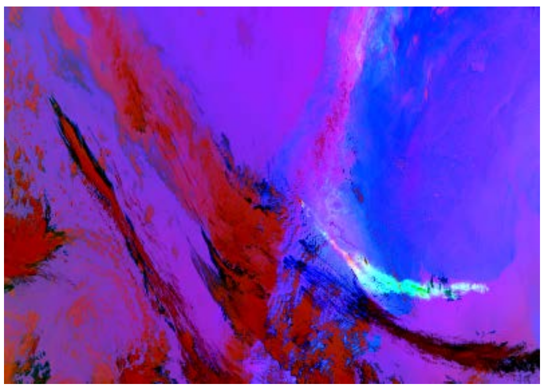
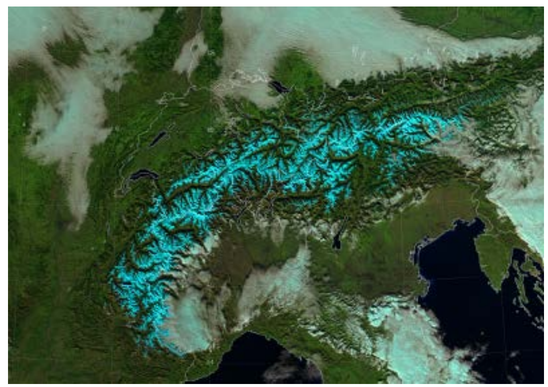
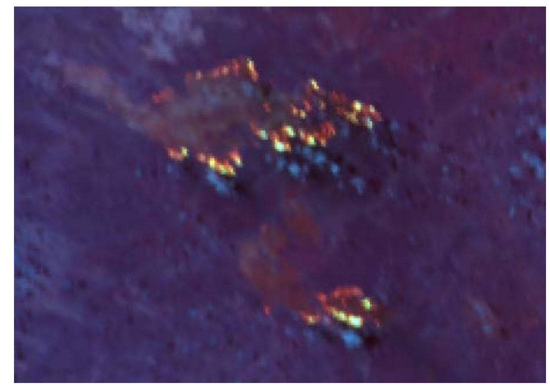
RGB Applications of VIIRS Imagery in Support of a Weather-Ready Nation







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Introduction to VIIRS

- VIIRS: Visible and Infrared Imaging Radiometer Suite
- Launched on Suomi-NPP, a polar-orbiting satellite with sun-synchronous (13:30 LT) orbit, on 28 October 2011
- Designed to combine the best of MODIS, AVHRR and DMSP OLS and improve upon them (where possible)

Table 1. VIIRS channels.

Band number/gain	VIIRS wavelength (μm)	VIIRS nadir pixel size along track × cross track (km)	Primary application
M1, dual	0.412	0.742 × 0.259	Ocean color, aerosols
M2, dual	0.445	0.742 × 0.259	Ocean color, aerosols
M3, dual	0.488	0.742 × 0.259	Ocean color, aerosols
M4, dual	0.555	0.742 × 0.259	Ocean color, aerosols
I1, single	0.640	0.371 × 0.387	Imagery, vegetation
M5, dual	0.672	0.742 × 0.259	Ocean color, aerosols
M6, single	0.746	0.742 × 0.776	Atmospheric correction
I2, single	0.865	0.371 × 0.387	Vegetation
M7, dual	0.865	0.742 × 0.259	Ocean color, aerosols
DNB, multiple	0.7	0.742 × 0.742	Imagery
M8, single	1.24	0.742 × 0.776	Cloud particle size
M9, single	1.38	0.742 × 0.776	Cirrus cloud cover
M10, single	1.61	0.742 × 0.776	Snow fraction
I3, single	1.61	0.371 × 0.387	Binary snow map
M11, single	2.25	0.742 × 0.776	Clouds
M12, single	3.70	0.742 × 0.776	Sea surface temperature (SST)
I4, single	3.74	0.371 × 0.387	Imagery, clouds
M13, dual	4.05	0.742 × 0.259	SST, fires
M14, single	8.55	0.742 ×0.776	Cloud-top properties
M15, single	10.76	0.742 × 0.776	SST
I5, single	11.45	0.371 × 0.387	Cloud imagery
M16, single	12.01	0.742 × 0.776	SST

From Lee et al. (2006), BAMS

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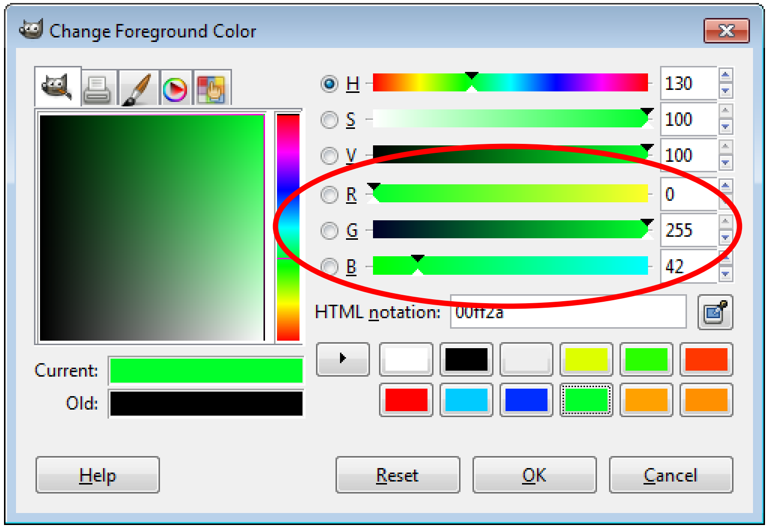
Introduction to RGB Composites

- Every color on a computer monitor may be expressed as 1-byte (8-bit) values of red, green and blue (0-255)
- RGB composites take three different values (channels or channel differences, for example), scale them from 0-255 and assign them to red, green or blue

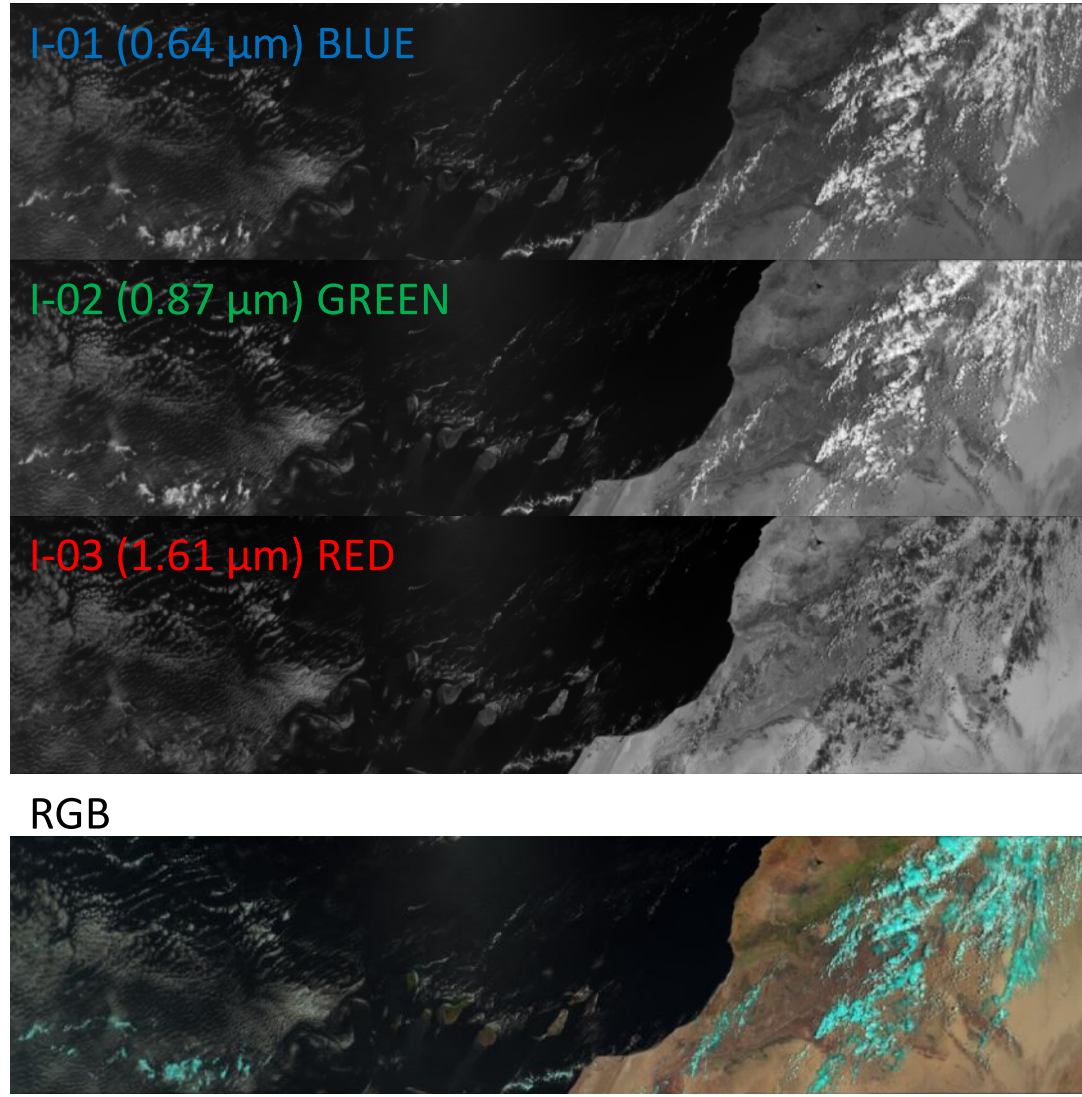


- In this way, three different images are combined to produce one color image

RGB Composites Example

Example: Take the VIIRS band I-01, I-02 and I-03 reflectances (on a scale from 0-1), scale them from 0-255, then assign them to blue, green and red as at right.

When you combine them into a single image, you get more information than any single channel can provide…



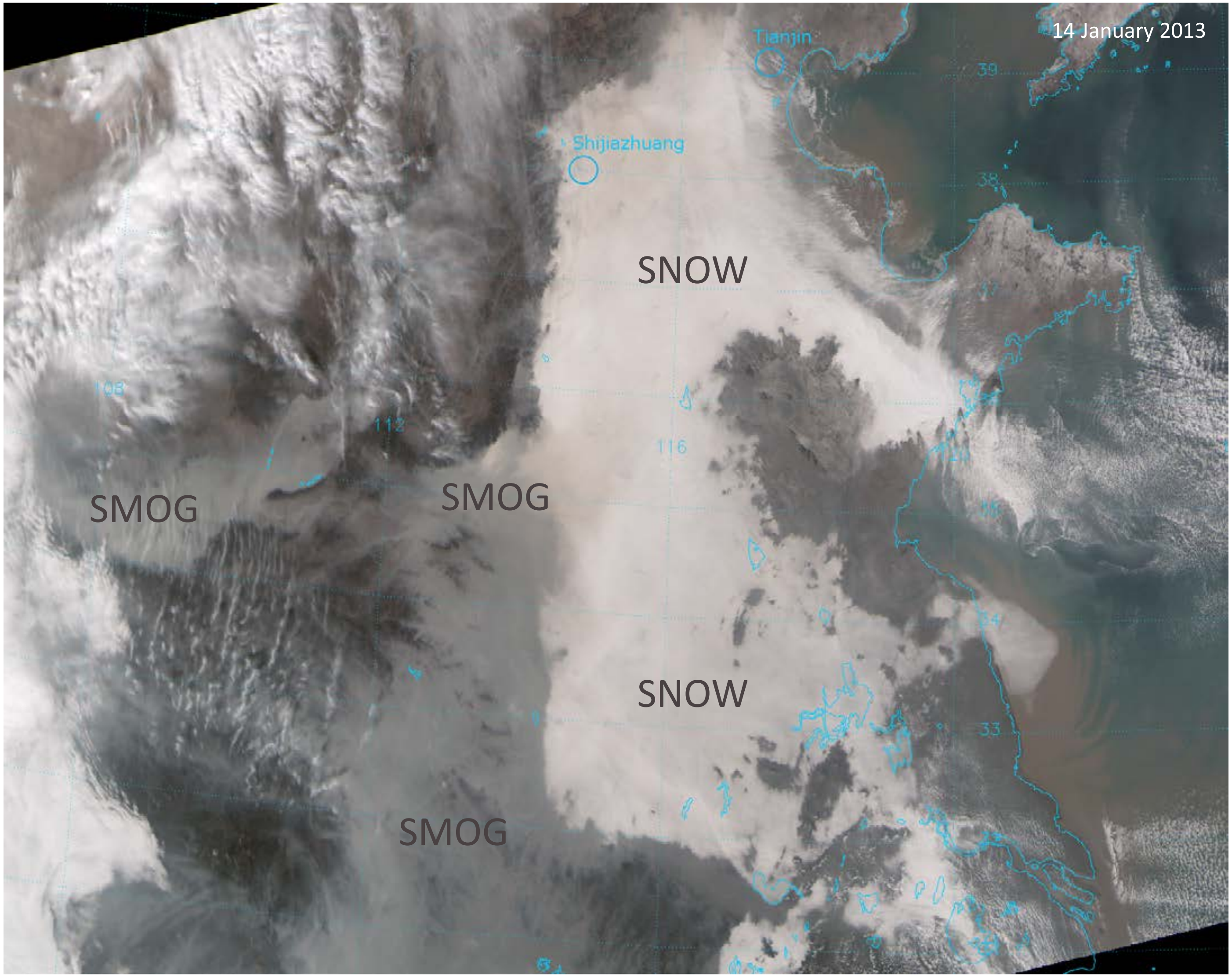
True Color RGB

When you combine channels in the blue, green, and red portions of the visible spectrum, you get the "True Color" RGB. (M-03/0.488 µm, M-04/0.555 µm, M-05/0.672 µm)

The True Color image represents what an astronaut would see from the International Space Station – the "true color" of the objects.

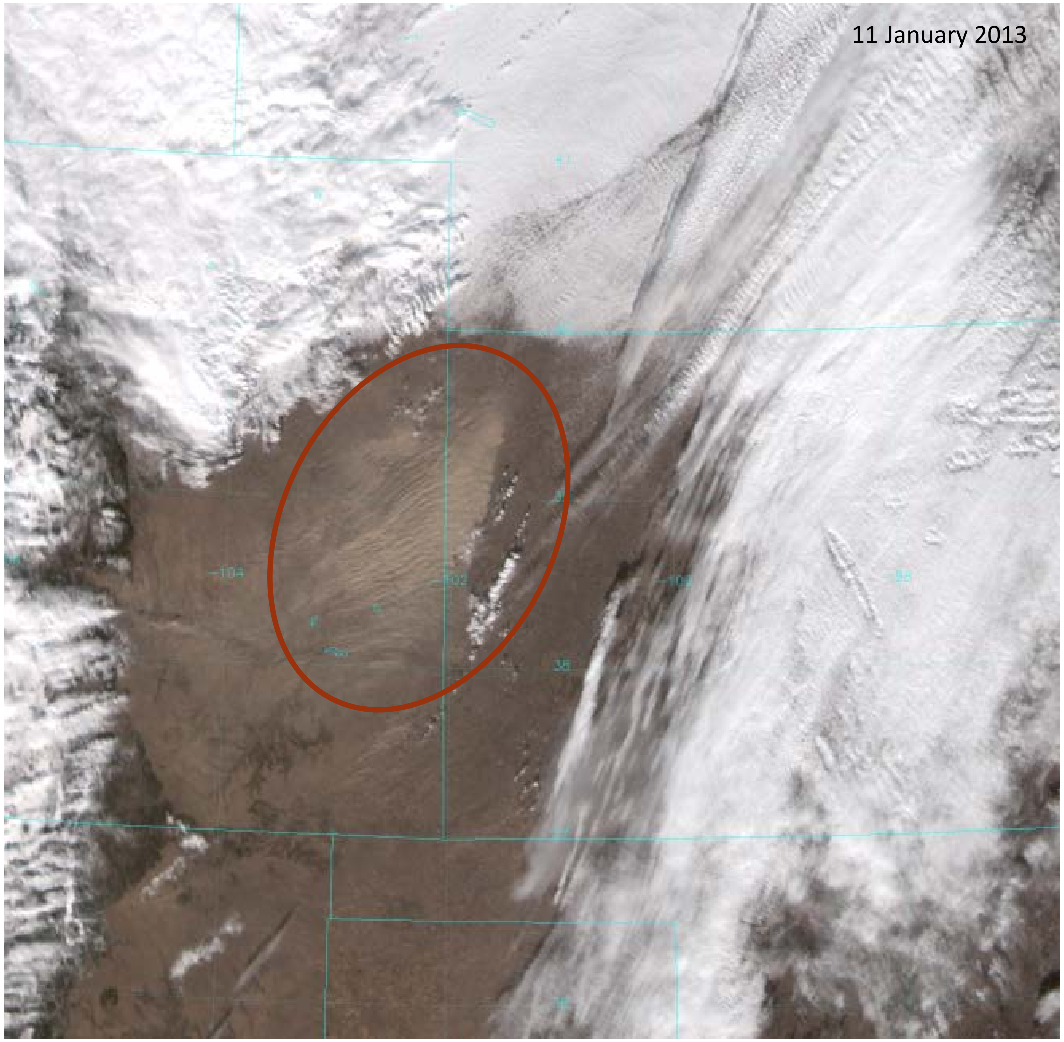
Very useful for detecting smoke, haze, smog, dust, water turbidity, vegetation health…

True Color RGB Example: Smog



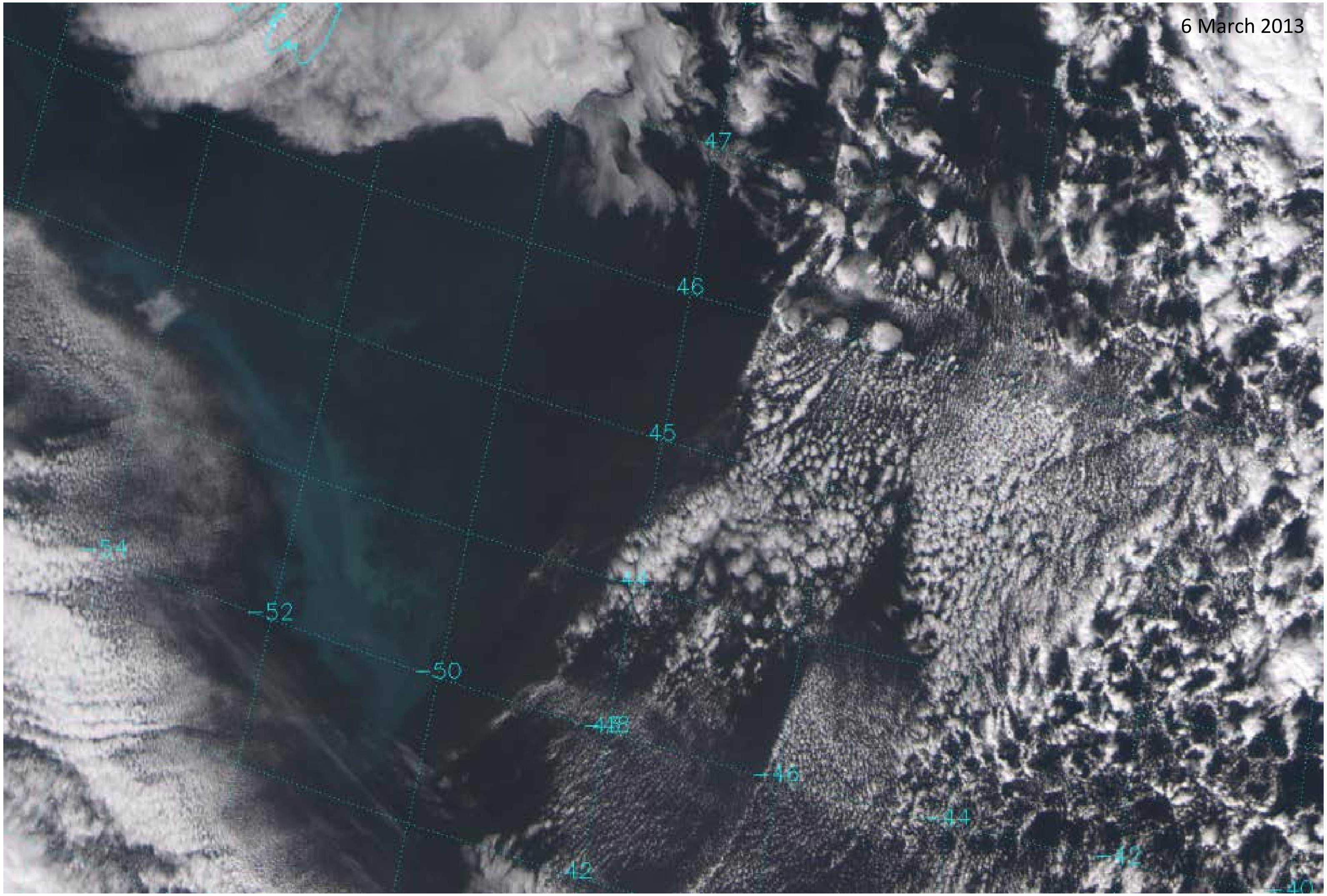
Smog over eastern China
14 January 2013

True Color RGB Example: Dust



Dust storm over eastern Colorado/western Kansas
11 January 2013

True Color RGB Example: Phytoplankton



Phytoplankton bloom off the coast of Newfoundland
6 March 2013

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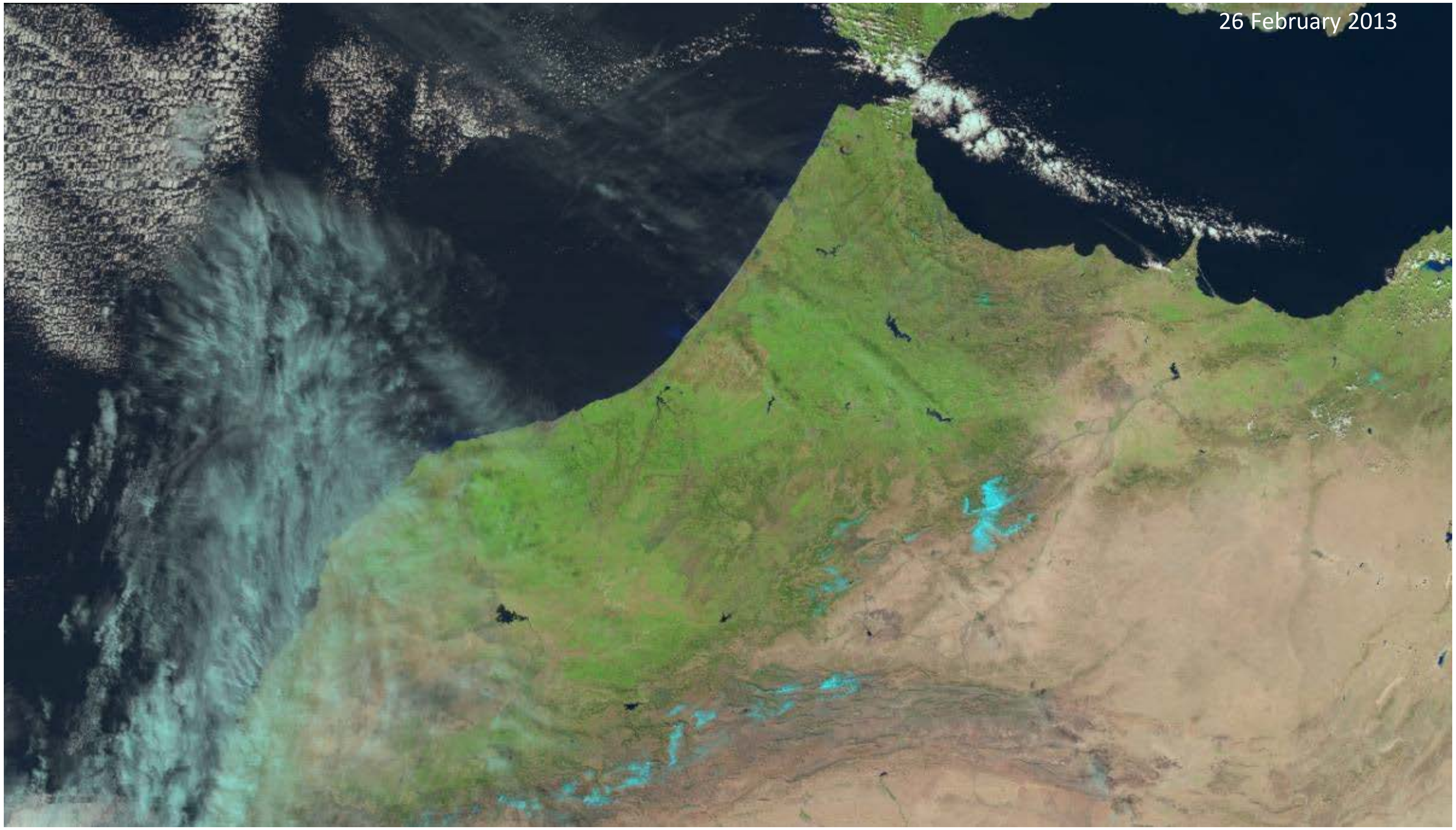
Natural Color RGB

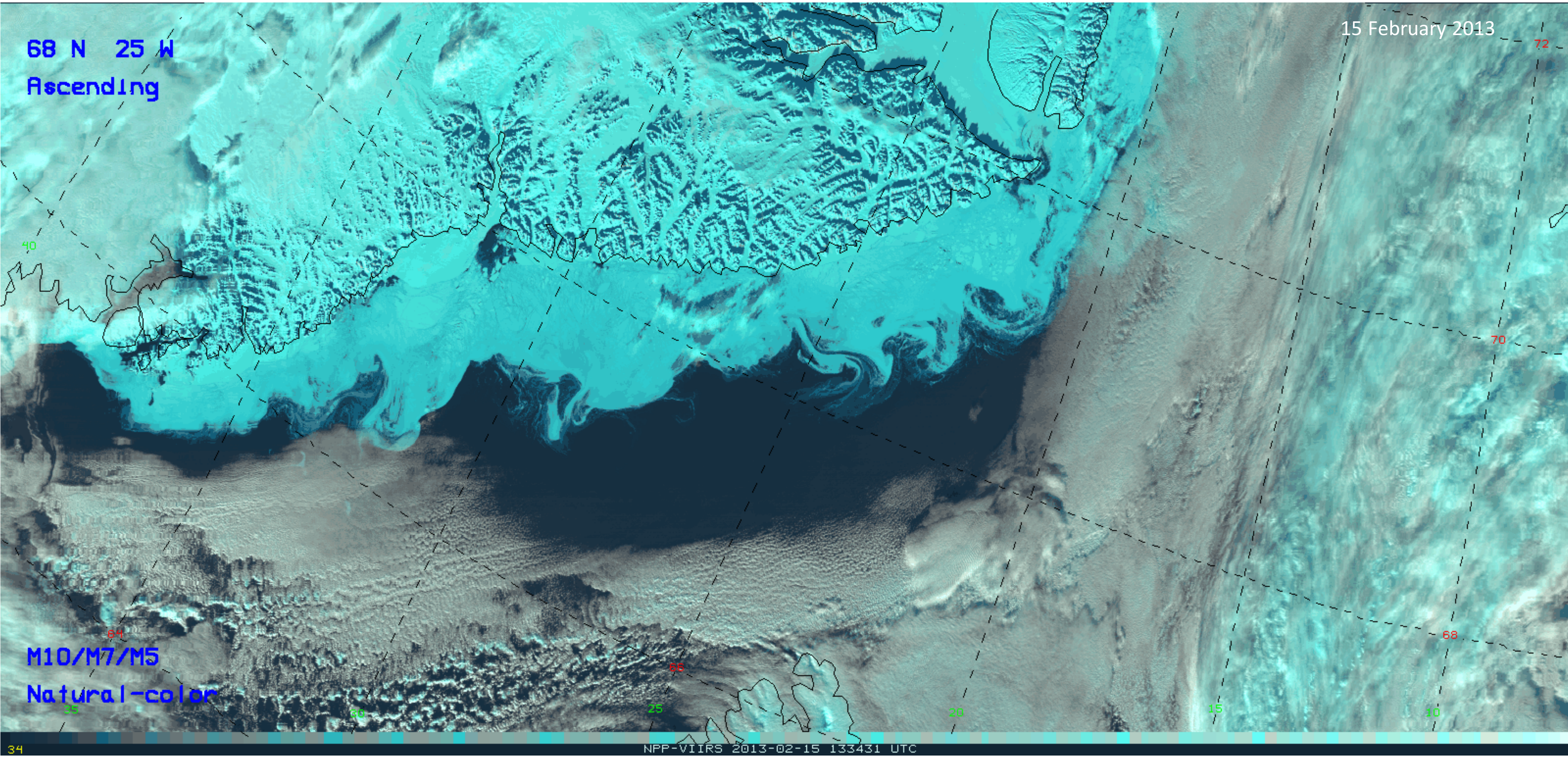


Originally developed by EUMETSAT, the Natural Color RGB is I-01/M-05/0.67 µm, I-02/M-07/0.86 µm, and I-03/M-10/1.61 µm.

Similar to True Color, except ice clouds and ice/snow stand out as the color cyan. Water appears nearly black. Strong vegetation signal. No atmospheric correction needed. Very useful for snow/ice discrimination, cloud phase discrimination, vegetation health and also for monitoring flooding…

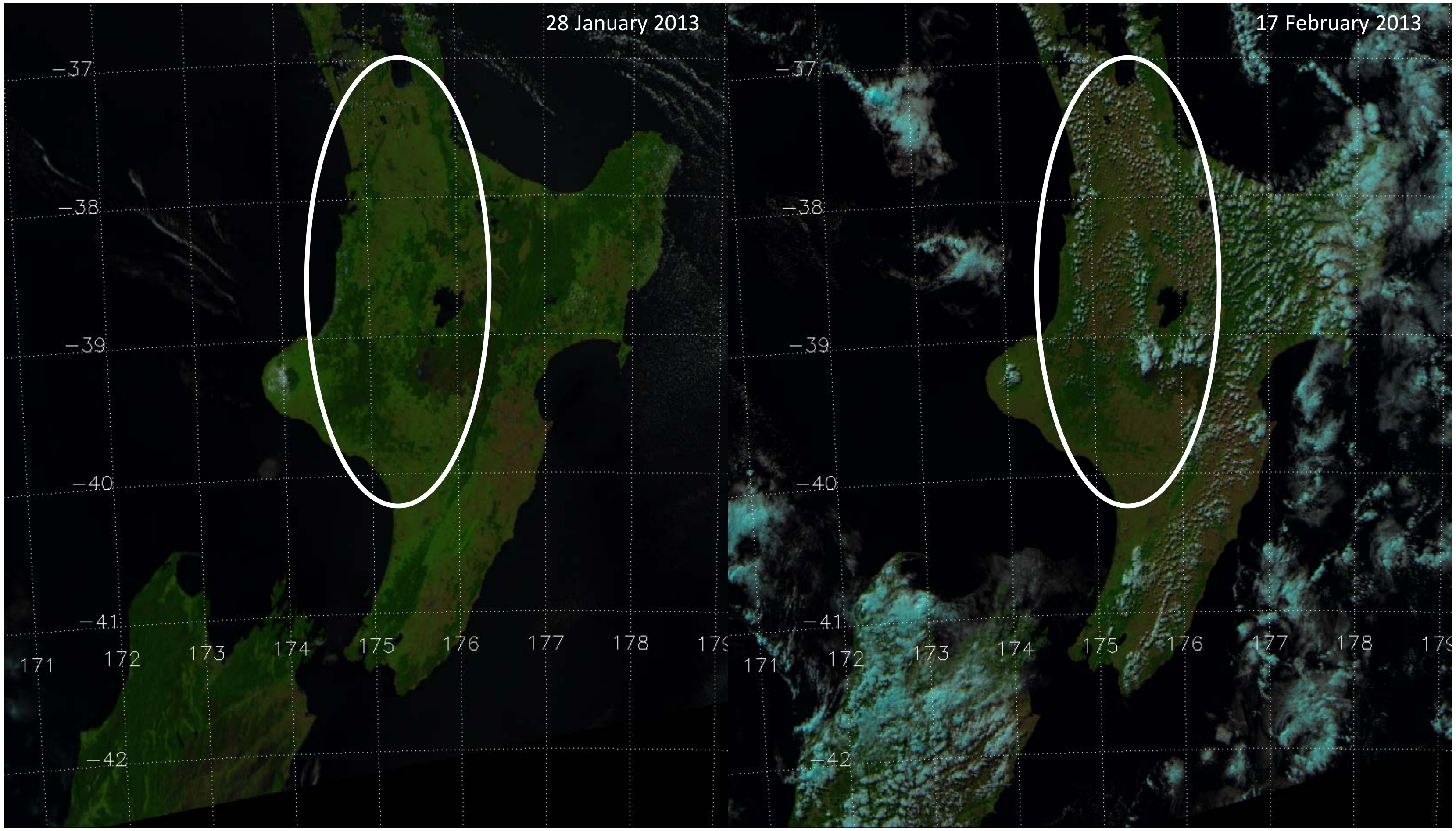
True Color and Natural Color images are featured in near-real time here: http://rammb.cira.colostate.edu/ramsdis/online/npp_viirs.asp

Natural Color Example: Ice Breakup



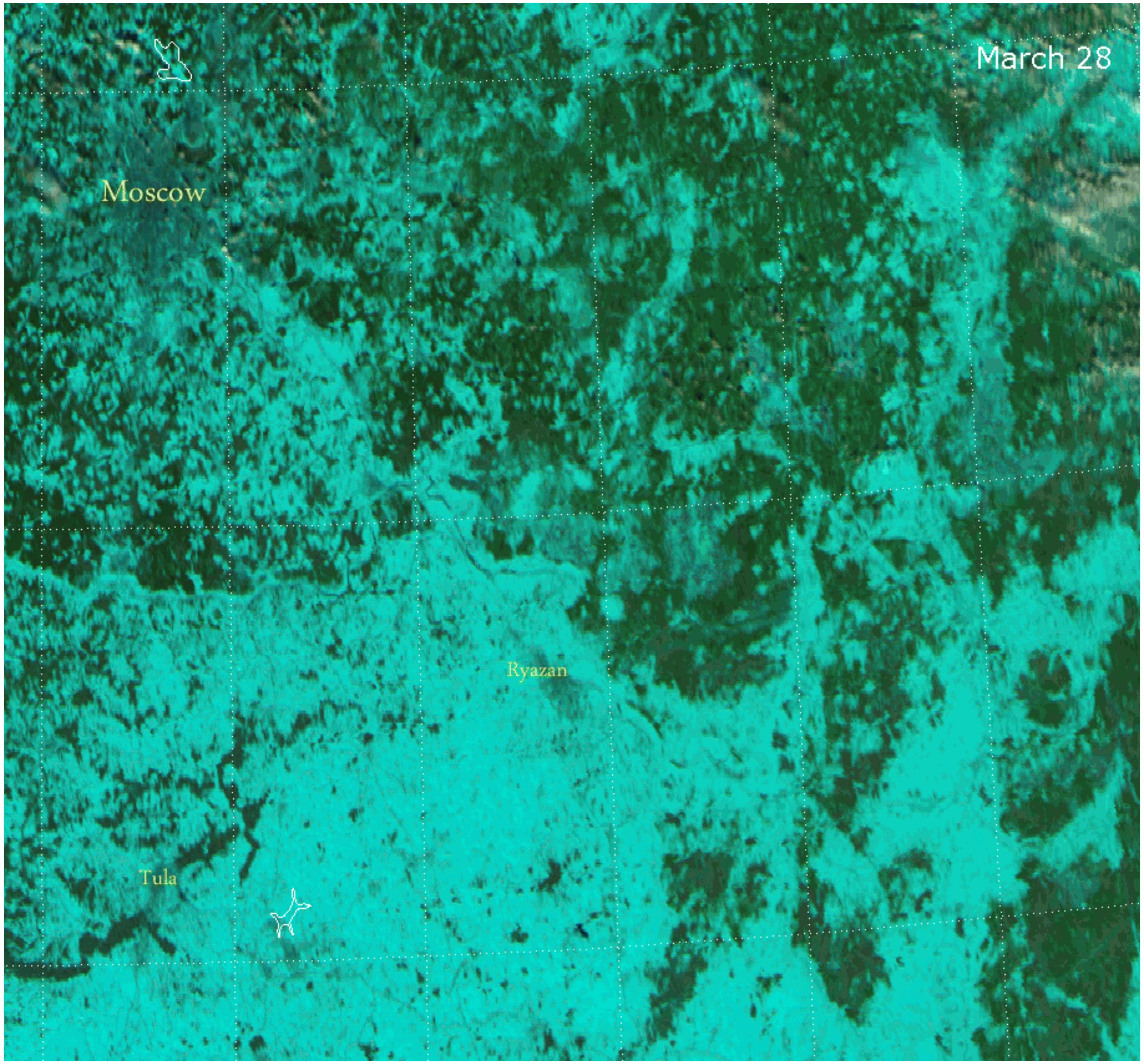
Ice shaped by eddies in the East Greenland Current off the coast of Greenland
15 February 2013

Natural Color Example: Monitoring Drought



Drought evident on the North Island of New Zealand
January-February 2013

Natural Color Example: Monitoring Floods



Record Spring snowmelt leads to flooding along the Oka River in western Russia
March-April 2013

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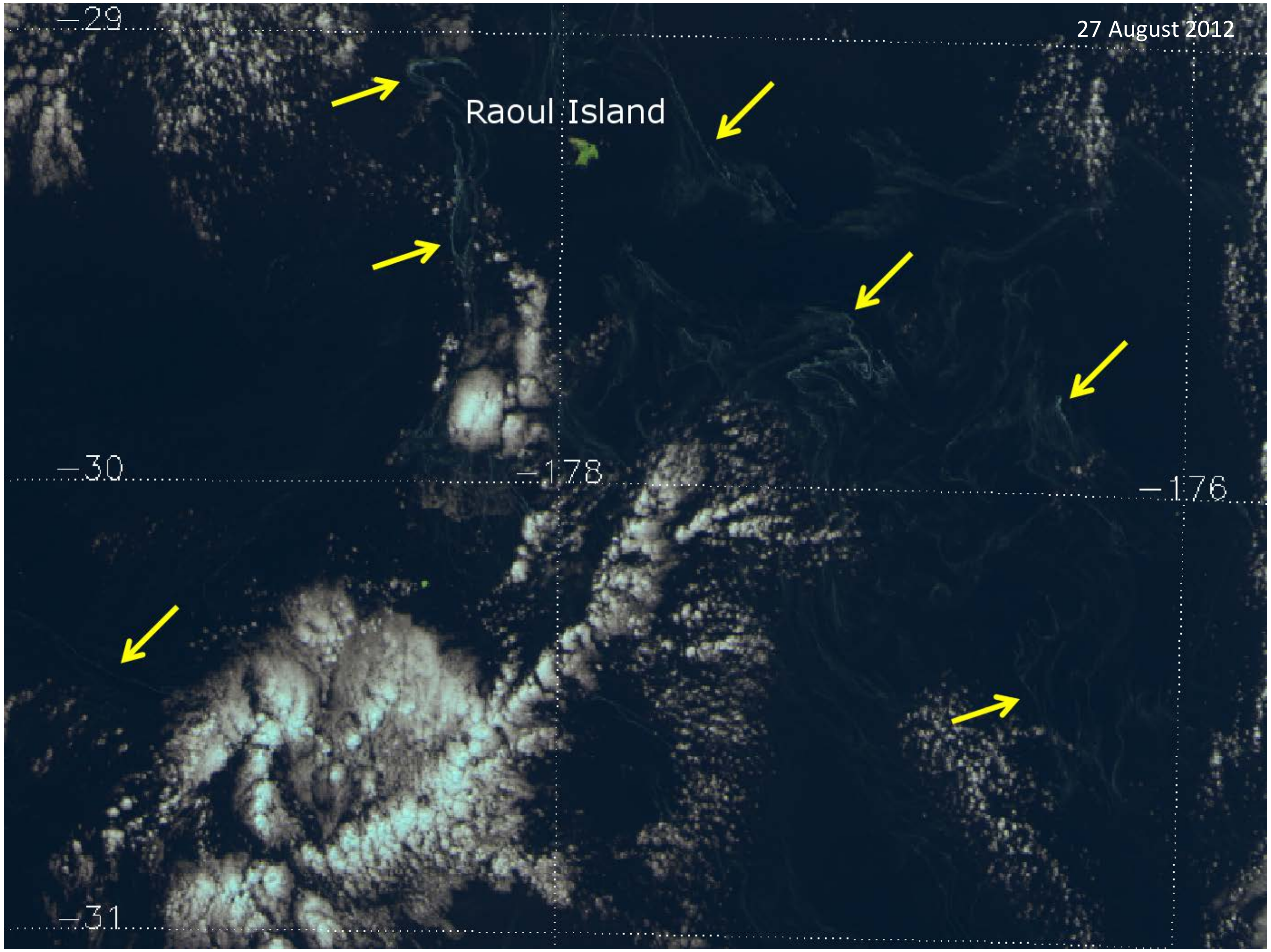
Natural Color Example: Pumice Rafts



Pumice rafts from the underwater eruption of the Havre Seamount
27 August 2012

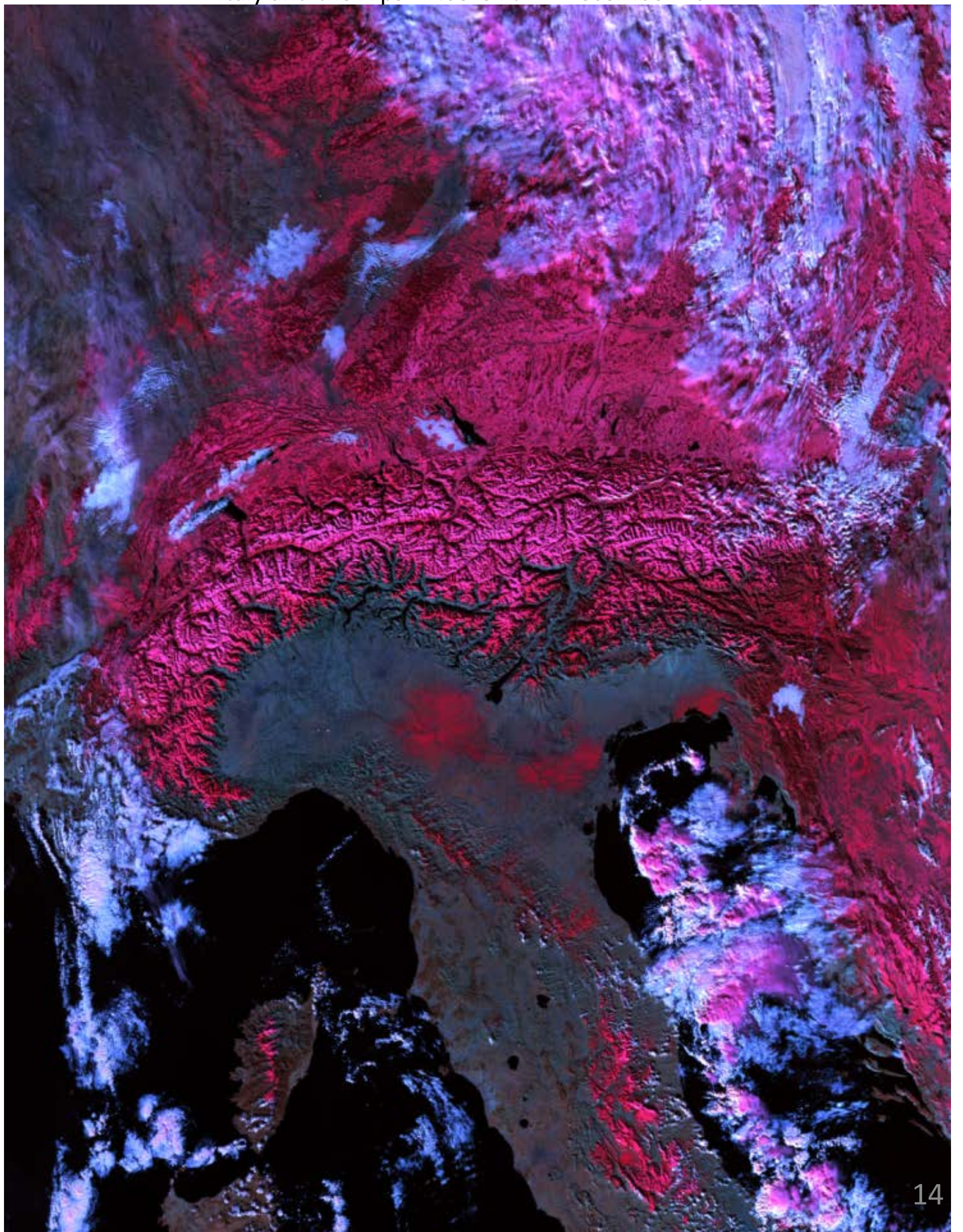
RGBs for Snow/Ice Discrimination

- True Color RGB of the Alps
  - What is snow and what is cloud?

- Natural Color RGB discriminates snow and ice from liquid cloud easily
  - some ice cloud present, not so easy to discriminate

- "VIIRS Snow" RGB highlights snow (red) against ice clouds (pale pink)
  - M-11/2.25 µm, M-10/1.61 µm, M-07/0.86 µm
  - Variation of "Snow RGB" from EUMETSAT, which uses 3.9 µm band in the place of the 2.25 µm band

Italy and the Alps 12:03 UTC 12 December 2012



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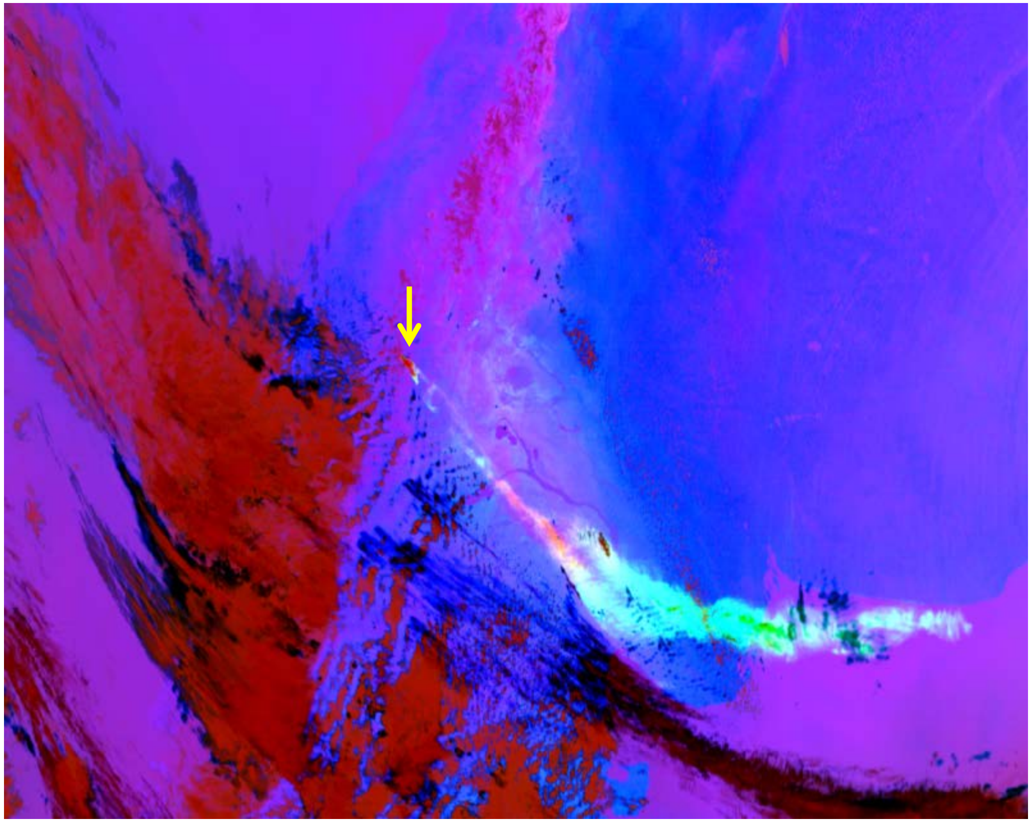
Volcanic Ash and SO_2 Detection

- Eruption of Copahue volcano, Chile/Argentina
- True Color image identifies ash plume as gray/brown cloud near volcano (yellow arrow)
- EUMETSAT "Dust" RGB detects SO_2 plume extending far away from volcano
  - M-15 (10.7 µm)
  - M-15 (10.7 µm) – M-14 (8.5 µm)
  - M-16 (12.0 µm) – M-15 (10.7 µm)

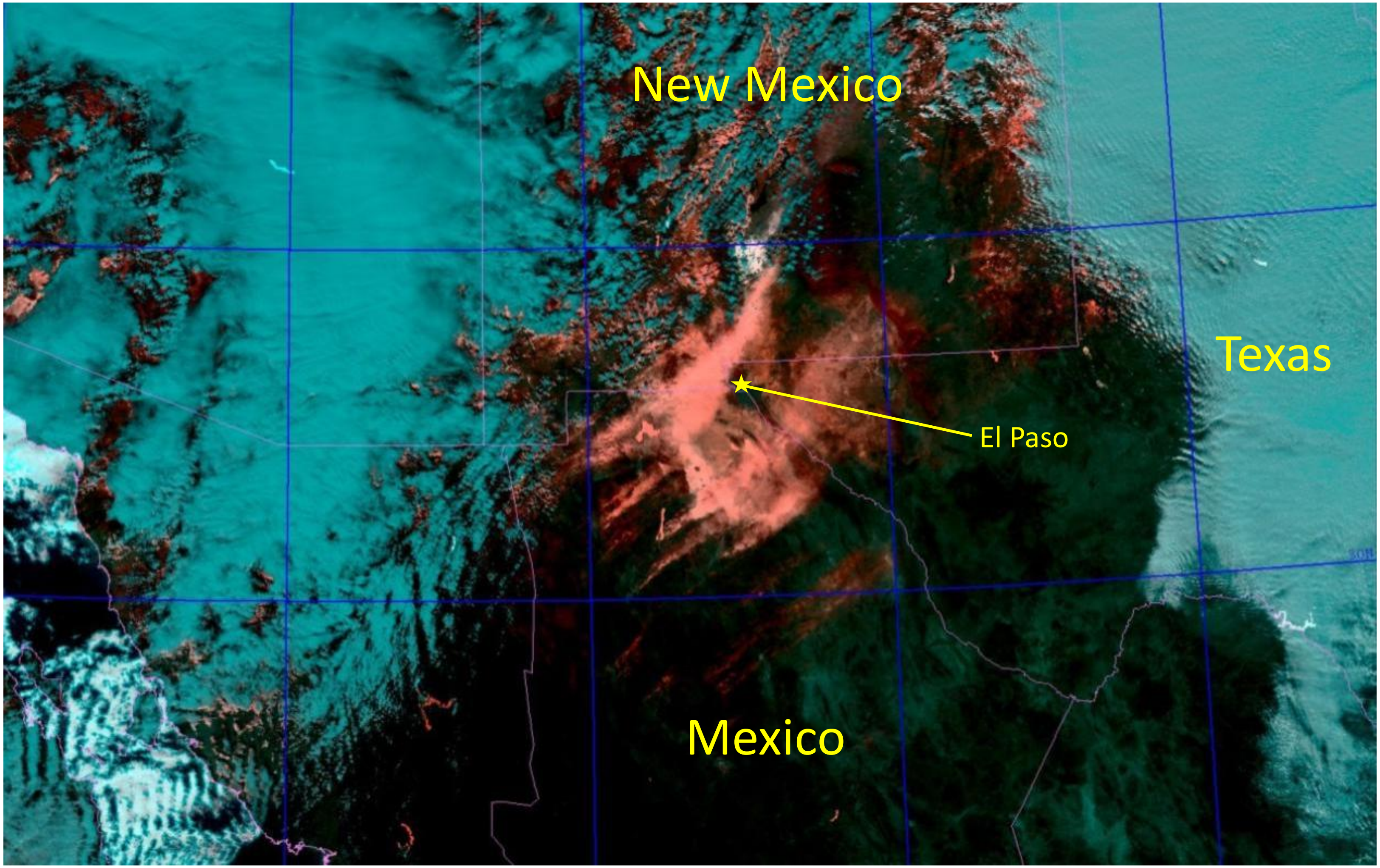
Copahue volcano, Chile/Argentina 18:38 UTC 22 December 2012



- The "Dust" RGB was developed by EUMETSAT to detect Saharan dust plumes, but is useful for detecting volcanic ash as an 8.5 µm channel is sensitive to SO_2, a common by-product of volcanic eruptions

Dust Enhancement RGB

Dust storm over northern Mexico/southwest United States



- Dust is difficult to see in single channel images as well as the "True Color" RGB
- The Dust Enhancement product is developed at CIRA and uses information from 7 bands in the VIS/NIR/thermal-IR portions of the spectrum to highlight dust

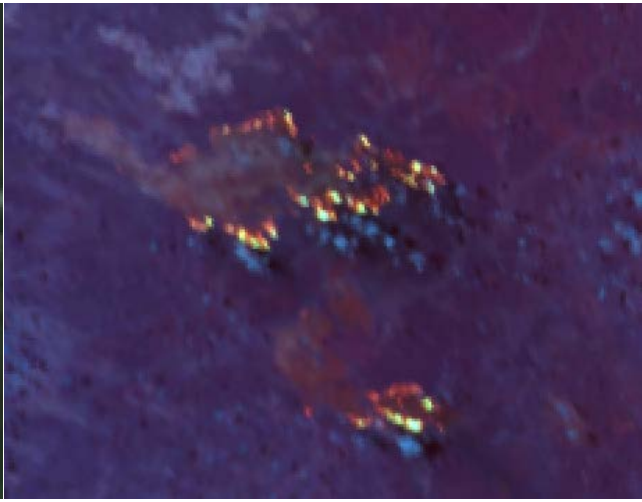
RGBs for Fire Detection

Fires in the Australian Outback 04:34 UTC 19 September 2012

SW-IR Image (3.9 μm)

“Natural Fire Color” RGB

“Fire Temperature” RGB



- Numerous fires visible in M-13/ 3.9 μm image (black hot spots)

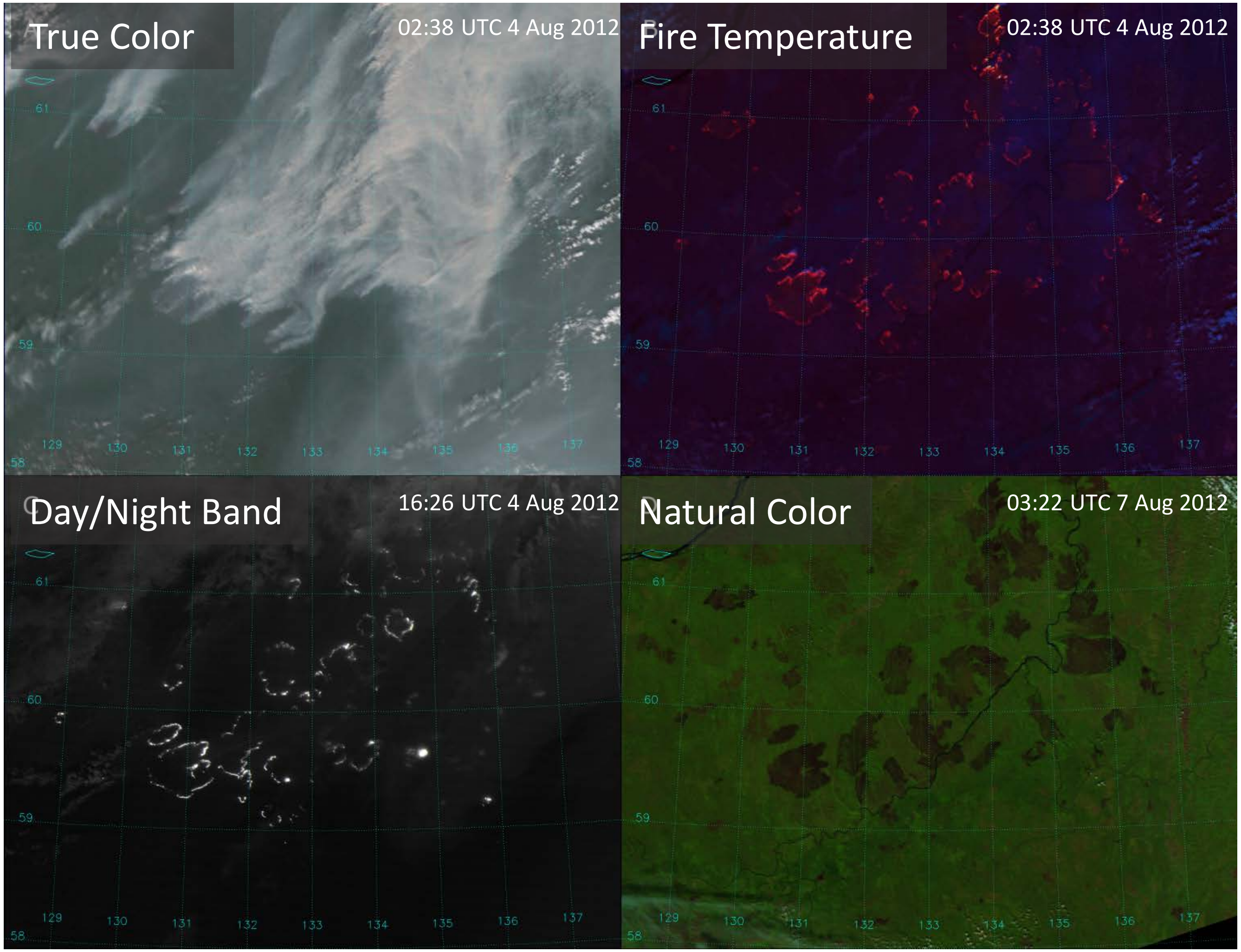
- CIRA’s “Natural Fire Color” RGB composite of M-5/0.67 μm, M-7/0.86 μm and M-11/2.25 μm

- CIRA’s “Fire Temperature” RGB composite of M-10/1.61 μm, M-11/2.25 μm and M-12/ 3.7 μm

- “Natural Fire Color” RGB is similar to the “Natural Color” RGB, except fires show up more easily (bright red pixels), detects lower temperature fires

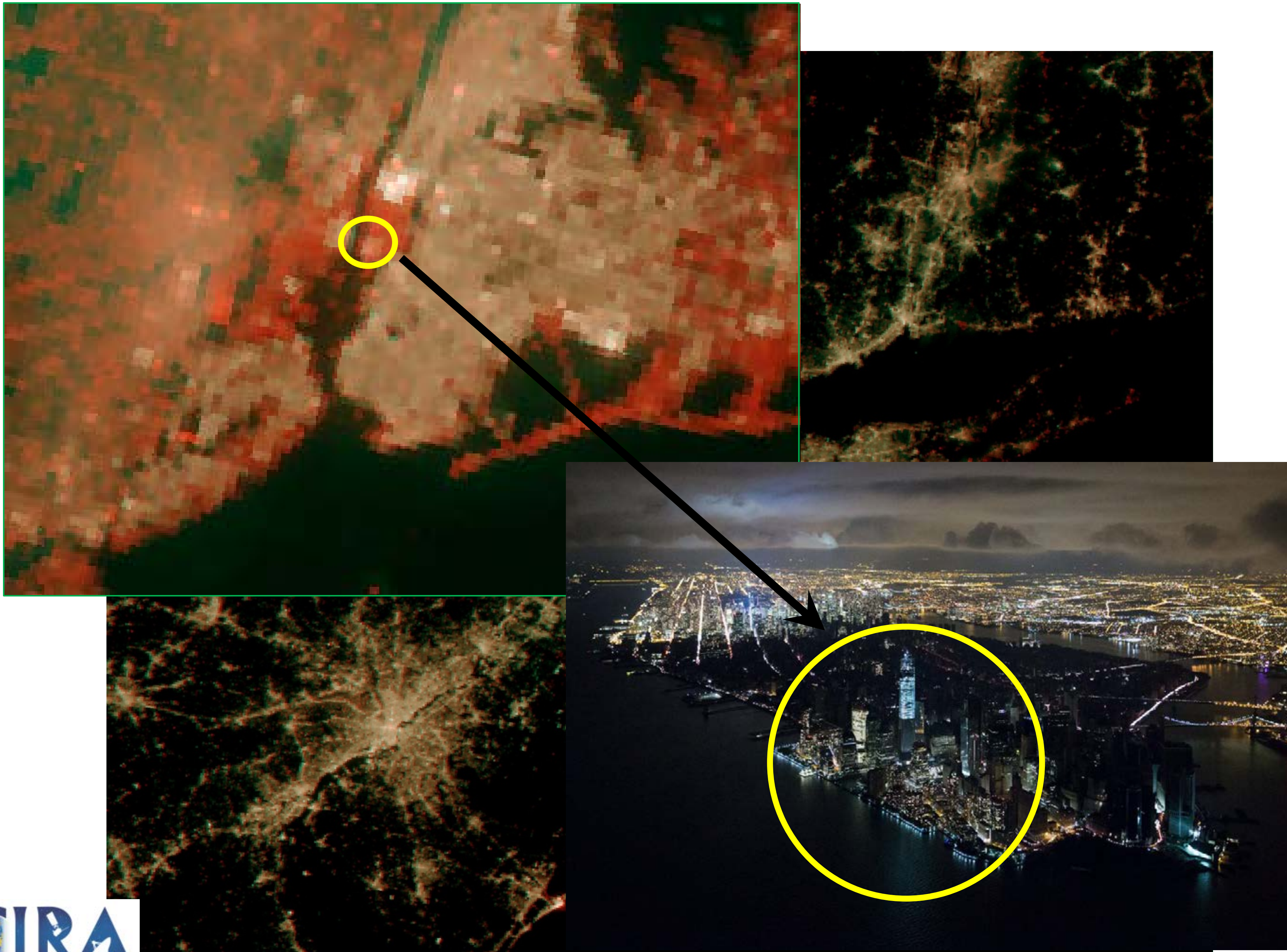
- “Fire Temperature” RGB has fires show up as white, yellow, orange or red (depending on temperature) against maroon-to-purple background

VIIRS and Fires: Bringing it all together



VIIRS RGBs capture fires from multiple perspectives: True Color detects smoke, Fire Temperature detects hot spots, DNB detects visible light emissions and smoke at night and Natural Color highlights the burn scars

Day/Night Band RGB for Power Outages



Summary

- VIIRS offers nearly limitless possibilities for RGB compositing
- RGB composites have many uses:
  - Snow/ice detection
  - Cloud phase discrimination
  - Smoke, dust, smog, volcanic ash
  - Fires
  - Droughts, floods
  - Vegetation health
  - Water turbidity, algae/phytoplankton blooms, pumice rafts
  - Power outages

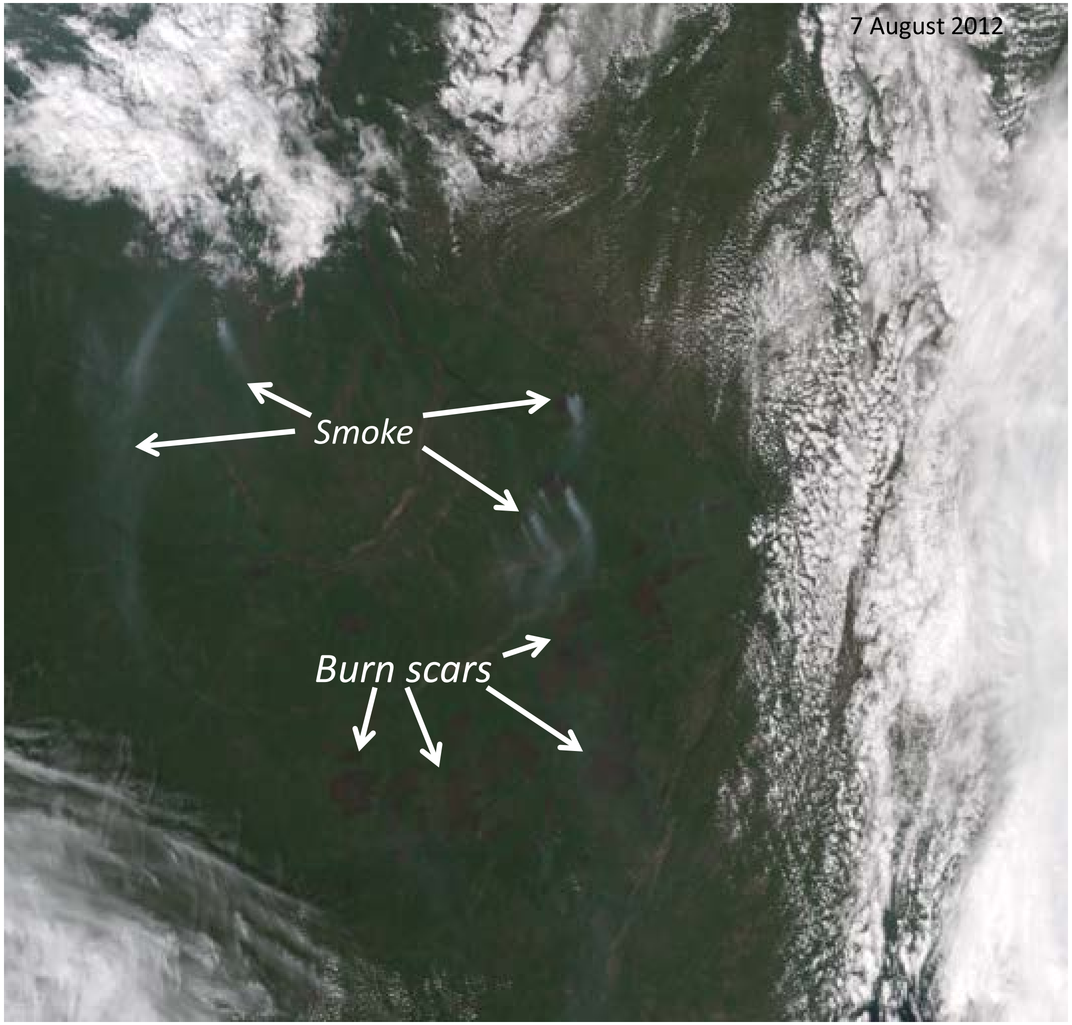
For more information:

VIIRS Imagery Blog: http://rammb.cira.colostate.edu/projects/npp/blog/

VIIRS EDR Imagery Team Website: http://rammb.cira.colostate.edu/projects/npp/

Journal article: Hillger et al. (2013), July issue of *BAMS*

True Color RGB Example: Fires



Fires in Siberia (Yakutia, Russia)
7 August 2012

RGBs for Fire Detection

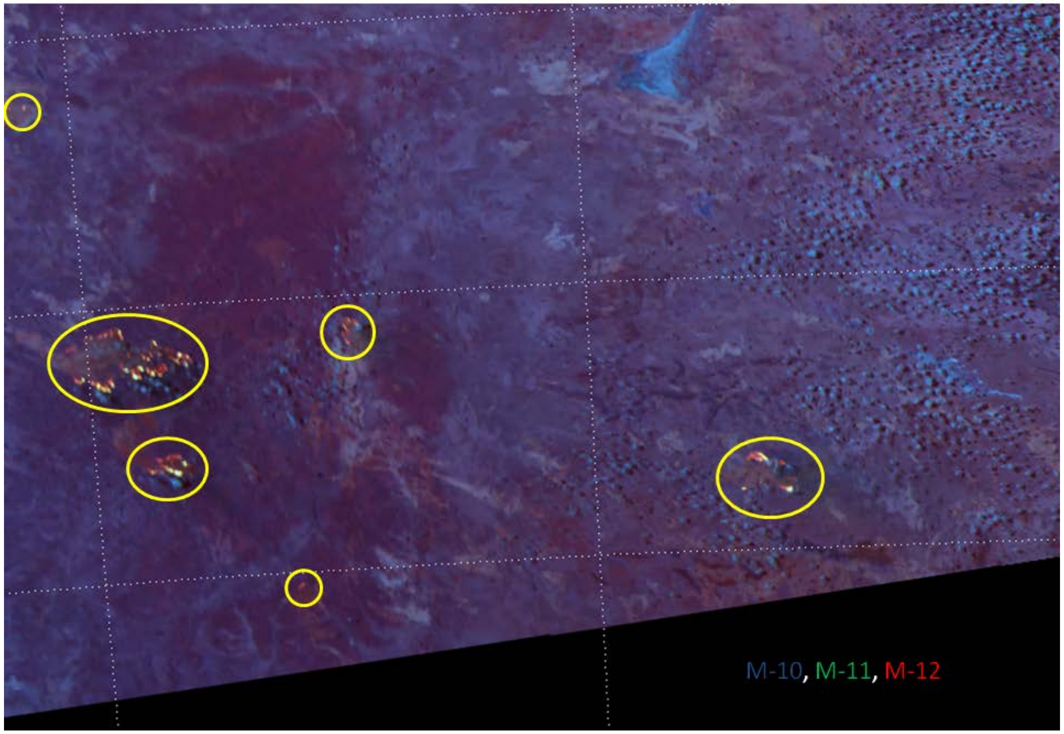
- Numerous fires visible in 3.9 µm image (M-13) of the Australian Outback

- "Natural Color" RGB detects hot active fires as red pixels

- "Natural Fire Color" RGB composite of M-5 (0.67 µm), M-7 (0.86 µm) and M-11 (2.25 µm)

- "Fire Temperature" RGB composite of M-10 (1.61 µm), M-11 (2.25 µm) and M-12 (3.7 µm)

04:34 UTC 19 September 2012



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