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Global inter-comparison of land surface heat flux estimates

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Land heat surface fluxes are essential components of the energy and water cycle. In situ measurements by flux tower networks exist, but they lack global coverage. For global coverage, the alternatives are formulations or models forced by global datasets providing information about the physical properties of the surface and/or atmosphere affecting the fluxes.

A global inter-comparison of land surface heat flux datasets for a selected period of time (1993-1995) at monthly time scales is presented here [1]. The inter-comparison includes a representative sample of the first emerging dedicated global products and some examples of estimates produced by weather reanalyses and off-line forced land surface models. The dedicated products include estimates provided by the University of Cali- fornia Berkeley, the University of Maryland, Paris Observatory, Princenton University, and the Max Planck Institute for Biochemistry. As reanalyses, estimates from MERRA, NCEP-DOE, and ERA-Interim are considered. As off-line forced models, estimates from the multi-model ensemble GSWP-2 and from the Mosaic, Noah, and CLM models driven by the Global Land Data Assimilation System (GLDAS) are presented.

The analysis was conducted by comparing the different estimates of latent heat (Qle) and sensible (Qh) fluxes, the associated net radiative fluxes (Rn), and the evaporative fraction (EF = Qle/Rn), with products homogenized into a common equal-area grid of 2.5x 2.5 degrees. Comparison of the global Q annual means shows a spread of 20 W/m2 for Qle and Rn (Qle ensemble mean and standard deviation of 45 and 6 W/m2), and a larger spread for Qh. An approximately similar spread is observed for Rn (but for an ensemble average of 90 W/m2). In general, the products correlate well with each other, (global Qle correlations between 0.86 and 0.91), but analysis of the global correlations for the 1993-95 inter-annual means (0.89 to 0.93) and deseasonalized monthly means (0.12 to 0.45) suggests that the large seasonal variability of the fluxes and the common forcings shared by some products could partly be responsible for the high correlations.

Inspection of the monthly mean flux distributions shows that in general the main geographical structures related to the main climatic regimes and geographical features are present in all products. Nevertheless, large Qle and Qh product differences are observed. Annual cycles for Qle peak for all products in July, with an spread of 25 W/m2 (ensemble mean and standard deviation of 60 and 10 W/m2). For Rn, the annual cycles peak between June and August, depending on the product. For the month of highest Qle, EFs of 0.4 to 0.7 for the different products points out to significant differences in the flux partitioning. The fluxes were spatially averaged for 10 major vegetation classes. The rain forest and desert have the largest Qle and Rn spread, respectively. For most of the vegetation classes, the correlation between Qle and Rn from the dedicated products and reanalysis is higher than for the off-line models. The fluxes were also averaged for 10 selected basins including some of the major tropical and mid-latitudes river systems. Relative large spread in Qle is observed for the Danube, Congo, Volga, and Nile basins. Inspection of monthly time series of basin averaged fluxes shows that the seasonality is in general well captured by all products, but some large differences in the flux partitioning are observed for some products and basins. Apart from the Murray basin, not much inter- annual variability was noticed in this three years.

This inter-comparison highlights the difficulties of producing global flux estimates. Some of the dedicated products inter-compared are first versions, and improvements in the analyzed products are already on its way, which should result in more consistent fluxes. Concerning the atmospheric reanalyses, important differences in some of the surface physical fields has also been noted elsewhere, and users are typically advised to use physical fields such as the fluxes with caution. Regarding the off-line forced models, the inter-comparison showed that even when forced with the same datasets, their parameterizations can have a large effect on the flux partitioning. Nevertheless, an increasing better understanding of the soil-atmosphere-vegetation transfer processes is driving the improvements of some of the inter-compared land surface models, which should result in a better flux estimation.

This inter-comparison has been made in the framework of the GEWEX activity LandFlux, and it is part of a series of inter-comparison exercises coordinated by the LandFlux-EVAL initiative. This type of exercises will contribute to the objective of iden- tifying and delivering robust procedures for production of global land surface heat fluxes.

[1] Jiménez, C., C. Prigent, B. Mueller, S. I. Seneviratne, M. F. McCabe, E. F. Wood, W. B. Rossow, G. Balsamo, A. K. Betts, P. A. Dirmeyer, J. B. Fisher, M. Jung, M. Kanamitsu, R. H. Reichle, M. Reichstein, M. Rodell, J. Sheffield, K. Tu, and K. Wang, (2011), Global intercomparison of 12 land surface heat flux estimates, J. Geophys. Res., 116, in press, doi:10.1029/2010JD014545.