“Comparison of MERRA with ERA-40 on river basin scales"

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Background references

- Betts, A. K., 2007: Coupling of water vapor convergence, clouds, precipitation and land-surface processes. *JGR, 2006JD008191*

- Betts, A.K., M.A.F. Silva Dias, G. Fisch, C. von Randow, J.C.P. Cohen, R. da Silva, D.R. Fitzjarrald, 2008. The Amazonian Boundary layer and mesoscale circulations. *Chapter B3 in IGBP Synthesis Vol. 'Amazonia and Global Change'. Eds. M. Keller, J. Gash, P. Silva Dias.*

Land-surface "climate view"

- Model "climate" is a 24-hr mean problem
  [with a superimposed diurnal cycle]
- Seasonal cycle is sequence of daily mean
  states + "*synoptic noise*"

- Spatial scale ≈ 900 km [24h at 10 m/s]
- River basins are a useful analysis scale

Clouds are the crucial link in surface-atmosphere coupling

- **Over land**, cloud fields are a tightly coupled component; with daily impact on surface energy budget and evaporation

- *Partly linked locally to 'soil wetness' which impacts evaporation, and LCL*

Key variables: 24-h mean

Water availability – distinguishes land from ocean

- ERA-40: soil moisture index, *SMI-L1*
  [0<SMI<1 as PWP<SM<FC]

  MERRA: *Koster land surface model*

  "Wetness" = $G_{wettop} - 0.5*Fr_{wilt}$

Closely linked to

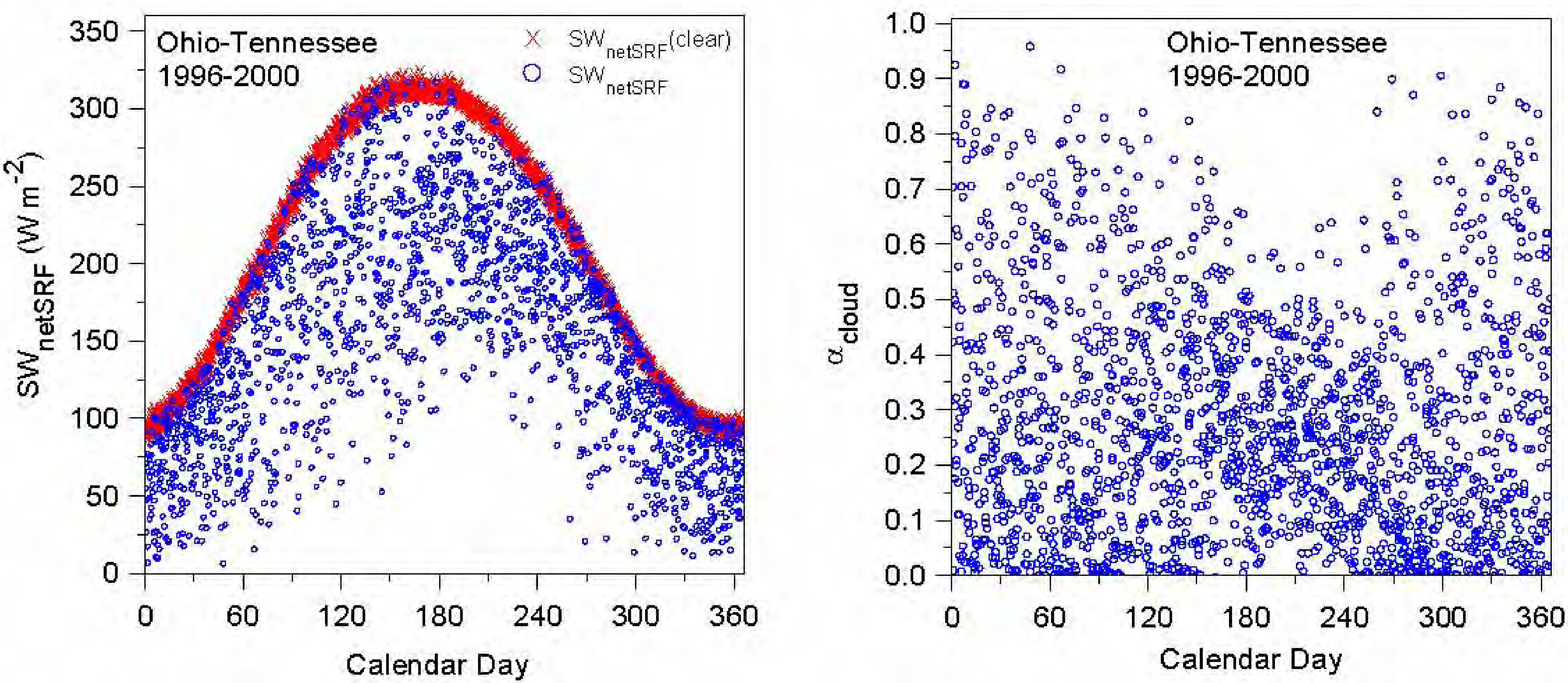
- EF : Evaporative fraction = LH/(LH+SH)
- P_{LCL}: LCL - cloudbase [in hPa]

Linked more loosely to

- α_{cloud} : 'cloud albedo' viewed from surface
  – *the surface SW cloud forcing*

Strong surface coupling though energy partition and LW and SW radiative budgets

ERA-40 Ohio-Tenn. river basin



- Cloud 'albedo': $\alpha_{cloud} = 1- SW_{netSRF}/SW_{netSRF}$ (clear)
  $= - SWCF/ SW_{netSRF}$ (clear)
- $SW_{netSRF} = (1- \alpha_{cloud})(1- \alpha_{SRF})\ SW_{dnSRF}$(clear)

Amazon basins

[40: La Plata]

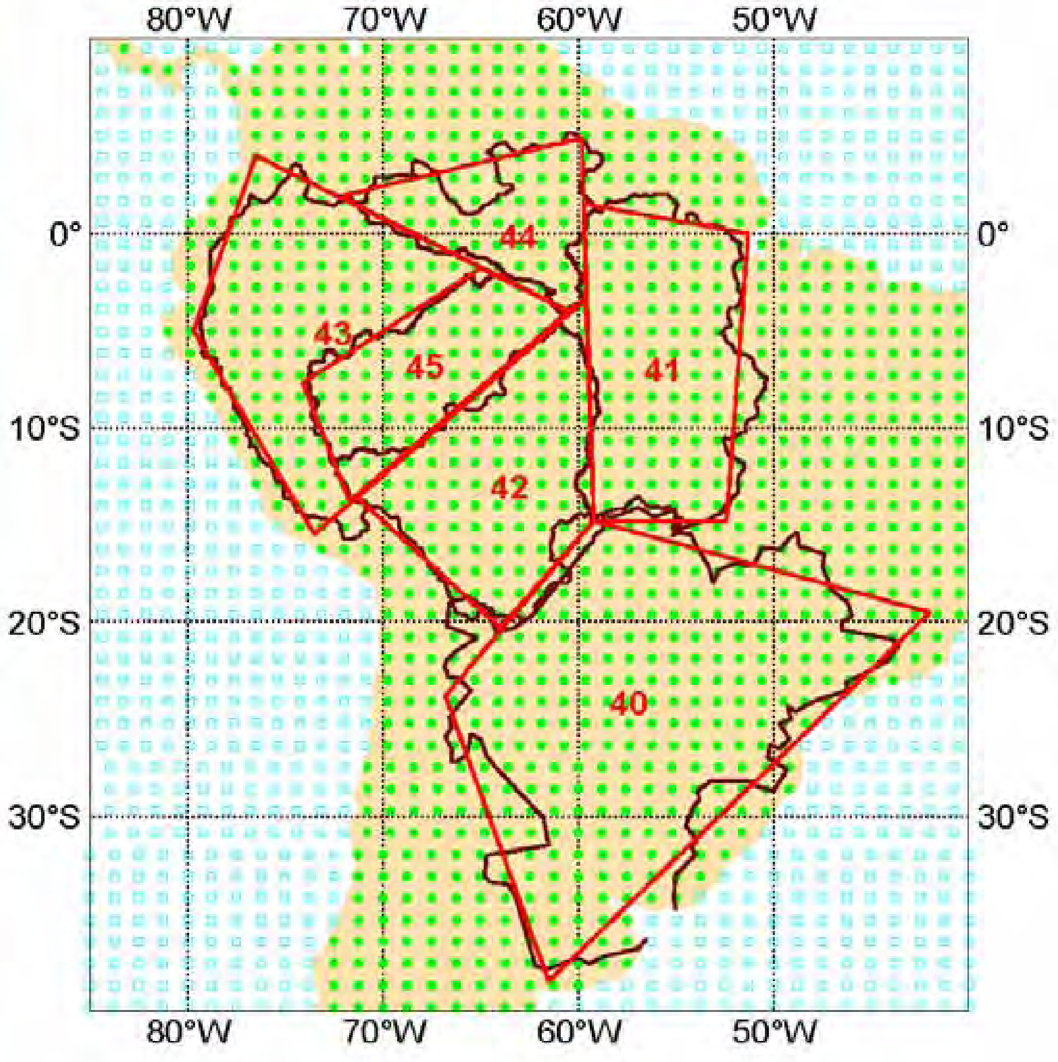
41: Tapajos-Xingu

42: Madeira

43: Amazonas

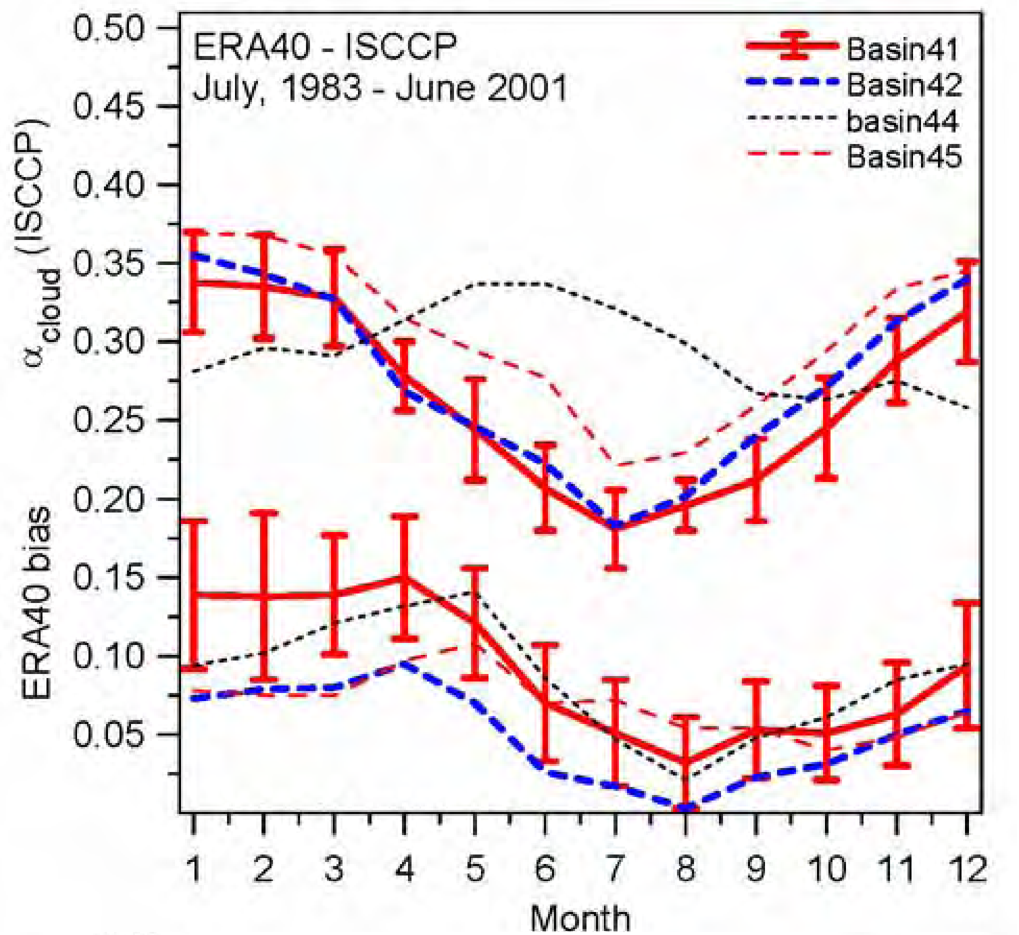
44: Negro

45: Jurua, Purus…

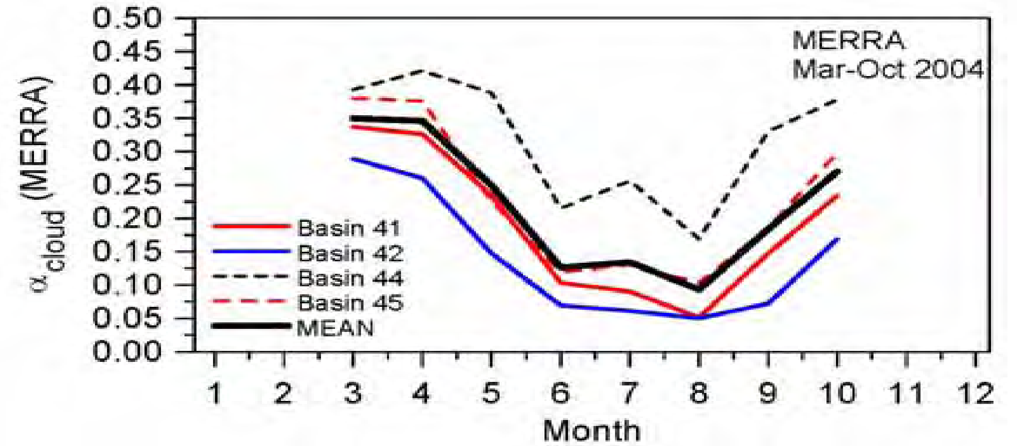


Seasonal cloud bias in ERA40 from ISCCP

- Systematic positive bias for all basins
- Largest positive bias in rainy season: +10%



- *Only 2004 from MERRA: too little cloud in dry season?*

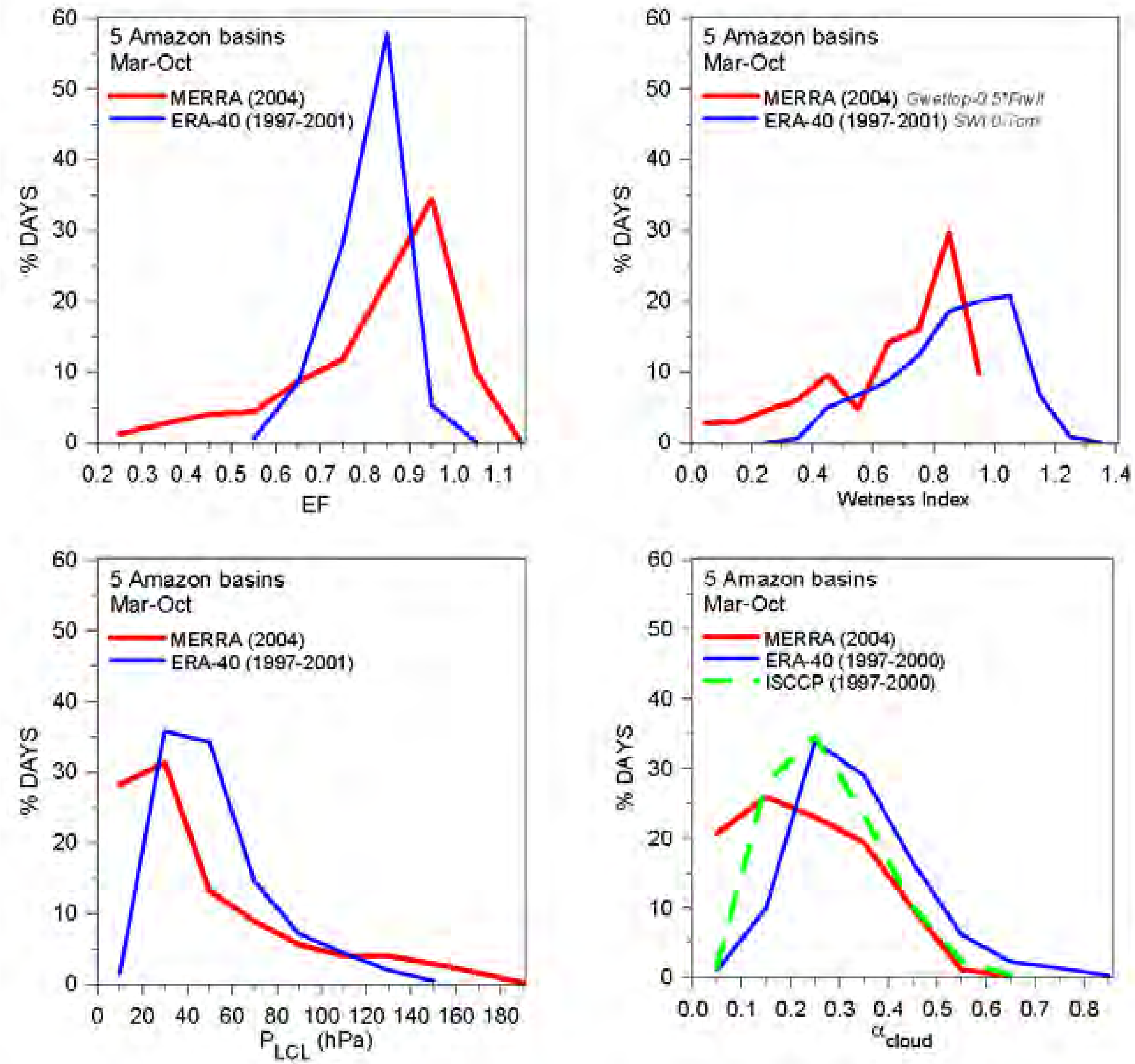


MERRA:p15 and ERA-40
5 Amazon basins

Distribution of days in MERRA and ERA-40 for

- EF, evap fraction
- ‘wetness’
- P_{LCL} : ‘cloudbase’
- α_{cloud} = -SWCF/SWdn (clear)

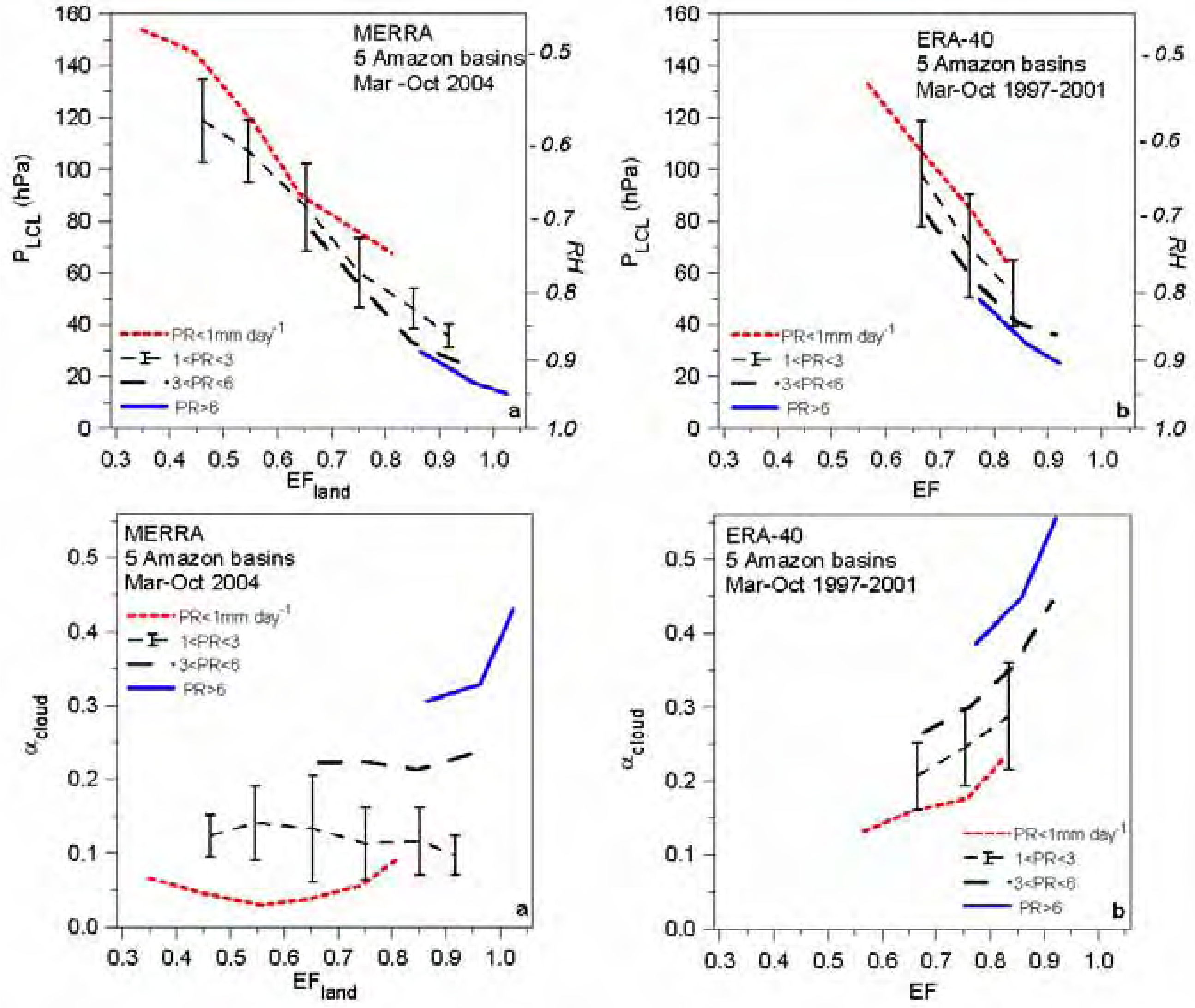
- **Fundamental differences**



MERRA:p15 and ERA-40
5 Amazon basins

Coupling of daily surface EF to

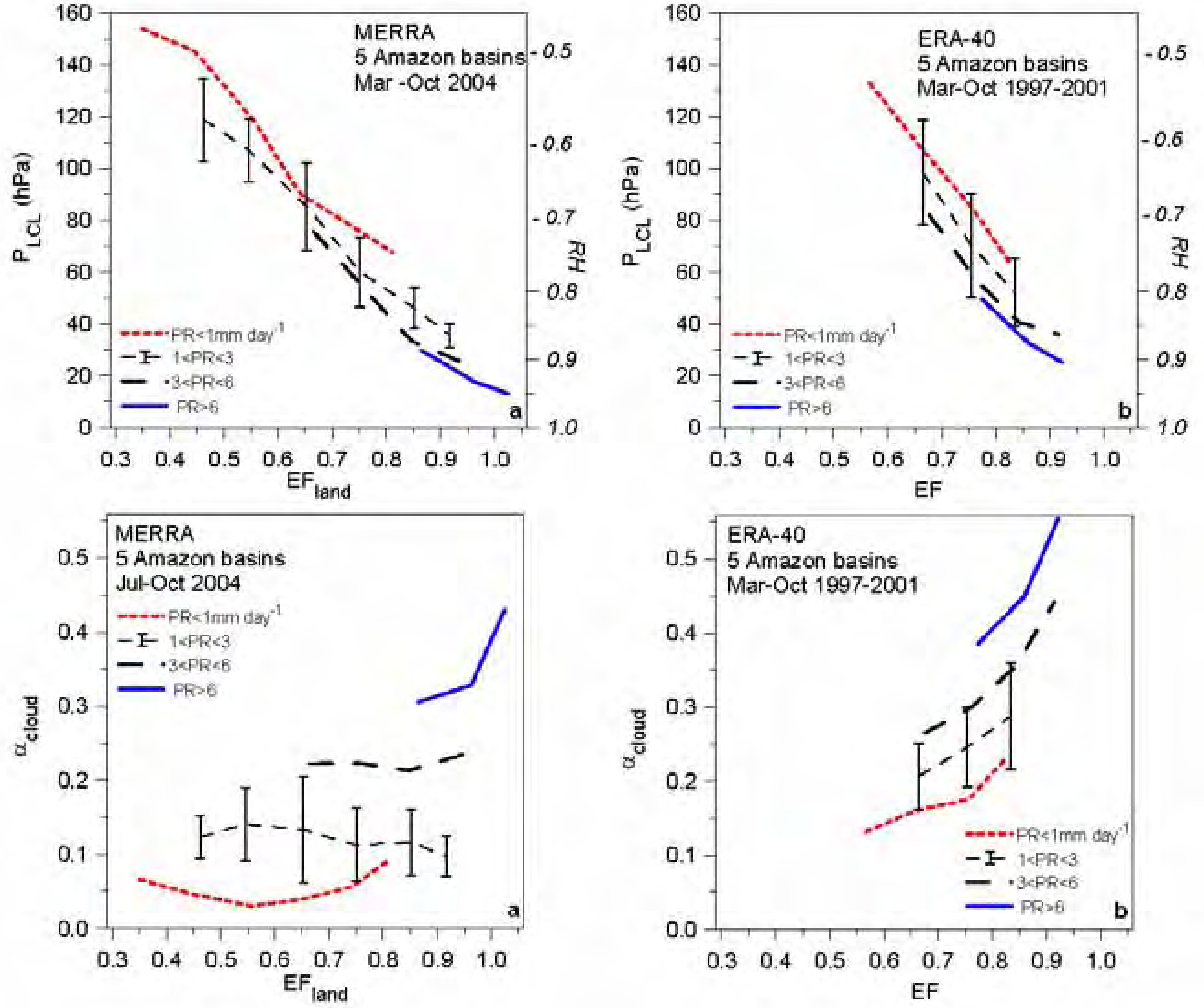
- P_{LCL} : 'cloudbase'
- α_{cloud} =
  -SWCF/SWdn (clear)
- Stratified by Precip



MERRA:p15 and ERA-40
5 Amazon basins

- **MERRA with Koster land-surface model** has a wider range of evaporative fraction over the Amazon, and strong coupling of EF to RH and P_{LCL}
- For high EF, MERRA is closer to saturation
- ***Coupling of EF to cloud fraction is quite different between ERA40 and MERRA.*** In undisturbed conditions (small daily precip), MERRA has little cloud cover, while ERA40 cloud cover increases quite steeply with EF

WHAT IS THE 'TRUTH'?



Mississippi basins

1: Arkansas-Red

2: Missouri

3: Upper Mississippi

4: Ohio-Tennessee

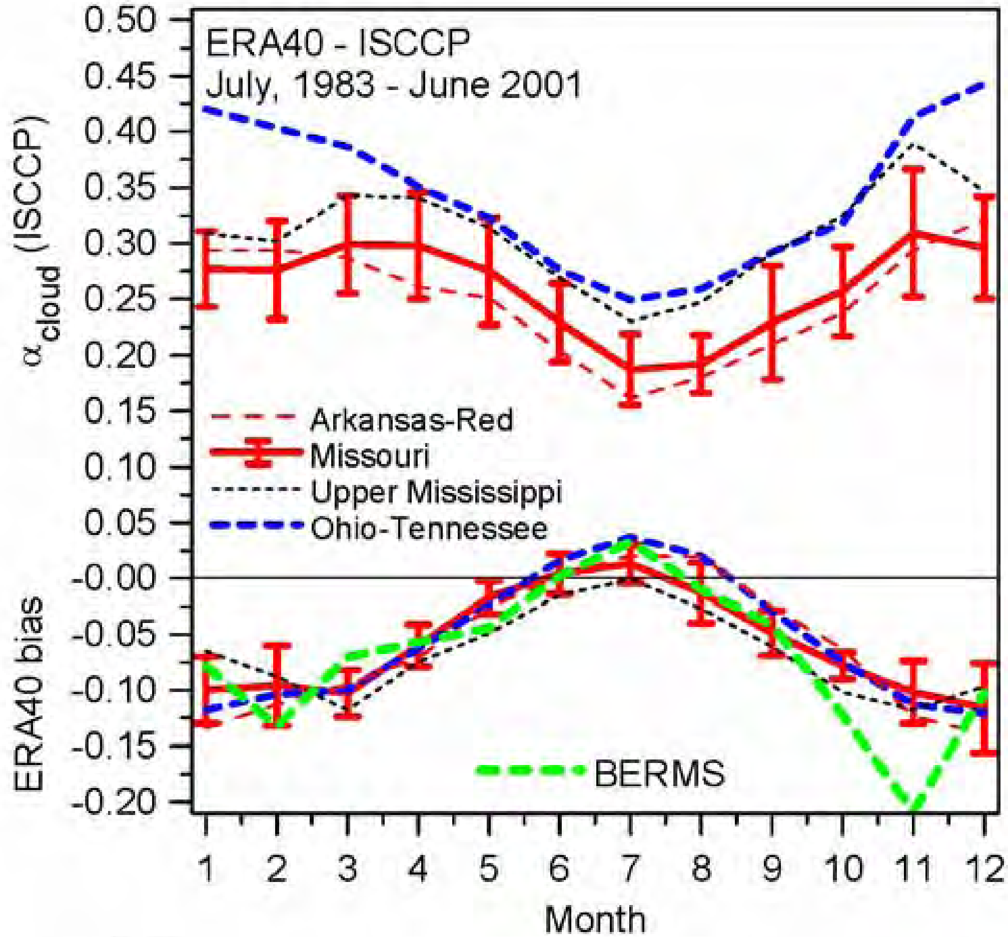
[5: Lower Mississippi]

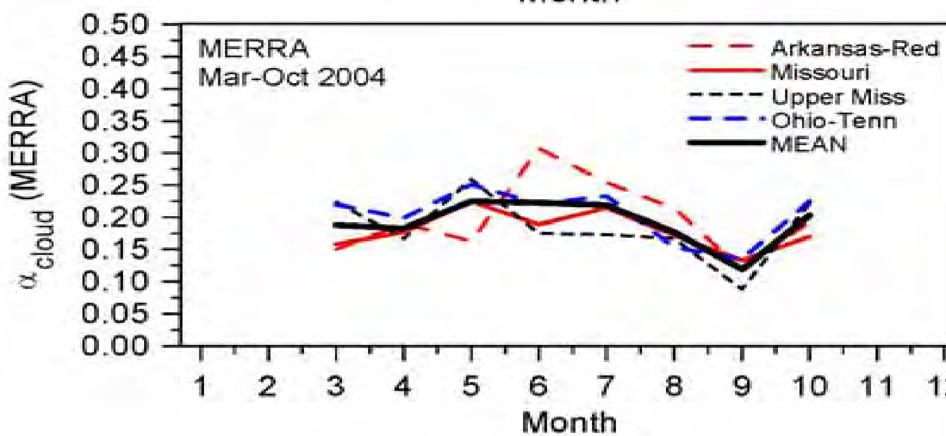
Seasonal cloud bias in ERA40 from ISCCP

- Systematic bias for all basins
- Largest negative in winter: -10%

[Betts, JGR, 2007]

- *Only 2004 from MERRA*





MERRA:p15 and ERA-40

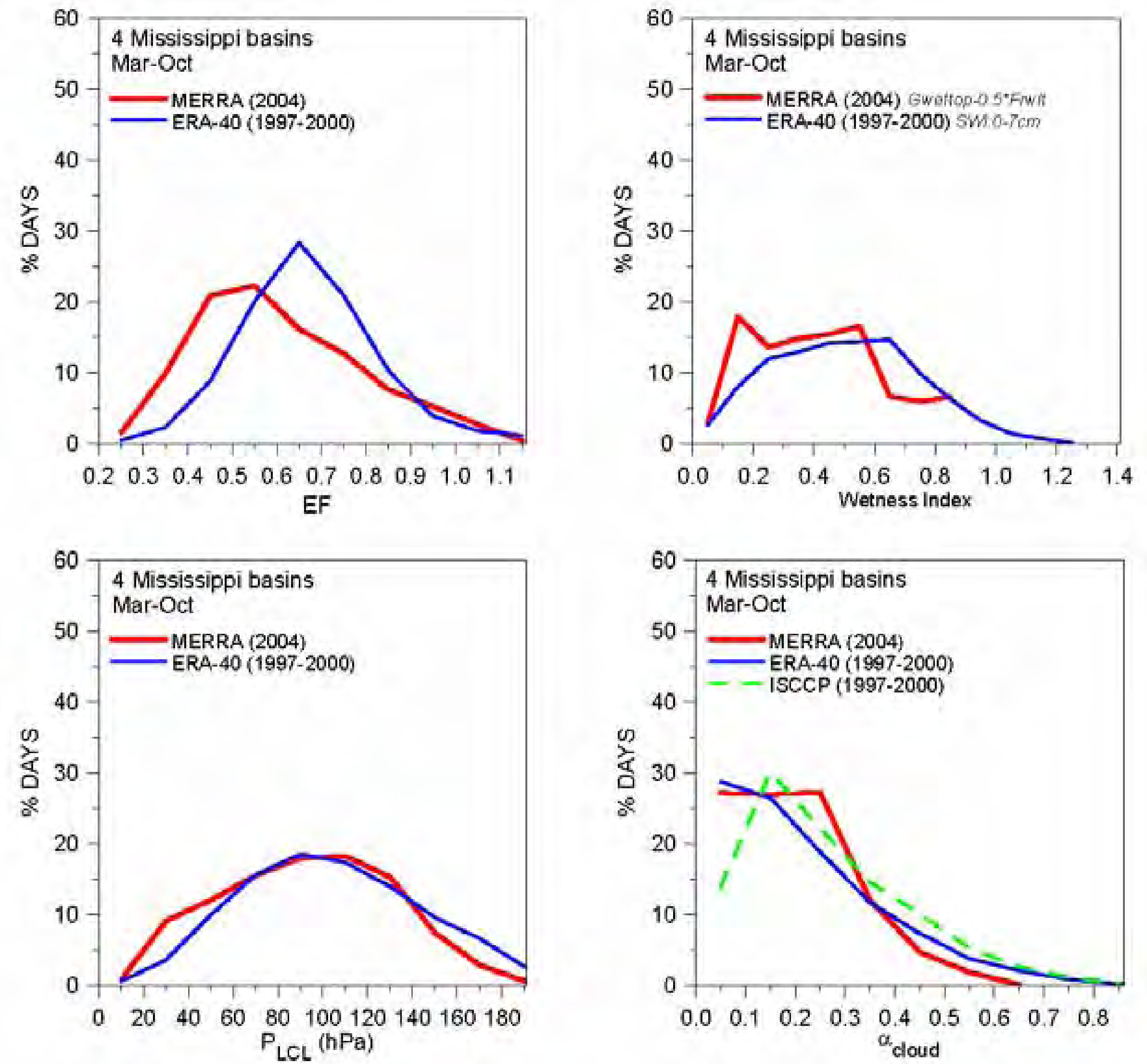
4 Mississippi basins

(Red-Arkansas, Missouri, Upper Miss. and Ohio-Tenn)

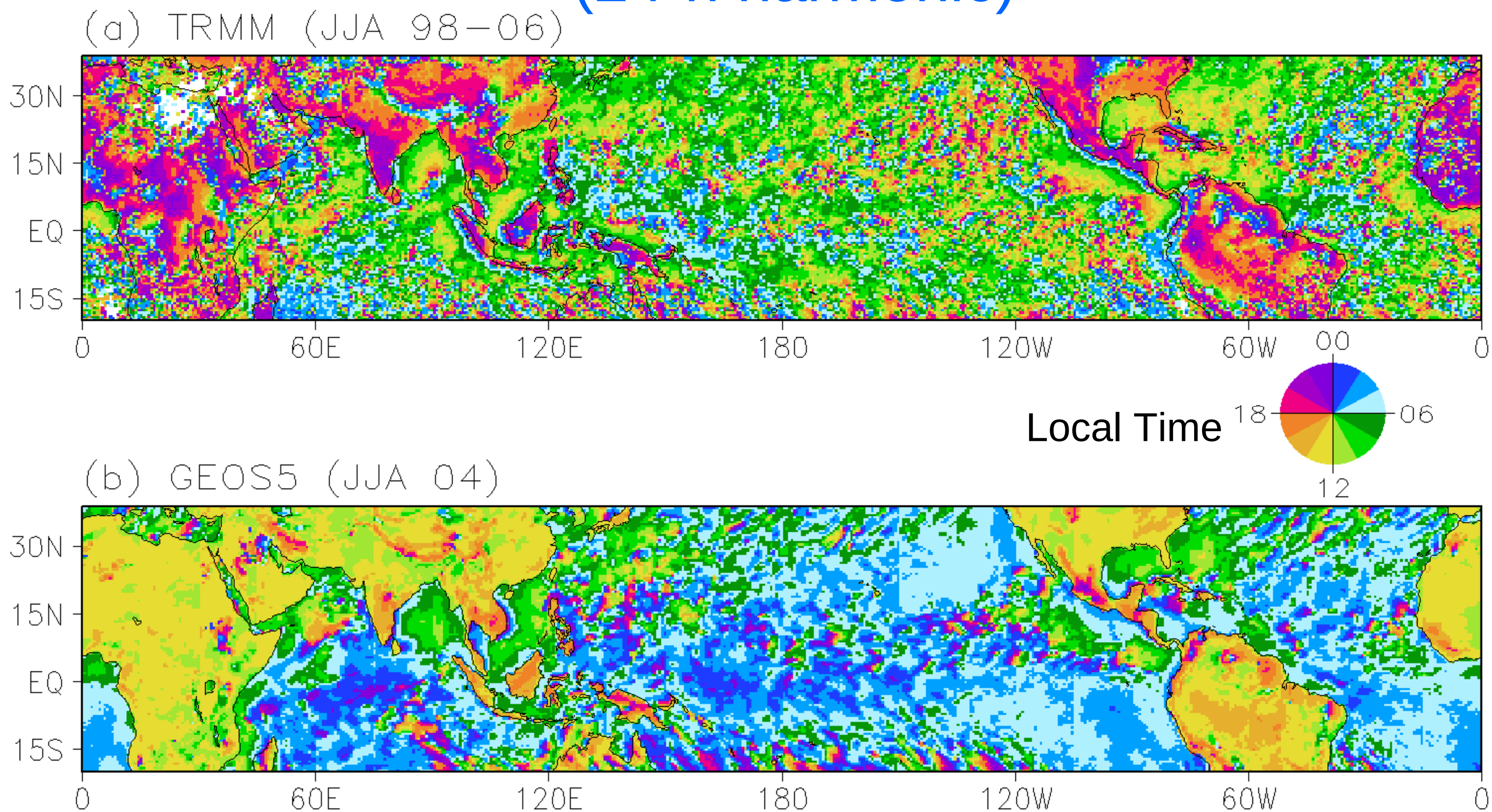
Distribution of days in MERRA and ERA-40 for

- EF, evap. fraction
- ‘wetness’
- P_{LCL} : ‘cloudbase’
- α_{cloud}

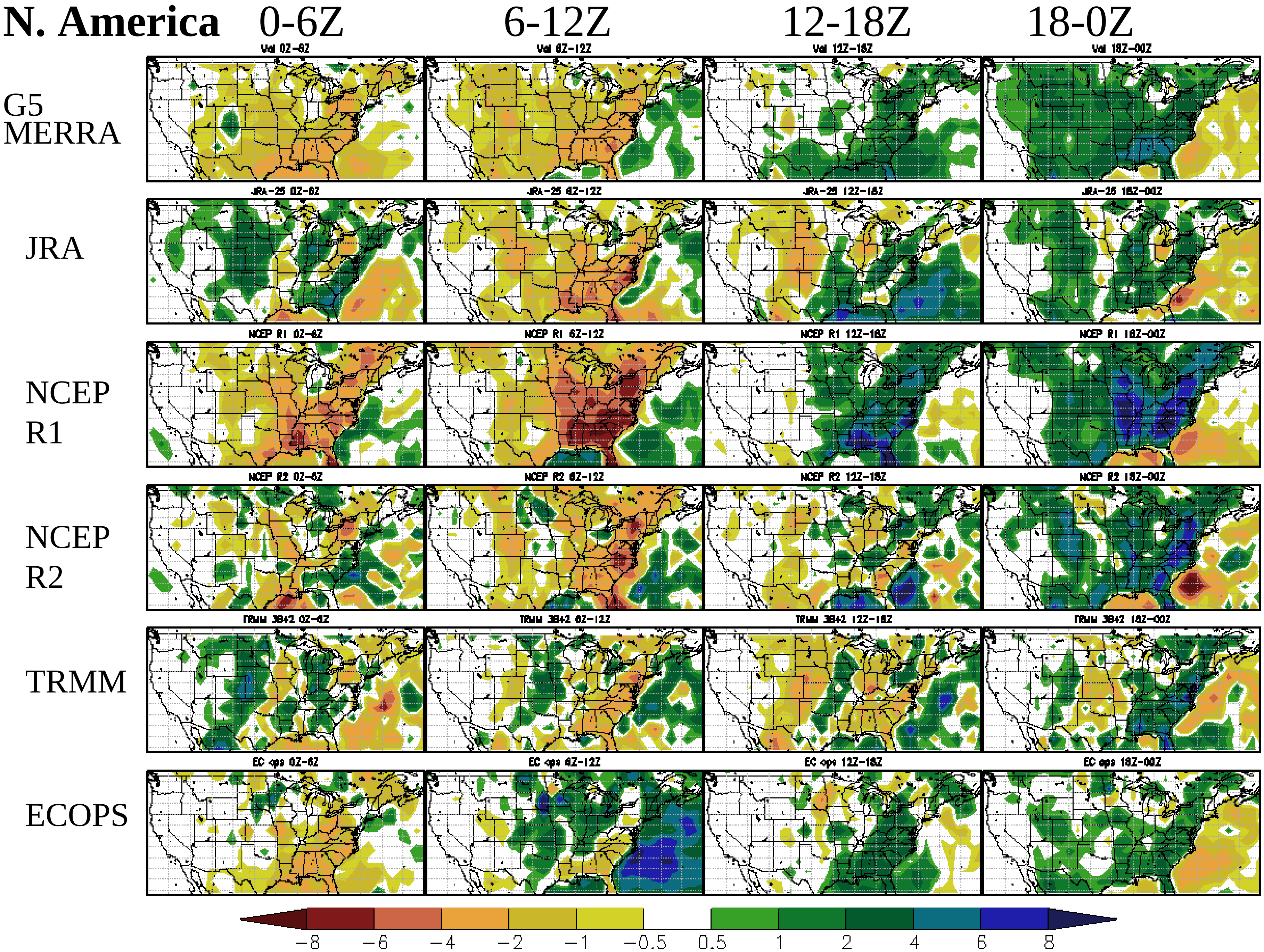
  1-SWCF/SWdn (clear)



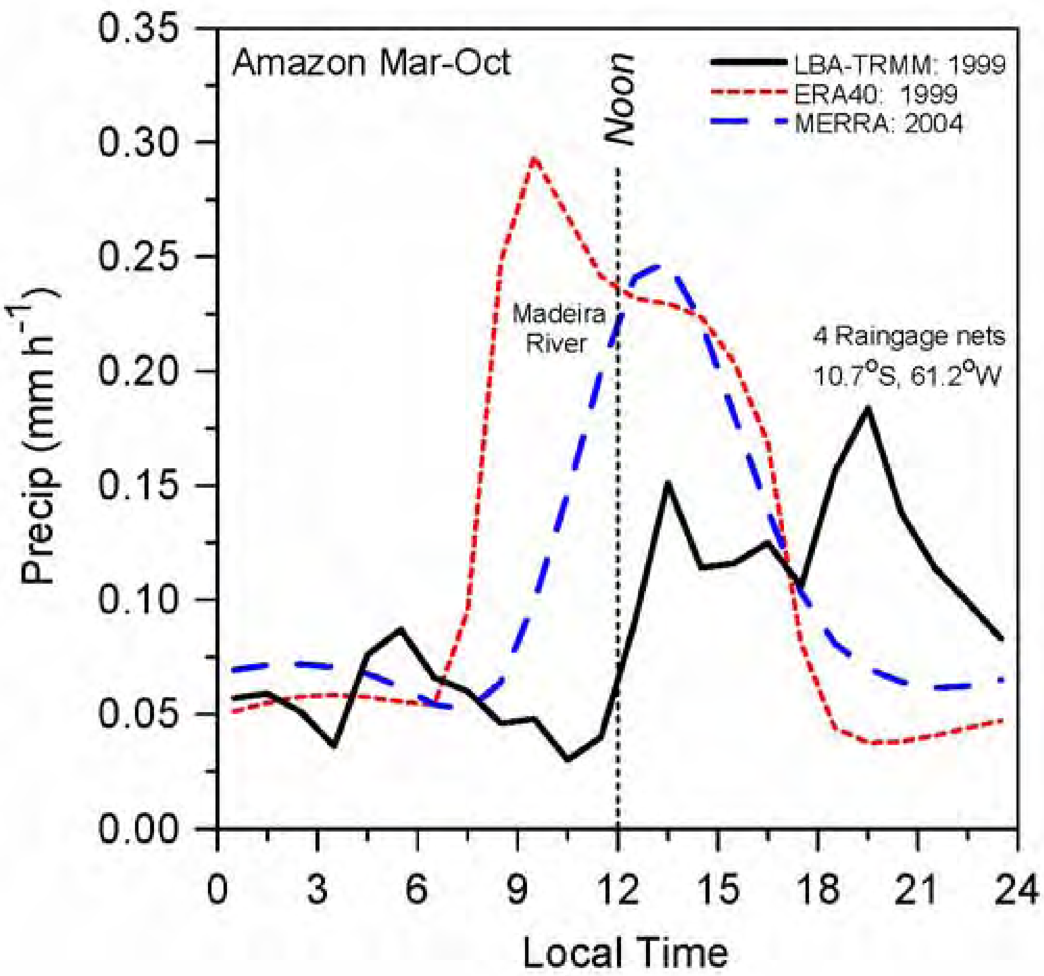
Max Phase of Precipitation Diurnal Cycle (24-h harmonic)



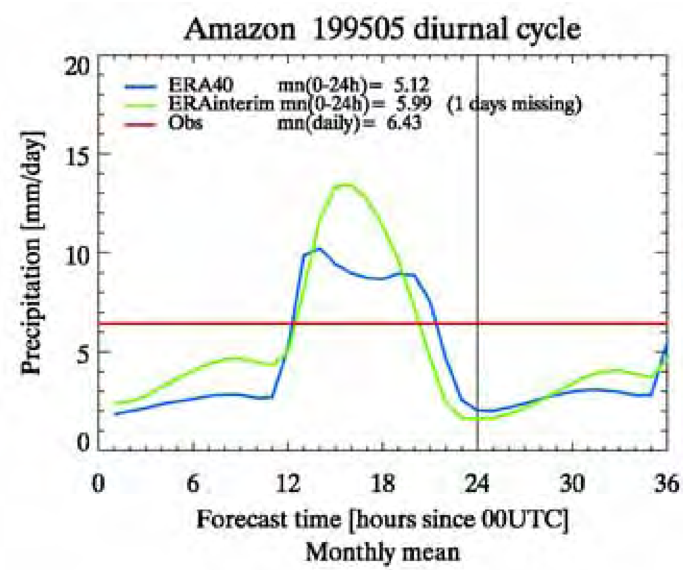
- GEOS5 simulation has noticeable phase biases over land: diurnal peaks during noon to early afternoon is quite dominant, which is several hours earlier than TRMM. Nighttime maximum is hardly reproduced.
- Oceanic diurnal cycle is also developing earlier than TRMM by a few hours, although the model shows early morning maximum over adjacent oceans consistent with TRMM


N. America
0-6Z
6-12Z
12-18Z
18-0Z
G5 MERRA
JRA
NCEP R1
NCEP R2
TRMM
ECOPS
-8 -6 -4 -2 -1 -0.5 0.5 1 2 4 6 8

Amazon diurnal cycle



ERA40 and ERA-Interim



- MERRA gets early afternoon peak but not evening peak
- ERA40 has a morning peak (in ERA-interim, noon peak)

Summary

- *Fundamental differences* between land-surface models in MERRA and ERA-40
- *Amazon*: MERRA has wider spread of EF & LCL with a lower cloud-base when wet
  - but too many cloud-free days
- *Daily*: Cloud cover increases with EF in ERA40 but not in MERRA
- *Diurnal*: MERRA precipitation peaks a little after local noon. Better than ERA40, but still poor representation of mesoscale precipitation