Satellite Processing *Command Overview*

The 2nd National OPC Observational Data Workshop

James Vermeulen

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Conventional Data Observations Manager
Satellite Data Program Manager
Interagency Office Federal Coordinator
Meteorology (OFCM)
Committee Operational Processing Centers (COPC)
Cooperative Support and Backup (CSAB)
Working Group-Operational Data (WG-OD)

*** Acknowledgement to our NRLMRY partners providing graphics and data points

May 24, 2018

This briefing is UNCLASSIFIED

Outline

- FNMOC Satellite Team
- Primary Customers Satellite Products
- Current FNMOC Polar/Geo Coverage and Data Ingest
- Data assimilation/Acquisition needs/Requirements
- New Satellite Data/Issues and Considerations
- Operationalizing Satellite Processing
- CONOPS Satellite Products
- CONOPS Data Ingest/Processing/Distribution
- CONOPS Programs & Future
- Current and Future Imagery (new sensor technology)
- FNMOC Top 3 Challenges

FNMOC Satellite Team

- Dr. Jeff Tesmer – OPS, NWP, DMSP, TCWEB, SAT_FOCUS, JMV METCAST, GEOSERVER NITES NEXT, Imagery, GeoIPS

- Ms. Yiping Wang – NWP, DMSP, TCWEB, Scatterometer, OPS

- Mr. Paul McCrone – NWP, FMQ/SMQ, NOAAPORT, TCWEB, Scatterometer, OPS, FTW or AMV

- Mr. George Shayne – NWP, OPS, KML, ISIS, GRIB data formatting, SCIF POC

FNMOC Satellite Team

- Dr. Craig Chester – NPP/JPSS Development, GeoIPS

- Supporting cast – N310, N39, N6, N6E, N61 Networks, N62, N63 System administrators, N65 Information Assurance, (this is not an all inclusive list)

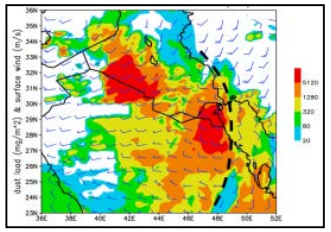
Primary Customer Satellite Products

- Global IA Numerical Weather Prediction (NWP)
- Tropical Cyclone Web Page (NOOC, JTWC)
- Satellite Focus Web Page (COCOMs, AOIs and Exercises)
- Tactical Area Meteorology (SCIF support)
- NCODA/Wave Watch 3 (assimilation, Web Page display, MCSST, altimetry SSH and SWH)
- MARKIVB Imagery (SAT_FOCUS)
- Databases - ATCF, ISIS, CAGIPS, JMV/METCAST, GEOSERVER, NITES NEXT

FNMOC Models and Applications

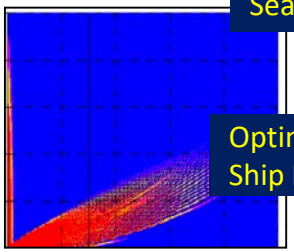
Ocean Acoustic Forecasting

Aircraft Routing OPARS



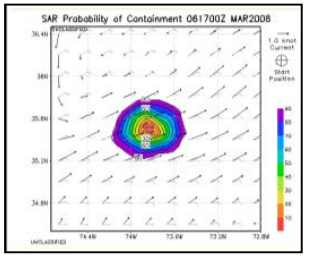
Visibility/Dust Forecasts

Automated High Seas / Wind Warnings

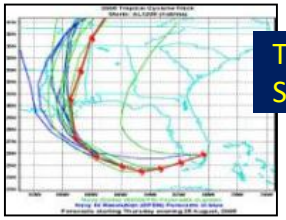


Electro-Optical Forecasts

Optimum Track Ship Route - WEAX



Search and Rescue



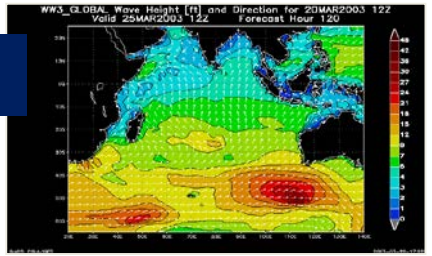
Target Weapon Systems

Dissemination
Tasking
Collection
Processing
Exploitation & Analysis
TCPED

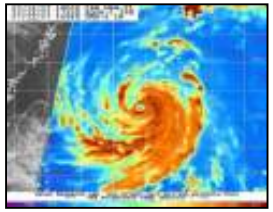
NAVGEM/GOFS
Global Modeling

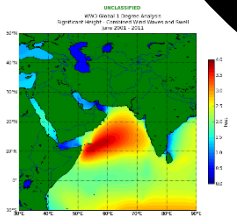
NCOM/COAMPS
Regional Modeling

Ice Forecasts



Long-Range Planning





Tropical Cyclone Forecasts

Operational Climatology

Coverage plots

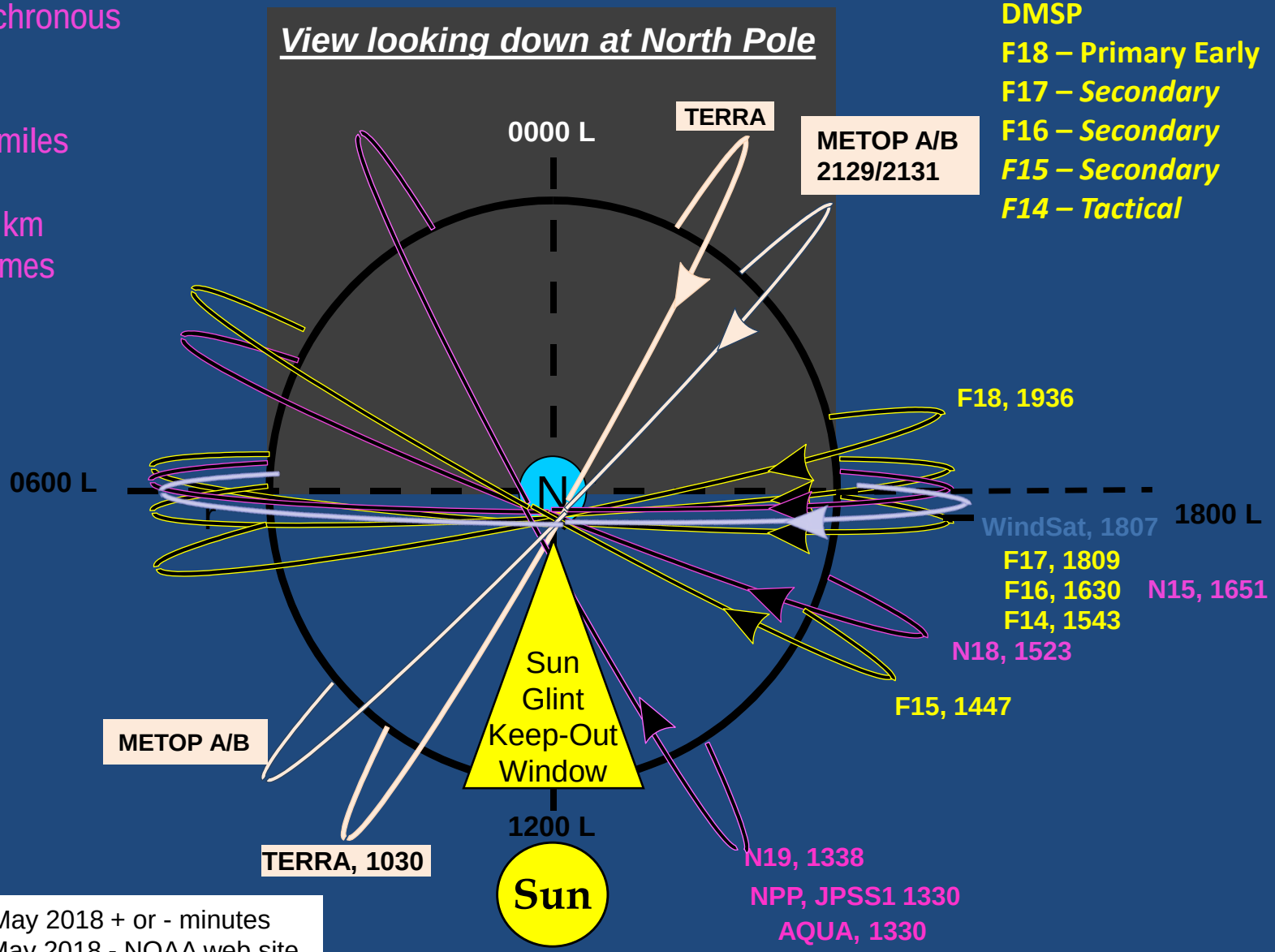
Satellite data coverage plots (Courtesy of N38 Cary McGregor)

How does a loss of data/coverage and additional latency affect the War-fighters?

US Operational LEO METSAT Constellation

NOAA: Sun-Synchronous
Incl. 98.74
Period 101 min.
Apogee 530/518 miles

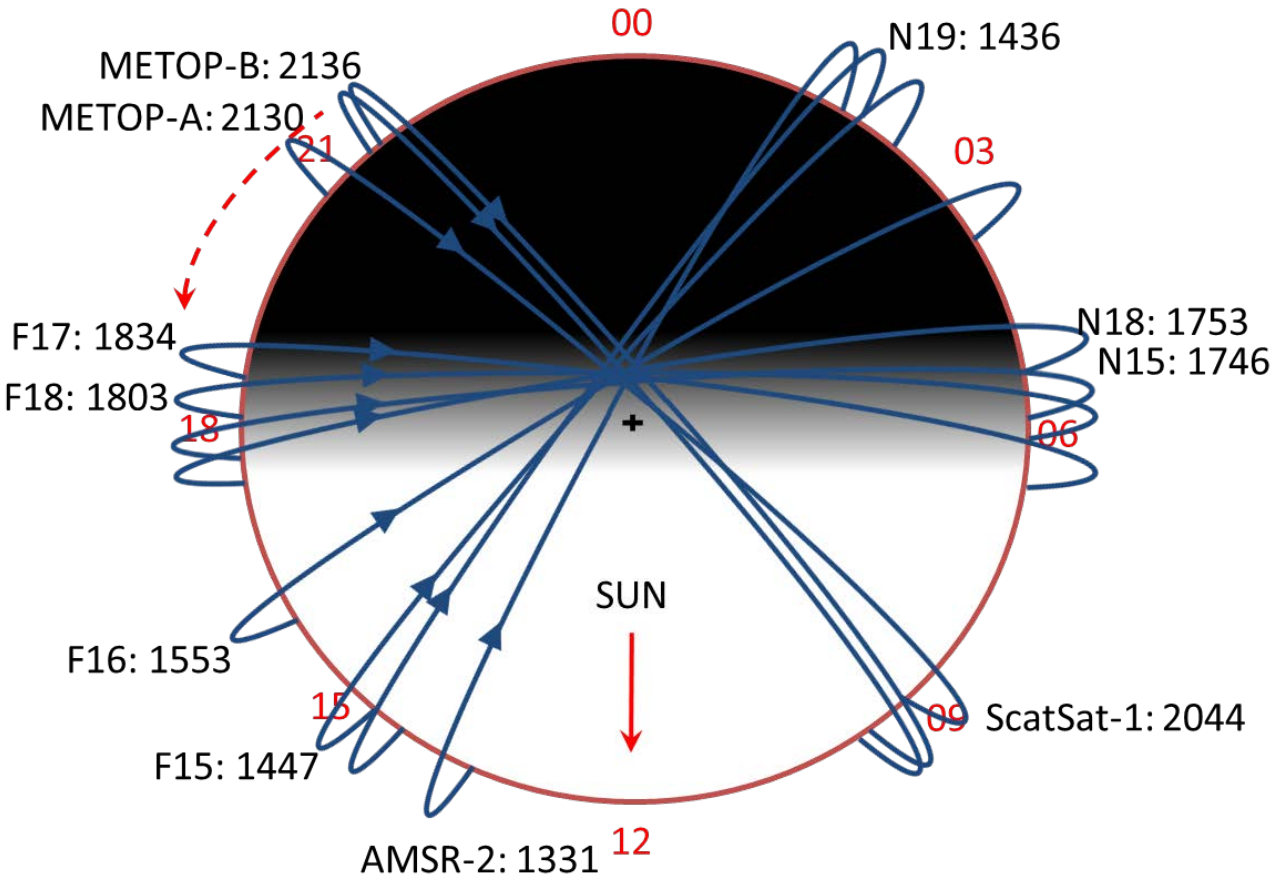
Scan width 2700 km
Circle Earth 14 times per day



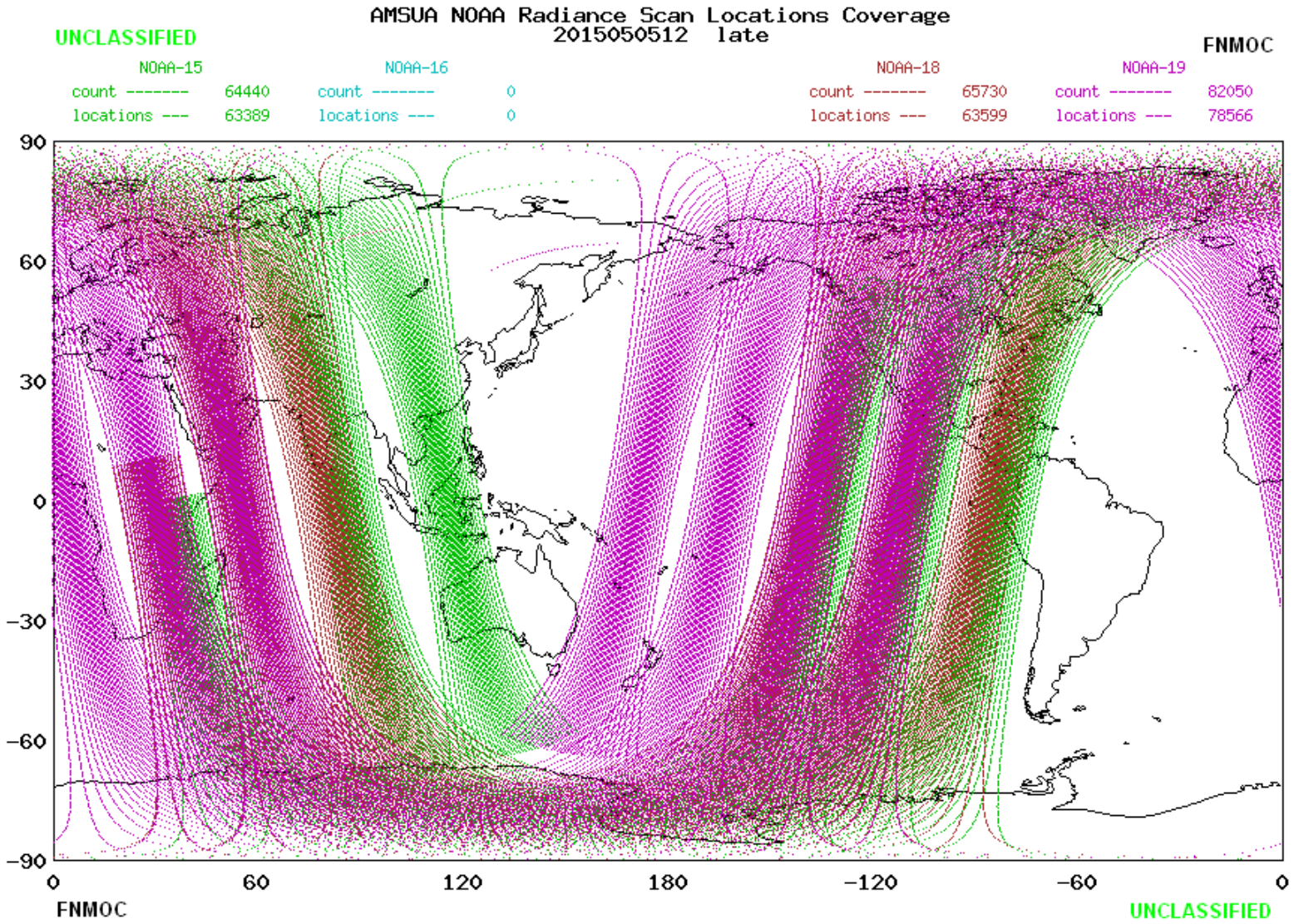
DMSP
F18 – Primary Early
F17 – *Secondary*
F16 – *Secondary*
F15 – Secondary
F14 – Tactical

DMSP LTAN as of May 2018 + or - minutes
NOAA LTAN as of May 2018 - NOAA web site

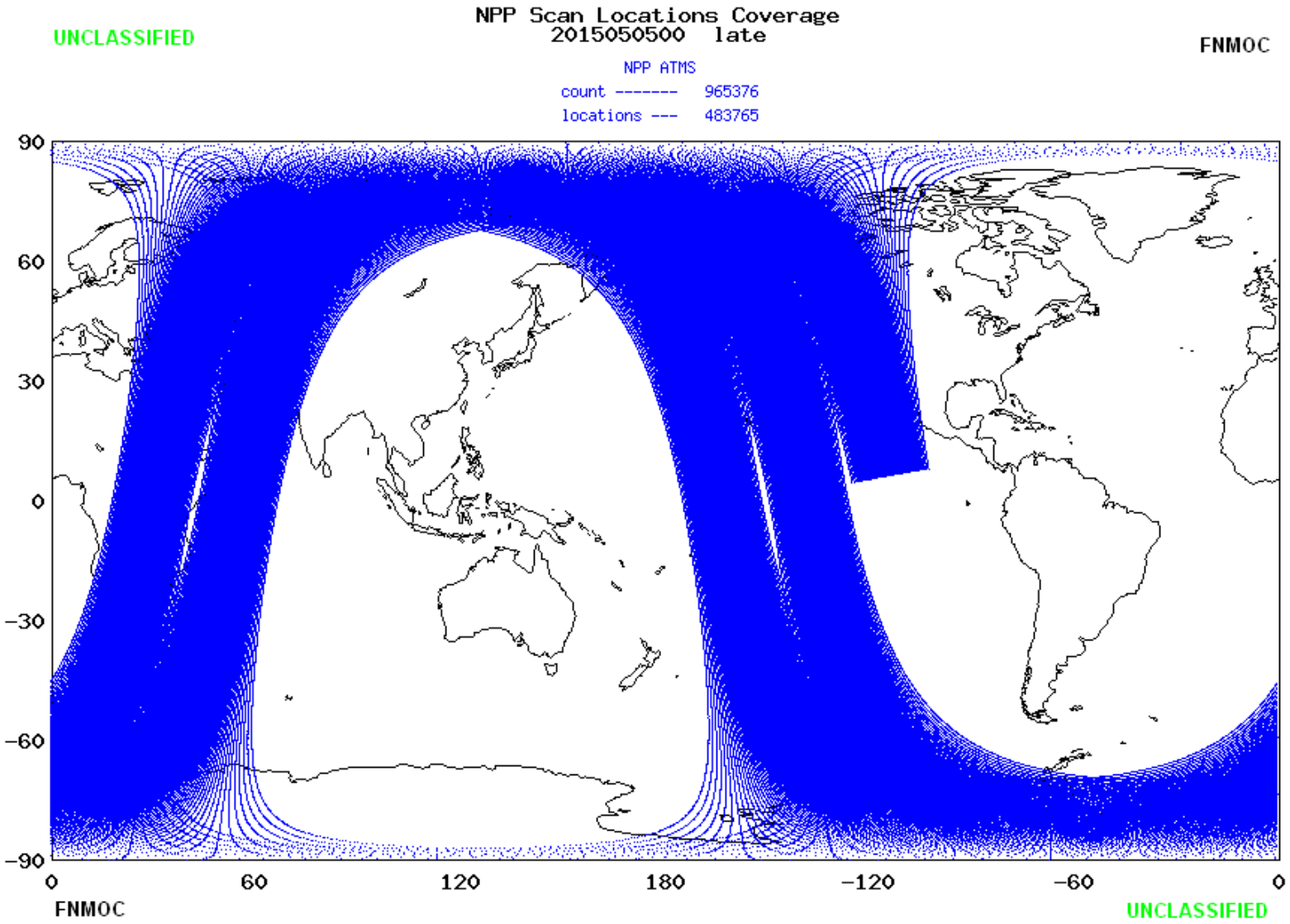
SSMIS Cal/Val
Current POES FoS LTAN Status



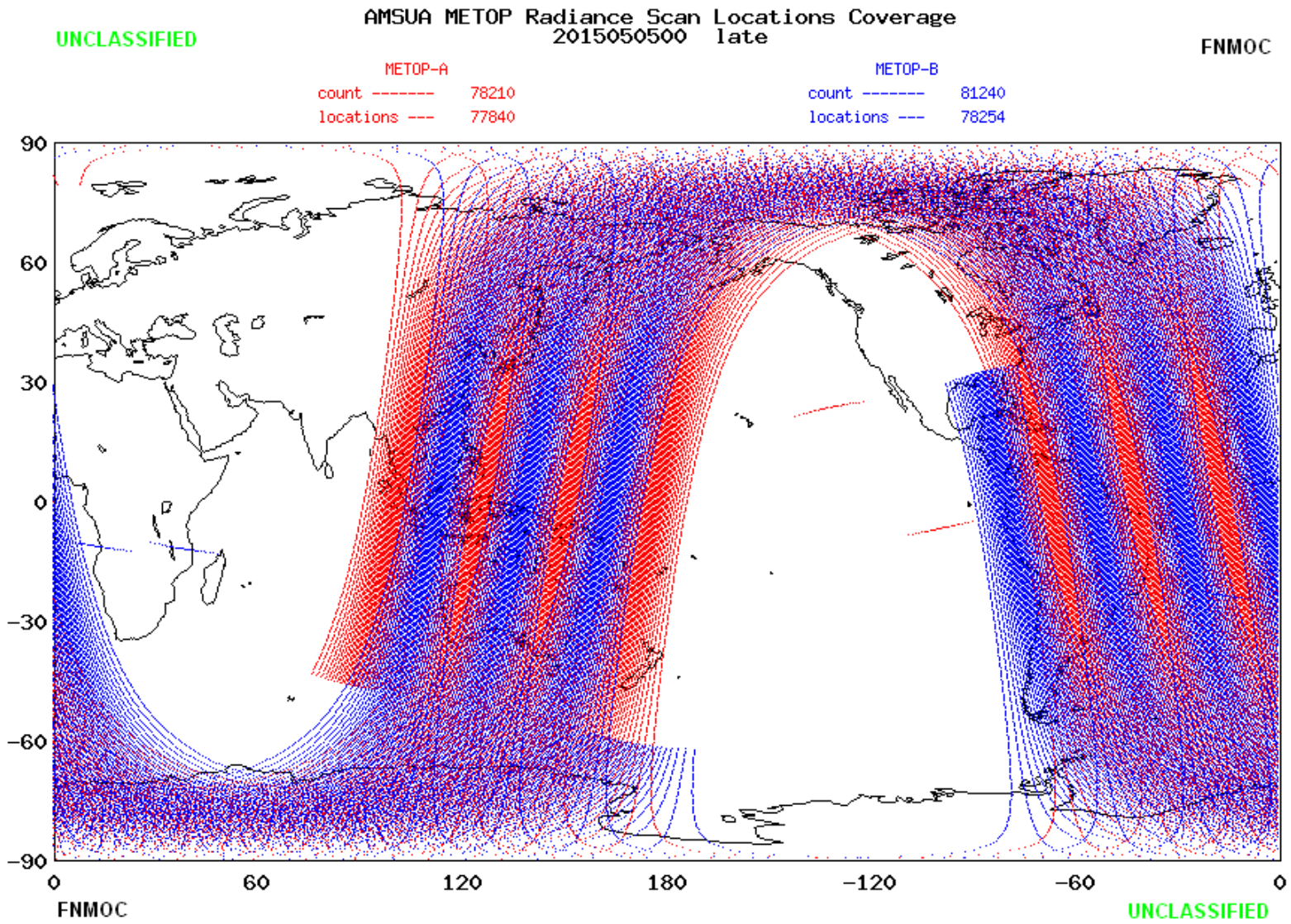
FNMOC AMSUA Polar Coverage PM afternoon orbit



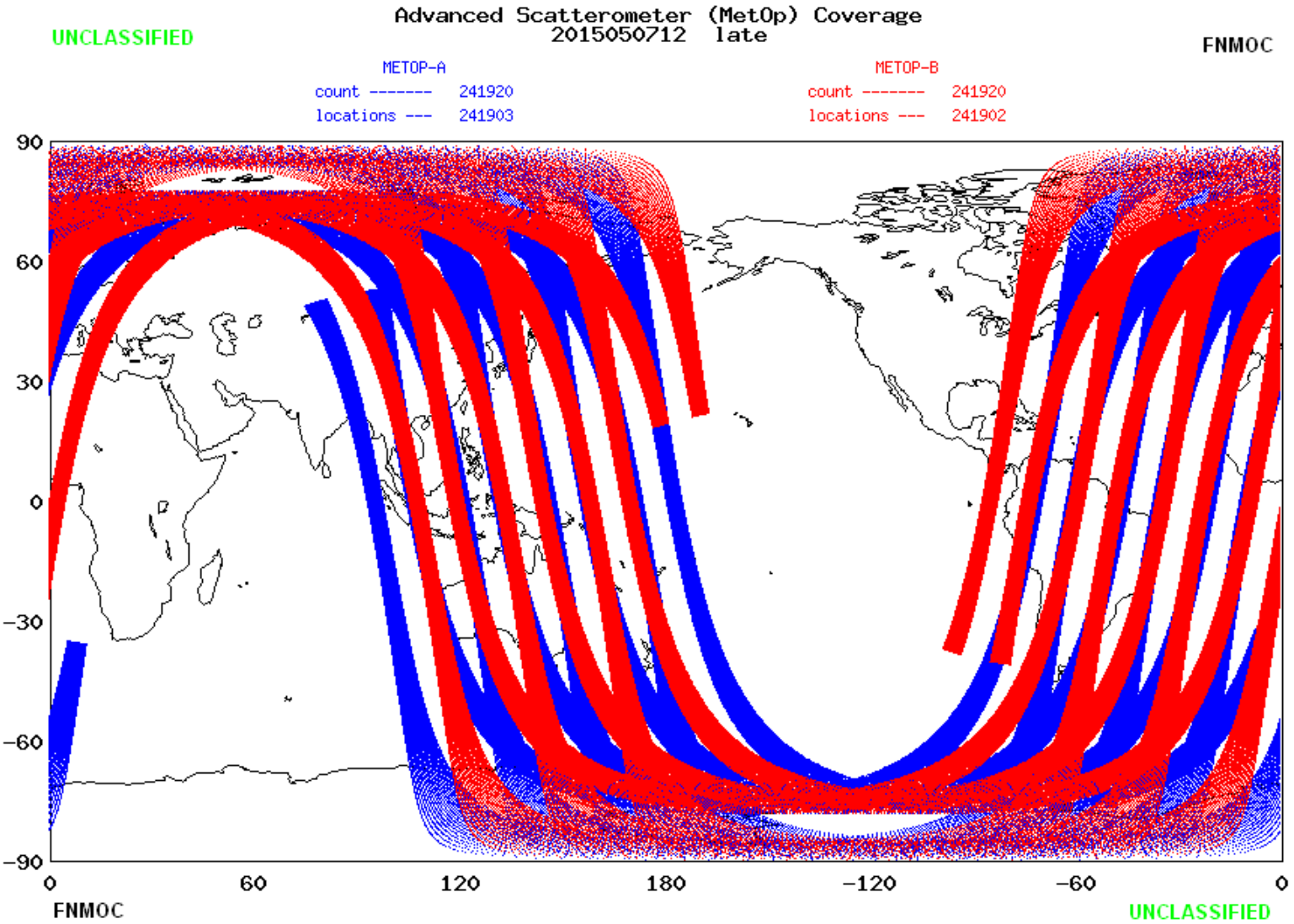
FNMOC NPP Polar Scan Coverage PM afternoon orbit-Primary



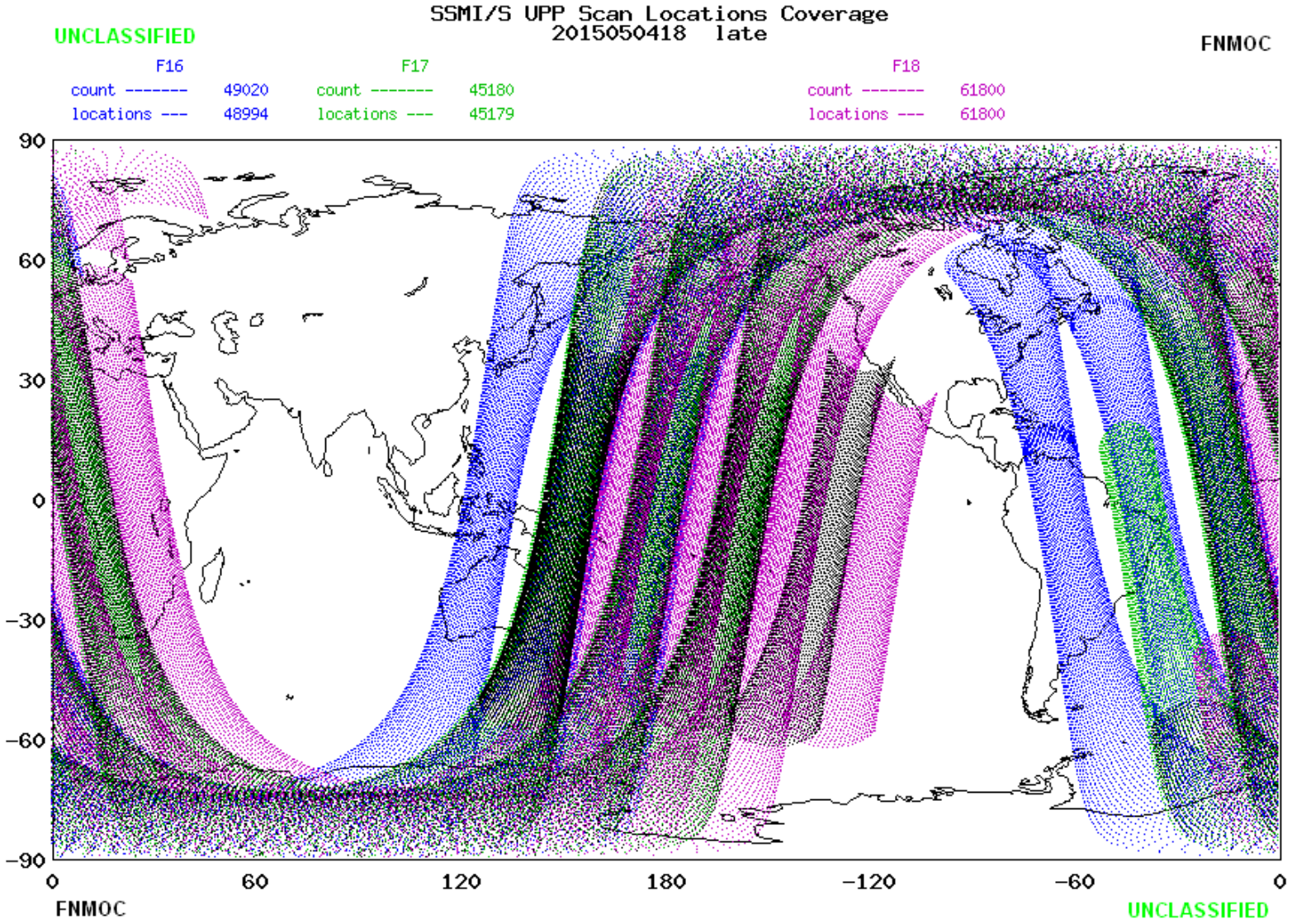
FNMOC AMSUA Polar Coverage AM mid-morning orbit



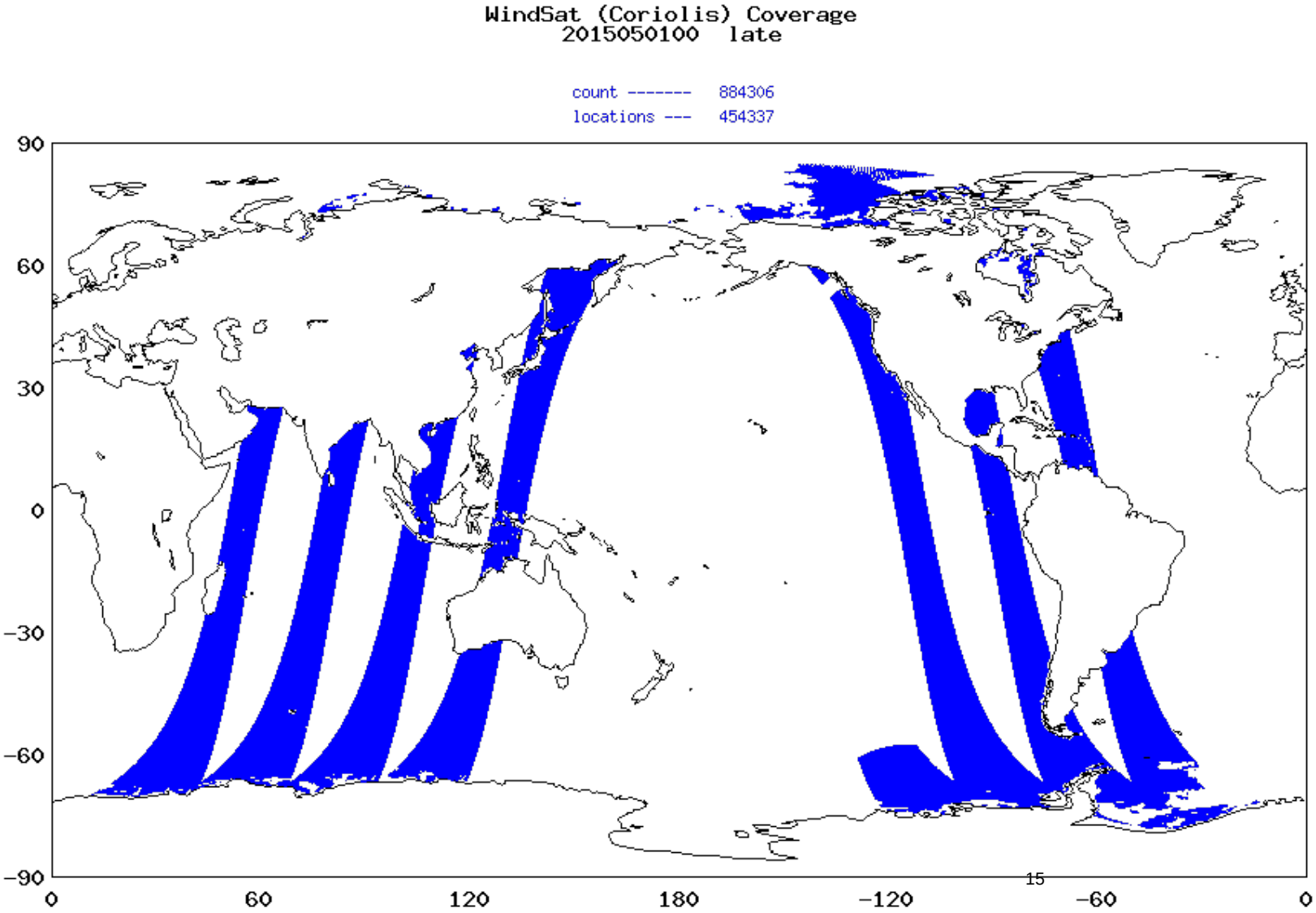
FNMOC ASCAT METOP Polar Coverage Mid-Morning orbit from ESA



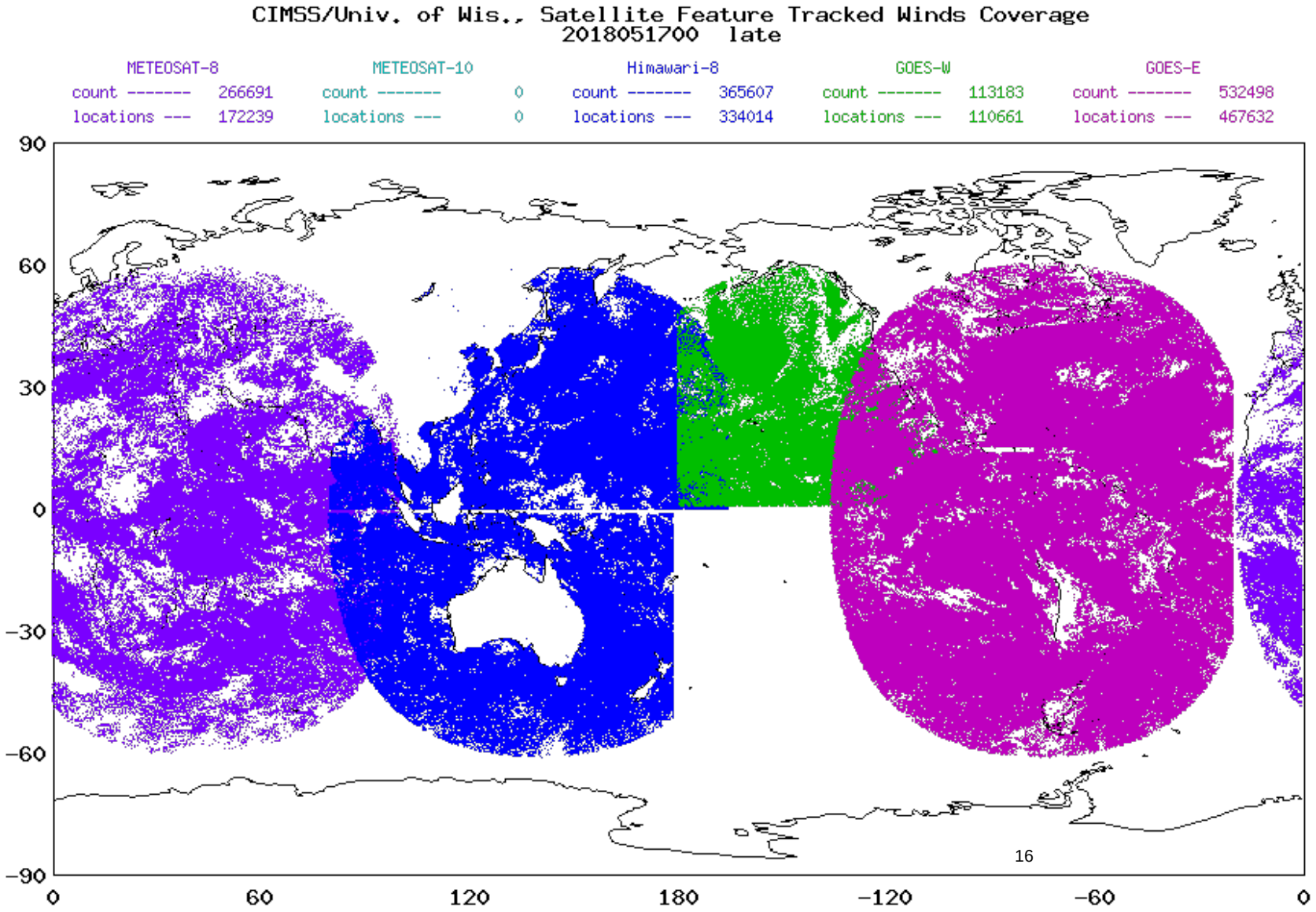
FNMOC DMSP Polar SSMI/S Coverage AM early morning orbit



FNMOC WINDSAT Polar Wind speed/direction and TPW Coverage



FNMOC Global Geostationary Coverage



FNMOC Presentation Outline

- Data used and sources of data
  - Separator/decoder process
  - Data quality control and preparation
  - Coverage plots
- **Data assimilation and acquisition Capabilities/Requirements**
  - **Model input**
- Models and products we provide
  - Models overview
  - Tactical imagery
  - Satellite data we provide
  - FNMOC website
- Projects in progress

DEPARTMENT OF THE NAVY
OFFICE OF THE CHIEF OF NAVAL OPERATIONS
2000 NAVY PENTAGON
WASHINGTON, DC 20350-2000

May 11, 2012

MEMORANDUM FOR SECRETARY OF THE AIR FORCE/DOD EXECUTIVE AGENT FOR SPACE AND DIRECTOR FORCE STRUCTURE, RESOURCES, AND ASSESSMENT, JOINT STAFF

SUBJECT: Navy Meteorological and Oceanographic Space Collection Requirements

Reference: (a) Joint Requirements Oversight Council Memorandum 020-12
(b) CJCSI 3810.01C

The recent termination of the Defense Weather Satellite System (DWSS) and issuance of reference (a) leaves the Department of Defense (DoD) without validated requirements for space-based Meteorological and Oceanographic (METOC) data. METOC data collected from space is vital to Navy's operation of global atmospheric and oceanic models to support Joint military operations. In support of the DoD DWSS follow-on effort, baseline METOC collection requirements needed to support safe, efficient, and effective military operations must be understood.

The space-based collection requirements most critical to the Fleet for tactical operational forecasting and global modeling are listed in priority order in attachment (1). Attachment (2) contains the full detailed collection requirements.

While the Navy fully endorses the tenet of leveraging non-DoD sources of space-based data to the greatest extent possible, reference (b) states, "U.S. military METOC forces must be capable of functioning without substantive dependence or reliance on non-DOD data or support." The Navy supports a solution or set of solutions to meet Fleet requirements that pays deference to the current fiscal environment while not leaving our METOC forces entirely reliant upon non-DoD sources for the most vital data.

The Director, Oceanography, Space, and Maritime Domain Awareness point of contact for this matter is CDR Andrew Lomax, (703) 614-1798, e-mail: andrew.lomax@navy.mil.

for
KENDALL L. CARD
Vice Admiral, U.S. Navy
Deputy Chief of Naval Operations
for Information Dominance

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NMOC Requirement Priorities

High Priority Parameter		What the parameter is used for (satellite imagery, atmospheric/oceanographic modeling, etc)
Sea Surface Height	1	Ocean Modeling
Ocean Surface Wind Speed/Direction	2	Tropical Cyclone Forecasting, Ship Routing
Microwave Sounding (radiances)	3	Atmospheric modeling, Tropical Cyclone Forecasting
Visible Imagery	4	Satellite Imagery
Infrared Imagery	5	Satellite Imagery
Sea Ice Concentration	6	Naval Ice Center, Navigation
Precipitable Water	7	Atmospheric modeling
Microwave Imagery	8	Satellite Imagery
Ocean Significant Wave Height	9	Acoustic Propagation, Ship Routing
Sea Surface Temperature	10	Ocean and Atmospheric Modeling
Water Vapor Imagery	11	Satellite Imagery
Ozone Profile	12	Atmospheric modeling
Ozone Total Column	13	Atmospheric modeling
Sea Ice Edge	14	Naval Ice Center, Navigation
Sea Ice Characterization	15	Naval Ice Center, Navigation
Precipitation Rate	16	Atmospheric modeling
Aerosol Optical Thickness	17	sensor performance characteristics
Atmospheric Vertical Moisture Profile (EDR)	18	Atmospheric modeling
Atmospheric Vertical Temperature Profile (EDR)	19	Atmospheric modeling
Fire Detection	20	Atmospheric modeling

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Satellite Capabilities Needed

Navy NWP requires sensors that are sensitive to:

- Ozone (O_3)
- Sulfur Dioxide (SO_2)
- Liquid & Solid H_2O
- Humidity sensitive radiances (H_2O Vapor)
- Temperature
  - Sensitive to Carbon Dioxide (CO_2)
  - Sensitive to Oxygen (O_2)
- Sea Surface Temperature
- Sea-ice/ice-concentration
- Surface wind speed and direction
- Land surface information (such as soil type, soil moisture, & others)
- Total precipitable water (globally and at the mesoscale)
- Clouds

Designed to help models perform calculations using Radiative Transfer Model (RTM)
Help the FNMOC assimilation system fine-tune the values used by the model.

These satellite measurements will help improve the values of…

Model Parameters to be Targeted

- **Pressure/altitude at various vertical levels**
  - *Surface pressure*
  - *Geopotential (φ)*
  - *Various vertical pressure levels*
- **Virtual potential temperature (θ)**
  - *Implies knowledge of temperature at various vertical levels*
  - *Needs channels sensitive to temperature at different levels*
- **Specific humidity (q) at all vertical levels**
- **Diabatic forcing (Q9)**
  - *Due to radiation*
  - *Due to latent heat release processes*
  - *Due to vertical mixing*
- **Horizontal winds to calculate vorticity and divergence**
  - *Wind speed/direction at various vertical levels*
  - *Need to determine the "u/v" components of wind*
  - *The ability to be more sensitive/accurate in determining the pressure level or altitude of the winds.*
- **Kinetic energy and vertical/horizontal fluxes of kinetic energy**
- **Potential energy and vertical/horizontal fluxes of potential energy**
- **Total precipitable water**

Model Parameters to be Targeted (cont'd)

Parameterizations are used to account for various physical phenomena in FNMOC NWP models. These Physical parameterizations include:

- Gravity wave drag due to mountain
- Vertical turbulent diffusion
- Shallow cumulus mixing
- Cumulus convection
- Large scale stable precipitation
- Heating due to longwave radiation
- Solar radiation
- Interaction between land and atmosphere (e.g. turbulent boundary layer)

NAVGEM/NAVDAS-AR Data Types Assimilated

Conventional Data Types

Vertical Profilers
- Radiosondes
- Pibals
- Dropsondes

Buoys and Driftsonde (Concordiasi)

Land and Ship Surface Obs

Aircraft Obs
- AIREPS
- AMDAR
- MDCRS

RAW SATELLITE DATA

Radiances and Bending Angles Assimilation Requires Forward Models

Hyper-Spectral IR Sounding Radiances
- IASI and AIRS

MW Sounding Radiances
- 6 AMSU-A (Ch 4-14)
- 3 SSMIS (Ch 2-7, 9-11, 22-24)
- SSMIS/AMSU-B/MHS 183 GHz (Operational)

GPS-RO Bending Angle
- Cosmic: FM1 - FM6
- Grace, GRAS, TRSX, CORISS

PRODUCTS

Surface Winds
- Scatterometer, ASCAT
- SSMI/SSMIS
- WindSat
- ScatSat-1

Feature Tracked Winds
- Geostationary (7 satellites)
- Polar Orbiters (AVHRR and MODIS)
- Combined polar/geo winds (CIMSS)

Total Water Vapor
- SSMI/SSMIS TVAP
- WindSat TVAP
- TVAP is being replaced by using the radiances

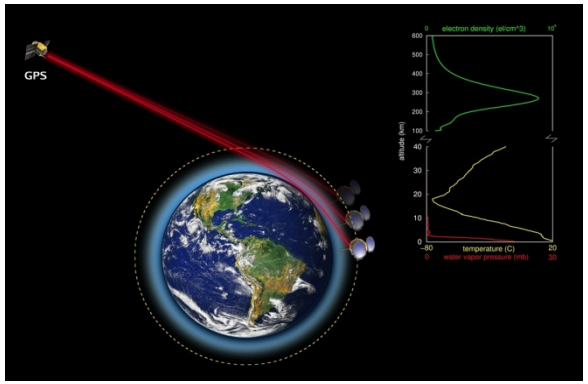
ATOVS Temperature Retrievals (COAMPS)

Advanced Satellite Assimilation

Satellite sounders provide temperature and moisture profiles
they have a **COMPLEMENTARY** nature forming a comprehensive system

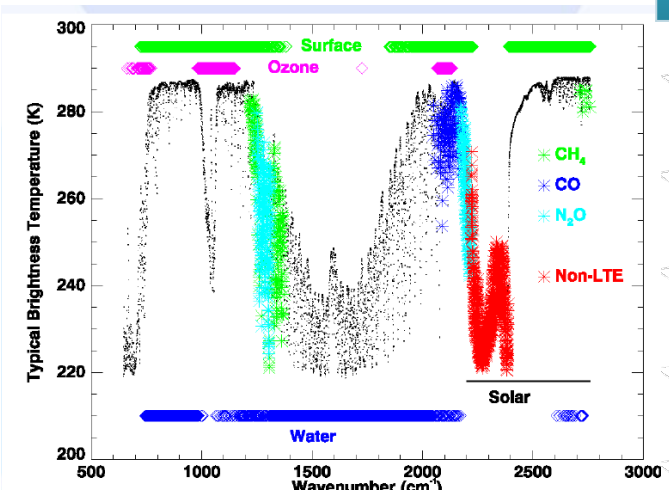
GPS-RO

Horizontal	POOR	200km
Vertical	GOOD	~8km-60km x200m
Cloud	GREAT	virtually no impact



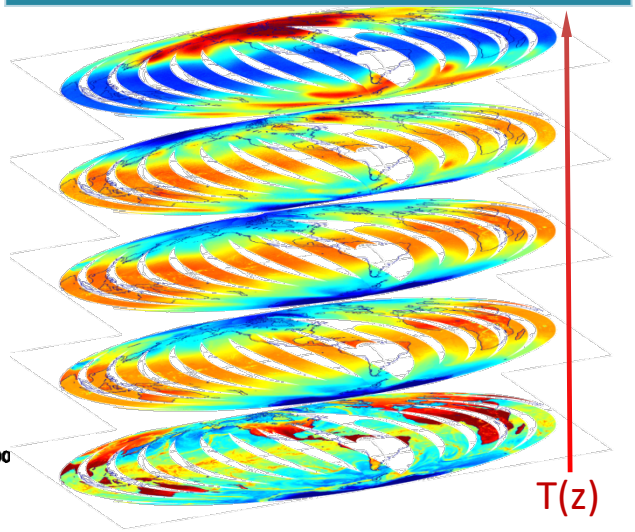
Infrared

Horizontal	GREAT	10km
Vertical	GOOD	surface-40km x2km
Cloud	POOR	stop at cloud top



Microwave

Horizontal	GOOD	25km
Vertical	GREAT	surface-90km x5km
Cloud	GOOD	stop at rain



Advanced Satellite Assimilation

FY17 – FY18:

Delivered **complete**

- **MW Imagers** SAPHIR, GMI, AMSR/2; enhanced SSMIS, AMSU-A and ATMS
- **Correlated error** ATMS SNPP, IASI, and CrIS
- **New Sensor Patches** ATMS NOAA20; GeoCSR (GOES-16, Himiwari-09, MeteoSat-11)

Pending **ongoing**

- **Extend correlated error** for MW humidity (SAPHIR, SSMIS, MHS)
- **CrIS FSR** (Full Spectral Resolution) SNPP and NOAA20
- **Aerosol impacts on radiances** hyperspectral and GeoCSR
- **Infrared window channels** assimilation for sensors IASI and CrIS

Waiting **waiting**

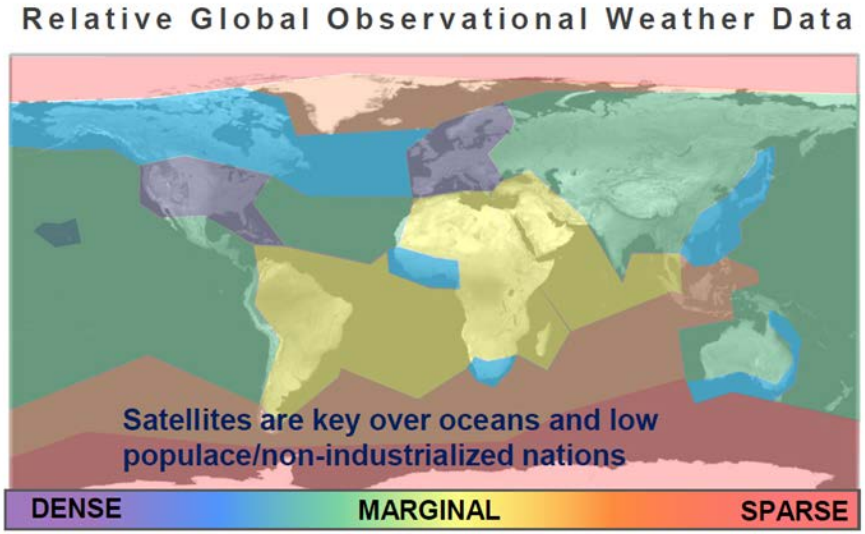
- **2D GNSS-RO** operator capability
- **Polarimetric MW** (microwave) assimilation for COWVR and WindSAT
  - New version of RT needed; ability for WindSAT V&H complete
  - COWVR launch delayed FY19

FY18 – FY19:

- **All-sky MW** approach, and emissivity sink for MW
- **COAMPS-AR v1.0 and v1.2** , MW radiances and add GNSS-RO respectively
- **Aerosol extinction** assimilation (w/Hyer 7544)
- **Dynamic observation error** (w/Tyndall DA)

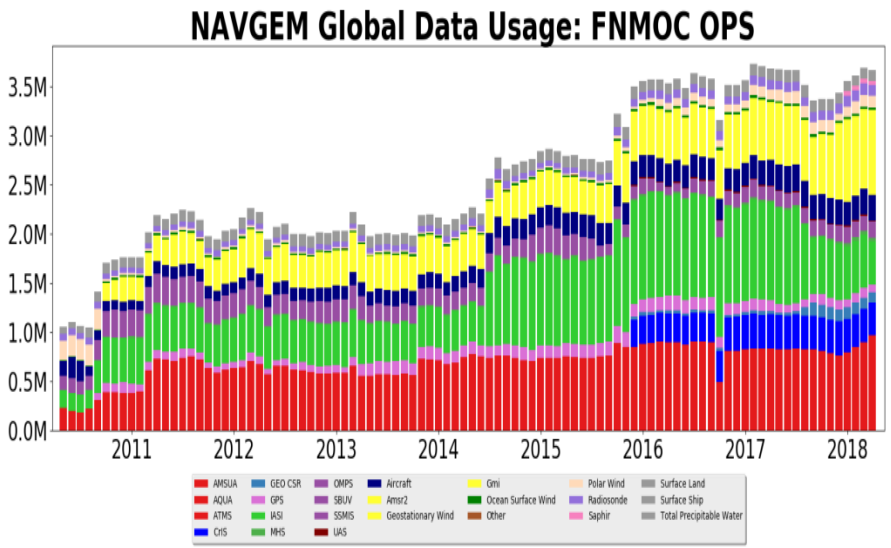
Advanced Satellite Assimilation

Key Accomplishments



Satellites provide ~85% of the assimilated observations
Satellite observations account for ~60% of the 24-hr forecast error reduction

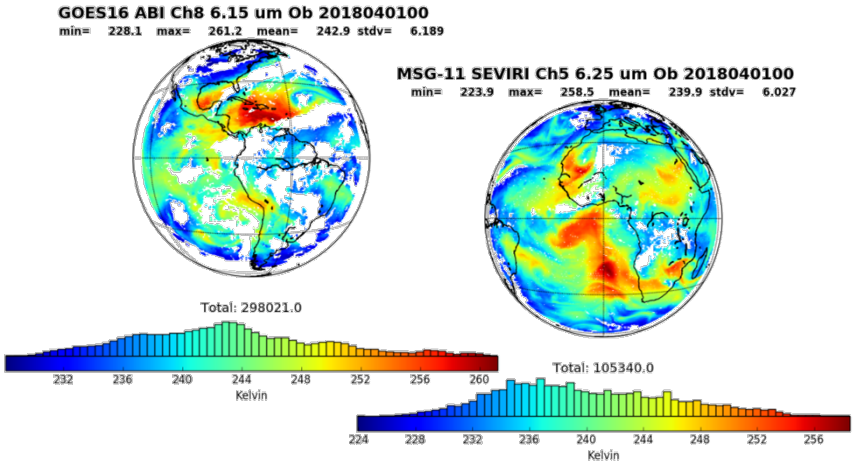
The number of satellite observations assimilated by NAVGEM has more than doubled over the past 5 years.
- and tripled in less than 10 -



Advanced Satellite Assimilation

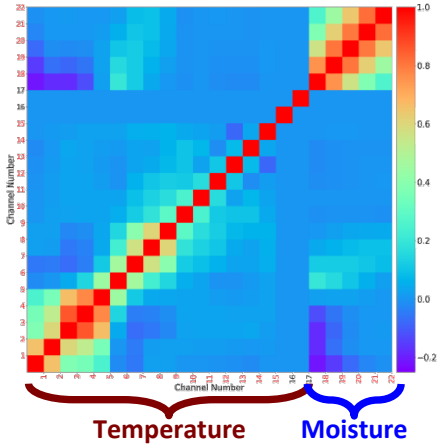
Key Accomplishments – NAVGEM v1.4.3 + patches

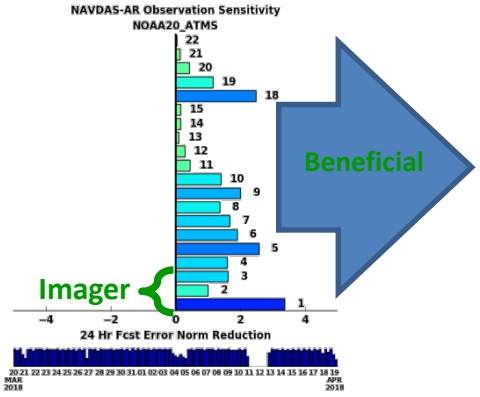
NAVGEM v1.4.3 Patches
GeoCSR: GOES-16, Himiwari-09, Meteosat-11
MW : ATMS NOAA20

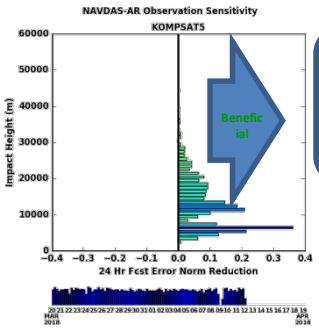


GeoCSR
GOES-16 & MeteoSat-11

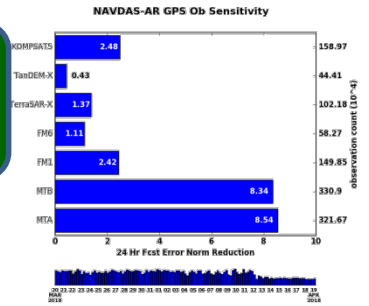
NOAA20 ATMS *pre*OPS







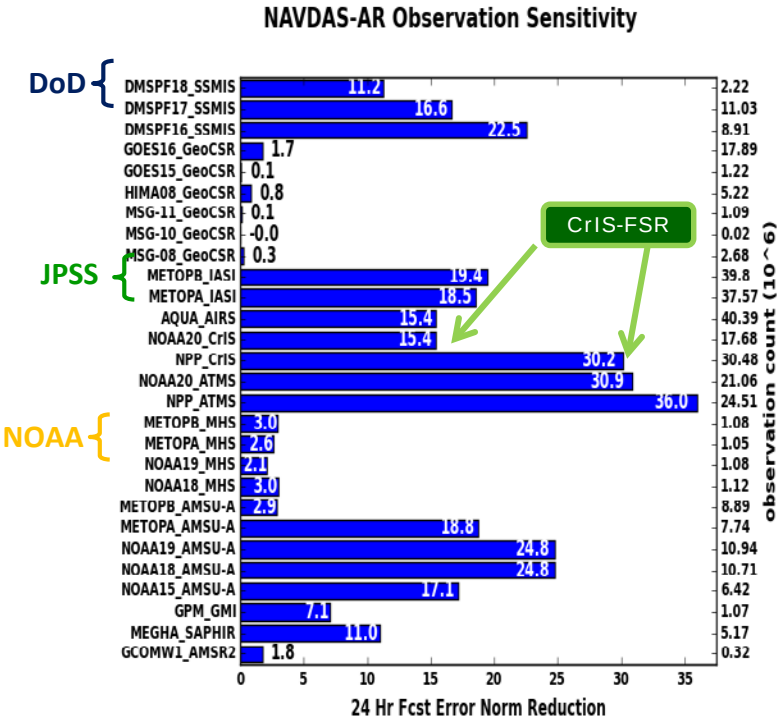
GNSS-RO
KOMPSAT5



Advanced Satellite Assimilation
Key Accomplishments – NAVGEM v1.4.5 and Beyond

Deliver NAVGEM v1.4.5 (and ESPC)

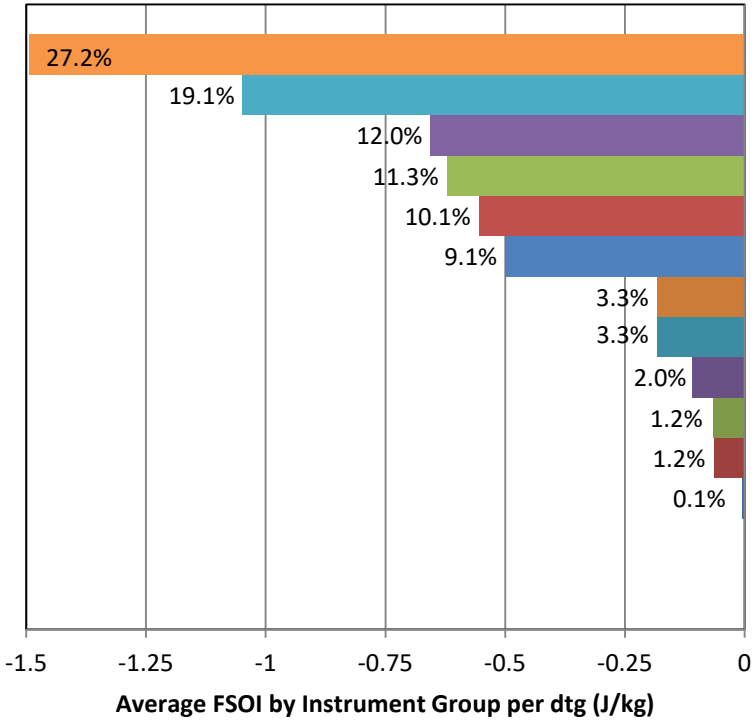
- CrIS-FSR (Full Spectral Resolution)
  - Spectrum of channels increases from 1305 to 2211
  - NOAA-20 transmission planned only in FSR mode
    - ➢ Data with provisional quality started 21Feb2018
- Aerosol aware radiances
- Correlated error for all humidity radiances

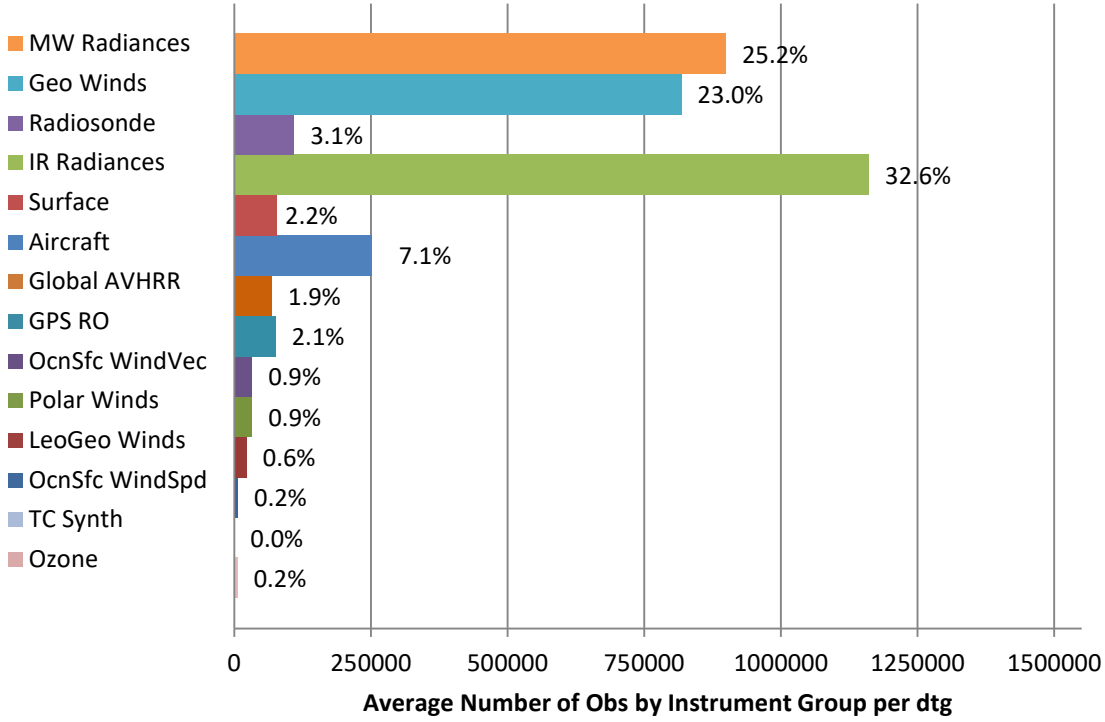


Future: **How to Maintain Technological Advantage**

- ➢ Cloudy and Aerosol aware DA
- ➢ More agile database to explore, exploit, extract information
- ➢ AI (artificial intelligence) for quality control, thinning, forward operators
- ➢ Cloud services for products and satellite simulations from forecasts

Relative Importance of Data Types





Hybrid 4DVAR--April 2018
Total Energy Norm
Total FSOI = --5.5 J/kg/dtg

Hybrid 4DVAR--April 2018
Total Energy Norm
Total Count = 3562350/dtg

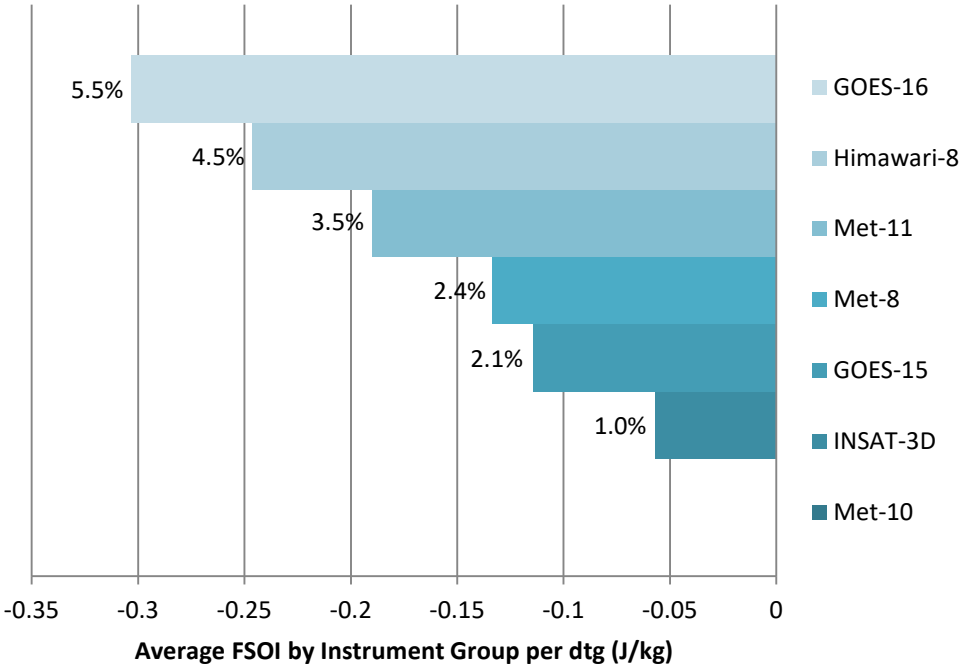
U.S. NAVAL RESEARCH LABORATORY

Relative Importance of Data Types

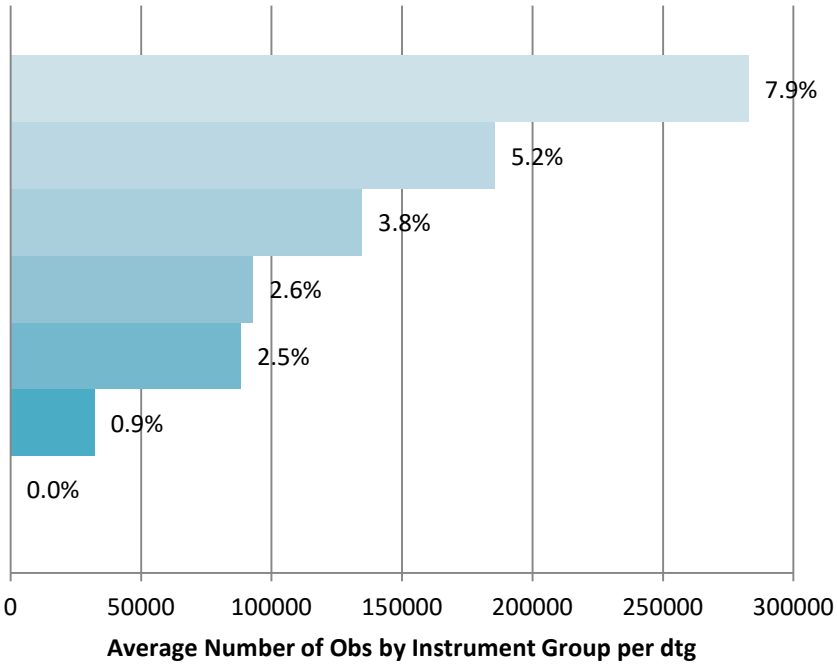
Groups of observations with % counts by category

- Microwave radiances
  - AMSU-A (43.7%)
  - ATMS (31.3%)
  - SSMIS (19.2%)
  - SAPHIR (5.0%)
  - MHS (4.2%)
  - SSMIS UAS (1.5%)
  - GMI (1.0%)
  - AMSR2 (0.4%)
- Infrared radiances
  - IASI (34.6%)
  - CrIS (29.2%)
  - AQUA AIRS (27.8%)
  - GeoCSR (8.4%)
- Radiosonde
  - Rawinsonde (97.4%)
  - Pibal (2.5%)
  - Dropsonde (0.0%)
- Surface
  - Land (69.6%)
  - Coast (14.6%)
  - Buoy (moored) (5.5%)
  - Buoy (drifting) (5.8%)
  - Ship (4.5%)
- Aircraft
  - WMO BUFR (87.2%)
  - Other AMDAR (9.1%)
  - AIREP (3.7%)
- Geo Winds
  - GOES-16 (34.6%)
  - Himawari-8 (22.7%)
  - Met-11 (16.5%)
  - Met-8 (11.4%)
  - GOES-15 (10.8%)
  - INSAT-3D (3.9%)
  - Met-10 (0.0%)
- Satellite Ocean Sfc Wind Vectors
  - ScatSAT (54.6%)
  - ASCAT (33.4%)
  - WindSat (12.0%)
- Polar Winds
  - AVHRR (41.9%)
  - MODIS (47.3%)
  - VIIRS (10.8%)

Relative Importance of Geo Winds



Hybrid 4DVAR--April 2018
Total Energy Norm
Total FSOI = --1.0 J/kg/dtg
Geo Winds = 19.1% of total



Hybrid 4DVAR--April 2018
Total Energy Norm
Total Count = 816387/dtg
GEO Winds = 23.0% of total

FNMOC Priorities for NWP (Coordinated with NOAA)

- NPP/JPSS1 (PM Primary) launched in October 2011/2017 – ATMS, CRIS, OMPS, VIIRS AMV
- N-19 (PM Primary) - AMSU-A, MHS, HIRS
- MetOp-B (AM mid-morning Primary) – AMSU-A, IASI, ASCAT, MHS, HIRS
- MetOp-A (AM mid-morning Backup) - AMSU-A, IASI, ASCAT, MHS, HIRS
- MetOp-C – September 2018?
- N-18 (PM Backup) - AMSU-A
- N-15 (AM Secondary) - AMSU-A, MHS, HIRS
- N-16 (PM Secondary) - AMSU-A
  - **Future Himawari-9 AMV ?, JPSS 2018**

FNMOC Priorities for Imagery

- N-19 (PM Primary) - AMSU-A, MHS
- MetOp-B (AM mid-morning Primary) - AMSU-A, MHS, ASCAT
- MetOp-A (AM mid-morning Backup) - AMSU-A, MHS, ASCAT
- N-18 (PM Backup) - AMSU-A, MHS
- NPP/JPSS1 (PM Primary) - VIIRS

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FNMOC Priorities for NWP (Coordinated with Air Force, CSAT, SLEP)

- F-18 (Primary Early Morning) – SSMIS, (TPW, WS, UPP soundings, ice)
- F-17 (Secondary Early Morning) – SSMIS, (TPW, WS, UPP soundings, ice)
- F-16 (Secondary Early Morning) – SSMIS, (TPW, WS, UPP soundings, ice)
- F-15 (Secondary Early Morning) – SSMI, (TPW, WS, ice concentrations)
  - Future COWVR, WSF-M, WSF-E, WSF-G

FNMOC Priorities for Imagery - Smooth (SSMI/S has priority over OLS, different than 557 WW [AFWA])

- F-18 (Primary) – SSMIS, OLS (TCWEB, SAT_FOCUS)
- F-17 (Secondary) – SSMIS, OLS (TCWEB, SAT_FOCUS)
- F-16 (Secondary) – SSMIS, OLS (TCWEB, SAT_FOCUS)
- F-15 (Secondary) – SSMI, OLS (TCWEB, SAT_FOCUS)
- F-14 – Still produce tactical RTD imagery only
  - **Future TBD – Possible WSF dependent**

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New/Ongoing Satellite Data / Transitions

- SNPP/JPSS1/GCOM-W1 – EAPs via JSH?
- Sentinel-3 via ESA altimetry via NAVO for NCODA?
- MARKIVB – SSMI/S, OLS, RTSIMPLE, Met8, MET-11,Himawari 14 channels, COMS
- DMSP/METOP/JPSS McMurdo ½ orbit data – March 2012 via 557th WW only
  - **Considerations/Issues conflicts with JPSS1 creates missed DMSP F18/17**
  - **Possible mitigation is looking at DMSP-16 instead which fly's later?**
- ESA moved MET-8 over the I/O replacing MET-7, how long? WSF-G?
- JMA GEO Himawari-9 replaces Himawari-8 ?
- GOES-S Operational 2018? – working with ESRP and Harris
- JPSS-1 Operational 2018 – working with NOAA
- COSMIC-2A will launch in FY2018 – working with NOAA/UCAR
- COWVR sensor flying on Int'l Space Station possibly – NASA/JPL 2019?
- **Foreign Satellite Data Dependency Study – OPNAV/NRL/FNMOC**
- **Spectrum Bandwidth sell off to Cell phone industry (MRY keep out zone)**

CONOPS FNMOC Satellite Data Ingest/Processing/Distribution

- DMSP & WINDSAT - DOMSAT
- NOAA GOES - FMQ-17
- NOAAPORT – New system recently integrated (satellite)
- 557th WW DMSP/WSF, Foreign GOES via OTN
- COPC DAPE NOAA/NESDIS/NAVO via OTN
- NASA EOS via OTN and NESDIS?
- ISIS, ATCF, CAGIPS, METCAST, NITES NEXT, GIS GEOSERVER
- MARKIVB – US Air Force direct read out regional coverage
- FMQ-17 – JTWC (Himawari), FWC-Norfolk (EUMETCAST)

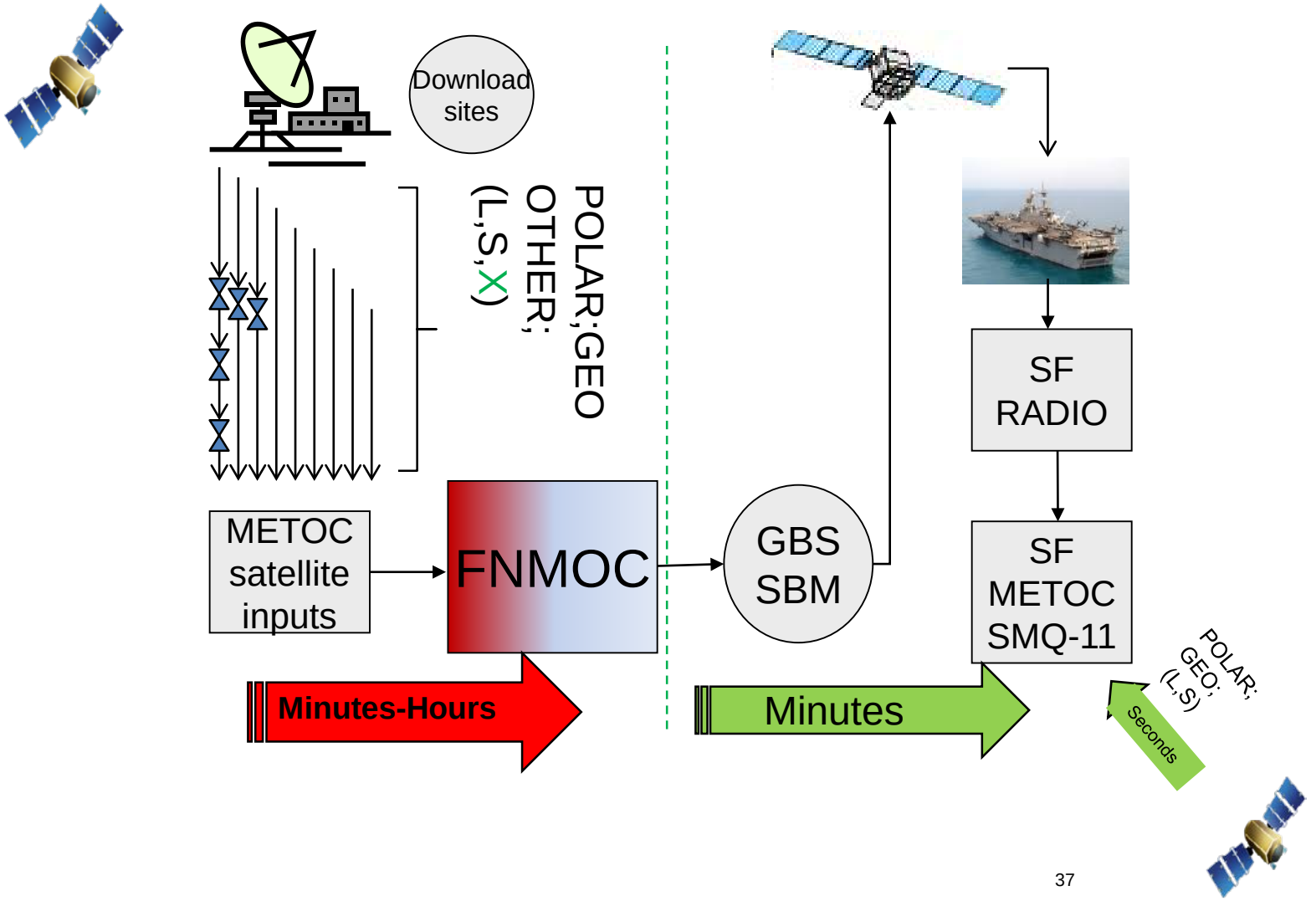
Satellite Data Provided to NOAA NESDIS/NCEP with GTS distribution to other global OPCs

- **DMSP SSMI/S Temperature Data Records (TDRs)**
- **DMSP SSMI/S Sensor Data Records (SDRs)**
- **DMSP SSMI/S Environmental Data Records (EDRs)**

- **DMSP SSMIS UPP Radiance data both in raw and BUFR**

- **WINDSAT xDRs in raw format**

Simplified METOC EDR Data Flow for GBS



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Proposed Navy/Air Force DoD SafetyNet CONOPS

- Connect Navy Shore Based FMQ-17 sites with Air Force MARKIVB sites to DoD METSAT Production Centers FNMOC, NAVO, 557 WW via DISA based fiber
  - Relieves dependencies on obtaining data from NOAA/NASA and foreign partners (single points of failure hops, skips, and jumps outside of DOD control)
  - Addresses latency, IA, and COOP contingencies globally
  - Use common interoperable formats and decoders

CONOPS Inter-agency Programs

- DMSP - CAL/VAL SMC LA AFB members
- JPSS, WSF? IDPS via NOAA/NASA JSH
- WINDSAT CODDS (risk reduction)- Navy
- NOAA POES/GOES, International
- NASA EOS – LANCE/NESDIS?
- FMQ-17/SMQ-11 ESRP – OPNAV N2/N6E2, CNMOC Review
- EUMETSAT/JAX/India/Russia/China - GTS

Current and Future Satellite War-fighter related Imagery (GeoIPS) transitioning to OPS and FNMOC from NRL

Tactical Imagery: Tropical Cyclone Web Page (TCWeb)

- Multi sensor , data and imagery fusion
- Aids JTWC and NHC forecasters and analysts in determining more accurate storm positions and intensities
- Available to the public

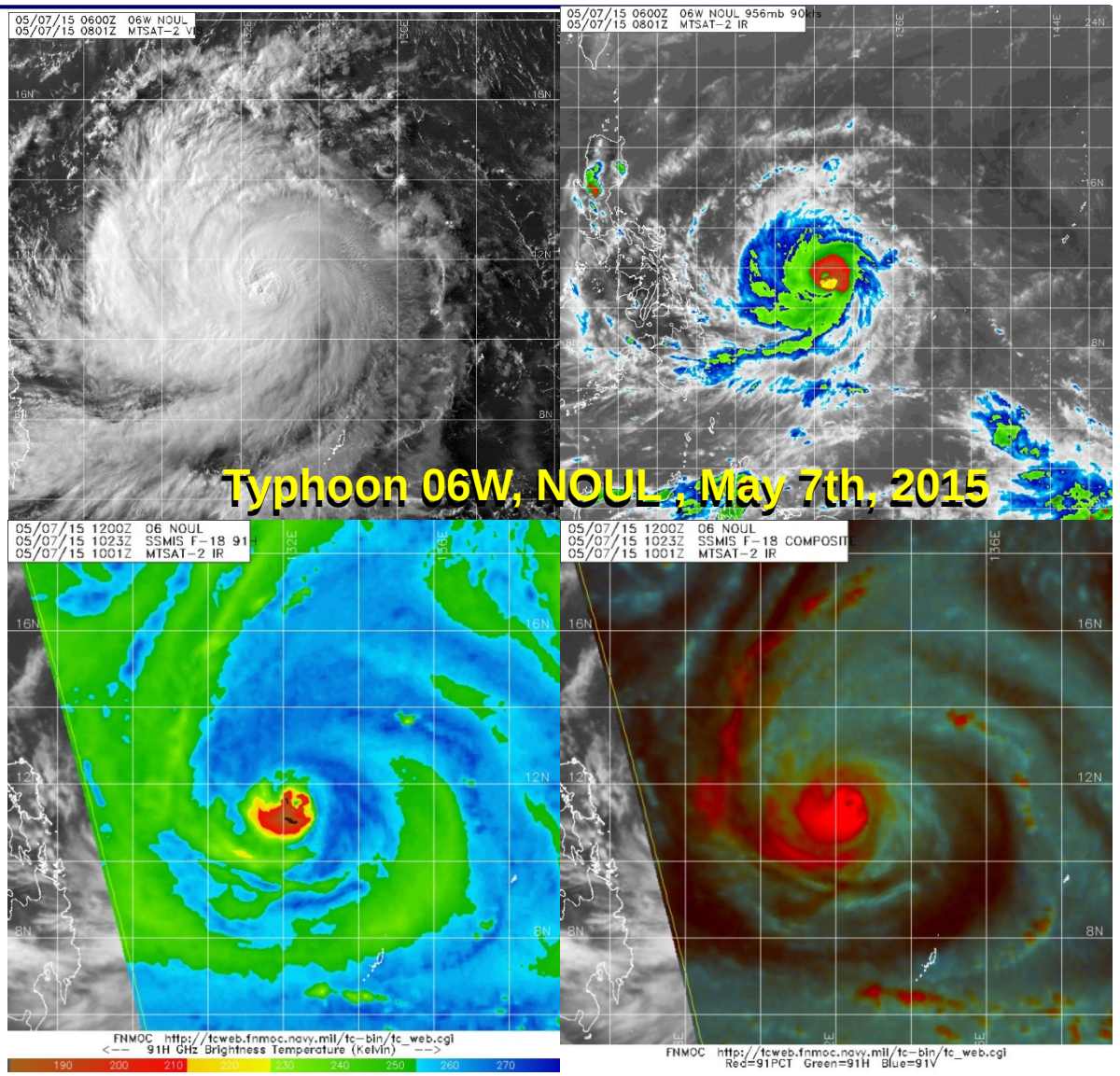
u.r. – MTSAT IR (color enhance)

u.l. – MTSAT VIS

l.l. - SSMI PCT/ GOES VIS

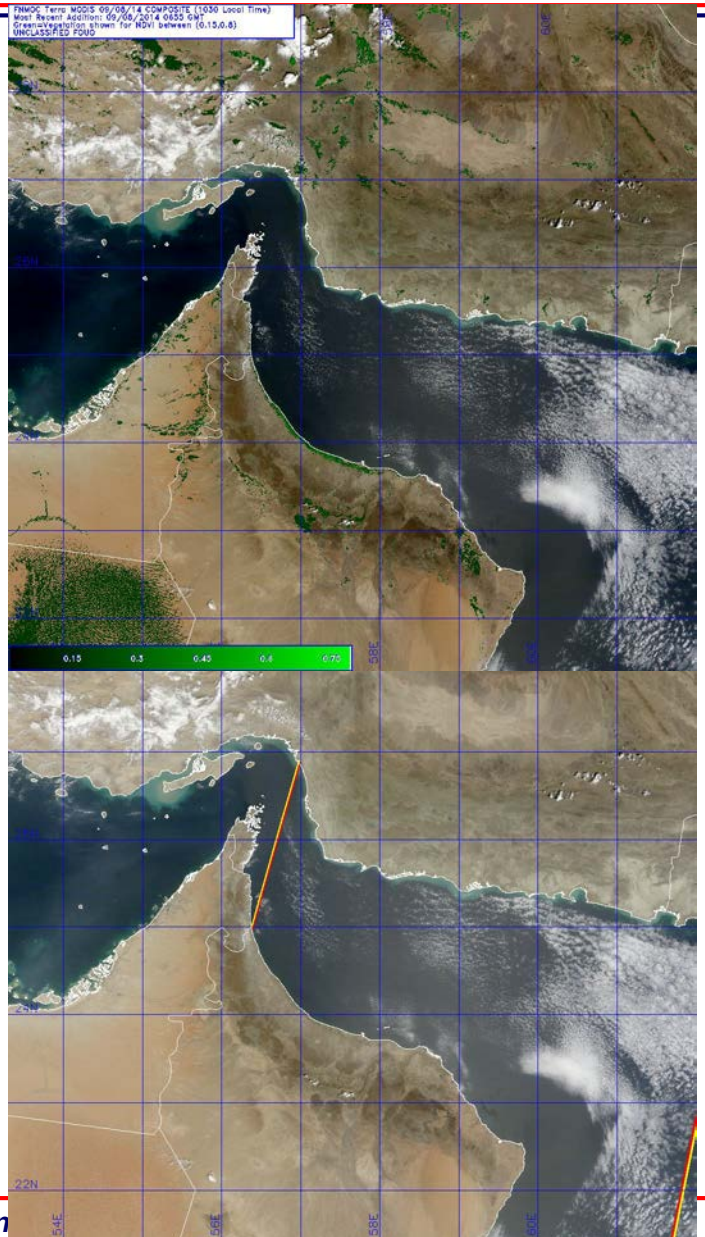
l.r. – SSMI Composite/MTSAT VIS

New data types include NOAA-20, MET-11, ScatSat-1, GMI, continuing legacy include SSMIS, AMSUA, and all geostationary, all polar microwave available.

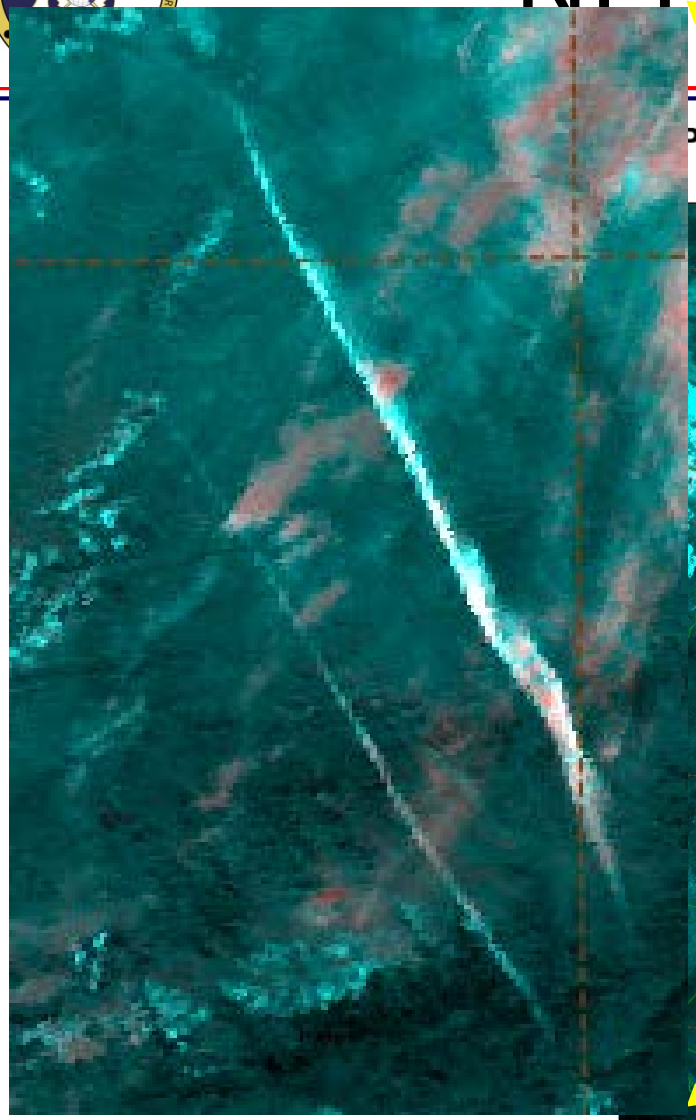


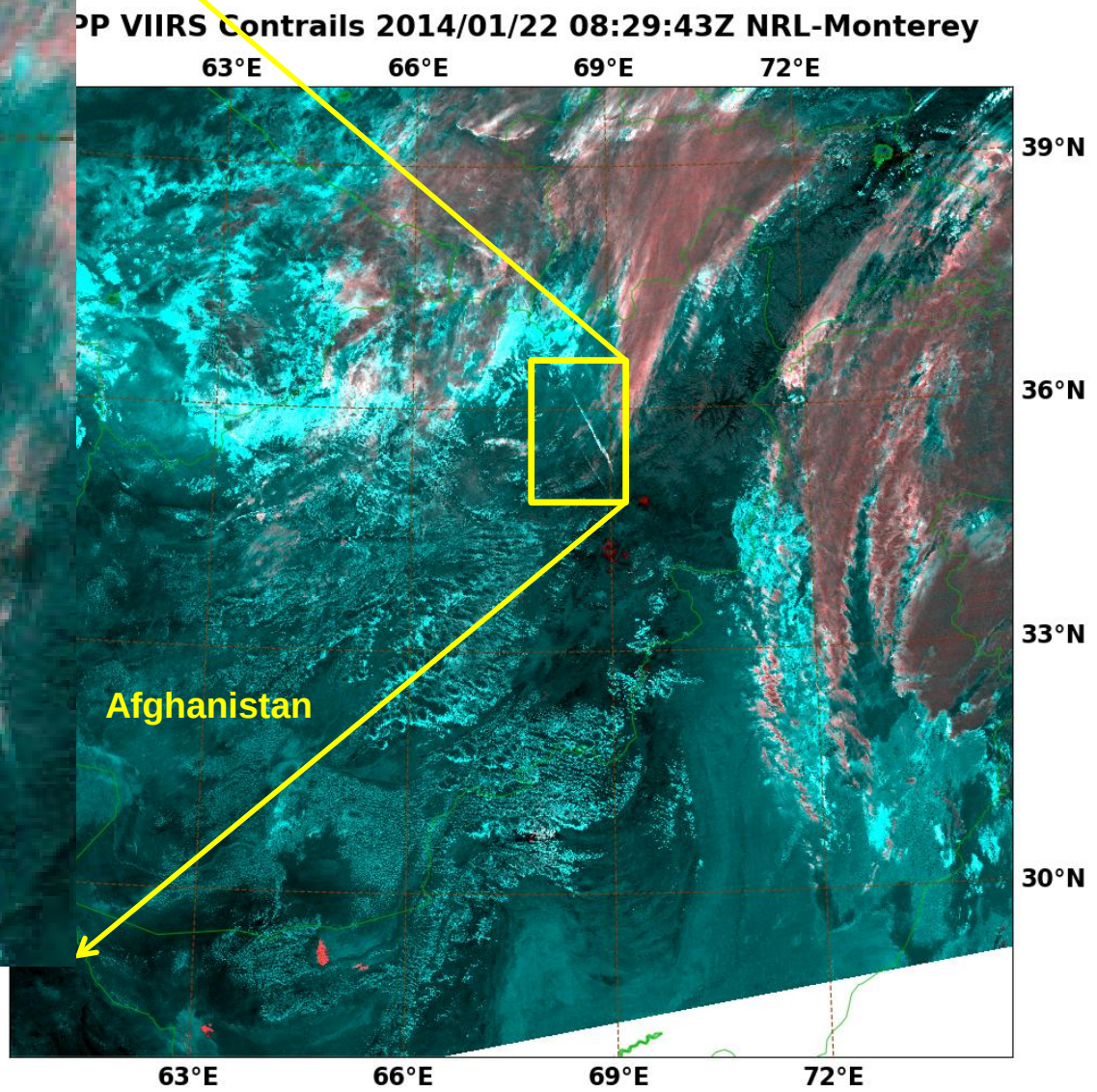
Tactical Imagery: SIPRNET Satellite Focus

- FNMOC presentation of operational satellite products
- In response to user request, region specific
  - Arabian Sea, Afghanistan, Persian Gulf
  - Where next? How does this affect warfighting?
- MODIS true color/dust enhancement, feature tracking winds
- New products – low cloud over snow, low clouds at night, convective cloud top heights
- MODIS dust enhancement over the Northern Arabian Sea, true color over land. Dust over the ocean appears as shades of pink. Dry lakebeds over land (often representing sources of dust) are also indicated in pink.
- Horizontal resolution of the data is 0.5 km.



NPP VIIRS Contrail Detection

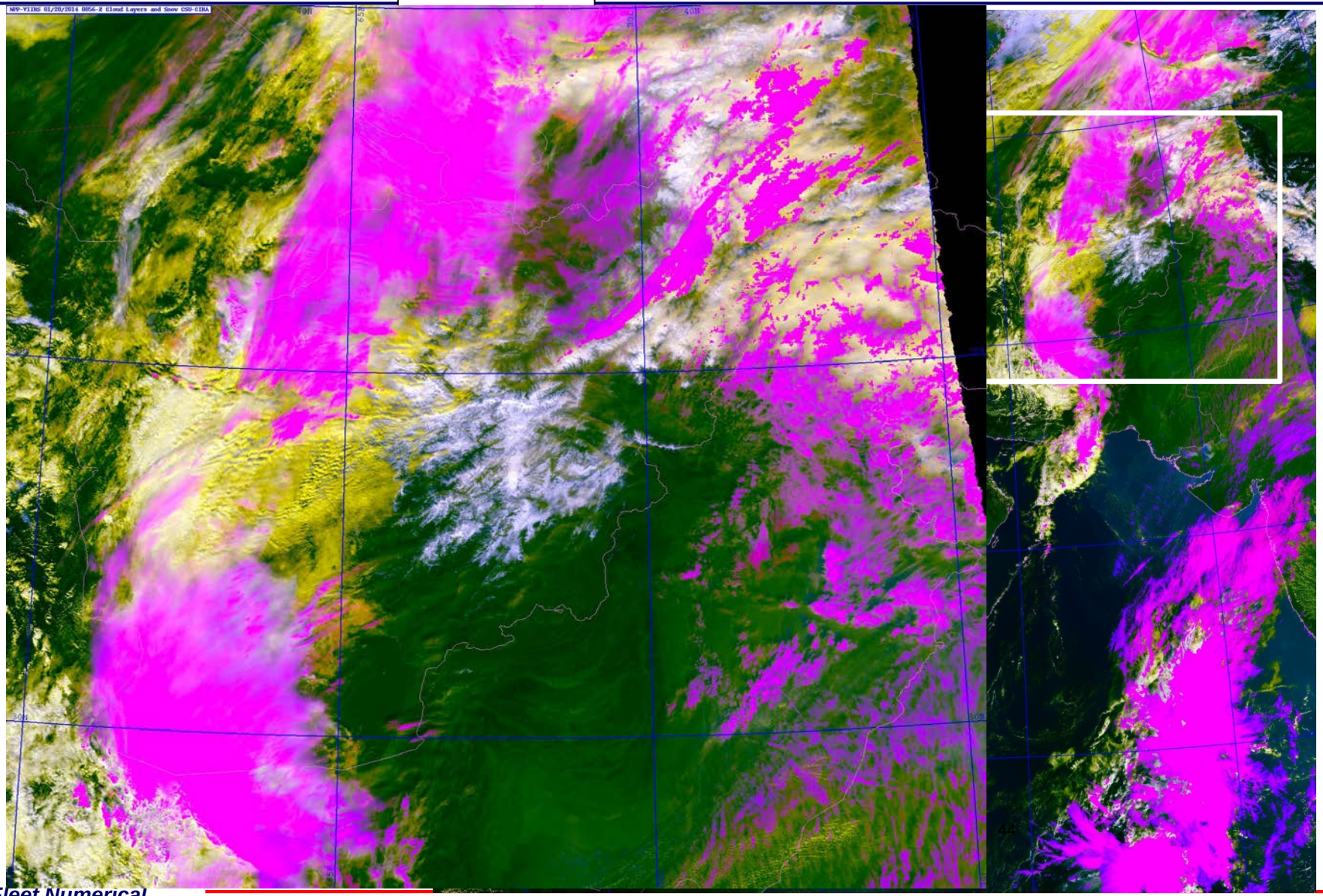




Transitioned to Operations

VIIRS Cloud/Snow Discrimination

20 Jan 2014



VIIRS (Blue-Light) Dust

GOAL: Enhance and isolate lofted dust over desert (daytime) to reduce or avoid the problems associated with limited visibility in airborne dust.

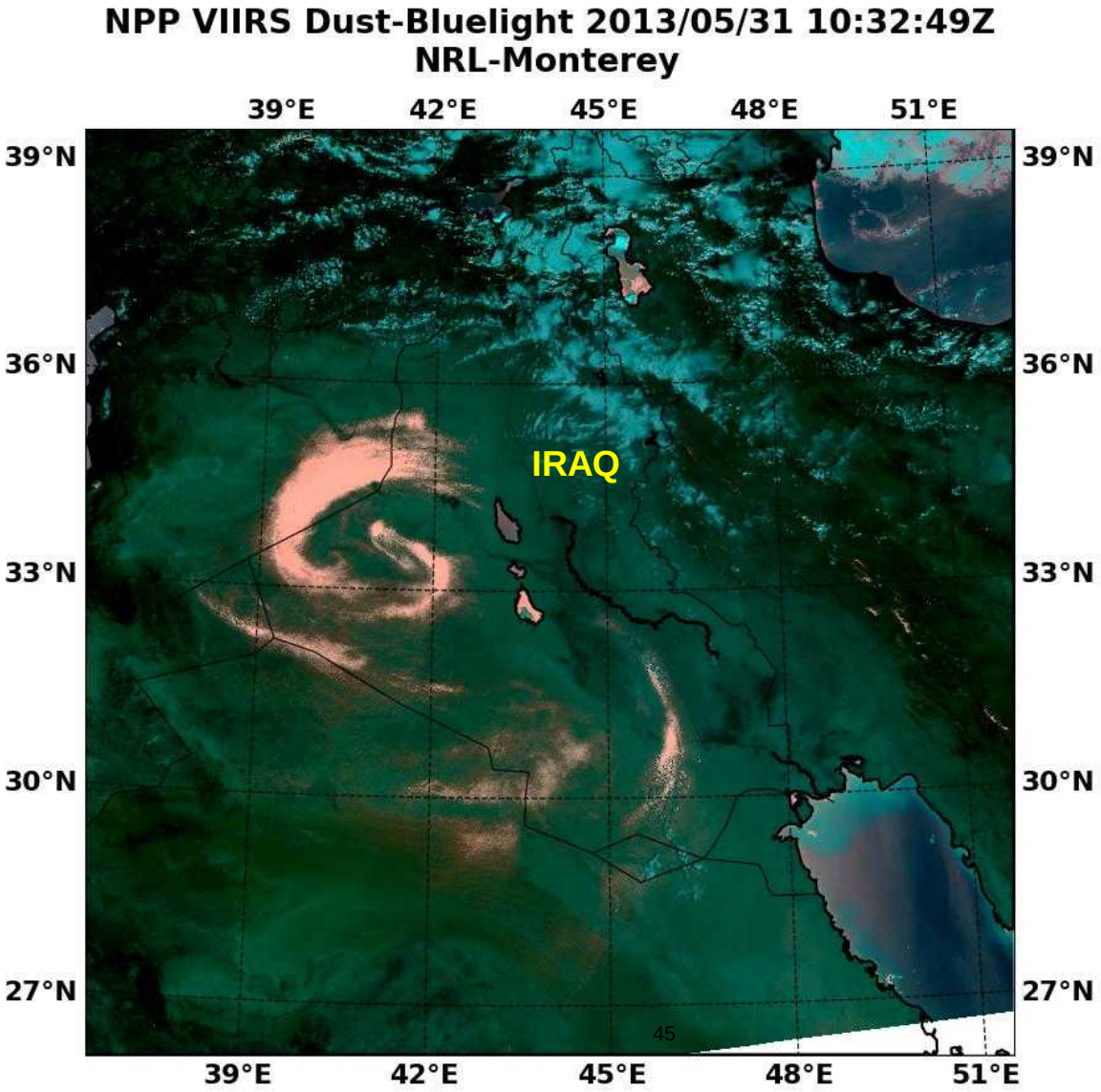
NRL Dust Enhancement Algorithm uses a multispectral (7-band) function that takes advantage of these dust properties:

- **Higher blue light absorption for dust**
- **Thermal contrast (dust and surface)**
- **IR split window difference (opposite in sign to Ci)**

A false-color enhancement is created to isolate the lofted dust:

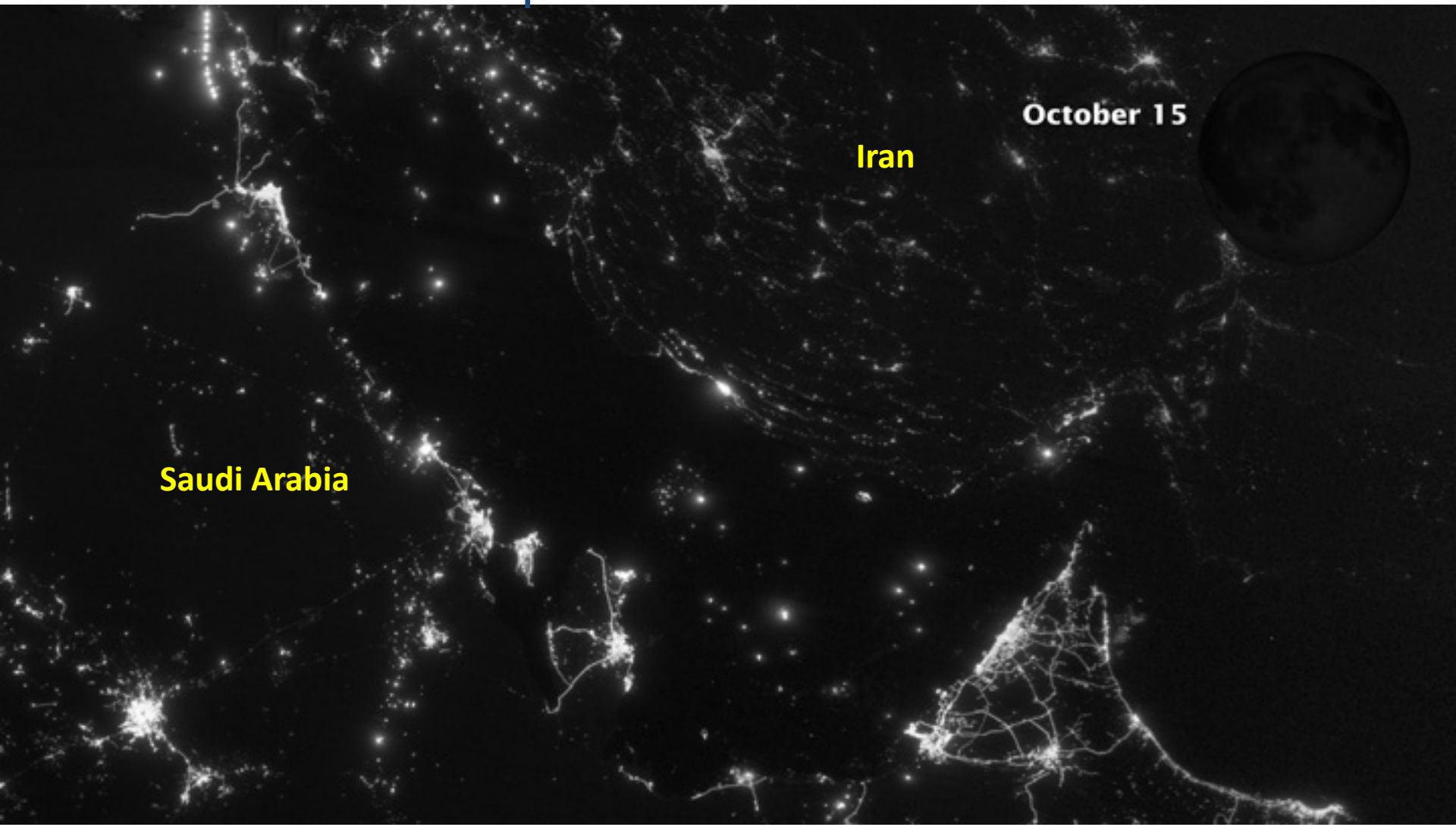
R: 7-band function (VIS/NIR/TIR)
G: Rayleigh-corrected green band
B: Rayleigh-corrected blue band

Transitioned to Operations

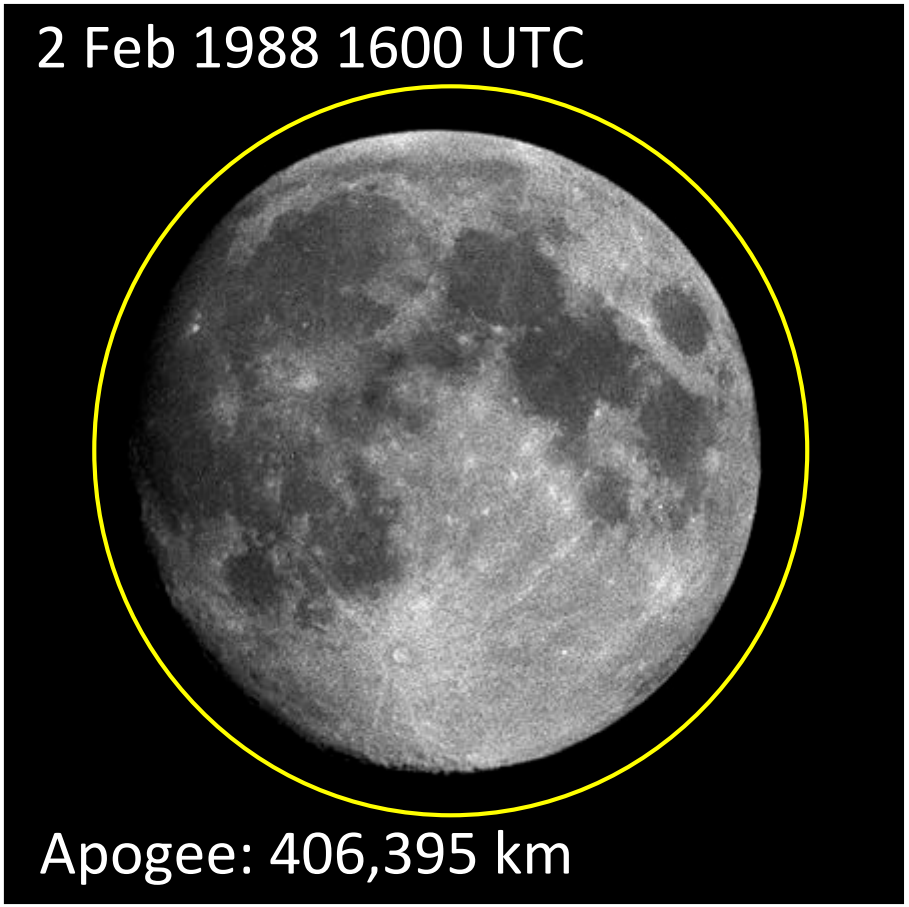


The Lunar Cycle

Sep 30 – Oct 15 2012



The Lunar Cycle

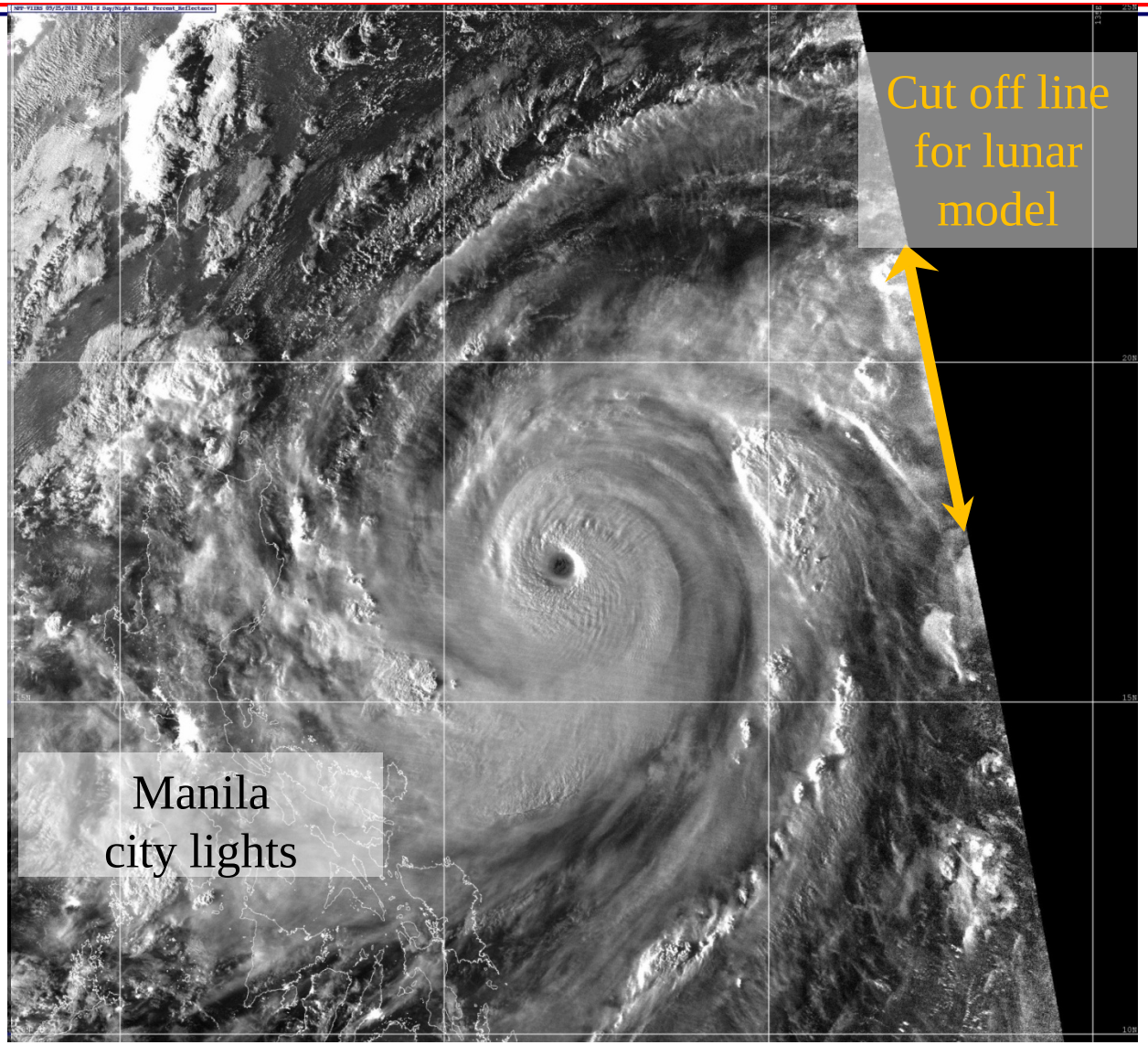


Quantitative Lunar Reflectances

Lunar model is used to produce a form of near constant contrast (NCC) imagery.

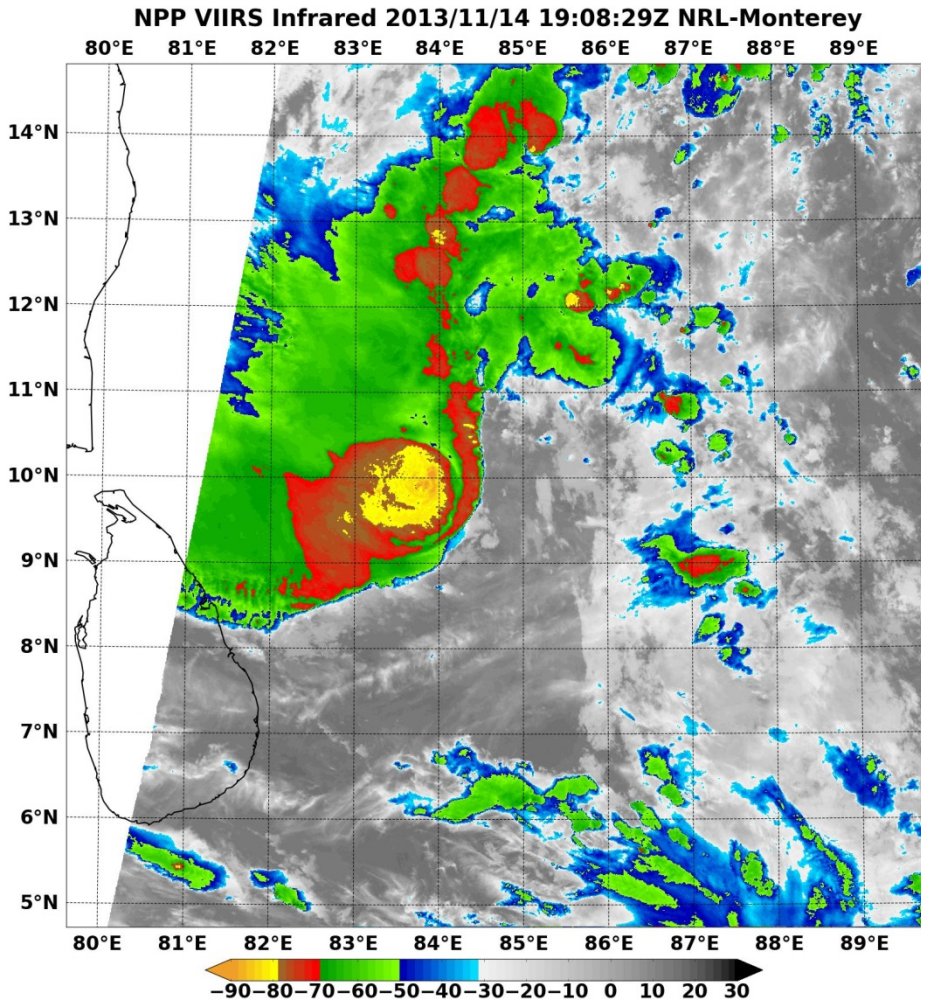
Not applicable to the day/night terminator where solar signal is present.

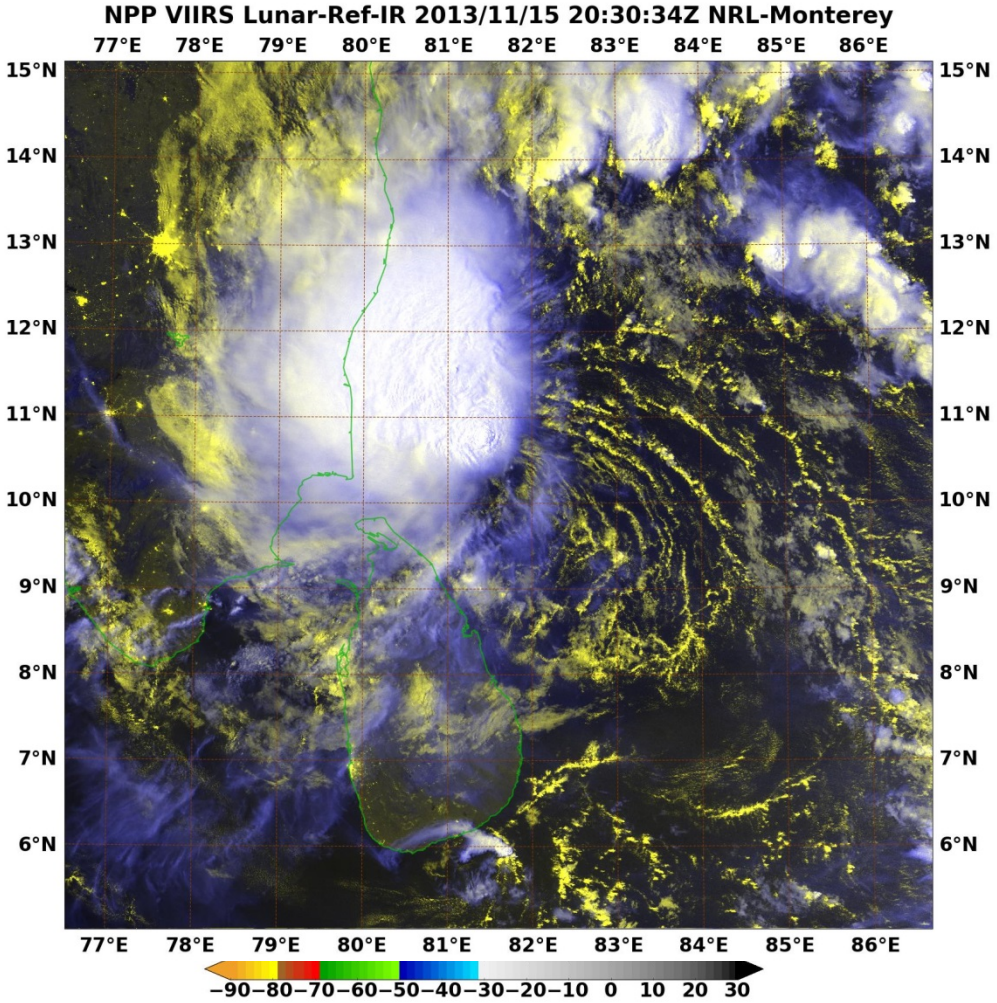
Moon phase: 80%



Quantitative visible reflectance values: many applications

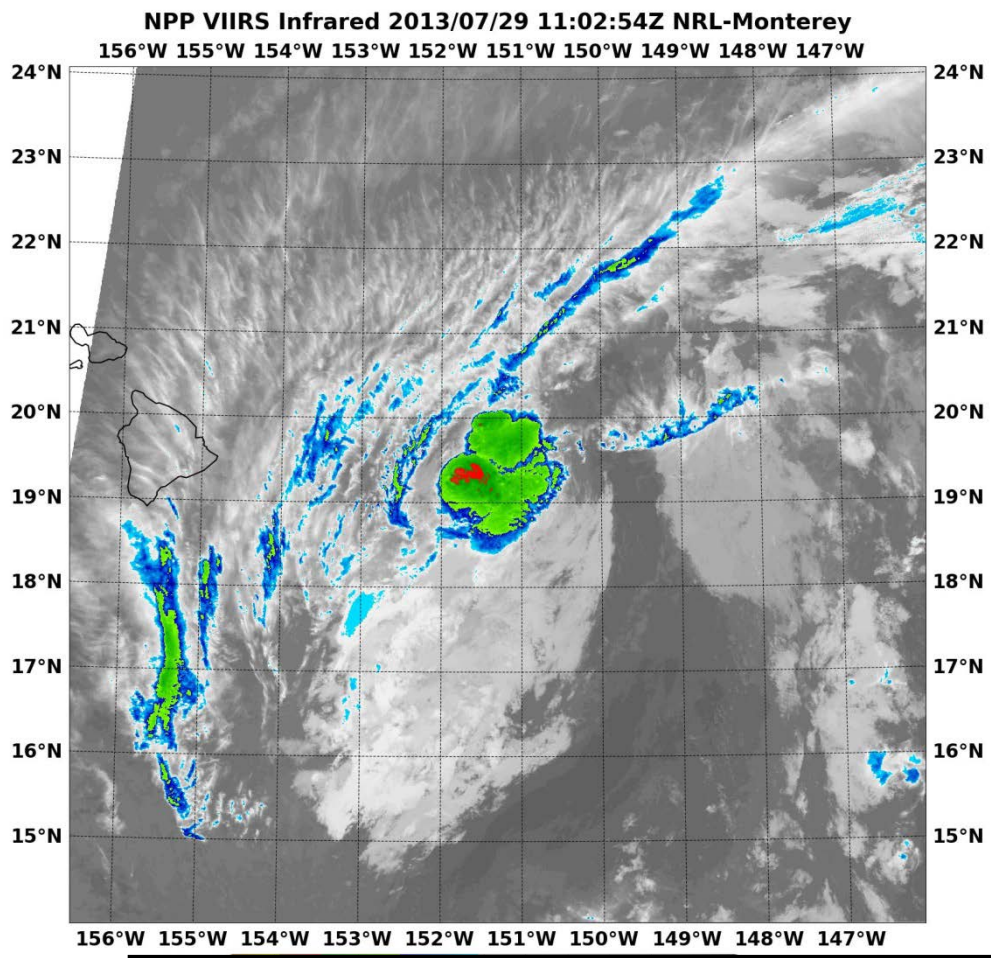
DNB Reveals Low-Level Features

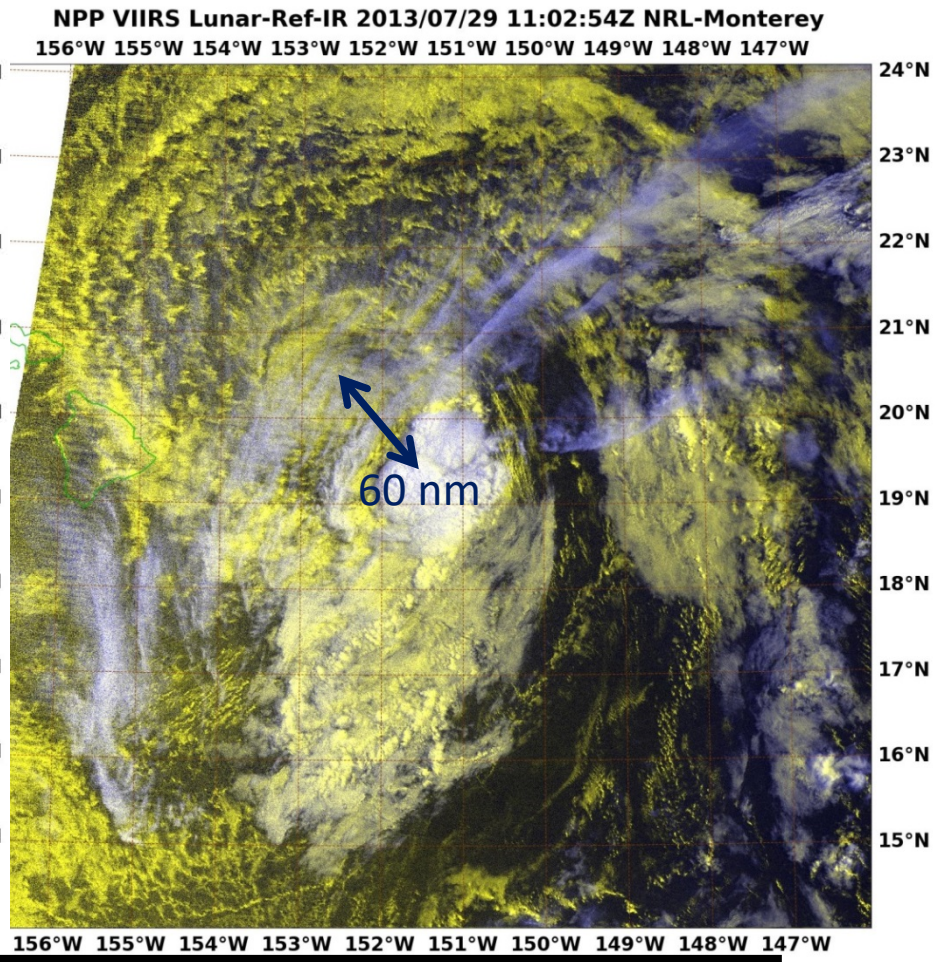




LLCC "exposed" by VIIRS DNB lunar illumination

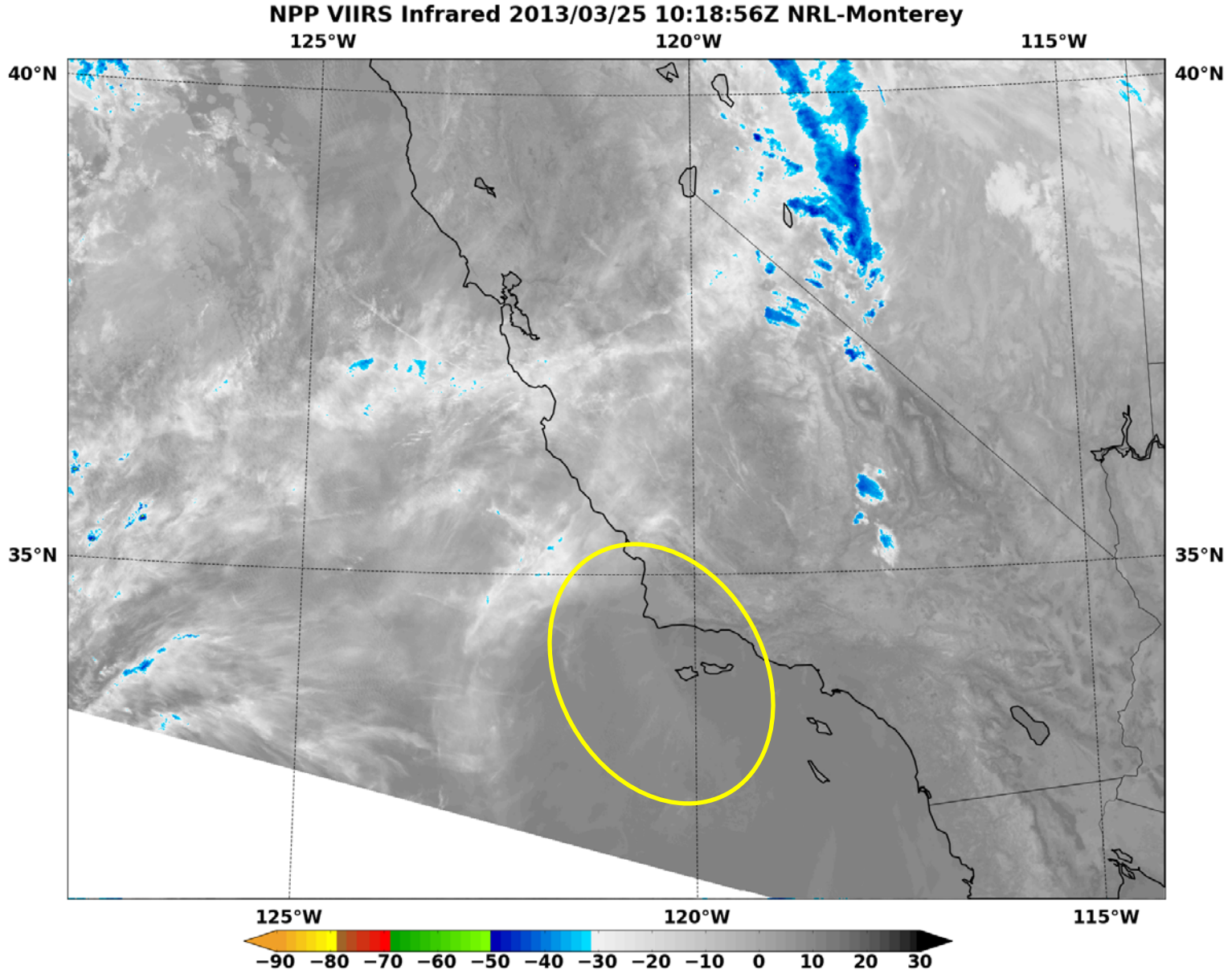
Nighttime TC Monitoring via DNB



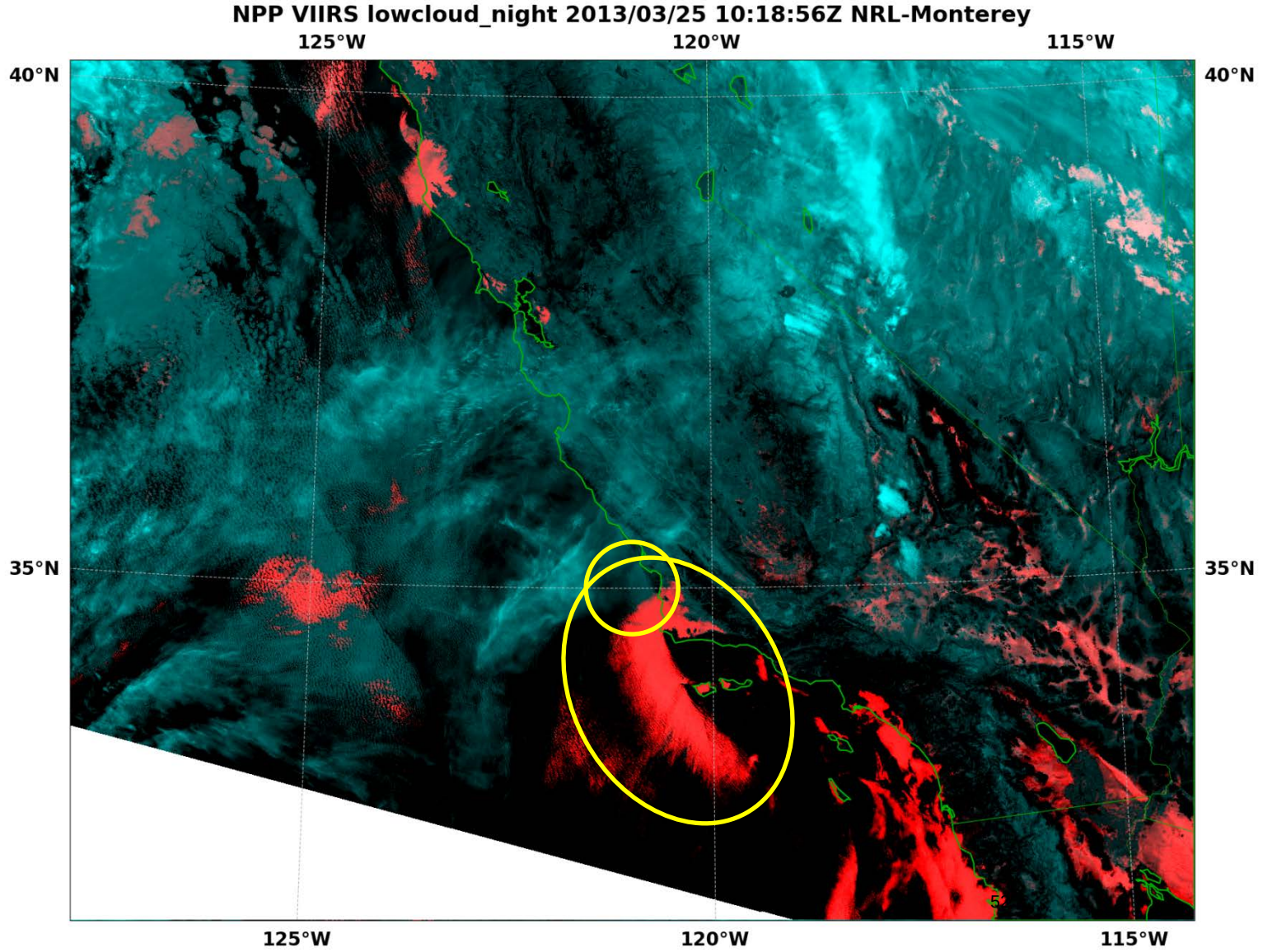


VIIRS DNB dramatically altered CPHC Flossie forecast to the NW, directly impacting landfall and day 1-3 day warnings

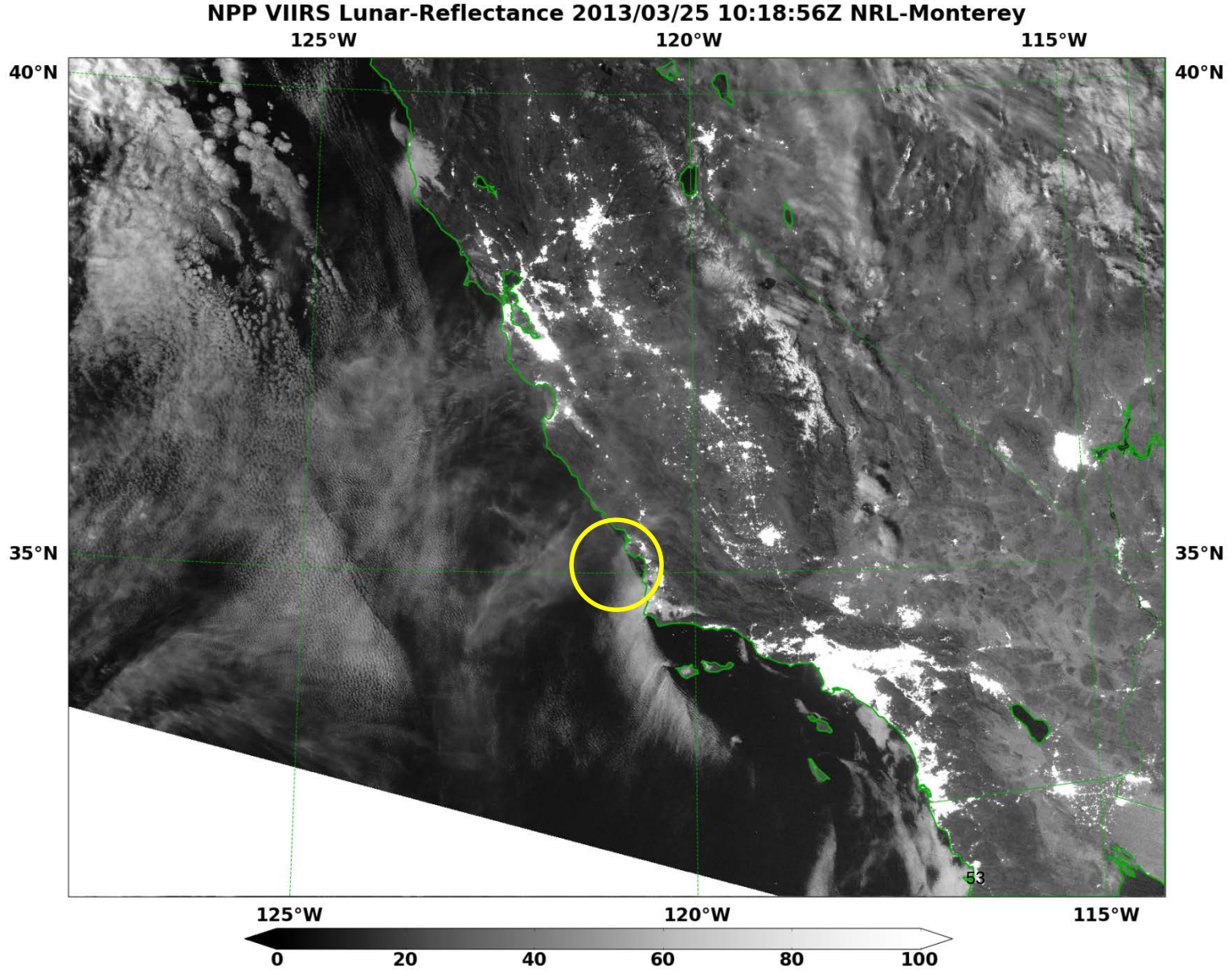
Low Cloud and Fog



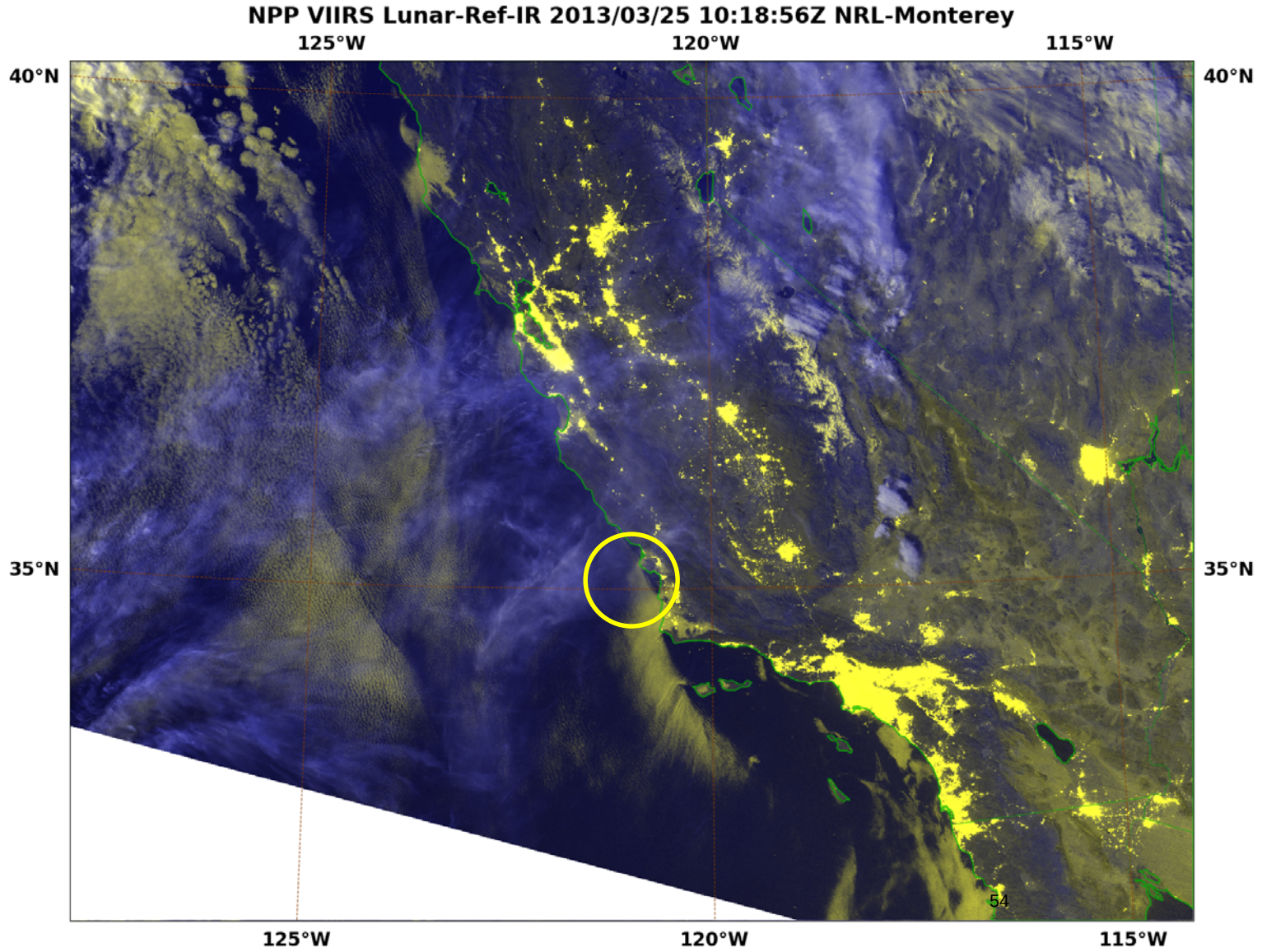
Low Cloud and Fog



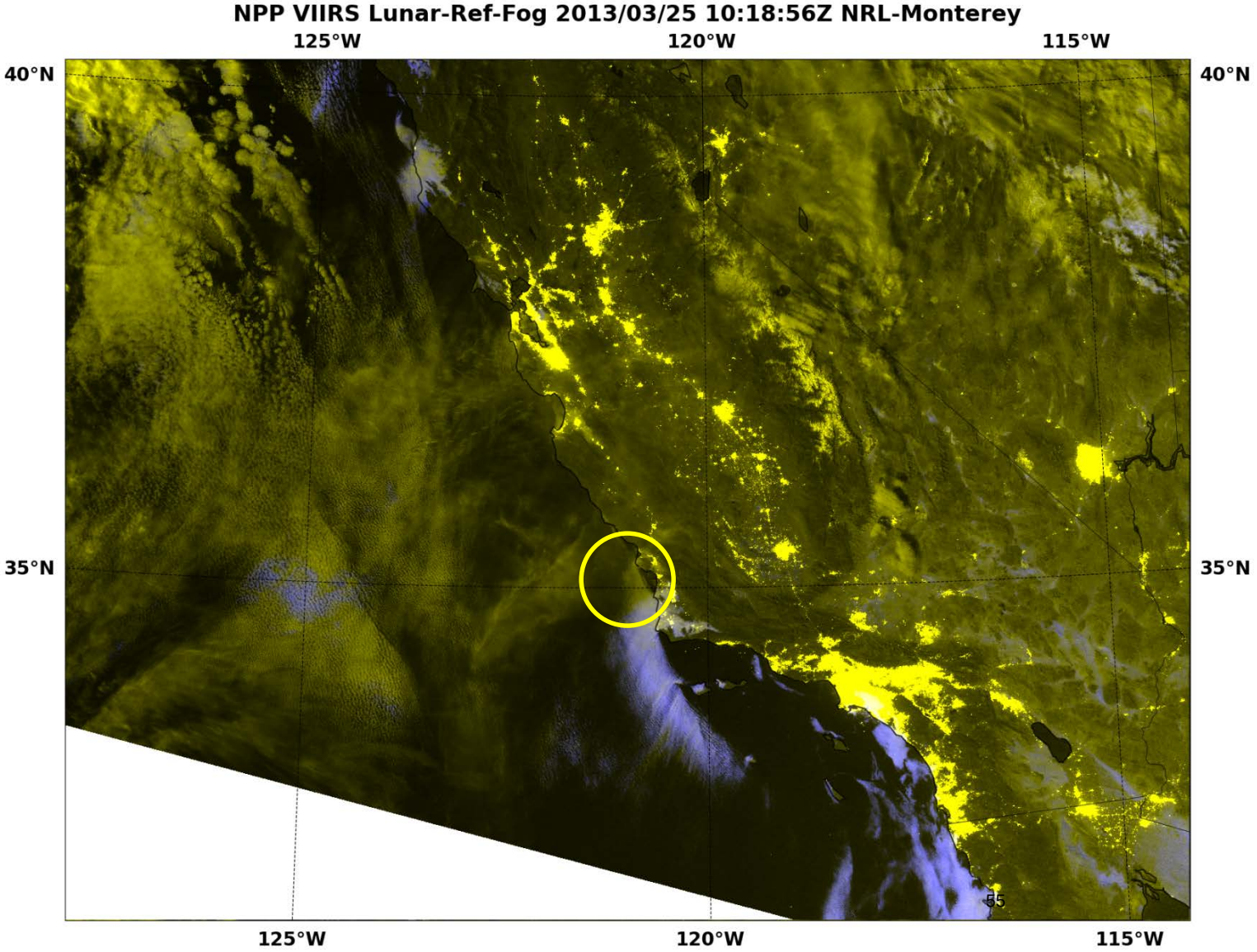
Low Cloud and Fog



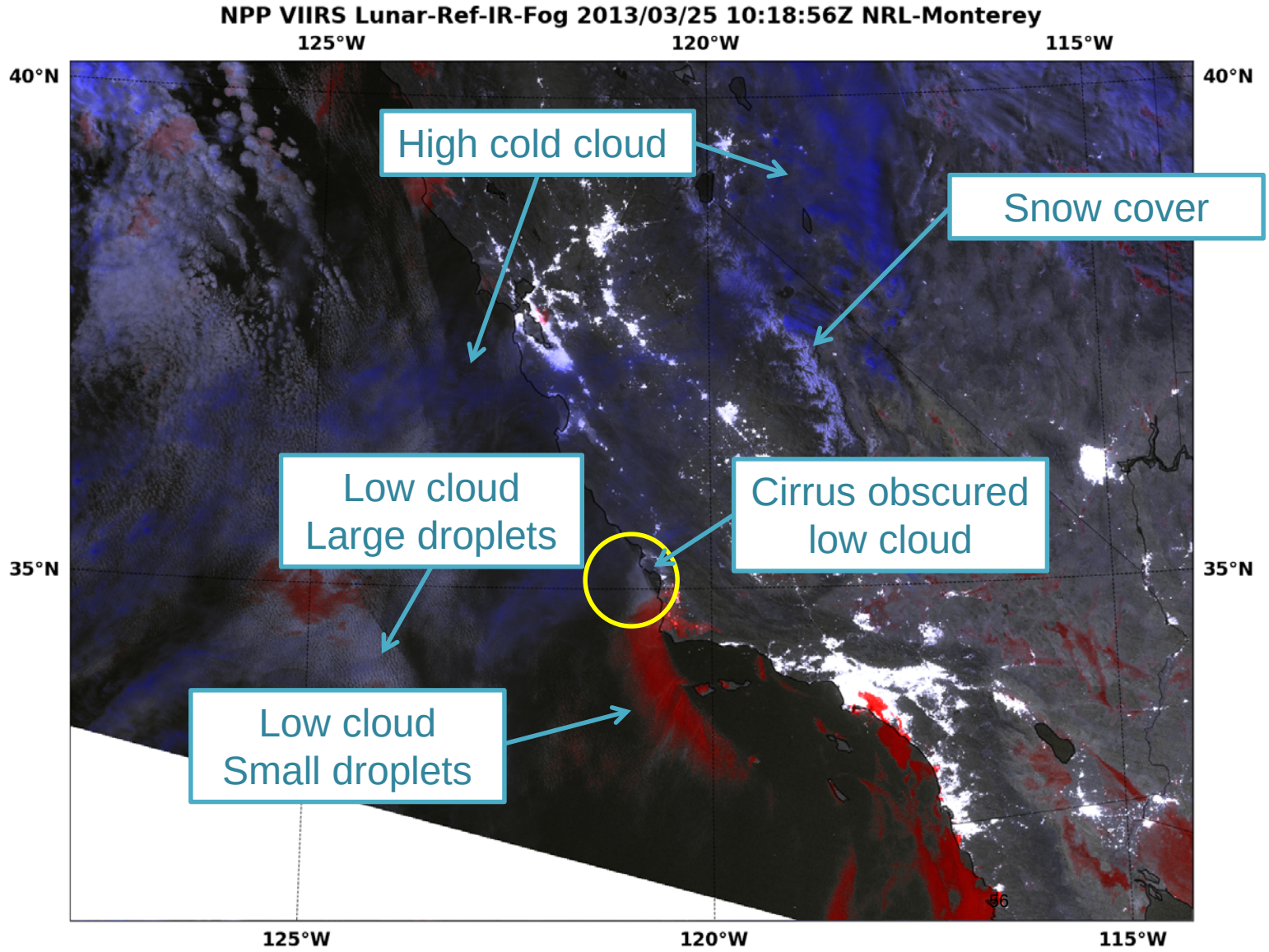
Low Cloud and Fog



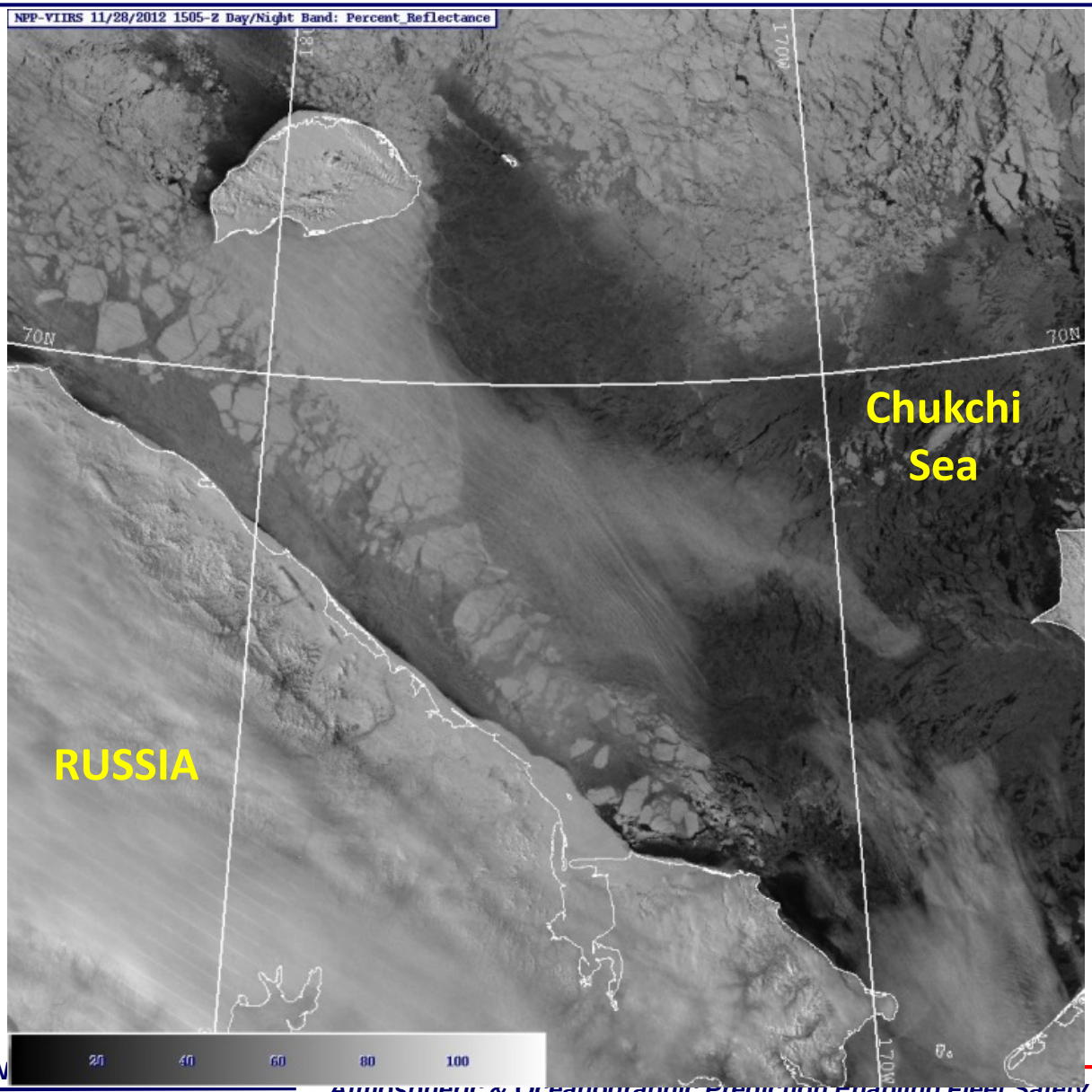
Low Cloud and Fog



Low Cloud and Fog

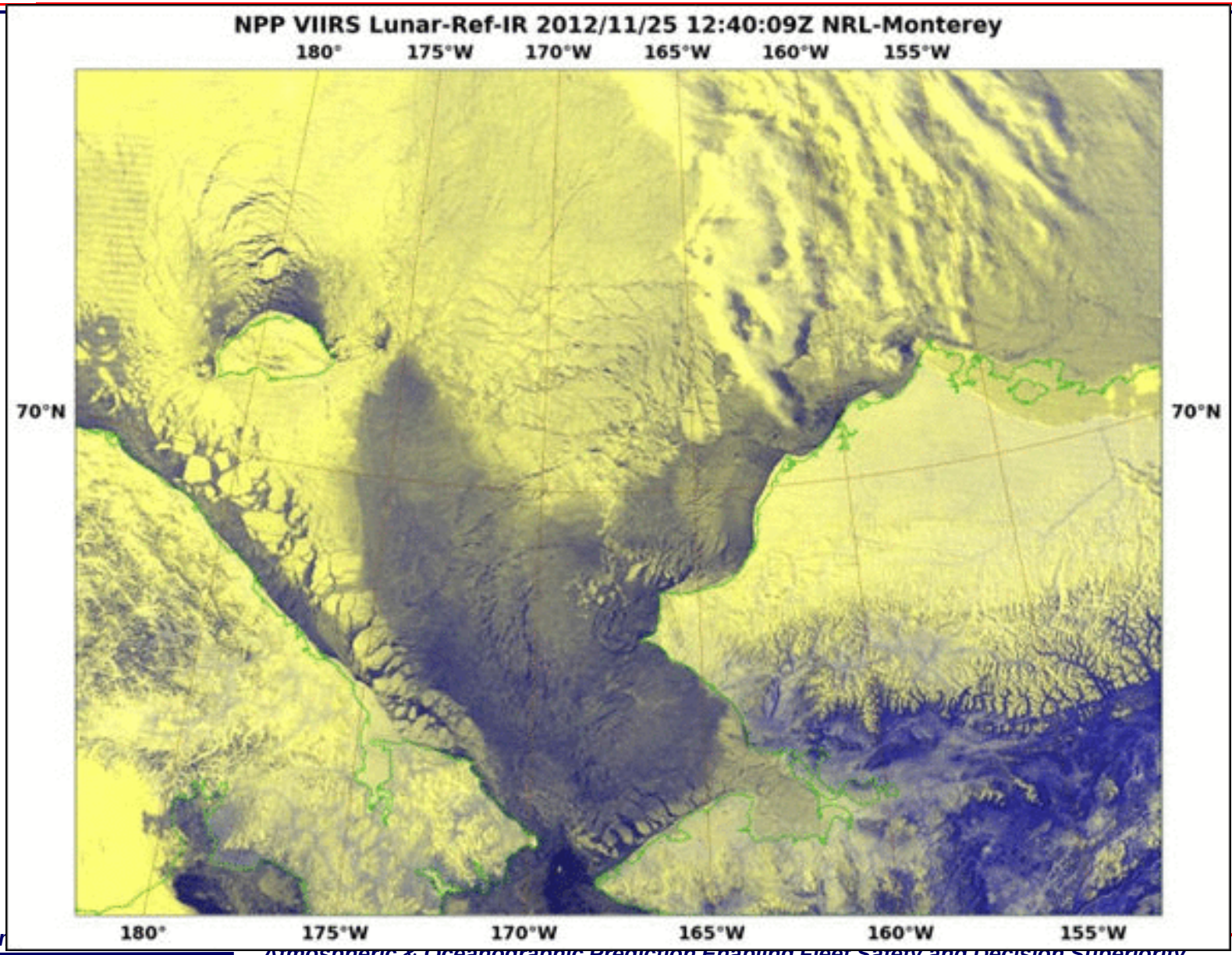


DNB For Nighttime Sea Ice



Lunar illumination passes through thin cirrus and reflects off sea ice below

DNB For Nighttime Sea Ice



FNMOC Top Three Challenges

- Planning for Future Satellite Launches and Requirements Definition (new satellites and sensors data availability and integration)
- Data acquisition from IA sources, CONOPS data distribution and planning addressing latency to provide data into the various functional areas we support, NWP, Tactical Imagery, Reach back in an IA ATO COOP approved system.
- Bridging the gap between Research and Operations (changes in technology, hardware, and software, cubesats, commercial sources, etc.)

Closing Recommendations

- Advocate that FNMOC has requirements for both NWP and tactical imagery (same data, war-fighter added value in different ways, A2 economies of scale)
- Advocate for continued MARKIVB/FMQ-17 regional support with high bandwidth circuits to FNMOC for development and COOP addressing ATO.
- Continued OPNAV/CNMOC support of DMSP and JPSS/DOD's WSF programs

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