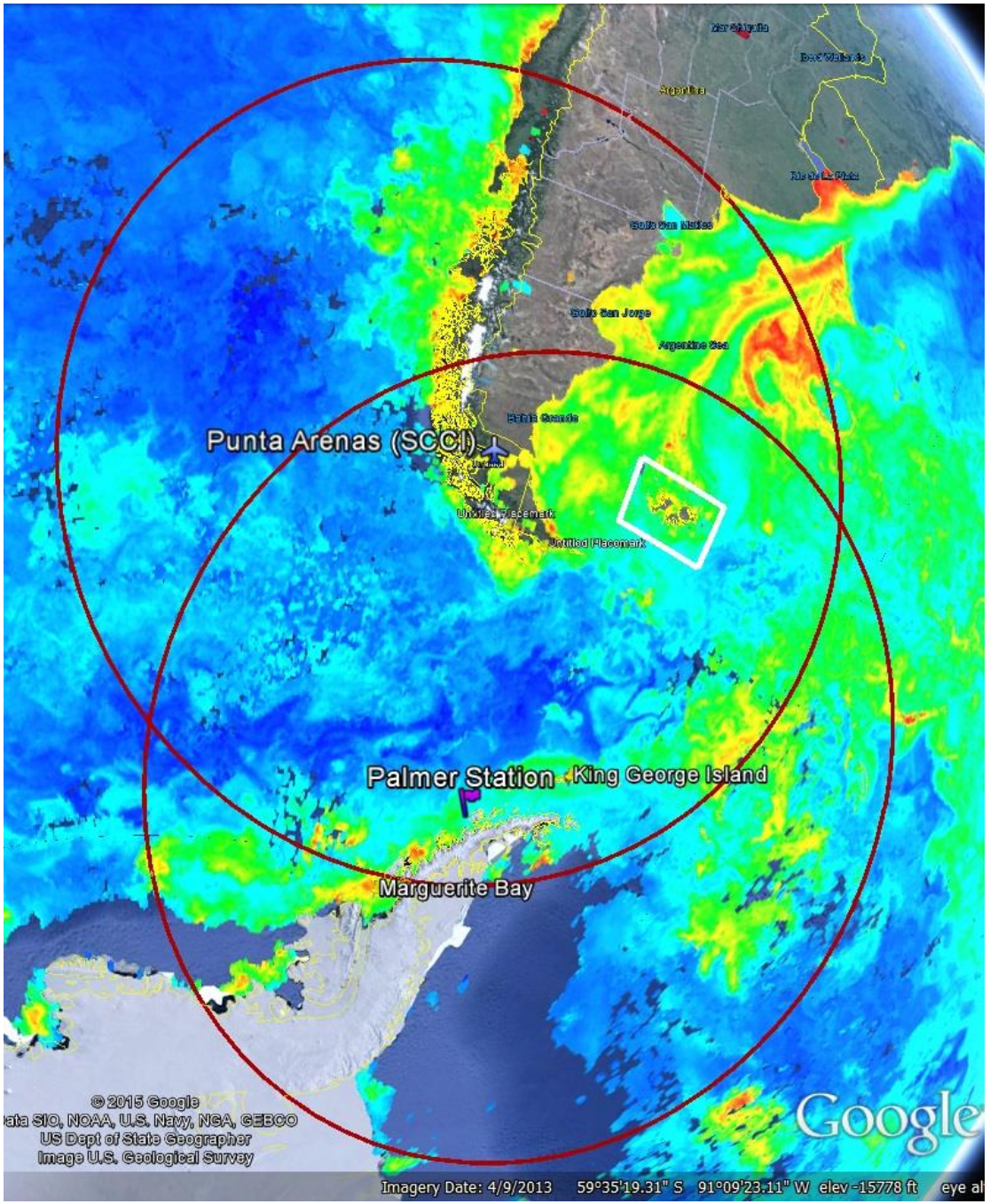
- **Synergistic observations:**
  - Palmer LTER cruise and $\Delta O_2/Ar$ sampling aboard the NSF ARSV L.M. Gould
  - pCO_2, DIC, nutrients, and atm. CO_2 and O_2 on the Gould
  - Palmer Station flasks
  - NSF OOI Southern Ocean node
  - SOCCOM biogeochemical profiling floats
  - biogeochemical gliders
  - OCO-2 satellite CO_2

GV Scientific Payload:

Instrument	Measurement	Institution
Airborne Oxygen Instrument (AO2)	$\delta(O_2/N_2)$, CO_2	NCAR EOL
Medusa Flask Sampler	$\delta(O_2/N_2)$, CO_2, $\delta(Ar/N_2)$, $\delta^{13}C$, $\delta^{18}O$, and $\Delta^{14}C$ of CO_2	NCAR/Scripps
Quantum Cascade Laser Spectrometer (QCLS)	CO_2, CH_4, N_2O, CO	Harvard/Aerodyne/NCAR
Picarro	CO_2, CH_4, H_2O	NOAA/CU
Portable Remote Imaging Spectrometer (PRISM)	Hyperspectral water-leaving radiance	JPL
Advanced Whole Air Sampler (AWAS)	Over 80 trace gases, including DMS, OCS, halocarbons, $MeONO_2$, isoprene	NCAR/U. Miami
HIAPER Trace Organic Gas Analyzer (TOGA)	Over 60 VOCs, including nitrate species, DMS, and VSL halocarbons	NCAR
VCSEL, King Probe, RICE, CDP, 2DC, CN, UHSAS, GNI, CLH-2	Cloud microphysics and aerosol size distributions	NCAR, CU

Approximate GV range

(without supplemental O_2 and doing a lot of BL sampling)



Link to Agenda

Goals of this meeting:

- Getting familiar with forecast resources and routine
- Getting feet wet making flight planning decisions
- Evaluating what tools or analysis still needed to optimize flights
- Specific questions
  - Benefit of SW and SE large scale pairs?
  - Better to fly 45-65 S or 50-70 S?
  - S/N for reactive gases vs. O_2 and CO_2
  - What do remote sensing flight plans look like?
  - Should large scale surveys be tailored to overfly cloudless areas?
  - What adjustments can be made pre-takeoff? During flight?
  - And many more

The O_2/N_2 Ratio and CO_2 Airborne Southern Ocean Study (ORCAS)

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Collaborative Science Team:

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