Extreme Precipitation Events in a Changing Climate using Regional Dynamically Downscaled Climate Projections

Greenhouse 2011

Cairns Convention Centre, Queensland, 4 - 8 April 2011

Christopher J. White[1,2], Stuart Corney[1], Michael Grose[1], Greg Holz[1], James Bennett[1,4], Luis (Augusto) Sanabria[3], Robert P. Cechet[3] and Nathaniel L. Bindoff[1,5]

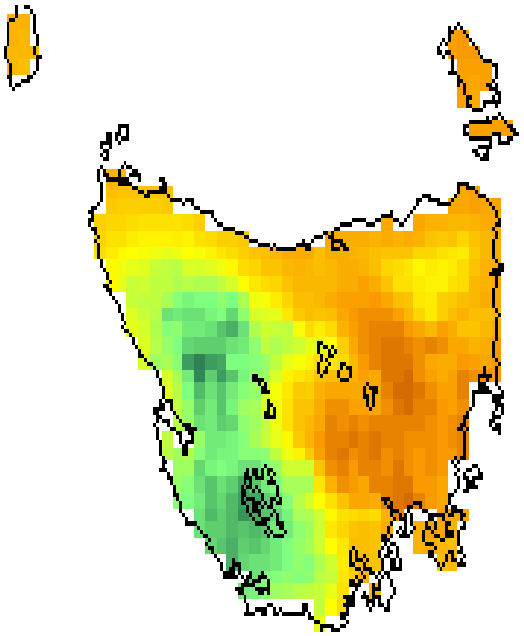
[1] Antarctic Climate and Ecosystems Cooperative Research Centre, Hobart, TAS, Australia
[2] Queensland Climate Change Centre of Excellence, Brisbane, QLD, Australia
[3] Risk & Impact Analysis Group, Geoscience Australia, Canberra, ACT, Australia
[4] Entura, Cambridge, TAS, Australia
[5] CAWCR, CSIRO Marine and Atmospheric Research, Aspendale, VIC, Australia

Climate Futures for Tasmania

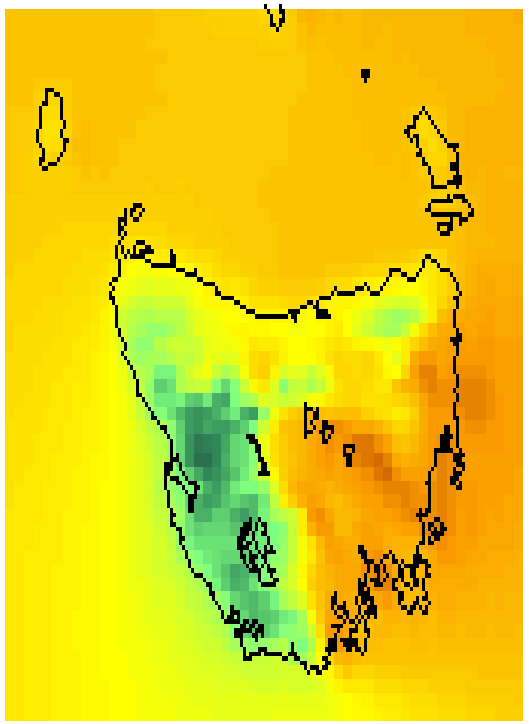
- CERF funded $7.5 million project managed by ACE CRC, Hobart, Australia
- 12 partners, 6 full-time staff, 15 complementary projects and more than 50 engaged end users
- Used the Conformal Cubic Atmospheric Model (CCAM) to downscale 6 GCMs to 0.1° (≈14 km) grid across Tasmania
- Two emission scenarios (SRES A2 & B1), 1961-2100, 6 min time steps, saved 3-hourly, >140 variables and >70 terabytes of data

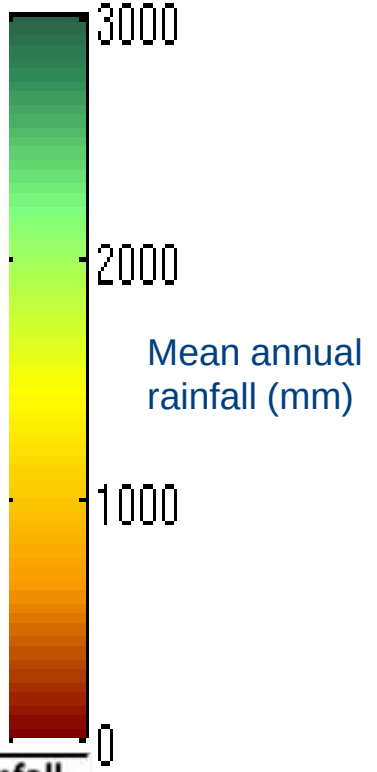
Climate Futures for Tasmania

observations



modelled





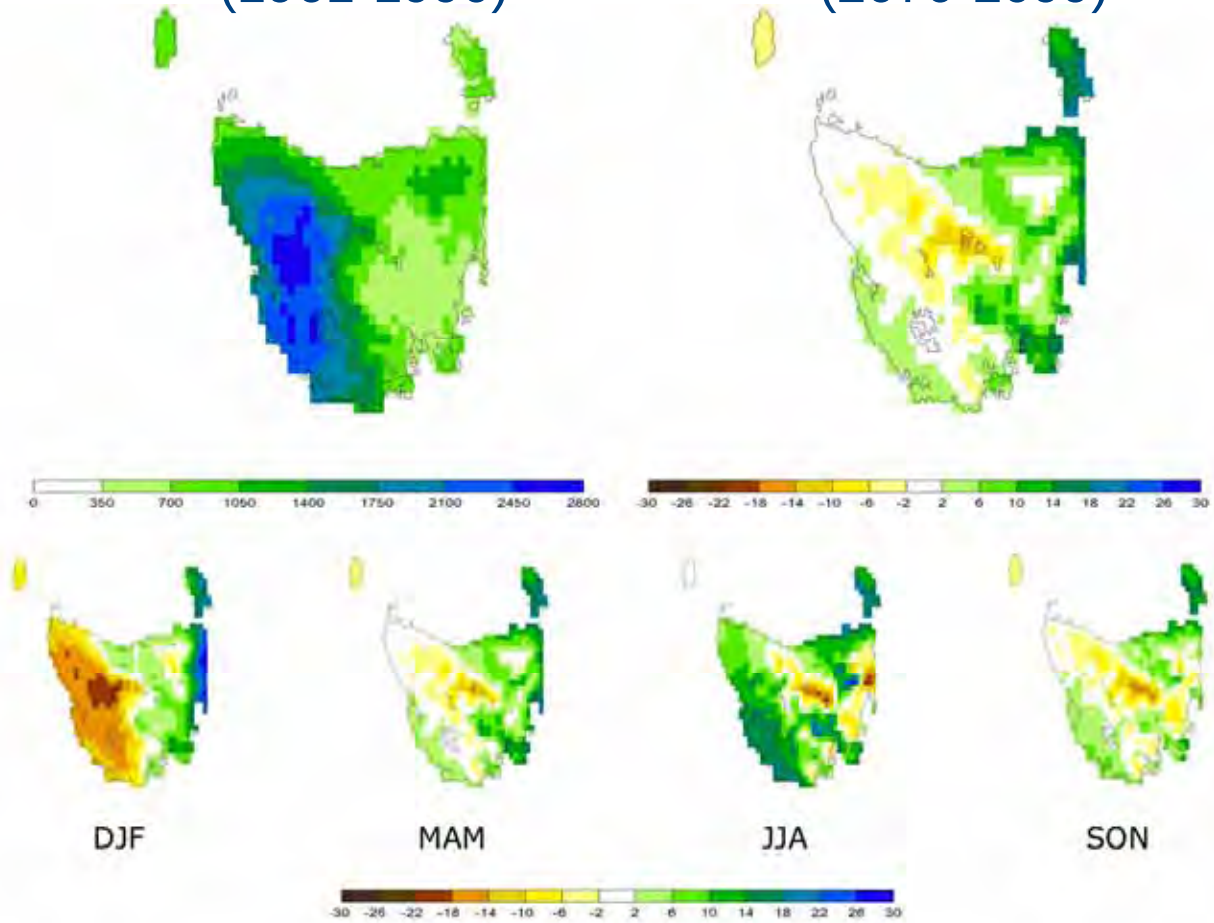
Mean annual rainfall (mm)

Model resolution	Mean Monthly Temperature	Mean Monthly Rainfall
GCM	0.45	0.28
0.5°	0.79	0.44
0.1°	0.93	0.63

changes to mean precipitation

mm
(1961-1990)

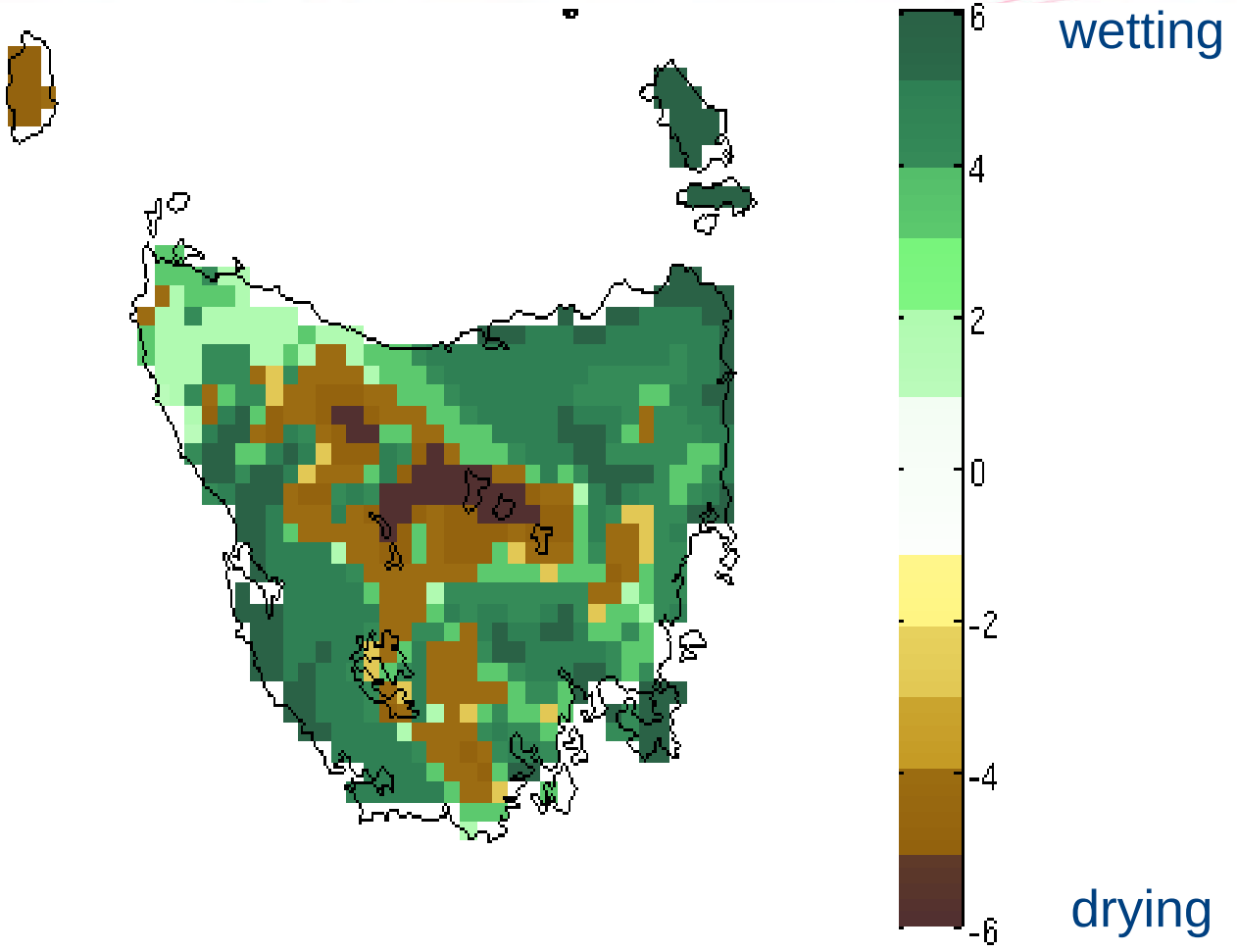
annual % change
(2070-2099)



seasonal
% change
(2070-2099)

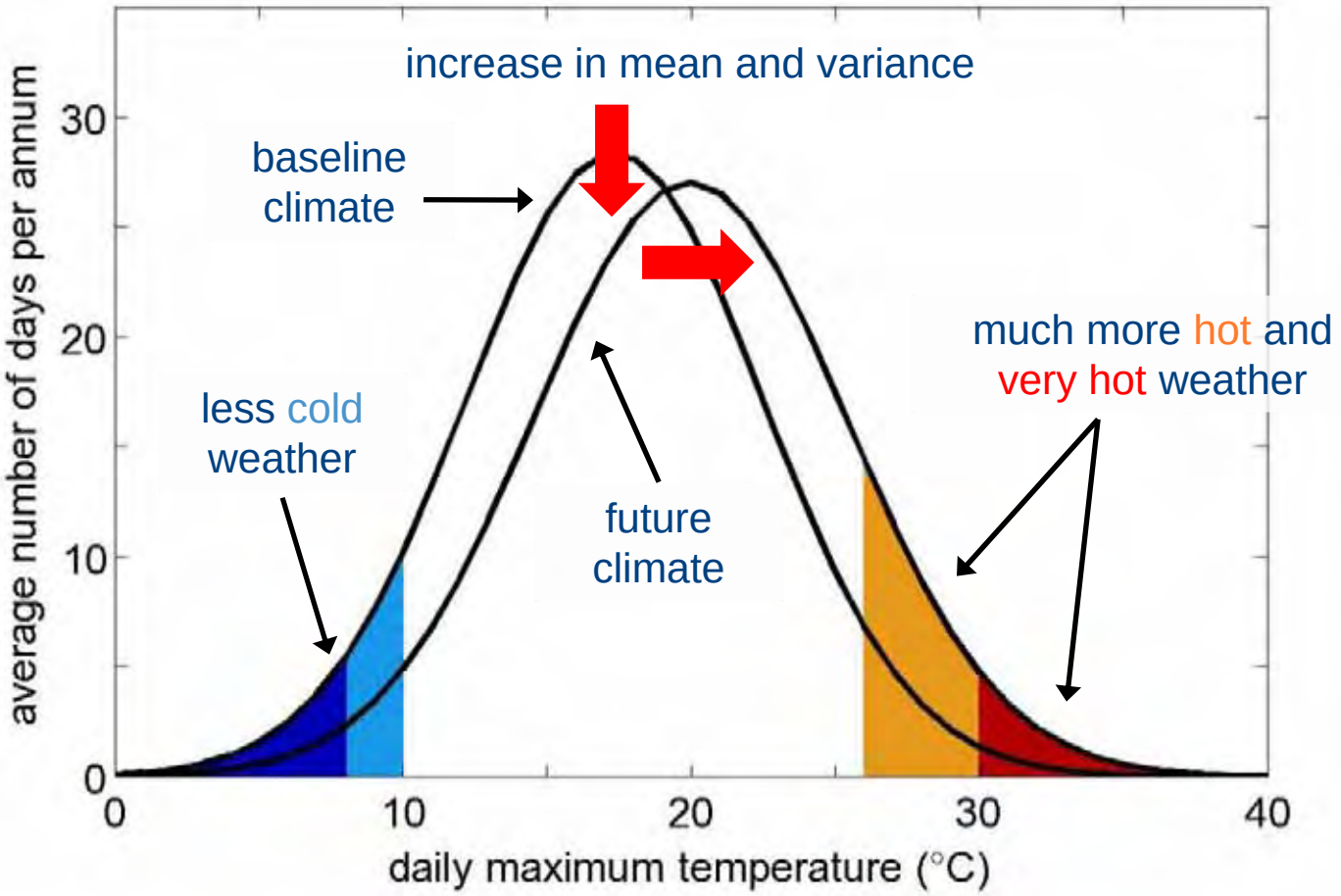
annual and seasonal mean total precipitation projections
(30-yr means, multi-model mean projections, SRES A2)

capturing uncertainty



number of models that show the same trend
(1980-2009 and 2070-2099)

changes to extremes



annual PDF of daily maximum temperature at Launceston Airport for 1961-1990 and 2070-2099
(multi-model means, SRES A2)

extreme events component

Temperature extremes

Extreme precipitation magnitudes, frequencies and event durations

Severe wind gusts and hazard mapping

Tidal surges and extreme sea levels

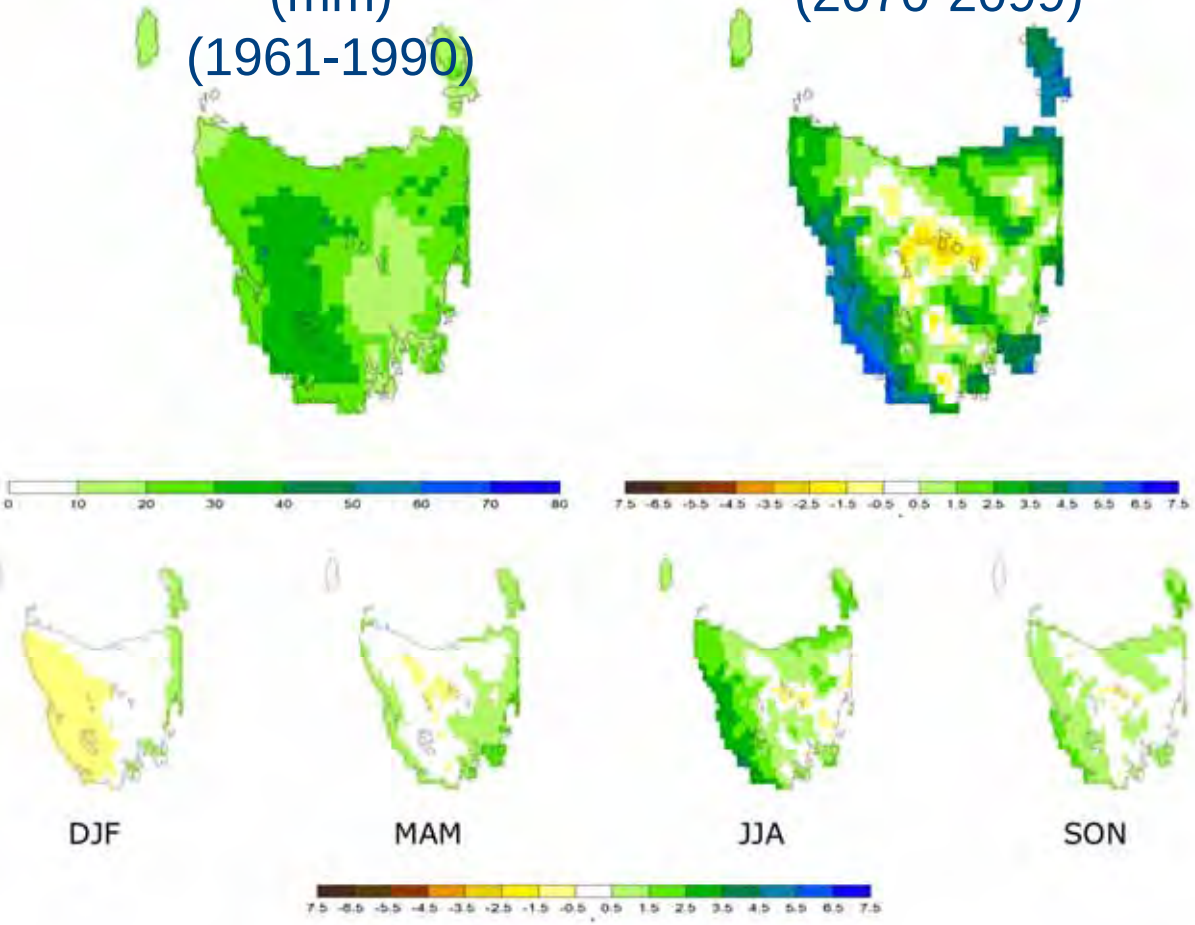
Inland flood risk mapping

Impacts of extremes on infrastructure

frequency of very wet days

95th percentile (mm) (1961-1990)

annual delta days (2070-2099)



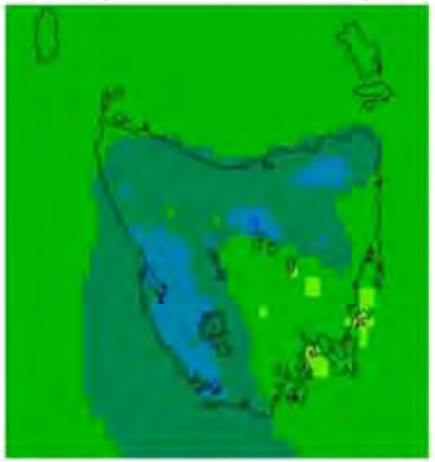
seasonal delta days (2070-2099)

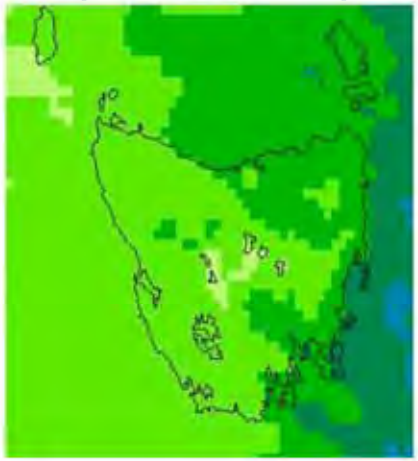
mean annual and seasonal number of very wet days relative to the 1961-1990 95th percentile of daily precipitation (30-yr means, multi-model mean projections, SRES A2)

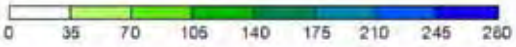
instantaneous ‘short burst’ precipitation intensity

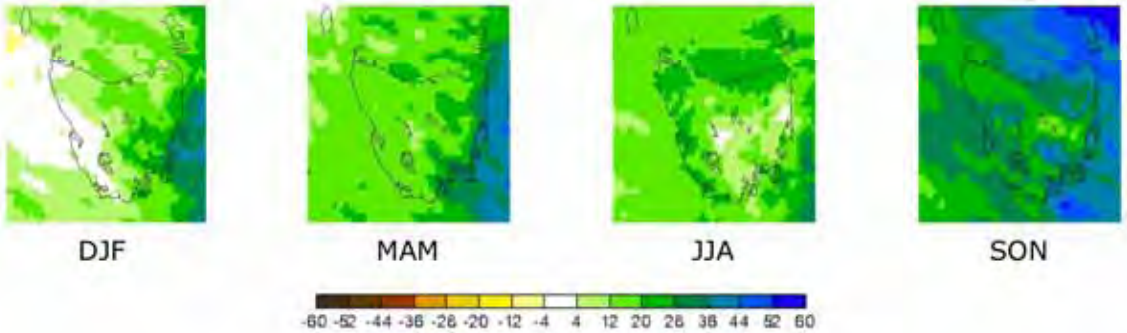
mm
(1961-1990)

% change
(2070-2099)







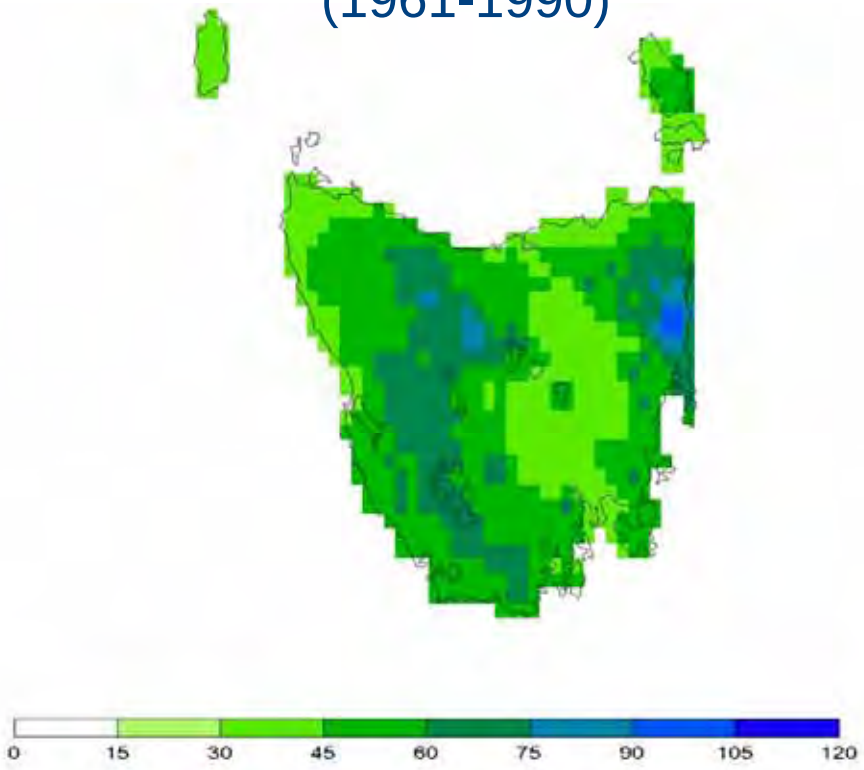


seasonal
% change
(2070-2099)

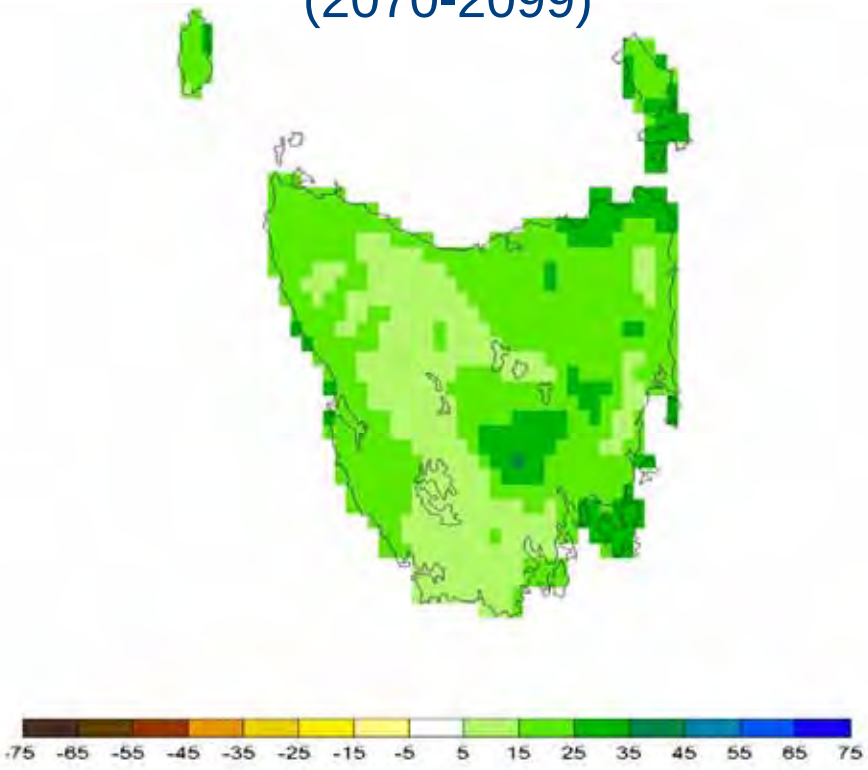
mean annual and seasonal maximum 6-min precipitation totals
(30-yr means, multi-model mean projections, SRES A2)

1-day precipitation intensity

mm
(1961-1990)



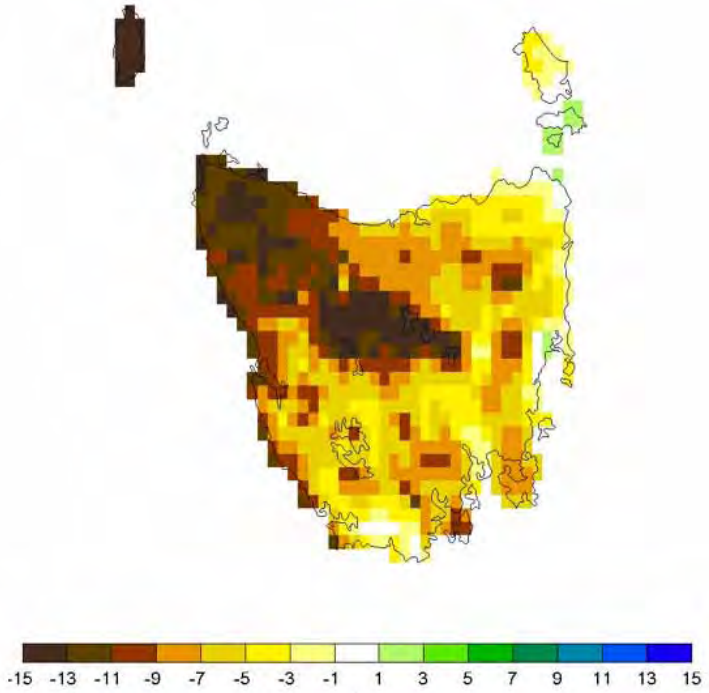
% change
(2070-2099)



mean annual maximum 1-day precipitation totals
(30-yr means, multi-model mean projections, SRES A2)

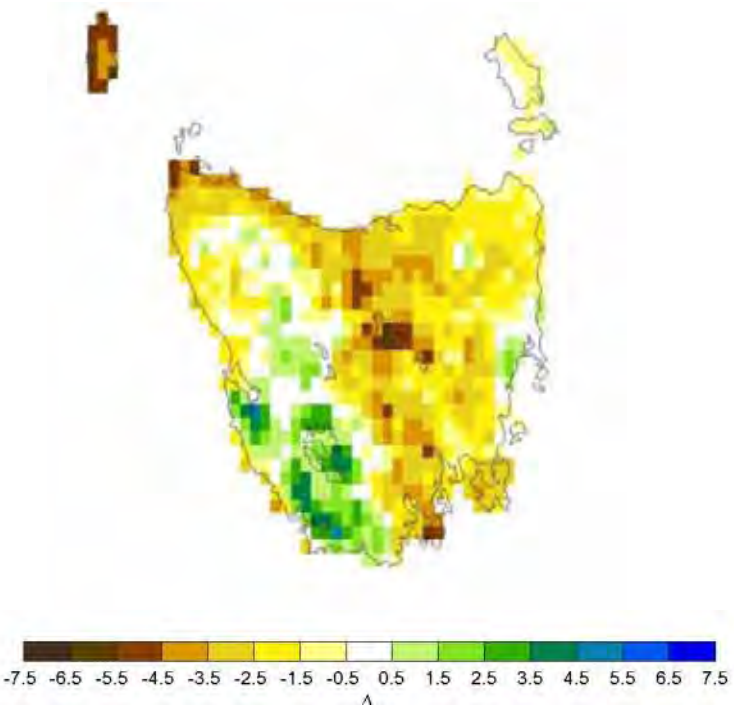
variability of precipitation events

number of rain days
(2070-2099)



days/annum

consecutive rain days
(2070-2099)

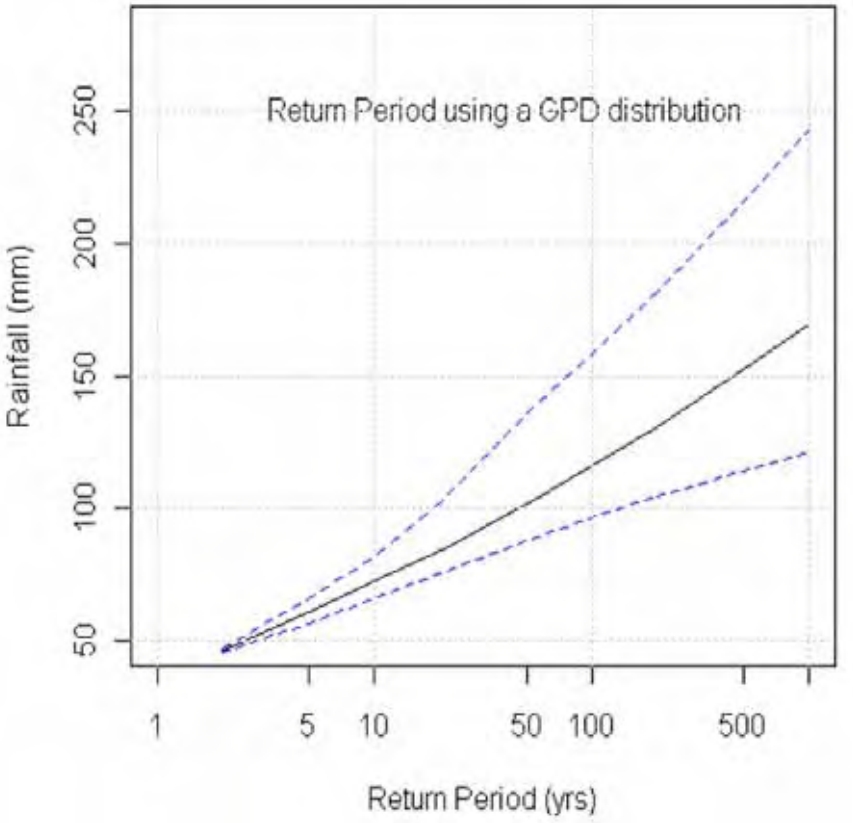


% change

mean changes for 2070-2099 relative to 1961-1990
(30-yr means, multi-model mean projections, SRES A2)


average recurrence intervals

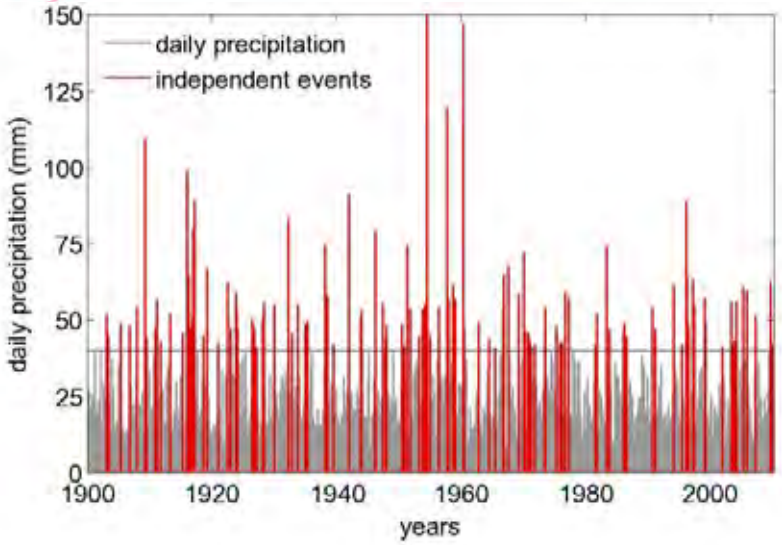
average recurrence intervals (ARIs)



- ARIs (or *return periods*) are used by engineers, emergency planners and scientists to assess flood risk, drainage etc.
- Used here to determine changes to extreme precipitation events (max 24-hr totals) relative to 1961-1990 baseline
- Daily total precipitation fitted to a Generalized Pareto Dist^{n} using extreme value analysis
- Very complex for large automated computations

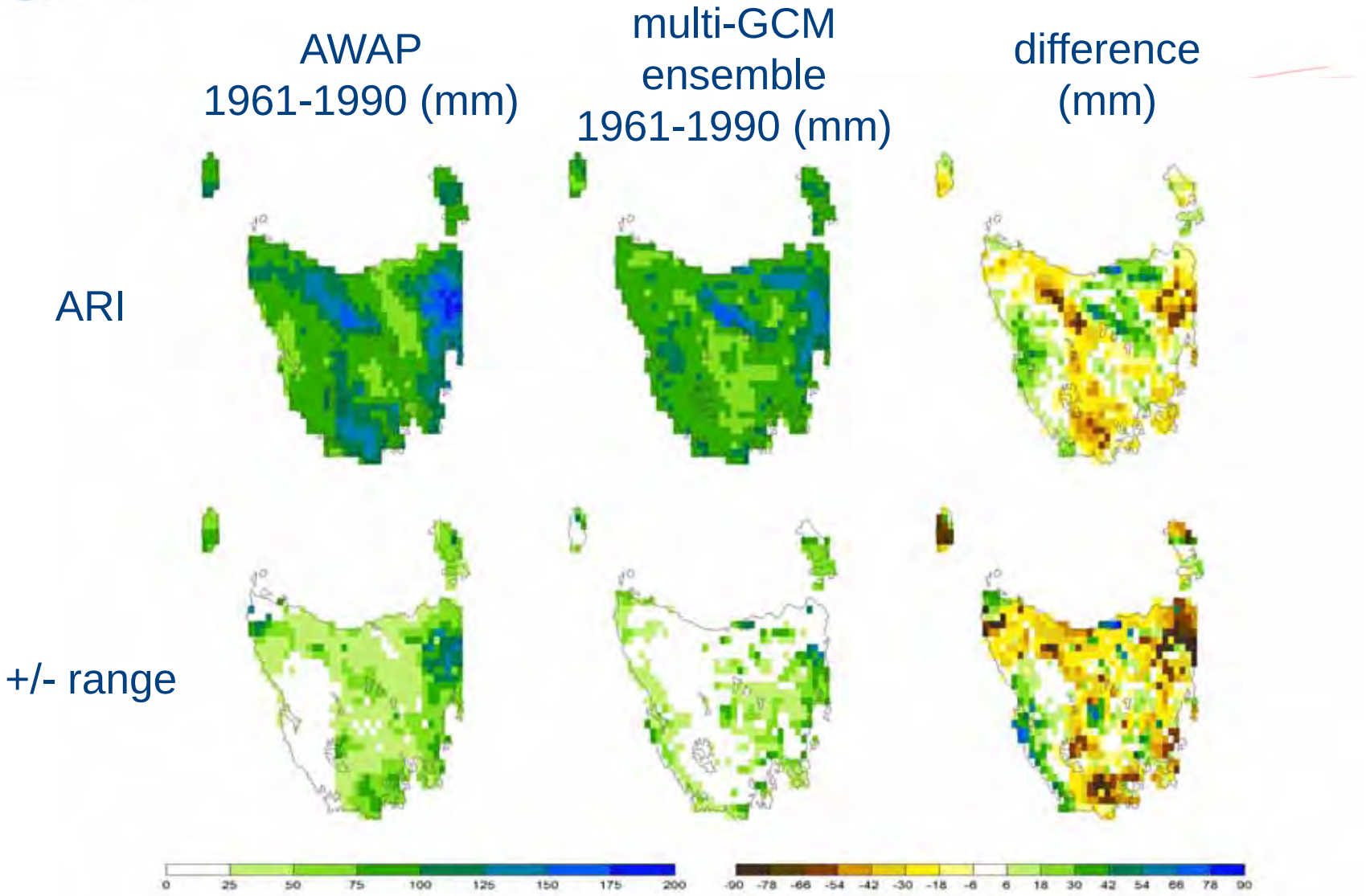
automated distribution fitting

- Automated distribution fitting procedure for gridded datasets:
  - 1. extract independent precipitation events (+/- 2 days exceeding an ‘extreme’ threshold)
  - 2. automated threshold selections for each grid cell
  - 3. fit the Generalized Pareto Dist^{n}
  - 4. return period estimates (from 1 in 2-yr to 1 in 1000-yr)



example selection of independent events at Hobart (AWAP observations 1900-2009)

performance and validation

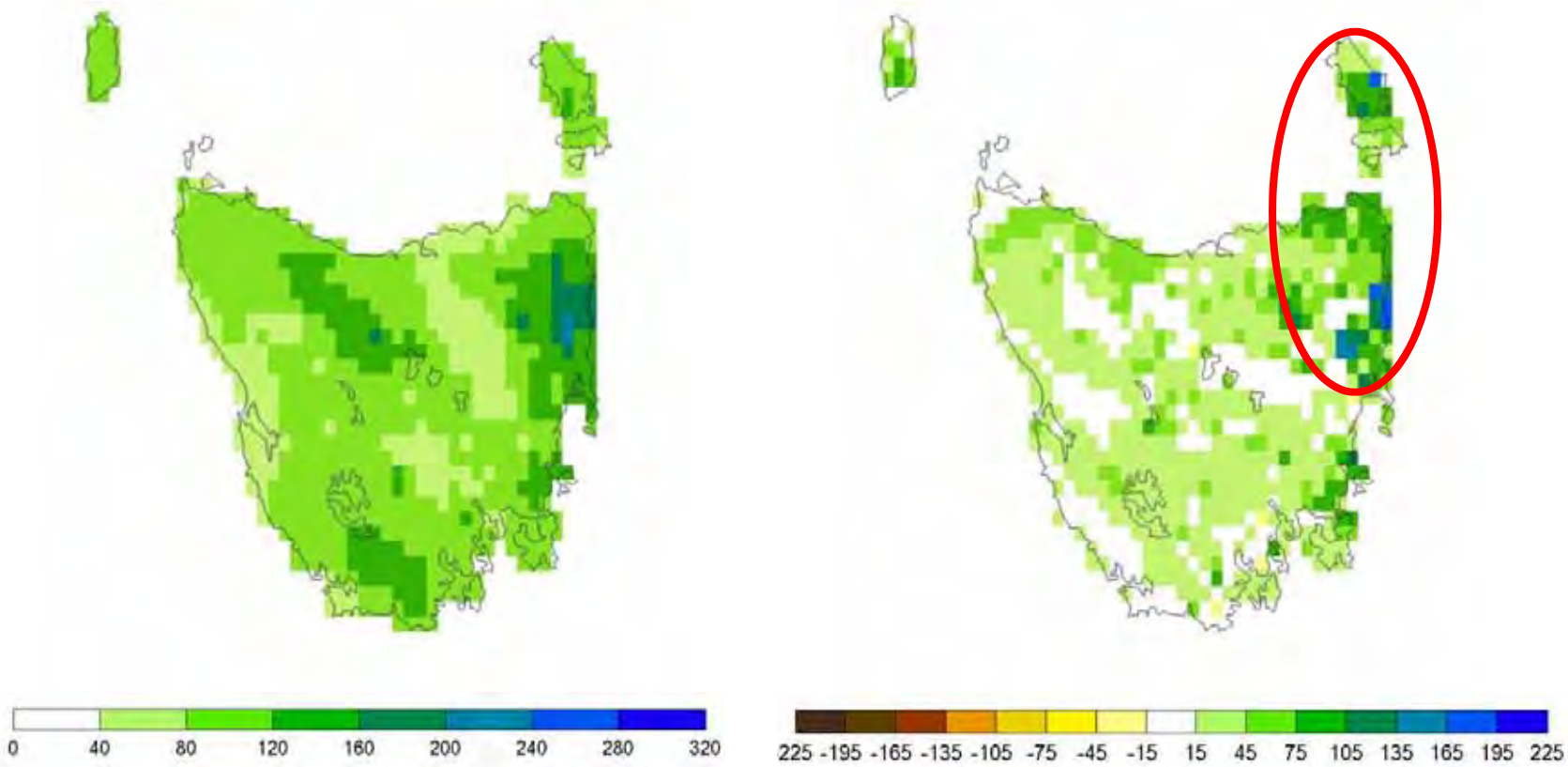


1 in 200 year average recurrence intervals for 24-hour duration totals
(30-yr means, ensemble projections, SRES A2)

200-yr average recurrence intervals

1961-1990
(mm)

delta 2040-2099
(mm)



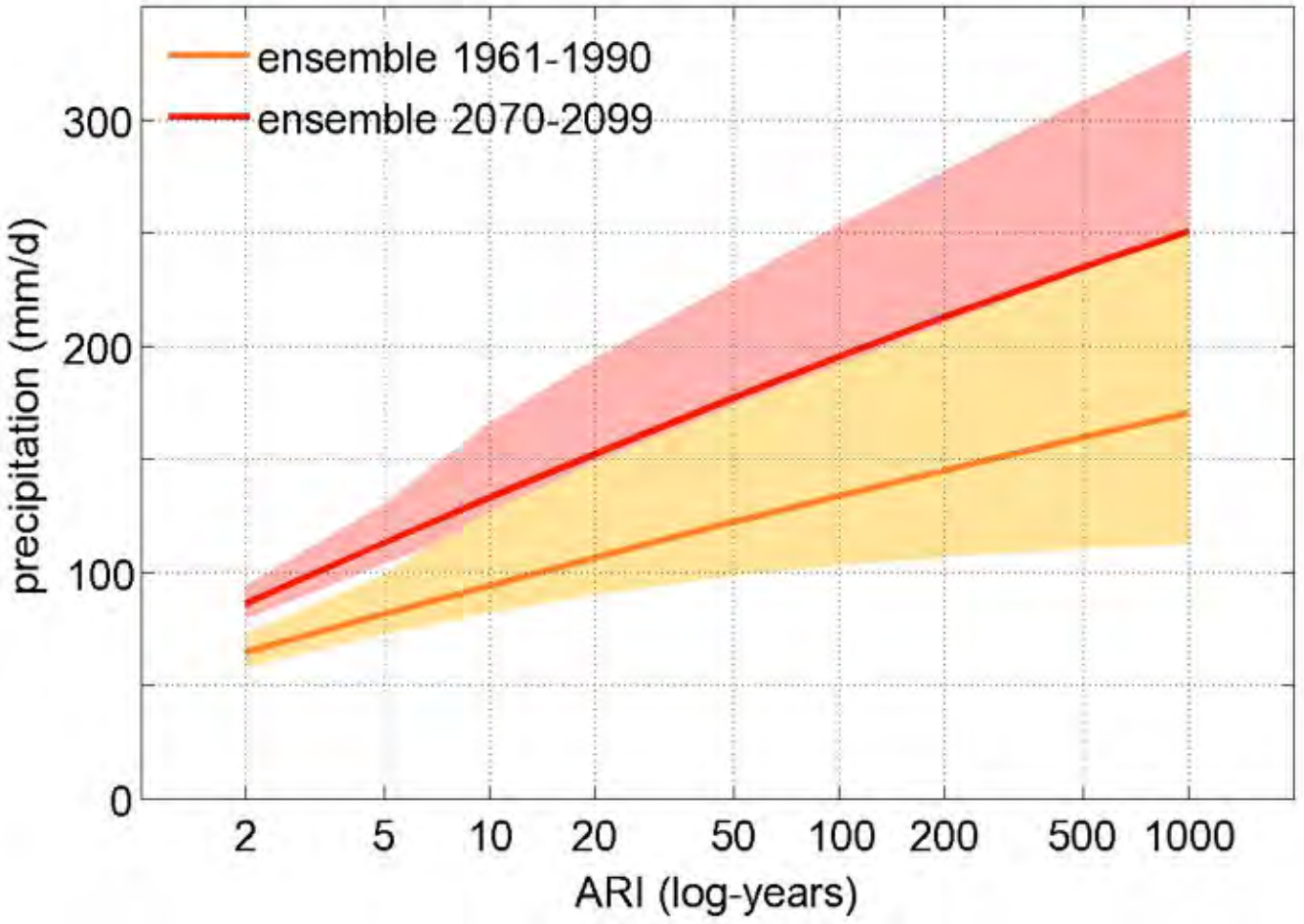
1 in 200 year average recurrence intervals for 24-hour duration totals
(30-yr means, ensemble projections, SRES A2)

200-yr average recurrence intervals

Location	ARI-200 (mm) AWAP (1961-1990)	Delta ARI-200 (mm) Multi-GCM ensemble (2010-2039)	Multi-GCM ensemble (2040-2069)	Multi-GCM ensemble (2070-2099)
Hobart	100 (76/128)	31 [31%]	40 [40%]	30 [30%]
Swansea	122 (91/162)	16 [13%]	14 [11%]	112 [92%]
St Helens	145 (107/210)	10 [7%]	40 [27%]	68 [47%]
Launceston	66 (51/85)	3 [4%]	34 [51%]	34 [52%]
Devonport	97 (76/131)	4 [4%]	23 [24%]	36 [37%]
Strahan	68 (65/73)	6 [9%]	8 [12%]	18 [26%]
Strathgordon	97 (93/105)	21 [21%]	30 [31%]	36 [37%]
Miena/Liawenee	98 (78/134)	50 [51%]	30 [30%]	5 [5%]

1 in 200 year average recurrence intervals for 24-hour duration totals
(30-yr means, ensemble projections, SRES A2)

example: St Helens



average recurrence intervals for 24-hour duration totals
(30-yr means, ensemble projections, SRES A2)

conclusions

- High-resolution dynamical downscaling able to detect changes to frequency, duration and magnitudes of extreme events better than GCMs
- Regional climate drivers, seasonality and spatial variance captured
- Changes to extremes do *not* follow mean projected changes
- Extreme events (and changes) are localised

publications acknowledgements

Extreme Events technical report currently being finalised: due for publication April 2011

General Climate, Agriculture and Water & Catchments technical reports published and are available on the Tasmanian Climate Change Office website: http://www.climatechange.tas.gov.au/government_action/climate_futures

Climate Modelling, Extreme Tide & Sea Levels and Severe Wind Hazard & Risk technical reports to follow shortly

Conference proceedings paper on the estimation of daily precipitation ARIs available from the iEMSs2010 conference website: http://www.iemss.org/iemss2010/index.php (S28: modelling extremes in climate variables)

Preliminary Results

The graphs and maps in this presentation were generated for Greenhouse 2011, Cairns, 4-8 April 2011. They are preliminary and in the process of being reviewed. These graphs should not be used/taken as final and are not for circulation outside of the conference.

Numerous journal papers being written/submitted


questions?