# Agency Briefing

Eric Lindstrom, NASA HQ
On behalf of:
NASA, NSF, NOAA, DOE
(and ONR)

# U.S. AMOC Program

*www.atlanticmoc.org*

A U.S. interagency program with a focus on AMOC monitoring and prediction capability

**NASA Earth Science Division**

Satellite data analyses, modeling and space-based observations

**NOAA Climate Program Office**

Observing systems, monitoring, climate modeling

**NSF Geosciences program**

Process studies, models, and observations

**U.S. Department of Energy**

Climate and process modeling, climate impacts

# NASA Support for AMOC

- Annual Program Announcement (around Valentines Day) for Physical Oceanography in ROSES (Research Opportunities in Space and Earth Sciences)
- ECCO State of Ocean Climate – Intend to solicit proposals for climate research using ECCO.
- Science Teams
  - Ocean Surface Topography (just completed)
  - Ocean Vector Winds
  - Salinity (Aquarius, SPURS)
  - Sea Surface Temperature (ongoing opportunity)

# Top Five Long-range (~5-10 Years) NOAA Climate Research Areas of Interest that Intersect with CLIVAR

- Predictability: Improving Understanding of Climate Processes and Improving Climate Models
- Climate prediction and projection
- Climate re-analyses
- Sustaining and enhancing the ocean/Arctic climate observing system
- Information to support climate decision-making on a regional scale

Climate Science-to-Service Thematic Areas: Water Resources/Droughts, Coastal Inundation/Sea Level Rise, Climate Extremes, Marine Ecosystems, and Information for Climate Policy Decision-makers

# NOAA CPO FY13 Federal Funding Opportunity

**Deadlines: Letters of Intent: 5:00 p.m. Eastern Time, August 29, 2012,**
**Final applications: 5:00 p.m. Eastern Time, November 6, 2012.**

Earth System Science (Lead, Jim Todd)

1) ESS - Understanding and Improving Prediction of Tropical Convection using Results from the DYNAMO Field Campaign (Prg Mgr: Sandy Lucas)

**2) ESS - AMOC Mechanisms and Decadal Predictability (Sandy Lucas)**

- **Multi-model analyses and experimentation that seek to better understand the mechanisms of AMOC variability and predictability in different models.**
- **The use of model ensembles developed for the Intergovernmental Panel on Climate Change Fifth Assessment Report (IPCC AR5) is highly encouraged.**

3) ESS - Atmospheric Chemistry, Carbon Cycle, and Climate (Ken Mooney, Monika Kopacz)

Modeling, Analysis, Predictions, and Projections (Lead, Don Anderson, Prg Mgrs: Annarita Mariotti, Dan Barrie)

4) MAPP - Research to Advance Climate Reanalysis
5) MAPP - Research to Advance Climate and Earth System Models

Climate and Societal Interactions (Lead, Roger Pulwarty)

6) CSI-Sectoral Applications Research Program (SARP) (Prg Mgr: Nancy Beller-Simms)

7) CSI-Coastal and Ocean Climate Applications (COCA) (Adrienne Antoine)

See www.cpo.noaa.gov for additional information

# AMOC projects funded by the Climate Observation Division, NOAA

Western Boundary Time Series (WBTS)

M. Baringer/C. Meinen /S. Garzoli

Meridional Overturning Variability Experiment (MOVE)

U. Send

South Atlantic Meridional Overturning Circulation (SAMOC)

C. Meinen/M. Baringer/S. Garzoli/G. Goni

# Open Ocean: Predictability of the Atlantic Meridional Overturning Circulation (AMOC) from Monthly to Decadal Timescales for Improved Weather and Climate Forecasts

## Objectives and Thrusts

**Objectives:**

- Assess predictability of basin-scale three-dimensional ocean circulation from monthly to decadal timescales using the RAPID dataset as validating observations.

**Thrusts:**

- Build upon the existing IPCC AR5 experiments to assess basic predictability of the net transport and sensitivity to forcing.
- Conduct high resolution coupled model simulations to look at detailed structure and air-ocean feedback.
- Conduct close collaboration with observational community to identify knowledge gaps in underlying processes and design new field efforts.

## Challenges & Approach

**Challenges:**

- It is not clear what is predictable about the AMOC. The AMOC is thought to be an important driver for the oceanic meridional heat flux and sea surface temperature, although the link between the AMOC and climate is not clear.
- Recent climate model studies have shown a slowdown in the AMOC with possible impacts on European regional seasonal climate, ENSO and hurricanes in the Atlantic Ocean.

**Approach:**

- Leverage existing USGCRP and IPCC AR5 simulations assessing AMOC and meridional mass, heat and salt transport
- Additionally assess ocean reanalyses fields against predictions at various timescales from the Estimating the Circulation and Climate of the Ocean (ECCO) and HYCOM groups for the strength and depth of the AMOC along with the variability and trends.

## Schedule and Key Performers

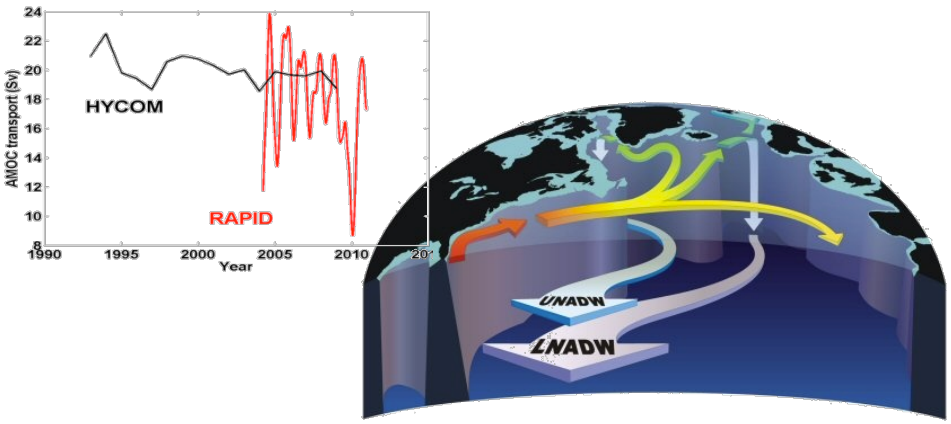

- Jim Richman, Oceanography Division, Code 7323, Bldg. 1009, Naval Research Laboratory, Stennis Space Center, MS 39529 (228) 688-4933 james.richman@nrlssc.navy.mil


- NRL/SSC, NRL/MRY, CESM , NCAR, LANL, UCSD-SIO, NASA/ GISS, NCEP, US AMOC Science Team, Duke U., AOML, NOAA / GFDL, WHOI, Texas A&M

- Year 1: Identify participating groups and experimental coupled model projects.
- Year 2: Coordinate workshops and develop common cases studies, skill metrics, output criteria, data management and analysis plans.

## Accomplishments

- FY13 Start leveraging ongoing work at contributing agencies



# NSF Support for AMOC

- Ongoing Physical Oceanography Program (2 X Year) receipt of proposals for observing system components and process studies.

# DOE Support for AMOC

- No information provided

# BACKUP SLIDES

# NOAA Details

# WBTS (Western Boundary Time Series)

Molly Baringer, Chris Meinen, Silvia Garzoli
NOAA AOML
Partners: RAPID, MOCHA

Monitoring the Western Boundary Currents off Florida -

- northward flowing Florida Current
- southward flowing Deep Western Boundary Current

~30 years

Cable, CTD/LADCP cruises, moored inverted echosounders

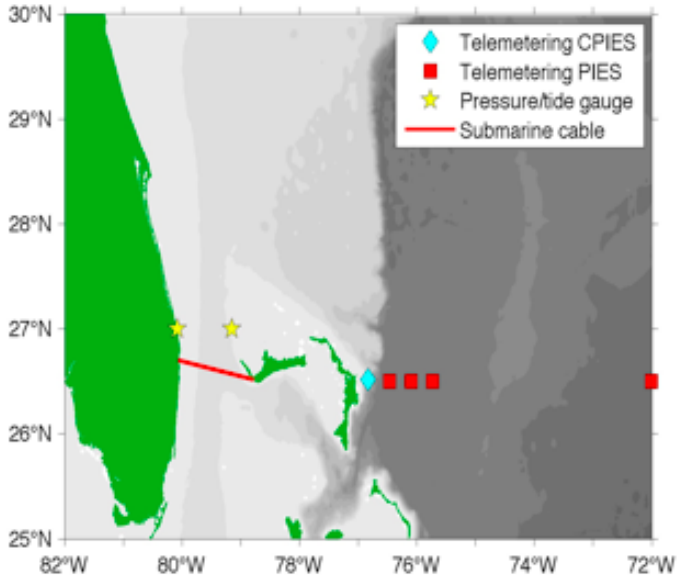



**Figure 1:** *Summary locations of continuous time series components of the Western Boundary Time*

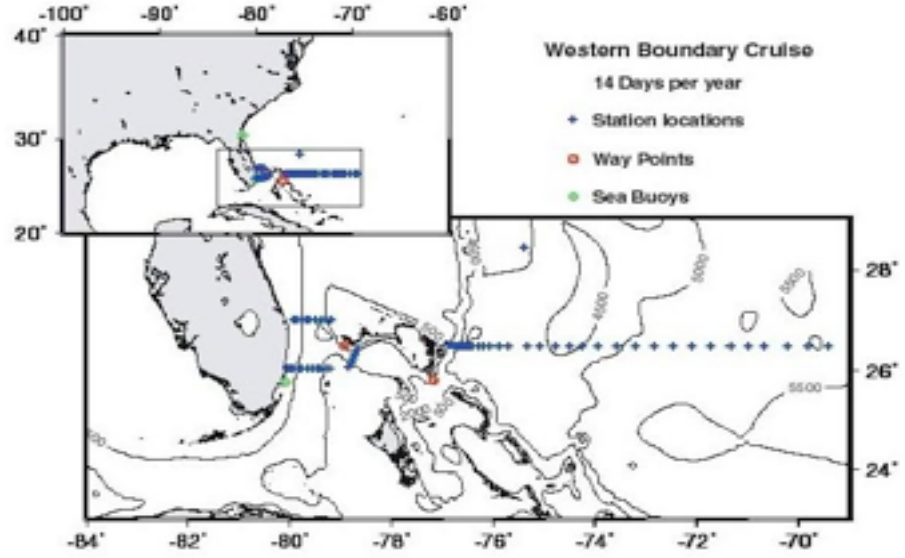



**Figure 2:** *Summary locations of discrete CTD/LADCP and dropsonde locations from the Western Boundary Time series program.*

With partners – spanning the N. Atlantic

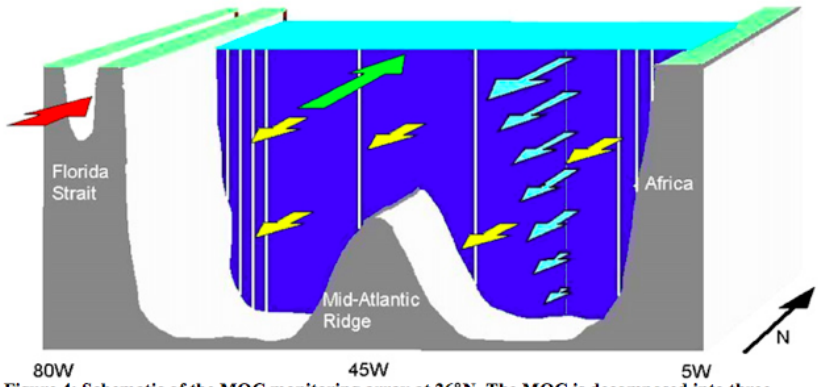



**Figure 4: Schematic of the MOC monitoring array at 26°N. The MOC is decomposed into three components: (1) Gulf Stream transport through the Florida Straits (red arrow), (2) the near-surface wind driven Ekman transport (green arrow) arising from the zonal wind stress, and (3) geostrophic (thermal wind) contribution (light blue arrows) calculated between adjacent pairs of ''moorings'' (vertical lines). Yellow arrows indicate a spatially constant velocity correction that ensures mass balance across the section. Modified from Rayner et al., 2011.**

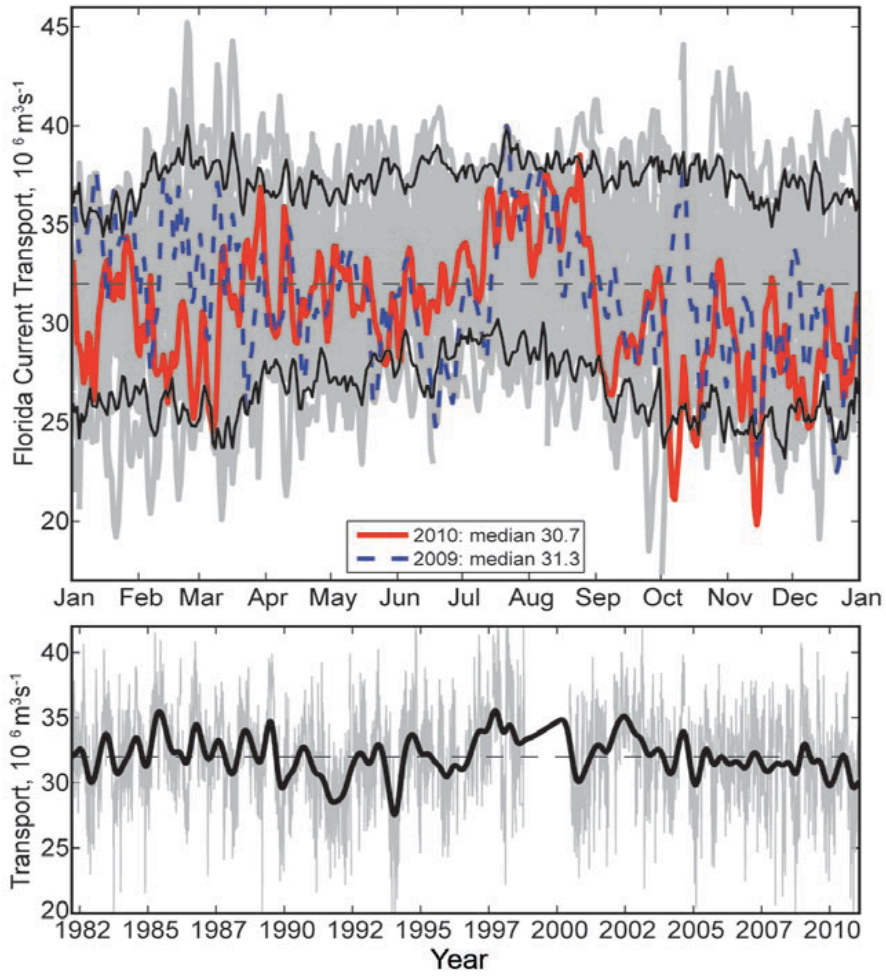



Figure 8 (top) Daily estimates of the transport of the Florida Current during 2010 (red solid line) compared to 2009 (dashed blue line). The daily values of the Florida Current transport for other years since 1982 are shown in light gray and the 90% confidence interval of daily transport values computed from all years is shown in black (solid line); the long-term annual mean is dashed black. The mean transport in 2010 of 30.7 ± 1.5 Sv decreased for the fourth year in a row, below the long-term mean for the daily values of the Florida Current transport (32.2 Sv). (bottom) Daily estimates of the Florida Current transport for the full time series record (light gray), a smoothed version of transport (heavy black line; using a 30-day running mean six times) and the mean transport for the full record (dashed black). (Baringer et al 2011)

# Florida Current Transport

Time series needed with high temporal resolution

The envelope of daily estimates – gray

Two different years – red and blue

Decreasing since 2000?

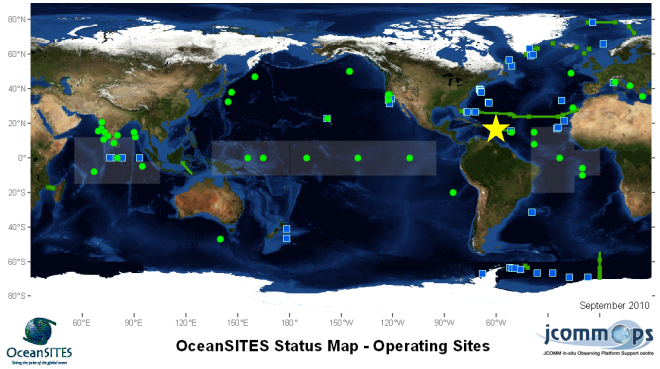
# MOVE ORS

(Meridional Overturning Variability Experiment)

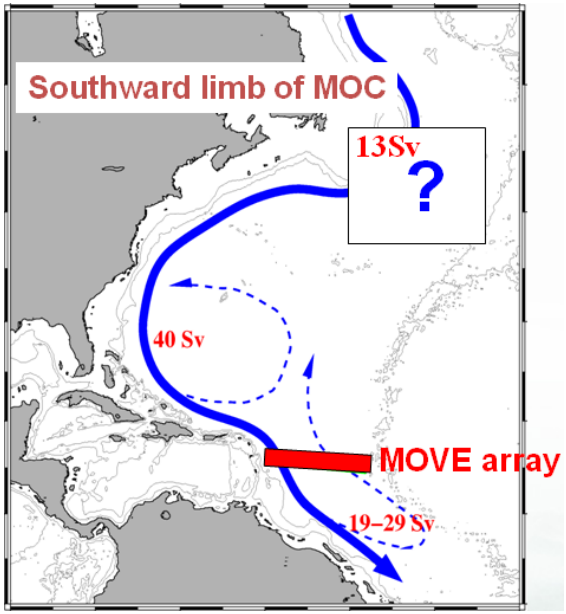

Uwe Send

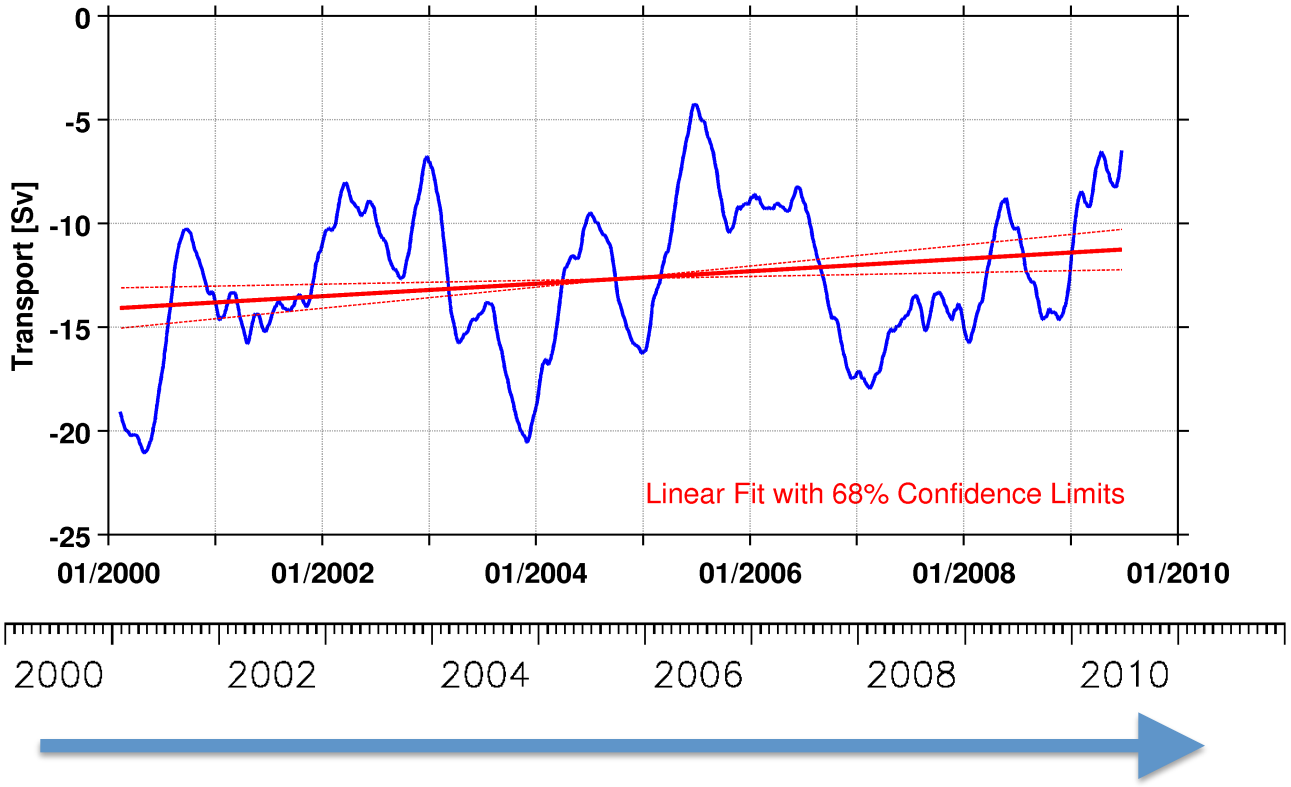
Scripps Institution of Oceanography

**Partners: NTAS** (A.Plueddemann)**, IfM-Geomar**


**Captures transport of the southward branch of the AMOC, i.e. the NADW.**
**3Sv weakening observed over 10 years, 87% significant.**



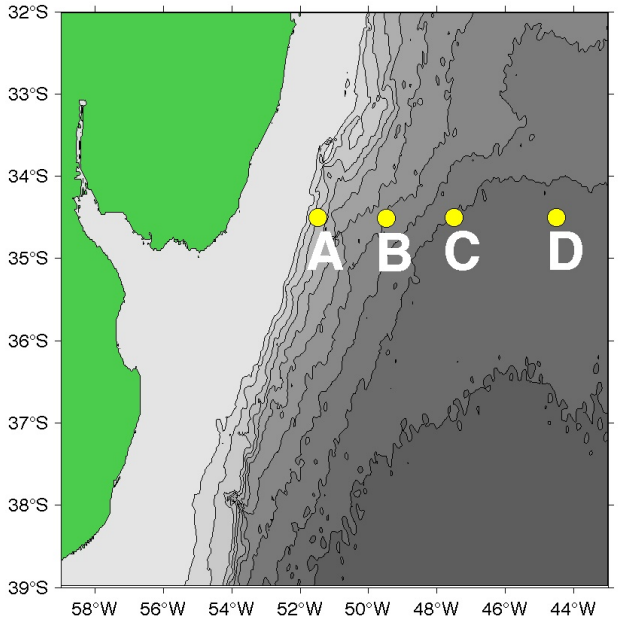

**MOVE**

# SAM -
# South Atlantic Meridional Overturning Circulation

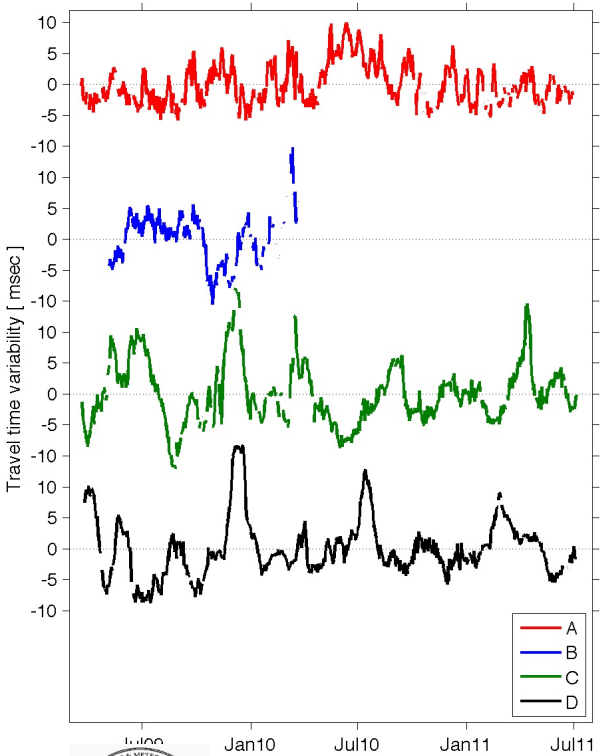
Chris Meinen, Molly Baringer, Silvia Garzoli, Gustavo Goni – AOML

**Partners: Argentina, Brazil – to the east, France and South Africa**

Beginning in 2008, three pressure-equipped inverted echo sounders (PIES) and one current and pressure-equipped inverted echo sounder (CPIES) at 34.5°S near the Atlantic western boundary. To measure key AMOC flows near the western boundary in the South Atlantic.




*Locations of the four instruments deployed as part of the SAM project.*



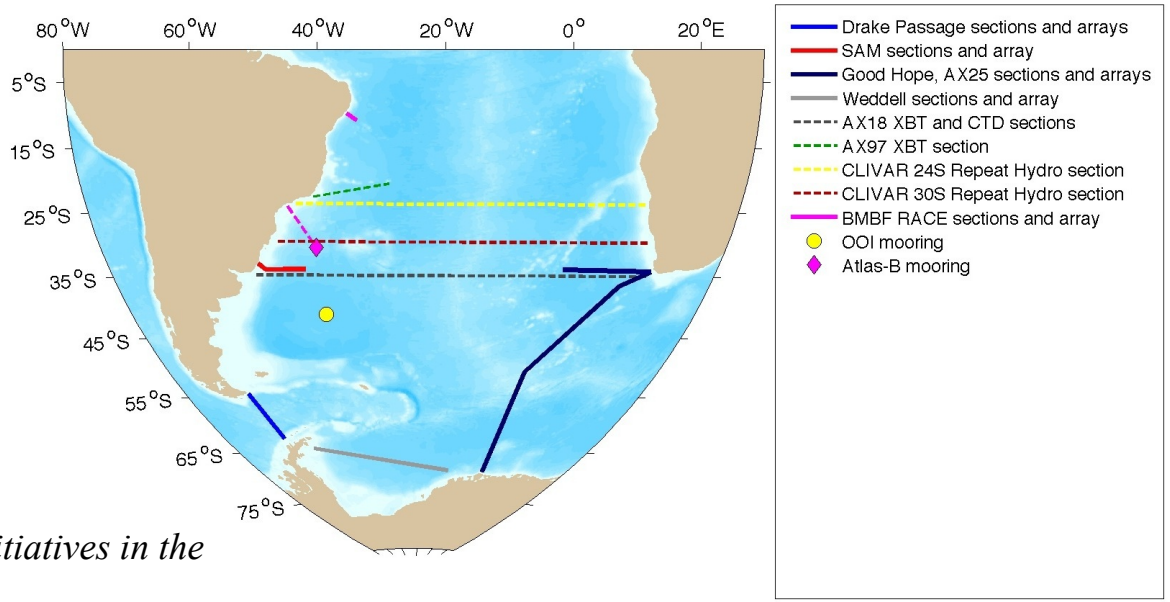

*Measured round-trip acoustic travel times from the PIES. These can be used to estimate full-water-column profiles of temperature, salinity, and density.*

# SAM (continued) - South Atlantic Meridional Overturning Circulation

Chris Meinen, Molly Baringer, Silvia Garzoli, Gustavo Goni – AOML

**Partners: Argentina, Brazil – to the east, France and South Africa**

The overarching goal of the SAMOC initiative is to observe and understand the mechanisms that control the mean and time-varying MOC in the South Atlantic and the interocean exchanges. The first SAMOC international meeting took place in Argentina, May 2007 and since then, the group has met regularly.



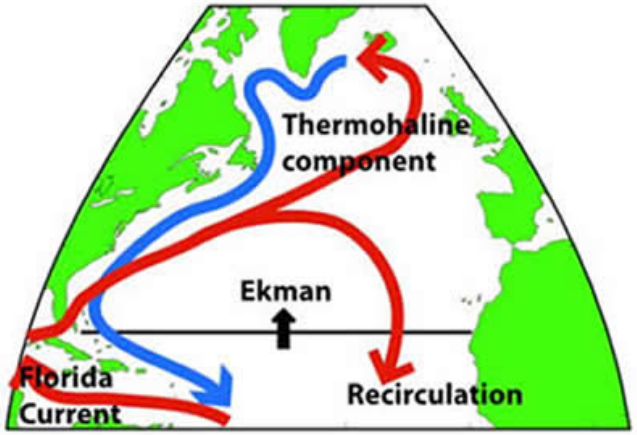

*SAMOC-related initiatives in the South Atlantic*

# ONR Details

# Decadal Climate Variation Demonstration

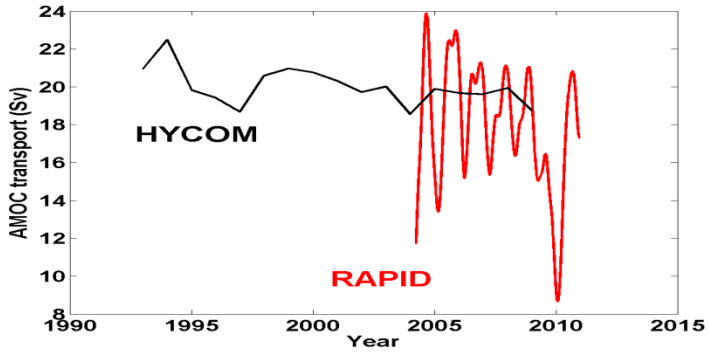

- Demonstration: Predictability of the Atlantic Meridional Overturning Circulation (AMOC)
  - Leverage the USGCRP investment in observations and modeling
  - Augment the IPCC AR5 AMOC comparisons with reanalyzes and high resolution coupled models
  - Science Team to include NRL NAVGEMS/ HYCOM, NCEP CFS and CESM High Resolution Modelers and Task Team leads from US AMOC Science Team

# Decadal Climate Variation Demonstration



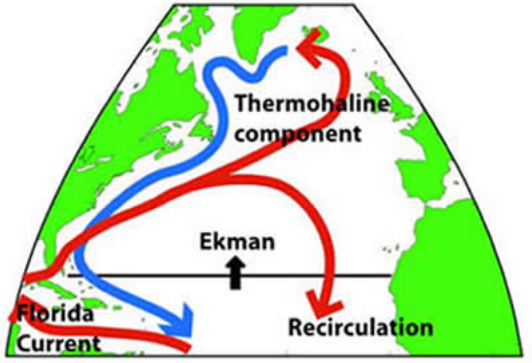

- Demonstration Science Team
  - High Resolution Modeling Groups
    - NRL NAVGEMS/HYCOM James Richman, SSC/Carolyn Reynolds,MRY
    - CESM (NCAR/LANL/SIO) Gohan Danobasglu, NCAR/Matt Maltrud, LANL/Julie McClean, SIO
    - NCEP CFS David Behringer, NCEP/Suranjana Suha, NCEP
  - US AMOC Science Team—Task Leaders
    - Observing System Susan Lozier, Duke/Molly Baringer, AOML
    - State Estimation Rong Zhang, NOAA GFDL
    - Predictability Young-Oh Kwon, WHOI
    - Climate Sensitivity Ping Chang, Texas A&M
- Team membership discussion at US AMOC Science Team Meeting in Boulder, CO 15-17 August, 2012

# Decadal Climate Variation Demonstration




- AMOC represents an opportunity and a challenge
  - By 2014, a 10 year time series of the AMOC at 26.5N plus other sites in North and South Atlantic. Rare to have a detailed complete observation of a potential climate driver
  - Heavy investment by USGCRP in AMOC observation
    - 60 funded investigation
    - IPCC AR5 AMOC comparisons
- Challenge—What is predictable about the AMOC?
  - The model estimates and observations are not the same
  - High frequency AMOC fluctuations driven by wind stress

# Decadal Climate Variation Demonstration




- Baseline Assessment
  - What is the strength and depth of the AMOC in current generation of coupled and uncoupled models?
  - For the models with long runs, what is the variability and trend of the AMOC?
  - Results from CMIP AMOC comparisons and sensitivity
- Science Goals for Demo
  - Decadal prediction of AMOC 2004-14 RAPID observations
  - Secondary prediction for other shorter or less complete observations
    - MOVE 16N, MV Oleander (Upper Ocean only) SAMOC 30S (proposed)
  - Determine what is predictable on 10 year time scale
    - Mean value
    - Variance
    - Seasonal cycle

# Decadal Climate Variation Demonstration


- Timeline
  - FY13 Establish Science Team, Baseline Assessment, Goals for demo
    - Presentation at US AMOC Science Meeting Aug 2012
    - Demonstration Science Team Meeting
  - FY14 Continue Baseline Assessment
    - Establish observational targets—mean, variability, trends, …
    - Analyze existing simulations and reanalyzes
    - Establish ground work for model Comparisons
  - FY15 CMIP like effort to predict 10 yr RAPID obs
    - Multi-Model Ensemble
    - Host data via ESGF
  - FY16 Evaluate Multi-Model Ensemble for AMOC climate sensitivity
  - FY17 Identify critical path, resource and technology issues for transition into operations

# Decadal Climate Variation Demonstration


- Caveats
  - Is the RAPID 2004-14 time series a reasonable dataset for comparison?
    - What is predictable?
  - Assumes access to complete US/UK dataset and active participation by observationalists
  - Can we use USGCRP/CMIP ESGF framework to host the comparison?
    - Need strong coordination with USGCRP AMOC Science Team
  - Assumes leveraging/additional support for NRL/ CESM/CFS efforts to participate in the demo







# Earth System Prediction Capability (ESPC)

July 2012

# ESPC Overview

Introduction

ESPC is an **Interagency collaboration** between DoD (Navy, Air Force), NOAA, DoE, NASA, and NSF for coordination of research to operations for an earth system analysis and extended range prediction capability.

It does not replace or take precedence over Agency requirements or resource decisions but rather seeks to improve communication and synergy, especially in the area of global medium range environmental forecasting at the challenging timescales of the **weather to climate interface**.

Thrusts

Common **prediction requirements and forecast model standards** that enable agencies to improve leverage and collaboration.

A **national research agenda** that will improve predictions from days to decades.

Cooperative five-year **demonstration projects** to inform S&T and R&D efforts.

Integration of atmosphere-ocean-land-ice and space predictions into a **fully coupled global prediction** capability.

# Charter

## Goals (2010)

… establish and maintain a multi-agency initiative that provides leadership and coordination to meet broad, but specific, agency mission requirements and interests for an earth system analysis and prediction/projection framework to support global forecasts from hours to decades at appropriate horizontal and vertical resolutions.

1. A national approach to an earth system numerical prediction capability providing advanced data assimilation, improved numerical model physics and increased computational efficiencies;

2. A common set of requirements and standards that enable agencies to meet their own mission requirements while providing improved leverage and collaboration where these missions can be mutually supportive;

3. A mechanism to develop a national research agenda that will improve earth system projections and predictions from days to decades; and

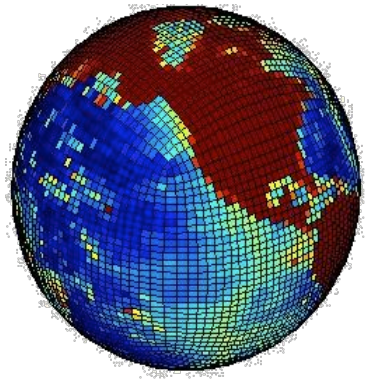
4. A cooperative set of demonstrations to inform future research and development efforts encompassing Federal, private and academic organizations.

# Charter Additions(2012)

… a *Science Steering Group* will be established composed of **subject matter experts** representing the Department of Commerce (NOAA), the Department of Defense (Navy and Air Force), Department of Energy, the National Aeronautics and Space Administration and the National Science Foundation as recommended by each Agency's members.

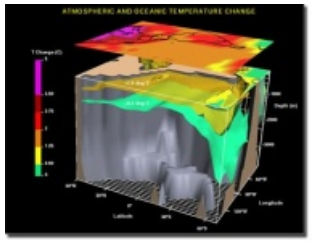
The *Program Manager* will initially be a Federal employee hired and employed by the US Navy or NOAA. The position rotates every three years with the Deputy Program Manager position. The **ESPC Program Office is located within NOAA in Silver Spring, MD** and Program Office office space, support staff, internet/ IT services and other administrative functions will be provided by NOAA.

# Approach



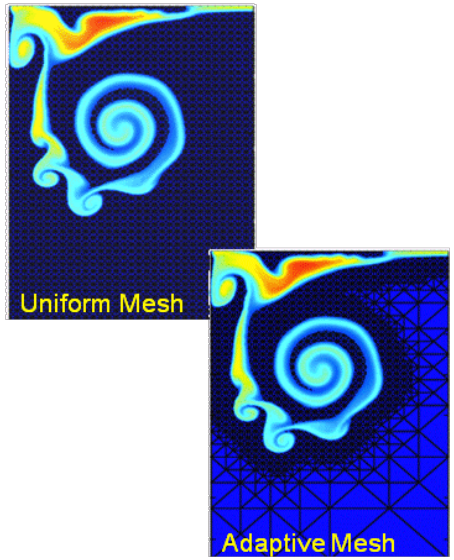
Seek Sources of Predictability through:

Improved Model Physics
- Coupled global modeling
- Improved resolution & parameterization



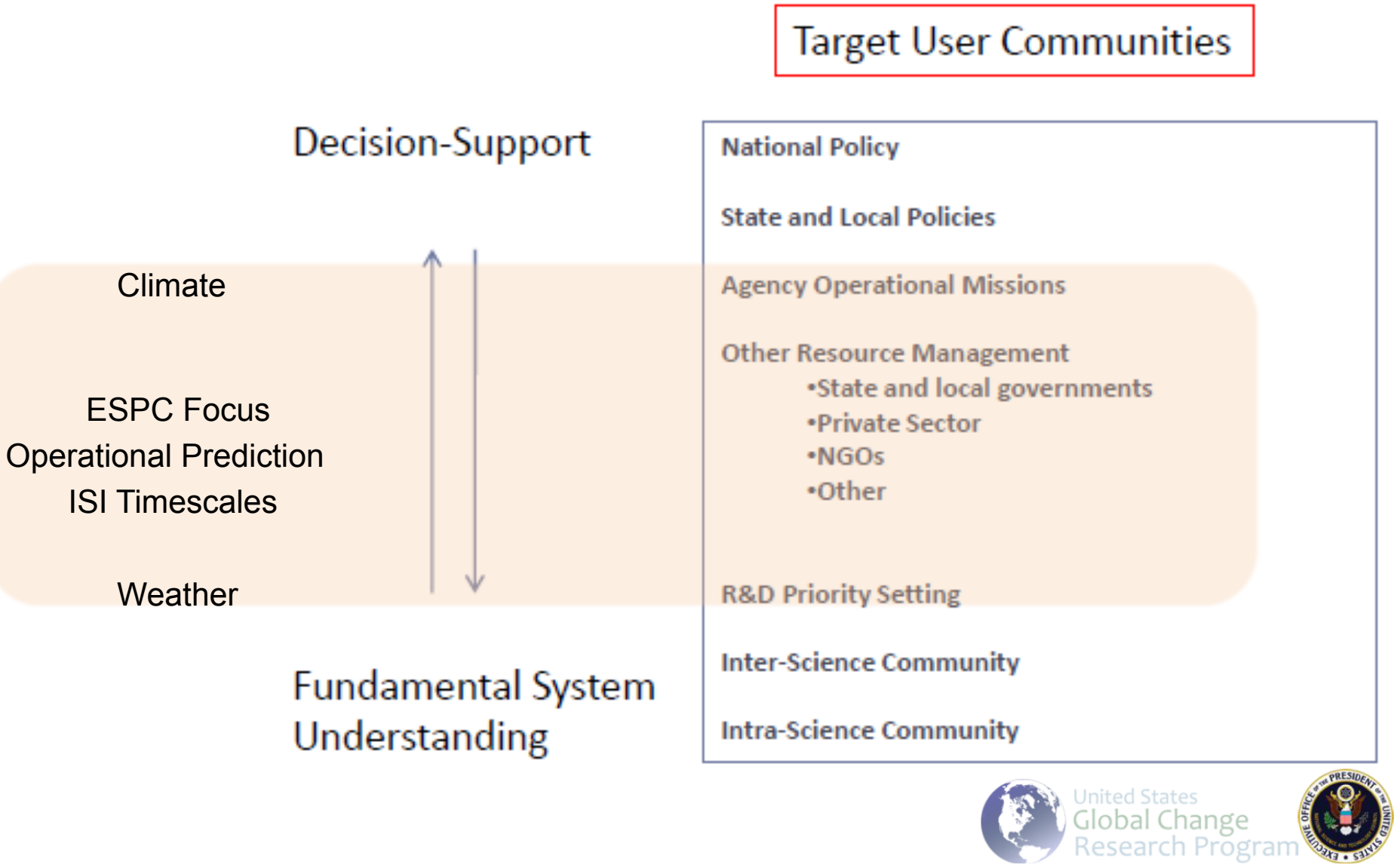
Improve Initial Value Problem through
- Joint observational retrievals
- New hybrid DA approaches

Increase Forecast Information through
- Stochastic prediction and post-model processing
- National Multi-model ensembles
- Seamless prediction



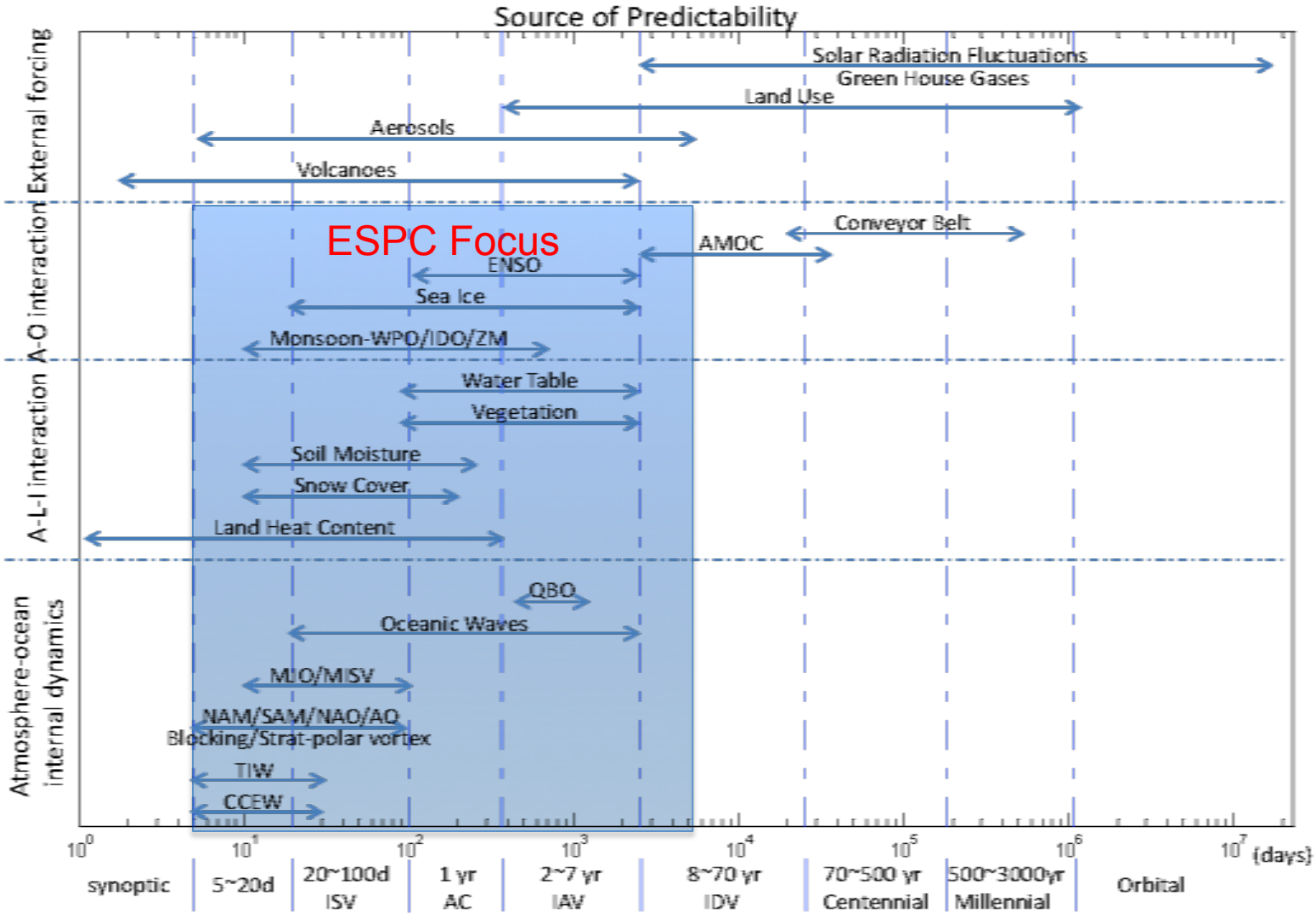

Increase System Resolution affordably through
- Efficient Computational Architectures
- Efficient Numerics/ Discretization

# Initial ESPC Focus: R2O and O2R at ISI Timescales




United States Global Change Research Program

# Seeking Sources of Extended Range Predictability and Operational Prediction




Assessment of Intraseasonal to Interannual Climate Prediction and Predictability, 2010, THE NATIONAL ACADEMIES PRESS • 500 Fifth Street, N.W. • Washington, DC 20001

# ESPC Demonstrations
## Workshop Results

Interim Science Steering Group (ISSG) Workshop 21-23 March, 2012

- Attended by scientists (ISSG), Operational Forecast Center representatives (for requirements mapping), Agency program managers (for cooperative resourcing of underlying research)

Outcomes:

- Lead Scientist/Coordinator for each Demonstration identified
- Agency reps, Modeling Center reps and Science Team agreed that the ***most needed and most scientifically feasible forecast timescales are in the 10-day to 1-2 year range based on our current and near term understanding and capability (ISI Timescales)***
- Linkages between climate research (USGCRP, US CLIVAR, etc.) and ESPC were identified for follow-on coordination within each Demonstration Science Team.
- Next ESPC Science Workshop planned for ~ Nov 2012

# ESPC Demonstrations

- Extreme Weather Events: Predictability of Blocking Events and High Impact Weather at Lead Times of 1-6 Weeks (Stan Benjamin, ESRL)

- Seasonal Tropical Cyclone Threat: Predictability of Tropical Cyclone Likelihood, Mean Track, and Intensity from Weekly to Seasonal Timescales (Melinda Peng, NRL MRY)

- Arctic Sea Ice Extent and Seasonal Ice Free Dates: Predictability from Weekly to Seasonal Timescales (Phil Jones, LANL)

- Coastal Seas: Predictability of Circulation, Hypoxia, and Harmful Algal Blooms at Lead Times of 1-6 Weeks (Gregg Jacobs, NRL SSC)

- Open Ocean: Predictability of the Atlantic Meridional Overturning Circulation (AMOC) from Monthly to Decadal Timescales for Improved Weather and Climate Forecasts (Jim Richman, NRL SSC)