PICTURE OF THE MONTH

The 1983 Ash Wednesday Fires in Australia

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ABSTRACT

Australia experienced the most disastrous bushfires in over 40 years on Ash Wednesday, 16 February 1983. This article describes the meteorological conditions prior to, during and after these fires, and includes photographs from GMS-2. It also discusses simple manual trajectory analyses which indicate the movement of the respective air masses, and the atmospheric effects of particulates.

1. Introduction

On 16 February 1983, Ash Wednesday, the most devastating bushfires in Australia in over 40 years occurred in the southeast of the continent in the states of Victoria and South Australia (see Fig. 1). Seventy-two lives were lost, over 1700 homes and buildings destroyed, stock losses in Victoria exceeded 30 000 and over 350 000 hectares of country were burnt out, not to mention the loss of native flora and fauna.

In summer, southeastern Australia from Sydney around to Adelaide is extremely prone to the hazards of forest fires and bushfires. The Great Dividing Range (maximum elevation 2230 m) runs north–south along the east coast and westward across south-central Victoria. A smaller range of hills lies to the east of Adelaide in South Australia. These highlands and large parts of the coastal areas are covered with temperate eucalyptus forest and bushland (eucalyptus oil being extremely volatile). Much of the remaining land has been cleared for open farming and grazing. Both forest and pasture dry out in summer to the point that lightning strikes cause spot fires every year. (Consequently, accidental or deliberately lit fires are also a major hazard each summer.)

In 1982, continuing into 1983, the eastern half of Australia experienced its worst drought on record, many parts having below normal rainfall for the fourth year in succession. Fig. 2 shows that a large proportion of eastern Australia had severe rainfall deficiencies during 1982, some areas recording their lowest ever annual totals (Bureau of Meteorology, 1982).

The remainder of these comments describes the meteorological conditions associated with the Ash Wednesday fires and relates them to the GMS-2 satellite imagery in which the smoke plumes can be identified clearly.

2. Conditions during February 1983

During the 16 days prior to the outbreak of these fires, no rain had been recorded in Melbourne and little or no rain had fallen in the states of Victoria and South Australia. Table 1 gives the daily maximum temperatures for four locations shown in Fig. 1. All of these sites experienced above normal temperatures for this period, the average over 16 days being 4°C or more above the long-term February mean. Thus, with the concurrent drought in eastern Australia, very high fire potential existed throughout the first half of the month.

Ash Wednesday itself was particularly hot throughout both states with temperatures above 42°C (Table 1) and the relative humidity less than 15%. Inland air, heated the previous day, was advected southward over Hamilton and Melbourne (Table 1) and the southern coastal areas. By midday major fires were reported to the south, east and north of Adelaide, while a total of 76 outbreaks (some deliberately set) were recorded in Victoria. Many of these started in the early mid-afternoon, as the wind gusts increased with the approaching front (see Section 3).

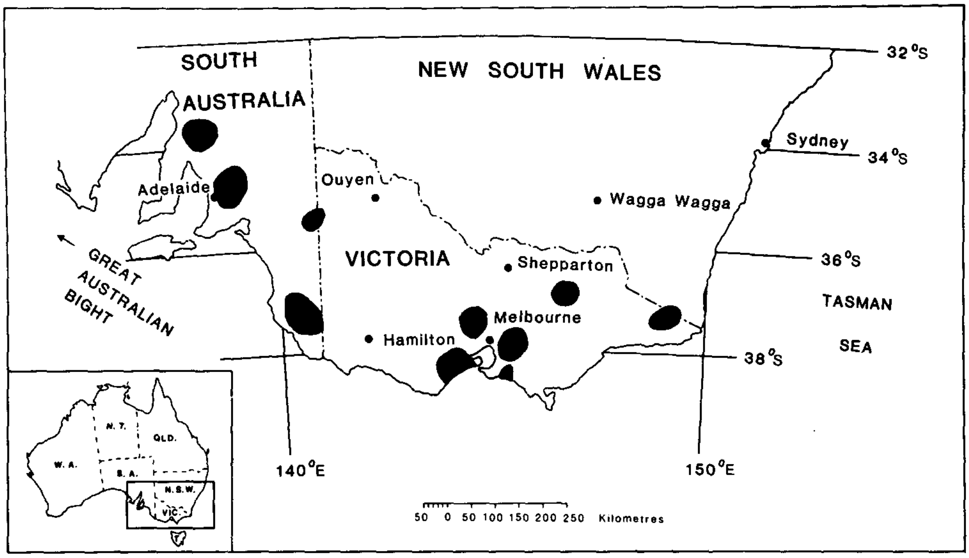

FIG. 1. Location map and approximate areas of the Ash Wednesday bushfires. The inset shows the region within Australia.

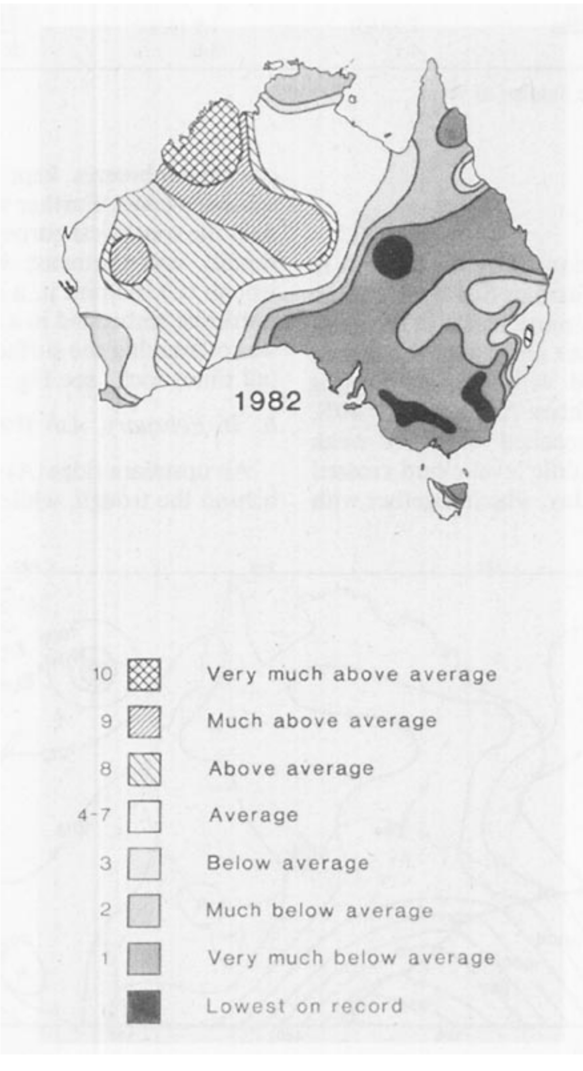

FIG. 2. Deciles of Australian annual rainfall distribution for 1982. The decile values are indicated beside the key.

TABLE 1. Daily maximum temperature (°C) for four Victorian locations for February 1983 prior to the bushfires.

Date	Melbourne	Hamilton	Shepparton	Ouyen
1	41	32	42	42
2	22	24	30	31
3	23	24	—	32
4	22	25	32	—
5	26	35	35	38
6	37	37	37	40
7	36	40	38	42
8	43	39	43	42
9	28	28	33	34
10	26	27	35	33
11	22	22	29	29
12	22	23	29	28
13	23	27	31	32
14	34	34	—	37
15	31	34	38	42
16	43	43	42	44
A. Average over 16 days	29.9	30.9	35.3	36.4
B. February 1983 average	28.8	30.0	33.6	35.7
C. Long-term February average	25.8	26.3	30.0	31.2
D. Long-term monthly* February standard deviation	1.5 (43)	1.9 (43)	1.6 (35)	1.7 (43)
Anomaly (A–C)	4.1	4.6	5.3	5.2

* Numbers in parentheses indicate number of years.

3. Synoptic situation

a. 15 February (Fig. 3a)

A ridge of high pressure, denoted by the letter A in Fig. 3a, extended from the Tasman Sea over eastern Australia. Over the continent, particularly in the western flank of this ridge, hot dry air underwent broadscale subsidence heating combined with sensible heating from the underlying land surfaces. At Eucla (31°40′S, 128°52′E) the temperature reached 47°C. A weak trough (B) with upper and middle level cloud crossed southern Victoria during the day, which together with coastal sea breezes, kept temperatures down along the southern coast. Further west, an upper air disturbance near the southwest corner of Western Australia moved rapidly east-southeast with an intensifying surface trough (C). Behind it, a cold front (D) moved rapidly northeast embedded in a major southern trough, which was overtaking the surface trough to the north at 2300 (all times local, see Fig. 3a).

b. 16 February, Ash Wednesday (Fig. 3b)

An upstream ridge (A) moved into Western Australia behind the trough, while the ridge in the Tasman Sea

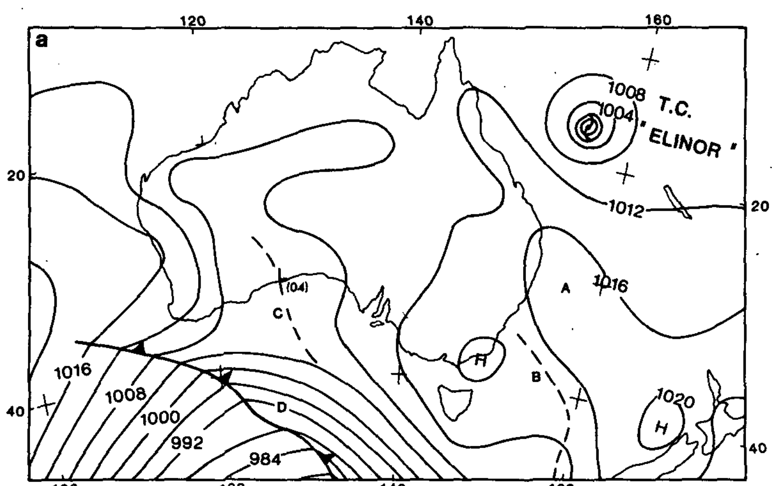

FIG. 3a. Mean sea level pressure analysis for 2300 local time (1200 GMT) 15 February 1983. Features mentioned in the text are indicated by the letters A–D.

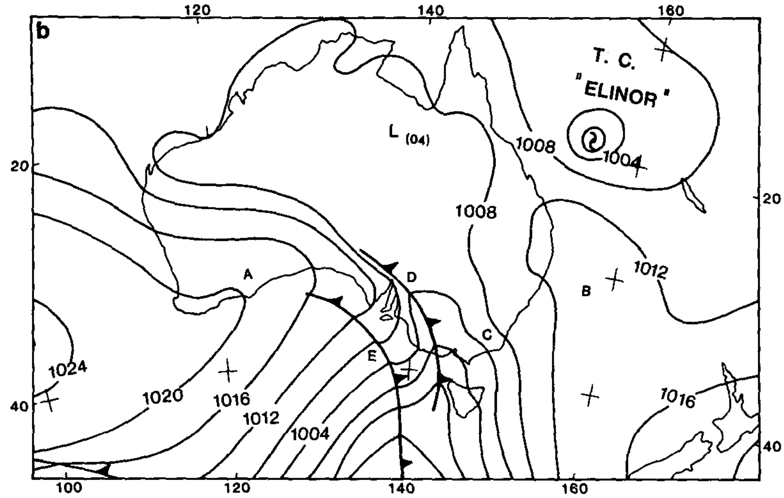

FIG. 3b. Mean sea level pressure analysis for 2000 local time (0900 GMT) 16 February 1983. Features mentioned in the text are indicated by the letters A–E.

persisted (B). The amplification of the meridional flow in this ridge–trough–ridge system led to increased advection southward of the hot air (C) and sharper temperature contrasts across the front. Winds strengthened during the afternoon with increased gusts (in excess of 30 m s^{-1} being recorded at several stations) as first the pressure trough and then the front approached South Australia and Victoria.

By 2000 (Fig. 3b), the trough had passed Adelaide with further frontogenesis being analyzed at its center (D). The new front and the following one (E) produced light rain near Adelaide which assisted in controlling fires that had been burning there during the day.

The frontal system passed through Melbourne at approximately 2100, accompanied by strong squally southwesterlies, but unfortunately, by very little rain. As a result, fires which had broken out in Victoria and which had been moving with the strong northwesterly winds, changed direction rapidly in the evening, making them very difficult to bring under control. The northern section of the front had started to weaken by this time, but the winds behind the front remained strong for many hours.

c. 17 February

The speed of the cold front as it traversed Victoria averaged in excess of 17 m s^{-1}, so that early on 17 February it had crossed Victoria completely (see Fig. 4). It continued to weaken when crossing New South

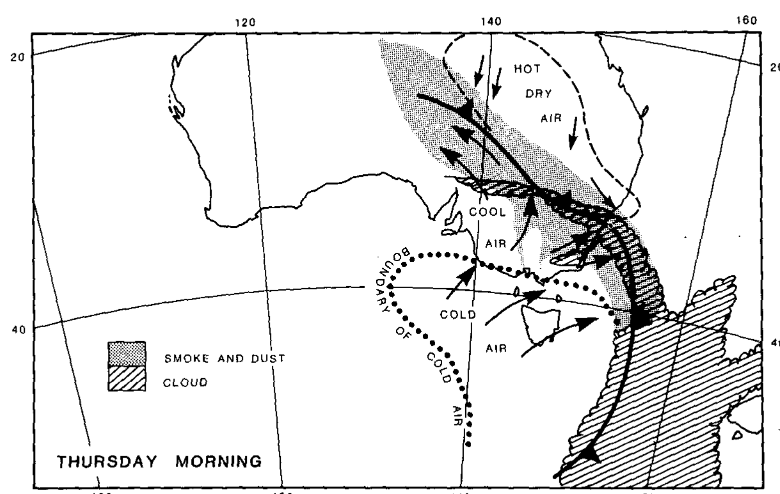

FIG. 4. Schematic diagram of the atmospheric circulation over eastern Australia corresponding to the GMS-2 satellite photograph in Fig. 5 (adapted from Bureau of Meteorology, 1983).

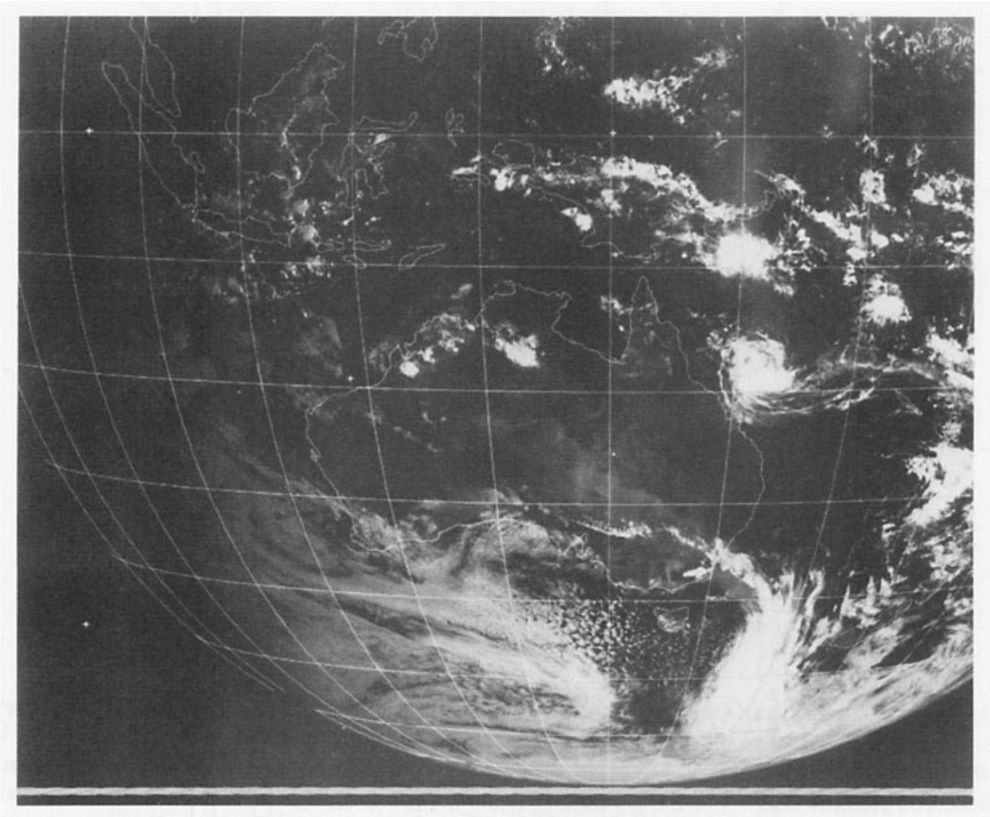

FIG. 5. GMS-2 visible satellite photograph 1100 local time (0000 GMT) 17 February 1983.

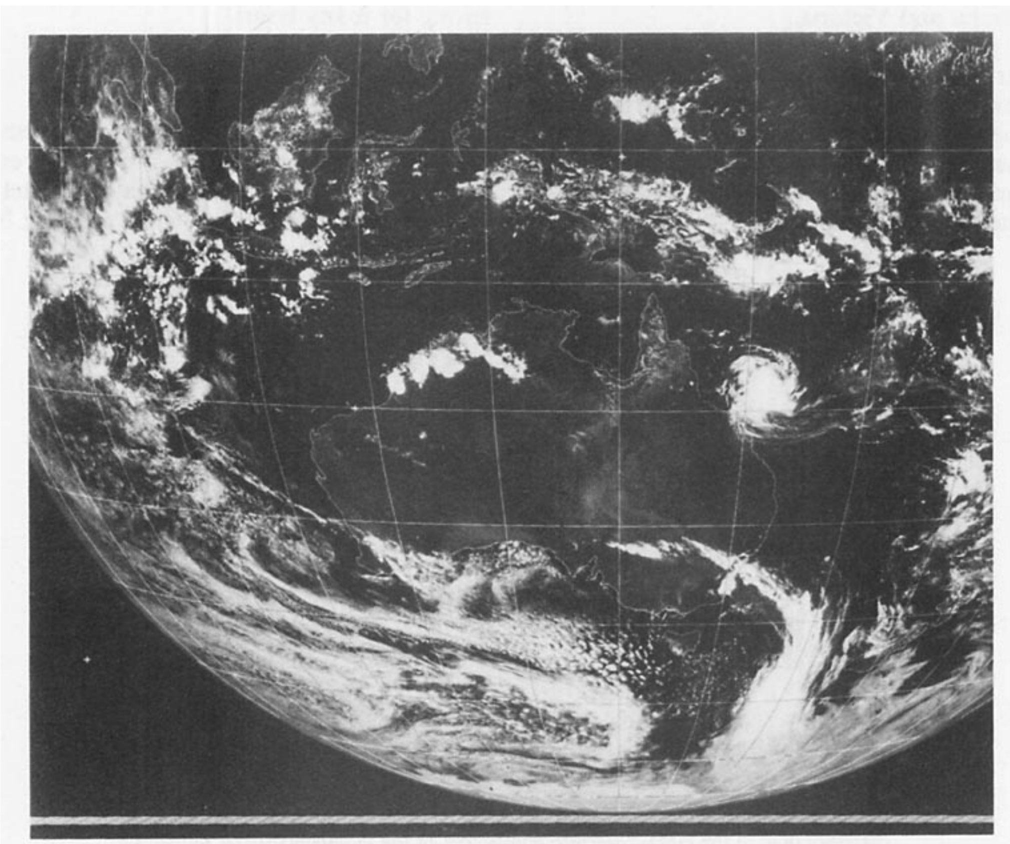

FIG. 6. GMS-2 visible satellite photograph 1400 local time (0300 GMT) 17 February 1983.

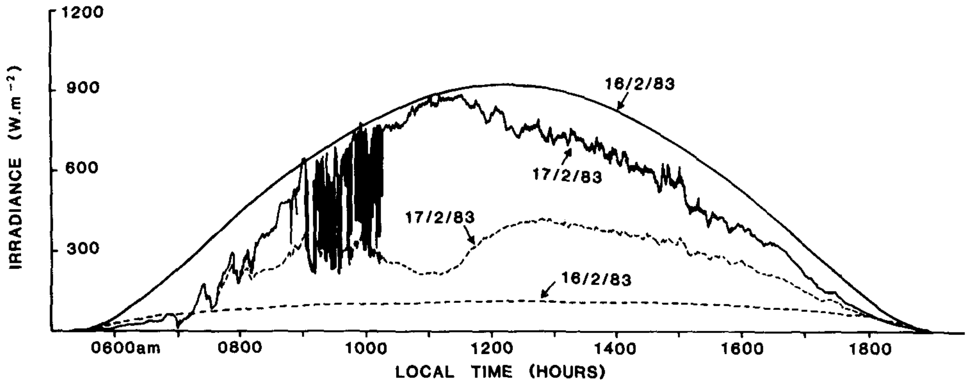

FIG. 7. Global (solid lines) and diffuse (dashed lines) irradiance traces registered at Wagga Wagga on the clear sky day, 16 February 1983, and the following day on which the cold front and smoke/dust band crossed New South Wales.

Wales (NSW) with slower northward movement and modification by its passage over land. A remnant of the Tasman Sea ridge lay over the east Australian coast to the north of the front, while the western ridge had moved over the Great Australian Bight. Most of the outbreaks of fire had been brought under control by this time, but they continued to smoulder, releasing considerable quantities of smoke into the atmosphere to the west and east of Melbourne as can be seen in the satellite photograph (Fig. 5). A schematic description of the essential features of the GMS-2 satellite picture (Fig. 5) is provided in Fig. 4.

4. Trajectories

Simple surface trajectory analyses, calculated manually from 3 h synoptic charts, indicate that the hot air mass crossing Adelaide and Melbourne on the afternoon of Ash Wednesday was located approximately 800 km inland to the north-northwest some 20 hours previously. A similar analysis after the passage of the cold front revealed that low-level smoke from the Adelaide fires would have moved north-northeast, with a greater eastward component at higher altitudes. Smoke from the Melbourne area caught in the surface flow can be seen to have moved almost due north, with the middle-level flow being northeast (see Figs. 4 and 5).

5. Atmospheric effects of particulates

The front carried large amounts of smoke from the bushfires as well as dust raised from the desiccated inland areas into central and eastern Australia. This is shown clearly by the satellite photograph (Fig. 5) and is illustrated in the corresponding schematic diagram (Fig. 4). Tracing movement of atmospheric dust clouds using satellites has been mentioned in recent literature. For instance, Robock (1983) pointed out that material erupted into the stratosphere from the volcano El Chichón in April 1982 could be identified on visible satellite imagery for 21 days. By contrast, the rapid dispersal of tropospheric material (smoke and dust in this case) can be seen by comparing the two GMS-2 satellite photographs (Figs. 5 and 6) which were taken only 3 h apart. In the next 24 hours, the dust and smoke haze lost its bandlike appearance and could no longer be identified clearly on visible imagery.

Figure 7 illustrates the effect of the smoke and dust on the solar beam at Wagga Wagga, the location of which is given in Fig. 1. Wagga Wagga, an Australian radiation station, lies to the north and the east of the many fire centers and was obviously in the path of the frontal band, which traversed the station on the day after Ash Wednesday (Fig. 4).

The global irradiance trace and the diffuse component trace (i.e., the contribution to the total due to scattering) are shown on the cloudless day, 16 February, prior to the front and on 17 February when the passage of the front occurred between 0800 and 1100. The 0900 observations on 17 February at Wagga Wagga recorded $^5/_8$ stratocumulus cloud cover. During those few morning hours, the magnitudes of the diffuse irradiance and global irradiance were similar, signifying this cloud. By noon, there was only $^1/_8$ cloud at Wagga Wagga and the afternoon was cloud-free. The diffuse irradiance for the afternoon of 17 February indicates increased atmospheric turbidity due to the smoke and dust haze, compared to the previous day which displayed normal diffuse irradiance for a clear day over inland Australia. On 17 February, the combined frontal cloud (lasting only a few hours), dust and smoke reduced the total global exposure (MJ m^{-1}) at the ground by 22.5% compared to the previous day (calculated from half-hourly digitized totals).

On the following two days, scattered cloud occurred at Wagga Wagga, but the diffuse irradiance trace still showed some indications of airborne dust and smoke. By the 20th, three days after the first appearance of the dust and smoke, the trace indicated clear conditions again.

6. Concluding remark

The GMS-2 imagery has provided an excellent opportunity to monitor an unusually large area of dust and smoke from fires which occurred on Ash Wednesday, 16 February 1983, in the Australian region.

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