



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**

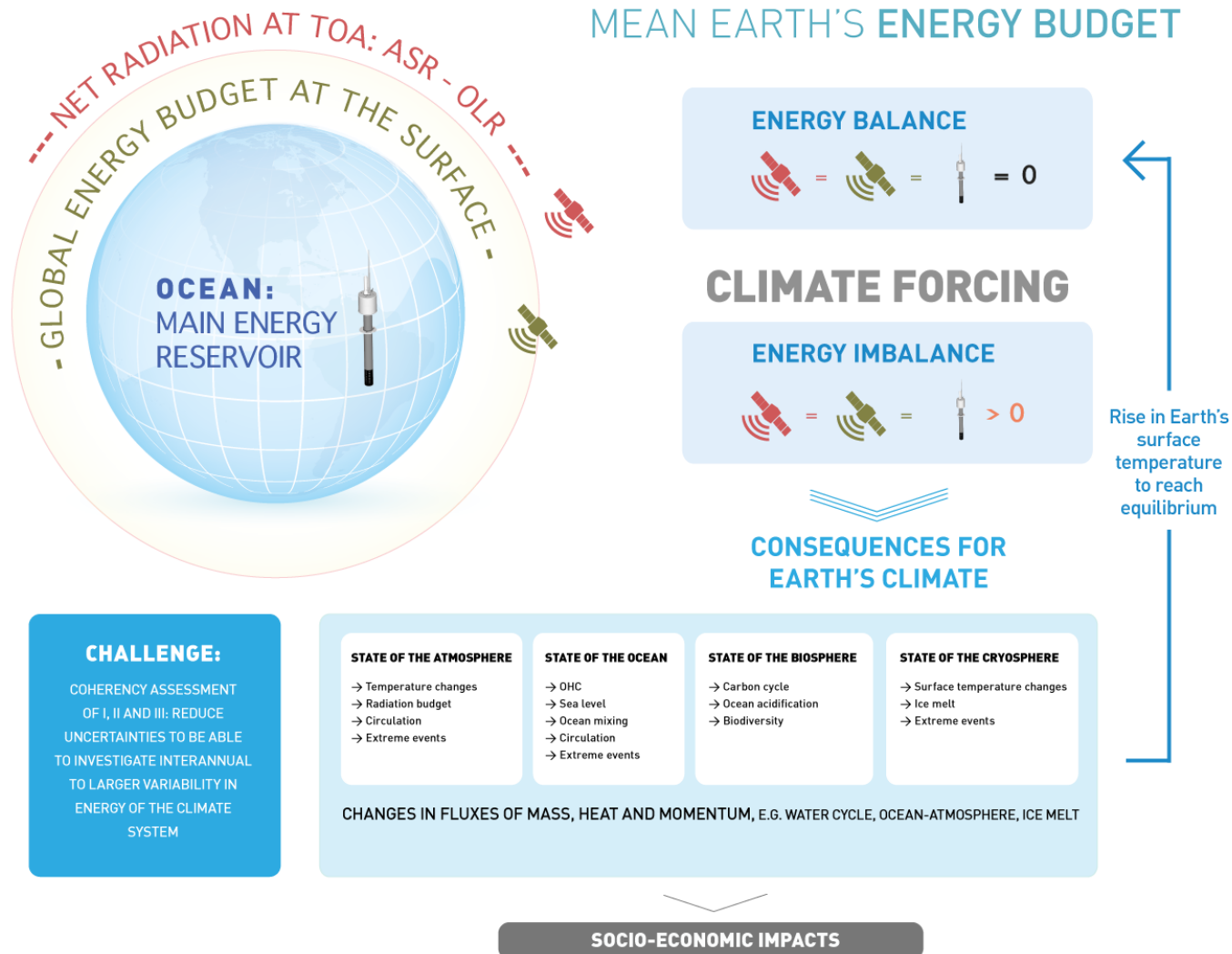
Consistency between planetary heat balance and ocean heat storage

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

*karina.von.schuckmann@ifremer.fr

challenge

CLIVAR research opportunity

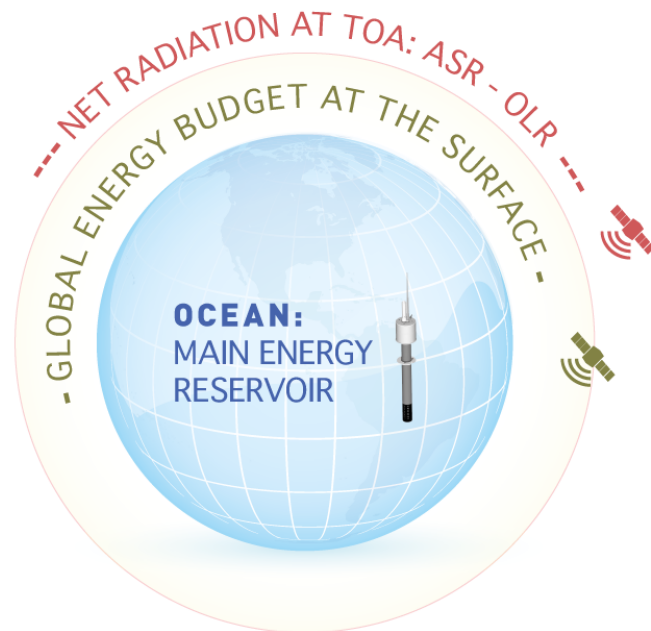


CHALLENGE:

COHERENCY ASSESSMENT OF I, II AND III: REDUCE UNCERTAINTIES TO BE ABLE TO INVESTIGATE INTERANNUAL TO LARGER VARIABILITY IN ENERGY OF THE CLIMATE SYSTEM

challenge

CLIVAR research
opportunity



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

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

**CLIVAR research
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

**CLIVAR research
opportunity**

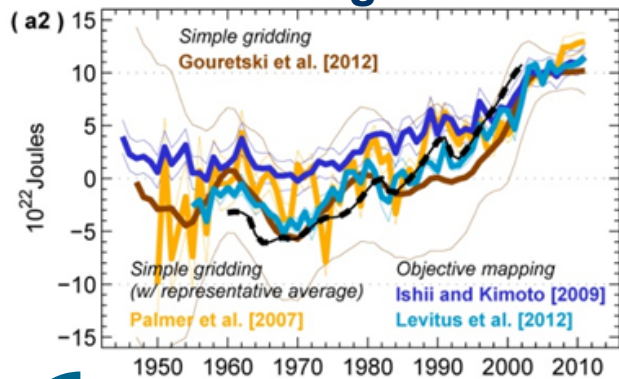
The main objective of the activity is to analyze the **consistency between planetary heat balance and ocean heat storage** estimates, data sets and information products based on different parts of the global observing systems (remote sensing (ESA/EO) and in situ) and ocean reanalysis under three foci:

- 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)

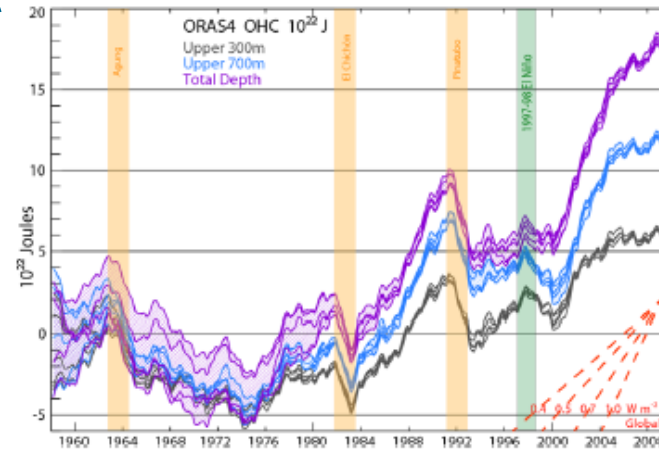
expected outcomes

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

Reconciling GOHC



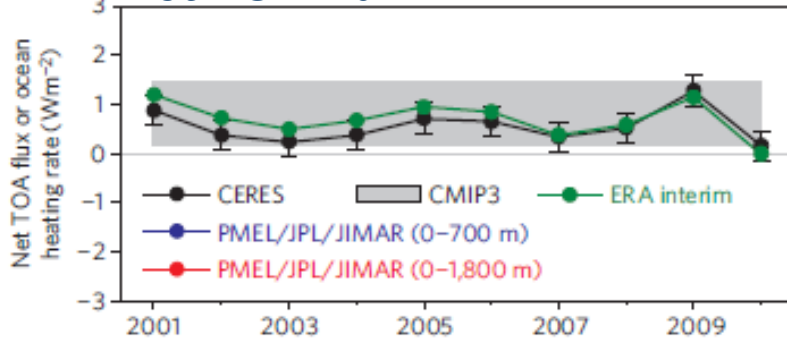
Abraham et al., submitted



Balmesada and Trenberth, 2013

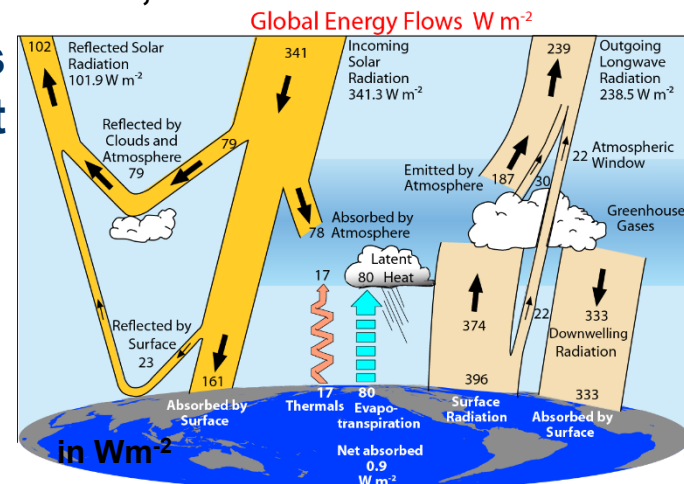
Estimations from reanalyses

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

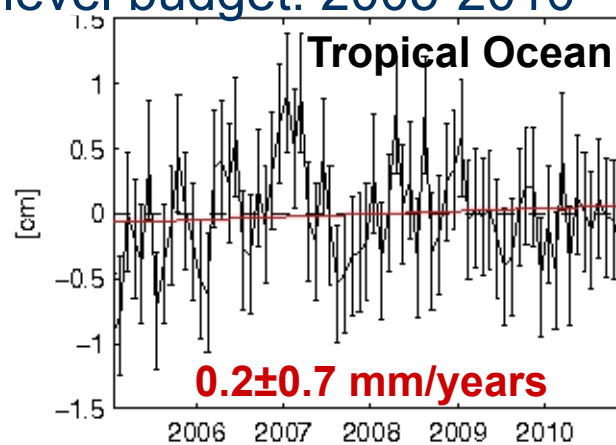
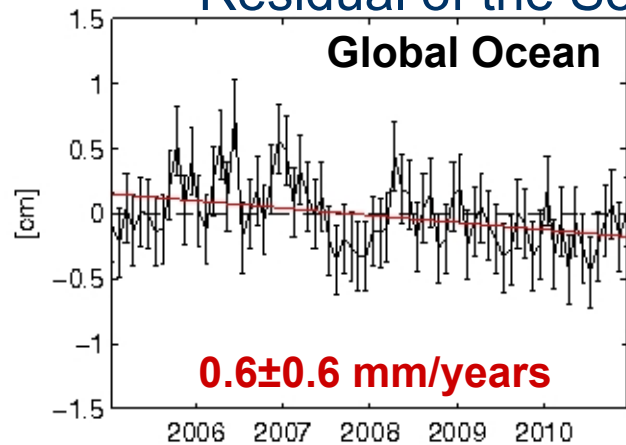
Averaged DM
gridded product,
AVISO

Chambers and
Schröter, 2011

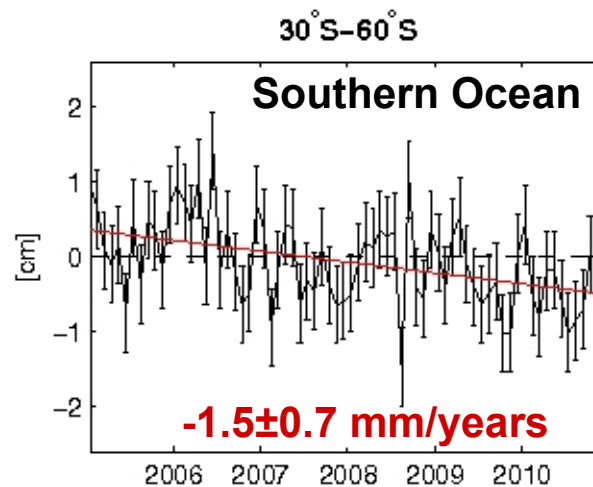
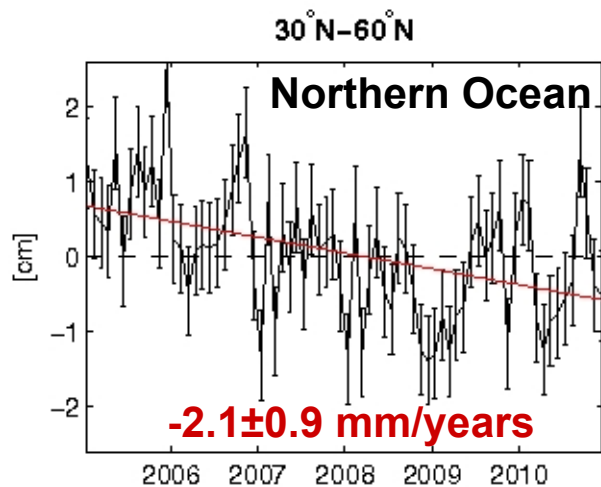
expected
outcomes

Evaluation of existing data sets and information products and their consistency

Residual of the Sea level budget: 2005-2010



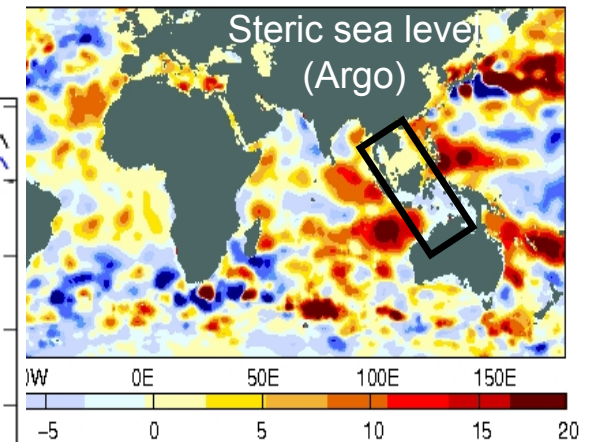
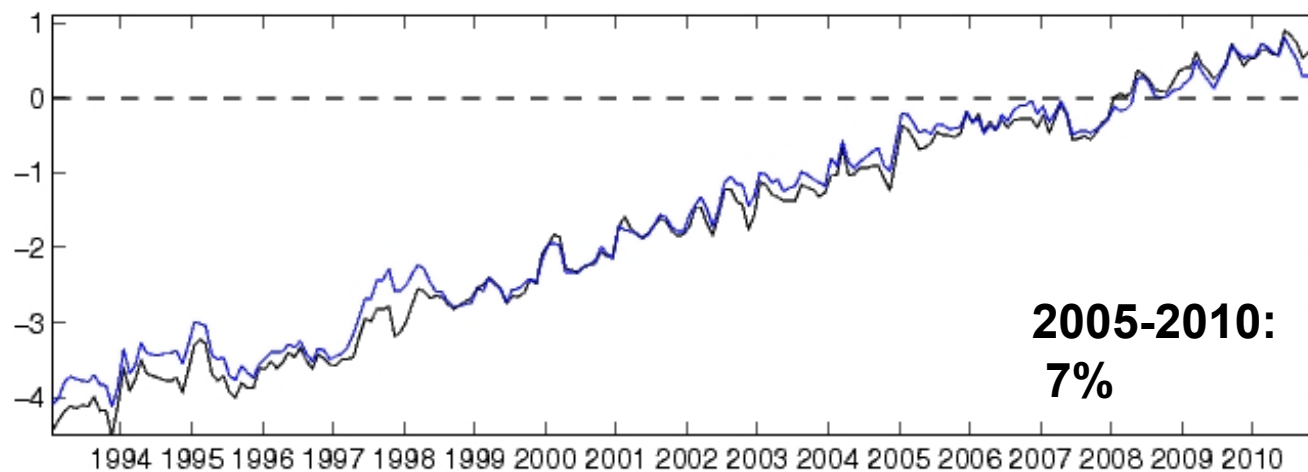
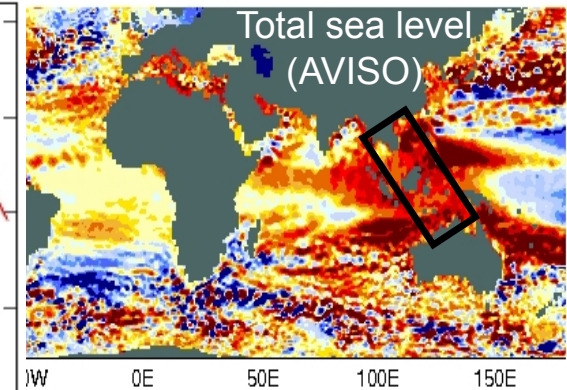
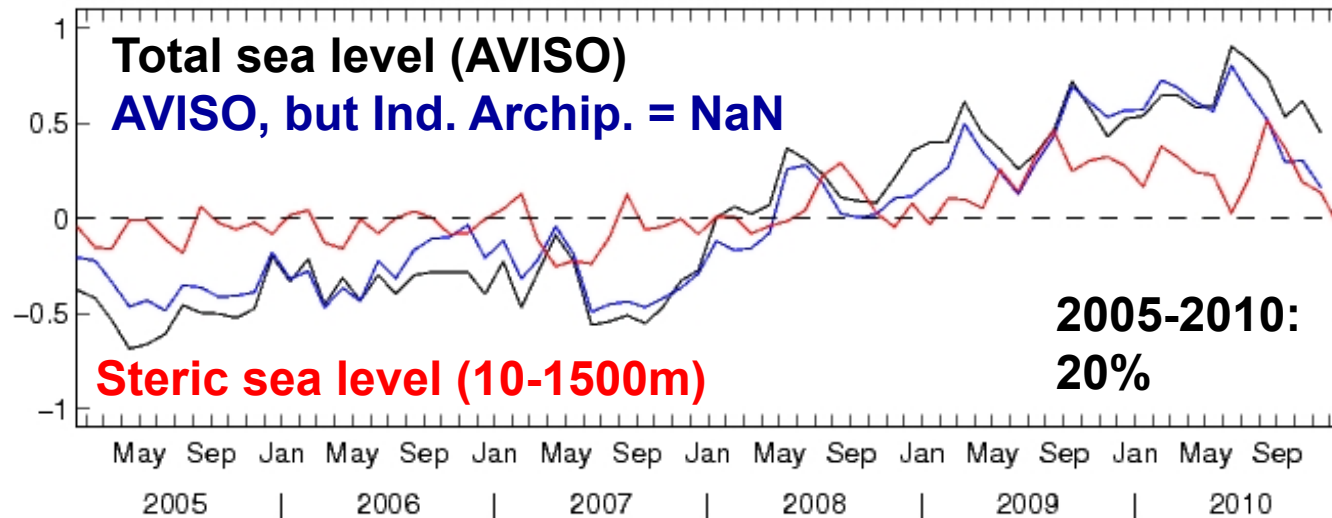
We could close the global and tropical sea level budget, but regional issues remain in the extra-tropics.



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



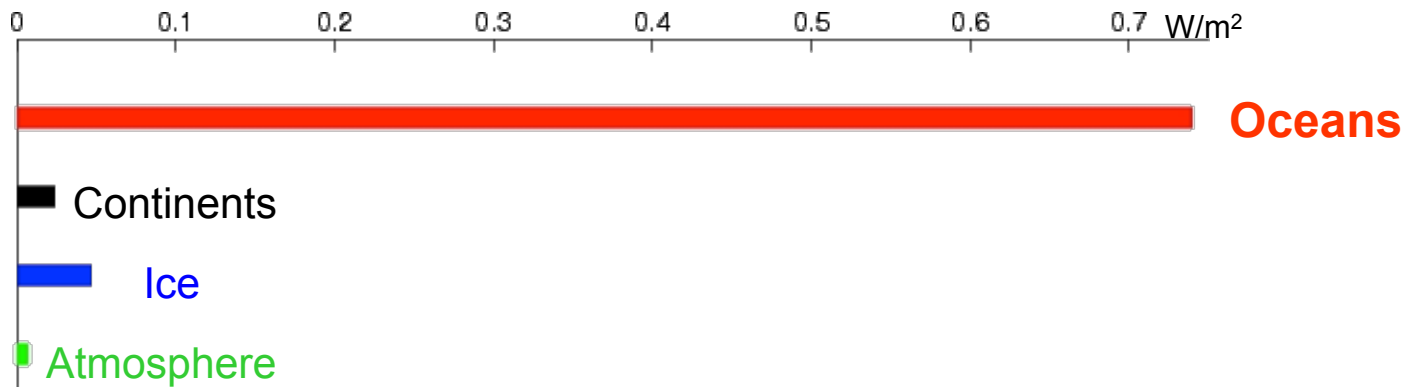
von Schuckmann et al., 2013
(under review)

**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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1.



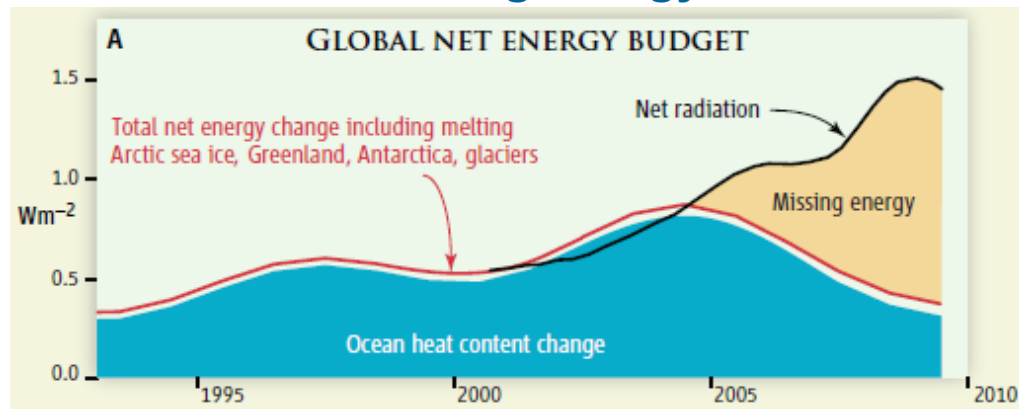
Levitus et al., 2005, Hansen et al., 2011, Church et al., 2011



expected
outcomes

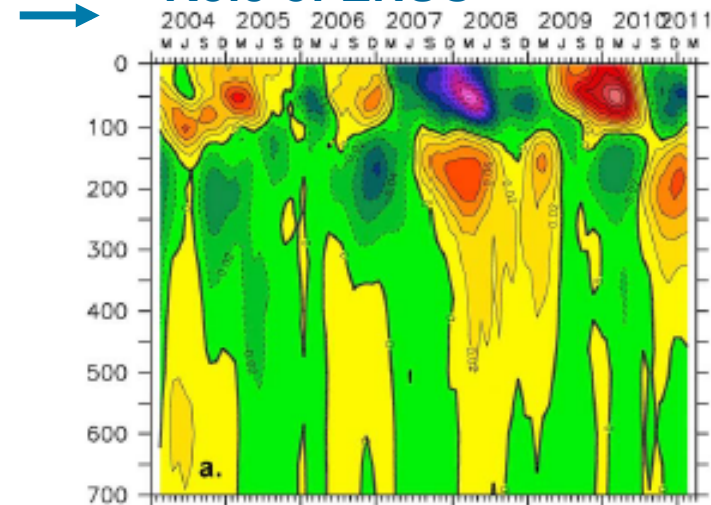
Contributing insights to related climate
research topics such as anthropogenic
climate change, seasonal climate prediction,
decadal variability, predictability and
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“missing energy”

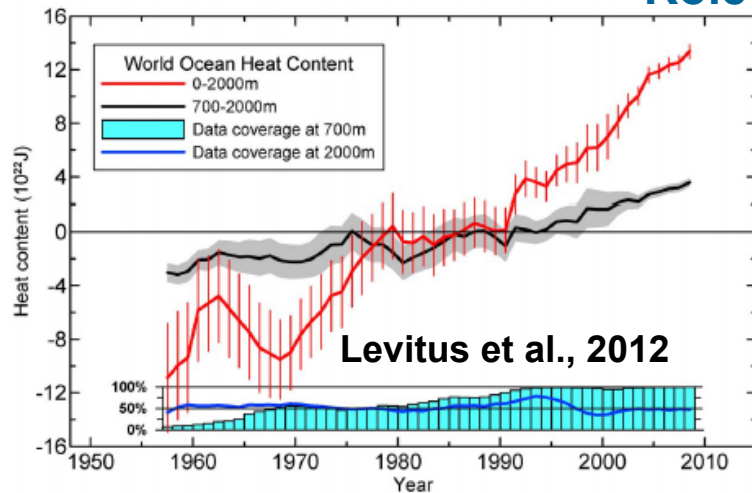


Trenberth and Fasullo, 2010

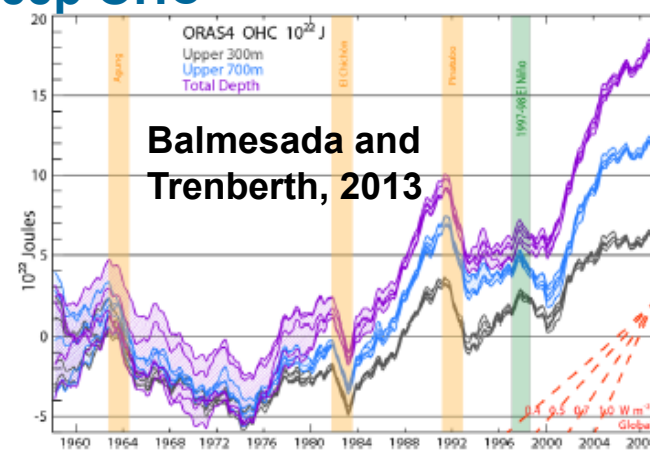
Role of ENSO



Role of deep OHC



Levitus et al., 2012



Balmesada and
Trenberth, 2013

Roemmich and
Gilson, 2011



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!