Network for Observation of Volcanic and Atmospheric Change (NOVAC)

Community technology development and implementation for volcanic gas monitoring

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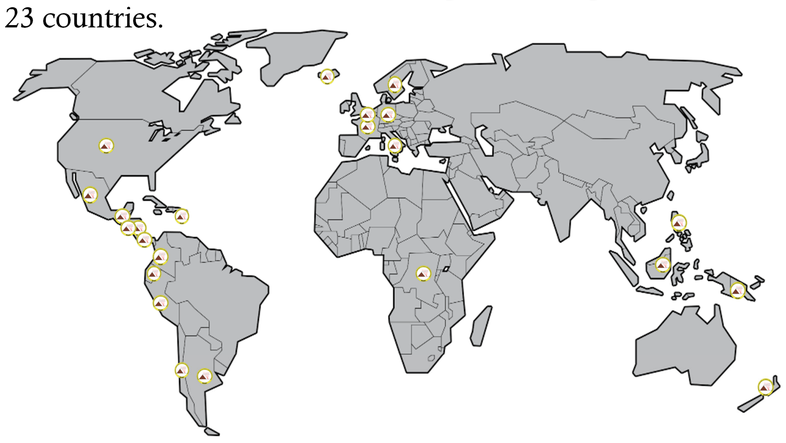
novac-community.org

What is NOVAC?

The Network for Observation of Volcanic and Atmospheric Change (NOVAC) is a community of volcano observatories and research institutions that together develop and apply ultraviolet differential optical absorption spectroscopy (DOAS) instruments to measure volcanic sulfur dioxide (SO_2) emission rates. The collected data are used for assessment of volcanic activity, eruption forecasting, research on volcanic processes, and studying the atmospheric impact of volcanic degassing. Since 2005, the NOVAC institutions have been running the largest global instrument network for monitoring volcanic gas emissions, currently at 54 volcanoes across 23 countries.



Symbols indicate countries with institutions participating in NOVAC

Building Community

Through joint technology development, regular workshops, and support from organizations such as USGS/VDAP, EU-FP7, UNESCO-IGCP, Chalmers University, and EGU, NOVAC provides a community for partners to share technology, training, and volcanic gas monitoring experience with researchers and engineers from institutions all over the world.

Partners

GLOBAL STUDIES
Chalmers (SE)
VDAP (US)
Heidelberg U. (DE)
IFM-GEOMAR (DE)
BIRA (BE)

IMO (IS)
Hekla
Krýsuvík
Katla

INGV (IT)
Vulcano
Stromboli
Etna

OVG (CD)
Nyiragongo

IGCP (FR)
Piton de la Fournaise

PHIVOLCS (PH)/EOS
Mayon
Canlaón

BPPTKG (ID)
Sinabung
Gamalama
Merapi

RVO (PG)
Rabaul
Ulawun

GNS-Science (NZ)
Ruapehu
Tongariro

USGS (US)
Mt. Cleveland
Mt. St. Helens

UNAM/CENAPRED (MX)
Fuego de Colima
Popocatépetl

MVO (MS)
Soufrière Hills

INSIVUMEH (GT)
Santiaguito
Volcán de Fuego

MARN (SV)
Santa Ana
San Miguel

INETER (NI)
San Cristóbal
Telica
Momotombo
Masaya
Concepción

OVSICORI (CR)
Rincón de la Vieja
Arenal
Poás
Turrialba

SGC (CO)
Nevado del Ruiz
Puracé
Galeras

IGEPN (EC)
Cayambe
El Reventador
Cotopaxi
Sierra Negra
Tungurahua
Sangay

IGP/INGEMMET (PE)
Sabancaya
Misti
Ubinas

SERNAGEOMIN (CL)
Isluga
Láscar
Planchón Peteroa
Nevados de Chillán
Copahue
Llaima
Villarrica

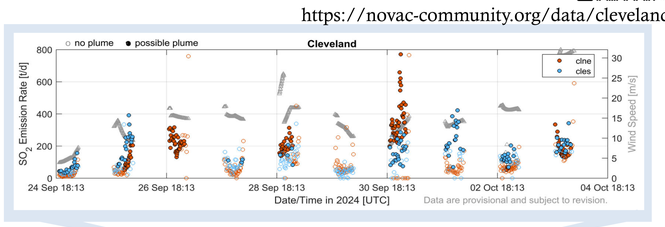
SEGEMAR (AR)
Planchón Peteroa

23 countries
25 institutions
50+ volcanoes
150+ stations

Remote Sensing of Volcanic SO_2 Emission Rates

Mobile and scanning DOAS instruments measure the absorption of UV skylight by volcanic gases overhead.

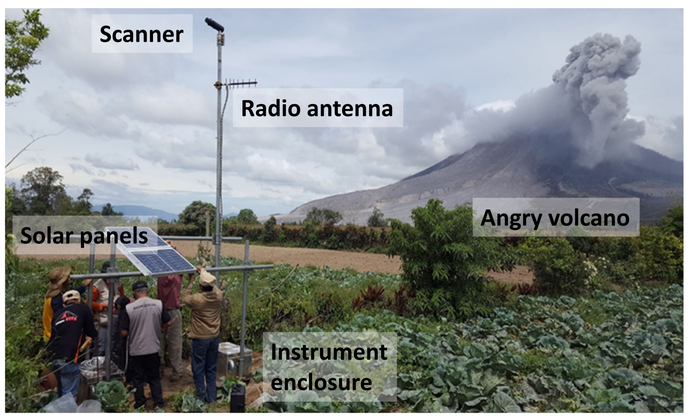
Live data feed:
https://novac-community.org/data/cleveland

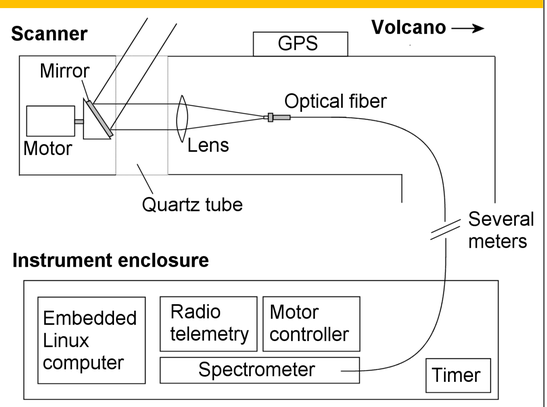


Either by passing across a volcanic plume or scanning the sky from a fixed location, the instruments determine the SO_2 burden in the plume cross-section. Multiplication with the wind speed yields the emission rate (e.g., in kg/s or tons/day). Ground-based measurements are about an order of magnitude more sensitive than satellite instruments and are thus more likely to catch weak, precursory degassing in the lead up to volcanic unrest.

NOVAC Instrumentation

NOVAC scanning DOAS installed on Sinabung Volcano, Indonesia



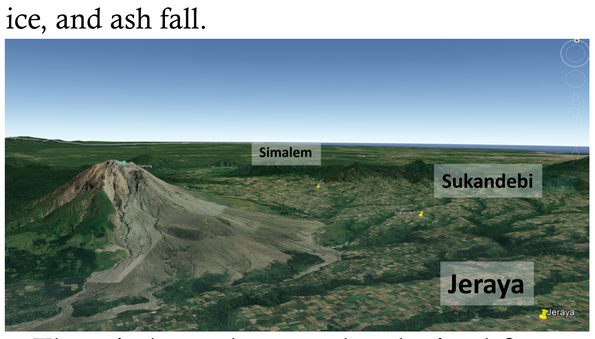


Schematic of 4th Generation NOVAC scanning DOAS instrument

The NOVAC scanning DOAS instruments are specifically designed to measure gas emission rates from volcanoes by measuring the absorption of skylight by gases in the plume. A scanner is mounted on a mast and scans the sky from horizon to horizon in a conical geometry. The collected light is coupled into an optical fiber and sent down the mast to a moderate resolution UV spectrometer (e.g., Avantes AvaSpec-Mini, Ocean Optics Maya Pro, or similar). An embedded Linux computer runs the measurements and stores the spectra on board. A GPS receiver provides accurate time stamps. A timer can be used to switch off the instrument at night. The instruments can run autonomously but are typically connected to the volcano observatory by radio or cellular telemetry. The instruments are designed to withstand harsh environmental conditions, including snow, rime ice, and ash fall.

Three NOVAC scanners were installed 6 km east of Sinabung Volcano, Indonesia in 2016. Scanners can be installed at any distance, but more distal instruments only cover a narrow range of wind directions. Installing multiple scanners allows the plume distance d to be triangulated, which is required for calculation of the SO_2 emission rate ϕ:

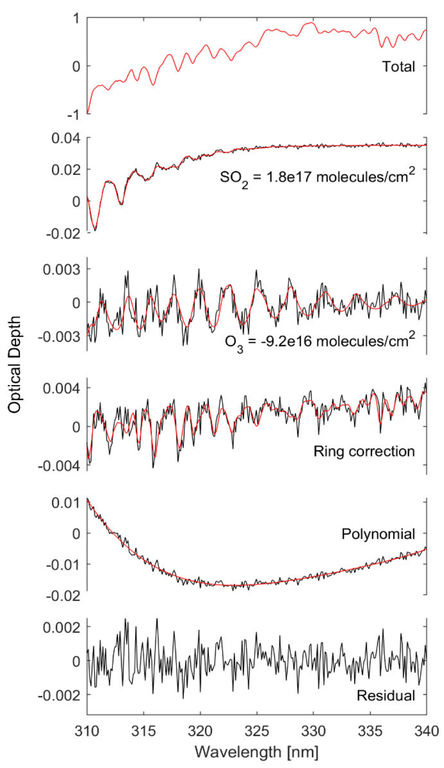
$$\phi = X \cdot v = v \cdot \int_{plume} S(\alpha) \cdot d \cdot cos(\beta)\, d\alpha$$



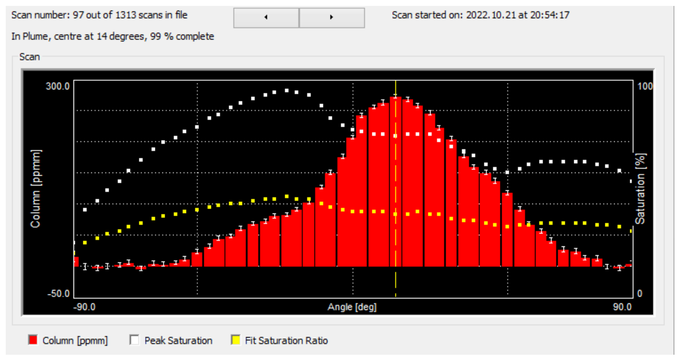
The wind speed v must be obtained from an independent source or meteorological model.

NOVAC Software

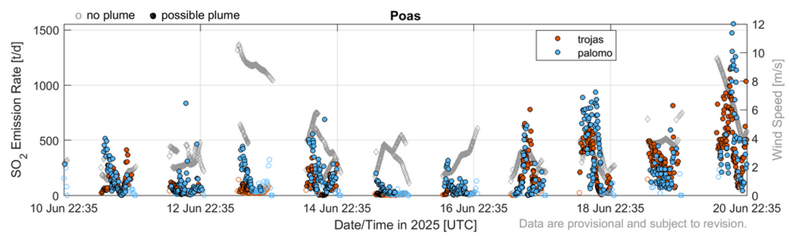
Working together, the NOVAC community has developed, tested, and distributed a wide range of software for analyses of volcanic gas measurements. Links to the freely available software packages are listed on the NOVAC website at https://novac-community.org/software. Some of the available features are listed below.



Example DOAS analysis of SO_2

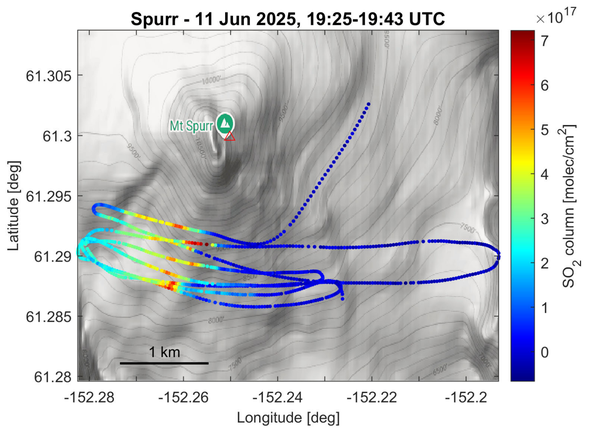


The **NOVAC Program** performs real-time DOAS analyses on all collected spectra, integrates the cross-sectional SO_2 burdens, downloads wind information from the NOAA Global Forecast System, and calculates SO_2 emission rates.



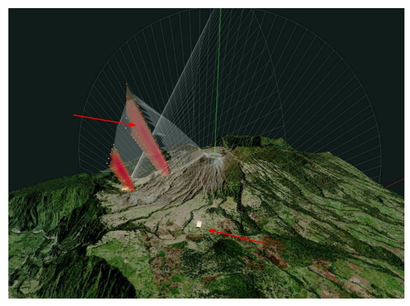
NOVAC Explorer allows plotting of near-real-time emission rates from data uploaded to the global data repository.

Mobile DOAS is used to acquire data from moving platforms such as vehicles and aircraft. Real time analysis and display allows users to adapt their measurements on the fly.



mDOAS provides tools for spectral and spatial analysis of mobile DOAS data as well as data mapping and visualization.

Inside each scanning DOAS instrument, data acquisition is performed autonomously by an embedded Linux computer. The '**kongo**' software drives the scanner motor and saves spectra on-board, tagging each with GPS time.



Volcanic Cloud Viewer allows tomographic reconstruction of plumes when they are observed by more than one scanning DOAS.