Some Thoughts on Assessing the Impacts of CABLE on Variability and Predictability Simulated by ACCESS

or

ACCESS **M**ulti-lss' **I**mpacts on **P**redictability **(AMIP)**

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For the ACCESS AMIP workshop (30 October 2008)

The current/potential facility to be offered by ACCESS

- UM with Met Office Surface Exchange Scheme (MOSES) through implicit PBL-LSM coupling

- Eva Kowalczyk (& others) is towards success in replacing MOSES with CSIRO Atmosphere Biosphere Land Echange (CABLE) through modified PBL-LSM coupling (explicit multi calls)

Aims of the proposed study is to examine IF & HOW:

1. Soil storage of water and heat leads to some slow-varying and-surface processes which could affect ACCESS variability and predictability at monthly and longer scales;

2. The land-air coupling strength in ACCESS (and other global models), i.e. the magnitudes and locations “hot spots” as identified by Koster et al. (2004), is influenced by the approaches used in coupling LSS with PBL.

Scientific Relevance:

- CliVAR recognizes the role of land-surface in global variability and predictability
- GLACE (GEWEX Land-Atmosphere Coupled Experiments) results from Koster et al. showed (a) strongest land-air coupling occurs in the transition zone (from wet to dry climate) ~ semi-arid climate as we are in; (b) large inter-model difference

So the fundamental questions are :

- What determines the strength of land-air interactions: Lss, PBL; Lss-PBL; convection etc?
- Which atmospheric processes and/or land-surface processes are important: fluxes, soil moisture, PBL mixing, convection trigger/fueling etc?

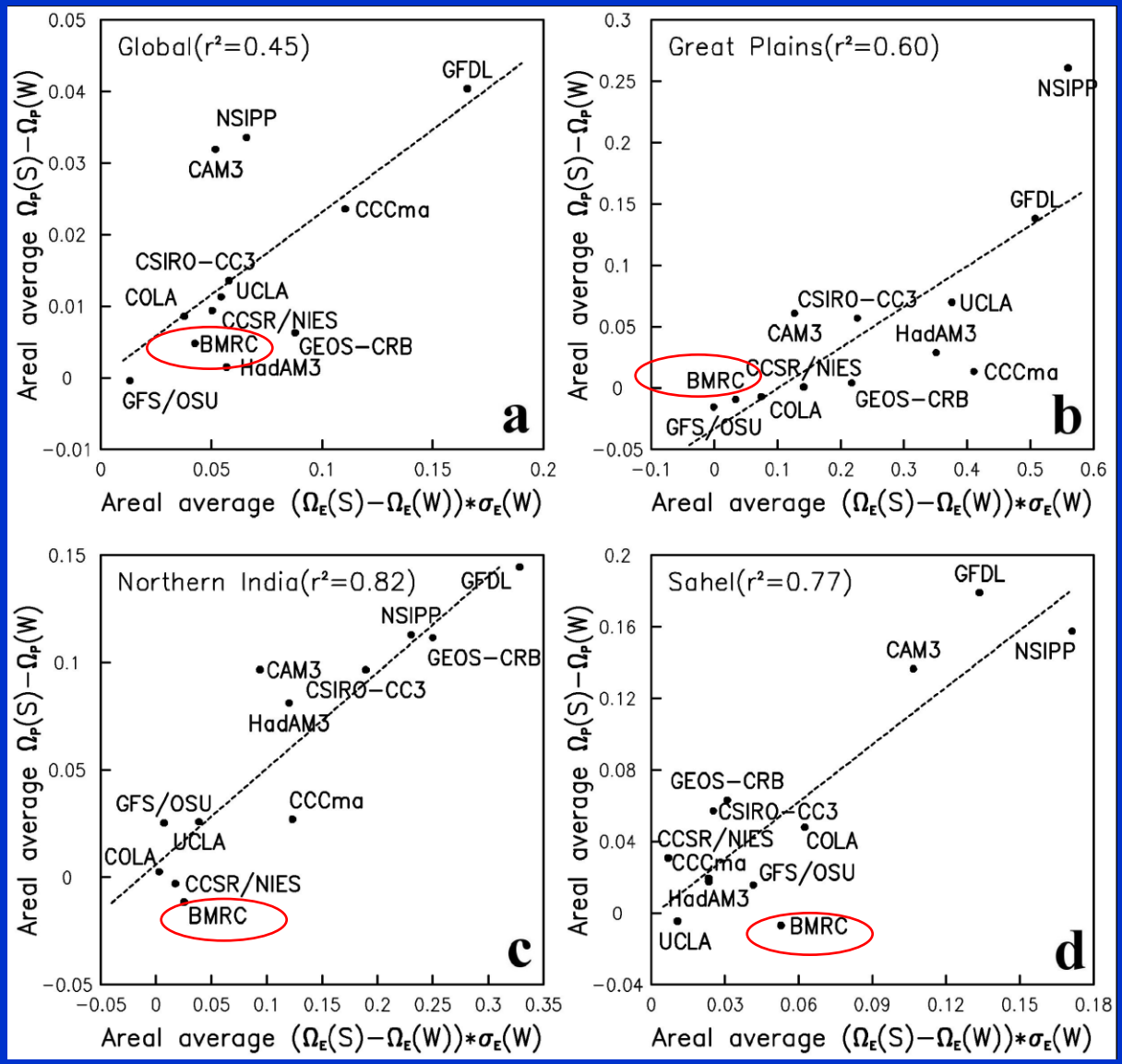
Lessons learnt from the past

1. Old BAM dynamical seasonal forecasting experiments using two different soil moisture initial conditions: one with climatology and the other used normalised reanalysis product (Zhang and Frederiksen 2003);
2. Impacts of different coupling methods in BAM-ECLSS on the model mean climate

Remember, this model had very very weak land-air coupling strength from its GLACE experiment!

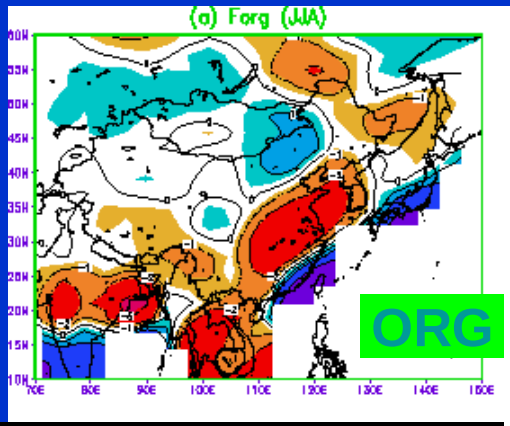
BAM

Coupling strength

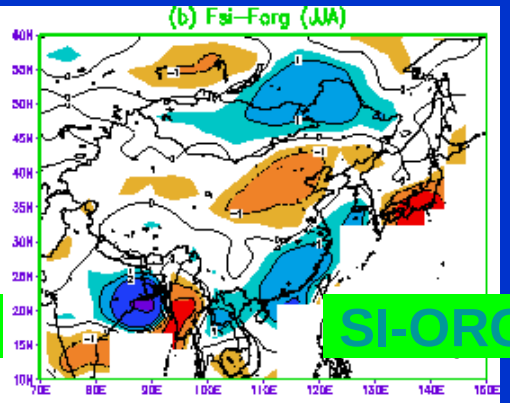


Results from GLACE experiments (Koster et al., 2006)

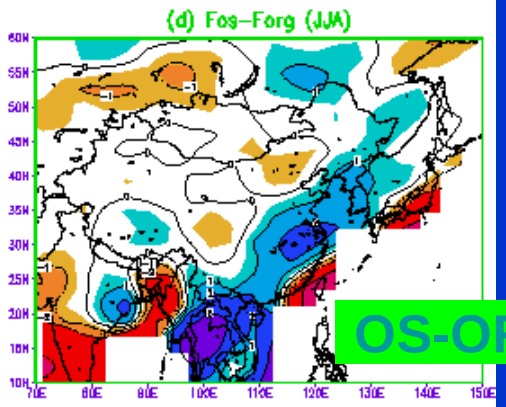
BAM experiments of 1998 floods in China



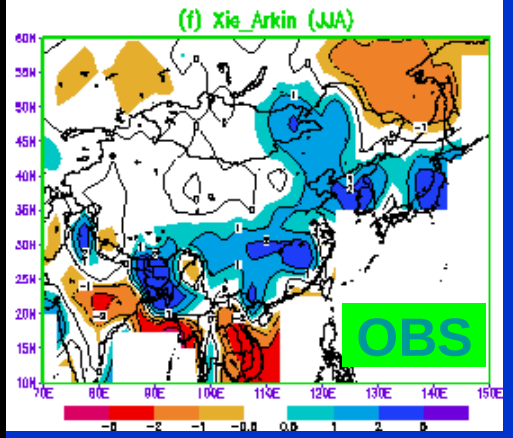
ORG



SI-ORG



OS-ORG



OBS

ORG: The model failed in forecasting the flood in the Yangtze River region but picked up the floods in Northeast.

SI: Using derived soil moisture anomalies increases rainfall over two Chinese flooding regions.

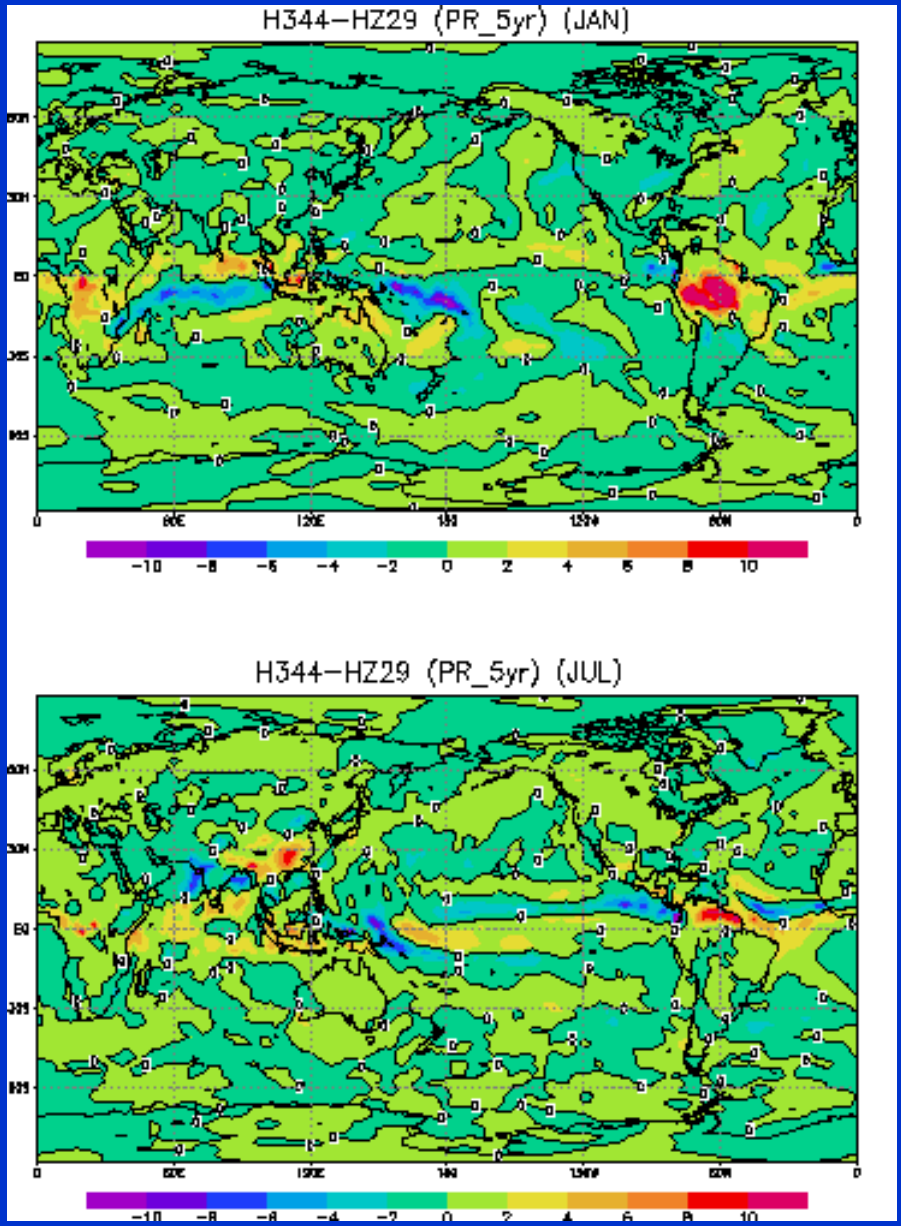
OS: Forcing the model with realistic SST anomalies improves forecasts of flood in the south.

BAM experience with LSS-PBL coupling

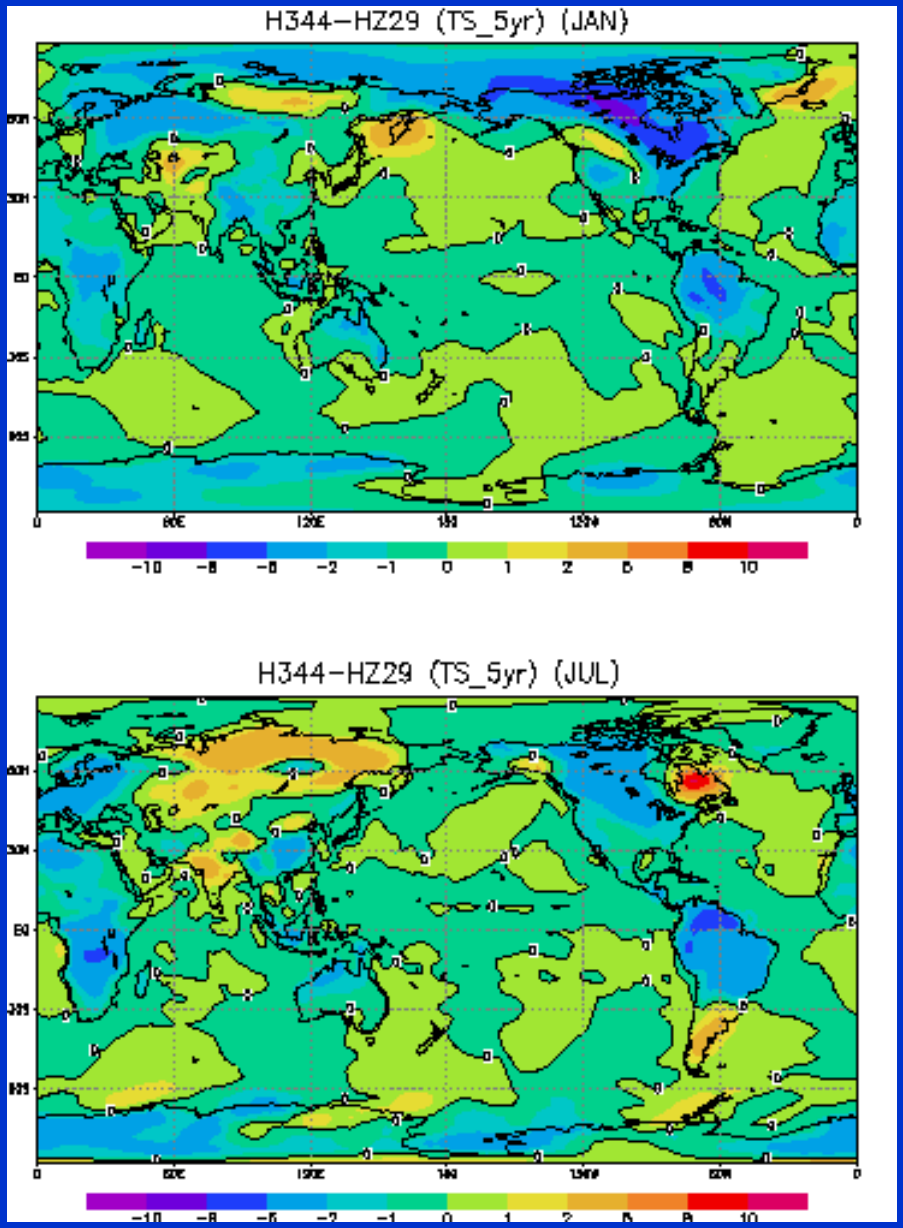
A version of BAM with ECLSS showed large dry and warm biases over land.

Experimental exercises by changing its ECLSS-PBL coupling showed huge impacts:

Dry bias over tropical land reduced.



warm bias reduced too



Therefore: the current ACCESS set-up gives us good opportunity to

- revisit these important issues for better understanding of climate variability and predictability in the system;
- this also has close associations with climate change, as studies such as Seneviratne et al(2006; Nature) suggesting land-air coupling hot-spots could vary with global warming.

What we can do:

1: Be part of the games such as GLACE. We can start to design and conduct some GLACE-type experiments for UM-MOSES; UM-CABLE; UM-MOSES (similar coupling as done for CABLE)

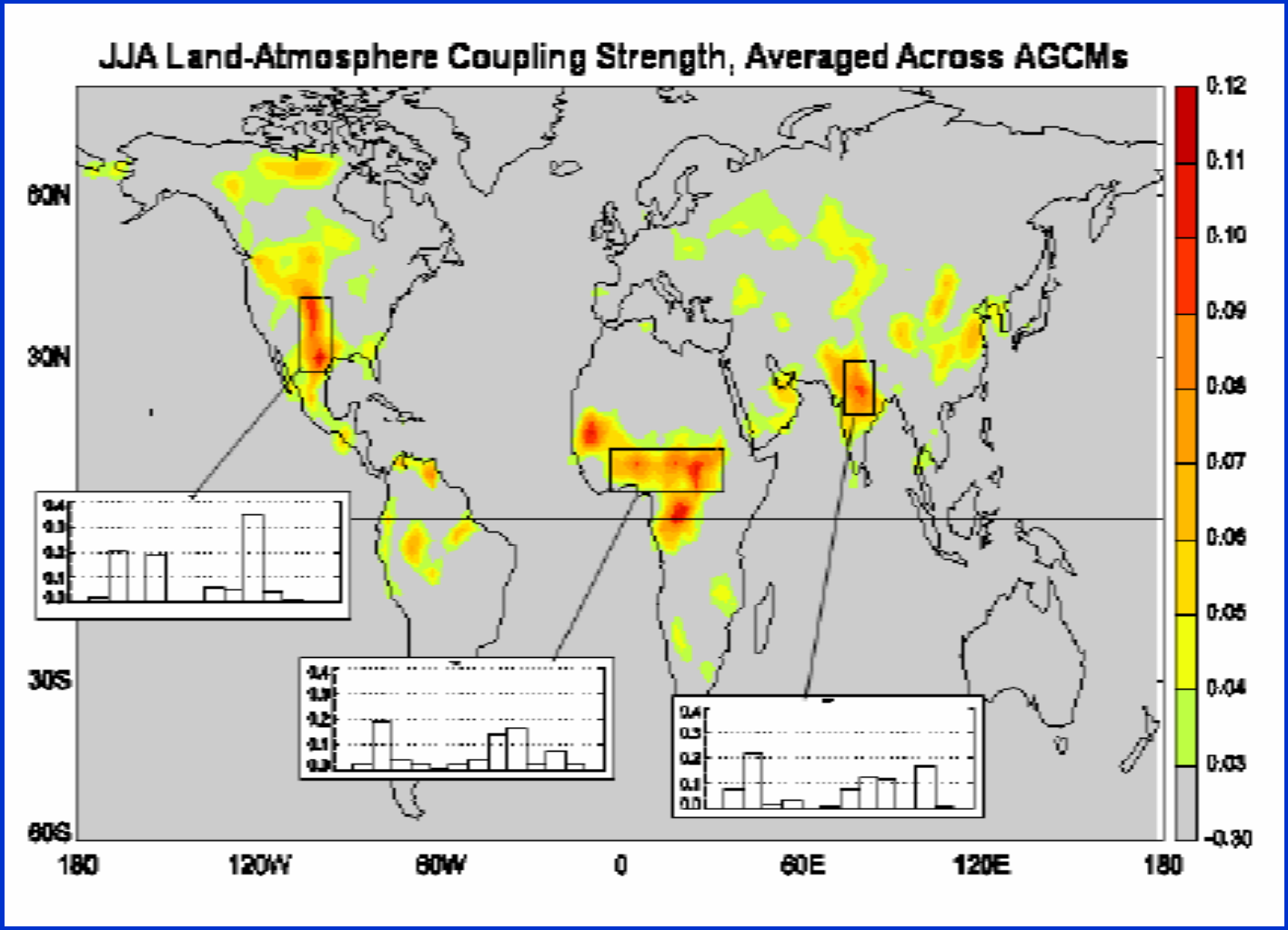
+ Eva Kowalczyk had GLACE experience (CCAM) & coupling expertise;

- Need conducting large number of experiments requiring decent IT and scientific support – competing for resource needed for fully implementing & refining UM-CABLE; importance not fully appreciated …

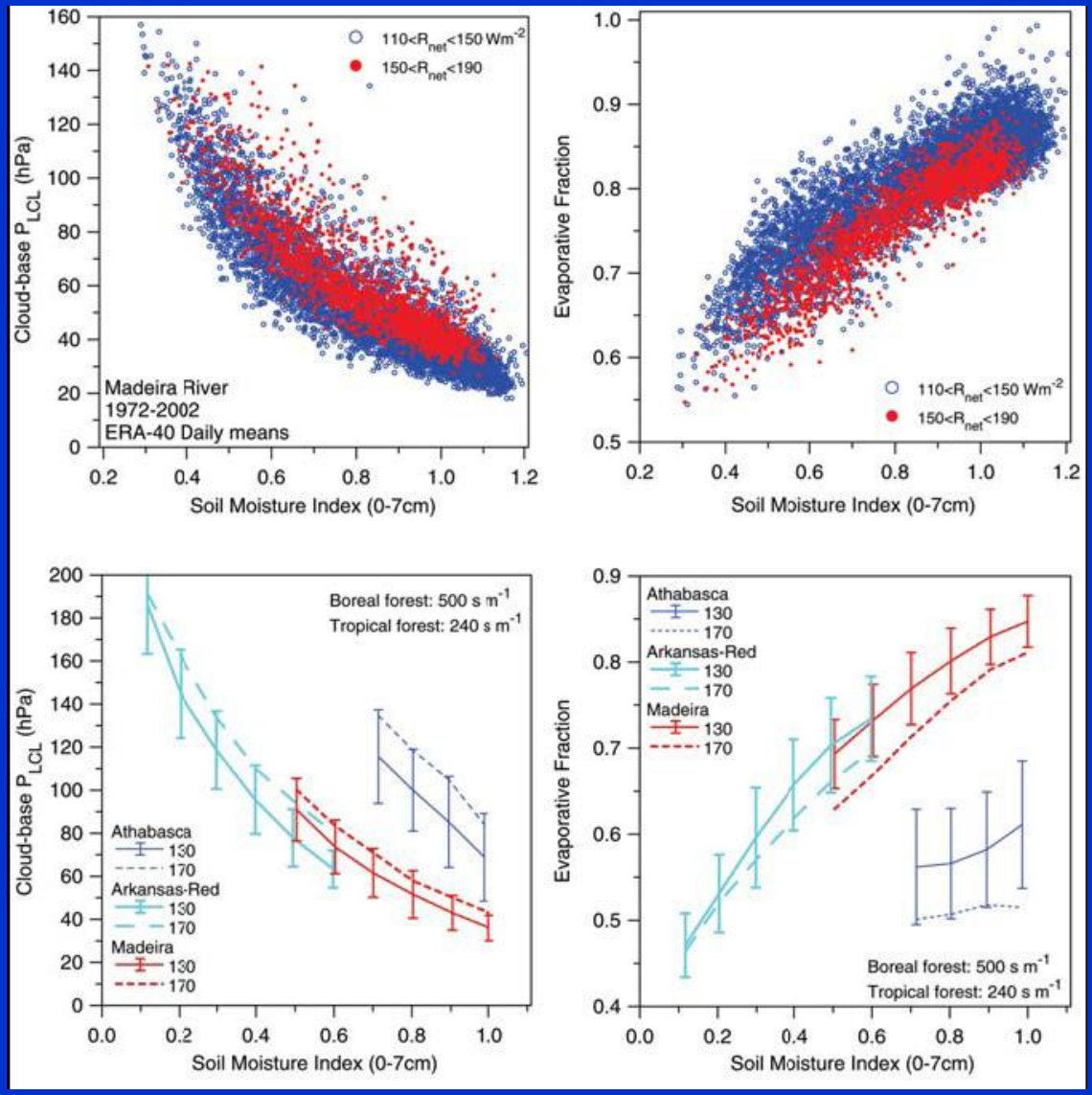
2: Use some new approaches for studying land-surface feedbacks

- GLACE's experimental design and analytical approaches
- Alan Betts's analysis on soil moisture; PBL, lifting condensation level (LCL) and clouds
- Diagnosis of land-surface on triggering and fuelling convection, together with SCM etc

3: In a systematic consideration: Offline ~ SCM ~ AMIP ~ CMIP



GLACE's framework diagnoses the coupling strength in climate models and can help to attribute and improve forecasting skills



Betts' framework diagnoses the linkages between soil moisture, surface flux, PBL, PBL clouds, surface energy balance

Likely Outcomes:

- ✓ Help to understand ACCESS behaviours when MOSES is replaced by CABLE in ACCESS;
- ✓ Help to explain some of the large inter-model differences in the GALCE-type experiments;
- ✓ Help to identify and quantify contributions of land-surface in climate variability and predictability in the region such as:
  - are some of the different ENSO flavours coming from land?
  - where should more land-surface observation and assimilation be?

Any comments and interests send to: h.zhang@bom.gov.au

Original BAM ECLSS_PBL coupling: fully implicit

In PBL

$$\psi_1^{t+1} = A\psi_1^{t-1} + B(\psi_1^{t+1} - \psi_s^{t+1}) \quad \text{leading to:} \quad \psi_1^{t+1} = A\psi_1^{t-1} + B\psi_s^{t+1}$$

In LSS

$$F_\psi^{t+1} = \rho C_d U(\psi_1^{t+1} - \psi_s^{t+1}) \quad \text{surface flux}$$

In PBL solving surface energy balance

$$R_s + R_l + F_T^{t+1} + F_q^{t+1} = \Delta(T_s^{t+1} - T_{g1}^{t-1})$$

$$F_q^{t+1} = L\rho C_d(\alpha q_1^{t+1} - \beta q_s^{t+1}) \quad \text{and linearizing} \quad q_s^{t+1} = q_s^{t-1} + \frac{\partial q_s}{\partial T_s}(T_s^{t+1} - T_s^{t-1})$$

SO:

$$R_s + R_l + A_T T_1^{t-1} + B_T T_s^{t+1} + A_q q_1^{t-1} + B_q T_s^{t+1} = \Delta(T_s^{t+1} - T_{g1}^{t-1})$$

and now you got Ts for t+1 and then backward substitute for PBL t+1

In this case, LSS is called in between PBL calculations

Testing EC LSS_PBL coupling: semi-implicit calculations

In PBL

$$\psi_1^{t+1} = A\psi_1^{t-1} + B(\psi_1^{t+1} - \psi_s^{t-1}) \quad \text{leading to}: \ \psi_1^{t+1} = A\psi_1^{t-1} + B\psi_s^{t-1}$$

In LSS

$$F_\psi^{t+1} = \rho C_d U(\psi_1^{t+1} - \psi_s^{t+1}) \quad \text{surface flux}$$

In solving surface energy balance $R_s + R_l + F_T^{t+1} + F_q^{t+1} = \Delta(T_s^{t+1} - T_{g1}^{t-1})$

$$R_s + R_l + A_T T_1^{t-1} + B_T T_s^{t+1} + A_q q_1^{t-1} + B_q T_s^{t+1} = \Delta(T_s^{t+1} - T_{g1}^{t-1})$$

In this case, PBL and LSS are separated. Such coupling was used before in EC and ECHAM.