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## 1. INTRODUCTION

Polyethylene film is used to cover grape vines in the region near Mildura, Victoria, in Southeast Australia. The films vary in thickness from 100-250 micrometers and contain titanium dioxide and ultraviolet (UV) stabilization at levels selected to allow for some light transmission while protecting the film from breakdown. Expected lifetimes for the films are 1-4 years. Field reports in the summer of 2003-2004 indicated a number of instances in which the film covers had burned plant buds. Anecdotal reports indicated the extent of this problem was significantly more severe than in the past half dozen years and suggested the summer temperatures and/or surface UV radiation levels may have been more extreme than in recent years.

## 2. OBSERVATIONS

### 2.1 Mildura Region Temperatures

Based on data from the Australian Bureau of Meteorology (BoM), the daily maximum temperatures at the Mildura Airport meteorological station (34.2 S latitude, 142.1 E longitude) in December 2003 and February 2004 were significantly higher than the climatic means and were higher than those recorded in the previous two years. (Analysis of data for prior years for Mildura is still underway and will be included in the final conference presentation.) The mean maximum daily temperature in summer (December to February for 1946 to 2003) at the Mildura Airport meteorological station is 30-32 C, and the highest maximum temperatures ever recorded in the three summer months are 44-47 C, Figure 1. The mean number of days with a maximum temperature of at least 40 C between 1946 and 2003 were 1, 2.2, and 1.2 for December,

January, and February, respectively. In December 2003 and February 2004, the mean maximum temperatures exceeded the climatic means by 2-3 C, while in January 2004, the mean maximum temperature was 1-2 C below the climatic mean. From 10 Dec 2003 to 20 Jan 2004, the daily maximum temperature exceeded 39 C in five of the six weeks. From 4 Feb to 24 Feb 2004, the daily maximum temperature exceeded 42 degrees in all three weeks, and from 11-17 Feb 2004, the mean maximum temperature exceeded 39 degrees. No daily maximum temperature exceeded the highest temperature on record, 50.7 C, which was recorded between 1889 and 1949 at the Mildura Post Office, but February 2004 was among the warmest months ever in the Mildura region.

### 2.2 Mildura Region Forecast UVI

There is no UV monitoring station in the Mildura region, but the BoM routinely forecasts values for the noon-time, cloud-free, UV Index (UVI) in that region as part of their standard operational forecasts (Lemus-Deschamps et al. 1999). The UVI is the biologically effective solar ultraviolet radiation, averaged over either 10 or 30 minutes (ICNIRP 1995). For forecasts, typically only the maximum UVI for the day is calculated. The UVI is determined by weighting the incident solar spectrum by the erythral response of human skin for the wavelength range 280-400 nm (Gies et al. 2004). The erythral response adopted by the Commission International d'Eclairage (CIE) in 1987 (CIE 1987) is used. The Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) compared their measured values for UVI over the period 1996-2000 in seven Australian cities with BoM forecasts and found the disagreement was less than 2 UVI units approximately 75% of the time (Gies et al. 2004). A UV Index value of 10 corresponds to an erythemally weighted biologically effective solar ultraviolet irradiance of 0.25 W m<sup>-2</sup>.

As shown in Figure 2, the forecast UVI values for most of December 2003, early January 2004, and a large portion of February 2004 were consistently

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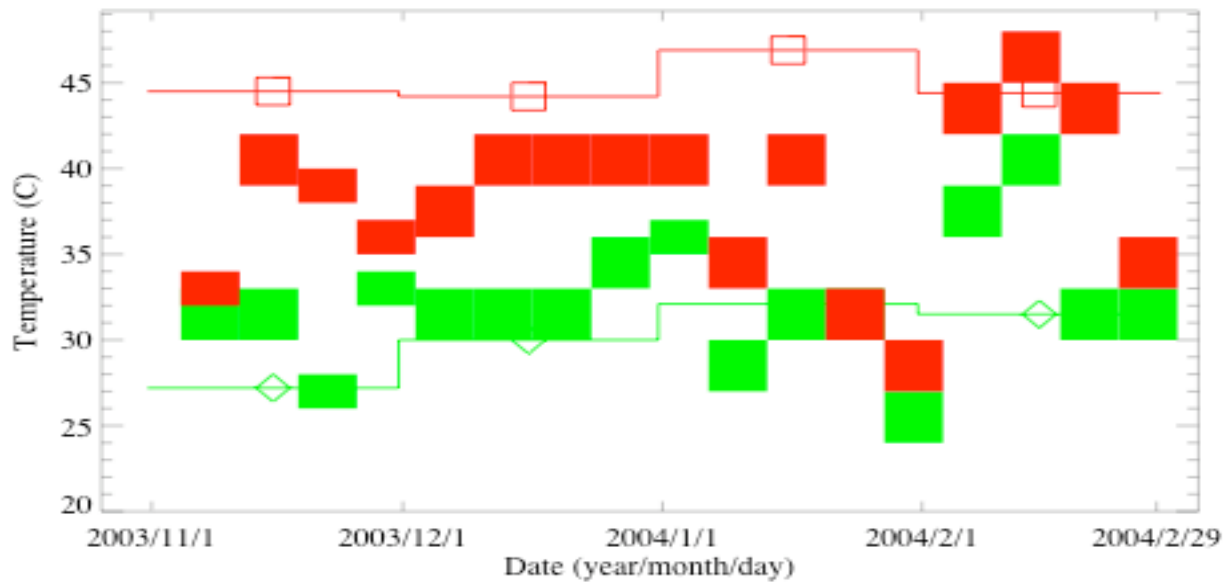


Figure 1. Climatic temperatures and observed summer 2003-2004 temperatures for Mildura Airport. Solid green line with green diamonds gives the mean maximum daily temperature for each month, averaged over 1946-2003. Solid red line with red squares gives the highest maximum daily temperature for each month over 1946-2003. Green boxes show the mean maximum daily temperature for each week from November 2003 to February 2004. Red boxes show the highest maximum daily temperature for each week from November 2003 to February 2004. Data obtained from the Australian Bureau of Meteorology.

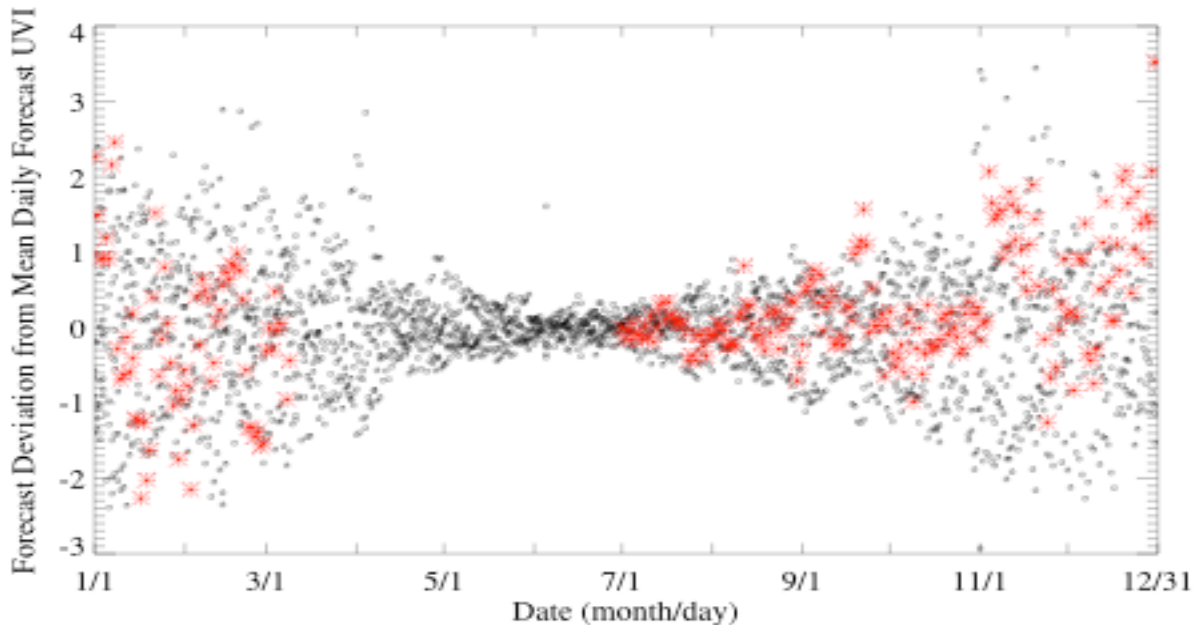


Figure 2. Deviation of forecast UVI (Figure 3) from daily mean of forecast UVI for the Mildura, Victoria, region. Daily mean of forecast UVI calculated for each day of the year over time period 1 Jan 1997 to 8 Mar 2004. UVI forecasts provided by the Australian Bureau of Meteorology. Values in red are from 1 Jul 2003 to 8 Mar 2004. Values in black are from 1 Jan 1997 to 30 Jun 2003.

larger than the daily means. The daily means have been calculated over the time period January 1997 to March 2004 based on the forecast values shown in Figure 3. The forecast UVI values were particularly large in December 2003, as shown in Figure 3. The largest UVI value over this seven year period, 16.7, was forecast for 31 Dec 2003

and the forecast UVI was at least 13 for most of the period from 14 Dec 2003 to 8 Jan 2004. 14-20 Feb 2004, when the maximum temperatures were unusually high, had UVI values between 12 and 13. For comparison, UVI values above 10 at low elevations in the Northern Hemisphere are rare (Gies et al. 2004).

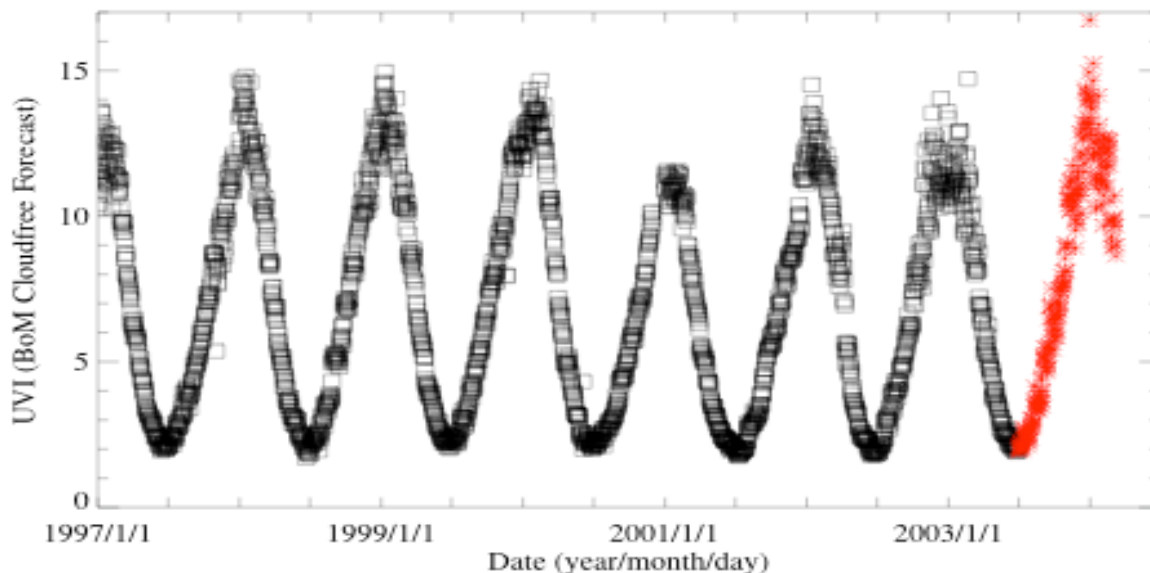


Figure 3. Forecast UVI from the Australian Bureau of Meteorology for the Mildura, Victoria, region. Values in red are from 1 Jul 2003 to 8 Mar 2004. Values in black are from 1 Jan 1997 to 30 Jun 2003.

### 2.3 Measured UV Irradiance In Tasmania

The nearest station at which surface UV measurements were available was the Cape Grim station on Tasmania (40.7 S latitude, 144.7 E longitude), which is about 750 km SSE of Mildura. The maximum daily UVB global irradiance at Cape Grim exceeded  $2400 \text{ mW m}^{-2}$  on three days in the summer of 2003-2004, and the highest value recorded was  $2506 \text{ mW m}^{-2}$  on 7 January 2004. Neither the number of days exceeding  $2400 \text{ mW m}^{-2}$  nor the maximum irradiance observed in the summer of 2003-2004 were unusual based on measurements that extend back to January 2000 at the Cape Grim site.

### 3. DISCUSSION

Extremes in both temperature and forecast UVI were experienced during the summer of 2003-2004 in the Mildura, Victoria, region. The forecast UVI in December 2003 reached the highest levels seen since 1997, and temperatures in February

2004 were comparable to the highest seen in any month since 1946.

UV irradiance measurements during the summer of 2003-2004 at Cape Grim, Tasmania, do not show significant departures from conditions observed there since 2000. UV irradiance data from the ARPANSA stations in Melbourne, Victoria, and Adelaide, South Australia, for the summer of 2003-2004 have not been released yet, so observational confirmation of the forecast UVI is not possible at present. Satellite measurements of total ozone will be examined to assess whether there was a significant decrease in total column ozone over the Mildura region in December 2003 (and over what areal extent), as such a decrease could account for the high values predicted for the UVI.

The unusually high temperatures observed at Mildura Airport in February 2004 were also observed throughout a broad region in central to eastern Australia, as shown in Figure 4.

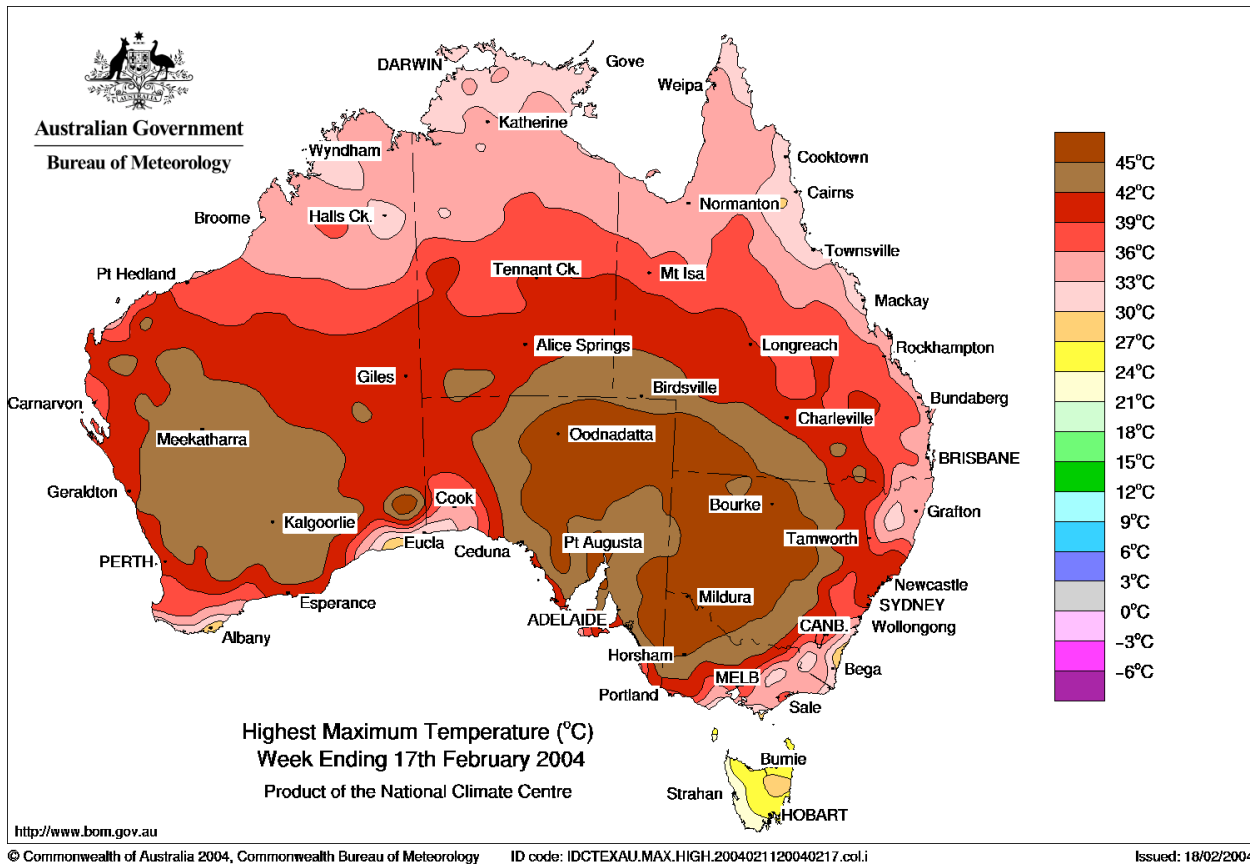


Figure 4. Highest maximum temperature for week ending 17 Feb 2004. The unusually high temperatures observed at Mildura in Southeastern Australia ( $> 45$  C) were also observed over a broad region in central to eastern Australia. This map was obtained from the Bureau of Meteorology (<ftp://ftp.bom.gov.au/anon/home/ncc/www/temperature/maxextm/hi/week/colour/history/nat/>).

#### 4. ACKNOWLEDGEMENTS

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#### 5. REFERENCES

- Commission International d'Eclairage (CIE), 1987: A reference action spectrum for ultraviolet induced erythema in human skin, *CIE J.* **6**, 17-22.
- Gies, P., C. Roy, J. Javorniczky, S. Henderson, L. Lemus-Deschamps, and C. Driscoll, 2004: Global Solar UV Index: Australian measurements, forecasts, and comparison with the UK, *Photochem. Photobio.* **79**, 32-39.
- Lemus-Deschamps, L., L. Rikus, and P. Gies, 1999: The operational Australian ultraviolet index forecast 1997, *Meteorol. Appl.* **6**, 241-251.
- International Commission on Non-Ionizing Radiation Protection (ICNIRP), 1995: *Global Solar UV Index*, Oberschleissheim, Germany.