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*'Understanding volcanoes and society: the key for risk mitigation'*



## **Developments in Multi-Parameter Monitoring of Active Volcanoes of the Philippines**

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PHIVOLCS' National Volcano Monitoring and Warning Program develops and manages integrated multi-parameter monitoring networks on the Philippines' eight most active volcanoes – Mayon, Taal, Bulusan, Kanlaon, Hibok-Hibok, Pinatubo, Matutum and Parker. These networks generate high-quality geophysical, geodetic, geochemical and other observation data in support of volcanic eruption early-warning and prediction services. Each network is equipped with end-to-end data communication systems for real-time telemetry to its corresponding Volcano Observatory, which also functions as base operations for eruption monitoring, periodic field-based methodologies and community engagement. Multi-parameter data from the Observatories are then automatically forwarded to PHIVOLCS headquarters for additional analyses. From the advent of digital short-period seismic monitoring in 2000, remote real-time monitoring alone now consists of 49 mainly broadband seismic, 4 infrasonic, 28 continuous operating GPS, 8 electronic tilt, 7 gas/physio-chemical, 5 IP camera and 3 electromagnetic stations. Support strategies include the application of new technologies and systems, adaptation of the WOVODat schema for digital database development and systems automation, implementation of operational standards and institutional partnering for the pilot implementation of experimental systems and observation technologies. The development of the monitoring systems entailed hazard and risk communication to various stakeholders, strategic planning, long-term funding, institutional partnerships, and sustained engagement with the community, local governments, national agencies and the media.

Enhanced multi-parameter monitoring has been generating new perspectives on the dynamics and timescales of, among others, magma/hydrothermal recharge, volatile transfer and intrusion; magmatic or hydrothermal forcing of observed ground deformation, surface degassing and volcanic to distal seismicity; and tectonic contribution to overall unrest. It is envisaged that multi-parameter data will ultimately yield highly constrained criteria that can be integrated into the five-tiered Alert Level Scheme used in eruption crisis response of local and national disaster authorities.

Key words: multi-parameter, monitoring, strategic planning, risk communication, partnerships