Enhanced sub-daily near real-time surface deformation analysis at Deception (South Shetland) and El Hierro (Canaries) Islands

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A methodology for near real-time surface deformation analysis was developed and applied at Deception Island. It relies on a minimum of three strategically deployed benchmarks' position variations at sub-daily rates determined by GNSS-GPS (Global Navigation Satellite Systems - Global Positioning System) geodetic techniques. The benchmarks' positions were reached every 30 minutes with the double-differenced ionosphere-free combination, a 10 degrees cut-off angle and precise ultra-rapid ephemerides, along with pre-processed 3-hourly ambiguity solutions and hourly tropospheric zenith delay corrections. Multipath and residual loading and meteorological effects were further dealt by a discrete Kalman filter. The method's position accuracy was accessed at 1mm in the northing and easting components and 2mm in the height component, when applied to baselines up to 300km, with a reference benchmark that is far away from the volcano's dynamic influence. Supported on accurate benchmarks' positions, a normal vector analysis was applied to triangles covering the monitored surface determining instantaneous strain and inclination.

In Deception Island significant ground deformation was identified in the 2003-2004 campaign before a three years extension process with an acceleration present throughout the 2006-2007 campaign. Along the 2003-2004 campaign the highest number of LP events was detected since the Spanish Antarctic campaigns are carried out, and an increase in the sulphur dioxide flow was detected. As the geodetic campaign ended in 2003-December while the LP events increase begun in 2004-January, ground deformation was precursory to the LP events and sulphur dioxide flow increases. Conversely, the three years extension process had no reported significant seismic activity or increase of gas emissions, with the 2006-2007 austral summer having one of the lowest number of detected seismic events per day. This seismic calmness contrasts with the campaign's 23 ppm/year triangle's extension rate. These methods were also applied in El Hierro Island during its unrest and eruption. Along the process all available benchmarks' position time series were made accessible in near real-time. Nine days before the eruption is detected through a volcanic tremor, a sudden southwards deformation for two days followed by a strong northwards compensation is identified. Some larger magnitude seismic events accompany these strong trend shifts. This sequence may be related to a rupture along the magma pathway, with fluid pressure decrease and its stabilization after. A correlation was also identified between ground deformation and larger magnitude seismicity. Several times an increase in height precedes a sequence of seismic events while heights decrease. The same can be observed in the northing component where these seismic events accompany southwards deformation. The ground deformation was precursor to the seismic activity, but also was influenced by seismic activity.