CIRA Support for High Latitude/Arctic Proving Ground

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Fairbanks and Anchorage, Alaska

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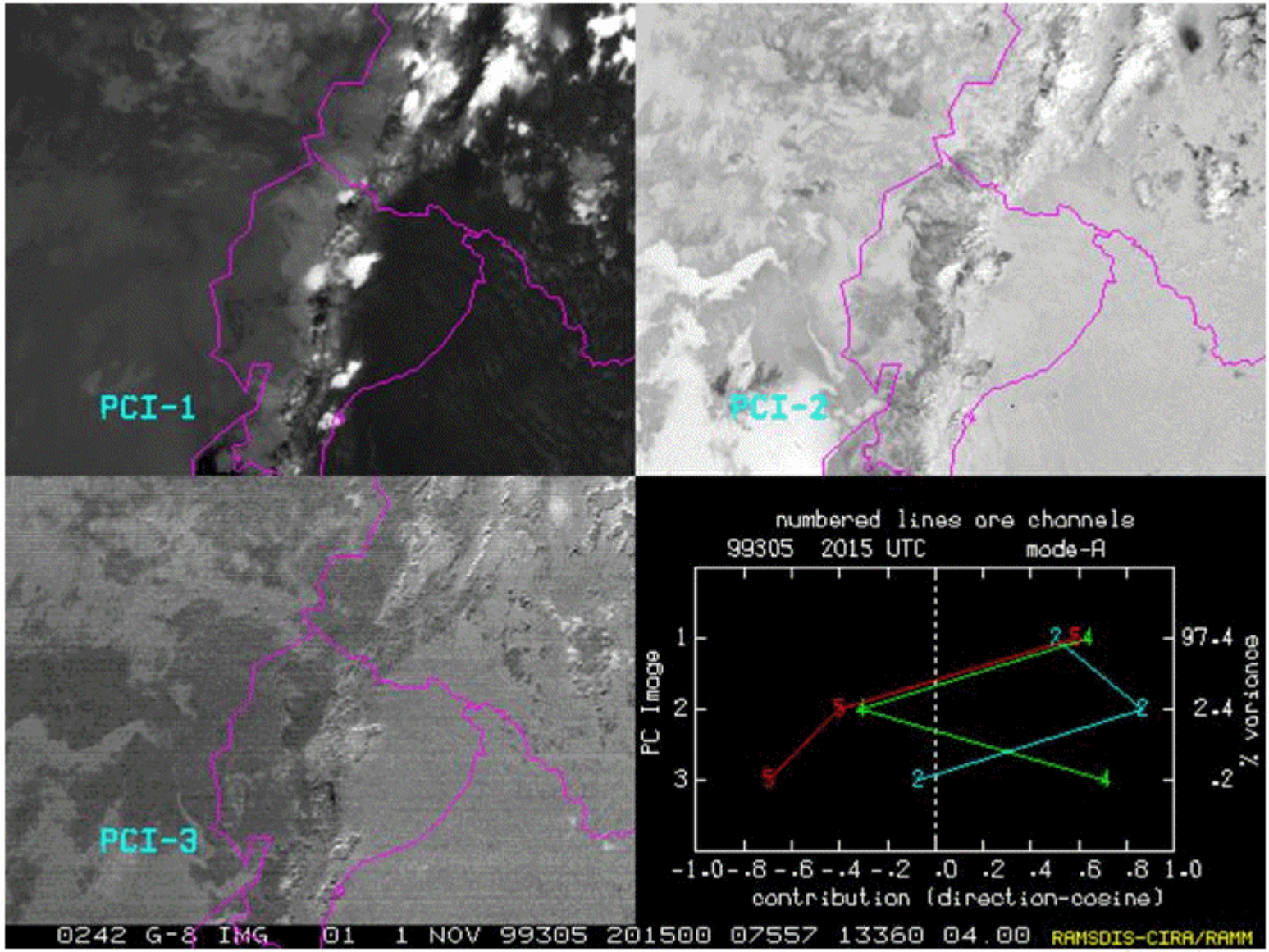
Outline

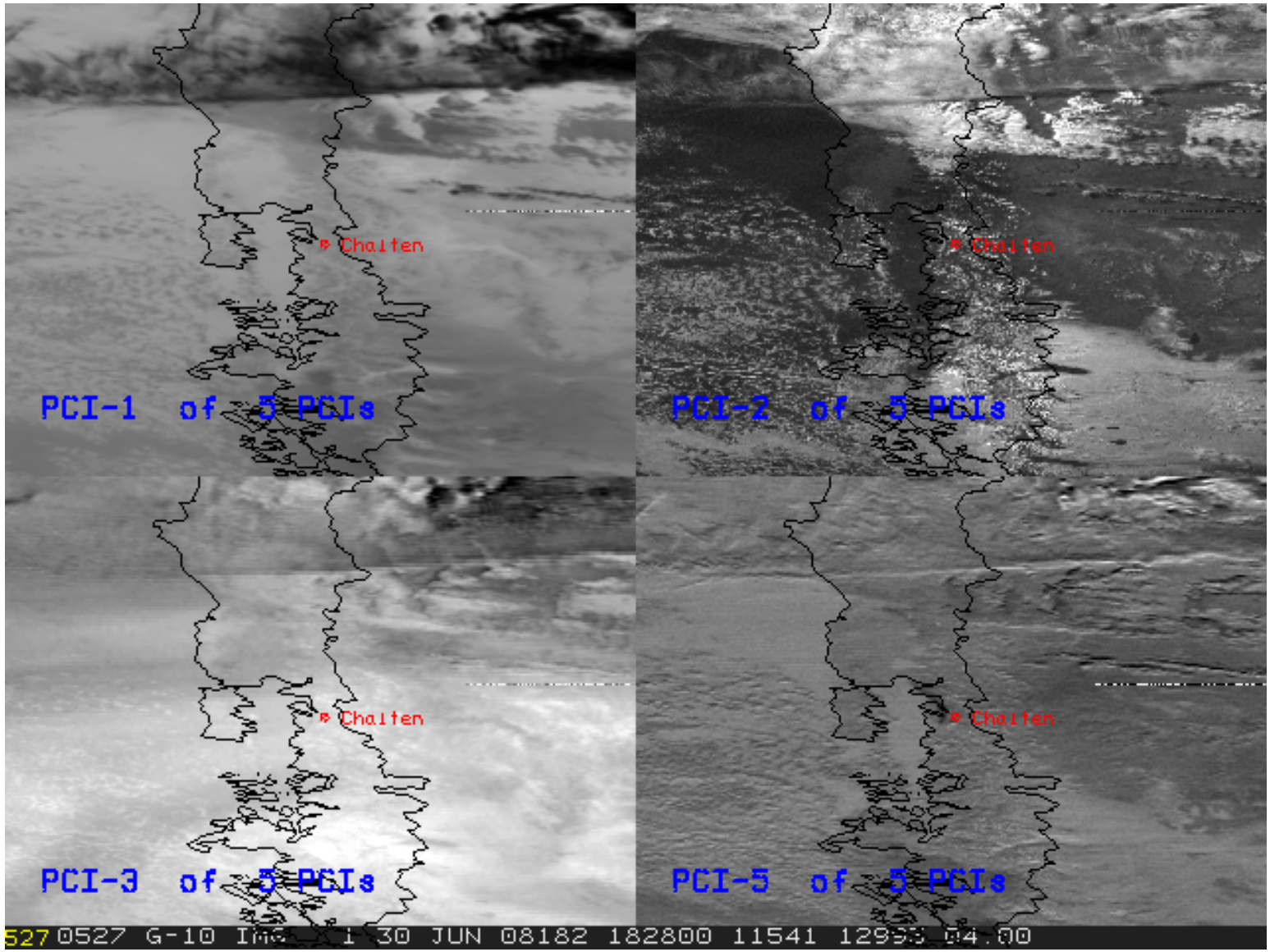
- Volcanic Ash Principal Component Imagery (PCI) applied to 5-band GOES Imager.
  - Started work with South American volcanoes for Washington VAAC
  - Continued with Aleutian/Alaska volcanoes
- Forward-model simulations of GOES-R ABI with smoke, and potentially volcanic ash
- Potential fog/stratus discrimination products for cold regions
- Additional PG products for detecting fires, snow cover, and low-light capabilities for observing aurora, low clouds, etc.

South American volcanoes



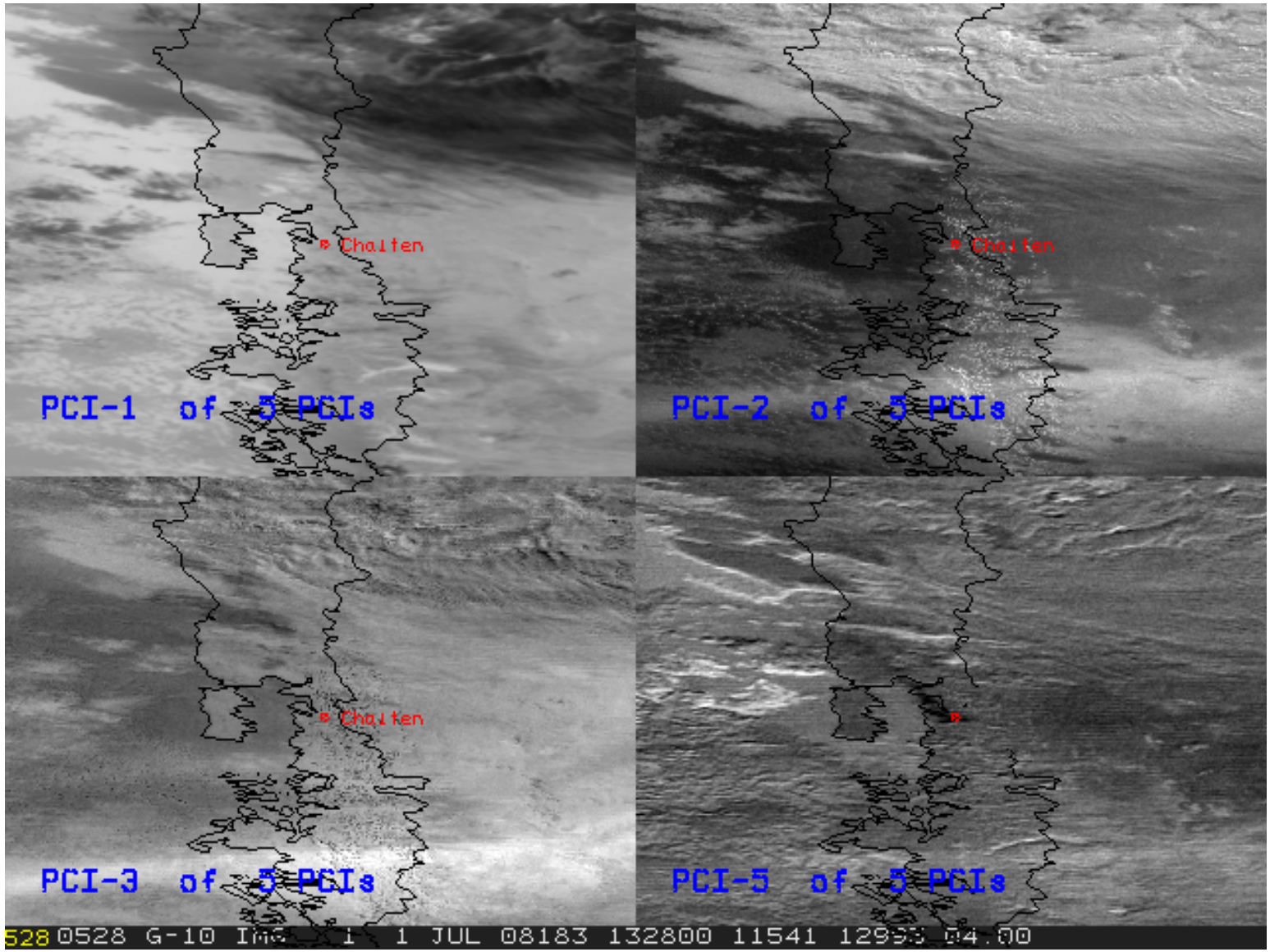
Analysis of Tungurahua volcano from 1999 for use by Washington VAAC

South American volcanoes



Analysis of Chaiten volcano from 2008 at high (southern) latitude

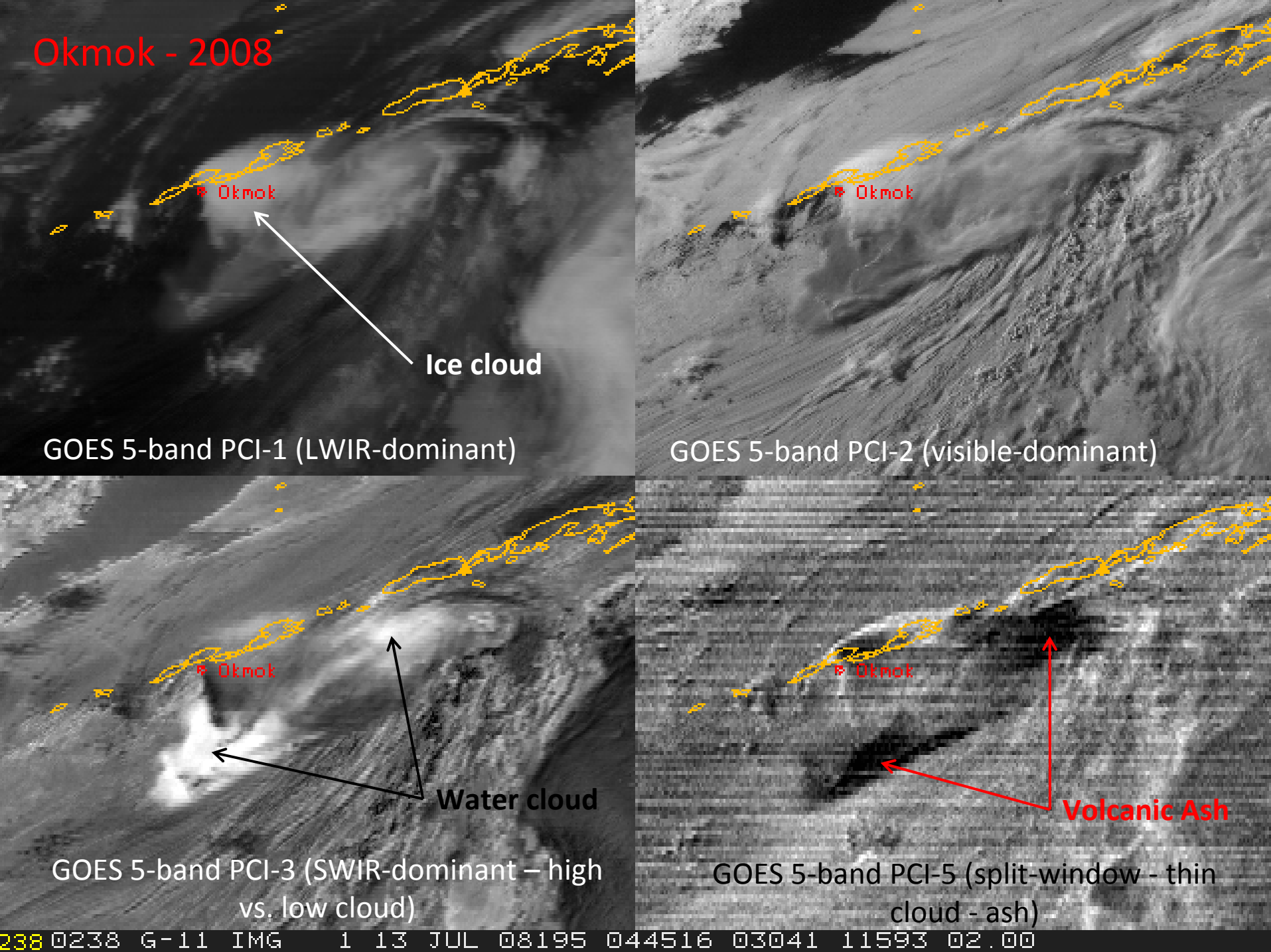
South American volcanoes



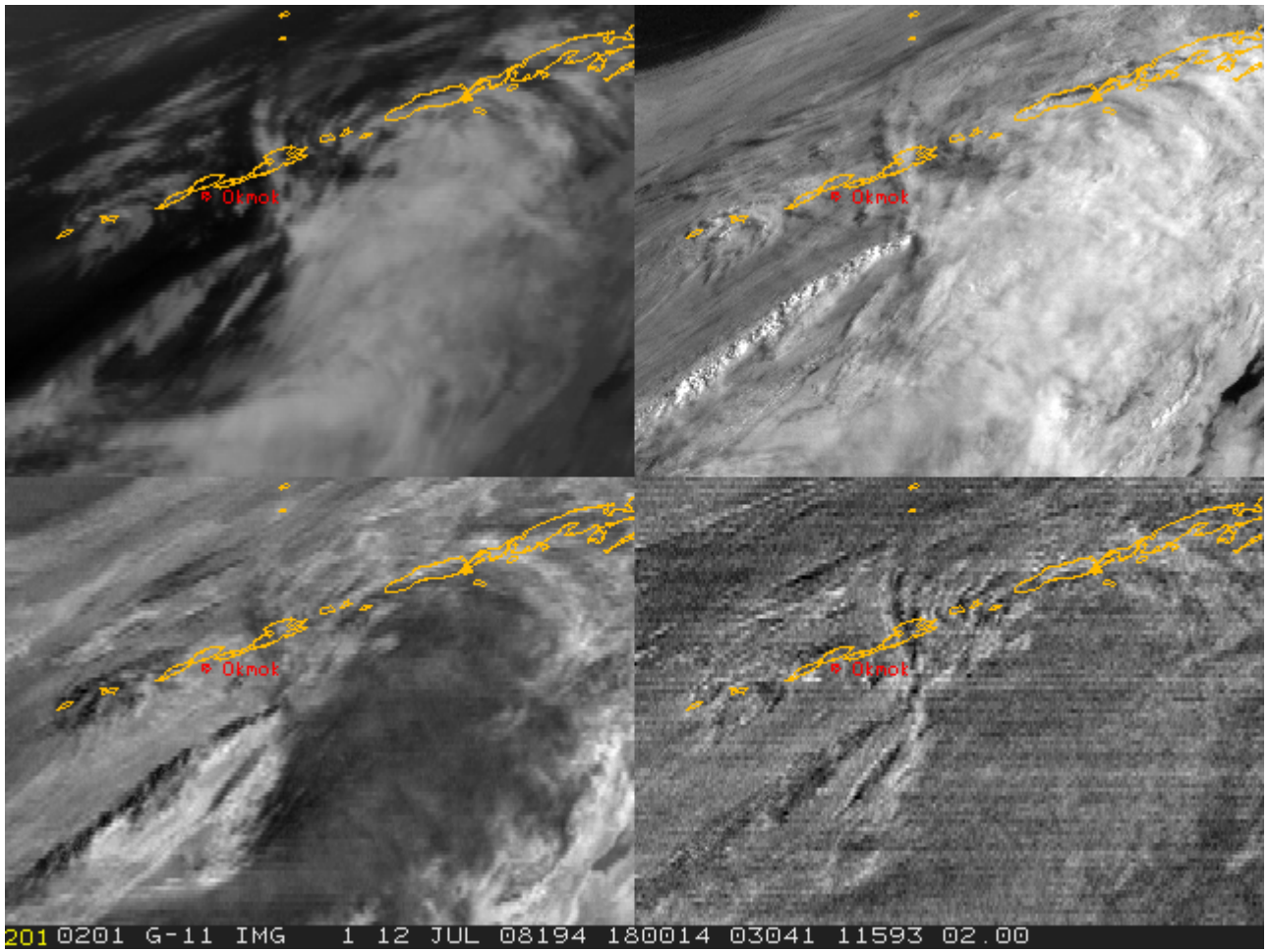
A second analysis of Chaiten volcano from 2008 at high (southern) latitude

Volcanic Ash Visualization

- Use of Principal Component Analysis (PCA) to create **Principal Component Imagery (PCI)**.
- Use **current GOES imagery** at 15 or 30 minute interval
- Best predictor is split window (11 minus 12 μm) difference.
- Develop visualizations for the PCIs:
  - 4-panel combinations
  - 3-color combinations

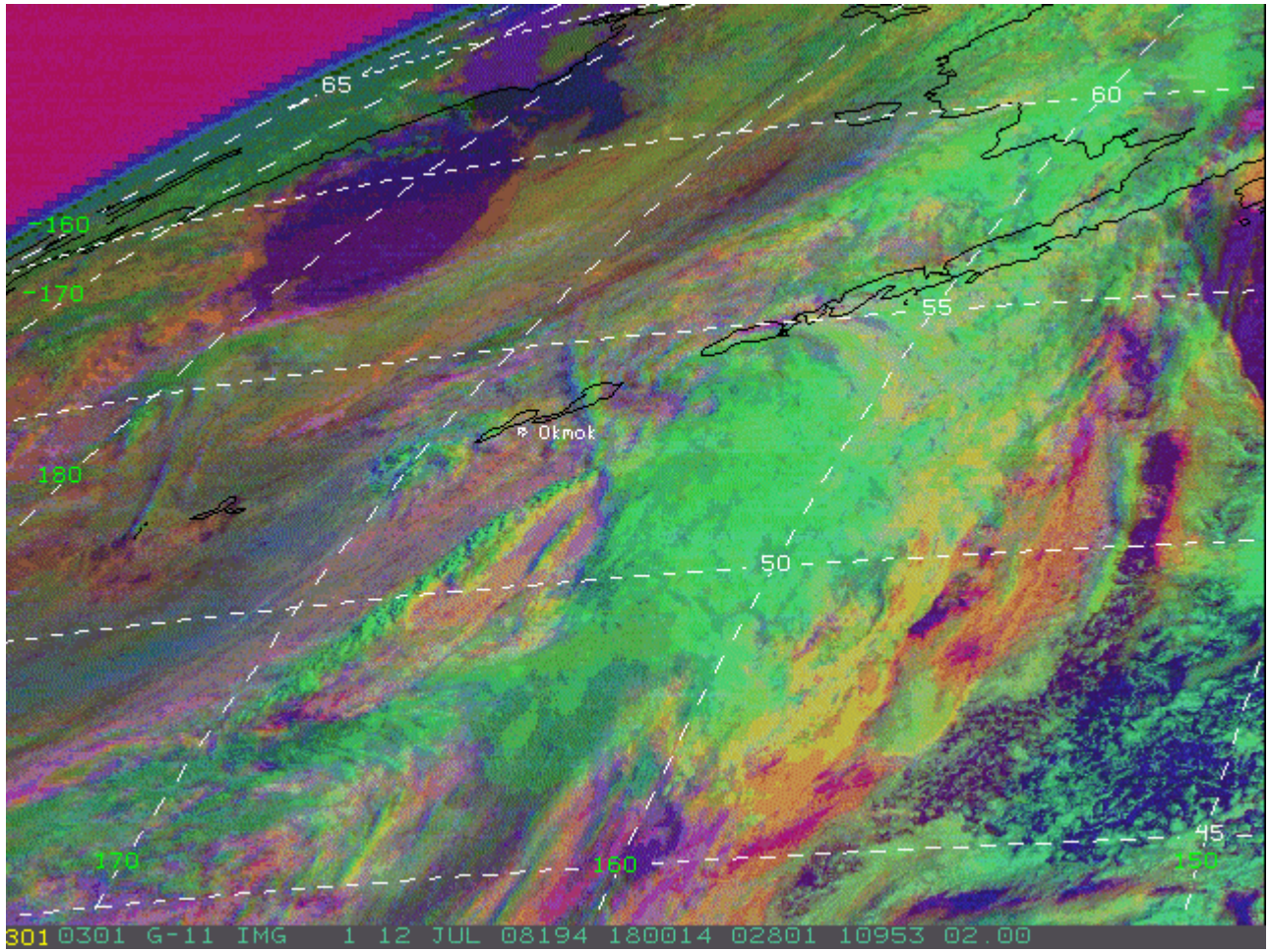

Okmok - 2008
Okmok
Ice cloud
GOES 5-band PCI-1 (LWIR-dominant)
Okmok
GOES 5-band PCI-2 (visible-dominant)
Okmok
Water cloud
GOES 5-band PCI-3 (SWIR-dominant – high vs. low cloud)
Okmok
Volcanic Ash
GOES 5-band PCI-5 (split-window - thin cloud - ash)
238 0238 G-11 IMG 1 13 JUL 08195 044516 03041 11593 02.00

Principal Component Image (PCI) Analysis: Volcanic Ash Enhancement



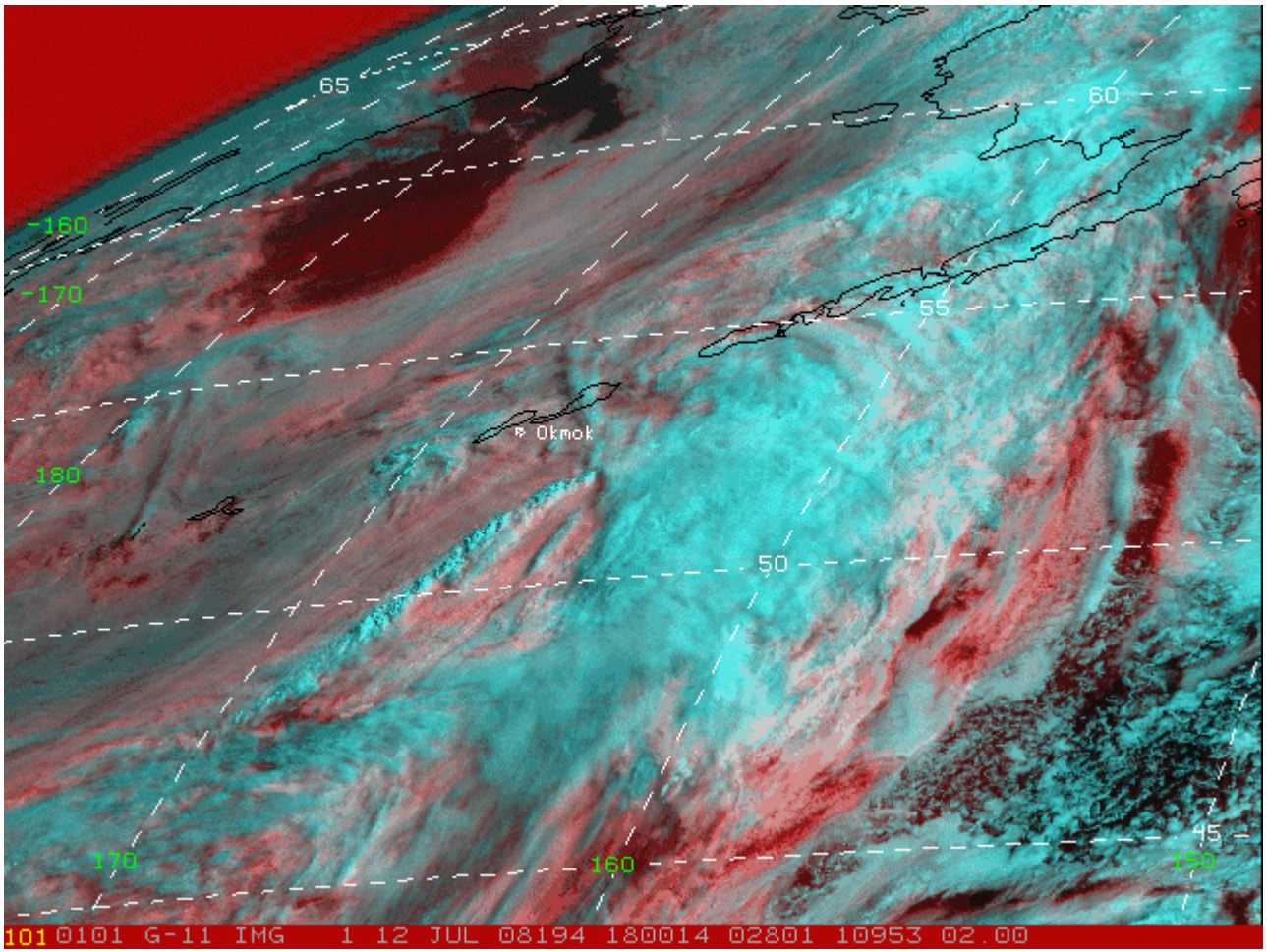
Analysis of Initial Okmok Eruption: Imagery for the Okmok (Alaska Aleutian) volcano eruption from 12/13 July 2008 has been analyzed thru Principal Component Image (PCI) analysis. PCIs extract dominant image combinations from the available GOES bands.

Principal Component Image (PCI) Analysis



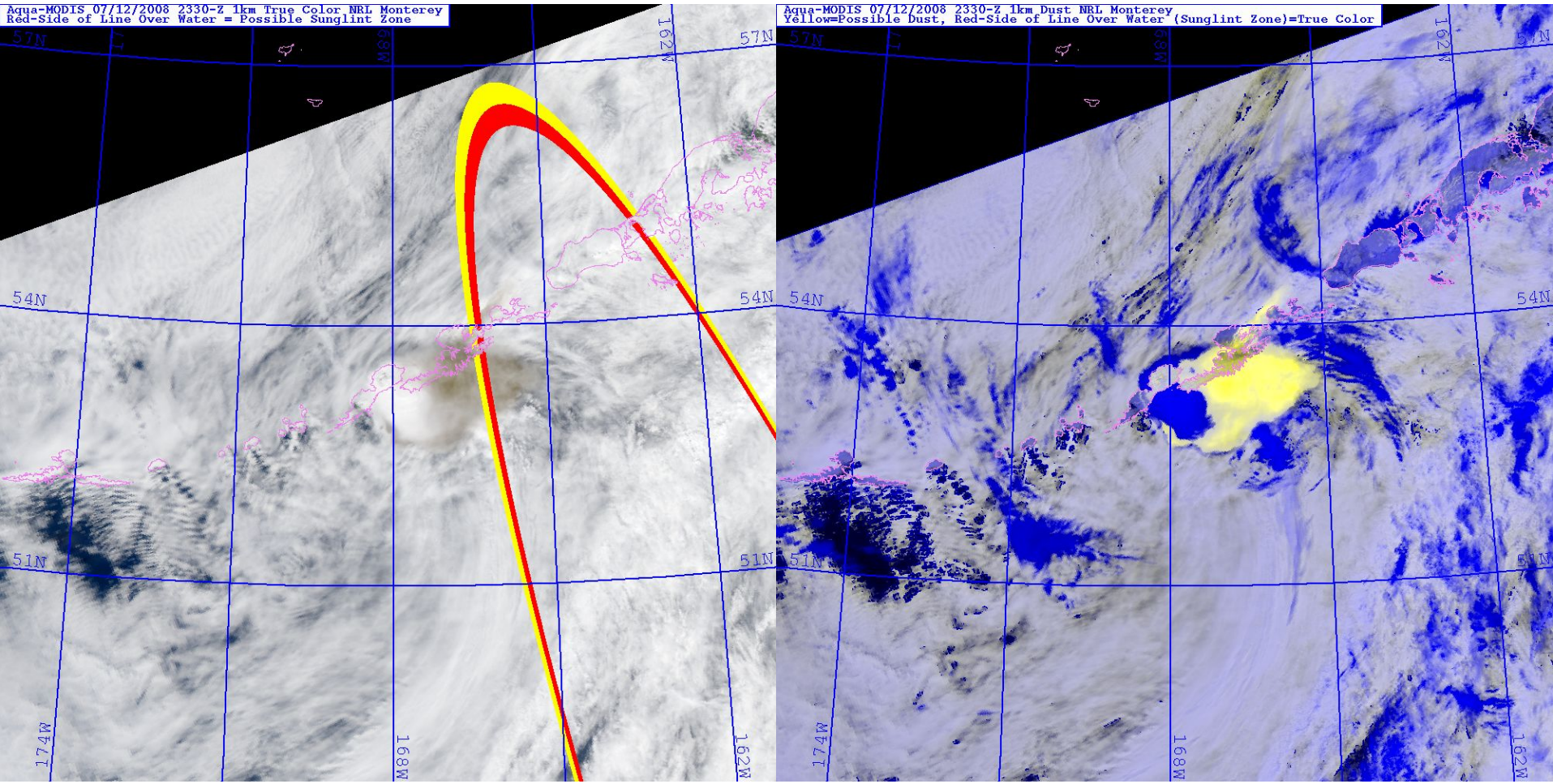
PCIs are combined in this image using RGB (3-color) analysis. The colors chosen to enhance the ash cloud, with PCI-3, 2, and 5 as Red, Green, and Blue, respectively. Clear areas in the image are deep purple, high clouds are mainly green, lower clouds are yellow, and heavily-ash-dominated cloud is orange. Note the higher concentration of ash in the plume south of the volcano vs. the plume east of the volcano.

Principal Component Image (PCI) Analysis



A two-color combination similar to the previous three-color combination, but repeating one of the colors

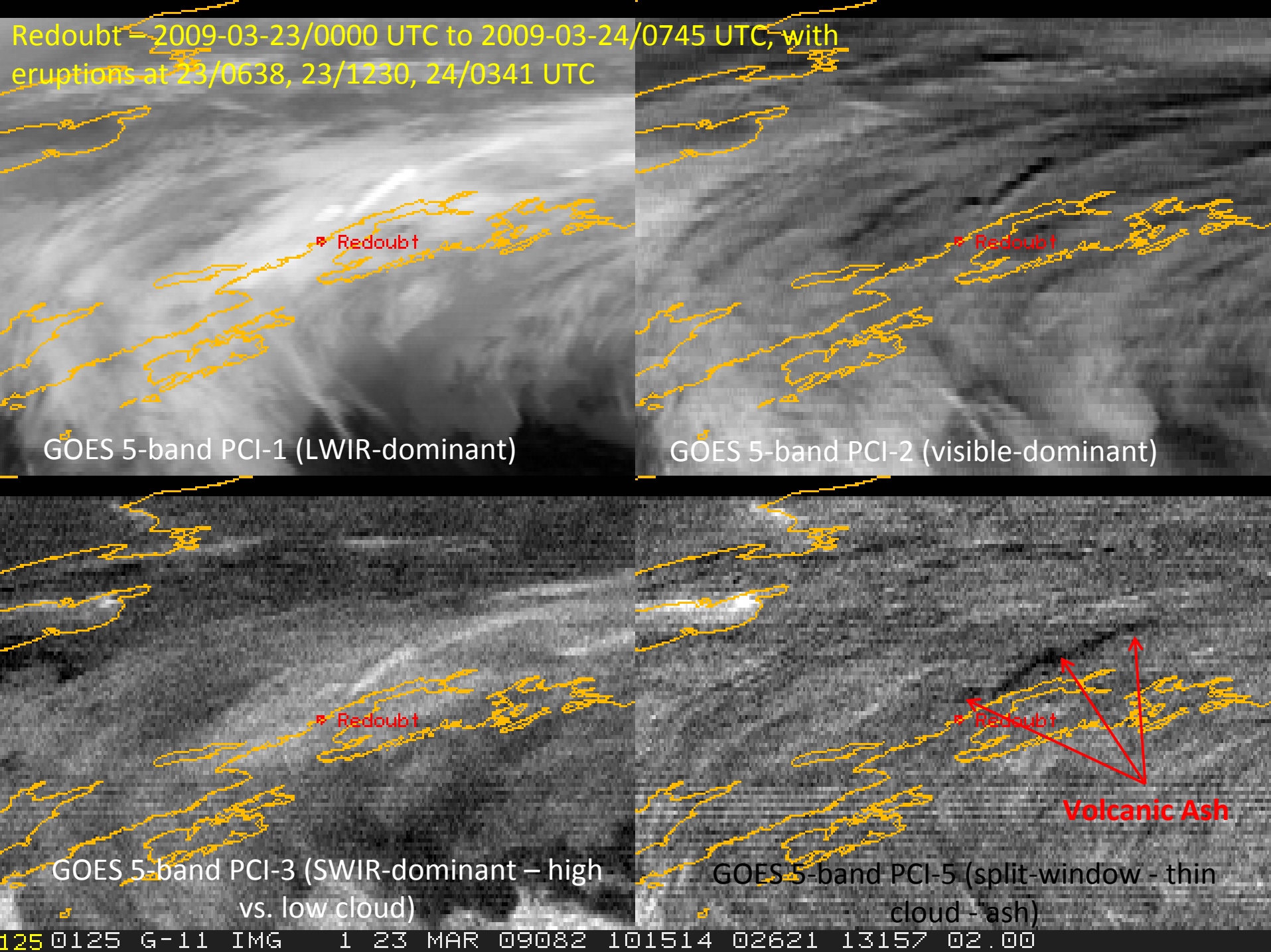
Okmok Eruption: Blue-Absorption



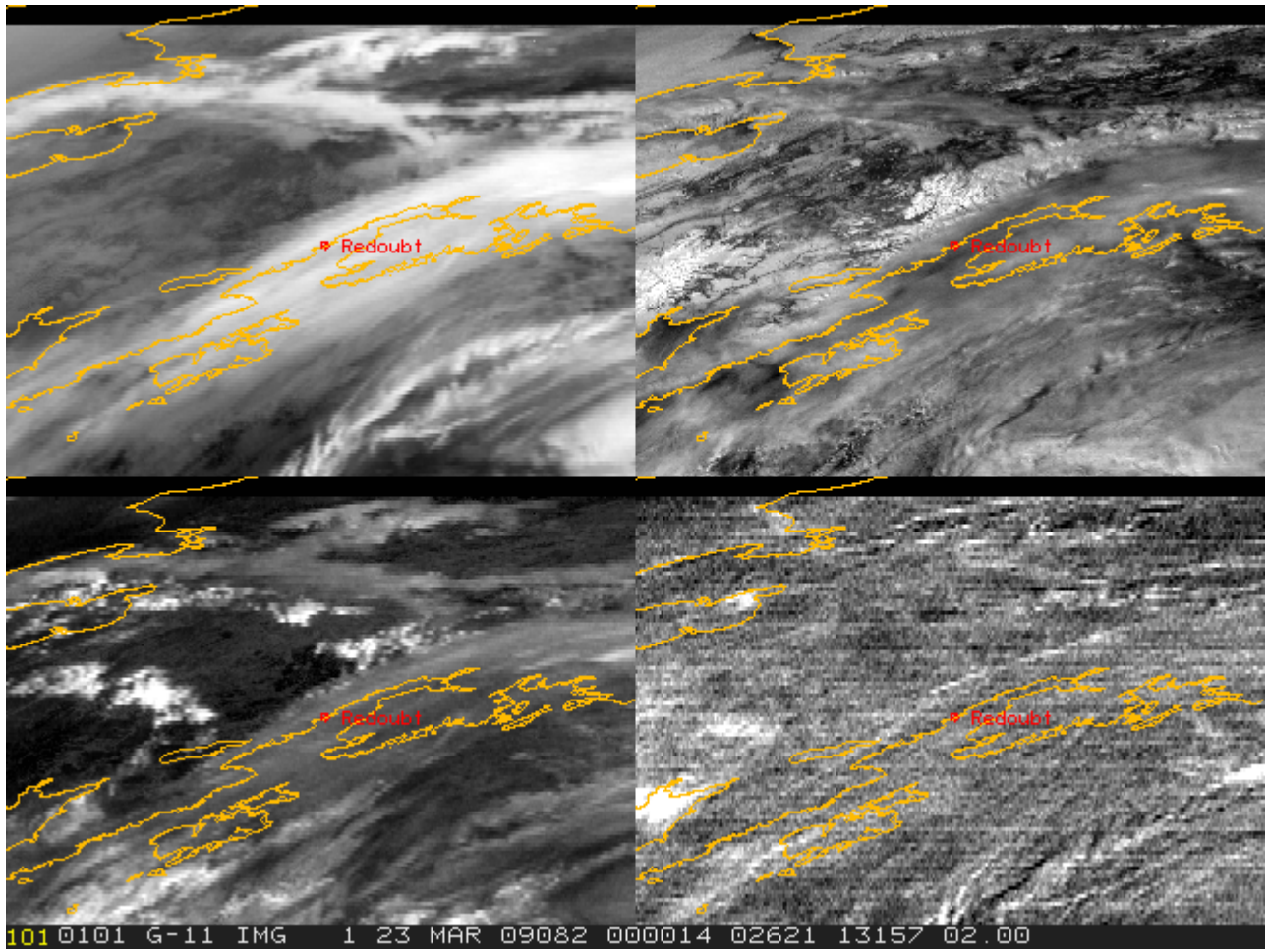
July 12, 2008 2330 Z

The Proving Ground allows users to assess the merits of various algorithms in an operational setting.

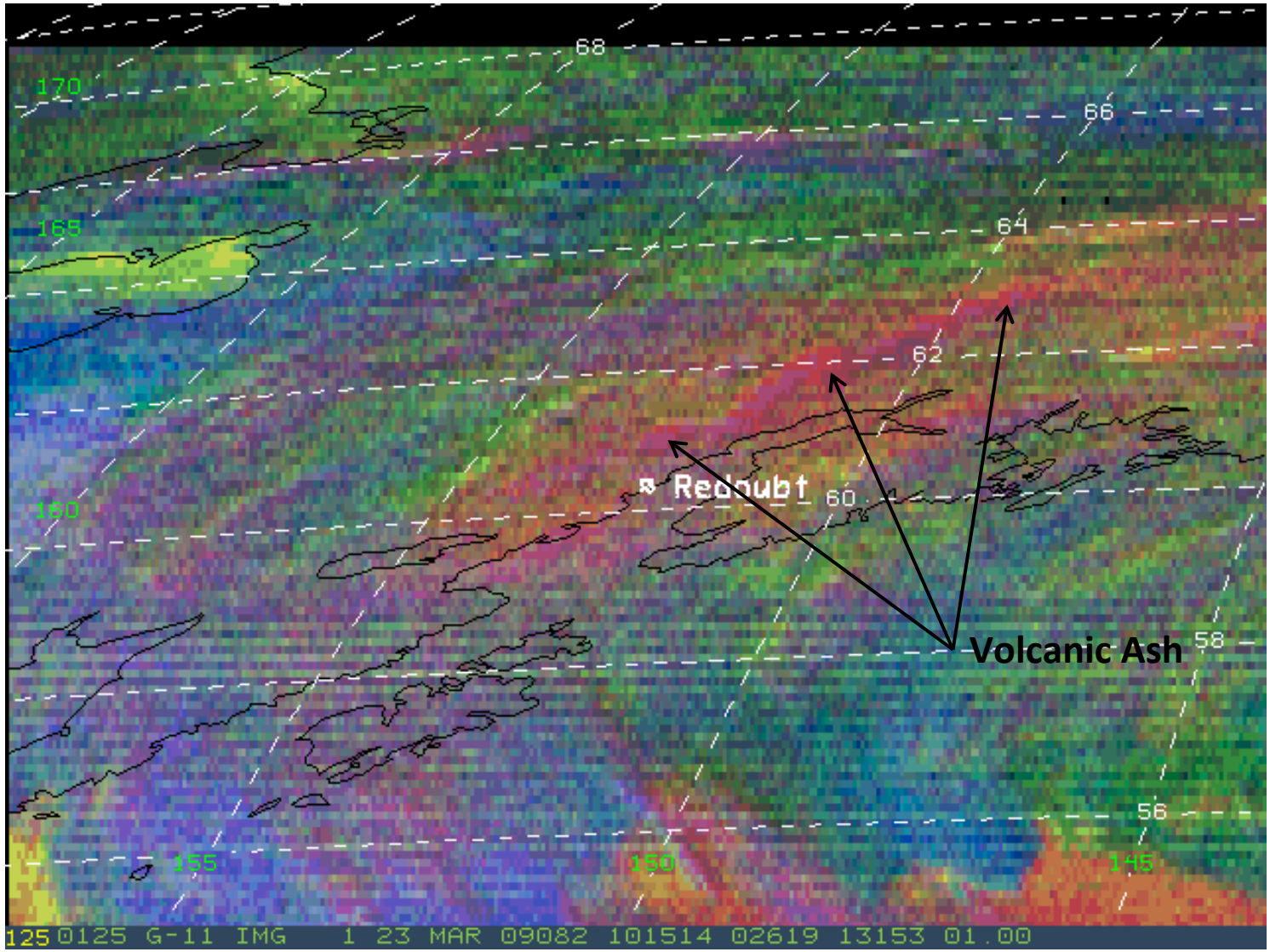
(*SME: Steve Miller*)


Redoubt – 2009-03-23/0000 UTC to 2009-03-24/0745 UTC, with eruptions at 23/0638, 23/1230, 24/0341 UTC
Redoubt
GOES 5-band PCI-1 (LWIR-dominant)
Redoubt
GOES 5-band PCI-2 (visible-dominant)
Redoubt
GOES 5-band PCI-3 (SWIR-dominant – high vs. low cloud)
Redoubt
Volcanic Ash
GOES 5-band PCI-5 (split-window - thin cloud - ash)
125 0125 G-11 IMG 1 23 MAR 09082 101514 02621 13157 02.00

Redoubt – 2009-03-23/24

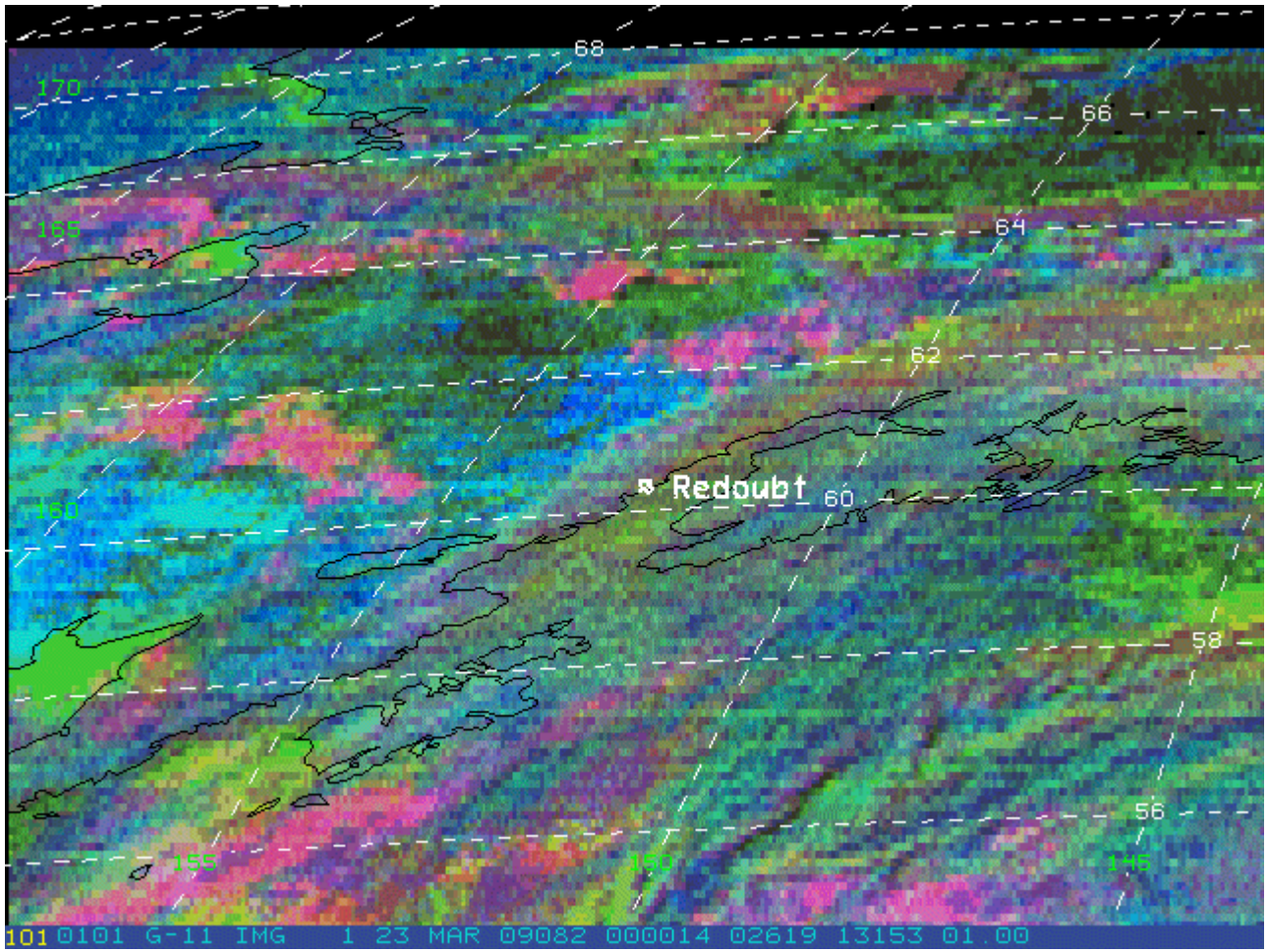


Redoubt – 2009-03-23/24

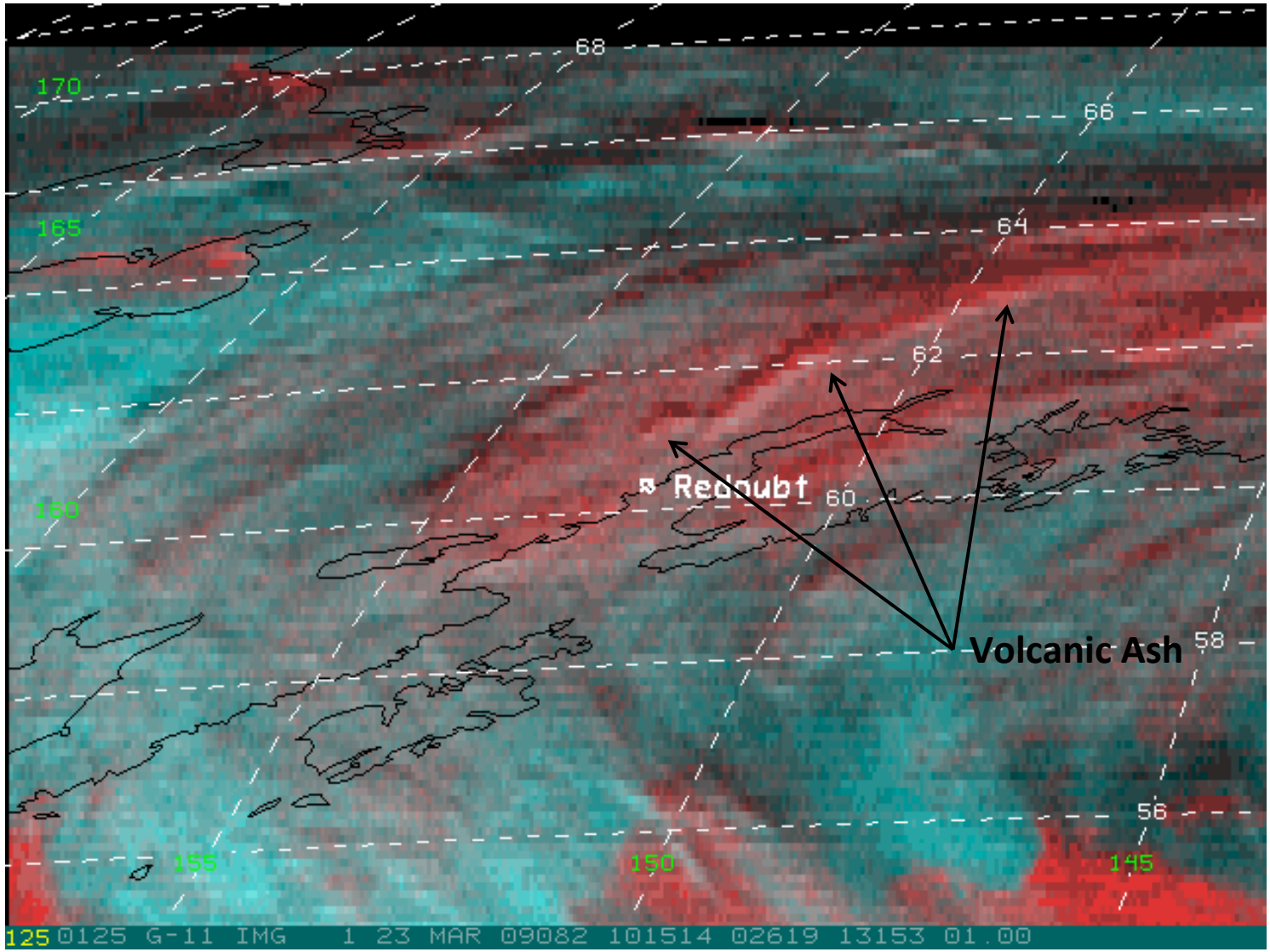


RGB (3-color): Red = PCI-3, Green = PCI-5, Blue = PCI-2

Redoubt – 2009-03-23/24

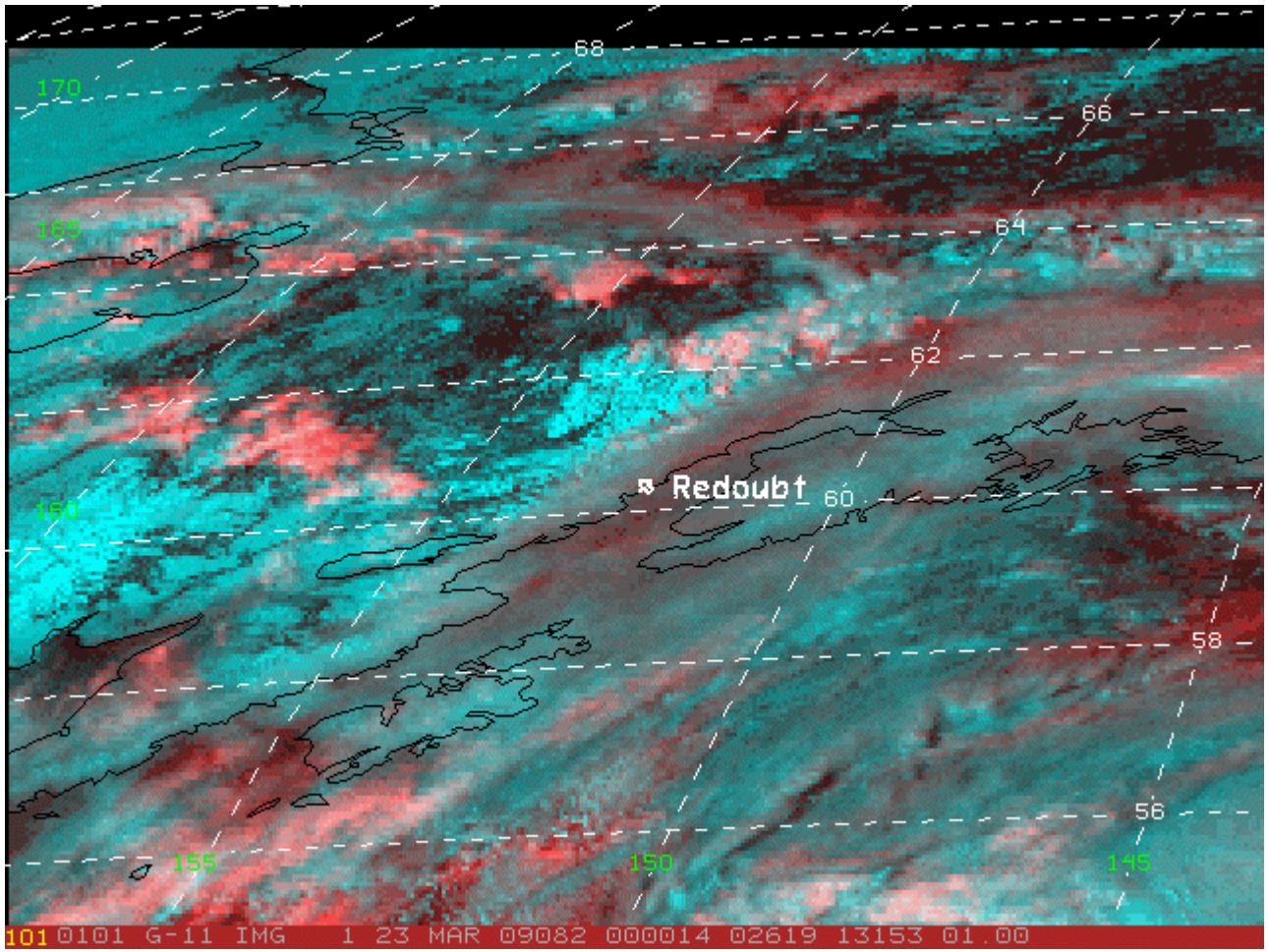


Redoubt – 2009-03-23/24



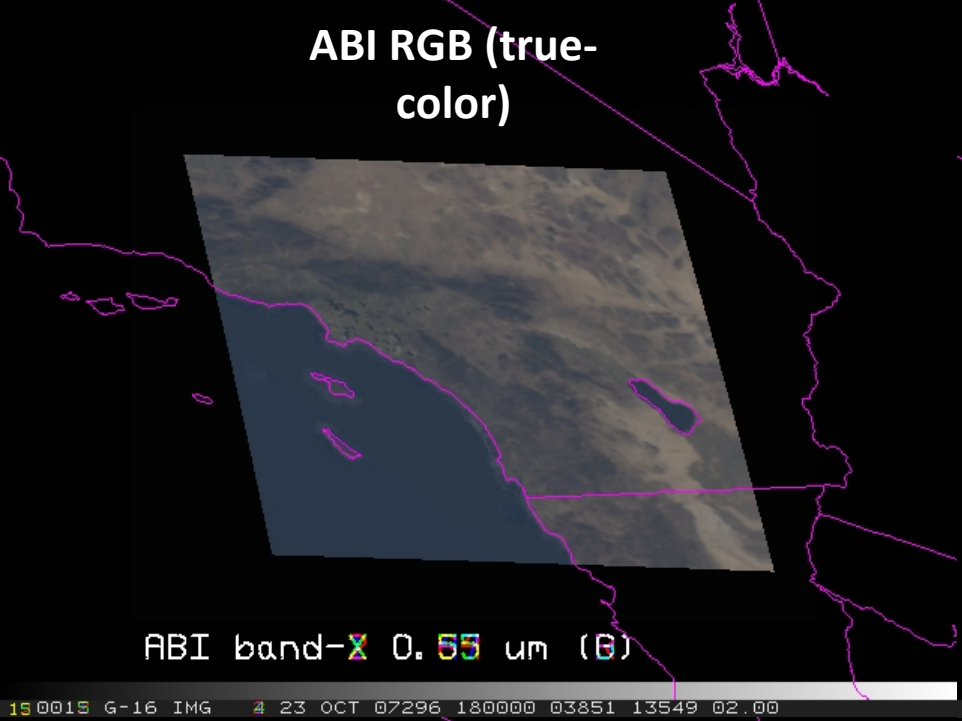
RGB (3-color): Red = PCI-3, Green = PCI-2, Blue = PCI-2
(Note that both Green and Blue are PCI-2 in this case.)

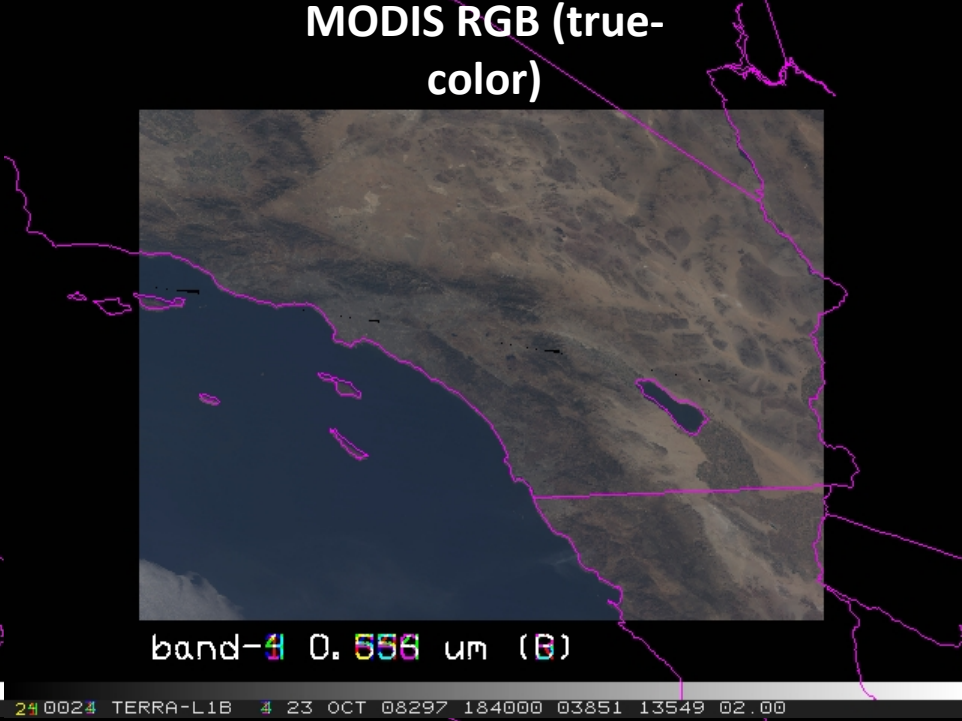
Redoubt – 2009-03-23/24

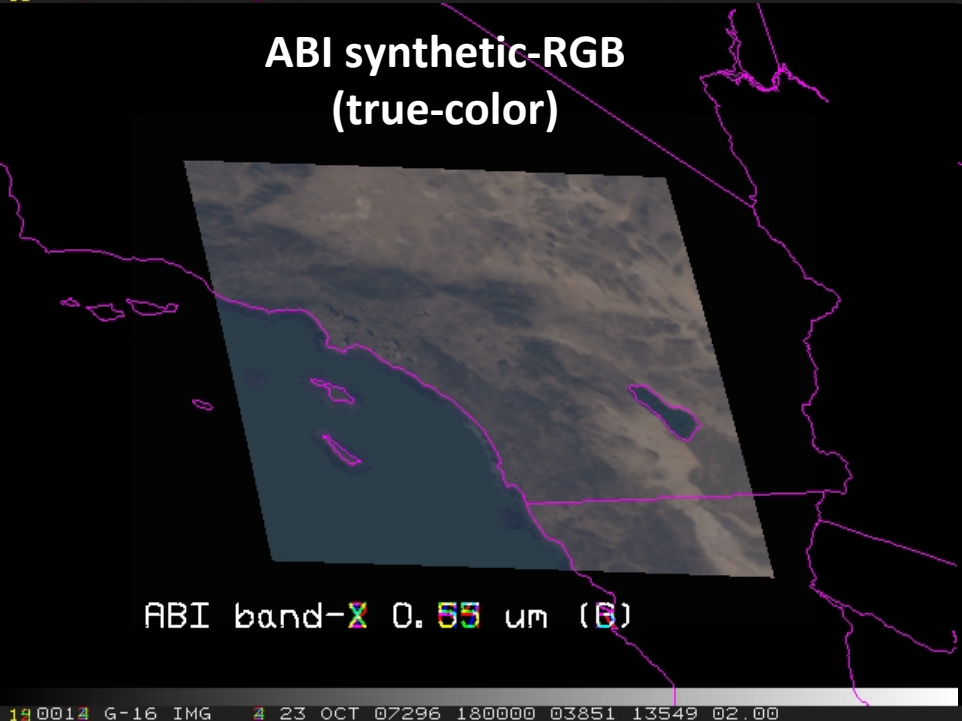


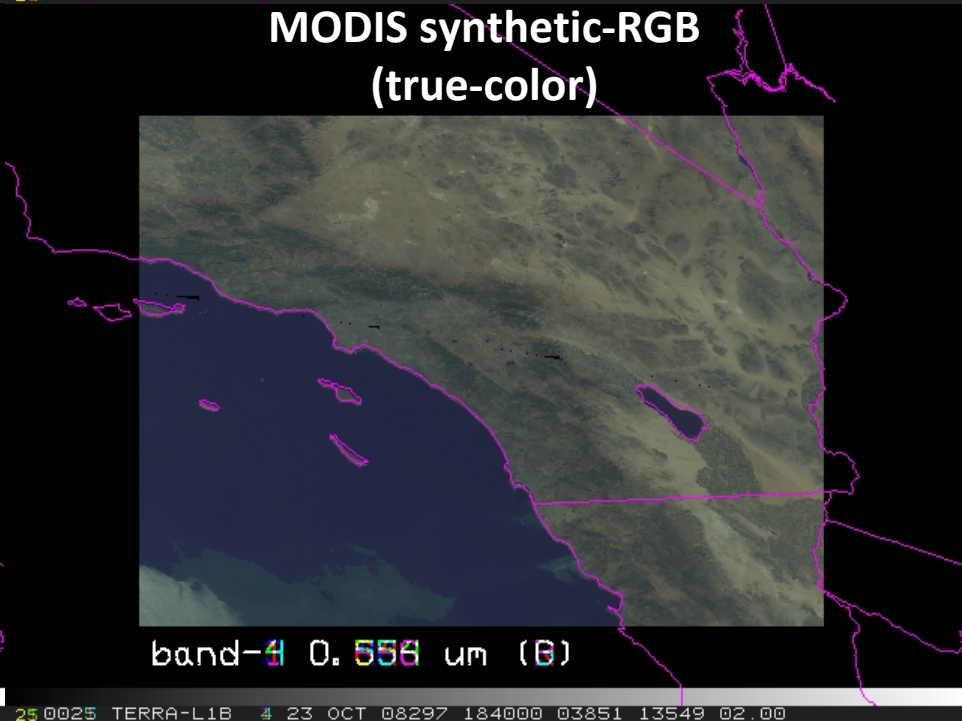
Model-Simulated ABI

- Initial work to develop a **true-color product for GOES-R ABI**, by first simulating the **Advanced Baseline Imager (ABI) "green" band**.
- **Forward-model simulations** have just begun, to include **smoke** particles in GOES-R ABI data.
- **Additional smoke simulations** are planned.
- **Volcanic ash** (and other aerosol) simulations are planned.
- May lead to development of **proxy datasets** for testing smoke and volcanic ash detection algorithms.

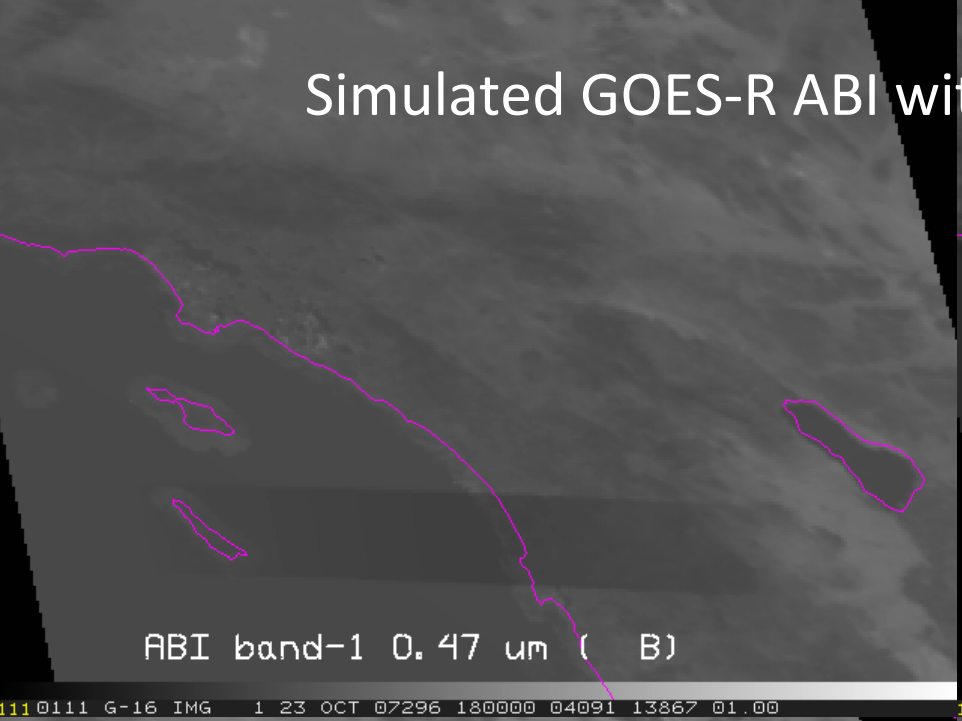

ABI RGB (true-color)
ABI band-X 0.55 um (G)
15 0015 G-16 IMG 4 23 OCT 07296 180000 03851 13549 02.00

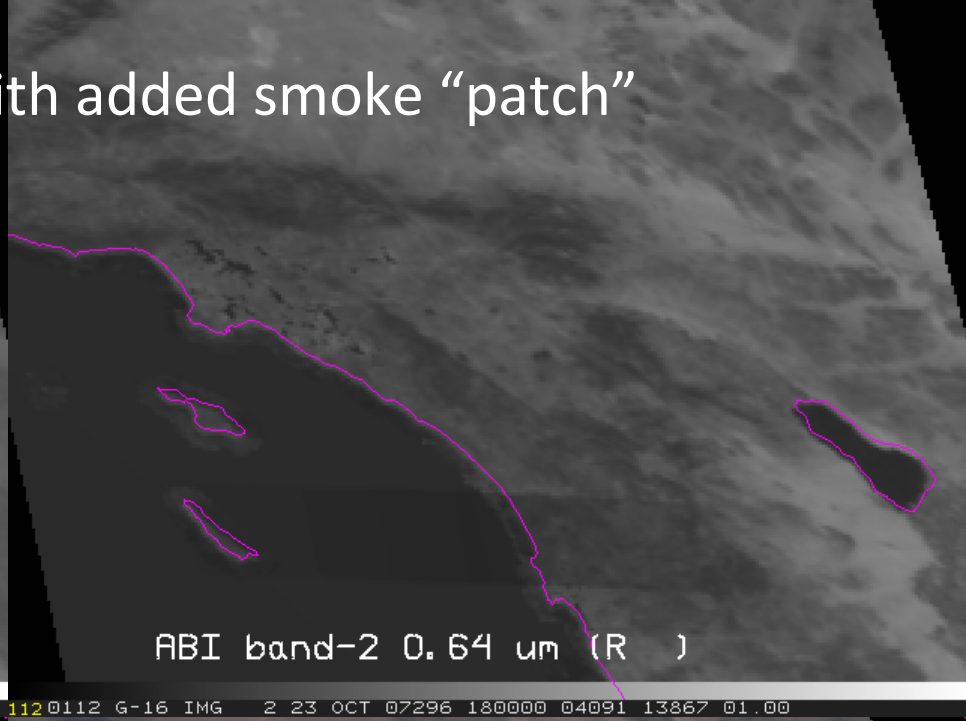

MODIS RGB (true-color)
band-4 0.556 um (G)
24 0024 TERRA-L1B 4 23 OCT 08297 184000 03851 13549 02.00

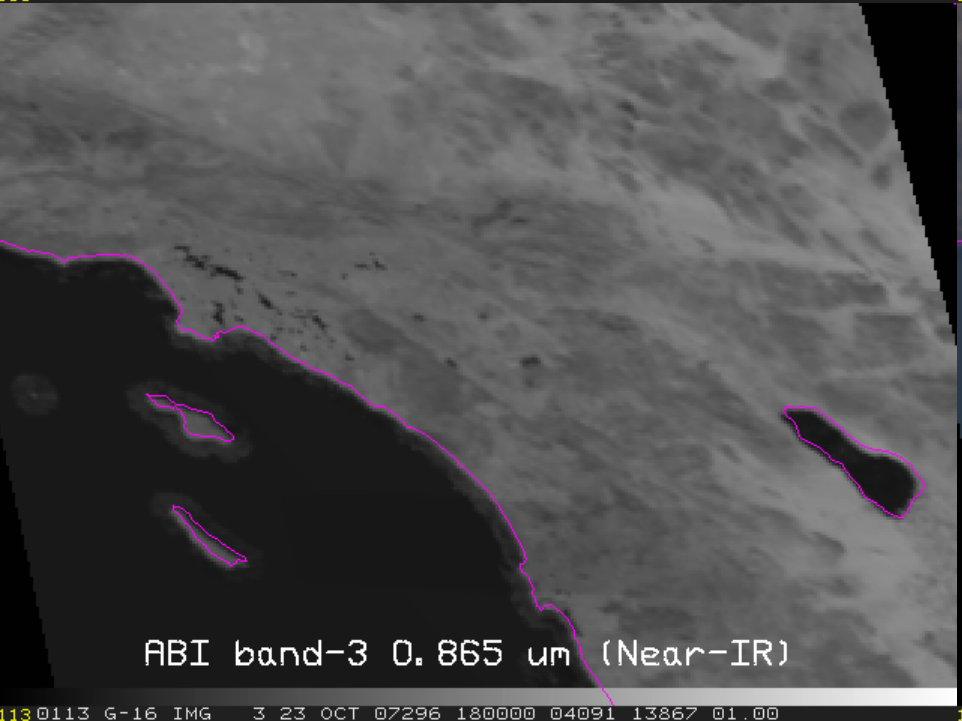

ABI synthetic-RGB (true-color)
ABI band-X 0.55 um (G)
14 0014 G-16 IMG 4 23 OCT 07296 180000 03851 13549 02.00

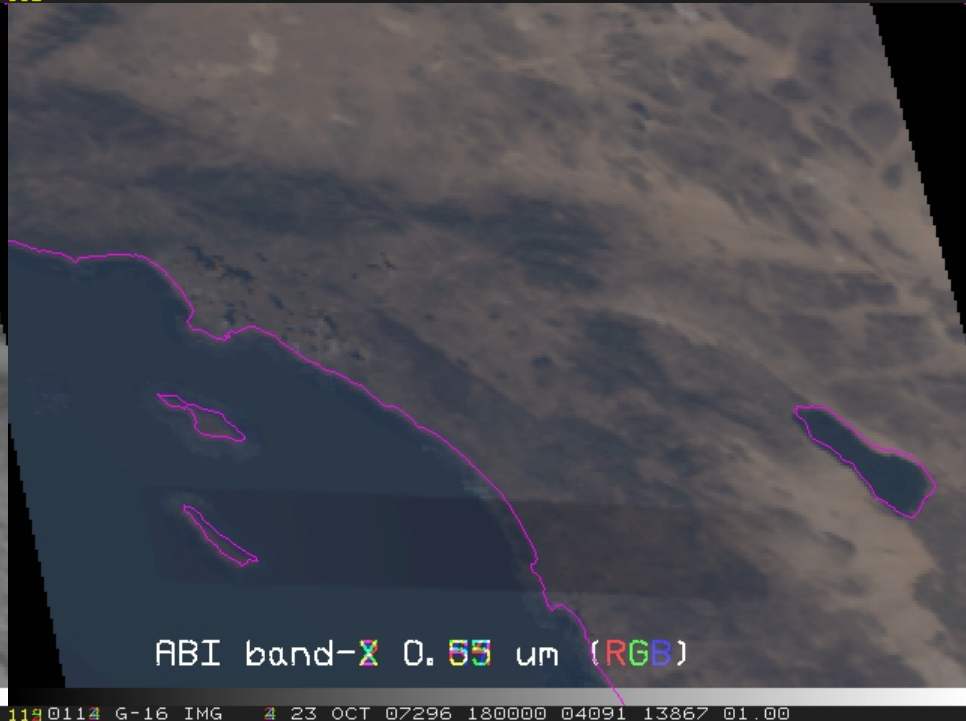

MODIS synthetic-RGB (true-color)
band-4 0.556 um (G)
25 0025 TERRA-L1B 4 23 OCT 08297 184000 03851 13549 02.00

Simulated GOES-R ABI with added smoke “patch”



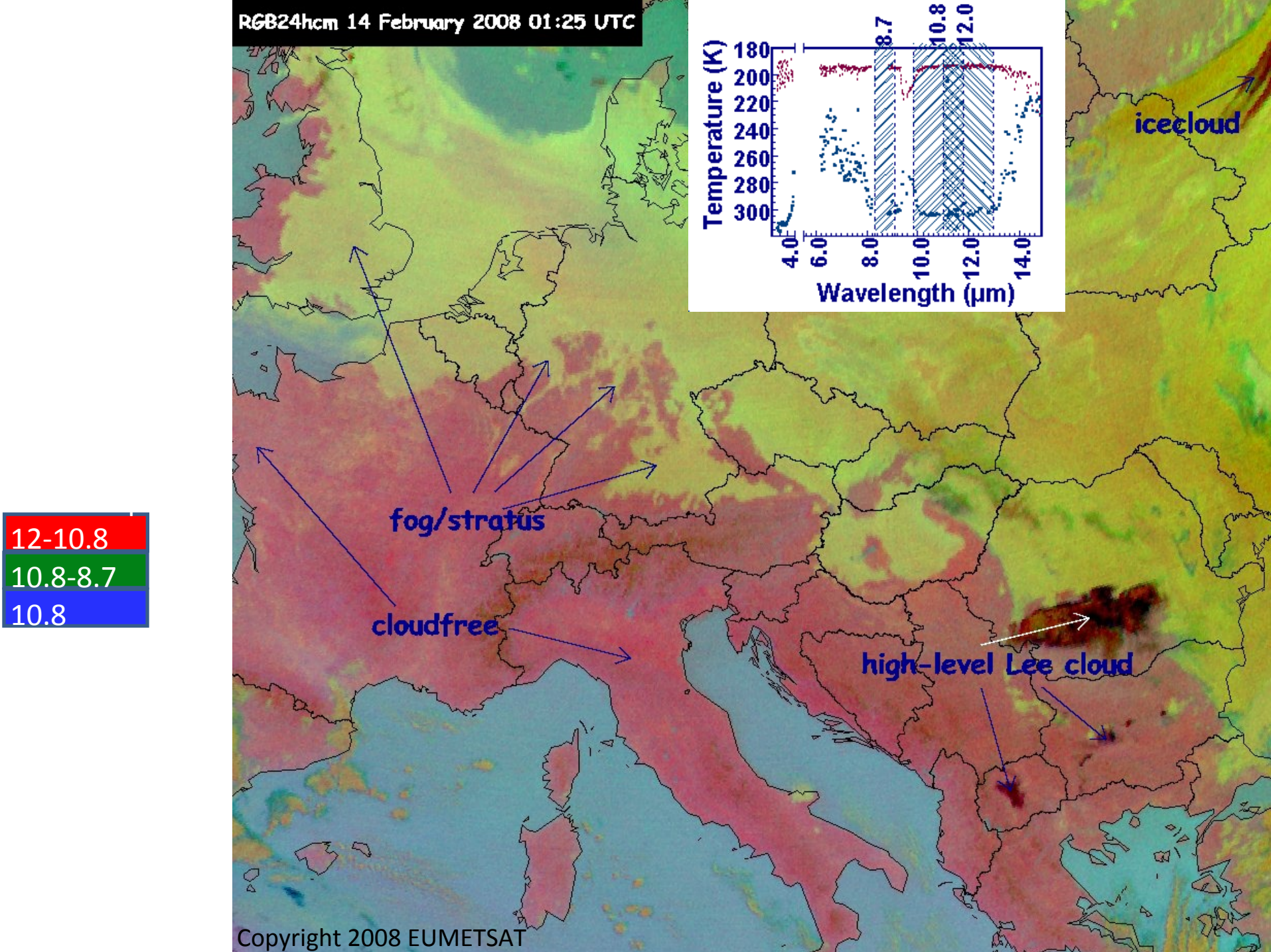




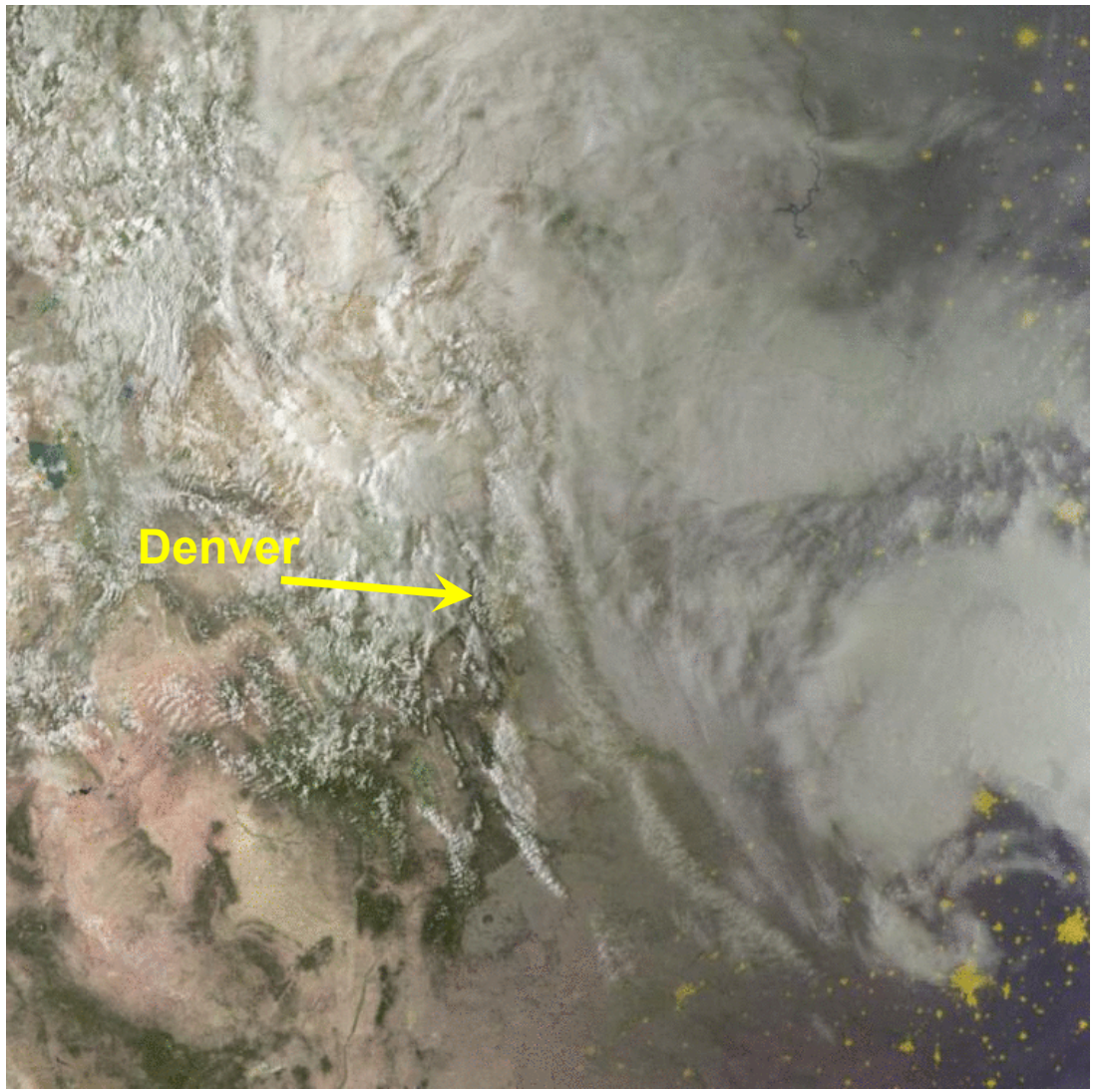


Fog/stratus discrimination in cold regions

- Use of **10.8 minus 8.7 µm difference** demonstrated with Meteosat Second Generation (MSG)
- Example courtesy of Eumetsat/Bernie Connell
- One of many three-color products we are testing for GOES-R ABI application.

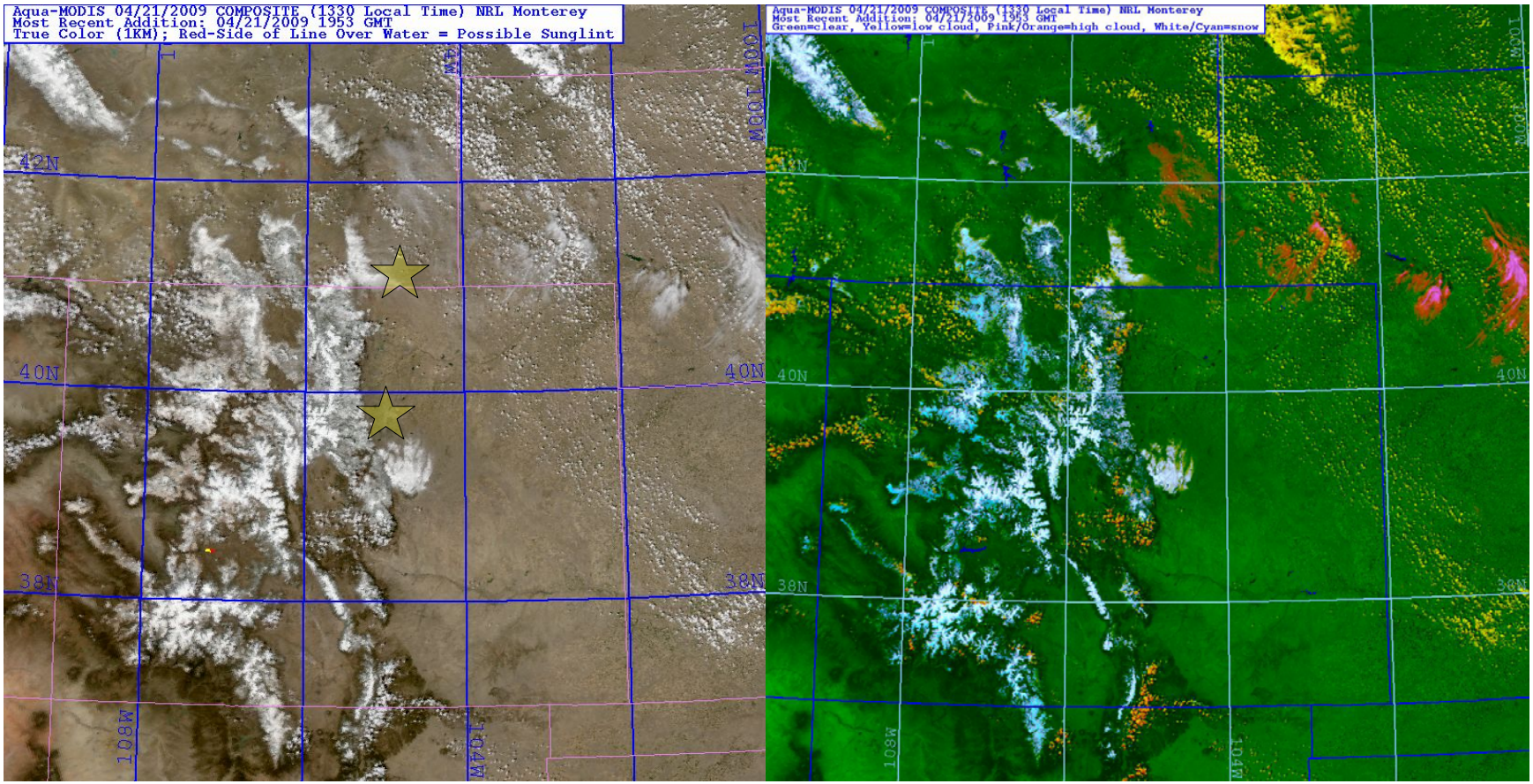

RGB24hcm 14 February 2008 01:25 UTC
Temperature (K)
180
200
220
240
260
280
300
8.7
10.8
12.0
4.0
6.0
8.0
10.0
12.0
14.0
Wavelength (µm)
icecloud
fog/stratus
cloudfree
high-level Lee cloud
12-10.8
10.8-8.7
10.8
Copyright 2008 EUMETSAT

Front Range Low Cloud & Fog



(*SMEs: Steve Miller, Don Hillger*)

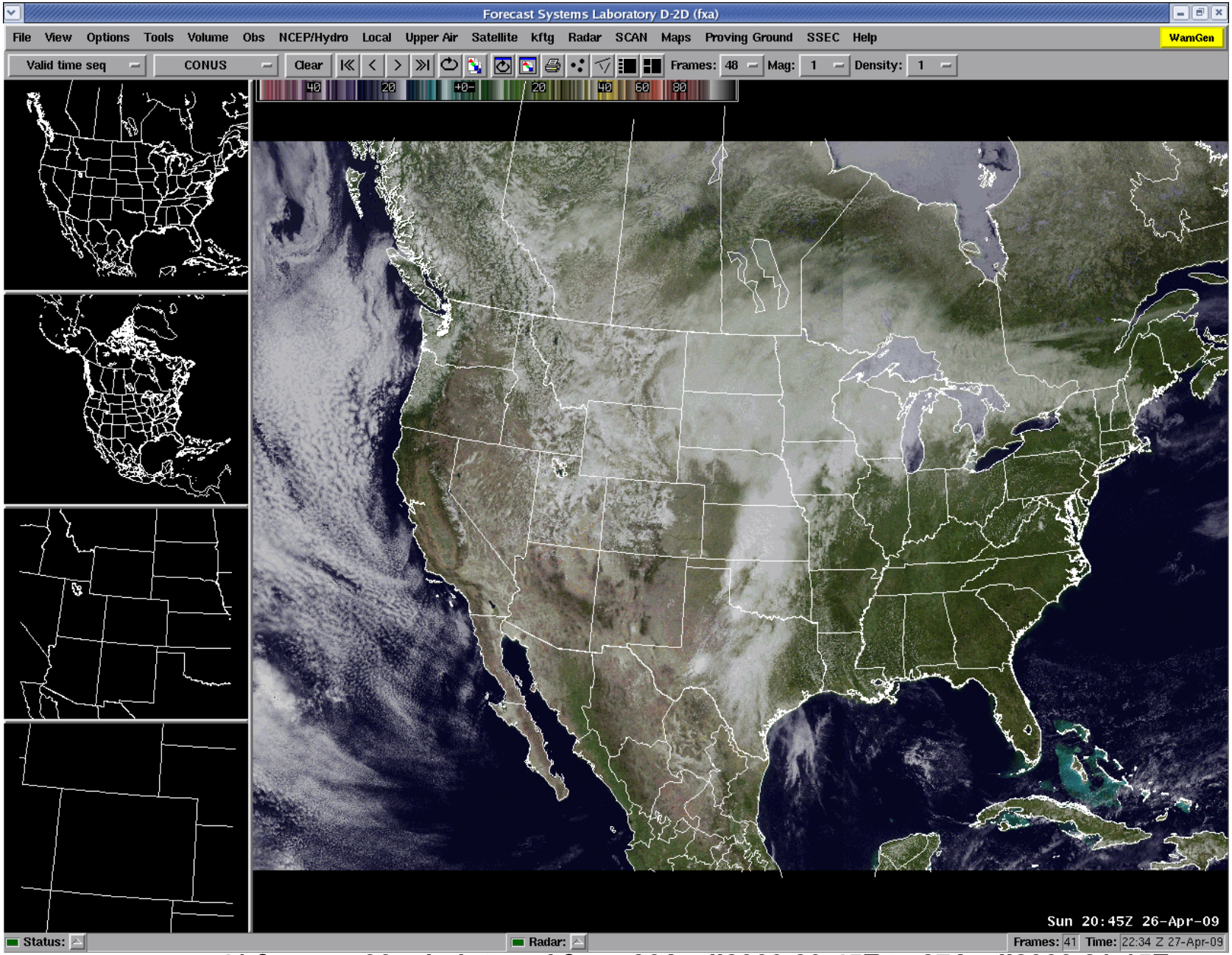
Tracking Snow Cover / Melt



→ Here, 2 passes per day may provide sufficient temporal resolution to provide useful information.

(*SMEs: Steve Miller, Don Hillger*)

GeoColor AWIPS PG Product at CYS and BOU



41 frames: 30 min interval from 26April2009 20:45Z to 27April2009 21:15Z

Detailed PG Product Descriptions available online

http://cimss.ssec.wisc.edu/goes_r/proving-ground.html

How is this product created now?

Figure 2 illustrates the various components of the GeoColor imagery blending technique. In the foreground of this image are the GOES E/W satellite visible and infrared datasets (upper-most left and right panels of Fig. 2, respectively.) For this image, which spans the full Continental U.S., we have stitched together the time-matched (here, 0000 Greenwich Mean Time (GMT) on 14 September 2005) Geostationary Operational Environmental Satellite (GOES); East (hovering over the equator at 75'W) and West (135' W) are stitched together along the 100'W meridian. In this example, the eastern half of the United States lies in total darkness, while the western half remains illuminated by late afternoon sun.

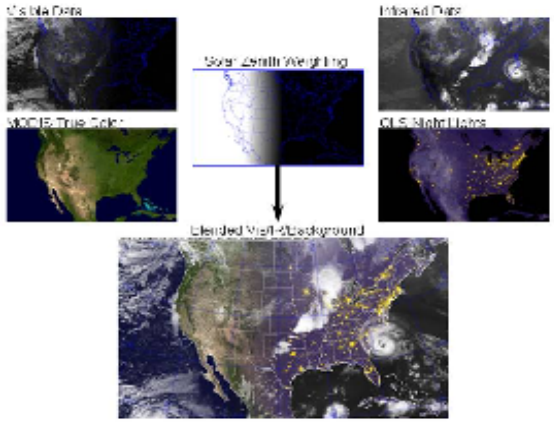


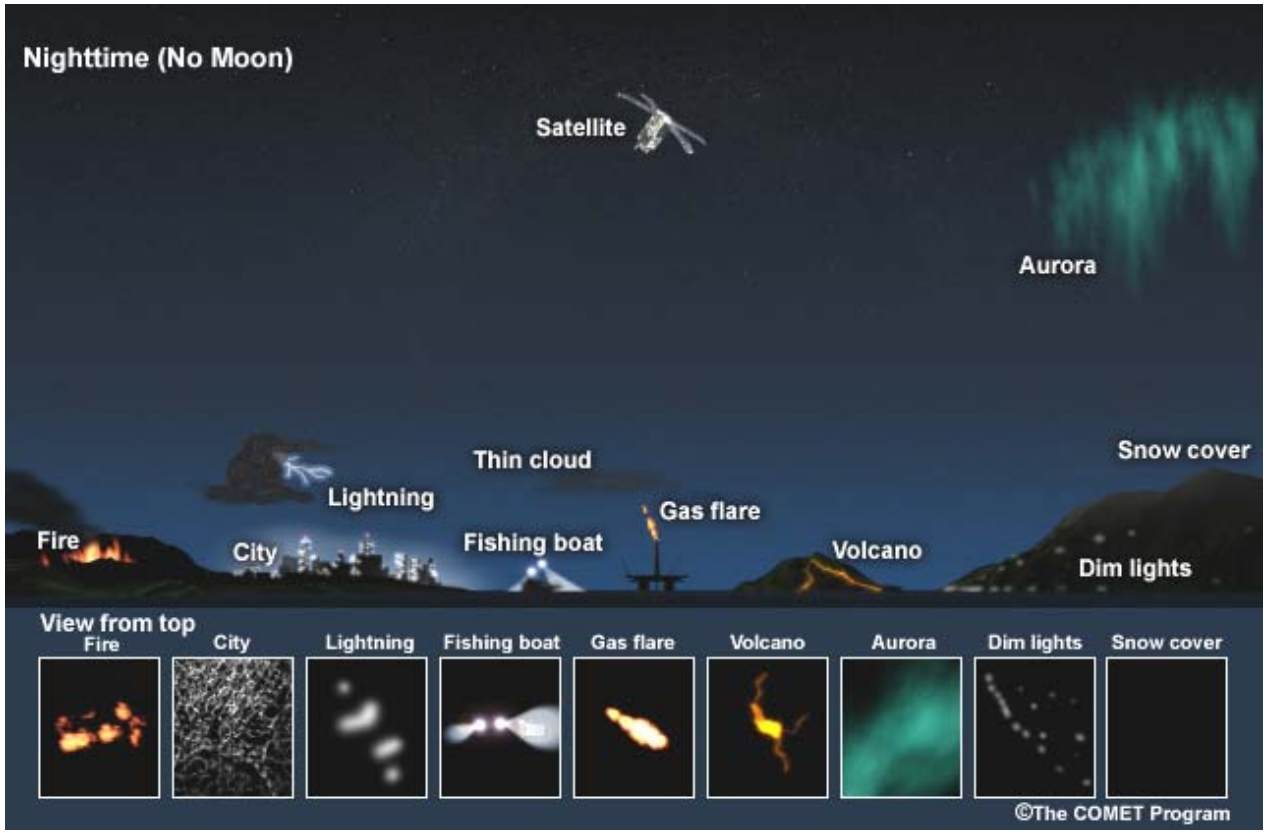
Fig. 2. Illustration of the five primary components contributing to the blended GeoColor imagery. Click on figure for full resolution.

Natural or "true" color backgrounds require channels that are not available from the current GOES. To simulate what

Note: The Proving Ground is *not* a web interface. The information provided online is intended to serve only as a 'menu' and high-level training for operational users and the general public.

Nighttime Low-Light Capabilities for a "Satellite Proving Ground"

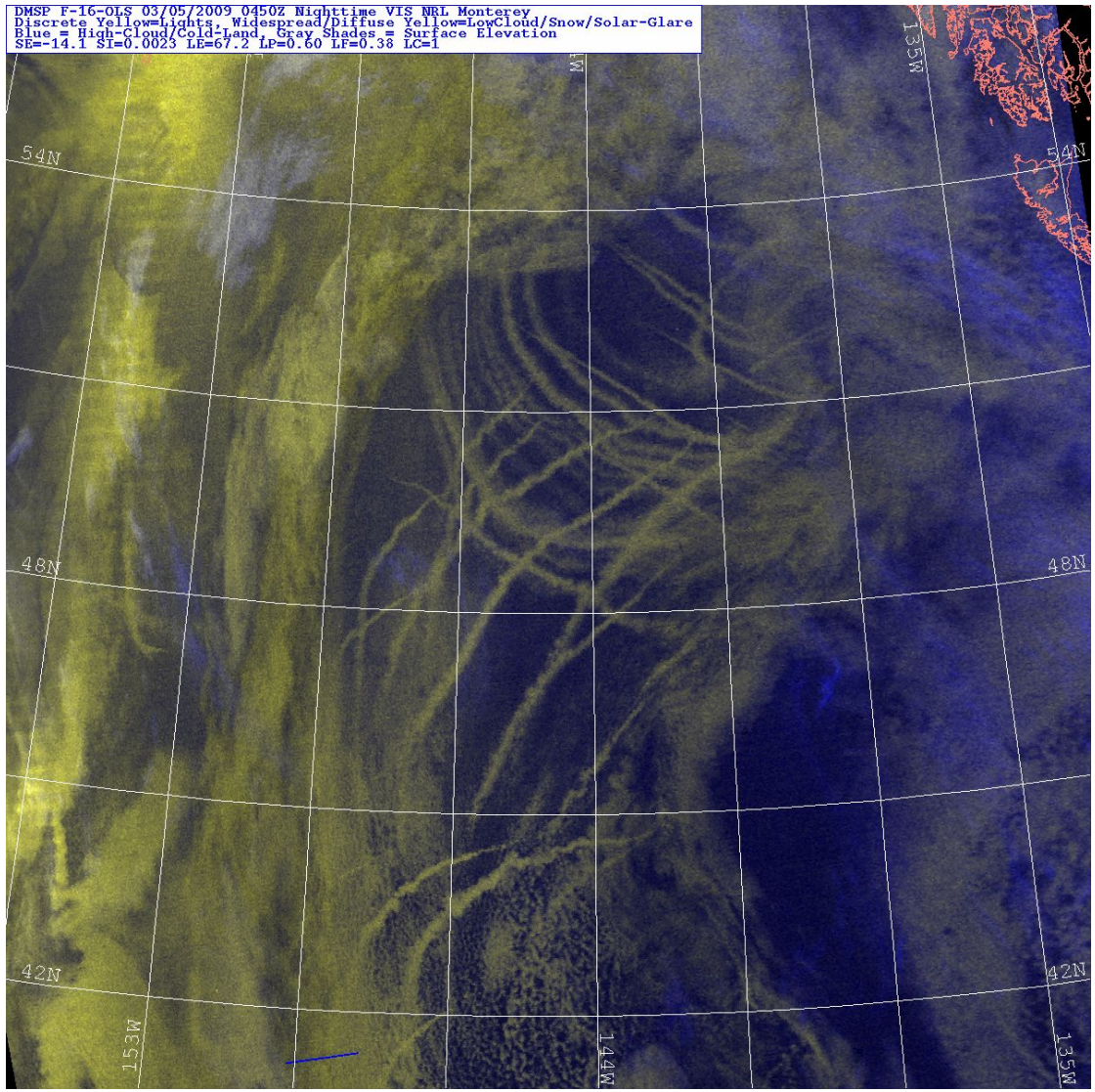
Low-Light Visible



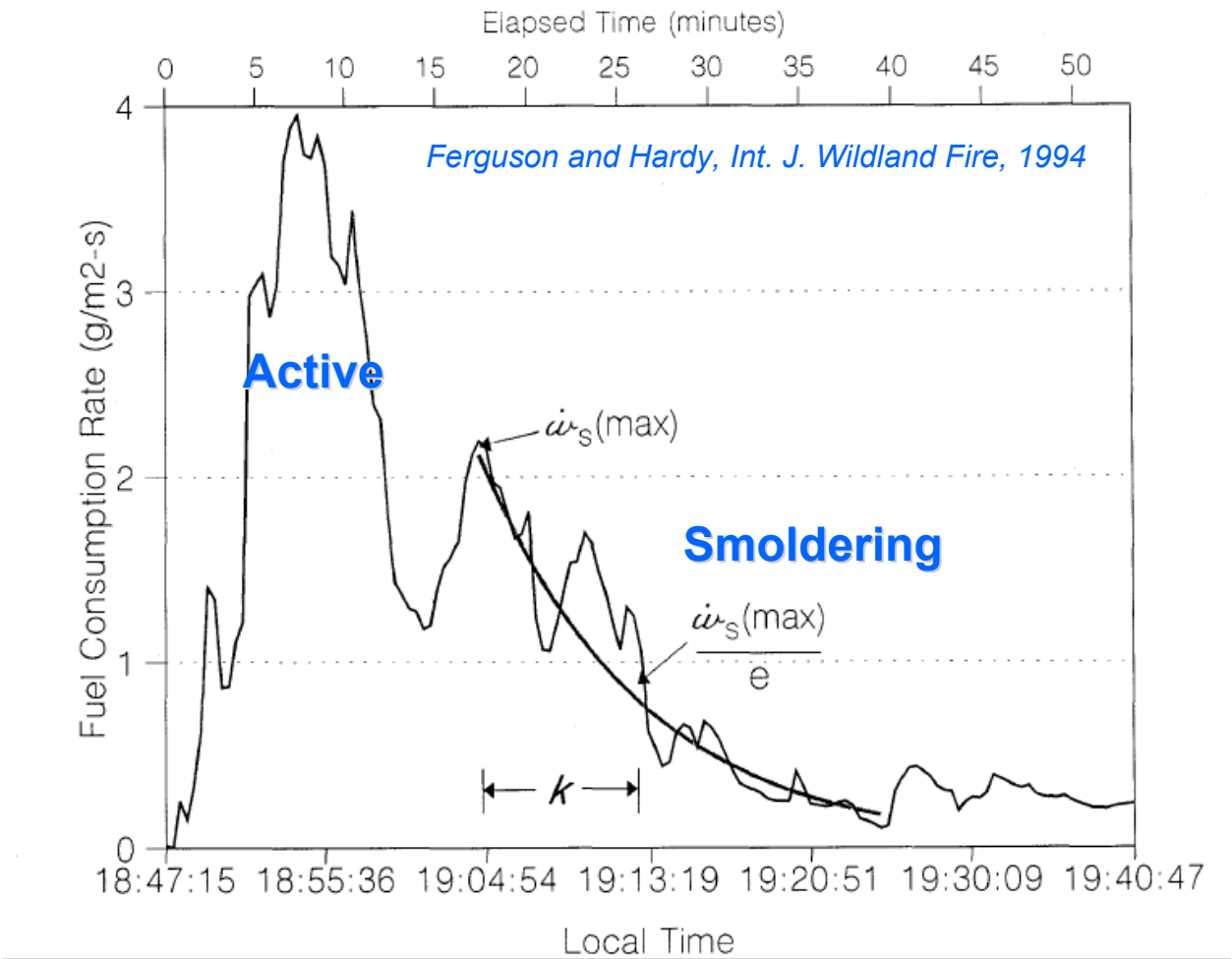
Both reflection and emission based applications can be exploited using the NPOESS-VIIRS Day/Night Band.

(*SME: Steve Miller*)

Ship Tracks Revealed by Moonlight



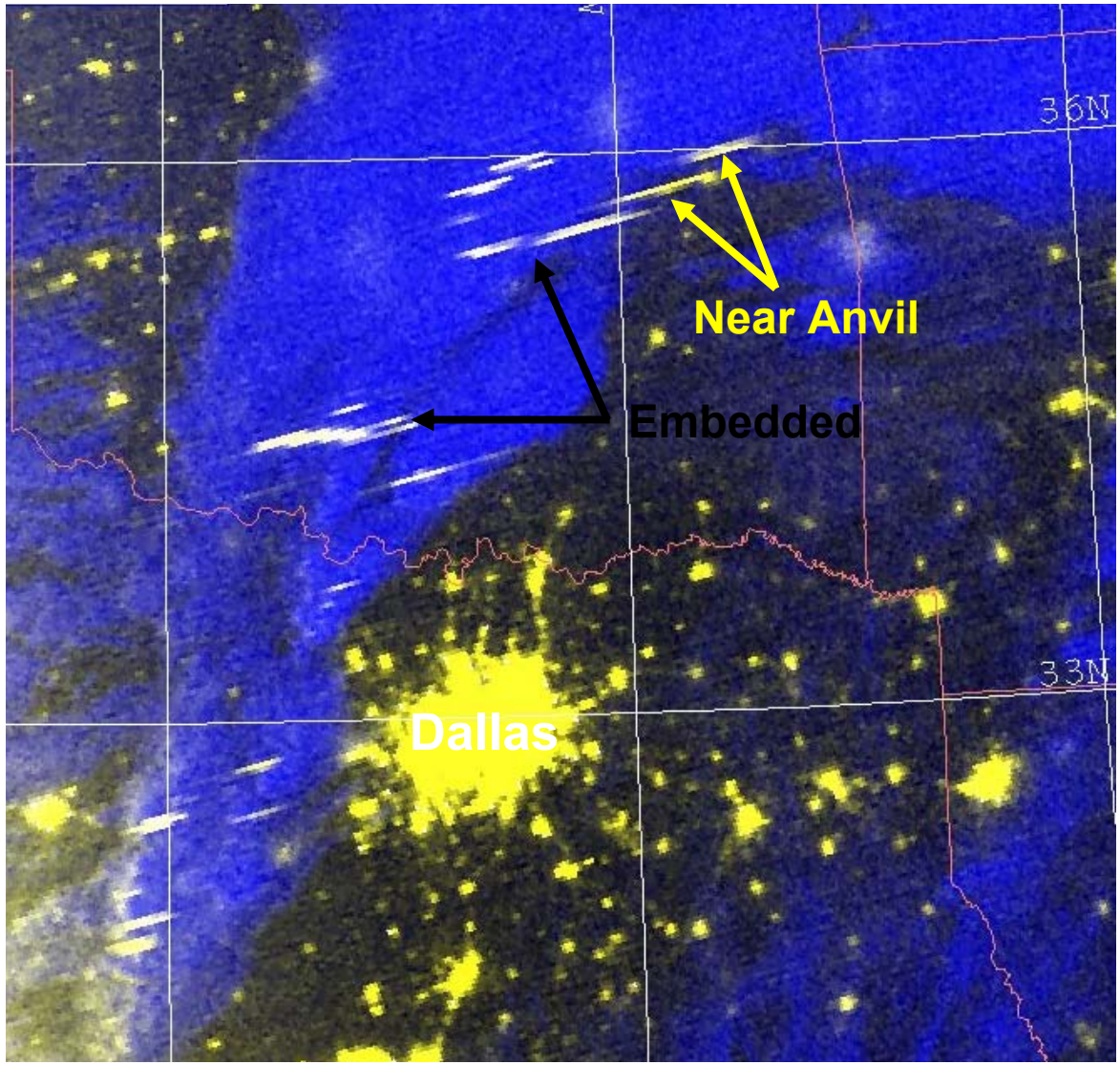
Active Fires at Night



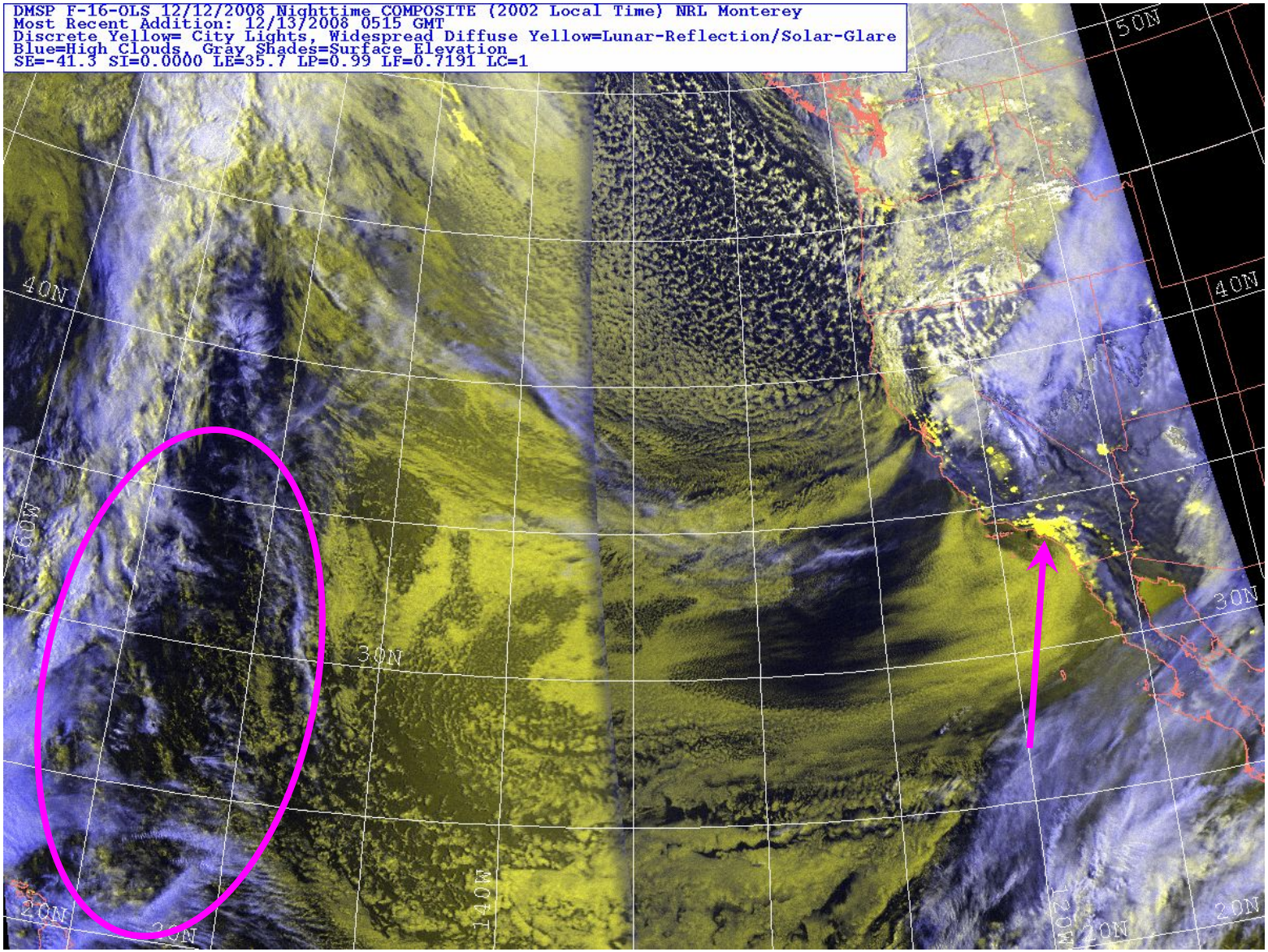
Active fires produce significantly greater smoke flux, potentially impacting nighttime visibility (T&D).

Nocturnal Lightning Detection

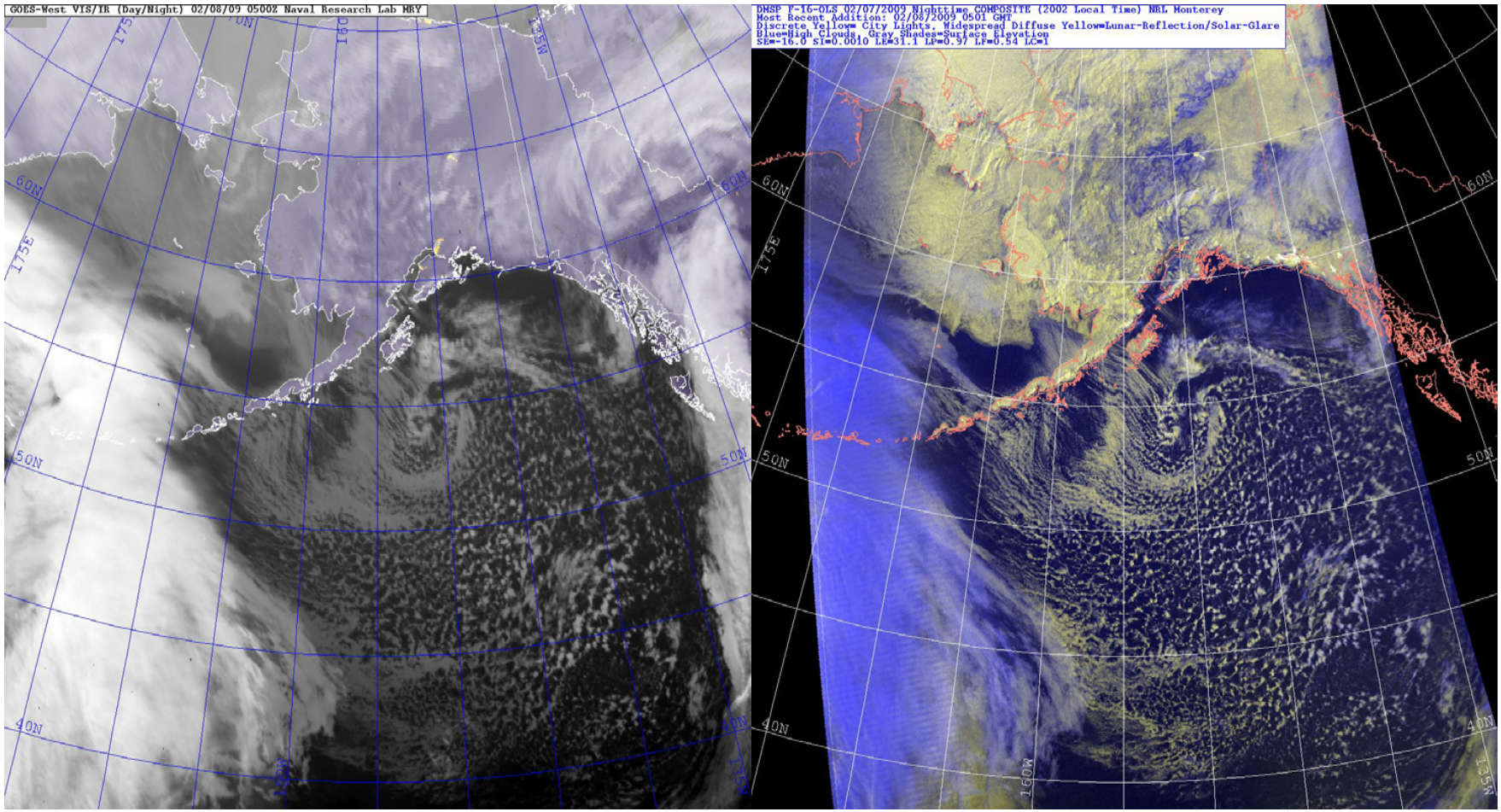
2/11/2009 ~0100 UTC



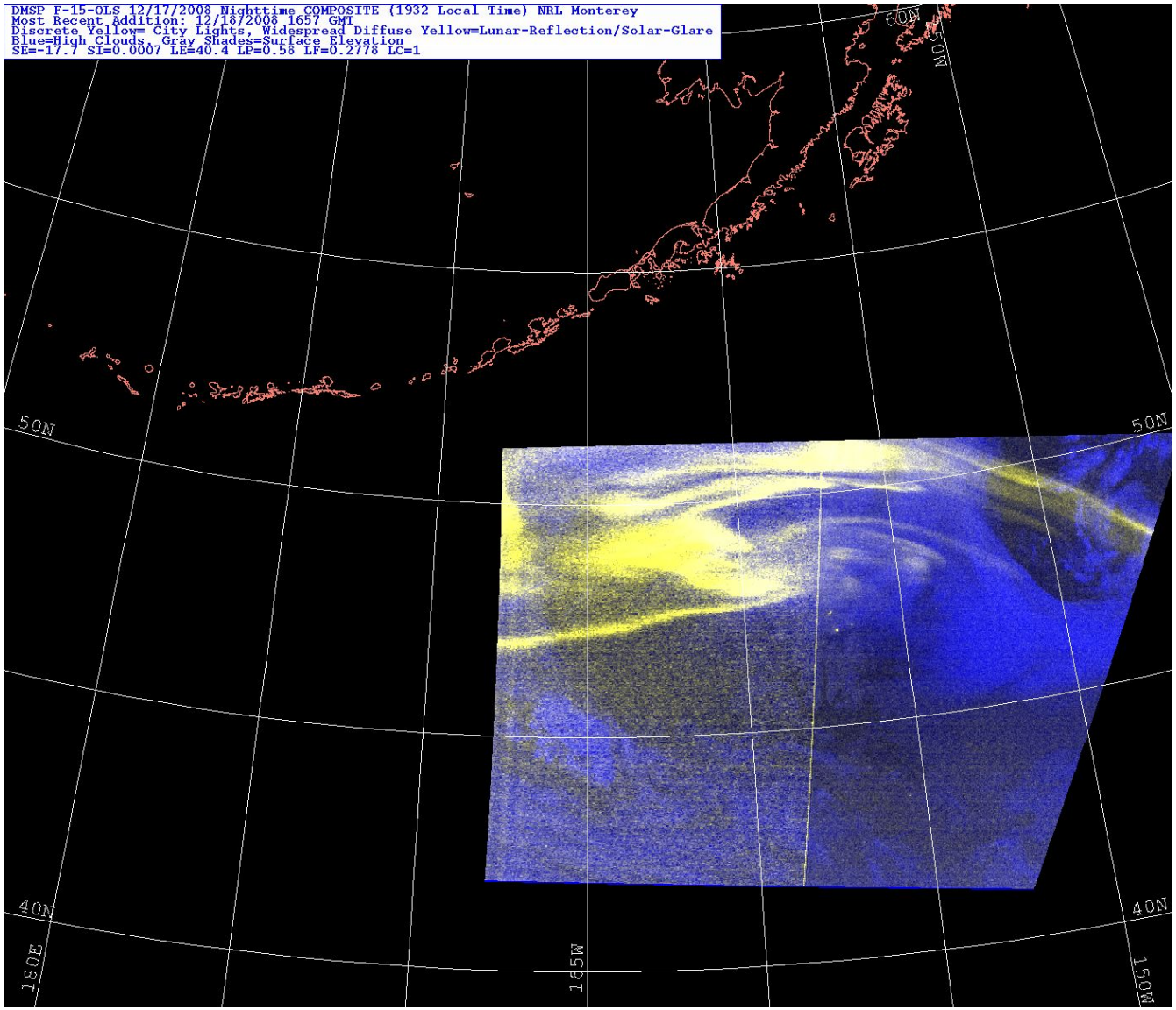
Low Cloud Detection at Night: Complementary Techniques



Nighttime Visible over the Aleutian Low and Alaskan Interior



Aurora Borealis



Conclusions

- CIRA has products available for Proving Ground testing in Alaska (Volcanic Ash PCI)
- PG products are being demonstrated online at http://rammb.cira.colostate.edu/goes_r_proving_ground/volcano_products.asp
- McIDAS code is available for re-working into TerraScan.
- Plans are to develop additional products with the high latitudes/arctic in mind.