SATELLITE OBSERVATIONS AND MEASUREMENTS OF THE 1991 MOUNT PINATUBO ERUPTION. Rick Holasek and Stephen Self (Hawaii Institute of Geophysics and Planetology and Hawaii Center for Volcanology, University of Hawaii, 2525 Correa Road, Honolulu, HI 96822)

We demonstrate the use of Geostationary Meteorological Satellite (GMS) and NOAA polar orbiting Advanced Very High Resolution Radiometer (AVHRR) satellite images of the June 1991 Mount Pinatubo volcanic eruption plumes in providing details of the dynamics and changing character of this major explosive eruption. Stratospheric sulfate aerosols generated by the Pinatubo eruption plumes have had a far-reaching impact on the Earth's radiation budget, atmospheric and surface temperatures, regional weather patterns, and atmospheric chemistry and optical properties, including environmentally important atmospheric effects such as global ozone depletion [1]. The presence of the Pinatubo stratospheric aerosol veil is responsible for an increased atmospheric optical depth [2], and resultant global cooling, possibly in excess of 0.5°C in 1992 [3, 4]. In order to better model the effects produced by volcanic aerosols it is important to understand the mechanisms responsible for injecting aerosol producing material to stratospheric altitudes. Of particular interest to volcanologists and atmospheric scientists is the altitude and duration attained by eruption plumes as indicators of atmospheric injection levels, quantities of ash and gas erupted and the dynamic conditions necessary for plumes to reach these altitudes.

Satellite images provide the only effective means of examining the series of large, stratospheric venting, eruption plumes produced from the 1991 eruption of Pinatubo. We examined more than 90 weather satellite images of the Pinatubo volcanic plumes with the aim of determining how much quantitative information about the timing and characteristics of eruptive events and eruption plume dynamics can be obtained from this type of remotely sensed data. Weather satellite analysis can provide details such as the timing of volcanic events, changes in eruptive behavior [5], maximum column height and therefore erupted tephra volume estimates [6], delineation of plumes from meteorological clouds in hazard mitigation to aircraft [7, 8] or the thermal history of eruption plume-tops which reflect their altitude in a stratified atmosphere [5, 9, 10, 11].

We determined the chronology of eruptive plume events at Pinatubo which culminated in a 9.5 hour-long climactic phase with maximum column altitudes of 40 km (Figure 1). Because eruption column altitudes are a function of thermal energy flux and eruptive rates at the vent [6], we were able to calculate eruption rates based on maximum column altitudes (Figure 1) and therefore estimated a total volume of erupted tephra from 12 to 16 June of ~5.5 km^3 DRE (Dense Rock Equivalent). Incorporating additional ground-based radar data [12] on plume altitudes from small eruptive events for the period after 16 June through late September 1991, we estimated ~6.1 km^3 total volume of tephra erupted which is supported by ground based estimates of tephra volume [13]. Also, reliable data on altitude and dispersal characteristics of eruption plumes is critical in determining the level of stratospheric injection of aerosol-forming gases and particles and to corroborate models of volcanic ash and gas dispersal [14, 11].

Delineating volcanic plumes from meteorological water/ice clouds with single channel satellite data has been difficult in the past [15, 16, 17]. Several authors have demonstrated multispectral techniques of discriminating volcanic plumes using AVHRR data [18, 19, 20, 9, 21, 22]. The AVHRR multiple channel thermal infrared data was used to improve the discrimination of volcanic clouds from Pinatubo. The algorithm is based on identification of areas where the brightness temperature difference, T4 (10.8 μm) - T5 (11.9 μm), is negative in volcanic plumes due to their dispersive nature [18, 22] and positive in water/ice clouds [23]. Figure 2 plots the temperature difference (T4-T5) against the temperature values from channel 4 (T4) and demonstrates this difference by showing the positive ΔT for meteorological clouds and a negative ΔT for a drifting volcanic plume on 12 June. Identifying volcanic plumes from other features in satellite data are of particular concern for the mitigation of hazards to aircraft and the utility of the differencing algorithm has been demonstrated at Pinatubo.

References:

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Figure 1

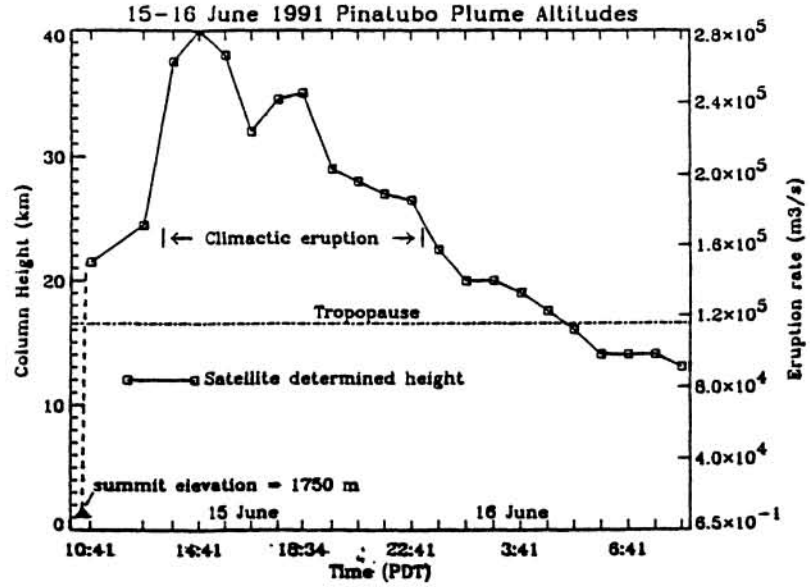

Figure 2