Possible diagnostics of land processes in the monsoon in CMIP5 models

Xubin Zeng
Department of Atmospheric Sciences
University of Arizona
xubin@atmo.arizona.edu

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(1) For monthly model output, compute land-precipitation coupling strength, Γ index (Zeng et al. 2010; J. Hydromet., 11, 980-995):

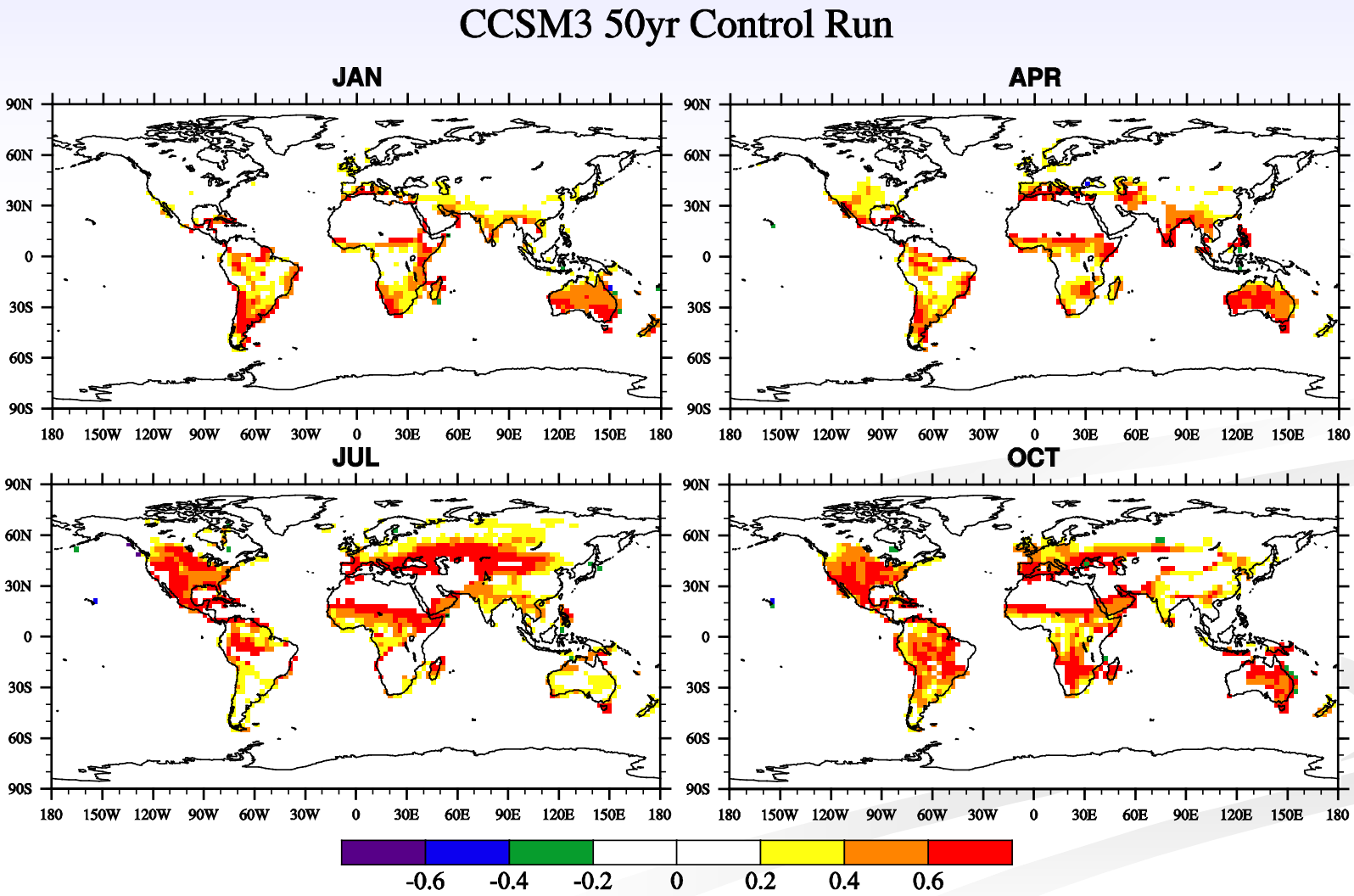
$$\Gamma = \Sigma E_i' P_i' / \Sigma P_i' P_i'$$

i: month;
Σ : summation over all available years
E': latent heat flux deviation from climatology for month i
P': precipitation deviation from climatology for month i

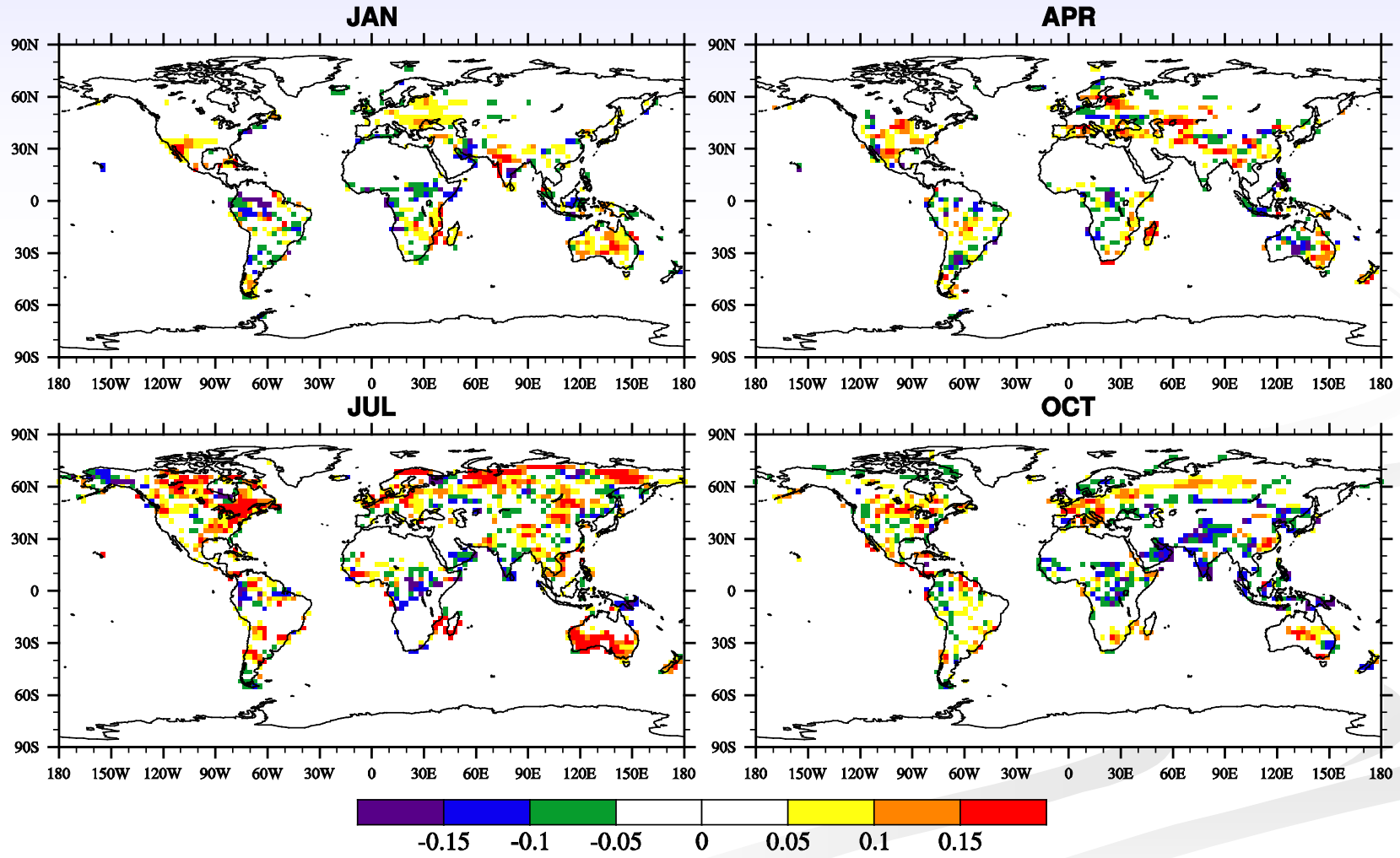
Strength: derived rigorously; easy to interpret physically
easy to compute from data or model output
Weakness: just a necessary condition for land-P coupling;
does not provide causality

Why not use time-delayed covariance $\Sigma P_i' E_{i-1}'$
a) it does not provide causality either (Wei et al. 2008)
b) $\Sigma P_i' E_{i-1}' / \Sigma P' P'$ does not have a clear meaning any more

Γ provides a simple indicator to characterize a GCM's coupling strength



CCSM3 50yr 2X CO2 - Control



(2) For monthly model output, compute correlations:

$r\,(E_i' , P_i')$ (concurrent)
$r\,(E_{i+1}' , P_i')$ (current month P versus next month E)
$r\,(E_{i-1}' , P_i')$ (current month P versus last Month E)

$r\,(SM_i' , P_i')$ (concurrent)
$r\,(SM_{i+1}' , P_i')$ (current month P versus next month SM)
$r\,(SM_{i-1}' , P_i')$ (current month P versus last Month SM)
(SM refers to total column soil moisture)

(3) For monthly output, compute ratios related to surface energy and water balance:

$R_1 = E/R_{net}$ (E: latent heat flux; R_{net}: net radiation)
(reason: R_{net} = latent heat flux + Sensible heat flux)

$R_2 = E/P$ (E: latent heat flux; P: precipitation)
(reason: P = E + runoff + change of soil moisture)

$R_3 = Runoff_{sur}/Runoff$ (surface runoff over total runoff)
(reason: total runoff = surface + subsurface runoff)

$R_4 = P_{int} / P$ (P_{int}: canopy-intercepted loss; P: precipitation)
(reason: intercepted P returns to atmosphere immediately)

$R_5 = E_v/E$ (E_v: canopy evaporation; E: latent heat)
$R_6 = T/E$ (T: transpiration; E: latent heat)
(reason: E = canopy E + transpiration + ground E)

For daily data

(4) For daily data, quantify the sensitivity of precipitation in summer to soil temperature and moisture conditions right before monsoon onset (e.g., compute the correlation of accumulated precipitation versus pre-monsoon soil moisture and temperature for monsoon region average).

Note that E can be quantified in mm/day (for water cycle) or W/m^2 (for energy cycle).

If these quantities for monthly and daily data are computed, Xubin will be happy to help interpret the results.