Towards an integrated view of the global Earth energy budget

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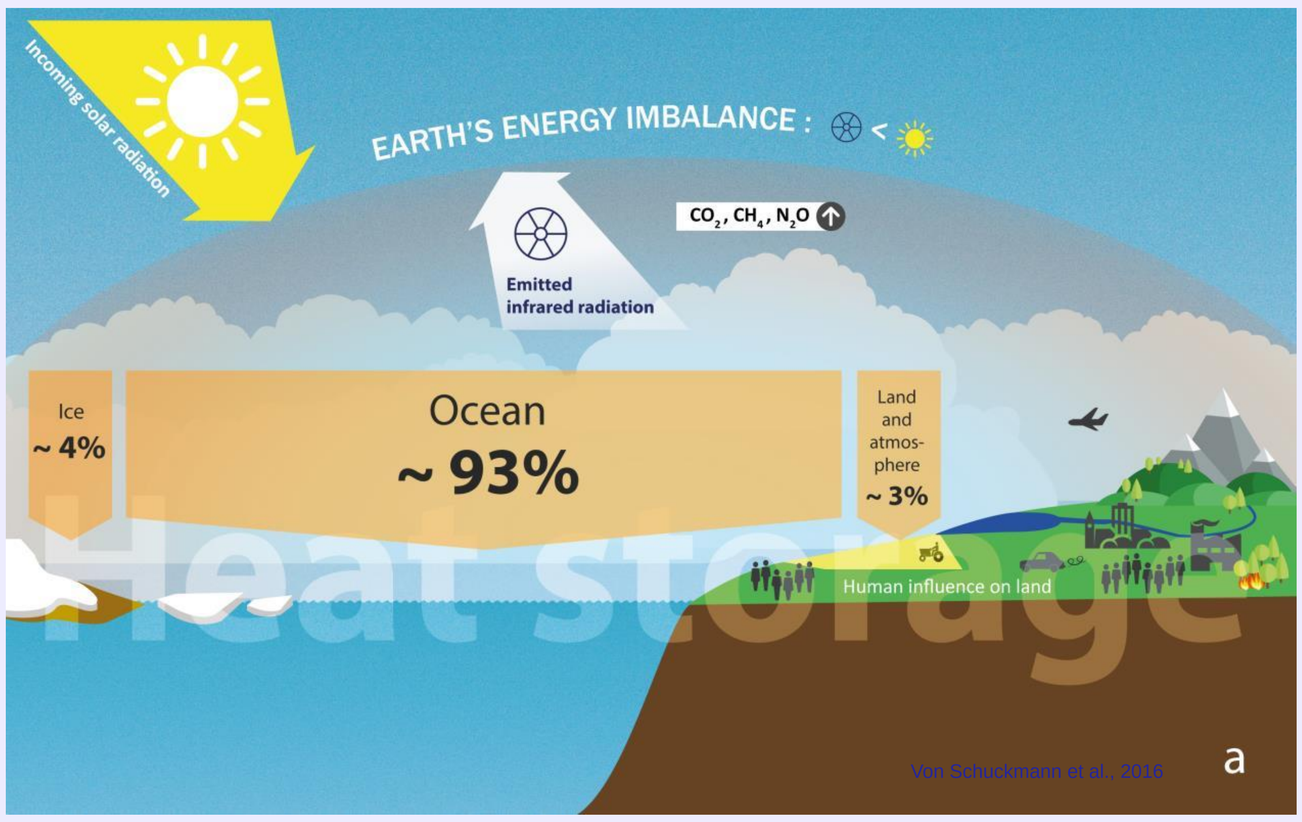
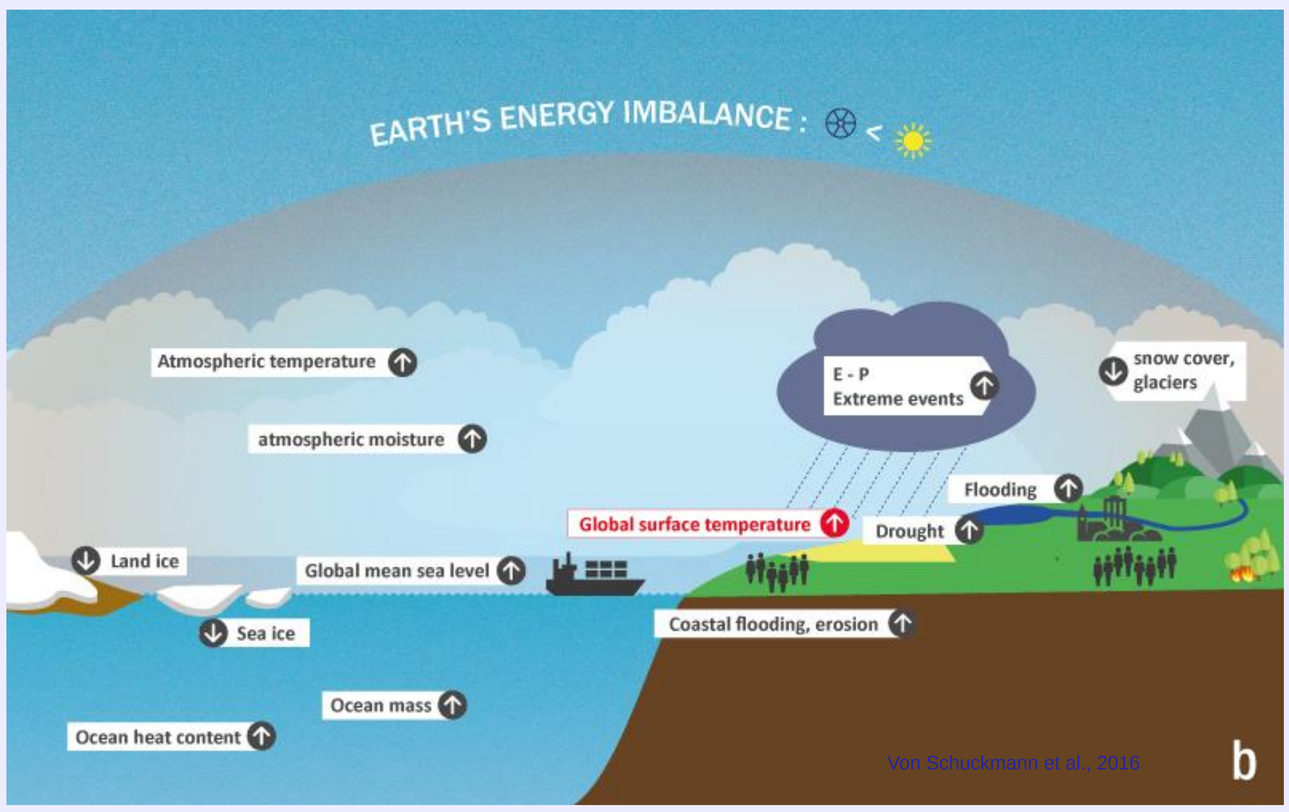
AN IMPERATIVE TO MONITOR EARTH'S ENERGY IMBALANCE

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 trap excess energy in the Earth system. In particular, human activity increases carbon dioxide from burning fossil fuels and emissions of other greenhouse gases. They produce 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**.

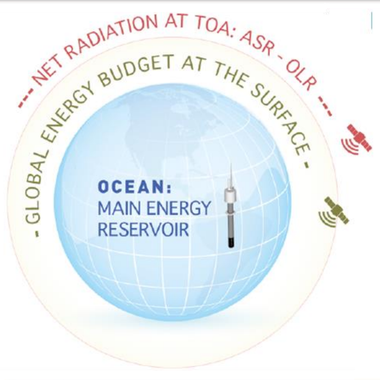
INCREASES in: ⬆

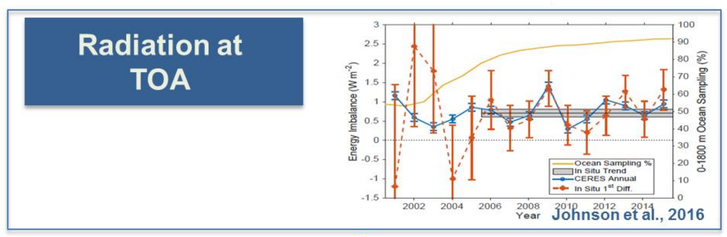
- sea level;
- atmospheric moisture;
- ocean heat content;
- surface temperature;
- evaporation, precipitation and extreme rainfall;
- flooding and drought.

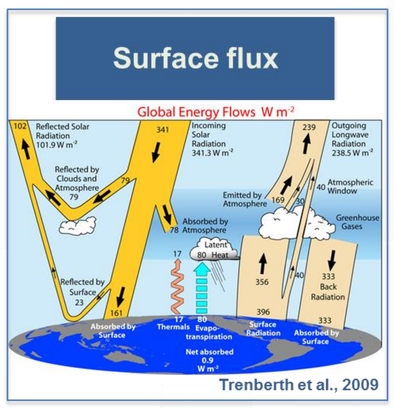
DECREASES in: ⬇

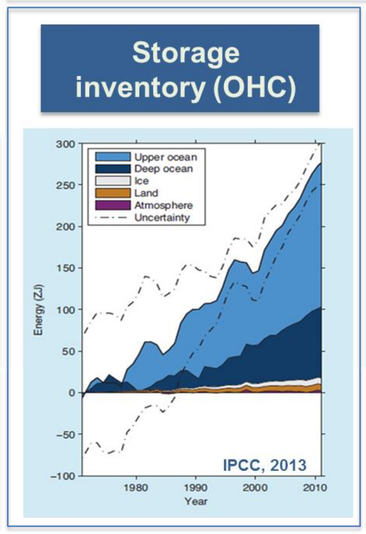
- land ice;
- sea ice;
- snow cover and glaciers.

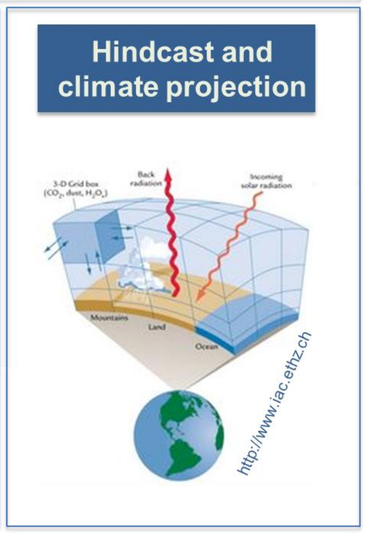
Different approaches determining Earth's energy imbalance











ESTIMATES OF THE EARTH ENERGY IMBALANCE

Four approaches:

1. **Net radiation** at the top of the atmosphere (satellite measurements)
2. The **Earth's surface energy budget** (satellite and in situ surface measurements and their analyses)
3. The change in inventory of **heat stored in the Earth's climate system**: Since > 90% of EEI is absorbed by the oceans, monitoring OHC change is essential (in situ measurements and ocean analyses)
4. Energy budget estimates and their evaluation in **climate models**

The Earth Energy Imbalance is currently about 0.5-1.0 Wm^{-2} over the surface area of the Earth (IPCC, 2013).

TOWARDS AN INTEGRATED VIEW OF THE GLOBAL EARTH ENERGY BUDGET

This initiative will use the four approaches to **develop a community-based synthesis of the Earth's energy budget as a key measure to understand and monitor the Earth's evolving climate**. Different approaches to estimating the EEI have their strengths and weaknesses, but they are complementary. Combining multiple climate measurements and tools in an optimal way holds considerable promise for reducing uncertainties in EEI. **Progress can be achieved with a concerted international effort.**

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