Development of a GOES-R Automated Volcanic Cloud Alert System

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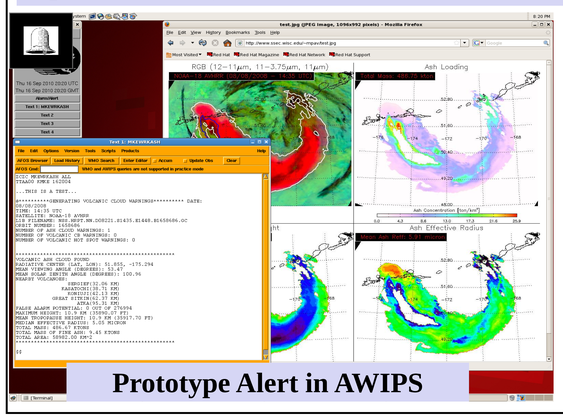
1. Project Goal and Operational Impacts

•**Main Project Goal:** ***Using the full capabilities of the GOES-R system, develop a unique (and globally applicable) automated alert system that can detect nearly all types of volcanic clouds***

•**Expected Operational Impacts: 1) Increase the timeliness and quality of volcanic ash advisories issued by VAAC's and SIGMET's issued by MWO's. 2) Improve dispersion model forecasts by providing fully automated and high quality satellite products to constrain and validate models**

•**Users at the Washington and Anchorage VAAC's will begin evaluating the alerts in Year 2 (project funds were received in September 2011).**



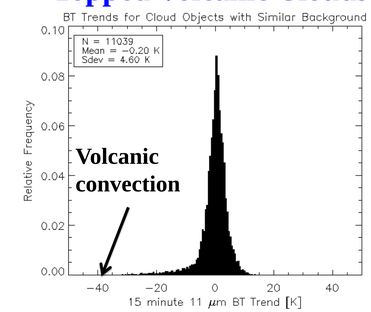
Prototype Alert in AWIPS

Main Alert Types:
1) Ash cloud alert (coupled with AWG ash products)
2) Ice topped volcanic cloud alert (ash content is initially obscured by ice)
3) SO_2 cloud alert (coupled with AWG SO_2 products)

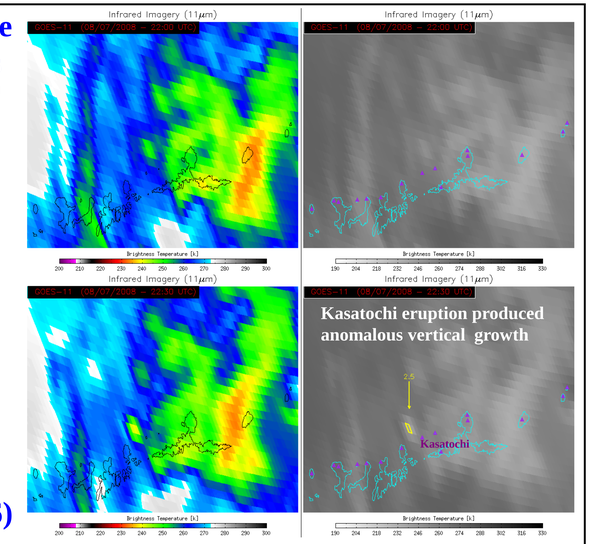
2. Main Accomplishments Thus Far

•**Developed a probabilistic ash detection approach that is used to issue ash cloud alerts**
•**Developed an objective approach that will be used to alert users when anomalously vigorous convection near volcanoes is found**
•**Started to modify AWG SO_2 product to allow for probabilistic output**
•**In order to accommodate a diverse user base, all alert criteria are highly configurable**
•**Began working with New Mexico Tech on incorporating lightning flash observations into alert system**

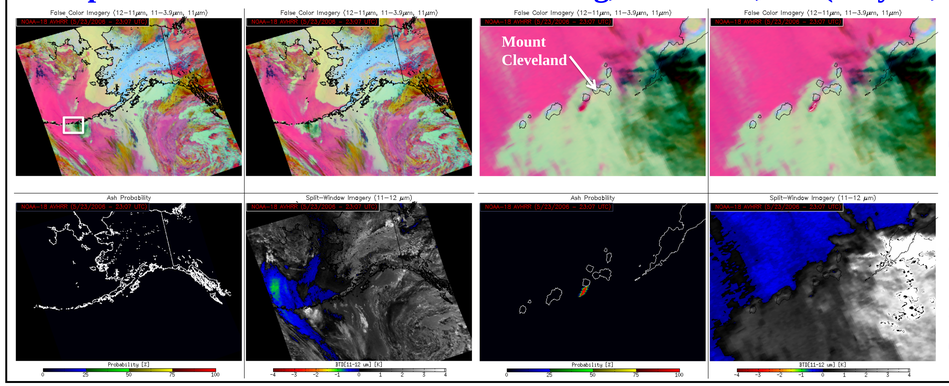
Example 2: Detecting Ice Topped Volcanic Clouds



Convection resulting from volcanic eruptions is anomalously vigorous



Example 1: Ash Cloud Detection and Alerting, Cleveland, AK (May 23, 2006)



The probabilistic ash detection method is much more skillful than existing methods. It can find "a needle in a haystack" and issue quantitative alerts.

Text Ash Cloud Alert

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@*********GENERATING VOLCANIC CLOUD ALERTS**********
DATE: 05/23/2006
TIME: 23:07 UTC
PRIMARY INSTRUMENT: AVHRR/3
LOCATION/ORBIT: LEO
L1 FILE: NSS.HRPT.NN.D06143.S2307.E2320.B0519696.GC
NUMBER OF ASH CLOUD ALERTS: 1
NUMBER OF VOLCANIC Cb ALERTS: 0
NUMBER OF VOLCANIC THERMAL ANOMALY ALERTS: 0
NUMBER OF SO2 CLOUD ALERTS: 0

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VOLCANIC ASH CLOUD FOUND
Radiative Center (Lat, Lon): 52.642, -170.215
Mean Viewing Angle (degrees): 57.84
Mean Solar Zenith Angle (degrees): 32.25
Nearby Volcanoes (meeting alert criteria):
                    Herbert(13.18 km)
Overall Ash Cloud Object Probability: 99.99998%
Mean Ash Probability of Object Pixels: 94.53343%
Area of Robust Ash Pixels: 0.00 km^2
Maximum Height [AMSL]: 6.8 km (22289.04 ft)
1-sigma Uncertainty of Maximum Height [AMSL]: 1.2 km (4092.99 ft)
Mean Tropopause Height [AMSL]: 12.3 km (40517.77 ft)
Total Mass: 0.15 ktons
Median effective particle radius: 7.26 um
Total Area: 52.41 km^2
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3. Future Research ("Year 2")

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@*********GENERATING VOLCANIC CLOUD ALERTS**********
DATE: 08/07/2008
TIME: 22:30 UTC
PRIMARY INSTRUMENT: GOES-11
LOCATION/ORBIT: GEO
L1 FILE: goes11_1_2008_220_2230.area
NUMBER OF ASH CLOUD ALERTS: 0
NUMBER OF VOLCANIC Cb ALERTS: 1
NUMBER OF VOLCANIC THERMAL ANOMALY ALERTS: 0
NUMBER OF SO2 CLOUD ALERTS: 0


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POSSIBLE VOLCANIC ERUPTION DETECTED
Radiative Center (Lat, Lon): 52.297, -175.907
Mean Viewing Angle (degrees): 71.22
Nearby Volcanoes (meeting alert criteria):
                    Kasatochi(29.94 km)
Observable Vertical Growth Rate Anomaly (number of stddev above mean): 2.5
Maximum Height [AMSL]: 10.7 km (35030.00 ft)
1-sigma Uncertainty of Maximum Height [AMSL]: 4.2 km (13779.53 ft)
Mean Tropopause Height [AMSL]: 10.9 km (35761.16 ft)
Total Area: 502.15 km^2
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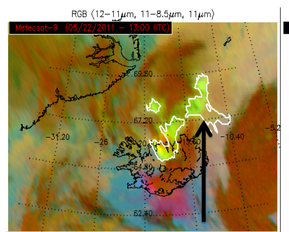
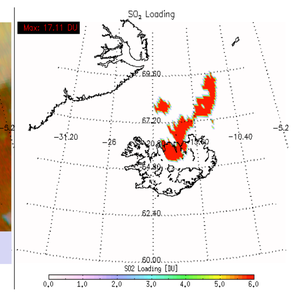
1) Refine volcanic convection methodology so that it is real-time capable; generate conditional ash probability tables for more sensors

2) Continue to modify AWG developed SO_2 detection to produce probabilistic output



SO_2 Detection



Credit: Marco Fulle

3) Using ground-based lightning as a proxy for GLM, incorporate lightning flash information into alert system

4. Anticipated 3rd Year Accomplishments

•**Demonstrate alert system at Anchorage and Washington VAAC's, collect feedback, and make improvements as needed**
•**Fuse GOES-R and JPSS volcanic cloud alerting capabilities**
•**Use WWLLN to simulate GLM**
•**Support model assimilation and validation studies by providing refined ash cloud products**
******In the absence of an automated alert system, the capabilities of GOES-R (and satellites in general) will be greatly under-utilized for volcanic cloud monitoring.******

We gratefully acknowledge the support of NOAA GOES-R3 for this effort