Global Aerosol Height Distribution from GLAS Satellite Lidar Data and MP Lidar Network

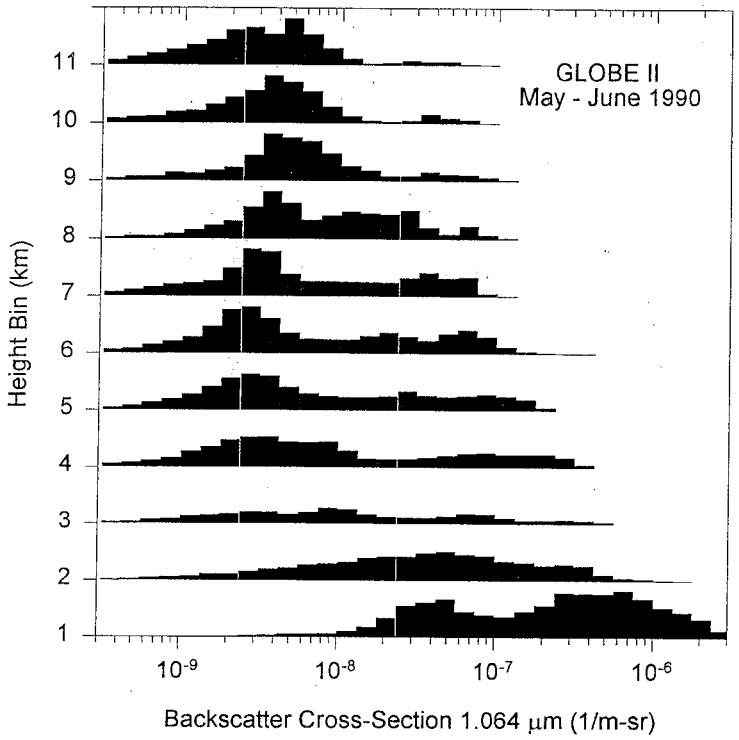
Jim Spinhirne,
Steve Palm, Judd Welton, Dennis Hlavka and Bill Hart

Geoscience Laser Altimeter System
Begin full data operation – Oct. 2003
Release of Aerosol Height Product – May 2004
Release Full Aerosol Data Products – Sept. 2004

Micro Pulse Lidar Network
Full time aerosol height profiling at Aeronet sites
Initiation - 2000

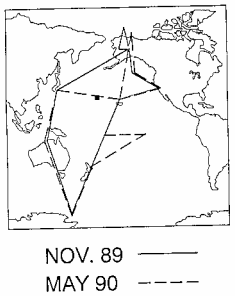
GLOBE - Global Backscatter Experiment

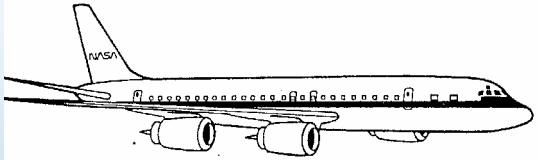
Definition of Space Lidar Requirements



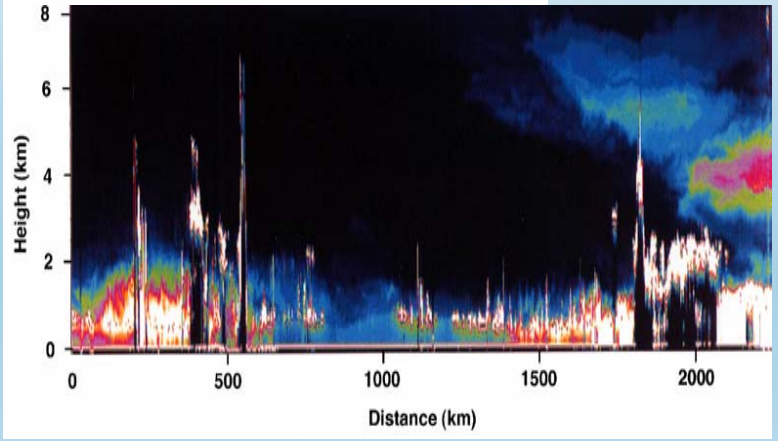
Menzies, Tratt, Spinhirne and Hlavka - JGR 2002

GLOBE





DC-8



- **Observe backscatter cross sections below 10^{-7} (1/m-sr) for aerosol transport**
- **Observe backscatter cross sections up to 10^{-3} for dense aerosol events**
- **Observe backscatter cross sections over six orders of magnitude including clouds**

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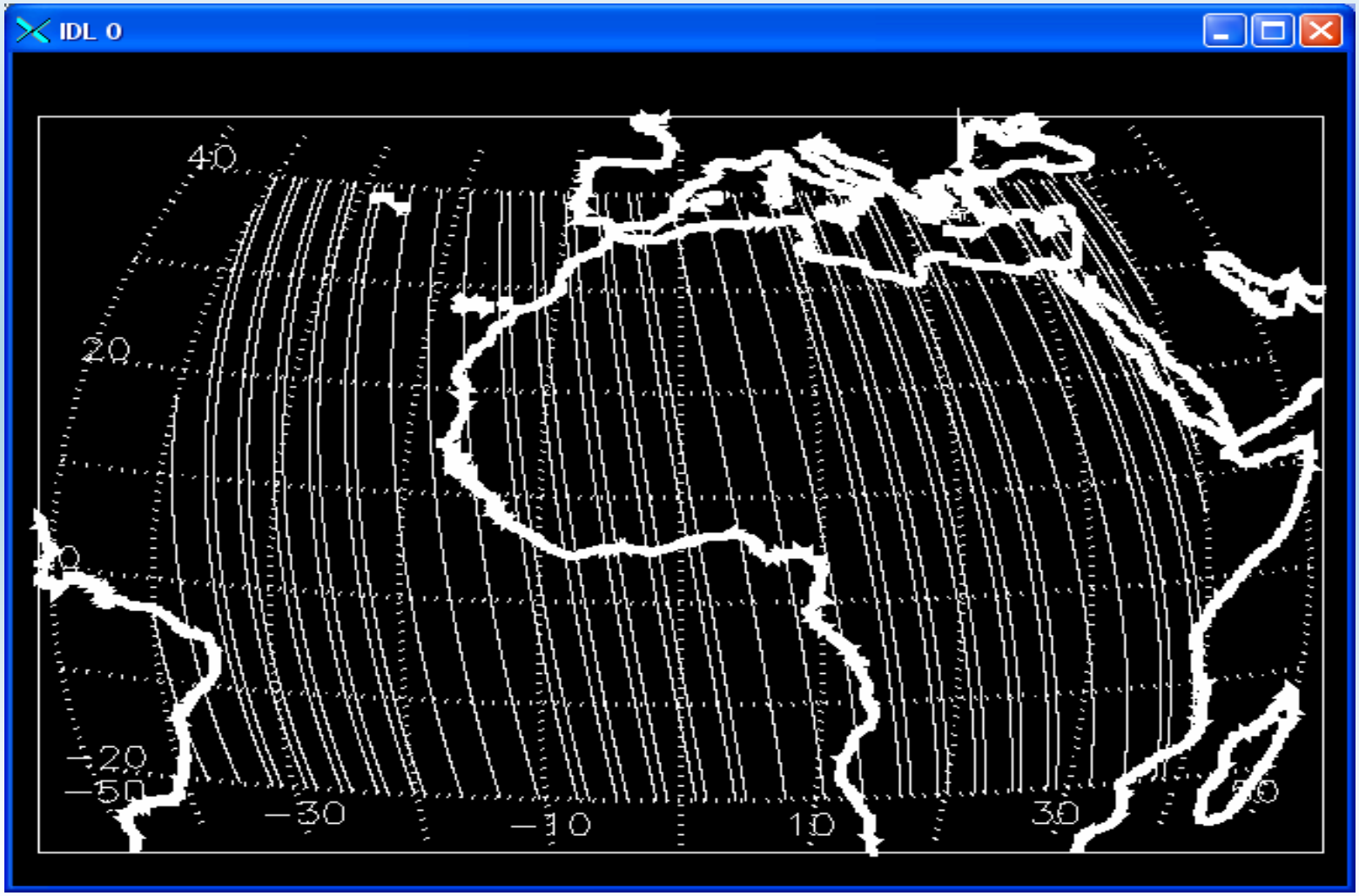
GLAS Data

October 3-17, 2003

Night Tracks



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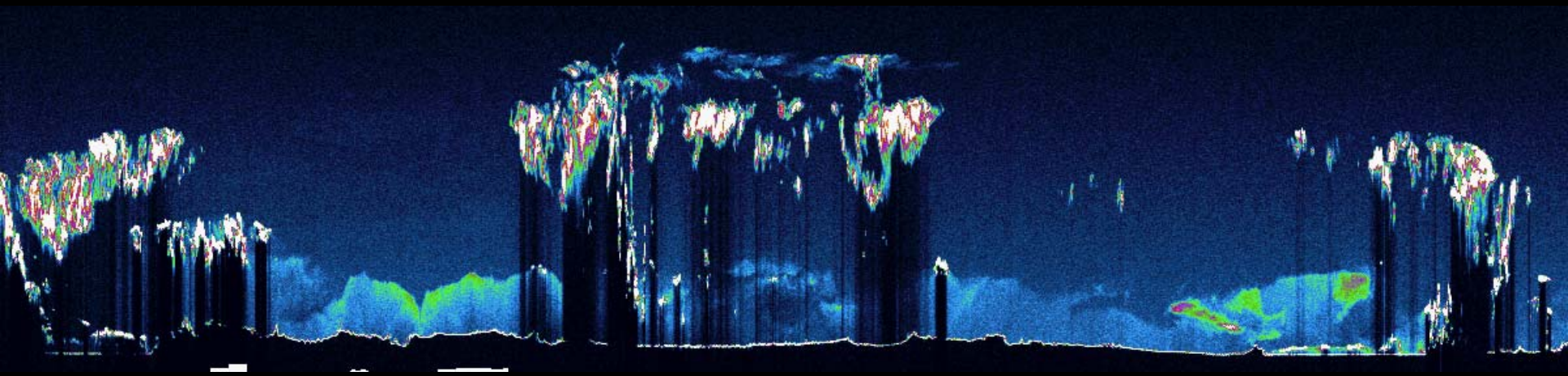
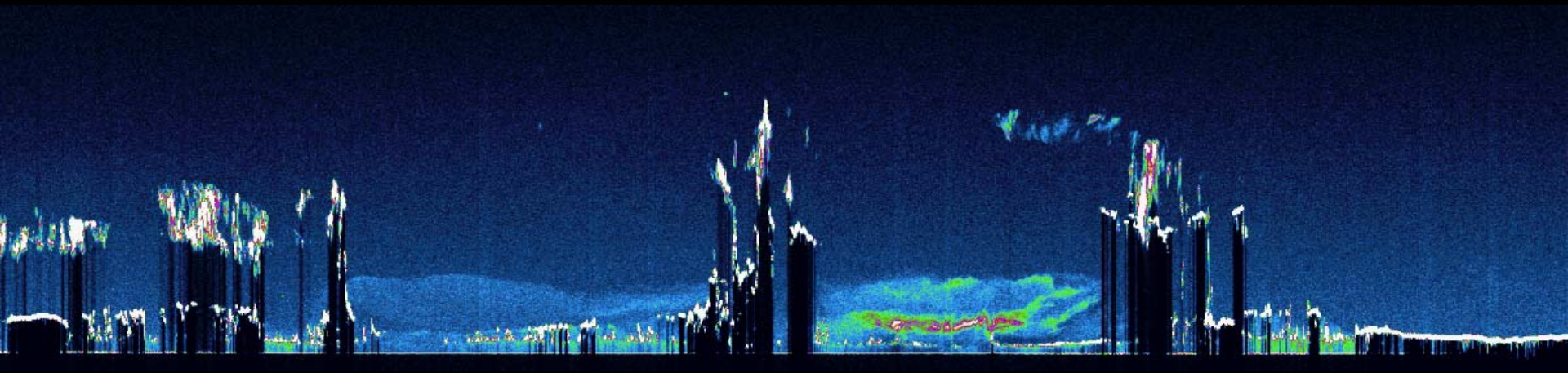
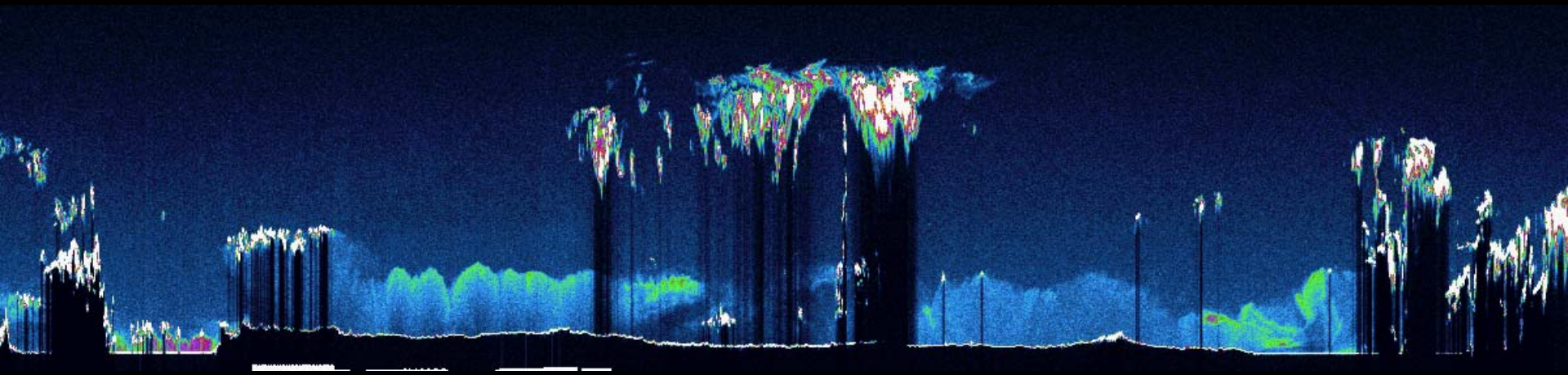
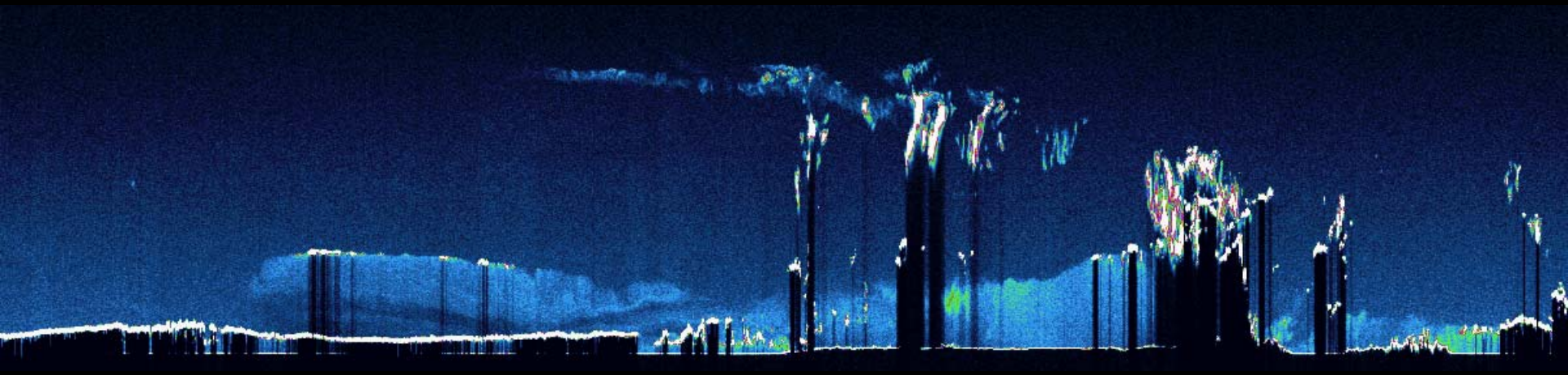
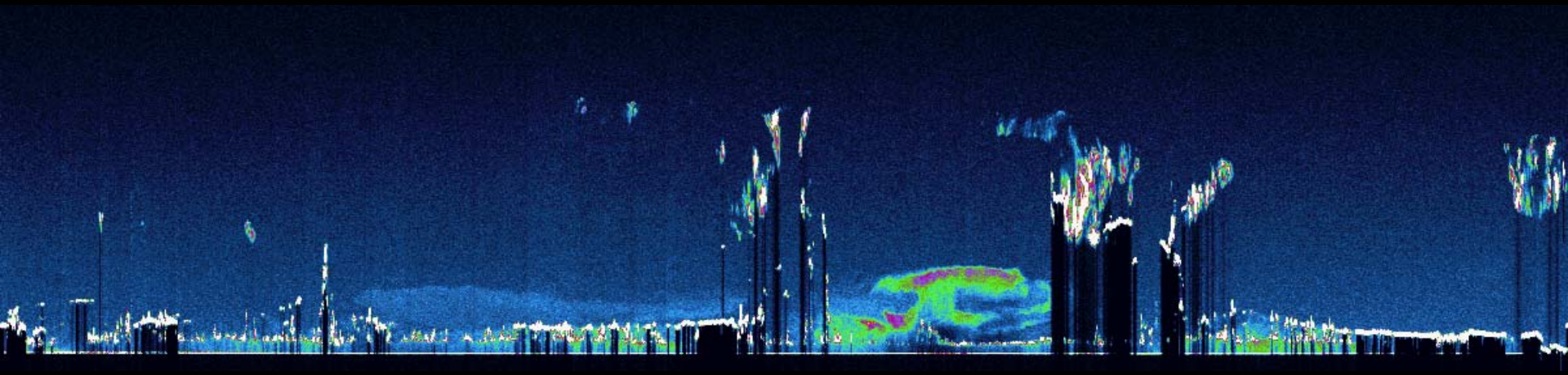


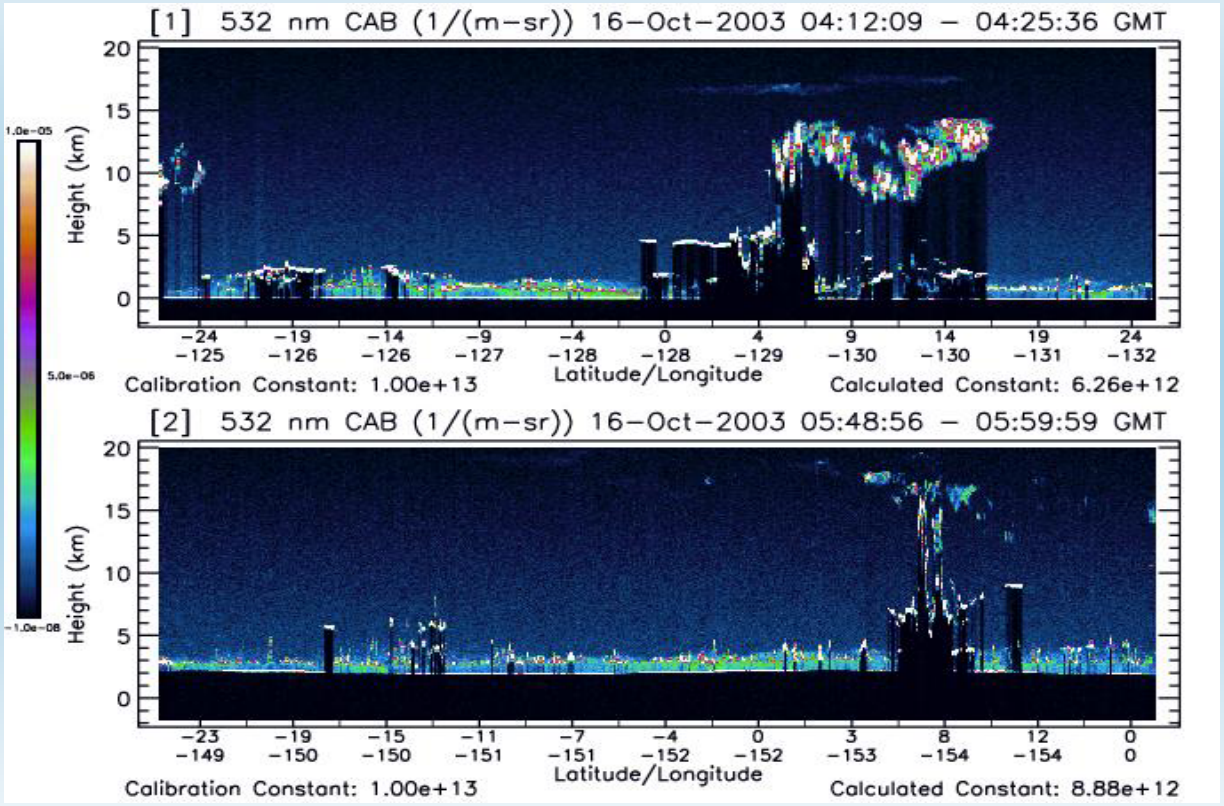




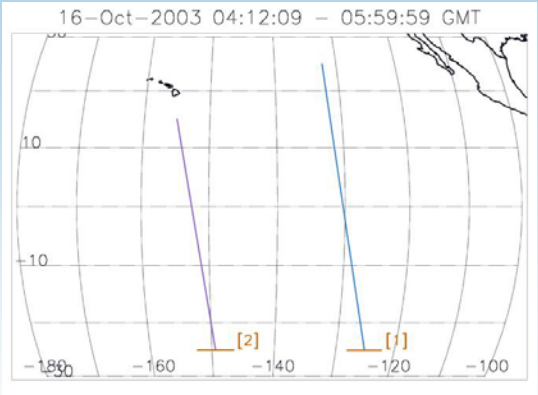




GLAS Detection of Aerosol
For Remote Oceanic Regions



Central Pacific



GLAS Measurement Components

Atmospheric Profiles at 1064 and 532 nm

$S(z) = C\ E\ B(z)\ T_e^2(z)\ /r^2$

Aerosol and Thin Cloud:

532 nm – GAPD Photon Counting

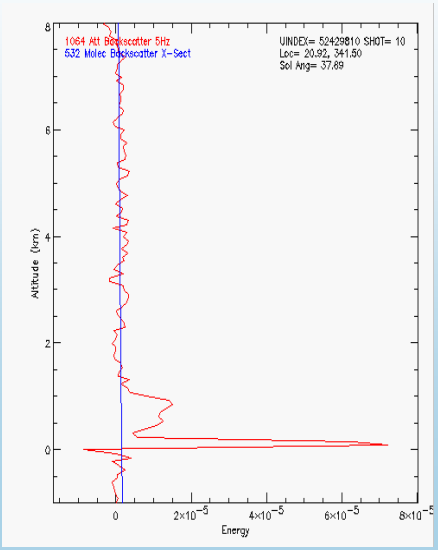
Denser Cloud:

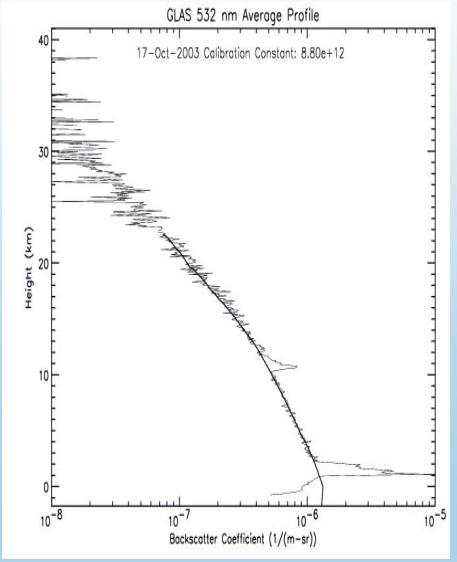
1064 nm – Analog APD

Vertical Resolution – 75 m (20 m)

Horizontal Resolution - ~ 175 m (500m)

Signal Range - -5 to 40 km





Surface Return Pulse at 1064 nm

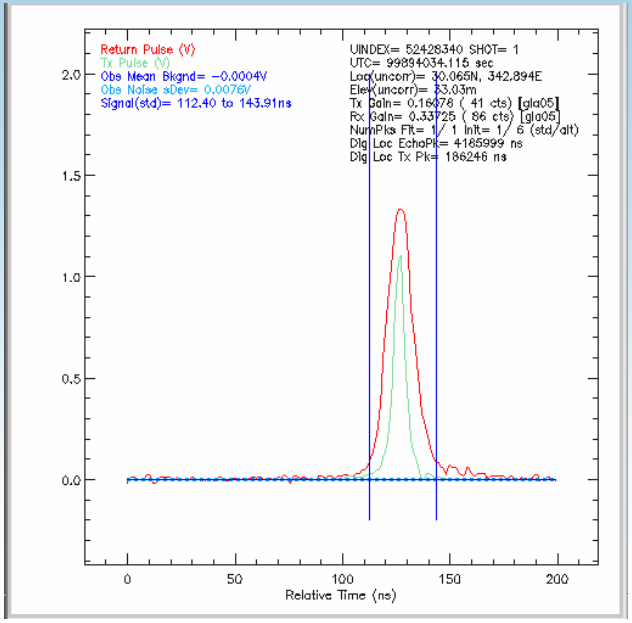
$E_s = E_o\ T_e^2\ \rho\ A/r^2 = Cp\ \rho\ T_e^2\ (z_o)$

Surface Pulse Waveform

Surface Pulse Reflectance

Vertical Resolution – 15cm

Signal Range - -100 to 300 m



Solar Background Radiance at 1064 and 532

$P = I\ \Omega\ \Delta\lambda\ A$

$S_p = C_b\ I$

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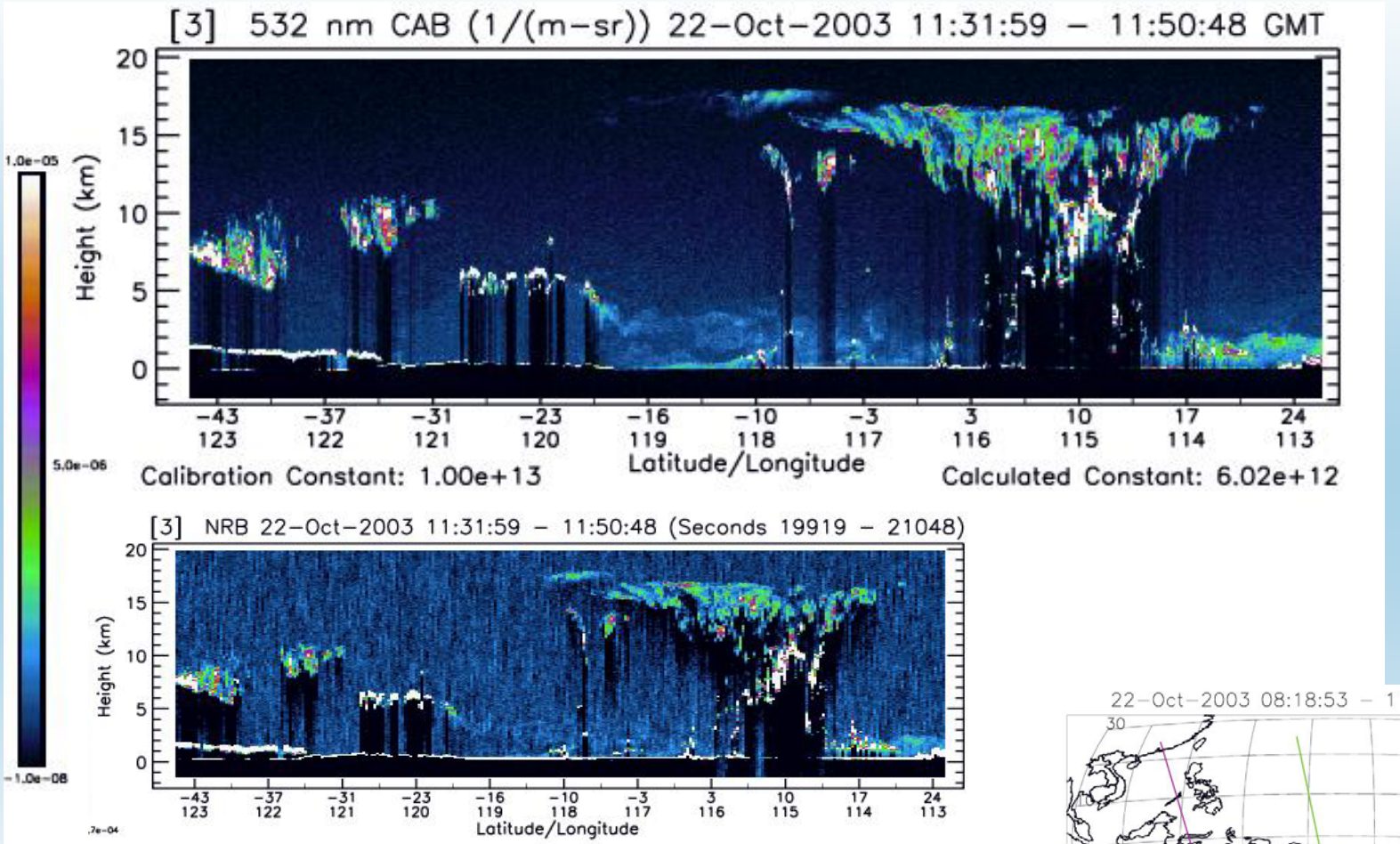
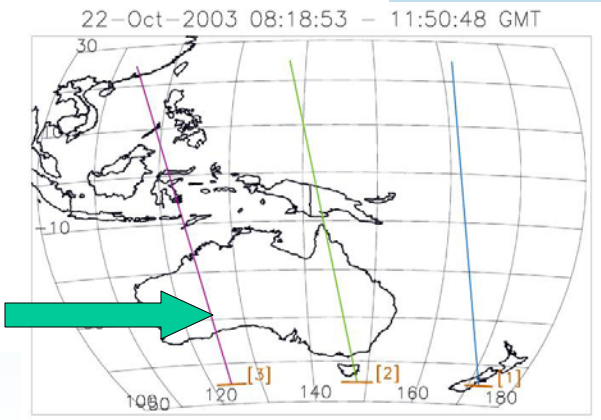
GLAS 532 and 1064 NM CHANNELS





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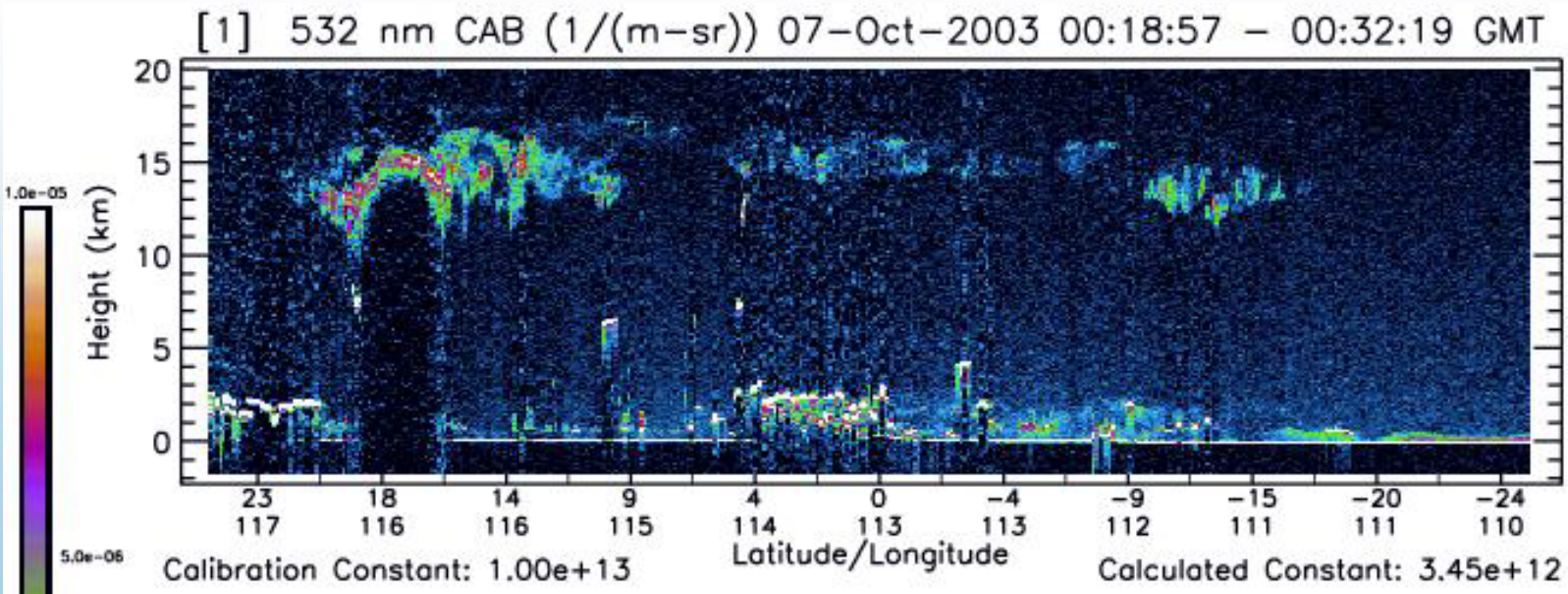
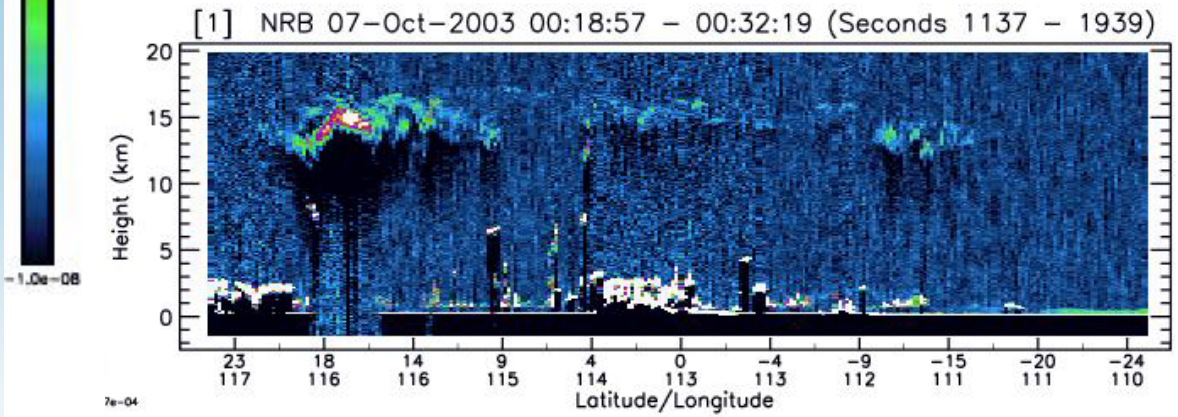
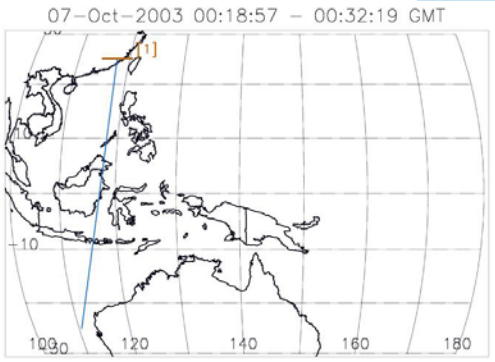
Daytime Data







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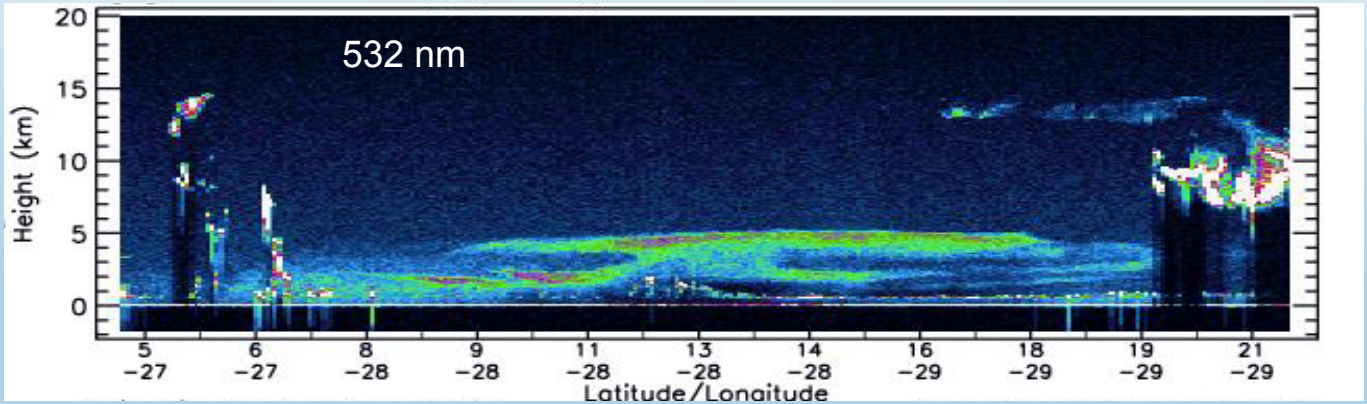
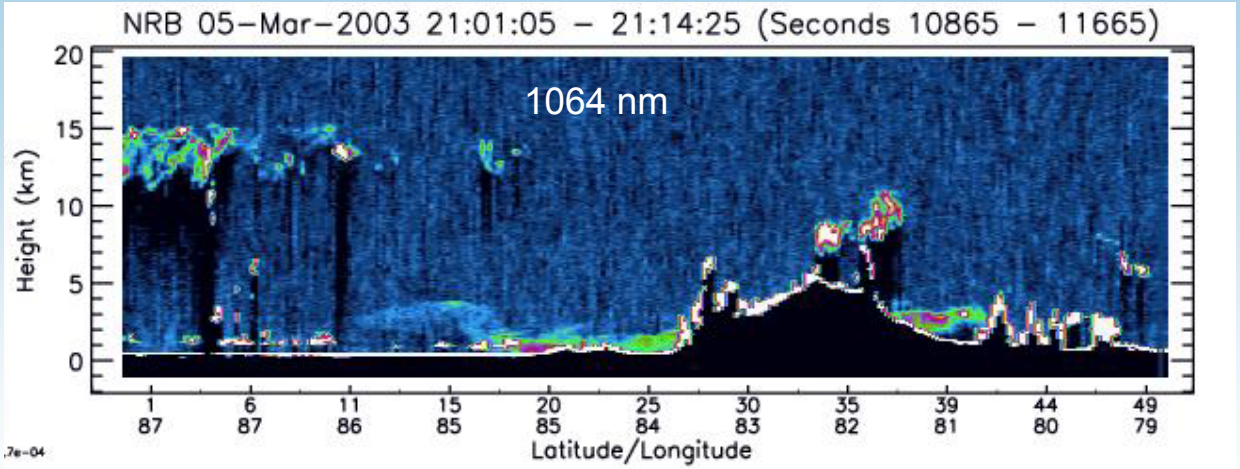
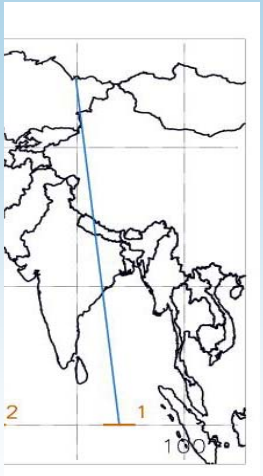
OBSERVATION OF THE DISTRIBUTION OF AEROSOL

GLAS View of Saharan Dust Layer

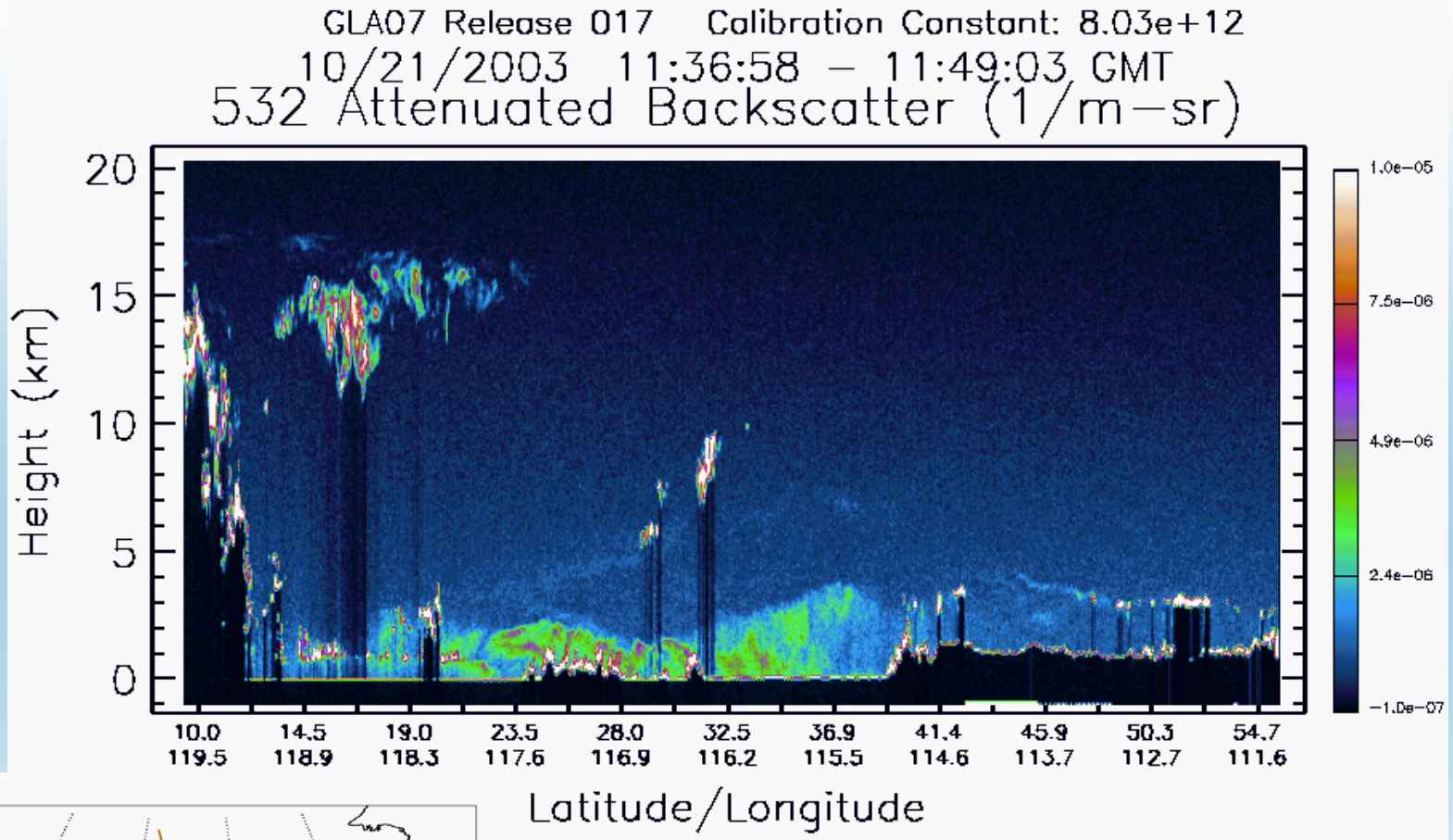


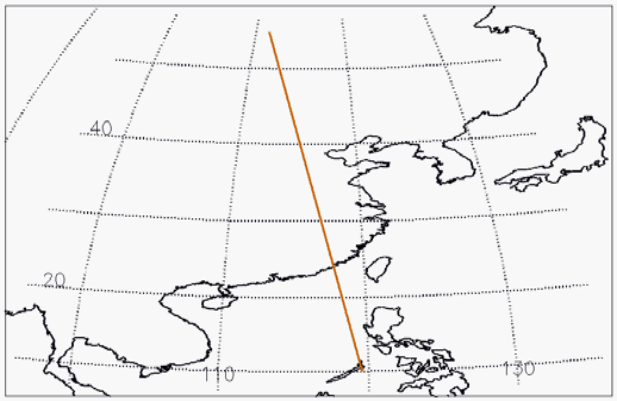




Asian Dust and Pollution

Example From First Operational Data Production – Release 17





Calibrated Backscatter

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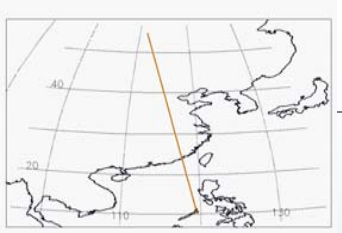
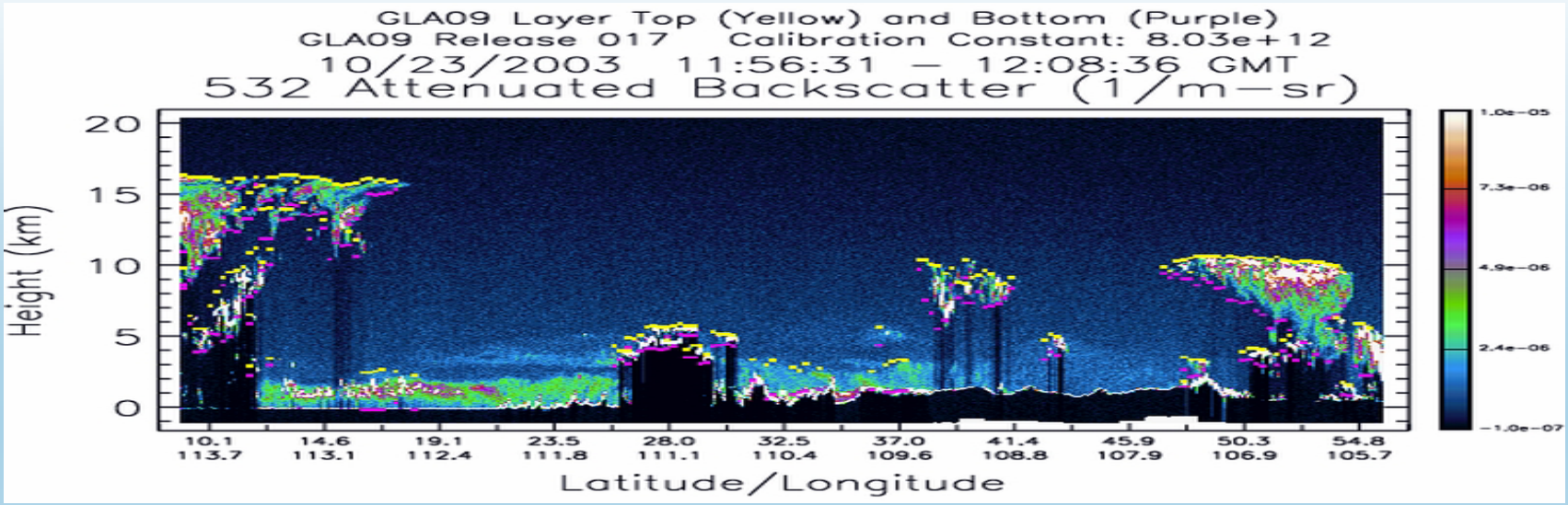
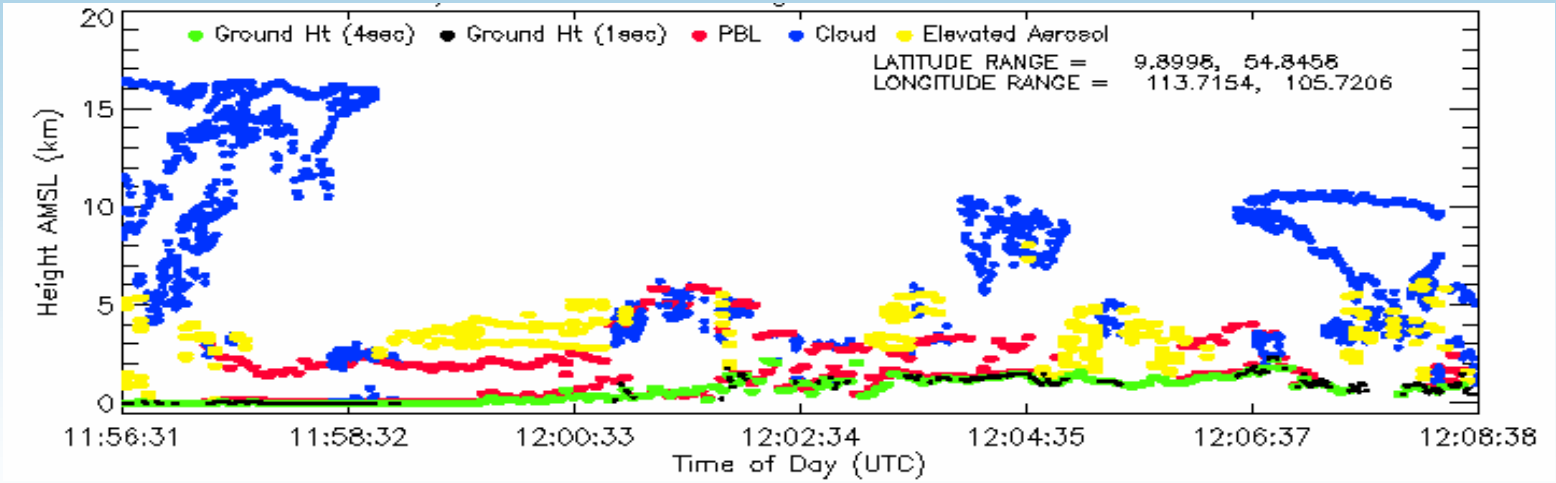


GLAS Layer Heights Data Product Example





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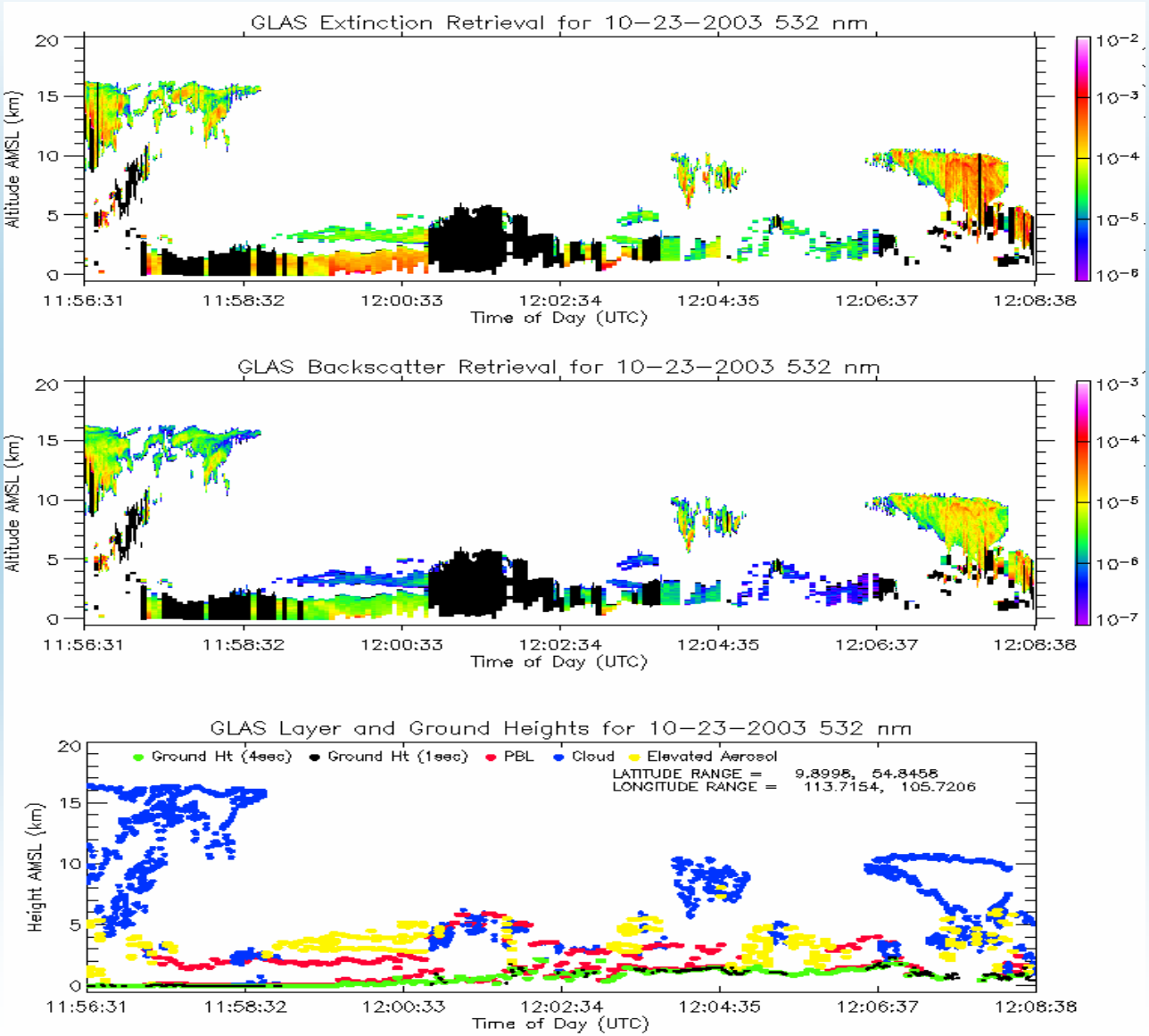
GLAS Layer Cross Section Data Products



Cross Sections
GLA10

Layer Heights
GLA08, 09

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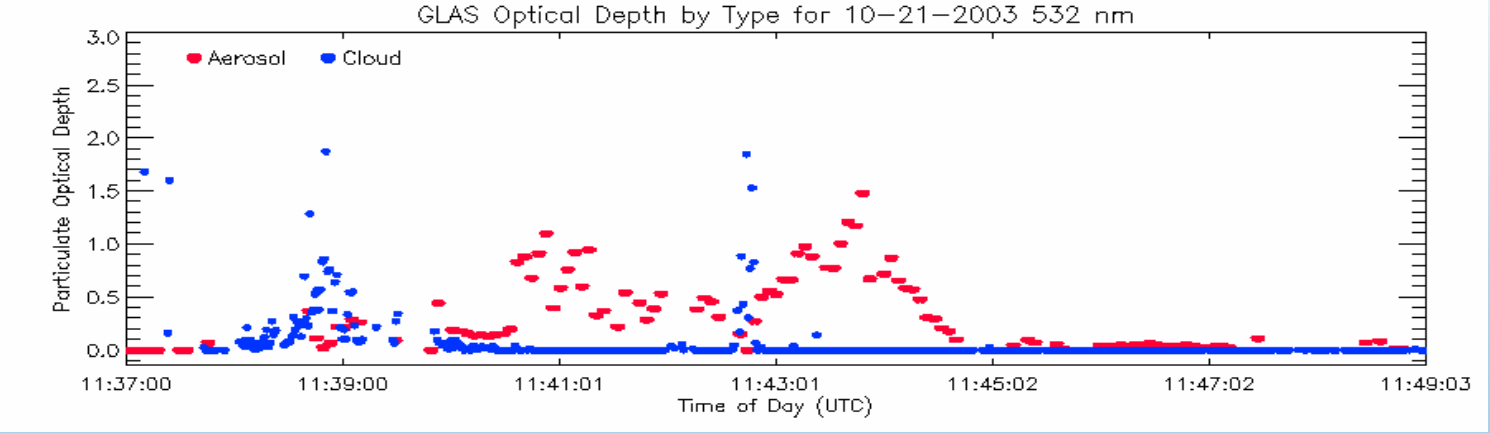
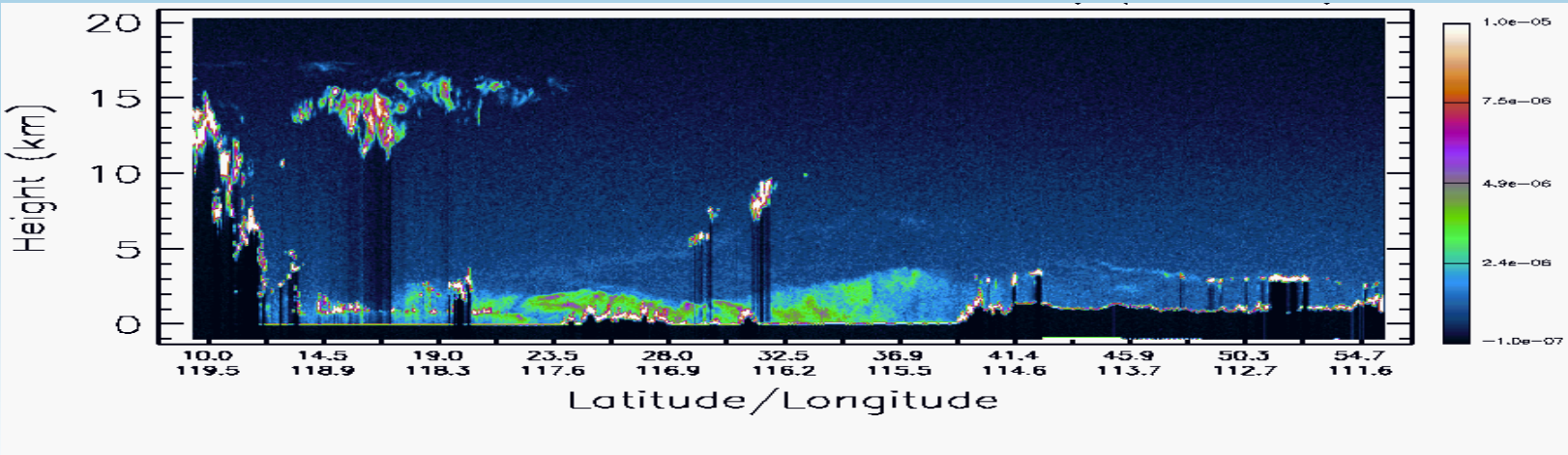
Aerosol and Cirrus Optical Depth Product





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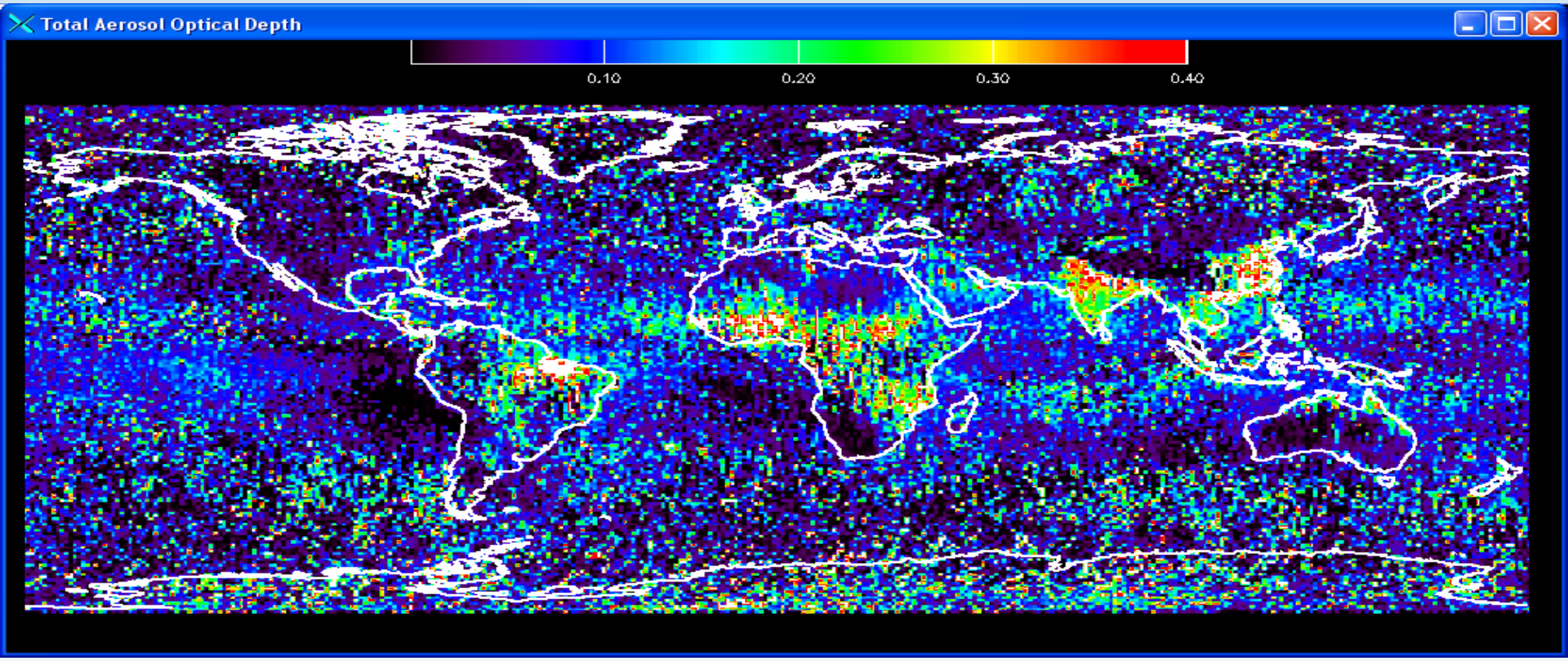
Global GLAS Aerosol Optical Depth

October 1 – November 16 2003



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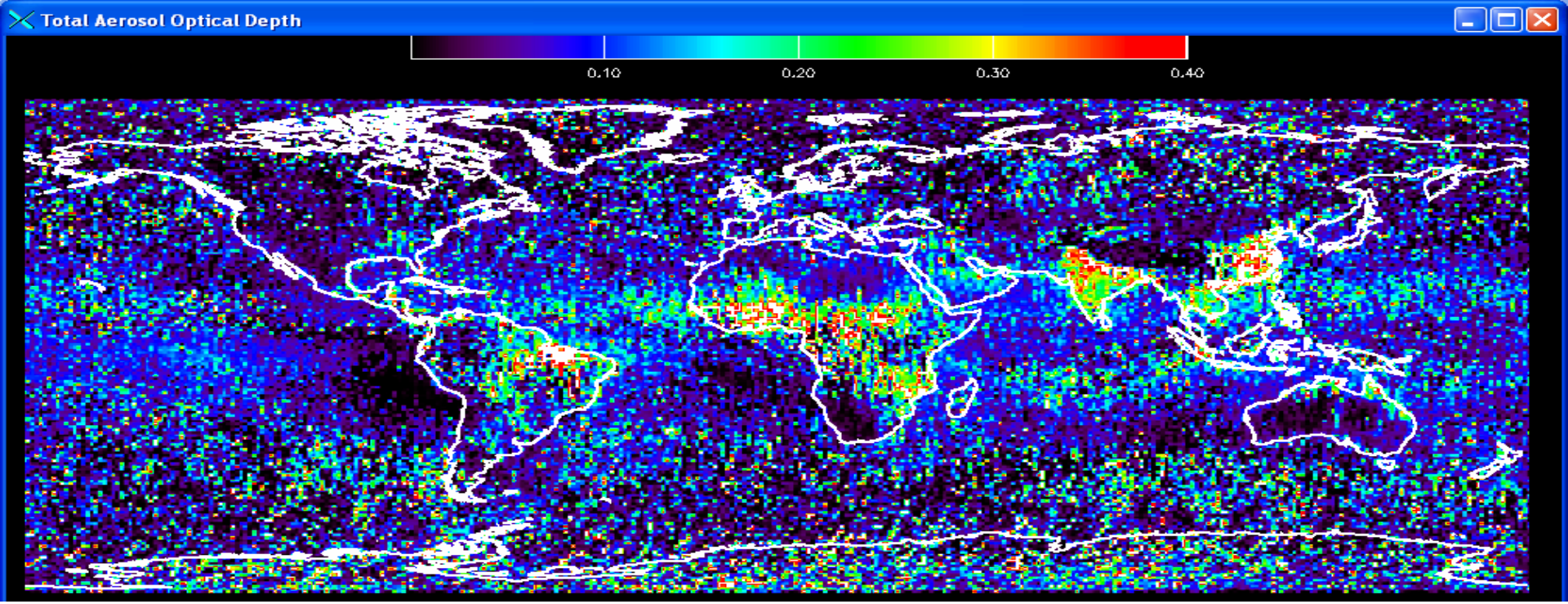
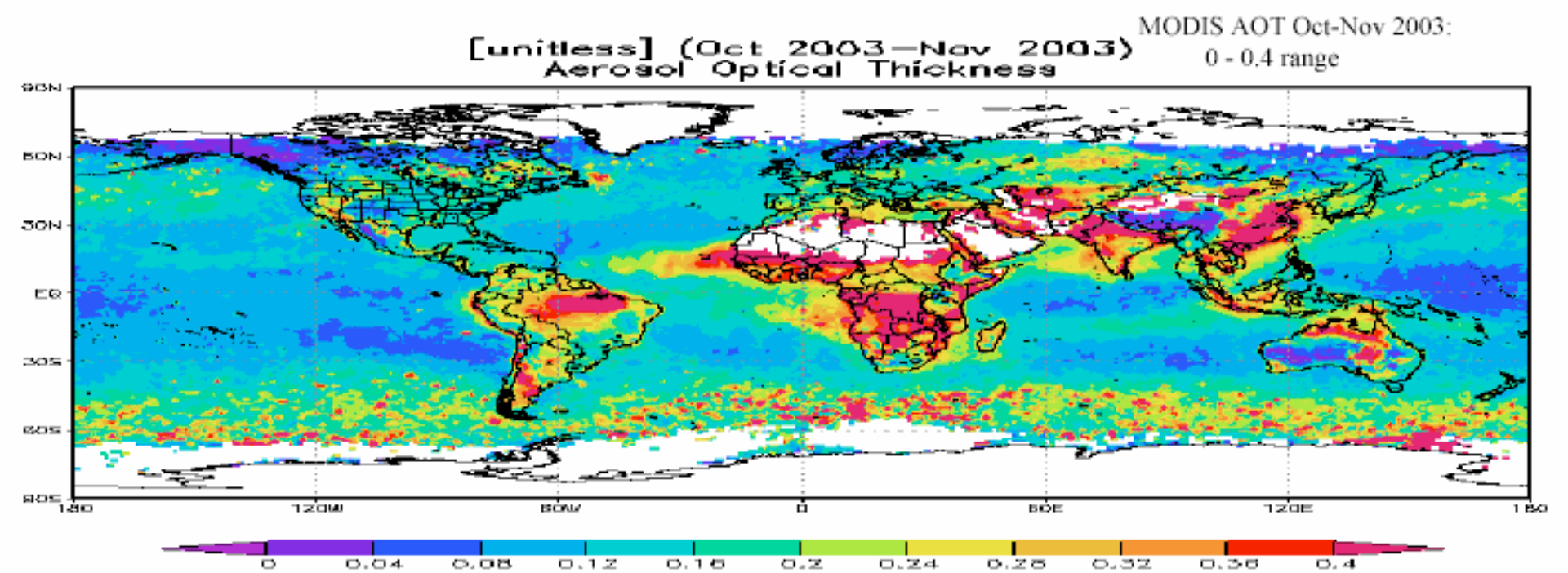
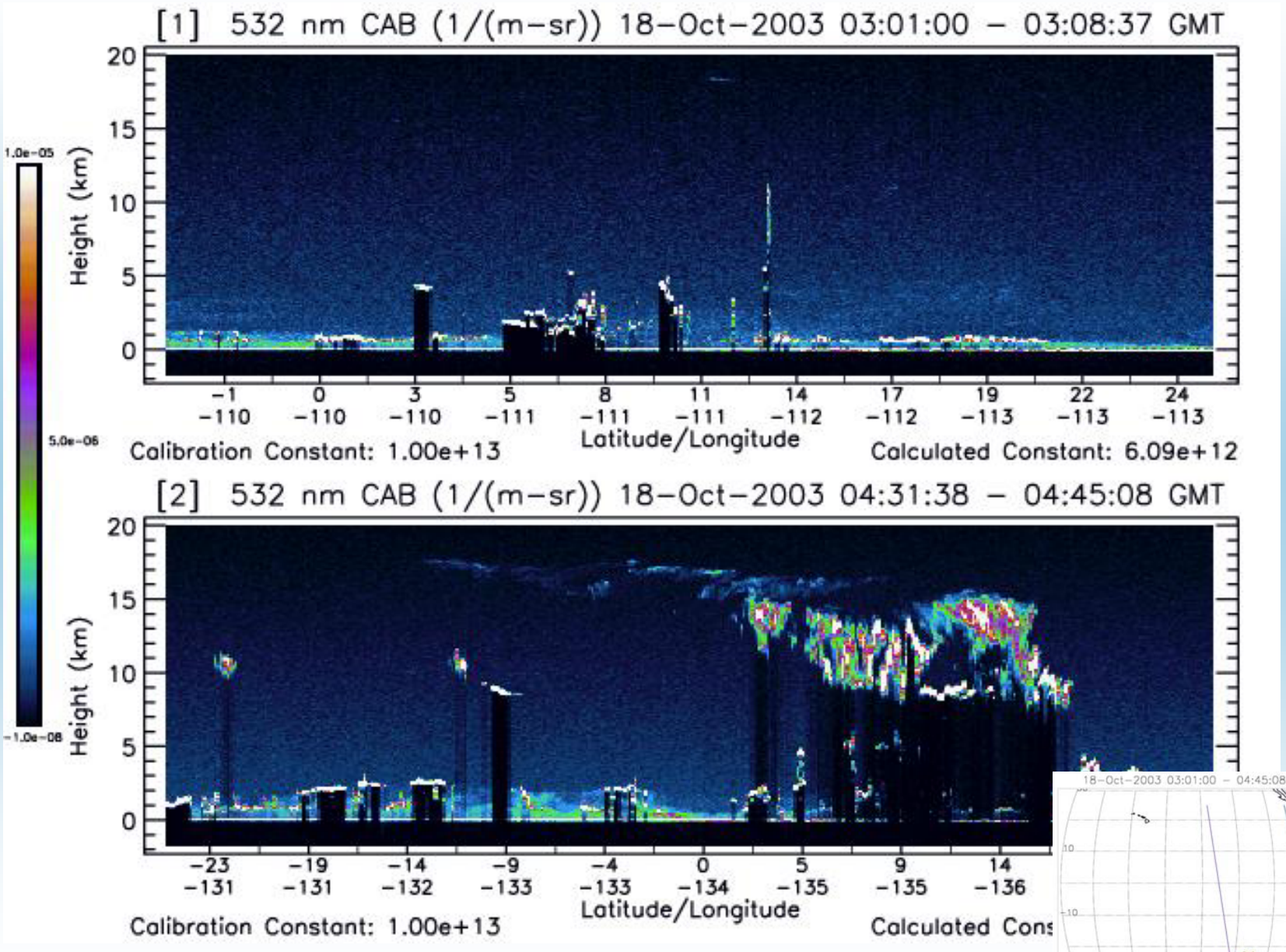


MODIS AOT Oct-Nov 2003:
0 - 0.4 range





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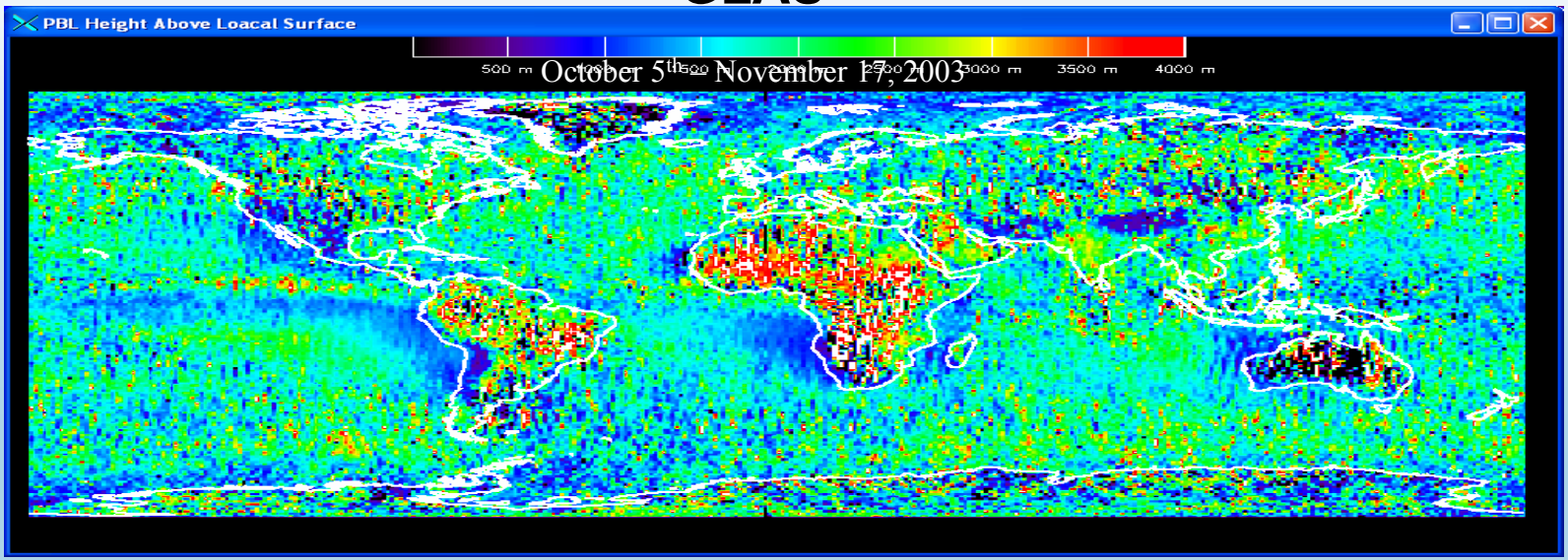
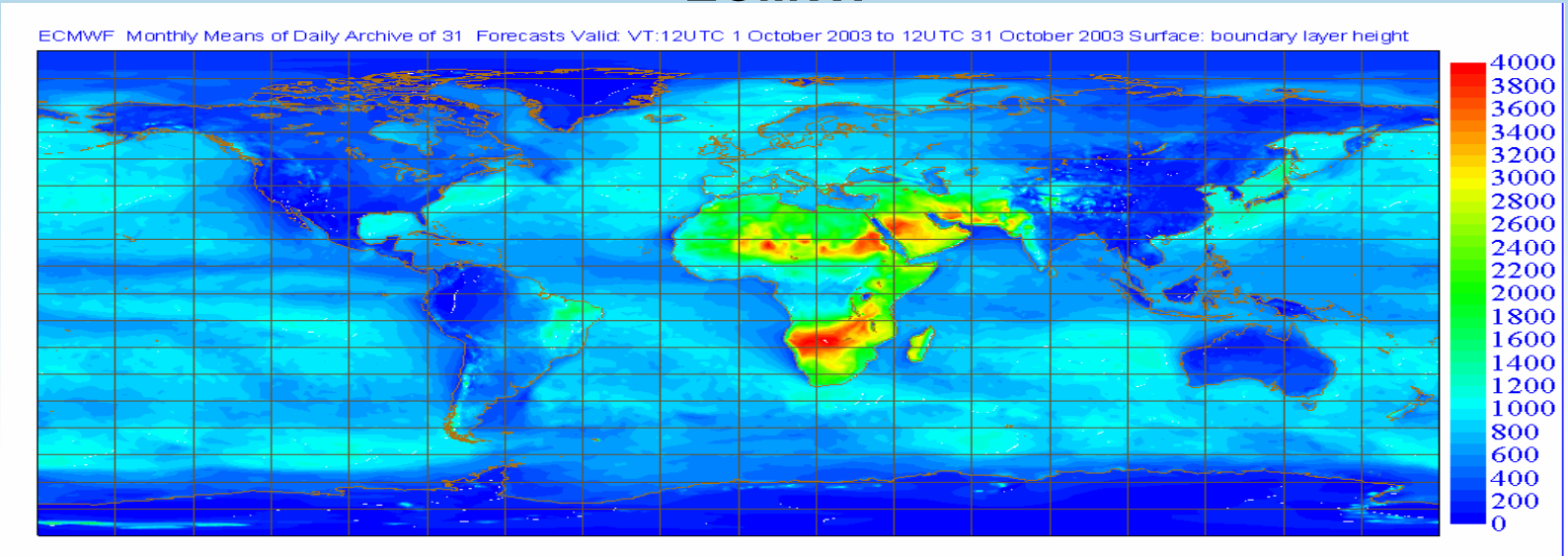
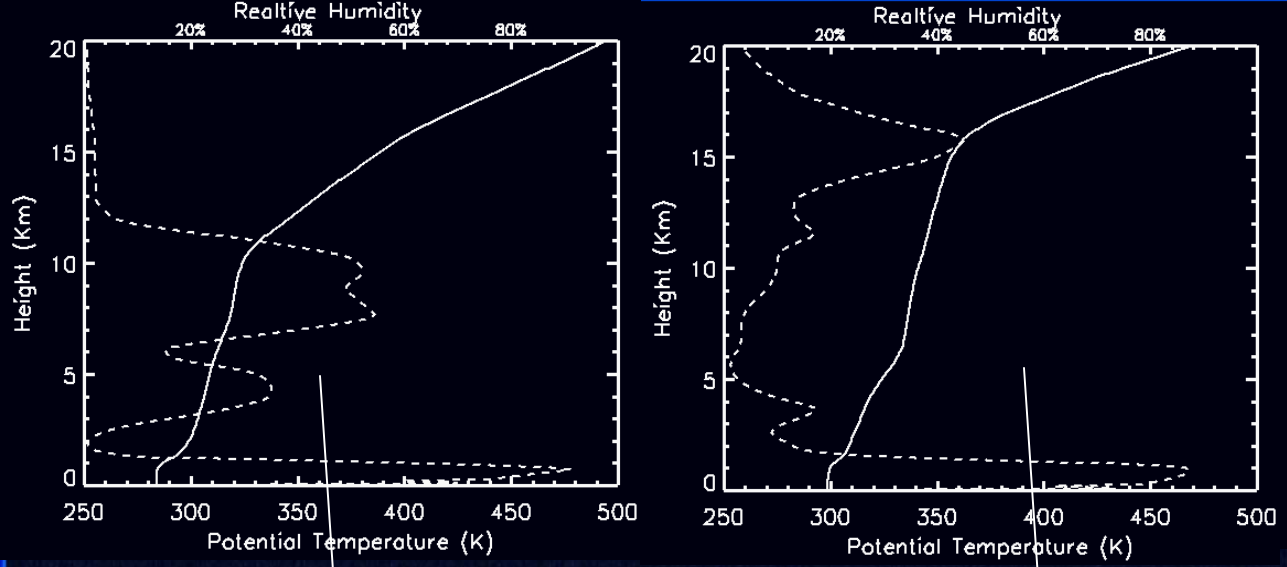
Global Measurements of Boundary Layer Height

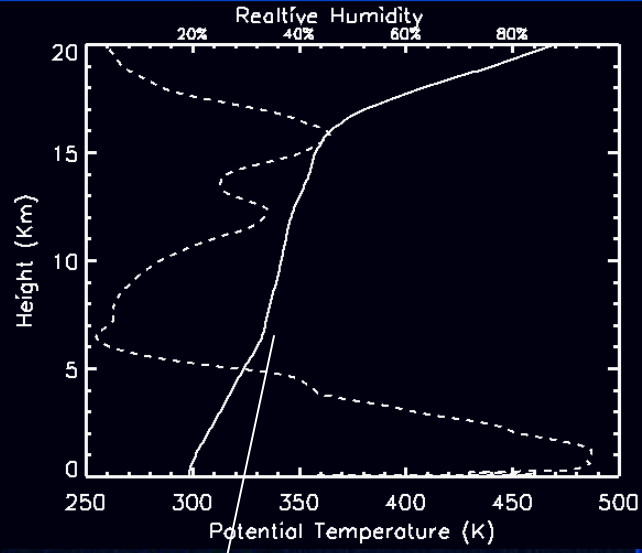
GLAS



ECMWF

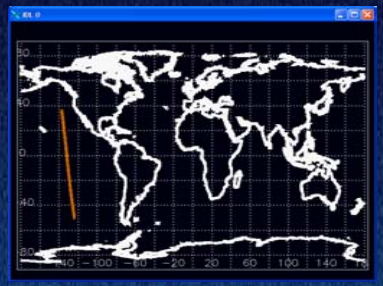






Latent Heat Flux

Sensible Heat Flux



12 km

8 km

4 km

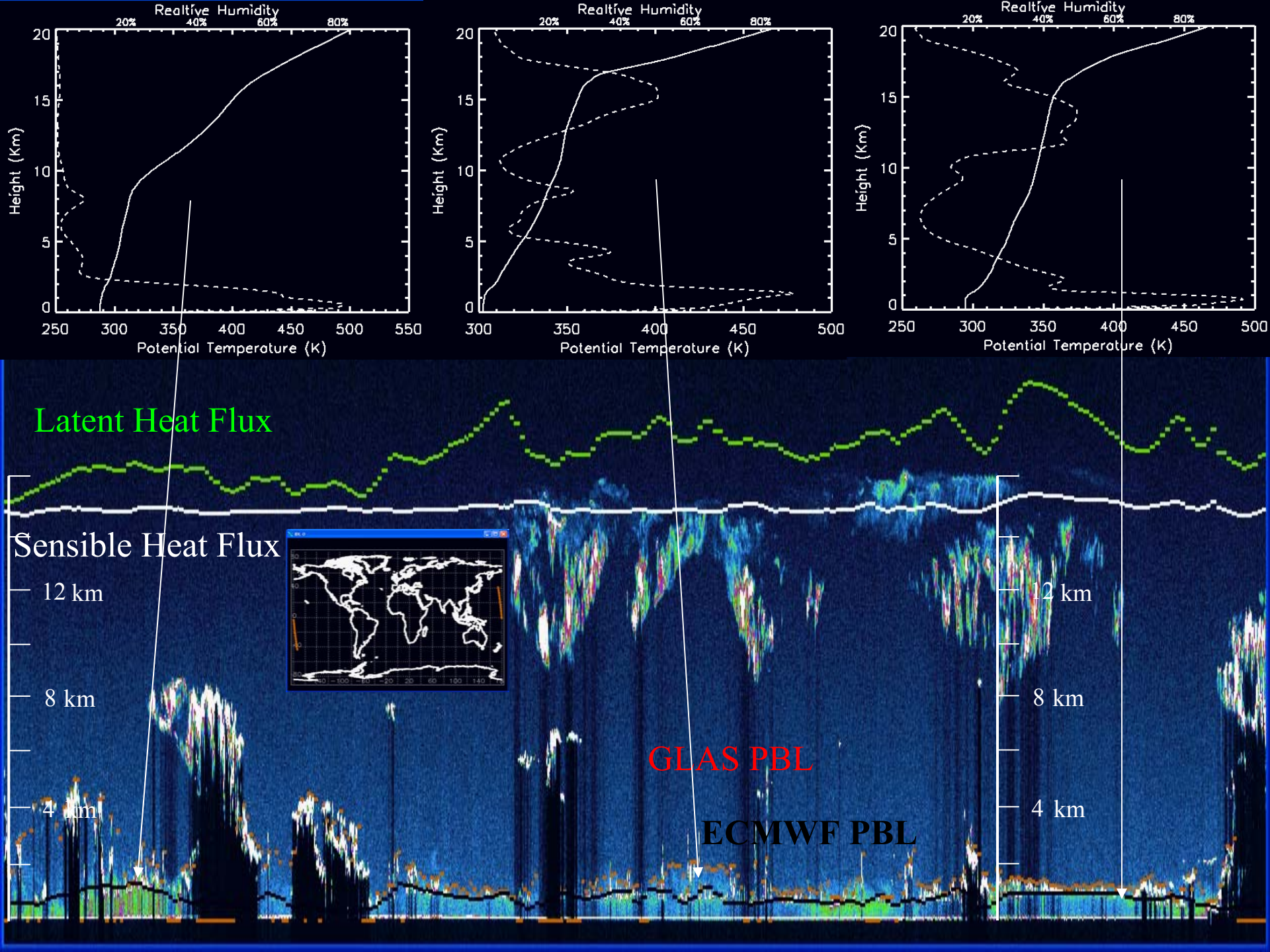
GLAS PBL

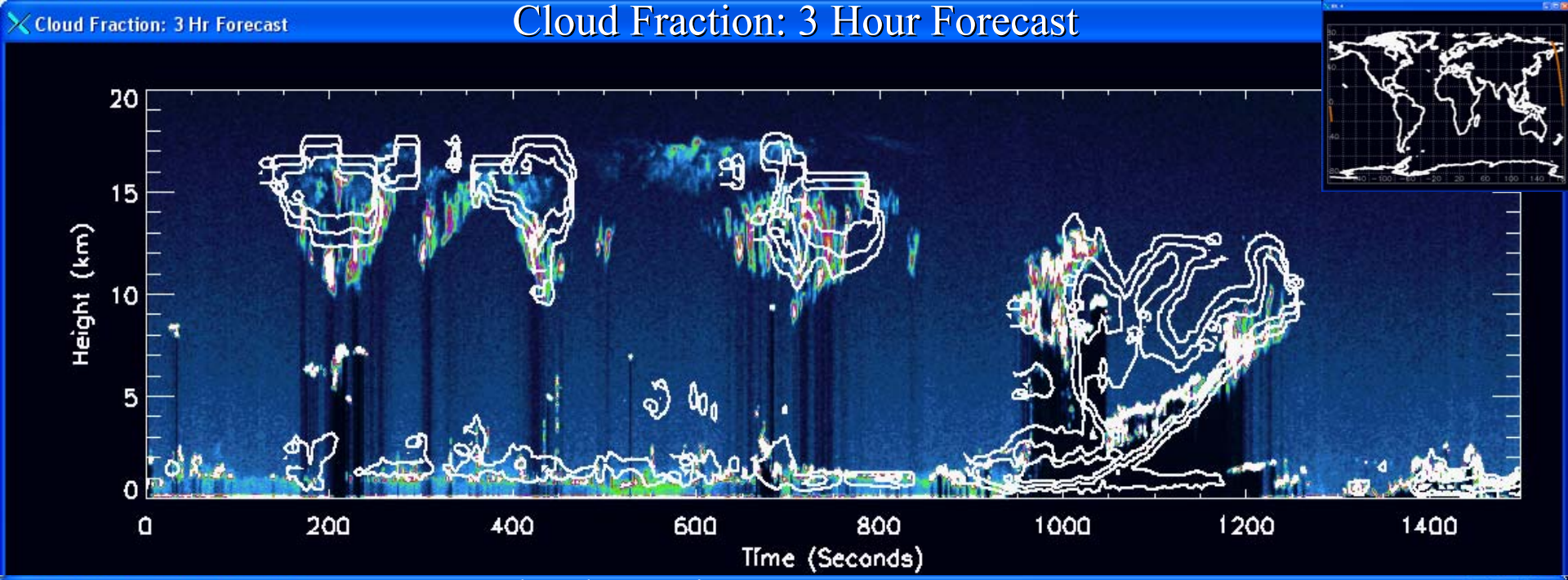
ECMWF PBL

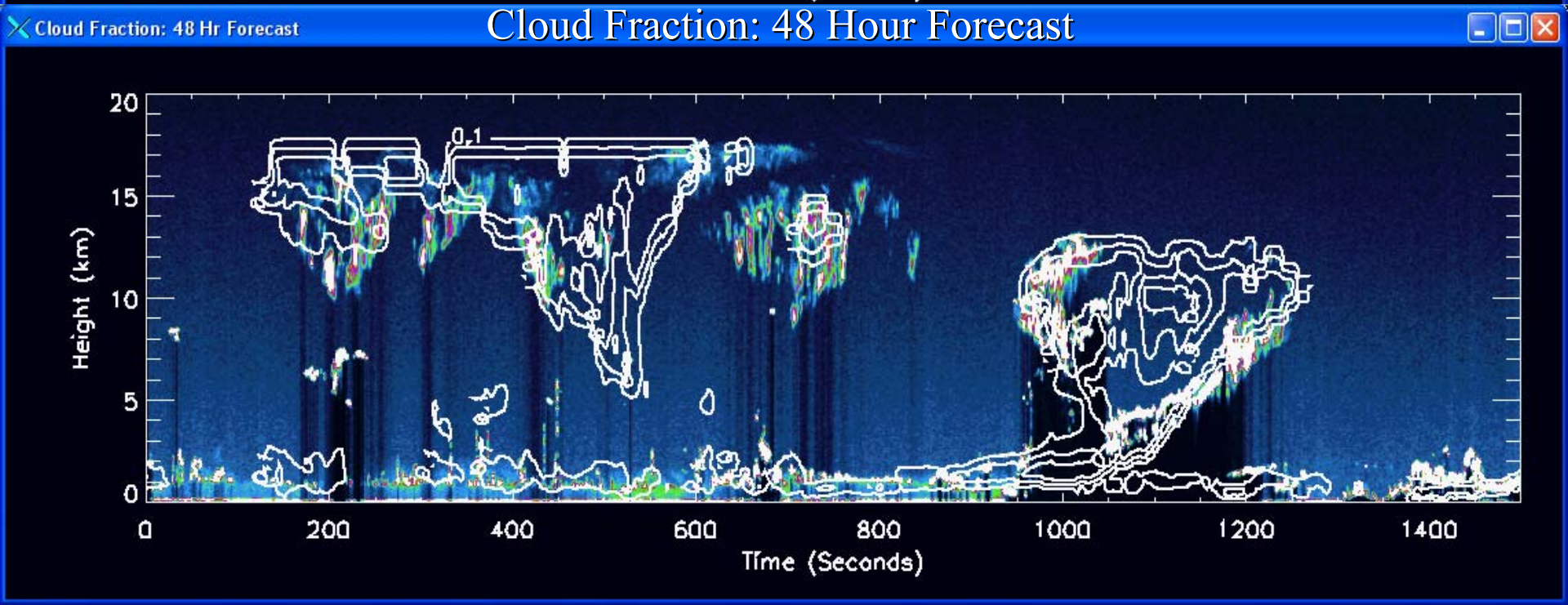
12 km

8 km

4 km

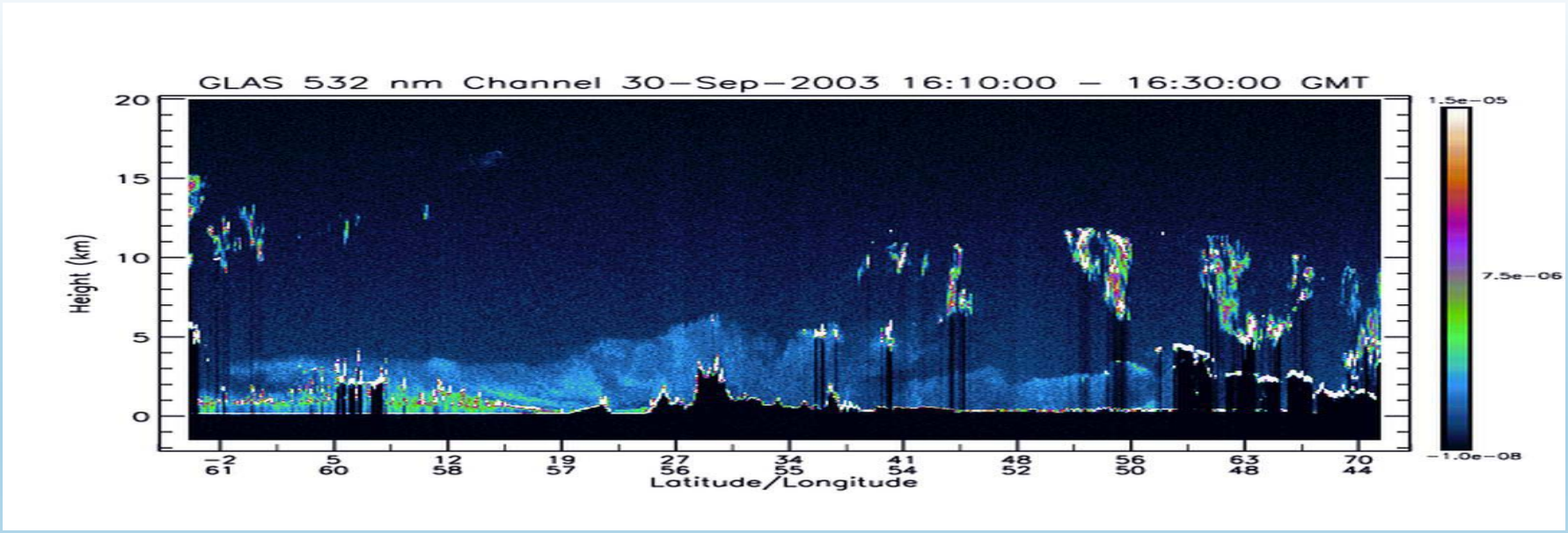

Realtive Humidity
20%
40%
60%
80%
Height (Km)
Potential Temperature (K)
Latent Heat Flux
Sensible Heat Flux
12 km
8 km
4 km
GLAS PBL
ECMWF PBL


Cloud Fraction: 3 Hr Forecast
Cloud Fraction: 3 Hour Forecast
Height (km)
0
5
10
15
20
0
200
400
600
800
1000
1200
1400
Time (Seconds)


Cloud Fraction: 48 Hr Forecast
Cloud Fraction: 48 Hour Forecast
0.1
Height (km)
0
5
10
15
20
0
200
400
600
800
1000
1200
1400
Time (Seconds)

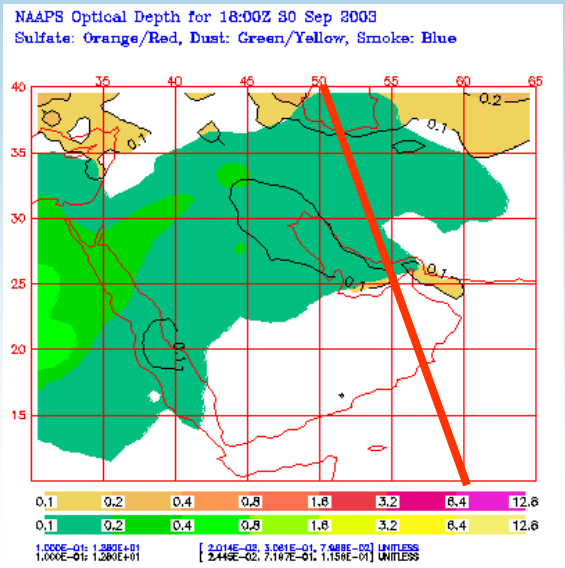
Geoscience Laser Altimeter System

Application to Aerosol Transport Models



GLAS 532 nm Data

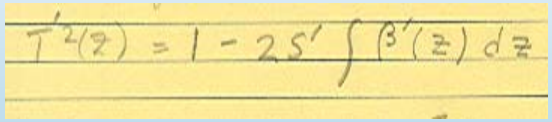
Naval Aerosol Analysis and Prediction System



J. Spinhirne /GSFC January 2004

Optical Depth and Extinction Cross Section Retrieval

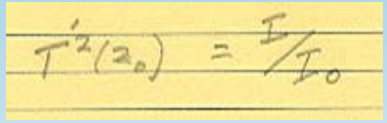
1. Forward integration solution with assumed ratio of extinction to backscatter ratio



Basic Approach for Aerosol and Cirrus Layer Optical Depth

- Applied from geo-location based look up table

2. Direct retrieval of extinction optical depth from atmospheric and surface signals



Aerosol Optical Depth – Molecular Scattering Under Layer

- requires clear layer below aerosol layer

(- cirrus effective ~50% of cases)

Aerosol Optical Depth – Ocean Surface Pulse Intensity

- In development

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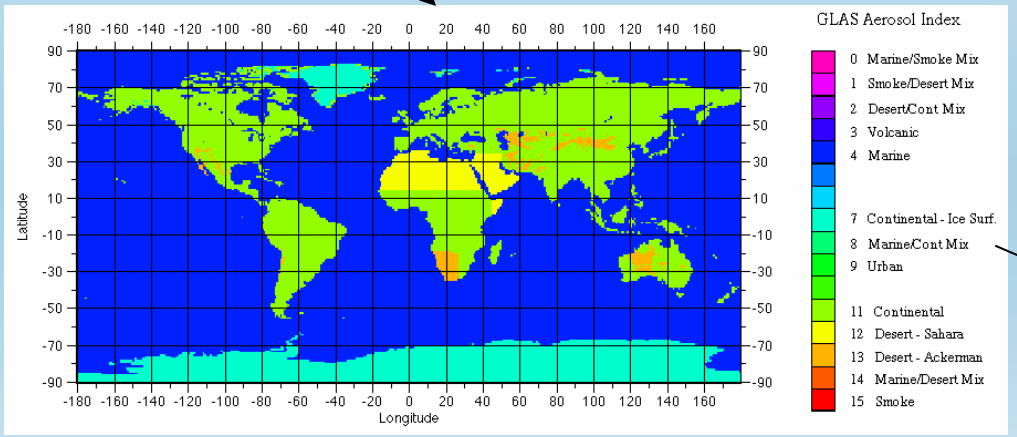
GLAS PBL Aerosol Extinction to Backscatter Ratio (S_p) Default Matrix

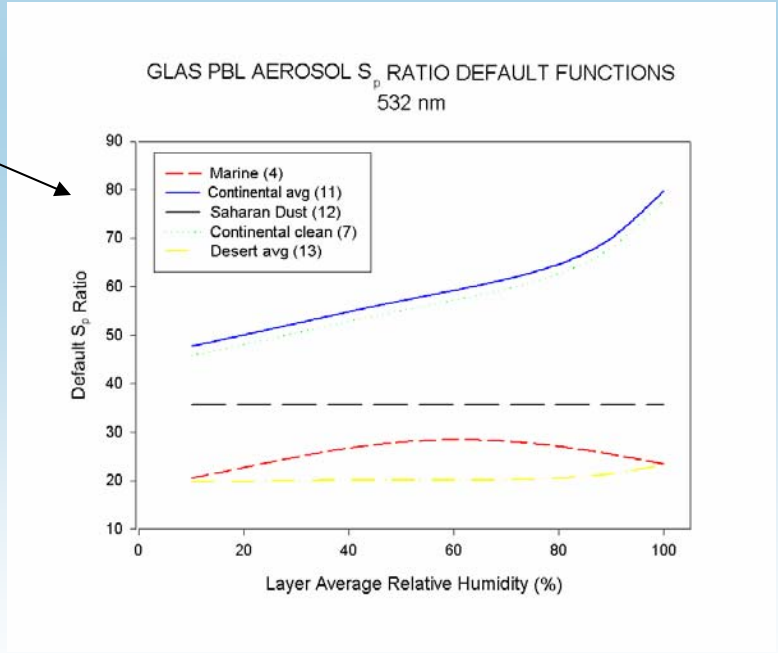
Aerosol layer Elevated or PBL?

Planetary Boundary Layer (PBL) Type?
Choose from PBL lat-lon index map

Elevated Aerosol

(con't next chart)





Index functions:

4,7,11,13 based on Ackermann, 1998

12 based on Welton, 2000 and Powell, 2000

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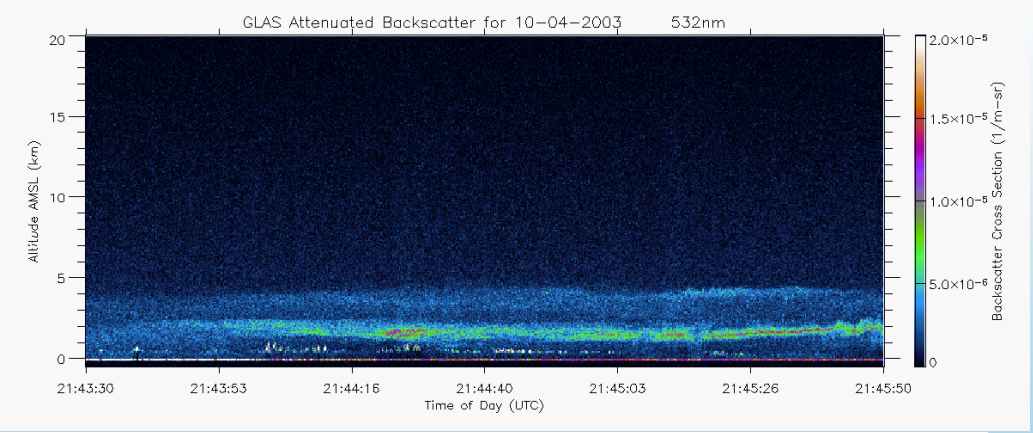
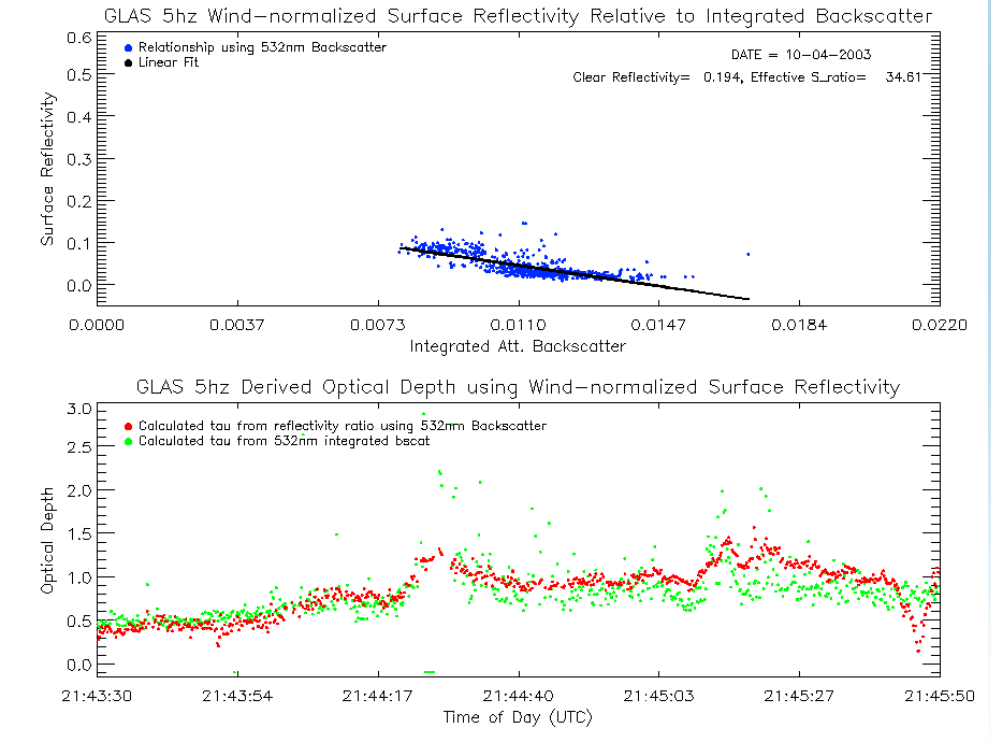
AOD Analysis with Surface Return Calibration



532 nm aerosol signal integrated through layer



Correlation of integrated signal and wind speed normalized surface reflectance

AOD from direct surface reflectance decrease and forward integration of aerosol signal

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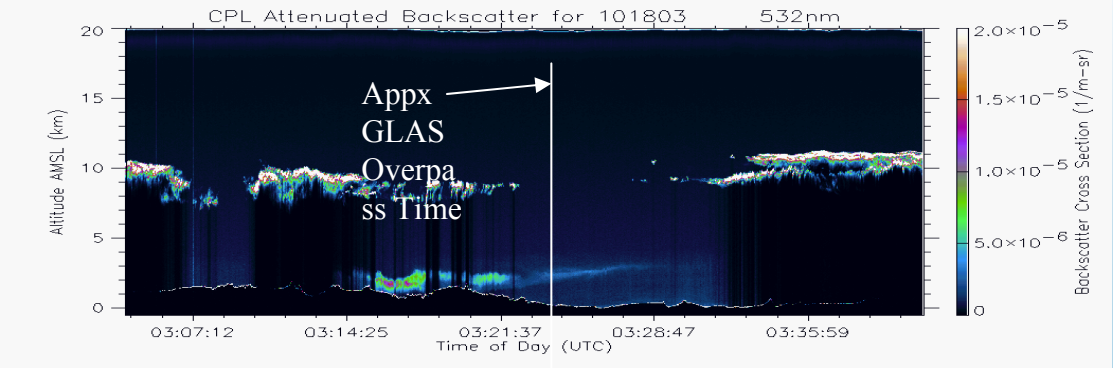
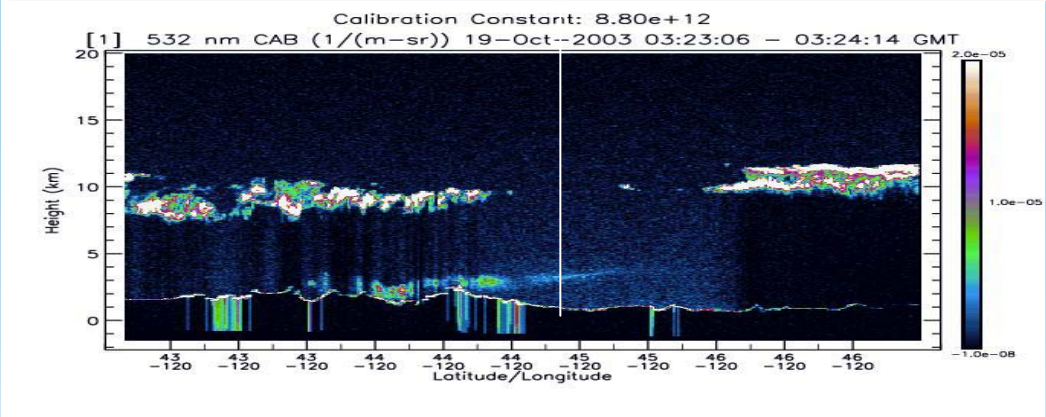
GLAS Atmospheric Validation Program

ER-2 Under flights – 18 to date

Surface Lidar and Photometer Pointing Events – 2 to 3 per day

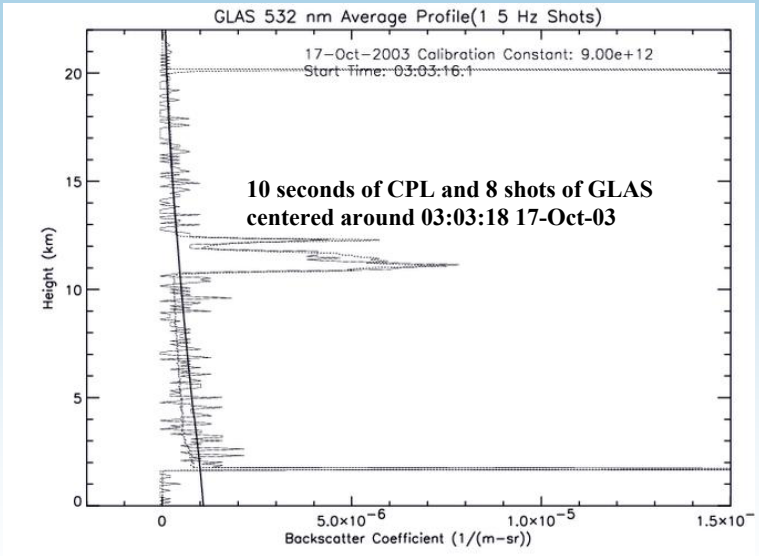
GLAS VRS. ER-2 CPL: 19-Oct-03





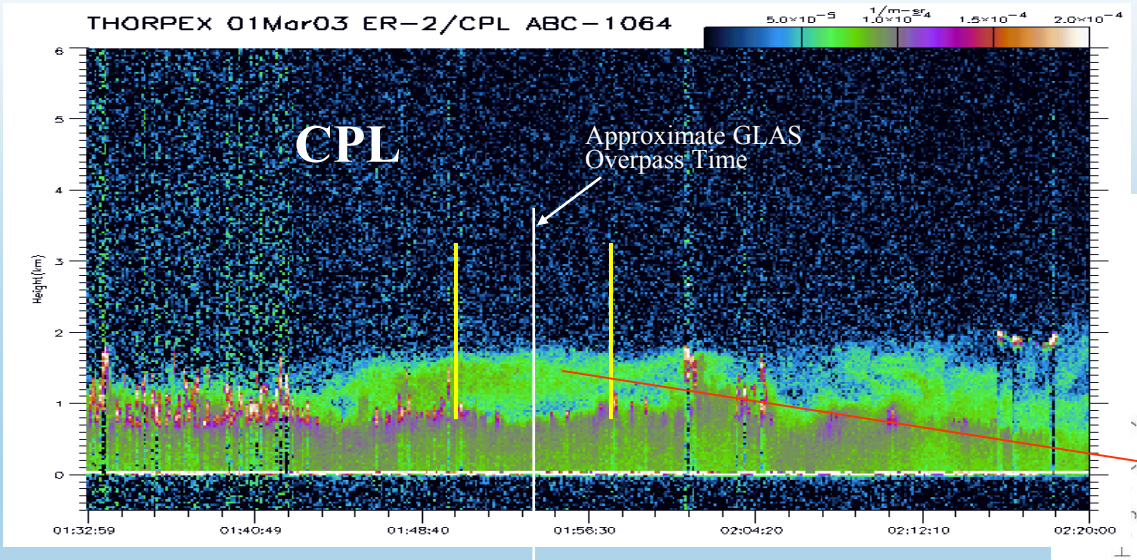
GLAS Minimum Detectable Backscatter Cross Section

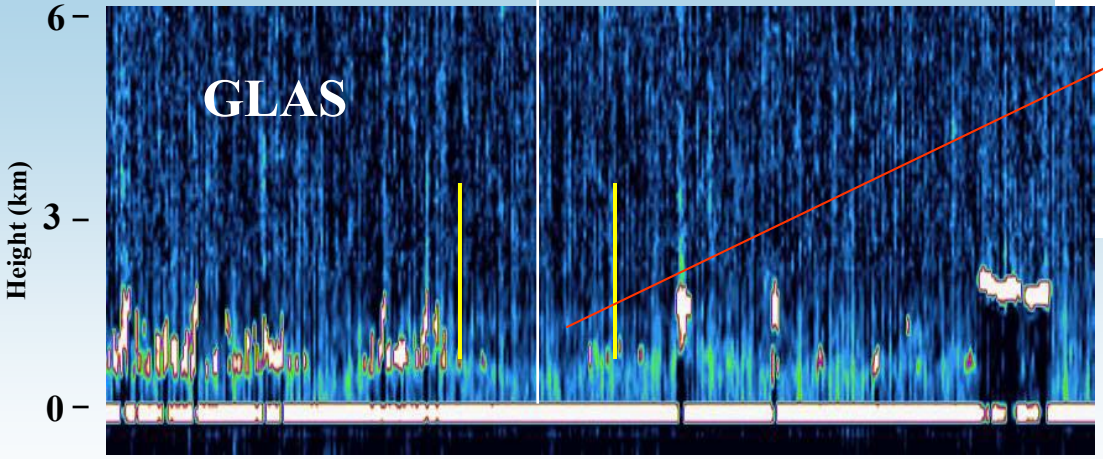
532 nm: less than 10^{-7} (1/m-sr)
1064 nm: less than 10^{-6} (1/m-sr)



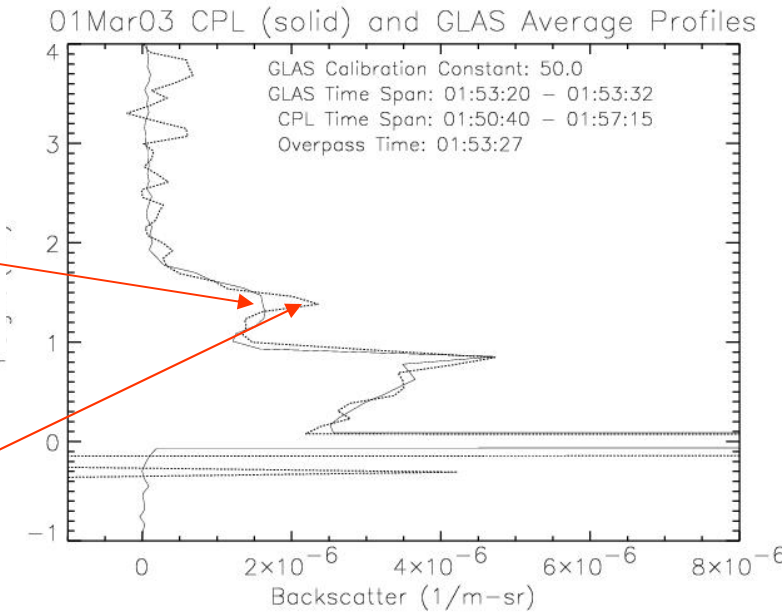
J. Spinhirne, February 2004

Validation of Cloud Digitizer Channel during THORPEX





1064 nm channel only
March 01, 2003



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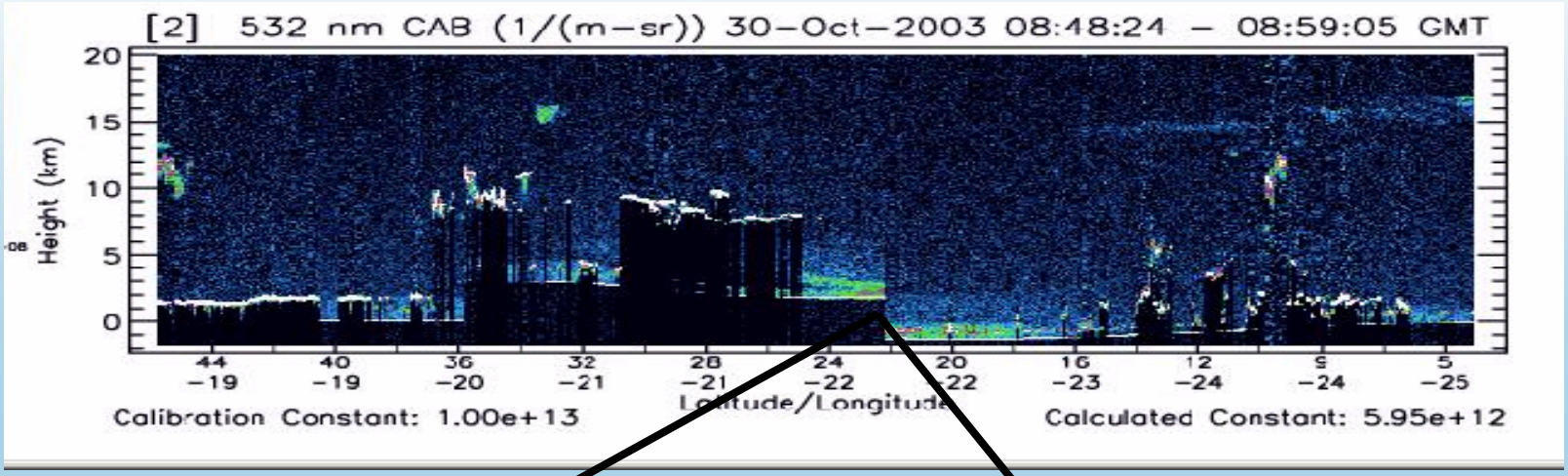
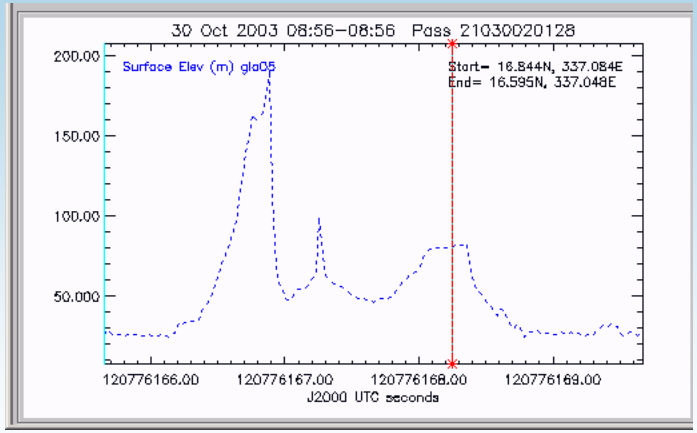
GLAS "Point To" Event

Aeronet Site on Cape Verdi On Oct. 30,



Level 0 Instrument Data



Elevation profile across Cape Verdi

GLAS Atmospheric Validation Program

Surface Lidar and Photometer Pointing Events – 2 to 3 per day

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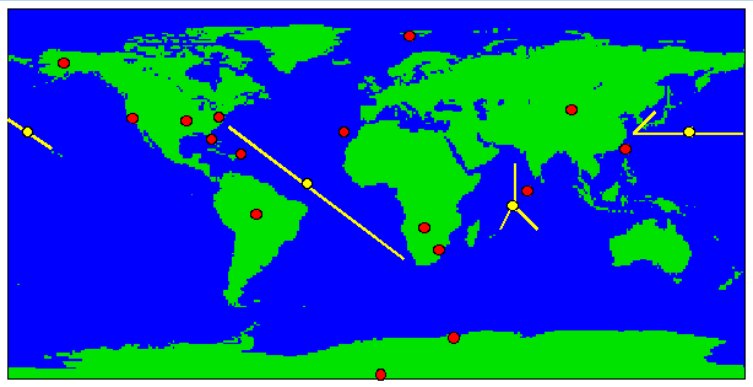
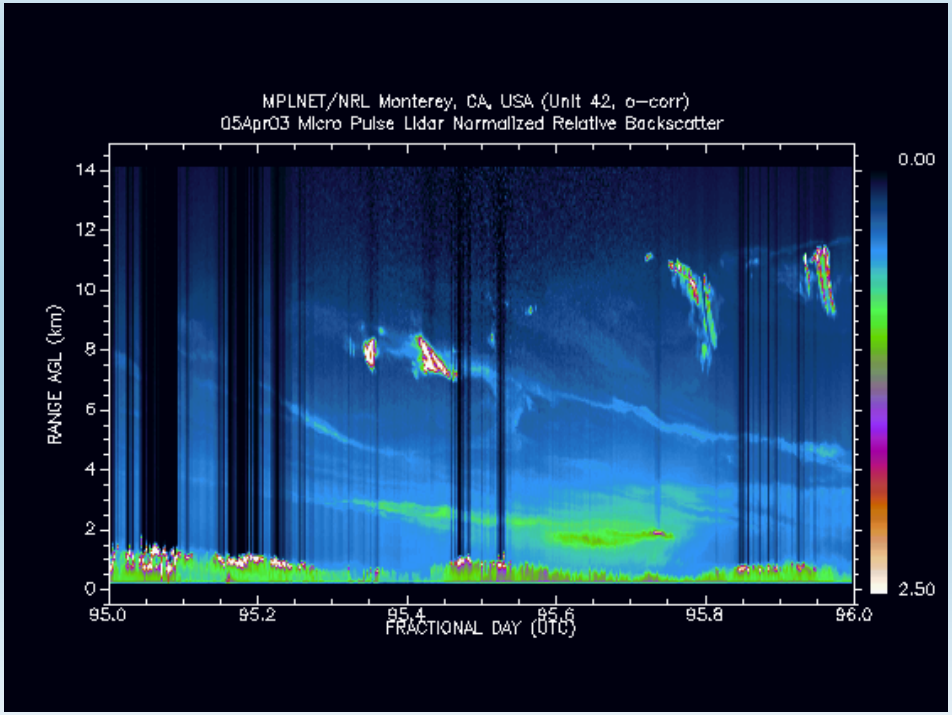
GLAS Data Product Verification
MPLnet sites

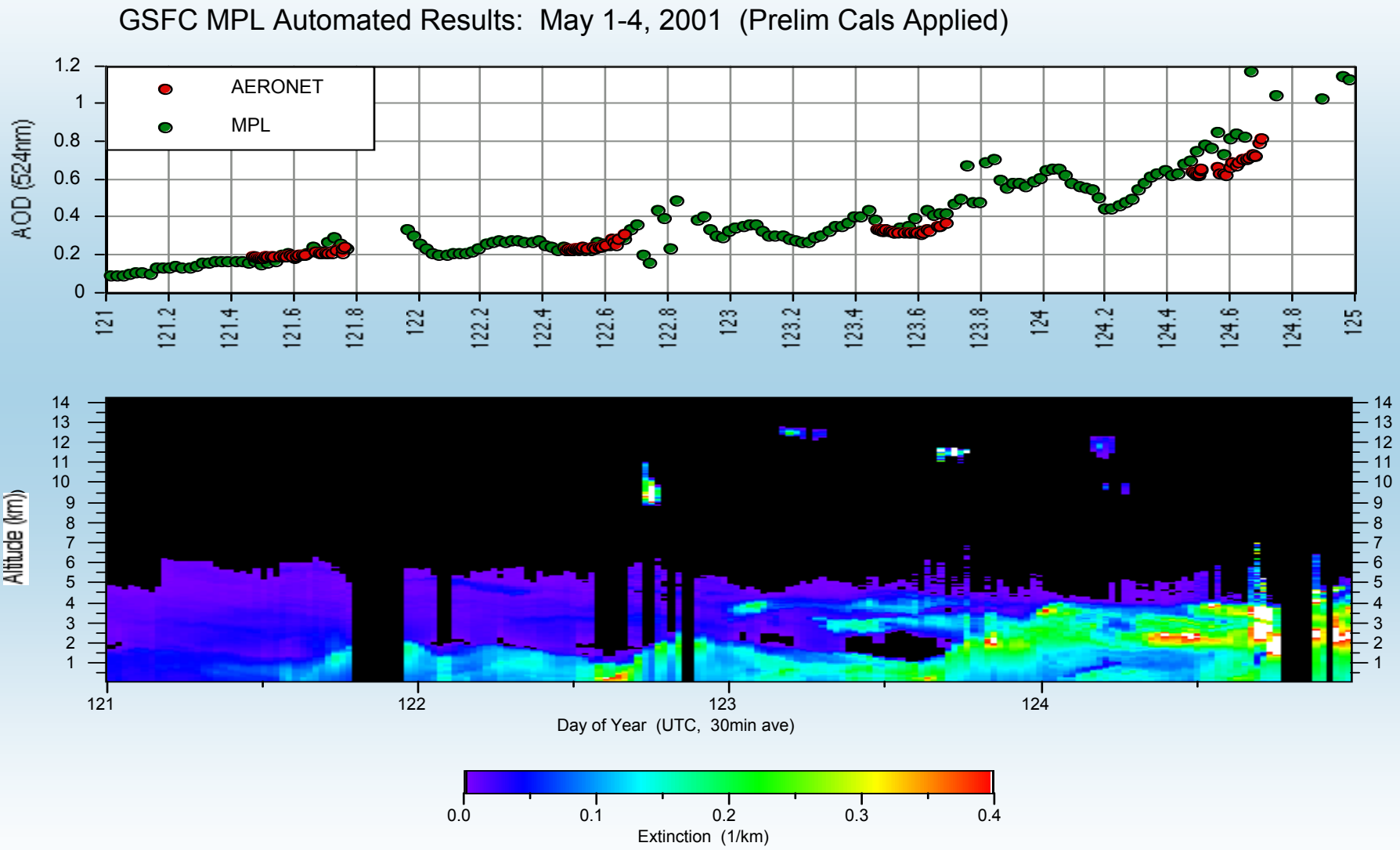
MPLNET





J. Spinhirne et al., Dec. 3, 2004

MPLnet - Aerosol Optical Depth and Cross Section Profile



SUMMARY
Aerosol Height Observations

- **GLAS atmospheric data fully meets the objective of profiling all radiatively significant cloud and aerosol layers.**
- **A laser technical problem has limited good quality measurements to 3 months of existing data.**
- **GLAS data products for 2003 are now in open release to the science community.**

  Quick look and data visualization: **http://glo.gsfc.nasa.gov/**

  Full Data Access: **http://nsidc.org/daac/**

- **The MPLnet provides full time aerosol height distribution at selected Aeronet ground observation sites**

  http://mplnet.gsfc.nasa.gov/