Heat stored in the Earth system: Where does the energy go?

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AN IMPERATIVE TO MONITOR EARTH'S ENERGY IMBALANCE

Earth's Energy Imbalance (EEI) is the most critical number defining the prospects for continued global warming and climate change. The EEI arises from alterations in the composition of the atmosphere which traps excess energy in the Earth system. The Earth is in radiative imbalance, with less energy exiting the top of the atmosphere than entering, since at least about 1970 and the Earth has gained substantial energy over the past 4 decades.

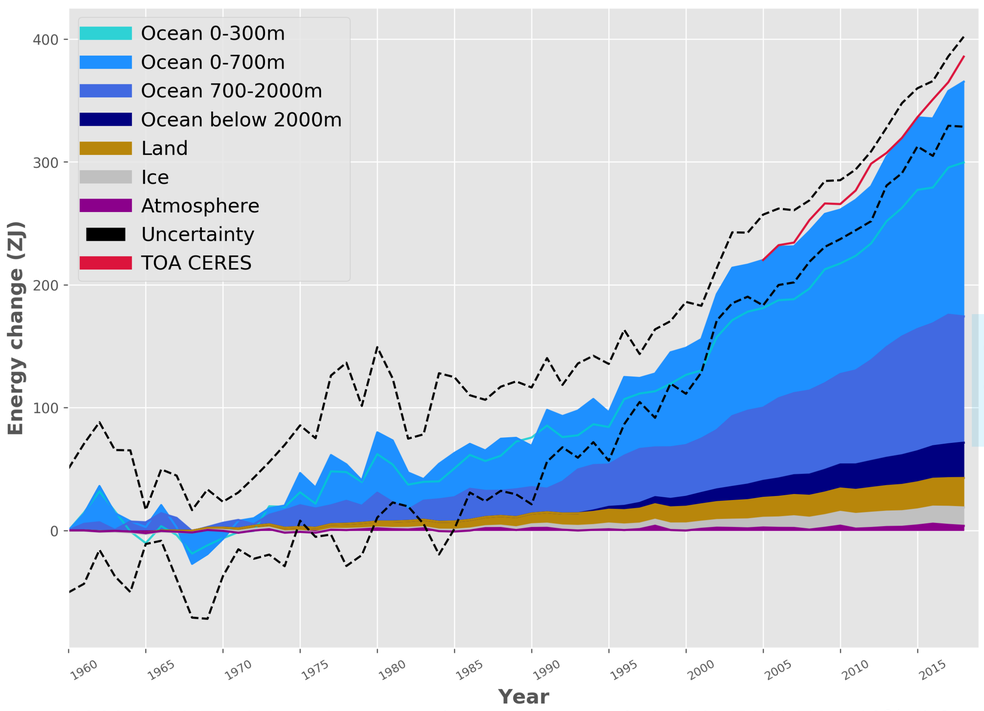
This study is a Global Climate Observing System (GCOS) concerted international effort to update the Earth heat inventory, and presents an updated assessment of ocean warming estimates, and new and updated estimates of heat gain in the atmosphere, cryosphere and land over the period 1971-2018.

EARTH SYSTEM INVENTORY : HEAT STORED IN THE CLIMATE SYSTEM FROM A POSITIVE EARTH ENERGY IMBALANCE

The knowledge of where and how much heat is stored in the different Earth system components from a positive EEI is of fundamental importance to unravel the current status of climate change, as well as to better understand and predict the implications of climate change, which are fundamental concerns for society.

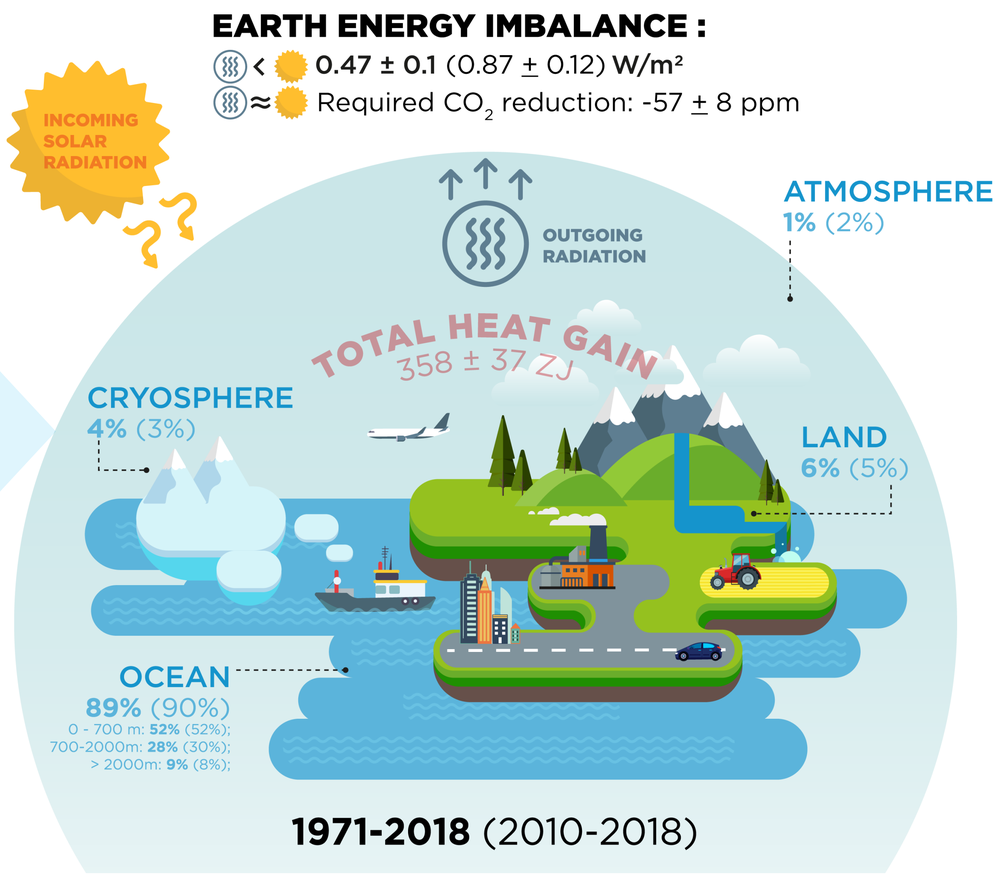
About 90% of this accumulated heat goes into heating the ocean, (4%) into melting of ice, (6%) heating the land and (1%) heating the atmosphere.

Total Earth's heat gain of 358 ± 37 ZJ for 1971-2018



1960-2018 Earth heat inventory (energy accumulation) in ZJ (1 ZJ = 10^{21} J) for the components of the Earth's climate system relative to 1960.
Dataset availabe at: doi: https://doi.org/10.26050/WDCC/GCOS_EHI_EXP_v2

equivalent to a heating rate (i.e. the EEI)



KEY MESSAGES

For the period **1971-2018**, the EEI amounts to **0.47 ± 0.12 W/m² –** thus continues at a comparable rate as reported in IPCC AR5.

Our results also show that **EEI is not only continuing, it is increasing**: the EEI amounts to 0.87 ± 0.12 W/m² during 2010-2018.

Stabilization of climate, the goal of the universally agreed UNFCCC in 1992 and the Paris agreement in 2015, **requires that EEI be reduced to approximately zero to achieve Earth's system quasi-equilibrium.**

The amount of CO_2 in the atmosphere would need to be reduced from 410 ppm to 353 ppm to increase heat radiation to space by 0.87 W/m², **bringing Earth back towards energy balance**.

This simple number, **EEI, is the most fundamental metric that the scientific community and public must be aware of**, as the measure of how well the world is doing in the task of bringing climate change under control, and **we call for an implementation of the EEI into the global stocktake** based on best available science.

Continued quantification and reduced uncertainties in the Earth heat inventory can be best achieved through the **maintenance of the current global climate observing system, its extension into areas of gaps in the sampling**, as well as to **establish an international framework for concerted multi-disciplinary research of the Earth heat inventory** as presented in this study.

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