MH370 – drift of potential debris:

One of the most tragic and mysterious aviation disasters of all time

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Australia suddenly found itself, on 18 March 2014, in charge of the most extensive search of the sea surface ever conducted.

The search was called off on 28 April, by which time the combined effects of splash point uncertainty and oceanic dispersal resulted in a potential search domain approaching the size of Western Australia. No items associated with the plane were found, despite the best efforts of up to 12 aircraft and 12 vessels.

CSIRO served as a member of AMSA's Drift Working Group, whose job was to simulate the drift of potential debris items, using a number of ocean models, for targets with a variety of leeway factors.

As was widely reported in the media, the focus of the search progressed in a generally north-eastward direction from as far south as 45°S in the early stages, to 19°S at one point, as various sections along the 7th arc (see Figure 1) were taken to be the potential crash zone, in the light of information as it came to hand.

On 26 June 2014, the ATSB released a report (http://www.atsb.gov.au/mh370/mh370-definition-of-underwater-search-areas.aspx) detailing a re-investigation into the potential location of the crash site. The panels (at right) result from re-running the same drift computations that were done by CSIRO during the search, but with splashpoints restricted to the ATSB 'highest probability' zone.

Time sequence of dispersal according to two models

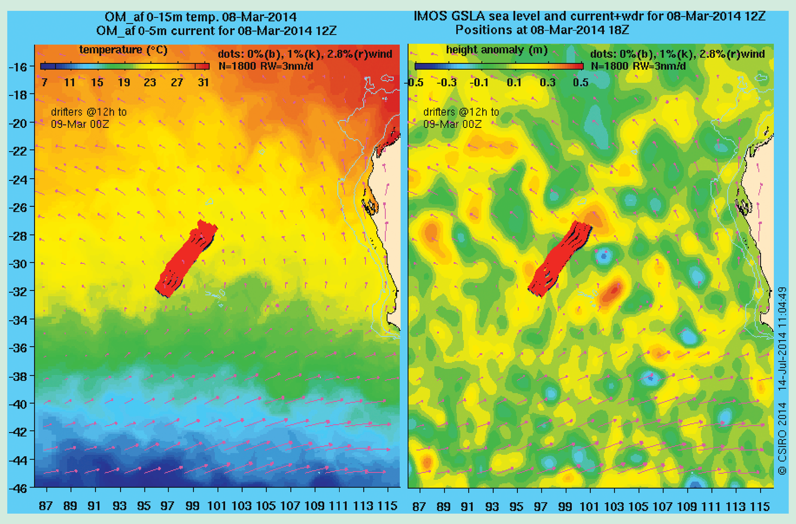


Figure 2a: Day of crash. ATSB high probability zone shown in red.

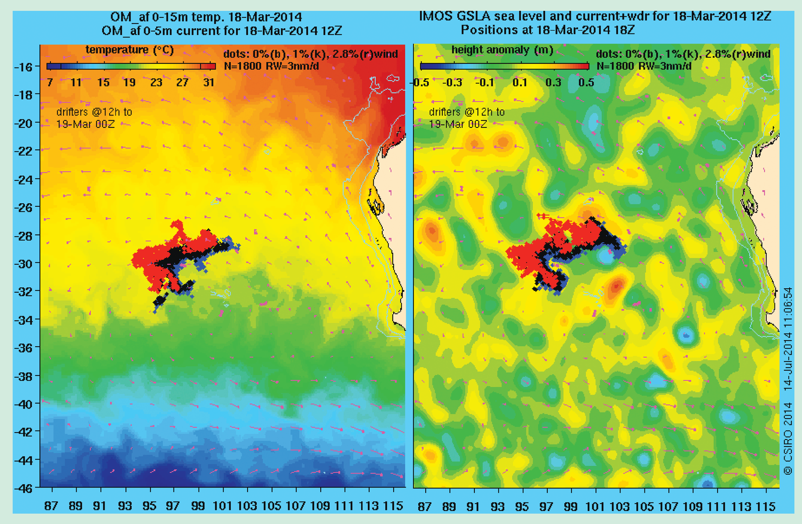


Figure 2b: Australia assumes coordination role. Search commences deeper in the Southern Hemisphere ~45° S than now thought optimal.

Figure 2a-2e Simulated drift of debris items with three degrees of exposure to the wind (red=high, black=low, blue=none), using two estimates of the surface current velocity (left= Bluelink model run at the Bureau of Meteorology, right= IMOS OceanCurrent with wind-driven surface current added). The background colour-fill is the sea surface temperature at left, and sea level anomaly at right for that day. Magenta arrows show the wind velocity.

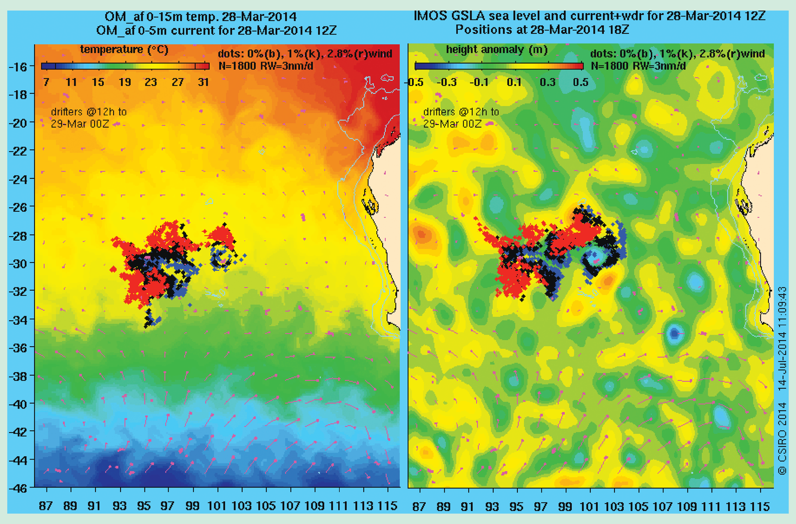


Figure 2c: Search effort moves north, to focus on what is now thought to be the likely crash zone. Potential debris items are now considerably dispersed.

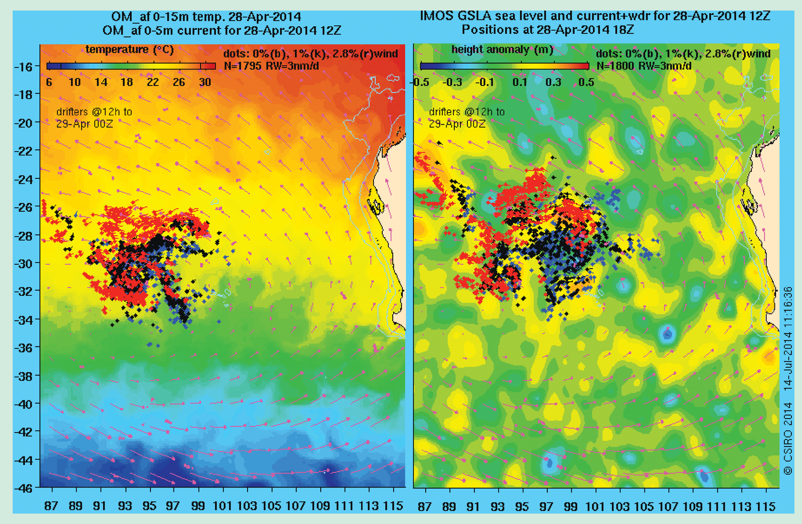


Figure 2d: Search effort terminated. Debris items are very widely dispersed.

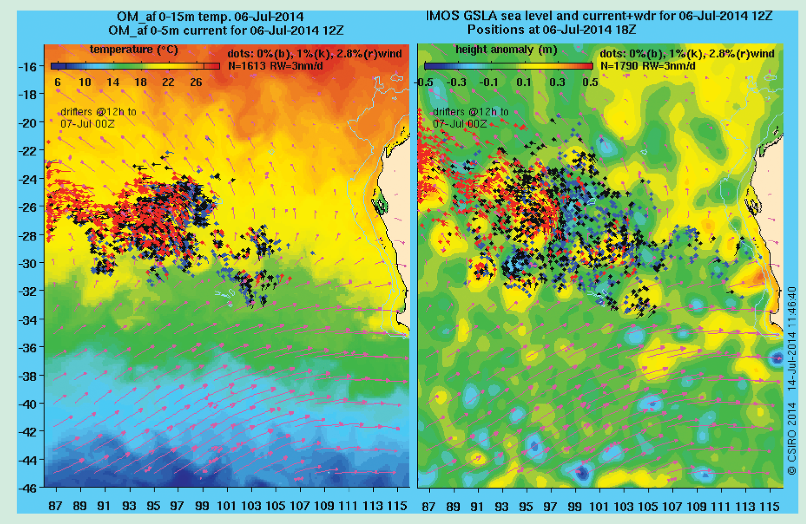
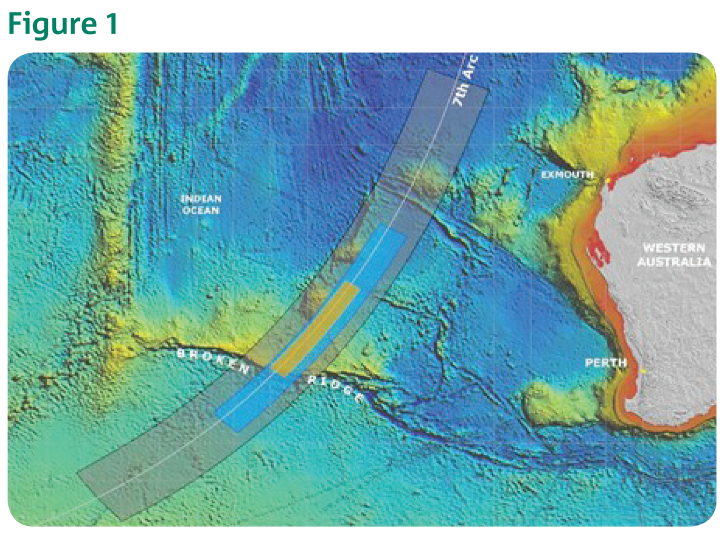


Figure 2e: July – there is now a slim chance, according to one of the models, that items could have drifted close to the Australian coast.

Figure 1



Technical information

- Debris with freeboard drifts with the wind+current (Figure 2). Items with leeway factors of 2.8% (in red) and 1% (in black) drift differently to the items with no freeboard (in blue) which drift with the current only.
- Near-surface current is sheared, so deep-drafted items drift differently to shallow-drafted items.
- Meso-scale (~50-250 km) and sub-meso-scale eddies (5-50 km) take items in various directions.
- Convergences (where there is downwelling) and divergences (upwelling) aggregate and disaggregate items.
- The Drift Working Group used two Australian ocean models (the Bluelink model run at the Bureau of Meteorology, and the IMOS OceanCurrent surface geostrophic analysis of satellite altimeter observations) and two US models and several particle-tracking software systems. In Fig 2 we show only the Australian models as inputs to the CSIRO particle-tracking software.
- AMSA deployed many satellite drifting buoys during the search. Several Global Lagrangian Drifters (which have sea-anchors, so they are deep-drafted items) were already in the search area at the time of the crash. Hindcasting the trajectories of all these buoys was done continuously during the search in order to assess and validate the drift modeling (e.g. Fig 3).

Drifting buoys were used for assessment and validation of the drift modeling done for the search. The trajectory of one of these buoys is particularly interesting because it shows that, in some circumstances, it is possible to simulate the drift of floating items for much longer than is usually the case.

Global Lagrangian Drifter 56566 became caught in a cyclonic eddy in December 2013, and on 8 March 2014 it was close to where the plane was thought to have possibly crashed. Figure 3 shows the looping trajectory of the drifter from 1 January to 31 May, as well as trajectories of some model drifters which are initialized along the trajectory of the real drifter at 4-day intervals, and travel at the velocity estimated in near-real-time by the ocean analysis system running at CSIRO for IMOS (http://oceancurrent.imos.org.au/). The model drifters continue to loop around the eddy in similar fashion to the real drifter for a remarkably long time – up to 130 days. The distance separating the model drifters from the real one is consequently restricted to being less than the ~100 km diameter of the eddy until late May, when many model drifters depart from the eddy.

Figure 3

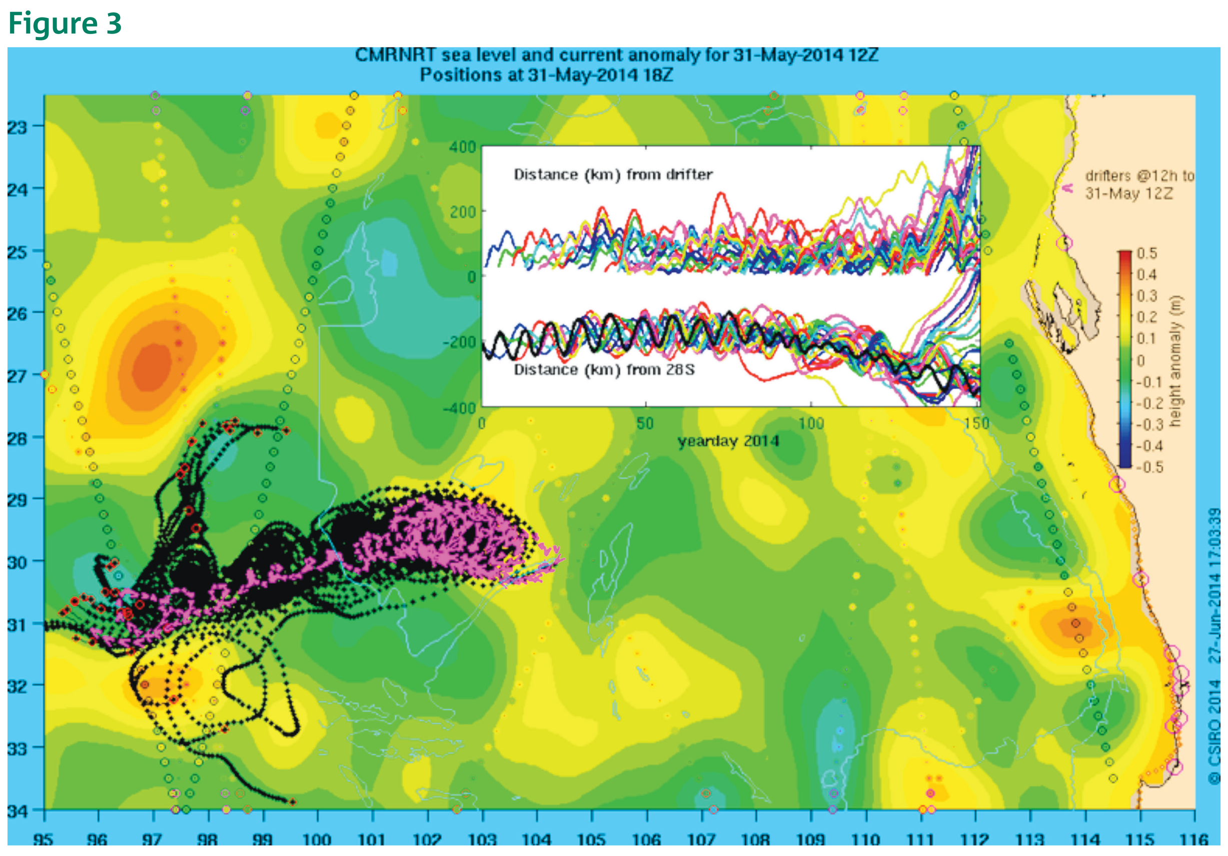


Figure 3 Trajectory of Global Lagrangian Drifter 56566 from 1 Jan 2014 to 31 May 2014, shown as magenta arrow heads looping to the west. Trajectories of model drifters released along its path are shown as black dots. These travel at the velocity determined (for each day) by geostrophy from the daily-updated sea-level anomaly fields (plus an estimate of the temporal mean from an ocean model) shown in colour for 31 May. Altimetric sea level estimates for 31 May are overlain on the fitted surface, with observations by SARAL (the newest altimeter) identified by black circles. The inset shows the time history from 1 January 2014 of i) the distance between modeled drifters and the real one, and ii) the meridional position of both.

Conclusions

We may never know why no debris from MH370 was found on the sea surface during the very extensive search.

The drift modeling work performed by the Drift Working Group was largely vindicated using the drifting buoys deployed for this purpose, and by buoys already in the water such as the one discussed above.

One thing is certain: Australia's drift modeling capabilities were thoroughly exercised during the search, and many improvements were made, hopefully for the benefit of future incidents.

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