

Pacific Climate Change Science Program

Projections of Climate Extremes over the Tropical Pacific (and the influence of evaluation on projections)

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Australian Government

Overview



- To explore the relationship (if any) between model performance and future projections of extremes over the western tropical Pacific
(Perkins, 2011, *Earth Interactions*)
- Earlier work has shown that higher-skilled models produce cooler extreme projections (Perkins et al., 2009, *Geophys. Res. Lett.*; 2010, *Int. J. Climatol.*)
 - Statistically significantly different from the all-model ensemble
 - A small sample of models
 - Over Australia only
 - Only for daily 1-in-20 year temperature events
- Same result over an ocean-based region? What about other extremes?
- Part of the Pacific Climate Change Science Program (PCCSP)



Data & Projections



- Extreme projections:
 - Daily 1-in-20 year event (RV_{20})
 - Heat wave duration index (HWDI) * **
 - Warm Nights (TN90) *
 - Very intense rainfall (VIP) *
 - Extremely heavy rainfall contribution (R99T)*
 - Rain days (RD) ^
 - Heavy rain days (HRD)^
 - Were chosen to represent various aspects of extremes, including magnitude and frequencies.
 - Interested in the ABSOLUTE VALUE of each projection, not the change
 - Is there a relation in current model bias and future projected values
 - Can we reduce SOME uncertainty based on evaluation?
 - Model data:
 - 13 CMIP3 GCMs
 - Tmax, Tmin, rainfall
 - 20c3m (1980-1999), SRES A2 (2081-2100) scenarios
 - “reference” datasets:
 - JRA25 (Onogi et al., 2007, *J. Meteorol. Soc. Jpn.*)
 - ERA40 (Kanamitsu et al., 2002, *B. Am. Meteorol. Soc.*)
 - NCEP2 (Uppala et al., 2005, *Quart. J. Roy. Meteorol. Soc.*)
- * For more information on the ETCCDI indices please see <http://cccma.seos.uvic.ca/ETCCDMI/>
- ** Threshold differs from original ETCCDI definition
- ^ Based on thresholds defined by Sun (2006) and Dai (2006), *J. Climate*



Methodology-Evaluation

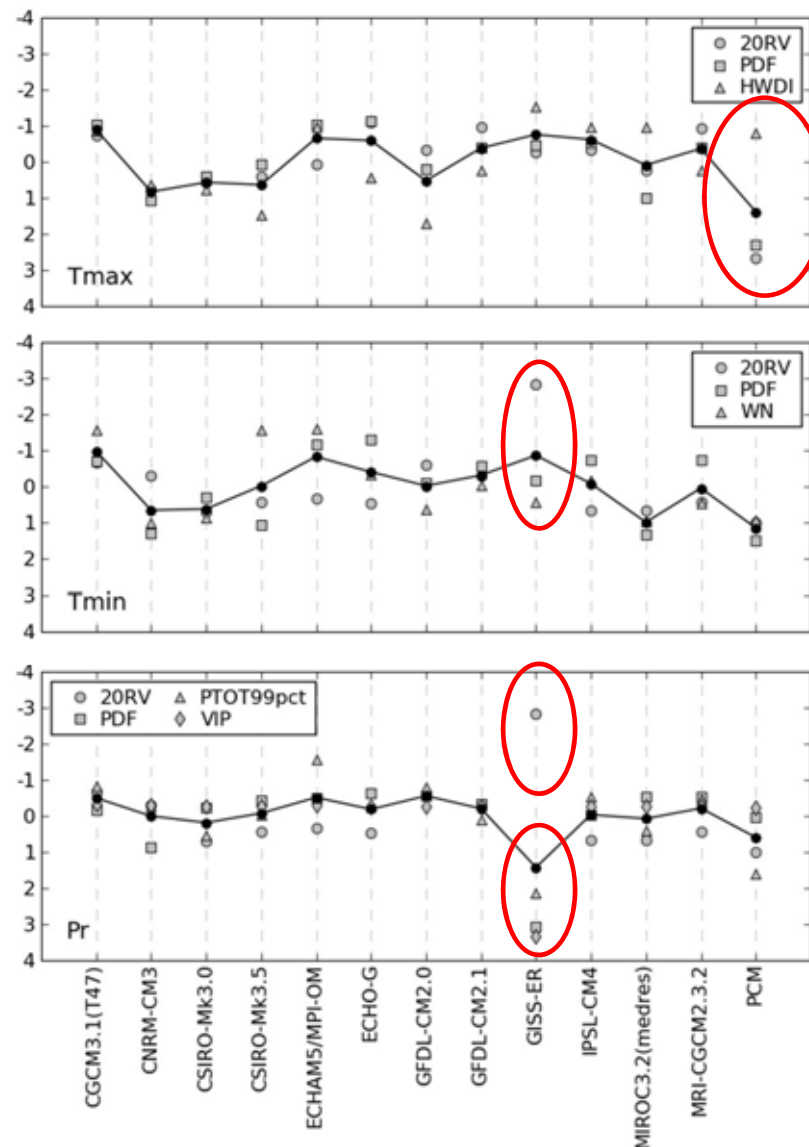


- Just because a model compares well to current climate does not signify it will do just as well in future....
- Evaluation:
 - Kept simple 😊
 - PDF overlap (Perkins et al., 2007, *J. Climate*)
 - Absolute bias in RV_{20} ; each index
 - Against each reanalysis per grid box, average taken
 - All metrics equally weighted
 - Metrics standardised

- Measures distance of models around an ensemble mean of 0
- Allows for comparison across metrics
- Metrics combined per variable, NOT overall

$$M_s = \frac{M_{\text{mod}} - \mu_{\text{all}}}{\sigma_{\text{all}}}$$

Pc

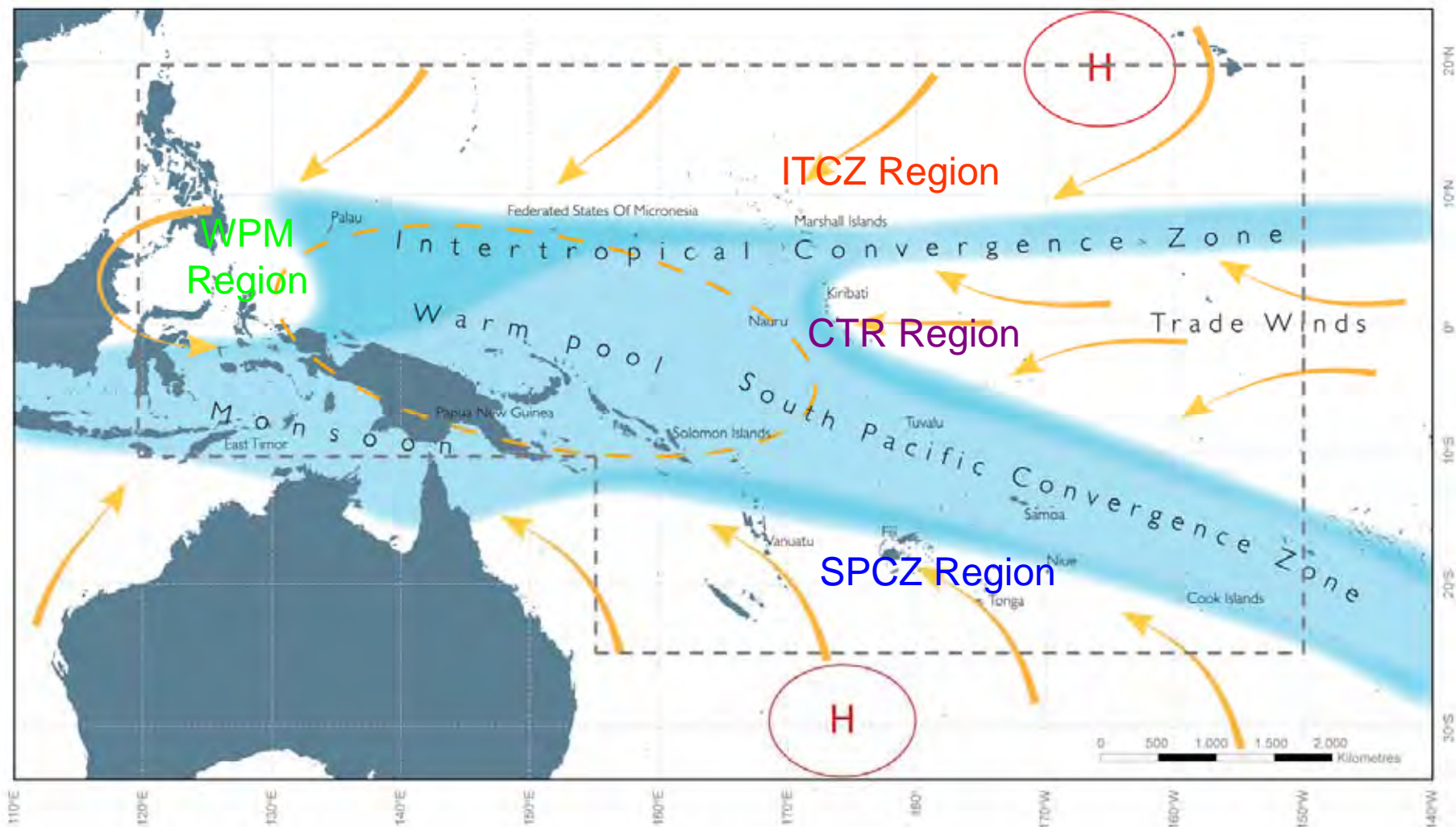


Methodology - Projections



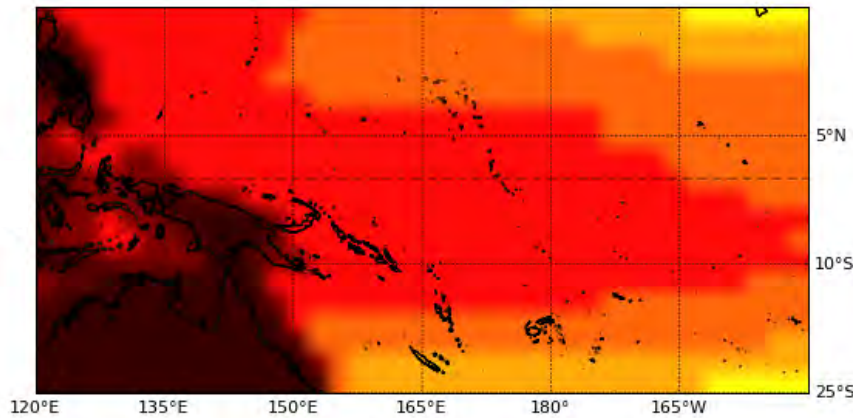
- Multi-model ensemble (MME) for each projection
 - Average value, change/frequency where appropriate
 - Standard deviation (σ ; model spread/agreement)
- Top 6 (T6) and Bottom 6 (B6) ensembles per variable (based on evaluation)
 - Bias in ensemble average against MME
 - Standard deviation
 - do the models agree more/less?
 - Statistical significance (Mann-Whitney; 5%) in both average and σ , compared to MME
 - PCCSP region
 - West Pacific monsoon (WPM)
 - South Pacific Convergence Zone (SPCZ)
 - Inter-Tropical Convergence Zone (ITCZ)
 - Cold Tongue region (CTR)
- Compared to mean climate projections
 - Is there more/less uncertainty in the projections of extremes compared to the respective mean?

Regions

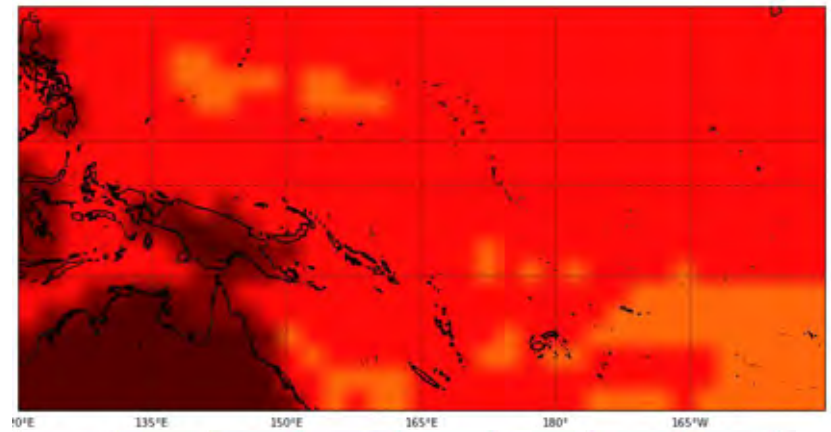


Results – Tmax RV₂₀

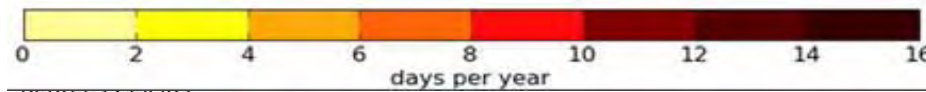
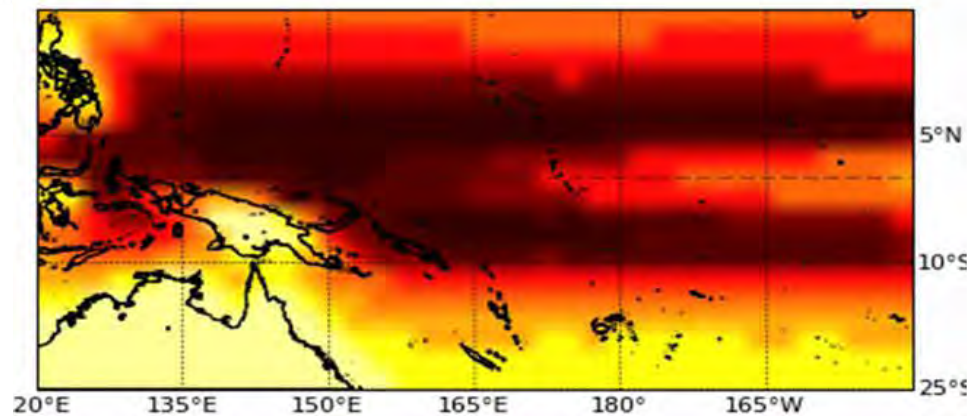
A2 2090 value



Change from 20thC

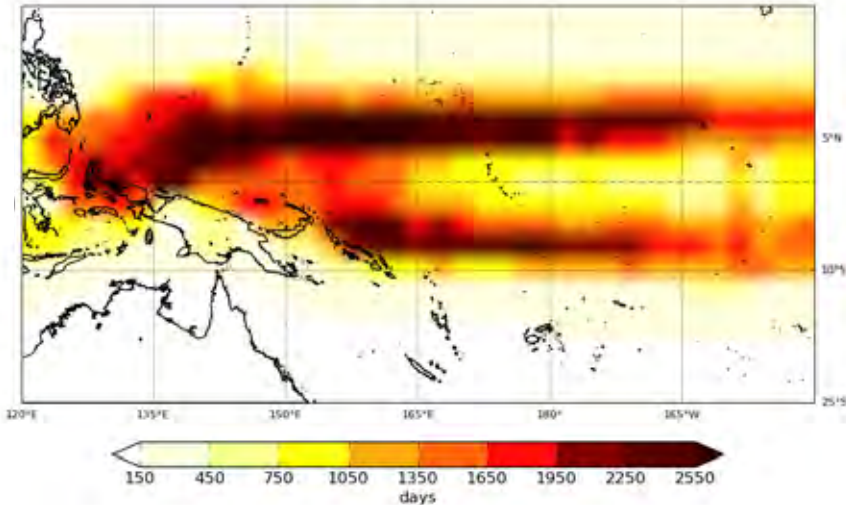


Change in Frequency

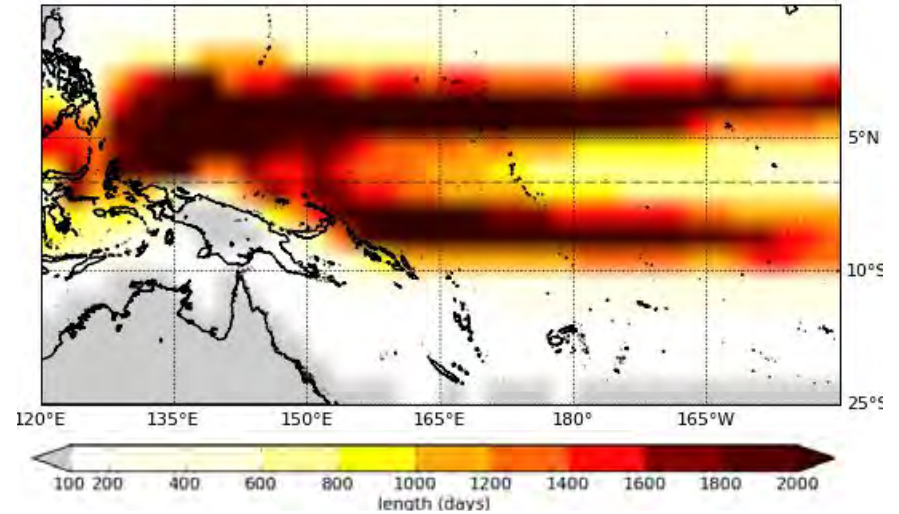


Results – HWDI – maximum length of heat wave

A2 2090 projection

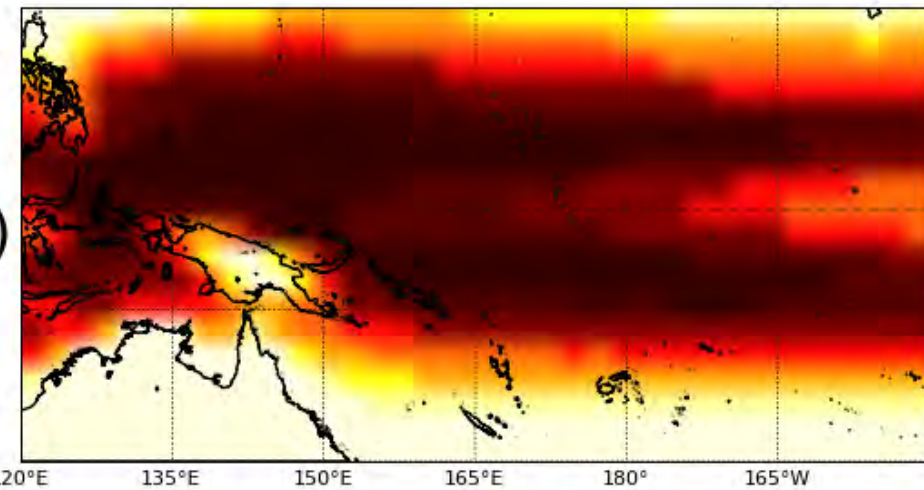


Change from 20thC

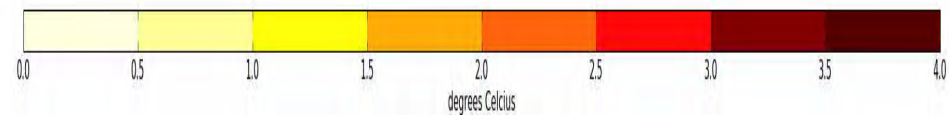
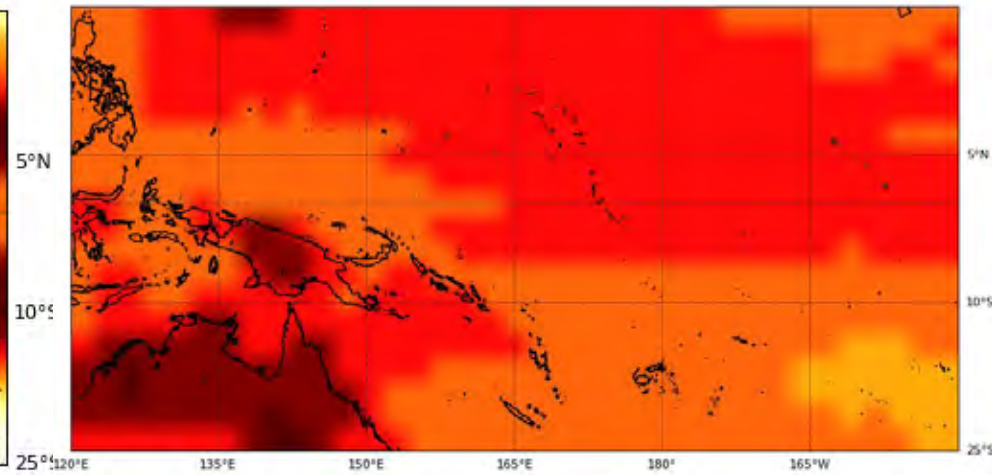


Results – Tmin RV₂₀

A2 2090 value



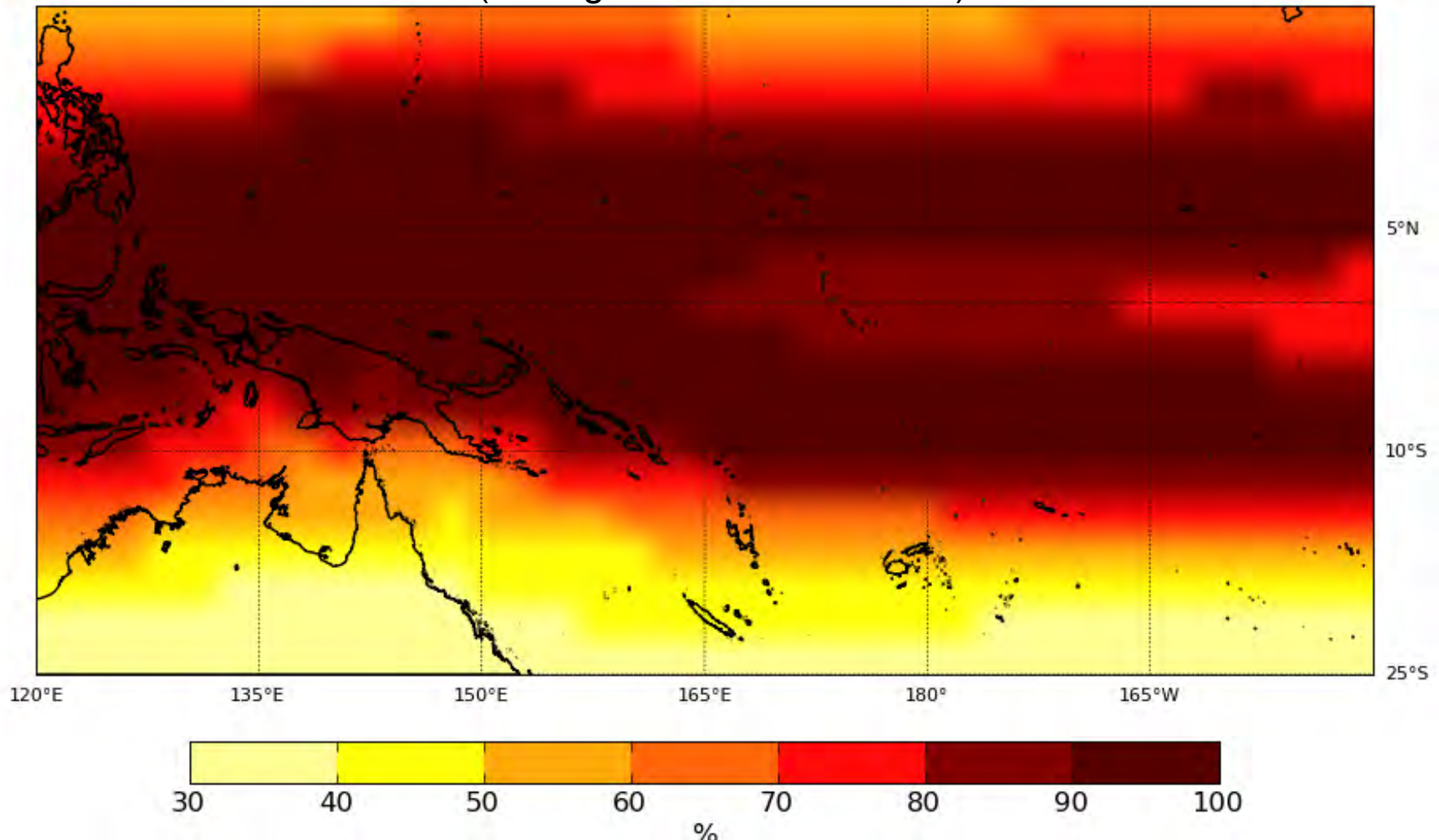
Change from 20thC



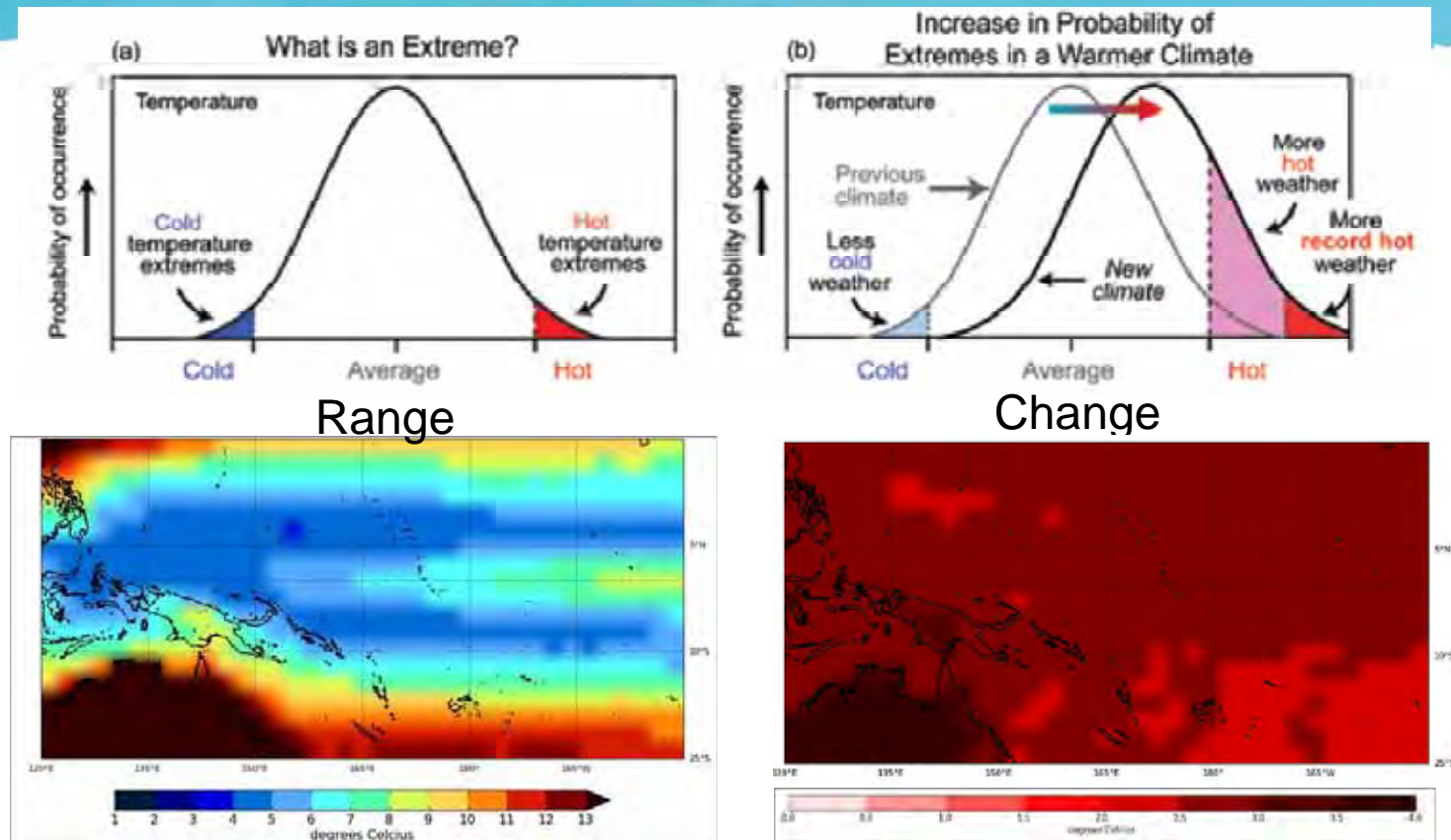
Results – Tn90 (warm nights relative to 20th Century)

A2 2090 Value

(Change from 20thC = -10%)



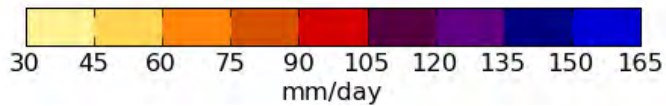
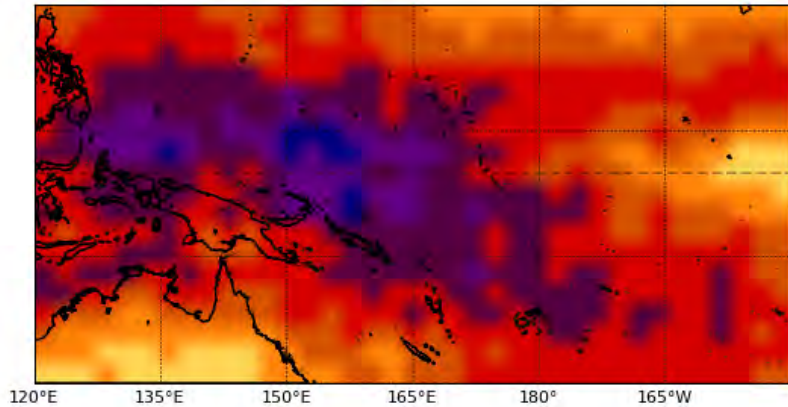
An Explanation of “extreme” changes in indices



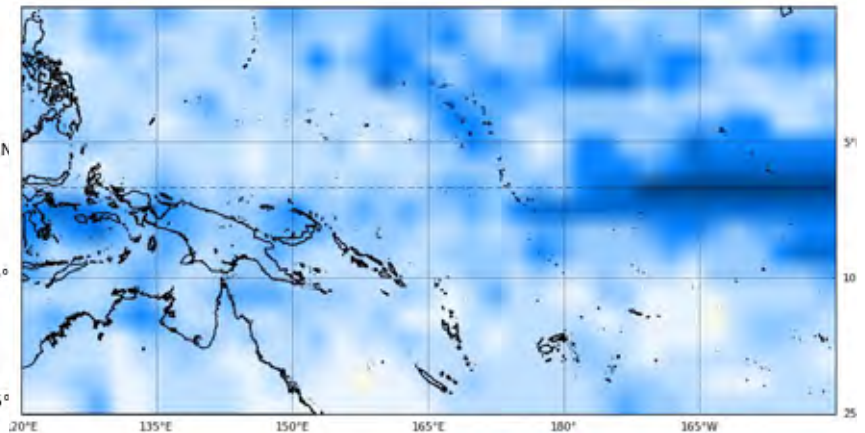
- Annual temperature range quite small
 - 5-6°C over Pacific equatorial areas
 - ~40°C for Melbourne/Sydney
- Shifting it 2°C-3°C = massive change in extremes (shifting distribution by 50% in some areas!)
- Temperature extremes *definitely* increasing in duration and frequency
- BUT are globally standardised indices appropriate for the PCCSP region?

Results – Rainfall RV_{20}

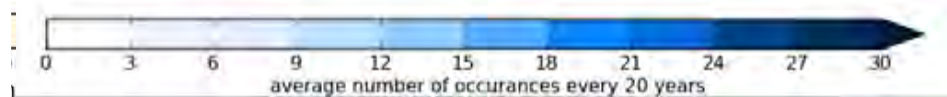
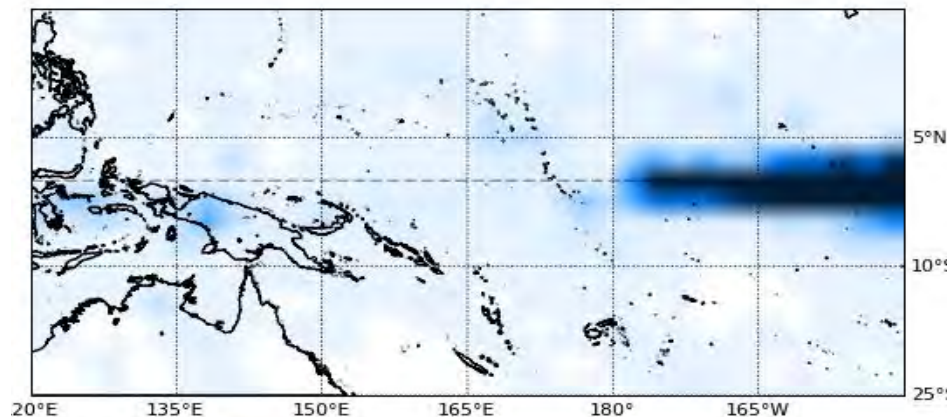
A2 2090 value



Change from 20thC

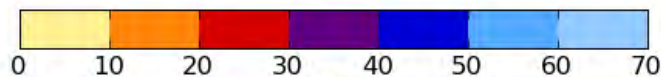
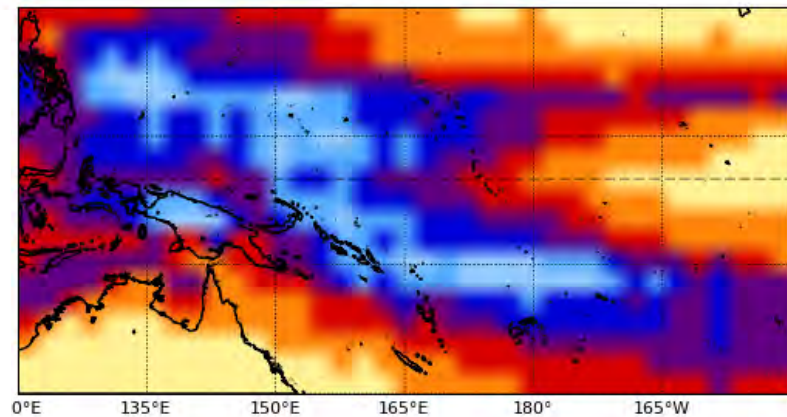


Change in Frequency

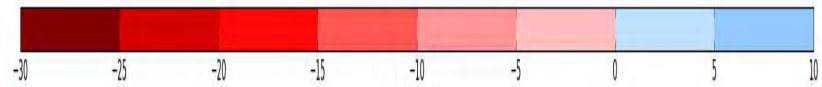
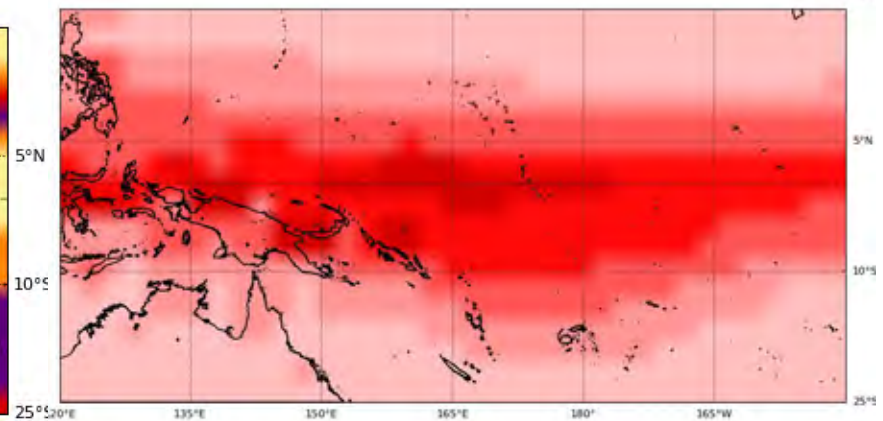


Results – VIP (days/20 years >50mm)

A2 2090 value

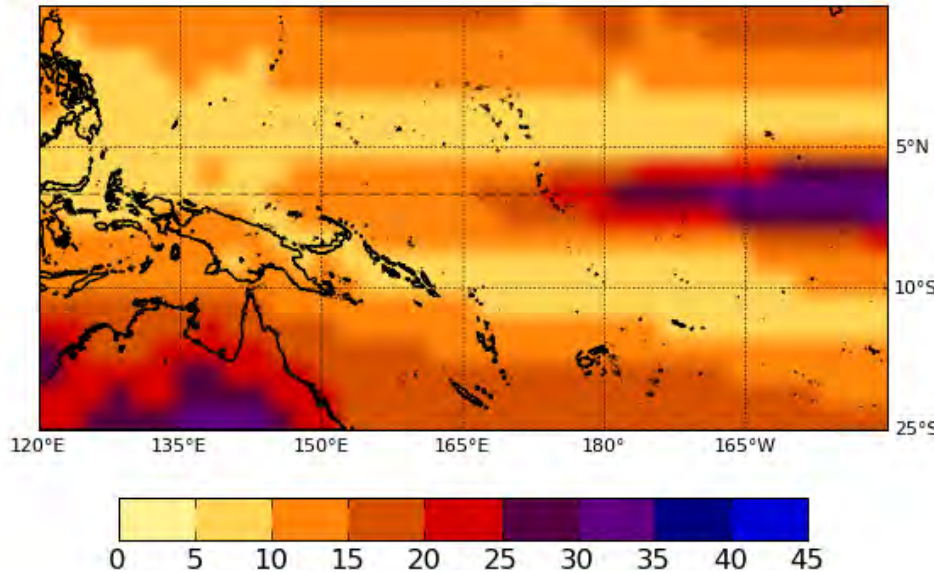


Change from 20thC

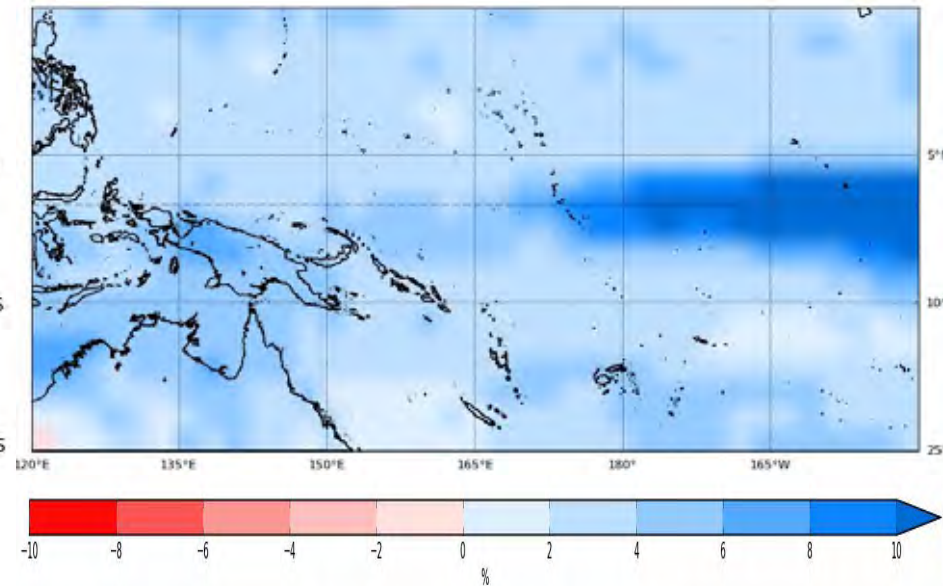


Results – P99T (% of annual total due to extreme rainfall)

A2 2090 value



Change from 20thC



Overall conclusions



- Systematic biases in ensemble projections based on model skill
- Increase in frequency, intensity and duration of temperature extremes
 - Model agreement not always improved when omitting models with weaker skill
 - Differs from other regional studies
 - Becomes poorer for rainfall extremes
 - Why?? What is going on in the future that can't be quantified in the current climate?
→ perhaps should also be included in evaluation process
- Still recommend omitting weaker models 😊
 - Very important first step!
- Are “universal” extremes really that universal?
 - Need to understand what “extreme climate” means at the local scale
 - Wind and humidity as well as heat waves
 - Work closely with partner countries
 - Require high-quality DAILY data
- Future work:
 - GCM extremes vs RCM extremes?
 - More (realistic??) information?
 - Changes in extremes & changes in variability/features
 - can temperature changes be explained by changes in ENSO; or precipitation due to the SPCZ?
 - can we determine *how much* of the change in temperature extremes is due to increases in greenhouse gases

Thank you!!! 😊

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