Land Surface-Monsoon Interactions

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Outline:

1.Land-monsoon interaction

2.Suggestions for future land-monsoon interaction research

3.Does land matter in weather and climate?

2. Current land modeling status

4. Land versus ocean interactions with atmosphere h

1. Land-monsoon interactions (quantifications are still model/data dependent)

•As part of general land-atmosphere interactions (e.g., GLACE, GSWP, Zeng et al. 2010)

•Winter/spring land state (e.g., snow cover and depth) on subsequent summer monsoon (numerous studies)

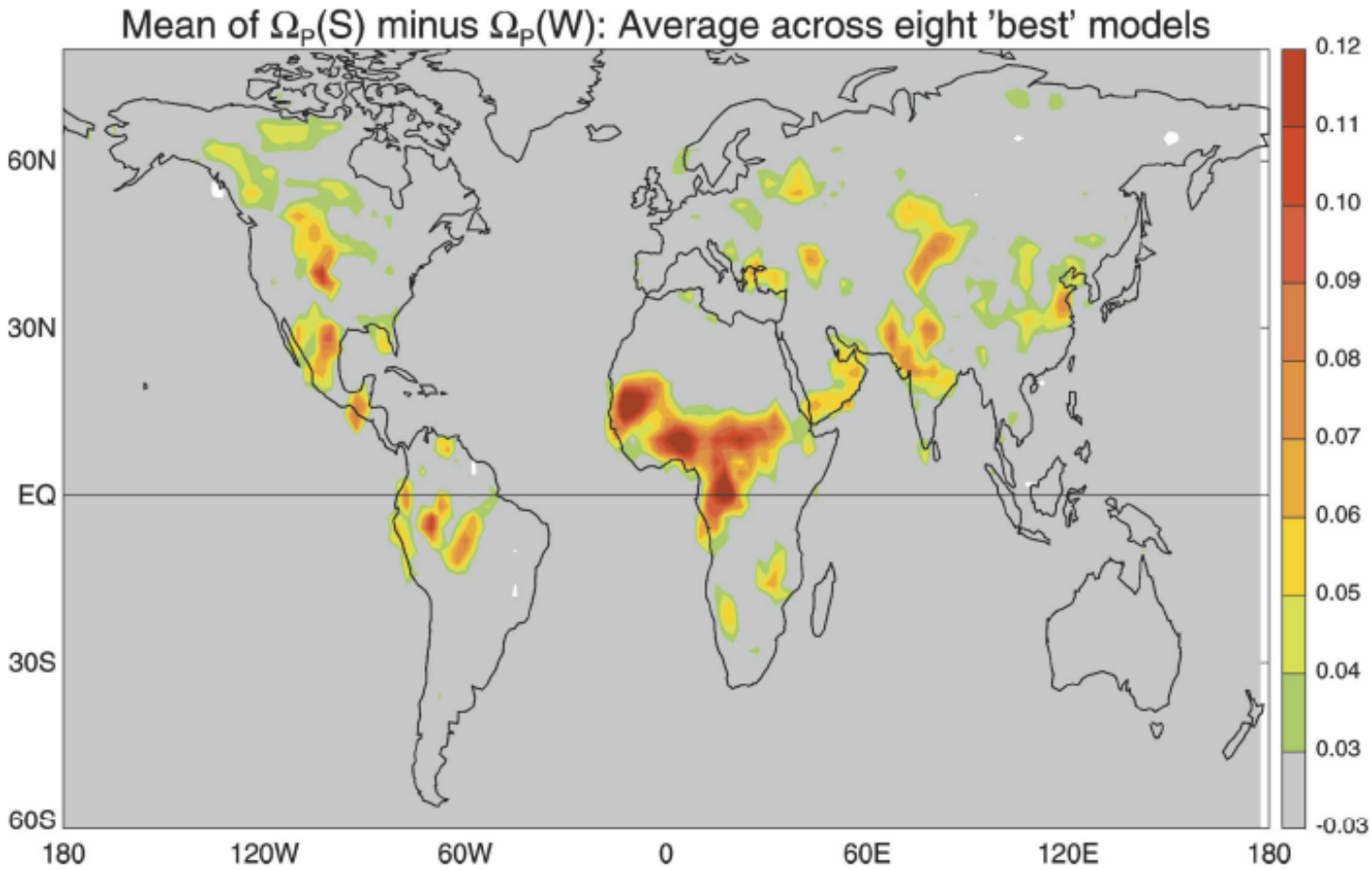
•Impact of using more comprehensive land models (versus simpler land models) on monsoon simulation (numerous studies)

•Intraseasonal monsoon variability (northward propagation) (e.g., Webster 1983; Ferranti et al. 1999; AMMA)

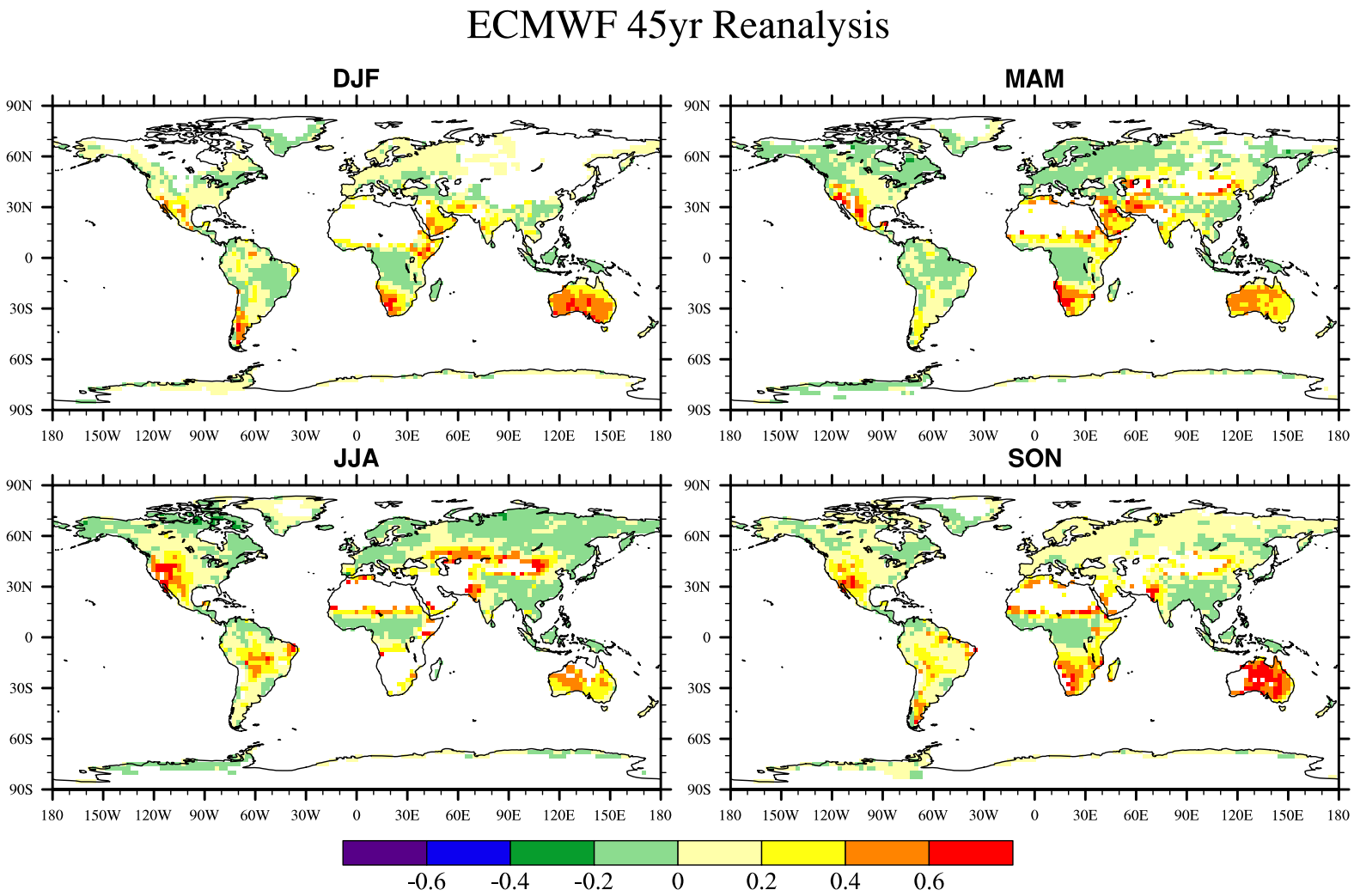
Model sensitivity: Hot Spots

Weakness: model-dependent; expensive computationally
Strength: interpretation is straightforward

Koster et al. (2006): GLACE; Also Wang et al. (2007)'s $\Delta\Phi$ index

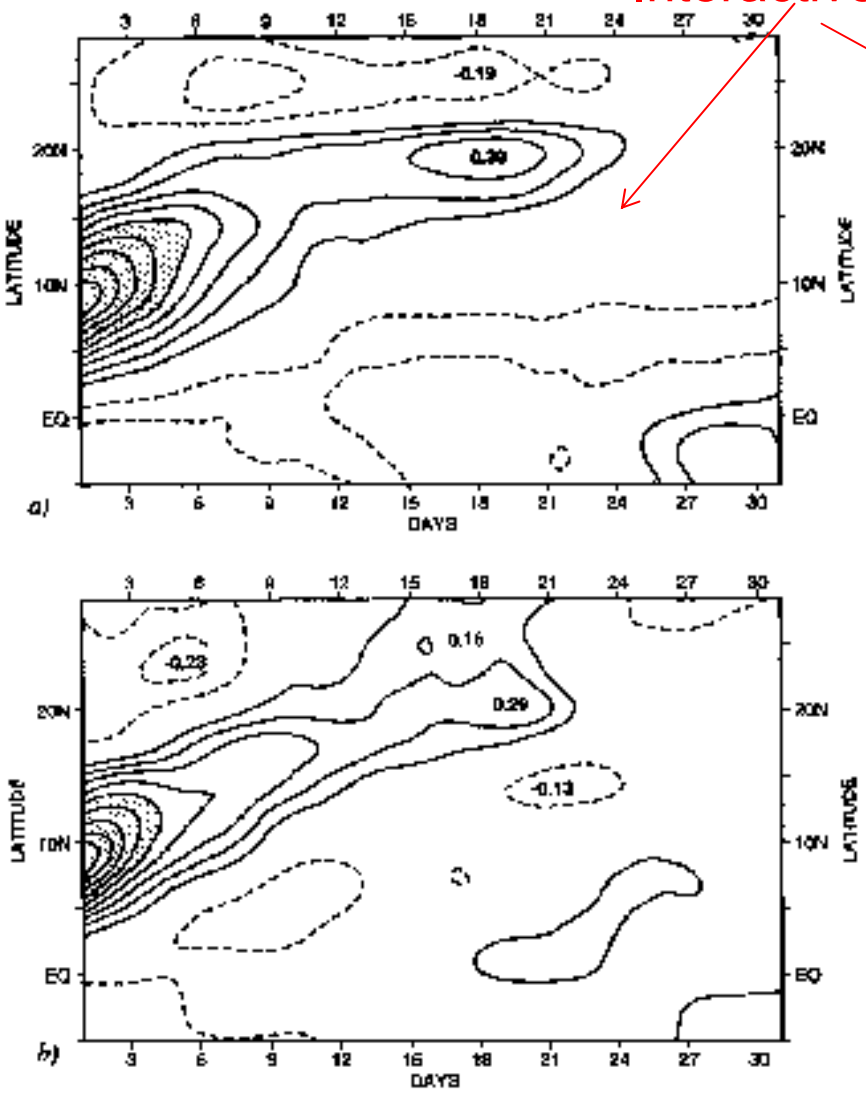


P not assimilated; σ_p < 0.2 mm/day masked



Zeng et al. 2010

Interactive land



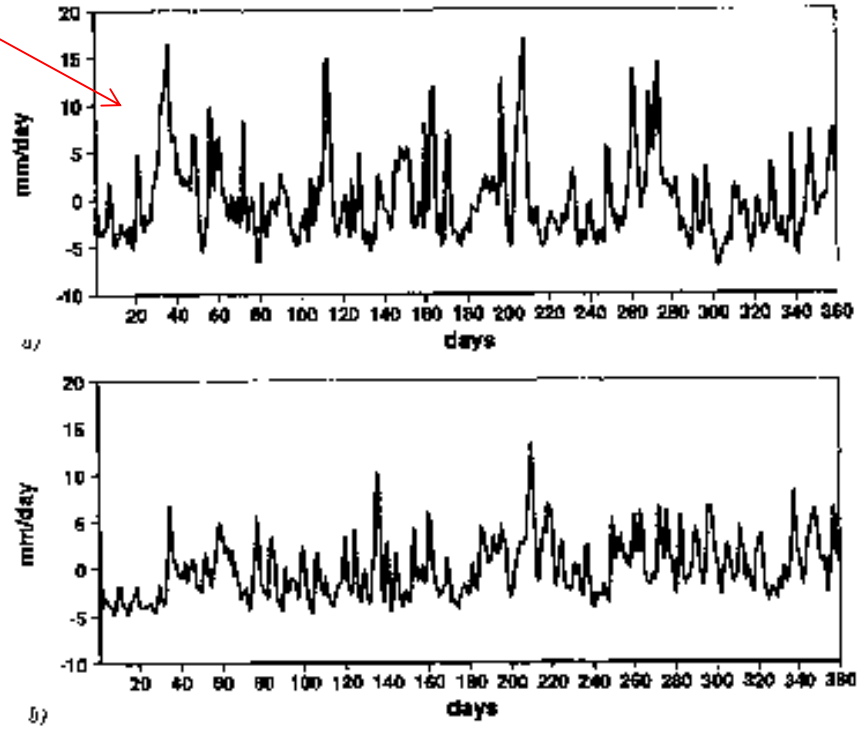


Figure 15. Daily series of precipitation anomalies over India (mm d^{-1}): (a) for the interactive soil-wetness (ISW) simulation; (b) for the prescribed soil wetness (PSW) simulation.

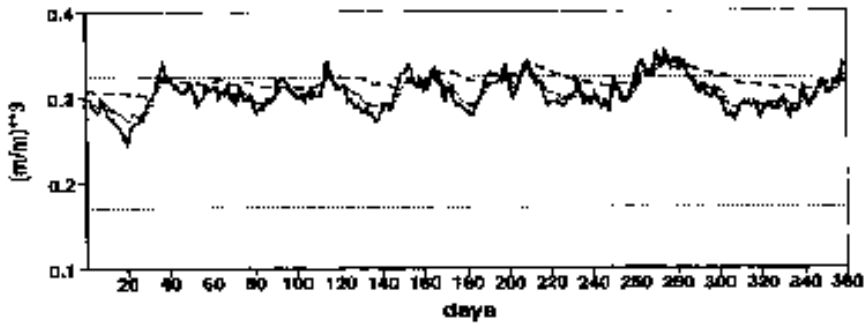


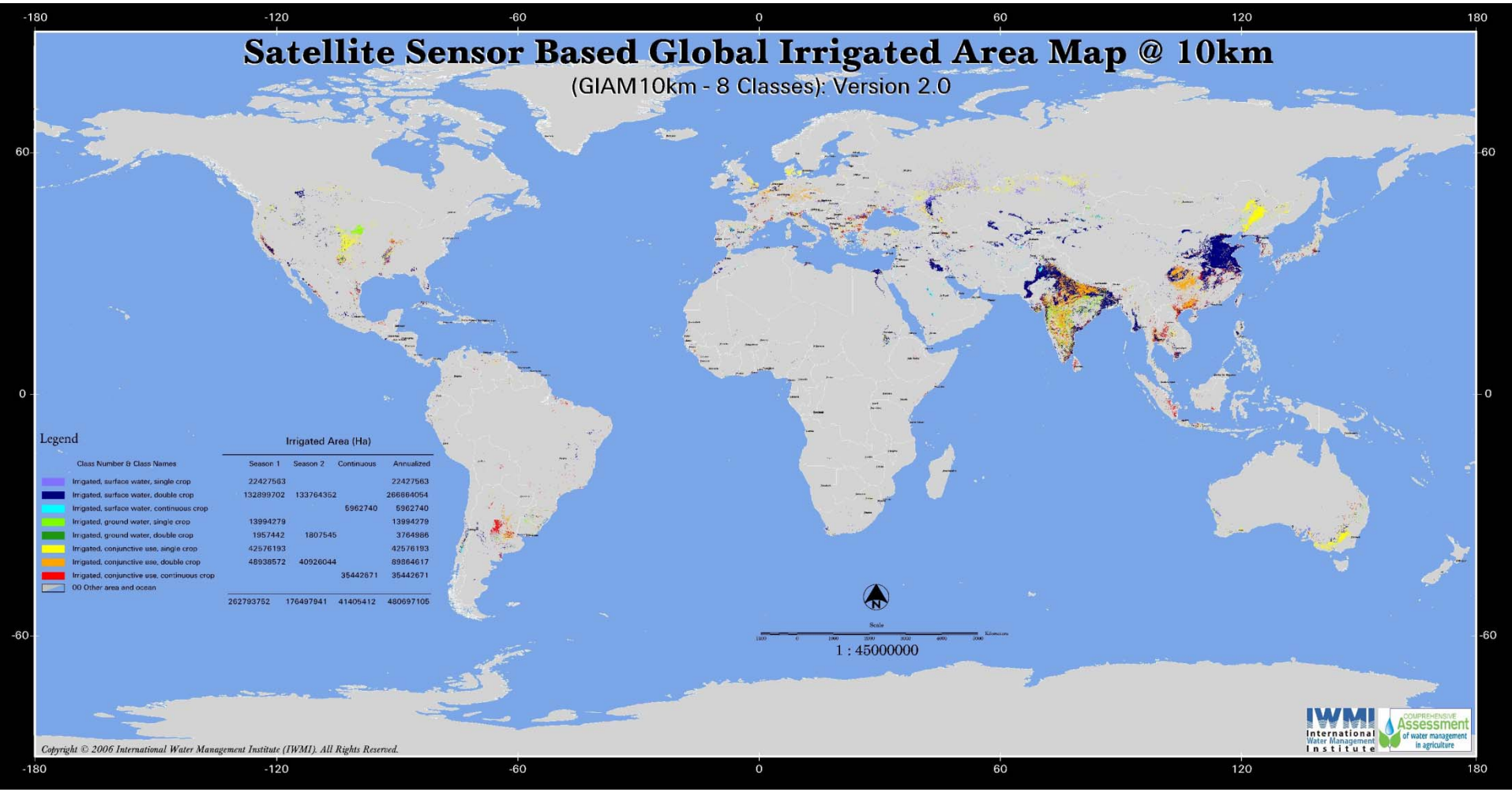
Figure 16. Daily series of soil wetness (m^3 m^{-3}) averaged over India, for the surface layer (solid line), the root zone (dotted line), and the deepest layer (dashed line).

Ferranti et al. (1999)

2. Suggestions for future land-monsoon interaction research

a. New experiments

- Atmospheric models with multiple land models
- Run atmosphere/land coupled models with fixed soil moisture from one simulation and with interactive land processes (GLACE design)
- Crop/irrigation effect on monsoon development
- Impact of Interannual vegetation variability over monsoon regions
- Terra-planet experiment (versus aqua-planet)


Satellite Sensor Based Global Irrigated Area Map @ 10km
(GIAM10km - 8 Classes): Version 2.0
-180
-120
-60
0
60
120
180
60
0
-60
Legend
Irrigated Area (Ha)
Class Number & Class Names
Season 1
Season 2
Continuous
Annualized
Irrigated, surface water, single crop 22427563 22427563
Irrigated, surface water, double crop 132899702 133764352 266664054
Irrigated, surface water, continuous crop 5962740 5962740
Irrigated, ground water, single crop 13994279 13994279
Irrigated, ground water, double crop 1957442 1807545 3764986
Irrigated, conjunctive use, single crop 42576193 42576193
Irrigated, conjunctive use, double crop 48938572 40926044 89864617
Irrigated, conjunctive use, continuous crop 35442671 35442671
00 Other area and ocean
262793752 176497941 41405412 480697105
N
Scale
1 : 45000000
IWMI
International Water Management Institute
Comprehensive Assessment of water management in agriculture
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b. Land-related analyses

- Averaged diurnal cycle of surface variables over different phases of intraseasonal variability

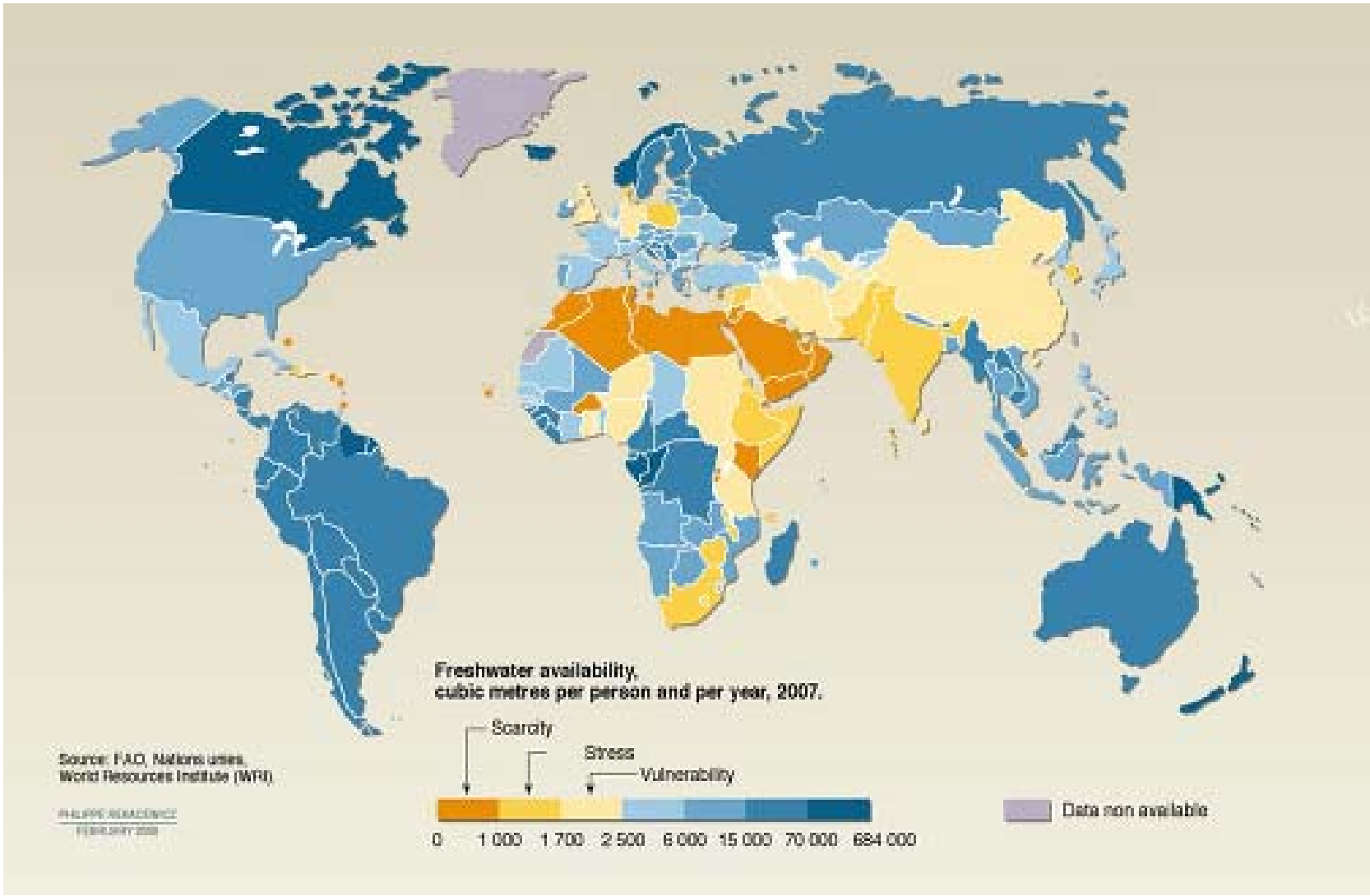
- Quantify the land-atmosphere coupling strength of different models at intraseasonal scale by computing the Γ index:

$\Sigma P'P' = \Sigma P'E' + \Sigma P'C'$; $C = F_{in} - F_{out} - dW/dt + \alpha$

$\Gamma = \Sigma P'E' / \Sigma P'P'$ E', P' are deviations from climatology

[Motivation: Zeng et al. (2010) analyzing global and regional reanalyses, offline model output, regional and global modeling output as well as 2*CO2 modeling output]

3. Land processes are obviously crucial to societal needs



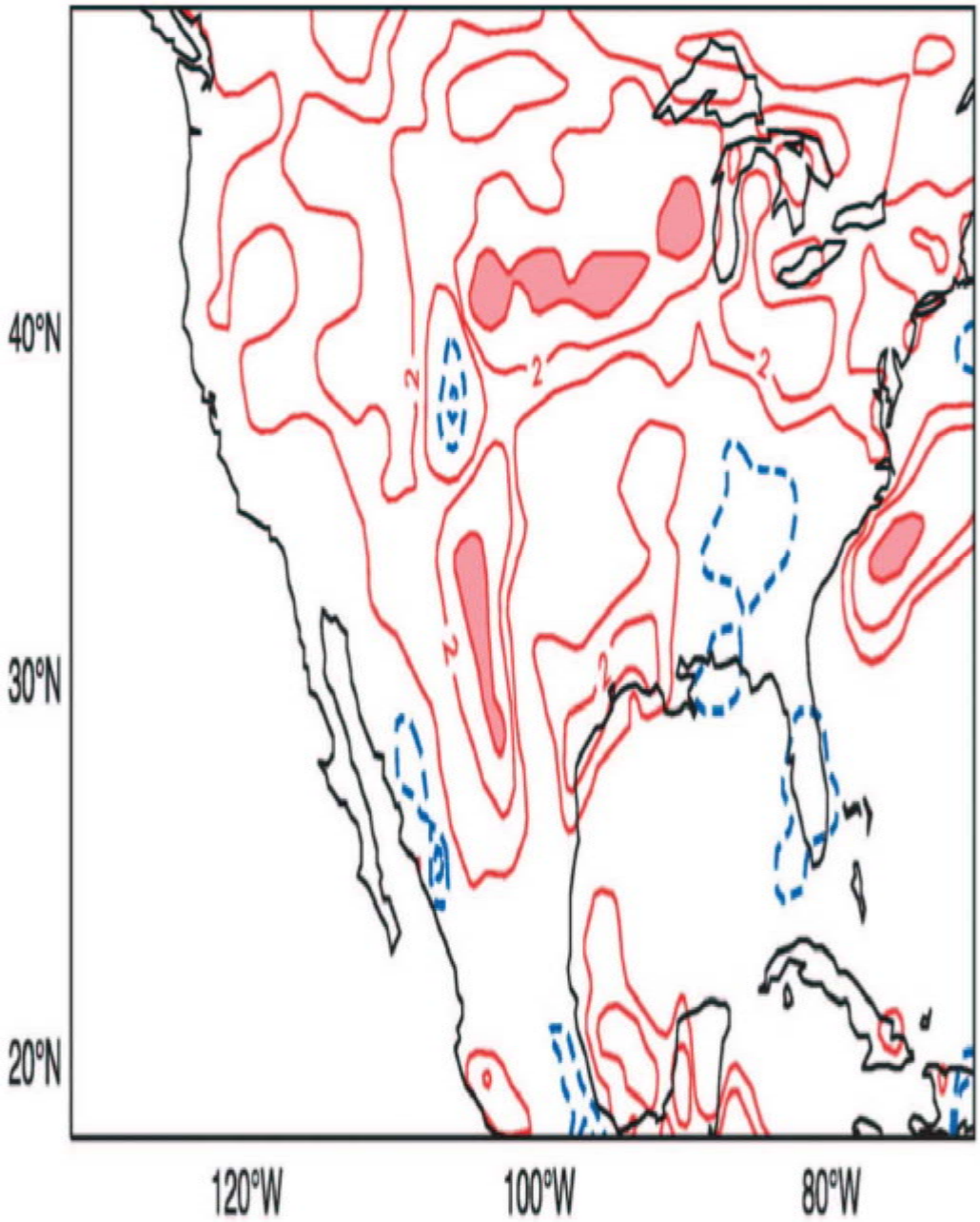
From UNEP

Overall Assessment of Influence

Land-Surface Influence	Plausible Physical Basis	Climate Record Evidence	Model Evidence	Further Evidence (Model, Obs., or Expt.)	Credibility (* see below)	Quantification (Good, Medium, Poor) Long-term	Quantification (Good, Medium, Poor) Short-term
<u>Influence of existing land-surfaces</u>							
Effect of topography	Yes	Yes	Yes	Yes	Ext. Likely	Medium/Low	
Contribution to atmos. water	Yes	Yes	Yes	Yes	Ext. Likely	Medium	
<u>Influence of transient changes</u>	**But can these be totally separated?**						
Effect of soil moisture	Yes	Yes	Yes	Yes	Very Likely	Poor	
Regional	Yes	Yes	Yes	Yes	Likely	Poor	
Meso-scale							
Effect of vegetation vigour	Yes	Yes	Yes	Yes	Very Likely	Poor	
Effect of frozen precipitation	Yes	Yes	Yes	Yes	Very Likely	Poor	
<u>Influence of change in land cover</u>							
Effect on 2 m climate	Yes	Yes	Yes	Yes	Ext. Likely	Good	
Effect of regional-scale changes	Yes	Yes	Yes	Yes	Very Likely	Medium	
Effect of imposed heterogeneity	Yes	Yes	Yes	Yes	Very Likely	Medium	

Extremely likely > 95%; Very likely > 90%; Likely > 66%;
More likely than not > 50%; Unlikely < 33%; Very Unlikely < 10%;
Extremely unlikely < 5%

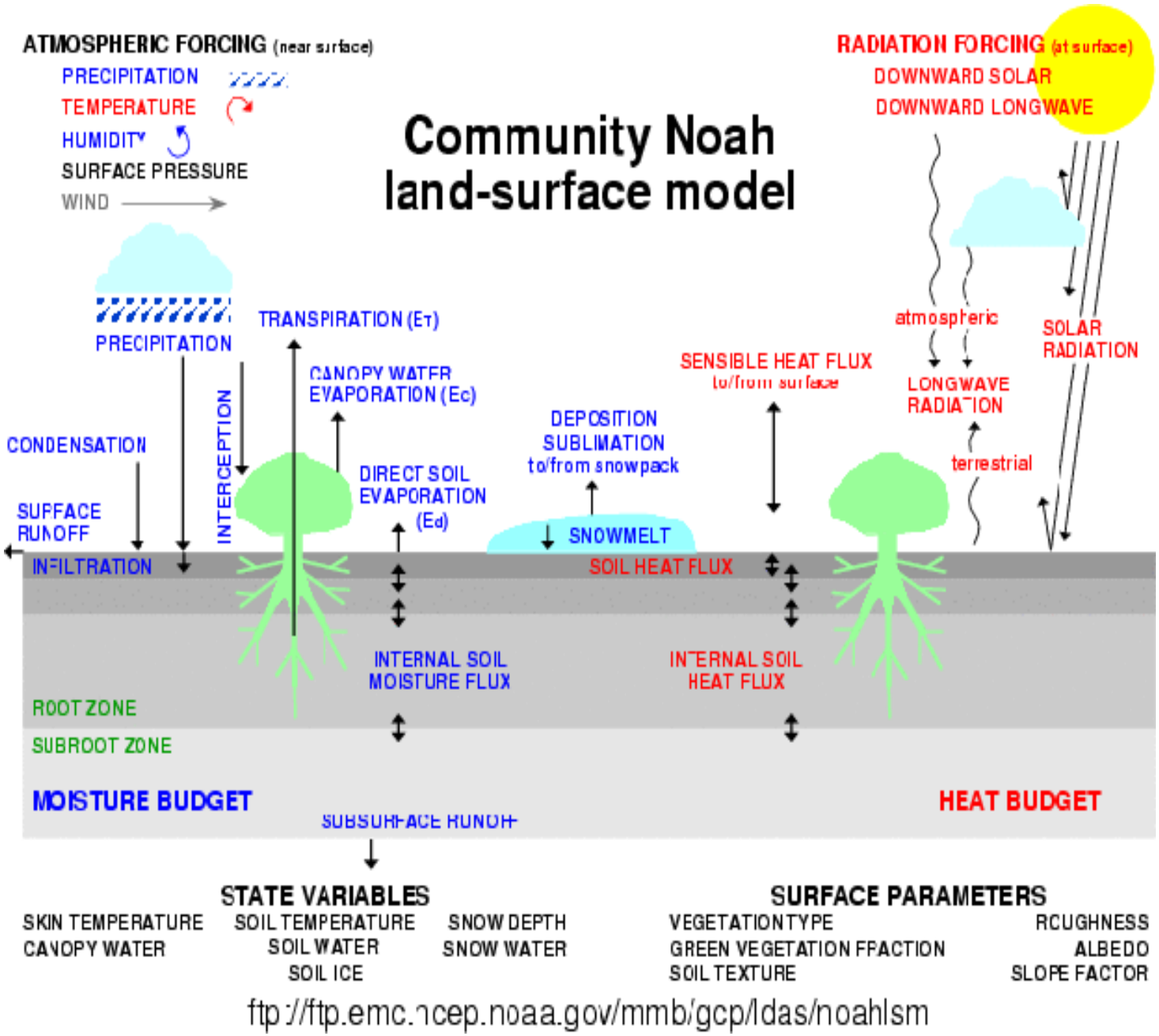
Shuttleworth (2010)



Land effect on weather prediction and climate simulation

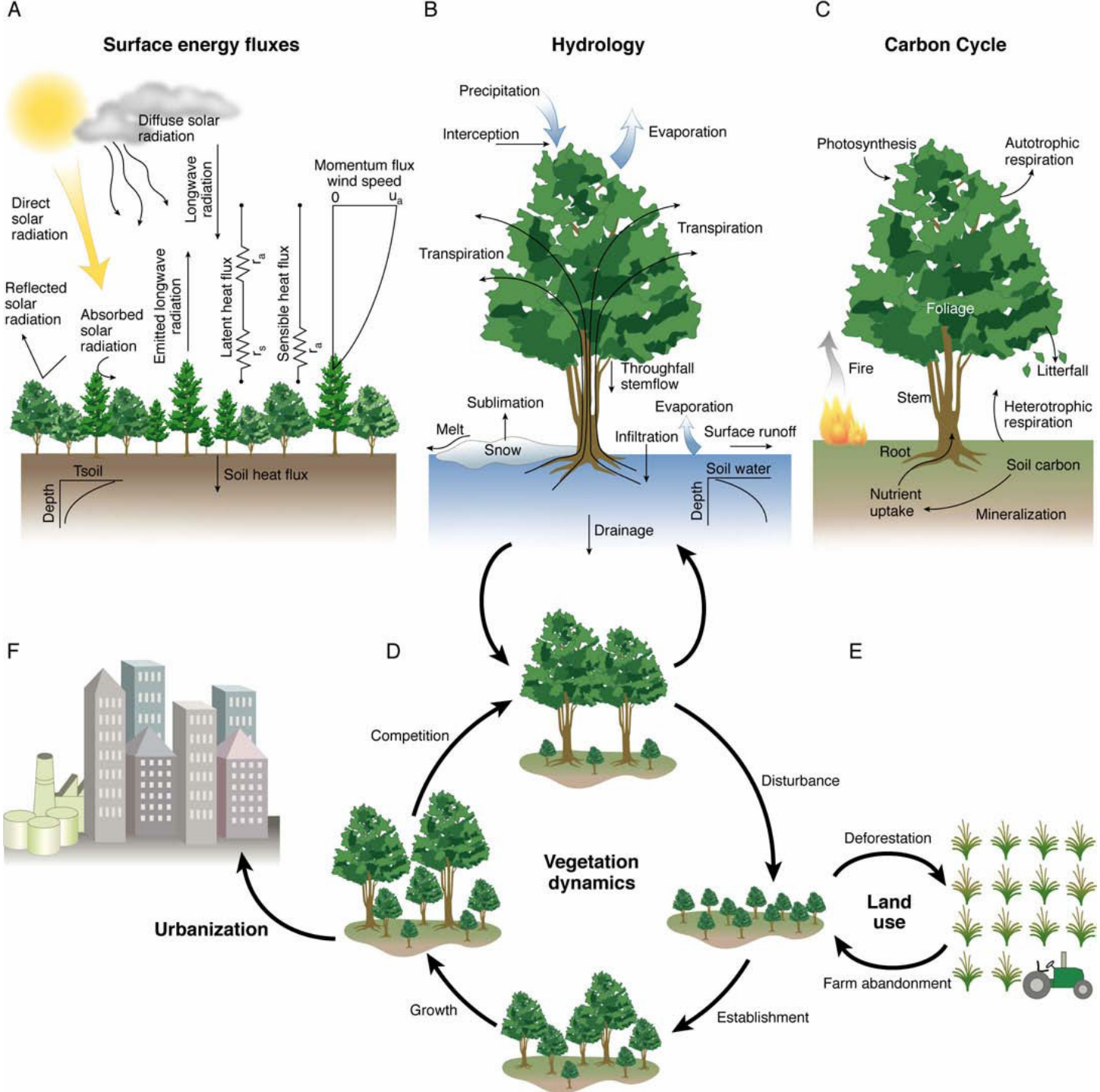
Difference in monthly forecast precip inJuly 1993 starting with wet and dry soils *(Beljaars et al. 1996)*

4. Current land modeling ststua

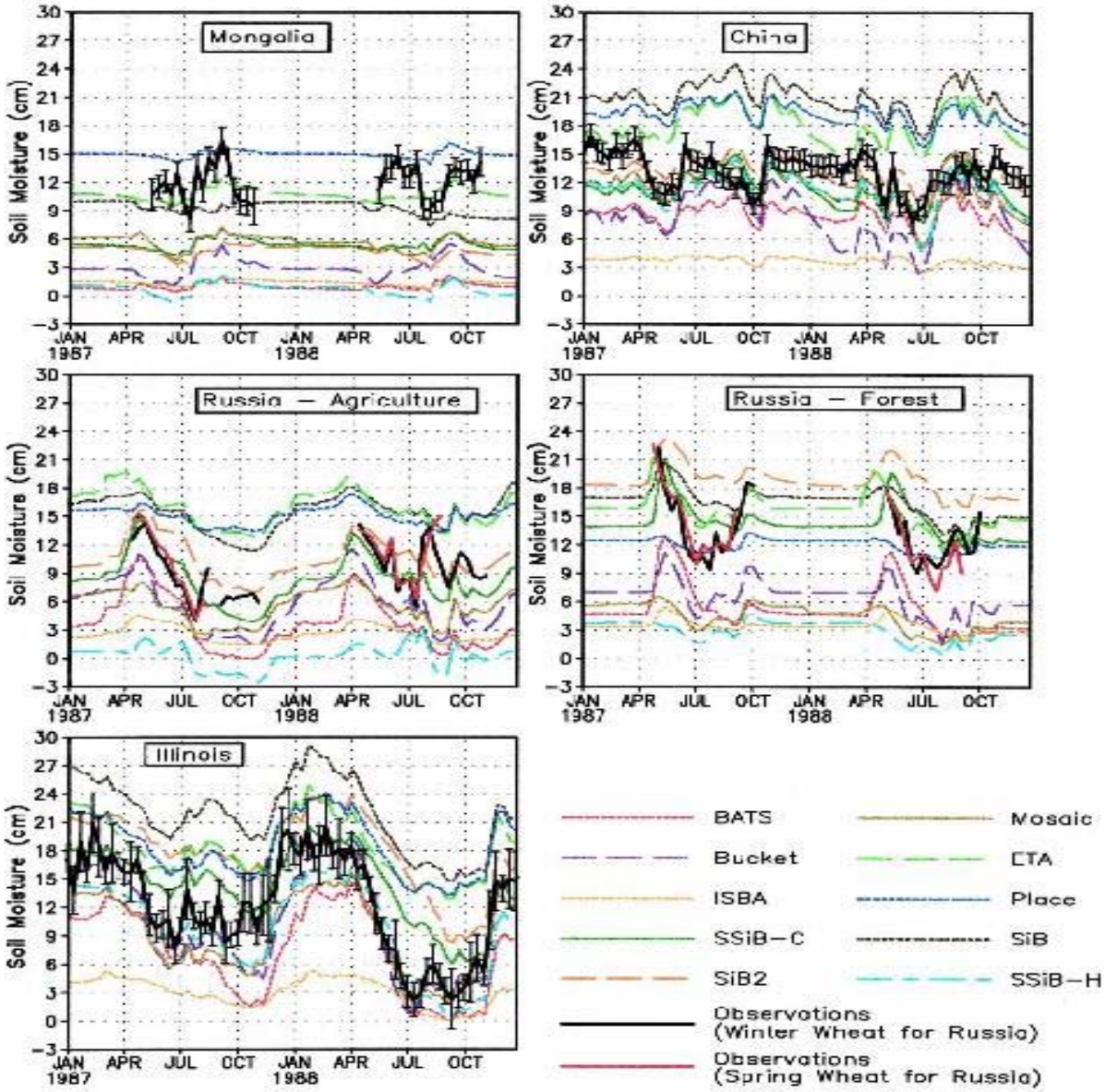


ftp://ftp.emc.ncep.noaa.gov/mmb/gcp/ldas/noahlsm

Noah used in NCEP, WRF



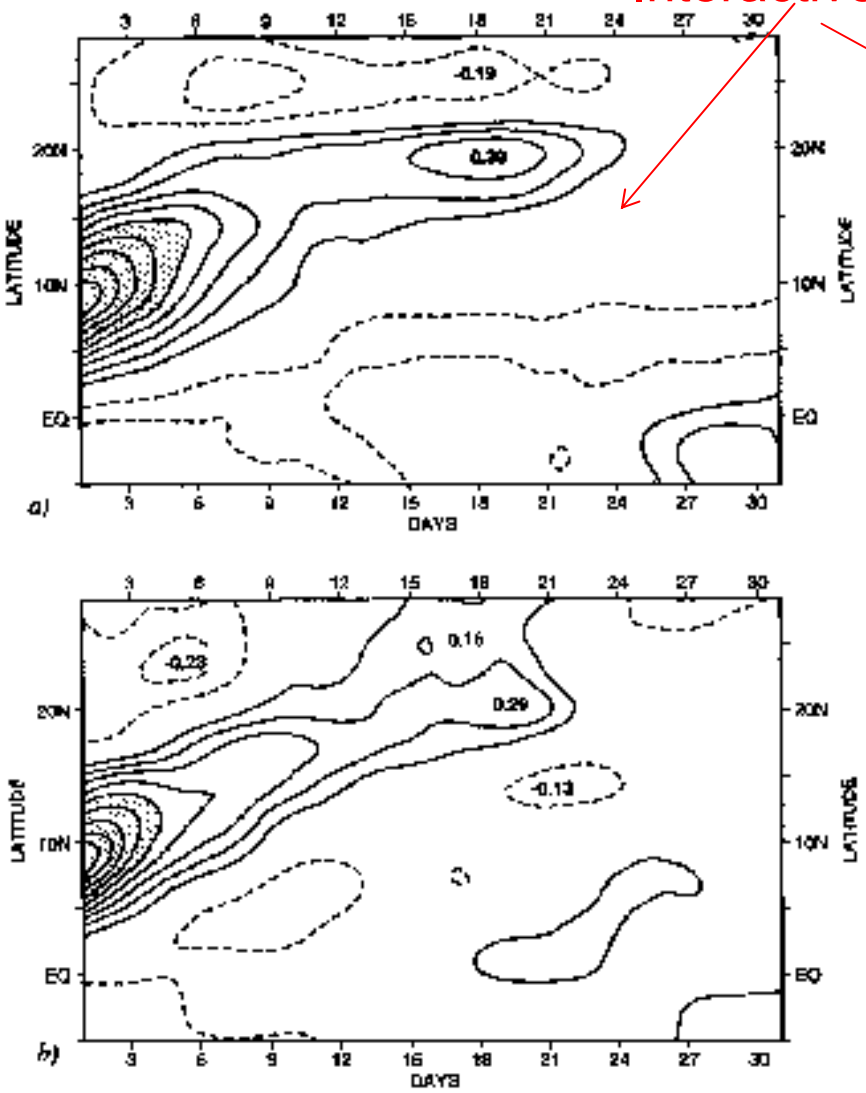
CLM4 used in CCSM

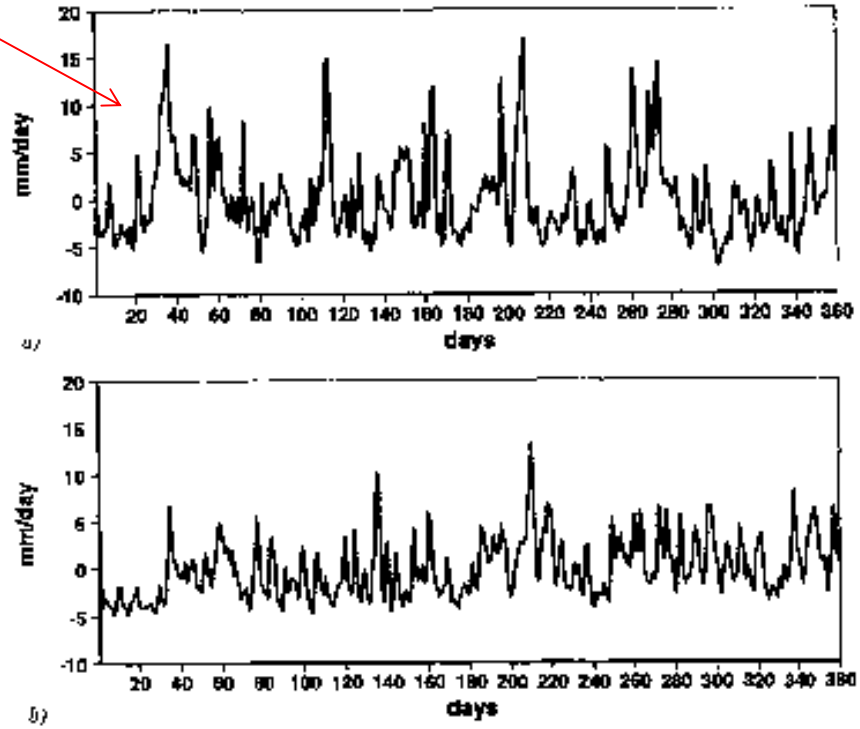


Difficulties in land modeling

PILPS, GSWP (Dirmeyer et al. 1999)

Interactive land





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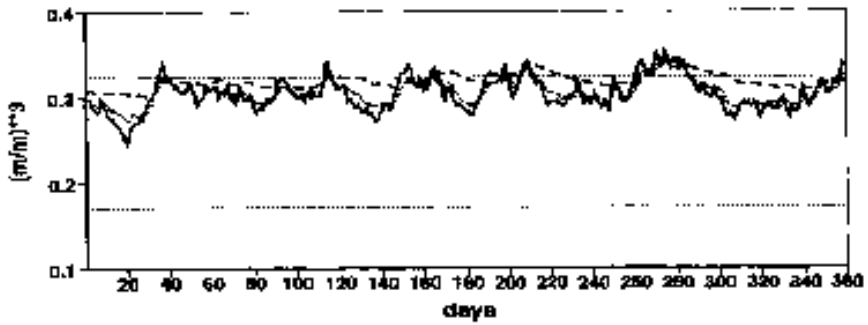

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Ferranti et al. (1999)

5. Land versus ocean interactions with atmosphere

Rnet = SWnet + LWnet = SH + LH + Fs,n

L: a) SW absorbed in a thin soil layer (~1 mm);
b) Fs,n = 0 for T > days;
→ Ts is a response variable with large diurnal cycle;
d) both Ts and SM are important state variables;
e) SH and LH partitioning is controlled by SM

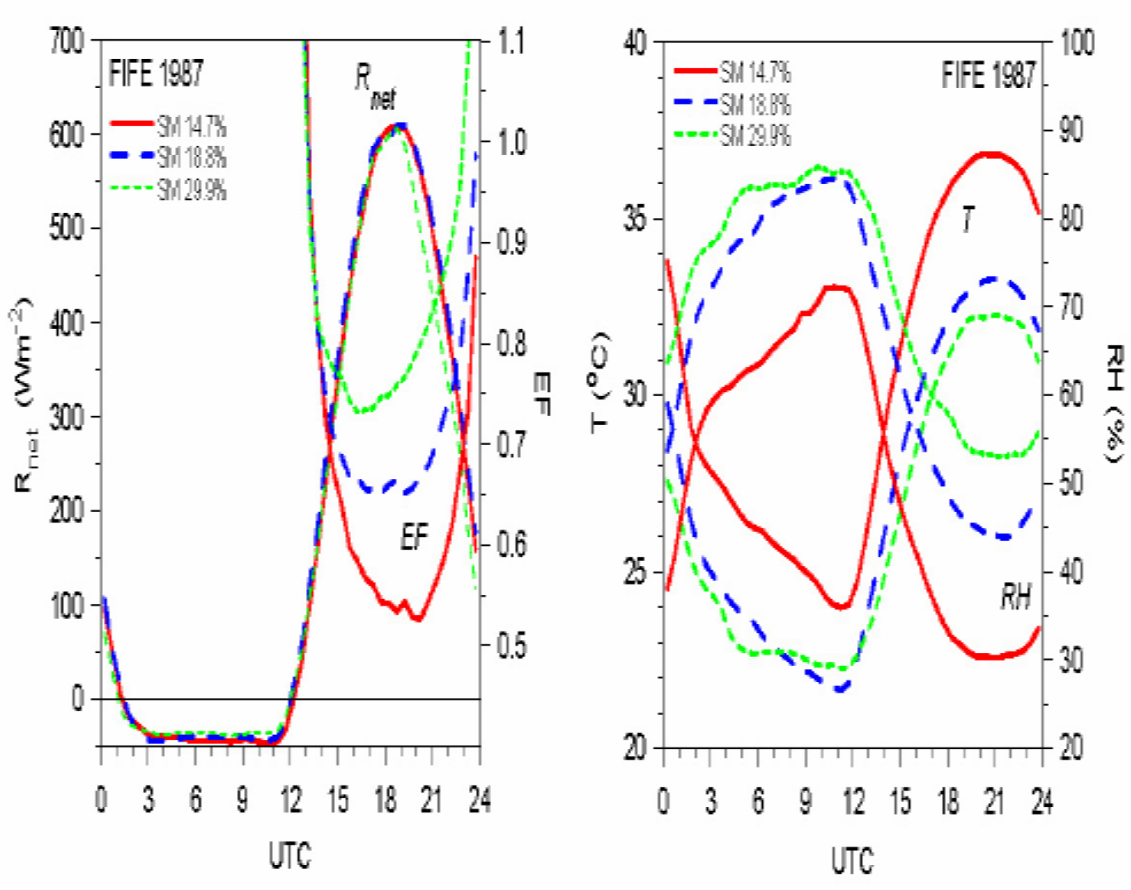
O: a) SW absorbed in a thick ocean layer (~50 m);
b) Fs,n ≠ 0 for T> days;
→ SST is a forcing variable;
d) SST is the primary state variable;
e) LH >> SH

SWnet is strongly affected by clouds

LWnet is strongly affected by clouds and water vapor

Rnet is not much affected by soil moisture

LH/SH partitioning is strongly affected by soil moisture



Evaporative fraction: EF = LH/(LH+SH), Betts (2009)

Land-atmosphere coupling

SM + → LH + → PLCL -- → Precip +

SM + → SH -- → T -- → buoy -- → Pre --

Albedo + → precip -- (Charney hypothesis)

Veg cover -- → Zo --
→ low level convergence change
→ precip change

Veg cover -- → dust + → CCN +
→ clouds and precip change

Veg cover -- → Albedo + → precip --