



## CLIVAR CONCEPT-HEAT

**Workshop on energy flow through the climate system  
29 September - 01 October 2015  
MetOffice - Exeter – UK**

### Agenda

#### Workshop Organising Committee

- K. von Schuckmann (MIO, France)
- T. Lee (JPL, USA)
- K. Haines (University of Reading, UK)
- M. Palmer (MetOffice, UK)
- Alvera Azcarate (Université de Liège, Belgium)
- N. Caltabiano (CLIVAR IPO, China)

#### Scientific Steering Committee for CONCEPT-HEAT

- K. von Schuckmann (MIO, France) - co-chair
- K. Trenberth (NCAR, USA) - co-chair
- M. Palmer (MetOffice, UK)
- K. Haines (University of Reading, UK)
- C.-A. Clayson (WHOI, USA)
- C. Domingues (CSIRO, Australia)
- S. Gulev (IORAS, Russia)
- N. Loeb (NASA, USA)
- P.-P. Mathieu (ESA)
- R. Weller (WHOI, USA)
- M. Wild (ETH Zurich, Switzerland)
- Y. Xue (NOAA/NCEP, USA)

The workshop will be organized in four different sessions, which are aiming to centralize main outcomes at the forefront of climate science as well as to highlight main challenges:

#### Session 1: The Earth's energy budget

Each of the existing independent approaches (satellite measurements at TOA, in-situ observations and reanalysis outputs for ocean heat content, estimates of EEI from climate models) to determine values for energy flows in the Earth's system has its own advantages and drawbacks in terms of sampling capability and accuracy, leading to different estimates, and associated uncertainties. In addition different communities are involved in delivering these estimates and as yet these communities have not worked closely together to allow different assumptions to be compared and for some of the uncertainties to be reduced. Thus evaluating and reconciling the resulting budget imbalance is a key emerging research topic in climate science, which has the potential to bring different communities together to make a major contribution to reducing climate change uncertainties. Errors involved in deriving single components without a coupled context can accumulate and have major impacts on the accuracy of climate indicators, leading to large imbalances differences in estimates of Earth's budgets and climate. Reconciling the different approaches remains a challenge. This session explores our capability to measure and understand the exchanges of energy in the Earth's climate system, in particular in the quantification of the magnitude and spatial distribution of heating in the system, and will hence give the introduction and background to our workshop. The principal scientific question will be "What is the magnitude and the uncertainties of our estimates of Earth's energy imbalance (EEI), and how does it vary over time?"

## **Session 2: Energy flow as estimated from reanalyses and climate models**

We need to further understand the role of resolution of climate models and reanalysis models in resolving natural climate variability and providing accurate error estimates, as well as to understand which are the relevant model physics and parameterizations that need further improvements. The combination of ocean models, atmospheric forcing fluxes and ocean observations via data assimilation methods has the potential to provide more accurate information than observation-only or model-only estimations. This session principally builds on the outcomes of the initiative ORA-IP, as well as from experts of COST-EOS dedicated to focus on main outcomes, achievements, and remaining challenges of estimating energy flows through (and storage) the climate system from this climate tool. Of particular focus will be outcomes for OHC. Addressing the energy budget in climate models is a powerful method for understanding future climate projections. A prerequisite thereby is an adequate representation of the energy budget in climate models, which requires a careful validation process and adequate reference datasets. This session is hence dedicated to address the following scientific question: “How can we improve validation requirements for and from coupled climate models to improve estimates of EEI?”

## **Session 3: Air-sea fluxes**

Characterizing the uncertainty and biases in surface fluxes is essential to address scientific challenges related to the Earth Energy budget, energy flows and understanding the observed interannual to interdecadal variability superimposed on the centennial-scale warming of the global ocean surface. Quantifying sea surface heat fluxes to the required level of accuracy needed to support the various applications is a very challenging task. The present level of uncertainties in global ocean estimates of heat and moisture fluxes is not adequate for many applications, including global and regional mass and energy budget closure and variability on different time scales. This prevents understanding the mechanisms of ocean climate variability. Biases in surface fluxes lead to the systematic errors in climate models and preclude their efficient use in climate simulation. Without accurate estimates of surface fluxes it is impossible to engage predictive potential of the ocean into weather and climate prediction. Thus, improvements in all aspects of producing surface flux estimates, including parameterizations, measurement techniques and post-processing are required for further progress. This session will hence discuss “How can we better constrain the surface energy fluxes and their spatio-temporal variations at regional scale?”

## **Session 4: OHC and atmospheric radiation**

Observed climate variations such as the current hiatus or unresolved inconsistencies of climate observations (e.g. “missing energy” in the climate system) underpin the need for fundamental research activities on the regional distribution of TOA and OHC (including vertical distribution), as well as their implication for their global estimates. Continued assessment and attribution studies of regional natural climate variability are essential to improve our estimates of global changes. There is also an urgent need to evaluate the relative importance of currently under-sampled regions of ocean heat content change (ice-covered ocean, marginal seas and deep ocean) and to understand how heat is transferred vertically. We have to evaluate how regional patterns change in time and if regional OHC tendency patterns can, along with other patterns e.g. regional sea level, be used to test/falsify model hypotheses. The use of physical budget constraints such as the global sea level budget are an important tool for this evaluation. In summary, this session will address the question: “How are TOA net radiation and ocean heating rate distributed in space and time?”

## Agenda: Workshop CONCEPT-HEAT

For each talks, 5 min. of discussion are planned.

**Monday, 28<sup>th</sup> Sep** (room C2 1+2): **Working session for participants only**

13:00-17:00: GSOP meeting (invitation only)

17:00-18:00: joint GSOP/CONCEPT-HEAT meeting (invitation only)

**Tuesday, 29<sup>th</sup> Sep** (Conference Rooms 3+4): **Open session**

8:30-9:00: Registration

9:00-9:20: Welcome and overview on CONCEPT-HEAT (K. von Schuckmann, K. Trenberth)

**Session 1 - The Earth's energy budget; session convener: M. Palmer**

9:20-09:50: Keynote: Approaches to addressing the Earth's energy imbalance (K. Trenberth)

09:50-10:20: Keynote: Surface radiation and energy budget (S. Kato)

10:20-10:50: Keynote: The Earth's surface budget: Outcomes, uncertainties and drawbacks (L. Yu)

**10:50-11:20 Coffee break**

11:20-11:30: Welcome and Introduction to the UK MetOffice (J. Slingo)

11:30-11:50: NASA NEWS energy budget perspectives (T. L'Ecuyer)

12:50-12:10: Energy exchanges between the dynamic components of the climate system: atmosphere and ocean (M. Mayer)

12:10-12:30: Short commentary on session discussion, including key questions for breakout session on Thursday (Session convener)

**12:30-14:00: Lunch break**

**Session 2 - Energy flow as estimated from reanalyses and climate models (15 min. talk + 5 min. questions); session convener: K. Haines**

14:00-14:30: Keynote: Climate models: distinctive climate signals and heating of Earth's climate, and challenges for model validation (M. Palmer)

14:30-14:50: Overview on CMIP6 (C. Senior)

14:50-15:10: Decadal Climate Variability and Predictability (Y. Kushnir, remote talk)

15:10-15:40: Earth's energy imbalance since 1960 in observations and CMIP5 models (D. Smith)

15:40-16:00: Keynote: An overview on ORA-IP (M. Balmaseda)

**16:00-16:30: coffee break**

16:30-16:50: Improving understanding drivers of ocean-only ocean and coupled near surface ocean biases using a novel heat flux climatology ([P. Hyder](#))

16:50-17:10: Freshwater and heat transports from global ocean synthesis ([M. Valdivieso](#))

17:10-17:30: Air-sea fluxes from atmospheric reanalysis ([R. Allan](#))

17:30-17:50: Accuracy of global ocean reanalyses ([A. Storto](#))

17:50-18:00: An overview on COST-EOS ([K. Haines](#), A. Alvera Azcarate)

18:00-18:10: Concluding remarks on session discussion, including key questions for breakout session on Thursday (Session convenor)

**18h10 End of first day**

**Wednesday, 30th Sep** (Conference Rooms 3+4 ): [Open session](#)

**Session 3 – Air-Sea fluxes; session convener: [S. Gulev](#)**

09:00-09:30: Keynote: Assessing and improving surface flux products across space-time scales: implications for surface energy budget ([S. Gulev](#))

09:30-09:50: Overview on Sea-Flux ([C.-A. Clayson](#))

09:50-10:10: Surface fluxes from in-situ observations and their use in models and parameterizations ([S. Josey](#))

10:10-10:30: Results from inter-comparison of various turbulent heat fluxes ([M. Kubota](#))

10:30-10:50: Air-sea fluxes in the Southern ocean: advancements and challenges ([R. Buss de Souza](#))

**10h50-11h10: Coffee break**

11:10-11:30: An overview on turbulent flux estimates: current progress and remaining challenges and the ESA-OHF project ([A. Bentamy](#))

11:30-11:40: Concluding remarks on session discussion, including key questions for breakout session on Thursday (Session convener)

**Session 4: OHC and atmospheric radiation; session convener: [C. Domingues](#)**

11:40-12:10: Keynote: Radiation at the Top of the Atmosphere ([N. Loeb](#))

12:10-12:30: Top of atmosphere radiative imbalance: forced trends versus internal variability ([A. Donohoe](#))

**12:30-14:00: Lunch break**

14:00-14:30: Keynote: A review of global ocean temperature observations: implications for ocean heat content estimates ([C. Domingues](#))

14:30-14:50: Overview on the Argo program, its maintenance and future extensions ([B. King](#))

14:50-15:10: The global ocean observing system: ways to complement Argo ([M. Cronin](#))

15:10-15:30: The ocean's role in Earth's climate change and variability: what have we learned so far from Argo? ([K. von Schuckmann](#))

15:30-15:50: Mechanisms of global and large-scale change ocean heat uptake on multidecadal and longer timescales ([J. Gregory](#))

15:50-16:10: An updated historical (1970-2014) upper ocean heat content estimate and the implication for the global energy budget ([L. Cheng](#))

**16:10-16:30: coffee break**

16:30-16:50: Climate sensitivity and feedbacks implied by TOA radiation versus temperatures ([K. Trenberth](#))

16:50-17:20: Deep Ocean Warming & Earth's Energy Budget: Observations & Plans ([G. Johnson](#), [remote talk](#))



17:20-17:50: Open comment session, in particular for those without talks (a couple of slides each)

17:50-18:00: Concluding remarks on session discussion, including key questions for breakout session on Thursday (Session convener)

**18:00-18:30: Meeting of CONCEPT-HEAT scientific steering team and conveners of breakout session DAY3 (invited)**

**18h30 End of day 2**

**20h00: No host dinner at "CIRCA 1924" Restaurant**

**Thursday, 1<sup>st</sup> October.** (Training Room 4): [Working session for participants only](#)

**Breakout-sessions: Consistency between planetary energy balance and ocean heat storage, conveners: T. L'Ecuyer, K. Haines, M. Palmer, M. Cronin (rapporteur).**

09:00-09:40: Summary and outcomes of each session, and introduction into breakout session from conveners

09:40-10:30: General discussion, chaired by session leaders

**10:30-11:00: coffee break**

11:00-11:30: General discussion, chaired by session leaders. Expected outcome: 15 min. presentation (overview, recommendations, and plans for the future, refinement of key scientific question)

11:30-12:30: Synthesis and commentary by chairs of CONCEPT-HEAT ([K. von Schuckmann](#), [K. Trenberth](#))

**12:30-14:00: Lunch break**

14:00-16:00: Meeting of CONCEPT-HEAT scientific steering team and conveners of breakout session DAY3 (invited): refine discussion aiming to define common way forward, to foster implementation of synergy community and to foster collaborations, and suggest strategies for funding opportunities. Discussion chaired by CONCEPT-HEAT co-chairs.

**16:00 End of workshop**

### Information on breakout sessions:

Key scientific questions had been developed in the frame of CONCEPT-HEAT white paper, together with recommendations how to move forward for each thematic. The breakout session is aiming to:

- i) agree to or refine key scientific questions
- ii) refine and complement recommended activities
- iii) discuss already existing programs and initiatives, and identify how they could be continued and or improved
- iv) identify opportunities for the future
- v) develop strategy for each session to join with other sessions
- vi) identify opportunities and strategies to foster international collaborations

Below an overview on existing key scientific questions for each session, as well as developed recommendations is given as a basis for developing the breakout sessions. Moreover, a key scientific question for the round table discussions is developed as well, together with recommended activities.

#### Round table: joining expertise, foster collaborations.

**Key scientific question:** Can consistency between planetary heat balance and ocean heat storage achieved and what are the major limitations?

Each of the existing independent approaches (satellite measurements at TOA, in-situ observations and reanalysis outputs for ocean heat content, estimates of EEI from climate models) to determine values for energy flows in the Earth's system has its own advantages and drawbacks in terms of sampling capability and accuracy, leading to different estimates, and associated uncertainties. In addition different communities are involved in delivering these estimates and as yet these communities have not worked closely together to allow different assumptions to be compared and for some of the uncertainties to be reduced. Thus evaluating and reconciling the resulting budget imbalance is a key emerging research topic in climate science which has the potential to bring 6 different communities together to make a major contribution to reducing climate change uncertainties. Errors involved in deriving single components without a coupled context can accumulate and have major impacts on the accuracy of climate indicators, leading to large imbalances differences in estimates of Earth's budgets and climate. Reconciling the different approaches remains a challenge. Only by using conservation and physical principles can we infer the likely resolution.

#### Recommended activities:

- i) Improve accessibility and information content of products to evaluate the different components of EEI (ocean reanalysis products, in situ OHC, net flux at TOA, climate models) for use by wider community. Develop improved evaluation of these products to quantify strengths and weaknesses to provide advice to a wider range of potential users.
- ii) Strengthen collaboration of interdisciplinary climate community by building up a synergy community. This requires funded collaboration initiatives (network funding for workshops, working visits at laboratories, etc., e.g. started with ISSI working group, COST Action ES1402).
- iii) Assessment of consistency between planetary heat balance and ocean heat storage as a multi-analysis approach from the synergy community to investigate uncertainties, quantify inconsistencies and understand their causes.
- iv) Develop a community review paper on all components of EEI