From ITPP, IAPP, IMAPP to CSPP – Supporting Direct Broadcast Users Over Three Decades

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Acknowledgement – CSPP, IMAPP, ISEE & Real Earth

- IMAPP (International MODIS/AIRS Processing Package):
  - Liam Gumley, Kathy Strabala, James Davies
- CSPP (Community Satellite Processing Package) LEO:
  - Liam Gumley, Kathy Strabala, Scott Mindock, Ray Garcia, Graeme Martin, Geoff Cureton, Elisabeth Weisz, Nadia Smith, Nick Bearson, James Davies, Jessica Braun
- CSPP (Community Satellite Processing Package) GEO:
  - Liam Gumley, Graeme Martin, Kathy Strabala, Scott Mindock, Geoff Cureton, Jessica Braun, Nick Bearson, Ray Garcia, Tommy Jasmin
- ISEE/Real Earth:
  - Dave Parker, Russ Dengel, Nick Bearson, Tommy Jasmin, Dave Santek, Sam Batzli

Sponsors: NOAA, NASA & SSEC

History of UW-CIMSS Polar Orbiting Satellite Direct Broadcast Processing Packages

1982

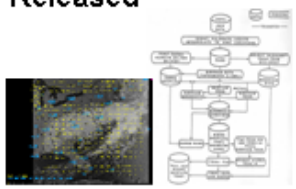
TOVS Export Package developed for NOAA polar operational satellite TIROS-N

1983

1st release of International TOVS Processing Package (ITPP) for NOAA-8

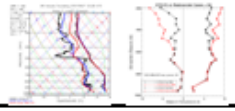
1995

ITPP Ver 5.0 Released



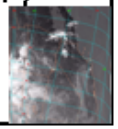
1999

1st released of International ATOVS Processing Package (IAPP) for NOAA-15



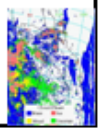
2000

1st Release of International MODIS & AIRS Processing Package (IMAPP) for Terra MODIS



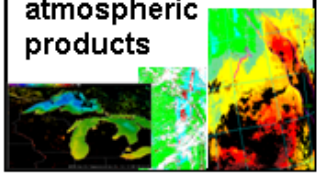
2002

1st IMAPP Science products released for Terra MODIS and 1st release to support both Terra & Aqua MODIS



2003

IMAPP Aqua/Terra Release of cloud property and atmospheric products



2003

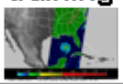
IMAPP tutorial on producing MODIS true color images

2004

1st release of IMAPP SST product S/W & 1st training workshop held in Nanjing, China

2005

1st IMAPP AMSR-E L1 & rain rate products. Held training workshops in Taiwan & Beijing



Release of IAPP v2.1

2005

1st release of IMAPP AIRS/AMSU/HSB sounding retrieval

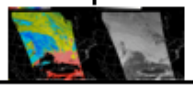
IMAPP release of MODIS L2 product collection 5 updates

2006

1st IMAPP SFOV UW AIRS L2 retrieval, & AMSR-E soil moisture products. Held workshops in Norway & S. Africa. Begin support of US NWS forecasters

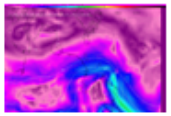
2007

IMAPP release of AMSR-E snow water equivalent; MODIS L2 product S/W V2.0. Held workshop in Brazil



2008

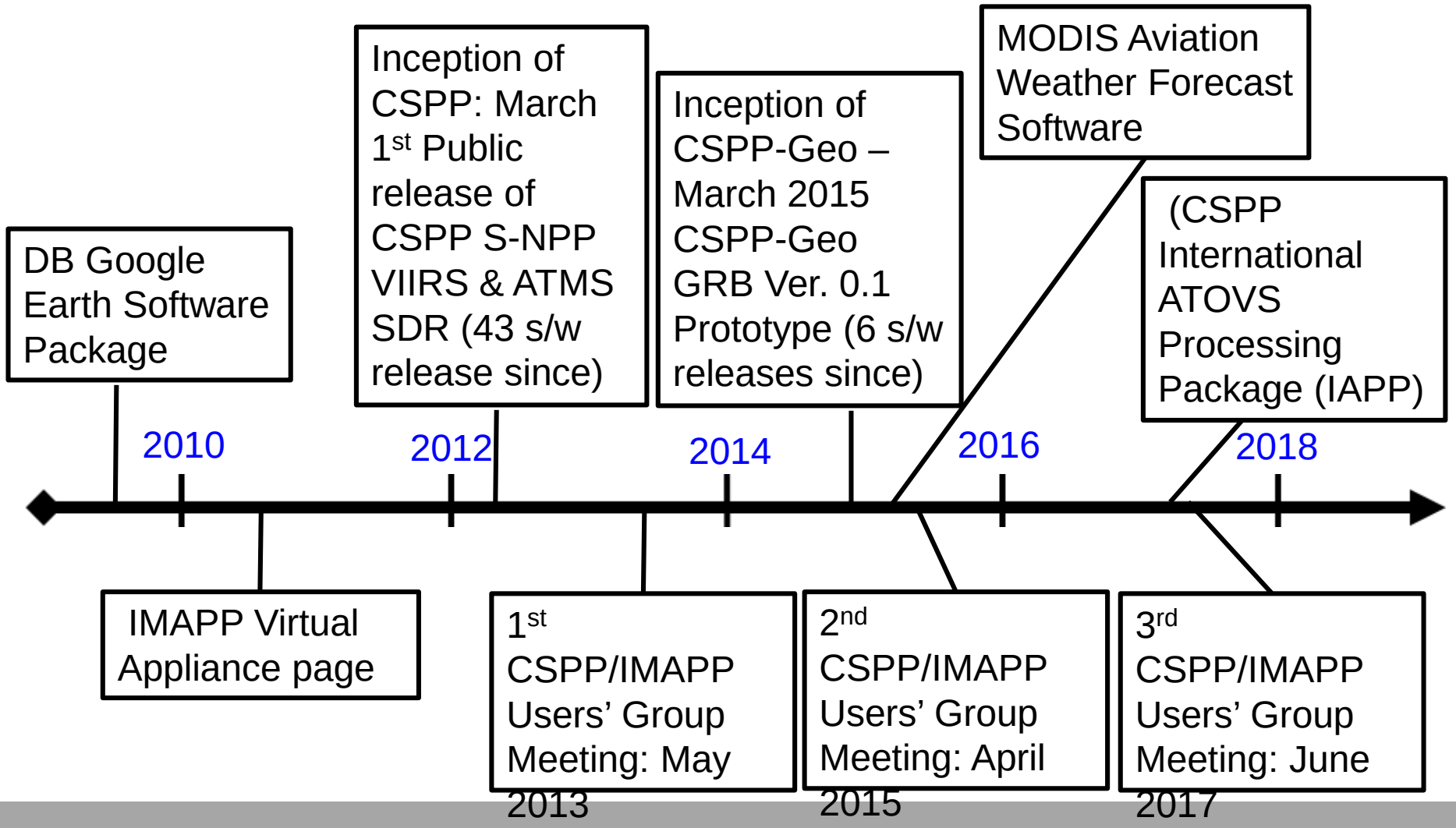
IMAPP release of AIRS/AMSU V5.2; MODIS IR band destriping; & DB CRAS NWP model



2009

1st IMAPP DB Google Earth; AIRS & MODIS collocation; AIRS L1B HDFEOS to Buffer. Held workshop in S. Africa. # of IMAPP users > 600

From ITPP, IAPP, IMAPP to CSPP – 2009 to 2017

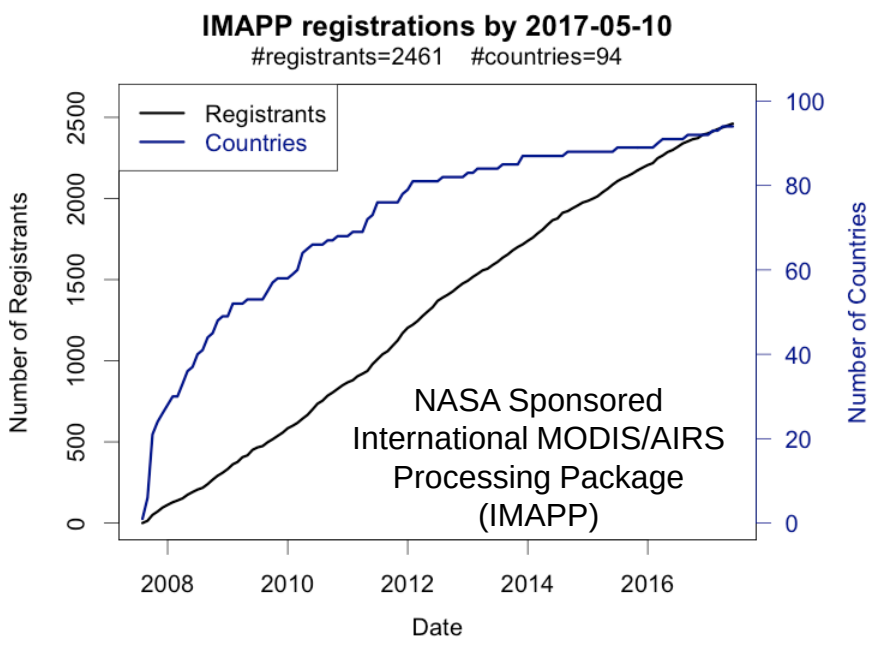


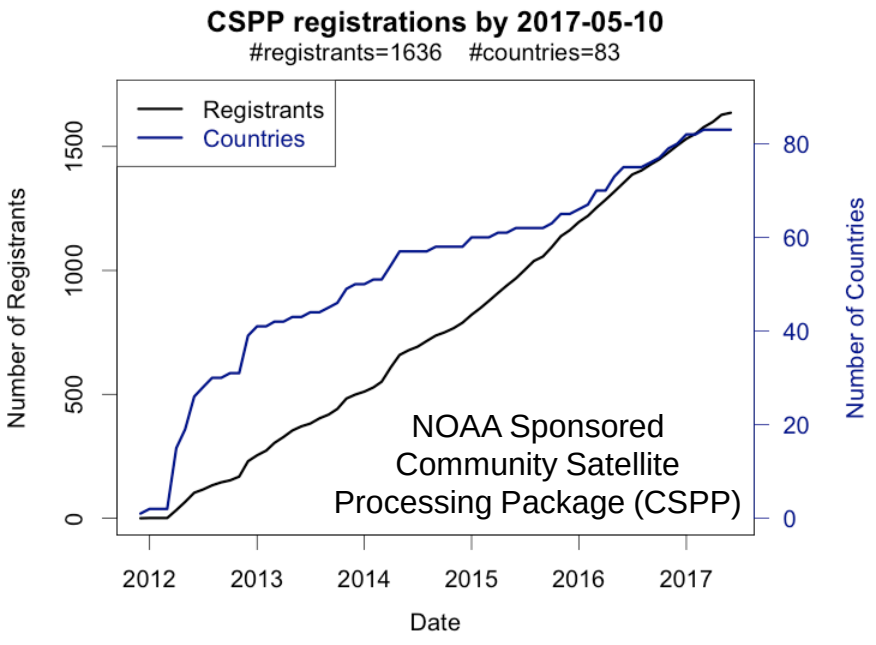
What is IMAPP?

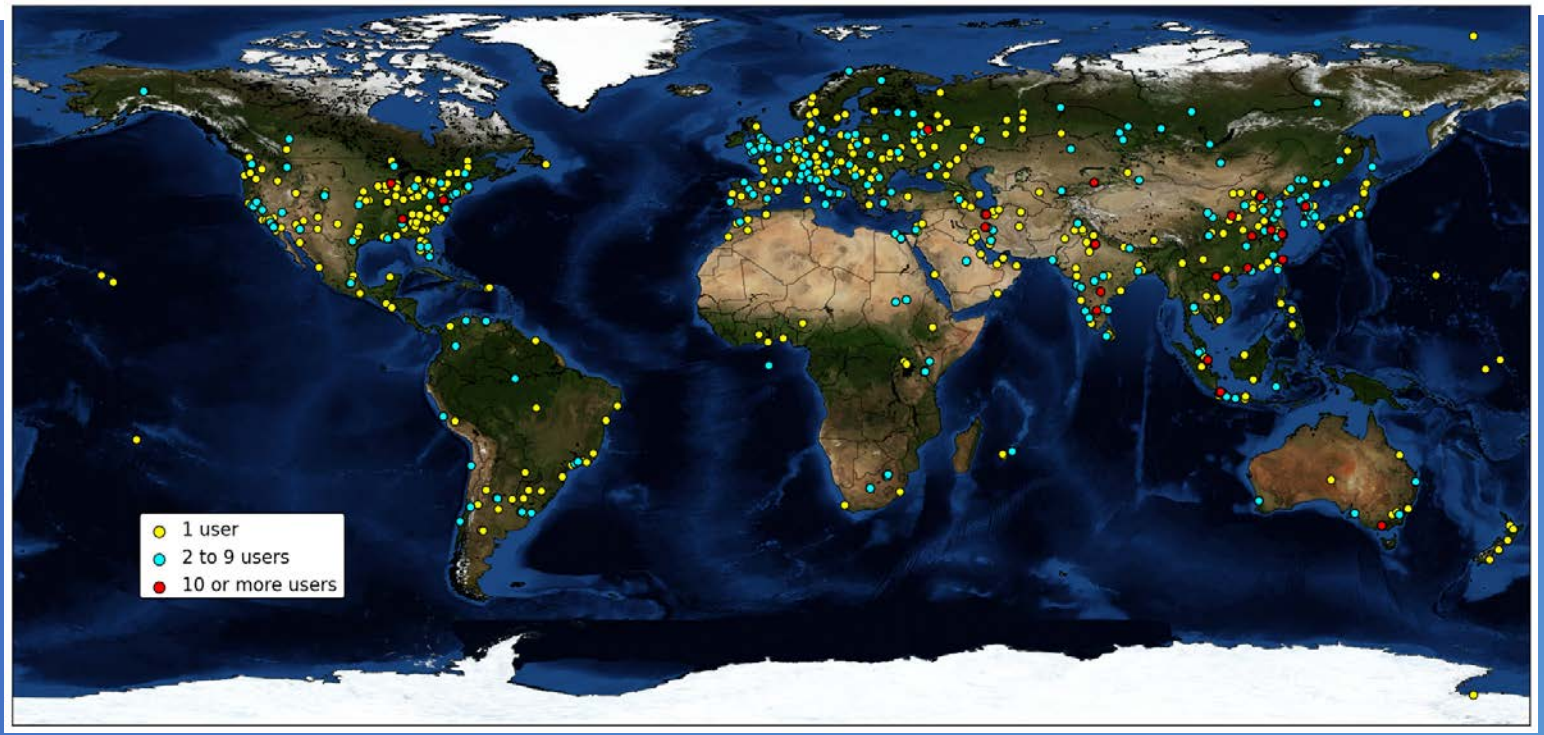
- IMAPP (International MODIS/AIRS Processing Package) is a collection of software systems for processing data from NASA Terra & Aqua satellites.
- The main goal of IMAPP is to support users who
  - Receive satellite data via direct broadcast;
  - Create MODIS, AIRS, AMUS, AMSR-E Level 1B & higher products & applications (SDR, EDR, IDR) in real time.
- Funded by NASA since 2000.

What is CSPP?

- CSPP (Community Satellite Processing Package) is a collection of software systems for processing data from 7 meteorological satellites (S-NPP, METOP A/B, NOAA, FY-3) so far.
- The primary goal of CSPP is to support users who
  - Receive satellite data via direct broadcast;
  - Create Level 1B and higher level products and applications (SDR, EDR & IDR) in real time.
- Conceived by Dr. Goldberg of NOAA & funded by JPSS NOAA since 2011.


IMAPP registrations by 2017-05-10
#registrants=2461 #countries=94
Registrants
Countries
Number of Registrants
Number of Countries
Date
NASA Sponsored
International MODIS/AIRS
Processing Package
(IMAPP)


CSPP registrations by 2017-05-10
#registrants=1636 #countries=83
Registrants
Countries
Number of Registrants
Number of Countries
Date
NOAA Sponsored
Community Satellite
Processing Package (CSPP)


1 user
2 to 9 users
10 or more users

IMAPP by the numbers (May 2017)

Satellites supported: 2

Software packages: 6

Sensors supported: 5

Releases and updates: 68

Registered users: 2461

Registered countries: 94

http://cimss.ssec.wisc.edu/imapp/

CSPP by the numbers (May 2017)

Satellites supported: 7

Software packages: 10

Sensors supported: 25

Releases and updates: 43

Registered users: 1636 (83 countries)

Individual downloads: > 5000

http://cimss.ssec.wisc.edu/cspp/

IMAPP S/W Suites (SDR, EDR & IDR)

MODIS Atmosphere and Polar Products

- Cloud mask
- Cloud top pressure and temperature
- Cloud optical depth and effective radius
- Temperature and moisture profiles
- Total precipitable water
- Stability indices
- Aerosol optical depth
- Ice Surface Temperature
- Snow Mask
- Ice Cover and Ice Concentration
- Inversion Strength and Inversion Depth

MODIS Land Products

- Land Surface Reflectance
- BRDF

MODIS Image Software

- MODIS in Google Earth (true color)

AIRS Level 1B

- Calibrated and geolocated radiances and brightness temperatures (AIRS)
- Calibrated and geolocated antenna temperatures (AMSU)

AIRS Retrievals

- JPL 3x3 FOV
- Dual Regression Single FOV

AIRS Utilities

- Collocating AIRS/MODIS utility
- AIRS HDF to BUFR utility

AMSR-E Level 1B

- Calibrated and Geolocated Antenna Temperatures

AMSR-E Products

- Rain Rate, Soil Moisture, Snow Water Equivalent

NWP Products

- Globally configurable regional numerical weather prediction model that assimilates MODIS DB products - DBCRAS

Aviation/Severe Weather Products

- Overshooting Tops Identification including turbulence and lightning potential

Air Quality Forecast Product – IDEA-I

Complete DB Processing System

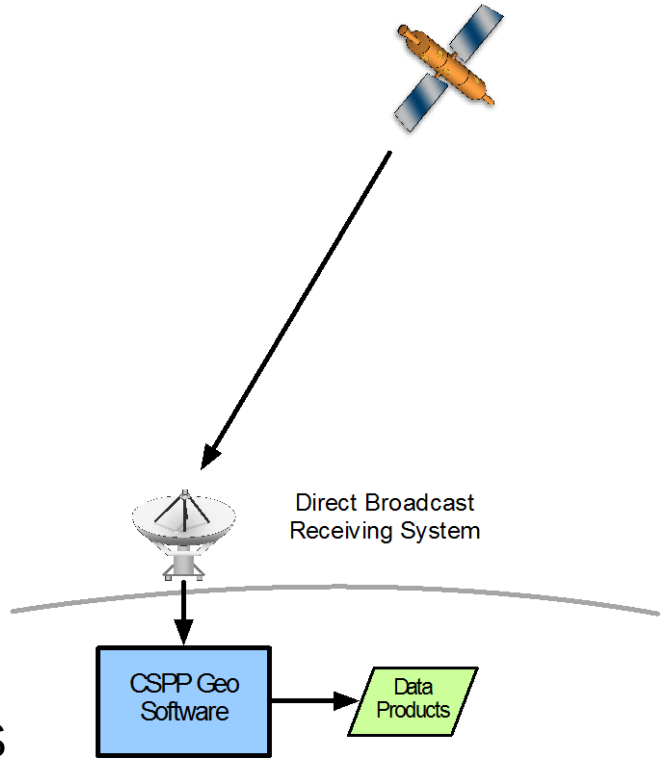
- VA for Mac, Windows and Linux

CSPP Software

CSPP Software	Product Description
1. SDR	VIIRS, CrIS, and ATMS geolocated and calibrated earth observations.
2. VIIRS EDR	VIIRS imager cloud mask, active fires, surface reflectance, vegetation indices, sea surface temperature, land surface temperature, and aerosol optical depth.
3. HSRTV	Hyperspectral infrared sounder retrievals of temperature and moisture profiles, cloud properties, total ozone, and surface properties.
4. Polar2grid	Reprojected imagery (single and multi-band) in GeoTIFF and AWIPS formats.
5. Hydra	Interactive visualization and interrogation of multispectral imagery and hyper spectral soundings.
6. MIRS	Microwave sounder retrievals of temperature and moisture profiles; surface properties; snow and ice cover; rain rate; and cloud/rain water paths.
7. CLAVR-x	Multispectral imager retrievals of cloud properties; aerosol optical depth; surface properties; ocean properties.
8. NUCAPS	Combined hyperspectral infrared sounder and microwave sounder retrievals of temperature and moisture profiles, cloud cleared radiances, and trace gases.
9. IAPP	Combined infrared sounder and microwave sounder retrievals of temperature and moisture profiles, water vapor, total ozone, and cloud properties.
10. ACSPO	Multispectral imager retrievals of sea surface temperature.

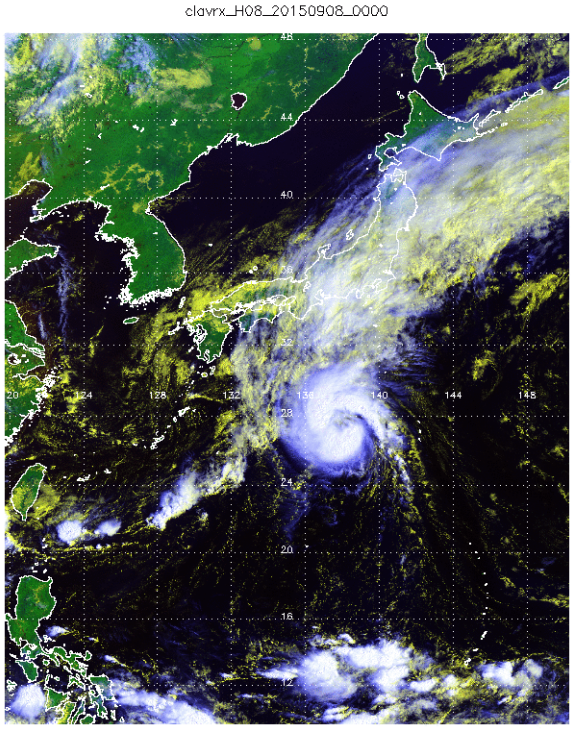
What is CSPP Geo?

- CSPP Geo = “Community Satellite Processing Package for Geostationary Data”
- The CSPP Geo project creates and distributes software allowing direct broadcast users to create products from geostationary satellite data
- The project draws on experience creating software allowing direct broadcast users to process data from polar orbiters (CSPP and IMAPP projects)
- Funded by the GOES-R Program Office
- Supported missions: **GOES-16, Himawari-8, GOES-13 and -15**
- Using Level 2 algorithms that were developed for ABI
- Users include vendors of DB receiving stations, US government, international Met agencies, research institutions

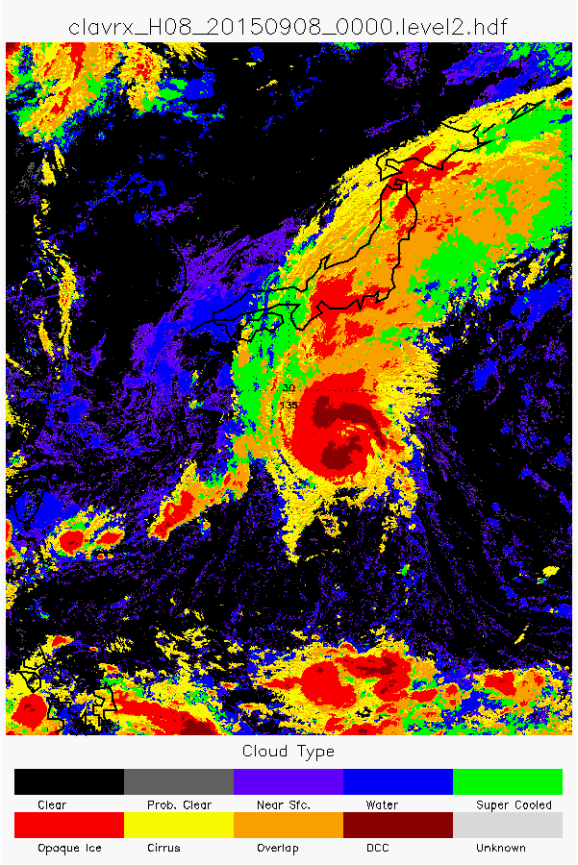


CSPP Geo CLAVR-x Cloud Products on AHI (1)

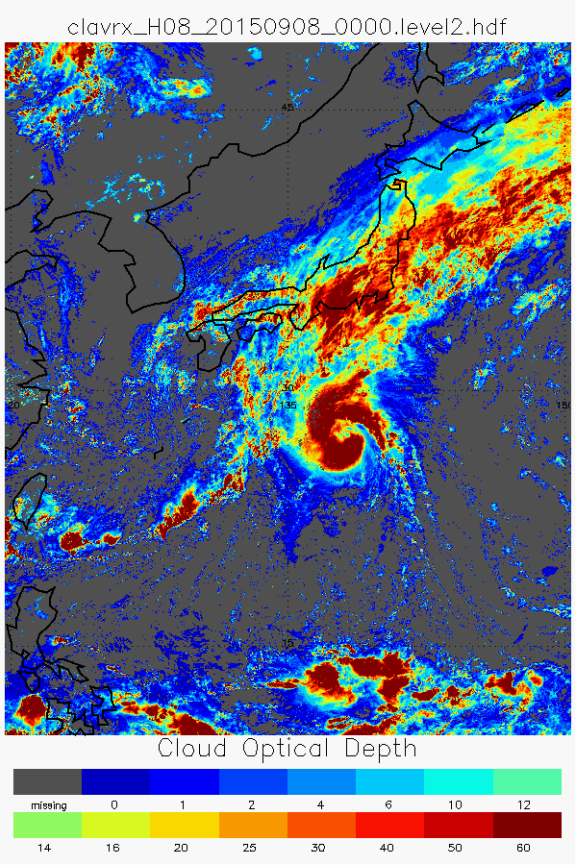
False Color Image (0.65, 0.86, 11μm)



Cloud Type



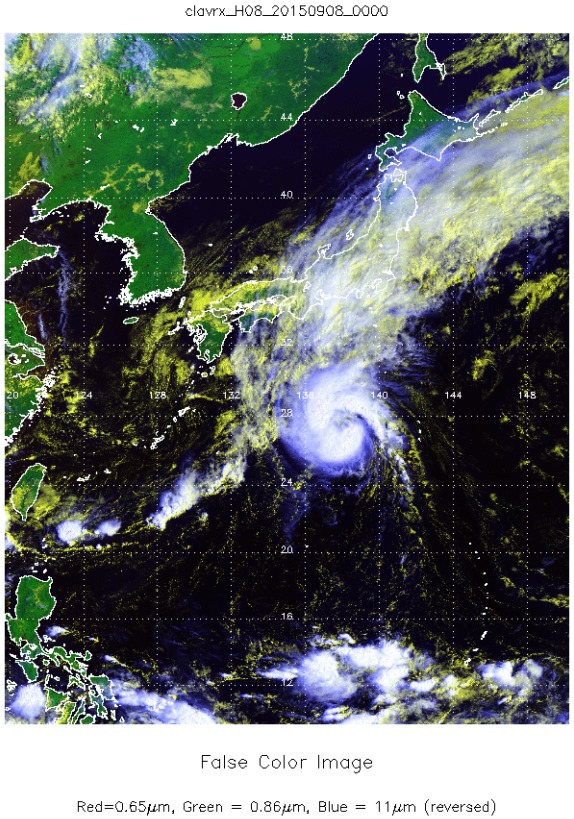
Cloud Optical Depth



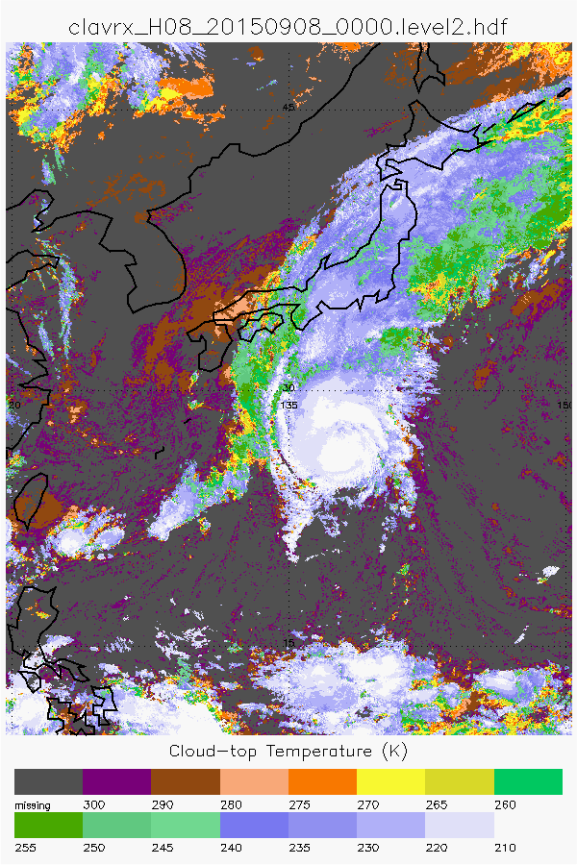
Himawari 8 - AHI, TS Etau, September 8, 2015

CSPP Geo CLAVR-x Cloud Products on AHI (2)

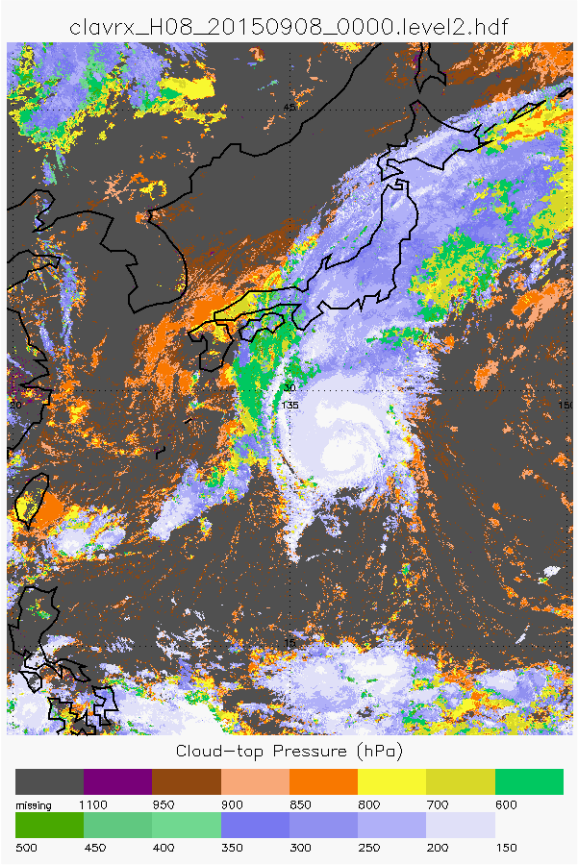
False Color Image (0.65, 0.86, 11μm)



Cloud Top Temperature



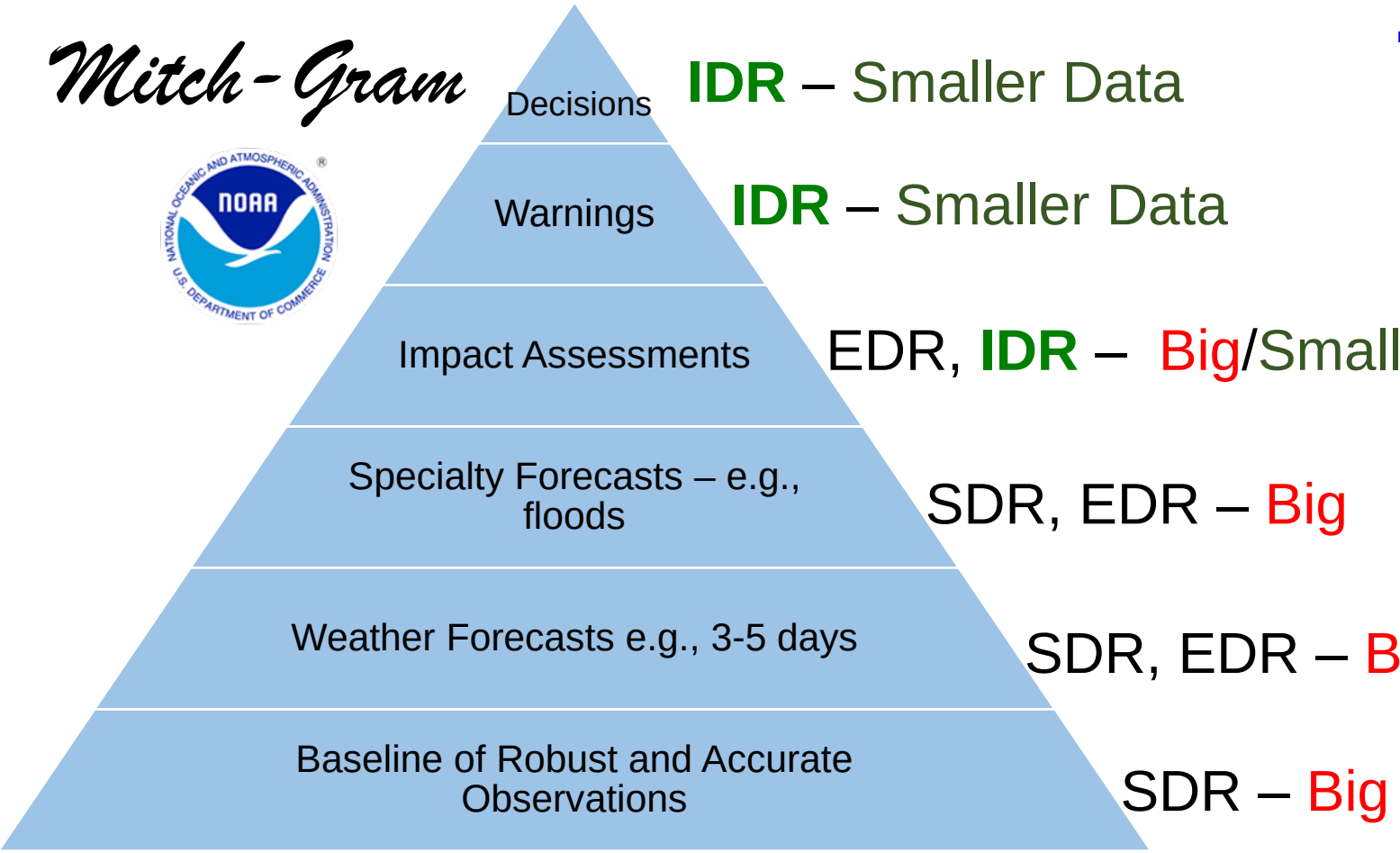
Cloud Top Pressure



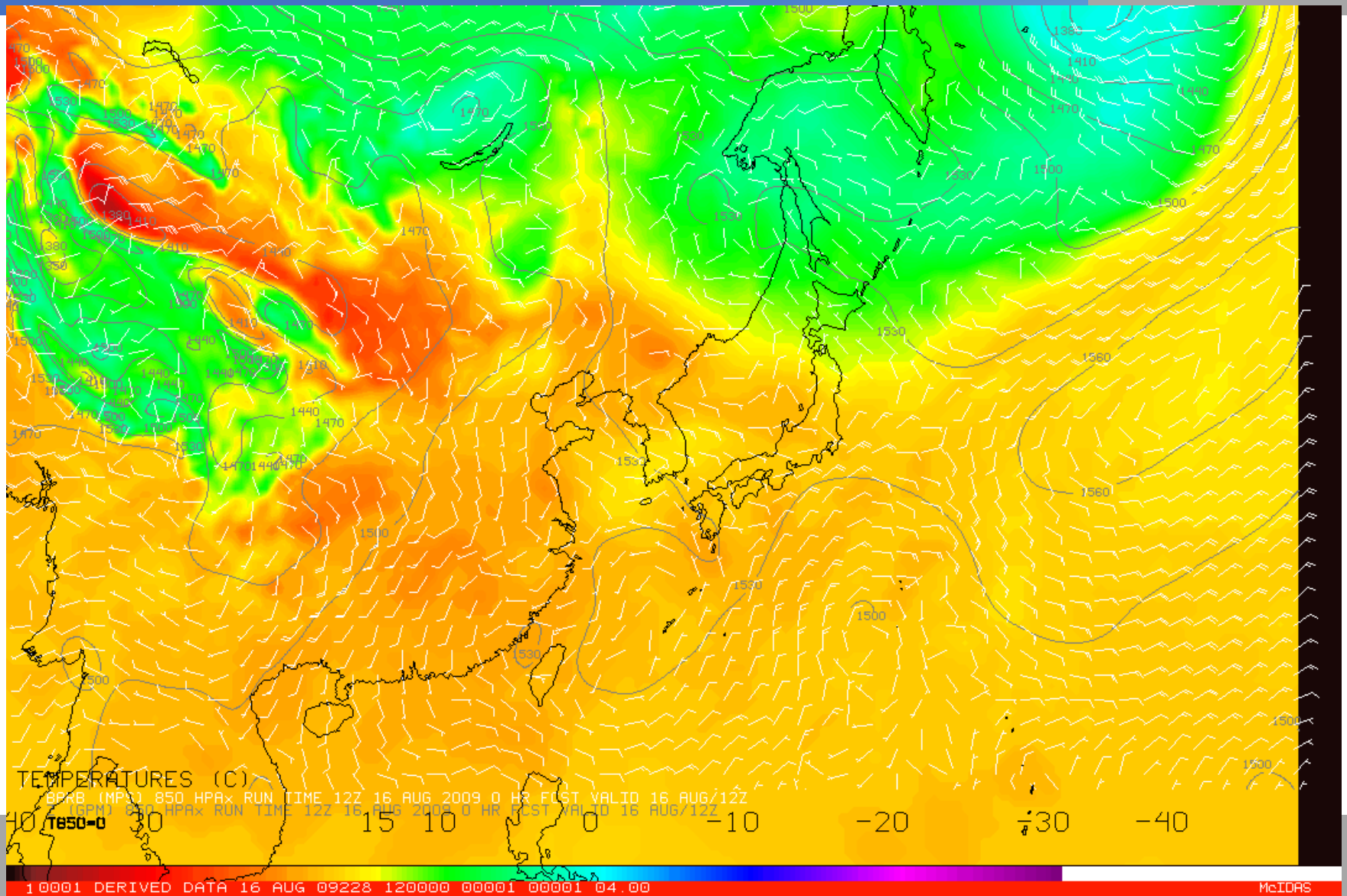
Himawari 8 - AHI, TS Etau, September 8, 2015

Big Data Pyramid: Satellite Informatics – "Big Data to Smaller Data": SDR to EDR to Information Data Record (IDR)

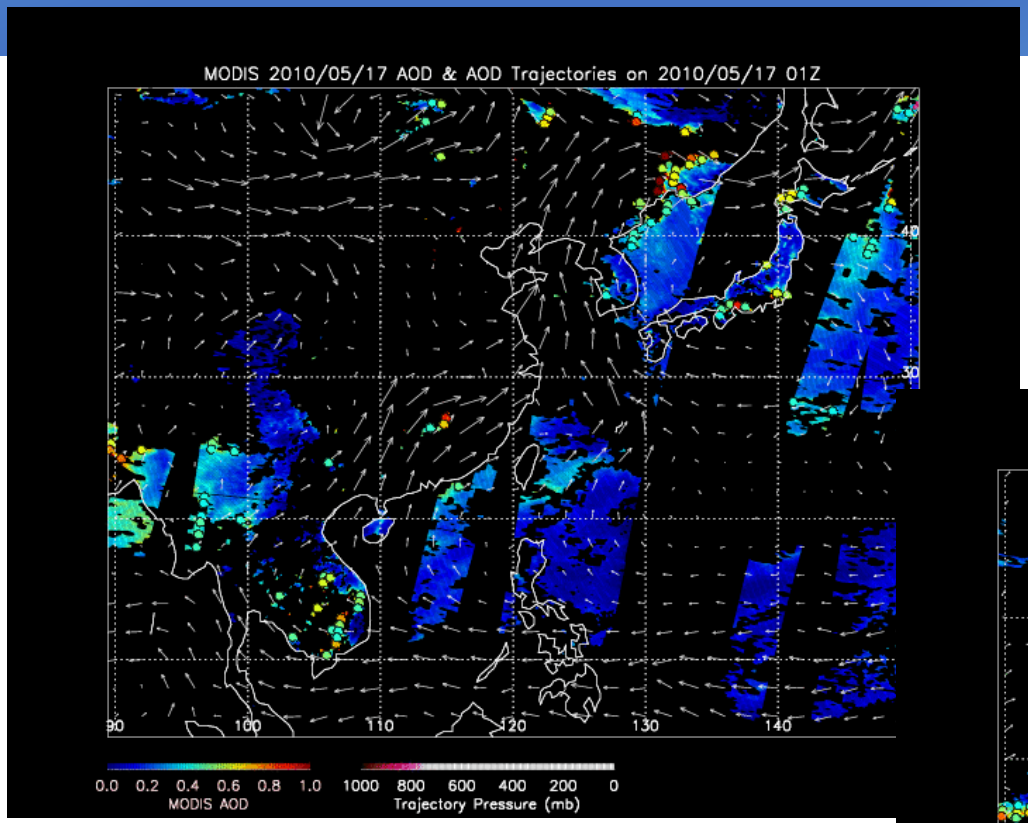
Mitch-Gram



Beyond EDR - Information Data Record:
Real-Time Regional Weather Forecasting



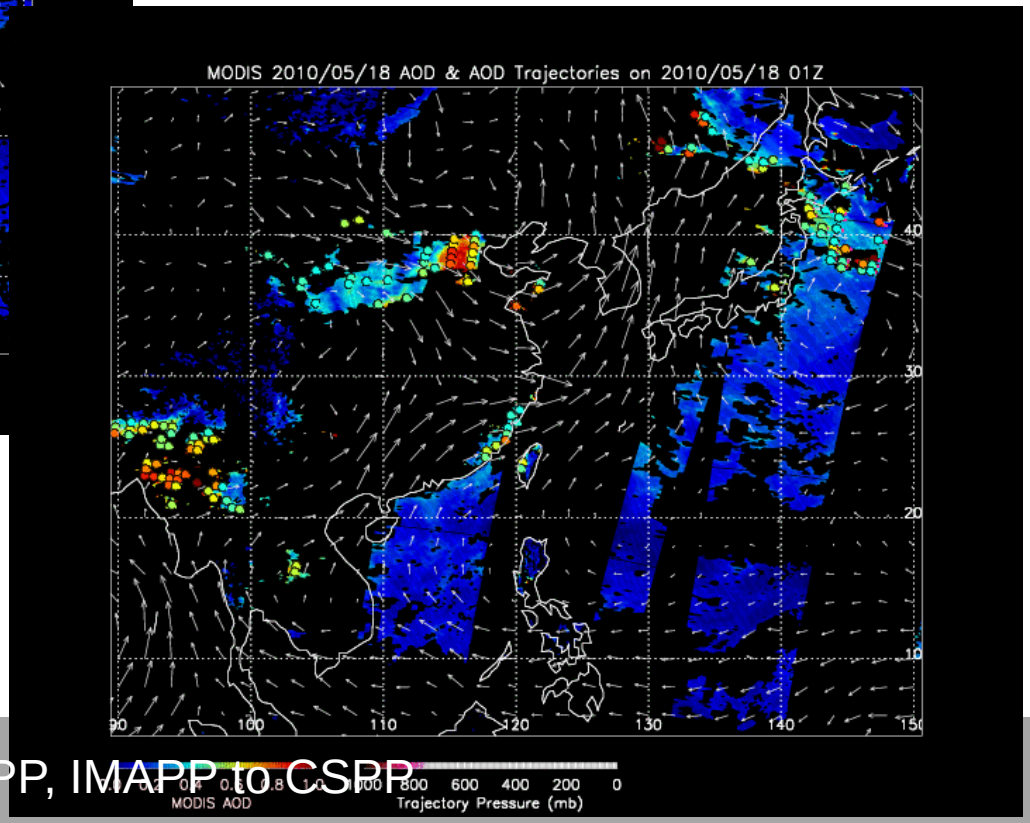
Beyond EDR - Information Data Record:
Real-Time Air Quality Forecasting



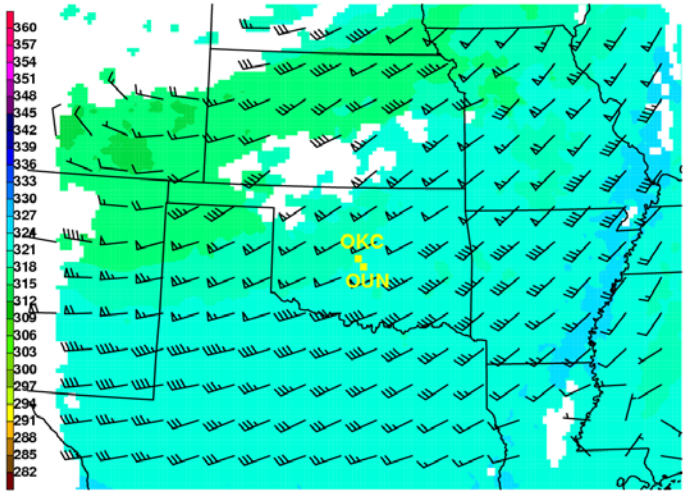
17 May, 2010

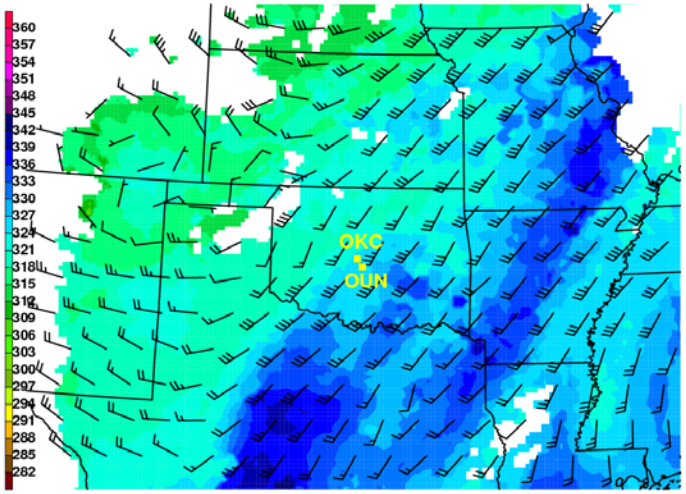
Shanghai IDEA-I Implementation

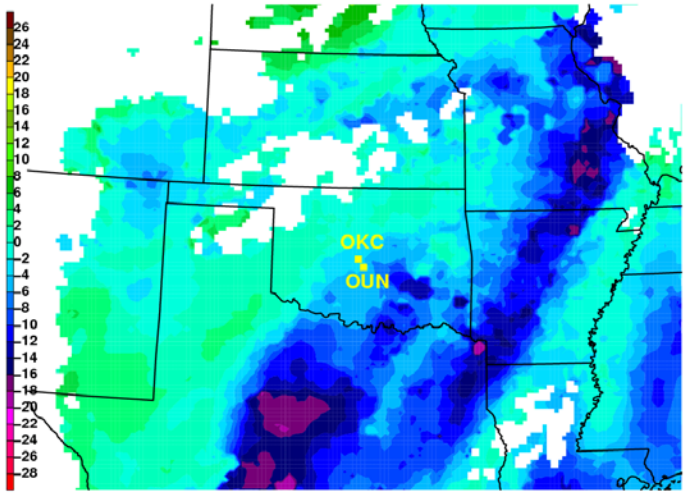
18 May, 2010



Beyond EDR - Information Data Record:
GOES Convective Instability Nearcasting





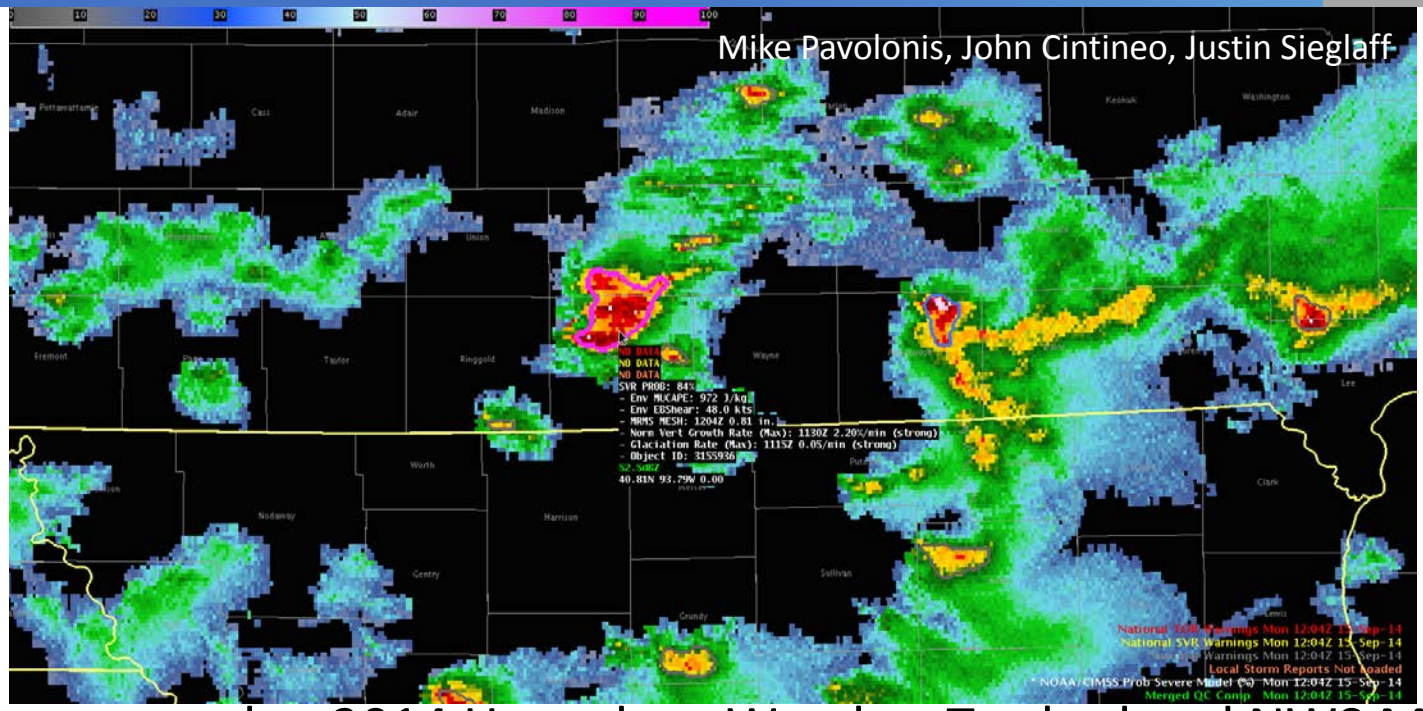


- Upper and Low-Level Theta-E Difference → 500-780-hPa Convective Instability
- Cool and dry air progressing east above a northward surge of low-level warm and moist air.
- This results in a destabilization of the region to the east of the cold front and dryline.

A Lagrangian transport model of upper and lower-level moisture observations from the GOES Sounder is used to make short-term predictions of convective instability.

Beyond EDR - Information Data Record:
ProbSevere Model for Storm Nowcasting

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



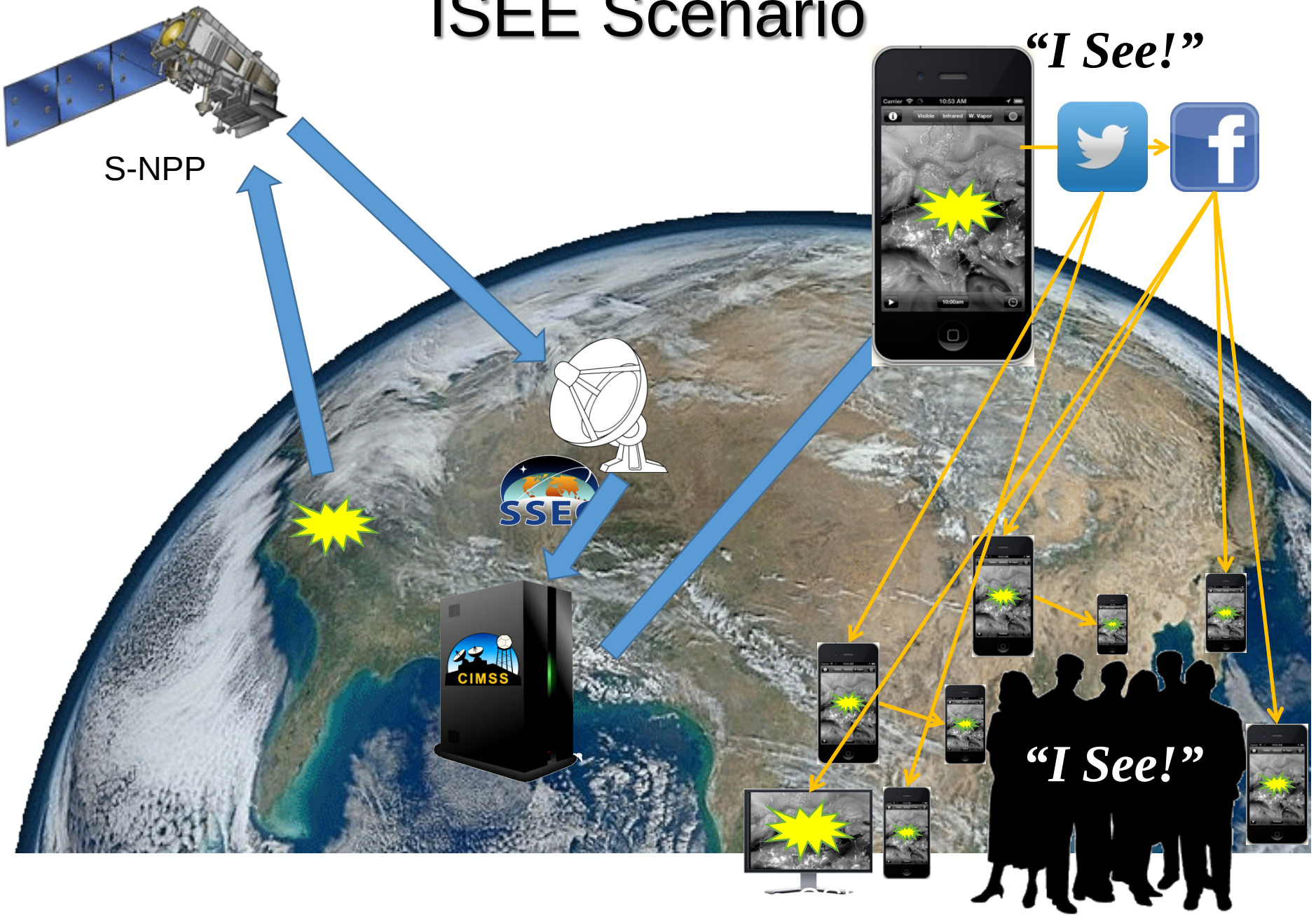
- Demonstrated at 2014 Hazardous Weather Testbed and NWS MKX
- 98% of forecasters would use it if available at their WFO (need AWIPS 2)
- 78% of forecasters found increased confidence in warning decision-making
- 47% of forecasters found increased lead-time to severe hazards—
  roughly doubles median lead time, adding an extra 10 minutes

ISEE: Innovative Satellite Enhancement Exploration

- Data processing
  - DB, Data Center, and RealEarth Servers
- Social Media Sharing
  - CIMSS Blog, Twitter, via RealEarth Browser
- Mobile display of data
  - WxSat
- Notifications
  - SatCam
- Simplification
  - (all the above)

Greater than the sum of its parts

ISEE Scenario



IMAPP and CSPP – Beyond 2017

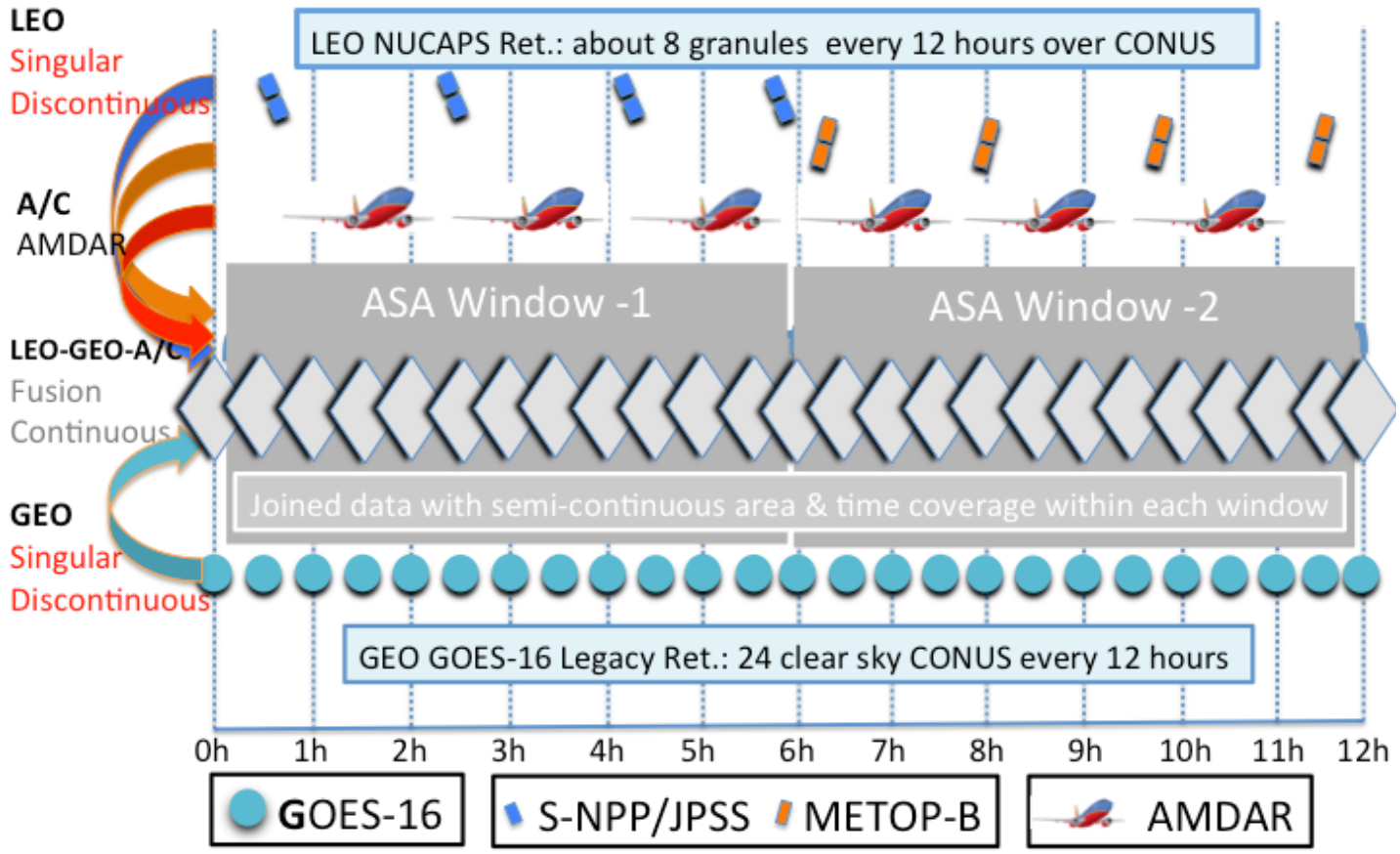
- The CSPP-LEO is funded by JPSS out to 2038!
- Actively seeking continuing support for CSPP-GEO
- The NASA support for IMAPP will continue for the lifetime of Terra & Aqua!

Our Guiding Principle:

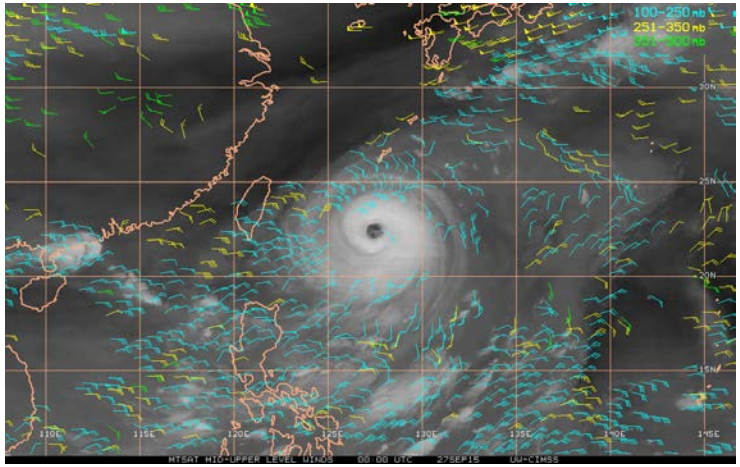
- ✓ Implementation of "Satellite Big Data Pyramid"
  - ❑ Enhanced EDR (Lev2)
  - ❑ Populate IDR (Lev3)
- ✓ Innovations and Friendly Competitions
  - ❑ Implementation of modern-day fusion technique
  - ❑ Leverage HPC, GIS, social media & mobile tech

IMAPP and CSPP – Beyond 2017

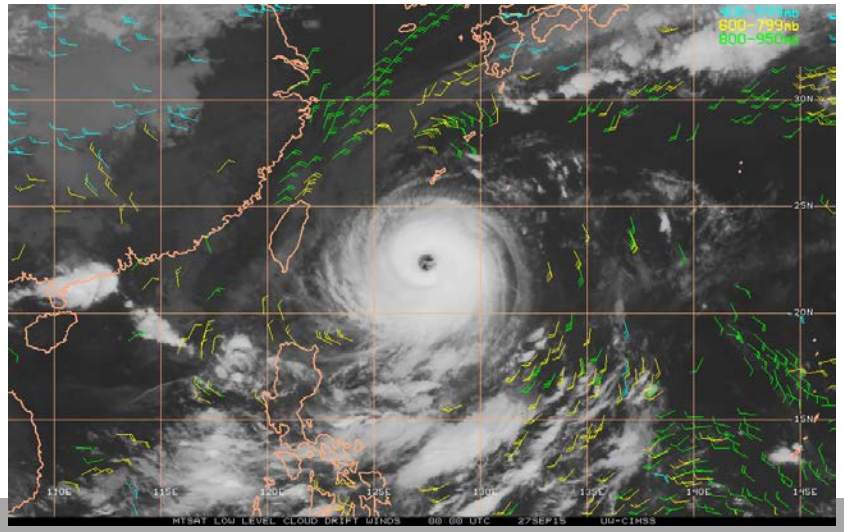
CSPP Innovation – Harness High Spectral, Temporal and Spatial Info. for Nowcasting

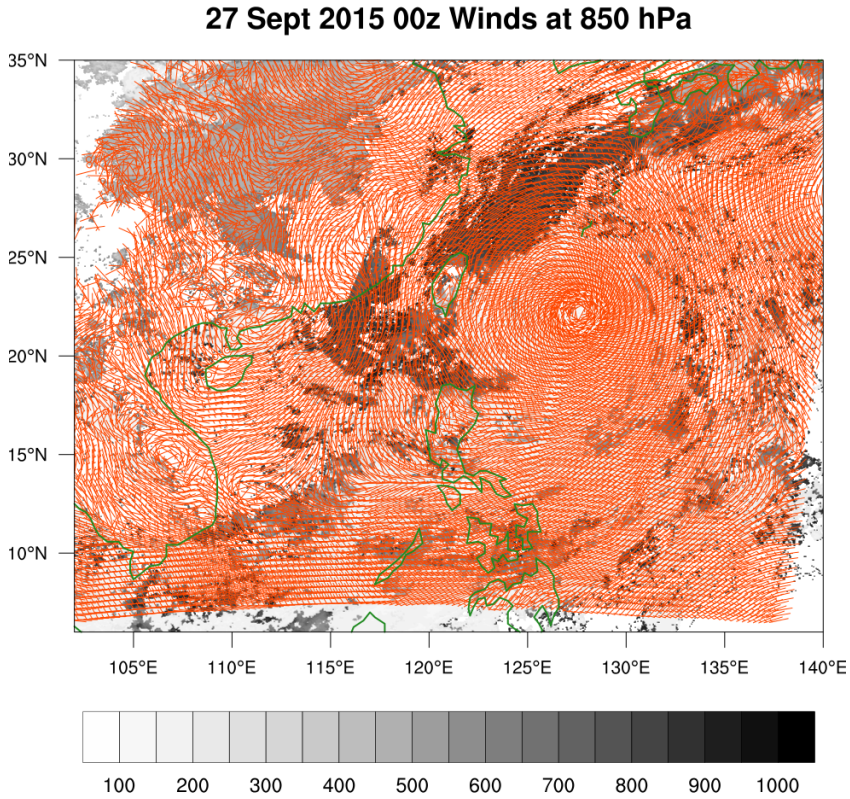


Enhanced Wind Profile with improved accuracy and vertical resolution - A friendly competition



Traditional Target Tracking AMV





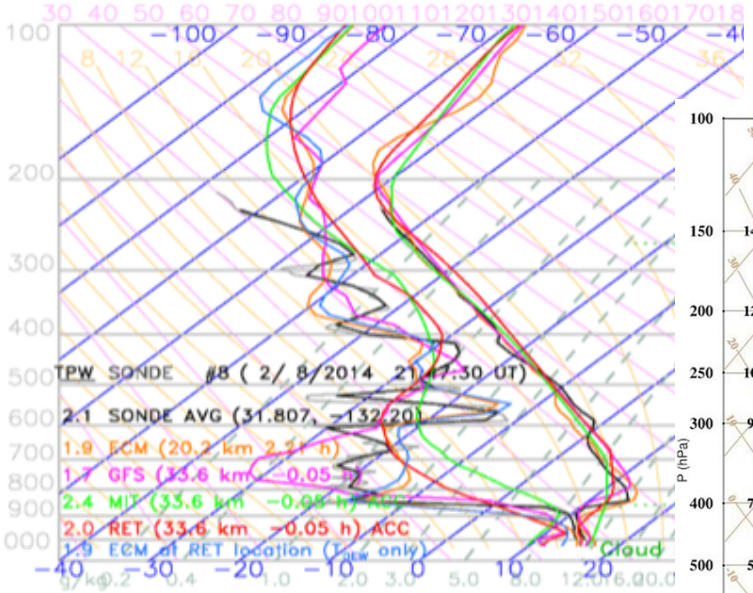
4D Variational AMV:

- Much higher yields (both H & V)
- No gaps in cloudy areas

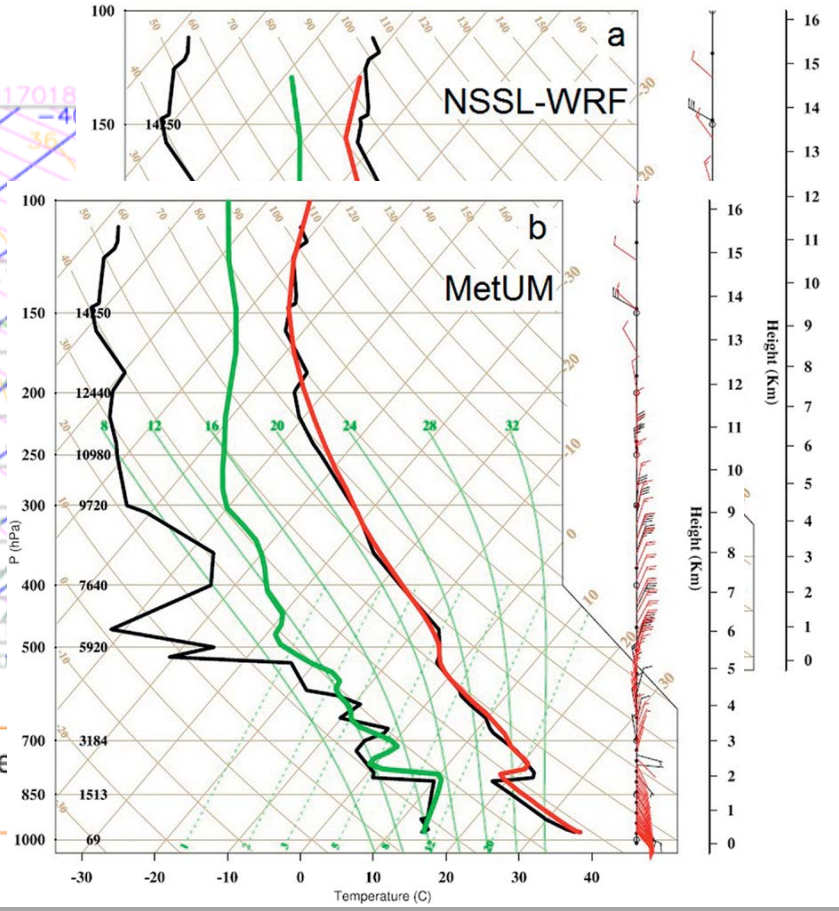
IMAPP and CSPP – Beyond 2017

Enhanced Sounding Profile with improved accuracy and vertical resolution - A friendly competition

- Black = dropsonde (full-res and smoothed)
- Cyan = GFS forecast interpolated to retrieval location
- Green = uW-only retrieval
- Red = IR+uW retrieval



This sonde was co-located at FOR #11 in the section



IMAPP and CSPP – Beyond 2017

SSEC is one of the Intel Parallel Computing Center & NVIDIA CUDA Research Center

Leveraging Accelerator (GPU, MIC) for HPC computing
- Technology Innovation

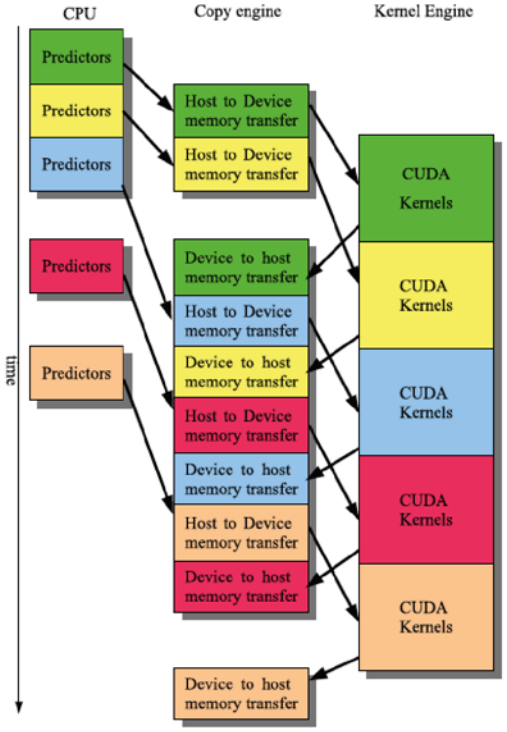


Fig. 2 Execution timeline of the radiative transfer model.

AMSU

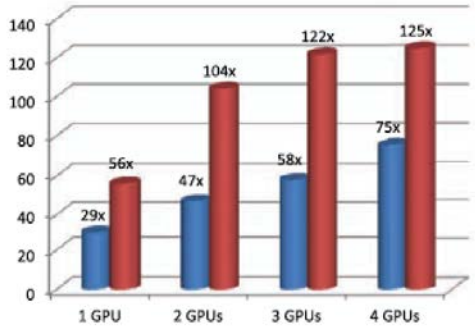


Fig. 9 Speedups for CPU/GPU-hybrid and pure-

Accelerating the RTTOV-7 IASI and AMSU-A radiative transfer models on graphics processing units: evaluating central processing unit/graphics processing unit-hybrid and pure-graphics processing unit approaches

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IASI

Table 5 Processing times and speedups for IASI for 1 to 4 GPUs.

Number of GPUs	Total time (ms)	Time per profile (ms)	Speedup
1	182.25	0.405	461×
2	185.20	0.206	908×
3	186.22	0.138	1354×
4	187.49	0.104	1793×

Journal of Applied Remote Sensing 051503-8 Vol. 5, 2011

IMAPP and CSPP – Beyond 2017

Leveraging Accelerator (GPU, MIC) for HPC computing
- Technology Innovation

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Parallel Construction of the WRF Pleim-Xiu Land Surface Scheme With Intel Many Integrated Core (MIC) Architecture

Melin Huang, Bormin Huang, and Hung-Lung Allen Huang

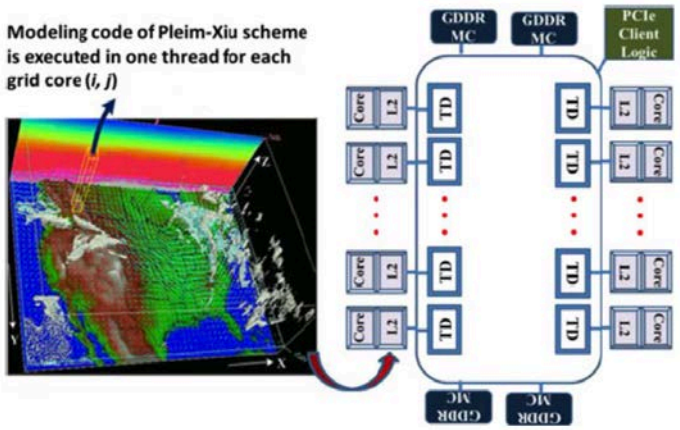

Fig. 2. Projection of each grid point (i, j) of the CONUS domain onto MIC thread domain, where each MIC processing core has four threads; the CONUS domain used in this work is 433 × 308 horizontal grid points with 35 vertical levels.

TABLE X
SUMMARY OF RUNTIMES AND SPEEDUPS OF THE PX SCHEME FOR VARIOUS IMPROVEMENT ACTIONS

Actions	runtime	speedup
Initial code on 1 CPU core	183.0 ms	
Initial code on1 CPU socket (8 cores)	35.3 ms	
Code on 1 MIC accelerator after *i*-loop fusion and combination of *if* statements	34.3 ms	1.0x/5.3x
Code on 1 MIC accelerator after scalarization	33.7 ms	1.1x/5.4x
Code on 1 MIC accelerator after applying vectorization directives and data process in parallel to subroutines *SOILPROP*, *PXSNOW*, and *SURFPX*	25.1 ms	1.4x/7.3x
Code on 1 MIC accelerator after applying vectorization directives and data process in parallel to subroutine *VEGELAND*	16.0 ms	2.2x/11.4x
Code on 1 MIC accelerator using optimal *CHUNK* = *32*	15.7 ms	2.3x/11.7x

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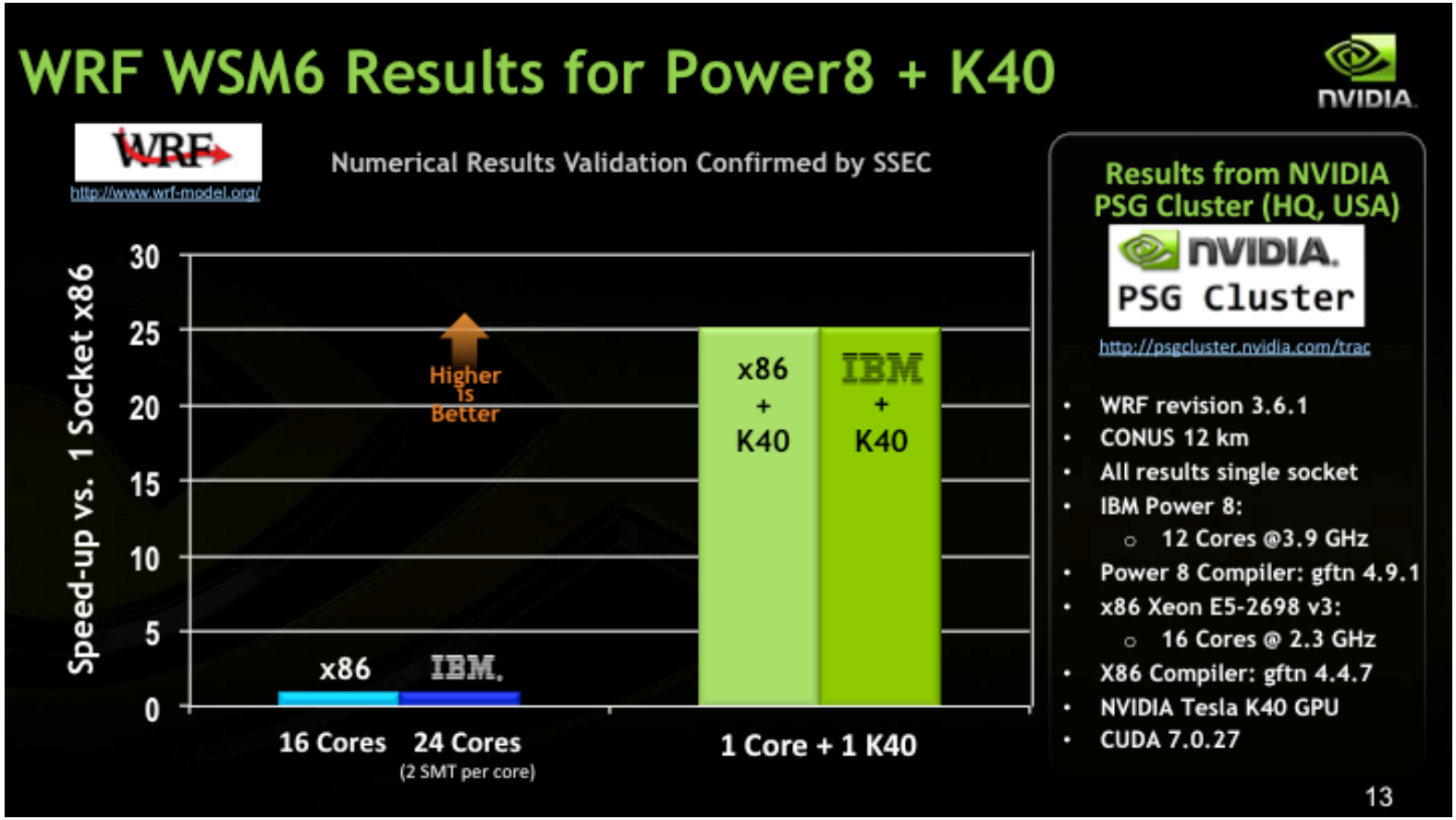

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SSEC Speedups of WRF Physics Modules

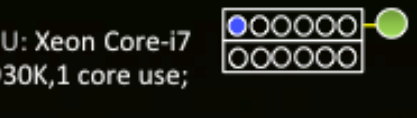
* Modules for initial NVIDIA-funded integration project

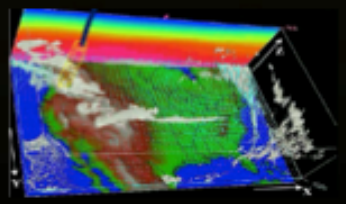
WRF Module	GPU Speedup (w-wo I/O)	Technical Paper Publication
Kessler MP	70x / 816x	J. Comp. & GeoSci., 52, 292-299, 2012
Purdue-Lin MP	156x / 692x	SPIE: doi:10.1117/12.901825
WSM 3-class MP	150x / 331x	
WSM 5-class MP *	202x / 350x	JSTARS, 5, 1256-1265, 2012
Eta MP	37x / 272x	SPIE: doi:10.1117/12.976908
WSM 6-class MP *	165x / 216x	Submitted to J. Comp. & GeoSci.
Goddard GCE MP	348x / 361x	Accepted for publication in JSTARS
Thompson MP *	76x / 153x	
SBU 5-class MP	213x / 896x	JSTARS, 5, 625-633, 2012
WDM 5-class MP	147x / 206x	
WDM 6-class MP	150x / 206x	J. Atmo. Ocean. Tech., 30, 2896, 2013
RRTMG LW *	123x / 127x	JSTARS, 7, 3660-3667, 2014
RRTMG SW *	202x / 207x	Submitted to J. Atmos. Ocean. Tech.
Goddard SW	92x / 134x	JSTARS, 5, 555-562, 2012
Dudhia SW *	19x / 409x	
MYNN SL	6x / 113x	
TEMF SL	5x / 214x	
Thermal Diffusion LS	10x / 311x	Submitted to JSATRS
YSU PBL *	34x / 193x	Submitted to GMD

Hybrid WRF Customer Benchmark Capability Staring in 2H 2015

Hardware and Benchmark Case

CPU: Xeon Core-i7 3930K,1 core use;





Benchmark: CONUS 12 km for 24 Oct 24; 433 x 308, 35 levels

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From ITPP, IAPP, IMAPP to CSPP –
Supporting Direct Broadcast Users Over Three Decades
Summary

Implementing NOAA/NASA Big Data Pyramid (SDR to EDR to IDR):

- Developing & maintaining IMAPP/CSPP infrastructure
  - MODIS/AIRS/AMSU IR/MW/VIS EDR
  - CrIS/ATMS/VIIRS IR/MW/VIS EDR
  - EDR to IDR (Now/Near Casting; Air Quality; Aviation Safety, …..)
- DB Network
- Fusion Innovation
- Open & Sharing
- Collaboration & Training
- Leveraging new technology

Make them available to all users & continue to maintain, upgrade, innovate, & support them!

Thank you!

Questions are welcomed

IMAPP: http://cimss.ssec.wisc.edu/imapp/

CSPP Leo: http://cimss.ssec.wisc.edu/cspp/

CSPP Geo: http://cimss.ssec.wisc.edu/csppgeo/

ISEE/RealEarth: http://isee.ssec.wisc.edu/