HYSPIRI MISSION APPLICATIONS – VOLCANIC HAZARDS

Application Question/Issue

Volcanic eruptions inject large quantities of ash into the atmosphere and ash clouds pose a hazard to aviation. The location of these ash clouds, the amount of ash they contain, and how these parameters change over time, needs to be quantified in a timely manner if the economic costs, and the danger posed to air passengers, are to be minimized.

Who Cares and Why?

Explosive volcanic eruptions can inject large amounts of ash into the atmosphere, which poses a significant hazard to air traffic, as exemplified during the 2010 eruption of Eyjafjallajökull volcano, in Iceland. During April and May of that year, ash in northern European airspace was responsible for the cancellation of over 100,000 flights, disrupting the travel plans of approximately 10 million passengers, at an estimated cost of $1.7 billion to the airlines. In this instance, the identities of the stakeholders are clear: the Federal Aviation Administration, the airlines, and travelling passengers. Information regarding the position and concentration of ash in the atmosphere and how these variables change over time is needed to i) determine whether aircraft can fly, and ii) validate and parameterize models that predict where the ash will disperse.

Needed Measurement(s)

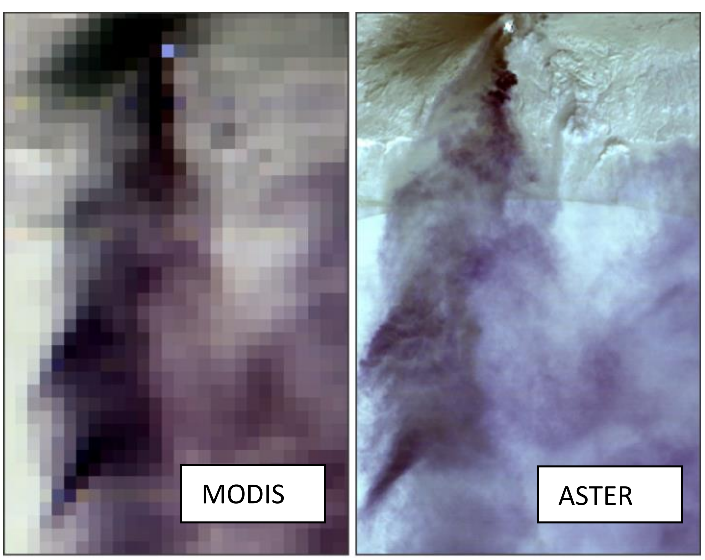
Detection of volcanic ash clouds depends on being able to discriminate these clouds from non-hazardous meteorological clouds, and to do this in a timely manner, both by day and by night. Measurements of the amount of energy emitted (at wavelengths of approximately 11 and 12 μm) from the Earth's surface allow detection to be achieved because of the contrasting transparency of ash and water clouds at these wavelengths. The amount of ash present also needs to be quantified. For example, the London Volcanic Ash Advisory Center (one of nine global VAACs responsible for issuing guidance to the aviation industry) now regards concentrations of $<2\times10^{-3}$ g of ash per cubic meter of air as safe for flight; this has replaced the previous zero tolerance policy for flying in the presence of ash. But values as low as 2×10^{-4} g of ash per cubic meter of air would need to be quantifiable to track these concentrations. The ability to detect volcanic sulfur dioxide, which exhibits strong absorption of light at 8.6 μm and which often accompanies ash, is also desirable, as it exists at low concentrations naturally and is thus relatively easy to detect in these thermal infrared wavelengths (often easier than the ash itself). Early-warning for the possible presence of ash (e.g., thermal anomalies on the ground that indicate an eruption has begun) is also of importance.

The NASA Response

The HyspIRI mission will provide important information for improving our ability to predict the hazard posed by such eruptions. The seven bands of long-wave thermal infrared data planned for HyspIRI are ideally suited to detecting volcanic ash in the atmosphere and distinguishing ash clouds from ordinary water clouds. The high spatial resolution (60 m) will allow more accurate determination of lower ash concentrations than is possible with lower spatial resolution sensors. Given the stakeholder need for timely information about cloud location and thickness, the 600 km wide swath of HyspIRI's thermal sensor bands, along with the fact that it can acquire data by day and night, means that HyspIRI will provide data hitherto unavailable, with high spatial resolution and global coverage, every five days. This is enhanced by the fact that the swaths overlap at high latitudes affording more frequent coverage at these latitudes. High northern latitudes are most likely to feature encounters between aircraft and ash clouds given the preponderance of active volcanoes (e.g., Alaska, Kamchatka) and the high volume of air traffic in these areas.

Given the temporally dynamic nature of volcanic ash clouds, very high temporal resolution (or more frequently available) data from geostationary sensors such as SEVIRI or polar orbiters such as AVHRR and MODIS will remain the primary source of information used by VAACs for ash cloud detection and monitoring (i.e., where the ash cloud is). However, the combination of high spatial resolution, the ability to detect ash, sulfur dioxide and thermal anomalies, by night and day, with better than five-day resolution, will make HyspIRI an important source of data for augmenting and calibrating the data obtained by these lower spatial resolution sensors. High spatial resolution measurements of ash cloud properties also allow for the parameterizing of numerical models that predict where ash will disperse. The following images show the ash cloud produced during the 2010 eruption of Eyjafjallajökull, and the enhanced detail afforded by the higher spatial resolution of the Terra ASTER sensor (90 m spatial resolution, right), when compared to the Terra MODIS sensor (1 km spatial resolution, left). HyspIRI will have higher spatial, spectral and temporal resolution than ASTER.

Comments or thoughts?
The HyspIRI website is designed to engage the community of practice, accept and process feedback and queries, support interactive workshops and disseminate user tutorials and other pertinent information. Comments and feedback can be sent to hyspiri@jpl.nasa.gov.



MODIS (32, 31, 29) ASTER (14, 13, 10)

Figure showing the data from two existing satellite sensors: MODIS on the left and ASTER on the right. ASTER has a pixel size of 90 m compared to 1 km for MODIS. The finer pixel sizes of ASTER allow it to provide more spatially detailed images. The image on the left is MODIS bands 32, 31 and 29 displayed in red, green, and blue (RGB) respectively and the image on the right is ASTER bands 14, 13, 10 displayed in RGB. The brighter the image, the hotter the ground, notice how the plume is colder than the volcano (white pixel at top of image).