

# McIDAS Activities Within The NASA Langley Research Center Clouds And Radiation Group

Kristopher Bedka

*Science Systems and Applications Inc @ NASA LaRC*

**In Collaboration With** (in alphabetical order)

J. K. Ayers, S. Bedka, T. Chee, M. Khaiyer, P. Minnis, L. Nguyen,  
R. Palikonda, B. Shan, W. Smith Jr., and D. Spangenberg

# NASA LaRC Clouds and Radiation Group: Background

- The NASA LaRC Clouds and Radiation group's major research responsibilities involve the development and application of advanced data analysis techniques to interpret satellite measurements of clouds and radiative characteristics of the Earth

- **Specific areas of research include**

- 1) *Developing a globally robust technique for retrieving cloud parameters and microphysical properties*

- 2) *Developing methods for detecting contrails from space and determining their impact on climate*

- 3) *Performing satellite and radiative transfer studies of cirrus, marine stratocumulus, and deep convective clouds*

- 4) *Developing methods for calibrating satellites*

- 5) *Determining radiative flux and cloud water profiles from remote sensing data*

- 6) *Assimilation of satellite cloud observations in numerical weather prediction models*

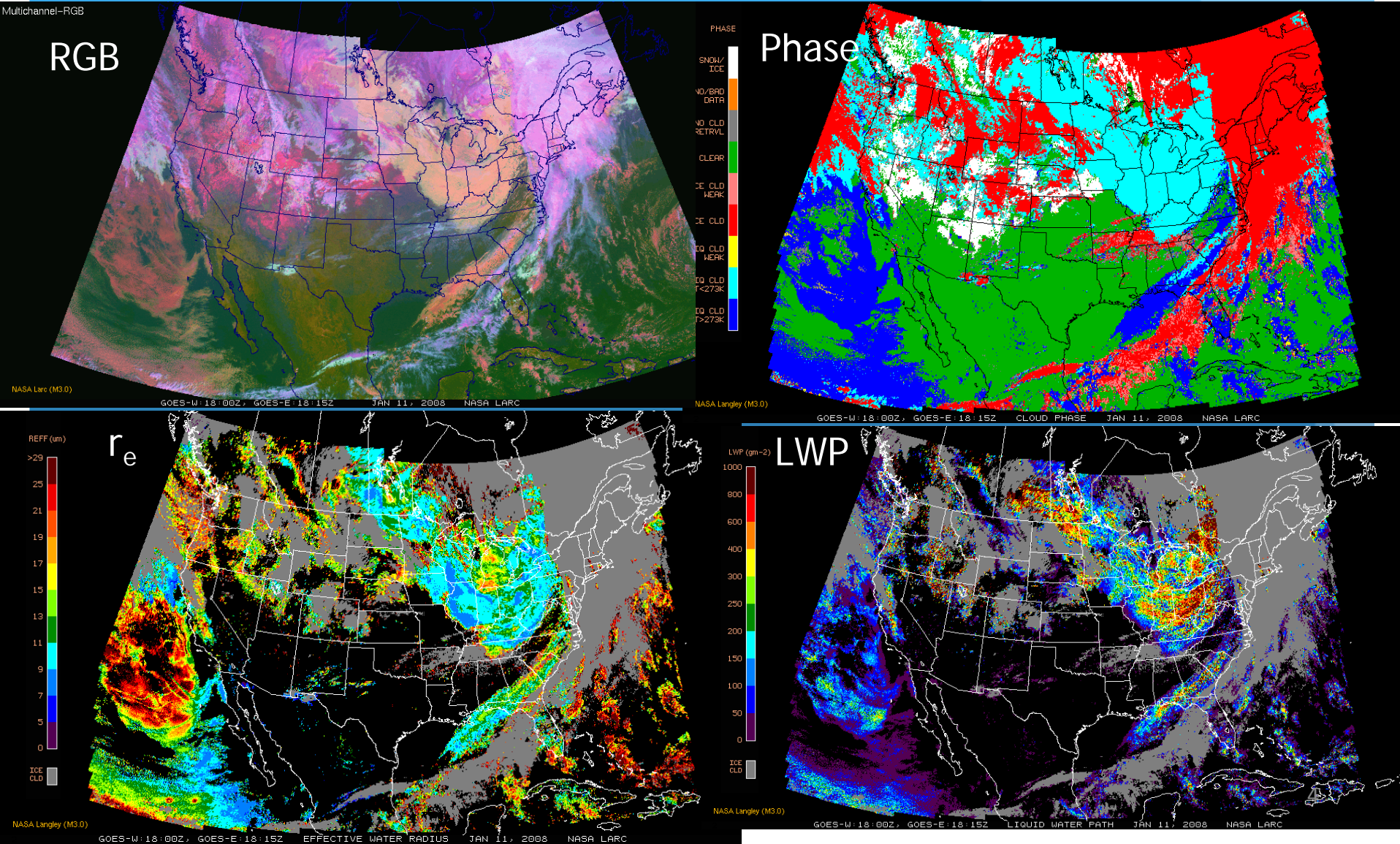
- 7) *Nowcasting aircraft icing conditions*

# McIDAS at NASA LaRC: Background

- NASA LaRC has been a McIDAS Users Group member for ~20 years
- McIDAS-X initially used to better visualize GOES data (versus a stack of printed B&W images), prototyping of a visible channel calibration algorithm, and aircraft contrail research
- McIDAS-X has been used to support the U.S. Department of Energy (DOE) Atmospheric Radiation Measurement (ARM) program and participation in field campaigns, which was significant to the early growth and success of the Clouds and Radiation group. These activities continue at the present time
- McIDAS used to acquire and process real time satellite imagery and numerical weather prediction model fields. Datasets are combined with McIDAS library/subroutine calls to produce real-time cloud property retrievals and radiative flux estimates
  - *Products ingested by the operational weather forecasting community at NCEP and NOAA ESRL. McIDAS-based graphical output is displayed on the web*
- McIDAS has played a critical role in LaRC research/development, real-time data acquisition, and product generation. We anticipate that this will continue in the McIDAS-V era

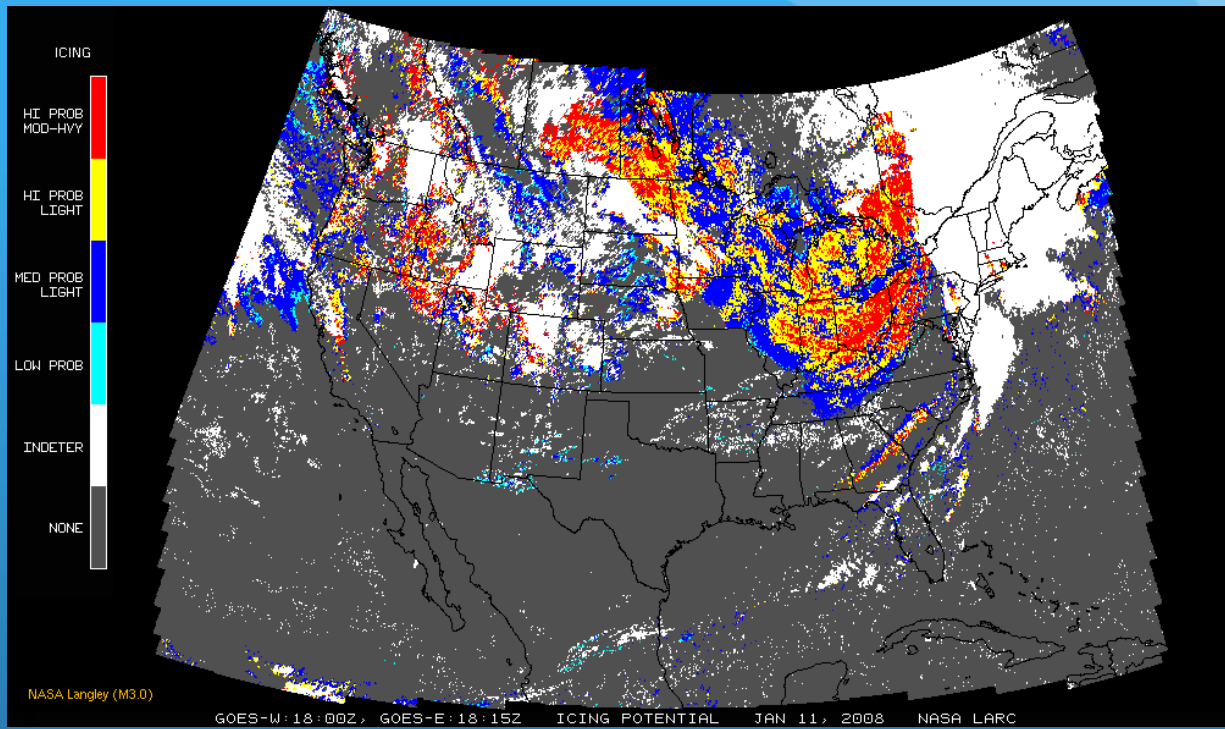
# McIDAS-X Imagery of LaRC Cloud Properties

- McIDAS-X is used within the LaRC cloud property retrieval algorithm and for production of real-time graphical output. GOES products are available online for ~6 years <http://angler.larc.nasa.gov>





# McIDAS-X Imagery of LaRC In-Flight Icing Potential



## In-flight Aircraft Icing depends on:

- *Presence of super-cooled liquid water*
- *Liquid water content*
- *Droplet size distribution*
- *Temperature*

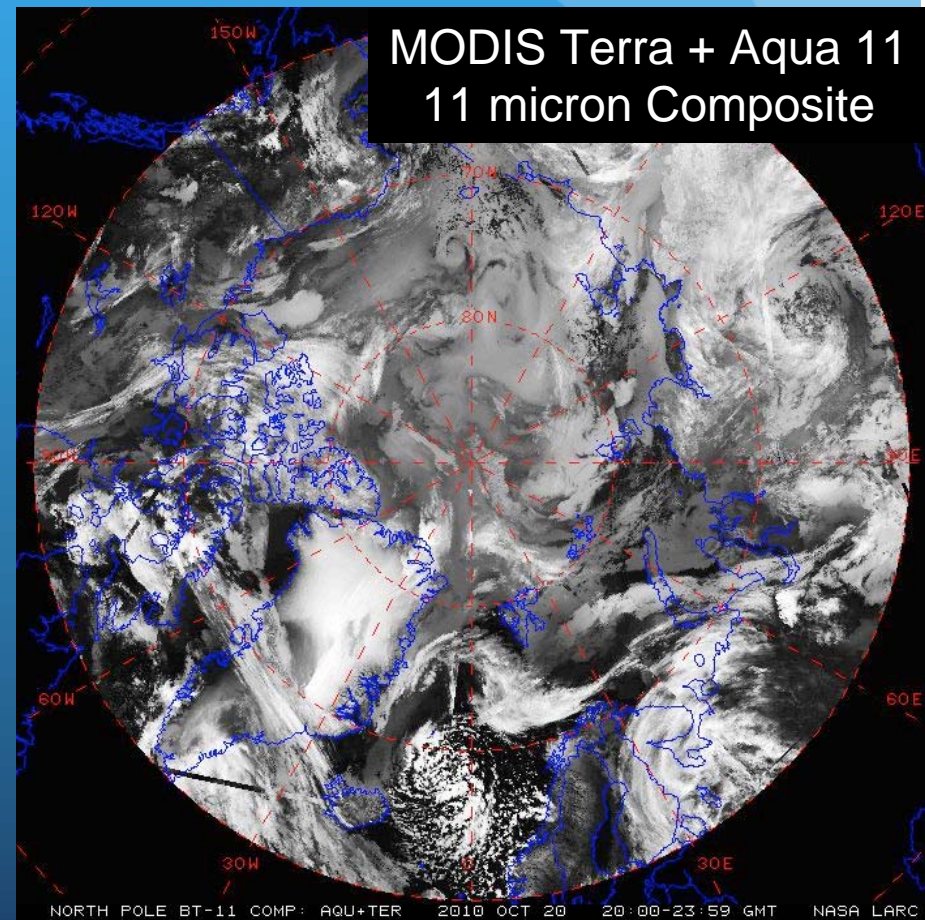
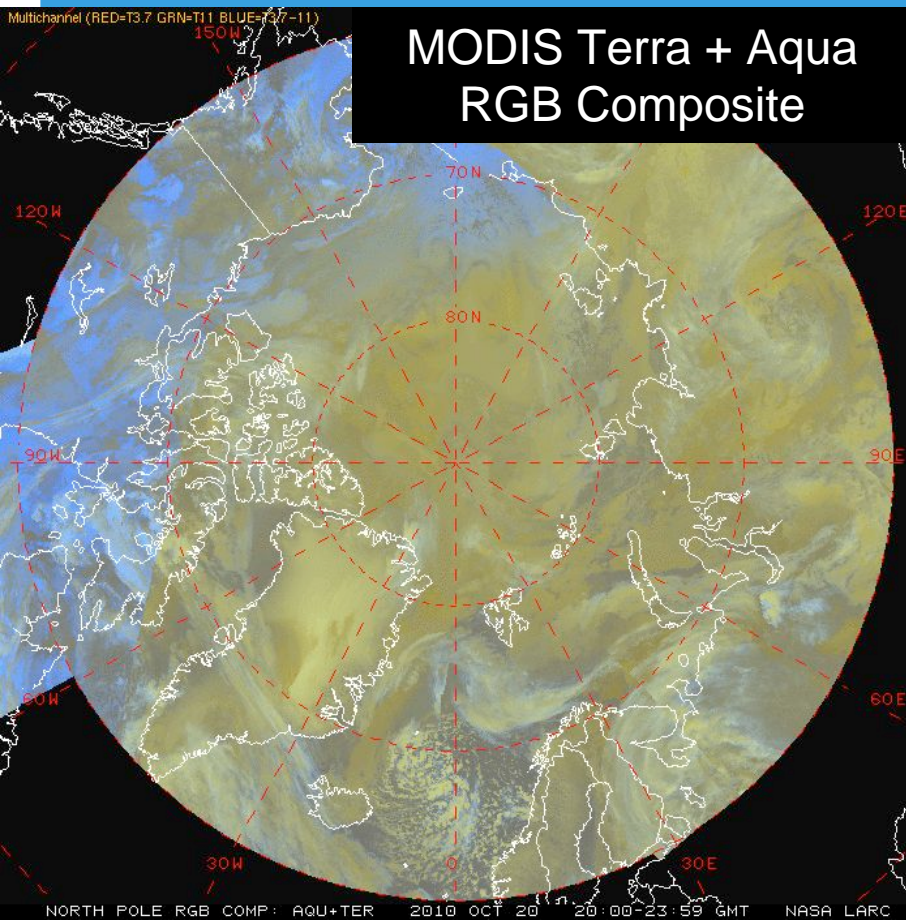
## Satellite remote sensing can provide

- *Cloud top temperature and phase*
- *Liquid water path*
- *Ice particle effective radius*

Probability of icing is estimated using an empirical fit of satellite-derived microphysical products and co-located pilot reports (PIREPS) of icing

# McIDAS-X MODIS Polar Composite Imagery

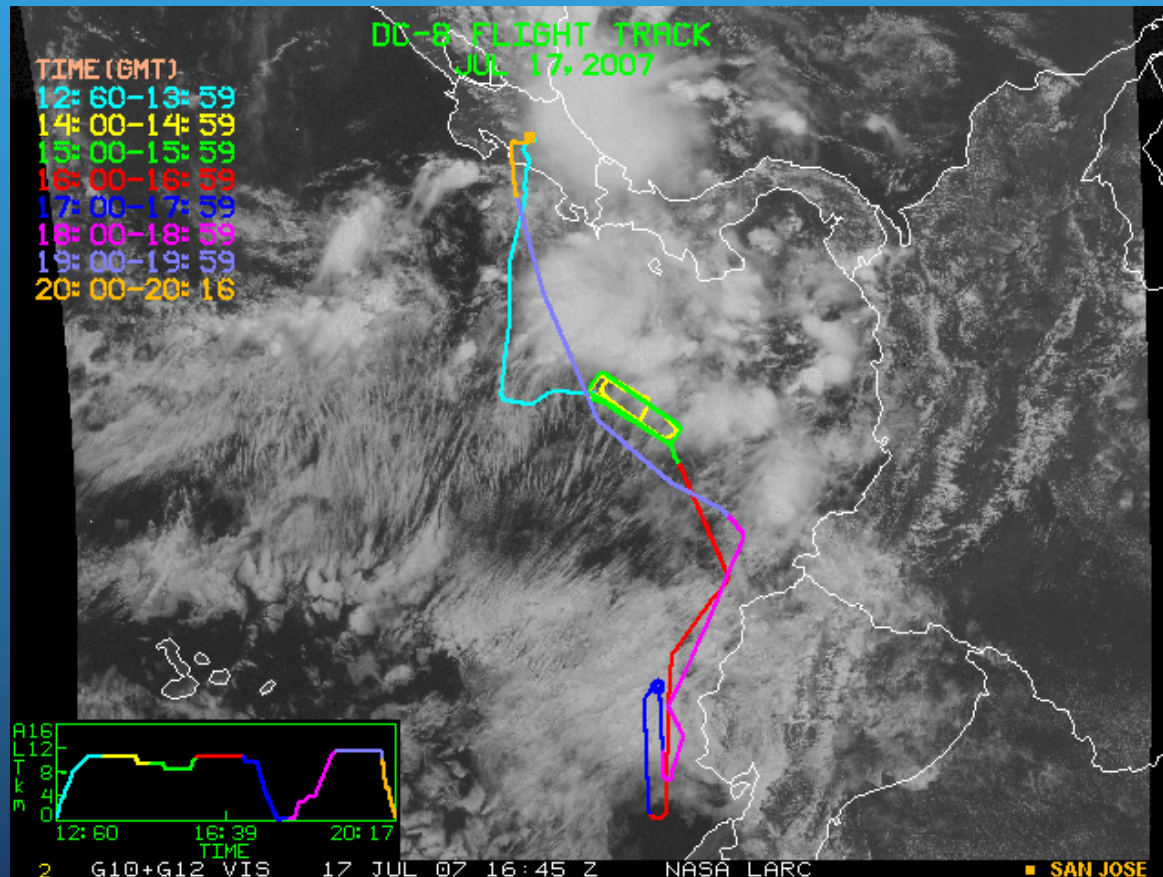
- McIDAS-X is used to merge, remap, and display a daily MODIS Terra and Aqua image and RGB composite





# Use of McIDAS-X in Support of Field Experiments

- Real-time NASA LaRC cloud property output displayed in McIDAS-X have been used for flight planning and near-real time tracking of research aircraft during field experiments
- McIDAS-X is also used to display aircraft flight tracks atop time matched geostationary satellite imagery. These are very helpful for identifying case studies featuring specific phenomena likely observed by the aircraft



# Use of McIDAS-X in Web-Based Applications: Satellite Overpass Predictor

- McIDAS is combined with LaRC-developed software to find and display the locations of various polar-orbiting satellite overpasses relative to a user selected coordinate. Imagery and an ascii text summary are provided to the user

## NASA LaRC Satellite Overpass Predictor

Satellite Name:  Instrument Swath:  Resolution:

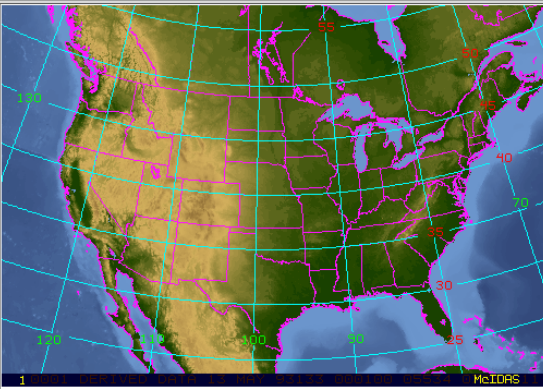
Start Date:    Number of predict days:

Limit satellite view angle (optional):  Limit solar zenith angle:  Day  Night  All

Generate 5 days of the Orbital Track (optional) [ may take additional 8-10 sec to generate the tracks ]  
 GIF Track  ASCII Track

\*Enter Lat/Lon/Site Name or click on the Map\*  
 Latitude:  Longitude:

Ground Site:



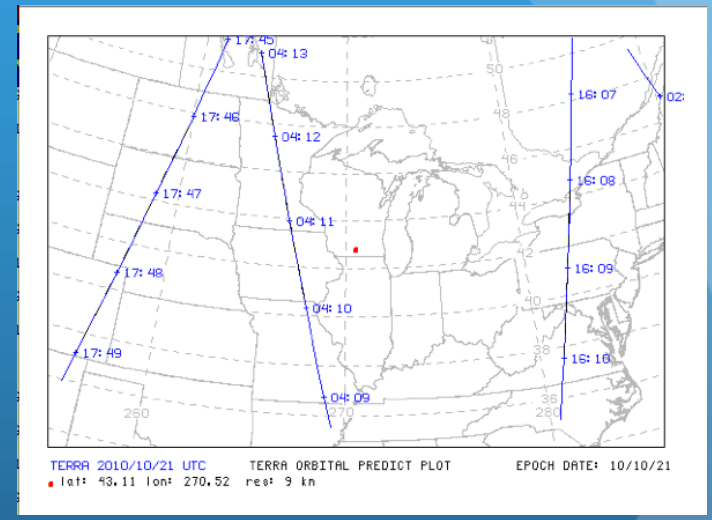
Continent/Country Maps:

U.S.A.  N. Pacific  N. Atlantic  N.America  World  Asia  
 Europe  Africa  Australia  S.America

Experiment Site Maps:

SGP  CRYSTAL  TWP  NSA  SHEBA  ATRC  
 UAE  NAMMA  TC4  AMF China  VOCALS

The predictions will take about 30 seconds to generate.



Site name is: Optional, Spacecraft is: TERRA  
 Geodetic latitude = 43.11N, Longitude = 89.48W, Geocentric latitude = 42.92N, Local radius = 6368.2km

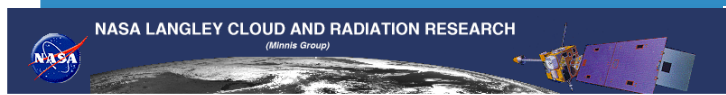
GMT	year	mo	da	hr	mn	sc	azimuth	elevation	zenith	zenith	azimuth	Relative (hh-180)	Scat ang	Glint	prob(t)	heading	direction	site	Dist to (1165 km)	MODIS (330 km)	MODIS (180 km)	ASTER (30 km)
2010 10 21 4 10 33	2010	10	21	4	10	33	258.27	66.04	23.96	142.04	63.16	999.99	0.00	346.10	ascend	281.46	+	+	-	-	-	
2010 10 21 16 8 53	2010	10	21	16	8	53	95.83	29.55	60.45	57.82	56.80	131.75	0.00	193.86	descend	995.14	+	+	-	-	-	
2010 10 21 17 46 34	2010	10	21	17	46	34	292.37	30.89	59.11	53.77	111.04	93.15	0.00	194.48	descend	952.49	+	+	-	-	-	
2010 10 22 3 15 42	2010	10	22	3	15	42	68.99	36.28	53.72	134.97	124.86	999.99	0.00	345.70	ascend	804.11	+	+	-	-	-	
2010 10 22 4 53 30	2010	10	22	4	53	30	265.48	24.98	65.02	146.37	72.54	999.99	0.00	346.24	ascend	1155.02	+	+	-	-	-	
2010 10 22 16 51 47	2010	10	22	16	51	47	102.88	78.96	11.04	55.31	62.07	129.22	0.13	194.03	descend	124.49	+	+	+	+	-	
2010 10 23 3 58 19	2010	10	23	3	58	19	256.23	86.58	3.42	141.24	60.58	999.99	0.00	346.04	ascend	38.17	+	+	-	-	-	
2010 10 23 15 56 34	2010	10	23	15	56	34	93.79	22.76	67.24	59.54	55.89	129.93	0.00	193.84	descend	1243.63	-	-	-	-	-	
2010 10 23 17 34 26	2010	10	23	17	34	26	290.25	39.76	50.24	54.49	112.50	97.59	0.01	194.35	descend	721.19	+	+	-	-	-	
2010 10 24 3 3 33	2010	10	24	3	3	33	66.87	28.33	61.67	133.67	126.51	999.99	0.00	345.57	ascend	1035.19	+	+	-	-	-	
2010 10 24 4 41 11	2010	10	24	4	41	11	263.46	32.47	57.53	146.13	69.20	999.99	0.00	346.21	ascend	906.84	+	+	-	-	-	
2010 10 24 16 39 32	2010	10	24	16	39	32	100.89	59.64	30.36	56.63	60.73	132.92	0.00	193.97	descend	368.60	+	+	-	-	-	
2010 10 25 3 46 6	2010	10	25	3	46	6	74.25	72.30	17.70	140.24	122.01	999.99	0.00	345.97	ascend	203.00	+	+	-	-	-	
2010 10 25 17 22 16	2010	10	25	17	22	16	288.15	51.99	38.01	55.33	113.91	104.06	0.15	194.24	descend	485.75	+	+	-	-	-	





# Use of McIDAS-X in Web-Based Applications: NWP Model Thermodynamic Profile Viewer

- McIDAS is called via a web-based tool to create a skew-T diagram from Rapid Update Cycle (RUC) model output at a user-selected coordinate
- This has been used by LaRC scientists to evaluate cloud retrievals and undergraduate students for weather analysis and forecasting



## PLOT SOUNDING FROM RUC ANALYSIS OR FORECAST

Select date and time. Then to request a sounding plot pick a location by either clicking on the MAP at that location or below you may submit the Lat/Lon, the Airport Code, or the Ground Site, then click DISPLAY.

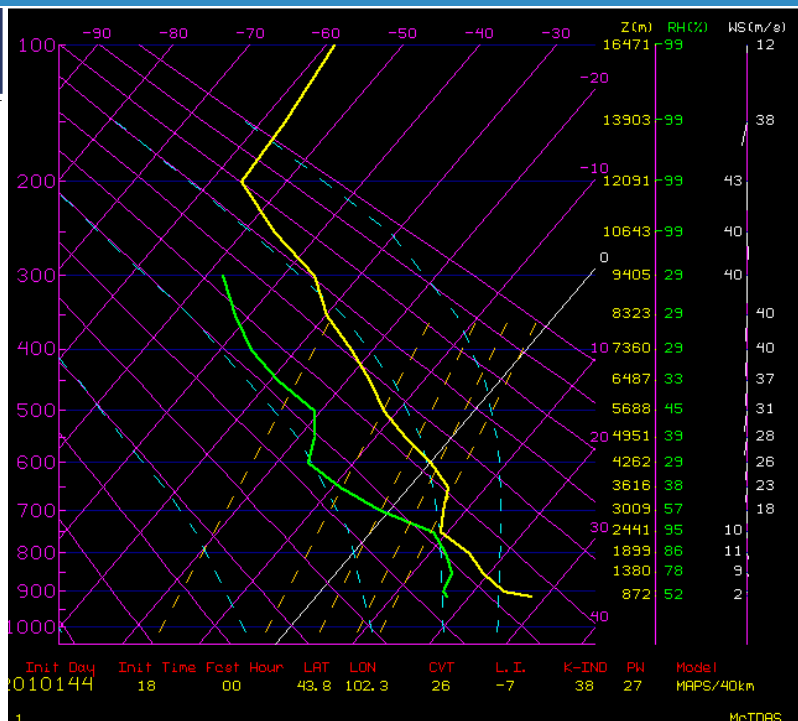
higher vertical resolution is provided for most recent month

YEAR: 2010 MONTH: May DAY: 24 TIME: 18:00 Z

LAT / LON(W+): xx.xx / xxx.xx  
AIRPORT CODE: CODE  
GROUND SITE: SGP-CF.36.62/97.50

Submit Submit Submit

(RESET) (DISPLAY)

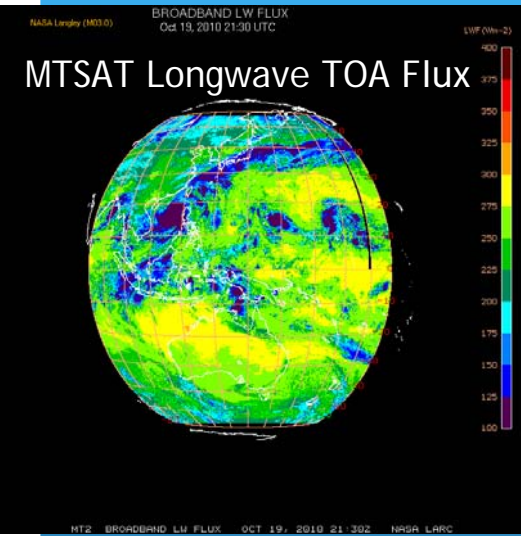


lev	P(mb)	Z(km)	T(K)	Td(K)	RH(%)
1	911.90	0.87	301.00	290.17	52.01
2	900.00	0.88	296.50	288.69	61.69
3	850.00	1.38	292.10	288.26	78.44
4	800.00	1.90	287.80	285.44	85.78
5	750.00	2.44	282.00	281.19	94.65
6	700.00	3.01	279.70	271.83	57.29
7	650.00	3.62	277.50	264.45	38.29
8	600.00	4.26	272.89	257.00	29.28
9	550.00	4.95	267.00	255.17	38.80
10	500.00	5.69	261.30	251.64	44.72
11	450.00	6.49	256.39	243.83	33.08
12	400.00	7.36	249.90	236.60	28.76
13	350.00	8.32	243.10	230.74	29.28
14	300.00	9.40	236.70	224.91	28.89
15	250.00	10.64	227.30	-99.00	-99.00
16	200.00	12.09	216.70	-99.00	-99.00
17	150.00	13.90	215.50	-99.00	-99.00
18	100.00	16.47	213.60	-99.00	-99.00

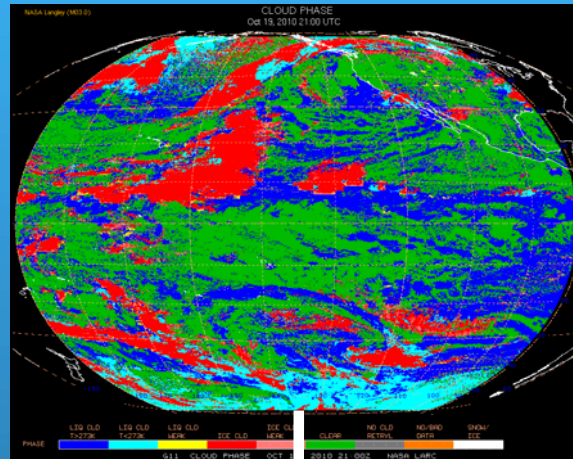
# Transitioning Into The McIDAS-V Era

- McIDAS-V provides the capability to synchronize a diverse array of data and user-derived products in a unified 4-D framework, offering a diversity of display and analysis capabilities provided by no other visualization software
- Due to our extensive experience with and dependence on McIDAS-X at LaRC, integration of McIDAS-V into our real-time product generation and analysis will require time investment and training
- Thus far, McIDAS-V has been used at LaRC to study and/or visualize:
  - Real-time global geostationary cloud and radiation products
  - Aircraft contrails and associated cloud microphysical retrievals
  - NASA MODIS, CALIPSO, and CloudSat imagery and products
  - Satellite-observed deep convective cloud top signatures and their relationship with severe weather and aircraft turbulence
  - Satellite-derived cloud vertical thickness, cloud icing intensity, and cloud water content profiles

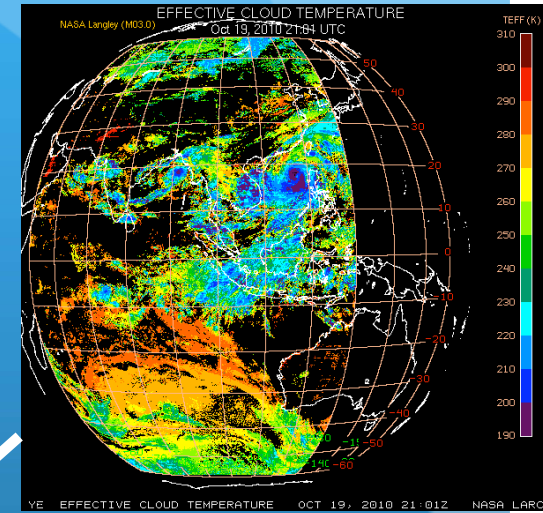
# Global Composite of LaRC Geostationary Cloud and Radiation Products



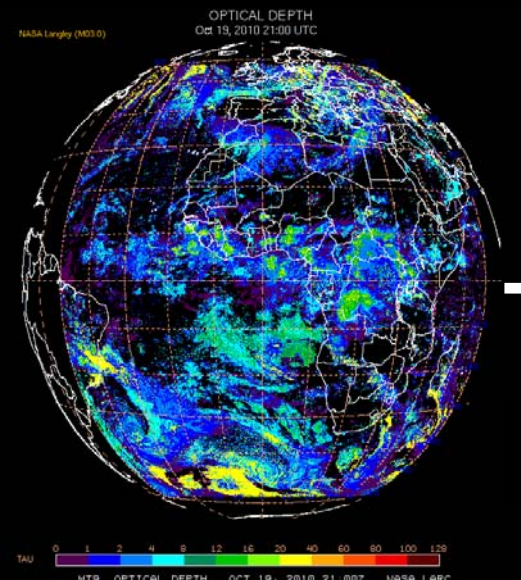
GOES-West Cloud Phase



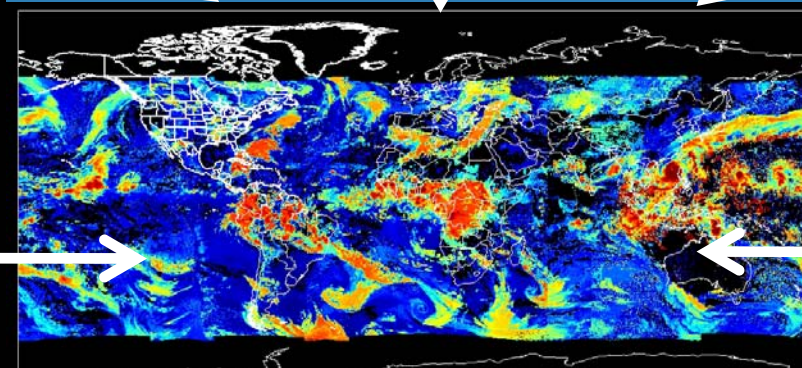
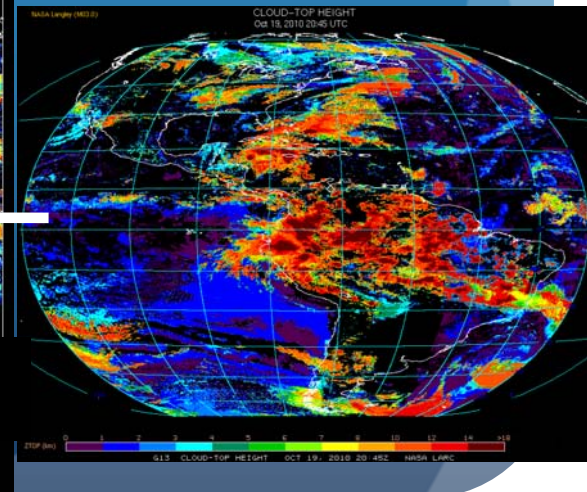
FY-2E Cloud Temperature



SEVIRI Cloud Optical Depth



GOES-East Cloud Height



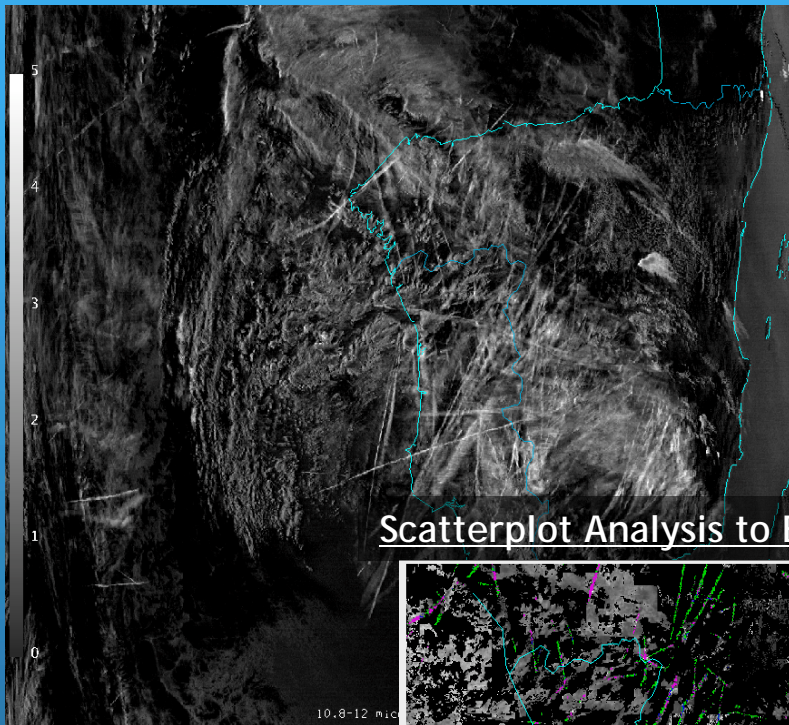
Global Geostationary Clouds and Radiation Composite in Mc-V via NetCDF



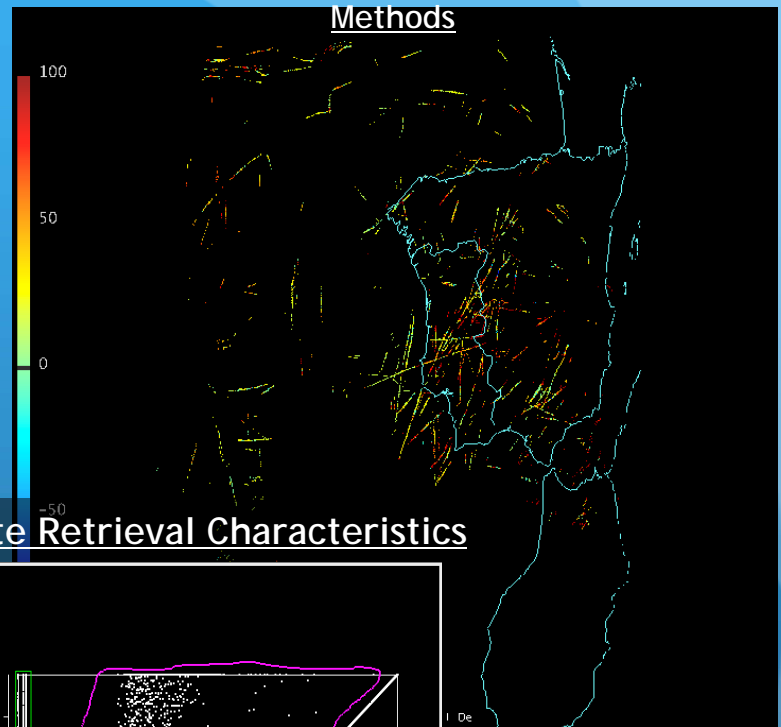


# McIDAS-V in MODIS Aircraft Contrail Research

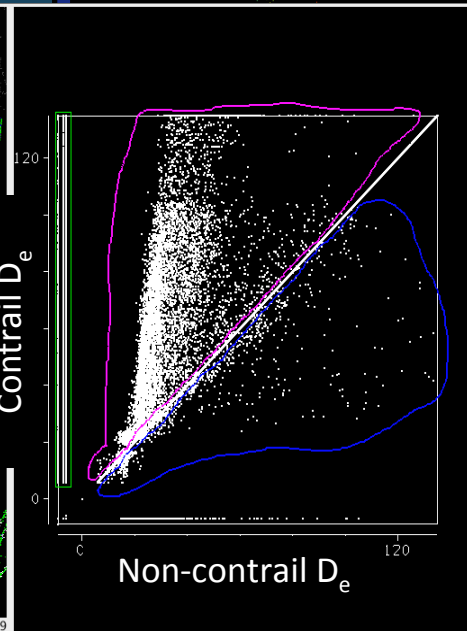
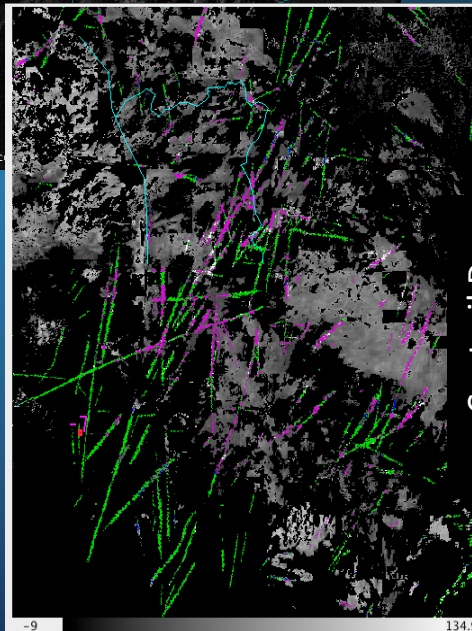
## Split Window Spectral Band Difference



## Difference Between Contrail Ice Particle Retrieval



## Scatterplot Analysis to Evaluate Retrieval Characteristics



320

300

280

260

240

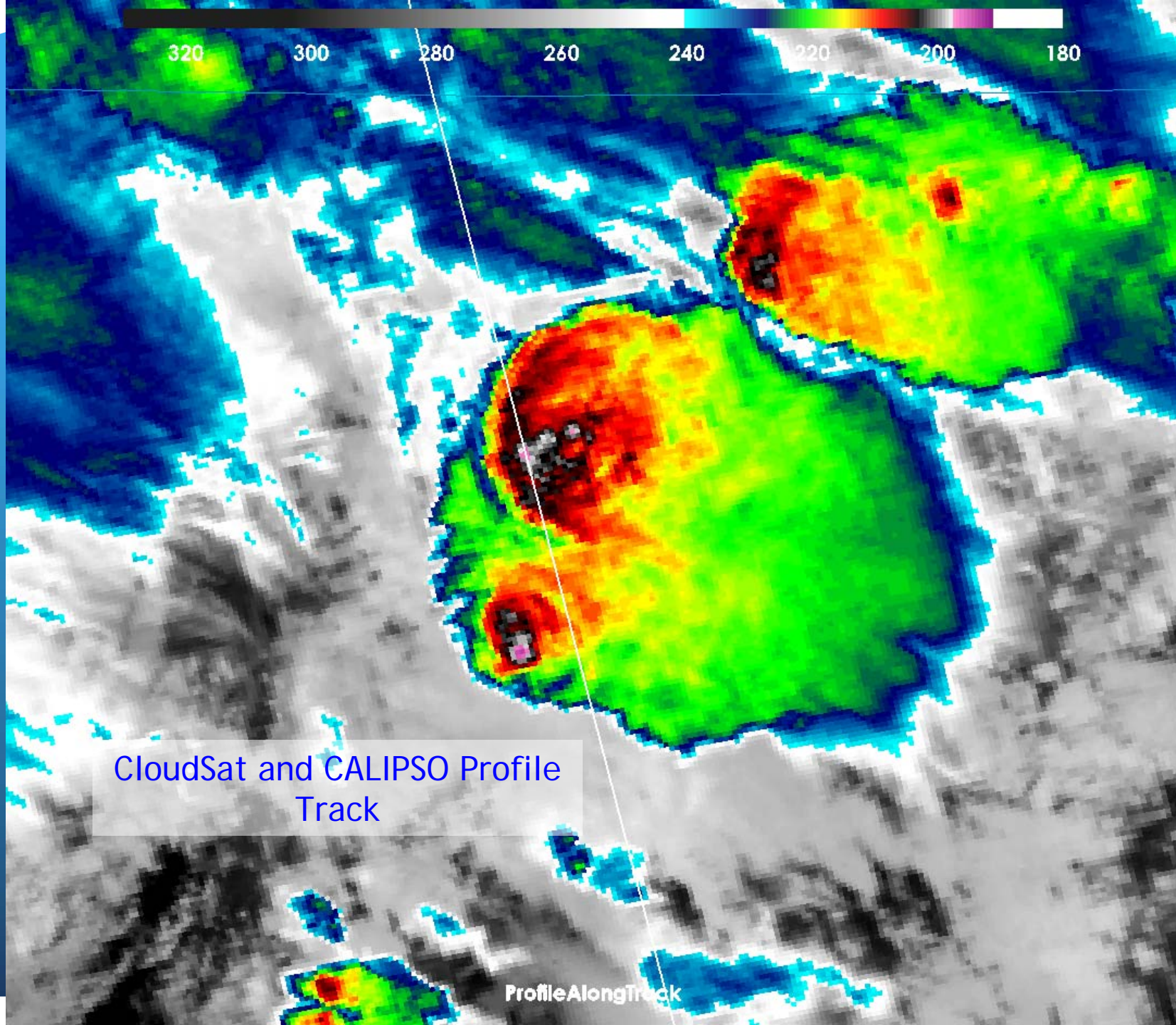
220

200

180

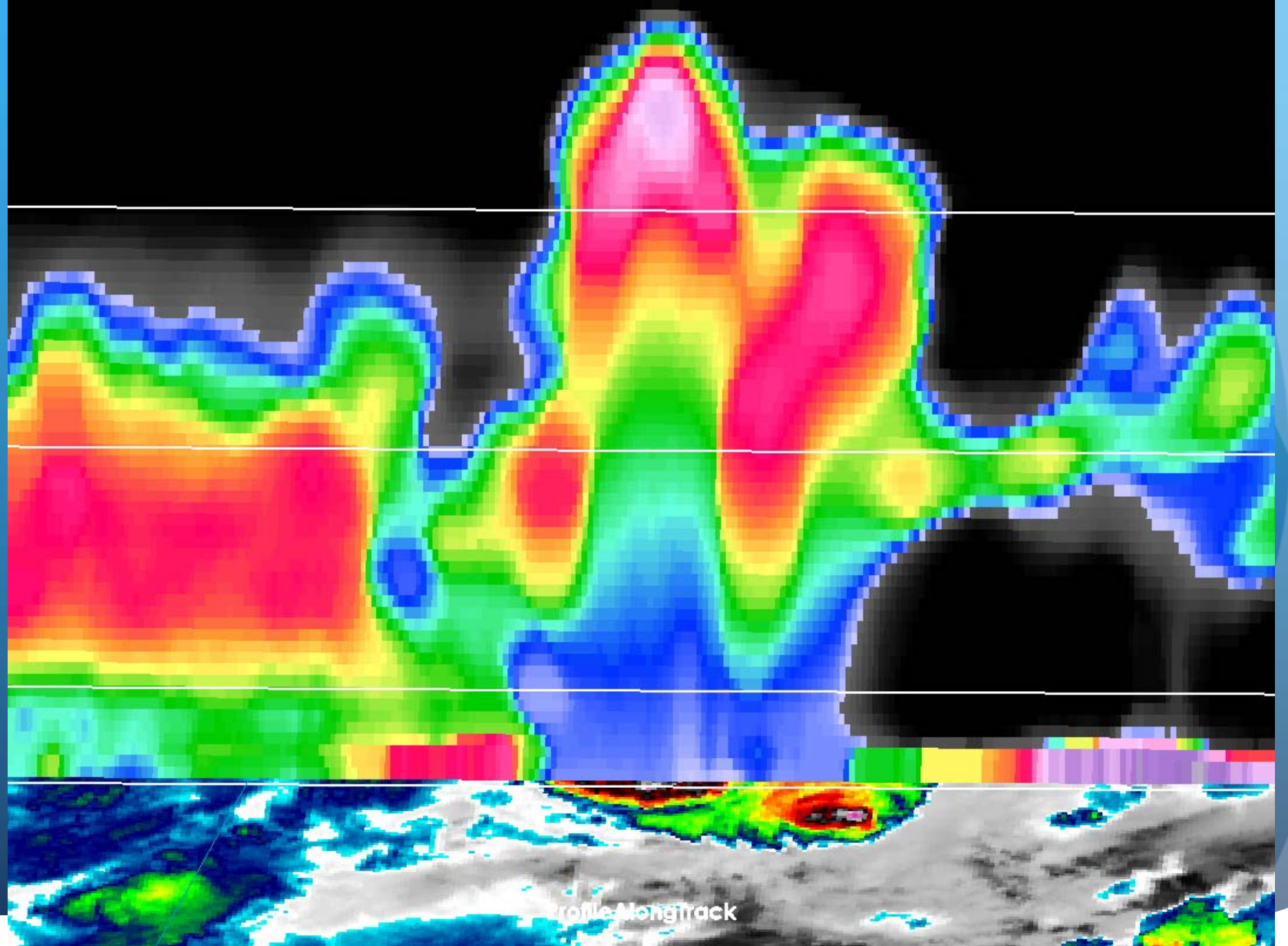
CloudSat and CALIPSO Profile  
Track

ProfileAlongTrack





# CloudSat Cloud Profiling Radar Reflectivity (2B-GEOPROF)





# McIDAS-V Visualization of GOES-R ABI

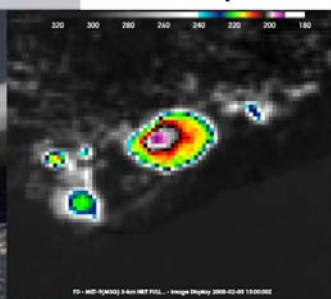
## Overshooting Top and Enhanced-V Detection Output

- MODIS/GOES/SEVIRI imagery, GOES-R ABI overshooting top and enhanced-V detection products, point severe weather, and point turbulence observations are synchronized in time and space. McIDAS-V helps us to show the accuracy and value of these satellite-derived products for identifying hazardous storms

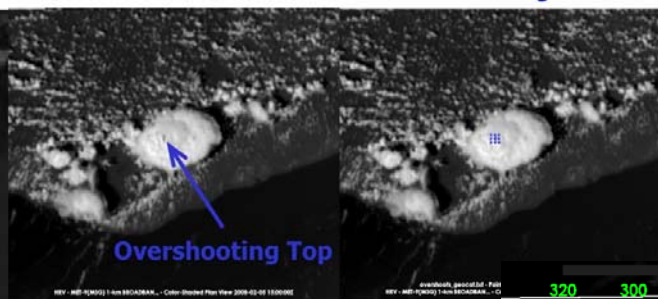
Photo From International Space Station



3 km MSG SEVIRI 10.8  $\mu$ m Infrared

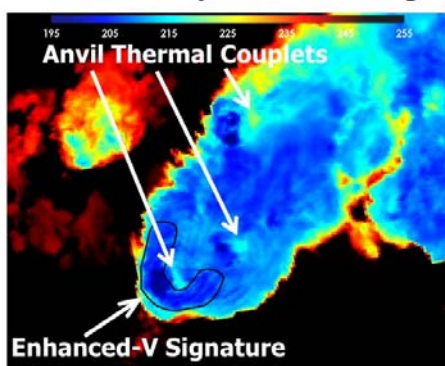


1 km MSG SEVIRI Visible

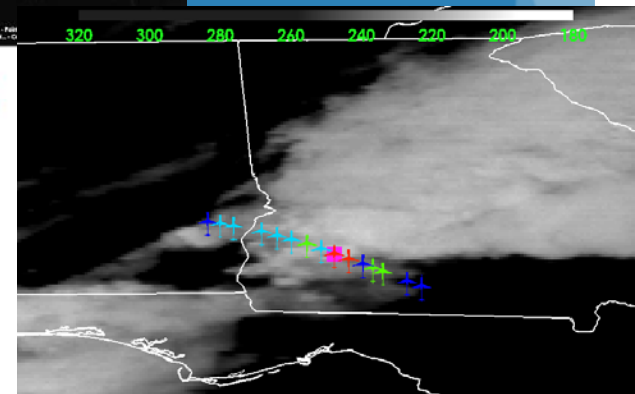
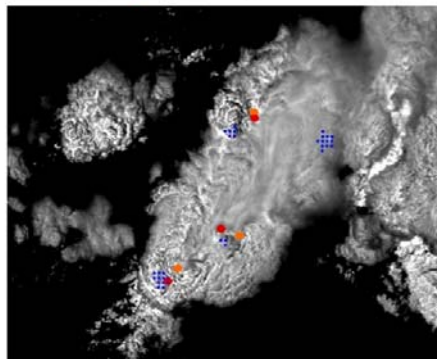


1 km MSG SEVIRI Visible With Overshooting Detection

1 km MODIS 11  $\mu$ m Infrared Imagery



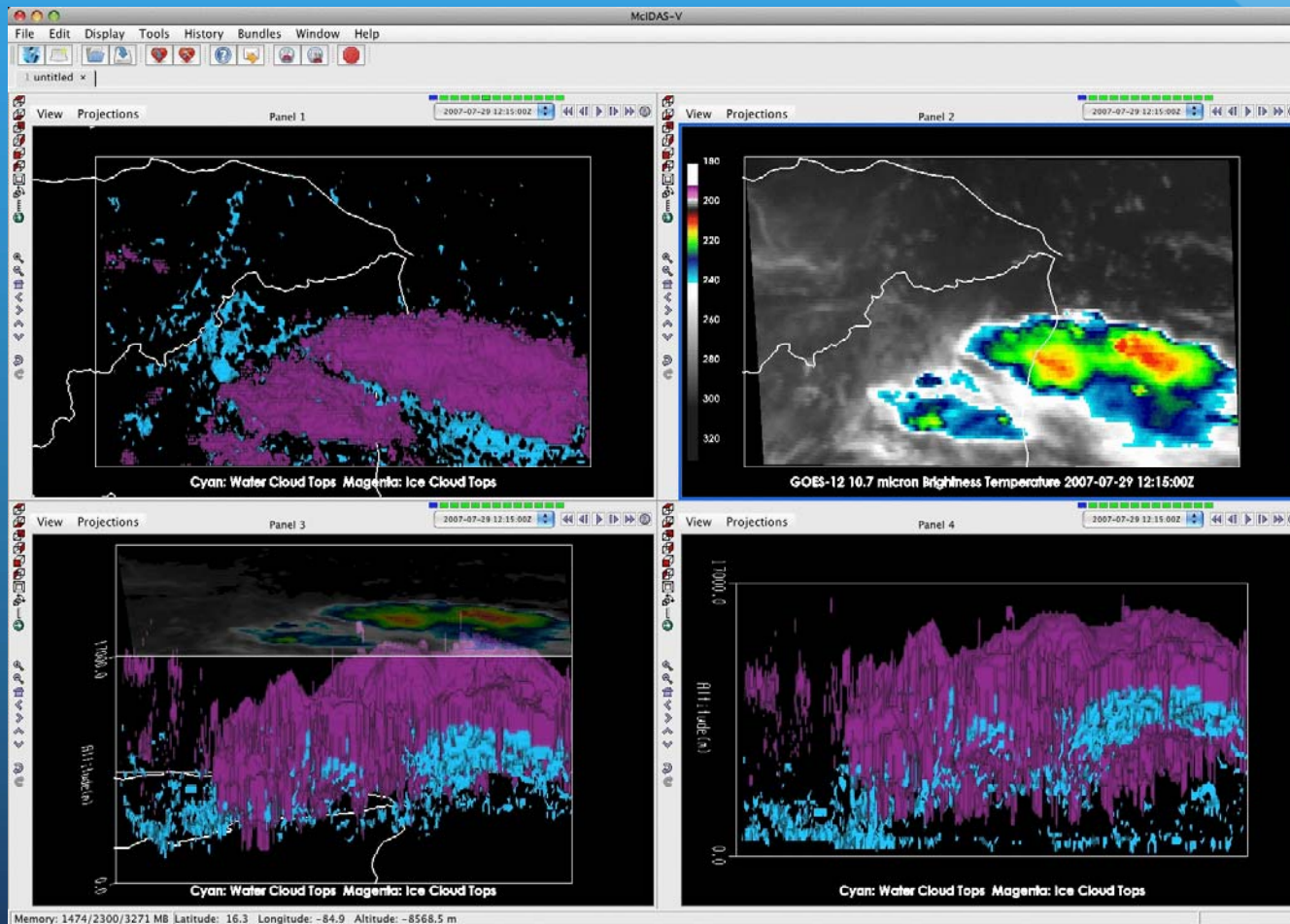
Overshooting Top Detections, Enhanced-V/Thermal Couplet Detections, and Severe Hail Reports Atop MODIS 250 m Visible



Overshooting top detection with objective United Airlines turbulence. Moderate and severe turbulence occurred near the detected OT

# 4-D Cloud Vertical Thickness and Colored By Cloud Top Microphysical Phase

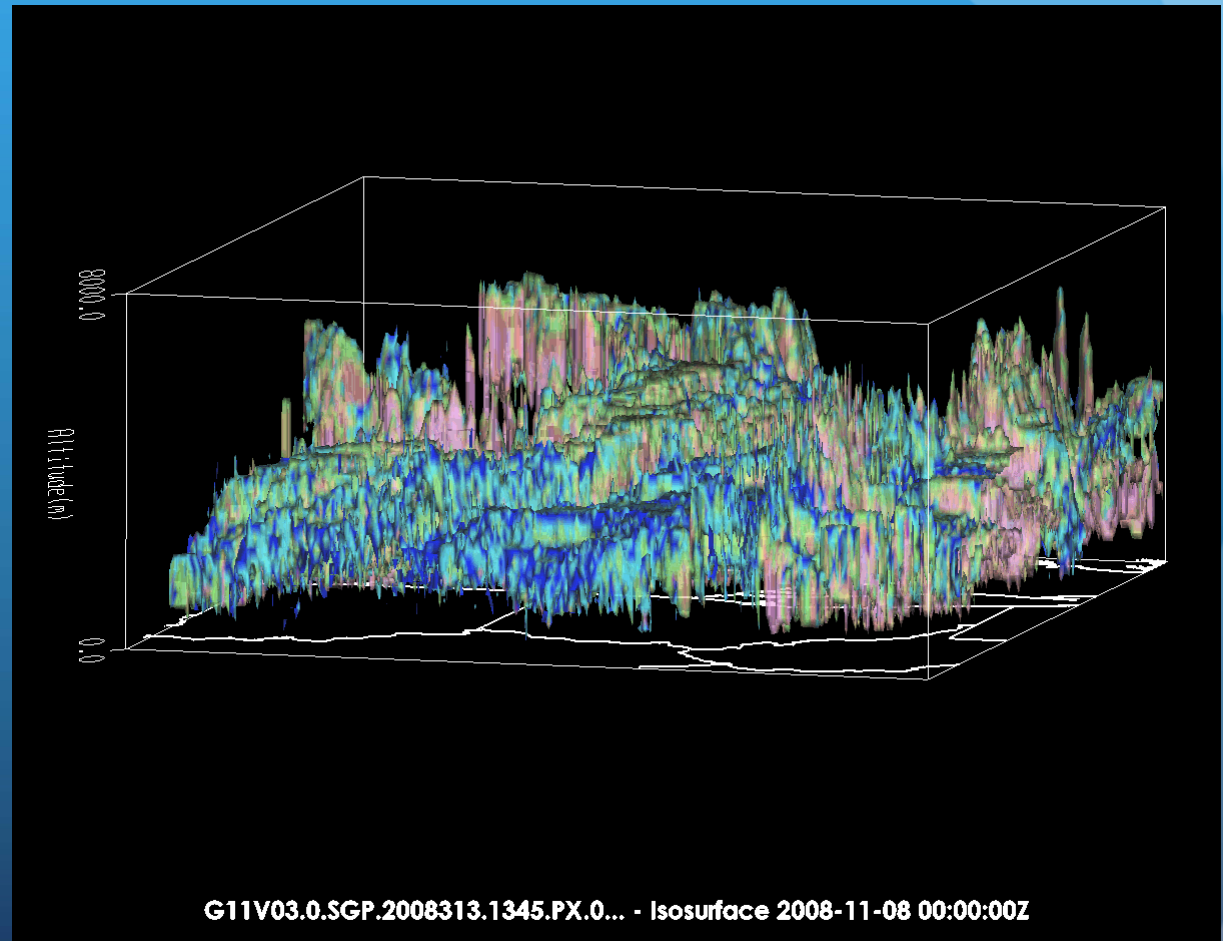
- Satellite-derived cloud top height and base estimates are used to create an isosurface which shows the 4-D cloud structure and time evolution of a tropical thunderstorm



# Volume Rendering of 4-D Satellite-Derived In-Flight Icing Intensity

- McIDAS-V volume rendering has been used to visualize 4-D volumes of a prototype in-flight icing intensity product. Transparency effects are used to eliminate areas of clear sky within the data cube.

Warm Colors  
Significant Icing Possible  
At A Given Altitude





# Additional McIDAS-V Capabilities That Would Benefit The LaRC Clouds and Radiation Group

- Automated image/animation creation capability via script on a remote machine which does not have a graphics card or monitor
- Increased support for HDF-4 and HDF-5 format datasets
  - *Currently specific NASA-EOS datasets such as MODIS Level 2, AIRS, CALIPSO backscatter, and CloudSat CPR are supported. LaRC users seek to visualize the spectrum of MODIS MOD0# products, products from the CERES program, CALIPSO/CloudSat cloud property profiles, NASA NWP model output, and GEOCAT output all of which are in HDF-4 or HDF-5*
- Development of a flexible data chooser requiring user input
  - *The number of “hardwired choosers” provided for individual datasets may get out of control given the spectrum of new products that consistently become available. CF standards not always applicable/convenient and diverse HDF structures are challenges*
  - *A chooser that probes the file, provides a list of available parameters, then asks the user to tell McIDAS-V the parameters corresponding to desired data, navigation, time, and/or altitude, would be worthwhile*

# Additional McIDAS-V Capabilities That Would Benefit The LaRC Clouds and Radiation Group

- Adjustable axis tick marks/labels, fonts, lat/lon labels, etc...
  - *Labels only at the top and bottom of the vertical scale makes data interpretation difficult at times. Users may not have (or want to use) graphic editing software to make a presentation quality image*
- A flexible 4<sup>th</sup> dimension for NetCDF datasets
  - *We produce data such as cloud amount dimensioned by (time, lat, lon, cloud phase) or (time, lat, lon, scene type). McIDAS-V wants the 4<sup>th</sup> dimension to be "altitude/level" or possibly "spectral band". Cloud phase could be a "band", but users may be confused by this*
- Support for datasets from the ARM program
  - *ARM datasets are vital for interpretation and validation of satellite-derived products. Examples of ARM data: stationary vertically pointing instruments, rawinsonde profiles, and time series of measured/derived quantities*
  - *ARM data are most often in NetCDF format and follow ARM-specified naming conventions, though are often not "CF-compliant"*
- Improved memory management and performance, especially for 4-D gridded datasets and point data