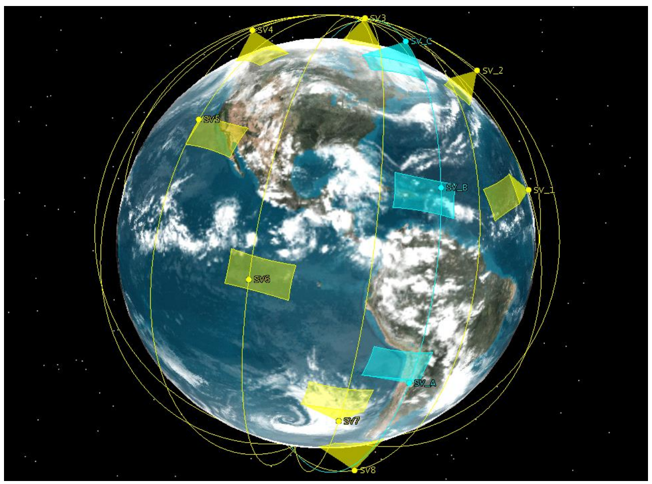
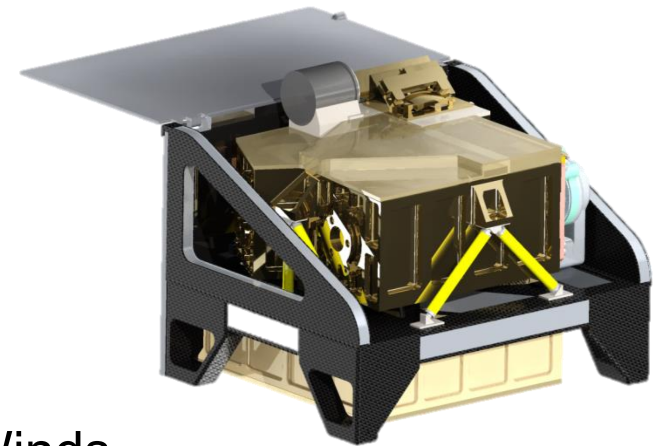
NASA Instrument Incubator Program (IIP)
MISTiC™ Winds
June 13, 2017

An Affordable System of Systems Approach for the Observation of Atmospheric Dynamics





NASA ESTO IIP PI:
Kevin R. Maschhoff,
BAE Systems
Science Team:
H. H. Aumann JPL
J. Susskind NASA GSFC

MISTiC™ Winds

- Provides High Spatial/Temporal Resolution Temperature and Humidity Soundings of the Troposphere
    - Atmospheric State and Motion
    - Improved short term weather forecasting
- Enabled by:
    - LEO Constellation Approach
    - Micro-Sat-Compatible Instrument
    - Low-Cost Micro-Sat Launch

POC:kevin.maschhoff@baesystems.com

Topics

- Instrument Concept and Mission Concept Summary
- Instrument Physical Concept Update
- Risks Reduction Progress
  - Airborne Hyperspectral Sounding and AMV Winds Instrument Demonstration
    - Airborne Instrument Engineering Check-Out Flights on ER2
    - Early Look at Spectra and Context Images
- MISTiC OSSE Highlights
- Next Steps
- IIP Summary

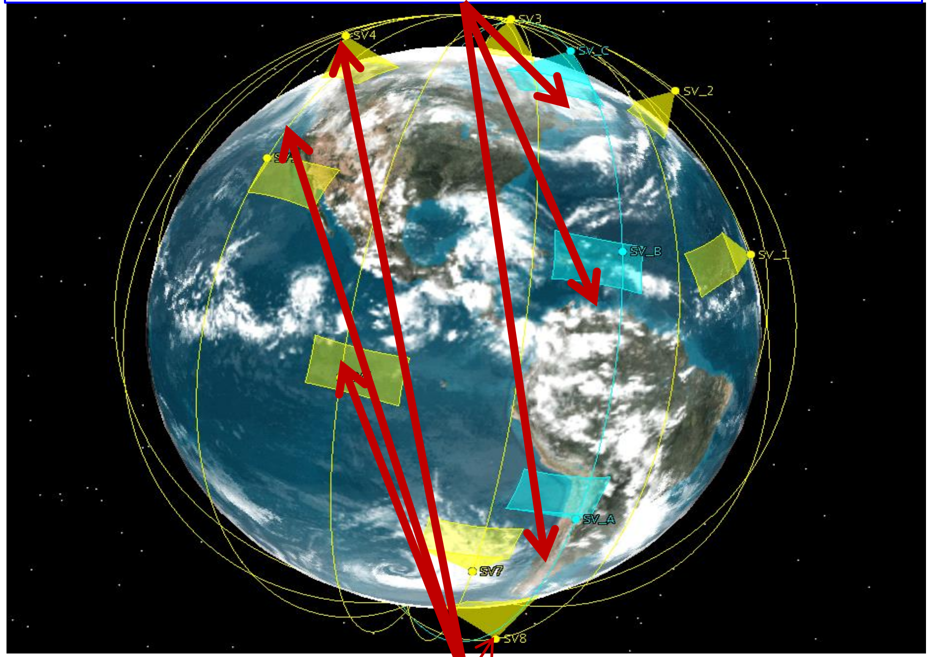
MISTiC™ Winds- Two Affordable Measurement Concepts to Reduce Weather Forecasting Errors

BAE SYSTEMS

- MISTiC™ Winds Temperature and Humidity Sounding Constellation Options.
  1. Frequent-Sounding Constellation
     - e.g. 90 min refresh-globally.
  2. **Wind-Vector Formations**
     - **e.g. 4 3-Satellite Formations for Cloud-Drift and Water Vapor Motion-Vector Winds**
       - **Provide 3-Hr Refresh for 3D Winds *and* Atmospheric Soundings (T, H_2O)**

Miniature Spectrometers Operated in Constellations Offer Lower Cost /Lower Risk Approach than GEO for Frequent-Refresh IR Soundings & 3-D Winds

Motion-Vector Winds Formation (blue)

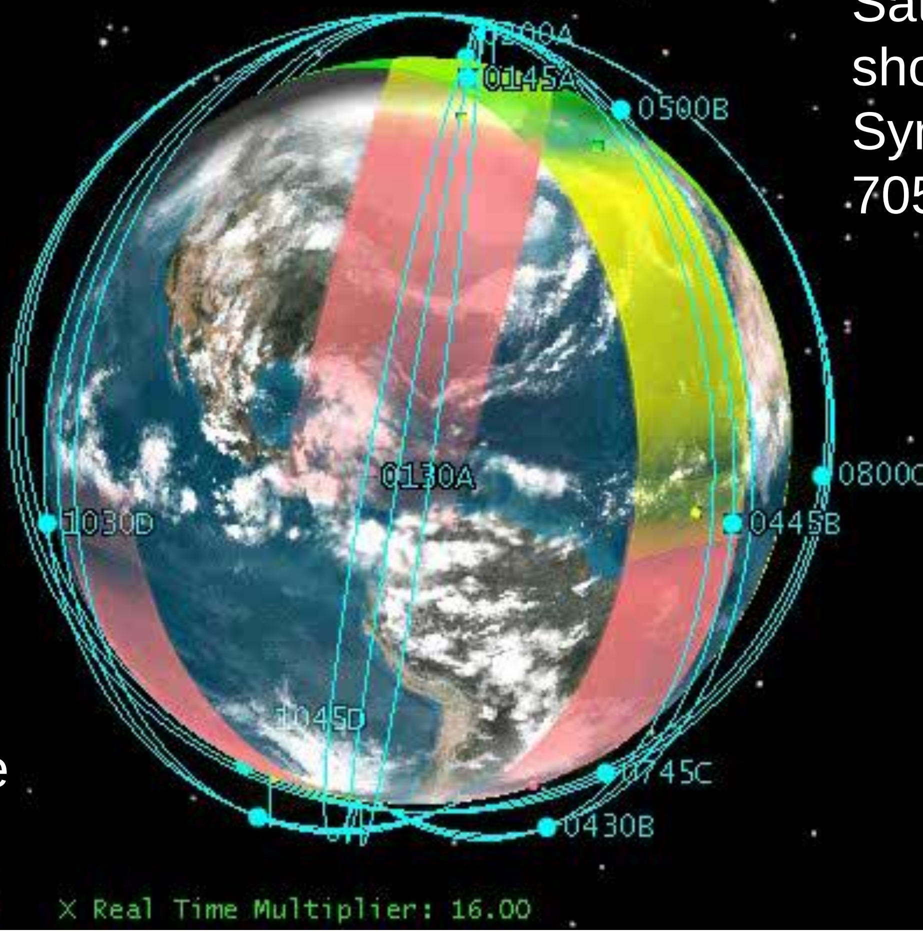


90 min Refresh of IR Soundings Provided by Spectrometers in 8 Orbital Planes (gold)

MISTiC Winds Constellation Provides Frequent Global Temperature, Moisture, and Wind Profiles

12 Nano-Satellites in 4 groups of 3 Observe both Wind and Vertical Profile Every 3 Hours

Each Wind Vector is Derived from Three Views of the Atmosphere

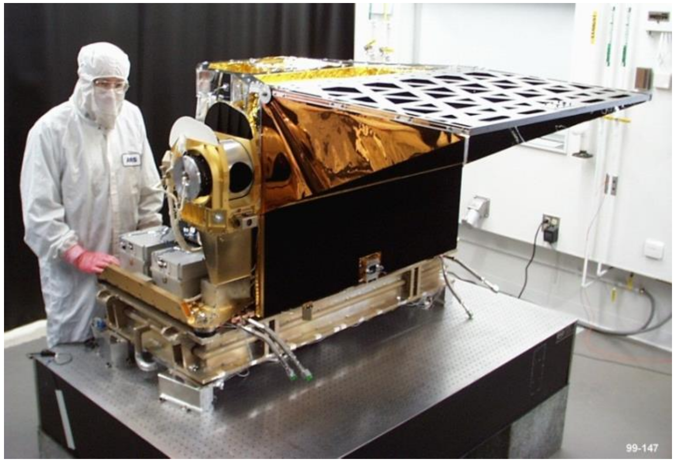


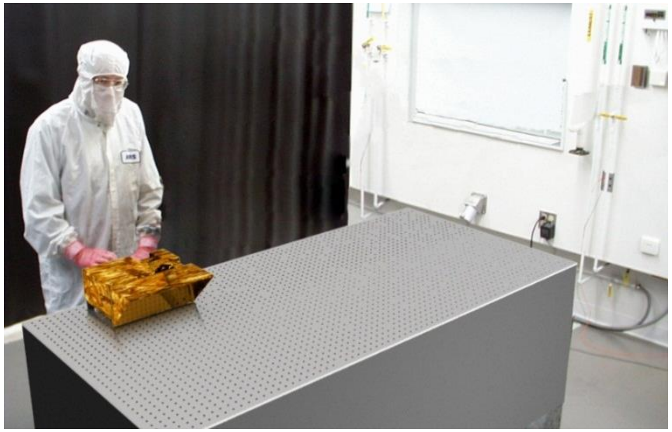
Satellites are shown in Sun-Synchronous 705 km Orbits

LEO orbit and SWIR/MWIR-only Spectra Enables MISTiC™ Instrument SWaP Reduction of 1-2 Orders of Magnitude

BAE SYSTEMS

- Size Drivers
  - Geo-Stationary Imagers /Sounders Driven by Orbit Radius
  - IR Sounders Driven by # of Channels and LWIR Band Cooling
- **Moving MISTiC™ to a LEO orbit and eliminating LWIR channels enables massive reduction in SWaP**
  - Current concept is 60-125X less volume than Sounders proposed for GOES-R
  - Reduce power demand with an advanced FPA technology that won't require as much cooling
- IIP Instrument Concept Design
- Baseline envelope consistent with hosting on a 50 kg ESPA-Class Microsatellite
  - "Objective" Envelope consistent with 27U Cube sat Envelope (about 1 cubic foot of spacecraft volume)
- **Small instrument size depicted continues to be feasible as instrument concept fidelity increases**

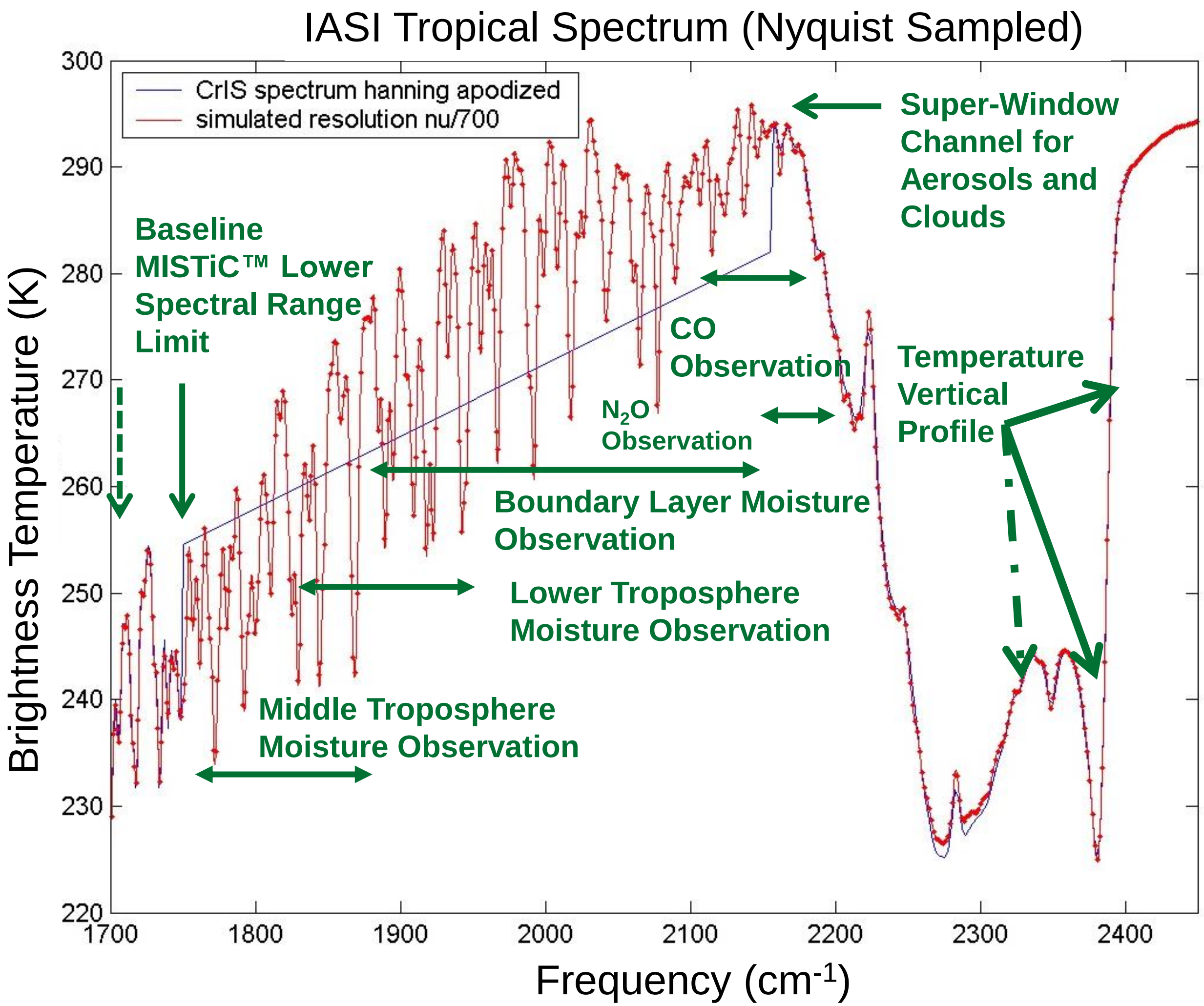




Artist's Rendering Depicts a MISTiC™ Instrument, for Comparison to AIRS

Achieve Reduced SWaP by Reducing Number of Spectral Channels to the Mid IR only-*Sufficient to Sound the Dynamic Portion of the Atmosphere*

BAE SYSTEMS



- SWIR Coverage at NEΔT and $\Delta\nu$ Sufficient for CO_2 R-Branch Temperature Sounding of Surface to Upper Troposphere
  - Sharper Vertical Resolution using Line Wings
  - Spectral Resolution > 700:1 is Sufficient
- Mid-Trop. CO
- Mid-Trop. N_2O
- Moisture in Planetary Boundary Layer
- Moisture Profile in Lower and Middle Troposphere
  - WV Motion Vector Winds
- Clouds
  - Cloud MV Winds

Channels Below 1750 cm^{-1} Needed to Observ in for Upper Troposphere—*but*, *UT is Observ Sufficient Frequency by CrIS/IASI and ATMS*

MISTiC™ Winds Level 1 Instrument Performance Characteristics and Level-2 Sounding Data Quality (updated)

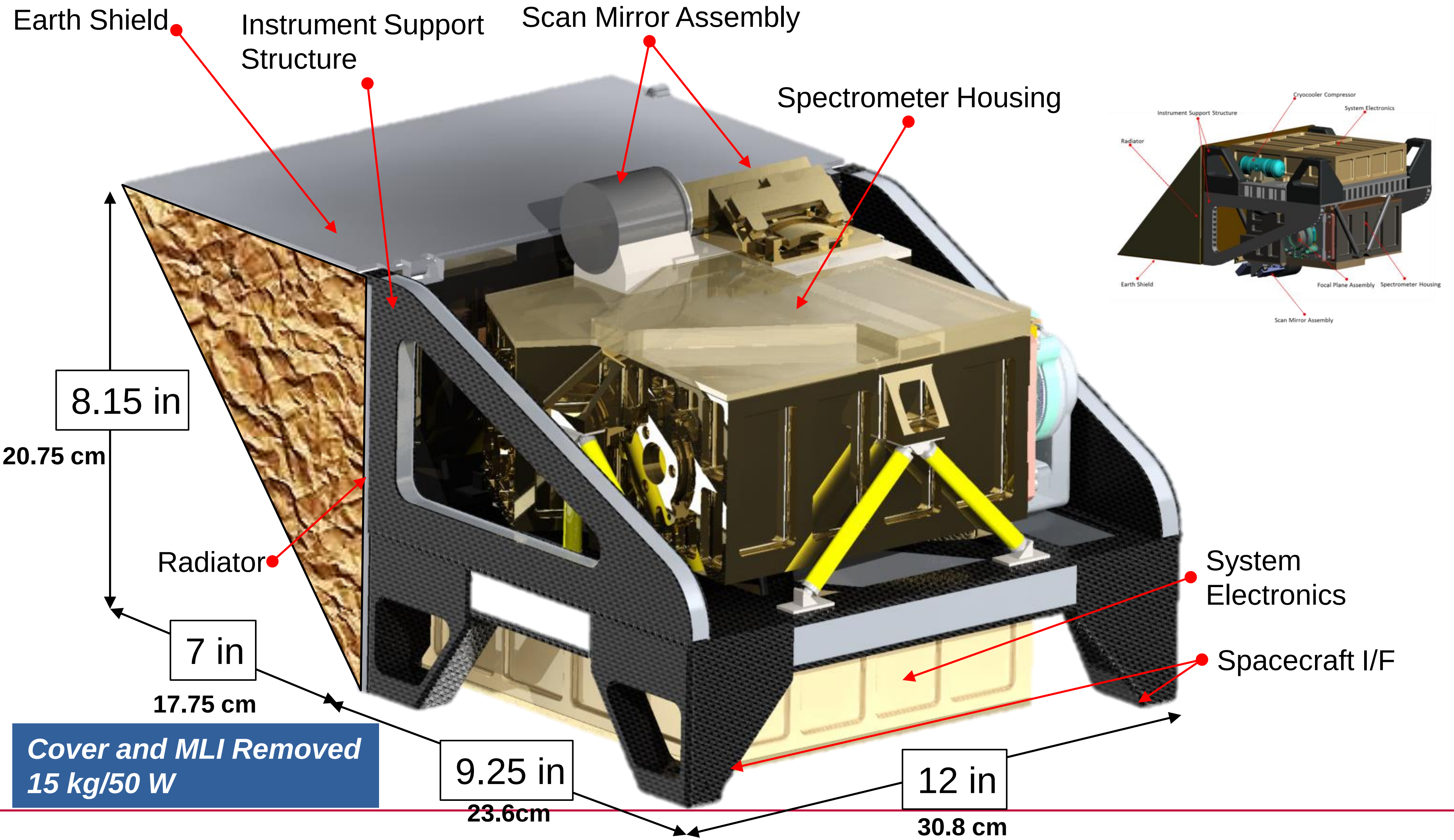
BAE SYSTEMS

MISTiC™ Key Instrument Performance Characteristics		
Characteristic	Value	Comments
Minimum Spectral Frequency	1750 cm^{-1}	5.72 μm
Maximum Spectral Frequency	2450 cm^{-1}	4.082 μm
Spectral Sampling	~ 2:1	<590 spectral samples
Spectral Resolution @ minimum	>700 :1	$\nu/\delta\nu$ ((comparable to CrIS-Apodized)
Spectral Calibration Knowledge	1/100,000	$\delta\lambda/\lambda$
Angular Sampling	1.6 mr (cross-dispersed)	1.38 km (@ Nadir)
Orbital Altitude and Orbit	705.3 km	Polar/Sun-Synchronous
Angular Range (cross-track)	1570 radians	90 Degrees—Same as AIRS
Spatial Resolution	<3.0 km (geometric mean)	@ Nadir
Radiometric Sensitivity	<200 mK (max)	(<150 mK @ 2380 cm^{-1})
Radiometric Accuracy	<1%	@ 300K Scene Background
Key Sounding Data Product Characteristics,		
Vertical Resolution—Temperature	~ 1 km	In Lower Troposphere
Layer Accuracy	~ 1.25 K	In Lower Troposphere
Vertical Resolution—Humidity	~ 2 km	In Lower Troposphere
Layer Accuracy—Humidity	~ 15 %	In Lower Troposphere

- MISTiC™ Data Quality Requirements Similar to those Demonstra-ed by NASA's Successful AIRS Instrument
  - Spectral Resolution
  - Spectral Calibration Stability
  - Radiometric Sensitivity/Accuracy
- Spatial Resolution Notably Finer than AIRS Resolution (13 km @Nadir for AIRS)
  - 3.0km @ Nadir
- Reduced Spectral Range Enables Major SWAP Reduction

MISTiC Winds IR Spectral Sounding Instrument Concept

BAE SYSTEMS



Cover and MLI Removed
15 kg/50 W

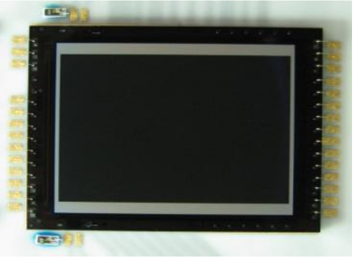
Primary Efforts under NASA IIP Address Instrument Concept, Technology and Measurement Challenges (Continued)

BAE SYSTEMS

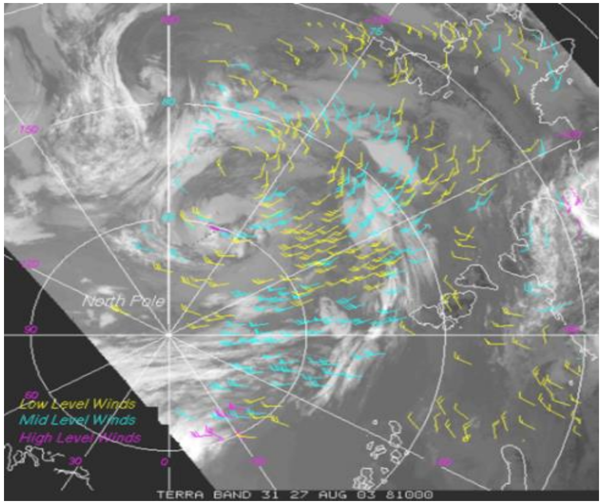
- ✓ Space Mission concept development
- ✓ Technology Risk Reduction

  Challenge: Get a higher operating temperature FPA in order to reduce cooler power

    - Benefit: Large reduction in SWAP
  - Approach: Use of new APD-Class MWIR FPA
    - Risk: APD Array Not Yet Tested in Space Radiation Environment
    - Mitigation: Radiation Testing on IIP *(by 9/15)*
- Observation Method Risk Reduction
  - Challenge: Application to Highly Vertically Resolved (3D) MV Winds is highly plausible-but not demonstrated
    - Benefit: MV Winds at Low Cost -> Better weather forecasting
    - Risk: Tracer De-correlation Behavior at finer vertical resolution unknown in detail
    - Mitigation: Airborne observations of Tracer De-Correlation Times & Behavior

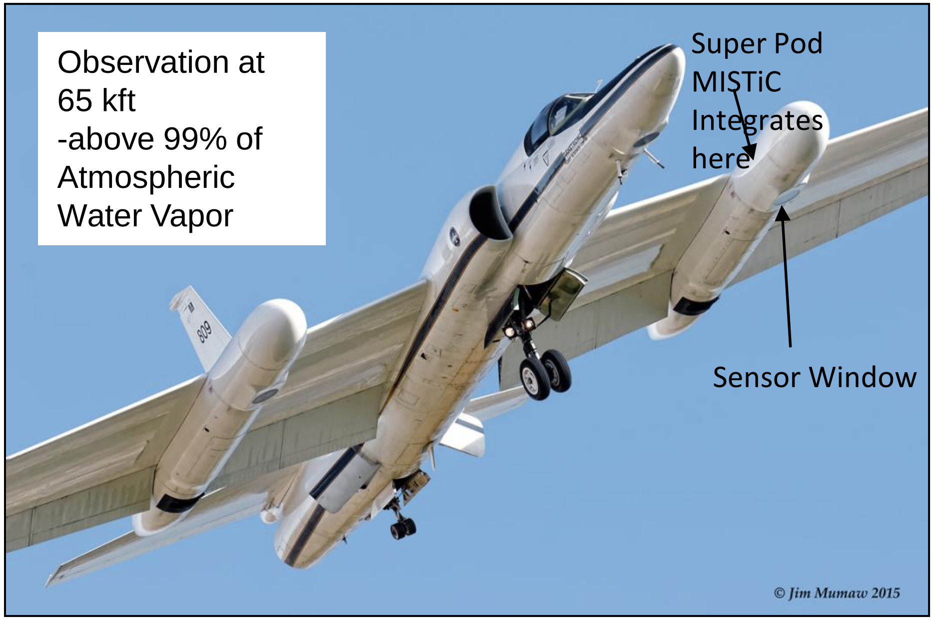


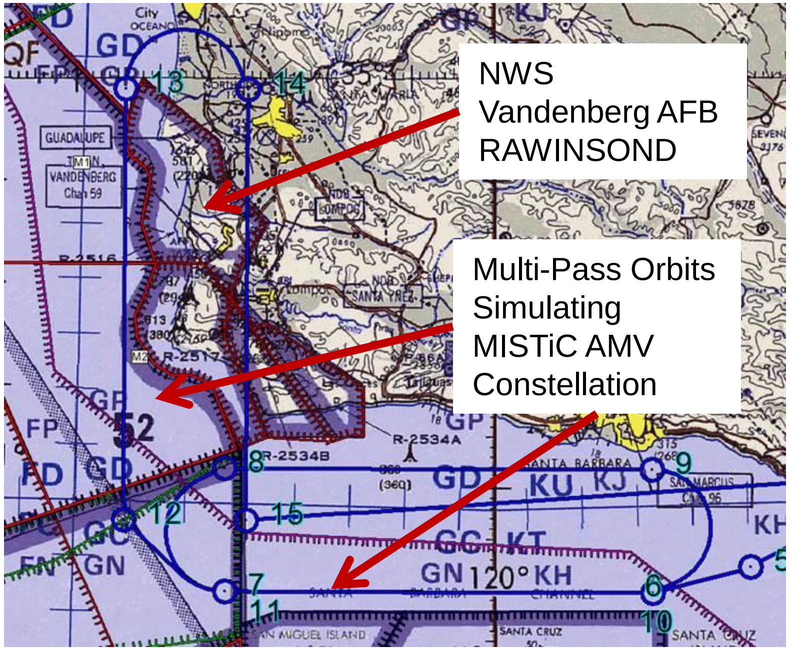
The MWIR HgCdTe Avalanche Photodiode-based IR Focal Plane Array Detector selected for MISTiC allows high-sensitivity hyperspectral measurements at 85K



MISTIC™ Winds Tracers Features Would Have Better Vertical Resolution Than MODIS Winds

Airborne Testing of MISTiC Spectrometer on the NASA ER2 Platform Reduces Observing Method Risks





Airborne Spectrometer Very Similar to Space Instrument--with these differences:

- Off-the shelf APD FPA, Filter (λ_{co} ~ 5.4μm vs 6)
- Active Cooling of Spectrometer- (in Vacuum Vessel)
- POD Window (outside cal. loop)
- (rugged) COTS electronics, coolers, etc

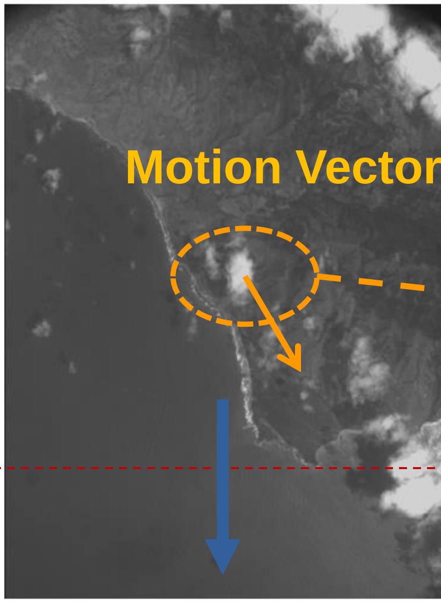
MISTiC and Independent Observations

- IR Imaging/Sounding Spectroscopy
- Visible Context Images
- NWS RAWINSONDEs
- METSAT Obs (IASI, AIRS, GOES)

For Airborne Test, Atmospheric Motion Vector From Tracking Features in Multiple Views of Scene with Δt~30 min

2017-05-15 T18:34:40.003	34.41757	-120.493

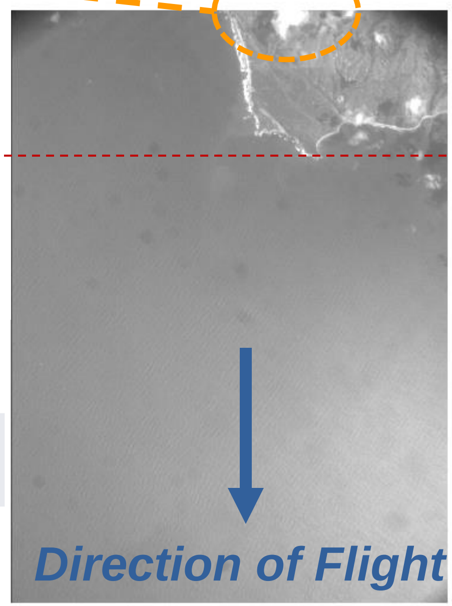
iwg1 Time

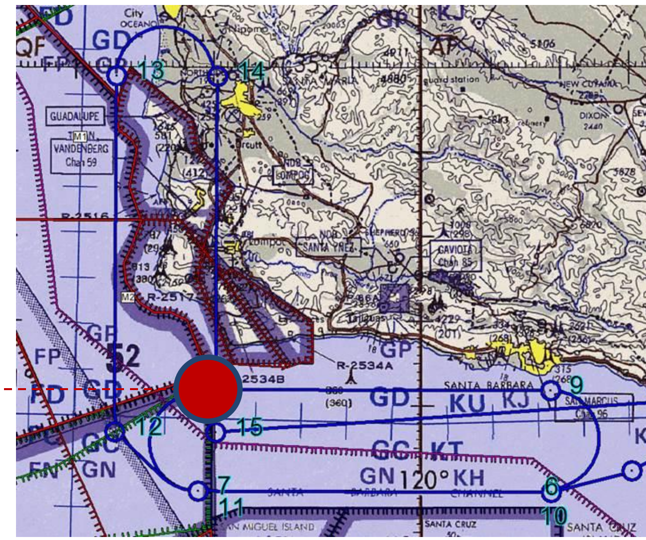


Direction of Flight

2017-05-15 T18:15:29.003	34.48168	-120.493

ER2 Latitude, Latitude



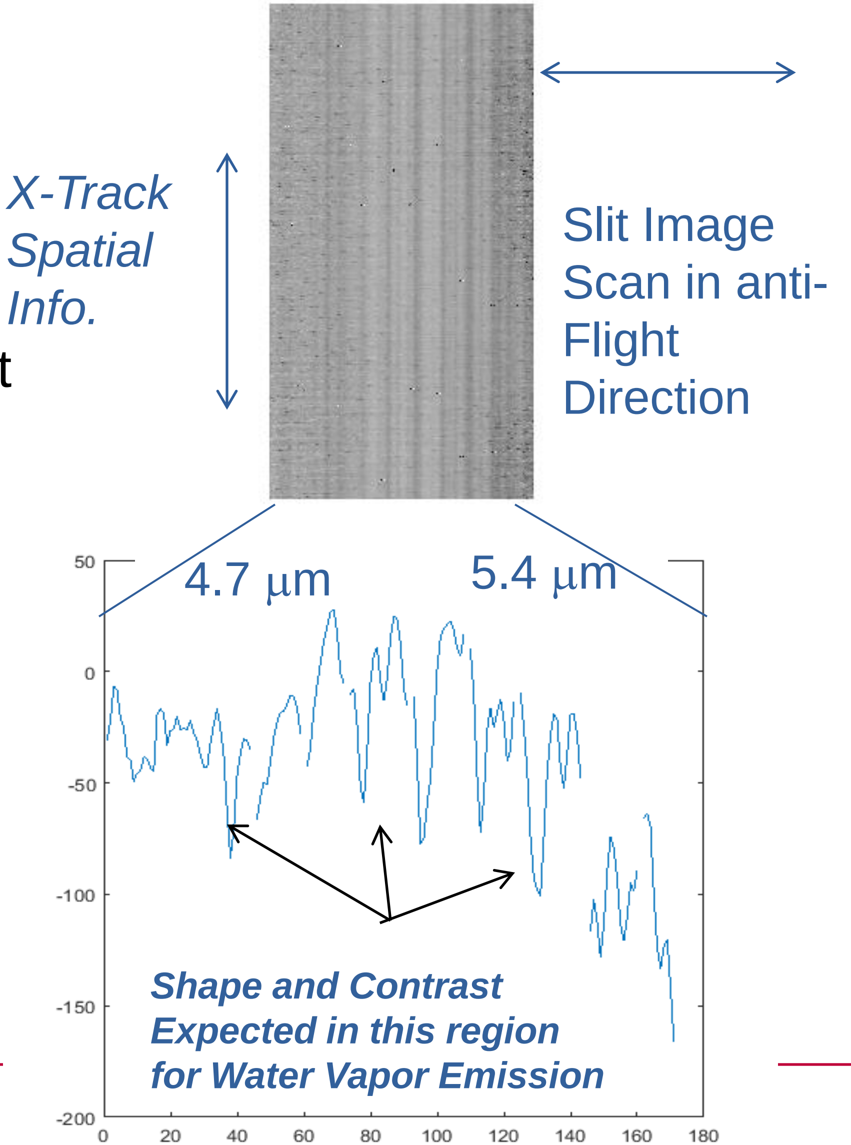


Example Visible-Band Cloud Motion-Vector Wind Observation Just South of Vandenberg AFB

Sweep 70 Order 2 Nadir Line Image and FOV-Average Spectrum South of Vandenberg AFB

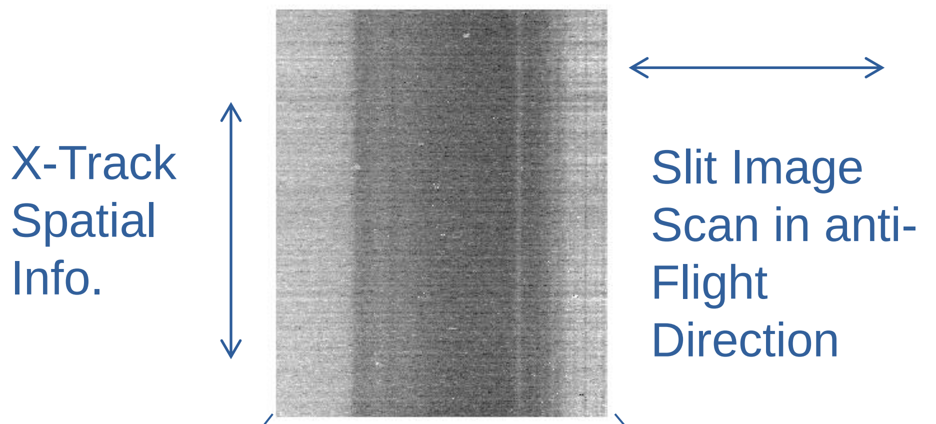
BAE SYSTEMS

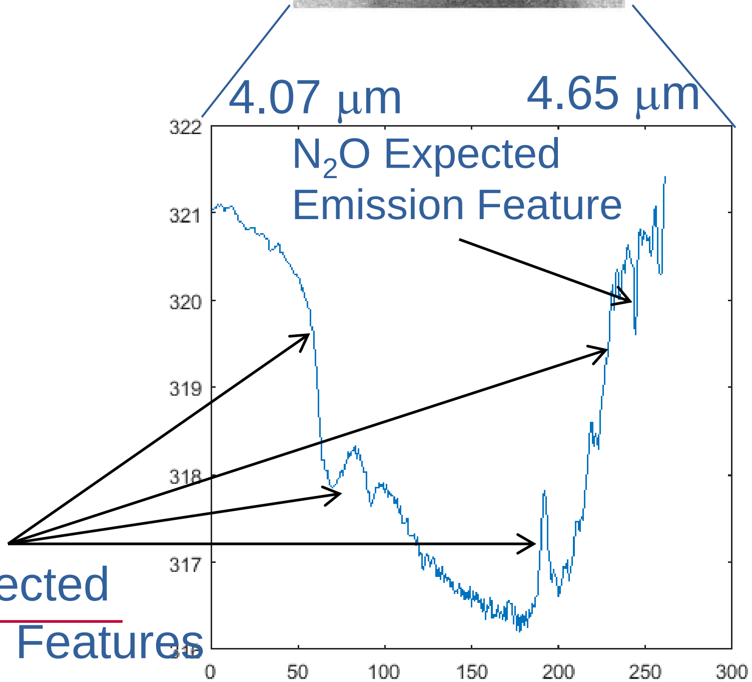
- 4.7-5.4 μmSpectral Image for one IFOV (above) and Average Spectrum for the IFOV (below), (vert axis proportional to digital counts)
- Darker lines correspond to low brightness, in regions where the dominant emission is from -high in the troposphere.
  - Brighter vertical lines show spatial contrast, corresponding to spatial variation near surface.
  - Darker regions show more uniform moisture emission from colder regions at higher altitude
- Average Spectrum Appear Reasonable, relative to other WV-region spectra—brightest near 5 microns (~ ch 70), and dimmer at higher wavelengths



ECO-1 Sweep 137 Order 3 Nadir Line Image and FOV-Average Spectrum

- 4.06-4.7 μmSpectral Image for one IFOV (above) and Average Spectrum for the IFOV (below), vert axis proportional to digital counts out of the A/D
- Order 3 IFOV-Average Spectrum Appear Reasonable—showing expected CO_2 Emission Spectral Features
- Bright emission from surface on far left, sharp edge due to R-Branch, and structured P-Branch on Right Side





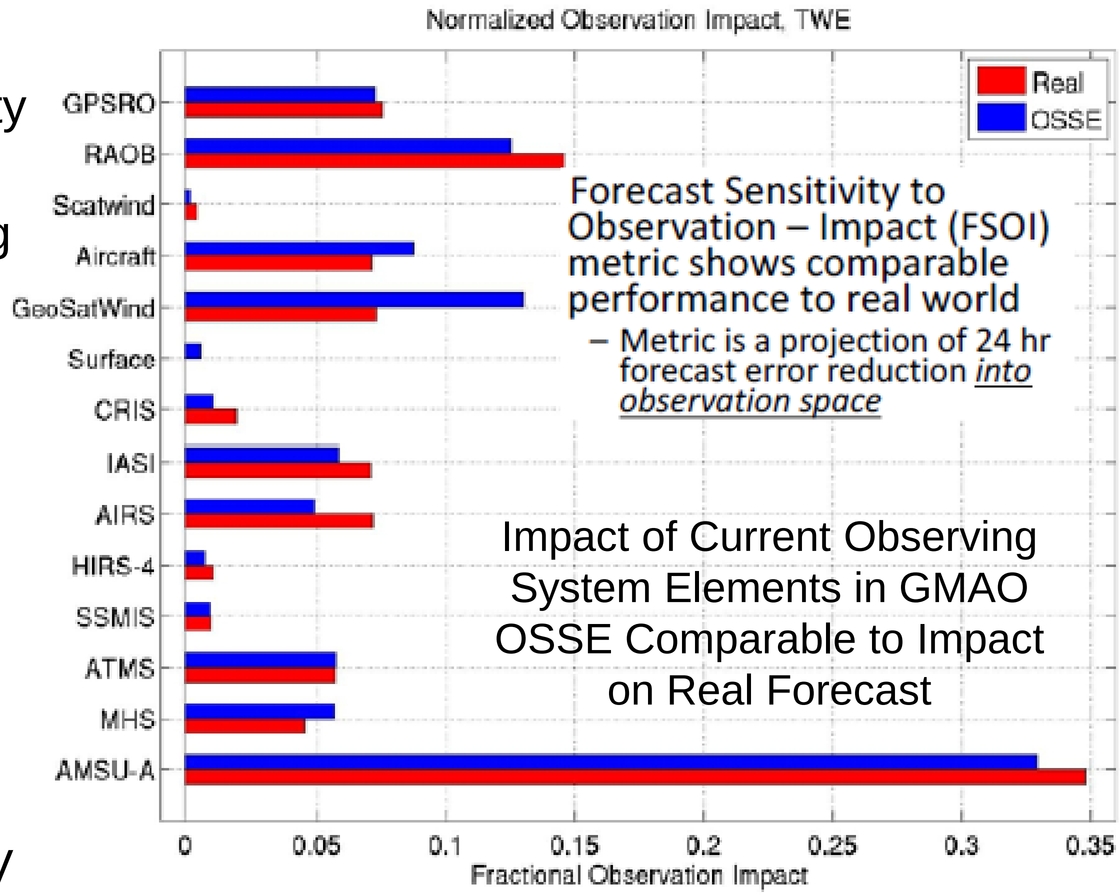
CO_2 Expected
Emission Features

Photos following MISTiC Winds Airborne Instrument ECO-1 Flight

- Top: NASA ER-2 Pilot (Nelson) Describing Scene Conditions During Flight and (good) Instrument Operation/Behavior to the instrument team
- Bottom: Instrument in Super-pod following ECO-1 flight, with some of BAE/UML team
  - Spectrometer/Optics Suspended Below Main Support Plate
  - Electronics Attached Upper Side of Support Plate
  - Primary Window Attached/Sealed to Super-pod
  - Univ. of Mass.-Lowell Grad. Student (now staff member) Sam Fingerman (center) Developed instrument control software

GMAO OSSE System (Used for MISTiC Winds OSSE)

- OSSE Performed by NASA GSFC GMAO
  - Team led by Dr Will McCarty
  - (BAE provided descriptions of MISTiC Winds Observing Approach)
- OSSE Top-Level Attributes
  - Nature Run is the 7-km GEOS-5 Nature Run
  - 3DVAR Data Assimilation System, on 6-Hour Cycle
  - Approach to Wind Observations Simulation:
    - Based on likelyhood of moisture and cloud AMV Observation Conditions in G5NR

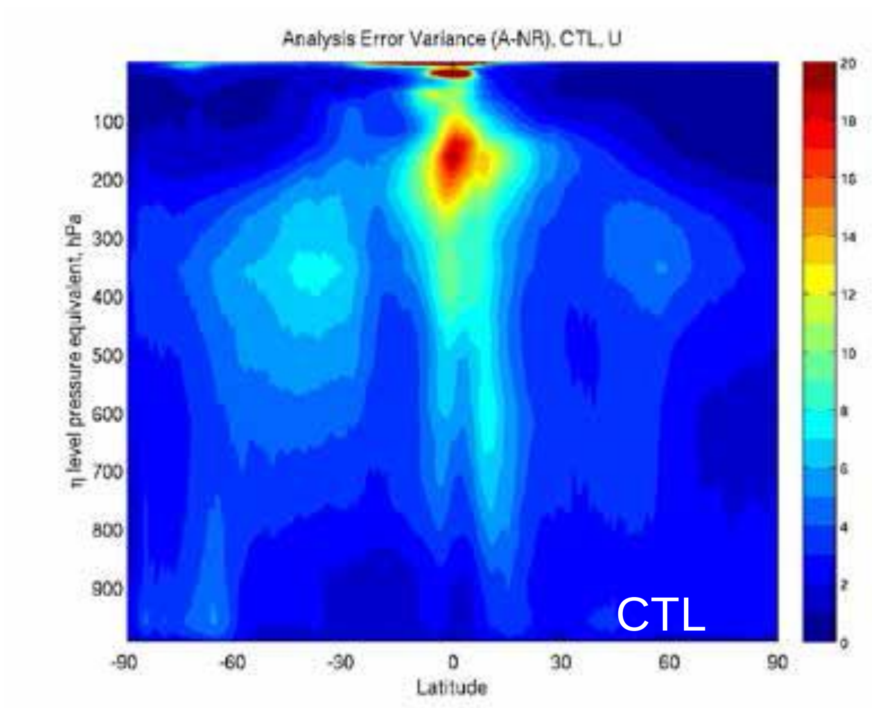


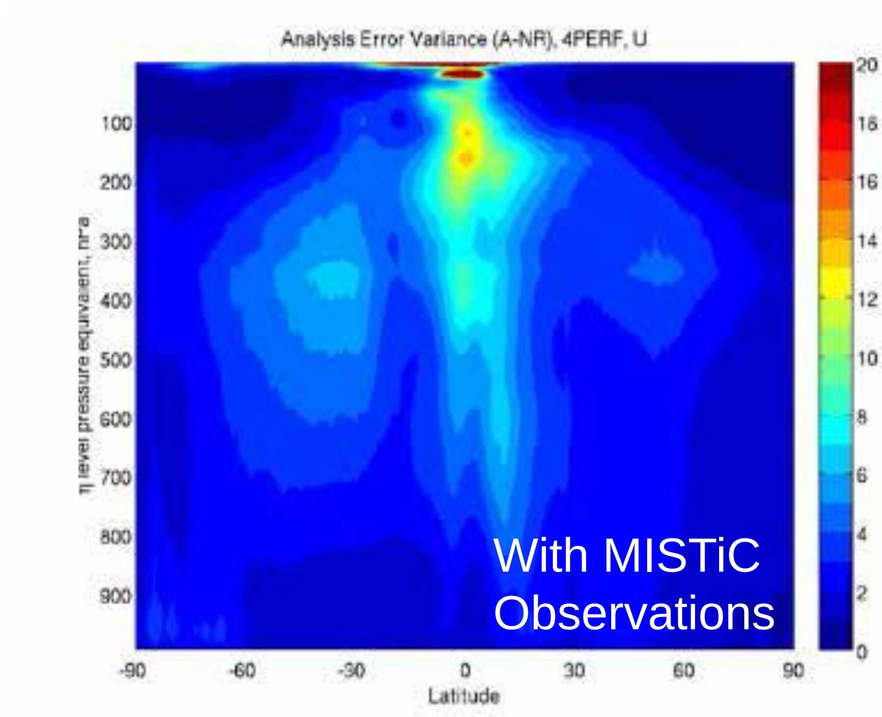
Forecast Sensitivity to Observation – Impact (FSOI) metric shows comparable performance to real world

– Metric is a projection of 24 hr forecast error reduction *<u>into observation space</u>*

Impact of Current Observing System Elements in GMAO OSSE Comparable to Impact on Real Forecast

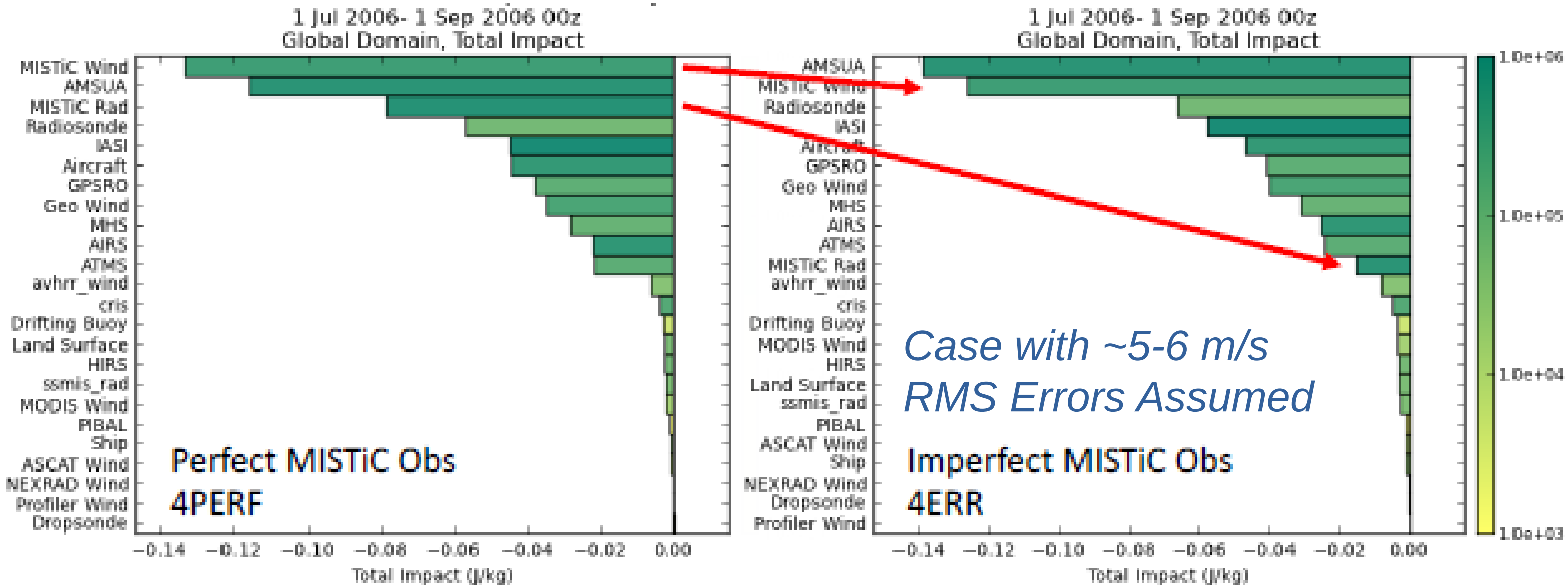
Zonal Wind Analysis Variance for Control and 4-Orbital Plane MISTiC Winds Constellation





Strongest Forecast Improvement Impact Seen in Upper Troposphere, Especially in Tropics-Where Current Forecast Errors are Largest

Forecast Impact (FSOI Metric)



Considering perfect observations, MISTiC has the potential for reducing 24 hr forecast error

- When realistic errors (approximated from convolved IASI data) are applied, the radiance impact is reduced greatly
- Additional results indicate that further development is needed to fully exploit the information content from MISTiC Radiances

Global Modeling and Assimilation Office
Goddard Space Flight Center
National Aeronautics and Space Administration

Development of Appropriate Error Estimates is Work-in-Progress (4ERR is for "Himawari Errors"

- *Contributions include Observing Error, Forecast Error, …*

Even with Current Weather Model Spatial Scales & Refresh Rates, OSSE Shows that MISTiC Winds has Significant Weather Forecast Improvement Potential

BAE SYSTEMS

Broader Objective and Next Steps:

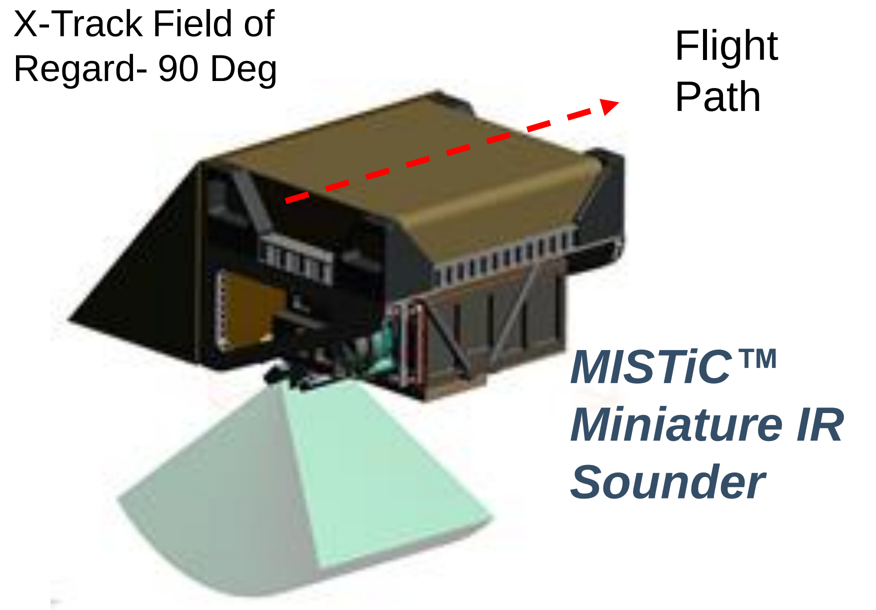
- Objective: Affordable Means to Improve Short-Term Weather Forecasts
  - Societal Benefits Include:
    - Airlines and Air Traffic Control-- having greater knowledge of weather 3 hours out to reduce flight delays
    - Improved Power Grid Load Forecasts (and more)
- Next Steps to Operational System
  - NASA IIP continues to mitigates risks
    - Spectral Sounding and AMV Feature-Tracking Demonstration
      - Airborne Instrument Integrated,
      - Infrared Imaging/Sounding Functions Demonstrated
        - Instrument Repairs to enable HSI AMV’s initiated
      - ER2 Hosted Science Flights Planned for Fall 2017
  - OSSE Modeling to Evaluate Impact on Numerical Weather Prediction
    - IR Hyperspectral AMV OSSE Demonstrates Significant Impact
  - MISTiC Winds Formation (Wind Triplet) Demonstration in Space

Miniature Spectrometers Operated in LEO Constellations Offer Affordable/Lower Risk Approach for Improved Short Term/Fine Scale Weather Forecasting

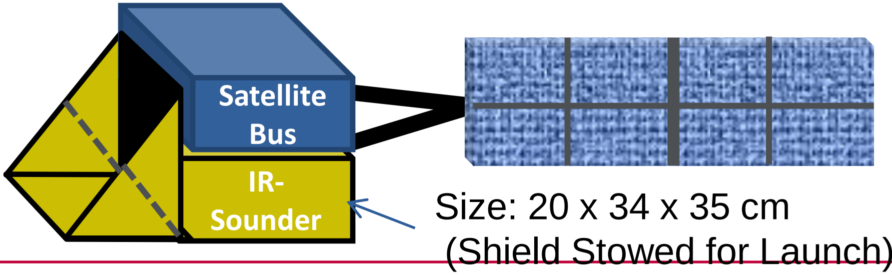
MISTiC™ Winds-A Miniature High Vertical Resolution Infrared Sounder for 3D Winds and Frequent IR Soundings

BAE SYSTEMS

- Miniature Spectrometers Enabled by:
  - Optimized Low-Impact Spectral Channel Selection Proven through a Decade of NASA's AIRS Experience
  - Innovative Opto-Mechanical/Thermal Design Minimizes S/C Resources Needed to Cool IR Spectrometer
  - Advanced Large-Format IRFPA, Miniature Cryocooler, and Electronics
    - *All Technologies TRL-5 or Higher*
- Compact IR Sounder Design, Mature Algorithms and Technologies Enable:
  - Payload Hosting on a Micro-Satellite for a Low-Cost Total IR Sounding Mission
  - ~1 km Vertical & ~3 km Horizontal Resolution (@Nadir) in the Troposphere
    - Temperature, Moisture, Wind Profile



Micro-Sat with Miniature IR Sounder Payload



Supplemental Material

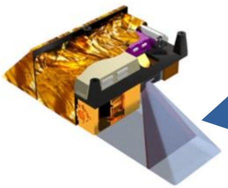
MISTiC Winds: Midwave Infrared Sounding of Temperature and humidity in a Constellation for Winds

BAE SYSTEMS

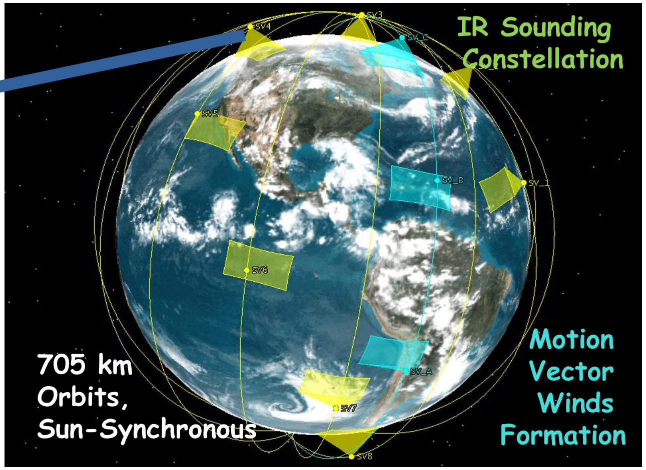
PI: Kevin R. Maschhoff, BAE Systems

Advance the readiness of a miniature, high resolution, wide field, thermal emission imaging spectrometer to measure vertically resolved tropospheric profiles of temperature and humidity for deriving global 3-D wind measurements.

- Provide ~ 2-3 km spatial resolution temperature and humidity soundings of the troposphere using an AIRS-like (Atmospheric Infra-red Sounding) method.
- Enable a LEO constellation approach that provides 3-D Wind field measurements and atmospheric state and transport observations at low system cost.
- Reduce technology risks with the Infrared Focal Plane Array (IRFPA) and spectrometer technologies critical for significant instrument size, weight and power reduction (20 x 30 x 30 cm, 15 kg, 50 W).



MISTiC Instrument will fit on a 27U CubeSat or a ESPA-Class Micro-Sat



- Optimize and refine space-based measurement approach based on experience with AIRS, AIRS-Light and small satellite provider experiences.
- Demonstrate calibration stability of miniature MWIR spectrometer (4.08 - 5.8 um) in ground testing.
- Demonstrate robustness of spectrometer by performing space level thermal fluctuation testing and vibration testing to launch levels.
- Verify instrument measurement capability of 3-D cloud-drift and water vapor motion vector winds on high altitude balloon or high-altitude fixed-wing platform.
- Demonstrate IRFPA space radiation tolerance (> 25 krad).

• Instrument science and payload requirements review	10/14
• Instrument science and payload concept review	12/14
• Airborne demonstration plan review	06/15
• Detector/ROIC radiation test/analysis complete	09/15
• Calibration stability test complete	07/16
• Airborne instrument design/build complete	10/16
• Airborne demonstration complete	2/17
• Airborne demonstration data analysis complete	4/17

Co-Is/Partners: J. Susskind, NASA GSFC; H. Aumann, JPL

$TRL_{in} = 4$ $TRL_{current} = 5$

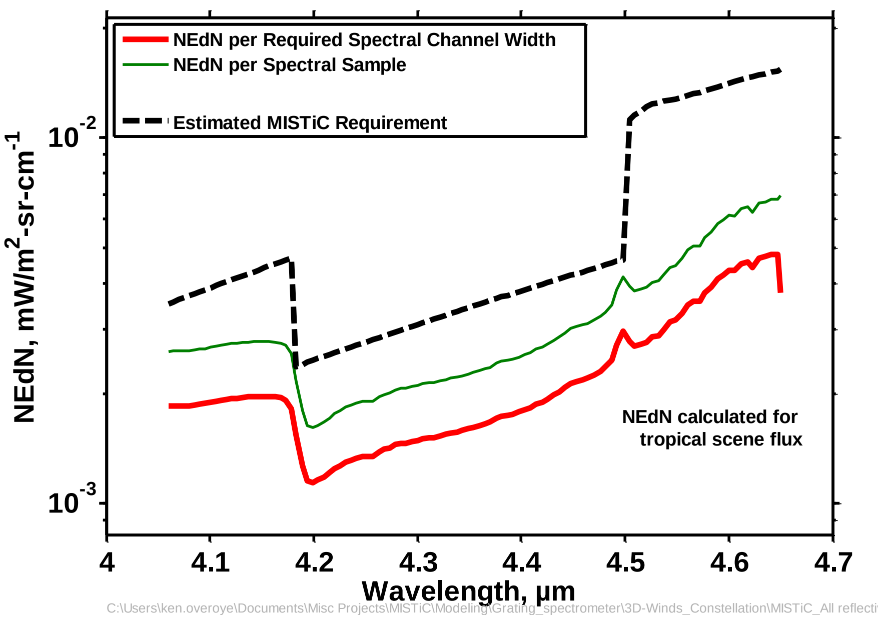
IIP-13-0004

GOES-R Advanced Baseline Imager, AIRS, and CrIS

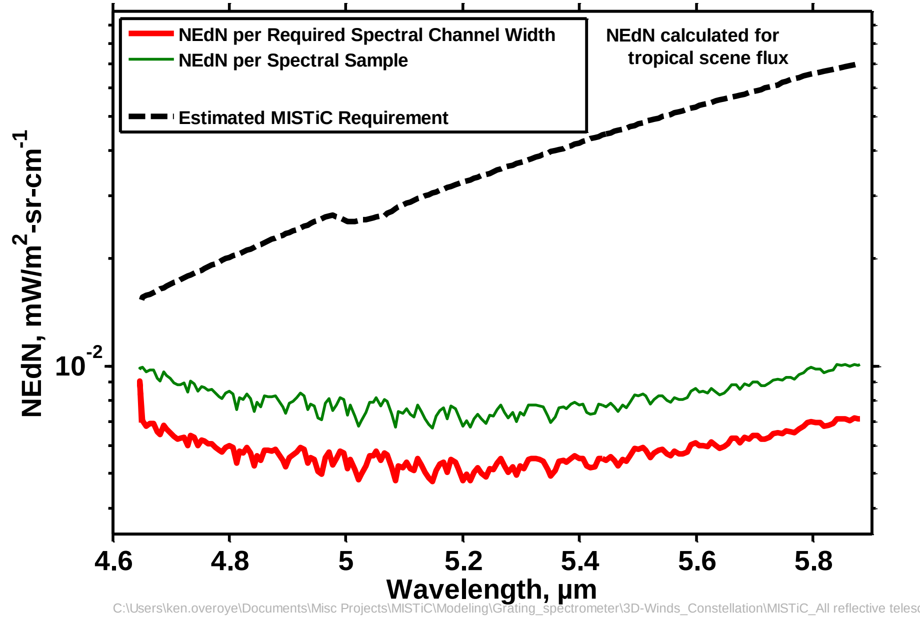
- Size of Geo-Stationary Imagers/Sounders Driven by Orbit Radius
- Size of IR Sounders Driven by # of Channels and LWIR Band Cooling

MISTiC™ Winds Instrument Radiometric Sensitivity Performance Estimates Show Solid Margin Against Requirements

Sounding NEdN vs Wavelength:



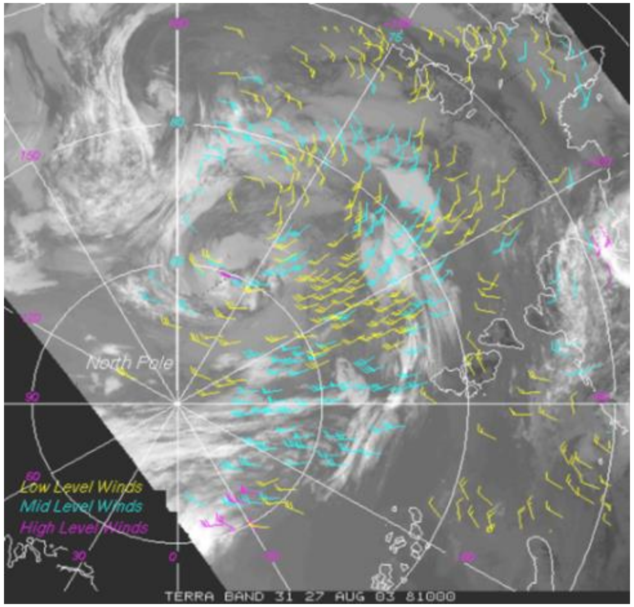
Sounding NEdN vs Wavelength:



- Spectrometer Radiometric Modeling Methods Developed for AIRS, GOES-R HES, etc used to Estimate MISTiC™ Winds Instrument Sensitivity
- Sensitivity Similar to AIRS (<200 mK @ 250K Scene) for low brightness temperature regions near 4.2 µm
- Updated APD detector noise modeling still be included in system model
  - APD FPA Vendor-modeled dark current and noise are in acceptable range for MISTiC™ at 90K

MISTiC Winds Observes the 3D Vector Wind Profile

- MISTiC Winds Observes 3D Atmosphere at 3 closely spaced times to Produce Multi-Altitude Motion-Vector Winds
  - Projected Wind Speed Error ~ 2 m/s rms
    - ~3x better than projected for GOES-R
  - SWIR/MWIR Imaging/Sounding Provides Much Better Tracer Height Assignment than GOES
    - 1K/1 km Temperature Sounding Enables Separation of Temperature and Moisture Concentration Contributions to Radiance
  - Both Moisture and Cloud Motion Vector Winds Observed by MISTiC
- OSSE's Show that 3D-Winds Observations Would Have the Largest Impact on Short Term Weather Forecast of Any New Observation
  - MISTiC Observes Thermodynamic State *and* Mass-Field Motion



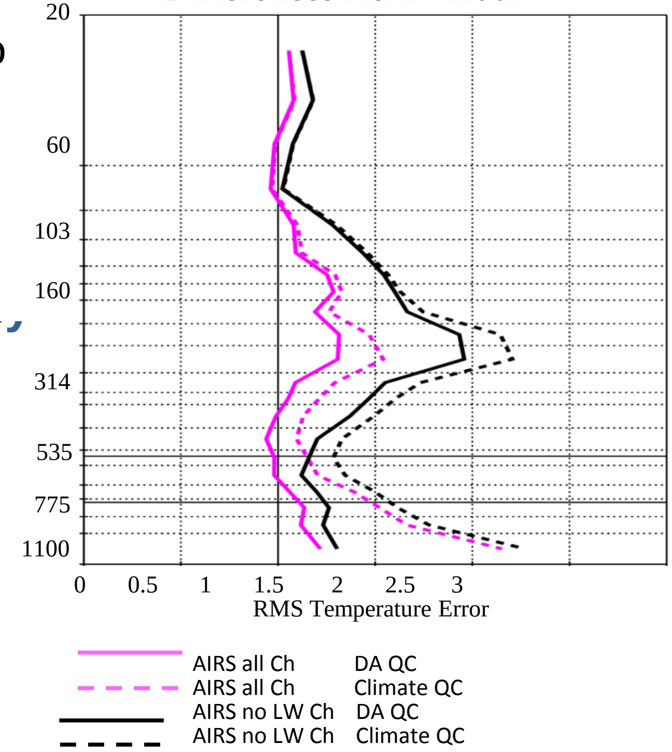
MISTIC Winds' Tracers Features Would Have Better Vertical Resolution Than MODIS Winds (shown) and GOES Imagers

MISTiC™ Winds' Concept Based on Proven Science From Current Flight Instruments

BAE SYSTEMS

- **MISTiC™ Winds' Vertical Temperature Profile Retrieval Comparable to AIRS & CrIS in Lower Troposphere**
  - Vertical Temperature Profile Retrieval Accuracy for Two Different Quality Control Thresholds Shown
    - Using All AIRS Channels—solid curves
    - Using SWIR/MWIR-Only –dashed curves
- **Additional Error experienced is modest using only SWIR/MWIR Channels**
  - ≤ 0.1K Added Error in Lower Troposphere
  - NOTE-AIRS Version 6 Algorithm Primarily uses /SWIR MWIR Channels for Sounding, using LWIR Channels **only for Cloud-Clearing**
- **Fine spatial resolution (~ 3 km @ nadir)a new benefit**
  - Yield of Cloud-Clear Observations much higher for MISTiC than for CrIS, IASI, and AIRS
  - Increased Cloud Contrast in Partly Cloudy Scenes

AIRS/AMSU Retrievals
Global Cases for July 10, 2012
Layer Mean RMS Temperature (K)
Differences from "Truth"



(from Joel Susskind NASA GSFC)

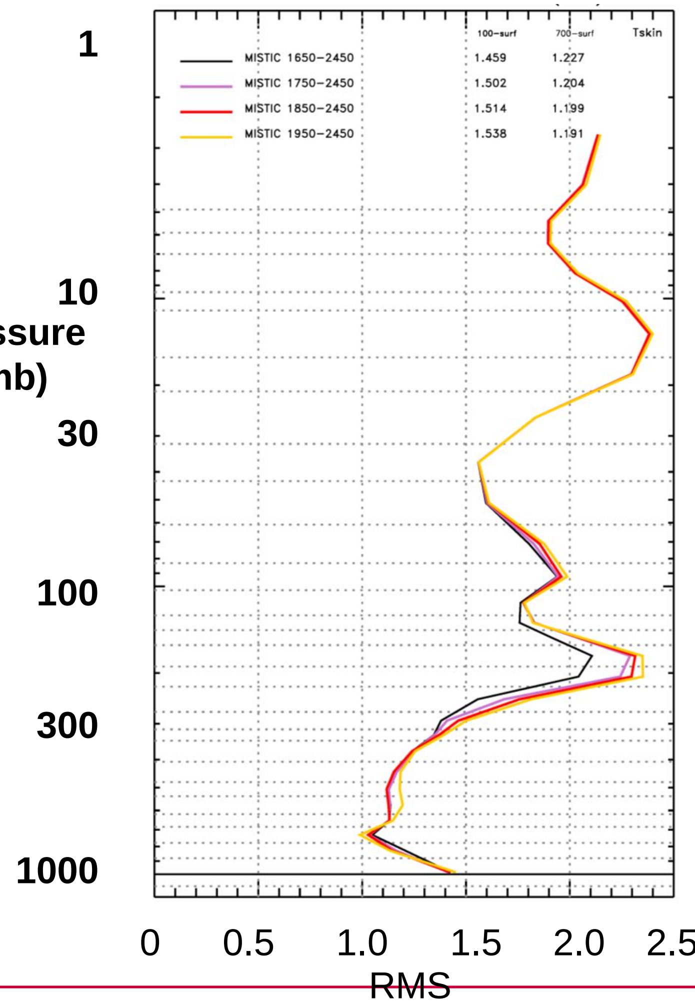
MISTiC™ Winds Retrieval Simulation Validates Chosen Spectral Range

1650-2450 cm^{-1}
1750-2450 cm^{-1}
1850-2450 cm^{-1}
1950-2450 cm^{-1}

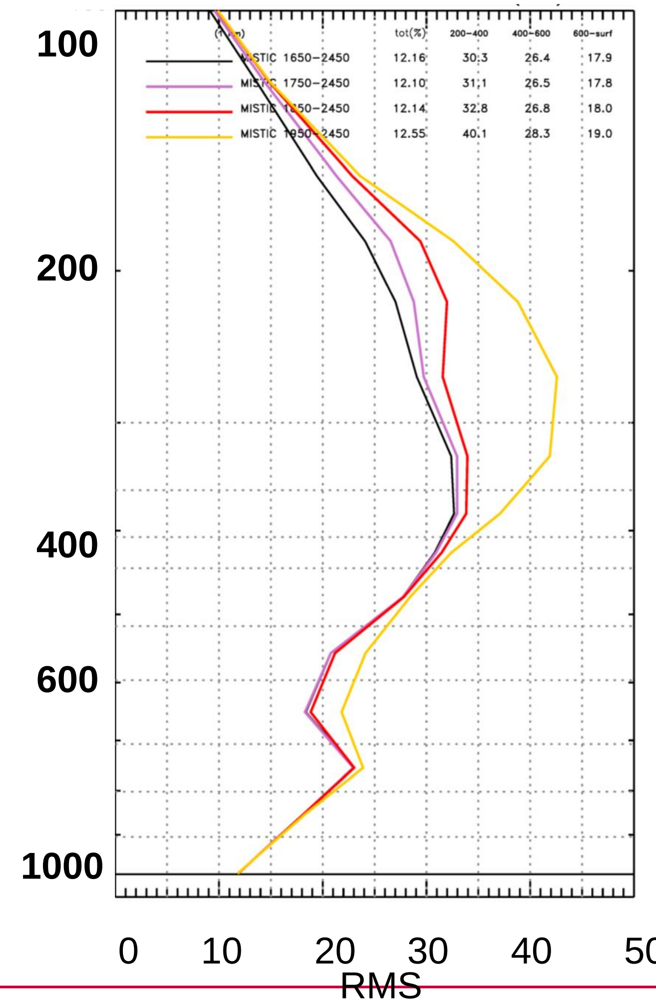
- Reasonably accurate temperature sounding can be done, using just the 4.2 micron band of CO2, up to about 200 mb
- Water vapor retrieval accuracy best at1650 cm-1 but good enough at 1750 cm-1 spectral cut-off validating MISTiC™ Winds spectral range selection

(from NASA GSFC Sounder Research Team)

1 Km Layer Temperature (K)
RMS Differences from Truth



1 Km Layer Precipitable Water RMS
% Differences from Truth

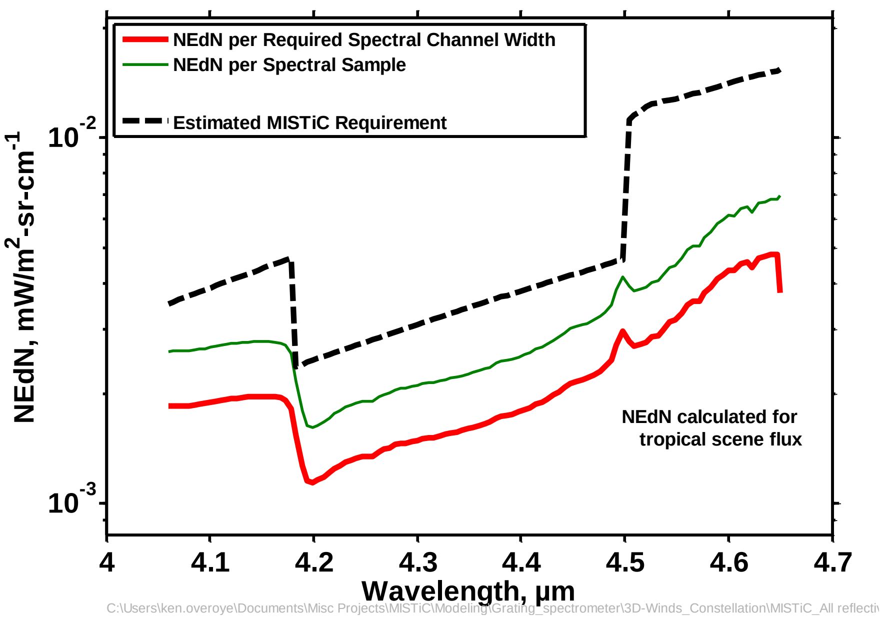


Truth = AIRS Retrievals version 6 - Ocean 50°N to 50°S December 4, 2013

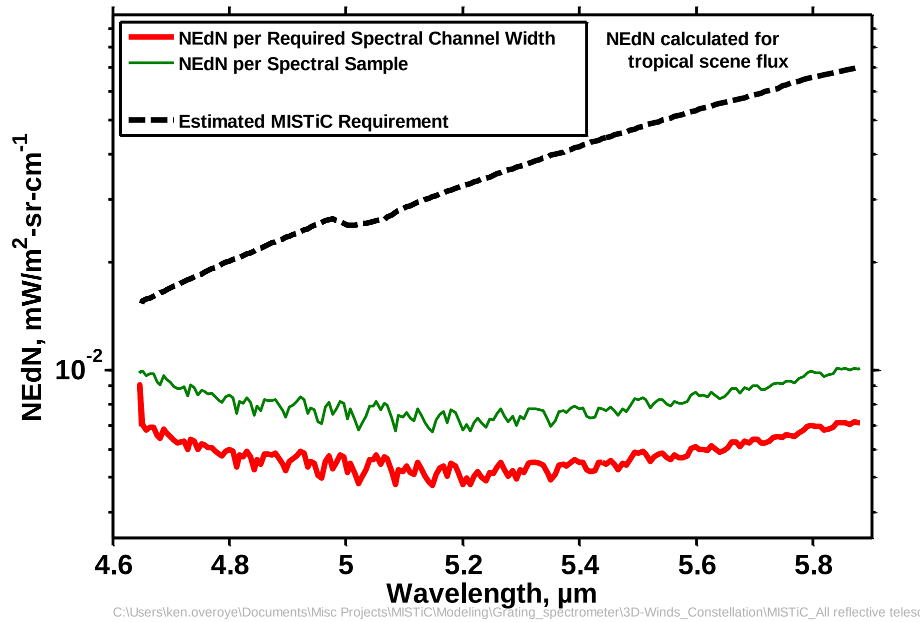
MISTiC™ Winds Instrument Radiometric Sensitivity Performance Estimates Show Solid Margin Against Requirements

BAE SYSTEMS

Sounding NEdN vs Wavelength:

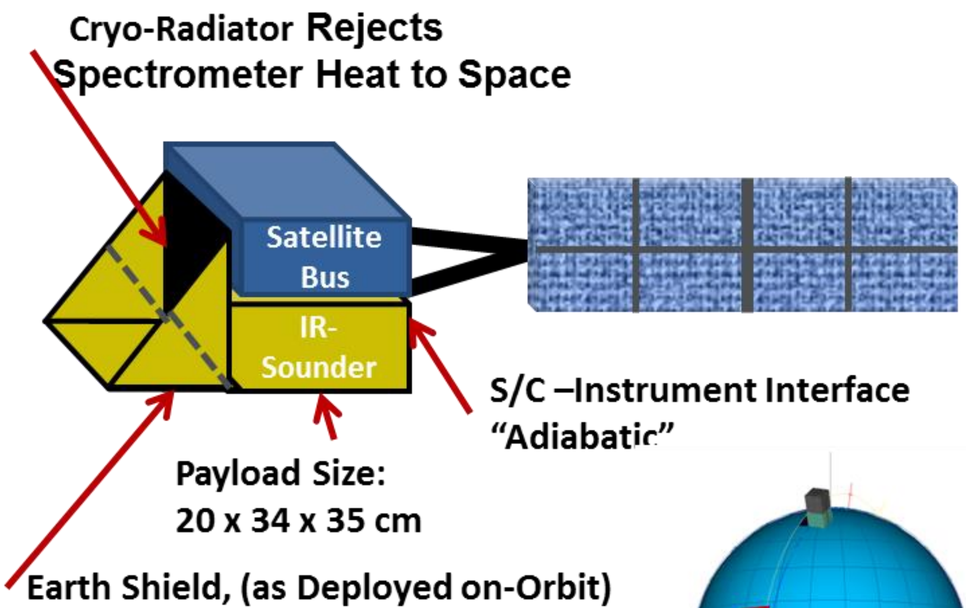


Sounding NEdN vs Wavelength:

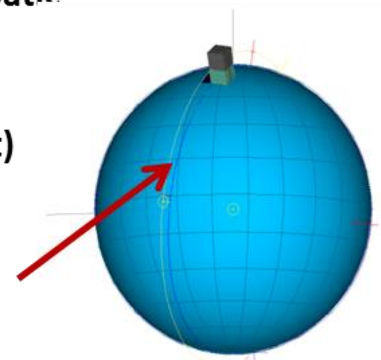


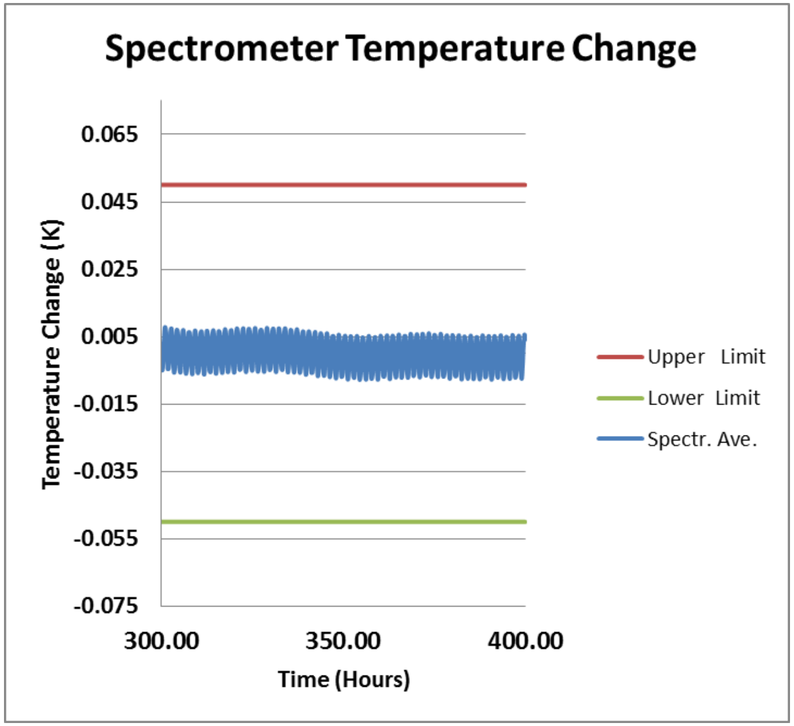
- Spectrometer Radiometric Modeling Methods Developed for AIRS, GOES-R HES, etc used to Estimate MISTiC™ Winds Instrument Sensitivity
- Sensitivity Similar to AIRS (<200 mK @ 250K Scene) for low brightness temperature regions near 4.2 μm
- Updated APD detector noise modeling still be included in system model
  - APD FPA Vendor-modeled dark current and noise are in acceptable range for MISTiC™ at 90K

Spectrometer Temp. Variation in Worst-Case Orbit is Small



Earth Shield Blocks some, but Not All Solar Illumination of Cryo-Radiator in 1:30 PM Orbit (Worst Case Orbit)





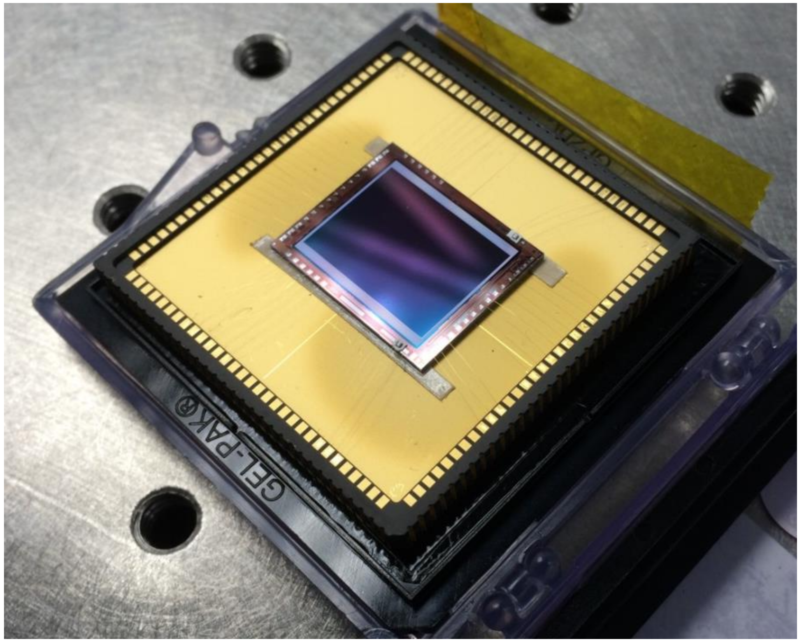
1000+-node Thermal Model Assessment

→MISTiC Meets Stringent IR Sounder Spectral Calibration Stability Requirements Within Envelope/Mass Limits of a Small Micro-Satellite

DRS 1093 ROIC – APD-Mode Focal Plane Array

BAE SYSTEMS

- 640 x 480 Array of APDs
- 25µm Pixel Pitch
- Frame rate 30Hz
- Master clock 12MHz.
- 77K Nominal Operating Temperature
    - Space Instrument Operating Temp 90K
    - Airborne Demo Temp 60K
- Active Power 200 mW
- 46 bond pads, 32 are to be bonded
    - 4 detector
    - 2 video output
    - 7 power
    - 8 ground and substrate
    - 3 external biases (2 tactical)
    - 6 digital inputs (5 tactical)
    - 10 internal bias overrides
    - 1 digital test out
    - 1 analog test out
    - 2 temp pads (4 temp wires)
    - 2 test diodes (not included in pad count)



APD IRFPA Demonstrated in Operational (Airborne) Hyperspectral Imaging Applications

BAE SYSTEMS

Ionizing Radiation Tests of HgCdTe APD FPA Completed

Ionizing Radiation Test Background:

- Test Performed by AFRL Infrared Radiation Effects Laboratory
- Test Type: Total Dose-Proton
  - 68 MeV Proton Energy
  - FPA Cooled/Under Operating Bias Voltages During Proton Irradiation
- FPA Radiometric Characterization Pre-Radiation and at 6 Dose Steps

Key Test Results:

- ROIC Essentially Unchanged to 70 krad
- Detector dark current (and noise) increase with dose, but acceptable rate
  - FPA Noise < Requirement at 20 krads Proton Dose\
  - Modest 1/f noise increase, at high APD gain at higher proton doses

Total Ionizing Dose (krad(Si))	Median Pixel Dark Current (A) (zero bias reference)
Pre-Rad	$1.3\text{x } 10^{-15}$
1	$1.26\text{x } 10^{-15}$
5	$1.82\text{x } 10^{-15}$
15	$3.5\text{x } 10^{-15}$
25	$6.3\text{x } 10^{-15}$
35	$8.0\text{x } 10^{-15}$
70	$16.0\text{x } 10^{-15}$

Allocated Dark Current Rqmt. < 5 fA/Pix

HgCdTe 640x480-Format APD-Mode IR FPA Technology Readiness Level Advanced to 5

BAE SYSTEMS

Key MISTiC 3D Winds System (of Systems) - Level Performance Requirements (draft)

KPP	KPP Attribute	Requirement
3D Motion Vector Winds (Moisture and Cloud Motion Vectors)	Layer Wind Speed Uncertainty	< 2 m/s rms
	Layer Wind Direction Uncertainty (above 10 m/s)	< 10 degrees rms
	Layer Height Pressure Height Assignment Error	<30 mB
	Layer Effective Vertical Thickness	<100 mB
	Minimum Pressure of Highest Pressure-Level	<350 mB (MMV) <500 mB (CMMV)
	Tracer Potential Density (Cloud-Free Conditions for MMV, Cloud Contrast for CMV)	>1 per 6 km sq per vertical layer :
Temperature Vertical Profile	Layer Effective Vertical Thickness	>100 mB (~ 1 km)
	Layer Temperature Accuracy	>1 K
	Sounding Measurement Potential Density	> 1 per 6 km sq
ObsFrequency	Observation Refresh Period	<3 hours (4 planes)

MISTiC Winds Observes both Total Wind Velocity Vector and the (via IR Sounding) the Geostrophic/Gradient Wind Vector Component in ≥ 6 Layers