BEHAVIOR OF WRF PBL SCHEMES AND LAND-SURFACE MODELS IN 1D SIMULATIONS DURING BAMEX

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OUTLINE

- Justification/Motivation
- Model/Experiment design
- Comparison of simulations with BAMEX observations
- Conclusions

Justification/Motivation

Why use 1D “WRF-like” PBL model ?

- Economical way to compare how PBL parameterization and land-surface models perform relative to each other under variety of atmospheric conditions.
- Study interaction of BL schemes with LSMs in isolation from other processes and detect problems.
- 1D models in general prove useful for nowcating (0-12 hours).
- Possibly provide guidance on PBL biases observed in 3D WRF.
- Possibly provide guidance on best suites of parameterizations…

- The present model is coupled to an ensemble (filter) data assimilation system (DART) and can be download http://www.image.ucar.edu/DAReS/DART/Iceland_release.html

Experiment design

- Dynamics

$$\frac{\partial u}{\partial t} = f\left(v - V_g\right) - \frac{\partial}{\partial z}\left\langle u' w' \right\rangle,$$

$$\frac{\partial v}{\partial t} = -f\left(u - U_g\right) - \frac{\partial}{\partial z}\left\langle v' w' \right\rangle,$$

$$\frac{\partial \theta}{\partial t} = -\frac{\partial}{\partial z}\left\langle w' \theta' \right\rangle,$$

$$\frac{\partial q}{\partial t} = -\frac{\partial}{\partial z}\left\langle w' q' \right\rangle.$$

- Full suite of WRF land surface, surface layer and PBL parameterizations (plus additional options).
- Interface between dynamics and physics same as in WRF.

Experiment design

- 12h simulations initialized at 1130z (0530LST, daytime) and 2330z (1730LST, nighttime) with atmospheric and soil profiles observed at ARMP site
  - wind
  - temperature
  - mixing ratio
  - soil temperature and moisture.

- External forcing from observations and RUC analyses
  - geostrophic wind (analysis)
  - shortwave/longwave radiation (observations)
  - precipitation (observations)
  - sensible and latent fluxes (observations).

Experiment design

- PBL parameterizations (first letter in figures)
  - YSU (a)
  - MRF (b, not shown)
  - MYJ (c).
- Surface parameterizations (second letter in figures)
  - Noah LSM (a)
  - RUC LSM (b)
  - FRB (c, not shown)
  - None - measured fluxes (d).

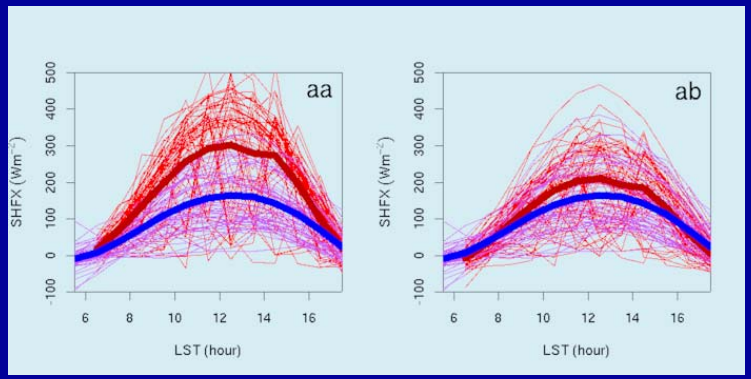
Daytime

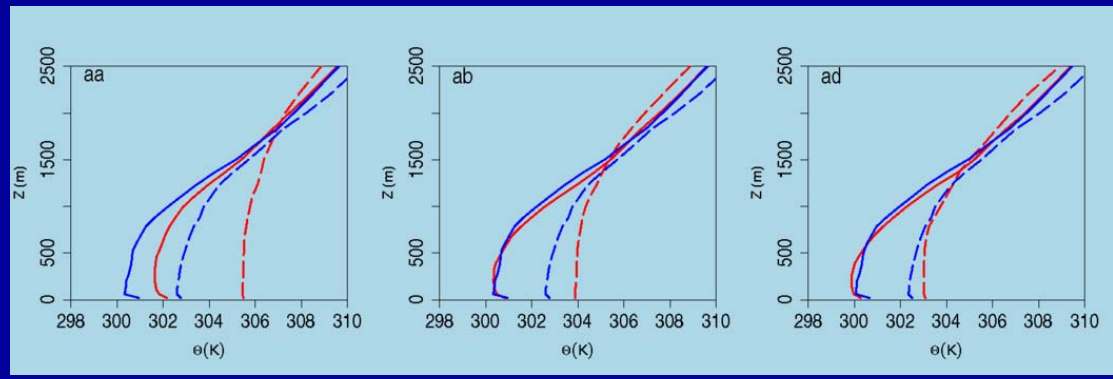
sensible heat flux

Averaged vertical profiles potential temperature

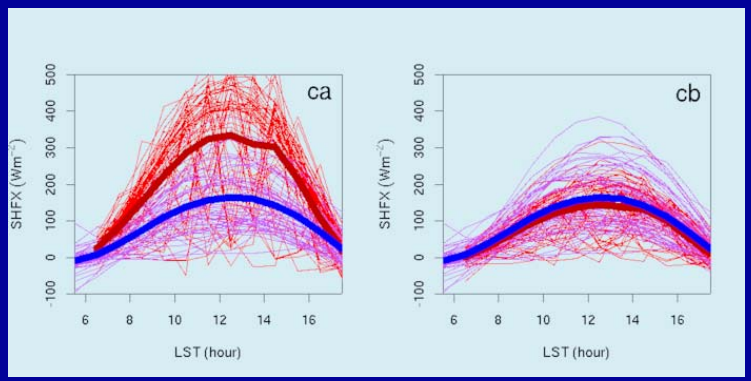
Noah RUC Noah RUC Obs

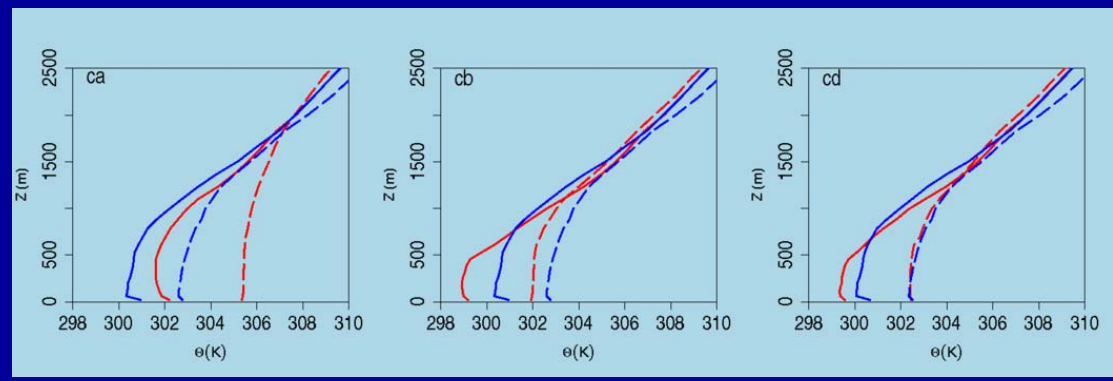
YSU





MYJ





purple thin – obs, blue bold – mean obs,

red thin – models, brown bold – mean models

red – model
blue - obs

———— 11:30 LST

- - - - - - - - - - 17:30 LST

WRF 2006

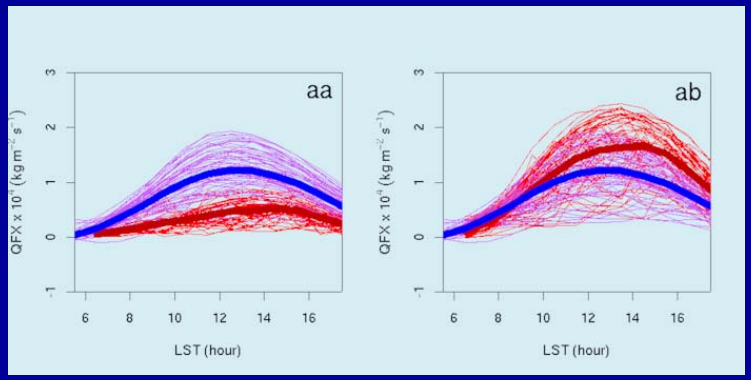
Daytime

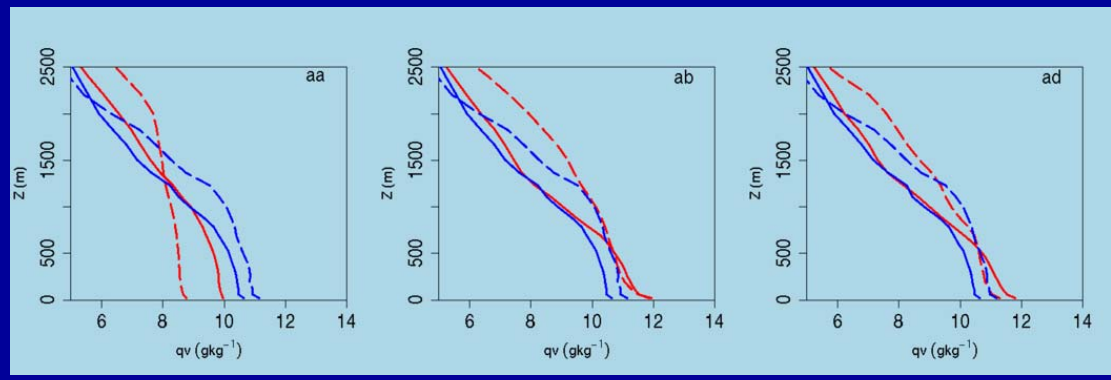
moisture flux

Averaged vertical profile mixing ratio

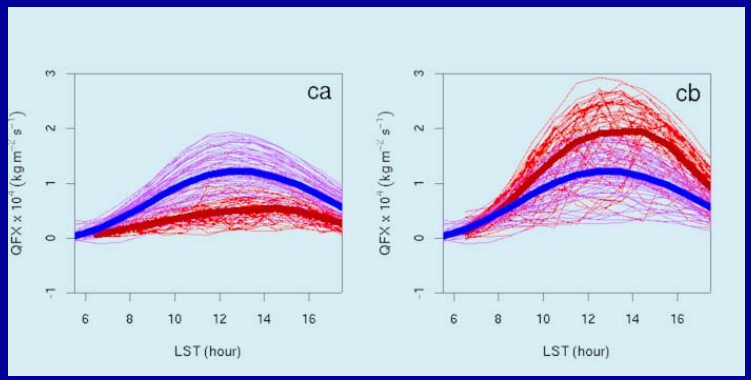
Noah RUC Noah RUC Obs

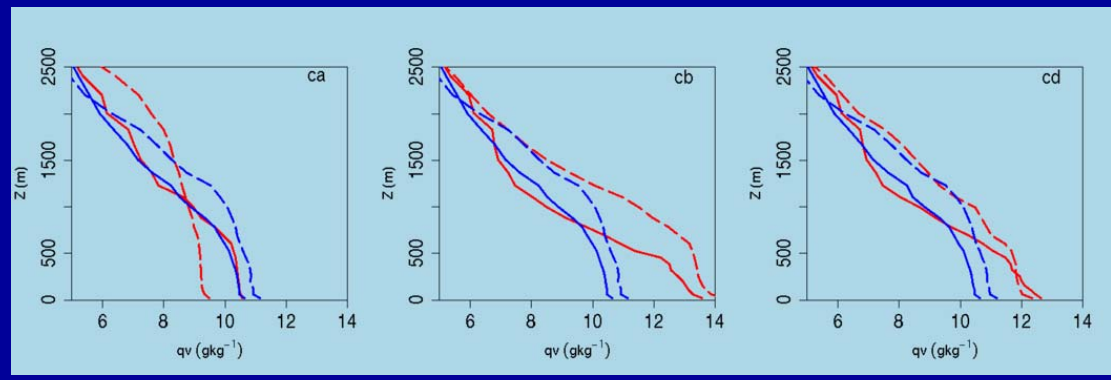
YSU





MYJ





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———— 11:30 LST
- - - - - - - - - - 17:30 LST

WRF 2006

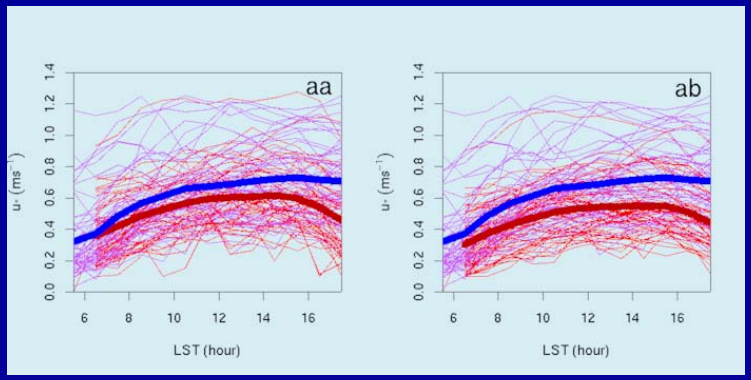
Daytime

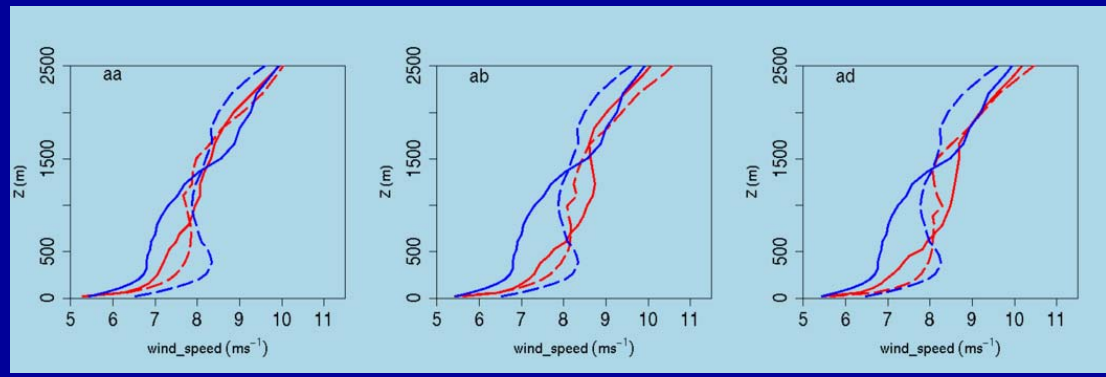
friction velocity

Averaged vertical profiles wind speed

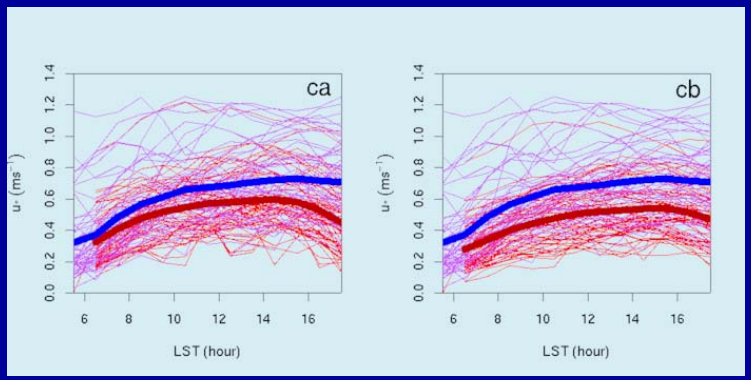
Noah RUC Noah RUC Obs

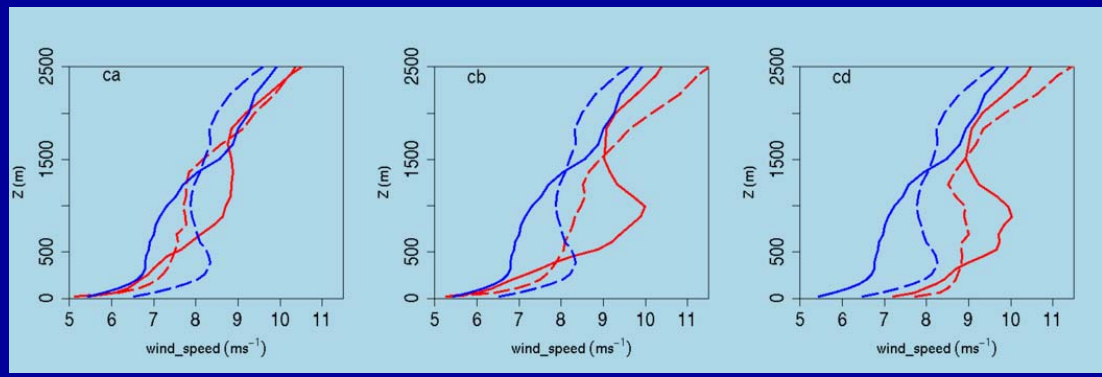
YSU





MYJ





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red – model
blue - obs

———— 11:30 LST

- - - - - - - - - - 17:30 LST

WRF 2006

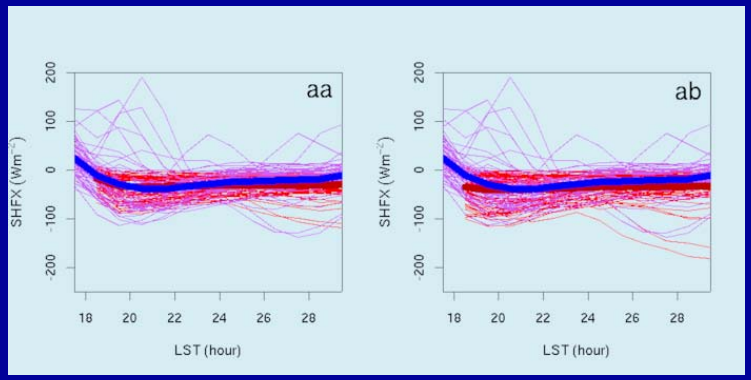
Nighttime

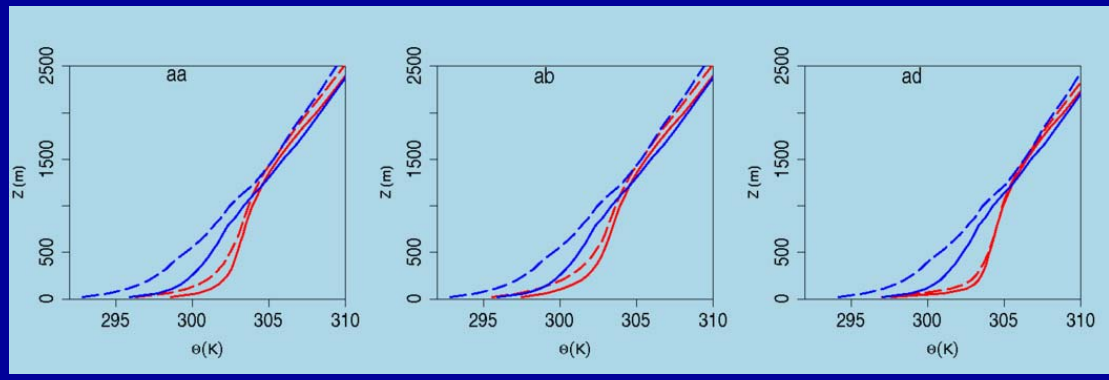
sensible heat flux

Averaged vertical profiles potential temperature

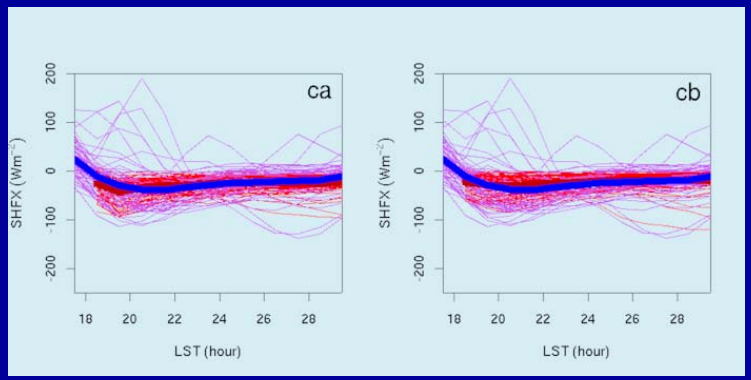
Noah RUC Noah RUC Obs

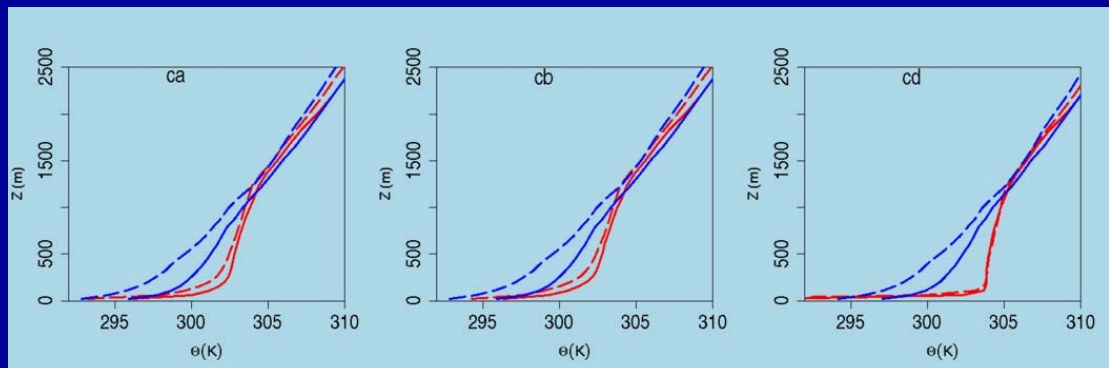
YSU





MYJ





purple thin – obs, blue bold – mean obs,

red thin – models, brown bold – mean models

red – model
blue - obs

———— 23:30 LST

- - - - - - - - - - 5:30 LST

WRF 2006

Conclusions

- Daytime:
  - Coupling PBL schemes with Noah LSM produces excessive sensible heat flux and insufficient moisture flux resulting in overheated and too dry PBL.
  - Coupling YSU/MRF PBL schemes with RUC LSM produces slightly too large sensible heat and moisture fluxes and leads to slightly overheated PBL.
  - Coupling MYJ PBL scheme with RUCLSM has quite accurate sensible heat flux but moisture flux too large resulting in too moist PBL.
  - In all instances friction is too small.

Conclusions

- Nighttime:
  - Mixing (turbulence) too small in all instances.
  - Fluxes have too little variance.
  - Coupling PBL schemes with Noah LSM produces insufficient moisture flux resulting in too dry BL.
  - Coupling PBL schemes with RUC LSM produces slightly too large moisture flux resulting in too moist surface layer most evident for coupling with MYJ.
  - In all instances friction is too small. Insufficient momentum transport might be a cause for the development of too strong nocturnal winds around dawn. On the other hand, low-level jet at the average observed height of 250m (MYJ, MRF).

Conclusions

Overall:

- In several cases, simulations using measured fluxes superior to simulations with fluxes obtained using LSMs.
- During the day performance generally better than at night.
- 1D simulations realistic.
- FRB and RUC LSM have similar performance suggesting that in short forecasts simple LSMs can be competitive (if properly initialized).
- Coupling PBL schemes with Noah LSM leads to large dry and warm biases (except too cold at night with MYJ).
- YSU and MRF have very similar performance.
- A certain limitation on generality as comprehensive measurements only available at a single site.