CEOP-based Diagnosis of Prediction Skill of Four GCMs and GLDAS

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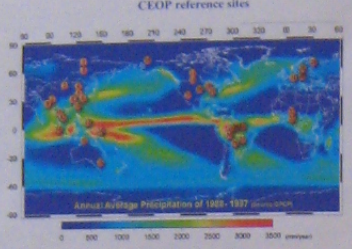
Abstract

Based on the platform of the Coordinated Enhanced Observing Period (CEOP) project, this study evaluated skill of four operational GCMs (BMRC, JMA, NCEP, and UKMO) and NASA GLDAS through comparisons between in situ data and model output of CEOP/EOP 3 (2002/10/1–2003/9/30). This evaluation not only contributes to improving forecast skill but also provides guidance for data users to choose appropriate data from these model products for their applications.

Data: In situ and model output at 27 CEOP reference sites

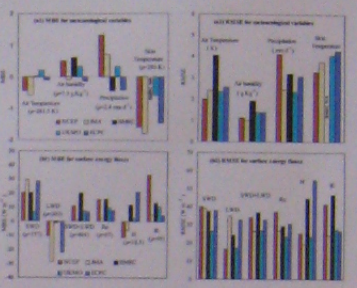
International inter-comparison projects

CEOP reference sites

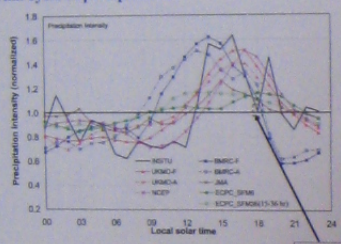


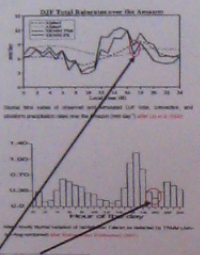
EOP3 data availability (blank – no data; ● - data used; ◎ - T_a used but q_a unavailable; O- data questionable or vegetation-type mismatched)

General Evaluation



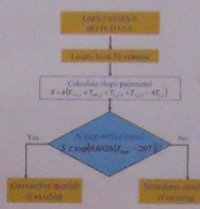
Diurnal cycle of precipitation

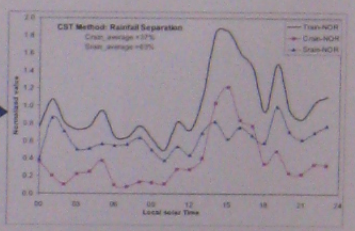




Why early-evening minimum?

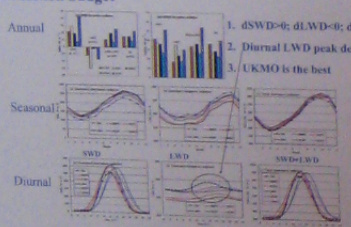
Separate convective and stratiform rainfall by T_b gradient





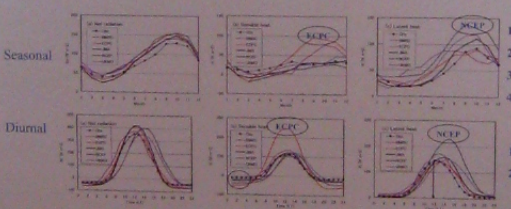
In early-evening, convective rainfall decreases while stratiform rainfall increases

Radiation budget



1. dSWD>0; dLWD<0; dRnet>0
2. Diurnal LWD peak delayed
3. UKMO is the best

Surface energy budget



1. Too strong seasonal variations
2. Highest sensible heat in ECPC
3. Highest latent heat in NCEP
4. BMRC does not follow seasonal trend

1. Unable to predict nighttime fluxes
2. Too late peak of latent heat

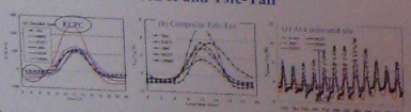
Water budget: Annual mean

Data	E	P	E/P
Observed	1.76	2.09	0.84
BMRC	**2.29**	**1.53**	**1.50**
ECPC_0-6	**2.09**	**1.24**	**1.61**
JMA	1.90	2.65	0.75
NCEP	**3.16**	**3.32**	**0.95**
UKMO	2.16	2.82	0.77

E/P sensitivity to model spin-up:

- Sensitive in ECPC/SFM,
- Insensitive in NCEP and UKMO
- Need more data for BMRC and JMA

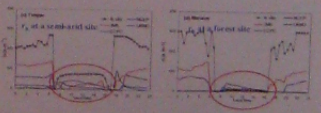
Error correlation between H and Tsfc-Tair



Why?

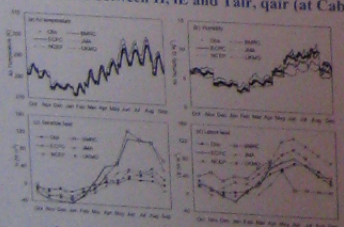
- Over-predict diurnal range of H
- Under-predict diurnal range of Tsfc-Tair?
- More severe in arid and semi-air regions

$$H = \rho c_p u (T_{sfc} - T_{air}) / r_h$$



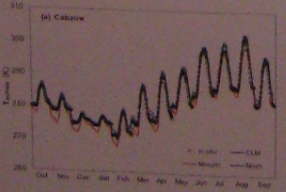
GCMs under-predict heat resistance, particularly in arid and semi-arid regions

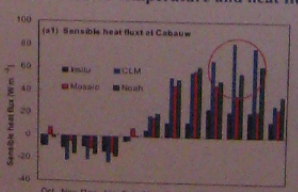
Error correlation between H, lE and Tair, qair (at Cabauw)

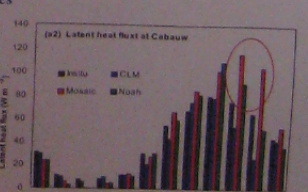


Less H → Lower Tair; Less E → Lower qair

GLDAS: Surface temperature and heat fluxes







1. GLDAS generally produces better surface temperature than the GCMs, but the improvement for arid regions (e.g., West Tibet) is limited (not shown).
2. Mosaic produces cold biases at nighttime
3. GLDAS LSMs do not show significant improvements in the simulation of surface energy partition.

Major findings:

1. Composite diurnal cycle of precipitation shows an afternoon peak and a low intensity in the early evening (around 18 LST). All the models have produced an afternoon peak but no model has produced the low intensity at 18 LST. The low precipitation is due to the rapid cease of convective rainfall in the early evening followed by the start of stratiform rainfall at that time.
2. SWD is over-predicted, LWD is under-predicted, and UKMO predicts better than others. Diurnal peak of LWD is predicted too late.
3. Models predict too strong seasonal variations of surface energy budget. Sensible heat fluxes are over-predicted for stable (nocturnal) boundary layers. Diurnal peak time of latent heat fluxes is predicted too late
4. The diurnal range of Tsfc-Tair is predicted too small, due to too small heat resistance in models

Reference

Yang et al., 2007: Initial CEOP-based Review of the Prediction Skill of Operational General Circulation Models and Land Surface Models. *J. Meteor. Soc. Jpn*, 85, CEOP special issue.