### Assessing the land-surface, boundary layer and cloud-field coupling in ERA-40

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# **Background references**

- Betts, A. K., 2004: Understanding Hydrometeorology using global models. *Bull. Amer. Meteorol. Soc.*, **85**, 1673-1688.
- Betts, A. K and P. Viterbo, 2005: Land-surface, boundary layer and cloud-field coupling over the south-we stern Amazon in ERA-40. *J. Geophys. Res.,* 110, D14108, doi:10.1029/2004JD005702.
- Betts, A.K., J.H. Ball, A.G. Barr, T.A. Black, J.H. McCaughey and P. Viterbo, 2006: Analysis of ERA-40 biases and surface-BL-cloud coupling using BERMS data. *Agric. For. Meteorol.* (submitted)
- Preprints: ftp://members.aol.com/akbetts

# Land-surface coupling

Models differ widely [Koster et al., Science, 2004]



SMI : soil moisture index [0<SMI<1 as PWP<SM<FC]  $\alpha_{cloud}$ : 'cloud albedo' viewed from surface

#### **ERA40:** soil moisture $\rightarrow$ LCL and EF



- River basin daily means
- Binned by soil moisture and R<sub>net</sub>

# ERA40: Surface 'control'



• Madeira river, SW Amazon

Soil water → LCL, LCC and LW<sub>net</sub>

# ERA-40 dynamic link (mid-level omega)



•  $\Omega_{mid} \rightarrow Cloud$  albedo, TCWV and Precipitation

# Compare ERA-40 with 3 BERMS sites

#### Focus:

- Coupling of clouds to surface fluxes
- Define a 'cloud albedo' that reduces the shortwave (SW) flux reaching surface
  - Basic 'climate parameter', coupled to surface evaporation [locally/distant]

# **Compare ERA-40 with BERMS**

- ECMWF reanalysis
- ERA-40 hourly time-series from single grid-box
- BERMS 30-min time-series from Old Aspen (OA)
   Old Black Spruce (OBS)
   Old Jack Pine (OJP)
- Daily Average



#### **Global model improvements [ERA-40]**



- Reanalysis T bias is now small in all seasons [ERA-40 land-surface model developed from BOREAS]
- BERMS inter-site variability of daily mean T is small

#### Comparison of BERMS and ERA-40



OBS to: OJP

OA

#### **ERA-40**

#### **Seasonal Evaporative Fraction**

- Data as expected
  OA>OBS>OJP
- ERA-40 too high in spring and fall
   [Lacks vegetation seasonal cycle]
- ERA a little high in summer?



## Comparison of BERMS and ERA-40



OBS to: OJP

OA

#### **ERA-40**

### **BERMS: Old Black Spruce**



• Cloud 'albedo':  $\alpha_{cloud} = 1 - SW_{down}/SW_{clear}$ 

### Cloud albedo comparison (daily)



OBS to:	OJP	ΟΑ	<b>ERA-40</b>
Correlation:	Good	Fair	Poor
Spacing:	<b>29km</b>	81km	[grid-point]

### **Cloud albedo and LW comparison**



[except summer]

#### How do fluxes depend on cloud cover?



- Quasi-linear variation
- Evaporation varies less than other fluxes

 $LW_{net}$  on RH and  $\alpha_{cloud}$ 



- Outgoing LW<sub>net</sub> falls as RH and cloud cover increase
- Higher RH means lower LCL & depth of ML
- LW coupling same for BERMS and ERA-40

# **Conclusions -1**

- Flux tower data have played a key role in improving representation of physical processes in forecast models
- Mean biases have been greatly reduced, but errors in cloud fields are visible
- Models can help us understand the coupling of physical processes

# **Conclusions - 2**

 Are observables coupled correctly in a model? Accuracy of model 'daily climate'

- Key non-local observables:
  - BL quantities: RH, LCL
  - Clouds: reduce SW reaching surface,  $\alpha_{cloud}$

# **Conclusions - 3**

 Cloud albedo is as important as surface albedo [with higher variability]

Clouds, BL and surface are a coupled system

• H depends more on  $\alpha_{cloud}$  than does  $\lambda E$ 

# **Background references**

- Betts, A. K and P. Viterbo, 2005: Land-surface, boundary layer and cloud-field coupling over the south-we stern Amazon in ERA-40. *J. Geophys. Res., 110*, D14108, doi:10.1029/2004JD005702.
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# Daily mean fluxes give model 'equilibrium climate' state

 Map model climate state and links between processes using daily means

 Think of seasonal cycle as transition between daily mean states

+ synoptic noise

Climate and weather forecast models

How well are physical processes represented?

• SMI  $\rightarrow$  Evaporation  $\rightarrow$  clouds  $\rightarrow$  SW<sub>net</sub>, LW<sub>net</sub>

 FLUXNET data can assess both biases and poor representation of some physical processes and their coupling

# Compare ERA-40 with 3 BERMS sites

- Focus: coupling of clouds to surface fluxes
- Define a 'cloud albedo' that reduces the shortwave (SW) flux reaching surface
- Basic 'climate parameter', coupled to surface evaporation [locally/distant]

 $P_{LCL} \rightarrow \alpha_{cloud} and LW_{net}$ 

