Land-surface, boundary layer and cloud-field coupling over the Amazon in ERA-40.

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Using ERA-40 to understand coupling of processes

- Land-surface processes
- BL processes
- SW and LW fluxes: coupling to clouds
- Coupling to precipitation and dynamics

- *Evaluate models; compare with data*
- *Betts (BAMS, 2004, Nov)*
Madeira River basin : 42

- Hourly archive: basin mean
- Generate daily means

[Hydrometeorology of the Amazon in ERA-40, Betts et al. 2005]
Cloud forcing; Cloud albedos

- \( \text{SWCF:TOA} = \text{SW:TOA} - \text{SW:TOA(clear)} \)
- \( \text{LWCF:TOA} = \text{LW:TOA} - \text{LW:TOA(clear)} \)
- \( \text{SWCF:SRF} = \text{SW:SRF} - \text{SW:SRF(clear)} \)
- \( \text{LWCF:SRF} = \text{LW:SRF} - \text{LW:SRF(clear)} \)

Atmosphere cloud radiative forcing are the differences
- \( \text{SWCF:ATM} = \text{SWCF:TOA} - \text{SW:SRF} \)
- \( \text{LWCF:ATM} = \text{LWCF:TOA} - \text{LW:SRF} \)

Define TOA and SRF cloud albedos

\( \text{ALB:TOA} = 1 - \frac{\text{SW:TOA}}{\text{SW:TOA(clear)}} \)
\( \text{ALB:SRF} = 1 - \frac{\text{SW:SRF}}{\text{SW:SRF(clear)}} \)
Soil moisture indices

• $0 < \text{SMI} < 1$ as $\text{PWP} < \text{SM} < \text{FC}$

• $\text{SMI:}L1$ -- 0-7cm
• $\text{SMI:}\text{root}$ -- 0-100cm [L123]
Seasonal Cycle and SMI -1

- $T$ and $Q$
- $LCL$ and $\theta_E$
Seasonal Cycle and SMI -2

- TCC, HCC, LCC
- $SW_{net}$, $LW_{net}$, $R_{net}$
Seasonal Cycle and TCWV

Note TCC, ALB and TCWV - ratio of ALBs

Seasonal cycle of P-E - zero in May/Sept
Seasonal Cycle - 4

- Scaled SEB
- $R_{\text{net}}$ falls, E flat

Convergence $\rightarrow$ TCWV, cloud
Coupling of soil moisture to $P_{LCL}$, LCC, $LW_{net}$

- Cloud-base, LCC and $LW_{net}$ tightly linked to soil moisture
Omega, TCWV, and albedo

TCWV, albedo and P

- TCWV, ALB driven by omega
- P, ALB linked to TCWV
Omega, P, E and TCWV

- Linear relationship P with omega
SW and LW cloud forcing

- Tight relation of TOA and SRF SWCF
- TOA and ATM LWCF - linked
Albedo, SW and LW coupling

SW very tight

- \( \text{ALB}: \text{SRF} = 1.45 \times \text{ALB}: \text{TOA} + 0.35 \times (\text{ALB}: \text{TOA})^2 \)
Scaled fluxes, P and omega binned by albedo

- Flat $\lambda E$, unlike $H$, $LW_{\text{net}}$
- EF increases with SMI

- ALB is fair measure of omega and $P$
Scaled fluxes, $P$ and omega binned by Soil moisture

- $\lambda E$ weak max.
- linear $H$ and $LW_{\text{net}}$

- $P$ has $\theta_E$ dependence as well as SMI
SMI to cloud-base

- LCL falls with SMI
- Precipitation into the sub-cloud layer lowers LCL
Binned by $P_{LCL}$

- $LW_{net}$ and ALB

$P$, EF, SMI, ALBs
- all decrease with LCL
SW and LW feedback of EF

- Greater EF
- reduces outgoing LW
- increases surface cloud albedo
Conclusions-1

- Models are powerful tool for understanding coupling of processes
- At the land surface, soil moisture, evaporation, precipitation, surface energy budget, LCL and cloud field are tightly coupled
- Omega field, precipitation, TCWV and cloud field are tightly coupled
- Daily mean data sufficient to describe the states and the transition between them
Conclusions-2

• Soil moisture directly impacts $P_{\text{LCL}}$, LCC, $LW_{\text{net}}$
• Surface $LW_{\text{net}}$ is tightly controlled by BL depth and cloud albedo (3 W/m$^2$)

• Omega field linked to TCC, ALB, P
• The TOA SW ‘cloud albedo’ is sufficient to determine surface (<0.5%) and atmospheric cloud forcing on basin scales
Conclusion-3

• How good is the coupling between processes in ERA-40, knowing that the diurnal cycle of precipitation is poor over land in the tropics? *Check Cy 28R1*

• Can we evaluate any of these relationships directly from satellite data or at surface flux sites?

• Can we use these relationships in our data assimilation methodology?