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NPOESS VIIRS: Design, Performance Estimates and Applications

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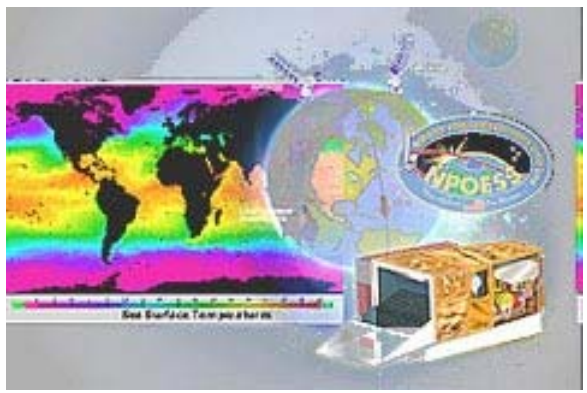
Overview

- The National Polar-orbiting Operational Environmental Satellite System (NPOESS) Visible Infrared Imaging Radiometer Suite (VIIRS) will offer dramatic spatial, spectral, and radiometric performance improvements over current operational capabilities
  - NOAA Advanced Very High Resolution Radiometer (AVHRR) offers 1 km nadir spatial resolution in 5 spectral bands
  - The Defense Meteorological Satellite Program (DMSP) Operational Line-scanning System (OLS) offers near constant contrast 1.8km day-night cloud imaging and visible and thermal imagery

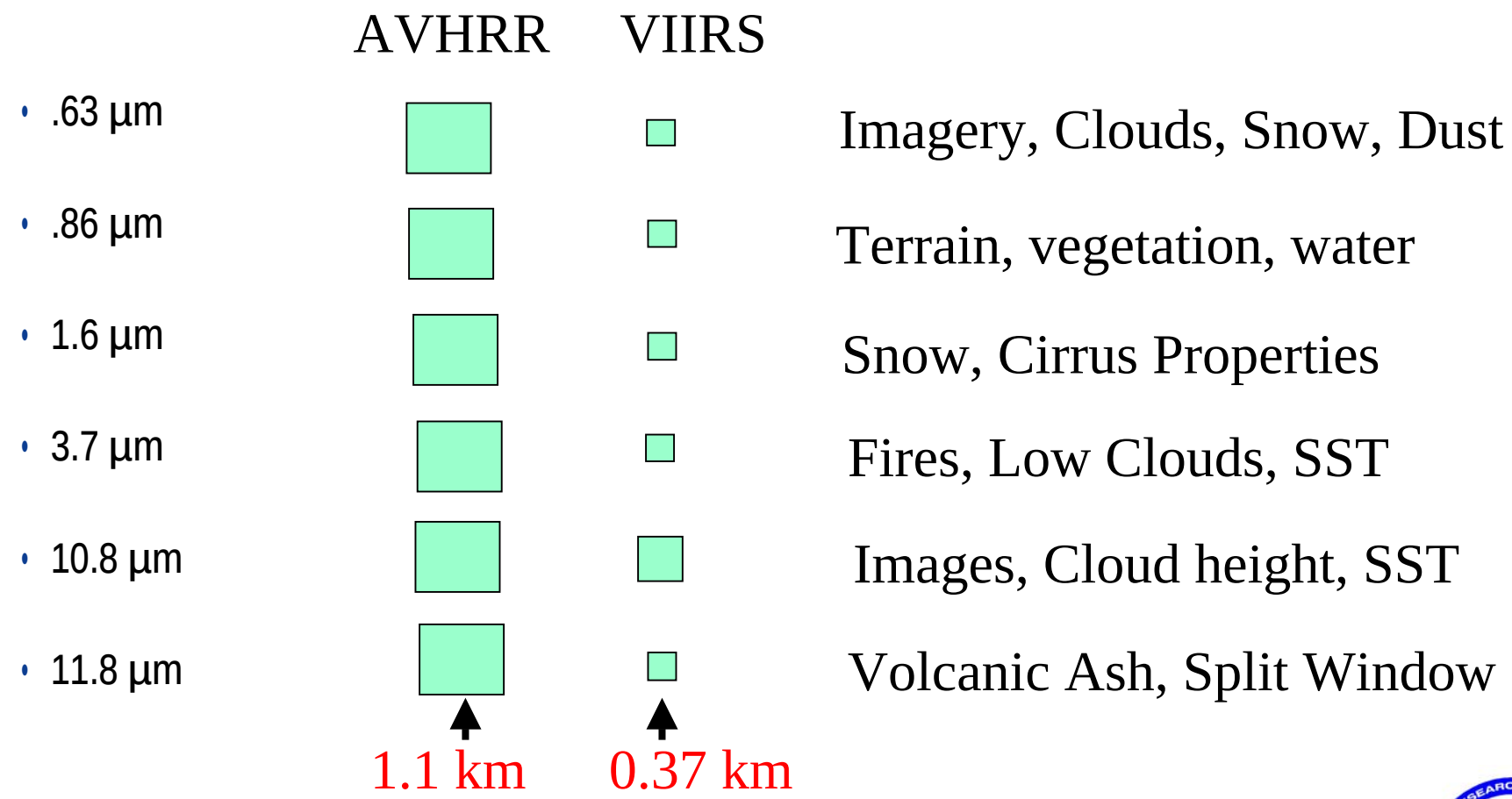


VIIRS

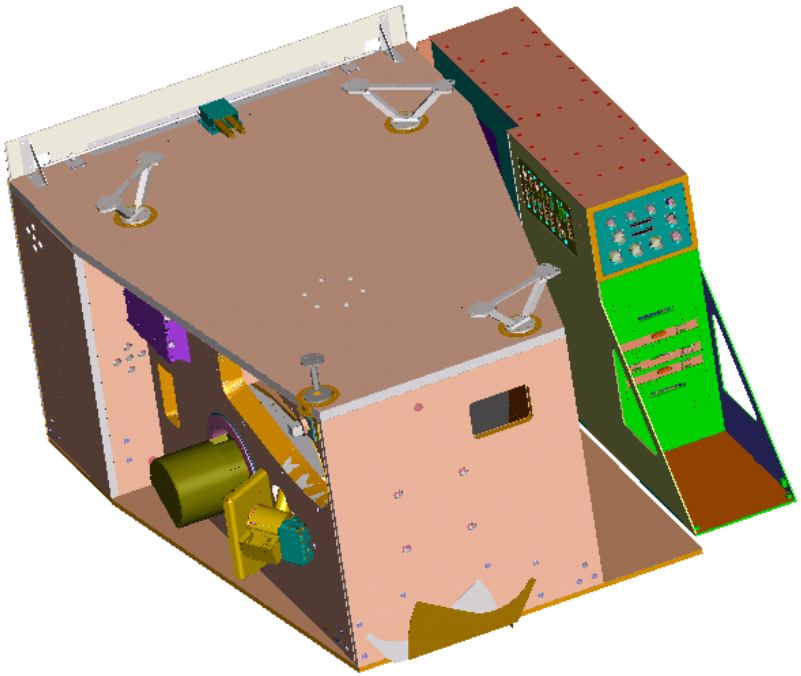
- VIIRS offers 22 band spectroradiometry comparable to NASA's MODerate-resolution Imaging Spectroradiometer (MODIS).

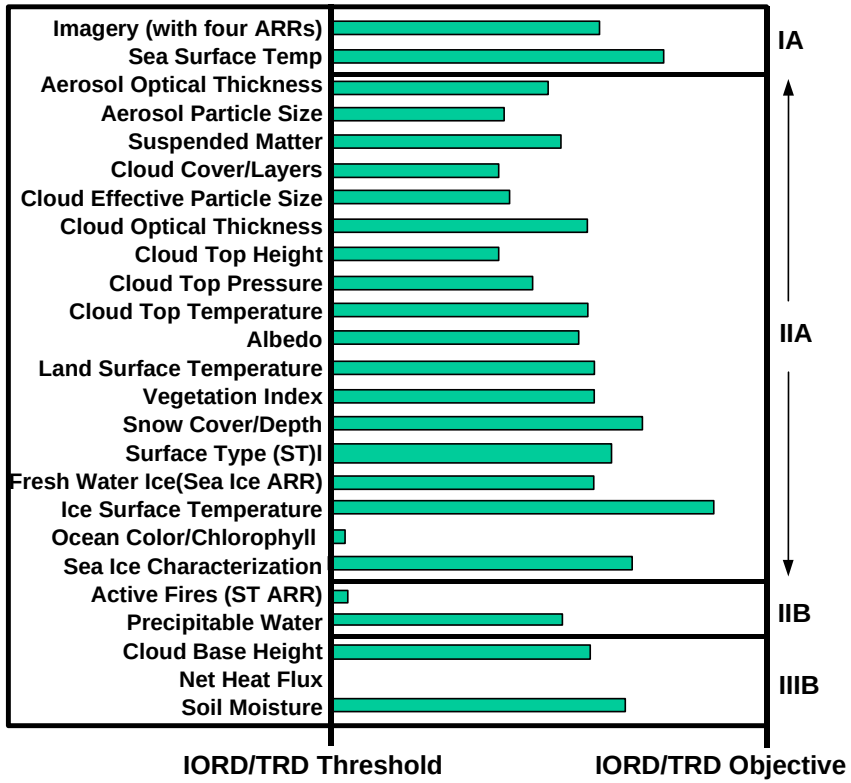
- On NPP and NPOESS
- 3000 Km Swath
- Day-night cloud imagery (constant contrast 750 m resolution)
- 4:1 better edge-of-scan spatial resolution than AVHRR or MODIS

NOAA AVRRR Contributions to VIIRS Subpoint Spatial Resolution



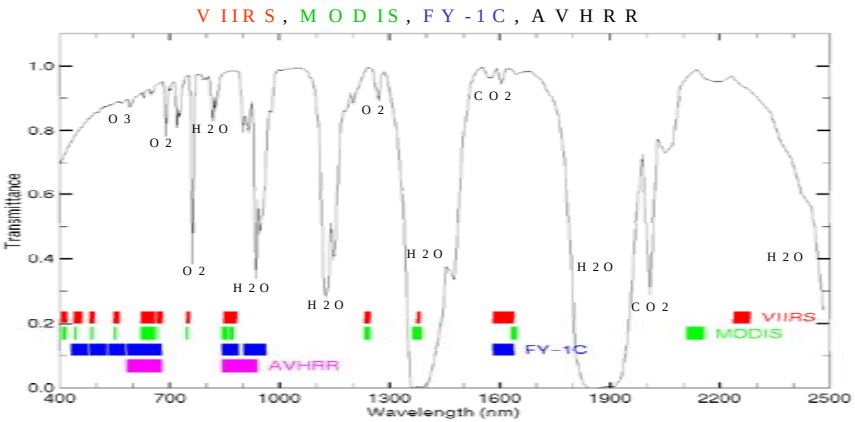
VIIRS System Provides Excellent Environmental Data Records (EDRs)

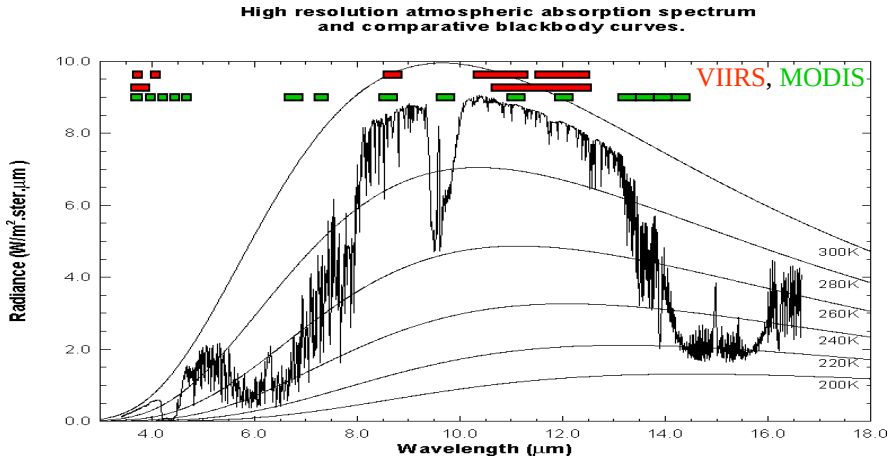




- VIIRS System Design based on integrated Sensor and Algorithms
- Engineering Development Unit (EDU) approaching integration
- EDR Science Algorithms developed, documented, and publicly released by Raytheon Technical Services Company (RTSC) Information Technology and Scientific Services (ITSS)

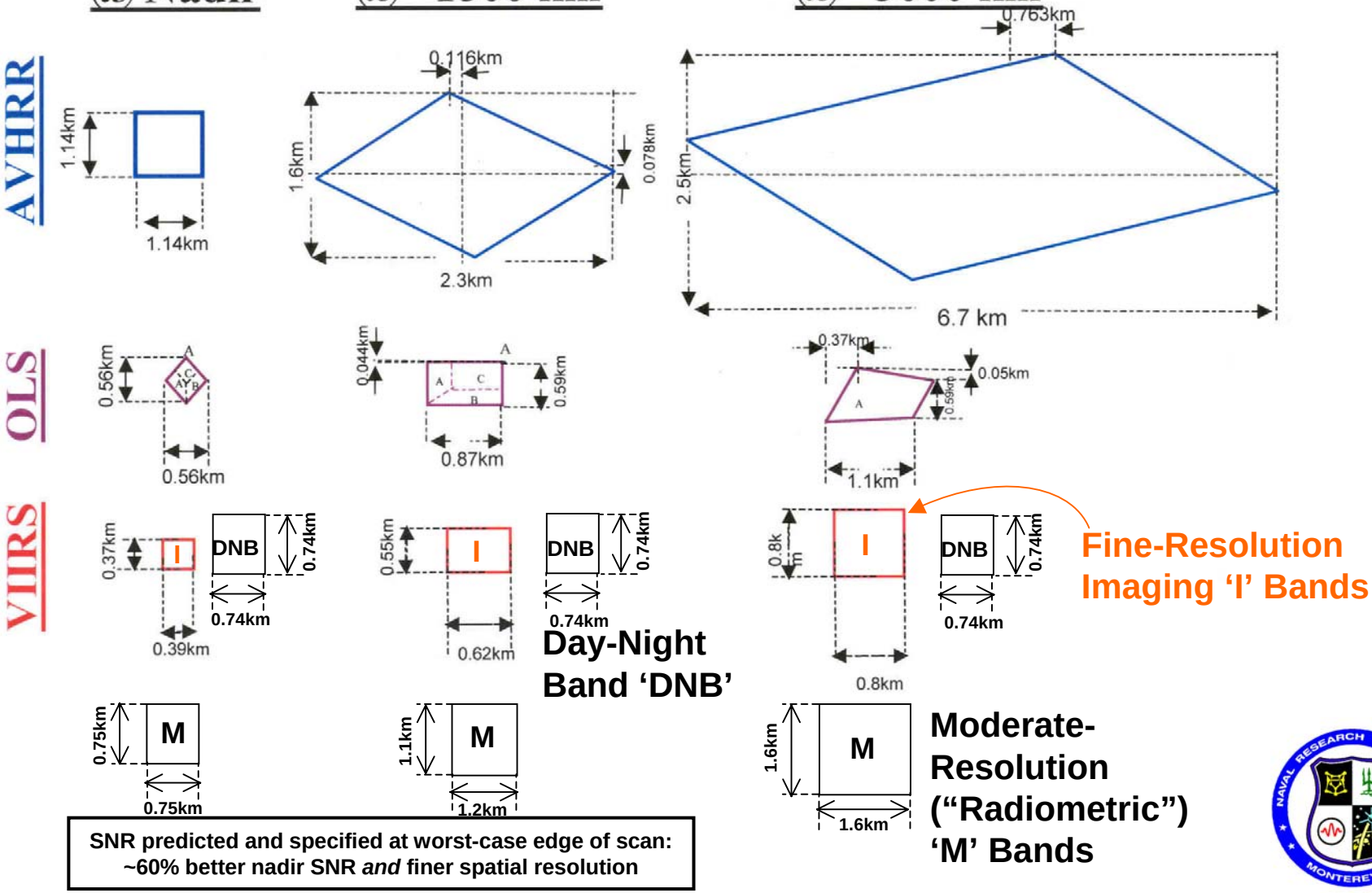
VIIRS VIS/NIR & IR Bands





		Band No.	Wave-length (μm)	Horiz Sample Interval (km Downtrack x Crosstrack)		Driving EDRs	Radi-ance Range	Ltyp or Ttyp
				Nadir	End of Scan			
VIS/NIR FPA	Silicon PIN Diodes	M1	0.412	0.742 x 0.259	1.60 x 1.58	Ocean Color Aerosols	Low High	44.9 155
		M2	0.445	0.742 x 0.259	1.60 x 1.58	Ocean Color Aerosols	Low High	40 146
		M3	0.488	0.742 x 0.259	1.60 x 1.58	Ocean Color Aerosols	Low High	32 123
		M4	0.555	0.742 x 0.259	1.60 x 1.58	Ocean Color Aerosols	Low High	21 90
		I1	0.640	0.371 x 0.387	0.80 x 0.789	Imagery	Single	22
		M5	0.672	0.742 x 0.259	1.60 x 1.58	Ocean Color Aerosols	Low High	10 68
		M6	0.746	0.742 x 0.776	1.60 x 1.58	Atmospheric Corr'n	Single	9.6
		I2	0.865	0.371 x 0.387	0.80 x 0.789	NDVI	Single	25
		M7	0.865	0.742 x 0.259	1.60 x 1.58	Ocean Color Aerosols	Low High	6.4 33.4
CCD		DNB	0.7	0.742 x 0.742	0.742 x 0.742	Imagery	Var.	6.70E-05
S/MWIR	PV HgCdTe (HCT)	M8	1.24	0.742 x 0.776	1.60 x 1.58	Cloud Particle Size	Single	5.4
		M9	1.378	0.742 x 0.776	1.60 x 1.58	Cirrus/Cloud Cover	Single	6
		I3	1.61	0.371 x 0.387	0.80 x 0.789	Binary Snow Map	Single	7.3
		M10	1.61	0.742 x 0.776	1.60 x 1.58	Snow Fraction	Single	7.3
		M11	2.25	0.742 x 0.776	1.60 x 1.58	Clouds	Single	0.12
		I4	3.74	0.371 x 0.387	0.80 x 0.789	Imagery Clouds	Single	270 K
		M12	3.70	0.742 x 0.776	1.60 x 1.58	SST	Single	270 K
		M13	4.05	0.742 x 0.259	1.60 x 1.58	SST Fires	Low High	300 K 380 K
LWIR	PV HCT	M14	8.55	0.742 x 0.776	1.60 x 1.58	Cloud Top Properties	Single	270 K
		M15	10.763	0.742 x 0.776	1.60 x 1.58	SST	Single	300 K
		I5	11.450	0.371 x 0.387	0.80 x 0.789	Cloud Imagery	Single	210 K
		M16	12.013	0.742 x 0.776	1.60 x 1.58	SST	Single	300 K

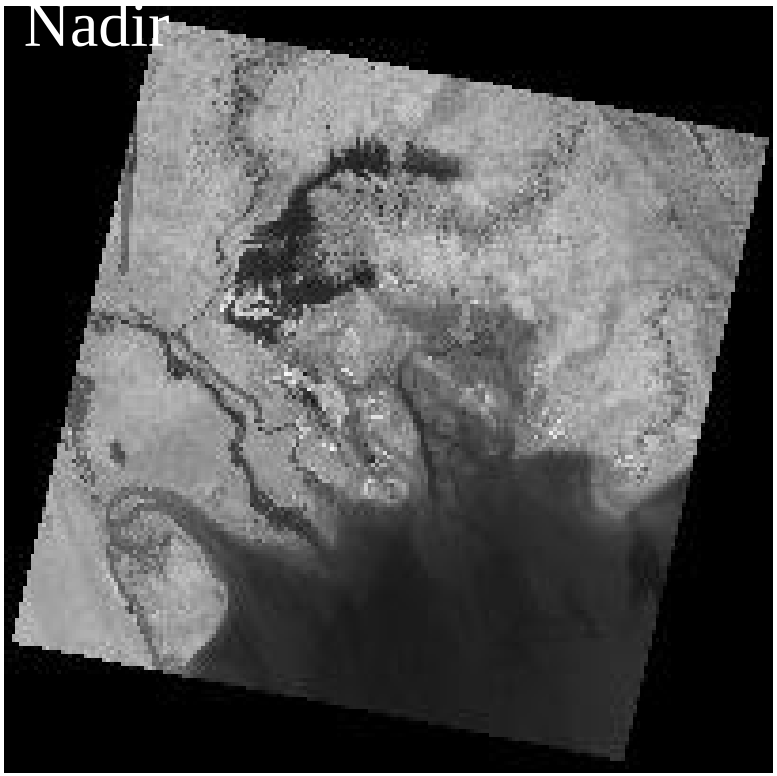
Finer Sampling, Spatial Resolution & Better Sensitivity



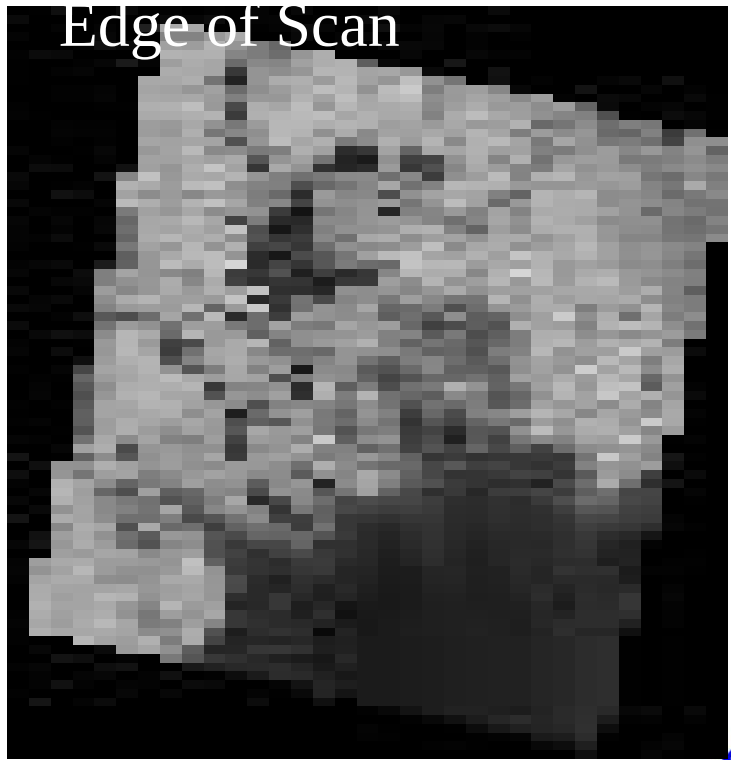
SNR predicted and specified at worst-case edge of scan: ~60% better nadir SNR *and* finer spatial resolution

AVHRR VISIBLE SIMULATION

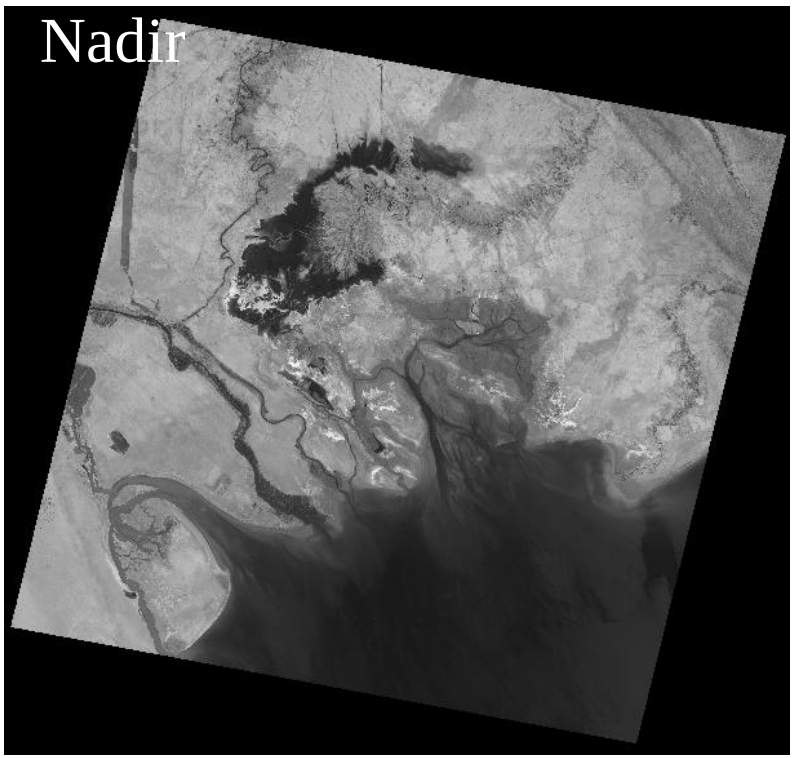
Nadir

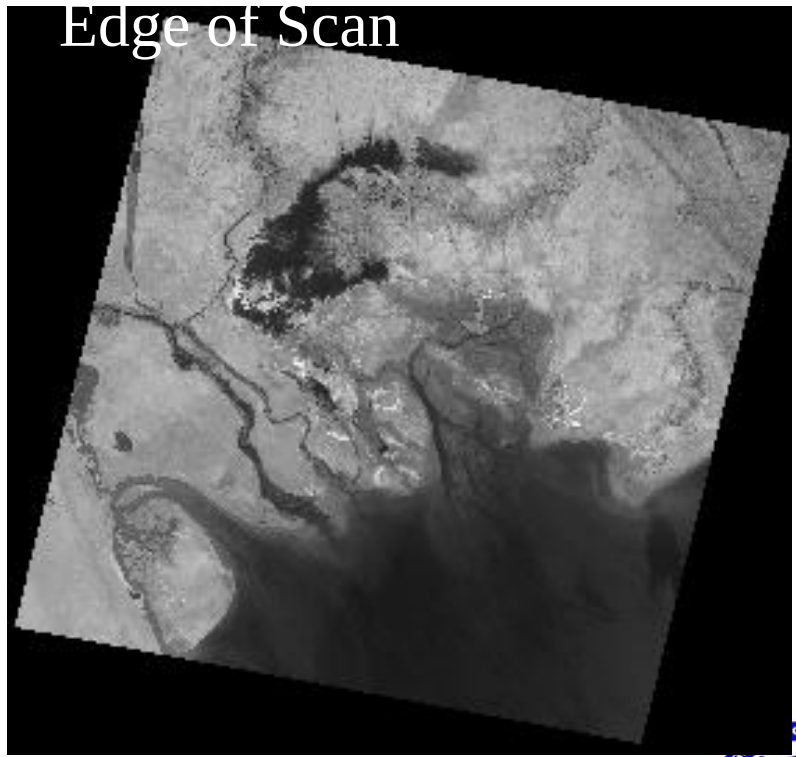


Edge of Scan

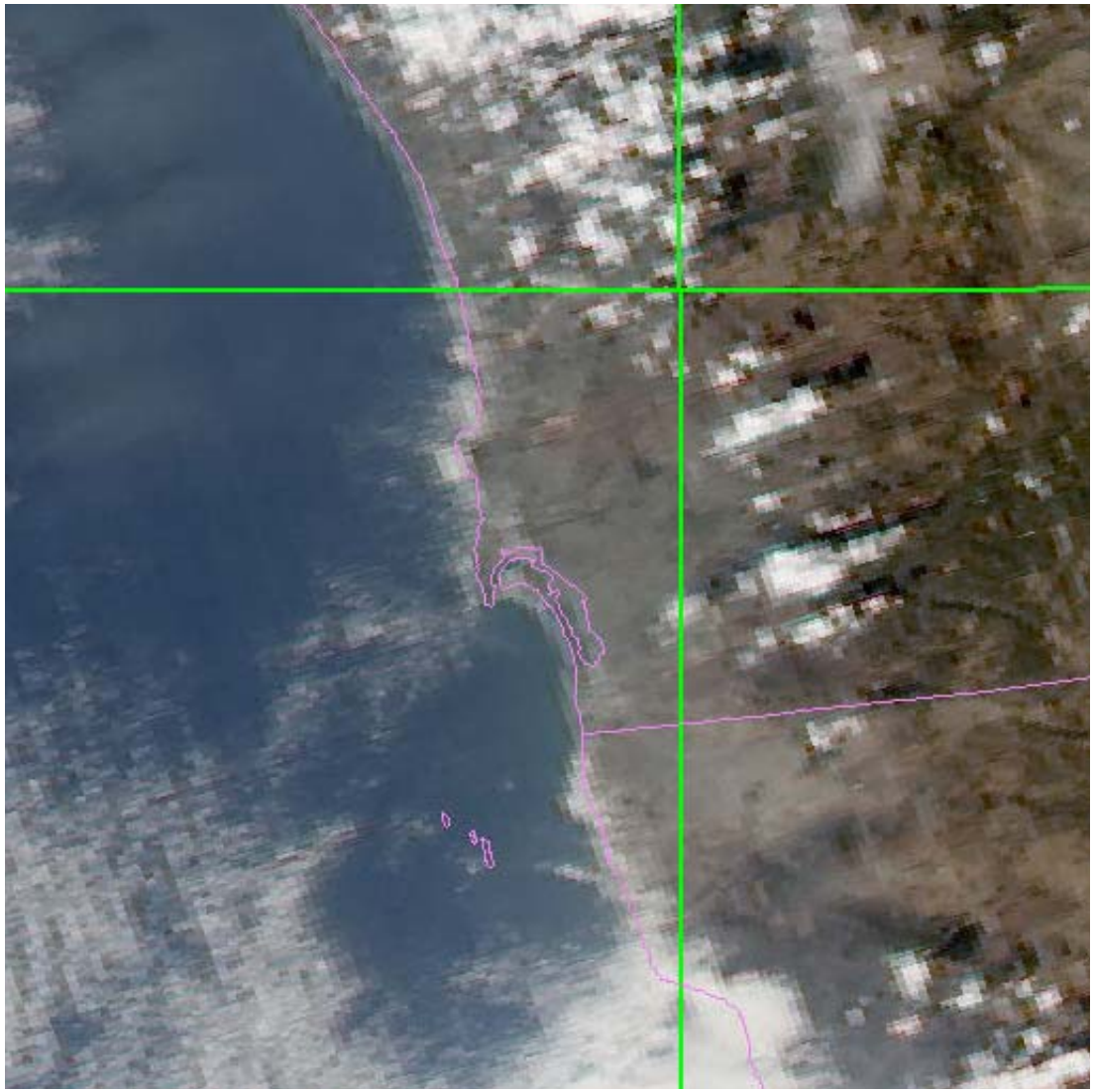


VIIRS VISIBLE SIMULATION

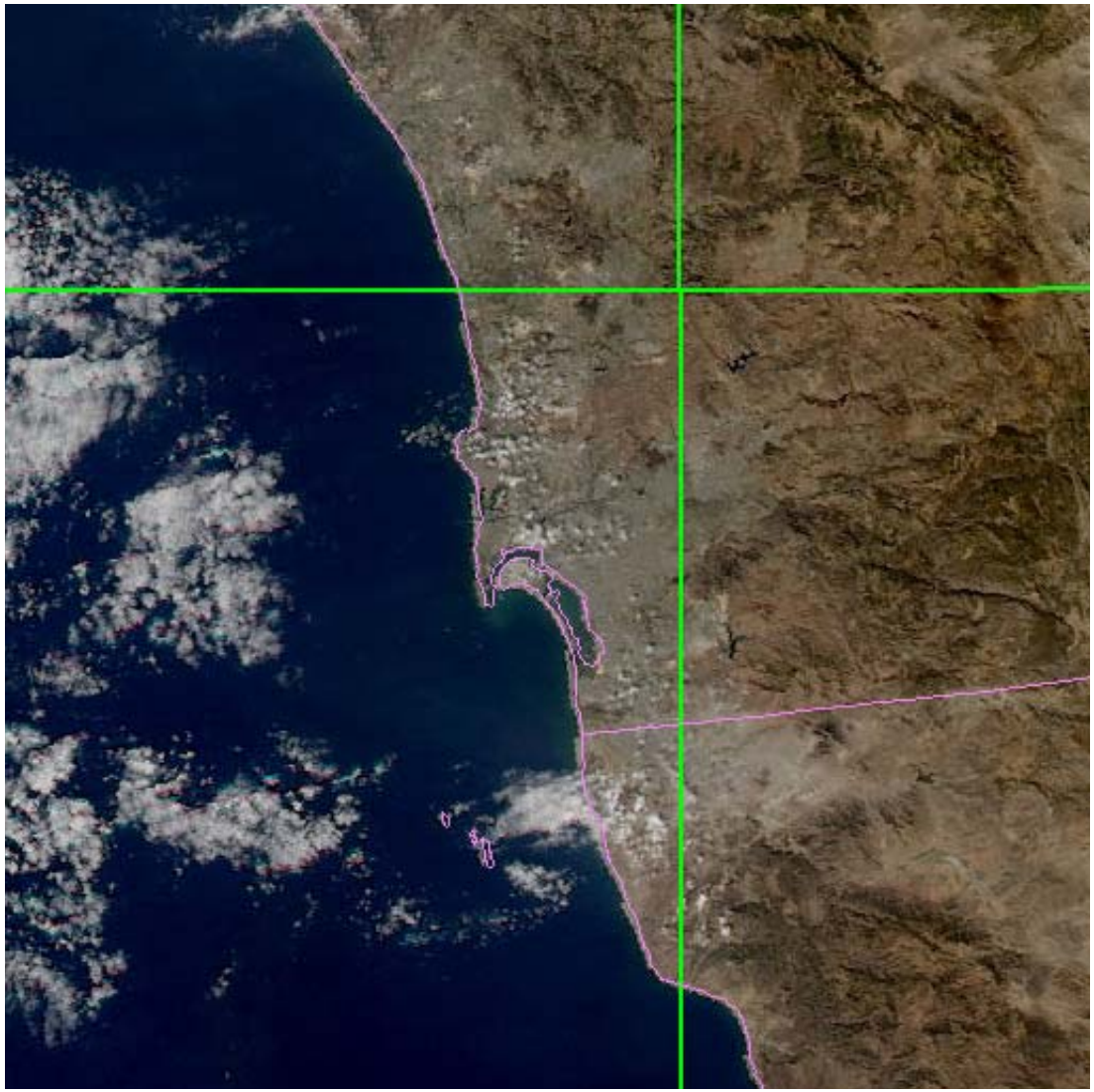




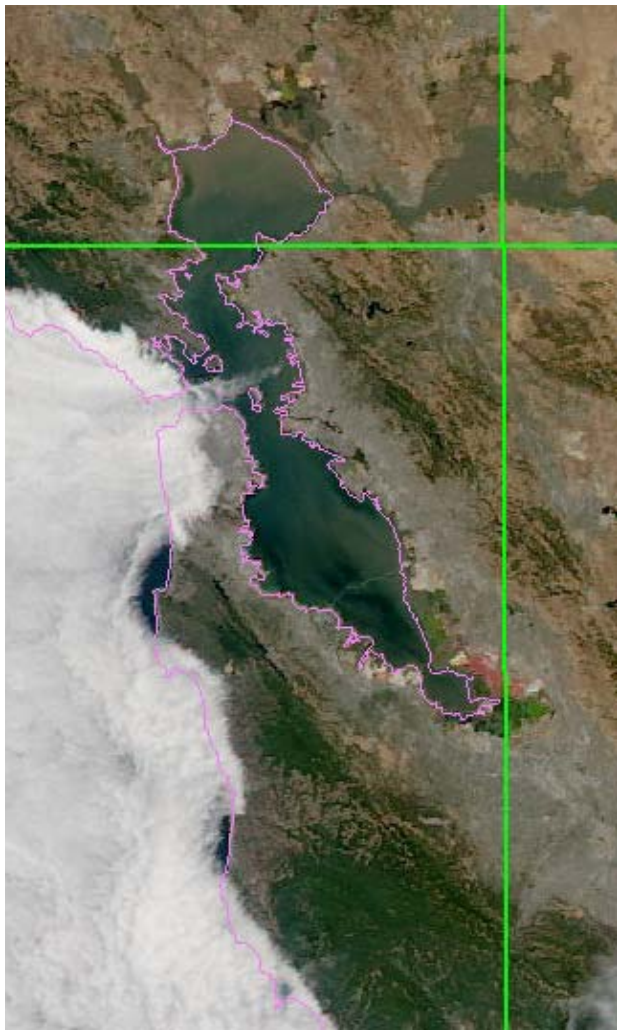
San Diego – MODIS Edge

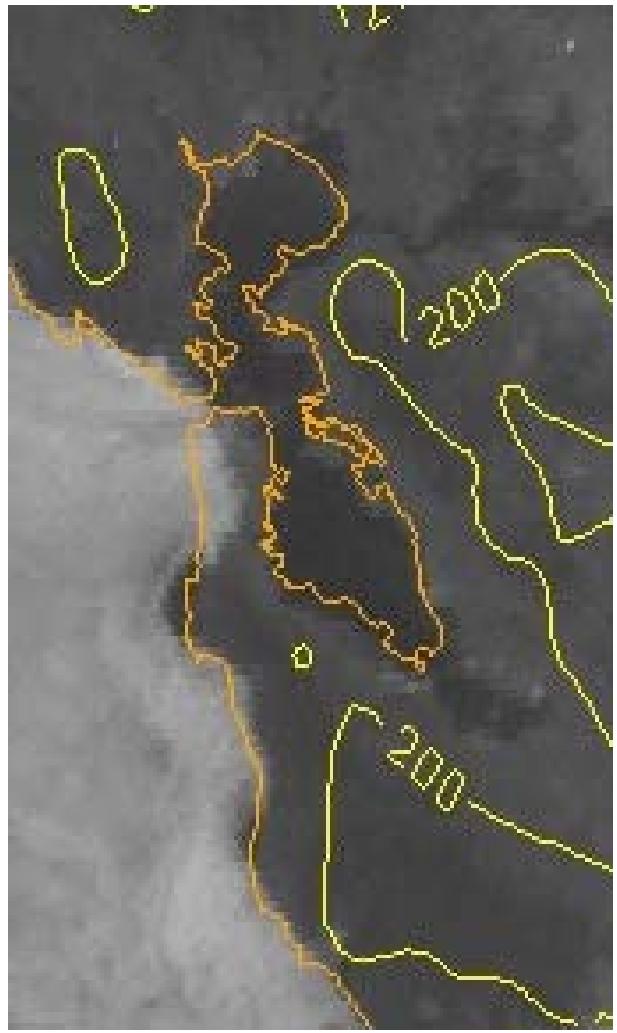


San Diego – MODIS Nadir



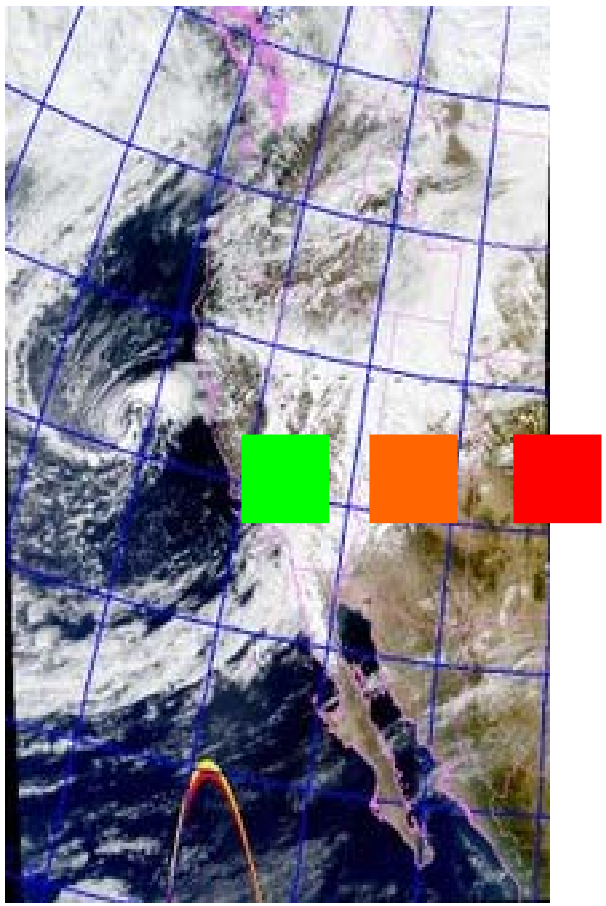
GOES versus MODIS





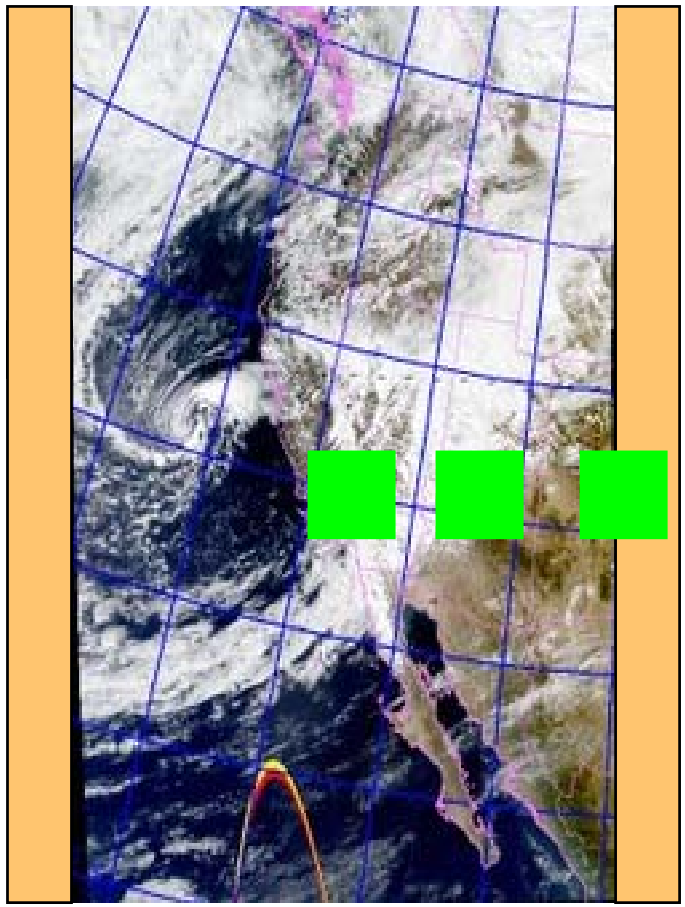
Quality of Subsectors

MODIS



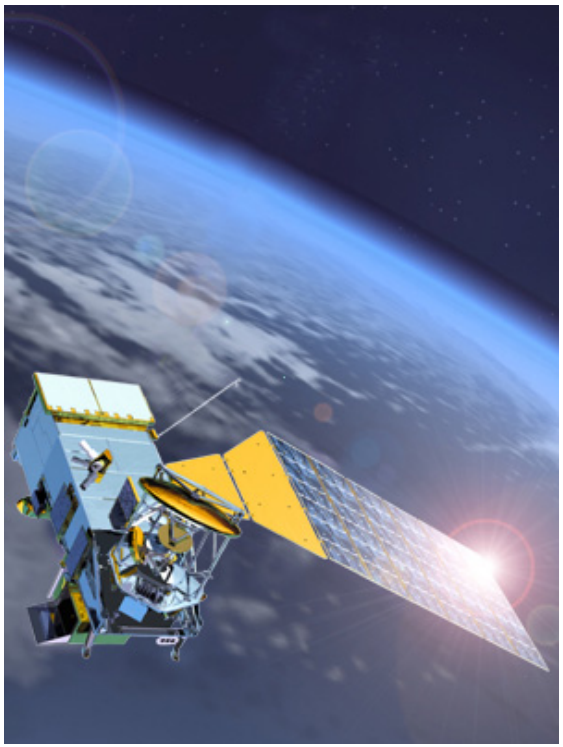
2300 km

VIIRS



3000 km

VIIRS value to forecasters multiplied by efficient data delivery!



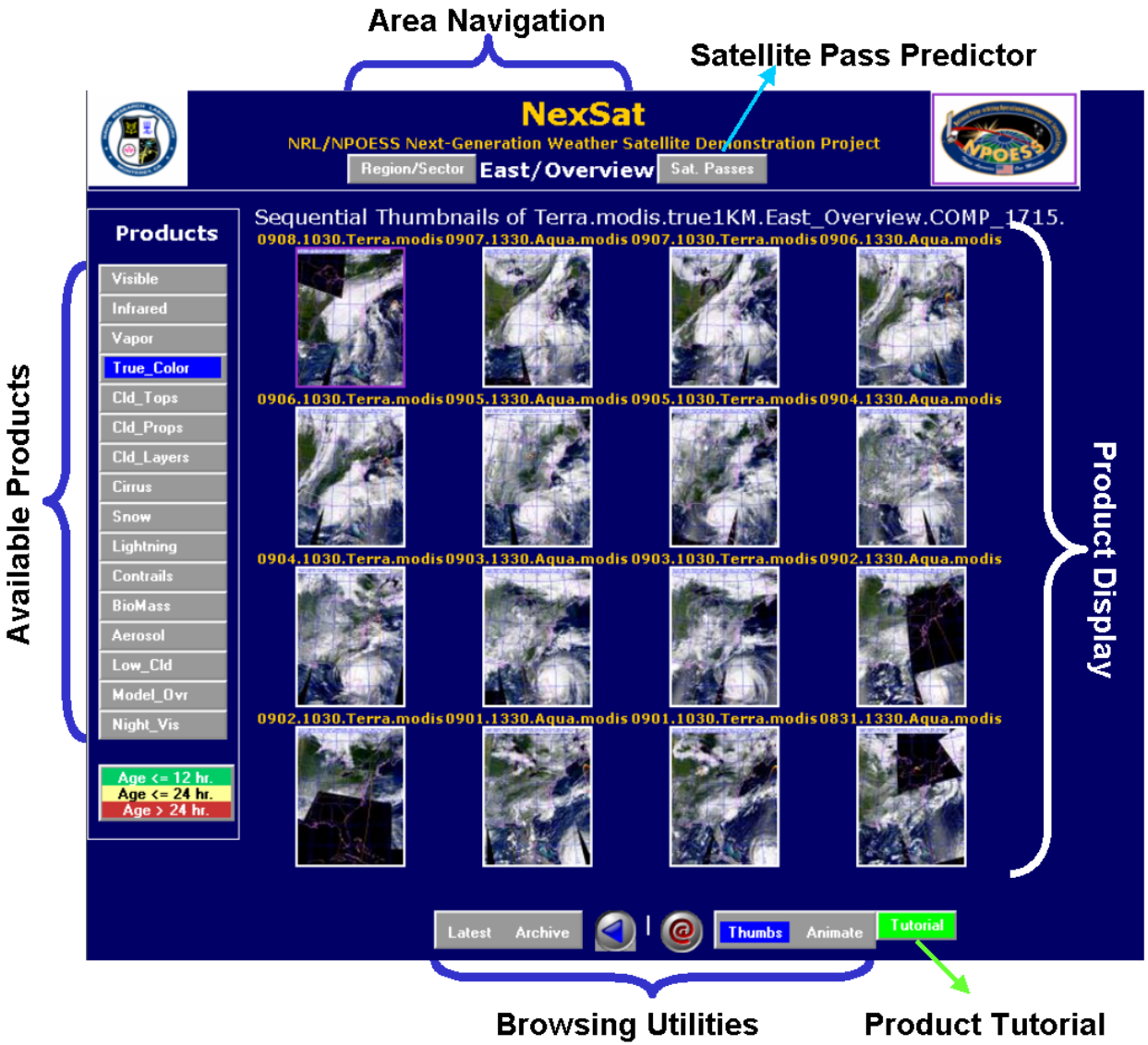
- 95 % of data delivered within 28 min to central processing stations
- Average delivery time 10.5 min
- Current prototypes using MODIS have latency 2-3 hours

NexSat WebPage: Audience and Scope

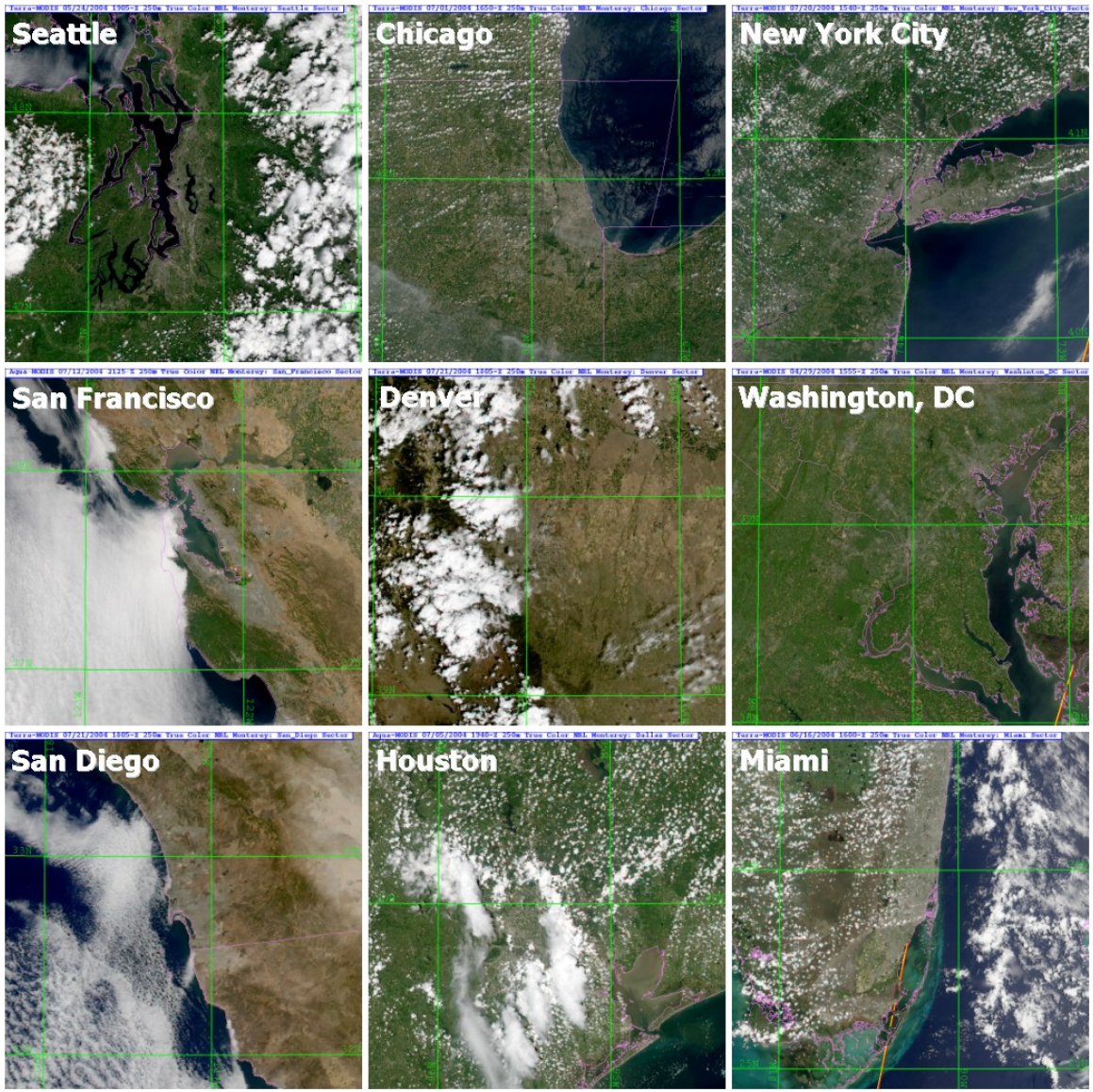
P*ublicly accessible* demonstration of Satellite Products over the continental United States:

1. Simulate future NPOESS capabilities in public forum
2. Near-realtime display of products, some not previously available (e.g., nighttime visible)

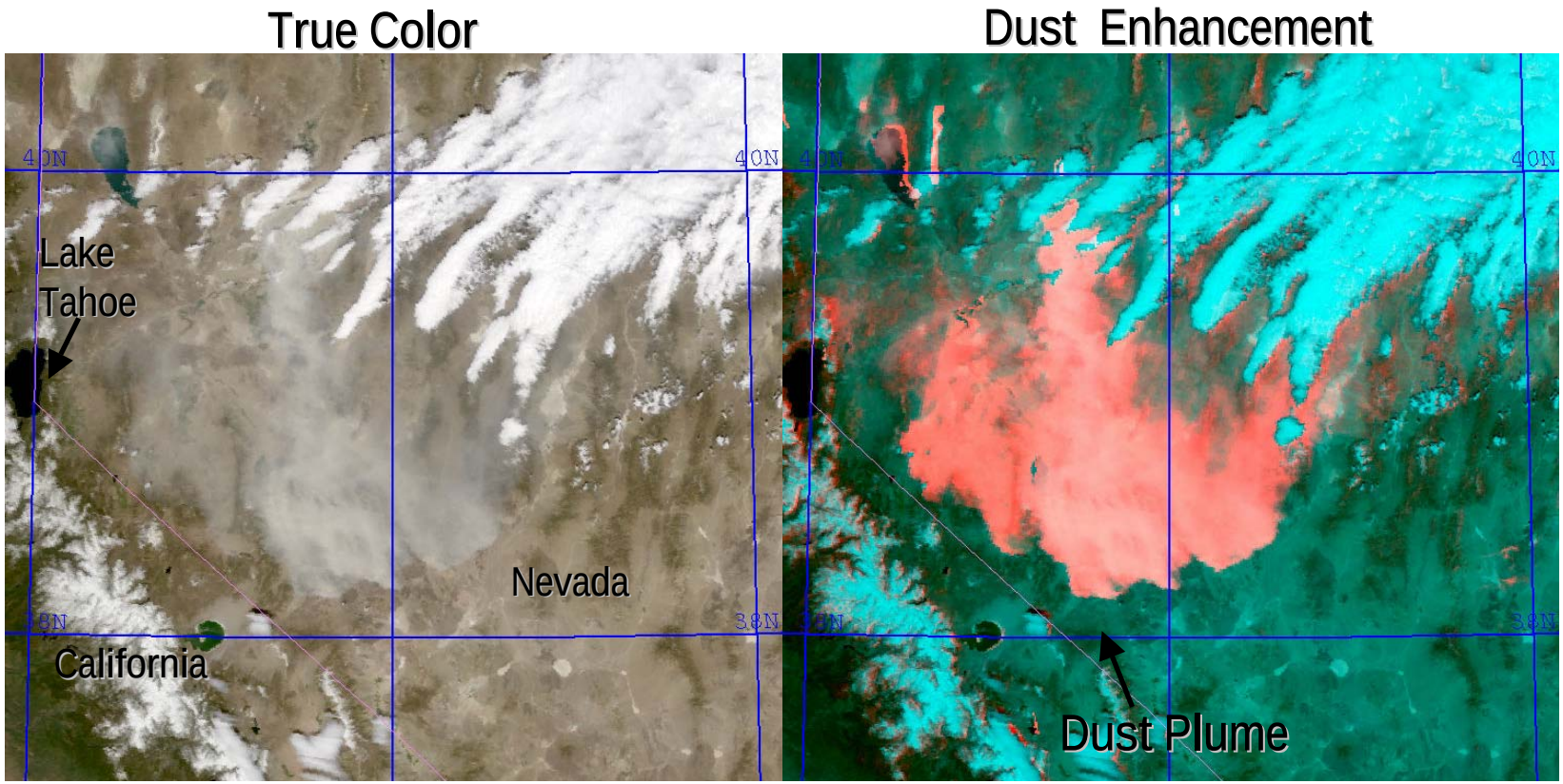
NexSat: Web Design



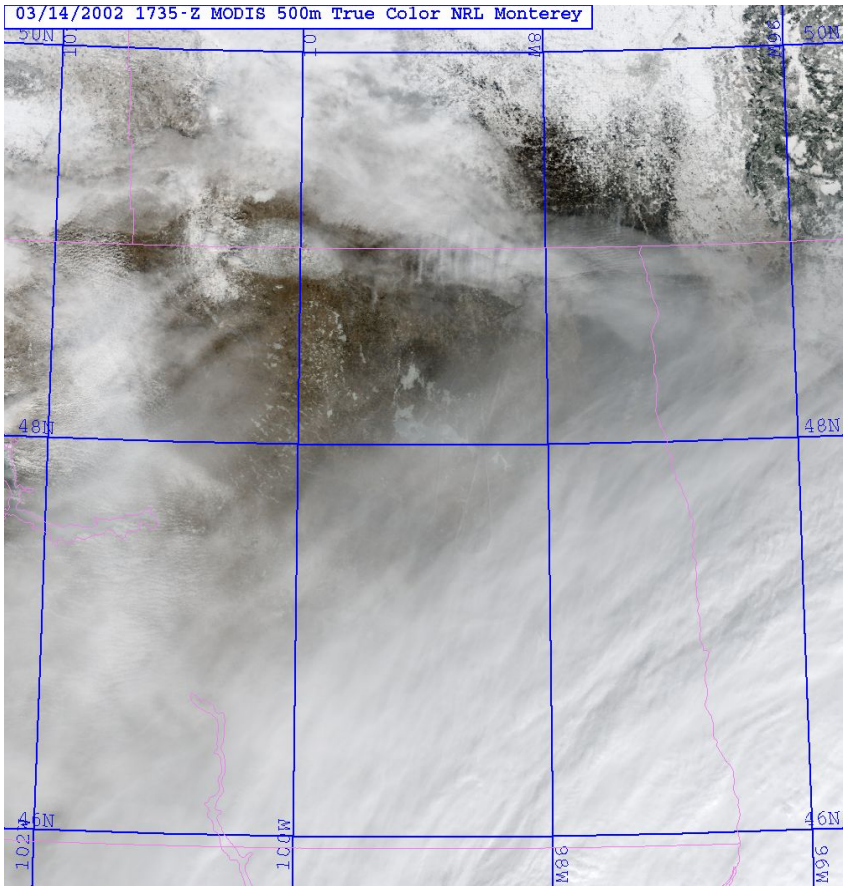
NexSat: 250m City Zooms

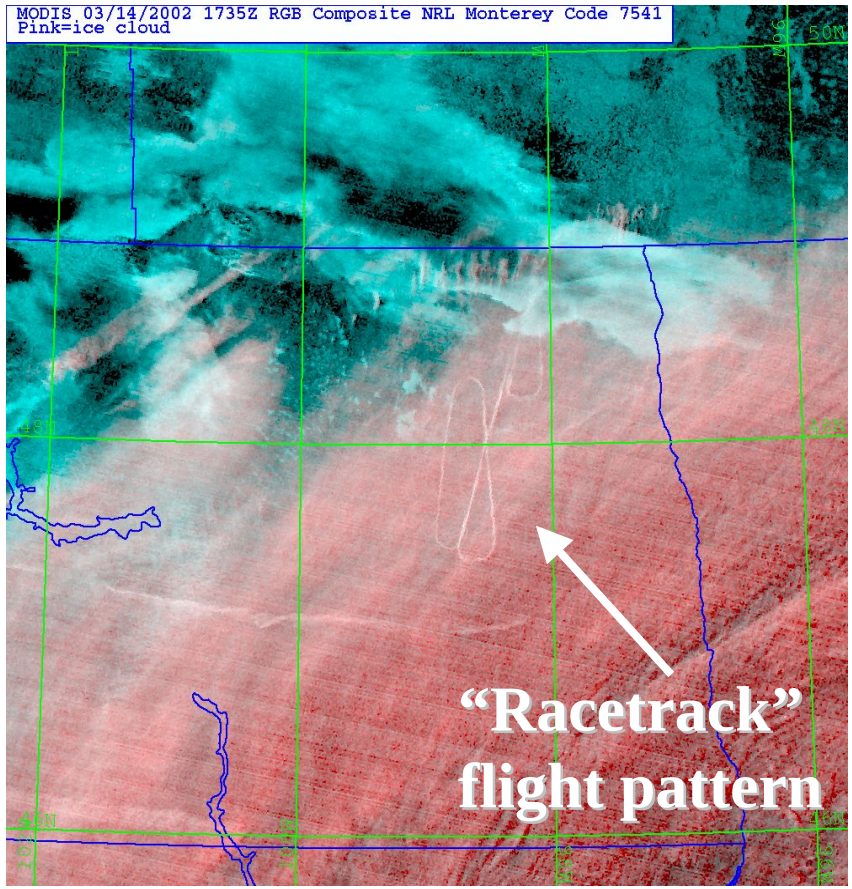


NexSat: Dust Storms

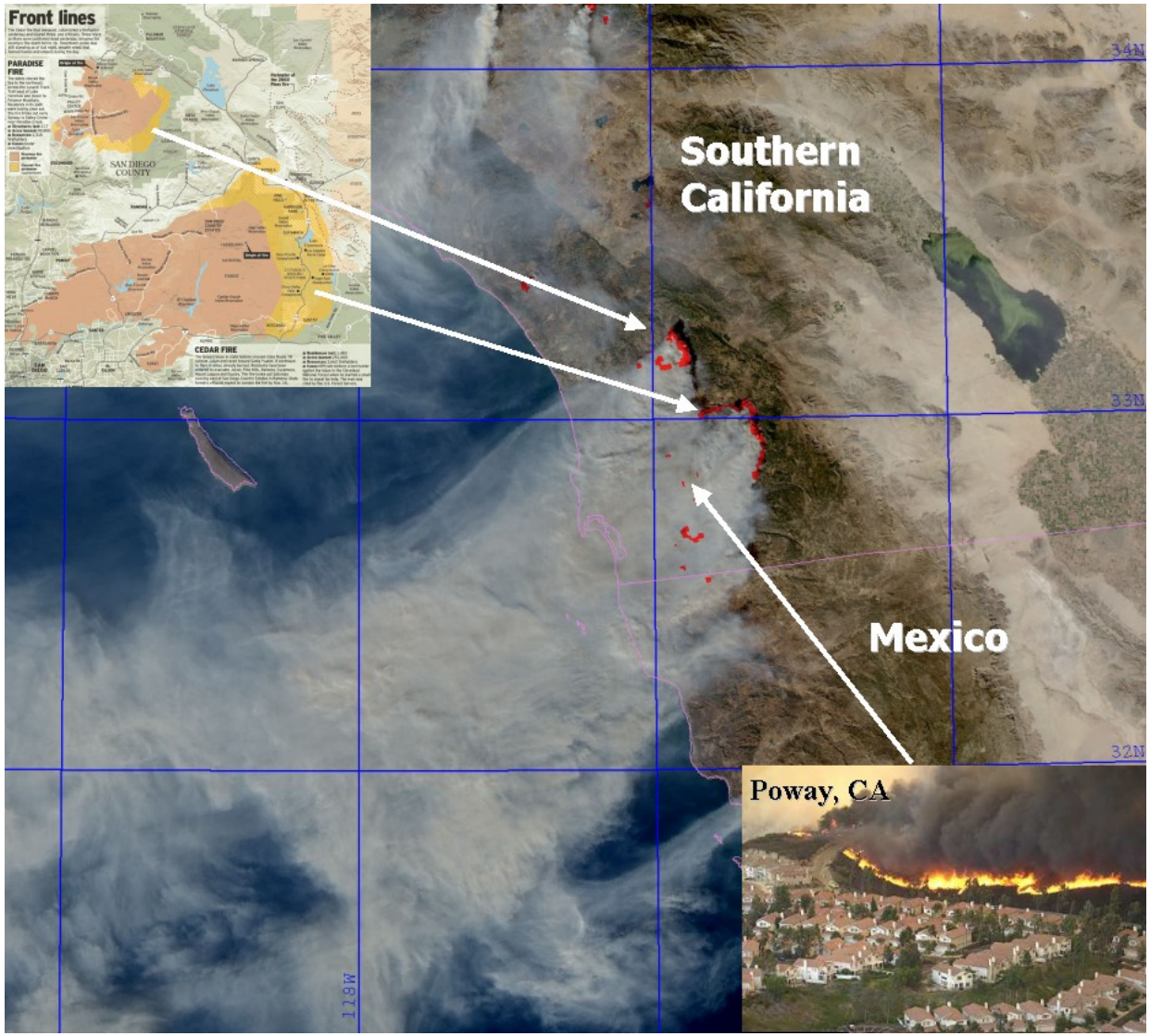


NexSat: Aircraft Contrails



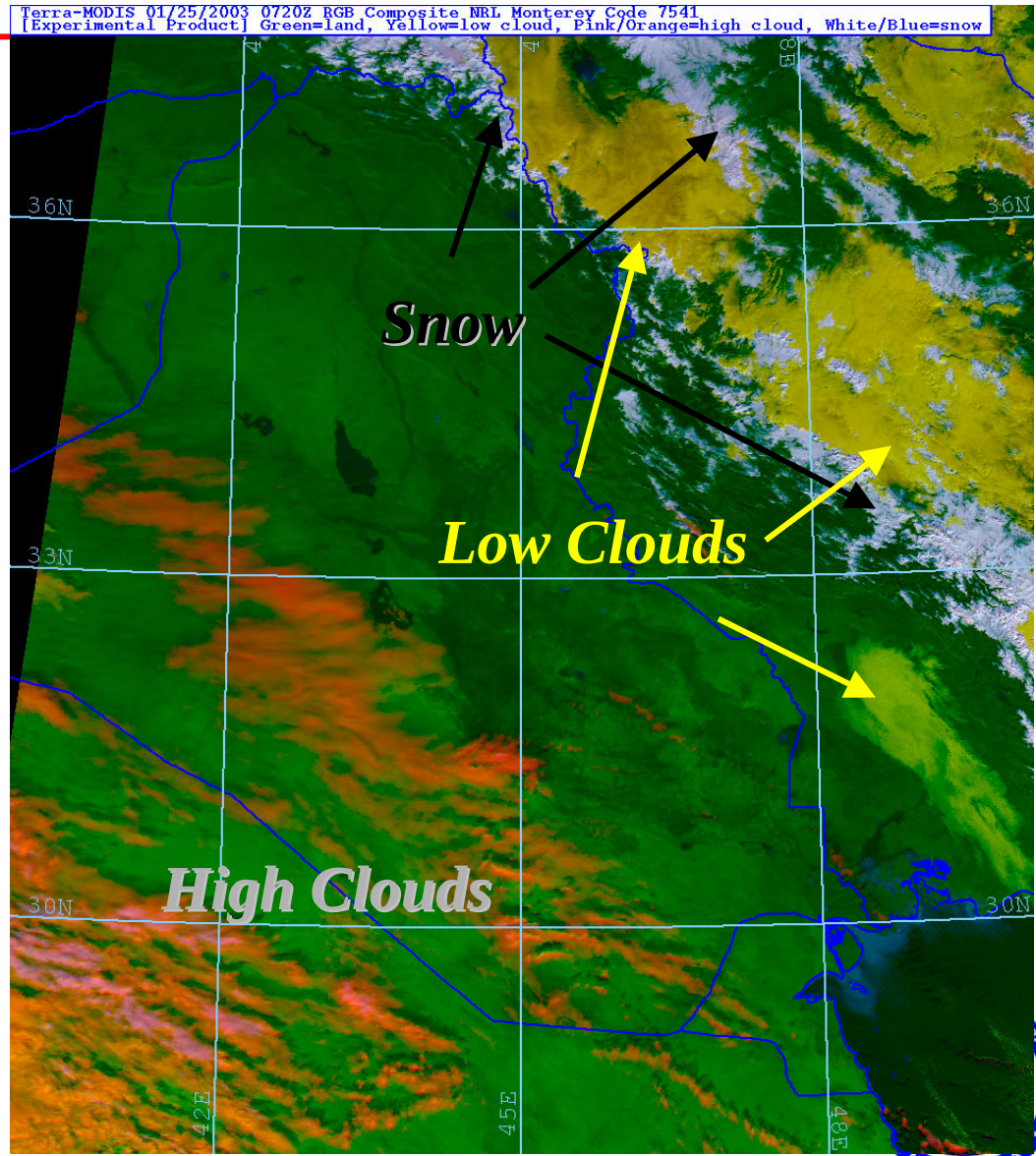


NexSat: Fire Detection



NexSat: Cloud/Snow Discrimination

- Complex snow/cloud scenes during winter in Southwest Asia
- Difficult to distinguish clouds from snow in single visible and window-infrared channels
- The ability to determine the presence of cloud over a snow field is useful to targeting, surveillance, navigation, etc.



DayNight Band (DNB) Constant Resolution

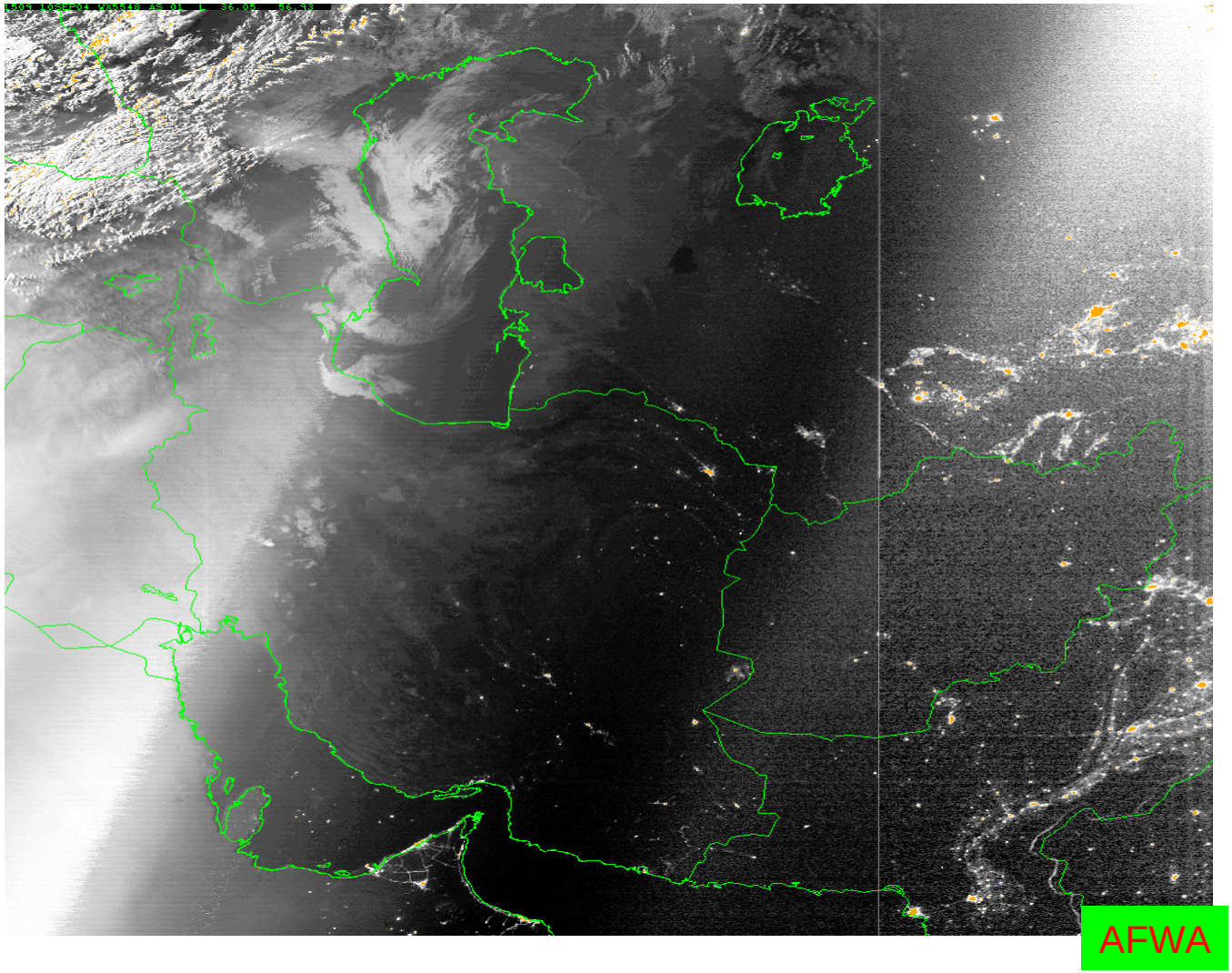
- Purpose: Replicate OLS capability but with updated technology and improvements
- 0.5 -- 0.9 µm broadband visible
- Detectors are aggregated to produce near-constant resolution
- More detectors aggregated near nadir for high SNR; fewer aggregated near edge for lower SNR

DNB "Constant Contrast"

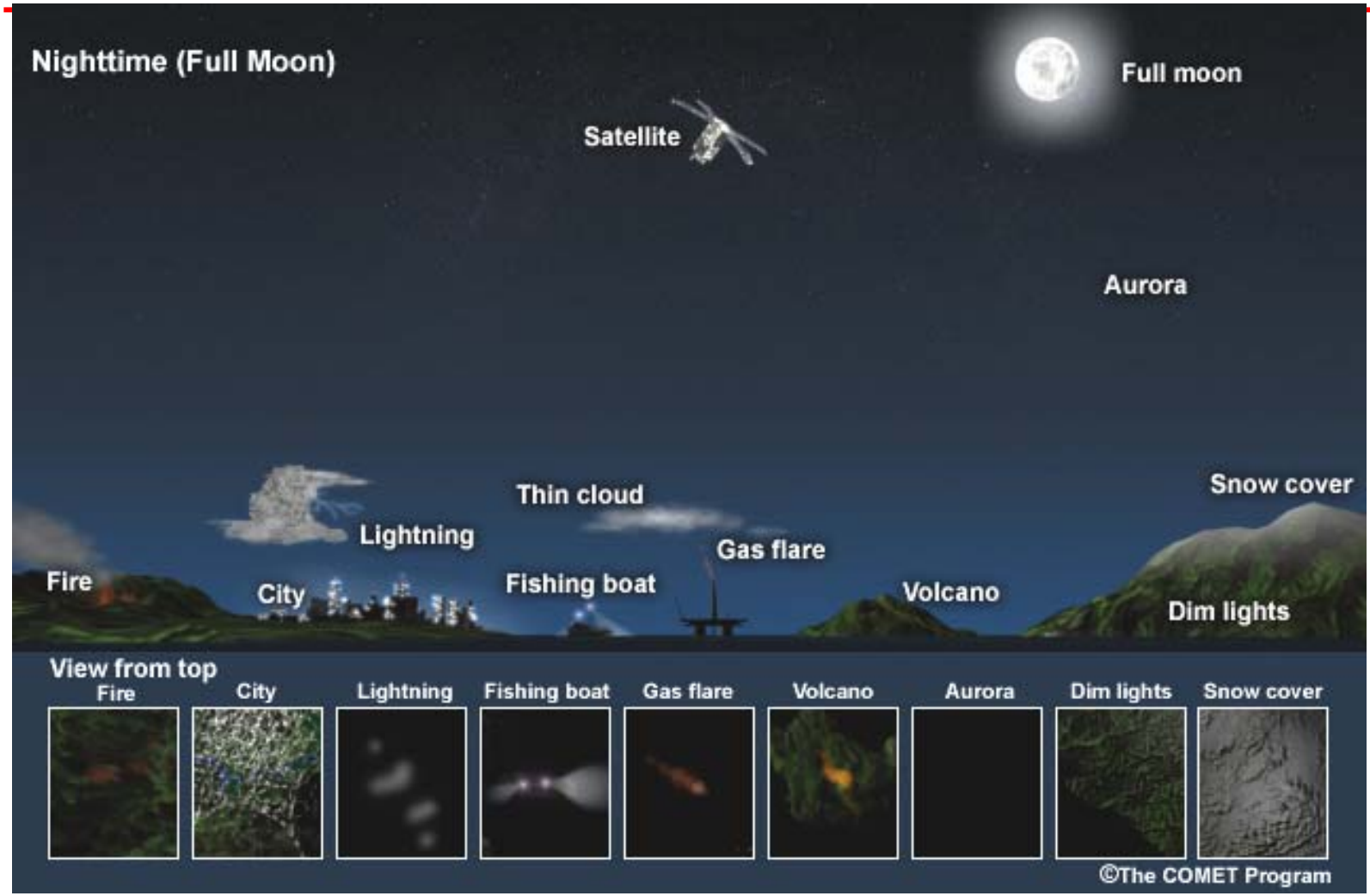
Three Gains	Relative Gain
High	119,000
Medium	477
Low	1

- Improves SNR at low radiances
- All pixels are imaged with all three gains
- Onboard processing selects the most sensitive gain setting without saturation for transmission to the ground
- Goal is "constant contrast" imagery

DMSP (F14) Terminator Image

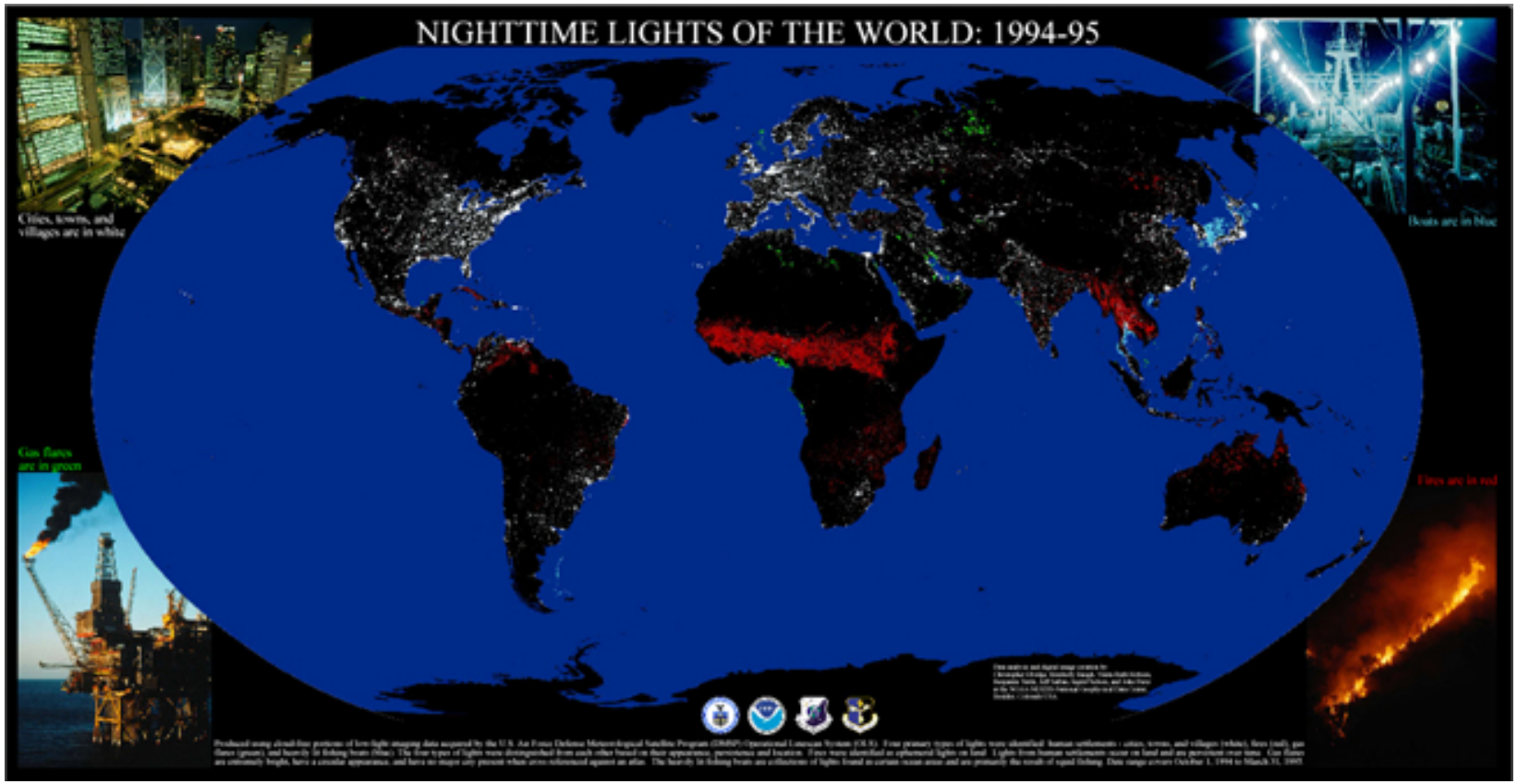


Full Moon

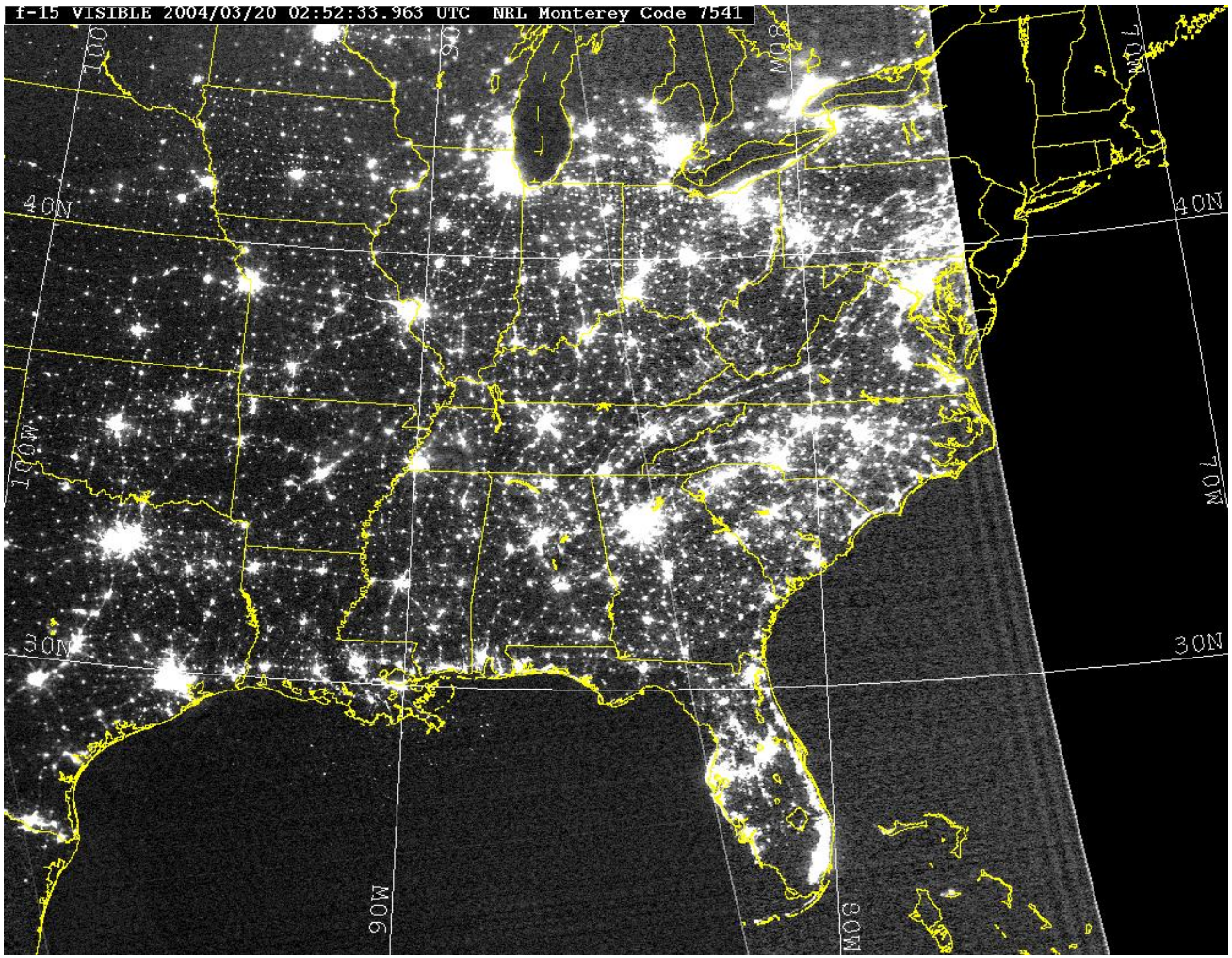

Nighttime (Full Moon)
Full moon
Satellite
Aurora
Thin cloud
Snow cover
Lightning
Gas flare
Fire
City
Fishing boat
Volcano
Dim lights
View from top
Fire
City
Lightning
Fishing boat
Gas flare
Volcano
Aurora
Dim lights
Snow cover
©The COMET Program

DMSP OLS

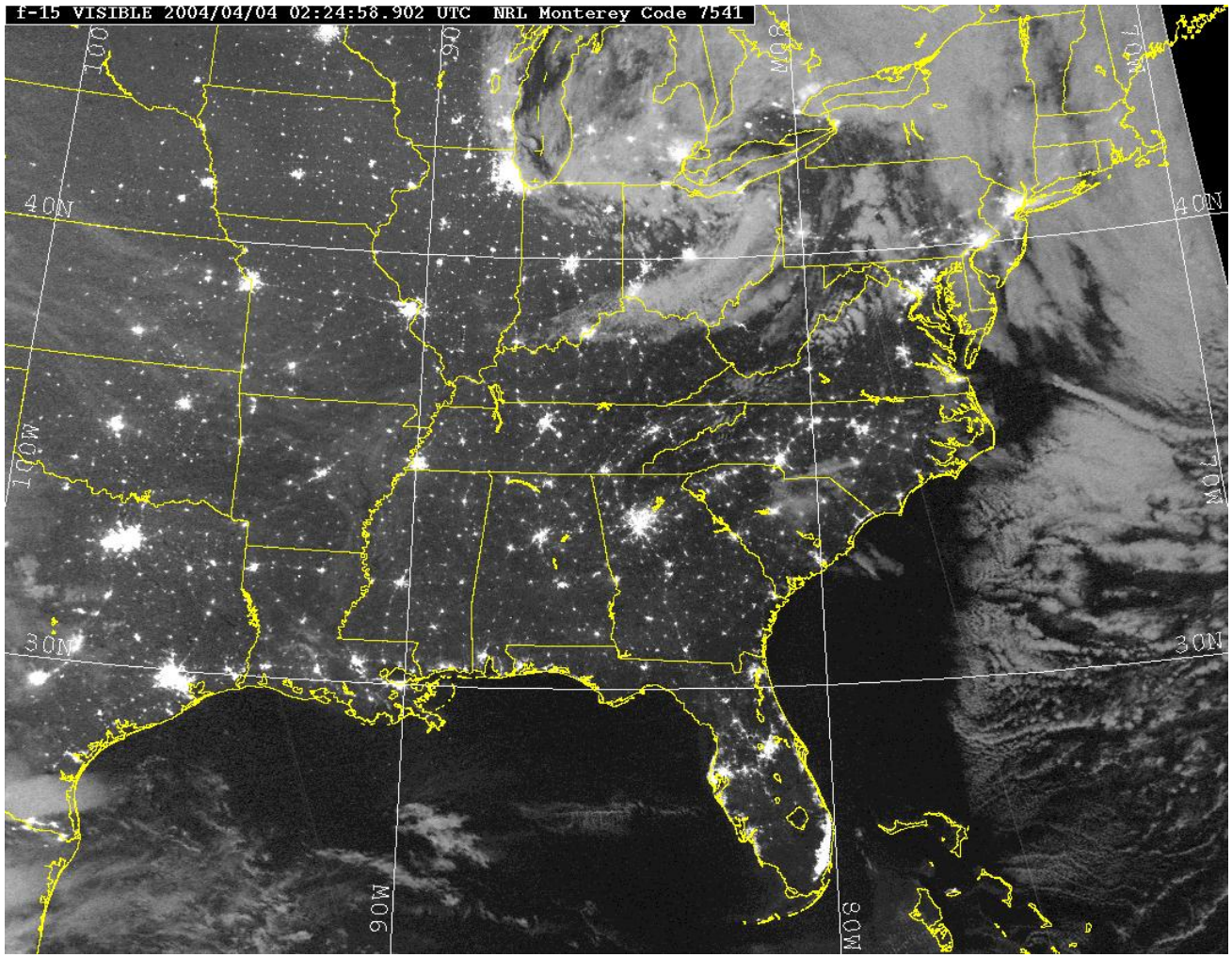
NGDC Poster



No Moon


f-15 VISIBLE 2004/03/20 02:52:33.963 UTC NRL Monterey Code 7541
40N
30N
100W
90W
80W
70W

Full Moon
98% full, 48.1º Elevation



VIIRS Improvement for DNB

	DMSP OLS	NPOESS VIIRS
1.	64 Gray shades	64 X = 4096 Gray shades
2.	2.2 km Field of View	0.75 km Field of View
3.	Limited Pixel Expansion	No Pixel Expansion
4.	Numerous Image Artifacts	Artifacts Eliminated

Lights over Korea

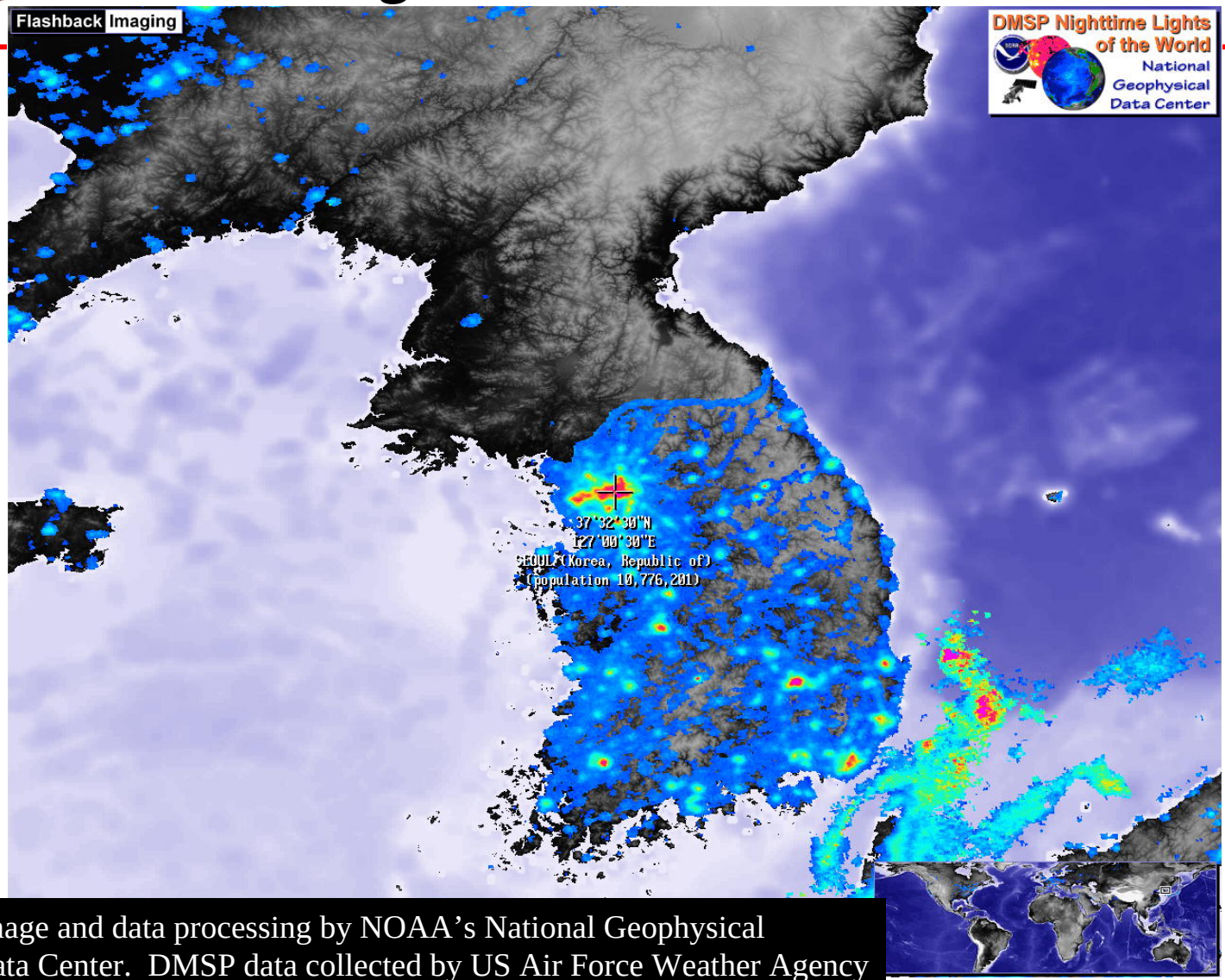
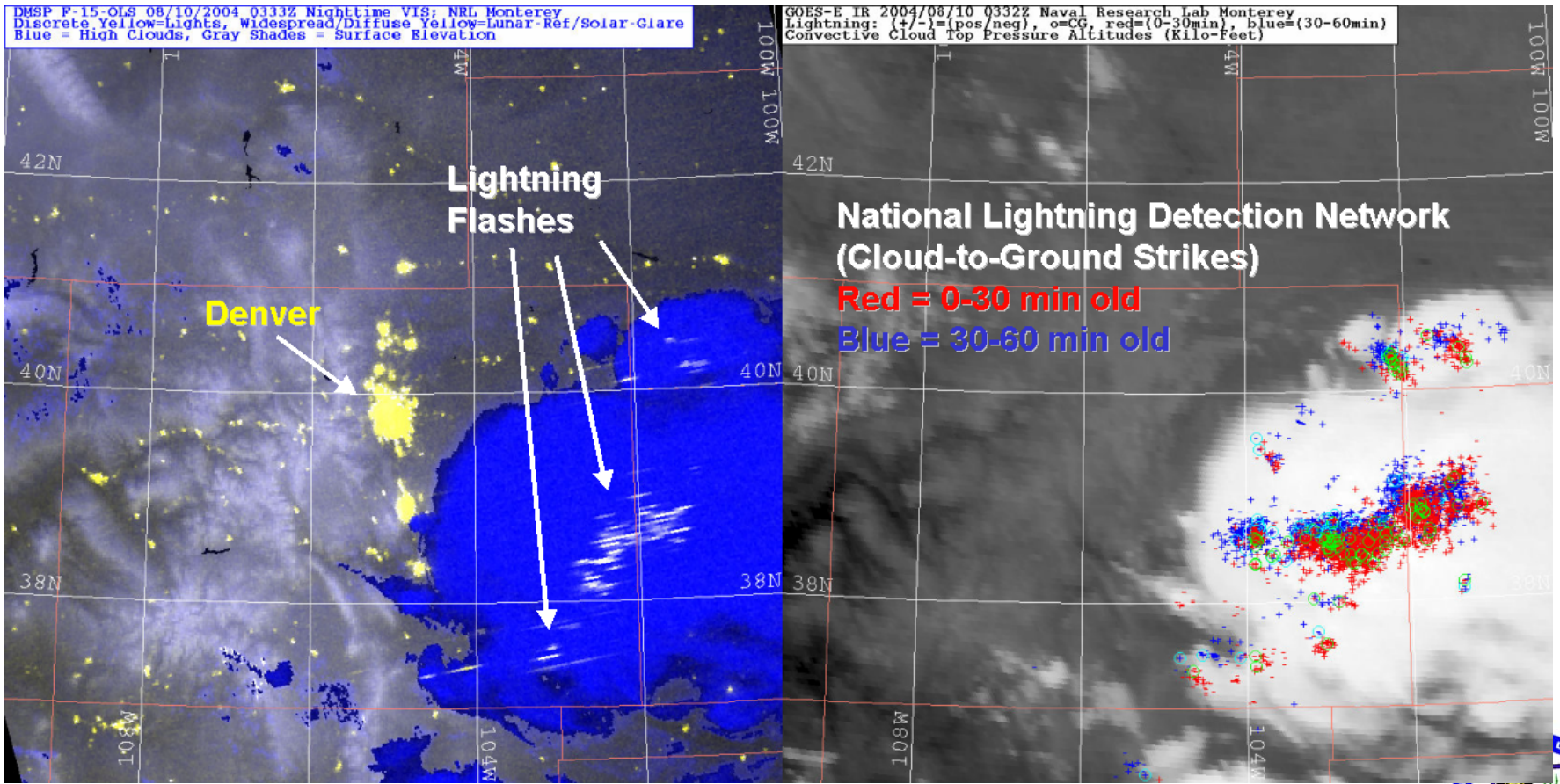
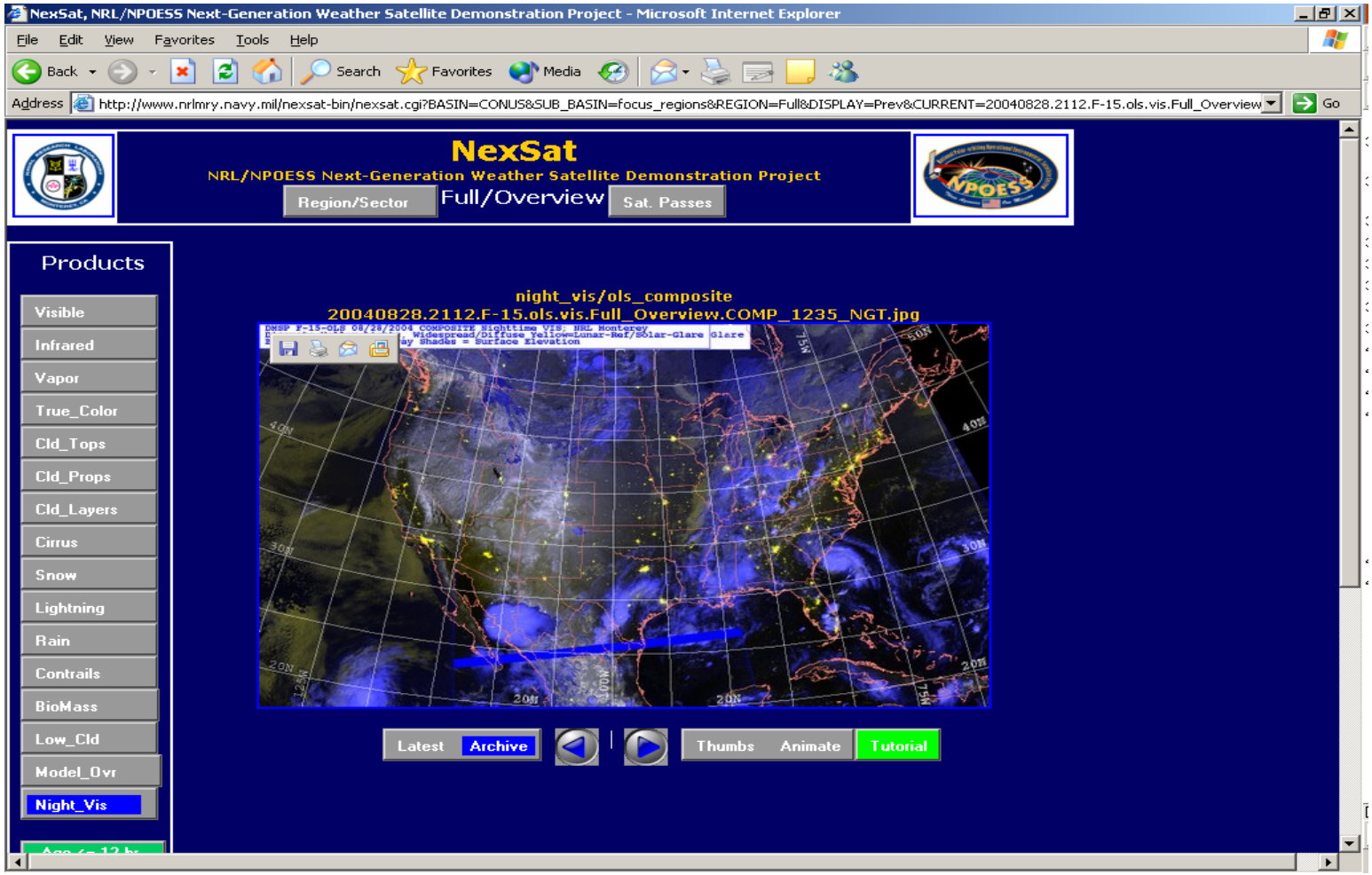


Image and data processing by NOAA's National Geophysical Data Center. DMSP data collected by US Air Force Weather Agency

OLS Lightning Detection



Near-Realtime Polar Products from NexSat



http://www.nrlmry.navy.mil/nexsat_pages/nexsat_home.html

Conclusions

- VIIRS adds advanced capability not available from MODIS
- NPOESS will truly be a forecaster's system
- Constant-Contrast/Constant-Resolution Data will produce vivid, information-rich images for DNB
- Preservation of footprint size will facilitate much more usable images
- VIIRS fine channels replicate the capability of AVHRR
- Many products in addition to EDRs
- True color capability preserved for VIIRS

International TOVS Study Conference, 14th, ITSC-14, Beijing, China, 25-31 May 2005. Madison, WI, University of Wisconsin-Madison, Space Science and Engineering Center, Cooperative Institute for Meteorological Satellite Studies, 2005.