# How “local” the local convective events are at the SGP region?

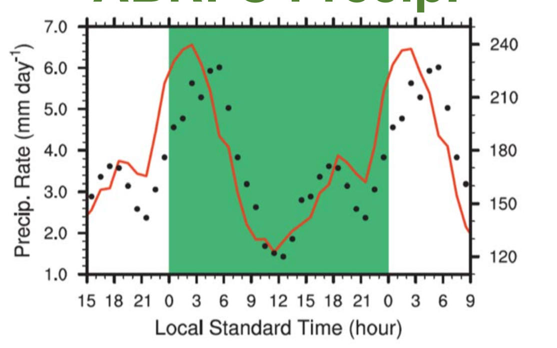

Lawrence Livermore National Laboratory

Cheng Tao (tao4@llnl.gov) and Yunyan Zhang

U.S. Department of Energy, Office of Science, Early Career Research Program


## Motivation

**ABRFC Precip.**



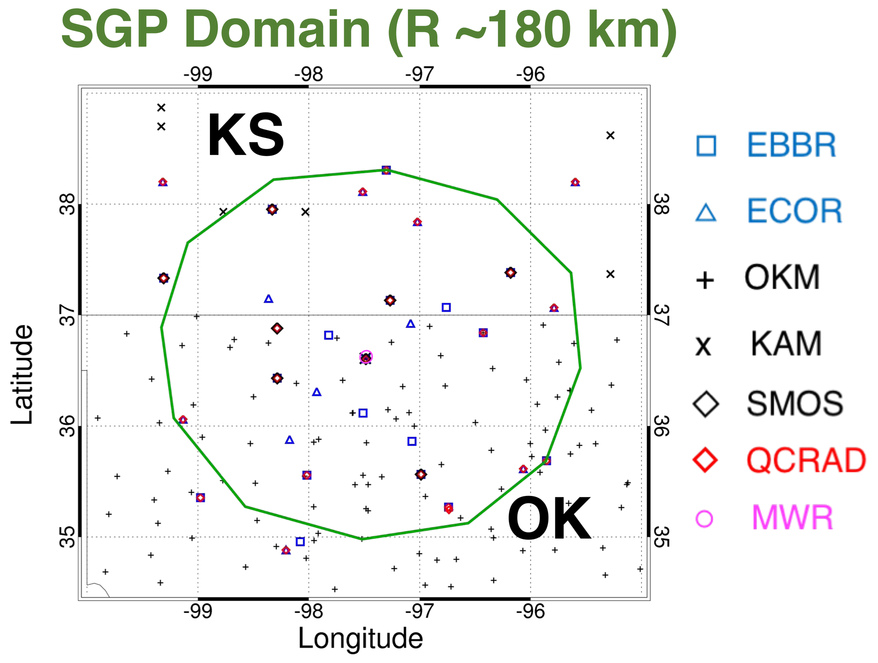

*From Zhang and Klein (2010)*

Recent observational studies indicated an important role of transported moisture in dominating the precipitation variability at the SGP, suggesting a relatively weak land-atmosphere coupling. But these focused on nocturnal precipitation, which is associated with eastward-propagating systems.

In this study, we investigate the strength of the land-atmosphere coupling at the SGP through the water and energy budget analysis. Specifically, we're interested in the dominant moisture sources for locally-generated convective events at the SGP.

## ARM continuous forcing data

**SGP Domain (R ~180 km)**




| Variables | Data/Instruments |
|---|---|
| Surface pressure, T, Q, U, V | SMOS, OKM, and KAM |
| T, Q, U, V profile | NOAA RUC |
| Precipitation | ABRFC |
| SH, LH | EBBR and ECOR |
| TPW | MWR |
| Surface all sky radiative fluxes | SIROS-QCRAD |
| Cloud fraction | GOES VISST |

Vertical profiles of the atmospheric state variables from RUC are adjusted through a CVA approach (Tang et al. 2016)

## Water budget analysis

**Assumption**: water vapor of externally advected and locally evapotranspired origins are fully mixed[2].

a. Water budget equations

$$\underbrace{\frac{1}{g}\frac{\partial}{\partial t}\int_S^T q\,dp}_{dPW} + \underbrace{\frac{1}{g}\int_S^T \vec{V}\cdot\nabla q\,dp}_{HA} + \underbrace{\frac{1}{g}\int_S^T q\nabla\cdot\vec{V}\,dp}_{HD} = E - P. \quad (1)$$

$$HA + HD = \frac{1}{g}\int_S^T \nabla\cdot q\vec{V}dp = \frac{1}{Ag}\int_S^T \oint qV_n dl dp = \frac{OF}{A} - \frac{IF}{A}. \quad (2)$$

$$E - P = \frac{OF}{A} - \frac{IF}{A} + dPW = MFD + dPW = -MFC + dPW. \quad (3)$$

b. Dynamic recycling model

This considers the change in the storage of water vapor and is applicable to time scales ranging from daily to seasonal[3].

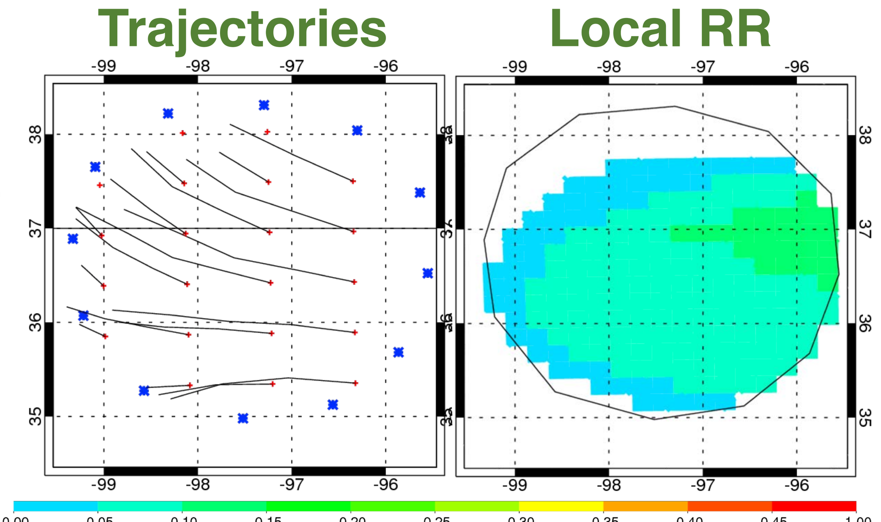
Local recycling ratio

$$R_l = 1 - \exp[-\int_0^\tau \frac{\epsilon(\chi,\xi,\tau)}{\omega(\chi,\xi,\tau)}\partial\tau']. \quad (4)$$

Regional recycling ratio

$$R_z = \frac{\sum_{n=1}^{N}(R_{ln}p_n\Delta A)}{\sum_{n=1}^{N}(p_n\Delta A)}. \quad (5)$$

**Trajectories** **Local RR**



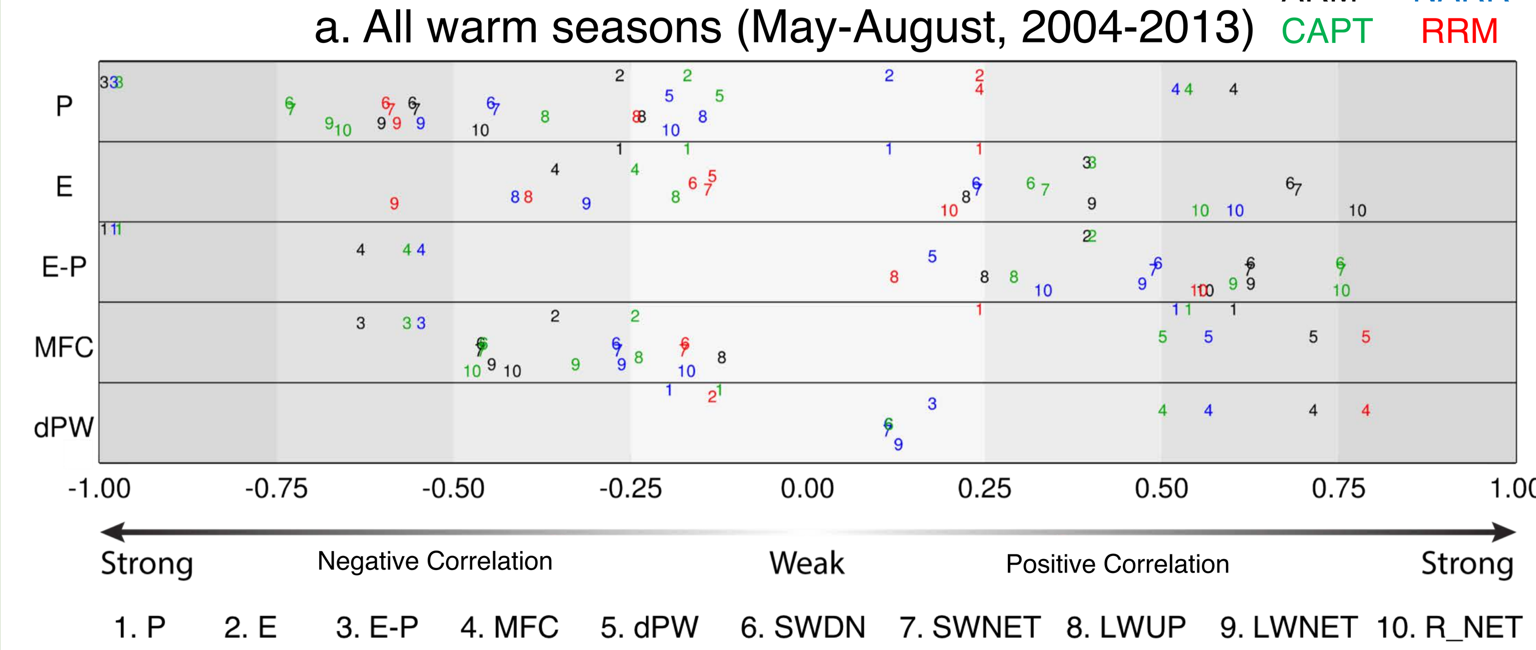
## Reference


1. Zhang and Klein, 2010: Mechanisms affecting the transition from shallow to deep convection over land: Inferences from observations of the diurnal cycle collected at the ARM SGP Site, *J. Atmos. Sci.*.
2. Zangvil et al. 2004: Investigation of the large-scale atmospheric moisture field over the Midwestern United States in relation to summer precipitation. Part II. *J. Climate*.
3. Dominguez et al. 2006: Impact of atmospheric moisture storage on precipitation recycling. *J. Climate*.

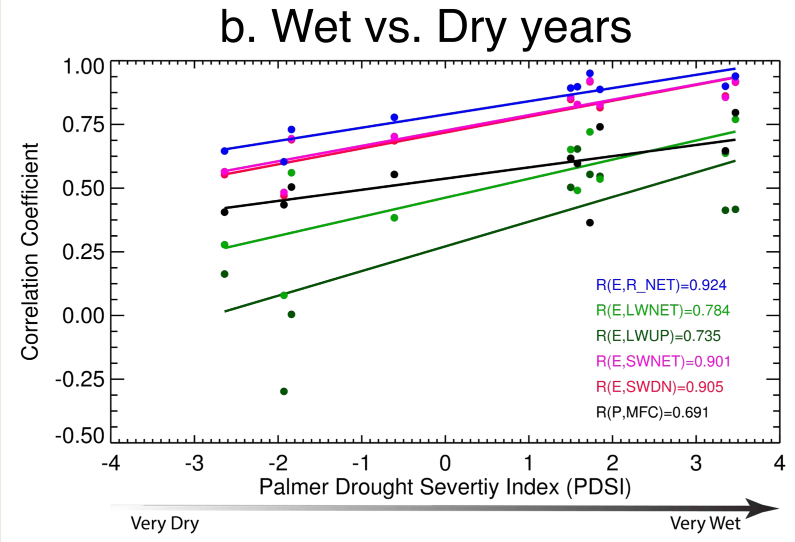

## What dominates the SGP regional water budget on the daily time scale?

**Linear correlation coefficients**

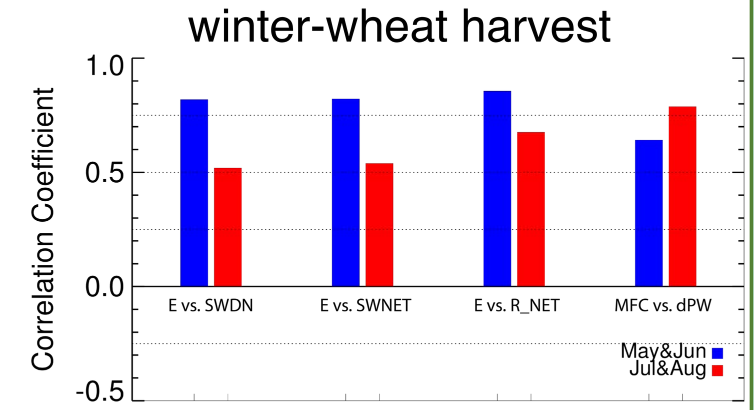
a. All warm seasons (May-August, 2004-2013)




b. Wet vs. Dry years




c. Before vs. After winter-wheat harvest

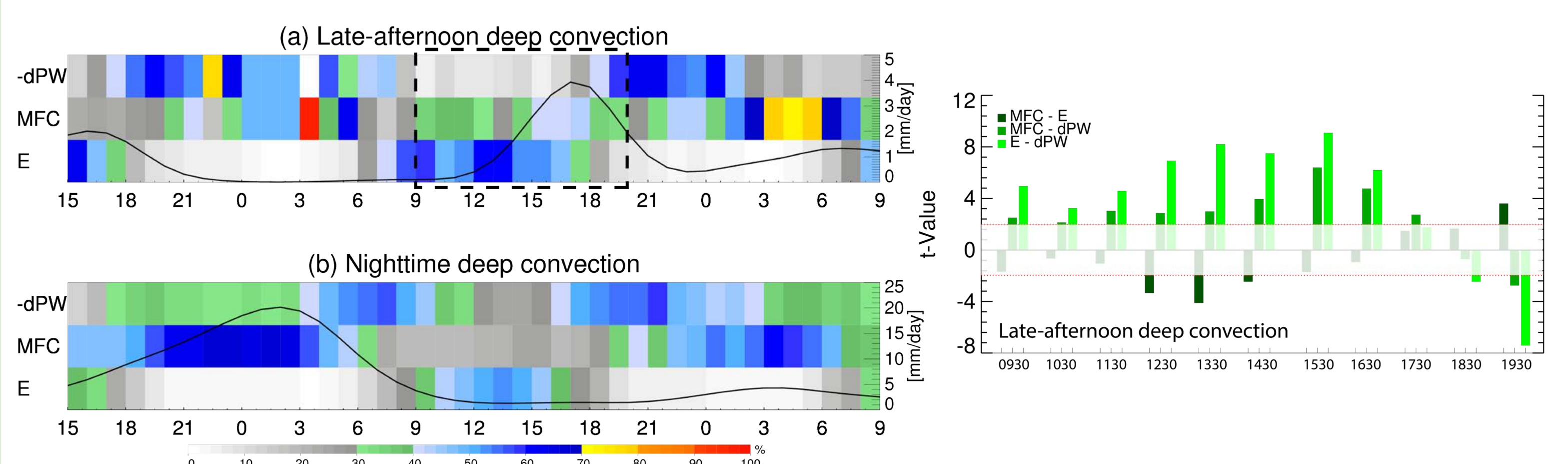



## What are the major moisture sources for late-afternoon & nocturnal precipitation regimes?

| Regime | Definition | Characteristics | Size |
|---|---|---|---|
| Late-afternoon | • $P_{max} \geq 1$ mm/day, occurs 15-21 LST, and is at least 1.5 times more than P at any other hour of the day<br>• P between 00-10 LST < 1.5 mm/day | Isolated, locally forced, unorganized convective cells | 49 |
| Nighttime | • $P_{max} \geq 1$ mm/day and occurs 0000-0600 LST | Usually associated with MCSs | 260 |

**Contribution to moisture sources**

From Eq. (3), P = E + MFC - dPW. Here, the sum of E, +MFC, and –dPW are considered as the total moisture sources for P in the two regimes.

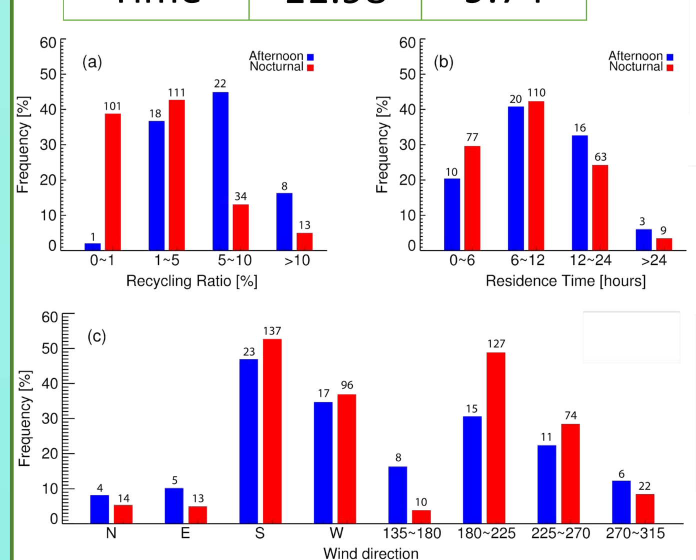



**Moisture recycling**

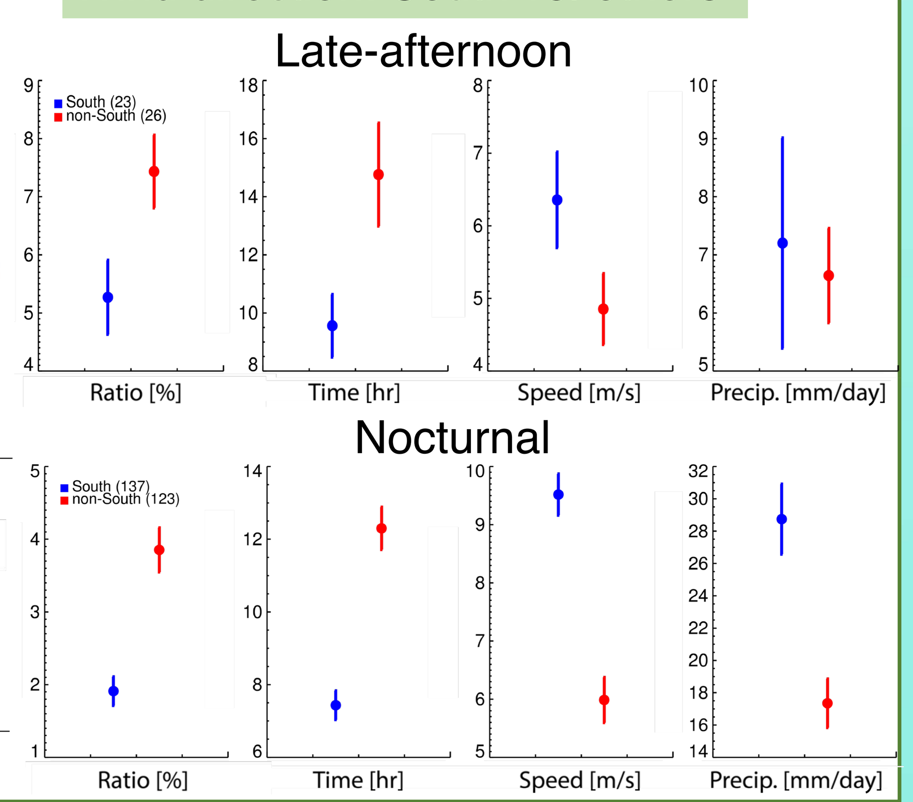
Daily-mean values are computed from 15-21 LST for late-afternoon and 00-06 LST for nighttime deep convection day.

**Frequency distribution**

| Mean | Aft. | Noc. |
|---|---|---|
| Ratio | 6.63 | 2.64 |
| Time | 11.98 | 9.74 |




**Wind direction: South vs. others**

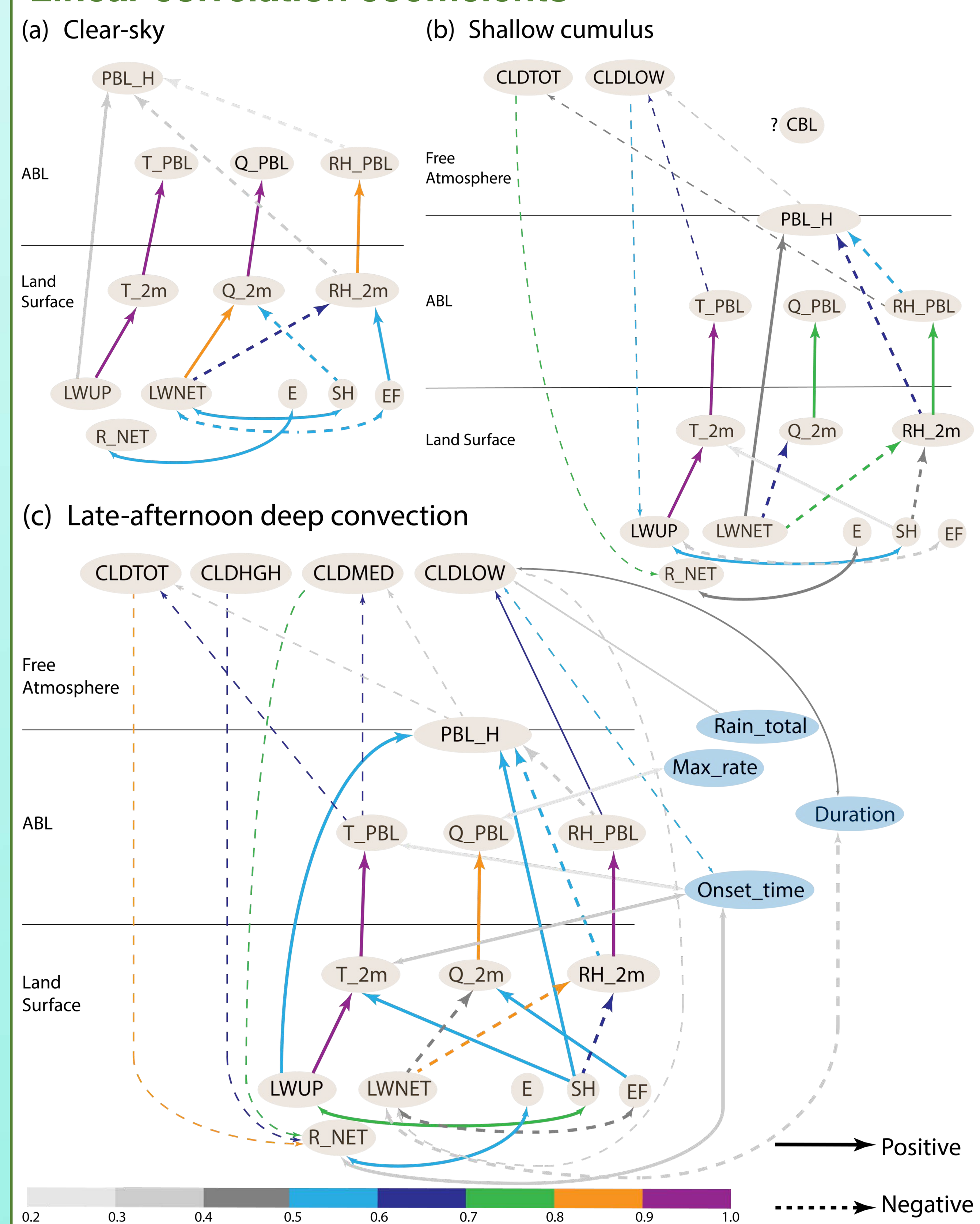



## Take-home messages

1. MFC dominates the SGP regional water budget on the daily time scale, from its strong correlation with P, dPW and E-P (|R| > 0.6).
2. MFC is the dominant moisture source for nighttime precipitation regime, while the major moisture source for late-afternoon precipitation regime varies at different stages.
   - The recycling ratio for late-afternoon deep convection, although a relatively small value (because of the domain size), is significantly higher than that for nighttime deep convection day.
   - ~ 50% of late-afternoon and nighttime deep convection days have moisture sources from the south, and these days have significantly lower recycling ratio, shorter moisture residence time, and greater wind speed, than days with moisture sources from other directions.
3. The strength of the land-atmosphere coupling for local convective regimes at the SGP are quantified from ARM observations.
   - Clear-sky: greater LWNET → lower RH_2m → higher PBL_H
   - Shallow cumulus: greater LWUP → higher T_2m → higher T_PBL → lower CLDLOW → greater LWUP (positive feedback)
   - Late-afternoon deep convection: greater LWUP → higher T_2m → higher T_PBL → lower CLDTOT → greater LWUP (positive feedback)

## What is the land-atmosphere coupling strength for local convective events?

**Linear correlation coefficients**

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