Satellite Cloud & Icing Products at NASA Langley Research Center

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Friends/Partner in Aviation Weather Forum

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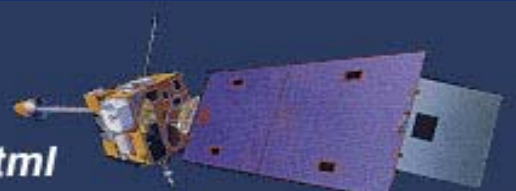
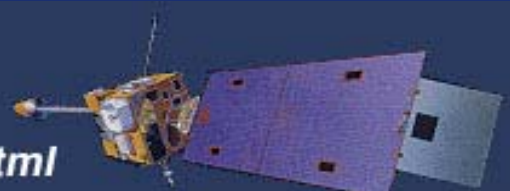
Langley Cloud And Radiation Group

http://www-angler.larc.nasa.gov/satimage/products.html



OBJECTIVE

- **Develop operational near-real-time satellite-derived cloud & icing products**
  - **for integration into the Current Icing Potential & Forecast Icing Potential products**
  - ***for assimilation into RUC***
  - ***for possible use as a cockpit product***



APPROACH

- **Apply cloud retrieval algorithms to half-hourly 4-km GOES imagery**
  - *cover CONUS with 2 satellites*
  - *relate cloud properties to known icing conditions*
- **Validate cloud & icing products w/ in situ & sfc remote sensing data**
  - *compare in situ, surface, & satellite μ-physical properties*
  - *compare cloud-base top & height for icing clouds with a/c altitude, radar, ASOS ceilometer data*
  - *determine where & when icing routine fails (PIREPS)*
- **Improve cloud & icing products**
  - *visual assessment, updating, & upgrading*
  - *respond to results of validations*
  - *adjust definitions of icing based on objective criteria*

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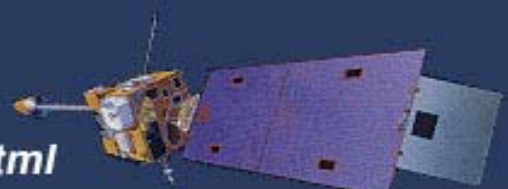


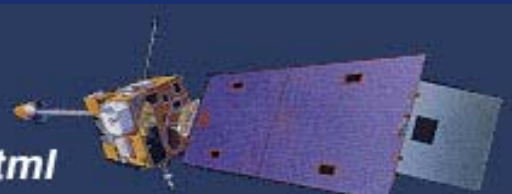
DATA

CONUS

- GOES-10/12 imager (4-km, 15-30 min) — N & S America
- Rapid Update Cycle (RUC 13-km => 1°, 1/hr)
  - *T(sfc), T(z), RH(z), u(z), v(z)*
  - *1-hr forecast for GOES real time processing*
  - *reanalysis for MODIS, AVHRR processing & GOES reprocess*

Other Areas

- Terra & Aqua MODIS (1-km, 1/day) — Global
- NOAA-16/18 AVHRR (1-km, 1/day) — Select areas
- Meteosat SEVIRI (3-km, half hourly) — Eur./Africa
- MTSAT-1 (5-km, hourly) — E. Asia/Austral./W Pac



SATELLITE PIXEL LEVEL CLOUD PROPERTIES

• CLEAR or CLOUDY	
• EFFECTIVE RADIATING TEMP	Tc
• EFFECTIVE HEIGHT, PRESSURE	Zc, pc
• TOP/BASE PRESSURE & HEIGHT	p_t, p_b, Z_t, Z_b
• THICKNESS	h
• PHASE (0 - 2)	P
• EMISSIVITY	ε
• WATER DROPLET EFFECTIVE RADIUS	re
• OPTICAL DEPTH	τ
• LIQUID WATER PATH	LWP
• ICE EFFECTIVE DIAMETER	De
• ICE WATER PATH	IWP
• ICING POTENTIAL	IP

AIRCRAFT ICING

ICING CONDITIONS ARE DETERMINED BY CLOUD

- liquid water content, *LWC* — **positive w/ intensity**
- temperature, *T(z)* — **negative w/ intensity**
- droplet size distribution, *N*(*r*) — ***r* positive w/ intensity**

SATELLITE REMOTE SENSING CAN DETERMINE CLOUD

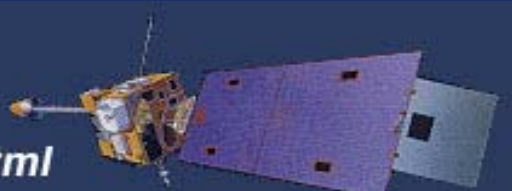
- optical depth, τ
- effective droplet size, *re*
- liquid water path, *LWP*
- cloud top temperature, *Tc*
- thickness, *h*

IN CERTAIN CIRCUMSTANCES

CLOUD PRODUCTS VS. ICING PARAMETERS

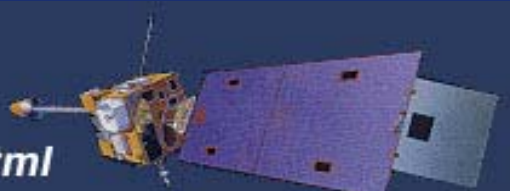
- $LWP = LWC * h$
- $re = f[N(r)]$
- Tc & h can yield depth of freezing layer
- z_t is top of icing layer
- cloud base height (ceiling) = $z_t - h$

IN MANY CASES, SATELLITE REMOTE SENSING SHOULD PROVIDE ICING INFORMATION



CURRENT STATUS OF GOES PROCESSING

- GOES-10 & 12 analyzed each half hour, 18°N - 55°N
  - G10: 85°W - 135°W G12: 65°W - 105°W
  - 8-km (every other line & pixel)
  - 30-min delay
- Algorithm continually undergoing changes
  - cloud detection
    - *new thresholds (especially night & twilight)*
    - *debugging (input errors, off switches, etc.)*
    - *multilayered clouds*
  - phase selection
    - *debugging*
    - *altered logic*



User Warning, Please read !

Site Map:

Minnis Group Homepage

Viewers/Tools:

NOAA AVHRR Viewer

MODIS Viewer

MID-Atlantic NEXRAD

ARM-SGP NEXRAD

Angles Viewer

Plot RUC Sounding

Gridded VISST Products

Satellite Overpass Predictor

Field Experiments:

TC4 2007 New!!

PACDEX 2007

COPS 2007

FRAM 2007

CCVEX 2006

TWP-ICE 2006

MASRAD Pt. Reyes

MIDCIX 2004

MPACE 2004

INTEX-NA

ATReC 2003

THORPEX

CRYSTAL

ARM SGP

CLAMS

INCA Spring 2000

SAFARI 2000

FIRE Arctic (1999)

Satellite Imagery And Cloud Products Page

Real-time and Historical Cloud Product Loops: The cloud products are derived with VISST/SIST algorithm. Select a domain from the table below to access the real-time (blue cells) and archived products. Java Applet (JV Applet) may not work on some Mac browsers, then use non-java version.

CLOUD PRODUCTS				
GOES WEST	**GOES EAST**	**MODIS TERRA/AQUA**	**MTSAT-1R**	**NOAA 15/16/17 and MSG**
West CONUS non-java JV Applet	**East CONUS** non-java JV Applet		**NAURU** JV Applet	**ARM-NSA** JV Applet
MERGED CONUS non-java JV Applet			**MANUS** JV Applet	**WEST EUROPE** JV Applet
ARM-SGP JV Applet	**ARM-SGP** JV Applet	**ARM-SGP** JV Applet	**DARWIN** JV Applet	New!! **MSG FULL-DISK** JV Applet
ARM-NSA JV Applet	**COVE** JV Applet	**COVE** JV Applet	**TWP** JV Applet	**ARM-NIAMEY** JV Applet
Monterey JV Applet	**ATReC/AIRS** JV Applet			**EUROPE** JV Applet
	CRYSTAL JV Applet			ATReC/AIRS
	OHIO JV Applet			TWP

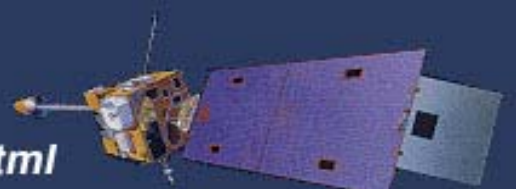
Real-time and Historical Satellite Imagery Loops: The links from the table below provide access to the real-time (blue cells) and historical image loops for various satellites.

SATELLITE IMAGERY				
Mid-West US (SGP) JV Applet	**Northeast US** JV Applet	**Mid-Atlantic US** JV Applet	**Southeast US** JV Applet	**CONUS** JV Applet
E. Pacific G-12 JV Applet	**Pacific/West** JV Applet	**TWPICE MTSAT** JV Applet	**TWPICE FY2C** JV Applet	**TWPICE MTSAT & FY2C** JV Applet
ATReC GOES-12 JV Applet	**Florida** JV Applet	**TWP GOES-9** JV Applet	GMS-5 TWP	PACS EPIC
MASRAD JV Applet	AVHRR CONUS	MODIS CONUS	AVHRR NSA	
FULL-DISK SATELLITE IMAGERY New!!				
GOES-W FD JV Applet	**GOES-E FD** JV Applet	**MET-9/0E FD** JV Applet	**MET-7/57E FD** JV Applet	**FY2C/105E FD** JV Applet
MTSAT/140E FD JV Applet				
COMPOSITE SATELLITE IMAGERY New!!				
Global Geostationary JV Applet	**North Pole MODIS** JV Applet	**South Pole MODIS** JV Applet		

Check the Notes on using Java Applets in browsers from Tom Whittaker for any difficulty of displaying the images on your browser.

Langley Cloud And Radiation Group

http://www-angler.larc.nasa.gov/satimage/products.html

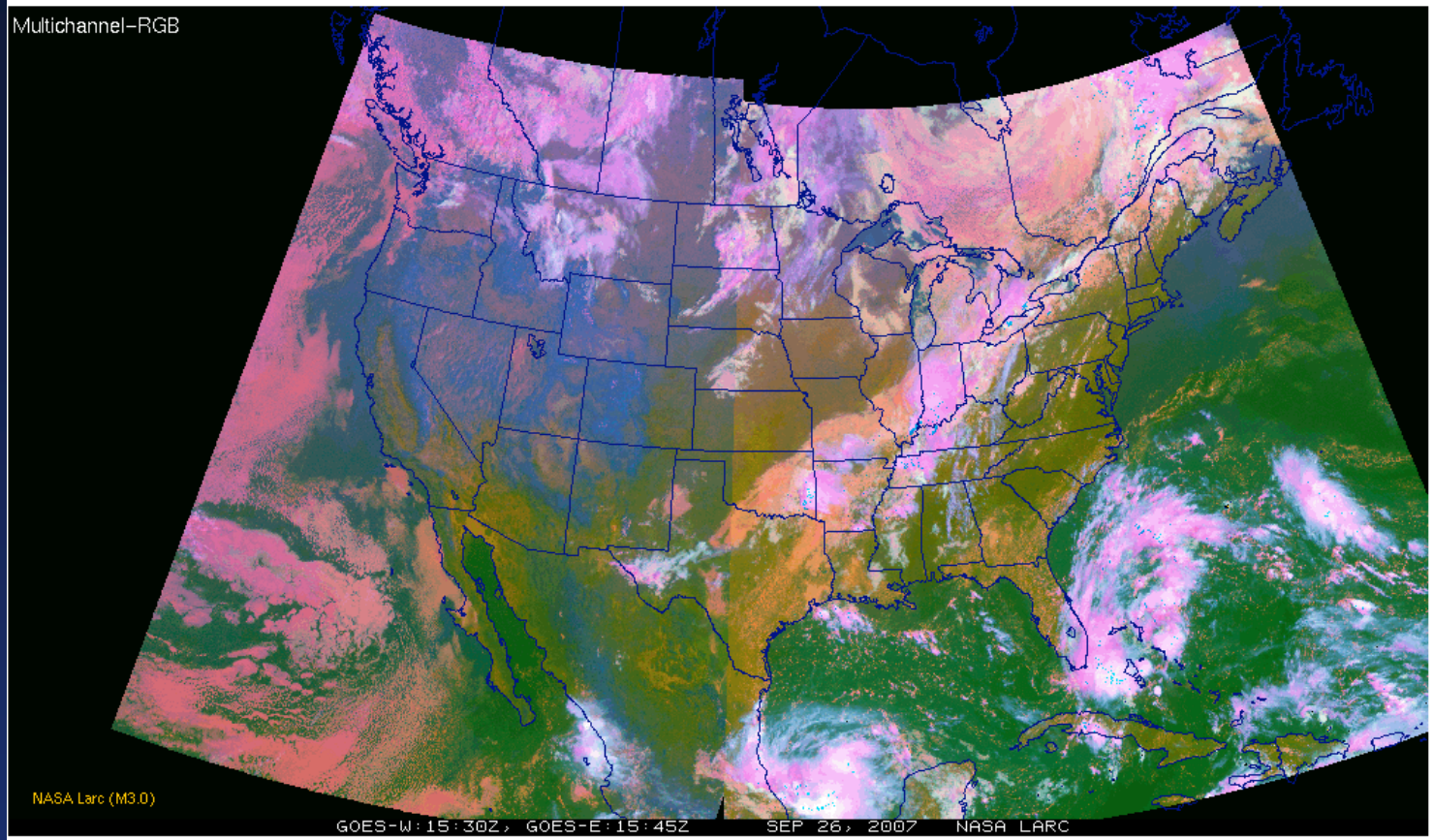


1545 UTC, 9/26/07

MERGED CONUS CLOUD PRODUCT

[VIEW FOUR VARIABLES] [VIEW ONE VARIABLE]

Left click – toggle on/off; Right click – show frame



Start | Set Animation Speed | < | > | Rock | Zoom

2007 | Sep | 26 | 15:45 Z | MULTICHANNEL-RGB | 1 frame | DISPLAY

o List Archive Summary Of MERGED CONUS CLOUD PRODUCT

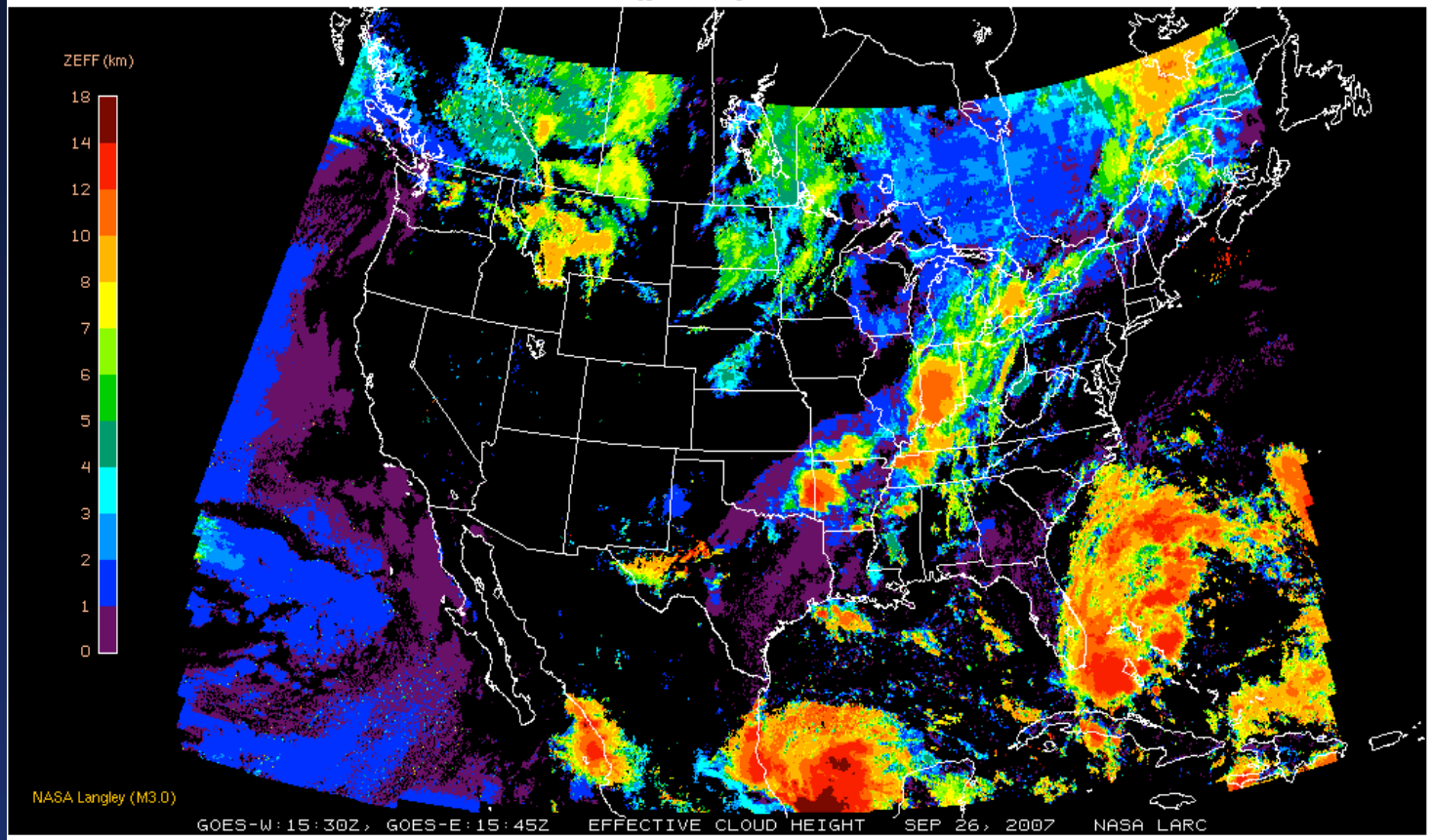
MINNIS GROUP HOMEPAGE | SATELITE IMAGERY AND CLOUD PRODUCTS | ARCHIVE

Cloud top height

MERGED CONUS CLOUD PRODUCT

[VIEW FOUR VARIABLES] [VIEW ONE VARIABLE]

Left click – toggle on/off; Right click – show frame



Start | Set Animation Speed | < | > | Rock | Zoom

2007 | Sep | 26 | 15:45 Z | EFF CLD HGT | 1 frame | DISPLAY

o List Archive Summary Of MERGED CONUS CLOUD PRODUCT

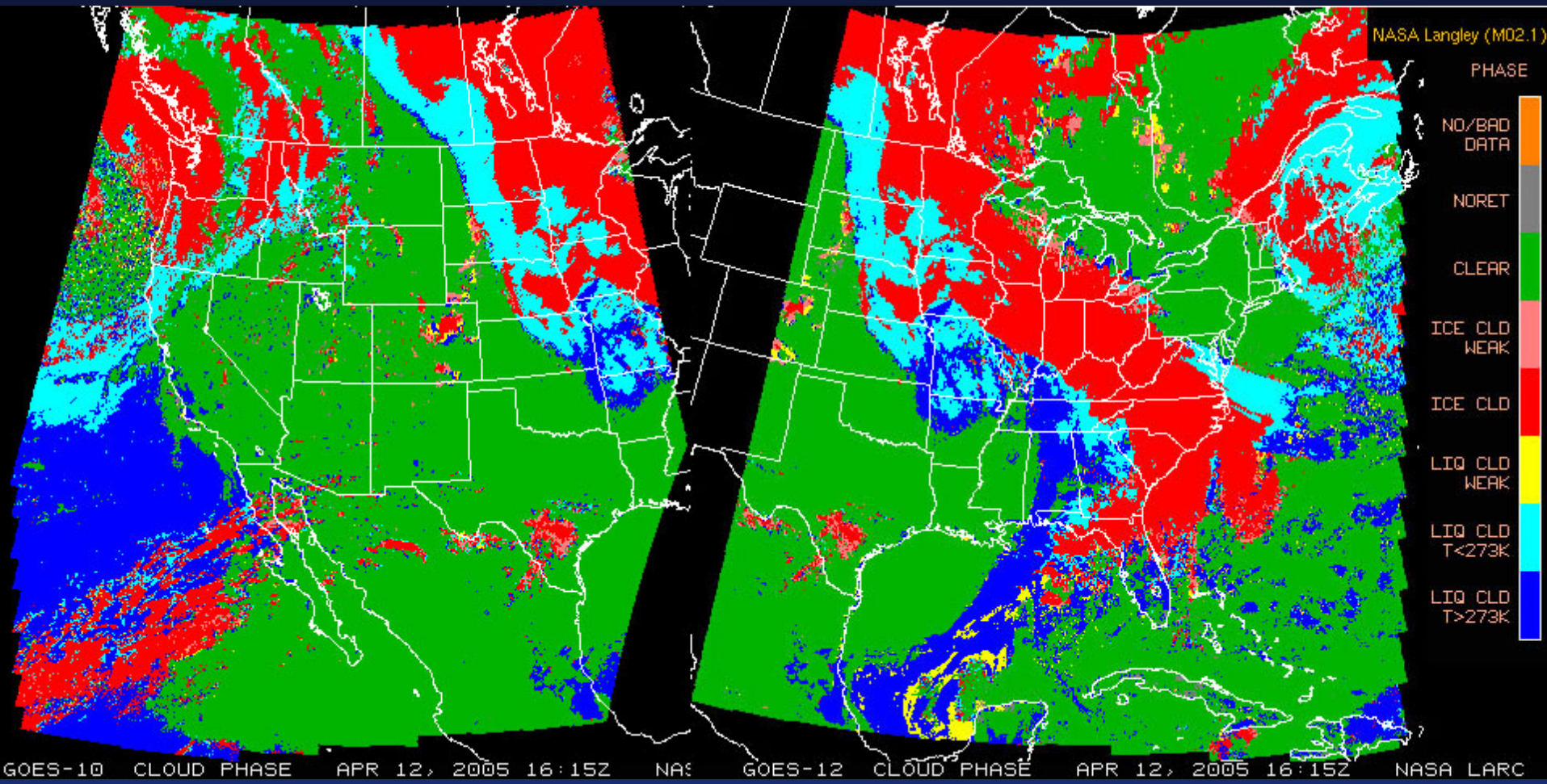
Langley Cloud And Radiation Group

http://www-angler.larc.nasa.gov/satimage/products.html

Example of G10/G12 Products, 1615 UTC, 12 April 2005

GOES-10 Phase

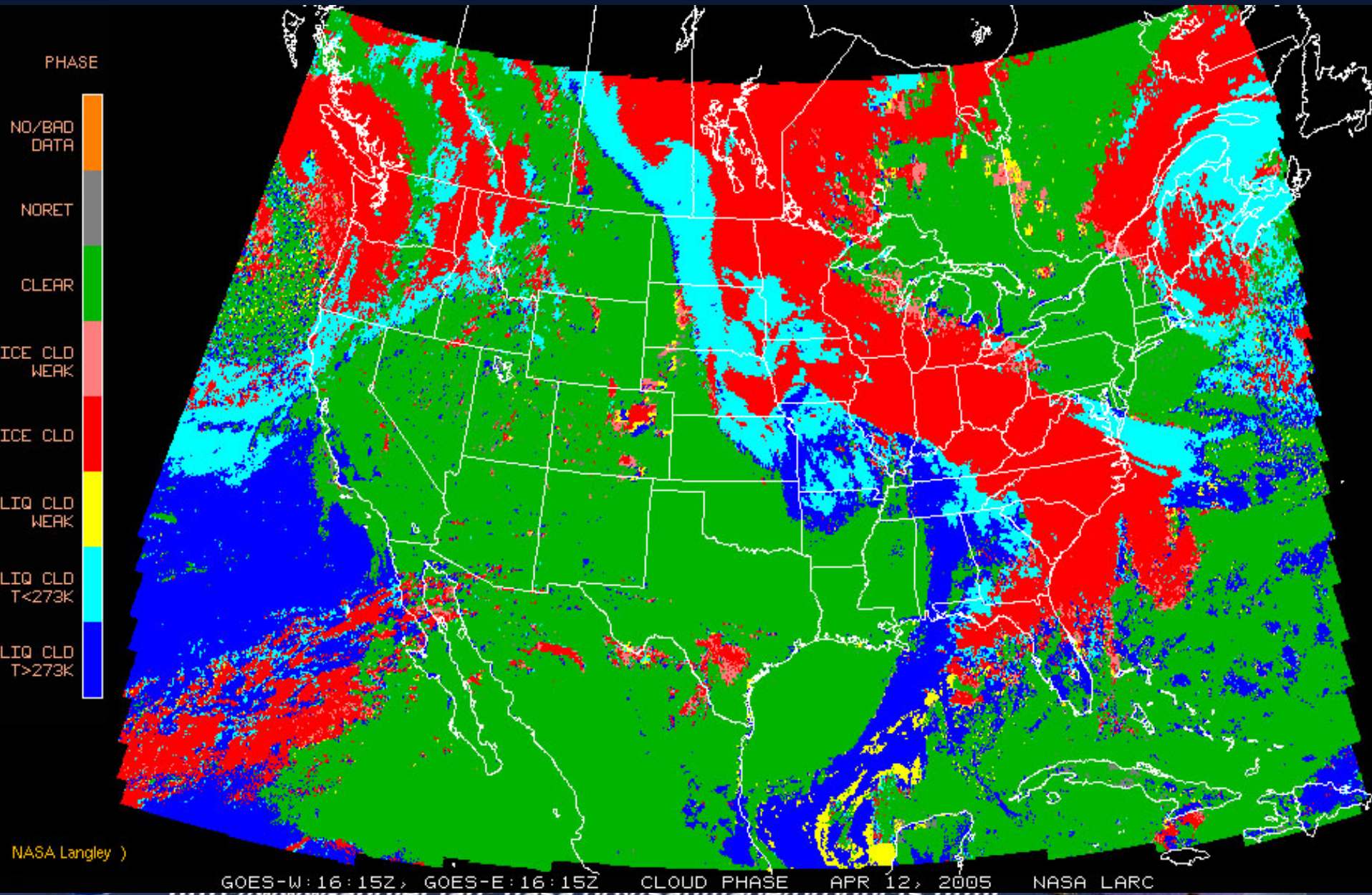
GOES-12 Phase



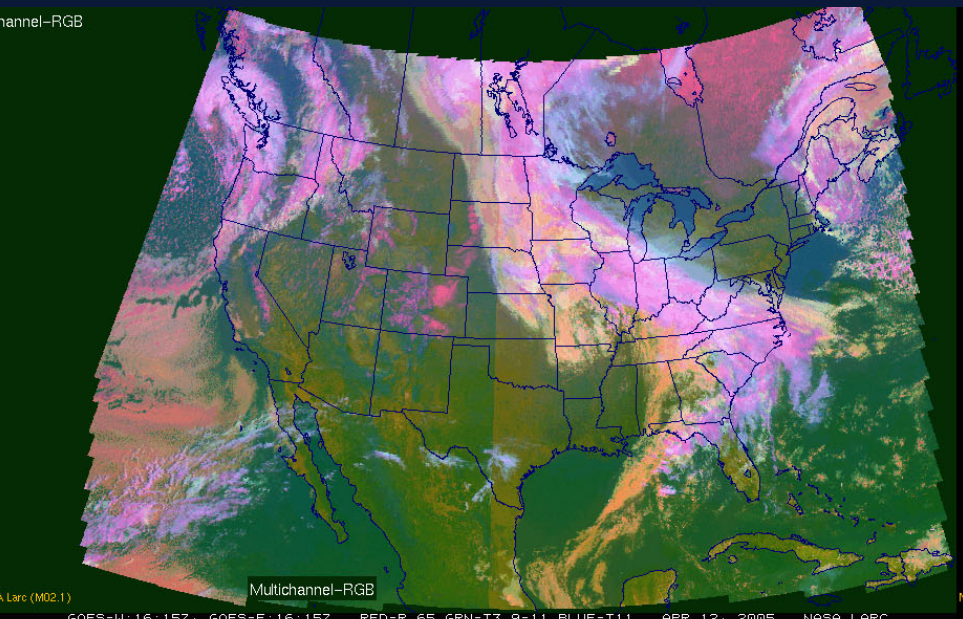
Langley Cloud And Radiation Group

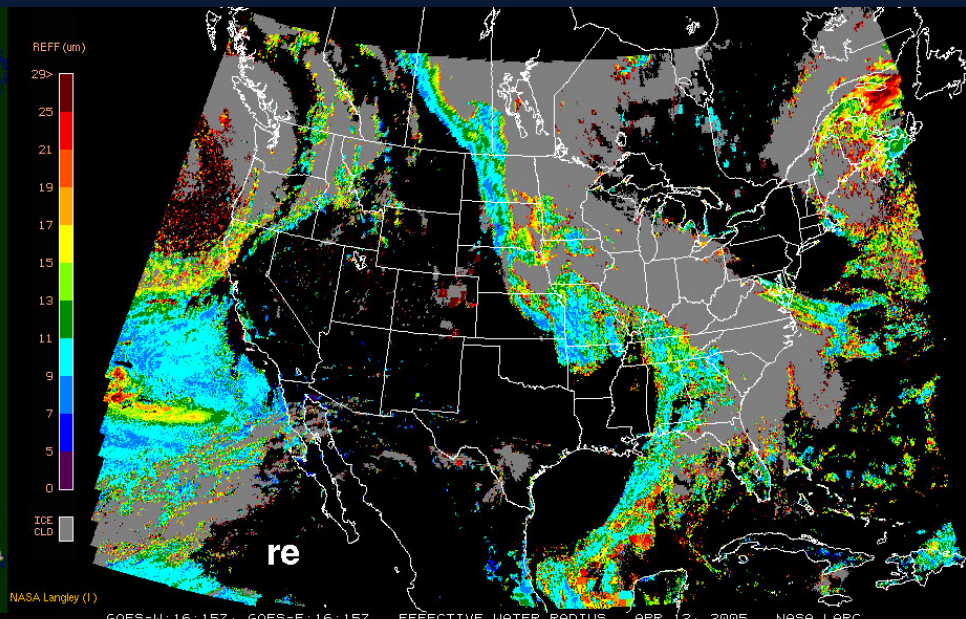
http://www-angler.larc.nasa.gov/satimage/products.html

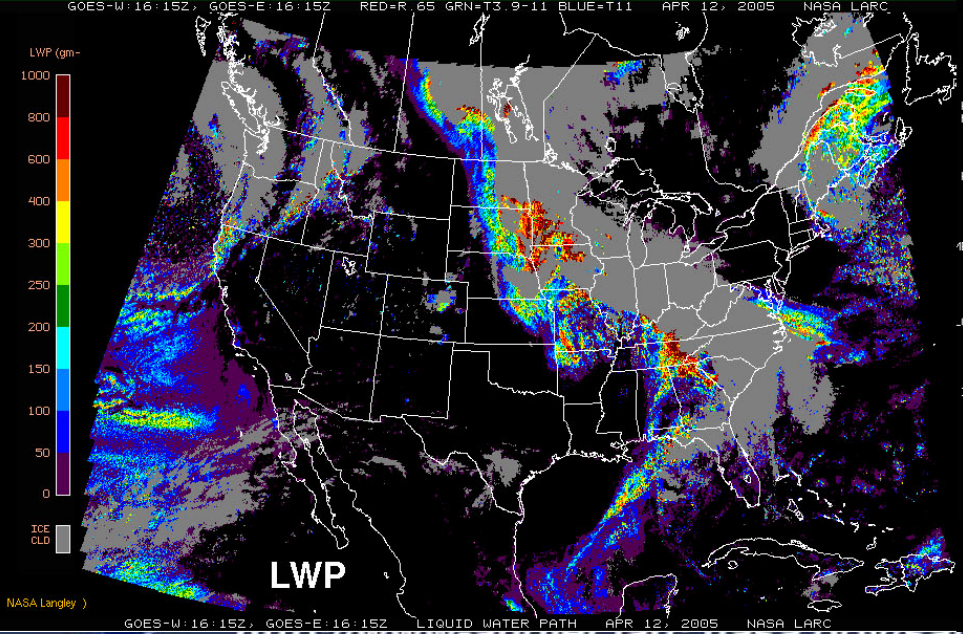
Merged G10/G12 Phase, 1615 UTC, 12 April 2005

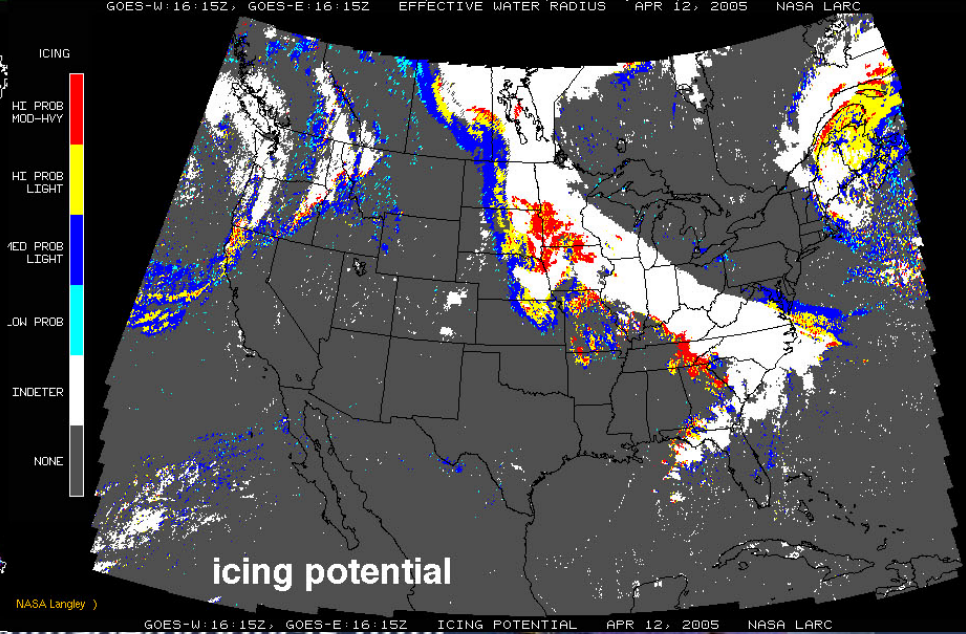


G10/G12 Icing Related Products, 1615 UTC, 12 April 2005



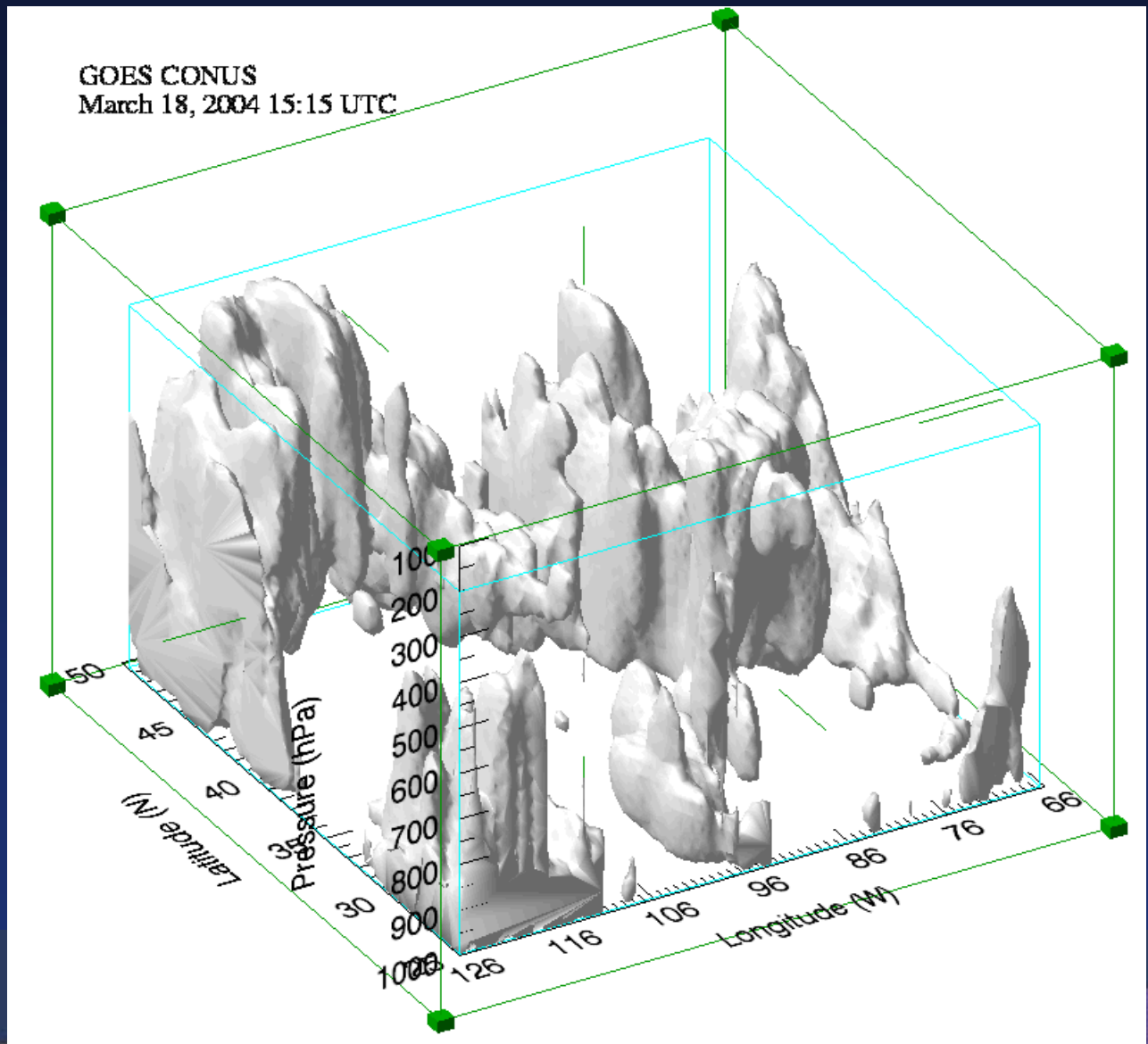






http://www-angler.larc.nasa.gov/satimage/products.html

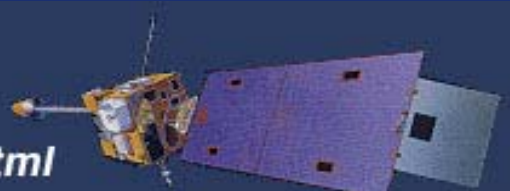
GOES OUTPUT IS A 3-D FIELD, ALBEIT SOMEWHAT CRUDE

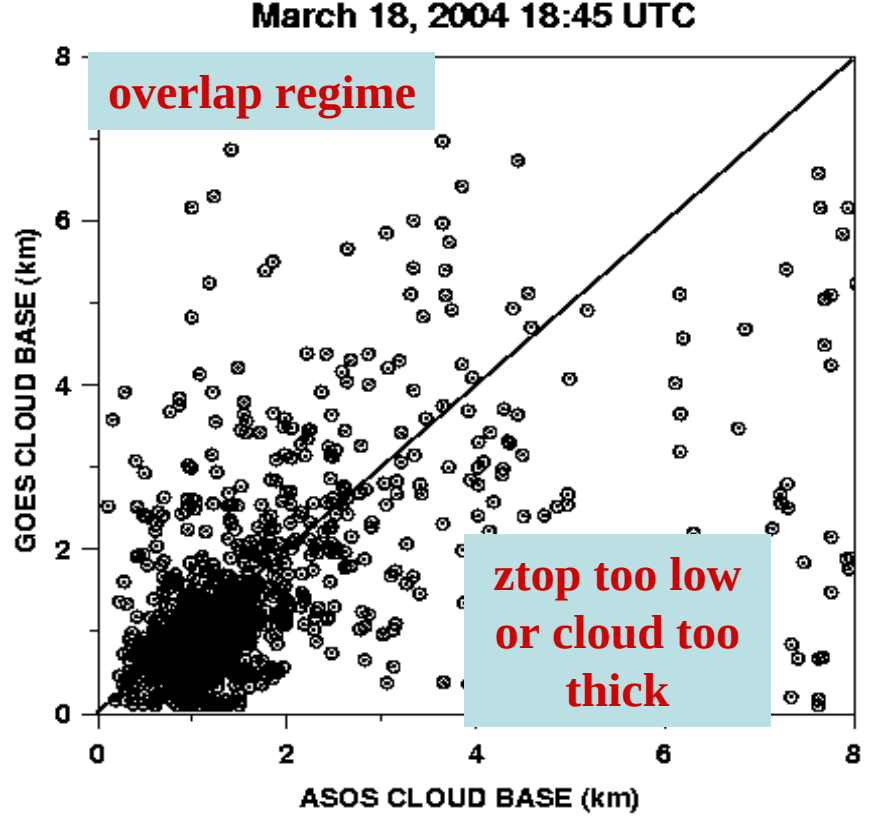


http://www-angler.larc.nasa.gov/satimage/products.html

VALIDATION

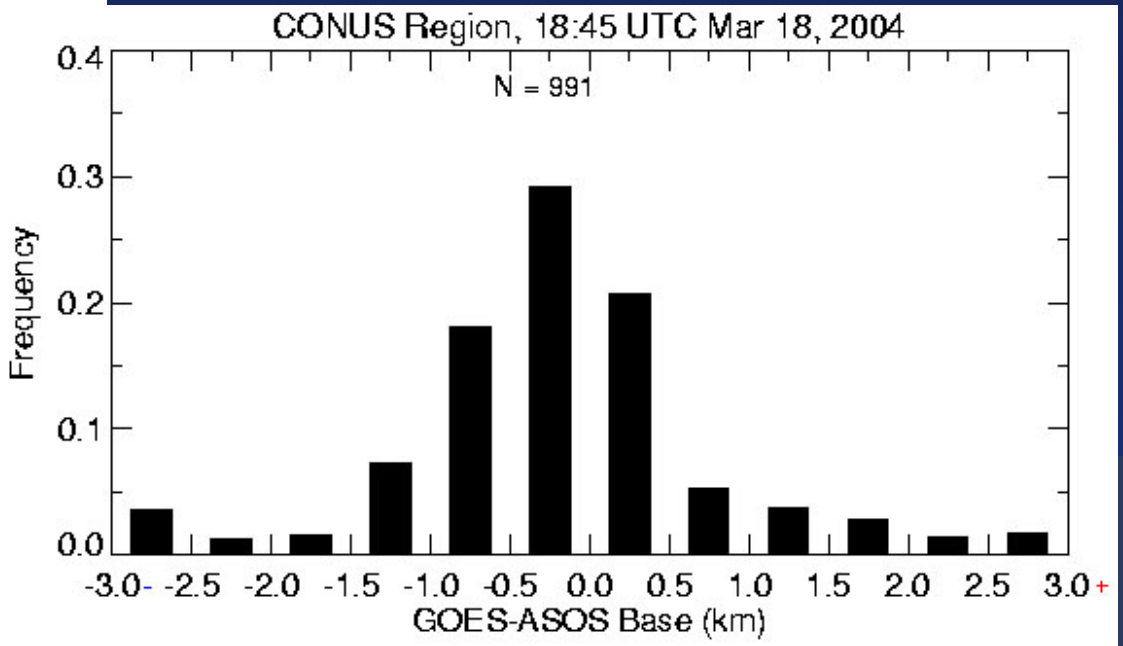
- **VISUAL:** Compare images with results
- **PIREPS:** Generally good comparisons
  - LaRC past & NCAR (Politovich talk)
- ***In situ*:** Generally good comparisons
  - TAMDAR, ATRECS, AIRS-II
- **Ceilometer:** Cloud base RMS ~ 0.8 km
  Cloud detection, excellent
- **Sfc LWP:** Generally unbiased except at high end (SGP)
- **Sfc radar:** Cloud top generally unbiased, RMS ~ 0.8 km





Comparison of cloud base heights from GOES retrievals & ASOS ceilometer data

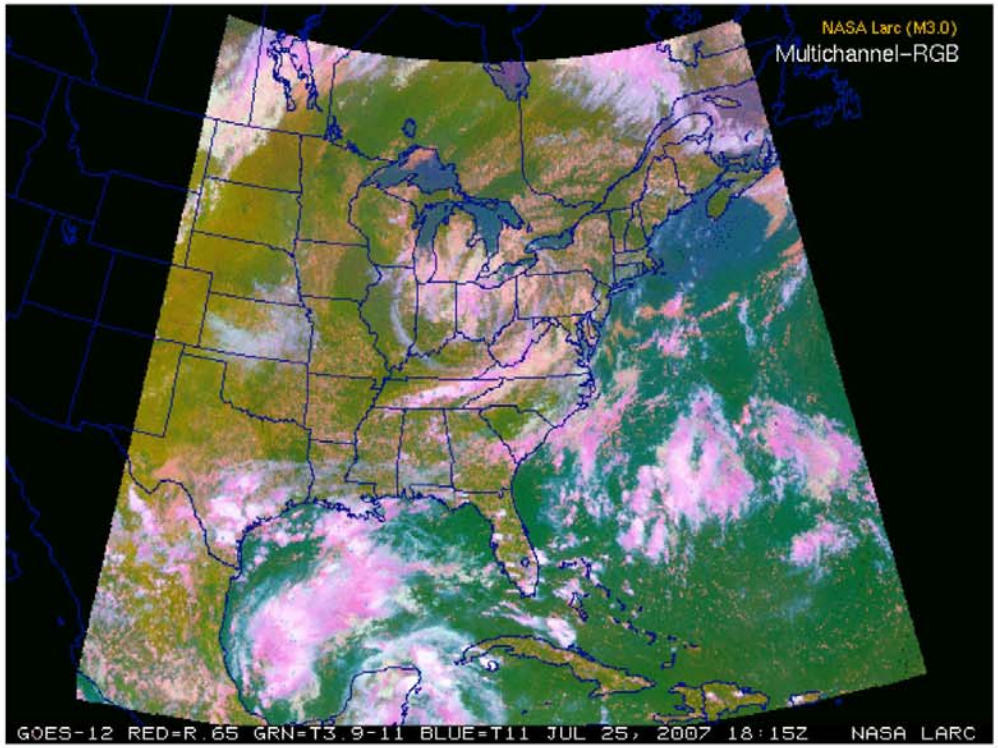
1900 UTC, 18 March 2004

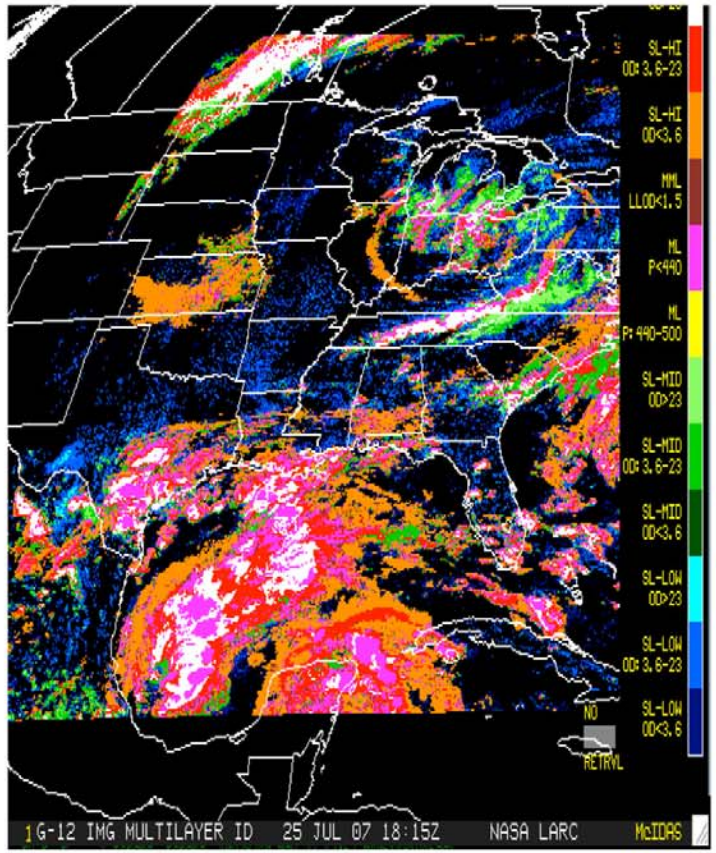


Multilayered Cloud Detection & Retrieval

1815 UTC, 25 July, 2007

Magenta denotes Ci over low clouds





Multilayer detection reduces indeterminate areas!

Future Plans

- **Test new RUC versions**
- **Continue validation**
- **Assess errors in nocturnal icing estimates**
- **Finalize overlap detection (remove false supercooled) & retrieval of low clouds underneath cirrus**
- **Optimize on Columbia Supercomputer**

=> lag time < 15 minutes

For product viewing & download:

http://www-angler.larc.nasa.gov/satimage/products.html