Welcome to the GLASS/WATCH workshop on local land/atmosphere coupling

Bart van den Hurk

Eleanor Blyth

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The LoCo theme

- Accurately understand, model and predict the role of **local land – atmosphere coupling** in the evolution of land-atmosphere fluxes and state variables, including clouds.
- Adresses academic questions like:
  - Can we trace physical mechanisms that are responsible for the variability in coupling strength found e.g. in GLACE?
  - Can we 'measure' land-atmosphere coupling?
- And practical questions like:
  - Does a 'PILPS'-type optimization of parameters give values that represent the real (coupled) world?
  - Can land data assimilation be done right without considering coupling between land and atmosphere?

Goals of this workshop

- Make a (selective) review of progress on local (hydrological) land-atmospheric coupling research
  - diagnostics and tools
    - Trends in pan/actual evaporation (*Jim Shuttleworth*)
    - Observation of coupling from space (*Richard de Jeu* and *Craig Ferguson*)
    - Single Column/Regional Models (*Roel Neggers* and *Joe Santanello*)
  - mechanisms
    - Relative Humidity tendency (*Michael Ek*)
    - Recycling in Europe (*Bernie Bisselink*)
    - Convective systems and soil wetness (*Chris Taylor*)
  - climatology and climate change effects
    - Land-atmosphere coupling in GCMs (*Stefan Hagemann*)
    - Coupling in present day climate (*Randy Koster*)
    - In future climate (*Sonia Seneviratne*)
- Draft a review paper and/or experimental design

Some logistics

- Finish
  - Friday 13:00 pm (lunch available)
  - If progress is rapid: see if we can finish Thursday evening
- Wireless: ask account at reception
- Free of charge (KNMI sponsors catering)
  - Conference dinner on Wednesday evening
- Travel support: contact me
- Kick-off: two presentations:
  - Some literature on the topic (*Bart vd Hurk*)
  - Coupling studies in WATCH (*Eleanor Blyth*)

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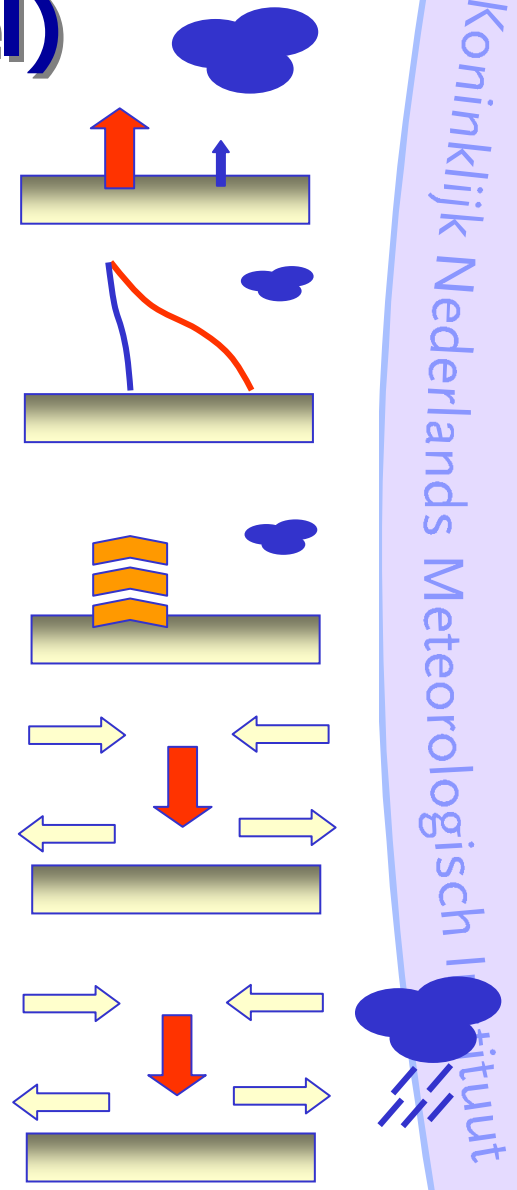
Charney's view on land-atm. feedback (Sahel)

- Dry regime → H/LE high (small evaporative cooling)
- High atmospheric T, low RH, low cloud cover
- Strong longwave cooling of surface → negative TOA rad.balance (heat loss by atmosphere)
- Compensated by high level convergence and subsidence (giving adiabatic heating) and low level divergence
- Possibly accompanied by latent heating in remote areas (local Hadley-type circulation)

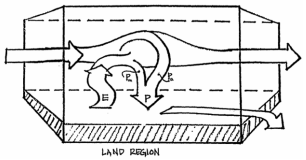


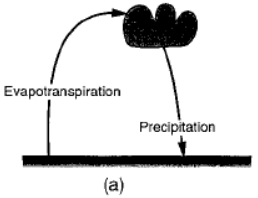
Charney (1975)

Feedback in conceptual models

- Based on budget equations: the soil acts as a buffering reservoir

$$F_{adv} \pm \sigma$$





  - Entekhabi et al (1992): variance of stochastic forcing (σ) is a factor determining aridity of climate and precipitation variability

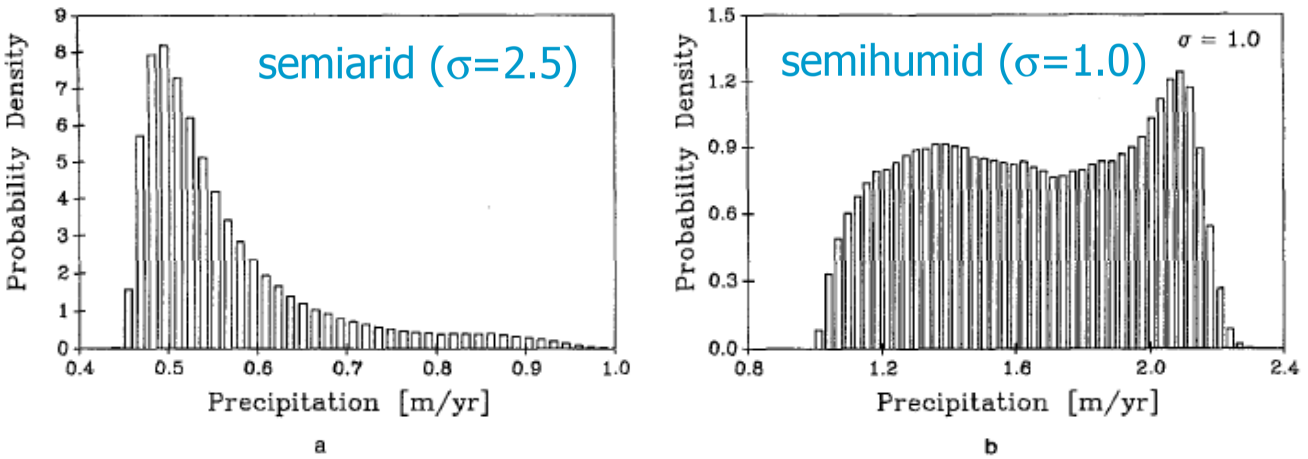
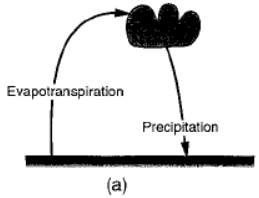


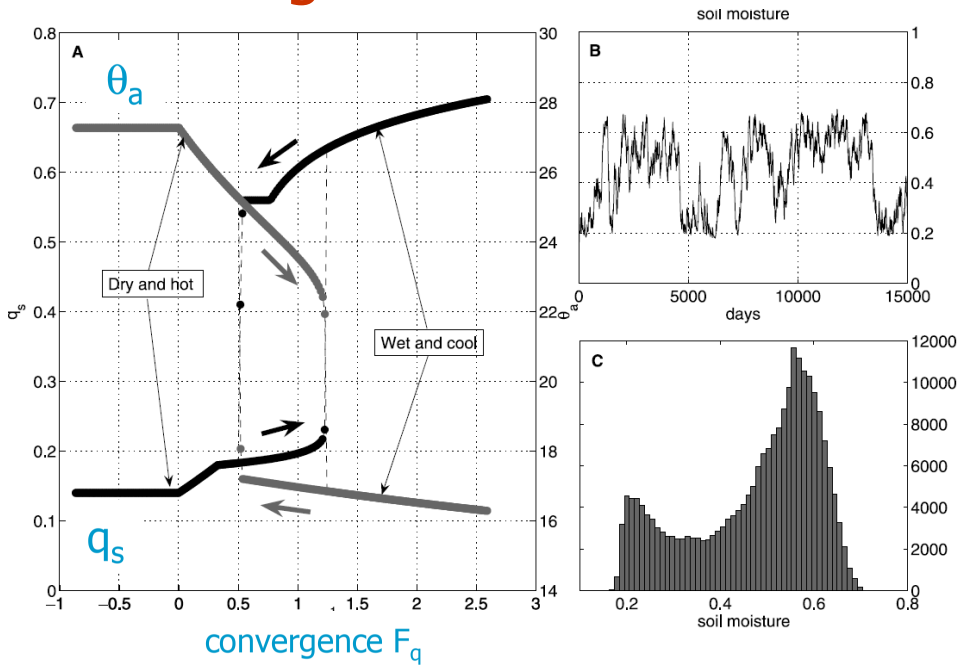
FIG. 17. The simulated probability density function for the total precipitation (in m yr^{-1}) in the (a) semiarid and (b) semihumid cases.

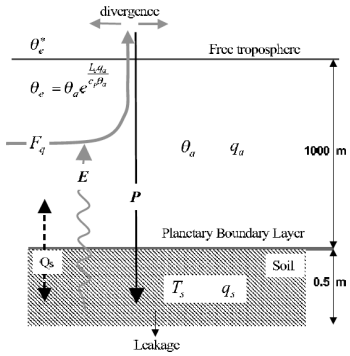
Feedback in conceptual models

- Based on budget equations: the soil acts as a buffering reservoir



  - d'Andrea et al (2006): hysteresis may occur in regimes with limited moisture convergence

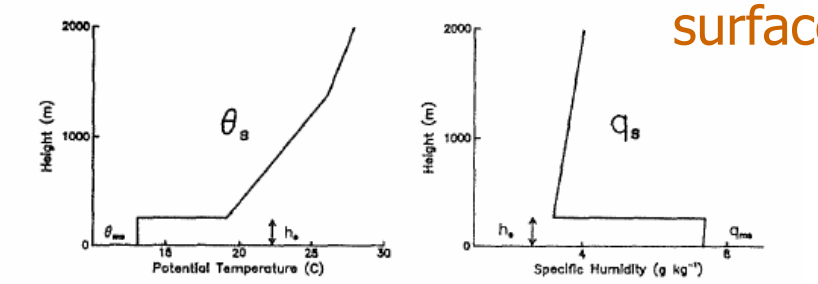


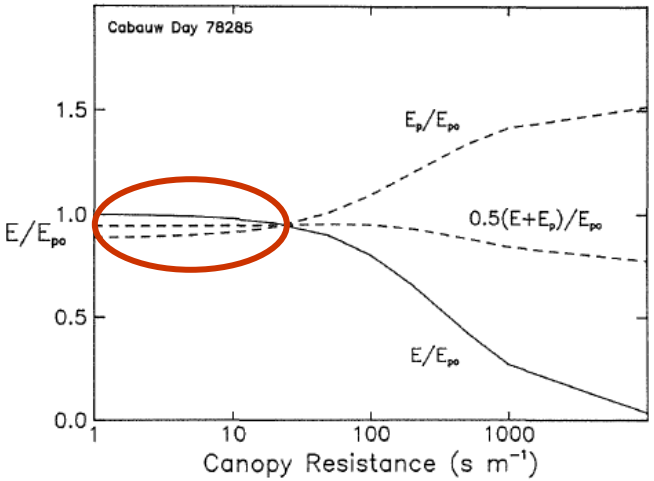


A PBL point of view

- McNaughton & Spriggs (1989): PBL growth and surface flux partitioning are strongly related

surface – slab PBL model





CR diagram for Cabauw day 78285 when the capping inversion was very strong at 21.9°C km^{-1}. CBL height growth was small in the simulations and changed conditions within the CBL strongly reflected the surface fluxes of heat and vapour. Calculated E_p is greatly increased at larger values of r_c when the sensible heat flux was large and the latent heat flux small.

E = evap
E_p = pot.evap acc. to assumption of unchanged atm.cond's
E_{po} = E(r_c=0) (wet surface)

E fairly constant due to negative feedback:
high E → low H → low entrainment of dry air → low deficit → low E

A PBL point of view

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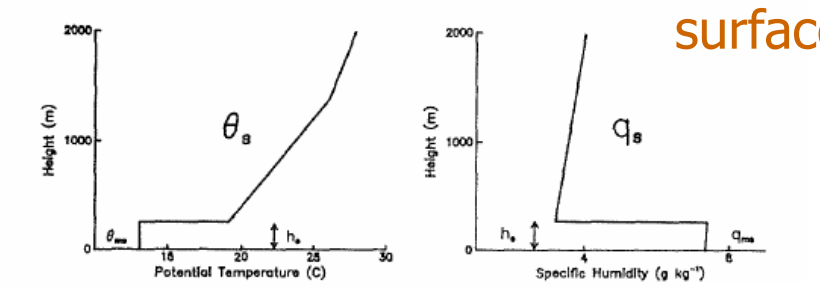

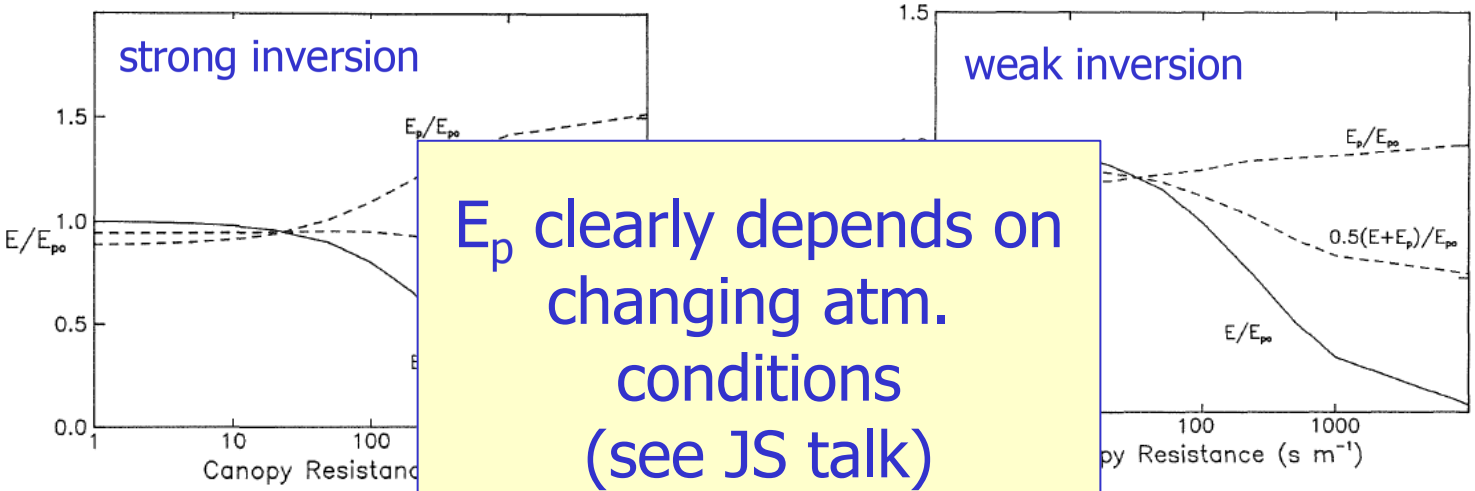

E_p clearly depends on changing atm. conditions (see JS talk)

CR diagram for Cabauw day 78285 when … at 21.9°C km⁻¹. CBL height growth was s… conditions within the CBL strongly reflect… vapour. Calculated E_p is greatly increased at larger values of r_c when the sensible heat flux was large and the latent heat flux small.

…7262 when the capping inversion was very weak at …s very rapidly in these simulations and saturation …of the CBL is closely controlled by the temperature and humidity of the air entrained from the inversion layer. Calculated values of E_p are fairly insensitive to changes in input values of r_c.

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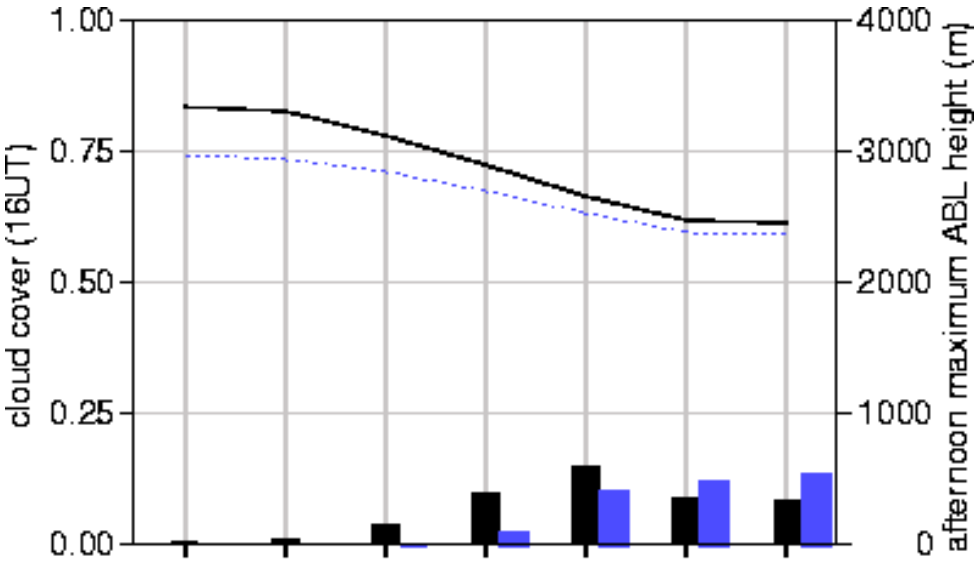
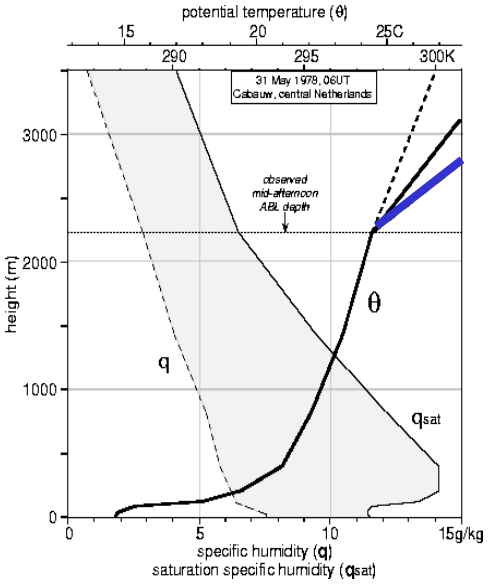
PBL involving (shallow) clouds

- Ek and Holtslag (2004): SCM including radiation, vertical turbulent exchange, cloud formation, land surface



vol. soil moisture



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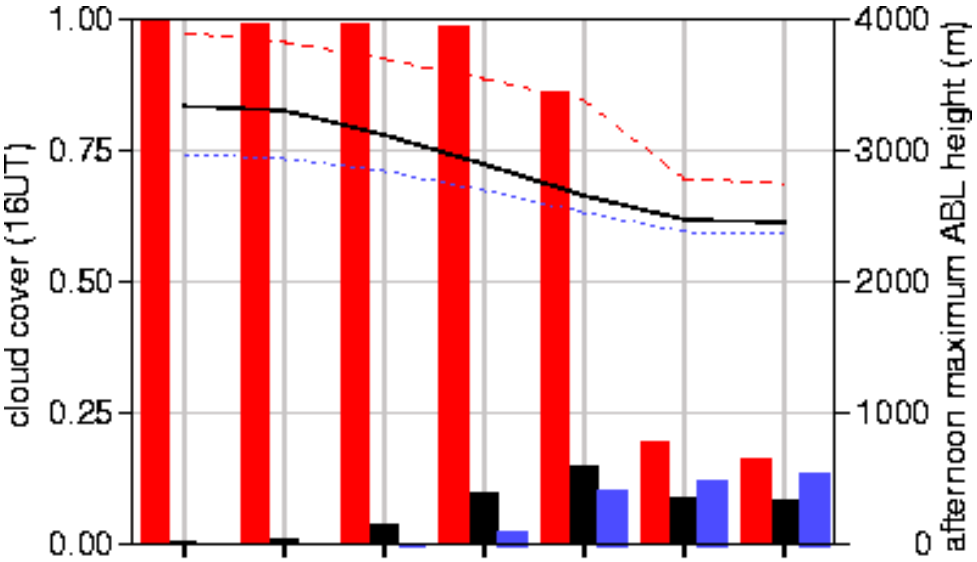

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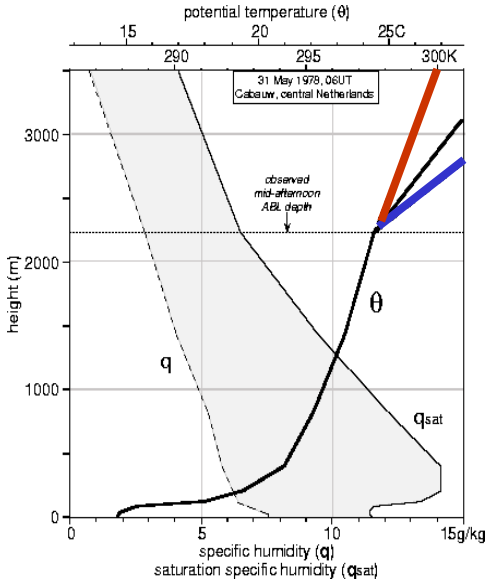
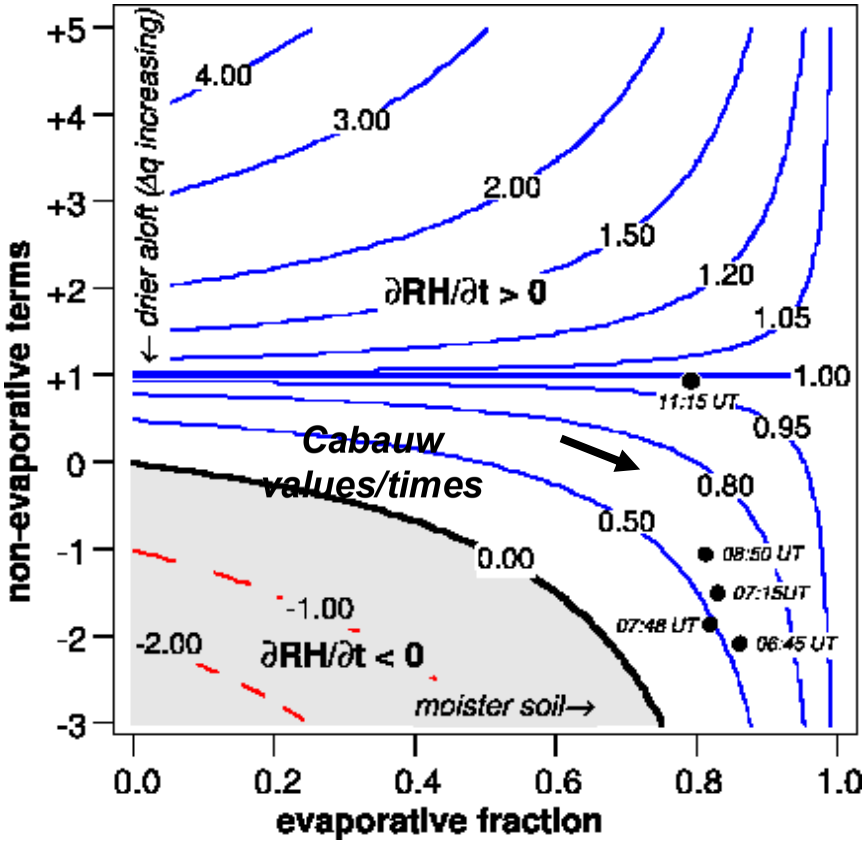


PBL involving (shallow) clouds

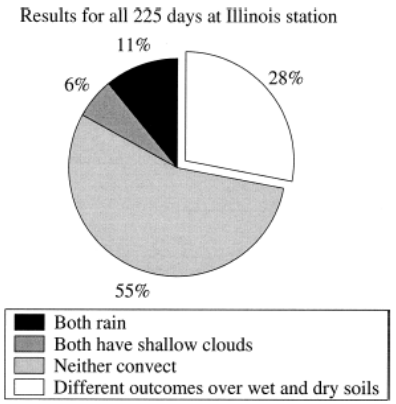
- Ek and Holtslag (2004): SCM including radiation, vertical turbulent exchange, cloud formation, land surface
- RH-tendency

expressed as function of surface evaporation and entrainment properties



A convection point of view

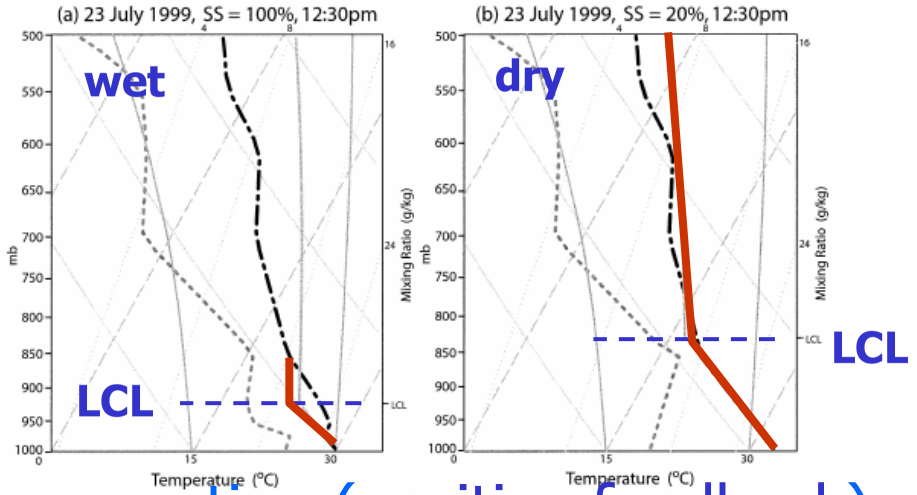
- Findell and Eltahir (2003) did a systematic analysis of soil moisture – precipitation feedback
- Start with atm. sounding of 6:00 am
- Use simple Land-PBL model driven by obs. soundings
- Diagnose convective triggering or shallow cumulus formation for 2 runs (dry and wet soil)
- Classes of cases:
  - soil has no impact (atm. controlled)
  - convection favoured over wet soils
  - convection favoured over dry soils



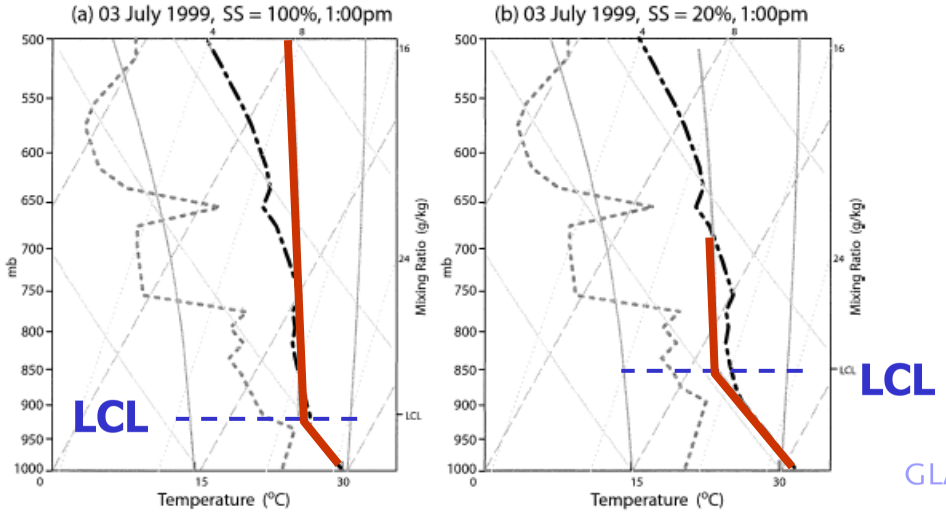
Soil-PBL feedback

- Dry soils favoring convection (negative feedback)

PBL growth reaches LCL



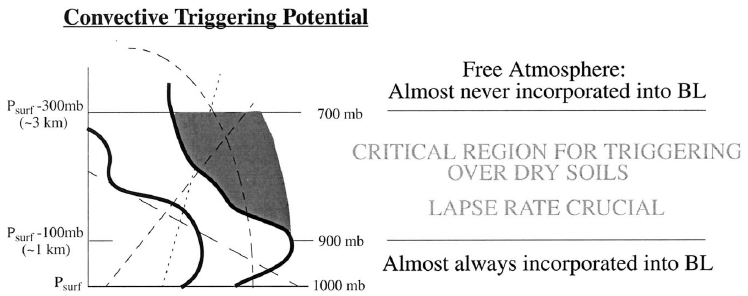
- Wet soils favoring convection (positive feedback)



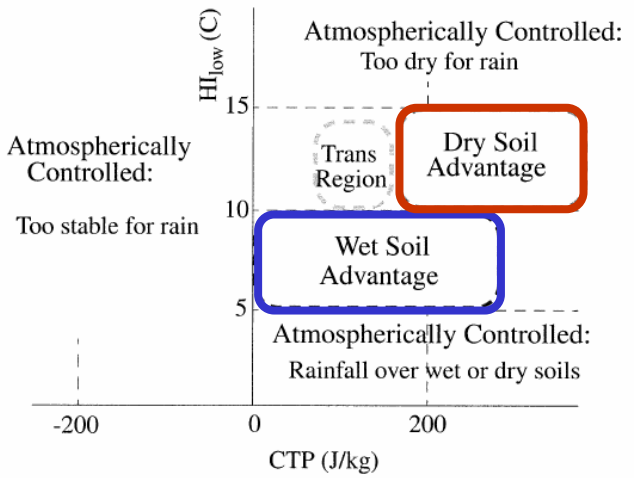
Build-up of MSE gives convective potential

Findell's diagnostics

- Convective Triggering Potential (CTP)



- Dewpoint depression in low levels (HI_{low}):
  - too wet: rain always likely
  - too dry: no moisture available



Findell's map of feedback

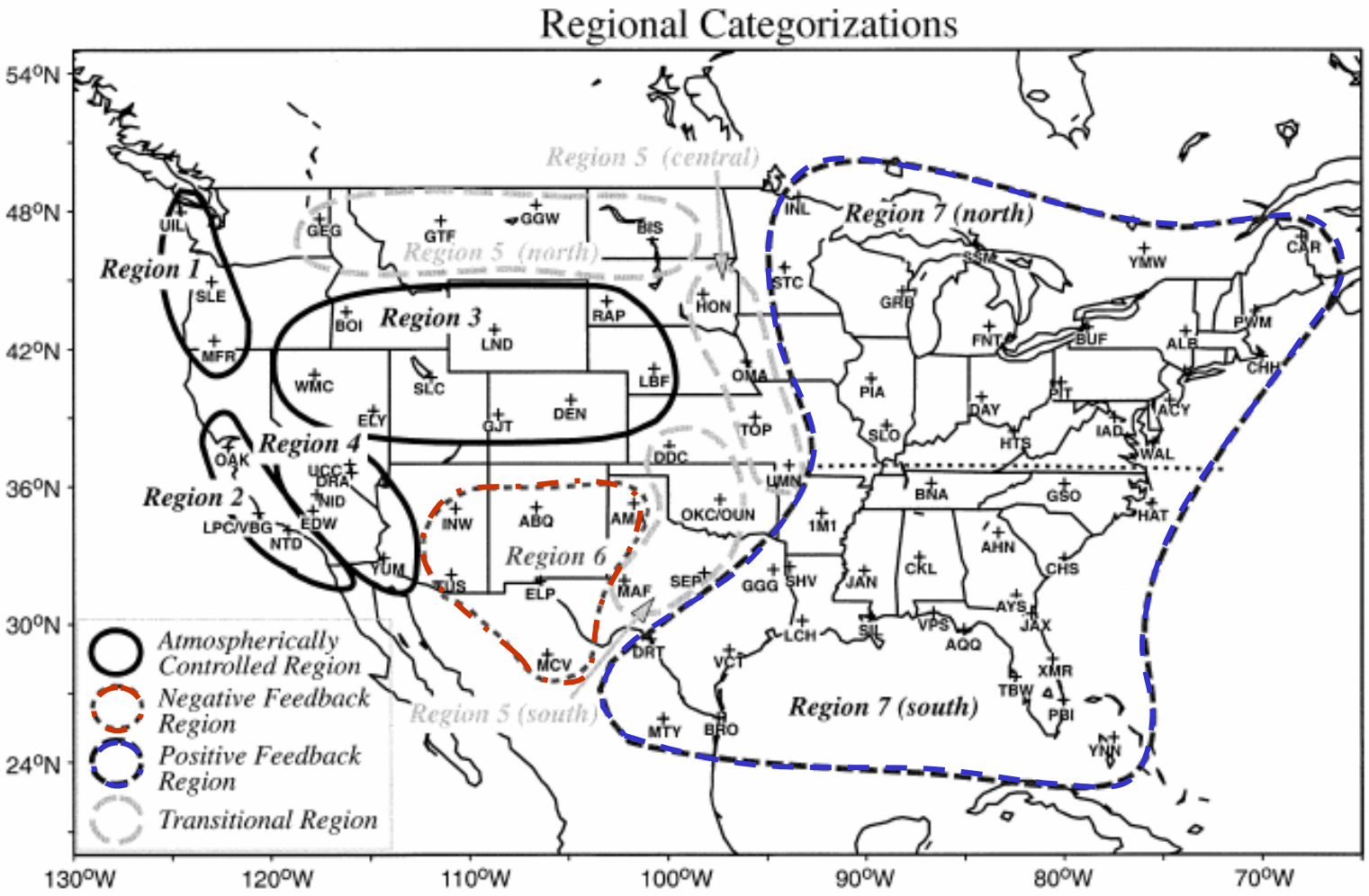
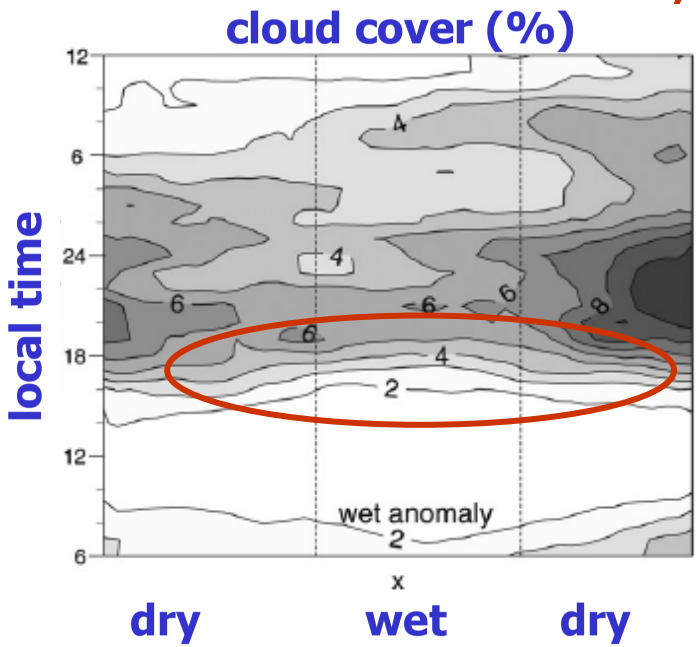
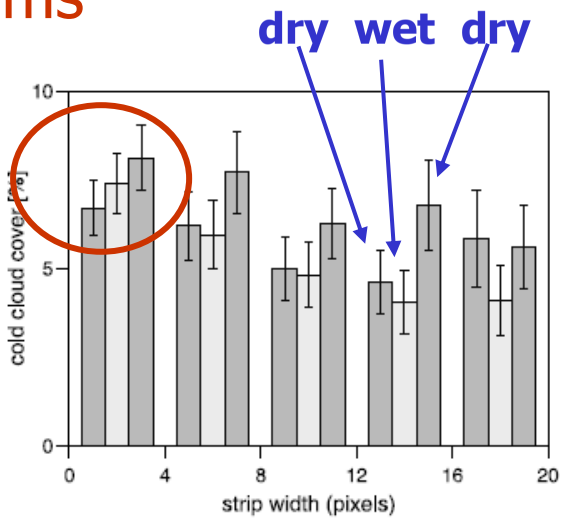


FIG. 2. Representative regions within the continental United States, based on CTP-HI_{low} scatterplots for the 89 stations with at least 10 yr of data during 1957–98 (see text for full description).

Convective organization

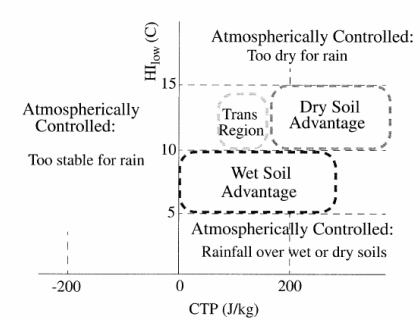
- Taylor and Ellis (2006): effect of soil moisture anomalies on cloud formation using TRMM/MSG
  - Negative feedback: wet soils expose less convection in afternoon/evening
  - Less clear for smallest systems

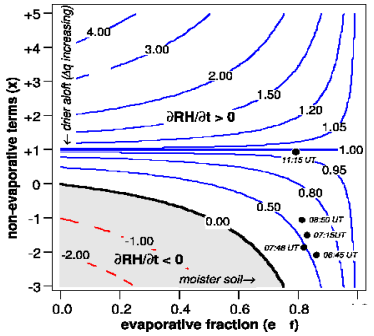




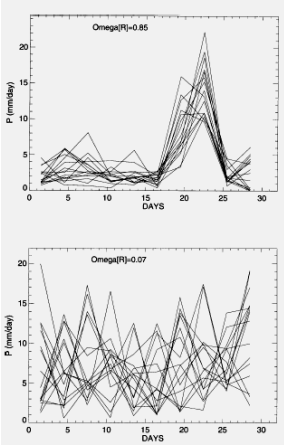
Views on diagnostics

- ∂RH/∂t



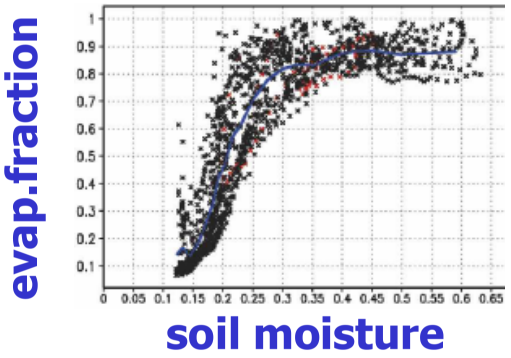


- CTP/HI_{low}
- Koster et al's (2004) coupling coefficient: how much of the precipitation variability is explained by soil moisture variability?
  - goodness of fit by Dirmeyer et al (2005)

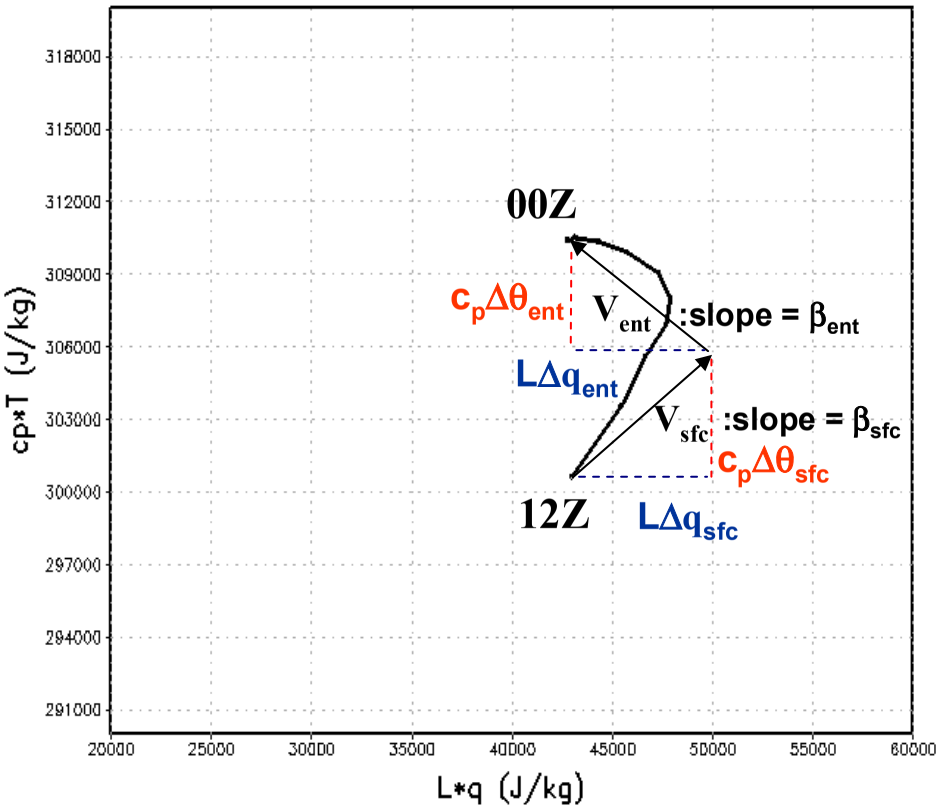


strong soil control

weak soil control



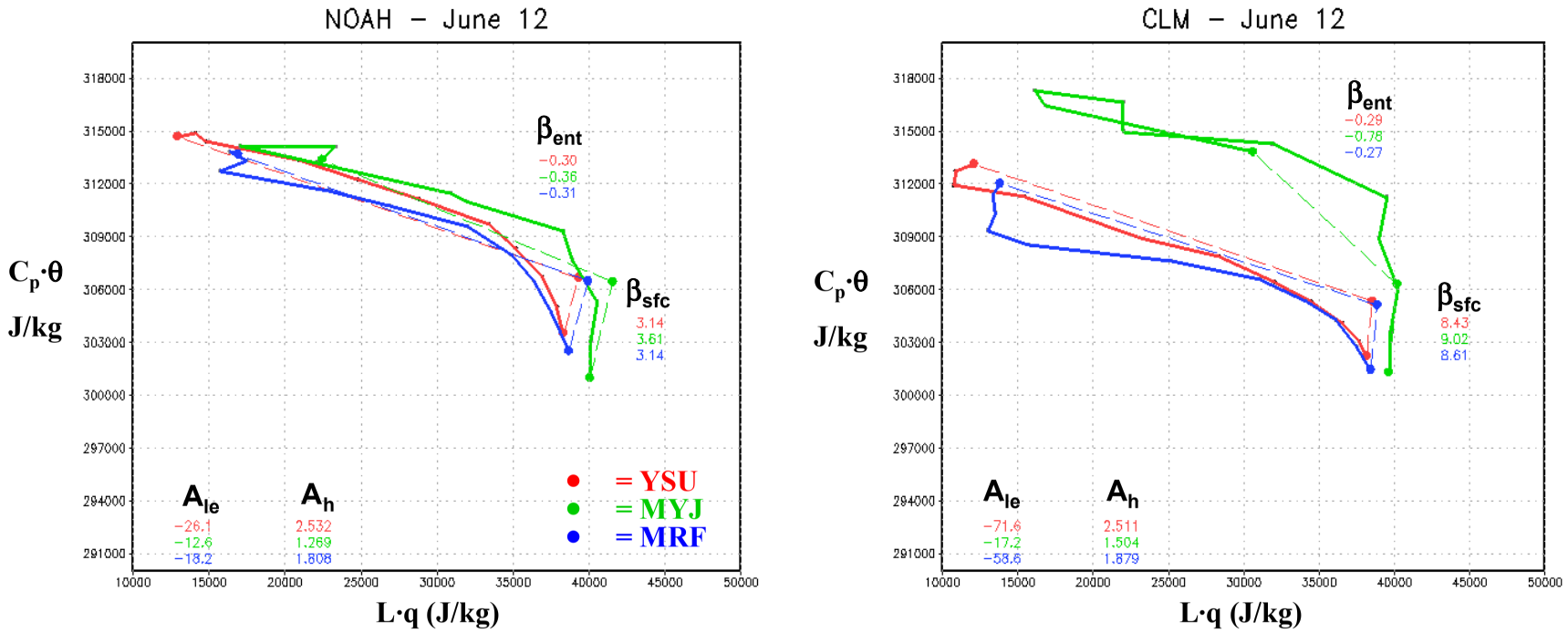
Diagnosing diurnal cycle



One day in June 2002, SGP (IHOP)

Santanello et al, submitted (?)

Application of LIS: Dry Soils

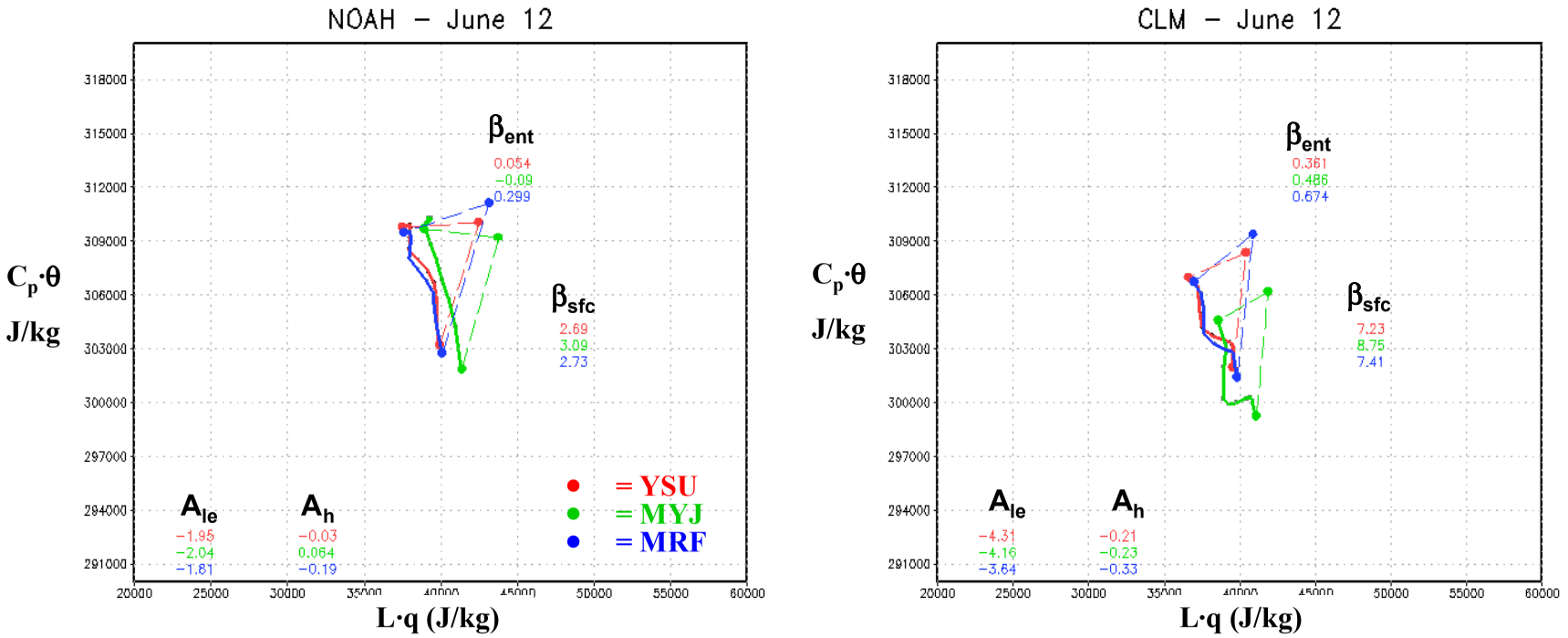


little evaporation and significant dry air entrainment

different LSM gives different correspondence between PBL models

Santanello et al, submitted (?)

Intermediate Soils

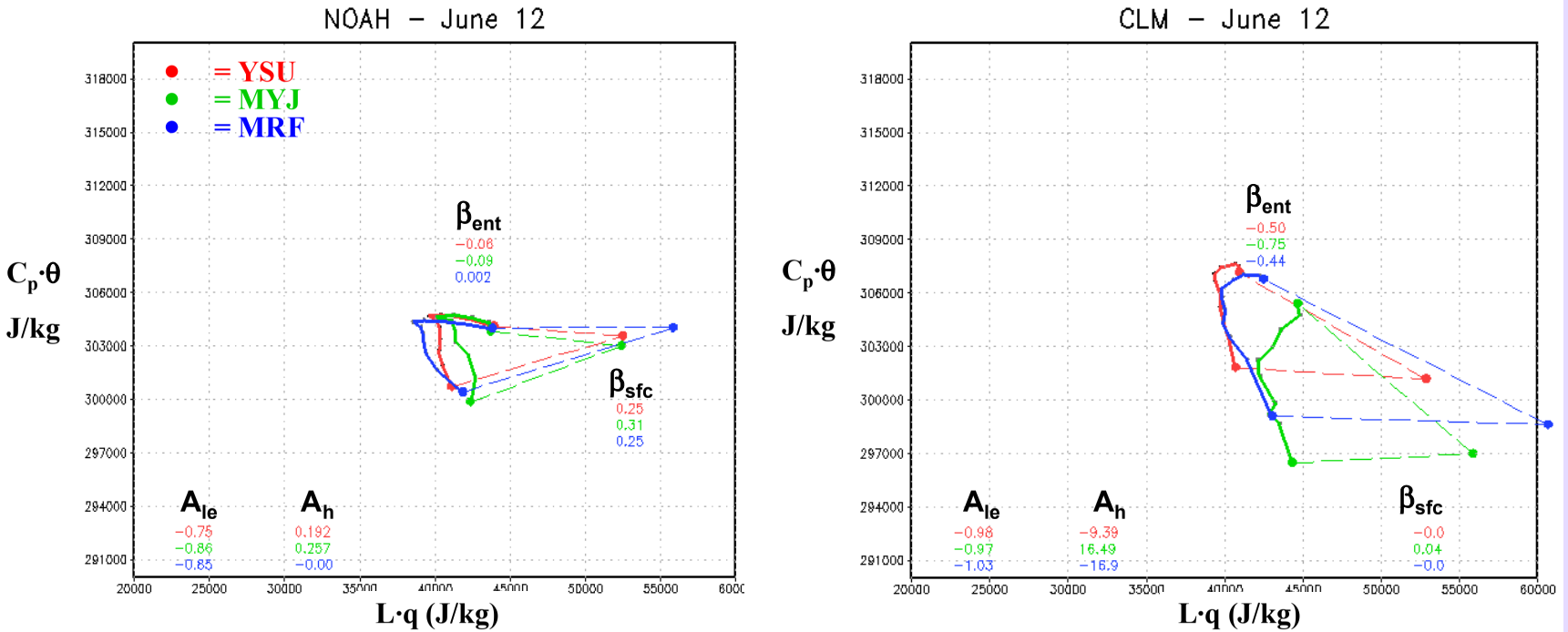


Stronger role of surface fluxes, less entrainment of heat

Drying due to PBL growth ≈ surface evaporation

Santanello et al, submitted (?)

Wet Soils



Moisture fluxes dominant (evaporation + dry air entrainment)

Very little surface heating and PBL growth (< 2.0 km)

Impact of ΔLSM > impact of ΔPBL model

Santanello et al, submitted (?)

Wrap-up
(to be discussed later)

- We can book progress in our models if we
  - let the appropriate parameterizations do the right things
  - can indicate the conditional importance of the land/PBL/convective parameterizations
  - explore observable diagnostics
  - cover a range of locations and time periods
- Good modelling platforms (see later this workshop):
  - LIS (Santanello et al)
  - SCM testbed (Neggers et al)

References

- Charney, J.G. (1975): Dynamics of deserts and drought in the Sahel; Quart.J.R.Met.Soc., 101, 193-202.
- D'Andrea, F., A. Provenzale, R. Vautard and N. De Noblet (2006): Hot and cool summers: multiple equilibria of the continental water cycle; Geophys.Res.Lett. 33, L24807
- Dirmeyer, P.A., R.D. Koster and Z. Guo (2006): Do global models properly represent the feedback between land and atmosphere; J.Hydromet. 7, 1177-1197.
- Ek, M. and A.A.M. Holtslag (2004): Influence of Soil Moisture on Boundary Layer Cloud Development; J.Hydromet 5, 86-99
- Entekhabi, D., I. Rodriguez-Iturbe and R.L. Bras (1992): Variability in large-scale water balance with land surface-atmosphere interaction; J.Climate 5, 798-813.
- Findell, K.L. and E.A.B. Eltahir (2003a): Atmospheric control on soil moisture-boundary layer interactions; Part I: Framework development; J.Hydrometeorol. 4, 552-569
- Findell, K.L. and E.A.B. Eltahir (2003b): Atmospheric control on soil moisture-boundary layer interactions; Part II: Feedbacks within the continental United States; J.Hydrometeorol. 4, 570-583
- Hohenegger, C., P. Brockhaus, C. S. Bretherton and C. Schär (in review): The soil moisture-precipitation feedback in simulations with explicit and parameterized convection
- Koster, R. and CoAuthors (2004): Regions of strong coupling between soil moisture and precipitation; Science, 305, 1138-1140.
- McNaughton, K.G. and T.W. Spriggs (1989): An evaluation of the Priestley and Taylor equation and the complementary relationship using results from a mixed-layer model of the convective boundary layer; IAHS Publ 177, 89-104
- Santanello, J.A., C. Peters-Lidard and Sujay (submitted): A Modeling and Observational Framework for Diagnosing Local Land-Atmosphere Coupling on Diurnal Time Scales
- Taylor, C.M. and R.J. Ellis (2006): Satellite detection of soil moisture impacts on convection at the mesoscale; Geophys.Res.Lett. 33, L03404

Program

Wednesday 25 June - Introduction		
9:30-10:15	Introduction and literature review	Bart van den Hurk
10:15-11:30	Feedback analyses in WATCH	Eleanor Blyth
11:30-12:30	Longterm change in actual and potential evaporation	Jim Shuttleworth
Wednesday 25 June - Observations of local land-atmosphere coupling		
13:30-14:15	Precipitation recycling in Europe	Bernie Bisselink
14:15-15:00	In search of land-atmosphere interactions in satellite derived soil moisture	Richard de Jeu
15:30-17:00	Assessing land-atmosphere coupling over the continental US form space	Craig Ferguson
Thursday 26 June - Diagnostic model studies		
9:00-9:45	The KNMI SCM testbed	Roel Neggers
9:45-10:30	Characterizing local land-ABL coupling with a single column model	Mike Ek
11:00-12:30	The Land Information System (LIS)	Joe Santanello
Coupling mechanisms derived from observational/modelling studies		
13:30-15:00	Land-atmosphere coupling in West Africa	Chris Taylor
15:30-17:00	Land-atmosphere coupling mechanisms with a potentially large scale impact	Stefan Hagemann
Friday 27 June - Spatial distribution of coupling strength		
9:00-10:30	Present day conditions	Randy Koster
11:00-12:00	Future conditions	Sonia Seneviratne
Conclusion		
12:00-13:00	Wrap up	Eleanor Blyth

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