OzClim: The Development of a Climate Scenario Generator for Australia

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Abstract: *OzClim* is a PC-based climate scenario generator developed by CSIRO Atmospheric Research in collaboration with the International Global Change Institute in New Zealand. It simplifies the process of calculating scenarios from climate change model output, applies scenarios to impact models and manages uncertainty. *OzClim* features a graphical user interface and point-and-click technology for ease of use, fast calculations and visualisation capabilities. A range of global climate models, emission scenarios and climate sensitivities can be harnessed using this system. The ability to 'plug in' impact models into the system and run the impact model with different scenarios using batching routines within *OzClim* are further advantages of the software. This paper focuses on: the benefits of using the software to create scenarios of future climate and conduct climate impact assessments; the additional observed and global climate model data; the various export functions available; coupling impact models based on different programming languages and batching impact model analysis. Outcomes include the release of *OzClim* 2.0.1 Beta in March 2001 and the inclusion of results from this version in the CSIRO scenario documents.

Keywords: OzClim; Climate; Hydrology; Modelling

1. INTRODUCTION

OzClim has been adapted for Australia from the CLIMPACTS software developed in New Zealand by The International Global Change Institute (IGCI). New or improved functionality within OzClim includes the addition of more climatic variables and global climate model patterns, new analysis tools and extraction procedures and improved linking capabilities to other programs.

OzClim has two main purposes. Firstly, to calculate future climate projections; and secondly, to apply the projections to impact models such as wheat, moisture deficit calculations, and hydrological modelling.

Some of the benefits of using OzClim rather than other systems include the fact that future climate change can be calculated within seconds, the point-and-click style of the user interface, and the ability to include further statistical analysis and impact models into the system.

By expending approximately the same resources that it would take to construct scenarios offline and apply these to an impact model, OzClim can be modified to create a modelling system that is far more powerful.

This paper describes some of the functionality and benefits of OzClim, in particular, the ability to generate climate projections and using the climate projections as input into impact models. Two hydrological models are discussed: a moisture deficit model and the New South Wales Department of Land and Water Conservation Integrated Quality Quantity Model (IQQM) for the Macquarie River system.

Jones and Page [2001] will present results from the coupling of OzClim and the IQQM model at this conference.

2. HISTORY AND BENEFITS OF OZCLIM

The International Global Change Institute (IGCI) based in Hamilton, New Zealand developed CLIMPACTS using Borland Delphi. [Kenny et al., 2000; Sims et al., 1996; Warrick et al., 1996; Ye et al., 1999]. The IGCI supplied the original code to CSIRO Atmospheric Research to develop an Australian version called OzClim. Since the initial

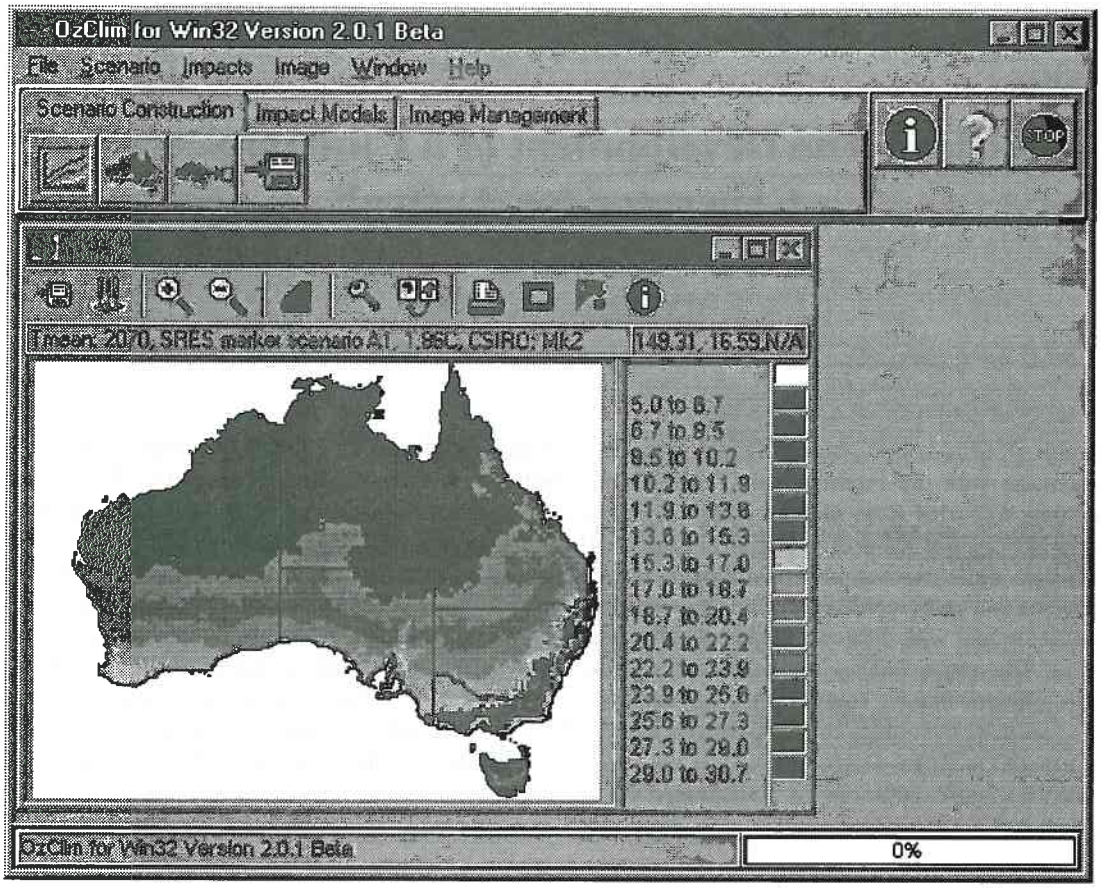

Figure 1. The main page of OzClim showing buttons to graph emission scenarios, generate climate projections, and export results. The map of Australia is generated from the selection of annual mean temperature, for the SRES A1 emission scenario and the CSIRO Mk2 climate model for 2070.

transfer, many changes and additions have occurred to the code that gives OzClim a higher focus on Australia and hydrology issues in particular.

OzClim has a graphical user interface that allows users to easily produce quality graphics. Figure 1 displays the main form of OzClim and the resulting map from the selection of annual mean temperature, for the SRES A1 emission scenario and the CSIRO Mark 2 climate model. From this form the scenario construction tab, impact models tab or image management tab can be selected.

OzClim can display projections of future climate (Figure 1) or the change from base climate using patterns of change extracted from global climate models [Hulme et al., 2000].

3. IMPROVED FUNCTIONALITY

3.1. Climatic Variables and Global Climate Data

OzClim contains monthly data for rainfall, minimum temperature, maximum temperature and average temperature, point potential evaporation and vapour pressure for the observed climate, eight global climate models (GCM) and two regional climate models.

Observed rainfall and temperature maps were created using monthly averages of station data, interpolated to a regular latitude/longitude grid using spline techniques [Hutchinson and Bischof, 1983]. Point potential evaporation and vapour pressure were created using data from the Climate Research Unit [New et al., 1999; New et al., 2000] and routines developed by Morton [1983].

Global climate model data from international institutions were obtained from the Data Distribution Centre of the International Panel on

Climate Change (IPCC) website[1]. Potential evaporation and vapour pressure were created using the same methods as for the observed dataset.

The climate patterns within OzClim were created using regression analysis rather than taking the difference between two time slices. Local change is regressed against global warming for each grid point. This enables the whole time series from a transient model run to be used for pattern extraction [Whetton et al., 2001].

To produce seasonal or multi-month results, the base climatologies are summed for precipitation or potential evaporation across the number of months selected and percentages calculated. For the temperature variables and vapour pressure the monthly base climatology is averaged. The regional pattern from the GCM is averaged for all climatic variables. These combined patterns are then used to create multi-month climate scenarios

3.2. Export Functions

Each export function can be performed on a user-created scenario or GCM data stored within the climate pattern database for each month and GCM pattern or for many months and many patterns.

The export functions within OzClim enable users to extract climate data for further analysis outside of the OzClim system. Climate images can be saved as a jpeg or bitmap, or as data in arcinfo format or as a text file.

Regridding is performed using bilinear interpolation [Press et al., 1986] from the original Australian grid of 110°E to 154°E at 0.25° resolution, 44°S to 10°S to the user-defined grid.

The user selects the latitude and longitude limits of the region to be averaged. Ocean points are not included in the average. Each land point has equal weighting in the calculation. An average can be generated for each month and each GCM pattern for a particular climatic variable to produce a text file containing a set of twelve monthly values for each GCM pattern.

3.3. Coupling Impact Models to OzClim

The impact models are currently linked in two different ways: as objects coded in Pascal code, and by executing DOS-driven command lines from within OzClim. The precipitation minus potential evaporation (P - Ep) impact module is written in Pascal, whereas the NSW Department of Land and Water Conservation's Integrated Quality Quantity Model (IQQM) has been linked using DOS-driven command lines within OzClim.

IQQM uses daily station rainfall and potential evaporation data to calculate runoff and stream flow for each subcatchment [Podger and Hameed, 2000]. OzClim modifies the input files based on climate change scenarios from a selection of climate models, then runs a sequence of DOS executables to determine river flow, environmental flows and irrigation allocations. Figure 2 shows the interaction between OzClim and IQQM to generate flow time series.

The user selects the climate scenarios, i.e. the climate model, climate sensitivity, emission scenario and the year. OzClim accesses the database and modifies the daily precipitation and evaporation files based on these selections. OzClim then executes the IQQM model with the new input data and generates mean daily flows and other hydrological data within the catchment. OzClim produces mean annual flow from the daily files.

[1] http://ipcc-ddc.cru.uea.ac.uk/

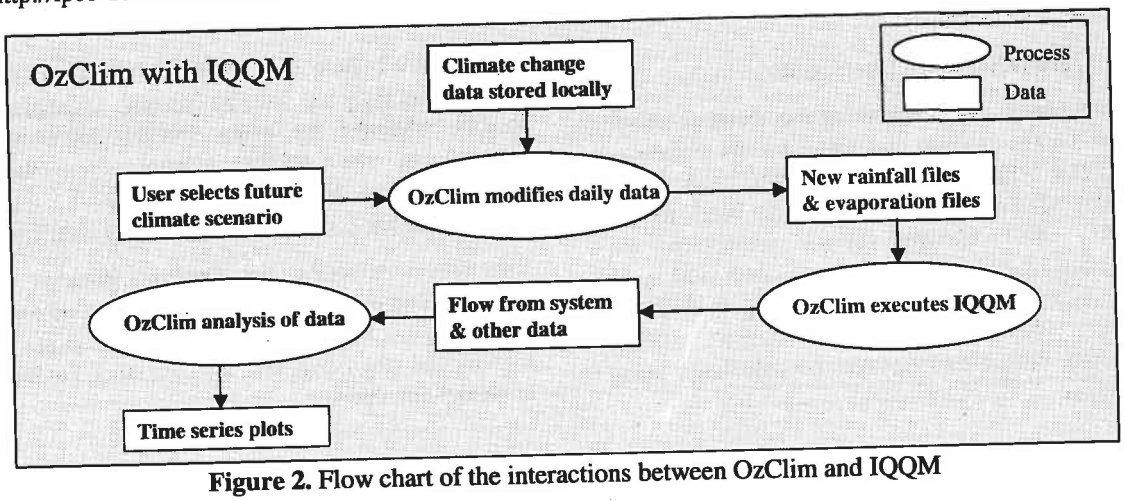

Figure 2. Flow chart of the interactions between OzClim and IQQM

3.4. Batching

Batching functions within OzClim save run time by minimising user interaction. Batch functions exist for area averaging, regridding and pattern extraction of GCM data. It is also possible to run impact models sequentially using batch files.

For example, when running the model once, the user selects the scenario and the Macquarie river IQQM takes approximately thirty minutes to generate a mean annual flow. Batching does not require constant user interaction or model input preparation.

Therefore, the advantage of batching becomes greater when a batch file containing sixty sets of scenarios can be completed within thirty hours while the user need only set the batch routine running.

OzClim is set up to run the IQQM model sequentially with different climate projections preselected by the user within a batch file. Three types of analysis can be performed through the batch file process, which modifies the precipitation, and potential evaporation files before running the IQQM model. They are:

- Run a sensitivity analysis with a range of precipitation and potential evaporation changes. E.g. apply the following changes to the daily input files:-
  Precipitation range from –15% to 15%,
  Potential evaporation range from 0% to 15%.
- Run from batch file. The file contains GCM model parameters. E.g. year, model name, climate sensitivity, emission scenario
- Run from batch file with the file containing twelve precipitation change values and twelve evaporation change values, one for each month.

4. OUTCOMES

4.1. CSIRO Scenario Documents

Results produced by executing the moisture deficit model within OzClim and based on the difference of future changes of precipitation and future change of evaporation have been used in the CSIRO 2001 climate change projections for Australia[2]. Eight global climate models were used to generate the results, which were exported so that further analysis could be performed offline. Moisture deficit analysis can be calculated using any sequence of months and any global climate model within OzClim.

4.2. Release of OzClim 2.0.1 Beta

OzClim 2.0.1 Beta was released in March 2001 as a self-extracting executable on CD. It contains the improved functionality described earlier in this paper, but does not include the IQQM model.

A database of future global warming for a series of emissions scenarios at low, medium and high climate sensitivity is also included.

OzClim currently contains four impact models. Three are based on degree day analysis including corn and maize growth models. The fourth is a moisture deficit model, which calculates the difference between future anomalies of precipitation and future anomalies of evaporation.

OzClim 2.0.1 Beta has links to online help at the CSIRO OzClim home page[3], which contains links to other sites and further explanations on how OzClim works. Several researchers are currently using OzClim as part of their research.

5. CONCLUSIONS

The OzClim software can quickly generate climate scenarios for Australia and apply these projections as input into various impact models within one software application. There are two ways in which impact models have been 'plugged into' OzClim, by writing native Delphi code or by executing the impact models through DOS command lines.

Improvements to OzClim have been made by including additional climatic variables from observed datasets and global climate models, extending export functionality, by coupling impact models with the scenario generator within OzClim, and by batching repetitive processes to simplify user interaction with the system.

OzClim 2.0.1 Beta was released in March 2001 and is currently in use by several researchers. Results obtained by using OzClim have been applied to the CSIRO climate projections documents and Jones and Page [2001] present results from the coupling of IQQM with OzClim.

The future direction for OzClim includes the development of more analytical and export tools, increasing the number of impact models within the system and obtaining and incorporating feedback from OzClim users.

[2] http://www.dar.csiro.au/publications/projections2001.pdf

[3] http://www.dar.csiro.au/publications/ozclim.htm

6. ACKNOWLEDGEMENTS

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8. WEBSITES

CSIRO Climate change projections for Australia. http://www.dar.csiro.au/publications/projections2001.pdf

CSIRO OzClim homepage. http://www.dar.csiro.au/publications/ozclim.htm

IPCC website http://ipcc-ddc.cru.uea.ac.uk/dkrz/dkrz_index.html