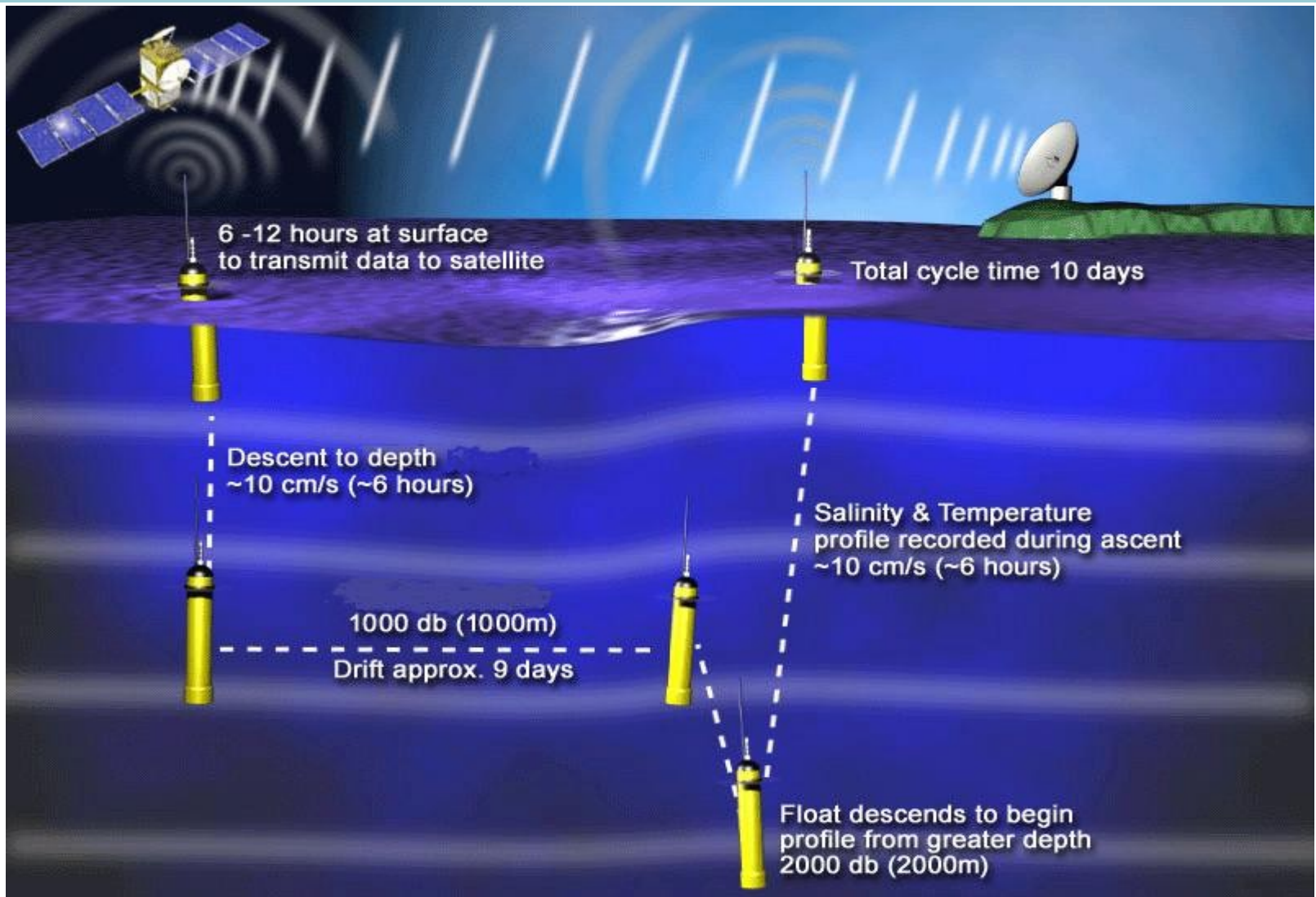# Argo
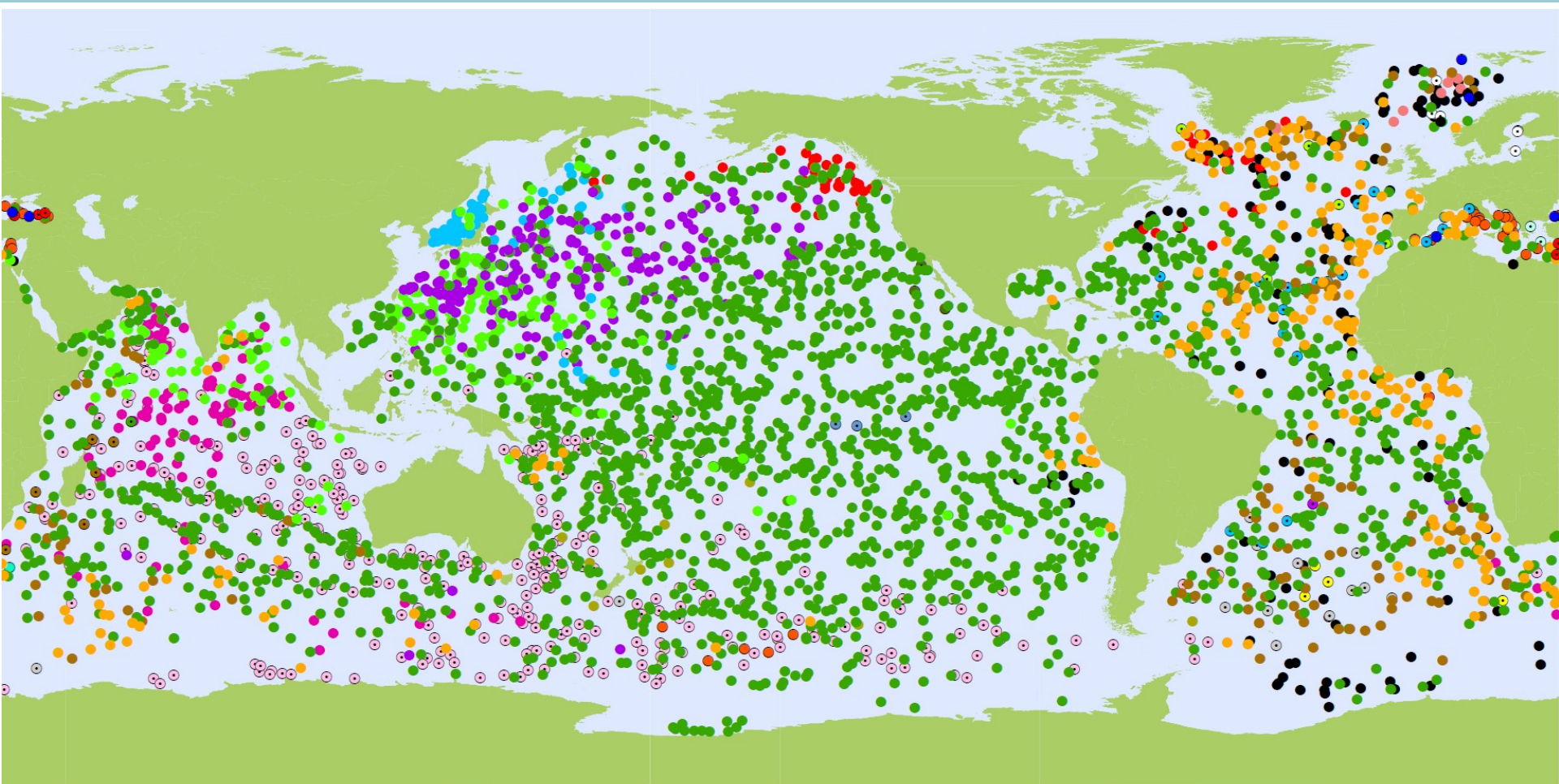## Achievements and developments

Andreas Sterl
KNMI, De Bilt

What is Argo?
Achievements
Current developments
Euro Argo

What is Argo?

- autonomous instrument
- probing the interior of the ocean

- carried horizontally by currents
- actively moving up and down the water column (every 10 days, 2 km)
- standard: T, S, p

- new sensors being developed

- 1 float per 3° x 3° box

6 -12 hours at surface
to transmit data to satellite

Total cycle time 10 days

Descent to depth
~10 cm/s (~6 hours)

Salinity & Temperature
profile recorded during ascent
~10 cm/s (~6 hours)

1000 db (1000m)

Drift approx. 9 days

Float descends to begin
profile from greater depth
2000 db (2000m)

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12.02.2015

3752 Floats

ARGENTINA (4)	CANADA (56)	FINLAND (6)	GREECE (4)	JAPAN (189)	MAURITIUS (7)	NORWAY (9)	TURKEY (5)
AUSTRALIA (355)	CHINA (201)	FRANCE (252)	INDIA (107)	KENYA (1)	MEXICO (3)	SOUTH AFRICA (1)	UNITED KINGDOM (151)
BRAZIL (2)	ECUADOR (3)	GABON (1)	IRELAND (6)	SOUTH KOREA (78)	NETHERLANDS (14)	SPAIN (24)	UNITED STATES (2 080)
BULGARIA (2)	EUROPEAN UNION (6)	GERMANY (137)	ITALY (38)	LEBANON (0)	NEW ZEALAND (10)	SRI LANKA (0)	

November 2014

jcommops

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Advantages

- cheap
  - 12.5 k€/float (several manufacturers)
  - deployment costs
  - 15 €/profile transmission
  - 150-200 profiles per float
  - => ~ 100 €/profile
  - data handling + quality control
  - no maintenance
- complement satellites (only surface)

Disadvantages

- less accurate than CTD (0.002 K, 0.002 psu, 2.4 dbar)
- salinity drift => delayed mode quality control (DMQC)
      => need for high-quality CTD data
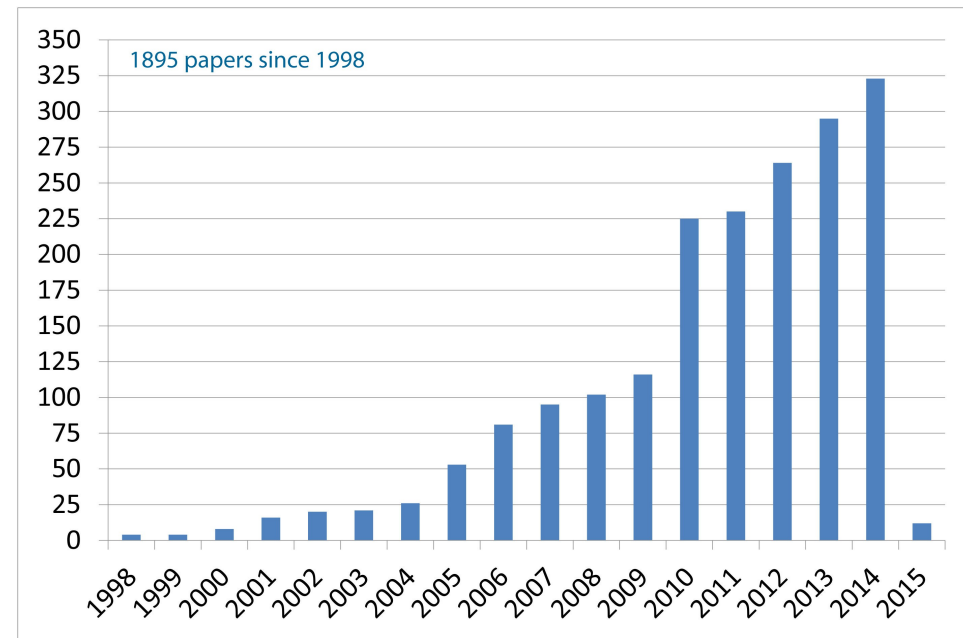- no influence on position after deployment

Argo Data Stream

- float => data centre
- automatic real-time QC (adding quality flags)
- direct distribution via GTS
- freely accessible via internet (within 24 h), netCDF
- DMQC (lag of one year)

free data policy

- basis for success
  - politically
    (sovereignty of coastal states)
  - scientifically (widely used)

1895 papers since 1998

Use of Argo data

- initialisation of ocean in long-range weather/climate forecasts
- monitoring the ocean, esp. heat content
- detecting changes
- inferring transports
- process studies

Argo Achievements

Data density

Observation type	T/S	Number per year	Max Depth	Geographical restriction
Ship-based temperature and salinity	T + S	5000 (to 1000m)	Full water depth	• Limited by ship endurance (100 per month) • Few at high latitude in winter • Typically along lines
Expendable XBT from merchant ships	T	25,000	750m	• Along shipping routes • Avoid high latitude in winter • Many areas unsampled
Argo	T + S	42,000 (May 2004) 100,000+ (2013)	2000m	• Ice free areas deeper than 2000m

2002

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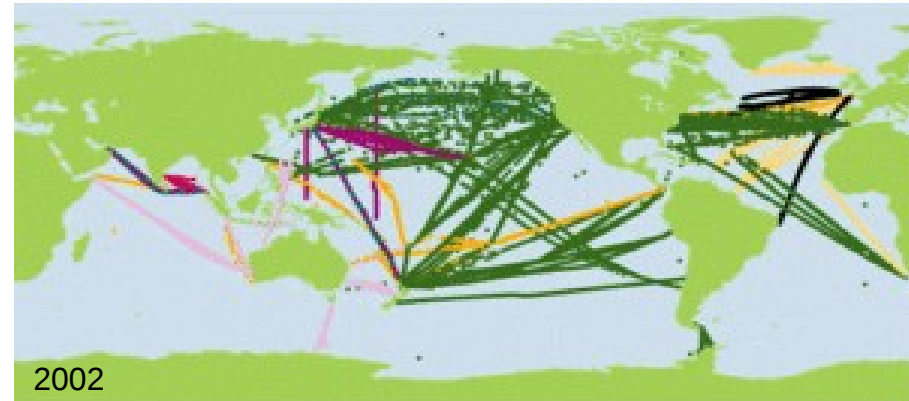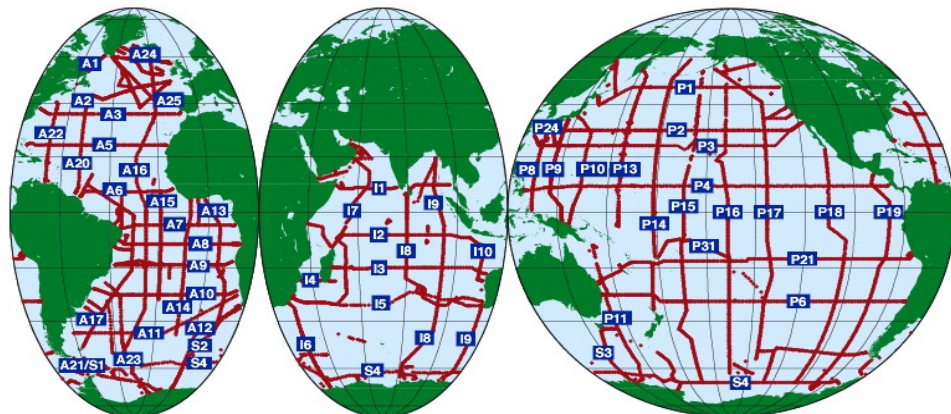
Bryden et al. (Nature, 2005):

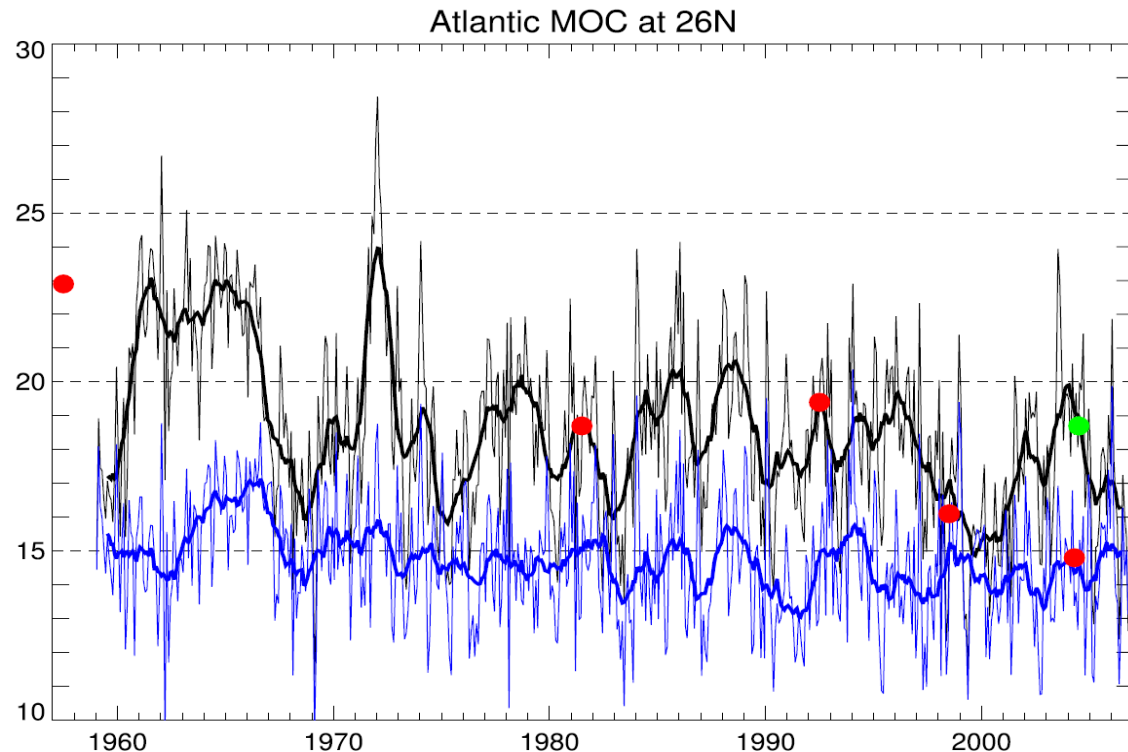"[...] the AMOC has slowed by about 30 per cent between 1957 and 2004"

based on five occupations of the 26°N transsect

Balmaseda et al. (GRL, 2007):
based on reanalysis, including
Argo data:

large variability, no large trend

corroborated by a lot of other
papers

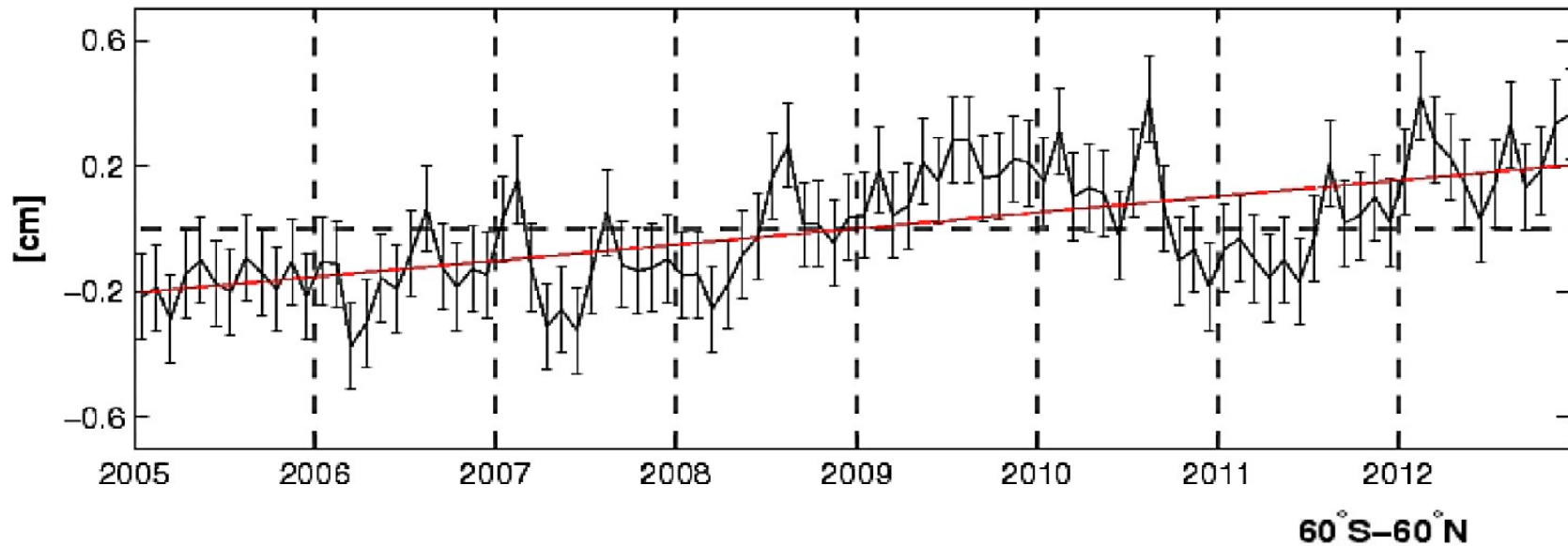=> continuous observations
necessary to capture
variability

Atlantic MOC at 26N

Budgets of heat and sea level

Global-mean sea level rise:

$$SLR_{Total} = SLR_{Mass} + SLR_{Steric} + SLR_{Res}$$

SLR_{Total} : total sea level rise   altimeter

SLR_{Mass} : glacier and ice sheet melt   GRACE

SLR_{Steric} : (thermal) expansion   Argo (upper 2000 m)

SLR_{Res} : residual: uncertainty + steric below 2 km

Global (60°N-60°S, upper 1,5 km) steric sea level change (upper)
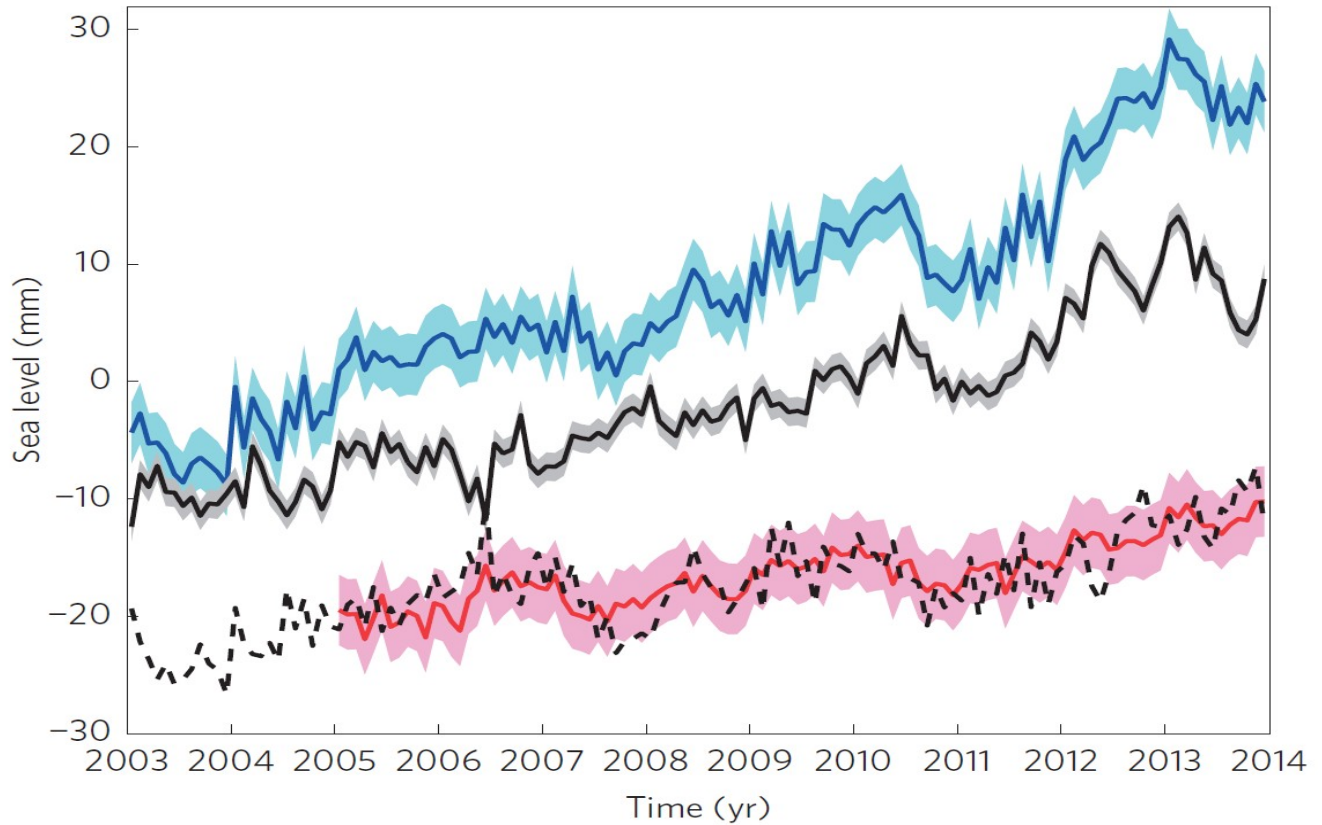
SLR$_{Res}$ (right)

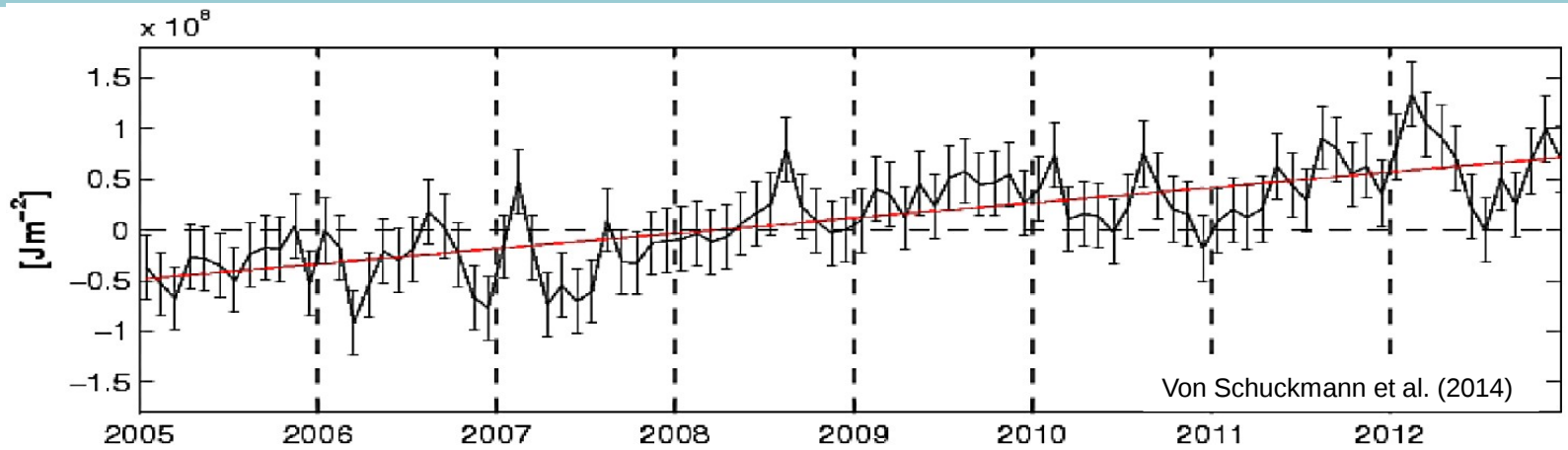SLR$_{Res}$ – small => budget (nearly) closed

Von Schuckmann et al. (2014)

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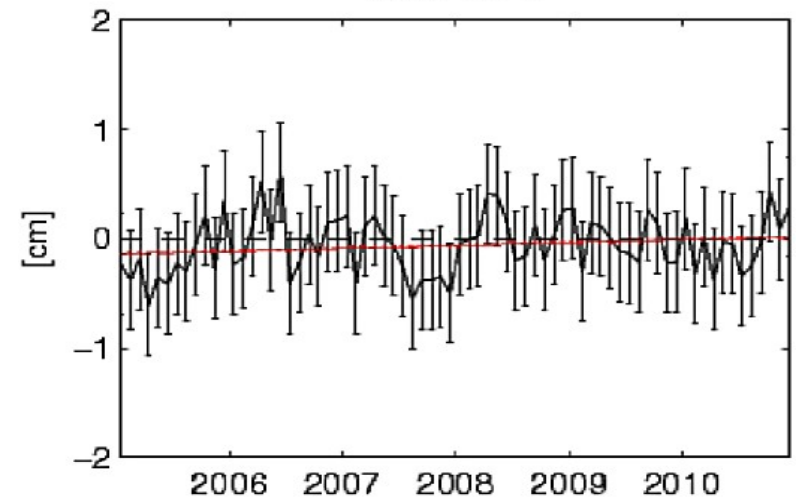
SLR_{Total}
SLR_{Mass}
$SLR_{Steric(2km)}$
$SLR_{Total} - SLR_{Mass}$

=> steric contribution below 2 km small

Von Schuckmann et al. (2014)

Global (60°N-60°S) ocean
heat content (upper 1,5 km)

=> 0.5 ± 0.1 W/m²

TOA imbalance: 0.5-1 W/m²

Trenberth et al. (2014)
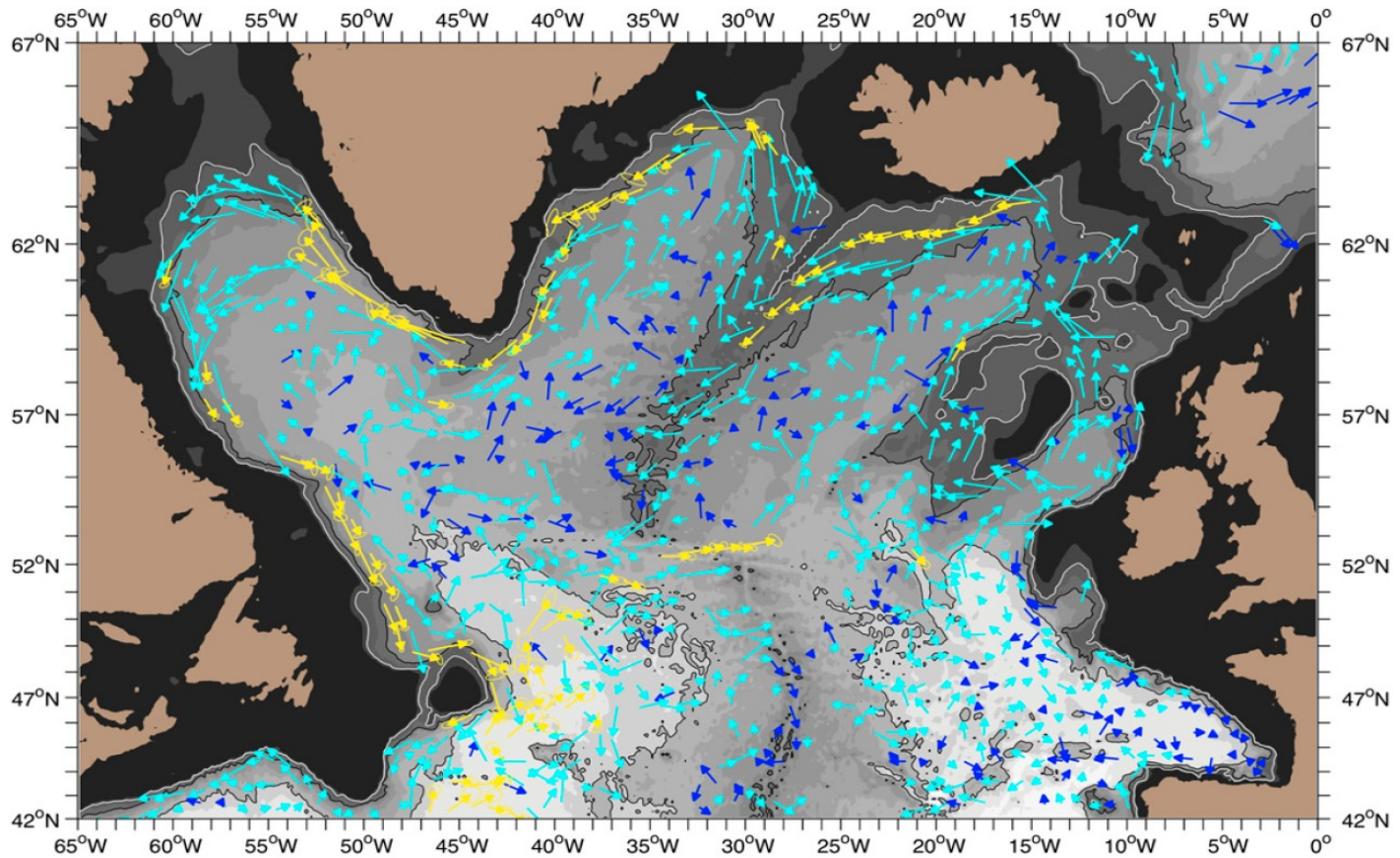
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12.02.2015
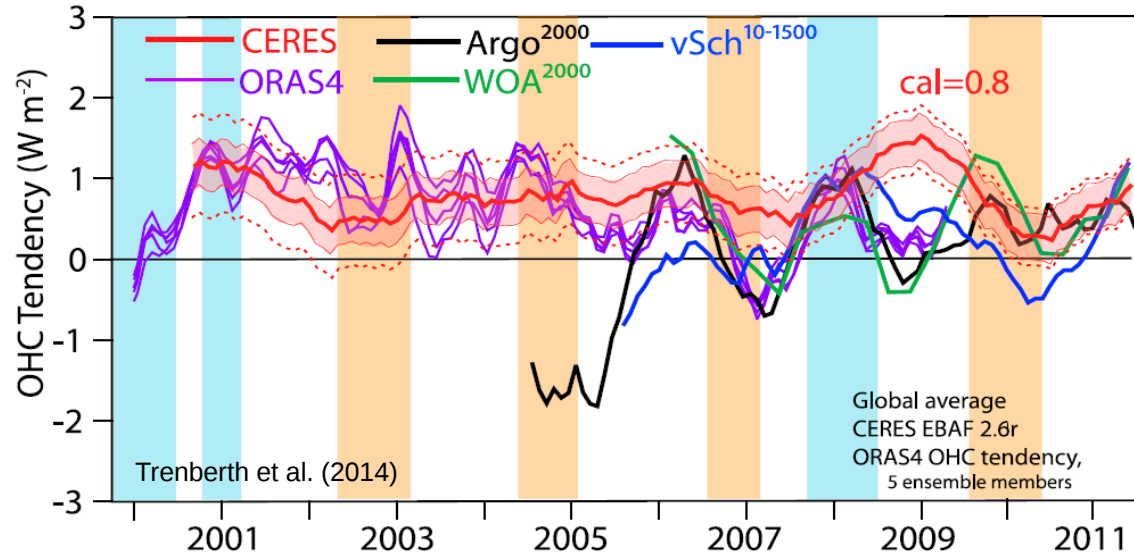
Impact of Argo on OHC estimates
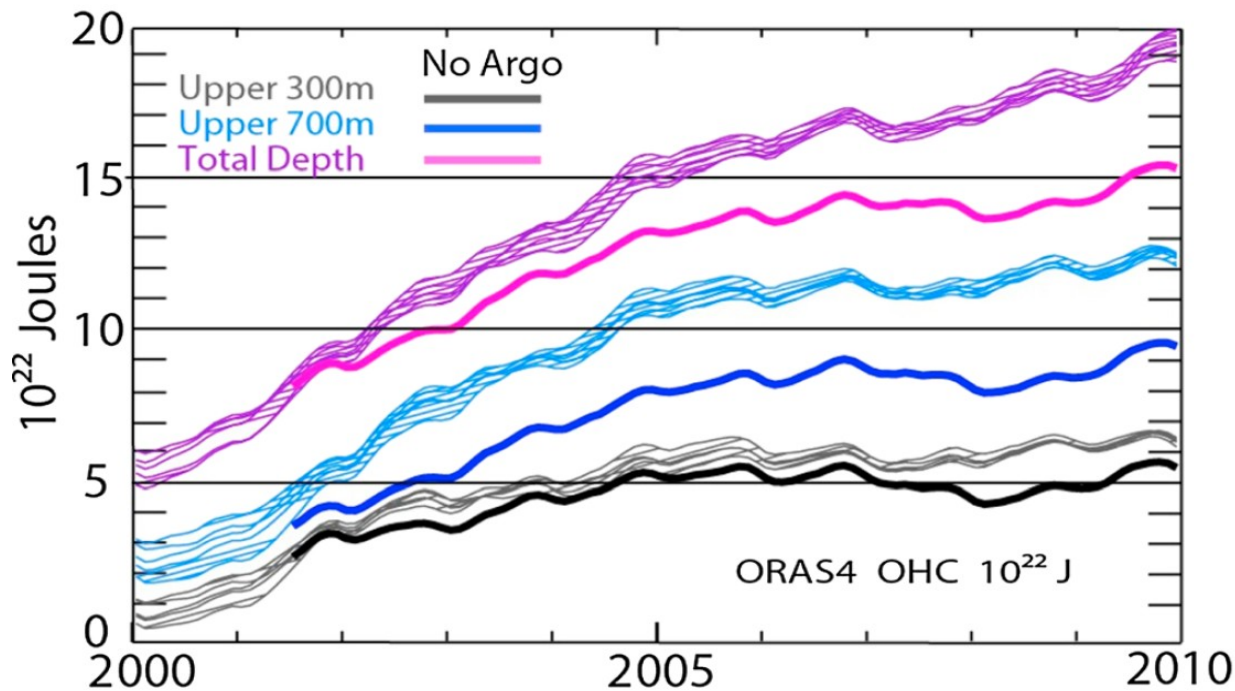
Without Argo, a substantial part of the OHC is missed.
Durack et al. (2014, Nat. Clim. Chng.): mainly SO

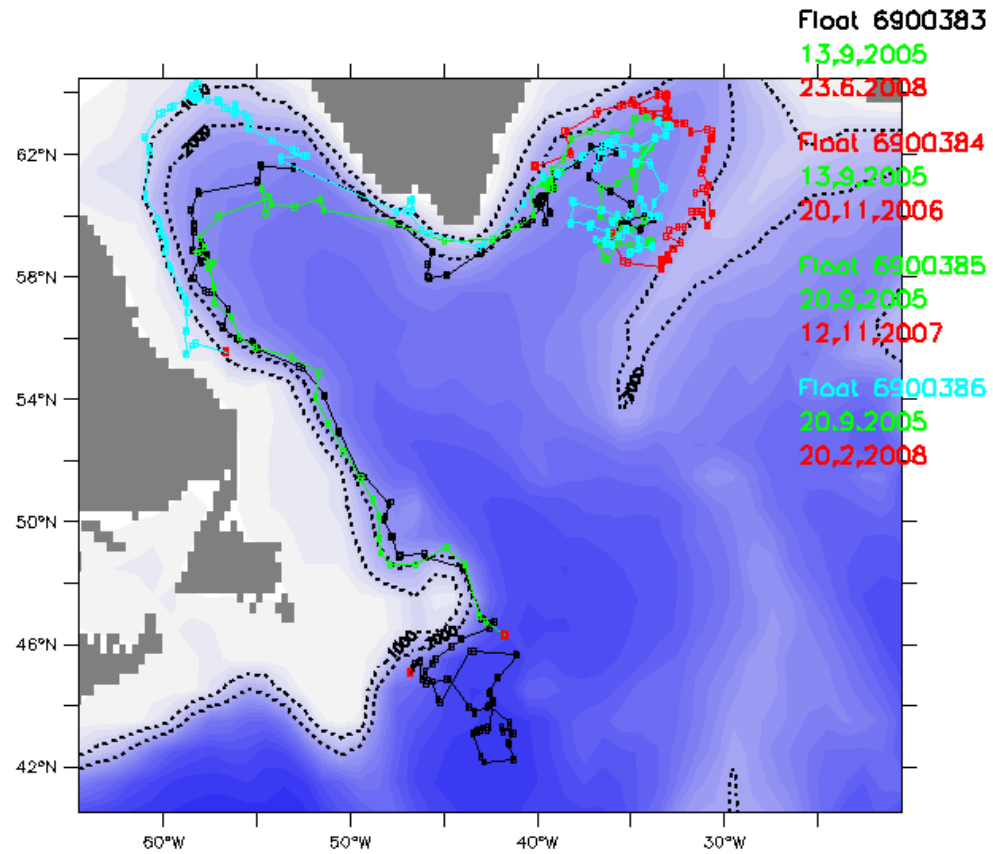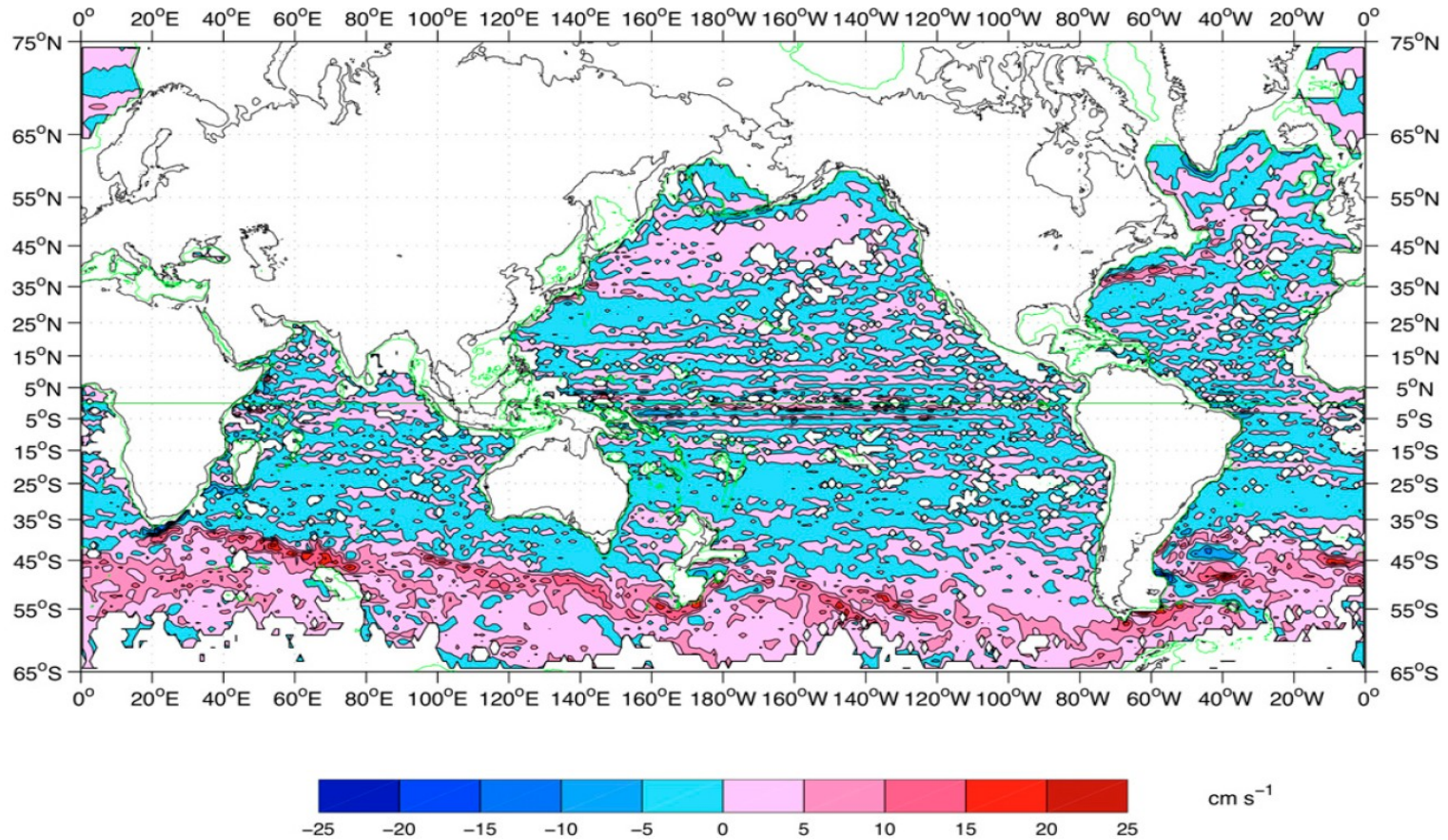# Currents at 1000 db (ANDRO)

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KNMI floats, 2005

ANDRO: mean zonal velocity at 1000 db

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Current developments

- two-way communication (alter mission parameters; limited steerability)
- under-ice capability (stay under ice, locate under ice)
- deep Argo (2-6 km)
- bio-Argo (additional new sensors)

Bio Argo

- concentration on "Hot Spots" (no global coverage)
- Focus on Biology and Biogeochemistry
- Variables
  - Oxygen
  - Chlorophyll
  - Spectral optical scattering (particles)
  - Nutrients (NO_3)
  - Spectral downward irradiance
  - pH
  - passive acoustics
  - ...

- interaction with physical processes
- spatial picture
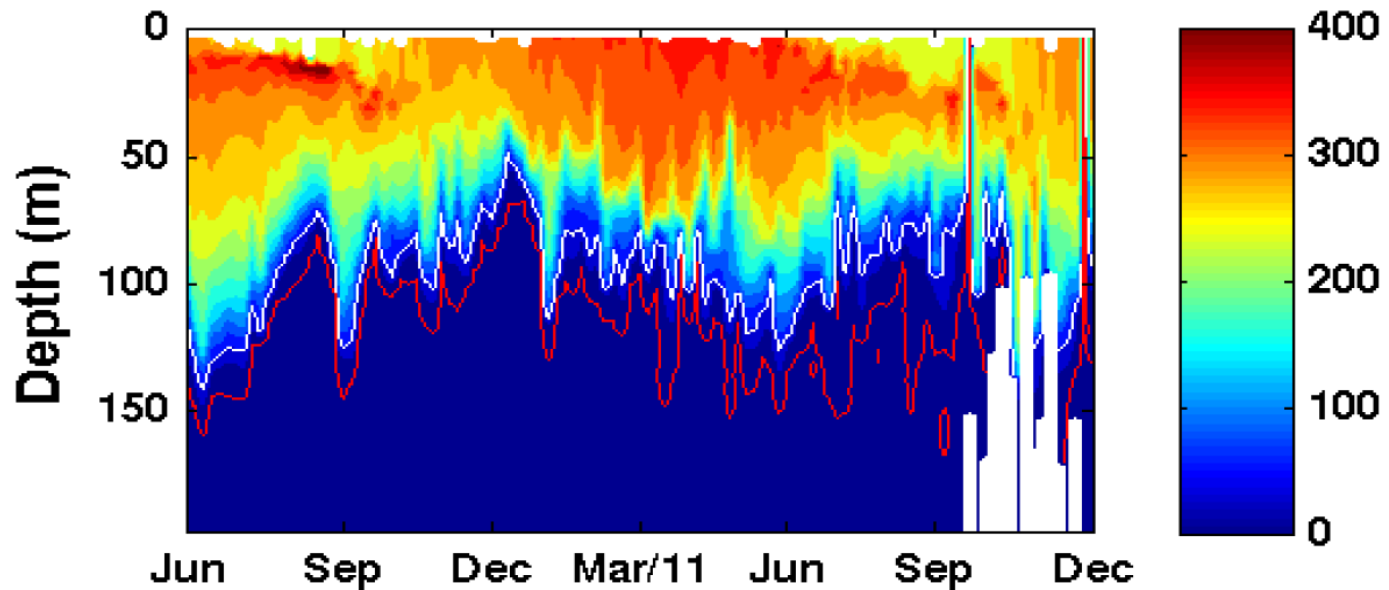- complement satellite observations

Oxygen in Black Sea

Figure 7. Temporal evolution of oxygen (in μM) as observed by float 7900466. The mesoscale variability of the interface between oxic and anoxic waters is well pronounced. The white and red isolines identify oxygen concentrations of 50 (5) _M, respectively. White vertical strips illustrate missing data due either to malfunction of sensors or to reaching the bottom (From Stanev et al., 2013).
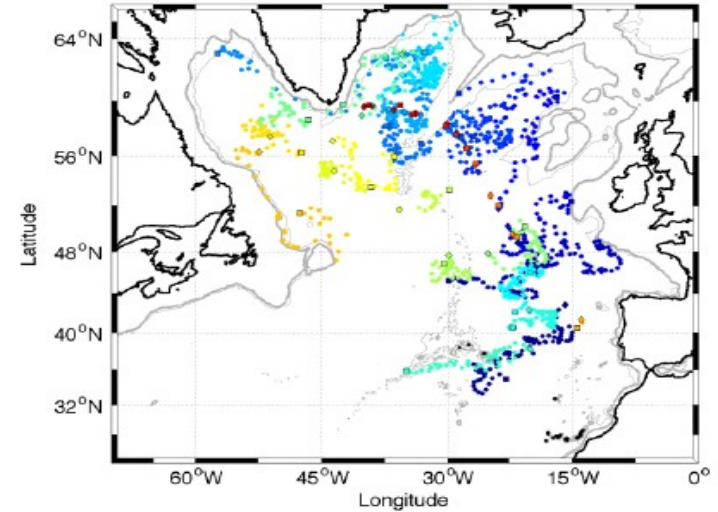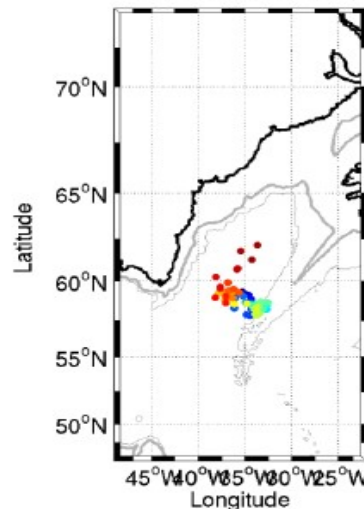
IFREMER
Field Test:

- North-Atlantic Ocean where
  - warm to cold water conversion occurs
  - oxygen and carbone storage take place
  - where deep convection occurs
- IFREMER has deployed 35 floats with Aanderaa optode sensors in the area
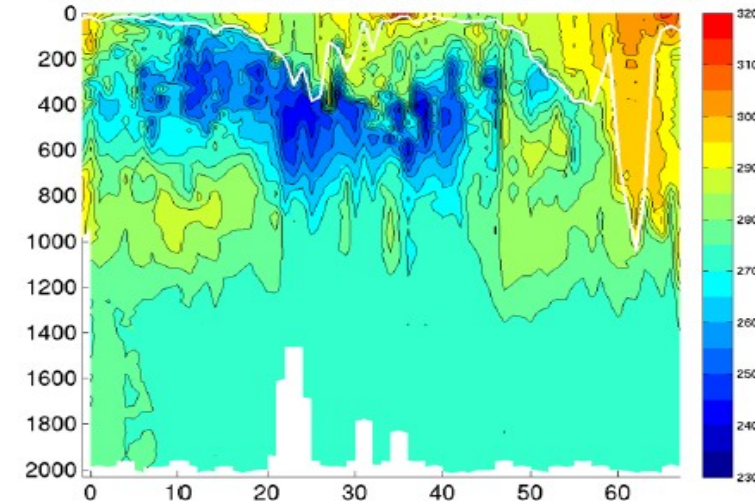
E-AIMS, WP 2, Task 2.1

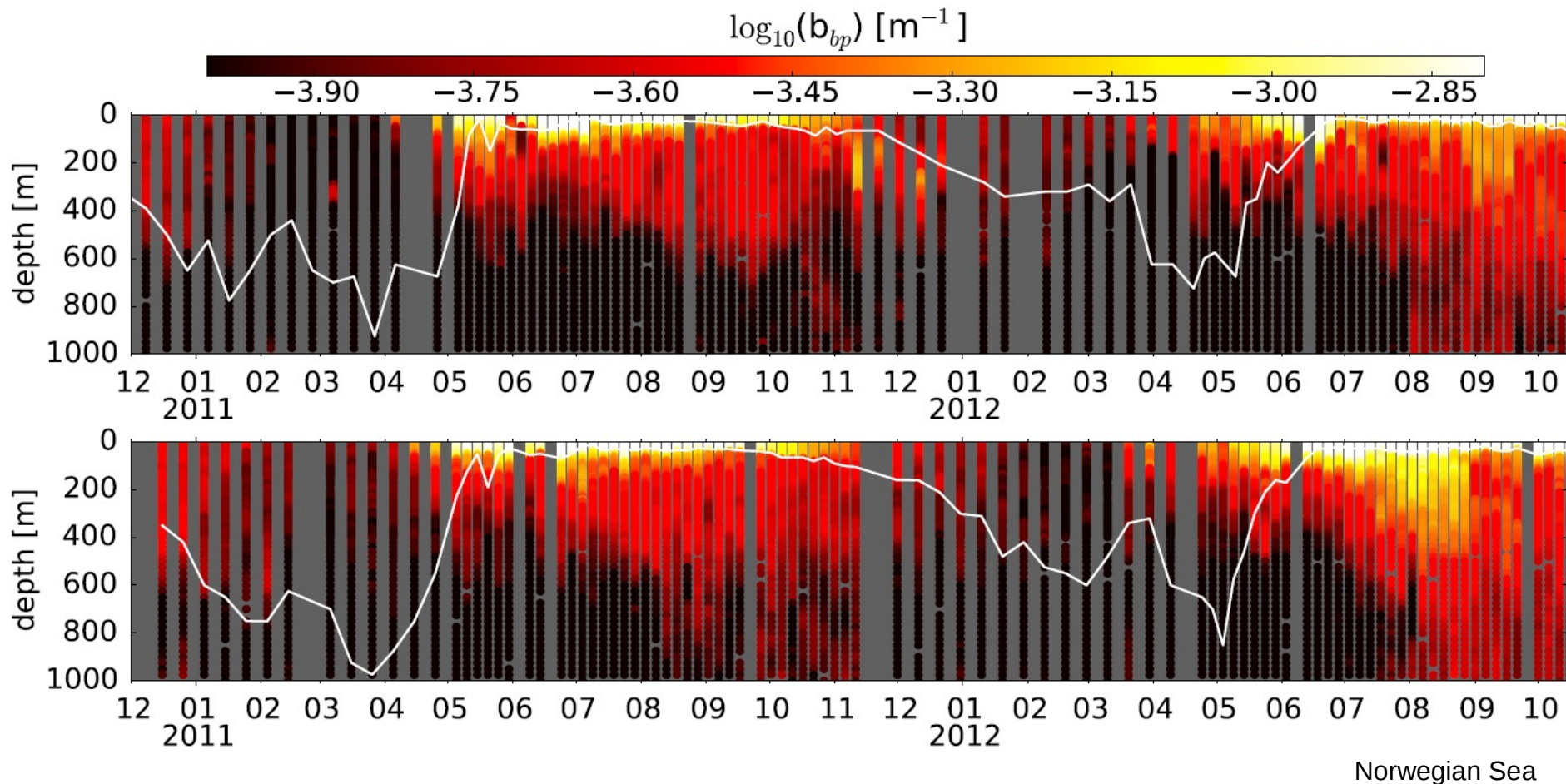Argo floats with DO sensor deployed during OVIDE

Float WMO 5902298

WMO 5902298 - DOXY - DOXY AJUSTED = 1 * DOXY + 18.5
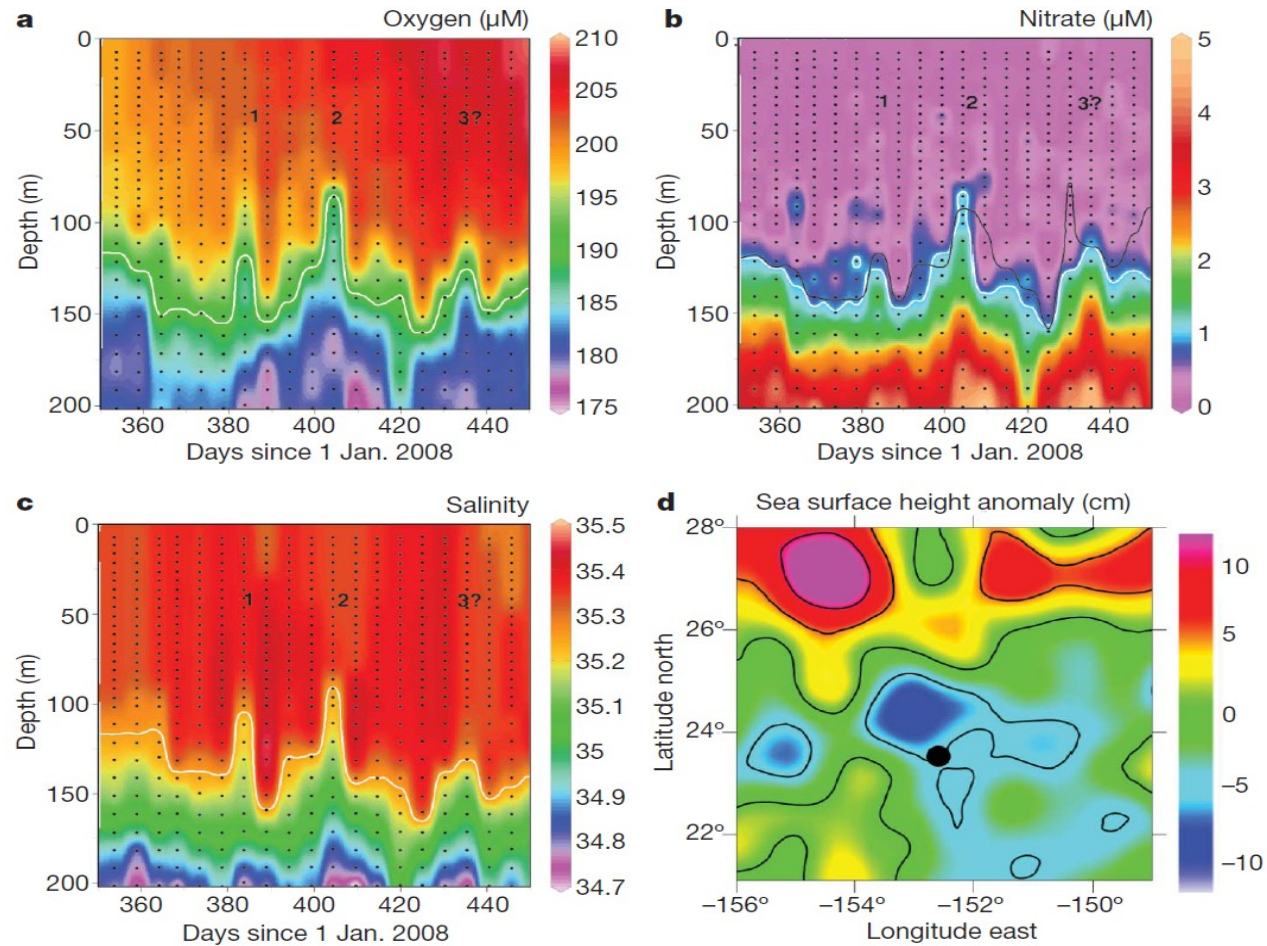
POC inventory & particle flux

Norwegian Sea

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12.02.2015

Nutrient budgets

Nitrate is transported into ML by eddies, sustaining net production

Johnson et al.
(Nature, 2010)

Organization

Argo International

- Argo Project Office
- Argo Information Centre (AIC)
- Argo Steering Team (AST)
- Global and regional data, and data assembly, centres

National contributions

Euro Argo

Euro Argo

- ERIC (European Research Infrastructure Consortium)
- 7 members (FR, GB, DE, NL, IT, FI, GR)
- 2 observers (NO, PO)
- 3 candidate members (ES, BG, IR)
- created 15 May 2014
- inaugurated 17 July 2014

Euro Argo

- coordinate European contribution
- secure sustained European funding
- aim: ¼ of global array
- marginal seas around Europe (Med, Black, Nordic)
- BioArgo & deep Argo
- outreach: get surrounding countries involved
- outreach: education (http://www.euroargo-edu.org/explore/)

Dutch contribution

- Euro Argo member, represented by KNMI

- started in 2004
- 69 floats in purchased
  - 17 working
  - 2 to be deployed soon
- mainly Atlantic region
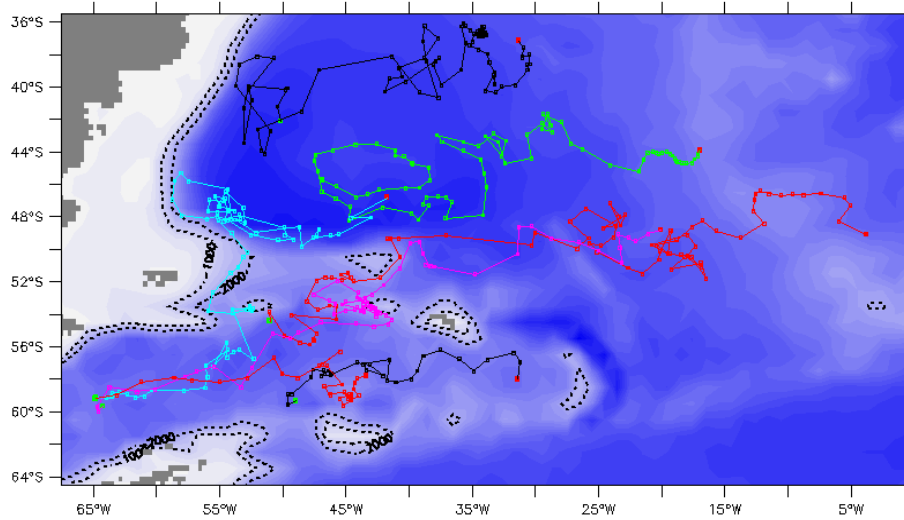- recent years from cruise ship *Plancius*
    near Antarctica

m/v Plancius in Antarctica
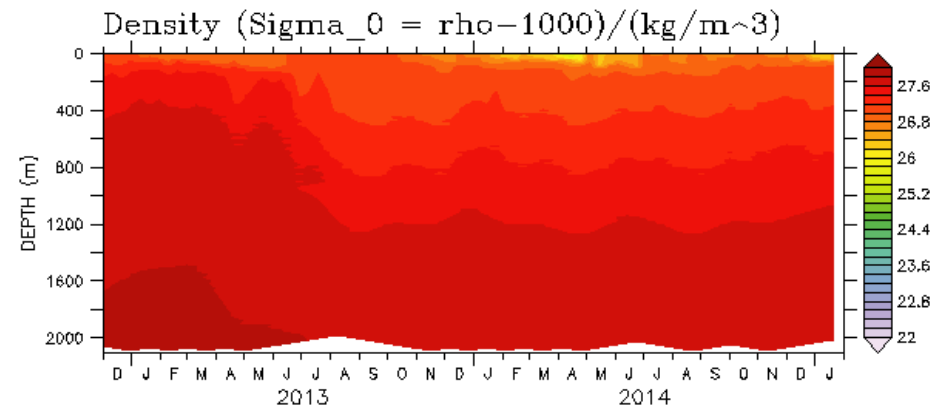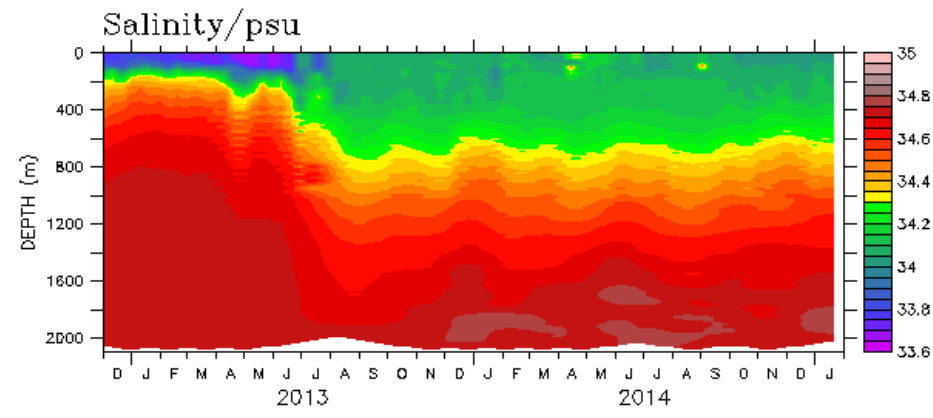© Robert van Poppel,
Oceanwide Expeditions

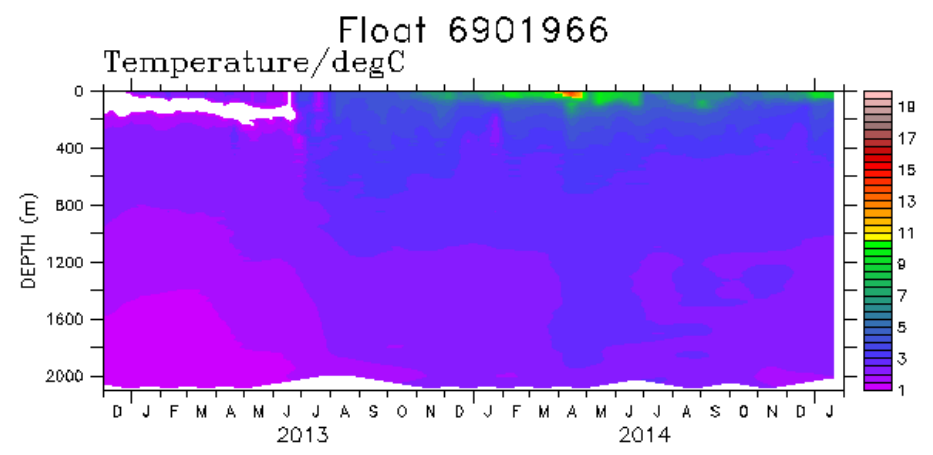# 2012 Dutch deployments

Float 6901963 Float 6901964 Float 6901965 Float 6901966
20.10.2012   01.11.2012   21.10.2012   02.12.2012
18.01.2015   20.01.2015   19.01.2015   21.01.2015

Float 6901967 Float 6901968 Float 6901969
12.12.2012   15.11.2012   21.11.2012
21.01.2015   01.09.2013   27.09.2013

Float 6901966

Temperature/degC

Salinity/psu

Density (Sigma_0 = rho−1000)/(kg/m~3)

6900746: from the Atlantic into the Indian Ocean
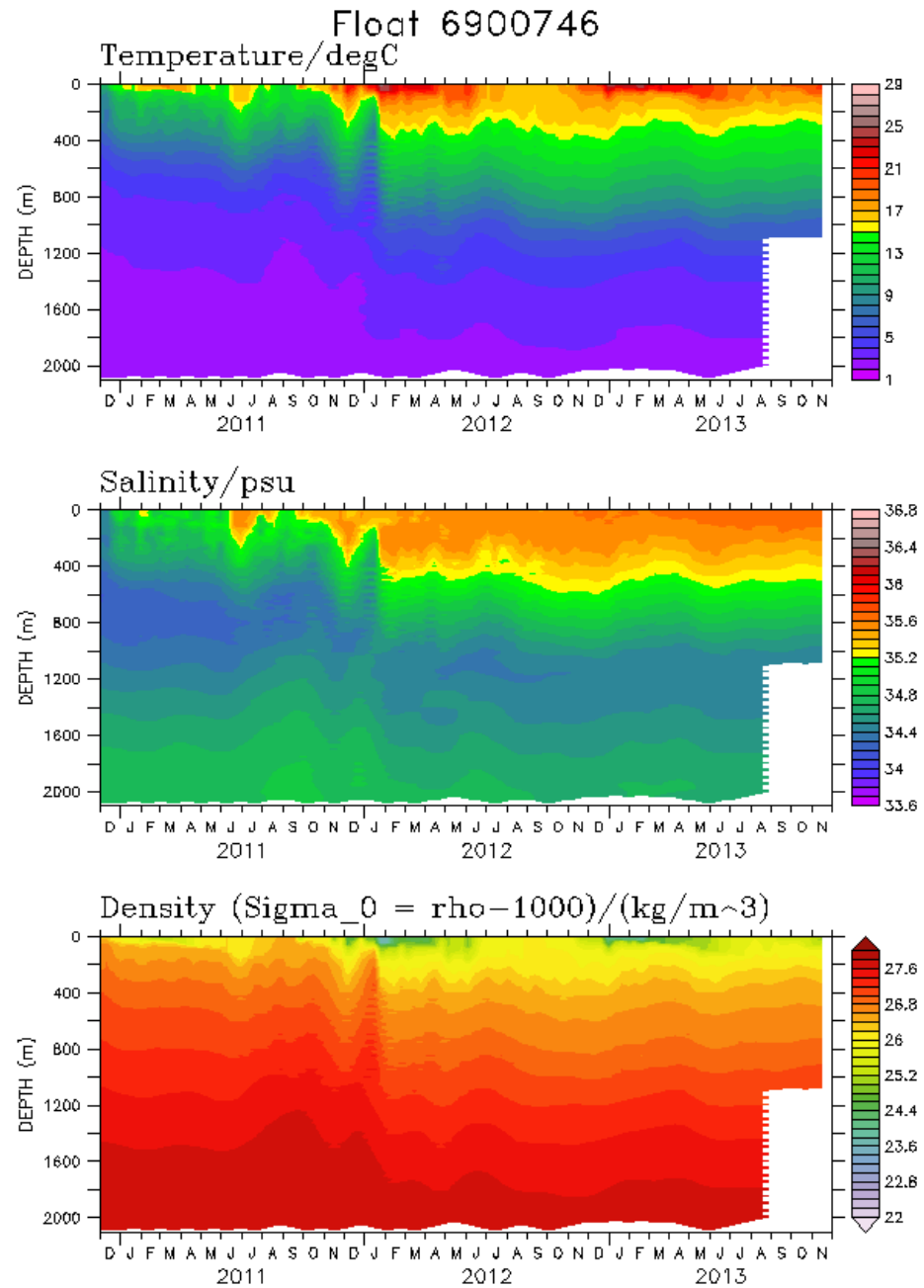
Summary

Argo

- has revolutionized ocean observations
- is cheap
- developing towards biological variables

- is an open community
- with open data policy

- welcomes new participants