An integrated approach to

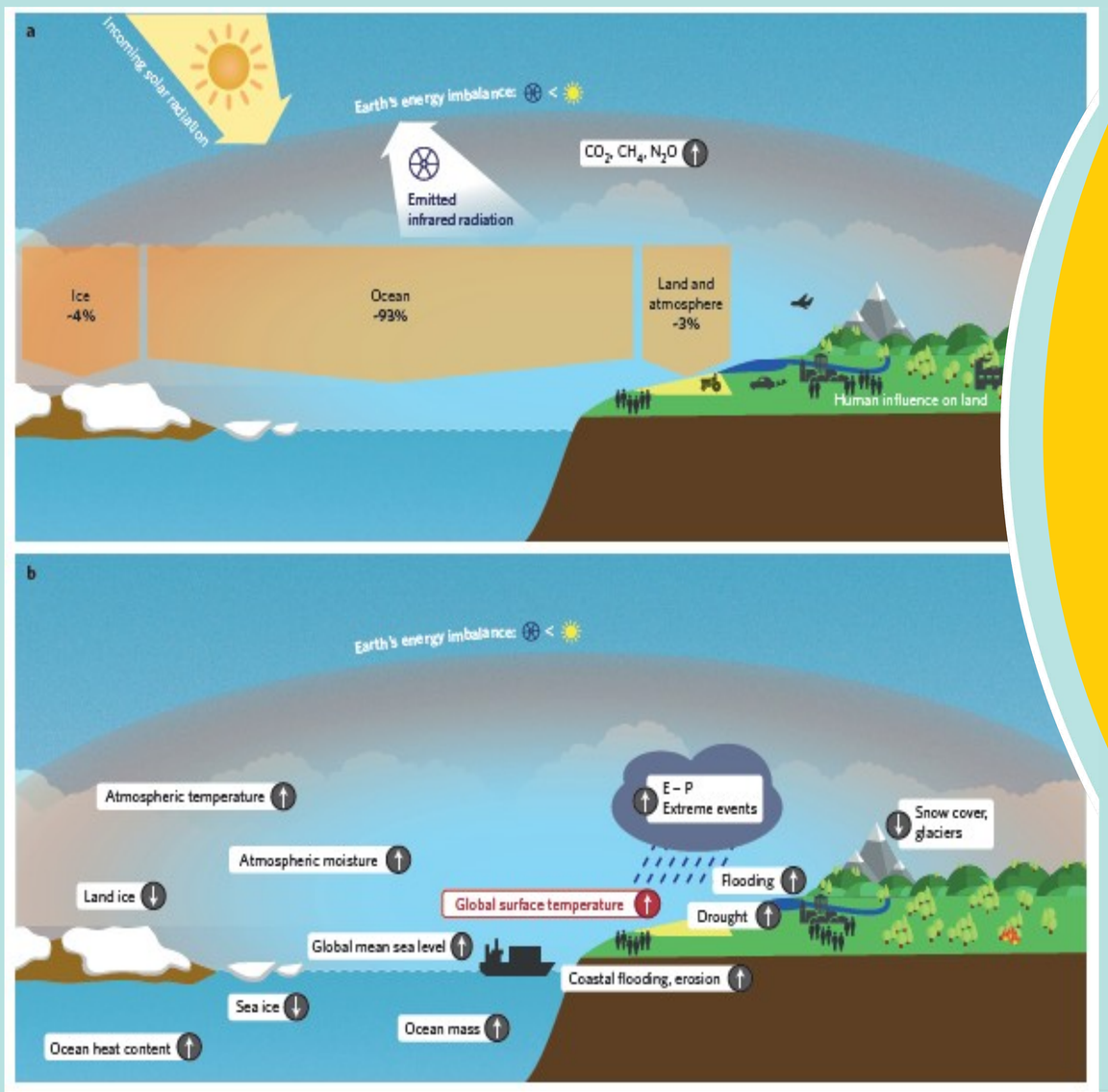
Earth Energy Imbalance

WCRP Science Community

WORLD METEOROLOGICAL ORGANIZATION · United Nations Educational, Scientific and Cultural Organization · Intergovernmental Oceanographic Commission · INTERNATIONAL COUNCIL FOR SCIENCE

WCRP 4

World Climate Research Programme #WCRP40



Schematic representations of the flow and storage of energy in the Earth's climate system and related consequences. **a**, EEI as a result of human activities. The global ocean is the major heat reservoir, with about 90% of EEI stored there. The rest goes into warming the land and atmosphere, as well as melting ice (as indicated). **b**, 'Symptoms' of positive EEI, including rises in Earth's surface temperature, ocean heat content, ocean mass, global mean sea level, atmospheric temperature and moisture, drought, flooding and erosion, increased extreme events, and evaporation – precipitation (E–P), as well as a decrease in land and sea ice, snow cover and glaciers.

Where does the Energy go?

EEI is a measure of the net input into Earth and we need to take careful stock of how well we estimate this from current. It requires deeper analyses and assessments for different components of the energy balance and factors associated with their changes, and furthermore, **an integrated view of the Earth's energy budget** from the TOA to surface. As the focus of the questions zoom down regionally, we require a greater understanding of energy transports within the atmosphere and by oceans.

WCRP has been building up a unique international scientific interdisciplinary exchange, spanning different science topics of all Earth system elements, to synthesize observations, allow attribution of what is happening and why, and make predictions and projections at a range of spatial and temporal scales.

A WCRP-wide framework for synergetic community effort aims to:

- Improve and quantify the absolute value of the EEI, including rigorous uncertainty assessments;
- Perform an inventory of the EEI and constant assessment of energy budget in the Earth system, for the storage of heat in the ocean, land, cryosphere and atmosphere from seasonal to longer time scales , as well as by improved physical budget constraints on the total EEI;
- Further increase knowledge on the implications of EEI and associated patterns of climate change for the benefit of societies.

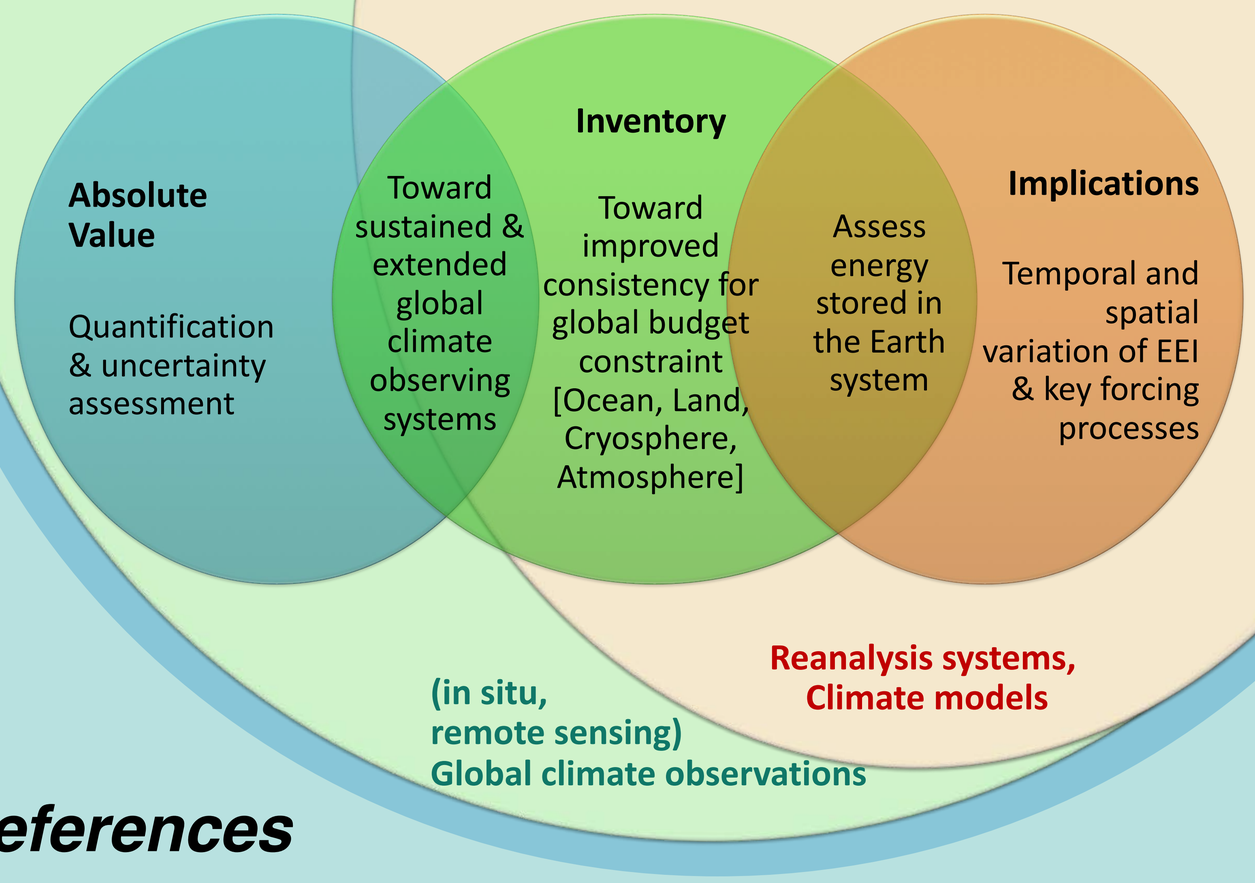
Our Planet continues to be out of balance with additional heat

The Earth's climate is determined by the flows (fluxes) of energy into and out of the planet and to and from the Earth's surface. The latitudinal variation of the top of the atmosphere (TOA) fluxes establishes one of the most fundamental aspects of Earth's climate determining how much heat is transported from low latitudes to high latitudes. The surface energy fluxes are fundamental to understanding the carbon, energy and water nexus; driving ocean circulations, determining how much water is evaporated from the Earth's surface, and governing the planetary hydrological cycle.

A radiative flux imbalance at the TOA drives global warming. The current Earth's energy imbalance (EEI) is mostly caused by human activity releasing heat-trapping gases like carbon dioxide. **The absolute value of EEI is the most fundamental metric defining the status of global climate change and expectations for continued global warming.**

Our planet continues to be out of balance with additional heat being added to it at the rate of 0.6 ± 0.4 Wm^{-2}, and the majority of this excess heat is stored in the oceans. The EEI can be best estimated from changes in ocean heat content, complemented by radiation measurements from space. Sustained observations from the Argo array of autonomous profiling floats and further development of the ocean observing system to sample the deep ocean, marginal seas and sea ice regions are crucial to refining future estimates of EEI.

CLIVAR · CliC · GEWEX · SPARC Stratosphere-troposphere Processes And their Role in Climate



References

Stephens, G. L., T. L'Ecuyer. 2015, The Earth's energy balance. Atmospheric Research, 166, 195-203, doi: 10.1016/j.atmosres.2015.06.024

Von Schuckmann, K., A. Cazenave, D. Chambers, J. Hansen, S. Josey, Y. Kosaka, N. Loeb, P.-P. Mathieu, B. Meyssignac, M. Palmer, K. Trenberth, M. Wild, 2016: An imperative to monitor Earth's energy imbalance, Nature Climate Change 6, 138–144, doi:10.1038/nclimate2876

… and numerous research coordinated conducted through the WCRP Core Projects CLIVAR (http://www.clivar.org), GEWEX (http://www.gewex.org), CliC (http://www.climate-cryosphere.org/), SPARC (https://www.sparc-climate.org/) and many other activities.

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