



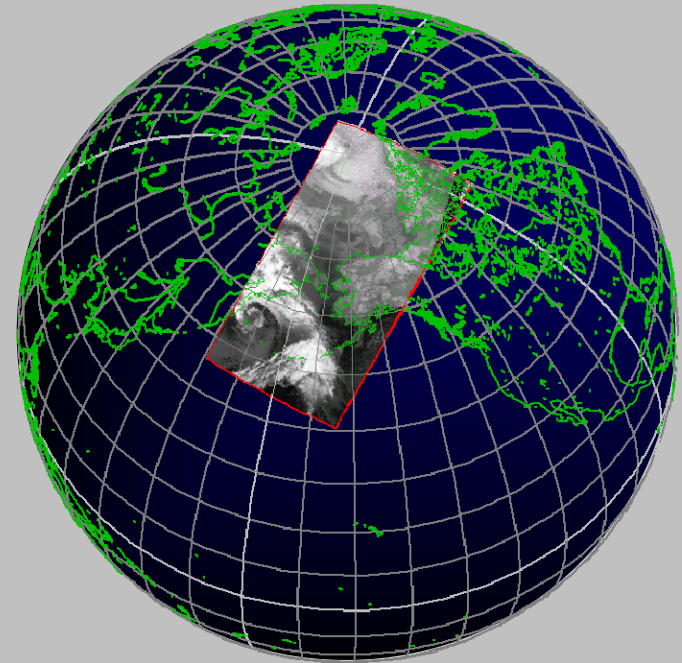
# Satellite Observations and Analyses of NOPAC Volcanoes



**Ken Dean, Alaska Volcano Observatory,  
Geophysical Institute**

**University of Alaska Fairbanks**

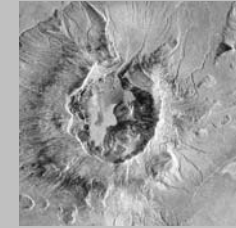
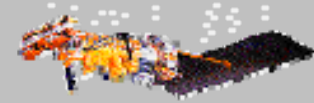
**Graphics supplied by: Faculty, Staff and  
Students of the Satellite Volcano Crew**



# Outline

## Subjects

1. Introduction and Perspective
2. Satellite Data Used for Detection
3. Satellite Analysis Techniques
4. Satellite Volcano Monitoring
5. Augustine Erupion 2006
5. New Developments
5. 30 years of Eruptions



# Introduction: Volcanoes in the North Pacific Region



**Approx. 70 historically active Volcanoes in region**

**Aleutian Islands  
Alaska Peninsula  
Alaska Mainland  
Kamchatka Peninsula,  
Russia  
Cascades**

**Prevailing Winds to East**

# Frequency of Eruptions in the North Pacific

AVO

## Really Large Events

Ash over 60,000 ft, Katmai 1912

Largest eruption 20th Century

Caldera forming events

3000 BP and 9000 BP

## Intermediate Events

Ash over 20,000 ft. 3-4/year

## Small Events

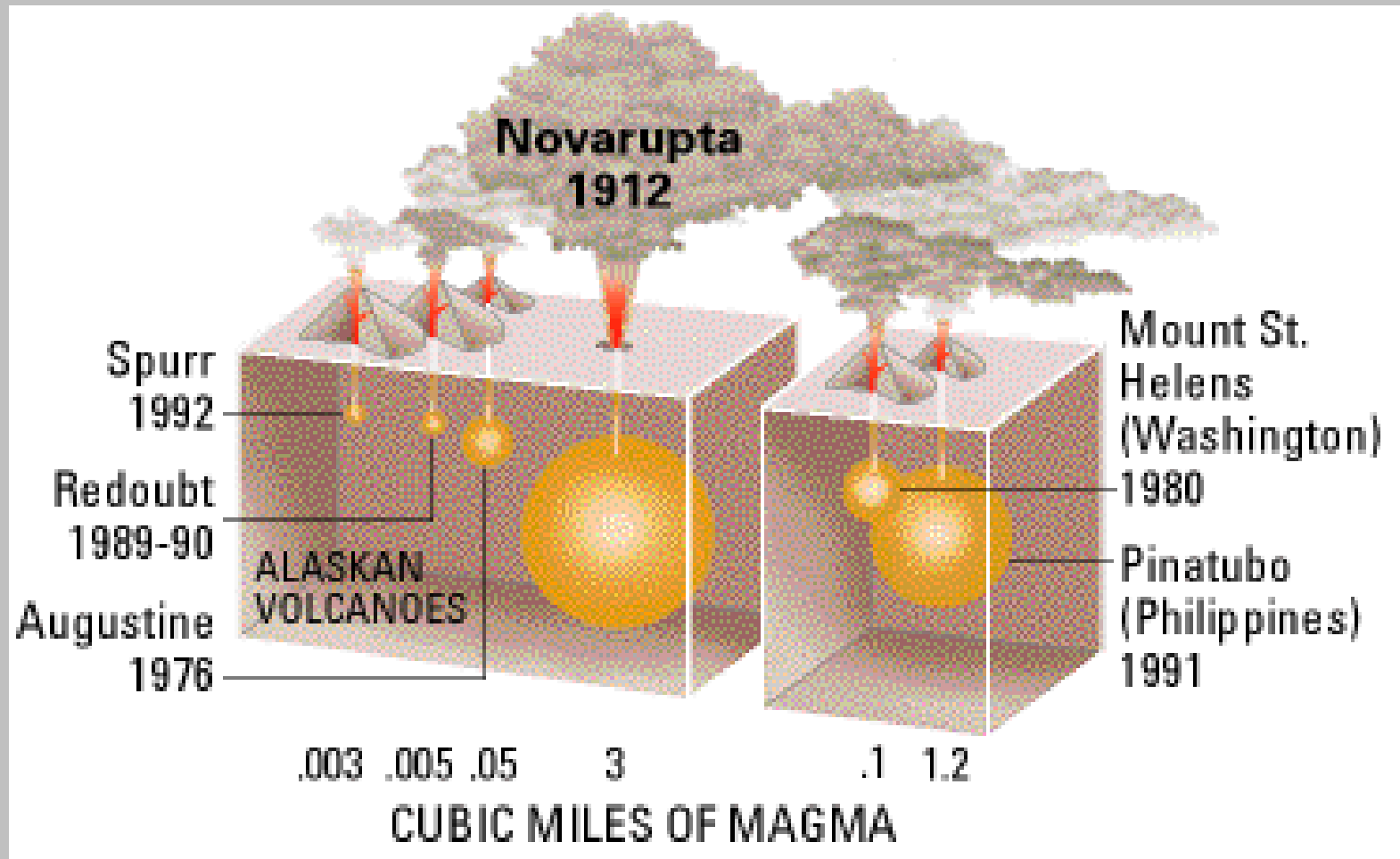
Plumes to <10,000 ft, thermal anomalies, or seismic activity

Observed daily

Any of these events may last from hours to many months



# Size of Eruptions in the North Pacific



USGS Hazards Program

# What volcanic features can we see from space?

Depends upon the Resolution:

Spatial

Temporal

Wavelengths

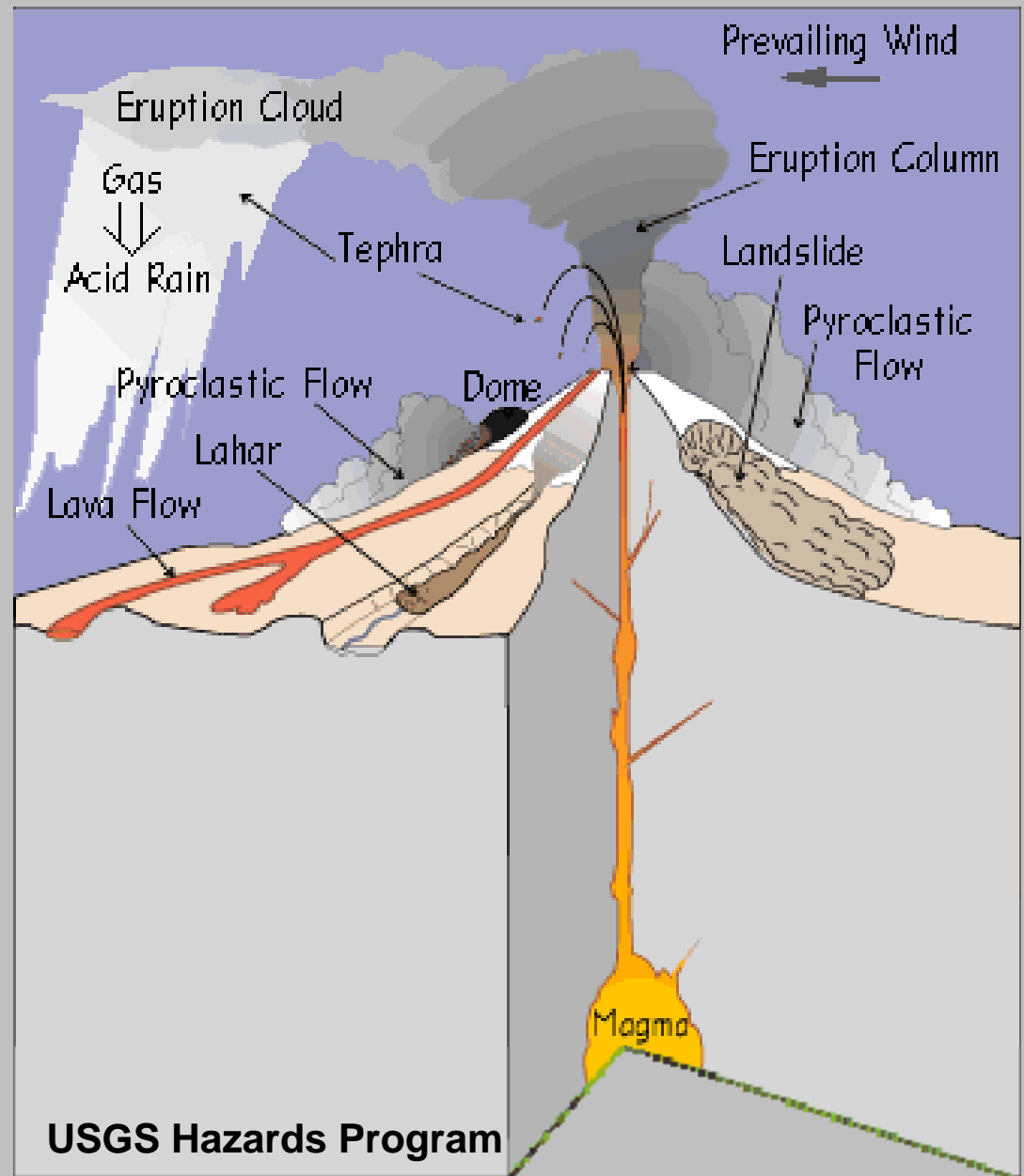
Thermal Infrared Response:

Eruption Cloud – Cold or Hot?

PF – Cold or Hot?

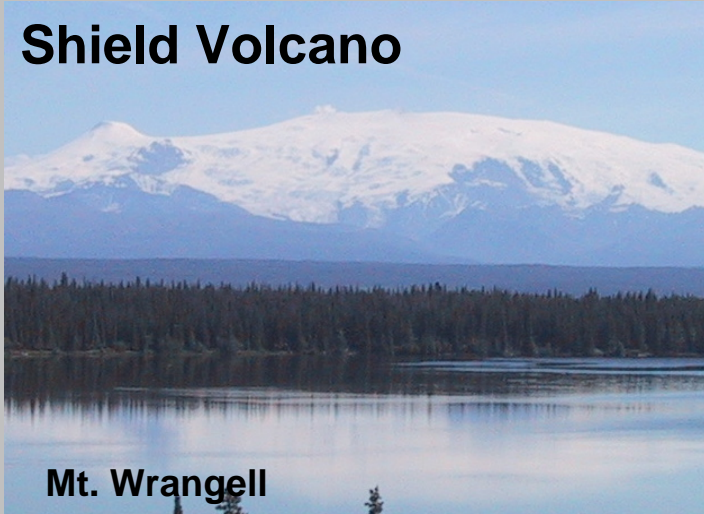
Dome – Cold or Hot?

Lahar – Cold or Hot?



# Types of Volcanoes in Alaska and Kamchatka

**Shield Volcano**



**Mt. Wrangell**

**Stratovolcano**



**Karymsky V.**

**Caldera**



**Okmok, Space Station**

**Dome**



**Bezymianny V.**

# Satellite Sensor Wavelengths

## Electromagnetic Spectrum

Bands:

Processes:

Viewing:

Visible

(Surface chemistry)

Day

Thermal Infrared

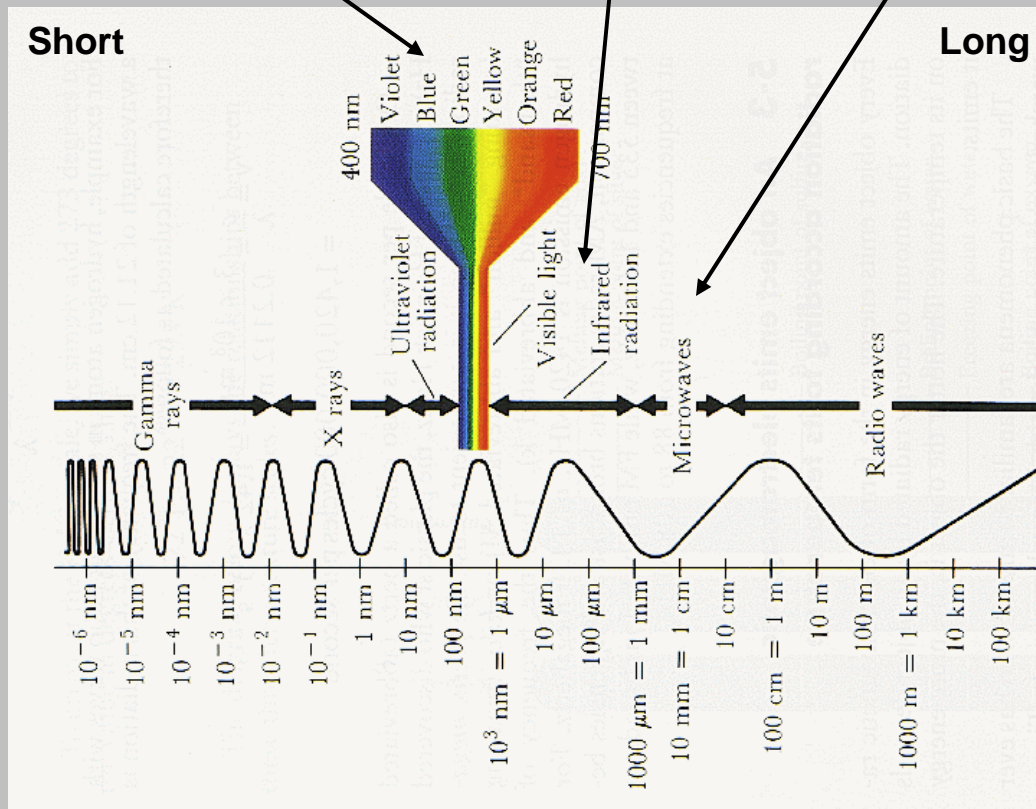
(Heat)

Day & Night

Radar

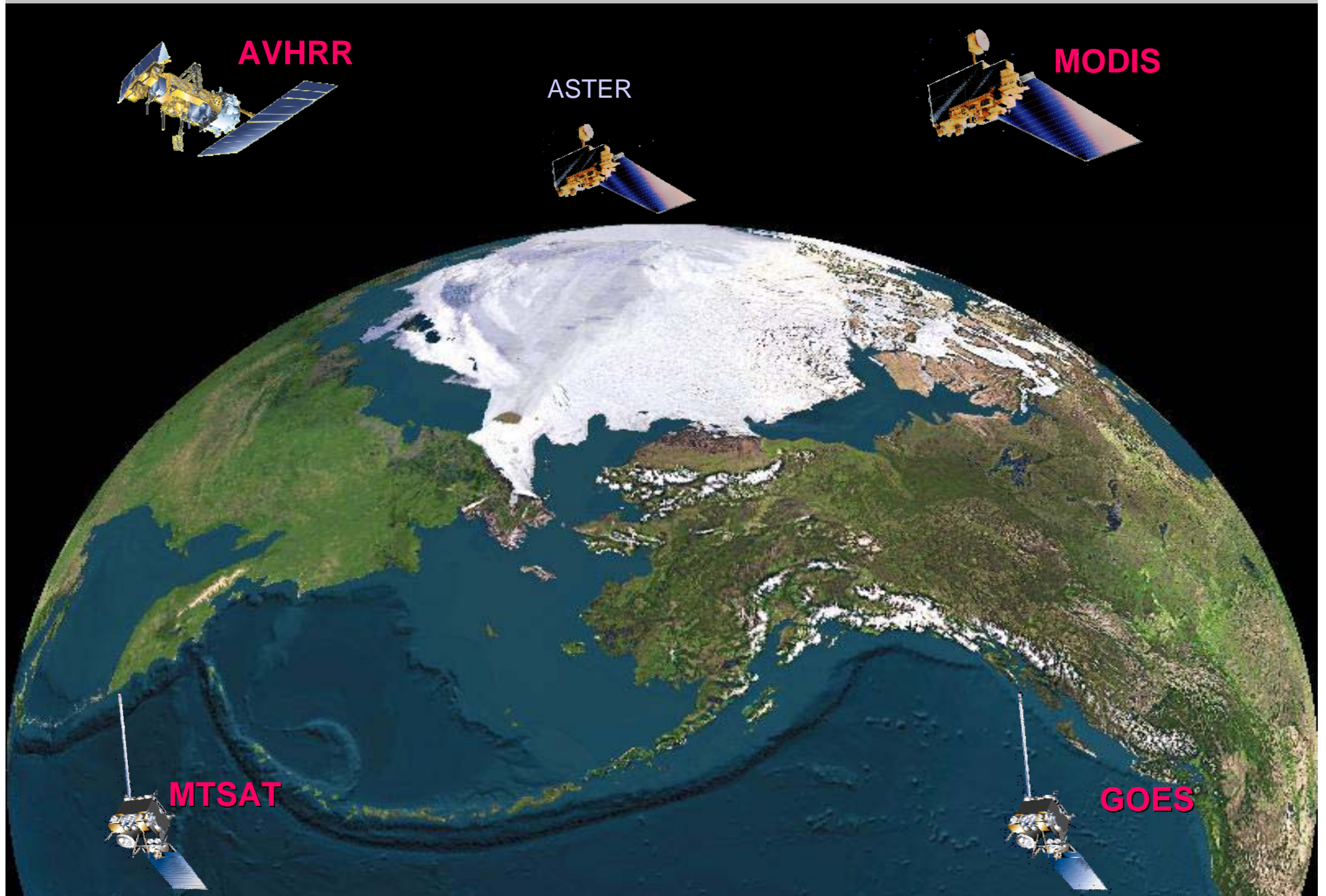
(Topography, Deformation)

Day & Night, Clouds





# Data Used for Monitoring





# GOES

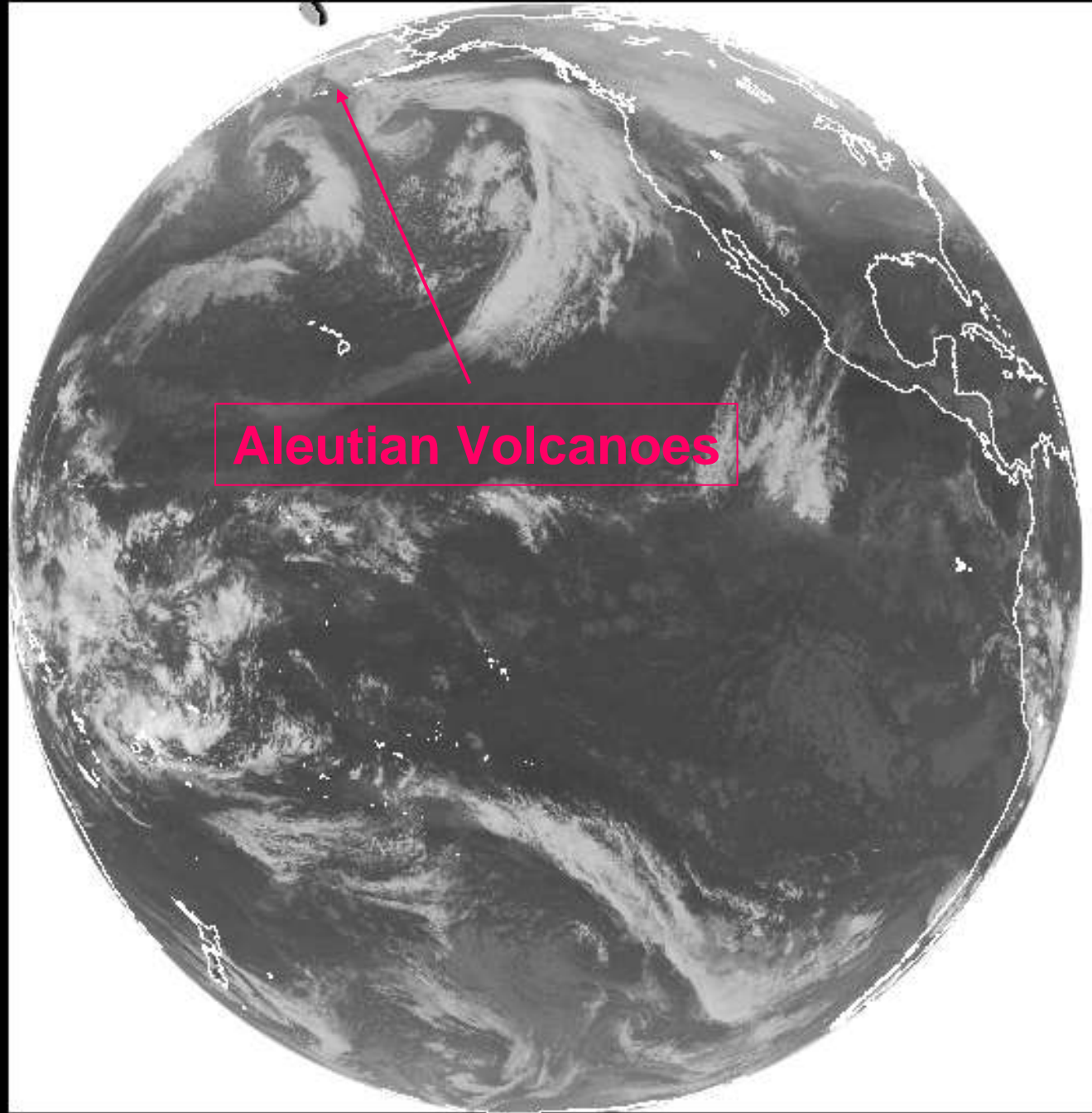
**Orbit: Equatorial**

**Temporal Res.:  
15 – 30 min**

**Spatial Res.:  
2-8km (Alaska)**

**Wavelength:  
Visible  
Thermal Infrared**

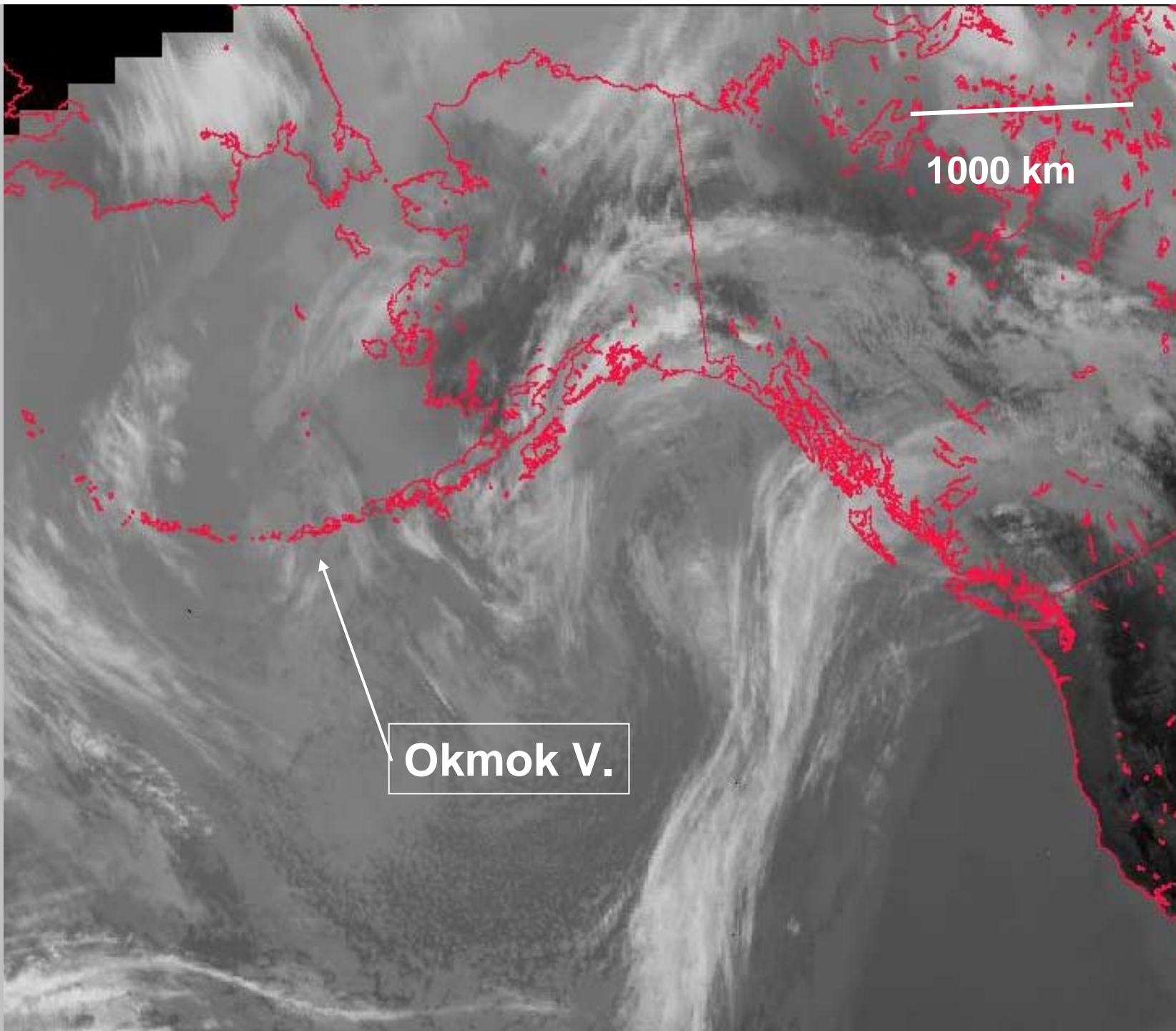
1 22 2003 0000Z



IR

NOAA

**GOES  
(Zoomed  
Image)**



1000 km

Okmok V.

**AVHRR**

**Orbit: Polar**

**Temporal Res.: hourly**

**Spatial Res: 1km**

**Wavelength: Visible &  
Thermal Infrared**

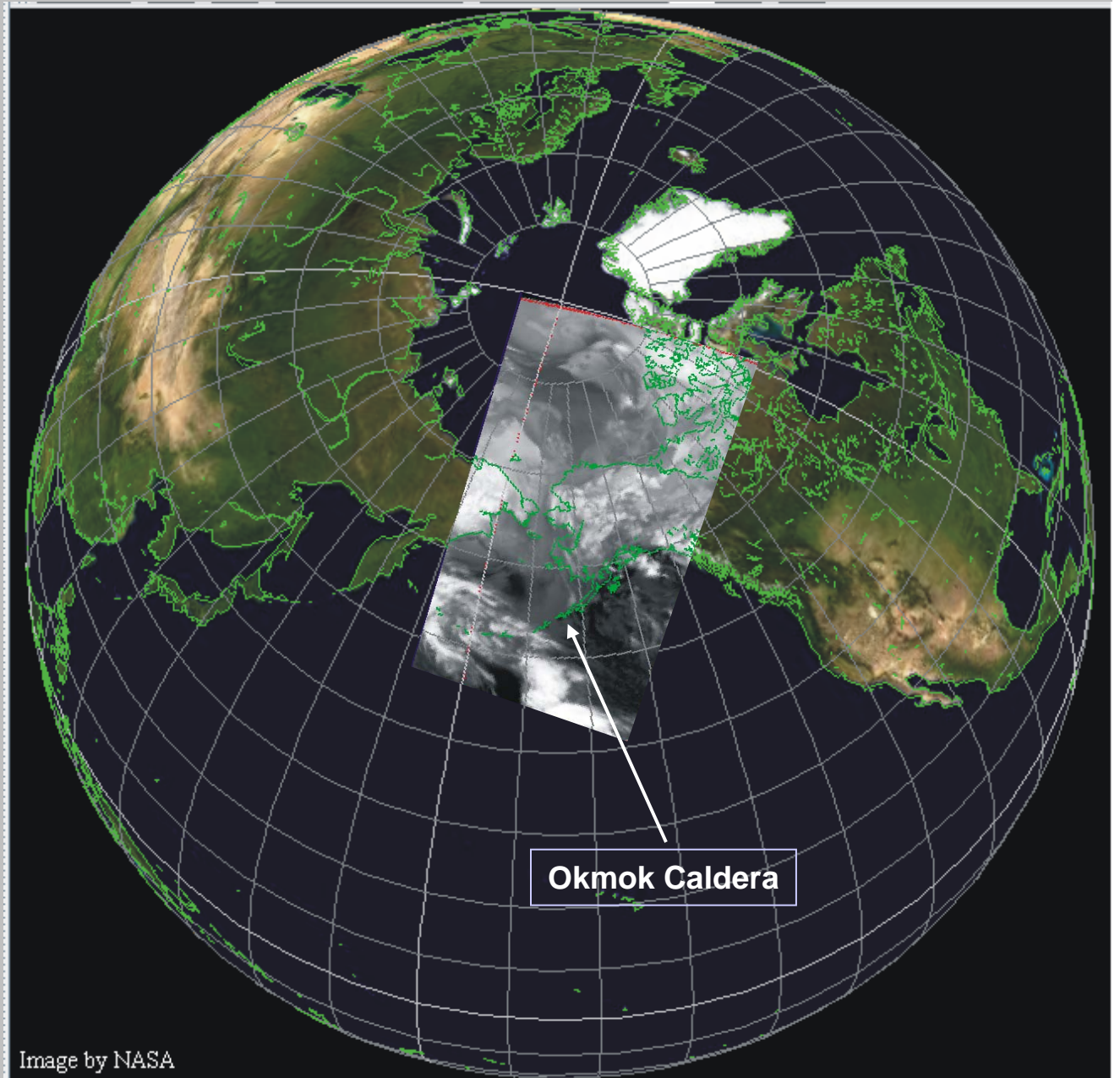
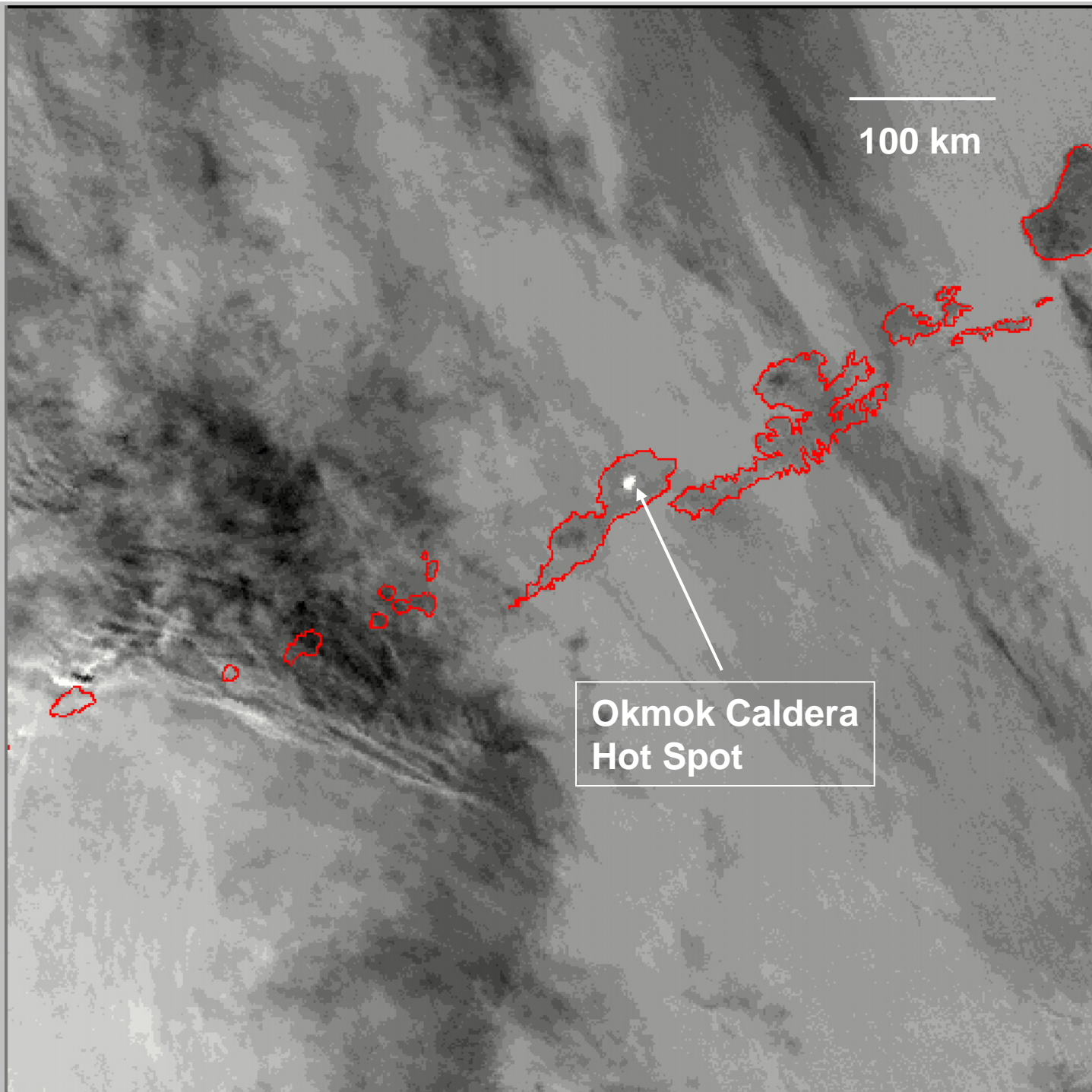


Image by NASA



**AVHRR  
(Zoomed  
image)**

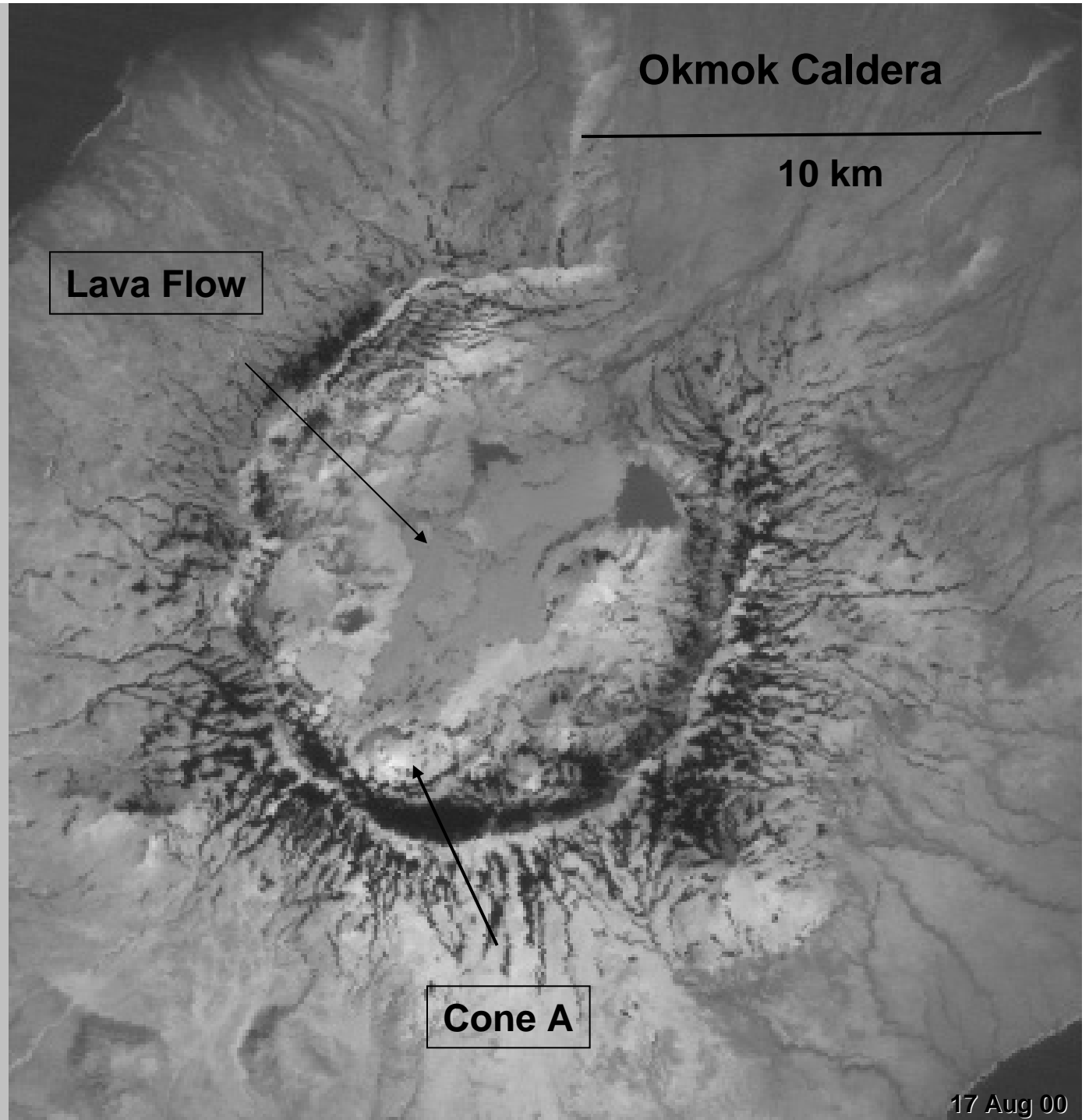


**Landsat (TIR)**

**Temporal Res.:  
2 monthly**

**Spatial Res:  
15 – 60 m**

**Wavelength:  
Thermal Infrared**



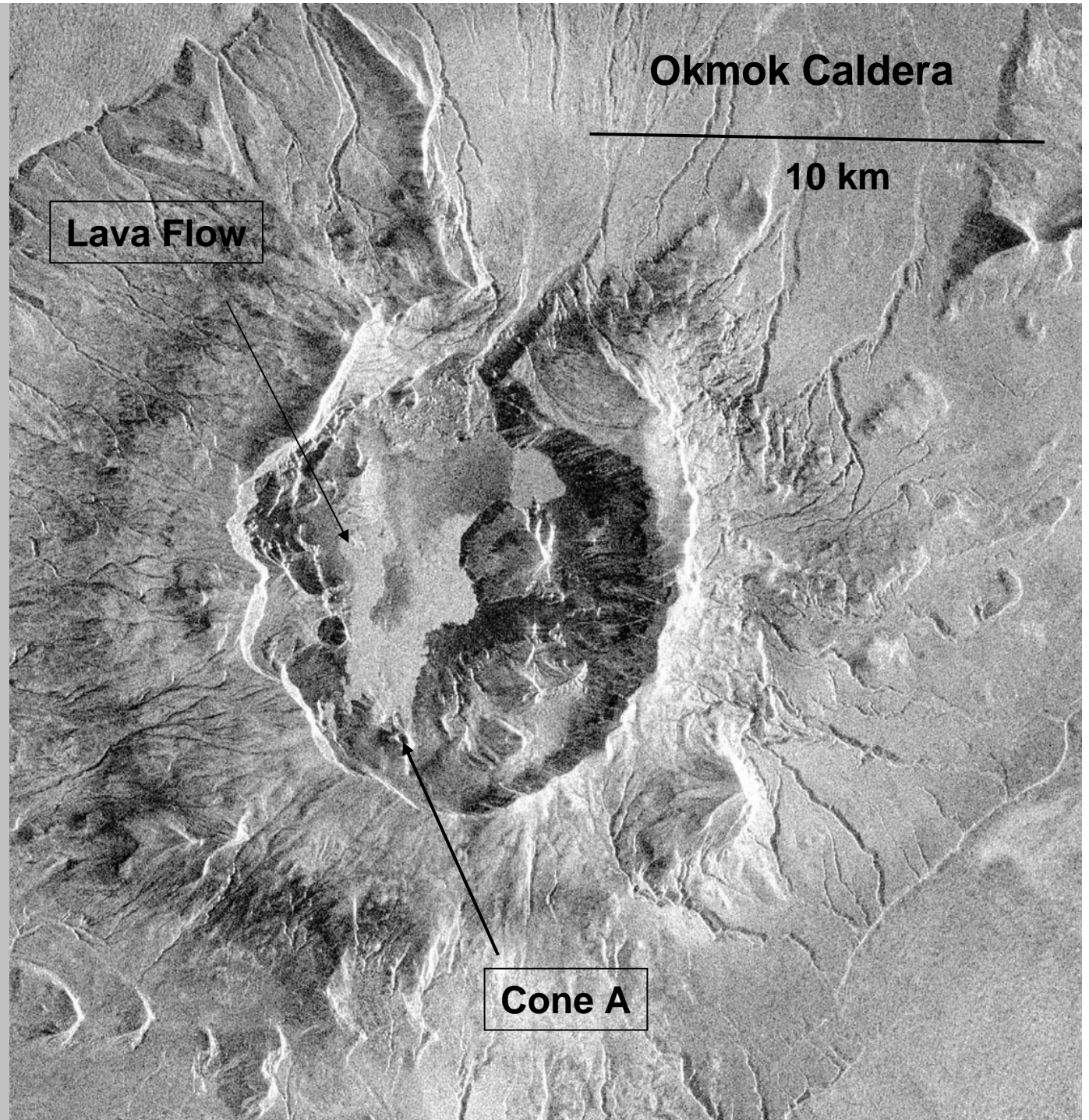


**Radar**

**Temporal Res.:  
2/month**

**Spatial Res:  
25 m**

**Wavelength:  
C-band Radar**

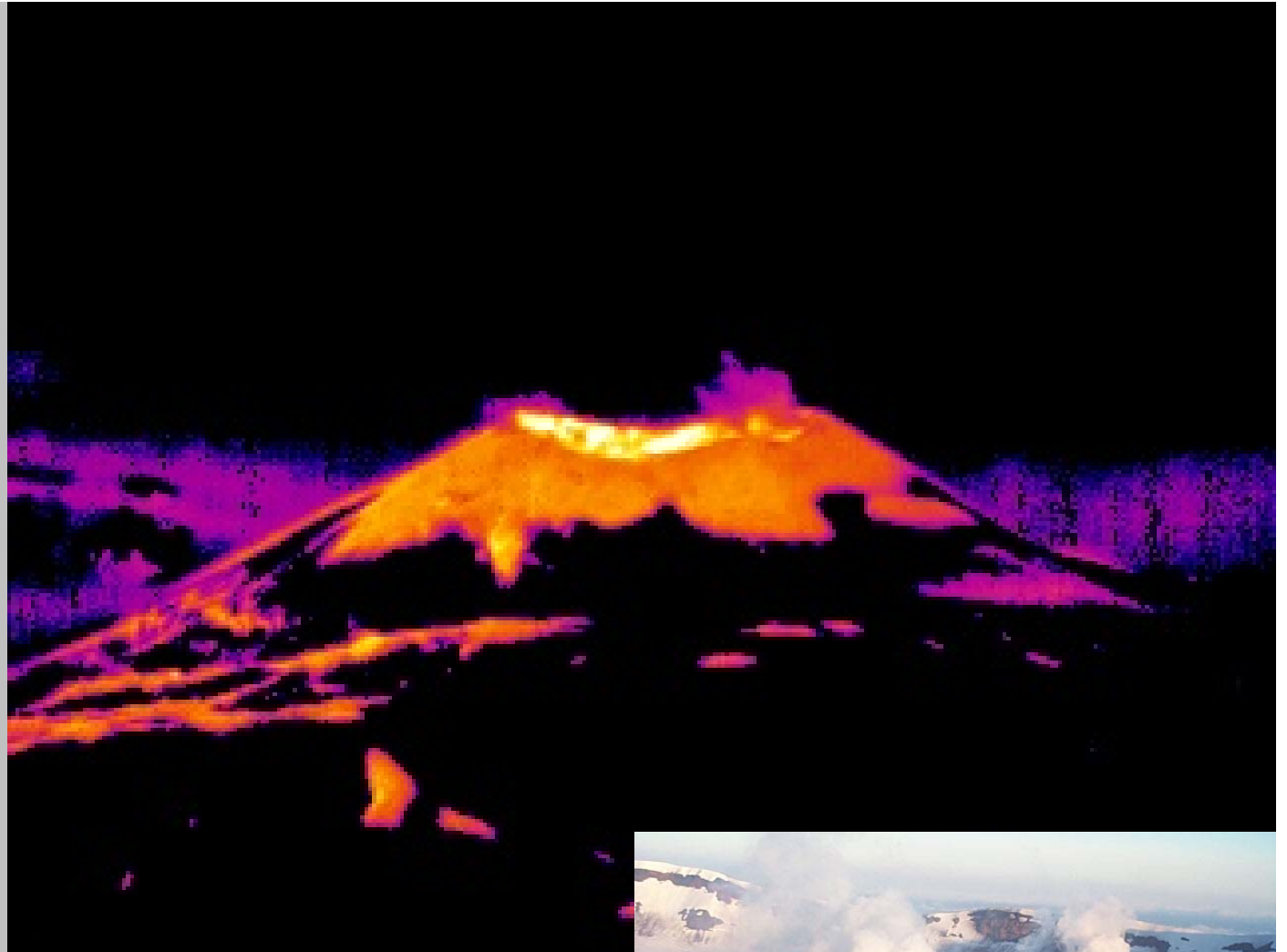


**Field Observations**  
**Orbit: No**

**Temporal Res.:  
Varies**

**Spatial Res:  
< 1 m**

**Wavelength:  
Thermal Infrared  
Visible**



John Eichelberger

6. 7. 2002

# Satellite Observations of Eruptions: Critical Volcanic Features

Hot Spots  
(Thermal  
Anomalies)

Volcanic  
Clouds

Volcanic  
Cloud  
Movement



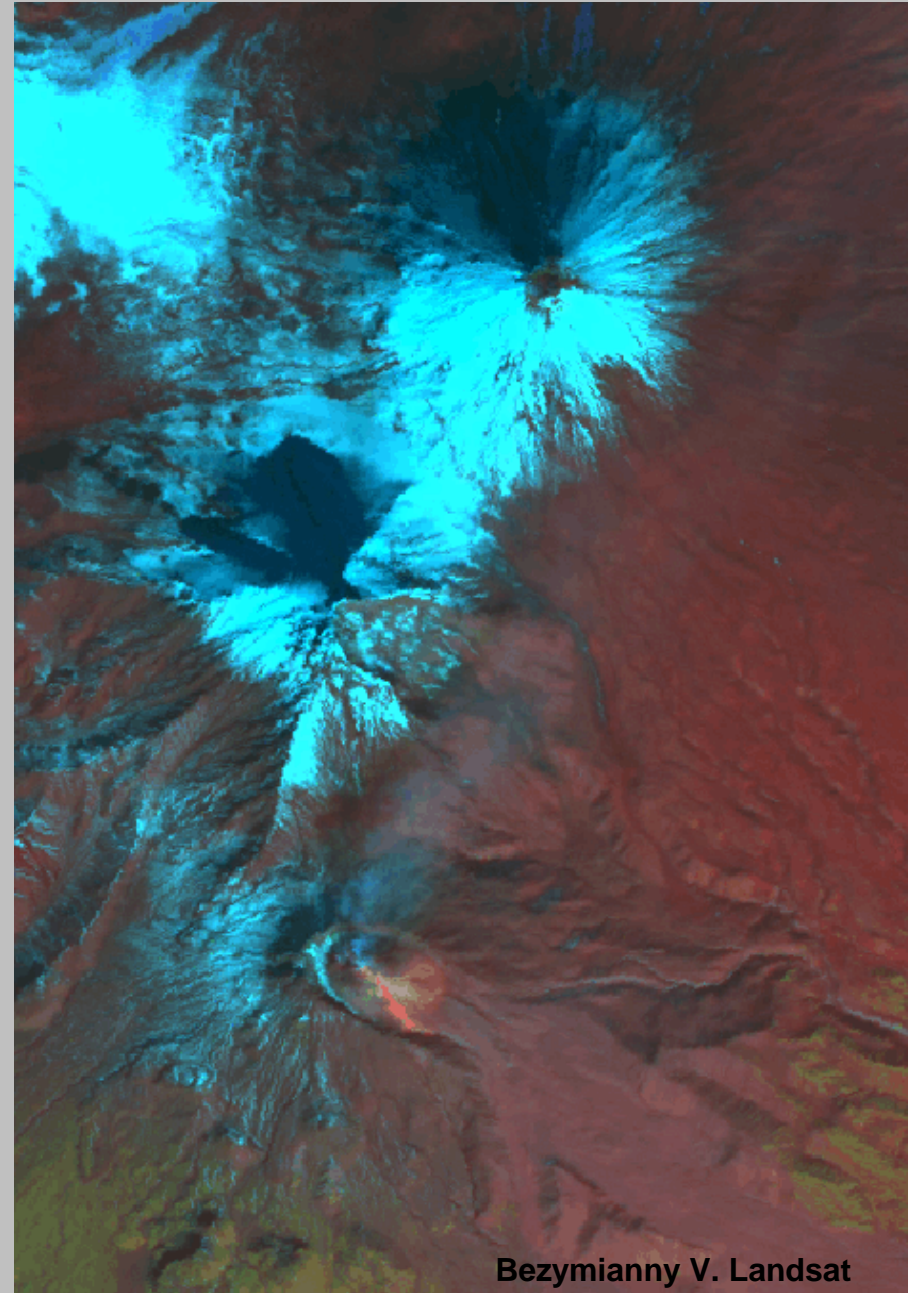


# Thermal Anomalies (Hot Spots)

**Thermal Anomalies:**  
Pixels with  
temperatures  
warmer than  
background

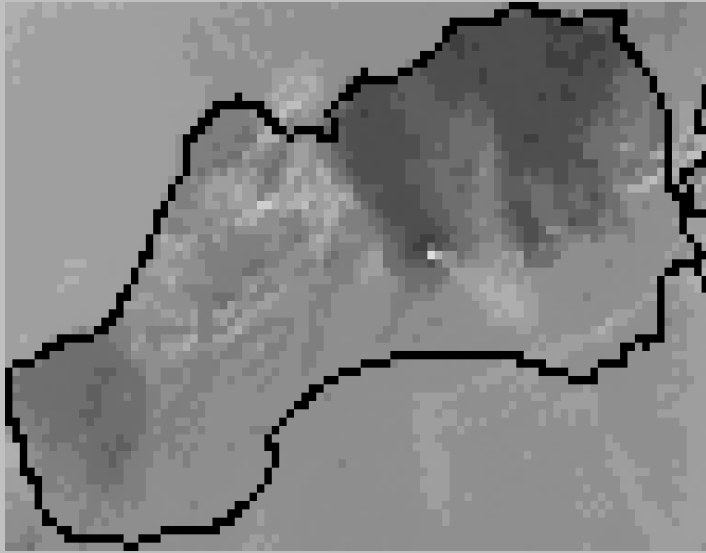
**Importance**  
Often precursor  
or early phase  
of an explosive  
eruption

**Source**  
Heated Domes  
Lava Flows  
Pyroclastic Flows  
Debris Flows



Bezymianny V. Landsat

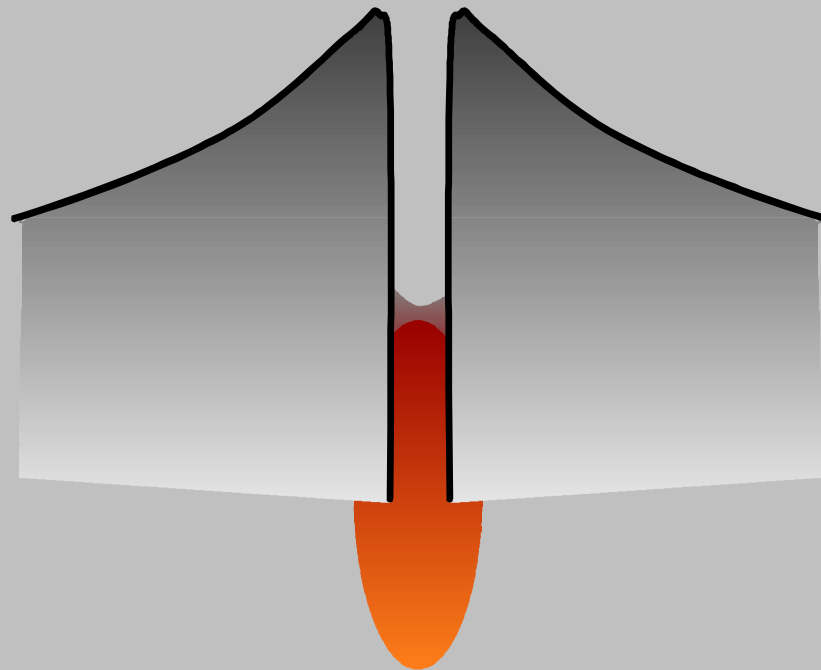
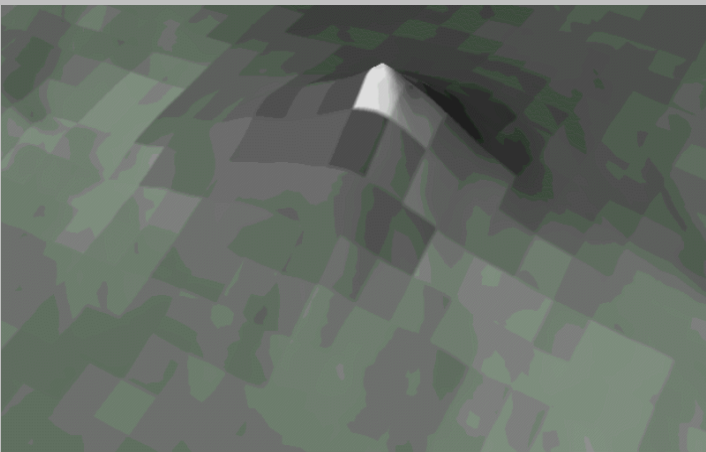
# Shishaldin: February 9, 1999



Thermal anomaly that led to a  
explosive eruption

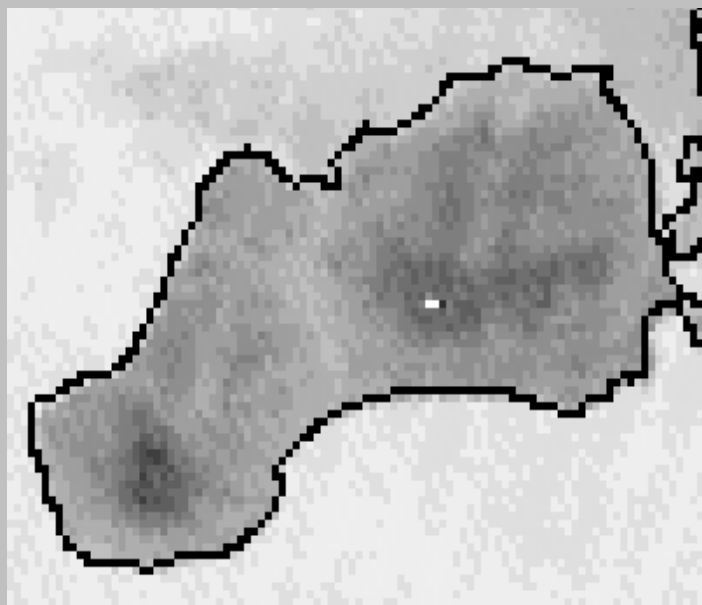
~400 m in crater,

Temperature 385°C.



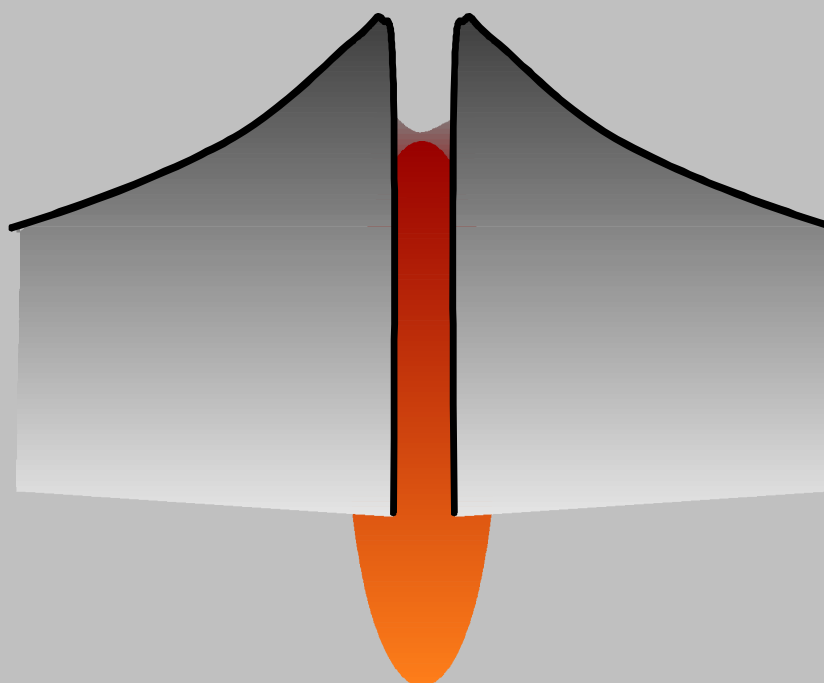
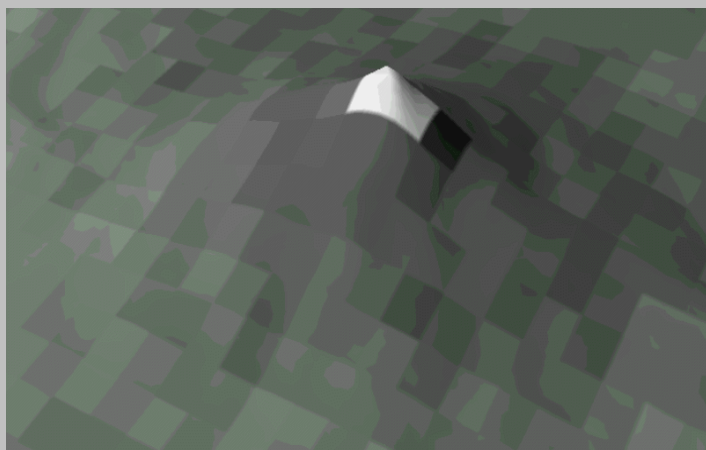


# Shishaldin: March 1, 1999

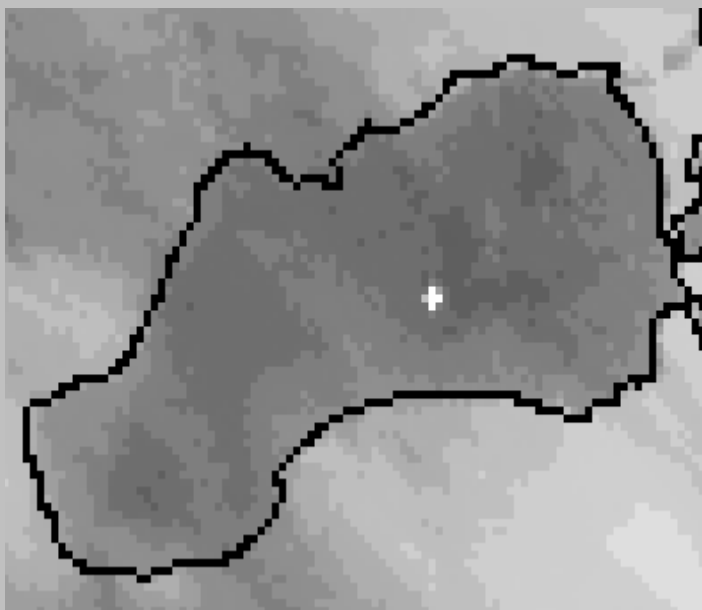


~ 100m below surface

Temperature 950°C

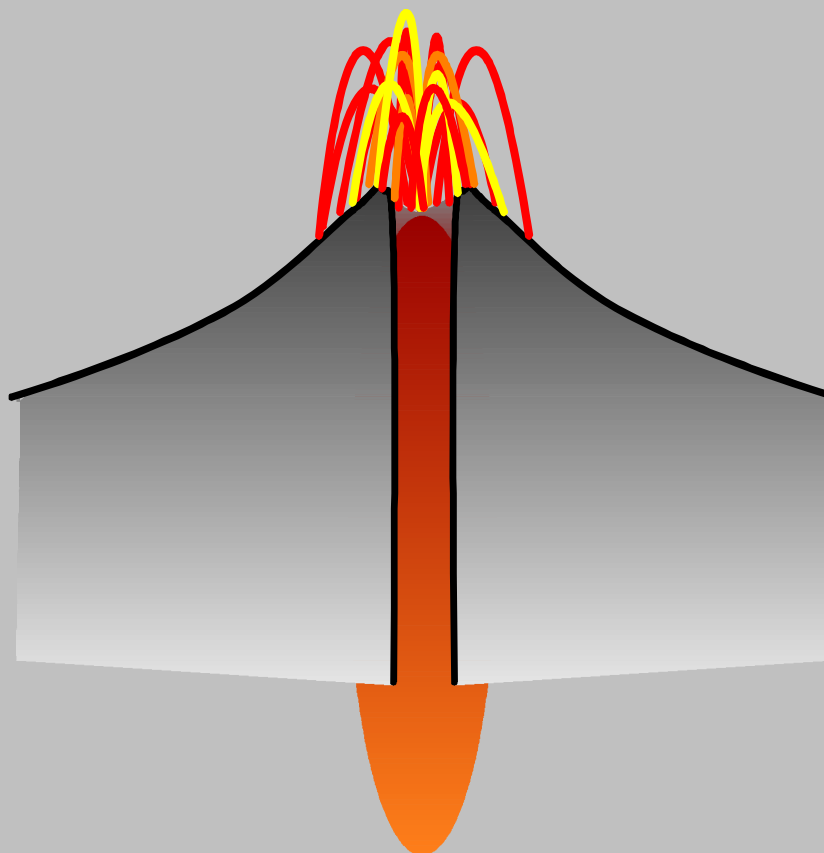
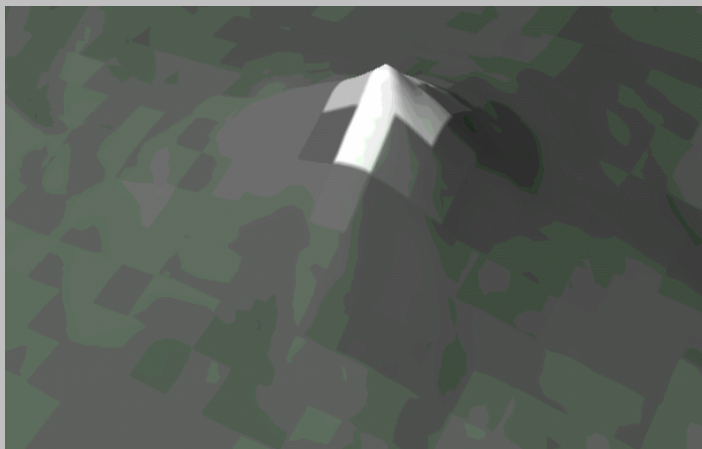


# Shishaldin: March 7, 1999

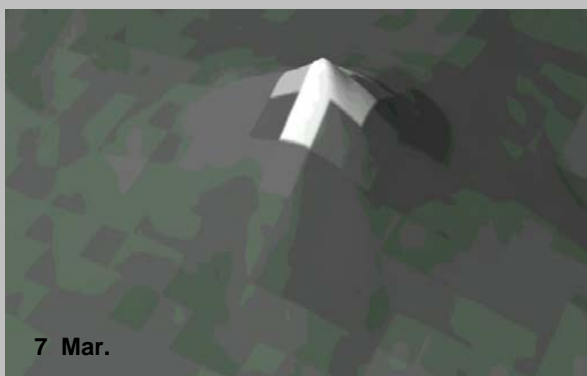
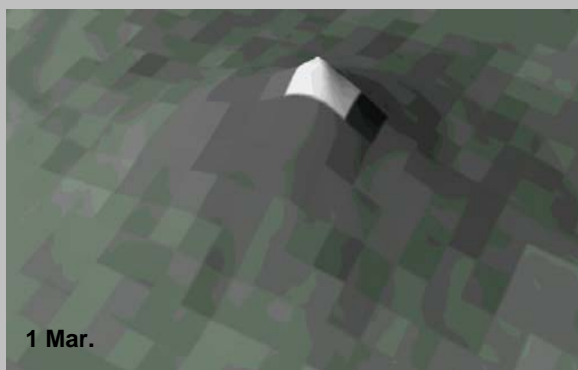
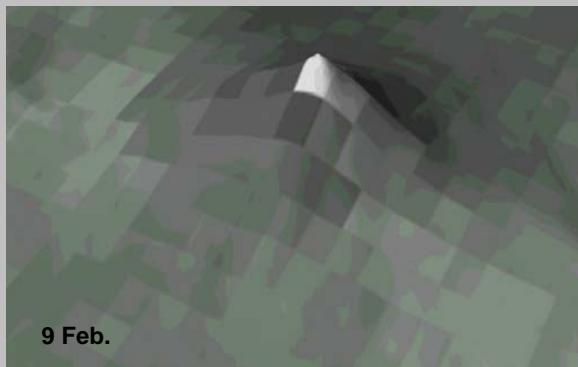


At surface, material airborne

Temperature 1060°C



# Hot Spots: Precursor to Explosive Eruption Shishaldin, 17 & 23 April 1999



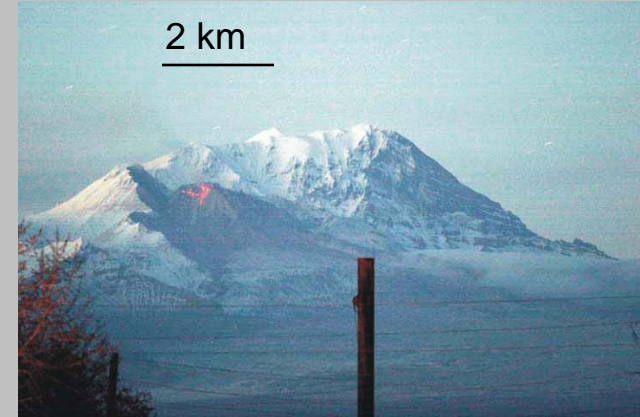
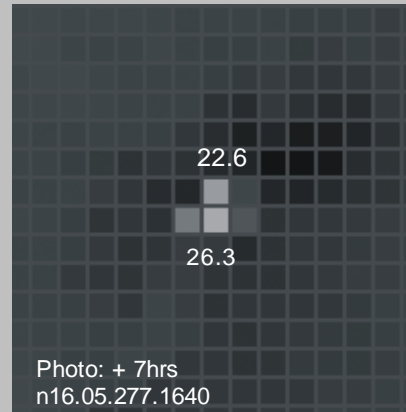
Sequence of thermal anomaly activity became two explosive eruptions in April



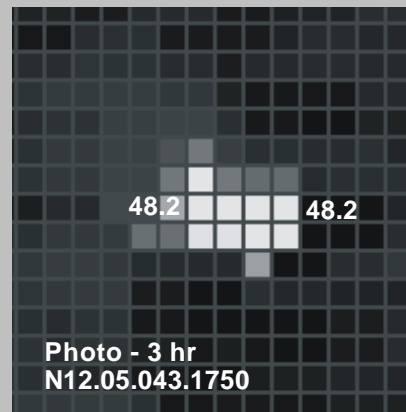
Are temperature or thermal flux predictors of eruptions?

# Hot Spots: Sources

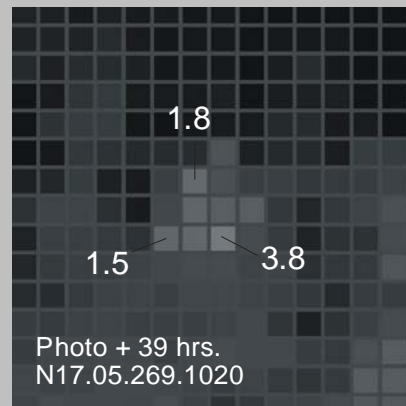
**Sheveluch V.**  
**Lava at the dome**  
**4 Oct. 05**  
**Sat Image +7hrs**



**Kliuchevskoi V.**  
**Lava flow on slope**  
**13 Feb. 05**  
**Sat Image -3 hrs**



**Karymsky V.**  
**Heated dome w/gas**  
**25 Sept. 05**  
**Sat Image + 39 hrs**





# Volcanic Clouds

**Clouds Evolve**

**Detection Evolves**

**Detection**

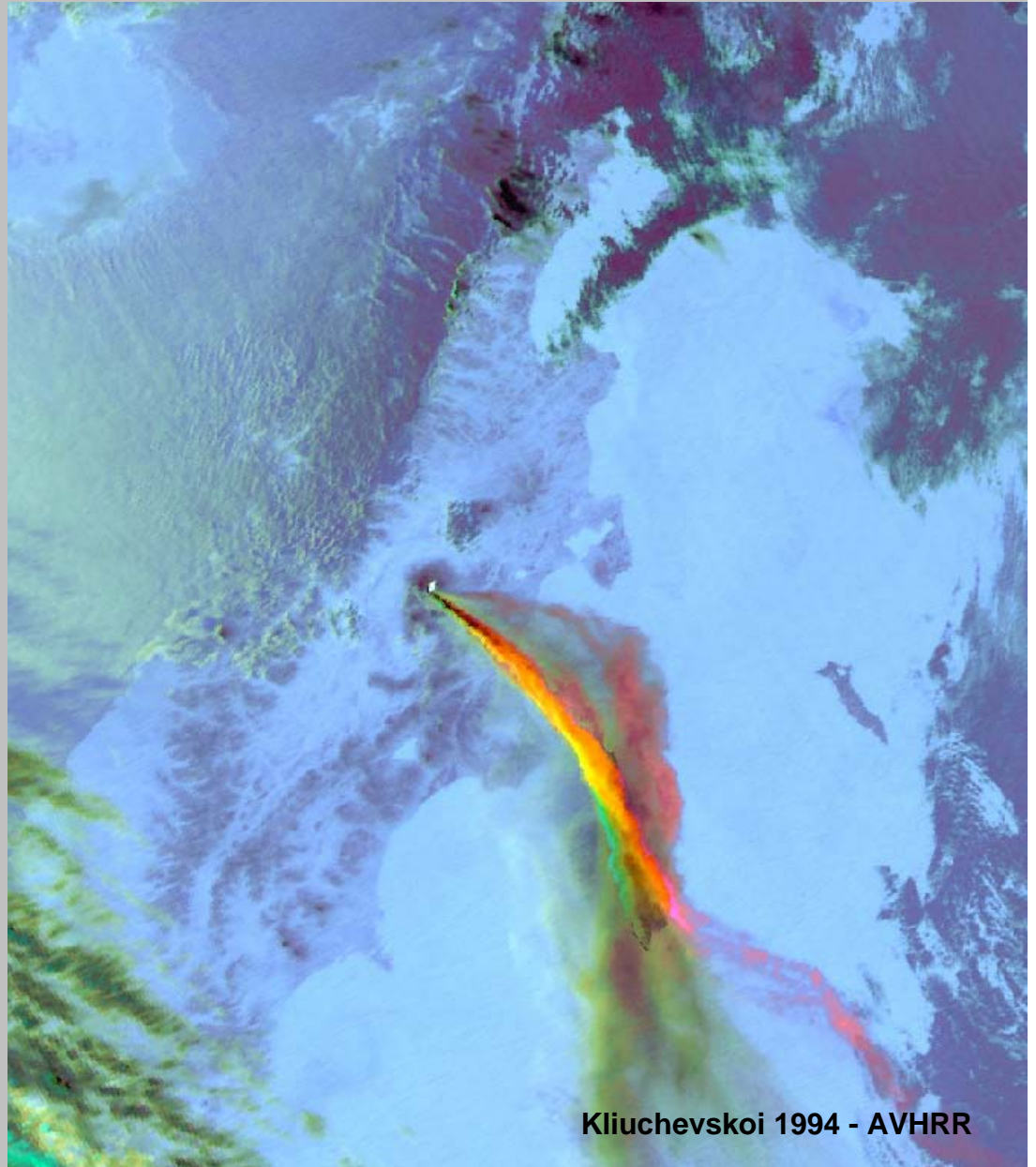
**Height, Location,  
Presence of Ash**

**Importance**

**Hazard to Aircraft  
Ground Infrastructure  
Health**

**Source**

**Explosive Eruptions  
NOPAC Region  
Primary Hazard**

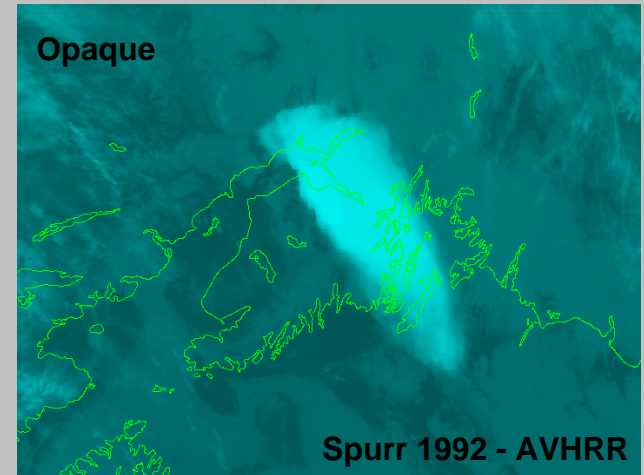




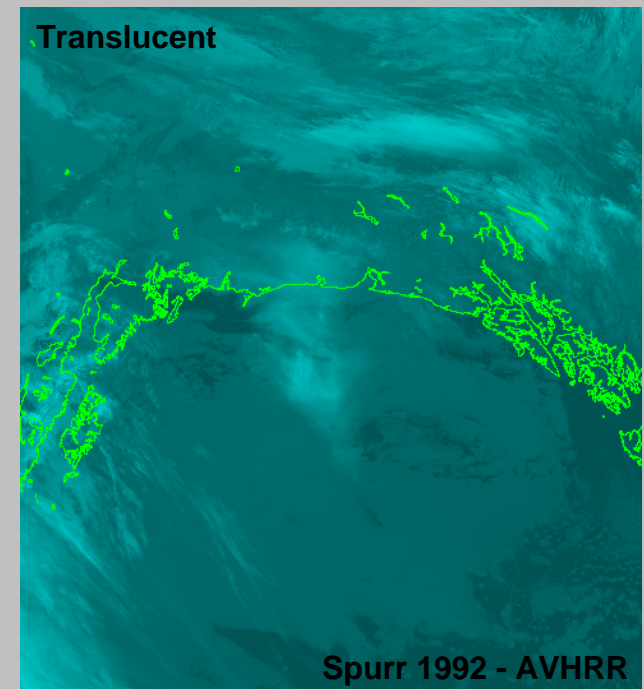
# Volcanic Cloud Analysis

## Plumes Evolve:

Opaque plumes = derive height



Translucent = presence of ash  
Band subtraction of 2 TIR Channels

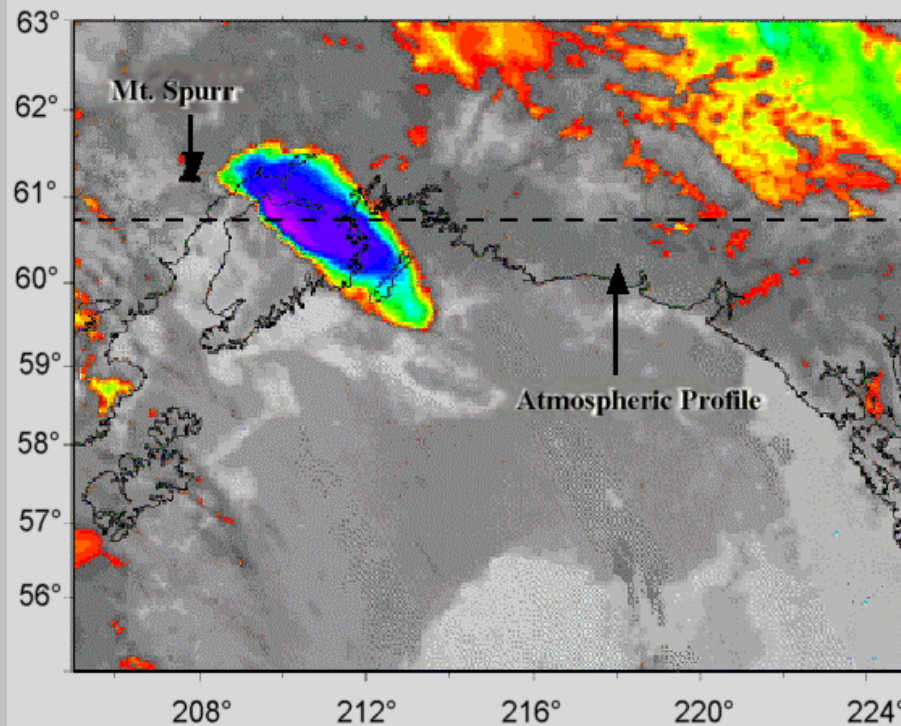


# Volcanic Cloud Height Estimate

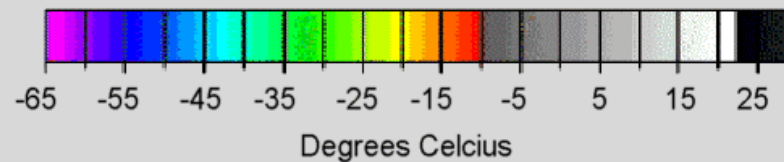
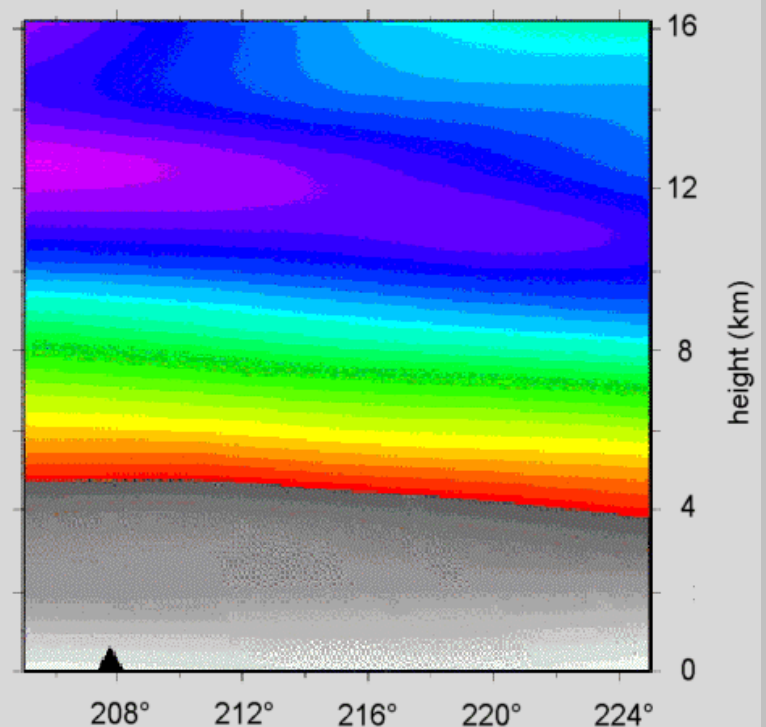
3 Methods: Cloud temperature, cloud shadow & wind shear

Use 10-12  $\mu\text{m}$  data, derive temp. compare to atm. temp.

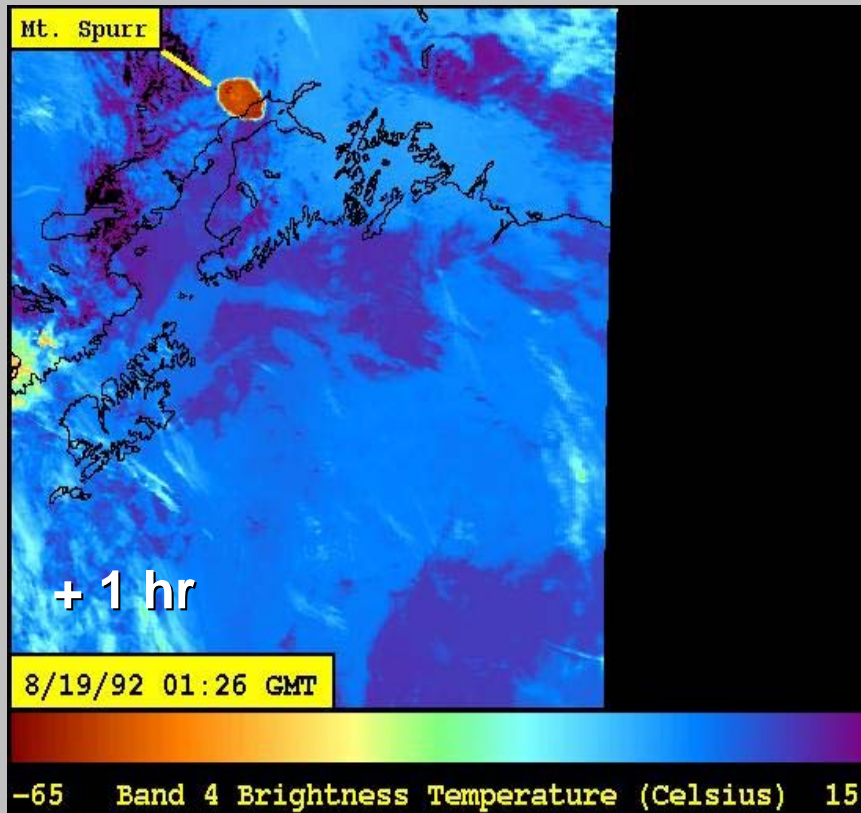
AVHRR Thermal Image (Band 4) 19 August 1992 05:12 UTC



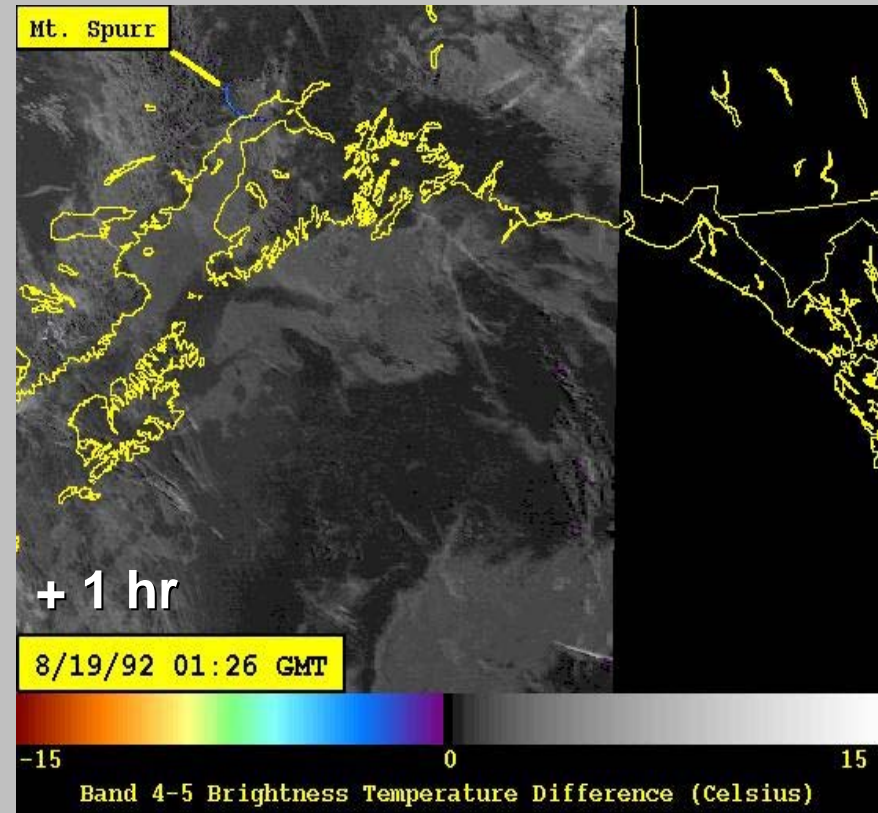
Atmospheric Temperature Profile at 60.75°N



# Volcanic Cloud Evolution



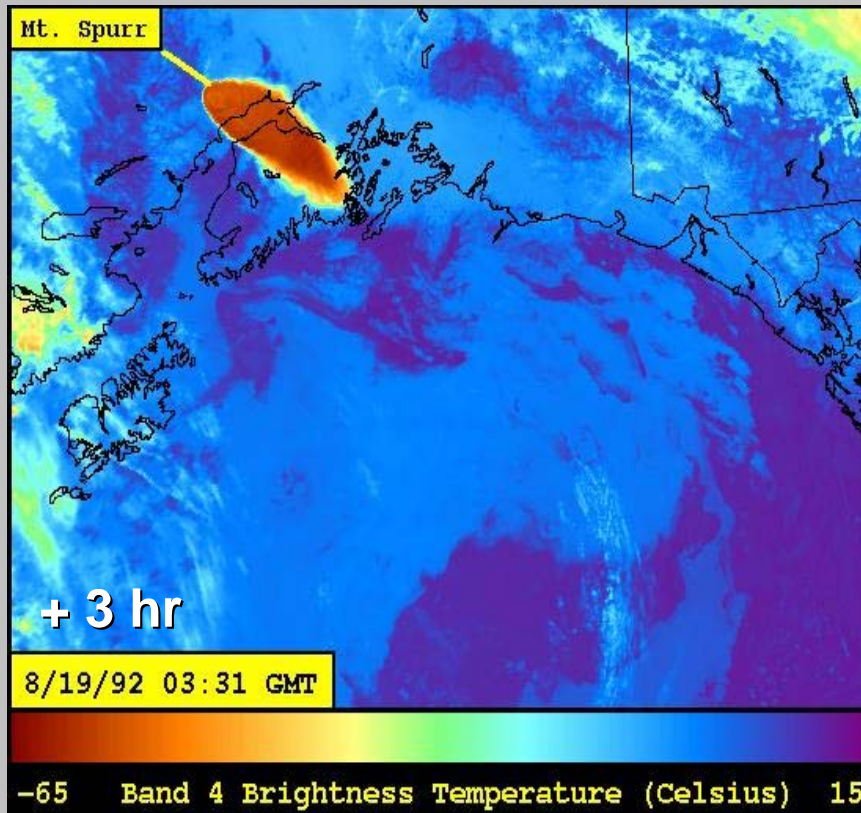
**AVHRR: Single Band (B4)**  
**Plume Clear evident**  
**Determine Cloud height**



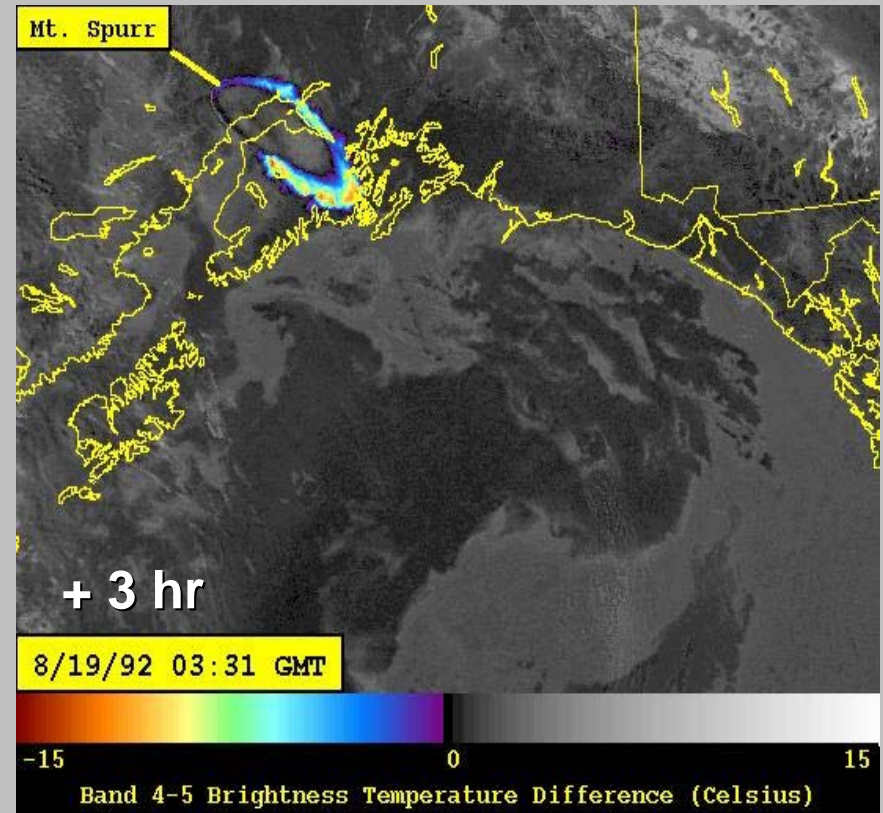
**AVHRR: Split Window B4 minus B5**  
**Ash signal not evident**



# Volcanic Cloud Evolution



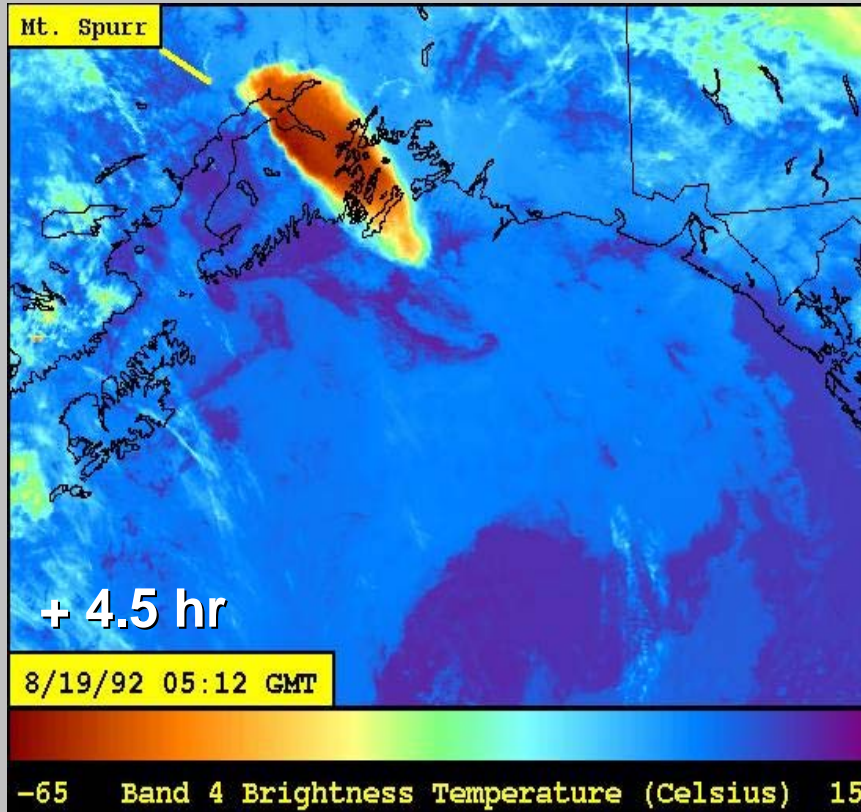
AVHRR: Single band (B4)  
Plume clear evident  
Determine cloud height



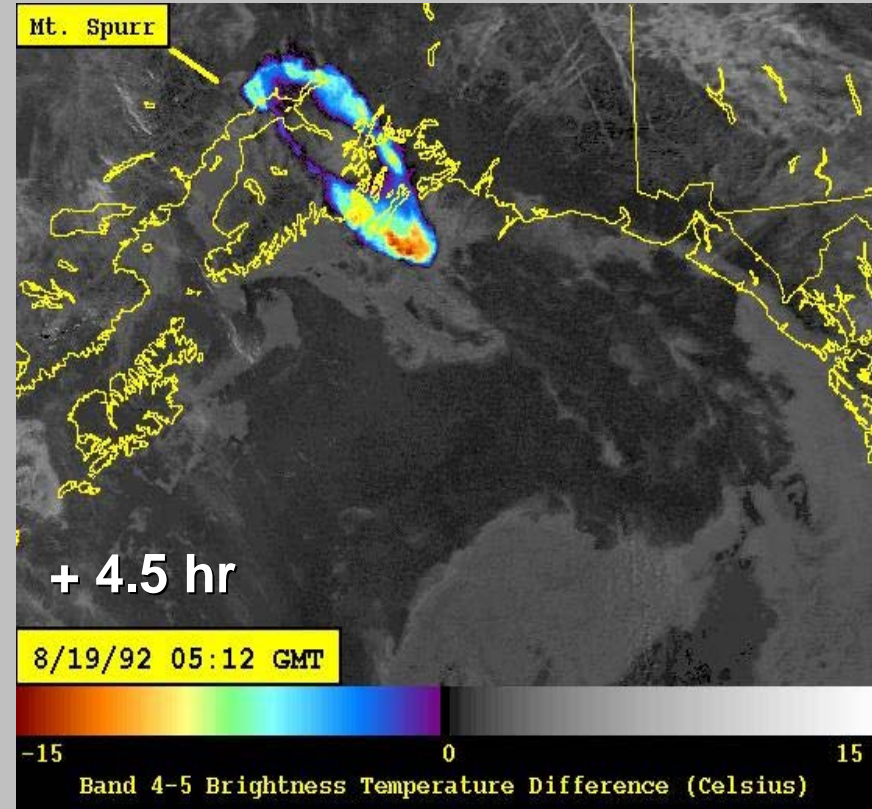
AVHRR: Split Window B4 minus B5  
Ash signal along fringes of plume



# Volcanic Cloud Evolution

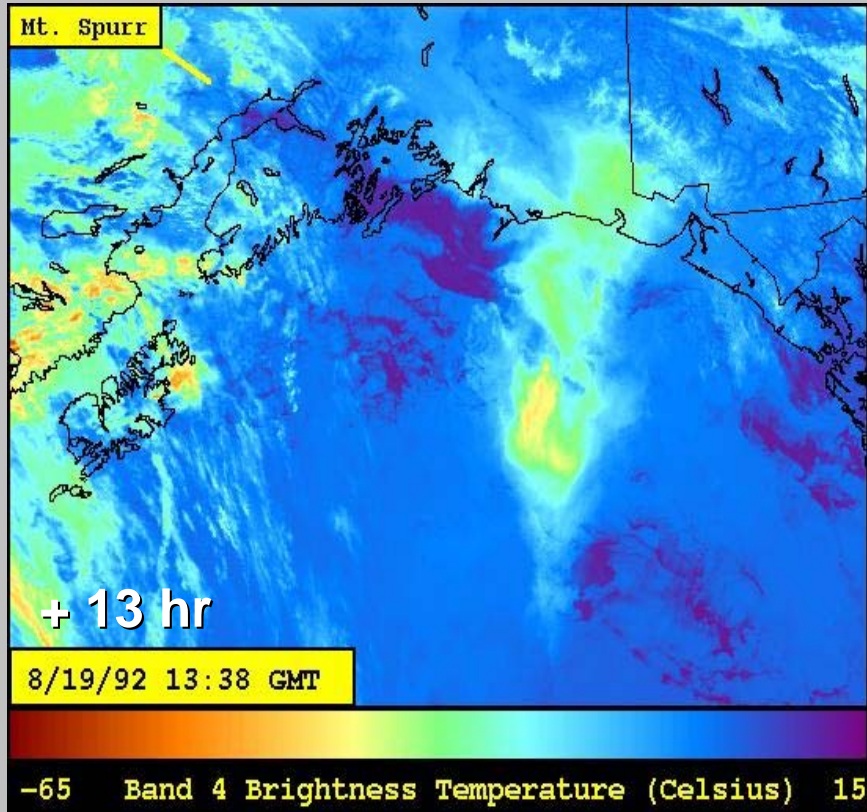


**AVHRR: Single band (B4)**  
**Plume clear evident**  
**Determine cloud height**

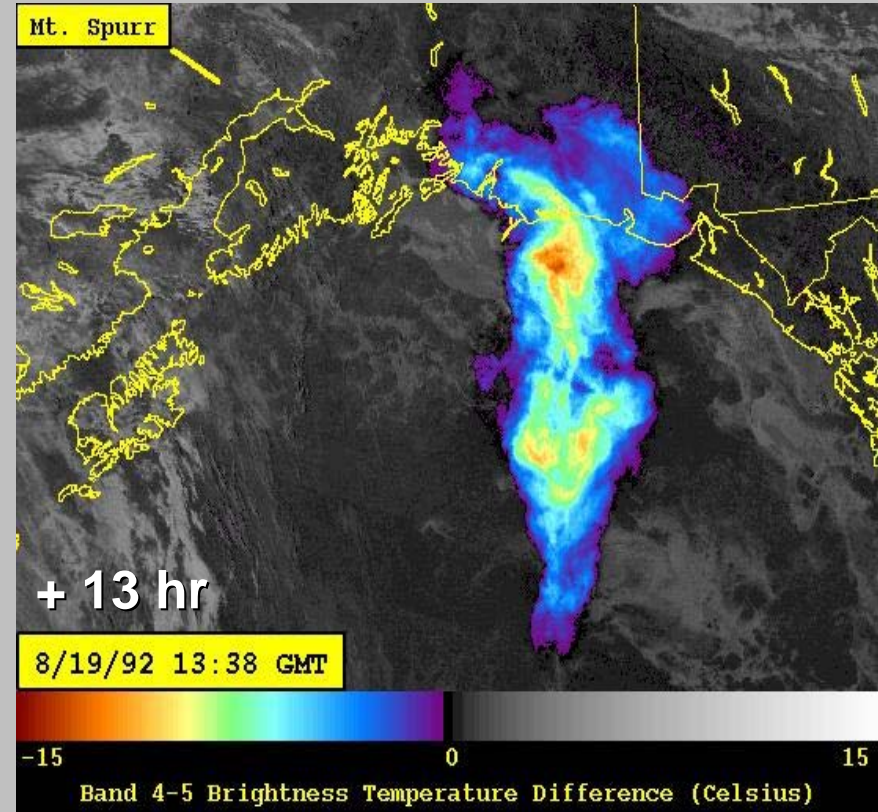


**AVHRR: Split Window B4 minus B5**  
**Ash signal along fringes of plume**

# Volcanic Cloud Evolution



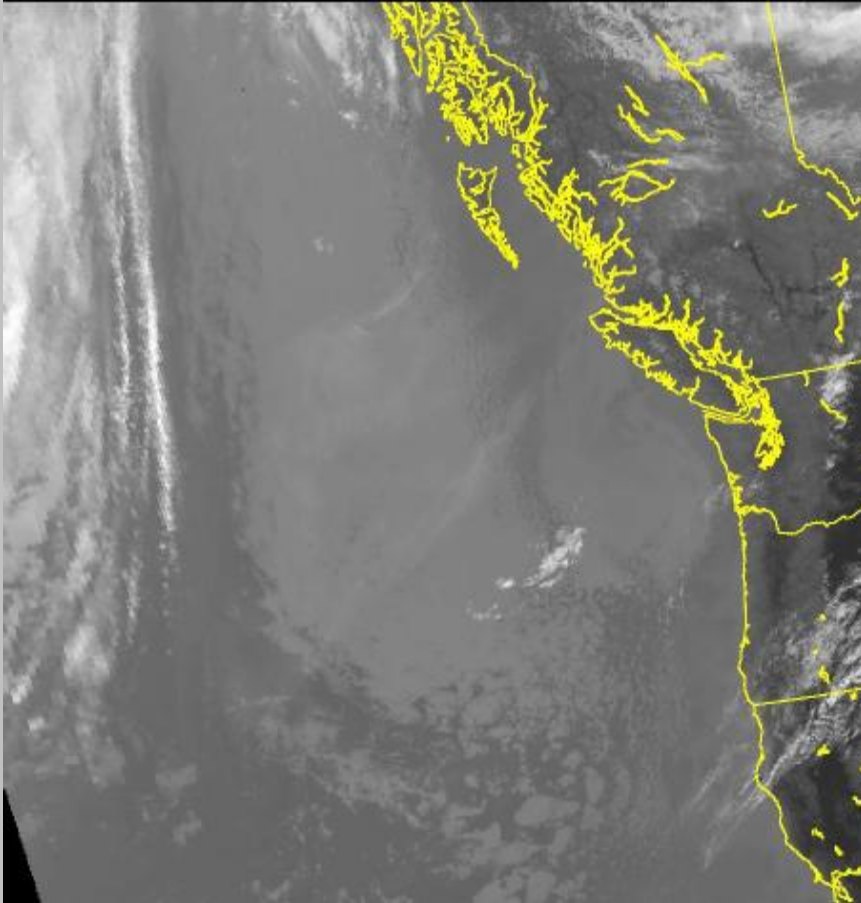
AVHRR: Single band (B4)  
Plume is translucent  
No cloud height



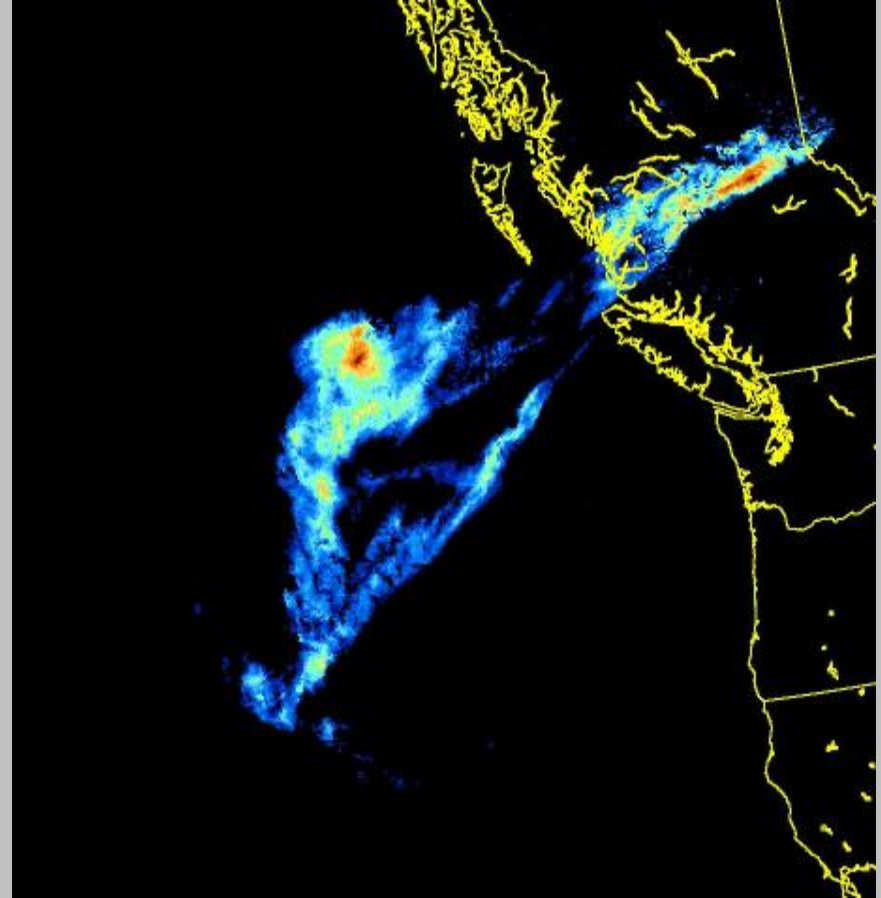
AVHRR: Split Window B4 minus B5  
Clear ash signal



# Volcanic Cloud Evolution



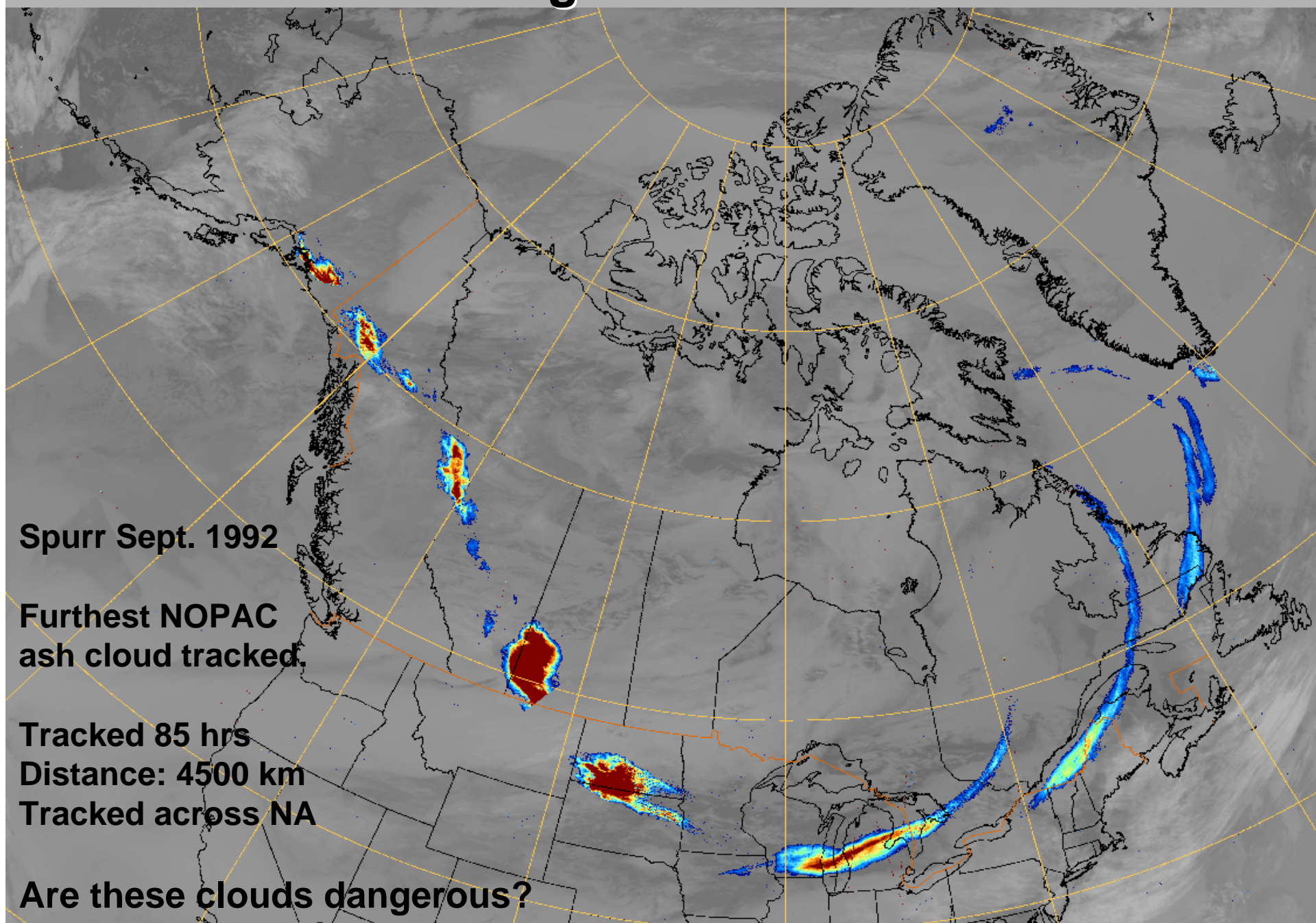
**AVHRR: Single band (B4)**  
**Plume not seen**  
**No cloud height**



**AVHRR: Split Window B4 minus B5**  
**Clear ash signal**

**What is the concentration of the ash?**

# Tracking Volcanic Cloud





# Predicting Plume Movement: Puff Model

- Specifically tailored for volcanic ash and 3D tracking of volcanic ash particles
- Hypothetical particles released over volcano
- Particles tracked over time
- Uses meteorological wind fields
- Initialization parameters include
  - Volcano name and location
  - Number of particles
  - Mean Particle size and spread
  - Plume dimensions (height, width and shape)
  - Length of model prediction and length of eruption
  - Output time step
  - Horizontal and Vertical Diffusion
  - Wind field model



(<http://puff.images.alaska.edu>)

# Dispersion Models

Predicts volcanic cloud movement

Information when satellite data is not available

Use satellite data for validation and calibration

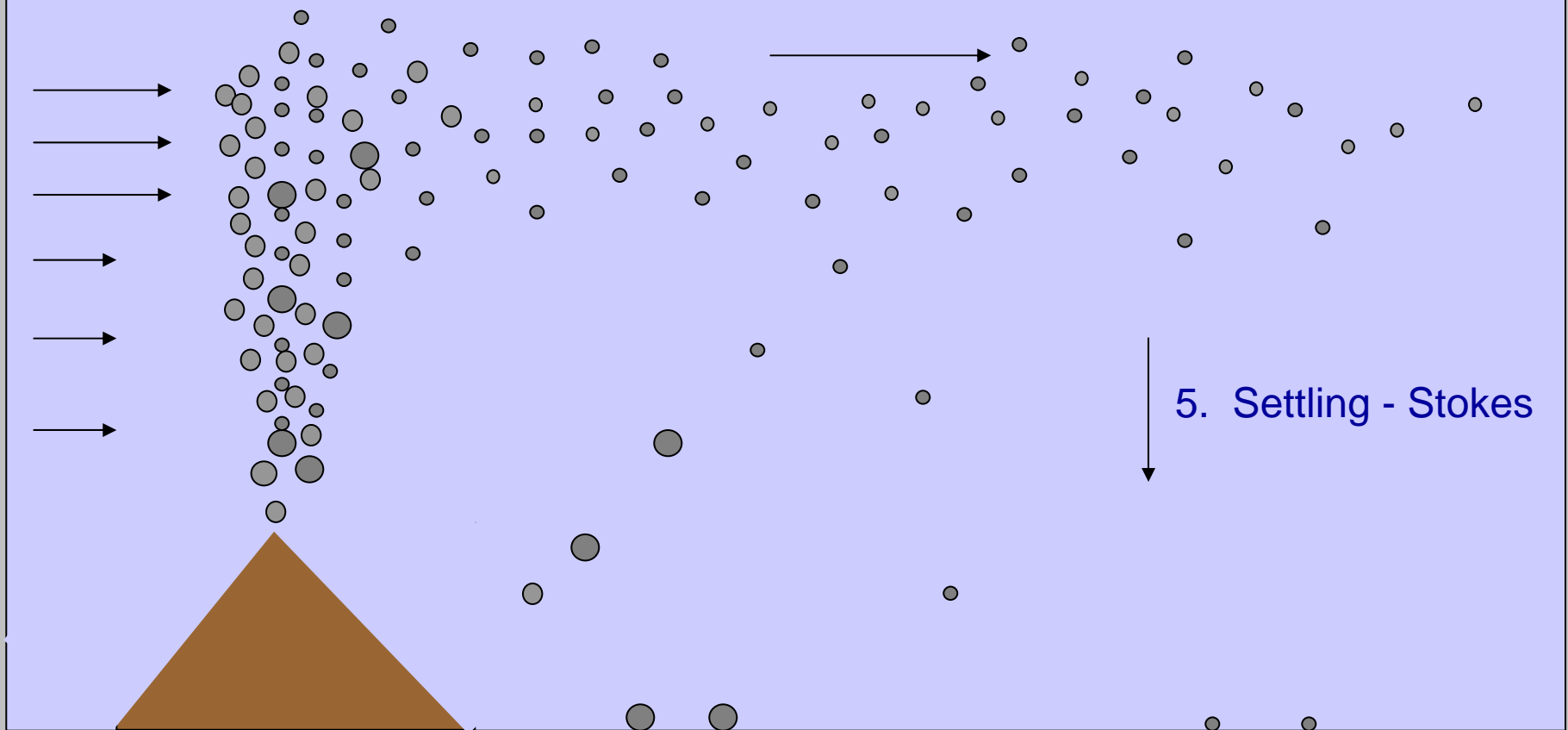
1. Global  
Wind Fields

2. Particle Size:  
variable  
Distribution: variable

3. Movement from wind,  
position tracked in  
space and time

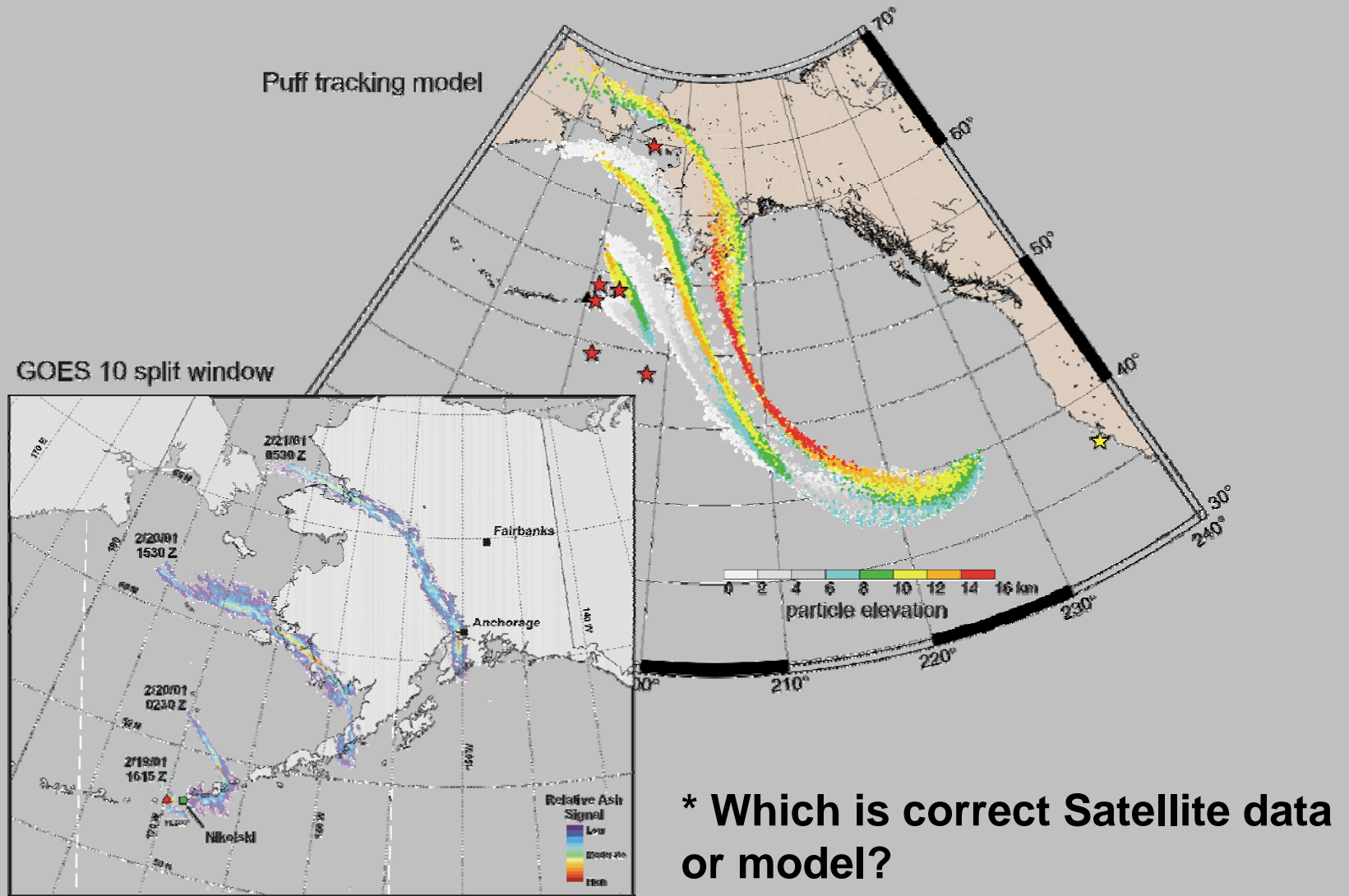
4. Dispersion &  
Diffusion - Constant

5. Settling - Stokes



# Comparison Puff and GOES Images, Mt. Cleveland Eruption

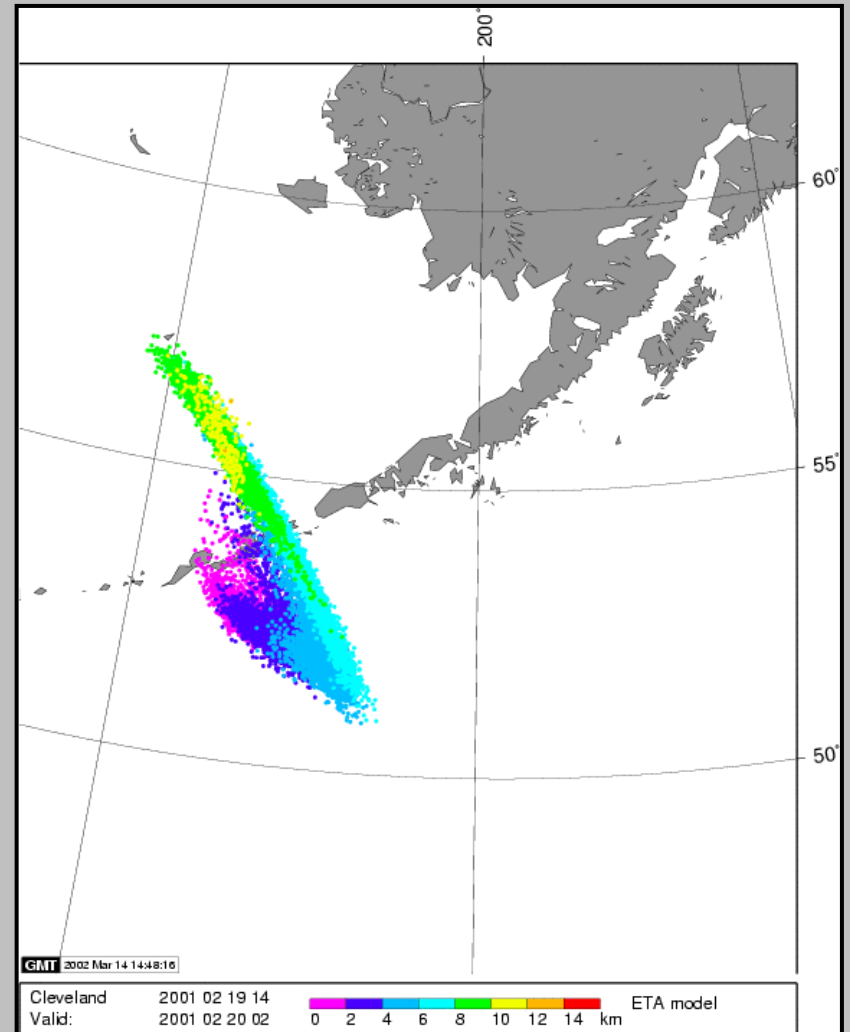
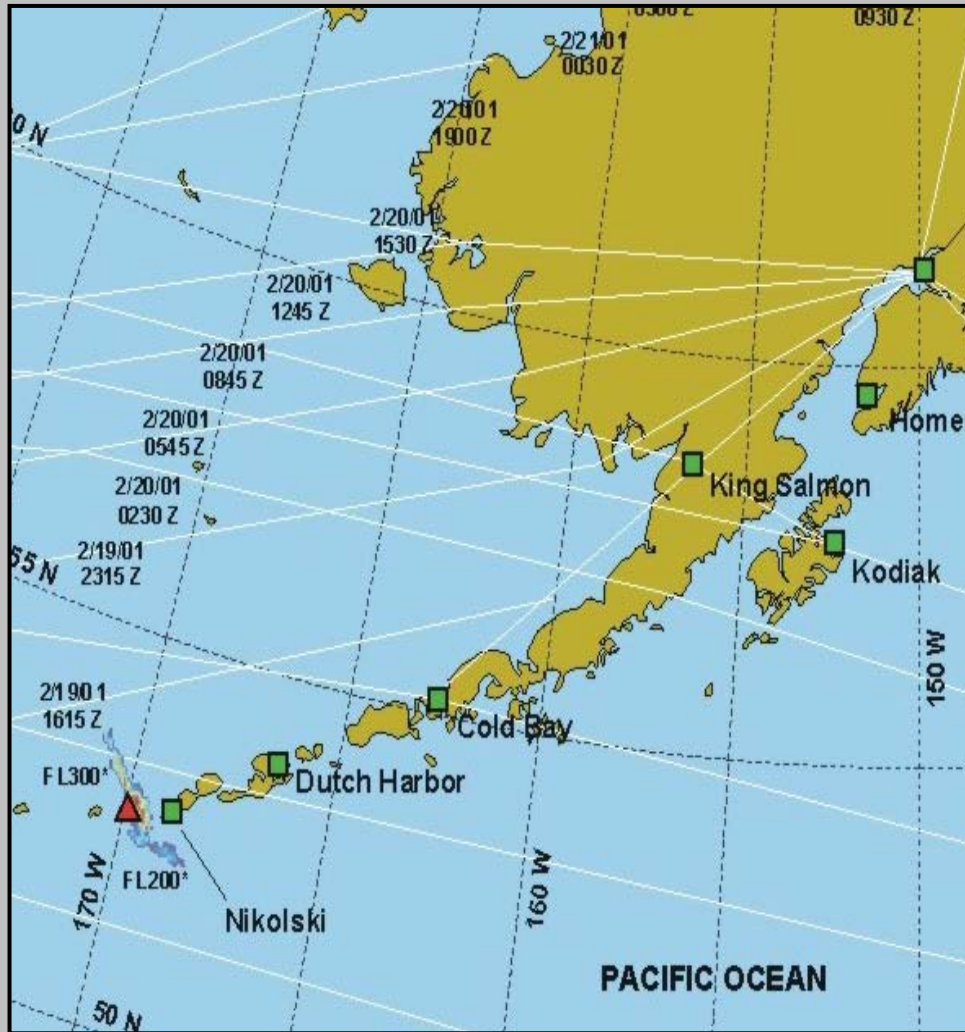
Satellite data is used to validate models.  
Satellite data detects less than the model.



# Dispersion Models: Cloud Height Estimation

GOES shows cloud to NW and SE

Puff shows clouds > 8km to NW & < 8km to SE

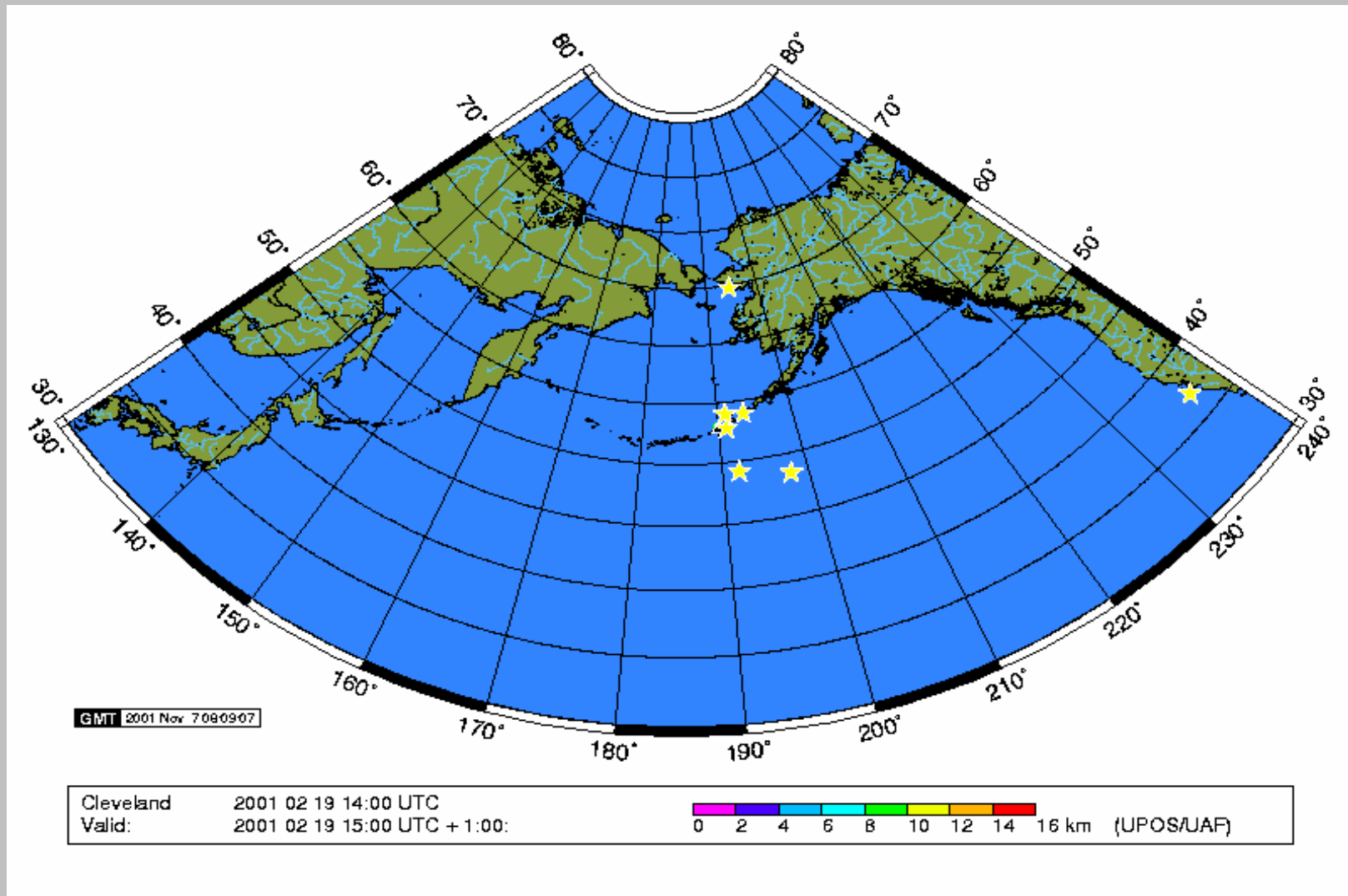




# Dispersion Models

Puff model run: take minutes on PC

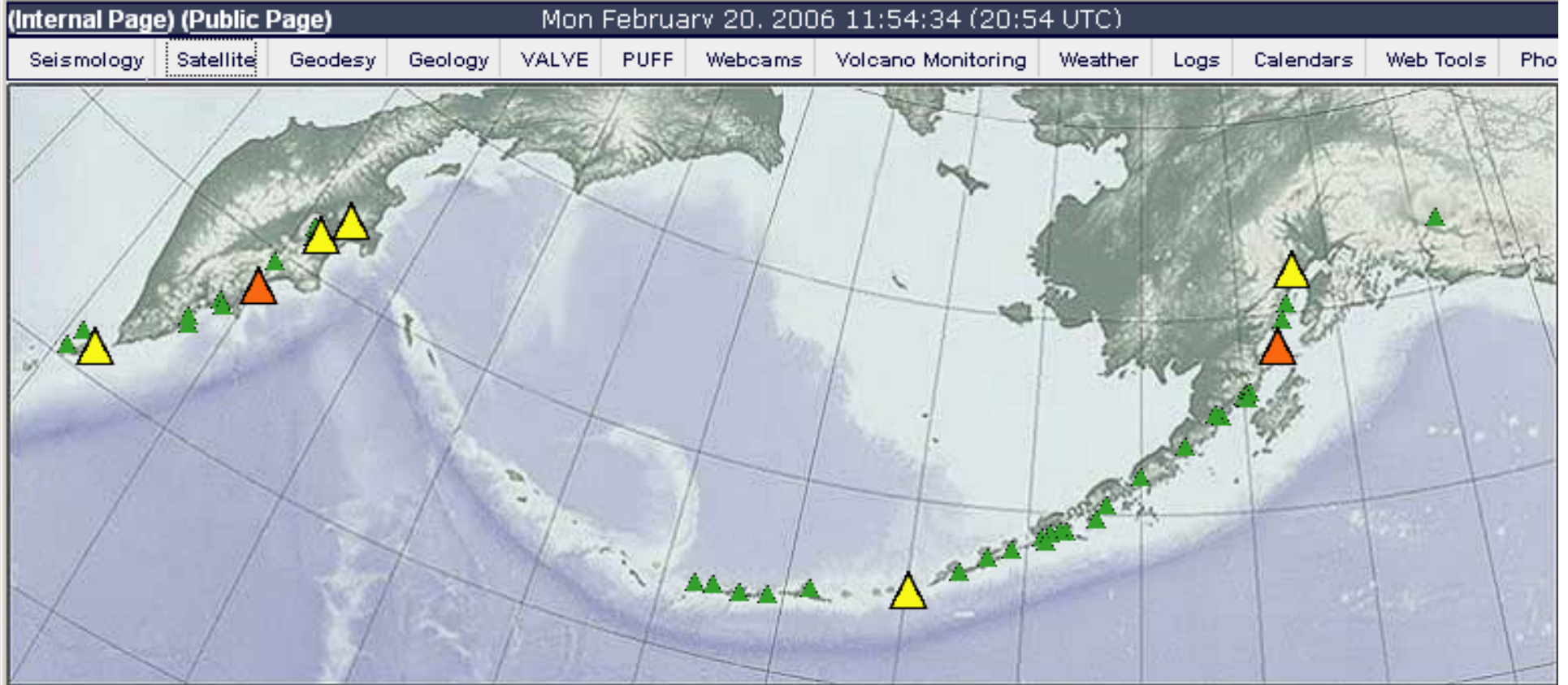
Significance Cleveland Eruptions 2001: Distal particles are valid



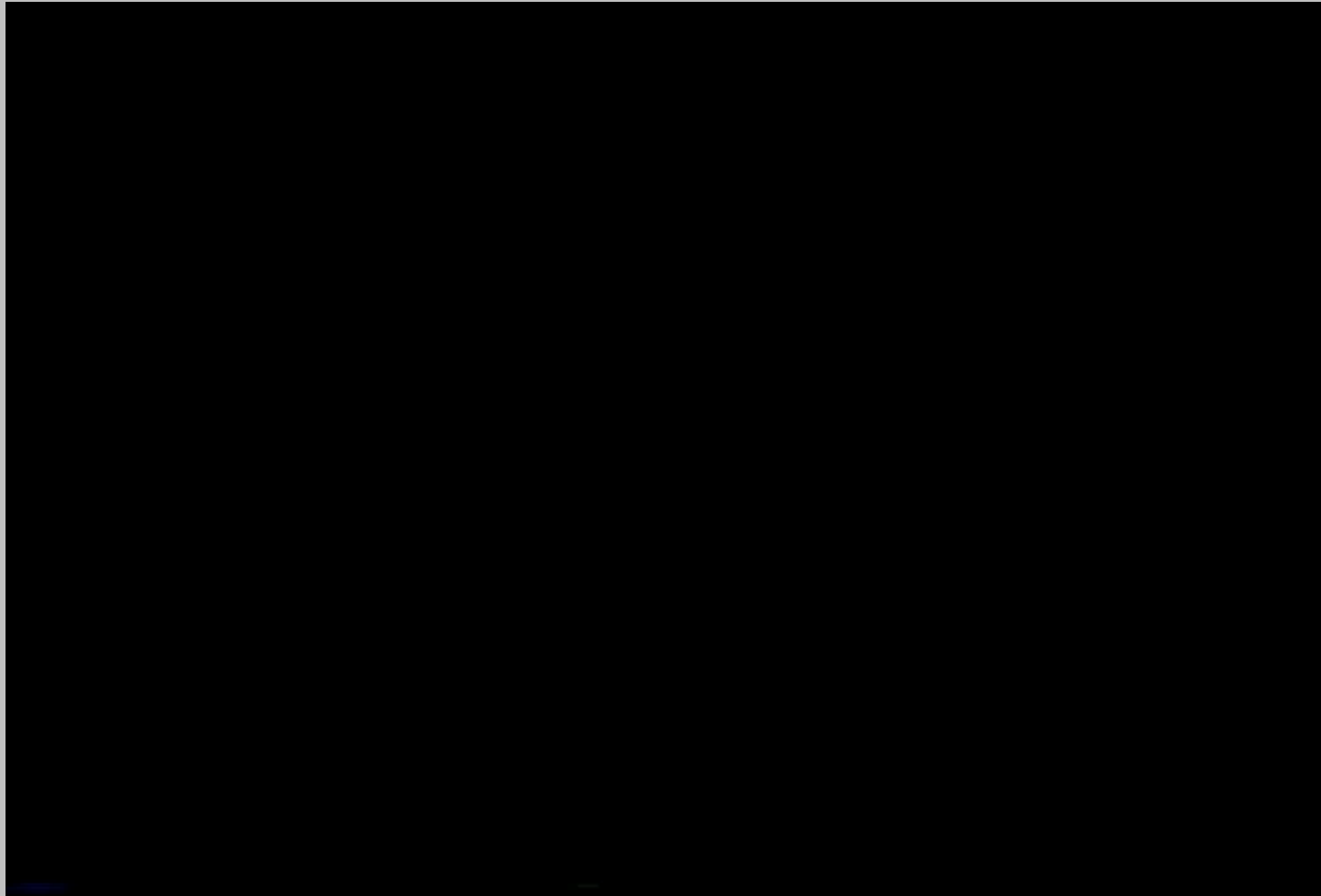
# Satellite Volcano Monitoring Program



Divisions of AVO: Remote Sensing, Seismic, Geodesy, Geology



# **British Air 747 (Speedbird 9): encounters ash cloud (Indonesia, Galunggung, 1983)**



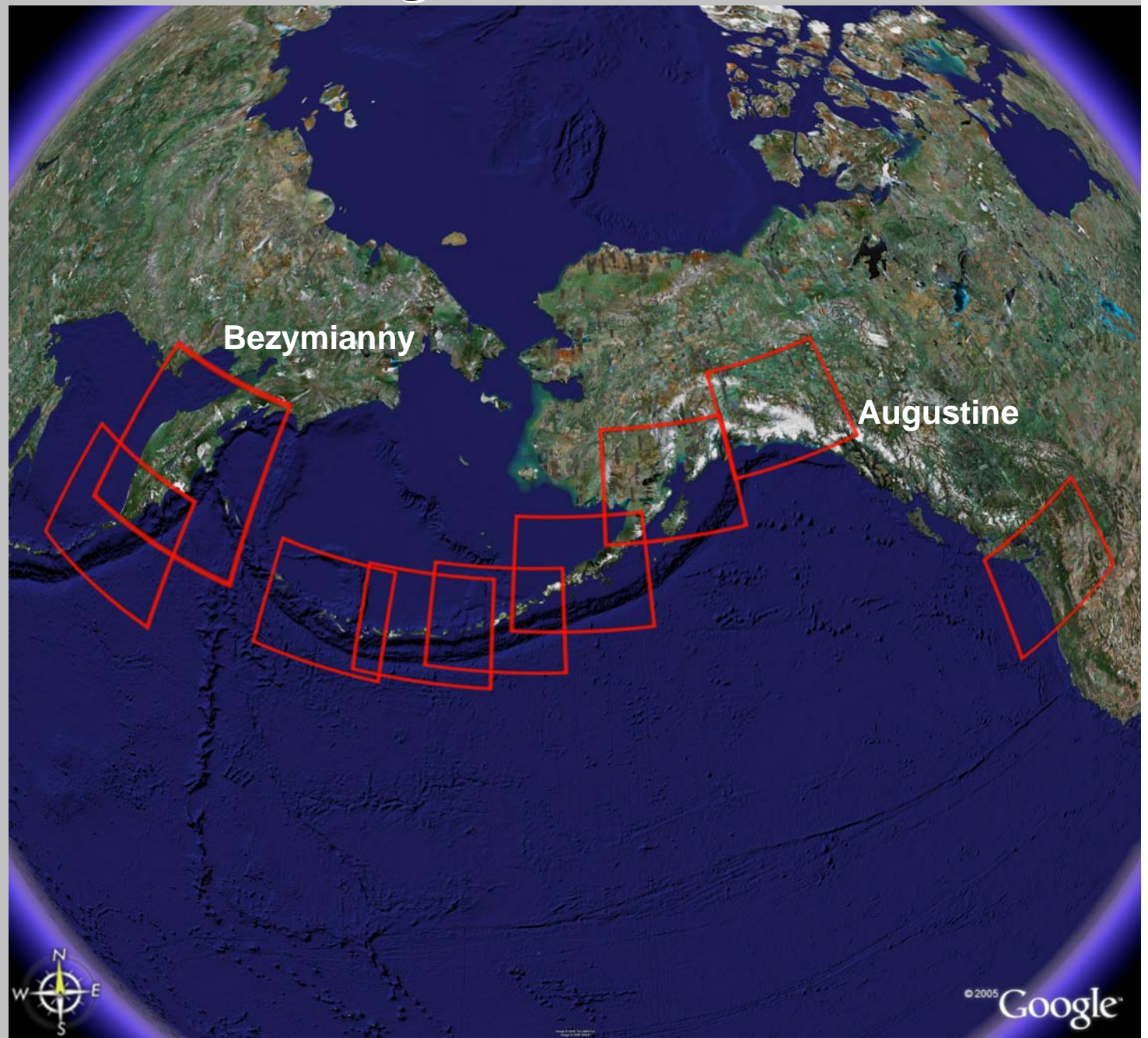


# Monitoring Sectors

**NOPAC Region**

**10 Sectors**

**Multiple Volc.  
in each sector**





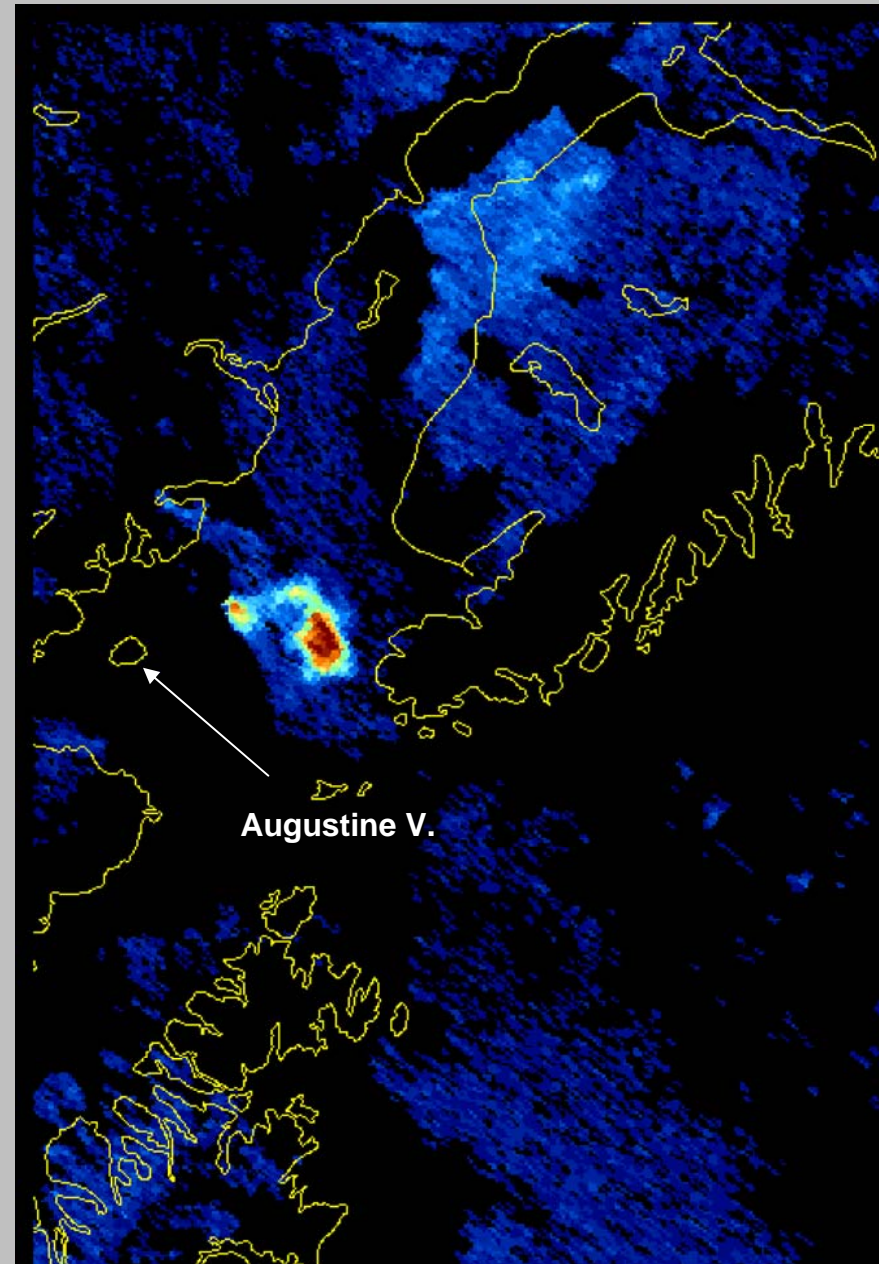
# Critical Features for Volcanic Cloud Monitoring

## Plumes (Eruption Clouds)

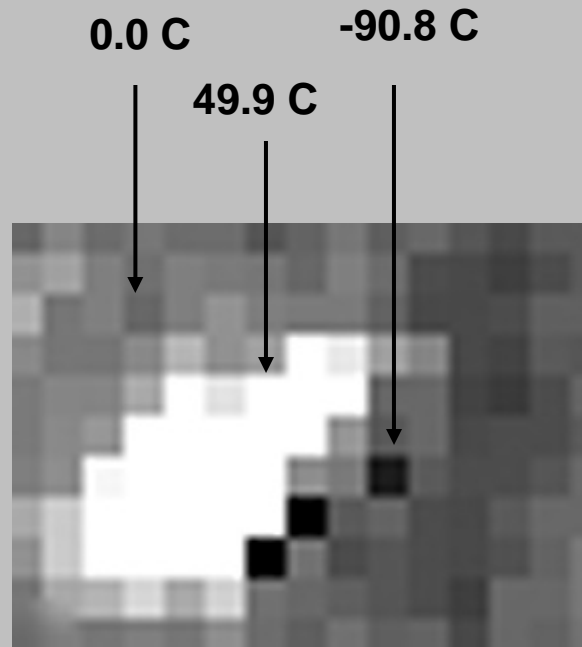
Health hazard, dangerous to  
Aircraft, local and global carriers

## Measured Parameters:

- Plume Direction: East
- Distance: 40 km
- Ash Signal:
- Temperature: NA
- Height: Puff
- Predictions: Puff
- Ashfall (under development)

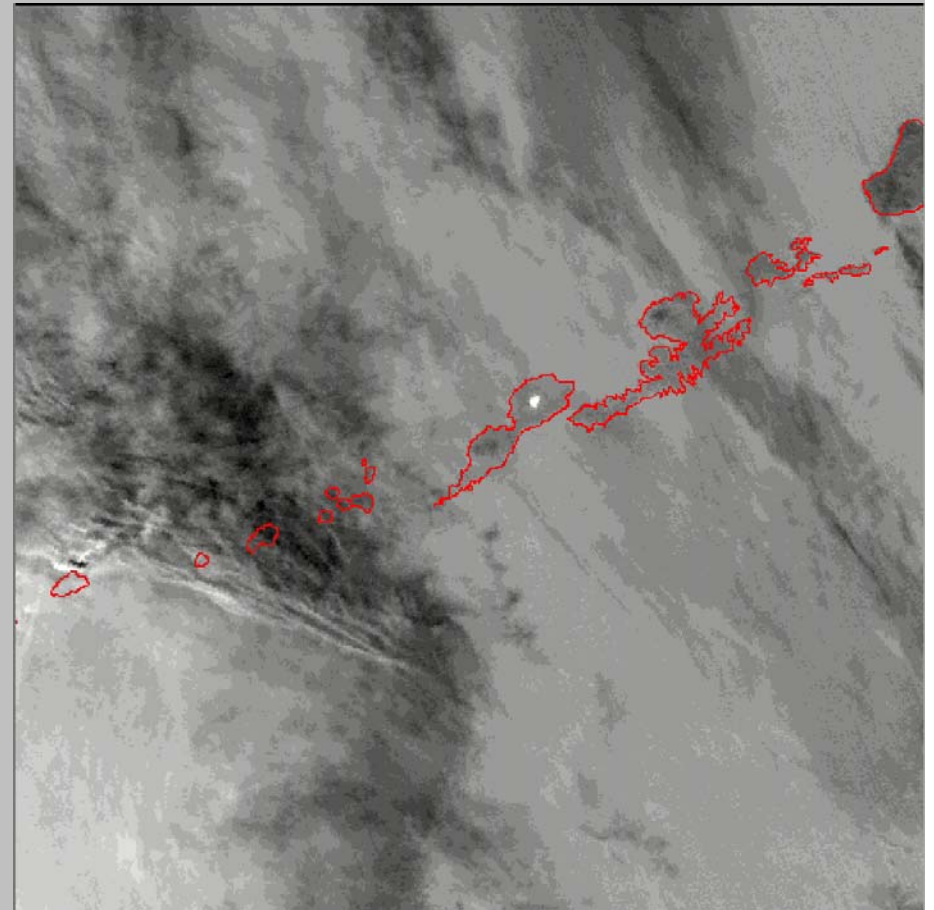


# Critical Features for Thermal Anomaly Monitoring



## Measured Parameters:

|                |          |
|----------------|----------|
| Location:      | Okmok V. |
| Hottest Temp.: | 49.9°C   |
| No. of Pixels: | 24       |
| Thermal Flux   | ----     |
| Effusion Rate  | ----     |



# Volcano Monitoring Systems

2 Types:

Manual

Automated



# Manual: Web-based Monitoring Database

Consistent entry

Automated report

Searchable records

|                           |  |                                     |                               |                                |
|---------------------------|--|-------------------------------------|-------------------------------|--------------------------------|
| <a href="#">Base Page</a> | <a href="#">Satellite Observations</a> | <a href="#">Camera Observations</a> | <a href="#">Preview Email</a> | <a href="#">Send and Store</a> |
|---------------------------|--|-------------------------------------|-------------------------------|--------------------------------|

| <p>Cloud conditions for volcanoes with elevated color codes:</p> <table border="1"> <thead> <tr> <th>Volcano</th> <th>Color Code</th> <th>Cloud Cond</th> </tr> </thead> <tbody> <tr> <td>Augustine</td> <td>Yellow</td> <td>No Coverage</td> </tr> <tr> <td>Veniaminof</td> <td>Yellow</td> <td>Clear</td> </tr> <tr> <td>St. Helens</td> <td>Orange</td> <td>Mostly Clear</td> </tr> <tr> <td>Bezymianny</td> <td>Yellow</td> <td>Partly Cloudy</td> </tr> <tr> <td>Karymsky</td> <td>Orange</td> <td>Mostly Cloudy</td> </tr> <tr> <td>Shiveluch</td> <td>Yellow</td> <td>Cloudy</td> </tr> </tbody> </table> | Volcano       | Color Code    | Cloud Cond | Augustine | Yellow | No Coverage | Veniaminof | Yellow | Clear | St. Helens | Orange | Mostly Clear | Bezymianny | Yellow | Partly Cloudy | Karymsky | Orange | Mostly Cloudy | Shiveluch | Yellow | Cloudy | <p>Cloud conditions for each region:</p> <table border="1"> <tbody> <tr><td>Wrangell</td><td>No Coverage</td></tr> <tr><td>Augustine</td><td>Clear</td></tr> <tr><td>Pavlof</td><td>Mostly Clear</td></tr> <tr><td>Vsevidof</td><td>Partly Cloudy</td></tr> <tr><td>Korovin</td><td>Mostly Cloudy</td></tr> <tr><td>Kiska</td><td>Cloudy</td></tr> <tr><td>Cascades</td><td></td></tr> <tr><td>Yellowstone</td><td></td></tr> <tr><td>Bezymianny</td><td></td></tr> <tr><td>Kurile</td><td></td></tr> </tbody> </table> | Wrangell | No Coverage | Augustine | Clear | Pavlof | Mostly Clear | Vsevidof | Partly Cloudy | Korovin | Mostly Cloudy | Kiska | Cloudy | Cascades |  | Yellowstone |  | Bezymianny |  | Kurile |  | <p>Last images viewed:</p> <table border="1"> <tbody> <tr><td>AVHRR</td><td>20:54 UTC</td><td>(?)</td></tr> <tr><td><a href="#">GOES11</a></td><td></td><td>(?)</td></tr> <tr><td><a href="#">MTSAT1</a></td><td></td><td>(?)</td></tr> <tr><td>MODIS</td><td></td><td>(?)</td></tr> <tr><td><a href="#">AugiCam</a></td><td></td><td>(?)</td></tr> <tr><td><a href="#">ChigCam</a></td><td></td><td>(?)</td></tr> <tr><td><a href="#">SpurrCam</a></td><td></td><td>(?)</td></tr> <tr><td><a href="#">SpurrCrCam</a></td><td></td><td>(?)</td></tr> <tr><td><a href="#">VeniCam</a></td><td></td><td>(?)</td></tr> <tr><td><a href="#">HelensCam</a></td><td></td><td>(?)</td></tr> <tr><td><a href="#">BezyCam</a></td><td></td><td>(?)</td></tr> <tr><td><a href="#">KluCam</a></td><td></td><td>(?)</td></tr> <tr><td><a href="#">ShivCam</a></td><td></td><td>(?)</td></tr> </tbody> </table> | AVHRR | 20:54 UTC | (?) | <a href="#">GOES11</a> |  | (?) | <a href="#">MTSAT1</a> |  | (?) | MODIS |  | (?) | <a href="#">AugiCam</a> |  | (?) | <a href="#">ChigCam</a> |  | (?) | <a href="#">SpurrCam</a> |  | (?) | <a href="#">SpurrCrCam</a> |  | (?) | <a href="#">VeniCam</a> |  | (?) | <a href="#">HelensCam</a> |  | (?) | <a href="#">BezyCam</a> |  | (?) | <a href="#">KluCam</a> |  | (?) | <a href="#">ShivCam</a> |  | (?) |
|--|---------------|---------------|------------|-----------|--------|-------------|------------|--------|-------|------------|--------|--------------|------------|--------|---------------|----------|--------|---------------|-----------|--------|--------|---|----------|-------------|-----------|-------|--------|--------------|----------|---------------|---------|---------------|-------|--------|----------|--|-------------|--|------------|--|--------|--|--|-------|-----------|-----|------------------------|--|-----|------------------------|--|-----|-------|--|-----|-------------------------|--|-----|-------------------------|--|-----|--------------------------|--|-----|----------------------------|--|-----|-------------------------|--|-----|---------------------------|--|-----|-------------------------|--|-----|------------------------|--|-----|-------------------------|--|-----|
| Volcano  | Color Code    | Cloud Cond    |            |           |        |             |            |        |       |            |        |              |            |        |               |          |        |               |           |        |        |   |          |             |           |       |        |              |          |               |         |               |       |        |          |  |             |  |            |  |        |  |  |       |           |     |                        |  |     |                        |  |     |       |  |     |                         |  |     |                         |  |     |                          |  |     |                            |  |     |                         |  |     |                           |  |     |                         |  |     |                        |  |     |                         |  |     |
| Augustine  | Yellow        | No Coverage   |            |           |        |             |            |        |       |            |        |              |            |        |               |          |        |               |           |        |        |   |          |             |           |       |        |              |          |               |         |               |       |        |          |  |             |  |            |  |        |  |  |       |           |     |                        |  |     |                        |  |     |       |  |     |                         |  |     |                         |  |     |                          |  |     |                            |  |     |                         |  |     |                           |  |     |                         |  |     |                        |  |     |                         |  |     |
| Veniaminof   | Yellow        | Clear         |            |           |        |             |            |        |       |            |        |              |            |        |               |          |        |               |           |        |        |   |          |             |           |       |        |              |          |               |         |               |       |        |          |  |             |  |            |  |        |  |  |       |           |     |                        |  |     |                        |  |     |       |  |     |                         |  |     |                         |  |     |                          |  |     |                            |  |     |                         |  |     |                           |  |     |                         |  |     |                        |  |     |                         |  |     |
| St. Helens   | Orange        | Mostly Clear  |            |           |        |             |            |        |       |            |        |              |            |        |               |          |        |               |           |        |        |   |          |             |           |       |        |              |          |               |         |               |       |        |          |  |             |  |            |  |        |  |  |       |           |     |                        |  |     |                        |  |     |       |  |     |                         |  |     |                         |  |     |                          |  |     |                            |  |     |                         |  |     |                           |  |     |                         |  |     |                        |  |     |                         |  |     |
| Bezymianny   | Yellow        | Partly Cloudy |            |           |        |             |            |        |       |            |        |              |            |        |               |          |        |               |           |        |        |   |          |             |           |       |        |              |          |               |         |               |       |        |          |  |             |  |            |  |        |  |  |       |           |     |                        |  |     |                        |  |     |       |  |     |                         |  |     |                         |  |     |                          |  |     |                            |  |     |                         |  |     |                           |  |     |                         |  |     |                        |  |     |                         |  |     |
| Karymsky   | Orange        | Mostly Cloudy |            |           |        |             |            |        |       |            |        |              |            |        |               |          |        |               |           |        |        |   |          |             |           |       |        |              |          |               |         |               |       |        |          |  |             |  |            |  |        |  |  |       |           |     |                        |  |     |                        |  |     |       |  |     |                         |  |     |                         |  |     |                          |  |     |                            |  |     |                         |  |     |                           |  |     |                         |  |     |                        |  |     |                         |  |     |
| Shiveluch  | Yellow        | Cloudy        |            |           |        |             |            |        |       |            |        |              |            |        |               |          |        |               |           |        |        |   |          |             |           |       |        |              |          |               |         |               |       |        |          |  |             |  |            |  |        |  |  |       |           |     |                        |  |     |                        |  |     |       |  |     |                         |  |     |                         |  |     |                          |  |     |                            |  |     |                         |  |     |                           |  |     |                         |  |     |                        |  |     |                         |  |     |
| Wrangell   | No Coverage   |               |            |           |        |             |            |        |       |            |        |              |            |        |               |          |        |               |           |        |        |   |          |             |           |       |        |              |          |               |         |               |       |        |          |  |             |  |            |  |        |  |  |       |           |     |                        |  |     |                        |  |     |       |  |     |                         |  |     |                         |  |     |                          |  |     |                            |  |     |                         |  |     |                           |  |     |                         |  |     |                        |  |     |                         |  |     |
| Augustine  | Clear         |               |            |           |        |             |            |        |       |            |        |              |            |        |               |          |        |               |           |        |        |   |          |             |           |       |        |              |          |               |         |               |       |        |          |  |             |  |            |  |        |  |  |       |           |     |                        |  |     |                        |  |     |       |  |     |                         |  |     |                         |  |     |                          |  |     |                            |  |     |                         |  |     |                           |  |     |                         |  |     |                        |  |     |                         |  |     |
| Pavlof   | Mostly Clear  |               |            |           |        |             |            |        |       |            |        |              |            |        |               |          |        |               |           |        |        |   |          |             |           |       |        |              |          |               |         |               |       |        |          |  |             |  |            |  |        |  |  |       |           |     |                        |  |     |                        |  |     |       |  |     |                         |  |     |                         |  |     |                          |  |     |                            |  |     |                         |  |     |                           |  |     |                         |  |     |                        |  |     |                         |  |     |
| Vsevidof   | Partly Cloudy |               |            |           |        |             |            |        |       |            |        |              |            |        |               |          |        |               |           |        |        |   |          |             |           |       |        |              |          |               |         |               |       |        |          |  |             |  |            |  |        |  |  |       |           |     |                        |  |     |                        |  |     |       |  |     |                         |  |     |                         |  |     |                          |  |     |                            |  |     |                         |  |     |                           |  |     |                         |  |     |                        |  |     |                         |  |     |
| Korovin  | Mostly Cloudy |               |            |           |        |             |            |        |       |            |        |              |            |        |               |          |        |               |           |        |        |   |          |             |           |       |        |              |          |               |         |               |       |        |          |  |             |  |            |  |        |  |  |       |           |     |                        |  |     |                        |  |     |       |  |     |                         |  |     |                         |  |     |                          |  |     |                            |  |     |                         |  |     |                           |  |     |                         |  |     |                        |  |     |                         |  |     |
| Kiska  | Cloudy        |               |            |           |        |             |            |        |       |            |        |              |            |        |               |          |        |               |           |        |        |   |          |             |           |       |        |              |          |               |         |               |       |        |          |  |             |  |            |  |        |  |  |       |           |     |                        |  |     |                        |  |     |       |  |     |                         |  |     |                         |  |     |                          |  |     |                            |  |     |                         |  |     |                           |  |     |                         |  |     |                        |  |     |                         |  |     |
| Cascades   |               |               |            |           |        |             |            |        |       |            |        |              |            |        |               |          |        |               |           |        |        |   |          |             |           |       |        |              |          |               |         |               |       |        |          |  |             |  |            |  |        |  |  |       |           |     |                        |  |     |                        |  |     |       |  |     |                         |  |     |                         |  |     |                          |  |     |                            |  |     |                         |  |     |                           |  |     |                         |  |     |                        |  |     |                         |  |     |
| Yellowstone  |               |               |            |           |        |             |            |        |       |            |        |              |            |        |               |          |        |               |           |        |        |   |          |             |           |       |        |              |          |               |         |               |       |        |          |  |             |  |            |  |        |  |  |       |           |     |                        |  |     |                        |  |     |       |  |     |                         |  |     |                         |  |     |                          |  |     |                            |  |     |                         |  |     |                           |  |     |                         |  |     |                        |  |     |                         |  |     |
| Bezymianny   |               |               |            |           |        |             |            |        |       |            |        |              |            |        |               |          |        |               |           |        |        |   |          |             |           |       |        |              |          |               |         |               |       |        |          |  |             |  |            |  |        |  |  |       |           |     |                        |  |     |                        |  |     |       |  |     |                         |  |     |                         |  |     |                          |  |     |                            |  |     |                         |  |     |                           |  |     |                         |  |     |                        |  |     |                         |  |     |
| Kurile   |               |               |            |           |        |             |            |        |       |            |        |              |            |        |               |          |        |               |           |        |        |   |          |             |           |       |        |              |          |               |         |               |       |        |          |  |             |  |            |  |        |  |  |       |           |     |                        |  |     |                        |  |     |       |  |     |                         |  |     |                         |  |     |                          |  |     |                            |  |     |                         |  |     |                           |  |     |                         |  |     |                        |  |     |                         |  |     |
| AVHRR  | 20:54 UTC     | (?)           |            |           |        |             |            |        |       |            |        |              |            |        |               |          |        |               |           |        |        |   |          |             |           |       |        |              |          |               |         |               |       |        |          |  |             |  |            |  |        |  |  |       |           |     |                        |  |     |                        |  |     |       |  |     |                         |  |     |                         |  |     |                          |  |     |                            |  |     |                         |  |     |                           |  |     |                         |  |     |                        |  |     |                         |  |     |
| <a href="#">GOES11</a>   |               | (?)           |            |           |        |             |            |        |       |            |        |              |            |        |               |          |        |               |           |        |        |   |          |             |           |       |        |              |          |               |         |               |       |        |          |  |             |  |            |  |        |  |  |       |           |     |                        |  |     |                        |  |     |       |  |     |                         |  |     |                         |  |     |                          |  |     |                            |  |     |                         |  |     |                           |  |     |                         |  |     |                        |  |     |                         |  |     |
| <a href="#">MTSAT1</a>   |               | (?)           |            |           |        |             |            |        |       |            |        |              |            |        |               |          |        |               |           |        |        |   |          |             |           |       |        |              |          |               |         |               |       |        |          |  |             |  |            |  |        |  |  |       |           |     |                        |  |     |                        |  |     |       |  |     |                         |  |     |                         |  |     |                          |  |     |                            |  |     |                         |  |     |                           |  |     |                         |  |     |                        |  |     |                         |  |     |
| MODIS  |               | (?)           |            |           |        |             |            |        |       |            |        |              |            |        |               |          |        |               |           |        |        |   |          |             |           |       |        |              |          |               |         |               |       |        |          |  |             |  |            |  |        |  |  |       |           |     |                        |  |     |                        |  |     |       |  |     |                         |  |     |                         |  |     |                          |  |     |                            |  |     |                         |  |     |                           |  |     |                         |  |     |                        |  |     |                         |  |     |
| <a href="#">AugiCam</a>  |               | (?)           |            |           |        |             |            |        |       |            |        |              |            |        |               |          |        |               |           |        |        |   |          |             |           |       |        |              |          |               |         |               |       |        |          |  |             |  |            |  |        |  |  |       |           |     |                        |  |     |                        |  |     |       |  |     |                         |  |     |                         |  |     |                          |  |     |                            |  |     |                         |  |     |                           |  |     |                         |  |     |                        |  |     |                         |  |     |
| <a href="#">ChigCam</a>  |               | (?)           |            |           |        |             |            |        |       |            |        |              |            |        |               |          |        |               |           |        |        |   |          |             |           |       |        |              |          |               |         |               |       |        |          |  |             |  |            |  |        |  |  |       |           |     |                        |  |     |                        |  |     |       |  |     |                         |  |     |                         |  |     |                          |  |     |                            |  |     |                         |  |     |                           |  |     |                         |  |     |                        |  |     |                         |  |     |
| <a href="#">SpurrCam</a>   |               | (?)           |            |           |        |             |            |        |       |            |        |              |            |        |               |          |        |               |           |        |        |   |          |             |           |       |        |              |          |               |         |               |       |        |          |  |             |  |            |  |        |  |  |       |           |     |                        |  |     |                        |  |     |       |  |     |                         |  |     |                         |  |     |                          |  |     |                            |  |     |                         |  |     |                           |  |     |                         |  |     |                        |  |     |                         |  |     |
| <a href="#">SpurrCrCam</a>   |               | (?)           |            |           |        |             |            |        |       |            |        |              |            |        |               |          |        |               |           |        |        |   |          |             |           |       |        |              |          |               |         |               |       |        |          |  |             |  |            |  |        |  |  |       |           |     |                        |  |     |                        |  |     |       |  |     |                         |  |     |                         |  |     |                          |  |     |                            |  |     |                         |  |     |                           |  |     |                         |  |     |                        |  |     |                         |  |     |
| <a href="#">VeniCam</a>  |               | (?)           |            |           |        |             |            |        |       |            |        |              |            |        |               |          |        |               |           |        |        |   |          |             |           |       |        |              |          |               |         |               |       |        |          |  |             |  |            |  |        |  |  |       |           |     |                        |  |     |                        |  |     |       |  |     |                         |  |     |                         |  |     |                          |  |     |                            |  |     |                         |  |     |                           |  |     |                         |  |     |                        |  |     |                         |  |     |
| <a href="#">HelensCam</a>  |               | (?)           |            |           |        |             |            |        |       |            |        |              |            |        |               |          |        |               |           |        |        |   |          |             |           |       |        |              |          |               |         |               |       |        |          |  |             |  |            |  |        |  |  |       |           |     |                        |  |     |                        |  |     |       |  |     |                         |  |     |                         |  |     |                          |  |     |                            |  |     |                         |  |     |                           |  |     |                         |  |     |                        |  |     |                         |  |     |
| <a href="#">BezyCam</a>  |               | (?)           |            |           |        |             |            |        |       |            |        |              |            |        |               |          |        |               |           |        |        |   |          |             |           |       |        |              |          |               |         |               |       |        |          |  |             |  |            |  |        |  |  |       |           |     |                        |  |     |                        |  |     |       |  |     |                         |  |     |                         |  |     |                          |  |     |                            |  |     |                         |  |     |                           |  |     |                         |  |     |                        |  |     |                         |  |     |
| <a href="#">KluCam</a>   |               | (?)           |            |           |        |             |            |        |       |            |        |              |            |        |               |          |        |               |           |        |        |   |          |             |           |       |        |              |          |               |         |               |       |        |          |  |             |  |            |  |        |  |  |       |           |     |                        |  |     |                        |  |     |       |  |     |                         |  |     |                         |  |     |                          |  |     |                            |  |     |                         |  |     |                           |  |     |                         |  |     |                        |  |     |                         |  |     |
| <a href="#">ShivCam</a>  |               | (?)           |            |           |        |             |            |        |       |            |        |              |            |        |               |          |        |               |           |        |        |   |          |             |           |       |        |              |          |               |         |               |       |        |          |  |             |  |            |  |        |  |  |       |           |     |                        |  |     |                        |  |     |       |  |     |                         |  |     |                         |  |     |                          |  |     |                            |  |     |                         |  |     |                           |  |     |                         |  |     |                        |  |     |                         |  |     |

|                |                            |
|----------------|----------------------------|
| Comments (?) : | Operational Notes:         |
|                | No GOES data was available |

|                                 |                             |
|---------------------------------|-----------------------------|
| Friday, July 21, 2006 18:15 UTC | Friday, July 21, 2006 10:15 |
| 202 18:15 UTC                   | 202 11:15 PDT               |
| 202 10:15 AKDT                  | 202 09:15 HADT              |
|                                 | 203 07:15 KDT               |



# Manual Database Entry: Satellite Observations

[Choose Observation](#)

[Base Observations](#)

Satellite Observations

[Camera Observations](#)

[Store Changes](#)

Start a new Observation (?):

AVHRR | Augustine | Augustine

Local image (?):

(image)

Other image, or image range: (?):

(manual)

Select an Existing Observation (?):

Veniaminof - t1.06017.0828  
 Augustine - g10.06017.1730  
 Augustine - n15.06017.0358  
 Augustine - n14.06017.1831  
 Augustine - t1.06017.0649  
 Augustine - n14.06017.0622  
 Augustine - g10.06017.1830

Expand Obs

Store Obs

Delete Obs

General Observations:

Cloud condition | Mostly Clear

Zenith angle | 40 (?)

Significant noise | Y / N (?)

Comments for this observation:

47 km maximum distance from the volcano, bearing NW at 130 degrees. Plume has a long axis of 73 km angled at bearing 115. No split window at this time.

Plume Observations:

*Blank lines are acceptable*

| Band | Length<br><i>km</i> | Height<br><i>km</i> | Dir | Value<br><i>various units</i> | Review                   |
|------|---------------------|---------------------|-----|-------------------------------|--------------------------|
| ch4  | 73                  | 8                   | 115 | -55 <i>undefined</i>          | <input type="checkbox"/> |

(add band)

Thermal Anomaly Observations:

*Blank lines are acceptable*

| Band | Pixels | Orient | Value<br><i>various units</i> | Bckgnd<br><i>various units</i> | Review |
|------|--------|--------|-------------------------------|--------------------------------|--------|
|------|--------|--------|-------------------------------|--------------------------------|--------|

(add band)

# Manual Database Entry: Camera Observations

|                                    |                                   |  |                     |                               |
|------------------------------------|-----------------------------------|--|---------------------|-------------------------------|
| <a href="#">Choose Observation</a> | <a href="#">Base Observations</a> | <a href="#">Satellite Observations</a> | Camera Observations | <a href="#">Store Changes</a> |
|------------------------------------|-----------------------------------|--|---------------------|-------------------------------|

|  |  |
|--|--|
| Start a new Observation:                                       | Select an Existing Observation (?) :   |
| Camera: <input type="text" value="AugiCam"/>                   | <input type="text" value="Augustine - AugiCam - 06/01/17 09:59 UTC"/>  |
| Volcano: <input type="text" value="Augustine"/>                |  |
| Image date: <input type="text" value="1/17/06 17:09 UTC"/> (?) |  |
| Image end date: <input type="text" value=""/>                  |  |
|  | <input type="button" value="Expand Obs"/> <input type="button" value="Store Obs"/> <input type="button" value="Delete Obs"/> |

|  |                      |
|--|----------------------|
| General Observations:  | Comments:            |
| Cloud condition <input type="text" value="Mostly Clear"/>                  | <input type="text"/> |
| Plume Visible Y <input checked="" type="radio"/> / N <input type="radio"/> |                      |
| Thermal Visible Y <input type="radio"/> / N <input type="radio"/>          |                      |

# Database Generated Observation Reports

**Twice Daily**

**365 Days/yr**

**TO: USGS**

**Information from  
reports go:**

**NWS**

**FAA**

**Others**

AM satellite report for January 17, 2006

**SUMMARY:**

Plume and thermal anomaly at Augustine, thermal anomaly at Veniaminof

**OBSERVATIONS:**

Augustine (Red): Mostly clear at volcano

1) Image n14.06017.1831: partly cloudy at volcano, sat zenith angle of 68

- comments: edge pass, plume visible

- ch4 plume: 75km long, heading 130, observed at -47 C, est. 8km high

Martin (Yellow): Mostly clear at volcano

Spurr (Yellow): Partly cloudy at volcano

St. Helens (Orange): Cloudy at volcano

**CLOUD CONDITIONS:**

Wrangells (Wrangell sector): Mostly Clear

Cook Inlet (Augustine sector): Mostly Clear

Alaska Peninsula (Pavlof sector): Partly Cloudy

Eastern Aleutians (Vsevidof sector): Partly Cloudy

**LAST IMAGES VIEWED:**

AVHRR: 18:31 UTC

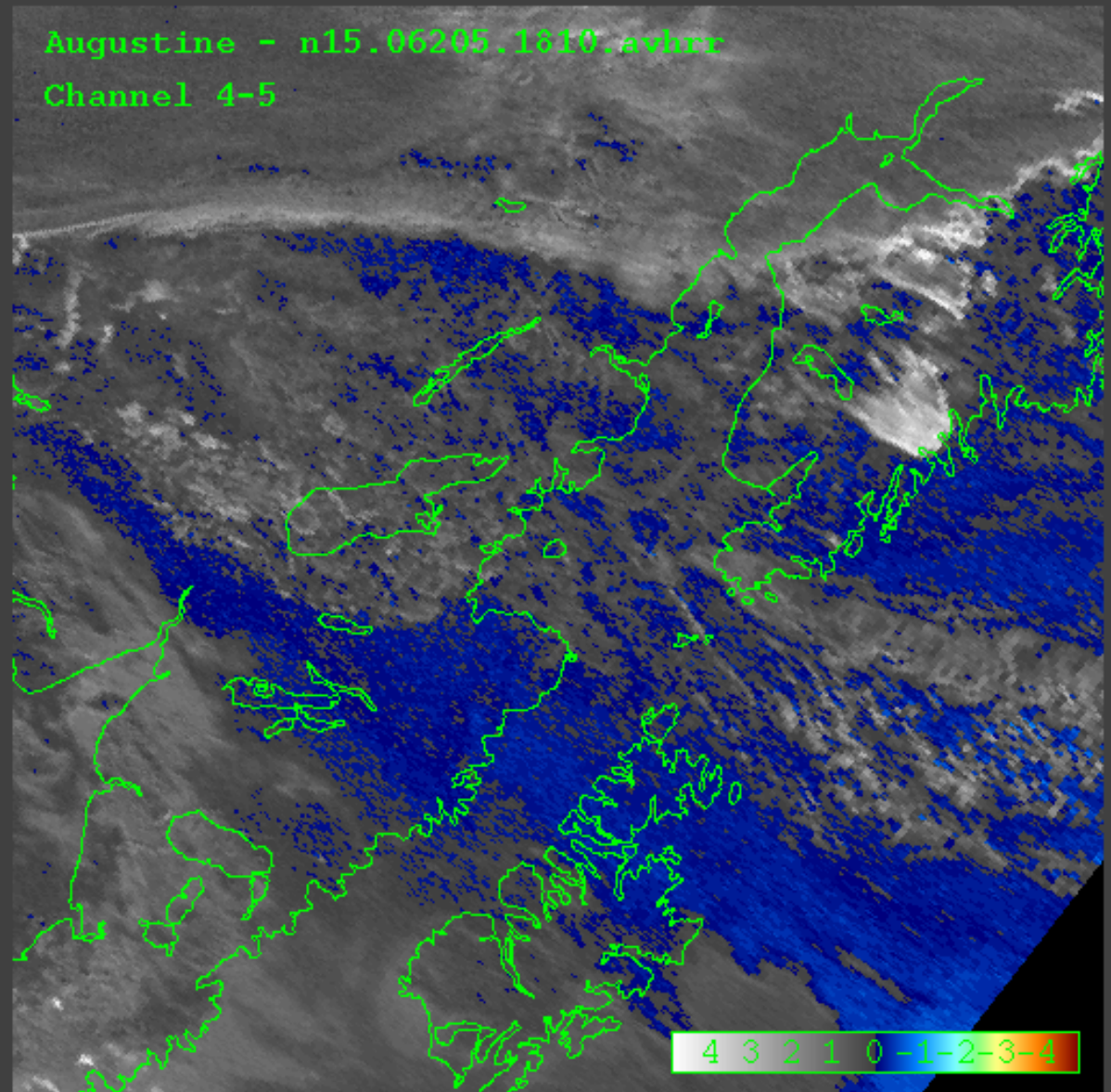
GOES10: 18:30 UTC

MODIS: 18:37 UTC

# New Web Tools: Image Animator/sector (512 x 512)

Alaska Volcano Observatory  
FTP Image Animator

|                           |  |
|---------------------------|--|
| Sector:                   | Augustine ▾  |
| Data Type:                | AVHRR and MODIS ▾  |
| Image Band:               | ash ▾  |
| Date Range:               | Past 12 hours ▾  |
| Viewing Delay:            | Two Seconds ▾  |
| Loop:                     | Y <input checked="" type="radio"/> / N <input type="radio"/> |
| Refresh:                  | Y <input checked="" type="radio"/> / N <input type="radio"/> |
| Showing image:<br>1 of 10 | Backwards  |
|                           | Pause  |
|                           | Forwards   |





# New Web Tools: Auto Observer (40 x 40)

Alaska Volcano Observatory  
Automatic Observation Viewer

Start date:

End date:

Subsector:

Image:  +








Band:

High trim: *auto*  +

Low trim: *auto*  +

| property                  | value           |
|---------------------------|-----------------|
| value at mouse            | -28.63          |
| max                       | 56.85           |
| min                       | -29.88          |
| mean                      | -13.88          |
| stddev                    | 5.21            |
| standard model IER        | 22.1            |
| standard model 5 day TADR | 10.0 (10 obs)   |
| sun zenith angle          | 99              |
| sat zenith angle          | 13              |
| automatic evaluation      | acceptable      |
| target volcanoes          | Augustine (red) |
| collateral volcanoes      | none            |

Key (some items can be toggled by clicking on them)

|   |  |   |   |   |   |   |
|---|--|---|---|---|---|---|
|  |  |  |  |  |  |  |
| data and NaN<br><i>pixel data received</i>  | hotspot<br><i>off</i>  | deviant<br><i>off</i>   | solar<br><i>off</i>   | solar cloud<br><i>off</i>   | cloud<br><i>off</i>   | cloud<br><i>off</i>   |

# Automated Alerts

## 2 Types:

Thermal Anomalies – operational  
Ash Clouds - underdevelopment

Cell phone text message  
Computer voice alert  
Automated email text message



Thermal anomaly detected in n18.06205.1557

Possible volcanoes are Bezymianny

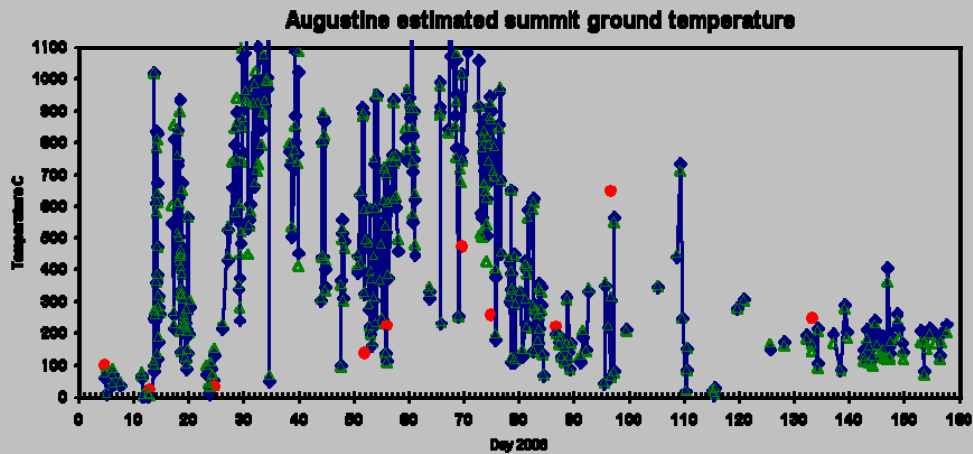
1 pixels 35.31C background 3.09C

sat zen 16

55.98N by 199.41W

[http://avo-animate.images.alaska.edu/auto\\_obs\\_viewer.phpk](http://avo-animate.images.alaska.edu/auto_obs_viewer.phpk)

# New Web Tools: Graphic Analysis of Database



## Alaska Volcano Observatory Graph Tool

[Prefab Queries](#)

[Basic Queries](#)

[Advanced Queries](#)

[Bulk Queries](#)

|   |  |
|---|--|
| Volcano   | Augustine  |
| Volcanoes Targeted                                      | Augustine  |
| Start date  | <input type="text" value="2006/1/10"/>   |
| End date  | <input type="text" value="2006/1/31"/>   |
| Platform types  | <input checked="" type="checkbox"/> AVHRR - <input type="checkbox"/> MODIS   |
| Subsector restrictions<br>(applied to subsector data)   | <input type="checkbox"/> nighttime pass<br><input type="checkbox"/> overhead pass<br><input type="checkbox"/> not noisy  |
| Subsector data series<br>(plot subsector data)          | <input type="checkbox"/> band3 bg mean<br><input type="checkbox"/> band4 bg mean<br><input type="checkbox"/> band5 bg mean<br><input type="checkbox"/> band4m5 min |
| Hotspot restrictions<br>(applied to hotspot candidates) | <input type="checkbox"/> band3+band4 > 50<br><input type="checkbox"/> band3-band4 > 35   |
| Hotspot data series<br>(plot hotspot candidates)        | <input type="checkbox"/> band3 max<br><input type="checkbox"/> band4 max<br><input type="checkbox"/> band5 max   |
| Axis label  | none   |
| String for invalid data                                 | NaN  |
| Output format   | graph  |
| <input type="button" value="query"/>                    |  |

# AUGUSTINE 2006

## Chronology

### January 11

AVHRR  
MODIS  
PUFF

### January 13-14

AVHRR  
MODIS  
GOES  
PUFF

### January 17

AVHRR  
MODIS  
PUFF

AVO :: UAF :: GI  
January 19, 2006



## January 11, 2006





# AUGUSTINE 2006

## Chronology

### January 11

AVHRR  
MODIS  
PUFF

### January 13-14

AVHRR  
MODIS  
GOES  
PUFF

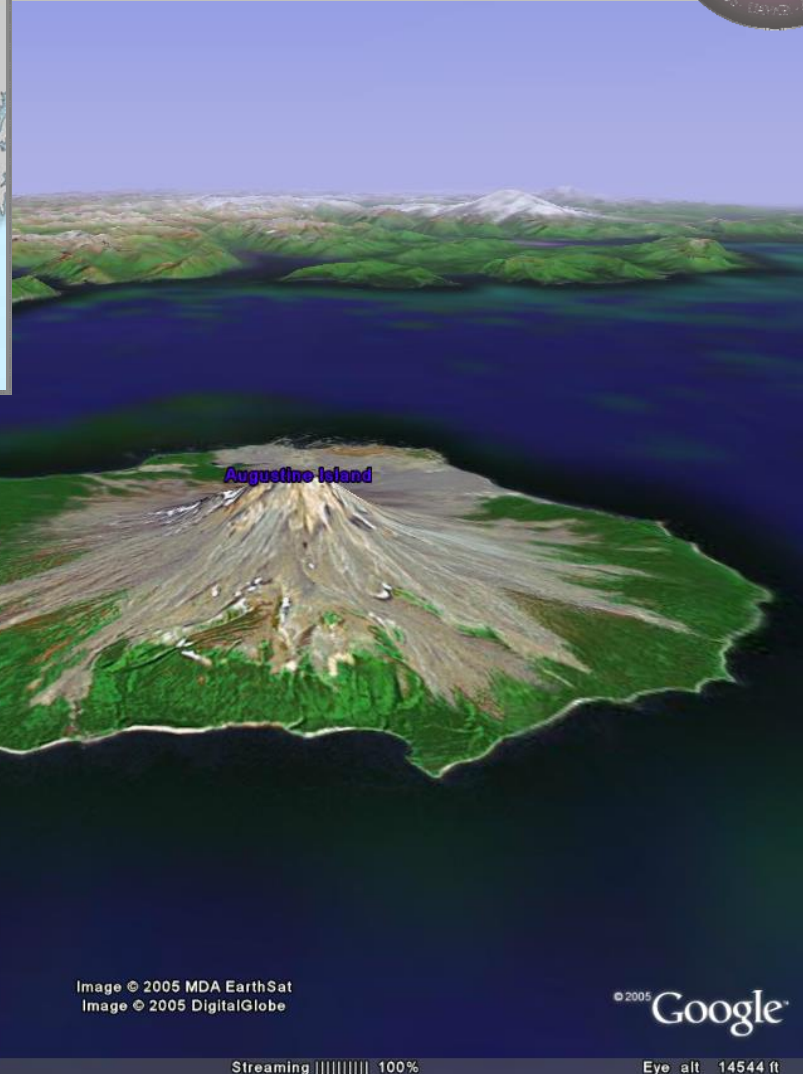
### January 17

AVHRR  
MODIS  
PUFF

AVO :: UAF :: GI  
January 19, 2006



## CHRONOLOGY AUGUSTINE LOCATION



# AUGUSTINE 2006

## Chronology

### January 11

AVHRR  
MODIS  
PUFF

### January 13-14

AVHRR  
MODIS  
GOES  
PUFF

### January 17

AVHRR  
MODIS  
PUFF

AVO :: UAF :: GI  
January 19, 2006



## CHRONOLOGY December 12 :: SO<sub>2</sub> Plume



# AUGUSTINE 2006

## Chronology

### January 11

AVHRR  
MODIS  
PUFF

### January 13-14

AVHRR  
MODIS  
GOES  
PUFF

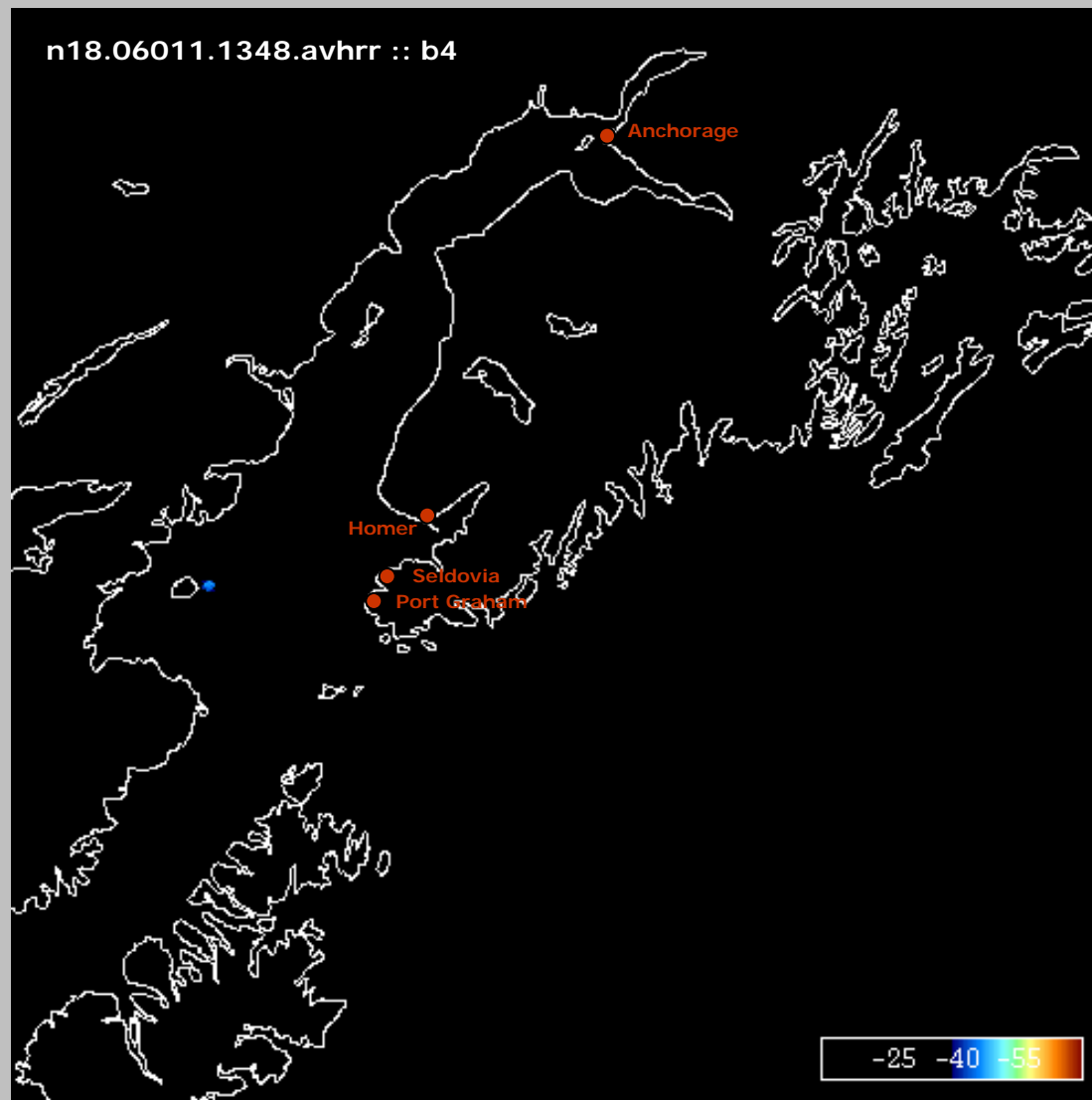
### January 17

AVHRR  
MODIS  
PUFF

AVO :: UAF :: GI  
January 19, 2006



## AVHRR/MODIS :: January 11, 2006





# AUGUSTINE 2006

## Chronology

### January 11

AVHRR  
MODIS  
PUFF

### January 13-14

AVHRR  
MODIS  
GOES  
PUFF

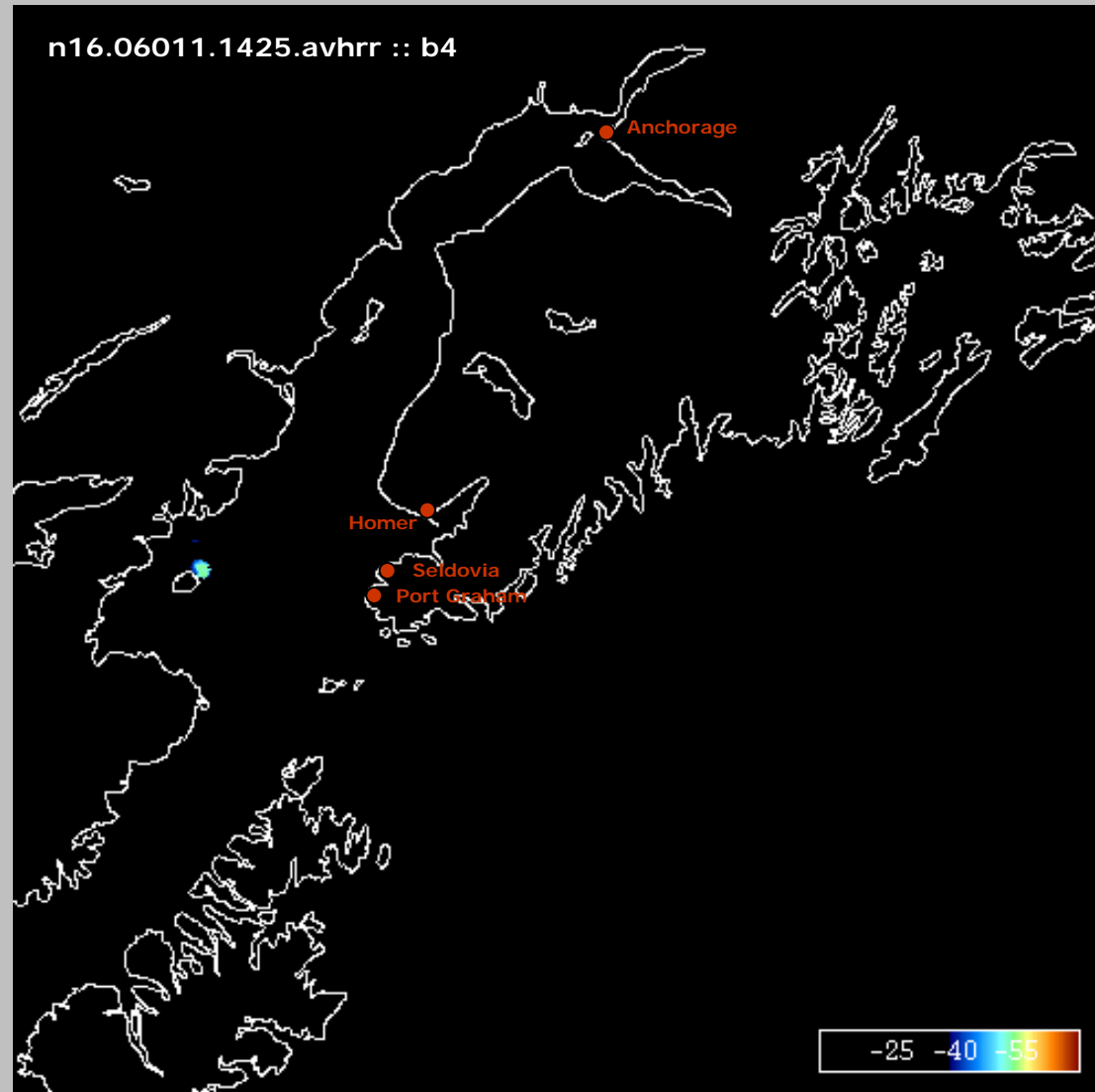
### January 17

AVHRR  
MODIS  
PUFF

AVO :: UAF :: GI  
January 19, 2006



## AVHRR/MODIS :: January 11, 2006



# AUGUSTINE 2006

## Chronology

### January 11

AVHRR  
MODIS  
PUFF

### January 13-14

AVHRR  
MODIS  
GOES  
PUFF

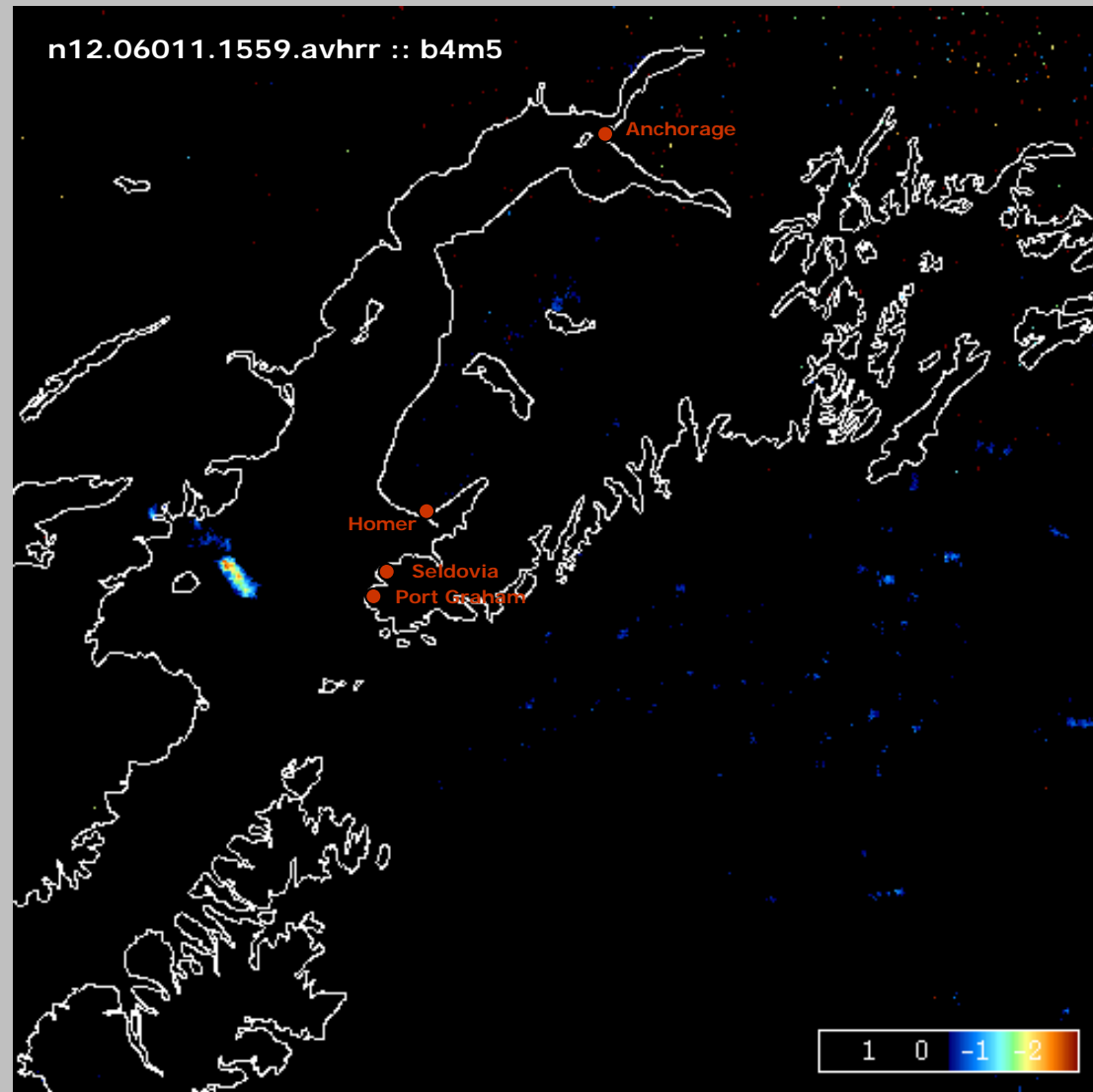
### January 17

AVHRR  
MODIS  
PUFF

AVO :: UAF :: GI  
January 19, 2006



## AVHRR/MODIS :: January 11, 2006



# AUGUSTINE 2006

## Chronology

### January 11

AVHRR  
MODIS  
PUFF

### January 13-14

AVHRR  
MODIS  
GOES  
PUFF

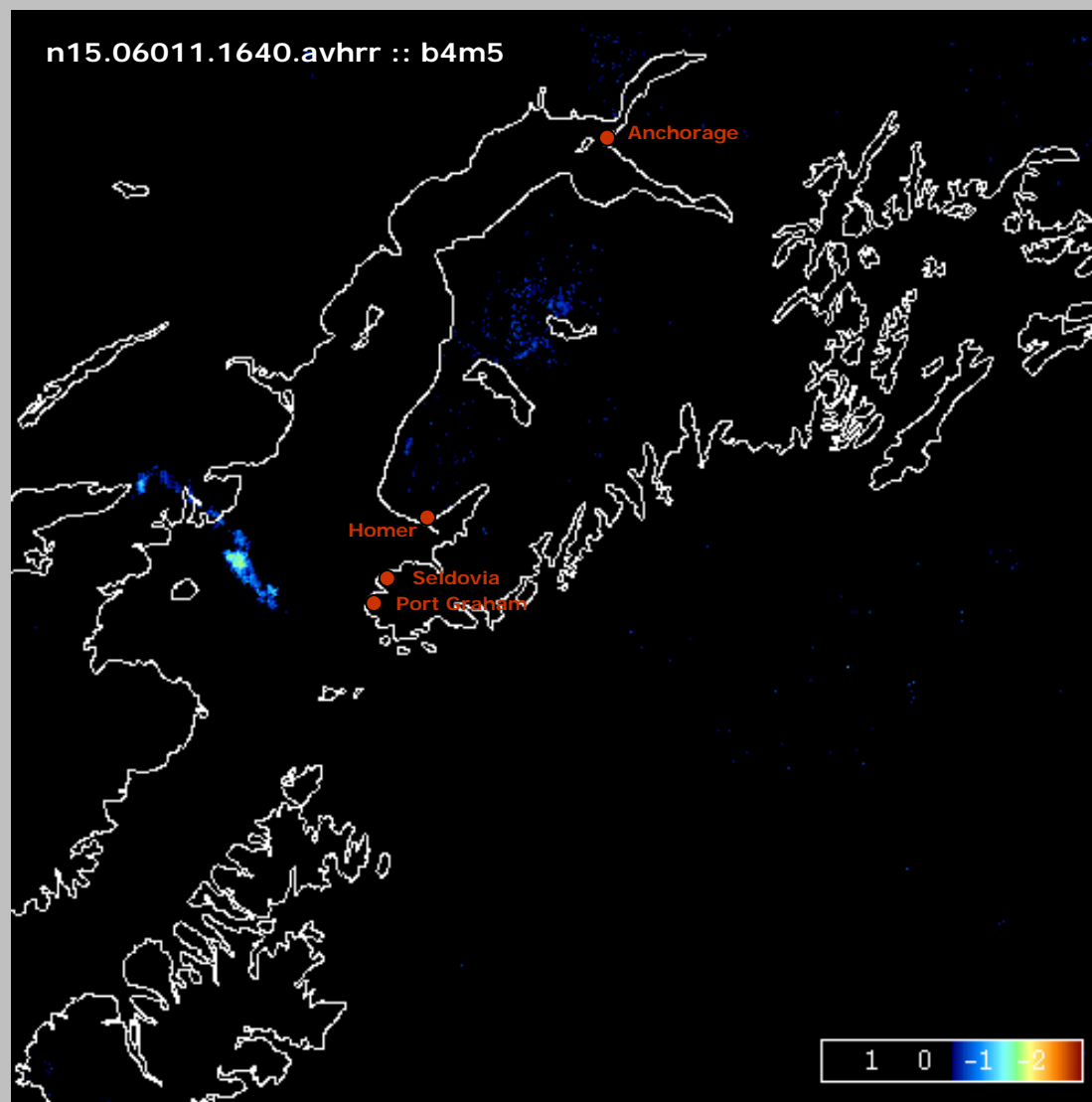
### January 17

AVHRR  
MODIS  
PUFF

AVO :: UAF :: GI  
January 19, 2006



## AVHRR/MODIS :: January 11, 2006



# AUGUSTINE 2006

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## Chronology

### January 11

AVHRR  
MODIS  
PUFF

### January 13-14

AVHRR  
MODIS  
GOES  
PUFF

### January 17

AVHRR  
MODIS  
PUFF

AVO :: UAF :: GI  
January 19, 2006



## January 13-14, 2006

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# AUGUSTINE 2006

## Chronology

### January 11

AVHRR  
MODIS  
PUFF

### January 13-14

AVHRR  
MODIS  
GOES  
PUFF

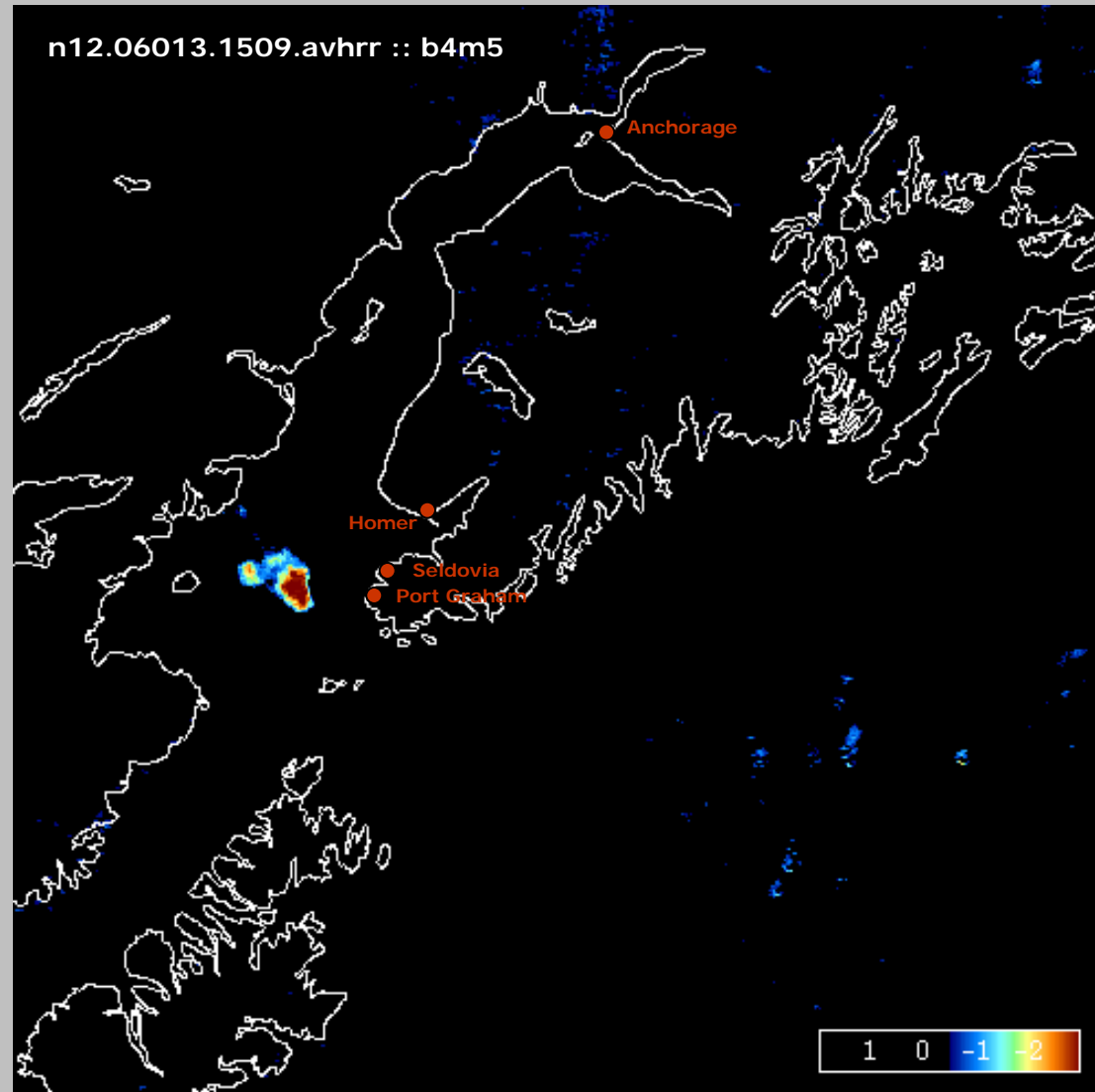
### January 17

AVHRR  
MODIS  
PUFF

AVO :: UAF :: GI  
January 19, 2006



## AVHRR/MODIS :: January 13-14, 2006



# AUGUSTINE 2006

## Chronology

### January 11

AVHRR  
MODIS  
PUFF

### January 13-14

AVHRR  
MODIS  
GOES  
PUFF

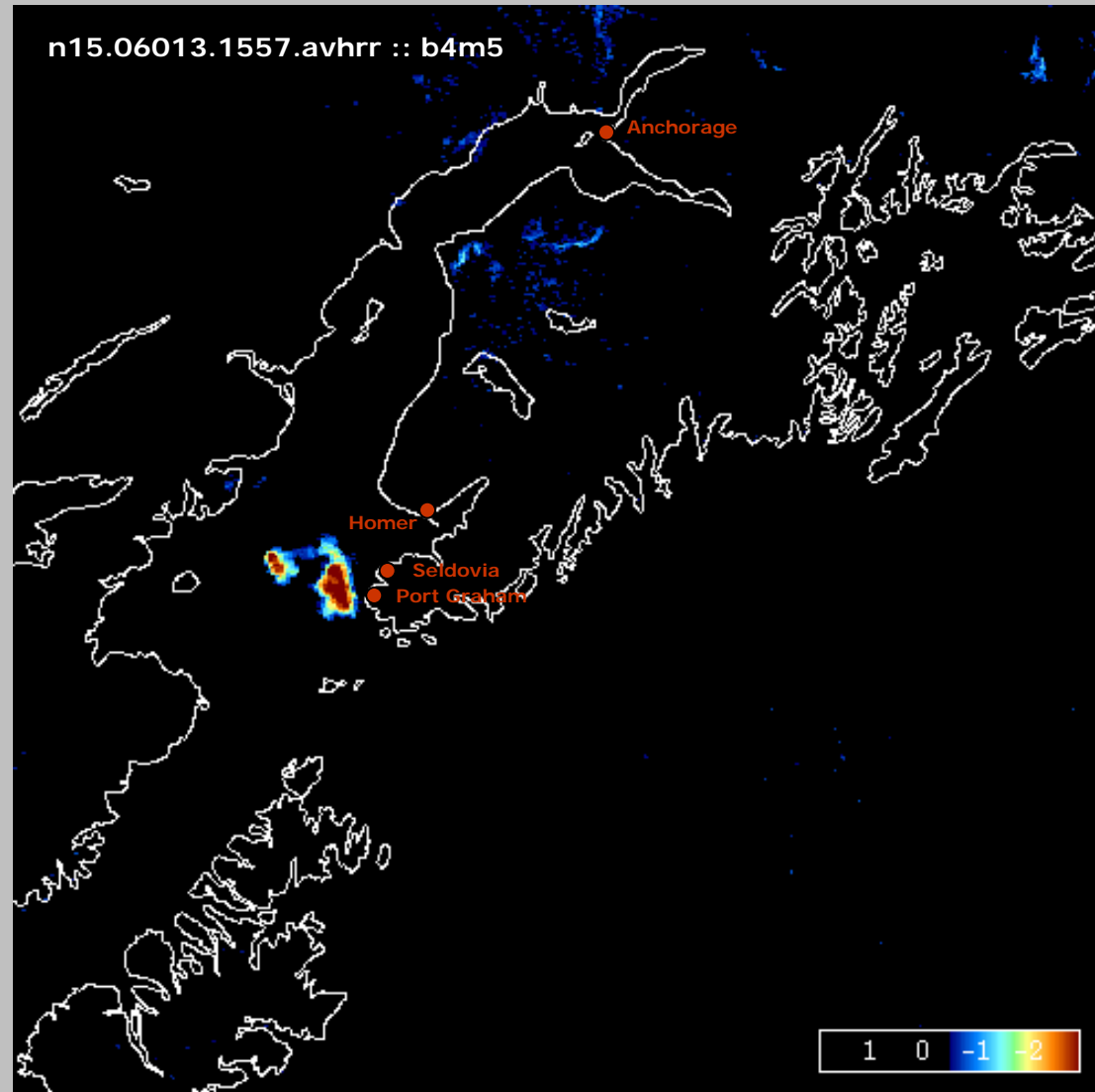
### January 17

AVHRR  
MODIS  
PUFF

AVO :: UAF :: GI  
January 19, 2006



## AVHRR/MODIS :: January 13-14, 2006



# AUGUSTINE 2006

## Chronology

### January 11

AVHRR  
MODIS  
PUFF

### January 13-14

AVHRR  
MODIS  
GOES  
PUFF

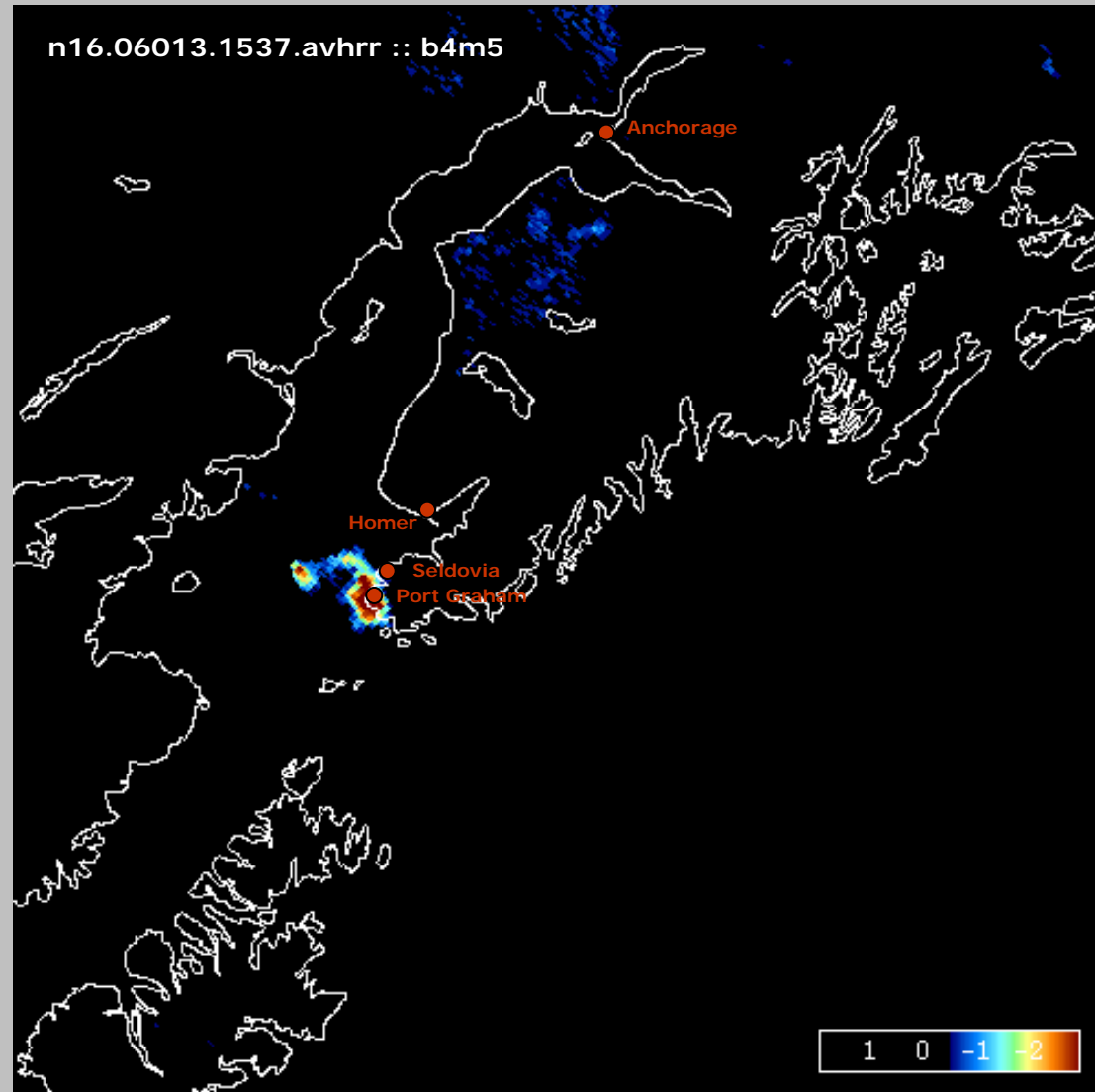
### January 17

AVHRR  
MODIS  
PUFF

AVO :: UAF :: GI  
January 19, 2006



## AVHRR/MODIS :: January 13-14, 2006



# AUGUSTINE 2006

## Chronology

### January 11

AVHRR  
MODIS  
PUFF

### January 13-14

AVHRR  
MODIS  
GOES  
PUFF

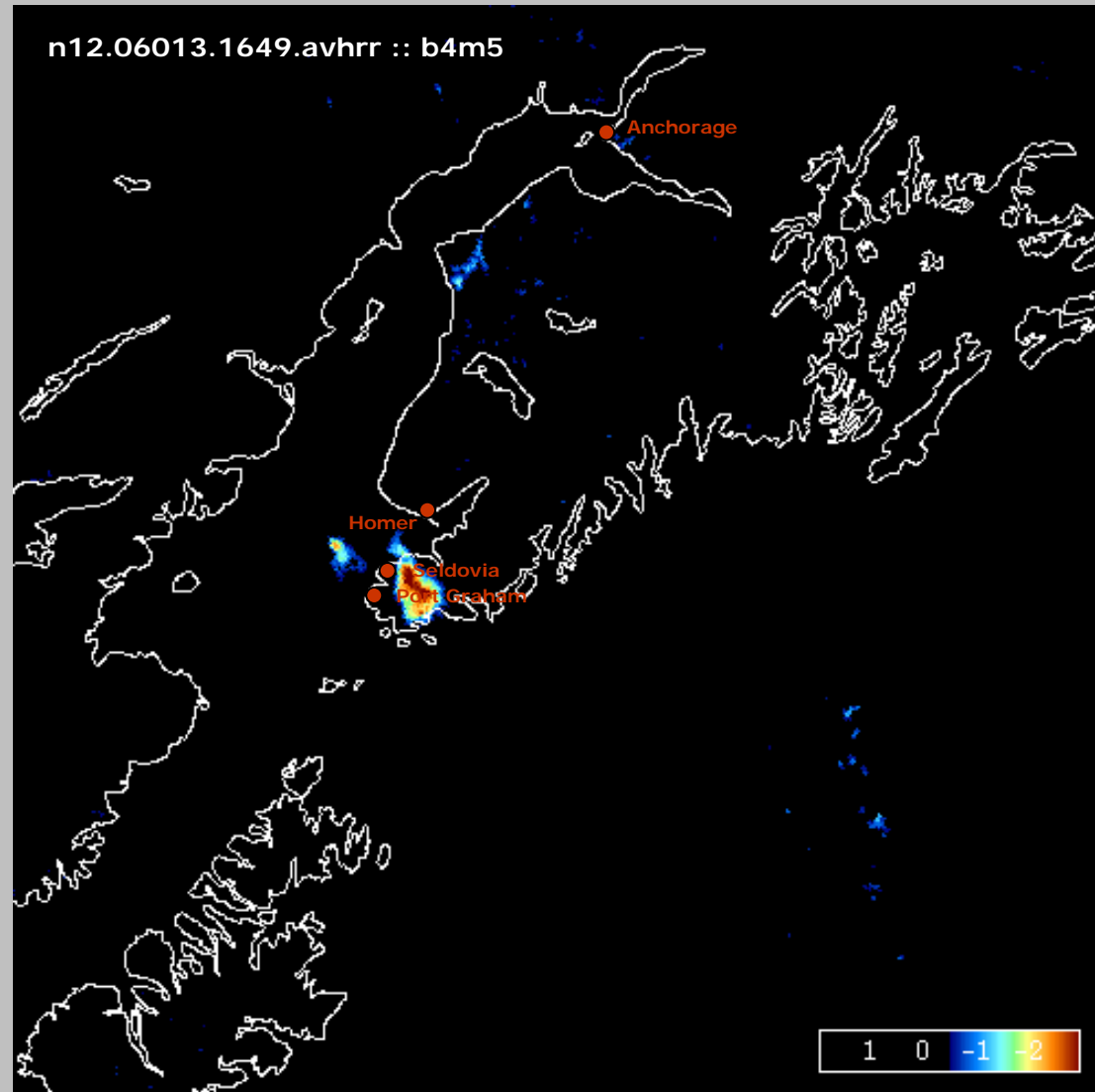
### January 17

AVHRR  
MODIS  
PUFF

AVO :: UAF :: GI  
January 19, 2006



## AVHRR/MODIS :: January 13-14, 2006





# AUGUSTINE 2006

## Chronology

### January 11

AVHRR  
MODIS  
PUFF

### January 13-14

AVHRR  
MODIS  
GOES  
PUFF

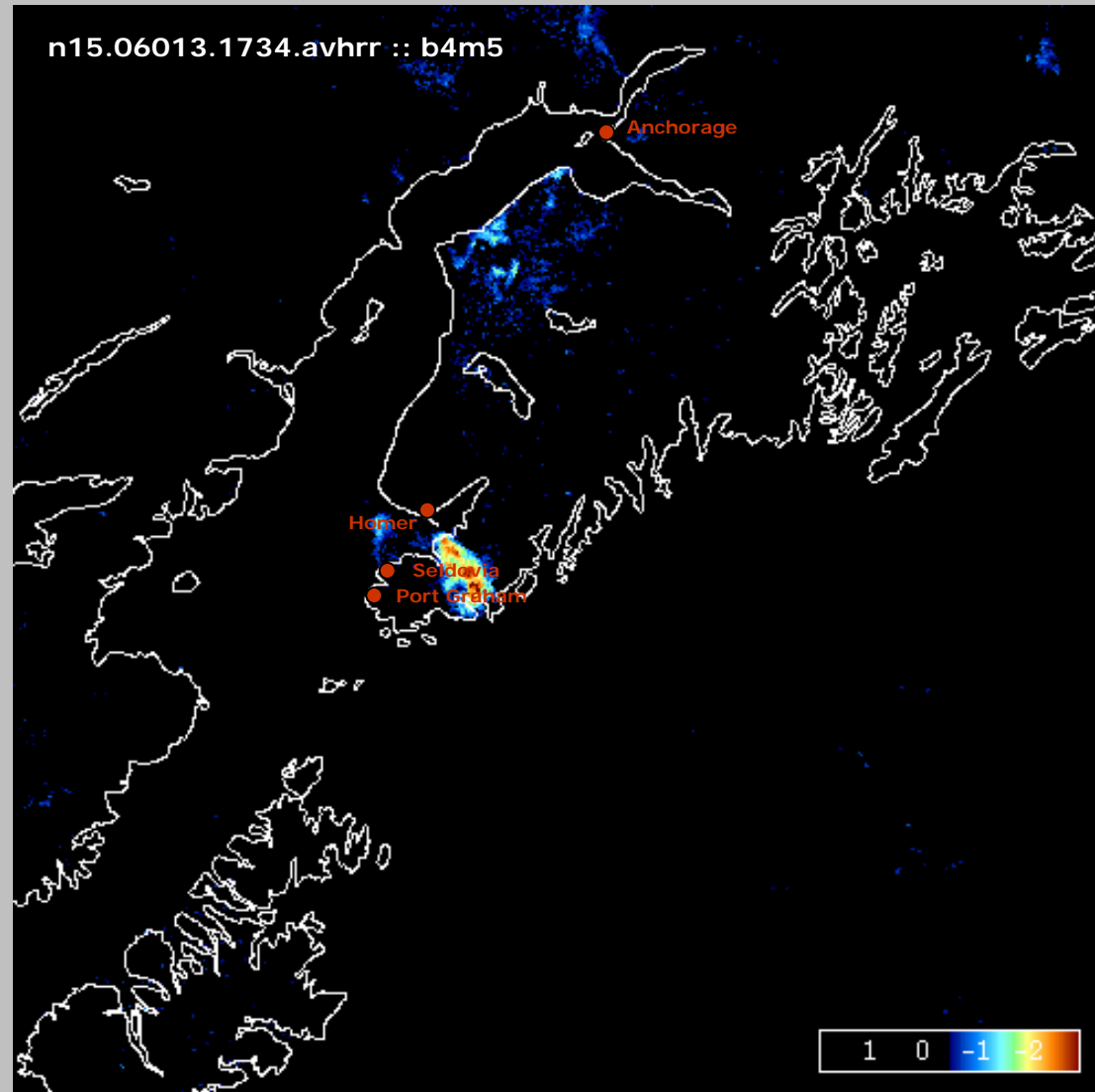
### January 17

AVHRR  
MODIS  
PUFF

AVO :: UAF :: GI  
January 19, 2006



## AVHRR/MODIS :: January 13-14, 2006



# AUGUSTINE 2006

## Chronology

### January 11

AVHRR  
MODIS  
PUFF

### January 13-14

AVHRR  
MODIS  
GOES  
PUFF

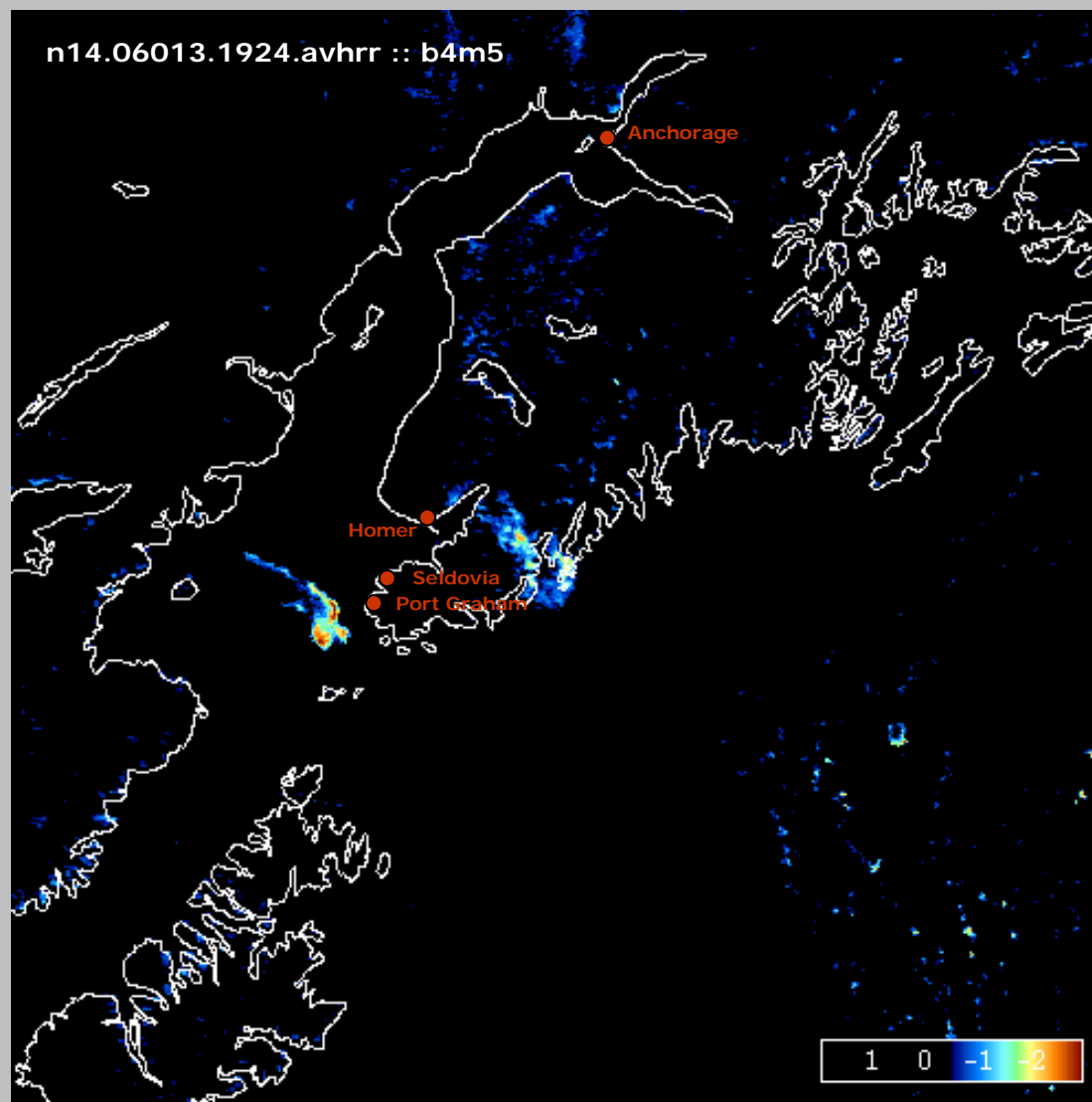
### January 17

AVHRR  
MODIS  
PUFF

AVO :: UAF :: GI  
January 19, 2006



## AVHRR/MODIS :: January 13-14, 2006



# AUGUSTINE 2006

## Chronology

### January 11

AVHRR  
MODIS  
PUFF

### January 13-14

AVHRR  
MODIS  
GOES  
PUFF

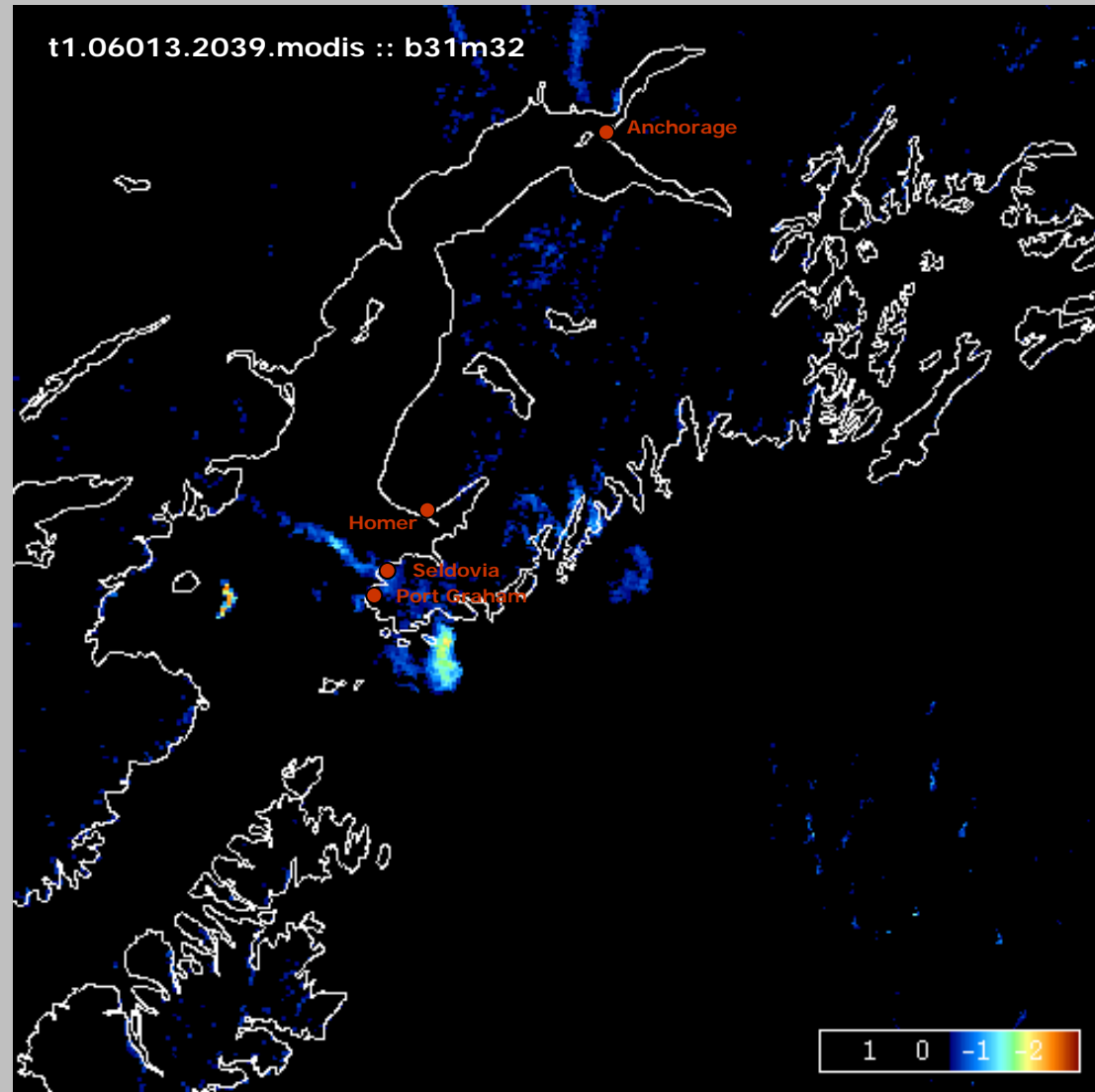
### January 17

AVHRR  
MODIS  
PUFF

AVO :: UAF :: GI  
January 19, 2006



## AVHRR/MODIS :: January 13-14, 2006



# AUGUSTINE 2006

## Chronology

### January 11

AVHRR  
MODIS  
PUFF

### January 13-14

AVHRR  
MODIS  
GOES  
PUFF

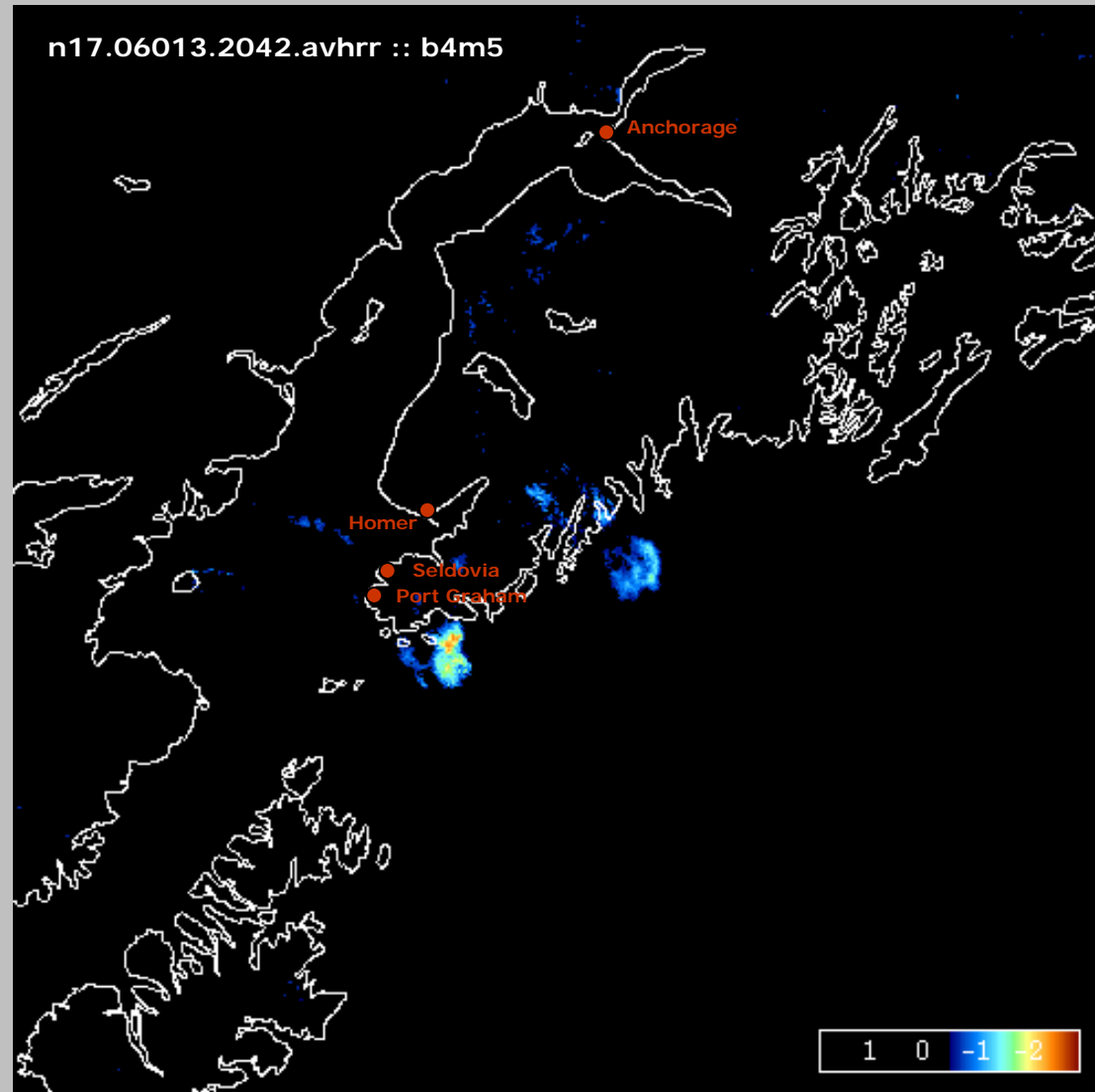
### January 17

AVHRR  
MODIS  
PUFF

AVO :: UAF :: GI  
January 19, 2006



## AVHRR/MODIS :: January 13-14, 2006





# AUGUSTINE 2006

## Chronology

### January 11

AVHRR  
MODIS  
PUFF

### January 13-14

AVHRR  
MODIS  
GOES  
PUFF

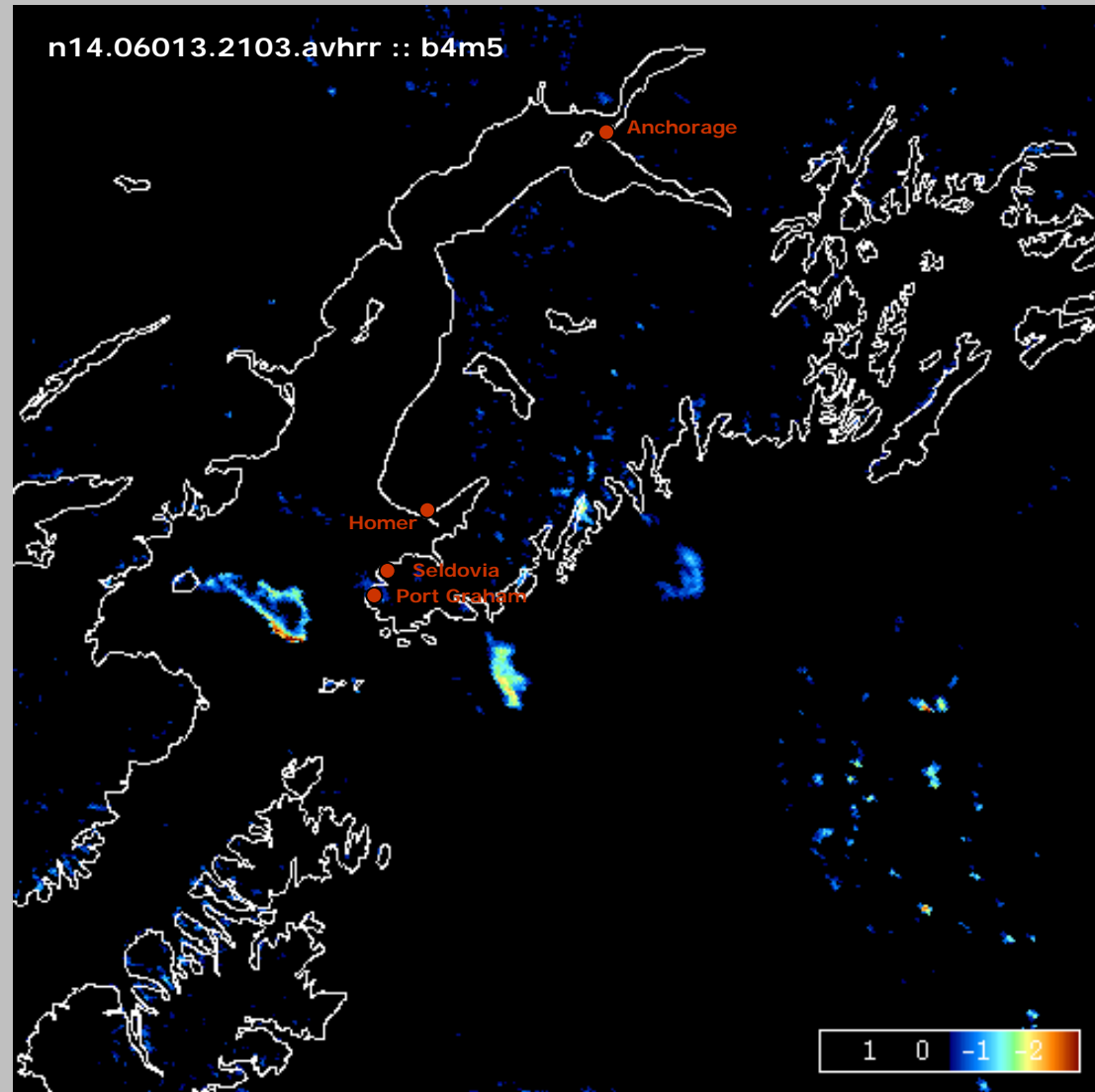
### January 17

AVHRR  
MODIS  
PUFF

AVO :: UAF :: GI  
January 19, 2006



## AVHRR/MODIS :: January 13-14, 2006



# AUGUSTINE 2006

## Chronology

### January 11

AVHRR  
MODIS  
PUFF

### January 13-14

AVHRR  
MODIS  
GOES  
PUFF

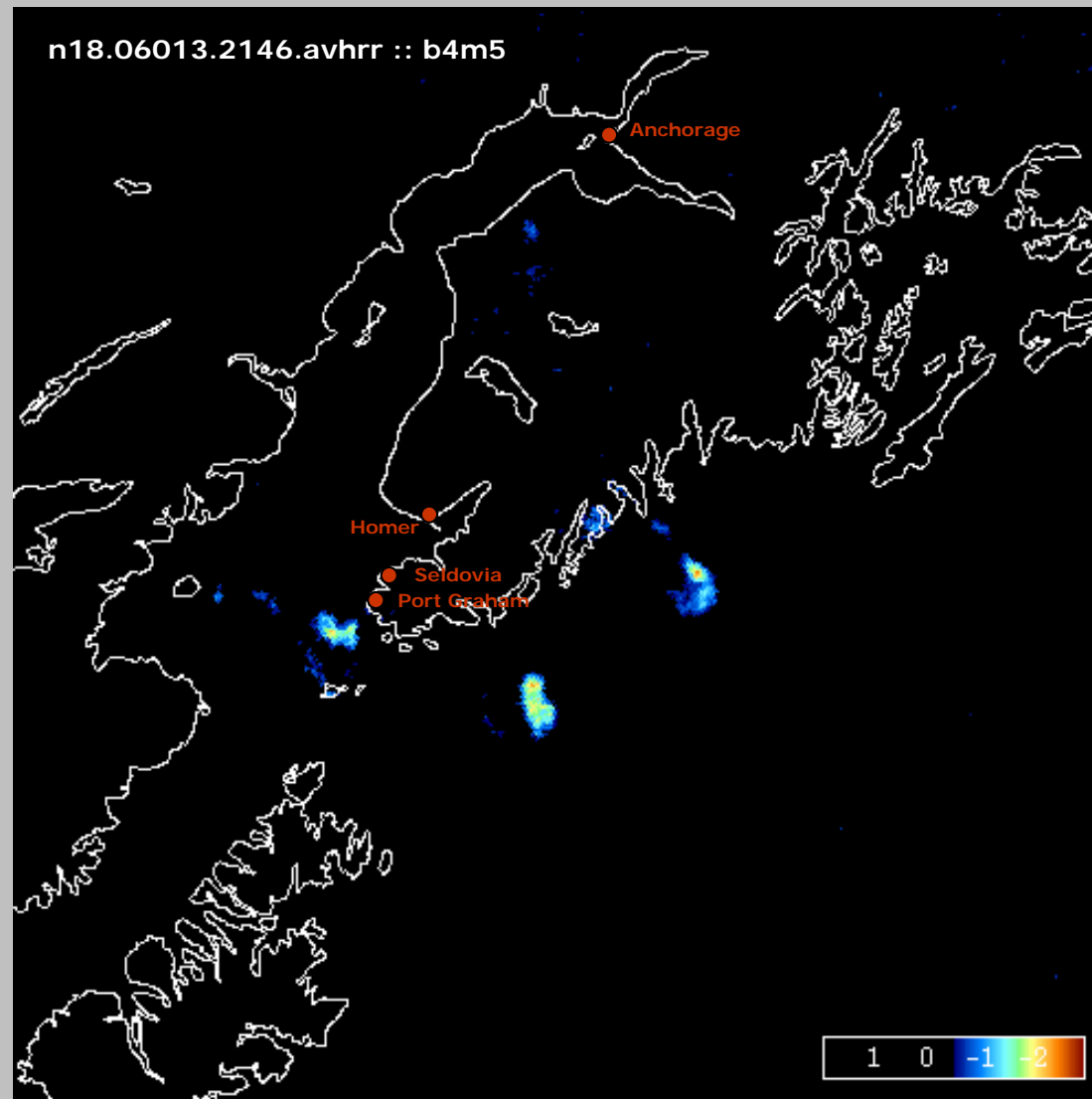
### January 17

AVHRR  
MODIS  
PUFF

AVO :: UAF :: GI  
January 19, 2006



## AVHRR/MODIS :: January 13-14, 2006



# AUGUSTINE 2006

## Chronology

### January 11

AVHRR  
MODIS  
PUFF

### January 13-14

AVHRR  
MODIS  
GOES  
PUFF

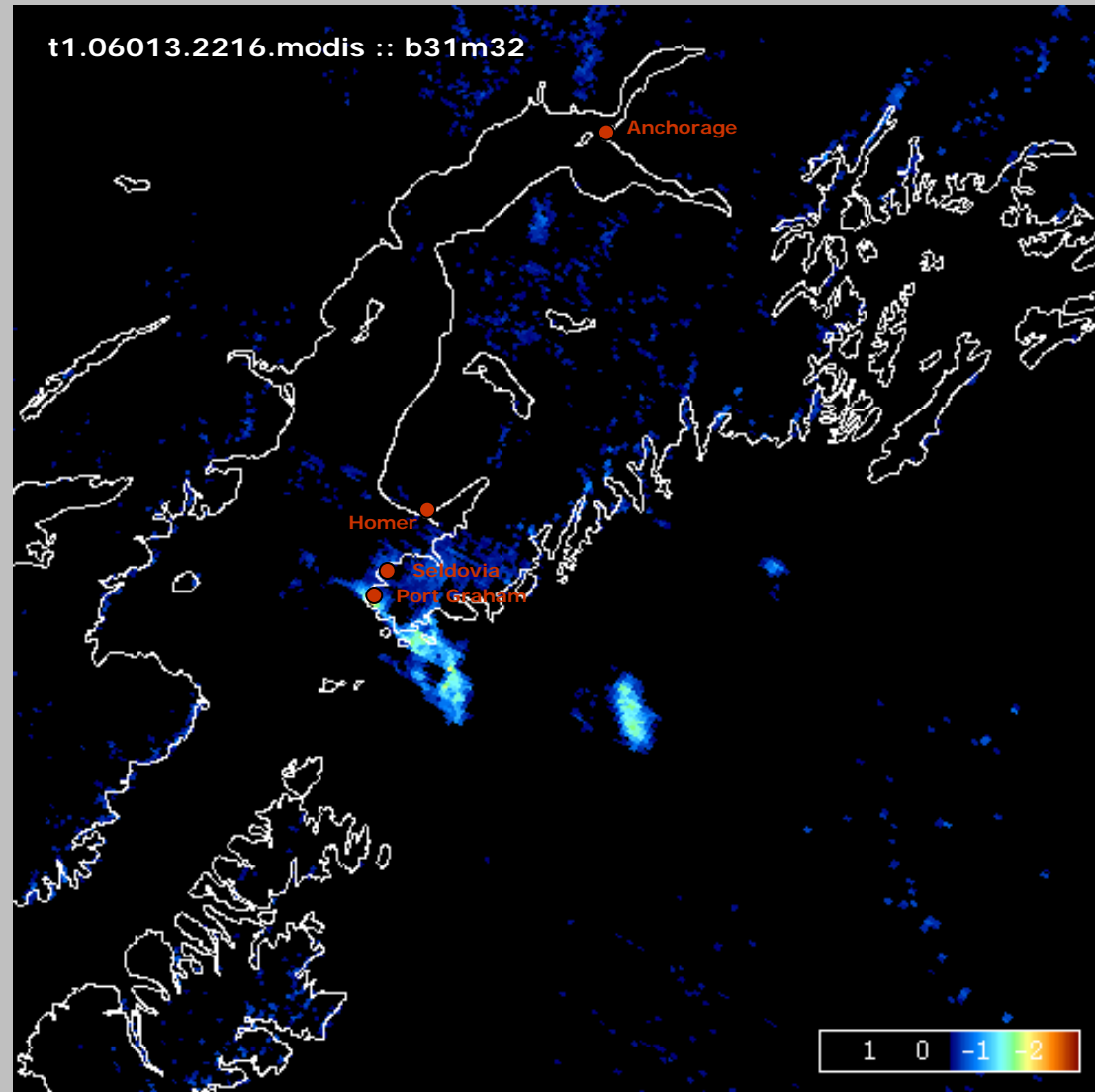
### January 17

AVHRR  
MODIS  
PUFF

AVO :: UAF :: GI  
January 19, 2006



## AVHRR/MODIS :: January 13-14, 2006



# AUGUSTINE 2006

## Chronology

### January 11

AVHRR  
MODIS  
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### January 13-14

AVHRR  
MODIS  
GOES  
PUFF

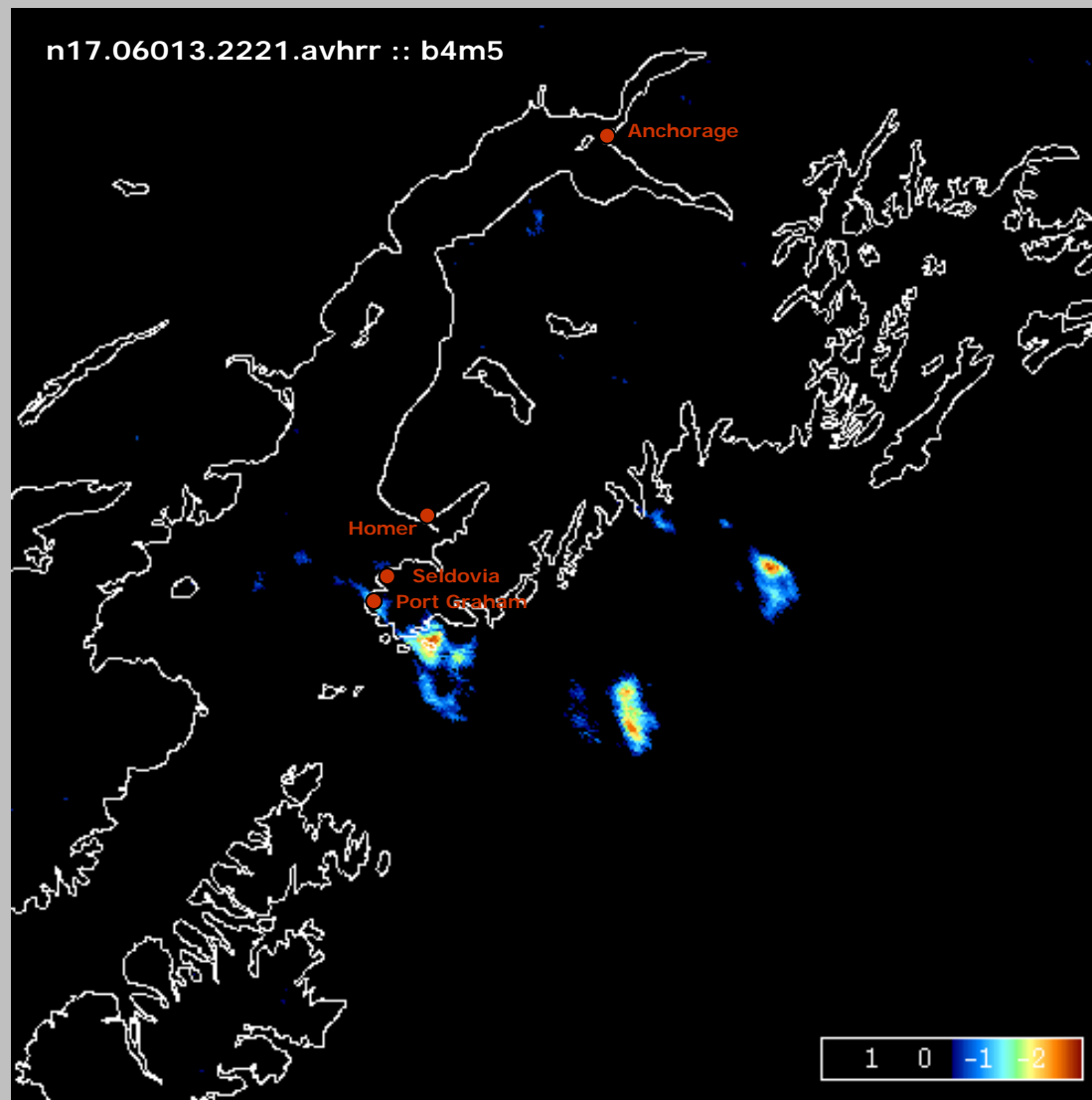
### January 17

AVHRR  
MODIS  
PUFF

AVO :: UAF :: GI  
January 19, 2006



## AVHRR/MODIS :: January 13-14, 2006





# AUGUSTINE 2006

## Chronology

### January 11

AVHRR  
MODIS  
PUFF

### January 13-14

AVHRR  
MODIS  
GOES  
PUFF

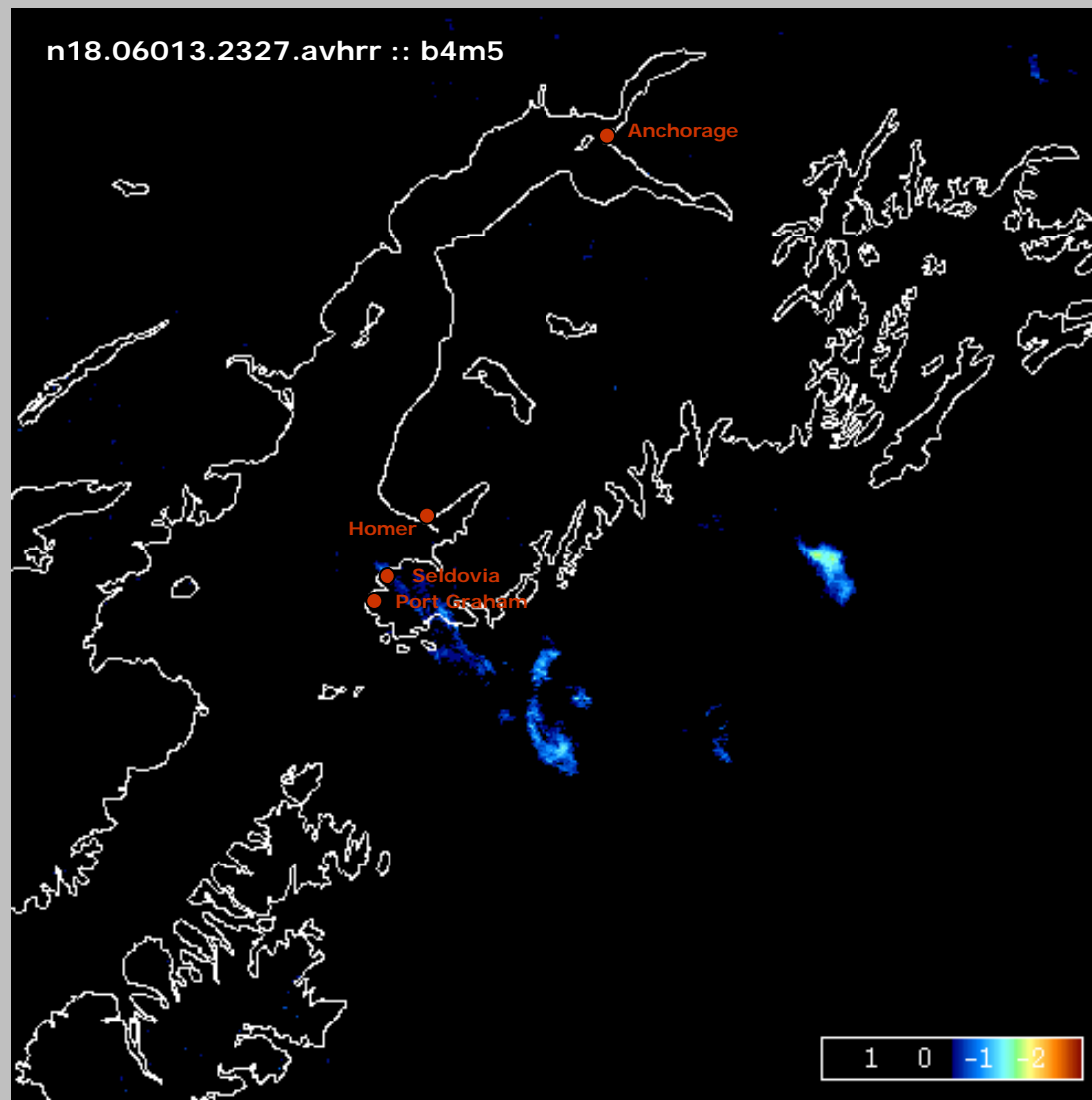
### January 17

AVHRR  
MODIS  
PUFF

AVO :: UAF :: GI  
January 19, 2006



## AVHRR/MODIS :: January 13-14, 2006



# AUGUSTINE 2006

## Chronology

### January 11

AVHRR  
MODIS  
PUFF

### January 13-14

AVHRR  
MODIS  
GOES  
PUFF

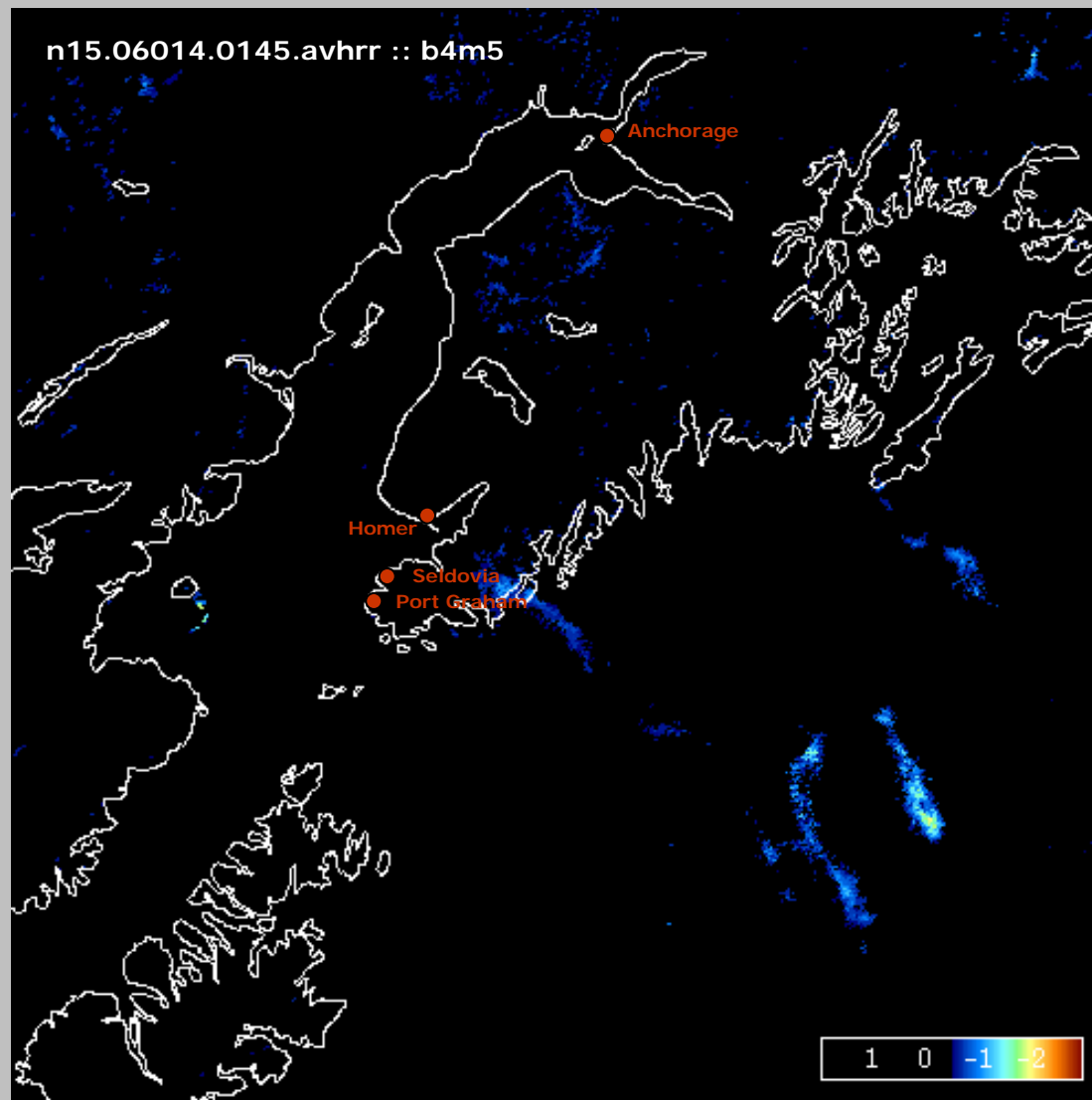
### January 17

AVHRR  
MODIS  
PUFF

AVO :: UAF :: GI  
January 19, 2006



## AVHRR/MODIS :: January 13-14, 2006



# AUGUSTINE 2006

## Chronology

### January 11

AVHRR  
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### January 13-14

AVHRR  
MODIS  
GOES  
PUFF

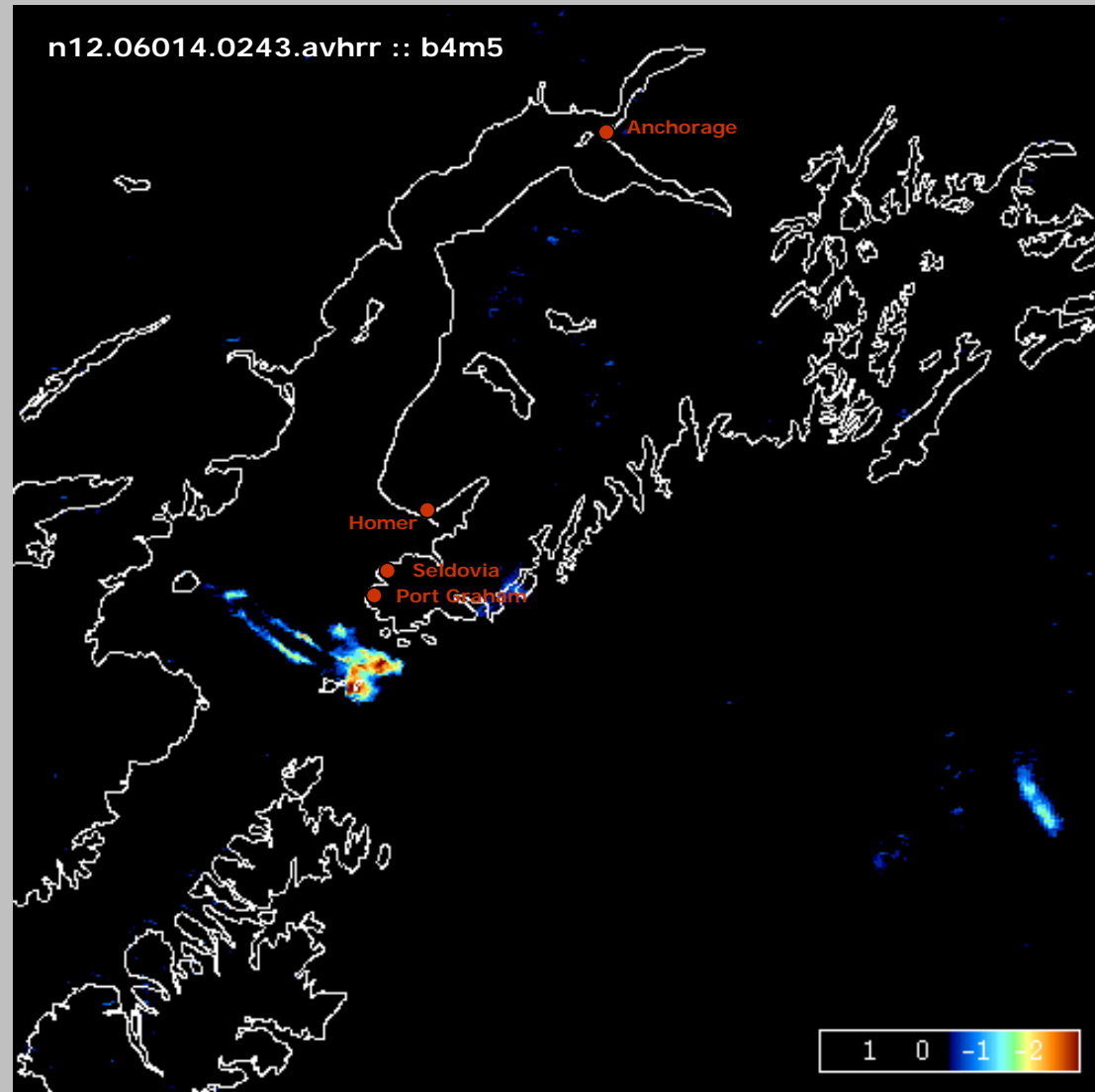
### January 17

AVHRR  
MODIS  
PUFF

AVO :: UAF :: GI  
January 19, 2006



## AVHRR/MODIS :: January 13-14, 2006



# AUGUSTINE 2006

## Chronology

### January 11

AVHRR  
MODIS  
PUFF

### January 13-14

AVHRR  
MODIS  
GOES  
PUFF

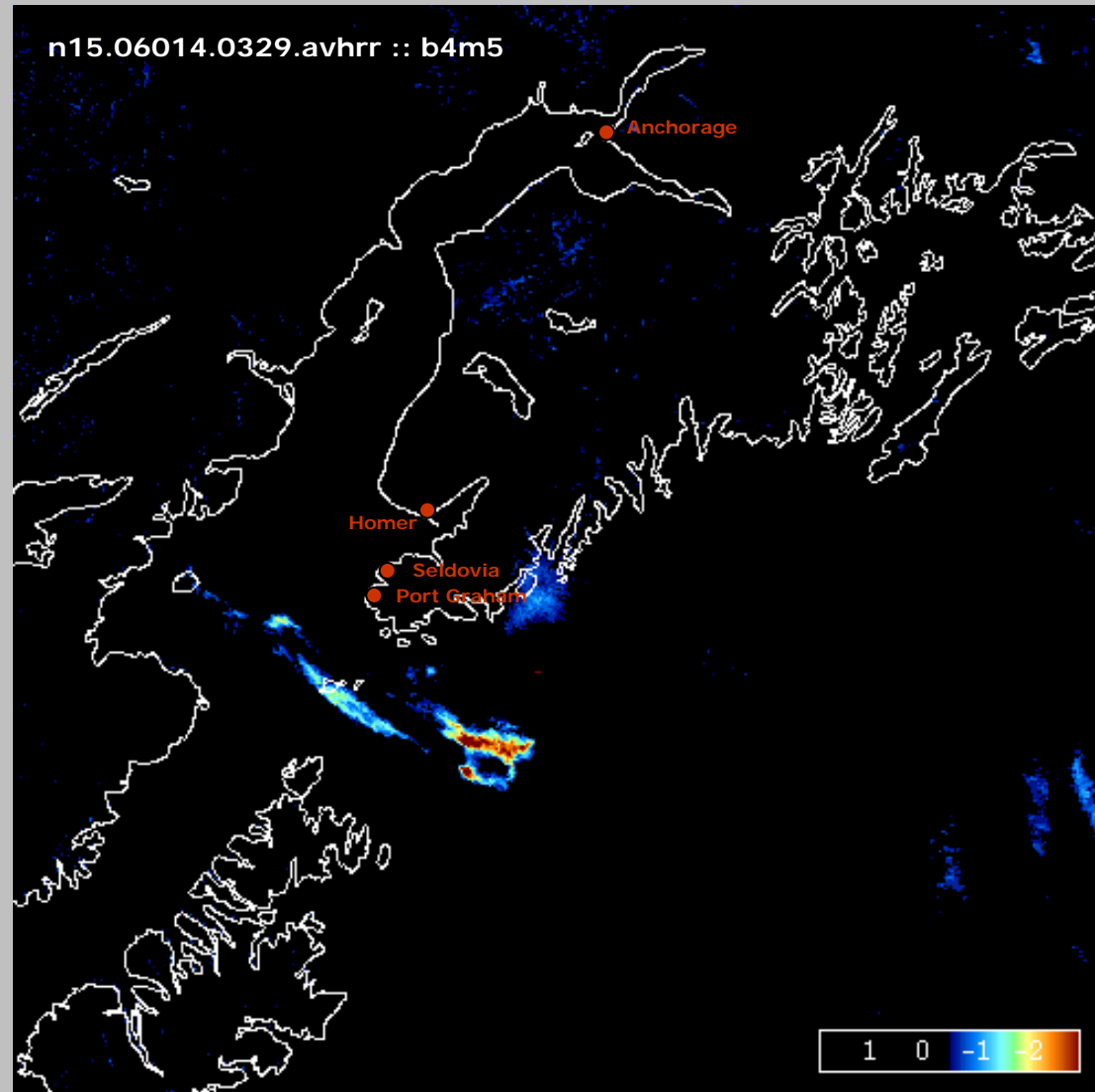
### January 17

AVHRR  
MODIS  
PUFF

AVO :: UAF :: GI  
January 19, 2006



## AVHRR/MODIS :: January 13-14, 2006





# AUGUSTINE 2006

## Chronology

### January 11

AVHRR  
MODIS  
PUFF

### January 13-14

AVHRR  
MODIS  
GOES  
PUFF

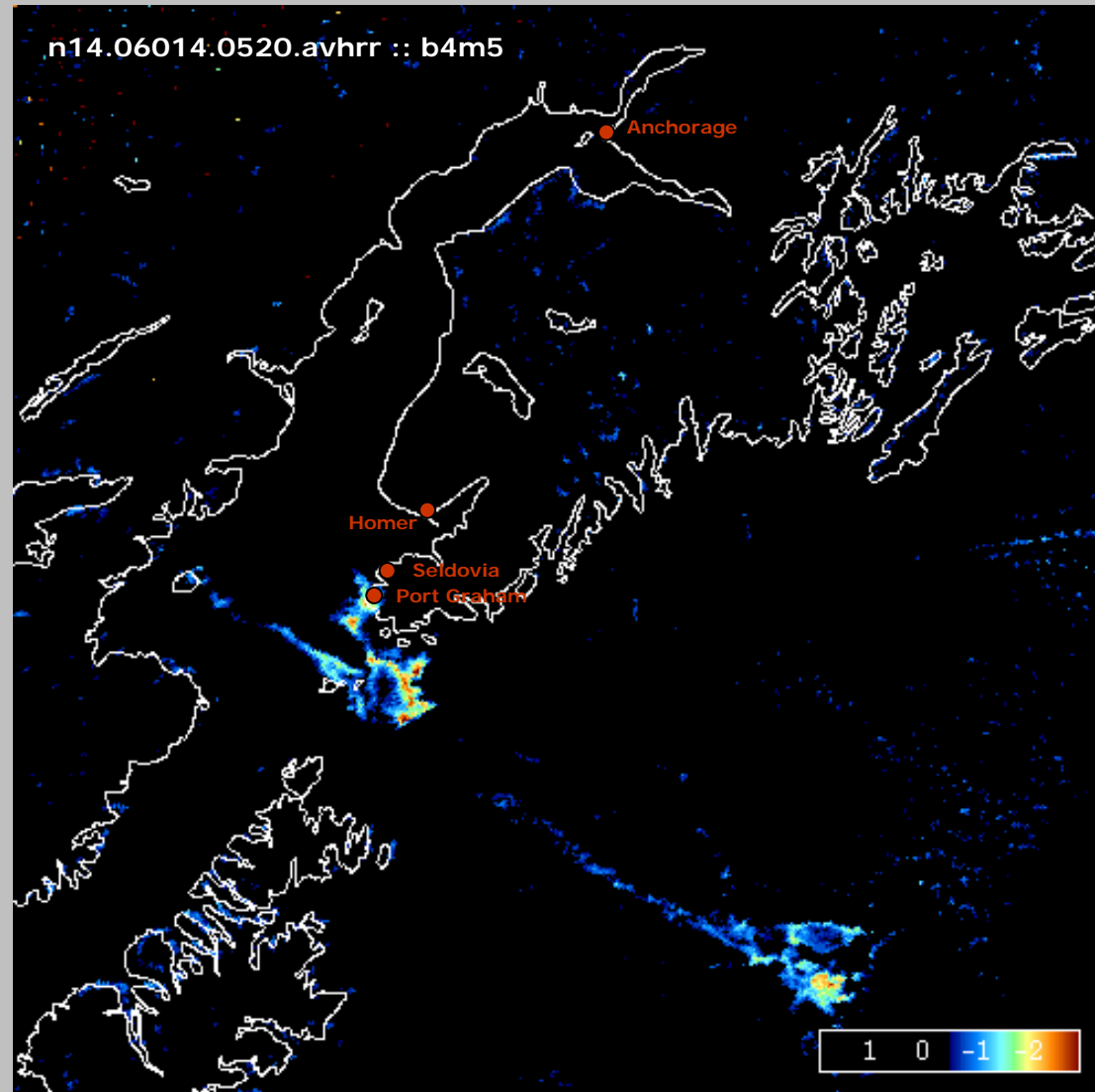
### January 17

AVHRR  
MODIS  
PUFF

AVO :: UAF :: GI  
January 19, 2006



## AVHRR/MODIS :: January 13-14, 2006



# AUGUSTINE 2006

## Chronology

### January 11

AVHRR  
MODIS  
PUFF

### January 13-14

AVHRR  
MODIS  
GOES  
PUFF

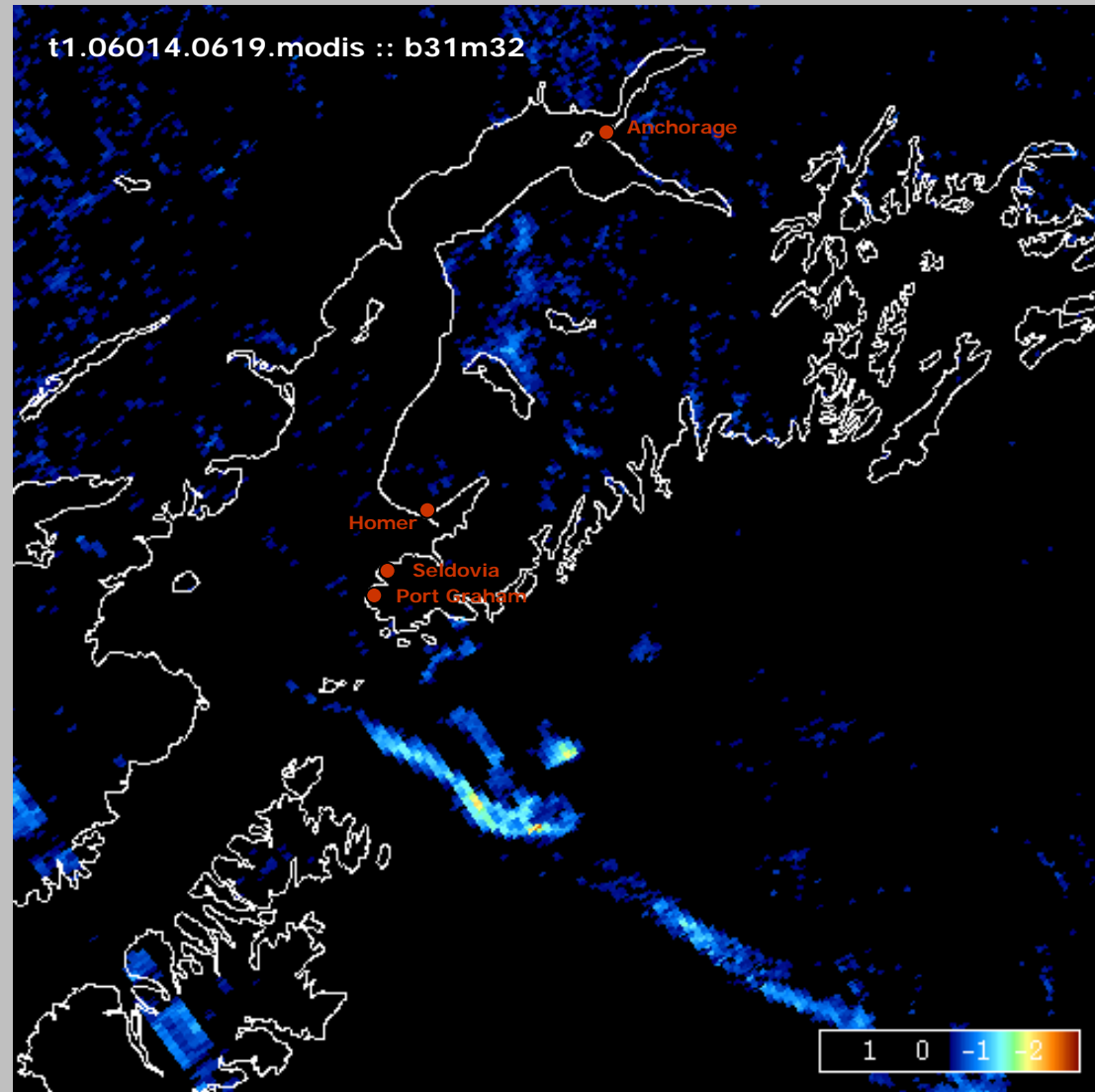
### January 17

AVHRR  
MODIS  
PUFF

AVO :: UAF :: GI  
January 19, 2006



## AVHRR/MODIS :: January 13-14, 2006



# AUGUSTINE 2006

## Chronology

### January 11

AVHRR  
MODIS  
PUFF

### January 13-14

AVHRR  
MODIS  
GOES  
PUFF

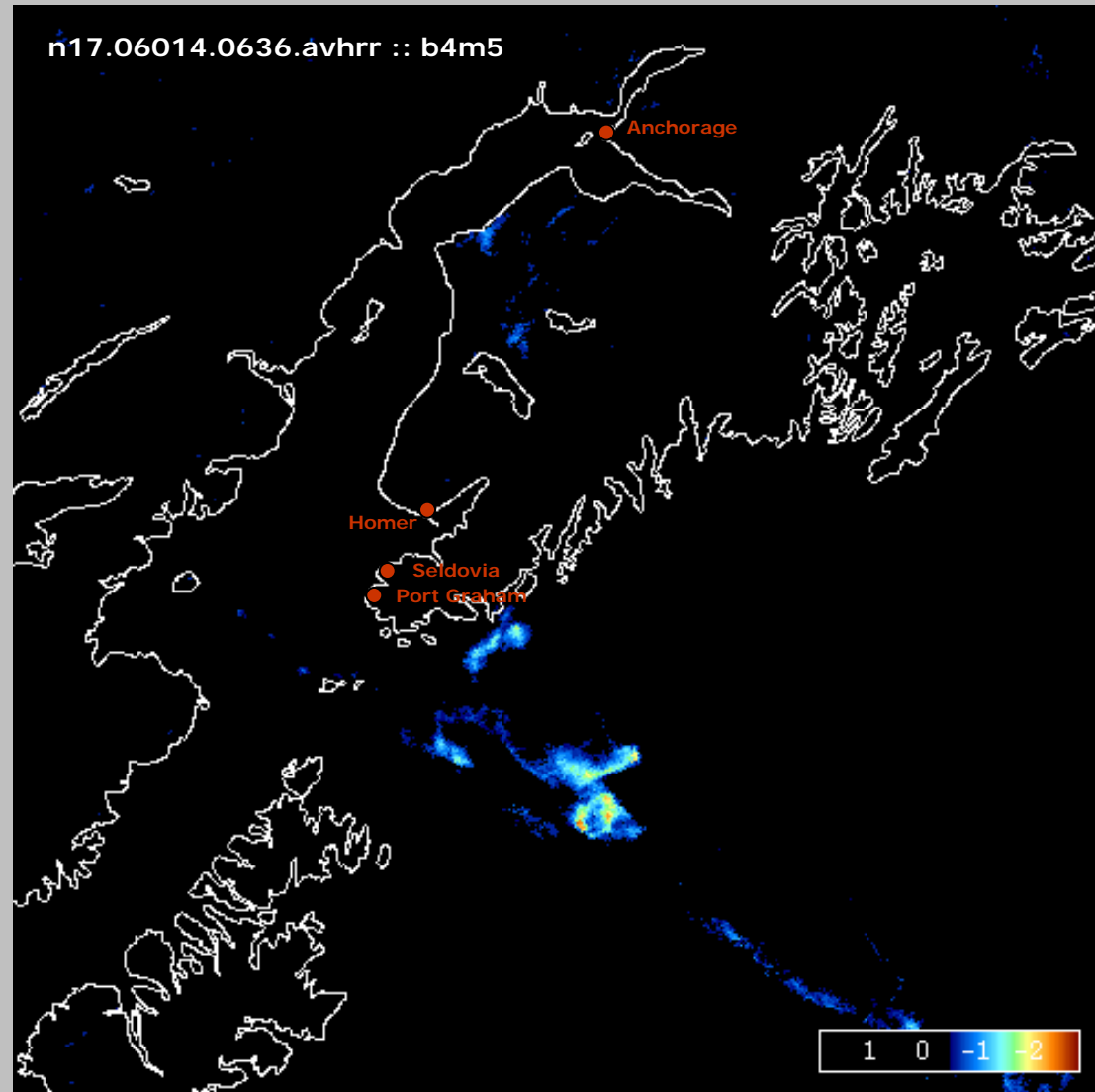
### January 17

AVHRR  
MODIS  
PUFF

AVO :: UAF :: GI  
January 19, 2006



## AVHRR/MODIS :: January 13-14, 2006



# AUGUSTINE 2006

## Chronology

### January 11

AVHRR  
MODIS  
PUFF

### January 13-14

AVHRR  
MODIS  
GOES  
PUFF

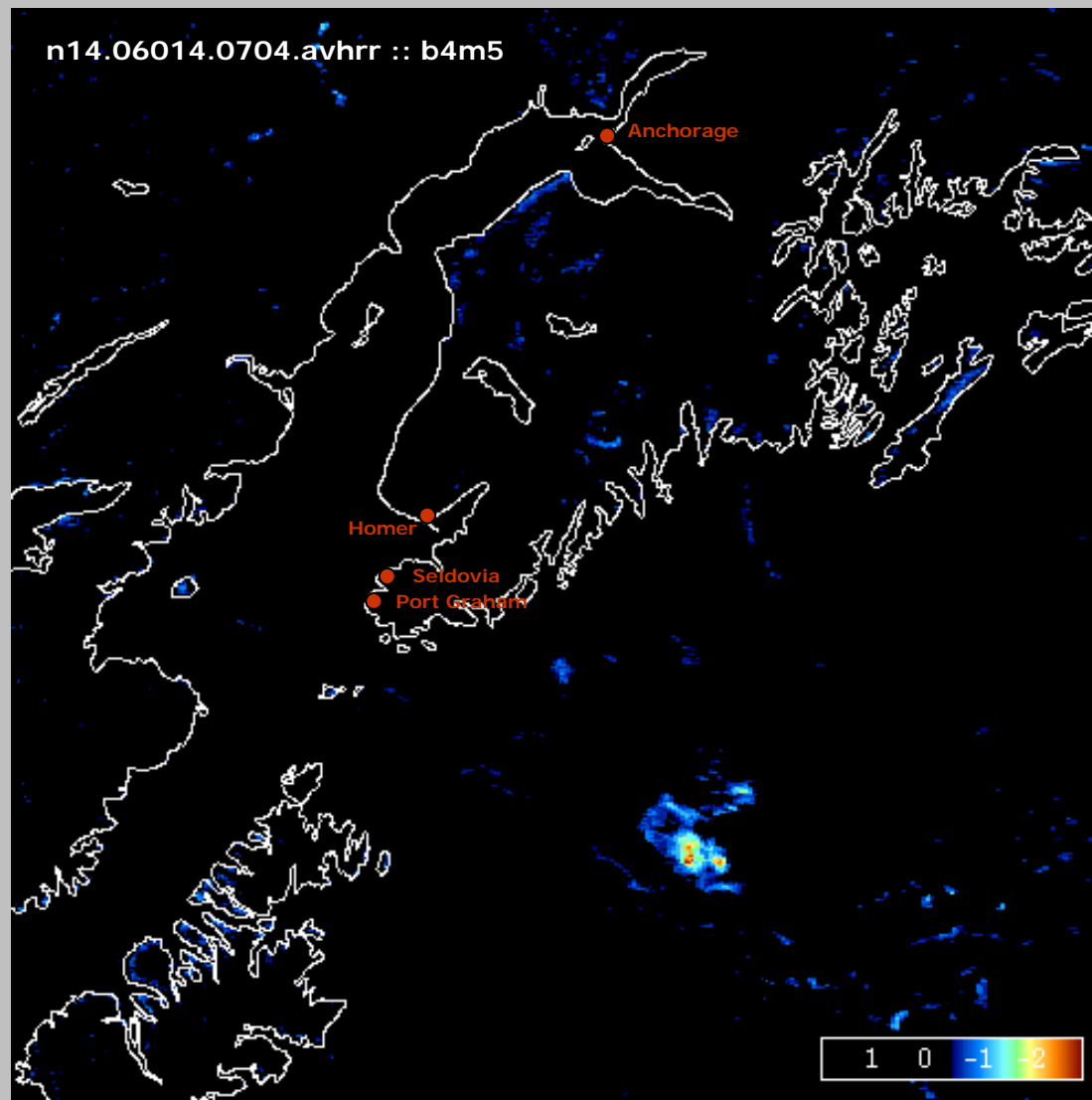
### January 17

AVHRR  
MODIS  
PUFF

AVO :: UAF :: GI  
January 19, 2006



## AVHRR/MODIS :: January 13-14, 2006





# AUGUSTINE 2006

## Chronology

### January 11

AVHRR  
MODIS  
PUFF

### January 13-14

AVHRR  
MODIS  
GOES  
PUFF

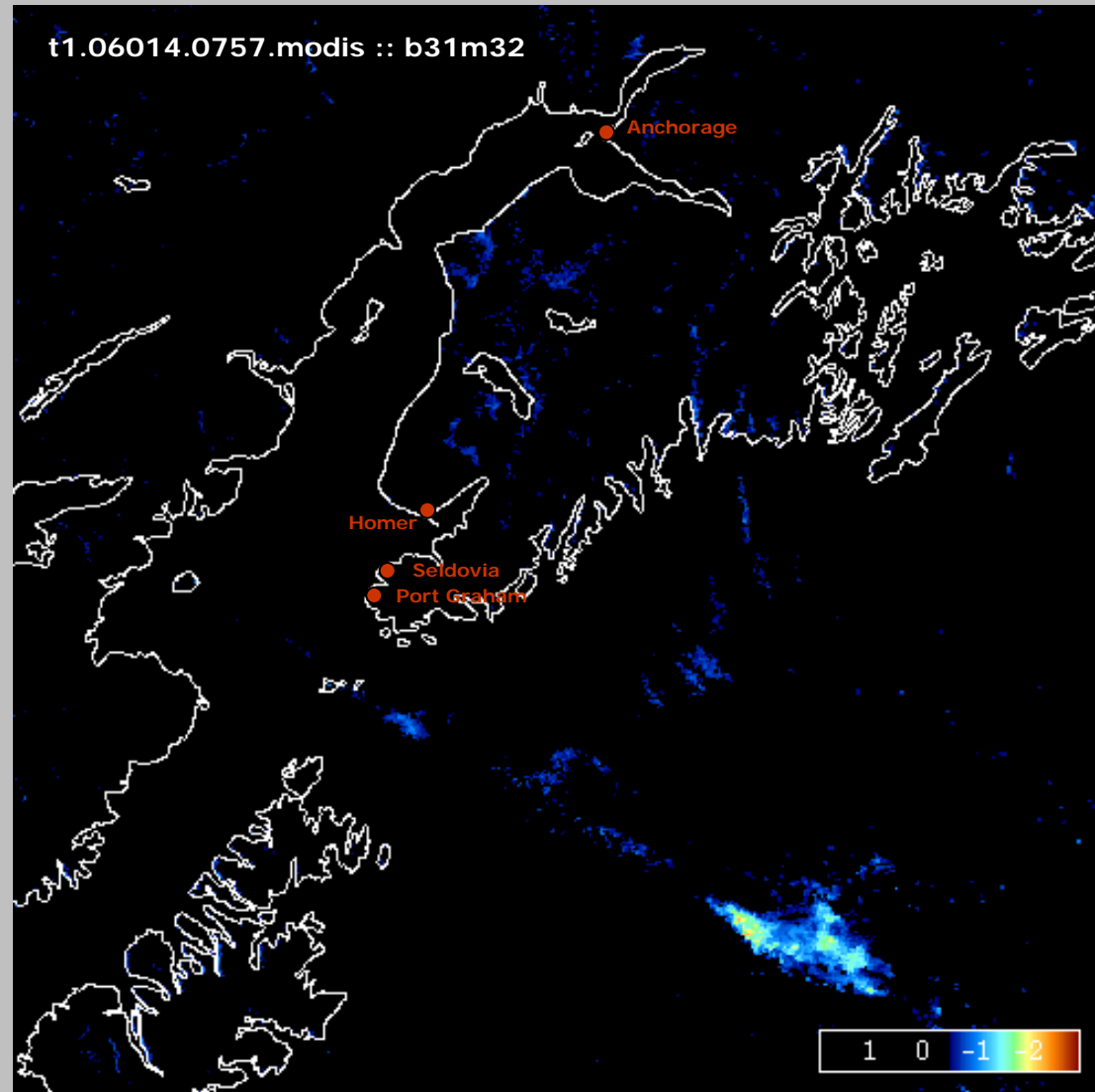
### January 17

AVHRR  
MODIS  
PUFF

AVO :: UAF :: GI  
January 19, 2006



## AVHRR/MODIS :: January 13-14, 2006



# AUGUSTINE 2006

## Chronology

### January 11

AVHRR  
MODIS  
PUFF

### January 13-14

AVHRR  
MODIS  
GOES  
PUFF

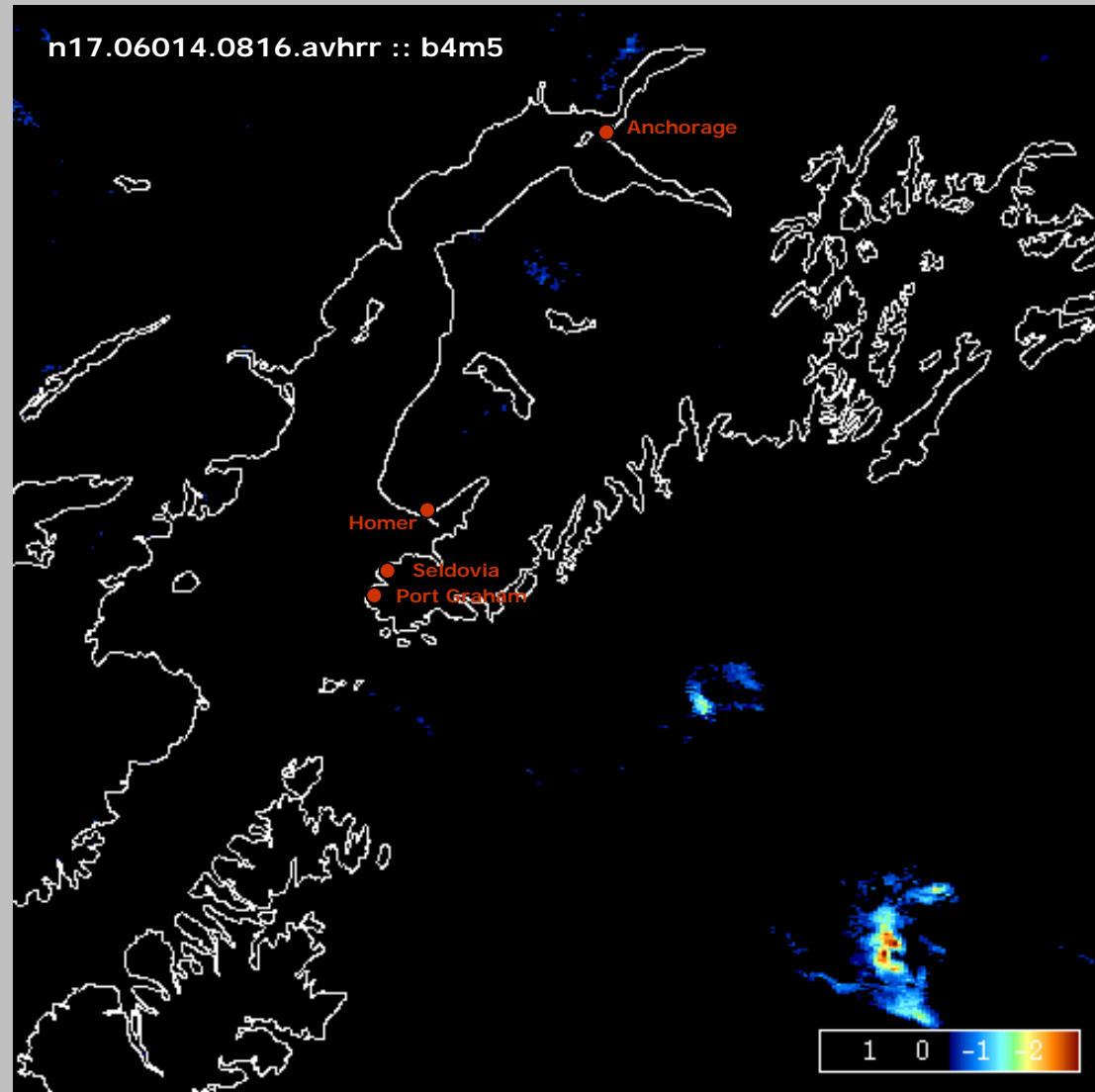
### January 17

AVHRR  
MODIS  
PUFF

AVO :: UAF :: GI  
January 19, 2006



## AVHRR/MODIS :: January 13-14, 2006



# AUGUSTINE 2006

## Chronology

### January 11

AVHRR  
MODIS  
PUFF

### January 13-14

AVHRR  
MODIS  
GOES  
PUFF

### January 17

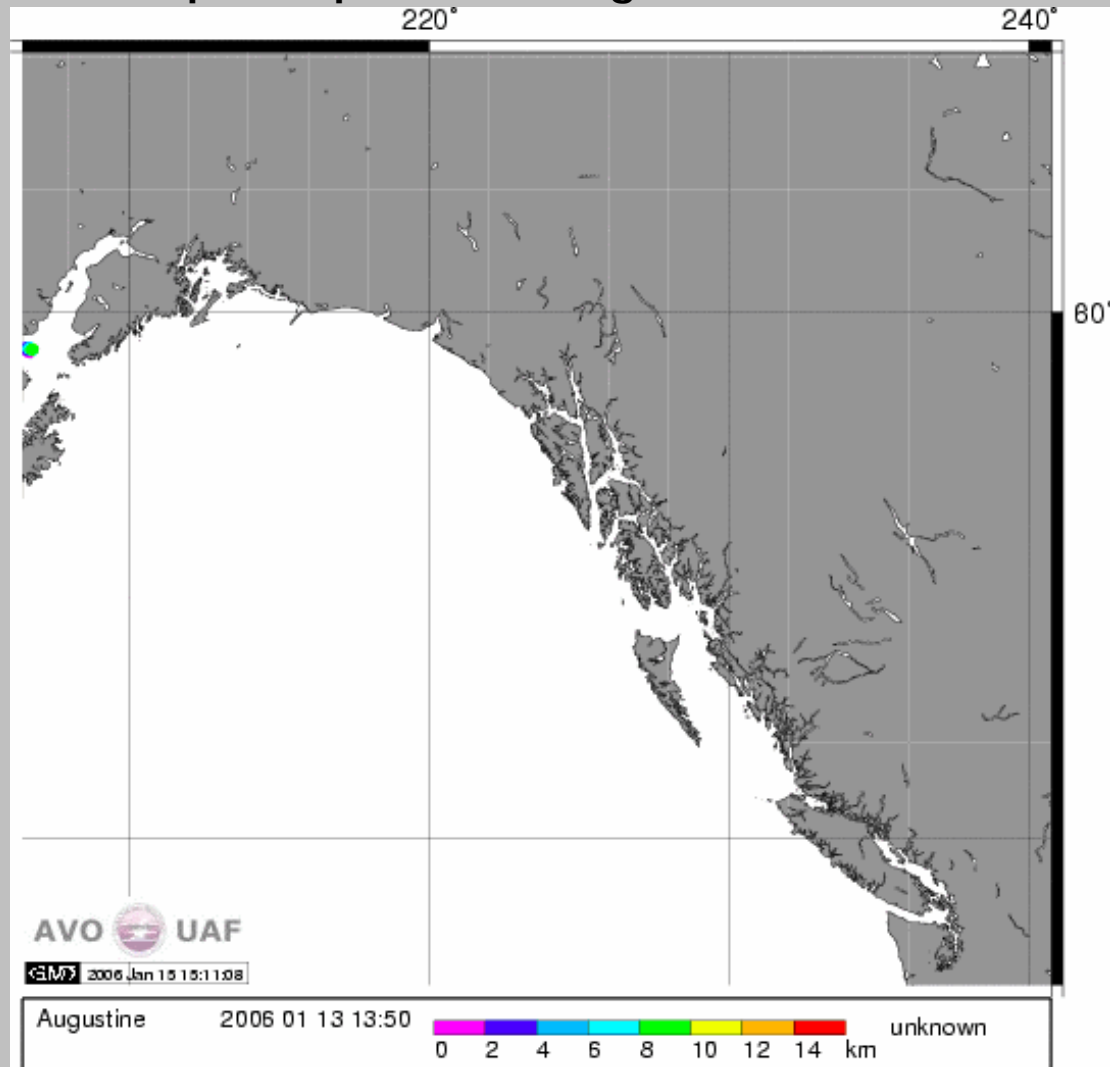
AVHRR  
MODIS  
PUFF

AVO :: UAF :: GI  
January 19, 2006



## PUFF MODEL :: January 13-14, 2006

### New: Multiple Eruption Tracking



# AUGUSTINE 2006

## Chronology

### January 11

AVHRR  
MODIS  
PUFF

### January 13-14

AVHRR  
MODIS  
GOES  
PUFF

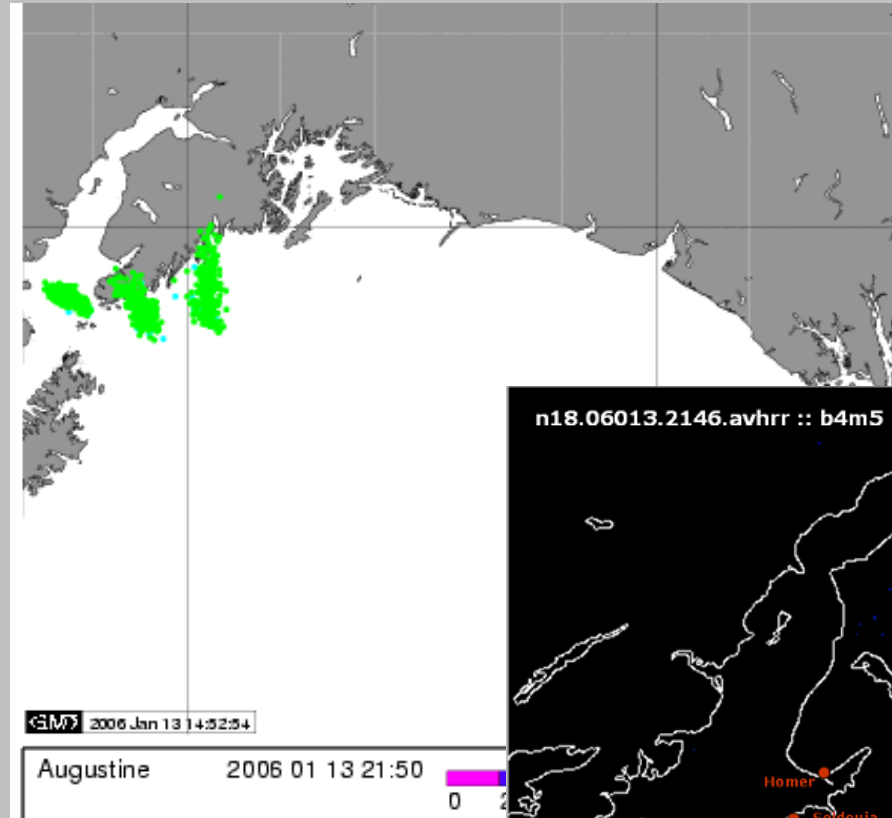
### January 17

AVHRR  
MODIS  
PUFF

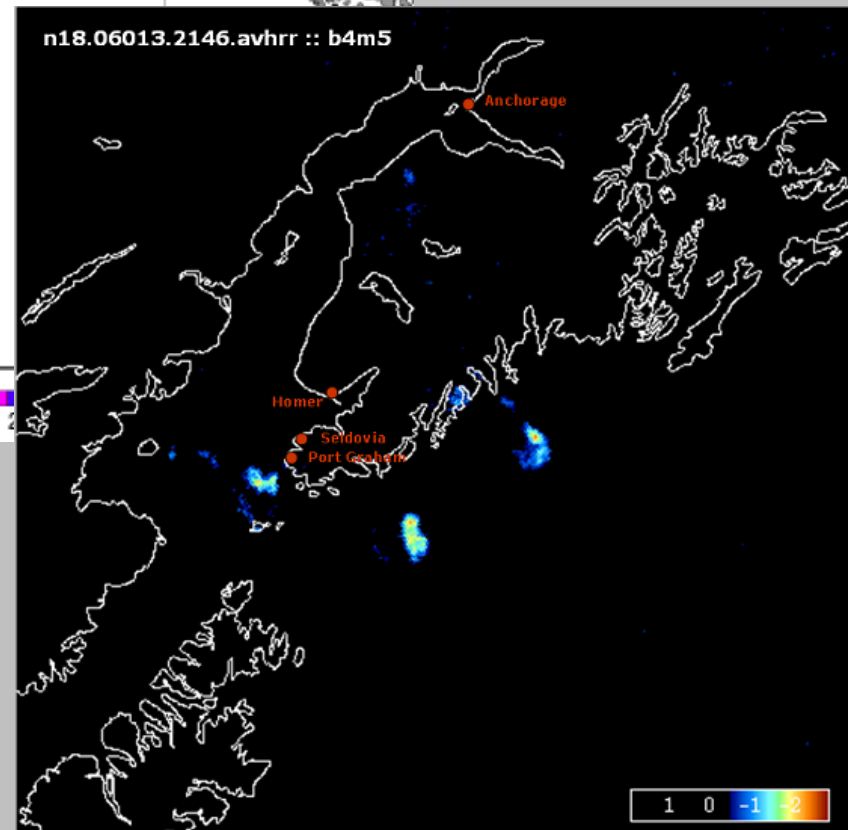
AVO :: UAF :: GI  
January 19, 2006



## PUFF MODEL :: January 13-14, 2006



**Puff output on Jan  
13th 2006, 2150 UTC  
(8 – 10 km)**



**AVHRR Ash Signal  
Jan 13th 2006, 2150  
UTC  
(8 – 10 km)**



# AUGUSTINE 2006

## Chronology

### January 11

AVHRR  
MODIS  
PUFF

### January 13-14

AVHRR  
MODIS  
GOES  
PUFF

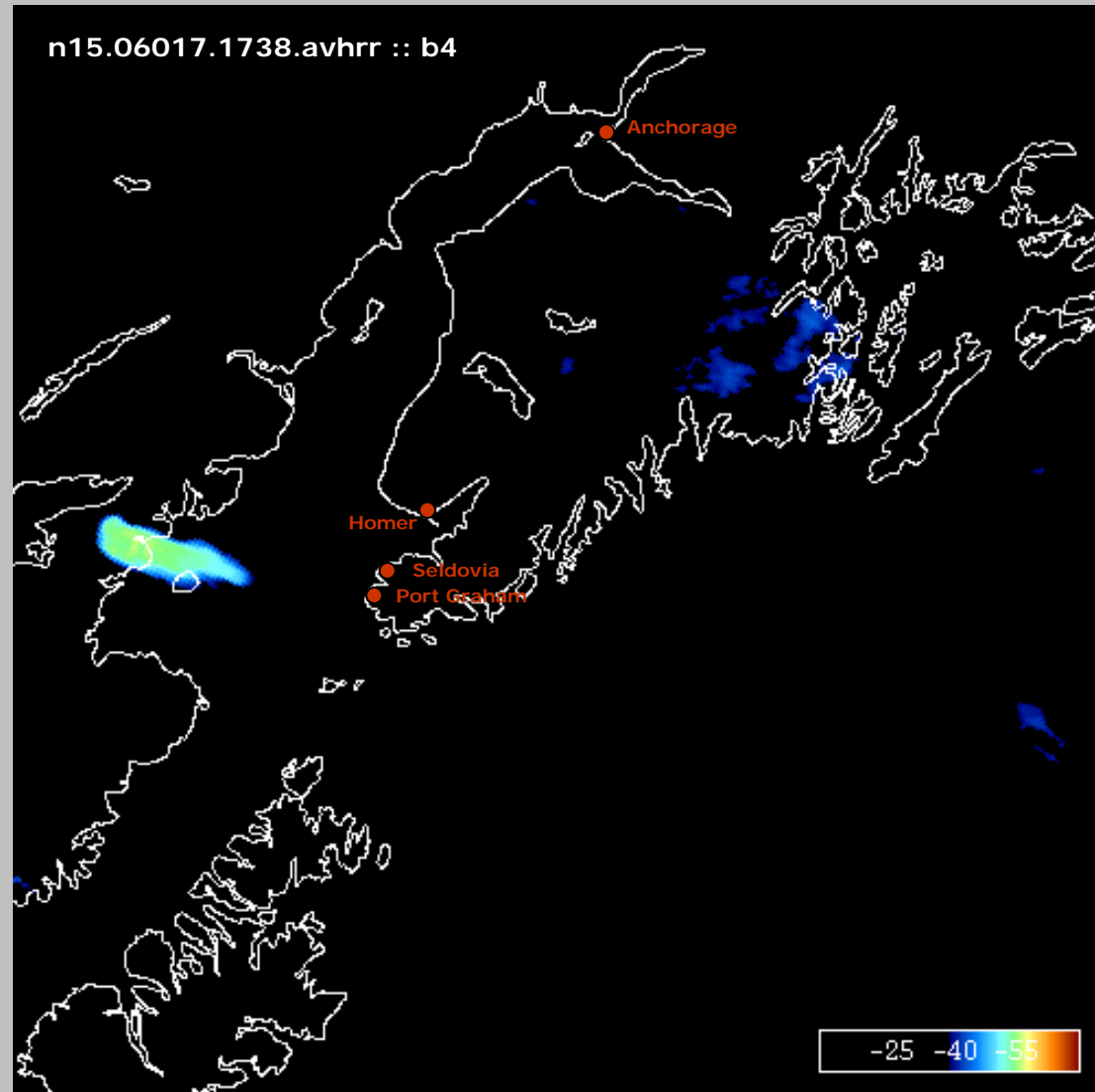
### January 17

AVHRR  
MODIS  
PUFF

AVO :: UAF :: GI  
January 19, 2006



## AVHRR/MODIS :: January 17, 2006

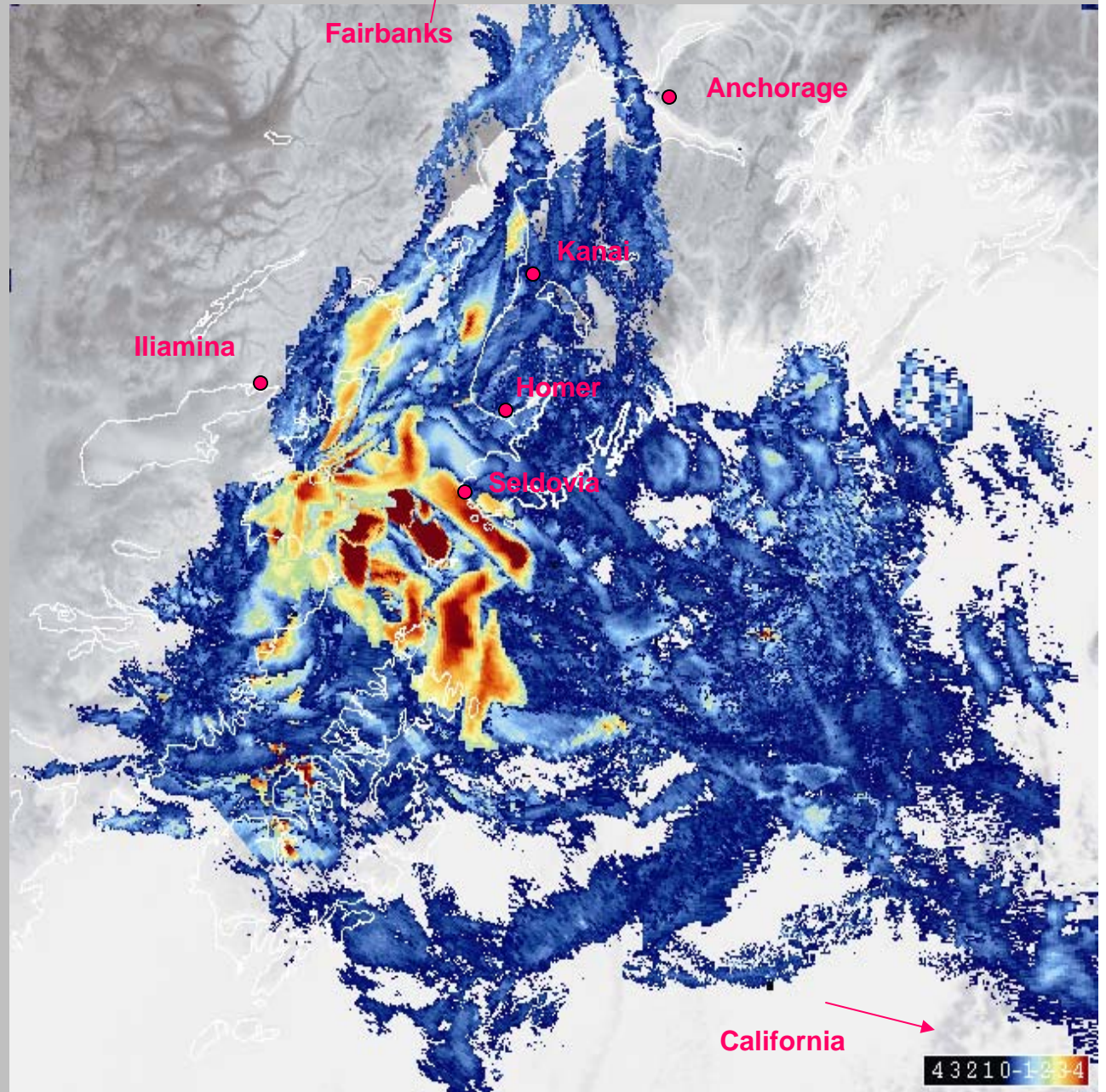


# Ash Cloud Composite

Total area affected  
by ash clouds  
(split-window)

Areas of ashfall

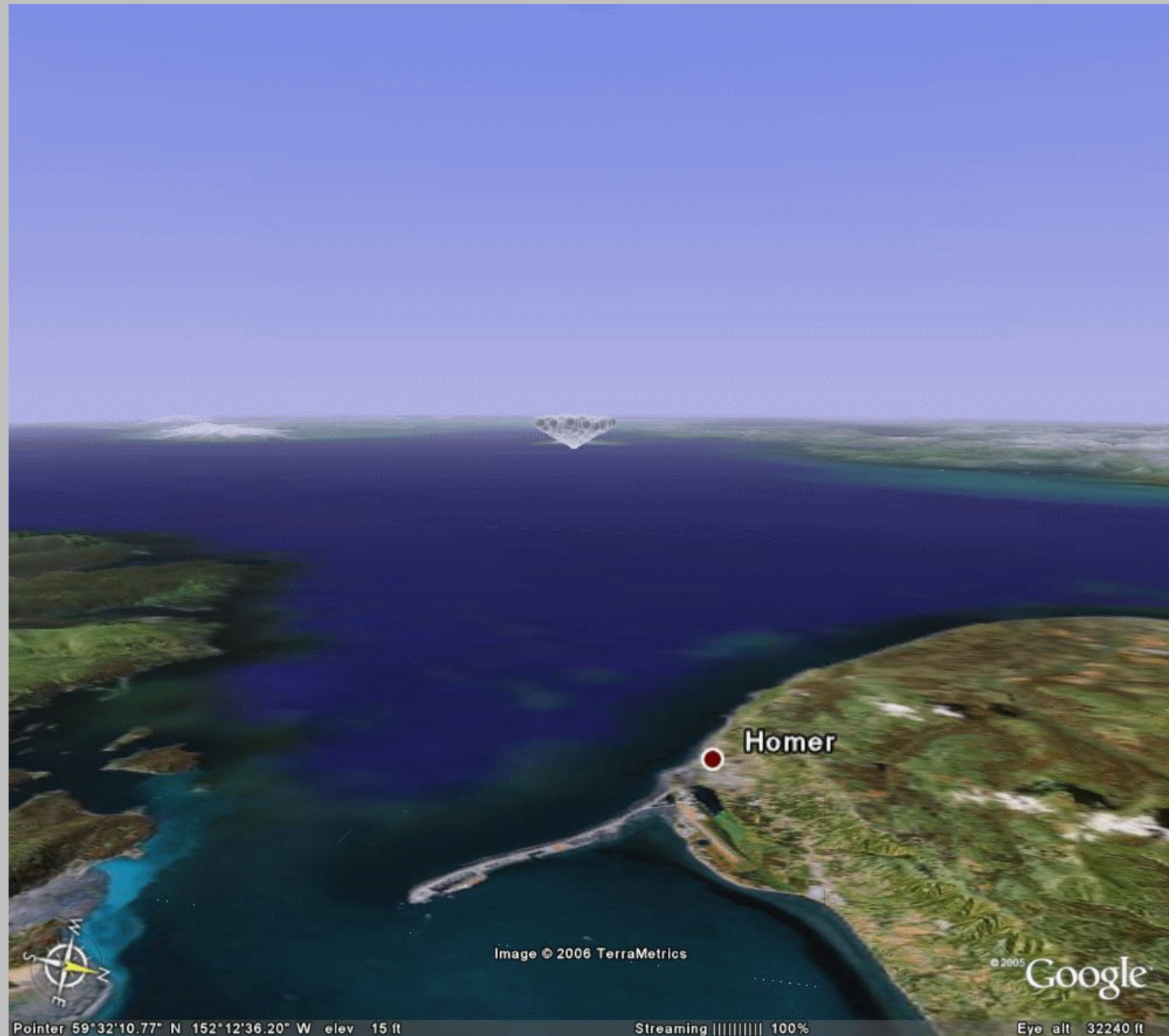
Augustine  
Eruption  
2006





# New: 3D Puff, Google Earth

Augustine  
Eruption  
14 Jan. 06



Pointer 59°32'10.77" N 152°12'36.20" W elev 15 ft

Streaming ||||| 100%

Eye alt 32240 ft

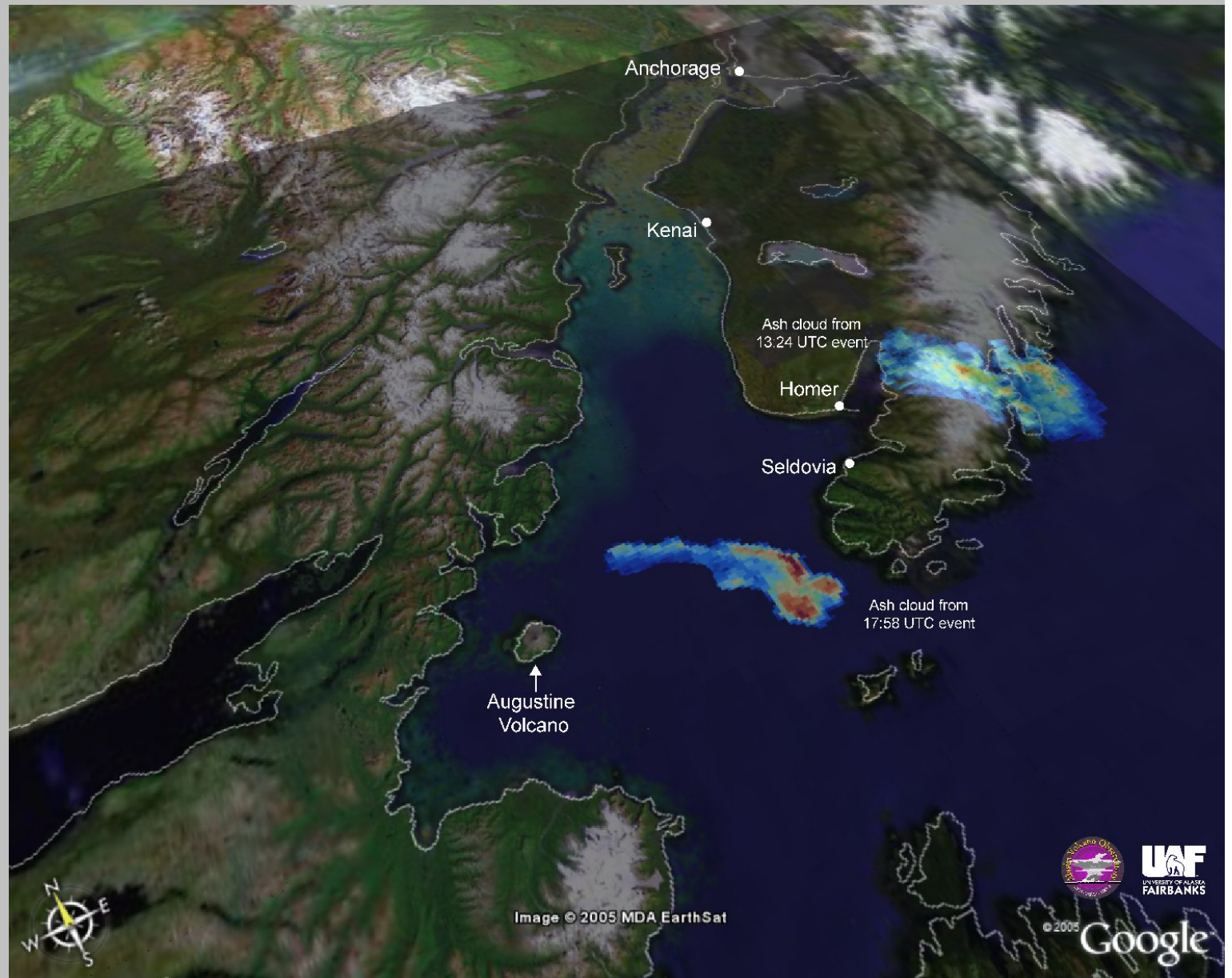
# New: Satellite Images in Google Earth

Augustine Ash  
Clouds, 13 Jan

Excellent  
Geographic  
Control

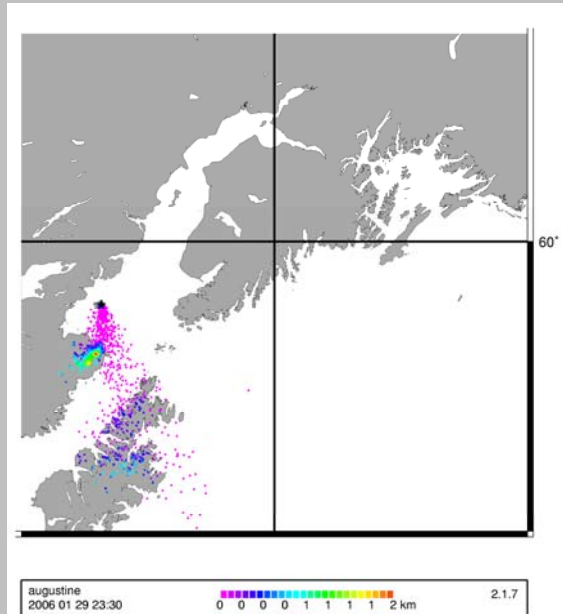
Simple interface

Easy for customers  
To use and  
understand

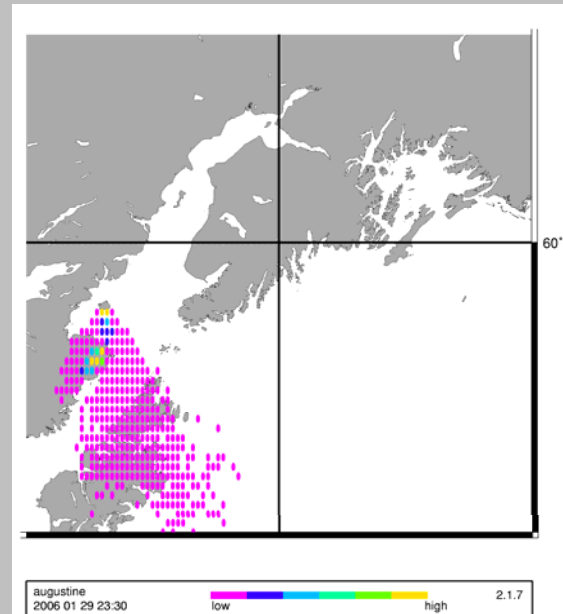




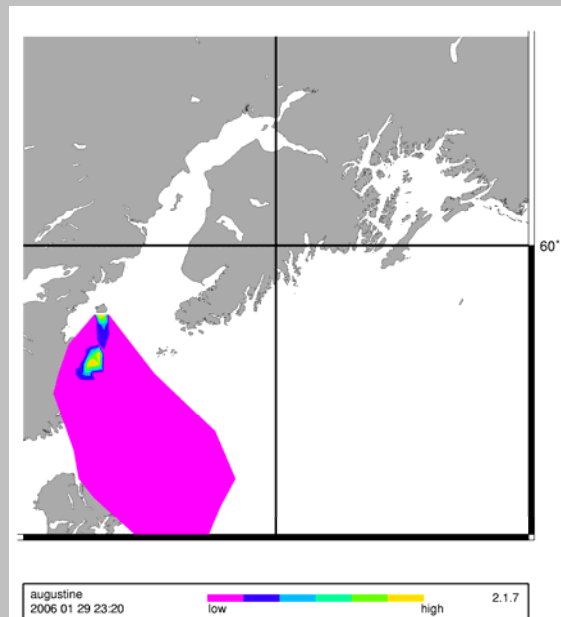
# Under development: Ash Fall Mapping



Ash fallout by height



Ash fallout concentration (Points)



Ash fallout concentration (Contours)

## *Delimas and Future Developments*

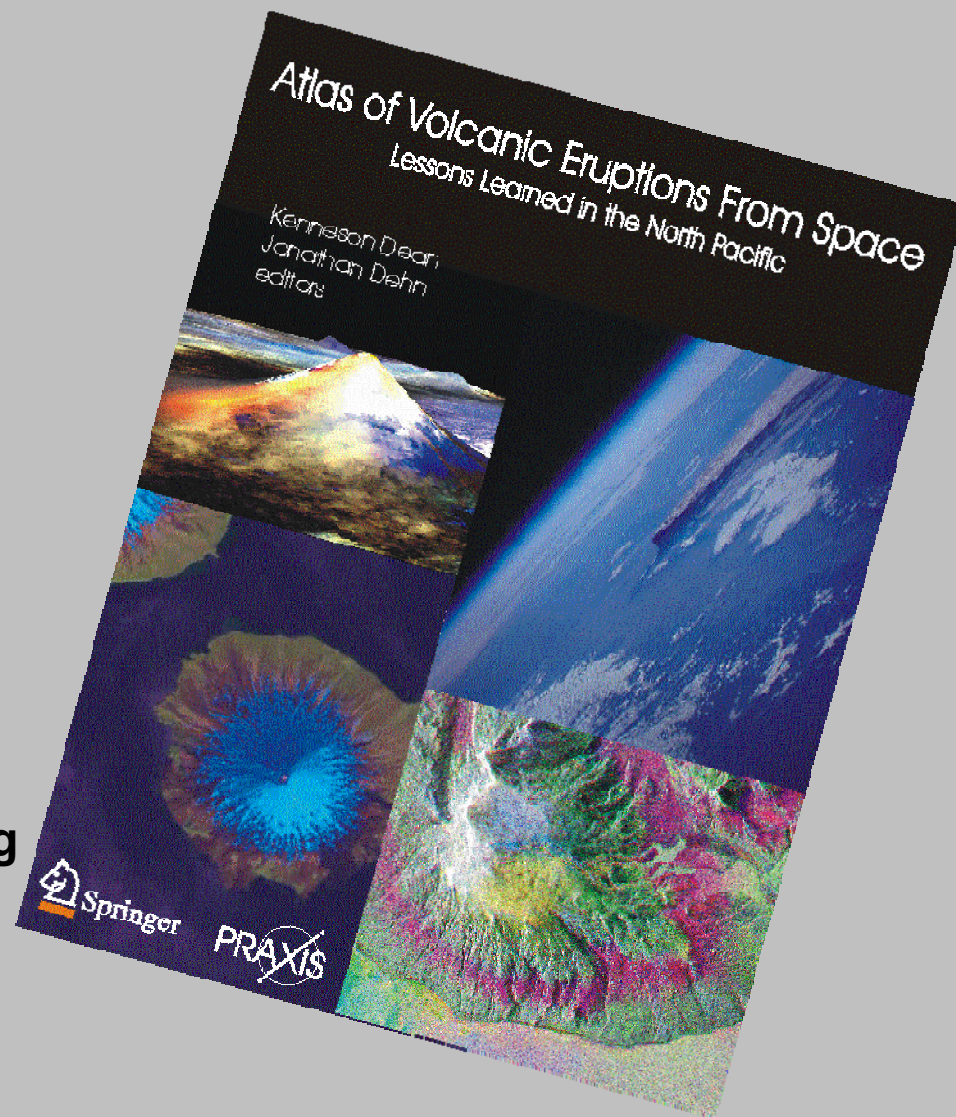
**Automated effusion rates or thermal flux to predict eruptions.**

**Quantification of ash concentration observed on Satellite data and predicted by models.**

**Incorporate SO<sub>2</sub> detection into monitoring system.**

**incorporate SAR deformation & amplitude into volcano monitoring program.**

**Book Publication Date: Summer 2007**



# Puff Model of 30 yrs of Eruptions



Volcanic Eruptions in North Pacific Region

Puff Volcanic Ash Dispersion Model

Time Series



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