WILL IT RAIN? MANAGING EL NIÑ0 RISKS WITH THE AUSTRALIAN RAINMAN COMPUTER PACKAGE

N.M. Clarkson[1], J.F. Clewett[1], D.T. Owens[1] and D.G. Abrecht[2]
[1]Queensland Department of Primary Industries, Toowomba QLD 4350, Australia
[2]Western Australian Department of Agriculture, South Perth WA 6151, Australia

ABSTRACT
The AUSTRALIAN RAINMAN computer package helps the management of climatic risks associated with the ENSO (El Niño/ Southern Oscillation) phenomenon in the southern Pacific region. The package uses historical rainfall and Southern Oscillation Index (SOI) records to provide a suite of analyses including user-defined seasonal forecasts. Examples are given of ENSO effects on precipitation in Australia and some other countries including Canada. The SOI has a multiplier effect on rain-dependent processes such as plant growth and stream flow, and its use provides valuable support for many agricultural and pastoral decisions. AUSTRALIAN RAINMAN is commercially available in Australia.

KEYWORDS
Rainfall, risk, climate, forecast, computer, El Niño, Southern Oscillation, ENSO, decision support

INTRODUCTION
In many countries climatic risks, especially those associated with low and unreliable rainfall, are major determinants of agricultural production and profit. Australia, with one of the most variable climates in the world (CSIRO, 1960), is well supplied with long-term rainfall records through its Bureau of Meteorology. Easy access to these records can provide information about climatic variability, but recent development of seasonal forecasting methods using the Southern Oscillation Index (SOI) has improved management of climatic risks and opportunities. AUSTRALIAN RAINMAN was developed to deliver these benefits to farm managers and others with personal computers.

MATERIALS AND METHODS
The basic AUSTRALIAN RAINMAN computer software package (Clewett *et al., 1994*) consists of two system disks and two data disks providing a summary for 270 monthly and 25 daily Australia-wide rain locations. Twenty extra disks expand the collection to 3887 locations; the system is suitable for IBM-compatible PCs (386+). A user guide includes maps of all locations and the book *Will It Rain?* (Partridge, 1994) which explains the effects of the Southern Oscillation and El Niño on Australia.

For each location, AUSTRALIAN RAINMAN can provide information about:
- monthly rain (summary, probabilities of monthly rain, historical data, all as tables and graphs)
- seasonal rain (seasons starting in any month and up to 12 months duration, with and without the effects of the SOI and the Indian Ocean sea surface temperatures [with 64 colour maps showing where and when SOI effects occur], chances of rain with XY plot graphs, deciles of rain with box plots, historical seasonal rain with line graph and adjustable moving mean)
- daily rain (tables of number of rain-days in fixed seasons [with SOI effect]; amount of rain per rain-day in these seasons; planting opportunities in fixed seasons; chances of user-defined rainfall, dry period or changing rainfall event after a nominated starting date, as tables and graphs)
- droughts (using three different definitions, provides a summary list of drought dates, duration, total rain; details of individual droughts, all as tables and bar graphs)
- relative humidity, temperature and evaporation (tables of monthly averages and some probabilities from suitable recording stations).

It also allows users to:
- update monthly data (simple forms for entering recent monthly data for rainfall, SOI and sea surface temperatures)
- enter their own data (simple form for entering personal monthly rainfall records)
- export data (for monthly and daily historical rainfall records required for a different purpose)

Missing values of monthly rainfall were patched using the thin plate smoothing spline technique developed by Hutchinson (1991). This enabled the patching of missing daily rainfall by apportioning the monthly total over the raindays of a nearby recording station. Minimum standards for selecting rain stations set the proportion of original data required (50% for monthly rain and 30 years for daily rain) and the length of record (minimum 30-70 years, depending on adequacy of the collection in each state of Australia).

The El Niño phenomenon is a pattern of temperature anomalies occurring every 3 to 6 years in the southern Pacific Ocean, in which the eastern waters off South America become significantly warmer than usual, and those in the west in the Indonesian region are slightly cooler than usual. This causes the equatorial atmospheric circulation to change, with the rain-bearing low pressure region moving east from Indonesia to the central south Pacific, thus often causing severe droughts in eastern Australia. When the ocean temperatures change periodically to the opposite anomalies, higher rainfall is experienced in regions of eastern Australia. The swing between these two states is known as the Southern Oscillation, and the SOI is most commonly defined in terms of the difference in atmospheric pressure anomalies between Tahiti (central Pacific) and Darwin (northern Australia).

Recent research has shown that the SOI can often improve skill in forecasting seasonal rain for the next few months, when used in a lag relationship to the season. AUSTRALIAN RAINMAN provides forecasting based on the average SOI for the last 3 months (Nicholls and Woodcock, 1989) and on trends or phases of the SOI in the last two months (Stone and Auliciems, 1992). The lag times and forecasting SOI periods may be varied by the user. The effect of Indian Ocean temperatures near Western Australia can also be analysed.

Examples of ENSO effects on rainfall and rainfall-related attributes are given.

RESULTS AND DISCUSSION
The greatest effect of the SOI on seasonal rainfall in the examples given (Table 1) is in the Northern Australian district of Charters Towers in the monsoonal tropics. Positive SOI values are associated with increased median rainfall in the southern hemisphere locations in Australia and South Africa, and with decreased rainfall in Chile and Peru. Both positive and negative effects are also present in the northern hemisphere; the SOI has a weak but positive effect in western and eastern Canada, but no effect in the interior (Winnipeg, Saskatoon and Edmonton - data not shown).

The SOI often produces larger effects on attributes other than rainfall, as shown in Table 2 for pasture growth and stream flows, because of a 'multiplier effect'. Thus its value as a management tool is enhanced. AUSTRALIAN RAINMAN can readily carry out seasonal analyses on these attributes once the historical monthly data is entered via the 'user data entry' option.

Farm managers in Australia are increasingly using decision support packages such as AUSTRALIAN RAINMAN to manage climatic risks and opportunities through adjustment of stocking rates in response to likely feed supply, agistment of livestock during droughts and management of herd structure. Tools that deliver basic climate information and the latest advances in seasonal forecasting will be essential to sustainable management in countries with high climatic variability.

REFERENCES

Clewett, J.F., Clarkson, N.M., Owens, D.O. and Abrecht, D.G. 1994. AUSTRALIAN RAINMAN: Rainfall Information for Better Management, (a computer package). Department of Primary Industries, Brisbane.

CSIRO. 1960. Climates. Chapter 2 in The Australian Environment (3rd rev. ed.) Melbourne University Press, Parkville, Vic.

Hutchinson, M. 1991. The application of thin plate smoothing splines to continent-wide data assimilation. Pages 104-113 *in* Data Assimilation Systems, BMRC Research Report No. 4, Bureau of Meteorology, Melbourne.

McKeon, G.M., Day, K.A., Howden, S.M., Mott, J.J., Orr, D.M., Scattini, W.J., and Weston, E.J. (1990). Management of pastoral production in northern Australian savannas. J. Biogeog. **17**: 355-372.

Nicholls, N. and Woodcock, F. 1981. Verification of an empirical long-range weather forecasting technique. Quarterly J. Royal Meteorol. Soc. **107**: 973-976.

Partridge, I.J. (editor) 1994. Will It Rain? Effects of the Southern Oscillation and El Niño on Australia. (2nd ed.) Department of Primary Industries Queensland, Brisbane, Information Series Q194015, 56 pp.

Stone, R.C. and Auliciems, A. 1992. SOI phase relationships with rainfall in eastern Australia. Internat. J. Climatology. **12**: 625-636.

Table 1

Examples of relationships between median seasonal rainfall (mm)[z] and the average SOI for the previous 3 months. % SOI effect is half the range in rainfall divided by the all-years average.

Country	Lat.	Long.	Elev. (m)	Season	SOI below –7	All years	SOI above +7	% SOI effect
Australia								
Charters Towers	–20.03	146.16	299	Sep-Nov	30	62	129	80
				Dec-Feb	214	331	441	34
				Mar-May	110	141	174	23
				Jun-Aug	24	47	50	28
Wagga	–35.10	147.28	221	Sep-Nov	101	136	175	27
South Africa								
Johannesburg	–26.12	28.06	1753	Dec-Feb	350	394	449	13
				Mar-May	148	170	197	14
Peru								
Piura	–5.07	–80.22	49	Jan-Apr	129	60	55	62
Chile								
Punta Tortuga	–29.54	–71.24	27	Feb-May	171	89	66	59
India								
Shimla	31.06	77.08	2205	Sep-Nov	168	195	235	17
				Dec-Feb	164	155	110	17
USA								
Shreveport	32.28	–93.39	78	Sep-Nov	284	226	195	20
				Mar-May	340	329	270	11
Santa Ana	34.06	–117.06	842	Sep-Nov	106	88	64	24
				Dec-Feb	231	322	338	17
				Mar-May	361	194	209	39
Canada								
Montreal	45.30	–73.36	57	Dec-Feb	245	250	294	10
Victoria	48.31	–123.20	19	Sep-Nov	193	207	243	12
				Dec-Feb	272	294	347	13
				Mar-May	86	99	106	10

[z] Historical monthly data for non-Australian locations supplied by Oak Ridge National Laboratory, USA.

Table 2

Relationship between the SOI and rain-related factors in north-eastern Australia.

Location	Attribute	Units	SOI below -5	All years	SOI% above +5	SOI effect
Charleville (Qld)	Annual rainfall	mm	400	489	574	18
	Annual pasture growth[z]	kg/ha	501	713	1034	37
	Annual pasture growth (grazed)[z,]	kg/ha	425	613	938	42
Burnett River (Qld)	Stream flow in summer	GL/mth	144	375	922	104

[z] Simulated by using the GRASP computer model. See McKeon *et al.* (1990).