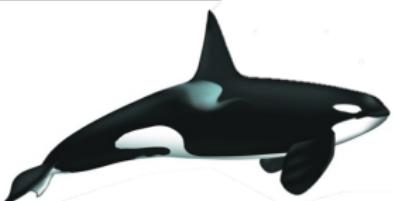


# The O<sub>2</sub>/N<sub>2</sub> Ratio and CO<sub>2</sub> Airborne Southern Ocean Study (ORCAS)



Principal Investigators:

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(National Center for Atmospheric Research)

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Eric Kort (U. Michigan)

Collaborative science team:

Nikki Lovenduski, and David Munro (U. Colorado);

Michelle Gierach (JPL); Heidi Dierssen (U. Connecticut);

Hugh Ducklow (LDEO); Scott Doney (WHOI); Nicolas Cassar (Duke);

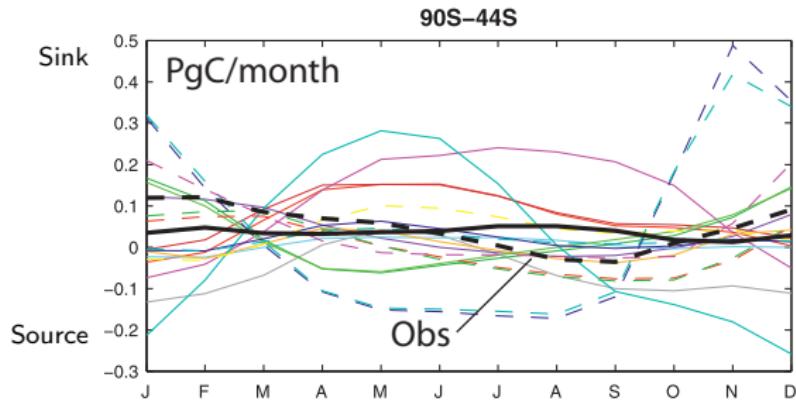
Oscar Schofield (Rutgers); Andy Thompson (CalTech);

Jorge Sarmiento (Princeton); Sue Schauffler and Eric Apel (NCAR/ACD);

Elliot Atlas (U. Miami); Jorgen Jensen (NCAR/EOL)

# Southern Ocean air-sea fluxes: model uncertainty

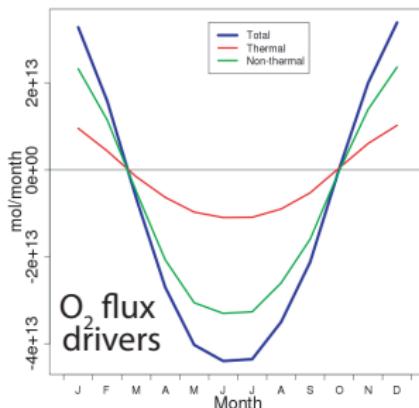
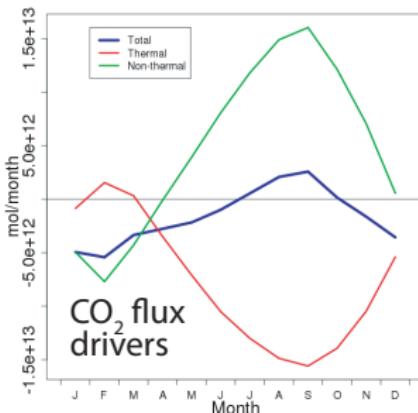
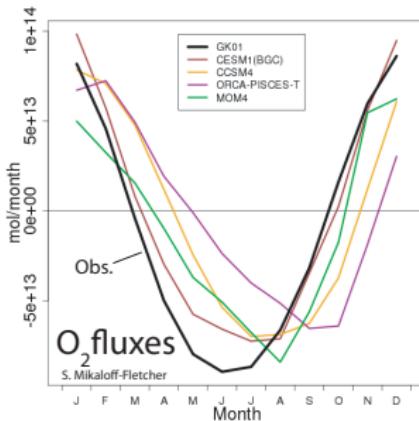
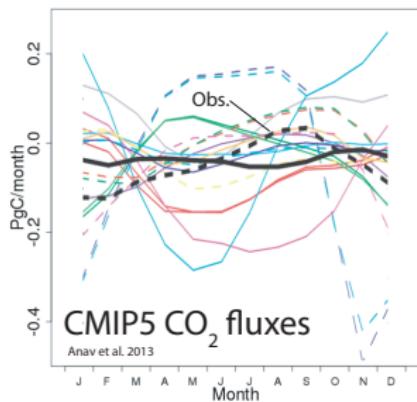
CMIP5 modeled air-to-sea CO<sub>2</sub> fluxes



Anav et al. 2013

# $\text{CO}_2$ flux is a small residual of opposing terms; $\text{O}_2$ flux is not

## Sea-to-air fluxes



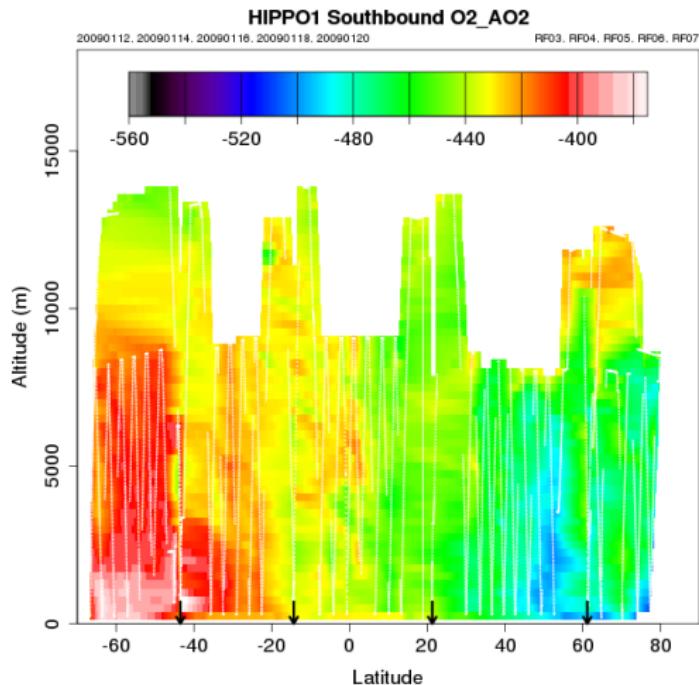
# NSF/NCAR HIAPER Gulfstream V

High-performance Instrumented Airborne Platform for Environmental Research



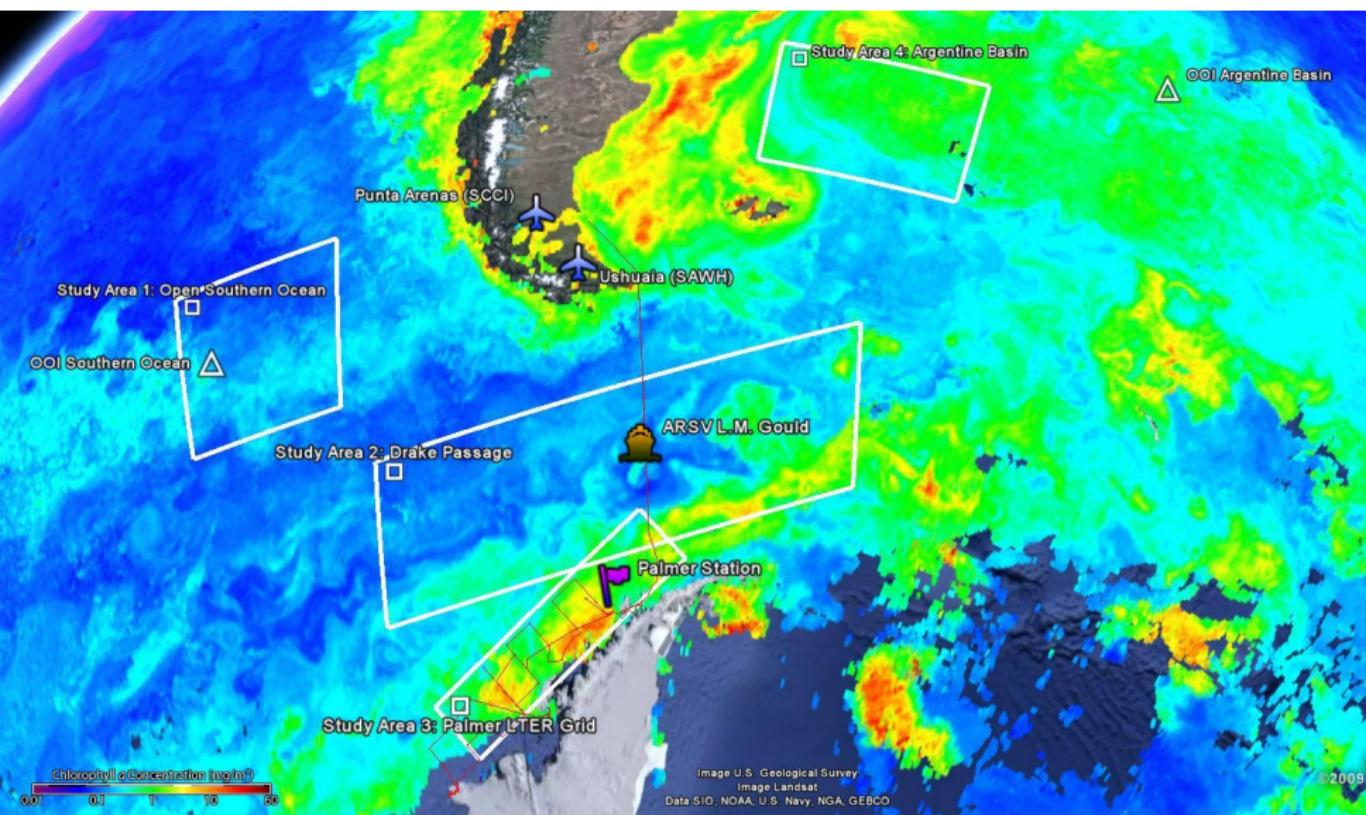
# Hemispheric scale O<sub>2</sub> plume

Meridional section: O<sub>2</sub> in Austral Summer



courtesy of B. Stephens

# O<sub>2</sub>/N<sub>2</sub> Ratio and CO<sub>2</sub> Airborne Southern Ocean Study (ORCAS)



## Research questions

- What are the magnitudes and interrelationships of summertime air-sea O<sub>2</sub> and CO<sub>2</sub> fluxes over the Southern Ocean at regional to zonal scales?
- What are the dominant processes driving the seasonal evolution and spatial variability in these fluxes?

# ORCAS Jan–Feb 2016?

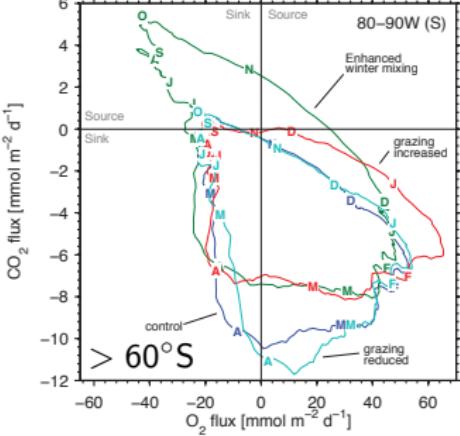
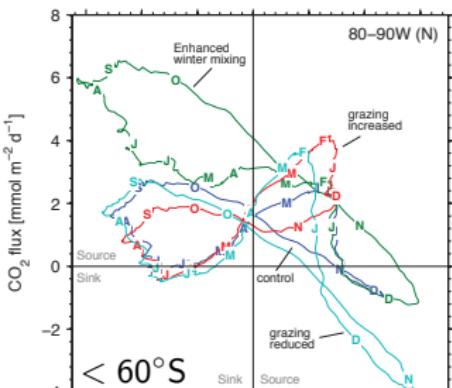
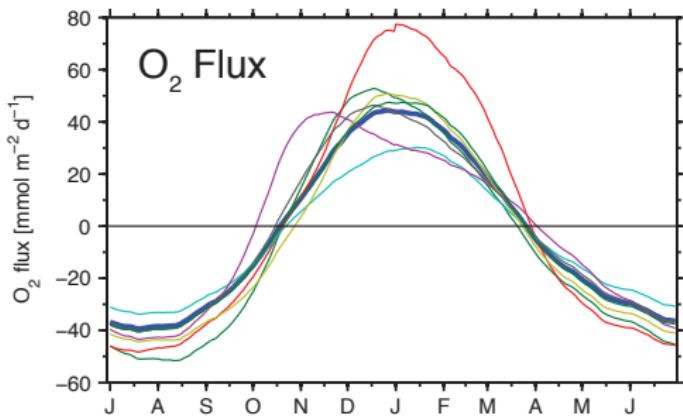
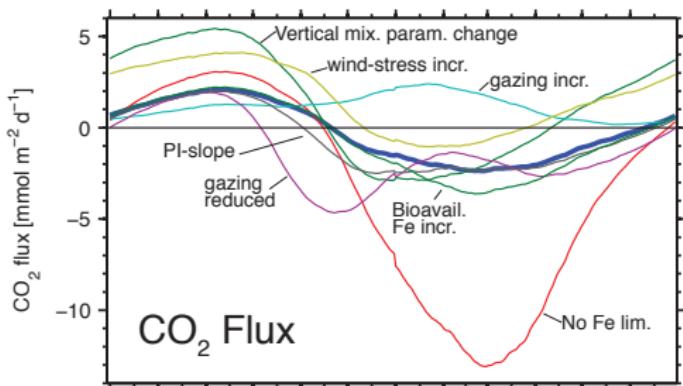
## Core measurement objectives

- ▶ Large-scale O<sub>2</sub> and CO<sub>2</sub> distributions: 50°S–70°S, 0–14km;
- ▶ Vertical O<sub>2</sub>:CO<sub>2</sub> ratios across boundary-layer top and through mid-troposphere;
- ▶ O<sub>2</sub> and CO<sub>2</sub> fluxes inferred from Lagrangian particle dispersion back-trajectories: (1) regional scale, using upwind/downwind flights 30-hr apart, (2) whole campaign.

## GV Scientific Payload

Instrument	Measurement	Institution
Airborne Oxygen Instrument (AO2)	$\delta(\text{O}_2/\text{N}_2)$ , CO <sub>2</sub>	NCAR EOL
Quantum Cascade Laser Spectrometer(QCLS)	CO <sub>2</sub> , CH <sub>4</sub> , N <sub>2</sub> O, CO	Harvard/Aerodyne/NCAR
Picarro	CO <sub>2</sub> , CH <sub>4</sub> , H <sub>2</sub> O	NOAA/CU
Medusa Flask Sampler	$\delta(\text{O}_2/\text{N}_2)$ , CO <sub>2</sub> , $\delta(\text{Ar}/\text{N}_2)$ , $\delta^{13}\text{C}$ , $\delta^{18}\text{O}$ , and $\Delta^{14}\text{C}$ of CO <sub>2</sub>	NCAR/Scripps
Portable Remote Imaging Spectrometer (PRISM)	Hyperspectral water-leaving radiance	JPL
Advanced Whole Air Sampler (AWAS)	Over 80 trace gases, including DMS, OCS, halocarbons, MeONO <sub>2</sub> , isoprene	NCAR/U. Miami
HIAPER Trace Organic Gas Analyzer (TOGA)	Over 60 VOCs, including nitrate species, DMS, and VSL halocarbons	NCAR

# Earth system models used for hypothesis testing



## Synergistic opportunities

- ▶ Palmer LTER cruise and  $\Delta O_2/Ar$  sampling aboard the *L.M. Gould*
- ▶ SOCCOM biogeochemical profiling floats
- ▶ Gliders?
- ▶ others?