TIE-OHF WP4 Progress

- WP4 tasks
- Estimates of errors and sources
- Experiments with retrieving errors in hypothetical independent flux data by triple collocation
- Feasibility of performing triple collocation using in situ, satellite, and analyses/forecasts
- Other: consideration of subdomains (for tomorrow)

WP41	Sensitivity studies and algorithm improvement	IFREMER	Analysis of the new bulk parameterization (e.g. Fairall et al,, 2011) impact on flux estimation over global ocean and over some specific regions such as the North Atlantic and tropical areas. Inputs for WP4.2.	
		IORAS	Assessemnt of sensitivity of probability density functions for different surface fluxes in generated products to the use fo different algorithms for flux computation, input for WP42, WP43	
WP42	Use improved retrieval methods for wind speed and humidity	IFREMER	Calculation of LHF and SHF based on the new available remotely sensed winds and brightness temperatures and ESA CCI SST. Calculation will be performed over global ocean at daily time scale and with a spatial resolution of 0.50°. Inputs for WP4.3	Calculation completed over one year with ESA CCI SST.
		DWD	Provision of SSM/I brightness temperatures	
		UR	Available to advise on how best to use SST CCI data in the context	
WP43	Evaluation of data sets, Error characterization	IFREMER	Comprehensive comparisons between satellite and in-situ flux estimates (see. Table 5.3). The results will be used for error characterization. Inputs for WP4.4	Completed. Report to be delivered to ESA.
		NERSC	Triple collocation error characterization of input variables to flux calculation. Here, the use of a short-term forecast variable instead of an analysis allows for independence among triple collocations. Simulation of error propagation in bulk flux estimates. Here, corrections to bulk fluxes are derived from an evaluation and intercomparison of the actual fluxes taken from a numerical model and corresponding fluxes obtained with bulk algorithms.	The in situ dataset is being sought. Coordination with the WP43 error characterization (above) is ongoing
		IORAS	Estimation of spatial and temporal inhomogeneities associated with different error sources in VOS, reanalyses and satellite-based flux data sest, input WP41, WP44, WP45	
		DWD	Cooperation / Exchange with DFG Research Unit 1740: Atlantic Freshwater Cycle, WP 2.1 (http://for1740.zmaw.de/), which has the objective to derive error estimates for HOAPS flux products.	
		UR	Available to advise on uncertainty characteristics of SST CCI data and how these can be propagated, as required	

WP4 Tasks

WP44	Ensemble generation	IFREMER	Accordingly to WP2 inputs, calculation of flux ensemble will be performed over global ocean for the period 1999-2009 at daily time scale and a spatial resolution of 0.50°. Inputs for WP4.5 and WP4.3.	
		IORAS	Estimation of probability density functions for different ensemble members, assessemnt of spread for fluxes fo different occurrences, input for WP45, WP46	
WP4.5	Consistency checks (“Cage Studies”)	IFREMER	Make available WP4.2, WP4.3, and WP4.4 inputs	
		MIO, IORAS, UR, DWD, WHOI	Inputs from WP33, in particular delivery of uncertainty characteristics from the evaluation phase of the cage experiments.	
		NERSC	Global computation of bulk fluxes for each of a group of input datasets (e.g., HOAPS, Ifremer, AOflux, and SeaFlux) to remove variations owing to the method of flux calculation (with evaluation being subject to the typical non-Gaussian heat flux pdf and uncertainty in radiative flux)	Based on input from WP43, a Fisher-Tippet comparison in terms of PDF tails (Gulev and Belyaev 2012) is of interest
		IORAS	Generation of ensembles of surface flux estimates from reanalyses, VOS data and available to date satellite data for at least 3-4 "cages" in the midlatitude North Atlnatic, Mediterranean Sea, Red Sea, Tropical Pacific, inputs for WP41, WP43, WP44, WP46	

WP4 Tasks

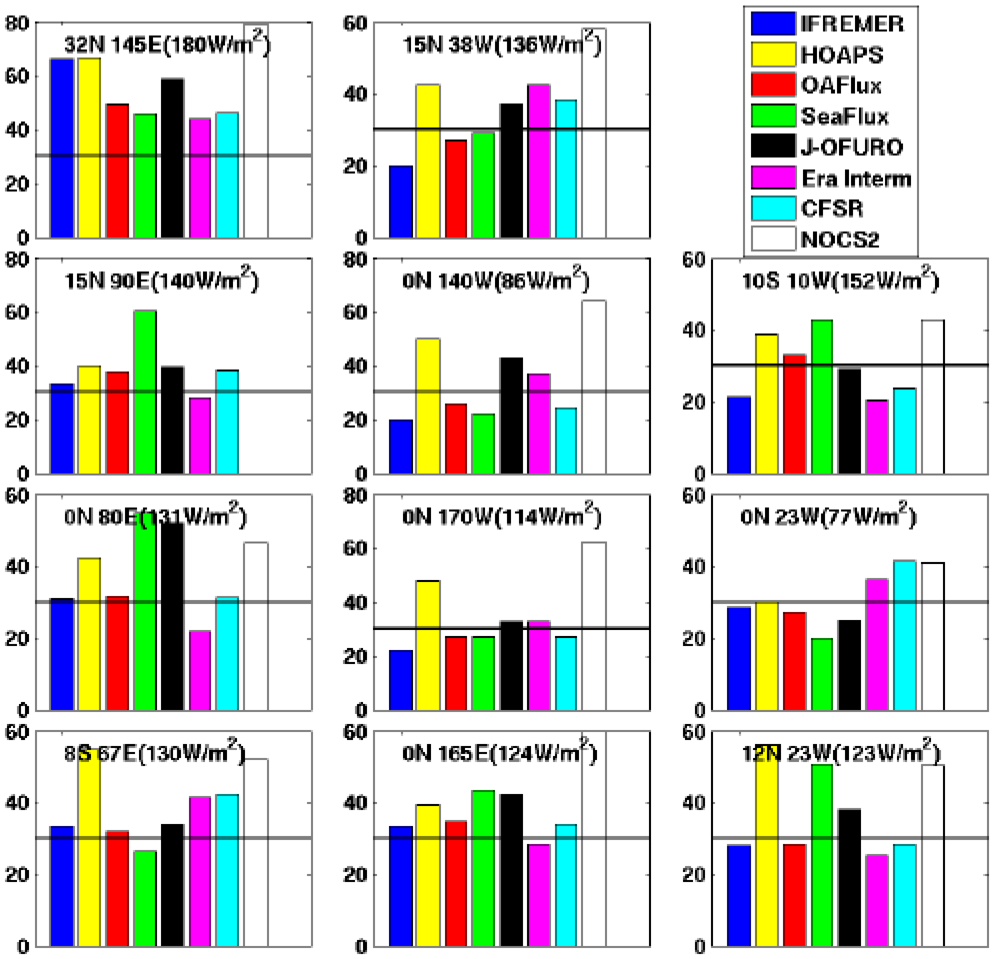
WP4.6	Sensitivity Examinations	IFREMER		
		PML	Use OC-CCI products and a spectrally-resolved model of light transmission underwater (Sathyendranath and Platt 1988), to compute the penetration of solar radiation into the ocean. (PML)	
			Combine these results with a one-dimensional general ocean turbulence model (Burchard et al. 1999) to study the sensitivity of the oceanic heat budget within the mixed layer and below the mixed layer, and of the air-sea exchange of heat, to the parameterization of light penetration in the ocean. (PML)	
			Combine satellite-derived surface chlorophyll with parameterization of vertical structure in chlorophyll, for example as in Longhurst et al. 1995), to study the impact of vertical structure in optical properties on upper-ocean stability and heat budget, using the turbulence model. (PML)	
			Examine the impact of optical properties of the sea and of optical processes at the air-sea interface on the diurnal variations in SST and hence on the heat budget of upper ocean and lower atmosphere and on air-sea fluxes. (PML)	
		IORAS	Quantitative estimate sof sensitivity of global, regional and local enegry fluxes to different types of errors, characterization of skills of generated product (local/regional/global) budgets, variability on different time scales	

Estimates of errors and sources

- Coupled Ocean–Atmosphere Response Experiment (COARE) family of algorithms (WGASF 2000; Fairall et al. 2003; Brunke et al. 2003) target an accuracy of 5 W/m2

- Uncertainties due to observational errors in variables routinely measured and estimated by VOS (Josey et al. 1999; Brohan et al. 2006; Kent and Berry 2005) amount to 15 W/m2 (or less with metadata)

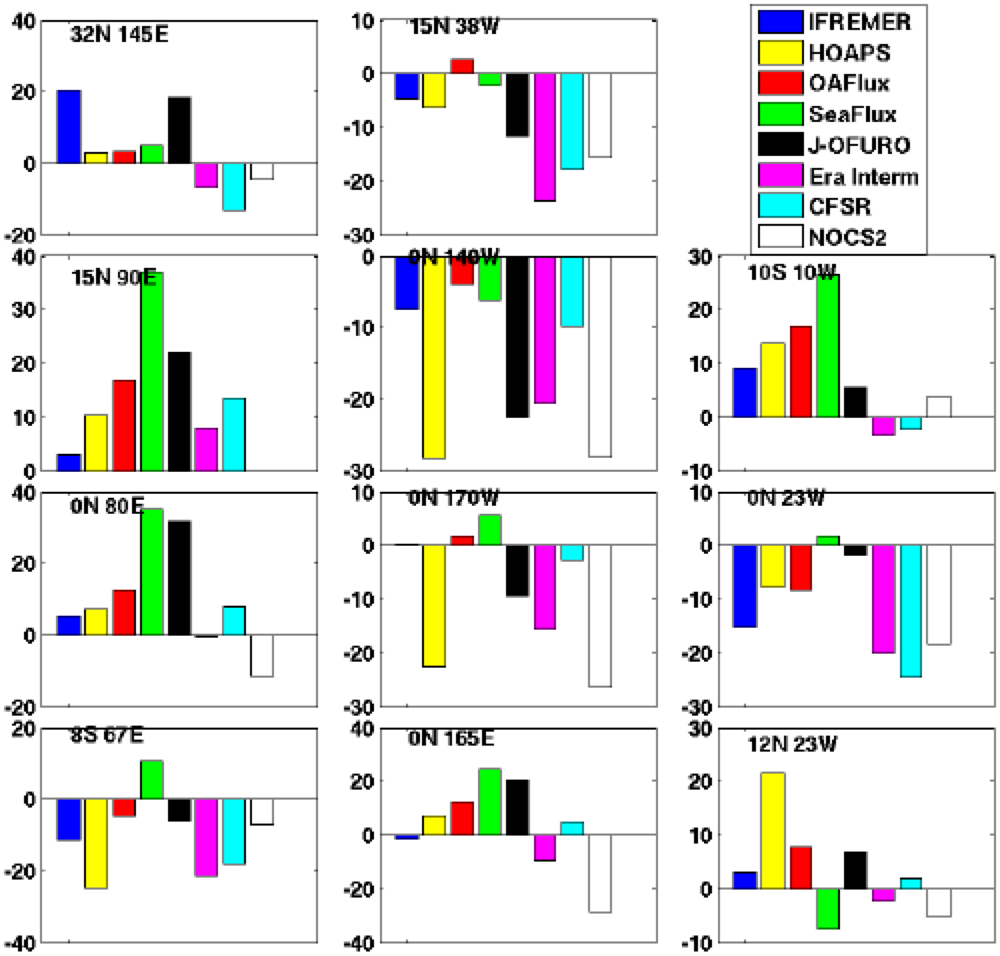
Estimates of satellite errors and sources



perhaps
30 W m/2

LHF RMS differences at OceanSites locations

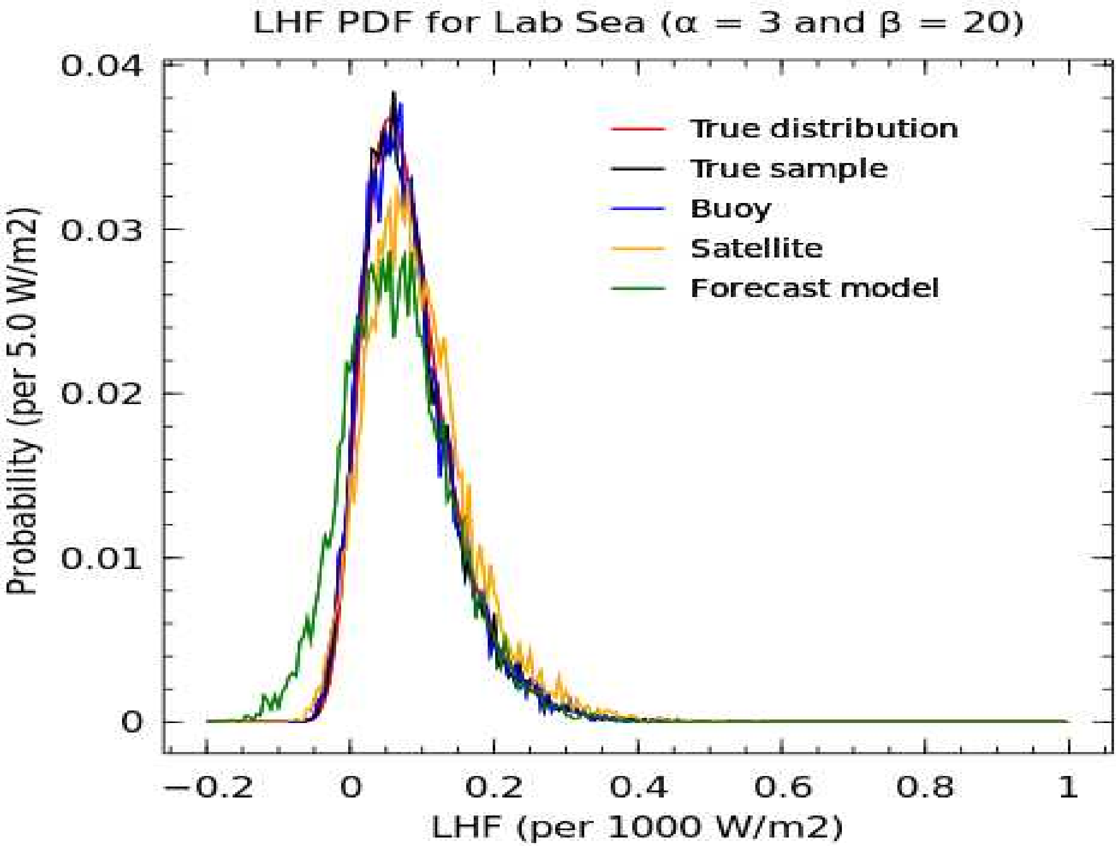
Estimates of satellite errors and sources



perhaps
10 W m/2

LHF bias at OceanSites locations

with retrieving errors in hypothetical independent flux data by triple collocation



$$
\begin{array}{rrcl}
\text{truth} & t & = & \alpha\beta e^{-\beta x} e^{-\alpha e^{-\beta x}} \\
\text{buoy} & x & = & t + 10 * \delta_x \\
\text{satellite} & y & = & 1.1 * t + 20 * \delta_y + 5 \\
\text{model} & z & = & 0.9 * t + 50 * \delta_z - 5 \\
\text{Gaussian errors} & \delta & & \text{(zero mean and standard deviation of 1)}
\end{array}
$$

with retrieving errors in hypothetical independent flux data by triple collocation

Specified (calibration, std,bias)	Retrieved following McColl et al. (2014), Extended triple collocation to correlation coefficients with respect to an unknown target
x : (1.0, 10, +0)	x : (1.0, 9.9, +0)
y : (1.1, 20, +5)	y : (1.09, 19.9, +5)
z : (0.9, 50, -5)	z : (0.89, 49.9, -5)
	x Signal:Noise 0.988
	0.962
	0.756

$$
\begin{array}{rrcl}
\text{truth} & t & = & \alpha\beta e^{-\beta x} e^{-\alpha e^{-\beta x}} \\
\text{buoy} & x & = & t + 10 * \delta_x \\
\text{satellite} & y & = & 1.1 * t + 20 * \delta_y + 5 \\
\text{model} & z & = & 0.9 * t + 50 * \delta_z - 5 \\
\text{Gaussian errors} & \delta & & \text{(zero mean and standard deviation of 1)}
\end{array}
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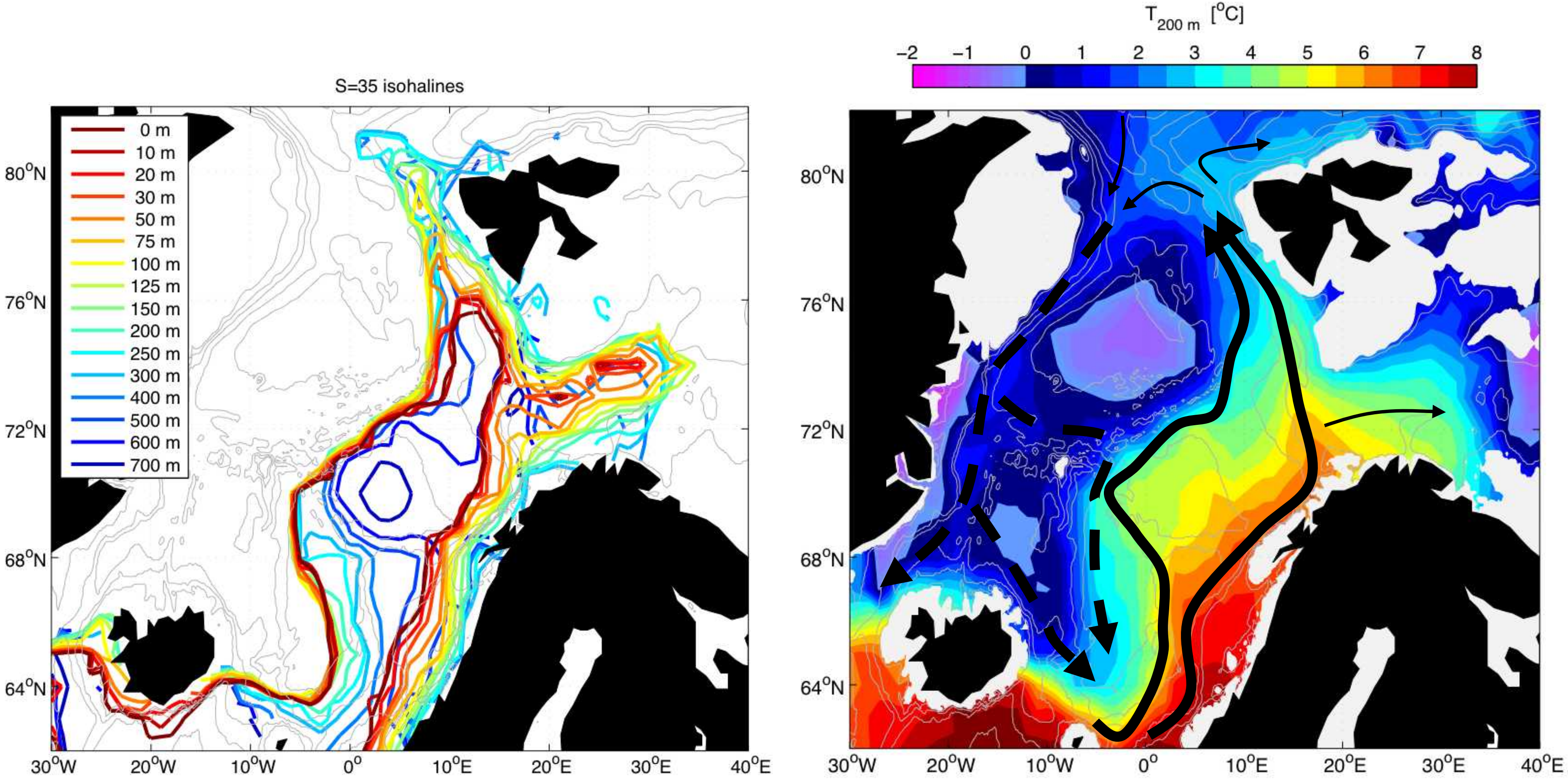
Feasibility of performing triple collocation

- Independence of data…specifically of analyses

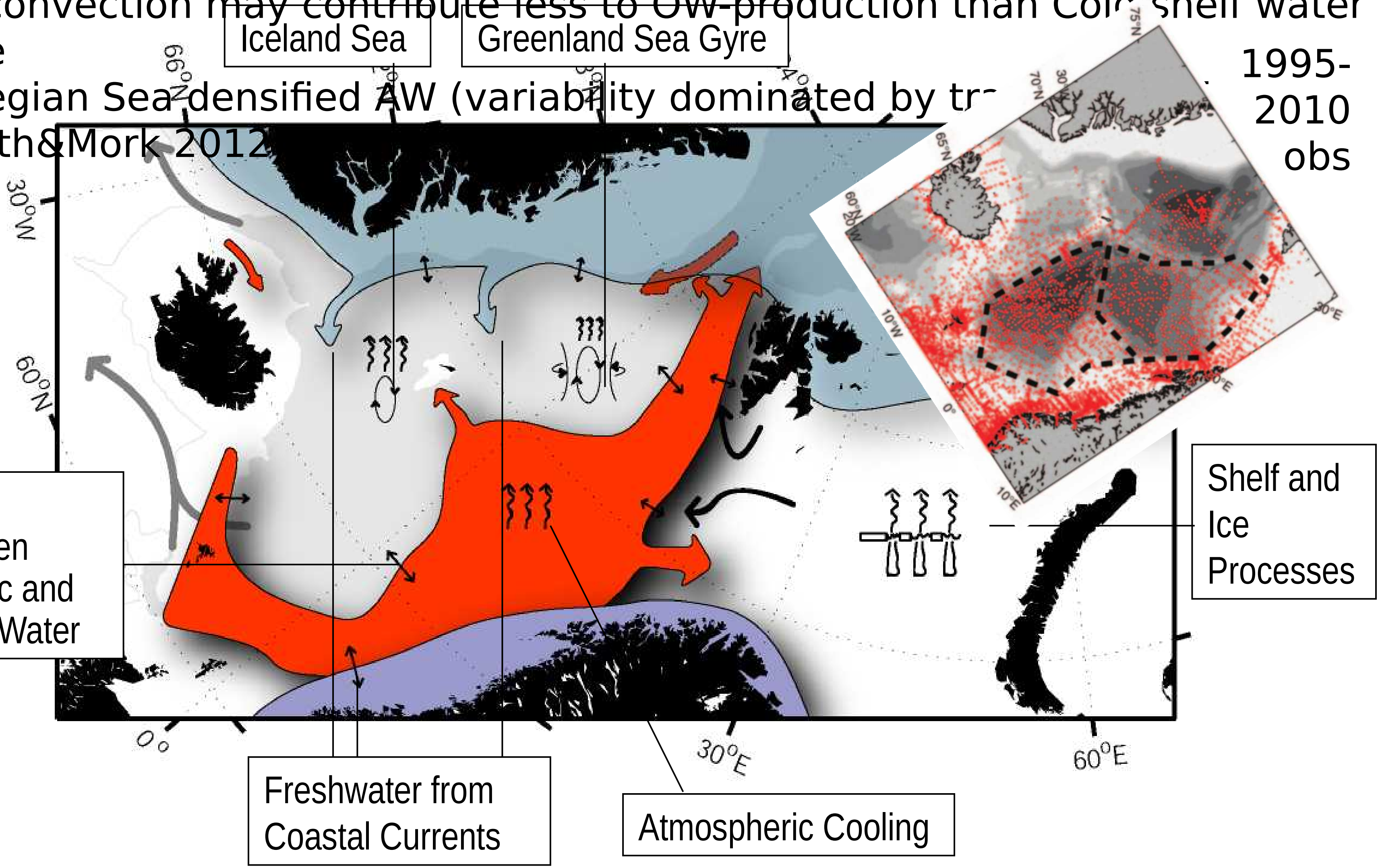
Atlantic Water and general circulation



Full year climatology from 1948-2006 hydrography

Transformation and ventilation hypotheses

- The Atlantic inflow loses 80-90% of its heat before it reaches the Arctic Ocean
- Heat exchanged across the Arctic Front may be similar to flux into the Barents Sea
- GSG-convection may contribute less to OW-production than Cold shelf water and the
  Norwegian Sea densified AW (variability dominated by tr
Skagseth&Mork 2012



1995-2010 obs

Iceland Sea

Greenland Sea Gyre

Mixing between Atlantic and Arctic Water

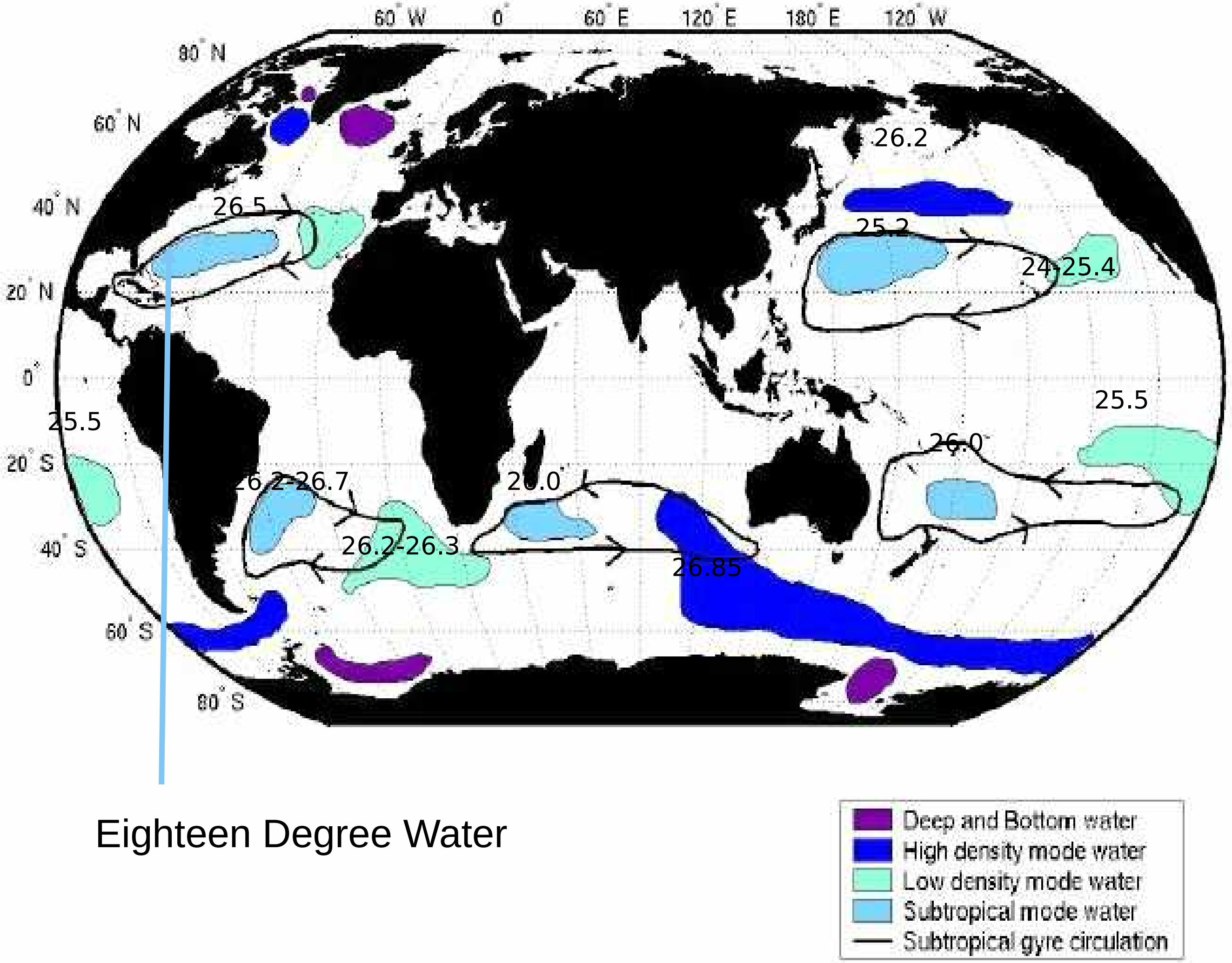
Shelf and Ice Processes

Freshwater from Coastal Currents

Atmospheric Cooling

Distinguish Mode Water Regions

- All have strong property correlations with atmospheric indices(?)
- Mode waters are upper ocean waters
- Uniform temperature over thickness of few 100-m
- Short renewal timescales



Eighteen Degree Water

Modified from Talley (2000)

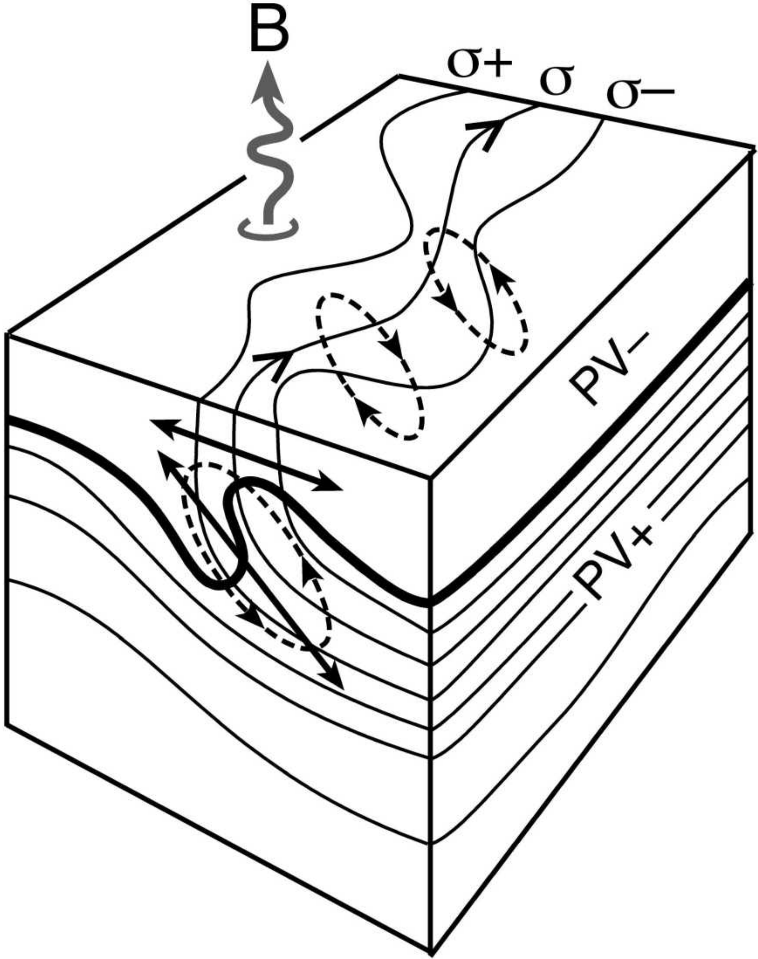
Rates & Mechanisms

Best available estimates of formation and dissipation rates:

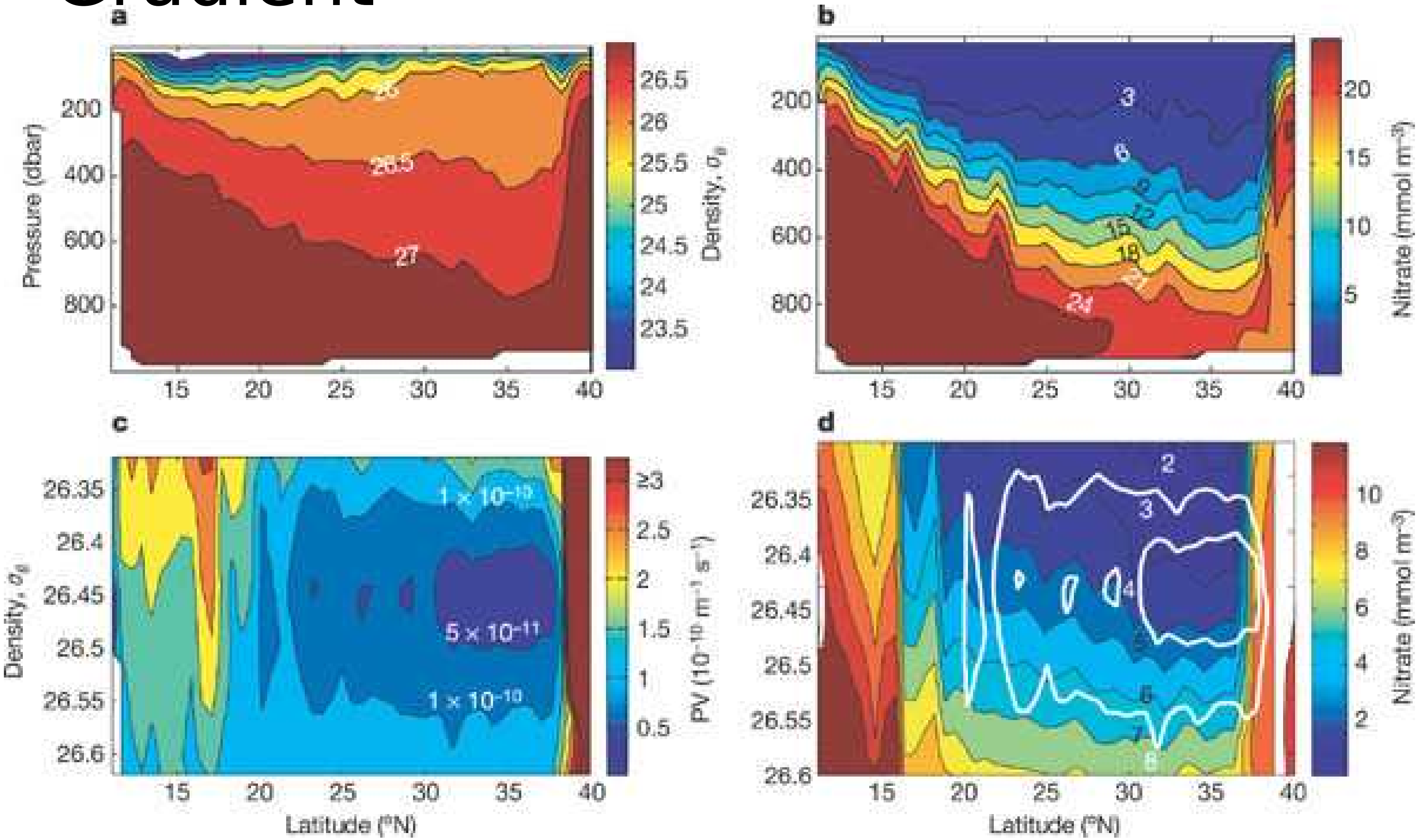
- ≈15-20 Sv yr^{-1} (indirect methods from air-sea fluxes)
- only about 5 Sv yr^{-1} inferred to be injected seasonally into the subtropical gyre

18° Water enters North Atlantic thermocline:

- Ekman pumping, and
- Eddy driven subduction

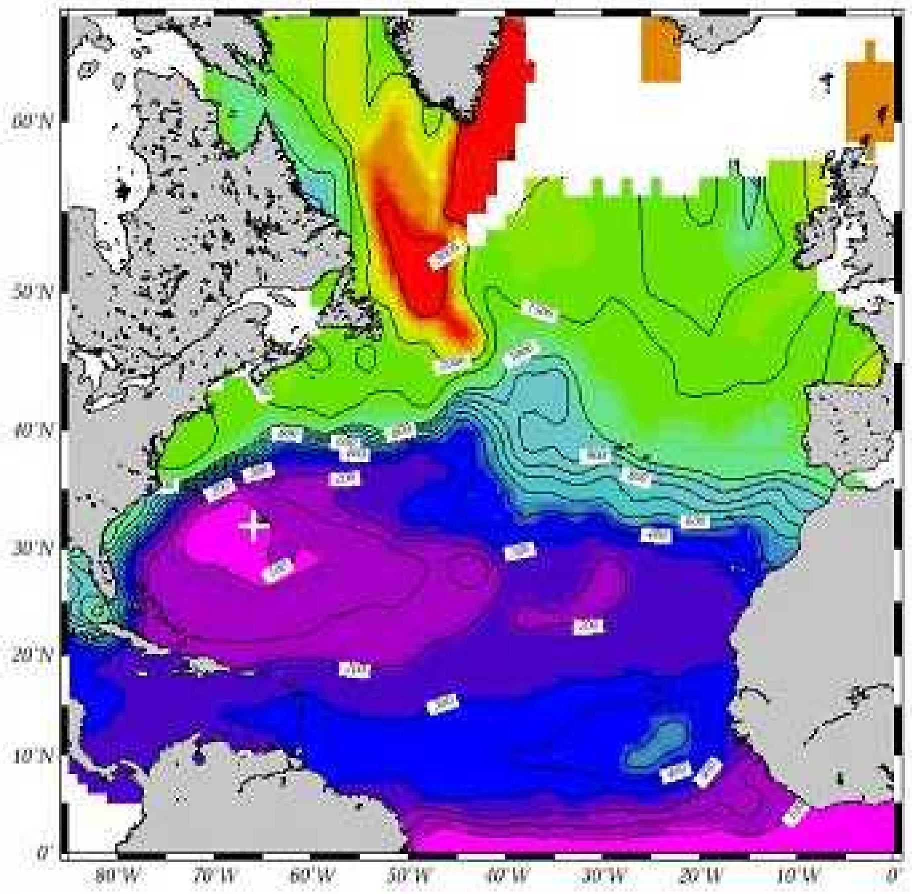


18° Water and the Nutrient Gradient



18° Water & Potential Vorticity

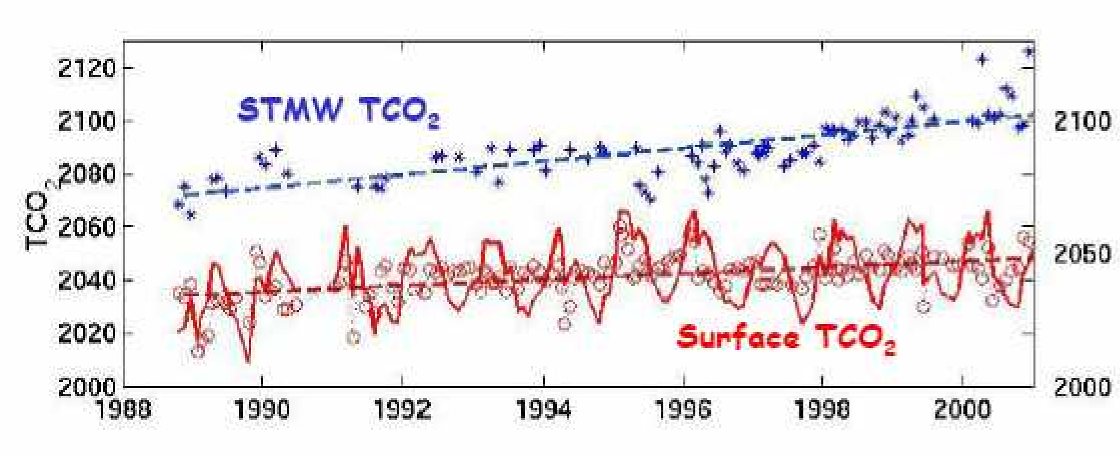
The presence of 18° Water is reflected in a substantial 1000 km diameter ‘bowl’ of low potential vorticity at depths of 200-500m found just to the south of the Gulf Stream



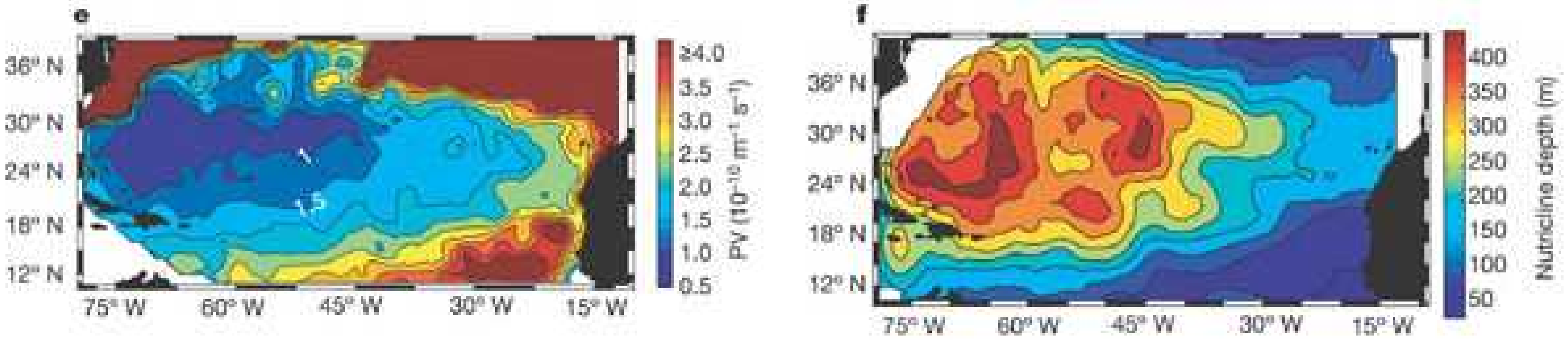
Red = high PV, Purple = low PV

Importance of 18° Water

- Dominant baroclinic and potential vorticity signal in the subtropical North Atlantic
- Substantial contribution to interannual variability in oceanic CO_2 uptake (0.03−0.24 Pg C yr^{-1} from 1998-2001)



- Can prohibit deep-ocean nutrients from directly upwelling to the "euphotic" zone (wedge of cool, nutrient-poor water)



References

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- http://www.nature.com/nature/journal/v437/n7059/full/nature03969.html
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- http://www.climode.org/documents/climode_science_final_overview_REFs.pdf
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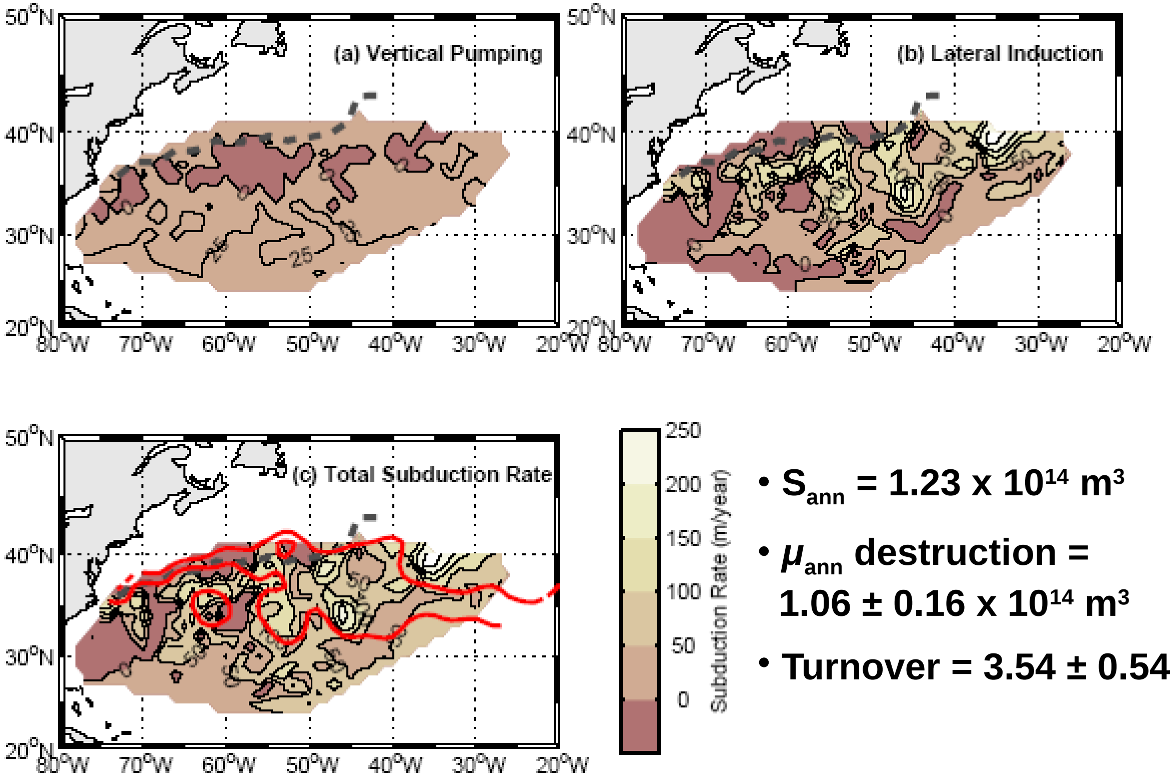
- http://www.uib.no/jgofs/Final_OSC/Bates.pdf
- http://sam.ucsd.edu/sio210/gifimages/shallowoverturn.gif
- http://www.climode.org/Meetings/NOV_04/kwon_nov04.pdf

18° Water Dissipation

- starts w/ subduction & advection into the western subtropical gyre
- also due to lateral flows, diapycnal mixing and fluxes
- ~48% observed winter volume destroyed annually.



- **S_{ann} = 1.23 x 10^{14} m^3**
- **μ_{ann} destruction = 1.06 ± 0.16 x 10^{14} m^3**
- **Turnover = 3.54 ± 0.54 yr**

Air-sea flux evaluation with turbulence resolving model PALM

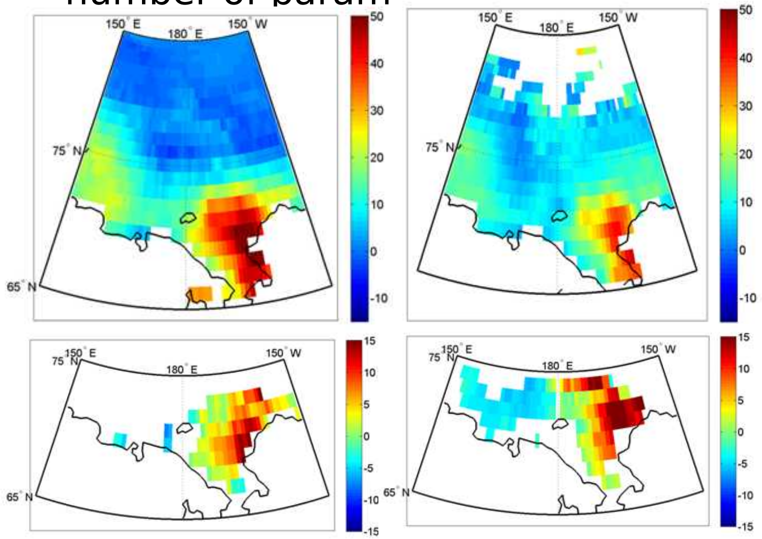
Background: The air-sea flux is evaluated with *semi-empirical bulk flux-gradient algorithms* (e.g. COARE by Fairall et al. JGR, 2003) or single-column models, which incorporate such algorithms (e.g. GOTM by Burchard et al. JPO, 2001; MLOM by Stephens et al. JClim, 2005)

Problems: (1) Very sensitive to the choice of empirical functions and parameters (differences in satellite flux products); (2) Does not account for non-local nature of turbulence (large biases in non-neutrally stratified layers); (3) Produce inconsistent fluxes within atmosphere and the ocean

Solution: For climatological estimations a set of correction to the bulk fluxes could be introduced based on evaluation and intercomparison of the actual flux taken from PALM runs and the flux obtained with bulk algorithms.

$$Flux = C \cdot U \cdot \nabla T$$

C is an empirical function (~10^{-3} in neutral, moderate wind PBL) with non-linear dependence on a number of parameters



Sensible (right) and latent (left) climatological September heat fluxes in two gridded satellite products (AOFLUX – upper raw; HOAPS3 – lower raw) using COARE algorithm with different