

Systematic bias and model independence in land surface models

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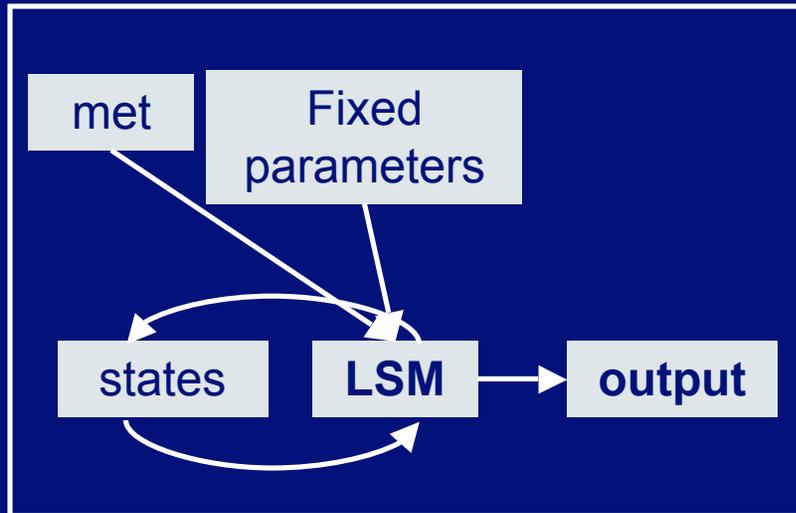
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A few thoughts on model bias:

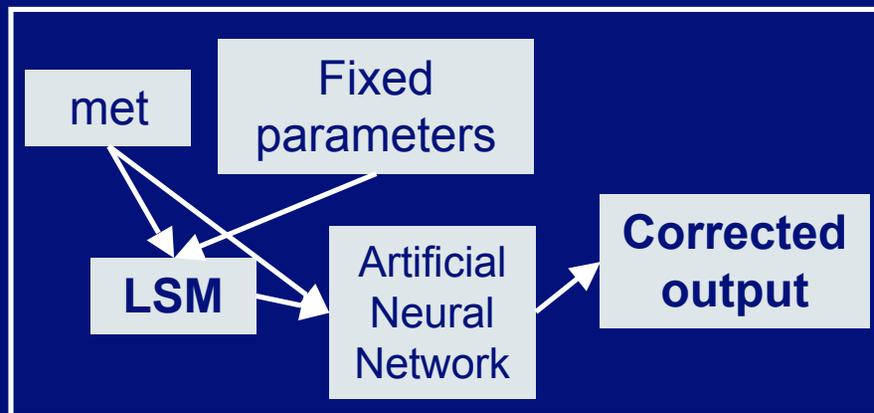
- All models have bias - infinite dimensional natural system, finite dimensional model: will have bias in some metrics. We will never have a “true” model.
- While we can remove bias from some metrics through ‘tuning’ (usually to the detriment of other metrics), we do not know which metrics are important for climate change, and so must try to remove bias from all metrics for which we have observed data.
- Bias in coupled models (excluding bias from coupling and scale issues) is the result of biases from each component model.
- These are made at the timescale of the component models’ time step size.
- Therefore, to reduce coupled model bias, we must reduce the bias in each execution of the component models - high temporal resolution data
- We can characterise a component model by the nature of its bias

Use statistical correction to characterise model bias

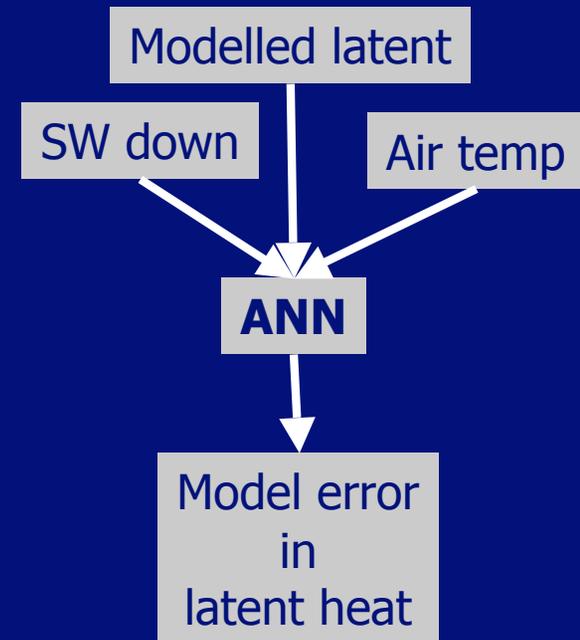
Land Surface Model (LSM):



Corrected LSM:



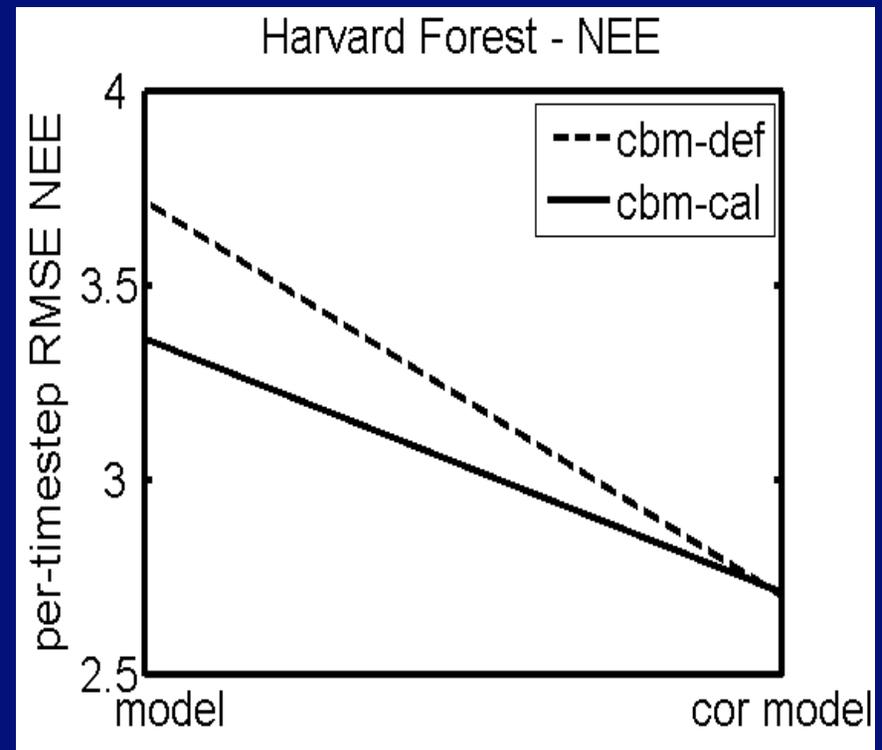
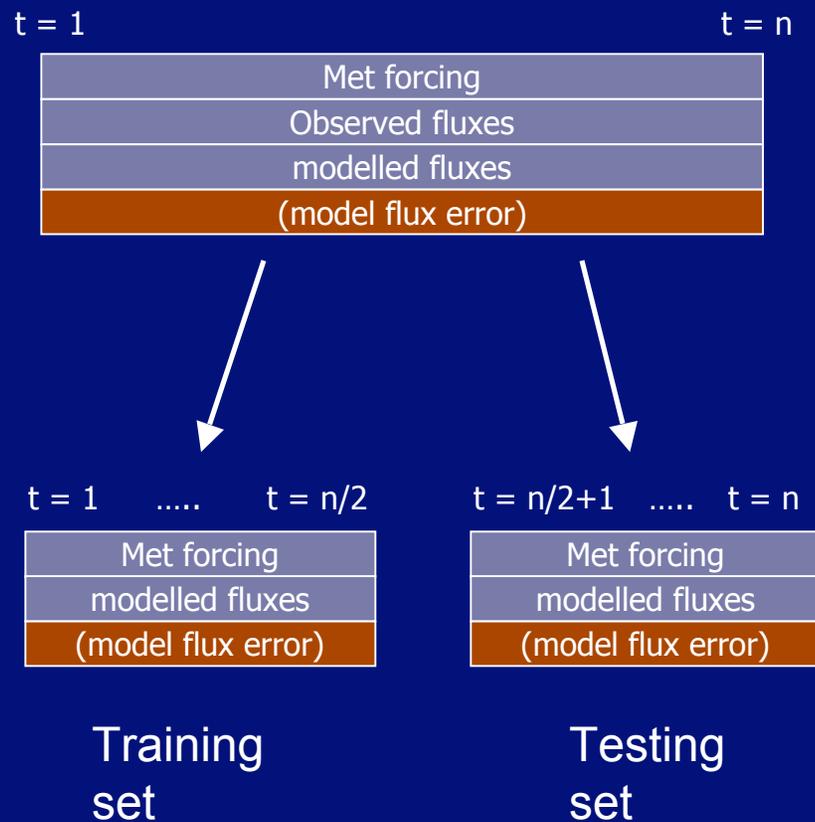
e.g.



- similar ANN setup for sensible heat and NEE corrections
- ANN used is Self-Organising Linear Output map (SOLO - Hsu et al, 2002)

A simple test: one flux tower site, one LSM

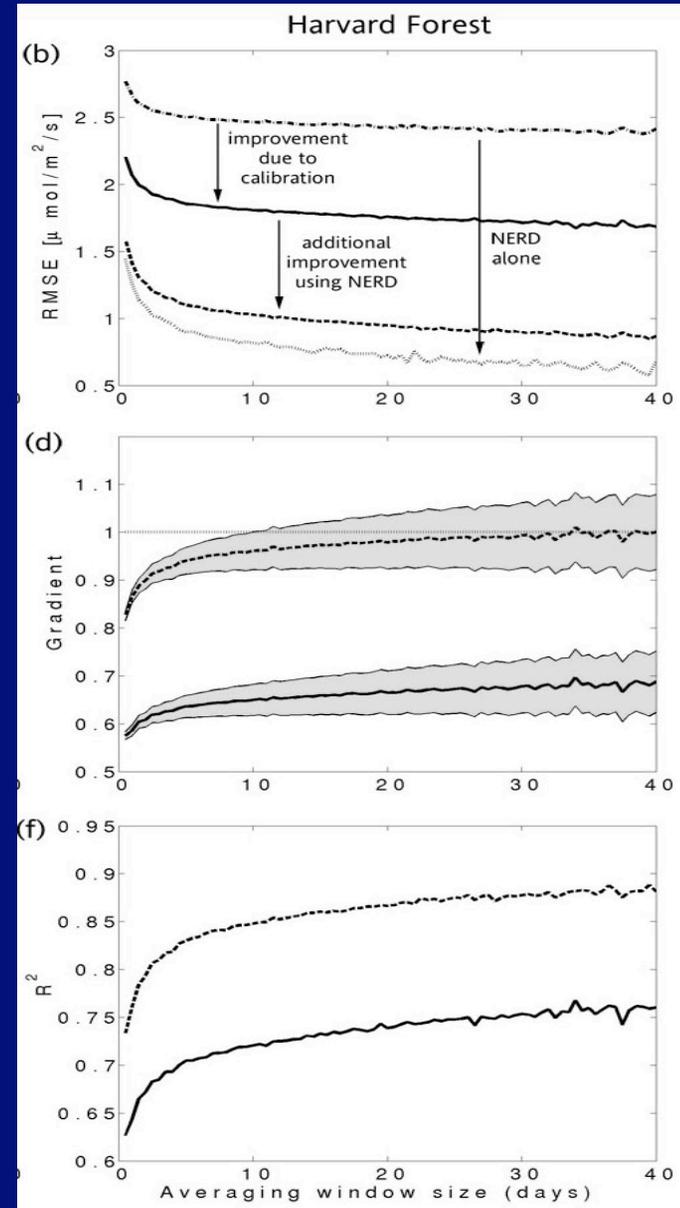
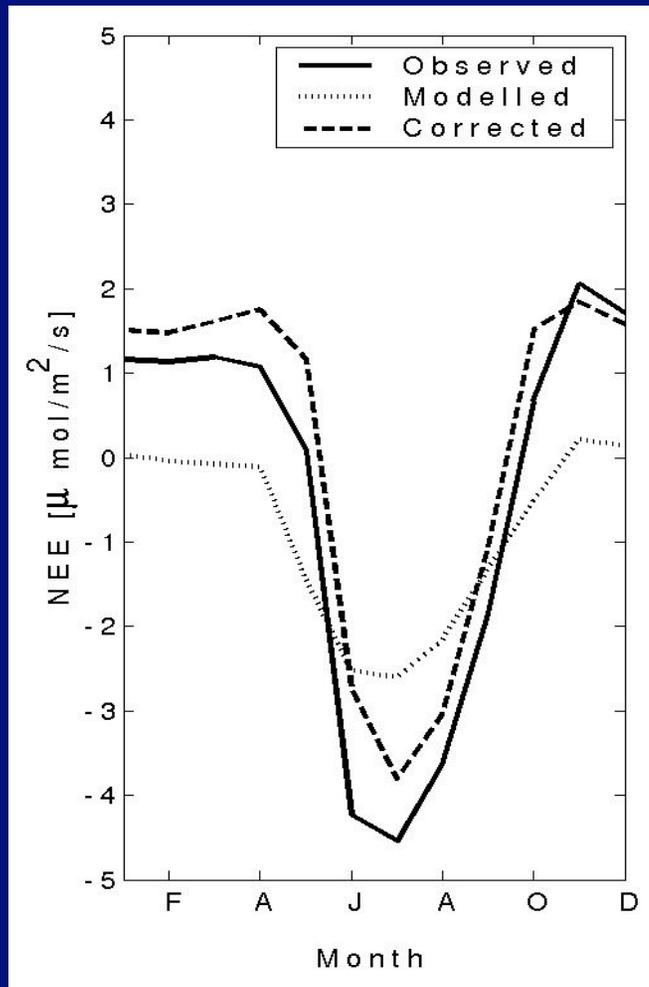
- Site: Harvard Forest, USA, eight years of hourly flux and met data.
- LSM: CSIRO Biosphere Model (CBM)
- Use first half of data to train ANN, second half to test ANN



~ 30% improvement in per-time step NEE RMSE

Improvements in other measures:

(Abramowitz et al, JHM, 2006)



A tougher test: 13 flux tower sites simultaneously, 3 LSMs

Forested sites:

- Aberfeldy (Scotland)
- Bordeaux (France)
- Flakaliden (Sweden)
- Hyytiala (Finland)
- Loobos (Netherlands)
- Metolius (Oregon USA)
- Norunda (Sweden)
- Tharandt (Germany)
- Weidenbrunnen (Germany)

Grassland/crop sites:

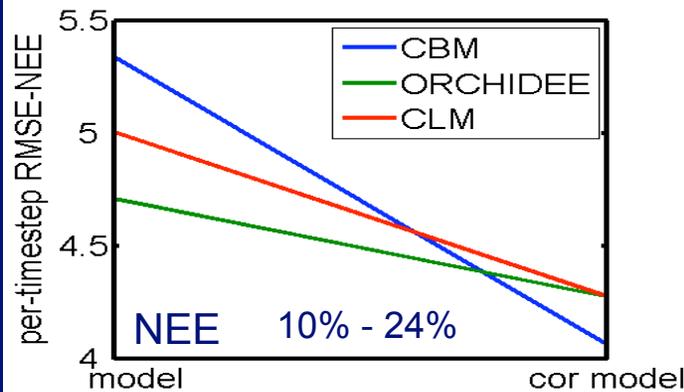
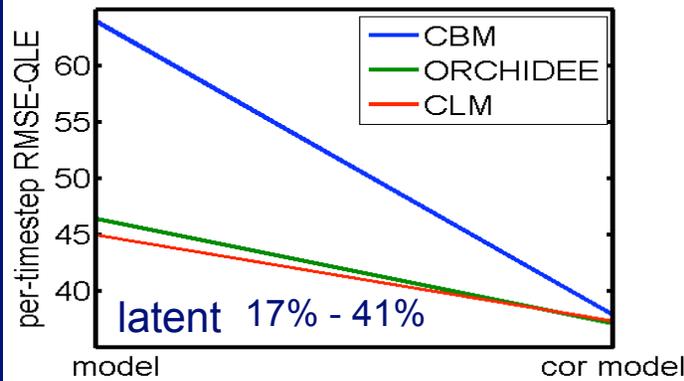
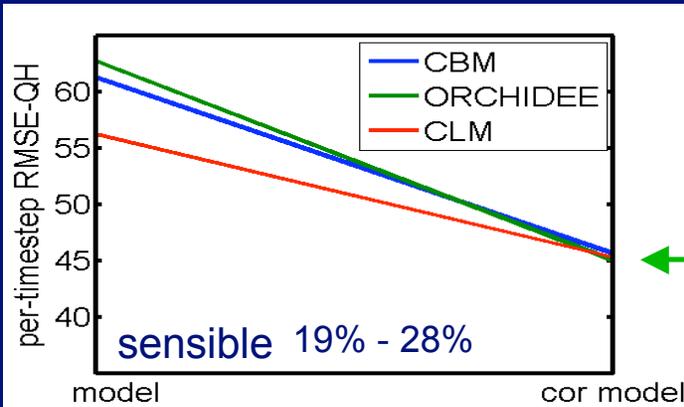
- Bondville (Illinois USA)
- Little Washita (Oklahoma USA)
- Ponca City (Oklahoma USA)
- Shidler (Oklahoma USA)

Three LSMs:

- CBM (Kowalczyk, Leuning, Raupach, Wang) - Australia
- ORCHIDEE (Krinner et al, 2005) - France
- CLM (Dai et al, 2003; Oleson et al, 2004; Levis et al 2004) - USA
- All used 'default' parameter sets, as though in a GCM simulation (from coarse global grids)
- 1st half of time series from all sites used to train ANN correction, second half to test ANN correction.

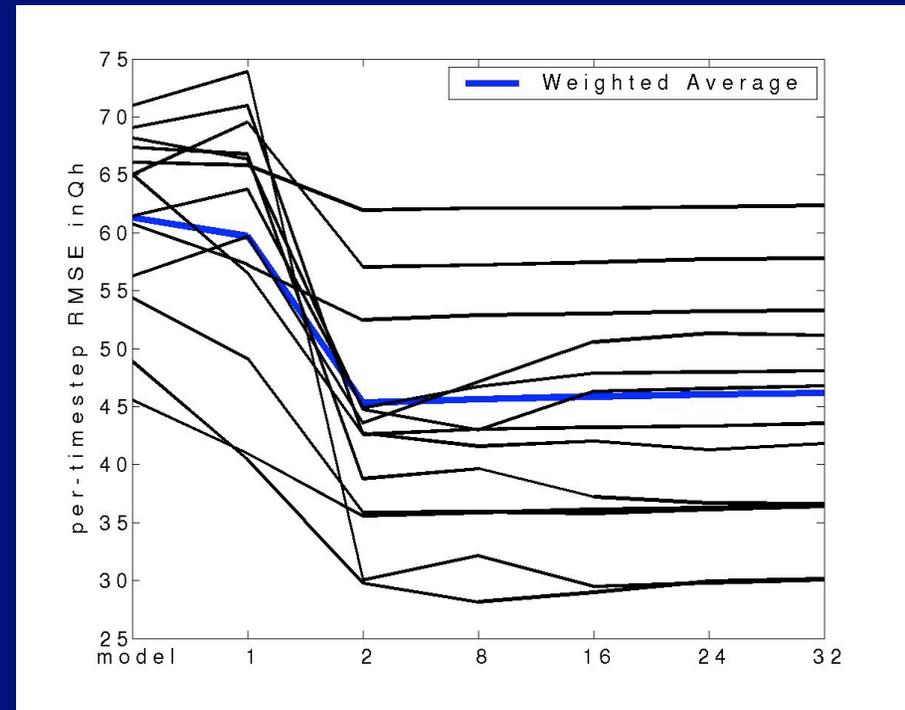
* Timesteps flagged by observational teams (gapfilled) were not used for ANN training.

Multiple site correction



Maximum utilisation of information in met forcing?
(i.e. the best we could expect a LSM to do?)

Average correction representative
(sensible heat, CBM, 13 sites):

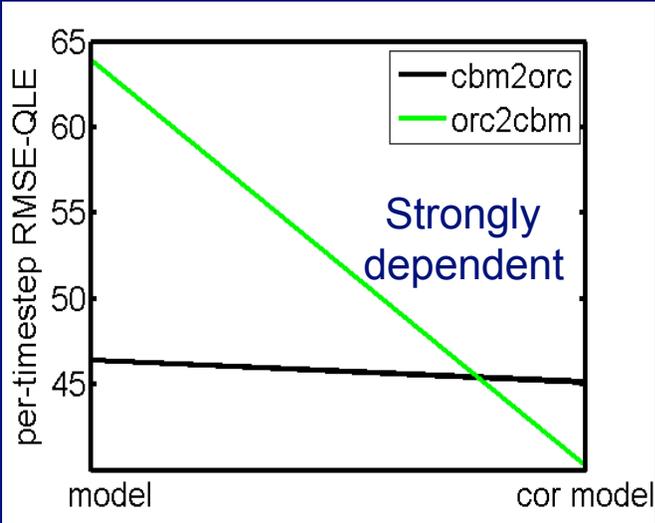


Train ANN on one model, test on another

- ANN captures nature of systematic bias of a LSM
- If an ANN trained to correct one LSM can correct another, they have similar biases, and are deemed to be dependent.

- All 13 flux tower sites;
- Same three LSMs - can CBM's ANN correct CLM and vice versa?
 - 6 model transitivity experiments
- Default parameter sets were used for all three LSMs.

Train ANN on one model, test on another - latent heat

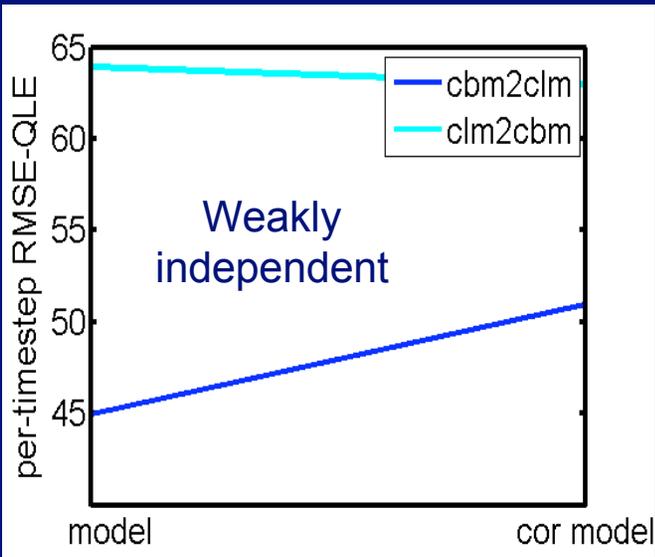


CBM & ORCHIDEE

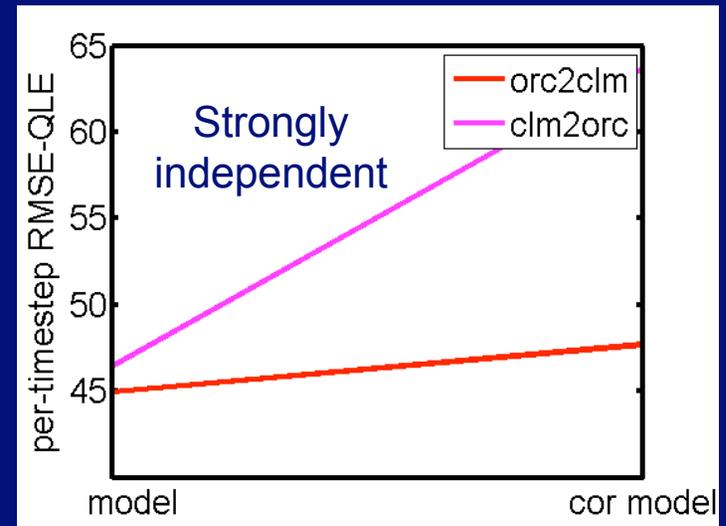
- can mutually correct each other
- bias in latent heat of a similar nature
- are DEPENDENT and not appropriate for mutual inclusion in ensembles w.r.t LATENT HEAT

CLM & ORCHIDEE

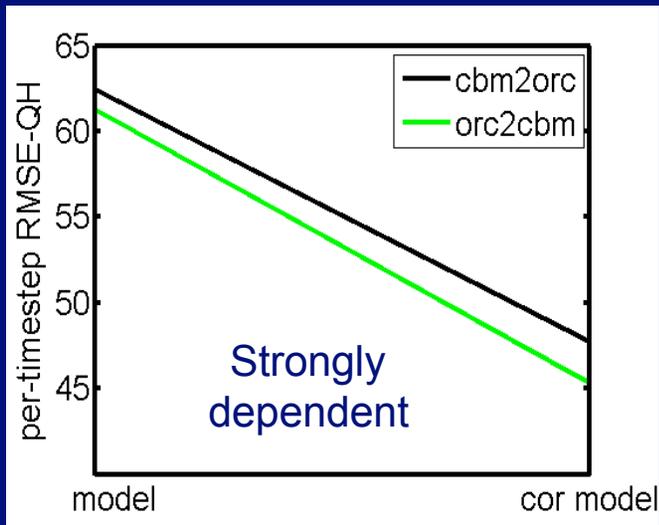
- cannot mutually correct each other
- bias in latent heat different nature
- are INDEPENDENT and appropriate for mutual inclusion in ensembles w.r.t Qle



CBM & CLM
inconclusive

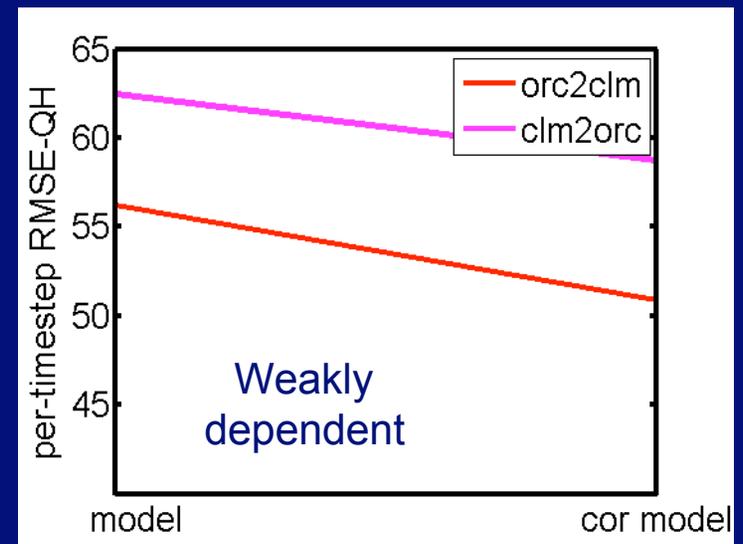
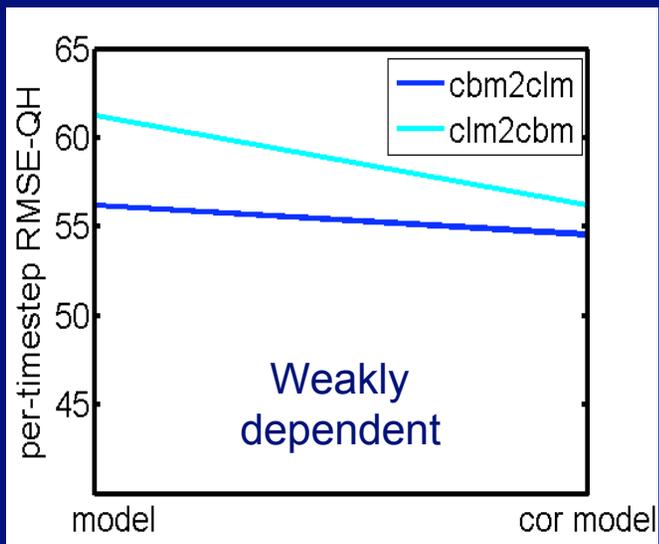


Train ANN on one model, test on another - sensible heat

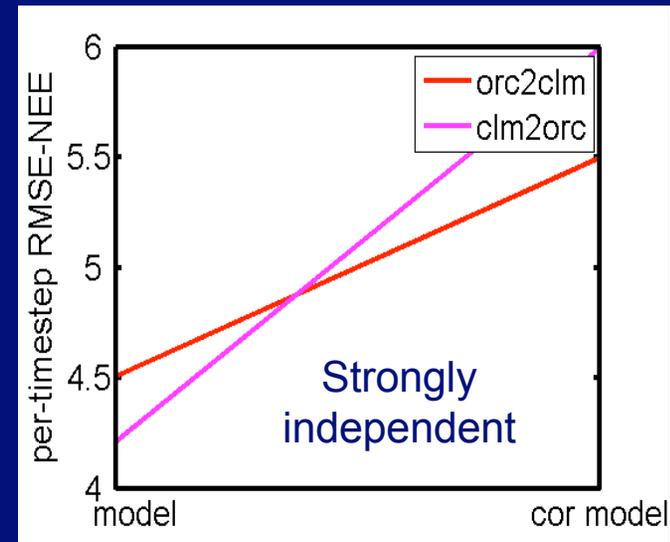
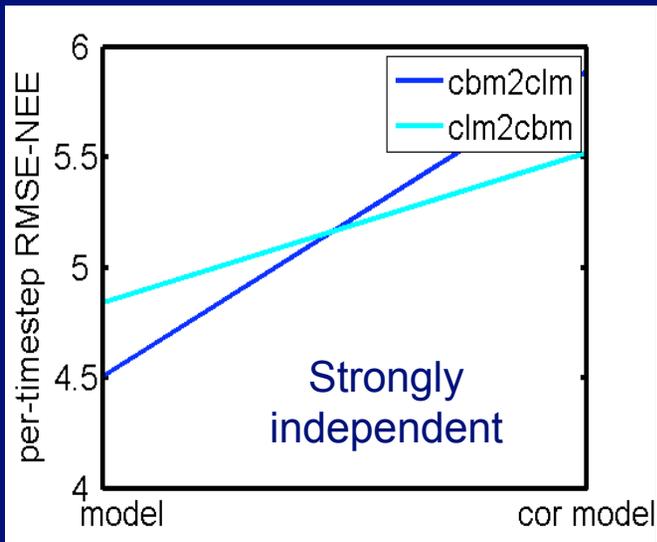
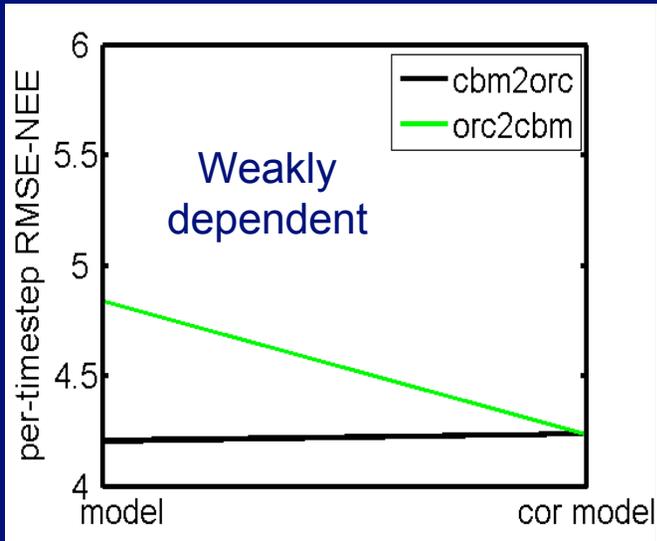


All three models:

- can mutually correct each other
- bias in sensible heat of a similar nature
- are DEPENDENT and not appropriate for mutual inclusion in ensembles w.r.t SENSIBLE HEAT



Train ANN on one model, test on another - NEE



Concluding remarks

- We can characterise a model by the nature of its bias.
- This bias can (at least partly) be captured by a statistical correction technique, at single sites and regionally (if high temporal resolution observations are available).
- The correction technique can be used to tell which models are biased in similar ways and therefore may be used as an independence metric for members of model ensemble simulations.
- Could be improved:
 - A more rigorous investigation of appropriate ANN inputs
 - ANN improvement: currently adding dimension reduction to inputs
 - More high quality, high temporal resolution data