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A multidisciplinary monitoring network at Mayon volcano, Philippines: A collaborative effort between PHIVOLCS and EOS

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Mount Mayon in Albay province (Philippines) is an openly-degassing basaltic-andesitic stratovolcano, located on the northern edge of the northwest-trending OAS graben. Its latest eruptions were in Aug-Sept 2006 and Dec 2009. Mayon's current status is PHIVOLCS' level 1 with low seismicity dominated mostly local and regional tectonic earthquakes and continuous emission of SO_2 from its summit crater. A research collaboration between the Earth Observatory of Singapore-NTU and the Philippine Institute of Volcanology and Seismology (PHIVOLCS) was initiated in 2009, aimed at developing a multi-disciplinary monitoring network around Mayon.

The network design comprises a network of co-located geophysical, geochemical, hydrological and meteorological sensors, in both radial and circular arrangements. Radially arranged stations are intended to capture and distinguish vertical conduit processes, while the circular station design (including existing PHIVOLCS stations in cooperation with JICA, Japan) is meant to distinguish locations and sector activity of subsurface events. Geophysical instrumentation from EOS currently includes 4 broadband seismographs (in addition to 3 existing broadbands and 3 short period instruments from PHIVOLCS & JICA), and 5 tiltmeters. Four continuous cGPS stations will be installed in 2012, complementing 5 existing PHIVOLCS stations.

Stations are also designed to house a multi-sensor package of static subsurface soil CO_2 monitoring stations, the first of which was installed in early 2012, and which include subsoil sensors for heat flux, temperature, and moisture, as well as meteorological stations (with sonic anemometers and contact rain gages). These latter sensors are all controlled from one control box per station. Meteorological stations will help us to validate tilt, gas permeability, and also know lahar initiation potential. Since early 2011, separate stations downwind of the two prevailing wind directions from the summit continuously monitor the SO_2 plume during daylight (the first Asian NOVAC dual-channel mini-DOAS). One unused agricultural well and one boxed spring were equipped with multi-sensor probes, installed in spring and summer 2011, to detect bulk volumetric strain and changes in chemical composition in high-gain and low-gain mode. All stations are autonomous in terms of their power source (solar), and are designed to withstand typhoons, break-in attempts and direct/indirect lightning strikes.

To telemeter the data from these instruments to the local PHIVOLCS observatory at Lignon Hill (Legazpi), we use spread-spectrum radios with our own repeater stations, GSM/GPRS radio modems, and 3G broadband Internet. High rate data including seismic and NOVAC SO_2 data are transmitted via spread-spectrum radio, whereas tilt, ground CO_2, meteorology, hydrology and soil parameters are transmitted via 3G and SMS. We designed a low-cost datalogger system, which has been operating since Jan 2011, performing continuous data acquisition with sampling rate of 20 minute/sample and transmitted through GSM network, for tilt data. The receiving station is the PHIVOLCS Lignon Hill Observatory (LHO), where an off-grid power system has been installed to ensure continuous operation of the monitoring computers and radios. Local pre-processing by observatory staff and local archiving ensures close to immediate availability of data products in times of crisis. The data are also forwarded via TCP/IP to servers at PHIVOLCS headquarters and at EOS. Network infrastructure and data flows will be completed in 2012.