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ALPINE GEOPHYSICS

Technical Memorandum 1

ISSUES RELATED TO EPISODE SELECTION

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1.0 INTRODUCTION

This memorandum is the first in a series of occasional technical 'white papers' aimed at addressing issues that arise in the performance of the San Juan County 8-hr Ozone Early Action Compact Study. The purpose of the memorandum is to identify current issues of concern, additional technical information regarding these issues, and a context for arriving at conclusions and/or a course of action with respect to each one. Below, we address three current issues:

> The potential impact of emissions from wildfires in the southwestern U.S during the Summer '02 episode and any impact they might have on the photochemical modeling episodes;

> The extent to which the current photochemical modeling episodes include 'stagnation' conditions that might provide a suitable test of the impact of locally-produced emissions on 8-hr ozone concentrations in the study area; and

> Feasibility of 'retrospective modeling' to confirm proper response to model sensitivity to emissions changes.

Hopefully, the information provided below will assist the Technical Peer Review Committee and interested project stakeholders in arriving at a consensus understanding in each area.

2.0 Potential Influence of Wildfires on Ozone Modeling Episodes

Issue: *Concerns have been raised regarding the extent to which VOC and NOx emissions from wildfires burning in the western states during the Summer '02 period (4 June-19 July 2002) may have contributed to the ozone levels recorded in San Juan County during the four intensive 8-hr modeling episodes. If wildfires were influential in peak ozone readings, does this disqualify such periods for regulatory 8-hr EAC ozone modeling?*

Comments: We examined the 8-hr ozone data at the Substation and Bloomfield monitors for the Summer '02 period and for the selected modeling days for the four embedded 8-hr ozone episodes: 5-8 June, 17-19 June, 1-3 July and 17-19 July. Particular emphasis was placed on the potential impact of fires on these episodes. To begin:

> The Missionary Ridge Fire (Durango) began 9 June and ran through 19 July;

> The Rodeo Fire (central Arizona) began 18 June and ran through 7 July;

> The Chedeski Fire (central Arizona) began 20 June and ran through 7 July;

Our analysis of each episode is presented below. In Figures 1 thorough 12 we present available satellite imagery which reveal the local and regional extent of visible smoke plumes from various fires burning in the southwest during the Summer '02 period.

Episode 1: (5-8 June): None of these fires impacted the 5-8 June episode (they hadn't started).

Episode 2: (17-19 June): The Missionary Ridge Fire likely didn't impact this episode. Figures 3-4e-g in the protocol show the surface and aloft regional winds out of the southwest. The Missionary plume would have been carried northeastward toward Lake and Gunnison counties in Colorado. This is

corroborated by MODIS satellite visible plume imagery from the Colorado fires (Missionary Ridge Fire, Hayman) burning on 19 June (Day 170). The synoptic weather on the 19th, confirming the HYSPLIT results on Figures 3-4e-g, show the plumes from the various fires moving toward the northeast. The MODIS satellite plot (Figure 1) shows the visible Rodeo plume at 1825 CST on 19 June (Day 170). The plume is still in it's infancy (just started the day before) and while it is moving toward the northeast (Gallup, NM) it is still a long way from Farmington and the Four Corners area. Thus, it appears to be very unlikely that the first two Summer '02 episodes were impacted at all by the Missionary/Rodeo/Chedeski fire systems.

Episode 3: (1-3 July). No satellite data are available on these dates. Figure 3-4h in the protocol shows the potential for transport from the north on 2 July. However, these HYSPLIT surface and aloft winds (an interpolation of measured winds across the western states NWS monitoring sites) is at odds with the local surface weather observations at the Bloomfield and Substation ozone monitors on the 1st and 2nd.

At Bloomfield, from midnight to 4 am, the surface winds were out of the north at about 1.4 m/s. But beginning at 5am through 2000 hours, the winds were not coming from the north, but rather had shifted to the south to southwest. Light northerly winds at Bloomfield returned at 2100 hours and continued through 0500 on 2 July, when the winds again shifted, coming from the southwest through the southeast for the remainder of 2 July. North winds did not result at Bloomfield until the early morning hours on the 3rd. Thus, these northerly flows on 1-3 July appear to be limited to nighttime hours, are the result of nocturnal drainage of the sloping terrain immediately north of Bloomfield, and do not appear to be larger synoptic scale transport from the San Juan Mountains/Durango area where the Missionary Ridge fire was burning.

At the Substation monitor, the surface winds were consistently out of the west for most of the 1-3 July period. Thus, a preliminary examination of the local flow fields in the Farmington area show no plausible linkage between the Missionary Ridge fire (> 100 miles north) and local wind patterns near the two San Juan County ozone monitors.

Episode 4: (17-19 July). The Rodeo/Chedeski Fires were out by the time this episode occurred. Missionary Ridge was contained by 19 July. The synoptic wind trajectories on 18 July (Figure 3-4i in the protocol) show persistent westerly winds at the ground and aloft on this day. Examination of the surface wind records at Bloomfield and Substation on 18 July show that the local winds were persistently upriver (i.e., out of the west to northwest) for most of the day. Thus, as with the 1-2 July episode, preliminary examination of the local flow fields shows no plausible linkage between the Missionary Ridge fire and local impacts at the two San Juan County ozone monitors.

Summary: Based on these analyses and examination of Figure 1 through 12, we see no direct evidence of wildfire impacts in the Farmington region from the Rodeo, Chedeski, Missionary Ridge or Hayman fires during any of the days that are being prepared for modeling. The only possible indication of an impact is the HYSPLIT trajectory results on 2 July (Figure 3-4h of the protocol). But even in this plot, the primary transport path is westerly. Even if there was aloft transport on this day from the Missionary Ridge fire (overriding the southerly flows at the ground level monitors), the fire plume would still need to mix to ground in appreciable quantities to affect ozone. Furthermore, sufficient NO or NO_2 would need to be retained in the fire plume to have an influence on ozone photochemistry. Given the fairly short lifetime of NO/NO_2 before it is removed chemically or physically, and the longer physical transport time from the Durango/Missionary ridge fire to Farmington, it is questionable whether any remaining photochemically active NOx would have an appreciable impact on ozone at Bloomfield and/or Substation. This can certainly be tested with CAMx

source apportionment once this episode has been set up and evaluated. If there is a fire plume impact on the 2nd and it becomes necessary to eliminate this day from the list of days used for 8-hr strategy decision-making, it will not adversely impact the San Juan EAC study; there are three other days during the Summer '02 episode (5 June, 19 June, 18 July) for which the Bloomfield monitor reported peak ozone close to the regions DV.

3.0 Existence of 'Stagnation' Days Within the Summer '02 Modeling Period

Issue: *Concerns have been raised regarding whether any of the four intensive 8-hr modeling episodes contained 'stagnation conditions' believed to be associated with 'locally-produced' ozone concentrations. If stagnation conditions are not present in the selected modeling episodes, how will the roles of local versus more distant source contributions to peak 8-hr ozone be separated out and addressed?*

Comments: Historically, some ozone episodes used for regulatory modeling have been loosely categorized as 'stagnation' episodes, meaning that the local winds were light and variable. Under such conditions, emissions from local sources are anticipated to play a much greater role in forming the daily maximum ozone readings at the monitoring stations since there is less opportunity for the transport of emissions from more distant upwind sources to occur under such light and variable local wind conditions. While we are unaware of any precise regulatory definition of a 'stagnation episode', the value of analyzing such episodes—should they exist in a particular area and be directly linked to high ozone events—is clear. In developing reasonable, effective, and appropriate emissions controls in a region, it is desirable to identify the extent to which local versus more distant upwind sources are contributing to each ozone episode of regulatory significance (either 1-hr or 8-hr).

Time constraints imposed by EPA's EAC schedule, insufficient ozone air quality monitoring data, and the limited number of historical 8-hr ozone episodes in San Juan County in the past 5 years preclude the application of robust statistical episode classification methods (e.g., CART, factor analysis, statistical pattern recognition) often used in other 'data-rich' urban areas such as Houston, Atlanta, Los Angeles, and Chicago. As indicated in the ozone modeling protocol, our episode selection procedure was based on analysis of recent historical ozone data, regional scale trajectory path modeling, and local aerometric data analysis. Given the existing ozone and meteorological data base in San Juan County, it is not feasible to conduct an intensive statistical episode classification analysis to clearly identify the meteorological characteristics, frequency of occurrence, and coincident 8-hr ozone concentrations associated with 'stagnation conditions' in the region. Two factors, however, will enable this study to address the role of local versus more distant emissions on 8-hr ozone impacts at the Bloomfield and/or Substation regulatory monitors.

First, the CAMx photochemical model contains a unique source attribution tool (the Ozone Source Apportionment Technology, or OSAT) which allows the modeler to identify the specific contribution to modeled ozone concentrations stemming from VOC and/or NOx emissions emanating from any local or upwind source or source category. In a typical application of OSAT, the analyst defines up to 30 key receptor locations (existing regulatory monitoring sites, cities, sensitive receptor sites, federal Class I areas, and so on) and as many as 20 source regions and source categories (sources in Farmington; sources in other local cities such as Durango, Aztec, Bloomfield; sources in other states such as Tucson, Los Angeles, Houston, Las Vegas, Flagstaff, Salt Lake City/Provo). In addition, the OSAT allows the user to specifically identify the ozone impact from individual sources or categories of sources (on road motor vehicles, biogenics, oil and gas exploration and development, electric power generation, light industrial, residential home heating, fuel combustion, and so on). Thus, with CAMx/OSAT, we will be able to specifically identify the contribution of individual emissions source

categories and source regions on the peak 8-hr ozone levels modeled in the base case and future years for each day during the four episodes. There is the opportunity, therefore, to quantify explicitly the role significance of 'transported' versus 'locally grown' ozone for each and every regulatory modeling day considered in this study.

Second, we have carried out a preliminary analysis of the hourly meteorological data during the four San Juan EAC episodes being modeled to identify the extent to which 'stagnation' conditions actually occur. Figure 13 summarizes these results. In the figure, we present the maximum 8-hr ozone concentrations recorded at the Substation and Bloomfield monitors during the key Summer '02 episode days. Superimposed on these data are the daily average wind speeds at the Bloomfield monitoring station. (Note that for ease of presentation we have multiplied the average daily speeds by 10 and plotted them on the same scale as the ozone results; thus, a speed of '20' corresponds to a mean daily wind speed of 2 m/s).

Across all 16 intensive ozone modeling days, the average daily wind speed at the Bloomfield monitor is 3 m/s. Of particular significance is the 16-19 June episode in which the daily average wind speed decreases as the episode ensues, culminating on the 19th with a mean daily wind speed below 2 m/s. Examination of the hourly wind data on the 19th reveals that the winds are light and variable for many hours during this 24-hour period. There appears to be no sustained local transport pattern on this or the previous days that would allow for direct impact from regionally transported emissions. This is not to say that there is no impact from more distant sources during the 16-19 June episode; indeed, the CAMx/OSAT analysis will quantify this contribution. Rather, it appears from this analysis that the conditions during the latter portion of the 16-19 June episode are consistent with the conceptual notion of a 'stagnation' episode. There are a few other days during the Summer '02 period where similar low local surface wind speeds also occur (e.g., 6 June, 7 June, 1 July, 17 July).

Summary: Limitations on ozone monitoring data and the existence of high 8-hr ozone days in San Juan County have precluded a rigorous statistically based classification of historical days into different weather types, including ozone stagnation days. However, the use of the CAMx/OSAT technology will allow the modeling team to explicitly quantify the interplay between local versus more distant emissions sources and source categories for each day of regulatory significance during the Summer '02 episode. Analysis of the local wind speeds and directions in the Farmington-Bloomfield area reveal several days when light and variable winds occur during portions of several intensive modeling days, offering ample opportunity to study the impact of 'stagnation' meteorology and the role of local emissions on potential ozone problems.

4.0 Retrospective Modeling To Confirm Model Response to Emissions Changes

Issue: *Concerns have been raised regarding the extent to which the photochemical model should be tested with other 'past episodes under different weather conditions' in order to establish that the model is responding correctly to (a) changes in emissions patterns and (b) different meteorological and air quality conditions.*

Comments: Part of the rationale underlying our recommendation for modeling the 45-day long Summer '02 episode was to test the MM5/CAMx modeling system under a very broad range of recent weather conditions potentially conducive to elevated ozone levels in San Juan County. The days falling within this period span a very broad range of ozone conditions from very clean days to some of the highest ozone day on record in recent years. Days are included that constitute ozone 'build-up' and 'clean-out' days, as the ozone levels gradually increase and then dissipate as the result of physical and chemical removal processes and broad-scale changes in the regional weather patterns. Traditional

regulatory ozone modeling studies have only examined episodes of a few days duration, say 3-5 days in length. In EPA's emergent 8-hr modeling guidance, however, the agency now recognizes the need for modeling much longer periods of time (up to a month or even the whole summer ozone season). Our approach in the San Juan EAC study is consistent with EPA's most recent and evolving guidance for 8-hr regulatory ozone studies.

Modeling scientists within and outside EPA have long recognized the need to test photochemical models ensure that they adequately simulate the effects of emissions changes. The best approach to this problem, known as 'retrospective modeling' entails setting up and exercising a model for two or more episodes over widely different time periods (say 10 years apart or more) over which time substantial emissions changes have occurred. In this way, the model's response to documented emissions changes could be tested. In practice, however, this type of modeling has never been undertaken in any systematic fashion by EPA or others. To be successful and reliable, such a study requires highly-accurate emissions inventories and extensive air quality monitoring data for both time periods (i.e., current conditions and 10-15 years ago) in order to set up the model and ensure that it is operating accurately for both periods. In the mid 1990s, a study of this type, sponsored by the American Petroleum Institute (API), was attempted using the richest emissions and air quality data base in the world—Los Angeles. The conclusions of the study were disappointing. Even with the richest, most highly developed emissions inventorying methods and surface and aloft weather and air quality monitoring data, it was not possible to construct the historical data base as a high enough level of reliability to adequately compare with current modeling and measurement conditions.

The implications for the San Juan EAC study are obvious. The emissions databases for the early 1990's in San Juan county are crude at best, if they even exist in useful form. The available ozone monitoring records in the county are grossly inadequate to support 'retrospective modeling'. Finally, the resource requirements and time needed to perform this type of modeling eclipse the capabilities and focus of an Early Action Compact study.

Comments: We believe that modeling a 45-day period during the Summer '02 season will provide the best possible test of the air quality model's ability to simulate a broad range of weather and air quality conditions, given the currently available data bases and the schedule/resource constraints of the San Juan EAC study. Moreover, as part of the MM5 and CAMx performance evaluations (carried out separately), we will compare the results for each San Juan EAC modeling day with other contemporary regulatory studies to assess the reliability of these tools for 8-hr ozone attainment demonstration modeling in the Four Corners region. The ultimate credibility of this modeling will depend, in large measure, on the adequacy and representativeness of the available local air quality and meteorological data with which to test the models. Accordingly, every effort should be undertaken to acquire and incorporate into other monitoring data germane to this regulatory study (e.g., the ozone and meteorological data collected on the Ute Indian Reservation).

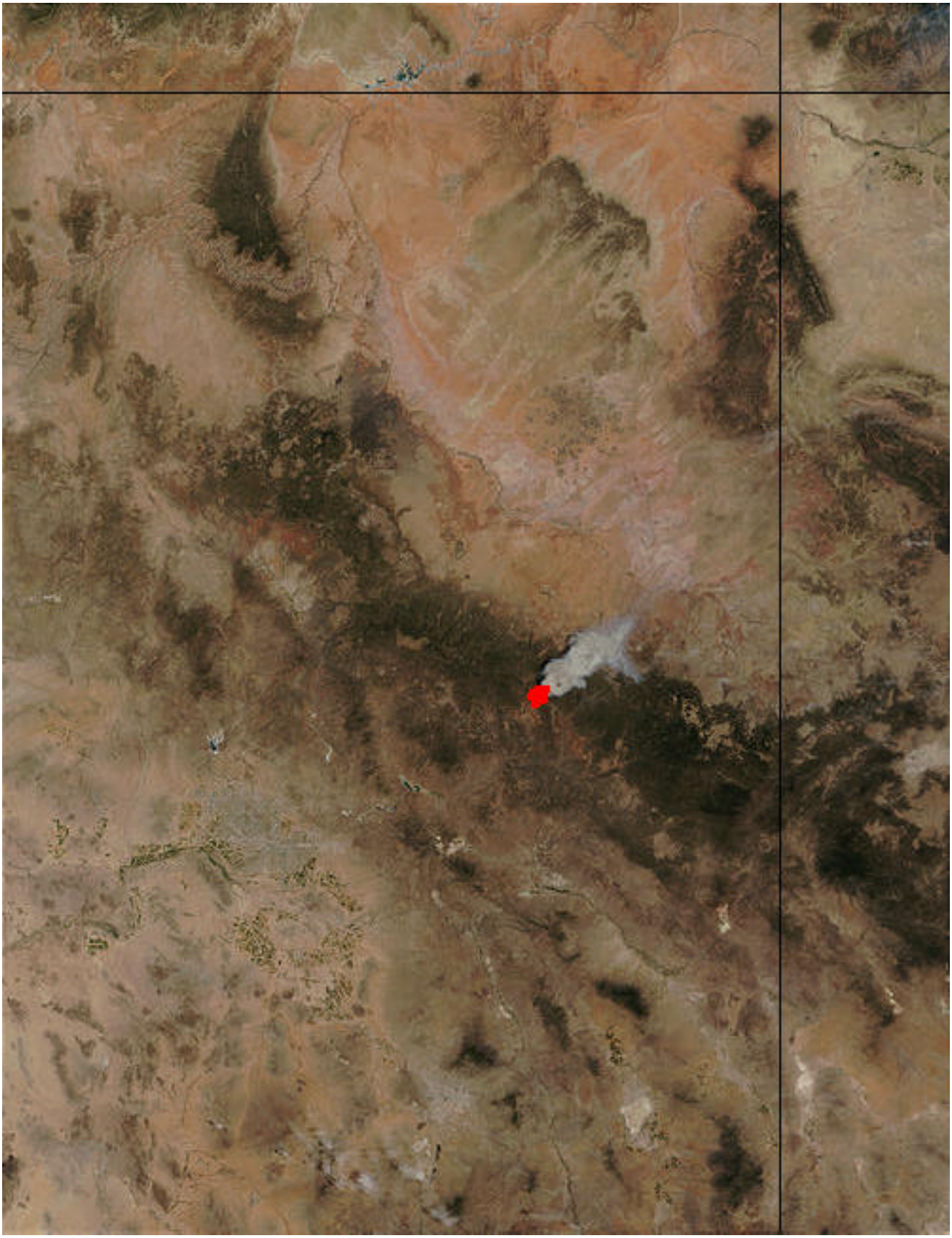

Figure 1. Satellite Imagery of Rodeo Fire on Day 170 (19 July 2002) at 1825 UTC.

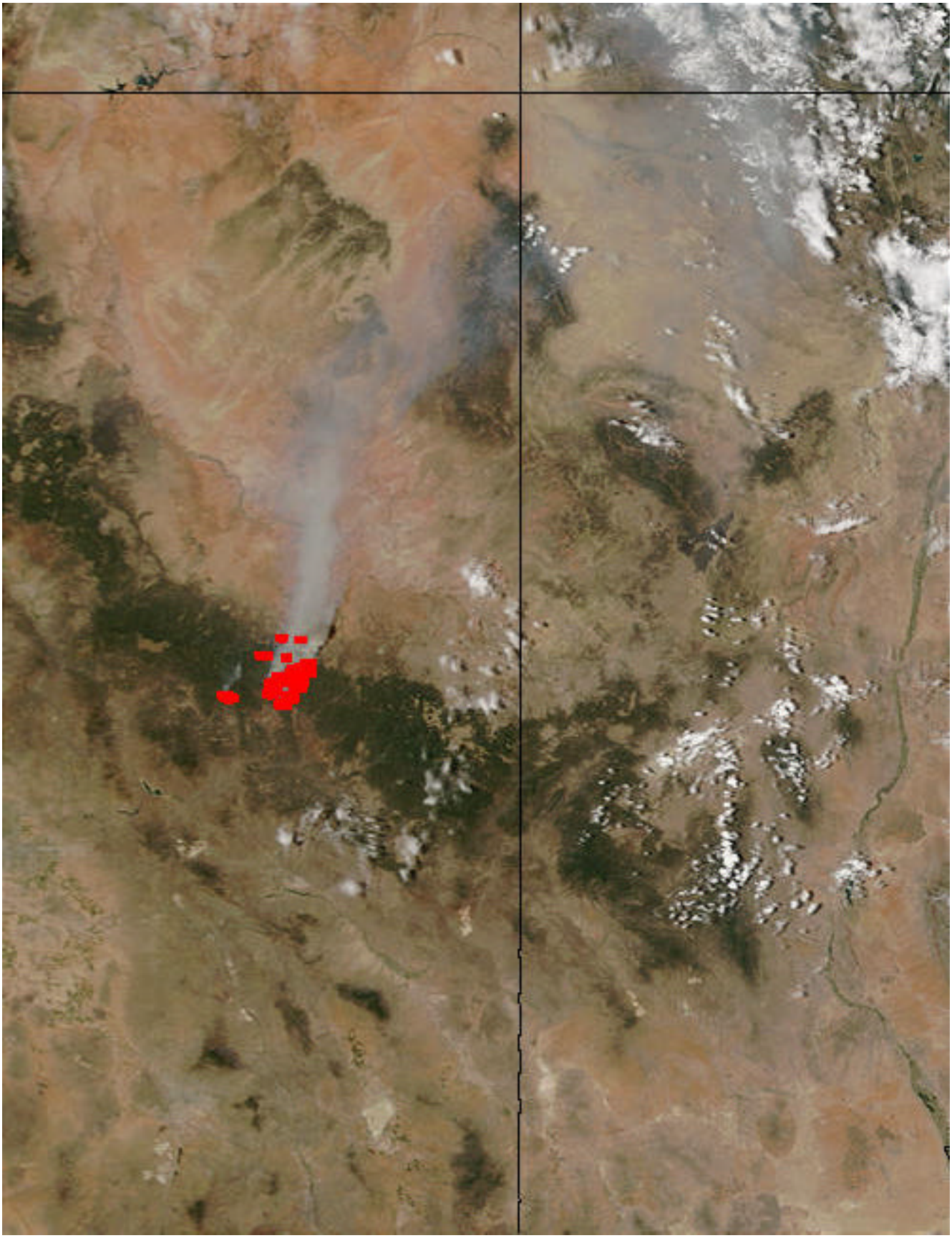

Figure 2. Satellite Imagery of Rodeo Fire on Day 171 (20 July 2002) at 1730 UTC.

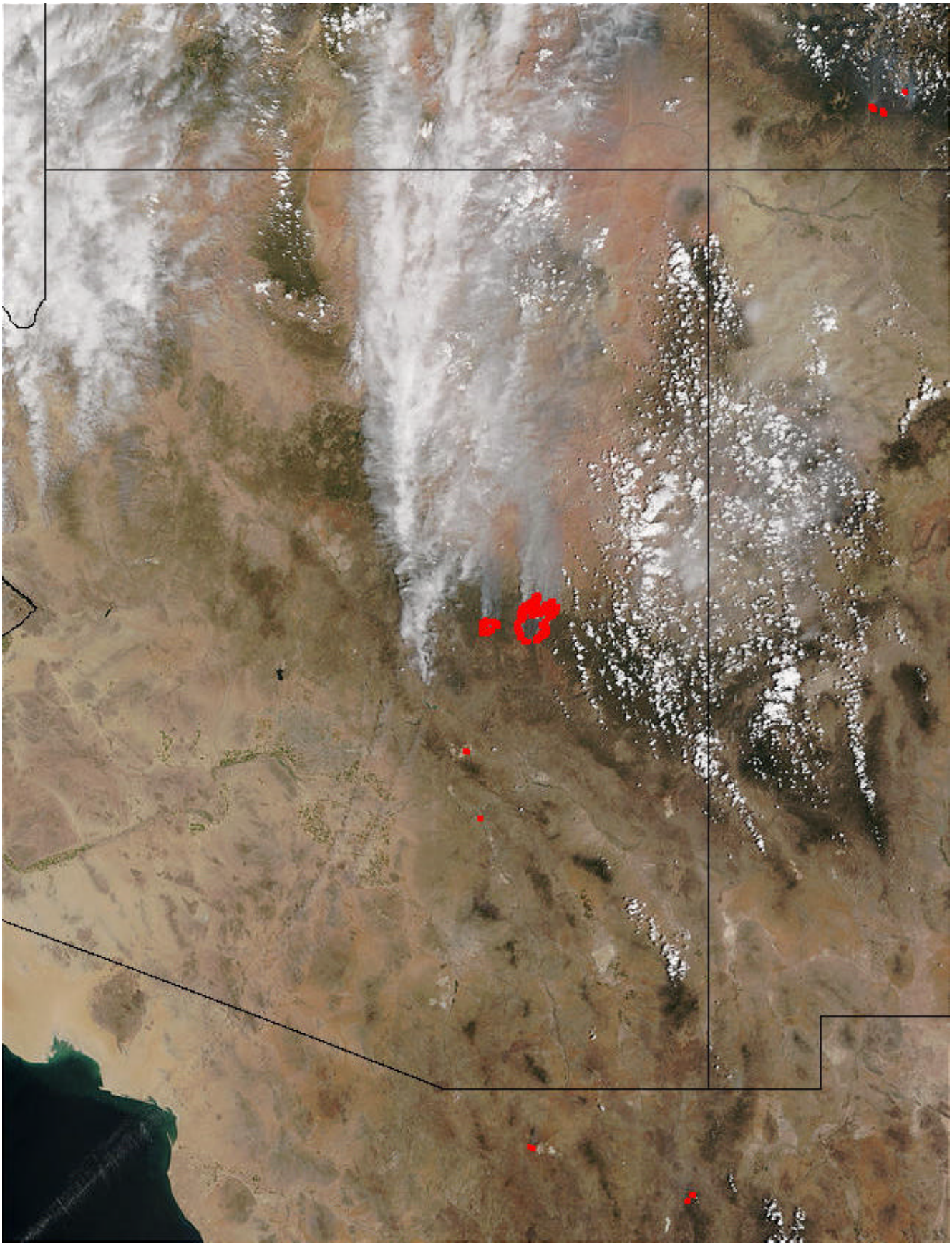

Figure 3. Satellite Imagery of Rodeo Fire on Day 172 (21 July 2002) at 1806 UTC.

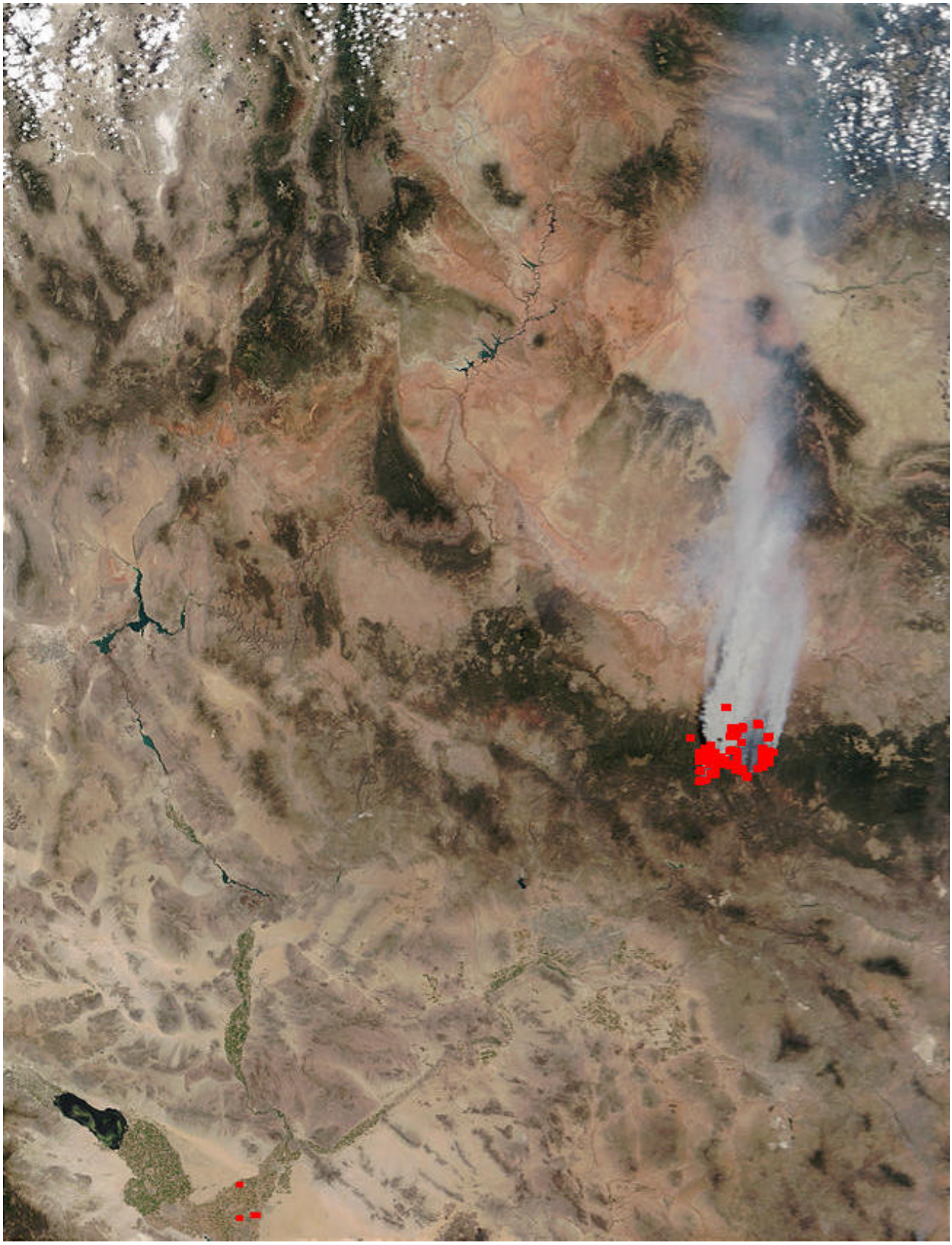

Figure 4. Satellite Imagery of Rodeo Fire on Day 173 (22 July 2002) at 1855 UTC.

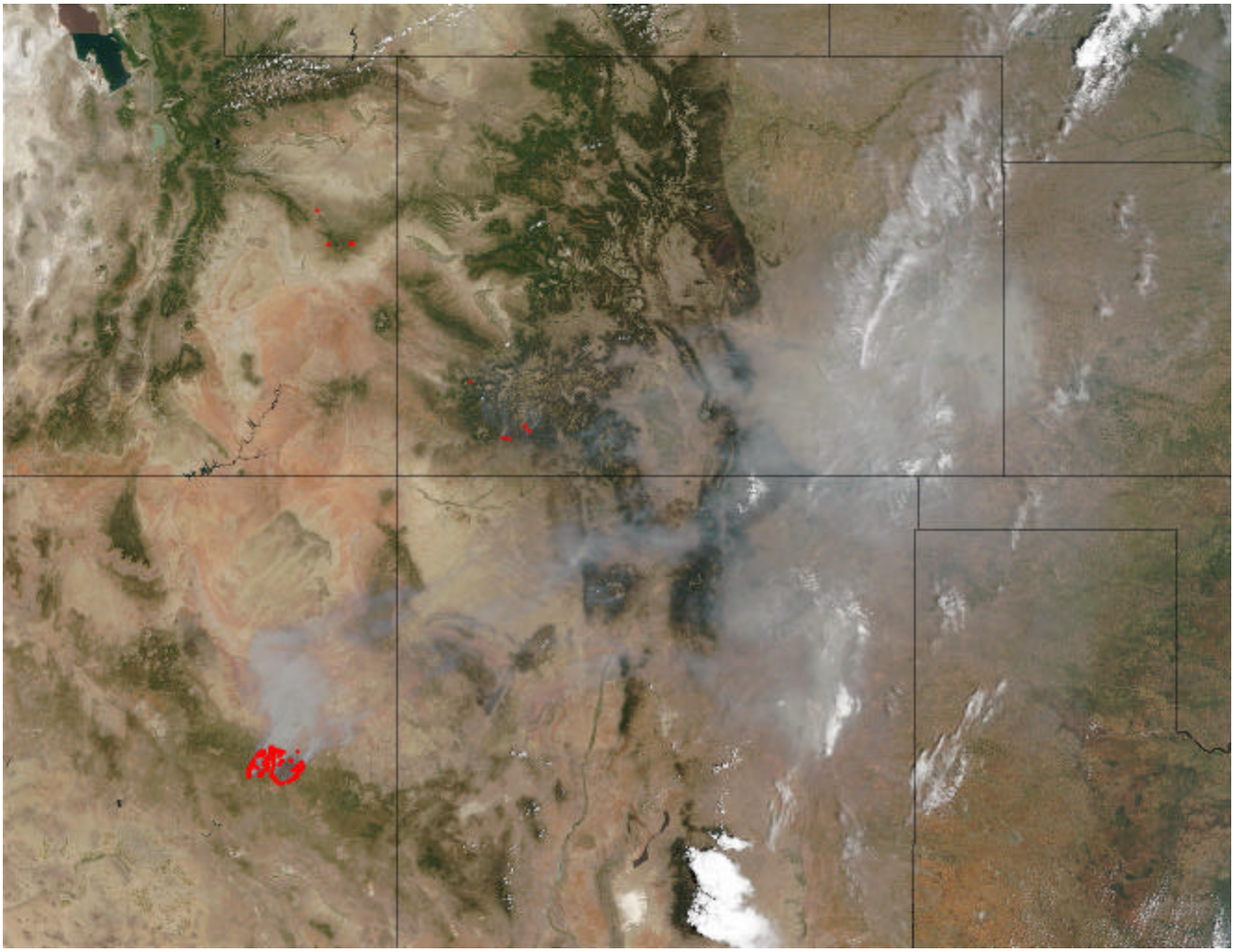

Figure 5. Satellite Imagery of Rodeo Fire on Day 174 (23 July 2002) at 1800 UTC.

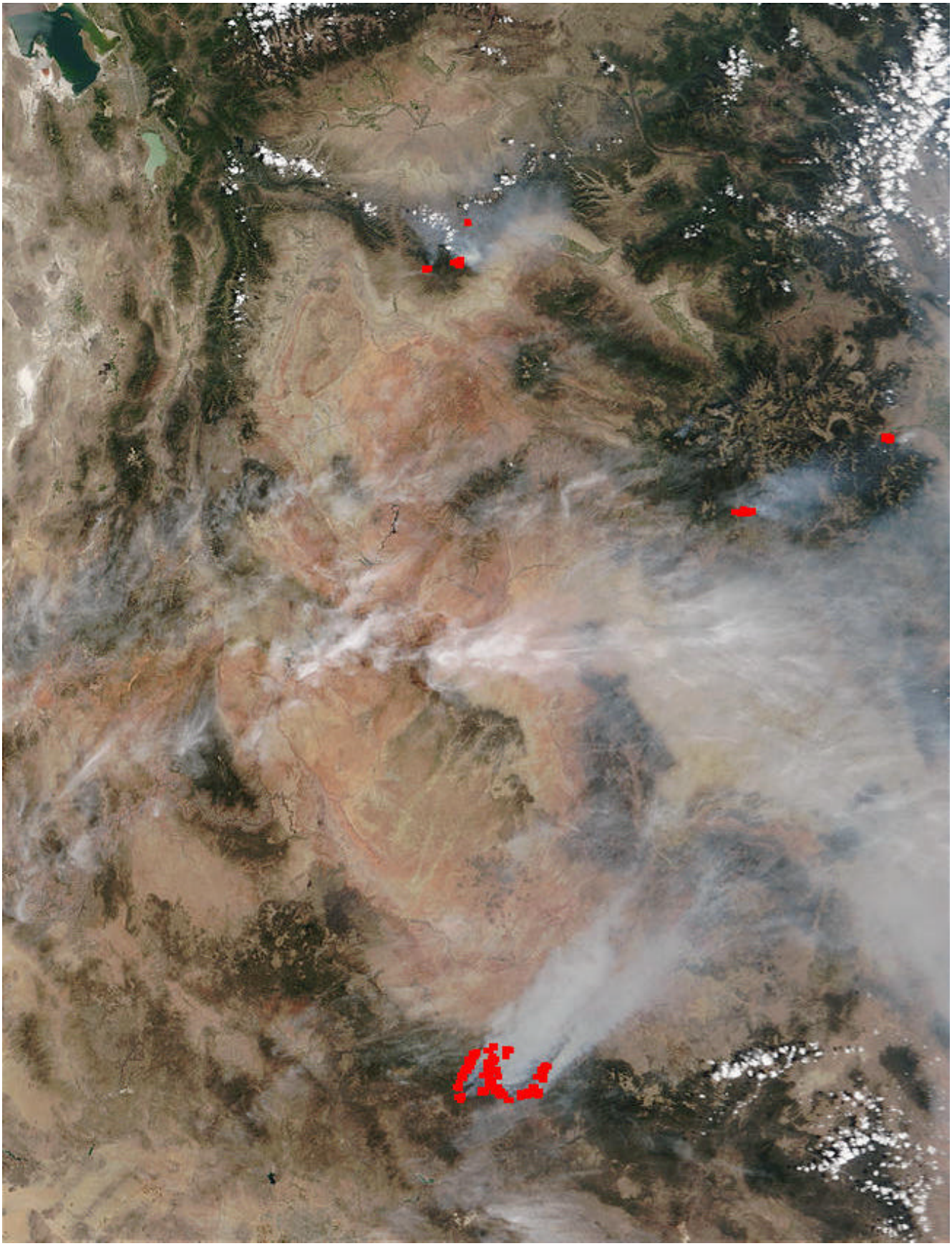

Figure 6. Satellite Imagery of Rodeo Fire on Day 175 (24 July 2002) at 1845 UTC.

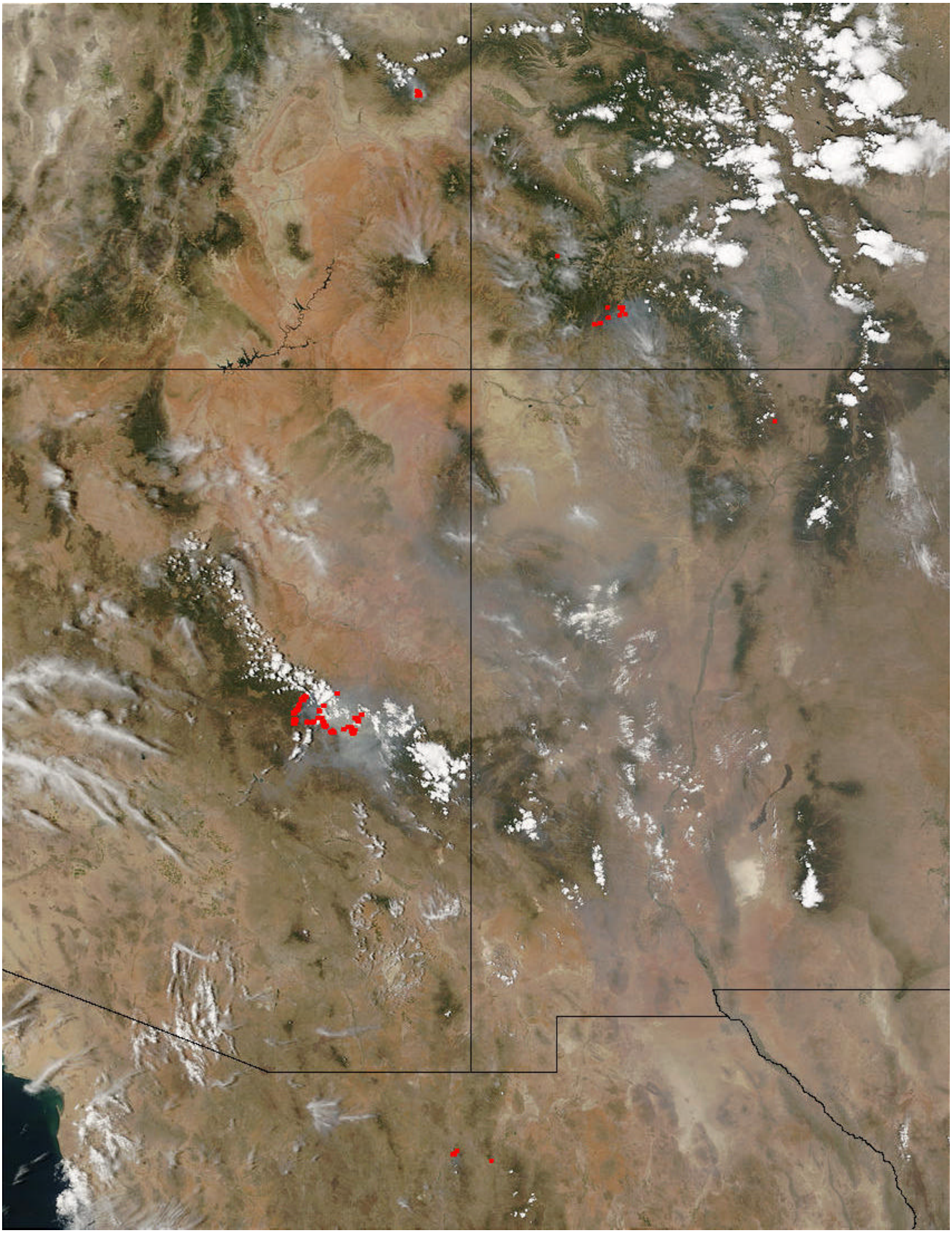

Figure 7. Satellite Imagery of Rodeo Fire on Day 176 (25 July 2002) at 1750 UTC.

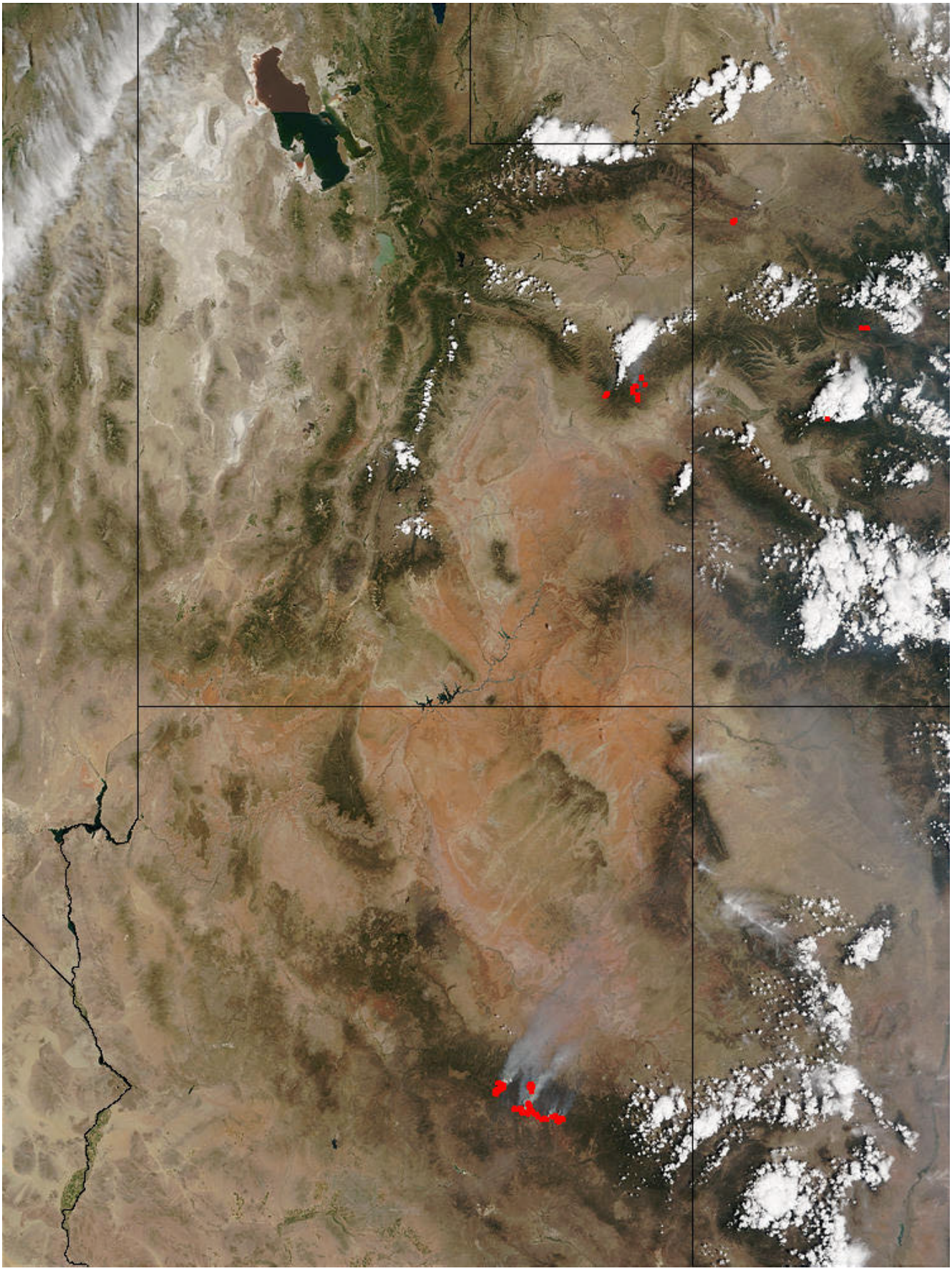

Figure 8. Satellite Imagery of Rodeo Fire on Day 179 (28 July 2002) at 1820 UTC.

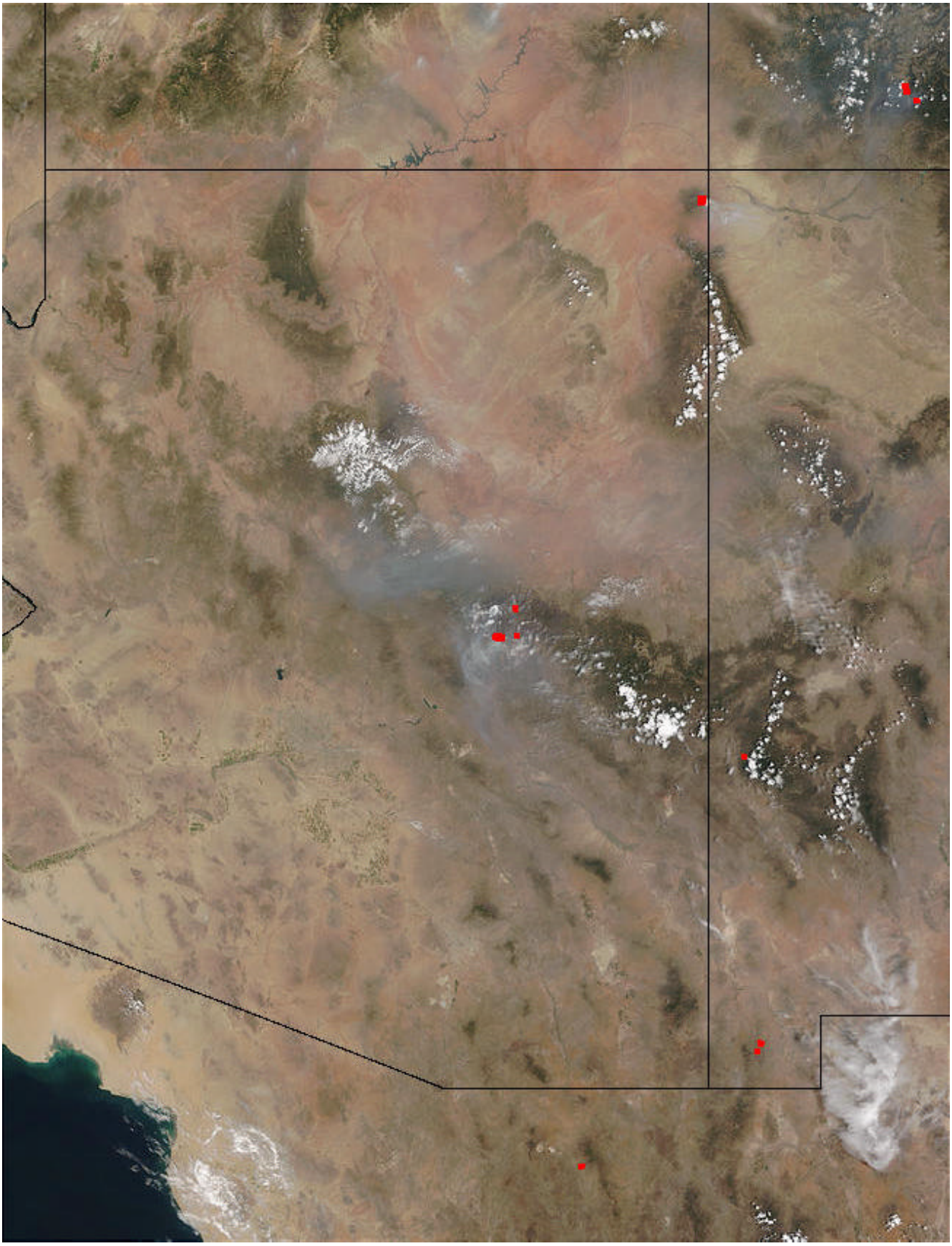

Figure 9. Satellite Imagery of Rodeo Fire on Day 181 (30 July 2002) at 1810 UTC.

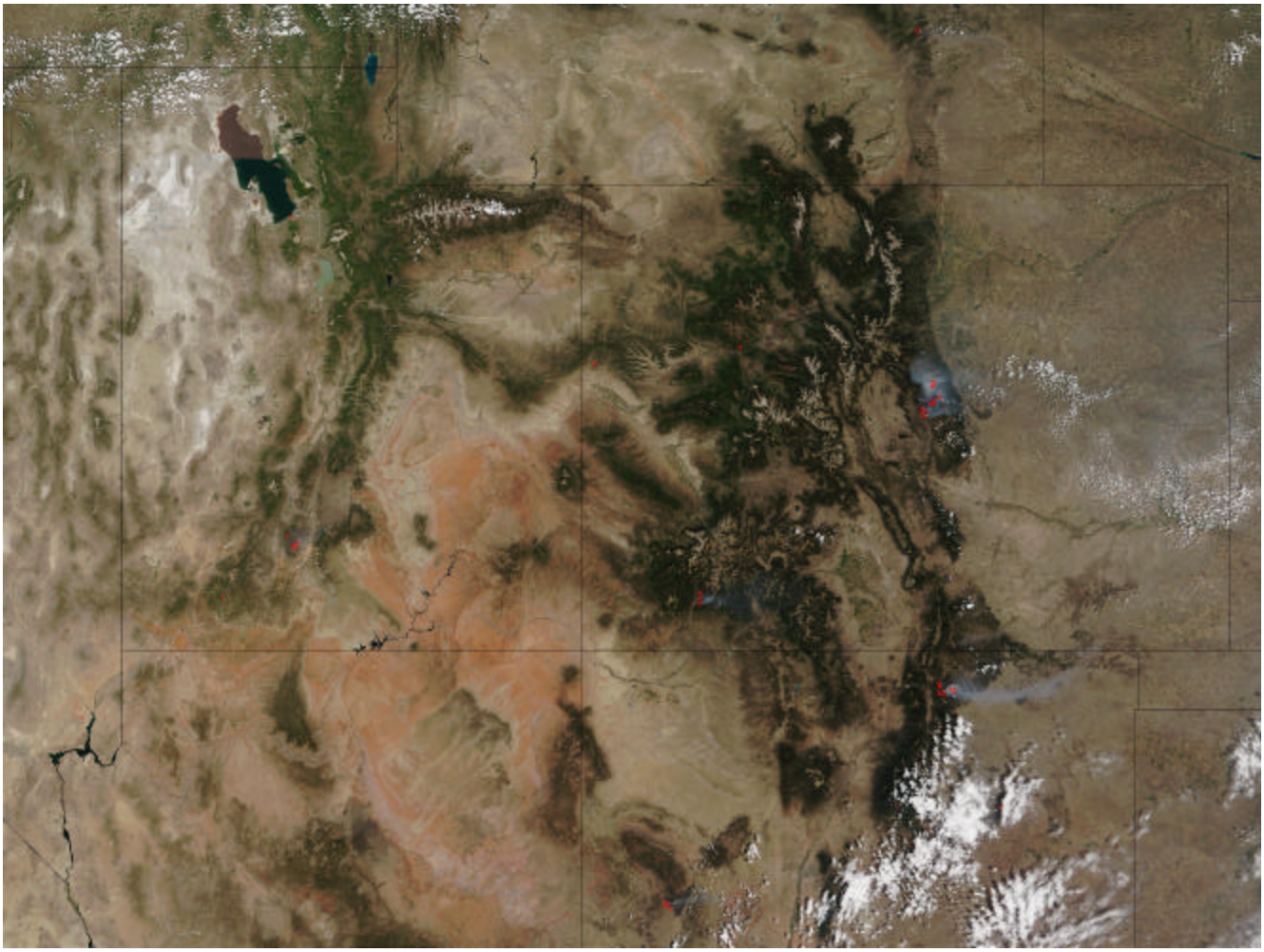

Figure 10. Satellite Imagery of Fires in Colorado and New Mexico on Day 163 (12 June 2002).

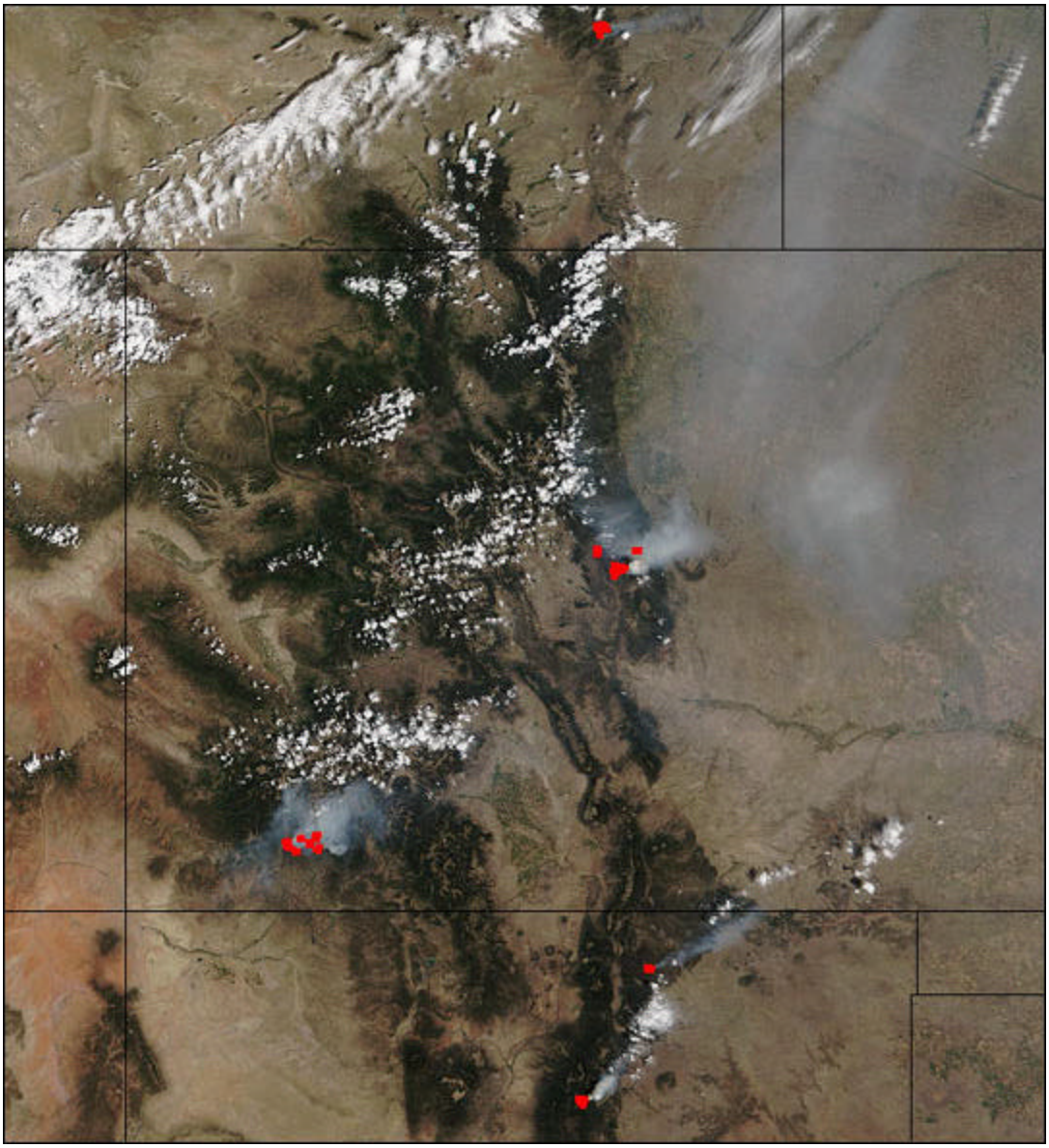

Figure 11. Satellite Imagery of Fires in Colorado and New Mexico on Day 170 (19 June 2002).

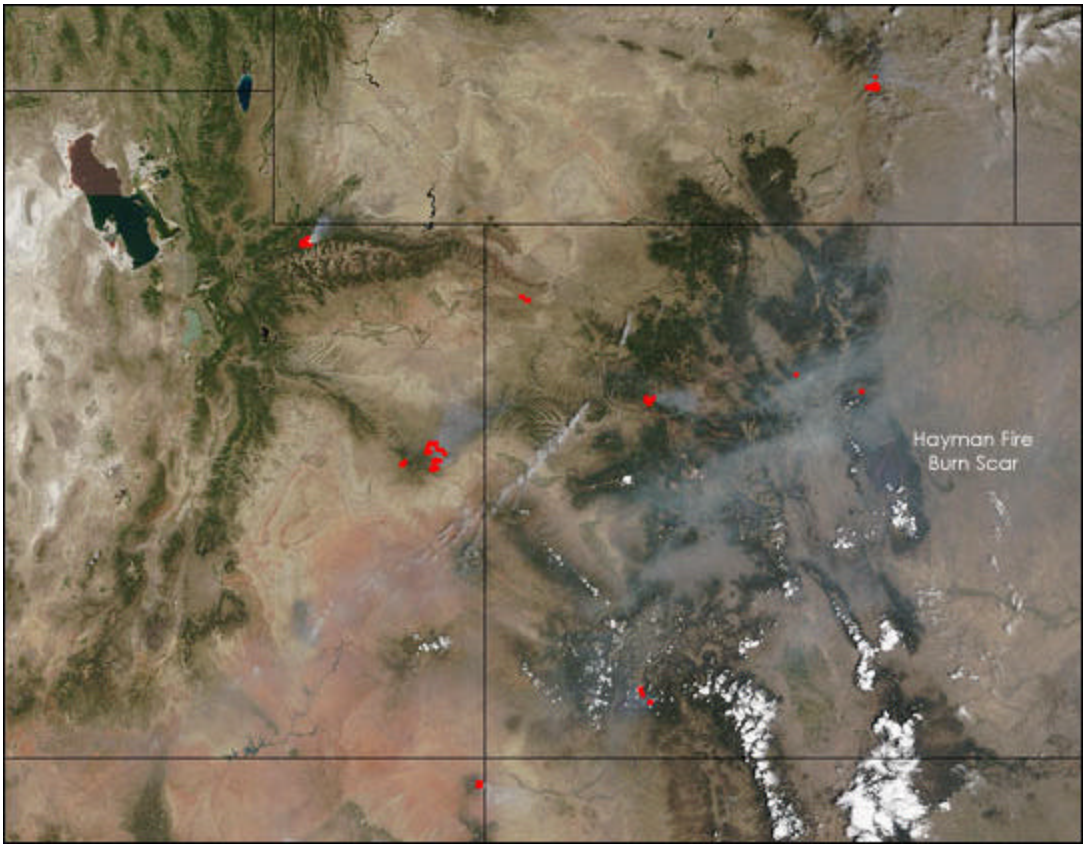

Figure 12. Satellite Imagery of Fires in Colorado and New Mexico on Day 181 (30 June 2002).

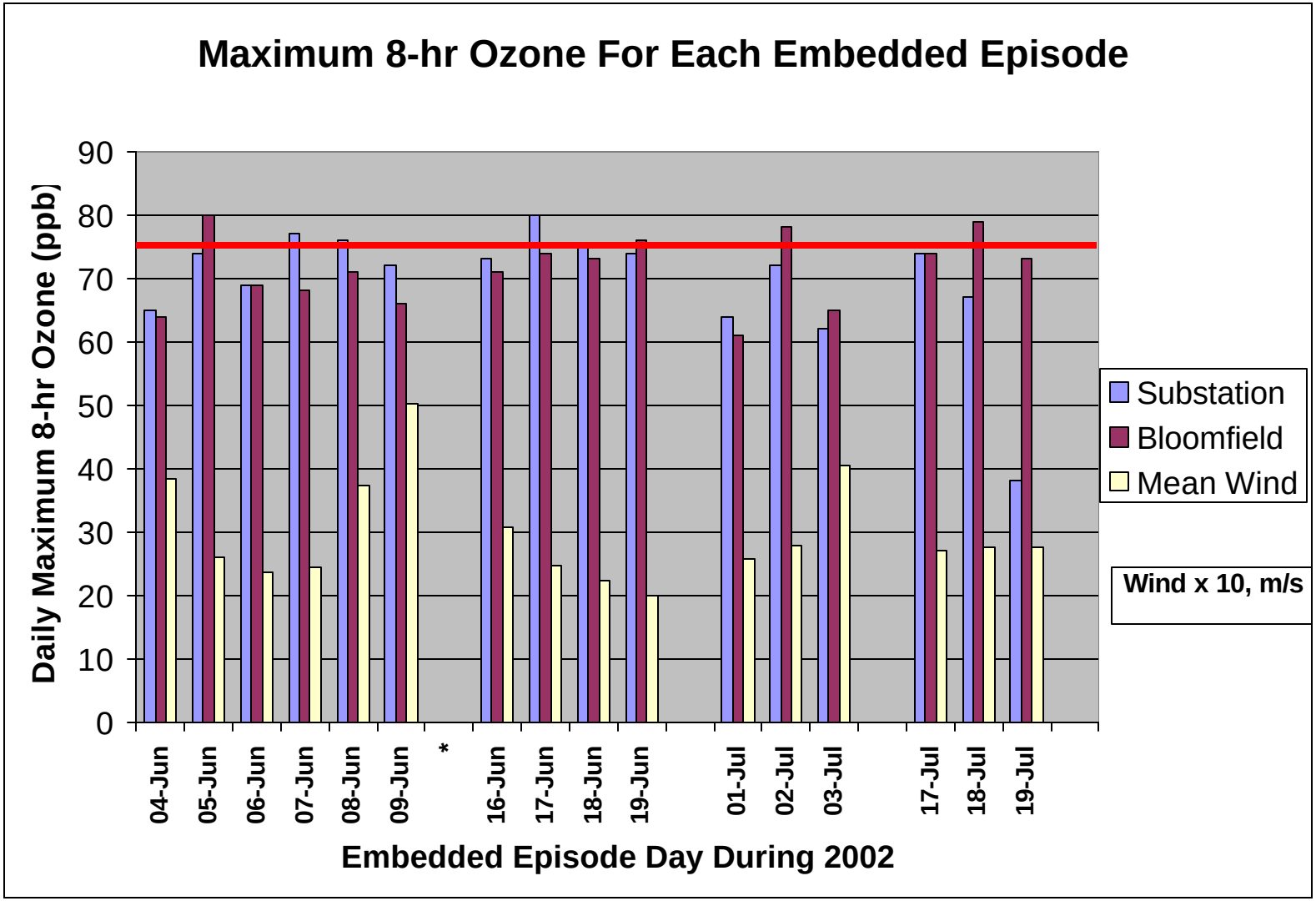

Figure 13. Daily Maximum 8-hr Ozone Concentrations and Mean Wind Speed at Bloomfield (x 10) for Summer '02 Modeling Days. Stagnation (light, variable winds) common during latter portions of 16-19 June episode.