An example of scalable and sustainable volcano monitoring network

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It is accepted that all volcano with probability of eruption must be monitored and as more and better instrumentation is better. However, in volcanoes with long period of repose, it is difficult to obtain founding for the acquisition, operation and maintenance of extensive monitoring networks. This situation is aggravated in limited resources countries where instruments could be donned but can not be operated or maintained. In addition, monitoring networks become obsolete and must be replaced before the volcano shows signs of unrest. A solution to optimize volcano monitoring and resources is to deploy a minimal instrumentation to detect the unrest and then complete it in a short time to attend a possible eruption. This instrumentation can be updated with reasonable cost, incorporating new technologies. We present an instrument designed for unrest detection, using current and available technological resources, consisting of seismic, deformation and gases sensors with remote data-access and software. This system has been developed using Raspberry Pi modules, having very wide support, hardware and software for its large users community. These modules are powerfully to manage both communications systems and multiple sensors. A low-cost sub centimeter GNSS with RTKLIB (or similar data process packages) and nondispersive Infrared (NDIR) CO_2 sensor are used. Low-cost 4.5 Hz seismic sensor (< \$100) with a preamplifier to expand the frequency response to 1.0 Hz and a 16 bits ADC to obtain an adequate dynamic range. Real-time data streams are mostly acquired over Internet using SeedLink or SSH protocols. In many occasions, there is preferable send data by e-Mail with GSE2 data format. Low-cost telemetry modules (up to 10 km) can be used to Internet access. This development is result from several years of experience in different volcanoes: Deception (Antarctica), Villarrica (Chile), Colima (México), Stromboli (Italia), Tungurahua (Ecuador), Tenerife and El Hierro (Canary Islands).