Introduction

Intro text...

It is always important to consider current climate inter-annual variability when one investigates the climate of a region. This gives an indication of the range of variability currently being experienced which is critical when one considers future changes. It is often the case that the current inter-annual variability of precipitation is very large compared to future projected changes, particularly for the near future (50 years). This is an important consideration for end users depending on the sector and the type of vulnerability under question.

The observed climate for the location is presented below in the form of graphs and summary tables. A map of the station location is presented in figure 1 with station names of the selected stations.

Observed climate

Observed seasonal rainfall

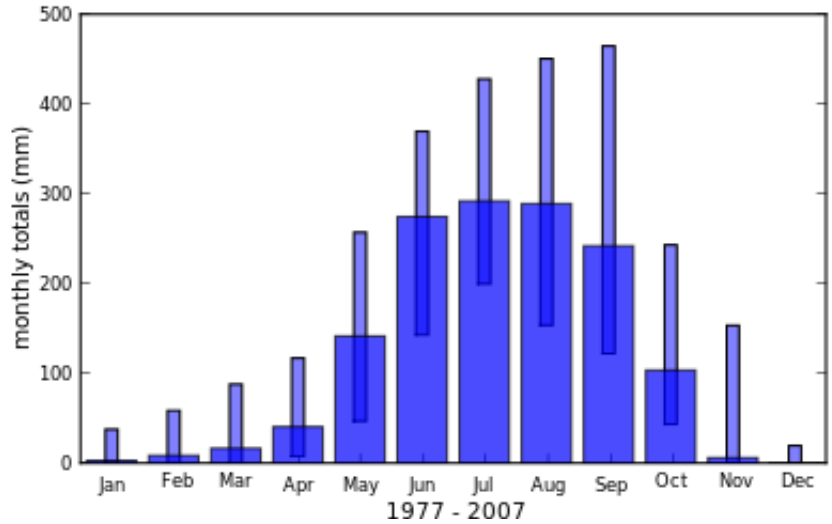

Figure 2: Annual cycle of monthly rainfall (mm) for station.
Wide bars indicate the median monthly rainfall for the climate period. Narrow bars indicate the 10th to 90th percentile range of monthly rainfall for each month during the climate period.

Observed seasonal mean dry spell duration

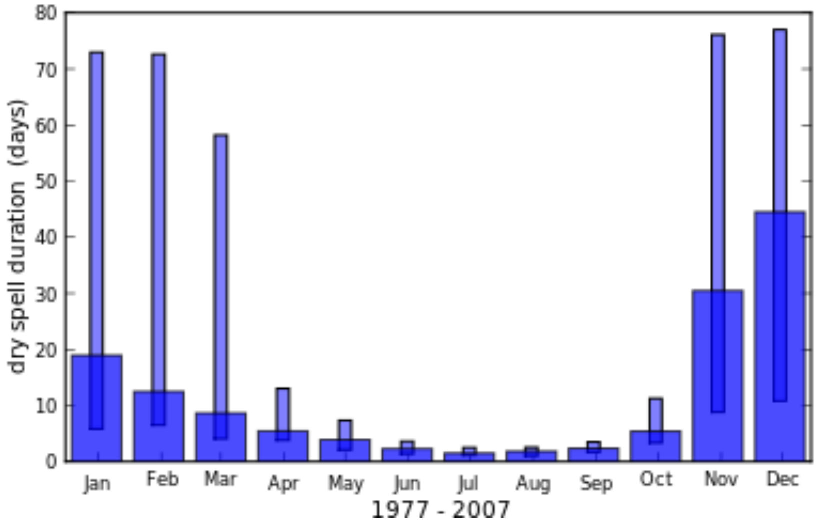

Figure 3: Annual cycle of monthly mean dry spell duration for station.
Wide bars indicate the median dry spell duration for the climate period. Narrow bars indicate the 10th to 90th percentile range of dry spell durations for each month during the climate period.

Observed seasonal daily maximum temperatures

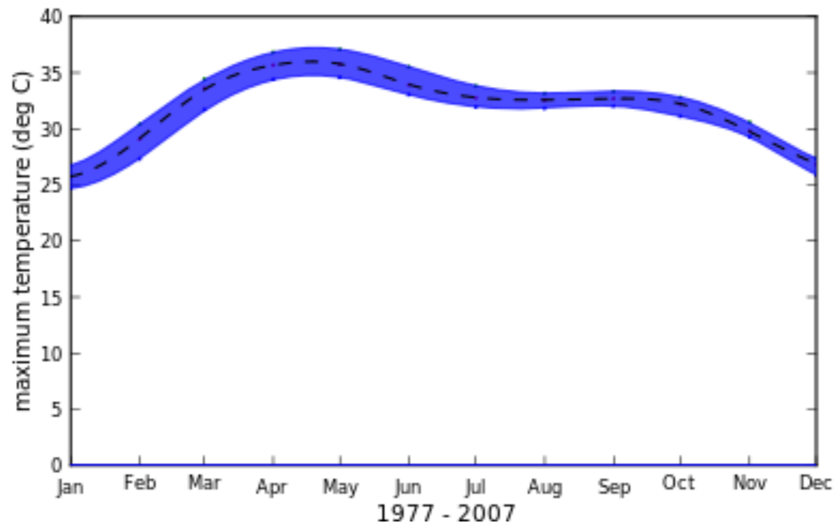

Figure 4: Annual cycle of monthly mean maximum daily temperatures (degC) for station.
The blue envelope represents the 10th percentile to 90th percentile inter-annual range.

Observed seasonal days/month exceeding 32 degC

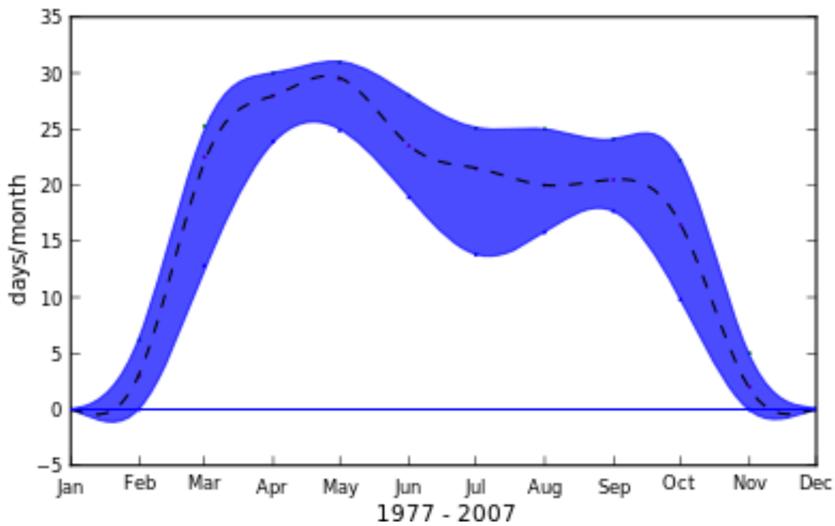

Figure 5: Annual cycle days/month exceeding 32 deg C for station.
The blue envelope represents the 10th percentile to 90th percentile inter-annual range.

Observed climate discussion

Observed climate discussion text....

Climate Projections

Global Climate Models (GCMs) are the foundation of climate change projections. These models attempt to simulate the global climate system by integrating known atmospheric physical processes through time. The models simulate the heating effect of the sun, the heat and moisture fluxes from the oceans, the effect of the land surface and vegetation, as well as the effect of green house gases on the atmospheric temperature profile. However, many processes occur at scales that cannot be resolved by the GCM numerics. These processes are approximated through parameterisations. Parameterised processes included cloud radiative effects, convection and precipitation, boundary layer mixing and many aspects of surface heat and moisture fluxes. Many differences between GCMs are a result of the different approaches to these parameterizations, particularly cloud radiative effects and precipitation processes. Another consequence of importance is that the skill of a GCM to simulate a particular region varies. Each GCM has better skill in some areas than others.

Multi-model selection

The temptation is to pick the GCM that best represents the climate of your region of interest. However this is not a valid approach because when generating climate change projections we are looking for an accurate response to changes in GHG concentrations. A GCM that accurately simulates observed climate does not necessarily accurately respond to changes in GHGs. Of course we do not know what an accurate response should be so we have to assume that all models represent an equally likely response. This is the basis of the development of climate projection envelopes which represent to the range of responses produced by the GCMs.

Model Bias

It is acknowledge that each GCM has a particular bias for a particular variable in a particular region. This bias can be significant in the case of precipitation. When developing future projections it is therefore important not to look at the raw GCM output fields only, but to also look at the anomalies between the GCM 20 th century simulate and the future simulation. These anomalies are calculated for each GCM and represent the GCM response or delta given the GHG forcing. In the figures below both the absolute downscaled GCM projection envelopes and the anomaly envelopes are presented. The absolute values are still useful to show the GCM seasonality as well as the agreement between GCMs.

Downscaling

The resolving scale of GCMs has improved significantly in the last 10 years with many state of the art GCMs able to resolve at a scale of around 100km. The CMIP3 archive GCMs are typically of lower resolution than 100km with resolution ranging between 200km and 400km. However, while the native resolution of GCM may be 200km, the skill of the model at this resolution is typically low due to the GCMs simplified topography and representation of regional processes. GCM skill is much higher when aggregated up to large scales such 500km to 1000km.

The problem is that these scales are far to course for most users who are dealing with regional issues such as water management and agriculture. Society and ecosystems typically operate at much finer scales. Downscaling is the concept based on the observation that local scale climate is largely a function of the large scale climate modified by some local forcing such as topography. There are two main types of downscaling, dynamical and empirical. Dynamical downscaling utilises a higher resolution, limited domain, dynamical model that follows the same principles as a GCM but because of the limited domain is able to be run at much higher spatial resolutions with moderate computation costs. Dynamical downscaling offers a physically based regional response to the large scale forcing. However dynamical modelling is complicated by similar problems to those of GCMs, namely bias and error.

Empirical downscaling utilises various statistical methods to approximate the regional scale response to the large scale forcing. Various methods have been developed. The method used in this report is called SOMD (Self Organising Map based Downscaling) developed at the University of Cape Town. Details of the method can be found in the referenced paper. The method recognises that the regional response is both stochastic as well as a function of the large scale synoptics. As such it generates a statistical distribution of observed responses to past large scale observed synoptic states. These distributions are then sampled based on the GCM generated synoptics in order to produce a time series of GCM downscaled daily values for the variable in question (typically temperature and rainfall). An advantage of this method is that the relatively unskilled grid scale GCM precipitation and surface temperature are not used by the downscaling but rather than relatively highly skilled large scale circulation (pressure, wind and humidity) fields are used.

Projections

The CMIP3 archive GCMs are used in this study. The downscaling methodology requires daily archive fields which limited the number of suitable GCMs to a total of 9 out of a possible 21. Each GCM has a number of simulations. The first is a simulation of the 20th Century climate (1961 to 2000) forced by observed GHG concentrations. This simulation is the GCMs representation of the observed climate period. It is important to note that there is no correspondence between real years and the years of the 20 th Century simulations. This means one can expect no likeness between a particular year in the 20 th Century simulation and that year in the observational record.

Then follows a number of simulations of future periods and GHG concentration scenarios. For this study the two future periods of 2046 - 2065 and 2081 - 2100 were selected and the future development scenarios A2. A total of 3 GCM simulations, one 20th Century period and 2 future periods are therefore analysed for each particular GCM. Each GCM simulation was downscaled to the station location and various appropriate climatological summary statistics were produced. These are presented below in the form of climate projection envelopes. As mentioned above, projection envelopes capture the range of GCM responses to GHG forcing and represent the level of agreement or disagreement between the GCMs.

Monthly total precipitation change (SRES A2 Scenario)

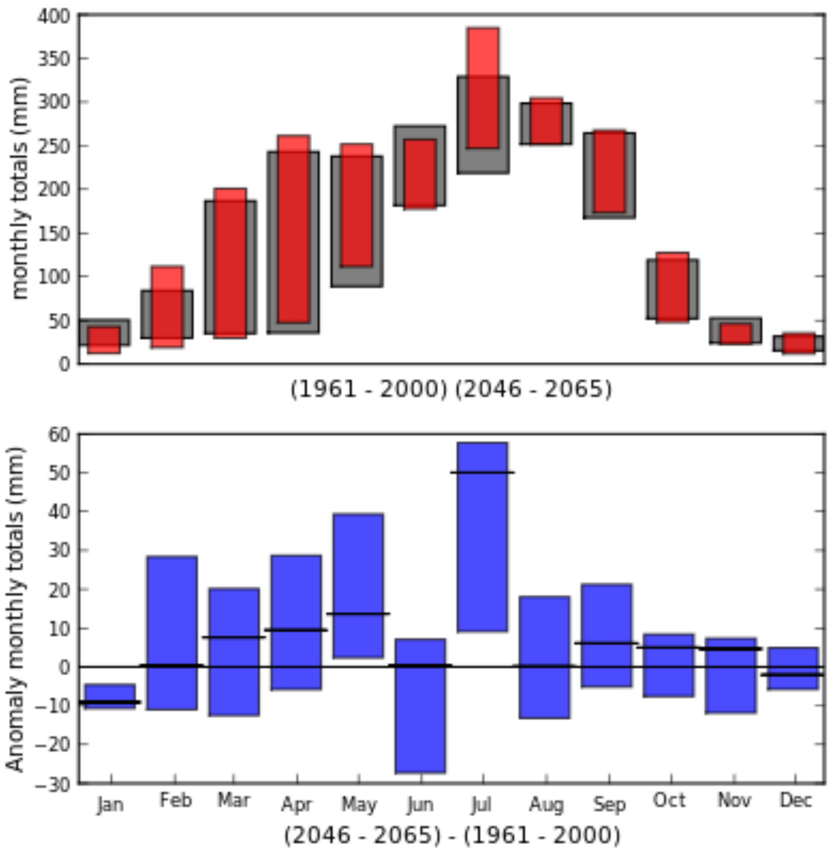

Figure 6: Change in monthly total rainfall (mm) for station. Grey bars represents 10th to 90th percentile range of the control period multi-model climatologies (1961-2000). Red bars represents the same but for the future period multi-model projections (2046-2065). Anomaly plot wide bars represents 10th to 90th percentile ranges of the future - control anomalies with the median change marked as a solid black line.

Monthly dry spell duration change (SRES A2 Scenario)

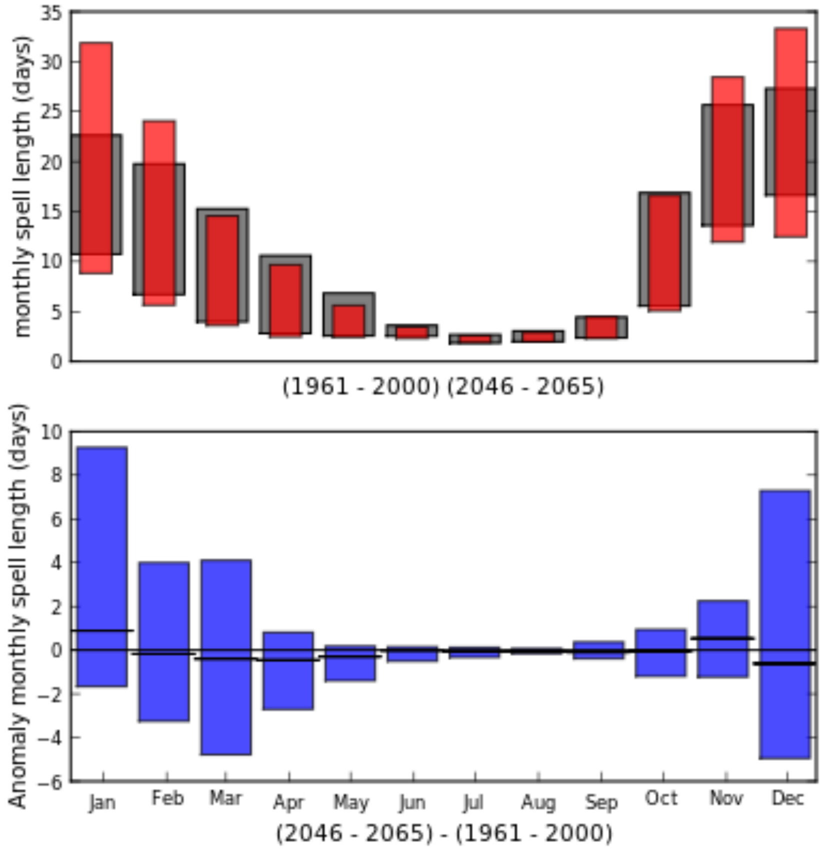

Figure 7: Change in monthly total rainfall (mm) for station. Grey bars represents 10th to 90th percentile range of the control period multi-model climatologies (1961-2000). Red bars represents the same but for the future period multi-model projections (2046-2065). Anomaly plot wide bars represents 10th to 90th percentile ranges of the future - control anomalies with the median change marked as a solid black line.

Monthly mean maximum daily temperature change (SRES A2 Scenario)

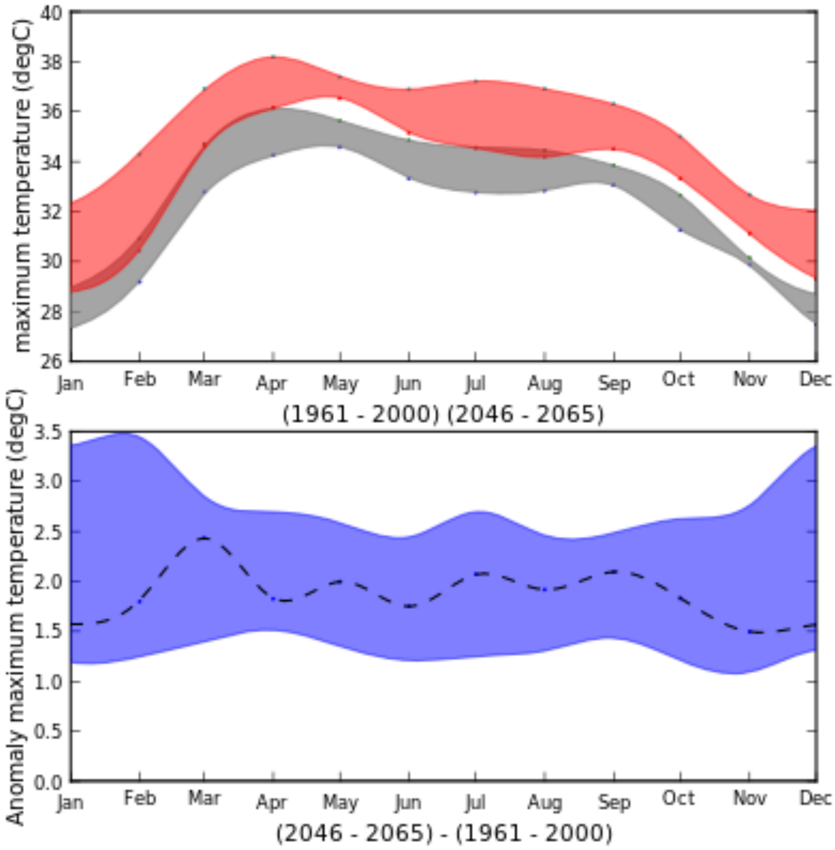

Figure 8: Change in monthly mean maximum daily temperature (deg C) for station. Grey envelope represents 10th to 90th percentile range of the control period multi-model climatologies (1961-2000). Red envelope represents the same but for the future period multi-model projections (2046-2065). Anomaly plot envelope represents the 10th to 90th percentile range of anomalies with the median anomaly as a dashed line.

Monthly mean change in days exceeding 32 degC (SRES A2 Scenario)

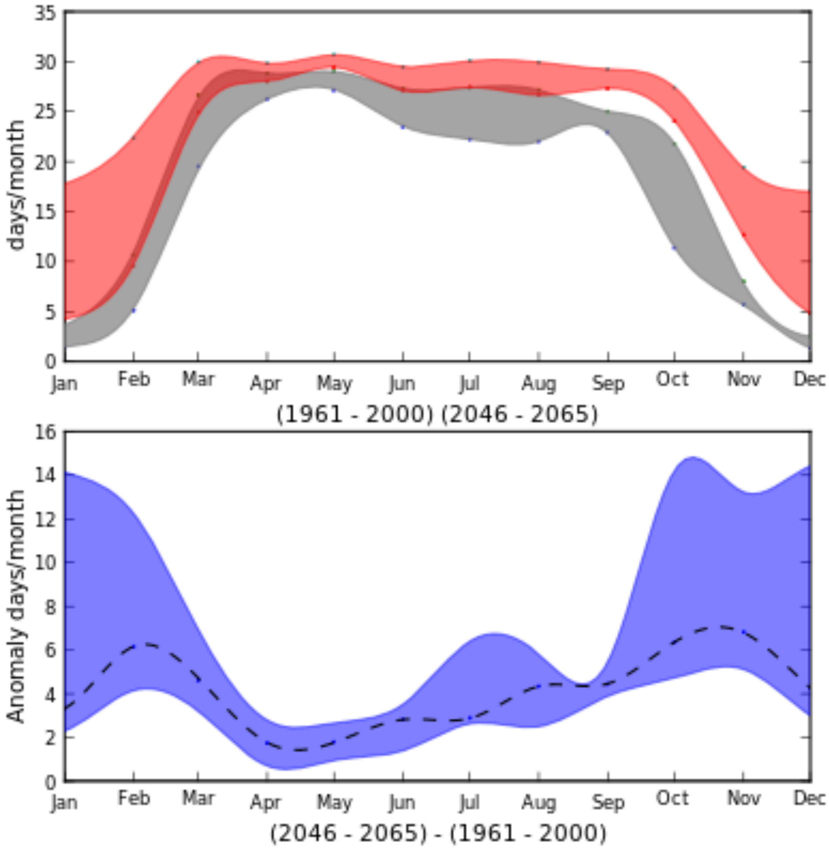

Figure 9: Change in monthly days exceeding 32degC for station. Grey envelope represents 10th to 90th percentile range of the control period multi-model climatologies (1961-2000). Red envelope represents the same but for the future period multi-model projections (2046-2065). Anomaly plot envelope represents the 10th to 90th percentile range of anomalies with the median anomaly as a dashed line..

Projected changes discussion

Projected changes discussion text...