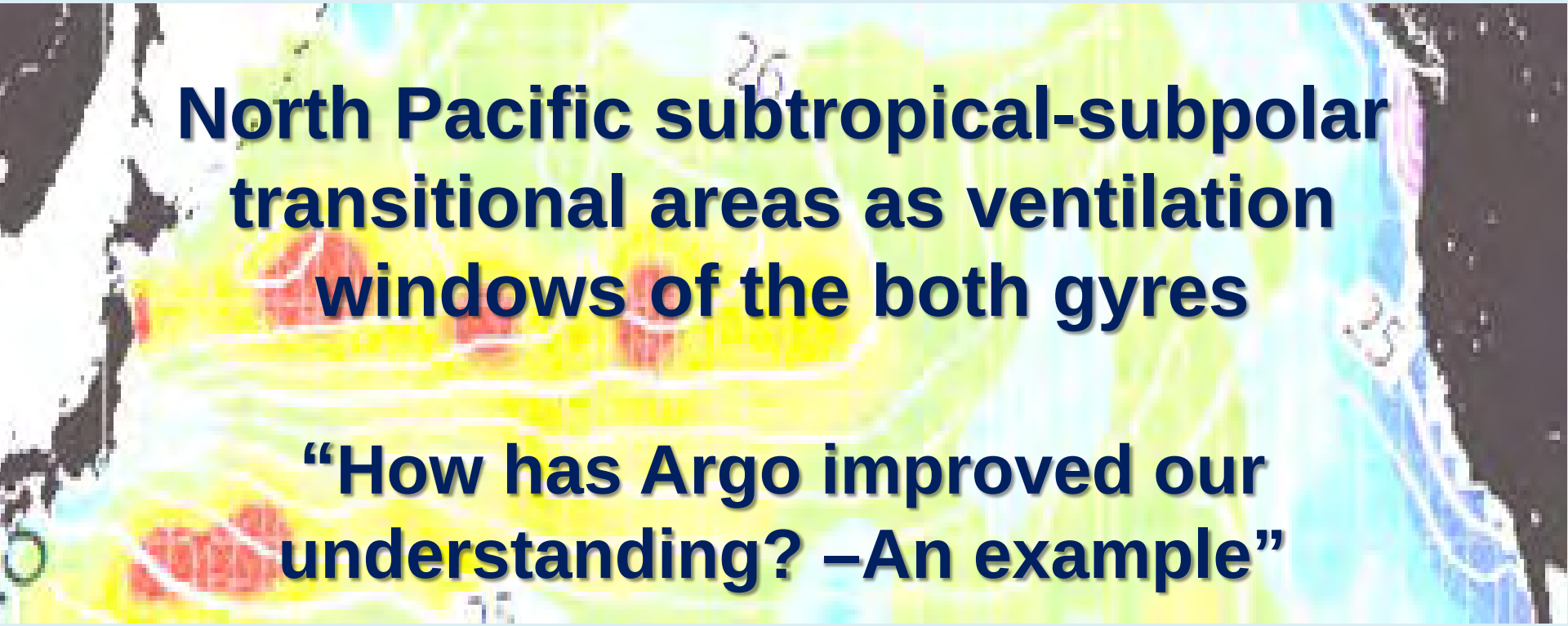
PICES international symposium on
"Understanding Changes
in Transitional Areas of the Pacific"
April 24-26, 2018, La Paz, Mexico

S3: Challenges in observing and modeling Pacific transitional areas



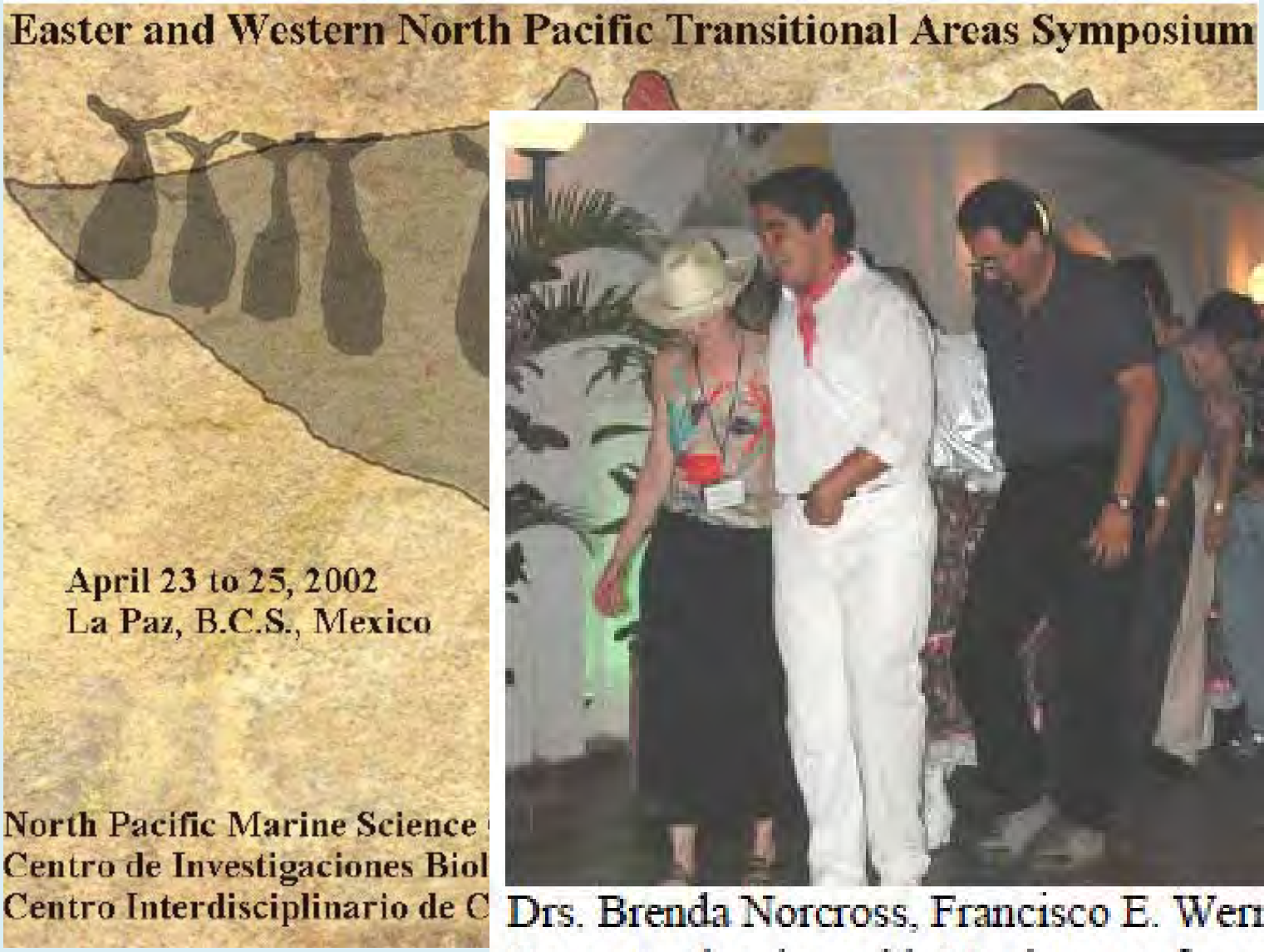
North Pacific subtropical-subpolar transitional areas as ventilation windows of the both gyres

"How has Argo improved our understanding? –An example"

Toshio Suga

Tohoku University/JAMSTEC

Symposium in 2002



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

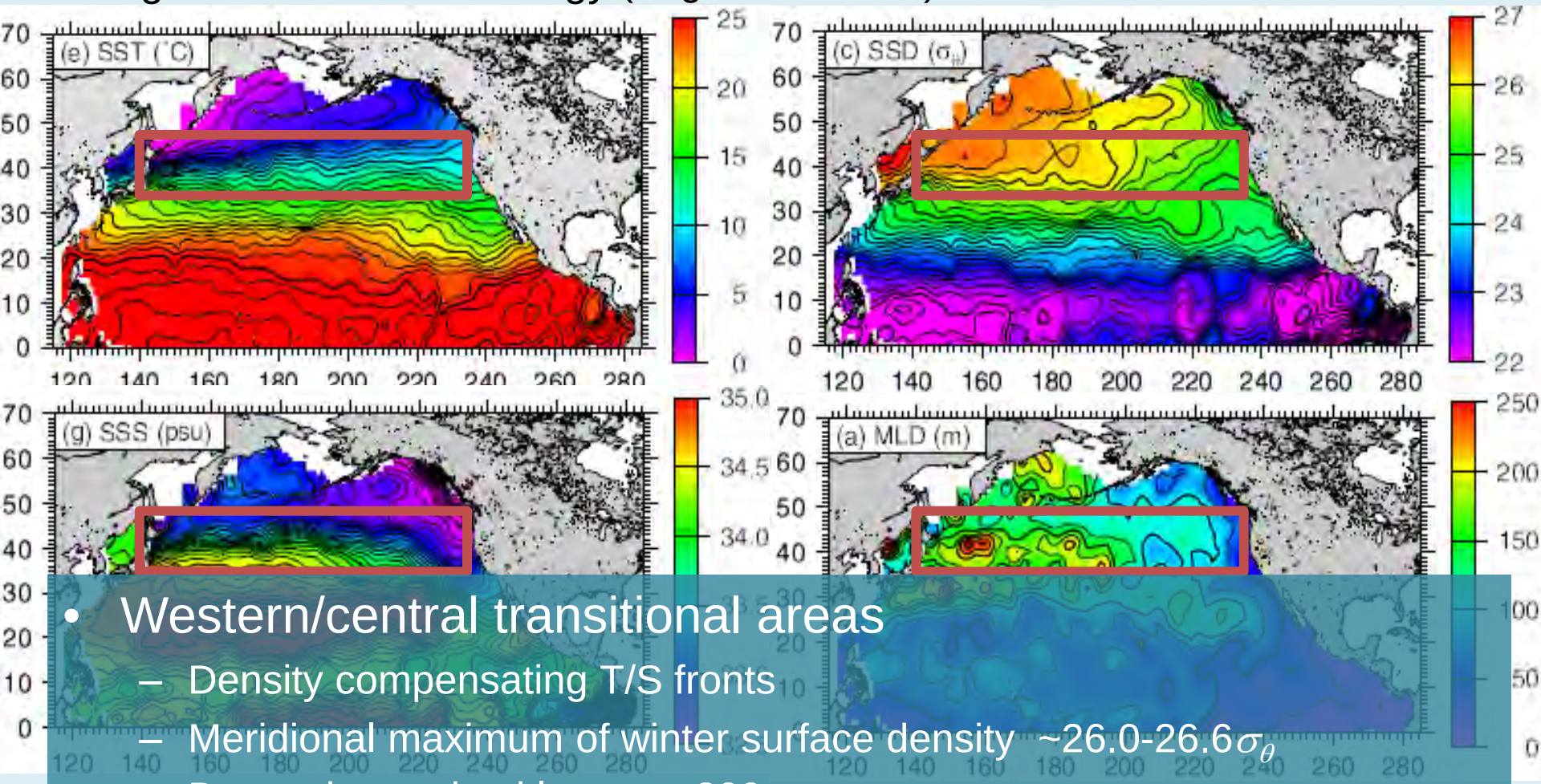
- how **Argo** data can be used in documenting changing strength and position of major fronts in both the North and South Pacific

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**

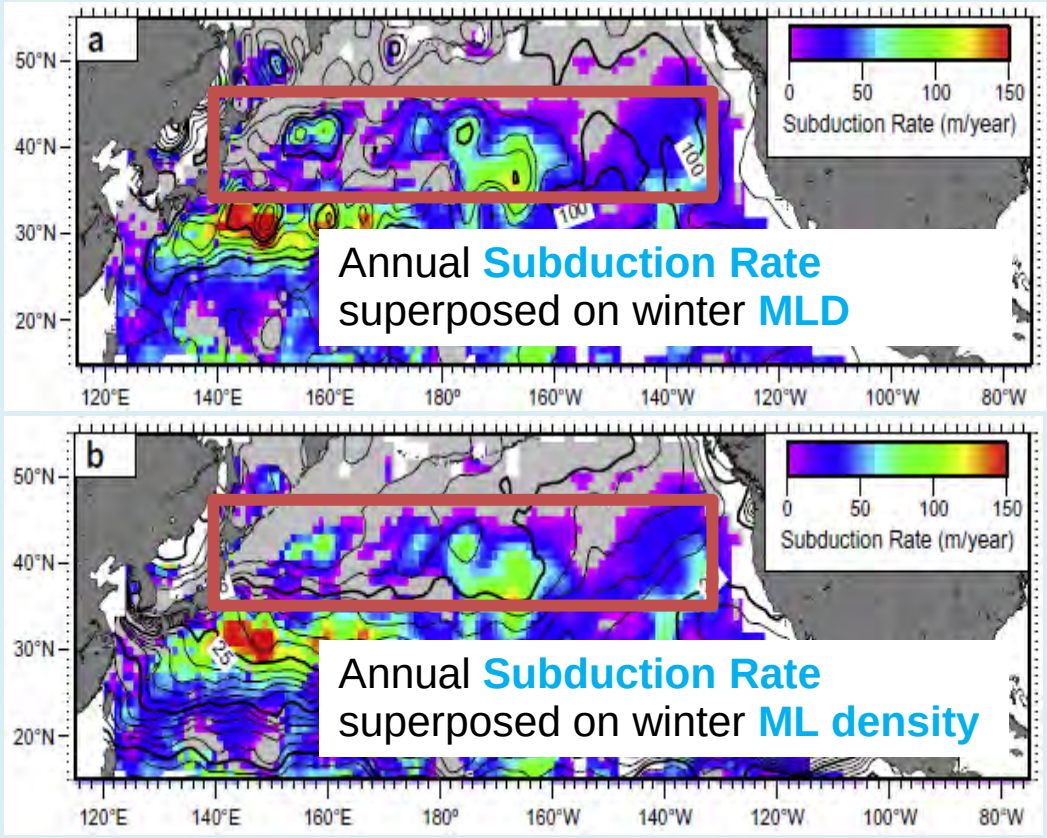


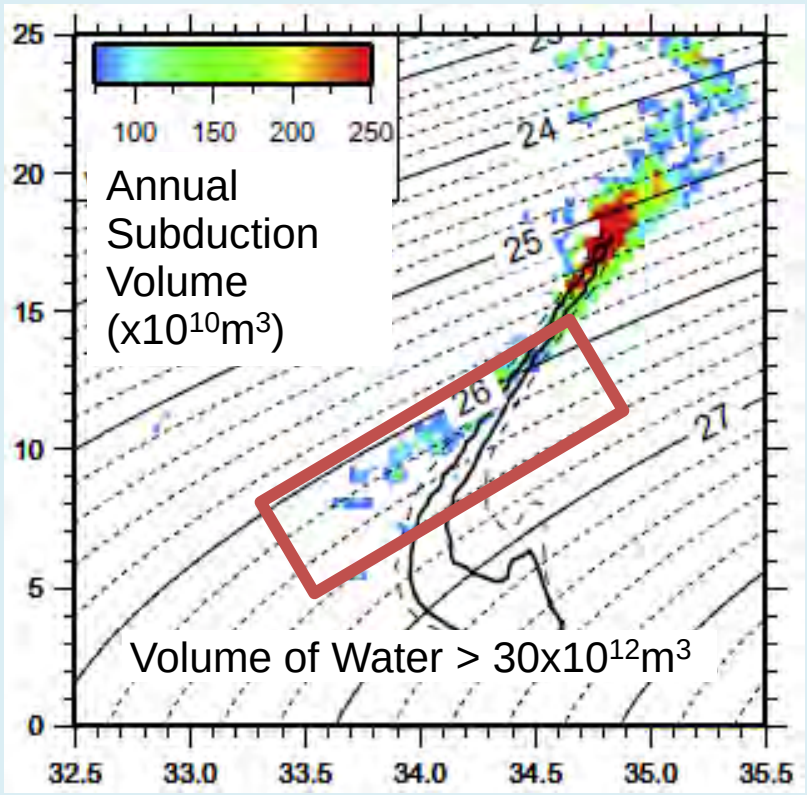
- Western/central transitional areas
  - Density compensating T/S fronts
  - Meridional maximum of winter surface density ~26.0-26.6σ_θ
  - Deep winter mixed layer > 200 m

    cf. “Stability gap” (Roden, 1970, 1972; Yuan & Talley, 1996)
  - A unique region to ventilate the densest part of the North Pacific pycnocline, influencing surface-subsurface exchanges of T/S/O/N/C, etc.

Introduction

Pre-Argo subduction climatology (Suga et al., 2008) **North Pacific Transitional Area**





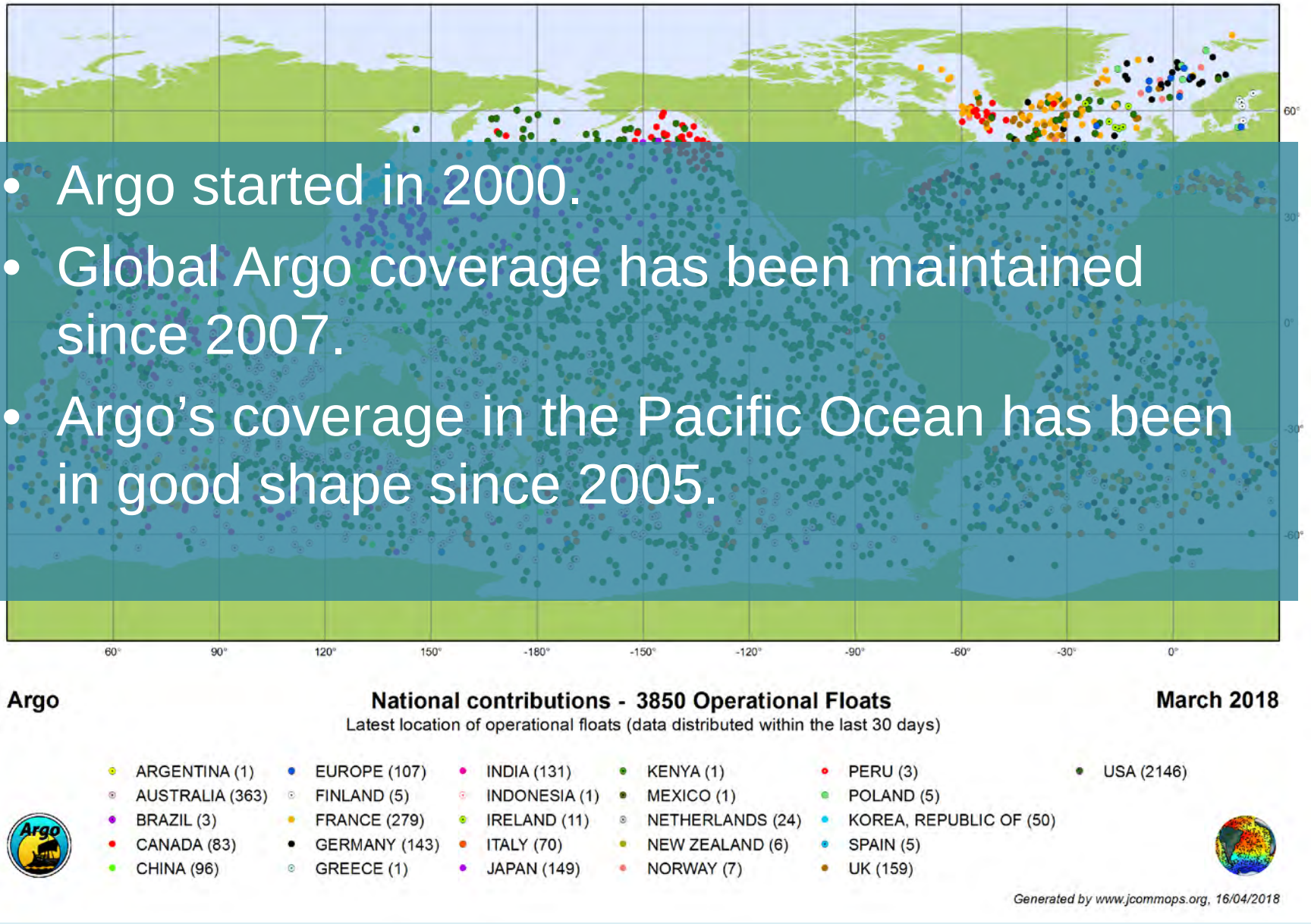
- How can Argo refine our view of the North Pacific Transitional Area (NPTA) as a ventilator of the densest part of pycnocline?
  - To exemplify approaches and results on how Argo can address challenges in monitoring/observing Pacific transitional areas

Outline

- ✓ 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

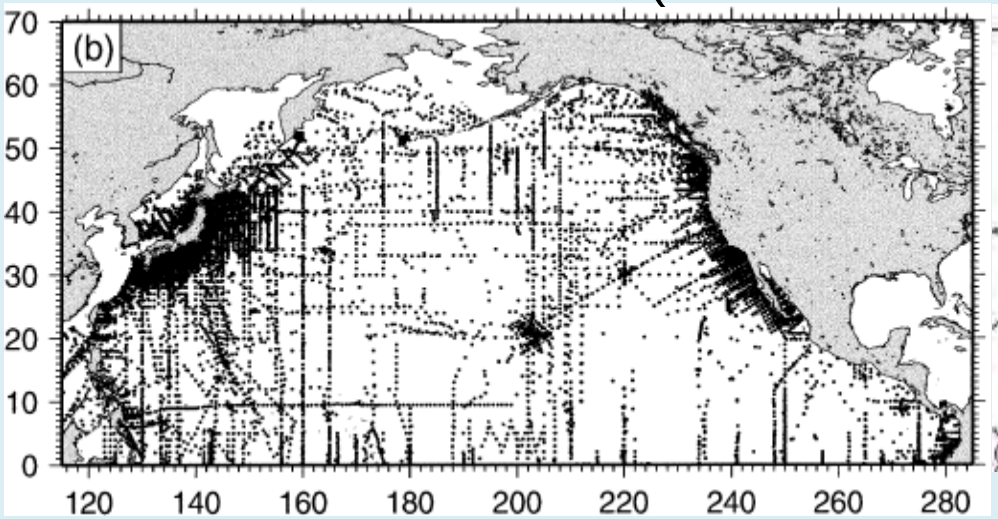
Argo: Coverage

- 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.

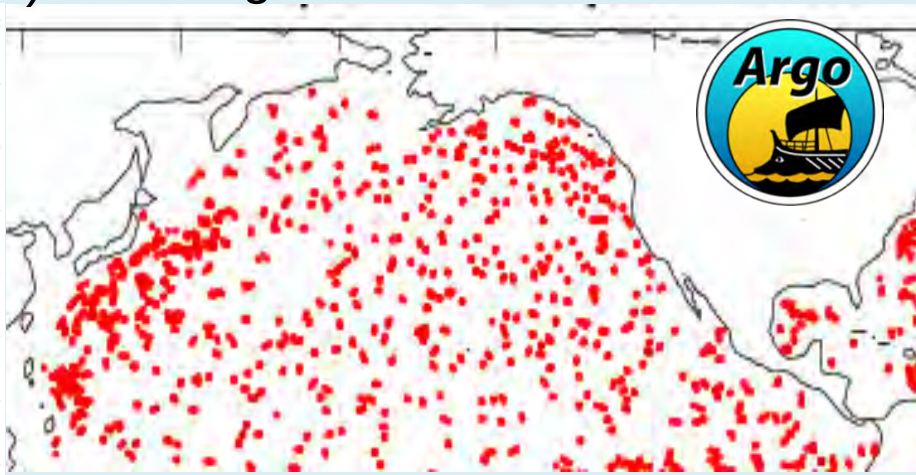


Argo: Coverage

Historical data in Feb/Mar (WOD98+WHP)



Argo floats in March, 2018



- Temporally and spatially unbiased sampling of Argo has improve 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

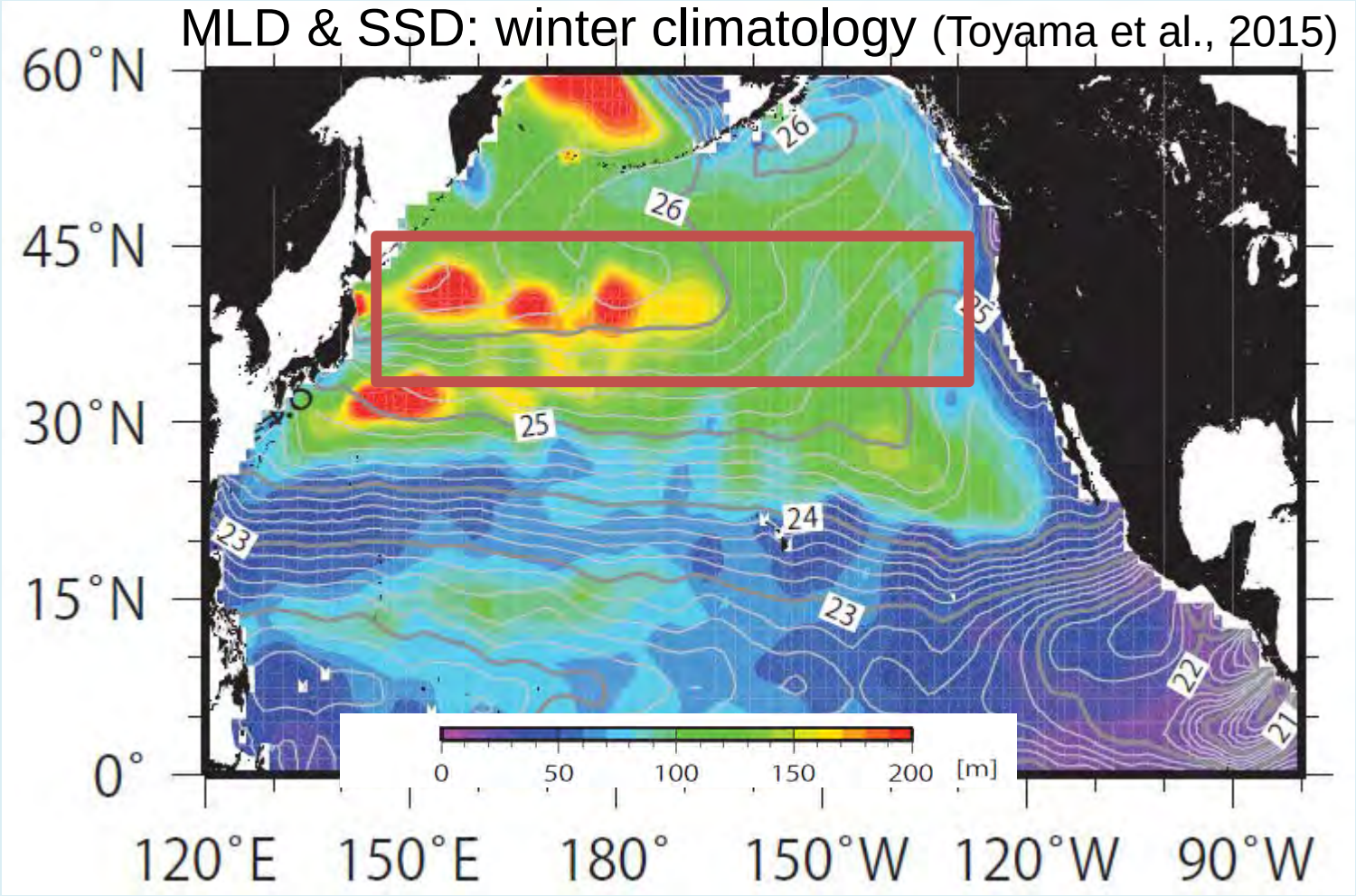
Global fields

Institution	Documentation	Gridded field description	Data Source	Spatial resolution	Vertical resolution	Temporal coverage	Temporal resolution	Update frequency	Access
Univ. Brest/Ifremer/ CNRS/IRD LOPS		**ISAS15: Global gridded NetCDF monthly fields and profile data base (2002-2015)**	- Argo only - Argo plus others	1/2 degree global	152 levels to 2000 m	2002 - 2015	monthly	every two years	**data access http://doi.org/10.17882/52367**
Copernicus Environment Monitoring Marine Service - Coriolis		**Global gridded NetCDF dataset produced by optimal interpolation yearly (CORA5)**	Argo plus others	1/2 degree global	250 levels to 2000 m	1950 - year N-2	monthly	yearly	**data access website**
CSIO		**Global gridded NetCDF or Matlab dataset produced by the Barnes Method (BOA-Argo) Includes temperature, salinity, isothermal layer depth, mixed layer depth and composed mixed layer depth**	Argo	1 degree global	58 levels to 1975 dbar	2004 - 2016	monthly	yearly	**data access**
CSIRO		**Global gridded netCDF dataset produced by LOES filter from all profile data including Argo but excluding bathythermograph. Also seasonal dynamic height and MLD. "CARS2009"**	Argo plus others	0.5 degree global	79 levels to 5500 m	1930 to May 2009	Mean and seasonal sinusoids	rarely	**Instructions via "Access" section of website**
CSIRO		**Global gridded netCDF dataset produced by LOES filter from all Argo. Also seasonal dynamic height and MLD. "CARS2009"**	Argo only	0.5 degree global	66 levels to 2000 m	All Argo, updated ~3 monthly	Mean and seasonal sinusoids	rarely	**Instructions via "Access" section of website**
IFREMER/LPO		**ISAS13: Global gridded NetCDF monthly fields and profile data base. Climatology 2004-2012.**	Argo plus others	1/2 degree Merc	151 levels to 2000 m	2002 - 2012	monthly	rarely	**website** email for data access: fabienne.gaillard@ifremer.fr
IPRC		**Global gridded ASCII and NetCDF dataset produced by variational interpolation from Argo only profiles (Aviso altimetry for Absolute Dynamic Topography fields**	Argo plus Aviso	1 degree global	27 levels to 2000 m	Since 2005-01-01	monthly	monthly	**website access**
JAMSTEC		**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)**	Argo plus others	1 degree global	25 levels to 2000 dbars	Since 2001-01-01	monthly	monthly	**website access**
JAMSTEC		**Global gridded NetCDF of Mixed Layer Depth with its related parameters. MILA GPV (MIxed Layer data set for Argo, Grid Point Value)**	Argo	1 degree global		Since 2001-01-01	monthly averages and monthly climatology	monthly	**website access**
Met Office		**Global gridded NetCDF objective analyses produced from all types of data including Argo (EN4 dataset)**	Argo plus others	1 degree global	42 levels to 5350 m	Including Argo since 1999-01-01	monthly	monthly	**website data access**
NOAA-PMEL / University of East Anglia		**Global gridded NetCDF files for isopycnal surface and mixed layer water properties and combined 0-1950 dbar pressure-gridded files, produced by objective mapping including front-finding and bathymetry-following algorithms. (MIMOC)**	Argo plus others	0.5 degree global	81 levels to 1950 dbars	Climatological year, emphasizing data since 2007	monthly	rarely	**website access**
Scripps Institution of Oceanography		**Global gridded NetCDF and Matlab Mixed Layer Depth climatology**	Argo only	1 degree global		Since 2001-01-01	climatology of monthly mixed layer depths and properties	occasionally	**website access**
Scripps Institution of Oceanography		**Global gridded NetCDF Argo only dataset produced by optimal interpolation**	Argo only	1 degree global	58 levels to 2000 dbars	Since 2004-01-01	monthly	monthly	RG_ArgoClim_Full.nc is no longer distributed as the file grew too large to easily append data. Therefore, the data is split up into the temperature variables (**ftp access for temperature file**) and the salinity variables (**ftp access for salinity file**). Alternately, you could build your own *Full.nc file from this **website with monthly updates**

MOAA GPV (Grid Point Value of the Monthly Objective Analysis using Argo data) produced by JAMSTEC (Hosoda et al., 2008)

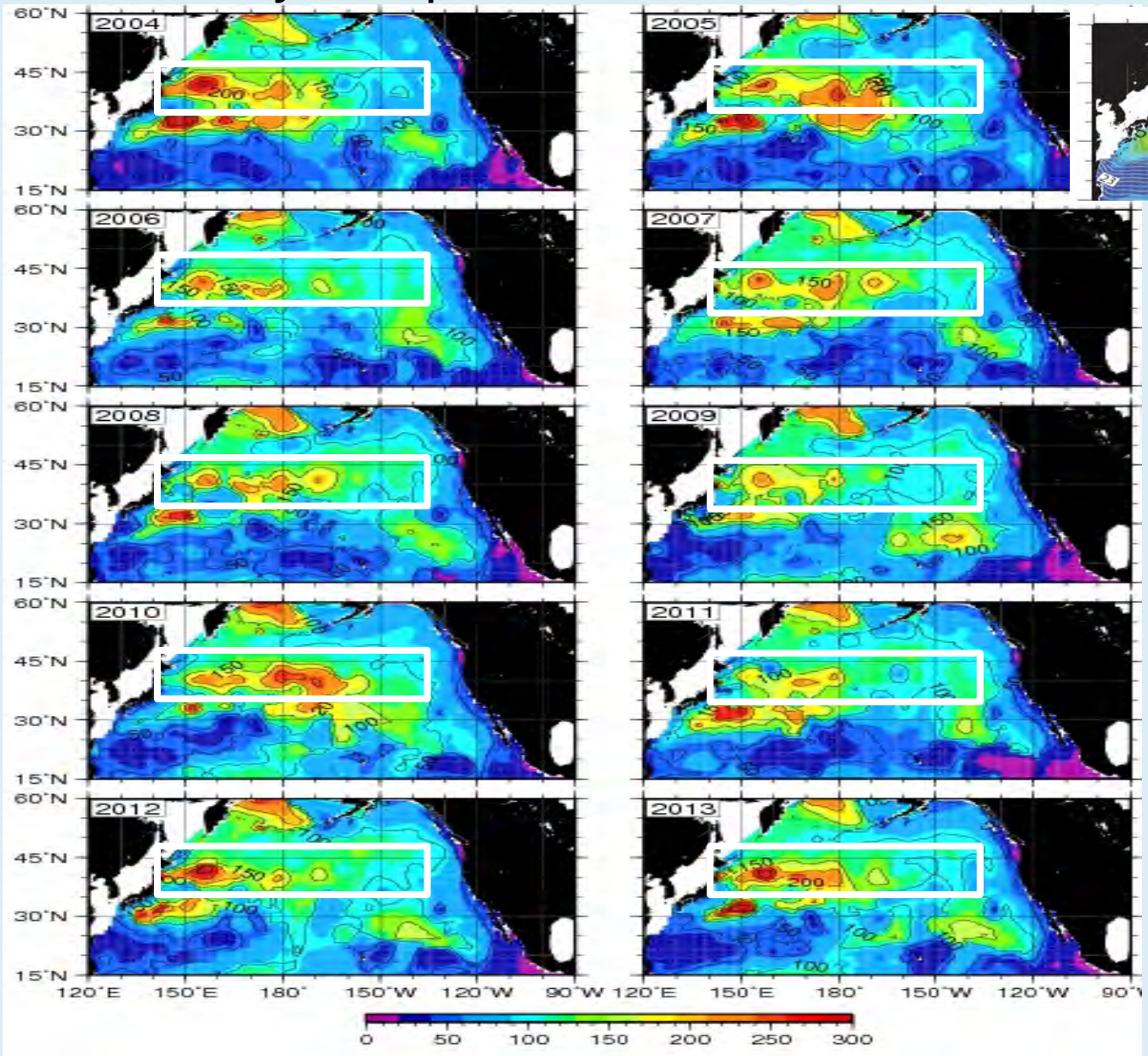
NPTA as a ventilator viewed from Argo data

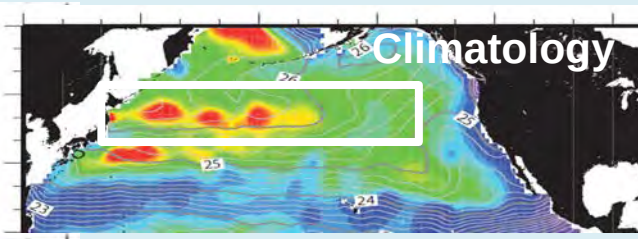
- Updated climatology of winter MLD and ML density
- Western/central NPTAs fields similar to the historical climatology, but…



NPTA as a ventilator viewed from Argo data

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

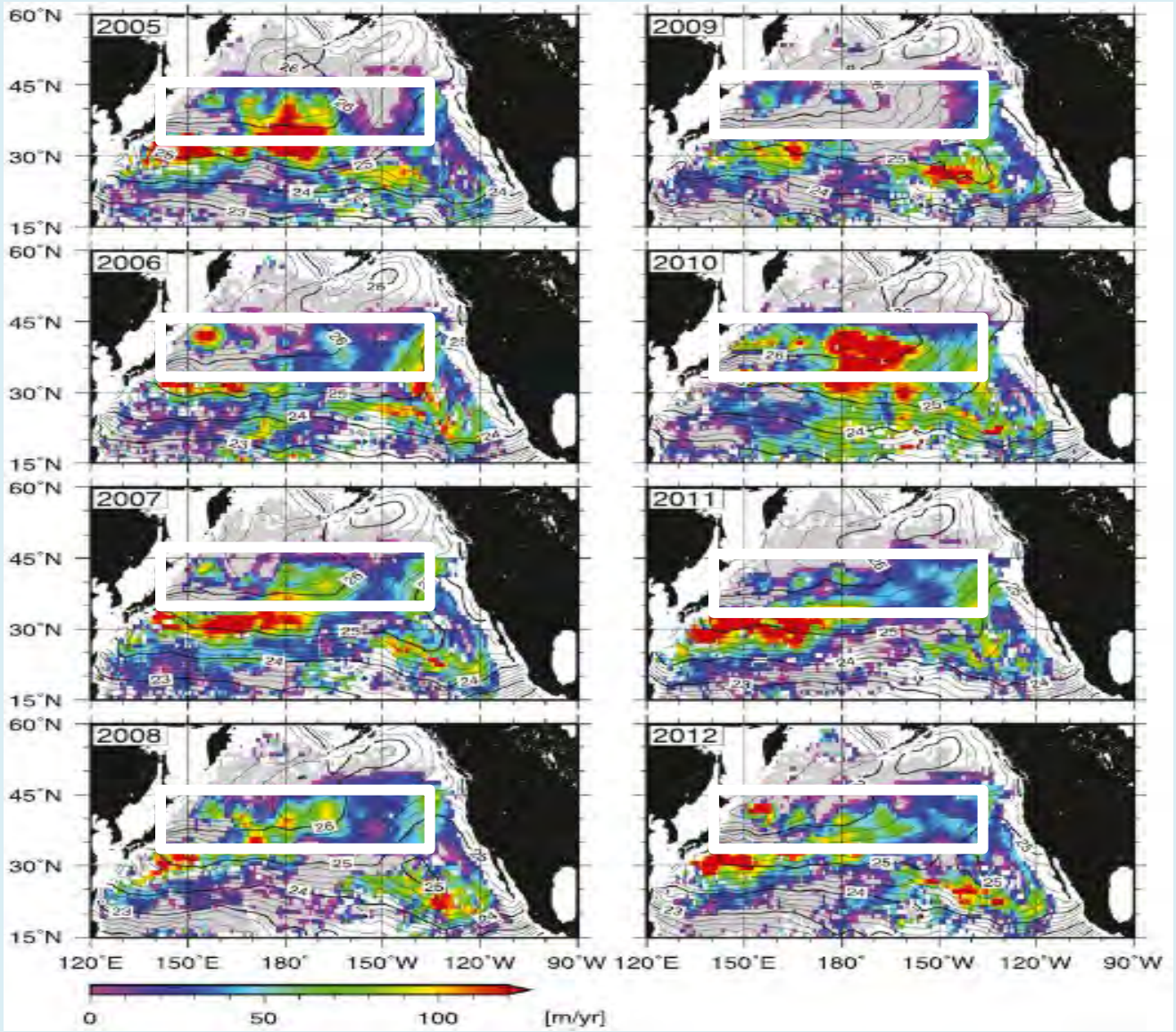




Significant interannual variation in MLD

NPTA as a ventilator viewed from Argo data

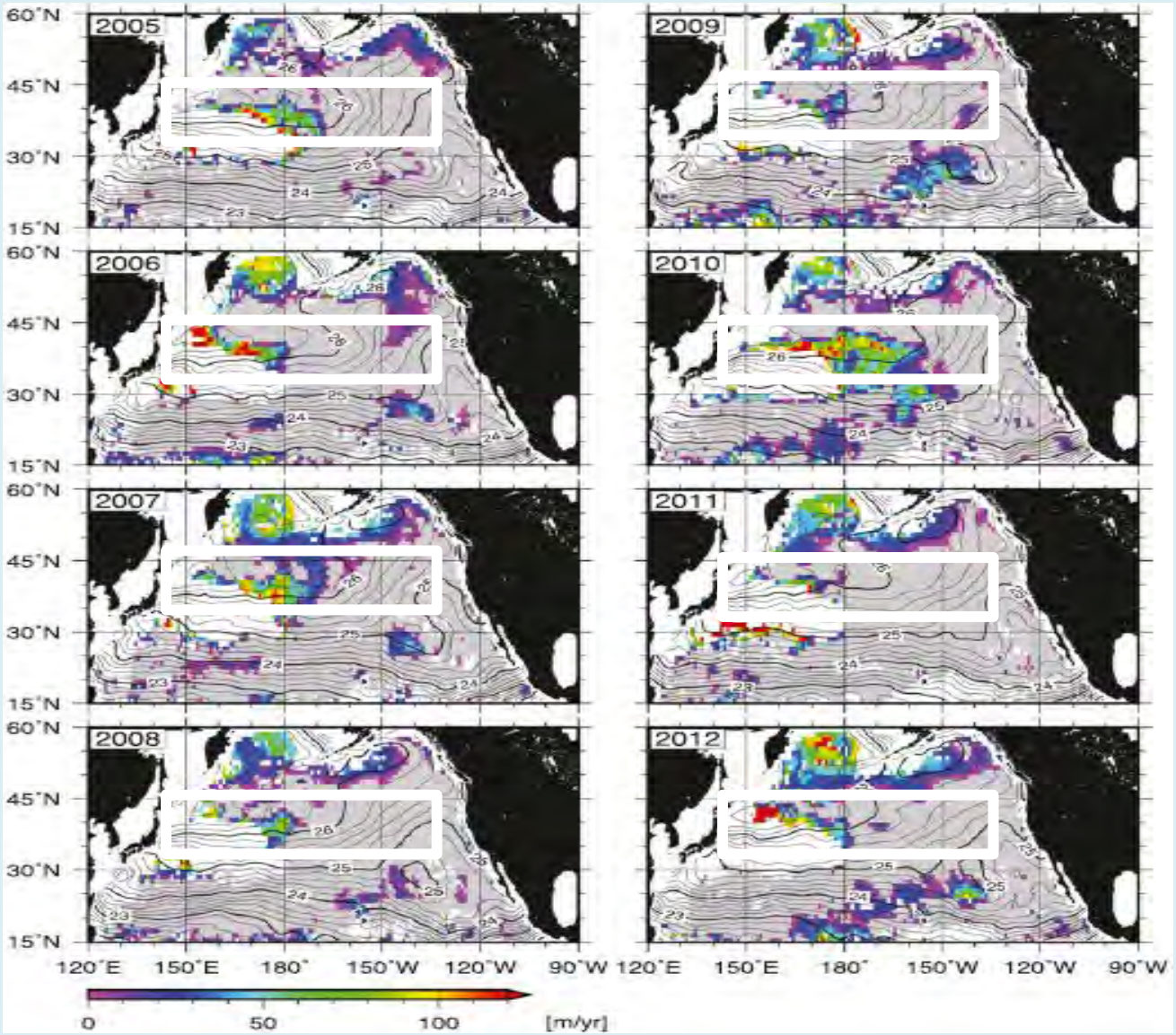
Annual subduction rate (Toyama et al., 2015)



Large variability in spatial distribution and intensity of subduction

NPTA as a ventilator viewed from Argo data

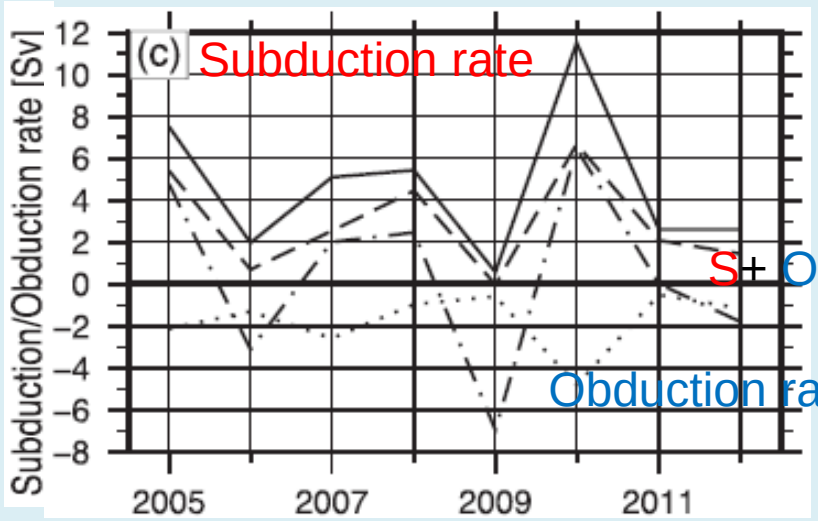
Annual obduction rate (Toyama et al., 2005)

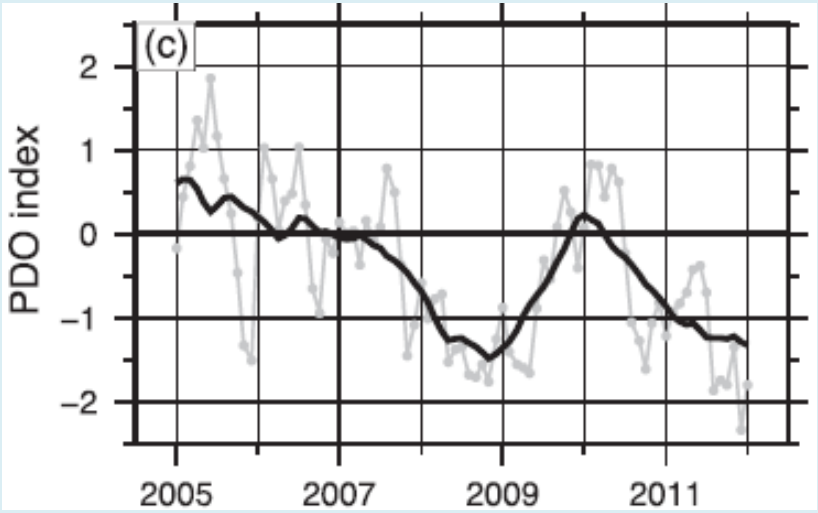


Large variability in spatial distribution and intensity of obduction

NPTA as a ventilator viewed from Argo data

(Toyama et al., 2015)



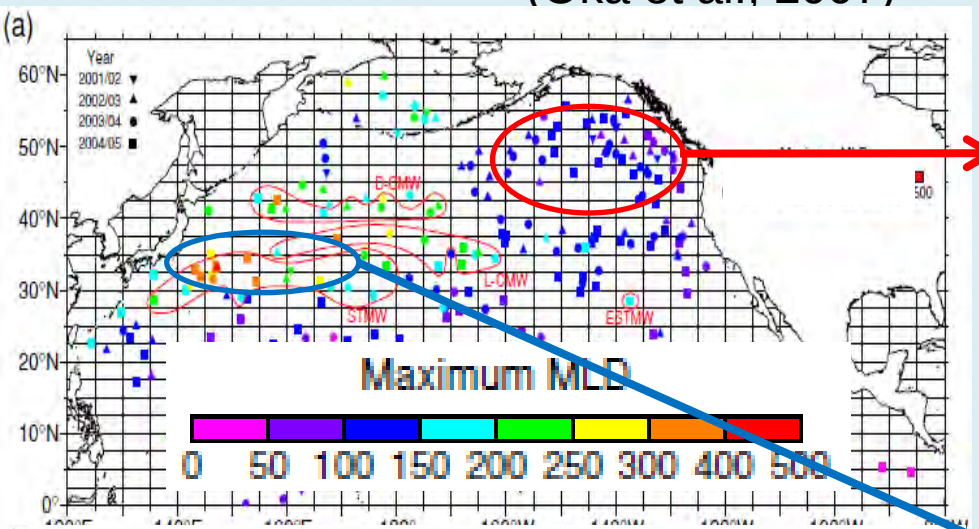


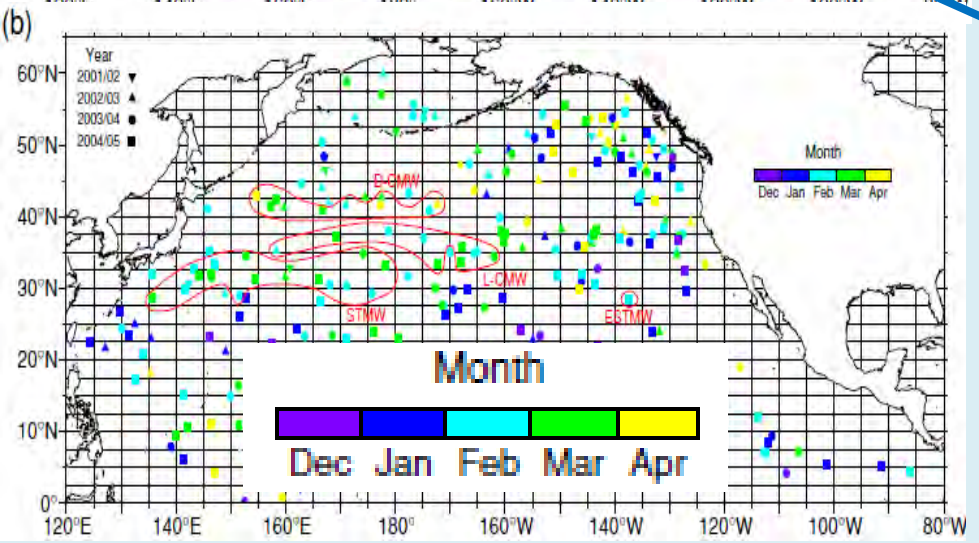
- Net exchange rate (S+O) varies from nearly zero to >10 Sv.
- Interannual variation of net exchange rate appears largely related to PDO.
- Large scale anomalies are tracked by Argo gridded data.

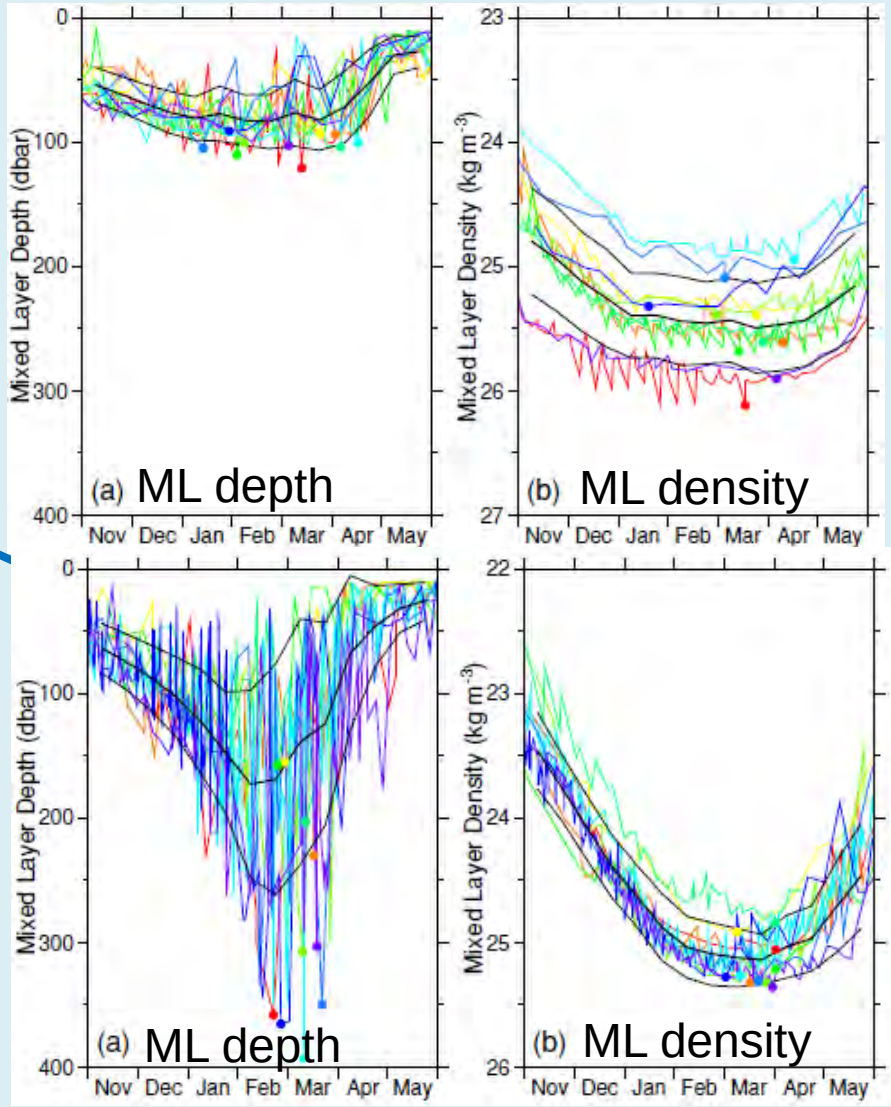
- How does this change affect biogeochemical properties in ML and pycnoclines?
- **Biogeochemical Argo** would be a way to go to answer this question.

Use of individual profile data

(Oka et al., 2007)



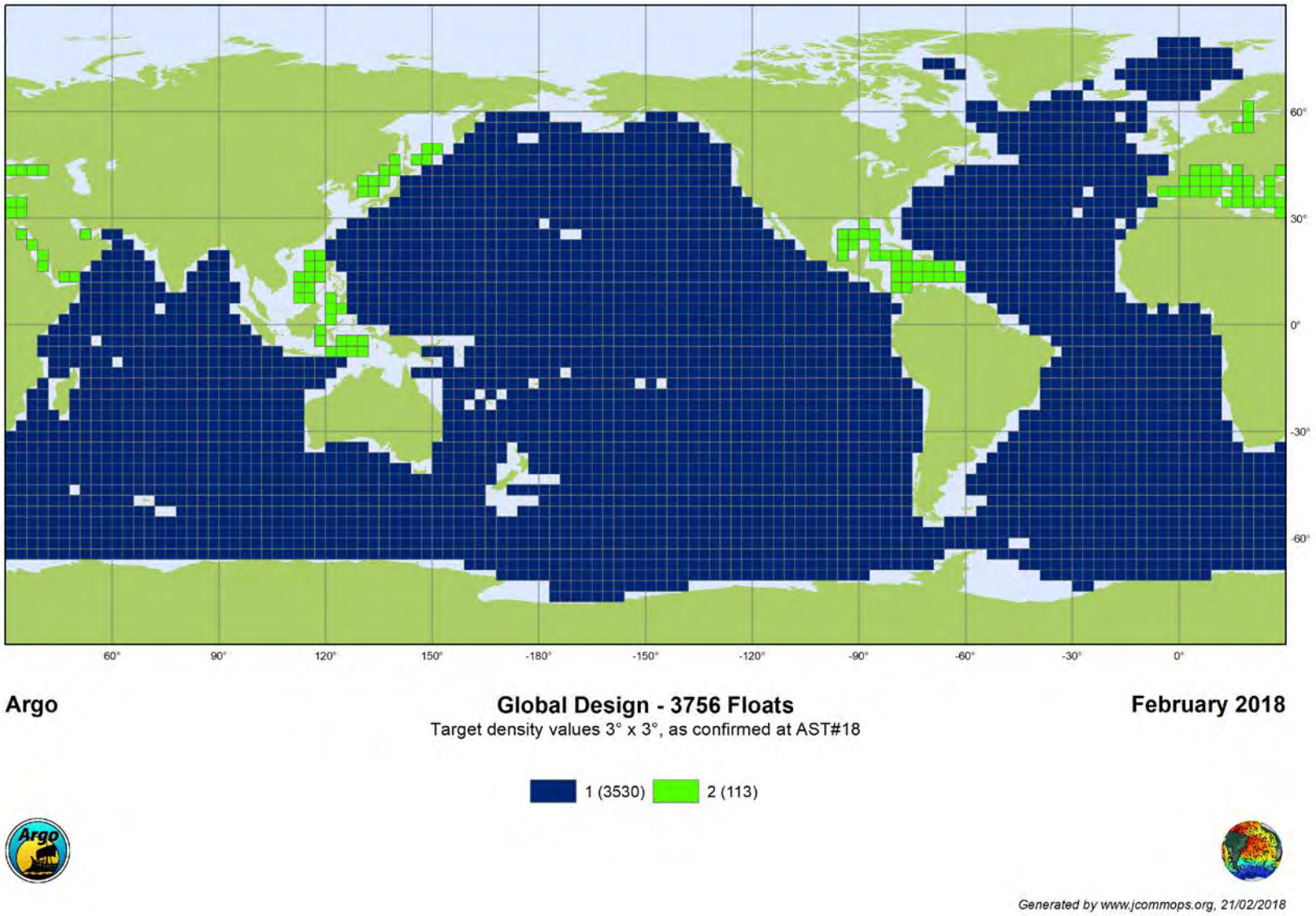




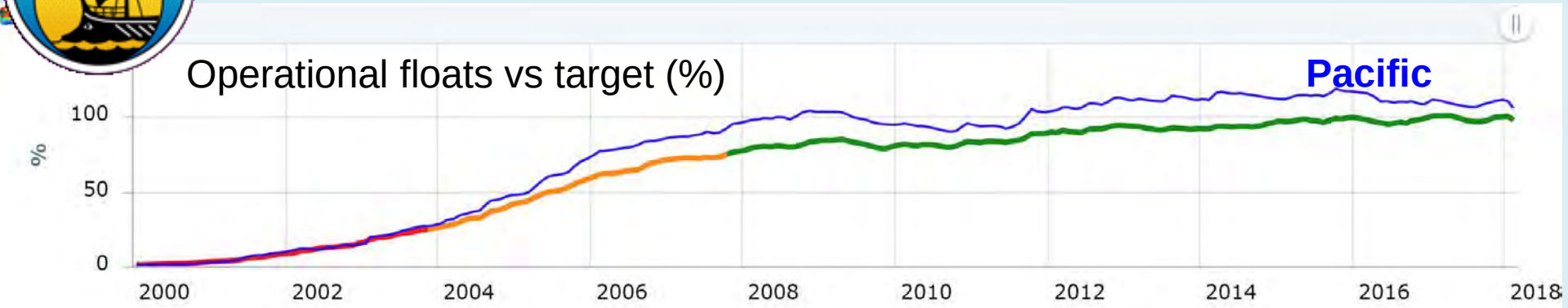
Individual profiles contain information on smaller spatial/temporal scale variability ⇒ Further understanding of ventilation processes

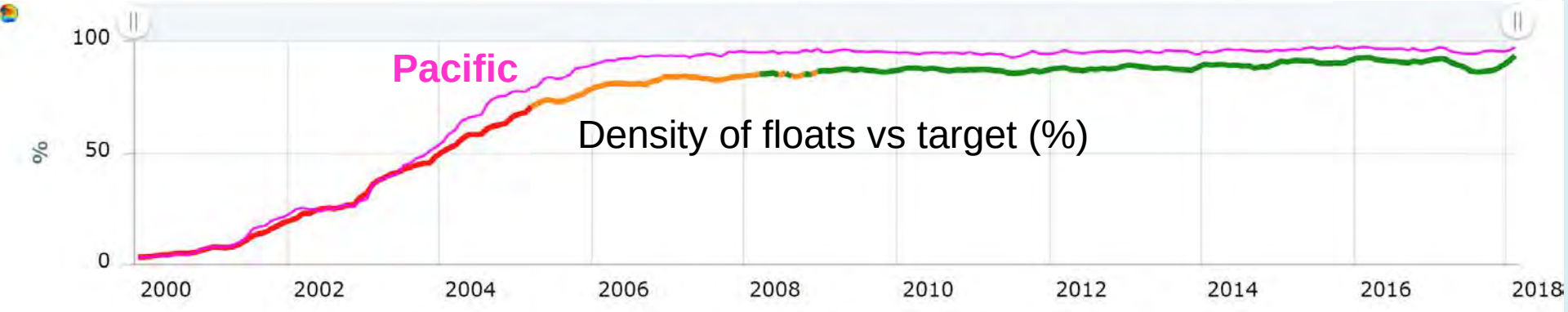
Argo: Status and Challenges

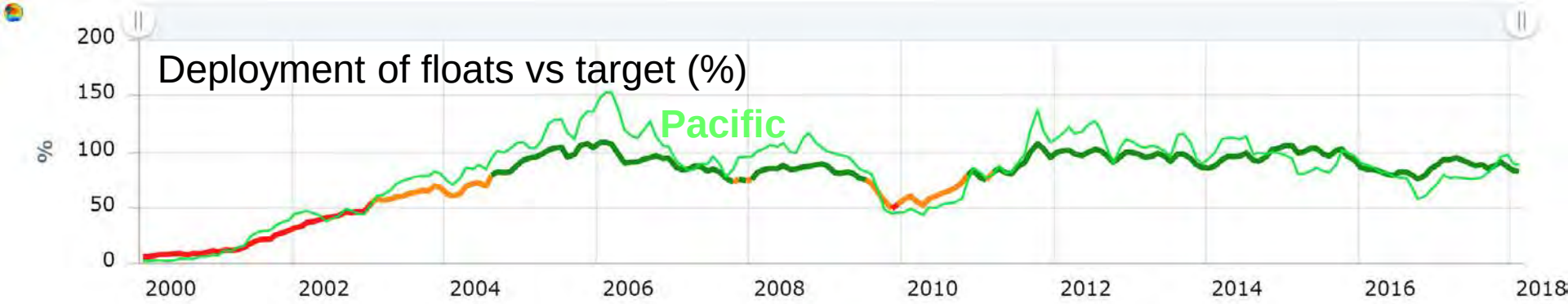
Current design of Argo



Argo: Status and Challenges



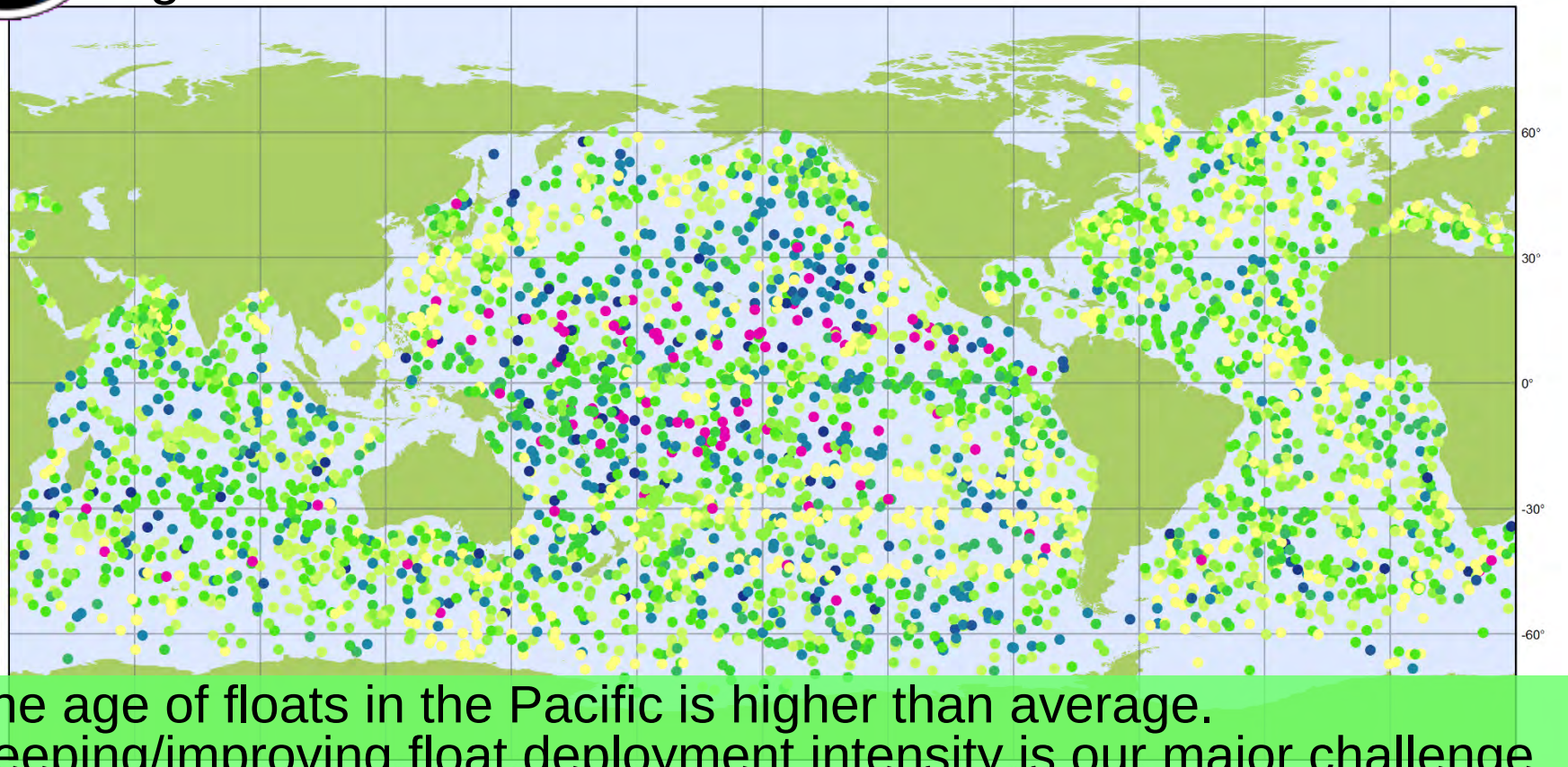




Argo is healthy in terms of both global and Pacific coverages, while there is a decreasing trend in the float deployment.

Argo: Status and Challenges

Age of floats



The age of floats in the Pacific is higher than average.
Keeping/improving float deployment intensity is our major challenge.

Argo **Age** **March 2018**

Profiling floats age distribution (in years)

<1 year (703) 2-3 (582) 4-5 (404) 6-7 (0) 8-9 (60) >10 years (95)
1-2 (791) 3-4 (593) 5-6 (200) 7-8 (357) 9-10 (65)

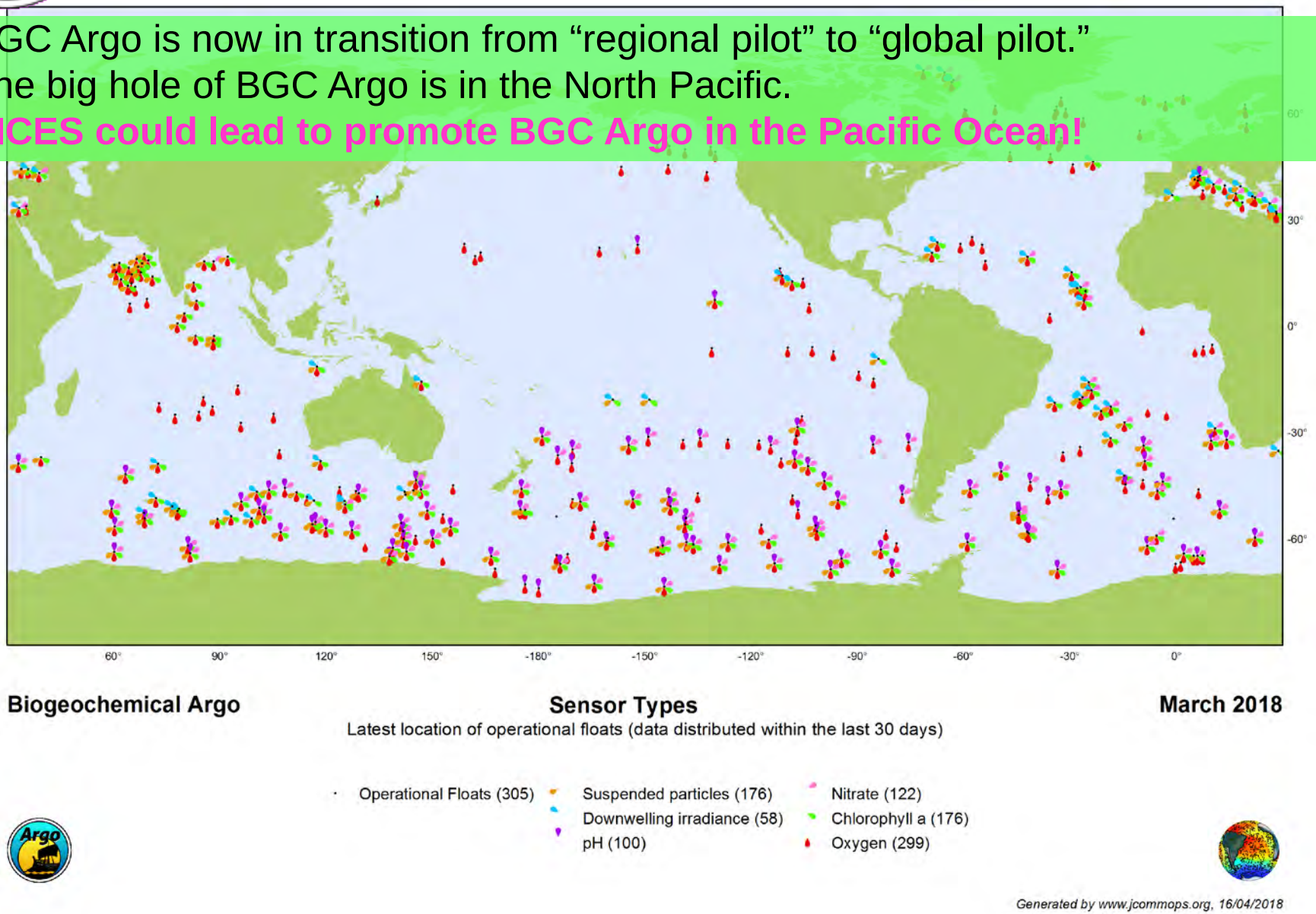
Mean = 3.25 Median = 2.65

Generated by www.jcommops.org, 16/04/2018

Argo: Status and Challenges

Biogeochemical Argo

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!