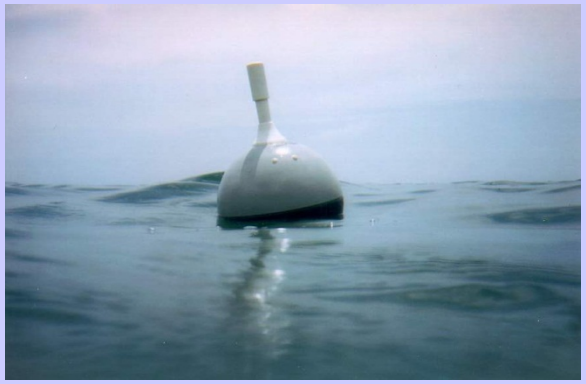
Reducing spurious climate-scale variations in surface drifter currents

Rick Lumpkin
(Rick.Lumpkin@noaa.gov)
National Oceanic and Atmospheric Administration (NOAA)
Atlantic Oceanographic and Meteorological Laboratory (AOML)
Miami, Florida USA

Work in collaboration with Semyon Grodsky and Jim Carton (Univ. Maryland), Luca Centurioni (SIO) , Marie-Hélène Rio (CLS), and Dongkyu Lee (Pusan National Univ.)

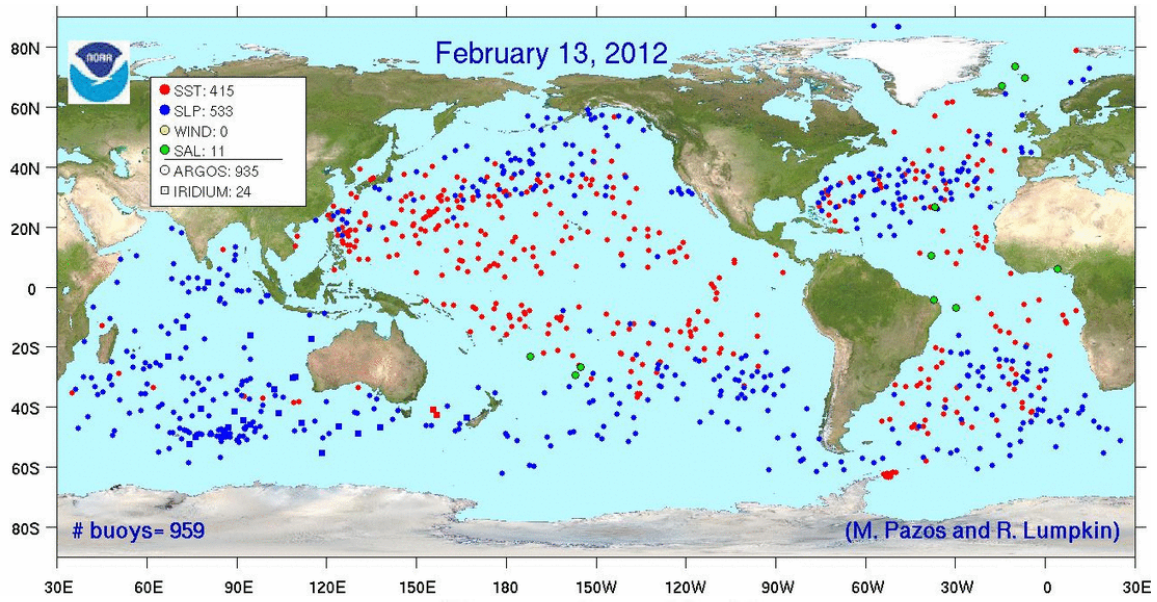
AOML collaborators: Erik Valdes, Mayra Pazos and Shaun Dolk

Measuring currents with drifters

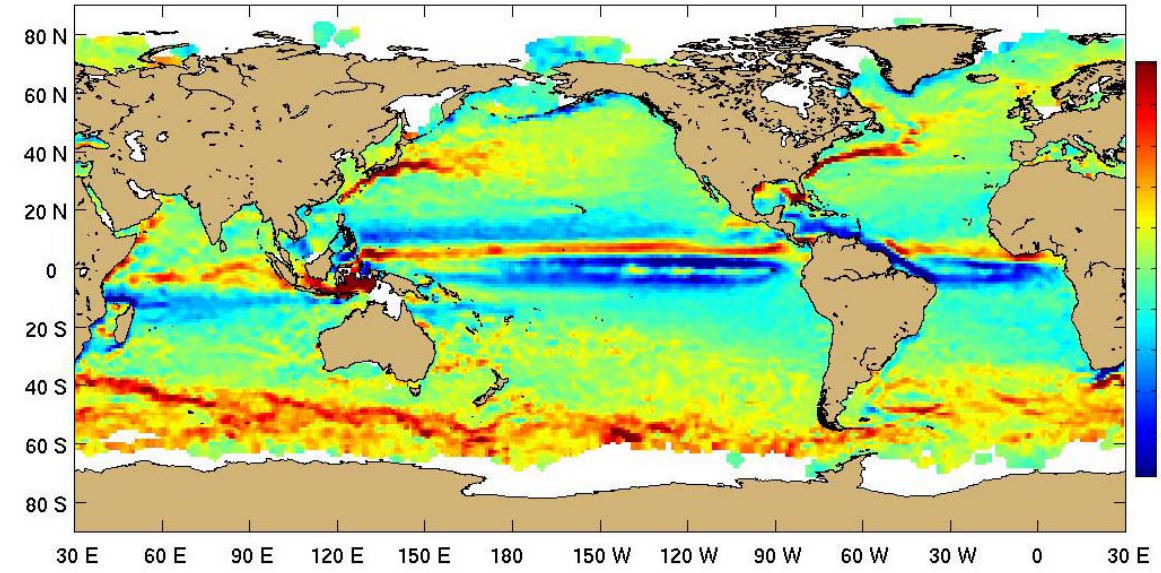


NOAA's Global Drifter Program: hourly measurements of near-surface (15m) currents.

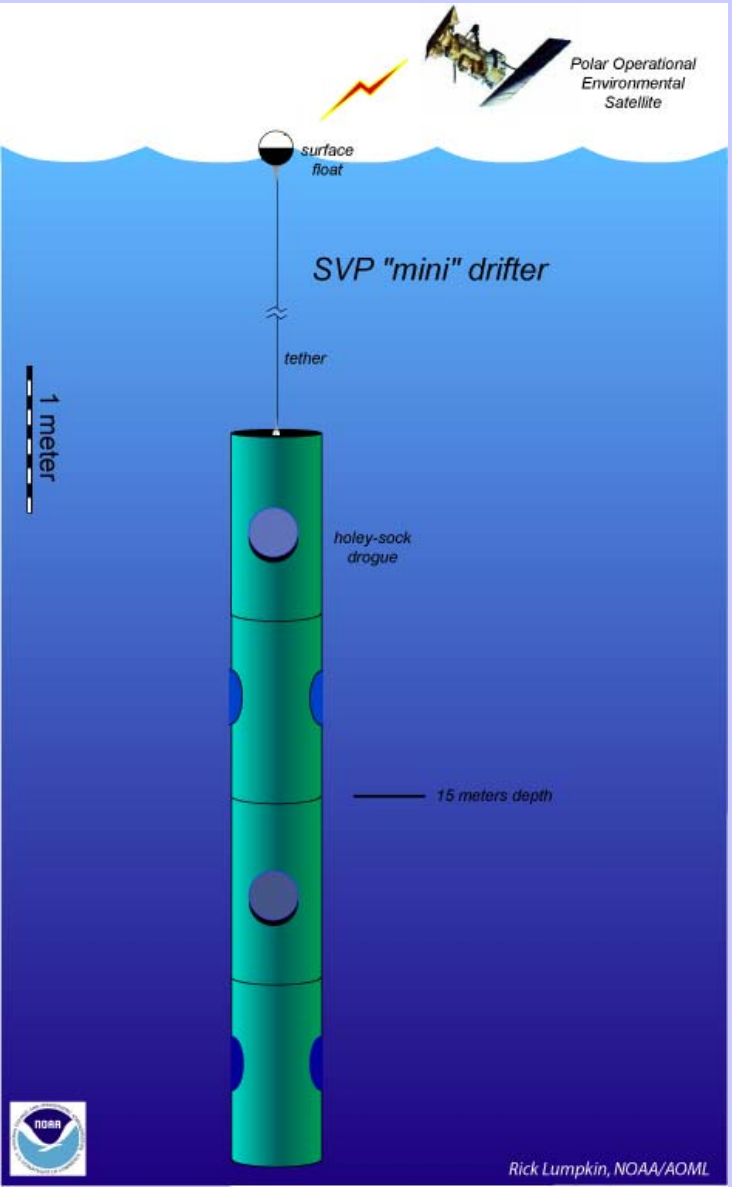
Data record spans three decades in Tropical Pacific, two in other basins. Valuable data set for climate studies.



Mean zonal current (cm/s)



Water-following characteristics



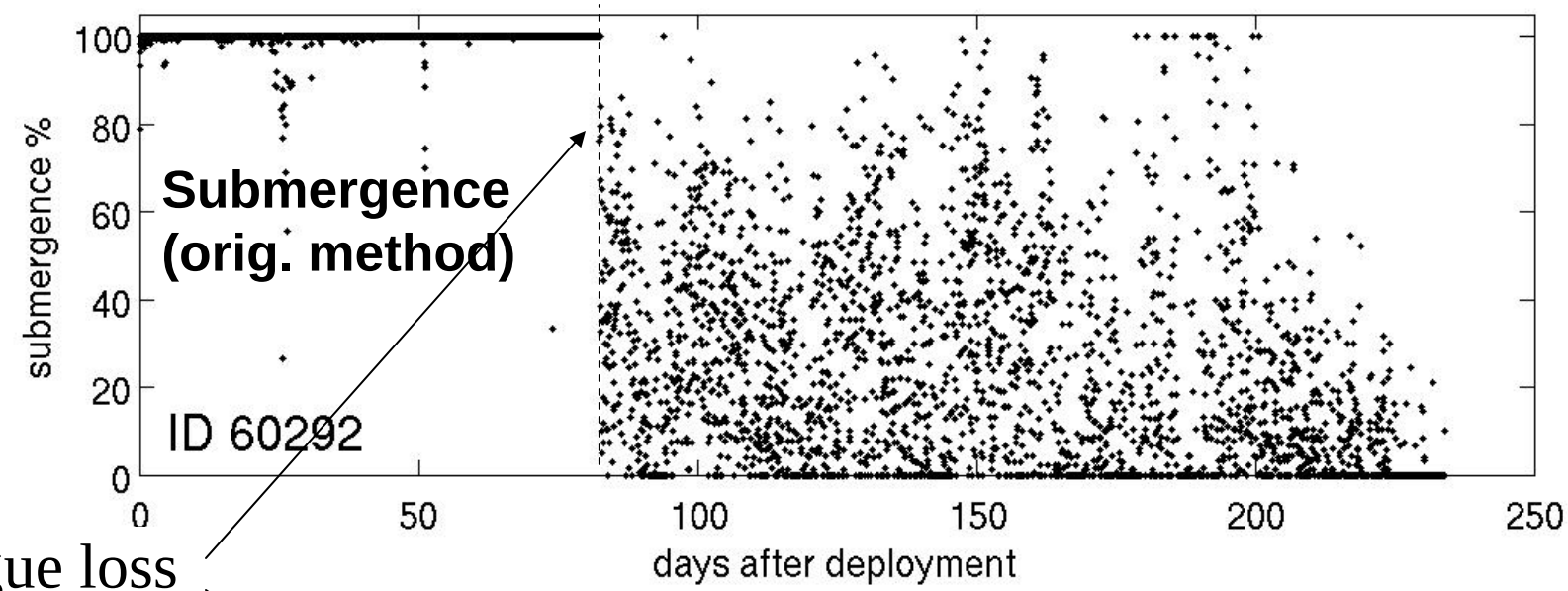
Drogue (sea anchor): provides 40:1 drag area ratio. Both original design and mini drifter are 40:1.

With drogue: downwind "slip" 0.7 cm/s per 10 m/s of wind (Niiler and Paduan, 1995, Niiler et al., 1999).

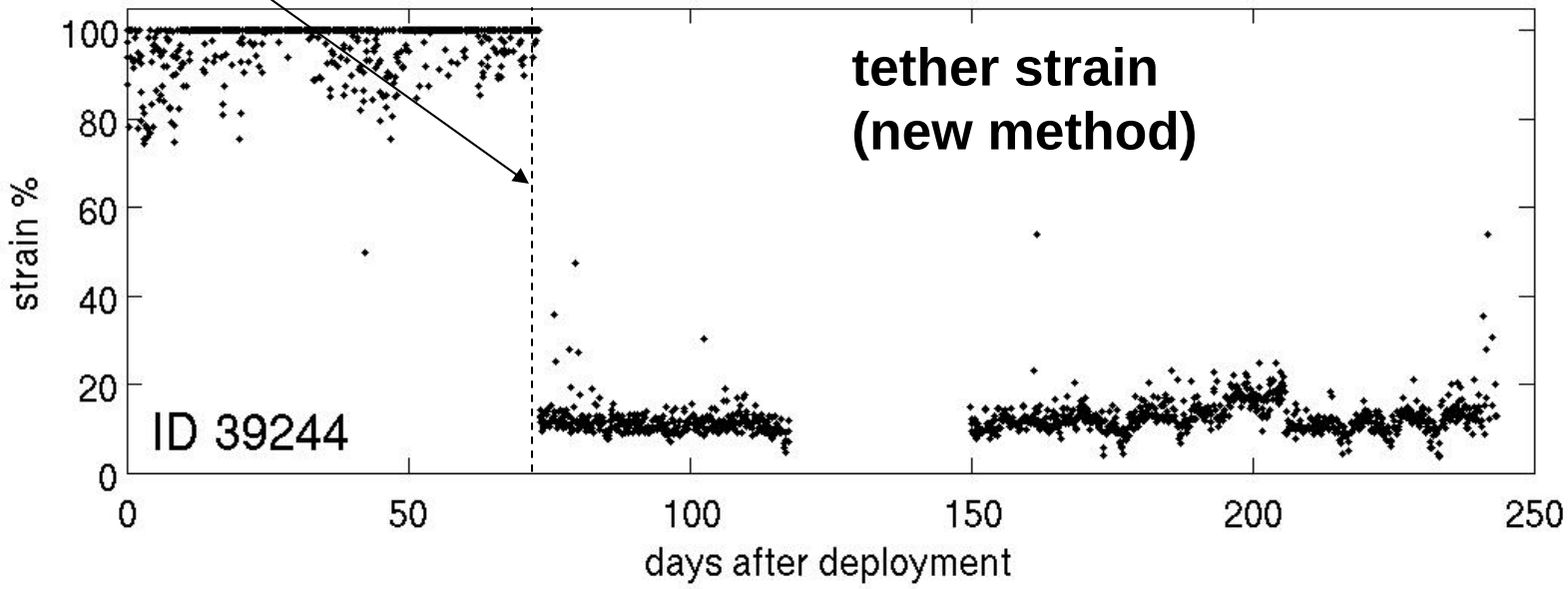
Drogue lost: 8.6±0.7 cm/s per 10 m/s wind (Pazan and Niiler, 2001).

Slip has not been measured at >8 m/s wind.

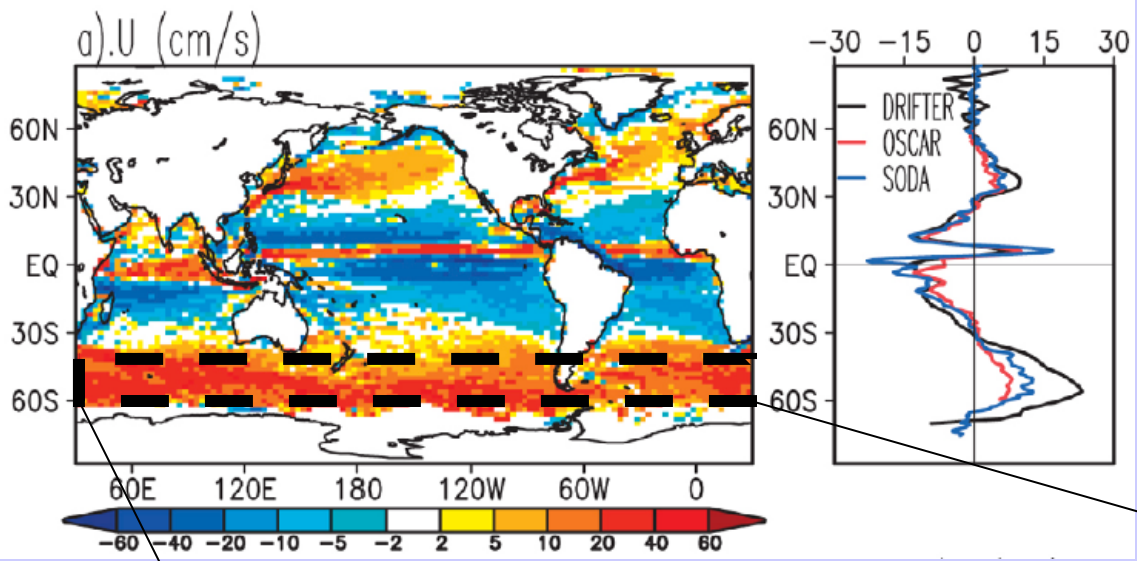
How do we know if the drogue is attached?



Drogue loss

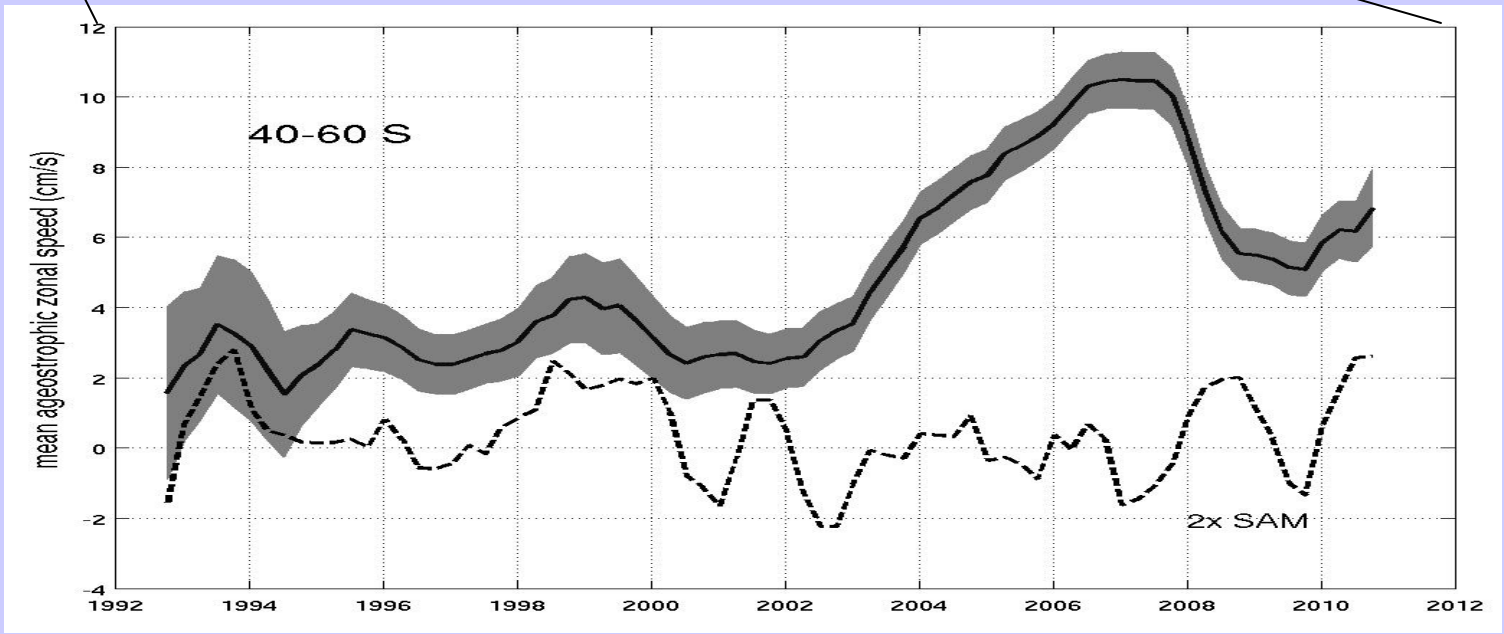


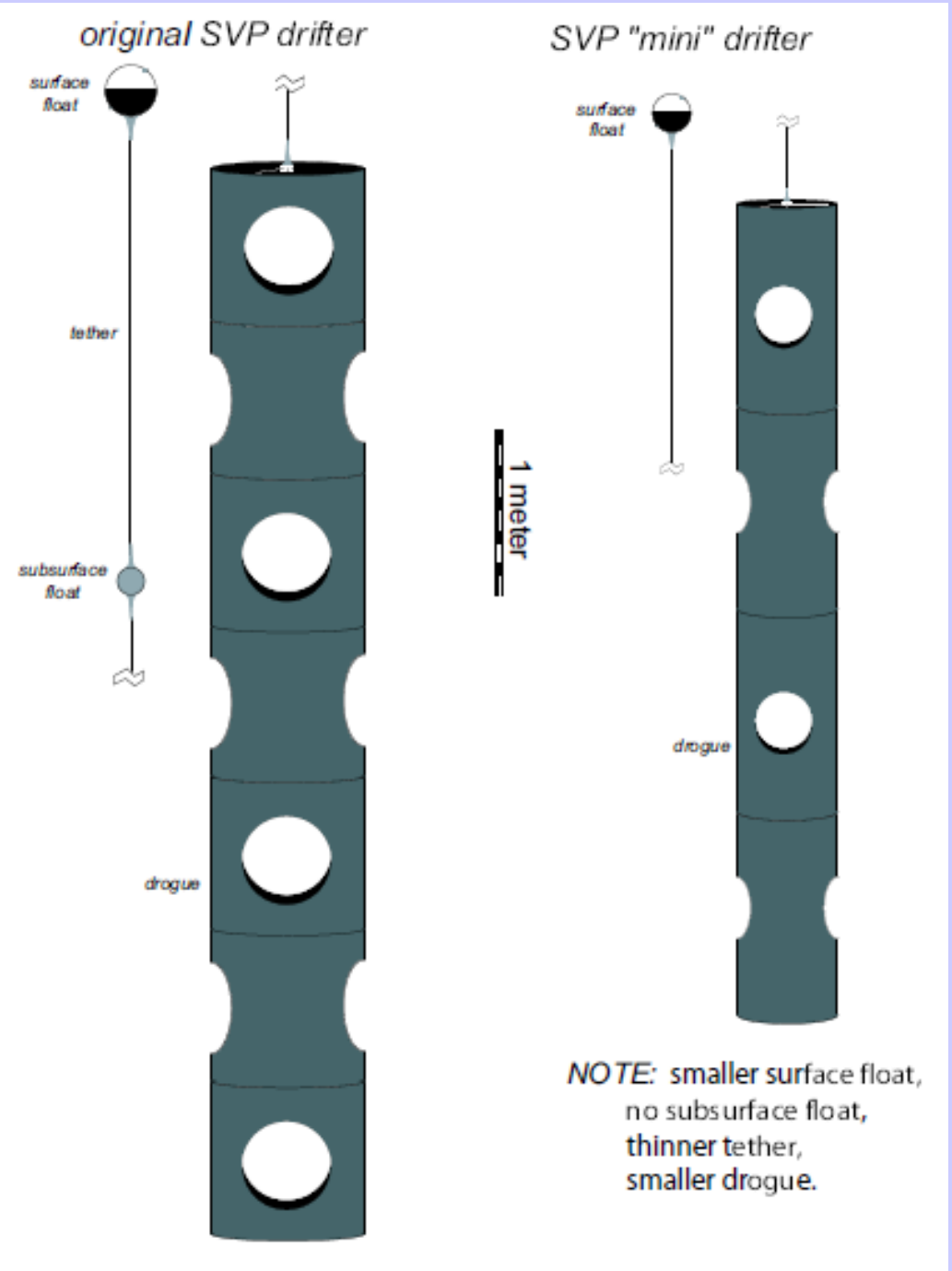
Evidence of problems



Left: time-mean zonal currents from drifters and two independent analyses (Grodsky *et al*., 2011).

Geostrophic component can be calculated from AVISO and CLS mean dynamic height (Rio *et al*.., 2011).



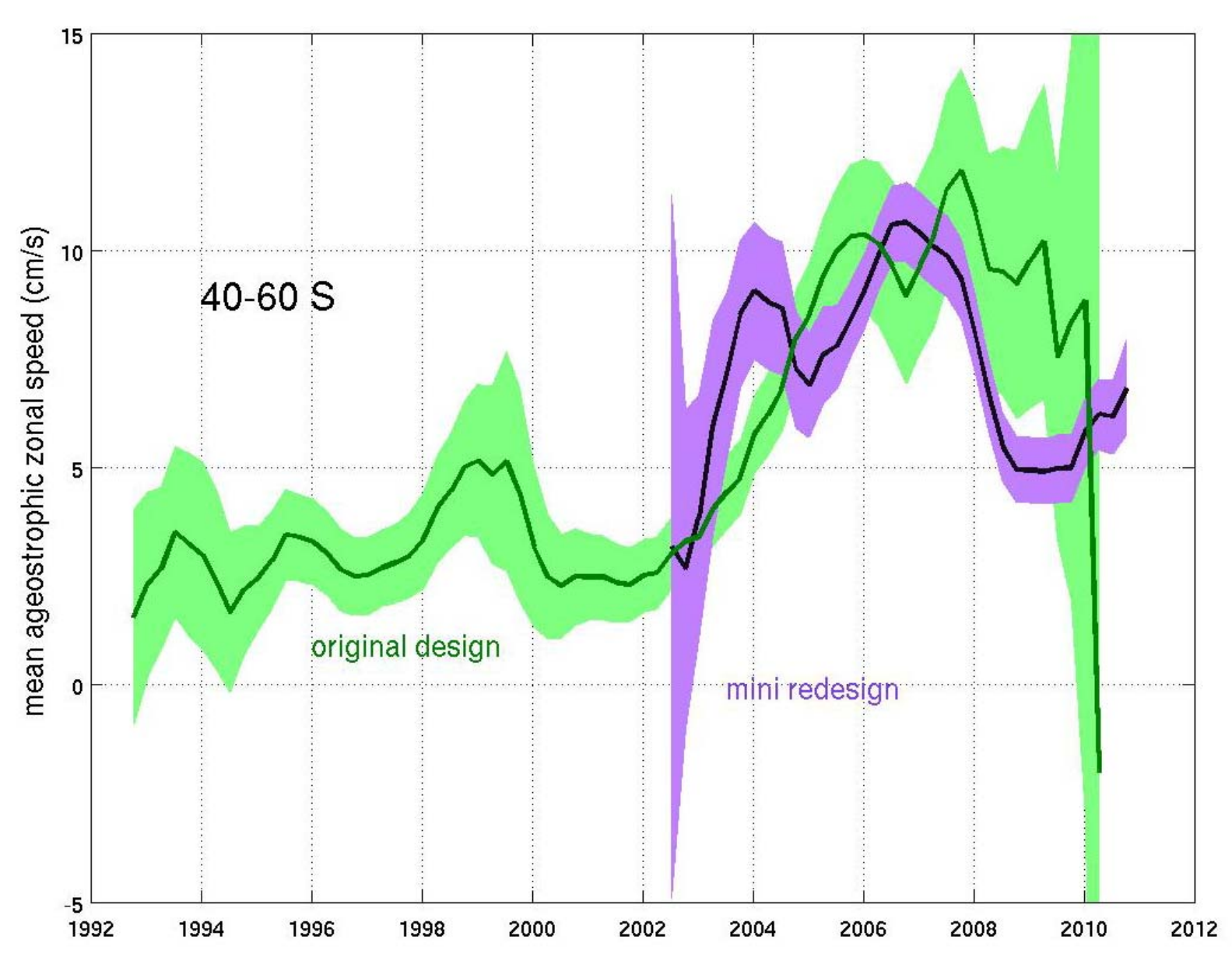


Hypothesis 1: design change

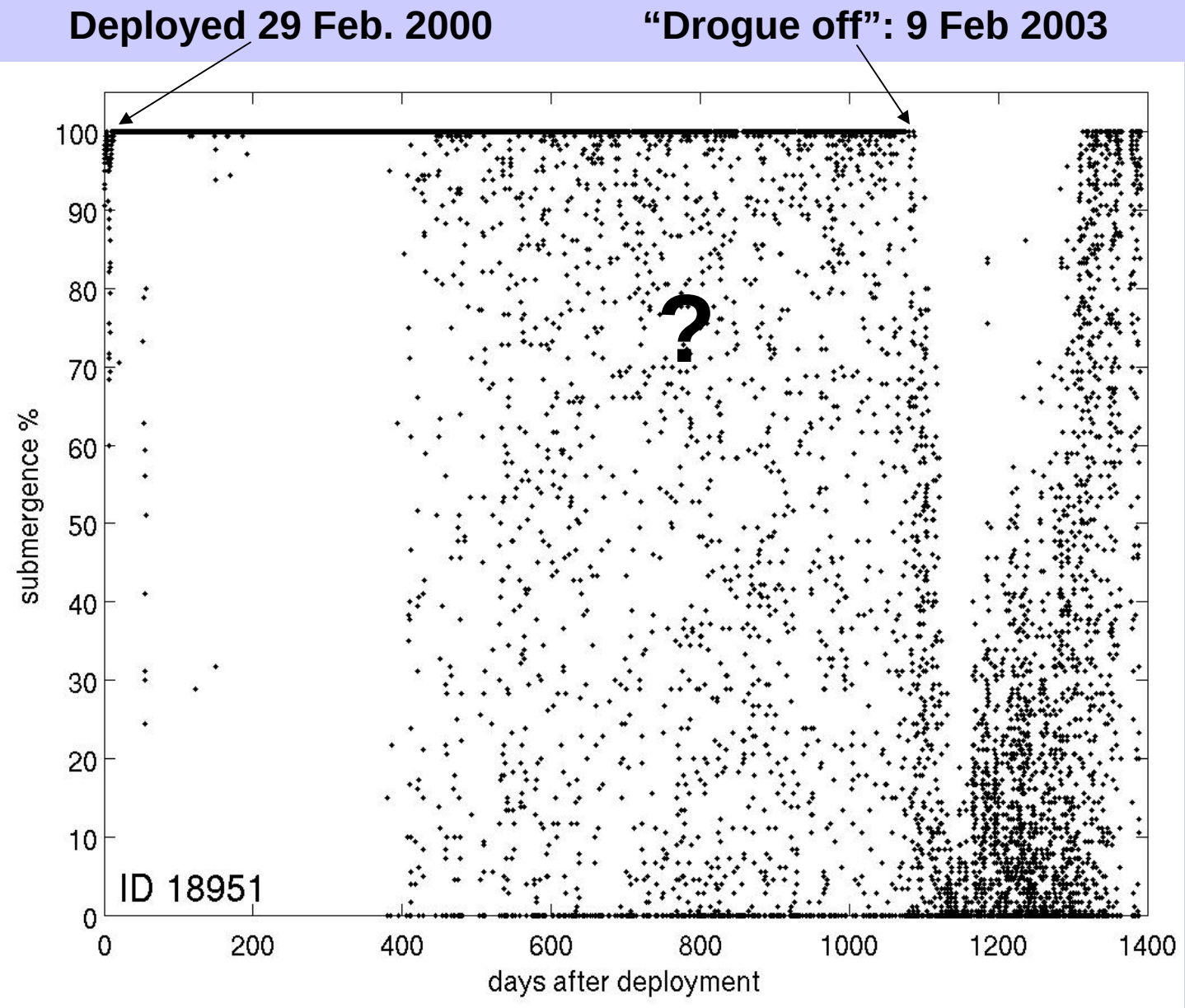
By 1993, the **original SVP design** had emerged from various competing designs for drogue, surface float, etc. (All earlier data in the GDP data set, 1979—1993, are from holey sock drifters, drogued at 15m, with drag area ratio of ~40:1).

"Mini" drifter design formally proposed in December 2002. Primary reason: reduced cost. Phased in 2002—2004. By 2005, nearly all drifters were mini.

Hypothesis 1: design change



Hypothesis 2: undiagnosed drogue loss



Submergence becomes noisy after ~400 days, includes low values as well as high ones.

Sharp drop after 1080 days (~3 years).

Manufacturer advice: drogue off at 1080 days.

Many more examples which died before exhibiting a drop: "drogue on" until end.

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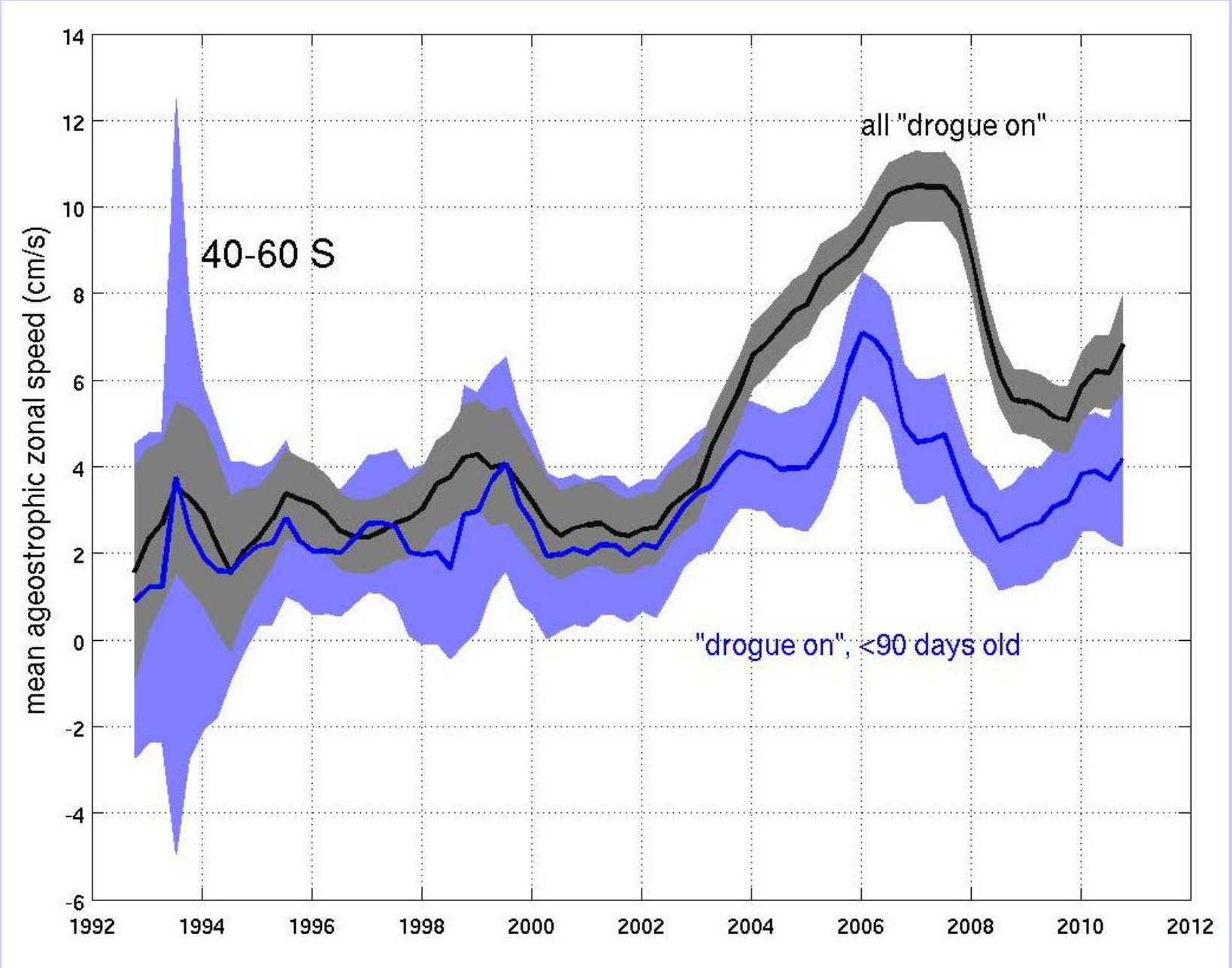
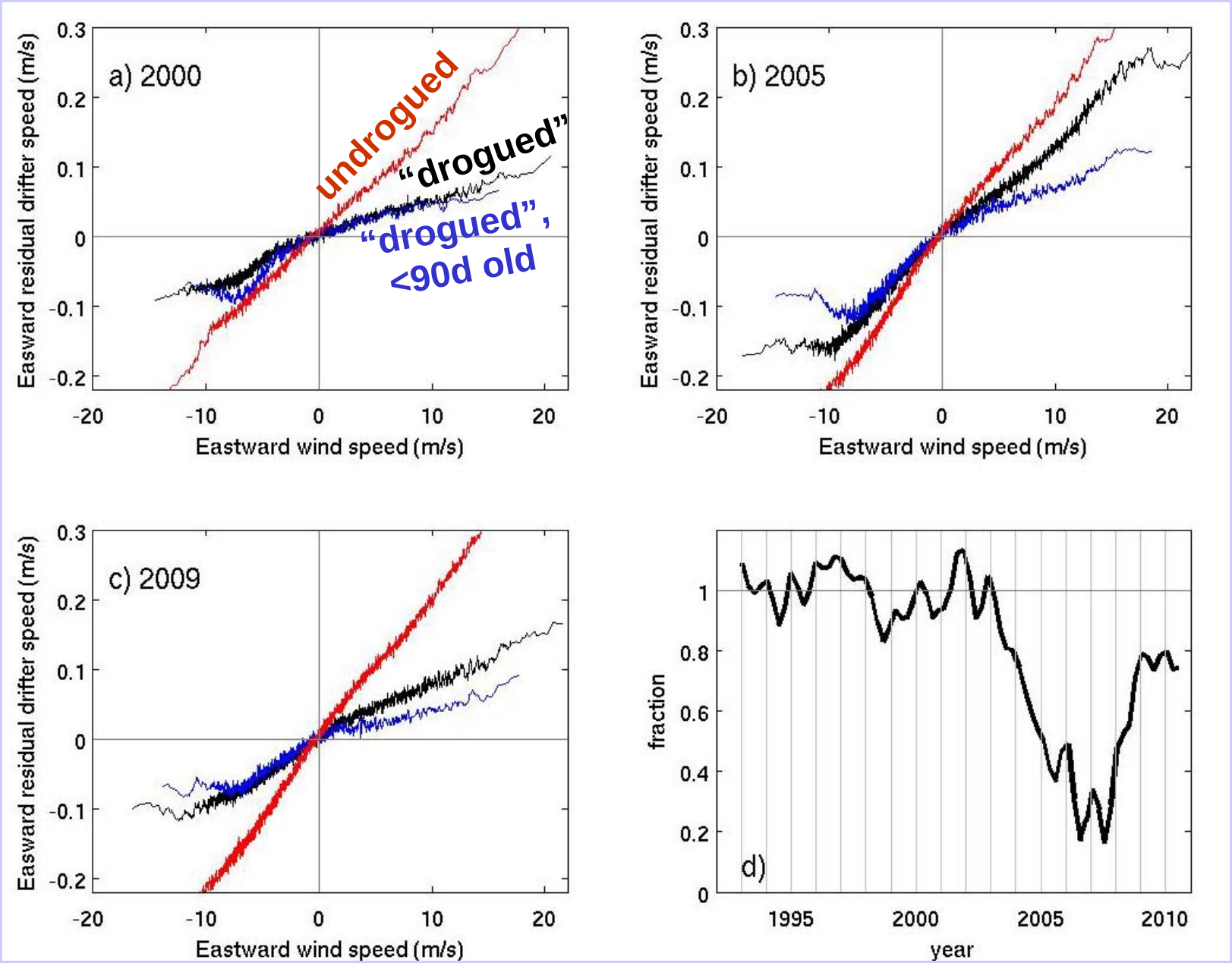


How many “drogued” drifters are actually undrogued?

(total minus geostrophic)



From Grodsky , Lumpkin and Carton (2011)

How can we fix the problem?

Short-term fix recommended by Grodsky *et al.* (2011): use only first 90 days of drifters for Jan 2004—December 2008. Eliminates 90% of data during this period!

Rio (2012): $u = \bar{u}_{geo} + u'_{geo} + A\tau\sqrt{1/|f|}.$

A (latitude, month) chosen to minimize residuals for all "drogue on" drifters <90d old.

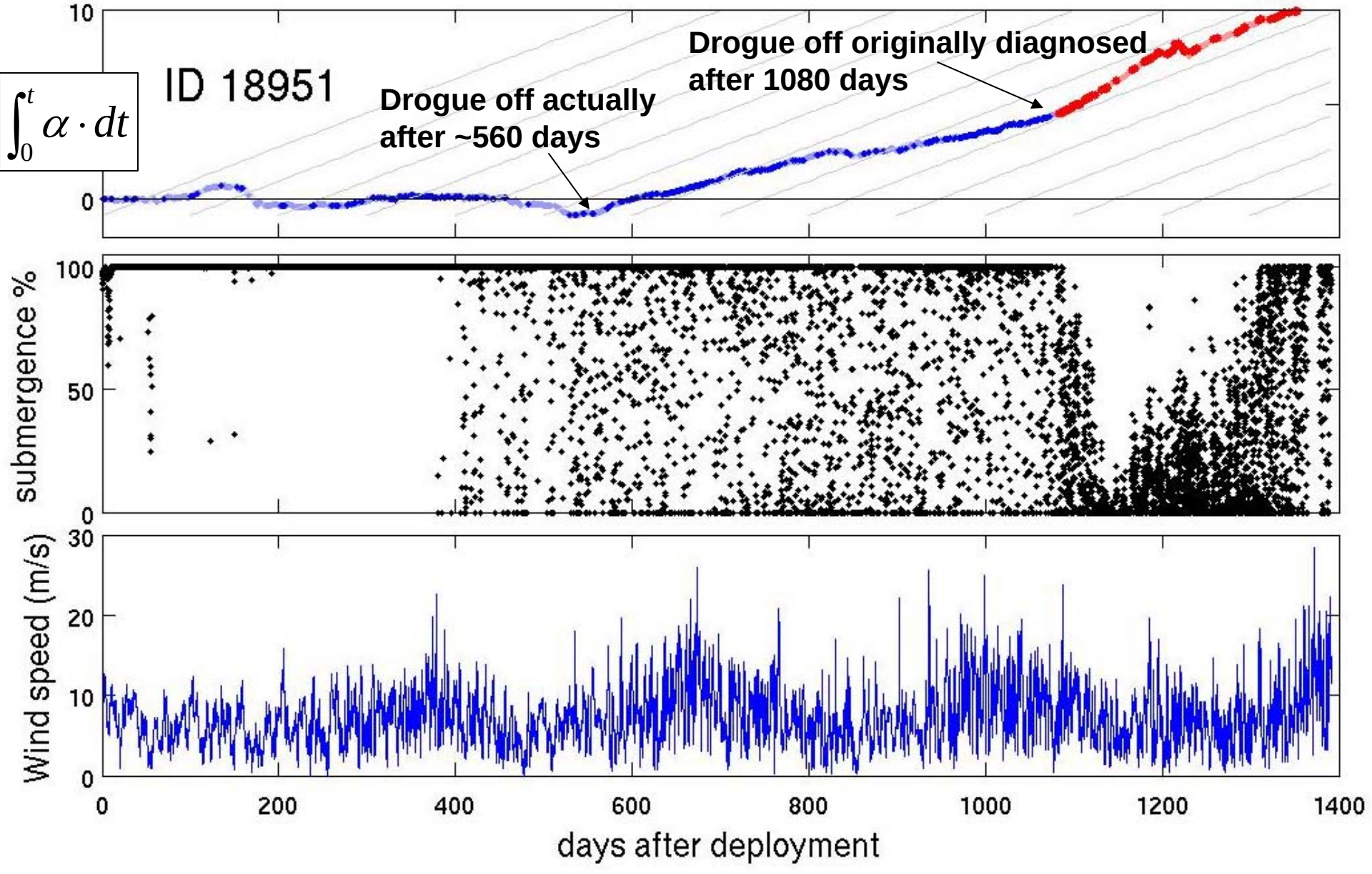
Then, for any drifter,

$$u_{downwind} - \left(\bar{u}_{geo} + u'_{geo} + A\tau\sqrt{1/|f|}\right)_{downwind} = \alpha W.$$

With drogue attached, $\alpha \sim 0$ (by construction).

Drogue lost: $\alpha = 0.015$—0.02.

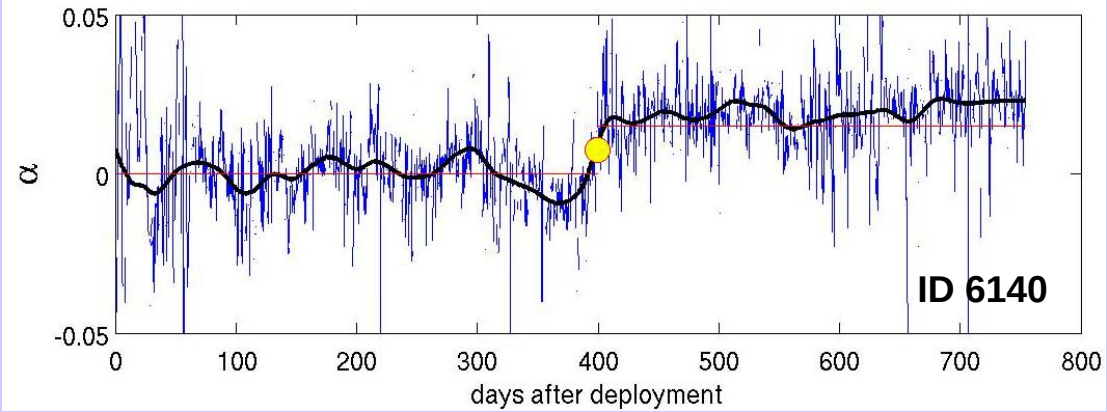
Fixing the problem



Automatic (first-pass) reanalysis

Follows methodology inspired by Marie-Hélène Rio.

Least-squares fit of step function to determine where α increases.



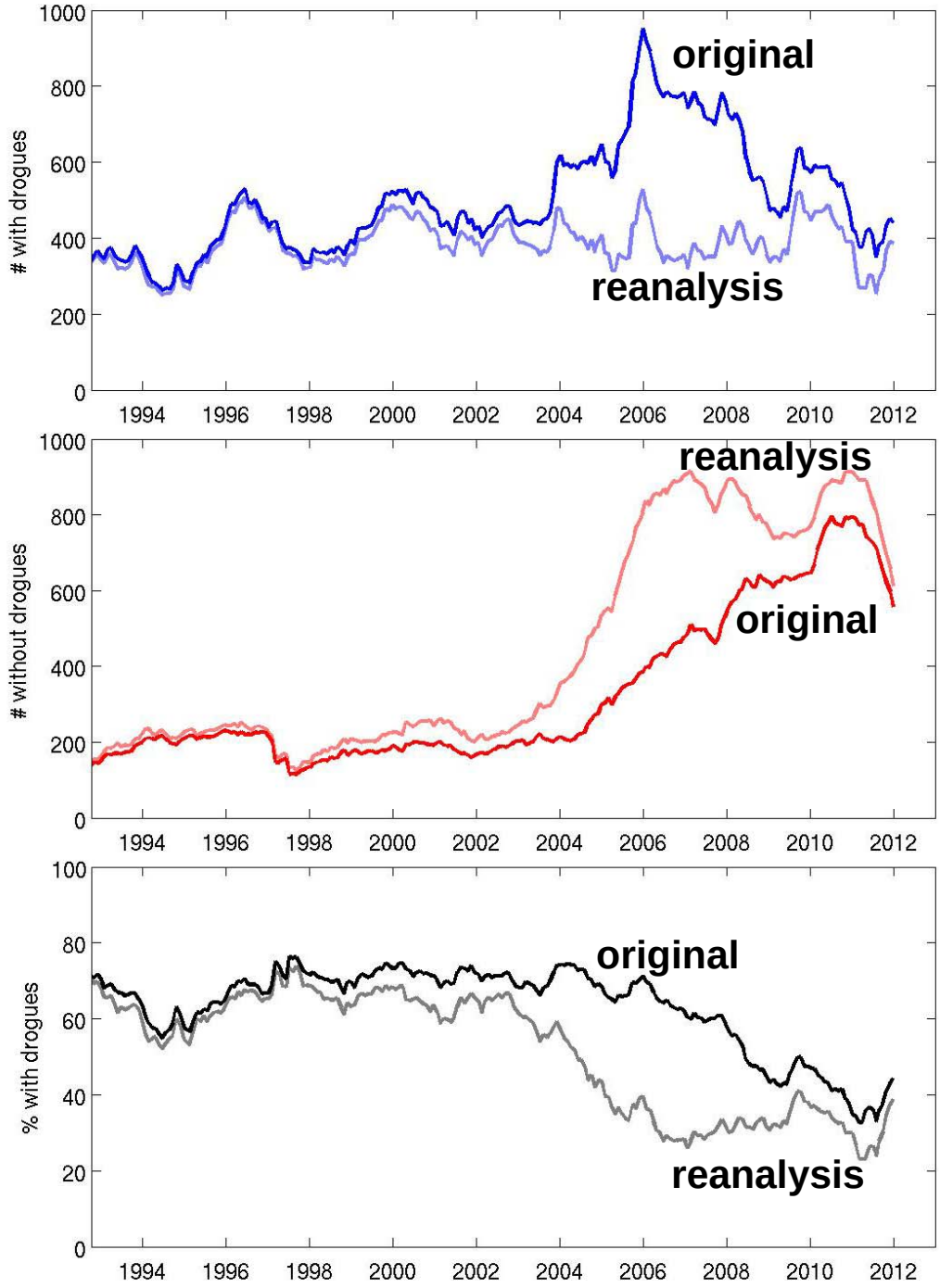
Results: 8.7k of 13.6k drifters (64%) : < 30d difference.

α method failed to identify 2055 “known” drogue loses.

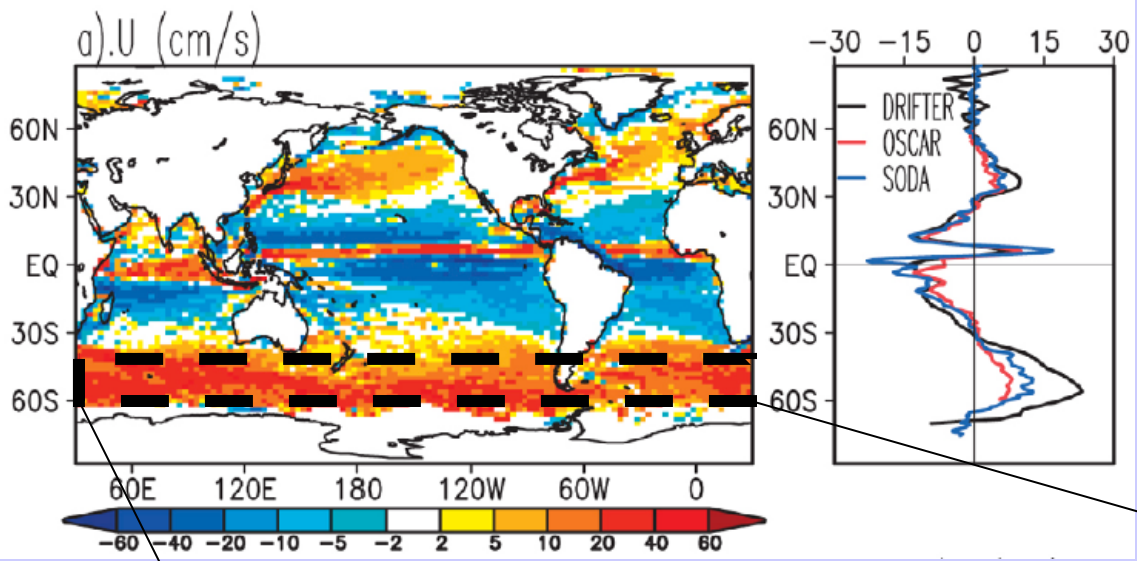
2848 drifters (21%) have drogue off date earlier by >30 days. 18% reduction in “drogue on” data for period Oct 1992—Dec 2010.

“Signal” in some submergence records that can be reinterpreted.

Comparison of data: before/after automatic reanalysis



Before automatic reanalysis



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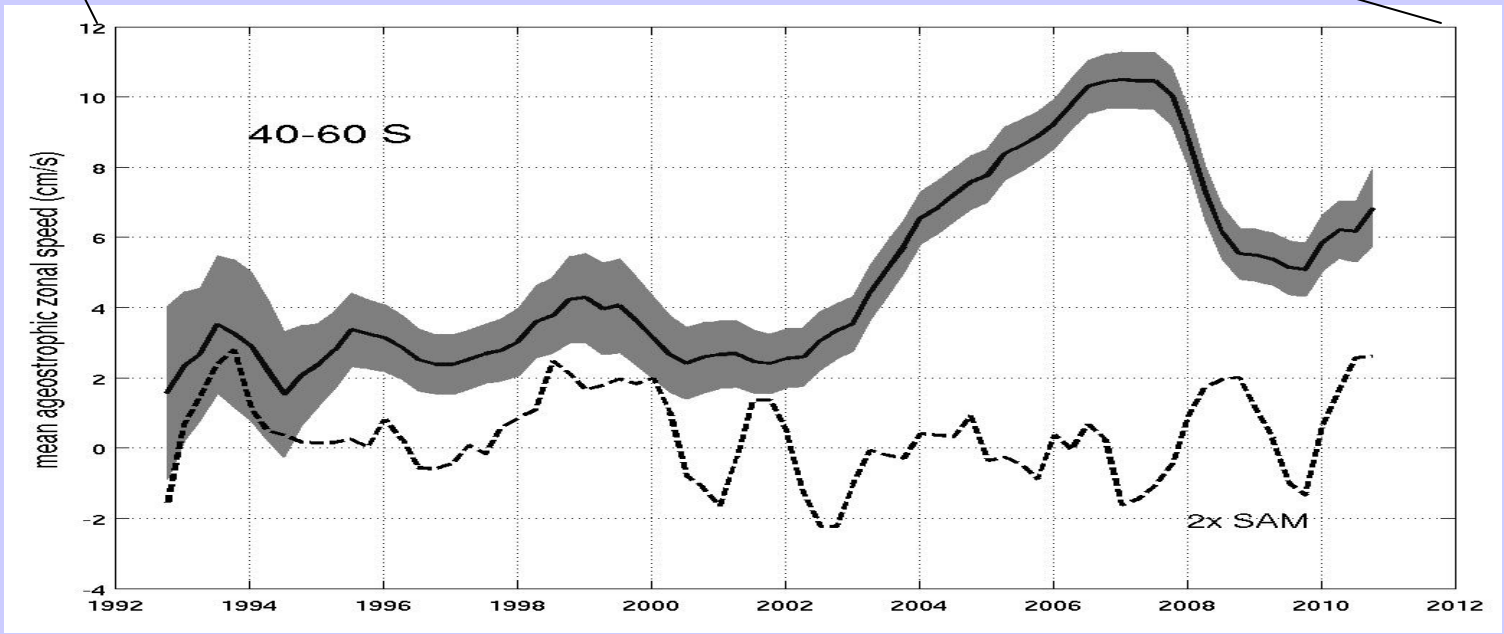
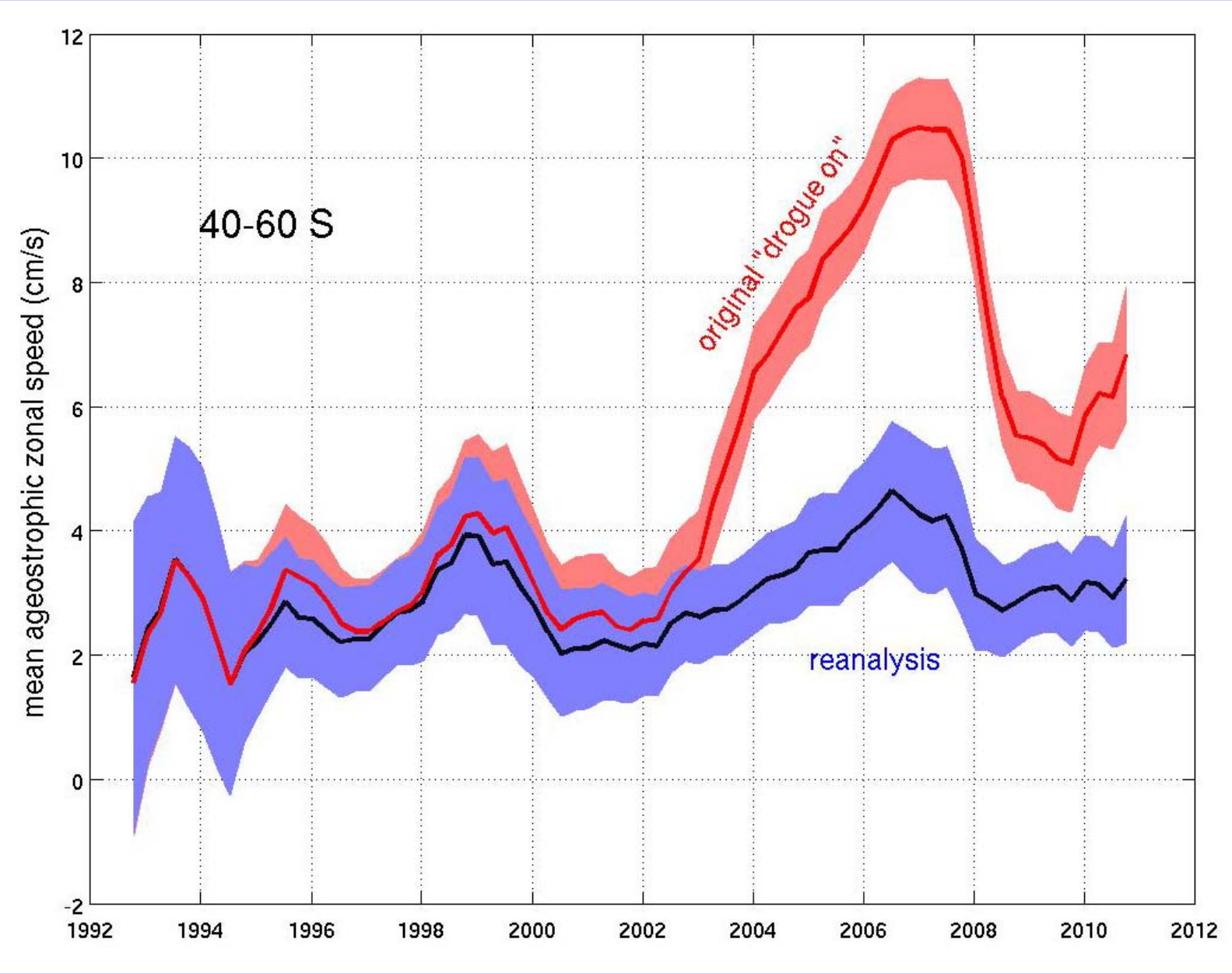
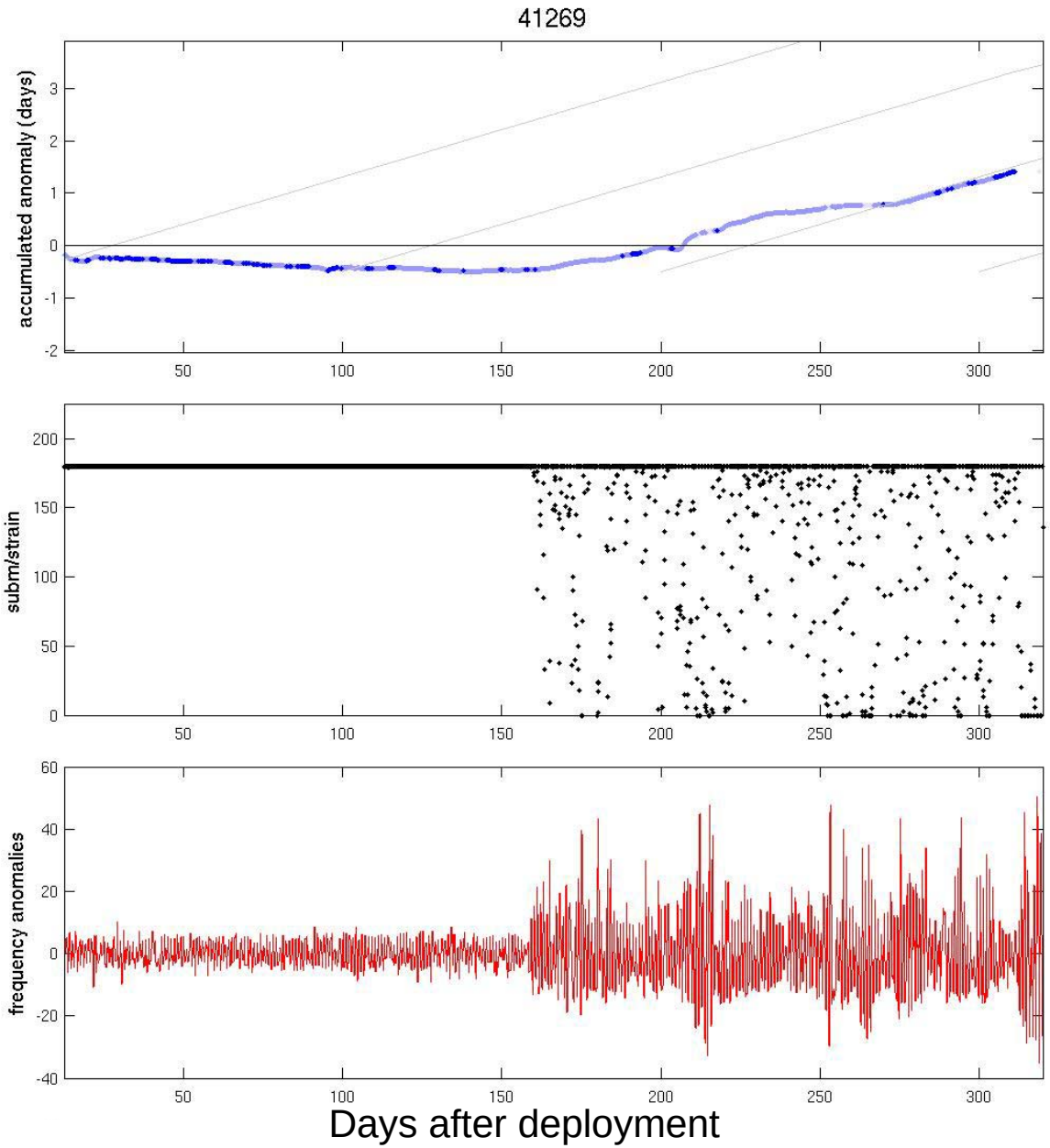


After automatic reanalysis



Example of “hidden signal” in submergence

$$\int_0^t \alpha \cdot dt$$

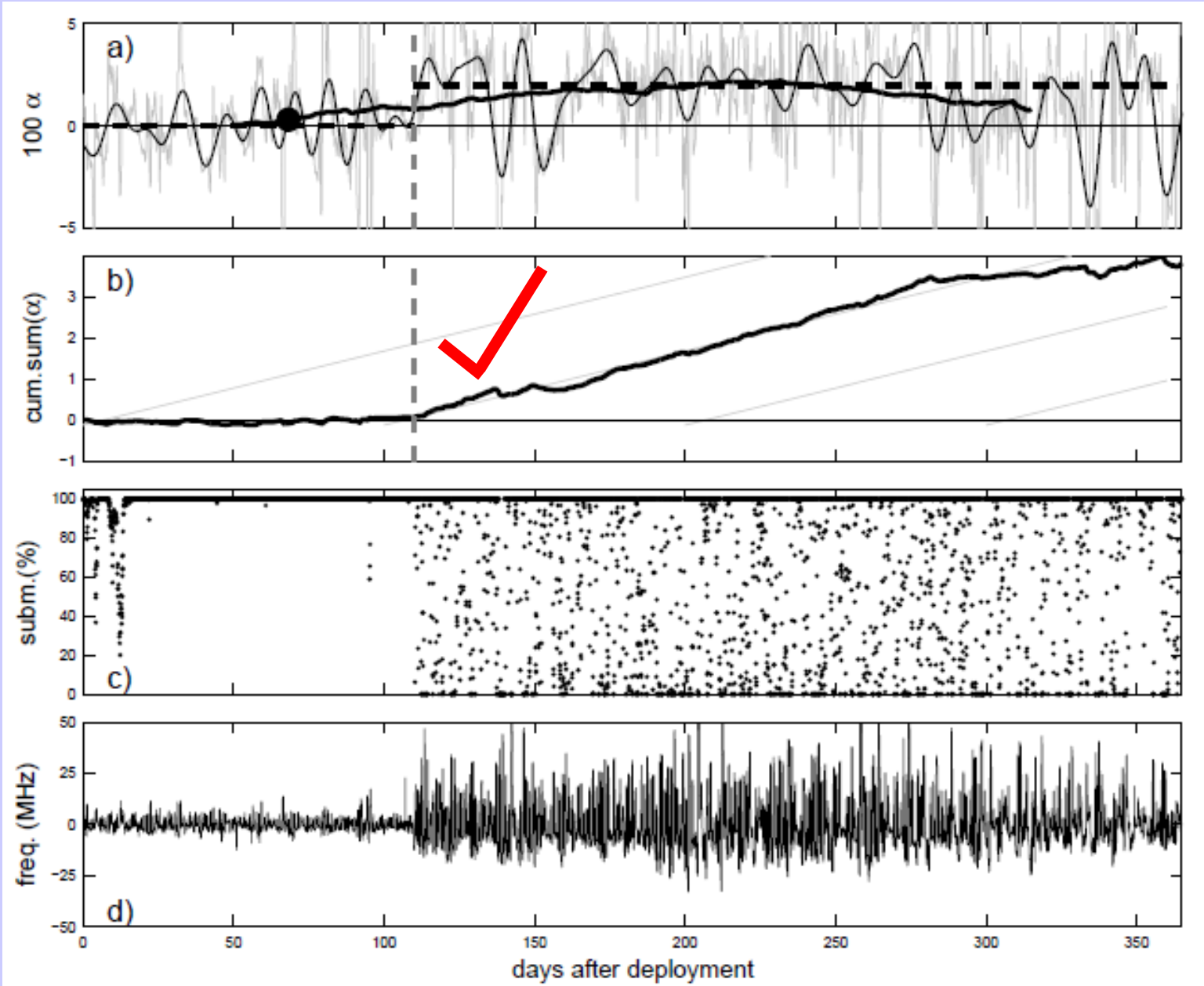


Manual reanalysis

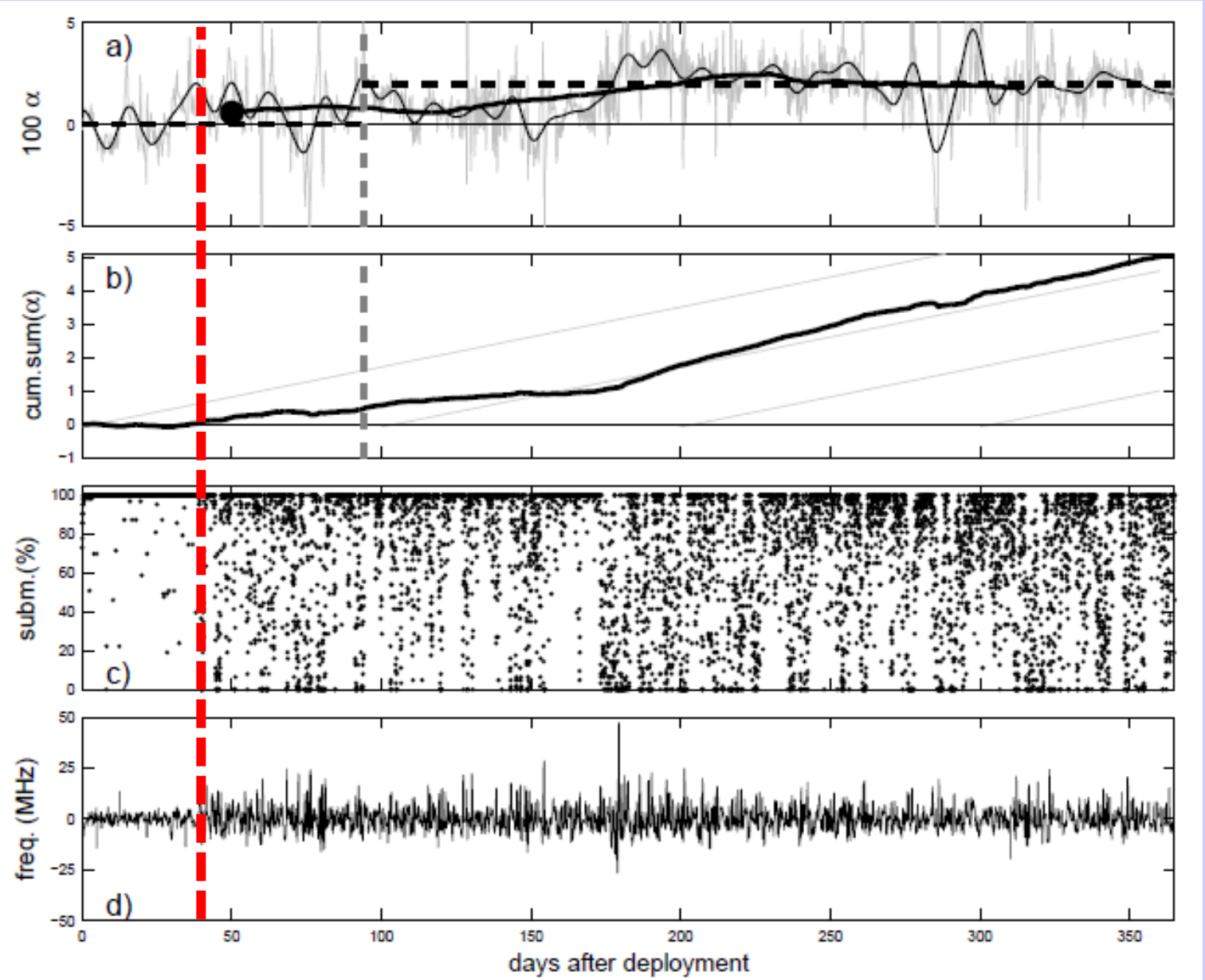
Use ALL information

- Combine submergence/strain, anomalous downwind motion, and frequency of transmissions.
- “Eyes on” for each of the 14,000+ drifters (post-Oct. 1992).
- 10,112 (74%) drifters reevaluated as of 31 August 2012.
- Results included in period updates of the metadata (directory file) starting August 2012.

Drifter 45975



Drifter 62587



Summary

DONE: automatic (first pass) reanalysis

- Developed from technique published by Marie-Hélène Rio (2012).
- Significantly improves quality of velocity data.
- Results available at
  ftp://ftp.aoml.noaa.gov/phod/pub/lumpkin/droguedetect/
- Methodology published in Lumpkin et al. (2012).

WORK NOW UNDERWAY: Full manual reanalysis

- Combine submergence/strain, anomalous downwind motion, and frequency of transmissions.
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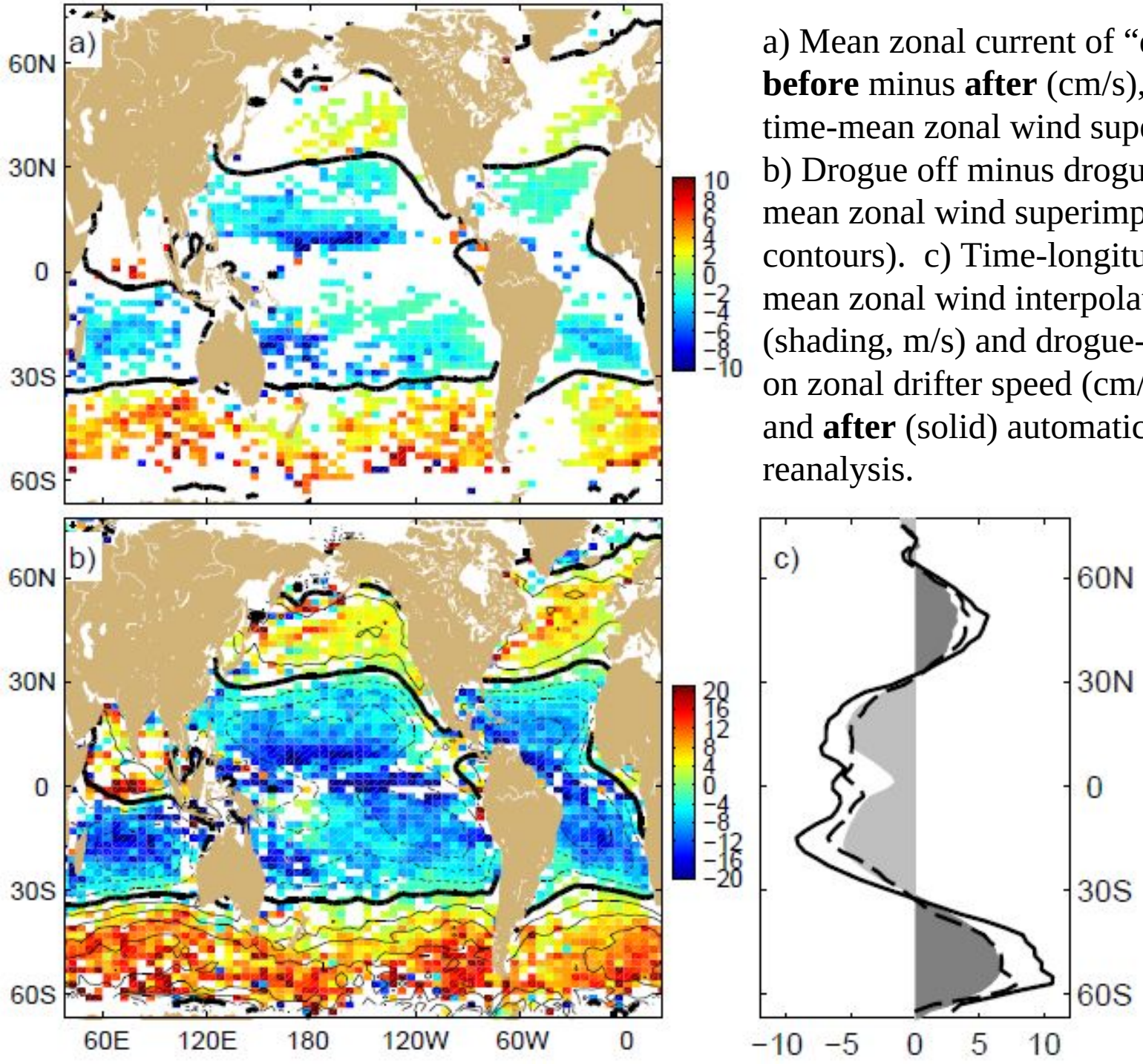
- Results included in metadata (directory file) updates.



a) Mean zonal current of “drogue on” drifters **before** minus **after** (cm/s), zero contour of time-mean zonal wind superimposed. b) Drogue off minus drogue on (**after**), time mean zonal wind superimposed (2 m/s contours). c) Time-longitude average of mean zonal wind interpolated to the drifters (shading, m/s) and drogue-off minus drogue-on zonal drifter speed (cm/s) **before** (dashed) and **after** (solid) automatic drogue reanalysis.

Drogue half-life