Relative Importance of Local Recycling versus External Advection for CLASIC Rainfall and Clouds

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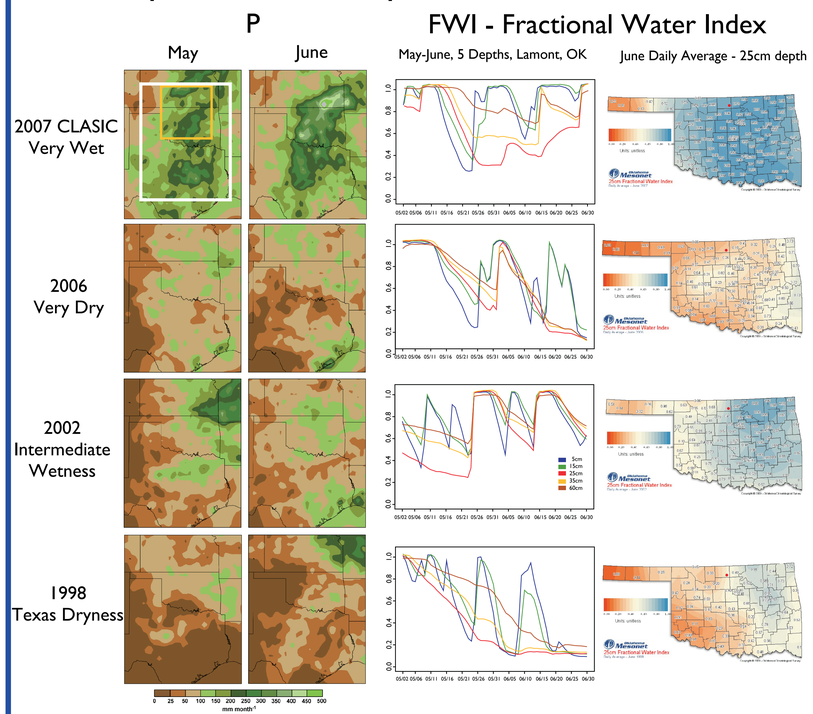
CLASIC Campaign

The Cloud Land And Surface Interaction Campaign was conducted over the Southern Great Plains (SGP) ARM Climate Reasearch Facility in June 2007. A primary goal of CLASIC is to understand the interactive roles of horizontal moisture advection and land surface processes in the evolution of cumulus convection.

Study Overview

Our study is providing the larger-scale (Oklahoma-Texas) atmospheric moisture budget background for the interpretation of results derived from the CLASIC observational platforms. Extremely wet conditions prevailed during CLASIC, when Oklahoma experienced its wettest June since records began in 1895. Three other contrasting May-June periods were chosen for analysis: 2006 (very dry), 2002 (intermediate wetness), and 1998 (very dry, especially upstream in Texas). Using a recycling methodology that was developed during an earlier investigation for the Corn Belt (Zangvil et al. 2004), estimates were made of the contributions of locally recycled versus externally advected water vapor for the precipitation (and cloud development) on a range of timescales (daily, monthly, bimonthly). Except for precipitation and soil moisture, we used the North American Regional Reanalysis (NARR) data for our calculations.

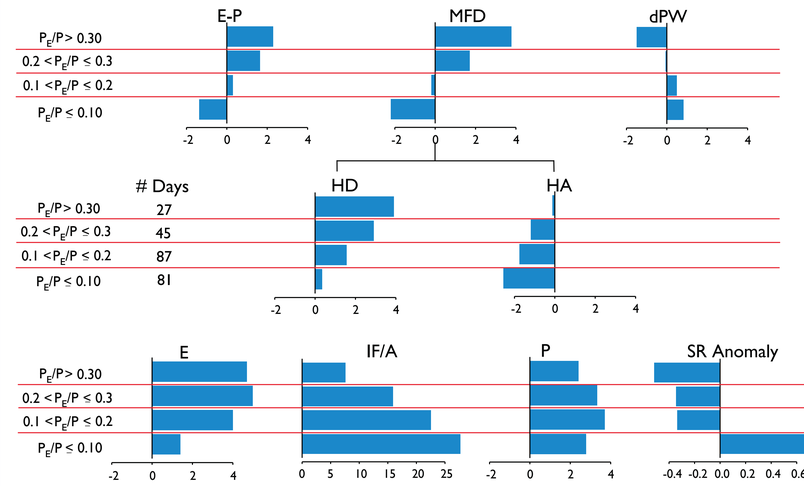
Comparison of Precipitation & Soil Moisture



P Data : Gridded Rain Gauge Analysis, Climate Prediction Center
Yellow Box: CLASIC ACRF Study Region
White Box: Moisture Budget Study Region

The FWI is calculated from data collected from an automated soil water and temperature profile system. The first column uses data from the SGP Central Facility near Lamont (indicated by a red dot on OK maps), the second column uses data from the Oklahoma Mesonet that is disseminated by the Oklahoma Climatological Survey. The FWI (see Schneider et al. 2003) ranges from 1.0 (near field capacity) to 0.0 (the lowest possible volumetric soil moisture).

Stratification of Daily Moisture Budget* & Related Variables by Recycling Ratio (P_E/P)



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

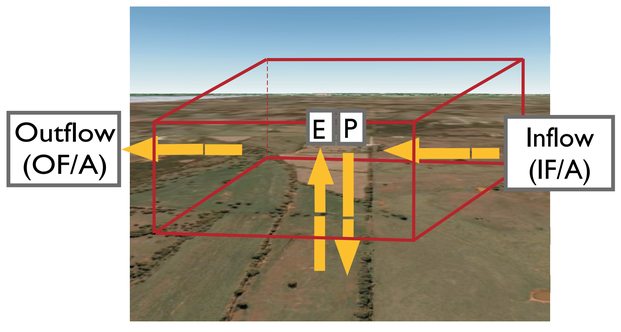
where E is evapotranspiration, P is precipitation, MFD is Moisture Flux Divergence with its components HA (horizontal moisture advection) and HD (horizontal velocity divergence in the presence of moisture), dPW is the change in atmospheric moisture storage. All units are in mm d^{-1} except for the unitless P_E/P and the SR anomaly (MJ m^{-2} d^{-1}).

HIGH Recycling Ratio:
Max: surplus (E-P), moisture flux divergence (+MFD), horizontal divergence (+HD), clouds
Min: external advection (IF/A), horizontal moisture advection (-HA)

Low Recycling Ratio:
Max: deficit (E-P), moisture flux convergence (-MFD), horizontal moisture advection (-HA), external advection (IF/A)
Min: horizontal divergence (+HD), clouds

Variations in the recycling ratio above 0.20 are reflected more in the externally advected moisture (IF/A) than evapotranspiration (E).

Recycling Method



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

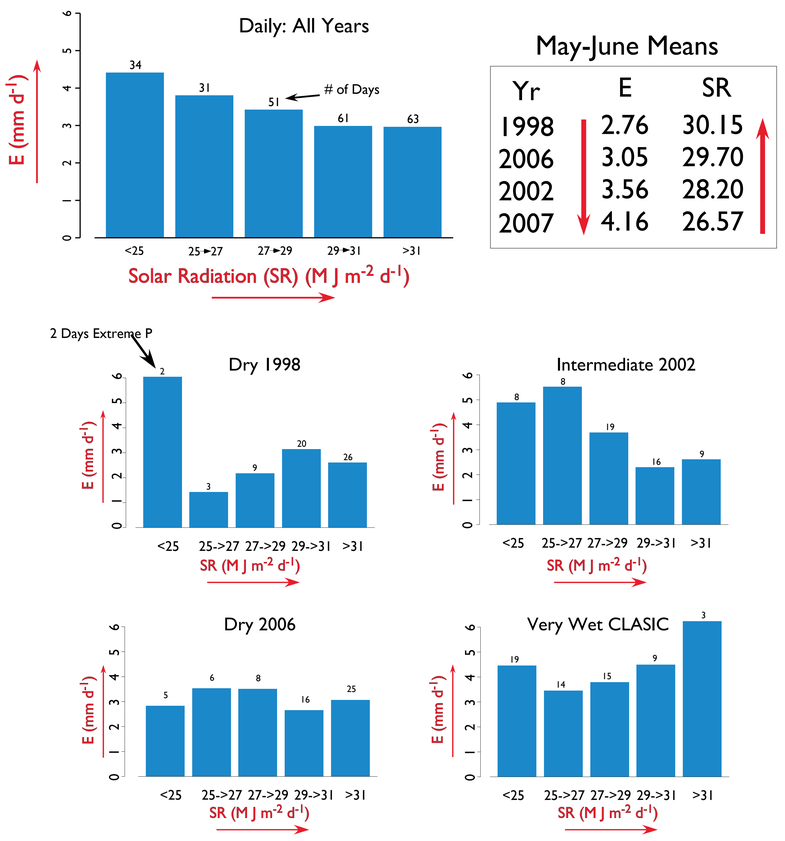
$$E - P = \frac{OF}{A} - \frac{IF}{A} + dPW$$

where
E is the local source of moisture
IF/A is the advective source of moisture
dPW is the change in atmospheric moisture storage

Based on this Tank Model, our recycling ratio is:

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

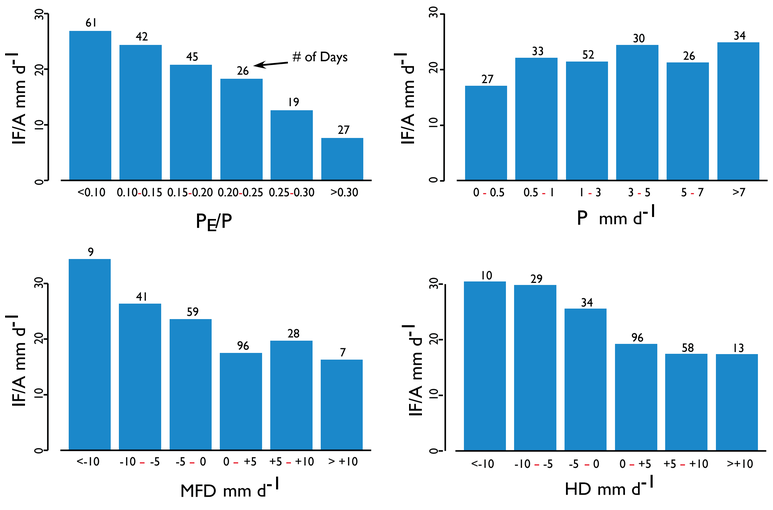
Over the SGP: Evapotranspiration limited more by available moisture than available energy



May-June Means

Yr	E	SR
1998	2.76	30.15
2006	3.05	29.70
2002	3.56	28.20
2007	4.16	26.57

A Closer Look at External Advection (IF/A)



External Advection has negative correlations with MFD (-0.32), HD (-0.39) and P_E/P (-0.59) with significance levels at 5%, 1% and 0.1% respectively.

References:
Schneider, J. M., D. K. Fisher, R. L. Elliot, G.O. Brown and C. P. Bahrmann, 2003. Spatiotemporal Variations in Soil Water: First Results from the ARM SGP CART Network. J Hydrometeorology, 4, 106-120.

Zangvil, A., D. H. Portis and P. J. Lamb, 2004: Investigation of the large-scale atmospheric moisture field over the Midwestern United States in relation to summer precipitation. Part II: Recycling of local evaporation and association with soil moisture and crop yields. J. Climate, 17, 3283-3301.