North Pacific subtropical-subpolar transitional areas as ventilation windows of the both gyres

“How has Argo improved our understanding? –An example”

Toshio Suga
Tohoku University/JAMSTEC
Symposium in 2002

Easter and Western North Pacific Transitional Areas Symposium

April 23 to 25, 2002
La Paz, B.C.S., Mexico

North Pacific Marine Science
Centro de Investigaciones Biol
Centro Interdisciplinario de C

Drs. Brenda Norcross, Francisco E. Werner and Toshio Suga etc. dancing with Mexican performers.
Requests from the symposium coordinator/conveners

To present:

• approaches and results on how Argo can address challenges in monitoring/observing Pacific transitional areas

and/or

• how Argo data can be used in documenting changing strength and position of major fronts in both the North and South Pacific

But

• Argo is designed to resolve large-scale features and won’t resolve fronts in general.

• I’ll thus focus on larger or more smoothed features in the transitional area today.
Introduction

Pre-Argo winter ML climatology (Suga et al., 2004)  
**North Pacific Transitional Area**

- **Western/central transitional areas**
  - Density compensating T/S fronts
  - Meridional maximum of winter surface density $\sim 26.0-26.6 \sigma_\theta$
  - Deep winter mixed layer $> 200$ m


  - A unique region to ventilate the densest part of the North Pacific pycnocline, influencing surface-subsurface exchanges of T/S/O/N/C, etc.
How can Argo refine our view of the North Pacific Transitional Area (NPTA) as a ventilator of the densest part of pycnocline?

- To exemplify approaches and results on how Argo can address challenges in monitoring/observing Pacific transitional areas.
Introduction

• Argo: Coverage and Products
• North Pacific Transitional Area (NPTA) as a ventilator viewed from Argo gridded data
• Use of individual profile data
• Argo: Status and Challenges
• Argo started in 2000.
• Global Argo coverage has been maintained since 2007.
• Argo’s coverage in the Pacific Ocean has been in good shape since 2005.
Argo: Coverage

- Temporally and spatially unbiased sampling of Argo has improved our ability to monitor the oceans.
- While Argo won’t resolve fronts and meso-scale features,
- Seasonal to decadal variation of large scale features can be tracked by several gridded data products based on Argo.
# Argo: Products

Global fields based on Argo  [http://www.argo.ucsd.edu/Gridded_fields.html](http://www.argo.ucsd.edu/Gridded_fields.html)

<table>
<thead>
<tr>
<th>Institution</th>
<th>Documentation</th>
<th>Gridded field description</th>
<th>Data Source</th>
<th>Spatial resolution</th>
<th>Vertical resolution</th>
<th>Temporal coverage</th>
<th>Temporal resolution</th>
<th>Update frequency</th>
<th>Access</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copernicus Environmental Monitoring Service - Coriolis</td>
<td>Global gridded NetCDF dataset produced by optimal interpolation yearly (CORAS)</td>
<td>Argo plus others</td>
<td>1/2 degree global, 250 levels to 2000 m</td>
<td>1950 - year N-2 monthly</td>
<td>yearly</td>
<td>data access website</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CSIRO</td>
<td>Global gridded NetCDF or Matlab dataset produced by the Barnes Method (BOA-Argo)</td>
<td>Argo plus others</td>
<td>0.5 degree 50 levels to 1975 m</td>
<td>1950 to May 2009 Mean and seasonal sinusoids rarely</td>
<td>Instructions via &quot;Access&quot; section of website</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fremer/LPO</td>
<td>Global gridded NetCDF dataset produced by LOES filter from all profile data including Argo but excluding bathythermograph. Also seasonal dynamic height and MLD, &quot;CAR52009&quot;</td>
<td>Argo only</td>
<td>0.5 degree 80 levels to 2000 m</td>
<td>All Argo, updated ~3 monthly</td>
<td>Mean and seasonal sinusoids rarely</td>
<td>Instructions via &quot;Access&quot; section of website</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fremer/LPO</td>
<td>Global gridded NetCDF dataset produced by LOES filter from all Argo. Also seasonal dynamic height and MLD, &quot;CAR52009&quot;</td>
<td>Argo only</td>
<td>0.5 degree 50 levels to 1975 m</td>
<td>1950 to May 2009 Mean and seasonal sinusoids rarely</td>
<td>Instructions via &quot;Access&quot; section of website</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>JAMSTEC</td>
<td>Global gridded NetCDF dataset produced by optimal interpolation from Argo only profiles (Arleq altimeter for Absolute Dynamic Topography fields)</td>
<td>Argo plus others</td>
<td>1/2 degree, 151 levels to 2000 m</td>
<td>2002 - 2012 monthly</td>
<td>rarely</td>
<td>website email for data access: <a href="mailto:fabienne.gallard@fremer.fr">fabienne.gallard@fremer.fr</a></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>JAMSTEC</td>
<td>Global gridded NetCDF dataset produced by optimal interpolation from all available data including Argo. MOAA GPV (Grid Point Value of the Monthly Objective Analysis using Argo data)</td>
<td>Argo only</td>
<td>1 degree global, 25 levels to 2000 m</td>
<td>Since 2001-01-01 monthly</td>
<td>monthly</td>
<td>website access</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MI3 Office</td>
<td>Global gridded NetCDF of Mixed Layer Depth with its related parameters. MILA GPV (Mixed Layer data set for Argo, Grid Point Value)</td>
<td>Argo only</td>
<td>1 degree, 42 levels to 1500 m</td>
<td>Since 2001-01-01 monthly</td>
<td>monthly</td>
<td>website access</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NOAA/PMEL / University of East Anglia</td>
<td>Global gridded NetCDF objective analyses produced from all types of data including Argo (EN4 dataset)</td>
<td>Argo only</td>
<td>0.5 degree 81 levels to 1950 m</td>
<td>Since 2001-01-01 monthly</td>
<td>monthly</td>
<td>website access</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scripps Institution of Oceanography</td>
<td>Global gridded NetCDF and Matlab Mixed Layer Depth climatology</td>
<td>Argo only</td>
<td>1 degree global, 50 levels to 2000 m</td>
<td>Since 2004-01-01 monthly</td>
<td>monthly</td>
<td>website access</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scripps Institution of Oceanography</td>
<td>Global gridded NetCDF Argo only dataset produced by optimal interpolation</td>
<td>Argo only</td>
<td>1 degree global, 50 levels to 2000 m</td>
<td>Since 2004-01-01 monthly</td>
<td>monthly</td>
<td>website access</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**MOAA GPV** (Grid Point Value of the Monthly Objective Analysis using Argo data) produced by JAMSTEC (Hosoda et al., 2008)
NPTA as a ventilator viewed from Argo data

- Updated climatology of winter MLD and ML density
- Western/central NPTAs fields similar to the historical climatology, but…

MLD & SSD: winter climatology (Toyama et al., 2015)
NPTA as a ventilator viewed from Argo data

Mixed layer depth in March (Toyama et al., 2015)

Significant interannual variation in MLD
NPTA as a ventilator viewed from Argo data

Annual subduction rate (Toyama et al., 2015)

Large variability in spatial distribution and intensity of subduction
NPTA as a ventilator viewed from Argo data

Annual obduction rate (Toyama et al., 2015)

Large variability in spatial distribution and intensity of obduction
NPTA as a ventilator viewed from Argo data

• Net exchange rate (S+O) varies from nearly zero to >10 Sv.
• Interannual variation of net exchange rate appears largely related to PDO.
• Large scale anomalies are tracked by Argo gridded data.

• How does this change affect biogeochemical properties in ML and pycnoclines?
• **Biogeochemical Argo** would be a way to go to answer this question.
Use of individual profile data

(Oka et al., 2007)

Individual profiles contain information on smaller spatial/temporal scale variability ⇒ Further understanding of ventilation processes
Argo: Status and Challenges

Current design of Argo

Global Design - 3756 Floats
Target density values 3° x 3°, as confirmed at AST#18

February 2018

1 (3530) 2 (113)
Argo is healthy in terms of both global and Pacific coverages, while there is a decreasing trend in the float deployment.
The age of floats in the Pacific is higher than average. Keeping/improving float deployment intensity is our major challenge.

<table>
<thead>
<tr>
<th>Argo</th>
<th>Age</th>
<th>March 2018</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Profiling floats age distribution (in years)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt;1 year (703)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1-2 (791)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2-3 (582)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3-4 (593)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4-5 (404)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5-6 (200)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6-7 (0)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7-8 (357)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8-9 (60)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>9-10 (65)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt;10 years (95)</td>
<td></td>
</tr>
</tbody>
</table>

Mean = 3.25
Median = 2.65
BGC Argo is now in transition from “regional pilot” to “global pilot.”
The big hole of BGC Argo is in the North Pacific.
PICES could lead to promote BGC Argo in the Pacific Ocean!
Summary

• Argo has greatly improved our ability to monitor the North Pacific Transitional Areas in terms of their large scale variability.

• Individual Argo profile data set is a “bonanza” of new information even on smaller scale variability in the NPTAs.

• Argo is healthy in the global and Pacific oceans.

• Continuous efforts for keeping/improving float deployment is essential to sustain Argo.

• BGC Argo is mostly science driven.

• The North Pacific is the big hole of the global BGC Argo array.

• PICES could lead to promote BGC Argo in the North Pacific!