Flux air-mer de CO_2 dans l'océan sud d'après 65 mois de mesures CARIOCA

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Plan

- Introduction
- Mesures CARIOCA
- Flux air-mer de CO_2
- Zoom sur la variabilité de fCO_2 :
  - Proche du front subantarctique
  - Proche du front subtropical
- Conclusion

Why the southern ocean (south of Subtropical front; ~40S-50S)?

- Large undersaturations of CO_2 observed in surface waters; large area; strong wind speeds => region suspected to be a strong sink of CO_2
- CO_2 sink could be affected by climate change (Lequéré et al 2007)

But:

- Discrepancy of about a factor 2 between air-sea CO_2 fluxes estimated by various methods (36S-56S) (Gloor et al. 2003)

- Large uncertainty in atmospheric inversions: e.g. Patra et al. 2005: uncertainty of 1.21PGC yr^{-1} (45S-60S), Baker et al. 2006: long term flux (1992-1996; soith of 45S): -0.28 to -0.55PgC yr^{-1}

- Few measurements, especially in winter

CARIOCA drifters

- Ocean measurements at 2m depth:
  - –fCO_2 (accuracy <3μatm)
  - –SST
  - –SSS
  - –Fluorescence
- Atm. measurements of:
  - –Wind speed
  - –Atm. Pressure
- Trajectory influenced by :
  - –15m depth currents

Lifetime: about 1 year

DIC deduced from fCO2, SST and SSS assuming Alk/SSS relationship (Lee et al, 2006)

F=K ΔfCO2; K from Wanninkhof (1992) rel.

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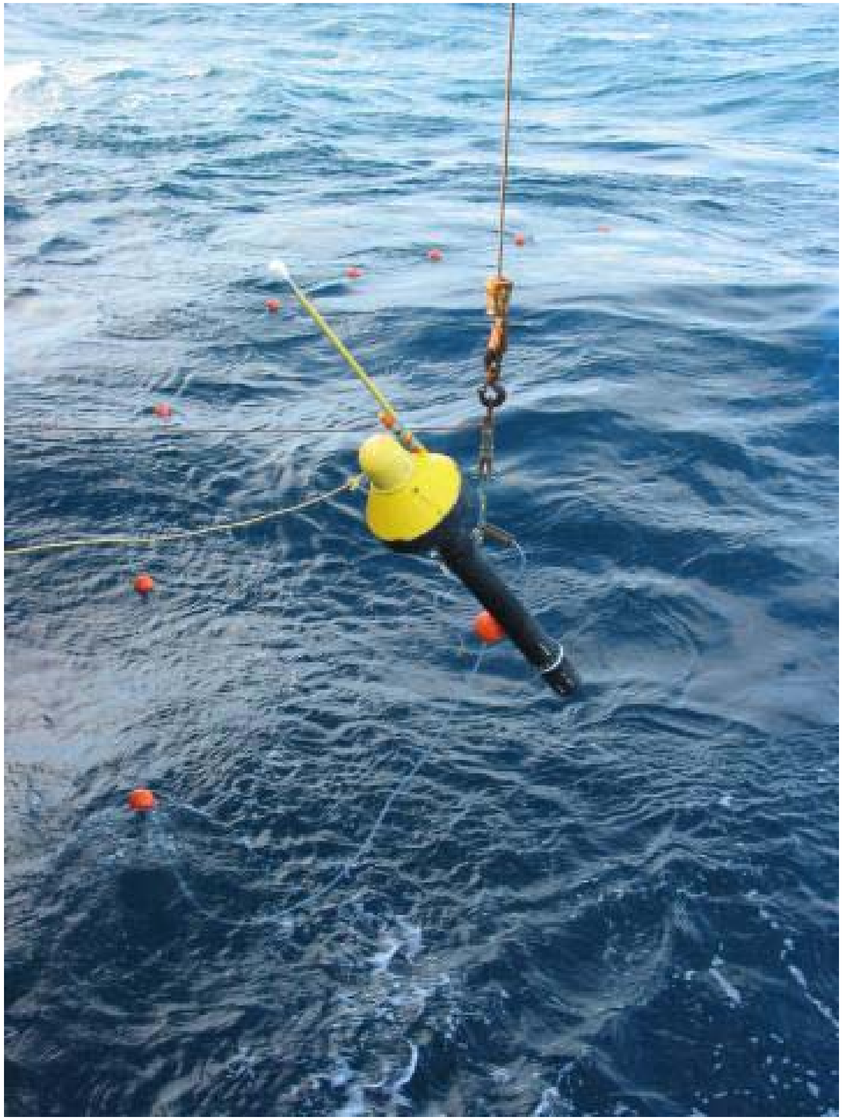
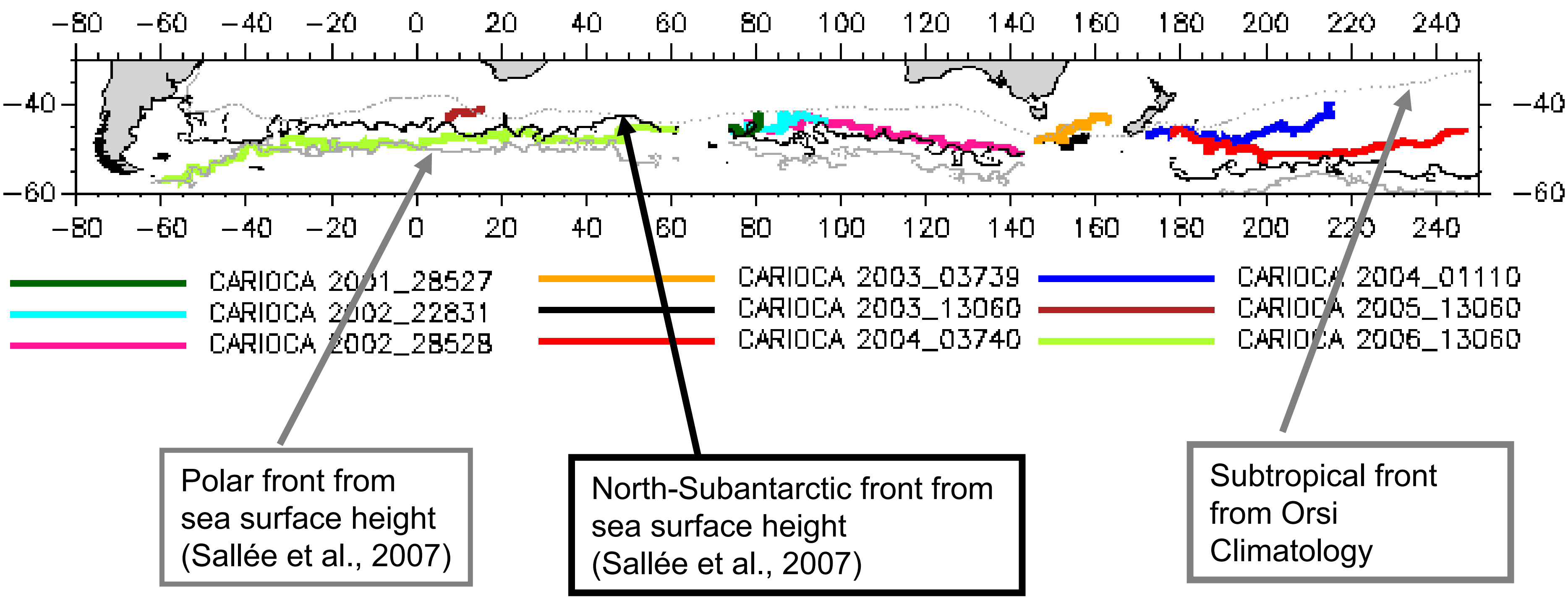


9 CARIOCAs deployed between 2001 and 2006 sampled SAZ and PZ during all seasons

CARIOCA TRAJECTORIES (Carioca # are color coded)



SAZ: Subantarctic zone between PF and SAF
PF: Polar zone between SAF and STF

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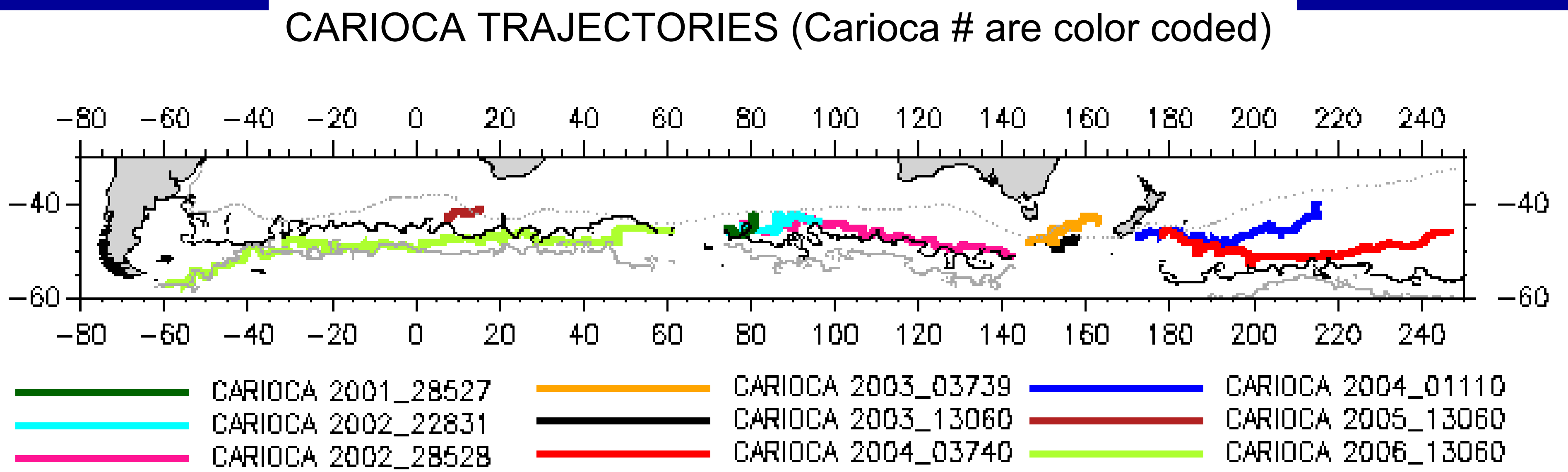

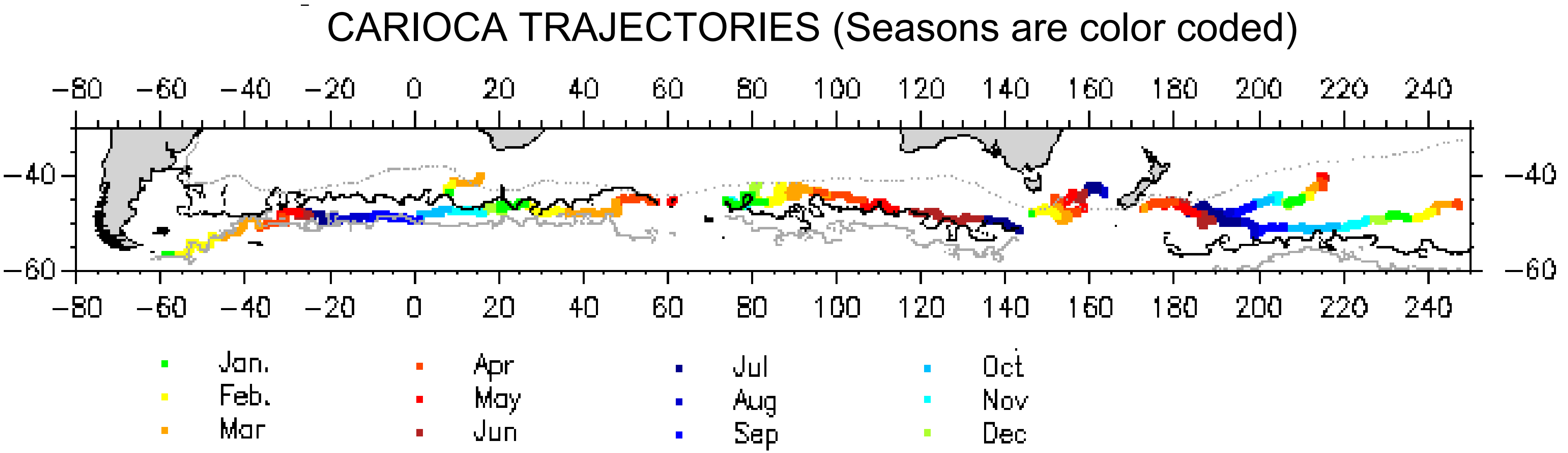

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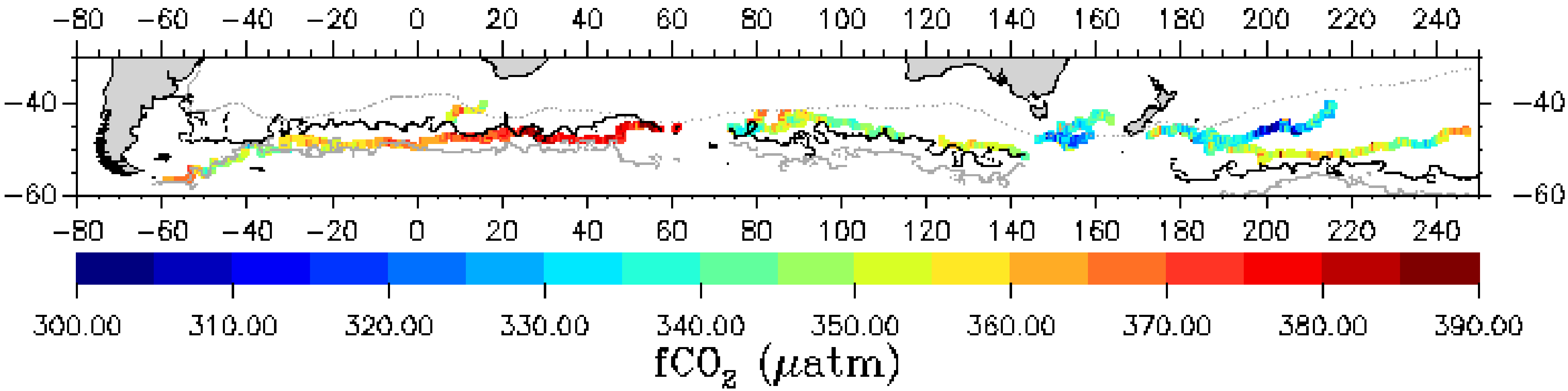
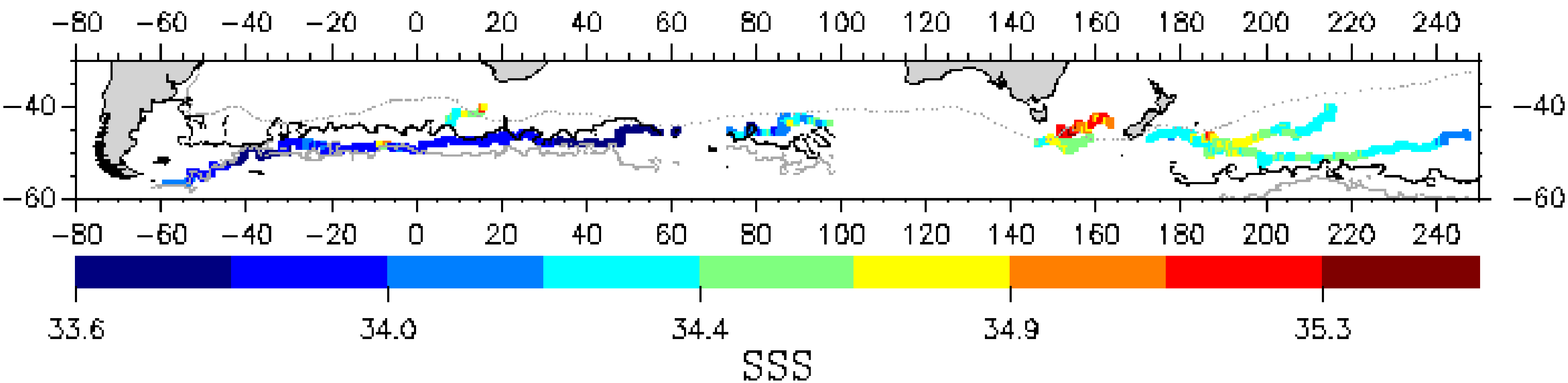
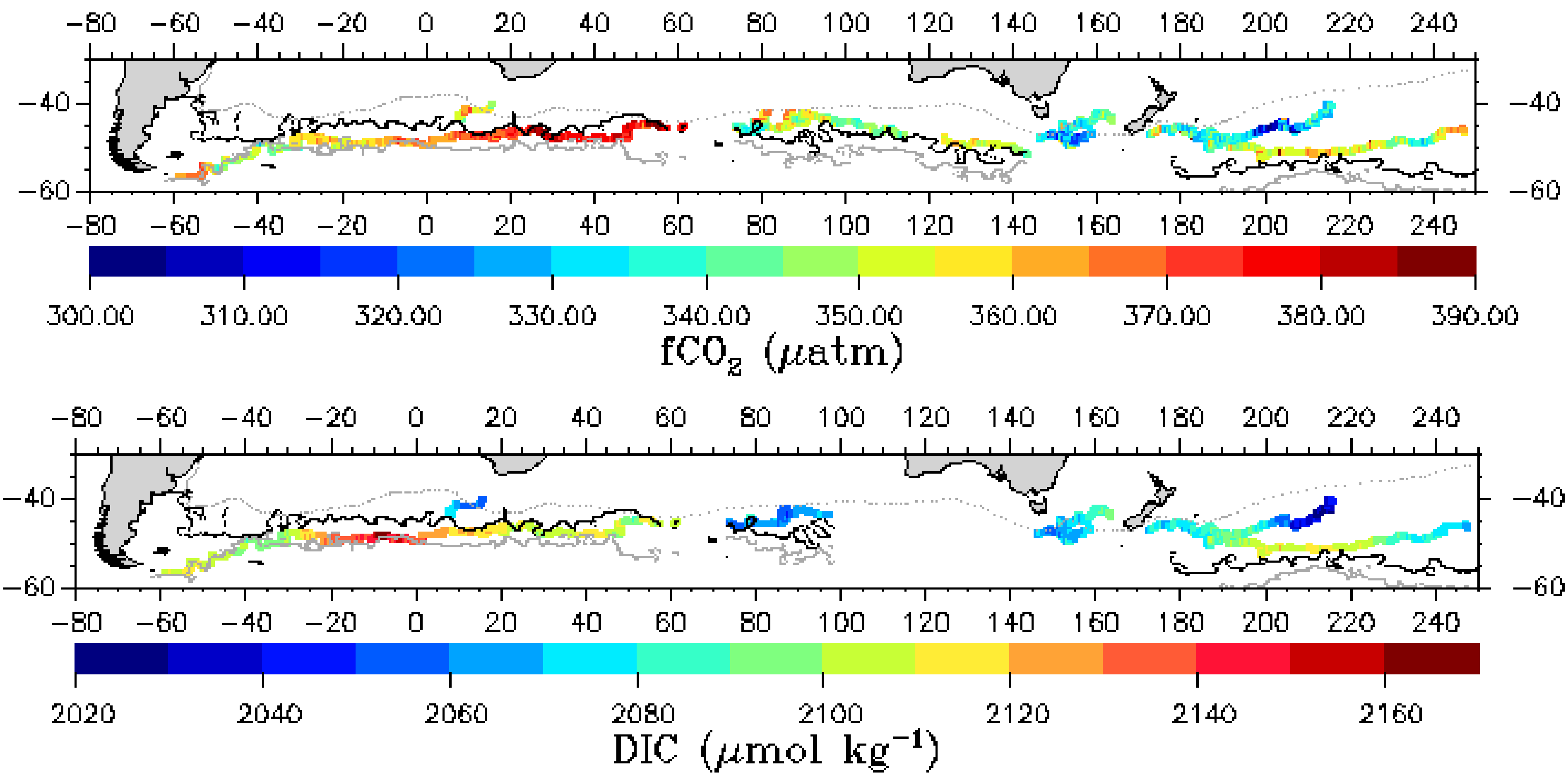
CARIOCA measurements





DIC deduced from fCO_2, SST, SSS using Lee et al. (2006) Alk-SSS relationship and Lueker et al. (2000) dissociation constants



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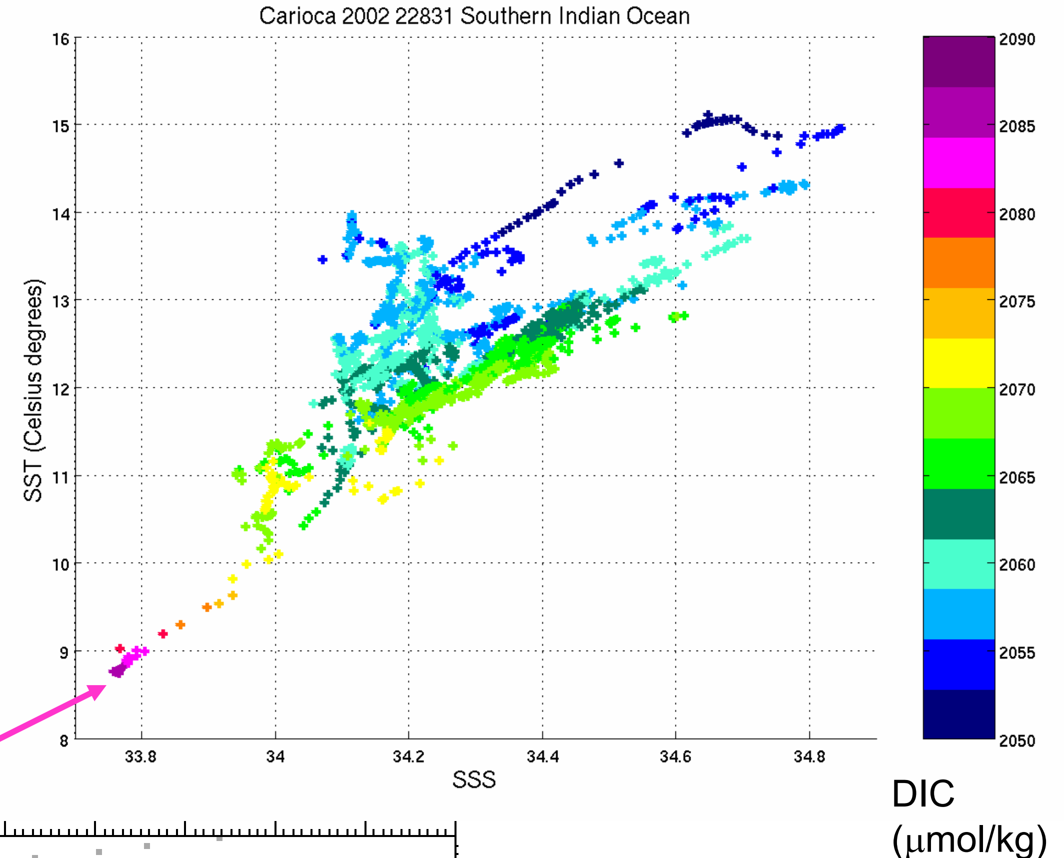
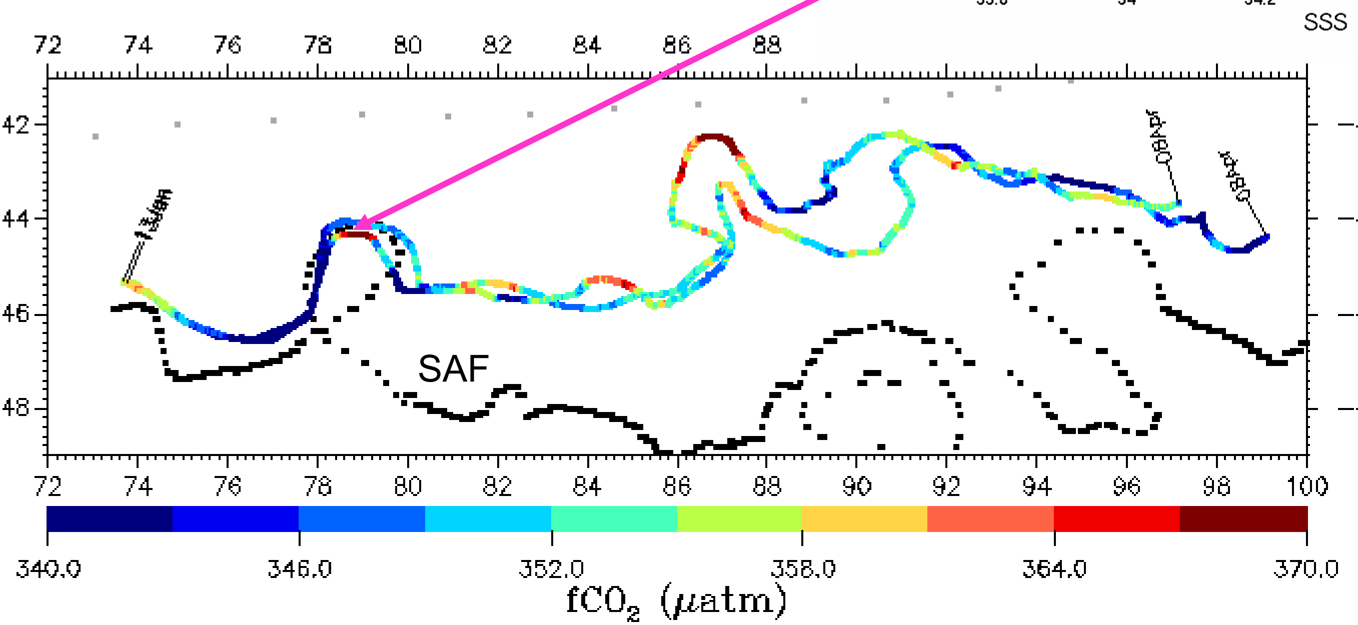
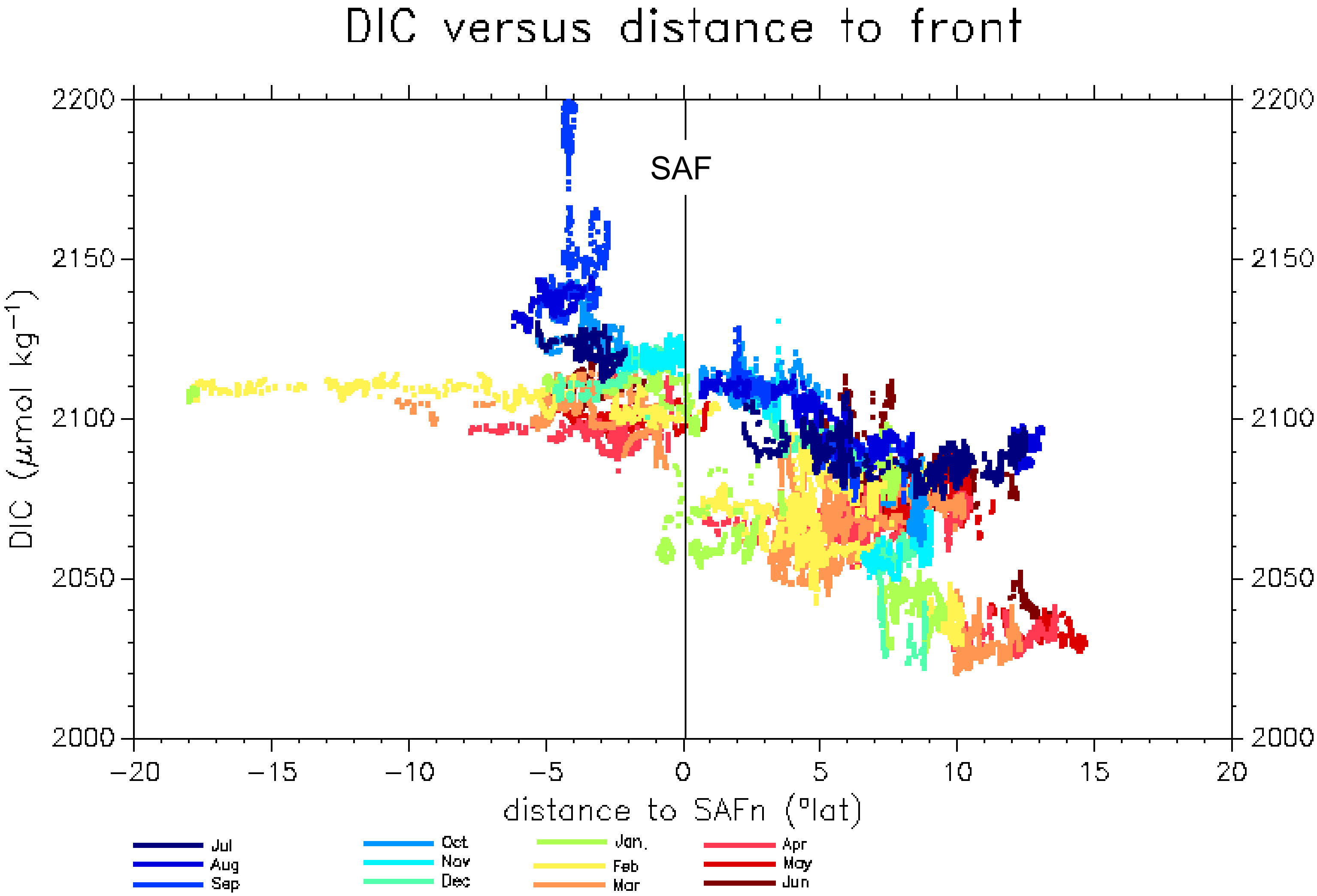
Example of SAF ‘altimetric’ front detection



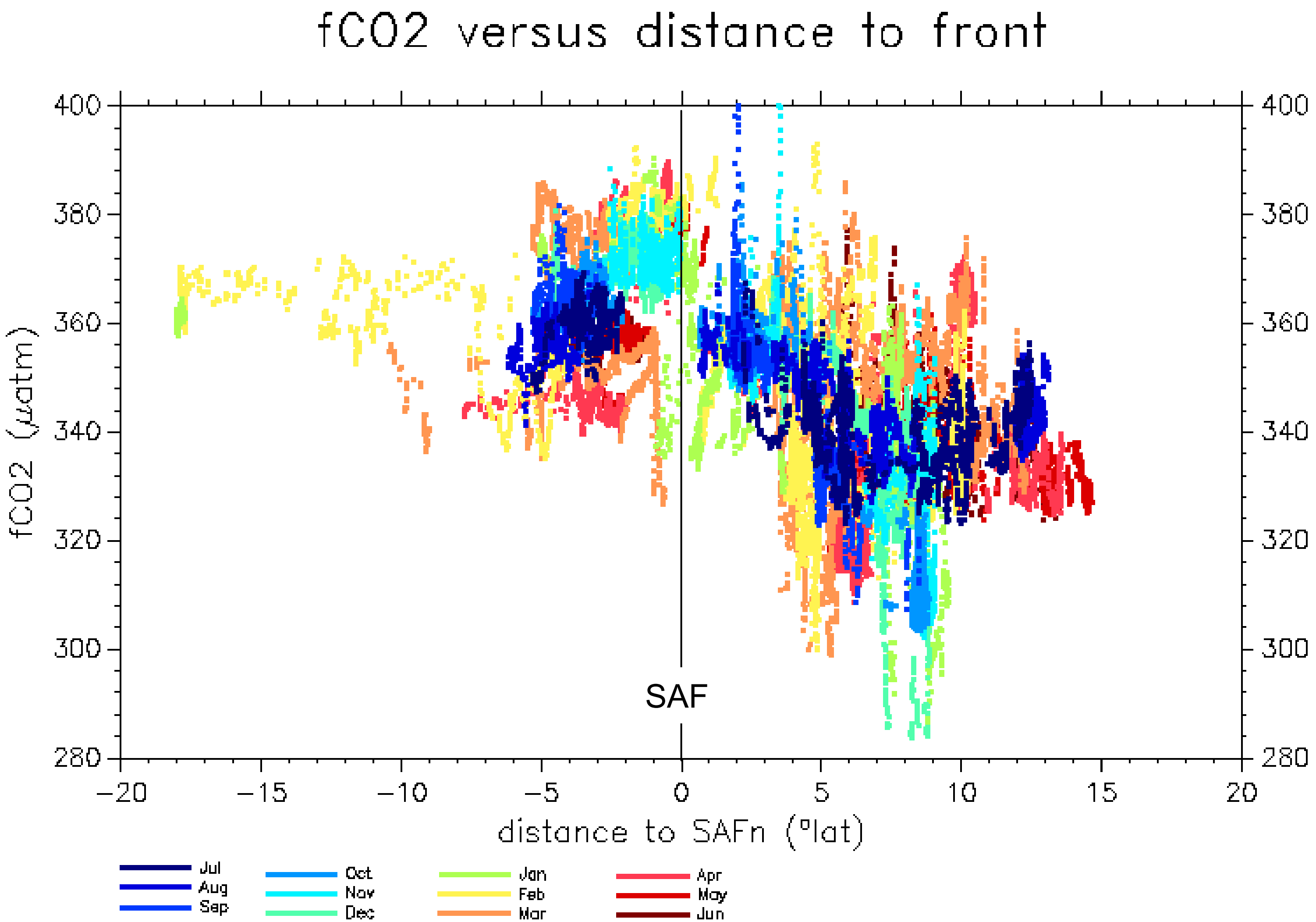
fCO$_2$ from 13 January to





In PZ: DIC between 2080μmol/kg and 2120μmol/kg (except during one episodic event in Sept. on PF close to 9W-49S) –seasonal variation<30μmol/kg

In SAZ: DIC between 2020μmol/kg and 2120μmol/kg; decrease of DIC from SAF to STF by about 40μmol/kg ; at a given distance to the SAF, seasonal variation of about 50μmol/kg with maximum in Aug-Oct and minimum in Jan-March



In PZ: fCO_2 between 330μatm and 390μatm – no clear seasonal variation

In SAZ: fCO_2 between 400μatm and 290μatm; decrease of fCO_2 from SAF to STF by about 30μatm ; no evidence of seasonal variation

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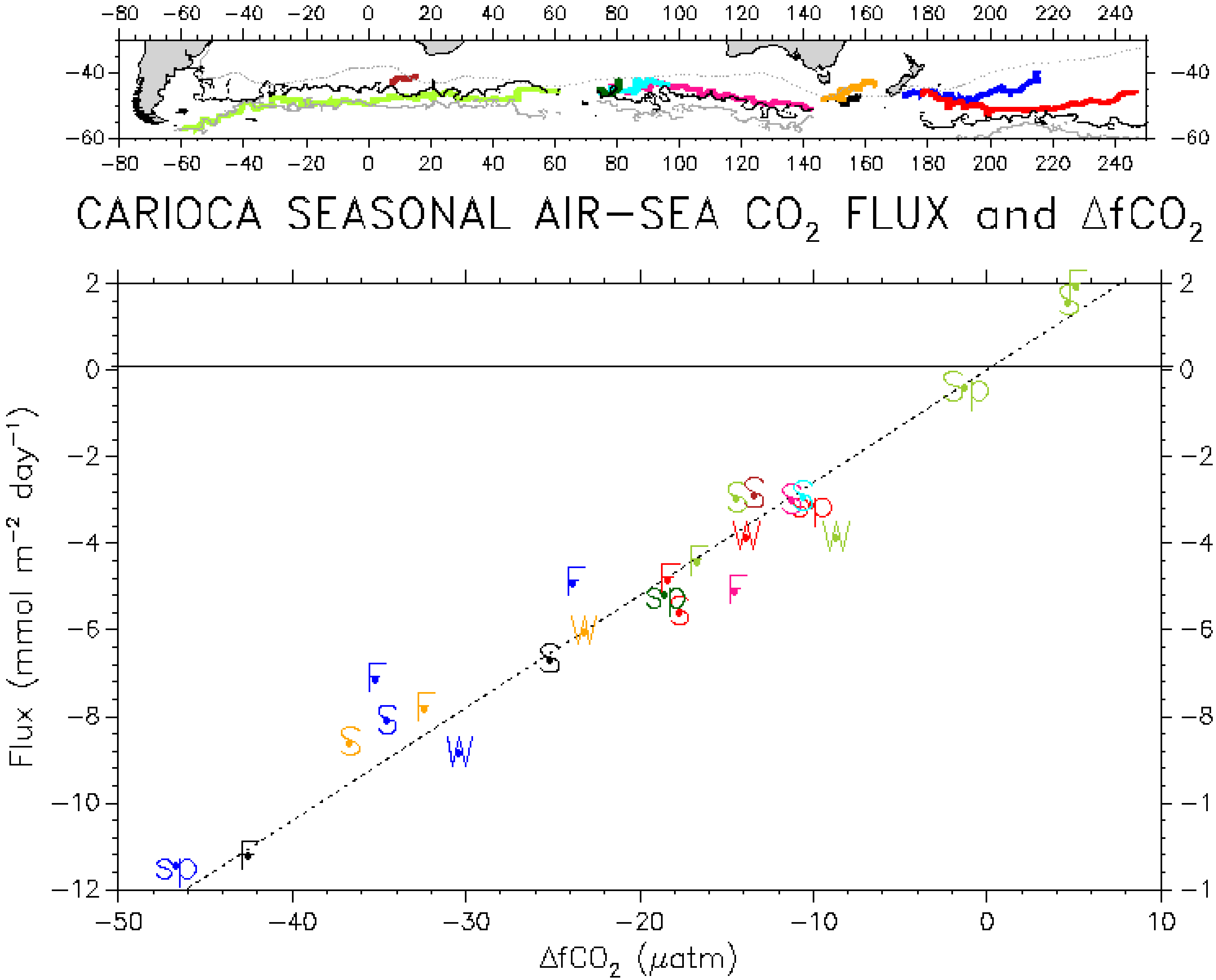
Air-sea flux of CO_2 along buoys trajectories

(Use of k-U relationship of Wanninkhof, 1992) and QSCAT wind speeds



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Air-sea CO_2 fluxes integrated by seasons in PZ and SAZ

	January-March	April-Jun	July-August	September-December	Yearly
Flux in SAZ (mmol m^{-2} d^{-1})	-5.4	-5.6	-6.4	-6.6	-6.0
Surface of SAZ (10^6 km^2)	31.3	31.3	30.6	30.7	31.0
Flux in SAZ (PgC)	-0.18	-0.19	-0.21	-0.22	-0.81
Flux in PZ (mmol m^{-2} d^{-1})	-0.70	-1.25	-3.87	-0.41	-1.56
Surface of PZ (10^6 km^2)	13.7	13.2	13.4	13.6	13.5
Flux in PZ (PgC)	-0.01	-0.02	-0.06	-0.01	-0.09

Due to large surface, low fCO_2 and large winds,
SAZ is a strong sink for atmospheric CO_2 (-0.8 PgC yr^{-1})

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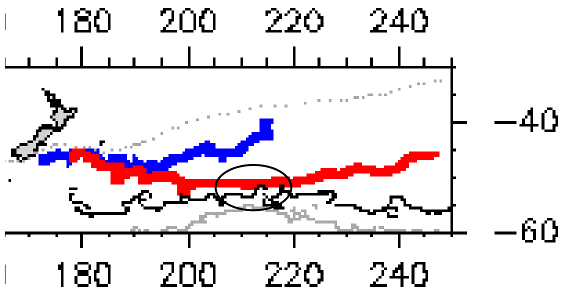
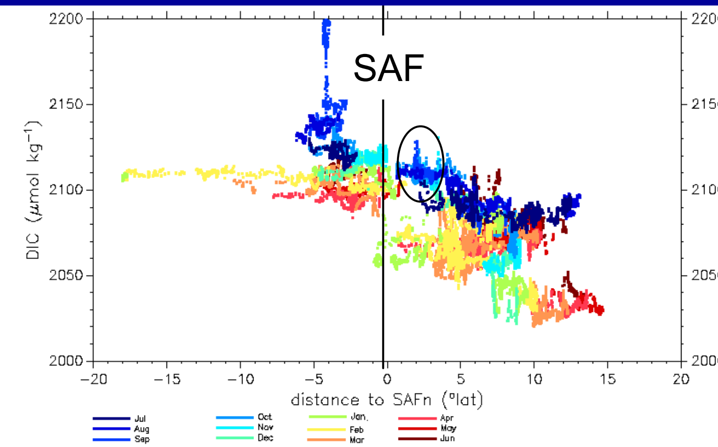
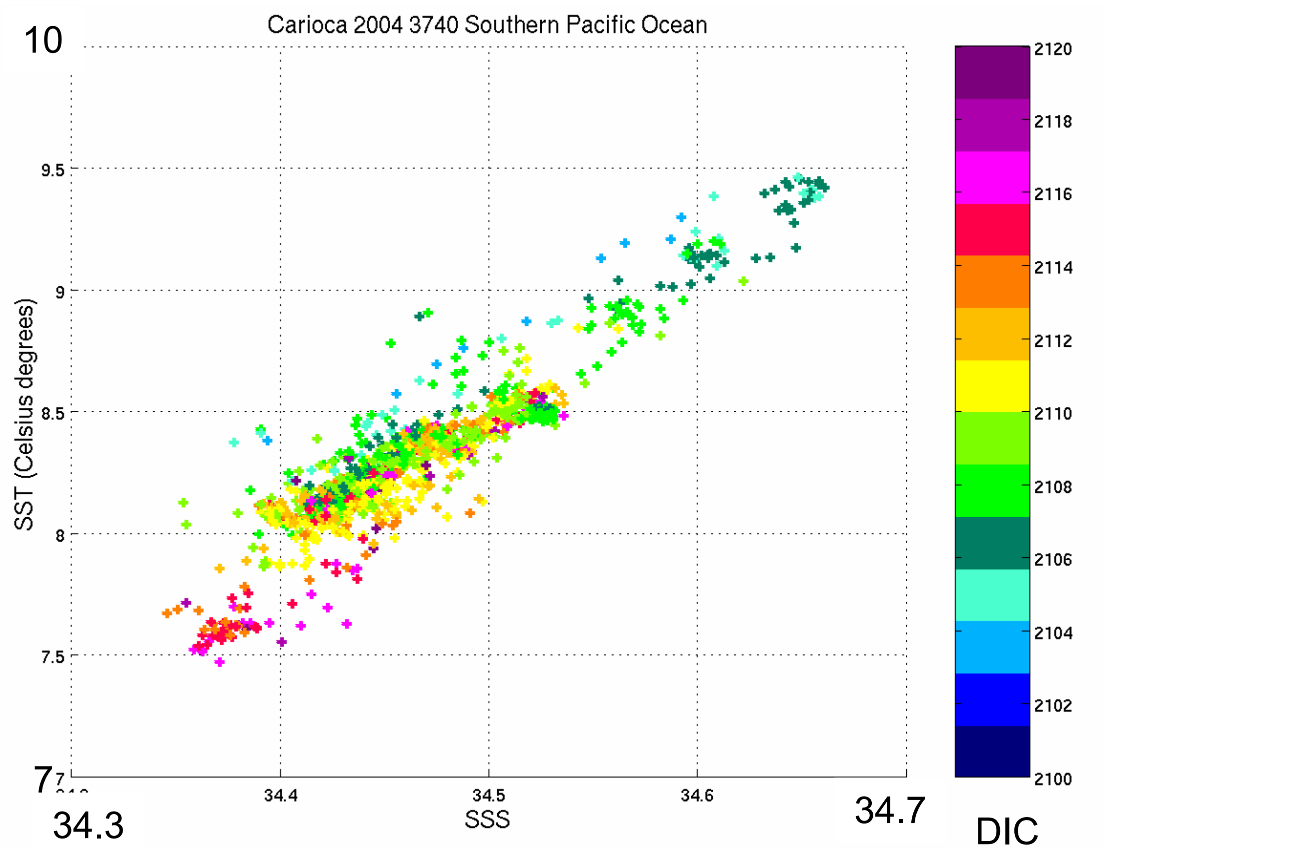
Mixing and high DIC close to SAF in the Pacific in Sept-Oct







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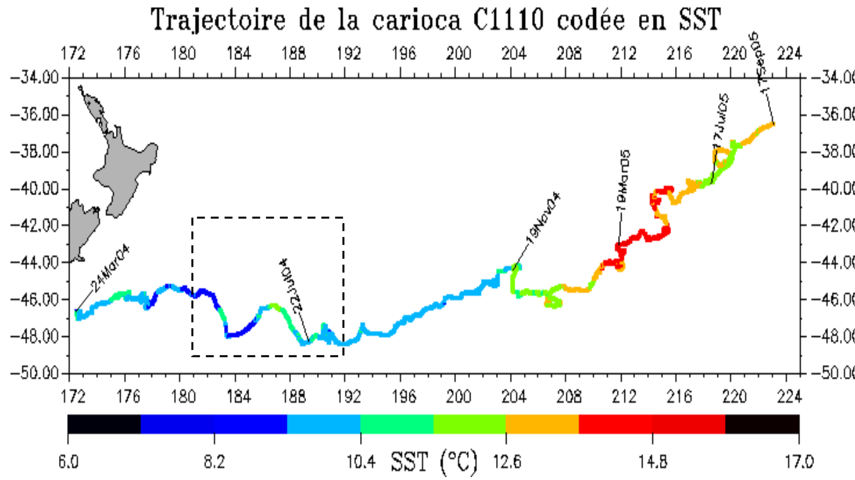
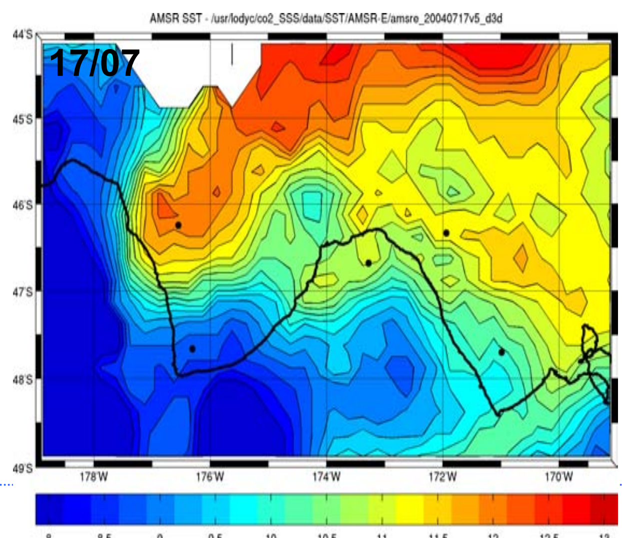
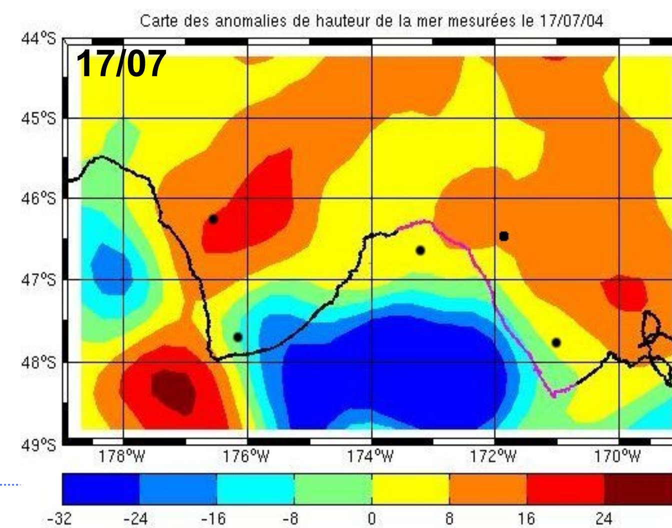
CARIOCA and ARGO floats close to subtropical front (Pacific Ocean)





SST



SSHA

8 12 °C

-32cm 32cm

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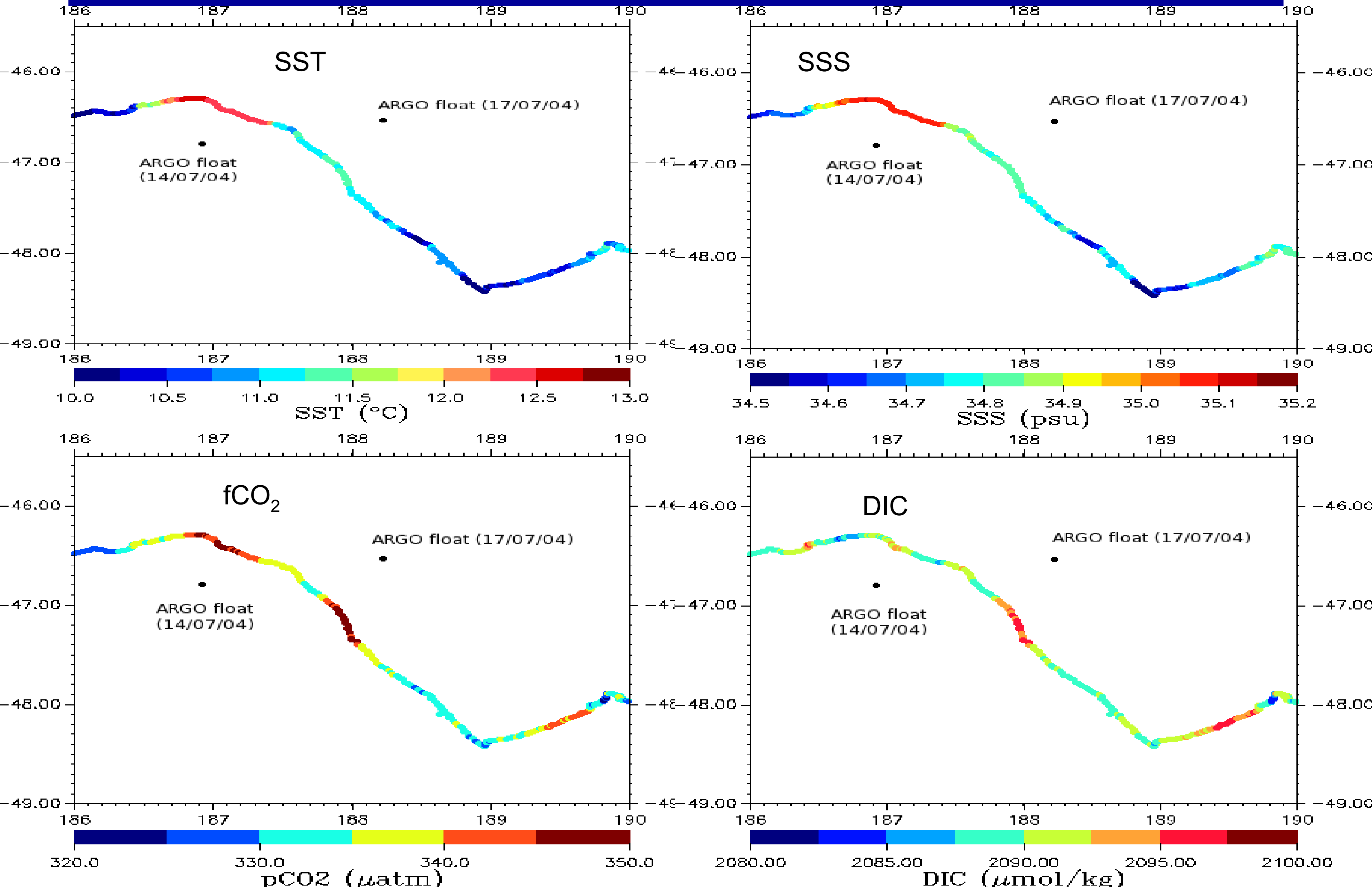
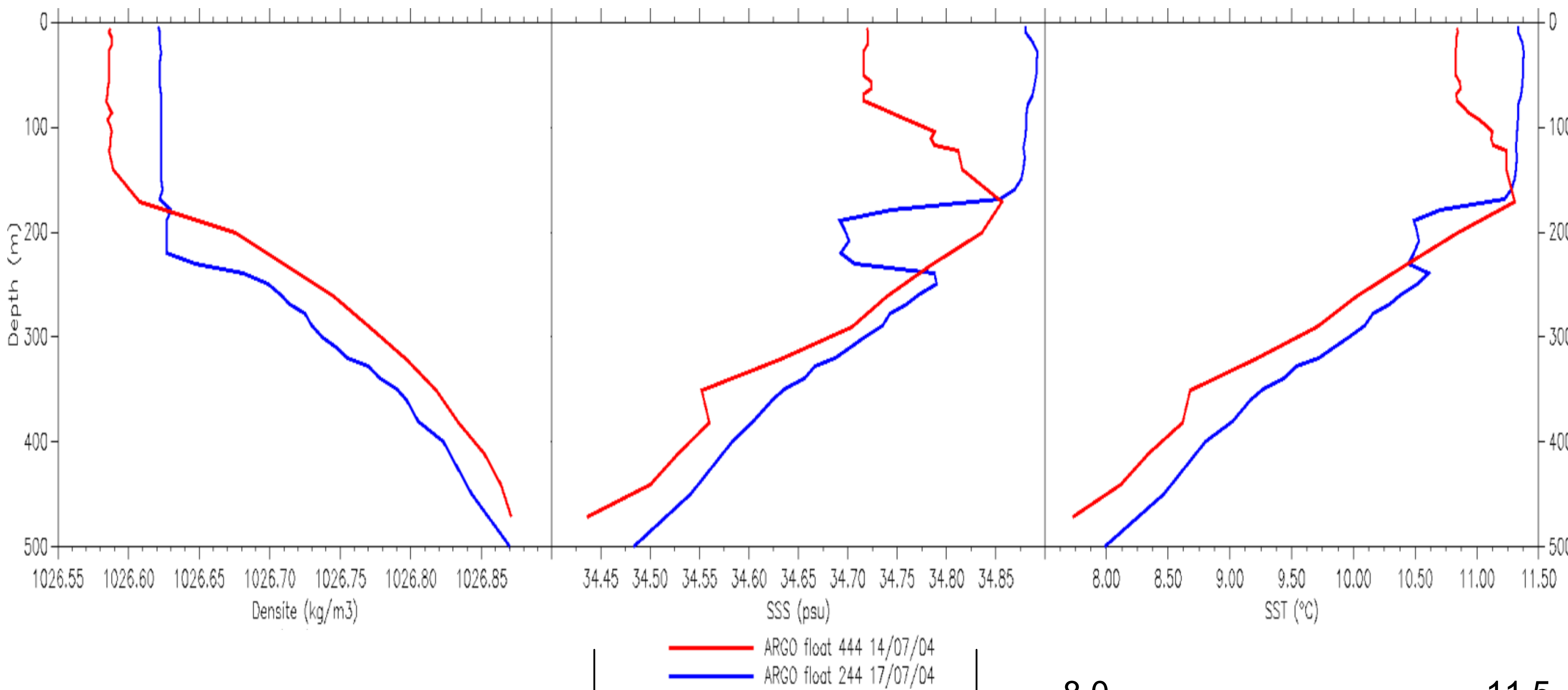
Stage Master HENOCQ Claire

CARIOCA and ARGO floats close to subtropical front (Pacific Ocean)



ARGO profiles=> compensated layers at 170-230m depth



Density (kg/m3) 34.45 S (psu) 34.85 8.0 T (°C) 11.5

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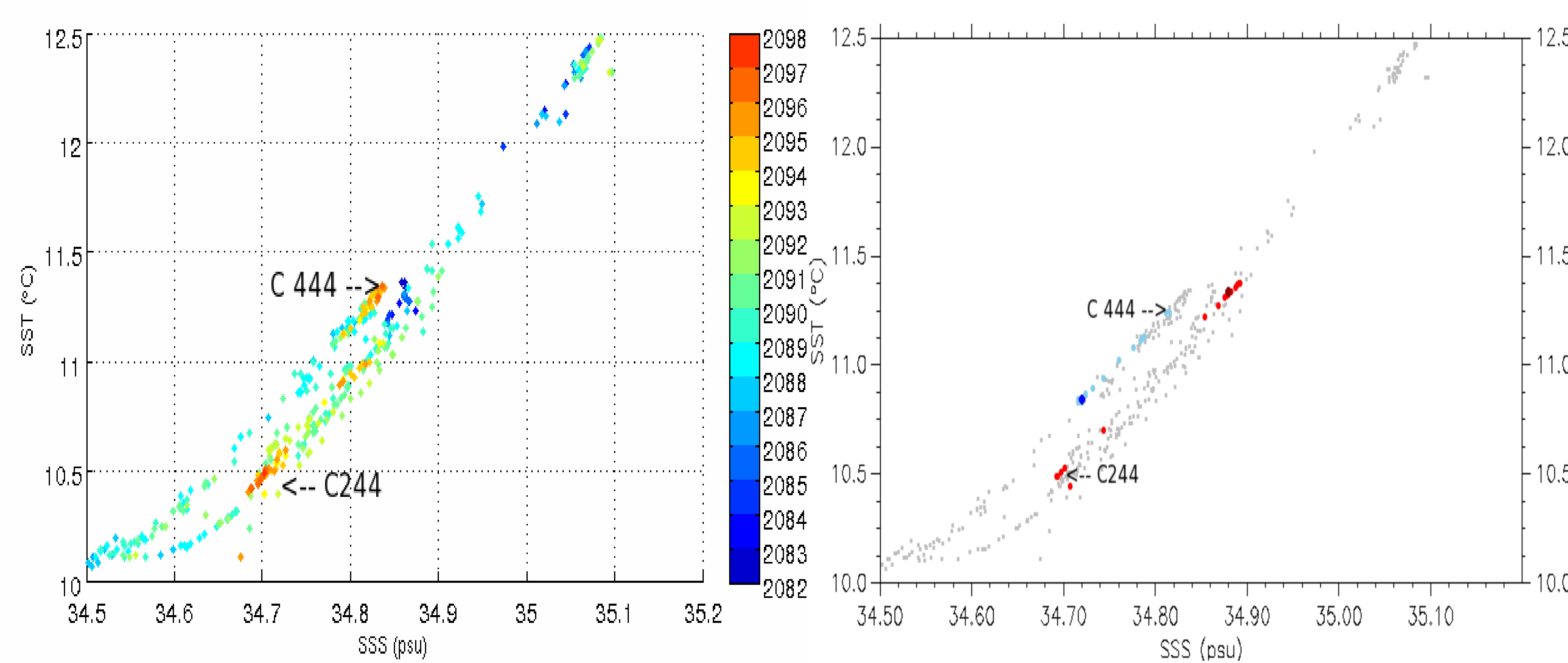
CARIOCA and ARGO T-S diagrams



DIC maxima observed at ocean surface by CARIOCA correspond to (T,S) observed at the basis of compensated depth on ARGO profiles (170-230m):

This suggests that basis of compensated layer is rich in DIC and outcrops at surface in some places

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Summary

65 months of CARIOCA measurements in SAZ and PZ =>

- SAZ strong sink (-0.8PgC yr^{-1}) contrary to PZ (-0.1PgC yr^{-1})
- Seasonal variation of DIC in SAZ (~50μmol kg^{-1}) but no seasonal variation of fCO_2 because of a compensation between DIC and SST variations

These conclusions are very consistent with McNeil et al. (2007) findings:

-Sink of 1.1+/-0.6PgC yr^{-1} between 40S and 50S

-Summertime depletion of DIC of 30-50μmol kg^{-1} but ~no fCO_2 variation

-Weak sink in PZ

- Decrease of DIC and fCO_2 (~40μmol kg^{-1} and 30μatm) from SAF to STF at all seasons (high biological activity close to STF)
- High DIC in region of SAMW formation close to SAF is linked to mixing in Sept-Oct
- Close to STF, in winter, large mesoscale fCO_2 variations could originate from the presence of high DIC in compensated layer outcropping at the ocean surface

Main unknown regions and seasons

- Pacific Ocean (in particular east Pacific)
- Middle of Atlantic

- Winter – early Spring seasons