Diurnal cycle Coupling Experiment (DICE)

GLASS + GASS joint project

Martin Best and Adrian Lock
Local Land-Atmosphere Interactions

incoming solar

above-ABL dryness

cloud cover

above-ABL stability

downward longwave

precipitation

entainment

boundary-layer growth

turbulence

relative humidity

temperature

sensible heat flux

emitted longwave

reflected solar albedo

moisture flux

canopy conductance

soil moisture

soil heat flux

soil temperature

*positive feedback for C3 & C4 plants and negative feedback for CAM plants for incoming solar; negative feedback above optimal temperatures

positive feedback

negative feedback

land-surface processes

surface layer & ABL

radiation

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Courtesy of Mike Ek
GLACE “hotspot” regions

Land-atmosphere coupling strength (JJA), averaged across AGCMs

Outline of the 3 stages of DICE

Stage 1
- LSM
- Observations
- SCM

Stage 2
- LSM
- SCM

Stage 3
- SCM
- LSM

LSM and SCM stand-alone performance against observations
What is the impact of coupling?
How sensitive are different LSM and SCM to variations in forcing?
• Field experiment in Kansas, USA
• We follow Steeneveld et al (2006)
  • 3 day simulation from 2pm local time on 23\textsuperscript{rd} October 1999
  • Recall GABLS II ran for from 2pm on 22\textsuperscript{nd} for 2.5 days
• Clear skies throughout
• Gives 3 nights of varying character
  • intermittent turbulence
  • continuous turbulence
  • very stable, almost no turbulent fluxes
Experimental protocol

LSM
- Soil spin-up:
  - 9 years from saturated using WATCH forcing data
  - 10th year forcing data from local site
- Two stage 1a experiments with forcing from 2m and 55m
- Stage 3a LSM experiments forced with stage 1b SCM data interpolated to 20m

SCM
- Large-scale forcing:
  - Time-varying geostrophic wind (uniform with height)
  - Large-scale horizontal advective tendencies for T, q, u, v estimated from a simple budget analysis of the sondes
  - Subsidence for T, q
- No relaxation
  - Radiation switched on in all simulations
- SCM in stage 1b use observed sensible and latent heat fluxes and u. (either directly or via $c_D$)
- Stage 3b SCM experiments forced with stage 1a LSM surface fluxes
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A challenging surface?
October grass was largely dead
Rain in September left soil moist
Excessive evaporation a feature of the first round of DICE
SCM grids

- Solid lines = control model
- Dotted/dashed lines = experiment
- Lowest grid-levels range from 1.5m to 85m
Stage 1a
Surface fluxes from 55m-forced LSMs

Round 1 data
Round 2 data

Remember these will be the SCM surface fluxes in Stage 3b

Not all LSM provided u.
(not compulsory under ALMA convention)
Stage 1b near surface evolution
SCM driven by observed surface fluxes

20m

55m
Stage 1b vs 2
Bulk PBL sensitivity (variables at 55m)

- More spread between coupled models in stage 2 than stand-alone SCM in stage 1b
  - More degrees of freedom
  - Moisture more sensitive than temperature?

Stage 1b

Stage 2
Stage 1b vs 2
Bulk PBL depth sensitivity

- Some suggestion that PBL depth is less sensitive when coupled

Stage 1b

Stage 2

PBL depth calculated as where $Ri_B=0.25$
Stage 1a vs 2
Surface fluxes

- Similar surface fluxes from LSMs when coupled to their SCM, despite differences in atmospheric moisture
  - to be confirmed from stage 3a
Stage 3b Daytime PBL sensitivity for 25th Oct
DICE: summary so far

- Simple case (clear skies, no precipitation, homogeneous surface) but still a challenge for models
- Climatological vegetation in LSMs can lead to large errors in evaporation
  - This dominated any signal of the impact of coupling in first round
  - Second round those LSMs that needed to constrained evaporation (adjusting LAI, root depth, bare soil behaviour)
  - Further discussion/developments are required to establish the best way to improve models
- Early results indicate interesting differences in different models’ sensitivity to changes in forcing that are likely to be important in GCMs and need to be understood
- Further analysis and DICE discussions at the GEWEX conference, 14-17th July 2014

More details at http://appconv.metoffice.com/dice/dice.html