Proposed CLIVAR research opportunity

"Consistency between planetary heat balance and ocean heat storage"

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Background information

The CLIVAR community has identified a number of scientific imperatives and is developing a small number of focused global research opportunities, that help to describe and understand climate variability and predictability on various time-scales, through the collection and analysis of observations and the development and application of data sets and models of the coupled climate system, in cooperation with other relevant climate-research and observing activities. 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.

Any changes to the Earth's climate system affects an imbalance of the Earth's energy budget due to natural or human made climate forcing. To understand how the Earth's climate system balances the energy budget, we have to consider processes occurring at the three levels: the surface of the Earth, where most solar heating takes place; TOA, where sunlight enters the system; and the atmosphere in between. At each level, the amount of incoming and outgoing energy, or net flux, must be equal (Figure 1). Quantifying with confidence how much extra heat is induced by human activities, and how it affects our climate system is one of the key challenges faced by the climate research community (Bindoff et al., 2007). There is a long history of studies based on both, observations and climate models to better quantify the different components of the planetary energy budget (e.g. Hansen et al., 2005; Bindoff et al. 2007; Hansen et al., 2011; Church et al., 2011; Trenberth and Fasullo, 2011; Loeb et al., 2012; Stephens et al., 2012). These studies have provided scientists with unique insight into the energy budget closure, while at the same time confronted with large uncertainties on the estimate of the energy flows, as well as the challenge of their accurate measurements at the global scale (Trenberth et al., 2011).

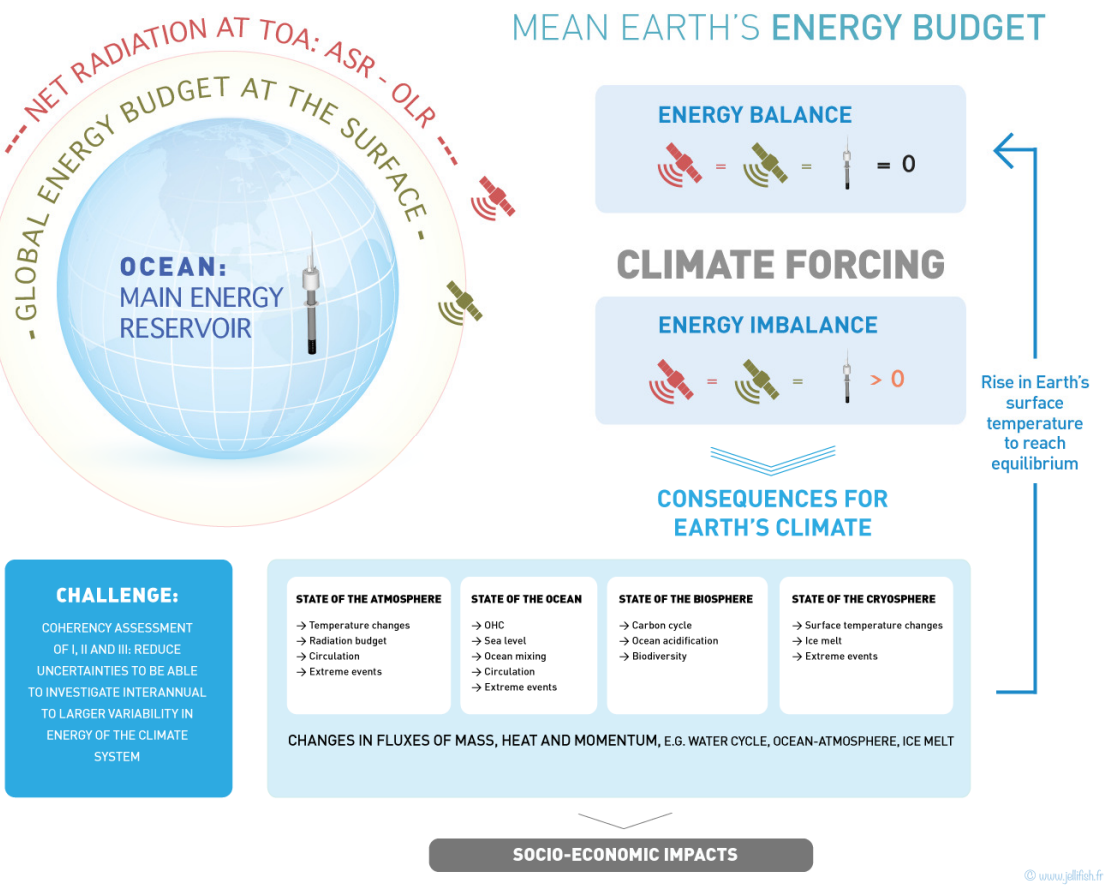

***Figure 1**: Preliminary overview graphic summarizing the proposed CLIVAR research opportunity "Consistency between planetary heat balance and ocean heat storage".*

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. Determining exact values for energy flows in the Earth system is an area of ongoing climate research. There are independent measurement approaches based on remote sensing and in situ measurements and each approach has problems. While deriving budgets of the Earth's Climate, errors involved in deriving the single components can accumulate and have major impacts on the accuracy of climate indicators, leading to large imbalances in estimates of global Earth's climate budgets. 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. Reconciling the different approaches remains a challenge. Energy balance can also be estimated from climate models, which in turn require validation to provide confidence in their results. Only by using conservation and physical principles can we infer the likely resolution.

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. The proposed initiative is envisaged to contain **three foci**:

- Earth Observation Measurement Constraints on Ocean Heat Budget (ESA/CLIVAR tender, …)
- 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, GEWEX SeaFlux, …)

Expected outcomes:

- 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, as well as sea-level variability and change.

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