Upper ocean in-situ observations

Status of sustained networks

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Additional input from Mike McPhaden, NOAA/PMEL

Temperature:

Drifters, moored buoys, Argo, XBT, VOS, …

Salinity:

Drifters, moored buoys, Argo

Mixed layer depth:

Argo, moored buoys, XBT

Surface/near surface currents:

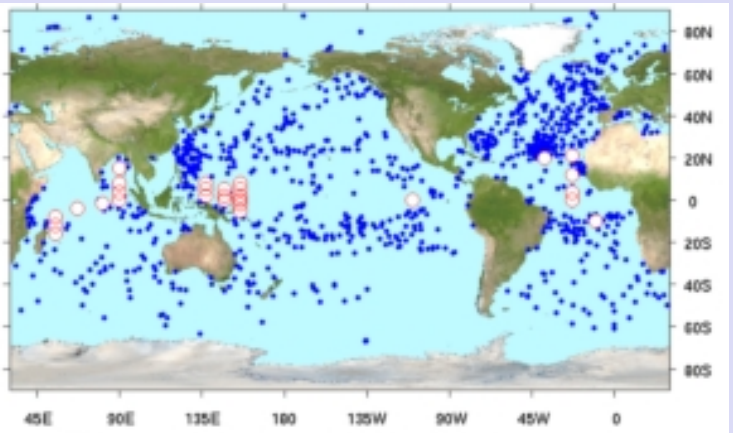
Drifters, moored buoys, coastal radar, ADCP

What we know well, what we don’t (focus on surface currents)

Observing System Status: 2013, Q2.
Surface Currents

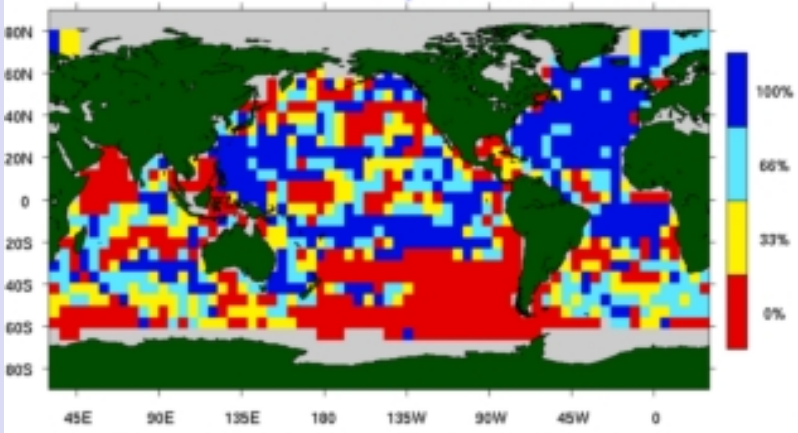
Requirement: 2 cm/s accuracy (drogue on);
600 km resolution;
1 sample per month (GOOS/GCOS, 1999)

Performance measure: reduce the error in global measurement of surface velocity

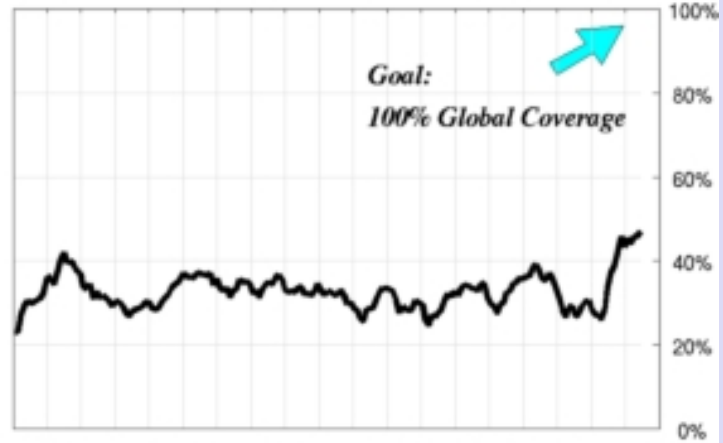


Observing system status, April-June 2013
● Drogued drifting buoys: 1069 ○ Moored buoys: 28

Requirement: all boxes blue

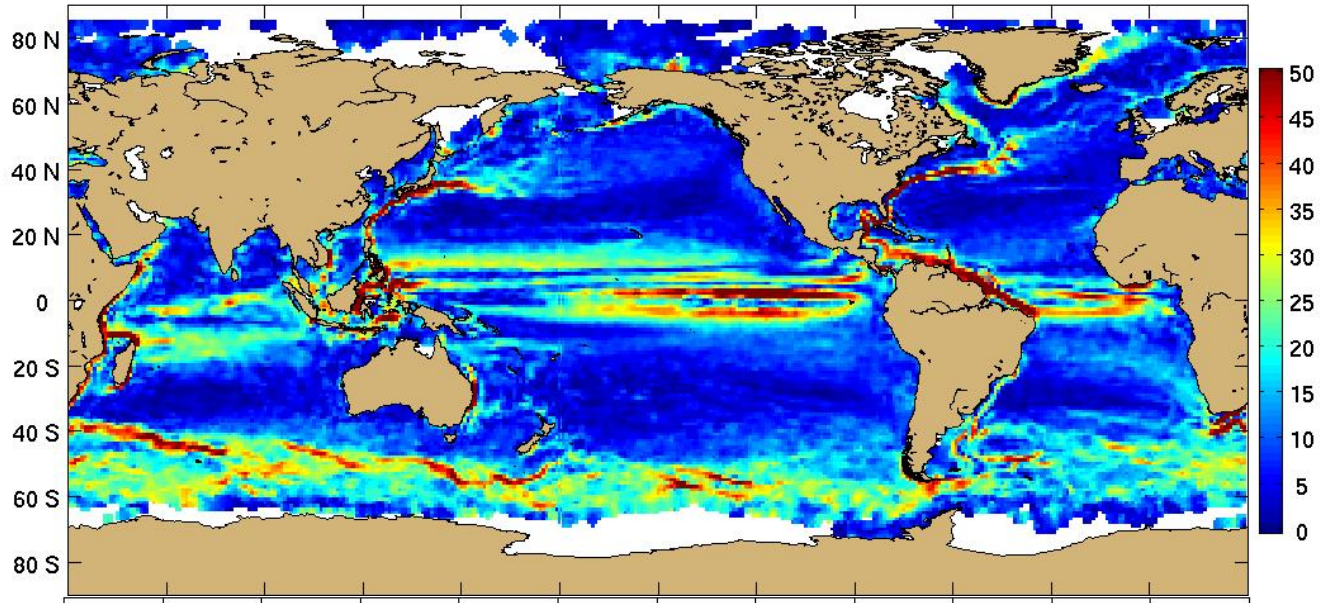


Percent of months in quarter with at least one observation

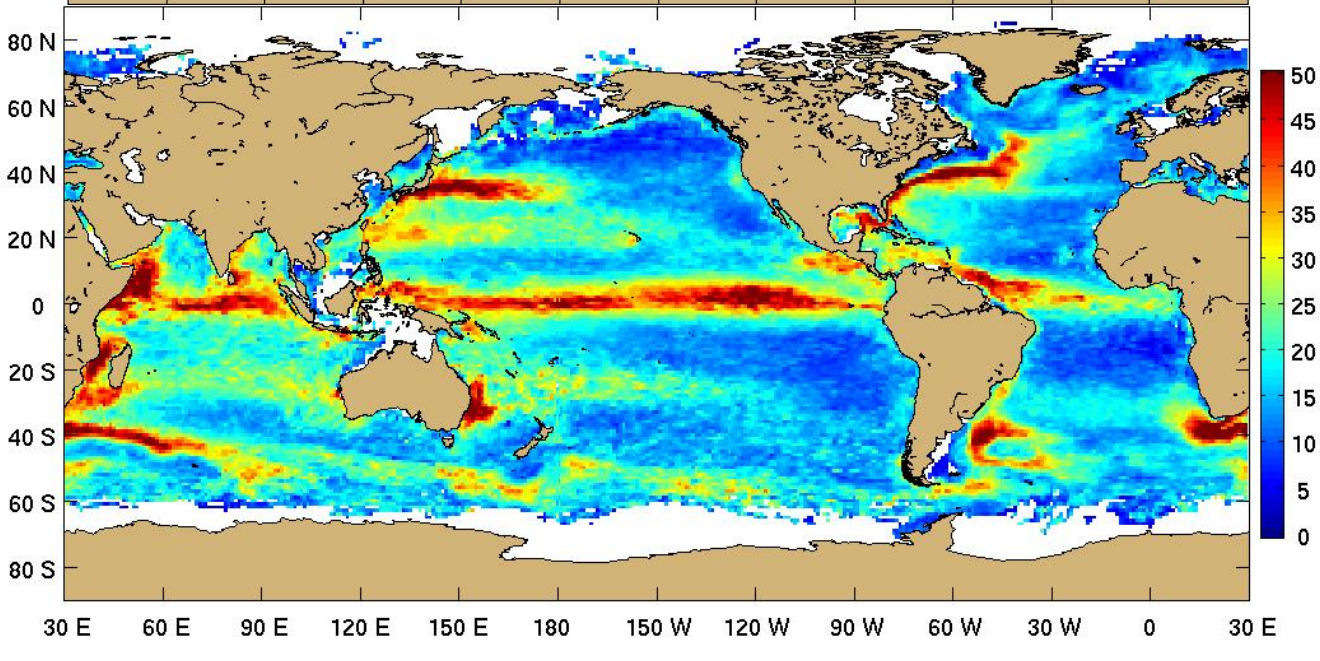


Percent of 600 km squares with one observation per month

Mapping ocean currents with in-situ observations



Average speed of surface currents (cm/s)



Root-mean-square variability of currents (cm/s)

Mapping the Kuroshio Current

(in situ + remote)

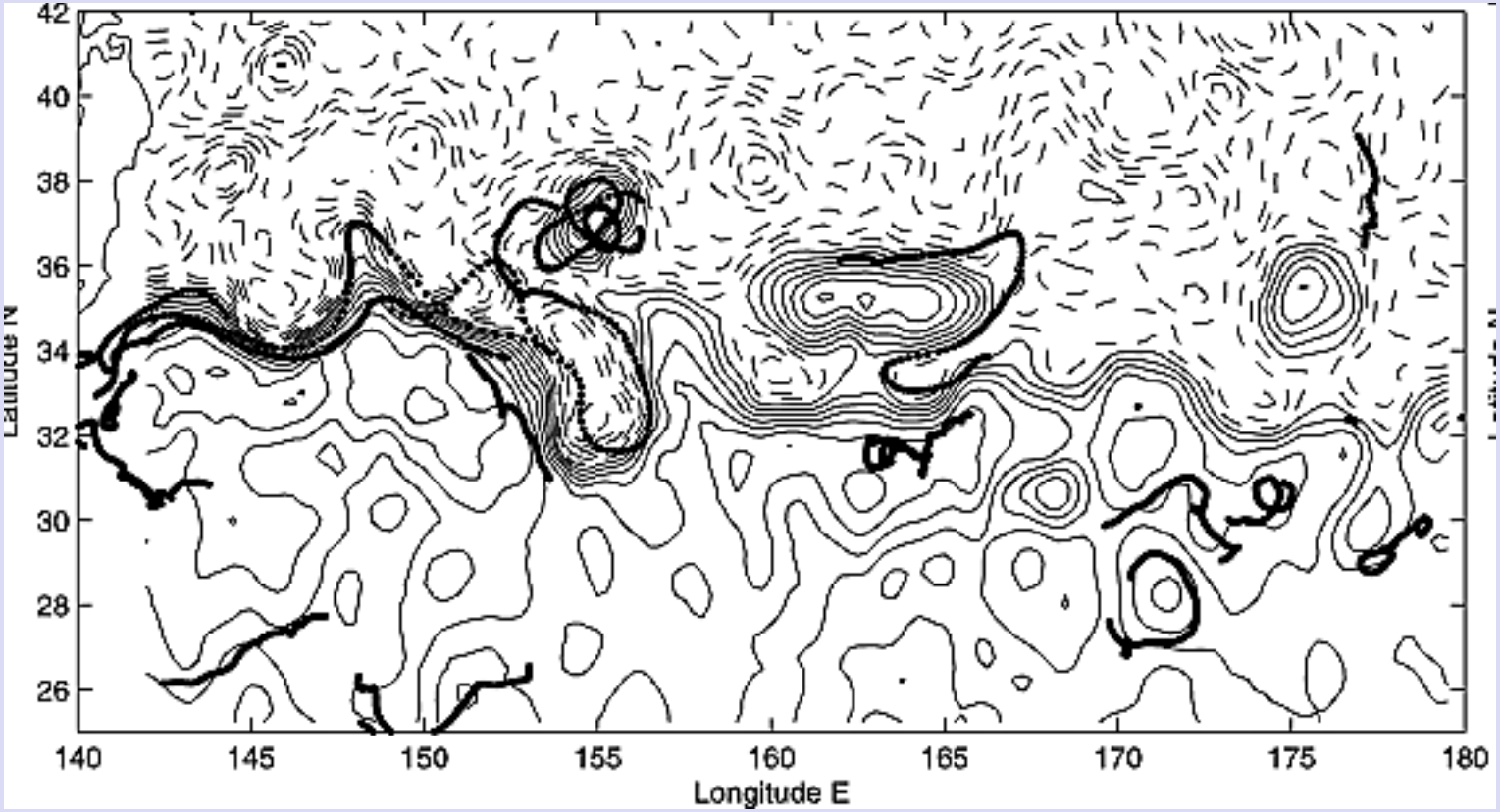
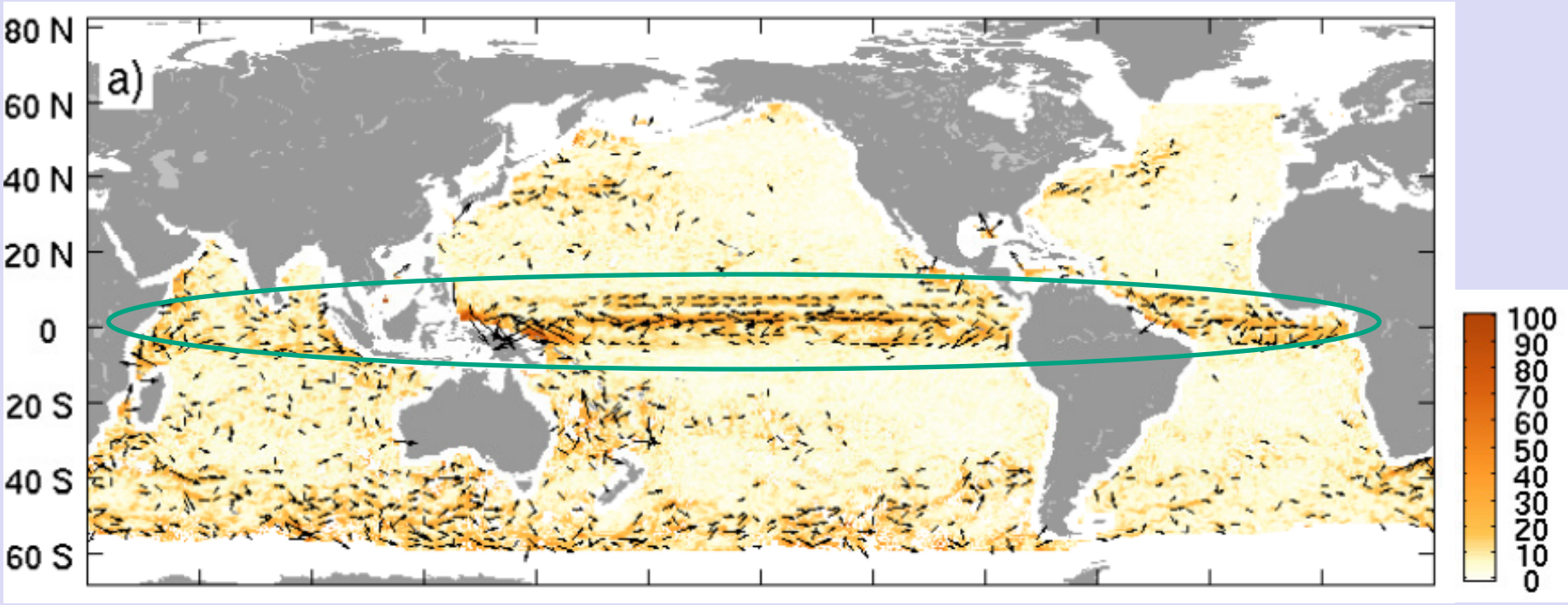


Image: Absolute sea level (area-mean subtracted) on 6 December 1993 computed from altimetry, drifters and wind (contours; interval is 10 cm), and trajectories of drogued drifters (solid black curves) from 16 November to 16 December 1993. From Niiler et al. (2002).

Drifter (in-situ) minus OSCAR (satellite)

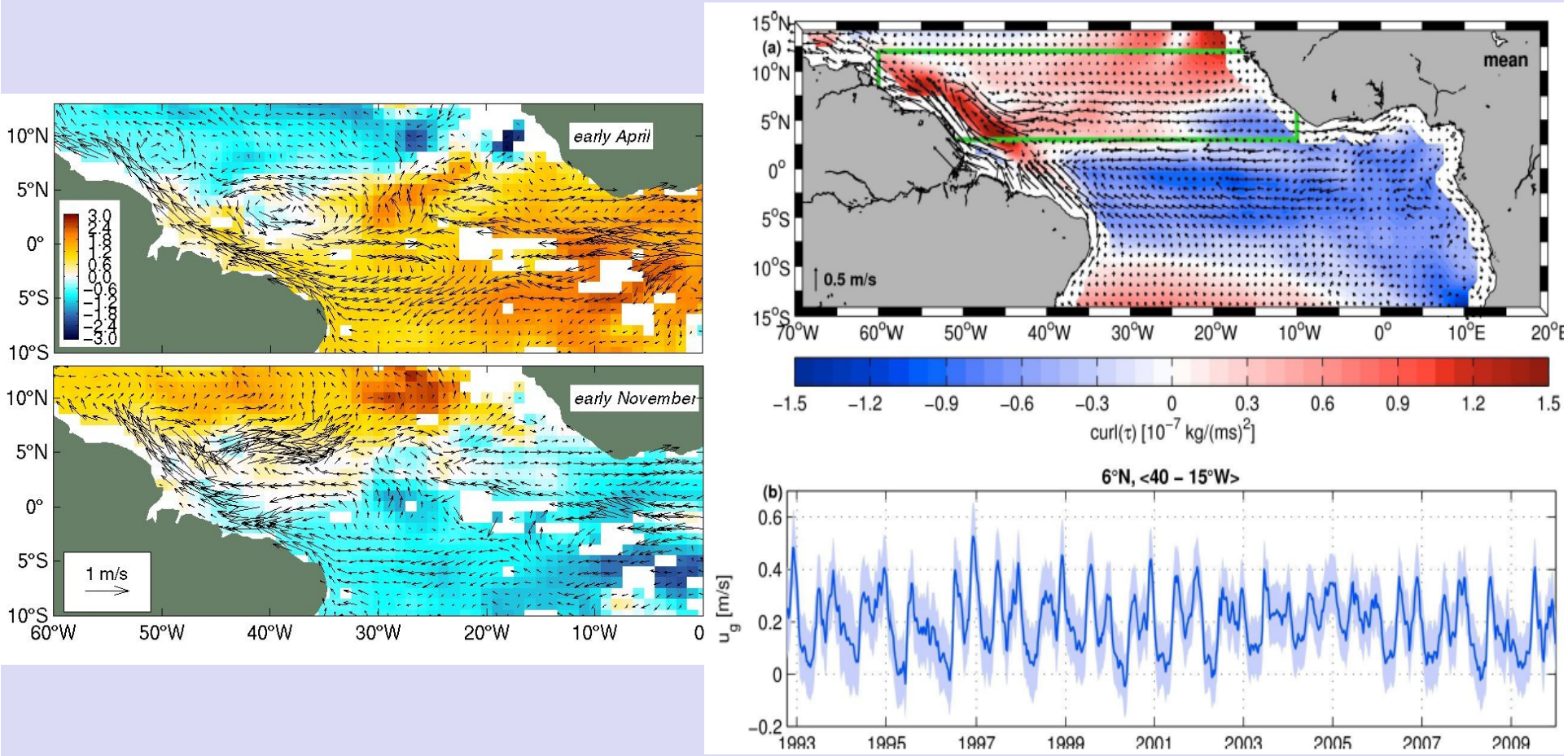
January 1993–December 2003 time-mean total speed, 1/3 degree resolution, unsmoothed



Large discrepancies on/near equator

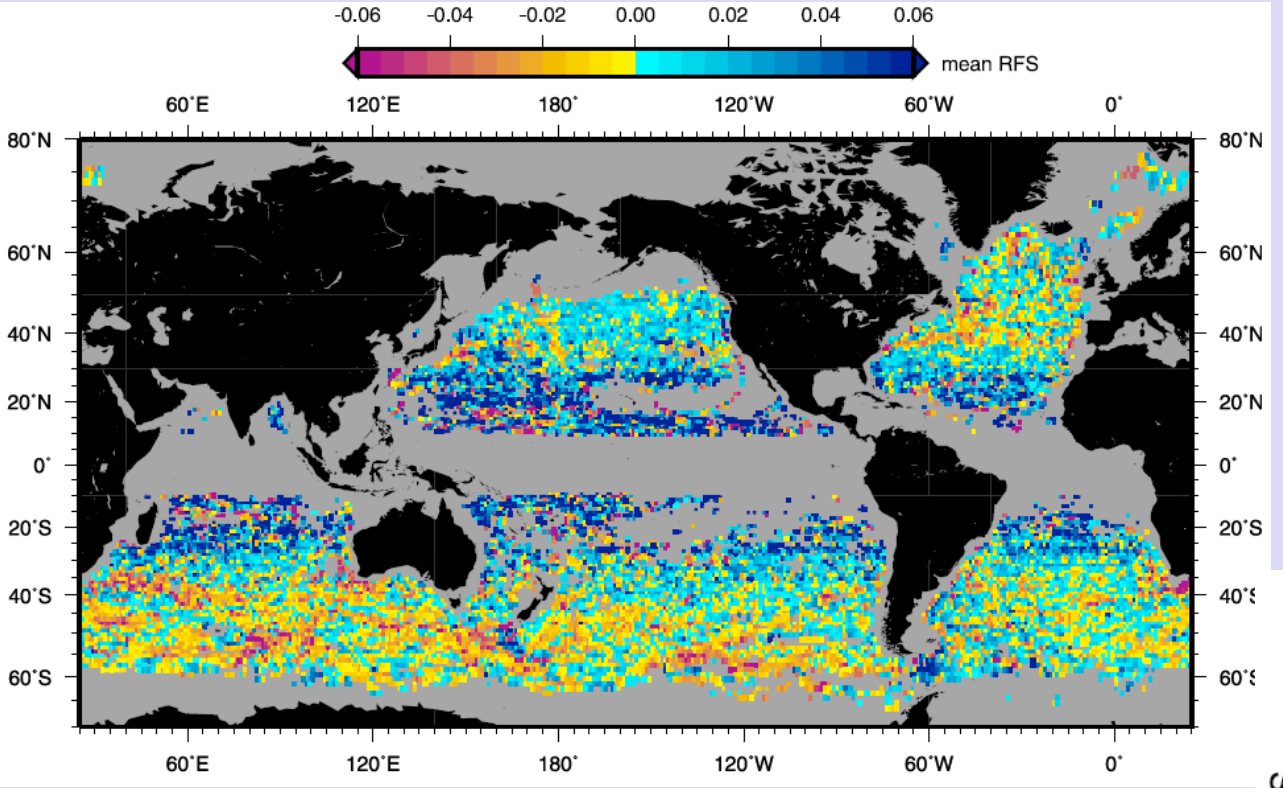
Lumpkin and Johnson (2013)

Seasonal to interannual variations

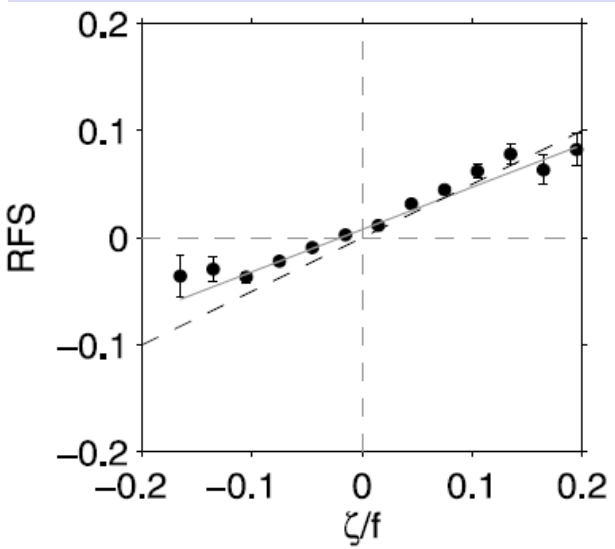


Left: Seasonal variations of surface currents in the tropical Atlantic ocean, mapped from drifter observations (Lumpkin and Garzoli, 2005). **Right**: Interannual variations of the North Equatorial Countercurrent (in green box, superimposed on mean wind stress curl) from a synthesis of drifters, winds and altimetry (Hormann *et al*., submitted).

Near-inertial waves and internal tides: energy input for diapycnal mixing

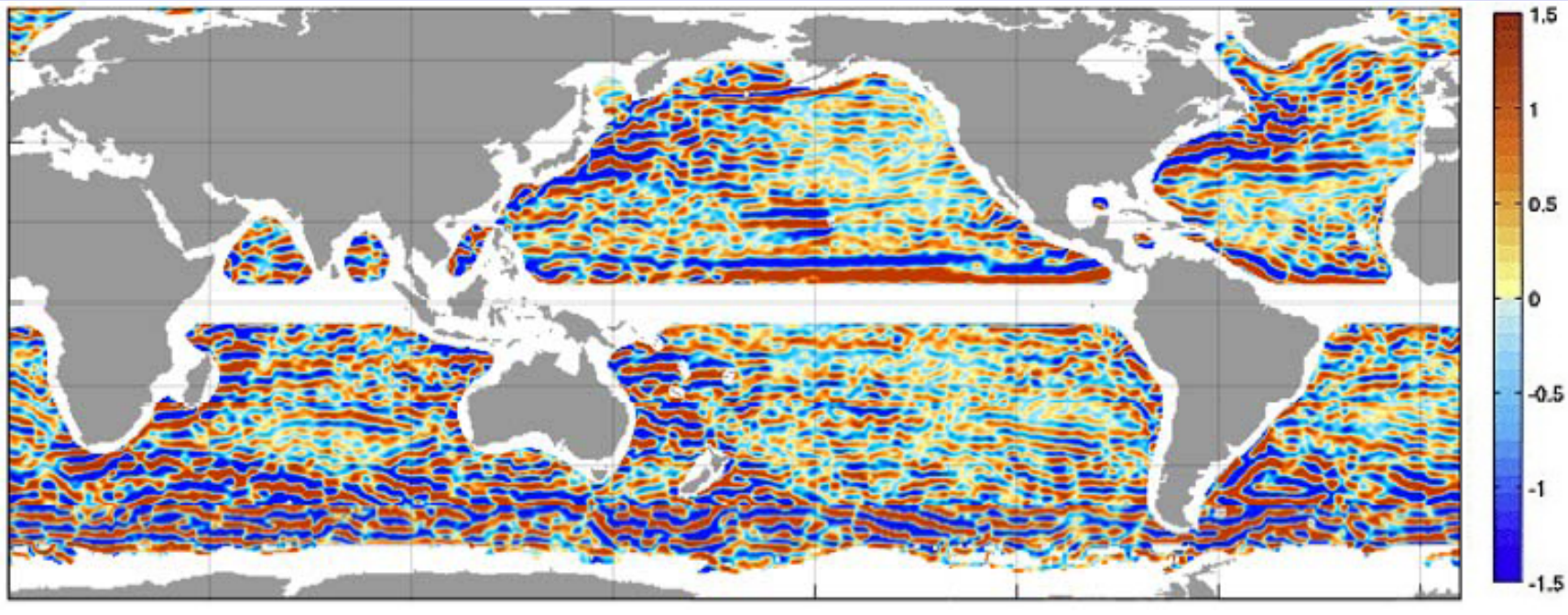


Left: relative frequency shift of near-inertial oscillations from the local inertial period (Elipot et al., 2010).



Right: relative frequency shift (vertical, from drifters) vs. background vorticity from altimetry (horizontal) (Elipot et al., 2010). The dashed line indicates the theoretical expectation (Kunze, 1985).

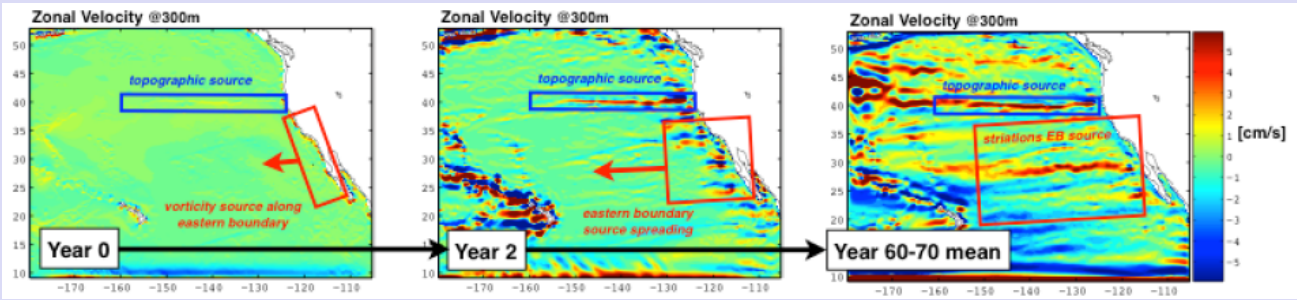
Ocean striations



Maximenko et al. (2008): MDT from GRACE, drifters, altimetry and winds. Highpass at 4°.

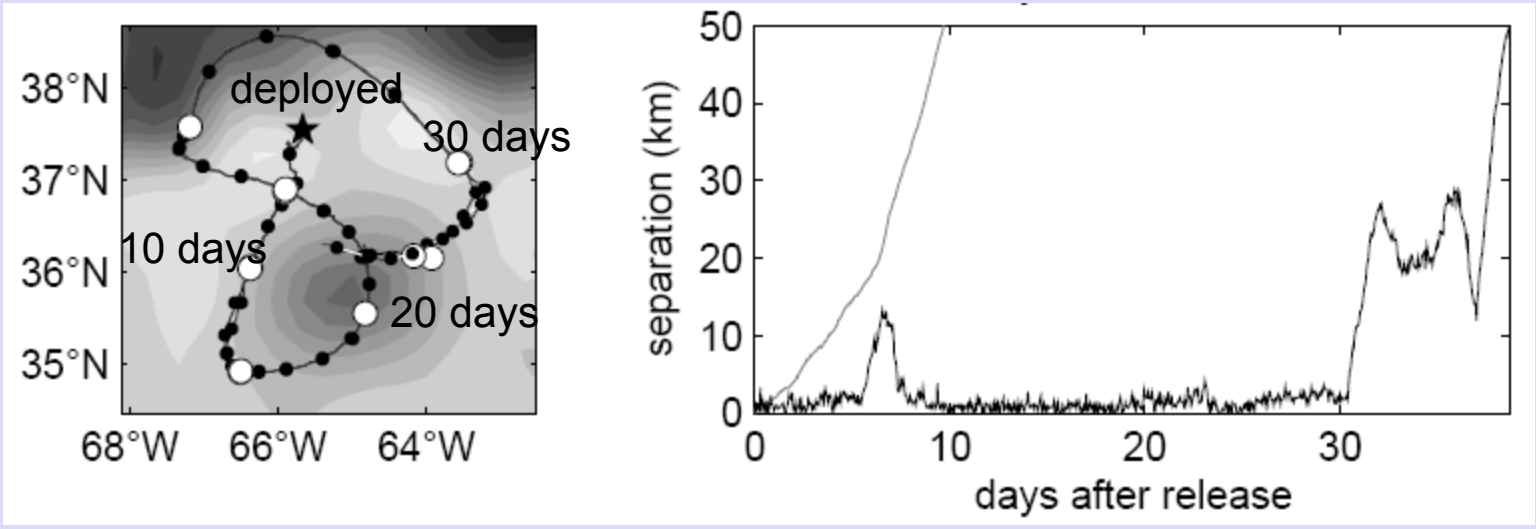
Beta-plume dynamics?

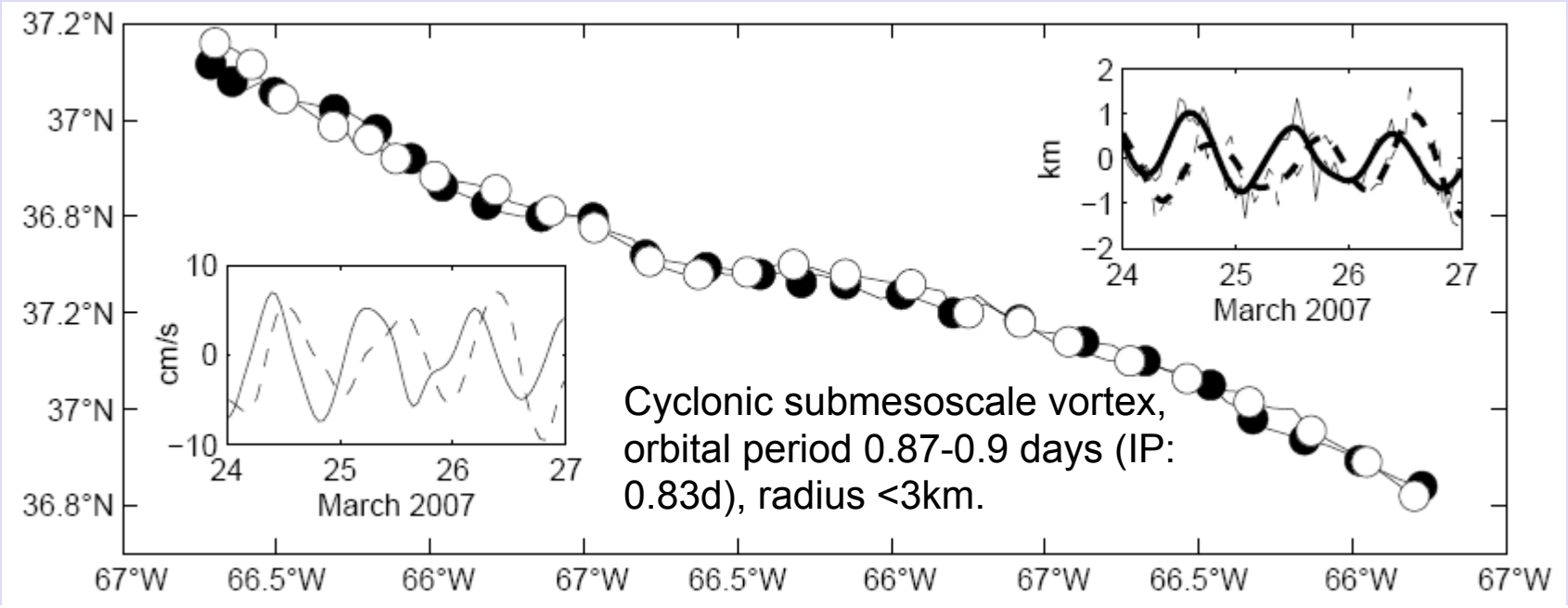
Rectification of undersampled eddies? (c.f. Schlax and Chelton, 2008)



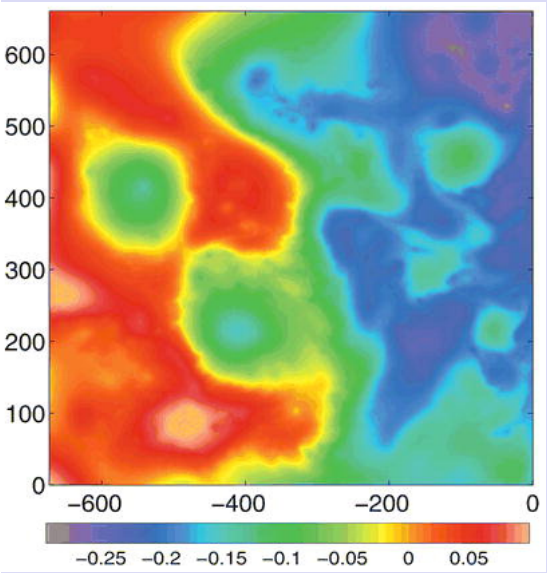
Emergence of beta-plum striations in ROMS simulation of the California Current System (Maximenko et al, 2010).

Submesocale motion



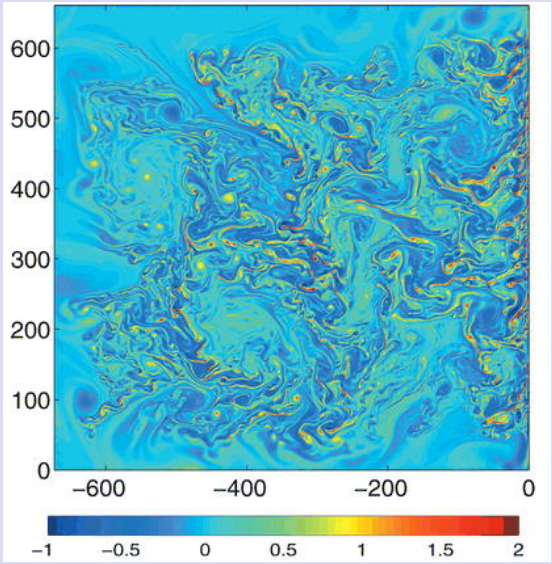


How important is the submesoscale?



Left: sea height (m) in a 0.75km-resolution simulation. Low R_o mesoscale vortices dominate.

Right: concurrent surface vorticity (scaled by *f*). High R_o, predominantly cyclonic submesoscale vortices dominate (Capet et al, 2008).



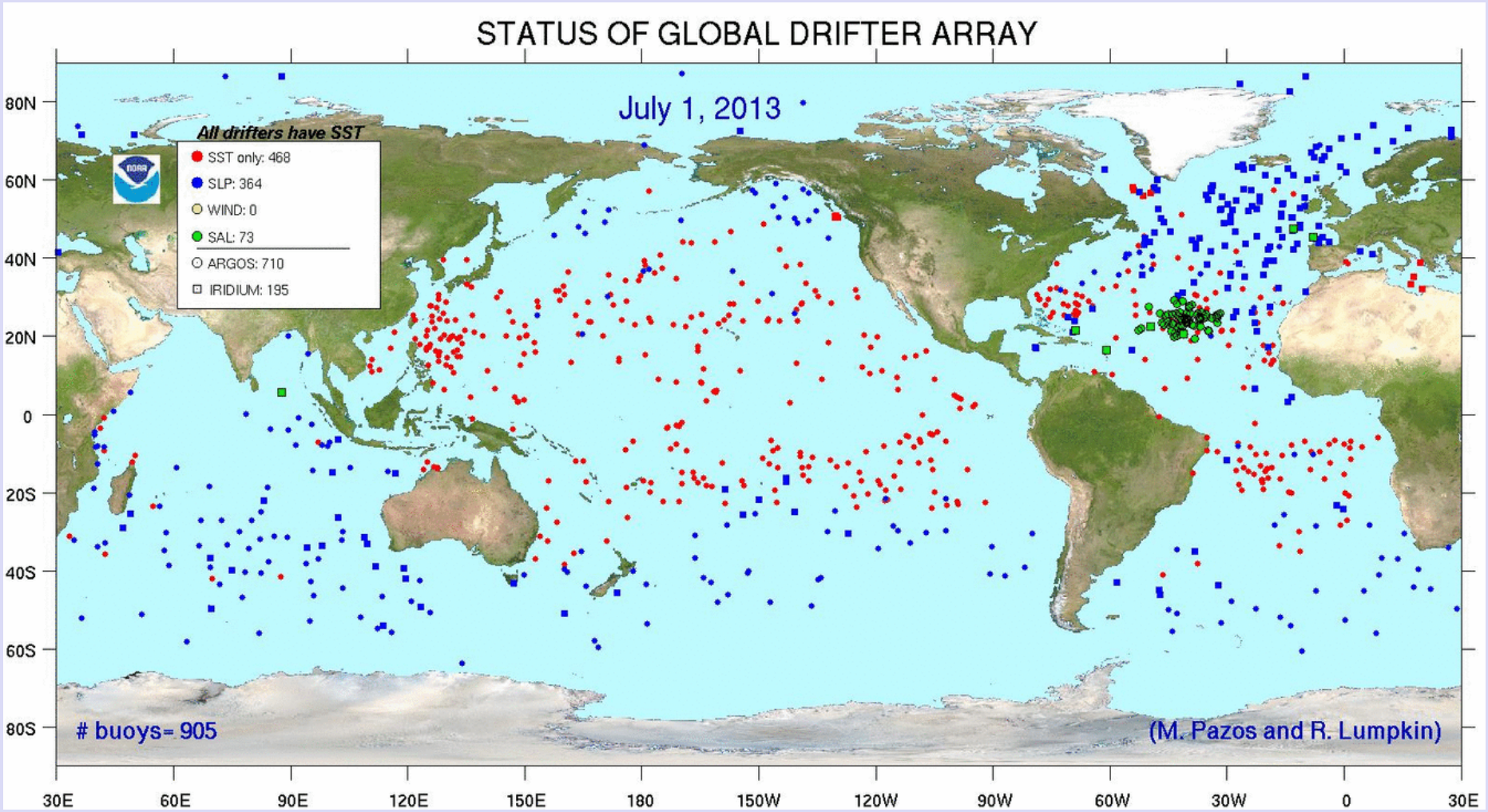
Surface Quasigeostrophic theory (*c.f.,* Blumen,. 1978; Klein et al., 2008):

- Submesoscale features associated with large vertical motion.
- Motions feed inverse energy cascade to small scales.
- Potential to flatten wavenumber spectrum at surface.

Challenge: intermittent, small (hard to observe, numerically expensive to resolve).

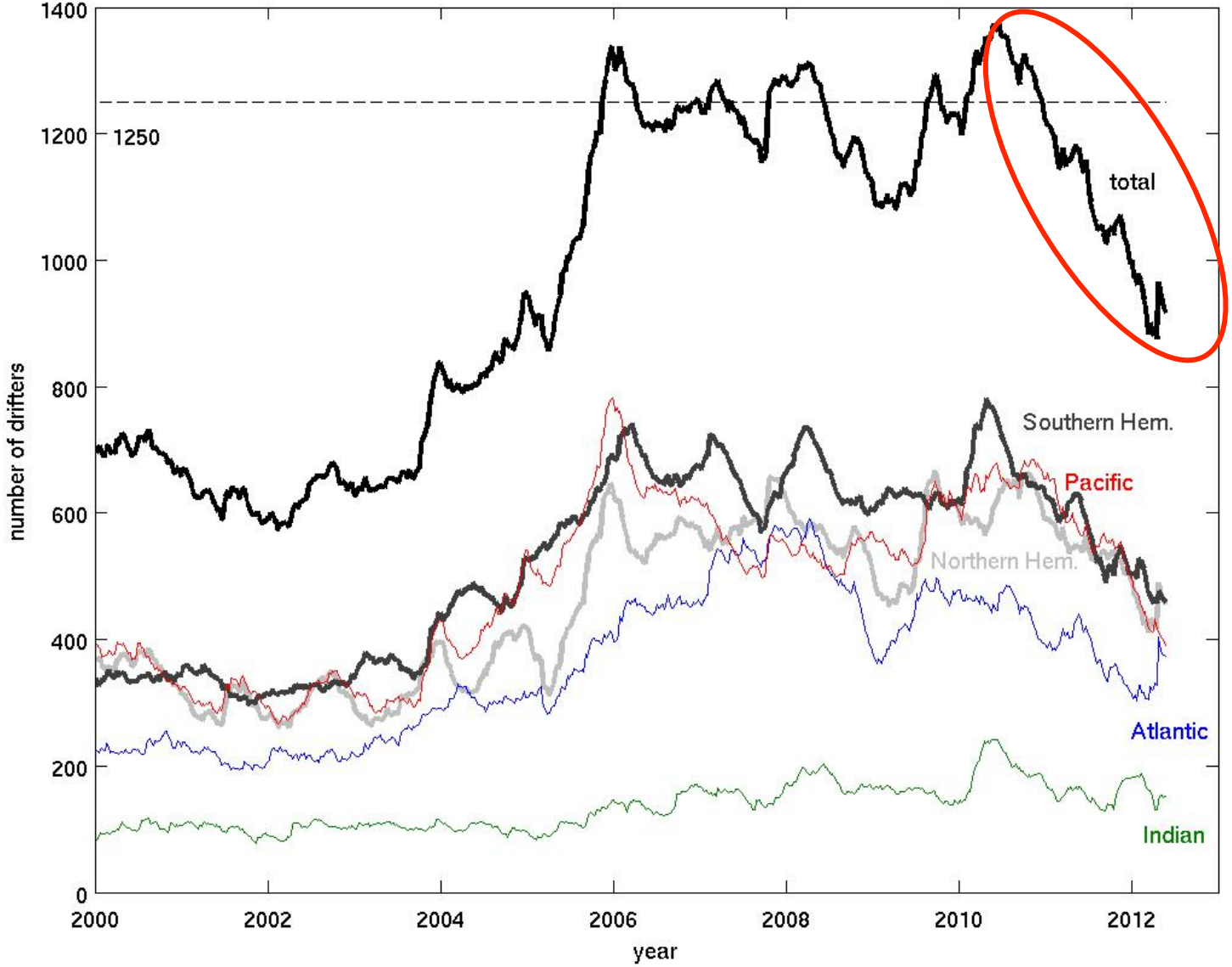
Status of in-situ observing networks

Global Drifter Program



Array size at ~900, well below goal of ~1250.
Still suffering from abbreviated lifetimes.

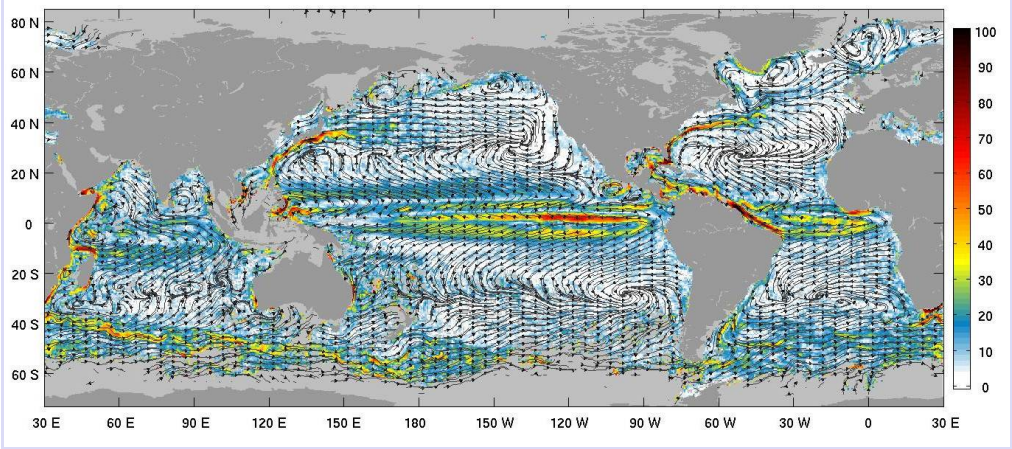
GDP array decline since mid 2010. Below 1250 threshold starting in early 2011



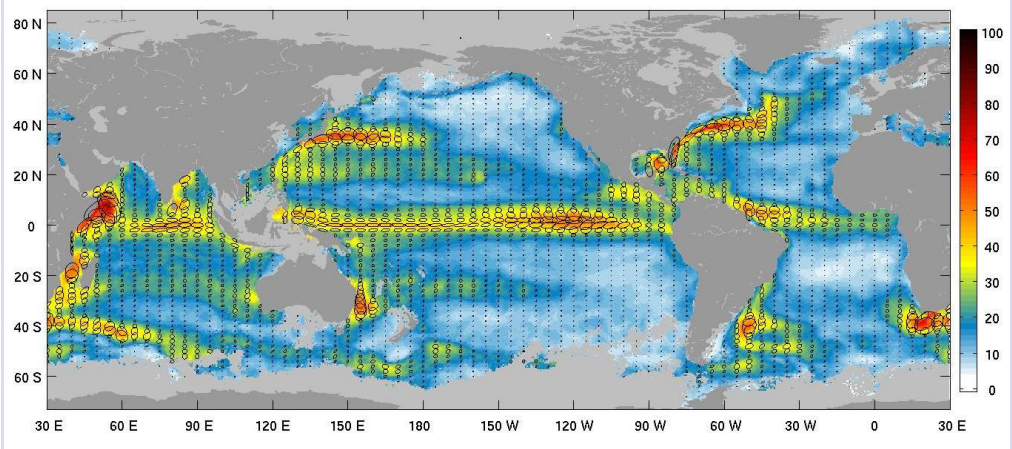
Evaluation of the Global Drifter Array: troubleshooting the anomalous death rate

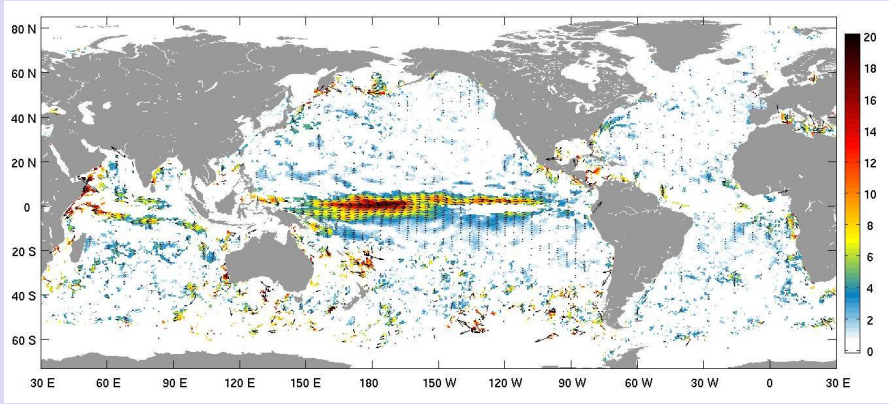
- Accelerated array decline appeared in fall ‘11;
- Already known (‘10&’11) and addressed cause was defective (leaking) battery packs (2 companies);
- Second cause, investigated (and addressed) in winter ‘11/’12 was “unconventional” design changes (1 company);
- Third cause pertains to higher energy consumption of new Argos 3 transmitter (PMT) when used in Argos 2 mode (3 companies).

New product: global near-surface currents, monthly, ½° resolution



Above: time-mean currents. Below: EKE.

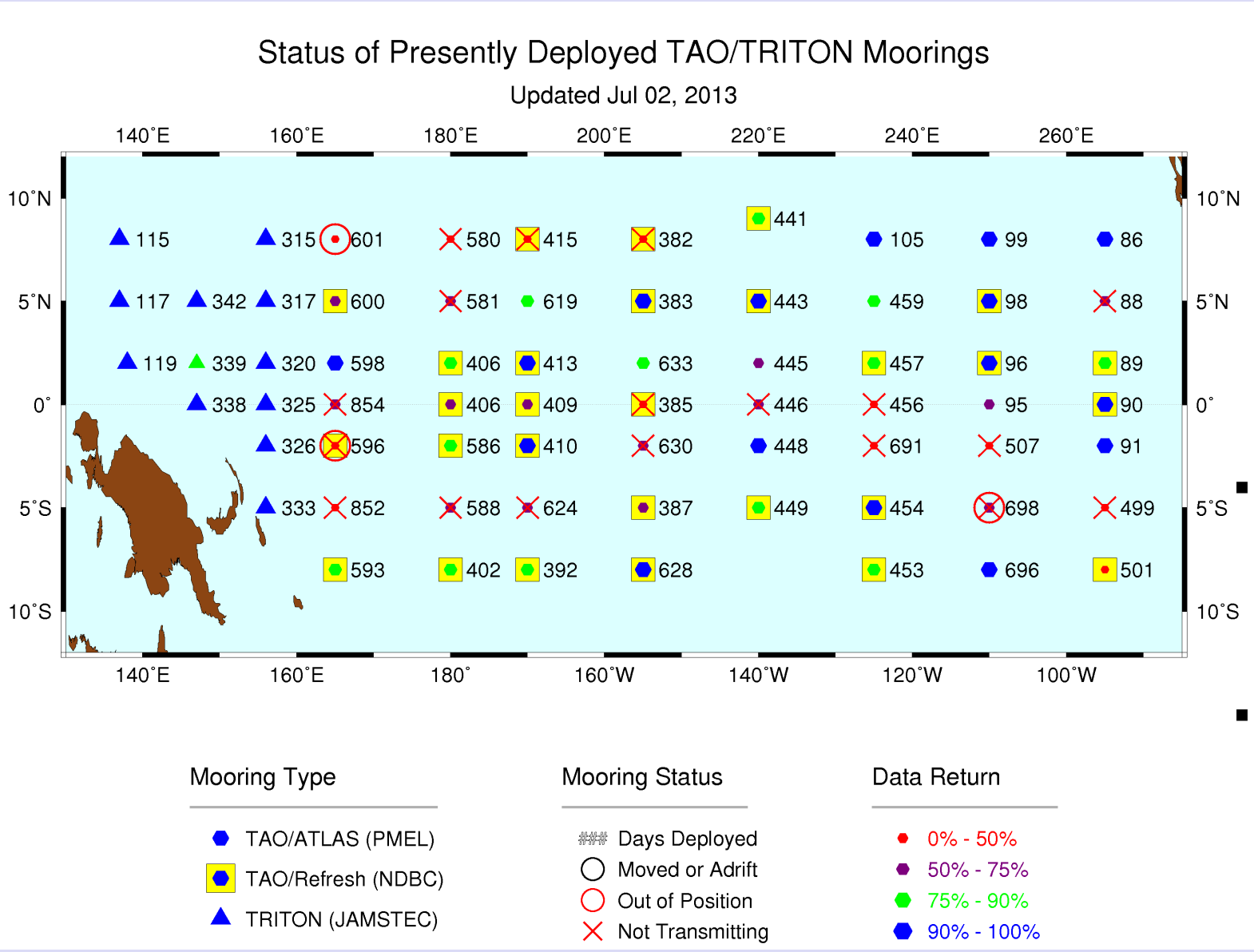




Current related to Southern Oscillation Index.

Lumpkin and Johnson, *J. Geophys. Res.-Oceans* (2013)

TAO/TRITON

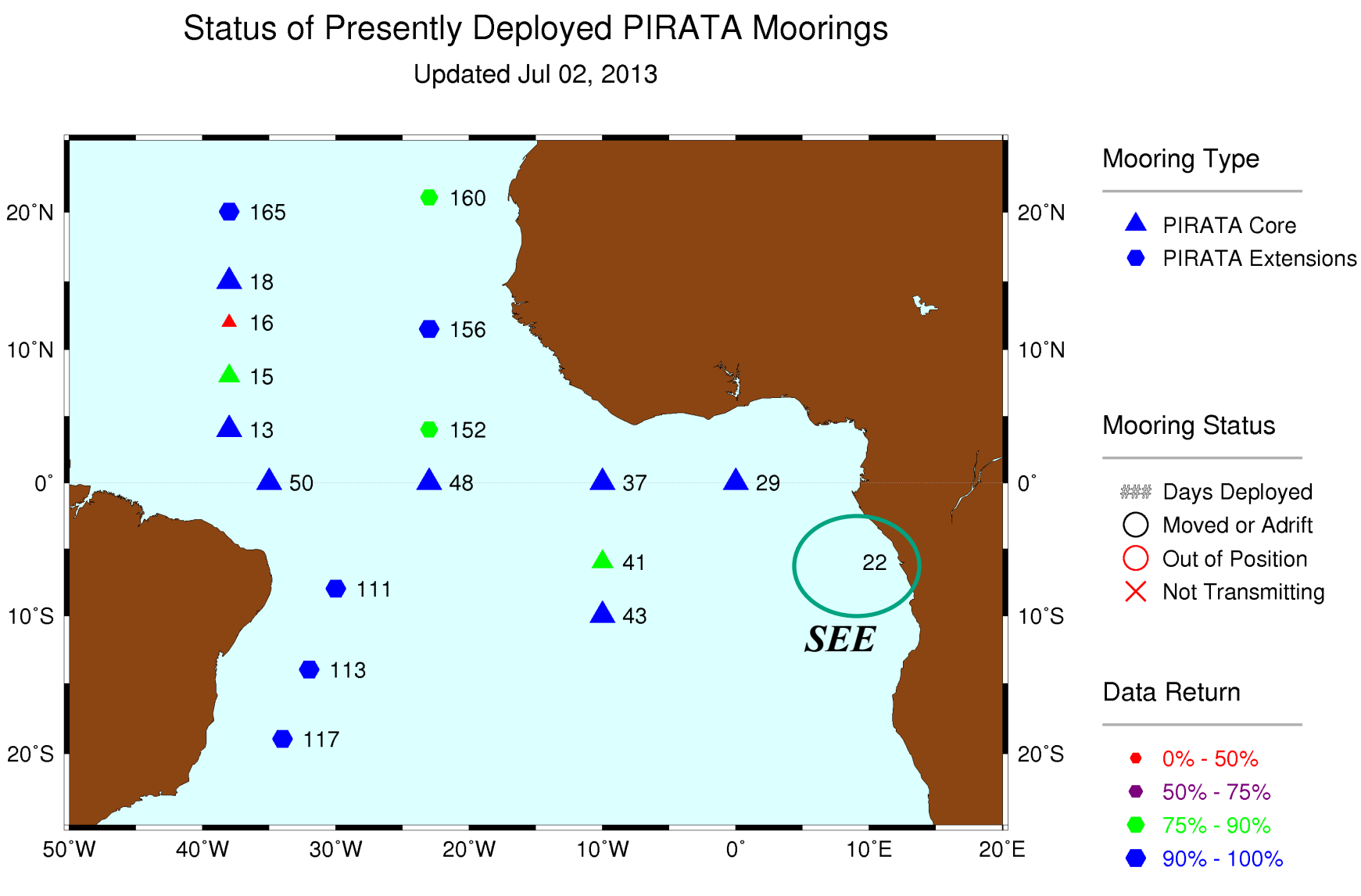


- **18 of 55 TAO moorings not transmitting at present**
- **Daily data return 39%**

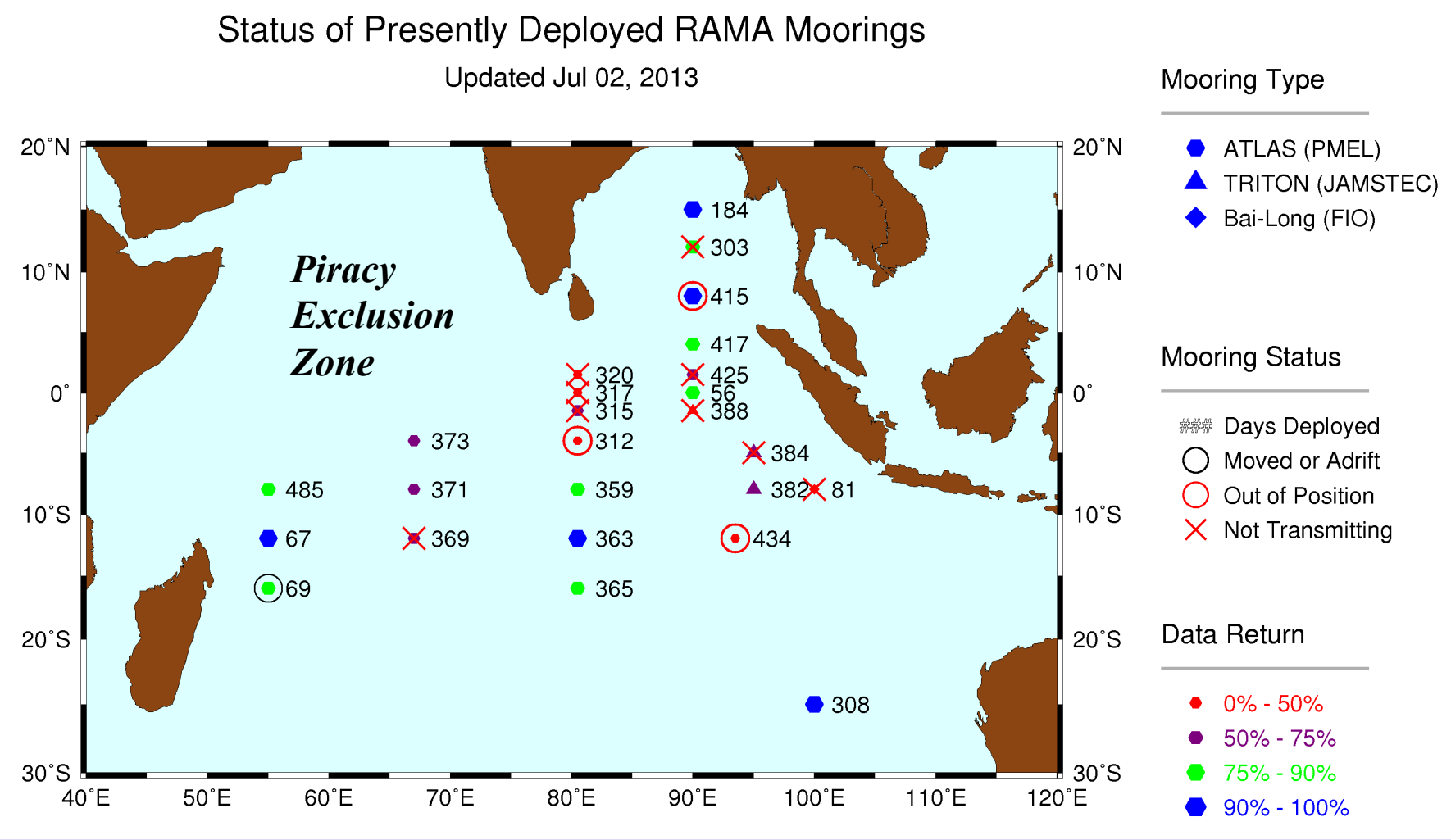
TAO Status

- *Ka'imi'moana*: laid up June 2012. No US TAO cruises subsequently conducted until January 2013. In meantime, almost all 95°W and 110°W moorings went offline.
- 18 of 55 TAO moorings not transmitting at present, daily data return 39%.
- Only 104 NOAA Sea Days available in FY 2013 (compared to 237 in FY 2010) on charter vessels *RV Ka`imikai-o-Kanaloa* (*KoK*) and MV *Bluefin* **(44% of FY10 sea days).**
- Only 26 of 55 TAO moorings will be serviced in FY 2013.
- In FY 2014, NOAA Ship *Ronald Brown* and MV *Bluefin* will service 48 of 55 moorings.
- No servicing of 170°W line in FY 2013 or FY 2014.

PIRATA


Status of Presently Deployed PIRATA Moorings
Updated Jul 02, 2013
165
160
18
16
156
15
13
152
50
48
37
29
41
22
111
43
SEE
113
117
20°N
10°N
0°
10°S
20°S
50°W
40°W
30°W
20°W
10°W
0°
10°E
20°E
Mooring Type
PIRATA Core
PIRATA Extensions
Mooring Status
Days Deployed
Moved or Adrift
Out of Position
Not Transmitting
Data Return
0% - 50%
50% - 75%
75% - 90%
90% - 100%

RAMA


Status of Presently Deployed RAMA Moorings
Updated Jul 02, 2013
Piracy Exclusion Zone
184
303
415
417
320
317
315
425
56
388
312
373
384
485
371
359
382
81
67
369
363
434
69
365
308
20˚N
10˚N
0˚
10˚S
20˚S
30˚S
40˚E
50˚E
60˚E
70˚E
80˚E
90˚E
100˚E
110˚E
120˚E
Mooring Type
ATLAS (PMEL)
TRITON (JAMSTEC)
Bai-Long (FIO)
Mooring Status
Days Deployed
Moved or Adrift
Out of Position
Not Transmitting
Data Return
0% - 50%
50% - 75%
75% - 90%
90% - 100%

Global Tropical Moored Array

PIRATA:

•Reoccupation of Southeast Extension site (6°S, 8°E) in June 2013.

•2014, 2015 (?): R/V *Ronald H. Brown* going to Pacific for TAO servicing. PNE: charter planning underway.

RAMA: Piracy still a major issue, but piracy rate declining in most recent few years.

International Workshop: The Future of the Tropical Pacific Ocean Observing System

Early 2014, Dates and Venue TBD

Sponsors: NOAA, JAMSTEC, IOC/WCRP (OOPC, CLIVAR Pacific), et al

Co-Chairs: David Anderson (UK, Ret.), Toshio Suga (Tohoku University)

International Workshop: The Future of the Tropical Pacific Ocean Observing System

Goals:

- Review and update requirements for a tropical Pacific Ocean (15S-15N) observing system, including physical, biological, and biogeochemical research communities as well as operational prediction communities;

- Review existing observing strategies and systems, their cost-effectiveness, and their adequacy to address these requirements;

- Assess readiness of new technologies under development and their potential contributions;

- Recommend revisions and/or adjustments to the current suite of observing systems in order to produce a more cost-efficient and sustainable observing system.

Status of Drifters and Tropical Moorings (summary)

•Drifter array: smaller than goal due to manufacturing and technical problems (NOT due to budget cuts, although budget constraints prevent aggressive redeployments)

•Tropical Moored array:

- TAO: suffering from budget shortfalls for ship time needs. Current solutions to address may cause shortfalls elsewhere
- PIRATA: currently healthy, but has suffered from past due to ship issues. NEE will rely on charter funds in 2014-1015. Newly-deployed SEE in region of large biases in coupled models.
- RAMA: large gap in planned array due to piracy exclusion zone

Suggested statement from POS: *The POS is extremely concerned by the degradation since mid-2012 of the TAO array, symptomatic of underfunding for ship time that has also impacted other observing system components. We emphasize the need to maintain the existing in-situ ocean observing system to provide uninterrupted (or at least minimally interrupted) climate time series in all ocean basins. Ameliorating this will require continued assessment of various components of the observing system, while recognizing interdependencies, e.g., ship time used to deploy Both TAO and Argo floats.*