Quantifying the overall added value of dynamical downscaling and the contribution from different spatial scales

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Motivation of the study

An essential requirement for RCMs is that they improve the representation of the climate compared to the global driving data (GDD), i.e., RCMs produce **added value (AV)**.
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- However, the search for AV has not shown unequivocal gains and the finding of **“mixed results”** (i.e., results showing improvements and deteriorations depending on the specific climate statistics/experimental setup) constitutes more the standard than exception in AV studies.
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Open question

- Which of these two situations (improvement/deterioration) is more dominant?

- Do RCMs produce in general a substantial overall improvement over the driving data?
Objectives of the presentation

1. To **evaluate the overall AV** of an ensemble of RCM simulations and its dependence on a variety of factors.

2. To decompose the AV according to the **contribution of different spatial scales**:
   - **large scales**: scales common to both the GDDs and the RCMs
   - **small scales**: scales only represented in the higher resolution RCMs

3. To explore how much of the AV can be attained using **simpler postprocessing methods**.
Two “Added Value” metrics

1. **Mean square error**: relative performance in terms of absolute values:

\[
AV_{MSE} = (X_{GDD} - X_{OBS})^2 - (X_{RCM} - X_{OBS})^2 = MSE_{GDD} - MSE_{RCM}.
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- Metrics are **normalized** to allow for comparisons across regions, seasons, etc.
- Quantities vary between -1 and 1 with positive values suggesting that there is some AV.
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Systematic sampling of factors influencing the AV including various experimental setups (ES) and several climate statistics (CS):
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<tbody>
<tr>
<td>1) $dx$ (RCM)</td>
<td>ES</td>
<td>2</td>
<td>10 and 50-km grid spacing</td>
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<tr>
<td>2) RCM</td>
<td>ES</td>
<td>4</td>
<td>R1, R2, R3, ensemble mean</td>
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**RCM domains**
- 50-km over Australasia
- 10-km over south-east Australia
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<td>5) Region</td>
<td>CS</td>
<td>3</td>
<td>coastal, topography, flat</td>
</tr>
<tr>
<td>6) Variable</td>
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<td>3</td>
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</tr>
<tr>
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**TOTAL NUMBER OF AV ESTIMATIONS**: 2592
mean square error: 

$$AV = \frac{(MSE_{GDD} - MSE_{RCM})}{\text{errors}_{\text{sum}}}$$
spatial correlation: \( AV = \frac{\text{corr}(RCM, OBS) - \text{corr}(GDD, OBS))}{\text{errors}_{\text{sum}}} \)
The AV of MSEs is dominated by the **large scale** term.
AV as a function of spatial scales

<table>
<thead>
<tr>
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<th>corr AV (RCM10)</th>
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<tbody>
<tr>
<td>total</td>
<td></td>
</tr>
<tr>
<td>300</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
</tr>
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- The AV of MSEs is dominated by the **large scale** term.
- The AV of spatial correlations is dominated by the **small scale** term.
AV with simple GCM-postprocessing: $T_{\text{min}}$

**Figure**: Overall AV for minimum temperature calculated using three different methods to interpolate GCM data.

- In general, about half of the AV in temperature variables can be obtained using simpler postprocessing.
For both AV metrics, the overall performance of RCMs is generally superior compared with the corresponding driving data:

- AV higher and more robust for spatial correlation metric.

\[
\text{AV}_{\text{MSE}} \approx \text{AV}_{\text{MSE}}^{\text{large scales}}
\]

\[
\text{AV}_{\text{correlation}} \approx \text{AV}_{\text{correlation}}^{\text{small scales}}
\]

A significant amount of the overall AV in temperature variables was shown to be attained using simpler post-processing methods.
Summary

- For both AV metrics, the overall performance of RCMs is generally superior compared with the corresponding driving data:
  - AV higher and more robust for spatial correlation metric.
- \( AV_{MSE} \approx AV_{MSE}^{large \ scales} \)
- \( AV_{correlation} \approx AV_{correlation}^{small \ scales} \)
- A significant amount of the overall AV in temperature variables was shown to be attained using simpler post-processing methods.

Are these results dependent on the specific ensemble used in this study?
References


**Thanks for your attention!!!**

**Questions? Comments?**
Spatial scale decomposition method
AV measures: mean Vs sign
AV as a function of spatial scales
**10-km RCM vs 50-km RCM**

**Figure:** AV values for the 50-km RCM simulations compared with the global driving data for different spatial scale terms.
**Figure** : Overall AV for minimum temperature calculated using three and different interpolation: nearest neighbor, bilinear and bilinear plus topographic correction.
**Figure**: Overall AV for maximum temperature calculated using three and different interpolation: nearest neighbor, bilinear and bilinear plus topographic correction.