Investigation of Southern Great Plains Atmospheric Moisture Budget for CLASIC

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CLASIC Campaign

The Cloud and Land Surface Interaction Campaign was conducted over the Southern Great Plains (SGP) ARM Climate Research Facility during June 2007. One of CLASIC's primary goals is to "improve understanding of the physics of the early stages of cumulus cloud convection as it relates to land surface conditions".

Motivations

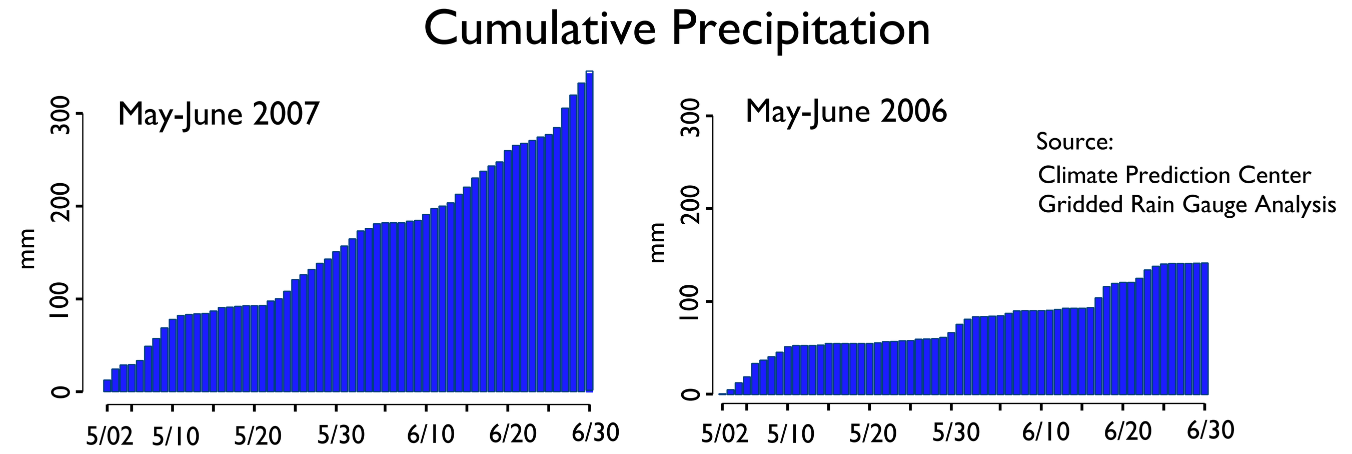
Our moisture budget analysis, conducted over an expanded region surrounding the SGP for CLASIC and three other contrasting May-June periods, provides a bulk approach for relating cloud properties to larger-scale atmospheric conditions. Moisture budget analysis is an important tool for studying land-atmosphere interactions, since the linkages among atmospheric dynamics, water vapor, surface conditions, and precipitation are constrained by the moisture continuity equation.

Summary

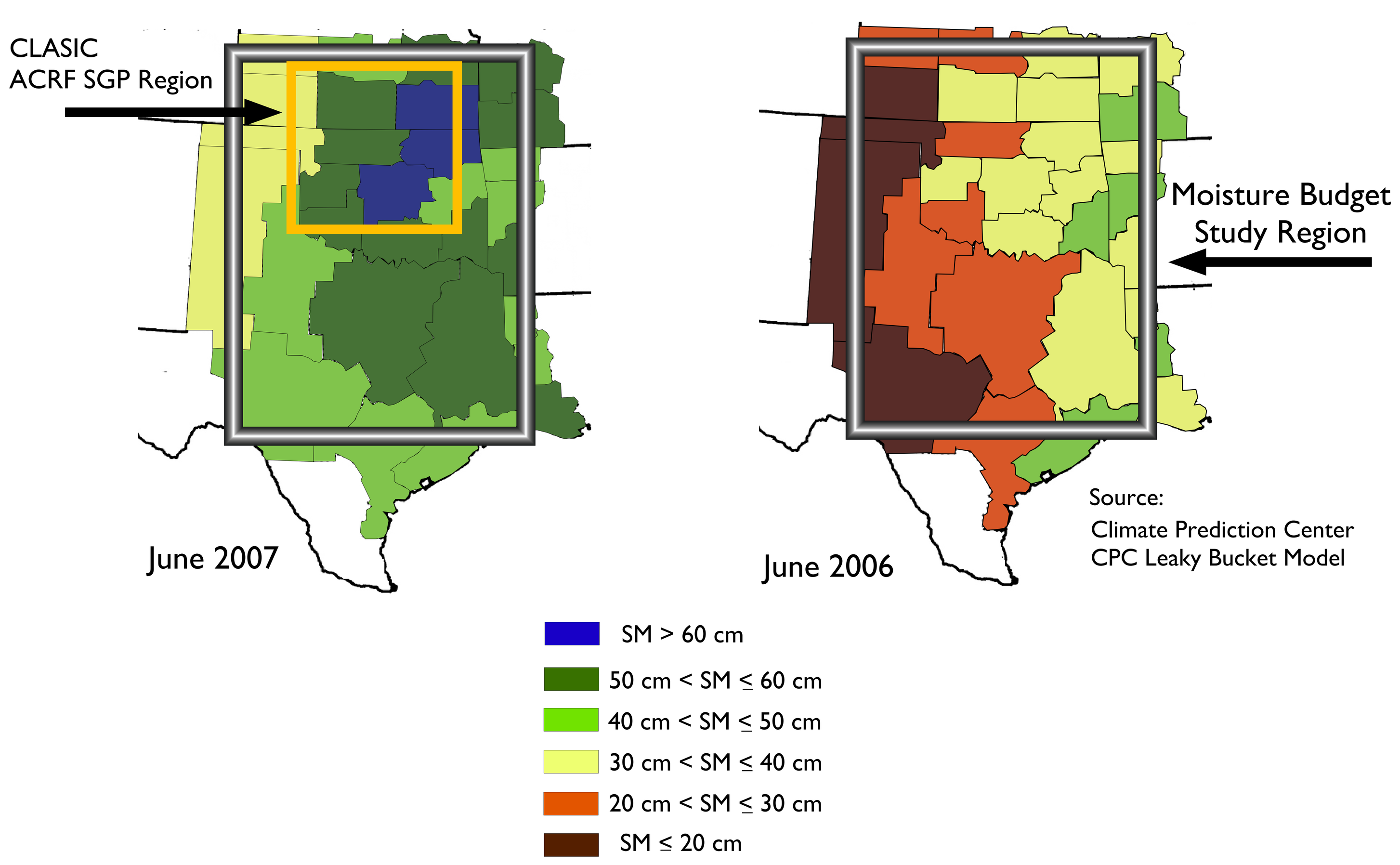
- Over the SGP, E (Evapotranspiration) = ~P (Precipitation) for many monthly means. However, this does not imply that E is the main moisture source for monthly P.
- On a daily timescale, the recycling ratio (P_E/P) is maximized in the 2-4 mm d^{-1} P range. This is the P range of most interest for CLASIC clouds.

Record Breaking Rainfall during CLASIC

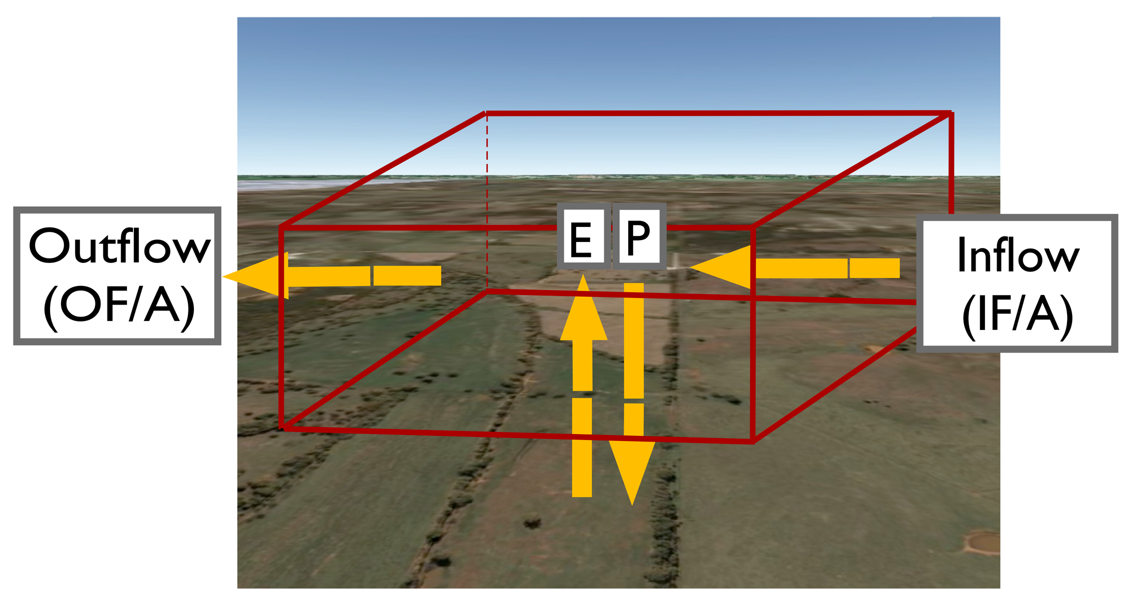
Cumulative Precipitation



Soil Moisture



Recycling Method



Bulk formula for the moisture budget has 4 boundary fluxes (E, P, OF/A and IF/A):

$$E - P = \frac{OF}{A} - \frac{IF}{A} + dPW$$

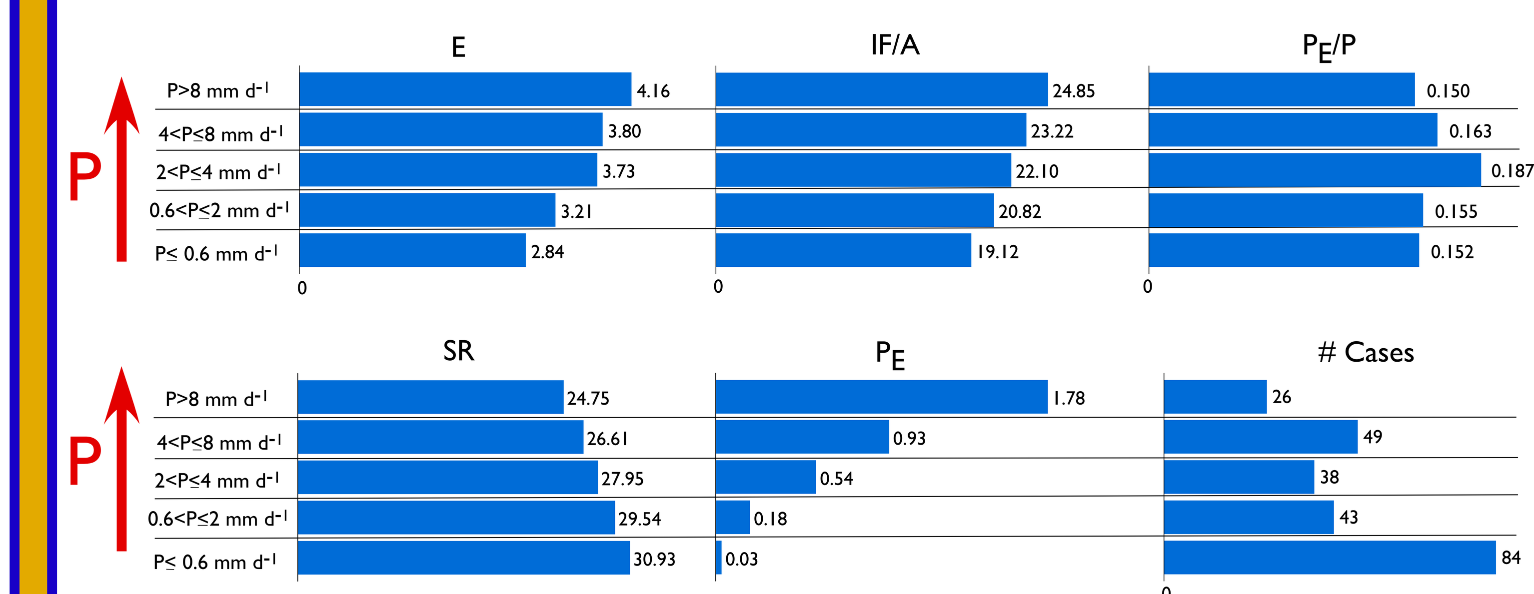
where
E is the local source of moisture
IF/A is the advective source of moisture

Based on this Tank Model, our recycling ratio is:

$$\frac{P_{local}}{P_{local\,+\,advective}} = \frac{P_E}{P} = \frac{E}{E + \frac{IF}{A}}$$

Characteristics of Daily Recycling within Precipitation Categories

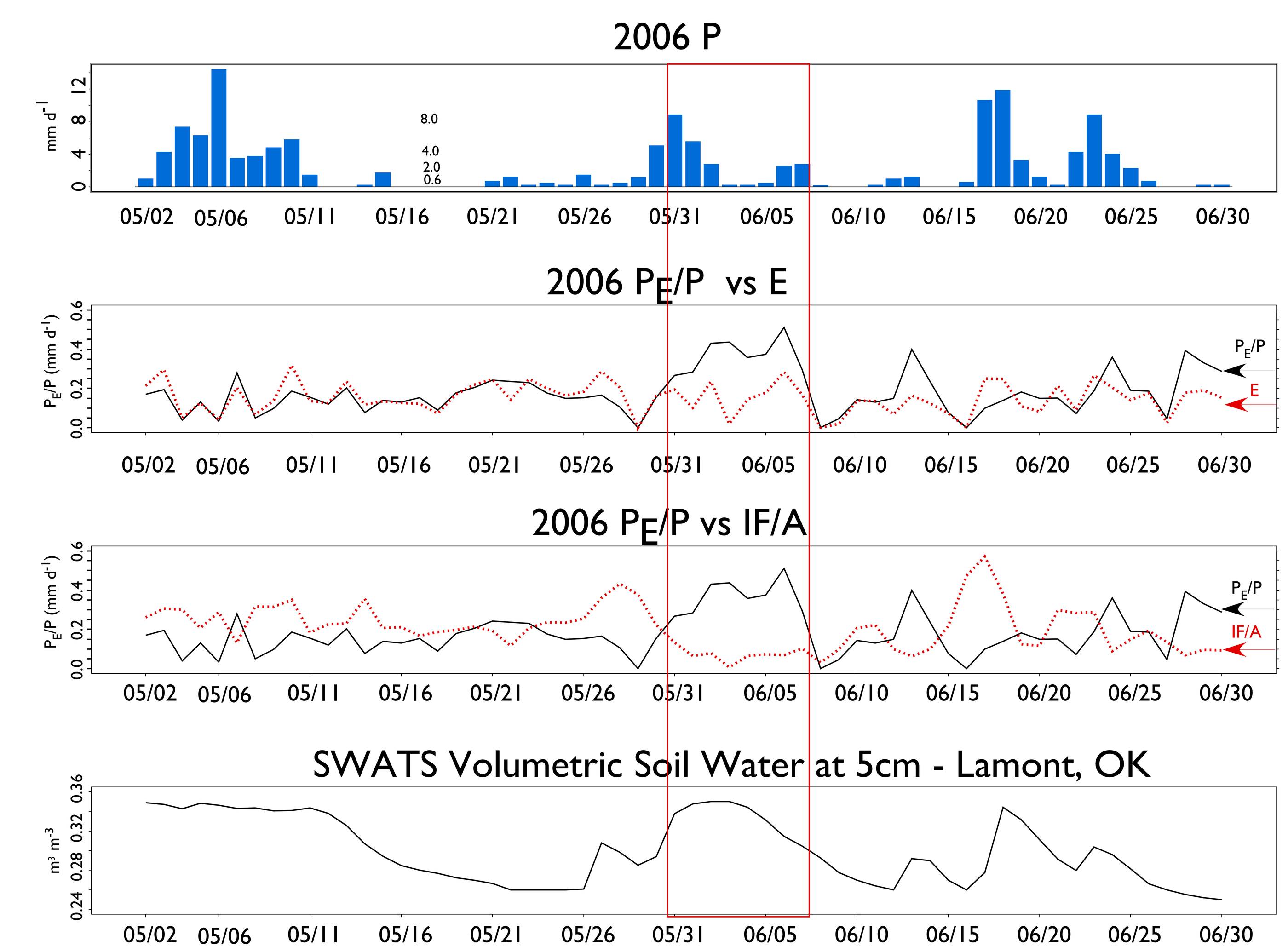
Daily Mean Recycling and Related Variables
May-June 1998, 2002, 2006, 2007



where
E is the local source of moisture (mm d^{-1}); IF/A is the advective source of moisture (mm d^{-1})
P_E/P is the recycling ratio ; SR is the solar radiation (MJ m^{-2} d^{-1});P_E is the recycled precipitation (mm d^{-1})

- **Recycling ratio is maximized in the 2-4 mm d^{-1} P Category.**
- **Both E and IF/A increase with increasing P.**
- **Variation among the recycling related components on a daily timescale is shown below for the dry year of 2006. The red box indicates a period of very high recycling rates when advected moisture was low but there was still soil moisture available for evapotranspiration.**

Variation of P, Recycling and Soil Moisture on a Daily Timescale

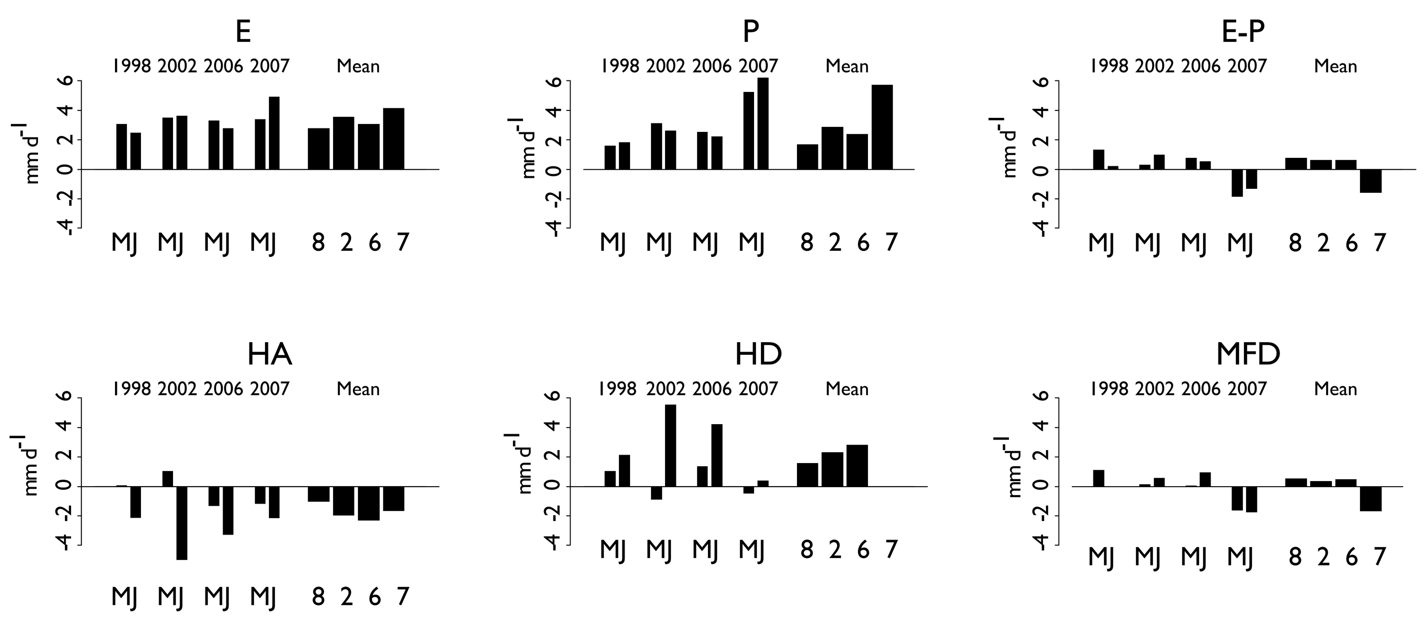


Monthly Mean Moisture Budget

May-June 1998, 2002, 2006, 2007

Conventional Form of the Moisture Budget Equation:
E-P = MFD +dPW= HA + HD +dPW

where E is evapotranspiration, P is precipitation, MFD is Moisture Flux Divergence with its components HA (horizontal moisture advection) and HD (horizontal velocity divergence in the presence of moisture), dPW is atmospheric moisture storage (which is negligible on a monthly timescale).



Recycling on a Monthly Timescale

Using the conventional form of the Moisture Budget Equation, one might assume that if E-P ~0 (or MFD ~0), then most of the precipitation (P) originates from evapotranspiration (E).

Over the SGP, E-P ~0 (except for the extremely wet May-June 2007 and the very dry May 1998).

However, using the bulk form of the Moisture Budget above, the ratio of precipitation originating from evapotranspiration to the total precipitation (P_E/P) is much less than 1.0.