mate goals: "Our job is to reclaim America for Christ, whatever the cost." Kennedy said at a February 2005 conference, "As the vice regents of God, we are to exercise godly dominion and influence over our neighborhoods, our schools, our government, our literature and arts, our sports arenas, our entertainment media, our news media, our scientific endeavors—in short, over every aspect and institution of human society."

Assuming you have become more concerned, here are some suggestions. Engage in discussions with fellow citizens who may be less enlightened or confused about why President Bush's comments are of such concern or why Judge Jones ruled against the Dover Area School Board. Present them with the following argument: Suppose ID is indeed taught in science classrooms as an alternative explanation of all natural phenomena and that there is an ID counter to evolution, to plate tectonics, to the age of the Earth and its immense history of deep time, to the Big Bang, and even to Hurricane Katrina, and so forth. What will these explanations consist of? In the context of the scientific method, which surely (?) would remain taught in science classrooms, what testable hypotheses can be formulated and tested by gathering what facts/observations to demonstrate ID as a viable "different school of thought"?

ID is proclaimed to be an agnostic principle. John West, Jr., senior fellow at the Discovery Institute has stated, "The theory of 'intelligent design' is agnostic regarding the source of design and has no commitment to defending Genesis, the Bible, or any other sacred text." If that is so, then I, just like numerous others, contend that a multitude of ID notions, including the Flying Spaghetti Monster (http://www.venganza.org/), must be given equal time in the classroom as a viable designer of the universe.

Contact your favorite or not so favorite reporters and journalists and explain to them the importance of the word theory and why theory should not be used in conjunction with ID and/or creationism. Cite the National Academy of Sciences definitions of the terms theory and hypothesis, and then ask them if they understand why these terms have such a special meaning in science. Explain to them the unfortunate difference between the colloquial term theory and the scientific term theory. Furthermore, emphasize that they do not have to constantly write 'theory of evolution'; evolution can stand alone. My interactions with the press, from NBC News to my local public radio station, have been very successful. I urge you to try.

Are the specific comments of President Bush's on 1 August to be taken lightly? Despite the recent Dover, Pa., ruling by Judge Jones, I think not. As a species, we have enormous challenges facing us on this fragile sphere we call home. As resources decline and the population in many parts of Earth spirals seemingly out of control, and as natural disasters and other problems present major challenges, the hard decisions we face as sentient beings require a well-educated society armed with the cold facts about how the natural world works, which rational inquiry has and will continue to remain capable of providing.

This well-educated society must understand that battles over attempts, however orchestrated, to include ID or any future form of creationist-like dogma in the science classroom are not battles between science and religion. We cannot be sufficiently ignorant to allow students to learn whatever may be taught as the 'theory of intelligent design' as a viable replacement for all scientific concepts. Just as nobody is above the law, we must continue to demonstrate that nobody can be above science.

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Sensor Web Enables Rapid Response to Volcanic Activity

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Rapid response to the onset of volcanic activity allows for the early assessment of hazard and risk [*Tilling*, 1989]. Data from remote volcanoes and volcanoes in countries with poor communication infrastructure can only be obtained via remote sensing [*Harris et al.*, 2000]. By linking notifications of activity from ground-based and space-based systems, these volcanoes can be monitored when they erupt.

Over the last 18 months, NASA's Jet Propulsion Laboratory (JPL) has implemented a Volcano Sensor Web (VSW) in which data from ground-based and space-based sensors that detect current volcanic activity are used to automatically trigger the NASA Earth Observing 1 (EO-1) spacecraft to make high-spatial-resolution observations of these volcanoes.

The fully-automated process allows for rapid acquisition and transmission—typically within 48 hours, though theoretically possible within 2–3 hours—of data products containing the most useful data content, namely the numbers, locations, and spectra of hot pixels. This information allows scientists to evaluate the instantaneous eruption extent and intensity. Prior to VSW, this process took weeks. In the future, the sensor web could become an integrated network of ground, airborne, and orbiting sensors that will enable seamless, rapid, autonomous reactions to the detection of volcanic activity.

Volcano Sensor Web

The VSW Figure 1; see also *Chien et al.* [2005a]) monitors volcanoes around the world, as follows:

1. Asset 1 [e.g., MODIS (Moderate-Resolution Imaging Spectroradiometer) instruments on the Aqua and Terra spacecraft] acquire low-resolution (one kilometer per pixel) data.
2. Data from Asset 1 are downlinked and automatically processed to detect anomalous thermal emission.
3. Event notification is entered into an automated operations planner that generates sequences of commands to be executed by spacecraft and instruments.
4. Asset 2 (EO-1) is tasked to acquire high-resolution data.
5. New science data and products are rapidly downlinked and transmitted to scientists.

Table 1 shows the current 'initial detection' systems (Asset 1). Two such detection systems are at the University of Hawaii (UH): MODVOLC [*Wright et al.*, 2004], which automatically processes daily MODIS data; and GOESvolc (http://hotspot.higp.hawaii.edu), which processes GOES (Geostationary Operational Environmental Satellite) data from the Pacific rim at lower spatial but higher temporal (15-minute) resolution.

The Asset 1 category also includes volcanic ash advisories, issued by the seven regional Volcanic Ash Advisory Centers (VAACs; http://www.ssd.noaa.gov/VAAC/), and through U.S. Air Force Weather Advisories (https://afweather.afwa.af.mil/). These alerts, mostly from satellite data interpretation, are e-mailed and placed on Web sites later queried by JPL.

Many volcanoes are monitored by in situ automatic systems, which generate activity notifications when pre-set thresholds are exceeded. For example, the Hawaiian Volcano Observatory (HVO) tiltmeter network [*Cervelli and Miklius*, 2004] keeps a watchful eye on Kilauea and Mauna Loa. Tiltmeters can detect near-surface magma movement before an eruption, and this detection sometimes yields lead times ahead of an eruption of 24–36 hours, which is enough time to allow spacecraft to be re-tasked to observe increased effusion.

A detection triggers a response. Eruption notifications (from Asset 1) are used to initiate observations by the VSW reaction asset (Asset 2). Currently, Asset 2 is the Hyperion hyperspectral imager on EO-1, which is in a 705-kilometer-altitude, highly-inclined orbit. Hyperion obtains continuous spectra from wavelengths between 0.4 to 2.5 microns with a spatial resolution of 30 meters per pixel, in swaths that are 7.7 kilometers wide and >80 kilometers long. Targets can be observed up to 10 times every 16 days (up to five daytime and five nighttime observations), with more

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observation opportunities for polar targets. Although Hyperion lacks a thermal infrared capability (wavelengths from 8–12 micron) capability, which is important for modeling thermal emission, data are at higher spatial and spectral resolutions than MODIS and GOES, allowing for accurate geolocation of the most volcanically active areas.

Software agents at JPL continuously search for new Asset 1 notifications, which are collated and assigned a high or low priority value. The target location and priority information is passed to the JPL-based operations planner and scheduling system (ASPEN, the Automated Scheduling Planning Environment), which searches for observation slots in the EO-1 operations sequence. Up to five EO-1 observations can be inserted per notification, if necessary, replacing lower-priority observations. The resulting high-temporal-resolution observation sequence can be used to determine if the volcanic activity is waxing, is steady, or is waning.

Also on board EO-1 is the NASA Autonomous Sciencecraft Experiment (ASE) [*Chien et al.*, 2005b; *Davies et al.*, 2005], which is comprised of three computer applications that turn EO-1 into an autonomous, science-driven spacecraft. ASE consists of data-processing algorithms that detect thermal emission in Hyperion data, using spectral shape from 1.65 to 2.23 microns [*Davies et al.*, 2005] and the CASPER (Continuous Activity Scheduling, Planning, Execution, and Replanning) planner, which allocates available resources and generates commands. These are executed by the final ASE component, SCL (Spacecraft Command Language), which controls EO-1.

Onboard EO-1, ASE processes Hyperion data, and generates 'thermal summary' products [*Davies et al.*, 2005] that contain the number of hot pixels detected, their locations, and, for up to ~320 pixels, 12-wavelength spectra—a summary of the relevant science content of the dataset. A positive thermal detection generates a repeat observation, if a slot is available within the next few days, and downlinks the thermal summary. This capability is independent of, but compliments, VSW operations. Summaries are posted on the JPL-VSW Web site (http://sensorweb.jpl.nasa.gov) and made available to scientists within hours of data acquisition, typically weeks in advance of the full Hyperion data set. The entire process is autonomous. The final stage of this development phase closes the information loop via the automatic generation of e-mails containing the thermal summary URL to the relevant volcano observatory.

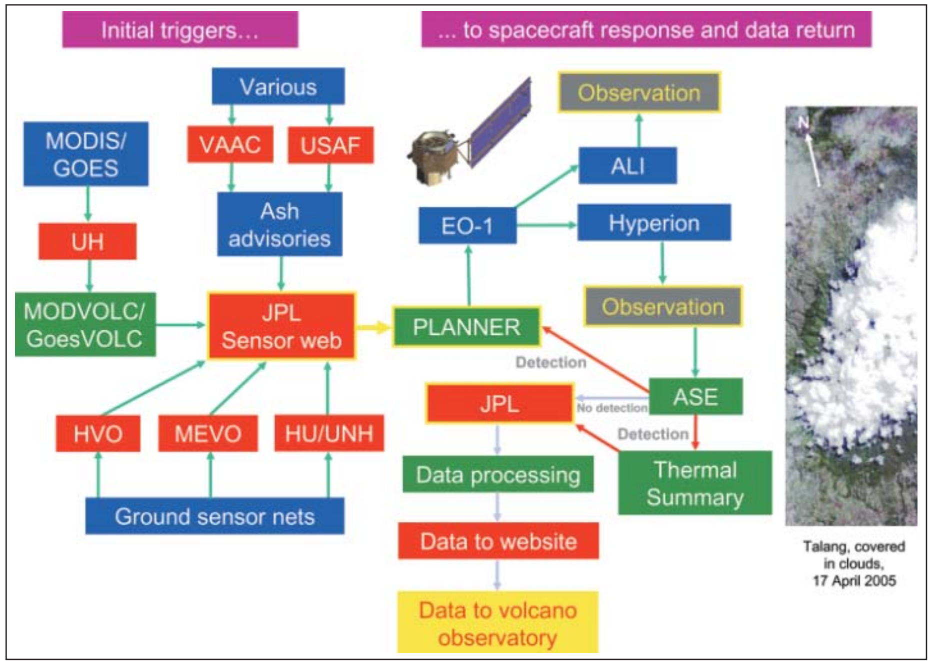
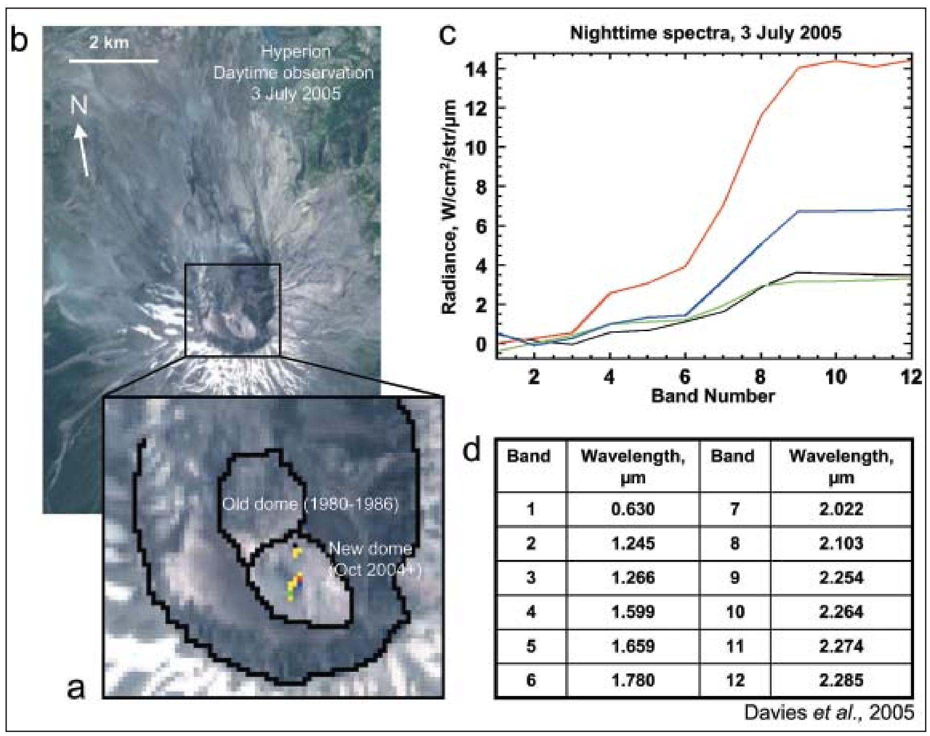


Fig. 1. VSW data flow. The Talang volcano observation, obtained on 17 April 2005, was triggered by a Darwin, Australia, VAAC ash advisory. The Hyperion image shows a cloud-covered Talang. No thermal emission was detected. The 7.7-kilometer-wide, stretched RGB image used Hyperion bands 28 (red), 20 (green), and 13 (blue).



Band	Wavelength, μm	Band	Wavelength, μm
1	0.630	7	2.022
2	1.245	8	2.103
3	1.266	9	2.254
4	1.599	10	2.264
5	1.659	11	2.274
6	1.780	12	2.285

Fig. 2. ASE detected 13 hot pixels in (a) a night observation of Mount St. Helens on 3 July 2005, (b) shown superimposed on the daytime reaction observation. Example of thermal summary spectra are shown in (c) for wavelengths in (d).

Using VSW on the Talang volcano

The Indonesian volcano Talang, located on the island of Sumatra, has offered one opportunity for using VSW. After centuries of dormancy, the volcano unexpectedly rumbled into life on 12 April 2005, producing a plume 1000 meters high that deposited ash on nearby villages.

Fearing a major eruption, local authorities began evacuating 40,000 people living nearby. At the United Nations Office for the Coordination of Humanitarian Affairs (OCHA), concern was great that further disaster would hit Sumatra in the wake of the December 2004 tsunami, and that already-stretched emergency-relief resources would be taxed even further. On 14 April, OCHA e-mailed volcanologists around the world, asking what systems were available to monitor Talang. But even as these e-mails were being read, the VSW had already picked up a notification of volcanic activity at Talang and re-tasked EO-1 to take a close look.

Subsequently, a Hyperion observation of Talang was obtained on 15 April. Two follow-up observations were inserted by operators on 17 April, a task easily accomplished by a JPL-based operator using ASPEN (now being used for planning all EO-1 operations). However, in this instance, a lack of a suitable time slot prevented thermal summary execution on the 17 April data. No thermal activity was detected in the 15 April data, but by this time volcanic activity had subsided, and the target was also obscured by clouds.

Nevertheless, it is striking that an autonomous system had detected the eruption alert and re-tasked a spacecraft before the full urgency of the situation had been realized. In the future, an ASE cloud detector could be used to determine whether a target is cloud-covered, allowing the onboard planner to schedule a repeat observation.

If thermal emission had been detected, the thermal summary would have been on the ground a few hours after data acquisition (Figure 2). Although in this example activity had ceased at the time of the response observation, the value of the autonomous sensor web was demonstrated to be superior to a purely human-driven response.

Table 1. Volcano notification systems incorporated into the sensor web: present and future

Application/Institution	Form of Notification
Space -Based	
Terra/Aqua MODIS (MODVOLC, UH)	thermal detection
GOES (Goes VOLC, UH)	thermal detection
U.S. Air Force Weather Advisory	volcanic ash and plume alert
International Aviation Authorities (VAACs)	volcanic ash advisory
Ground-Based	
U.S. Geological Survey Hawaiian Volcano Observatory (HVO)	tilmeter network: Kilauea, Manuna Loa
Mount Erebus Volcano Observatory (New Mexico Institute of Mining and Technology)	seismic, infrasound, tilt (presently manual)
Reventador (Harvard University/University of New Hampshire)	infrasound + satellite phone link to Web site
Future Deployment	
Anywhere ("Harris box" [*Harris et al.*, 2005])	thermal, seismic, etc.

VSW Under Construction

The VSW continues to grow. Other ground-based systems currently incorporated into the VSW include the geophysical network on Mount Erebus, Antarctica, which transmits data in real time to the Mount Erebus Volcano Observatory (MEVO) at the New Mexico Institute of Mining and Technology [*Aster et al.*, 2004]. Strombolian events in the summit lava lake show up in seismic and infrasound spectrograms, often augmented with video surveillance. Currently, the notification process is not fully automated, but progress towards full automation is under way.

Also now incorporated into the VSW are the portable wireless infrasonic and seismic networks that have been deployed by the University of New Hampshire and Harvard University at Reventador, a remote volcano in Ecuador [*Werner-Allen et al.*, 2005]. Data are transmitted from sensors to a central hub, relayed to Harvard via satellite telephone, and posted on a Web site. The summer 2005 deployment was dogged by intermittent connectivity, but future deployments are planned.

In the future, it could be possible to rapidly deploy self-contained monitoring stations to volcanoes at times of volcanic unrest. Examples of self-contained, inexpensive thermal monitoring systems [*Harris et al.*, 2005] have been successfully tested on Kilauea, Hawaii, and data-collecting and transmitting 'spiders' have been deployed on Mount St. Helens. With the appropriate applications to process data and generate activity notifications, connection to the existing VSW is straightforward.

Between December 2004 and December 2005, the VSW generated over 150 observations of more than 35 volcanoes around the world. Operations are continuing through 2007, observation frequency is increasing, and the VSW is expanding as new systems are added. Volcano observatories are invited to examine current resources and consider adding notifications to the VSW.

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