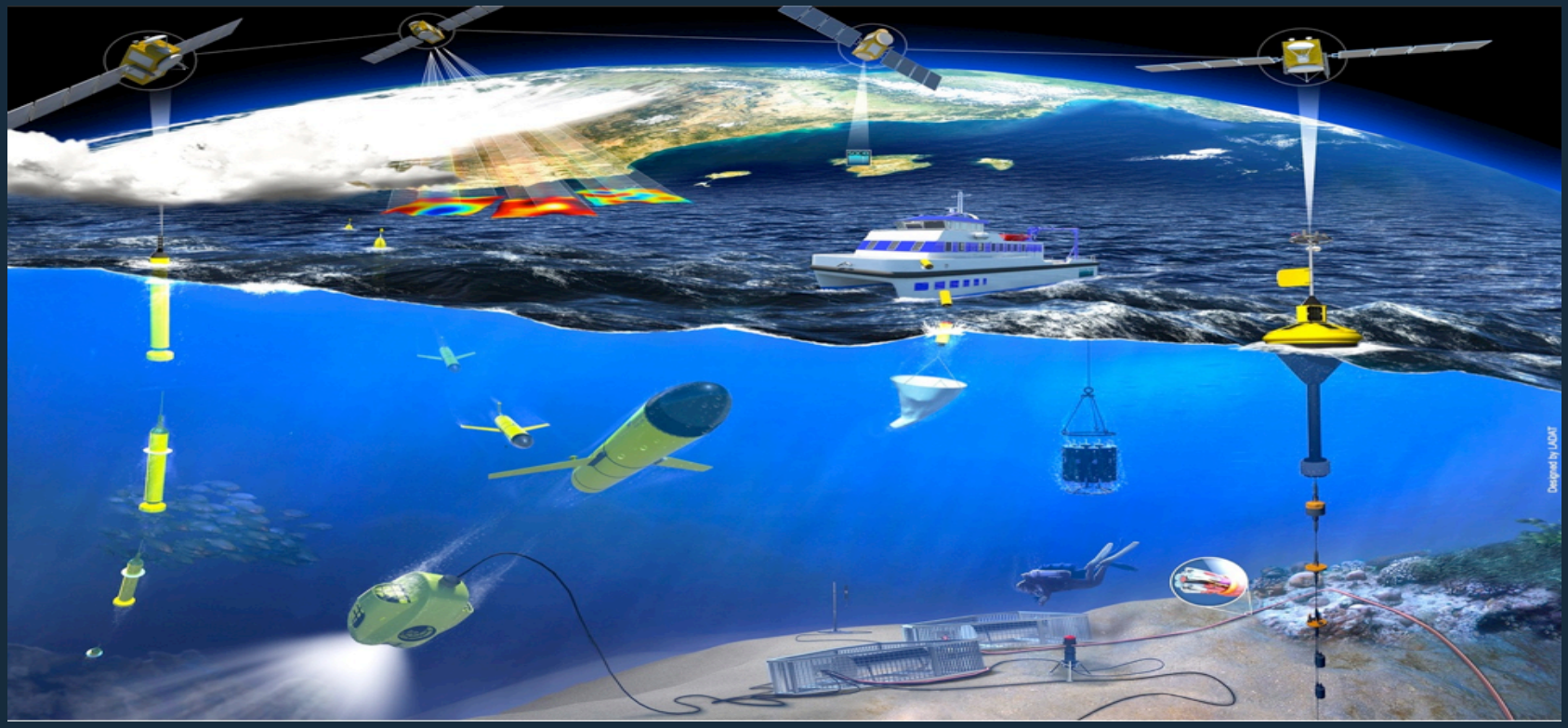
The quiet revolution?

Evolution in ocean science:

- New multi-platform integrated ocean observatories - observing for long term/range of scales,
- Monitor ocean state and ocean variability, now delivering results…
- Carefully and systematically improving our knowledge of ocean variability – a quiet revolution



Why study variability in ocean circulation?

Societies increasing need:

- Mange ocean resources based on knowledge and data
- Detect and understand climatic change

Need:

- Long time series
- Synoptic data

In 2009, the RAPID array records a 30% drop in average current strength, that lasted a year

"We need data, ... models are becoming untestable" (Carl Wunsh, 2010)

>> Variability in ocean circulation affects the distribution of heat and salt, also biological nutrients and marine organisms

- Improved knowledge of variability:
- increase model forecast skill
- link physical processes to ecosystem response
- detect future climatic change

IN FOCUS NEWS

OCEANOGRAPHY

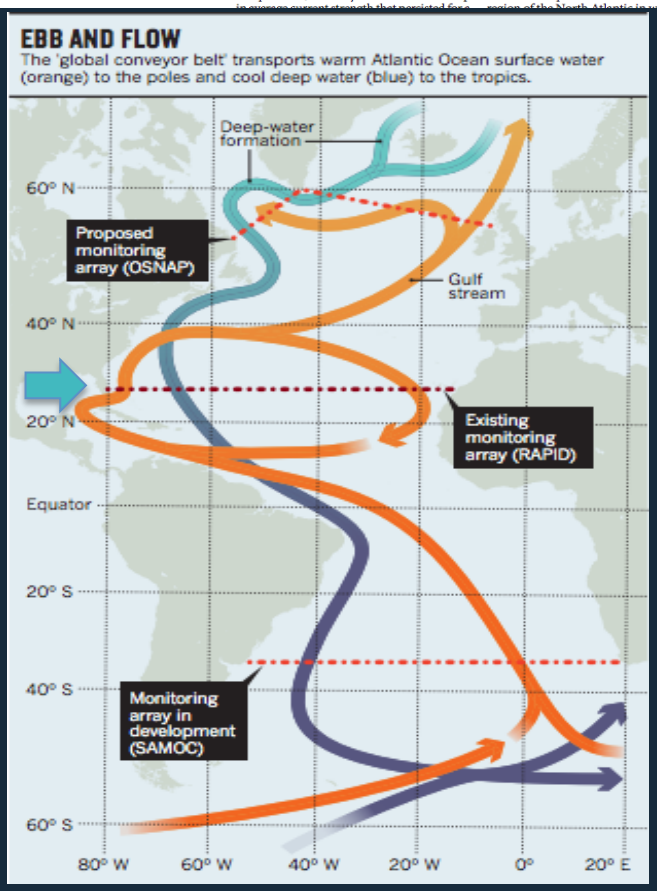
Oceans under surveillance

Three projects seek to track changes in Atlantic overturning circulation currents.

BY QUIRIN SCHIERMEIER

In April 2009, the array recorded[2] a 30% drop

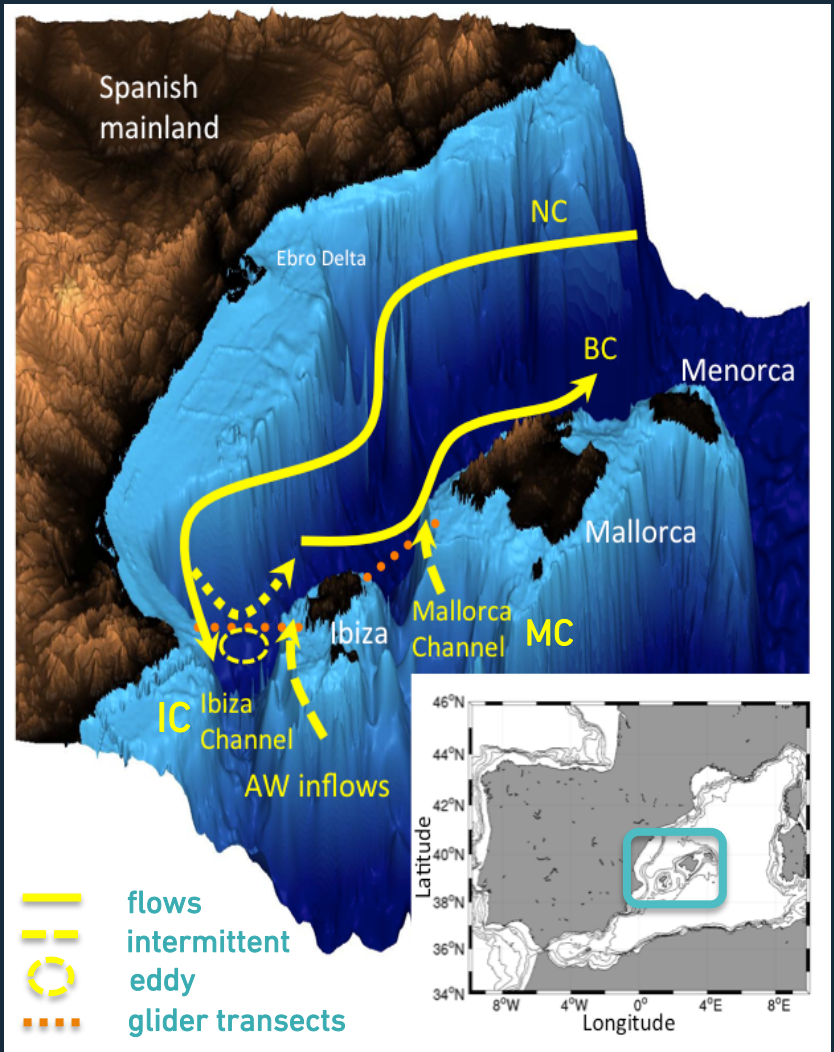
a crucial component of the conveyor belt: the



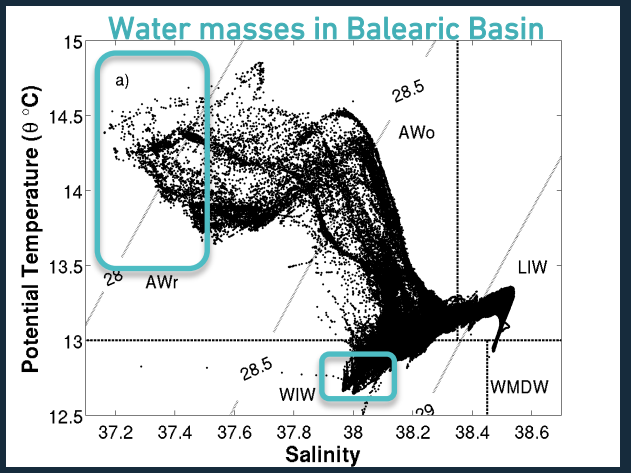
Nature May 2013

Why study the Ibiza Channel?

Ibiza Channel: an important ‘choke’ point in basin scale circulation



- Northern Current flows south, - basin circulation – more saline longer residence AW
- From south, inflows of less saline, warmer water AW more recent Atlantic origin
- Fresher AW inflows influence spawning grounds of Atlantic bluefin tuna
- Eddies ‘block’ channel - NC to recirculates to north
- WIW plays role as eddy core
- IC governs important N/S exchange



What known about variability previously?

Seasonal strengthening of Northern Current in winter (Astraldi et al. 1989)
'large cruise-to-cruise variability in transport' (Pinot and Ganachaud 1999)

The CANALES experiment - (Pinot et al. 2002)

- 2.5 year and seasonal ship sampling (13 cruises) to resolve variability in the exchange
- Seasonal max. and min. in transport through IC

This study:

- 2011 SOCIB commenced monitoring with gliders
- Higher frequency, year-round observations

Reference	Date	Survey	South (Sv)		North (Sv)		Net (Sv)	
Ibiza Channel			**Winter**	**Summer**	**Winter**	**Summer**	**South**	**North**
Font, Salat and Tintoré, (1988)	historical data	Ships CTD	-1.00	-0.50				
Castellon et al., (1990)	May - June 1989	Ships ADCP		-0.24				
Lopéz-Jurado and del Rio, (1994)	Nov 1990 - May 1991	Ships CTD	-0.65	-0.56	+1.08	+0.51		
Pinot et al., (1995)	May - June 1991	Ships CTD		-0.20		+0.50		
Pinot and Ganachaud, (1999)	June 1993	Ships CTD		-0.55		+0.55		
Pinot et al., (2002)	Mar 1996 – Jun 1998	Ships CTD	-1.20	-0.30	+0.20	+0.70	-1.05	+0.35
Mallorca Channel								
Pinot et al., (2002)	Mar 1996 – Jun 1998	Ships CTD					-0.30	+0.05

Historical 'seasonal' estimates of transport through the IC and MC, most cruises in summer

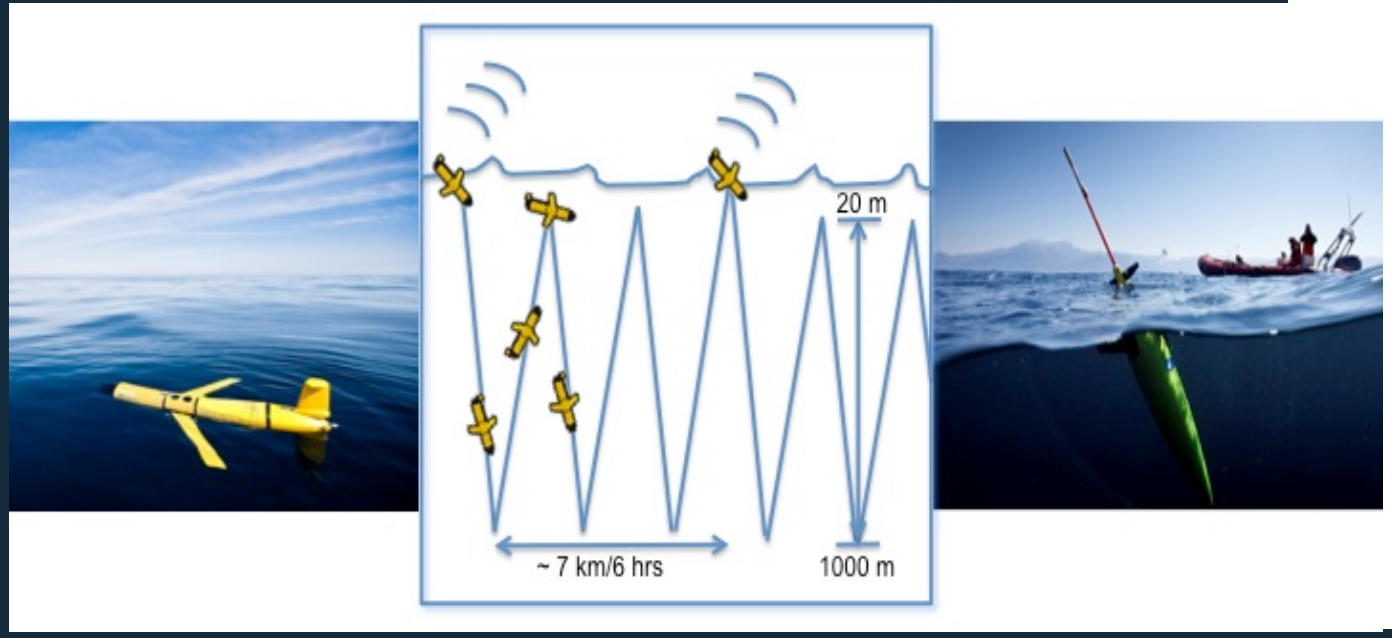
02 Combining glider and historical ship data

Glider CTD Data 2011 - 2013:

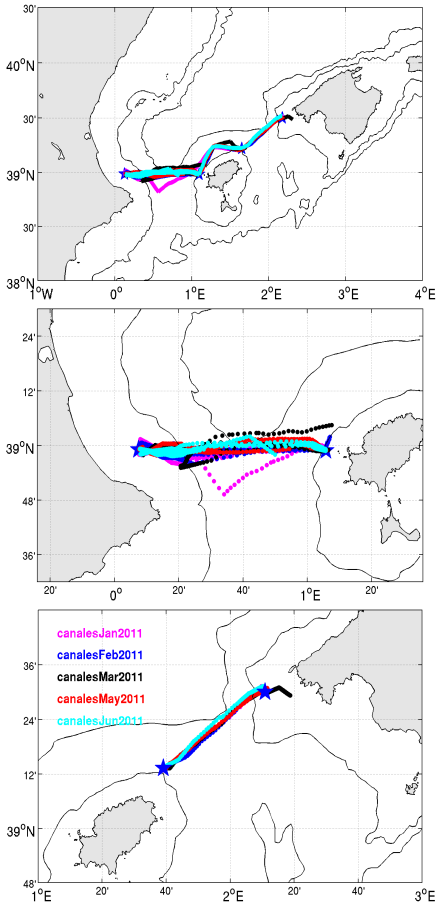
- 3 years quasi-continuous monitoring
- Repeat transects IC, full channel depth
- Profile resolution ~2.7 km (deep channel)

3 years - 66 IC transects, 22 MC transects

~13,000 profiles



Glider missions 2011



02 Combining glider and historical ship data

Ship CTD data 1996 – 2013:

- From IEO (IBAMar 2.0 dataset)
- 18 years ‘seasonal’ ship campaigns
- Station resolution 10 km

18 years - 54 IC transects, 48 MC transects

~ 1100 profiles

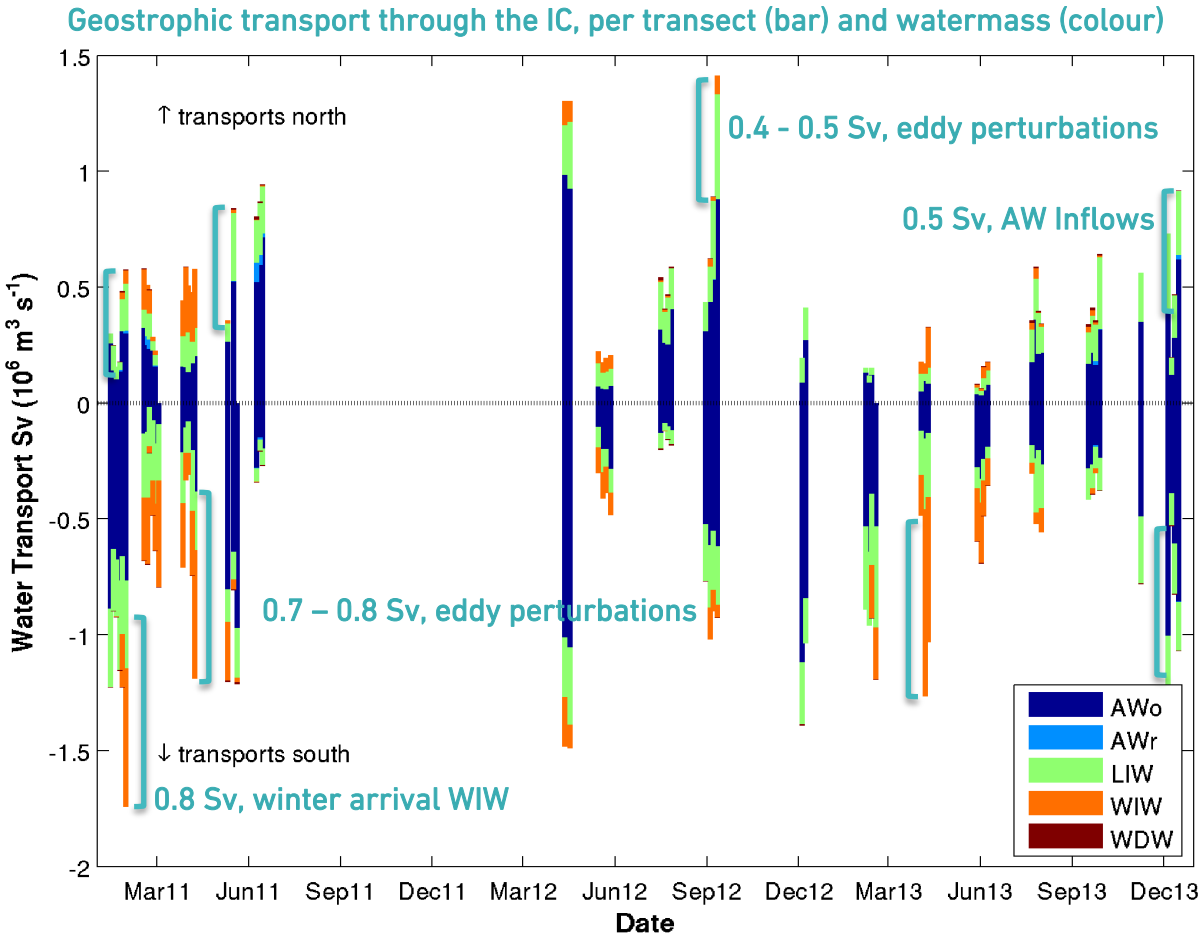
IC	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1996			s	s	s	s		s				
1997		s		s	s		s	s				
1998	s					s						
1999					s							
2000									s		s	
2001			s			s					s	
2002			s		s				s			
2003			s			s				s		
2004			s		s					s		
2005			s			s				s		
2006				s		s						
2007							s			s		
2008		s		s			s			s		
2009					s							
2010				s								
2011	gggg gg	s gg gggg	gg	ggg	s ggg	s ggg	s					
2012				gg	gggg		gggg	g	ggg			gg
2013		gggg		s gggg	g	s ggg	gggg		ssss gggg		g	gggg ss

MC	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1996			s	s	s	s		s				
1997	s			s	s		s	s				
1998	s			s		s						
1999					s							
2000											s	
2001				s	s	s					s	
2002			s		s				s			
2003					s					s		
2004			s		s					s		
2005			s			s			s			
2006				s		s				s		
2007							s			s		
2008		s			s		s				s	
2009					s		s					
2010				s								
2011		gg	g		s g	g	s					
2012			s g		g		gg	g		g	g	g
2013	g		s		g	s g	g		g	g	g	s

>> **Temperature and salinity used to calculate geostrophic velocity**

High frequency variability

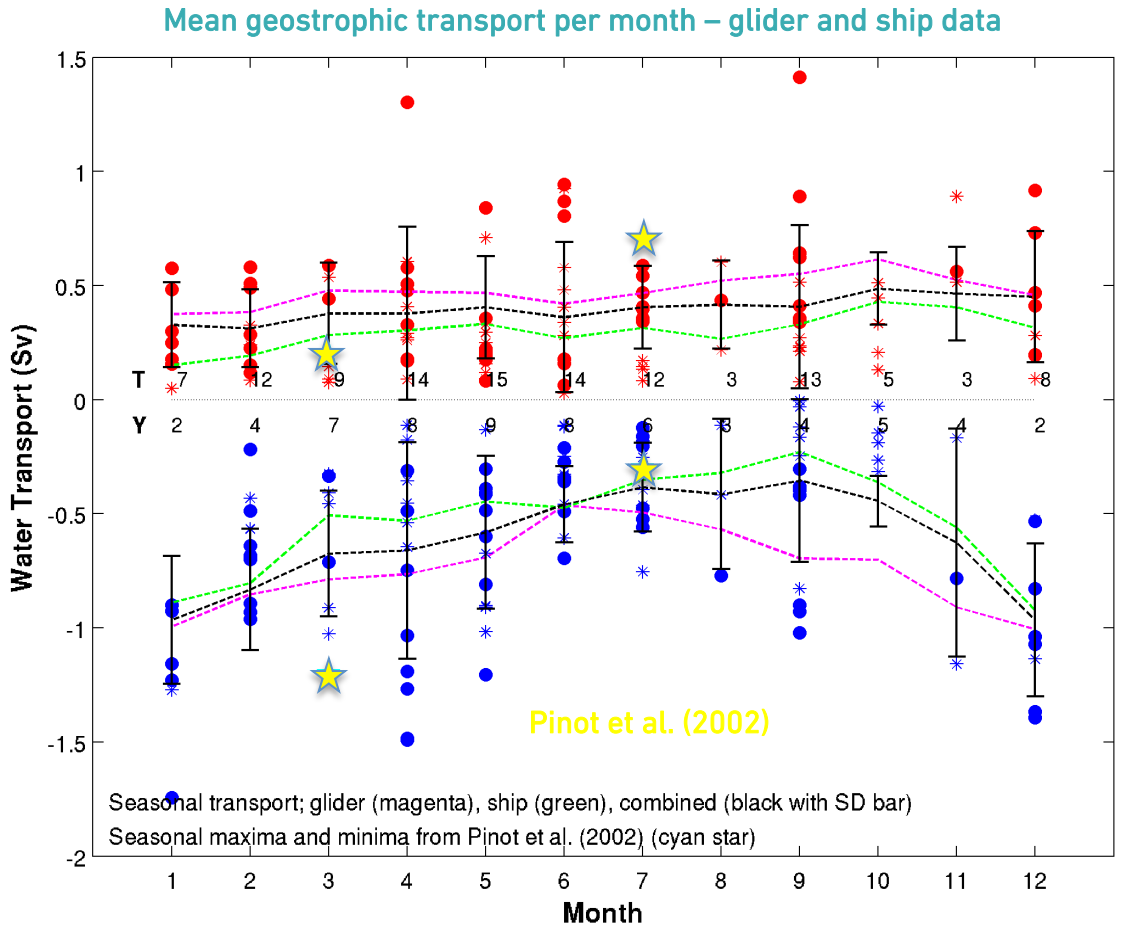
Gliders observe high frequency variability in the transport of watermass



- Changes in transport on a par with the previously defined seasonal signal
- BUT occurring over timescales of days to weeks
- Causes:
  - arrival of WIW
  - eddies
  - strong AW inflow
- Heslop et al. (2012)

Seasonal variability Ibiza Channel

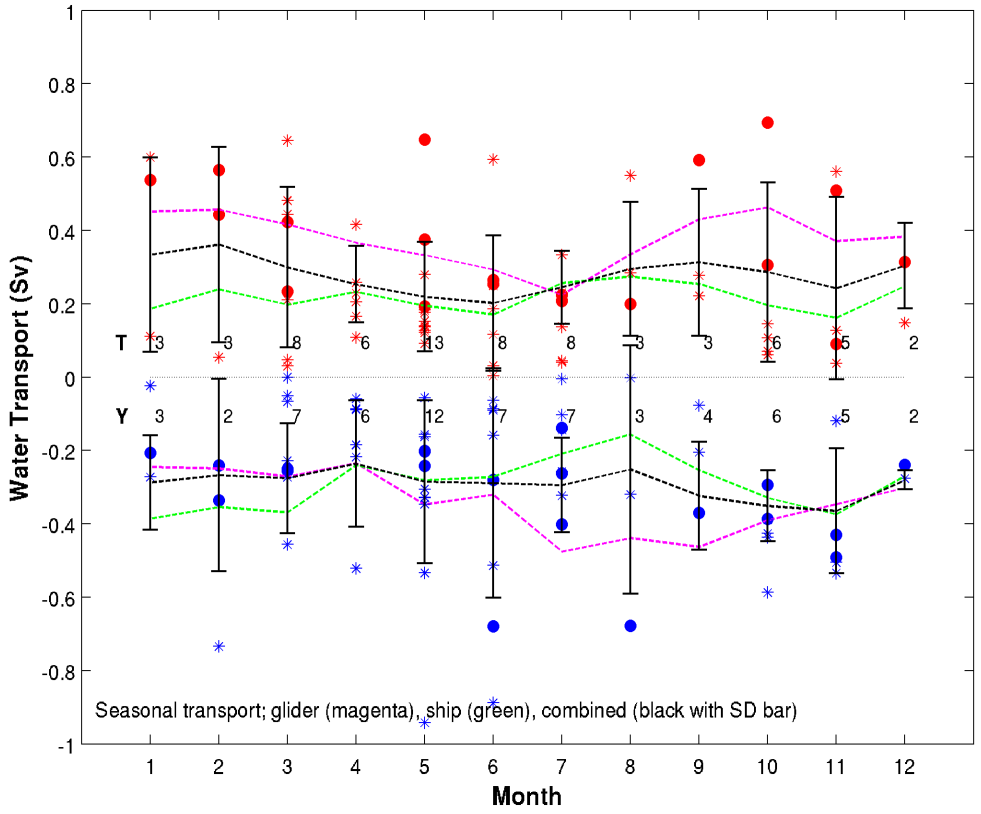
Interannual mean seasonal cycle of transport in the IC



- Seasonal cycle in transport S:
  - ➢ full annual cycle (mean)
- No pattern in transport N:
  - ➢ high variability
  - ➢ interannual mean ~0.4 Sv
- Close agreement between glider and ship
- Changes our view of exchange
- Different drivers to N and S combine influence flow through the IC ‘choke’ point

Seasonal variability Mallorca Channel

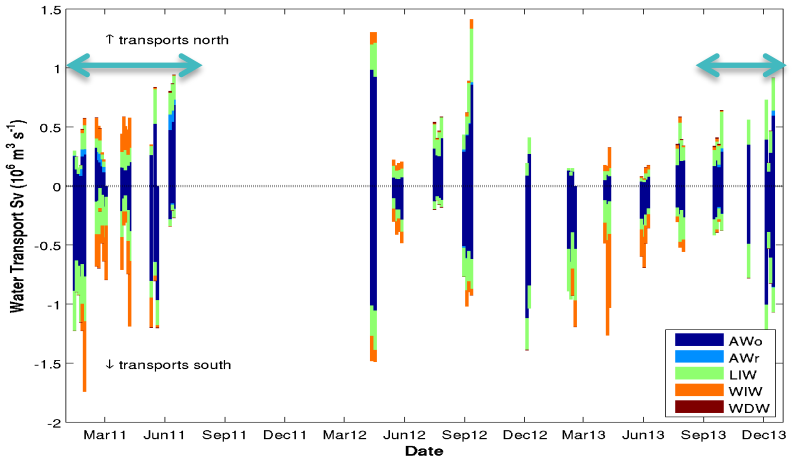
For MC the picture is not as clear

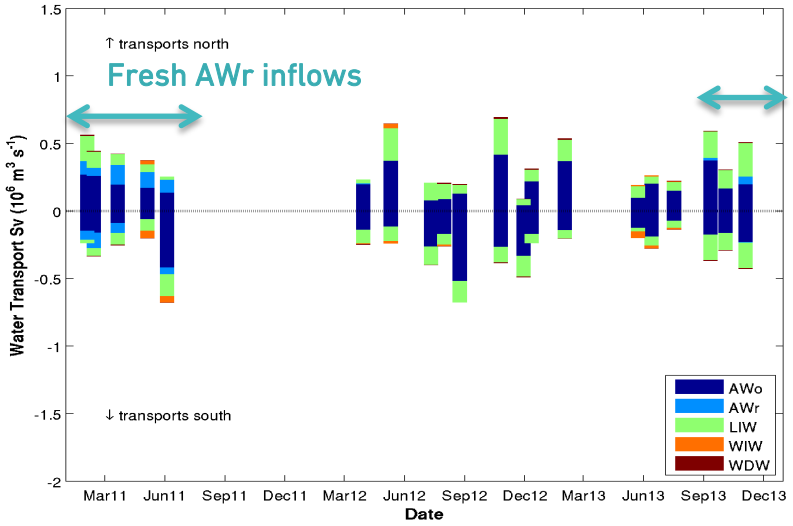


- No agreement glider and ship data
- Except little or no Net exchange - interannual means

Seasonal variability Mallorca Channel

IC and MC connection clear

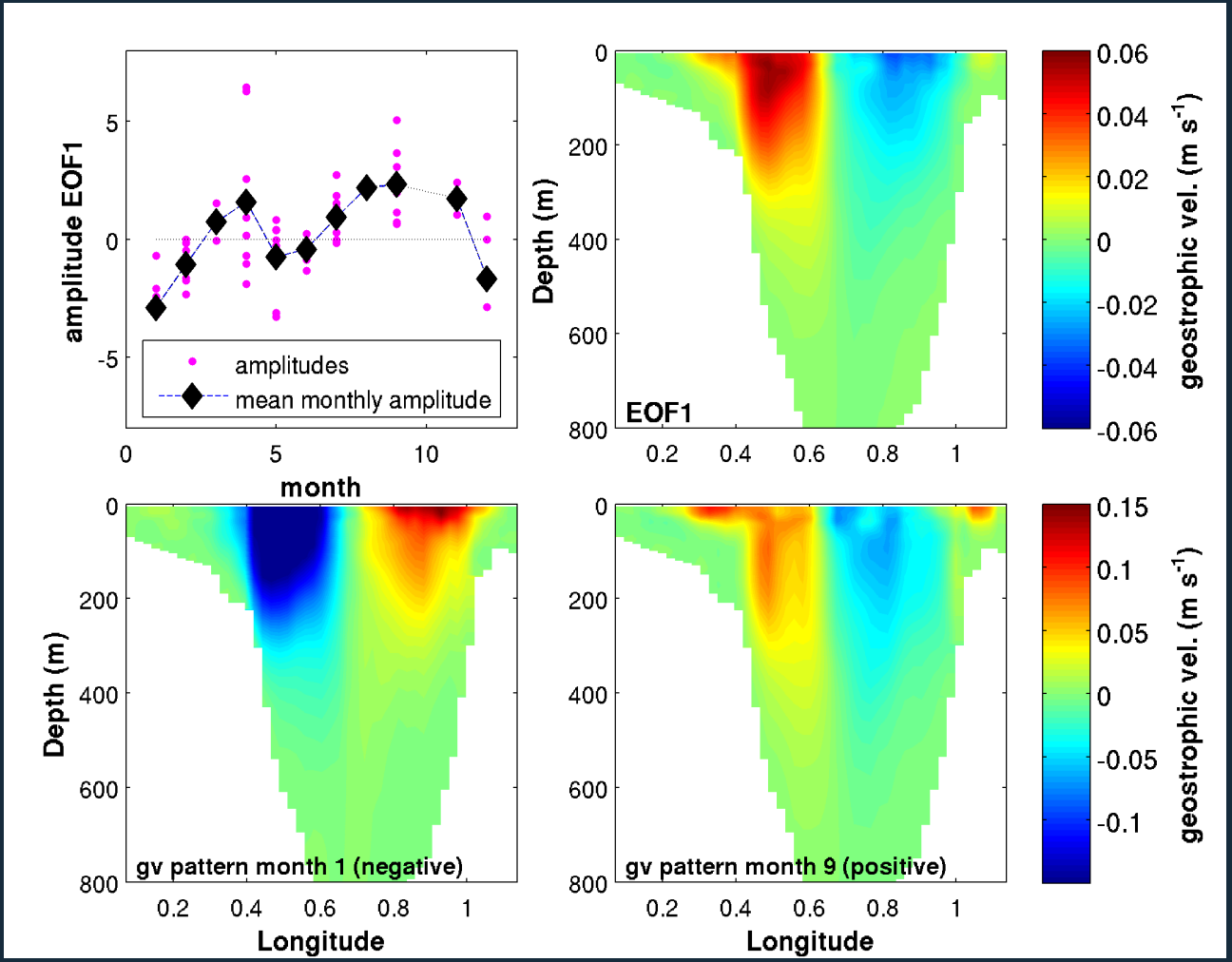




- New view fresh AW inflows:
  - ➢ synchronous through IC/MC
  - ➢ Episodic, several months duration
  - ➢ MC slightly fresher
- Inflow events most likely influenced patterns in gyres to S
- Operational alerts

Seasonal interplay between basin and mesoscale

First EOF of geostrophic velocity in the Ibiza Channel



- First EOF:
  - 42%
  - amplitude seasonal pattern
- 'Winter/early summer':
  - negative amplitude
  - strong NC
- 'Spring/autumn':
  - positive amplitude
  - Anticyclonic eddy
- Preliminary seasonal cycle for eddy activity

The quiet revolution

- Use of new technology, multi-platform integrated ocean observatories
- Careful systematic observation and analysis
- Unravel variability at a range of scales at important circulation ‘choke’ point

With this improved knowledge:

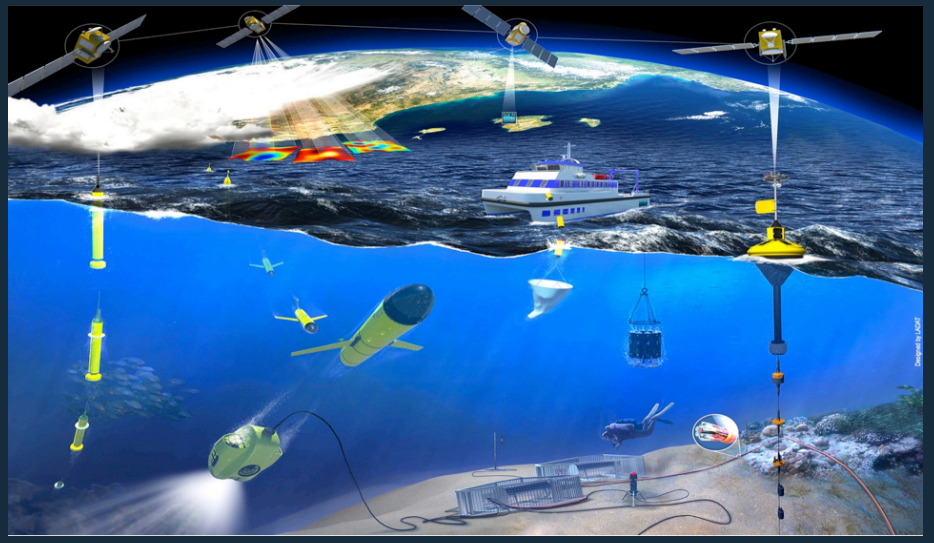
- Verify models and improve forecasting capability
- Interannual variability and ‘extreme’ events – transport, eddies, WIW, etc.
- Identify drivers of variability

>> potential products for society

- RT ‘inflow alerts’ from SOCIB operational network
- Inflow prediction from altimetry (gyre patterns)

Continued monitoring/work required:

- Clarify role MC
- Characterise fresh AW inflows / seasonal eddy cycle
- Long term detection of climatic change



Q & A

Questions, comments, ideas.....

Thursday am - Diego Alvarez (SOCIB/IEO) - operational oceanography tool for predicting spawning bluefin tuna

Data available for download from www.socib.es