

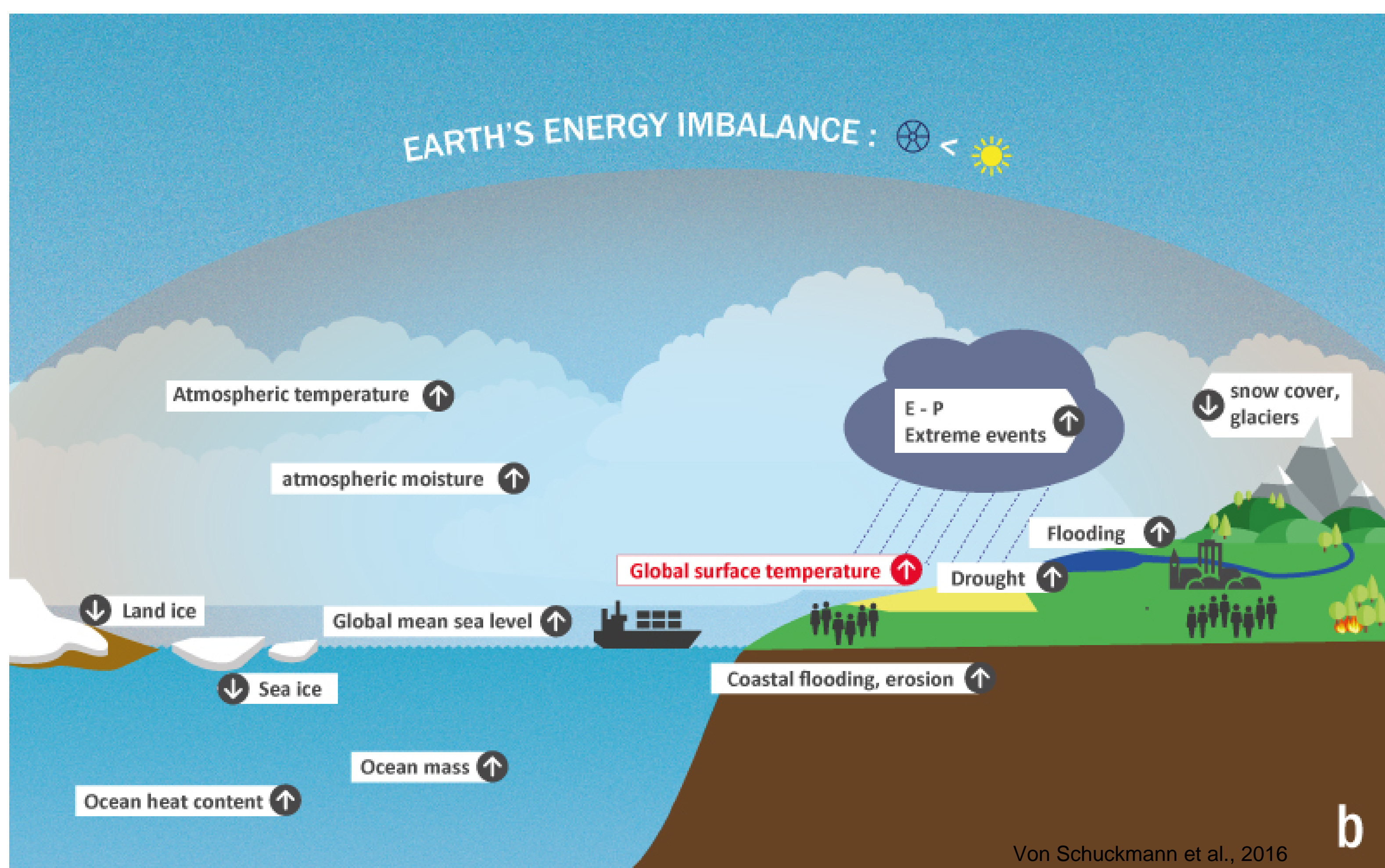
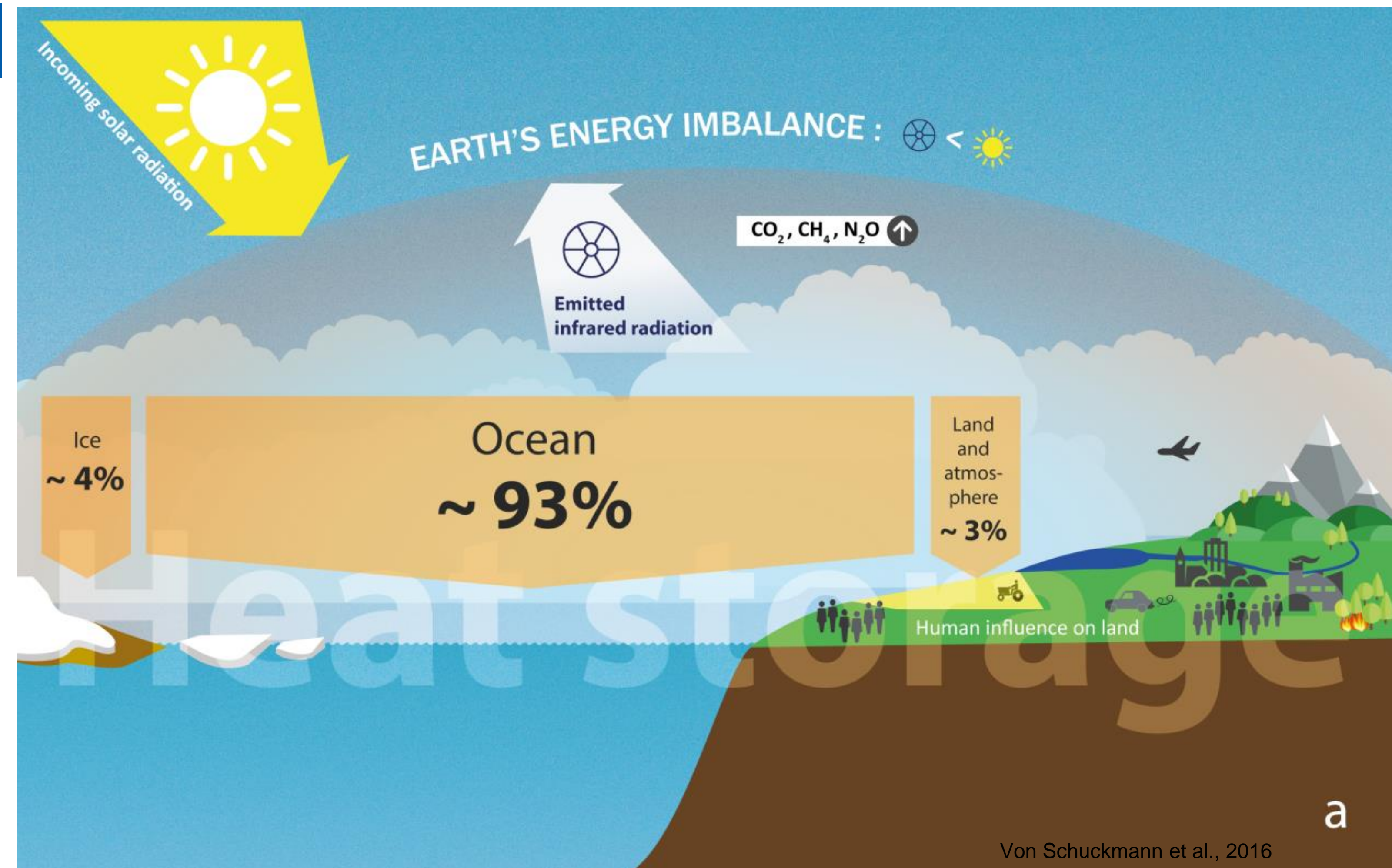
Heat stored in the Earth system: Where does the energy go?

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AN IMPERATIVE TO MONITOR EARTH'S ENERGY BALANCE

Earth's Energy Imbalance (EEI) is the most fundamental metric defining the rate of global climate change. The EEI arises from alterations in the composition of the atmosphere which traps excess energy in the Earth system. In particular, human activity increases carbon dioxide from burning fossil fuels, land use change and forestry and emissions of other greenhouse gases and is the key ingredient for the production planetary heating and give rise to observed global warming and climate change. These changes interfere with the natural variability of energy flows through the climate system.

More than 90% of this energy imbalance goes into heating the ocean, with much smaller amounts going into melting of ice and heating the land and atmosphere. This ocean heating cannot be measured from surface temperatures alone as the heat penetrates into subsurface layers through the mixing and ocean dynamics in ways that are only partially understood.



THE 'SYMPTOMS' OF EARTH'S ENERGY IMBALANCE

The Earth system adjusts to energy imbalances in a number of ways that have a direct impact on both the marine and terrestrial environment. The familiar elements of global warming including global surface temperature rise, reductions in snow and ice cover, sea level rise as well as increases in many extremes are all symptoms of the Earth Energy Imbalance.

INCREASES in: ☀

- sea level;
- atmospheric moisture;
- ocean heat content;
- surface temperature;
- evaporation, precipitation and extreme rainfall;
- flooding and drought.

DECREASES in: ☁

- land ice;
- sea ice;
- snow cover and glaciers.

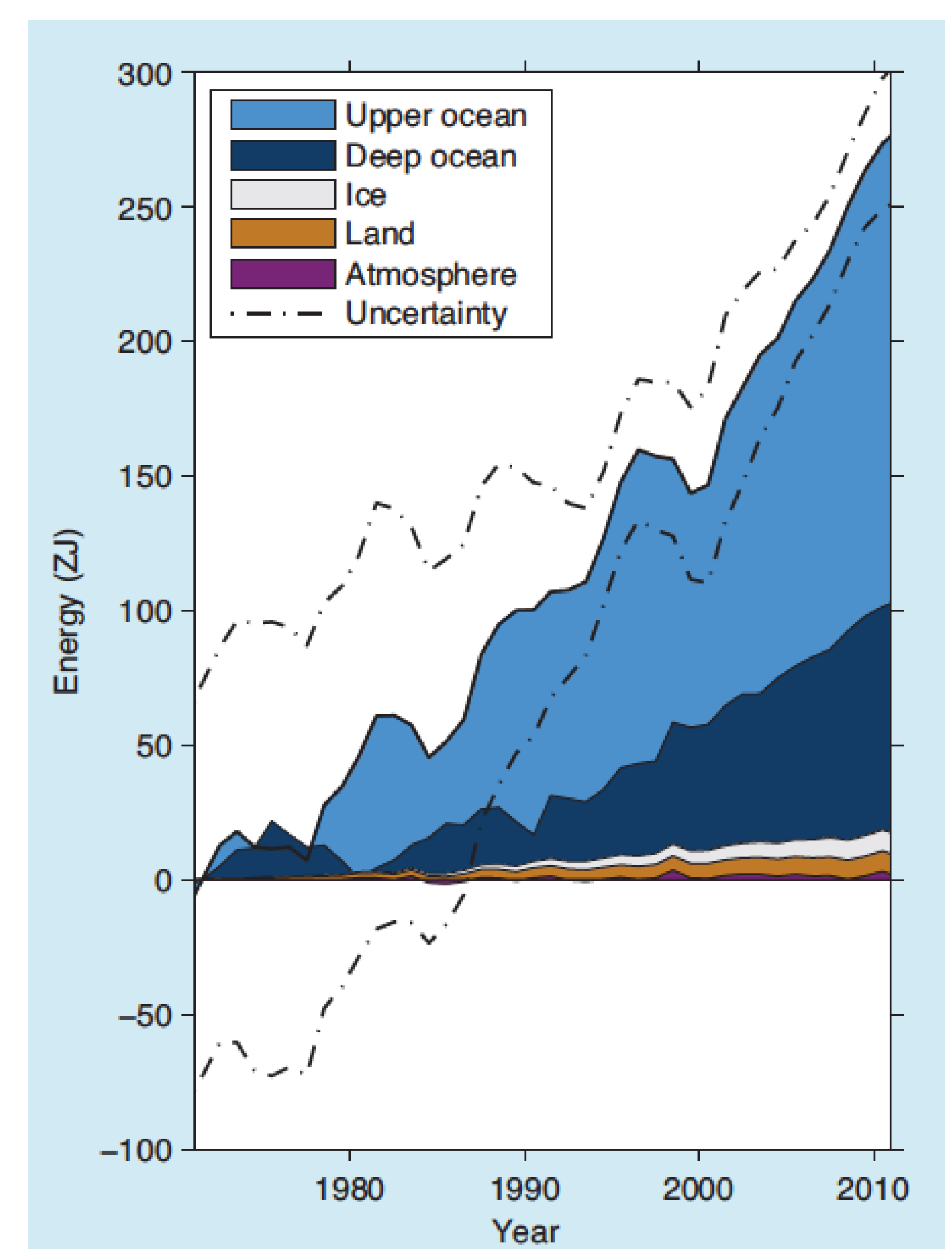
EARTH SYSTEM INVENTORY : HEAT STORED IN THE CLIMATE SYSTEM FROM A POSITIVE EARTH ENERGY IMBALANCE

Global warming is unequivocal and contemporary increases in the Earth energy imbalance are directly attributable to increases in carbon dioxide and other greenhouse gases in the atmosphere from human activities (IPCC, 2013).

The knowledge of where and how much heat is stored in the different Earth system components from a positive EEI through an Earth heat inventory 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.

INTERDISCIPLINARY COMMUNITY APPROACH

This interdisciplinary and international scientific community paper is aiming to analyze the current status of the Earth heat inventory for the ocean, atmosphere, cryosphere and land, together with an evaluation of uncertainties and observing system capabilities. It consists of an enormous multi-disciplinary effort involving the entire climate science community. The expected outcome is an update of the Earth heat inventory and scientific sound recommendations for the Global Climate Observing System. Combining multiple climate measurements (in-situ, remotely sensed and derived) and tools (models, data assimilation) in an optimal way holds considerable promise for reducing uncertainties in climate science. Progress can be achieved with a concerted international effort.



- References
- IPCC, 2013: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp, doi:10.1017/CBO9781107415324.
 - 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