

Hydrologic cycles – Land

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[BettsHydrologicCycle2004.pdf](http://alanbetts.com/research/BettsHydrologicCycle2004.pdf)

Are we losing the ability to make essential improvements in model physics because we are more concerned with fine tuning existing representations?

[Easier if scientific ‘supervision’ weak and resources diffused]

Are we losing the ability (and perhaps the will) to make critical but often arduous tests of model physics against **observations**?

[Need real-world link]

Is the emphasis on quantifying model uncertainty diluting efforts to improve model physics?

[Quantify “uncertainty”, when model interactions poorly understood!!]

The following questions: [‘simulation versus understanding’]

1. *What is the status of and what are the major errors associated with the parameterization of physical processes in atmosphere-ocean-land (A-O-L) models ranging from local-daily scales to regional-decadal scales? What effects do these errors have on model output compared to other sources of error?*

Global water cycle: the primary source of error is in the Tropics.

Coupling of WV, P, E, R, cloud-field, radiation field and BL processes

.. Illustrate with Amazon

2. *How can model parameterizations be improved to represent the essential physics in A-O-L models? How can these parameterizations be tested rigorously, and what supporting infrastructure is needed to do so?*

Locally at “points”

On river-basin scales

Coupling of “observables/processes”

Where is the data?

Was it assimilated [error field]? Do we have test data independent of model?

3. *What is the appropriate balance between the efforts being directed toward improving physical parameterizations and the efforts being directed toward other model development and application activities?*

Process:

Quantify model errors on range of time and space scales

Identify links/causes in either data assimilation

or representation of physical processes

Basic research on new representations of physics

- in parallel with pragmatic improvements

Feed back to model development cycle; complete cycle in 3-4 years

Appears simple, but very few centers actually complete this cycle [eg.

ECMWF] because it requires **science-driven** [as opposed to institutional] management and adequate resources/efficient utilization of resources

‘Simulation versus understanding’ ??

False conflict:

Earth system is too complex to understand without simulation.

The real question is “how well do we *understand* our simulations?”
[which requires a scientific attitude]

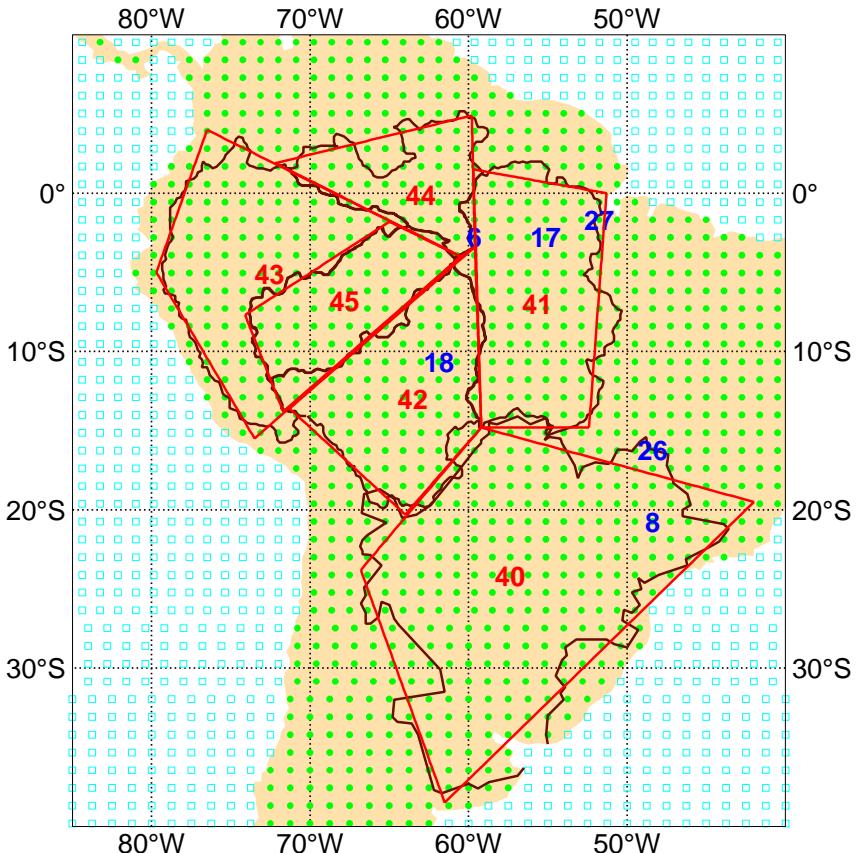
Shift emphasis to:

How do the physical processes interact?

How does the coupled system behave in terms of *observables*?

ECWWF Reanalysis ERA-40 Amazon basins

- a) Amazon-mean
- b) 42: Madeira River



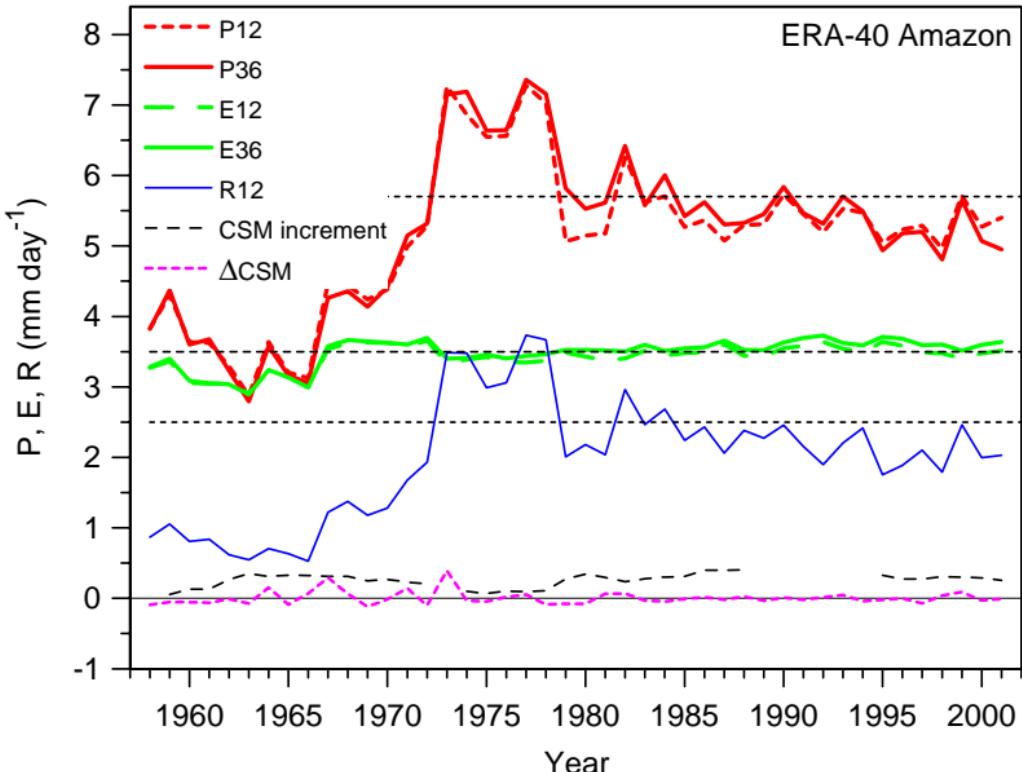
ERA40 Annual means 1957-2001

P: precipitation

E: evaporation

R: runoff

CSM: Column soil water

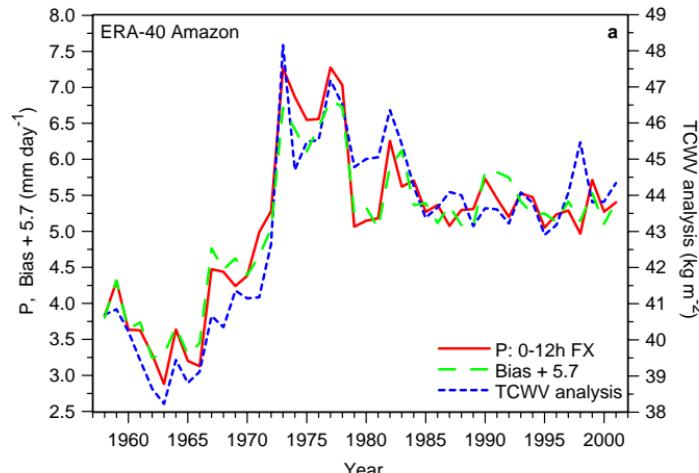


Annual means

TCWV: Total column water vapor

P: precipitation

P-bias from observations

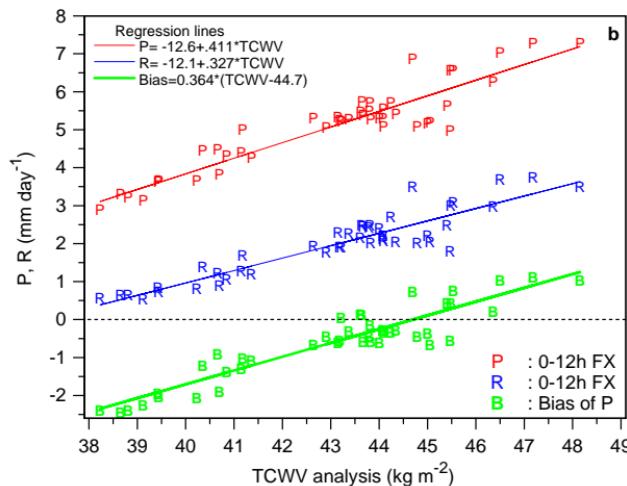


Regression on TCWV

P: precipitation

R: runoff

P-bias



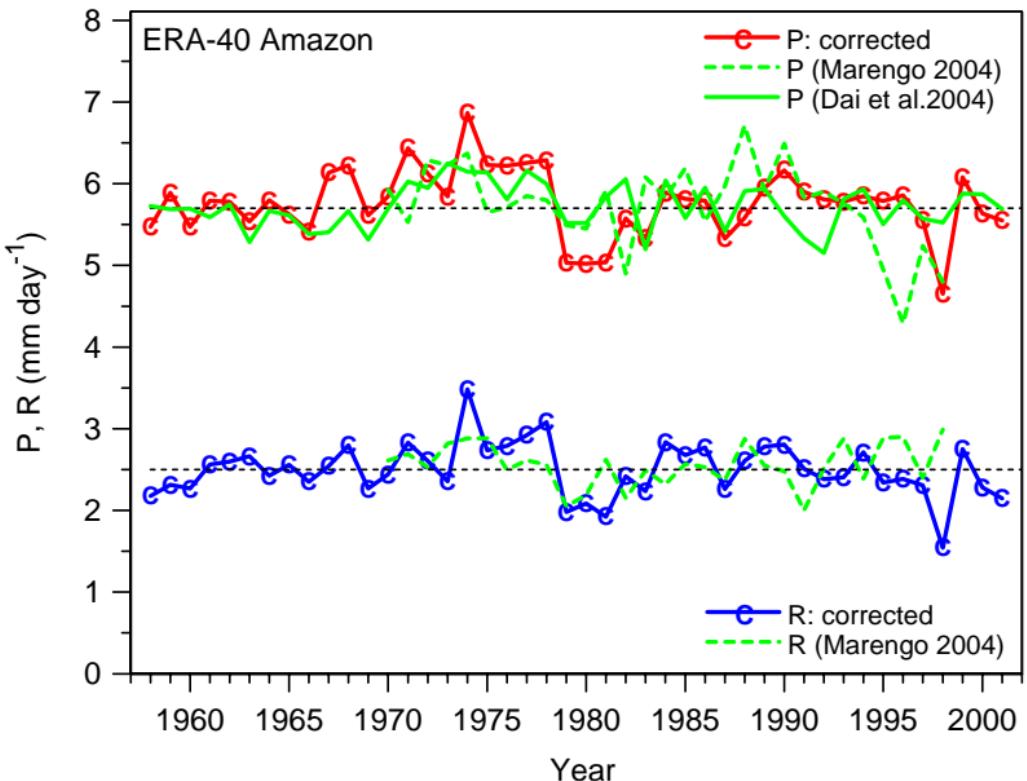
ERA40

Annual means corrected

Mean is $\pm 10\%$, but

Little signal in
interannual variability

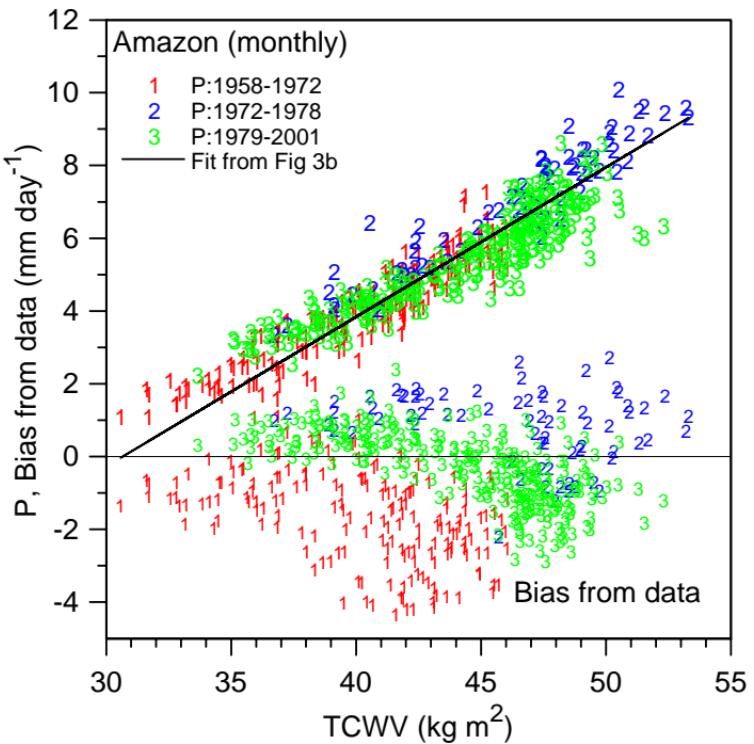
Data for P uncertain

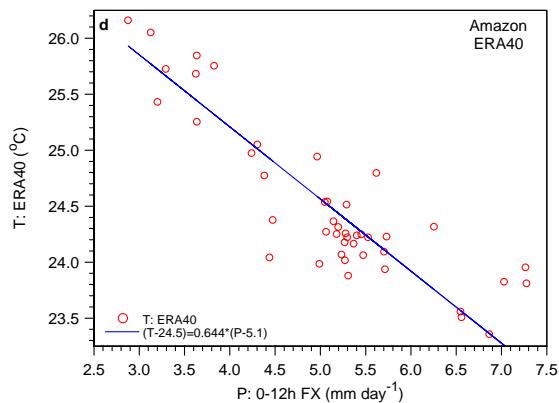
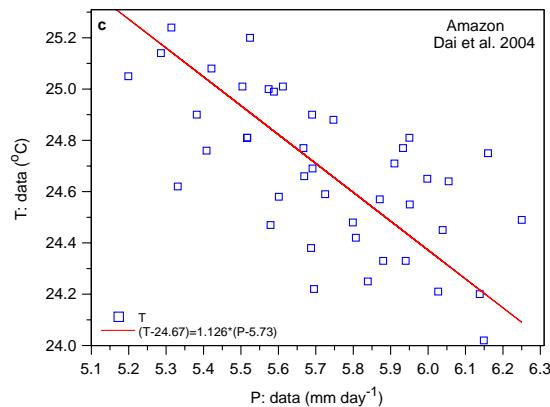
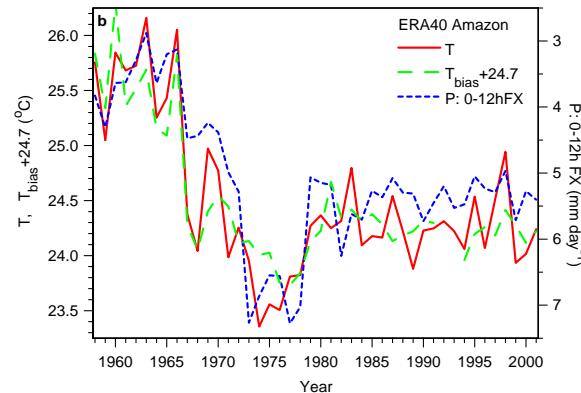
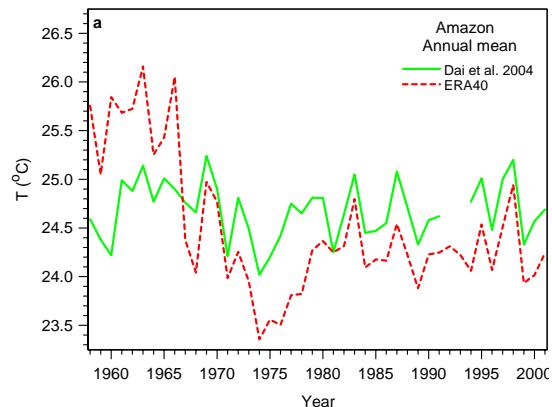


Monthly precipitation and P-bias from observations against TCWV

P against TCWV:
[similar to annual]

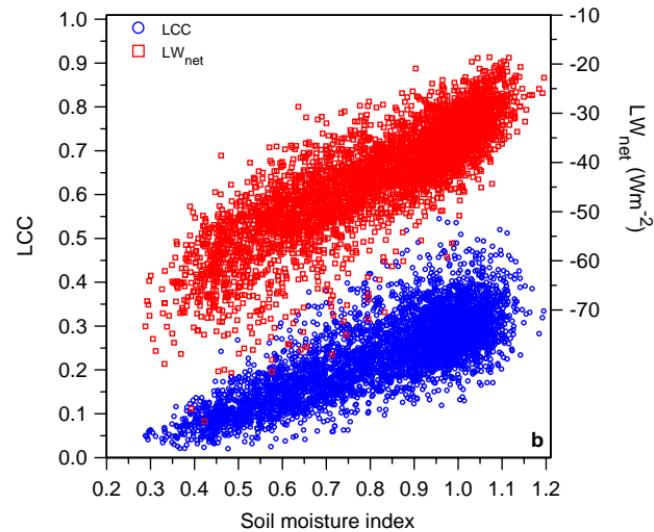
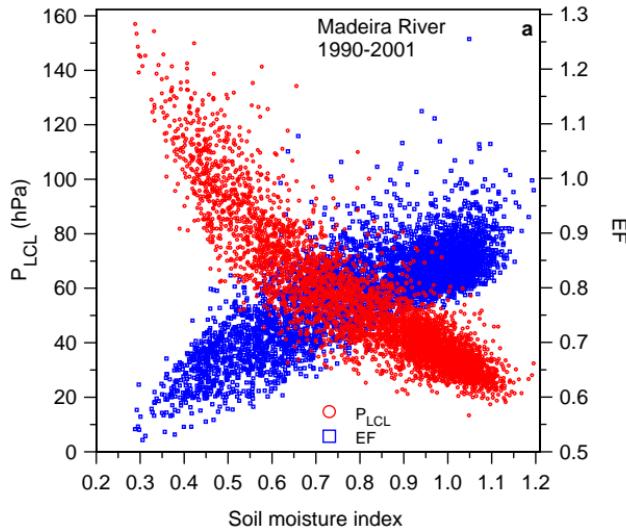
Bias against data
ERA40 is
wet in dry season
dry in wet season
[if P-data is correct]





T control by precipitation

Surface-coupled physics



Daily Means (Madeira River)

Soil moisture index against

P_{LCL} : LCL of cloud-base

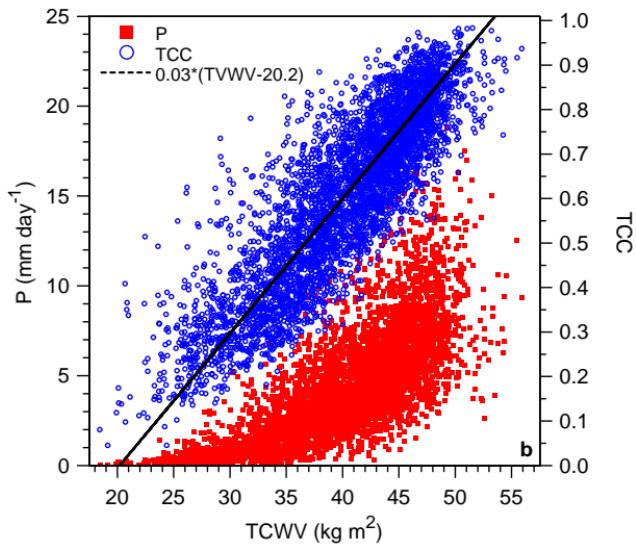
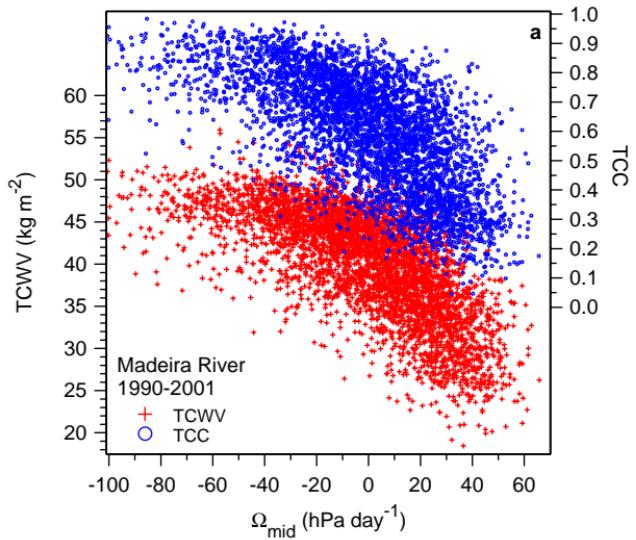
EF: Evaporative fraction

Soil moisture index against

LCC: Low cloud cover

LW_{net} : surface net longwave

Tropospheric-coupled physics

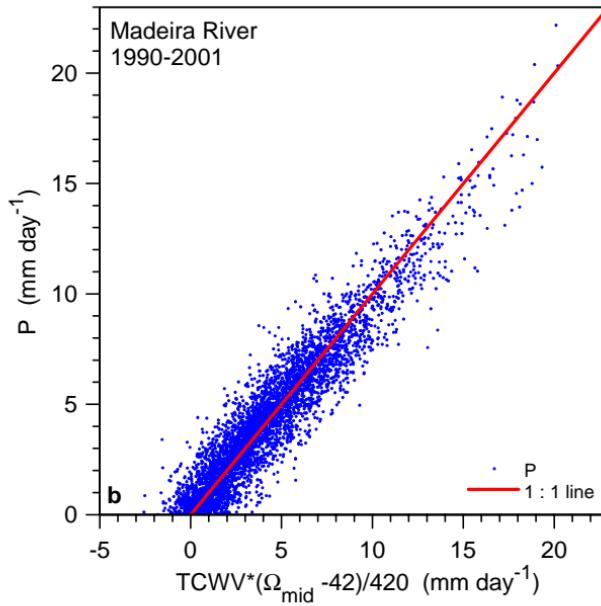
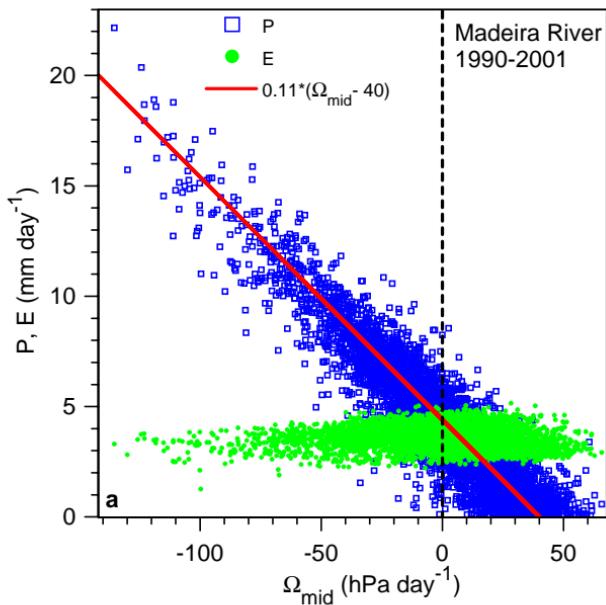


Daily means

Ω_{mid} : mid-tropospheric omega
against TCWV and TCC

TCWV against
Precipitation and TCC
[Linear regression]

Coupling of ascent with precipitation



Daily means

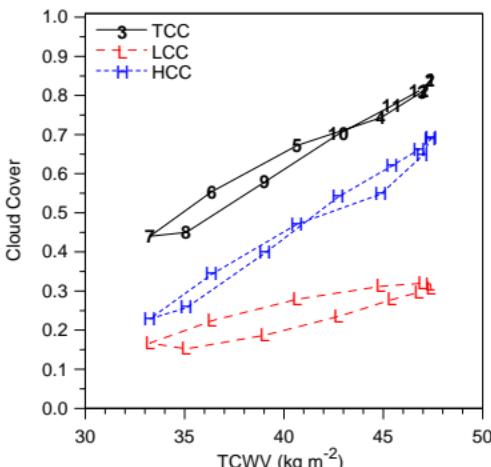
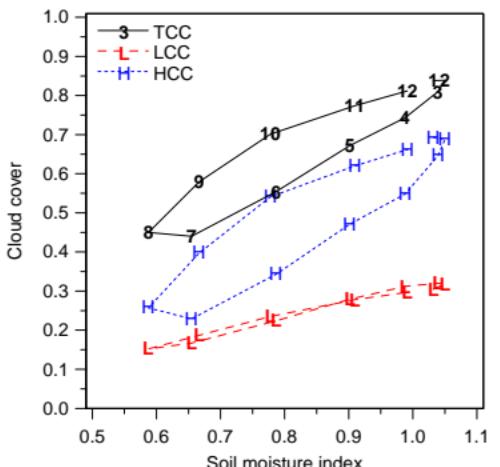
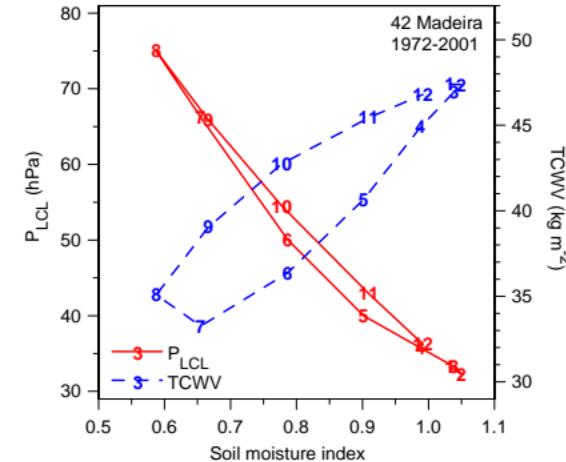
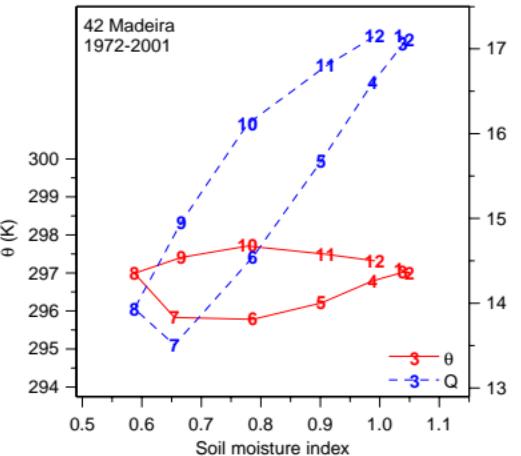
P and E against

Ω_{mid} : mid-tropospheric omega

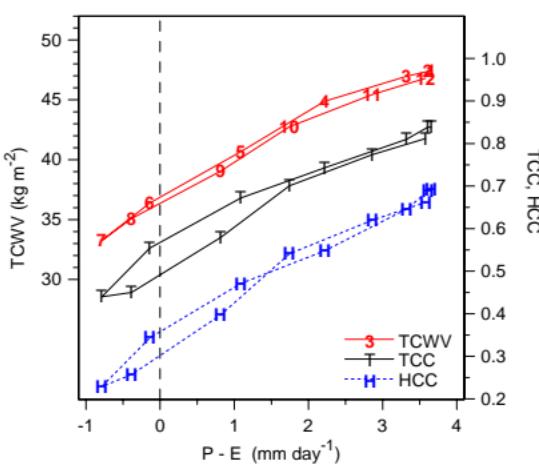
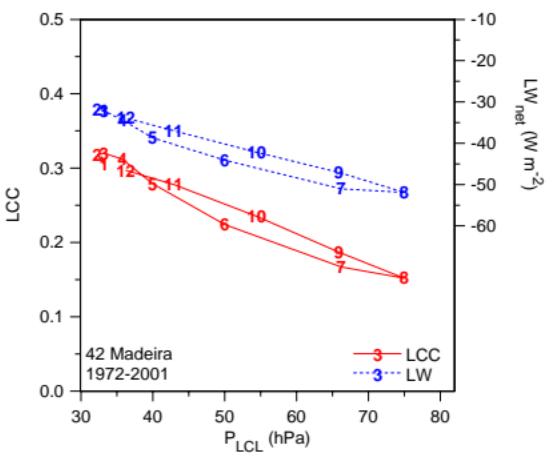
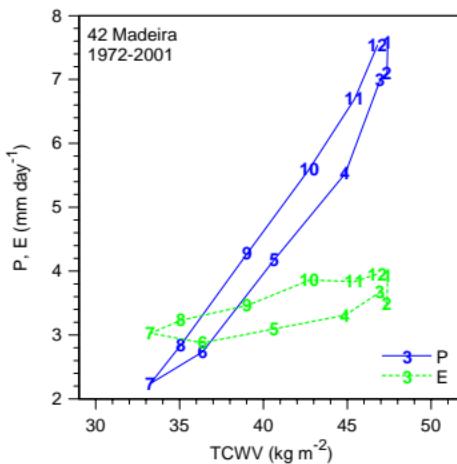
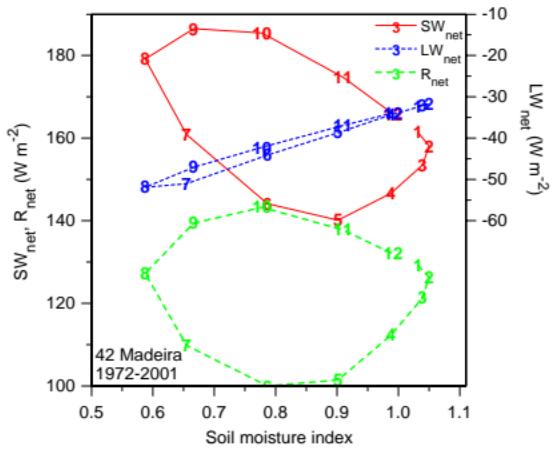
Note $P=0$ at $\Omega_{mid} \sim 40 \text{ hPa/day}$

“Moist circulation”
and precipitation

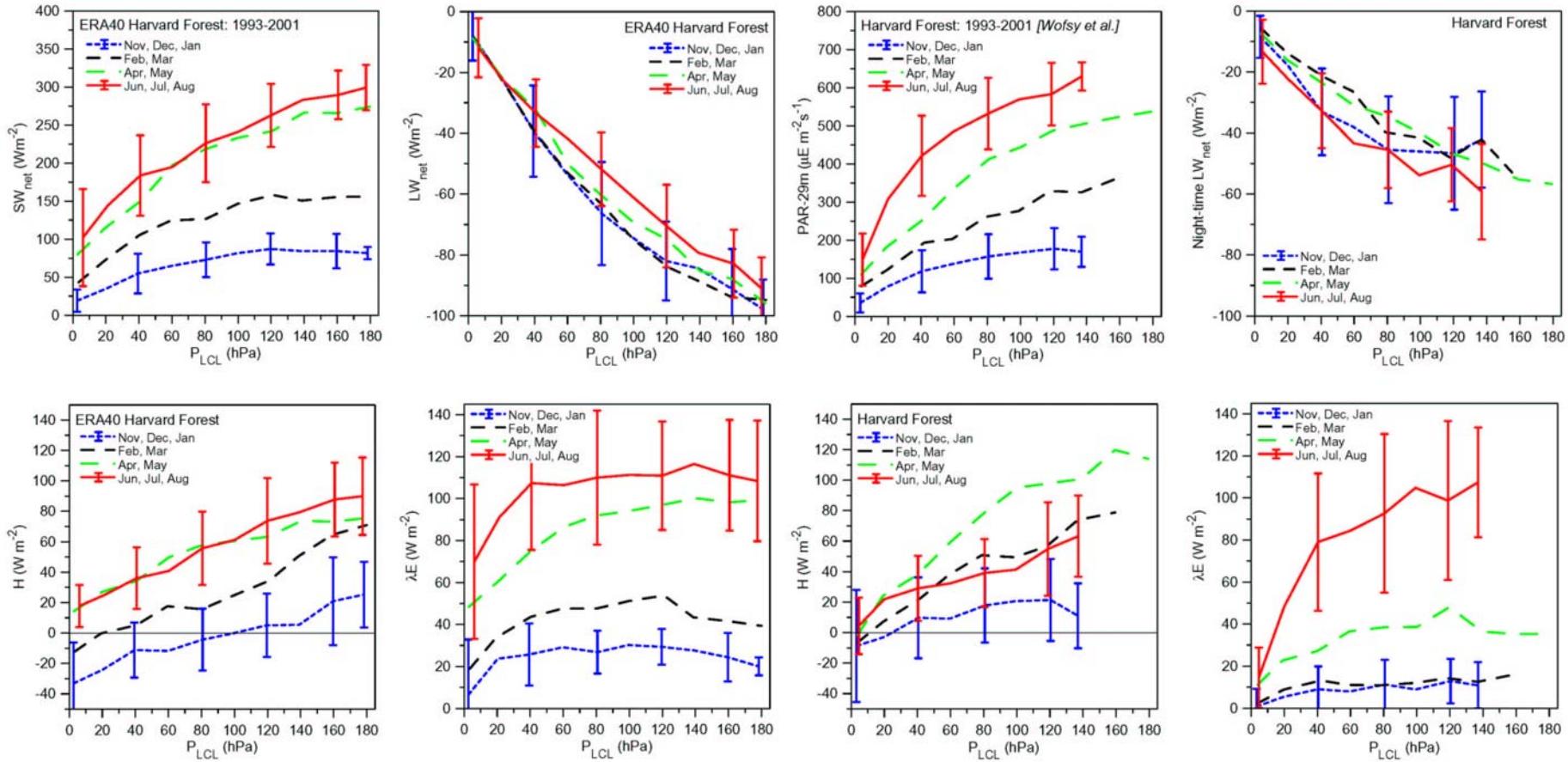
Annual cycle-1 Madeira River



Annual cycle-2



Comparisons with data



ERA-40 ‘point’

Harvard forest tower

SW-cloud coupling to P_{LCL}

- Total cloud cover: ERA40
- Transmitted fraction SW
- Transmitted fraction PAR
- compare LW coupling

