

# The Southern Ocean Time Series moored observatory

## A technical and scientific review

[www.cawcr.gov.au](http://www.cawcr.gov.au)



Presented by Diana Greenslade on behalf of:

*Eric Schulz<sup>1</sup>, Tom Trull<sup>2</sup> & Simon Josey<sup>3</sup>*

1 CAWCR, Bureau of Meteorology

2 CAWCR, CSIRO, UTAS, ACECRC

3 NOCS

October 2012



**Australian Government**  
Bureau of Meteorology

The Centre for Australian Weather and Climate Research  
A partnership between CSIRO and the Bureau of Meteorology



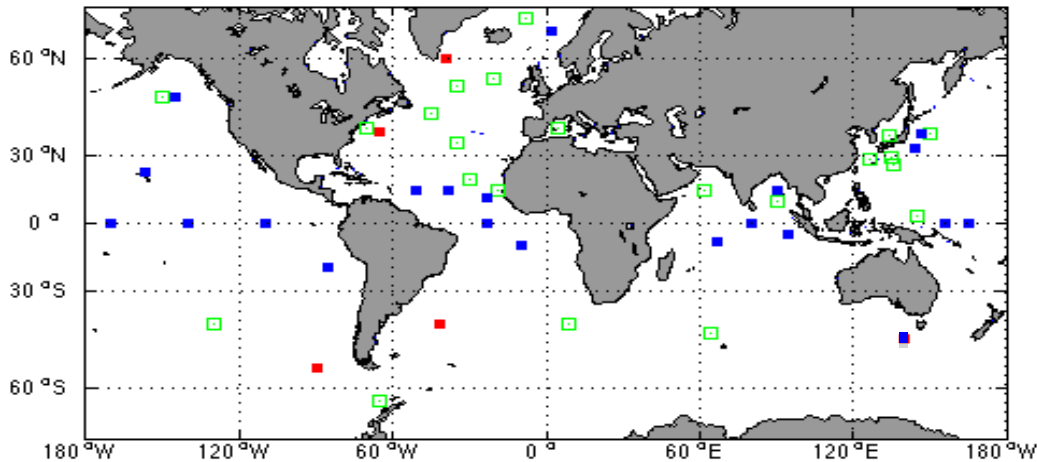
# Motivation



- The Southern Ocean is large (22% of world ocean) and is expected to play a significant role in the global climate system
- Role in the carbon, heat and mass cycle?
- Very few in situ observations due to harsh and remote nature
- Poorly constrained for these air-sea fluxes
  - How much carbon is trapped in the deep ocean?
  - How much heat absorbed, transported and released?
- The Sub-Antarctic Zone occupies half of the Southern Ocean and is a region of extensive surface water subduction

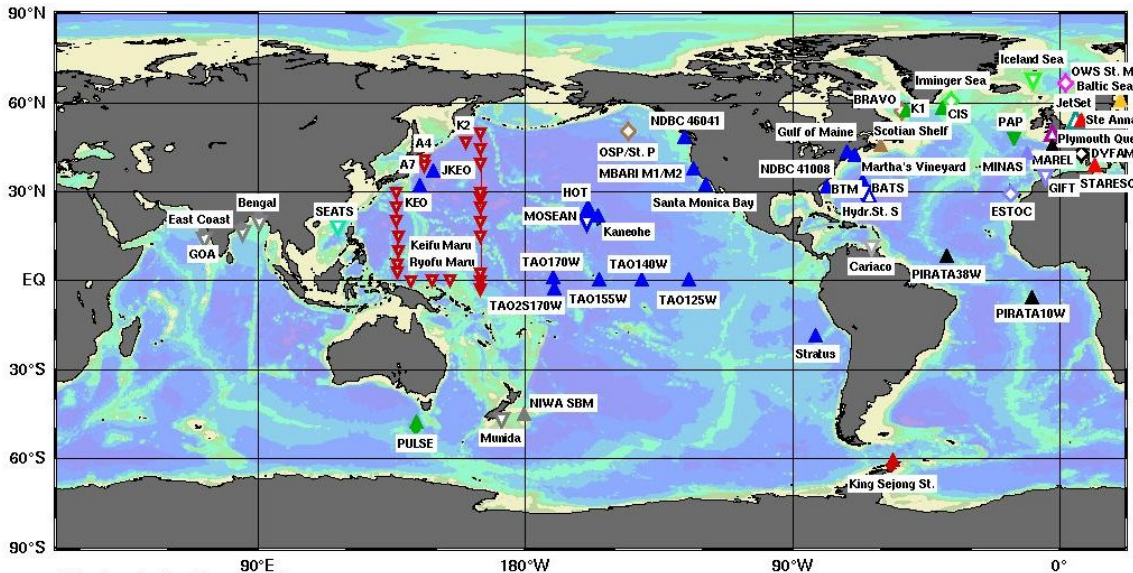


# Southern Ocean observations



## OceanSITES Flux Reference Stations (2010)

Operating  
Under construction  
Wish list



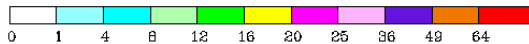
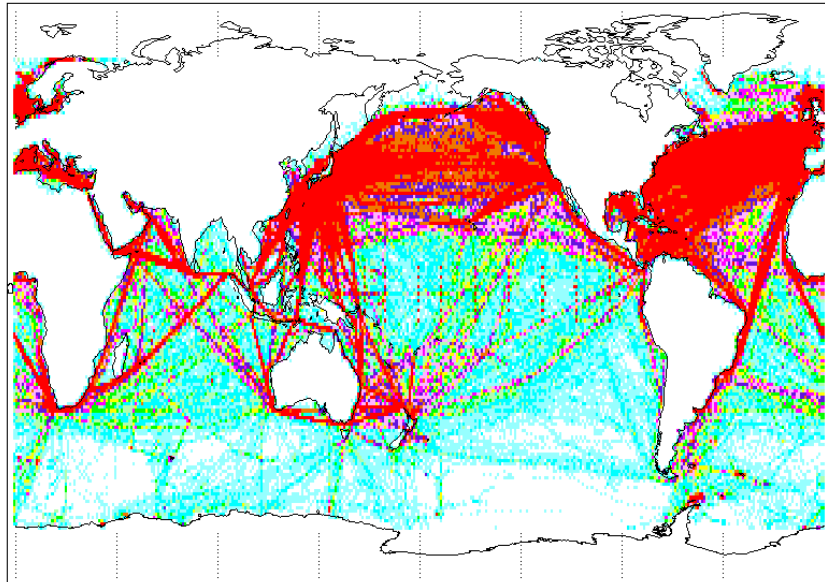
## International Ocean Carbon Coordination Project

Triangles - Surface Measurements  
Inv. Triangles - Water Column Measurements  
Filled - Buoy, Tower  
Empty - Ship, Platform

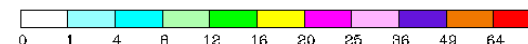
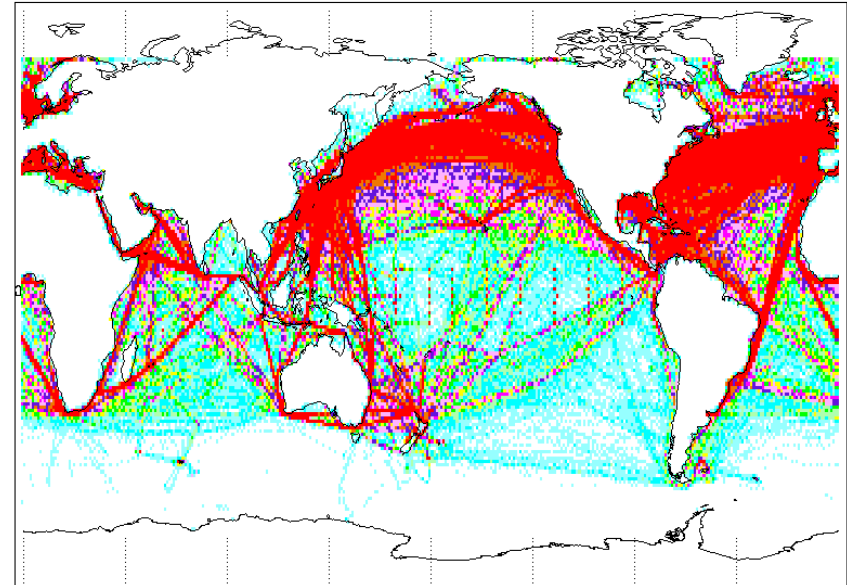
US	Canada	Spain	Iceland	Venezuela
Japan	France	Norway	UK	Sweden
Germany	Belgium	Taiwan	India	Australia
New Zealand	Netherlands	Korea	Proposed	



# Southern Ocean observations



Summer (DJF)



Winter (JJA)

Average number of observations per season (1994-2004) FSU Heat fluxes  
(credit: M. Bourassa)



Australian Government  
Bureau of Meteorology

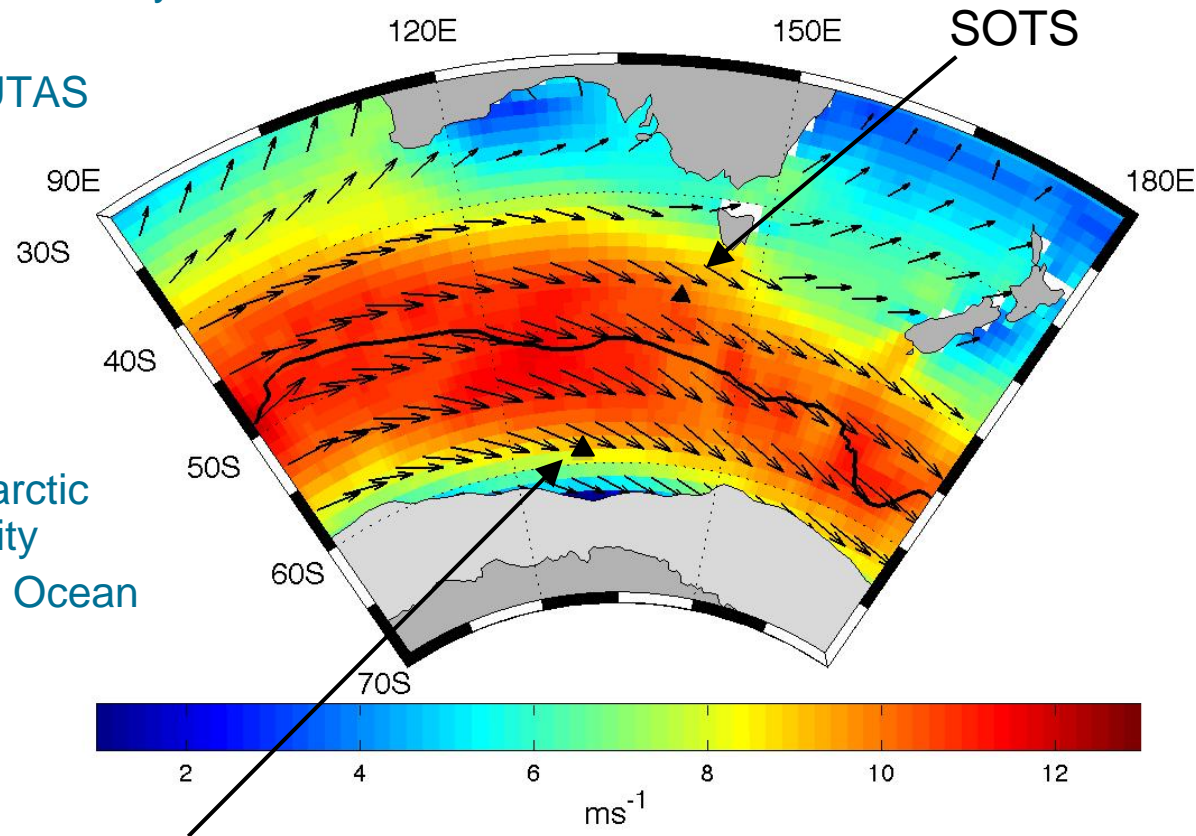
The Centre for Australian Weather and Climate Research  
A partnership between CSIRO and the Bureau of Meteorology



# SOTS Location



- Southern Ocean Time Series Observatory
- Funded by IMOS
- Operated by Bureau, CSIRO & UTAS
- 3 Moorings
- Gliders & Profiling Floats
  
- 46.75°S, 142°E
- 350 NM SW of Tasmania
  
- Situated centrally in the Sub Antarctic Zone, with strong biological activity
- Australian sector of the Southern Ocean



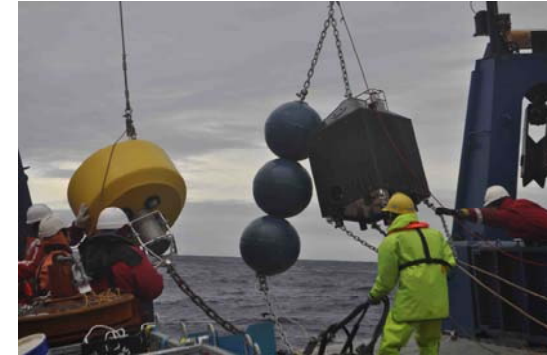
- Pilot deployment flux buoy at 60°S 140°E, 2012, JAMSTEC



# Southern Ocean Time Series

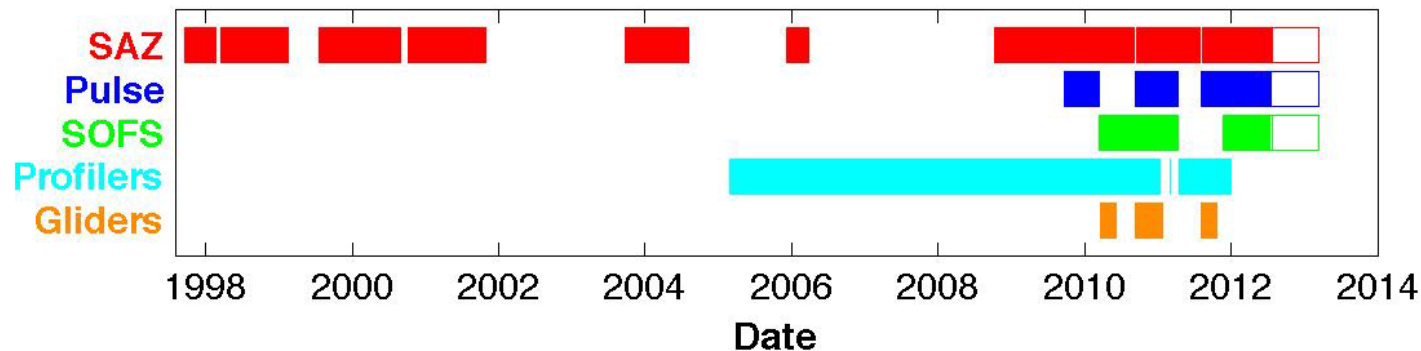
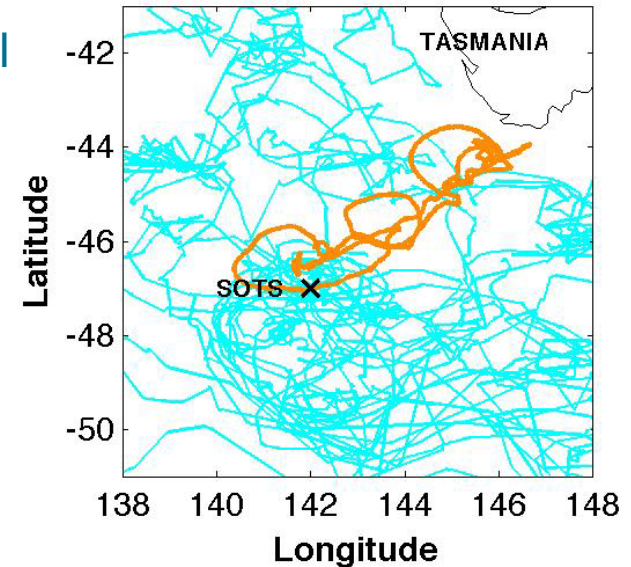


- Sustained Ocean observatory
- Multidisciplinary (met, ocean, BGC)
  - Multiple platforms
    - **SAZ** mooring (sediment traps) – transfer of carbon to deep ocean
    - **Pulse** mooring (BGC) – consumption of  $\text{CO}_2$  in mixed layer
    - **SOFS** mooring (weather, fluxes,  $\text{CO}_2$  physical ocean) – physical fluxes through ocean surface
    - **Gliders** (physical and BGC) – spatial context & vertical profiles
    - **Drifting Profilers** (physical and BGC) – spatial context & vertical profiles

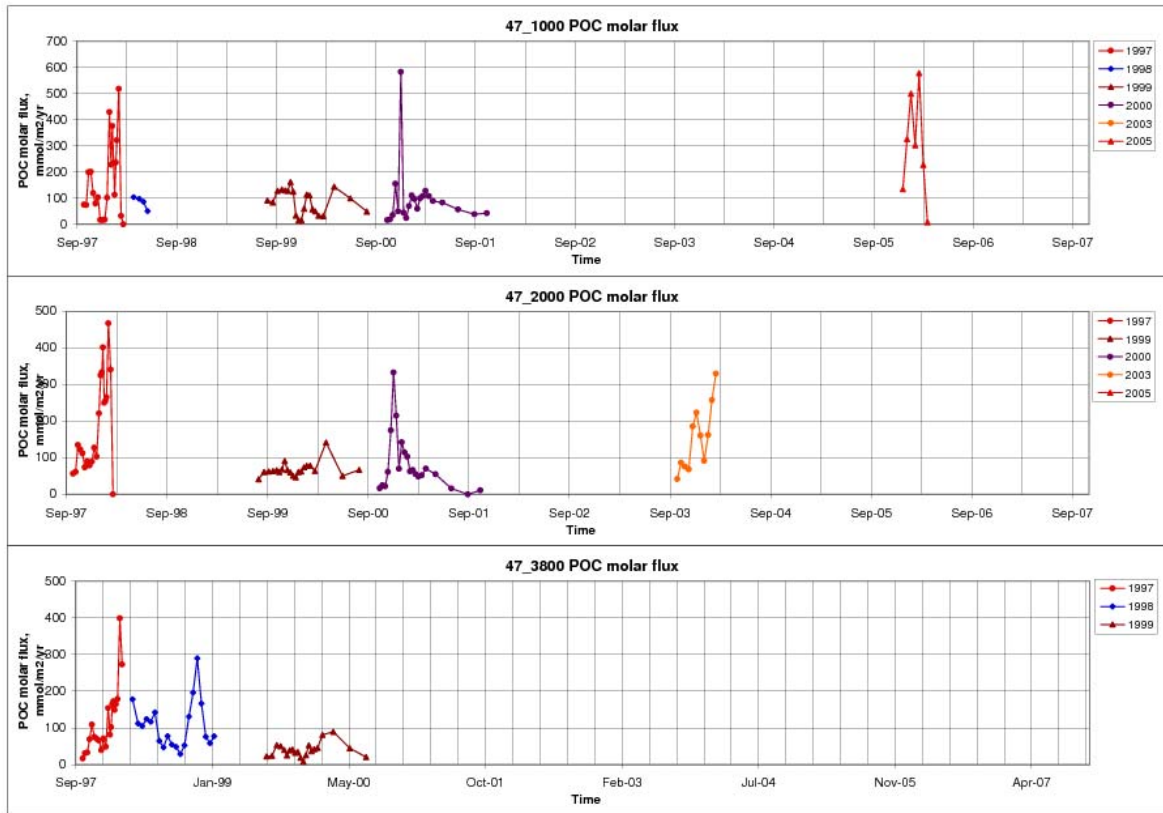


# Data availability 1998-2012

- Started with SAZ sediment traps in 1997
- Added Pulse BGC in 2009 – summer only; annual since 2011
- Added SOFS in 2010
- Dedicated profilers (2005) & gliders (2010)
- Halted in 2011 with technical issues
- Gaps in SAZ are due to instrument and mooring failures



# Data from SAZ



- Seasonal cycle of biogenic fluxes to deep ocean moored sediment traps
- Short pulses account for large fractions of the total annual flux



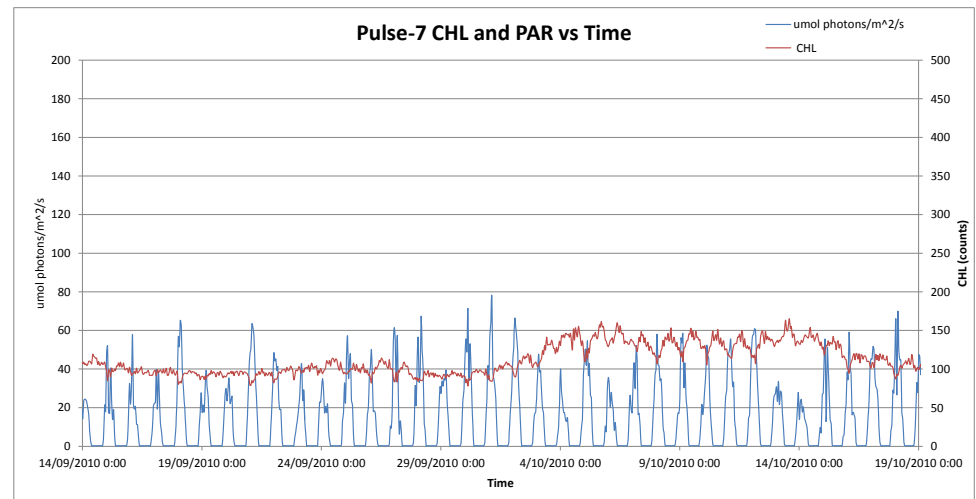


# Pulse observations



## Photosynthetic Active Radiation and surface mixed layer Chlorophyll

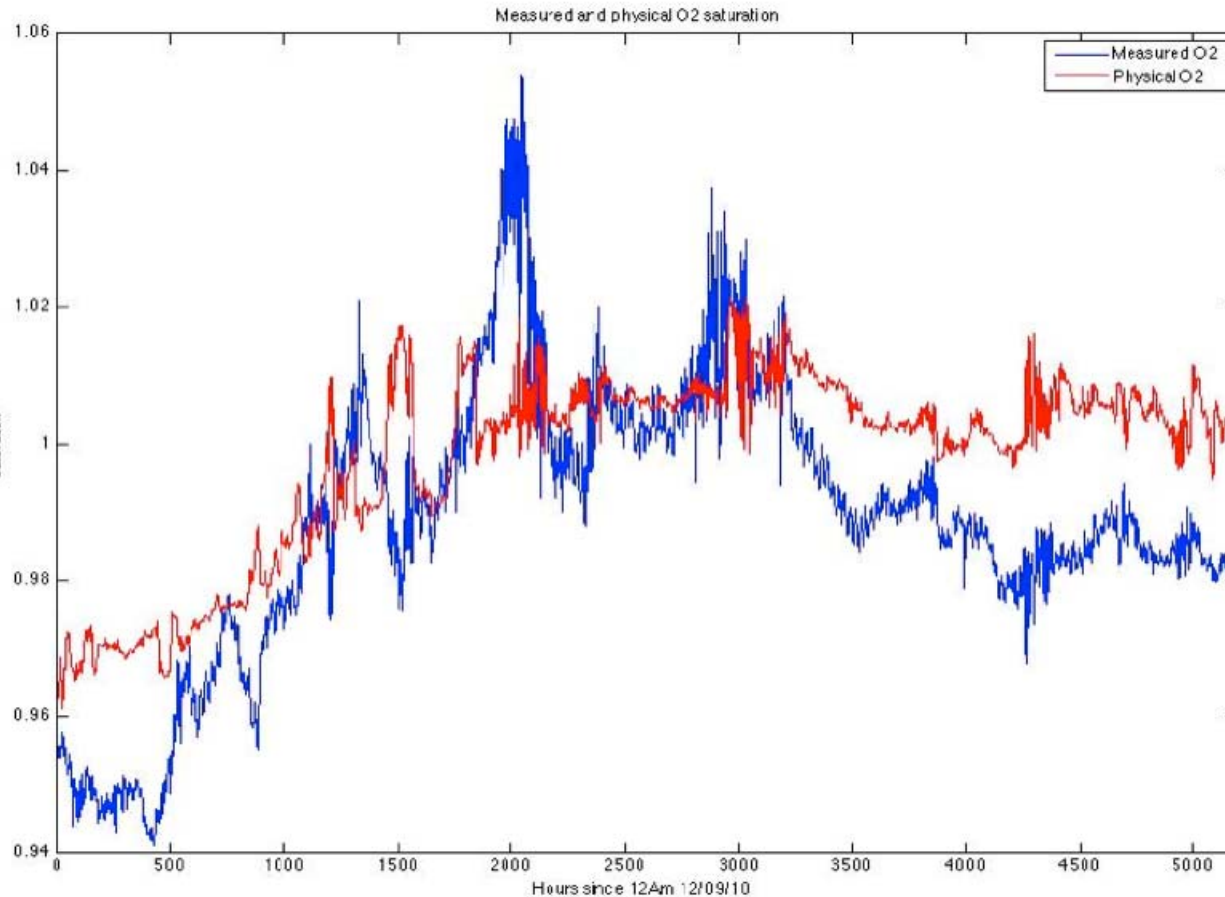
- Chlorophyll at 35m (red)
- PAR in blue
  
- Lagged correlation with PAR over week-long timescales



# Pulse application



## Surface mixed layer oxygen variations during Pulse-7



Total dissolved oxygen saturation level @35m (blue)

Expected levels due to physical processes (red)

Difference due to biology (net community production)

Weeding and Trull, manuscript in preparation

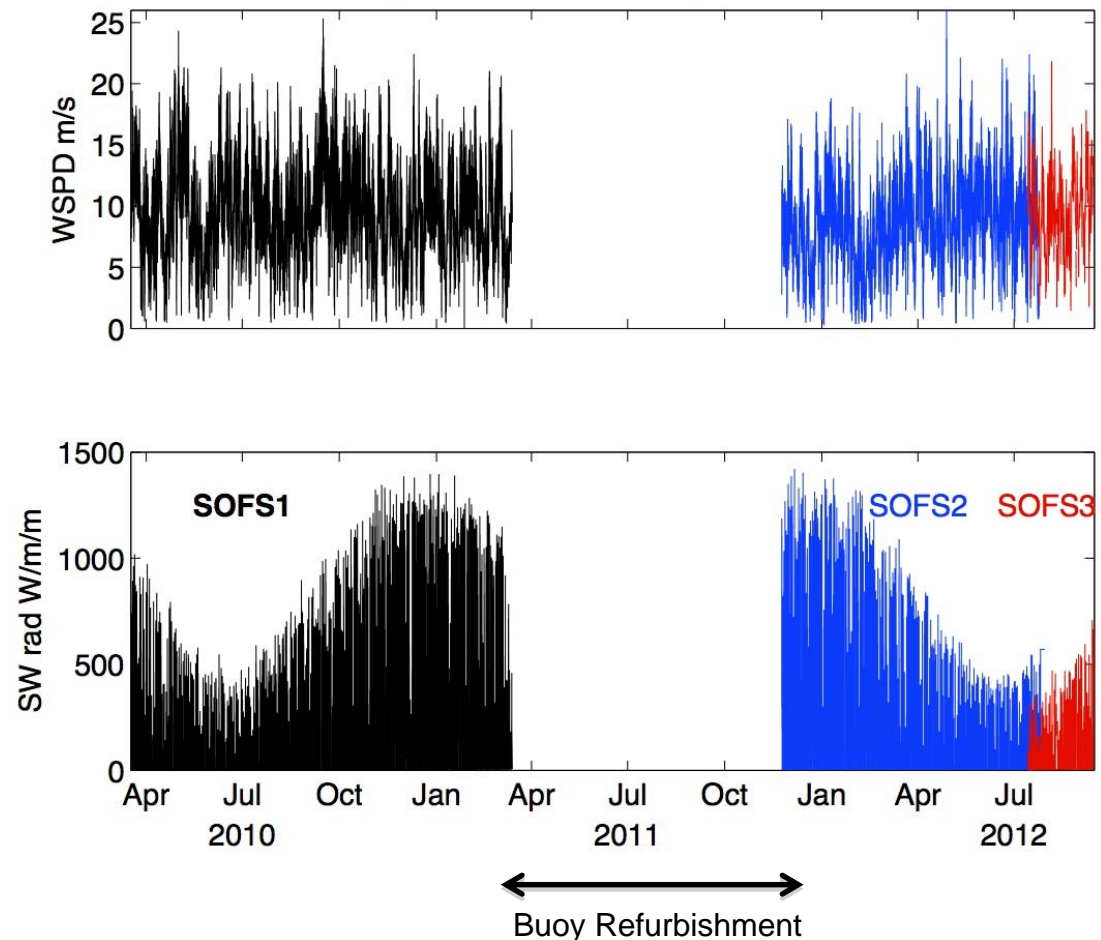


# SOFS observations



- 9-month refurbishment gap between SOFS1 & 2, now back-to-back deployments
- Winds peaking ~50kts
- Distinct solar radiation annual cycle
- SOFS3 data plotted is hourly and real-time, (rather than 1 minute delayed mode) so less variability than SOFS1 & 2

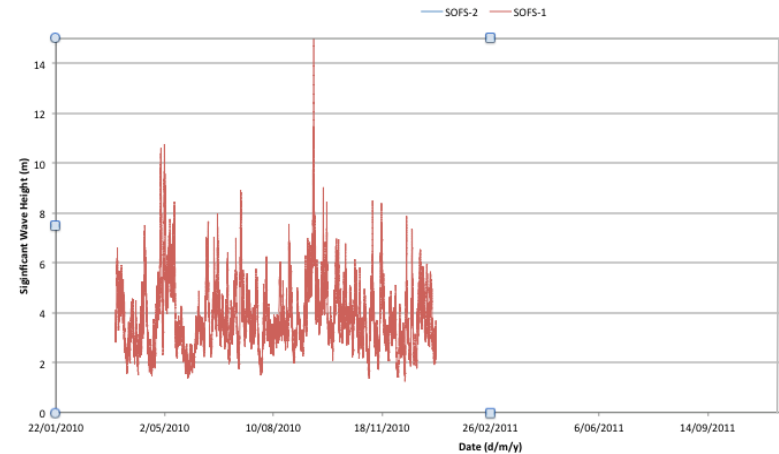
SOFS Wind Speed and Incoming Short-Wave radiation



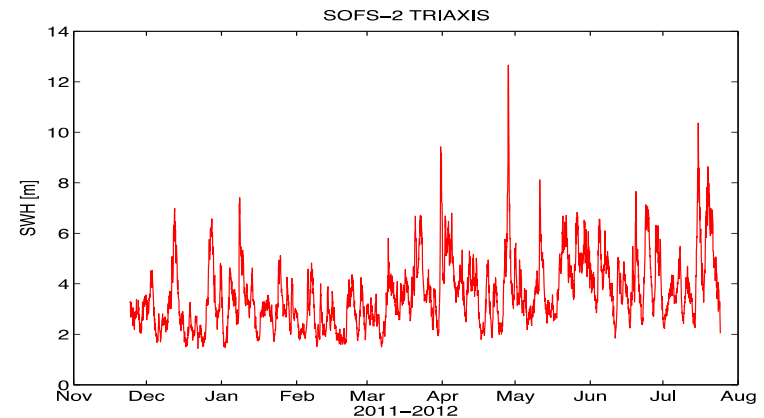
# SOFS observations - waves



- Waves from buoy motion
- Accelerations sampled at 5 Hz for 10 - 20 minutes every hour
- Real-time telemetry of spectrum, SWH
- Max SWH measured at 21 m
- Also measured on Pulse buoy



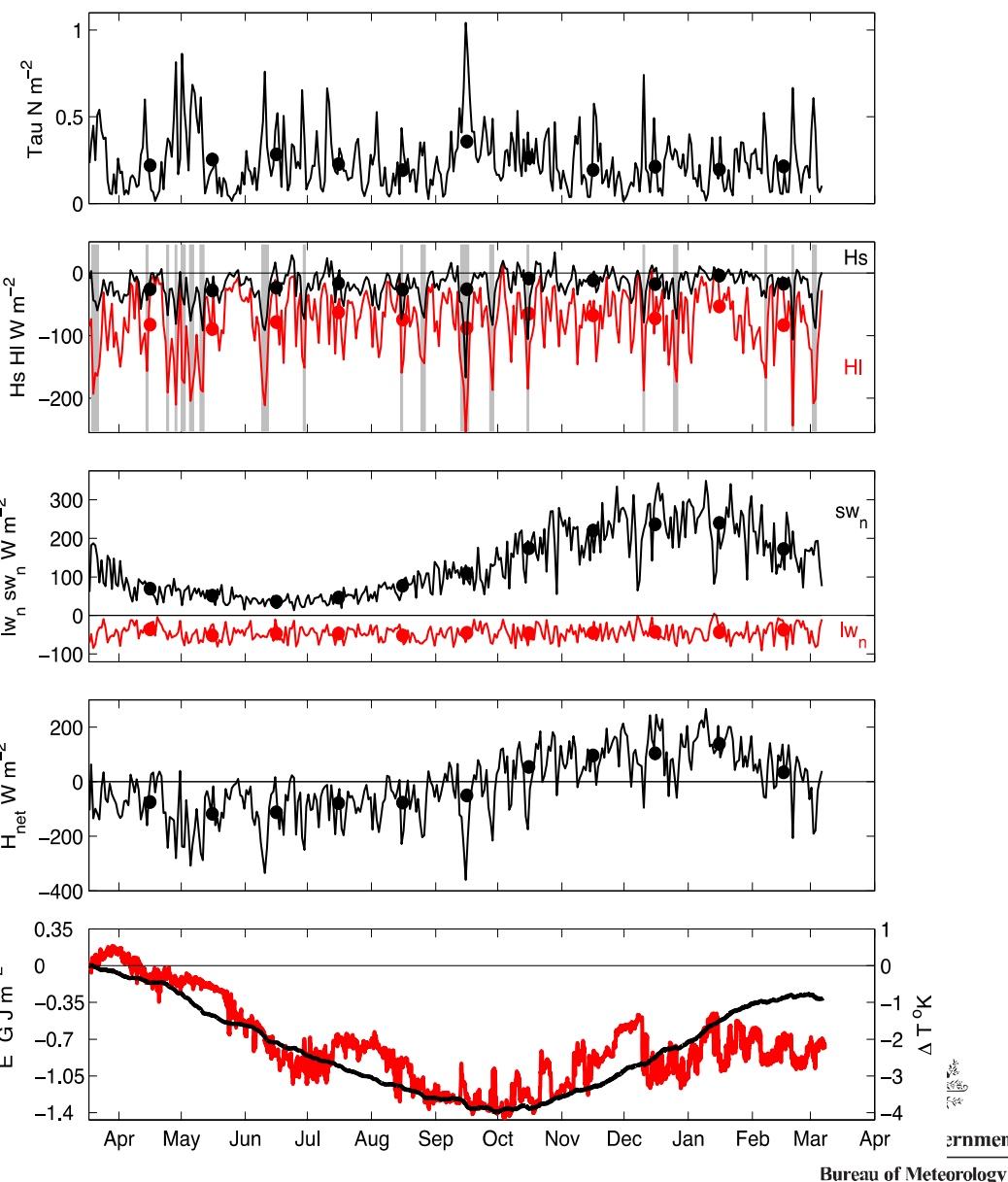
SOFS1 (Mar to Dec 2010)



SOFS2 (Dec 2011 - Jul 2012)



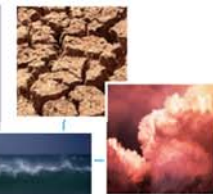
# SOFS application: Air-Sea Fluxes



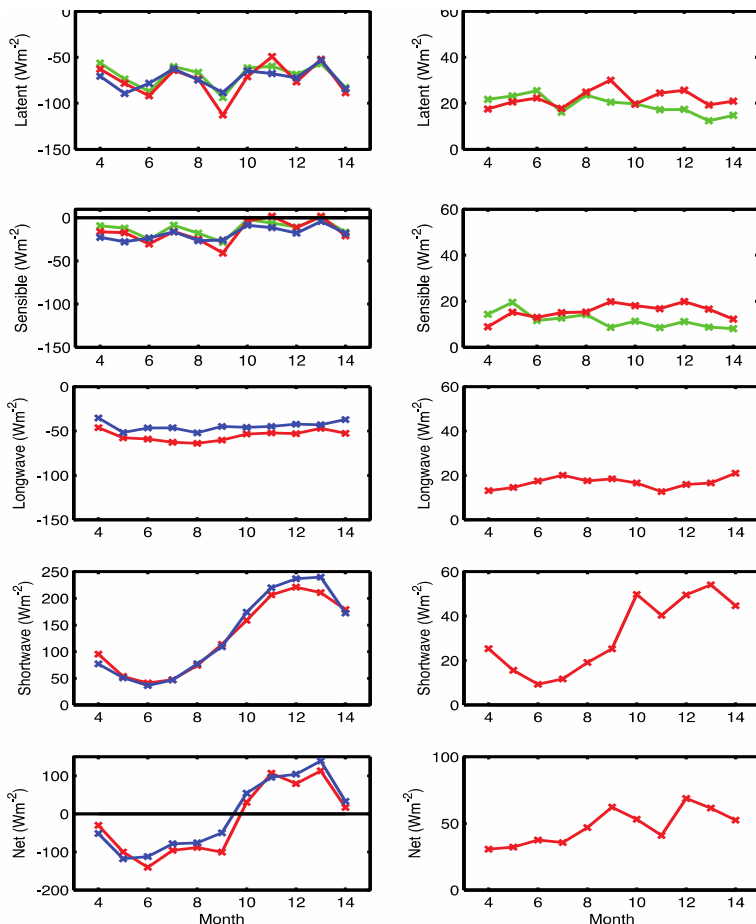
• Bulk fluxes from SOFS1:  
March 2010 - March 2011

- Net deployment - ocean cooling of  $10 W m^{-2}$
- Asymmetric seasonal signal in Net
- Incoming SW dominates seasonal signal
- Severe short-term ocean turbulent cooling events ( $>400 W m^{-2}$ ) with cold, dry southerly winds.
- Frequent ocean heating events from sensible heat flux ( $H_s$ )
- Ocean heat content shows trend agreement with air-sea flux on seasonal scale.
- See Schulz et al., 2012, GRL

# SOFS application: NWP Flux Verification



## Monthly means SOFS, OAFlux & NCEP



March 2010

March 2011

- Latent and sensible heat flux in reasonable agreement across all 3 datasets
- RMS differences smaller for OAFlux Indicates improvement relative to NCEP
- No radiative/net heat flux information for OAFlux over this period
- NCEP net long wave flux has stronger heat loss than buoy
- Results in persistent NCEP net heat flux bias of 10-15 Wm<sup>-2</sup> too much heat loss relative to SOFS
- Thanks to Simon Josey (NOCS)
- OAFlux data thanks to Lisan Yu



# Summary



- Sustained, year-round observations in the Sub-Antarctic Zone are high value due to their rarity in this remote and harsh Southern Ocean region.
- SOTS is now over a decade old with recent enhancements to make it a multi-disciplinary carbon, heat and mass ocean observatory.
- Starting to capture interannual variability as well as high frequency day-week scale events.
- Sustained observations require a sustained commitment to operate.  
This is a challenge!





**Australian Government**  
**Bureau of Meteorology**

**The Centre for Australian Weather and Climate Research**  
A partnership between CSIRO and the Bureau of Meteorology



*Eric Schulz, Tom Trull, & Simon Josey*

Email: [e.schulz@bom.gov.au](mailto:e.schulz@bom.gov.au)  
Web: [www.cawcr.gov.au](http://www.cawcr.gov.au)

# Thank you

[www.cawcr.gov.au](http://www.cawcr.gov.au)

