



# CLIVAR OCEANS & CLIMATE

variability, predictability and change

*The World Climate Research Programme's project on ocean-atmosphere interactions*

To improve understanding and prediction  
of ocean-atmosphere interactions  
and their influence on climate variability and change,  
to the benefit of society and the environment.



## **CLIVAR core Research Areas & Imperatives**

- **Anthropogenic Climate Change**
- **Intra-to-Seasonal Variability, Predictability and Prediction**
- **Decadal Variability, Predictability and Prediction**
- **Improved Atmosphere and Ocean Components of ESMs**
- **Data Synthesis and Analysis**
- **Ocean Observing System**
- **Knowledge Exchange**
- **Capacity Building**



## **CLIVAR Focused & Integrated Research Opportunities**

- **Intraseasonal, seasonal and interannual variability and predictability of monsoon systems**
- **Decadal variability and predictability of ocean and climate variability**
- **Trends, nonlinearities and extreme events**
- **Marine biophysical interactions and dynamics of upwelling systems**
- **Dynamics of regional sea level variability**
- **Consistency between planetary heat balance and ocean heat storage**
- **ENSO in a warmer world**
- **...**

# CLIVAR Scientific Steering Group

# ICPOs

## Core Panels

## Focused & Integrated Res. Opportunities

- Ocean Model Development Panel
- Global Synthesis and Observations Panel
- Climate Dynamics Panel
- Atlantic Region Panel
- Pacific Region Panel
- Indian Ocean Region Panel
- Southern Ocean Region Panel
- Monsoons Panel
- ETCCDI
- Knowledge Exchange and Capacity Building Panel



- Predictability of monsoon systems
- Decadal climate variability and predictability
- Biophysical interactions and dynamics of upwelling systems
- Dynamics of regional sea level variability
- Prediction and attribution of extreme events
- ENSO in a warmer climate
- Planetary heat balance & ocean heat storage
- NEW





**CLIVAR research  
opportunity**

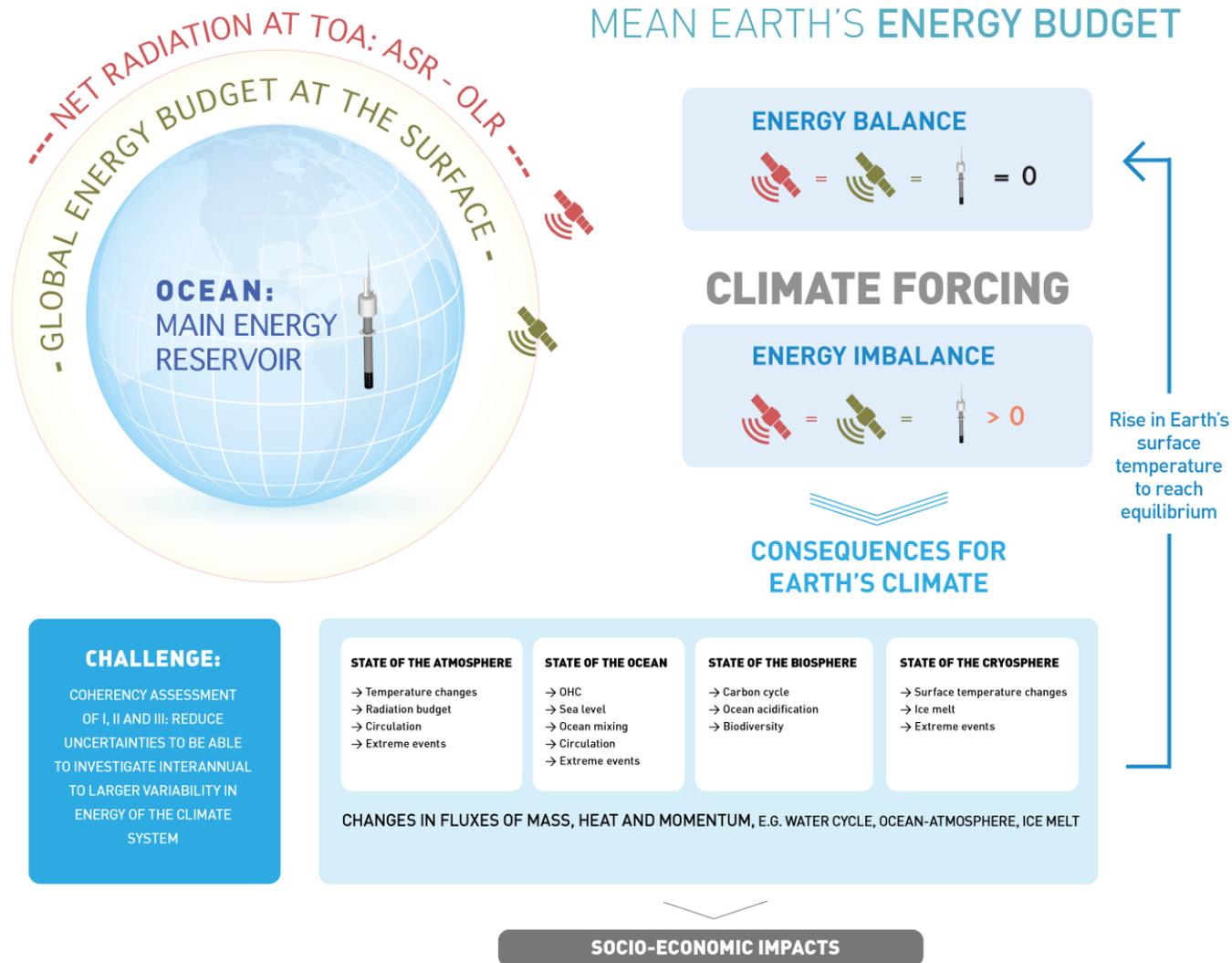
## **Consistency between planetary heat balance and ocean heat storage**

Karina von Schuckmann\*, Martin Visbeck, Pierre-Philippe Mathieu,  
Keith Haines, Sergey Gulev, Bernard Barnier

\*[karina.von.schuckmann@ifremer.fr](mailto:karina.von.schuckmann@ifremer.fr)

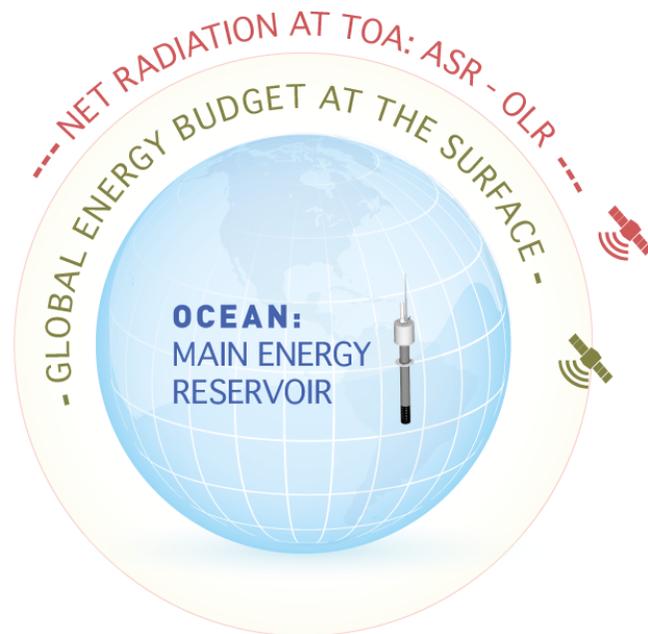
challenge

CLIVAR research opportunity



challenge

CLIVAR research  
opportunity



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Large **uncertainties** on the estimate of the **energy flows and storage**, as well as the **challenge of their accurate measurements** at the global scale.

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An overarching scientific challenge facing the whole climate science community is related to achieve the adequate **accuracy necessary for climate state and variability studies**, thus dealing with the **detection and decrease of uncertainties of the global climate observing systems** and related data and information products.



**motivation**

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opportunity**

Improving the **accuracy of our estimates of Earth's climate state and variability** is critical for advancing our understanding and prediction of the evolution of our climate.

There are **independent measurement approaches** based on remote sensing and in situ measurements, as well as from climate models and ocean synthesis.

- Each approach has problems. **Reconciling the different approaches remains a challenge.**
- There is merit in pursuing all methods, because confidence in the result will become high only when they agree or at least the reasons that they differ are understood.
- Only by using conservation and physical principles can we infer the likely resolution.



**Scientific  
key  
questions**

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opportunity**

- ➔ How can we improve observations and models of Earth's mean state and variability?
- ➔ How can we use conservation and physical principles to reconcile independent measurements and syntheses to advance our understanding of climate variability and change ?
- ➔ How can we detect and decrease uncertainties in global climate estimates from observing systems and ocean reanalyses ?



**objective**

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opportunity**

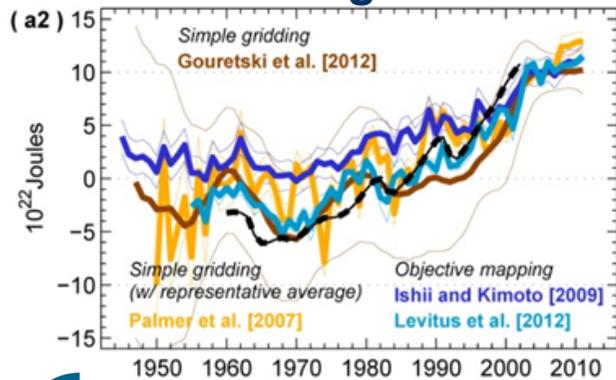
The main objective of the activity is to analyze the **consistency between planetary heat balance and ocean heat storage** estimates, data sets and information products based on different parts of the global observing systems (remote sensing (ESA/EO) and in situ) and ocean reanalysis under three foci:

- Earth Observation Measurement Constraints on Ocean Heat Budget (ESA EO)
- In situ observations of ocean heat content changes (GOOS and CLIVAR/GSOP)
- Ocean reanalysis for atmosphere-ocean heat exchange and ocean heat content estimate (CLIVAR/GSOP, SeaFlux)

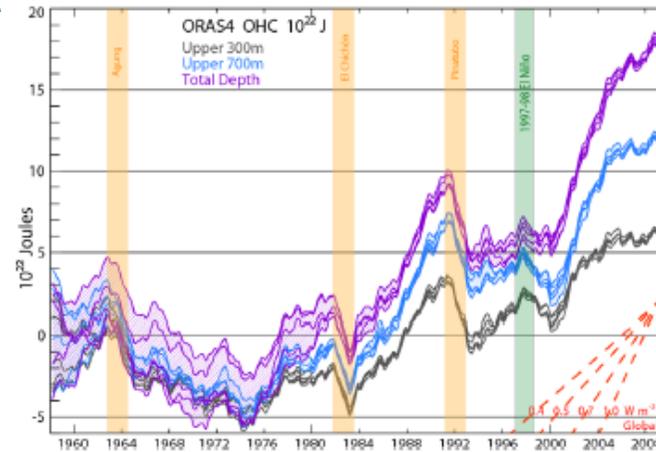
expected outcomes

Refinement of a scientific framework on consistency between planetary heat balance and ocean heat storage

### Reconciling GOHC



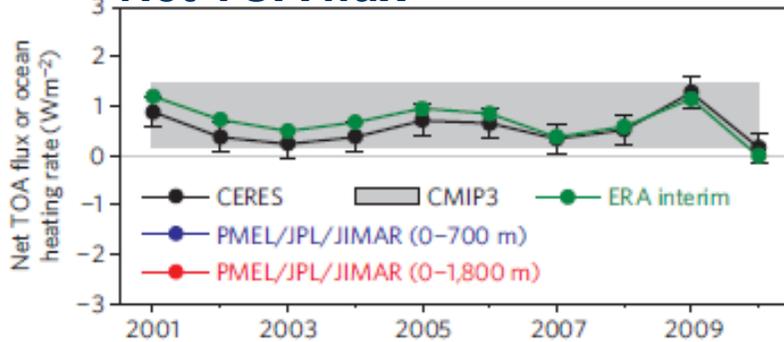
Abraham et al., submitted



Balmesada and Trenberth, 2013

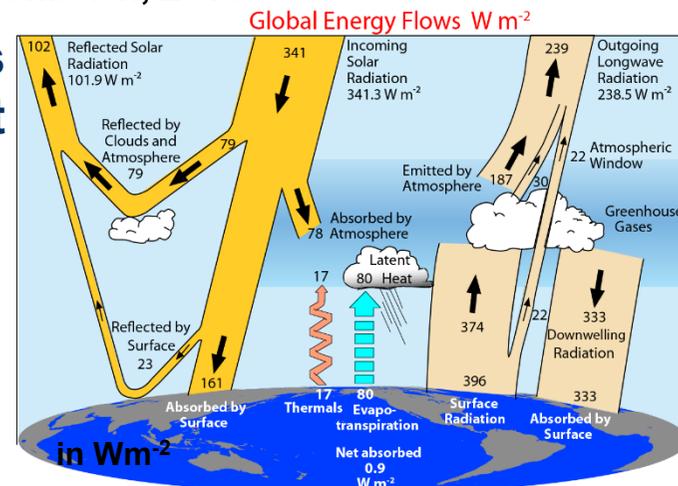
Estimations from reanalyses

### Net TOA flux



Loeb et al., 2012

### Mean Earth's energy budget



Trenberth and Fasullo, 2011

expected  
outcomes

Evaluation of existing data sets and  
information products and their consistency

$$SL_{\text{steric}}(\text{Argo}) + SL_{\text{res}} = SL_{\text{total}} - SL_{\text{mass}}$$



**Argo:**  
2000-2012

Changes below  
Argo depths  
&  
Estimation errors  
(sampling and  
processing  
issues, systematic  
biases)



**Altimetrie:**  
1993-2012



**GRACE:**  
2002-2012

Overlapping time window for global and re-qualified data 2005-2010:  
Methods developed for global estimations

von Schuckmann  
and Le Traon, 2011

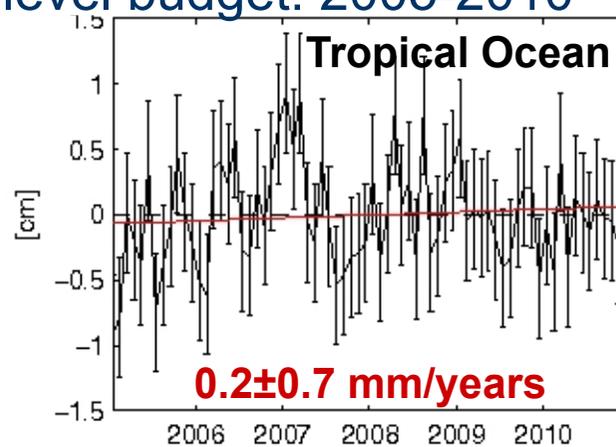
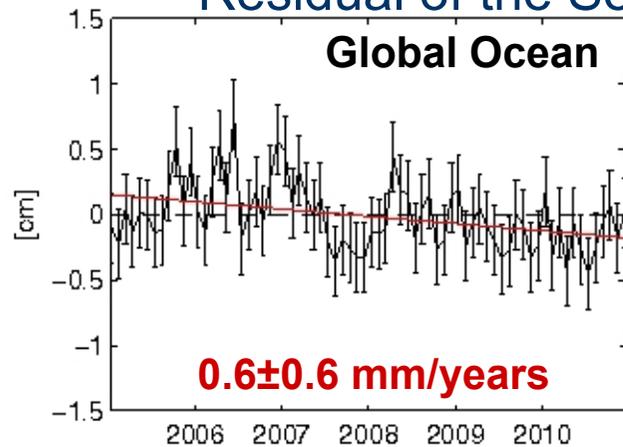
Averaged DM  
gridded product,  
AVISO

Chambers and  
Schröter, 2011

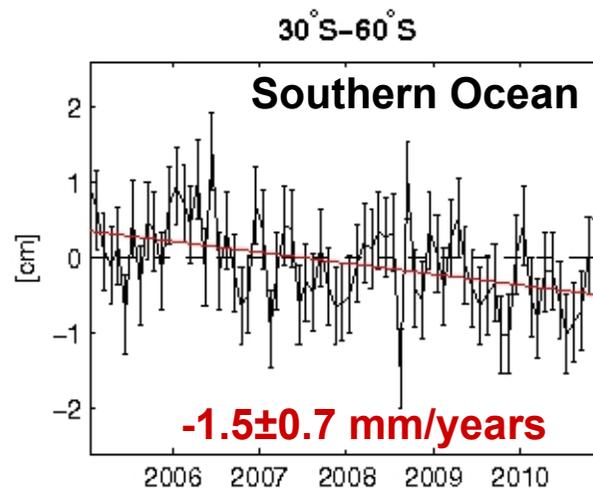
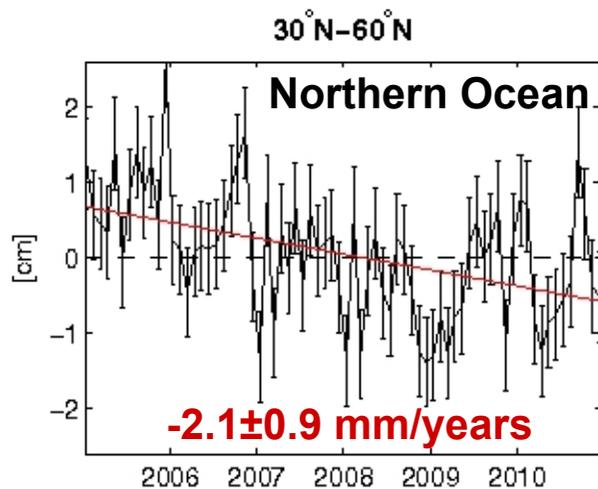
expected  
outcomes

## Evaluation of existing data sets and information products and their consistency

### Residual of the Sea level budget: 2005-2010



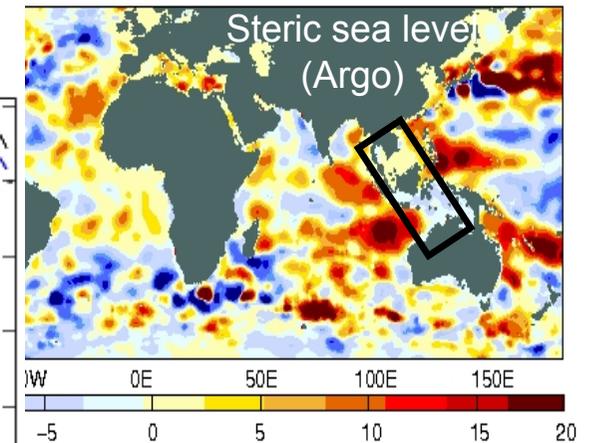
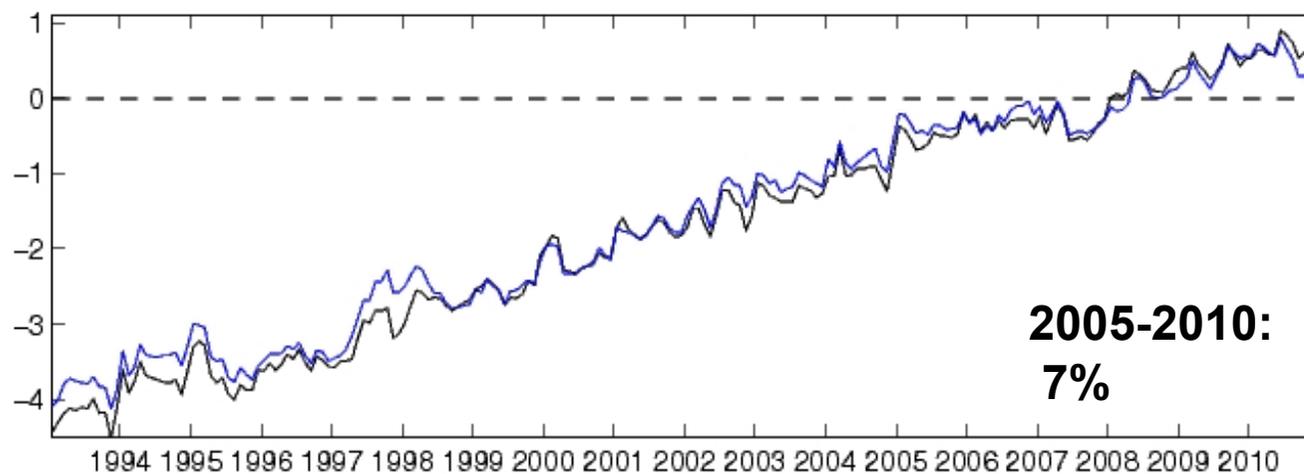
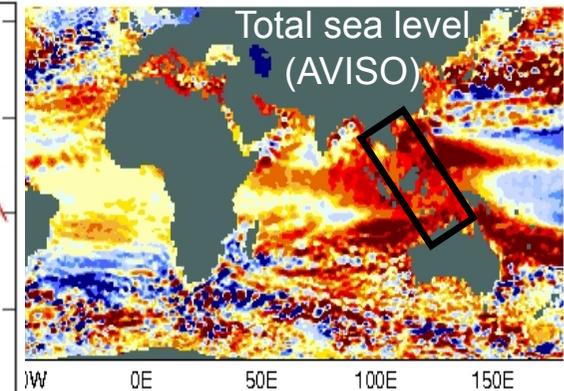
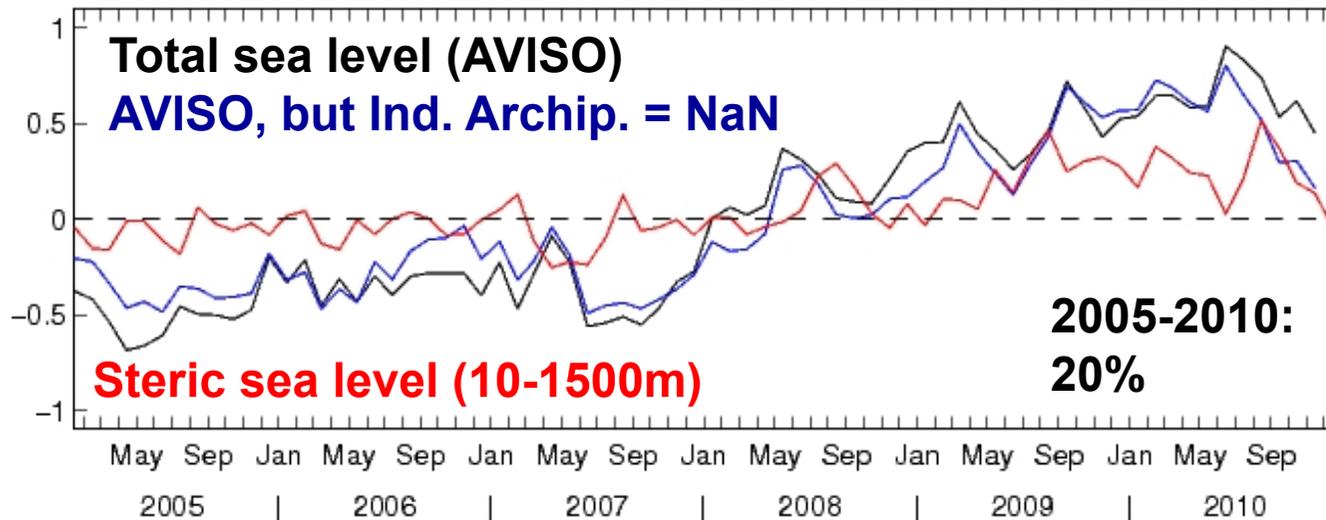
We could close the global and tropical sea level budget, but regional issues remain in the extra-tropics.



von Schuckmann et al., 2013  
(under review)

expected  
outcomes

Recommendations on how to improve the  
observing systems and derived information  
products, assimilation methods, ocean and  
climate models and surface fluxes



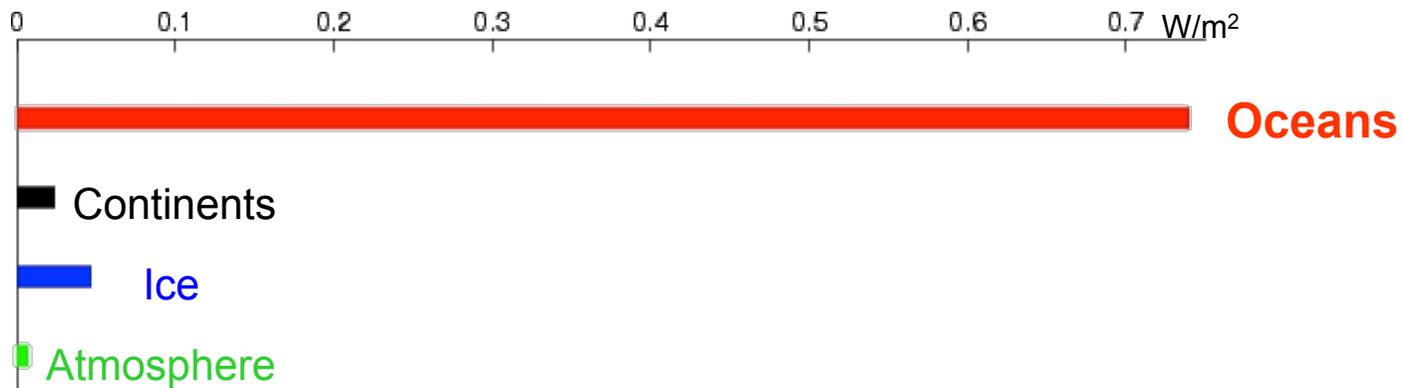
von Schuckmann et al., 2013  
(under review)

**expected  
outcomes**

**Contributing insights to related climate  
research topics** such as anthropogenic  
climate change, seasonal climate prediction,  
decadal variability, predictability and  
prediction, sea-level variability and change



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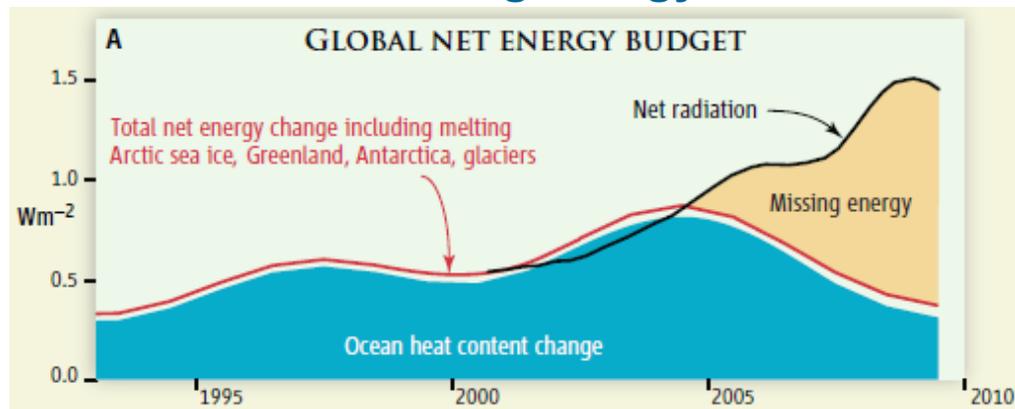
Levitus et al., 2005, Hansen et al., 2011, Church et al., 2011



expected  
outcomes

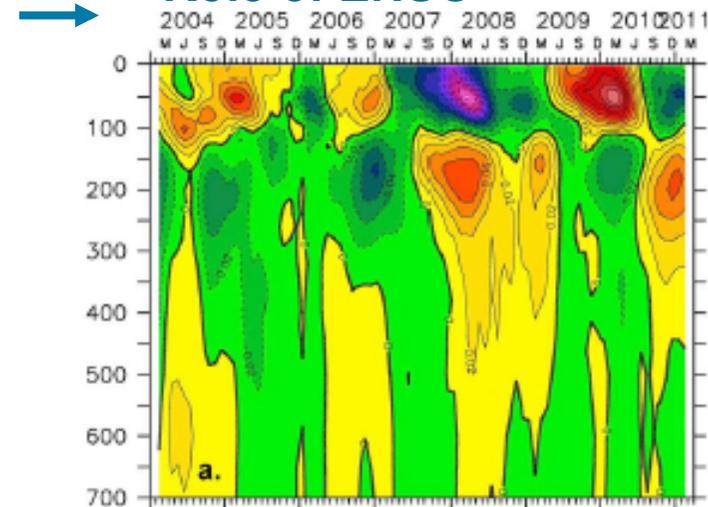
Contributing insights to related climate  
research topics such as anthropogenic  
climate change, seasonal climate prediction,  
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“missing energy”



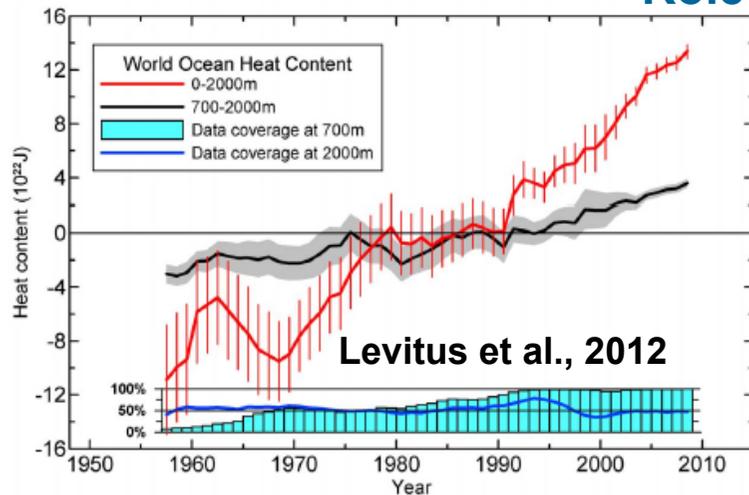
Trenberth and Fasullo, 2010

Role of ENSO

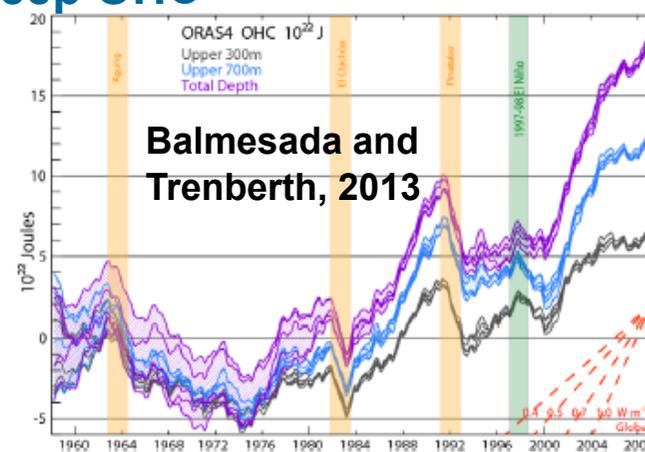


Roemmich and  
Gilson, 2011

Role of deep OHC



Levitus et al., 2012



Balmesada and  
Trenberth, 2013



expected  
outcomes  
and white  
paper  
roadmap

CLIVAR research  
opportunity

- **Refinement of a scientific framework** on consistency between planetary heat balance and ocean heat storage
- **Evaluation of existing data** sets and information products and their consistency
- **Recommendations** on how to improve the **observing systems and derived information products, assimilation methods, ocean and climate models and surface fluxes**
- **Contributing insights to related climate research topics** such as anthropogenic climate change, seasonal climate prediction, decadal variability, predictability and prediction, sea-level variability and change



**Thank you!**