CALIPSO Mission Science and Validation

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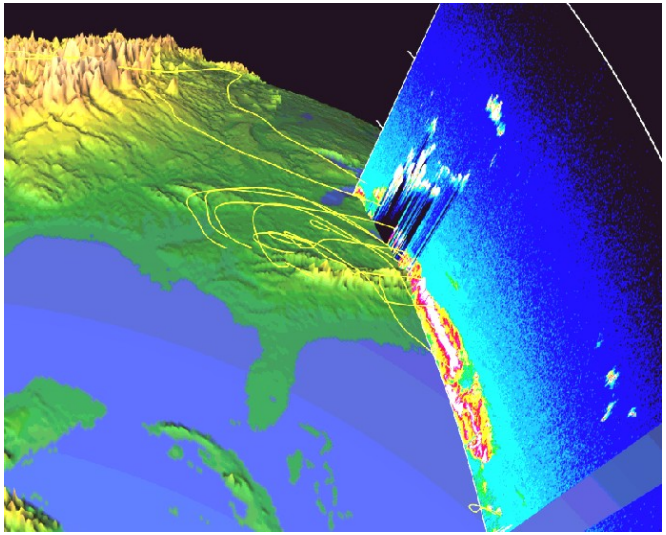
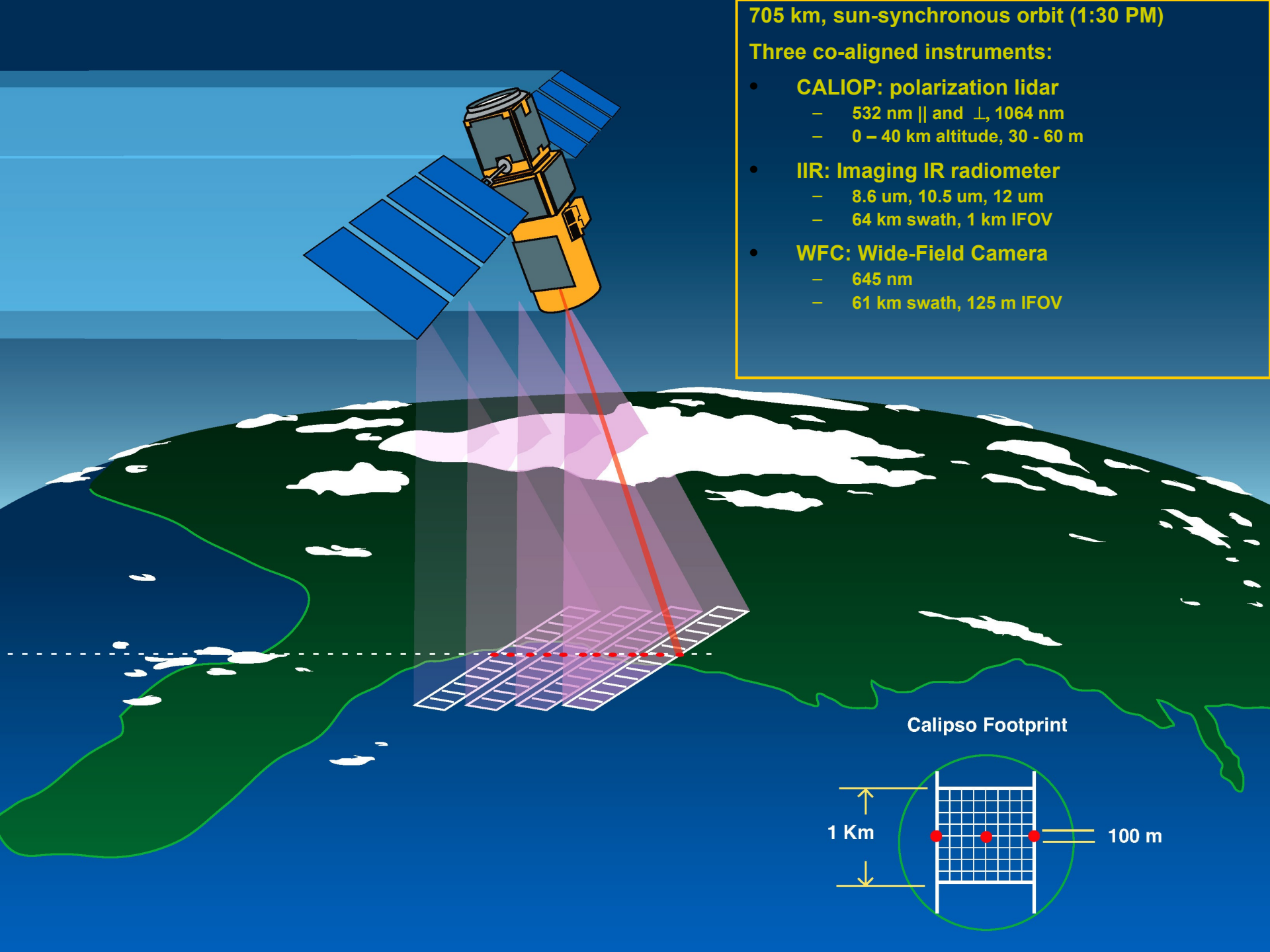
CALIPSO Mission Objectives

CALIPSO flies as part of the A-train, providing observations needed to improve:

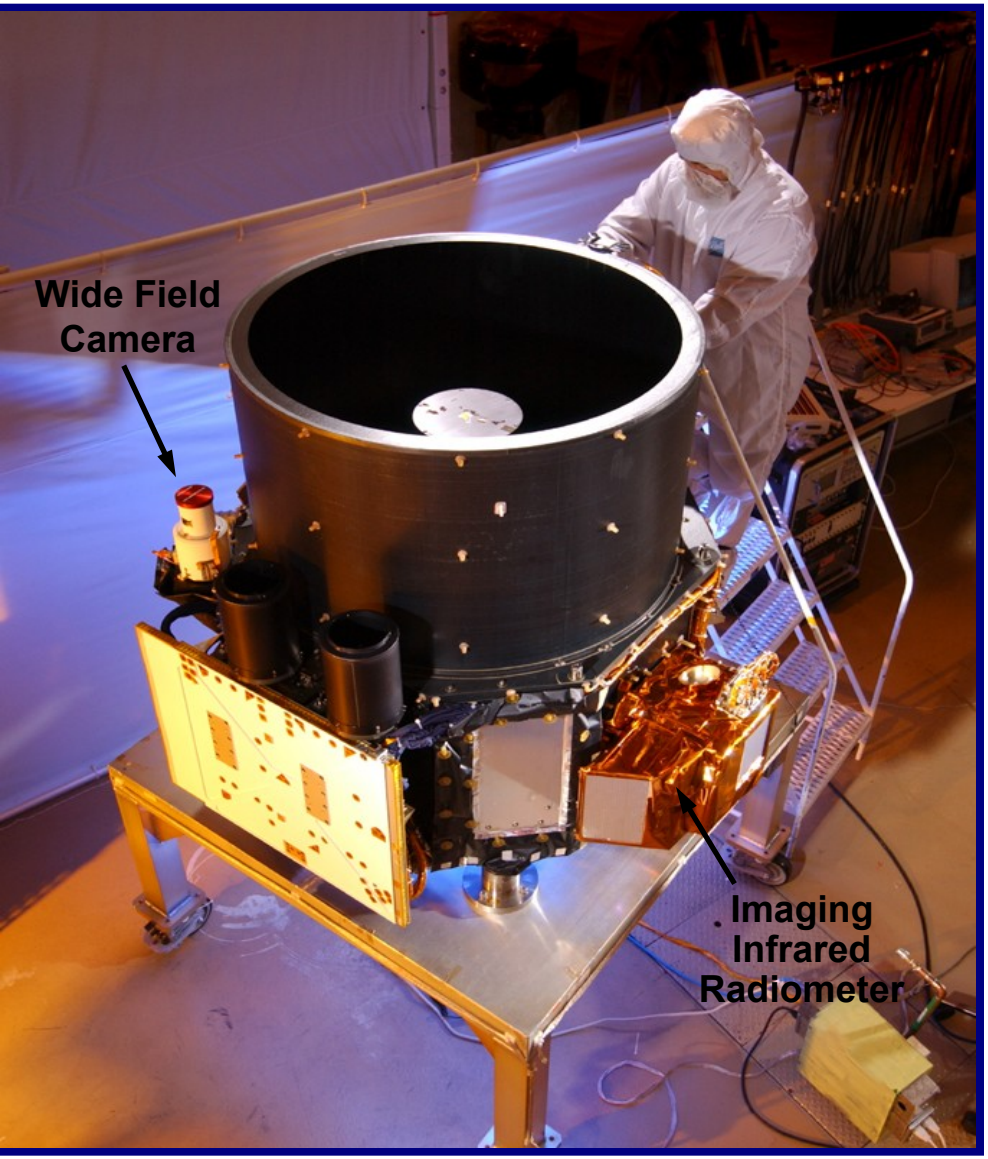
- **Our understanding of the role of aerosols and clouds in the processes that govern climate responses and feedbacks**
  - **Direct and indirect aerosol effects**
  - **Cloud forcing and feedbacks**



- **The representation of aerosols and clouds in models**
  - **Improved climate predictions**
  - **Improved models of atmospheric chemistry/air quality**


705 km, sun-synchronous orbit (1:30 PM)
Three co-aligned instruments:
• CALIOP: polarization lidar
– 532 nm || and ⊥, 1064 nm
– 0 – 40 km altitude, 30 - 60 m
• IIR: Imaging IR radiometer
– 8.6 um, 10.5 um, 12 um
– 64 km swath, 1 km IFOV
• WFC: Wide-Field Camera
– 645 nm
– 61 km swath, 125 m IFOV
Calipso Footprint
1 Km
100 m

Instrument Specifications



CALIOP

Laser	Nd: YAG, 2x110 mJ
Wavelength	532 nm, 1064 nm
Repetition rate	20.25 Hz
Receiver telescope	1.0 m diameter
Polarization	532 $\parallel$ and $\perp$
Footprint/FOV	100 m / 130 μrad
Vertical resolution	30 - 60 m
Horizontal resolution	333 m
Lin. dynamic range	22 bits

Wide-Field Camera (WFC)

Wavel ength	645 nm
Spectral bandwidth	50 nm
IFOV / Swath	125 m / 61 km

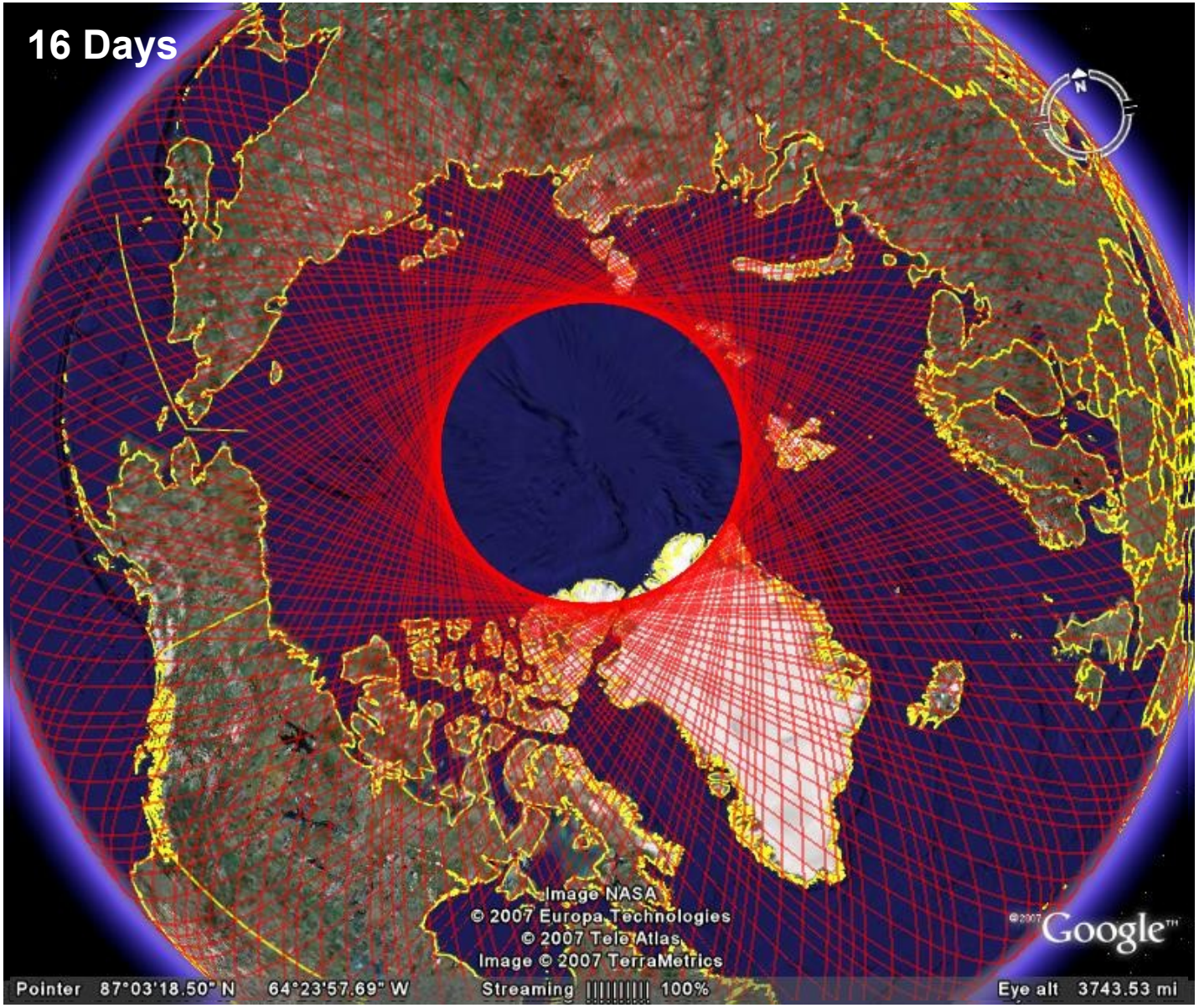
Imaging Infrared Radiometer (IIR)

Wavelength	8.65, 10.6,12.05 μm
Spectral resolution	0.6-1.0 μm
IFOV / Swath	1 km / 64 km
NETD @ 210K	0.3 K
Calibration	±1 K

CALIPSO Participation in ARCTAS

- **Motivation**
  - CALIOP provides the only satellite observations of aerosol in the Arctic
    ... as well as unique observations of smoke and clouds
- **Pre-campaign activities**
  - Analysis of 2006/2007 CALIOP data to support planning activities
- **Support of field activities**
  - CALIPSO representative in the field during campaign
  - Provide near-real time CALIPSO data products and flight planning guidance to the ARCTAS team
    - > Forward trajectories initialized with CALIOP aerosol observations (Duncan Fairlie, Chieko Kittaka)
  - Identify specific CALIPSO validation needs and opportunities for incorporation into flight plans.
- **Post-campaign activities**
  - collaboration with other ARCTAS researchers in investigations combining CALIPSO data with aircraft measurements and modeling

Orbit Coverage



Lidar Data Products

Level 1 (geolocated and calibrated)

- DP 1.1 - profiles of attenuated lidar backscatter (532, $532_{\perp}$, 1064 nm)
- DP 1.2 – IR radiances (8.65, 10.6, 12.05 μm)
- DP 1.3 – Visible radiances (650 nm) (WFC)

Level 2

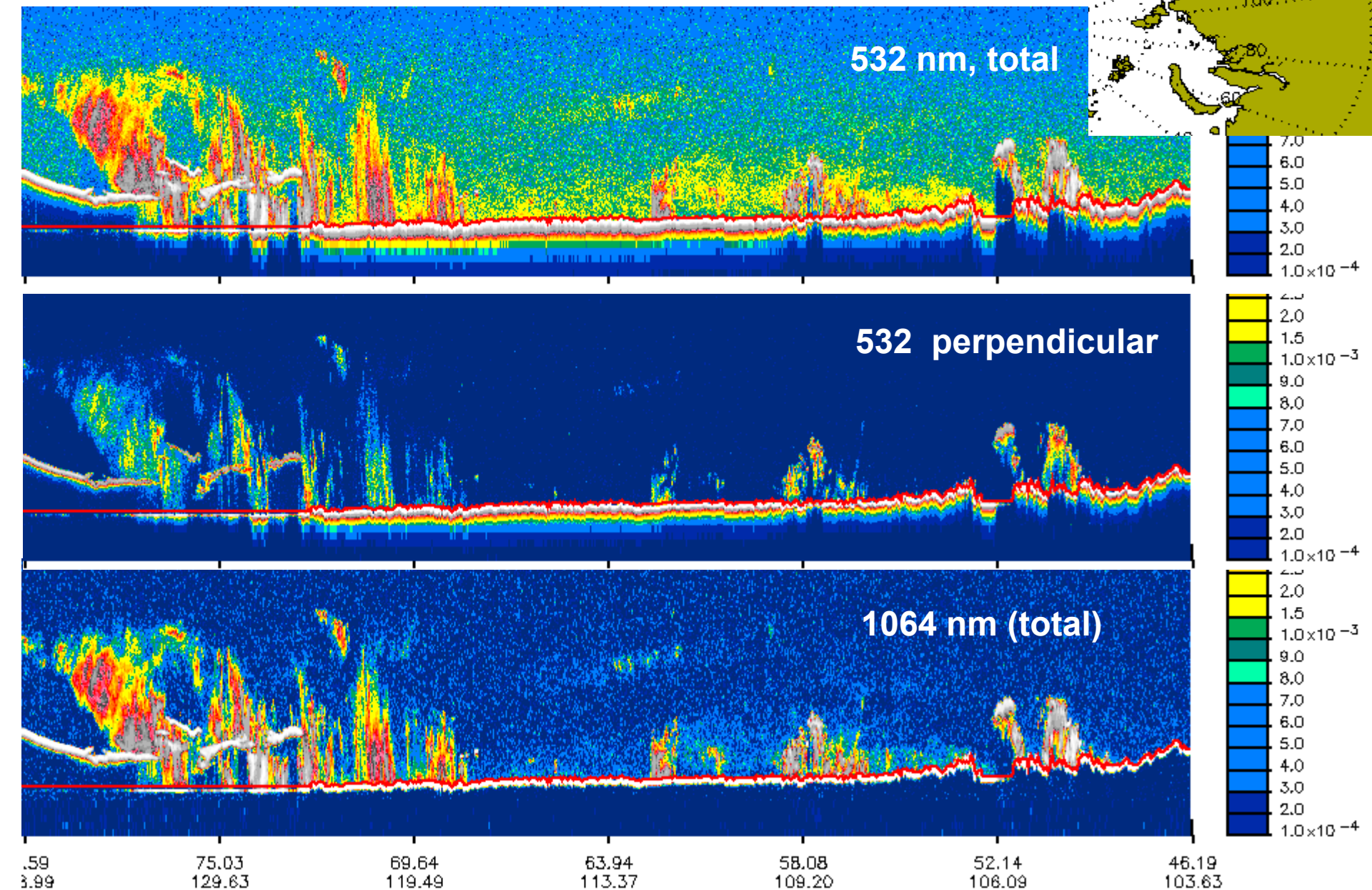
- DP 2.1A – Cloud/Aerosol layer product
  - layer base and top heights, layer-optical depth, cloud I/W phase
- DP 2.1B – Aerosol profile product
  - backscatter, extinction, depolarization profiles
- DP 2.1C – Cloud profile product
  - backscatter, extinction, depolarization, ice/water content profiles
- DP 2.1D – Vertical Feature mask
  - cloud/aerosol locations, aerosol type
- Also: products from IIR + CALIOP + WFC: cloud $T_B(\lambda)$, emissivity, r_e

Level 3

- Summary statistics on a global grid

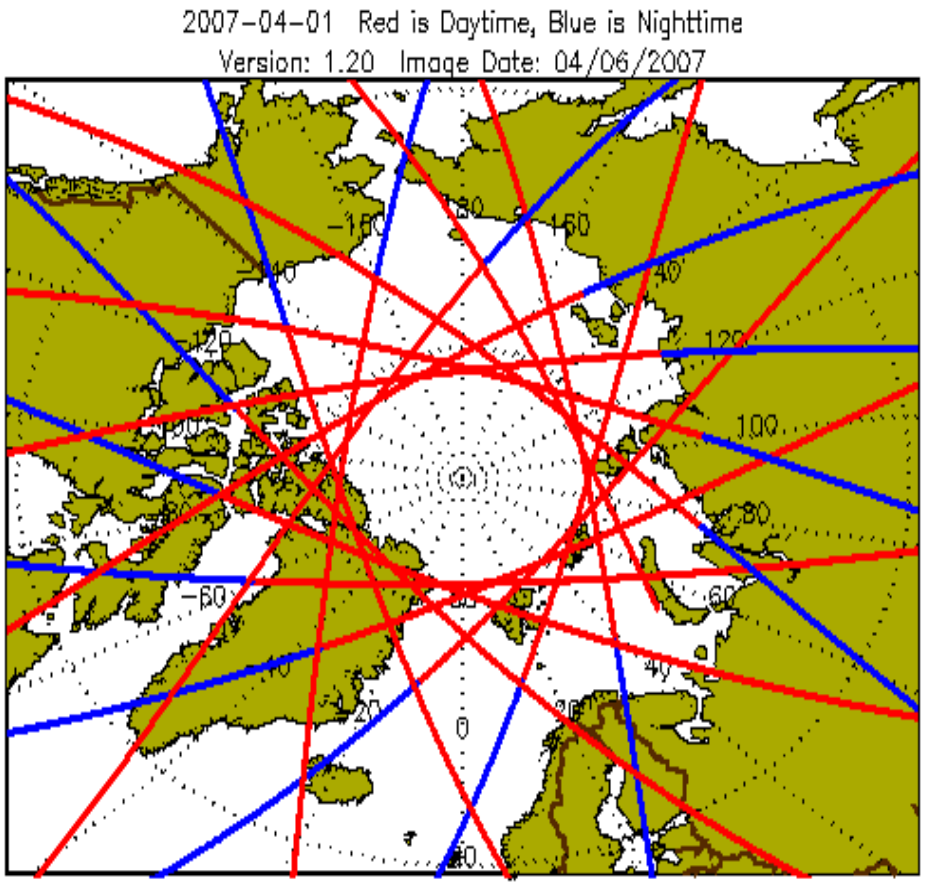
(available at http://eosweb.larc.nasa.gov)

CALIOP Signals (night): Feb 12, 2007

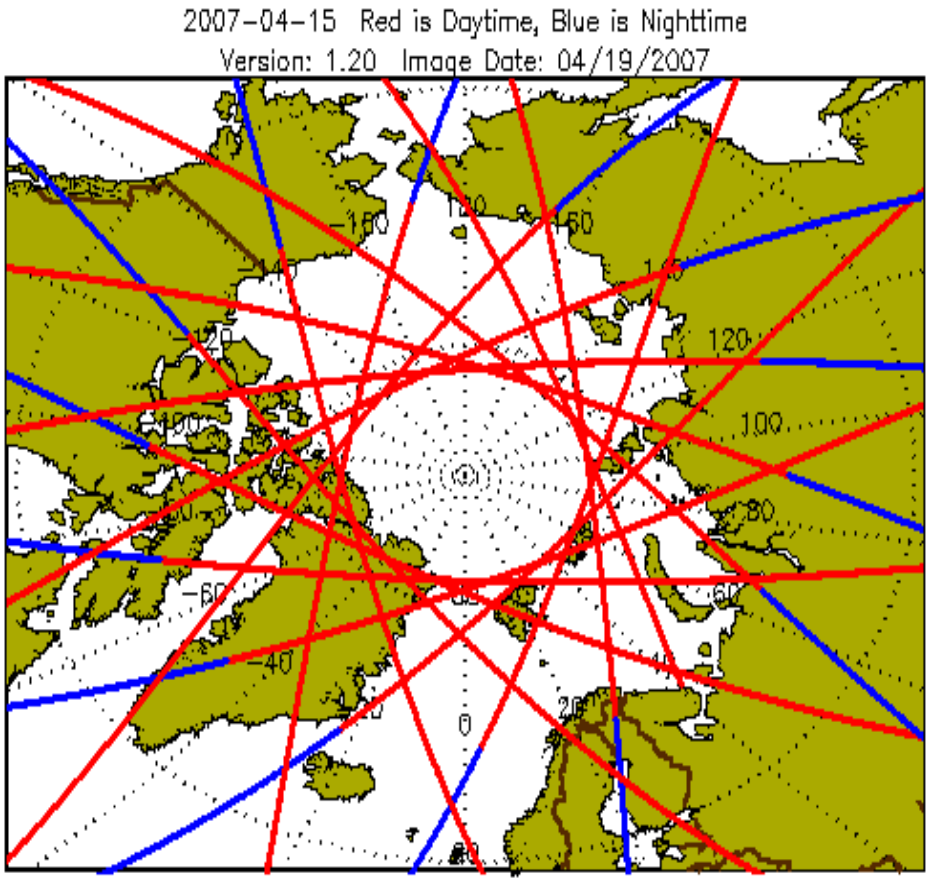


Terminator Locations

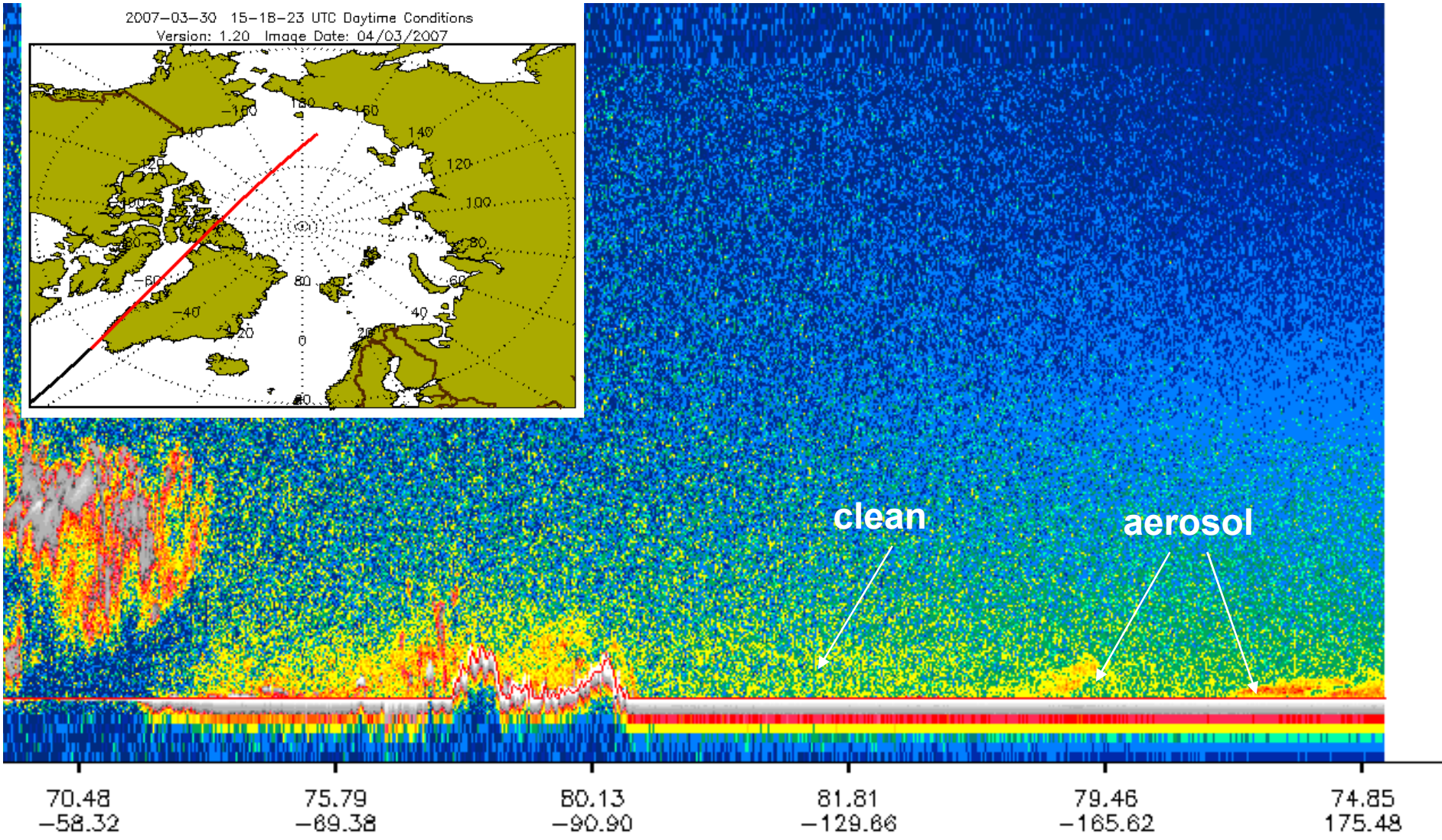
April 1



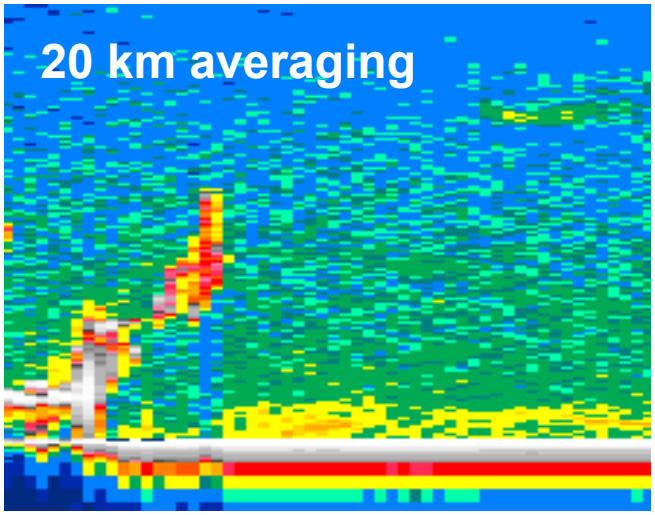
April 15

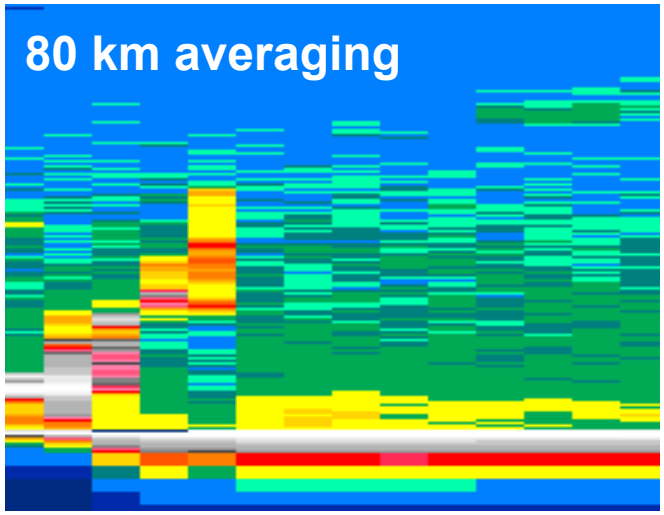


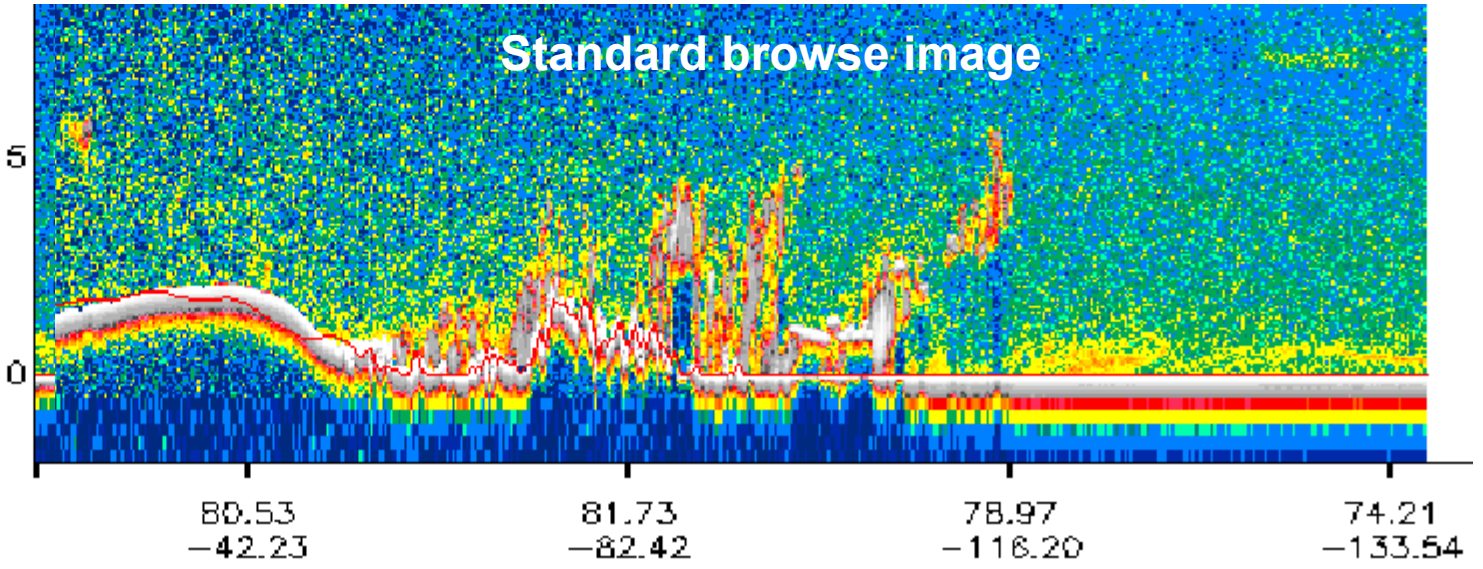
Daytime Observations – March 30, 2007

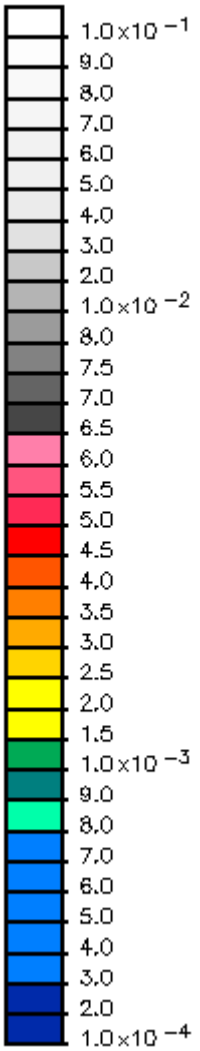


Arctic Aerosol (day, 1 April 2007)

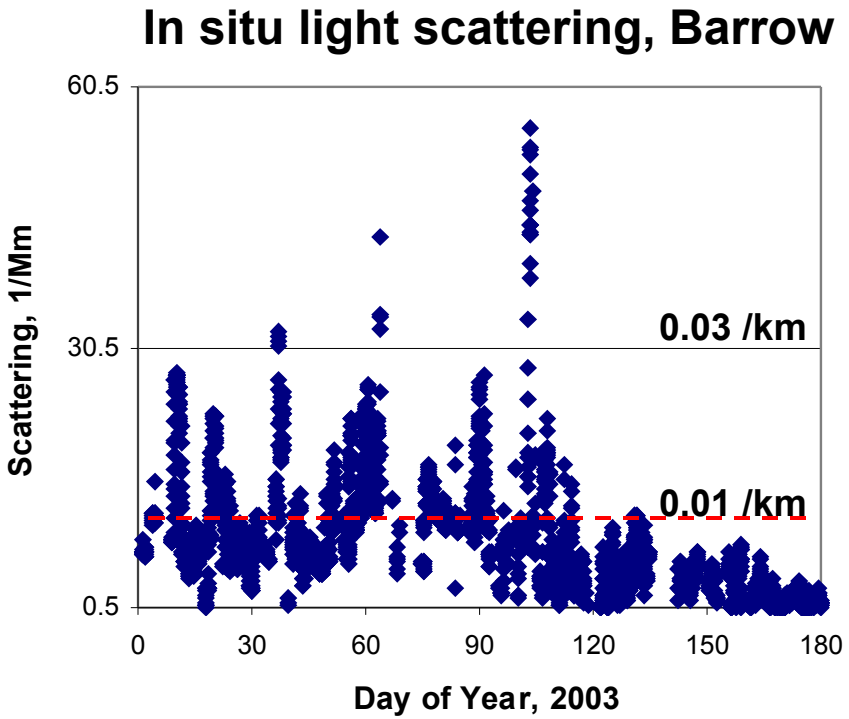


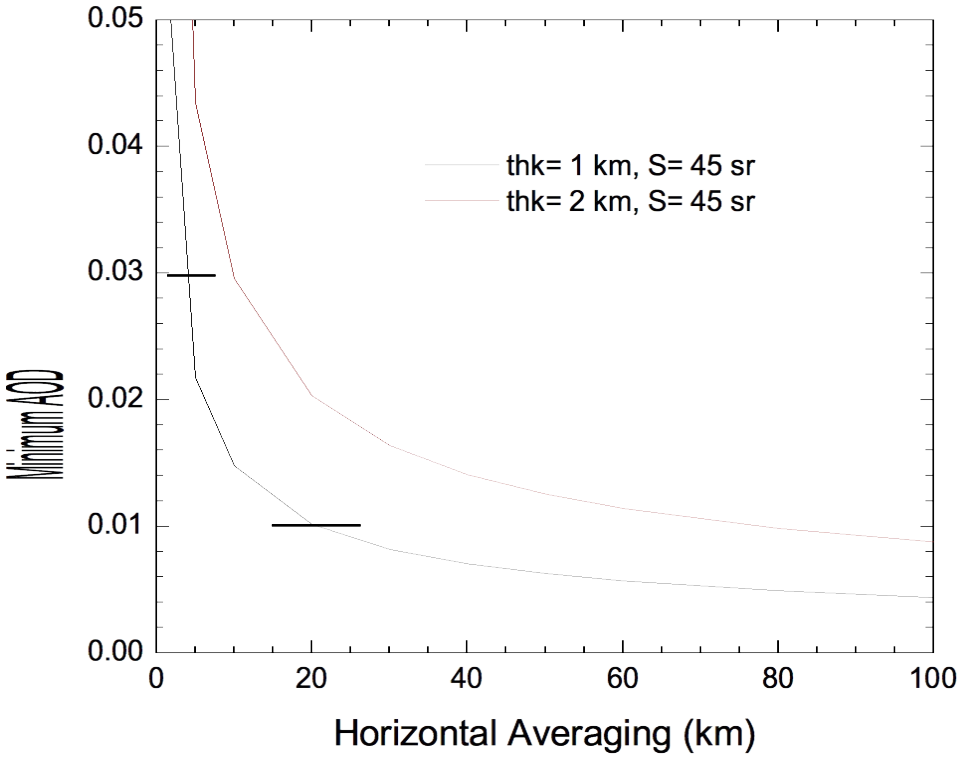






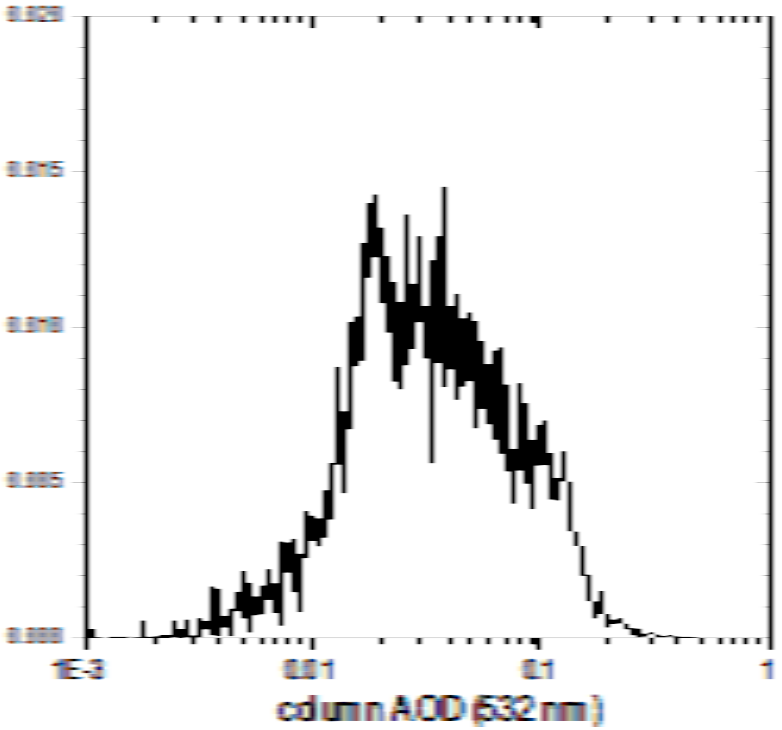
Episodic haze events at Barrow



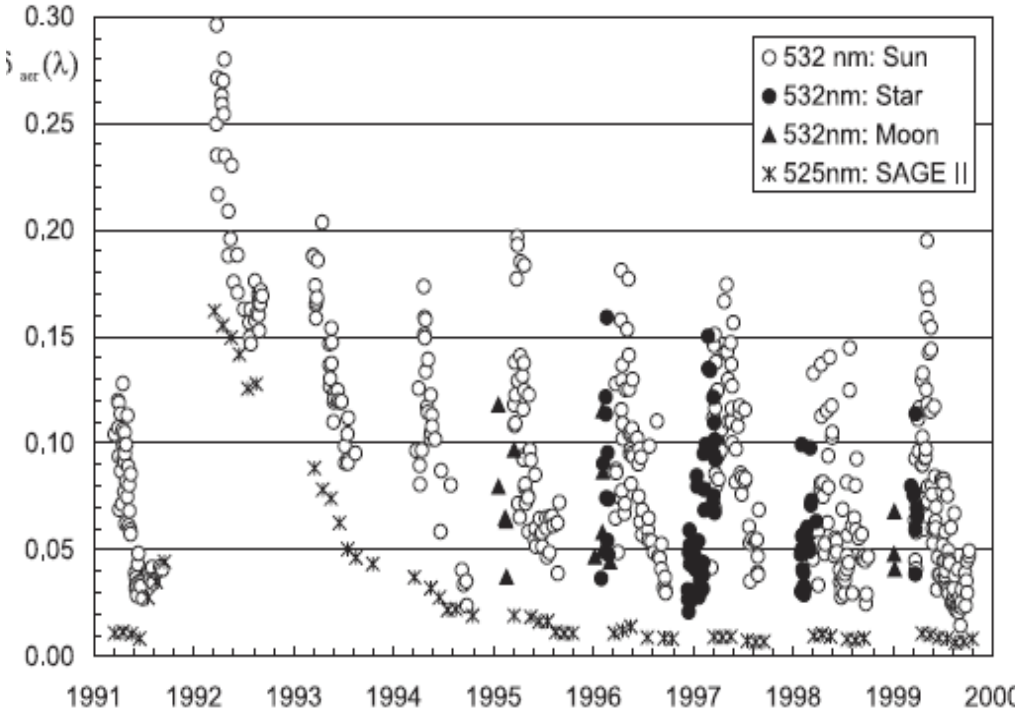


(courtesy Trish Quinn)

PDF of CALIOP AOD - April

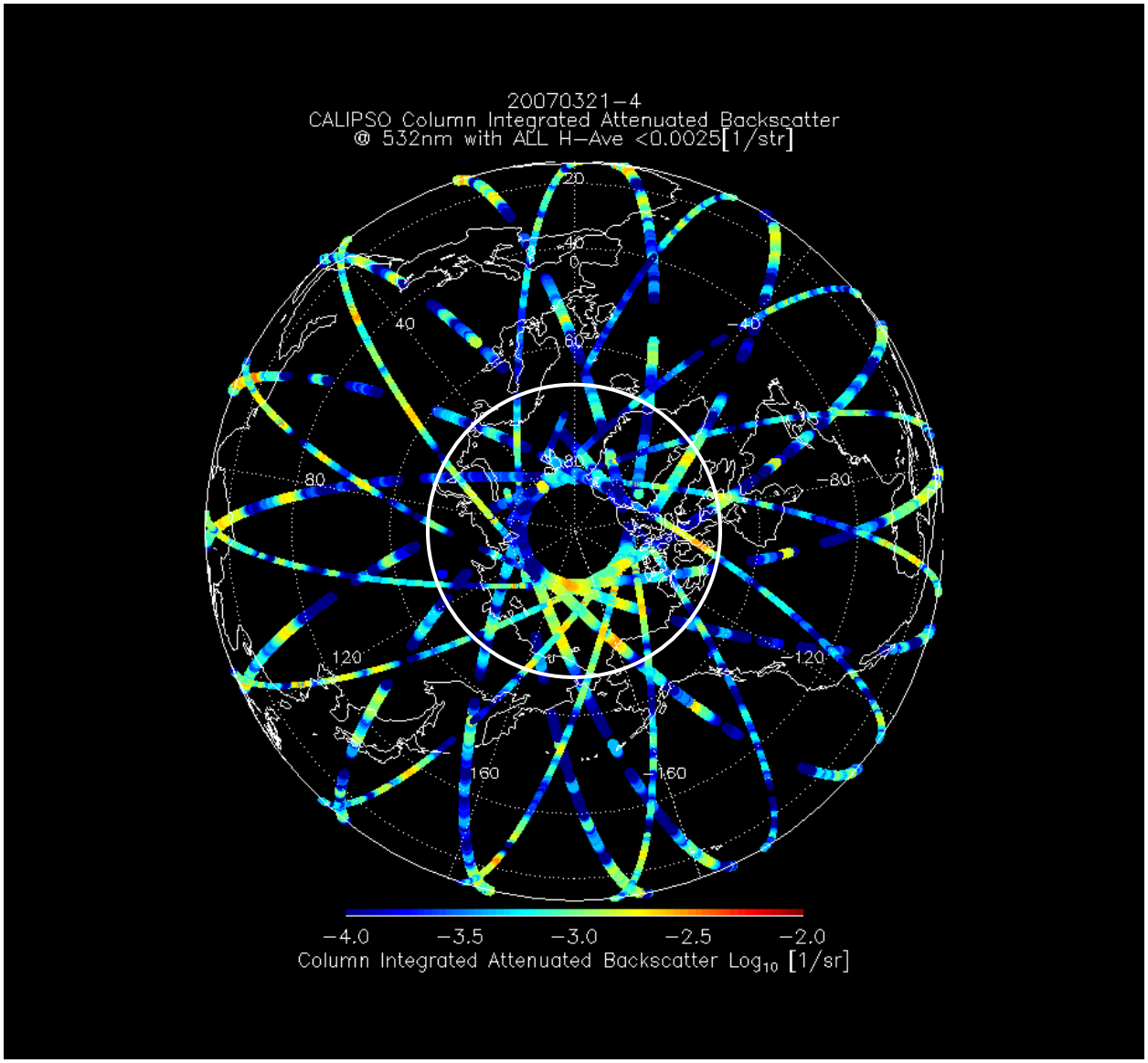


Star photometer measurements: Ny Alesund



(Herber et al., Aerosol Measurements in the Arctic, JGR 2002)

One-day Aerosol Distribution



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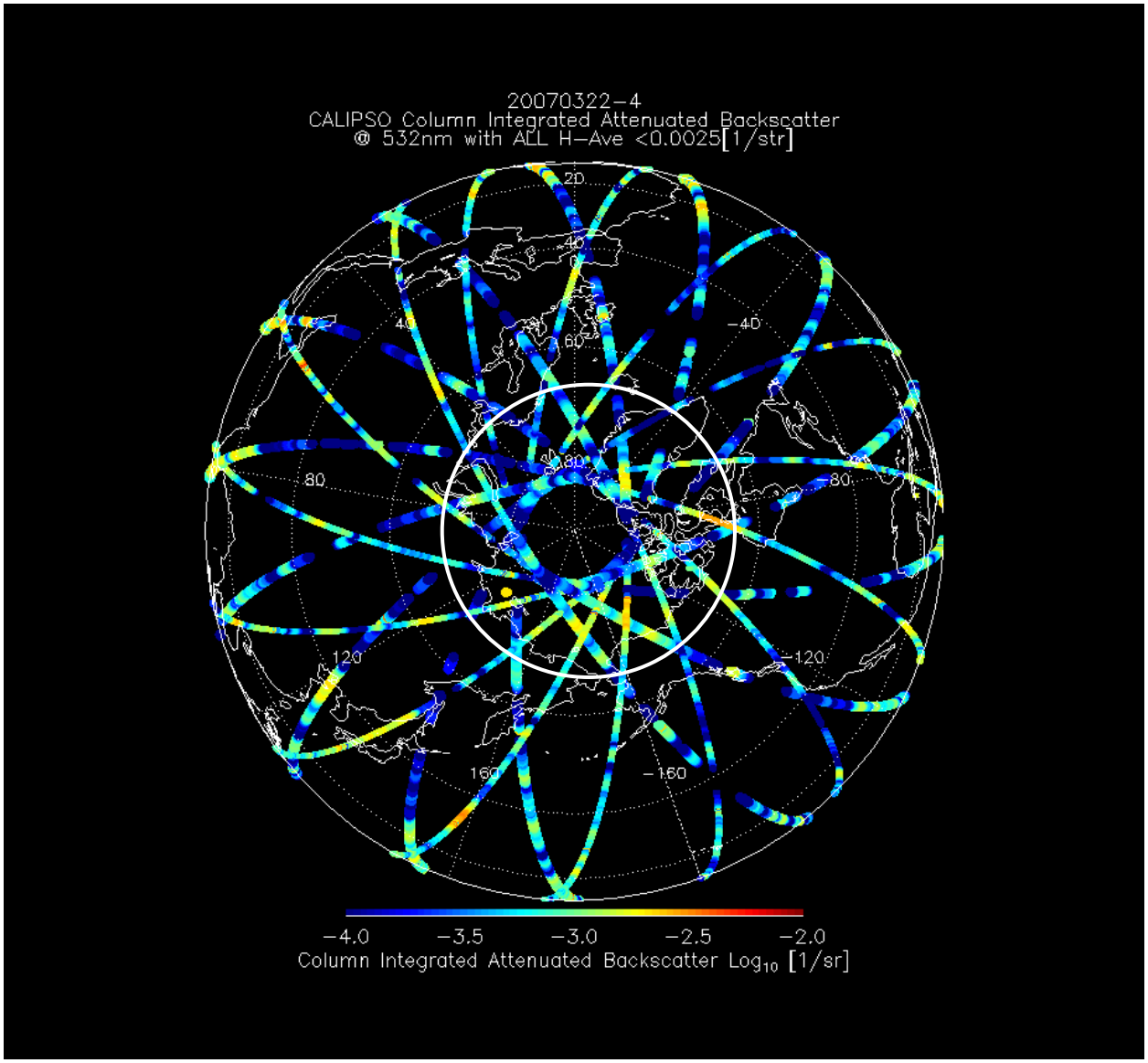
One-day Aerosol Distribution



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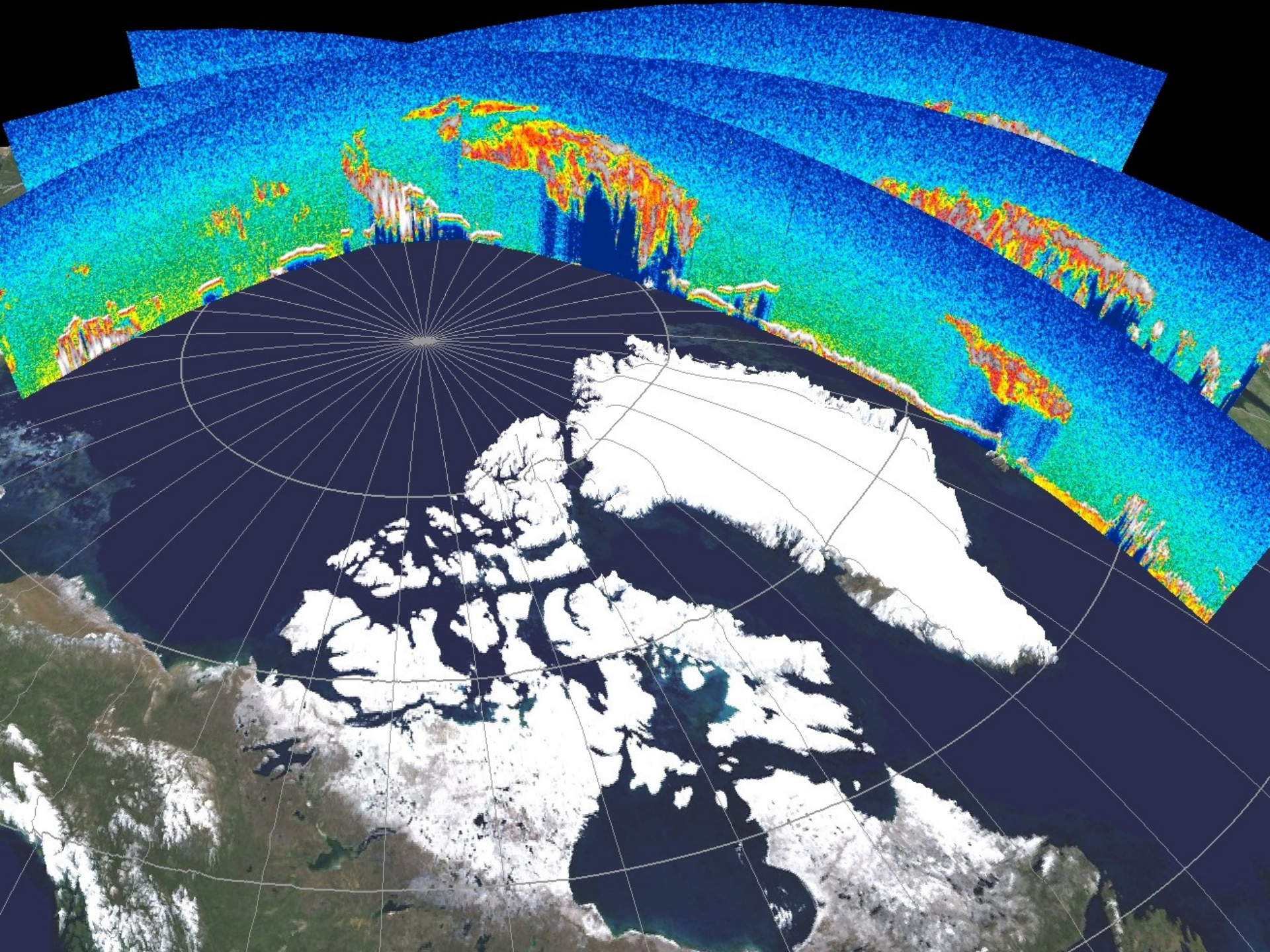
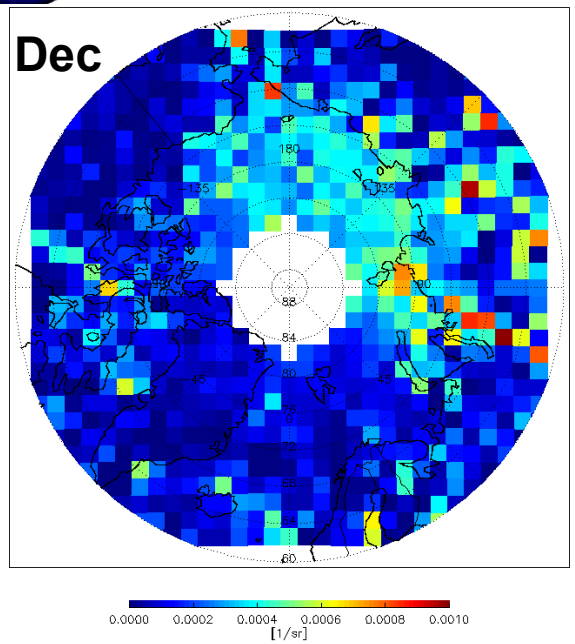
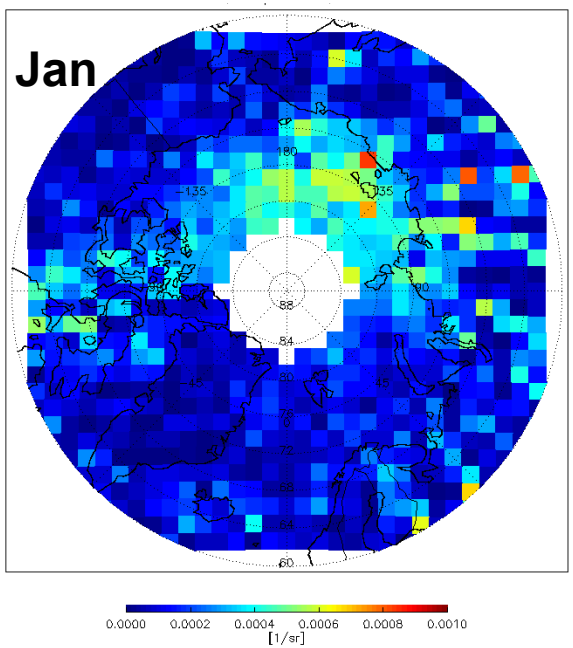
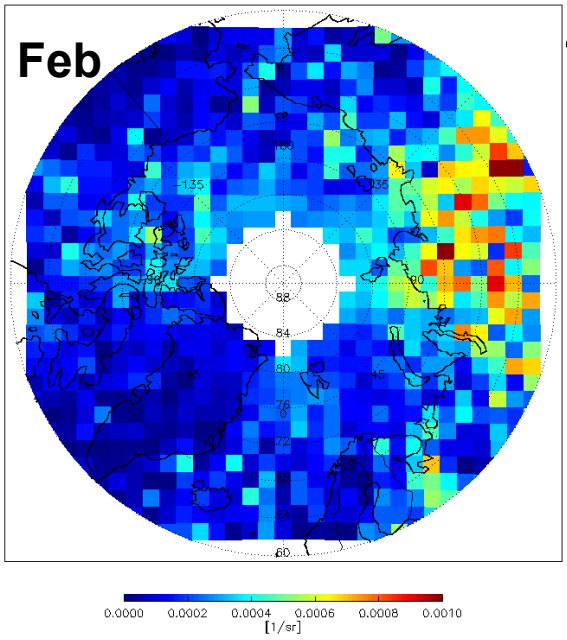
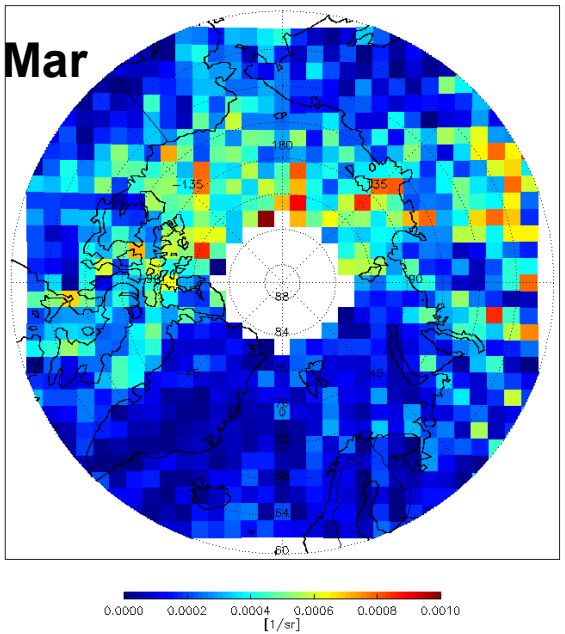


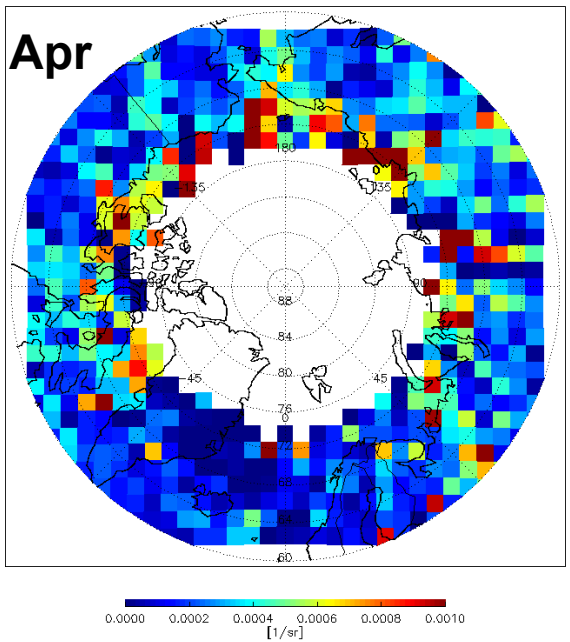
Monthly-mean Aerosol IAB (night)





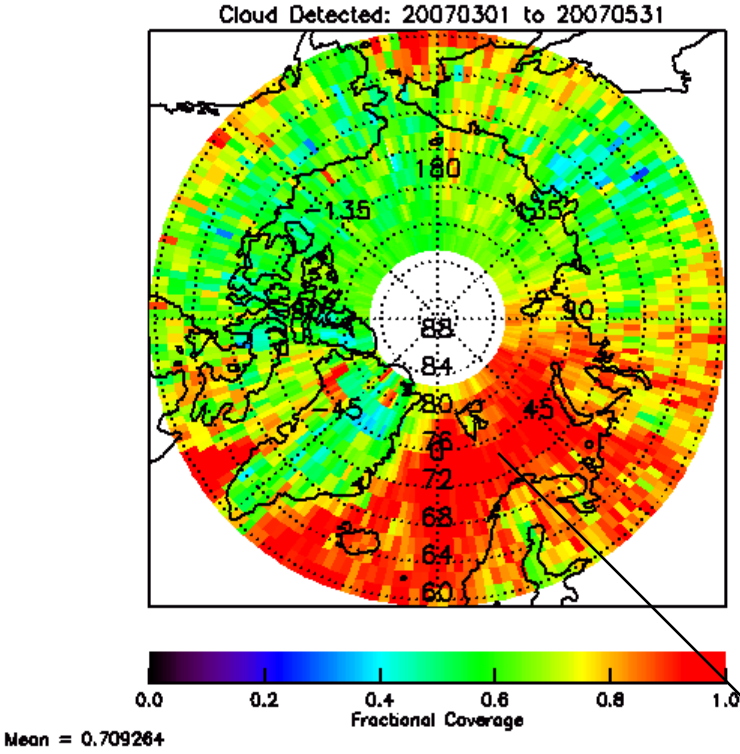




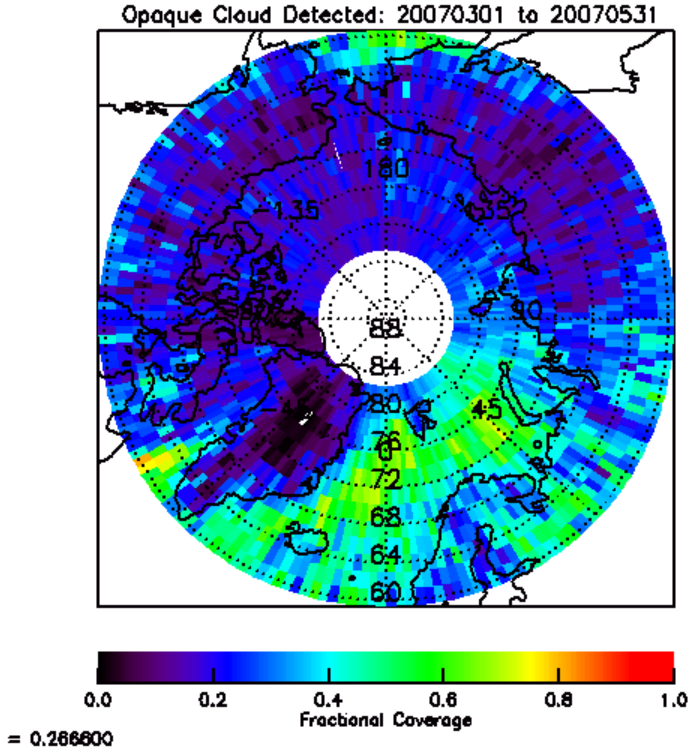


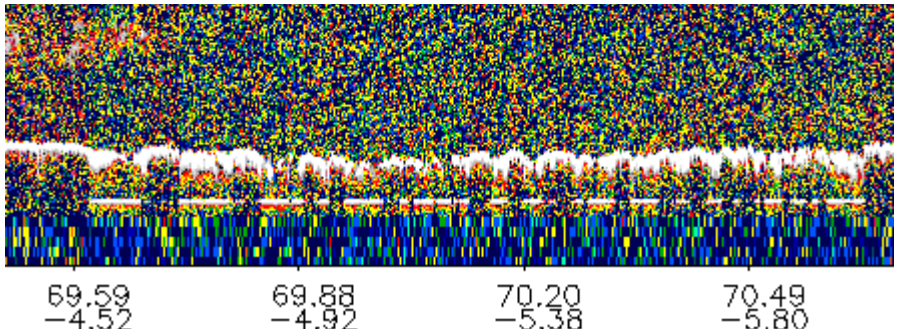
Arctic cloud: MAM

Cloud Fraction: All cloud

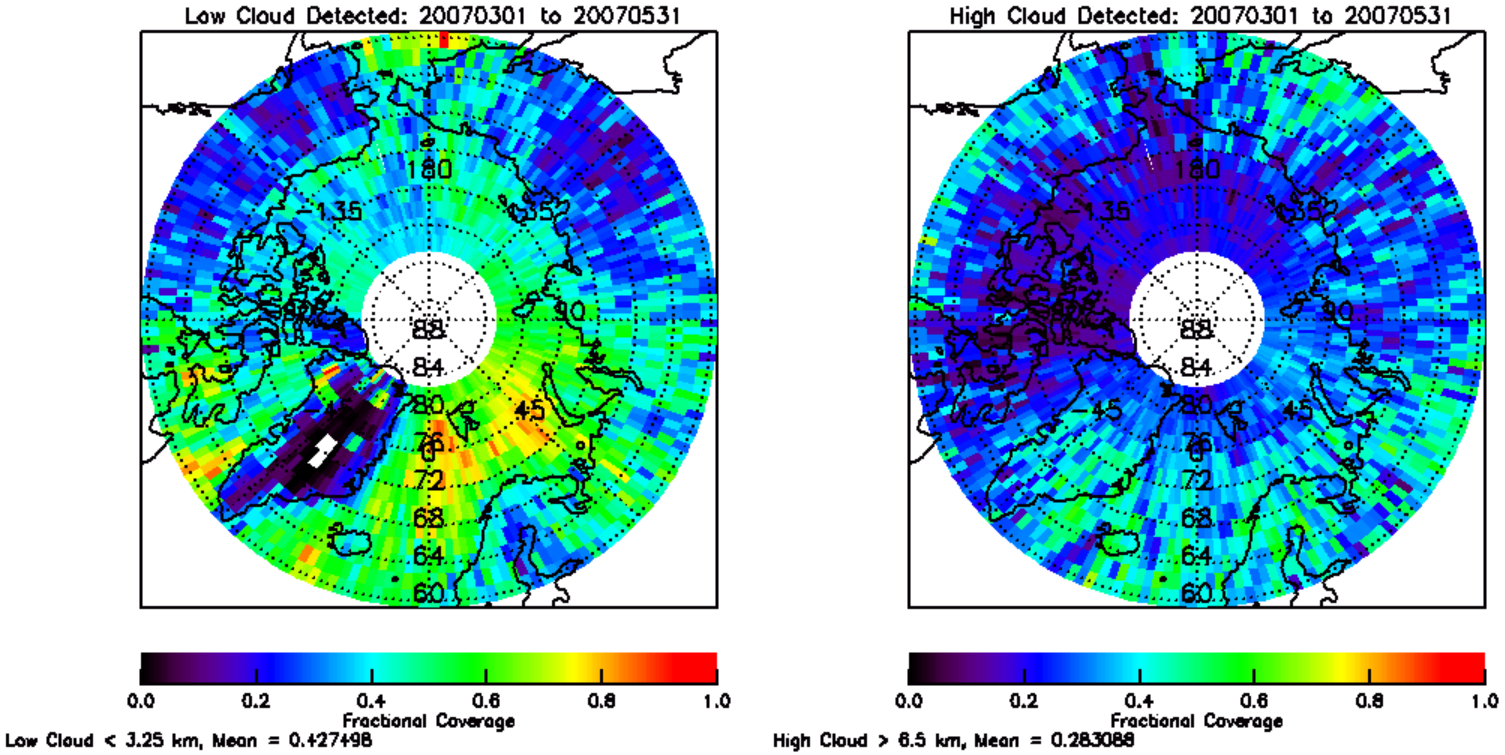


Opaque cloud



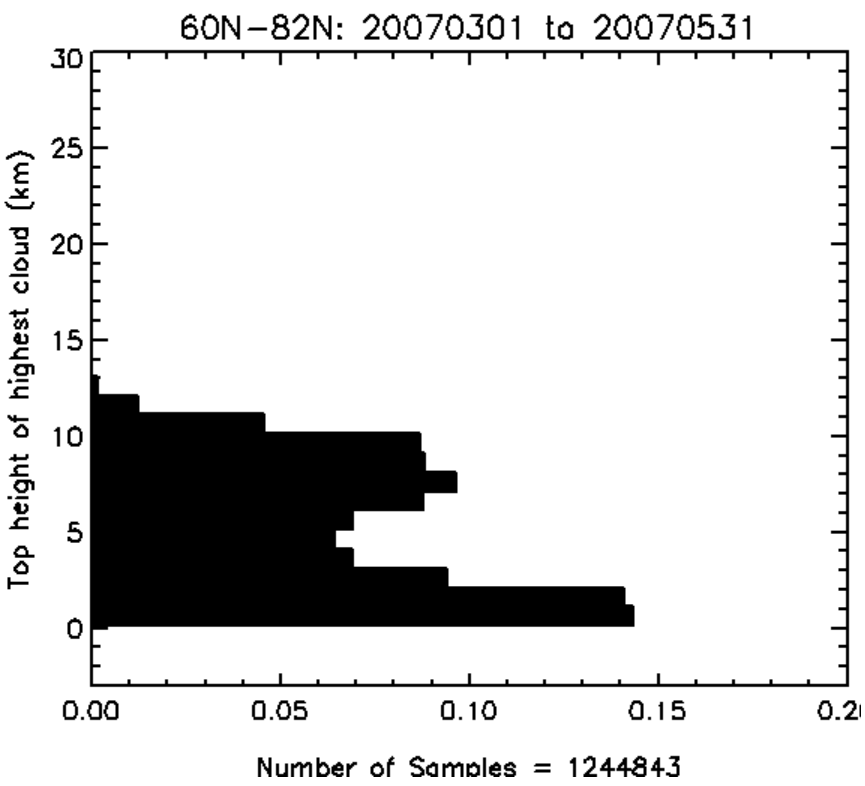


Low vs. High Cloud

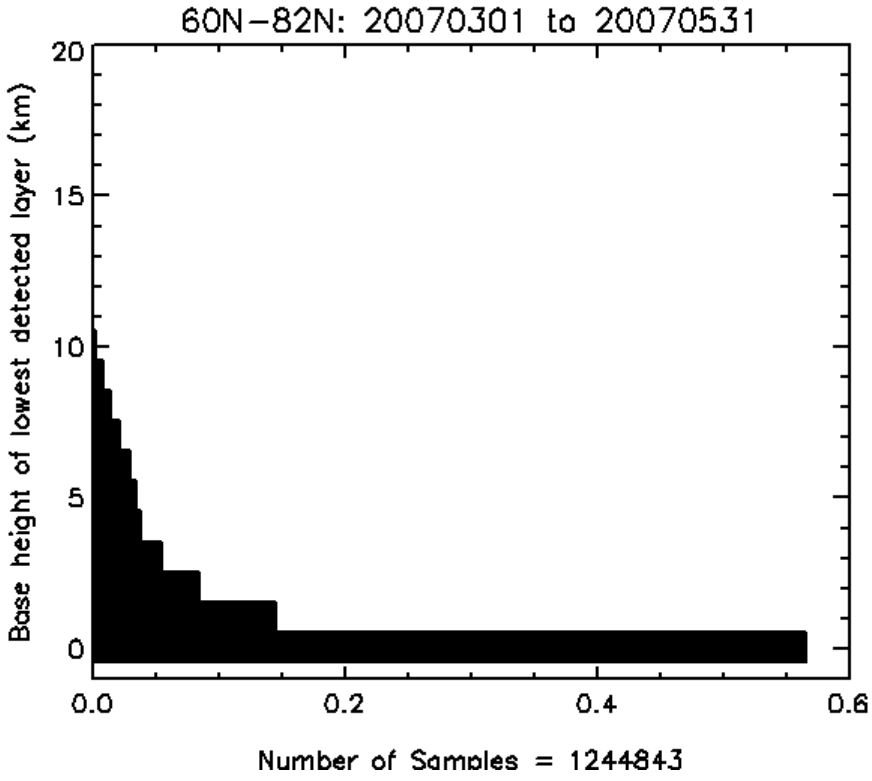


Cloud Vertical Distribution: MAM, 60°N – 82°N

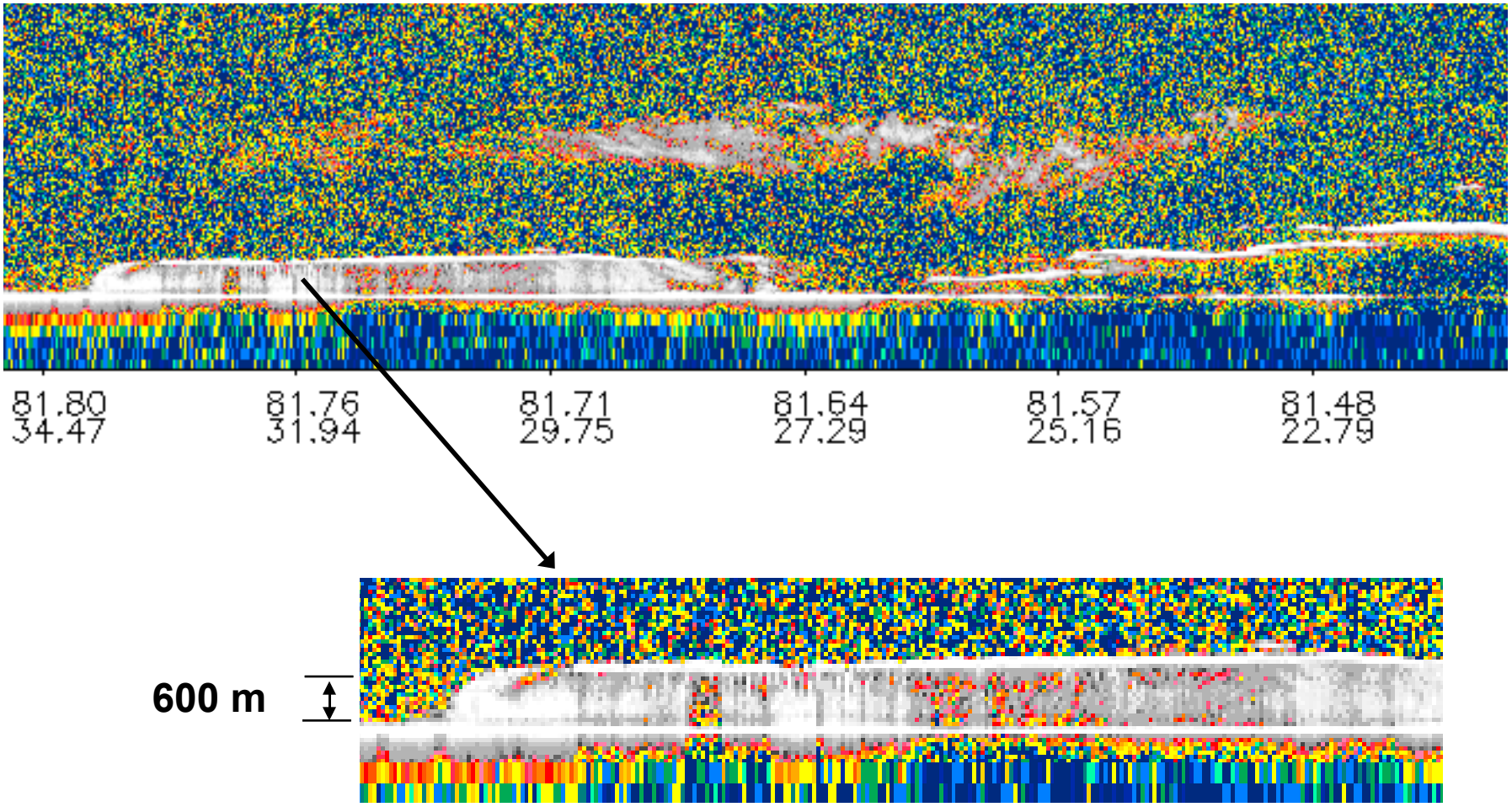
Highest cloud top



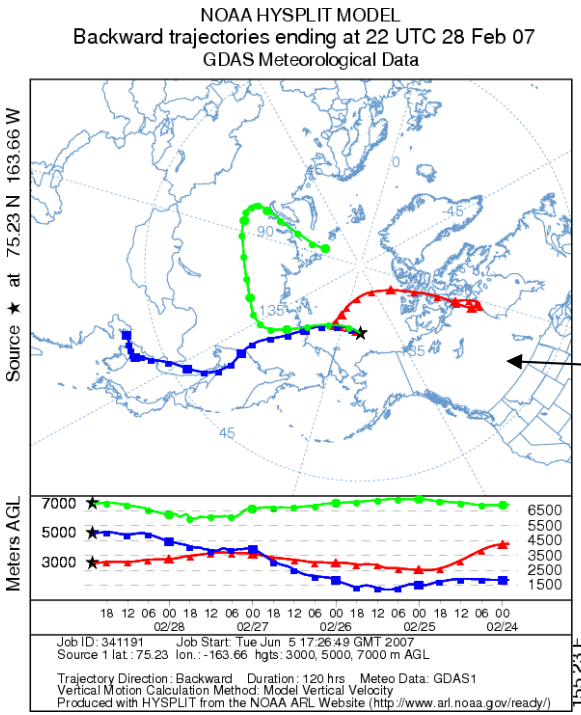
Lowest cloud base

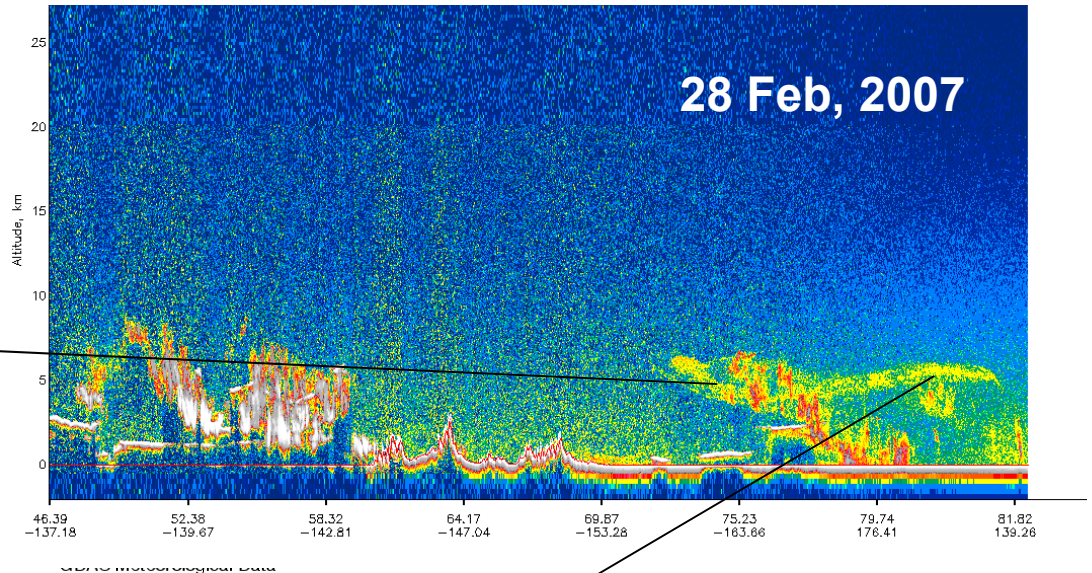


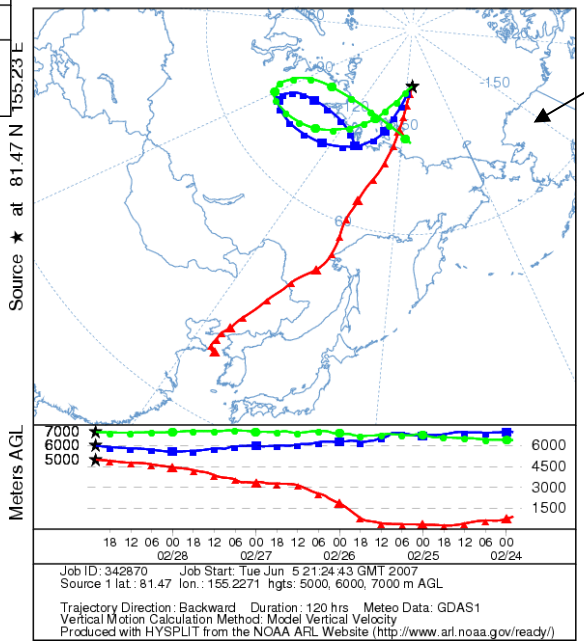
Arctic Stratus at full resolution (30 m x 300 m)



Occasional elevated layers: Chinese source?







Validation Activities

Validation includes:

- Targeted aircraft campaigns
- International field campaigns
- Ground-based networks
- Satellite comparisons

Activities to date:

• Flights of LaRC HSRL	Jun-Sep 2006, Jan 2007
• CC-VEX (Georgia)	Jul-Aug 2006
— CPL, CRS (ER-2), HSRL	
• Flights of CNES HSRL (Niger)	Jul 2006
• NASA AMMA (Cape Verde)	Aug 2006
• GoMACCS (Houston)	Aug-Sep 2006
• DLR ASTAR (Svalbard)	Mar-Apr
• CIRCLE-2	May
• NASA TC^4 (Costa Rica)	Jul-Aug

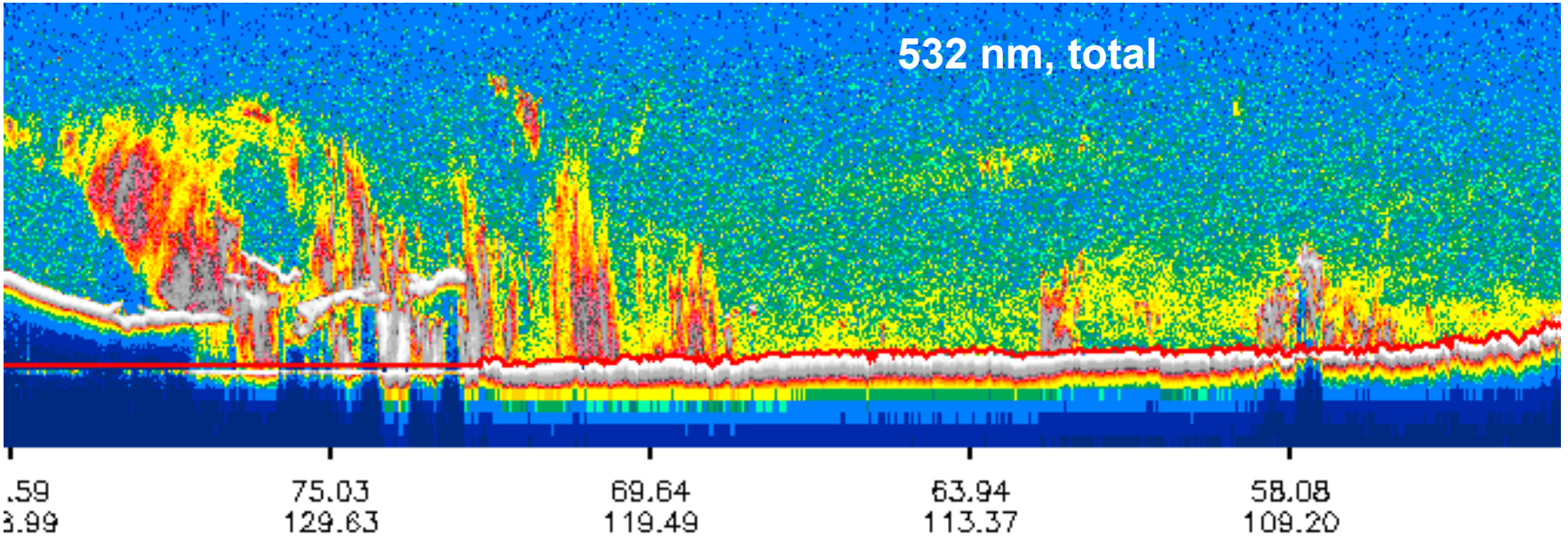
Plans for 2008:

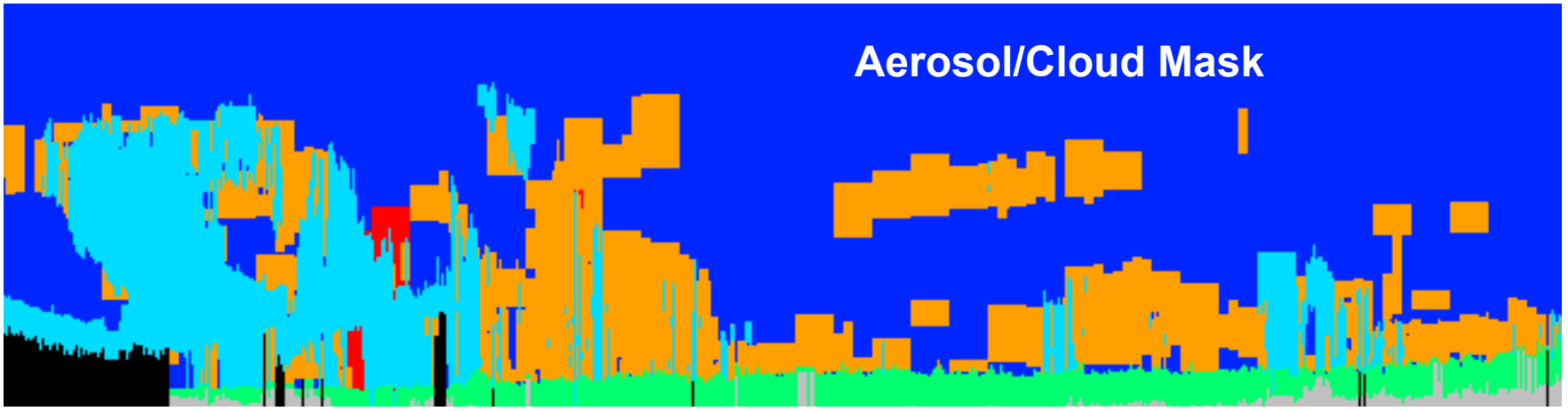
- ARCTAS, PolarCat (Kiruna, Greenland)

CALIPSO Validation Needs

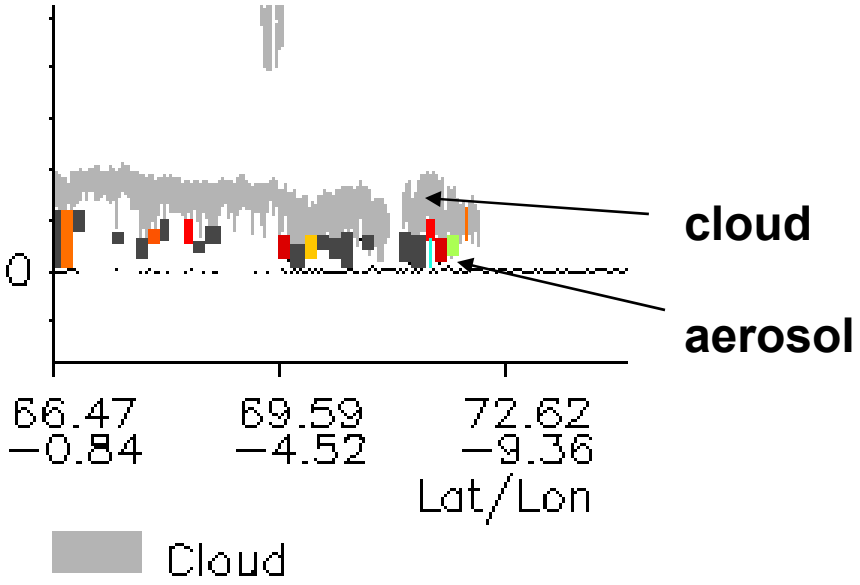
- **Validation of 532 nm, 1064 nm calibration**
  - **HSRL**
  - **DIAL?**
- **Determine CALIOP detection limits (aerosol)**
- **Validation of cloud/aerosol discrimination**
  - **High SNR 532 nm, 1064 nm, and depolarization data (HSRL, DIAL)**
  - **HSRL allows discrimination of aerosol and tenuous water cloud via lidar ratio**
  - **Can use in situ data for discrimination of aerosol and thin cloud**
- **Validation of aerosol extinction profiles (10^{-4} to 10^{0} /km):**
  - **Profiles of aerosol extinction, backscatter: HSRL, in-situ/AATS**
  - **Verification of aerosol lidar ratio (σ/β): HSRL, in situ**
    - **Need lidar ratios at both 532 nm and 1064 nm**
- **Additional in situ measurements:**
  - **Aerosol composition: to validate "aerosol type", aerosol lidar ratio**
  - **Aerosol mass, extinction, size distribution, composition: to relate CALIOP observations to models**

Validation: Aerosol/Cloud Discrimination

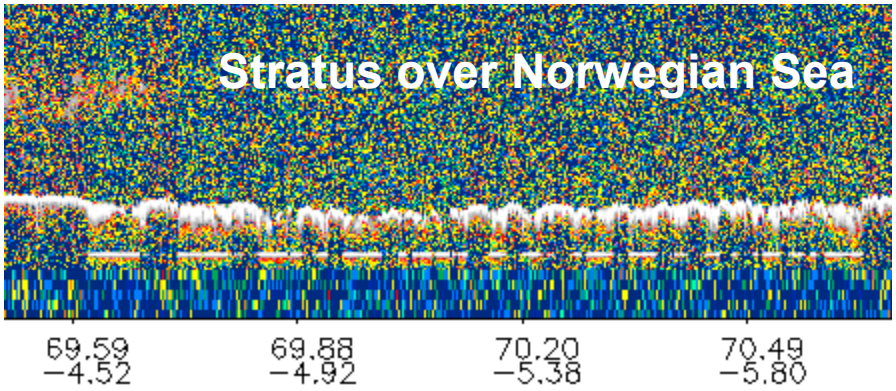




Aerosol under marine stratocumulus?



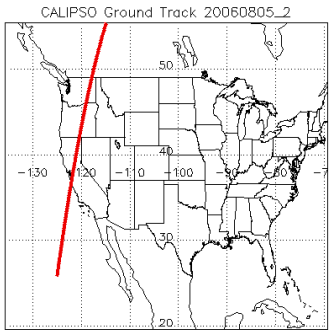
aerosol layers are often found underneath stratus, but IAB values are highly suspect

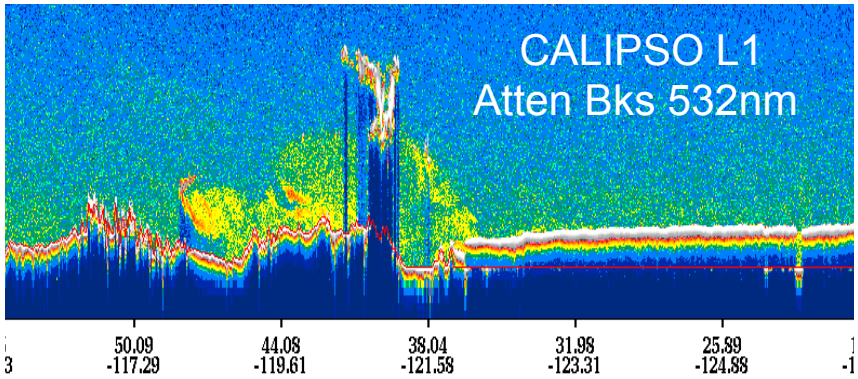


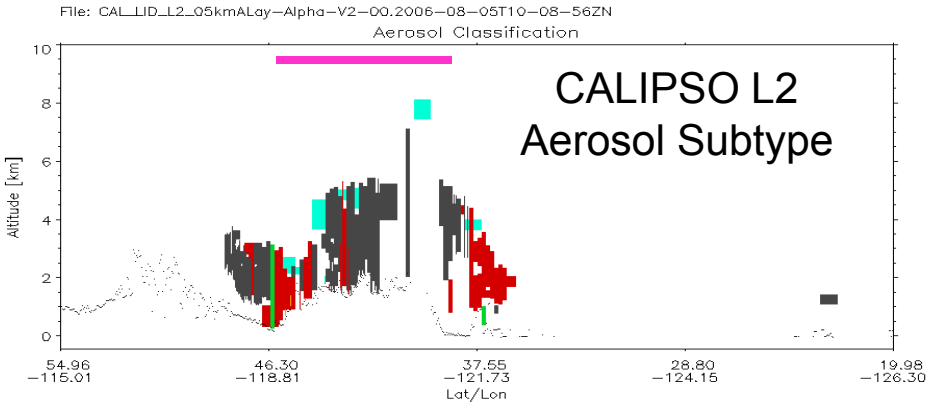
17 April

CALIPSO-Model Intercomparisons

Height of Smoke layer near the source:







Blue: Clean Marine

Orange: Dust

Green: Polluted Continental

Cyan: Clean Continental

Red: Polluted Dust

Dark Gray: Smoke