Estimation of the precipitation recycling ratio

by

Carlos Andrés Sánchez Altamirano

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Thesis Committee

Assistant Prof. Pat J.-F. YEH                NUS
Prof. Shie – Yui LIONG                    NUS
Prof. H. H. G. Savenije                   TU Delft
Prof. Herman Russchenger                  TU Delft
Dr. Ir. Ruud van der Ent                  TU Delft
1.1 Abstract

The recycling ratio $R$ is said to be an indicator of the potential interaction between surface hydrologic processes and atmospheric hydrologic processes for a determined equilibrium state Eltahir and Bras (1994). Several precipitation recycling models that provide an estimate of $R$ have been developed in literature, with each having various assumptions and limitations Brubaker et al. (1993), Eltahir and Bras (1994), Dominguez et al. (2006), Van Der Ent (2010).

The present thesis is focused on applying some of the most commonly used precipitation recycling models (models of Brubaker et al. (1993), Eltahir and Bras (1994), Dominguez et al. (2006) or dynamic model and Van Der Ent (2010) or Water Accounting Model (WAM)) to the upper Mississippi region including U.S. Midwest under the hypothesis that it is possible to estimate the recycling ratio making use of observed relationships. The data used comes from satellite observations and reanalysis products from the ERA-Interim.

Estimates of precipitation recycling obtained by using the models of Brubaker et al. (1993) and Eltahir and Bras (1994), which are applicable at monthly timescale, are approximated with a linear equation of the form $R = a + bE$, where $E$ is the evaporation [L] and $a$ and $b$ are empirical coefficients. The coefficient of determination ($R^2$) between the model estimates and the linear equation are 0.91 and 0.82, for the period 2004-2014, respectively for Brubaker et al. (1993) and Eltahir and Bras (1994).

Although several attempts of estimating the daily recycling ratio based on the dynamic model, the WAM, and the atmospheric fluxes were made, it was not possible to identify an equation that produces estimates within an acceptable range ($R^2 > 0.65$). However, when the definition of the recycling ratio was applied to the daily estimates in order to determine the monthly values, the correlation between the monthly evaporation and the monthly recycling ratio improved significantly.

Previous researches have correctly claimed that the recycling ratio is dependent on the size of the region studied Eltahir and Bras (1996), Dominguez et al. (2006), Van Der Ent (2010), some have even proposed equations that estimate the regional recycling ratio in seasonal or annual timescales as a function of the area Dominguez et al. (2006), Dirmeyer and Brubaker (2007). As a means to quantify the influence of the size of the region, the recycling ratio was estimated with the WAM without considering the influx of locally generated water vapour so that the transport of moisture within the region is null, and it was found that the maximum contribution of the evaporation to the recycling of moisture was approximately 15 %.

With the analysis of three regions with different sizes, it was demonstrated that the dependence of the regional recycling ratio on the size of the region is due to the transport of moisture generated in the upwind zones to the downwind zones, and that in small regions (region 1 in this study) there was not a clear difference between the effects of local coupling and moisture recycling, which agrees with the findings of Goessling and Reick (2011).

The estimates of the regional recycling ratio from the three regions were fitted to an equation of the form $R = 1 - e^{-EA/b}$, later named eq. (34), where $EA$ is the monthly volume of water evaporated in the region and $b$ is representative of the size of each region. The term $b$ is estimated with a lineal curve which is function of the size of the region.

Finally in order to test accuracy of the estimates obtained with the equation (31), the monthly recycling ratio of two new regions are determined with the WAM, both have different geometry, sizes and are located in different zones. The estimates obtained with the equation (31) showed to have a good correlation, $R^2=0.86$ and 0.90 respectively, with the estimates from the WAM.