PROJECT 2.4: PHYSICAL-STATISTICAL MODELLING OF EXTREME EVENTS

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Key research findings and highlights

Milestone 2.4.1 *Selection of high-quality weather recording stations* – The selection of high-quality stations. This milestone was due for completion at the end of 2008 but an extension is requested until November 2010 to build a high-quality dataset with data from a range of sources due to the sparseness of high quality daily BoM sites.

Milestone 2.4.2 *Availability of modelled data that could be integrated with observed records to in-fill gaps* – With the exception of data on green vegetation cover, all data have been collected. This milestone was due for completion at the end of 2009 but an extension to the end of 2010 is requested due to the late commencement of the project.

Milestone 2.4.3 *Predictor selection methodologies and their application* – Have demonstrated proof-in-principle use of automatic variable selection methods for selecting atmospheric drivers of extreme events in NWWA. These will be further developed and then integrated with existing downscaling methods. This milestone is currently due for completion at the end of 2010.

Milestone 2.4.4 *New statistical model for extreme temperature (and rainfall) events* — Two new statistical models have been developed, and ongoing work will refine and then use them to model extreme temperature events in SWWA and NWWA. This milestone was due for completion at the end of 2009 but an extension to the end of 2010 is requested due to the late commencement of the project and delays due to the need to modify code to take account of variations in the pluvio data.

Milestone 2.4.5 *Key atmospheric predictors for extreme heat (and rainfall) events* — We have identified two potential synoptic patterns that may be related to extreme temperature events in SWWA. Ongoing work will aim to identify atmospheric predictors of extreme temperatures in NWWA, and to quantify their effects. This milestone was due for completion at the end of 2010 but an extension to June 2011 is requested due to the late commencement of the project and delays in processing pluvio data.

Milestone Reports

Milestone 2.4.1 *Selection of high-quality weather recording stations*

The high quality data sets described by the BoM are spatially sparse in the NW. We have therefore used raw rainfall data sets, and will carefully scrutinise them to ensure that we can select the top *r* rainfall values for a season within a year. Note that the model we use does not require continuous runs of data over seasons, so we can be less stringent in our requirements. This can, to some extent, alleviate the need to use modelled data for infilling.

We use not only daily rainfall records but also data from pluvio graphs (essentially continuous measurements of rainfall). BoM data has been supplemented with data from DAFWA and Dept of Water.

Data from the NT (both daily and pluvio), close to the WA border, has also been acquired.

Milestone 2.4.2 *Availability of modelled data that could be integrated with observed records to in-fill gaps*

It is not clear that either global or regional climate models currently do good job at reproducing the characteristics of extremes, particularly rainfall extremes. We have decided to handle the problem of infilling by using lower quality data sets (recognising that BoM is currently revising their data sets) with greater spatial coverage, and using both daily and pluvio data sets. We are exploring an approach based on combining this extended data set with a regression-based approach to model extreme rainfall in regions of low data coverage.

Covariates such as distance from coast, height above sea-level are being derived/calculated so that they can be included in models for extreme rainfall in regions that are sparsely sampled. A satellite-based measure of green vegetation cover (normalized difference vegetation index, or NDVI) will also be considered.

Milestone 2.4.3 *Predictor selection methodologies and their application*

While high-quality datasets are being compiled, we have been developing contemporary variable selection methods using existing data from NWWA. Currently, these methods can be used for modelling rainfall occurrence or extremes. Preliminary work shows that for modelling rainfall occurrence at single sites, these methods can be used to select a small group of variables for use in existing, and more complex, models such as non-homogeneous hidden Markov models. Furthermore, we have used these methods for identifying potential drivers of extremes in the NW, but this work is still under development.

Milestone 2.4.4 *New statistical model for extreme temperature (and rainfall) events*

A Poisson Generalized Pareto Distribution (Poisson-GPD) point process model for temperatures has been developed. Results include: (a) mean cluster size of temperature extremes and (b) distributional results and asymptotic theorems of the first epoch of cluster of extremes. Ongoing work includes developing R functions to estimate the first epoch of cluster of extremes, distribution of the cluster size, and linking climate drivers to model parameters.

An aggregated Markov chain (MC) model for temperature extremes has been developed. Given the transition rate matrix, results on sojourn time of each aggregated states of temperature extremes has obtained. Ongoing work includes (a) an R implementation to estimate the transition rate matrix and (b) linking climate drivers to transition rate in the MC model.

Milestone 2.4.5 *Key atmospheric predictors for extreme heat (and rainfall) events*

We are currently collating daily maximum temperature (T_{max}) gauged at 103 high-quality stations over Australia and comparing the difference between observed and 0.5° grid T_{max} data. There are only 8 stations over SWWA and 7 stations over NWWA with long temperature records. Because there are consecutive missing days (longer than 5 days) in T_{max} before 1957, we have focused on the statistical modelling of temperature extremes during the period from 1957 to the present. A paper is under preparation by Li et al. (2010) to document these results. The key findings include:

- Over the whole Australian continent, the first four leading modes capture more about 70% variance of very hot days with T_{max} higher than 35°C. The 0.5° grid data show a similar structure as observed first leading two modes.
- Trends in SWWA hot days were investigated using station data. There are significant upward trends over the northwest part of SWWA, but no trend, or a downward trend, are found over the southwest part. This motivates us to study the atmospheric circulations that may induce such opposing trends in SWWA hot days.
- We have found that the dominant modes of very hot days have a strong link to a regional monsoon-like circulation called the Southwest Western Australia Circulation (SWAC, Feng, Li and Li, JCLI2010) in summer. The upward trend over northwest SWWA and downward trend over southwest SWWA is due to the upward trend in the SWAC, which brings more synoptic anticyclones to SWWA corner, leading to hot days over north SWWA.
- The research on hot spells and extreme heats event in NWWA is ongoing.

Summary of any new research opportunities that have arisen

- Need to develop approaches for analysing extreme data that can use censored data, which will enable the integration of more data sets
- Need to develop new methodology on the statistical modelling of hot spells and heat waves using extreme value theory.
- We have developed a strong linkage with National Centre for Atmospheric Research, Boulder, CO, USA. Dr Rick Katz from NCAR visited CSIRO during 7-20 June 2010. In addition, Yun Li has been invited to visit NCAR, 11 October-22 October 2010. Our linkage with NCAR will help us form collaborations with them to develop new methodology on the statistical modelling of hot spells and heat waves.

List of publications accepted and submitted.

Feng, J., Li, J., and Y. Li, 2010: Is there a relationship between the SAM and Southwest Western Australian winter rainfall?" *Journal of Climate* (*in press*).

Li, Y., Lau, R. and C. Liu 2010: On the large-scale circulations and their linkages to temperature extreme events over southwest Western Australia, (*in preparation*).

List of IOCI-related presentations at national or national and international conferences, symposia and workshops.

Phatak, A., Chan, C., and H. Kiiveri, 2010: Fast variable selection for extreme values. Proceedings of International Environmental Modelling and Software Society (iEMSs)2010 International Congress on Environmental Modelling and Software, Fifth Biennial Meeting, Ottawa, Canada