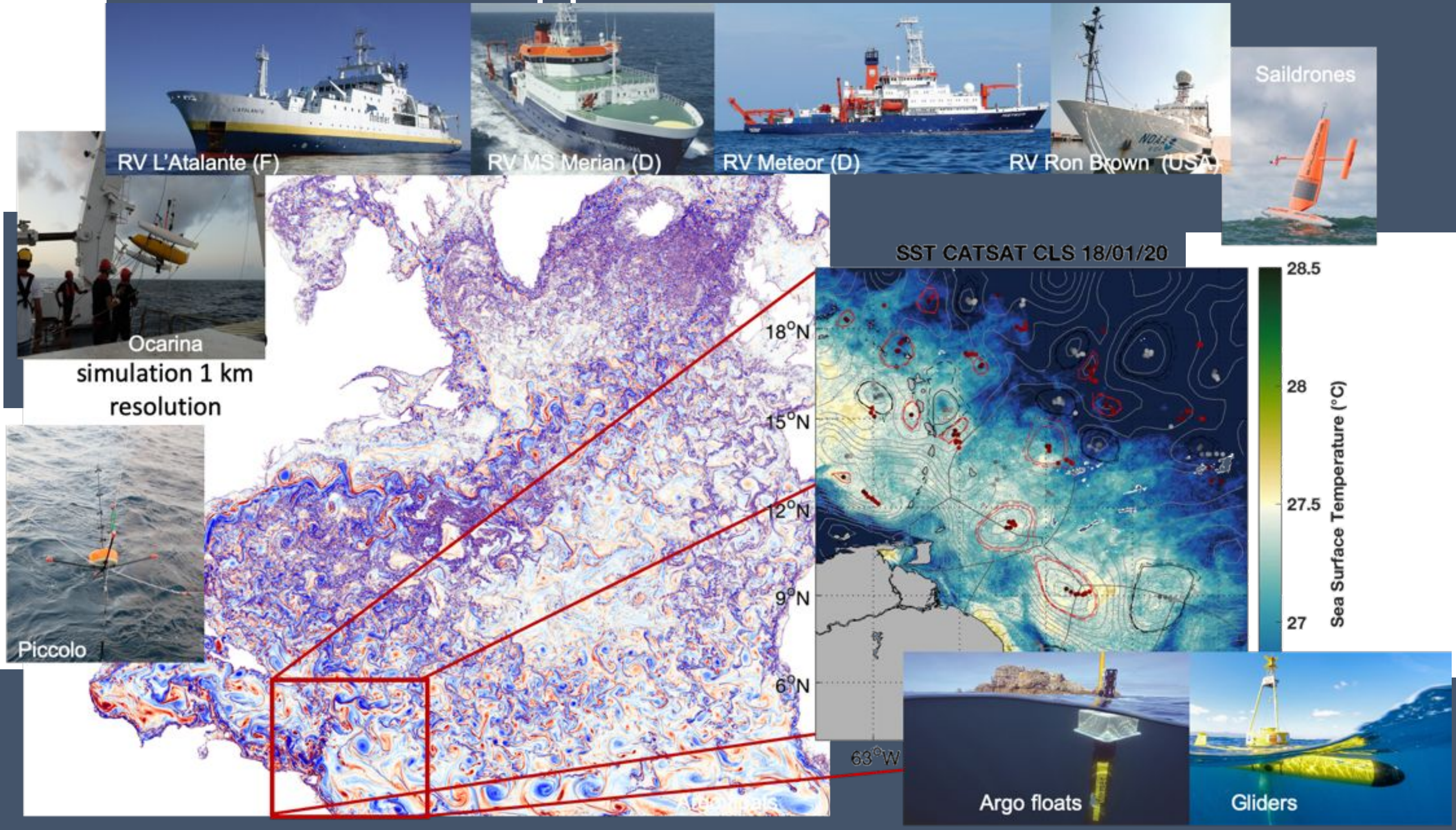
EUREC4A-OA &ATOMIC

JPI Climate · JPI Oceans · CLIVAR · WCRP World Climate Research Programme

Improving the representation of small-scale nonlinear ocean-atmosphere interactions in Climate Models by innovative joint observing and modelling approaches



EUREC^{4}A: The scientific context

http://eurec4a.eu

Among many others, 2 factors are major in regulating the warming of our climate linked with the increase of GHGs in the atmosphere:

- The reaction of clouds to warming
- The absorption of heat and CO_2 by the ocean and how they are transferred back to the atmosphere

We know very little about how the ocean absorbs heat and gases and how the ocean and atmosphere actually interact

EUREC^{4}A-OA will aims to diagnosis and evaluate physical and biogeochemical processes that impact the ocean-atmosphere interface to provide new model parameterizations of such processes

EUREC^{4}A: The international context

EUREC^{4}A

ATOMIC

EUREC^{4}A-OA

JPI Climate

JPI OCEANS

cnes
CENTRE NATIONAL D'ÉTUDES SPATIALES

EUREC^{4}A-U

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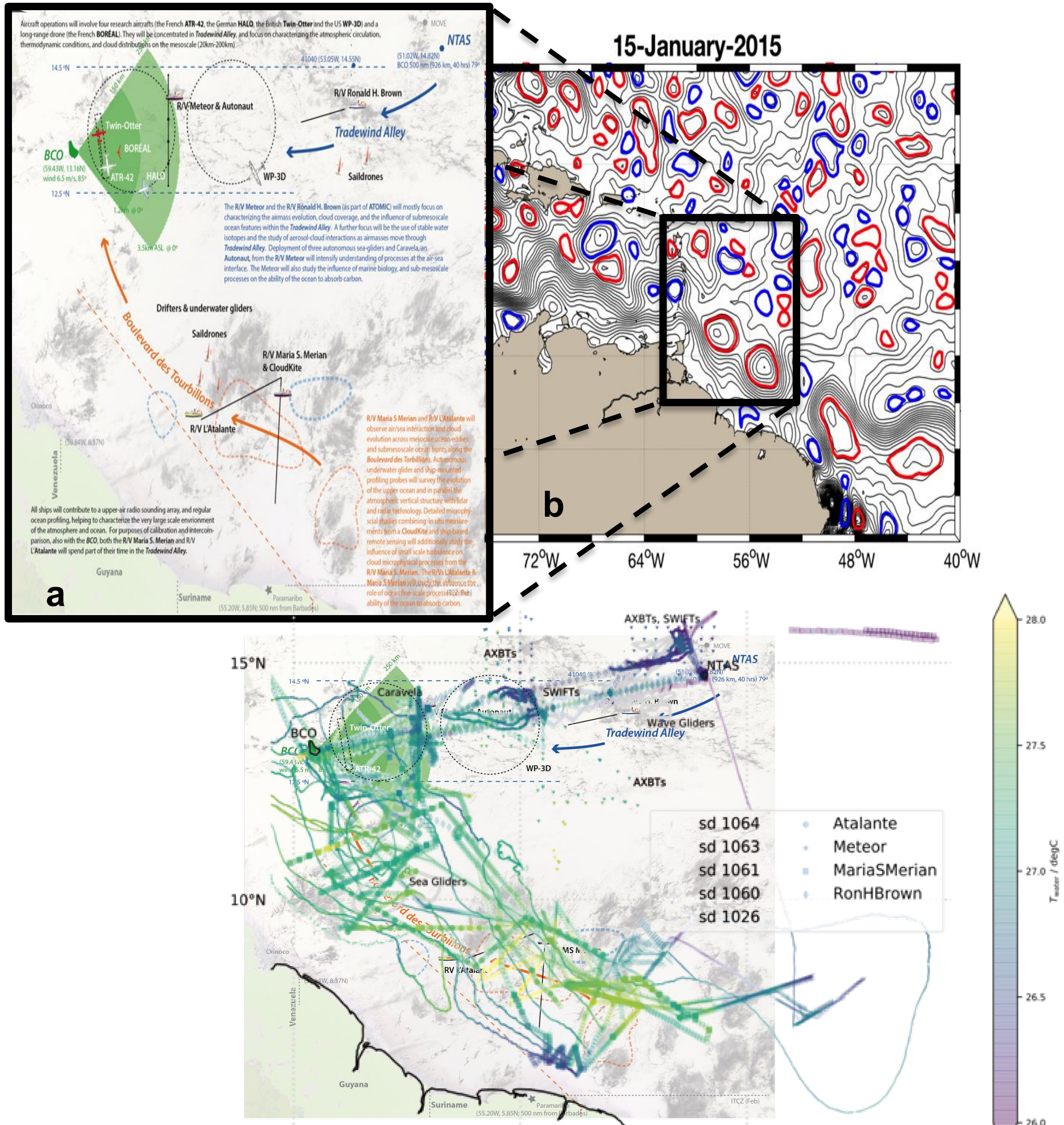
World Climate Research Programme

EUREC4A-OA

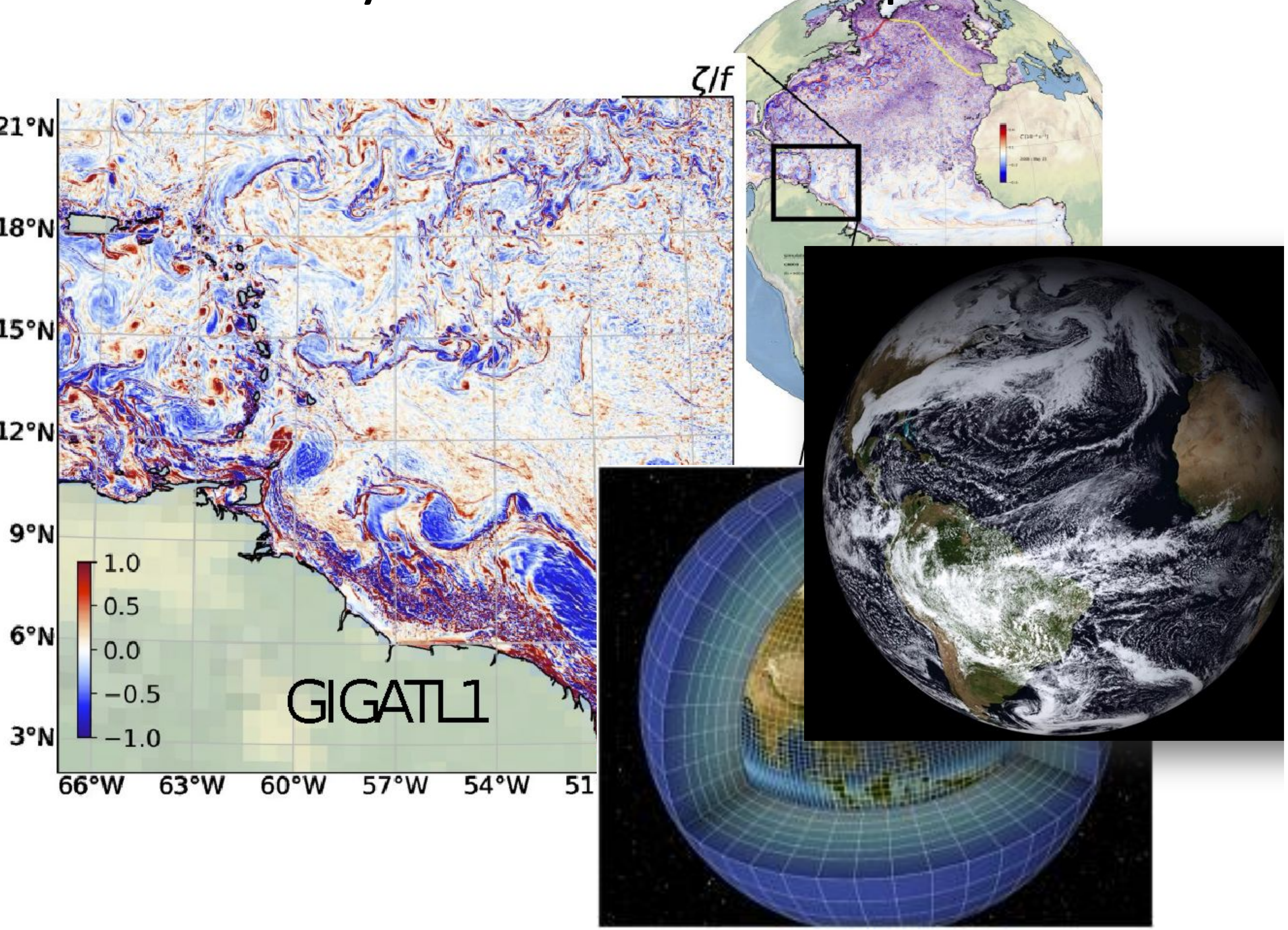
The EUREC^{4}A-OA global strategy

A multiplatform, multi-disciplinary
1-month field experiment



The EUREC^{4}A-OA global strategy

A hierarchy of forced and coupled ocean and atmosphere simulations



The EUREC^{4}A-OA global strategy

WORK ALONG 2 PATHWAYS:

- Processes understanding
- Processes parameterization and metrics

PROJECT STATUS

The **EUREC^{4}A-OA** project has been organized in 4 steps which have been structured under different funding sources:

DONE

1. The preparation and execution of the field experiment in January and February 2020;

ALMOST DONE

2. The validation, calibration and analyses of the *in situ* and satellite data;

ALMOST DONE

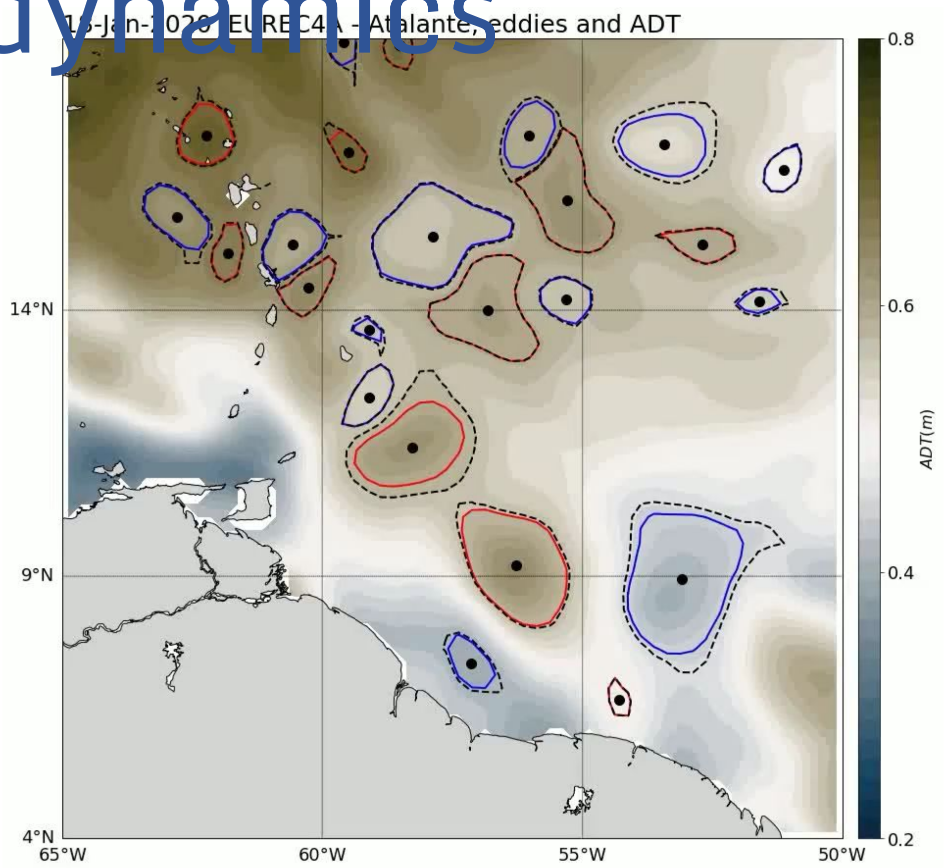
3. The preparation, production and analyses the large set of numerical experiments;

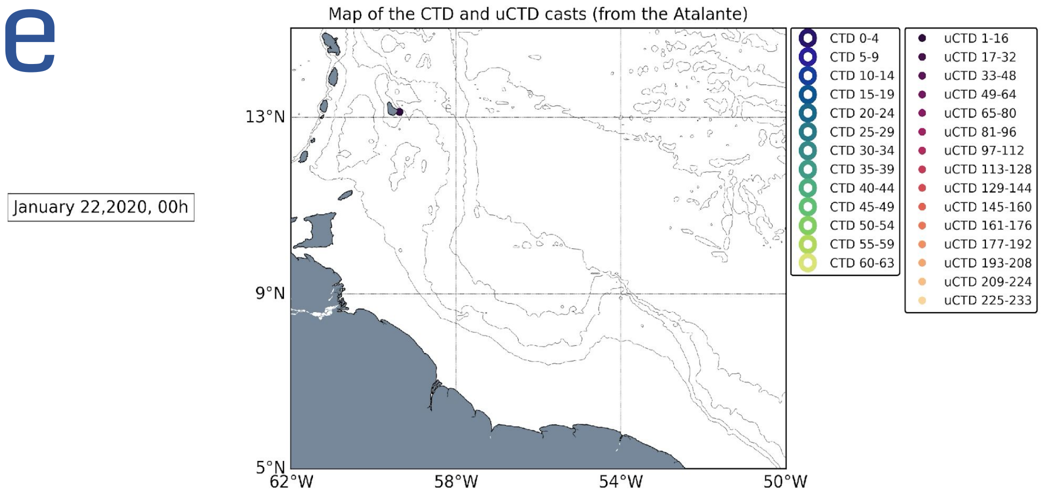
WORK IN PROGRESS

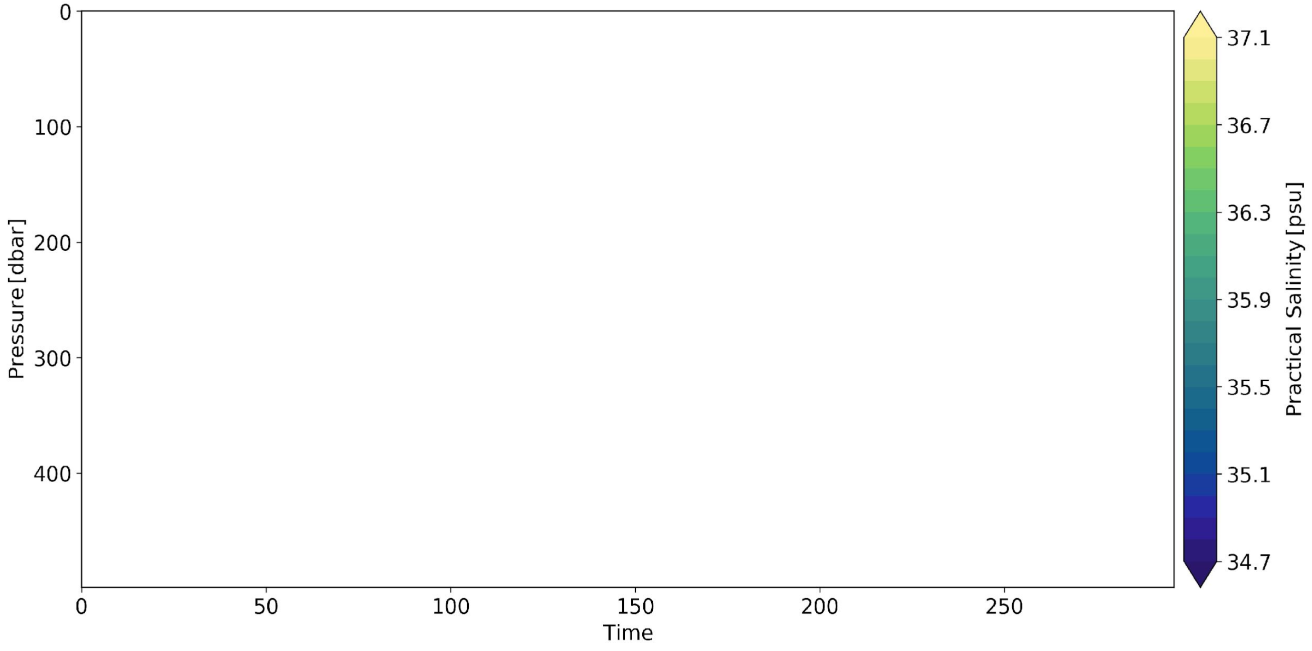
4. The comparison between observations, models and numerical sensitivity studies and parametrization developments.

A PROMENADE THROUGH A SET OF ONGOING STUDIES

Characterization of the oceanic Small-scale dynamics

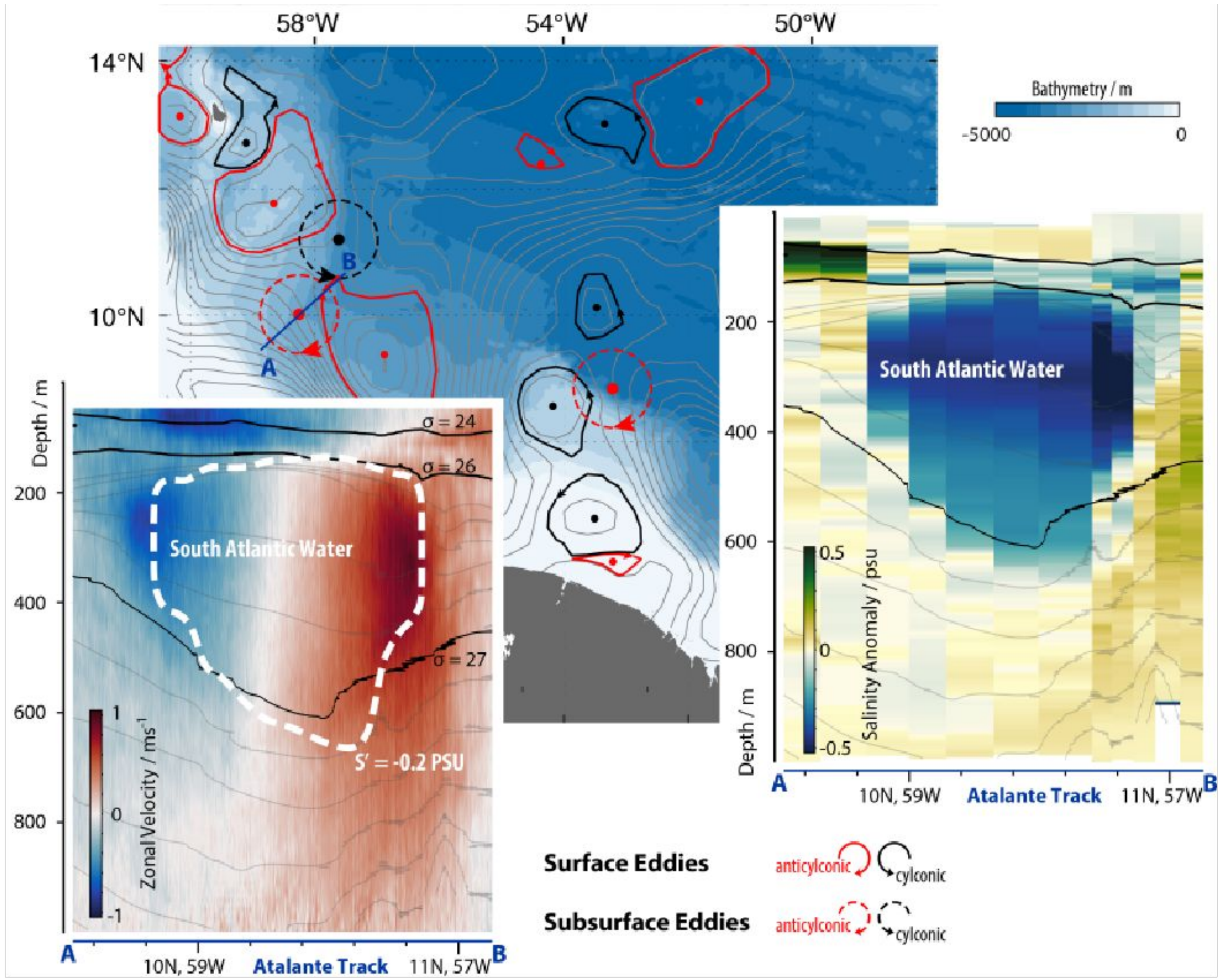






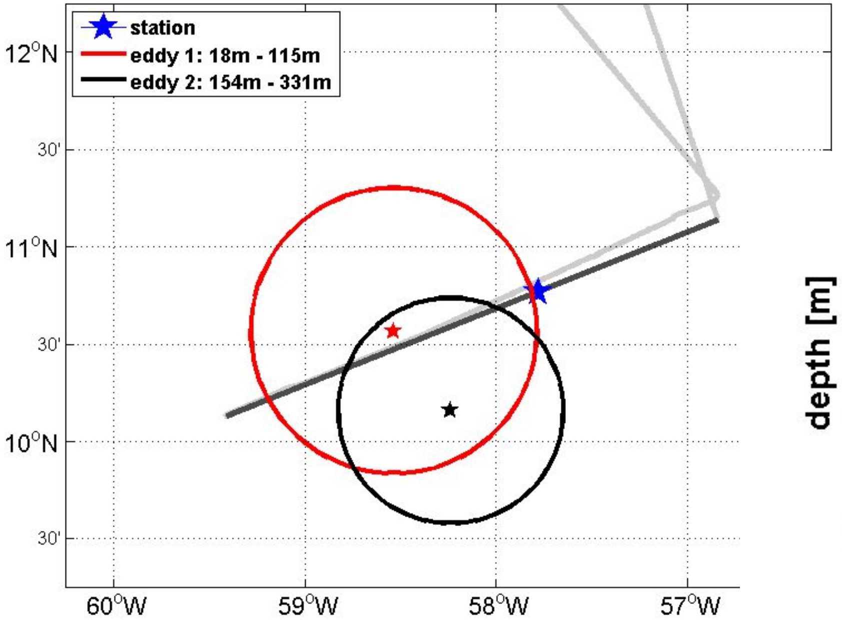
Pierre L’Hégaret, Sabrina Speich, C. Subirade, Xavier Carton

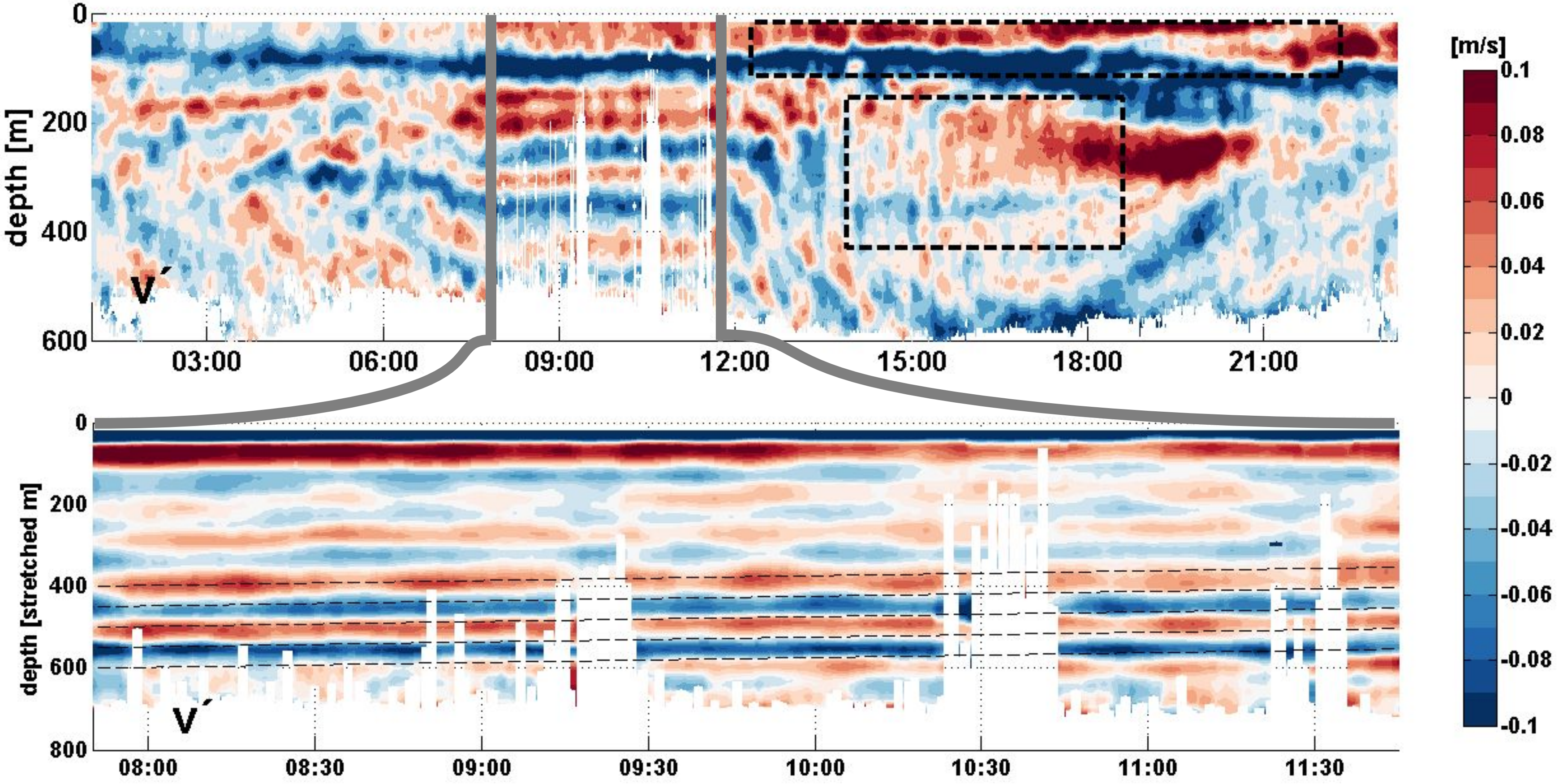
Ocean mesoscale eddies along the Boulevard



- Surface and subsurface North Brazil Rings;
- Disconnected from each other;
- Advecting different water masses and properties northward
- Subsurface anticyclones providing fresh and high-oxygenated water from the South Atlantic

Vertical propagation of Near-Inertial Waves





Eddy properties:

	Eddy 1	Eddy 2
radius	82 km	65 km
Vorticity		
Max. velocity		

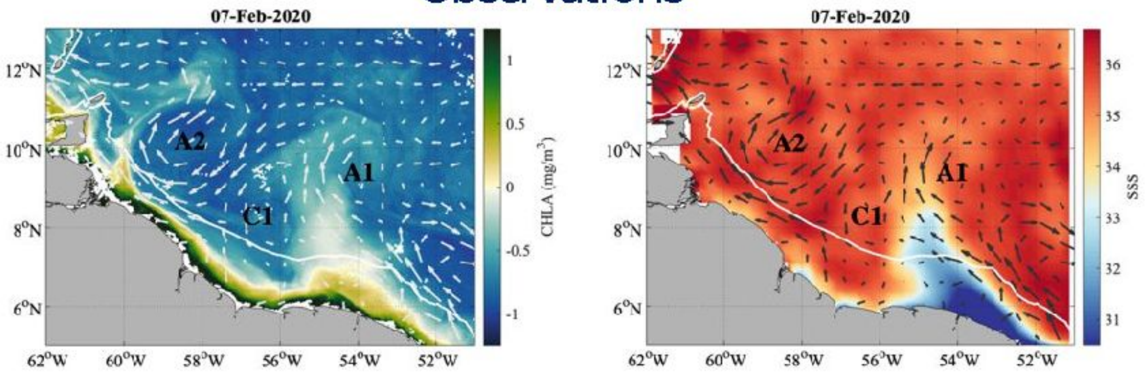
Dynamics of river plumes and their interactions with vortices

Objectives: Characterize the dynamics of the Amazon and Orinoco river plumes; the plume frontal instabilities and filamentation processes and their interaction with NBC rings and other eddies

Methods: Atlantic high-resolution simulations (GIGATL) and an eddy-tracking algorithm / in-situ and satellite data.

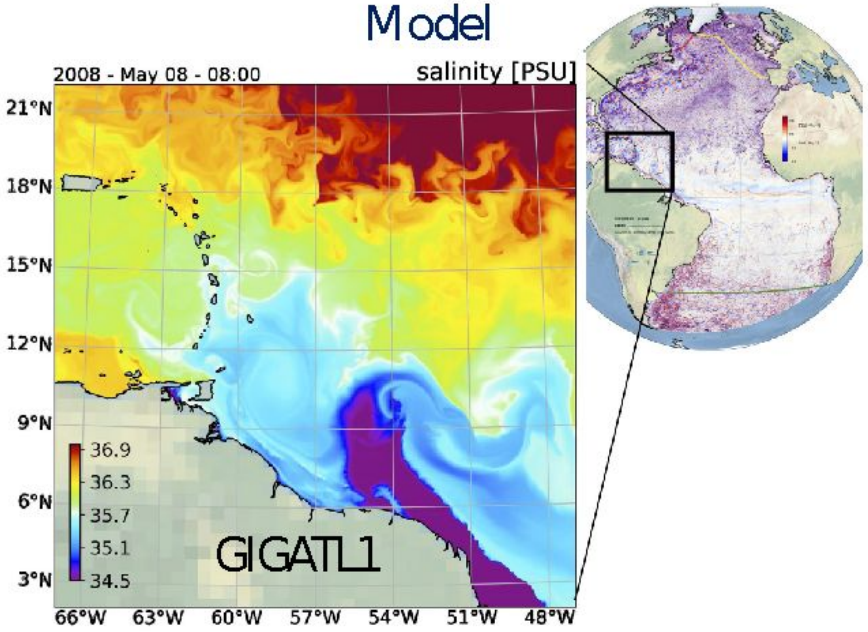
Transport of surface freshwater from the equatorial to the subtropical North Atlantic Ocean, Foltz et al (2015).
Sea surface salinity interannual variability in the western tropical ... Ferry & Reverdin (2004)
North Brazil Current ring generation and evolution observed with sea WiFS, Fratantoni et Glickson (2002)

Observations

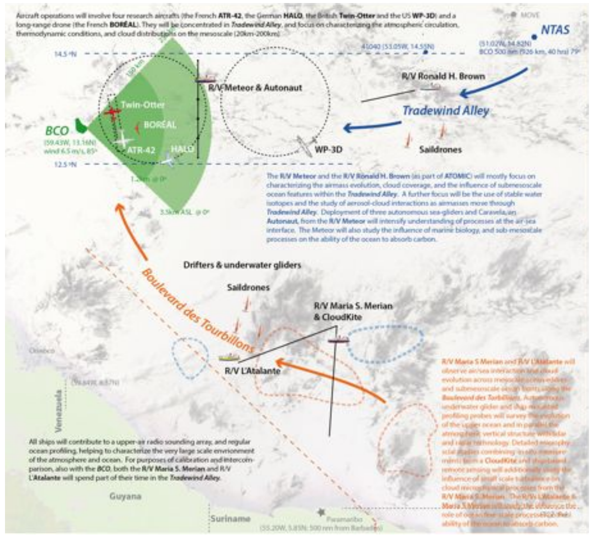


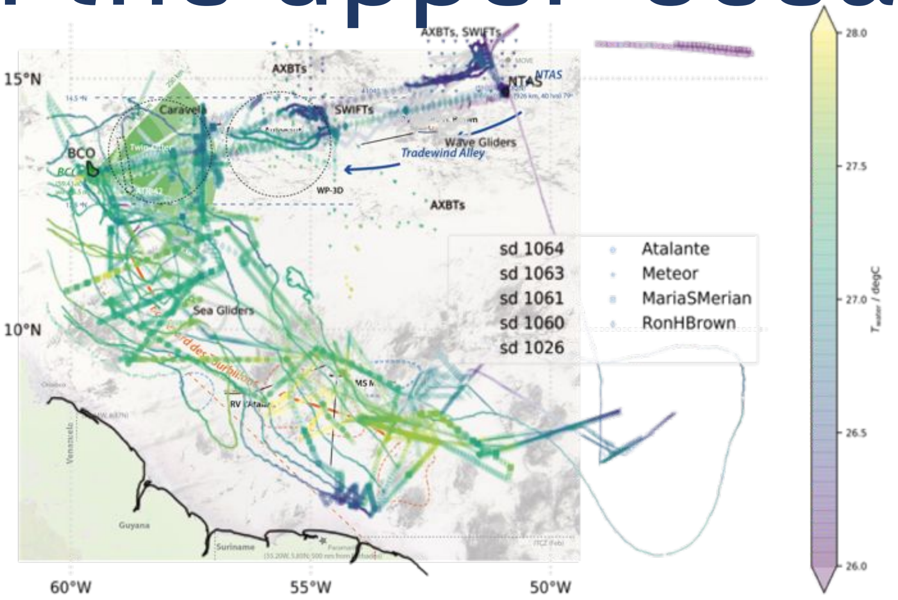
[Reverdin et al, 2021]

Model

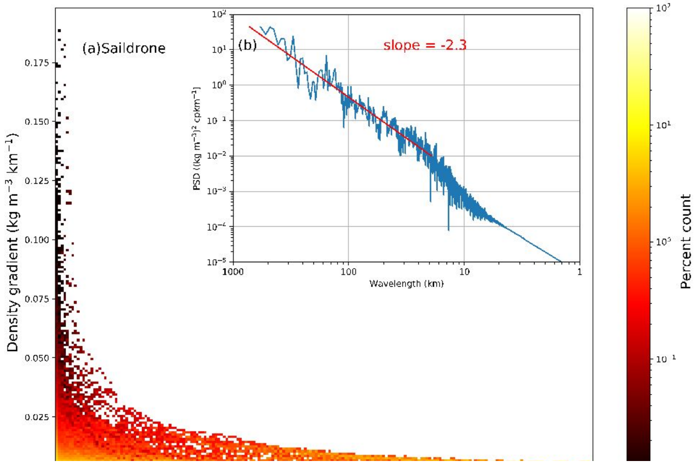


Upper-ocean horizontal scales & links with the upper-ocean stratification





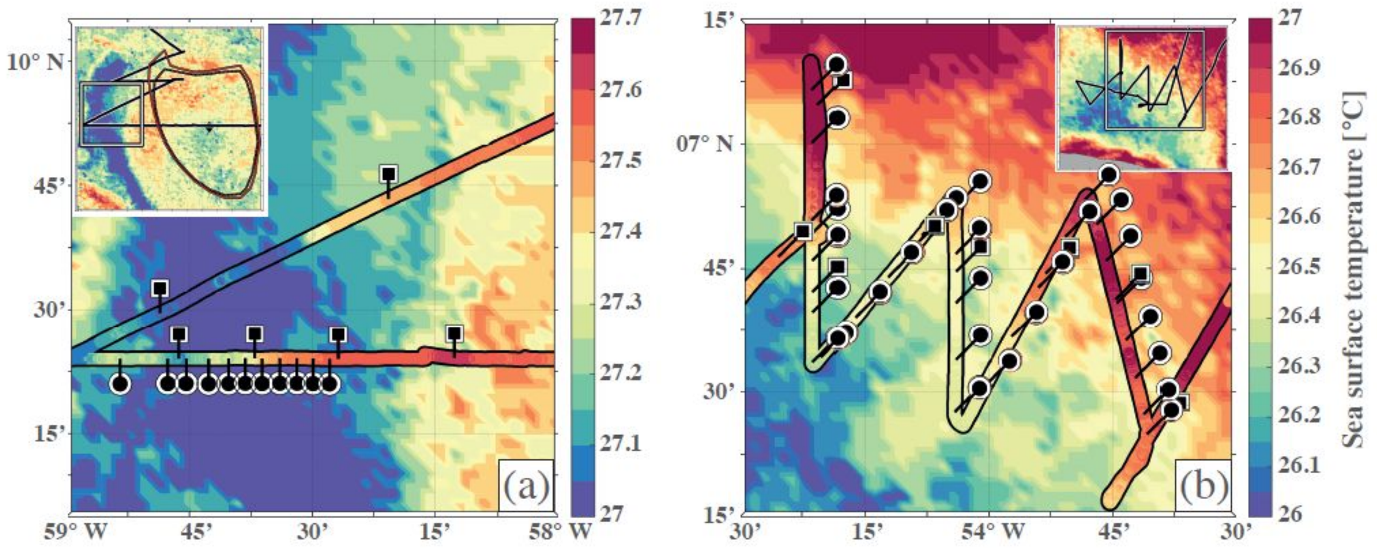
- Internship of A. Ledanois (S. Speich & S. Swart, U. Goteborg & Saildrones teams)
- Internship of N. Myshalack (M1, S. Speich)

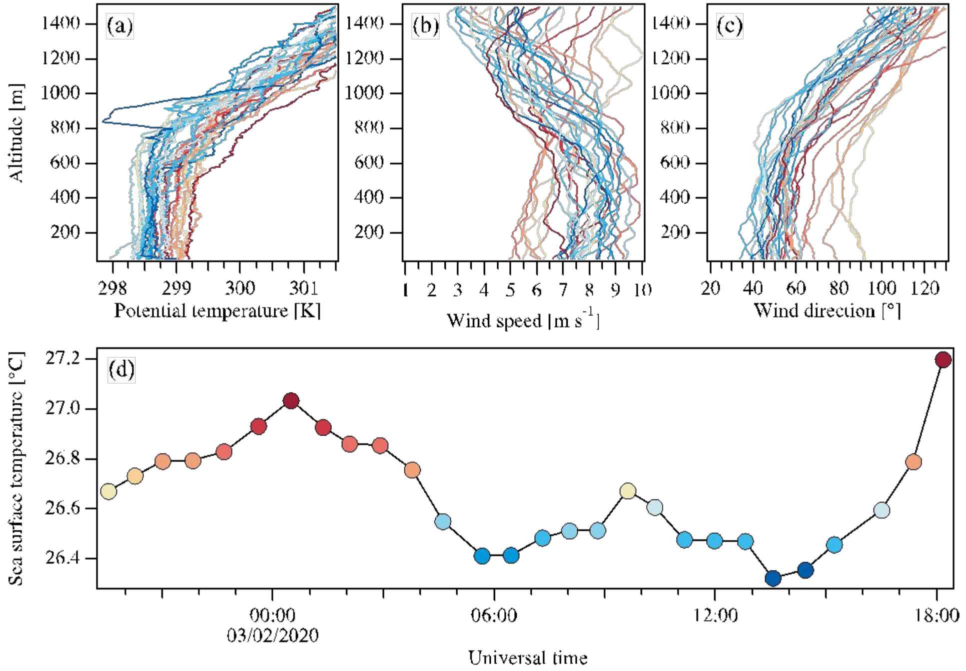


Very large spectrum of observed horizontal scales in density from Saildrones data

- Analyses of Saildrones data in the two regions (Trade Winds Alley and Eddy Boulevard);
- Stratification from MVP, uCTD
- Comparison with ocean models (GIGATL, ROMS/WRF)?

Impact of SST on atmospheric boundary-layer structure from radiosondes observations





- Transect across a cold filament stired by a mesoscale eddy (+11 MeteoModem)

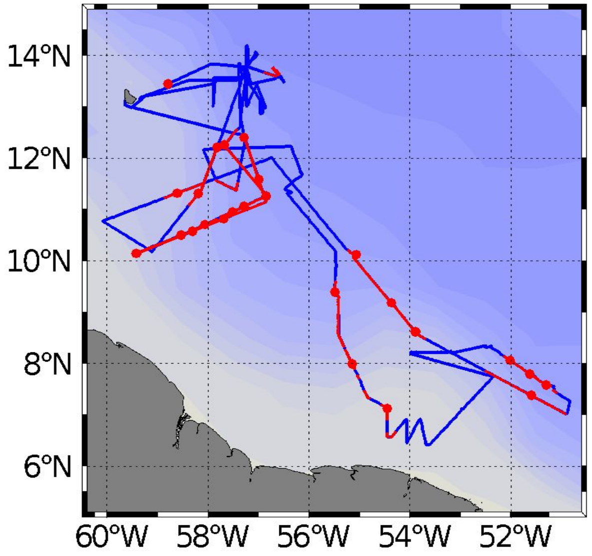
- Zigzags across the boundary of a coastal upwelling (+28 MeteoModem)

Stephan et al. 2020 Hugo Bellenger (LMD) and Richard Wilson (LATMOS)

Thermal feedback due to (sub-) mesoscale features based on observations

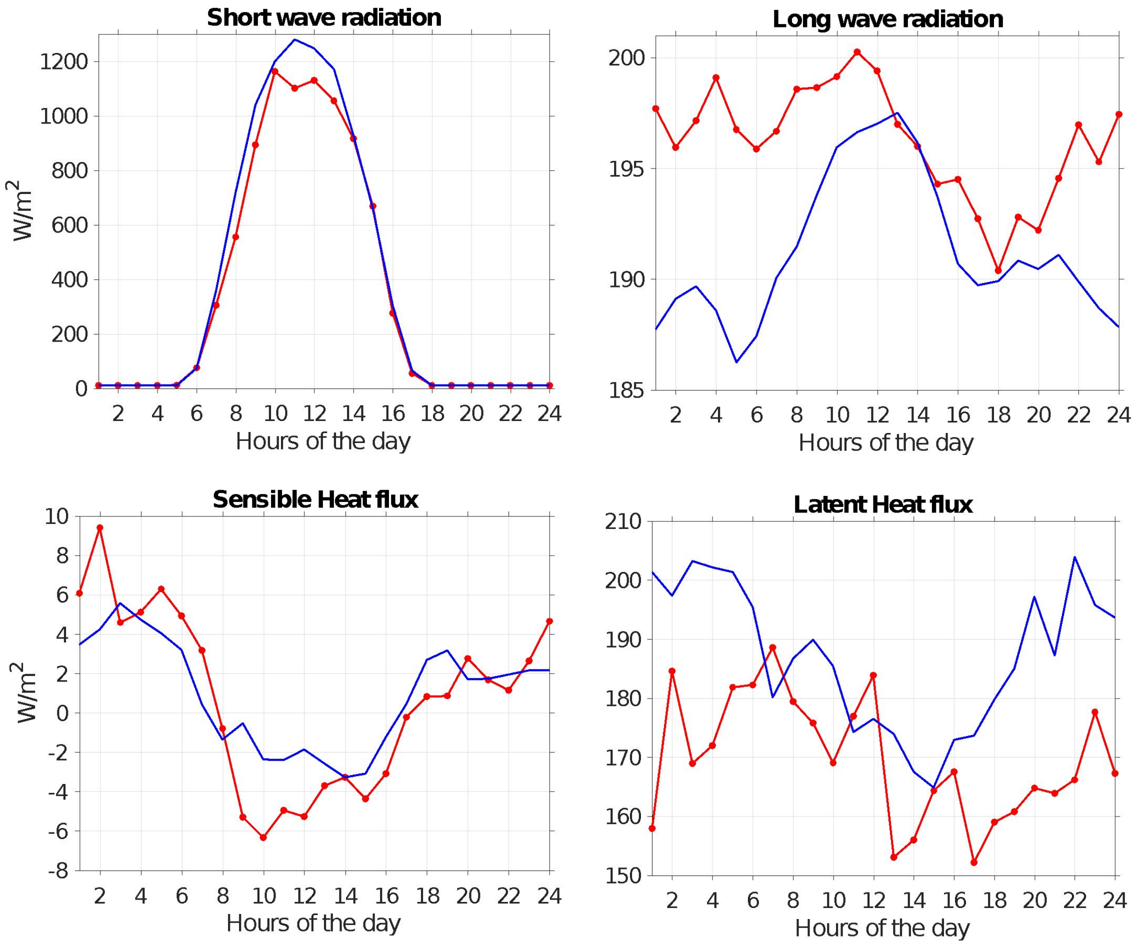
GEOMAR

Theme: Diurnal cycle – Panel: Process understanding



Eddy -●-

No Eddy —



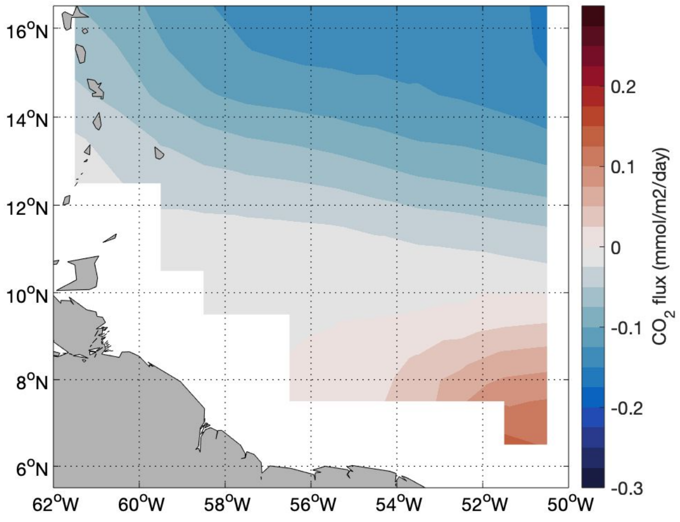
Outlook:

- use direct measured Turbulent heat fluxes *(in cooperation with Sabrina Speich)*
- use surface currents by radar measurements *(in cooperation with Jochen Horstmann)*
- do the same analysis in models *(in cooperation with Jing-Song von Storch)*

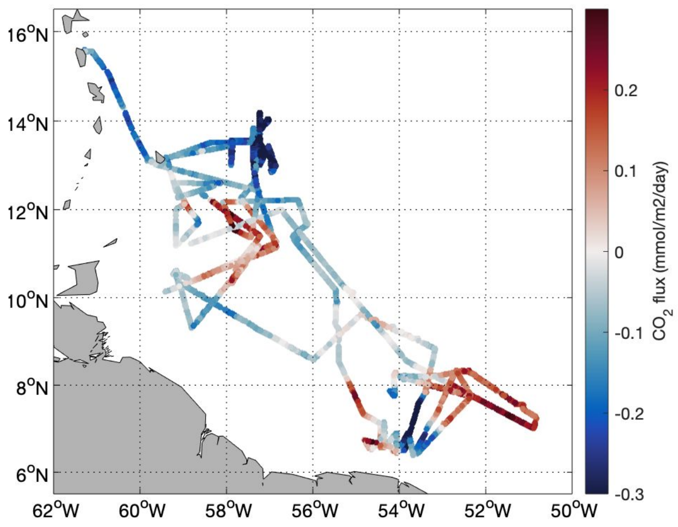
HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

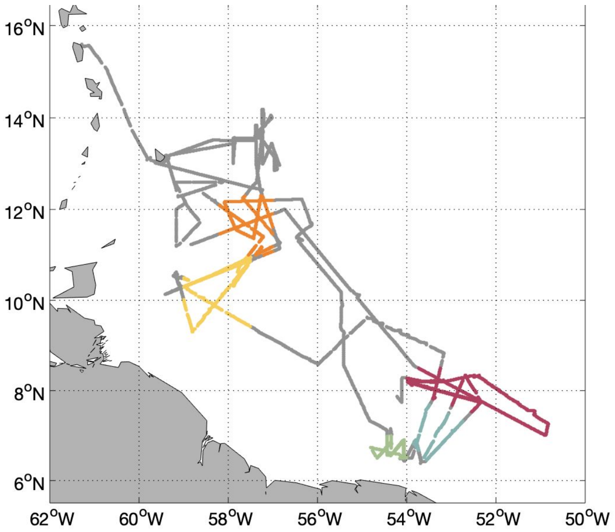
Signature in pCO2 from ocean small-scale structures

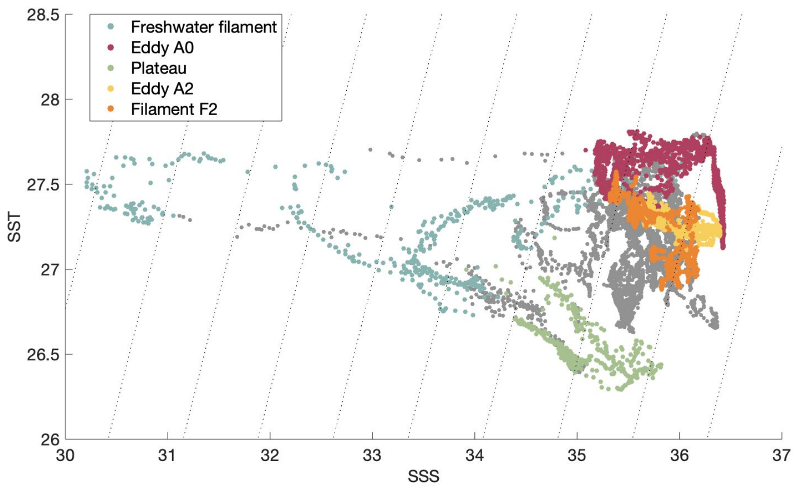
February climatology
(Landschutzer, 2016)



RV Atalante & Merian data







Air-sea CO2 fluxes mainly dominated by the mesoscale and submesoscale dynamics

- Anticyclonic eddies rich in surface DIC, but signal eroded over time

- Eddies steer filaments, that can either act as a strong sink or source of CO2 depending if they come from the Amazon river or from the shelf

Current feedback due to (sub-) mesoscale features based on observations

Theme: Diurnal cycle – Panel: Process understanding

GEOMAR

WHAT?

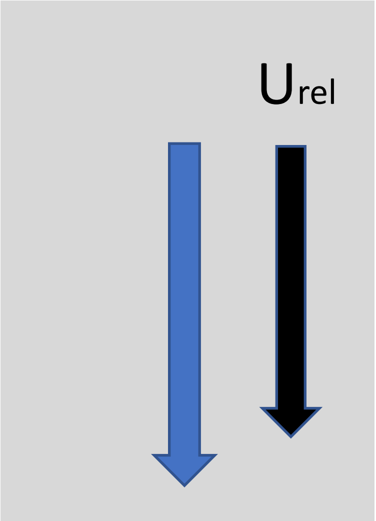
- Bachelor thesis: Effects of the Current Feedback on Air/Sea Heat and Momentum Fluxes
  - Using DSHIP and ADCP data of Maria S. Merian
- Current Feedback (CFB): influence of surface currents (U_c) on the wind relative to moving surface (U_{rel})
  - calculation of fluxes dependent on wind

HOW?

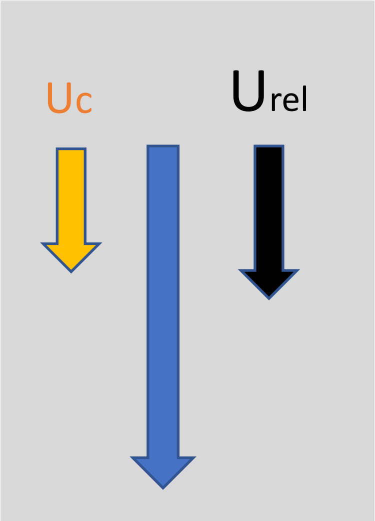
- Comparison of fluxes calculated with and without current feedback
- Calculation with COARE toolbox

RESULTS

- on average: effect of CFB on fluxes neglectable
- high current velocities: CFB influences fluxes



a) no CFB



b) with CFB

Air-sea interactions from modelling sensitivity experiments

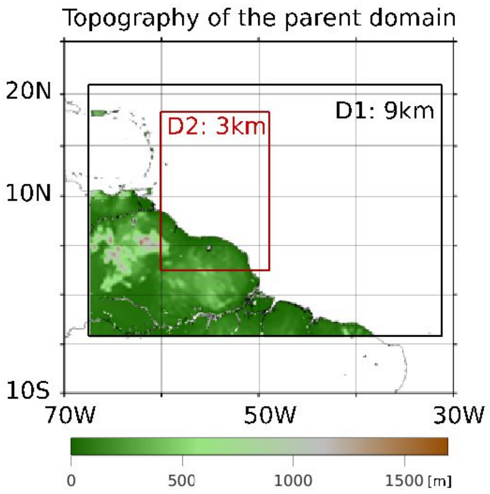
Sensitivity to Aerosols and SST forcing

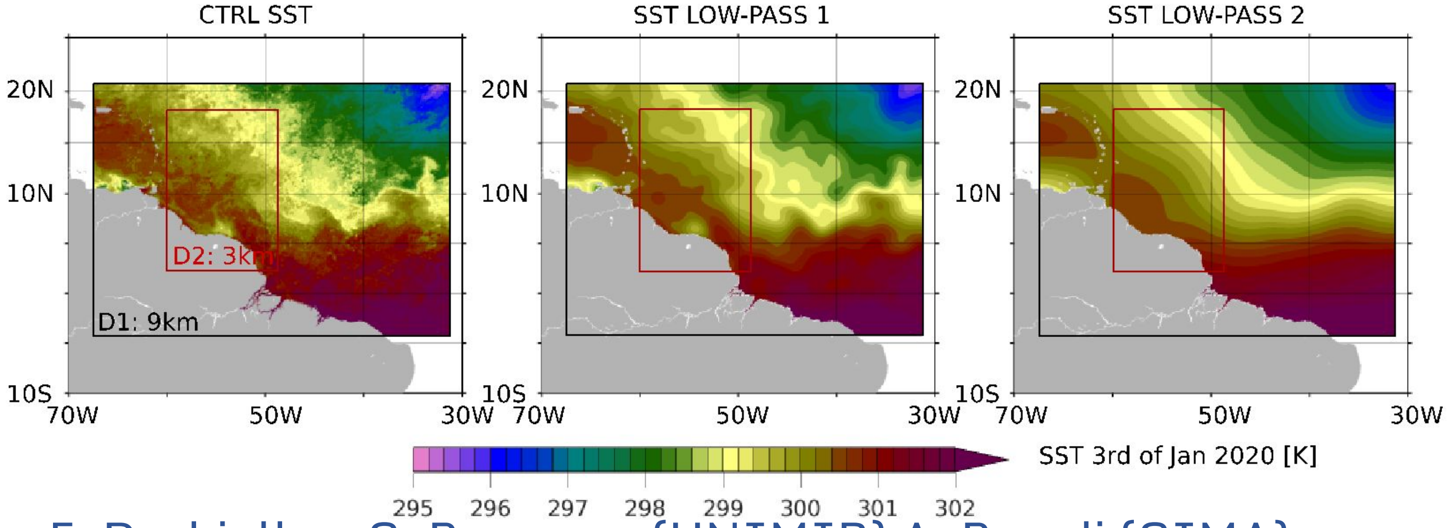
CTRL RUN
- bdy ERA5
- SST: MUR daily given at 1km on the native grid
- **Main params:** YSU (PBL), Kain-Fritsch, (Cumulus), Thompson microphysics.

SENS Aerosols

Aerosols concentration and size.

SENS SST
- **Spatial** scales of SST (low-pass filtered, cut-off wavelength to be dtermined).
- **Temporal** scales: daily, 6hourly, hourly





F. Desbiolles, C. Pasquero (UNIMIB) A. Parodi (CIMA)

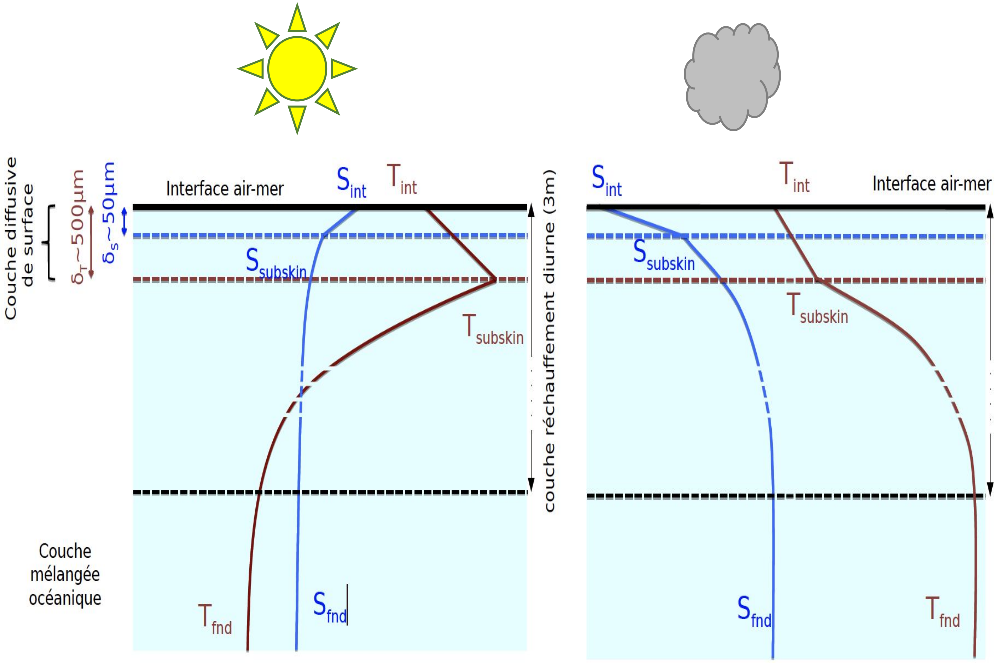
Atmospheric simulation Nested Domain (AROME & MesoNH)

Δx=10 km

Δx=1km

H. Giordani, CNRM

New parametrizations in ESMs



Implementation of a parameterization of ocean surface stratification (cool and salty skin, warm layers and rain freshwater lenses, Bellenger et al. 2017) in IPSLCM6 (on-going)

Implementation of the impact of rain on CO_2 transfer velocity (Ho et al. 1997.

Hugo Bellenger et Laurent Bopp (LMD)

Precipitation Biases in NorESM

DJF JJA

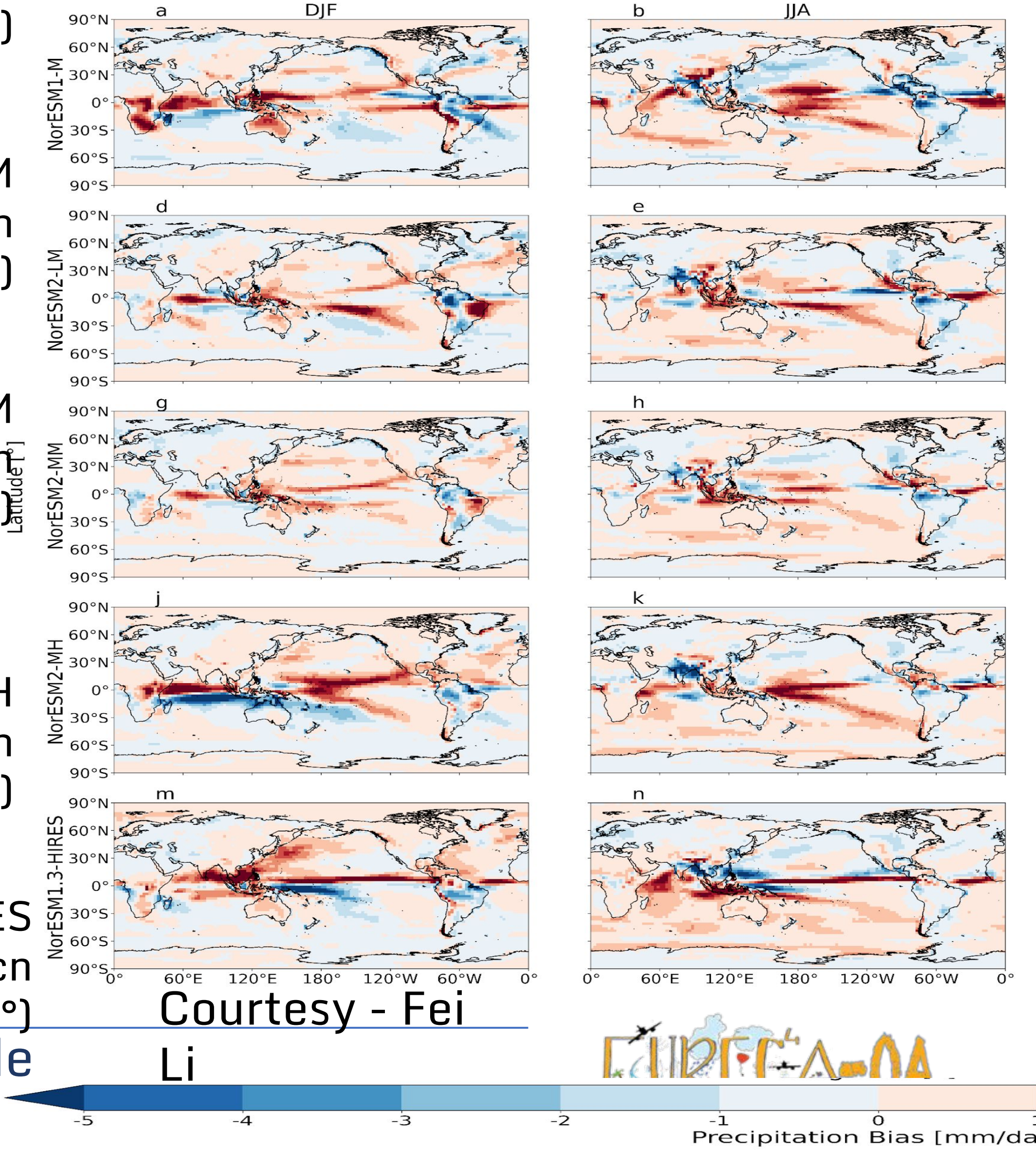
NorESM1-M (atm 2° & ocn 1°)

NorESM2-LM (atm 2° & ocn 1°)

NorESM2-MM (atm 1° & ocn 1°)

NorESM2-MH (atm 1° & ocn 0.25°)

NorESM1.3-HIRES (atm 0.25° & ocn 0.25°)



Courtesy - Fei Li

Noel Keenlyside (UiB)

Adressing processes with Storm-scale global models

EUREC^{4}A Observations

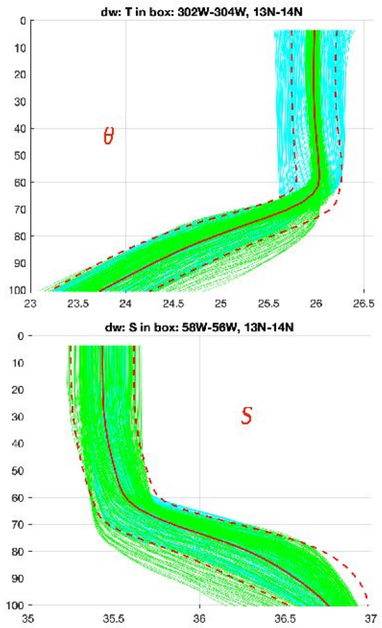
EUREC^{4}A: atmospheric & oceanic profiles near the surface at 57W 13.5N

Line: θ
Color: S, RH

From B. Stevens

DYAMOND Coupled Simulations

Simulated oceanic profiles within (58W-56W, 13N-14N)



Dyamond Winter using coupled ICON model:

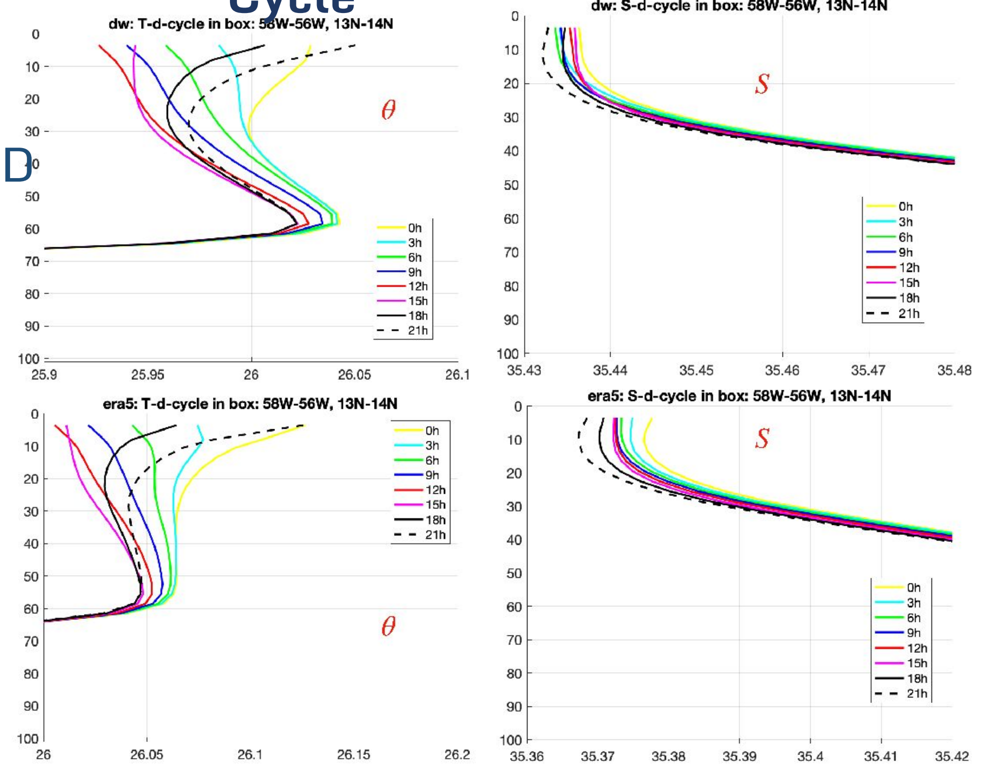
- 5km
- L90 / L128
- From Jan 20 2020 -
- Oceanic initial state obtained from a 10-year spin-up forced by 1-hourly ERA5

Red: averaged over all records
Green: averaged over time
Cyan: averaged over grid points

DYAMOND Diurnal Cycle

COUPLED

FORCED



The EUREC^{4}A-OA web page

http://eurec4a-oa.eu