MISR Observations of Houston Aerosol Pollution and Aerosol-Cloud Interaction Processes

Michael J. Garay and **Ralph A. Kahn**

Jet Propulsion Laboratory, California Institute of Technology

John H. Seinfeld and **Miao-Ling Lu**

California Institute of Technology

Graham Feingold

NOAA Environmental Technology Laboratory

Athanasios Nenes

Georgia Institute of Technology

Principal Findings Data Analysis Workshop
TEXAQS II/GoMACCS
May 31, 2007

Outline

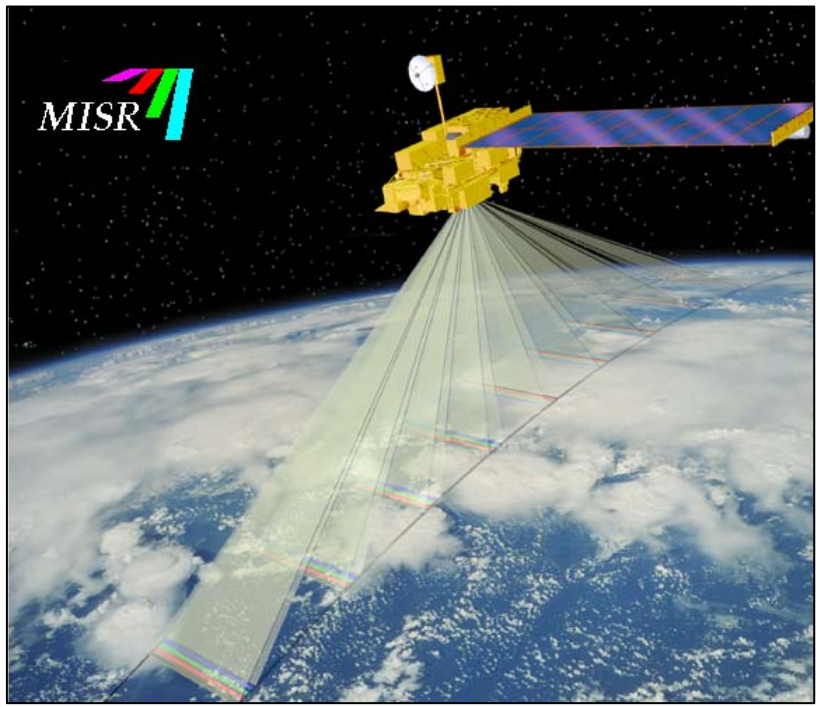
- Overview
- MISR observations of **local pollution** and **transport** in the Texas region
- MISR observations of **long-range transport** of Saharan dust into Houston
- Satellite and sub-orbital observations for studying **cloud-aerosol interactions**

MISR Participation: GoMACCS/TexAQS Campaign

Michael Garay & Ralph Kahn - Jet Propulsion Lab / Caltech
With Contributions from: The MISR, GoMACCS, TexAQS Teams

MISR Site Coverage GoMACCS Campaign

Site Name	Date	UTC Time	Orbit	Path	Block
Cameron_LA	30-Jul-06	17:02	35188	24	67
Gulf_Shelf_W	01-Aug-06	16:50	35217	22	69
La_Copita	04-Aug-06	17:21	35261	27	68
Houston	06-Aug-06	17:08	35290	25	67
Cameron_LA	08-Aug-06	16:56	35319	23	67
Houston	13-Aug-06	17:14	35392	26	67
Cameron_LA	15-Aug-06	17:02	35421	24	67
Gulf_Shelf_W	17-Aug-06	16:50	35450	22	69
La_Copita	20-Aug-06	17:21	35494	27	68
Houston	22-Aug-06	17:08	35523	25	67
Cameron_LA	24-Aug-06	16:56	35552	23	67
Houston	29-Aug-06	17:14	35625	26	67
Cameron_LA	31-Aug-06	17:02	35654	24	67
Gulf_Shelf_W	02-Sep-06	16:50	35683	22	69
La_Copita	05-Sep-06	17:21	35727	27	68
Houston	07-Sep-06	17:08	35756	25	67
Cameron_LA	09-Sep-06	16:56	35785	23	67
Houston	14-Sep-06	17:14	35858	26	67
Cameron_LA	16-Sep-06	17:02	35887	24	67
Gulf_Shelf_W	18-Sep-06	16:50	35916	22	69
La_Copita	21-Sep-06	17:21	35960	27	68
Houston	23-Sep-06	17:08	35989	25	67
Cameron_LA	25-Sep-06	16:56	36018	23	67
Houston	30-Sep-06	17:14	36091	26	67
Houston	09-Oct-06	17:02	36222	25	67

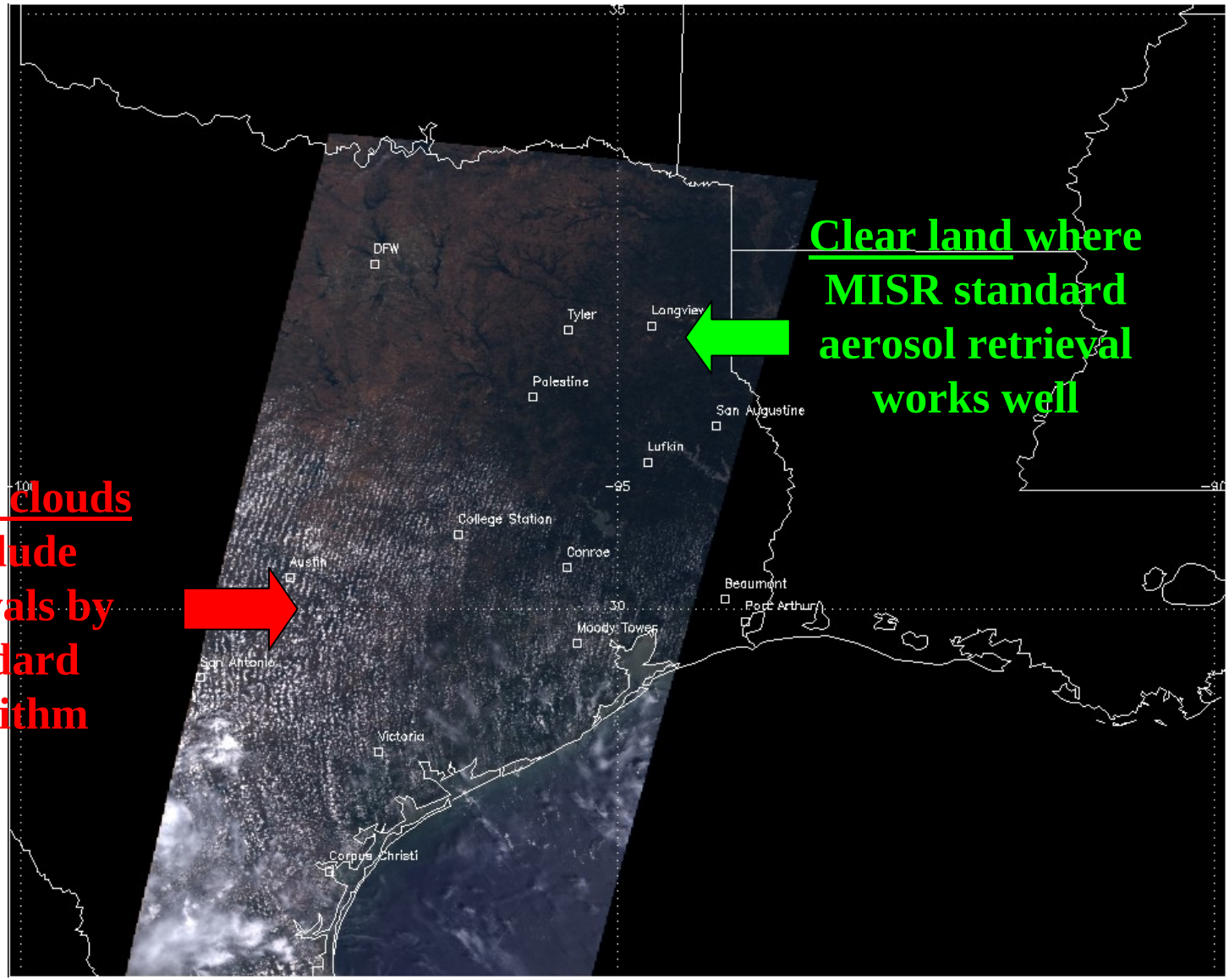


…9 MISR Opportunities over Houston itself

- **Validate MISR Land & Water Urban Aerosol Pollution Retrievals**
  - **-- Accuracy, Minimum AOT Sensitivity, Particle Property Information**
- **Provide Regional AOT & Aerosol Type Maps/Analyze w/Sub-Orbital Data & Models**
- **Explore Aerosol-Cloud Interactions with coordinated, multi-platform data**
- **Test AEGIS multi-angle-spectral + Lidar Mission Concept**

MISR Observations of Local Pollution and Transport in the Texas Region

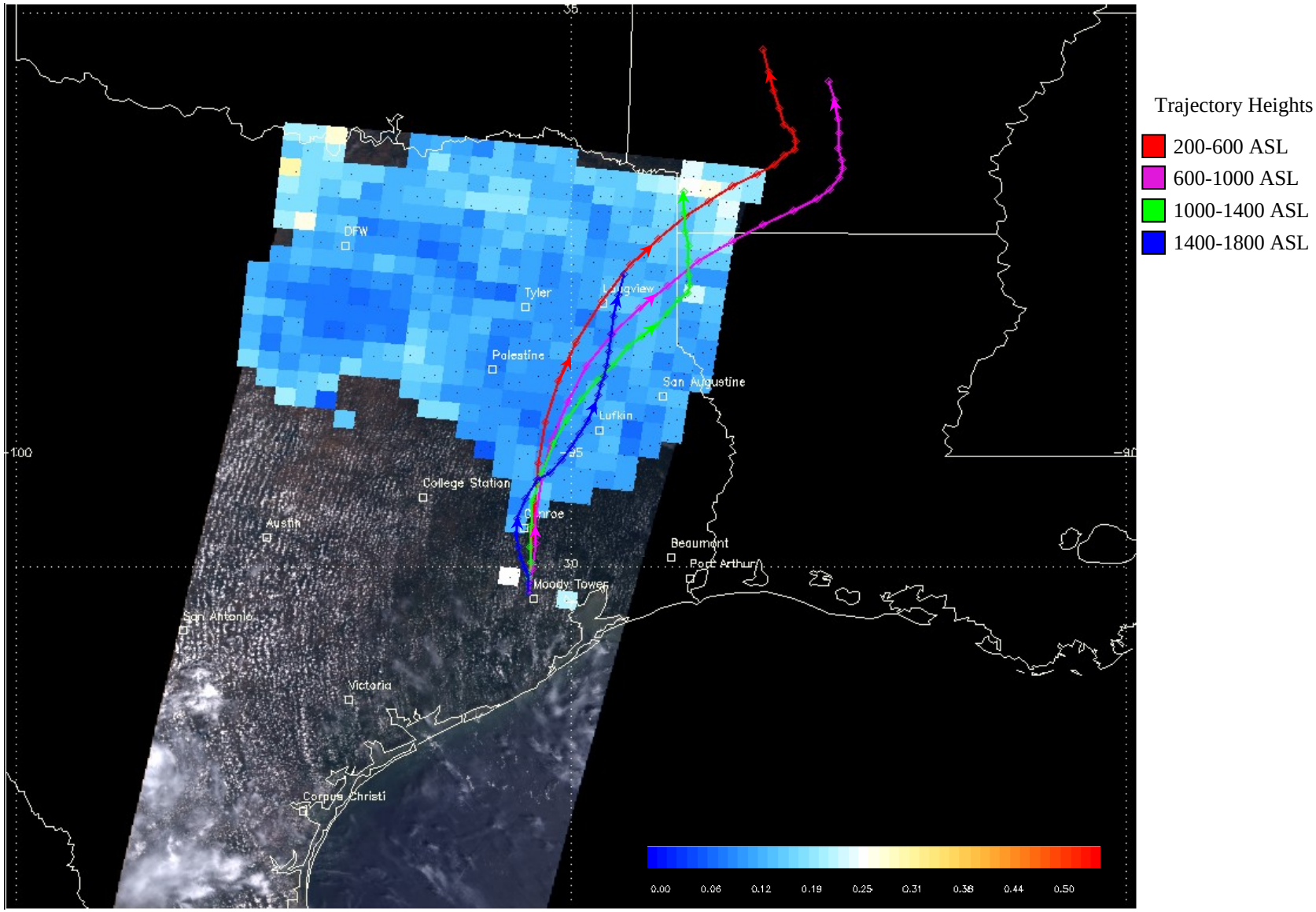
MISR 1.1 km RGB Image from **13 August 2006**



Clear land where MISR standard aerosol retrieval works well

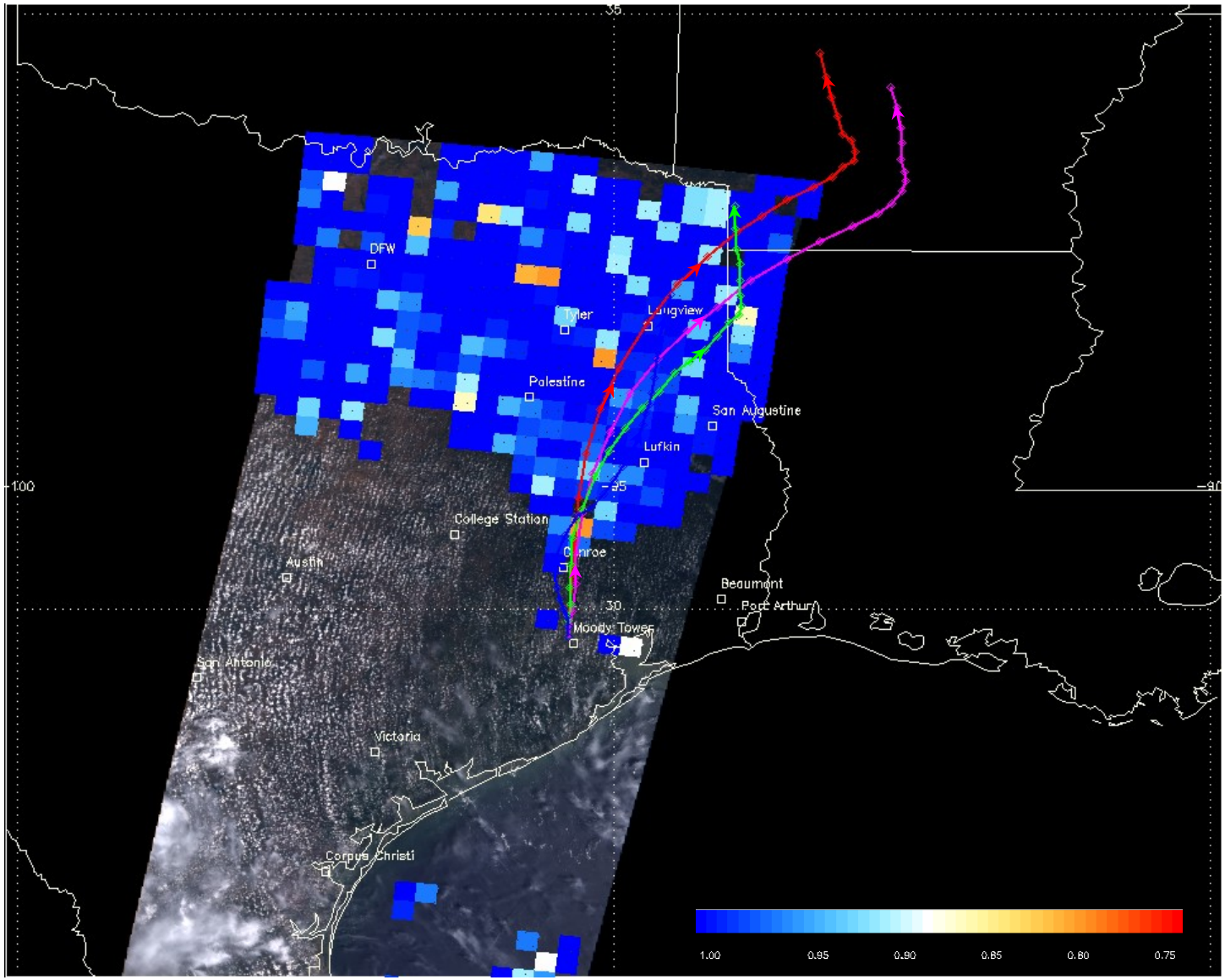
Broken clouds preclude retrievals by standard algorithm

MISR Best Estimate **Green Band Optical Depth** (V20)



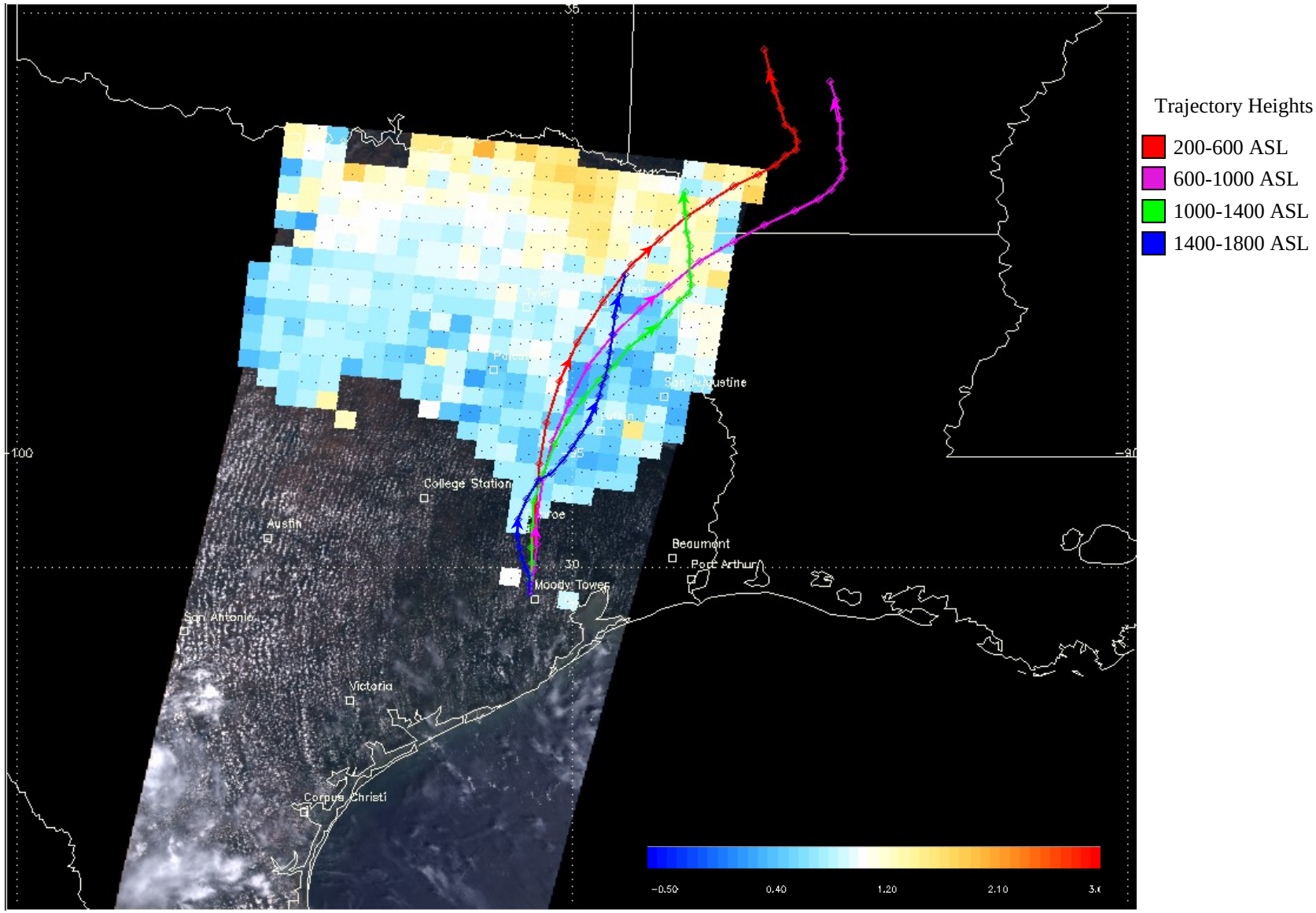
24 hour forward trajectories starting at 00 UTC 12 August from http://www.etl.noaa.gov/programs/2006/texaqs/traj/

MISR Lowest Residual **Green Band SSA** (V20)



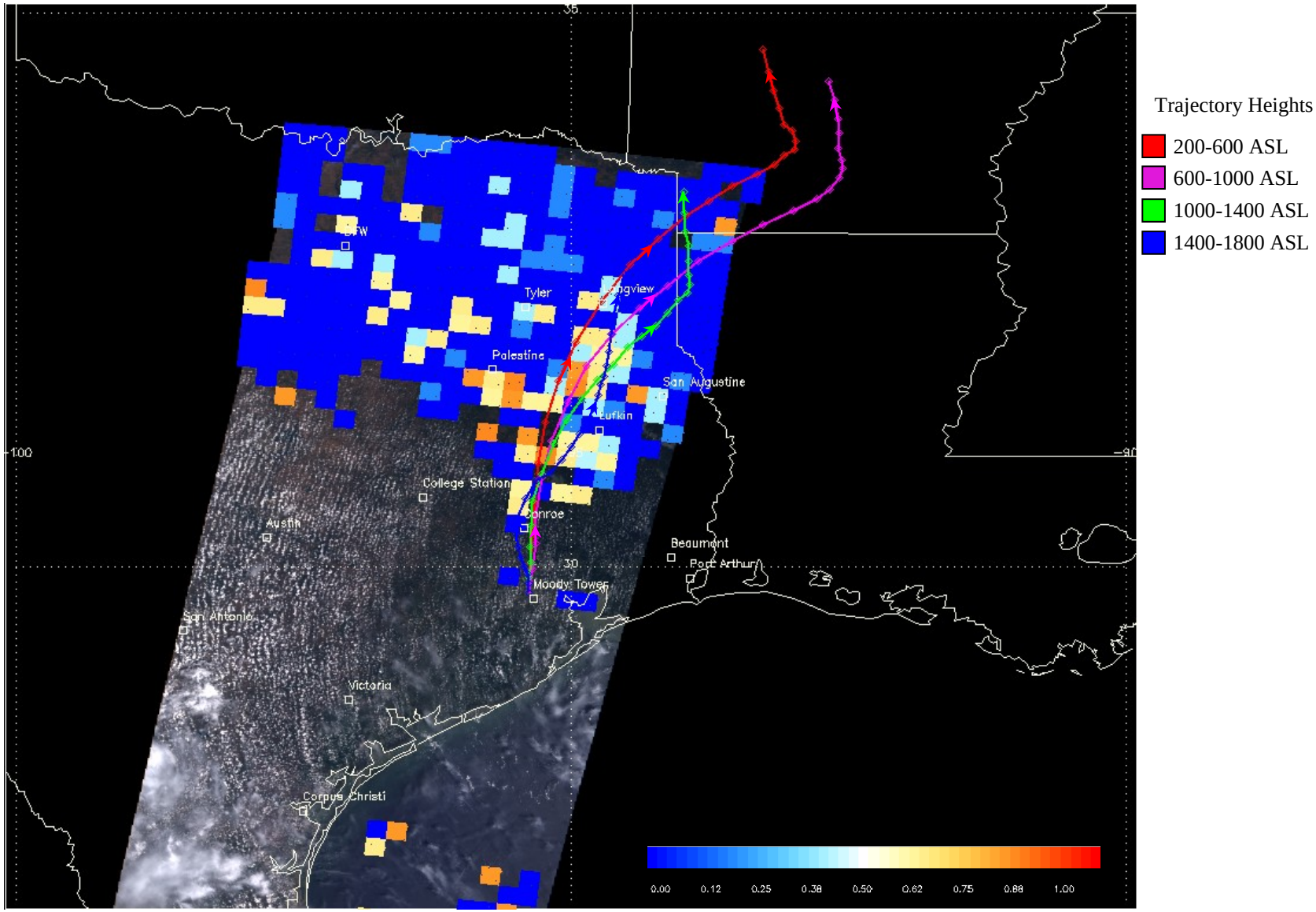
24 hour forward trajectories starting at 00 UTC 12 August from http://www.etl.noaa.gov/programs/2006/texaqs/traj/

MISR Best Estimate **Angstrom Exponent** (V20)



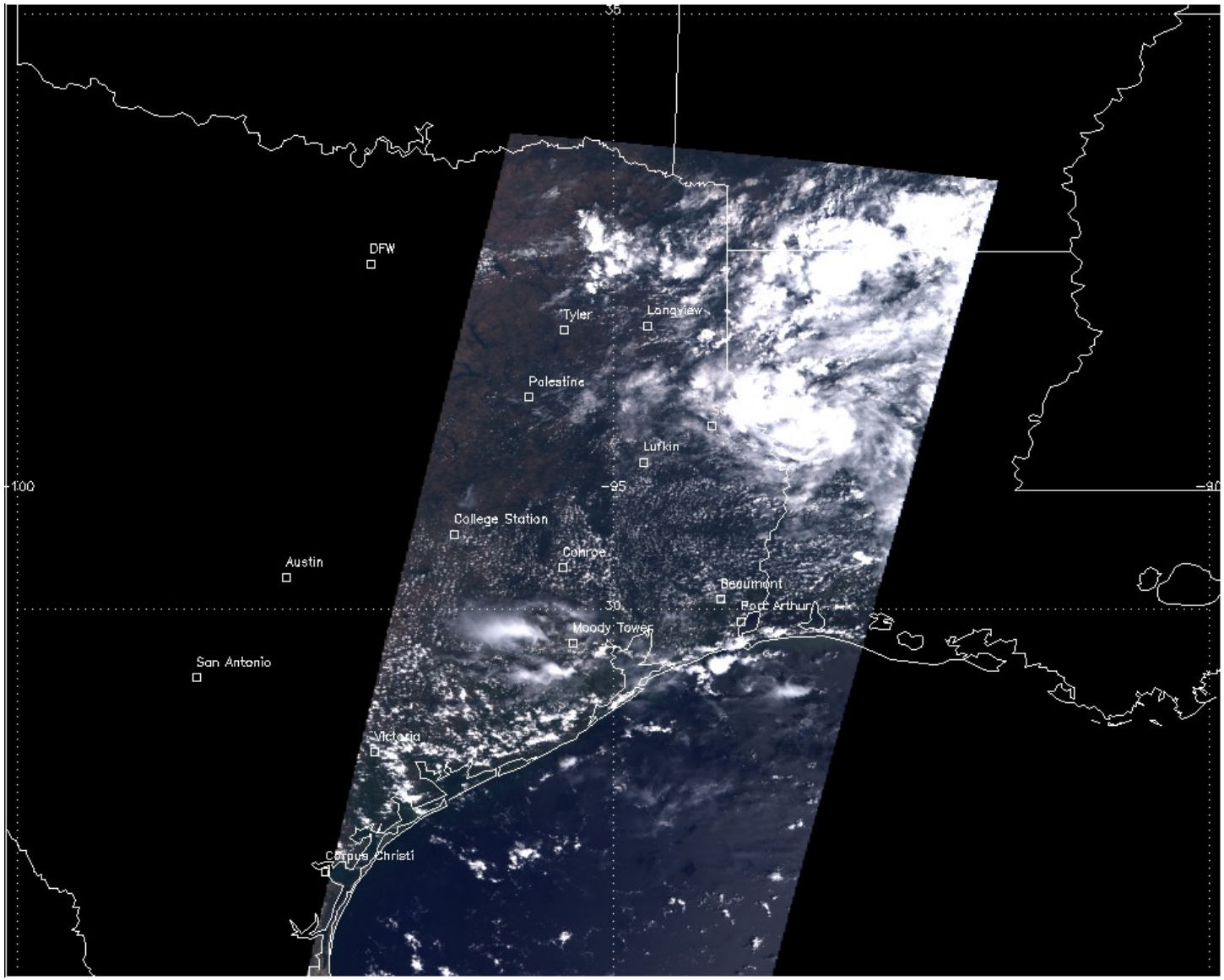
24 hour forward trajectories starting at 00 UTC 12 August from http://www.etl.noaa.gov/programs/2006/texaqs/traj/

MISR Lowest Resid. **Green Band Nonspherical Fraction** (V20)

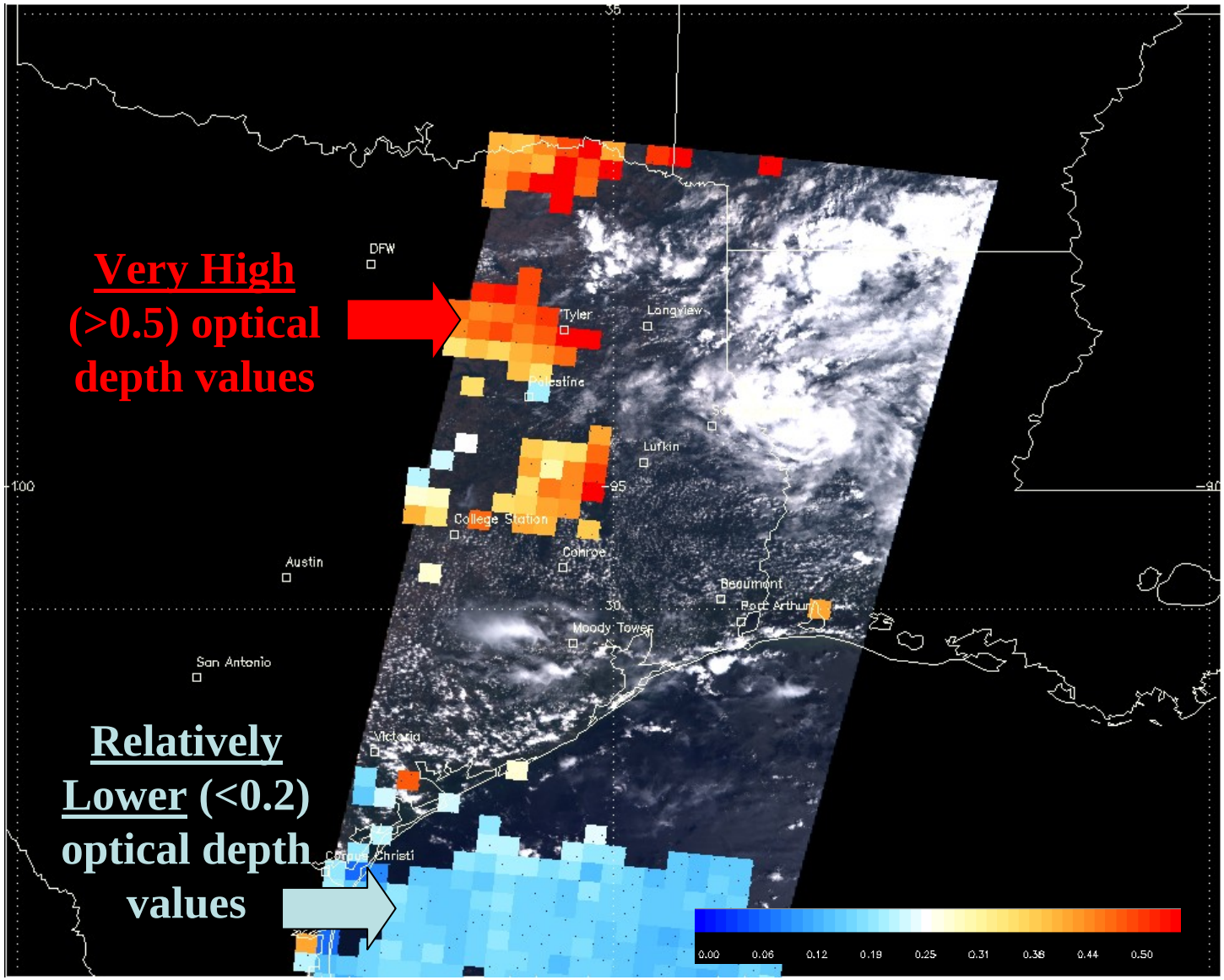


24 hour forward trajectories starting at 00 UTC 12 August from http://www.etl.noaa.gov/programs/2006/texaqs/traj/

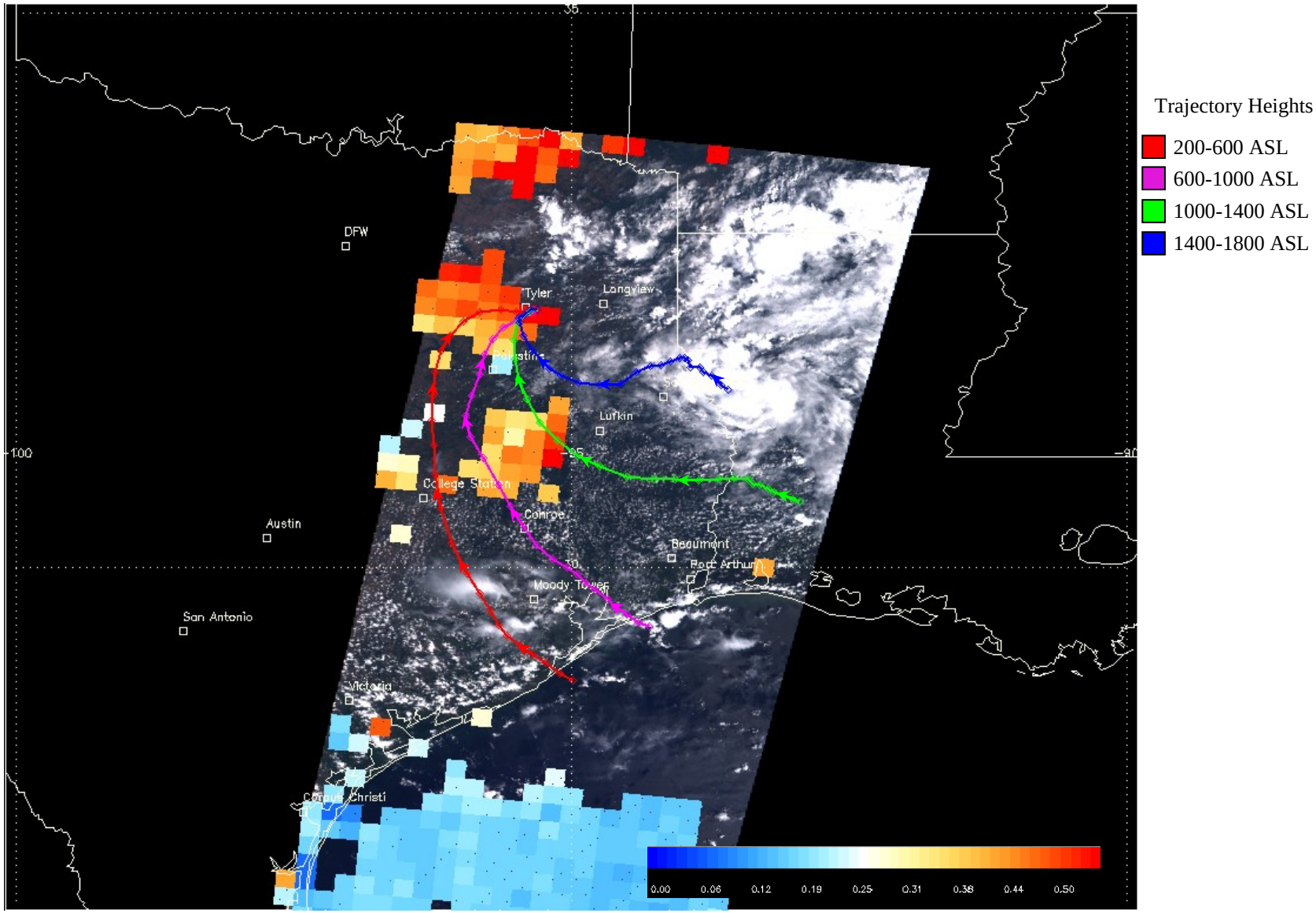
MISR 1.1 km RGB Image from **22 August 2006**



MISR Best Estimate **Green Band Optical Depth** (V20)

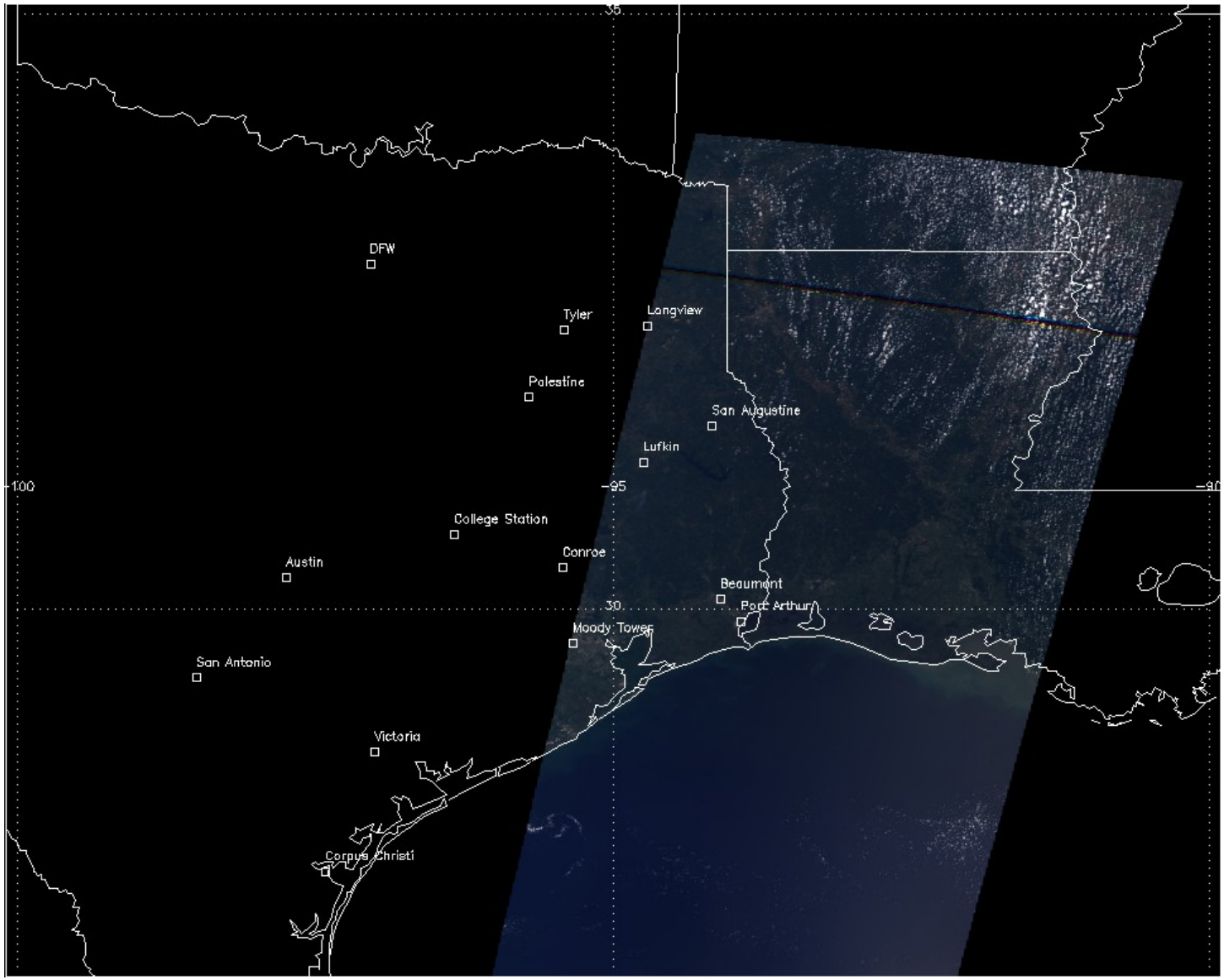


MISR Best Estimate **Green Band Optical Depth** (V20)

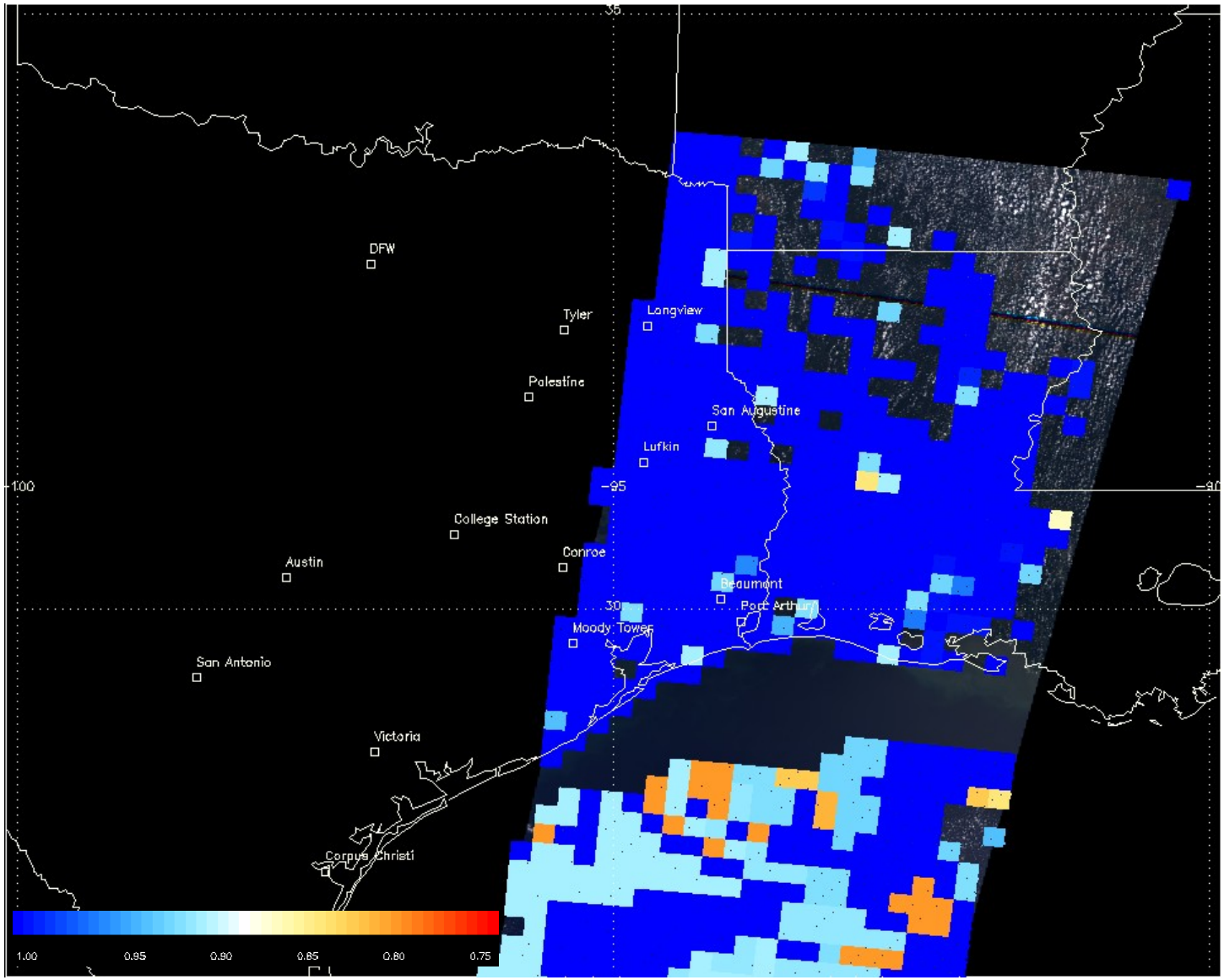


24 hour back trajectories starting at 1700 UTC 22 August from http://www.etl.noaa.gov/programs/2006/texaqs/traj/

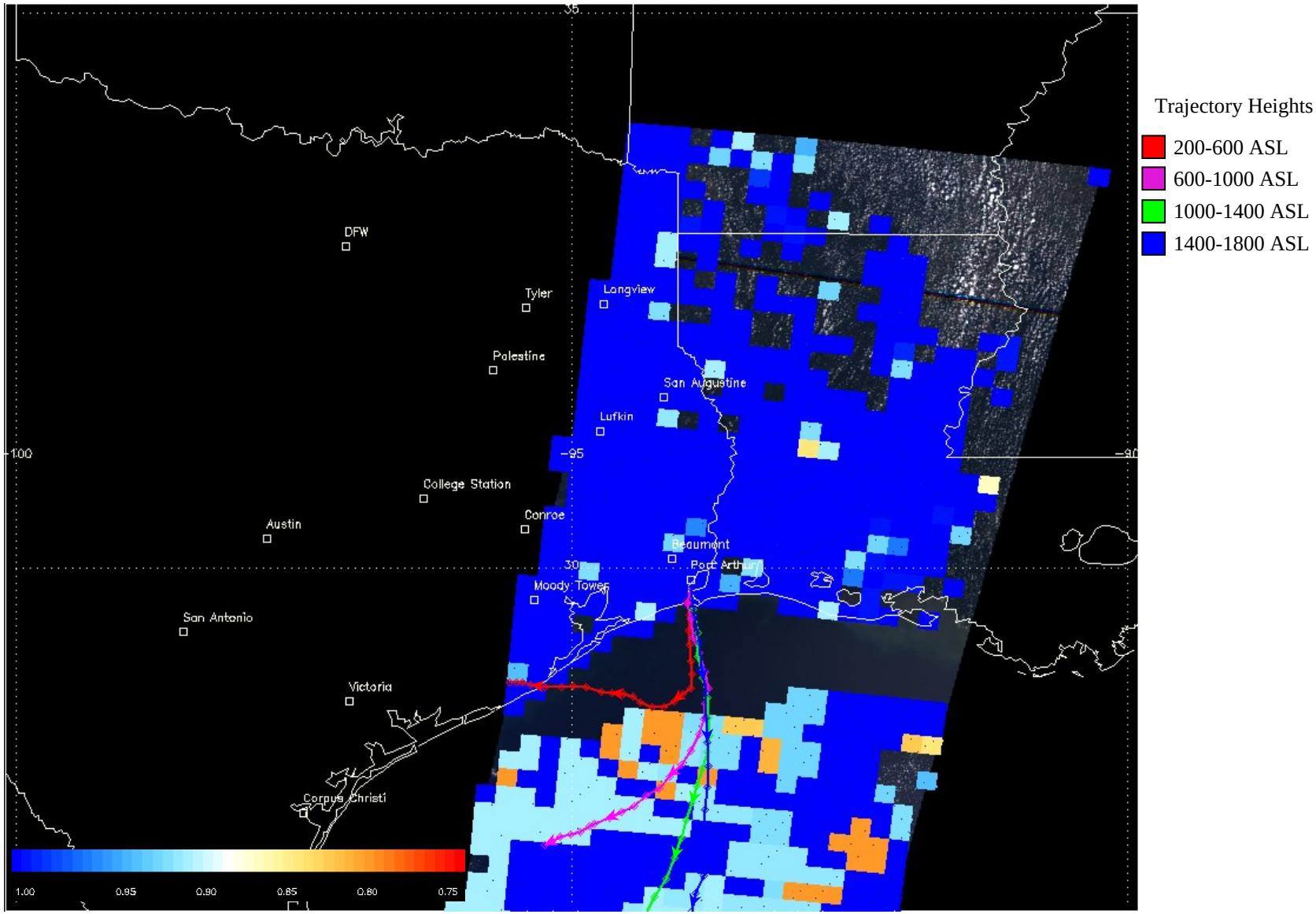
MISR 1.1 km RGB Image from **31 August 2006**



MISR Lowest Residual **Green Band SSA** (V20)

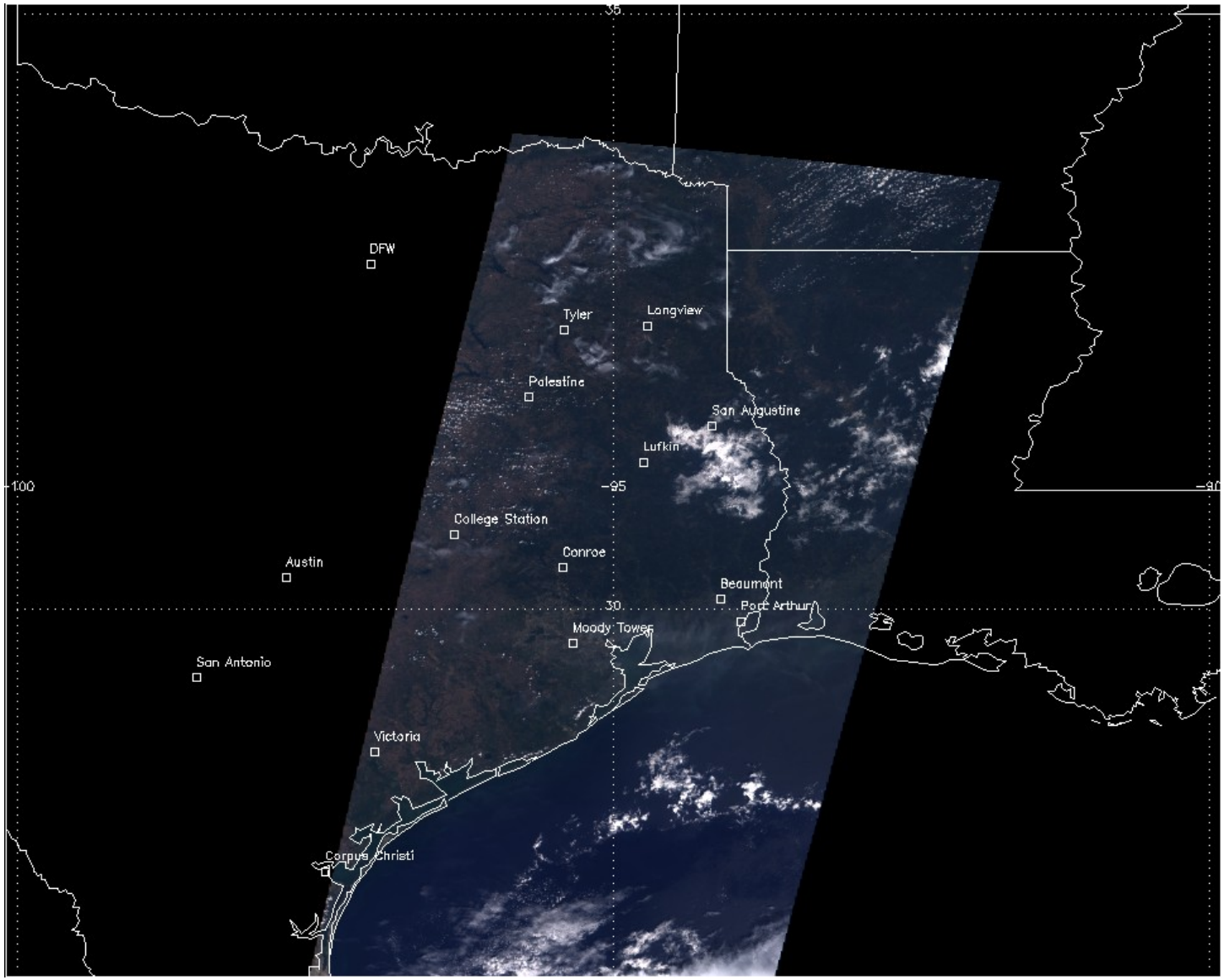


MISR Lowest Residual **Green Band SSA** (V20)

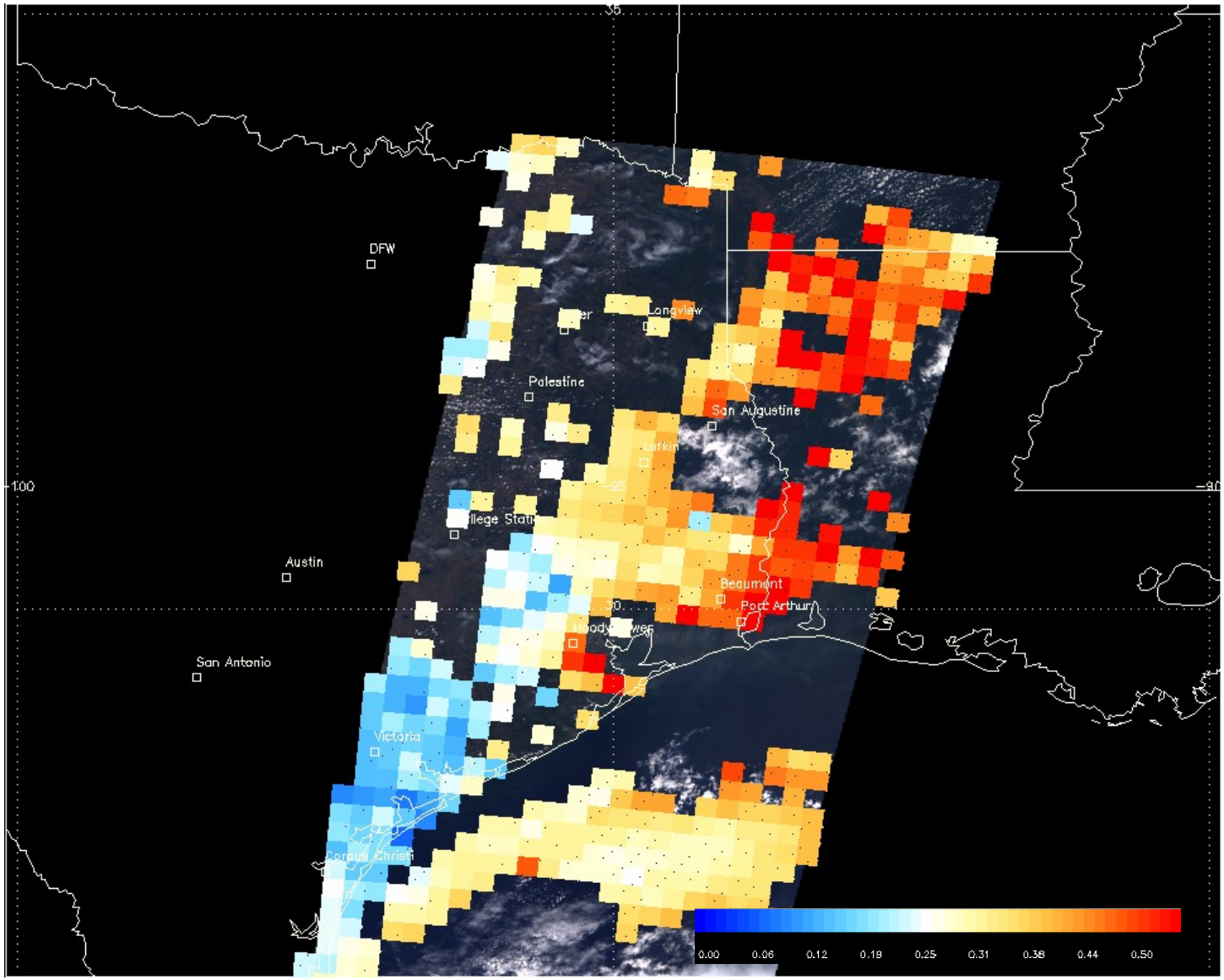


24 hour forward trajectories starting at 1700 UTC 30 August from http://www.etl.noaa.gov/programs/2006/texaqs/traj/

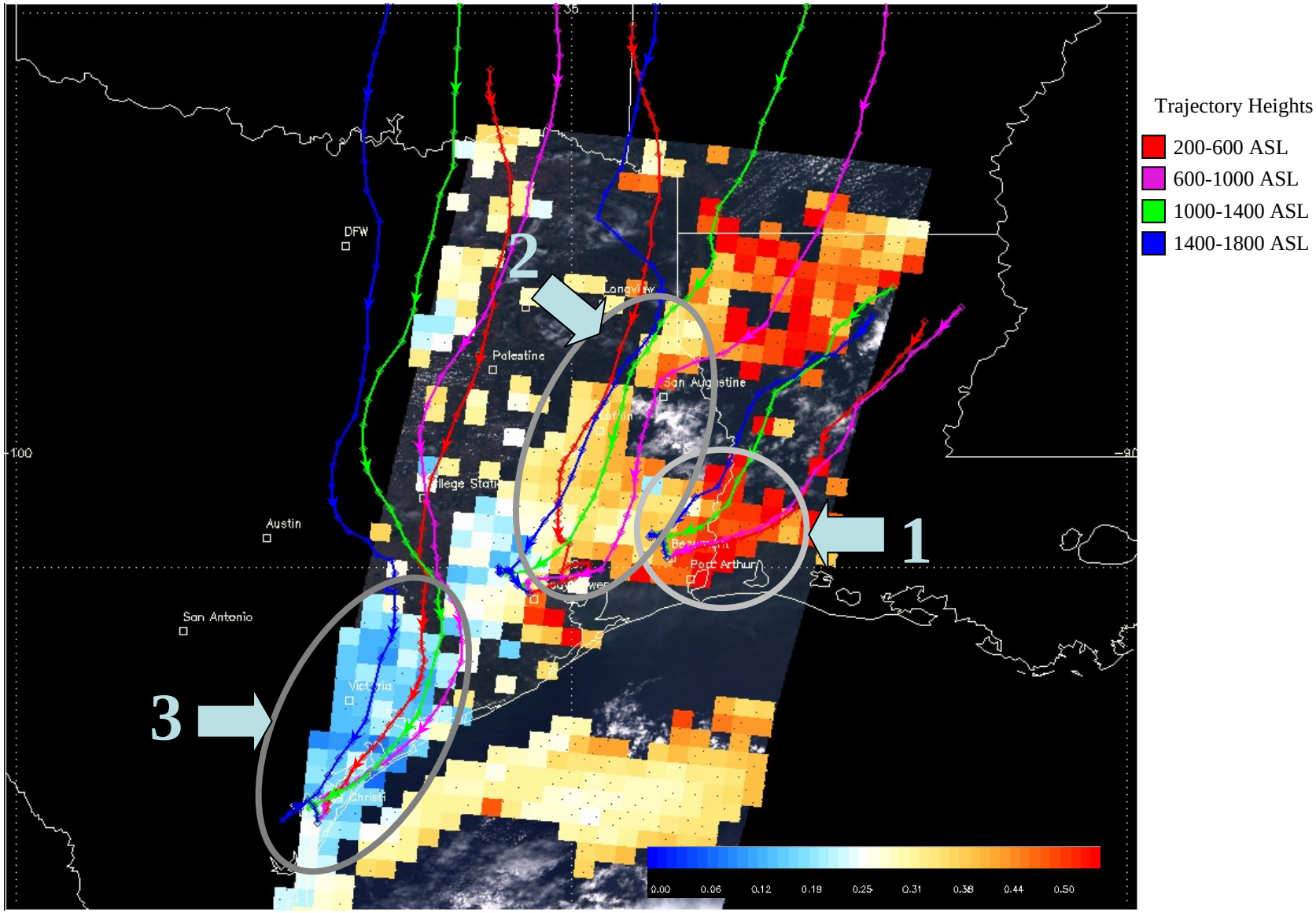
MISR 1.1 km RGB Image from **7 September 2006**



MISR Best Estimate **Green Band Optical Depth** (V20)



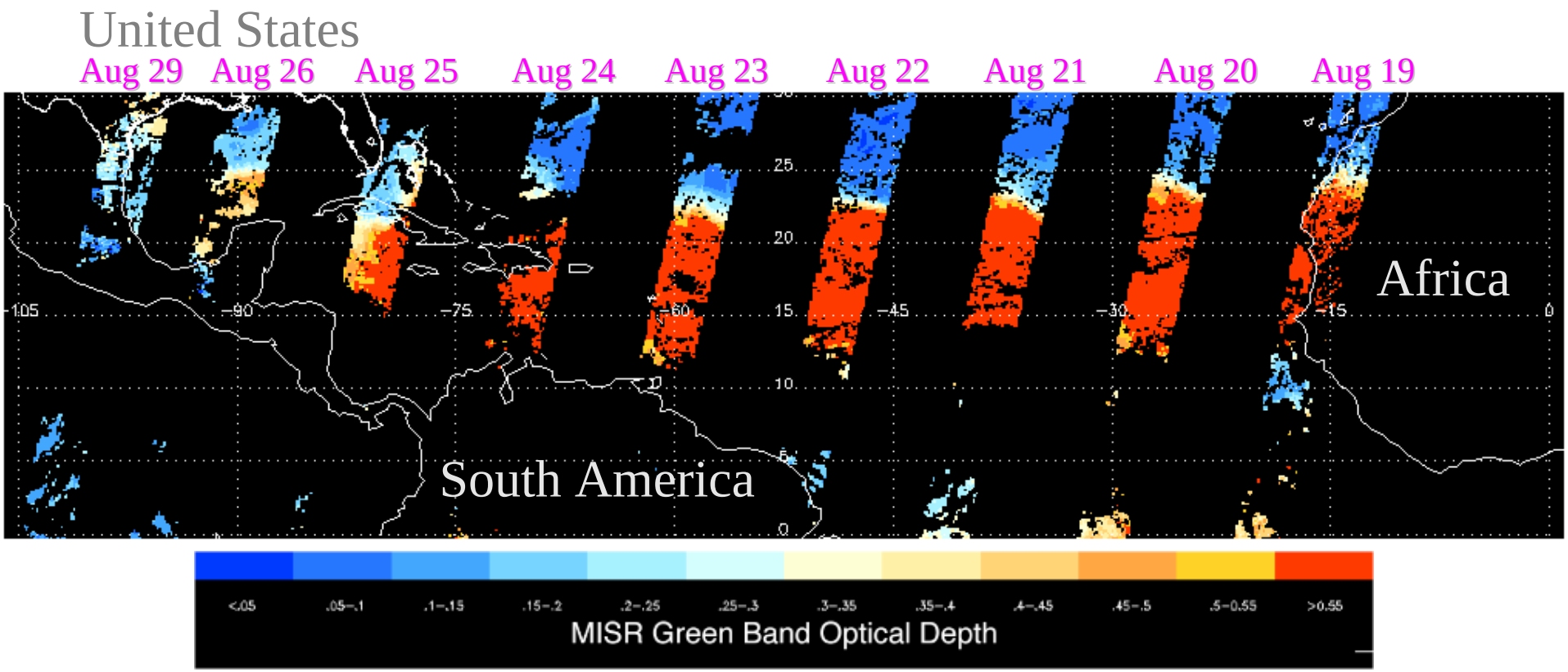
MISR Best Estimate **Green Band Optical Depth** (V20)



24 and 48 hour back trajectories starting at 1700 UTC 7 September from http://www.etl.noaa.gov/programs/2006/texaqs/traj/

MISR Aerosol Optical Depth Sequence Showing Dust Transport into Houston from Africa with Comparisons to the NAAPS Model and Surface PM 2.5 Measurements

Dust from the Sahara Desert Reaches Houston, Texas



Observations from the Multi-angle Imaging SpectroRadiometer (MISR) Instrument on NASA's EOS Terra Satellite

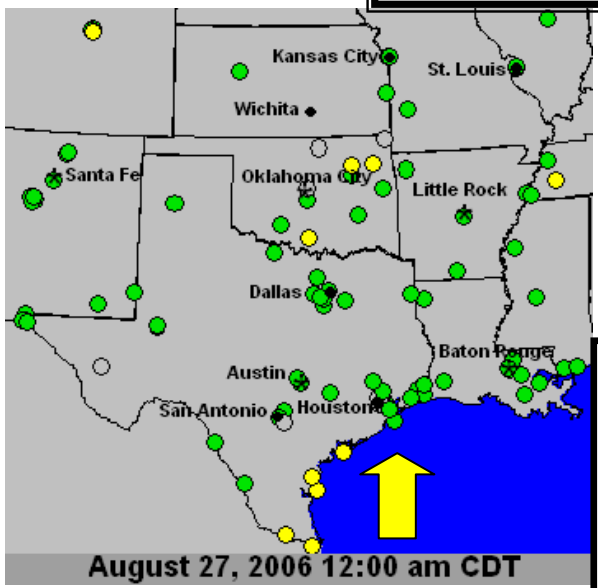
NAAPS Model: **Dust** Aerosol Optical Depth

Aug 2006 12:00 UTC

The NAAPS model shows dust enters Texas from the south on Aug. 27 and remains in the Houston area until Aug. 29

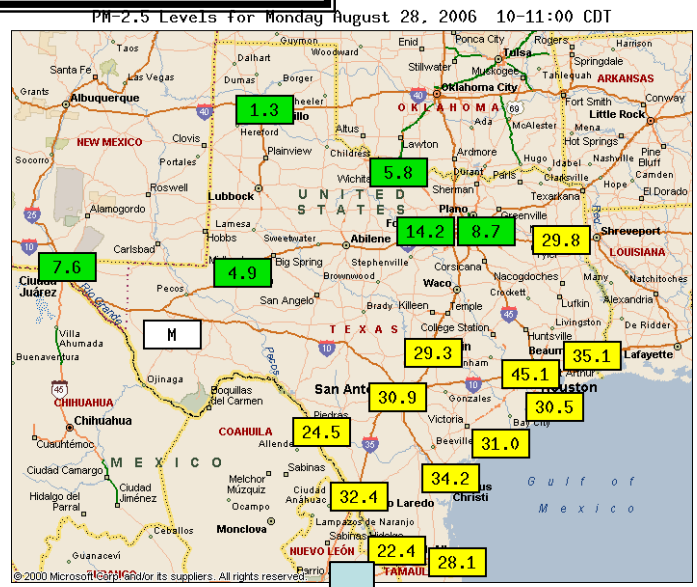
Model data from http://www.nrlmry.navy.mil/aerosol/

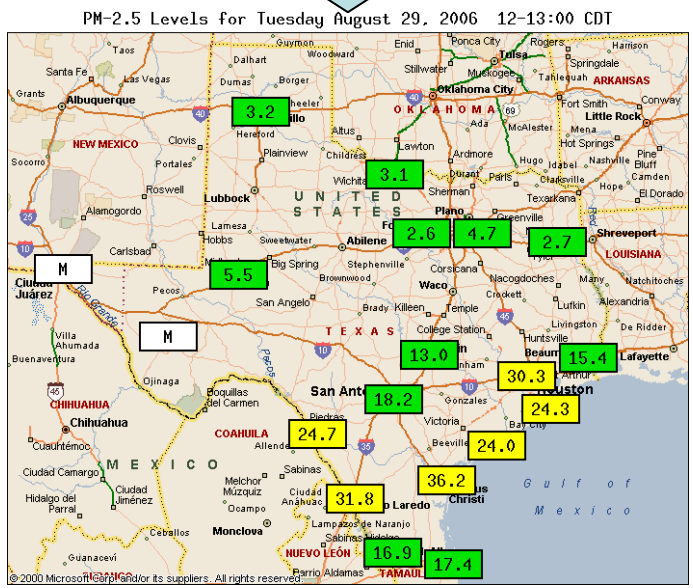
Surface PM 2.5 Measurements

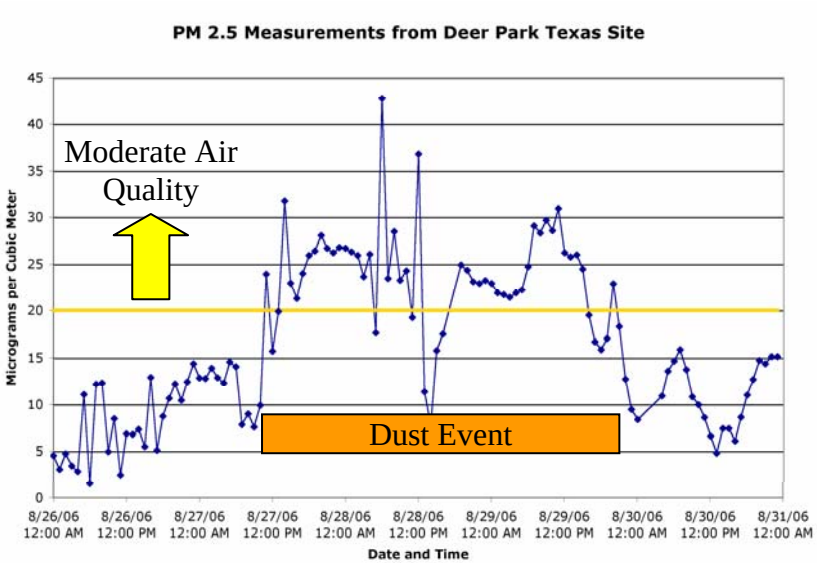


Animation from http://airnow.gov

Animation shows PM 2.5 increases over time from Southern to Central TX





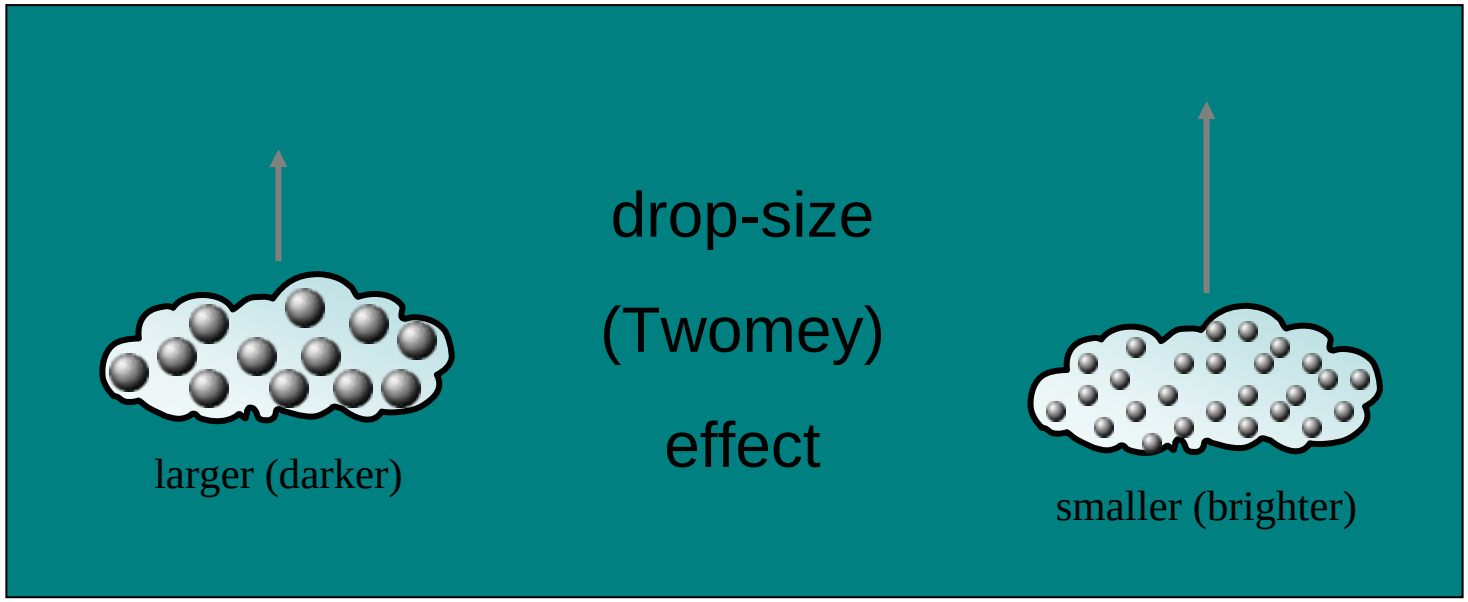


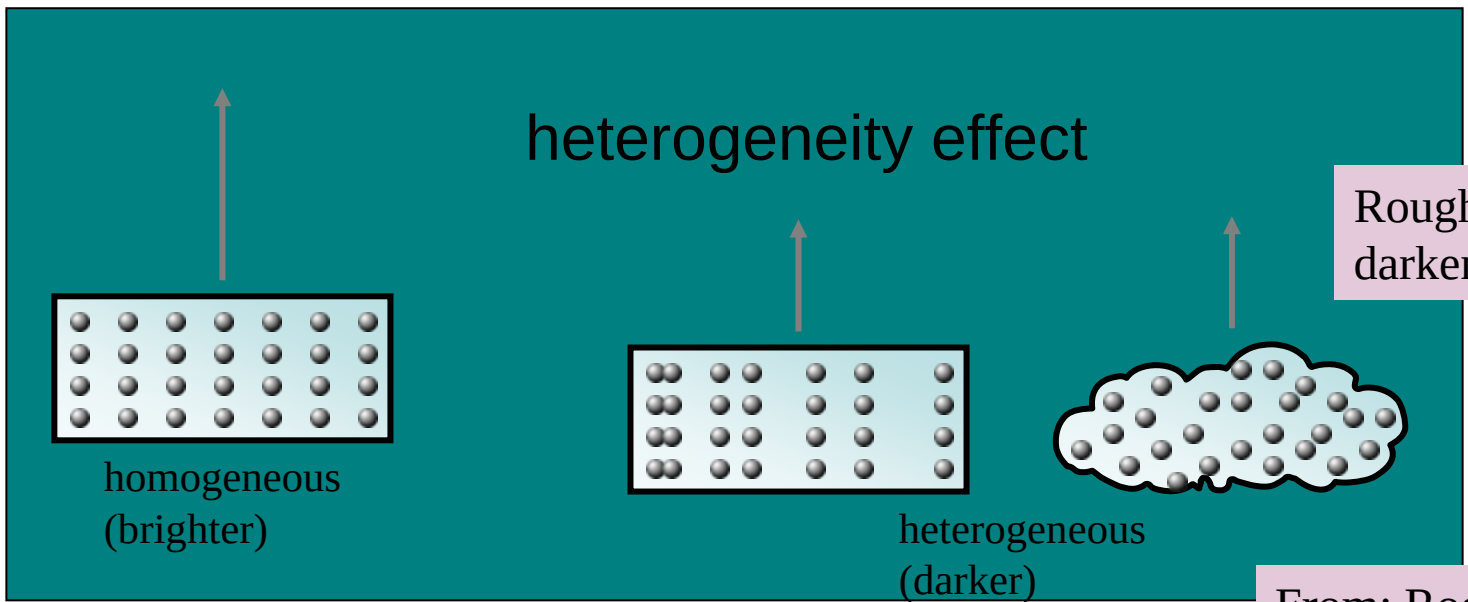
Surface data from http://www.tceq.state.tx.us/cgi-bin/compliance/monops/daily_summary

Time of MISR Overpass

Aerosol-Cloud Interactions and the Potential of Combined MISR and Suborbital Observations

Some Potential Aerosol Effects on Clouds



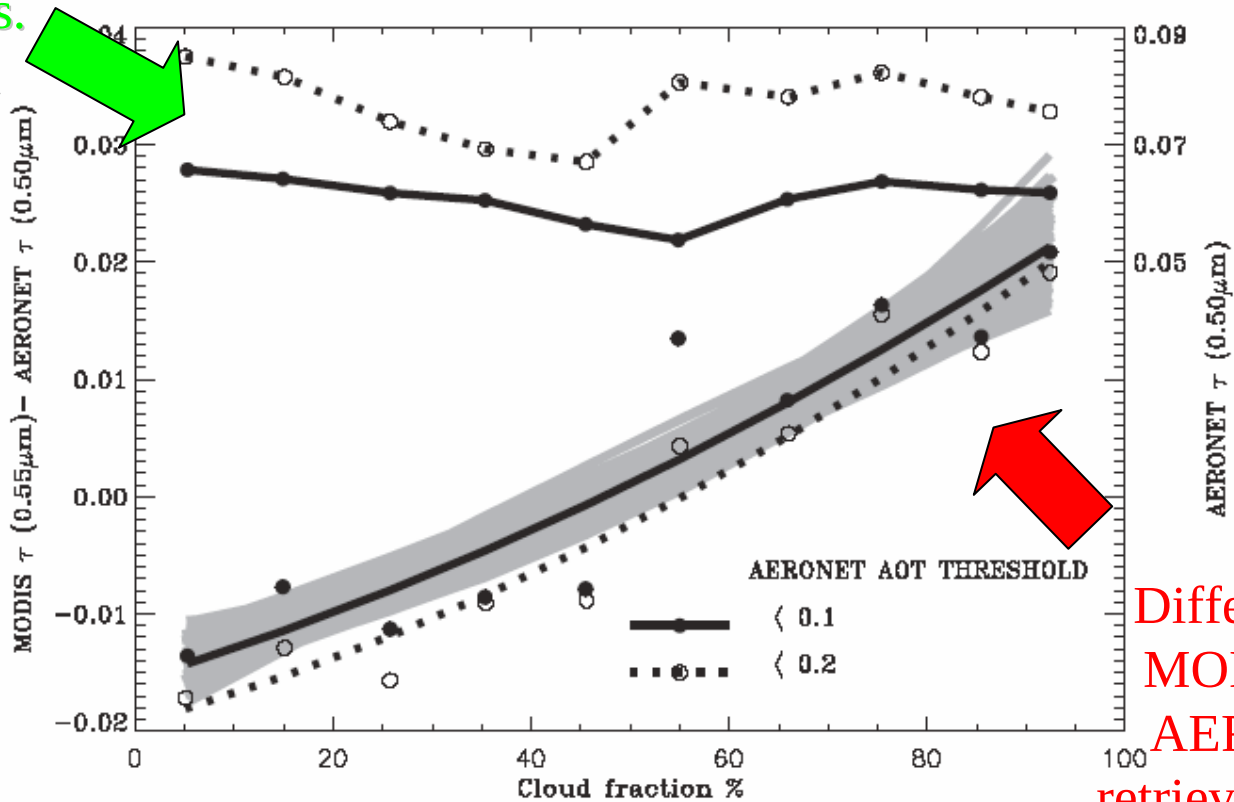


Rough texture darkens clouds

From: Roger Davies

Evidence of the Effect of Clouds on Aerosol Retrievals

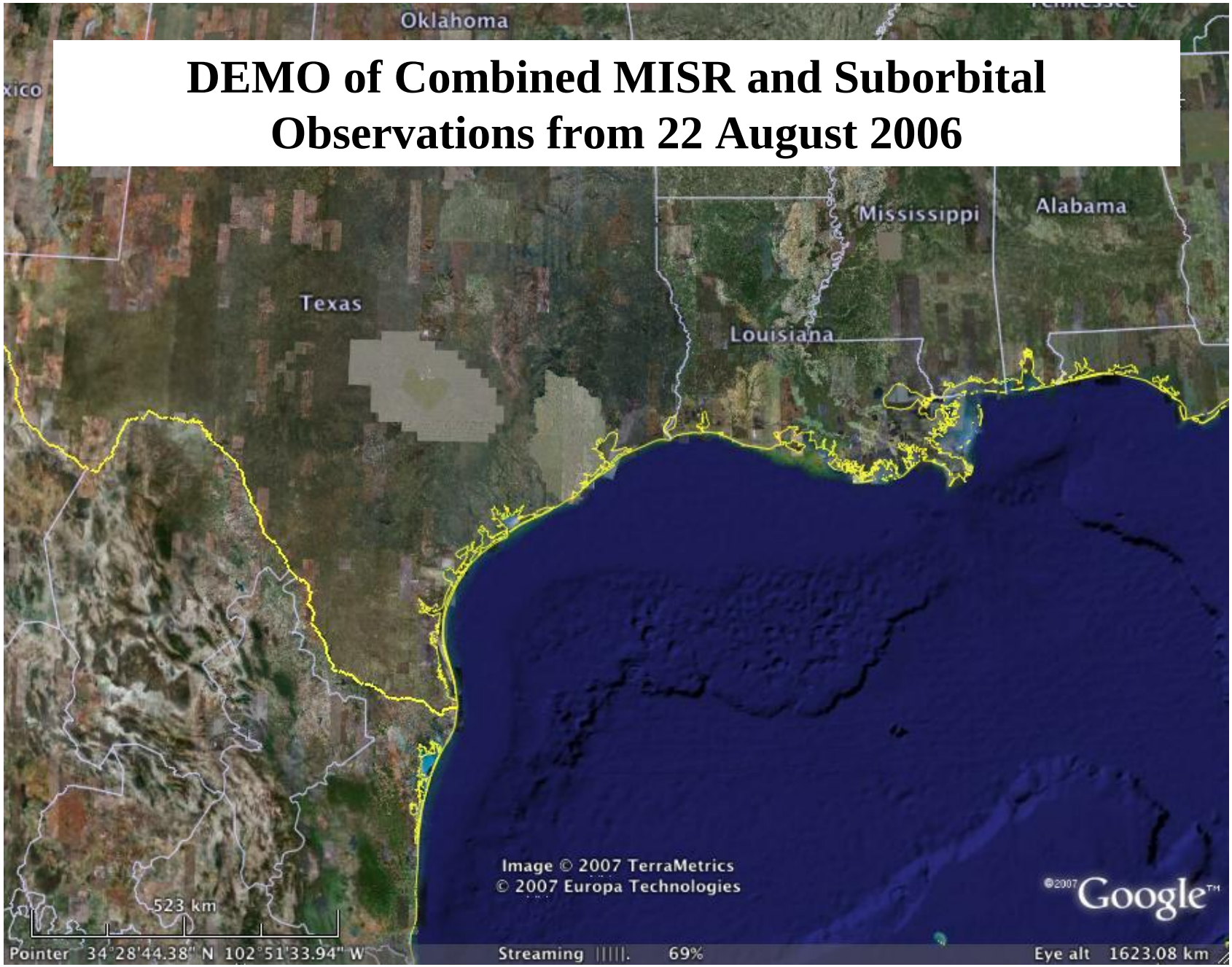
AERONET optical depth vs. cloud fraction



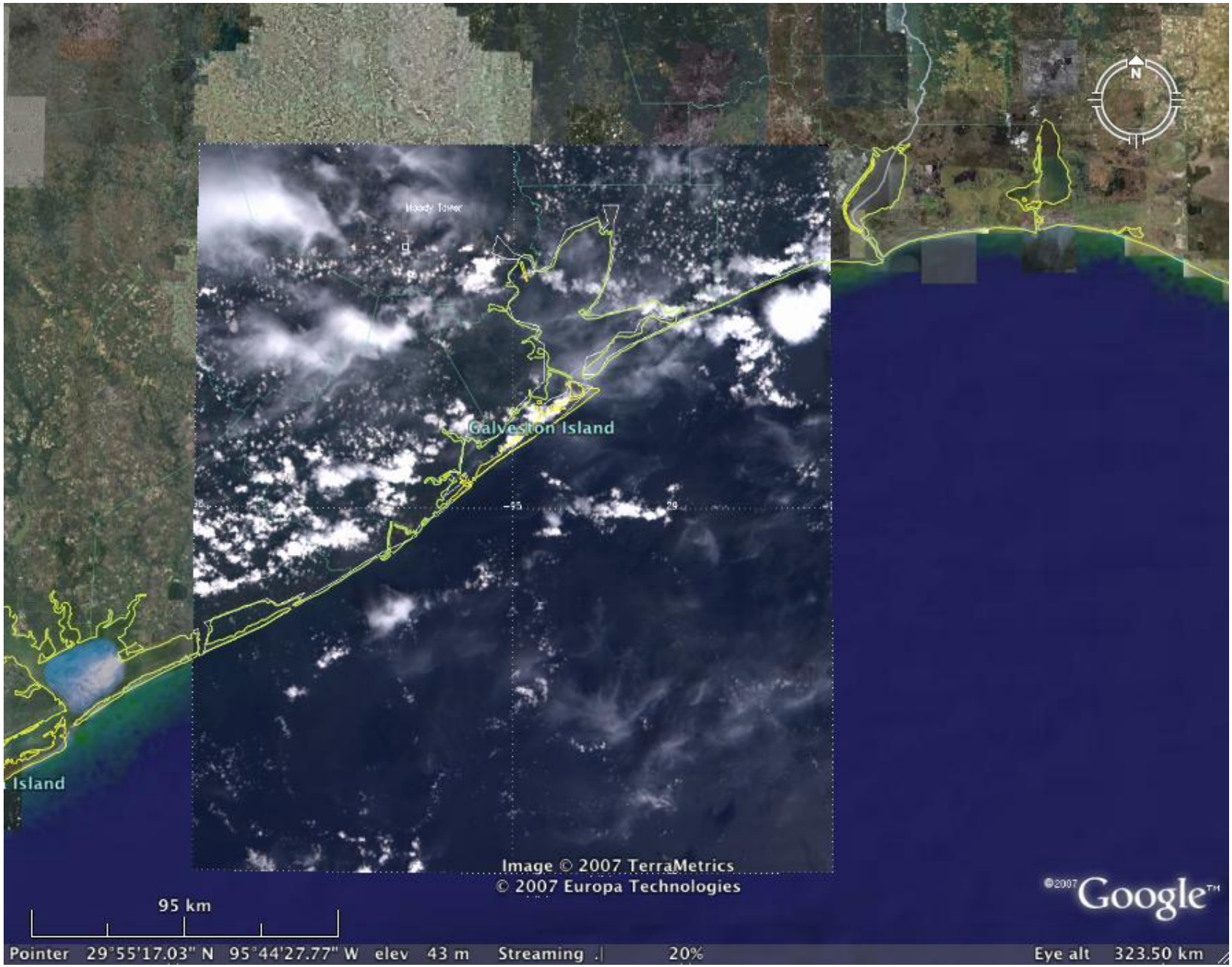
Difference in MODIS and AERONET retrieved aerosol optical depth vs. cloud fraction

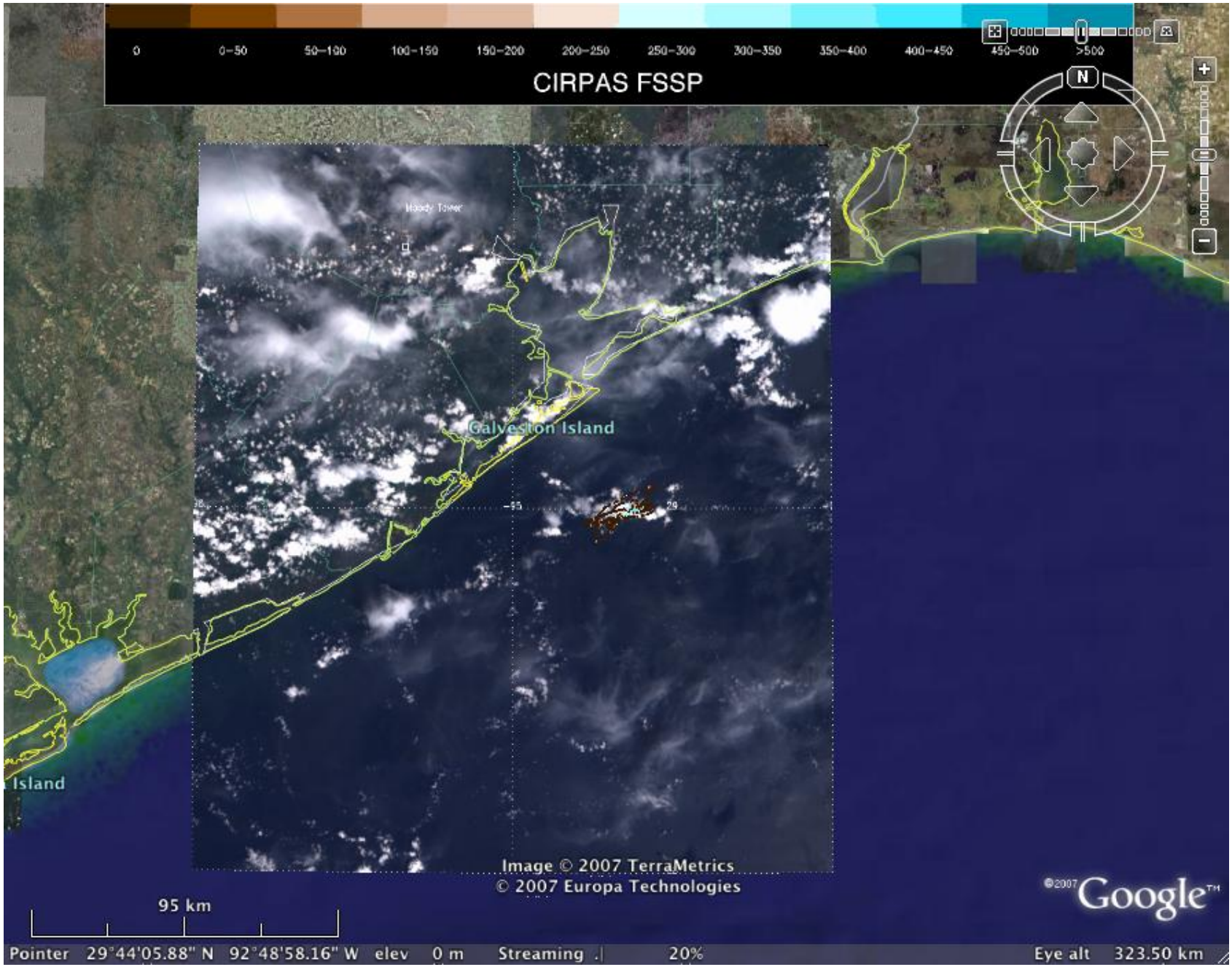
Figure from J. Zhang, J. S. Reid, and B. N. Holben (2005), An analysis of potential cloud artifacts in MODIS over ocean aerosol optical thickness products, *Geophysical Research Letters.*

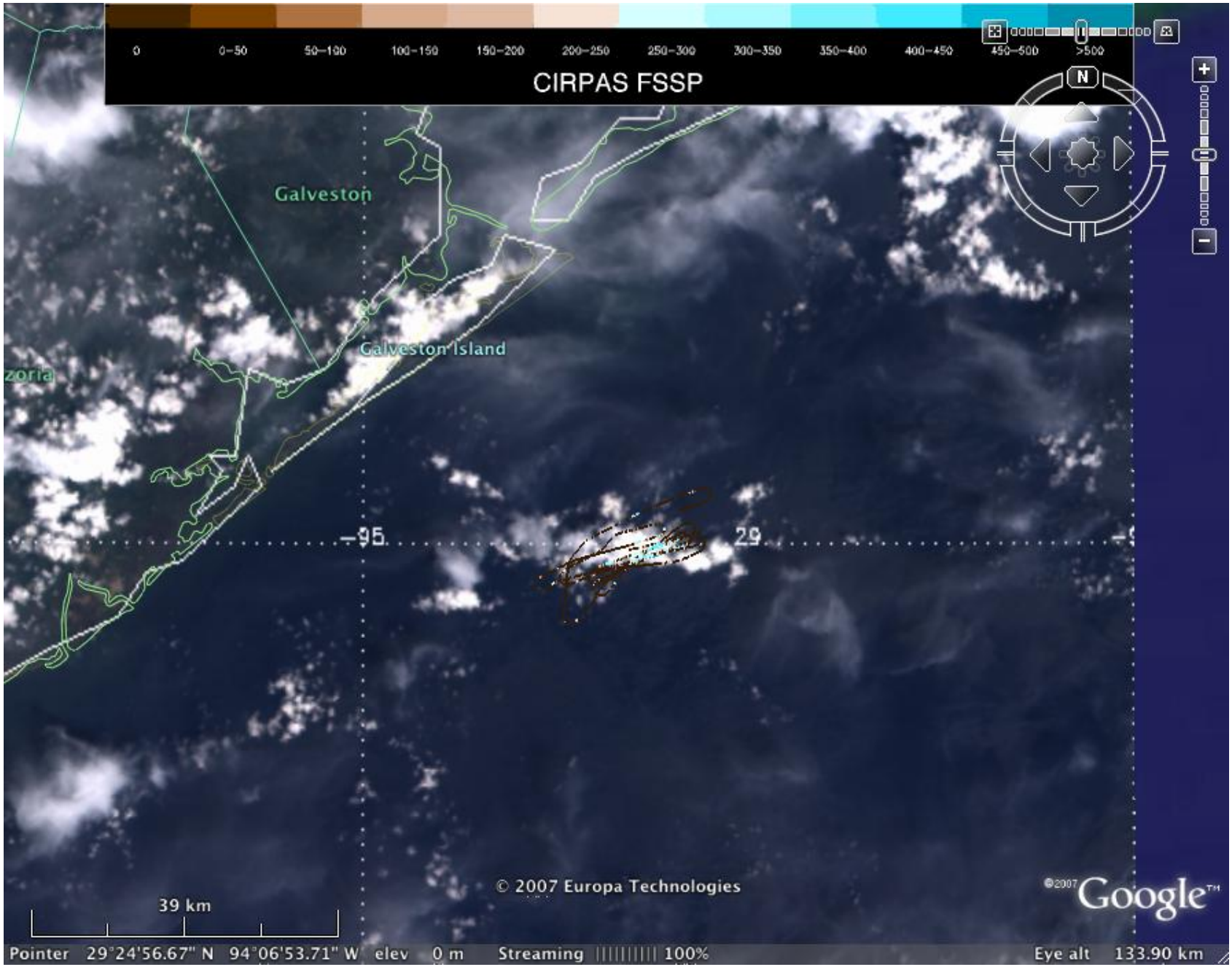
DEMO of Combined MISR and Suborbital Observations from 22 August 2006

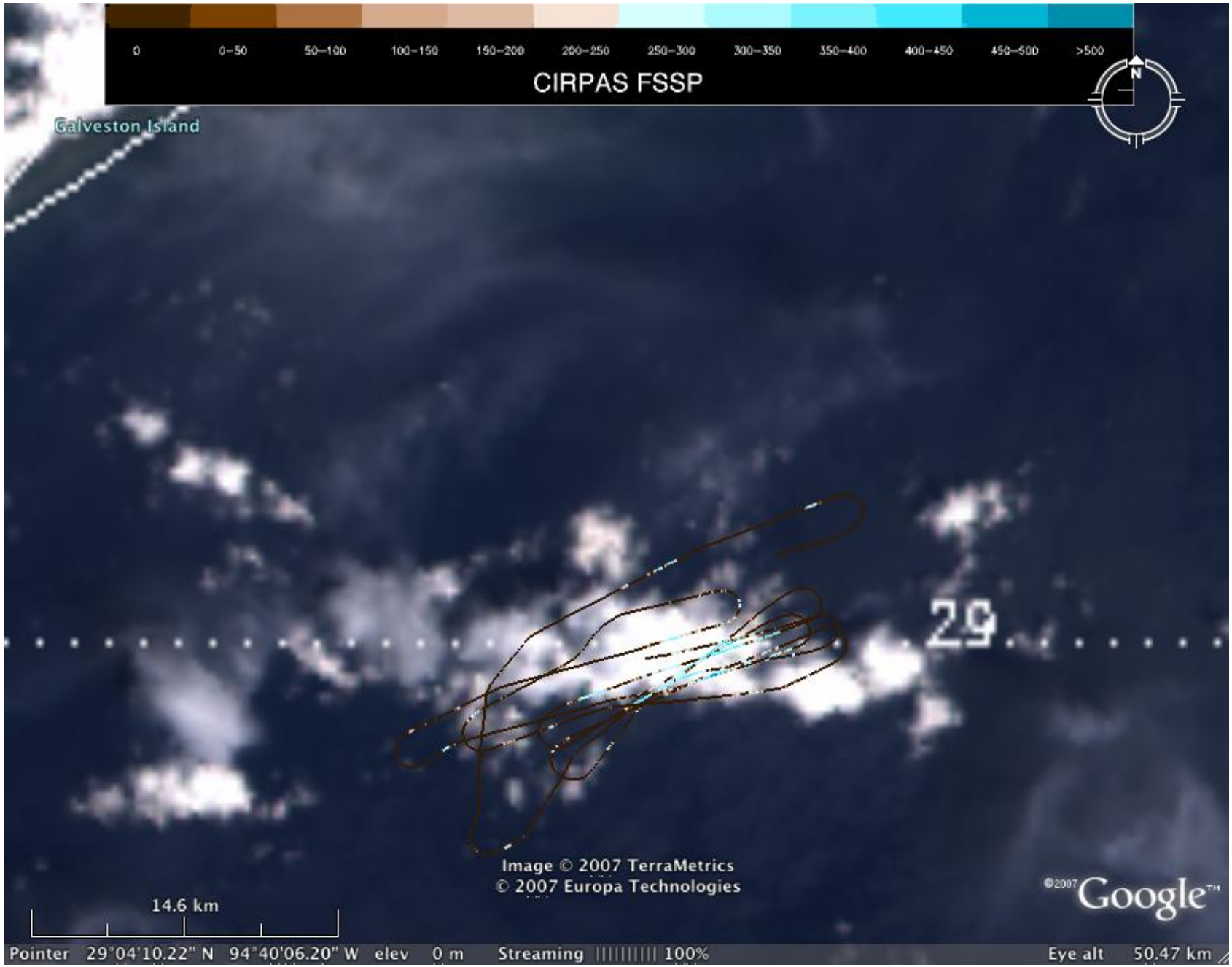


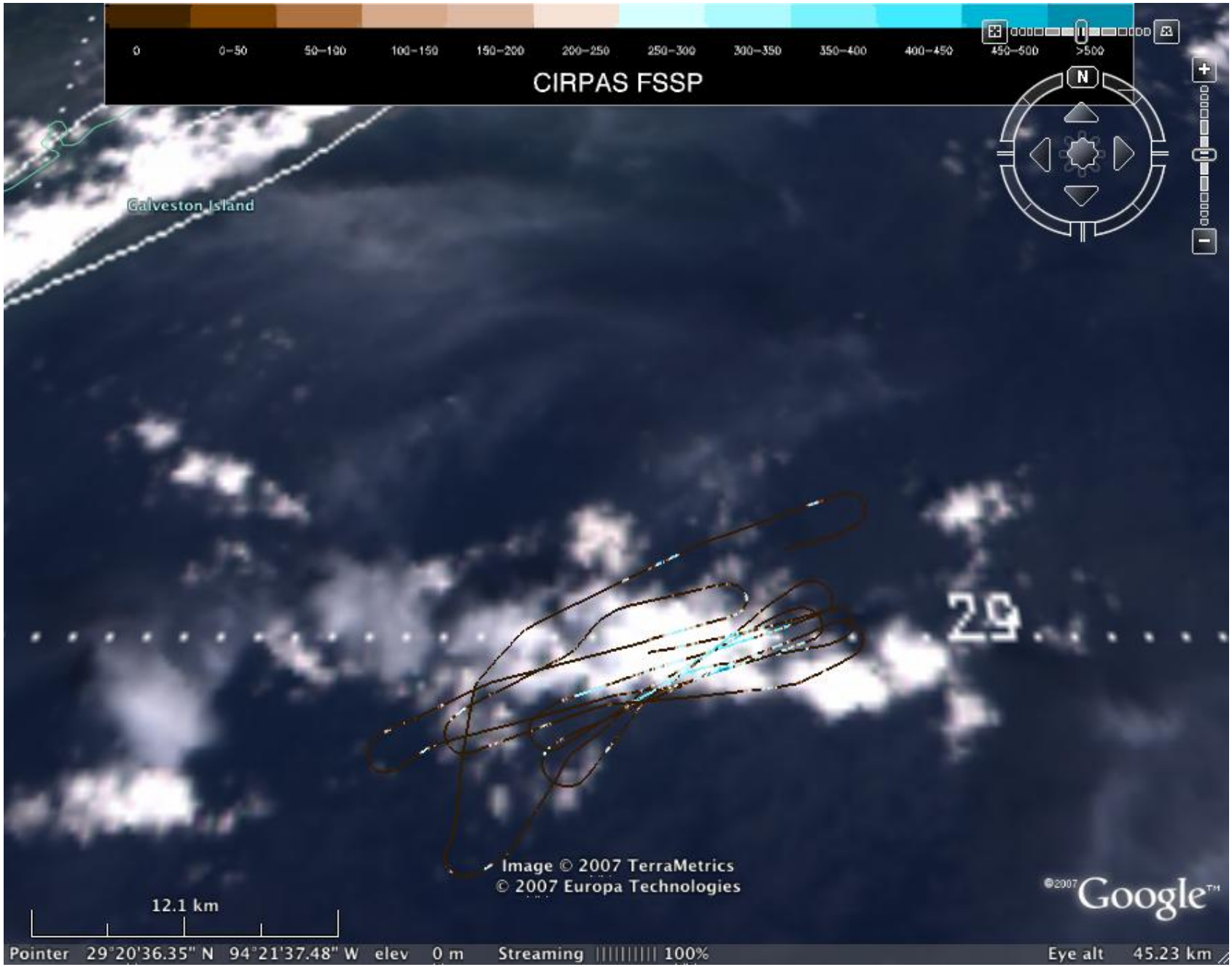
N
Galveston Island
Island
Image © 2007 TerraMetrics
© 2007 Europa Technologies
95 km
©2007 Google™
Pointer 29°31'19.76" N 96°32'29.10" W elev 70 m Streaming 20%
Eye alt 323.50 km

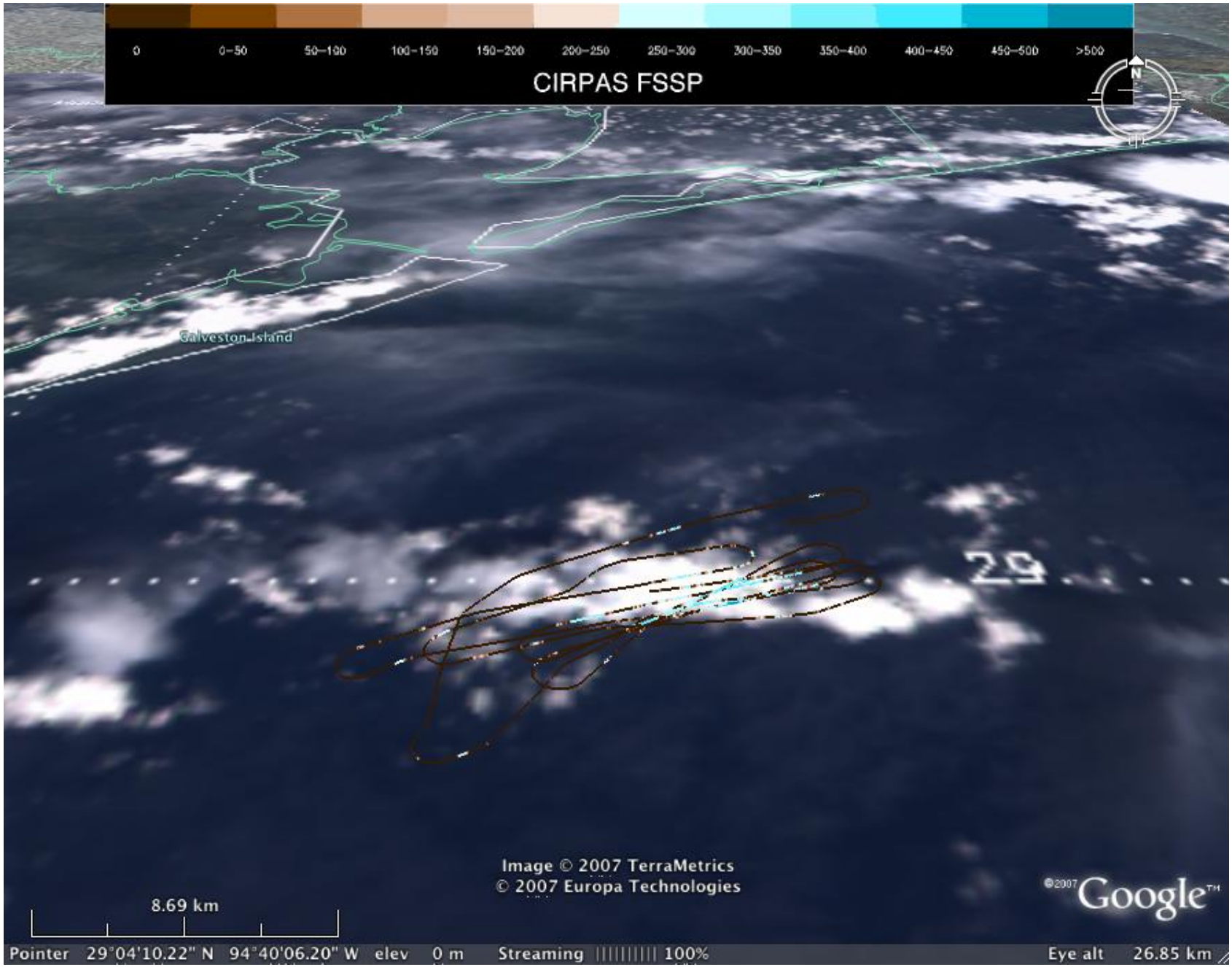

Galveston Island
Island
Image © 2007 TerraMetrics
© 2007 Europa Technologies
95 km
©2007 Google™
Pointer 29°55'17.03" N 95°44'27.77" W elev 43 m Streaming 20%
Eye alt 323.50 km

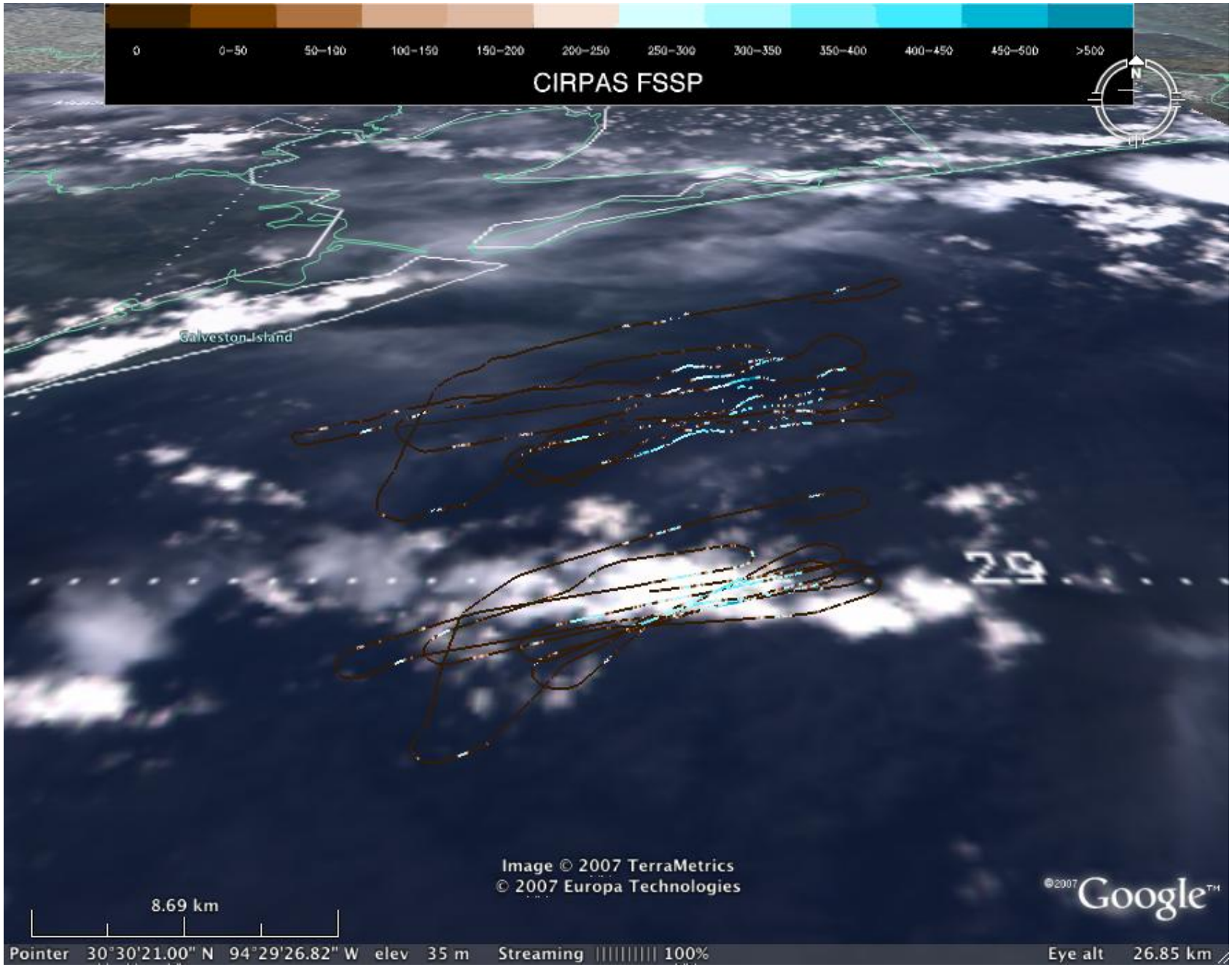

0
0–50
50–100
100–150
150–200
200–250
250–300
300–350
350–400
400–450
450–500
>500
CIRPAS FSSP
Galveston Island
Island
Image © 2007 TerraMetrics
© 2007 Europa Technologies
95 km
©2007 Google™
Pointer 29°44'05.88" N 92°48'58.16" W elev 0 m Streaming 20%
Eye alt 323.50 km


0
0–50
50–100
100–150
150–200
200–250
250–300
300–350
350–400
400–450
450–500
>500
CIRPAS FSSP
Galveston
Galveston Island
-95
29
© 2007 Europa Technologies
39 km
©2007 Google
Pointer 29°24'56.67" N 94°06'53.71" W elev 0 m Streaming 100%
Eye alt 133.90 km


0
0–50
50–100
100–150
150–200
200–250
250–300
300–350
350–400
400–450
450–500
>500
CIRPAS FSSP
N
Galveston Island
29
Image © 2007 TerraMetrics
© 2007 Europa Technologies
14.6 km
©2007 Google™
Pointer 29°04'10.22" N 94°40'06.20" W elev 0 m Streaming 100%
Eye alt 50.47 km


0
0–50
50–100
100–150
150–200
200–250
250–300
300–350
350–400
400–450
450–500
>500
CIRPAS FSSP
Galveston Island
29
Image © 2007 TerraMetrics
© 2007 Europa Technologies
12.1 km
©2007 Google™
Pointer 29°20'36.35" N 94°21'37.48" W elev 0 m Streaming 100%
Eye alt 45.23 km


0
0–50
50–100
100–150
150–200
200–250
250–300
300–350
350–400
400–450
450–500
>500
CIRPAS FSSP
N
Galveston Island
29
Image © 2007 TerraMetrics
© 2007 Europa Technologies
8.69 km
©2007 Google™
Pointer 29°04'10.22" N 94°40'06.20" W elev 0 m Streaming 100%
Eye alt 26.85 km


0
0–50
50–100
100–150
150–200
200–250
250–300
300–350
350–400
400–450
450–500
>500
CIRPAS FSSP
N
Galveston Island
29
Image © 2007 TerraMetrics
© 2007 Europa Technologies
8.69 km
©2007 Google™
Pointer 30°30'21.00" N 94°29'26.82" W elev 35 m Streaming 100%
Eye alt 26.85 km

Conclusions

- **Local pollution and transport**
  - MISR **standard** aerosol product appears to retrieve **particle properties** in **air masses consistent** with local production and transport
  - Need further **surface/aircraft validation** of these observations
- **Long-range transport**
  - MISR observes long-range transport of **Saharan dust** on **at least one occasion** during the field intensive
  - Work is underway to better understand the **composition** and **changes** within the transported dust and the **underlying physical mechanisms** that allow transport across the Atlantic
- **Aerosol-cloud interactions**
  - MISR multi-angle measurements at **275 m spatial resolution**, in **combination** with measurements from **suborbital instruments** provide the capability of exploring the **details** of this problem
  - Much work remains to be done, including **collecting and combining additional data sets** and extensive **modeling**

Contact Info: Michael.J.Garay@jpl.nasa.gov