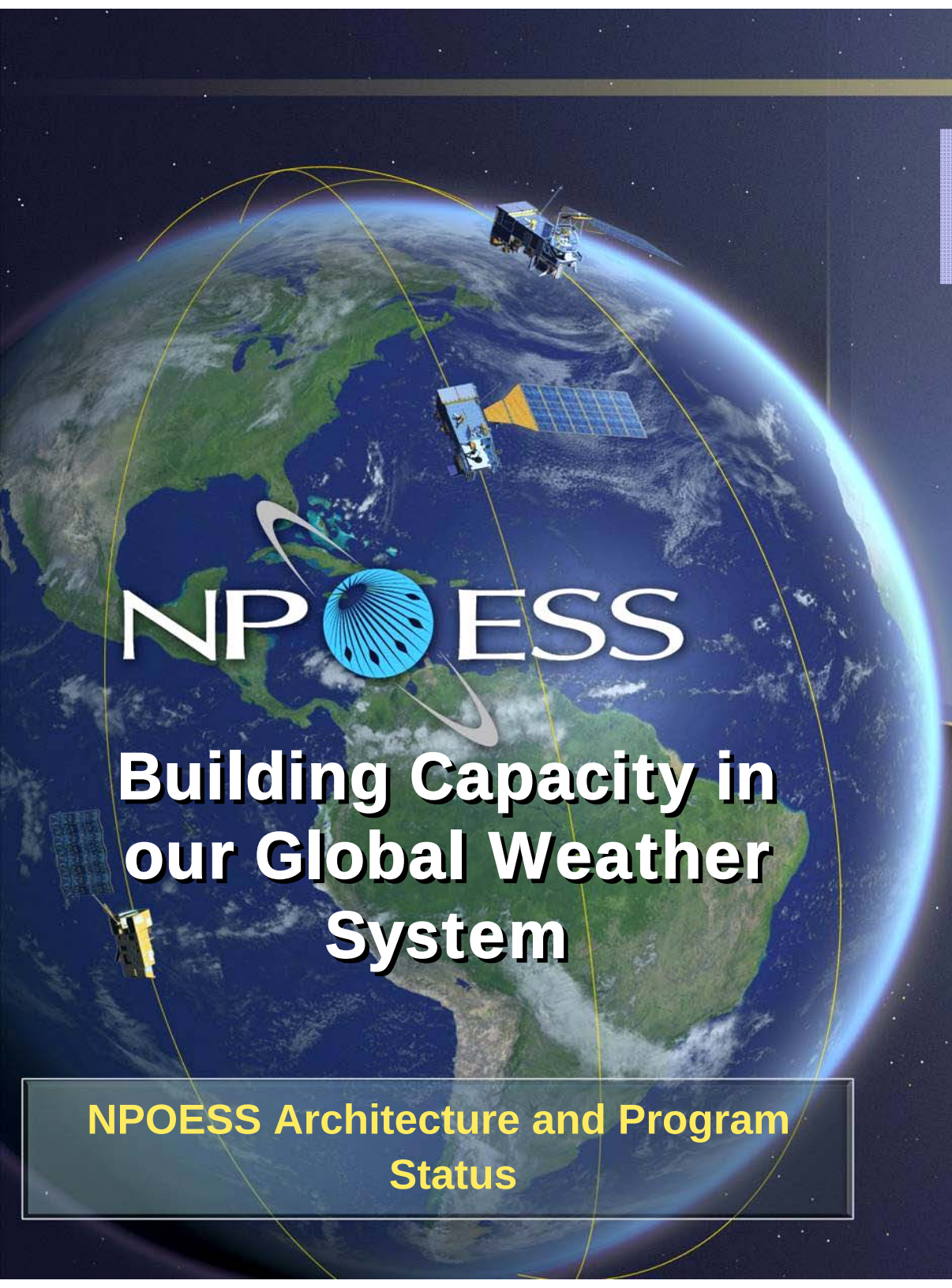


Building Capacity in our Global Weather System

NPOESS Architecture and Program Status

MISSION

Environmental Monitoring System in Support of Defense and Civil Applications

FEATURES

- Rapid data delivery 4x faster than legacy systems enables quicker reaction to changing conditions
- 10x the data of existing systems
  - Accurate data - better forecasts
- International collaboration
- Contributes to 14 of 26 Essential Climate Variables

BENEFITS

- Critical inputs to weather forecast models and global change monitoring
- Science quality data to operational users and research scientists
- Continuity of climate data records

NPOESS Environmental Monitoring Regimes

Weather, Oceanography

Clouds, temperature, wind, precipitation, currents, tides, land use

Nowcasting, Forecasting

- Routine weather, disasters, military ops

Space Environment

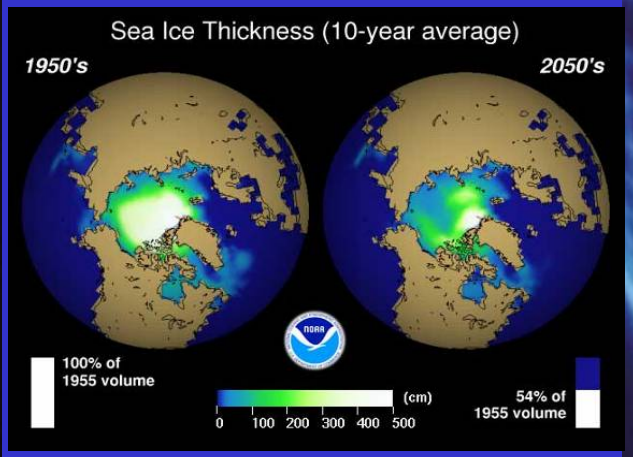
Auroral particles, high energy space radiation

Space Environmental Monitoring

- Anomaly resolution, human space flight safety

Climate Environment

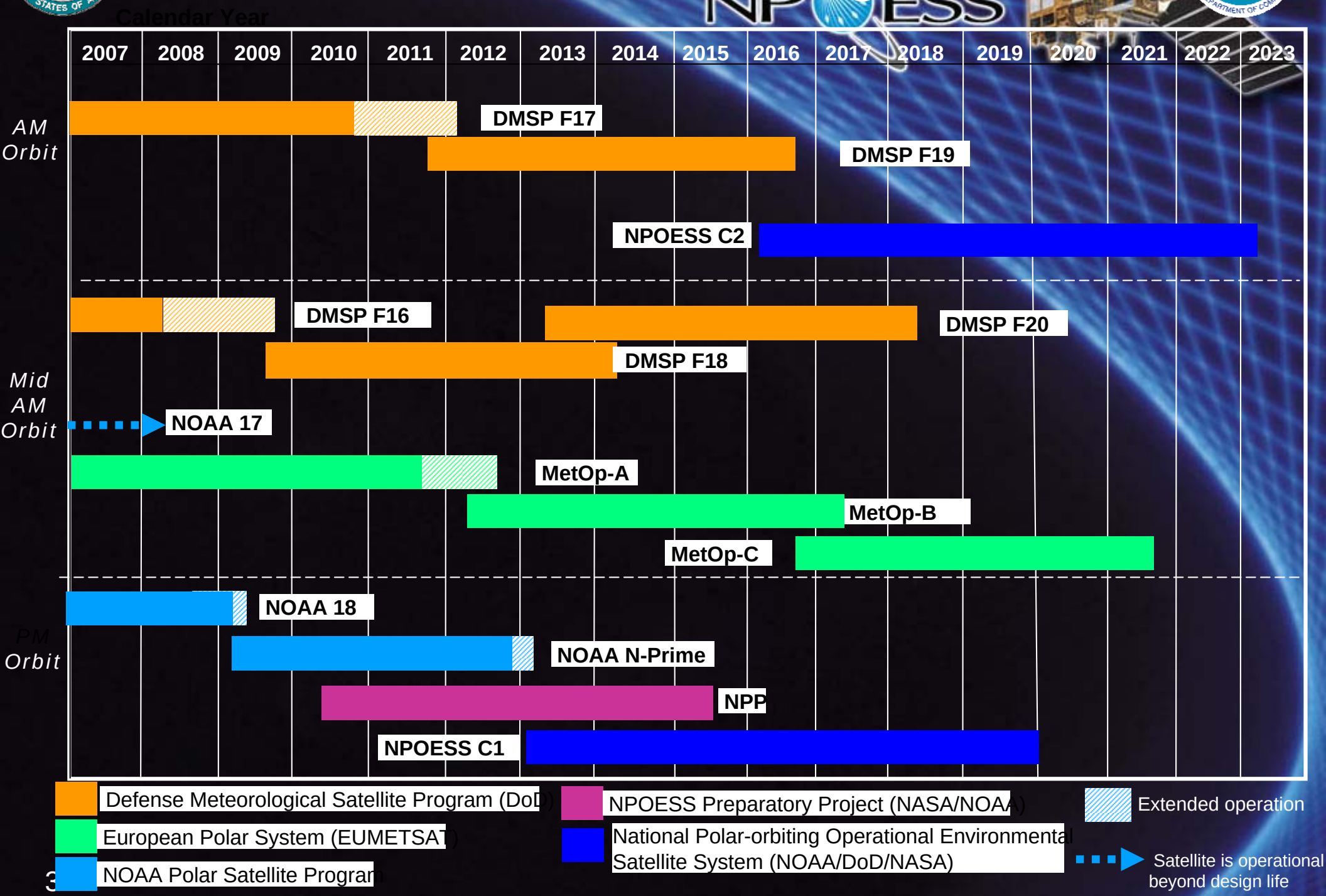
Chemistry, water, land use



Long Term Monitoring

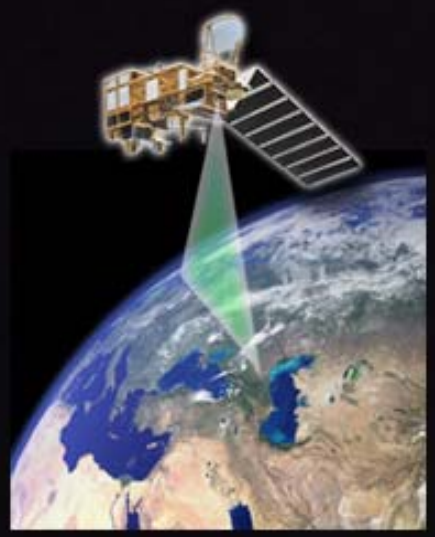
- Global change implications

Polar Satellite Programs

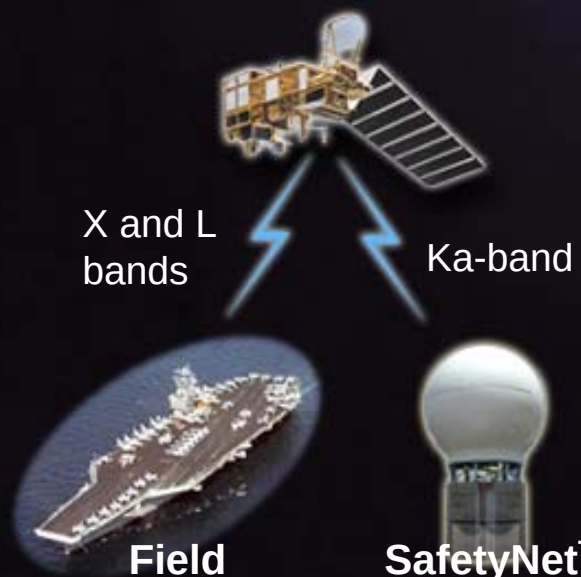


Concept of Operations

1. Sense phenomena



2. Downlink raw data



3. Transport data to Centrals for processing

Global fiber network connects 15 receptors to Centrals

Monitor and control Satellites and Ground Elements

Mission Management Center (Suitland)

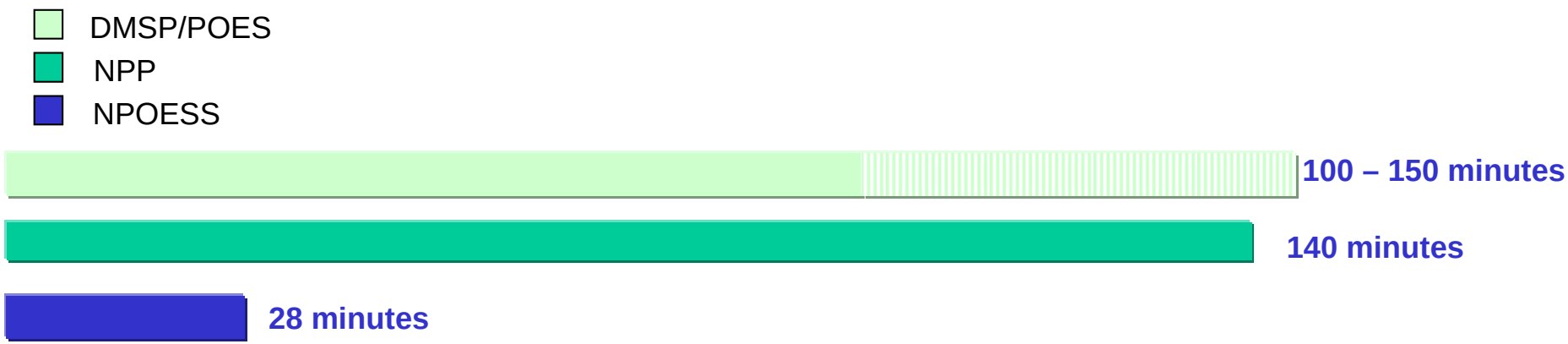
Alt. MMC (Aurora, CO)

4. Process raw data into EDRs and deliver to Centrals

Full IDP Capability at each Central NOAA, Air Force, and 2 Navy sites

Data Delivery

DATA LATENCY – Delivery of Data to Users



Improvements Over Heritage	Data Rate	Data [1] Volume	Encryption	Spectral Capability	Vertical Resolution
Heritage	1.5 Mbps	6.3 GB/Day	Total	5 bands	40 bands
NPOESS	20 Mbps	5.4 TB/Day	Selective	22 bands	1300 bands

[1] Data Volume per Satellite

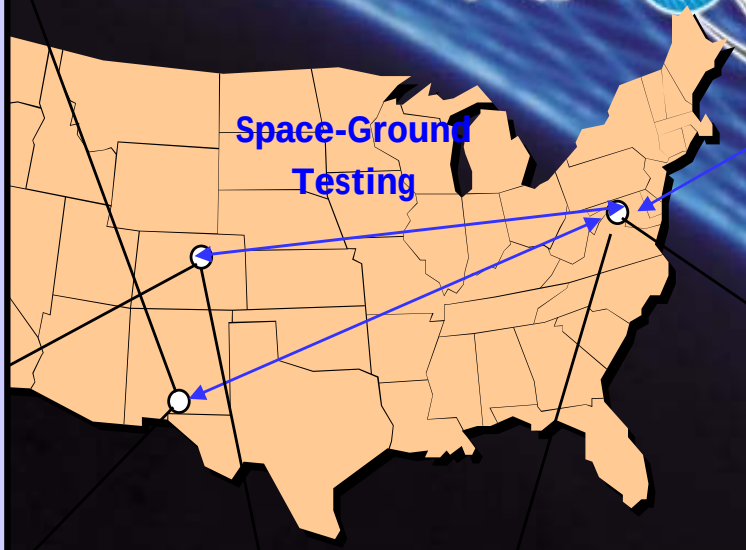
NPOESS improves robustness, accuracy, and timeliness of delivery of essential weather and climate data

NPP Space-Ground Testing

NPP / NPOESS Backup Relay C&C Equipment White Sands, New Mexico

NPP/NPOESS C&C Backup Relay

- C3S Racks/ Equipment

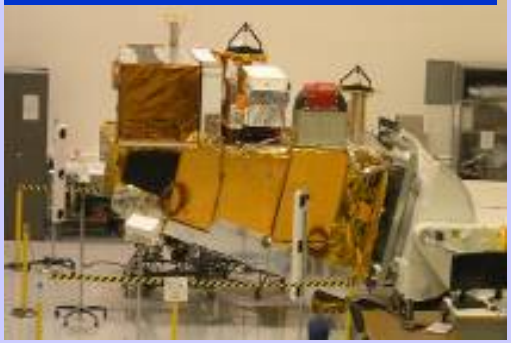


NPP / NPOESS Command & Control Station Svalbard, Norway

NPP/NPOESS C&C

- C3S Racks/ Equipment

NPP Spacecraft I&T Facility Boulder, Colorado



NPP Satellite

- NPP Spacecraft
- ATMS Flight Unit
- CrIS Engineering Model (EDU)
- VIIRS Engineering Model (EDU)

NOAA Satellite Operations Facility Suitland, Maryland

NPP/NPOESS Ground Elements

- C3S Command and Control Segment
- IDPS Processing Segment
- O&S Team

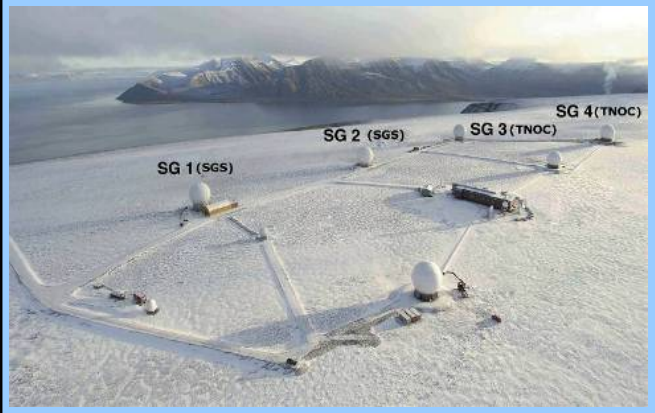
Ground Segment

NOAA Satellite Operations Facility

Ground Segment

- NOAA Satellite Operations Facility (NSOF) complete
- Command and Control for NPP completed and installed
- NPP Flight Vehicle Simulator installed

Downlink at Svalbard



- NPP Svalbard Modifications Completed
- Communications services to NSOF established
- End to End compatibility checkouts conducted
- WindSat data relay operational

Integrated Data Processing System Development

- IDP Segment
  - Build 1.4 completed qualification testing
  - Final NPP Software Increment Build 1.5 in development
  - Acceptance Test at sites in Summer 2008

Ground Segment on schedule and on path to meet goals

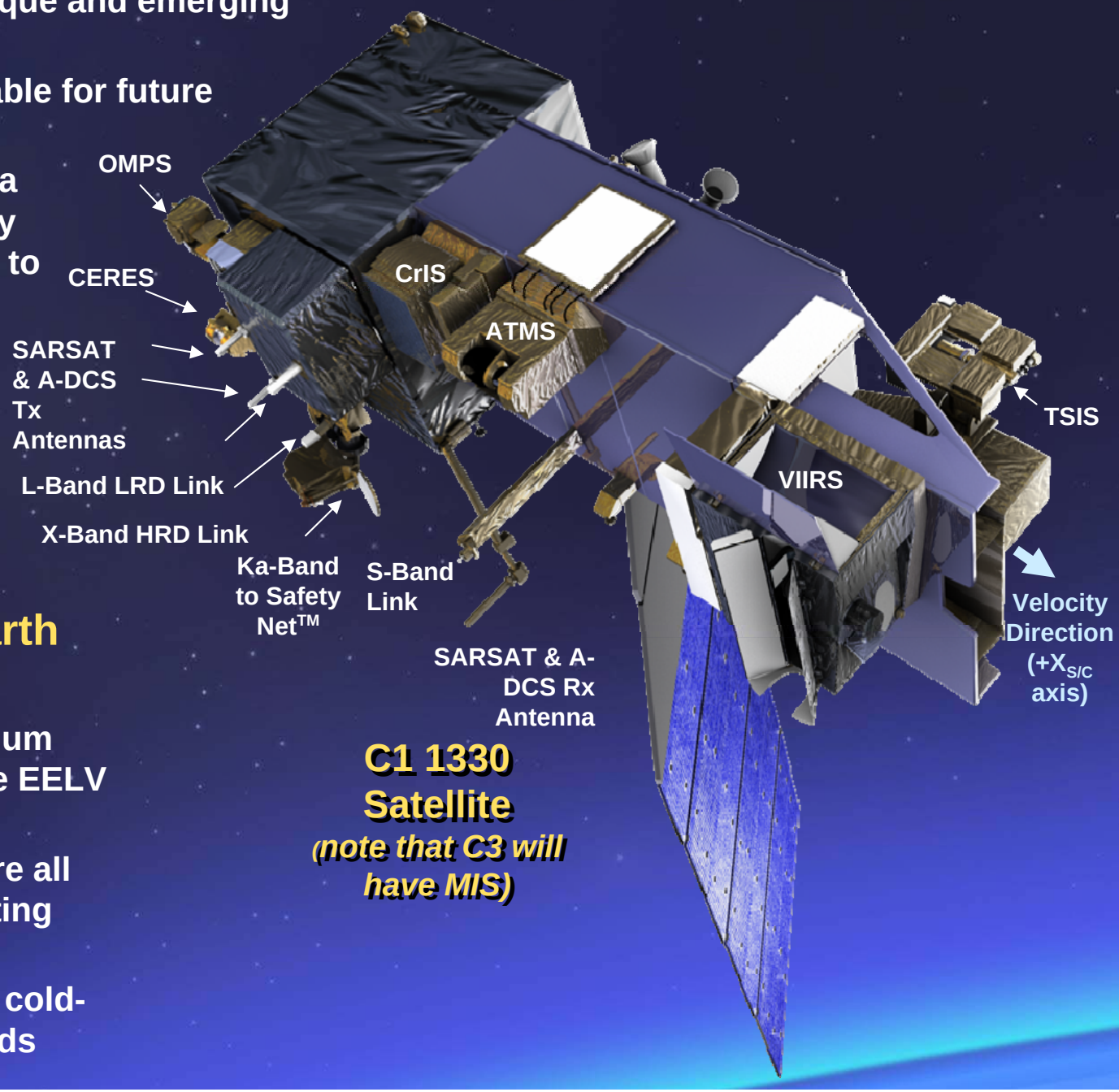
Satellite Architecture

Plug and play avionics architecture

- Accommodates 1553, 1394, unique and emerging payload interfaces
- 1553 and 1394 data ports available for future additional sensors
- On-board compression and data selection enables VIIRS imagery and CrIS sounding data access to low rate data field users
- Highly autonomous capability satisfies NPOESS mission requirements
- Advanced 32-bit architecture enables handling of all satellite processing functions

Spacecraft designed for Earth observation missions

- Large nadir platform for maximum payload accommodation on the EELV launch vehicle
- Optical bench stability to ensure all sensors meet demanding pointing requirements
- Thermally optimized with large cold-side access for science payloads



C1 1330 Satellite

(note that C3 will have MIS)

Spacecraft Configuration

Overall Satellite

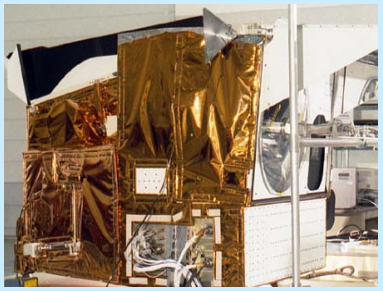
- Orbit: 828 km with C1 ascending node crossing at 13:30 and C2 ascending node crossing at 17:30
- 7-year mean mission duration to ensure no operational gaps
- Designed to accommodate over 13 sensors with capacity to transmit 5.4 Terabytes (half the library of Congress) a day
- Ka-Band downlink to SafetyNet™ enables down link of all collected data with 4x improvement of data latency (95% of collected data delivered as Environmental Data Recorders (EDRs) in 28 min)
- Large on-board recorder capacity and SafetyNet™ architecture provides 99.99% data availability
- Leverages NASA's Earth Observation Satellite (EOS) heritage and experience

C2 1730 Satellite

Sensors for NPP, C1, C2

Environmental Sensors developed through EMD contract

VIIRS

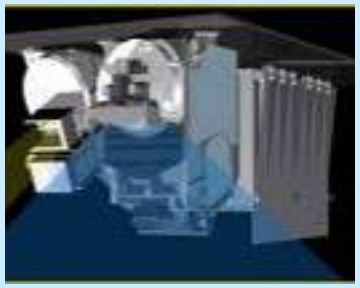


(3)

CrIS

(2)

OMPS



(2)

ATMS**

(2)

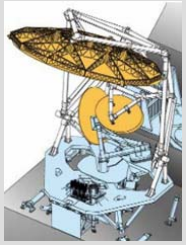
** 1st procured by NASA 2nd by NG

Government Furnished Sensors being delivered for integration

CERES

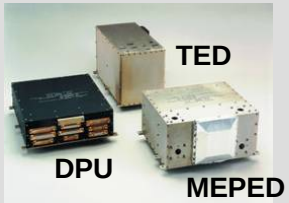
(1+1)

MIS



(1)

SEM



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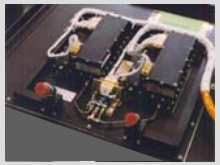
A-DCS

(2)

SARSAT



(2)

NPOESS Sensor suite delivers 38 Environmental Data Records and 14 Essential Climate Variables

NPOESS Payload Development Status – Nov 2008

CrIS Instrument (ITT)

Cross-track Infrared Sounder

with ATMS provides atmospheric temperature, moisture, and pressure profiles

- EDU successfully tested with NPP spacecraft and returned
- CrIS Thermal Vacuum (TVAC) testing shows excellent low noise performance
- Internal Calibration target (ICT) anomaly resolved. ICT replaced and sensor completed TVAC test
- Upcoming: Delivery to NPP satellite for integration

VIIRS Instrument (Raytheon)

Visible/Infrared Imager/ Radiometer Suite

provides 22 EDRs of atmospheric and surface environmental data

- Pre-Environmental Test Review completed April 2008
- Sensor Suite integrated and environmental testing started
- EMI testing completed, over test corrections in place with no impact on hardware
- Upcoming: Vibration testing

OMPS Instrument (Ball)

Ozone Mapping & Profiler Suite

provides ozone data

- All testing successfully completed (Vibration, EMI and TVAC)
- Successfully delivered a “high quality” instrument (per Pre-Ship Review Independent Review Chair)
- Upcoming: Integration onto NPP satellite

NPOESS Payload Development Status – Nov 2008

ATMS Instrument (NGES)

Advanced Technology Microwave Sounder

with CrIS provides atmospheric temperature, moisture, and pressure profiles

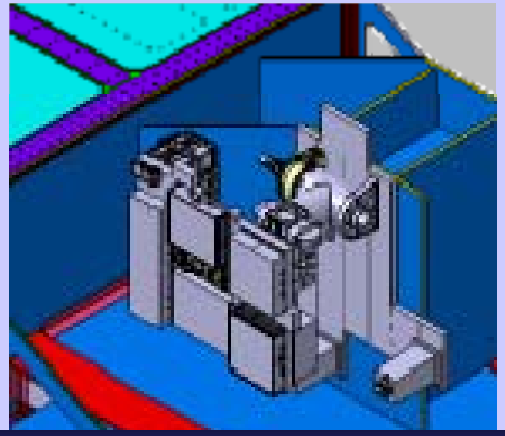
- **Flight Unit 1 delivered for NPP satellite integration in 2005**
- **Delta Critical Design Review (CDR) for replacement of obsolete components held in Sep 2008**

CERES Instrument (NGST)

Clouds and Earth's Radiant Energy System

provides data on incoming and outgoing radiant energy

- **Flight Module 5 approved for flight by NASA for NPP satellite.**
- **Successfully delivered and integrated onto the NPP satellite in Nov 08**



TSIS Instrument (LASP)

Total Solar Irradiance Sensor

provides data on the amount of energy emitted by the Sun incident on Earth

- **Approved by EXCOM for C1 satellite on 1 May 2008**
- **NASA to procure TSIS from Laboratory of Atmospheric and Solar Physics (LASP)**
- **Delivery planned for Dec 2011 to C1 satellite**

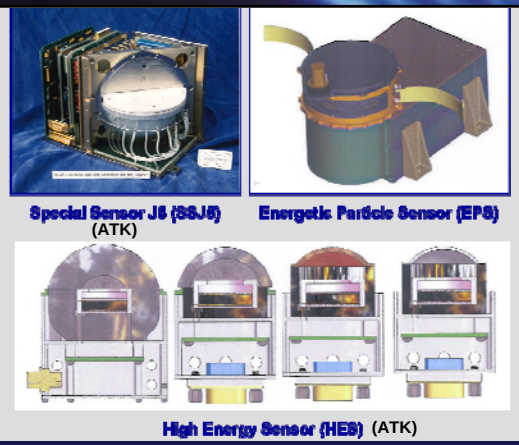
NPOESS Payload Development Status – Nov 2008

MIS Instrument (NRL)

Microwave Imager Sounder

provides soil moisture and sea surface winds

- **Naval Research Center (NRL) chosen as the sensor provider with authority to proceed (ATP) in Jun 08**
- **Flight 1 Critical Design Review in 2011 with delivery in 2014 providing adequate margin to the C2 satellite need date**

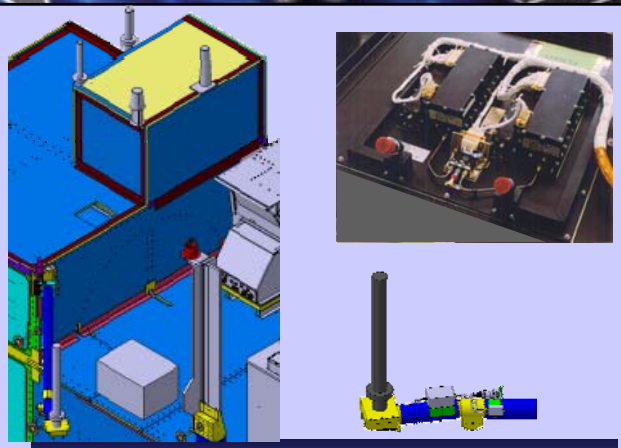


SEM Instrument (JHU/APL)

Space Environmental Monitor

provides data on charged particles entering the Earth's atmosphere

- **NAVSEA/JHU team officially started work in Sept to support delivery to C1**



A-DCS (CNES) & SARSAT (DND)

Advanced Data Collection System & Search and Rescue Satellite-Aided Tracking

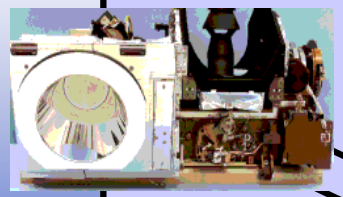
monitors data from unmanned sites & relays distress signals from mariners and aviators in distress

- **In production and on track**

VIIRS Incorporates Key Features From and Improves Upon Previous Operational and R&D Sensors

Operational Sensors

- **OLS**



- **74 kg**
- **2 bands**

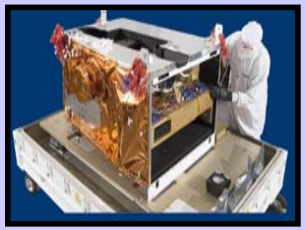
- **High Spatial Resolution**
- **Day/Night Band**
- **Minimize Resolution Growth Over Scan**

- **Radiometric Accuracy**
- **SST Band Continuity**

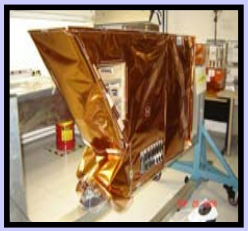
- **AVHRR**

- **33 kg**
- **5 bands**

- **VIIRS**



OMM



EM

- **275 kg**
- **22 bands**

R&D Sensors

- **MODIS**

- **220 kg**
- **36 bands**

- **Band Selection/Continuity**
- **Thin Cirrus Band**
- **Solar Diffuser**
- **Earthshine Lessons Learned**

- **Ocean Color Bands**
- **Rotating Telescope**

- **SeaWiFS**

- **45 kg**
- **8 bands**

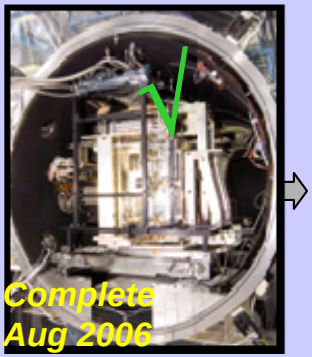
VIIRS Flight 1 Instrument has progressed to Final Environmental Testing Phase

Environmental Test of Eng Model

2006 - VIIRS EDU on Vibration Table

- Design Validation

TVAC Testing of Engineering Model



2006 - VIIRS EDU In TVAC Chamber

- Design Validation, Initial Performance Assessment

NPP Integration Risk Reduction Testing

2007 - VIIRS EDU integrated with NPP S/C

- Validated Electrical, Data, & Mechanical interfaces

Early Space to Ground Interface Testing

2007/2008 - VIIRS EDU, CrIS EDU, ATMS, NPP and NSOF

- Exercised Commands, Telemetry, & Loads/Dumps

VIIRS Flight 1 Component Testing

2008 - Cryoradiator in TVAC

- Component Performance

VIIRS Flight 1 Ambient Testing

2007/2008 - VIIRS Ambient Testing

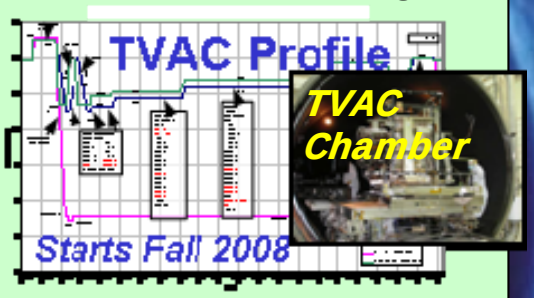
- Integrated Instrument Performance Testing

VIIRS Flight 1 Environmental Test

2008 - VIIRS EMI Testing

- Verification to Environments

VIIRS Flight 1 Final TVAC Testing



2009 - Comprehensive TVAC Testing

- Final Performance at Temperature

VIIRS Senior Science Review - February 2008

- **VIIRS Senior Science Team Review**
  - 2 day review of VIIRS Performance Predications and status
- **Excerpts from Findings (From VIIRS Senior Science Team Report)**
- " VIIRS is performing very well (except in some cases at the edge of scan beyond 45 degrees)"
- " the KPPs of imagery and SST will likely be within specification,"
- " delivery of FU1 on schedule as much as possible is a high priority,"
- "The review team was pleasantly impressed with the expected performance of the FU1 and the expectations for FU2;"
- "it appears that VIIRS will be an effective sensor and offer much to be excited about even as measured against the performance of MODIS or other heritage sensors. "
- " In an overall view, it appears that the VIIRS/FU-1 will perform in a manner equal to or better than the MODIS instrument. "
- "This observation in itself indicates that FU-1, given other considerations of cost and schedule, should be launched as soon other aspects of the total program can be shown as ready."

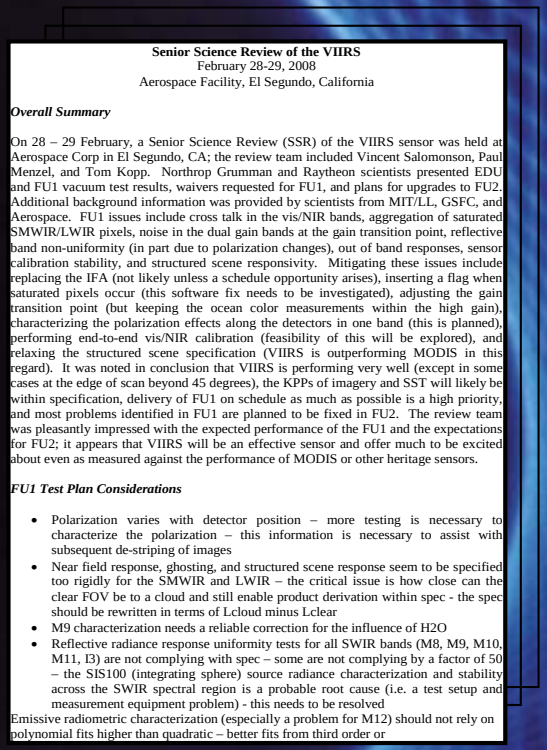
Vince Salomonson
MODIS Science Team Lead

W. Paul Menzel
MODIS Prin. Investigator

VIIRS Senior Science Review Report

February 2008

8 pages



Senior Science Review of the VIIRS
February 28-29, 2008
Aerospace Facility, El Segundo, California

Overall Summary

On 28 – 29 February, a Senior Science Review (SSR) of the VIIRS sensor was held at Aerospace Corp in El Segundo, CA; the review team included Vincent Salomonson, Paul Menzel, and Tom Kopp. Northrop Grumman and Raytheon scientists presented EDU and FU1 vacuum test results, waivers requested for FU1, and plans for upgrades to FU2. Additional background information was provided by scientists from MIT/LL, GSFC, and Aerospace. FU1 issues include cross talk in the vis/NIR bands, aggregation of saturated SMWIR/LWIR pixels, noise in the dual gain bands at the gain transition point, reflective band non-uniformity (in part due to polarization changes), out of band responses, sensor calibration stability, and structured scene responsivity. Mitigating these issues include replacing the IFA (not likely unless a schedule opportunity arises), inserting a flag when saturated pixels occur (this software fix needs to be investigated), adjusting the gain transition point (but keeping the ocean color measurements within the high gain), characterizing the polarization effects along the detectors in one band (this is planned), performing end-to-end vis/NIR calibration (feasibility of this will be explored), and relaxing the structured scene specification (VIIRS is outperforming MODIS in this regard). It was noted in conclusion that VIIRS is performing very well (except in some cases at the edge of scan beyond 45 degrees), the KPPs of imagery and SST will likely be within specification, delivery of FU1 on schedule as much as possible is a high priority, and most problems identified in FU1 are planned to be fixed in FU2. The review team was pleasantly impressed with the expected performance of the FU1 and the expectations for FU2; it appears that VIIRS will be an effective sensor and offer much to be excited about even as measured against the performance of MODIS or other heritage sensors.

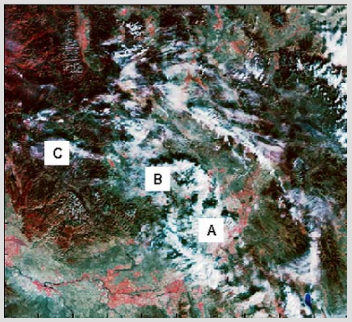
FU1 Test Plan Considerations

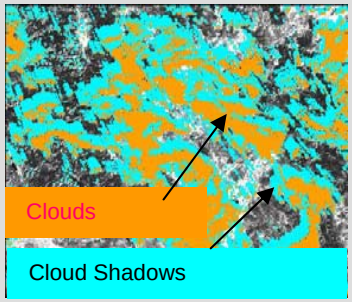
- Polarization varies with detector position – more testing is necessary to characterize the polarization – this information is necessary to assist with subsequent de-striping of images
- Near field response, ghosting, and structured scene response seem to be specified too rigidly for the SMWIR and LWIR – the critical issue is how close can the clear FOV be to a cloud and still enable product derivation within spec - the spec should be rewritten in terms of Lcloud minus Lclear
- M9 characterization needs a reliable correction for the influence of H2O
- Reflective radiance response uniformity tests for all SWIR bands (M8, M9, M10, M11, I3) are not complying with spec – some are not complying by a factor of 50 – the SIS100 (integrating sphere) source radiance characterization and stability across the SWIR spectral region is a probable root cause (i.e. a test setup and measurement equipment problem) - this needs to be resolved

Emissive radiometric characterization (especially a problem for M12) should not rely on polynomial fits higher than quadratic – better fits from third order or

NPOESS/VIIRS Supports Superior AFWA Cloud Forecasting

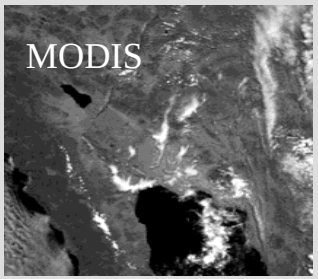
- 22 spectral bands
- Co-registered multi-spectral imagery
- Cloud & Aerosol Detection bands
- Thin Cirrus & Dual gain bands
- Cloud Top Height, Cloud Top Base, Cloud Cover Layer, & Opt. Properties

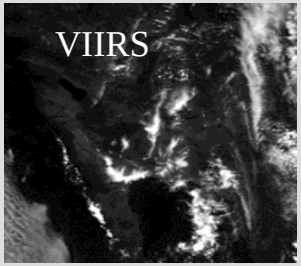




Better CFLOS

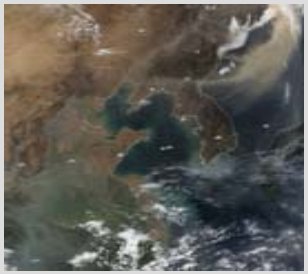
Superior Cloud Detection/Discrimination improves Cloud Free Line of Sight (CFLOS) determination

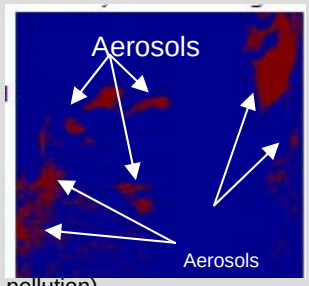




Better Detection

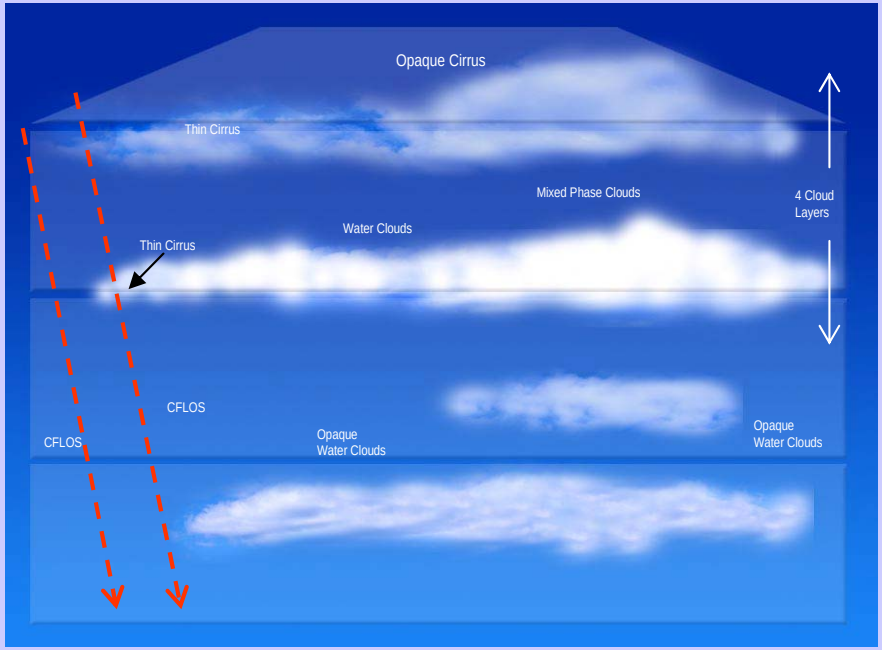
412nm Dual Gain band gives superior contrast over desert and improved detection of smoke, dust, and haze





Aerosols Detection

Superior Aerosol detection (dust, smoke, pollution)



VIIRS/NPOESS Provides:

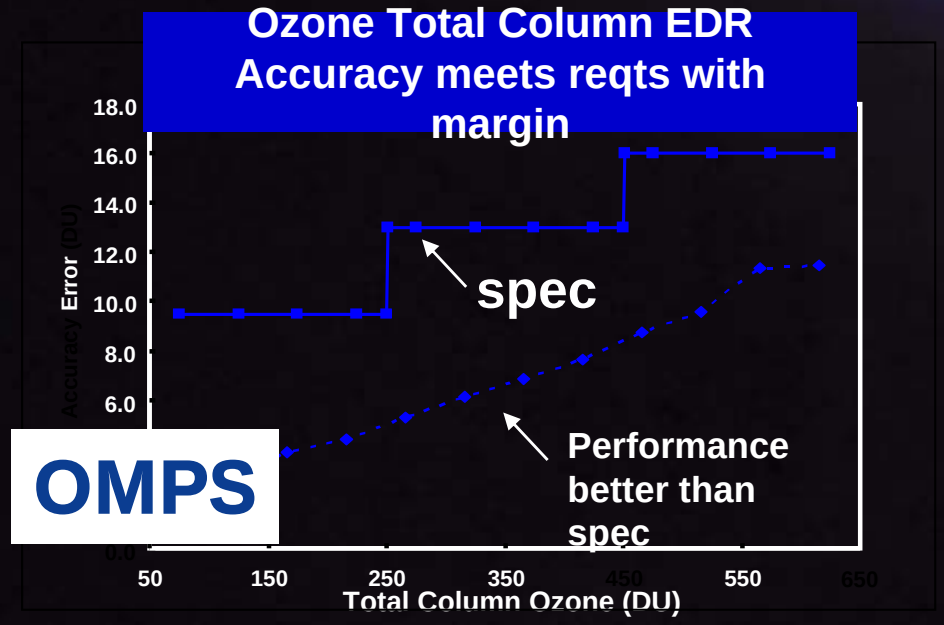
- 3D gridded cloud product, near Uniform Cell Size
- CTH, CTB, CCL, COP and EPS Products
- Feeds directly into AFWA high resolution Cloud Forecast Models

AFWA Cloud Forecast Models

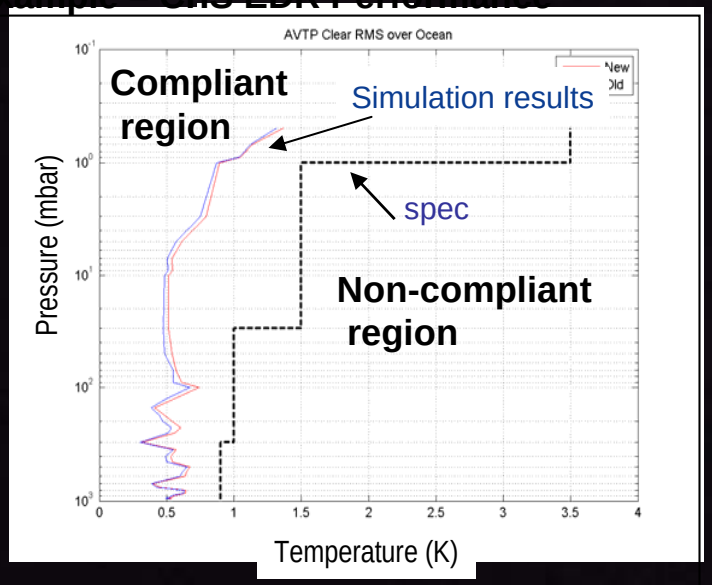
- Improved Cloud Analyses for AFWA forecast models
- Enhanced Aerosol Cloud Discrimination procedures
- Increased knowledge of CFLOS to support missions
- Higher quality products for military applications

Instrument Performance very promising – meets / exceeds KPPs and EDRs

OMPS



CrIS



CrIS Atmosphere Vertical Temperature and Moisture Profile KPP EDRs met with margin due to outstanding sensor performance

VIIRS

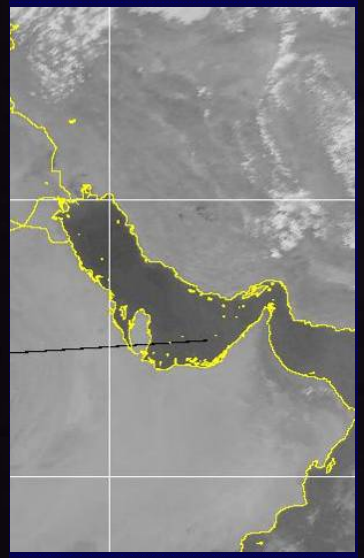
GOVERNMENT ASSESSMENT of NPP EDRs

ALBEDO (SURFACE)		OCEAN COLOR/CHLOROPHYLL	
CLOUD BASE HEIGHT		SUSPENDED MATTER	
CLOUD COVER/LAYERS		VEGETATION INDEX	
CLOUD EFFECTIVE PART SIZE		AEROSOL OPTICAL THICKNESS	
CLOUD OPTICAL THICKNESS		AEROSOL PARTICLE SIZE	
CLOUD TOP HEIGHT		ICE SURFACE TEMPERATURE	
CLOUD TOP PRESSURE		*IMAGERY*	
CLOUD TOP TEMPERATURE		SEA ICE CHARACTERIZATION	
LAND SURFACE TEMP		SNOW COVER	
SURFACE TYPE		*SURFACE TEMPERATURE*	

- All KPPs (bold box) Green
- All EDRs green except Aerosol Optical Thickness and Ocean Color (based on flight sensor ambient testing)
- TVAC testing will characterize Aerosol Optical Thickness and Ocean Color Performance

Advanced Imagery Improves Interpretation

Current Operational Weather



Black & White

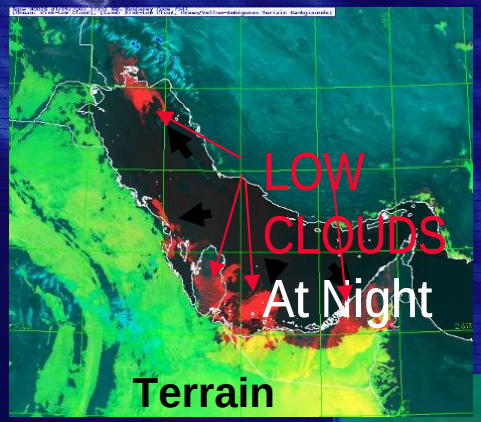
BANDS
OLS: 1 Vis; 1 IR
AVHRR: 1 Vis; 5 IR

Future Operational Weather

3 Band True Color

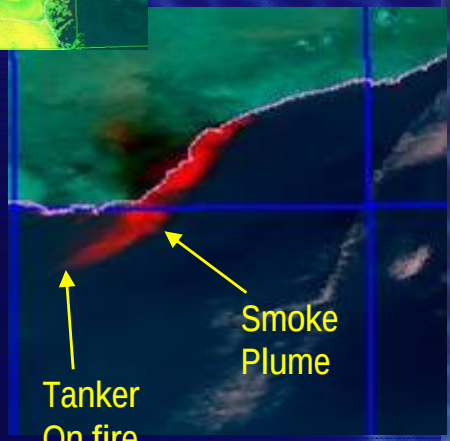
Dramatic enhancement of image content over single-band pan imagery [e.g. land surface types, water turbidity, and dust – cloud discrimination

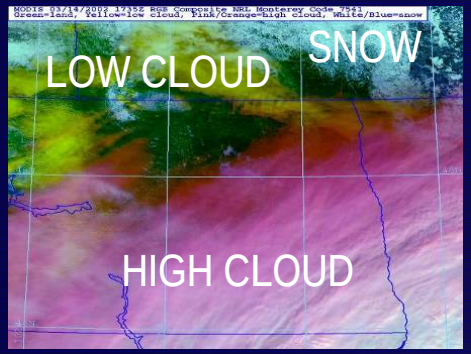
Tough Problems Solved



False Color

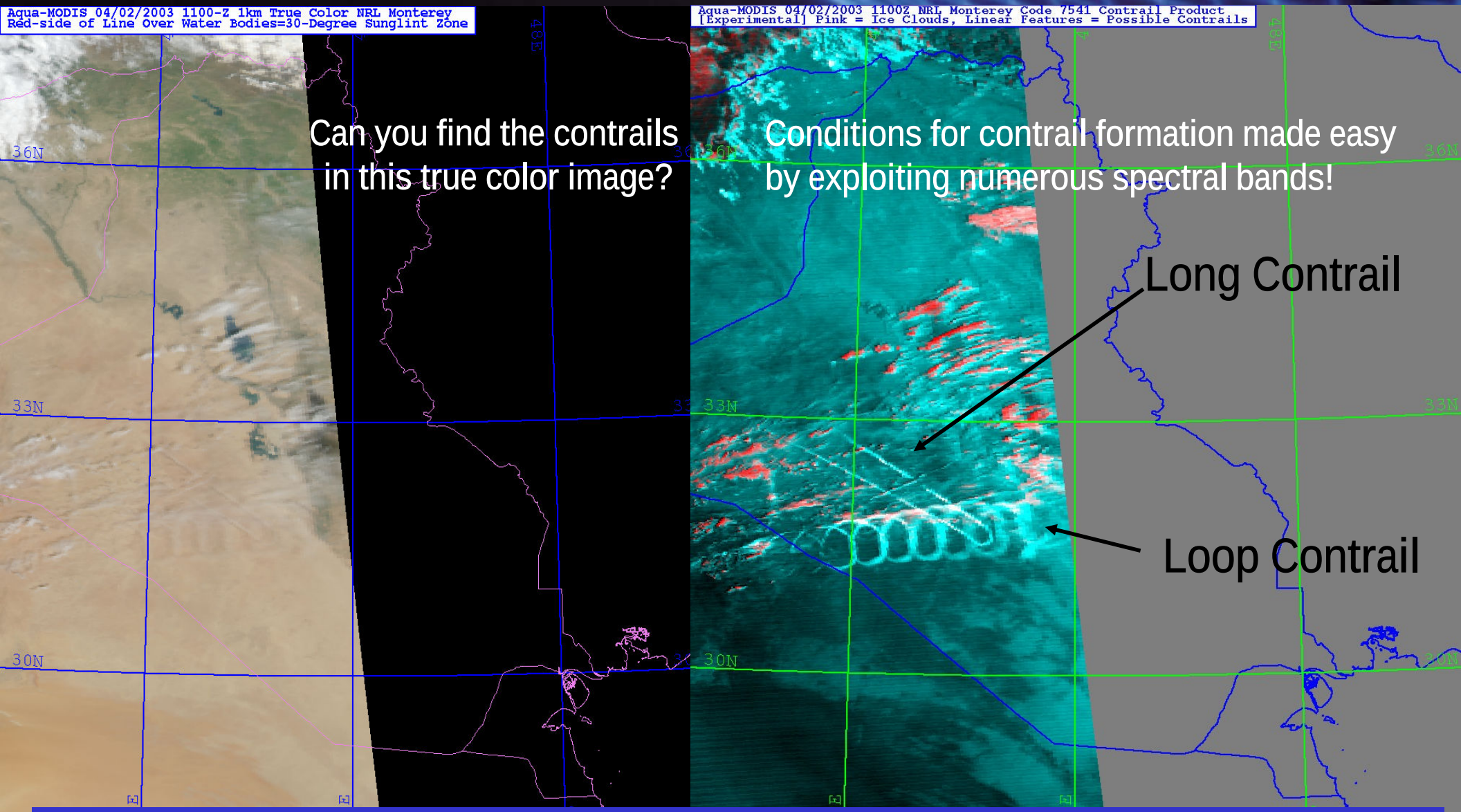
VIIRS 22 bands will provide improved discrimination of scene features





Multispectral capability greatly enhances scene feature discrimination

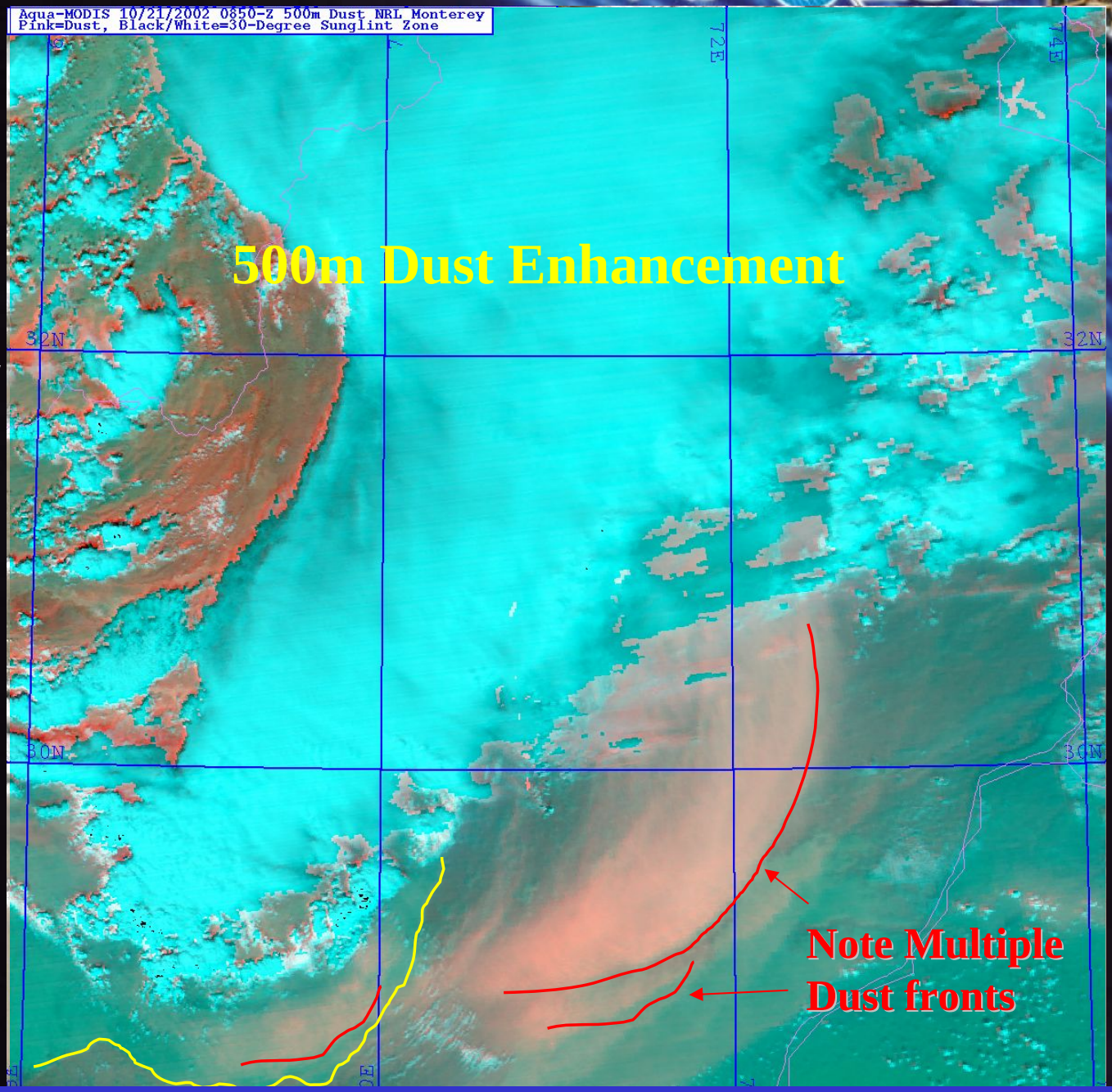
Advanced Visible Imagery Supports Aviation



NASA MODIS Processed Imagery Courtesy NRL Monterey

Advanced Vis/IR Imagery Improves Discrimination

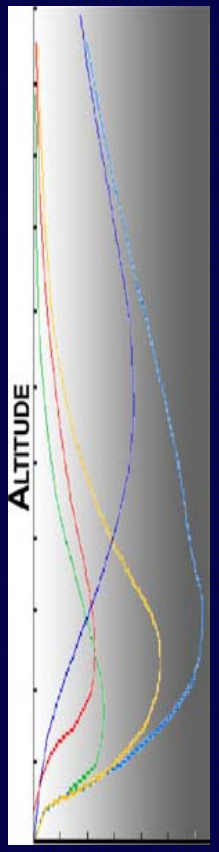
Indus River Valley
Pakistan



NRL Monterey Special Dust Enhancement Algorithm Shows Dust Fronts

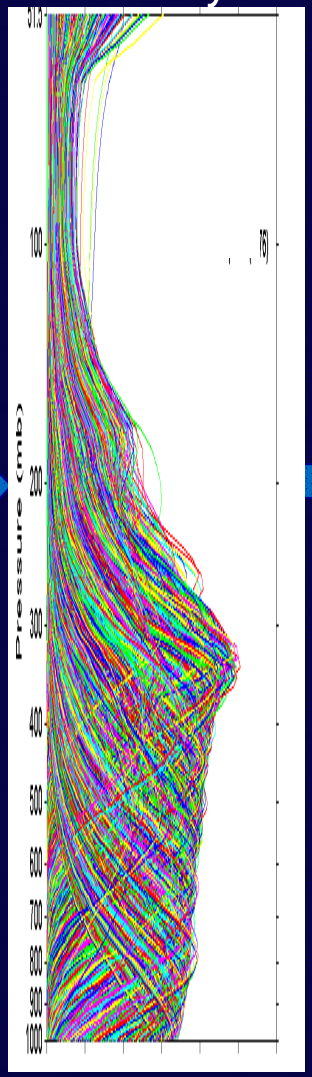
Advanced Soundings Result in Better Forecasts

Current Fidelity



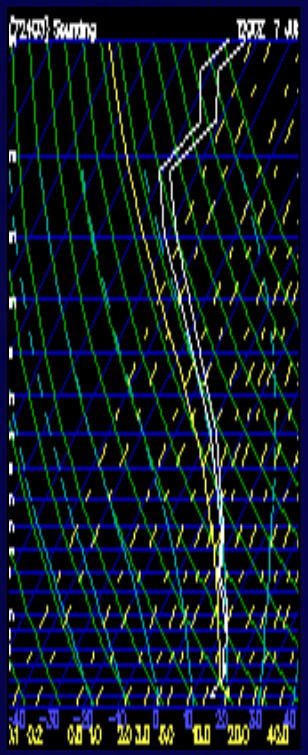
Currently 5–15 Channels

NPOESS Fidelity



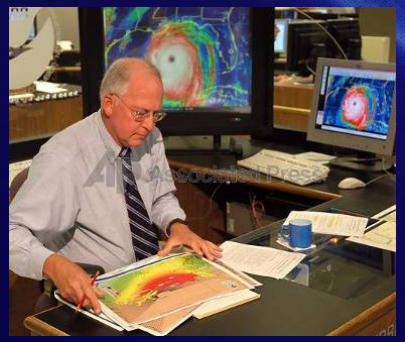
Hundreds of Channels

Produces Global Forecast for national and military users

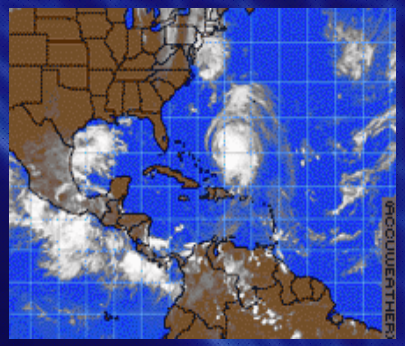


Temperature and moisture profiles

Nat'l Hurricane Center



Where is Isabel headed?



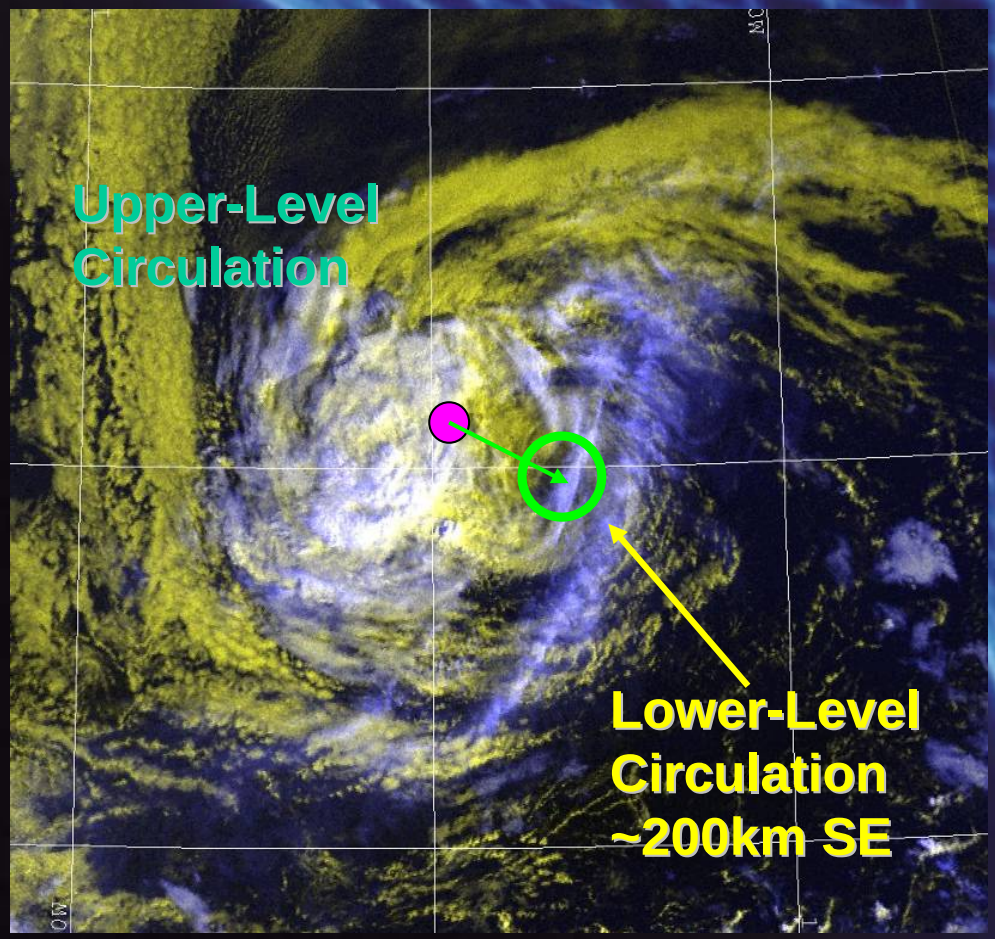
Tanker Airlift Control Center

What Air Refueling route is optimal?

All forecasts start with a global model

Monitoring Tropical Cyclones at Night

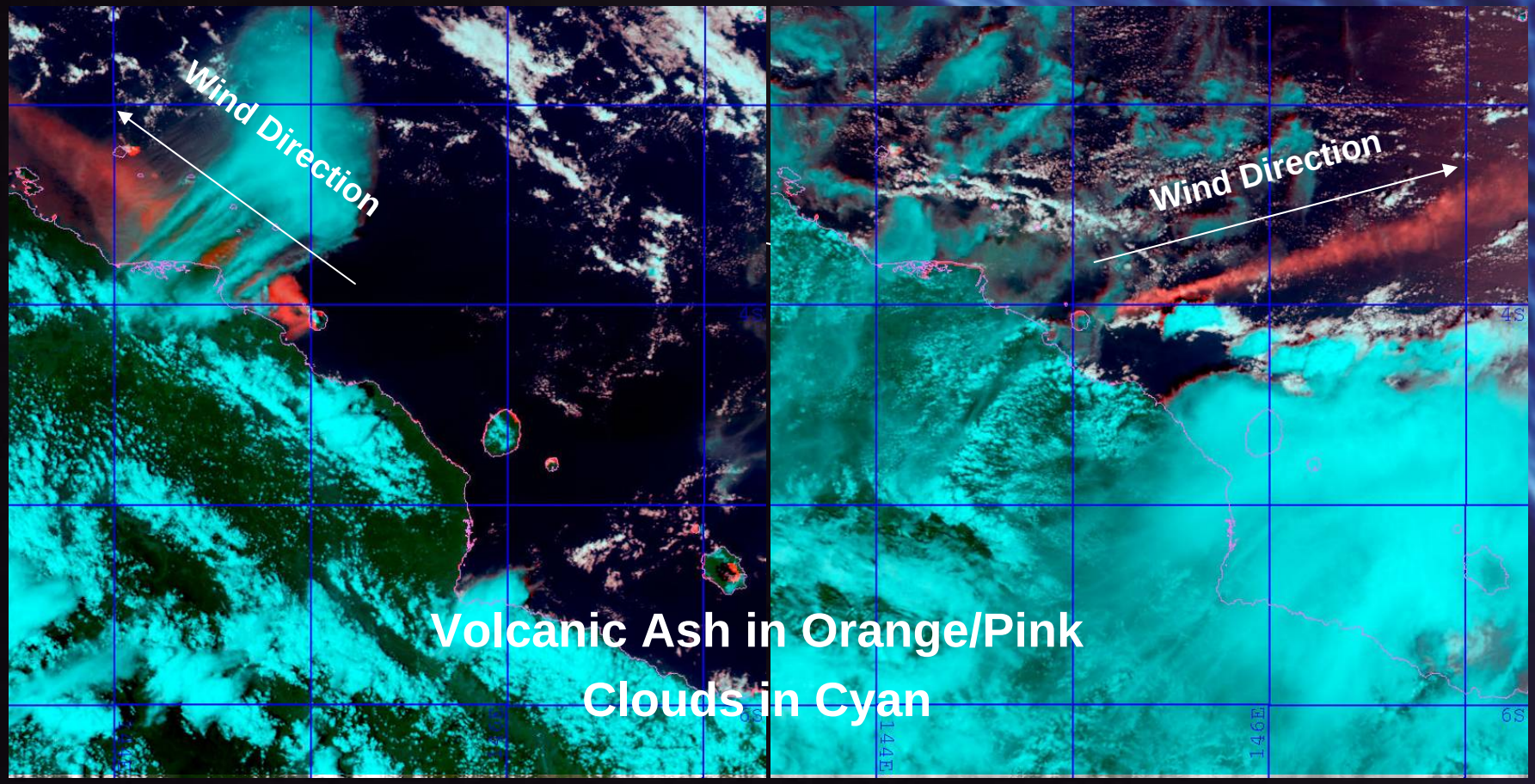
- High-level circulation seen in Infrared
- Lower level cloud fields revealed via DMSP night time visible sensitivity
- High vertical shear displacements between upper and lower level centers can be 200 km in some cases



Avoiding the "Sunrise Surprise"

NPOESS VIIRS Day Night Band will provide better spatial resolution with less noise

Volcanic Ash Monitoring



Volcanic glass particles melt/damage turbine engines

Synopsis

- Real hardware and software being delivered
- Command, Control and Communications System complete & installed at NOAA Satellite Operations facility (NSOF); transitioned to Operations and Support
- Integrated Data Processing System is in transition to Operations and Support at NSOF and will be complete by June 2009
- NPOESS Sensor EDU integration and test with NASA NPP spacecraft completed
- Sensor Flight Hardware completing rigorous testing
- Operational Space Segment development on track for implementing Nation's next generation environmental monitoring system

On plan to provide critical national weather and climate monitoring system for assured data continuity