Geophysical Research Abstracts
Vol. 17, EGU2015-8433, 2015
EGU General Assembly 2015

Estimates of the climatological land surface energy- and water balance derived from thermodynamic constraints

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The land surface energy and water balances are tightly coupled by the partitioning of absorbed solar radiation into terrestrial radiation and the turbulent fluxes of sensible and latent heat, as well as the partitioning of precipitation into evaporation and runoff. Evaporation forms the critical link between these two balances. Its rate is strongly affected by turbulent exchange as it provides the means to efficiently exchange moisture between the heated, moist surface and the cooled, dry atmosphere. Here, we use the constraint that this mass exchange operates at the thermodynamic limit of maximum power to derive analytical expressions for the partitioning of the surface energy and water balances on land. We use satellite-derived forcing of absorbed solar radiation, surface temperature and precipitation to derive simple spatial estimates for the annual mean fluxes of sensible and latent heat and evaluate these estimates with the ERA-Interim reanalysis data set and observations of the discharge of large river basins. Given the extremely simple approach, we find that our estimates explain the climatic mean variations in net radiation, evaporation, and river discharge reasonably well. We conclude that our analytical, minimum approach provides adequate first order estimates of the surface energy and water balance on land and that the thermodynamic limit of maximum power provides a useful closure assumption to constrain the energy partitioning at the land surface.