Surface Drifter Program
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1. Project Summary

The Surface Drifter Program is the Atlantic Oceanographic and Meteorological Laboratory’s (AOML) contribution to NOAA’s Global Drifter Program (GDP), a branch of NOAA’s Integrated Ocean Observing System, Global Ocean Observing System (IOOS/GOOS) and a scientific project of the Data Buoy Cooperation Panel (DBCP). The primary goals of this project are to maintain a global 5ºx5º array of satellite-tracked surface drifting buoys to meet the need for an accurate and globally dense set of in-situ observations transmitting in real time for weather forecasting, and to provide a data processing system for the scientific use of these data that support short-term (seasonal-to-interannual, “SI”) climate predictions as well as climate research.

AOML’s GDP responsibilities are to: (1) recruit ships and manage drifting buoy deployments around the world using research ships, Volunteer Observation Ships and aircraft; (2) insure the data is placed on the Global Telecommunications System (GTS) for real-time distribution to meteorological services everywhere; (3) maintain metadata files describing each drifter deployed, (4) quality control and interpolate the data (updated quarterly) and archive it at AOML and at Canada’s Buoy Data Management Center; (5) develop and distribute data-based products; (6) maintain the GDP; and (7) maintain liaisons with individual research programs that deploy drifters.

The drifters provide sea surface temperature (SST) and near surface currents. A subset of the drifters also measures air pressure, winds, subsurface temperatures and salinities. These observations are needed to calibrate SST and sea surface salinity observations from satellites, initialize global SI forecast models to improve prediction skill, and provide nowcasts of the structure of global surface currents. The surface drifter array provides the largest area coverage of all components of the global ocean observing system for surface temperature and currents, with observations provided by the drifters at approximately hourly resolution. Secondary objectives of this project are to use the resulting data to increase our understanding of the dynamics of SI variability and to perform model validation studies, in particular in the Atlantic Ocean. Thus, this project addresses both operational and scientific goals of NOAA’s program for building a sustained ocean observing system for climate. The data are made available in near-real time on the Global Telecommunications System for weather forecasting efforts, and in delay
mode (approximately three months, after quality control and interpolation) at the GDP web page and 
(with an additional six months’ delay) at the data archive at Canada’s data center.

2. Scientific and Observing System Accomplishments

The global drifter array became the first component of the IOOS that reached completion, with 1250 
active drifters in September 2005. Until FY11, this number was approximately maintained on average; 
in FY11, many drifters exhibited abnormally short lifetimes and by the end of FY11 the array size had 
rapidly dropped below the goal of 1250 despite increased deployments. During FY12, the GDP 
interacted with the manufacturers to diagnose manufacturing problems and recall/repair/redploy 
drifters, and drifters from two new manufacturers (DBi and SIO) were built and deployed. In FY12, the 
array size dropped from 1049 (3-Oct-2011) to a minimum of 875 on 15-Apr-2012. At that point, 
deployments (which had been aggressively ramped up) began to outpace deaths and the array size began 
increasing at a mean rate of 35—40 each month, to reach 1069 on 24-Sep-2012. In FY13, a then-record 
number of drifters were deployed (1427 drifters deployed in the period 1-Oct-2012 to 30-Sep-2013), but 
death rates continued to increase through late 2012. The SIO component of the GDP, aided by analysis 
from AOML’s component, worked aggressively to diagnose the cause of drifter deaths and determined 
that two main problems were primarily responsible: (1) increased power consumption associated with 
use of the Argos-3 system and/or inefficient GPS fixes, and (2) decreased battery life due to problems 
with the alkaline batteries or with the battery packs. The GDP issued revised recommendations based 
on this diagnosis. Through FY14, a record number of deployments (1556) were conducted in 
coordination with national and international GDP partners, and the lifetimes of these drifters 
demonstrably increased. As a consequence of these actions, and implementation of improved 
deployment strategies (see Section 2.6), the death rate dropped from ~138 deaths per 1250 drifters per 
month in early 2013 to <80 deaths per 1250 drifters per month now. Combined with the increased 
deployments, the size of the array recovered from 1051 drifters on 30 Sep 2013 to 1382 drifters on 29 
Sep 2014. The array size now (17 Nov 2014) stands at 1393 drifters.

2.1 Deliverables

The FY14 work plan outlined the following deliverables:

1. medata files maintained that document information for each drifter deployed in the 
global array. Information includes manufacturer, deployment time, and deployment 
location, the “death” location and time, and the time of drogue loss. Status: 
Accomplished.

2. On a quarterly basis, the GDP’s drifter Data Assembly Center (DAC) will produce a 
dataset of quality-controlled, evenly-interpolated drifter data of research quality. This 
data set will be archived at AOML and at Canada’s buoy data management center for 
public access. Status: Accomplished.

2. The DAC will continue to produce products derived from the drifter observations 
including time-mean and seasonal maps of currents, animations of currents in particular 
regions, and population reports. These products are publicly available at 
Status: Accomplished.
In FY14, all data deliverables were achieved. A delay of six months, compared to the goal of three months delay, was experienced for delayed-mode QC data in much of the FY due to failure of the VAX system at AOML, and manpower needed to transition operations to the UNIX system; this transition is now completed, quality-controlled data is currently available through 30 June 2014 at http://www.aoml.noaa.gov/envids/gld/, and the next update is expected to return to three month delay from real-time. Data through December 2013 have been archived at Canada’s buoy management center. All drifter data were made available in near-real time via the Global Telecommunications System. The drifter data management plan is described in the OceanObs’09 Community White Paper “Data Management System for Drifting Buoys” by Keeley, Pazos and Bradshaw, available at http://www.oceanobs09.net/blog/?p=225.

2.2 Analysis of the global drifter array size: deployments and deaths

During the fiscal year, the Surface Drifter Program coordinated worldwide deployments of 1556 drifters, an all-time high for the program (the previous record, in FY13, was 1427). AOML managed observations from 2535 unique drifters during FY14. Deployments for the major manufacturers are tabulated in Table 1 and shown in Fig. 1.

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clearwater</td>
<td>469</td>
<td>390</td>
<td>355</td>
<td>445</td>
<td>4</td>
<td>409</td>
<td>168</td>
<td>69</td>
</tr>
<tr>
<td>DBi</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>158</td>
<td>280</td>
<td>152</td>
</tr>
<tr>
<td>Marlin-Yug</td>
<td>6</td>
<td>17</td>
<td>24</td>
<td>10</td>
<td>0</td>
<td>7</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Metocean</td>
<td>220</td>
<td>143</td>
<td>216</td>
<td>199</td>
<td>219</td>
<td>153</td>
<td>100</td>
<td>109</td>
</tr>
<tr>
<td>Pacific Gyre</td>
<td>113</td>
<td>270</td>
<td>264</td>
<td>231</td>
<td>357</td>
<td>199</td>
<td>281</td>
<td>258</td>
</tr>
<tr>
<td>SIO</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>103</td>
<td>256</td>
<td>79</td>
</tr>
<tr>
<td>Technocean</td>
<td>274</td>
<td>175</td>
<td>279</td>
<td>394</td>
<td>252</td>
<td>29</td>
<td>21</td>
<td>33</td>
</tr>
</tbody>
</table>

Table 1: deployments per calendar year by manufacturer. Values for 2014 are for Jan-June.
A time series of the number of drifters in the global array is shown in Fig. 2. The GDP seeks to maintain an annually averaged array size of 1250 drifters. The mean size of the array in FY14 was 1207 with a standard deviation of 148, and ranged from a minimum of 1011 on 25-Nov-2013 to a maximum of 1401 on 23-Jun-2014 (the average during FY13 was 990, ranging from a minimum of 898 to a maximum of 1087).

Drifter deaths are caused by “internal” reasons such as battery failures or hull leakage, and “external” reasons such as running aground or being picked up. The odds that each drifter died due to an external reason can be assessed for each drifter (Lumpkin et al., 2012). Table 2 shows the half-life of “quit” drifters due to internal reasons for each major manufacturer, as a function of calendar year, after eliminating all drifters which had a >25% chance that its death was due to dying or running aground, and also deaths poleward of 55°N/S (as they could be due to ice interaction). Values for the most recent year are for January through June. Values are shown as a percentage of the number of drifters deployed that year; values much greater than 100 indicate many more “quit” deaths than deployments that year.
Table 2: half-life (days) of “quit” drifters, by manufacturer and calendar year. Values for 2014 are for Jan-June. “*” indicates no data that year to calculate results. “>X” indicates a minimum value, as more than half were still alive as of the calculation.

Table 3 shows the percent of drifters that quit <90 days after being deployed. This was calculated by dividing the number that anomalously “quit” 0—90 days after deployment, divided by the number deployed in each year. These extremely short-lived drifters indicate recent major manufacturing problems or, in individual cases, problems such as improper deployment from a particular vessel.

Table 3: percent dying <90 days after deployment, by manufacturer and calendar year.

2.3 Evaluating the ocean observing system for Sea Surface Velocity (SSV)

The GOOS includes an array of moored and drifting buoys that measure SST and near-surface currents throughout the world’s oceans. The success of the GOOS in resolving surface currents is evaluated by the project “Evaluating the Ocean Observing System: Sea Surface Velocity (SSV)”, funded at $31,200 for FY14. This evaluation is motivated by the climate significance of surface currents, which carry massive amounts of heat from the tropics to subpolar latitudes, leading (and potentially improving prediction of) SST anomalies. Current anomalies can also be an early indicator of phase shifts in the ENSO, NAO, and possibly other climate cycles. The GOOS/GCOS (1999) report specified that the GOOS should resolve surface currents at 2 cm/s accuracy, with one observation per month at a spatial resolution of 600 km. There is currently no requirement for potential satellite bias in surface currents.

The goal of the SSV add-task is to maintain a quarterly “Observing System Status Report for Surface Currents”, which evaluates how well the GOOS satisfied the GOOS/GCOS requirements, and evaluate the evolution of the globally averaged potential satellite bias. Near-real time drifter data is obtained at weekly resolution from the Global Drifter Program’s drifter Data Assembly Center (DAC). The DAC
identifies drifters which have run aground or been picked up, and removes these from the data stream. The DAC separate maintains a metadata file documenting the drogue-off date (date when each drifter lost its sea anchor). When a drifter has lost its drogue, it is significantly affected by direct wind forcing and no longer satisfies the GOOS/GCOS quality requirement for surface current measurement accuracy. We thus eliminate drogue-off drifters from our analysis. Because of the recent reevaluation of drogue presence (see section 2.5 of this report) which determined earlier drogue off dates for many drifters in the historical data set, the assessment of the GOOS’s performance has become more pessimistic than prior to this reevaluation.

Moored current measurements are collected by near-surface point acoustic meters on the Tropical Atmosphere-Ocean (TAO)/TRITON array in the Pacific, the Prediction and Research moored Array in the Tropical Atlantic (PIRATA), the sustained array of ATLAS moorings in the tropical Indian Ocean (RAMA), the Kuroshio Extension Observatory (KEO) mooring at 32.3°N, 144.5°E and the PAPA mooring at 50°N, 145°W. Currents at daily resolution are downloaded from the TAO Project Office at PMEL each quarter to quantify the number of observations at each site, and the TAO office separately provides a record of days of observations per site, per quarter.

The most recent SSV quarterly report (Fig. 4) presents the overall spatial coverage of surface current measurements for that quarter (top right), the spatial distribution of success at meeting GOOS/GCOS requirements (bottom left, requirements stated in top left panel), and a time series showing the month-by-month fraction of the world’s oceans that were measured at the resolution and accuracy stated by these requirements (bottom right). Since 1995, the success of the GOOS as hovered at 30—40% of complete global coverage. This curve does not increase with the increase in the global drifter array size in 2003—2006, primarily because the phase-in of the less expensive mini drifter design was concurrent with a sharp decrease in drogue lifetimes (Lumpkin et al., 2012). Note that some fraction of the recent uptick in coverage may be an artifact of drogue detection which is conducted in delayed mode, and is reevaluated upon release of the quality-controlled GDP data set on an approximately quarterly basis. However, this caveat is only true for data after June 2014; much of the increase predates this, and thus represents true progress in maintaining a larger array of drogued drifters for SSV measurements.

With support from the SSV project, PI Lumpkin worked with G. Johnson (NOAA/PMEL) to generate a new surface current climatology at monthly and ½ degree resolution, as noted in last year’s report. The climatology includes annual means, monthly means, the current component related to the ENSO cycle, and the variance ellipses of residuals (eddy kinetic energy) with respect to these time-mean components. The SSV project provides the support necessary for PI R. Lumpkin to generate periodic updates of the surface current climatology products in various formats and to offer them on the GDP web page at http://www.aoml.noaa.gov/phod/dac/dac_meanvel.php.
2.4 Drogue detection and lifetimes

While a drifter’s drogue is attached, it slips downwind at <1 cm/s in 10 m/s wind. Once the drogue is lost, however, this increases by approximately a factor of 10 and wind forcing can significantly contaminate drifter-derived currents. Drogue presence is detected by either a submergence sensor, as the drogue frequently pulls the surface float under water, or more directly by a tether strain sensor at the tether/surface float connection.

With the ability to reassess drogue loss in the historical data set (Lumpkin et al., 2013), we have conducted an evaluation of drogue lifetime by manufacturer. As a function of calendar year, the half-lives of drogues from the various manufacturers, in days, is given in Table 4.

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clearwater</td>
<td>72</td>
<td>101</td>
<td>104</td>
<td>95</td>
<td>84</td>
<td>&gt;293</td>
<td>&gt;356</td>
</tr>
<tr>
<td>DBi</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>279</td>
<td>228</td>
<td>242</td>
</tr>
<tr>
<td>Marlin-Yug</td>
<td>152</td>
<td>72</td>
<td>57</td>
<td>167</td>
<td>*</td>
<td>0</td>
<td>*</td>
</tr>
<tr>
<td>Metocean</td>
<td>&gt;373</td>
<td>269</td>
<td>224</td>
<td>77</td>
<td>89</td>
<td>110</td>
<td>&gt;210</td>
</tr>
<tr>
<td>Pacific Gyre</td>
<td>210</td>
<td>206</td>
<td>241</td>
<td>248</td>
<td>207</td>
<td>&gt;228</td>
<td>&gt;200</td>
</tr>
<tr>
<td>SIO</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>66</td>
<td>&gt;164</td>
<td>0</td>
</tr>
<tr>
<td>Technocean</td>
<td>45</td>
<td>33</td>
<td>63</td>
<td>74</td>
<td>154</td>
<td>&gt;62</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 4: drogue half-lives (days), by manufacturer and calendar year.

The fraction of drogues that were lost in 90 days or less is shown in Table 5.
Table 5: fraction of drifters with drogues loss 90 days or less after deployment.

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clearwater</td>
<td>55%</td>
<td>36%</td>
<td>30%</td>
<td>36%</td>
<td>39%</td>
<td>14%</td>
<td>4%</td>
</tr>
<tr>
<td>DBi</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>25%</td>
<td>11%</td>
<td>12%</td>
<td></td>
</tr>
<tr>
<td>Marlin-Yug</td>
<td>0%</td>
<td>41%</td>
<td>46%</td>
<td>40%</td>
<td>*</td>
<td>43%</td>
<td>*</td>
</tr>
<tr>
<td>Metocean</td>
<td>13%</td>
<td>17%</td>
<td>26%</td>
<td>40%</td>
<td>46%</td>
<td>35%</td>
<td>14%</td>
</tr>
<tr>
<td>Pacific Gyre</td>
<td>20%</td>
<td>21%</td>
<td>17%</td>
<td>10%</td>
<td>16%</td>
<td>21%</td>
<td>9%</td>
</tr>
<tr>
<td>SIO</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>40%</td>
<td>22%</td>
<td></td>
</tr>
<tr>
<td>Technocean</td>
<td>65%</td>
<td>78%</td>
<td>53%</td>
<td>46%</td>
<td>27%</td>
<td>31%</td>
<td>29%</td>
</tr>
</tbody>
</table>

The GDP is examining these results in the context of design changes, particularly tether material and drogue attachment technique, so that recommendations to improve drogue lifetimes can be issued to the manufacturers.

2.5 Development of an hourly drifter product

Led by co-investigator Renellys Perez, in collaboration with PI Lumpkin and Dr. Shane Elipot (Univ. Miami), the Global Drifter Program at AOML is currently developing an hourly drifter product to complement the standard six-hourly product offered since the earliest days of the Global Drifter Program. The new product will contain data commencing in late 2004, when Argos drifters switched to multisatellite processing and data resolution increased to a global average of one observation every 1.2h per drifter (Elipot and Lumpkin, 2008). The product is being tested using “truth” offered by GPS drifters and also by simulated drifters with spectral characteristics matching the observations. Various interpolation schemes, such as kriging, local polynomial fitting, and weighted polynomial fitting, are being evaluated for this product. The product will be extremely valuable for research into high frequency motion such as near-inertial oscillations, tidal fluctuations and submesoscale structures.

2.6 Development of improved deployment tools

Shaun Dolk (drifter operations center manager) and R. Lumpkin developed a tool to optimize drifter deployments: the deployment value map (http://www.aoml.noaa.gov/phod/dac/doc_valuemaps.php). To create these maps, the current array is projected into the future using climatological average currents and planned deployments. Each drifter is evaluated for how many sensors (including drogue presence) are working, with higher deployment value placed in areas corresponding to no or poorly-performing drifters. Areas are also evaluated for historically high death rates due to drifters dying or running aground, and the value is decreased in these regions (the value goes to zero if the expected lifetime drops below 65 days). Code was developed to input a cruise track, interpolate the values onto the track, and pick five-degree spaced coordinates that maximize the deployment values; these coordinates can then be relayed to the ship. The value maps are also being used by partners such as the US Navy that cannot reveal cruise plans ahead of deployment. The maps are offered globally as well as in individual regions, and in ASCII format for those interested in creating their own versions of the maps.
2.7 Scientific advances

Foltz, G. R., C. Schmid and R. Lumpkin, 2013 (Seasonal Cycle of the Mixed Layer Heat Budget in the Northeastern Tropical Atlantic Ocean. *J. Climate*, 26, 8169–8188, [http://dx.doi.org/10.1175/JCLI-D-13-00037.1](http://dx.doi.org/10.1175/JCLI-D-13-00037.1)) used drifter-derived velocities and observations at the PIRATA moorings, along with other observations and products, to quantify the mixed layer heat budget in the region 0°–25°N, 18°–28°W. Three distinct regimes within this region are identified: a trade wind region (15°–25°N), the ITCZ core region (3°–8°N) and the Equatorial region, each characterized by different terms in the heat budget with different timings. These results emphasize the importance of the surface heat flux and vertical turbulent mixing for the seasonal cycle of mixed layer heat content in the northeastern tropical Atlantic.

Fox-Kemper, B., R. Lumpkin and F. Bryan, 2013 (Lateral Transport in the Ocean. Chapter 8 of "Ocean Circulation and Climate, 2nd Ed. A 21st century perspective", ed. G. Siedler, S. Griffies, J. Gould and J. Church, Academic Press, pp. 185-205, [http://dx.doi.org/10.1016/B978-0-12-391851-2.00008-8](http://dx.doi.org/10.1016/B978-0-12-391851-2.00008-8)) reviews the role of lateral transport, including transport driven by eddy mixing, including new results using ocean models and the most recent set of global drifter observations.


Le Hénaff, M., V. H. Kourafalou, R. Dussurget and R. Lumpkin, 2014 (Cyclonic activity in the eastern Gulf of Mexico: characterization from along-track altimetry and in situ drifter trajectories. *Progress in Oceanogr.*, 120, 120-138, [http://dx.doi.org/10.1016/j.pocean.2013.08.002](http://dx.doi.org/10.1016/j.pocean.2013.08.002)) characterizes the structure, frequency of occurrence, and evolution of cyclonic frontal eddies that have a strong effect on the evolution of the Loop Current Retroreflection and formation of Loop Current Rings in the Gulf of Mexico, using satellite and drifter observations.


affected advection of oil spilled during the Deepwater Horizon oil spill of 2010. Drifter observations were an extremely important ground truth for altimetry-derived fields, indicating before those fields did that Loop Current Ring “Franklin” had separated from the Loop Current and that advective connectivity between the northern Gulf and the Loop Current had been terminated. The trajectories of all drifters in the GDP data base reveal that the west coast of Florida is relatively less exposed than is the east coast for a spill at the DWH site during climatological conditions.

3. Outreach and Education

PI R. Lumpkin worked with Dr. Diane Stanitski, Shaun Dolk, and members of Education Development Center, Inc (EDI) to incorporate drifter data in the “Ocean Tracks” project. This NSF-funded project seeks to streamline student access to and use of ocean data with accompanying exercises of increasing difficulty. Lumpkin also served on the Ph.D. thesis committees for University of Miami students Greta Leber (Lisa Beal, advisor), Thania Papapostolou (Bill Johns, advisor), and Matt Archer (Nick Shay, advisor), reviewed numerous manuscripts and proposals, and collaborated with authors from NOAA’s climate.gov web site on numerous occasions.

Co-investigator R. Perez gave a presentation on “Sea Level Rise” during a panel discussion entitled "The Future of Fort Lauderdale: Protecting our Paradise against Rising Seas and Stronger Storms" for the Broward County young professional community. She also mentored three MAST high school students for a week on developing a demonstration on buoyancy. She gave a presentation for children attending the NOAA/AOML Bring Your Child to Work Day involving a demonstration on convective ocean currents. She also gave a presentation for Immaculate Conception School 3rd to 5th grade students on the importance of the oceans. She was a guest lecturer for dual-enrolment college and high school Oceanography class at the Maritime and Science Technology (MAST) Academy, and gave a Career Day presentation at Somerset Academy Silver Palms School to middle/high school students.

4. Publications and Reports

4.1. Publications by Project Investigators

FY2015

Submitted

Dong, S., G. Goni and R. Lumpkin: Mixed-layer salinity budget in the SPURS region on seasonal to interannual time scales and its link to large-scale dynamics. Submitted to TOS Oceanography special issue for SPURS, August 2014.


Accepted/In Press


Published


FY2014


4.2. Other Relevant Publications (not by project investigators)


5. Slides

NOAA’s Global Drifter Program

Mixed layer currents, sea surface temperature, atmospheric pressure, winds and salinity

www.aoml.noaa.gov/phod/dac/gdp.html

FY14: global array averaged 1207 drifters, currently at 1393. A record number of drifters, 1556, were deployed in FY14, while the death rate per 1250 drifters dropped precipitously.

Data, products and more information at the GDP web page.

Rick Lumpkin, NOAA/AOML

FY14 Global Drifter Program scientific achievements

Understanding the structure and evolution of frontal eddies

Right: looping trajectory of a drifter (blue) trapped in a Loop Current Frontal Eddy (LCFE) within the Gulf of Mexico and concurrent altimeter pass (black). These observations were used to characterize the structure, frequency of occurrence, and evolution of LCFEs (Le Hénaff et al., 2014).

Evaluating advective pathways from the DWH spill site

Left: trajectories of all drifters in the GDP data base after passing within the heavy circle and closest to the site of the location of the Deepwater Horizon oil spill. The trajectories reveal that the west coast of Florida is relatively less exposed than is the east coast during climatological conditions. Drifter trajectories concurrent with the spill, along with currents estimated from altimetry, revealed that the Loop Current was separated from a large ring and the advective pathway to east Florida was not at that time available. From Smith et al. (2014).