SSEC Overview

Hank Revercomb, SSEC Director

University of Wisconsin - Madison
Space Science and Engineering Center (SSEC)

International TOVS Study Conference
Lake Geneva, WI, 28 Oct-3 Nov 2015

Space Science and Engineering Center

UW-Madison Research Center

- **Mission: To conduct atmospheric, oceanic, environmental, and astronomical research using space or space-age techniques to discover and apply the physical properties of our universe for the benefit of humanity**
  From Idea, to Concept, to Implementation, to Information about the world
- Symbiotic relationship with Department of Atmospheric & Oceanic Sciences symbolized by shared building provided by NSF, NASA, & the State

Total Research Expenditures
Top Five Universities

	1989	1990	1991	1992	1993	1994	1995	1996
1	Hopkins	Hopkins	Hopkins	Hopkins	Hopkins	Hopkins	Hopkins	Hopkins
2	MIT	MIT	Mich	Mich	Mich	Mich	Mich	Mich
3	Cornell	Mich	Minn	Stanford	Wisc	Wisc	Wisc	Wisc
4	Stanford	Wisc	Wisc	Wisc	MIT	MIT	Wash	Wash
5	Wisc	Stanford	MIT	MIT	Wash	T A&M	MIT	MIT

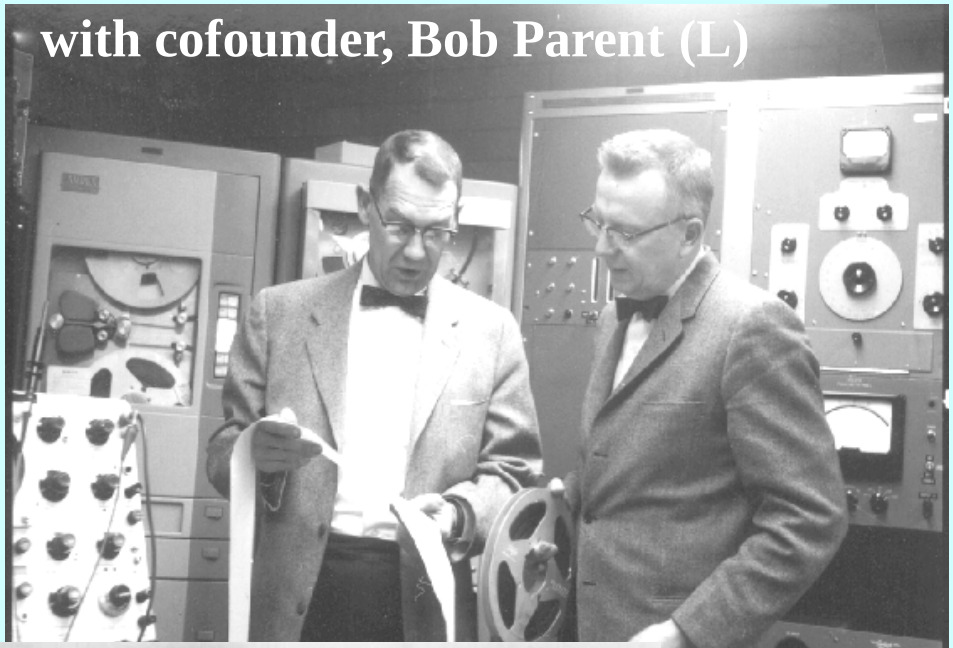
	1997	1998	1999	2000	2001	2002	2003	2004
1	Hopkins	Hopkins	Hopkins	Hopkins	Hopkins	Hopkins	Hopkins	Hopkins
2	Mich	Mich	Mich	Wisc	UCLA	UCLA	UCLA	UCLA
3	Wisc	UCLA	Wisc	Mich	Wisc	Mich	Mich	Mich
4	MIT	Wisc	Wash	UCLA	Mich	Wisc	Wisc	Wisc
5	Wash	Wash	UCLA	Wash	Wash	Wash	Wash	UCSF

	2005	2006	2007	2008	2009	2010	2011	2012
1	Hopkins	Hopkins	Hopkins	Hopkins	Hopkins	Hopkins	Hopkins	Hopkins
2	Mich	Wisc	UCSF	UCSF	Mich	Mich	Mich	Mich
3	Wisc	UCLA	Wisc	Wisc	Wisc	Wisc	Wash	Wisc
4	UCLA	Mich	UCLA	Mich	UCSF	Wash	Wisc	Wash
5	UCSF	UCSF	Mich	UCLA	UCLA	Duke	Duke	UCSD

2013
4th

Celebrated on 10 September 2015

SSEC works to maintain the spirit of exploration of its 1st Director, Verner E. Suomi (1915-1995)



1959: 1st Meteorological Satellite Experiment

Earth Radiation Balance Observations on Explorer VII

1966: 1st Earth Imaging from GEO

Spin-scan Camera on 1st Advanced Technology Satellite

1980: 1st Infrared Sounder from GEO

VISSR Atmospheric Sounder on GOES-4

"Father of Satellite Meteorology"

McIDAS

(Man-computer Interactive Data Access System)

- Initially developed to derive winds from cloud tracking; inspiration for earliest digital TV weather forecasts
- McIDAS going strong at 42
  100's of National and International users, including international weather services, aviation weather providers, researchers, NOAA Storm Prediction Center…
- New McIDAS-V version 1.0 for dealing with STORM-type hyperspectral data and distributed data/computer resources has had over 4,000 downloads

Weather Satellite renamed "Suomi NPP"

On 25 January 2012 NASA & NOAA renamed their newest Earth-observing satellite after UW-Madison space pioneer

And SSEC provided the 1st Light Products for the 2 Main Instruments!

& Phase A CrIS Sounder Design in 1991

Nature of the Organization

Space Science & Engineering Center

- Matrix Organization: PIs are the Cornerstone
  (~40 internal staff + 10 AOS Faculty)

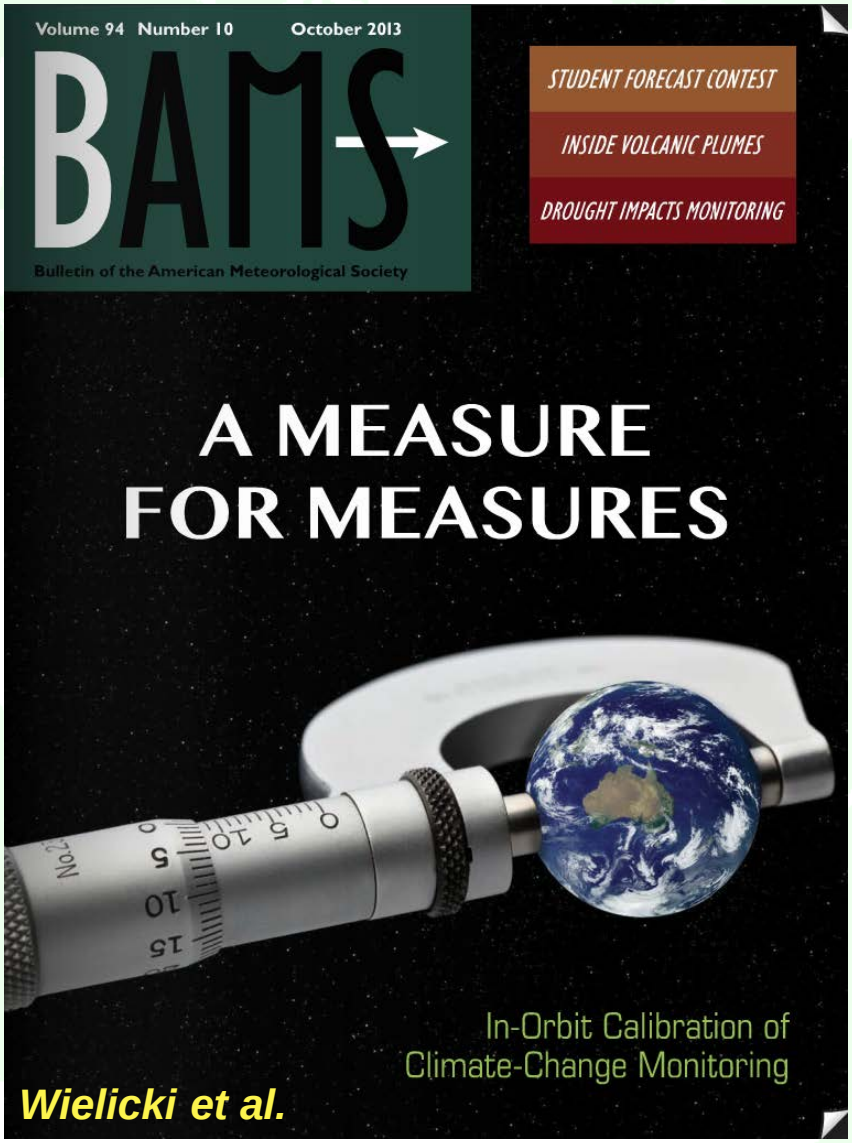
- SSEC includes a major institute & long-term projects
  - **Cooperative Institute for Meteorological Satellite Studies (CIMSS):** NOAA and NASA CI established 1980, Professor Steve Ackerman, Director
  - **Antarctic Meteorological Research Center (AMRC):** Providing Automated Weather Stations since 1980, Matthew Lazzara, Director
  - **US Ice Drilling Design & Operations (IDDO):** Providing NSF-sponsored researchers with ice coring & drilling capabilities in polar and high- altitude sites; Kristina Slawny, Director; Mark Mulligan, PI

SSEC areas of technical expertise

- **Observational Science** (spacecraft system/mission design, instrumentation, field programs, spaceflight instrument fabrication, including CAMPUS SCIENCE SUPPORT to PHYSICS, ASTRONOMY, BOTANY, GEOLOGY)
- **Computational & Visualization Science**
  (hardware & software systems for information generation, data management, &communication)
- **Analytical Science & Applications**
  (satellite & conventional data analysis, technical development & analysis)

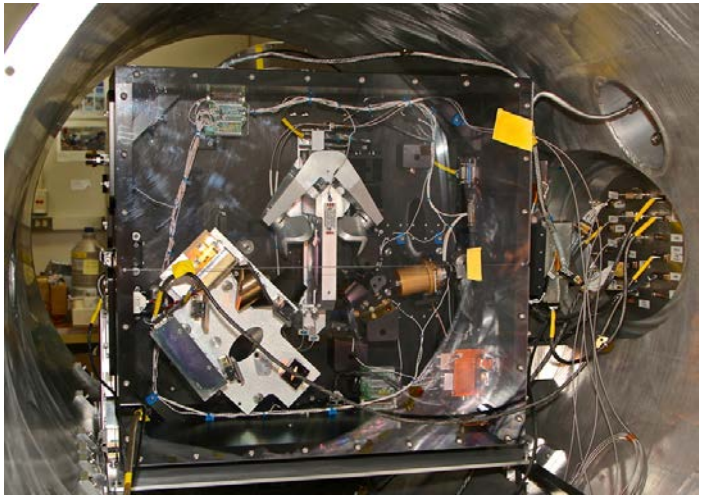
New Approach to Monitoring Decadal Climate Trends: NASA CLARREO and SSEC ARI

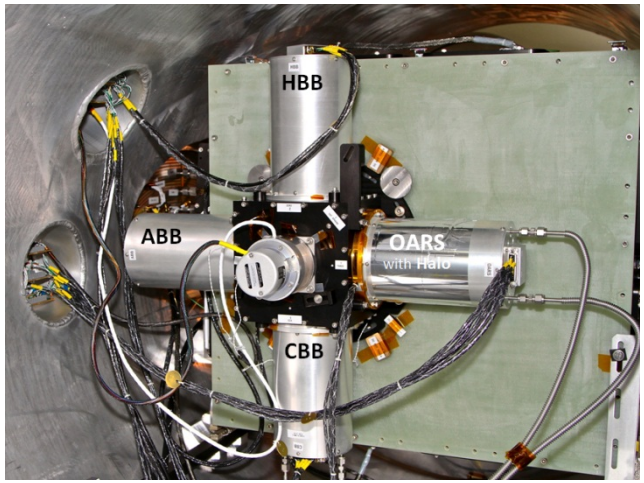
- **CLARREO (Climate Absolute Radiance & Refractivity Observatory) a 2007 Decadal Survey Tier 1 mission**
  - IR & Reflected Solar spectra coupled with GPS occultation data offer unprecedented accuracy & information content to provide much higher climate change sensitivity than existing records (from total integrated IR & Solar data)
  - Metrology lab on-orbit serves as "NIST in orbit"
- **CLARREO to Benchmark the Earth's climate**
  - Analogous to marking a glacier's current extent
- **CLARREO to be an Inter-calibration Standard**
  - GSICS (Global Space-based Inter-Cal System)
  - e.g. Greatly enhancing the value of the climate record from high spectral resolution IR sounders starting in 2002 (AIRS, IASI, CrIS)
- **Absolute Radiance Interferometer (ARI) is an IR prototype instrument with new on-orbit verification technology ready for CLARREO or a pathfinder mission**

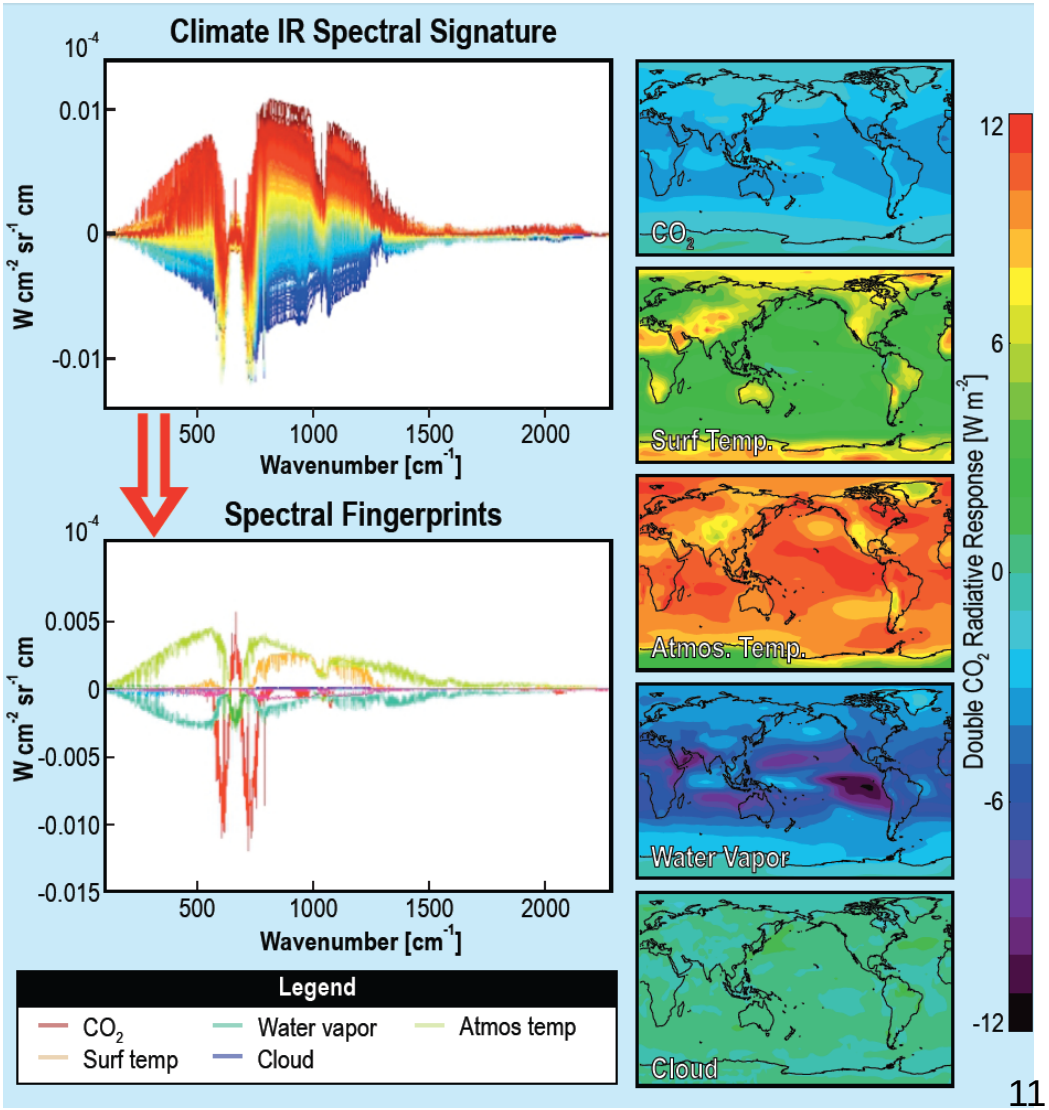


New Technology for Spectrally Resolved Climate Observing System Proven

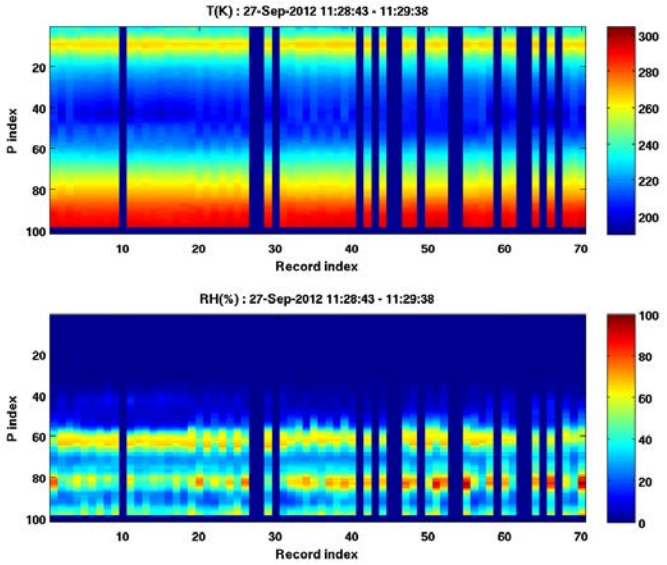
SSEC ARI prototype Achieves NASA Technical Readiness

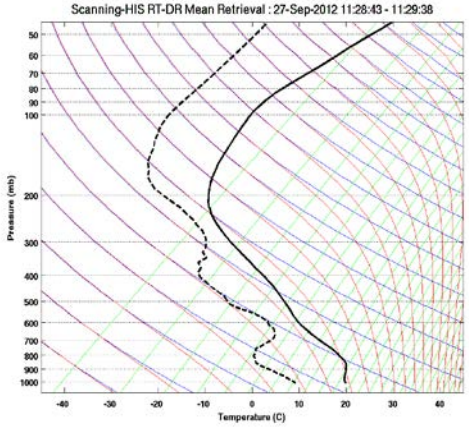






S-HIS on Global Hawk



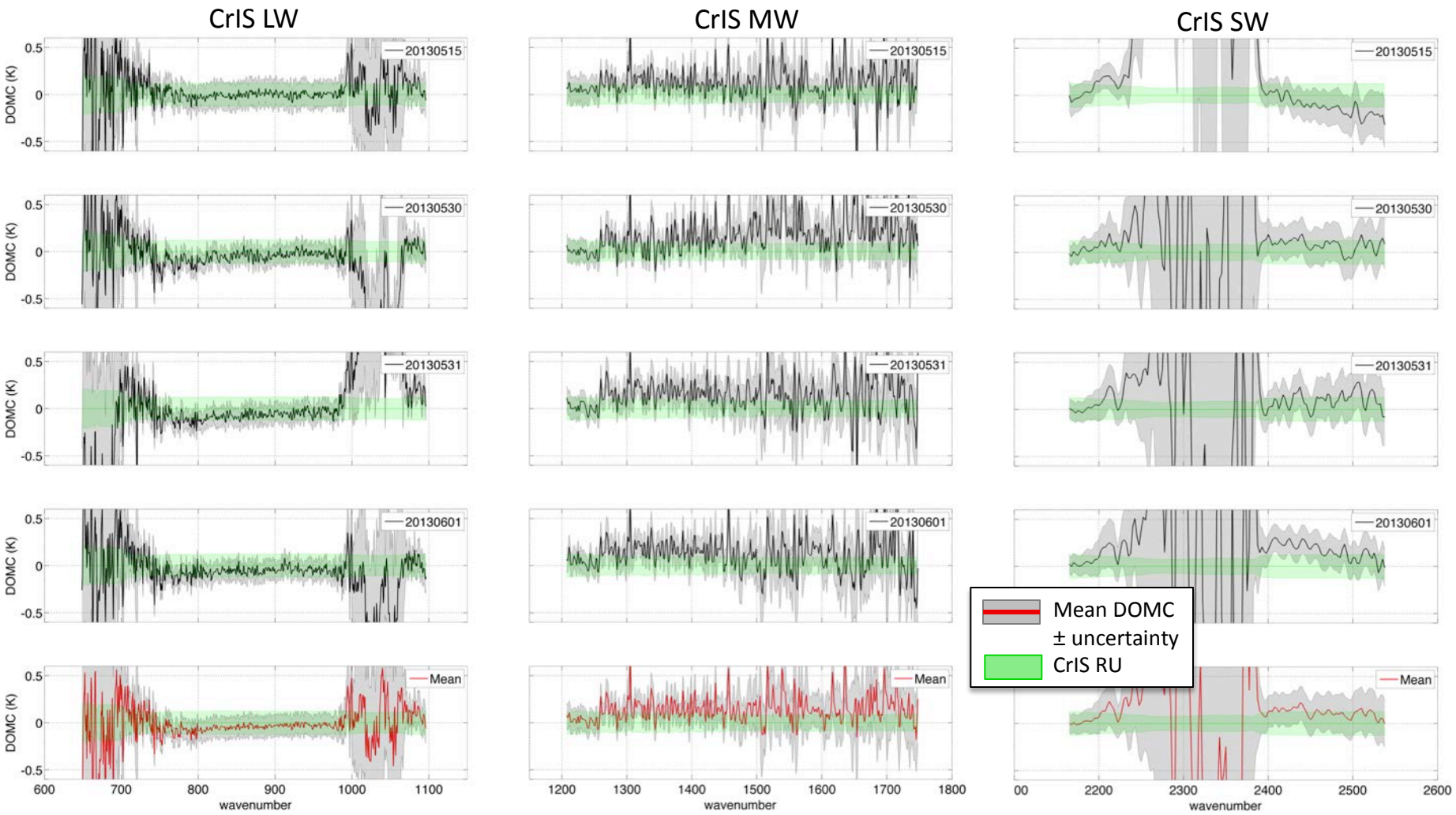


T & Water Vapor retrievals served to Payload Trailer with < 1 minute latency!!

CrIS/S-HIS Underflight Results

Hamming apodization

Calibration Verification Results (Double Obs – Calc Methodology)



Consistent with combined uncertainty estimates

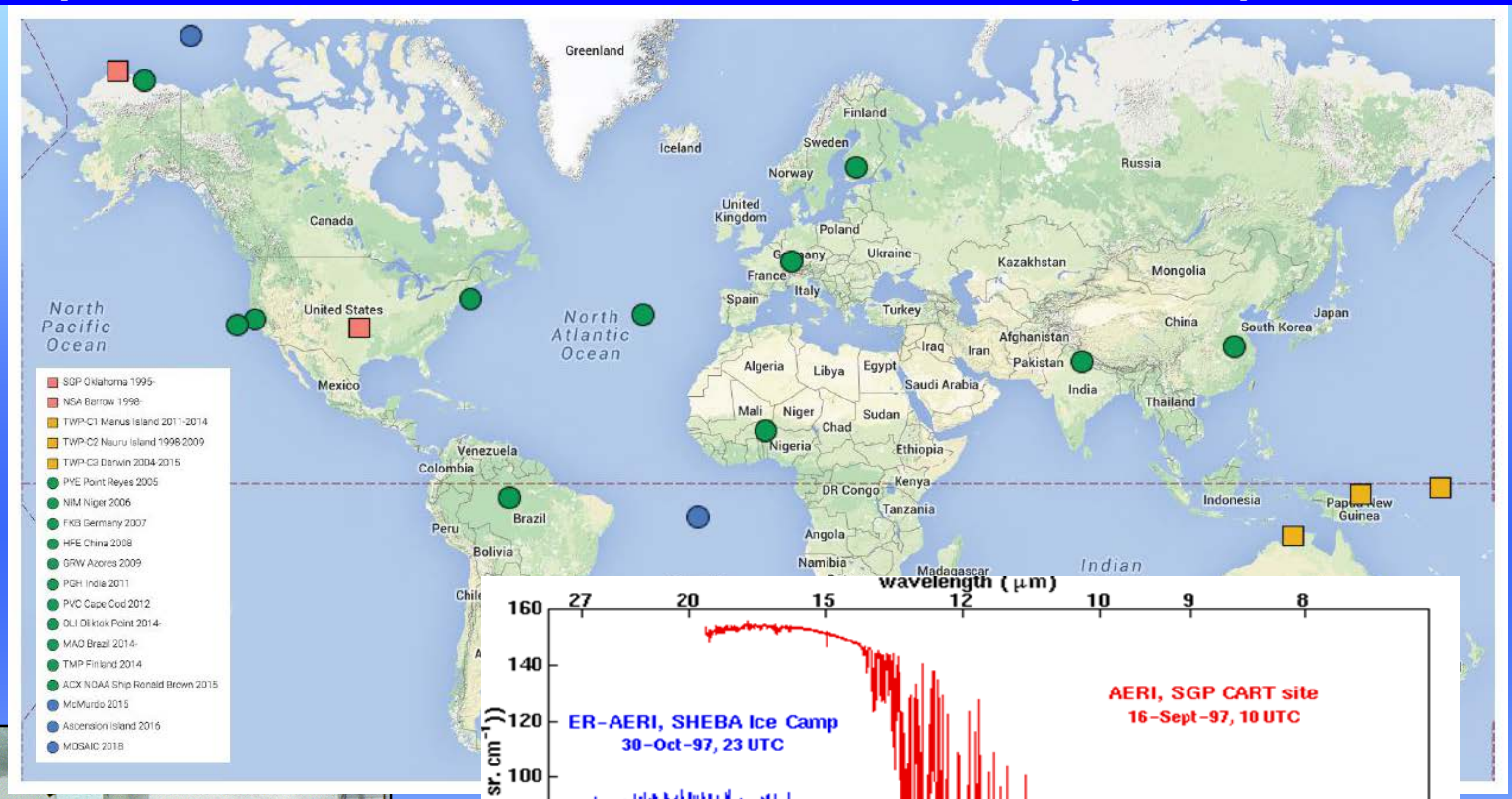
Dave Tobin

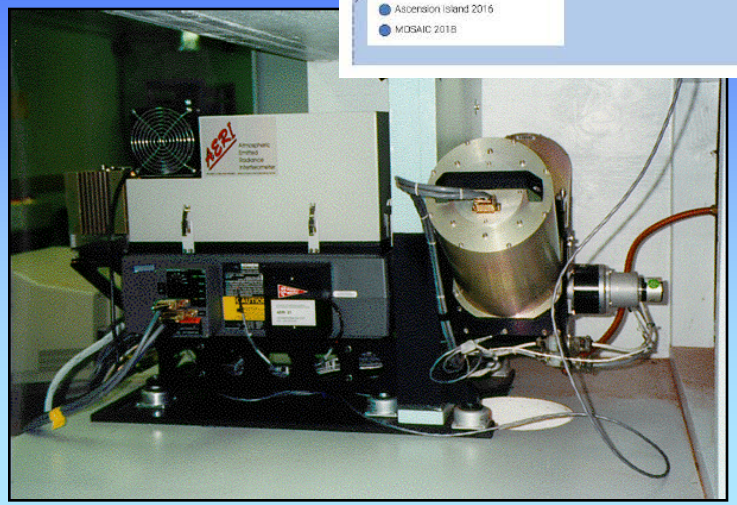
AERI Systems Around The World

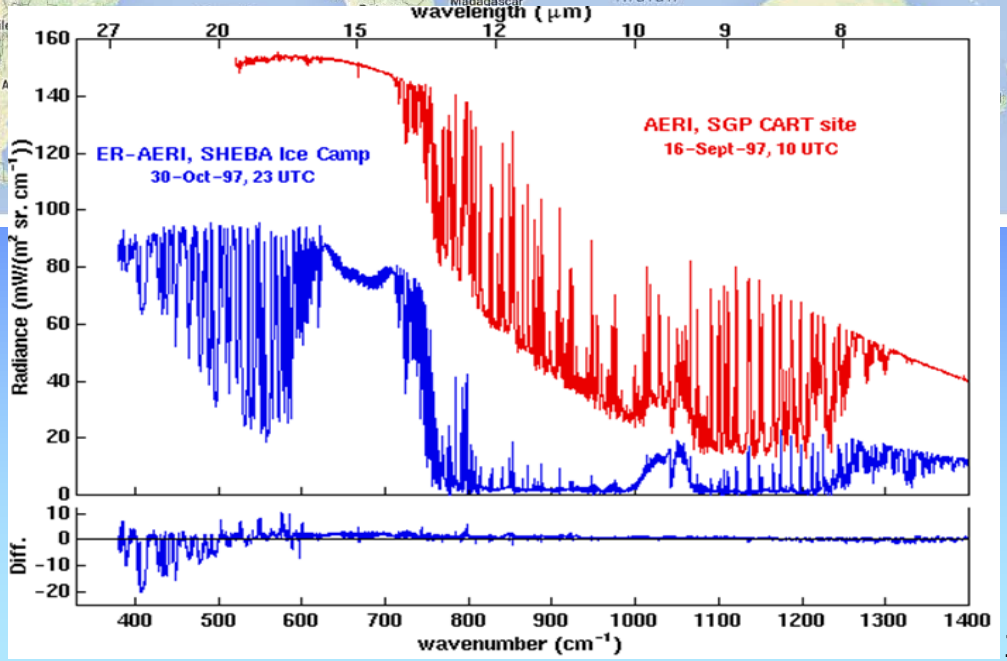
(Atmospheric Emitted Radiance Interferomter; 1990-present)

SSEC

1st frequent boundary layer remote sensing & valuable new IR spectroscopy







Key Radiative Forcing Result

nature International weekly journal of science

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Research > Letters > Article

NATURE | LETTER

Observational determination of surface radiative forcing by CO_2 from 2000 to 2010

D. R. Feldman, W. D. Collins, P. J. Gero, M. S. Torn, E. J. Mlawer & T. R. Shippert

Affiliations | Contributions | Corresponding author

Nature (2015) | doi:10.1038/nature14240

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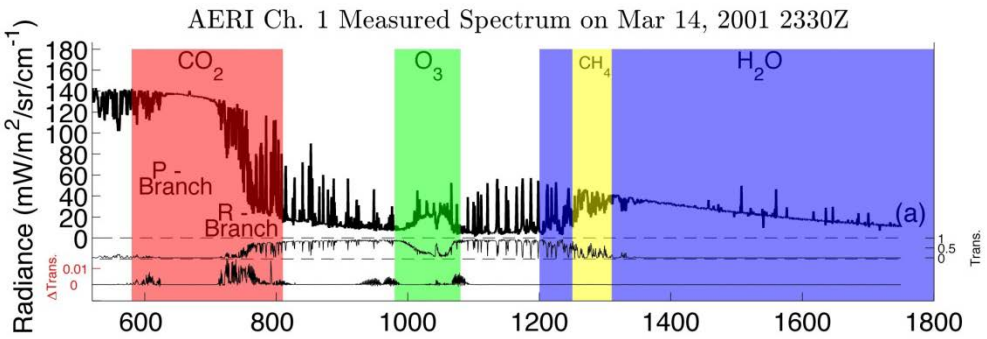
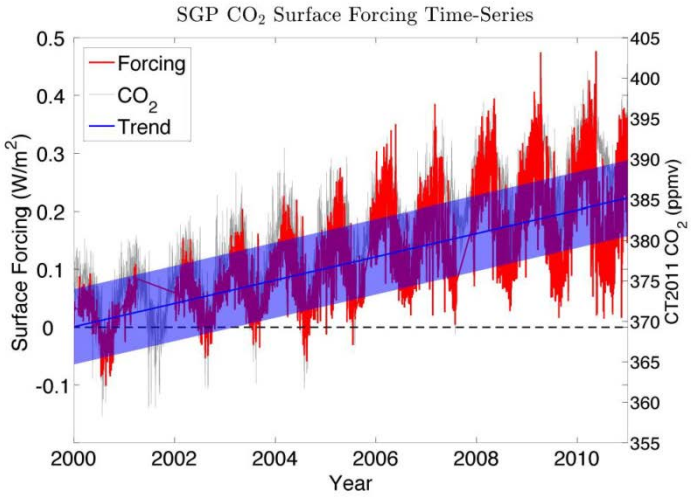
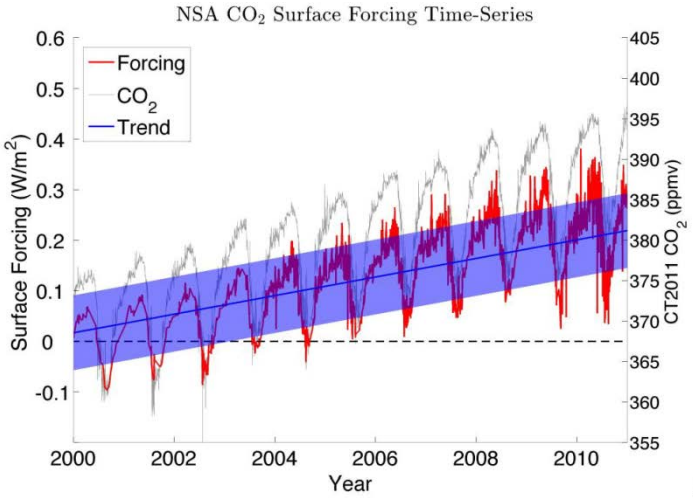
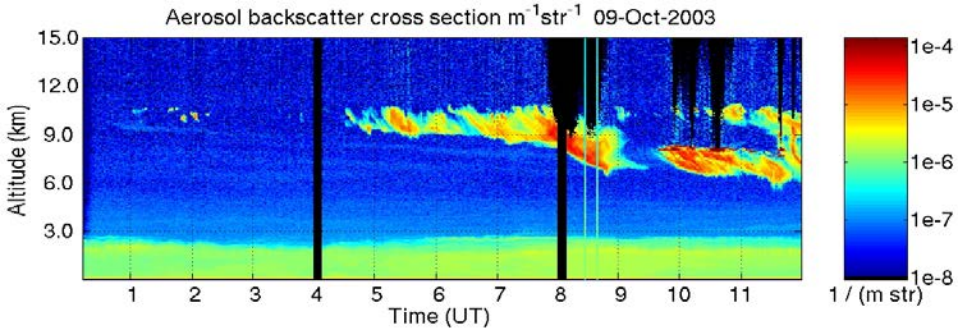


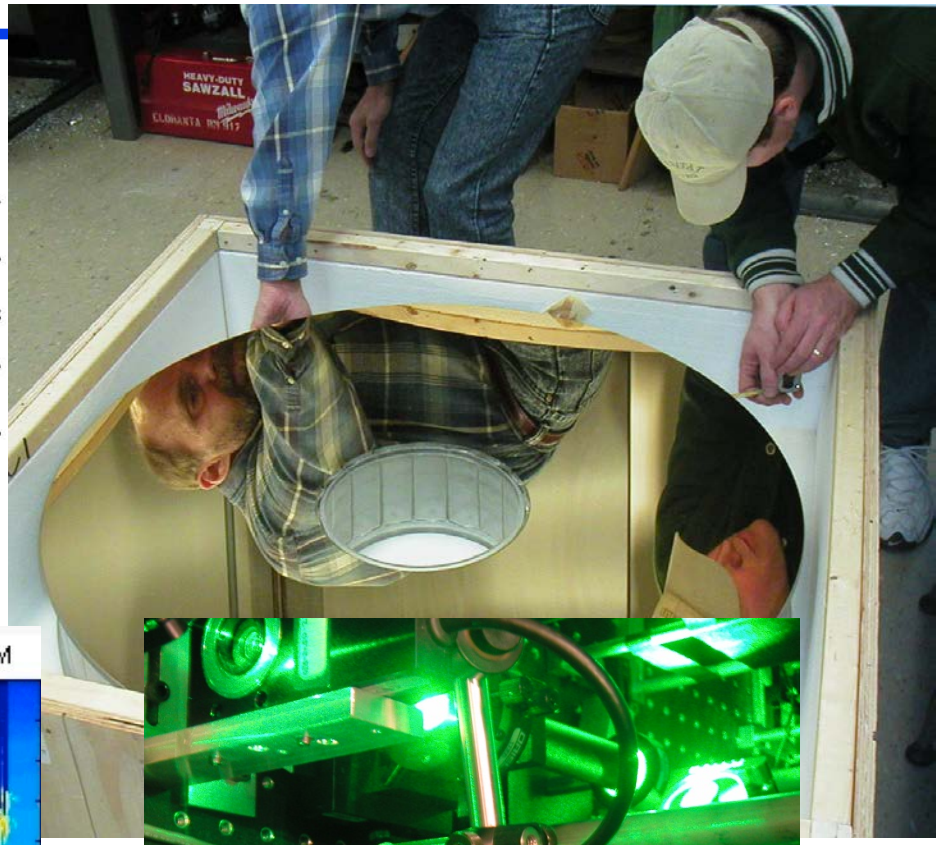




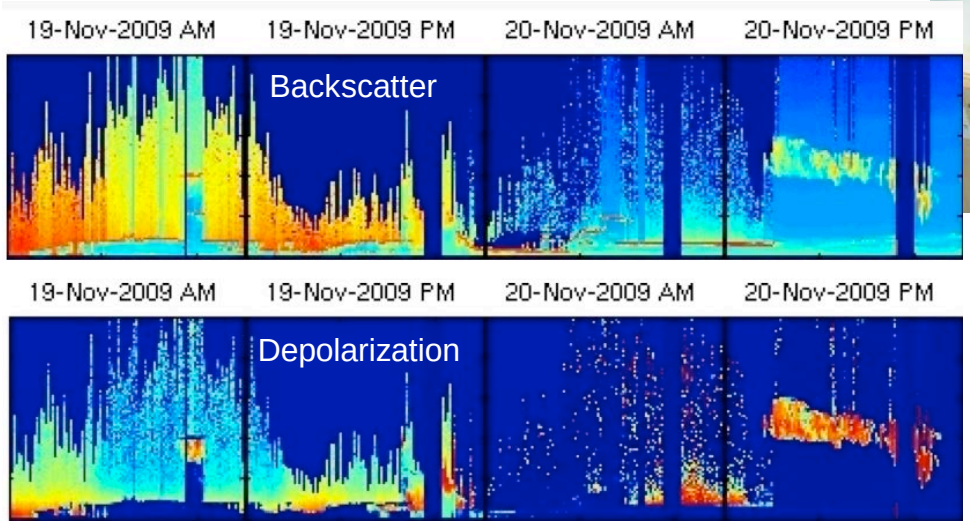
High Spectral Resolution Lidar

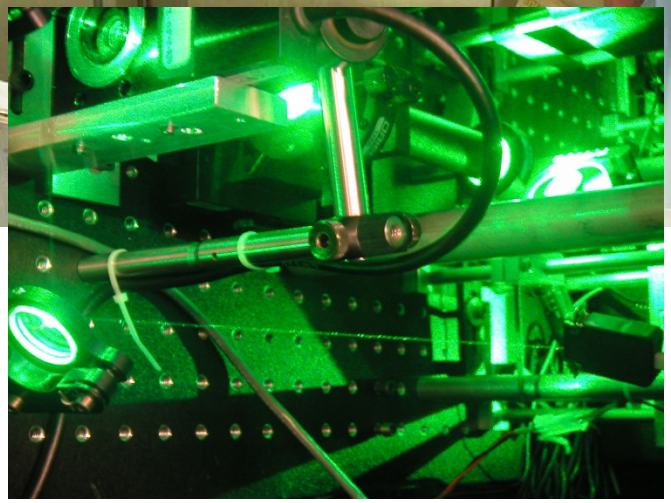
Ground-based





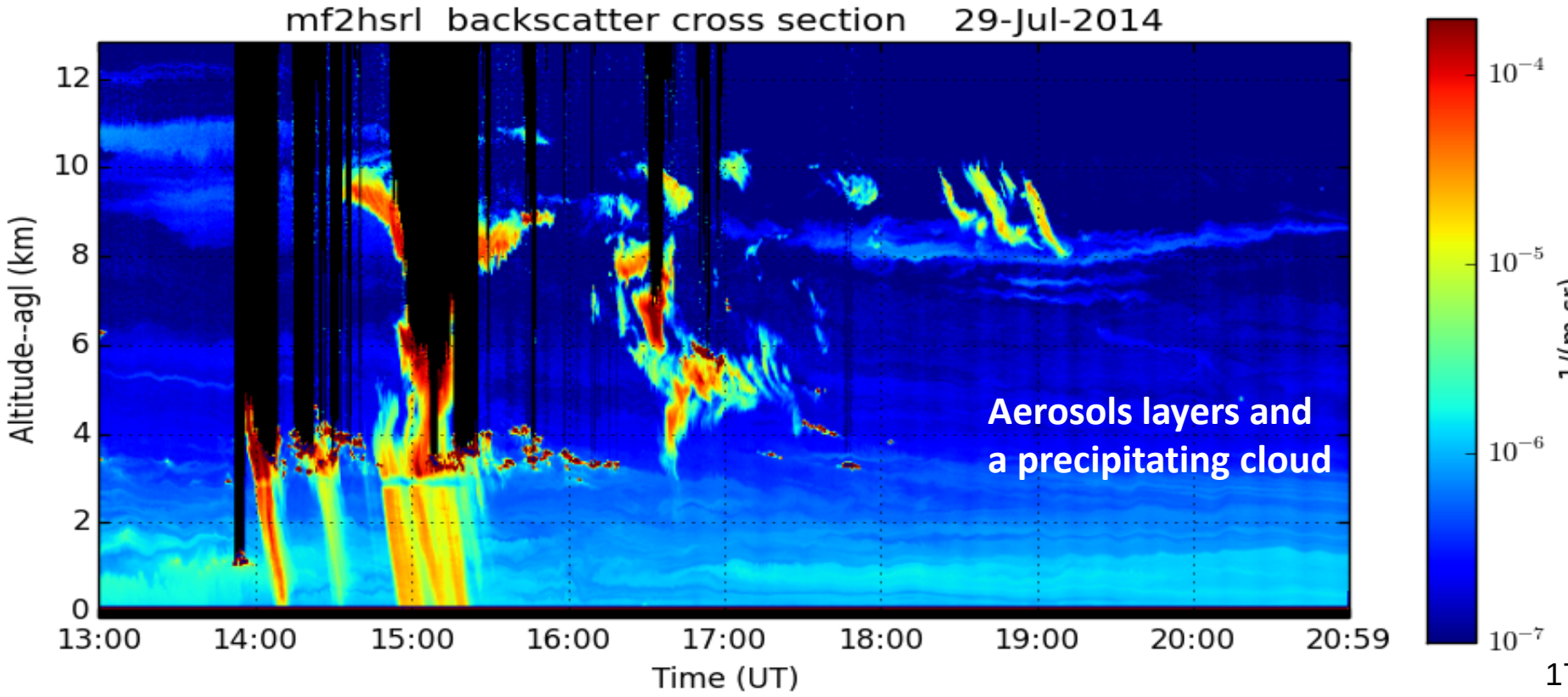
NCAR Gulf Stream Aircraft





lidar.ssec.wisc.edu

ARM Mobile Facility – Hyytiälä, Finland

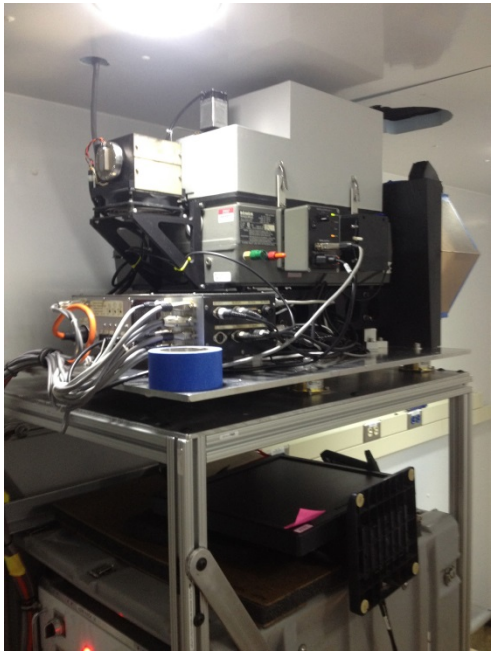


SPARC

SSEC Portable Atmospheric Research Center

AERI

Atmospheric Emitted Radiance Interferometer



HSRL

High Spectral Resolution LIDAR

Plus:

- ❑ Vaisala Ceilometer
- ❑ Met Surface Station
- ❑ Radiosonde System
- ❑ GPS Total Precipitable Water Instrument

University of Wisconsin SSEC Data Center

1. SSEC ingests and processes over 2 TBs of real-time weather satellite data every day from over 20 different satellites
2. SSEC has built the largest and most comprehensive geostationary weather satellite archive in the world
3. Has been ingesting, processing, distributing and archiving weather satellite data for almost 40 years.
4. Distributes over 3 TBs of data to government, educational, and private sector (both domestically and internationally) every day

WISCONSIN
UNIVERSITY OF WISCONSIN-MADISON

SSEC

JCSDA Supercomputing Infrastructure

JIBB and S4: Resources for JCSDA Scientists and Researchers

- Designed in house by SSEC IT group utilizing off the shelf components
- Largest HPCC in the University of Wisconsin System
- Funded by NOAA: 10 % allocated for UW-SSEC use., 90% NOAA selected.
- Intended to run experiments with operational NOAA weather models and satellite data assimilation

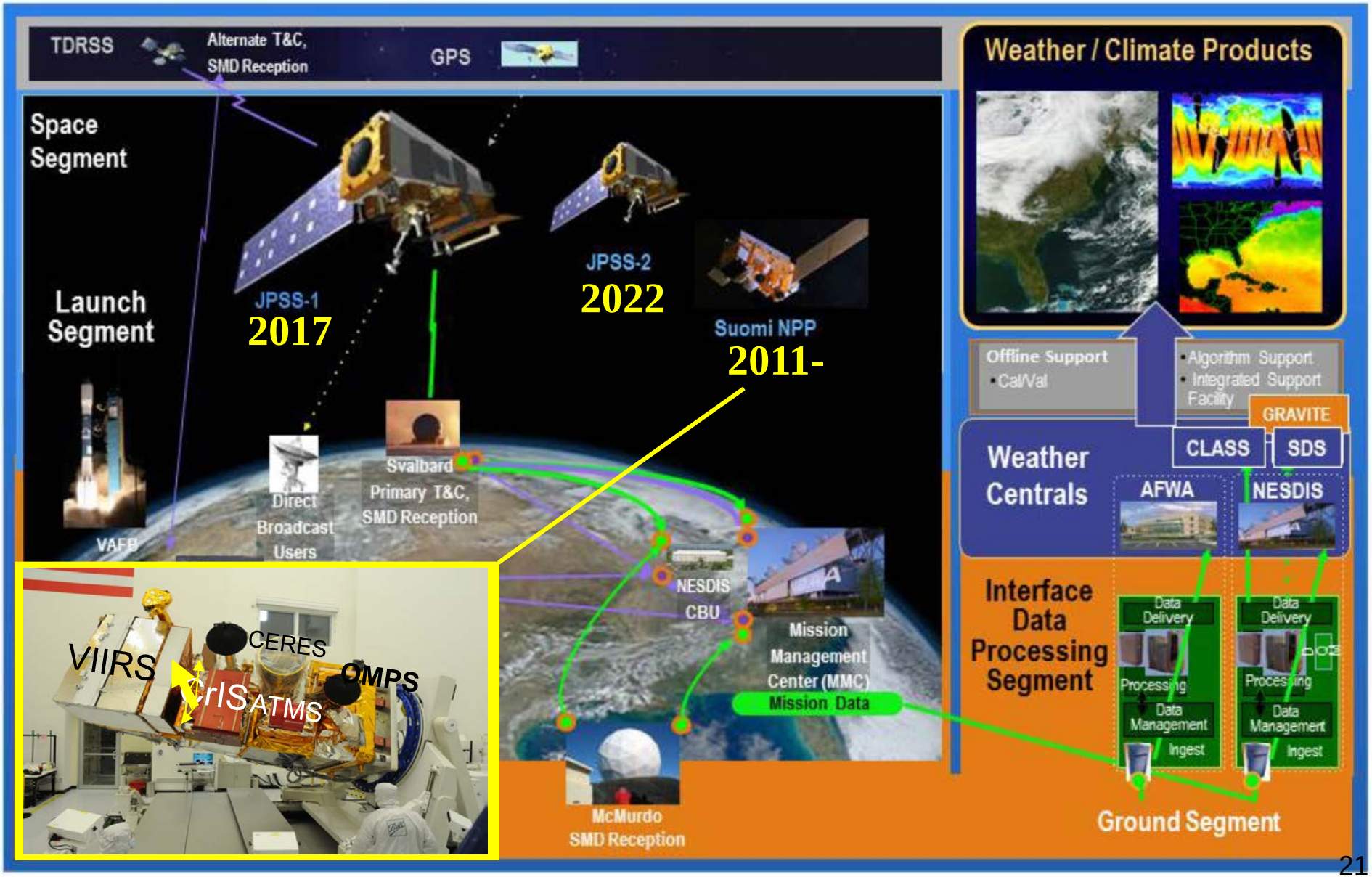
S4 with major upgrade

A collaboration between NESDIS and CIMSS, the Supercomputer for Satellite Simulations and data assimilation Studies (S4) is designed for the broader scientific community to foster the development of ideas that may be further from NWP operations.

WISCONSIN
UNIVERSITY OF WISCONSIN-MADISON

SSEC

Nation's next generation polar-orbiting operational environmental satellite system



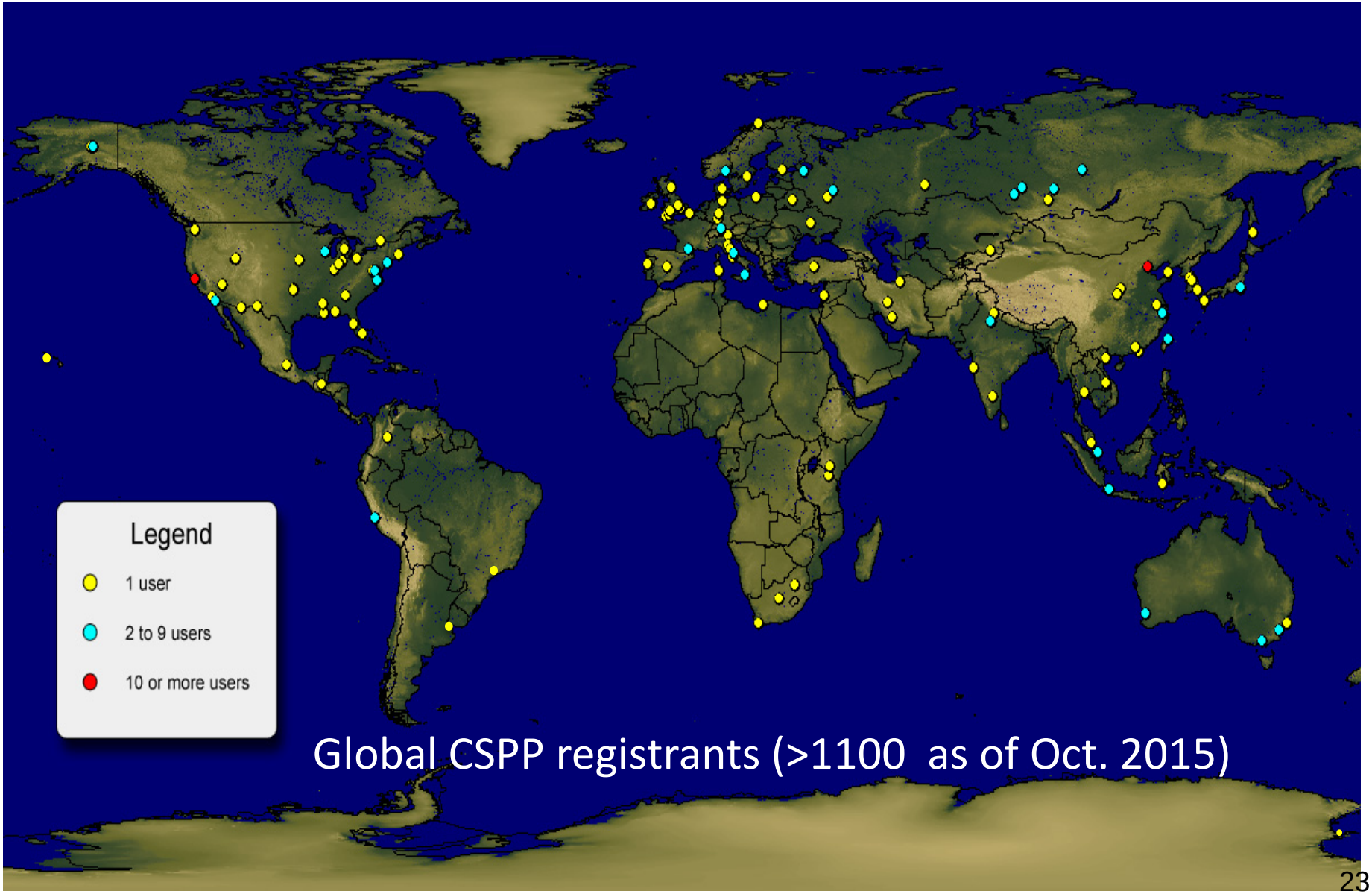
Community Satellite Processing Package (CSPP)

Liam Gumley, Kathleen Strabala, Ray Garcia, Graeme Martin, Geoff Cureton, Scott Mindock, David Hoese, Elisabeth Weisz, Nadia Smith & Allen Huang

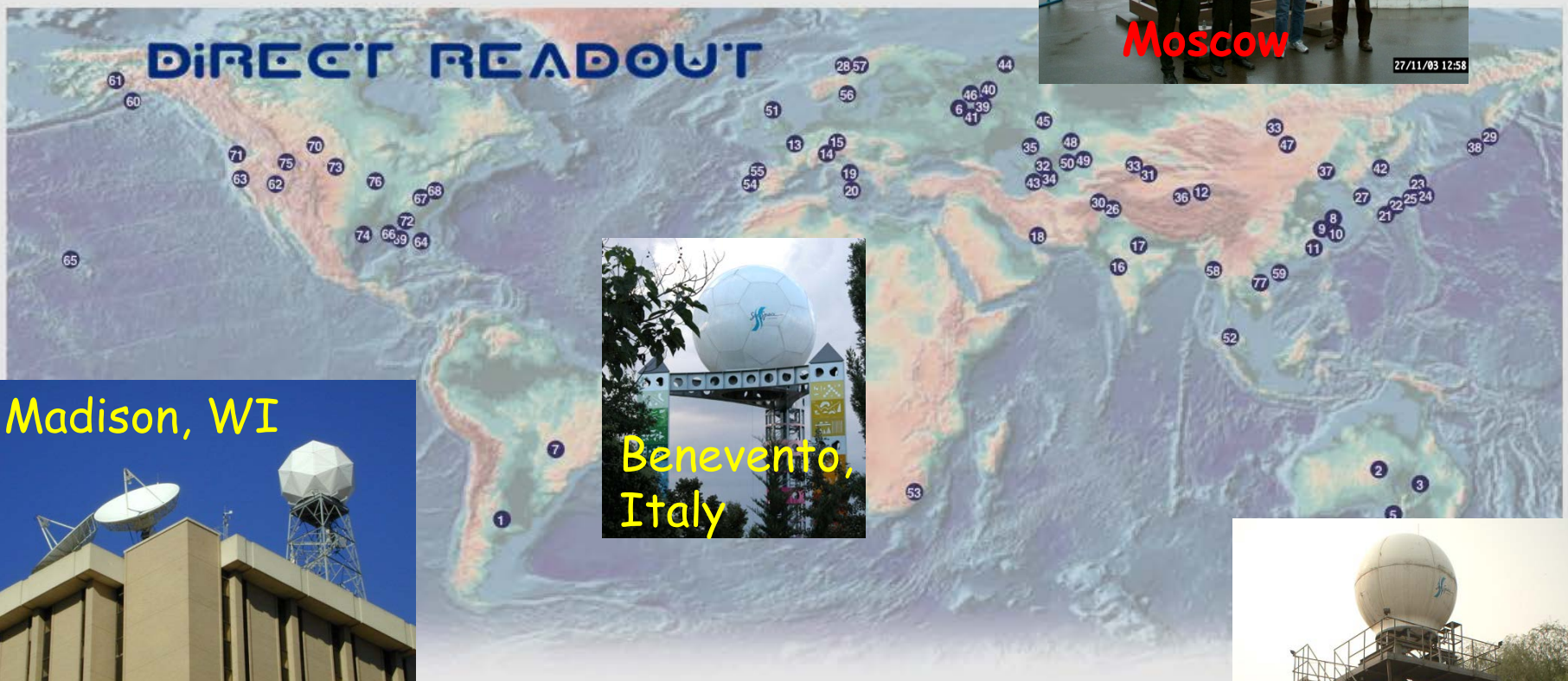
- Community based Suomi NPP VIIRS/CrIS/ATMS Processing Package for Direct Broadcast Users funded since 2011
- **Enables exceptionally Low Latency to major regions (e.g. N. America)**
- CSPP releases so far include:
  - VIIRS, ATMS & CRIS RDRs to EDRs
  - VIIRS EDRs (subset of Land, Ocean, & Atmosphere)
  - VIIRS SDR reprojection S/W for GeoTIFFs and AWIPS NetCDF files
  - UW CrIS, AIRS & IASI dual regression single FOV EDR retrieval
  - VIIRS/ATMS/CRIS & Aqua/Terra HYDRA2 toolkit
  - NOAA/NESDIS/STAR Microwave Integrated Retrieval (MIRS) system for ATMS, NOAA-18, -19 & MetOP-A, B, AMSU-A & MHS
  - VIIRS Imagery EDR
  - VIIRS, MODIS & AVHRR (POES & MetOP) Cloud & Land surface retrievals from CLAVR-x
  - NOAA/NESDIS NUCAPS sounder retrieval S/W

Community Satellite Processing Package

Enabling Worldwide use of Suomi NPP/JPSS!



EOS Direct Broadcast Sites



Over 150 sites around the world

The Valley of Death is Being Crossed

From the NWS Milwaukee WFO Website 2012/11/26

VIIRS DNB data acquired by direct broadcast at SSEC, and processed by CSPP

Check it Out! Satellite Instrument Measures Night-time Illumination

www.crh.noaa.gov/news/display_cmsstory.php?wfo=mkx&storyid=89688&source=0

ERB Movies ERB Camera SatCam IDL Group MODIS Today SSEC DB MODIS Products EOS-FES data LAADS Search WiscCal

National Weather Service Weather Forecast Office

Milwaukee/Sullivan, WI

weather.gov

Home Site Map News Organization Search for: NWS All NOAA Go

Local forecast by "City, St" or Zip Code

City, St Go

XML RSS Feeds

Current Hazards
Watches/Warnings
Outlooks
Submit Report

Current Conditions
Observations
Radar
Satellite
Snow Cover
Snowfall Analysis
Precip Analysis

Forecasts
Forecast Discussion
Activity Planner
Aviation Weather
Fire Weather
Marine Weather
Severe Weather
Winter Weather
Hurricane Center

Hydrology
Rivers & Lakes

Climate
Local
National
Drought
More...
Local Drought Info

Weather Safety
Preparedness
Weather Radio
StormReady
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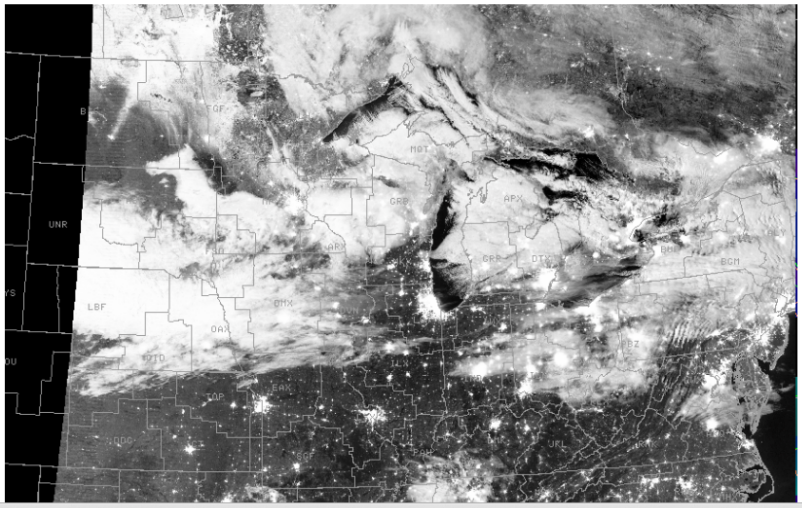
Check it Out! Satellite Instrument Measures Night-time Illumination

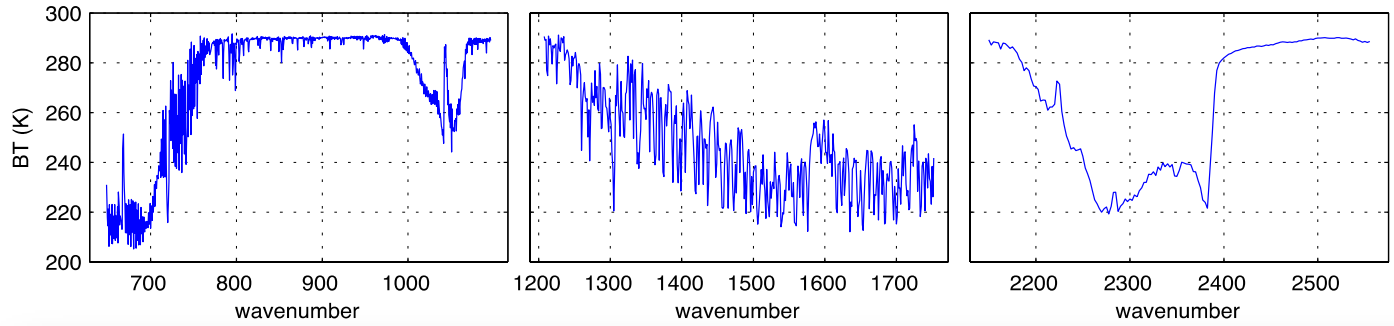
The Visible Infrared Imaging Radiometer (VIIRS) instrument that was included in the payload on the Suomi Polar Orbiting satellite launched into orbit in October 2011 has the capability of measuring night-time illumination on the earth's surface. Depending on the phase of the moon and stray light, the following can be detected by VIIRS at night:

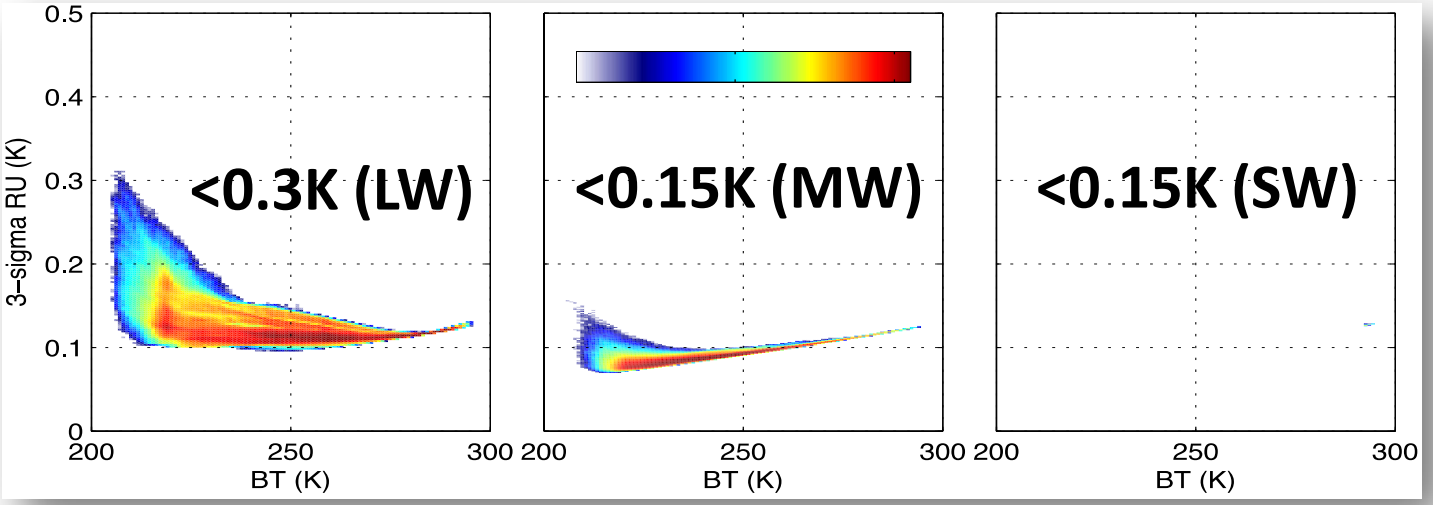
Cities, Smoke, Dush, Ash, Low Clouds, Fog, Fires, Volcanoes (Lava), Auroras, Lightning, Boats

The below image was taken by VIIRS shortly after 2 am CST early Monday morning. The image clearly shows city illumination and reflectance of the metropolitan areas across the southeastern U.S. The moon phase at the time was waxing gibbous or increasing. The moons surface was 95.9% lit, so the moon was nearly full.



Refining Excellent Suomi NPP Sounder (CrIS) Calibration



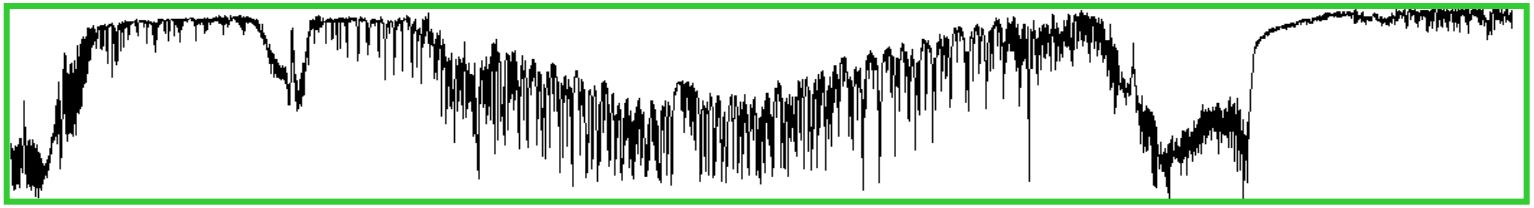


Working to quantify yet unaccounted for Uncertainties

- Localized ringing artifacts: Discovered & implementing correction
- Polarization artifacts: Characterizing size for possible correction
- Shortwave zero artifact: Very small non-linearity suspected

Looking Ahead: Future US Polar Sounding

- **CrIS provides a foundation well suited to the upgrades needed for Next Generation US Weather & Climate Monitoring**
- **Modular design allows achieving**
  (1) Contiguous spectral coverage
  (2) Higher spatial resolution with more complete coverage
  by just changing to a 2-D detector array with different optical bandpass filters

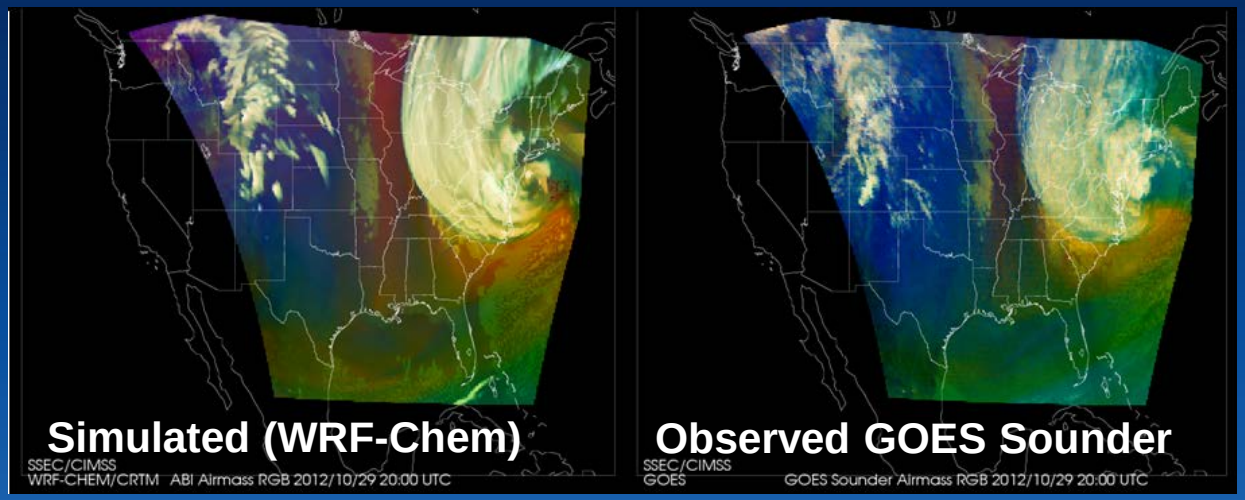


GOES-R Launch early 2016

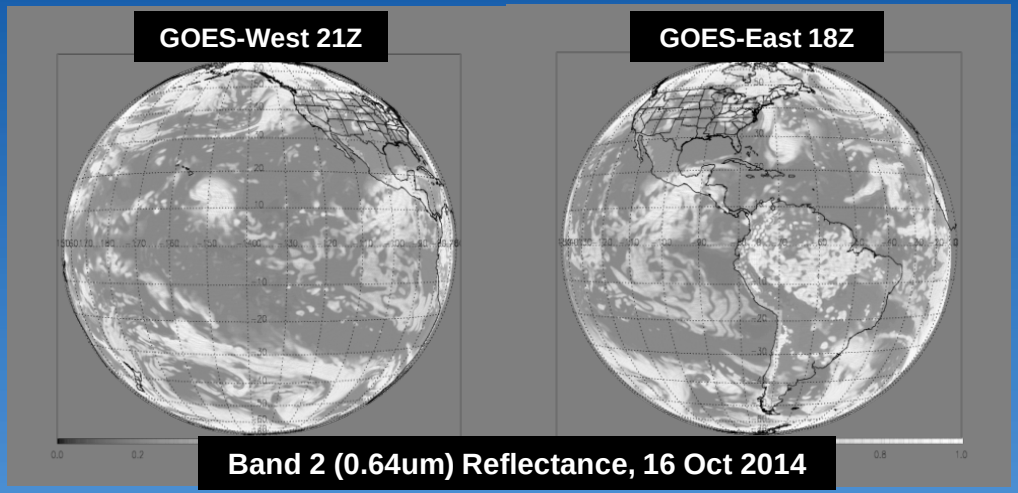
1st of the New Geostationary Environmental Satellite Series

GOES-R Real-time Proxy

- Distribution of real-time proxy ABI radiances, RGB imagery, and Product retrievals for Proving Ground demonstration, ground system testing product validation, and testing for AWIPS II

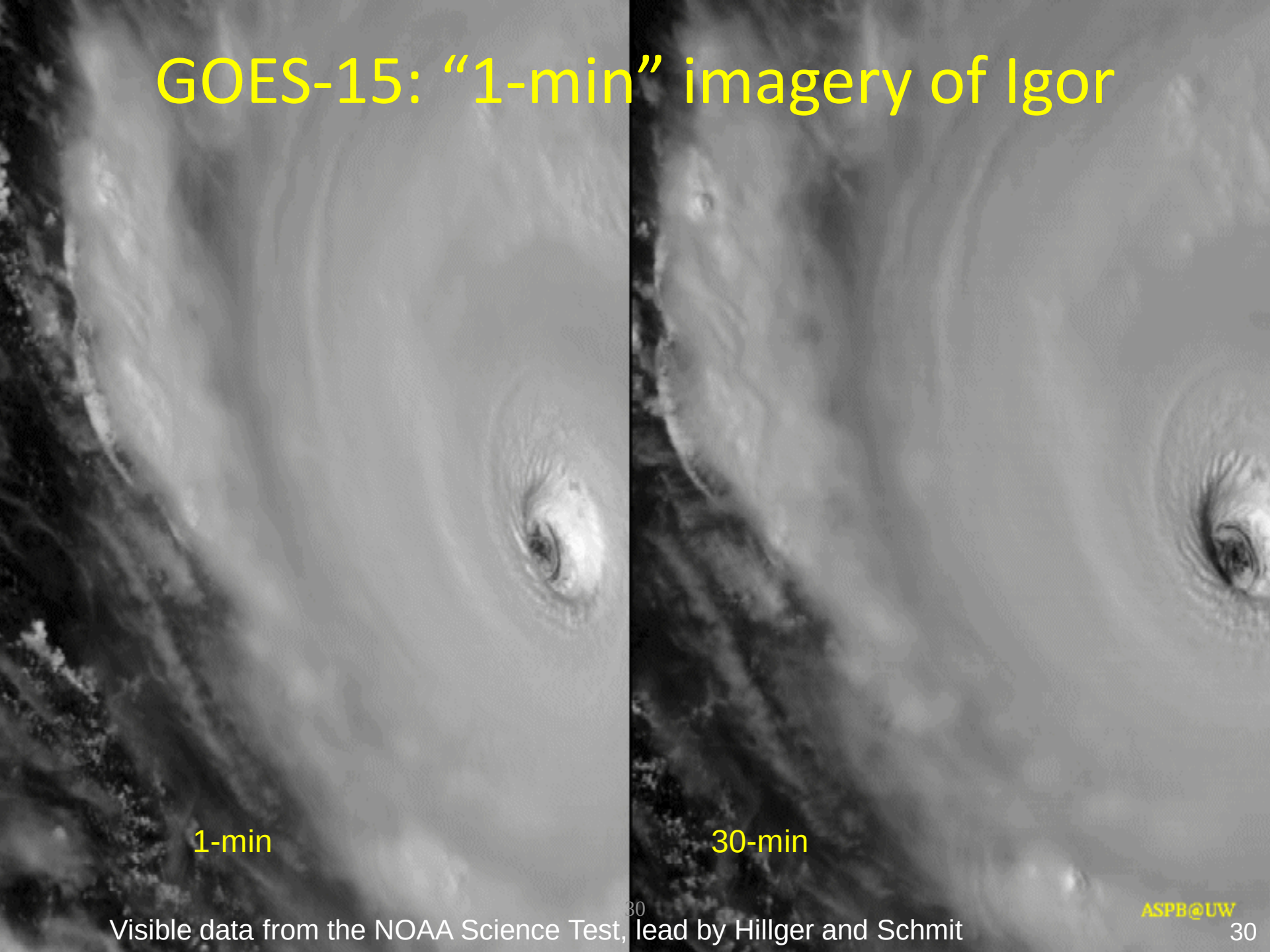


Validation of proxy Air Mass RGB imagery for Hurricane Sandy (Greenwald et al. 2014)



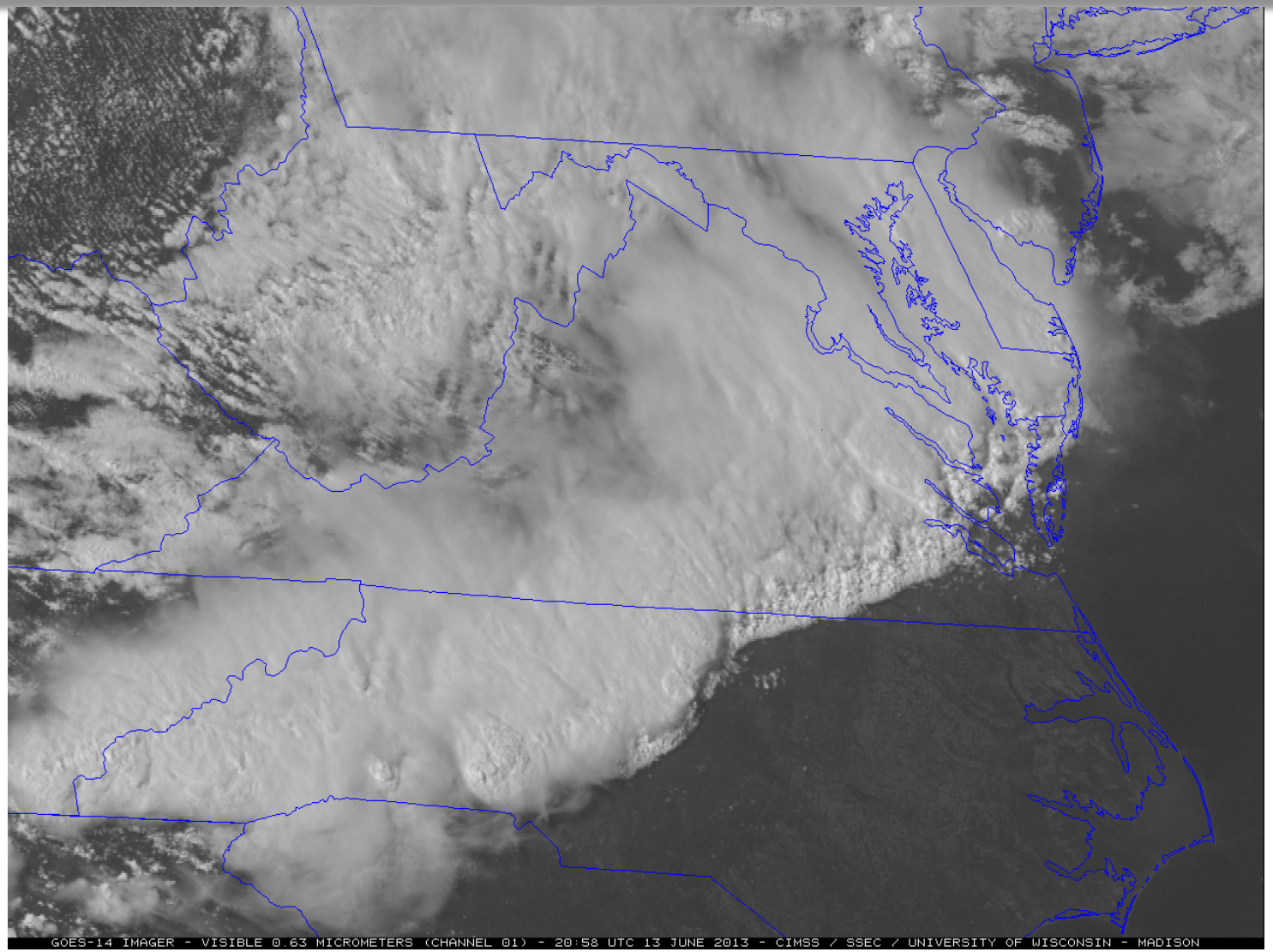
Real-time GFS/CRTM full disk proxy data

GOES-15: “1-min” imagery of Igor



Visible data from the NOAA Science Test, lead by Hillger and Schmit

The June 13, 2013 Derecho: 1-minute GOES-14



16 October 2014

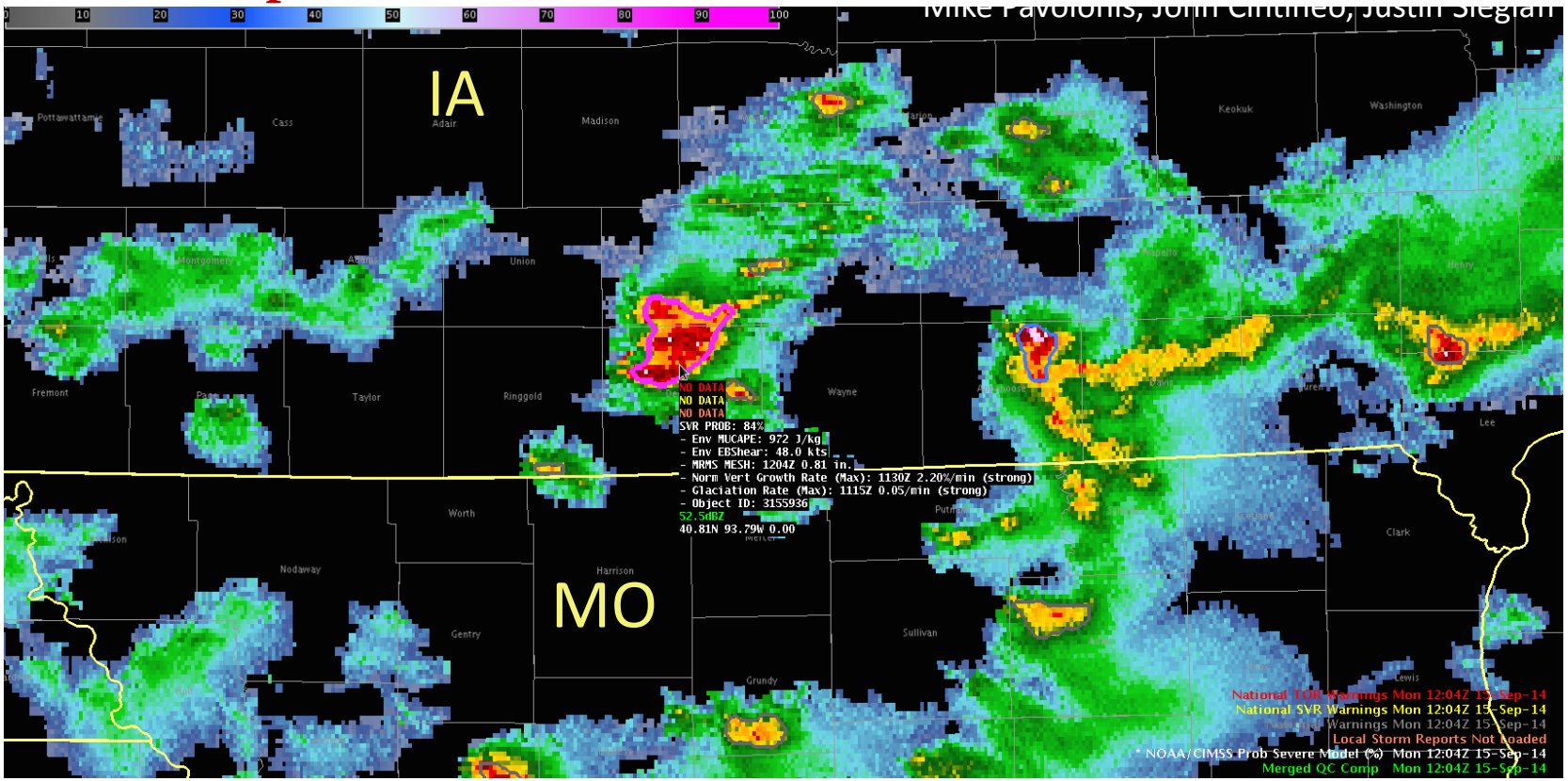
Himawari-8 enters GEO orbit

Carrying AHI, a close cousin to GOES-R ABI

- **Himawari, meaning sunflower**, is the next-generation Geostationary Met. Satellite of the Japan Meteorological Agency (JMA)
- **Operations to started mid-2015** after completion of in-orbit testing and checking of overall system
- AHI now provides real data for testing GOES-R algorithms

NOAA/CIMSS ProbSevere Model

Impressive now—will be even better with GOES-R



P(severe) = *f* (GOES, NWP, RADAR)

- Demonstrated at 2014 Hazardous Weather Testbed and NWS MKX
- 98% of forecasters would use it if available at their WFO (need AWIPS 2)
- 78% of forecasters found increased confidence in warning decision-making
- 47% of forecasters found increased lead-time to severe hazards—

roughly doubles median lead time, adding an extra 10 minutes

Mike Pavolonis, John Cintineo, Justin Sieglaff

Temperature & Water Vapor IR Sounder Staircase

Spectral Resolving Power ($\lambda/\Delta\lambda$)

~Resolving Power @ 14 μm

We need to restore advanced sounding capability over the US

(1200) *HES, GOES-R* (2013-)

(1200) *GIFTS* (2008-)

(2200/2800) **CrIS / IASI** (2006-)

(1200) **AIRS** (2002-)

(30) *GOES Sounder* (1994-) – **(3-Axis)**

(30) *VAS* (1980-) – **1st Geo Sounder (Spin-Scan)**

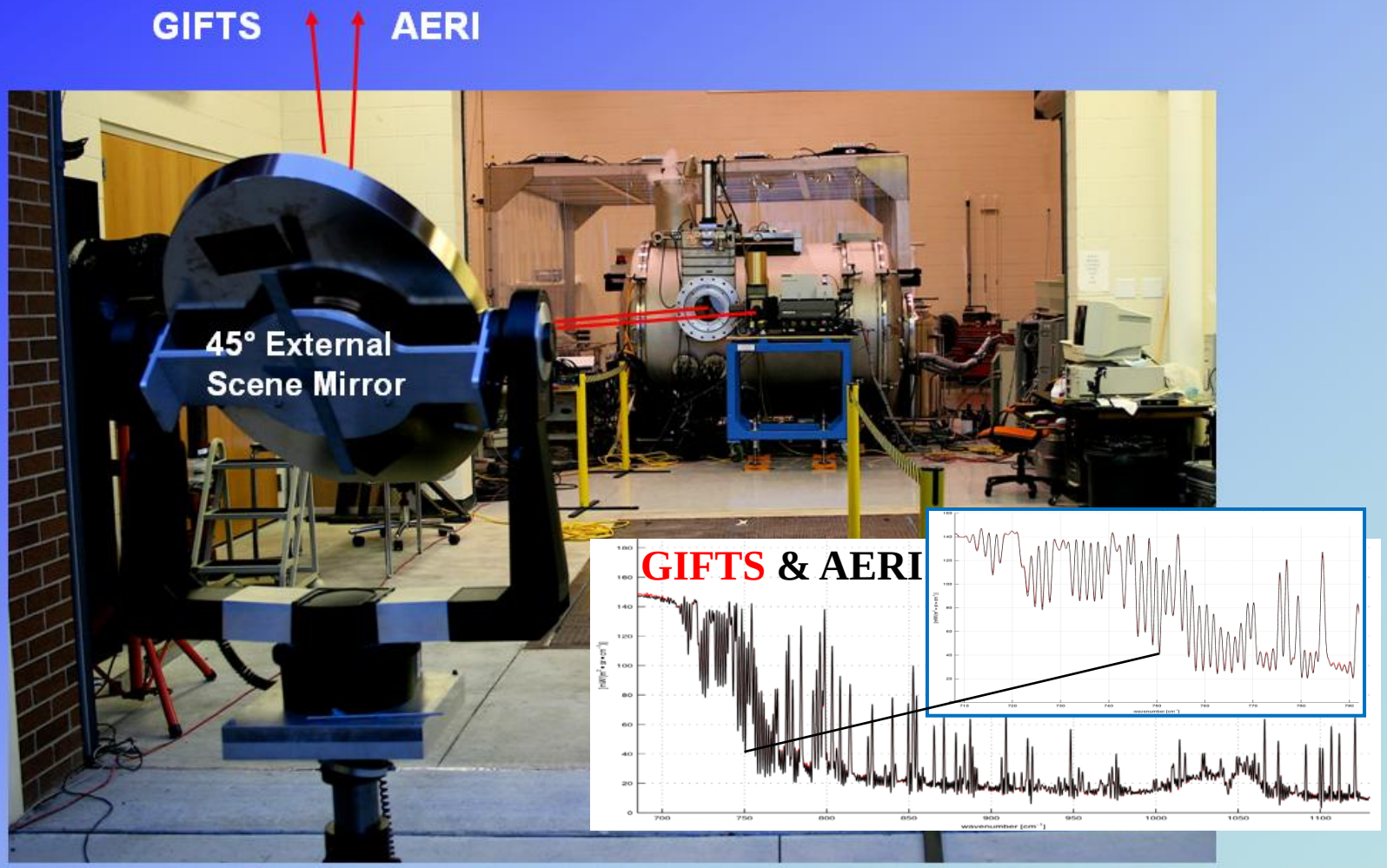
(30) **ITPR,VTPR** (1972) / **HIRS** (1978-)

(150-300) **IRIS / SIRS** (1969-70) – **1st Sounders**

BLUE = Leo ***Purple = Geo***

from 2004 AMS Revercomb et al.

SSEC AERI confirms GIFTS Sky-viewing Accuracy at SDL in 2006



GIFTS / AERI Inter-comparison
Testing at USU/SDL, September 2006

Chasing Storms on Uranus

Team Uranus (collaboration on observing and analysis):

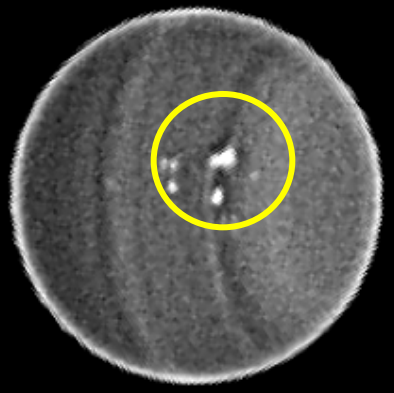
Tracked for 106 days (so far)

Brightest ever at 2.2 μm.

5 August 2014

6 August 2014

2 October 2014



14 October 2014

Near-IR imaging with the **10-m Keck** telescope found record setting storm activity on Uranus in 2014.

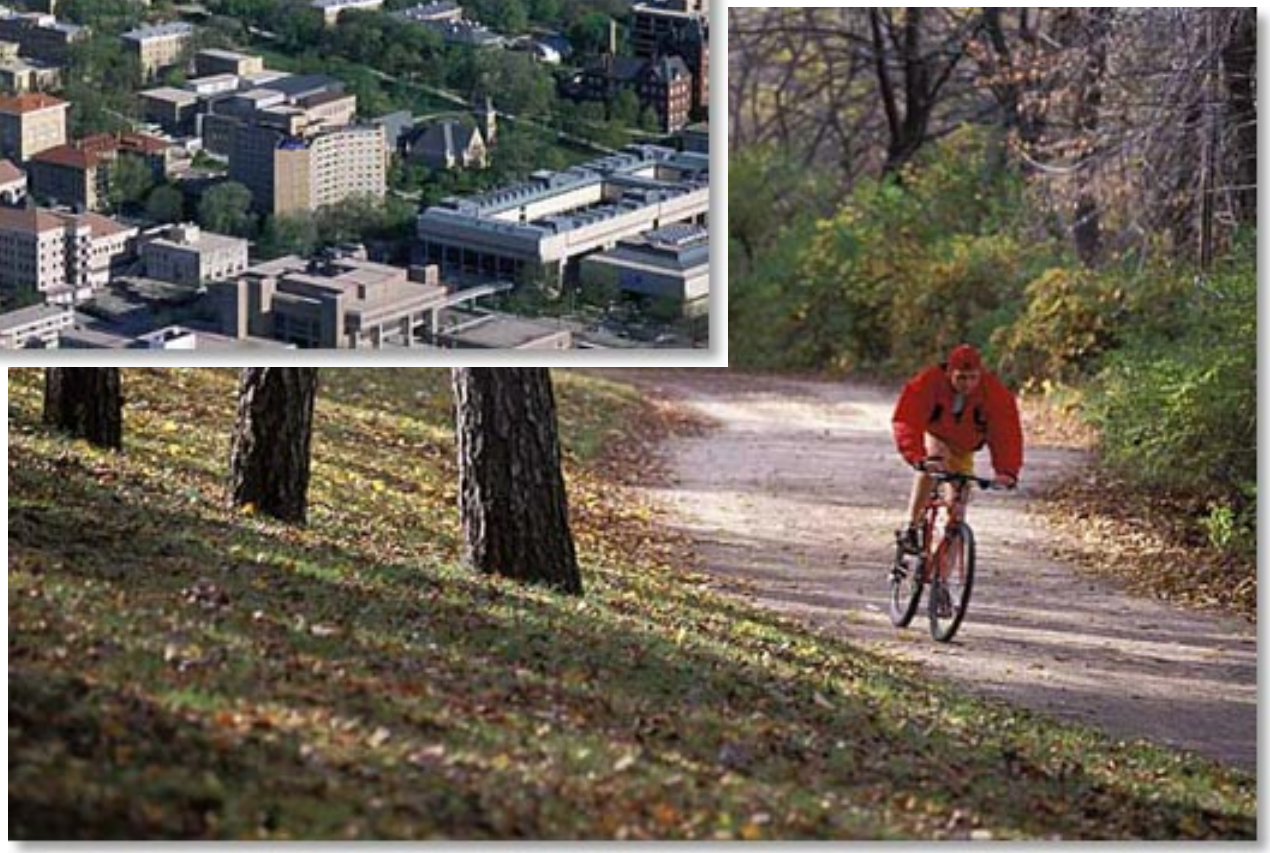
Active for more than 106 days!

One storm was so bright in visible light that **amateurs** found it with a 14" telescope and a red filter.

It was also seen in October and November **Hubble Space Telescope and Gemini** images.

Lake-side

running, walking, biking trails



Memorial Union

Signature Spot on Campus

capitol

capitol

State Street

Campus to Capitol

Staying longer

Saturday Morning

Farmer’s Market