# Assessing representations of model uncertainty in seasonal forecast ensembles

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Thanks to

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# ENSEMBLES
## "ENSEMBLE-based Predictions of Climate Changes and their ImpactS"

### Multi-model ensemble (MME)

- five coupled atmosphere-ocean GCMs for seasonal forecasts developed in Europe
- 9 initial condition ensemble members → 45 members

### Perturbed parameter ensemble (PPE)

- uncertainty in poorly constrained cloud physics and surface parameters in HadCM3
- 8 model versions with simultaneous perturbations to 29 parameters + 1unperturbed member
- no control run available

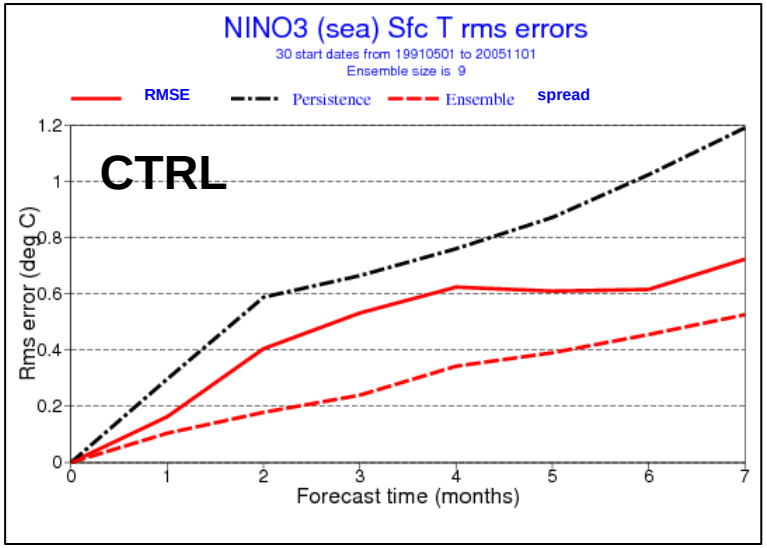
### Stochastic Physics Ensemble (SPE)

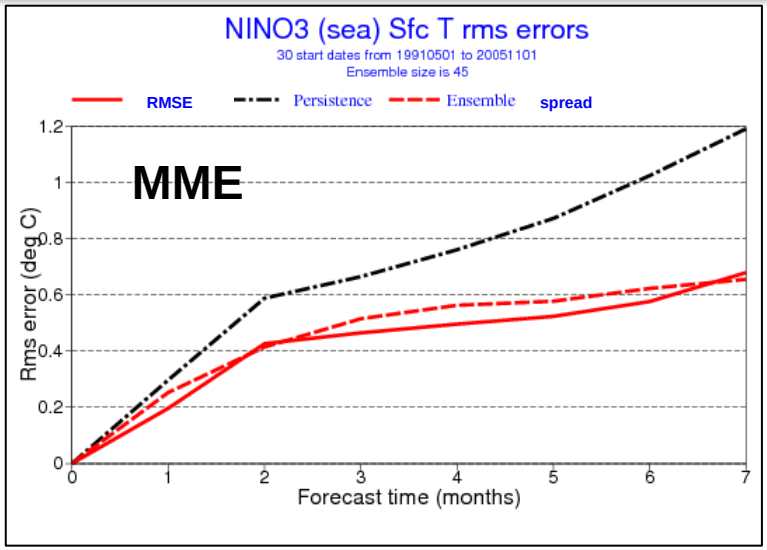
- model uncertainty in coupled ECMWF model due to variability of the unresolved scales
- two-scale perturbed diabatic tendency scheme: $\tau$=6h/30d and L=500km/2500km
- kinetic energy backscatter scheme
- 9 initial condition ensemble members

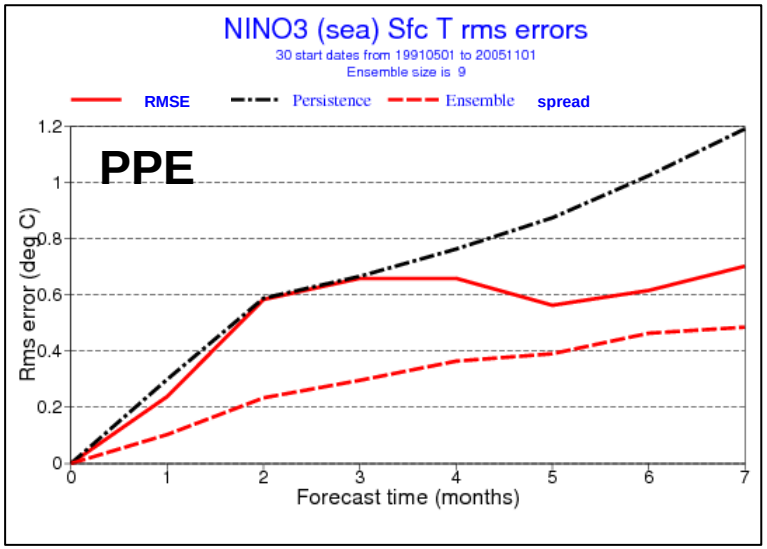
- control run without any stochastic physics (CTRL)

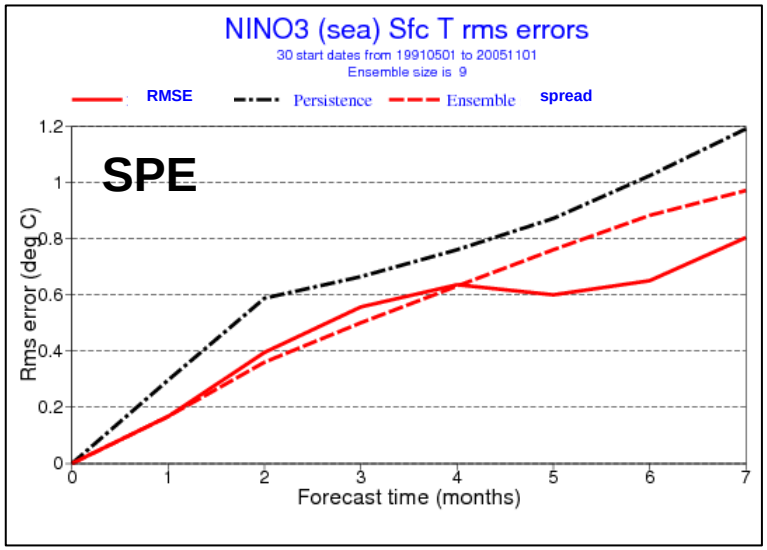
**Coupled seasonal forecasts over the period 1991-2005**
**Initialised on 1st May and 1st November each year**
**Assessment of monthly and seasonal forecast skill**

# Niño3 SST forecasts: spread-skill



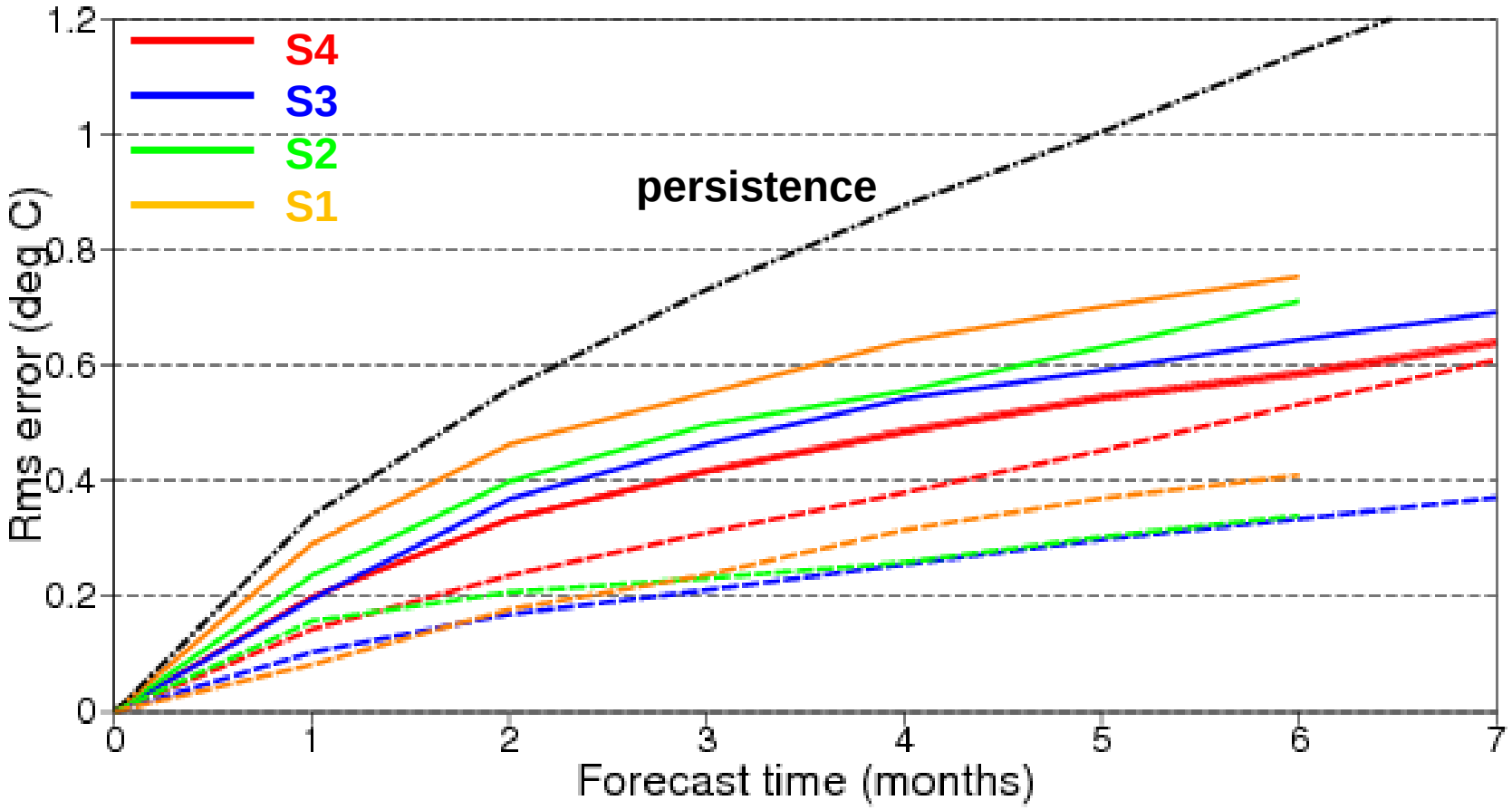




**Weisheimer et al. (2011)**

# Niño3 SST forecasts: spread-skill in operational systems

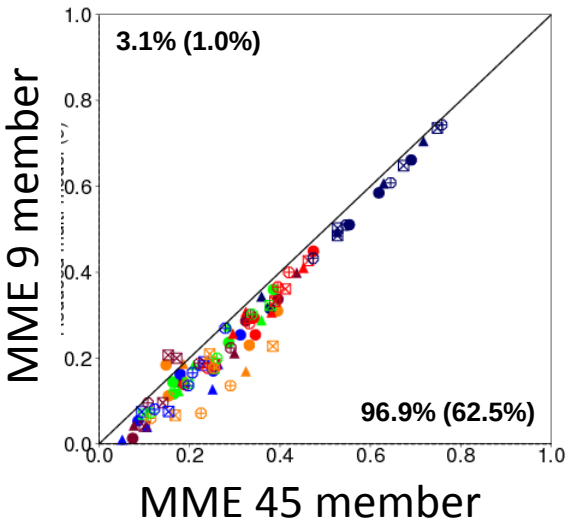
## Performance of the new operational seasonal forecasting system S4 (new stochastic physics) versus previous systems



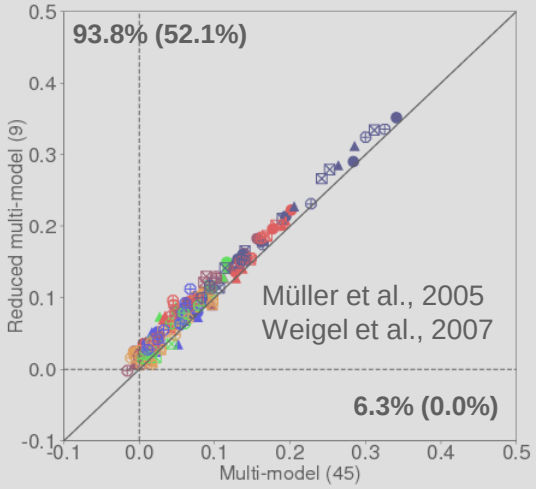

Courtesy Tim Stockdale

# Impact of ensemble size

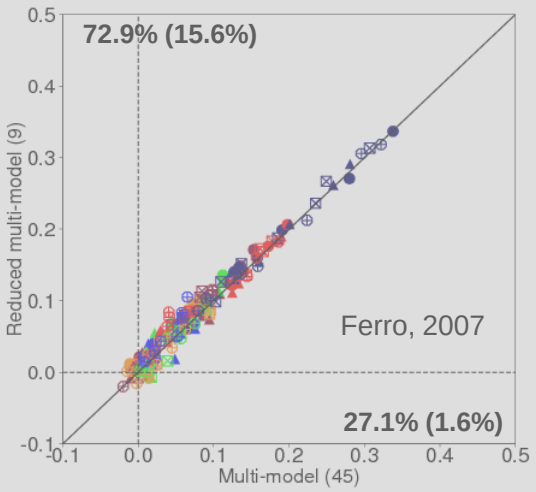
**Anomaly correlation**



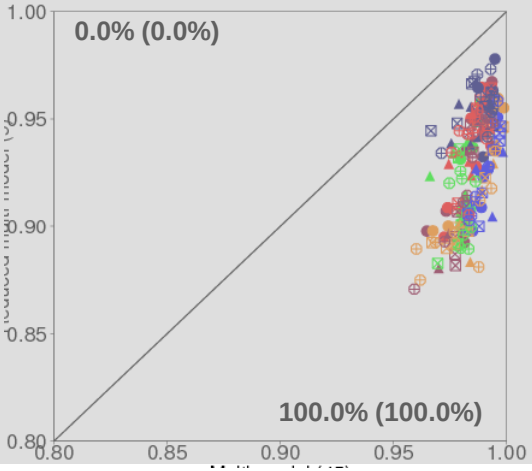

**Debiased Brier Skill Score**



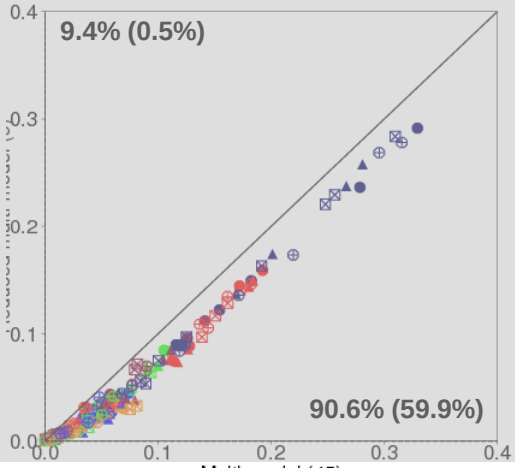

**Infinite size ensemble Brier Skill Score**




**Reliability skill score**

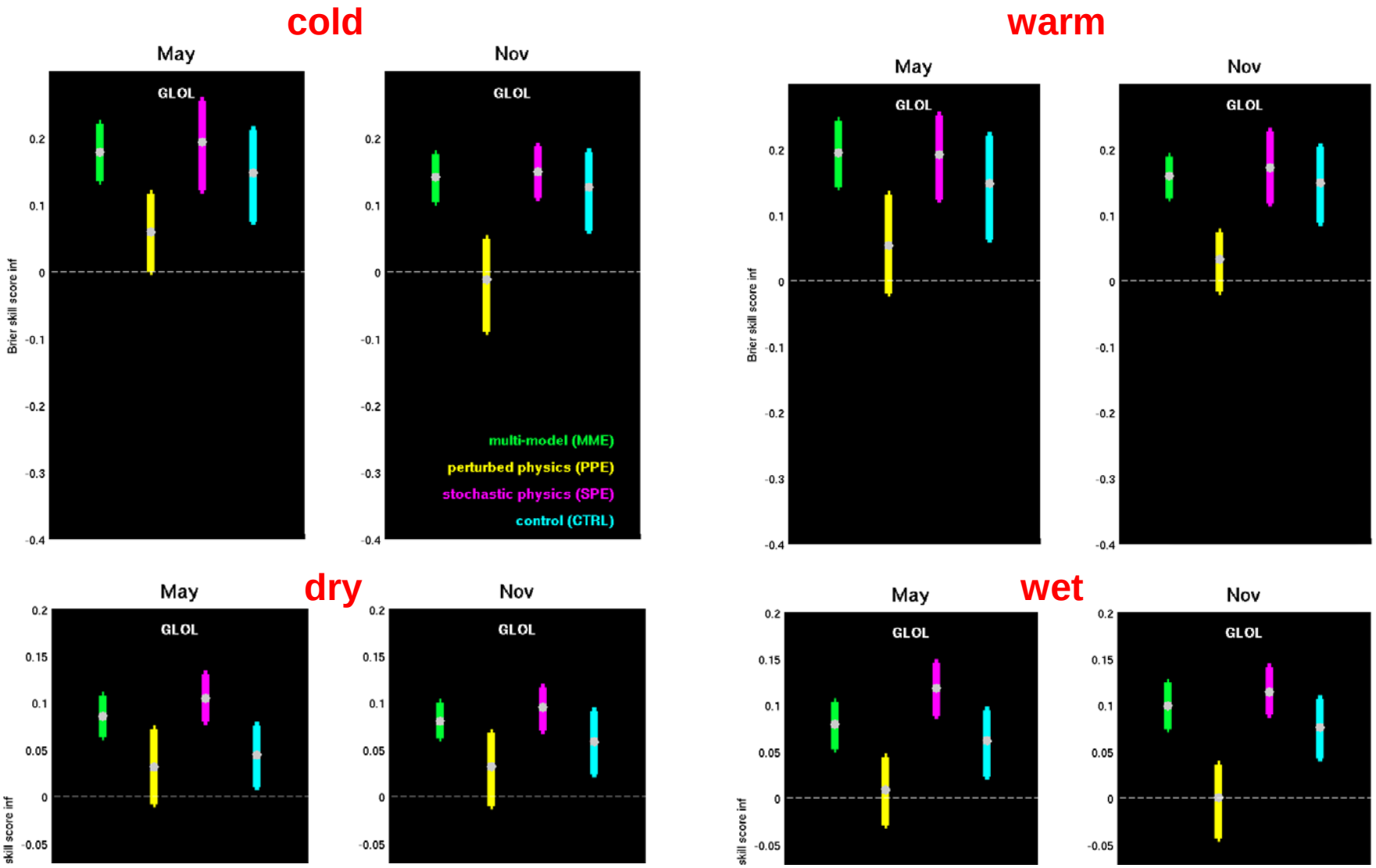



**Resolution skill score**



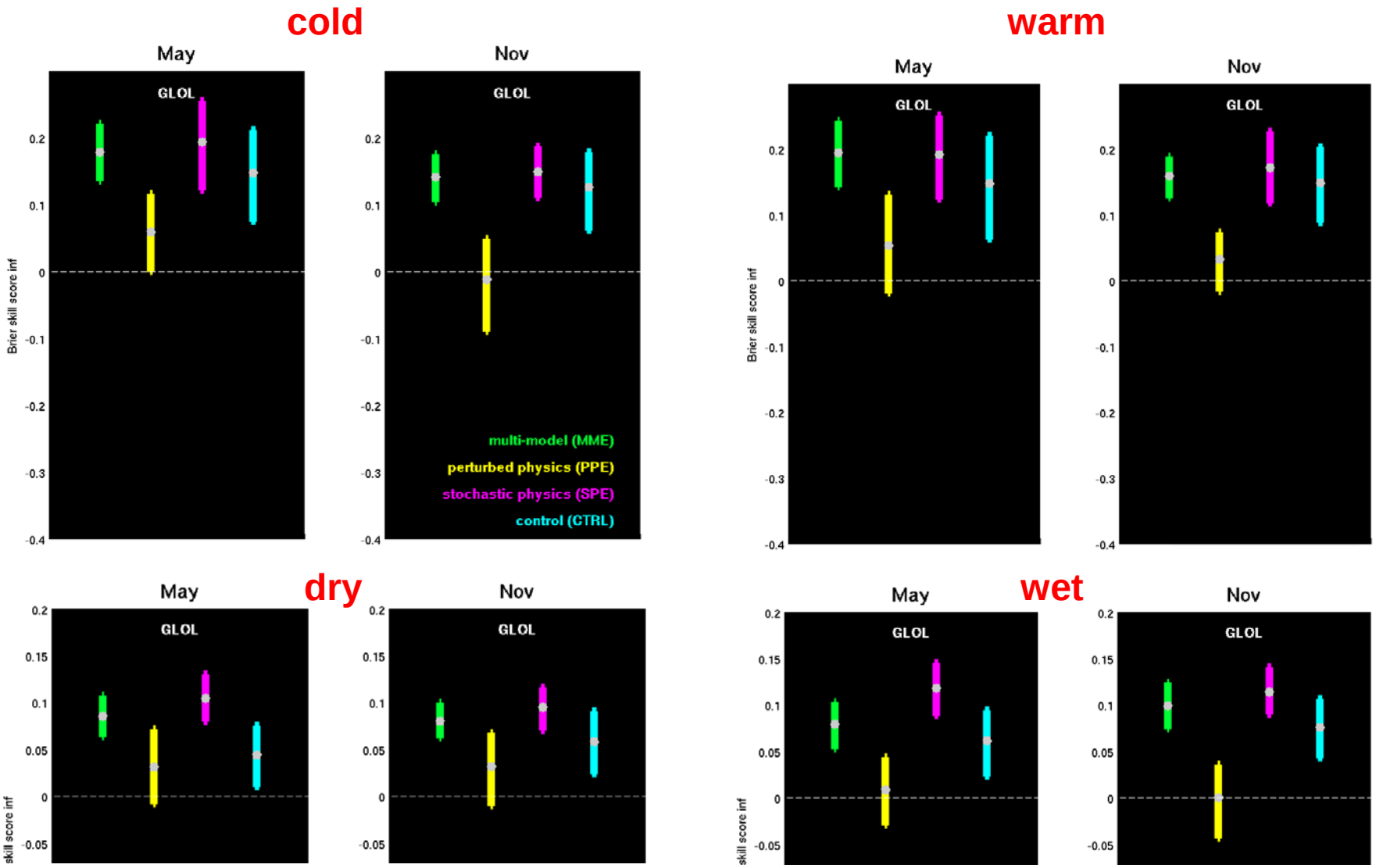

- near-surface temperature (1960-2005) and precipitation (1980-2005)
- six large-scale regions (tropical/NH/SH land/ocean)
- Feb, May, Aug and Nov start dates
- lead times 2-4 and 5-7 months
- lower and upper tercile events

# Global land areas  Brier Skill Score ∞  1st month



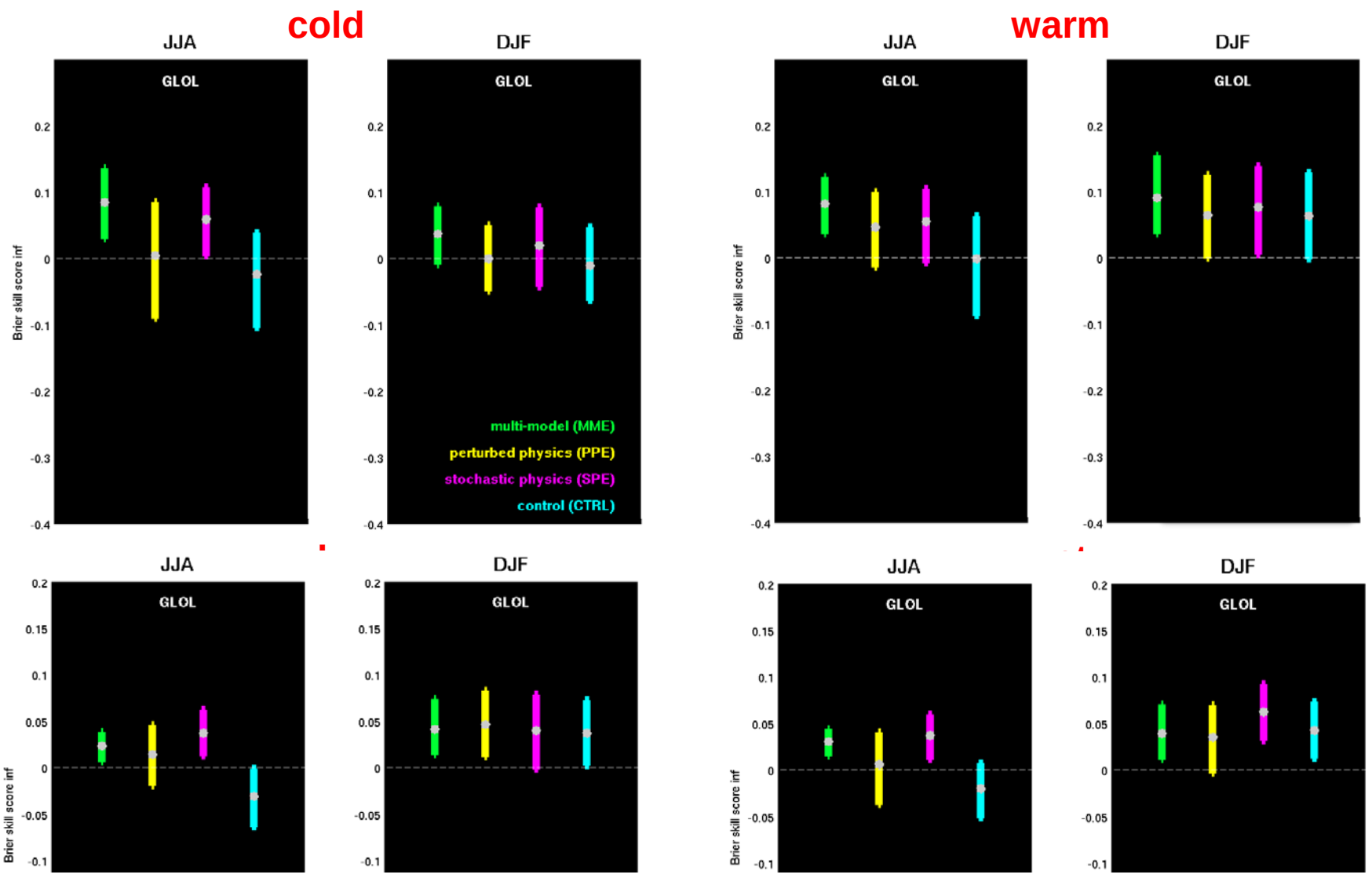

Weisheimer et al. (2011)

# Global land areas  Brier Skill Score ∞  1st month




Weisheimer et al. (2011)

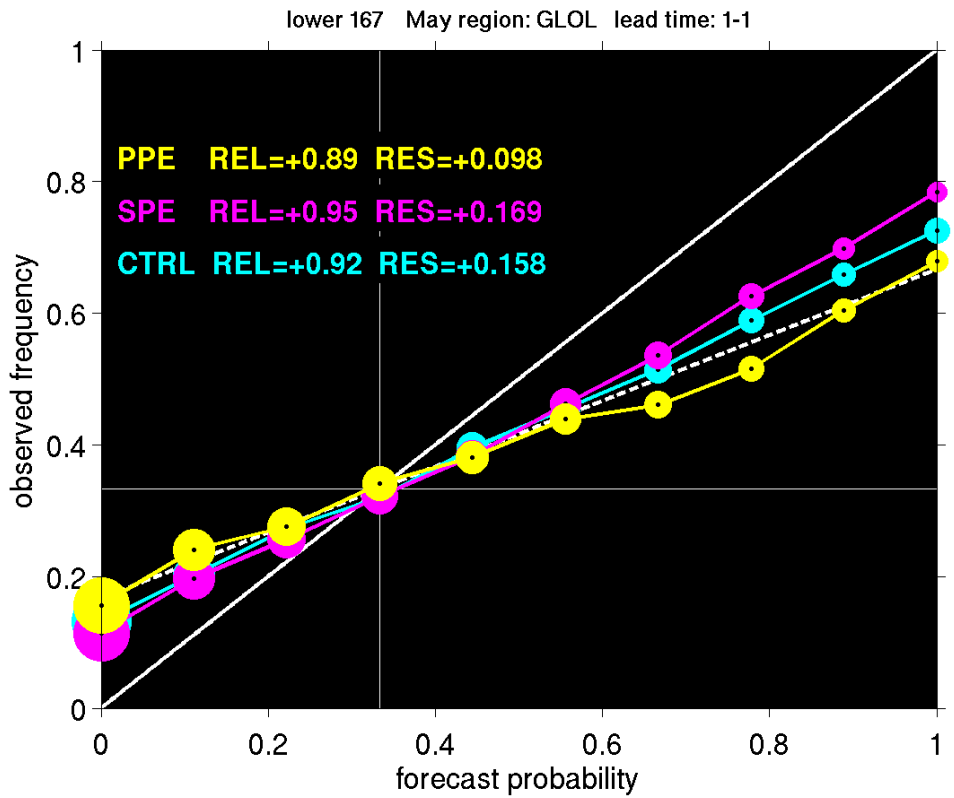
# Global land areas  Brier Skill Score ∞  months 2-4



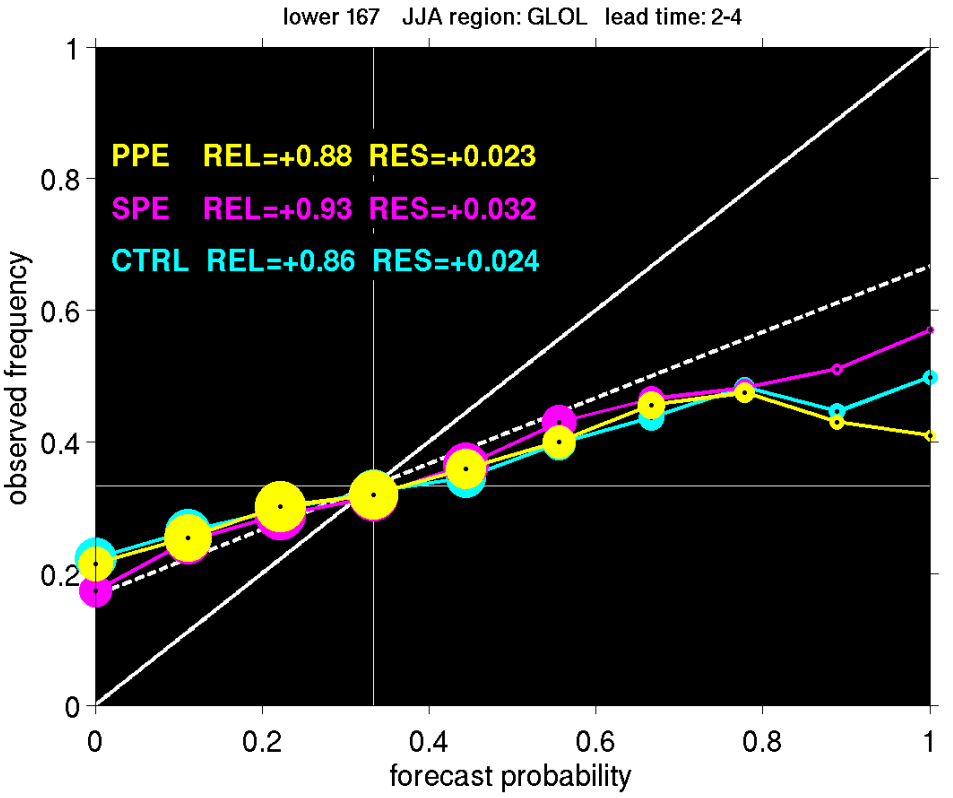
# Global land areas reliability diagrams

## cold events

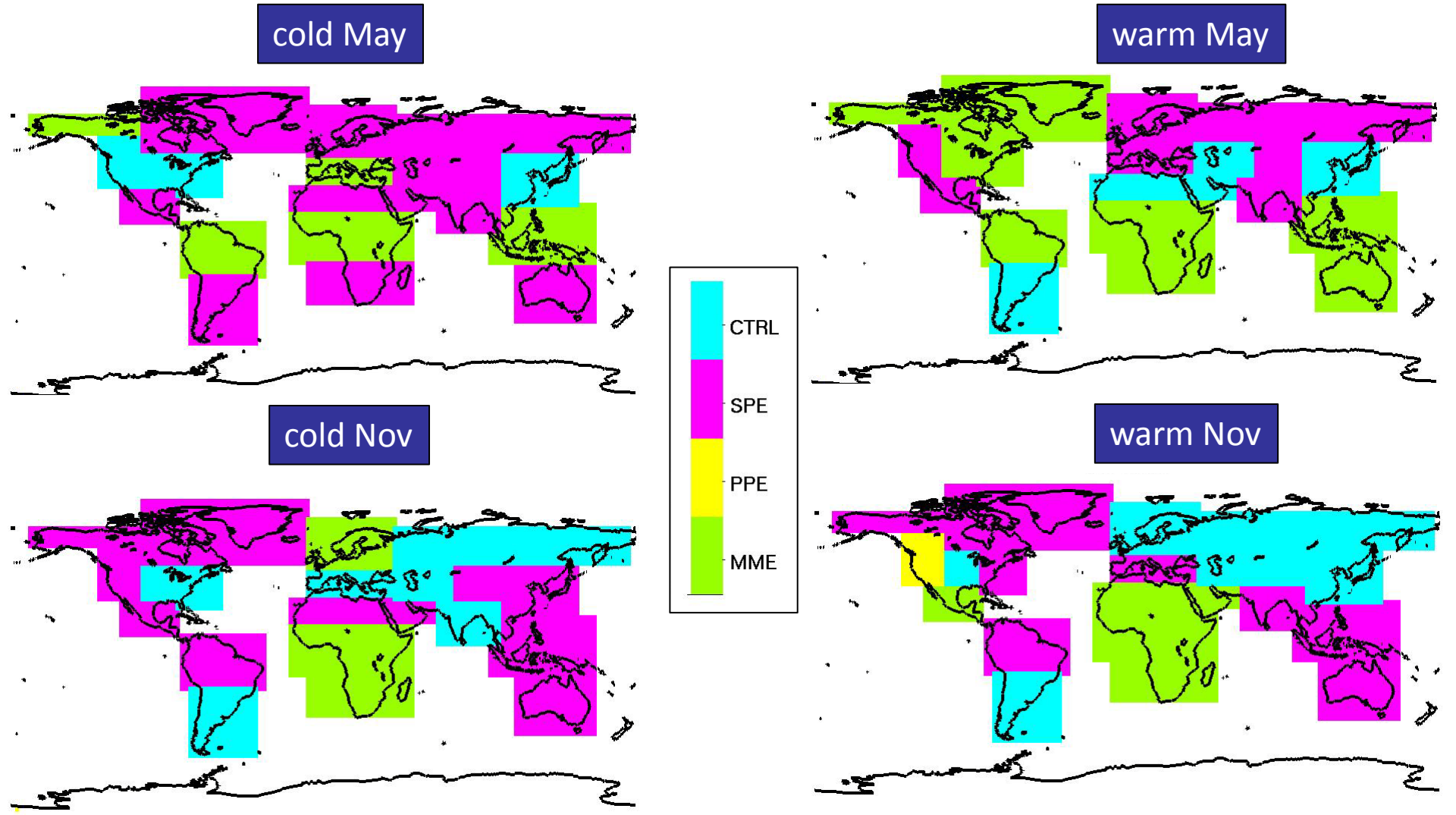
### May



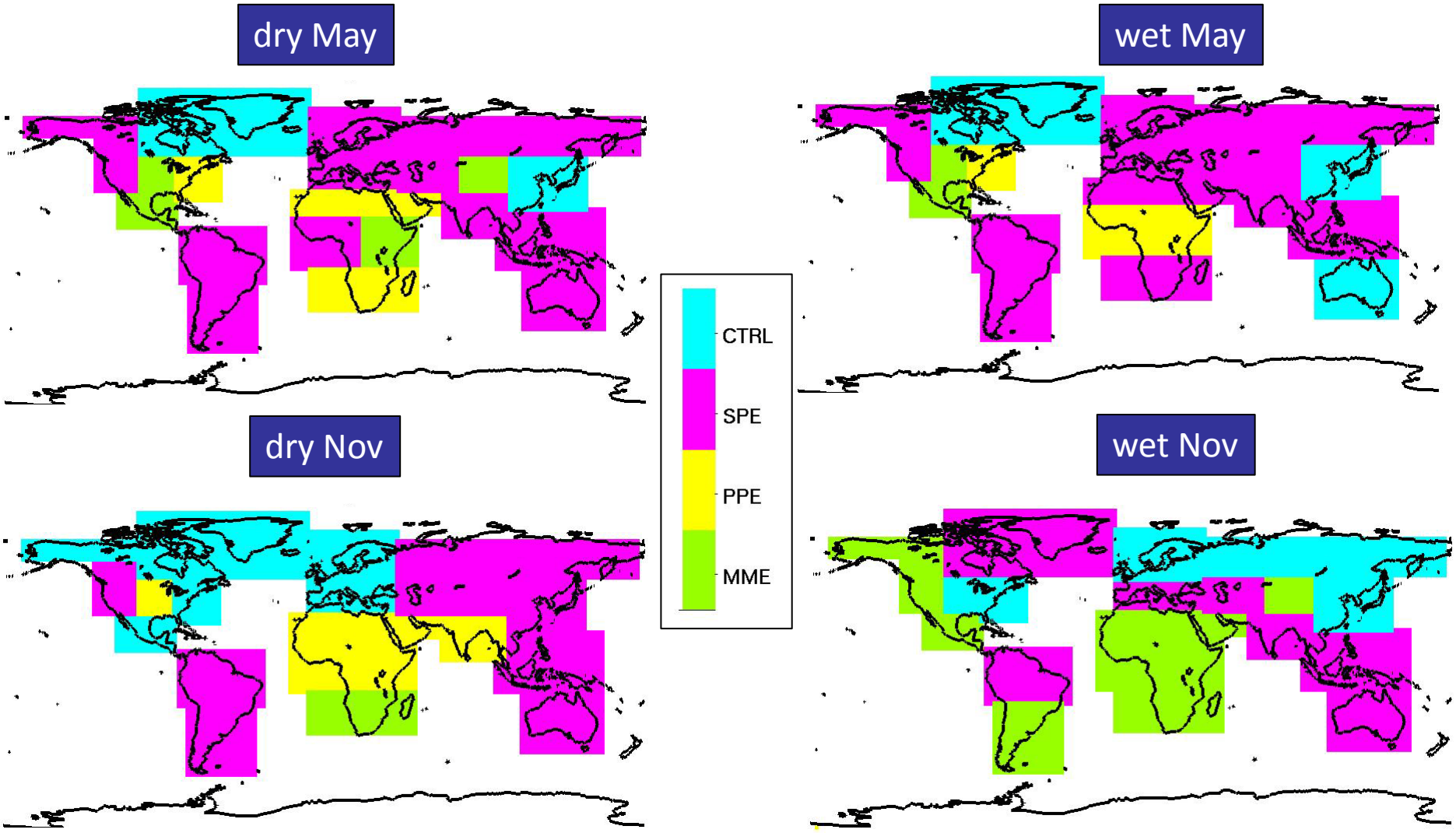

### JJA



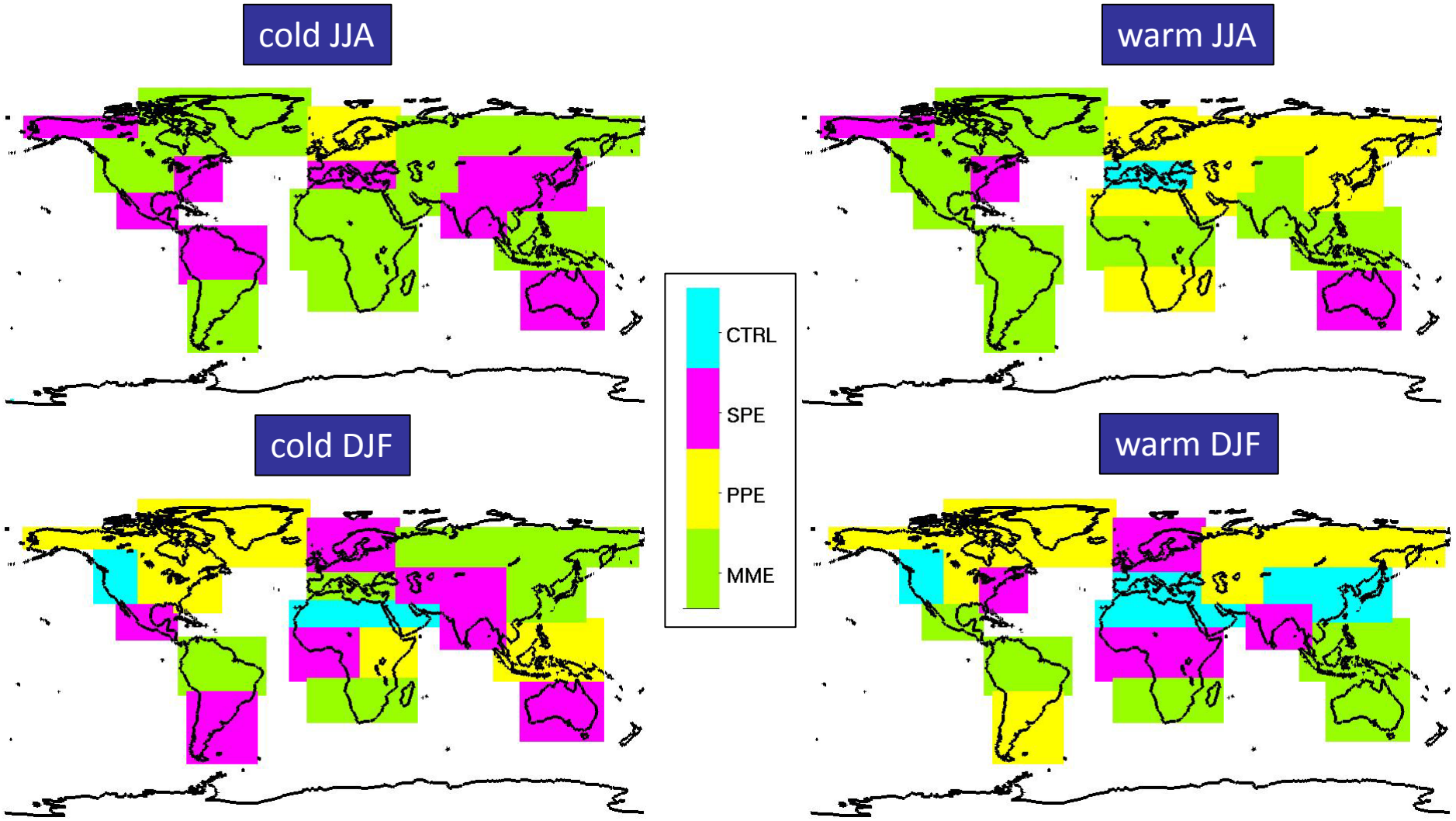
# temperature highest BSS ∞ 1st month



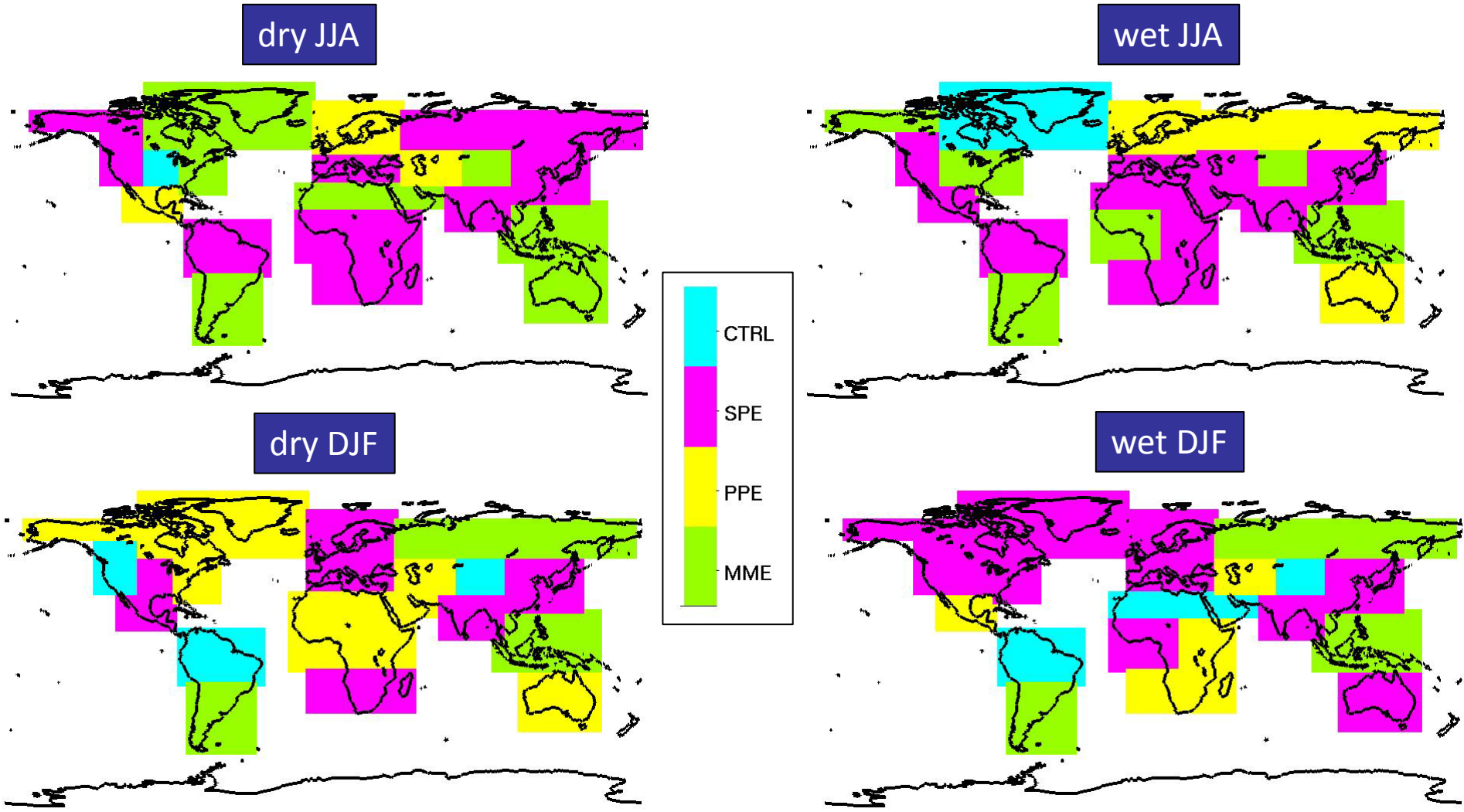
# precipitation highest BSS ∞ 1st month



# temperature highest BSS ∞ 2-4 months



# precipitation highest BSS ∞ 2-4 months

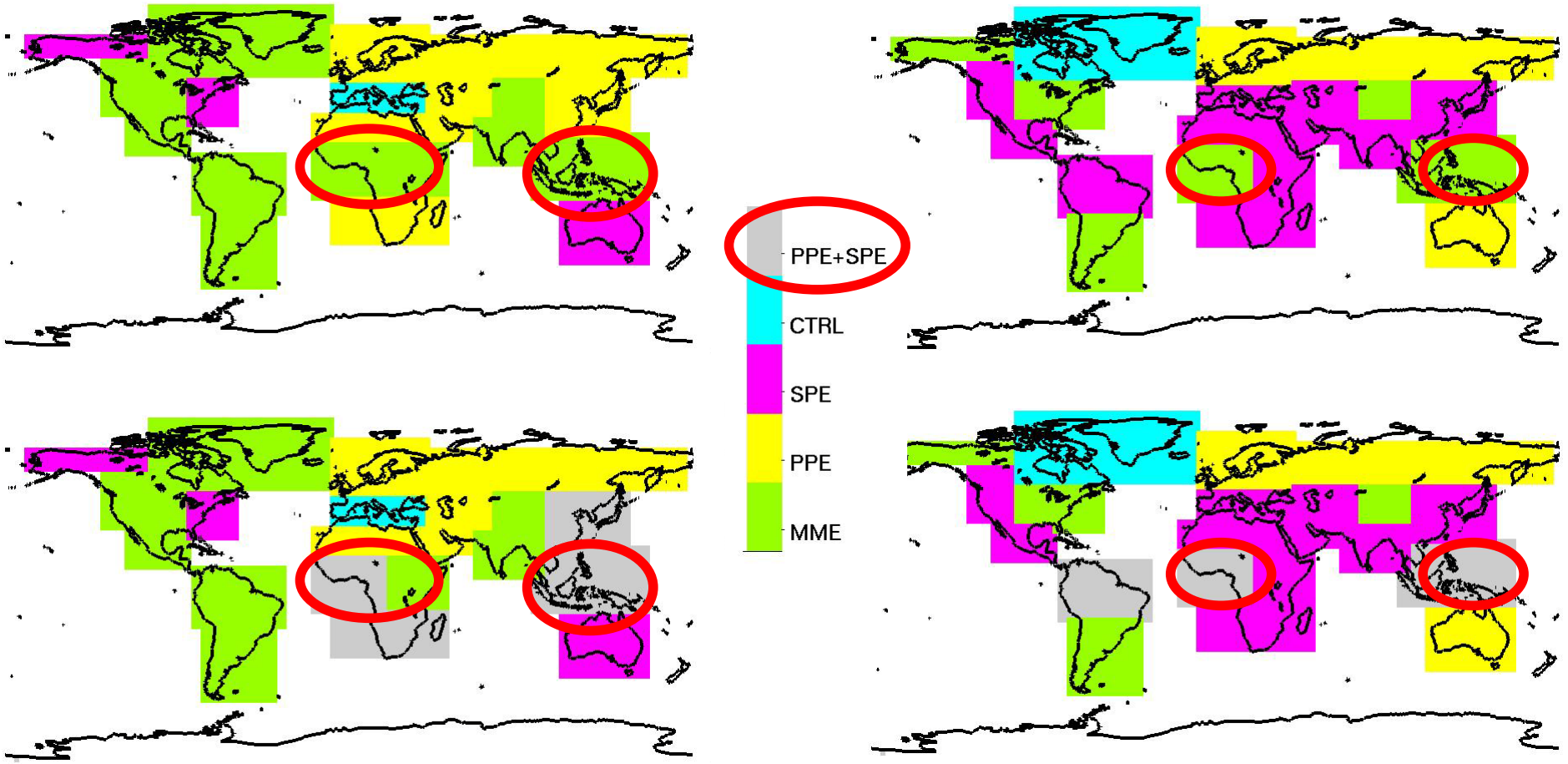


# combined PPE & SPE

2-4 months

warm JJA

wet JJA

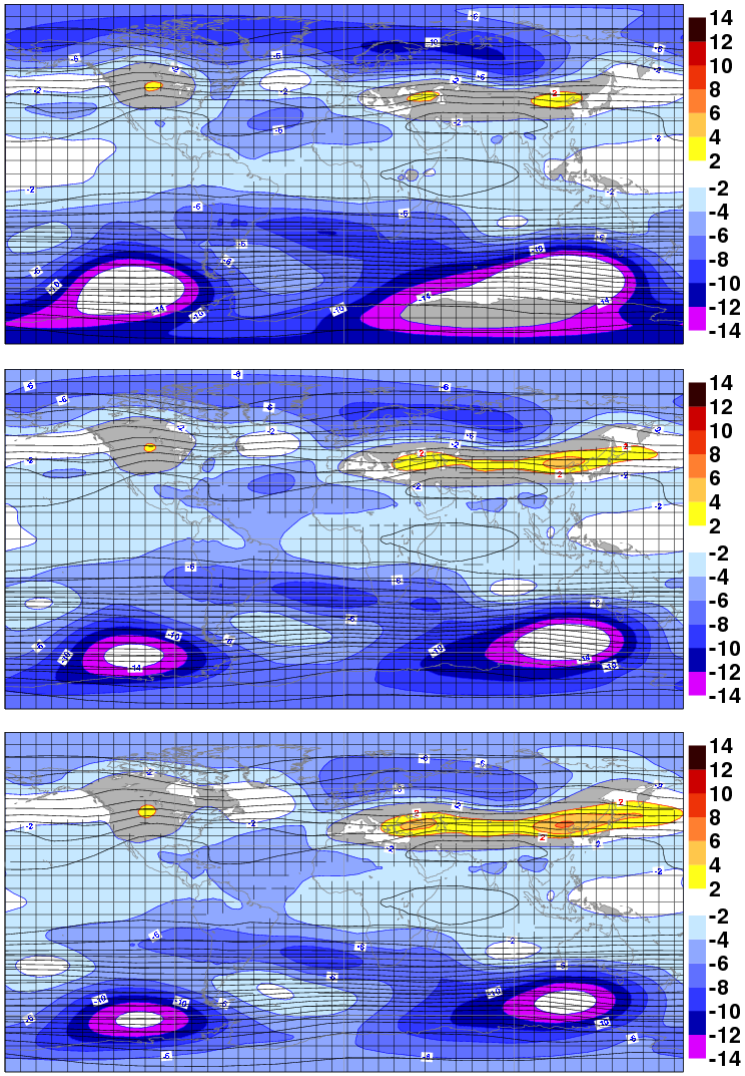


# Outlook: vorticity confinement

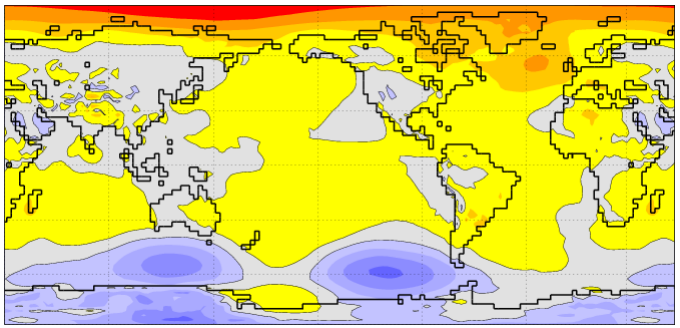
**Z200 in JJA**

**model bias**

**MSLP in JJA**

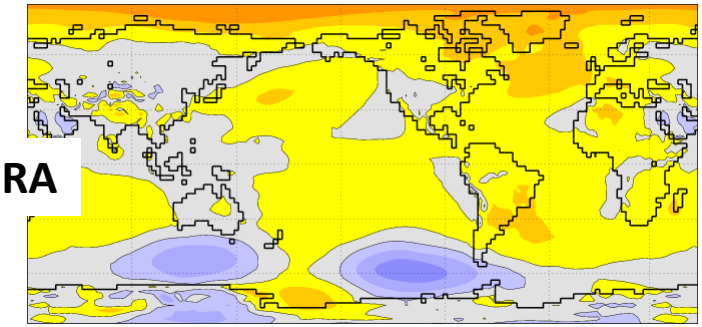



**Ctrl - ERA**



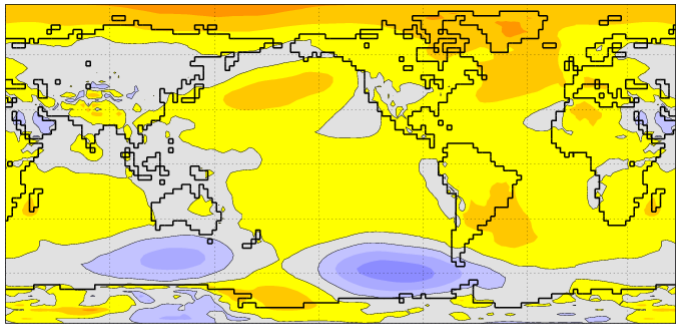



**determVC - ERA**



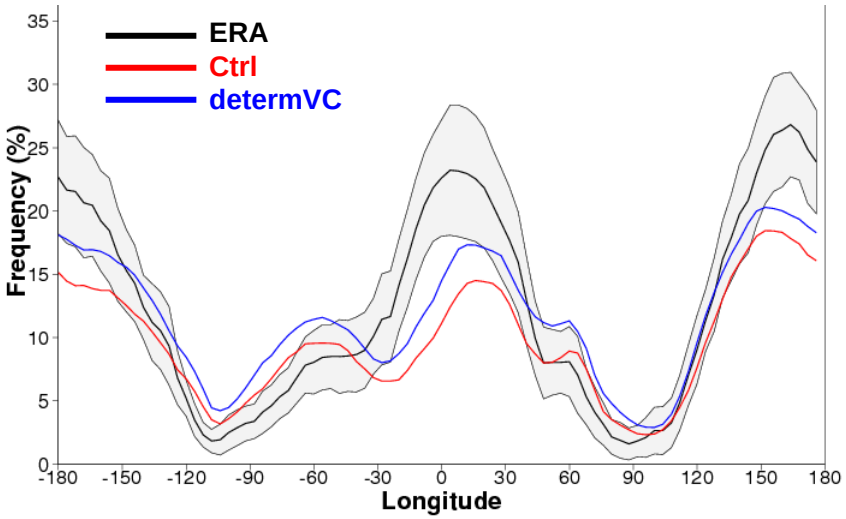


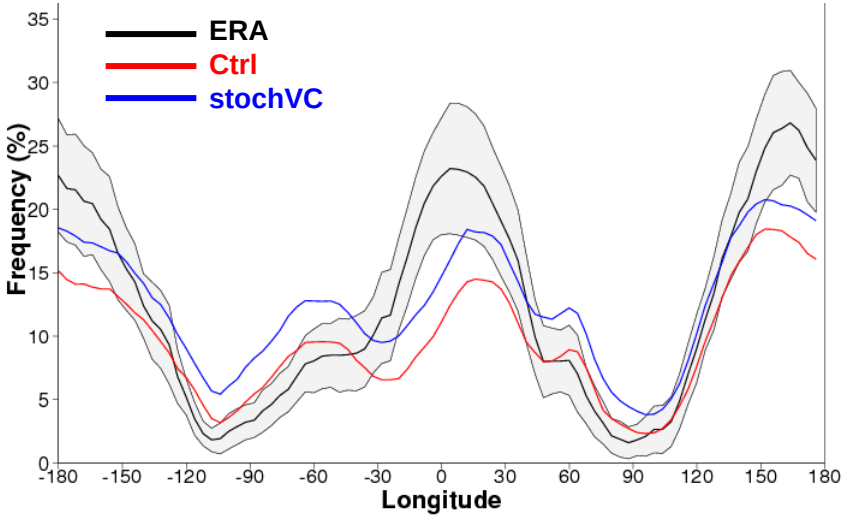

**stochVC - ERA**



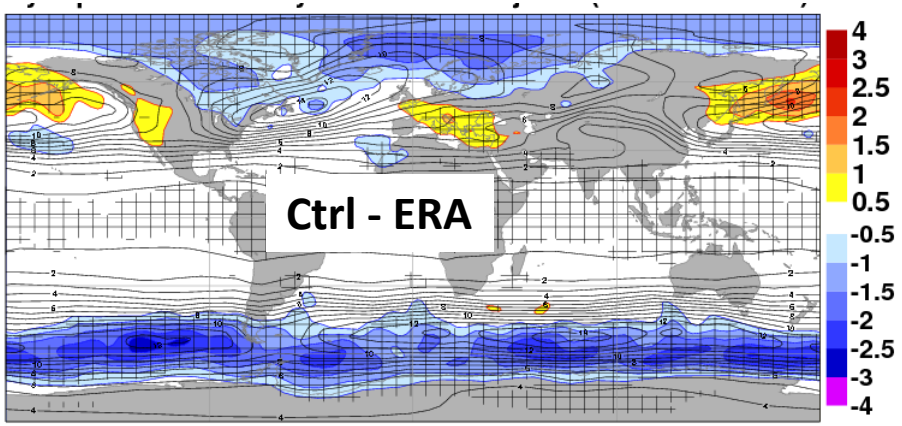
# Outlook: vorticity confinement

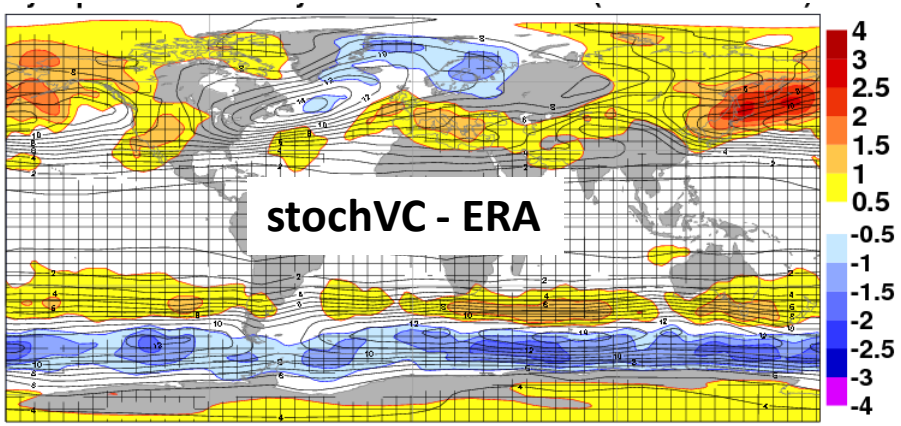
## blocking frequency




## DJF Z500 synoptic activity

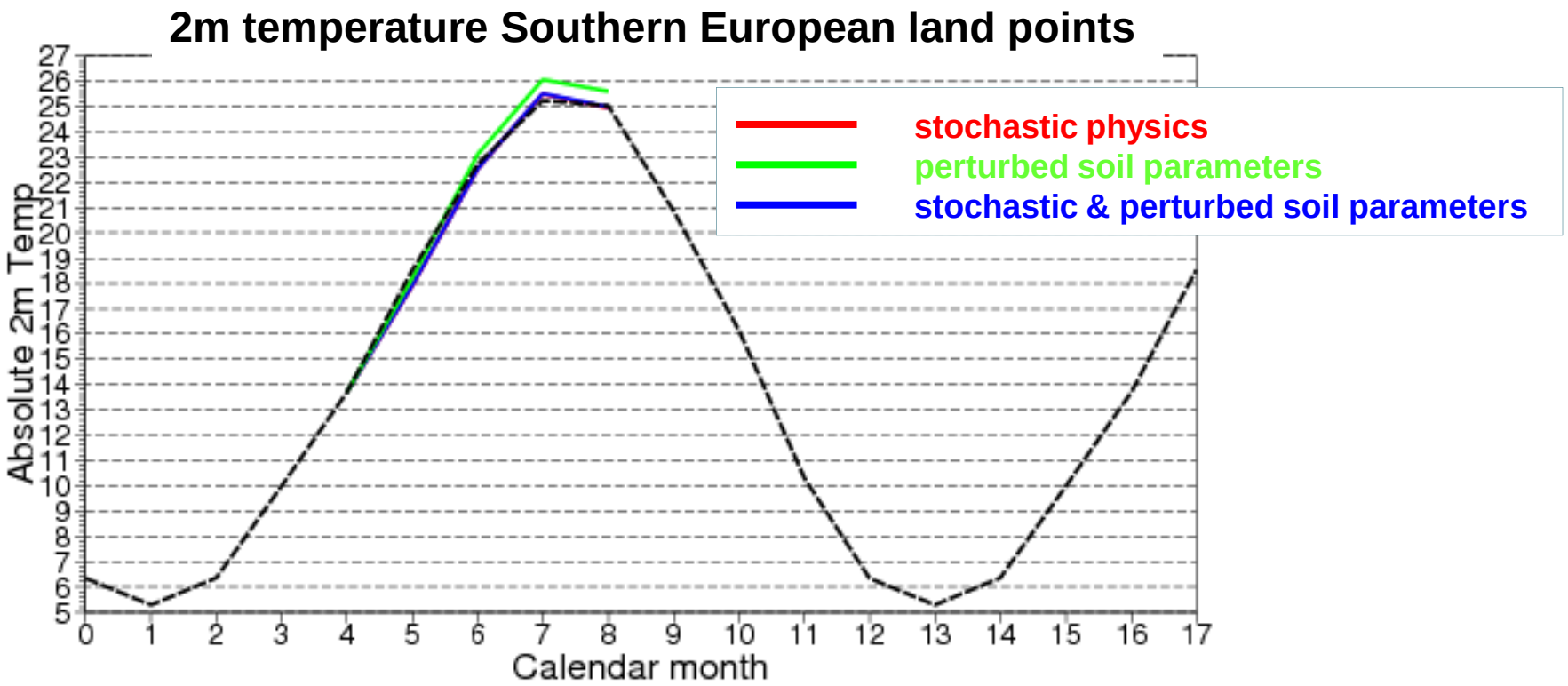


# Outlook: Land surface parameter uncertainty

**seasonal forecast ensemble:**
- **T159, 25 members**
- **1989-2008**
- **May start dates (→ JJA)**

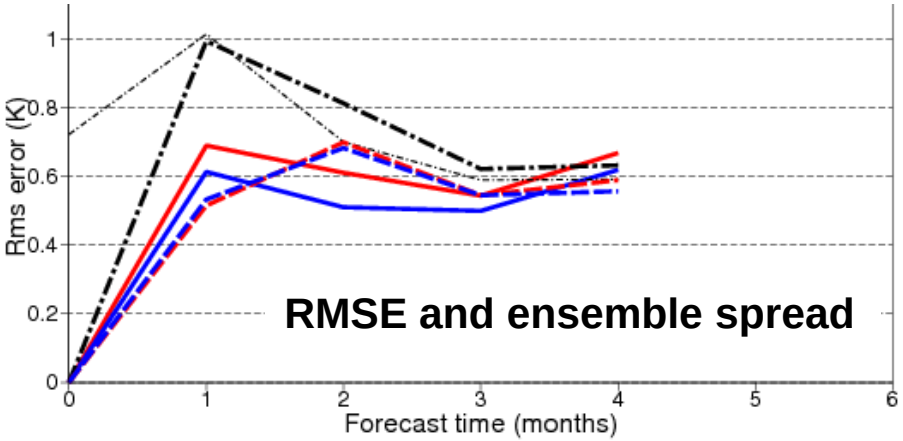
Perturbed land-surface parameters (+/- 20%):
- Hydraulic conductivity
- Curve shape parameter of soil moisture characteristic (van Genuchten $\alpha$)

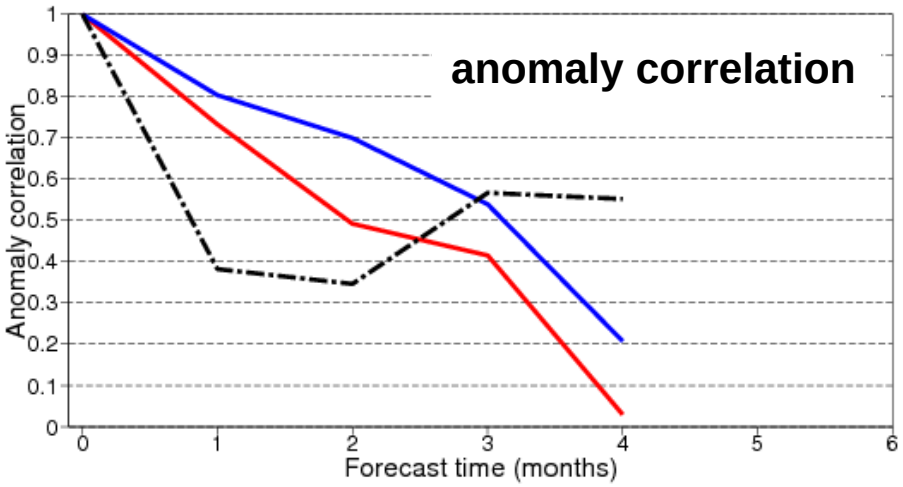


# Outlook: Land surface parameter uncertainty

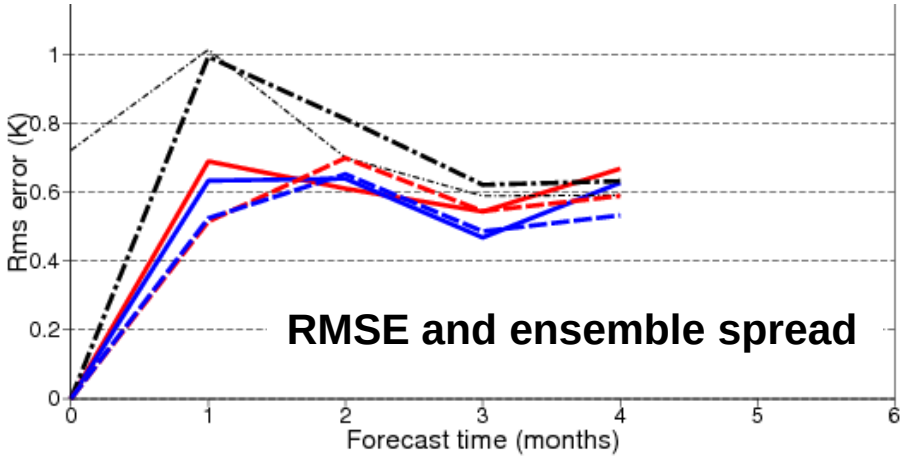
## 2m temperature Southern European land points

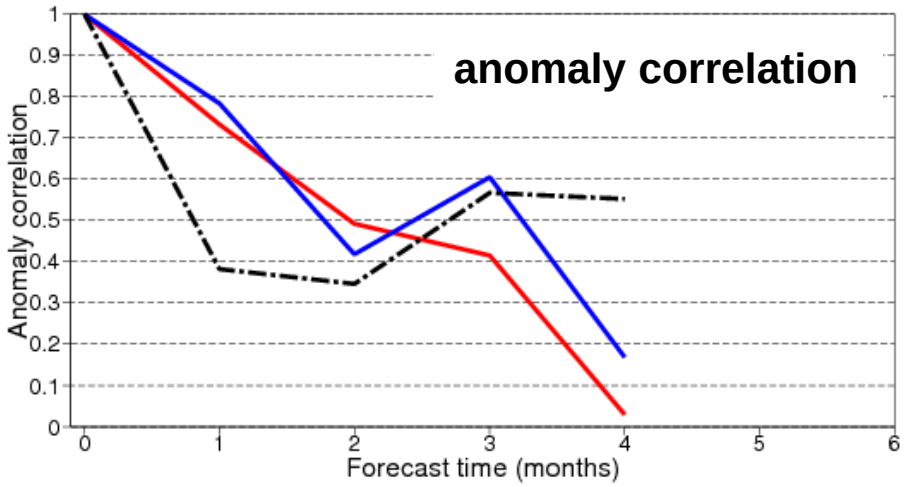
control (stoch phys only)
+ perturbed soil parameters




only stochastic physics
only perturbed soil parameters



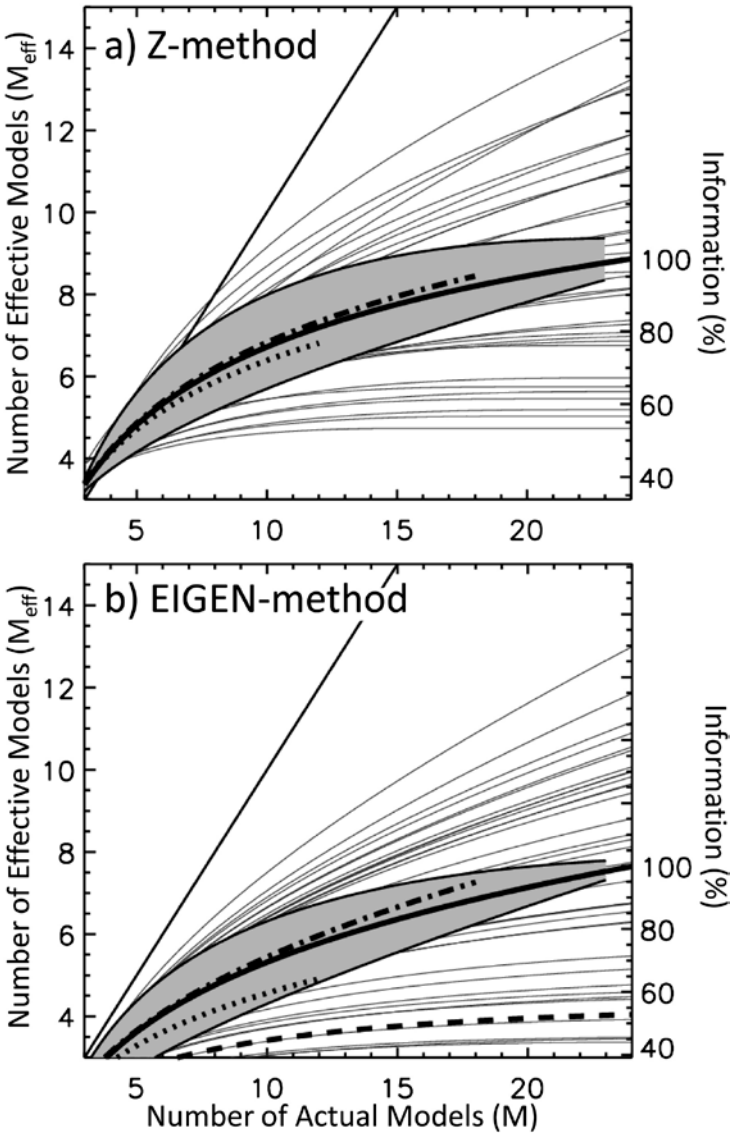
# Effective size of multi-model ensembles

24 CMIP-3 climate models for the 20th century, 35 quantities

$M_{eff}$ for individual quantities:
3 … 15

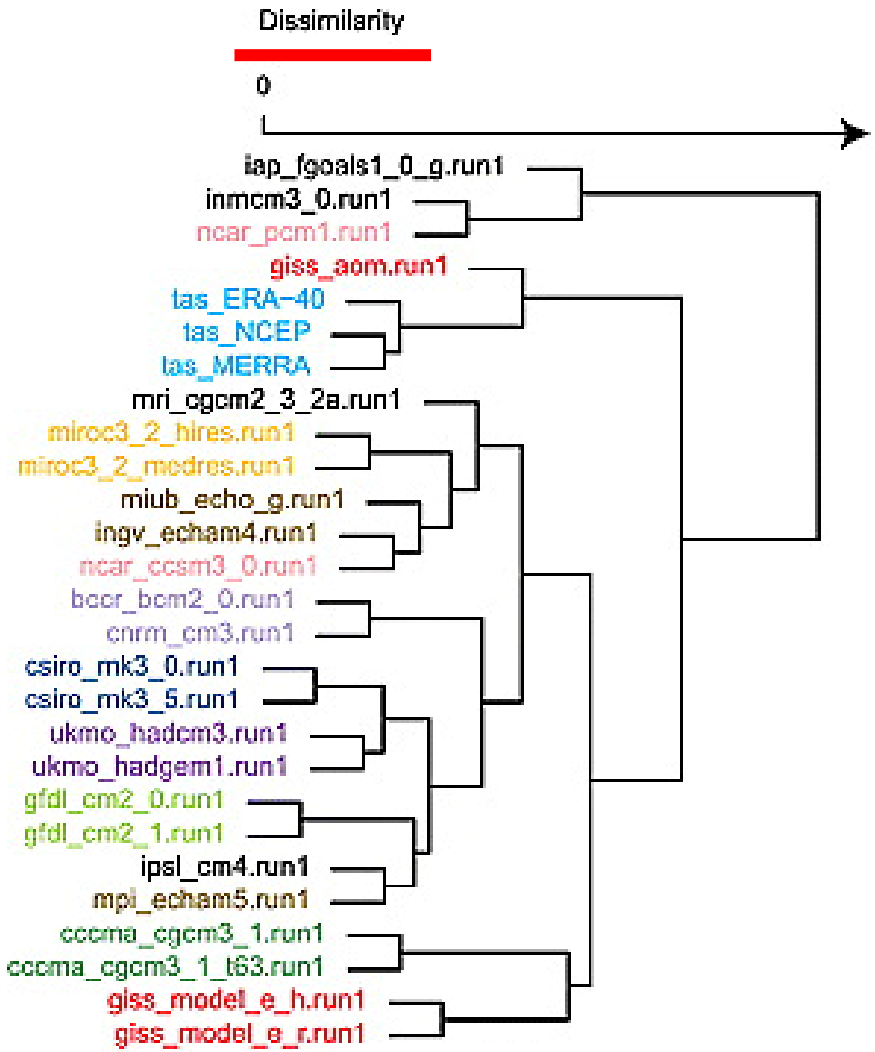
$M_{eff}$ averaged over all quantities:
7.5 … 9

Current interpretations of MME may lead to overly confident predictions

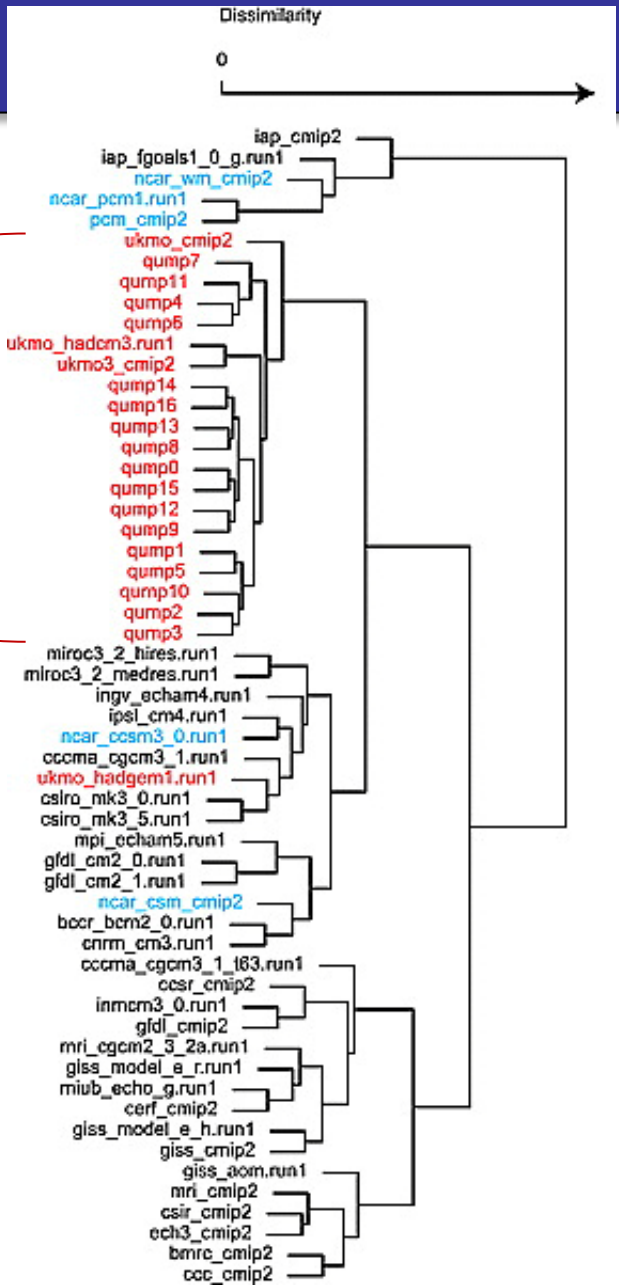



**Pennell and Reichler (2011)**

# Model similarity in MMEs and PPEs




PPE




**Masson and Knutti (2011)**

# Conclusions

- MME performs on average better than any single model ensemble due to reduced overconfidence
- **ENSO: MME very good, SPE improved over CTRL, PPE rather poor**
- **Monthly forecasts: SPE globally most skilful for most land temperature and precipitation events, regional variations**
- **Seasonal forecasts: MME (SPE) on average most skilful for temperature (precipitation) over land, regional variations**
- **PPE: no control ensemble available → quality of base model?**
- **SPE becomes competitive to MME and should also be included in uncertainty estimates of climate predictions/projections**
- **Combination of PPE and SPE has potential to improve skill further beyond the MME**
- Some promising test results with vorticity confinement (mean flow, blocking, synoptic activity)
- Preliminary test on including uncertainty in land surface parameter perturbations (improved forecast skill over southern Europe summer temperatures)

# References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