

Introduction

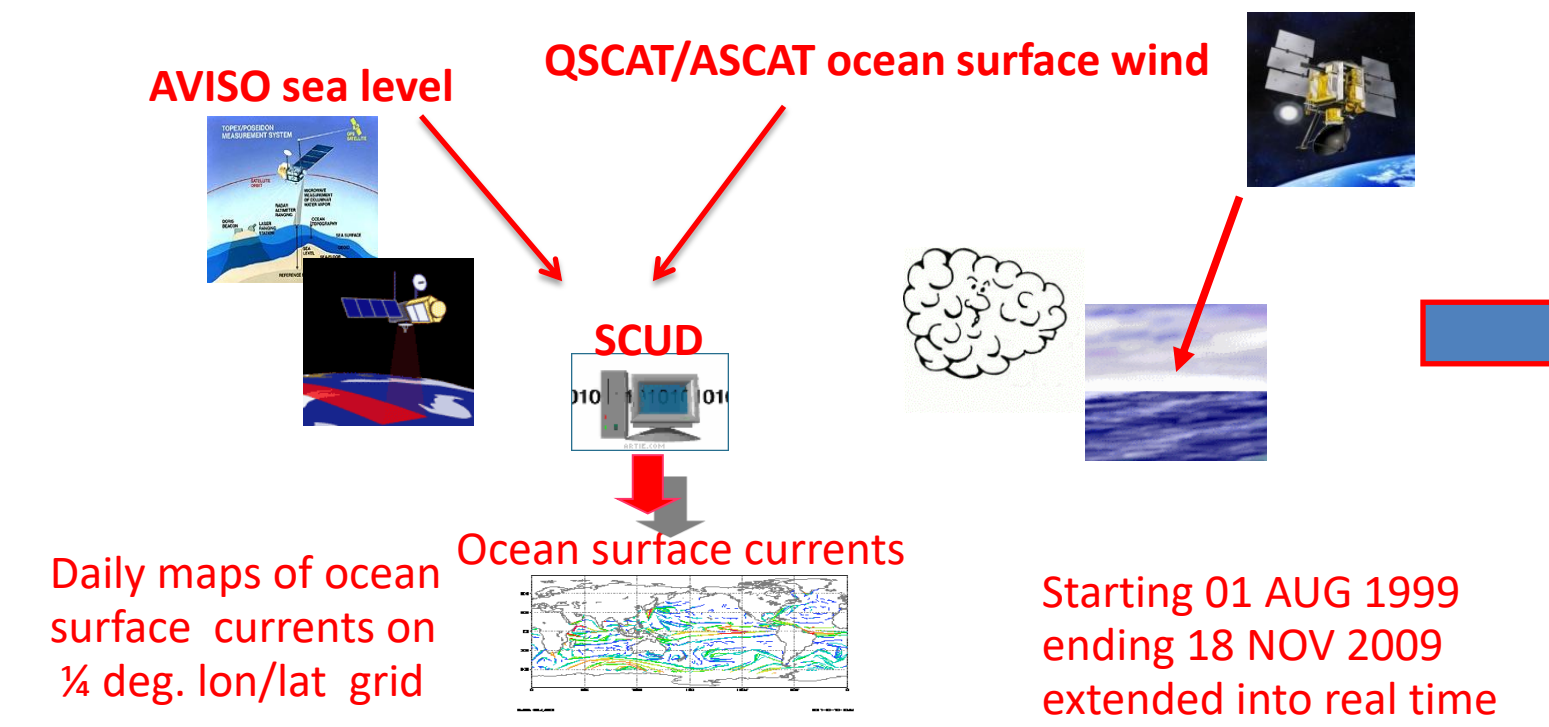
Studies of marine debris transport over large distances are very limited. Long term position tracking is required to collect the necessary data. In general the transport of marine debris is determined by the surface ocean currents and winds. The effect of wind on marine debris motion is called windage; high windage debris is affected by the wind more than low windage type. The 2011 tsunami in Japan was a very tragic event that generated a large amount of unusual debris. Data of tsunami debris were used as an experiment of the nature and many pieces could be directly traced back to origin (e.g. registration numbers on boats). SCUD (Surface CUrrents from Diagnostic model) model was employed to simulate the drift of tsunami debris from the coast of Japan across the N. Pacific to Hawaii.

2012



Timeline of JTMD in Hawaii

SCUD - Surface CUrrents from Diagnostic model



Formulation of the diagnostic model SCUD

$$U_{SCUD}(x,y,t) = U_0 + U_{hx} \cdot \nabla_x h(x,y,t) + U_{hy} \cdot \nabla_y h(x,y,t) + U_{wx} \cdot wx(x,y,t) + U_{wy} \cdot wy(x,y,t)$$

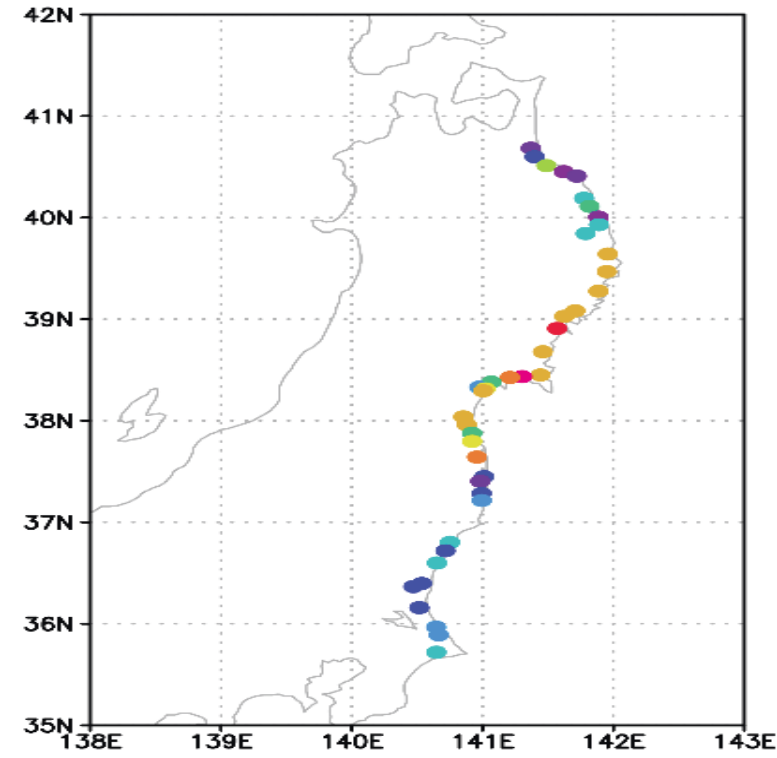
$$V_{SCUD}(x,y,t) = V_0 + V_{hx} \cdot \nabla_x h(x,y,t) + V_{hy} \cdot \nabla_y h(x,y,t) + V_{wx} \cdot wx(x,y,t) + V_{wy} \cdot wy(x,y,t)$$

Where: U_{SCUD}, V_{SCUD} - modeled ocean current components
 U_0, V_0 - constant coefficient (mean)
 h - sea level anomaly
 wx, wy U and V component of surface wind (QSCAT)
 $U_{hx}, U_{hy}, U_{wx}, U_{wy}$ - U component coefficients corresponding to sea level gradient and surface wind (function of x and y only)
 $V_{hx}, V_{hy}, V_{wx}, V_{wy}$ - similarly corresponding V component coefficients

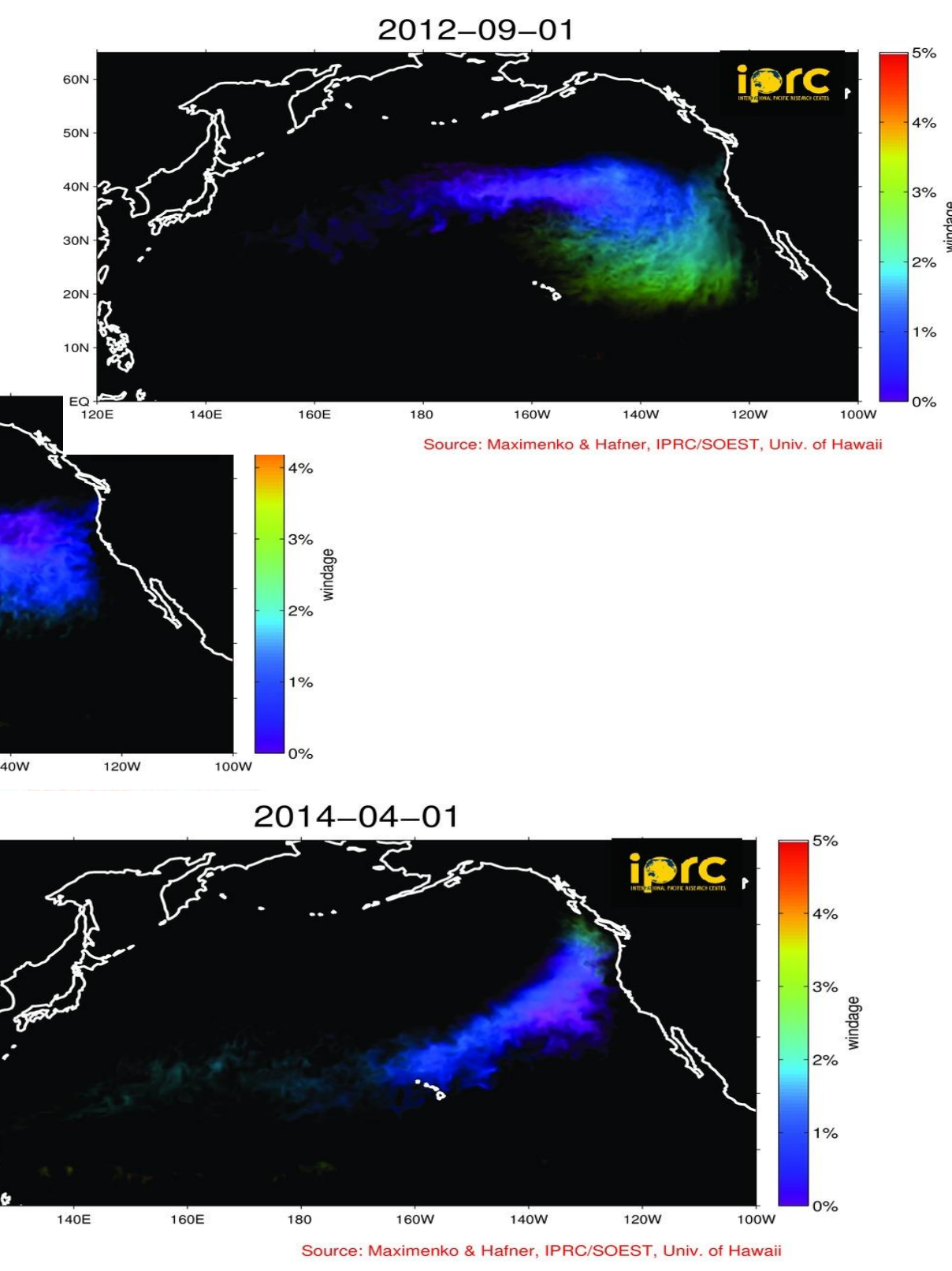
Japanese Tsunami 2011

We applied SCUD model to simulate the drift of Japanese Tsunami Debris (JTMD) across the North Pacific Ocean. Virtual tracer was placed along the East coast of Japan and its magnitude was weighted by the reported number of damaged houses. Then the tracer was advected by model currents and winds. As to the effect of wind it was considered in the 0-5% range (0=5% windage).

The source function along the East Japanese Coast

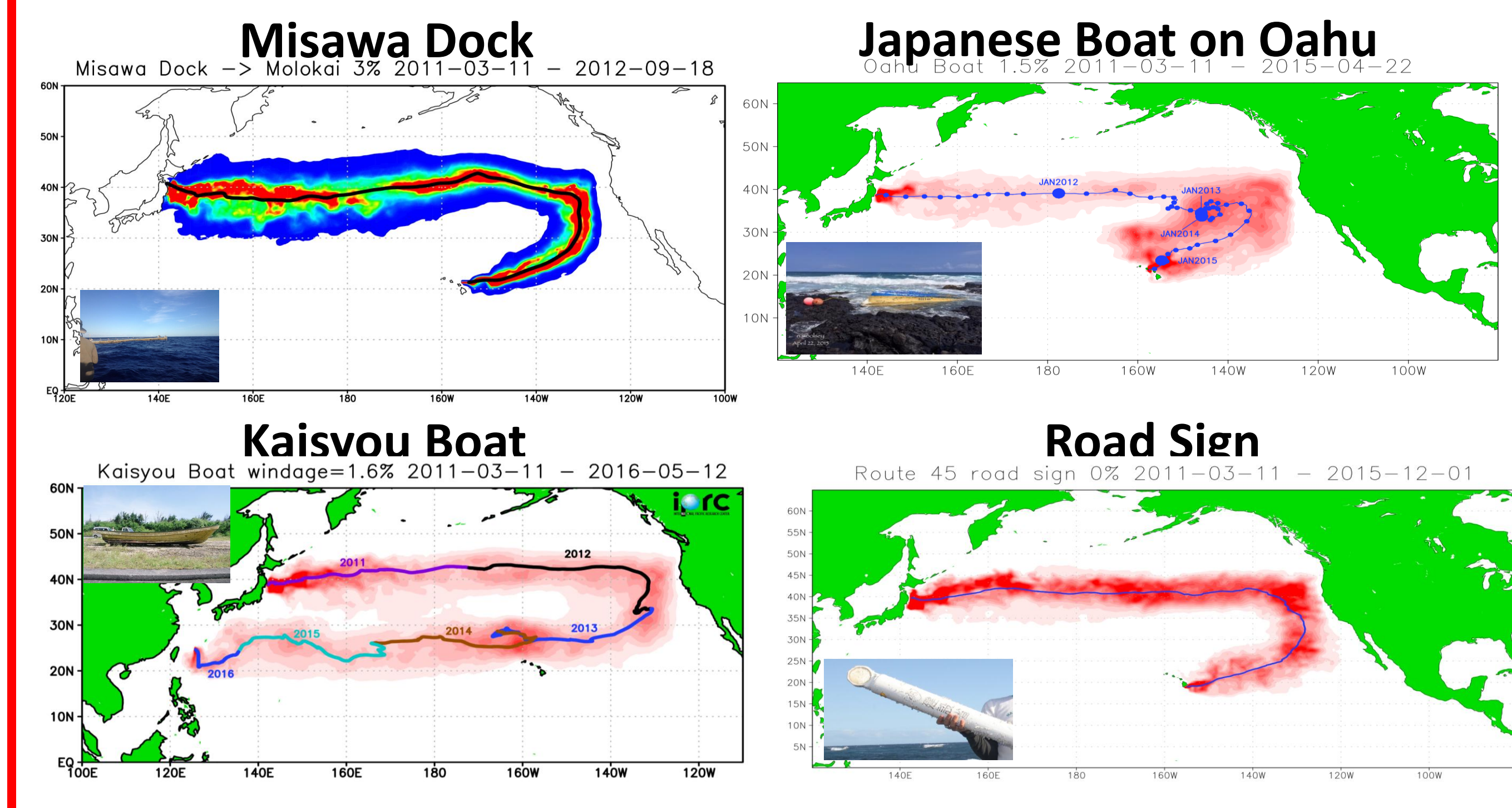


Model solution

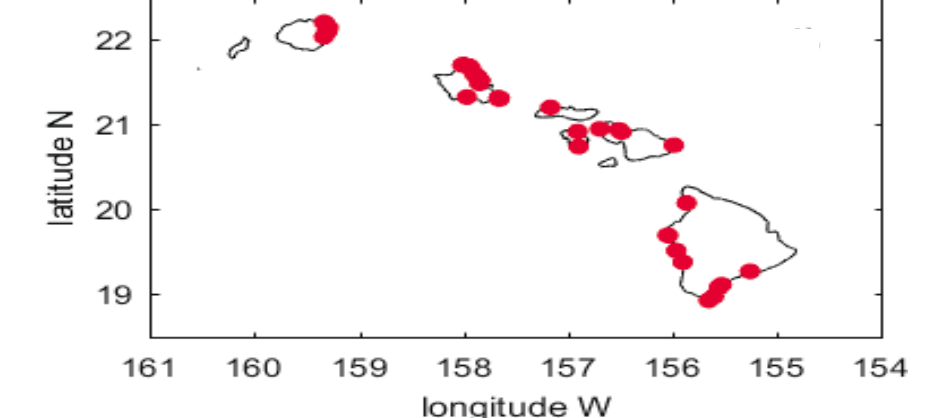


Special Cases

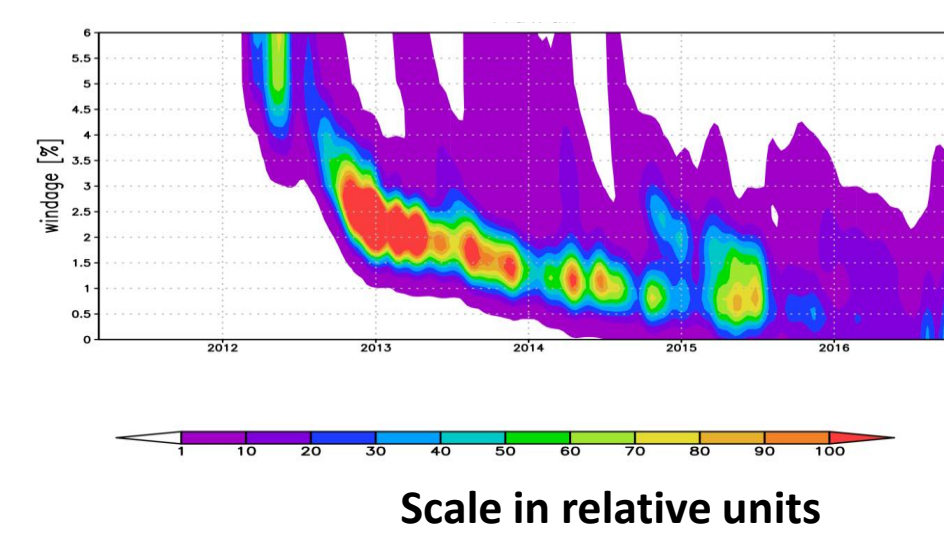
With known times and locations of origin and destination of a particular marine debris the model can calculate probabilistic trajectory. Combination of forward (from the origin) and backward (from the destination) model tracer solutions results in



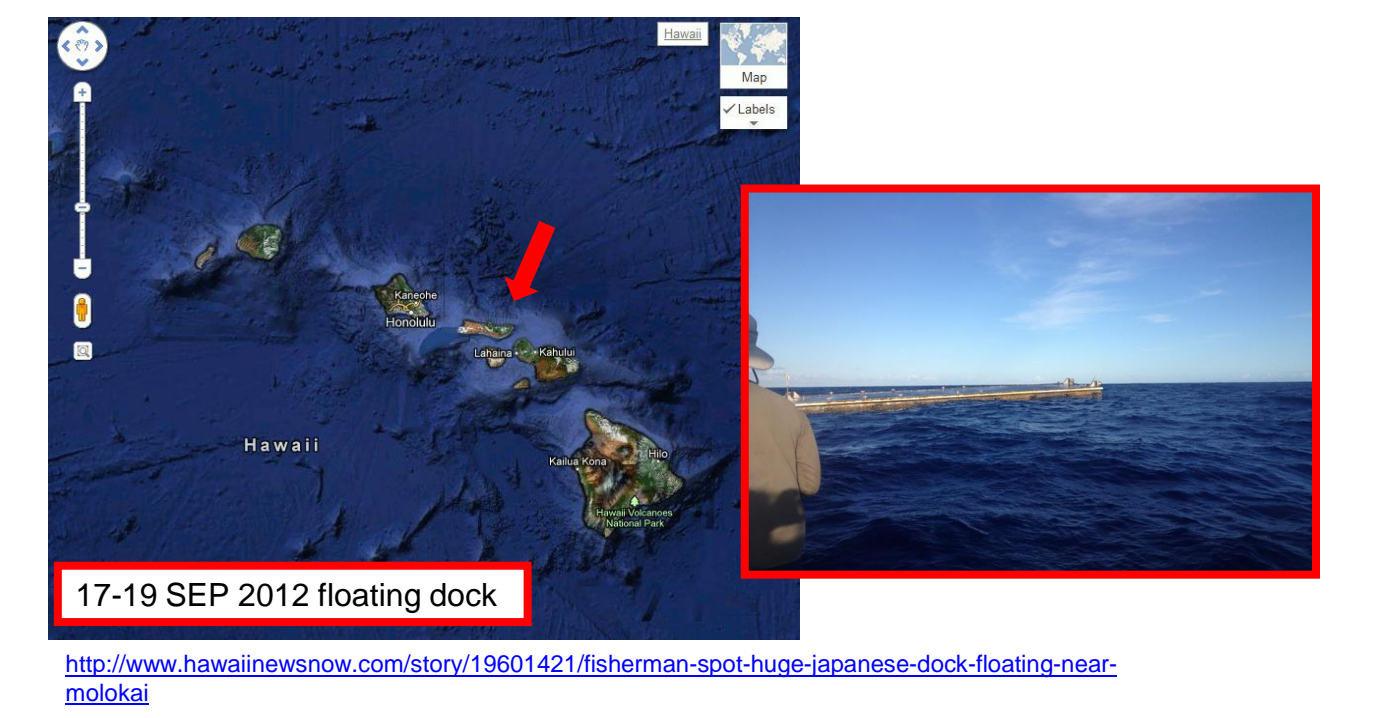
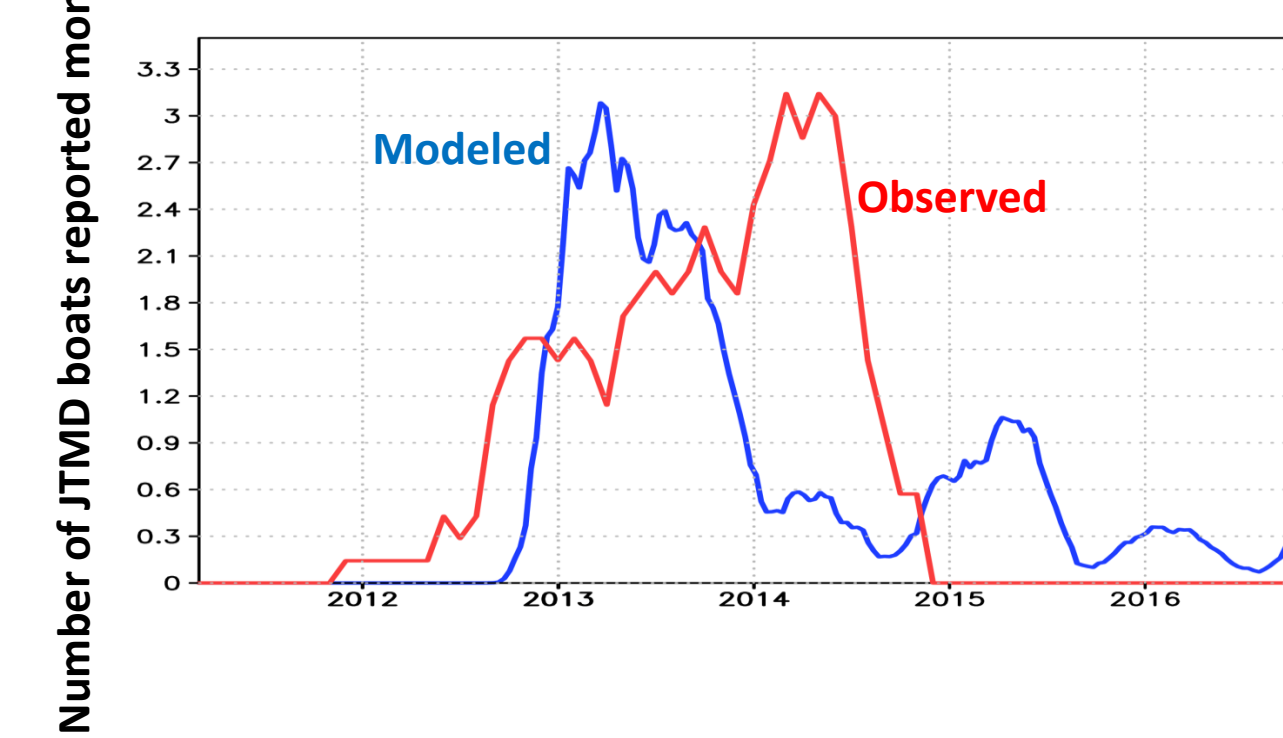
Location of boat reports relative to the shoreline.



SCUD modeled flux in Hawaii



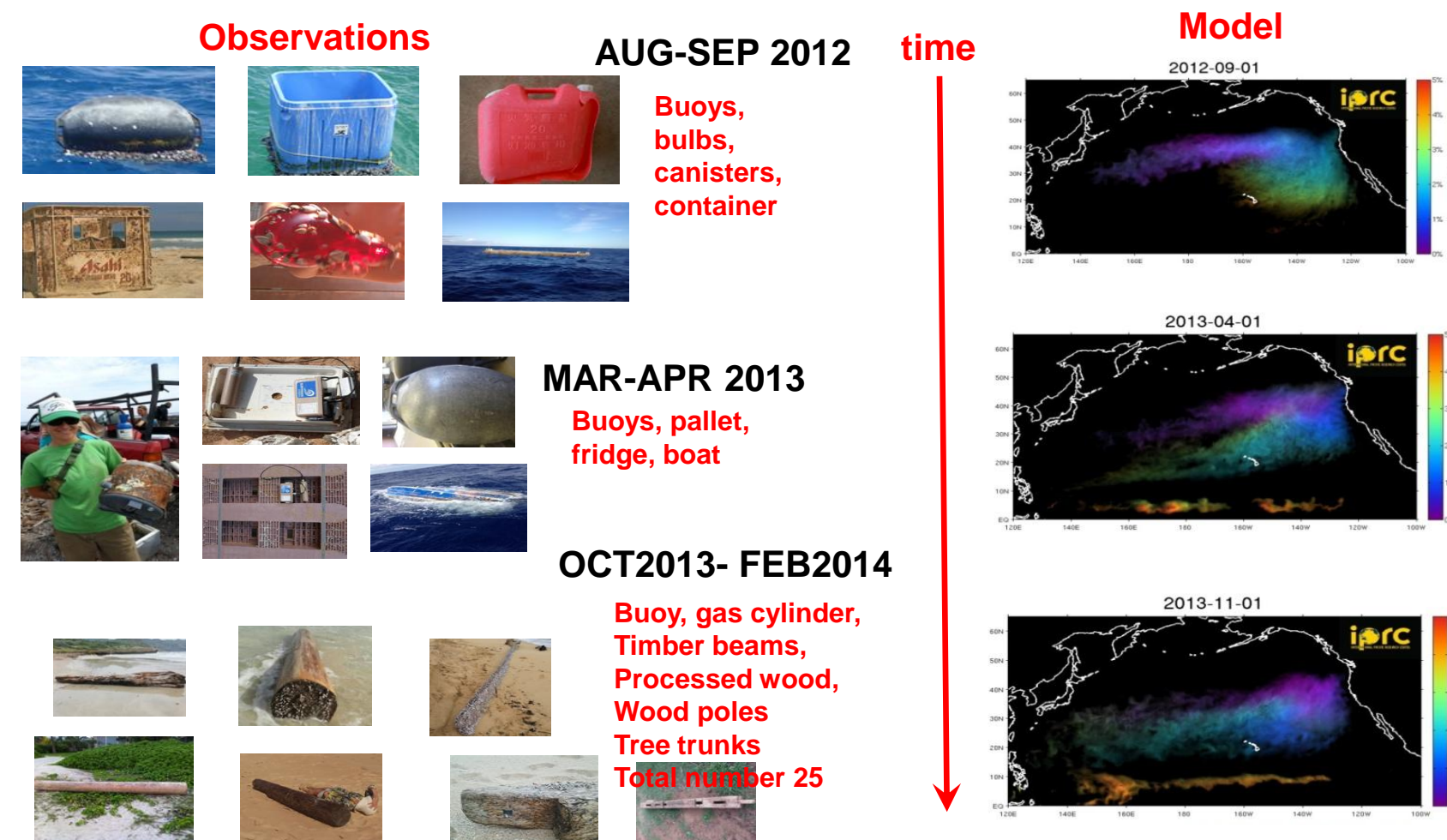
JTMD boat reported in Hawaii and model solution (2% windage)



2013



The Story: Changing composition in time



2015



Timeline of JTMD in Hawaii

Timeline of JTMD in Hawaii