The energy balance over land and oceans

based on direct observations and CMIP5 models

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Summary

The global mean energy budget has been estimated in Wild et al. (2013a,b) / IPCC AR5 as given in Fig. 1 below. Here we separate the global energy budget further into its land and ocean mean components (Fig. 2 and Fig. 4).

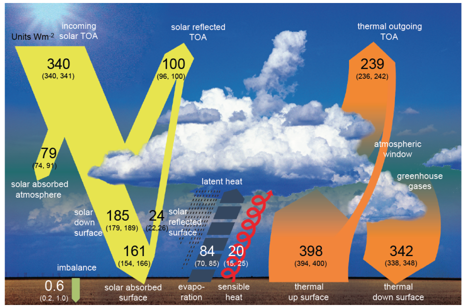

Fig. 1: global mean energy budget from Wild et al. (2013)

We combine a comprehensive set of radiation observations with 43 state-of-the-art climate models from CMIP5 to infer best estimates for downward solar and thermal radiation averaged over land and ocean surfaces. Over land, where most direct observations are available to constrain the surface fluxes, we obtain 185 and 305 Wm^{-2} for solar and thermal downward radiation, respectively (Fig. 3). Over oceans, with weaker observational constraints, corresponding estimates are around 185 and 356 Wm^{-2} (Fig. 5). These estimates closely agree, mostly within 3 Wm^{-2}, with the respective quantities independently determined from recent state-of-the-art reanalyses and satellite-derived products. This remarkable consistency enhances confidence in the determined flux magnitudes, which have traditionally introduced large discrepancies in the energy budget estimates and often hampered an accurate representation of surface climates in models. Considering additionally surface albedo and emission, we infer an absorbed solar and net thermal radiation of 137 and -67 Wm^{-2} over land, and of 170 and -53 Wm^{-2} over oceans, respectively (Figs. 2, 4). The surface net radiation is thus estimated at 70 Wm^{-2} over land and 117 Wm^{-2} over oceans, which may impose additional constraints on the respective sensible and latent heat fluxes. Combining these surface budget estimates with satellite-determined TOA budgets (CERES-EBAF) results in an atmospheric solar absorption of 76 and 82 Wm^{-2} over land and oceans, respectively (Figs. 2, 4).

Land mean budget

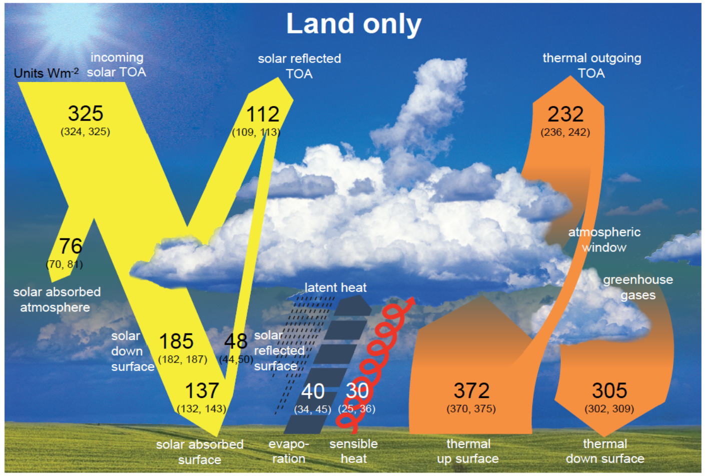

Fig. 2: land mean energy budget infered from surface and TOA observations

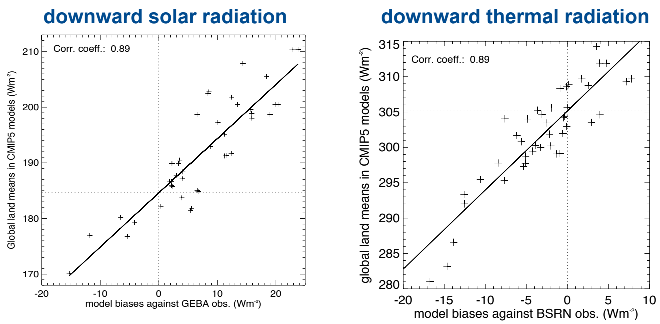

Fig. 3: To infer best estimates for the land mean surface downward solar (left) and thermal (right) radiation, for 43 CMIP5 models their average biases at land-based surface observation sites are related to their respective land mean values. Each cross represents a climate model, with its mean radiation bias compared to the surface sites on the horizontal axis, and its respective land mean value on the vertical axis. A best estimate can be inferred from the linear regression at the intersect where the bias against the surface observations becomes zero (dashed lines).

Ocean mean budget

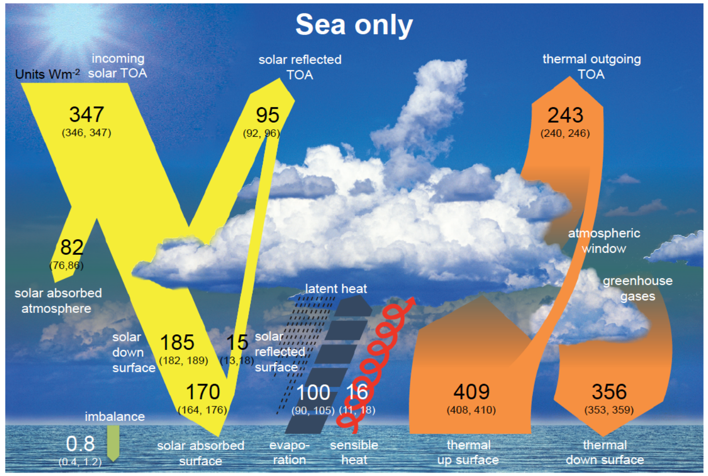

Fig. 4: sea mean energy budget infered from surface and TOA observations

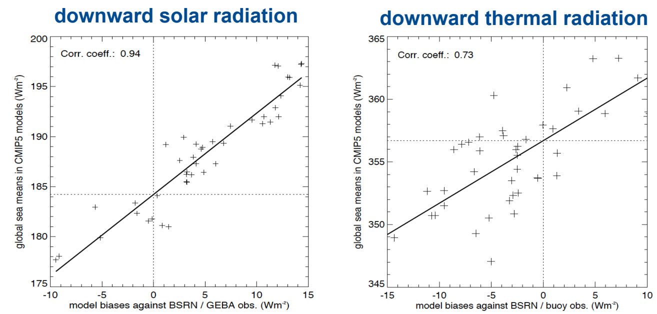

Fig. 5: To infer best estimates for the ocean mean surface downward solar (left) and thermal (right) radiation, for 43 CMIP5 models their average biases at surface observation sites in maritim environments are related to their respective ocean mean values. Each cross represents a climate model, with its mean radiation bias compared to the surface sites on the horizontal axis, and its respective ocean mean value on the vertical axis. A best estimate can be inferred from the linear regression at the intersect where the bias against the surface observations becomes zero (dashed lines).

References

Wild, M. et al. 2013a: The global energy balance from a surface perspective, *Climate Dynamics*, **40**, 3107-3134, doi:10.1007/s00382-012-1569-8.
Wild, M. et al. 2013b: A new diagram of the global energy balance, *AIP Conf. Proc.*, **1531**, 628-631, doi: 10.1063/1.4804848.
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