NOAA Climate Program Office Ocean Climate Observation Program Update

David M Legler

Climate Observation Division

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

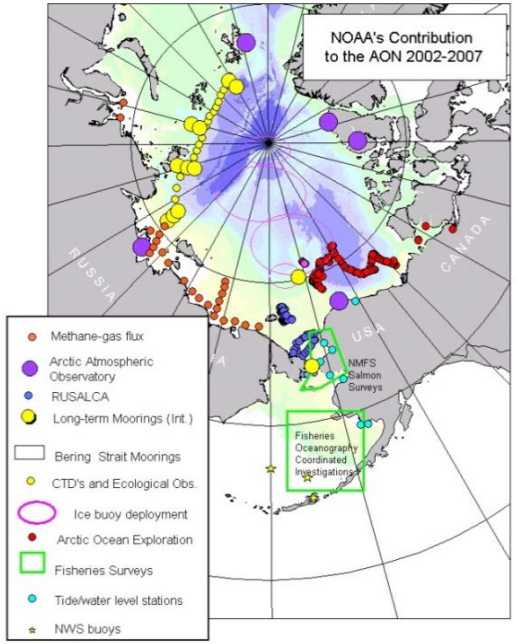
June 2013

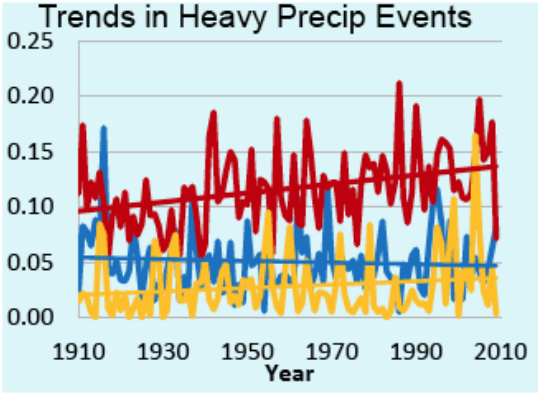
Climate Program Office
Climate Observations Division

David Legler, Division Chief

Our mission is to develop and sustain, with national & international partners, an in situ global observing system to monitor, understand, & support prediction of the coupled ocean, arctic, & atmosphere systems;

To provide long-term, high quality, timely global observational data, information, and products in support of communities of researchers, forecasters, other service providers, and users, for the benefit of society





Key Activities

- Global Ocean Observing System
- Arctic Research and Arctic Observing Network
- Monitoring

Strategic Partners

•NOAA Ctrs/Labs (PMEL, AOML, GLERL, GFDL, CPC, EMC, NCDC, NODC, ESRL,), US Navy, …

•Academia (Scripps, WHOI, UW, Miami, FSU, CIs)

•Int'l Research Programs in Europe, Asia, Russia, etc and engaged/coordinated through bilaterials, IOC, and efforts like Argo and GLOSS.

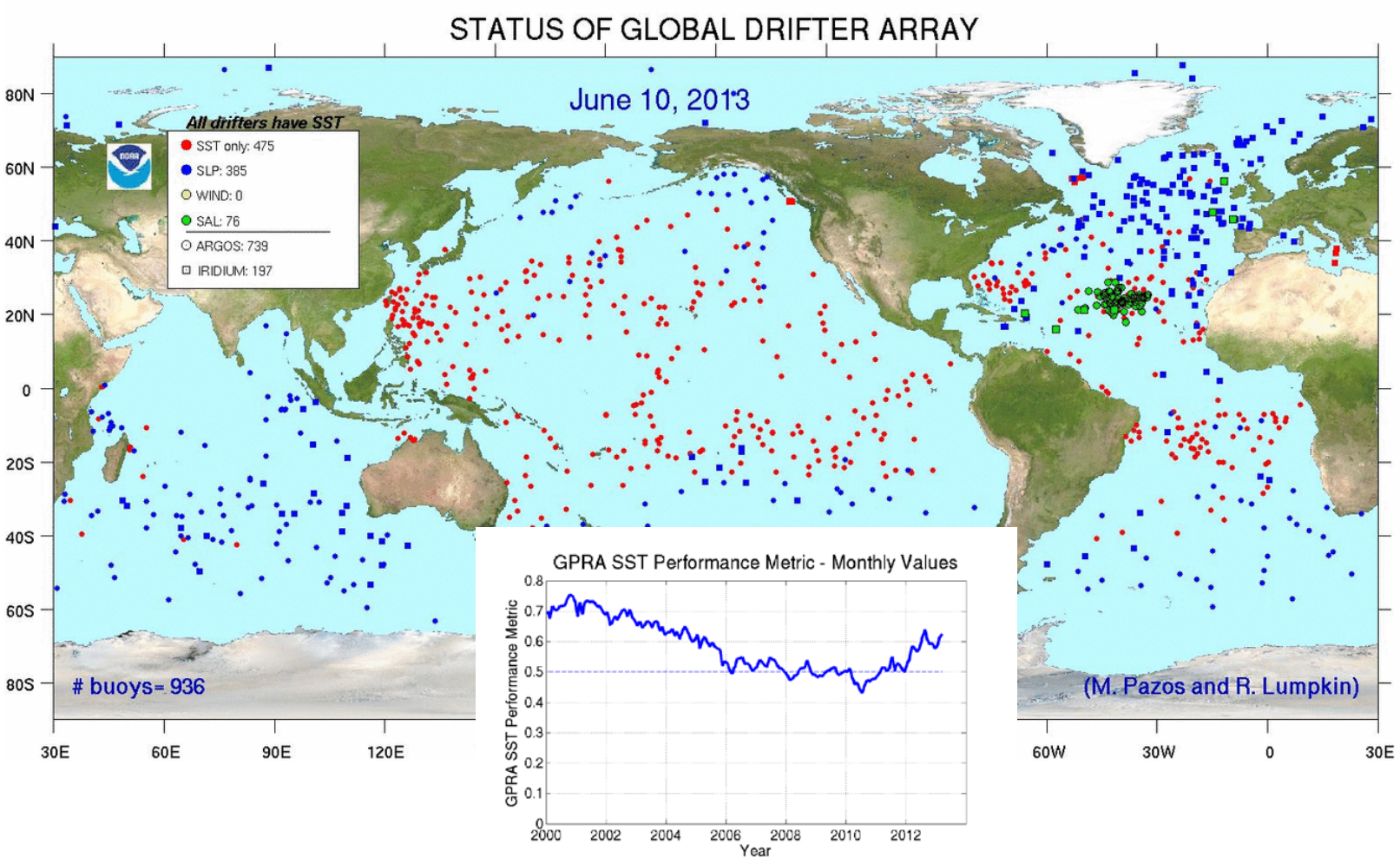
Ocean Climate Observation Program
Why We Observe the Ocean

- **Thanks to the efforts of the international community, we are now observing the surface and global upper ocean *systematically* for the first time in history.**
- **It is a major international achievement and the Ocean Climate Observation (OCO) program has played a central role in developing the in-situ components**
- **Ocean state and its variability continue to provide the foundation for climate research; climate and weather forecasting; & assessments (e.g. IPCC, US National Assessment).**
- **Increasingly, the marine environment is recognized to be undergoing change (for a variety of reasons and in response to a number of drivers). NOAA's OCO program is well-positioned to provide global sustained ocean observations useful to monitor, understand, and ultimate predict these changes.**

Outline

- Highlights
- Budget update
- Outlook for FY14
- Trends, Concerns
- Moving forward – strategically

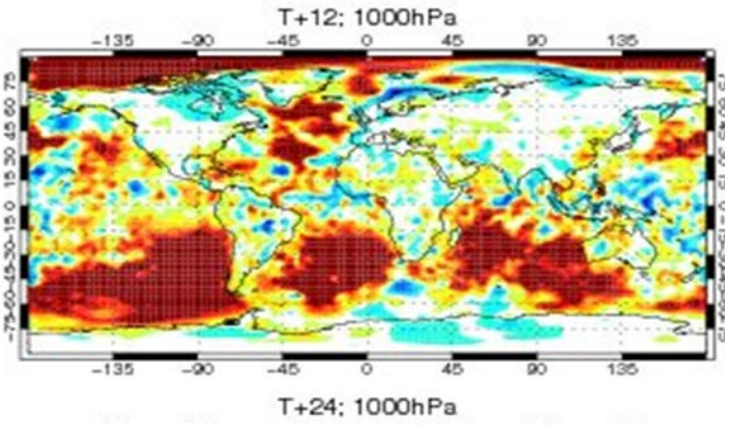
Global Drifting Buoy Array



Ocean Climate Observation Program
Impacts on NWP of SLP from drifters

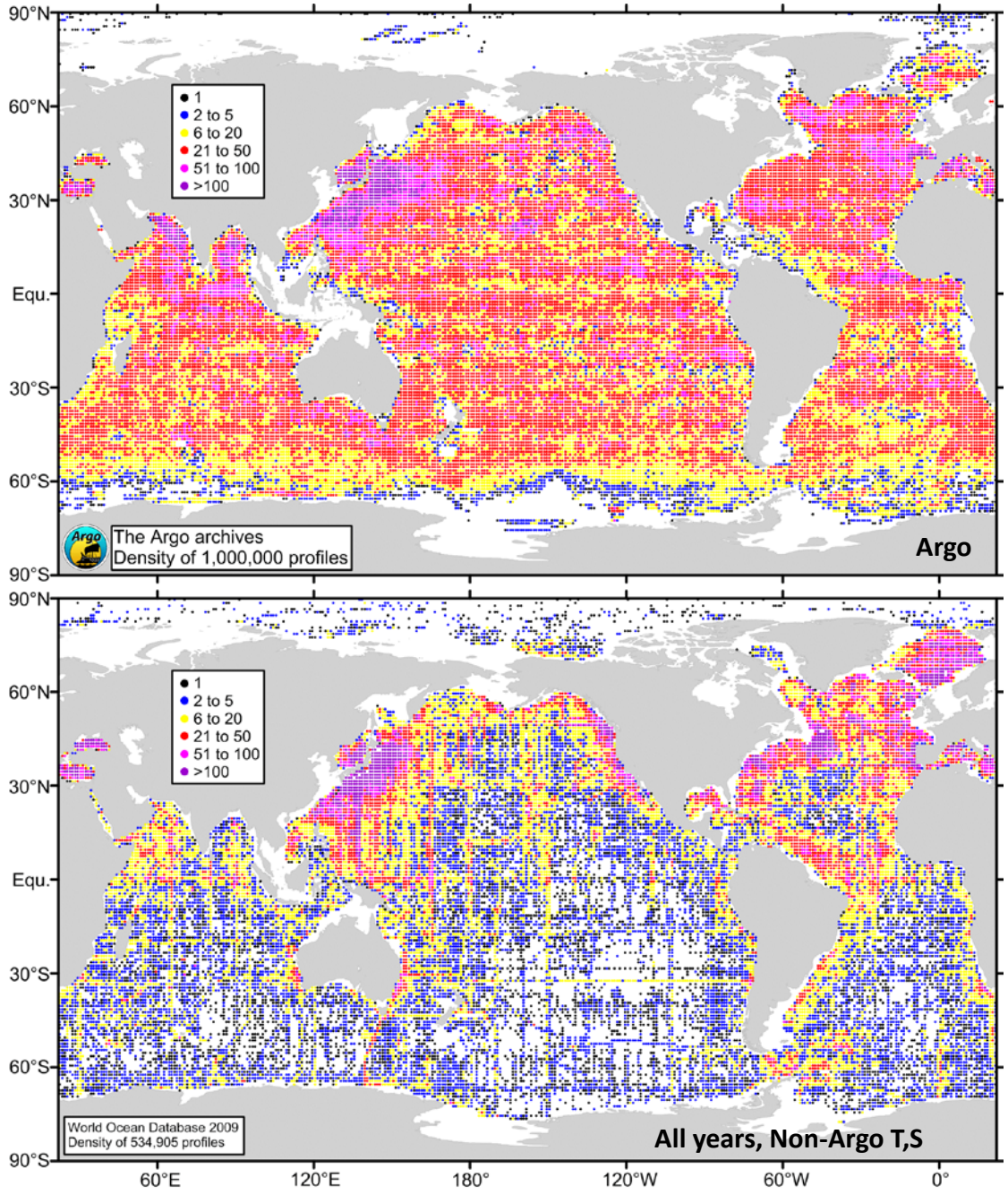
- SLP data from drifters are accurate (+/-1 mbar)
- Provide a correction for inverse barometer effect (1hPa=1cm) on sea-level
- Barometers on drifters enhance deployment opportunities through collaboration with meteorologists
- SLP data from drifters improve the quality of NWP by anchoring the surface pressure field
- Positive effects are felt up to 48 hours ahead, both at the surface and in the lower troposphere (700 mbar)

Results: SP-Denial versus Control



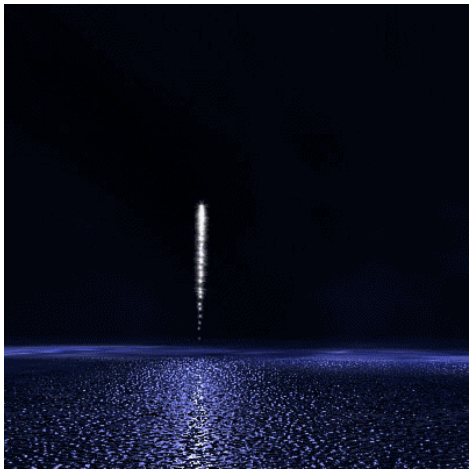
OSE RUN AT ECMWF - DRIFTERS SLP WAS DENIED Credit Carla Cardinali, ECMWF

For more info:
Luca Centurioni, CIMEC-SIO,
lcenturioni@ucsd.edu



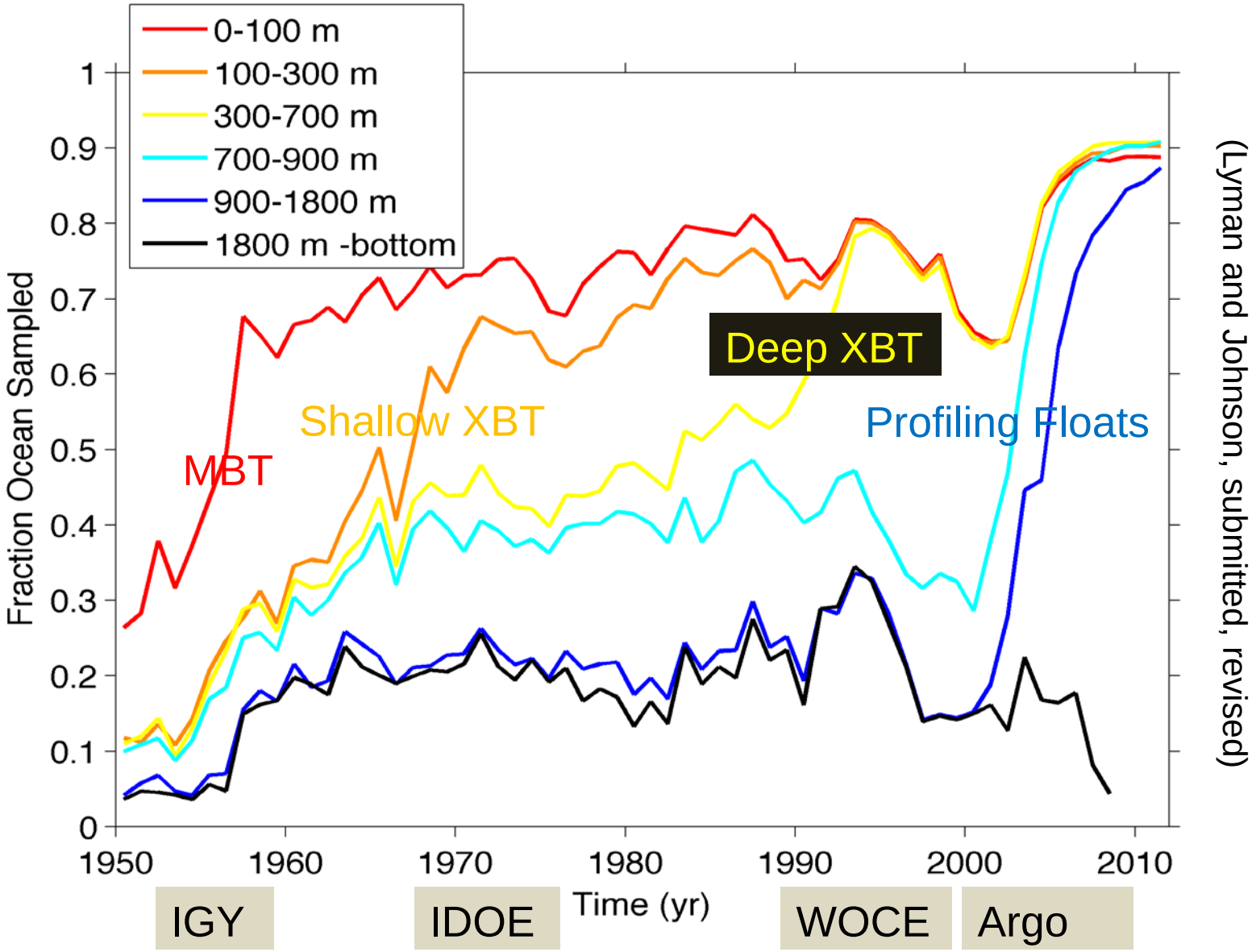
Argo's 1,000,000th profile was collected in November 2012!

Global Oceanography

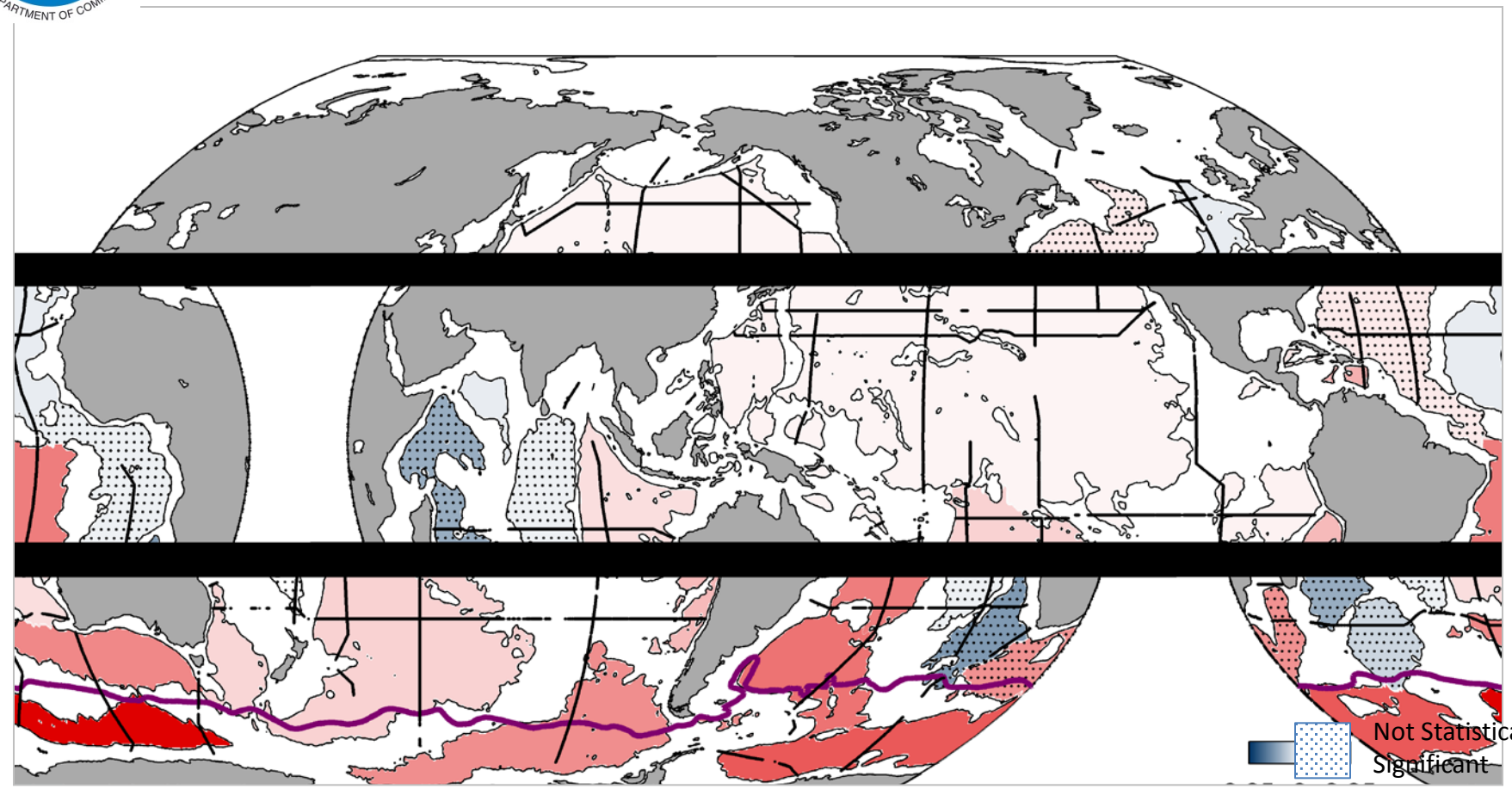


Global-*scale* Oceanography

Ocean Climate Observation Program
Fraction of Ocean Sampled for Temperature



Ocean Climate Observation Program
Warming Rate Below 4000m

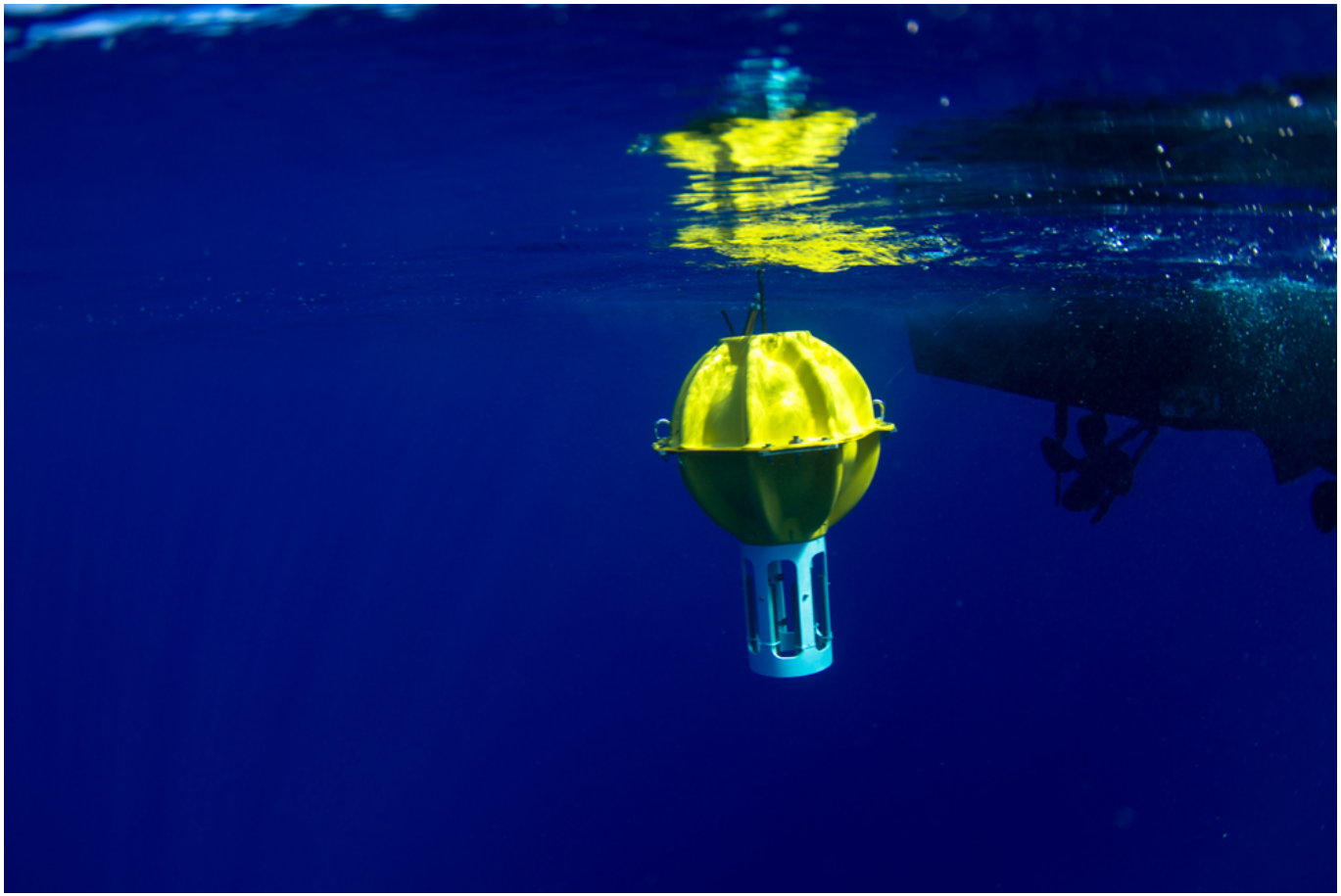


- Warming strongest around S. Ocean, where AABW is formed
- Most warming statistically significant at 95% confidence
- **Deep warming (z > 2000 m) is 50 (±28) TW (about 1/4 of total global estimate!)**

(Purkey & Johnson, 2010)

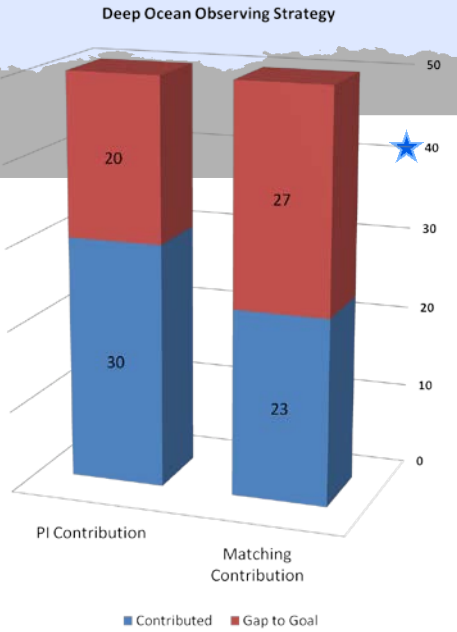
Ocean Climate Observation Program

Deep Argo testing



A prototype of a Teledyne/Webb 6000 m Argo float, deployed near Hawaii

OceanSITES Deep Ocean Observing Strategy

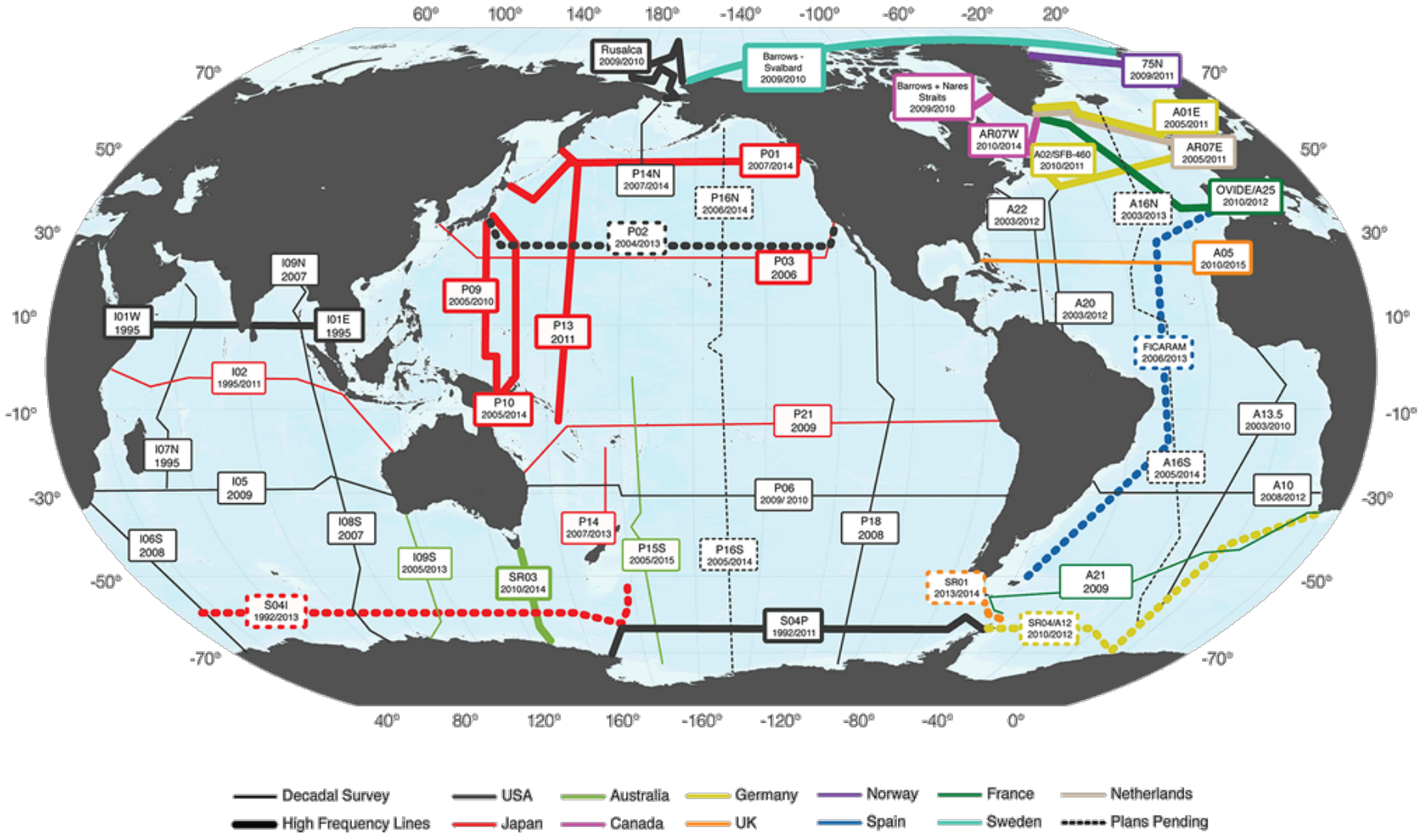


Installed (14) Previously Existing (57) Planned (13)

OceanSITES moorings at about 20 sites already carry deep T/S sensors. The plan is to deploy another 50 within a year, requiring 50 sensors for initial deployments and another 50 to swap out. OceanSITES PI's are pledging to add such sensors to their existing moorings, and 50 matching sensors are sought via donations from institutions, agencies, and companies.

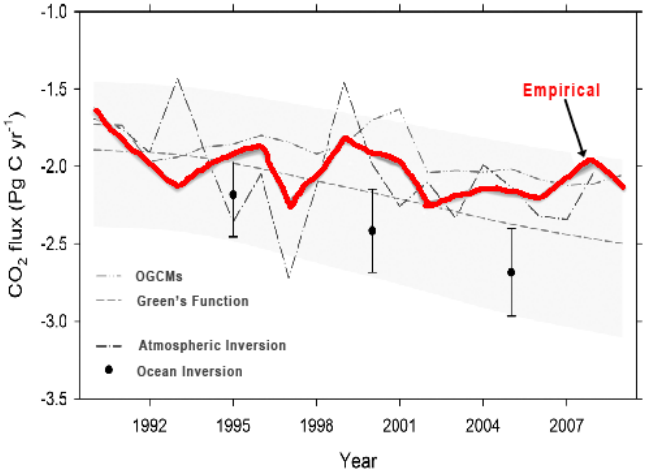
Ocean Climate Observation Program

Global Ocean Ship-Based Hydrographic Investigators Program: GO-SHIP



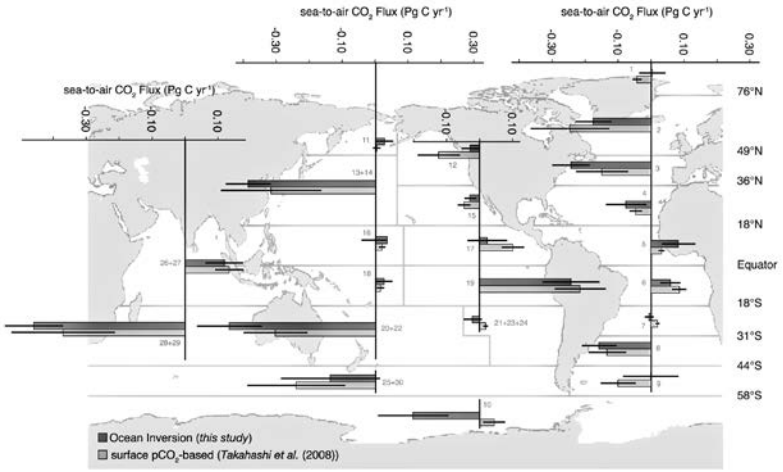
Ocean Climate Observation Program
Inferred Uptake of CO2 by the Ocean

- Current uptake of CO_2 by the oceans is estimated to be 2.0 ±0.2 Pg C/yr, (about 25% of human CO_2 emissions)
- Sea-to-air CO_2 fluxes based on empirical data based approaches show less uptake than inventory based measurements and models used in projections
- The rate of CO_2 uptake appears to be slowing down (i.e., the ocean surface layer is saturating)



Increasing and Temporally Variable Ocean Uptake: Anthropogenic sea-to-air CO_2 fluxes derived from empirical analysis of ocean observations

Wanninkhof et al, Biogeosciences **10**, 1983-2000 (2013)

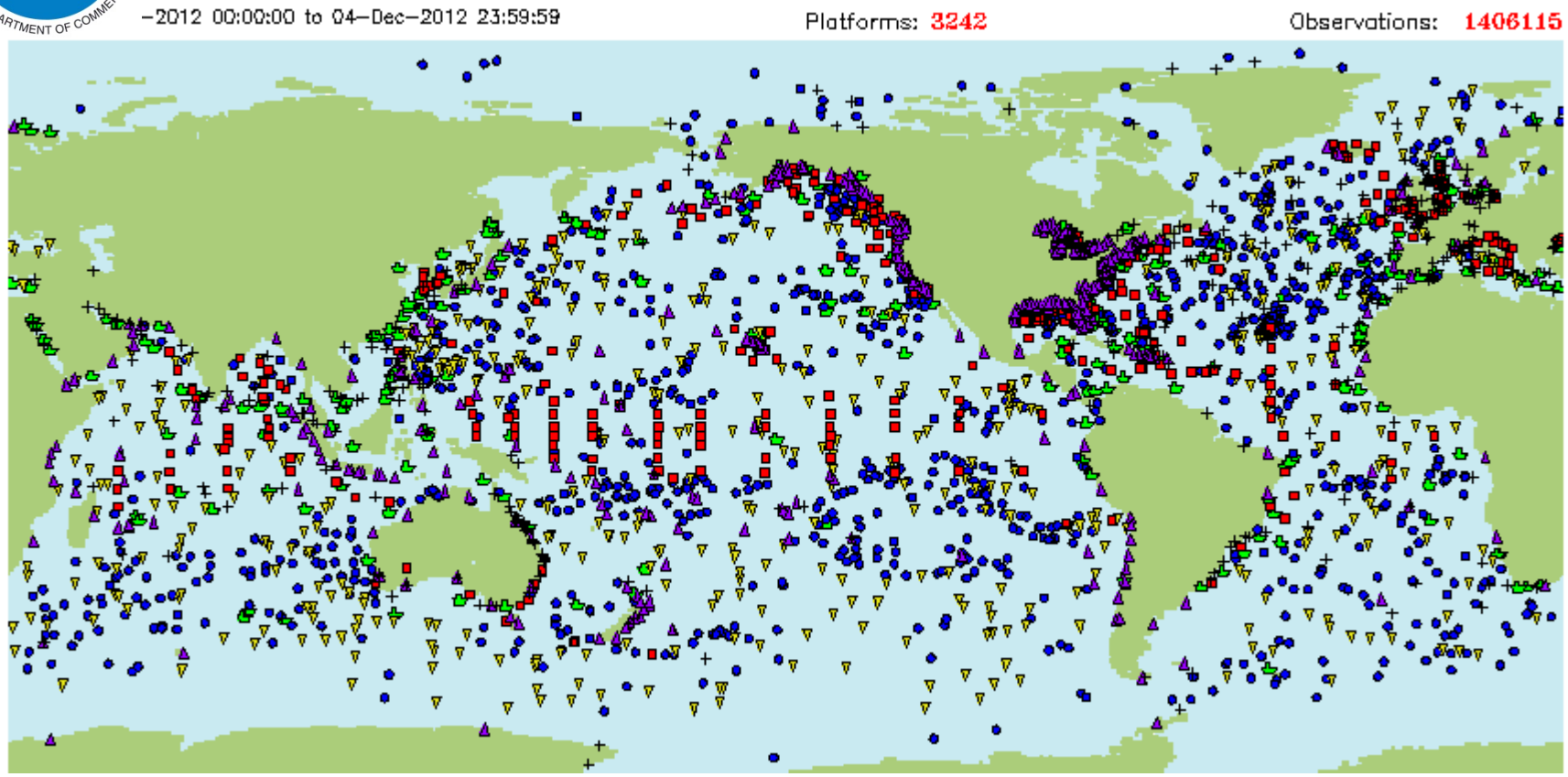


Spatially Variable Ocean Carbon Uptake
Comparison of the ocean inversion estimate (from Gruber et al., 2009) of sea-to-air CO_2 flux with that based on the CO_2 climatology of Takahashi et al (2009). Positive values indicate net fluxes from sea-to-air (outgassing), and negative values net fluxes from air-to-sea (uptake).

Gruber et al., Global Biogeochemical Cycles, 23 (2009)

- Ocean uptake of CO_2 varies with location and season
- Currently, about half of all annual CO_2 uptake occurs in the Southern Ocean

Ocean Climate Observation Program
Monitoring Global In-Situ Ocean Observing



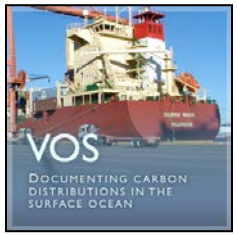
www.osmc.info

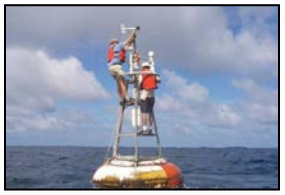
- Argo: 34 countries
- Arctic : 13 countries
- Global Sea-Level System: 57 countries

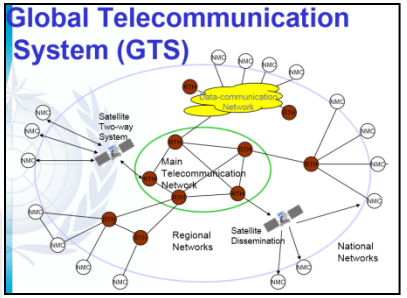
www.jcommops.org

- Surface Drifters: 14 countries
- Tropical Moored Buoy Arrays: RAMA (15) and PIRATA (3)

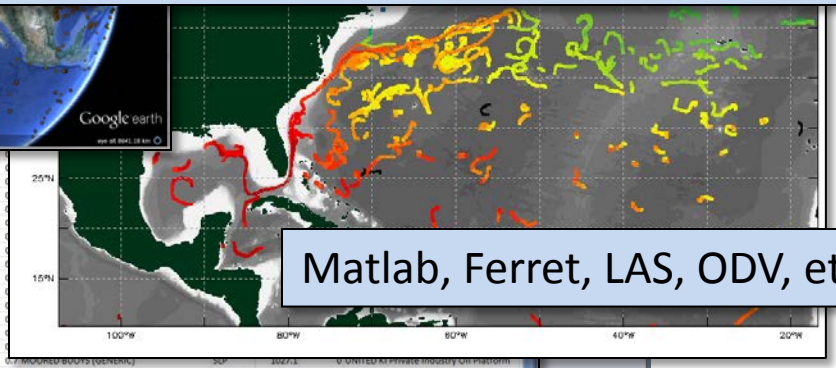
From Monitoring to Data Integration

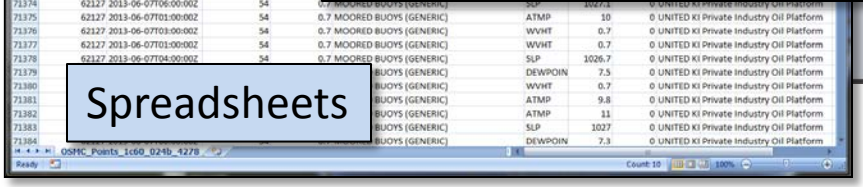






GTS data on the web*
One hour delay, multiple formats





OSMC

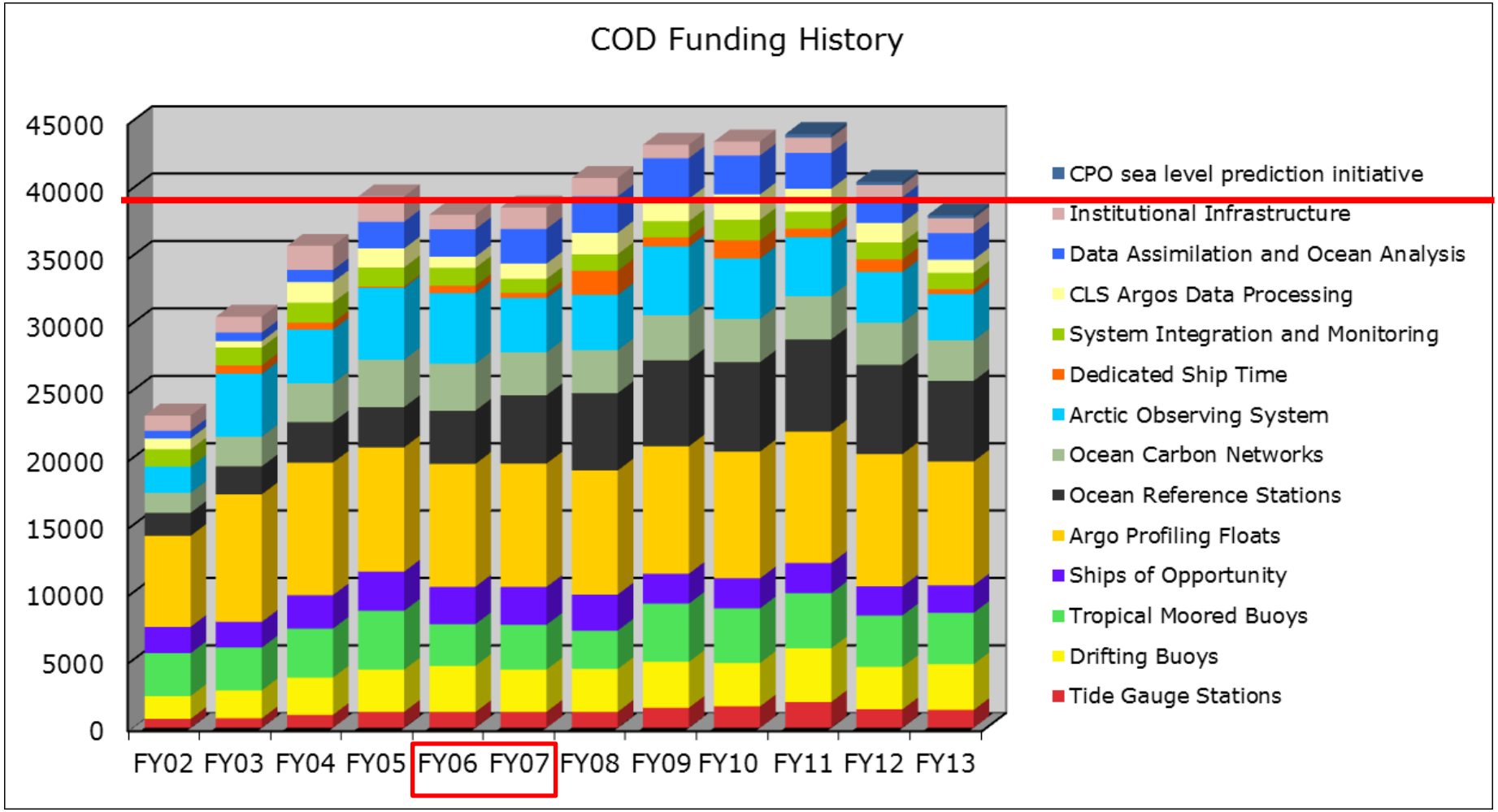
*Currently being evaluated for data assimilation by coastal ocean modelers

Division Spending FY13 (FY12)

Climate Observation Division $40.8M ($45M)		
Ocean Climate Observations $34.5M ($37.5M)	Arctic Program $3.4M ($3.7M)	Climate Monitoring $2.8M ($3.7M)
Diane Stanitski, Candyce Clark, Sidney Thurston, Joel Levy, Steve Piotrowicz	Kathy Crane, Janet Intrieri (temporary duty)	Bill Murray

18% resources drop since FY11

Ocean Climate Observation Program
Budget History

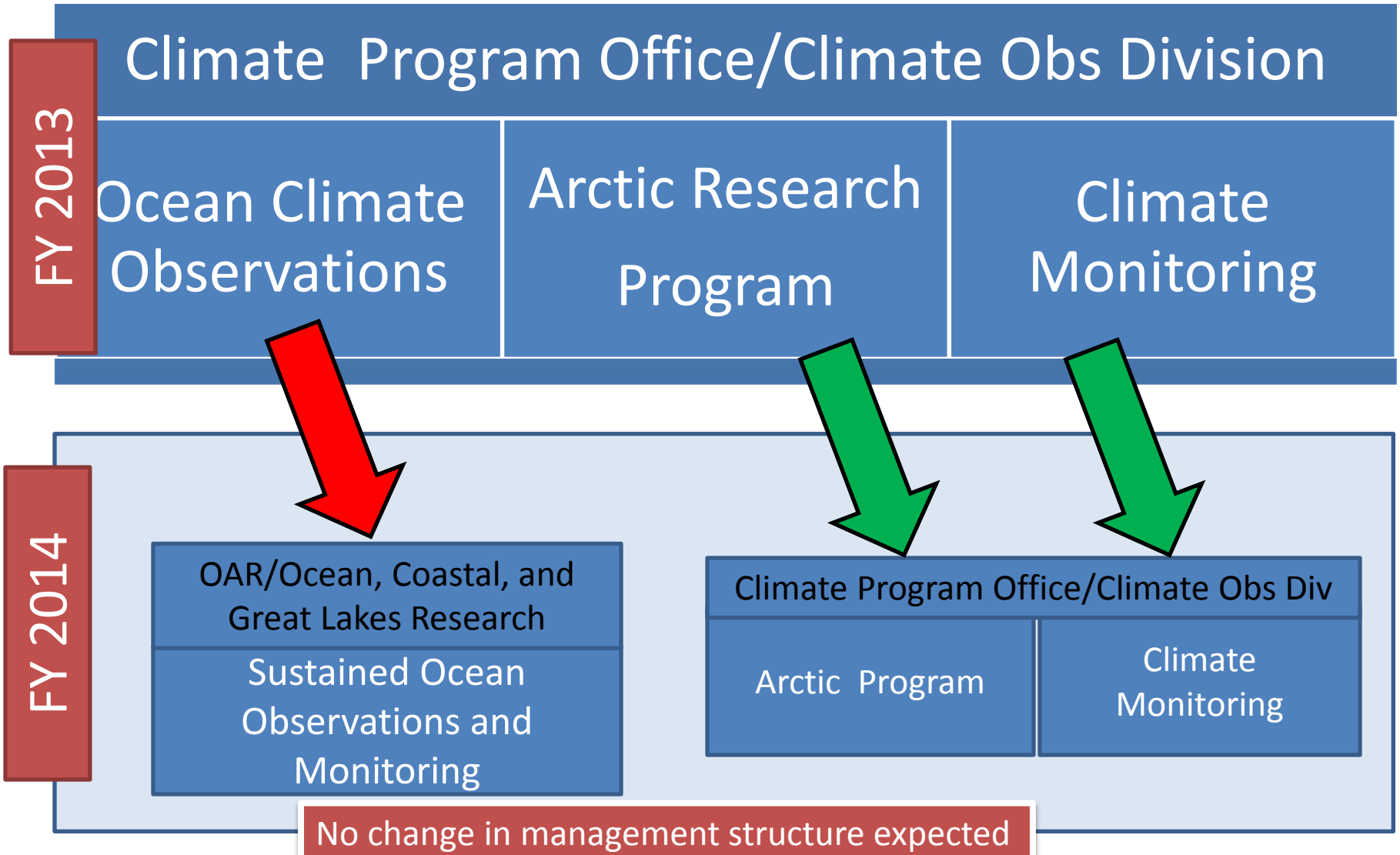


Ocean Climate Observation Program
FY13 Budget Priorities for Ocean Climate Obs

- Sustaining ocean observing systems that are routinely used by wide range of researchers and prediction centers
- Centralized and system-specific data management (to meet NOAA data management mandates and make ocean data more easily accessible)
- Complete deep Argo testing
- Testing of alternative observing technologies in the tropical Pacific

Lower priority areas include model/data assimilation development and new technology development.

Ocean Climate Observation Program
Budget reorganization within OAR



Ocean Climate Observation Program
Prospects for FY14

- President's Budget: $4+M increase for ocean observing
  - Testing and pilot array of deep Argo floats
  - Address critical ocean observations and analysis
  - Small increase for Arctic research
- Sequestration still in effect or FY14
  - Increases in President's Budget would only restore funding to slightly less than FY12
- Program's ability to mitigate budget reductions likely to be smaller in FY14…

Ocean Climate Observation Program
Trends/Concerns

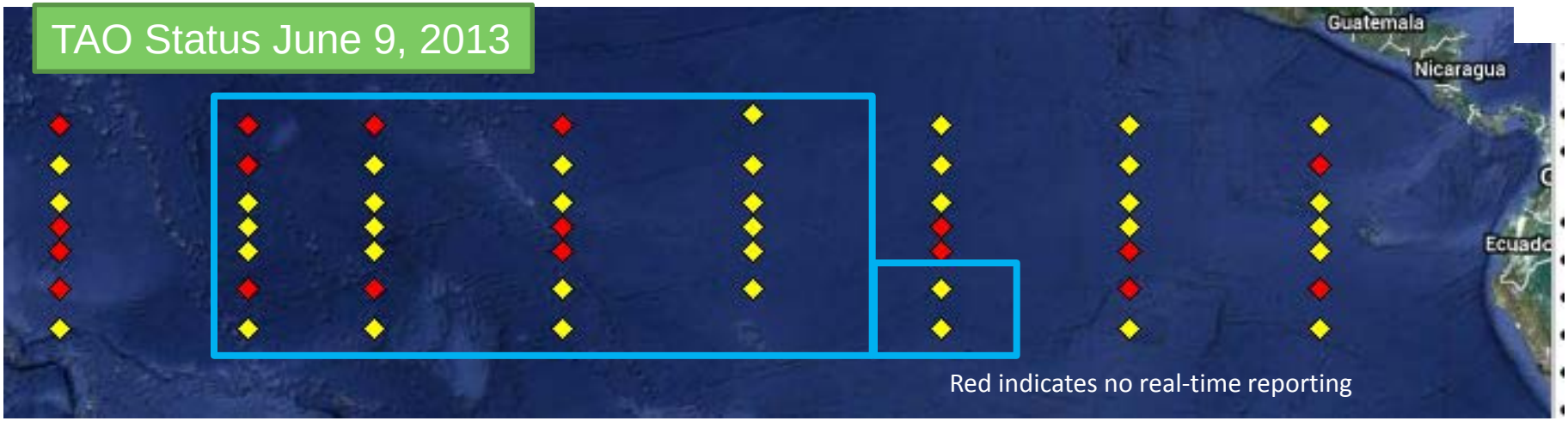
- Ship time has become very large and unpredictable budget and planning dynamic within each FY
  - NOAA allocation of ship time subject to huge swings due to CR/sequestration/late budget decisions by Congress
  - Increased $$ risk to programs for early FY cruises if they are not sufficiently high priority
  - NOAA requesting equip to be offloaded from NOAA ships at each port call increase shipping costs to program
- Reduce reliance on ships where it makes sense to do so and transition carefully to maintain climate records; hasten testing of alternative technologies (autonomous vehicles?)
- Anticipate dynamic funding planning

Ocean Climate Observation Program
Trends/Concerns

- Current level of contributions to GOOS stagnate/may decline and continuity of climate records at risk
  - We've tried to be careful to maximize efficiency, and minimize damage to sustained observing
  - While aspirations of the global ocean observing communities have historically guided our efforts, budget realities in NOAA mean we may not be able to support the scope and/or number of platforms the international community expects
  - Activities may have to more closely align with NOAA's interests
  - Anticipate more thorough evaluations/reviews
  - Not everything may be continued
  - Increase the use of limited-time financial arrangements

Climate Observations & Monitoring
Concern: TAO

- TAO transferred from research to *operations* over 5 years ago improving standardization and freeing up funding for other research activities
- Constraints on ship-time (less than ½ of that 2 years ago) and program cuts within NWS now threaten TAO



As of Oct 1, 2013 no servicing in past 18 months

NOAA Cross Line Office Working Group Addressing TAO Challenges

Ocean Climate Observation Program

Workshop: Future of the Tropical Pacific Observing System

Late 2013; Location likely Seattle or La Jolla

- Review scientific and forecasting requirements for sustained tropical Pacific Ocean* (15° S-15° N) observations
- Review existing observing strategies and systems, and evaluate their adequacy to address the identified requirements
- Assess readiness of new technologies under development and their potential to contribute.
- Recommend revisions and/or adjustments to the current suite and configuration of observing systems within anticipated envelop of resources. Recommend new observing technologies with greatest potential to meet critical requirements and how to test and incorporate into the observing system.
- Assess interests and potential contributing capabilities of new collaborators (in addition to Japan and the US)

Identify strategy and changes to make the Tropical Pacific Observing System sustainable

Moving Forward - Strategically

- Telling our story….better.
- Mature and sustainable observing systems
- Future opportunities!

Developing the Global Ocean Observing System for Climate

Status against the GCOS Implementation Plan and JCOMM targets

continuous satellite measurements of sea surface temperature, height, winds, ocean colour, and sea ice

Total ***in situ*** **networks** **61%** May 2010

87% **Surface measurements** from volunteer ships (VOSclim)

200 ships in pilot project

100% Global **drifting surface buoy** array

5° resolution array: 1250 floats

62% **Tide gauge** network (GCOS subset of GLOSS core network)

The value/notion of completing 100% of array does not easily translate into payoff/outcome!

100% Argo **profiling float** network

3° resolution array: 3000 floats

Reference time series 24%

58 sites

48% Global **reference mooring** network

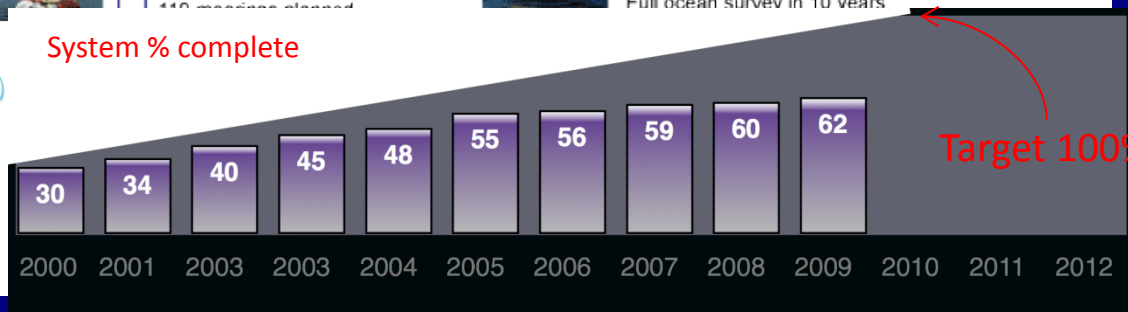
29 moorings planned

79% Global tropical **moored buoy** network

43% Repeat **hydrography** and **carbon inventory**

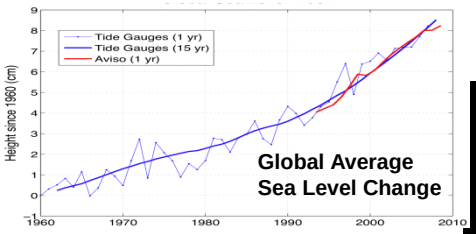
Full ocean survey in 10 years

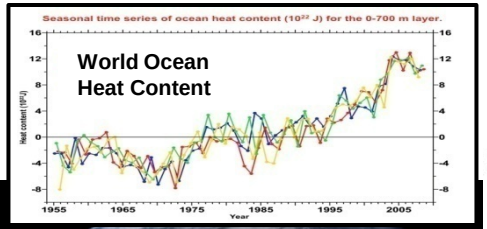
System % complete

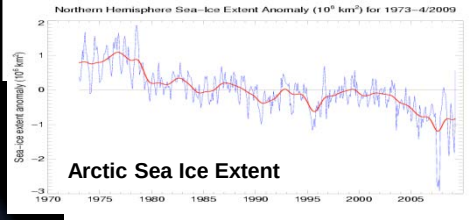


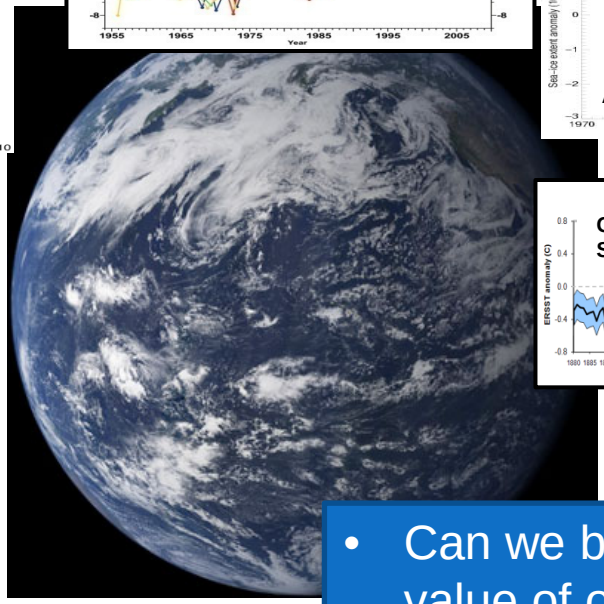
Global Ocean Observing System for Climate (and other needs)

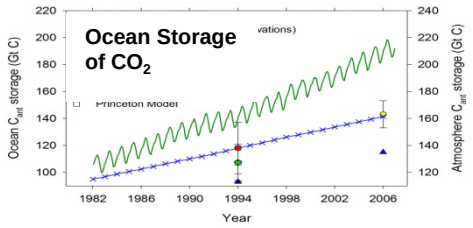
Making a better case for ocean observing to address key research questions, forecast needs, assessments, and monitoring of the oceans for multiple needs

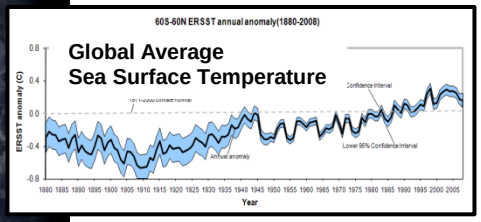


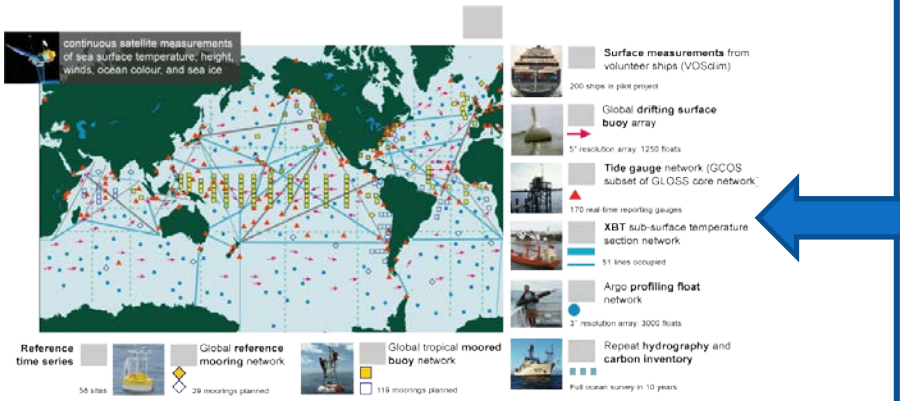












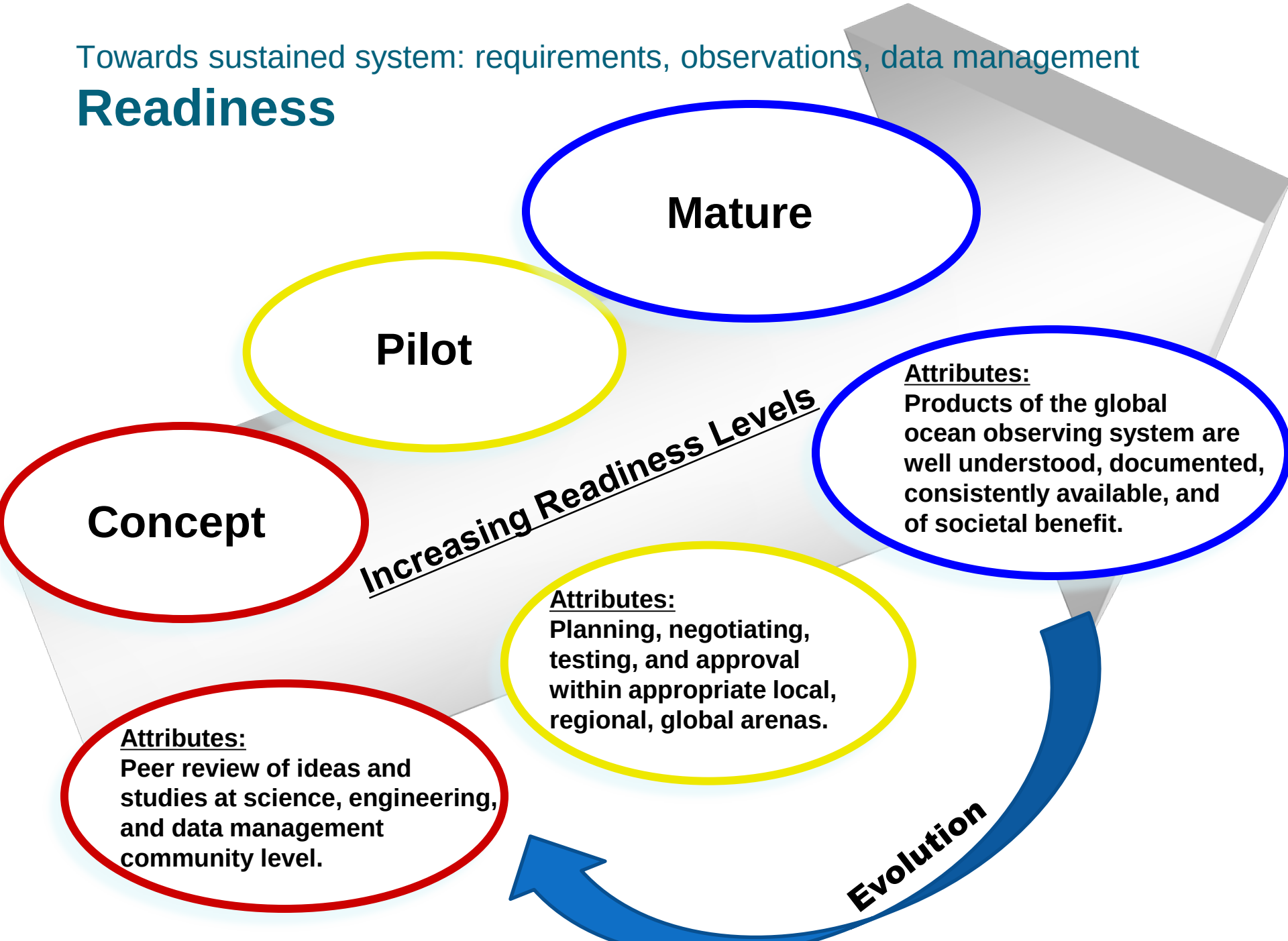
- Can we better express the continuing value of ocean observations in the context of scientific and societal benefits?
- What are the key research questions, monitoring products (indices and diagnostics), and capabilities (ENSO prediction) that we can use as our language expressing value?

Mature and sustainable observing systems

- OCO Program activities and performance must be strongly motivated scientifically, and also guided so that they contribute towards a sustainable observing system that evolves and matures
  - Develop expectations/best practices/attributes of sustainable observing system activities
  - Develop a strategy that encourages progress towards mature and sustained observing
  - Develop a strategy for considering and testing pilot evolutionary and revolutionary technologies (e.g. wave gliders) and resource it at appropriate levels

Towards sustained system: requirements, observations, data management

Readiness



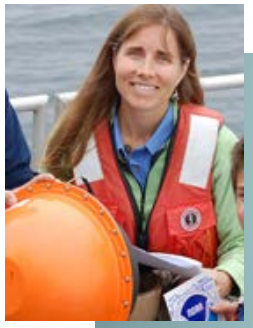
Ocean Climate Observation Program
Future Opportunities

- THERE WILL BE OPPORTUNITIES! Be Prepared!
- Budgets will increase (eventually!)
- What are the most pressing research questions and needs in the FY15-18 time frame?
  - Climate services initially focused on sea-level/inundation, marine ecosystems, extremes, and water resources….what about the Arctic?
  - What are the most pressing questions and observing capabilities that NOAA would be interested in?
  - Exploit linkages with WCRP/CLIVAR and other programs
- What are the opportunities to increase ties between global ocean observing system and communities who could (eventually) take advantage of our capabilities and platforms for the benefit of NOAA and its partners?

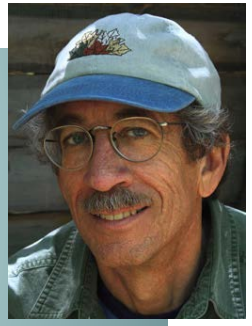
Summary

- Congratulations on success of observing activities to date
- Many compelling reasons to continue observing; and opportunities will present themselves to expand and improve the program (be prepared!)
- Thank you for your personal and institutional support of the program.

Observations & Monitoring Program







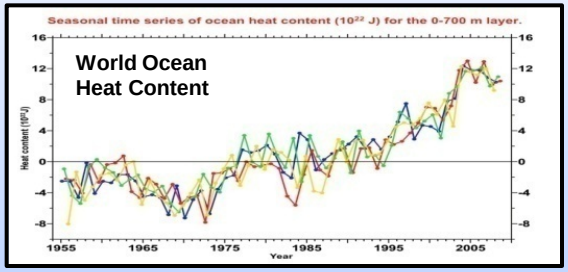
Thanks all and the COD Team

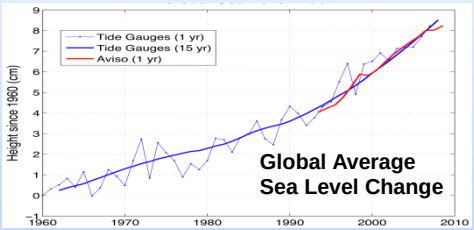


Ocean Climate Observation Program

Telling a better story: Linking Observing to Questions, More Capabilities, etc

Argo, XBT, etc





Observations -> Products -> Describing change, answering questions, etc
How would an increase/decrease in observing impact this ability?

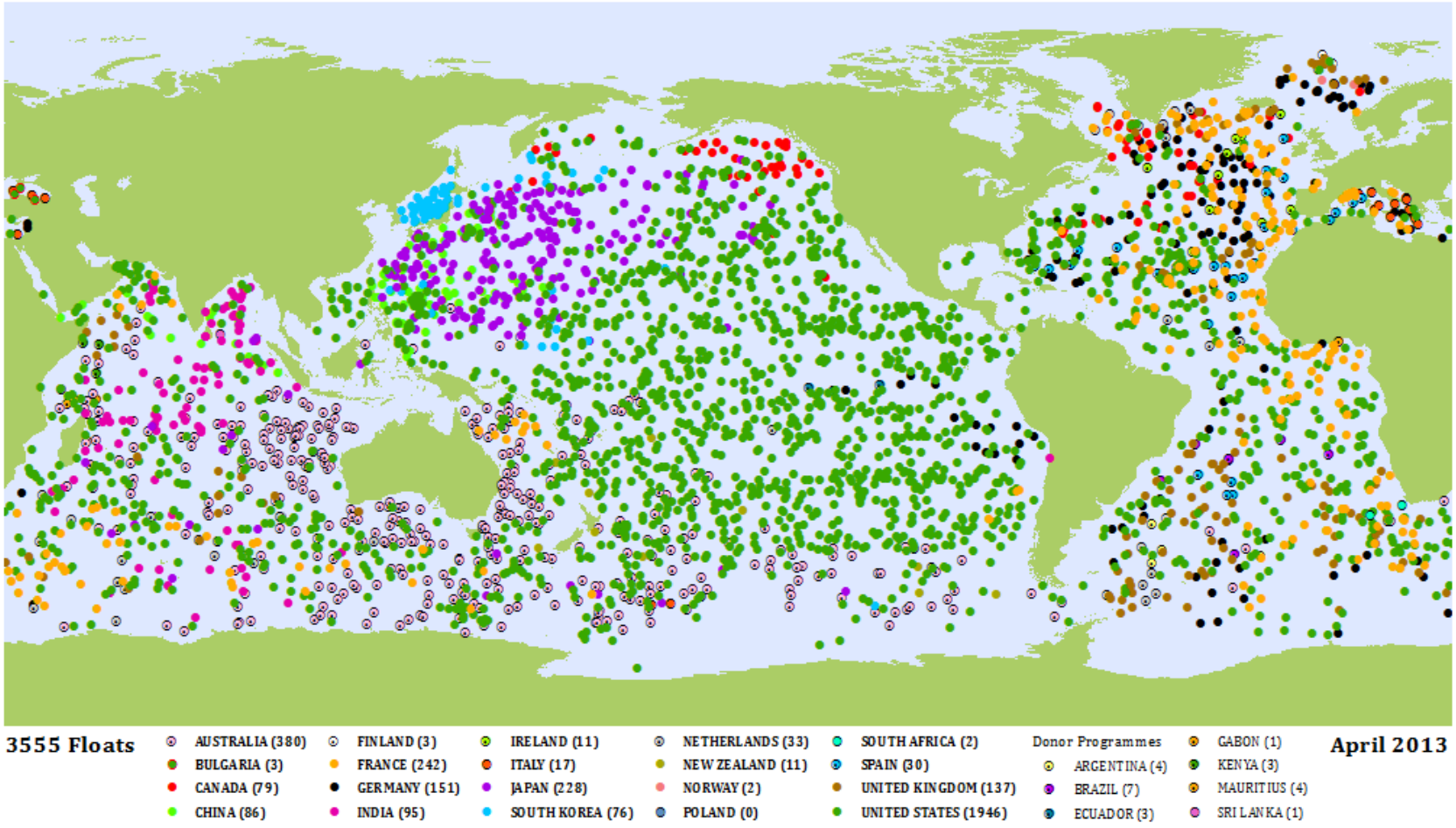
Question for PI's

What are the products, research questions, and capabilities of interest to NOAA that your activities address ?

Organize around essential ocean variables and a few research questions

Ocean Climate Observation Program
Argo

Location of 3555 active Argo floats in April 2013, color–coded by nation.



C-SOBOM Goal: ~40/year

Salinity, Temperature, Depth

pH

ISUS Nitrate, built into float

Iridium Comms., GPS

Oxygen

Chlorophyll fluorescence& particle concentration