Pacific Climate Change Science Program

Evaluating global climate models for the purpose of informing climate change projections

A Pacific Climate Change Science Program (PCCSP) perspective

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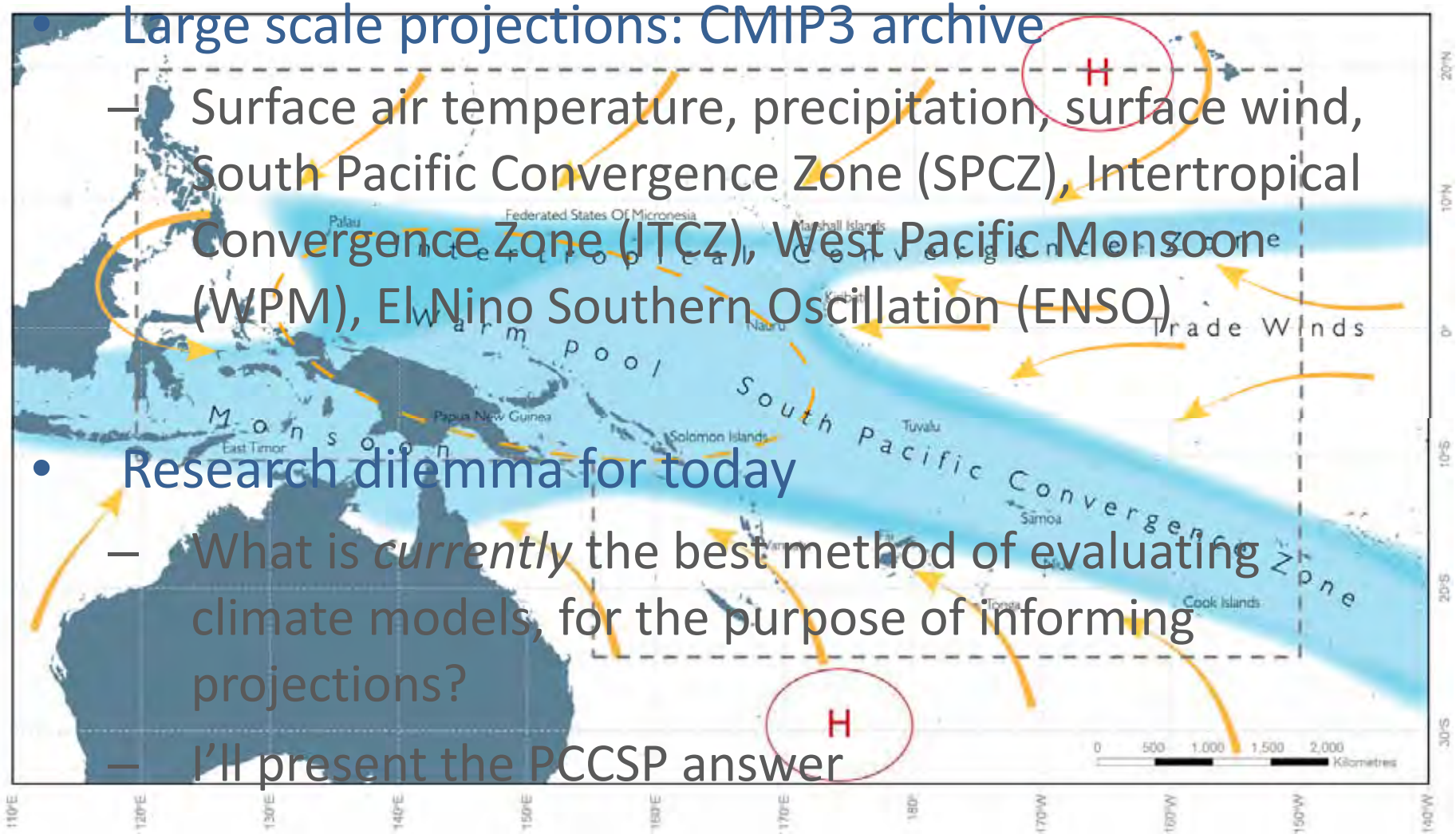
The PCCSP climate projections

- Large scale projections: CMIP3 archive
  - Surface air temperature, precipitation, surface wind, South Pacific Convergence Zone (SPCZ), Intertropical Convergence Zone (ITCZ), West Pacific Monsoon (WPM), El Nino Southern Oscillation (ENSO)
- Research dilemma for today
  - What is *currently* the best method of evaluating climate models, for the purpose of informing projections?
  - I'll present the PCCSP answer

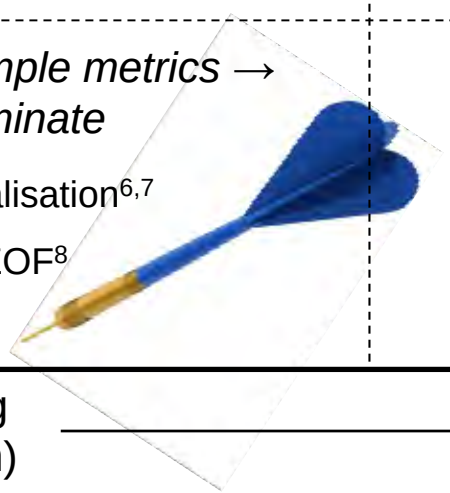


Options for incorporating model evaluation into regional climate projections

Narrow range of model aspects

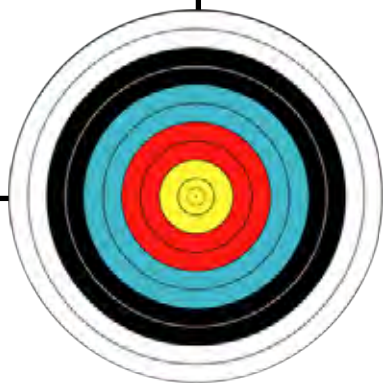
Broad range of aspects

Complex metric → eliminate	*Complex metric → weight*
PDF overlap[1]	M-statistic[3]
Taylor diagram[2]	REA Method[4]
	Bayesian analysis[5]
Combine simple metrics → eliminate	
Normalisation[6,7]	
EOF[8]	



Equal weighting (with elimination)

Individual weighting



(6) Gleckler et al 2008 *J Geophys Res* 113 D06104 doi:10.1029/2007JD008972

(7) Santer et al 2009 *Int J Climatol* 29 1702–19

(8) Weigel et al. 2010, Risks of model weighting in multi-model climate projections, *Journal of Climate*

Methods

Overview

Category	Components	Tests
Climate variables	tas, pr, wind	Mean state, seasonal cycle (phase & amplitude), spatial features (location & amplitude)
Climate features	SPCZ, ITCZ, WPM	Location, interannual variability
Climate variability	ENSO	Strength, frequency, spatial pattern, link with precipitation
Climate stability	Drift (tas & pr)	Drift magnitude (PIcntrl; 1950-1999)
Warming signal	SST	Trend error (1950-1999)

Temporal domain: 1979-1999 monthly data

Spatial domain: PCCSP region

Tests: Correlations, variance ratios, errors

Observations: ERA-40, NCEP-2, JRA-25, CMAP, GPCP, HadISST, ERSSTv3, Kaplanv2

Methods

Normalisation of model performance metrics

$$f(E) = \frac{E - \mu_E}{\sigma_E}$$

E = Absolute error (i.e. distance from the perfect (or observed) score)

μ_E = Multi-model average absolute error

σ_E = Intermodel standard deviation

Results

Climate variables

Aspect	Statistical test	Data
Mean state	Grid point average magnitude of difference between model and observed field (***E***)	1979-99 annual mean field
Seasonal cycle (phase)	Grid point average temporal correlation (r_t)	Spatial field containing 12-step timeseries of the 1979-99 mean value for each month
Seasonal cycle (amplitude)	Grid point average temporal standard deviation ratio (model/obs; $\sigma_{r,t}$)	
Spatial features (location)	Monthly time-step average spatial (or pattern) correlation (r_p)	1979-99 mean field for each month
Spatial features (amplitude)	Monthly time-step average spatial standard deviation ratio (model/obs; $\sigma_{r,x}$)	

Results

Climate variables (e.g. surface air temperature)

Mean state (error)

E = 1.02 (0.48) ° C

Seasonal cycle (phase)

r_t = 0.74 (0.06)

Seasonal cycle (amplitude)

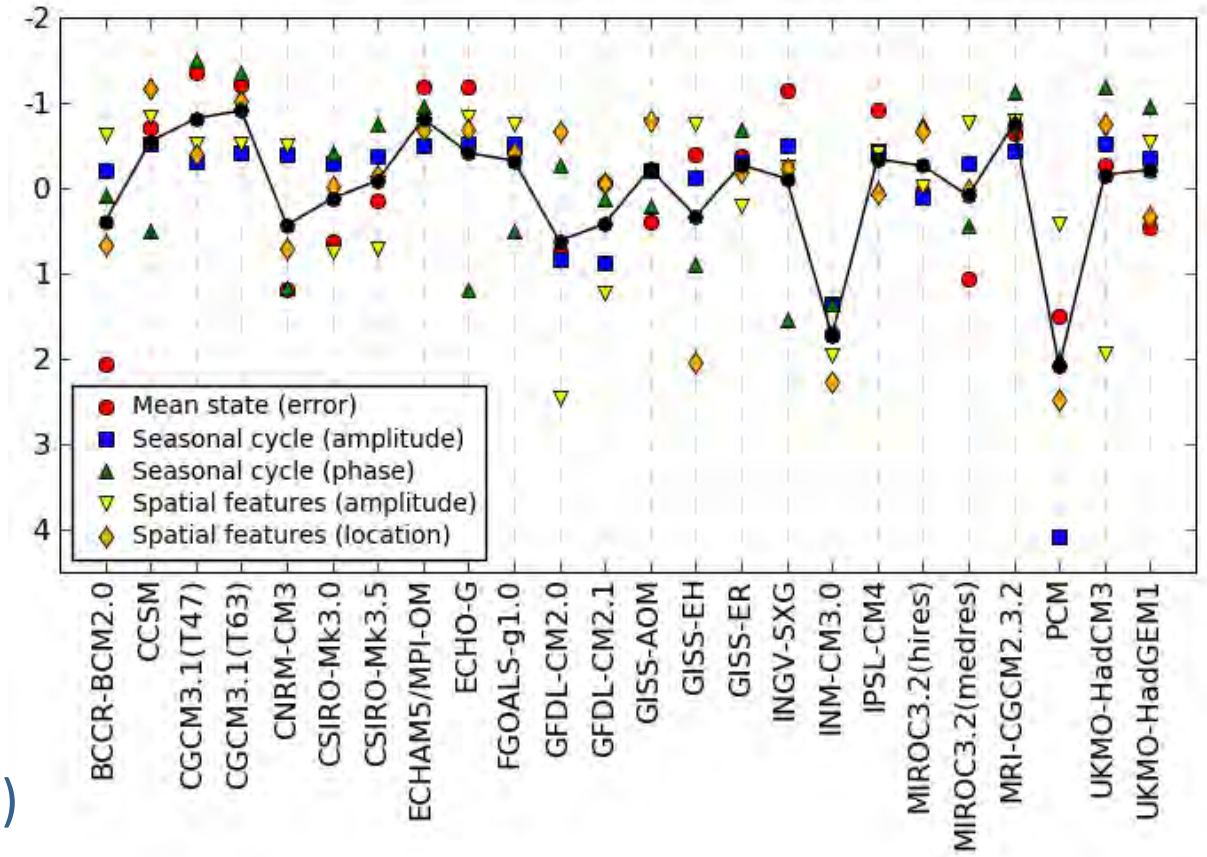
σ_r = 1.18 (0.23)

Spatial features (location)

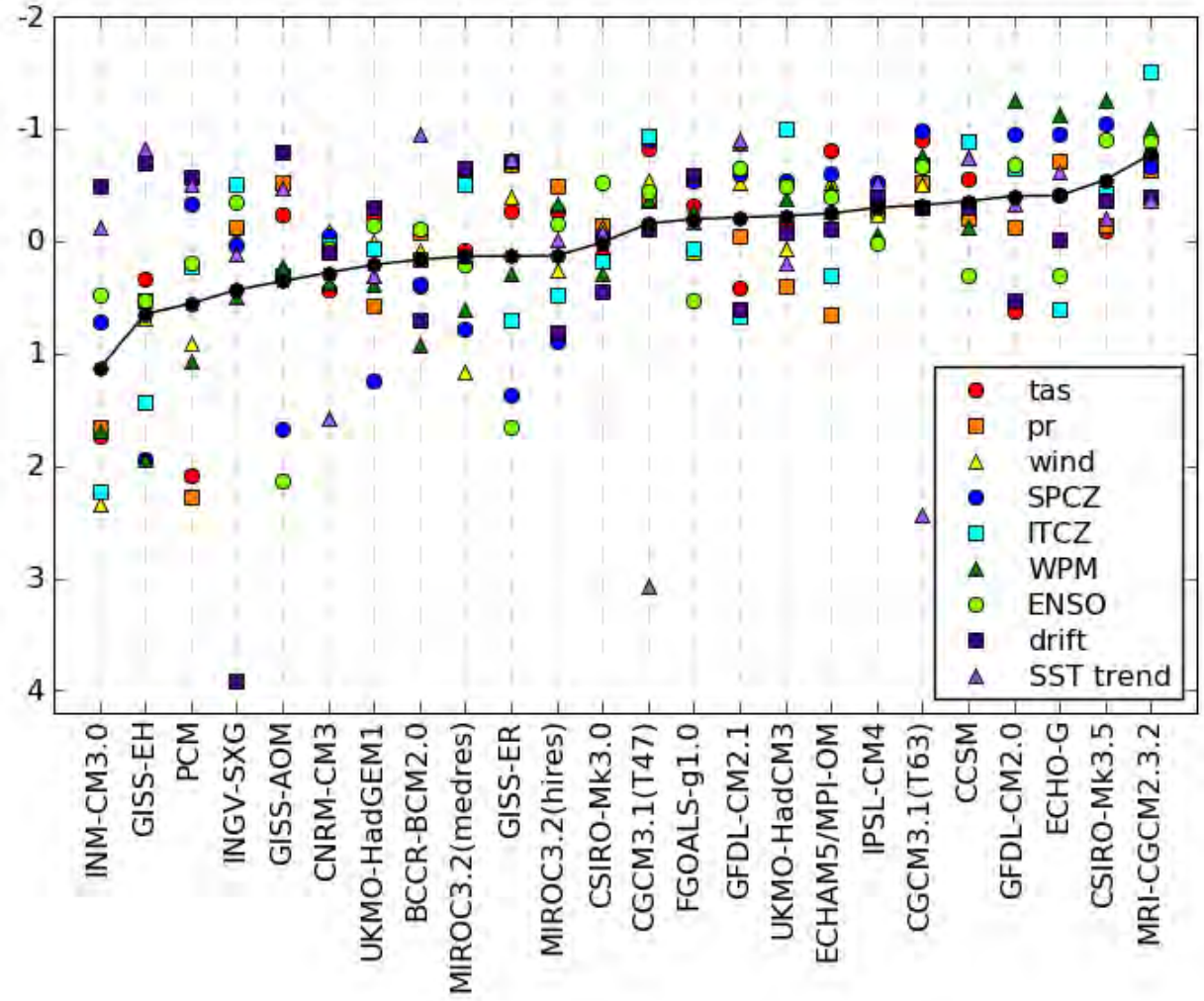
r_p = 0.89 (0.05)

Spatial features (amplitude)

σ_r = 1.08 (0.11)



Climate model selection



Eliminated:

- ENSO
  - GISS-AOM, GISS-ER
- Drift
  - INGV-SXG
- Overall
  - INM-CM3.0, GISS-EH, PCM

Discussion

- Methodological decisions
  - Least important: Metric selection
  - Most important: Breadth of assessment
- Possible improvements
  - Normalisation procedure
    - Assumption: Collective model performance on each test is approximately equal, both in terms of the mean and the distribution about that mean
    - Normalisation process independent of the remainder of the ensemble is required[1]
  - Definition of unacceptable performance

(1) Xu et al (2010) *Clim Res* **41**:61-81

Conclusion

What is *currently* the best method of evaluating climate models, for the purpose of informing projections?

- PCCSP answer:
  - Broad ranging assessment that captures multiple key aspects of a climate model simulation
  - Equal model weighting (with possible elimination)
  - Could be adapted to suit any region and set of climate model simulations

Questions?

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