

NASA Earth Science Update

Presented to: **Doppler Wind Lidar Working Group**



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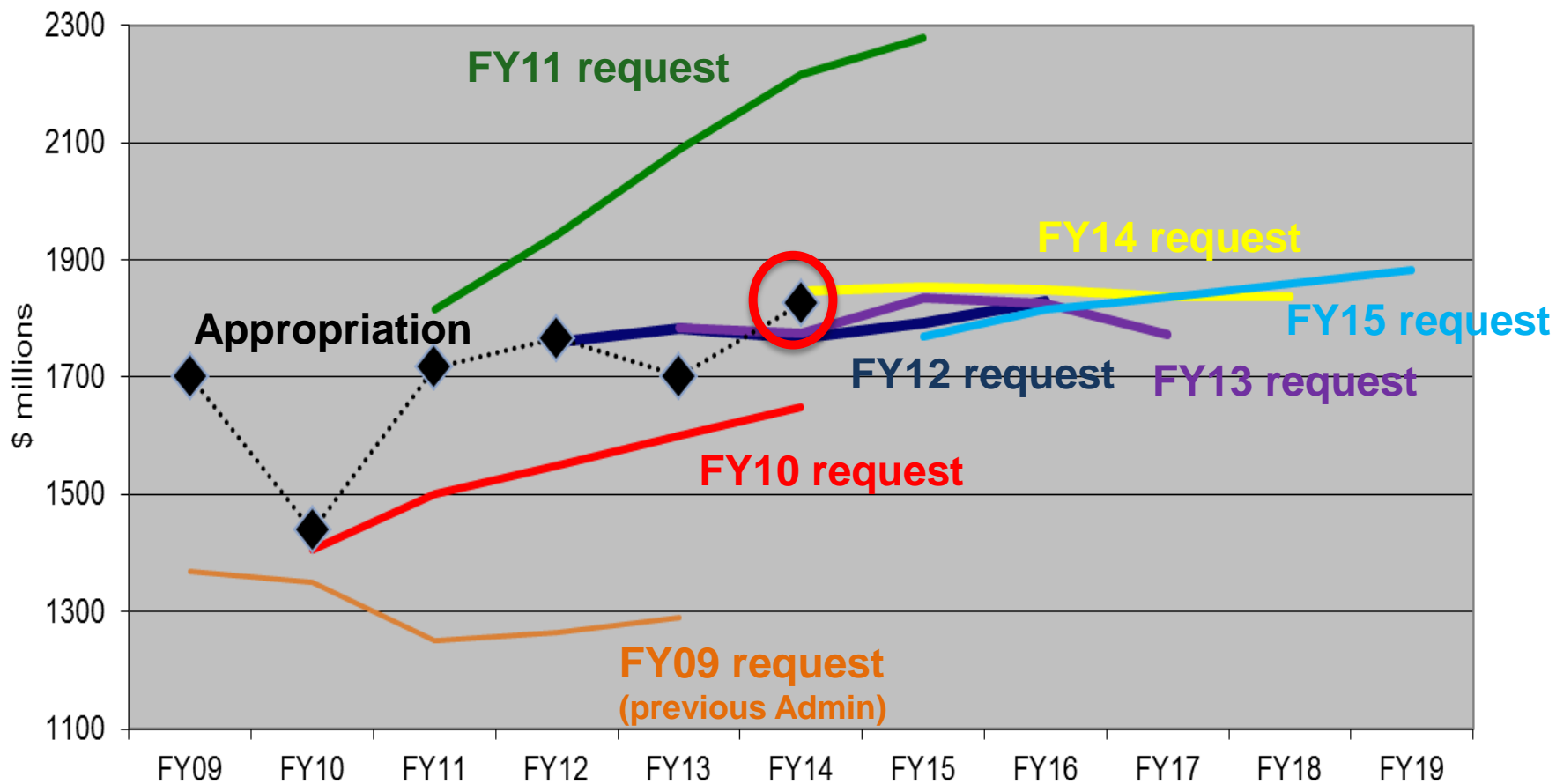
Earth Science Program Overall Strategy

Maintain a ***balanced program*** that:

- advances **Earth System Science**
- delivers **societal benefit** through applications development and capacity building
- provides **essential global spaceborne measurements**
- develops and demonstrates **technologies** for next-generation measurements, and
- complements and is coordinated with activities of **other agencies** and **international partners**



Earth Science Budget: FY15 Request/Appropriation





FY 2015 Budget Request

				Notional			
	FY 2013 Op Plan*	FY 2014 Enacted**	FY2015	FY2016	FY2017	FY2018	FY2019
Science	4,781.6	5,151.2	4,972.0	5,021.7	5,071.9	5,122.6	5,173.9
Earth Science	1,659.2	1,826.0	1,770.3	1,815.5	1,837.6	1,861.9	1,886.3
Planetary Science	1,274.6	1,345.0	1,280.3	1,304.9	1,337.1	1,355.7	1,374.1
Astrophysics	617.0	668.0	607.3	633.7	651.2	696.8	993.0
James Webb Space Telescope	627.6	658.2	645.4	620.0	569.4	534.9	305.0
Heliophysics	603.2	654.0	668.9	647.6	676.6	673.3	675.5
Aeronautics	529.5	566.0	551.1	556.6	562.2	567.8	573.5
Space Technology	614.5	576.0	705.5	712.6	719.7	726.9	734.2
Exploration	3,705.5	4,113.2	3,976.0	4,079.9	4,061.2	4,119.5	3,673.4
Exploration Systems Development	2,883.8	3,115.2	2,784.4	2,863.3	2,917.7	2,993.9	3,106.6
Commercial Spaceflight	525.0	696.0	848.3	872.3	791.7	730.9	172.0
Exploration Research and Development	296.7	302.0	343.4	344.3	351.8	394.7	394.7
Space Operations	3,724.9	3,778.0	3,905.4	3,951.9	4,051.0	4,073.8	4,601.8
Space Shuttle	38.8		0.0	0.0	0.0	0.0	0.0
International Space Station	2,775.9		3,050.8	3,126.5	3,266.9	3,290.3	3,818.6
Space and Flight Support (SFS)	910.2		854.6	825.4	784.1	783.5	783.2
Education	116.3	116.6	88.9	89.8	90.7	91.6	92.6
Cross Agency Support	2,711.0	2,793.0	2,778.6	2,806.4	2,834.4	2,862.8	2,891.4
Center Management and Operations	1,991.6		2,038.8	2,059.2	2,079.7	2,100.5	2,121.6
Agency Management and Operations	719.4		739.8	747.2	754.7	762.3	769.8
Construction & Envrmtl Compl Restoration	646.6	515.0	446.1	379.0	382.7	386.6	390.4
Construction of Facilities	589.5		370.6	302.7	305.7	308.7	311.8
Environmental Compliance and Restoration	57.0		75.5	76.3	77.0	77.8	78.6
Inspector General	35.3	37.5	37.0	37.4	37.7	38.1	38.5
Grand Total	16,865.2	17,646.5	17,460.6	17,635.3	17,811.5	17,989.7	18,169.7

*As reflected in the August 2013 Operating Plan, FY 2013 includes rescissions per P.L.113-6 Division G, Section 3001(b)(1)(B) and Division G, Section 3004(c)(1) and reductions due to sequestration per BBEDCA Section 215A.

**FY 2014 reflects funding amounts specified in P.L. 113-76, Consolidated Appropriations Act, 2014, including amounts noted in the Explanatory Statement. Where amounts were not specified, no amount is shown in the budget table.

Note: Funds associated with out-year estimates for programmatic construction remain in programmatic accounts.



- Formulation
- Implementation
- Primary Ops
- Extended Ops

SLI-TBD
Formulation in 2015

JPSS-2 (NOAA)

RB1
OMPS-Limb

TSIS-2

NI-SAR

PACE

SWOT

TEMPO

GRACE-FO (2)

ICESat-2

CYGNSS

SAGE III (on ISS)

SMAP

OCO-2

TRMM

QuikSCAT

EO-1

Landsat-7
(USGS)

ACRIMSAT

Terra

Aquarius

SORCE

Suomi NPP
(NOAA)

Aqua

CloudSat

CALIPSO

Aura

Landsat-8
(USGS)

GPM

GRACE (2)

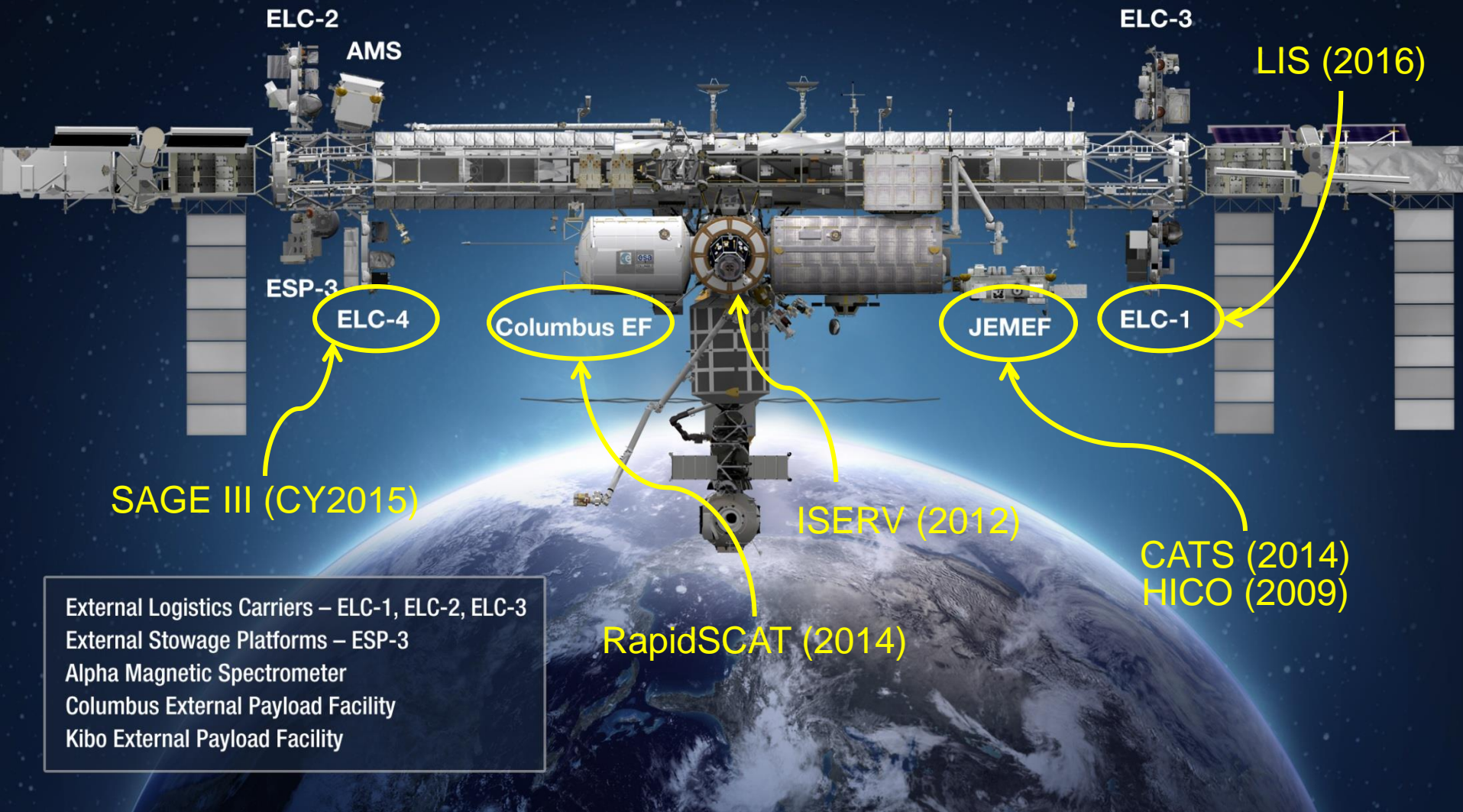
OSTM/Jason 2
(NOAA)

NASA Earth Science Planned Missions (2013-2023)



International Space Station

Earth Science Instruments



Earth Science Technology Office (ESTO) Opportunities

The Earth Science Technology Office is a **targeted, science-driven, competed, and actively managed technology program**. The investment elements include:

Observation



Instrument Incubator Program (IIP)

robust new instruments and measurement techniques

17 new projects added in FY14 (total funding approximately \$71M over 3 years)

Information



Advanced Component Technologies (ACT)

development of critical components and subsystems for instruments and platforms

15 new projects added in FY11 (total funding approximately \$16M over 3 years)



Advanced Information Systems Technology (AIST)

innovative on-orbit and ground capabilities for communication, processing, and management of remotely sensed data and the efficient generation of data products

18 new projects added in FY12 (total funding approximately \$23M over 3-4 years)

Validation



In-Space Validation of Earth Science Technologies (InVEST)
















on-orbit technology validation and risk reduction for small instruments and instrument systems that could not otherwise be fully tested on the ground or airborne systems

First 4 projects added in FY13 (total funding ~\$13M over 3 years)



The current portfolio of active investments supports all of the 2007 NRC Decadal Survey mission concepts. 65% directly support Tier 1 and 2 missions, ~ 15% support Tier 3 missions, and the remainder are crosscutting.

Technology Program Budget/Schedule

(\$M)		FY14				FY15				FY16				FY17				FY18				FY19			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
ROSES Solicitations																									
ATI/ACT Solicitation NRA Release		ACT-14 				InVEST-15 								ACT-17 				InVEST18? 							
Budget																									
IIP Solicitation NRA Release										IIP-16 												IIP-19 			
Budget																									
AIST Solicitation NRA Release		AIST-14 								AIST-16 								AIST-18 							
Budget																									
In-Guide Totals (\$M)		55.1				56.2				55.1				56.1				56.1				56.1			



Instrument Incubator Program (IIP) 2013 Solicitation Awards

17 proposals awarded in 1/2014
Total value approximately \$71 million



ACTIVE

Microwave



Wide-swath Shared Aperture
Cloud Radar (WiSCR)
- Lihua Li, GSFC



Three Band Cloud and Precipitation
Radar (3CPR) - Gregory Sadowy, JPL



Enhancement, Demonstration, and
Validation of the Wideband Instrument for
Snow Measurement (WISM) - Tim Durham,
Harris Corporation

Optical



HSRL for Aerosols, Winds, and Clouds using
Optical Autocovariance Wind Lidar (HAWC-
OAWL)
- Sara Tucker, Ball Aerospace



2-Micron Direct Detection Airborne Lidar
For Simultaneous and Independent CO₂ and H₂O
Column Measurement
- Upendra Singh, LaRC

Multi-wavelength Ocean Profiling
and Atmospheric Lidar
- Chris Hostetler, LaRC



Other



High Accuracy Vector Helium
Magnetometer
(HAVHM) - Andy Brown, Polatomic, Inc.



Cold Atom Gravity Gradiometer
for Geodesy - Babak Saif, GSFC



PASSIVE

Microwave

UWBRAD: Ultra Wideband Software Defined Microwave Radiometer
for Ice Sheet Subsurface Temperature Sensing
- Joel Johnson, Ohio State University



Snow and Water: Imaging Spectroscopy for coasts and snow
cover (SWIS) - Pantazis Mourou



A Compact Adaptable Microwave Limb Sounder for Atmospheric
Composition - Nathaniel Livesey, JPL



Wide-band Millimeter and Sub-Millimeter Wave Radiometer
Instrument
to Measure Tropospheric Water and Cloud ICE (TWICE)
- Steven Reising, Colorado State University

Ka-band Doppler Scatterometer for Measurements
of Ocean Vector Winds and Surface Currents
(DopplerScatt)
- Dragana Perkovic-Martin, JPL



Signals of Opportunity Airborne Demonstrator (SoOp-AD)
- James Garrison, Purdue University

Optical

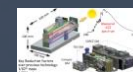
MISTiC Winds: Midwave Infrared Sounding of
Temperature
and Humidity in a Constellation
for Winds - Kevin Maschhoff, BAE Systems



TIRCIS: A Thermal Infrared, Compact Imaging
Spectrometer for Small Satellite Applications
- Robert Wright, University of Hawaii



Development of a Compact Solar Spectral Irradiance
Monitor with High Radiometric Accuracy and Stability
- Erik Richard, University of Colorado



Current ESTO Investments in Active Optical Technology (19)

Title	PI	Org	Program
ASCENDS Lidar: Acceleration & demo of key space lidar technologies	Abshire	GSFC	IIP-10
ASCENDS CarbonHawk Experiment Simulator (ACES)	Obland	LaRC	IIP-10
High Power Mid-IR Laser Development to 3.5 microns	Anderson	Harvard	ACT-10
Combined HSRL & Optical Autocovariance Wind Lidar (HOAWL) Demo	Delker	Ball Aerospace	ACT-10
Advancement of the O2 subsystem to Demo Retrieval of XCO2 using Simultaneous Laser Absorption Spectrometer Integrated Column Measurements of CO2 and O2	Dobler	ITT	ACT-10
A compact remote sensing Lidar for High Resolution Measurements of Methane	Riris	GSFC	ACT-10
Design and Fabrication of a Breadboard, Fully Conductively Cooled, 2-Micron, Pulsed Laser for the 3-D WindsDecadal Survey Mission	Singh	LaRC	ACT-10
Ball Aerospace Fabry-Perot for the Integrated Direct Detection Lidar (FIDDL)	Tucker	Ball Aerospace	ACT-10
A 2-micron Pulsed Laser Transmitter for Direct Detection Column CO2 Measurement from Space	Yu	LaRC	ACT-10
Development and Integration of a Pulsed 2-micron Direct Detection Integrated Path Differential Absorption (IPDA) Lidar for CO2 Column Measurement from Airborne platform	Singh	LaRC	ATI-QRS-12
Development of a prototype 2 micron fiber-coupled seed laser for integration in lidar transmitter	Forouhar	JPL	ATI-QRS-12
High Power UV Laser Lifetime Demonstrator	Hovis	Fibertek, Inc	ATI-QRS-13
Multi-wavelength Ocean Profiling and Atmospheric Lidar	Hostetler	LaRC	IIP-13
Triple-Pulsed 2-Micron Direct Detection Airborne Lidar for Simultaneous and Independent CO2 and H2O Column Measurement Novel Lidar Technologies and Techniques with Path to Space	Singh	LaRC	IIP-13
HSRL for Aerosols, Winds, and Clouds using Optical Autocovariance Wind Lidar (HAWC-OAWL)	Tucker	Ball Aerospace	IIP-13
Initial Development Work for the Cloud-Aerosol Multi-Angle Lidar (CAMAL)	McGill	GSFC	ATI-QRS-14
Preparing the Doppler Aerosol Wind Lidar (DAWN) for Calibration/Validation Activities for the Aeolus Mission	Koch	LaRC	ATI-QRS-14
Phase IIE funding to flight harden a Methane DIAL Transmitter	Nehrir	LaRC	ATI-QRS-14
Widely Tunable Quantum Cascade Laser (QCL)			
Local Oscillator for IHEARS	Kostiuk	GSFC	ATI-QRS-14





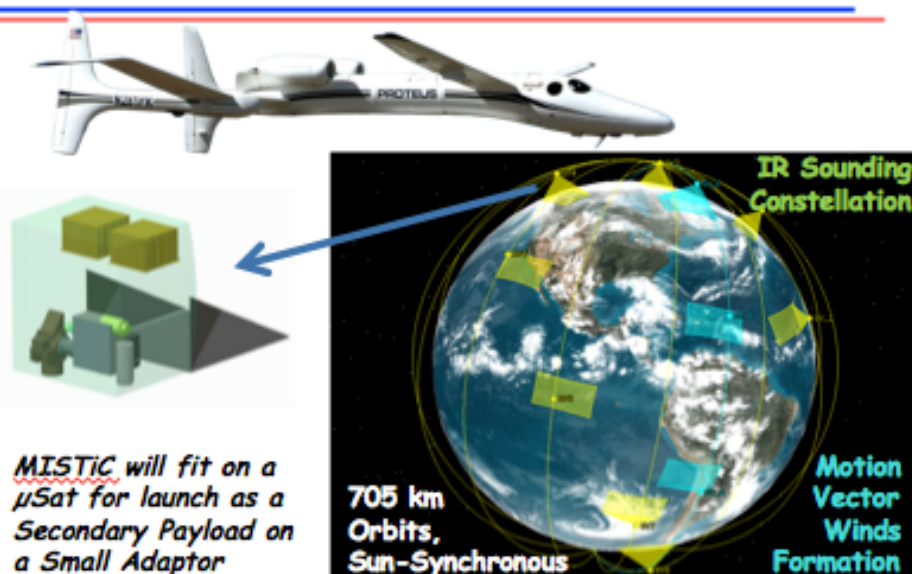
MISTiC Winds: Midwave Infrared Sounding of Temperature and humidity in a Constellation for Winds

PI: Kevin R. Maschhoff, BAE Systems

Objective

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 (15 x 25 x 25 cm, 15 kg, 50 W).



Approach

- 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 (4.082 - 5.128 μ m) in the lab.
- 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 Proteus platform.
- Demonstrate IRFPA space radiation tolerance (> 25 krad).

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

Key Milestones

• Instrument science and payload requirements review	08/14
• Instrument science and payload concept review	03/15
• Detector radiation test complete	04/15
• Airborne demonstration plan review	07/15
• Airborne instrument design complete	01/16
• ROIC radiation test complete	03/16
• Calibration stability test complete	09/16
• Airborne demonstration complete	11/16
• Airborne demonstration data analysis complete	03/17

TRL_{in} = 4 TRL_{current} = 4



Technology Empowers our Future

