P3.13 GLOBAL COMPOSITE OF VOLCANIC ASH "SPLIT WINDOW" GEOSTATIONARY SATELLITE IMAGES

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1.0 Introduction

Volcanic ash is exceptionally hazardous for jet aircraft in flight. Flying through ash can quickly damage the jet engines, causing surging, flame out and immediate thrust loss. Pilots can inadvertently penetrate volcanic ash clouds because airborne weather radar will not reflect off the small ash particles, and the visual appearance of an ash cloud may look very similar to an ordinary meteorological cloud. To aid pilots in avoiding ash cloud areas, the International Airways Volcano Watch (IAVW) agreements have developed under the guidance of the International Civil Aviation Organization (ICAO). Central to the IAVW are the Volcanic Ash Advisory Centers (VAACs) which have the responsibility of continually monitoring active volcanoes for potential ash clouds. The globe has been divided into areas of responsibilities, which have been assigned to 9 VAACs. The VAACs provide ash information to the Meteorological Watch Offices who issue official warnings (SIGMETs), which are used by airspace control centers to route aircraft away from the hazardous areas. The VAAC's use a variety of satellite image processing techniques which enhance the signature of ash clouds, while diminishing the signature of ordinary meteorological clouds. Generally these derived images of ash are not widely available outside of the VAAC and Watch Offices. On several of the VAAC web sites (such as Washington VAAC web site http://www.ssd.noaa.gov/VAAC/), some of the derived images are made available for the localized areas around frequently active volcanoes. However they do not make wide area products available that would cover the drifting ash cloud from a major eruption.

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Pilots and air traffic controllers generally like to have satellite image products that show the flight hazards, as well as the official SIGMET products. The flight crews like to verify the existence of the hazard as well as judge how close to the hazard area it is prudent to fly. The present effort has been to develop global composites of geostationary ash products that can be made available to pilots, dispatchers, etc. to supplement and help explain the official volcanic ash hazard products coming from the VAACs and Watch Offices.

2.0 Split Window Volcanic Ash Image Generation

The original derived ash satellite product was the so called "split-window" or "reverse absorption" technique (Petra, 1989) which used the temperature difference between the 11 and 12 micron imager channels on the polar orbiting satellites. This technique takes advantage of an absorption band of silicates which influences the 12 micron image, but not the 11 micron image. The disadvantage of this technique is that there is also an absorption band for water that influences the 12 micron image, so the technique does not work well for new volcanic clouds which contain large amounts of steam. The technique also is of limited use for low ash clouds in a humid atmosphere. However, for jet aircraft operations, this technique offers a clear signature of high, dry ash that is readily identifiable by operational aircraft personal. Other ash detection techniques have been developed that take advantage of the 3.9 micron channels on the geostationary satellites. However, the 3.9 micron channel is influenced by solar reflection, so the use of these multi-channel ash techniques generally requires specialized user training.

The 11 micron channel (the "window" channel) has been available on all the geostationary satellites for many years. The 12 micron channel has been available on the GOES satellites until recently. GOES-12 (current GOES-east) through GOES-15 do not have a 12 micron channel. The new European Meteosat Second Generation (MSG), Chinese FY2C, and Japanese MTSAT geostationary satellites all have a 12 micron image channel, as well as the current GOES-west (GOES-11). The GOES-10 is currently being used for research scans over South America, and has been included in the processing for that region. These operational satellites make it possible to generate global mosaics every 30 minutes of the split window ash product, with the exception of a eastern US which is covered every 3 hours because of the lack of the 12 micron channel on GOES-east (GOES-12). The processing takes the difference between the 12 micron and 11 micron temperatures. The resultant temperature difference is stretched into the entire image brightness range so that ash looks white, no difference looks gray, and ice clouds look black. The temperature difference of zero is assigned a gray scale of 85 (out of a range of 0-255). The zero black scale is a temperature difference of -5 degrees K, and the white (255) is a temperature difference of +10 degrees K. The differencing is done in the original satellite projections and then mapped into a 4 km rectilinear (equal latitude, longitude) 4 km grid. The various satellite grids are then combined into a global 4 km grid. The boundaries between satellites are fixed with no overlap between satellite coverage. The global composite is generated every 30 minutes. Gif images are generated at various locations and resolutions and posted to the Embry-Riddle web site at http://wx.erau.edu/erau_sat/. Figure 1 shows a sample of the composite showing the Western Hemisphere area of coverage for Dec. 19, 2007 at 19:00 GMT. The United States split window coverage is generated from the GOES-west satellite. While the western half of the US is covered every 30 minutes, the eastern half of the US is covered only every 3 hours during the full disk scans of the GOES-west and GOES-South. Figure 2 shows the Eastern Hemisphere area of coverage.

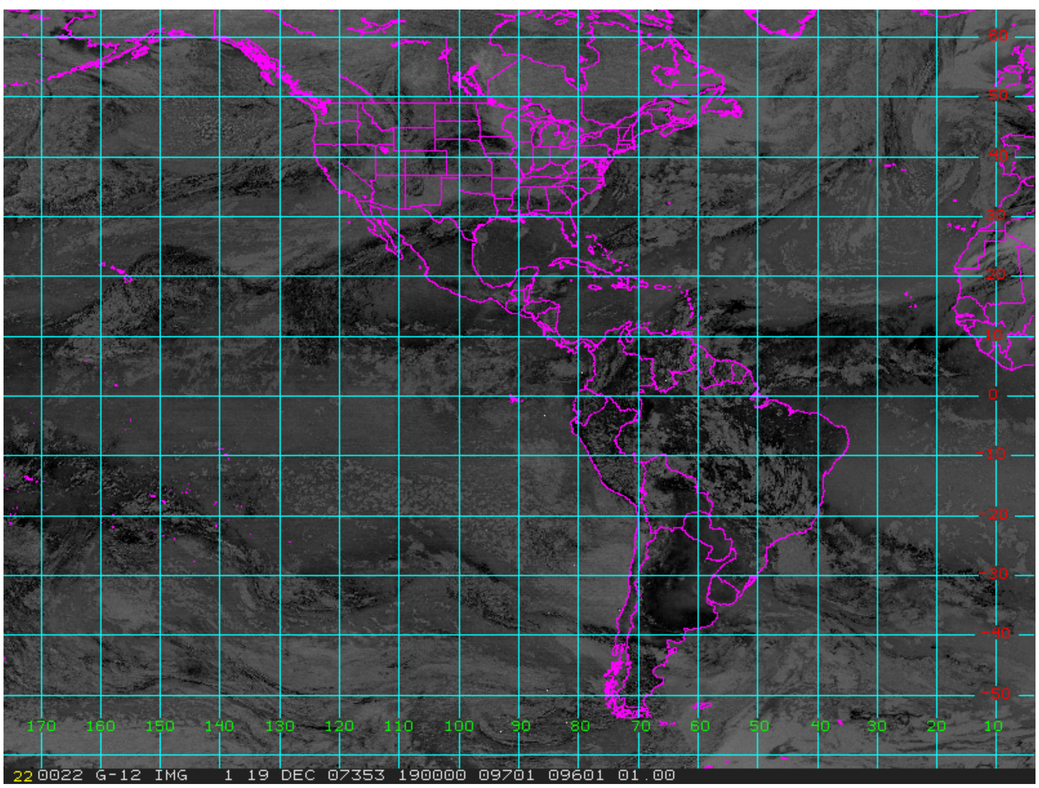

Figure 1. Western Hemisphere coverage of the split window ash composite for 19 Dec. 2007 19Z.

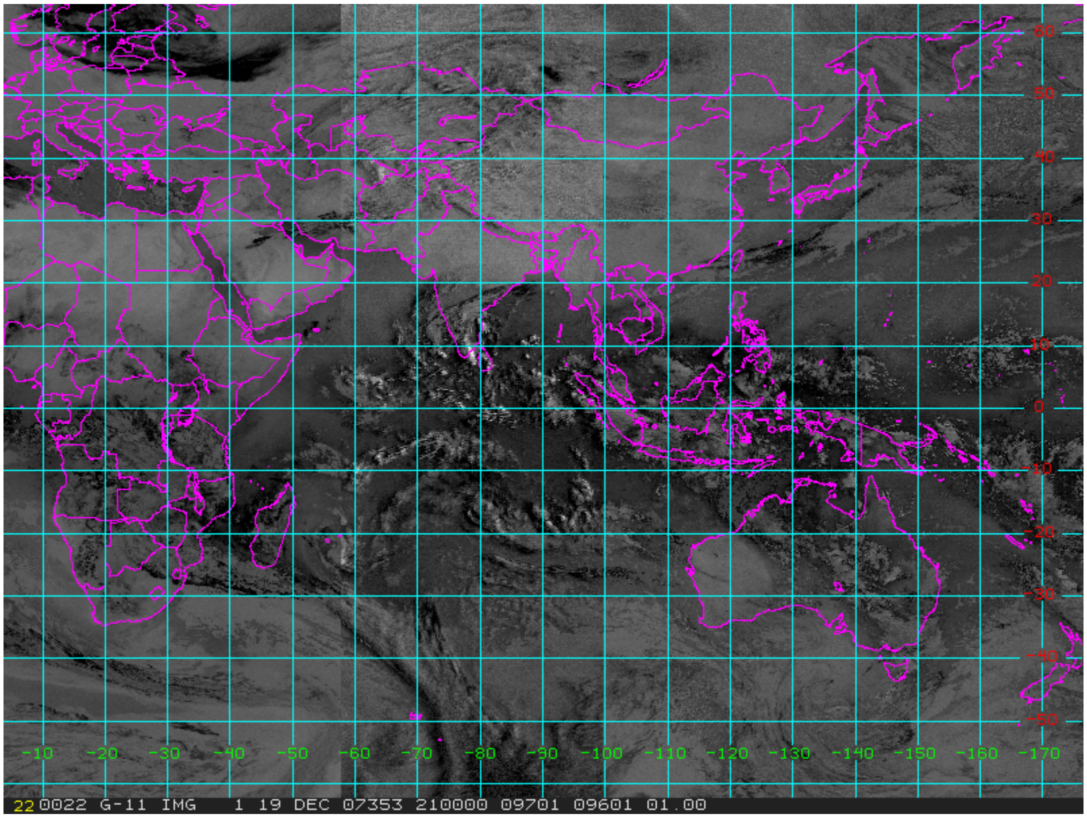

Figure 2. Eastern Hemisphere coverage of the split window ash composite for Dec. 19, 2007 at 21:00 GMT.

In figure 2, note the small white cloud over the Russian Kamchatka Peninsula. This is a volcanic ash cloud emitted by the Sheveluch volcano.

Figure 3a and 3 b show the Kamchatka Peninsula at 11:45 and 19:00 GMT at the original 4 km resolution of the global mosaic.

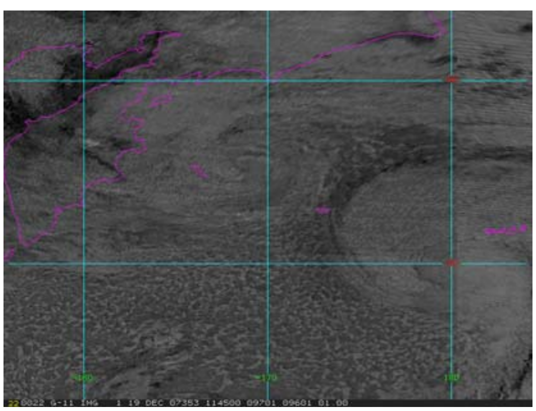

Figure 3a. Kamchatka Peninsula Dec. 19, 2007 at 11:45 GMT

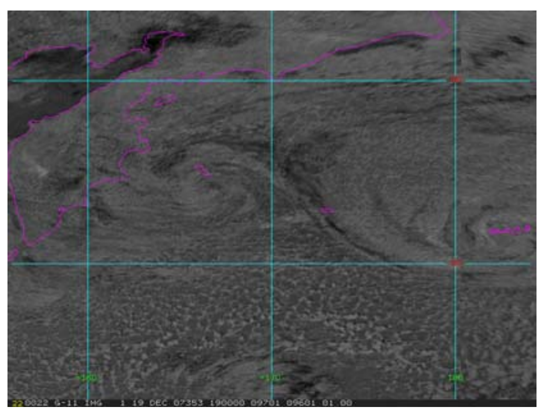

Figure 3b. Kamchatka Peninsula Dec. 19, 2007 at 19:00 GMT

In addition to being able to detect high, dry volcanic ash, the split window images can also detect dust raised by dust storms and large dust devils. Figure 4 shows a sector over the Western Sahara showing dust clouds being raised by large dust devils.

Figure 5 shows the Skew-T sounding from Tamanrasset in southern Algeria for 12Z . The sounding shows superadiabatic lapse rate near the surface and an adiabatic lapse rate extending up to 650 mb. This will allow any dust raised at the surface to be lifted up to the middle atmosphere around 500 mb.

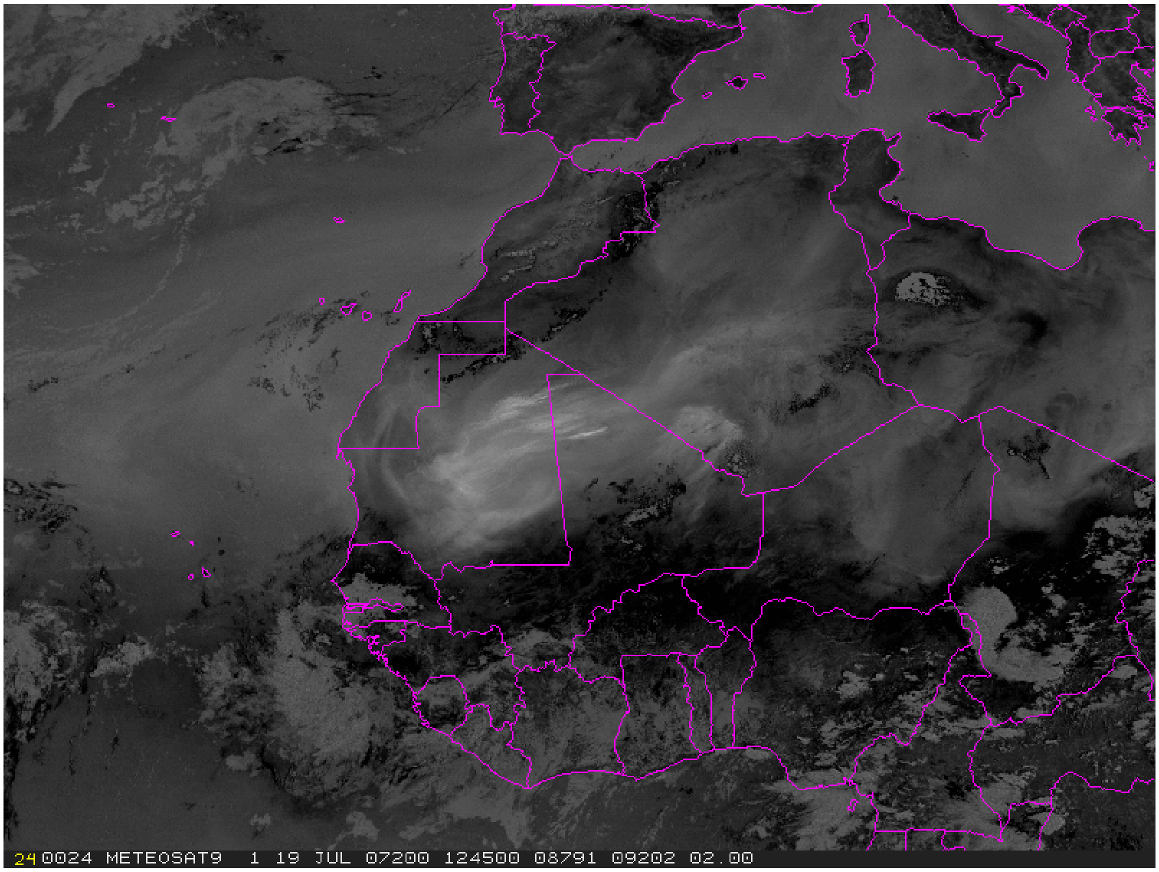

Figure 4. Split Window ash technique showing dust clouds in the western Saharan desert for July 19th at 12:45 GMT.

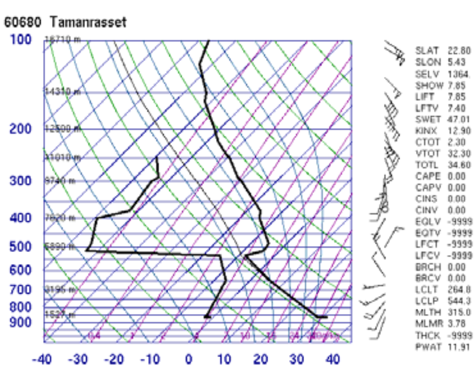

Figure 5. SkewT diagram of the sounding from Tamanrasset in southern Algeria for 12Z on July 19th.

3.0 Problems with Global Composite

The most significant problem with the global volcanic ash composite is the hole caused by GOES-12. The 12 micron channel needed for this two channel algorithm is not on GOES-12 through GOES-15. This leaves the GOES-east position as a hole in the composite. The GOES-west position is GOES-11, and it should operate for a number of years before having to be replaced with a newer satellite. Several things have been done to try to fill the GOES-east hole in the composite. The Meteosat coverage has been extended as far west as possible, to about 67 W longitude. Over South America, currently the GOES-10 satellite is being used for a research program which has 15 minute scans over South America. This GOES-10 data has been incorporated into the composite when available. The GOES-10 is an old satellite that has exhausted its fuel supply, so it cannot perform orbit maneuvers. Consequently, it has a large excursion in the sky, so that a fixed receiving antenna cannot receive data continuously. Currently the satellite antenna receiving the GOES-10 does not have a tracking capability and the data is lost for several hours during the day and night. For the eastern US, the only data coverage is from GOES-west during the full disk scans every three hours. Hence the GOES-east coverage is filled by a combination of Meteosat coverage in the Atlantic, GOES-10 coverage over South America, and GOES-west coverage every 3 hours for the remainder of the area.

A second problem that has been noted is the Central Asia coverage derived from the Chinese FY2C satellite. Figure 2 shows the weather clouds having texture which is not evident in other regions. It appears that the 11 and 12 micron channels of the FY2C have different response time characteristics, so that the transition from warm ocean to cold cloud has differing time scales for the two channels. This causes the difference between the two channels to have a white region on the east side of the cloud, and a dark region on the west side of the cloud. This makes it difficult to interpret the product in that region, since volcanic ash normally would show up as white .

4.0 References:

Prata, F., 1989; Observations of Volcanic Ash in the 10-12 μm Window Using AVHRR/2 Data. *Int. J. Remote Sensing,* 10, 751-761.