GABLS-4 : GEWEX Atmospheric Boundary Layer Study

SCM/LSM and LES intercomparison at DomeC (Antarctic Plateau)

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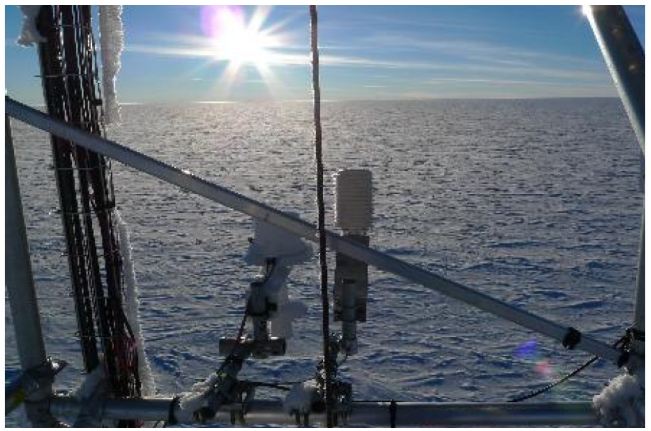


http://www.umr-cnrm.fr/aladin/meshtml/GABLS4/GABLS4.html

GABLS4: "DICE-over-ice"

Project started in 2015 to *study the interactions between the ice/snow-surface & atmospheric boundary layer under conditions of strong stability*.

Leads: E. Bazile, F. Couvreux, P. Le Moigne (Météo-France)

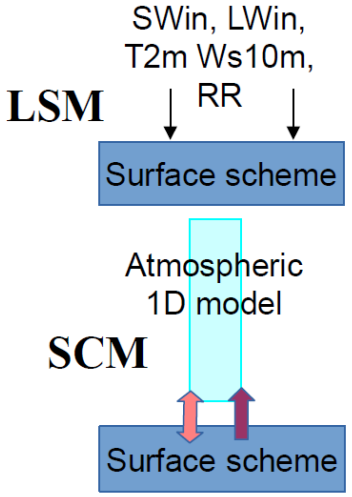
Dome C - Antarctica (Southern Great Plains, USA)

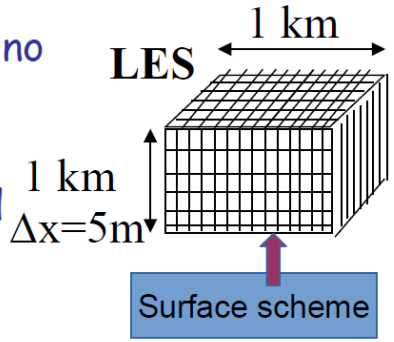
- Joint activity between GLASS and GASS.
- Several models/centers participating.
- Follow-on to earlier GABLS studies with focus on very stable conditions, and a surface with low conductivity and high cooling potential over snow/glacier, and following the earlier DICE experimental design, as well as including LES studies.
- Initial results presented at GABLS4-DICE Workshop, 20-22 May 2015, Météo-France.

http://www.cnrm.meteo.fr/aladin/meshtml/GABLS4/GABLS4.html

GABLS4: Case setup

- **Stage 0:** LSM (snow scheme) driven by observations for 15 days
- **Stage 1:** SCM with all the physics and surface interaction: 36h forecast starting the 11th Dec 2009
- **Stage 2:** LES and SCM, stage1 atmospheric forcing but the surface temperature is prescribed.
- **Stage 3**: LES and SCM. "ideal GABLS4" or simplified: no radiation, no specific humidity, constant geostrophic wind, no advection, Ts prescribed.
- Can we use stage3 with the LES results to understand the SCM deficiencies in stage2 and 1 ?





- 16 SCM participants
- 9 LES participants
- 7 LSM participants

GABLS4: Preliminary results

- The different sets of forcing of the SCM has been run to understand the model variability
- The more idealized SCM simulations show more consistency with tower observations than running with model specific surface properties (e.g. surface roughness and albedo)
- LES results show relative good agreement during convective conditions and large differences during night that likely are related to the subgrid scale schemes

Larcform 1:
The first Lagrangian Arctic air formation experiment

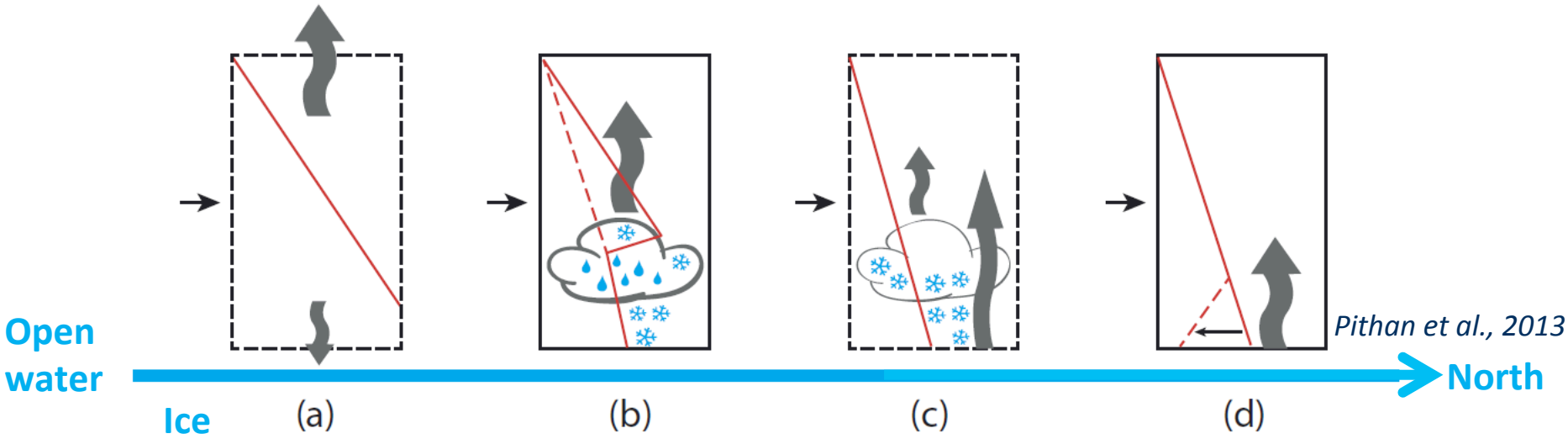
Motivation:

Climate models have large biases in surface fluxes and representing the inversions

Involves a suit of parametrisations and their interactions

Overview:

This idealized case examines how the airmass is transformed when warm and moist air is advected in over sea-ice



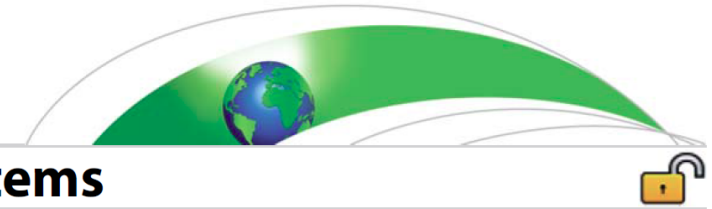
Pithan et al., 2013

GASS GEWEX WCRP Global Atmospheric System Studies

Larcform 1:
The first Lagrangian Arctic air formation experiment

AGU PUBLICATIONS

Journal of Advances in Modeling Earth Systems



RESEARCH ARTICLE

10.1002/2016MS000630

Key Points:

- A Lagrangian-style single column model experiment can reproduce Arctic air mass formation
- Model deficiencies are caused by mixed-phase microphysics, process interaction, and surface representation
- Lagrangian, i.e., air mass-following observations would allow for a tighter constraint on model behavior

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Select strengths and biases of models in representing the Arctic winter boundary layer over sea ice: the Larcform 1 single column model intercomparison

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Planned activities during 2017

- 1-day GABLS 4 LES workshop in Delft, Netherlands, in the international workshop on "Turbulence in Stably Stratified planetary boundary layers", March 27th – 31st, 2017
- Write-up of SCM and LES results for GABLS4
- Workshop GALBS and WWRP PPP YOPP to discuss continuation of Larcform and other possible SCM & LES studies to aid model development in polar regions

BACKGROUND: Diurnal land/atmosphere coupling experiment (DICE-1)

Project started April 2013 to *study the interactions between the land-surface & atmospheric boundary layer*.

- Leads: Adrian Lock, Martin Best (UKMO).
- Joint activity between GLASS (land-surface modellers) and GASS (atmospheric boundary-layer modellers).
- 12 models participating.
- Follow-on to GABLS-2, where land-atmosphere coupling was identified as a important mechanism.

CASES-99 Experiment (Southern Great Plains, USA)

Workshops:

- 1st: 14-16 Oct 2013, UK Met Office.
- 2nd: 14-18 Jul 2014, GEWEX conf./Neth.
- 3rd: 20-22 May 2015, Météo-France.

Manuscript in preparation (for JHM).

GASS GEWEX WCRP Global Atmospheric System Studies

http://appconv.metoffice.com/dice/dice.html

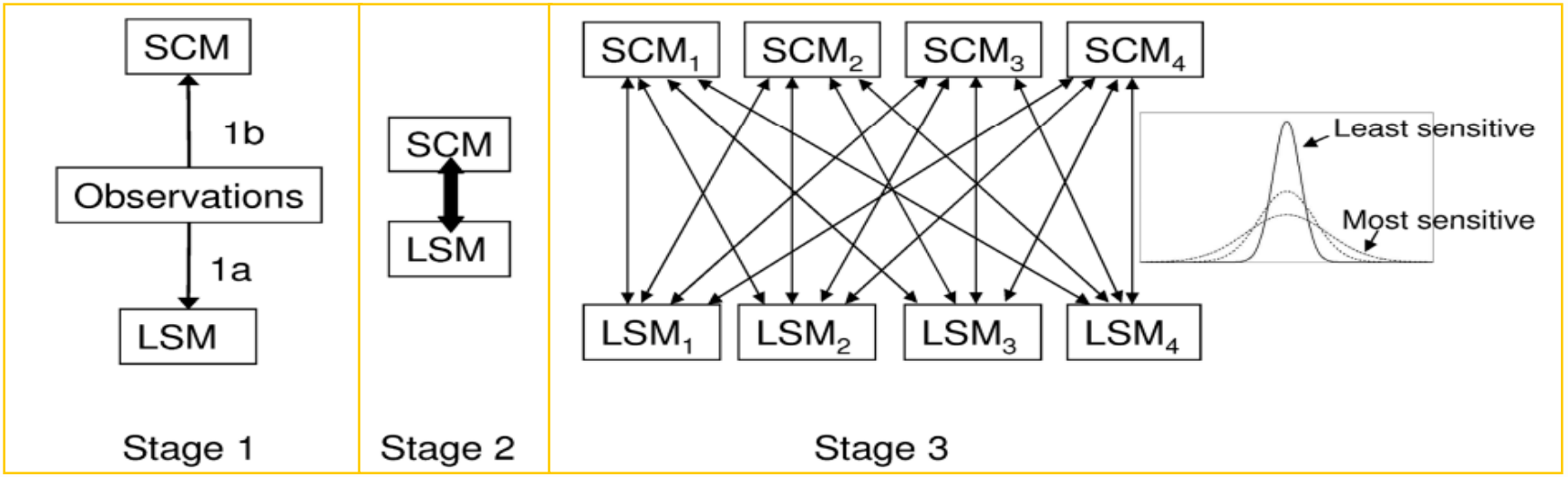
DICE-GABLS: Participants/Institutes/Contributions

Model	Contact scientist	Institute	Stages submitted	Levels	Sensitivity tests
Arome	Eric Bazille	Meteo France	All	60/70	resolution
Arpege	Eric Bazille	Meteo France	All	60/70	resolution
ECEARTH	Reinder Ronda	Wageningen	SCM only	91	LAI
GDPS3.0	Ayrton Zadra	CMC	All	79	
GFDL	Sergey Malyshev	Princeton	All	24	
GISS_E2	Ann Fridlind, Andy Ackerman	GISS	All	40	
IFS/HTESSEL	Irina Sandu, Gianpaolo Balsamo	ECMWF	All	137	LAI
MESO_NH	Maria Jimenez	UIB	All	85	Bare soil
UM/JULES	Adrian Lock, Martin Best	Met Office	All	70	Vegetation
WRF-NOAH	Weiguo Wang	NUIST	All	60	Lots!
WRF	Wayne Angevine	NOAA	?	119	PBL scheme
CAM5, CLM4	David Lawrence	NCAR	1a, 1b	?	
PBCM	Pierre Gentine	Columbia	Not yet		

DICE Experimental Design

Objective: Assess impact of land-atmosphere feedbacks.
Stage 1: stand alone land, and single column model (SCM) alone.
Stage 2: Coupled land-Single Column Model (SCM).
Stage 3: Sensitivity of LSMs and SCMs to variations in forcing.

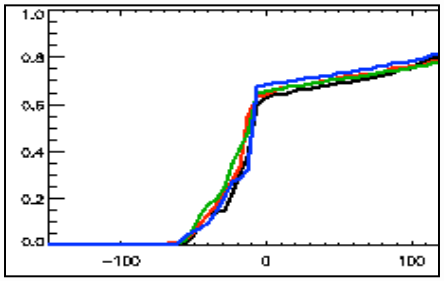
Data Set: CASES-99 field experiment in Kansas, 23-26 Oct 1999 using 2.5 days and 3 nights with intermittent turbulence (night one), continuous (two), radiatively-driven/no turbulence (three).

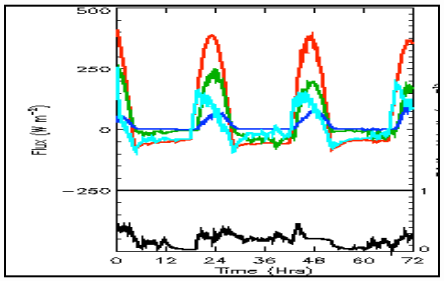


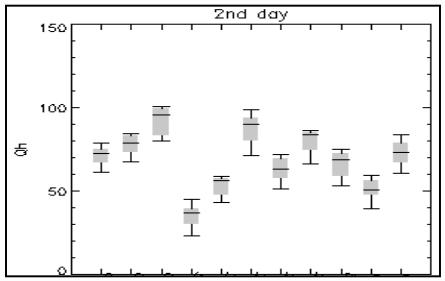
Martin Best and Adrian Lock (UKMO) et al.

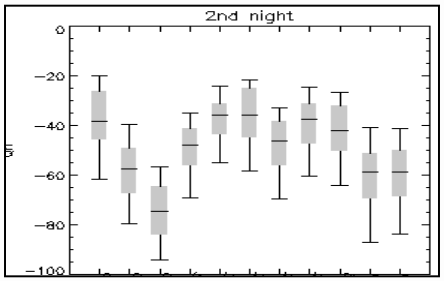
DICE Status/Summary

- 12 pages and 80 figures of results for stages 1, 2, 3!
- 9-year spin-up for LSMs.
- SCM: no relaxation of time-varying geostrophic wind (uniform with height); subsidence of T,q; horizontal advection of T,q,wind; radiation switched on in all simulations.
- Stage 1a (LSM): LHF generally far too large (LSMs didn't account for dead grass, adversely affecting bowen ratio); SHF and stress too large at night; 55m forcing too high for LSMs (vs 10m) especially for stable nighttime conditions.
- Stage 1b (SCM): Difficulty with wind profiles, particularly 1st night (intermittent turbulence); large differences in daytime parameterized entrainment; potential inaccuracy of (prescribed) large-scale forcing; SCM generally can be forced by observed fluxes and stresses.





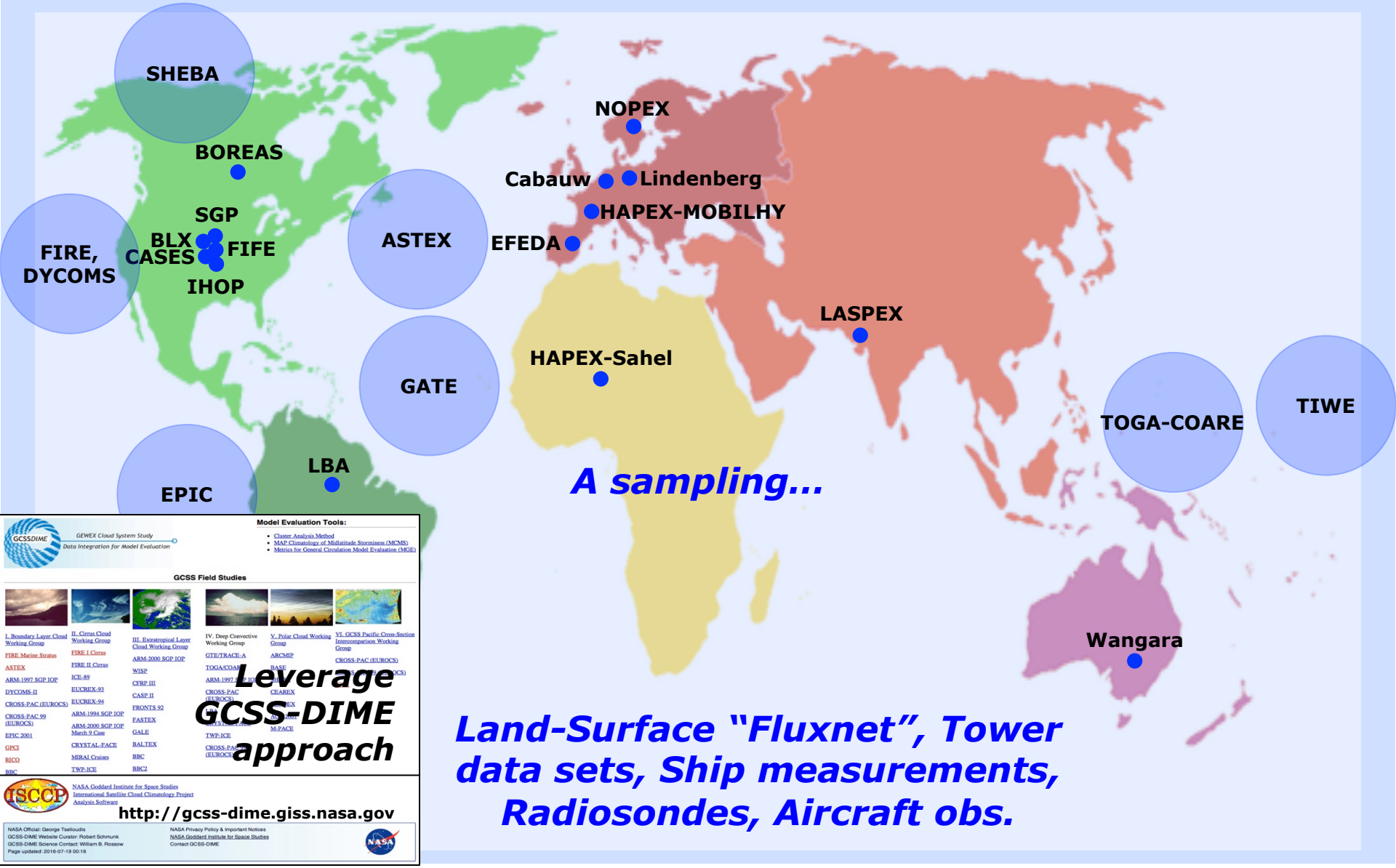




DICE Status/Summary (page 2)

- Stage 2 (LSM+SCM): excessive drag from LSMs generate deeper/less stratified SBLs; soil-surface coupling sensitivity at night; daytime PBL differences dominated by LSM surface fluxes, with RH dominated by SHF; more spread in PBL moisture; daytime PBL temperature evolution a “slave” to surface fluxes with PBL moisture more complicated.
- Stage 3a (LSM ensemble spread due to PBL variability forcing): largest variation in SHF during day & at night for more continuous turbulence.
- Stage 3b (PBL ensemble spread due to LSM variability forcing): day-time PBL: T, q dominated by sfc fluxes with variability between different SCMs similar, but sensitivity of inversion height very different.
- *Summary: surface momentum flux and momentum profiles should be examined by DICE community; large errors in evaporation may dominate signal and the impact of coupling; further examine nocturnal fluxes and boundary layers and soil-surface coupling sensitivity.*
- *Repeat for many other sites (DICEs), e.g. GABLS project for Antarctica: GABLS4 or “DICE-over-ICE” (next page).*
- *Differences in different models’ (LSM+SCM) sensitivity to changes in forcing are likely important in GCMs; needs to be better understood.*

Possible Future DICE efforts: *Field Programs for Model Physics Development, Surface-Atmosphere Interaction (land, ice, even ocean)*



Leverage GCSS-DIME approach

Land-Surface "Fluxnet", Tower data sets, Ship measurements, Radiosondes, Aircraft obs.