

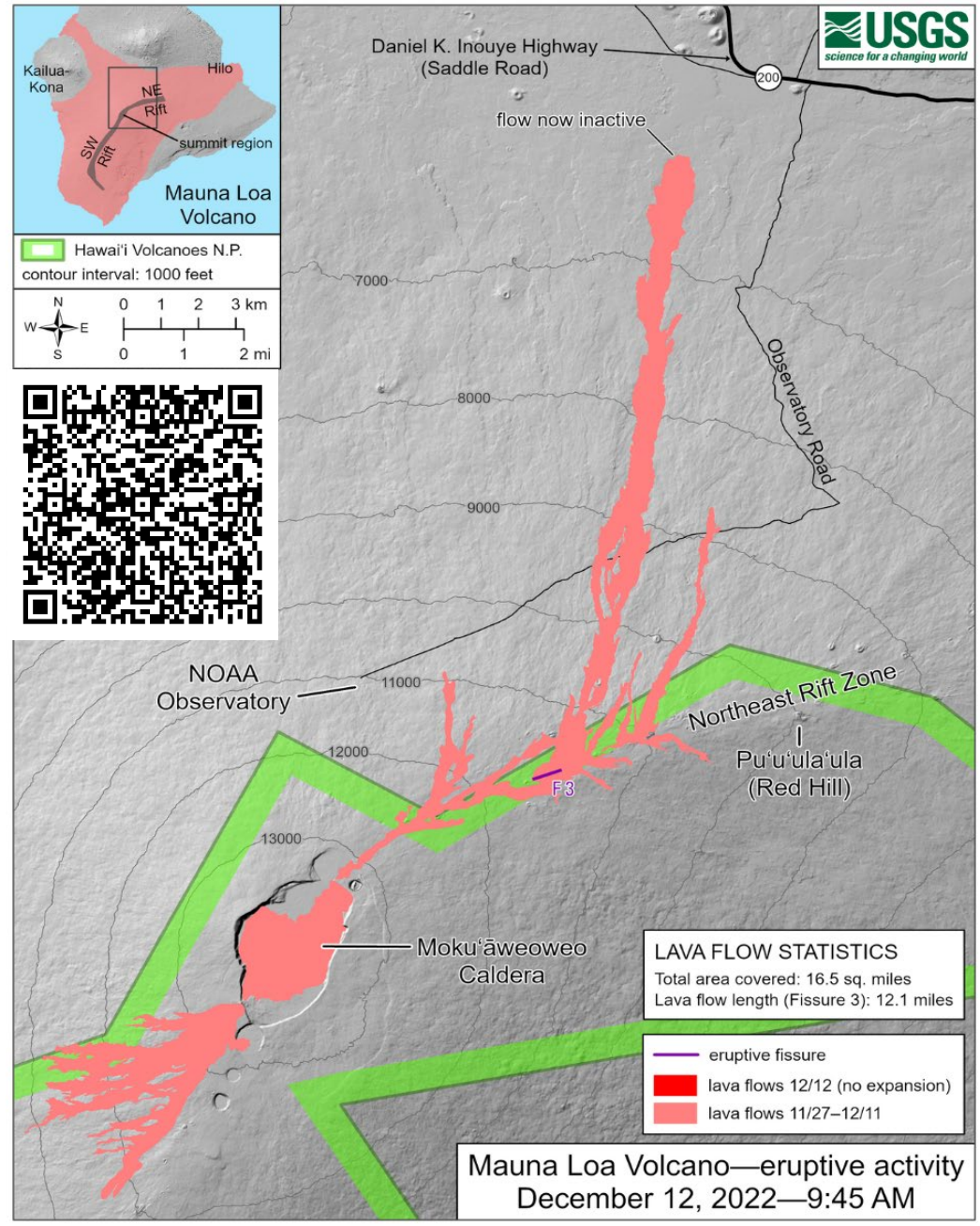


PROBABILISTIC ASH FORECASTS: Case study of Mauna Loa eruption in 2022

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Eruption of Mauna Loa



Mauna Loa erupted on 27 November 2022 for the first time in 38 years. The ash producing portion of the eruption was relatively short. The eruption was first reported to the Washington Volcanic Ash Advisory Center (W-AAAC) by the Honolulu Weather Forecast Office (WFO) and the Hawaiian Volcano Observatory (HVO). Two of the most difficult aspects during the initial stages of the eruption were determining how much ash was in the plume and the plume top height. Later on, the biggest challenge was estimating how long the ash would remain in the distal cloud.

Figure 1: The Northeast Rift Zone eruption of Mauna Loa that began the evening of November 27, 2022, continues at greatly reduced levels as of December 12, 2022 (fifteenth full day). Only incandescence was observed within fissure 3 overnight. This morning, field crews heard small explosions accompanied by sprays of spatter from the west end of the fissure 3 vent. The channels below the vent appear drained of lava and no longer feed the main flow front. For this reason, the total area covered by lava is unchanged since yesterday. (Courtesy of USGS) <https://www.usgs.gov/media/images/december-12-2022-mauna-loa-eruption-map-fsience>



VAA's Issued

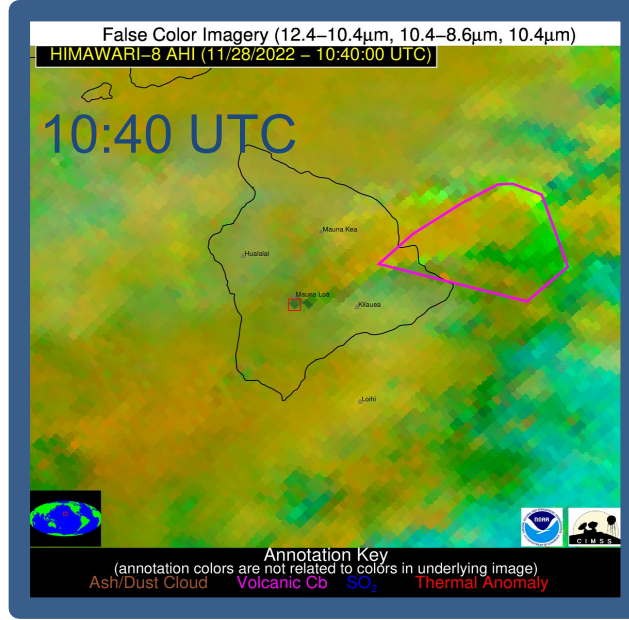
Washington VAAAC issued VAA and VAG for Event:

Initial VAA – 10:22 UTC 28 November 2022

First forecast VAA – 10:46 UTC 28 November 2022

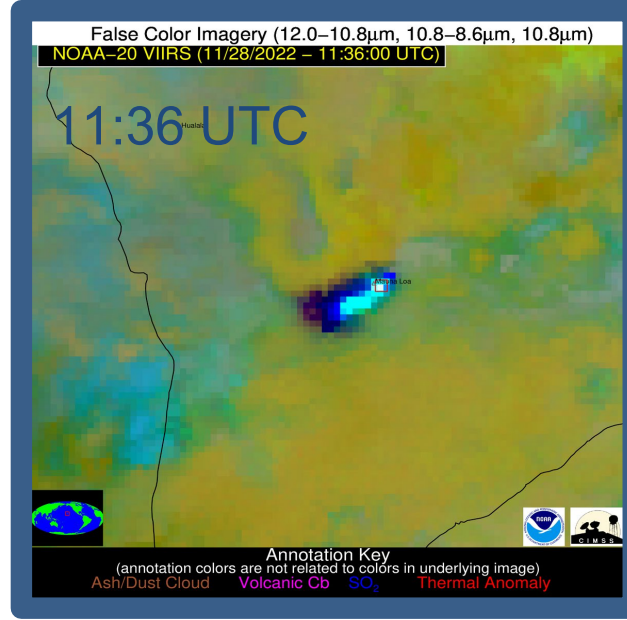
Updated forecast VAA – 12:29 UTC 28 November 2022

End VAA – 04:15 UTC 29 November 2022



VOLCAT False color imagery from Himawari about 1 h after the eruption. Detected plume outlined in magenta.

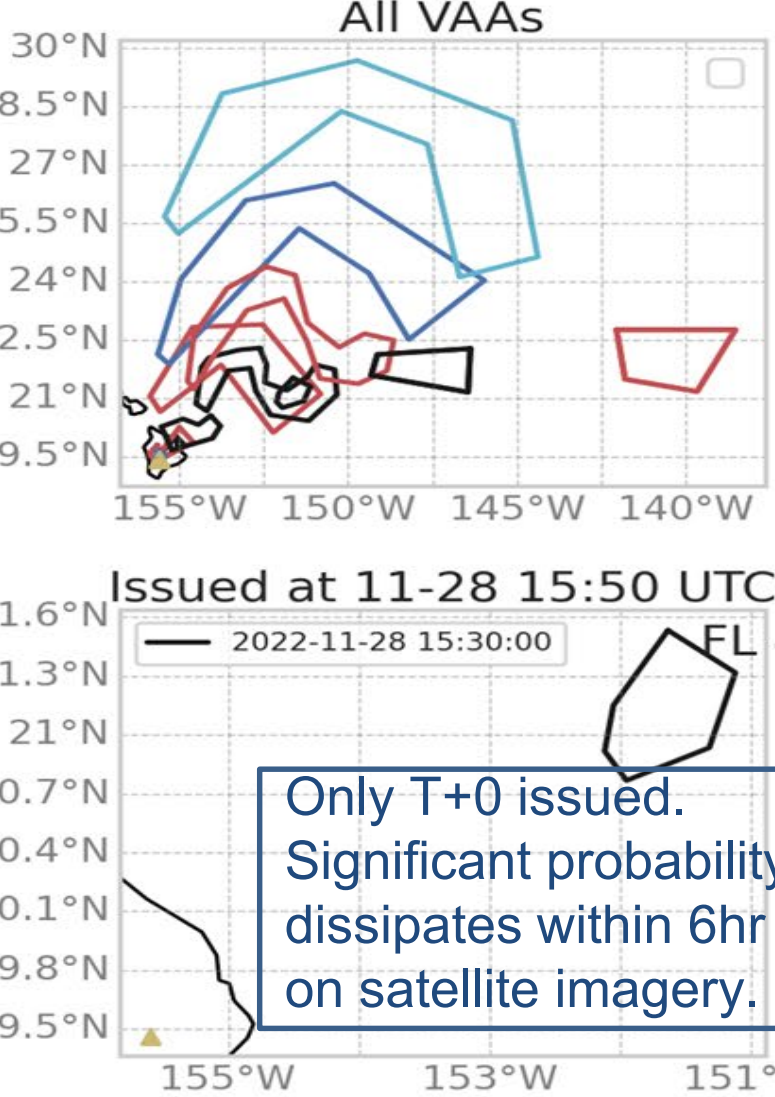
Initial large uncertainty in amount of ash in the plume as well as whether eruption would be ongoing. RIK: LRG ERUPTION OBS AT SUMMIT FM STLT AND WEBCAM. OBSERVATORY AND WFO RPTD THAT VA IS LIKELY MIXED INTO LRG PLUME NW NE THRU HILO AIRPORT. MDL WINDS EXP TO REMAIN NE THRU T+6 HRS.



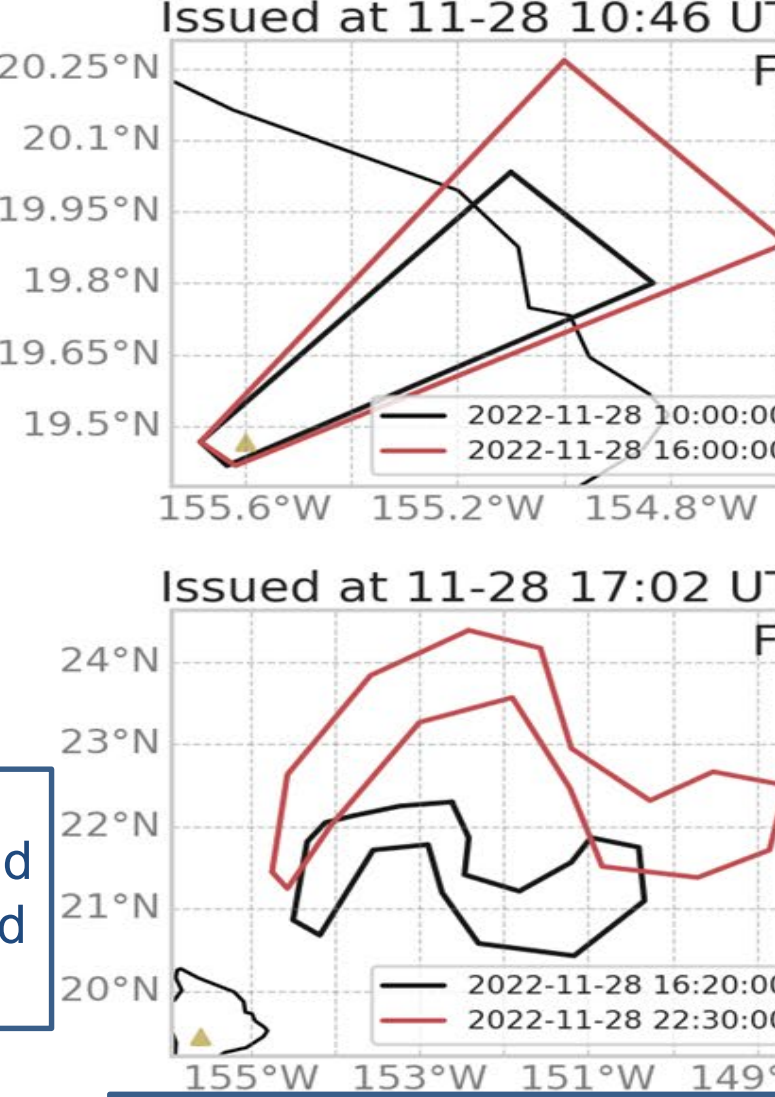
VOLCAT False color imagery from VIIRS about 2 h after the eruption. No more ash emissions are observed.

Probability that the ash cloud could remain and not dissipate. Forecast out to T+18 issued.

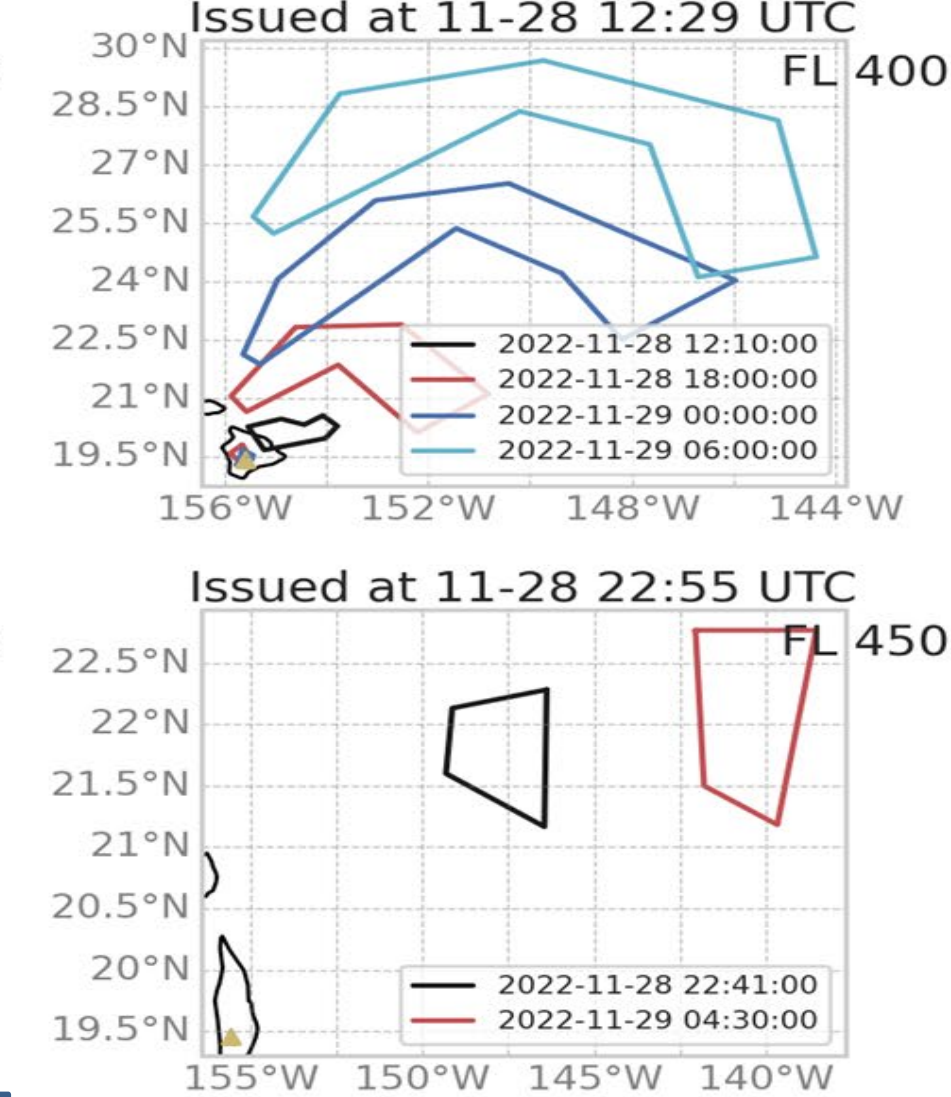
RIK: STRONG VA EHS OBSD IN SAT. VA CLOS EXTD APPX 100NM NE FM SUMMIT. USGS AND NNP MDL FCST NE WINDS THRU T+18HRS. ...ZENG



RIK: LGT VA PLUME MIXED WITH GAS OBSD IN SAT APPX 250NM NE FM SUMMIT. GAS PLUMES MOVG NE. NNP MDL FCST THRU T+6HR. ...ZENG



RIK: AFTER REEVALUATION, LKLY MORE ASH MIXED WITH GAS PLUMES MOVG NE FM SUMMIT. VA CLOS EXPANDD E AND NE AT FL450. MDL FCST CONS LTGCG MOVEMENT THRU T+6HRS. ...ZENG



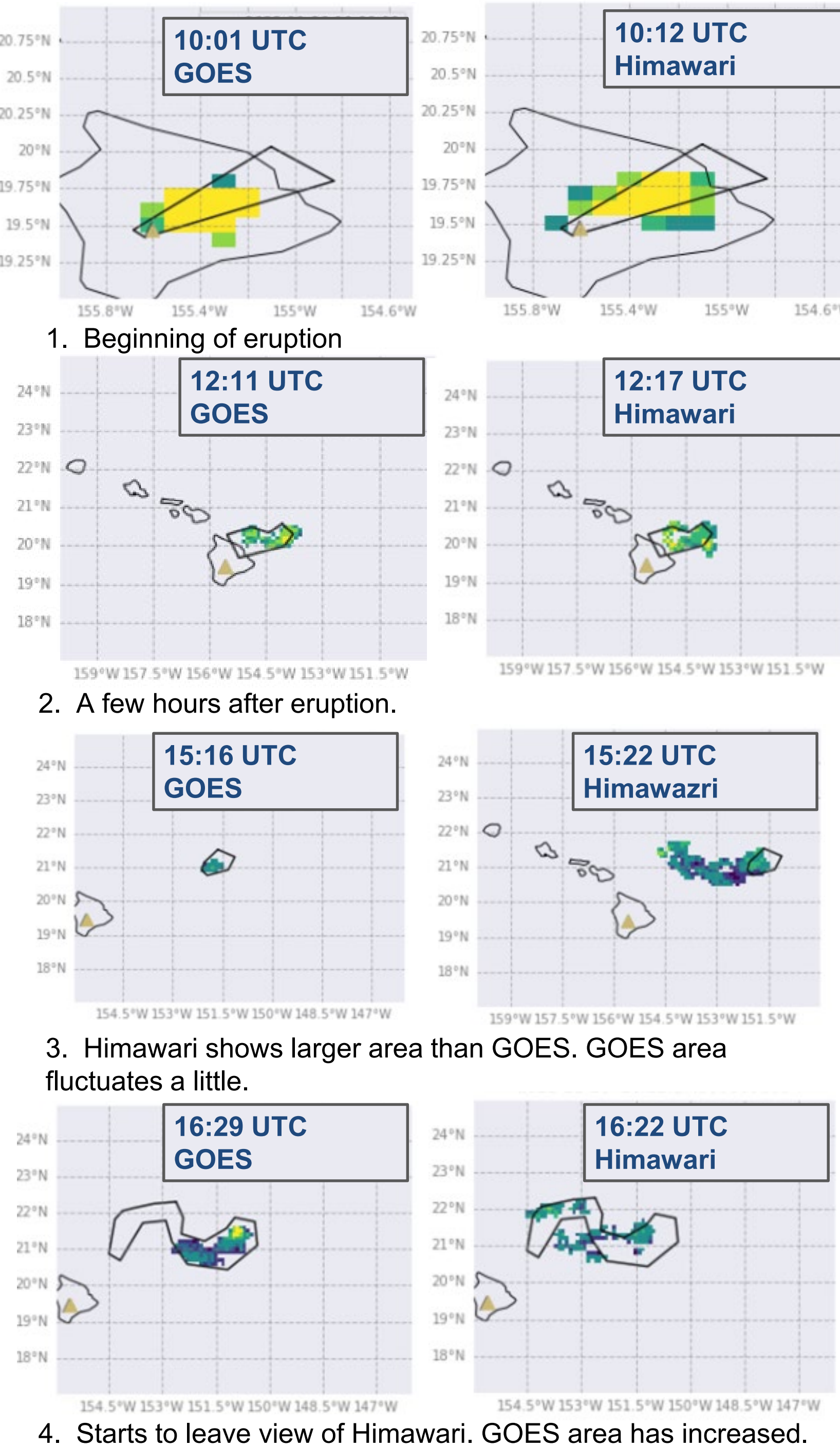
RIK: THE GAS MIXED WITH LGT VA FM THE REMNANT GAS AND LGT VA IS OBS CONT MOV E, CURRENTLY AT ABOUT 450NM NE FM THE SUMMIT IN PACIFIC OCEAN. THE MOV WILL CONT E WARD BASED ON NNP MDL WND. ...ZHU

Final advisory: 04:15 UTC 29 November 2022

RIK: NO VA OBS IN MULT STLT IMAGERY PRODUCTS. EHS FM EARLIER NOW LOCATED OVER THE EASTERN PACIFIC OCEAN APPEARS TO BE COMPRISED OF STEAM/GAS. PLUME OF STEAM/GAS OBS NEAR SUMMIT. A NEW ADV WILL BE SENT OUT IF ANY NEW VA EHS ARE OBS. ...COVERDALE

It was difficult to assess when the ash would dissipate. As the ash and gas cloud continued to move east northeast in satellite imagery the analyst could see that the cloud was becoming mostly gases. Although that was translated in the advisory, users who had access to the same satellite imagery and volcanic ash information, had many questions and concerns once the forecast was downgraded from the T+18 hrs. Multiple users requested a longer duration forecast.

Observations



VOLcanic Cloud Analysis Toolkit (VOLCAT) system satellite retrievals from Himawari-8 and GOES-17, available approximately every 5-10 minutes for the event could support data fusion modeling capabilities (see right panel). Between about 12 and 15 UTC, Himawari showed a larger area of ash than GOES due to its larger viewing angle. Below, just a few of the satellite retrievals of column mass loading are shown which were close in time to issued VAAs (T+0 polygons are shown in black). The satellite retrievals have been parallax corrected and regridded onto a regular lat-lon grid.



column mass loading (g/m²)

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Email: alice.crawford@noaa.gov Tel: 301-683-1380

A preview of QVA

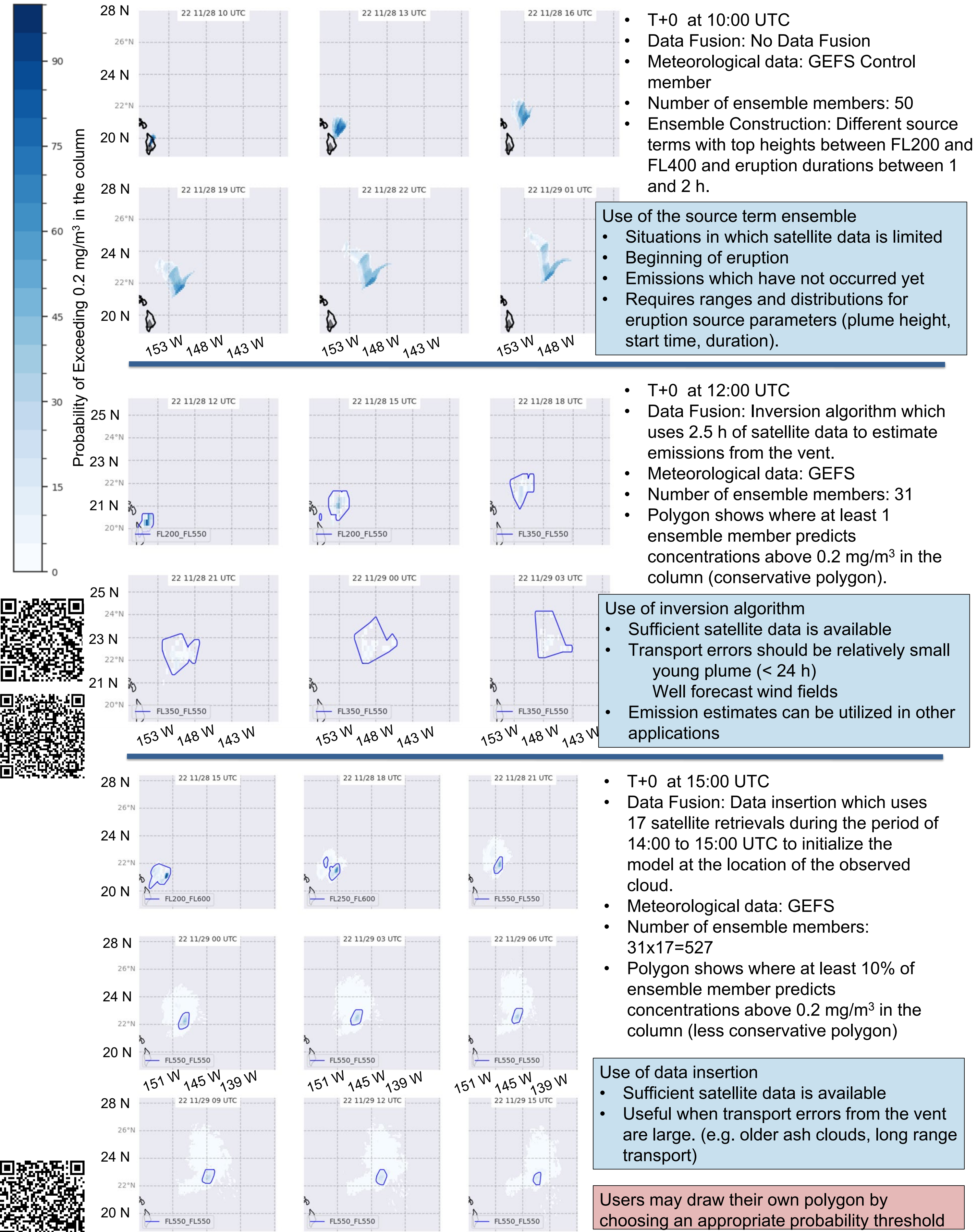


New modeling capabilities are being transitioned to operations to support the production of QVA.



- Satellite data can be ingested into the modeling system using data fusion techniques to ensure model output is consistent with observations.
- 31 members of NOAA global ensemble forecast system (GEFS) can be used with HYSPLIT to capture uncertainty in the meteorological fields, particularly wind.
- Uncertainty in source term can be captured using a source term ensemble

Figures: Graphical summaries of possible QVA forecasts. The summaries show maximum probability of exceedance of 0.2 mg/m³ in the column. The vertical resolution of the gridded data is FL50. Two of the summaries only show forecast through T+15 although the full forecast goes through T+24



- T+0 at 10:00 UTC
- Data Fusion: No Data Fusion
- Meteorological data: GEFS Control member
- Number of ensemble members: 50
- Ensemble Construction: Different source terms with top heights between FL200 and FL400 and eruption durations between 1 and 2 h.

Use of the source term ensemble

- Situations in which satellite data is limited
- Beginning of eruption
- Emissions which have not occurred yet
- Requires ranges and distributions for eruption source parameters (plume height, start time, duration).

- T+0 at 12:00 UTC
- Data Fusion: Inversion algorithm which uses 2.5 h of satellite data to estimate emissions from the vent.
- Meteorological data: GEFS
- Number of ensemble members: 31
- Polygon shows where at least 1 ensemble member predicts concentrations above 0.2 mg/m³ in the column (conservative polygon).

Use of inversion algorithm

- Sufficient satellite data is available
- Transport errors should be relatively small (young plume < 24 h)
- Well forecast wind fields
- Emission estimates can be utilized in other applications

- T+0 at 15:00 UTC
- Data Fusion: Data insertion which uses 17 satellite retrievals during the period of 14:00 to 15:00 UTC to initialize the model at the location of the observed cloud.
- Meteorological data: GEFS
- Number of ensemble members: 31x17=527
- Polygon shows where at least 10% of ensemble member predicts concentrations above 0.2 mg/m³ in the column (less conservative polygon)

Use of data insertion

- Sufficient satellite data is available
- Useful when transport errors from the vent are large. (e.g. older ash clouds, long range transport)

Users may draw their own polygon by choosing an appropriate probability threshold

QVA Information Service

A NOAA QVA prototype currently consists of two independent components:

- A RESTful API using an Open Geospatial Consortium (OGC) Application Programming Interface (API) - Environmental Data Retrieval (EDR) "locations" query type
- A Publication/Subscription framework making use of OGC API-EDR:Part 2:Publication Subscription Framework for the **message payload** and **SWIM compliant** for the **message broker protocol**

The Publication Subscription implementation will consist of 4 channels, a **root level** channel and **3 channels** to register at a collection level

The OGC API-EDR for QVA consists of 3 collections

- Probabilistic NetCDF gridded data
- Deterministic NetCDF gridded data
- IWXXM QVACI XML feature collections

Home

Time: 2022-11-28 15:00:00Z
Vertical: FL400

Get Data

Select a Collection: qvac_iwxxm

Select an Instance: 2022112814

Select a Location: Krakatau

Select a Datetime: ALL

custom query builder with summary graphic for deterministic gridded data in netcdf format.

Get Data

Select a Collection: qvac_iwxxm

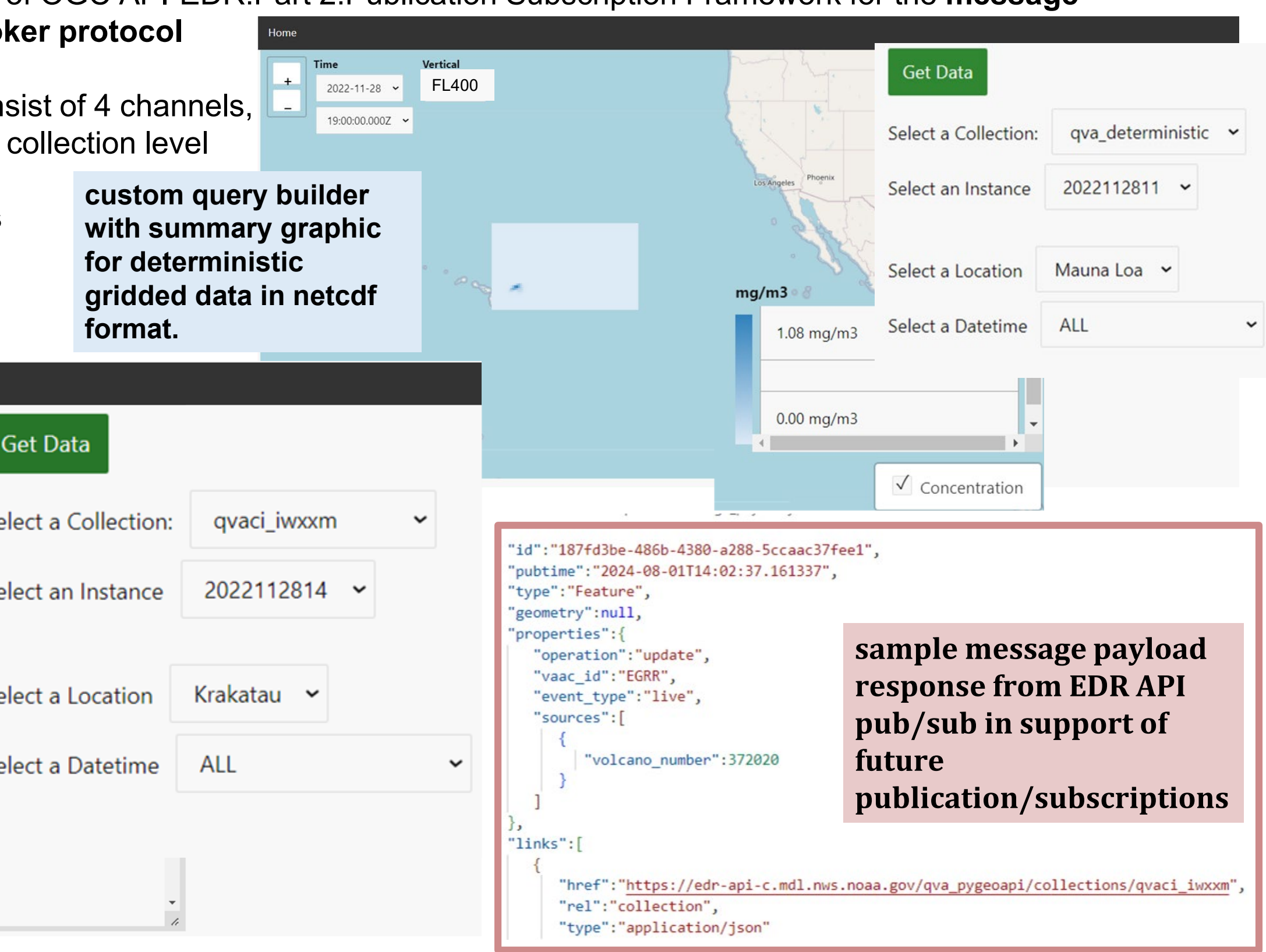
Select an Instance: 2022112814

Select a Location: Krakatau

Select a Datetime: ALL

Custom query builder and IWXXM Response

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sample message payload response from EDR API pub/sub in support of future publication/subscriptions

Discussion

- Current advisories provide an estimate of the likely location of ash and convey uncertainties through the remarks. Analysts use their judgement to include or exclude areas in the polygon which have low probabilities of discernible ash being present.
- Transitioning new modeling tools to operations will support analysts creating the current VAA as well as production of the new QVA information.
- The development of new modeling tools has followed the development of satellite products which provide near real time detection and alerting of ash clouds as well as retrievals of volcanic ash cloud properties. Improvements in observations leads to improvements in forecasting.
- It is expected that new modeling capabilities will be transitioned to operations and updated over a period of many years.
- The full QVA information will be available through an API and a subset of the information will be provided through supplemental graphics.