Climate Change Down Under: Challenges, Opportunities and Uncertainty

Bryson Bates
Leader, Pathways to Adaptation Theme
16 November 2010
Background

- Australia is the driest inhabited continent with dramatically variable climate & weather extremes
- Climatic change is evident across southern Australia – moving beyond envelope of historical variability (temperatures, rainfall & drought)
- Water resources, marine & terrestrial ecosystems &, to lesser extent, agriculture are under stress
- Estimates of costs of future climate change range from 3-7% of GDP, and if more serious climate feedbacks are included, 20% of GDP
Minimum & maximum temperatures
Annual dam inflow series
Atmosphere is more stable

(1975 to 1994) — (1949 to 1968)

Reductions in:
- vertical mean meridional temperature gradient
- upper tropospheric jet-stream winds near 30° S
General circulation models

Argonne National Laboratory
Model Coupling Toolkit (MCT)
### GCM evaluation

<table>
<thead>
<tr>
<th>Climate Model</th>
<th>van Oldenborgh (realistic ENSO)</th>
<th>Perkins (Aust)</th>
<th>CMAR (Aust)</th>
<th>Maxino (MDB)</th>
<th>Charles (SE MDB MSLP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GFDL2.0</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>GFDL2.1</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>ECHAM5</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>GISS-ER</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>CSIRO Mk3</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>MRI-CGCM</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>CGCM3.1</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>IPSL-CM4</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>—</td>
</tr>
</tbody>
</table>
Some issues that need to be resolved

- GCMs should be able to simulate present climate
- Good simulation of present climate neither necessary nor sufficient condition for accurate simulation of climate change
- Over which geographic domain should a GCM be evaluated
  - global or
  - continental or
  - study 'region' or
  - all of the above?
- Which climate variables should be evaluated
  - upper air features that largely control surface climate or
  - surface climate variables used in impact studies?
Temperature projections (2050)

23 GCMs; 1980–1999 baseline

Rainfall projections (2050)

23 GCMs; 1980–1999 baseline

Downscaling methods for climate applications

- **Empirical**
  - constant scaling/translation
  - daily scaling
  - daily quantile matching

- **Statistical**
  - regression
  - ANNs
  - hidden Markov

- **Dynamical**
  - RCMS
  - Stretched-grid AGCMs
Nonhomogeneous hidden Markov model

- **Observed process:** sequence of regional precipitation occurrence patterns $R_t$: $t = 1, ..., T$
- **Hidden discrete-valued process:** sequence of weather types (or states) $S_t$
- State to state transitions driven by atmospheric information (predictors) $X_t$

\[
P(R_t) \quad R_1 \quad R_2 \quad R_3 \quad R_4 \quad R_5 \quad R_6
\]
\[
P(R_t|S_t) \quad S_1 \quad S_2 \quad S_3 \quad S_4 \quad S_5 \quad S_6
\]
\[
P(S_t|S_{t-1}) = P(S_t|S_{t-1}, X_t)
\]
Season: May to October
Period of interest: 1958 – present
Fitting: sequential estimation – BIC
Number of weather states: 6
Atmospheric predictors:
- mean MSLP
- N-S MSLP gradient
- DTd\textsuperscript{850} = T\textsuperscript{850} – Td\textsuperscript{850}
- 1\textsuperscript{st} canonical variate
Testing: split sample testing & physical scrutiny
Split sample validation for NHMM

[Graph showing precipitation trends with validation and fitting periods, and scatter plots comparing observed and simulated daily rainfall.]
Stakeholder responses – a sample

Change of ±x% where |x| >> 0 & median x ≈ 0

- Silent shrug … (water planners)
- "This is not helpful" (agricultural scientists)
- "You are not telling me anything" (agricultural scientists, again)
- "Is that the best you can do?" (taxi drivers)
- "What do you expect me to do with that?" (pick a profession)
- "Well, we know they can't even predict next week's weather with their precious models let alone …" (pick your 'favourite' sceptic)

Can we weight/rank GCMs and derive a credible estimate of the pdf of x?