Development of PUFF Model and the Application to Wild Fire

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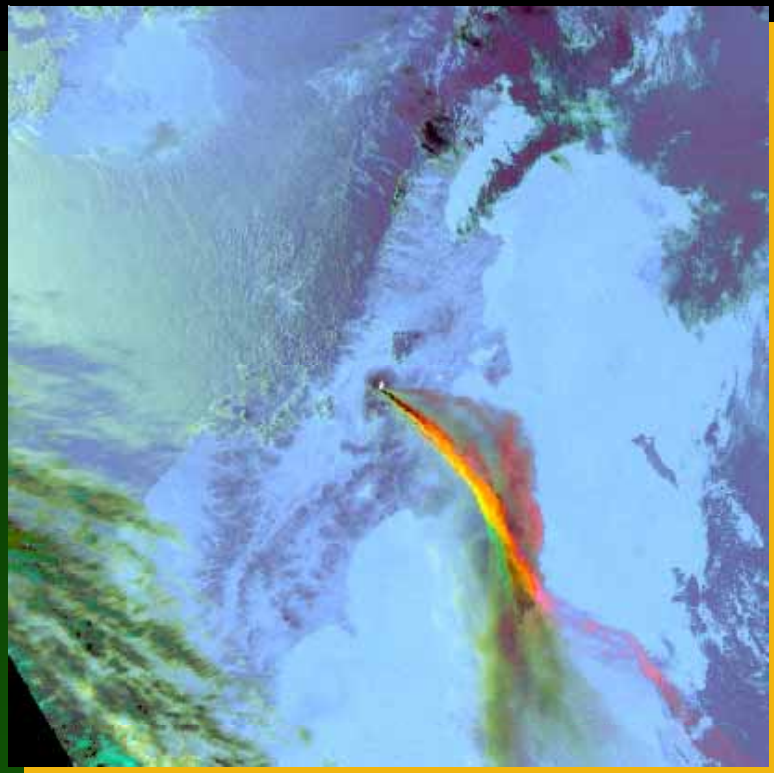
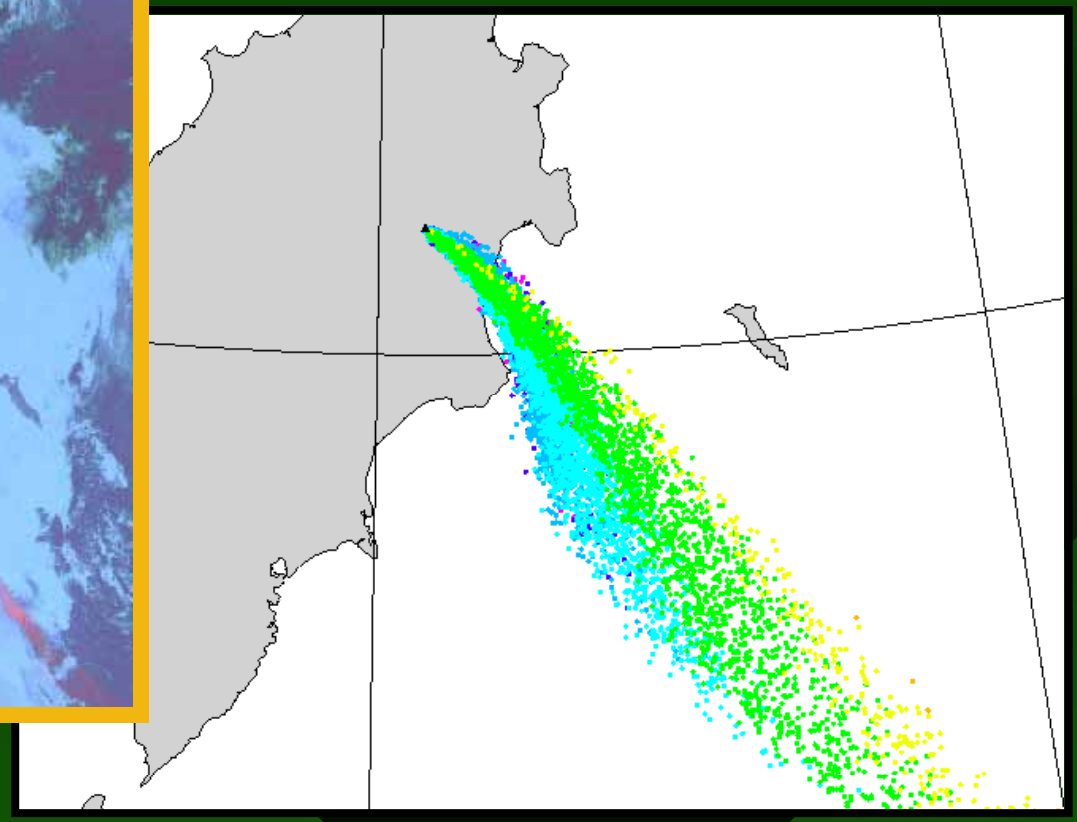
The PUFF mode was developed for the real-time volcanic plume tracking in 1990 during the eruption of Mt. Redoubt in Alaska

Eruption Cloud Characteristics Observed on Satellite Imagery and the Puff Tracking Model

Presented By: Ken Dean, University of Alaska Fairbanks, Geophysical Institute

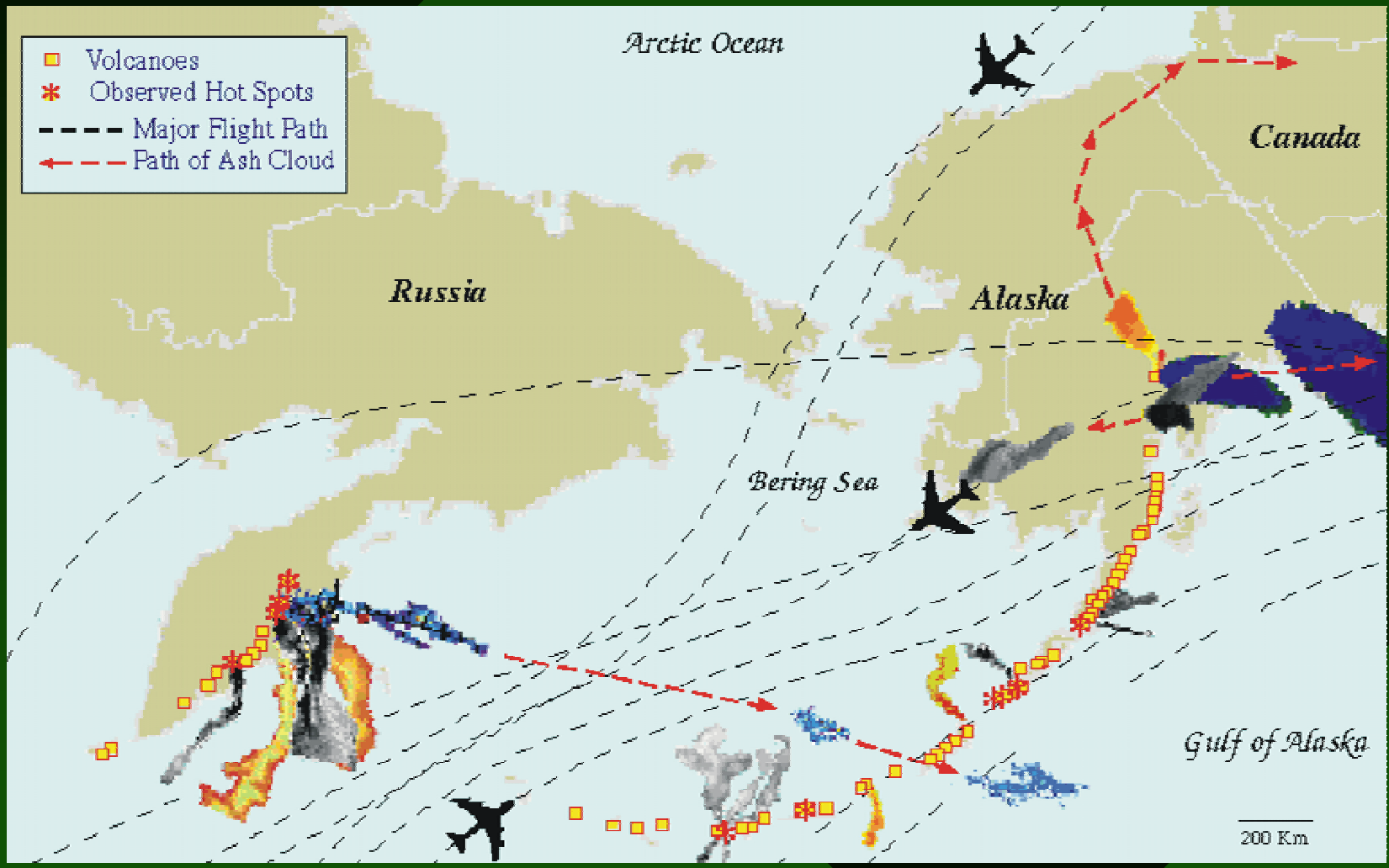




Satellite Data Used to Validate and Calibrate Puff Model

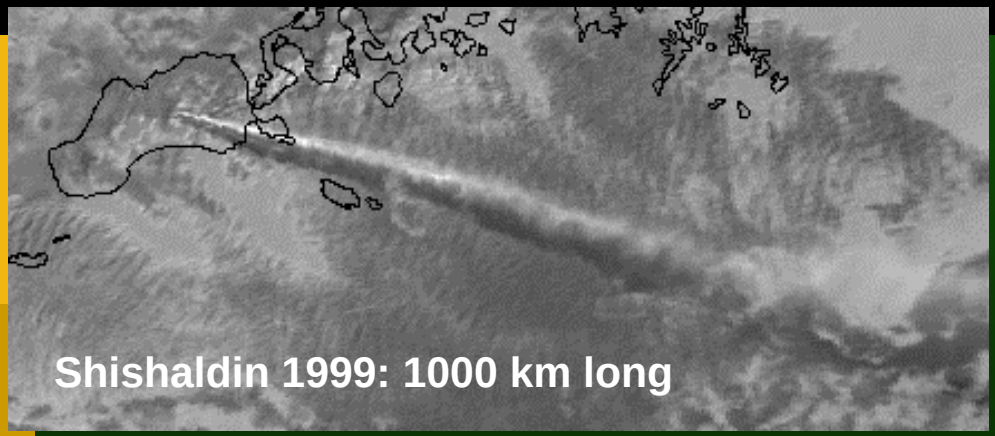
SATELLITE	TEMPORAL RES.	SPATIAL RES.	SPECTRAL RES.
Polar Orbiter:			
AVHRR	1 / 3 hr. Avg.	1 km	5 channels, mm
			1: visible; 0.58 - 0.68
			2: visible-NIR; 0.725 - 1.1
			3: SW-TIR; 3.55 - 3.93
			4: TIR; 10.3 - 11.3
			5: TIR; 11.4 - 12.4
MODIS		1 km - 250 m	36 channels mm
			01-19: Vis.-NIR; 0.405 - 2.155
			20 - 36: TIR; 3.660 - 14.385
Geostationary:			
GOES	1/0.25-.05 hr	2-8 km at 60 ° N	5 channels mm
			1: visible; 0.52 - 0.72
			2: SW-TIR; 3.78 - 4.03
			3: TIR; 6.47 - 7.02
			4: TIR; 10.2 - 11.2
			5: TIR; 11.5 - 12.5
GMS	1/0.25-.05 hr	2-8 km at 60 ° N	5 channels mm
			1: visible; 0.52 - 0.72
			2: SW-TIR; 3.78 - 4.03
			3: TIR; 6.47 - 7.02
			4: TIR; 10.2 - 11.2

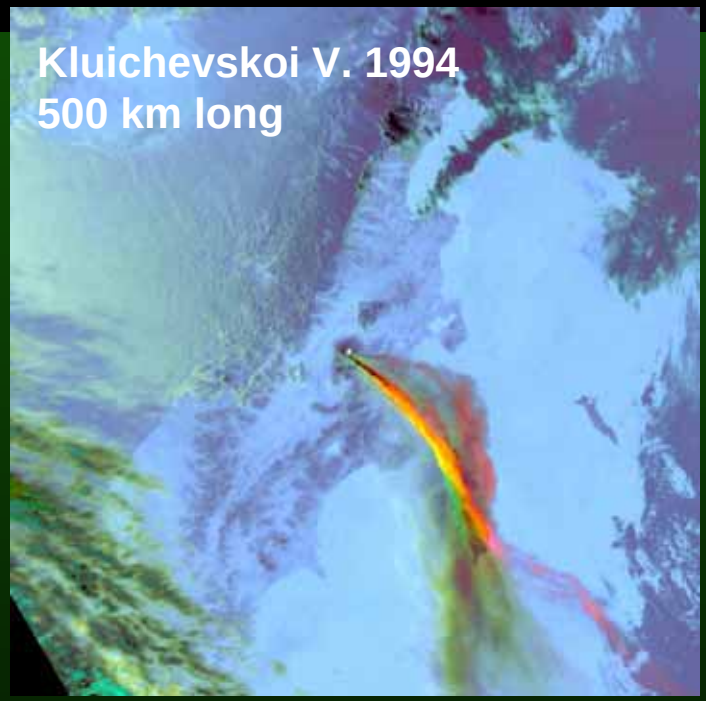
Satellite Images

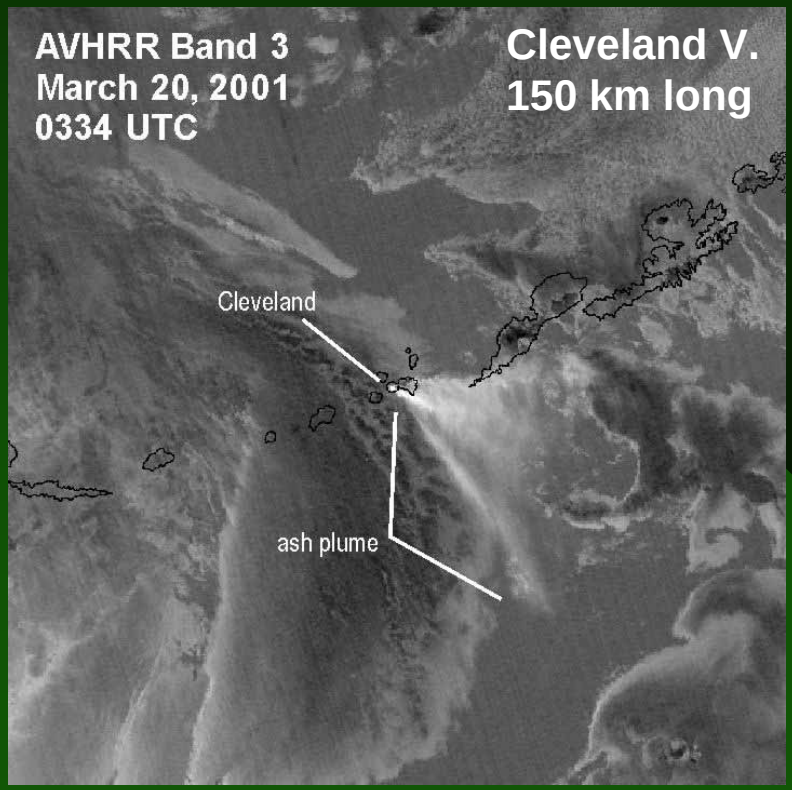


Volcanoes, eruption clouds (1990 to 1996) and aircraft routes in the North Pacific Region. These are only some of the larger eruptions during that period.

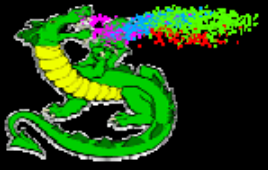
Satellite Images







Plumes come in many different shapes and sizes and are composed of ash and gas



Ash Dispersion Models

- There are many ash dispersion models including; Puff, VAFTAD, CAMERM and HYSPLIT

- All require current wind fields to model the movement of volcanic clouds.

- The accuracy of the models depends on the of the wind fields.

- All require satellite data for validation.

- Puff differs from others: higher spatial resolution, physics, implementation, and it is used in research and operational settings

- Puff is currently in use at:

  University of Alaska Fairbanks (Geophysical Institute)
  University of Tsukuba
  University of Messina, Sicily
  US Geologic Survey
  Japan Weather Association
  National Weather Service
  Japan Airlines

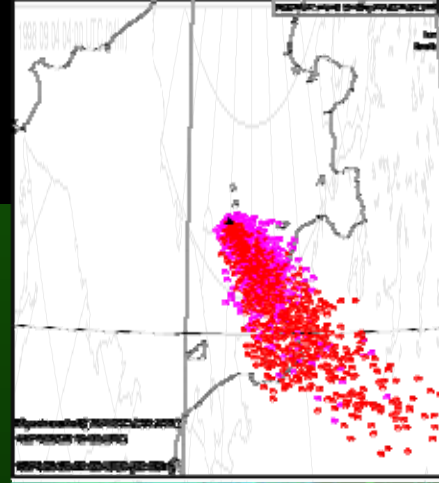
Evaluating Composition and Structure of an Eruption Cloud

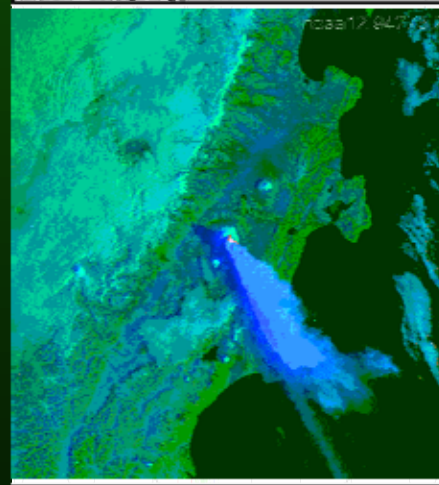
1. Puff Simulation using default values
   Horiz. dispersion = 20,000
   Vertical dispersion = 10
   Height = 16 km
   Mean Particle size = 0.01 mm (10 um)

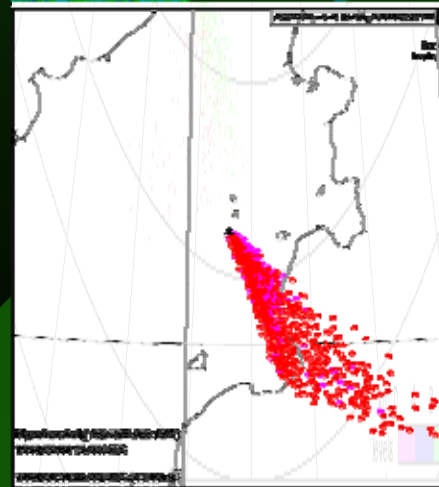
2. Validation of Puff: Model:
   AVHRR Satellite image of volcanic cloud
   (Kliuchevskoi V. 1994)

3. "Tuning" input parameters to match the satellite image of the cloud: Dispersion = 2000

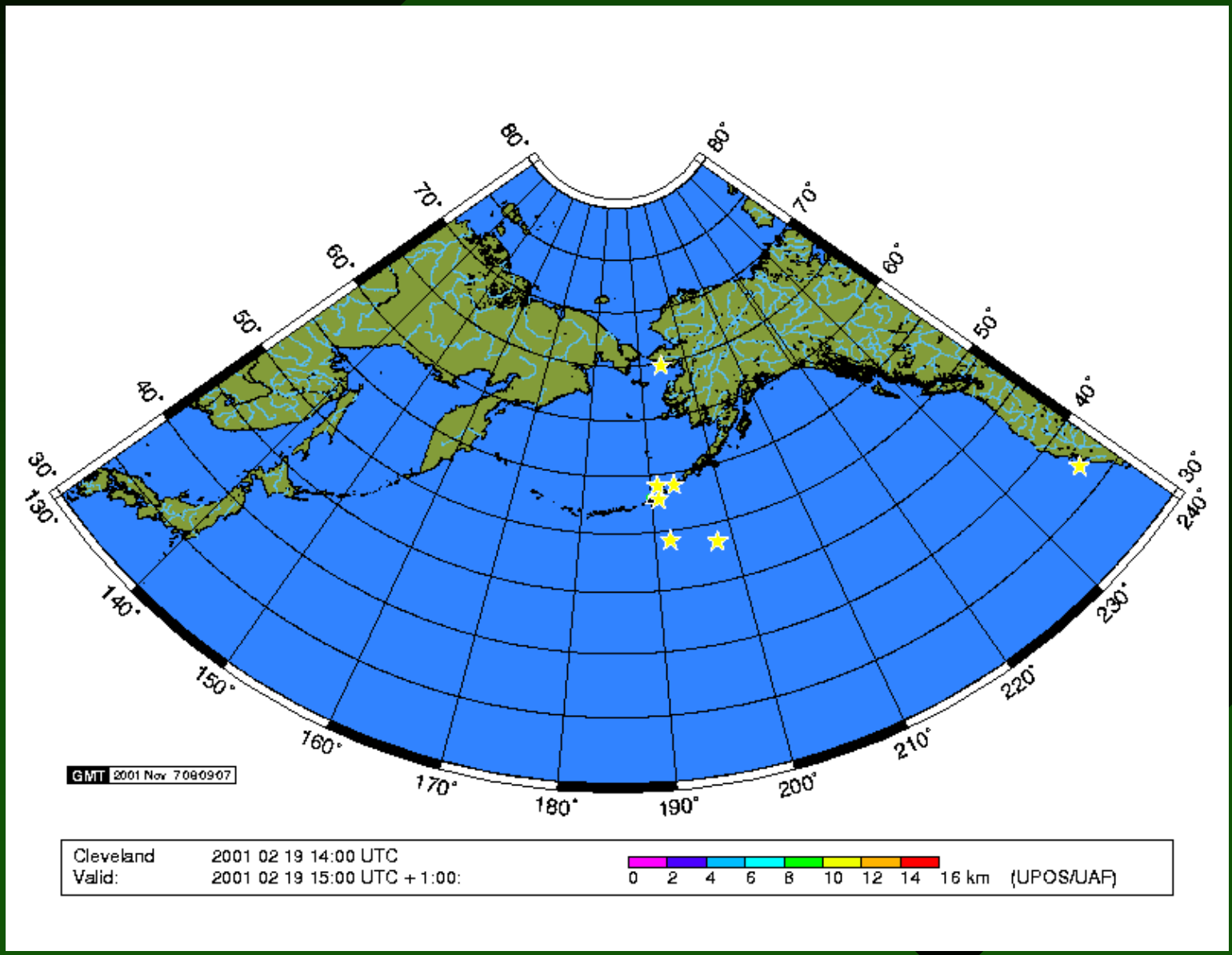
4. "Tuning" may provide relative information on the distribution of particles observed on satellite images







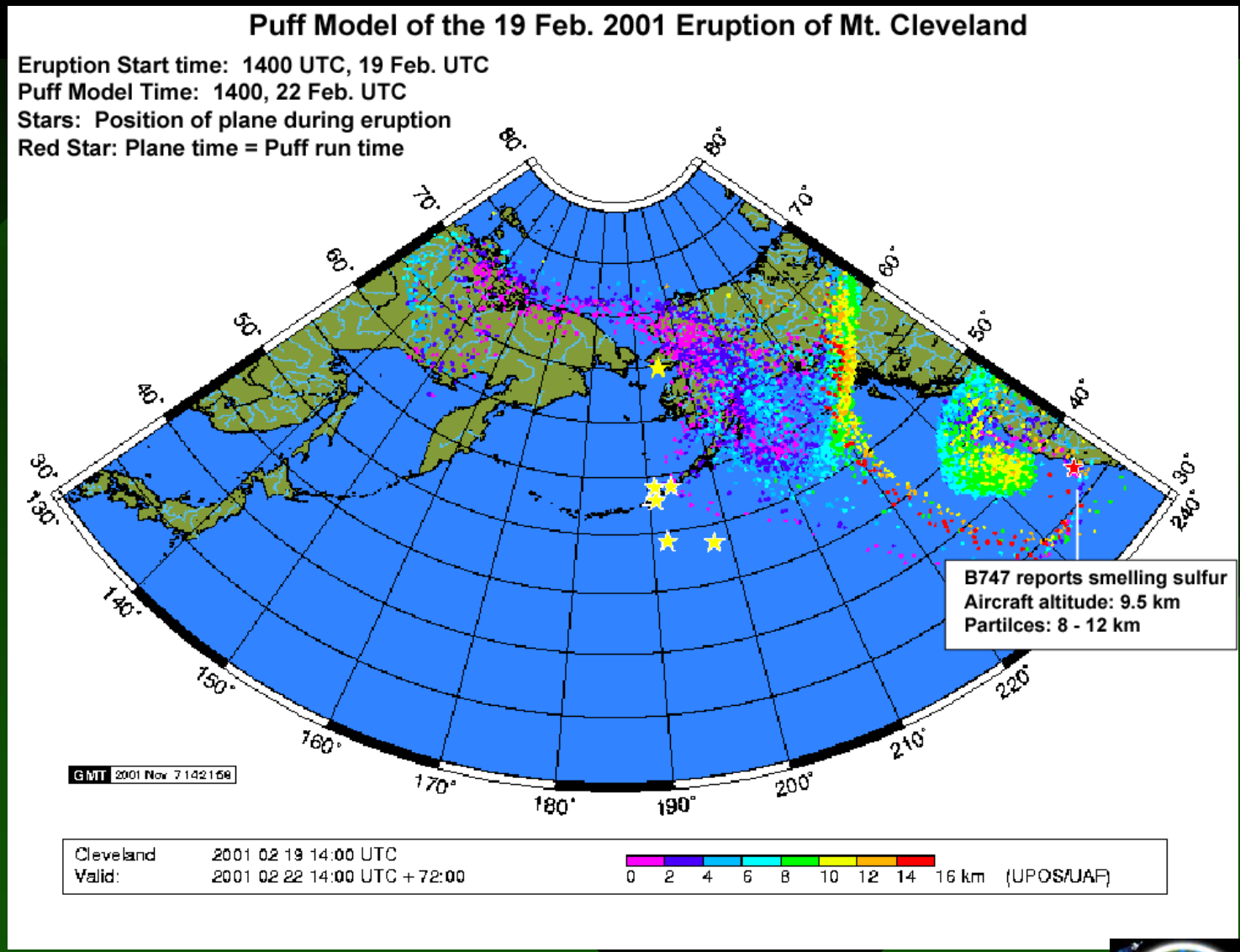
Puff Animation of Mt. Cleveland Eruption 19 February 2001
Aircrafts encountered ash cloud



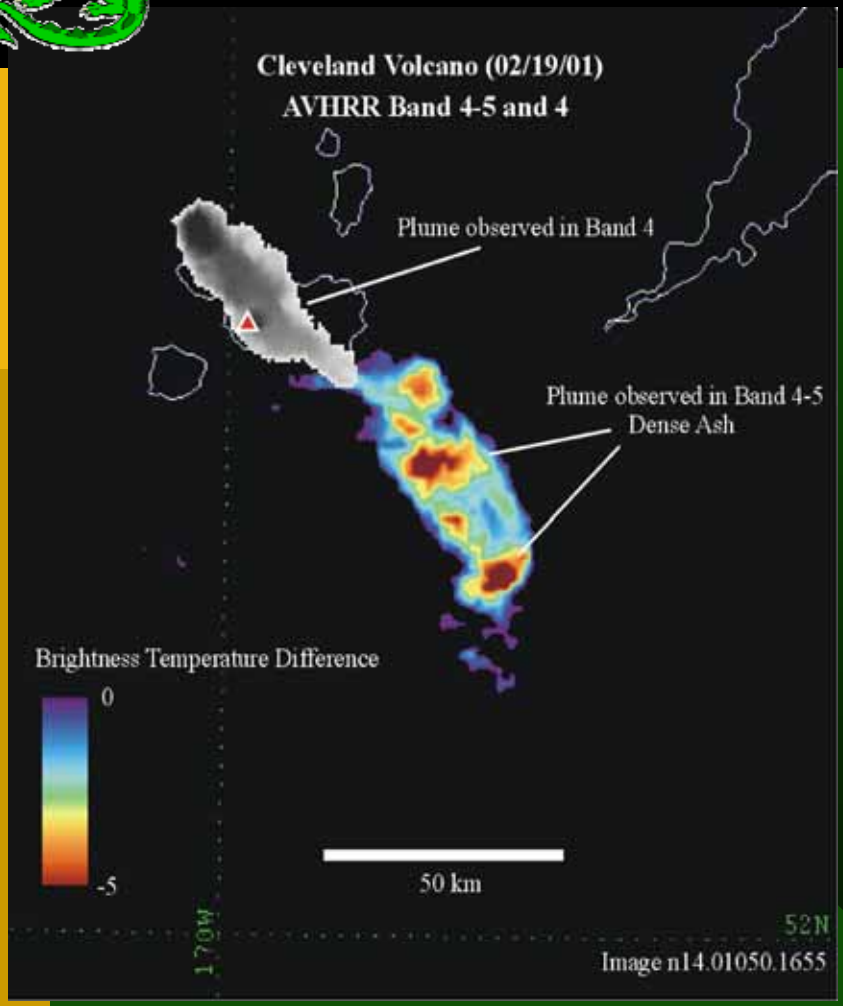
Pilot Reports of Cleveland Eruption Cloud

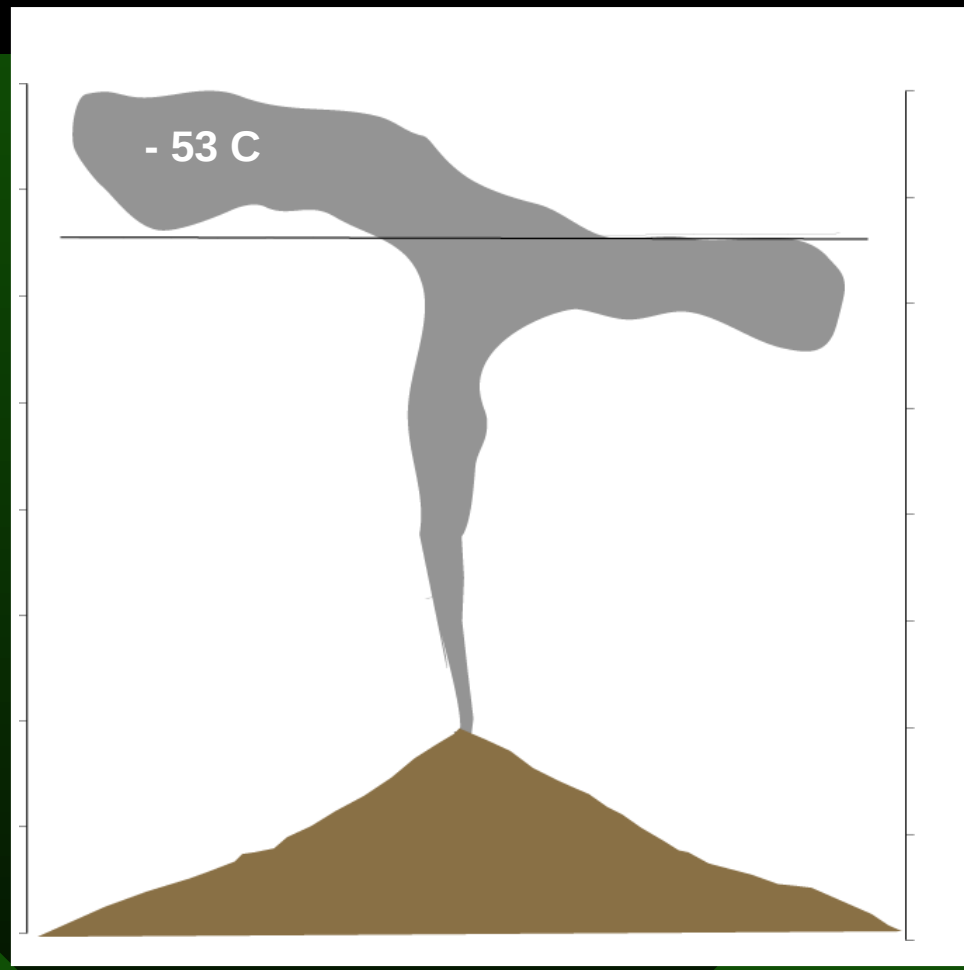
Aircraft near San Francisco (4,000 km away)

- Reports sulfur smell
- GOES data shows not likely
- Puff models says possible



Wind Shear at Cleveland Volcanic Cloud

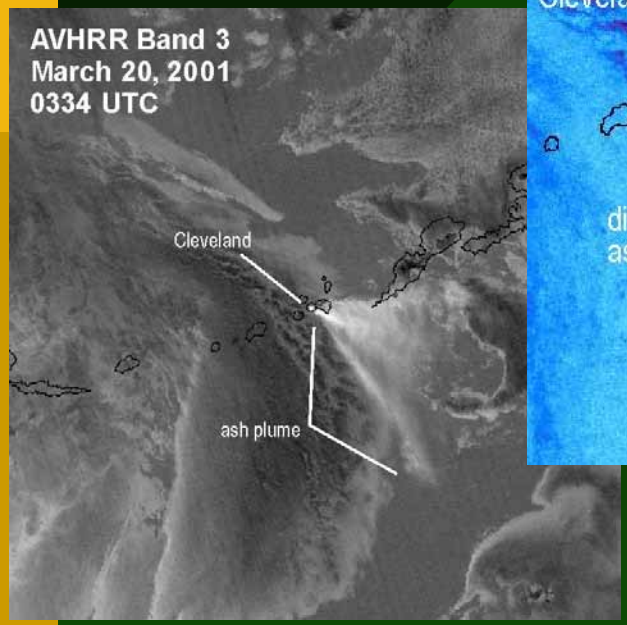


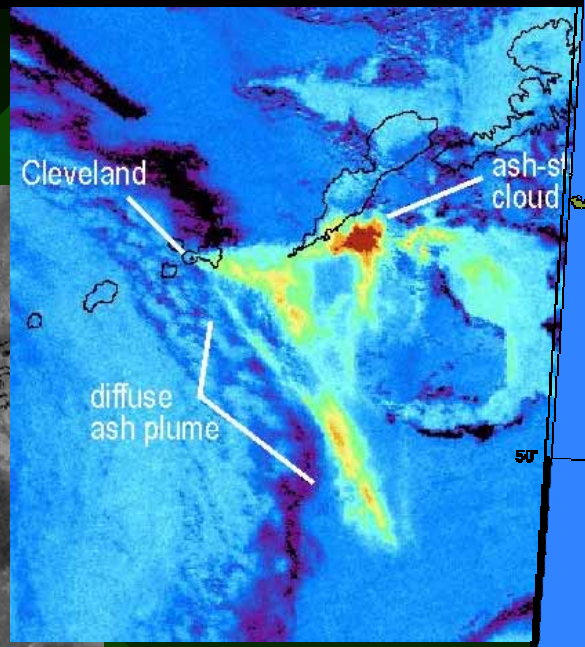


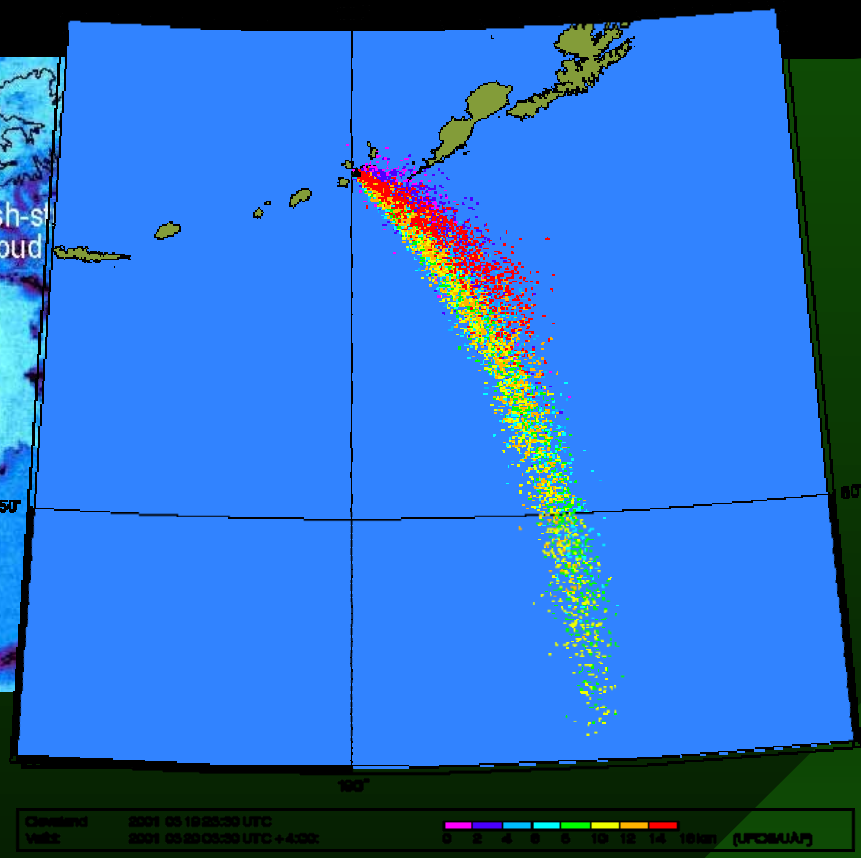
Initial AVO Observation (AVHRR):

- B4 shows opaque cloud blowing to NW
- Cloud temperature –53 C = 8km altitude
- B4m5 shows ash-rich cloud blowing to SE
- Puff model shows winds shear at 6 - 7 km

Errors on wind field models lead to Puff errors

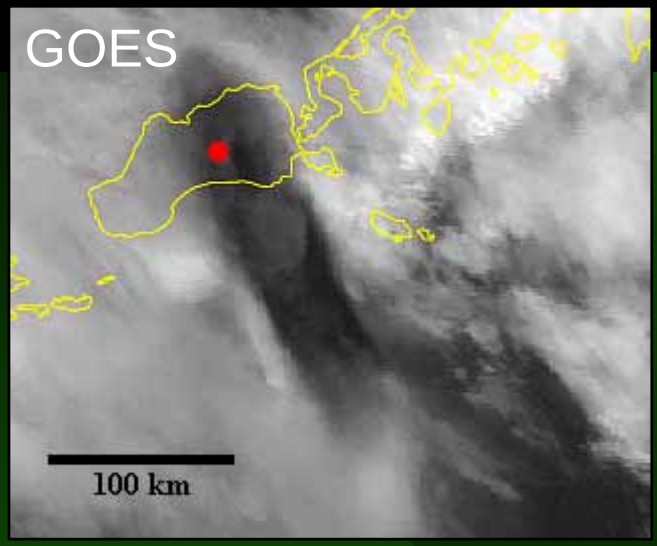


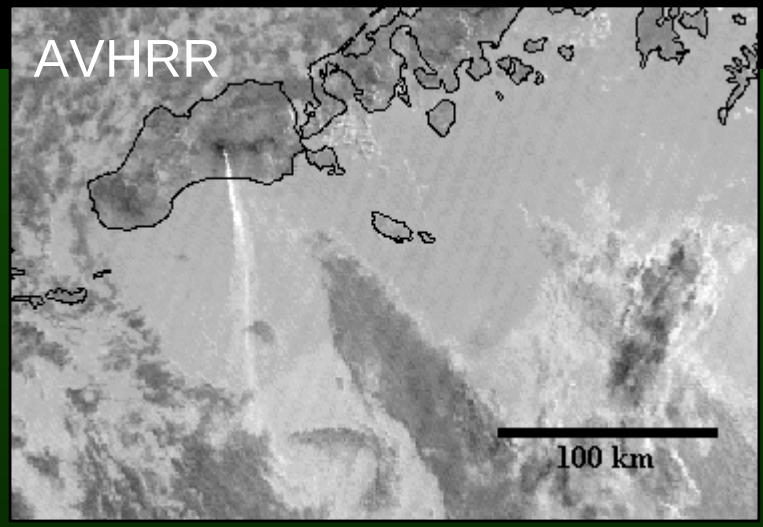


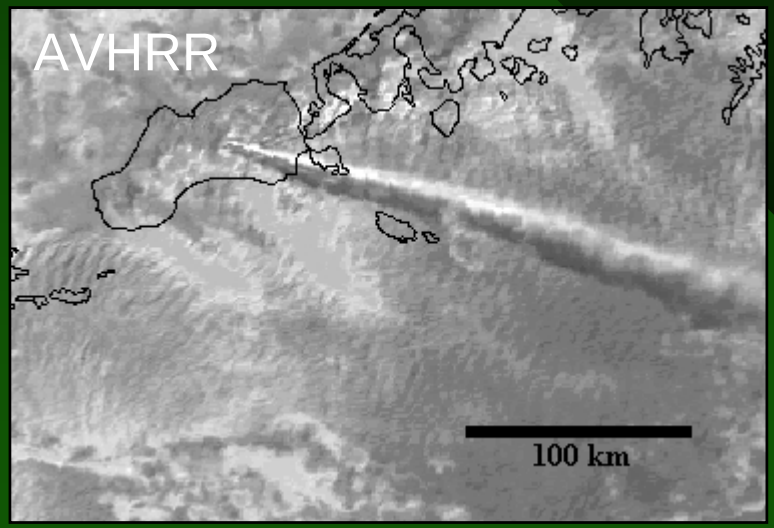


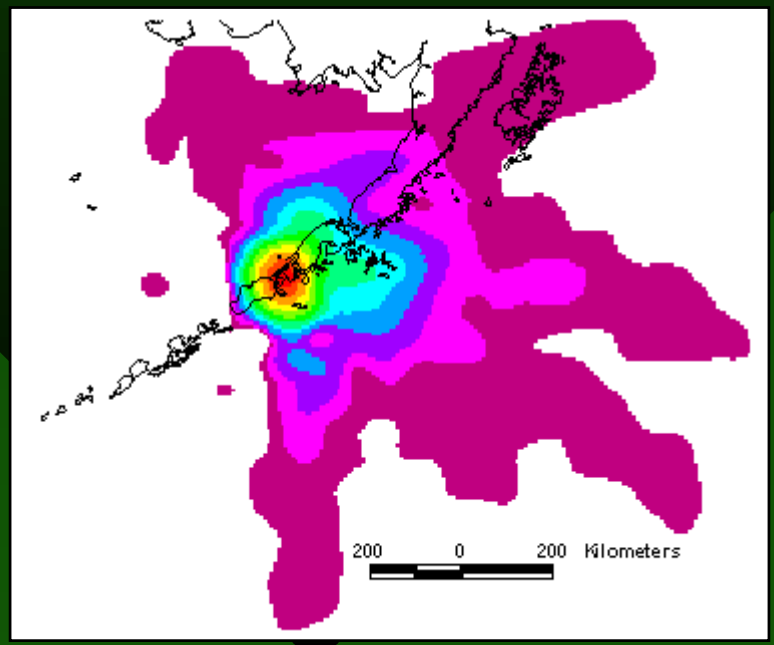
1. Wind field errors produce inaccurate Puff runs.
2. Satellite data needed to validate model
3. 19 March 2001 Cleveland eruption Puff did not predict the east drifting portion of the plume seen on satellite data.

Airborne Hazard Map of Shishaldin Volcano
Based on Puff simulations run daily using 1 year of data

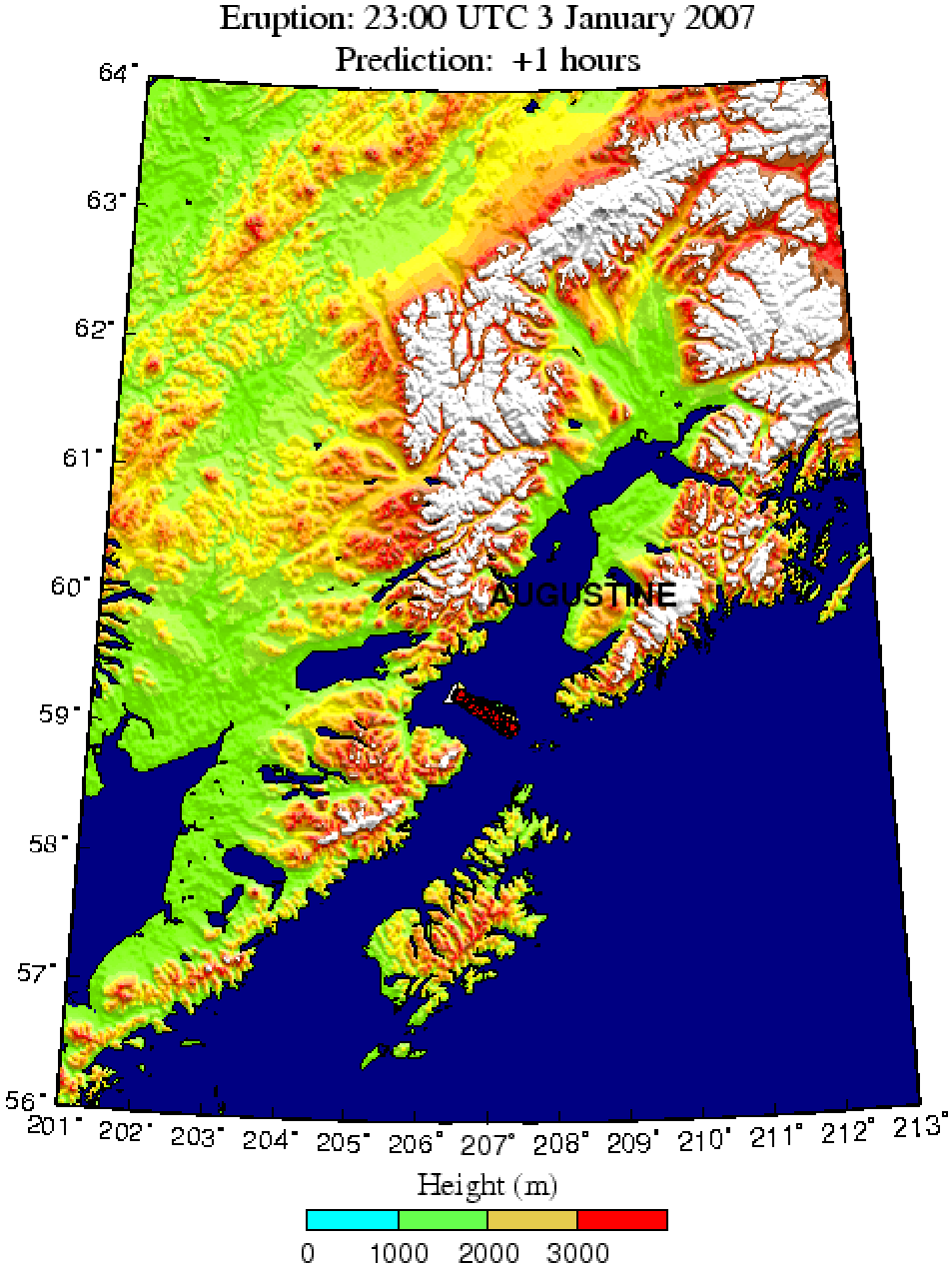


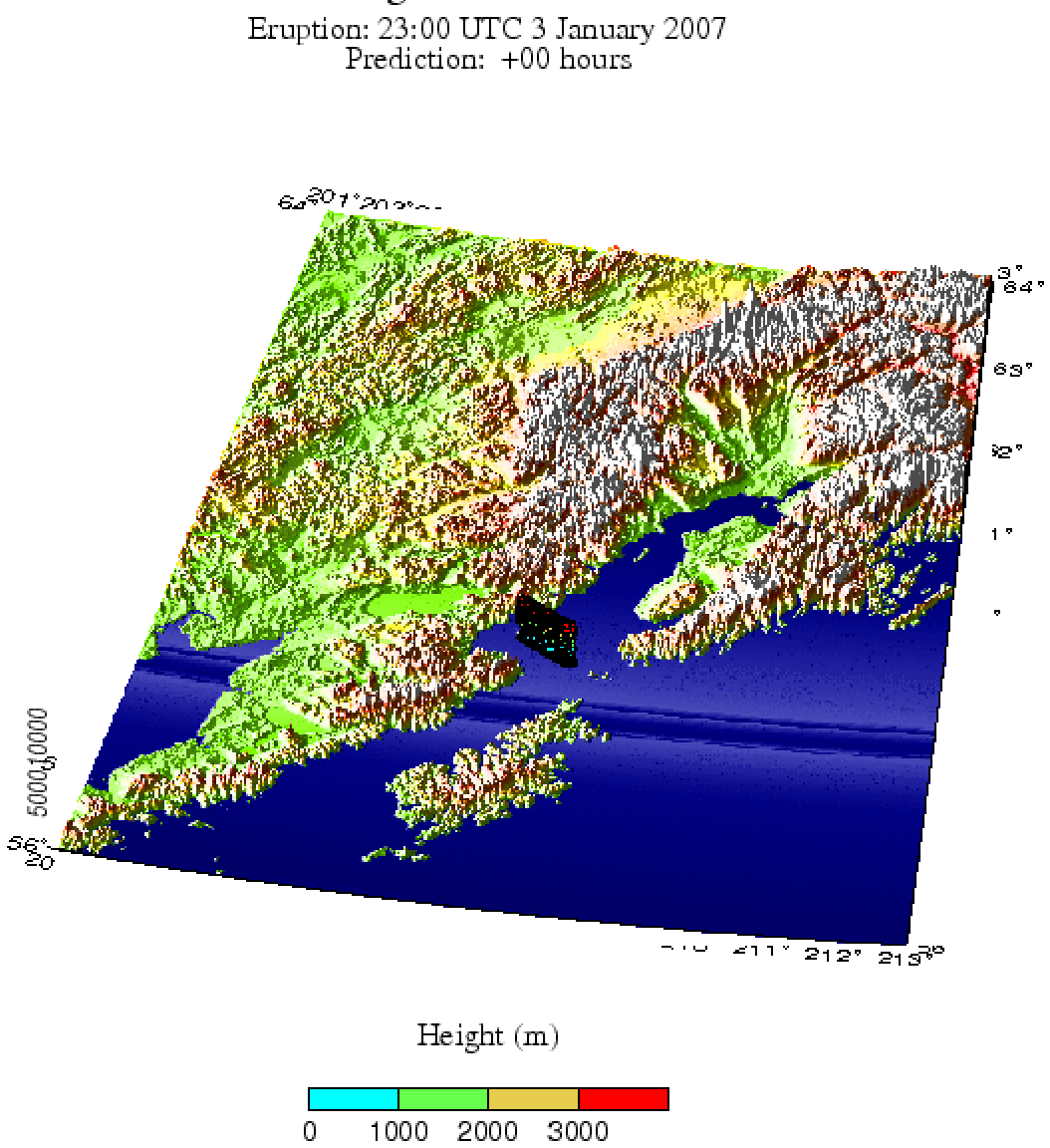






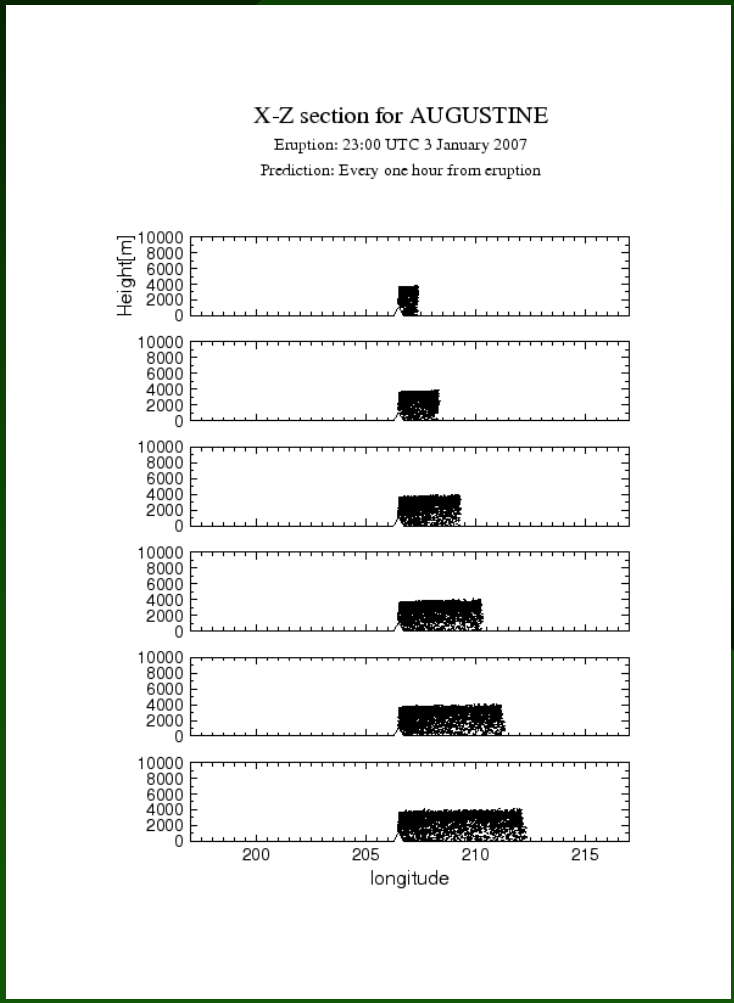
AUGUSTINE

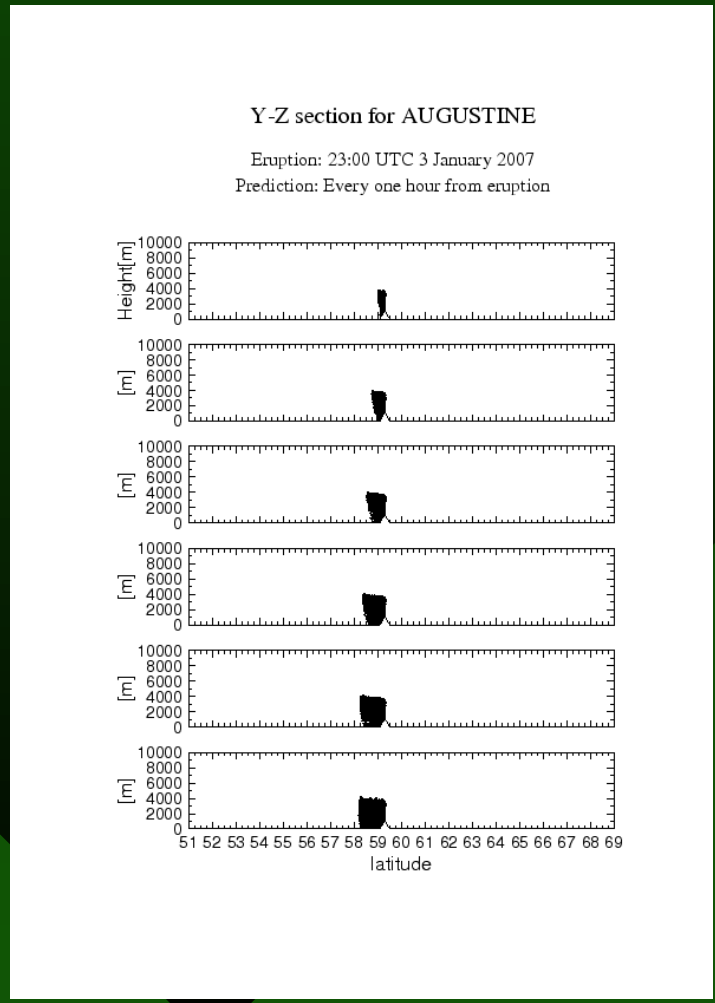

Eruption: 23:00 UTC 3 January 2007
Prediction: +1 hours
64°
63°
62°
61°
60°
59°
58°
57°
56°
AUGUSTINE
201° 202° 203° 204° 205° 206° 207° 208° 209° 210° 211° 212° 213°
Height (m)
0 1000 2000 3000



Realtime prediction in on the Internet

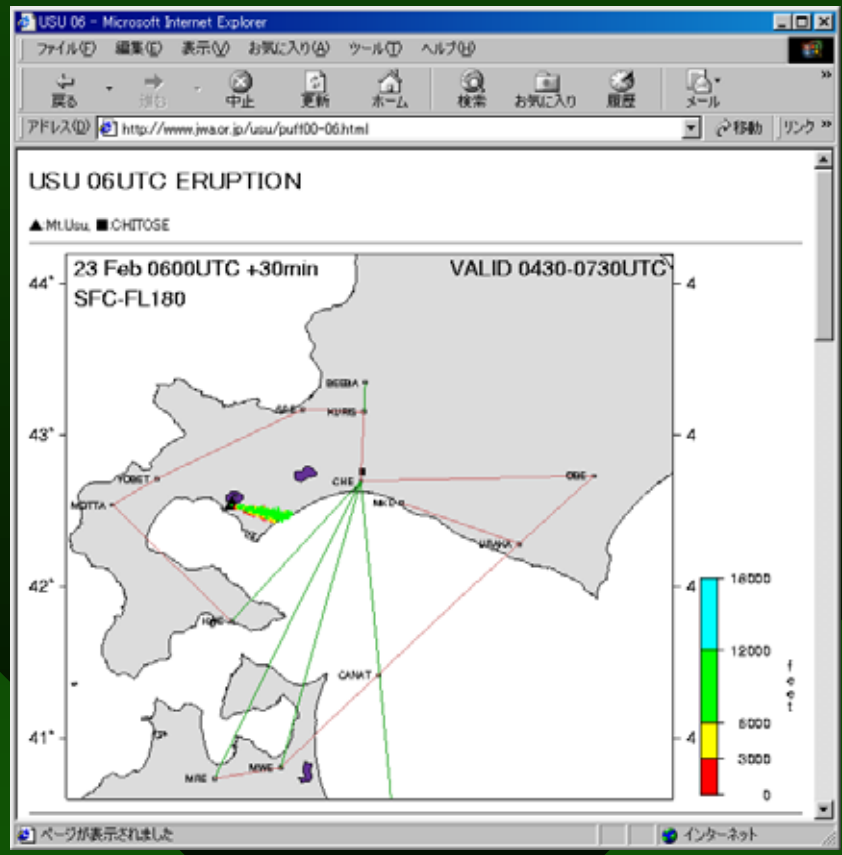
Vertical sections (x-z) and (y-z)





Demonstration of the PUFF model rediction for Usu volcano in February 2000

- Sakura-jima
- Asama-yama
- Usu volcano
- Miyake-jima



Usu volcano hypothetical eruption

Eruption: 23 Feb. 2001 , 0600UTC

Plume height: 12,000 feet

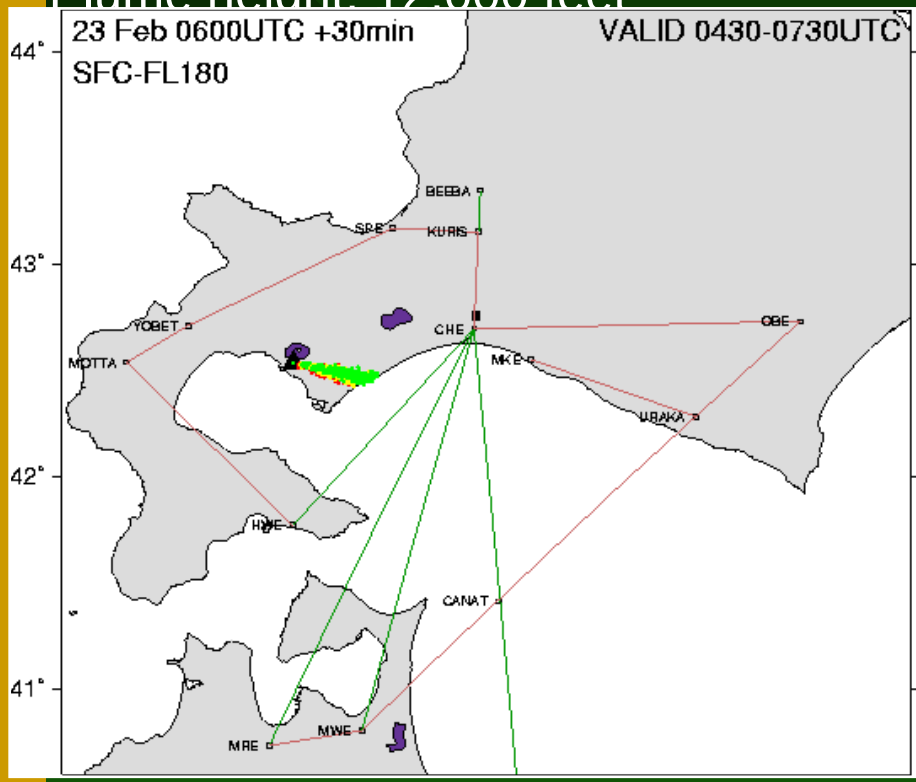


Fig.1 30min. After the eruption

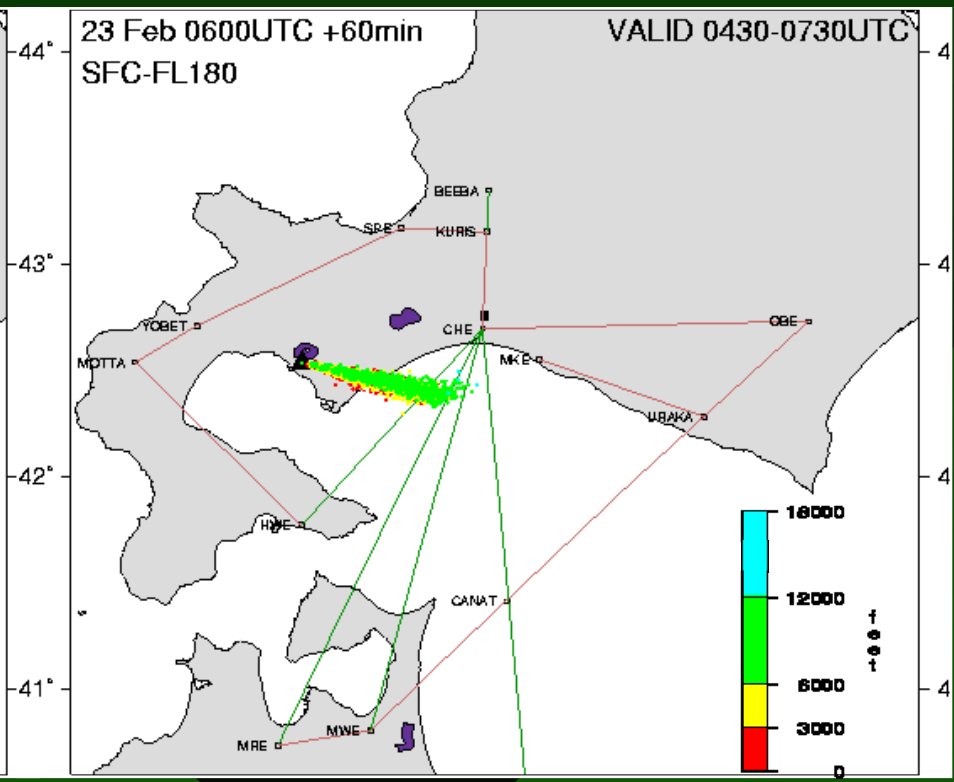


Fig.2 60min. After the eruption

Usu volcano hypothetical eruption

Eruption: 27 Apr. 2000 , 2100UTC

Plume height: 10,000 feet

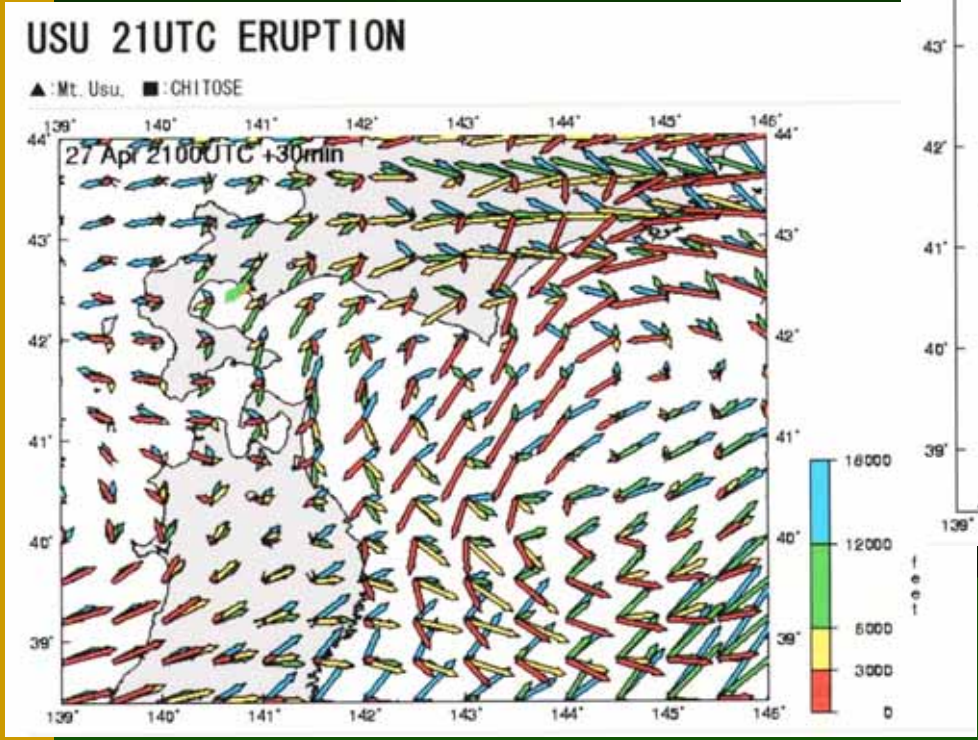


Fig.1 30min. After the eruption

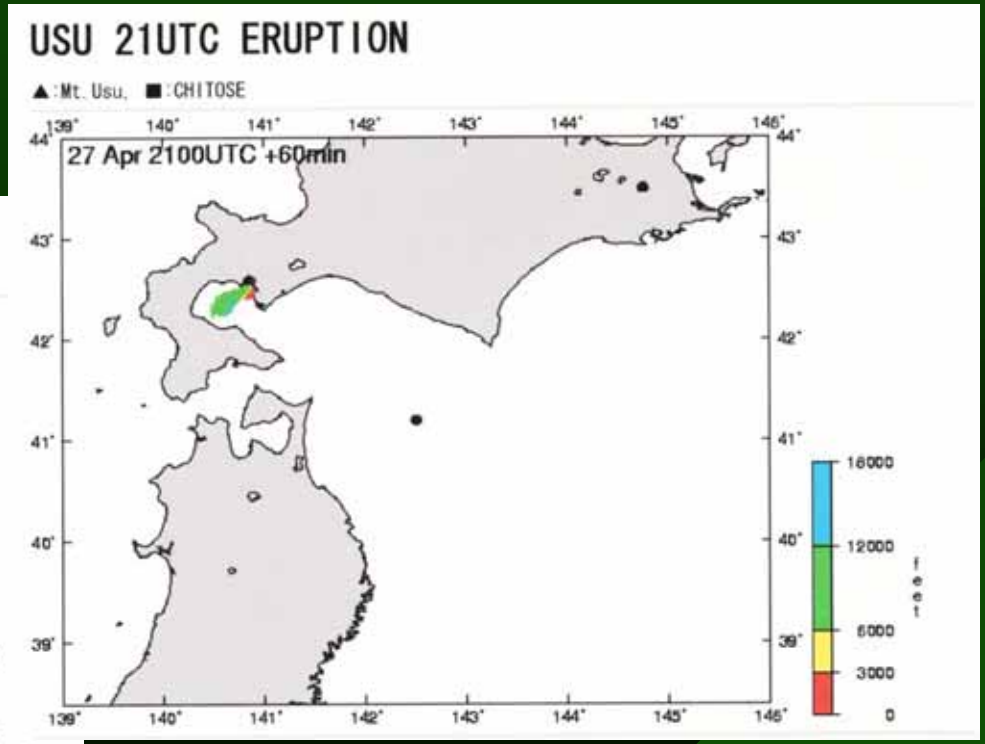


Fig.2 2hr. After the eruption

Miyake-jima eruption compared with image

Eruption: 09 Aug. 2000 , 2100UTC

Plume height: 10,000 feet

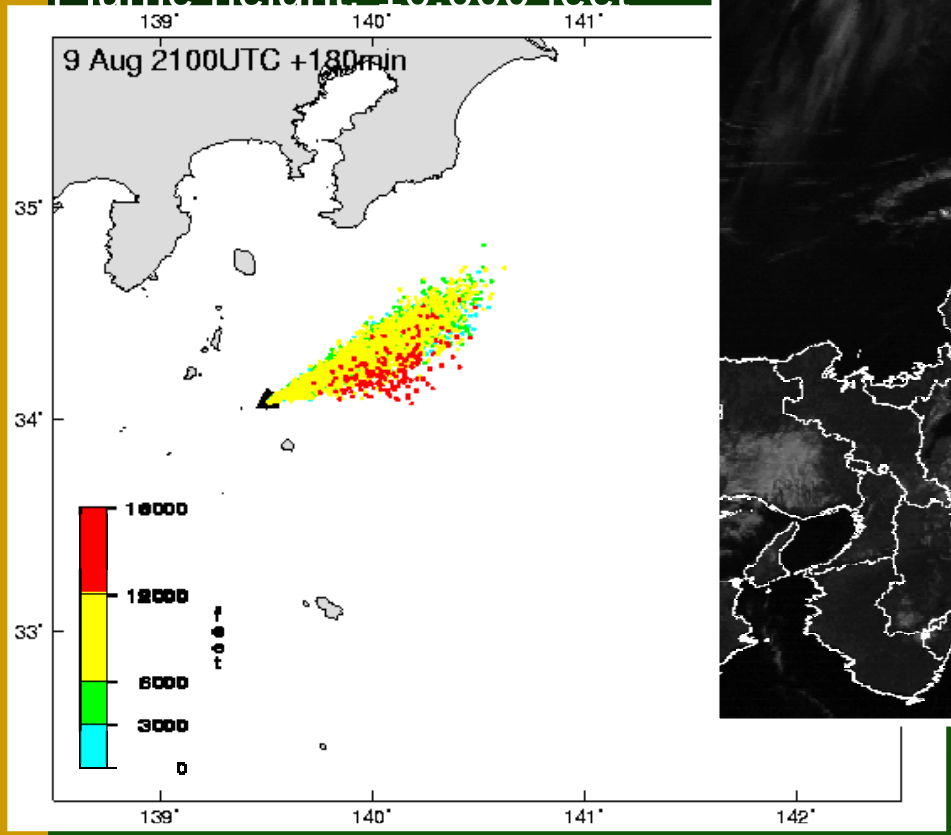


Fig.1 Prediction: 10 Aug. 2000, 0000UTC

Real Eruption:

09 Aug. 2000 , 2159UTC

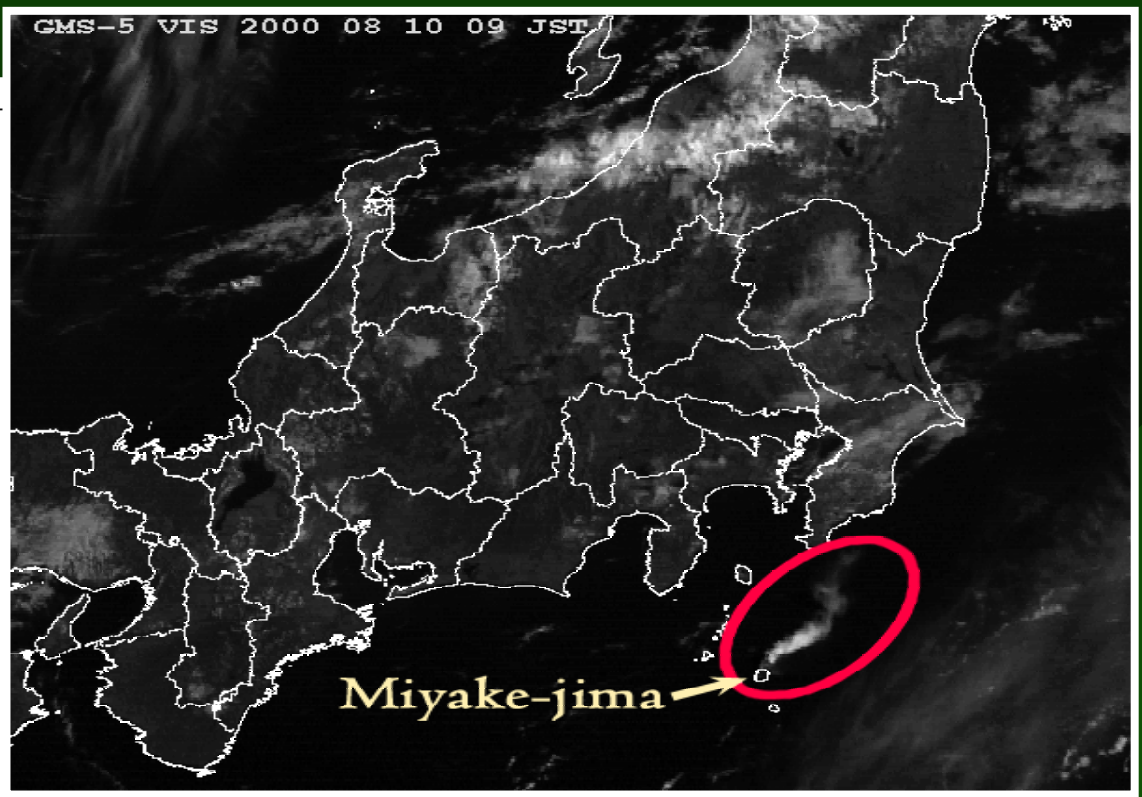
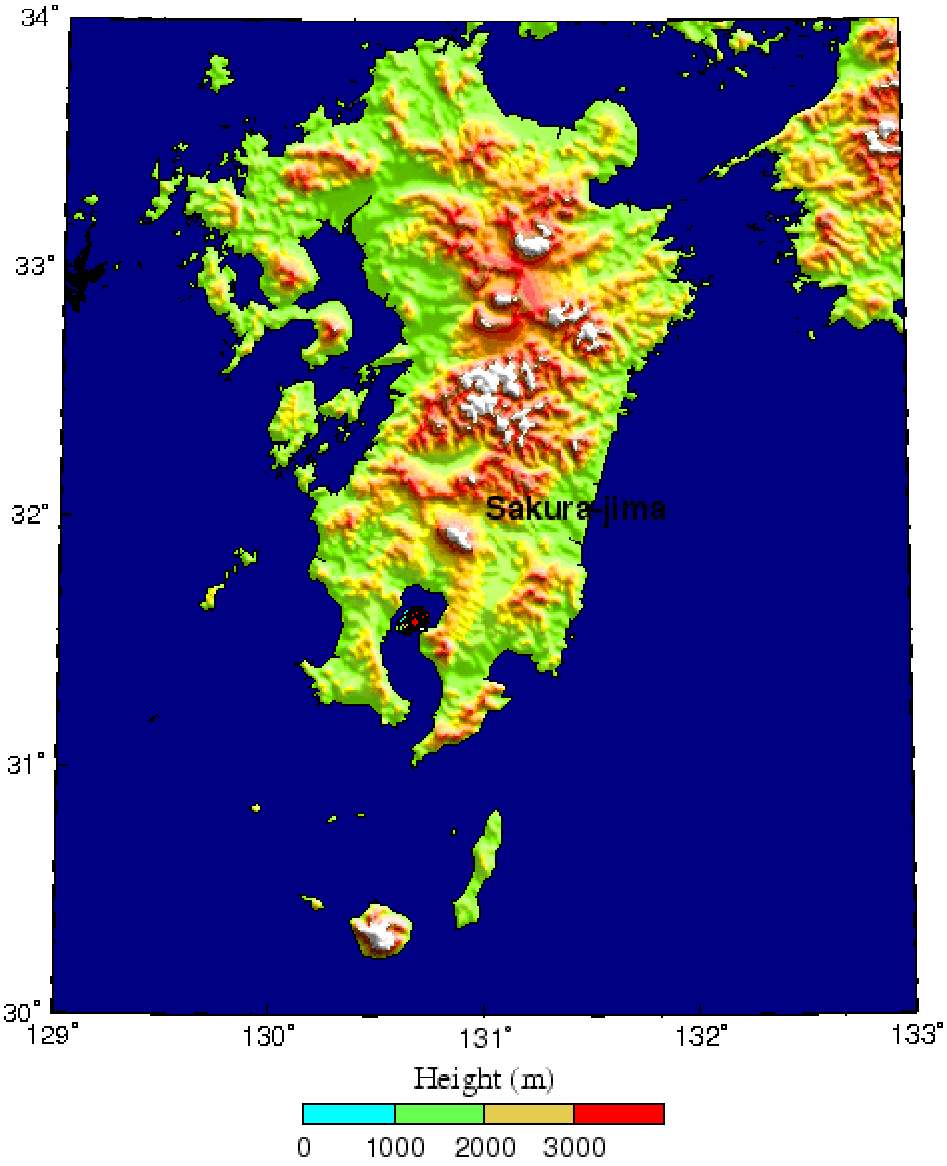


Fig.2 satellite image: 10 Aug. 2000, 0000UTC

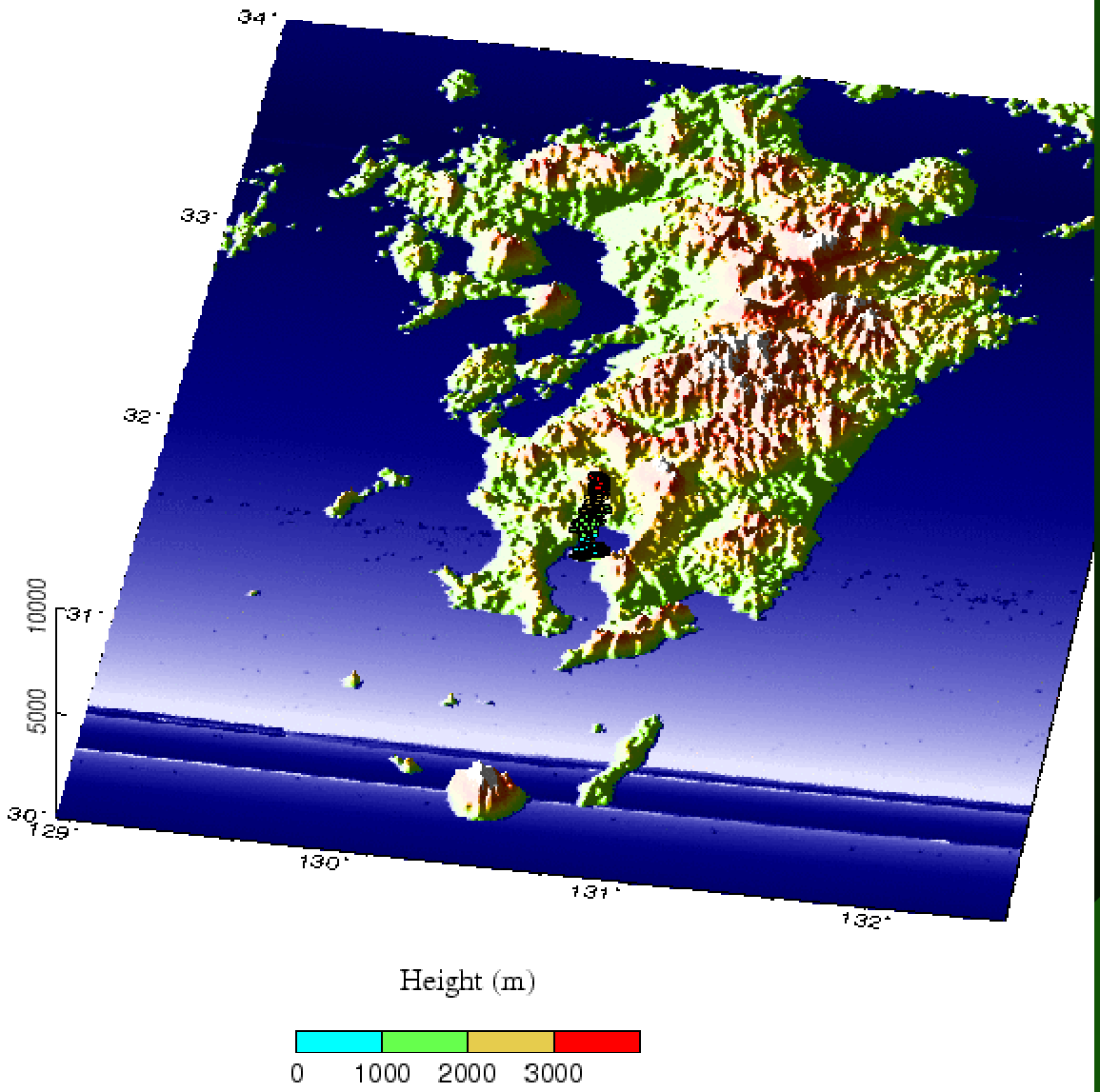
Sakura-jima

Eruption: 22:00 UTC 3 January 2007
Prediction: +1 hours

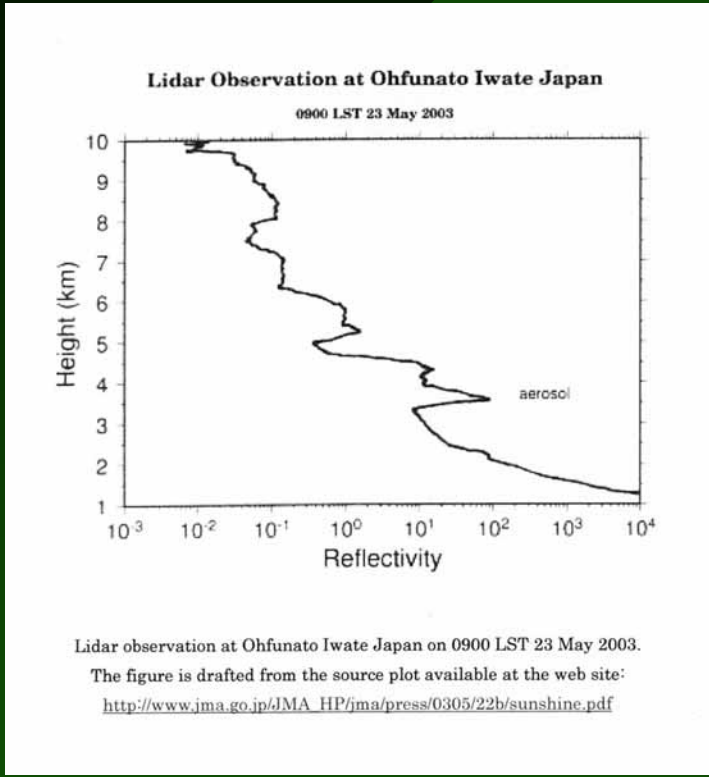


3-D image for Sakura-jima

Eruption: 22:00 UTC 3 January 2007
Prediction: +00 hours



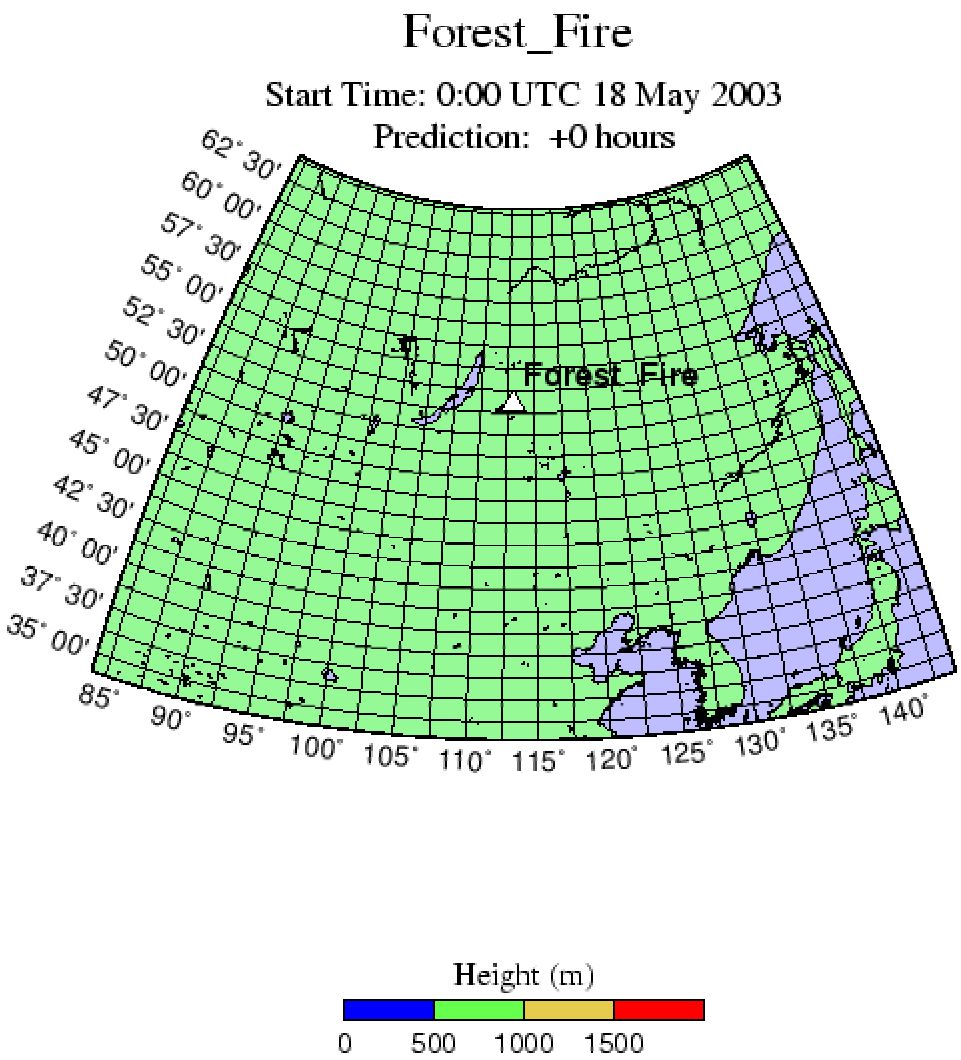
Application to Wildfire Smoke

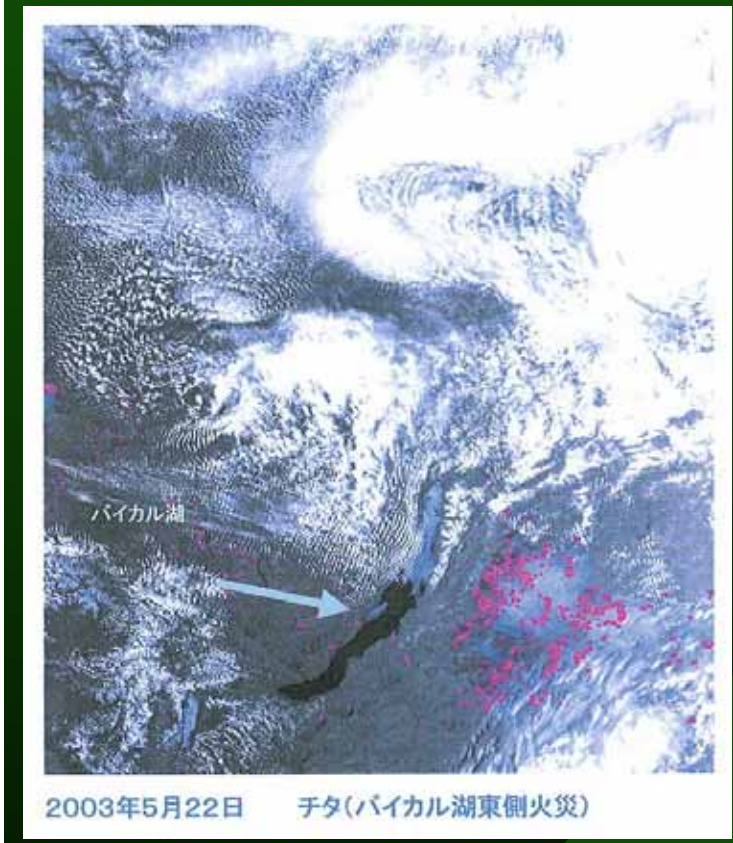


Lidar observation at Ohfunato Iwate Japan on 0900 LST 23 May 2003.
The figure is drafted from the source plot available at the web site:
http://www.jma.go.jp/JMA_HP/jma/press/0305/22b/sunshine.pdf

A red sun observed at Sapporo on 23 May 2003 was speculated to have been caused by wildfire in Siberia, but who knows the truth.

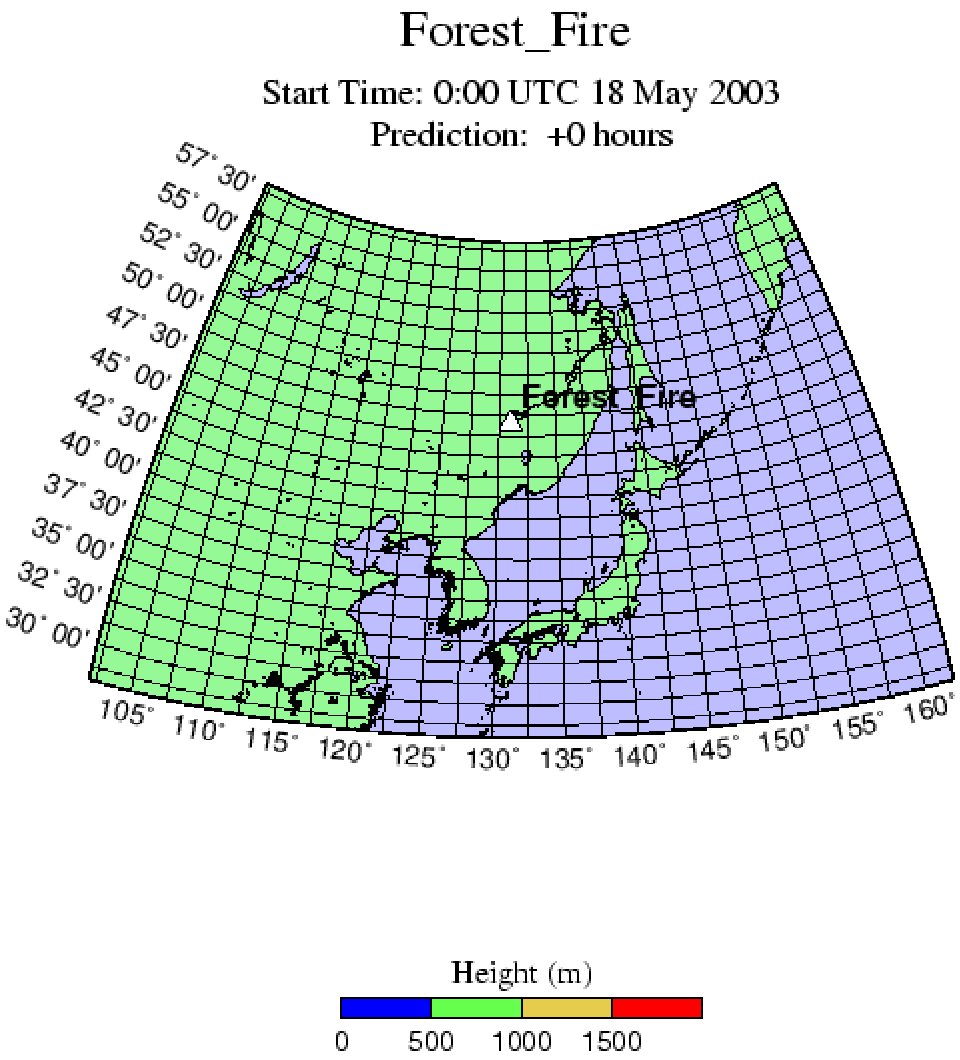
A report of wildfire near the Lake Bykal





We found it’s not from the Lake Bykal

The smoke came from the Lake Khanka

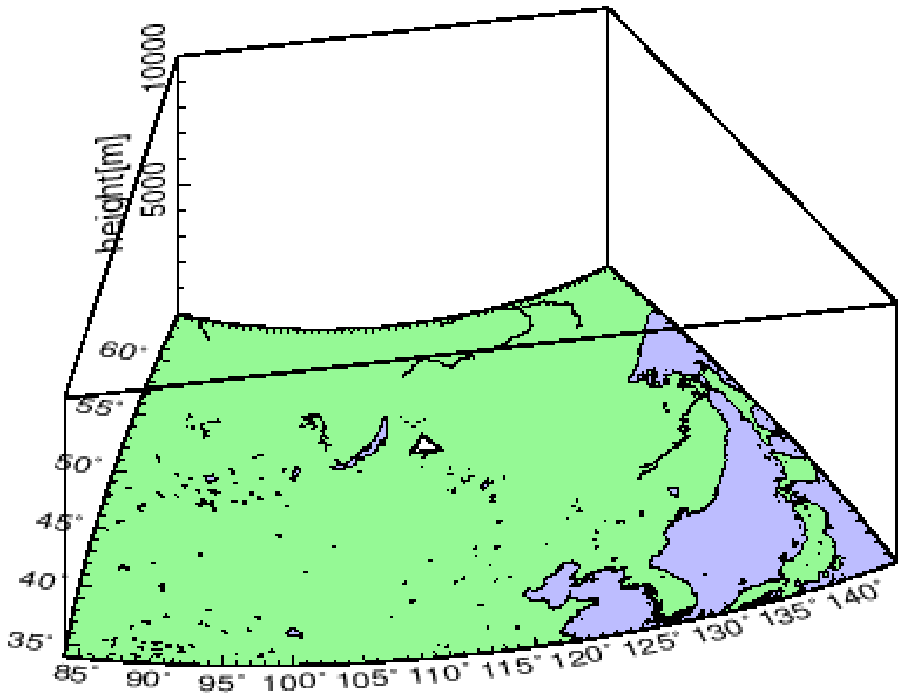


PUFF model is useful for the wildfire

3-D image for Forest_Fire

Start time: 0:00 UTC 18 May 2003

Prediction: +0 hours

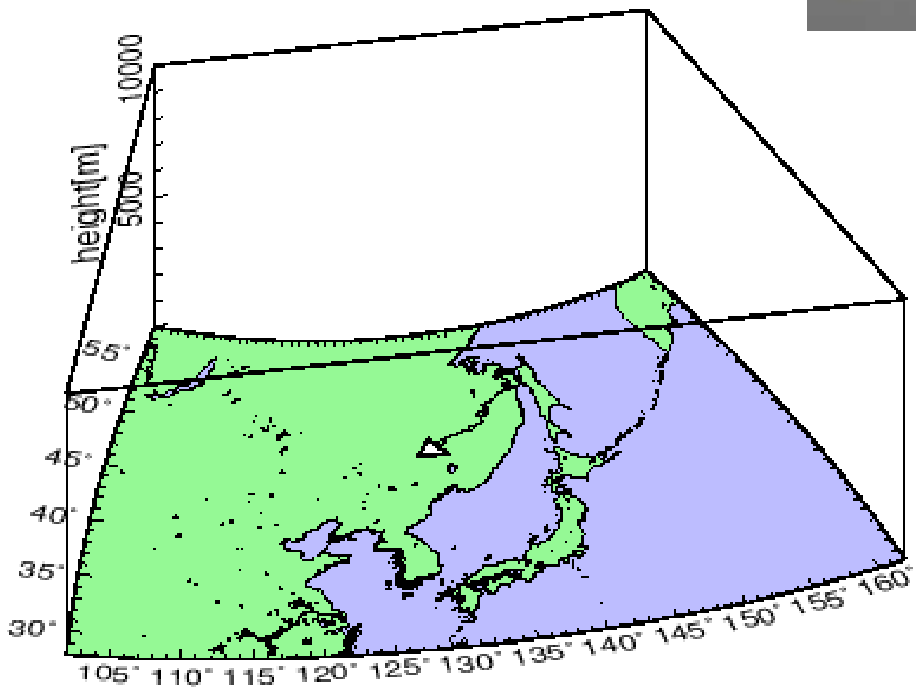


Height

3-D image for Forest_Fire

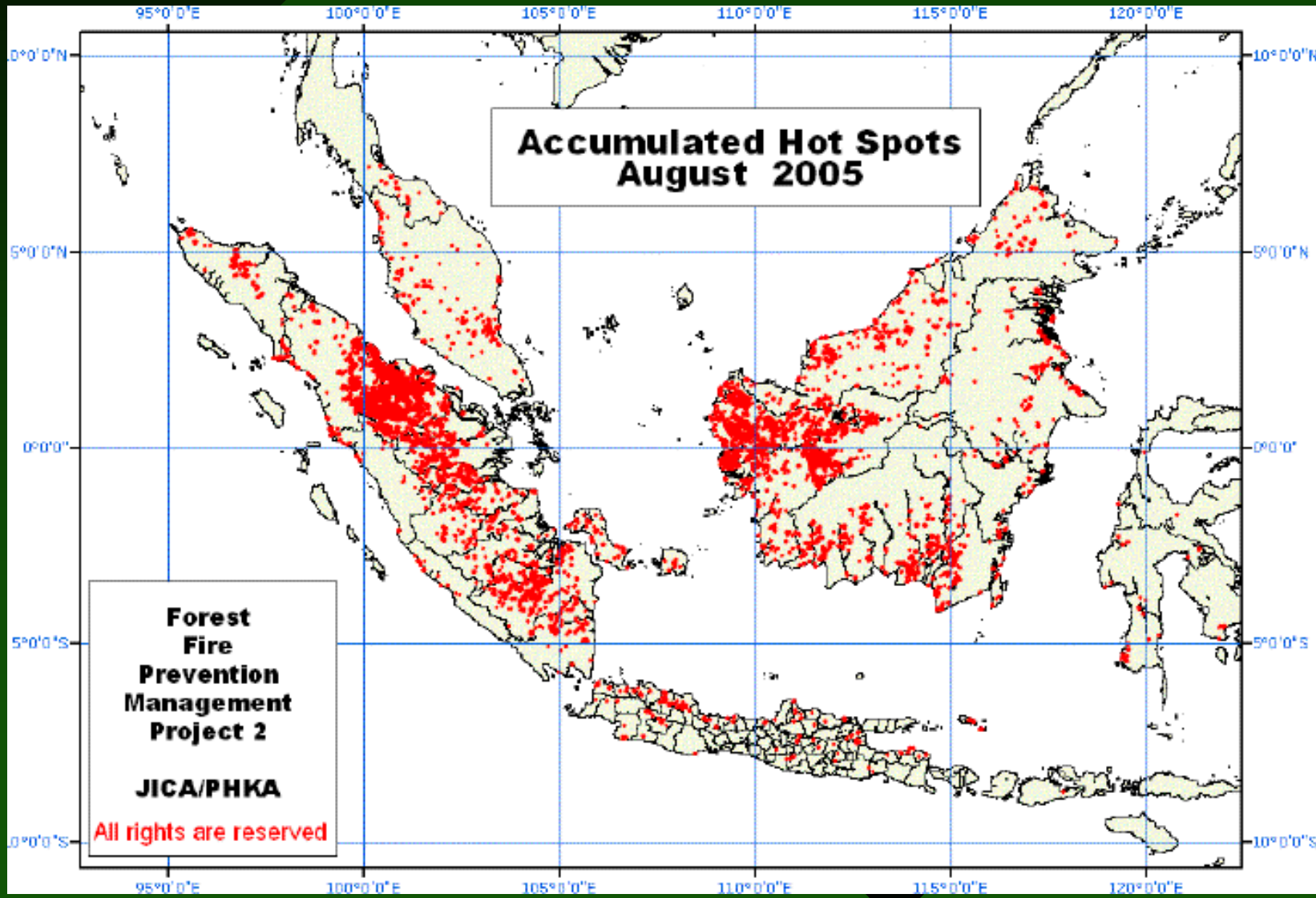
Start time: 0:00 UTC 18 May 2003

Prediction: +0 hours



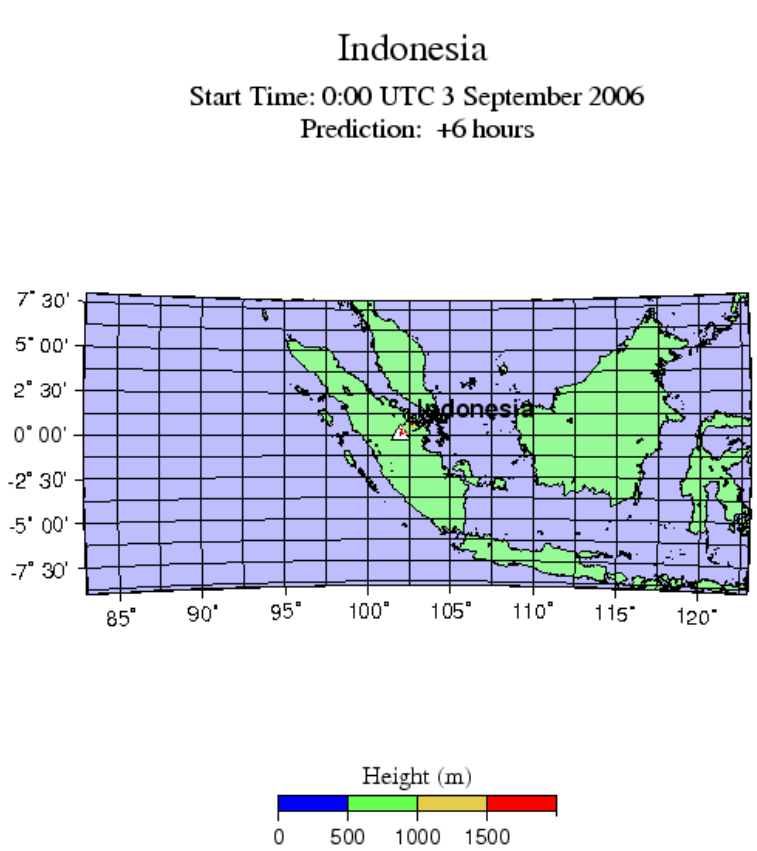
Height

Wildfires in Indonesia



2005・176

(By Hayasaka)

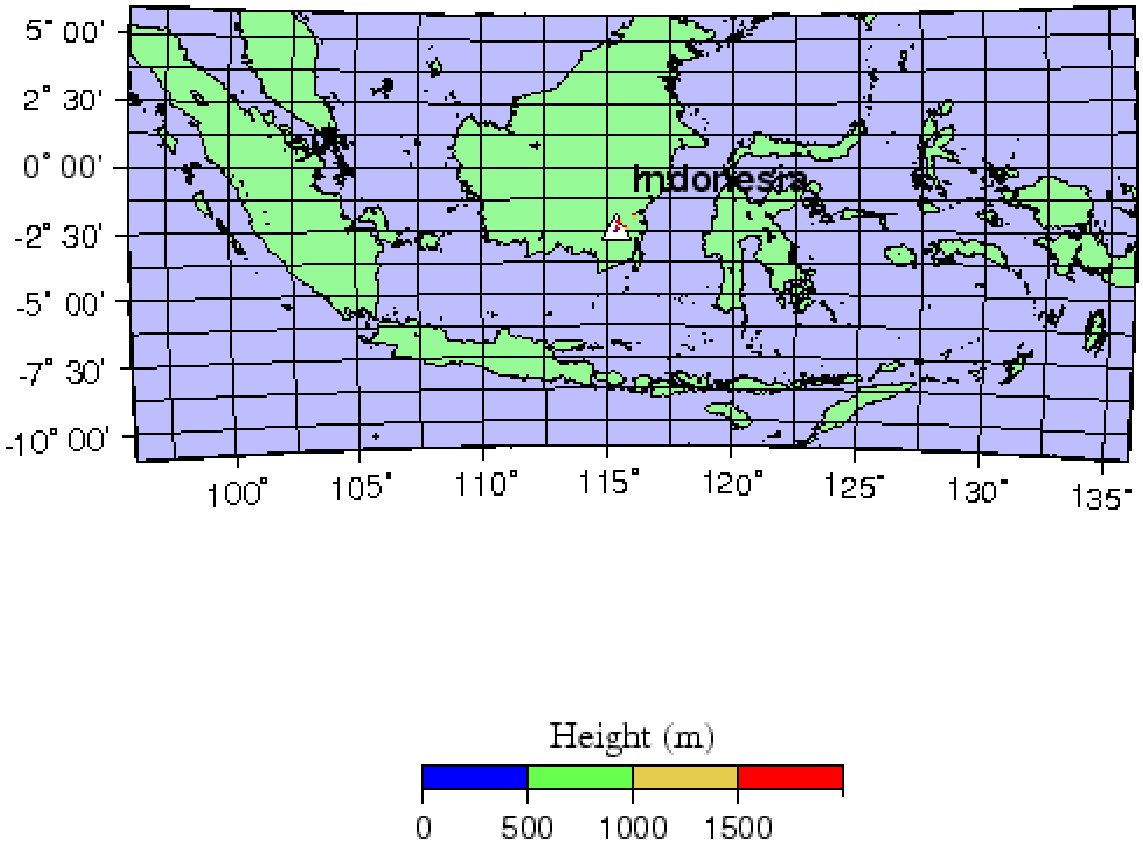


2006・10・7

(By Hayasaka)

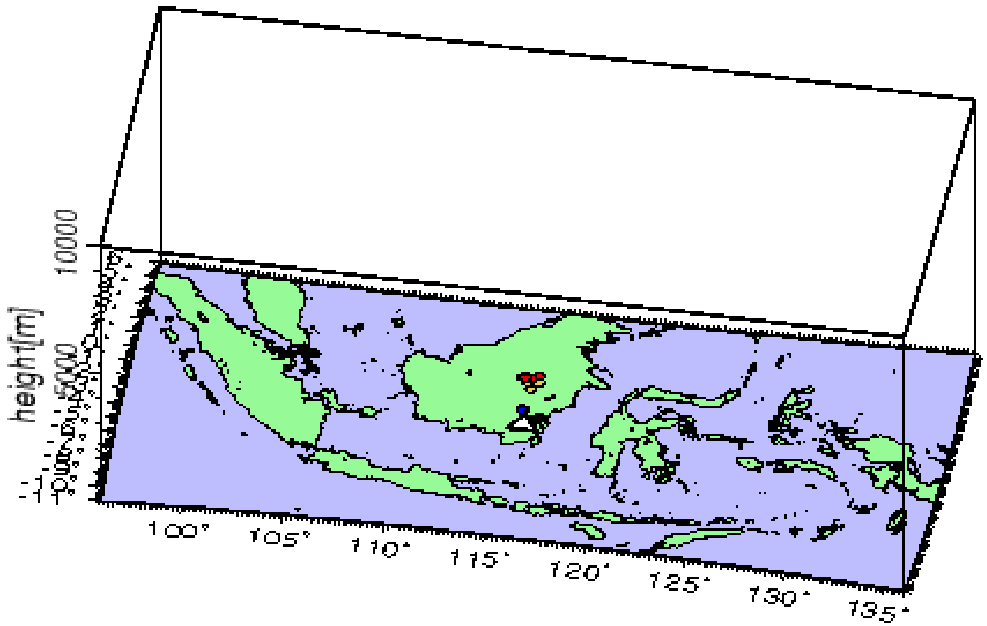
Indonesia

Start Time: 0:00 UTC 6 October 2006
Prediction: +6 hours

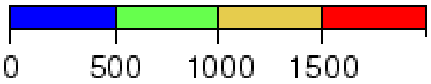


3-D image for Indonesia

Start time: 0:00 UTC 6 October 2006
Prediction: +6 hours

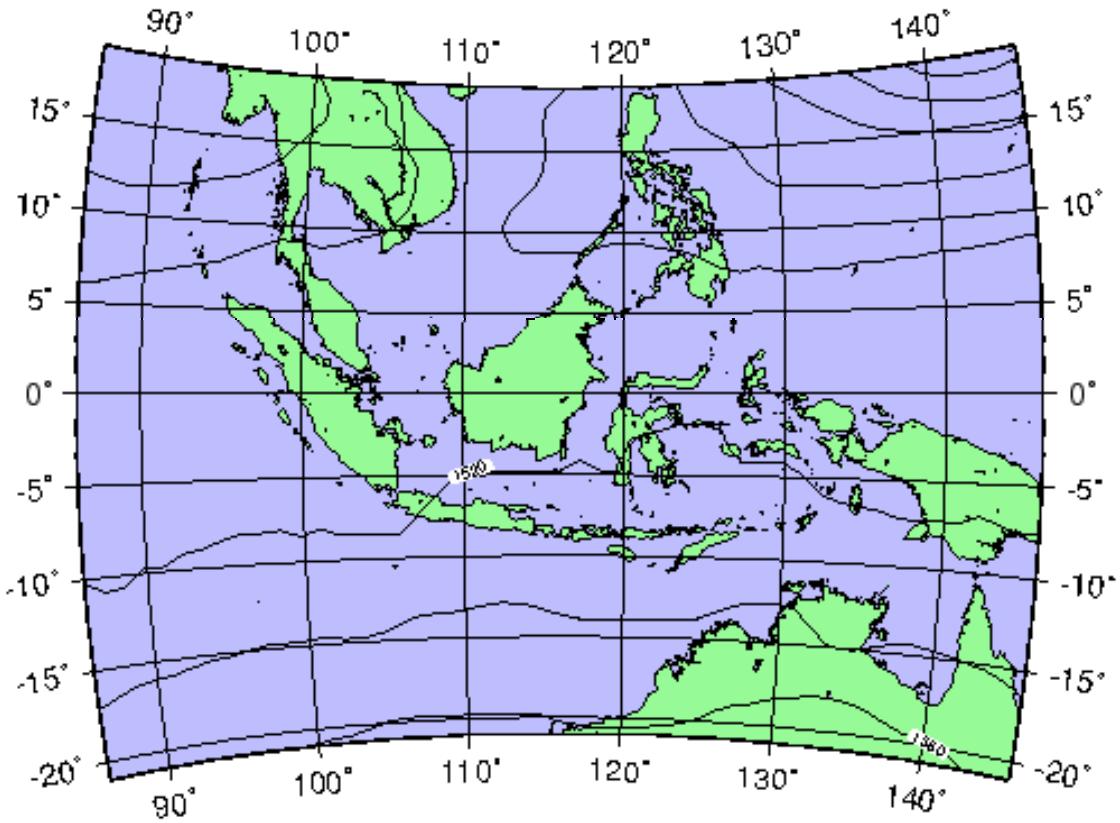


Height



850 hPa Height

GPV/JMA 200627900



Accurate wind data is essential

Conclusions

1. Puff model may provide information on the relative distribution airborne particles observed on satellite images.

2. Puff predicts the movement of volcanic ash and aerosols, some of which are detected on satellite images.

3. The height of smoke can be estimated by comparing the morphology of simulations to observed on satellite.

4. Puff can predict the location of aerosols on satellite images so analysts can target that area for further processing.

5. Satellite data are critical to validating Puff models. Incorrect wind field will produce erroneous Puff simulations.

6. Airborne hazard maps can be generated by Puff using multiple years of wind field data.

Thanks