Downscaling climate change information potential hydrological applications and water management in the Murray-Darling Basin

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Australian Government
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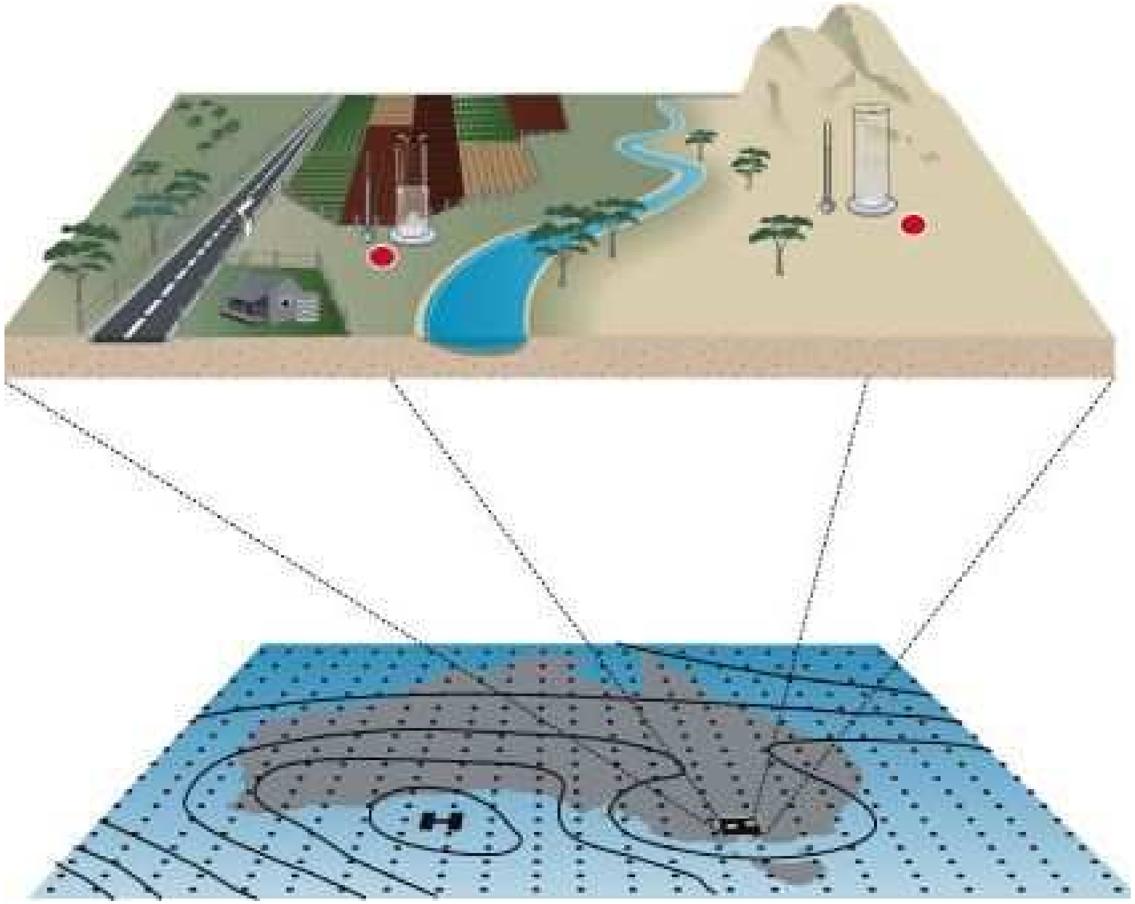
Statistical downscaling for Hydrological applications

Outline:

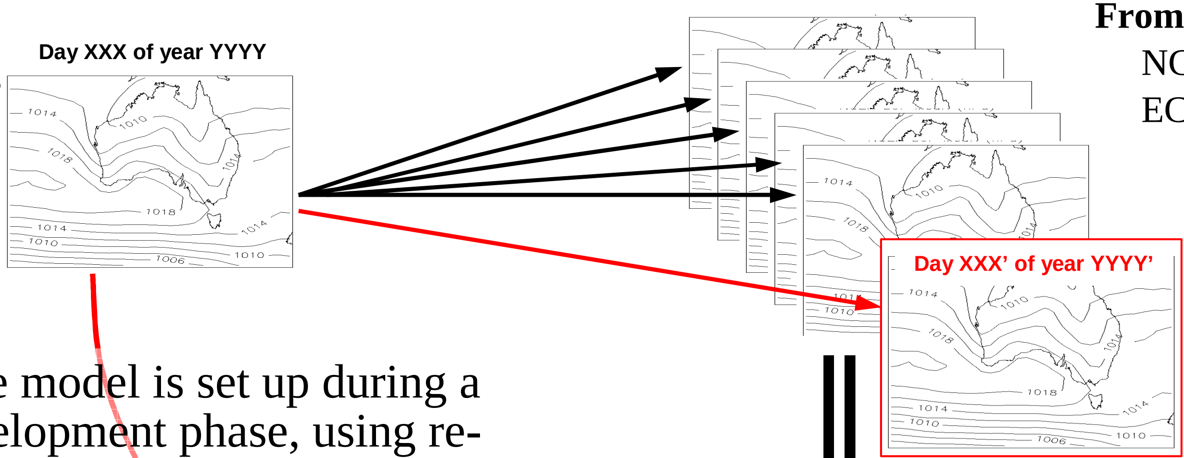
- Statistical downscaling: how do we do it?
- Application toward integrated hydrological impact assessments



- Need for *daily* site data that have the same statistics as observed
- *Daily at-site* data is used to drive models of natural resource systems
- Getting *daily* statistics correct is very important.
- GCMs provide grid-average

BoM Statistical Downscaling Model (BoM-SDM):
daily meteorological analogues

Step 1 (L)
Daily synoptic situation, described by:
- several predictors
- upper air fields
- small regions



From a pool of re-analyses:
NCEP/NCAR (1948-2008)
ECMWF (1958-2001)

Step 2 (α)
Analogue Model:
- Smallest Euclidean Dist.
- Choice of predictors
- Series of parameters

The analogue model is set up during a **(Step 3)** development phase, using re-analyses.

It is then applied to an independent period **(Step 4)** following a climate shift to provide a cross-validated estimation of the skill and a test of the model sensitivity to an observed change in the climate.

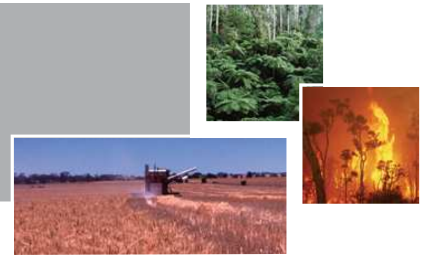
It is then applied to Climate Change simulations or other GCM applications

	Rain
stat 1	0
stat 2	15
stat 3	[illegible]

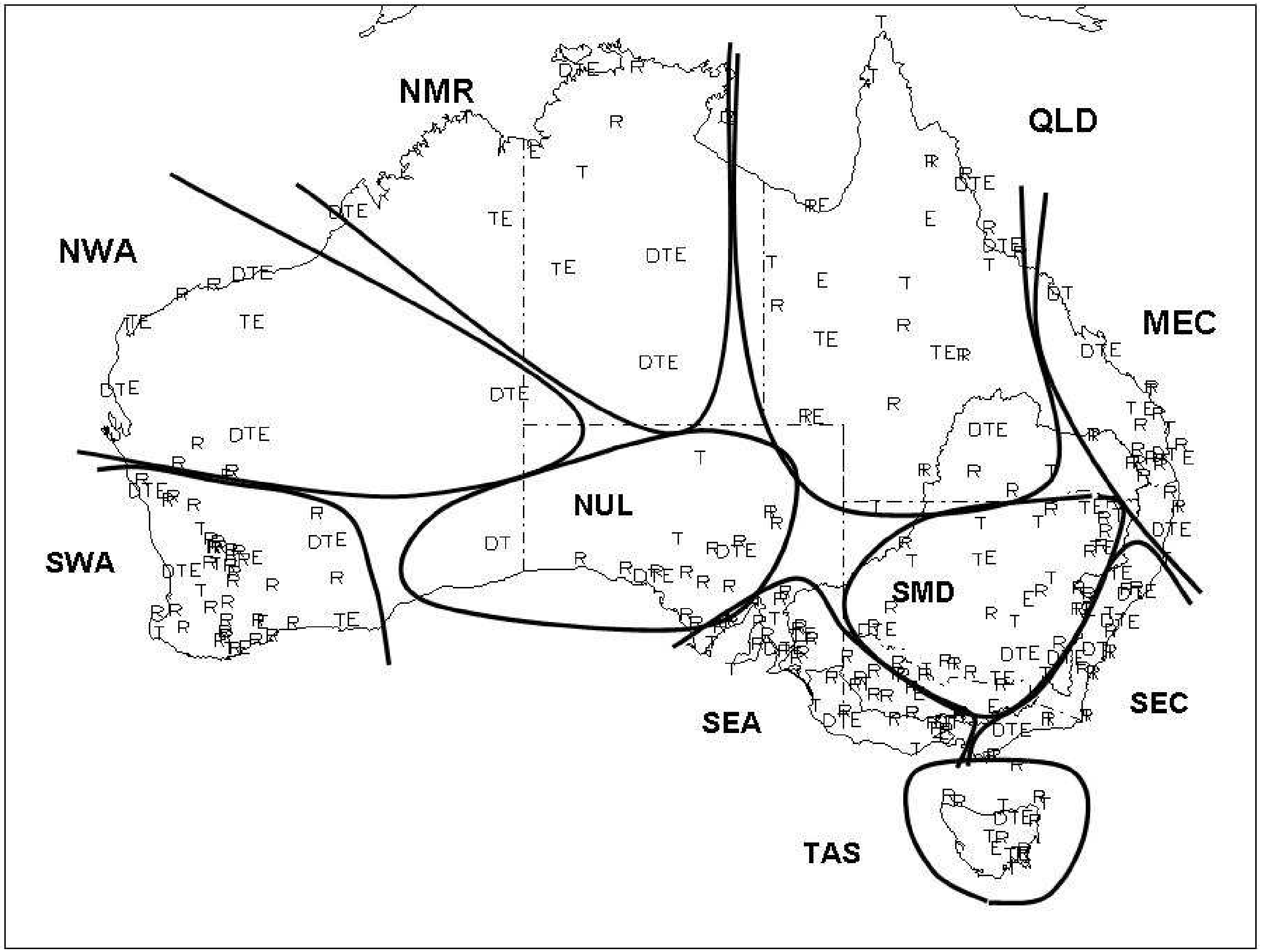
	Rain
stat 1	240
stat 2	37
stat 3	0

Associate with observed predictands:
- Rainfall amount
- Rain occurrence
- Tmax, Tmin
- Surface humidity

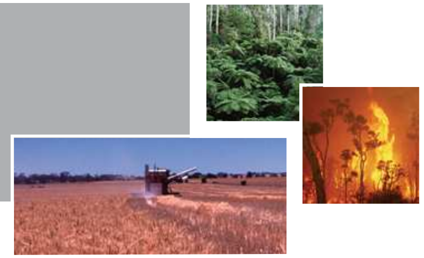
Application Australia wide of the BoM-SDM



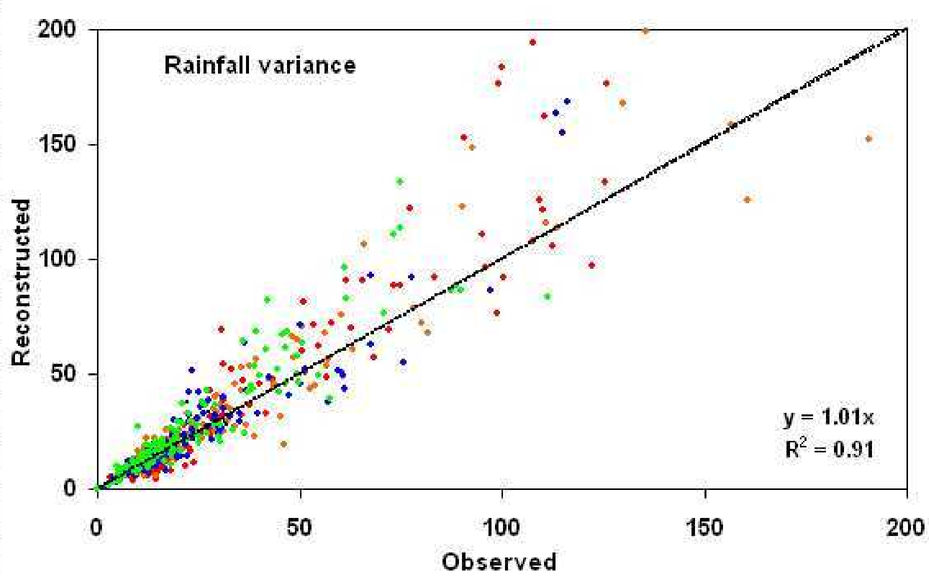
- Australian continent divided in physically based climate “*entities*”
- Several climate type recognised across the MDB
- SMD optimised on the very sparse HQ dataset network

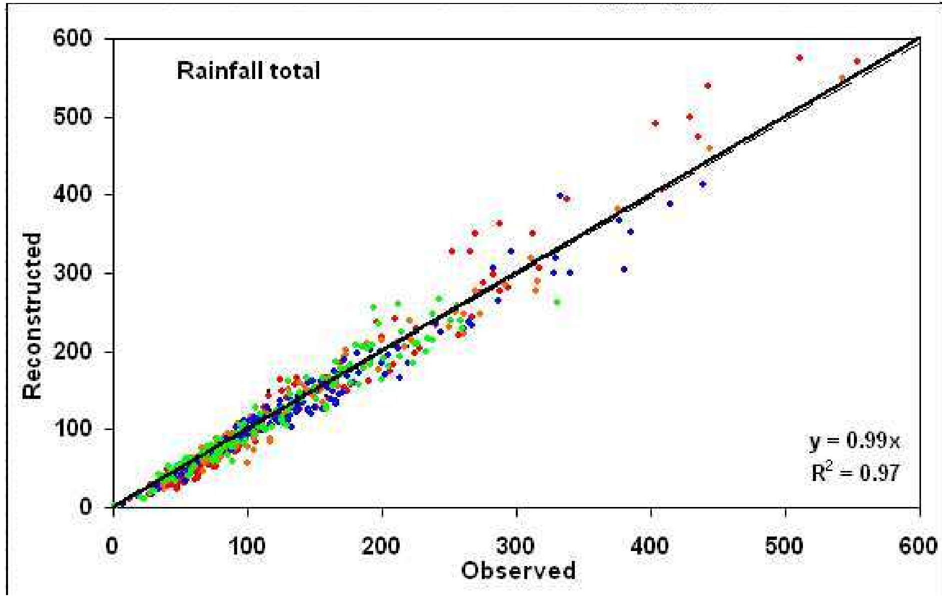


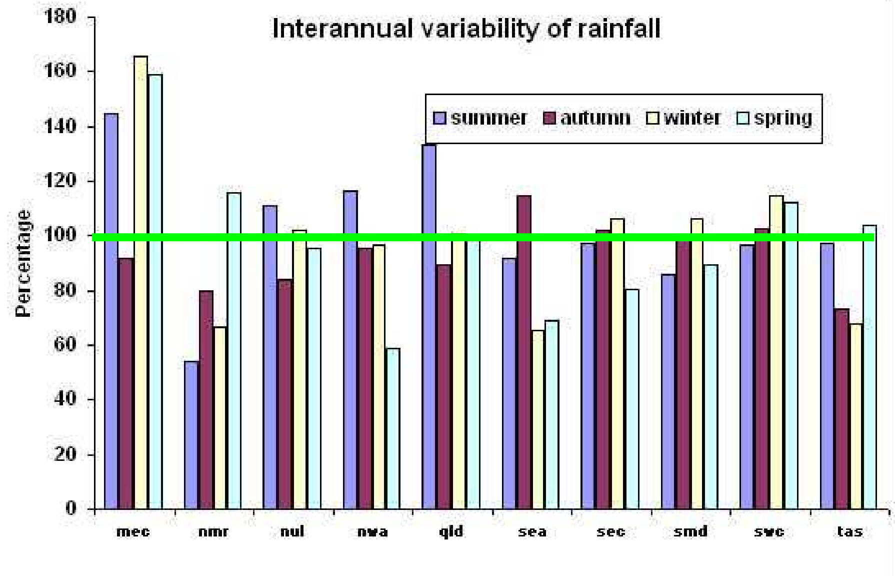
Optimisation of the individual SDM



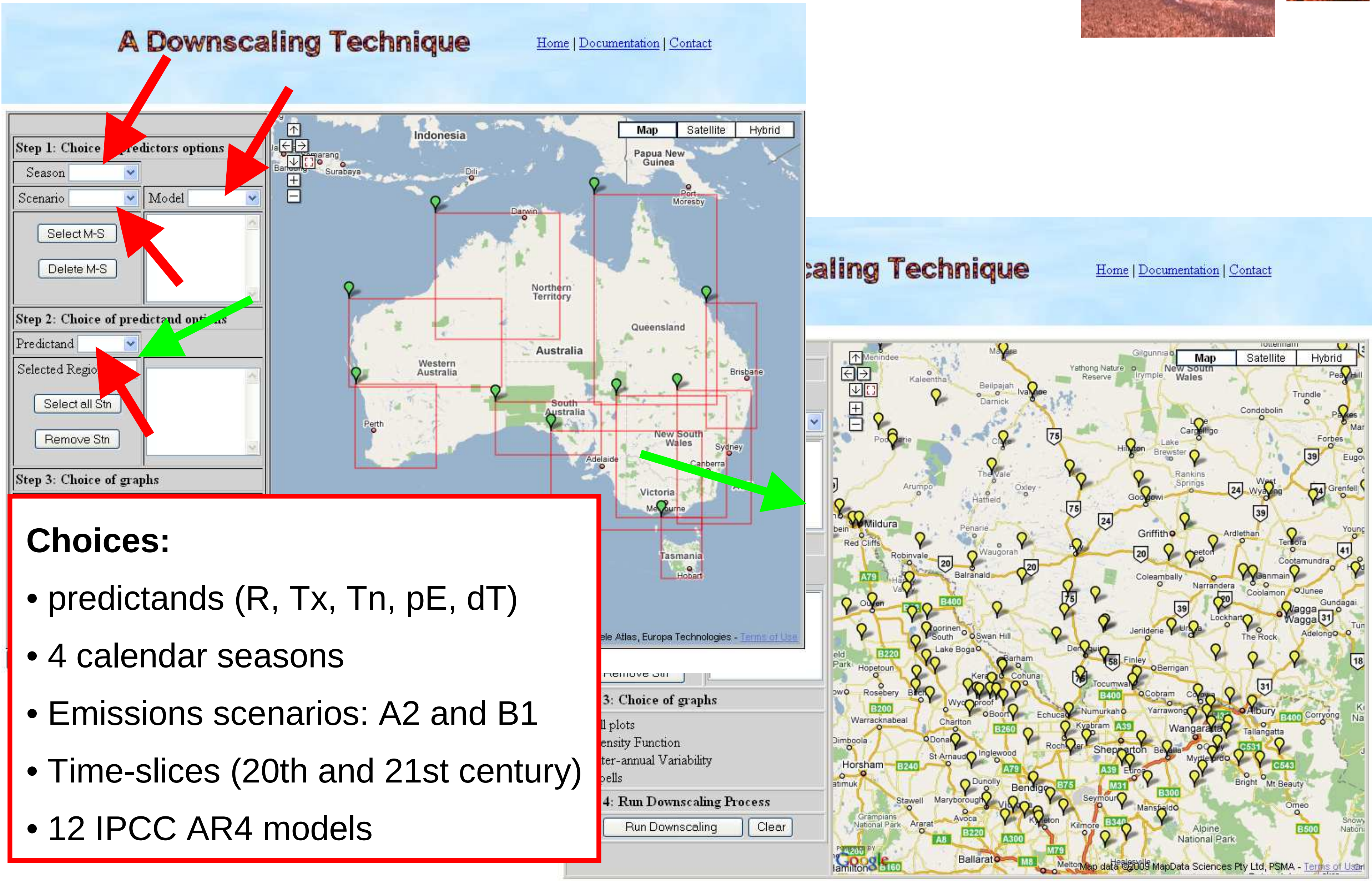
- Range of statistics evaluated:
  - Daily variance
  - Interannual variability
  - Mean rainfall
- Performed for all predictands (target variables: R, Tmax, Tmin, p-Evap, dTmax, dTmin)
- Per season, per climate region, per predictand





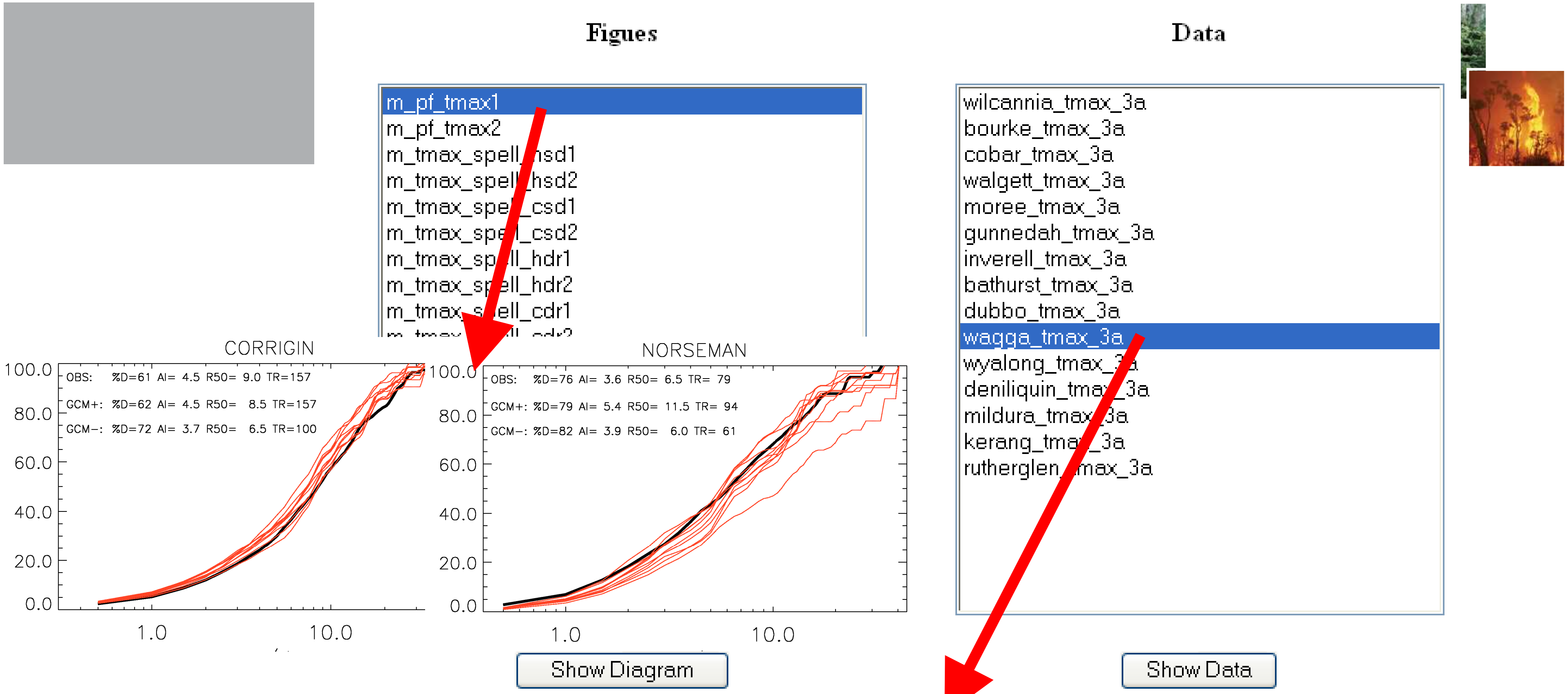


A graphical interface to access local projections



Choices:

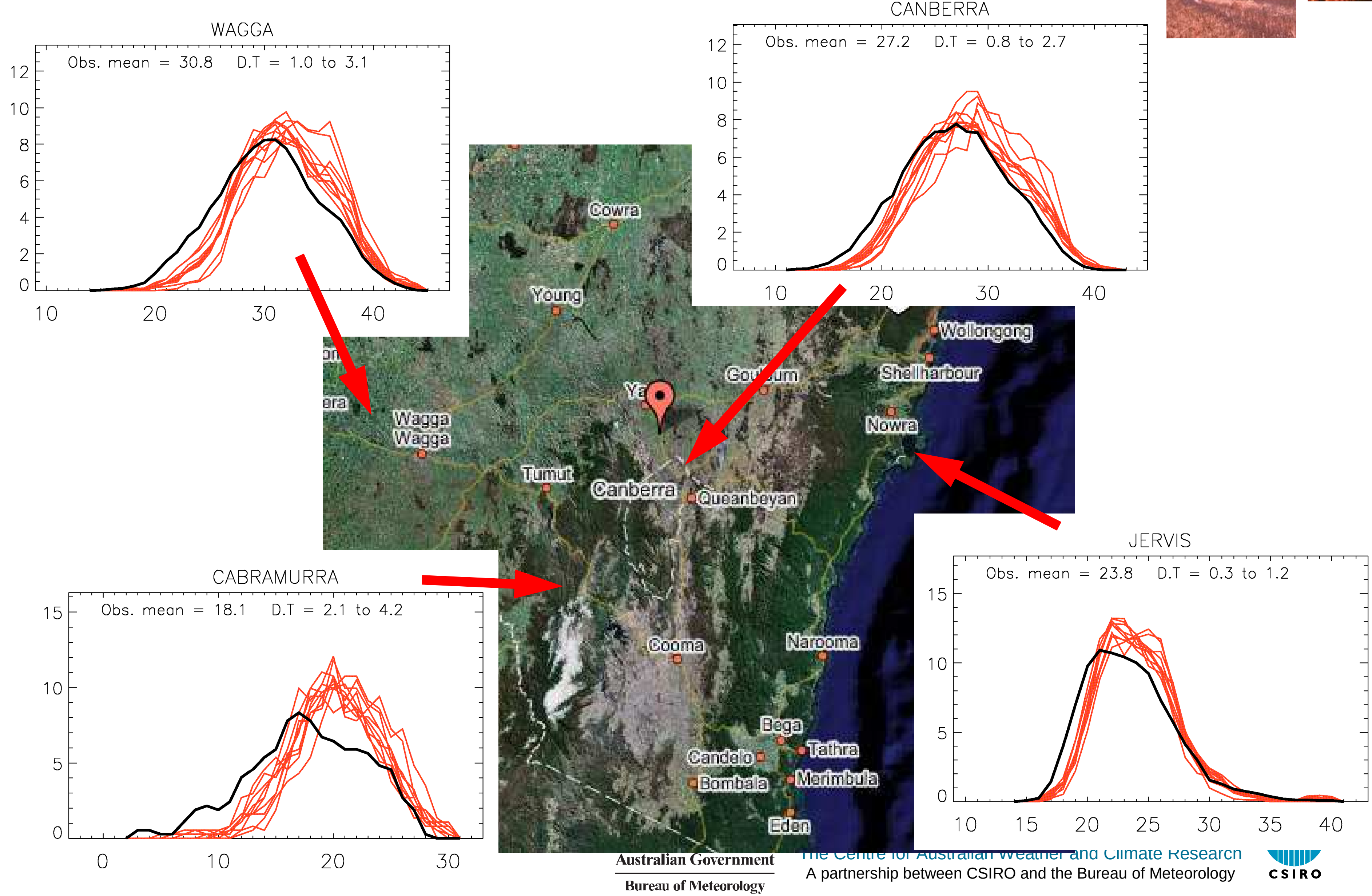
- predictands (R, Tx, Tn, pE, dT)
- 4 calendar seasons
- Emissions scenarios: A2 and B1
- Time-slices (20th and 21st century)
- 12 IPCC AR4 models



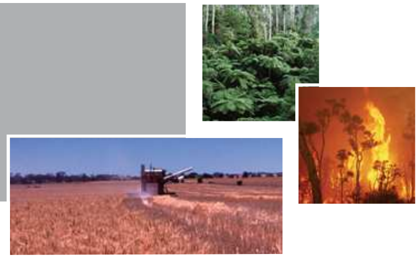
wagga_tmax_3.data

Date	CCM	CNRM	CSIRO	GFDL1	GFDL2	GISSR	IPSL	MIROC	MPI	MRI	Observation
01061961	7.80	19.10	12.90	14.00	13.30	14.60	13.80	13.60	15.10	13.70	17.40
02061961	12.60	15.20	10.70	14.30	13.10	14.60	12.50	11.30	9.00	13.30	15.20
03061961	13.30	12.90	17.60	9.90	11.40	14.60	14.30	11.60	13.40	14.70	16.30
04061961	10.60	11.90	9.30	13.30	16.00	16.20	9.90	14.50	19.60	13.40	17.10
05061961	10.70	14.10	12.40	15.60	12.40	14.60	11.70	14.80	14.20	14.60	20.50
06061961	10.60	12.40	10.00	15.40	13.70	15.90	12.50	14.90	15.30	18.20	17.80
07061961	13.20	9.80	13.80	15.40	9.30	15.40	11.00	15.80	16.90	18.80	16.20
08061961	13.00	10.10	12.00	15.00	13.20	13.90	10.70	15.90	15.00	18.80	17.70
09061961	8.90	13.50	12.80	16.60	12.20	12.40	11.00	14.10	13.70	18.80	14.40
10061961	12.40	13.40	10.80	10.10	18.10	13.30	13.00	14.80	13.90	18.20	10.70
11061961	12.40	14.90	13.90	13.60	14.50	11.70	13.10	13.10	14.80	20.50	11.60
12061961	11.40	16.40	12.90	17.20	9.60	10.20	13.30	17.10	13.80	21.50	16.00
13061961	10.30	15.40	11.90	14.80	12.40	12.00	8.80	16.10	13.80	13.80	16.90
14061961	13.10	12.10	12.90	14.30	12.50	13.40	13.10	12.20	16.60	14.40	15.70
15061961	13.10	13.00	7.30	12.80	14.70	13.40	8.90	12.80	14.30	14.80	12.70
16061961	15.20	12.70	12.40	11.90	14.70	13.40	14.20	13.40	15.00	15.00	15.20
17061961	15.60	11.80	10.90	14.50	15.50	14.00	14.20	14.90	15.00	12.00	11.60
18061961	13.90	13.10	10.30	15.00	11.20	13.00	16.40	15.00	12.10	12.10	11.80
19061961	13.90	13.30	13.10	16.10	15.80	12.50	14.30	14.80	12.10	12.70	9.70
20061961	14.30	13.00	11.70	15.10	15.00	14.80	14.00	15.40	11.80	10.20	7.90
21061961	13.70	11.00	13.10	13.60	14.30	16.70	12.10	13.60	13.90	8.40	8.40
22061961	7.90	12.40	11.90	12.90	14.80	19.60	10.00	11.60	11.80	11.50	9.60
23061961	15.00	15.60	11.90	16.40	12.20	17.90	10.00	18.10	13.90	14.20	9.80

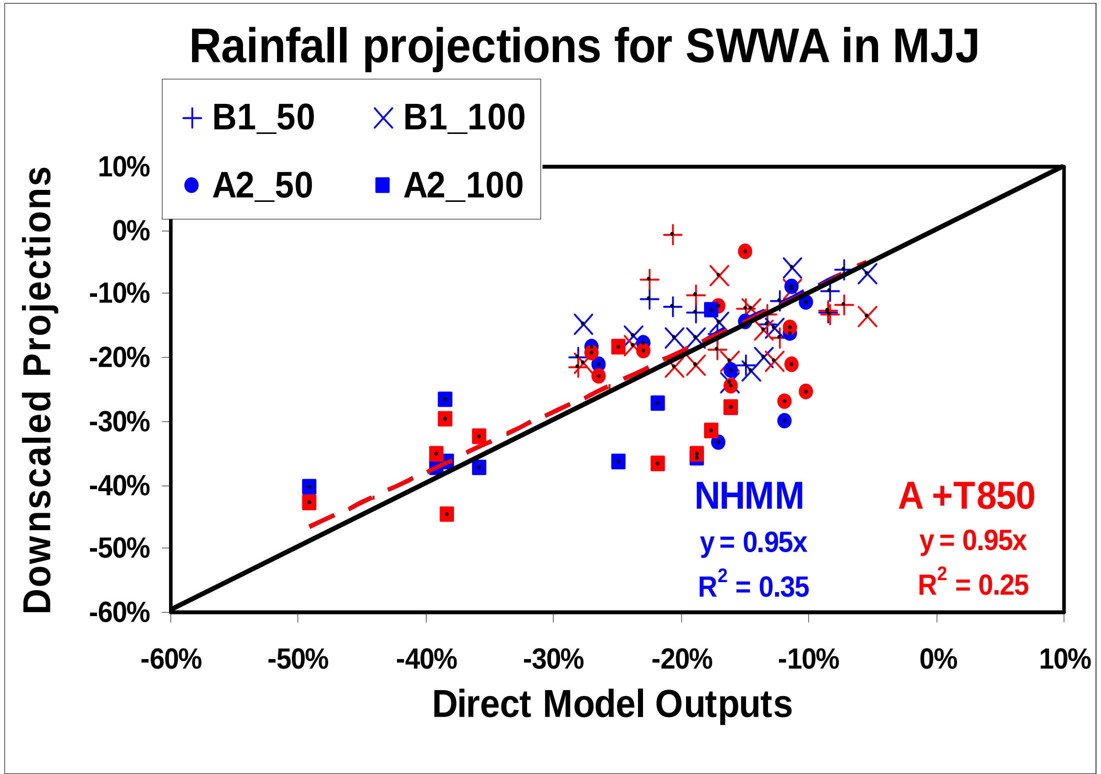
Sub-grid heterogeneity:



Large-scale consistency:

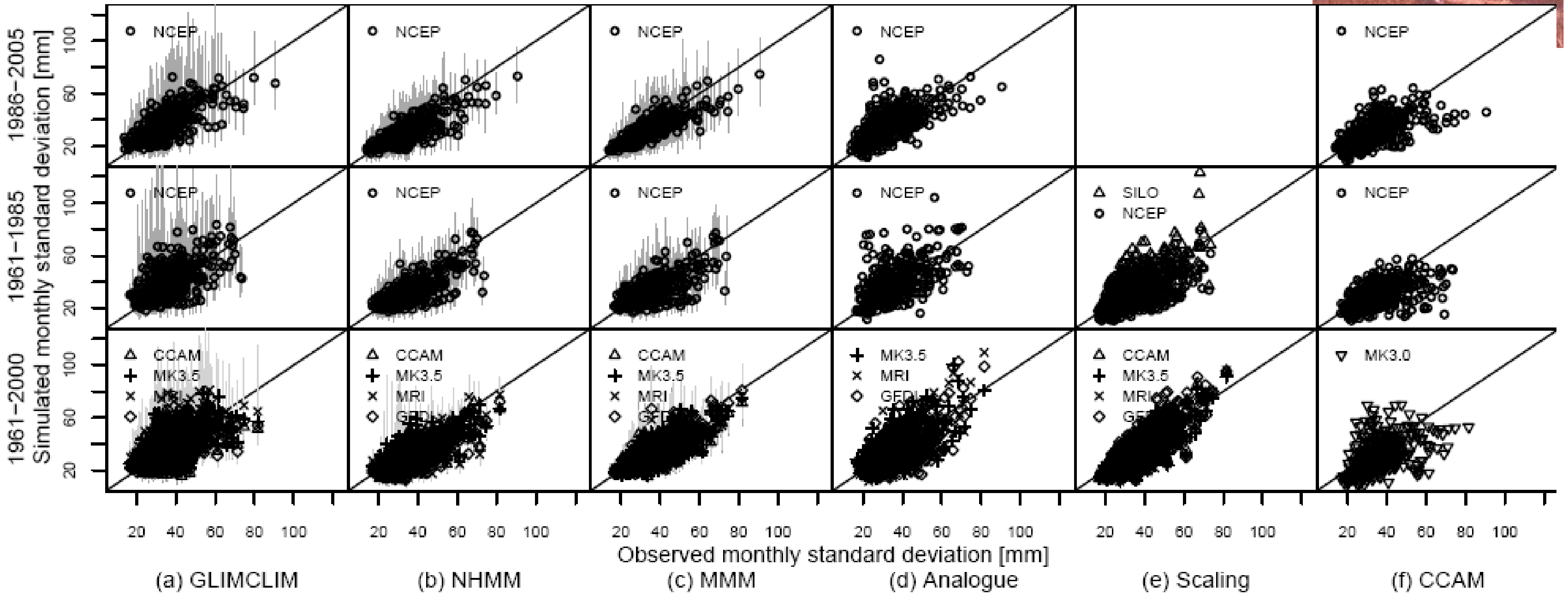


- Evaluate the consistency of statistical downscaling vs. Direct Climate Model projections
- Two SDMs were compared (**BoM Analogue** and **CSIRO NHMM)**
- The choice of predictors is ***essential*** to match the dynamical projections



- Each points is an average
  - several GCM boxes
  - All the local downscaled series
- From different GCMs
- Across as many GCMs and scenarios possible

Inter-comparison: evaluating uncertainties



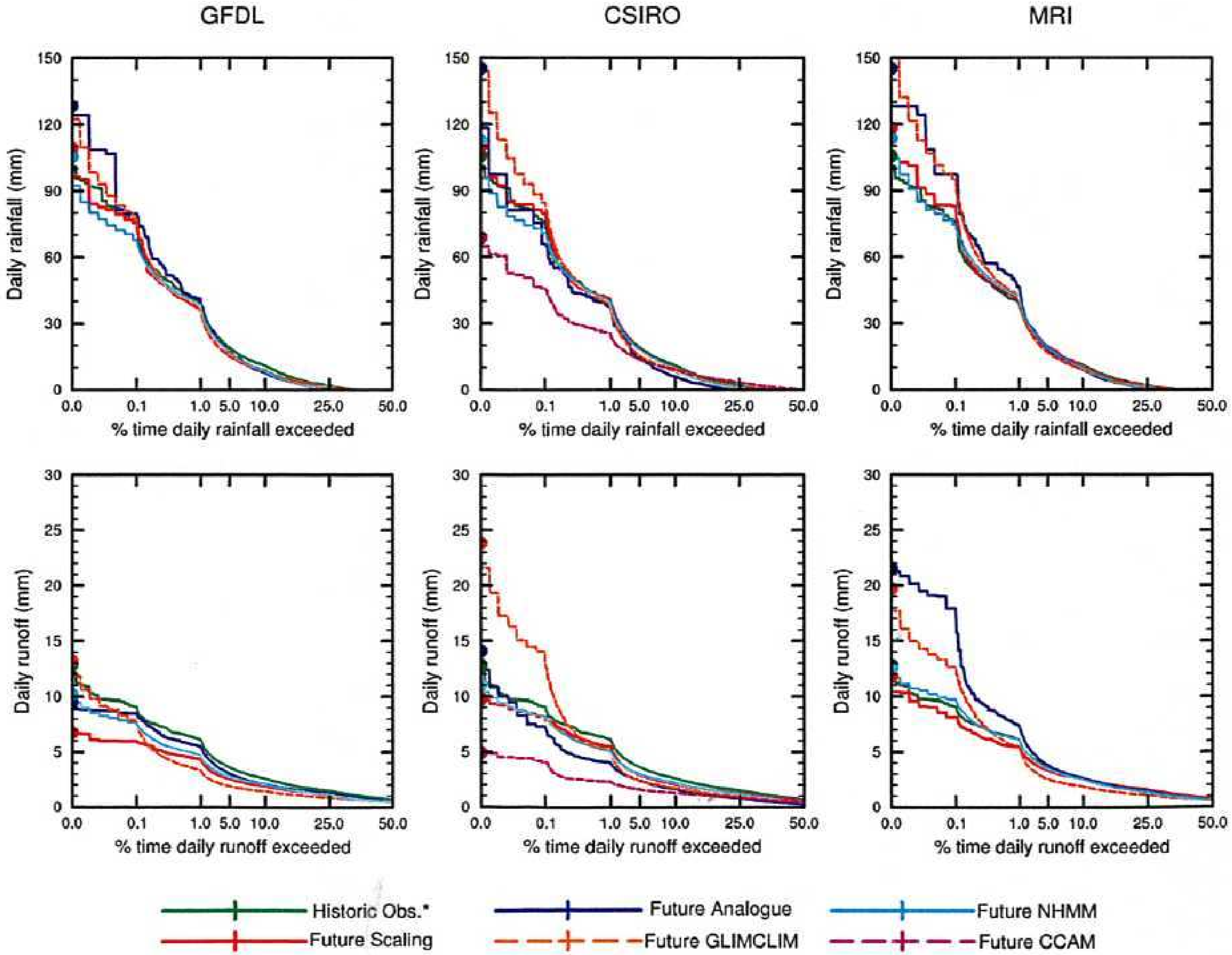
Monthly standard deviation

On-going intercomparison by Frost et al. (2009)

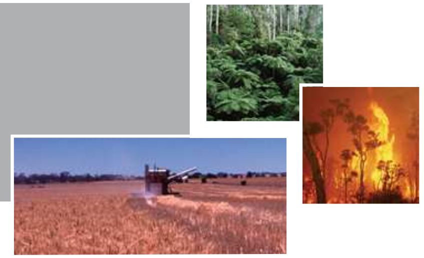
- insight on
  - the issue of statistical fitting (and over-fitting)
  - ability to deal with GCM biases
  - strength and weakness of each technique on different key stats.

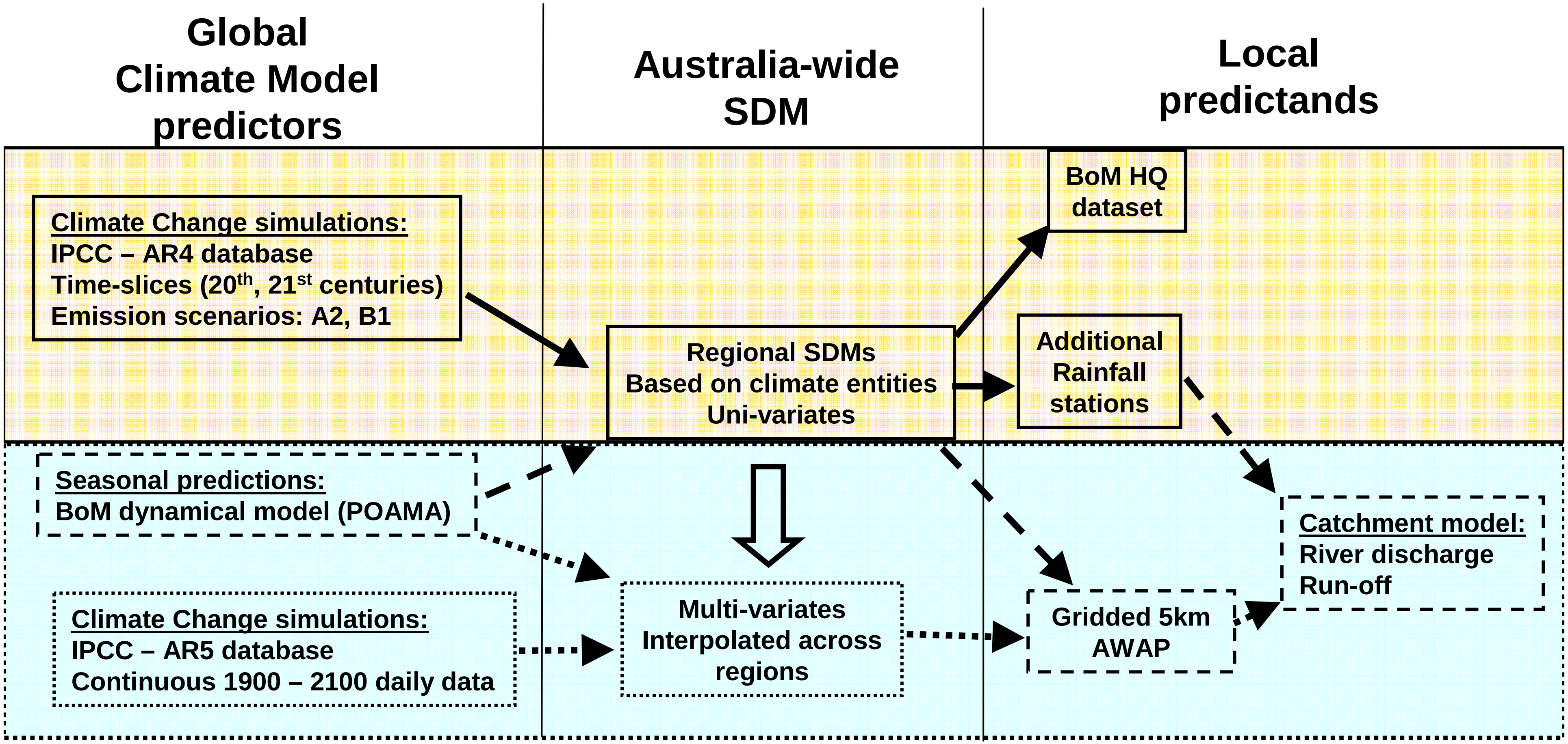
Inter-comparison: future projections uncertainties

- Comparisons of future rainfall daily characteristics
- Impact on runoff
- Scaling method leads to different future impact.
- Paper by Chiew et al. (2009)



Long-term development of the BoM-SDM





Conclusions:

<u>Statistical Downscaling for Hydrological applications:</u>

We have available SDMs:

- BoM-SDM
- developed Australia-wide
- For rainfall and additional meteorological variables
- Being used for integrated hydrological assessment (SEACI, WIRADA)
  (Seasonal Forecast and Climate Change projections)

Downscaling is needed:

- To provide sub-grid heterogeneity
- Scaling method can be misleading (no heterogeneity, constant PDFs)
- SDMs on large-scale should be consistent with GCMs but not locally
- All elements will impact hydrological variables

Framework in place to deliver integrated hydrological climate change impact assessment across Australia with the next round climate simulations: IPCC-AR5

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BoM-SDM documentation:

- **Science:** Timbal, Fernandez and Li. 2009: "**Generalization of a statistical downscaling model to provide local climate change projections for Australia**", *Environmental Modelling and Software*, 24, 341-358
- **GUI:** Timbal, Li and Fernandez. 2008: "**The Bureau of meteorology Statistical Downscaling Model Graphical User Interface: user manual and software documentation**", *CAWCR research report*, 4, pp 95

Thank you

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