

# SOUTH AFRICAN TRACE GAS EXPERIMENT (SATRE): COORDINATED CONTINUOUS OCEAN-ATMOSPHERE MEASUREMENTS ONBOARD THE R/V METEOR

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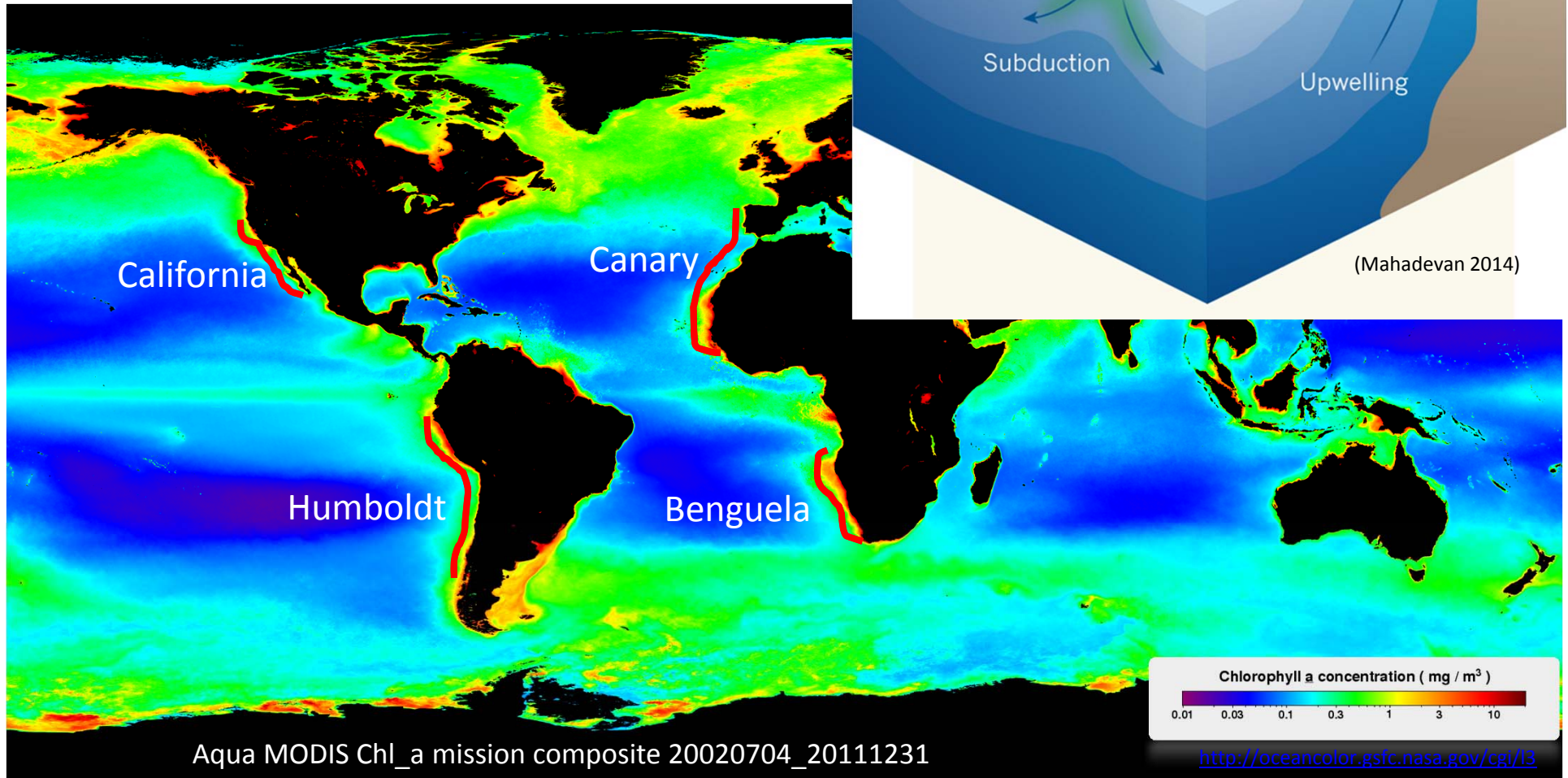
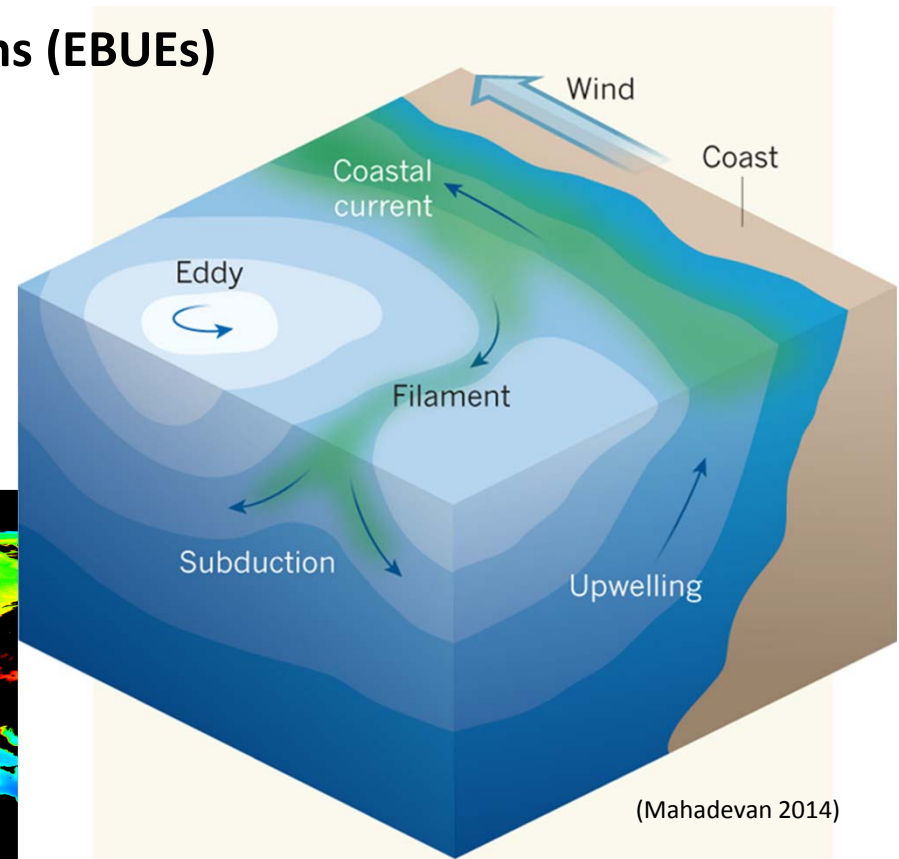


# Main Eastern Boundary Upwelling Ecosystems (EBUEs)

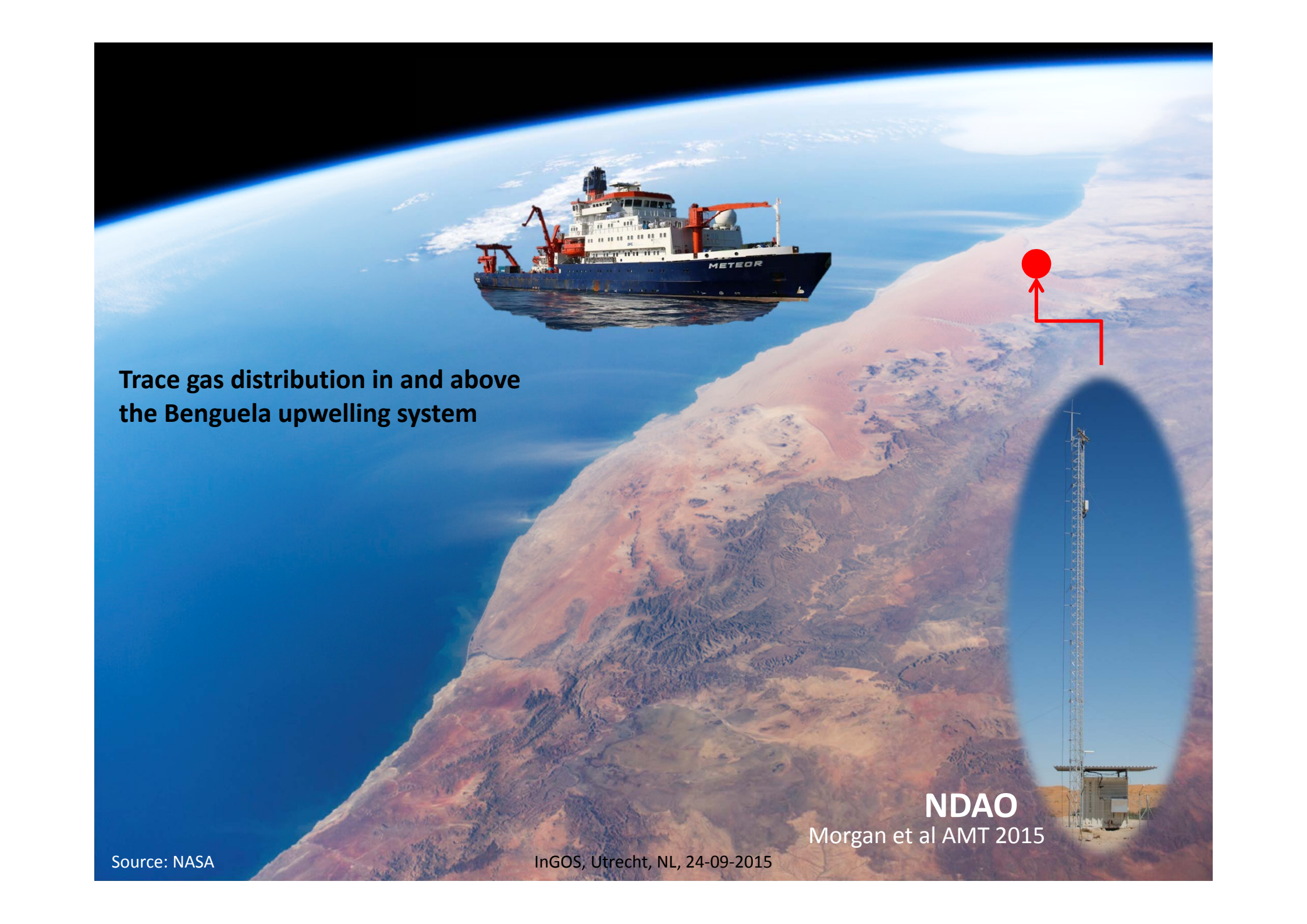
The four main EBUEs:

**Canary, California, Humboldt and Benguela currents** provide one fifth of the marine fish global catch.

(Freon et al 2009)







Trace gas distribution in and above  
the Benguela upwelling system

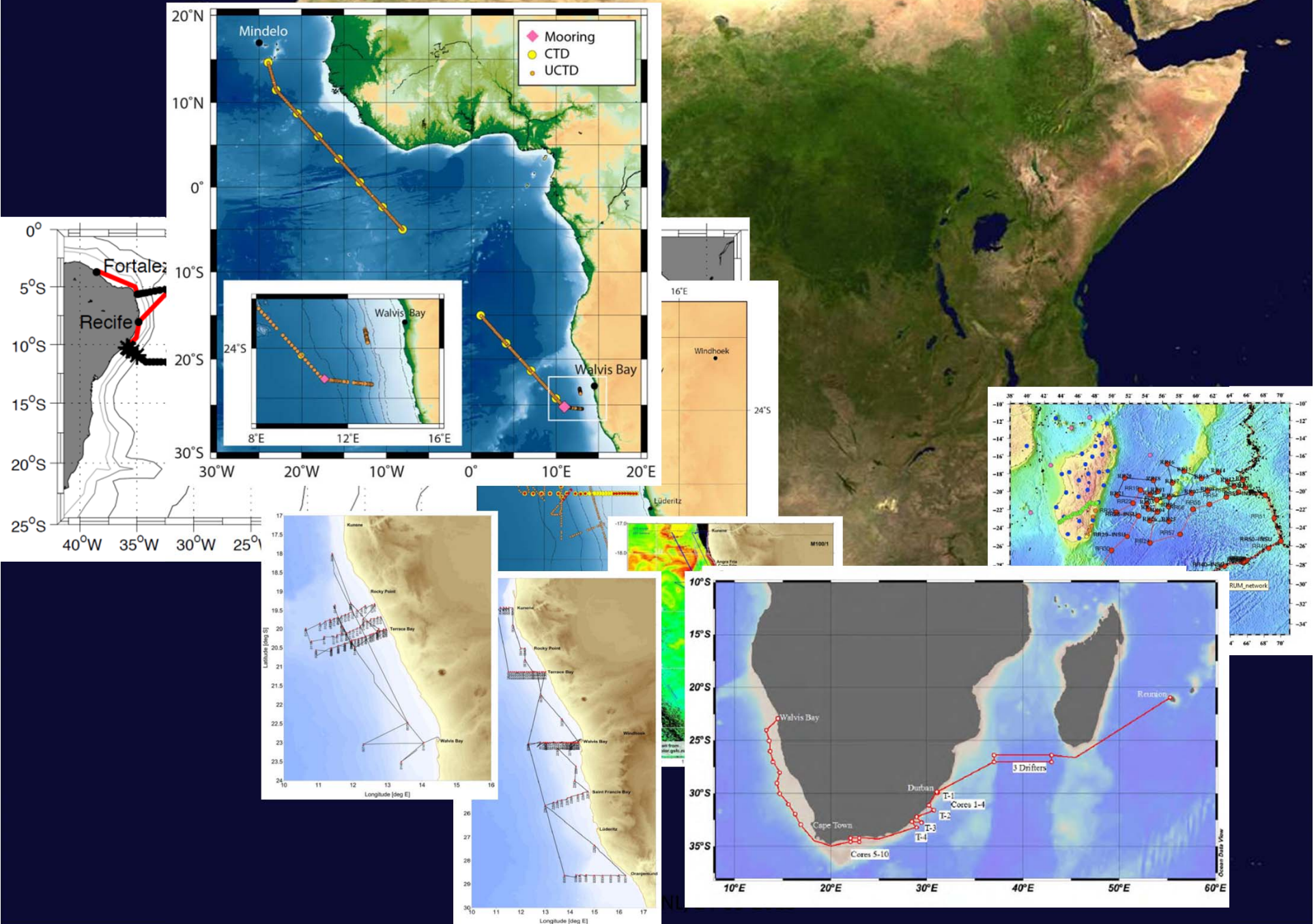
Source: NASA

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**NDAO**  
Morgan et al AMT 2015



# CRUISES R/V METEOR M98-M104 (08/2013 -> 03/2014)

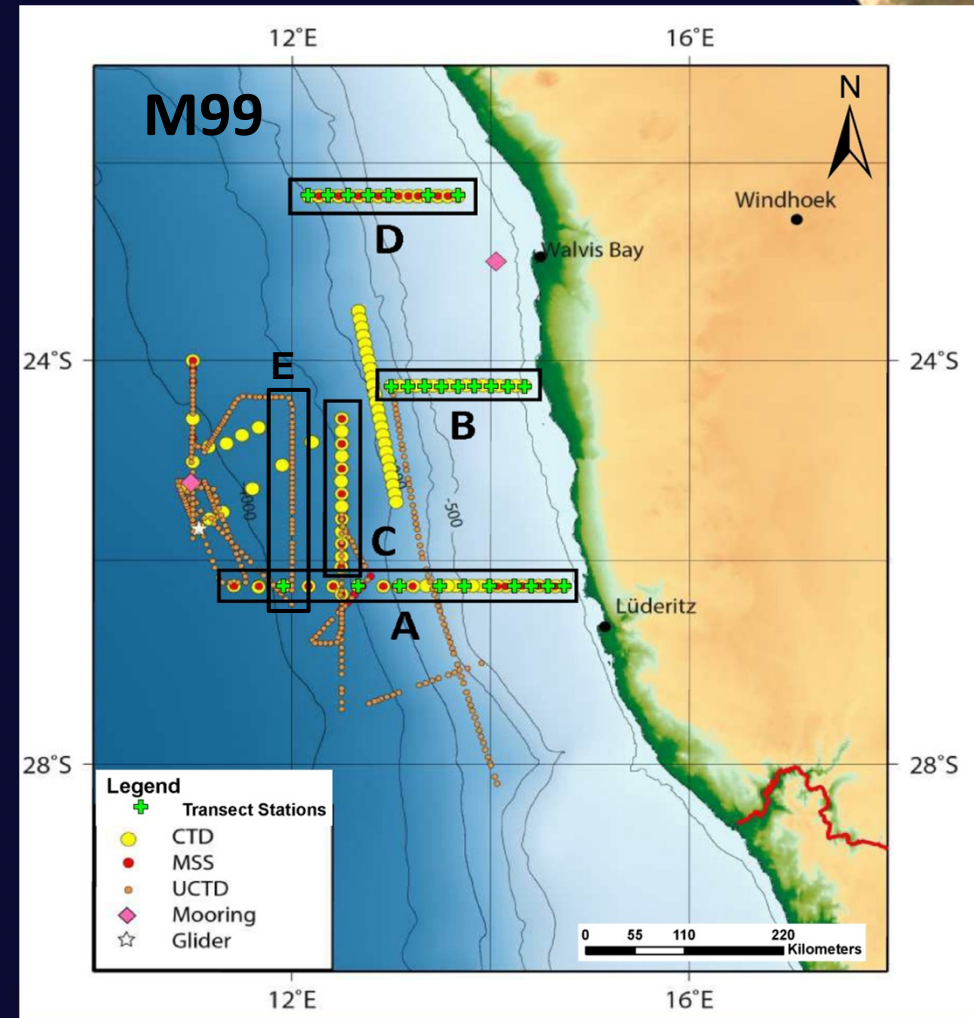




# CRUISE R/V METEOR M99 (08/2013)

## Benguela upwelling

- All year with varying intensity, different water characteristics in the North and the South
- 3 hydrographic sections perpendicular to the coast (A,B,D), plus offshore transects C,E (filaments)
- Generally lower oxygen concentrations in the upwelled waters in the north of the working area

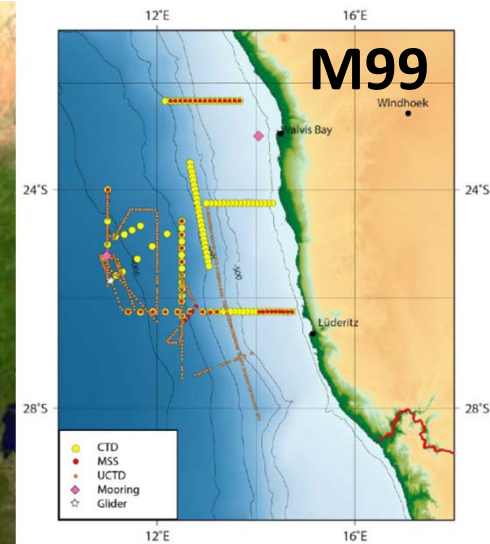


CTD Conductivity-Temperature-Depth sonde  
MOR Mooring  
MSS Micro Structure Sonde

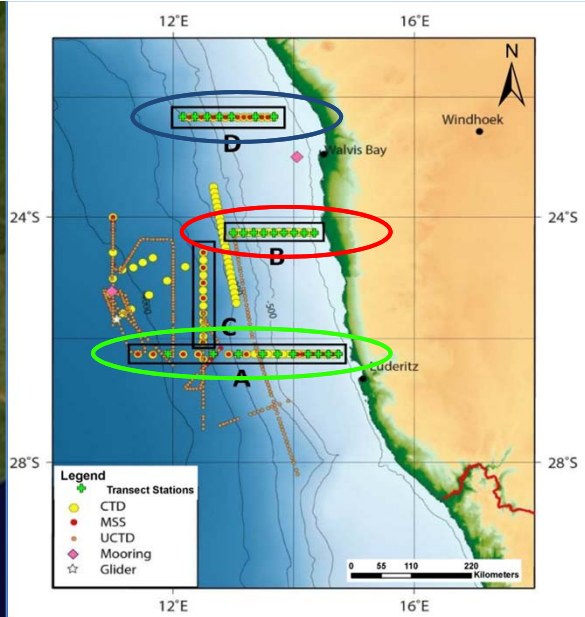


# MEASURED PARAMETERS

Parameter	Methods								
	G1301	G2201-i	SUNDANS	FerryBox	DSHIP	Titration	OA-ICOS	GO	Flow-through-box
<b>ATMOSPHERE</b>									
xCO <sub>2</sub>	X							X	
δ <sup>13</sup> C (CO <sub>2</sub> )									
xCH <sub>4</sub>	X								
δ <sup>13</sup> C (CH <sub>4</sub> )									
Pressure			X		X				
Wind direction					X				
Wind speed					X				
xN <sub>2</sub> O							X		
xCO							X		
+ flasks									
<b>WATER</b>									
xCO <sub>2</sub>			X					X	
δ <sup>13</sup> C (CO <sub>2</sub> )									
xCH <sub>4</sub>									
δ <sup>13</sup> C (CH <sub>4</sub> )									
SST					X				X
Salinity					X				X
Oxygen									X
EQ-Temp.			X					X	
pH									
TA									
xN <sub>2</sub> O							X		
xCO							X		

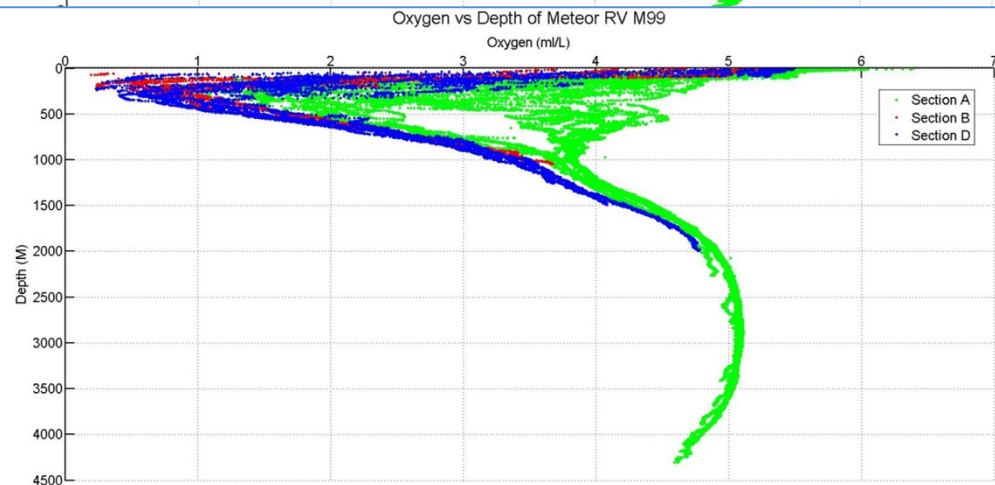
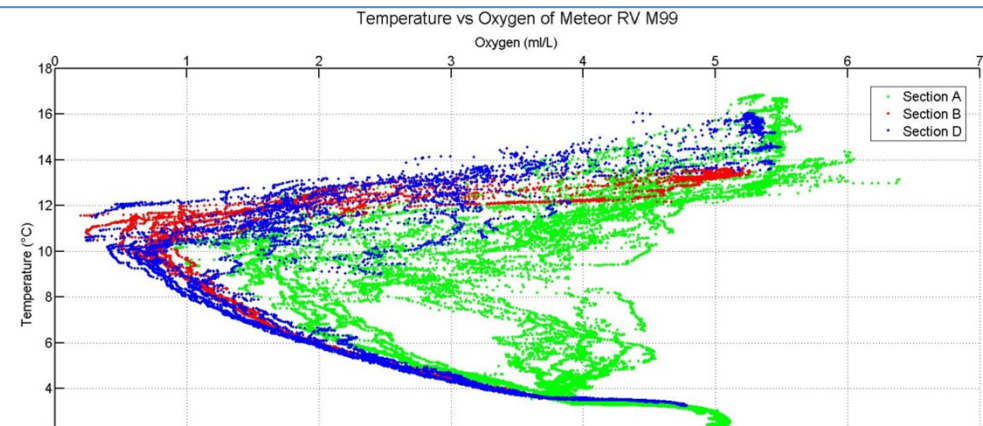
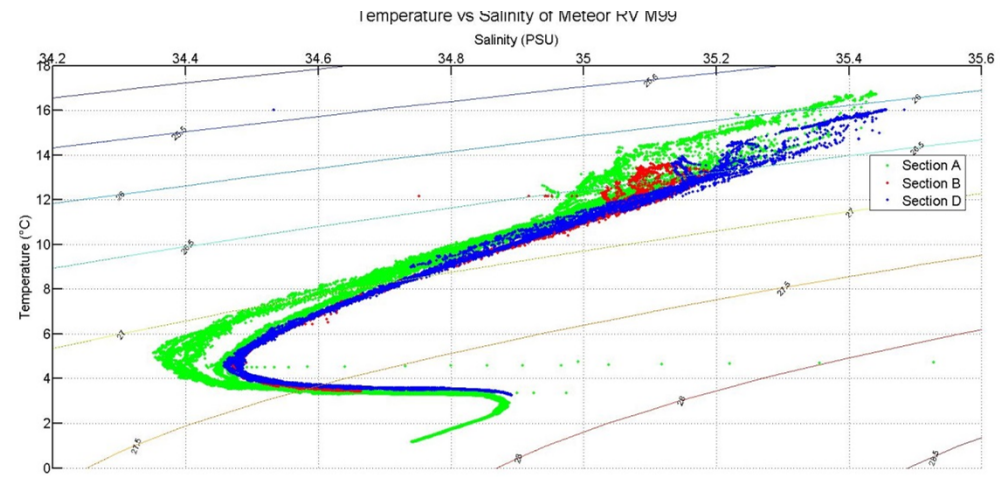






## Water mass characteristics

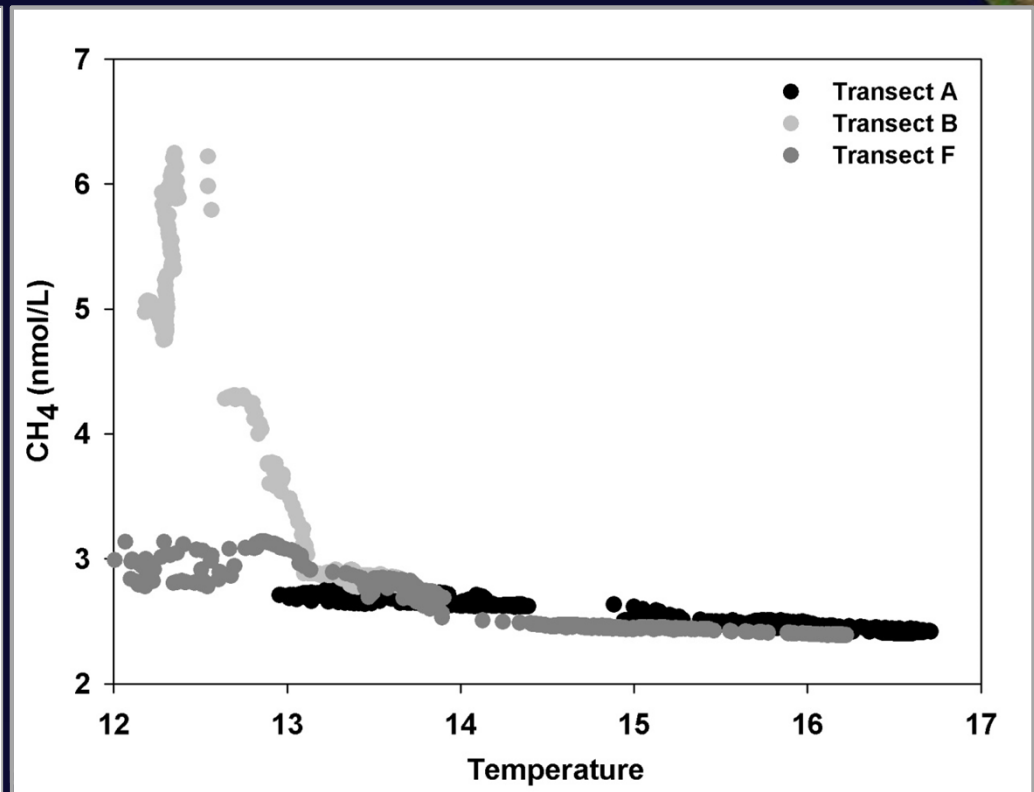
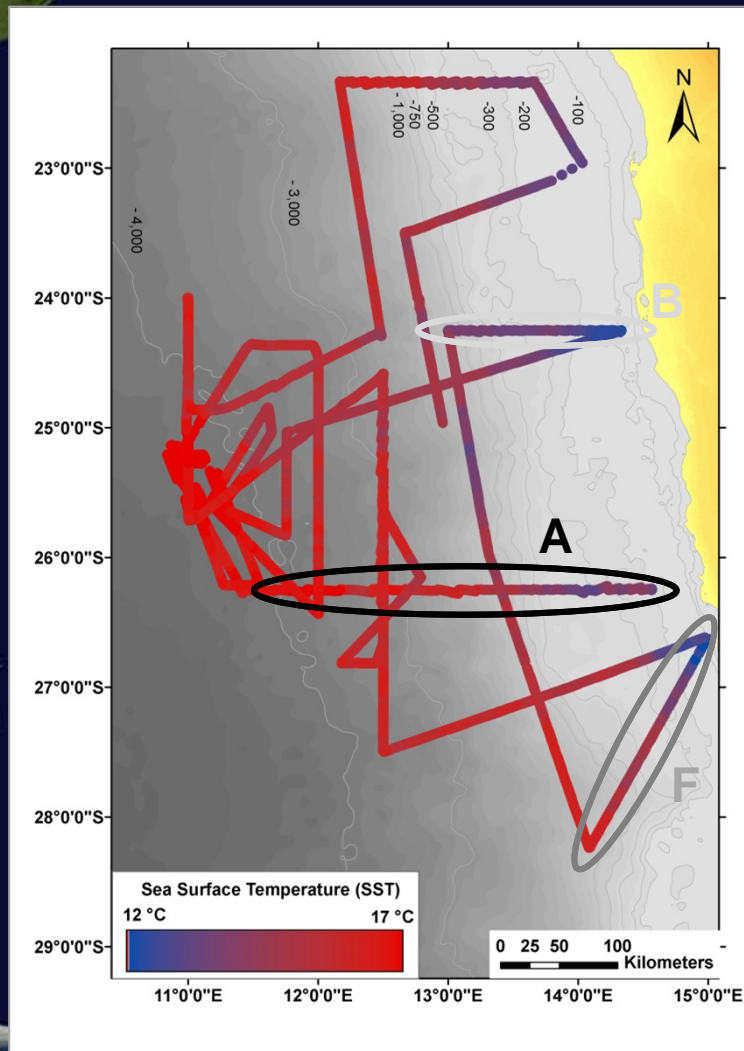
- Intermediate water of section A distinct
- Intermediate water of section A with higher oxygen levels, both vs T and vs depth
- Coldest waters at surface in section B





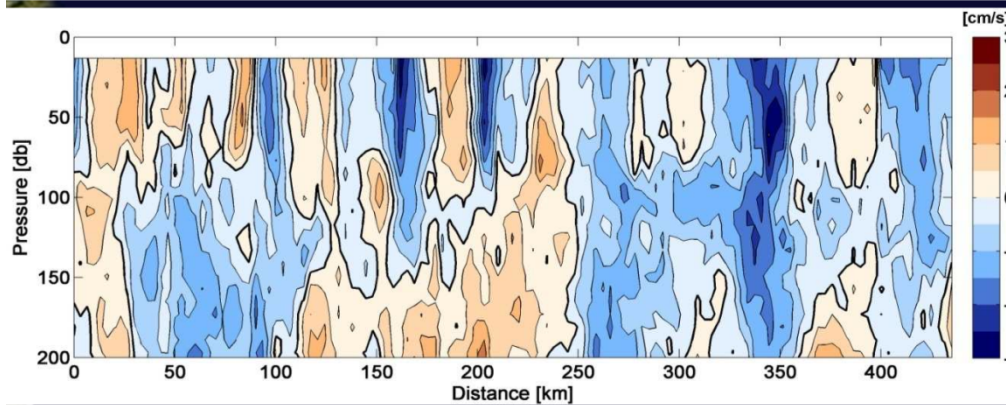
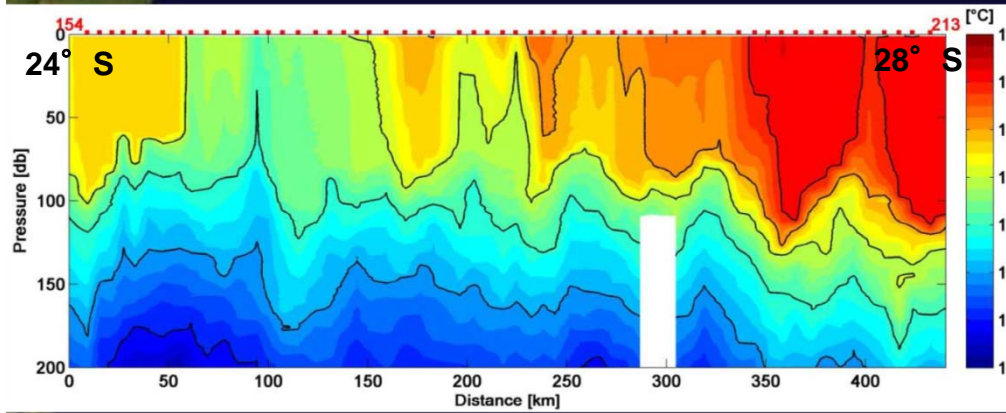
# North vs. South

The effect of the source of upwelled waters



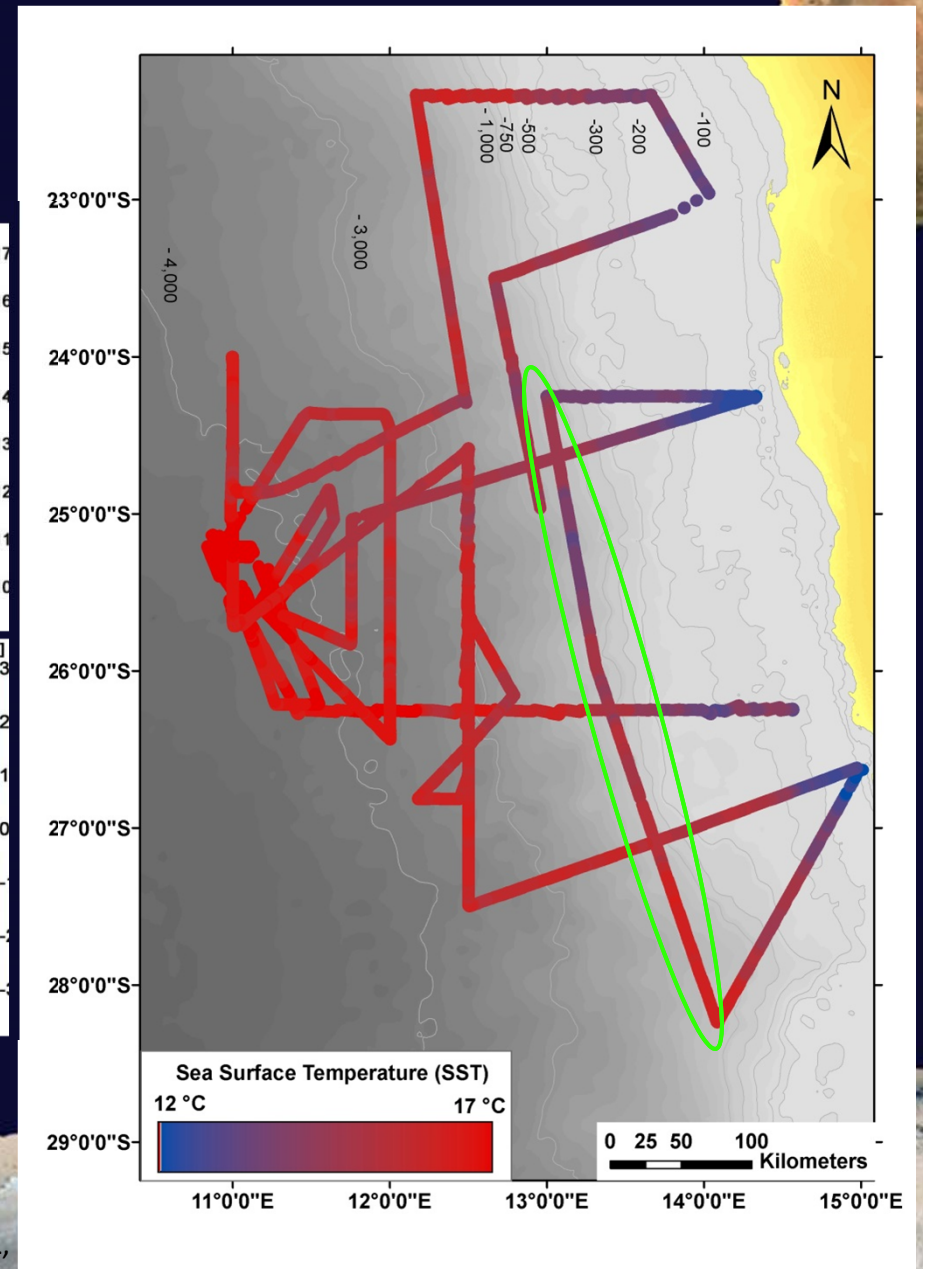
# Spatial patterns

- Temperature
  - Cold inshore surface waters
  - Indications of filaments 100+ km offshore



Pot. temperature and westward velocity on a UCTD transect between 24° S and 28° S

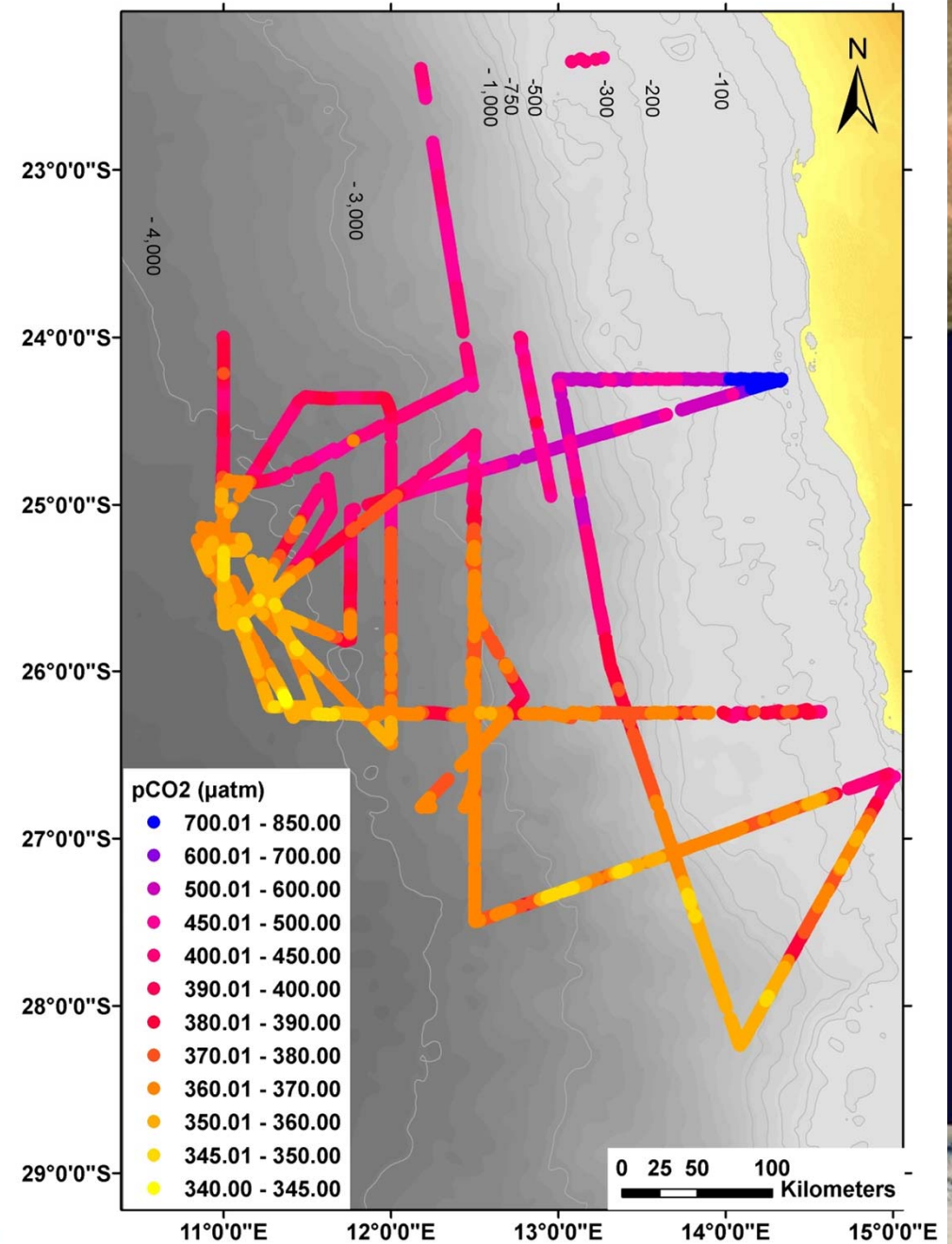
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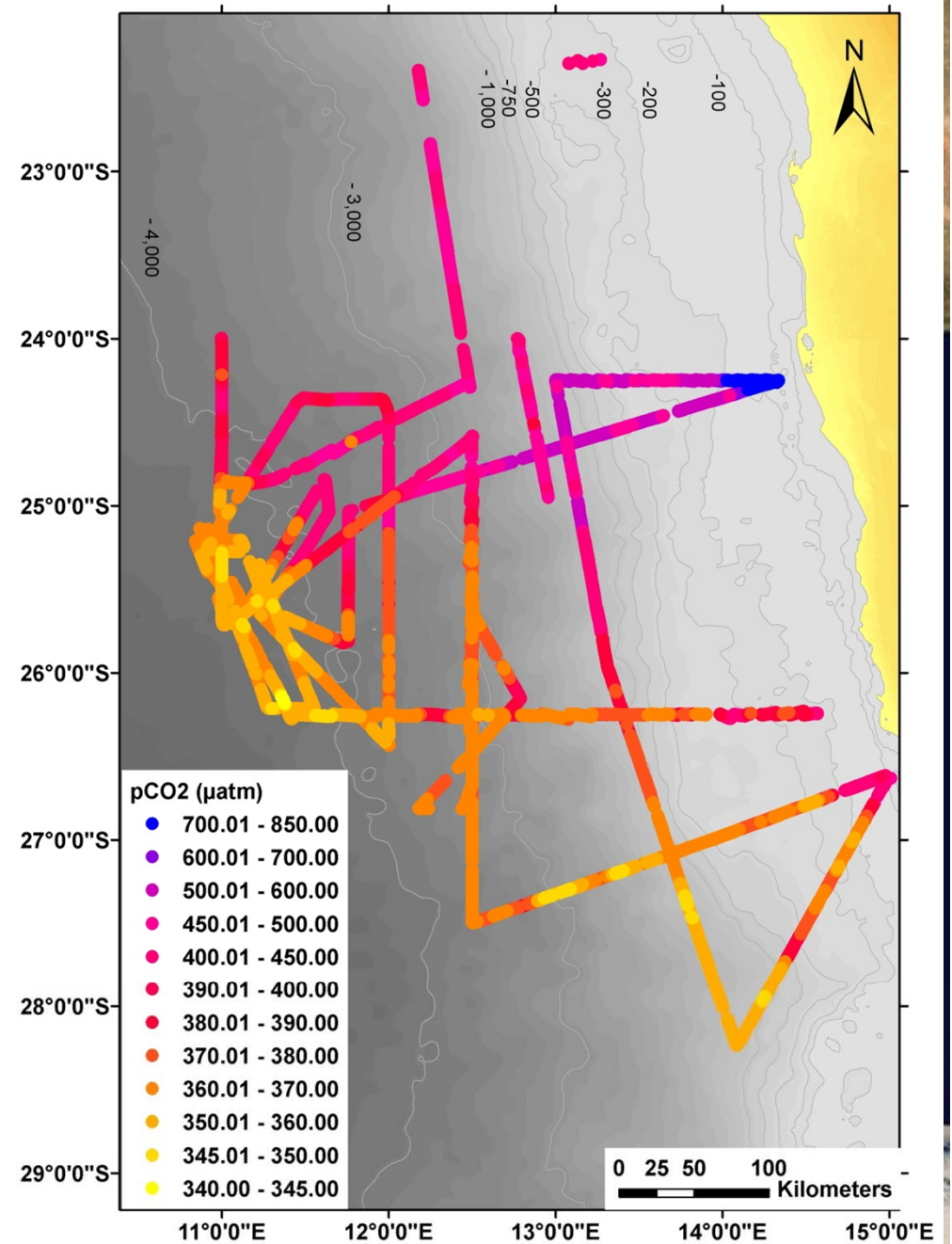
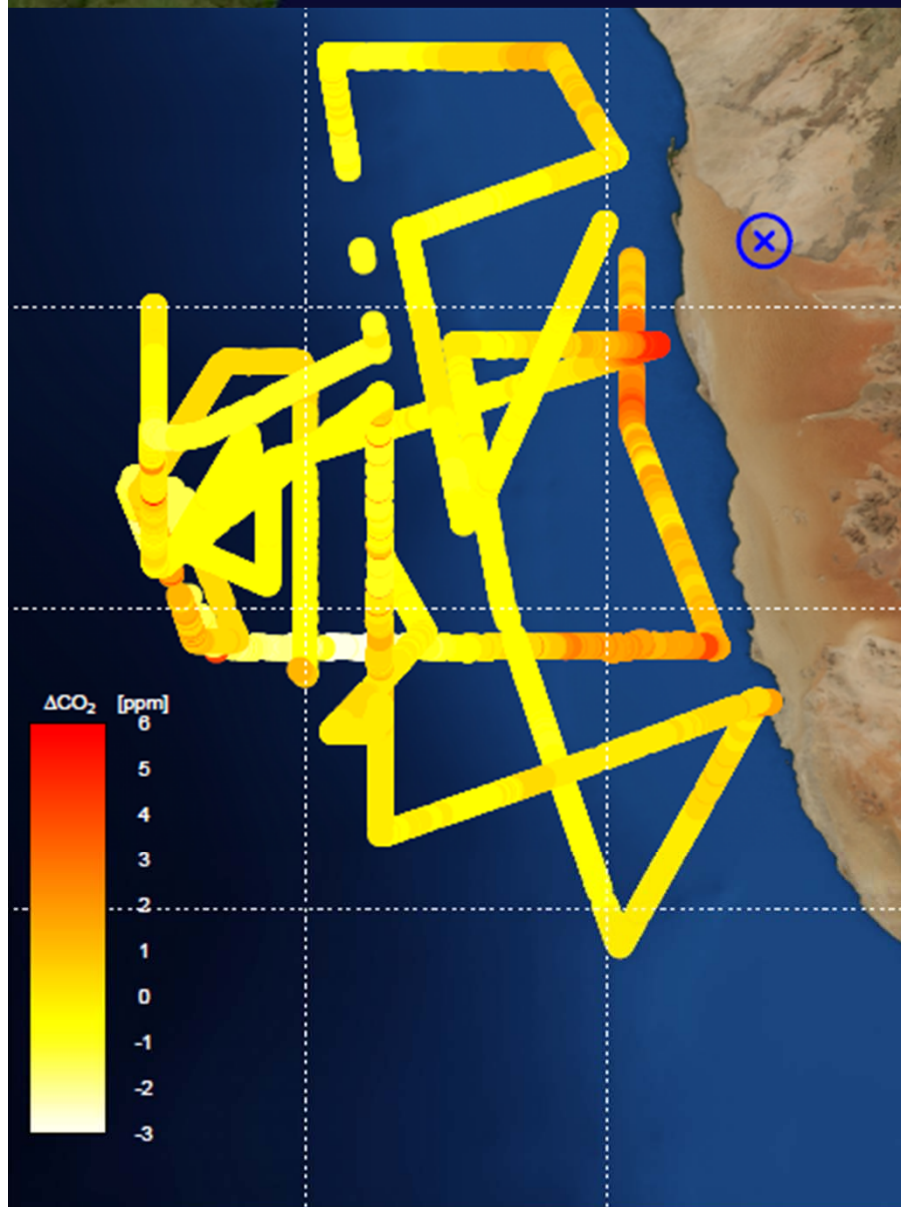


## Spatial patterns pCO<sub>2</sub>

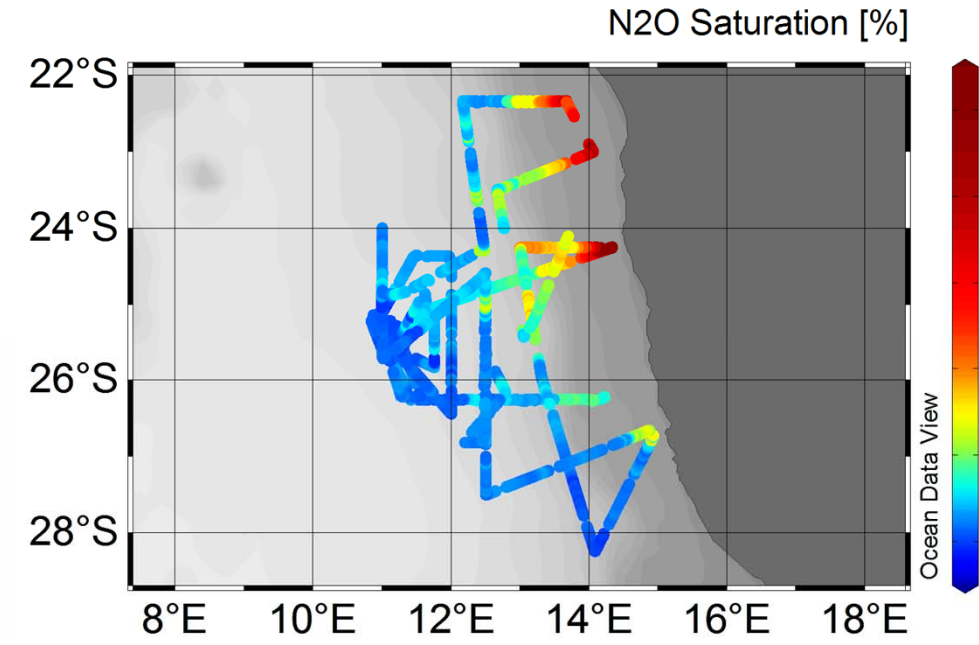
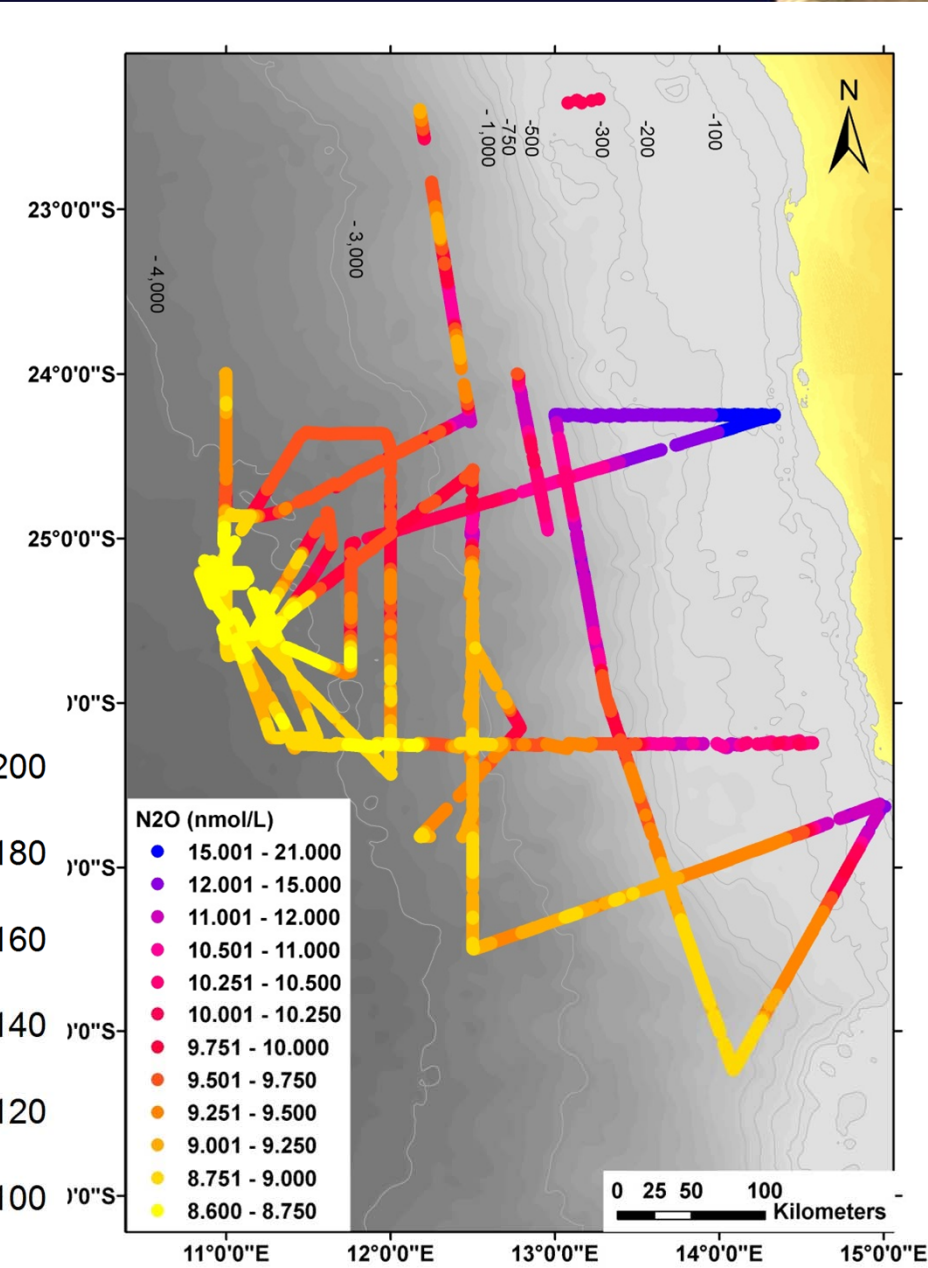
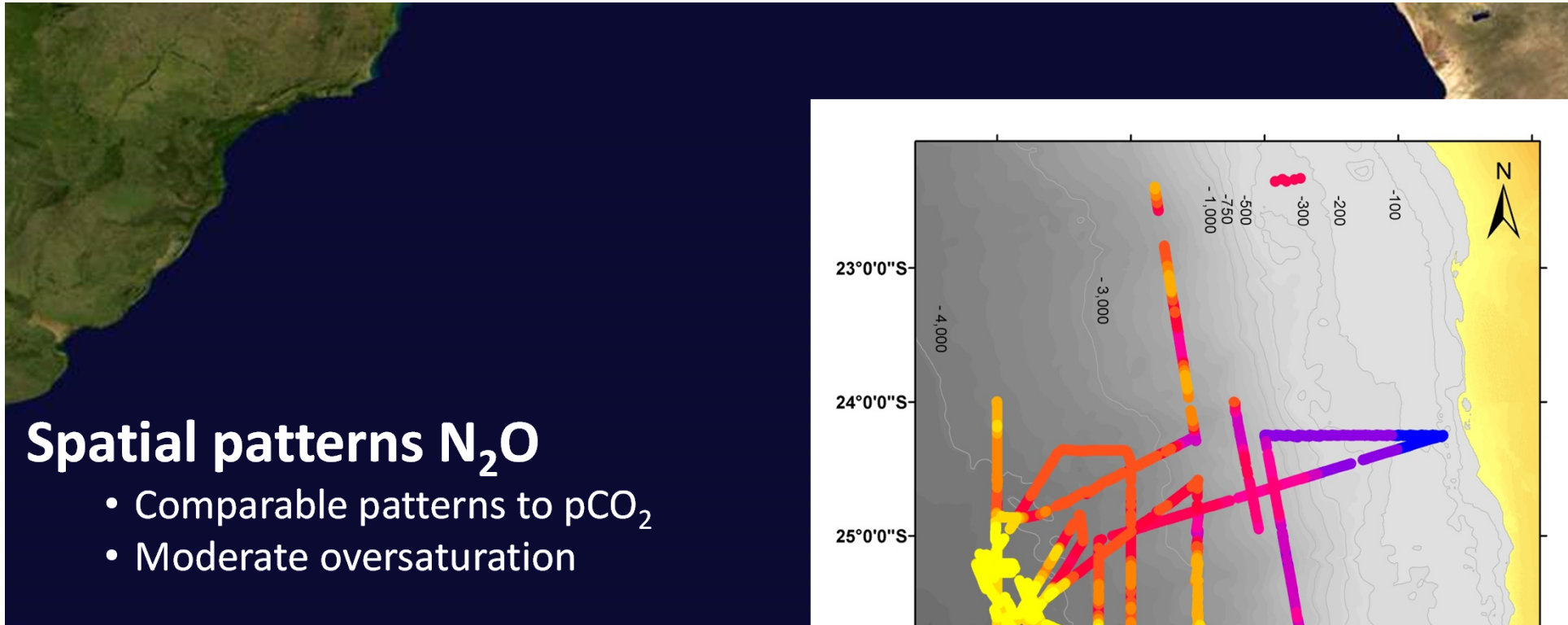
- Highest partial pressures near shore
- Front between 25° S and 26° S further offshore



Atmospheric enhancement of CO<sub>2</sub> in the near-shore region of the NBU, relative to NDAO.

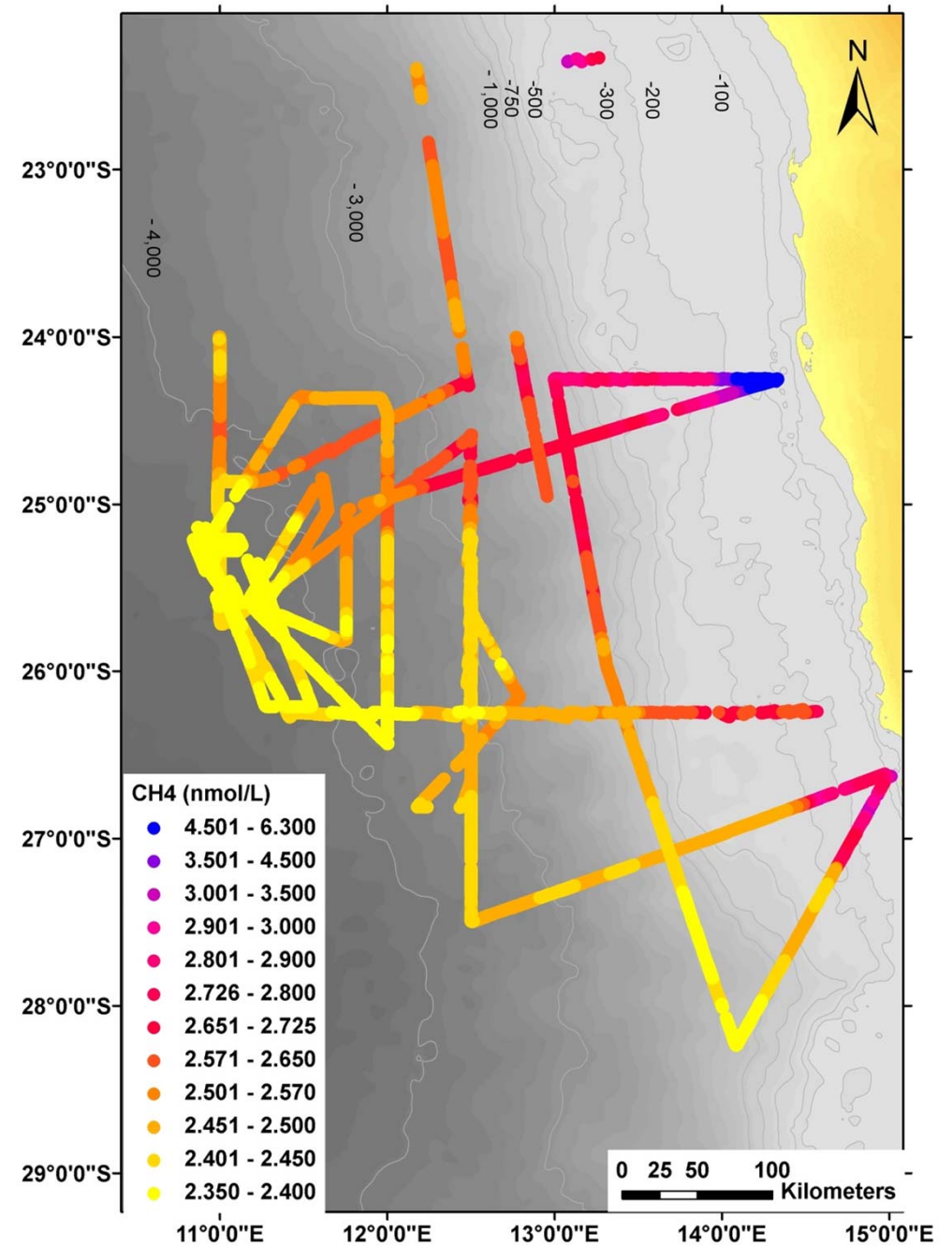






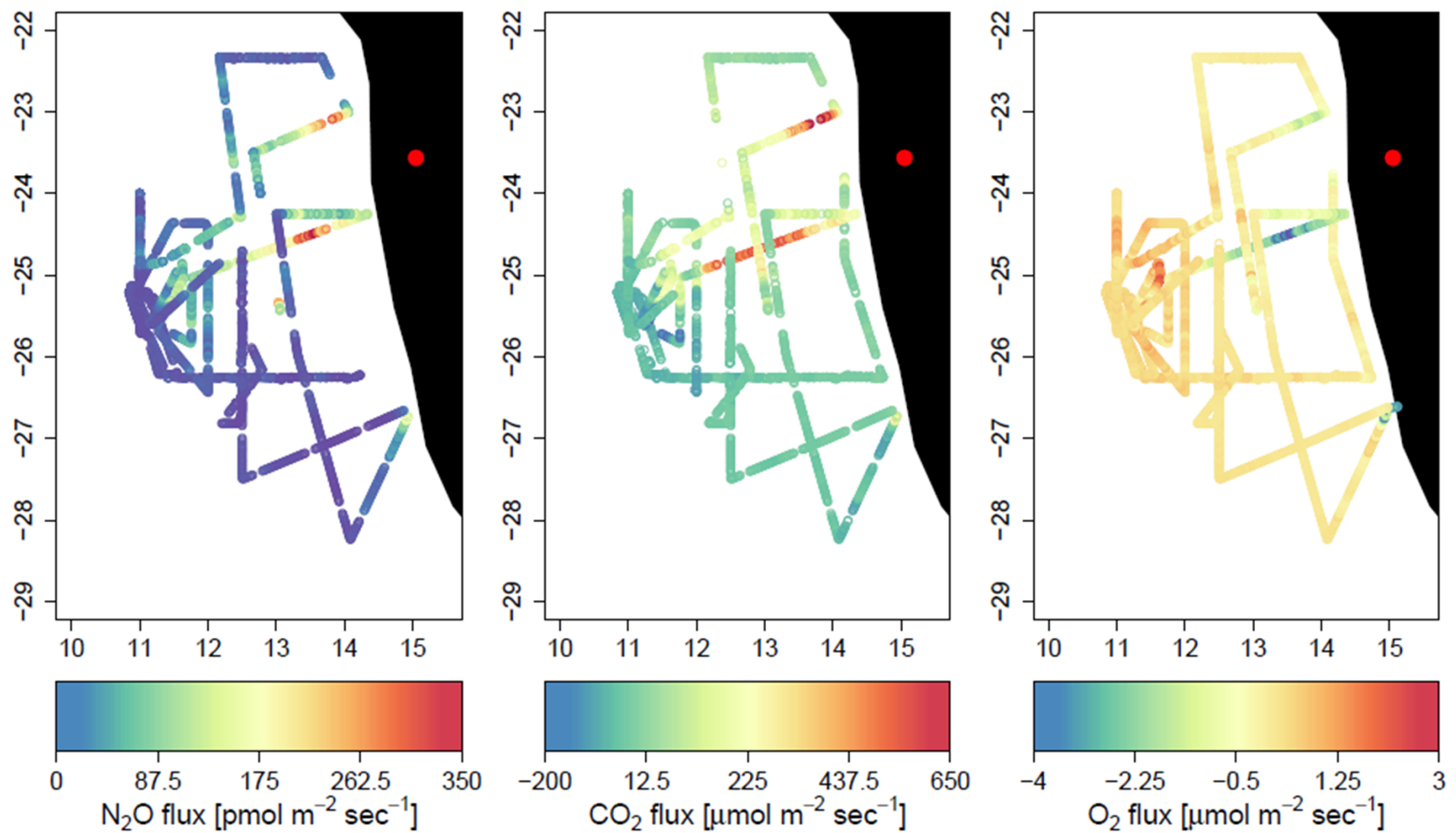
## Spatial patterns CH<sub>4</sub>

- Moderate max. oversaturation of 200 %
- High concentrations bound to inshore upwelled waters





# Flux densities estimated from shipboard measurements during M99 (red dot = NDAO)



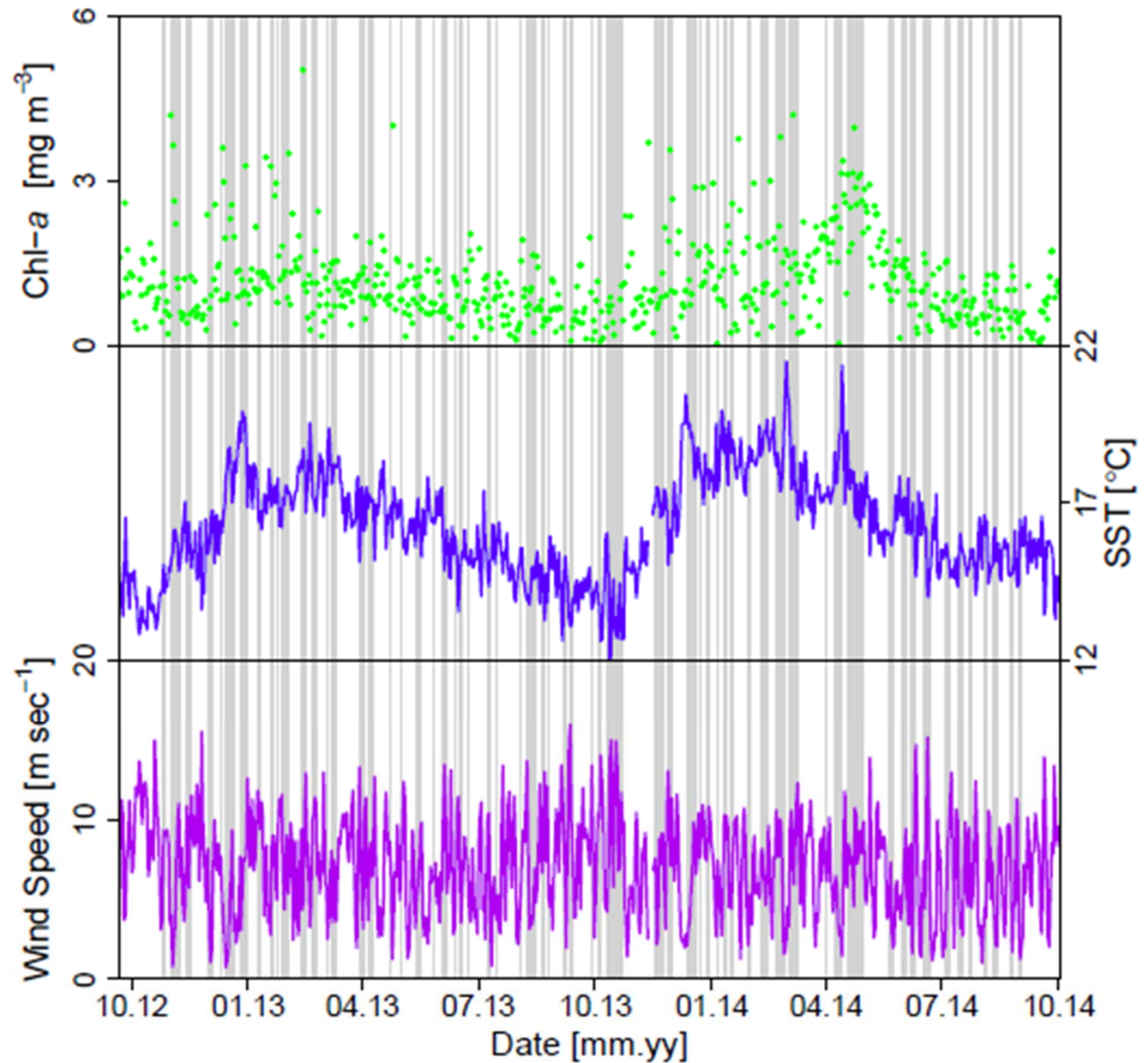
Morgan et al, in prep

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Surface chlorophyll a, SST, and 10-m wind speed for the Lüderitz domain over the course of the two-year study period.

Days which have been flagged as containing an upwelling event have been shaded.

Morgan et al, in prep





## SUMMARY

- CEOD techniques -> drastically enhanced resolution and potential for new insights into sea surface patterns of trace gases
- Benguela upwelling in austral winter 2013 was characterized by relatively moderate surface trace gas concentrations, but clear relation of enhanced partial pressures with SST
- Enhanced trace gas concentrations and relation to SST holds true even in upwelling filaments > 200 km offshore
- Different oxygen content of underlying water masses drives distinct surface partial pressure / SST relations in the southern and northern part of the working area.
- Atm. anomalies of CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, CO, and O<sub>2</sub> can be related to upwelling events in the Lüderitz and Walvis Bay cells
- The top-down estimates of surface fluxes have been validated with in situ surface fluxes determined from shipboard measurements. Observations at NDAO provide the opportunity to capture these episodic and short-lived events that cannot be seen without continuous monitoring.
- Coastal upwelling events near Lüderitz and Walvis Bay result in a large net invasion of O<sub>2</sub> and regionally significant emissions of the major GHGs



**THANK YOU**

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