percent of tremor episodes accompany eruptions, while 20-40 percent do not. Thus there is a significant chance that no eruption is occurring. Second, for each VEI, there is a range of DR, so it is possible to overestimate or underestimate the VEI from the DR. Hence there will always be a false alarm rate of about 10 percent. Improvements can be made in the estimates if the types of eruptions, shapes of vents, and gas contents are known. These can be estimated in advance from previous eruptions or measured near-real-time from independent data. However, adding additional information takes time, thus delaying forecasts. A primary benefit of seismic data is that it is real-time, it is not affected by darkness, and is usable during poor weather, although the signal-to-noise ratio can be worsened. Monitoring tremor DR is thus an effective way to characterize eruptions in progress.

V22C-06 1445h

Puffers and Chuggers: Statistical Curiosities in Volcano World

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Several on-going, low level volcanic explosions exhibit background phenomena commonly known as puffing, or in some cases chugging. Recently these events have been scrutinized because of the initiation of infrasonic monitoring, whereas earlier the events may have gone undetected. The activity associated with a puffer at a volcanic vent is generally small in magnitude and is often not observed audibly. The low frequency signals are readily observed on sensitive acoustic instrumentation and they provide a new dimension for our understanding of volcanic processes at volcanoes like Stromboli and Etna that have constant puffing signals. At other volcanoes, like Karymsky volcano in Kamchatka and Sangay Volcano in Ecuador, chugging signals associated with Strombolian style eruptions also provides new insights into the physics of the conduit systems. Here we present a statistical method of event detection, and event cluster association. When multiple vents work in unison it may be difficult to separate out chugging and puffing signals between spatially separated vents. The cluster analysis automatically differentiates between the vents based on waveform characteristics in the acoustic and seismic wavefields. Data examples from May, 2001, at Stromboli and Etna, show extensive periods of puffing (1-5 second frequency) superimposed on a background of vigorous, small-scale explosive activity. At Karymsky and Sangay non-linear, dynamic models explain the fluid flow through vents which gives rise to chugging. Furthermore, the frequency of chugging events appears to be associated with the intensity of lava flows and eruption rate.

V22C-07 1520h

Sensitivity of a Hydrothermal System to Small Seismic Events

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The hydrothermal systems of Yellowstone National Park,well known to have experienced widespread impacts following M7 events in 1959 and 1983, have also shown more localized responses to several smaller events in recent years. Comparison of geyser activity reports with earthquake catalogs leads to a preliminary guideline: if $M - 2\log D > 2$, significant changes are likely, while if $M - 2\log D < 1$, even minor changes are unlikely, where M is the earthquake magnitude and D is the distance from epicenter to the hydrothermal system in km.

Distinguishing localized effects of a small nearby seismic event from normal changes in a hydrothermal system's behaviour is not a trivial task. As a case study, the dramatic changes in activity of the White Creek Group of the Lower Geyser Basin in summer and fall 1996 were examined. Evidence for attributing these to a M3.7 event on 30 June 1996, and not to other events in mid-July 1996 or to nonseismic processes, is discussed.

URL: http://denali.frontier.iarc.uaf.edu/~grb/quakes.htm

V22C-08 1535h

WOVOdat: A New Tool for Managing and Accessing Data of Worldwide Volcanic Unrest

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WOVOdat (World Organization of Volcano Observatories database of volcanic unrest) will for the first time bring together data of worldwide volcanic seismicity, ground deformation, fumarolic activity, and other changes within or adjacent to a volcanic system. Although a large body of data and experience has been built over the past century, currently, we have no means of accessing that collective experience for use during crises and for research.

WOVOdat will be the central resource of a data management system; other components will include utilities for data input and archiving, structured data retrieval, and data mining; educational modules; and links to institutional databases such as IRIS (global seismicity), UNAVCO (global GPS coordinates and strain vectors), and Smithsonians Global Volcanism Program (historical eruptions). Data will be geospatially and time-referenced, to provide four dimensional images of how volcanic systems respond to magma intrusion, regional strain, and other disturbances prior to and during eruption.

As part of the design phase, a small WOVOdat team is currently collecting information from observatories about their data types, formats, and local data management. The database schema is being designed such that responses to common, yet complex, queries are rapid (e.g., where else has similar unrest occurred and what was the outcome?) while also allowing for more detailed research analysis of relationships between various parameters (e.g., what do temporal relations between long-period earthquakes, transient deformation, and spikes in gas emission tell us about the geometry and physical properties of magma and a volcanic edifice?).

We are excited by the potential of WOVOdat, and we invite participation in its design and development. Next steps involve formalizing and testing the design, and, developing utilities for translating data of various formats into common formats. The large job of populating the database will follow, and eventually we will have a great new tool for eruption forecasting and research.

URL: http://www.wovo.org/wovodat.htm

V22C-09 1550h

An Interactive Geospatial Database and Visualization Approach to Early Warning Systems and Monitoring of Active Volcanoes: GEOWARN

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Large parts of southern and central Europe and the Pacific rim are situated in tectonically, seismic and volcanological extremely active zones. With the growth of population and tourism, vulnerability and risk towards natural hazards have expanded over large areas. Socio-economical aspects, land use, tourist and industrial planning as well as environmental protection increasingly require needs of natural hazard assessment. The availability of powerful and reliable satellite, geophysical and geochemical information and warning systems is therefore increasingly vital. Besides, once such systems have proven to be effective, they can be applied for similar purposes in other European areas and worldwide. Technologies today have proven that early warning of volcanic activity can be achieved by monitoring measurable changes in geophysical and geochemical parameters. Correlation between different monitored data sets, which would improve any prediction, is very scarce or missing. Visualisation of all spatial information and integration into an "intelligent cartographic concept" is of paramount interest in order to develop 2-, 3- and 4-dimensional models to approach the risk and emergency assessment as well as environmental and socio-economic planning.

In the framework of the GEOWARN project, a database prototype for an Early Warning System (EWS) and monitoring of volcanic activity in case of hydrothermal-explosive and volcanic reactivation has been designed. The platform-independent, web-based, JAVA-programmed, interactive multidisciplinary multiparameter visualization software being developed at ETH allows expansion and utilization to other volcanoes, world-wide databases of volcanic unrest, or other types of natural hazard assessment. Within the project consortium, scientific data have been acquired on two pilot sites: Campi Flegrei (Italy) and Nisyros Greece, including 2&3D Topography & Bathymetry, Elevation (DEM) & Landscape models (DLM) derived from conventional satellite data; geological, seismic, magnetotelluric, remote and land-based IR thermal, and geodetic data (differential GPS), interferometry, as well as time series of various geochemical and meteorological measurements in addition to historical and published data. Among the main objectives of the project are the visualisation of the different monitored data sets, correlation of all spatial information and their intergration into an "intelligent cartographic concept". As result, easy and user friendly interaction allows 2, 3, and 4D modelling of hazards (scenarios, zonation), vulnerability, risk and emergency assessment. Different customizable access levels and -types for contributing scientists and observatories, administration (civil defense etc.) and the public (outreach, awareness, education) ensure a safe operation over a long period of time.

URL: http://www.geowarn.org

V22C-10 1605h

On the Identification of the Precursory Patterns of Volcanic Eruptions

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The complexity of the process responsible for volcanic eruptions makes a theoretical approach to forecasting the evolution of a volcanic unrest rather unrealistic. The only viable strategy appears to be the identification of possible repetitive schemes (patterns) in the pre-eruptive unrest of volcanoes. Nevertheless, the scarce availability and the heterogeneity of pre-eruptive data, and an objective difficulty in quantitatively recognizing complex pre-eruptive patterns, make this task very difficult.

In this work we address this issue by using a pattern recognition approach, which is a powerful multivariate technique that has been successfully applied to complex systems in many scientific disciplines. This technique analyzes data belonging to different classes, taking into account, for each data, several variables potentially influent on the process at a time. The procedure adopted has been proved to give satisfactory results also in dealing with few data, even if not normally distributed and/or discrete. Moreover, it gives useful information on which variables really play a predominant role in the process, among all those suspected to.

As regards the dataset used, in this work we have retrieved data relative to seismicity recorded during several volcanic unrests around the world. The predominant use of seismic data is caused by their availability for the largest part of volcanic systems undergoing to volcanic unrest and because they are of prominent importance in characterizing the unrest before an eruption.

The main goal is to provide new insights concerning possible patterns among the volcanic unrests preceding an eruption, and their dependence on the magnitude or on the type (close or open conduit) of the impending eruption.

The results show evidence of energetic differences existing in the seismicity between unrests preceding an eruption (especially if it is a large and explosive one) and isolated unrests. On the opposite, if the unrest is followed by an eruption, it seems that the seismic energy released in the unrest is not indicative of the magnitude of the impending eruption. Generally, unrests followed by the largest explosive eruptions have a longer repose time than those related to moderate eruptions.

V22C-11 1620h

Probabilistic modeling of the long-term spatial patterns of eruptive centers: Case studies from Higashi-Izu and Kannabe-Oginosen monogenetic volcano groups, Japan

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