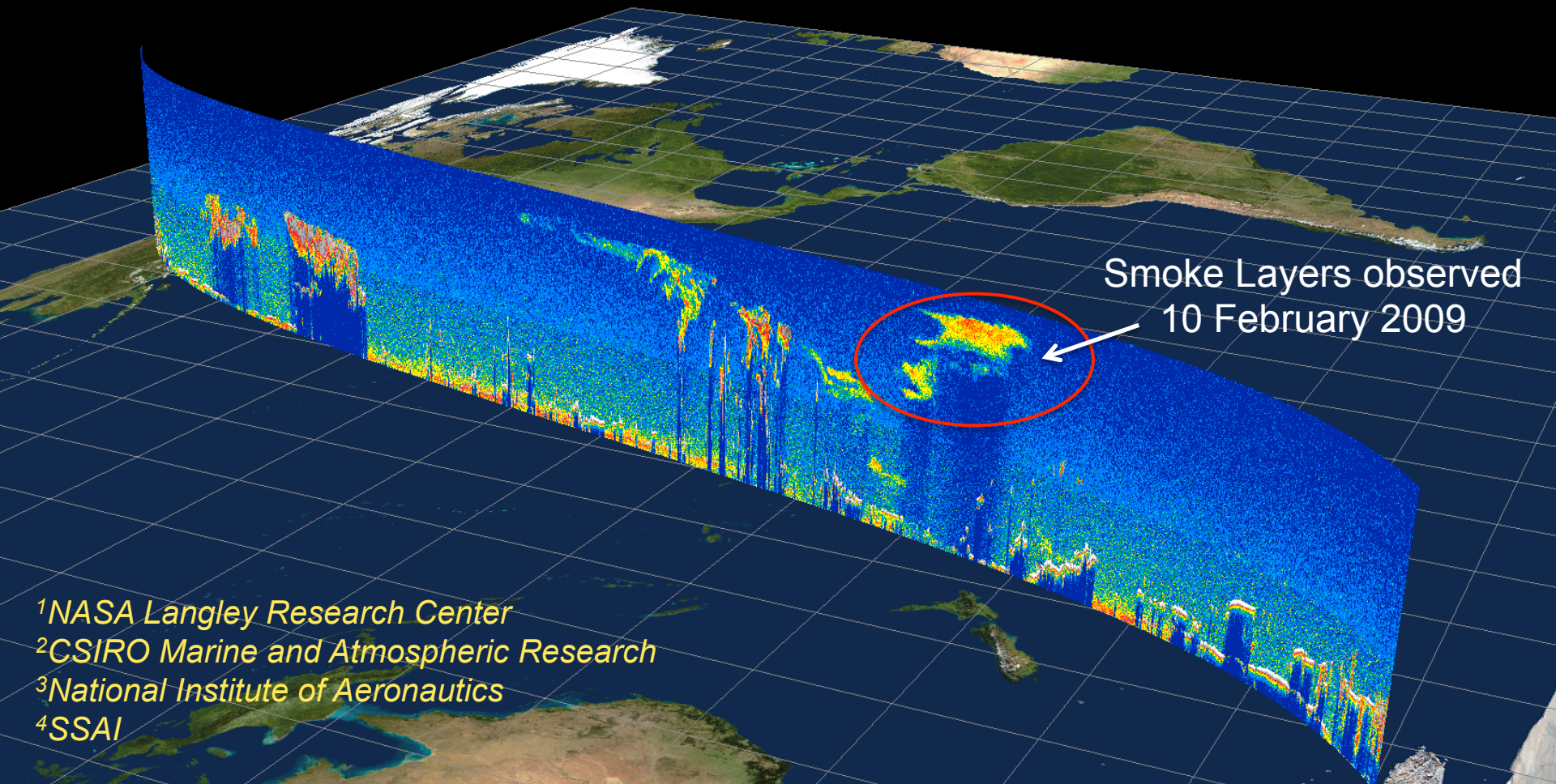


The Dispersal of Smoke in the UTLS Region Following the Australian PyroCB Event of February 2009

C. Trepte¹, M. Vaughan¹, S. Young², S. Kato¹, Z. Liu³, and R. Kuehn⁴



¹NASA Langley Research Center

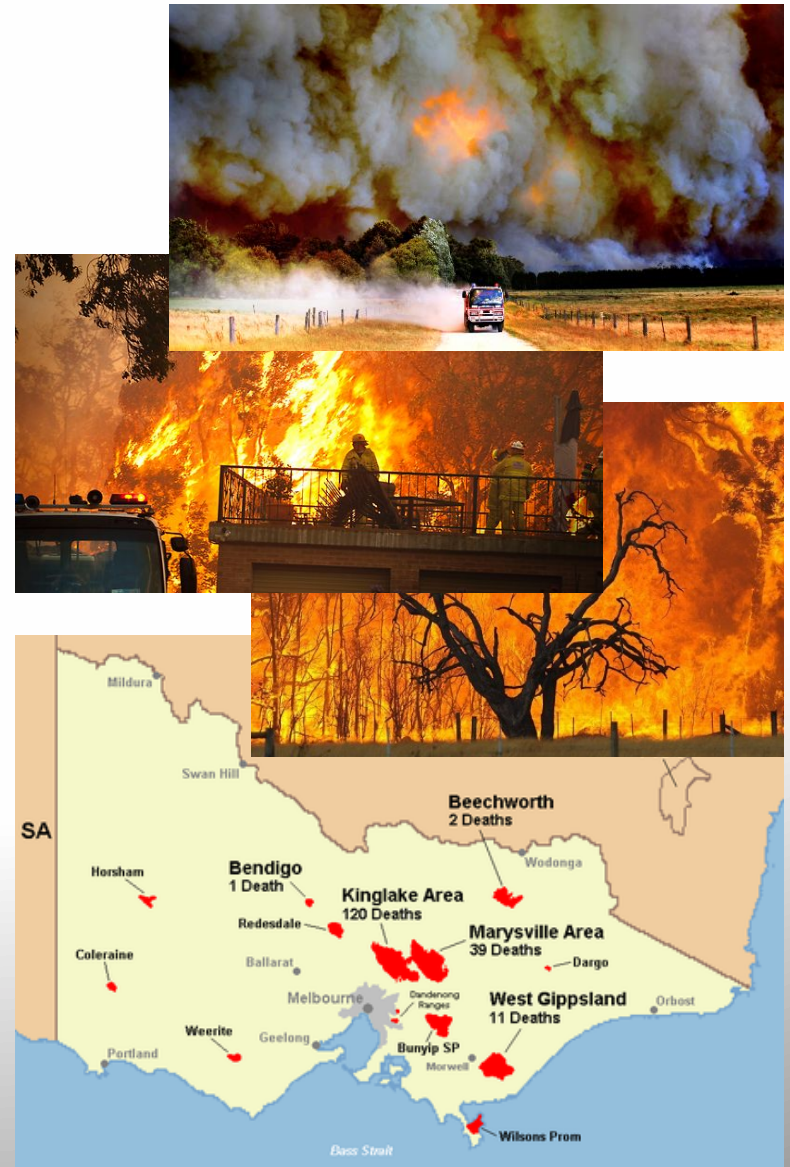
²CSIRO Marine and Atmospheric Research

³National Institute of Aeronautics

⁴SSAI

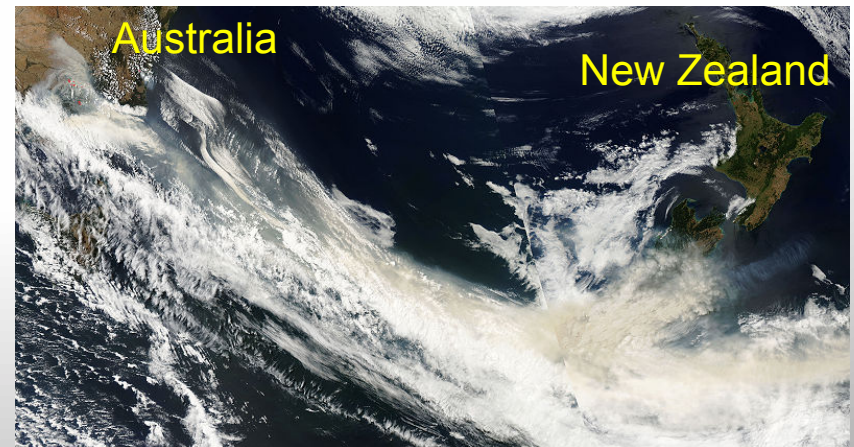
Black Saturday Bushfires

- A series of bushfires (>400) ignited on 7 February 2009 and raced across the Australian State of Victoria
- Fires developed in extreme weather conditions:
 - prolonged 2 month drought and heat wave preceded event
 - on Feb 7th air temperature peaked at 45-47°C (*highest recorded in Melbourne)
 - winds > 100 km/h, reaching 120 km/h after frontal passage
- Tragic event ranks 2nd in Australian natural disasters with 173 fatalities and > 2000 homes destroyed



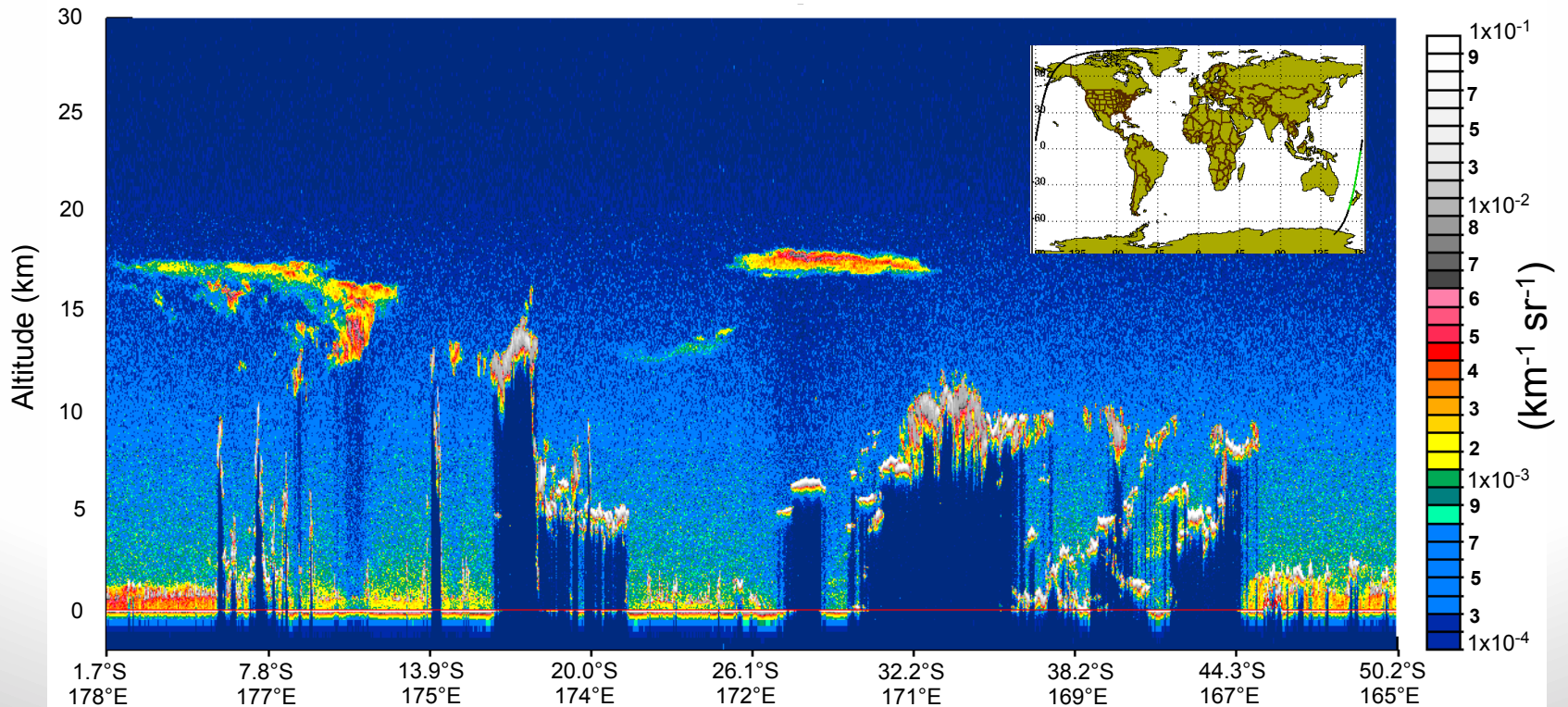
Pyrocumulonimbus

- Several large ‘PyroCBs’ formed over the most intense fires
- Lofted smoke into Tropical Tropopause Layer
- Smoke quickly carried first eastward
- Traces of smoke were also transported westward near equator and eventually near 22 km
- Observed by OMI, AIRS, MLS, OSIRIS*



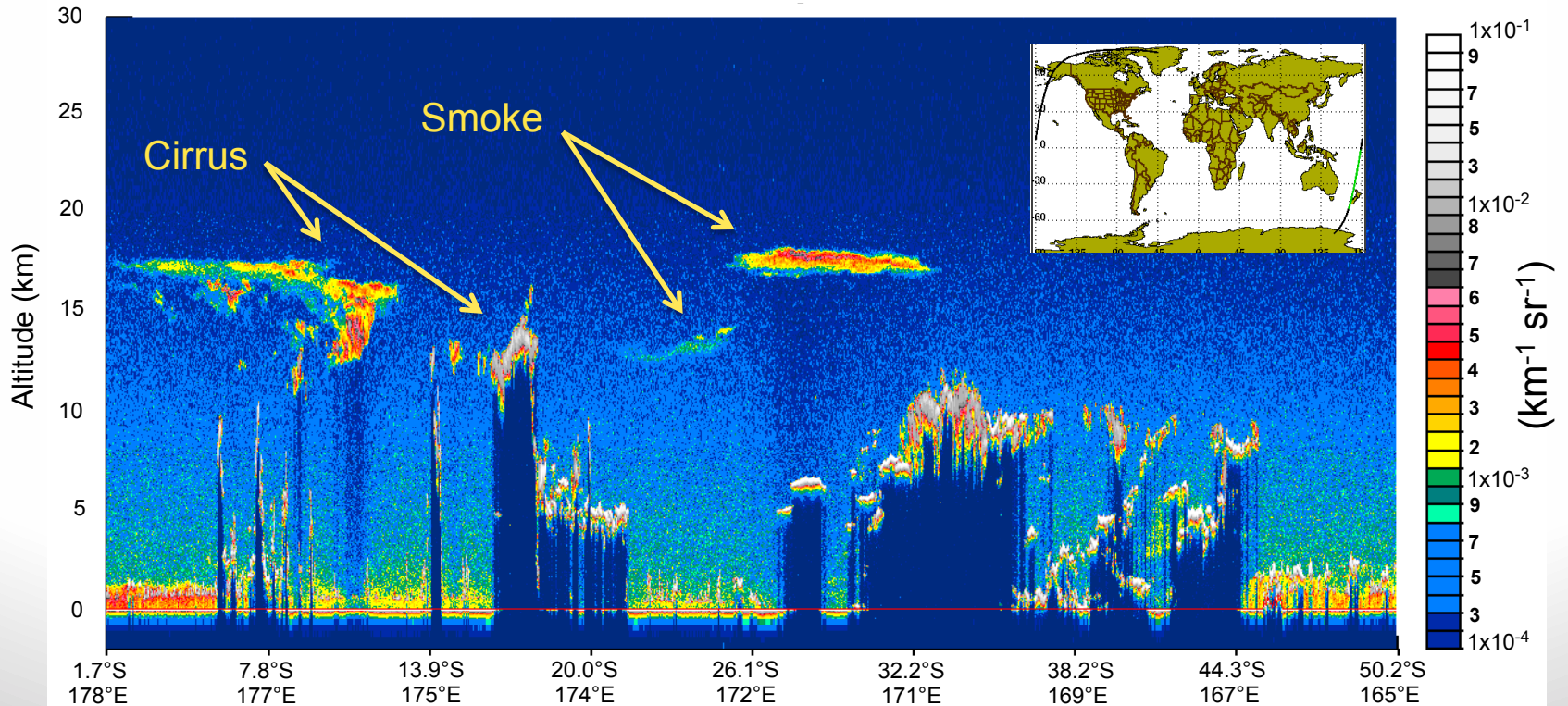
532 nm Total Attenuated Backscatter

9 February 2009 13:55 UTC



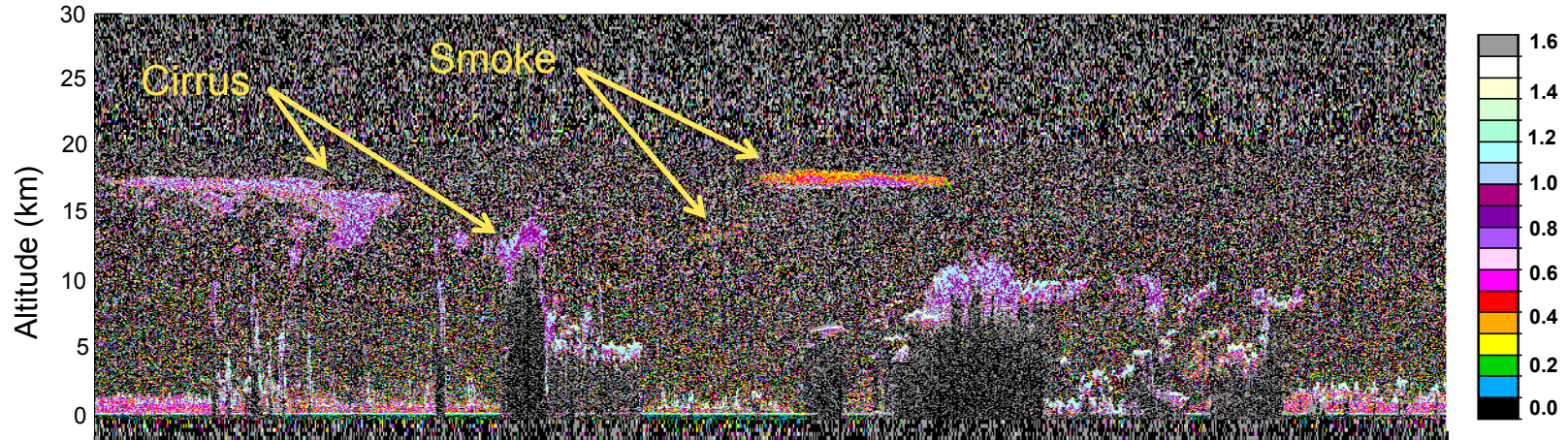
532 nm Total Attenuated Backscatter

9 February 2009 13:55 UTC

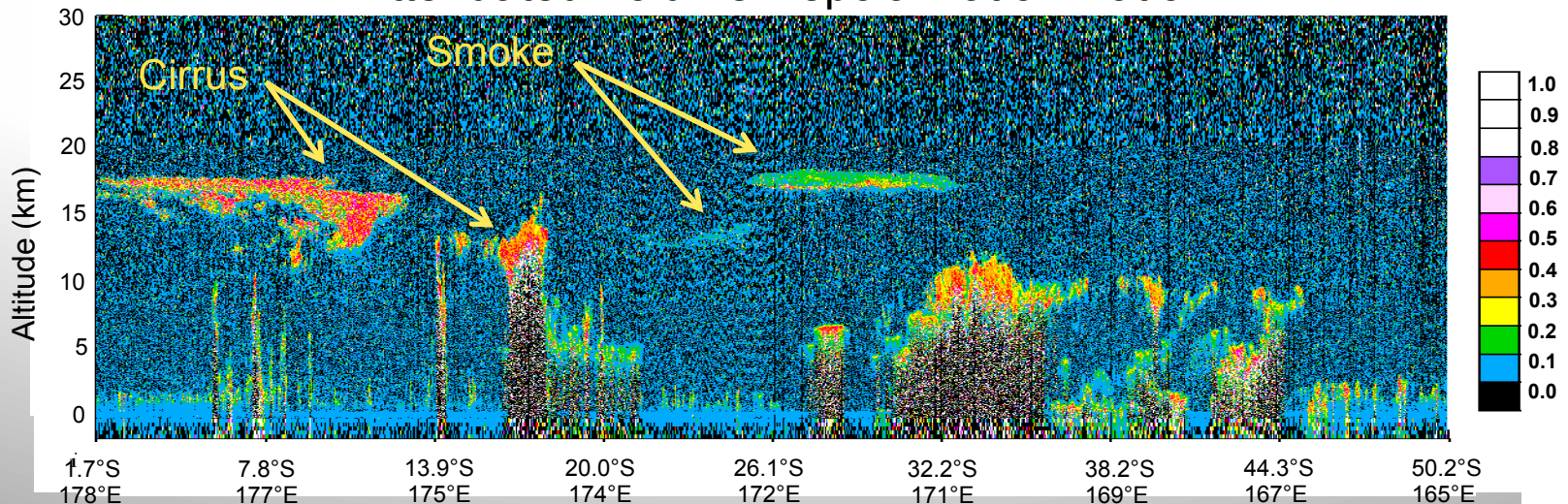


Intensive Aerosol Optical Properties

Attenuated Color Ratio

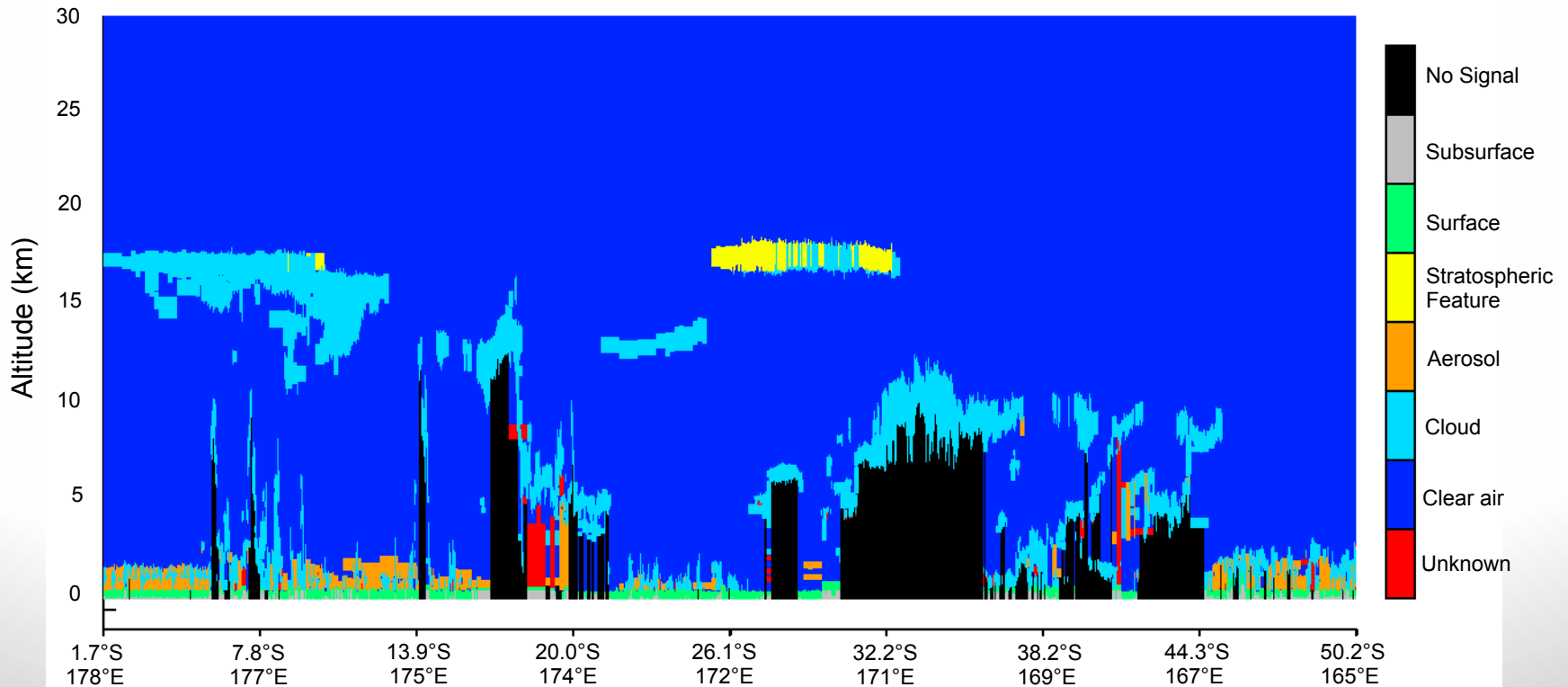


Attenuated Volume Depolarization Ratio



Aerosol/Cloud Feature Mask

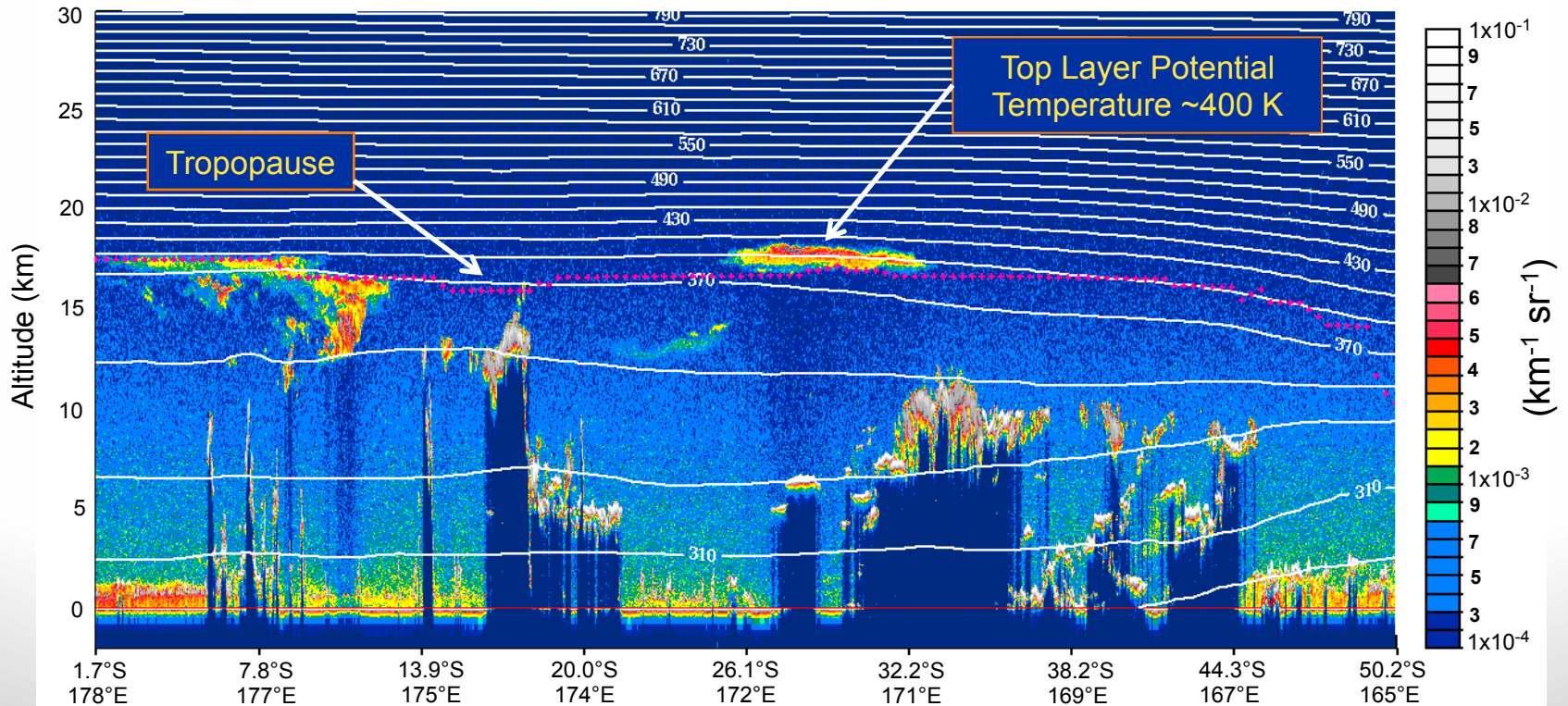
9 February 2009 13:55 UTC



CALIPSO Version 3 algorithm misidentifies the Victorian Smoke Layers as either Cloud or Stratospheric Sulfate Features

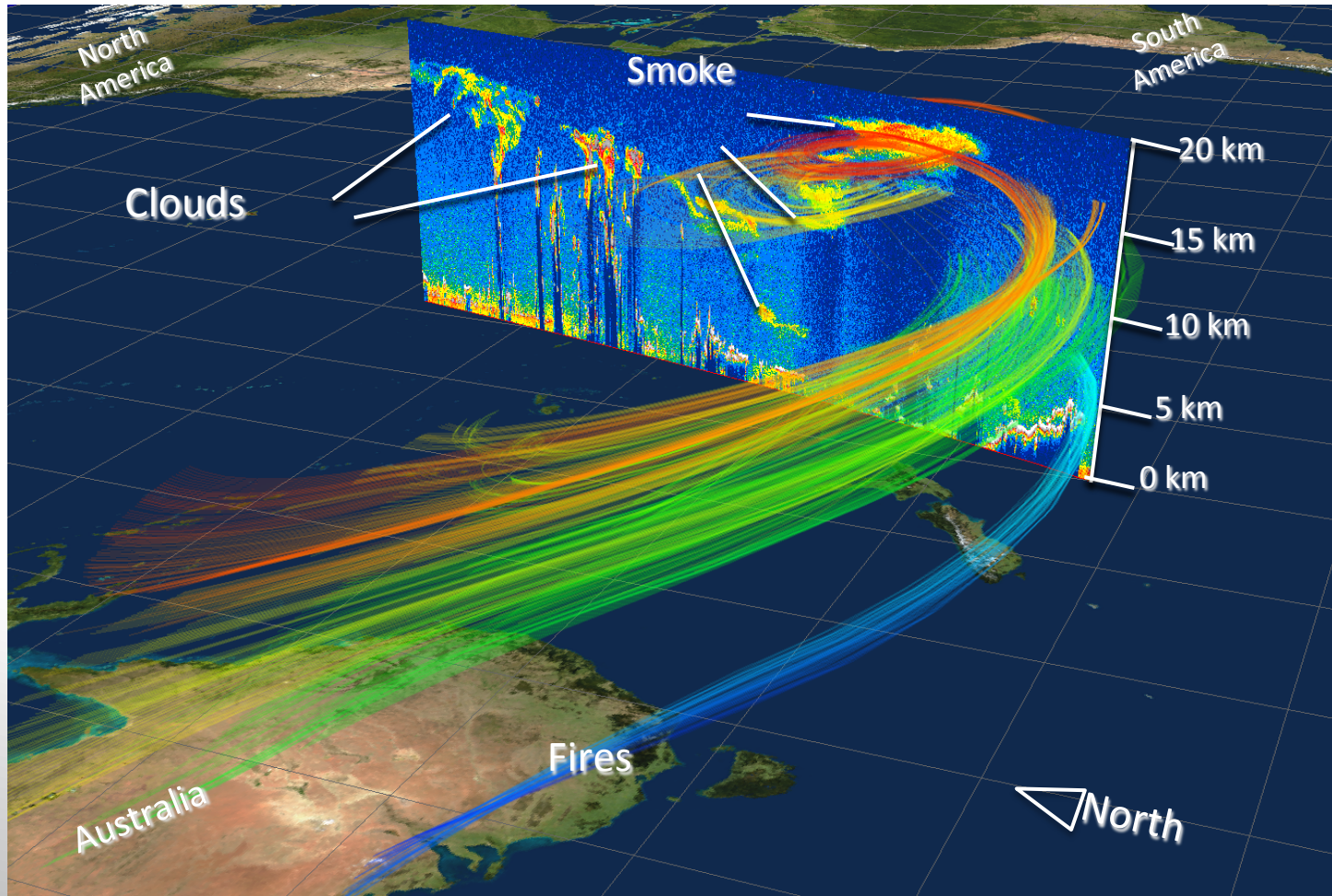
532 nm Total Attenuated Backscatter

9 February 2009 13:55 UTC



Backtrajectory Analysis

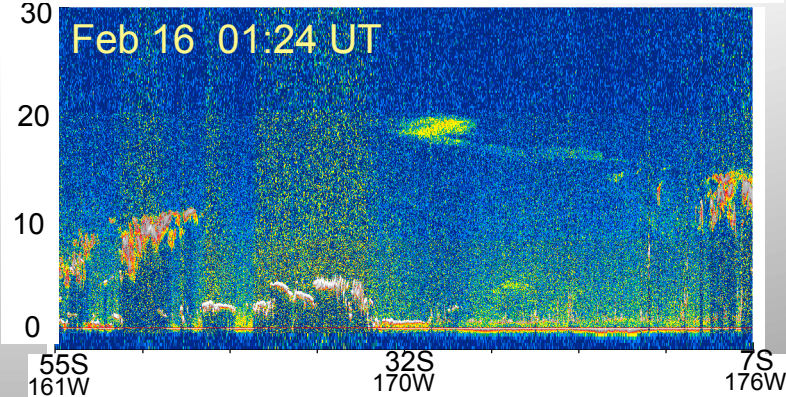
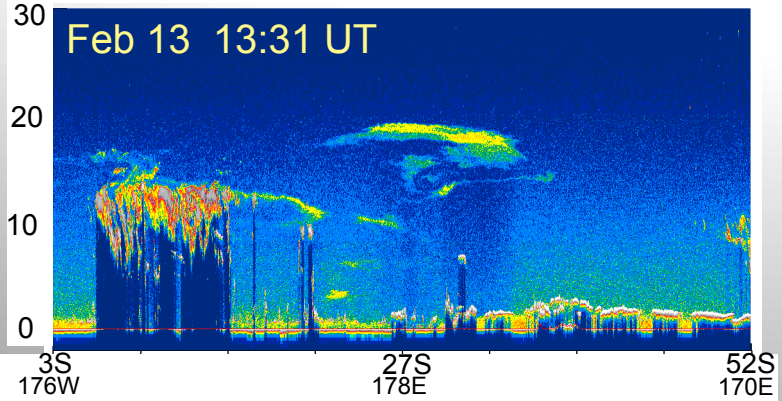
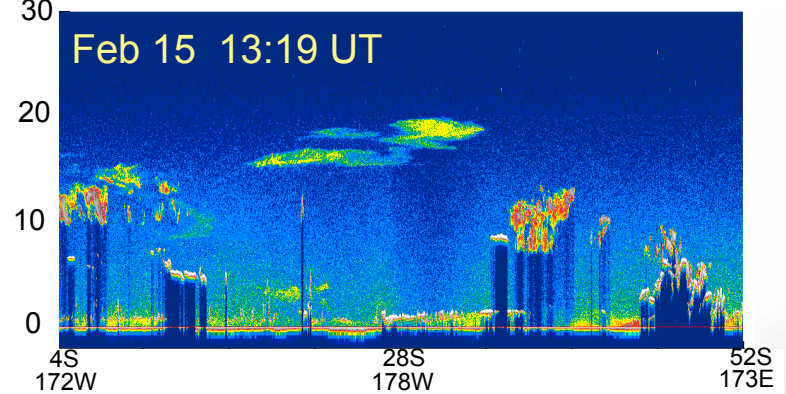
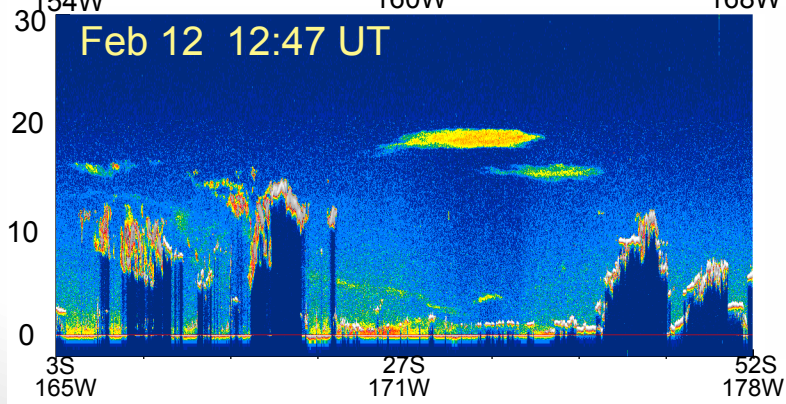
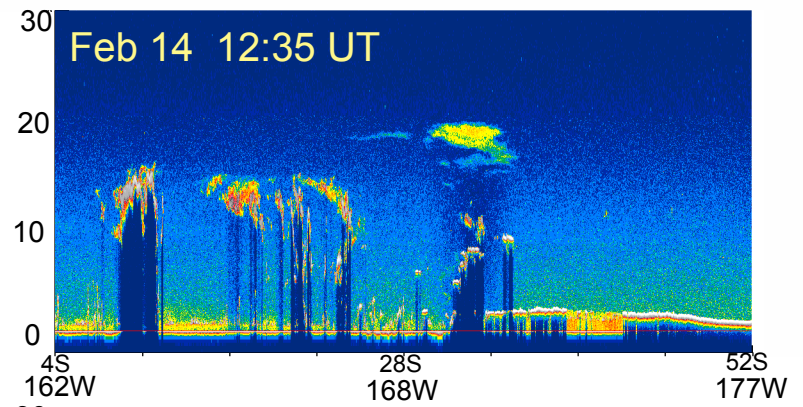
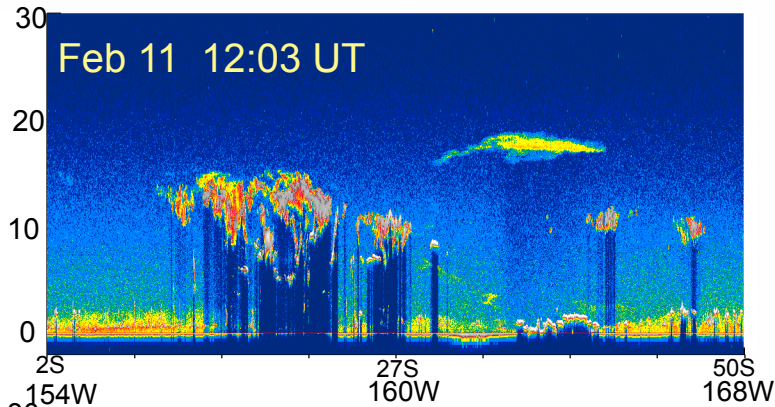
February 10, 2009



Backtrajectories colored by altitude

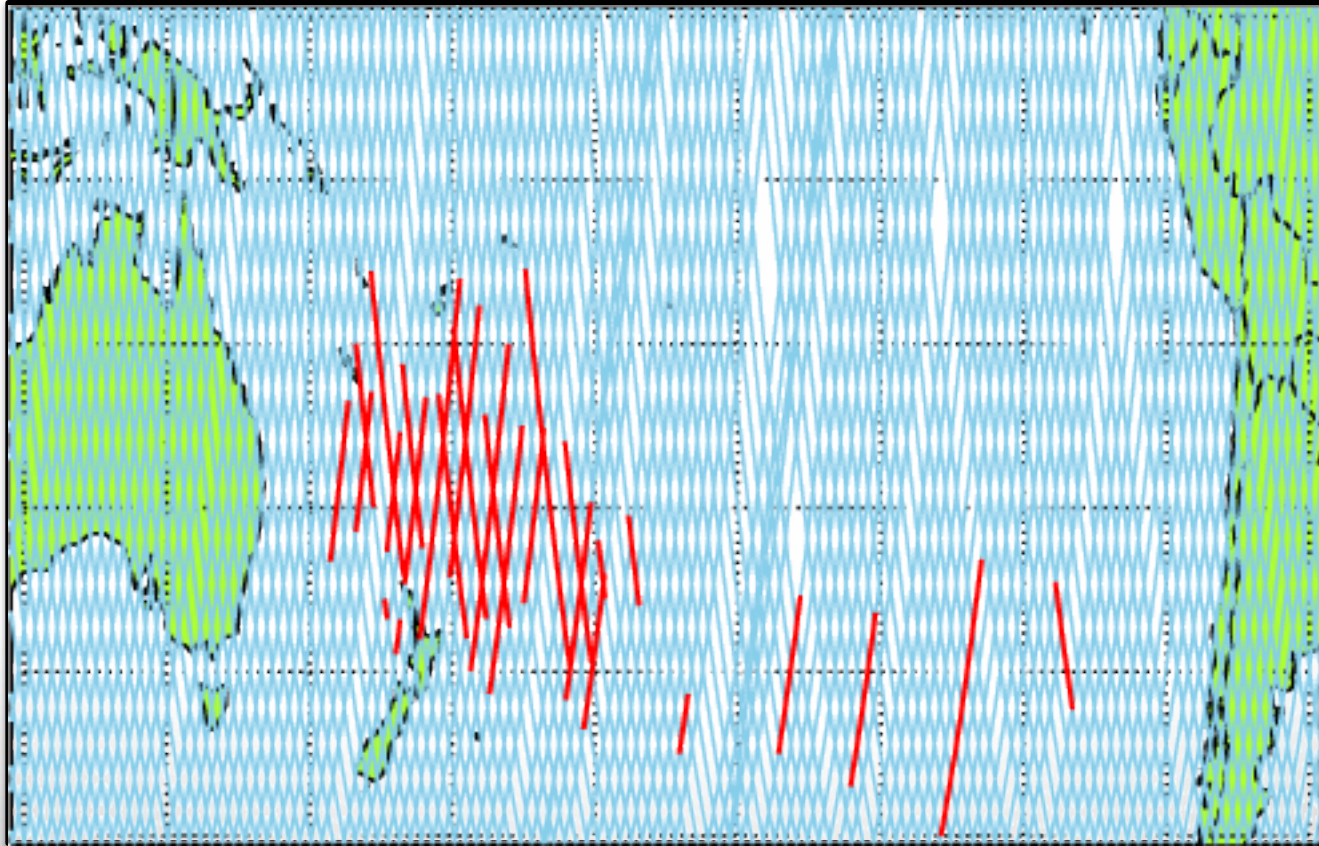
Kittaka and Severance, 2009

Smoke Layer Cross Sections



Location of Elevated Smoke Layers

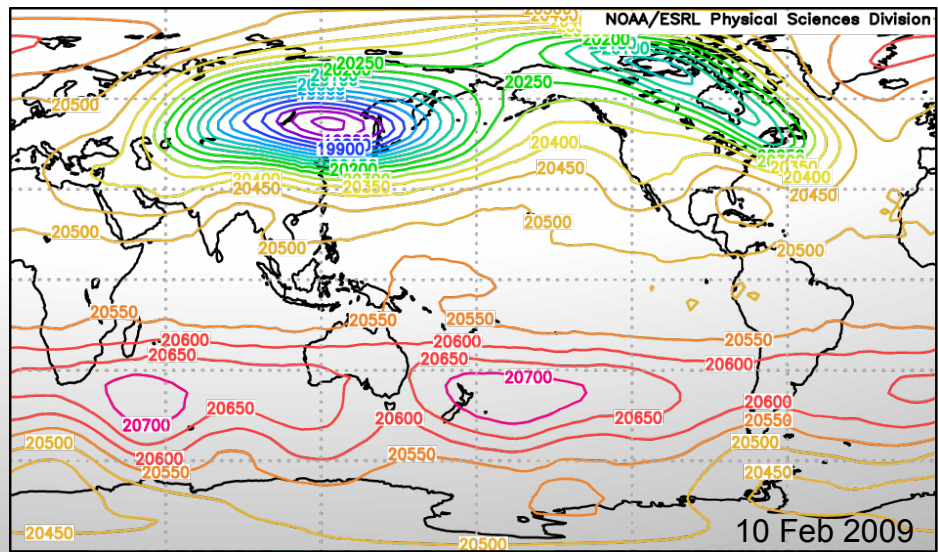
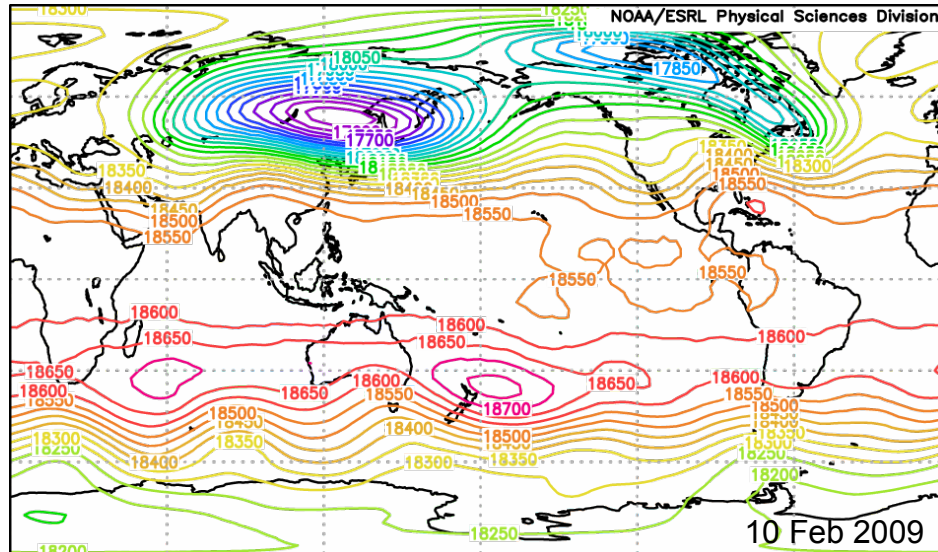
CALIPSO coverage February 1-16, 2009



*Red Segments represent location of smoke
layers > 10 km*

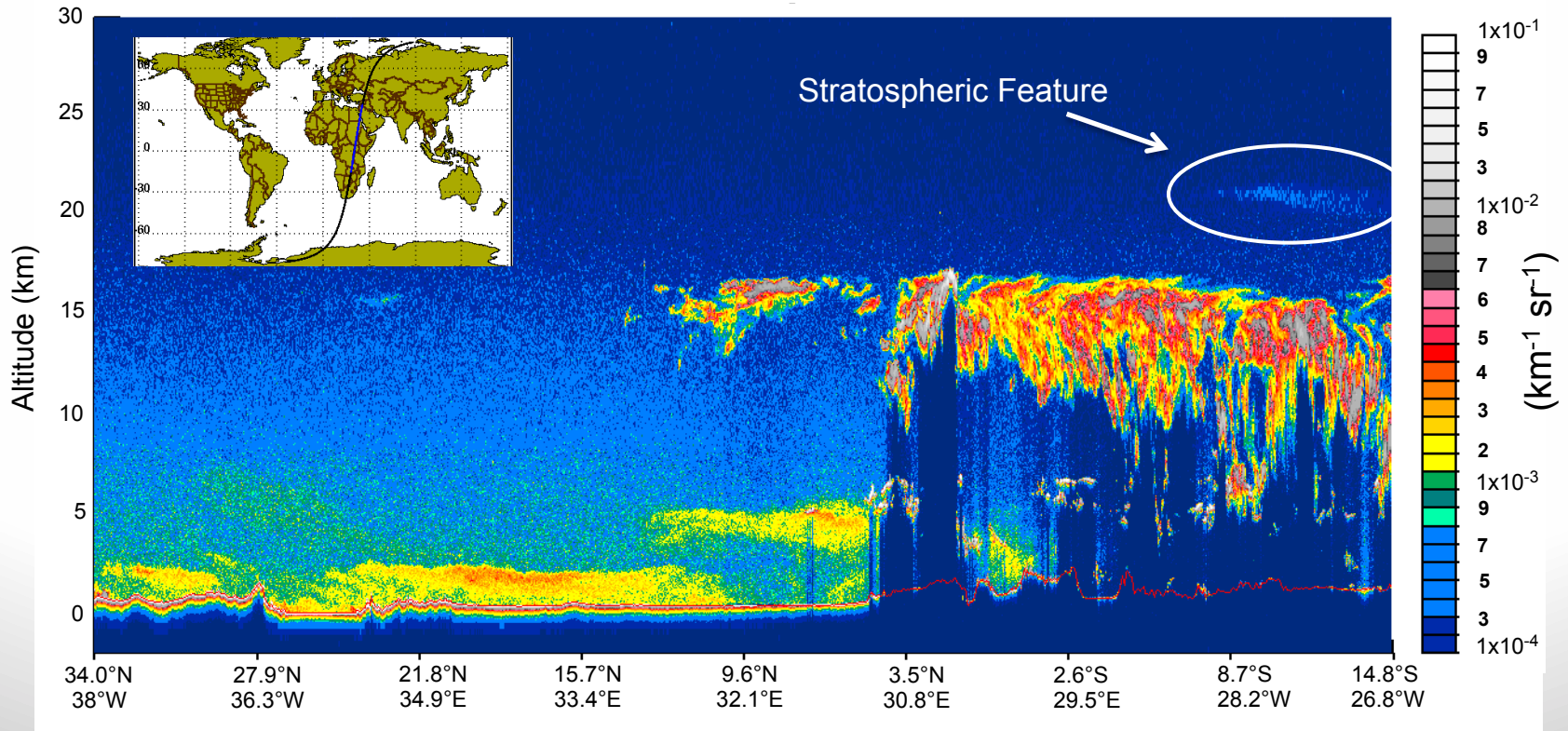
Smoke Trapped in Anticyclone

- Belt of easterlies displaced south of equator (westerly phase of QBO)
- Anticyclone east of Australia persisted for 2 weeks (amplitude decayed with height)
- Smoke within Anticyclone remained concentrated
- Shearing along southern edge permitted more rapid dispersal



532 nm Total Attenuated Backscatter

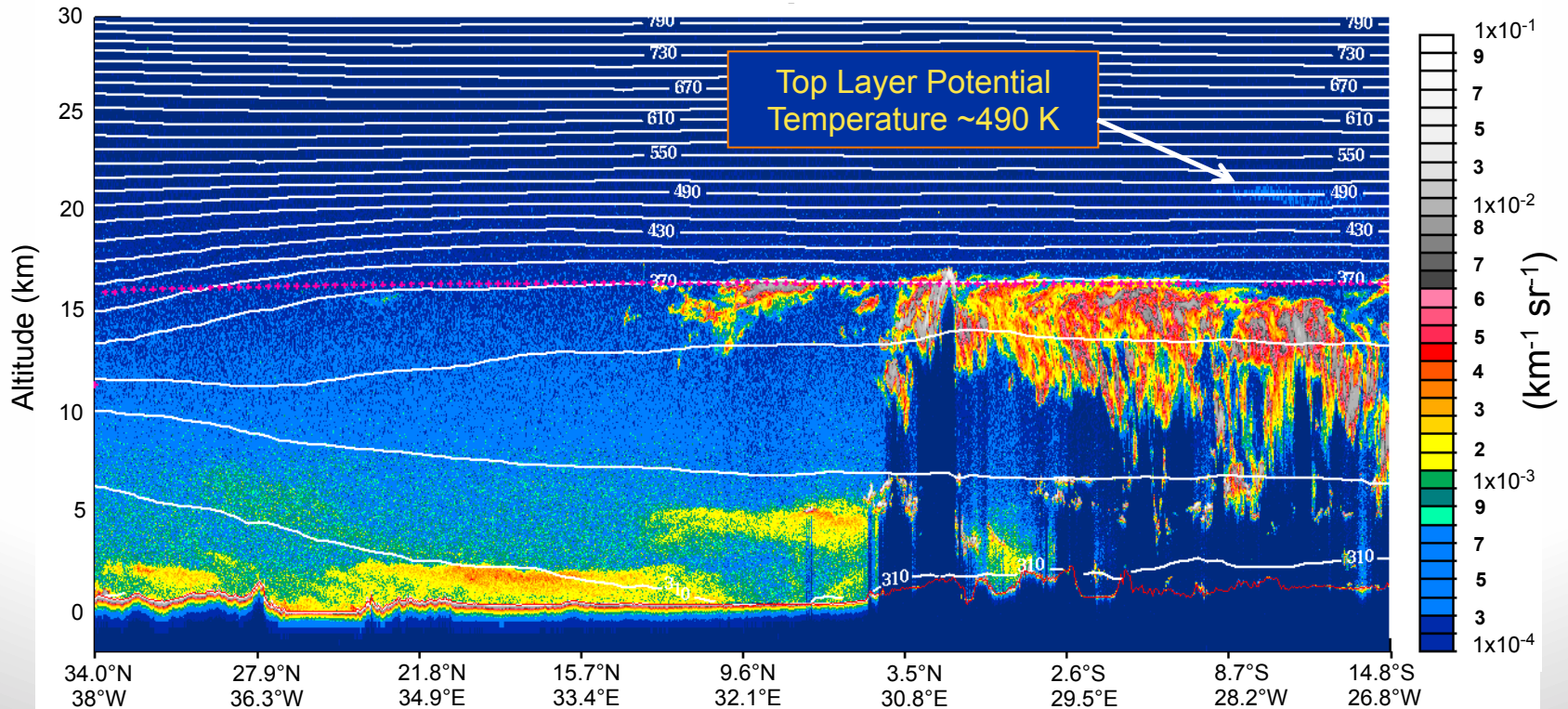
13 March 2009 23:26 UTC



Stratospheric Features are visible in browse images through March 29th.

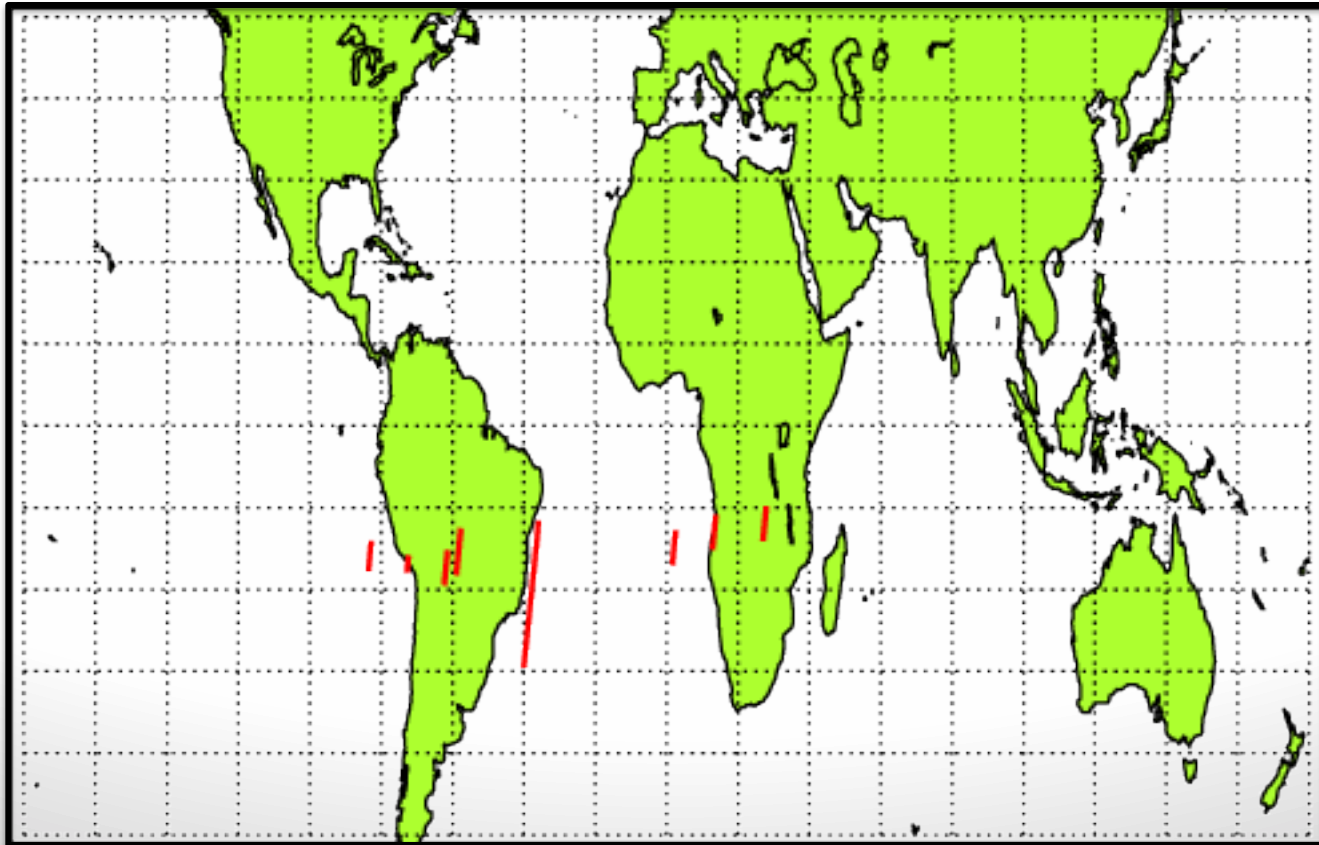
532 nm Total Attenuated Backscatter

13 March 2009 23:26 UTC



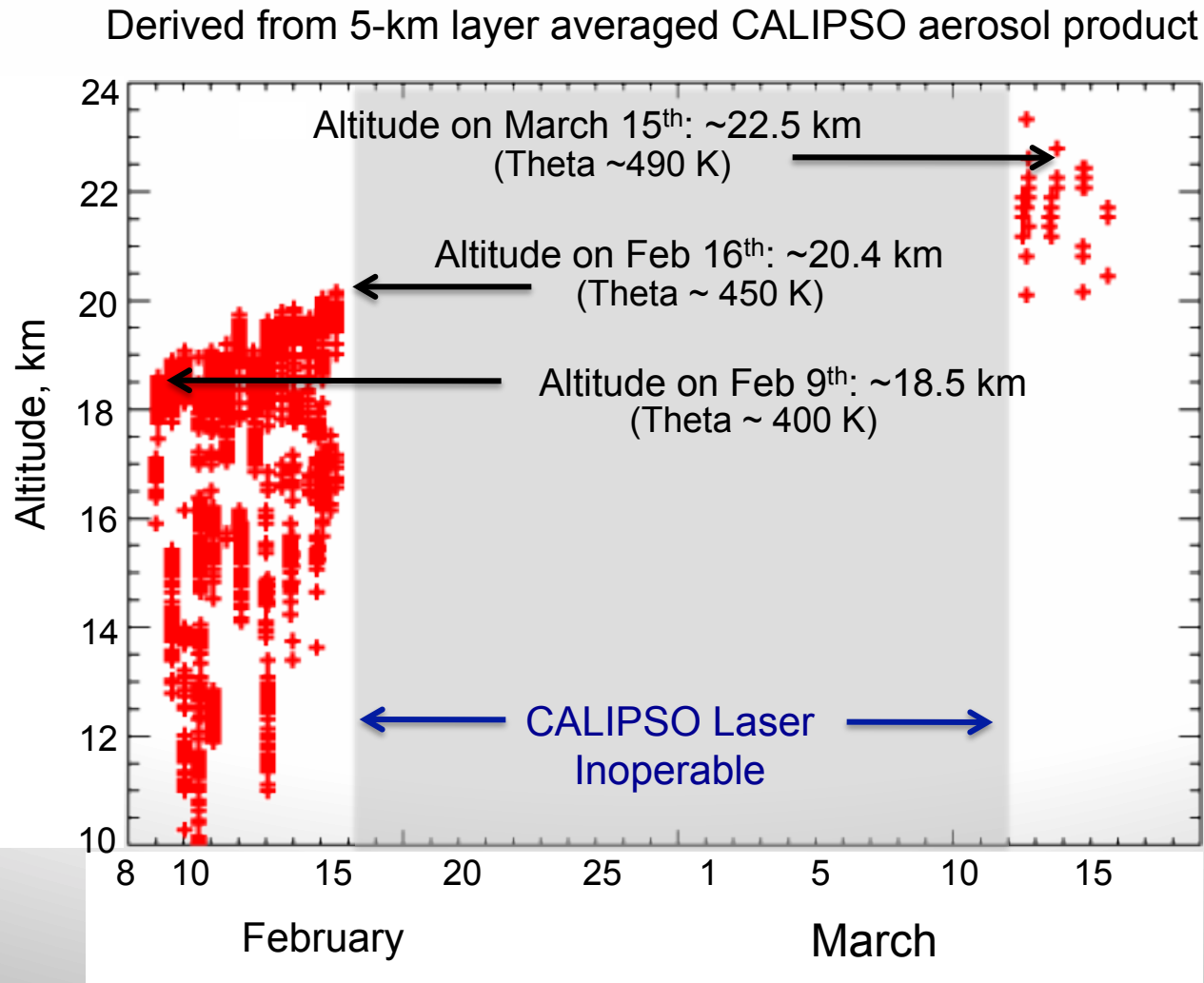
Location of Elevated Smoke Layers

CALIPSO coverage March 12-18, 2009



Smoke Layer ~ 21-22 km

Altitude History of Smoke Layer Tops



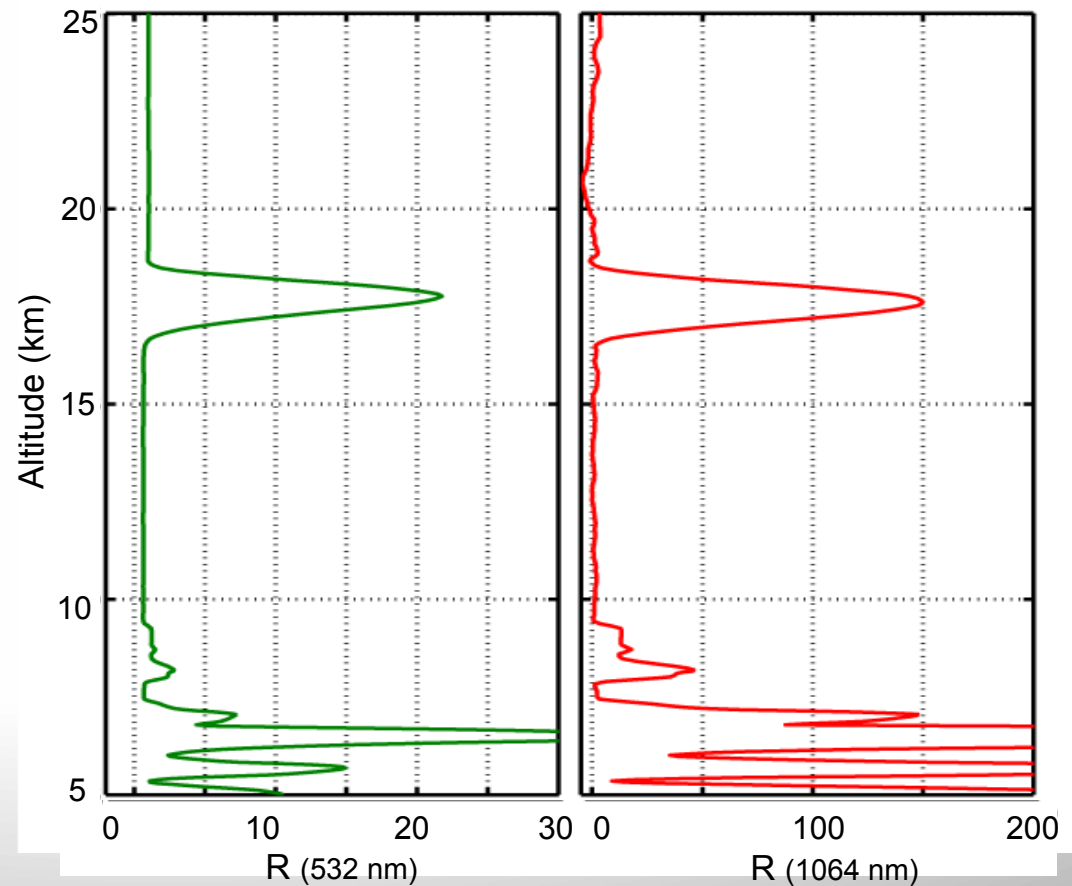
Attenuated Aerosol Scattering Ratio

- Aerosol Scattering Ratio

$$R' = \frac{\beta_a + \beta_m}{\beta_m} T^2$$

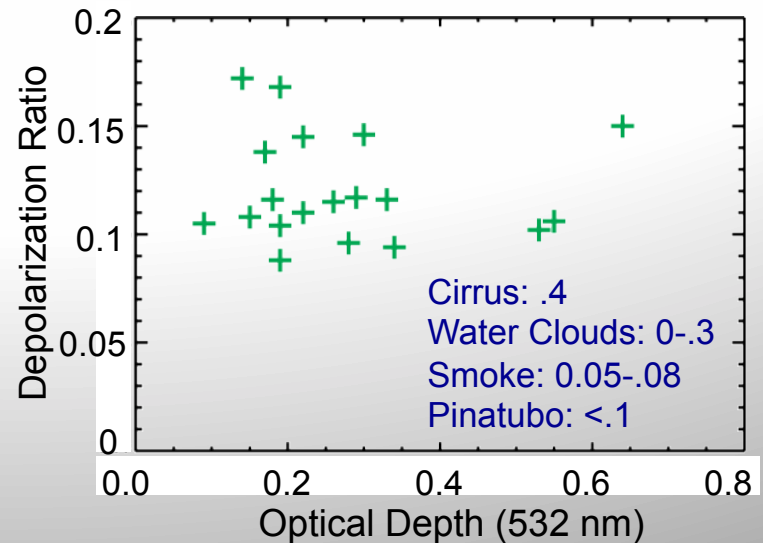
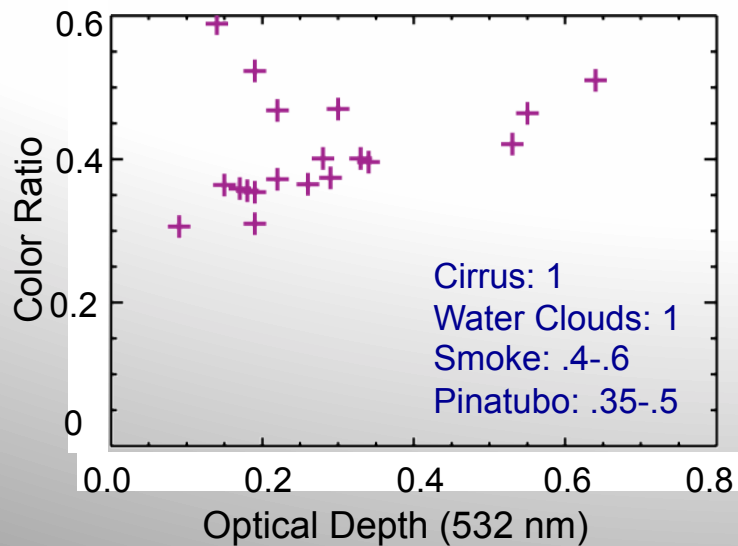
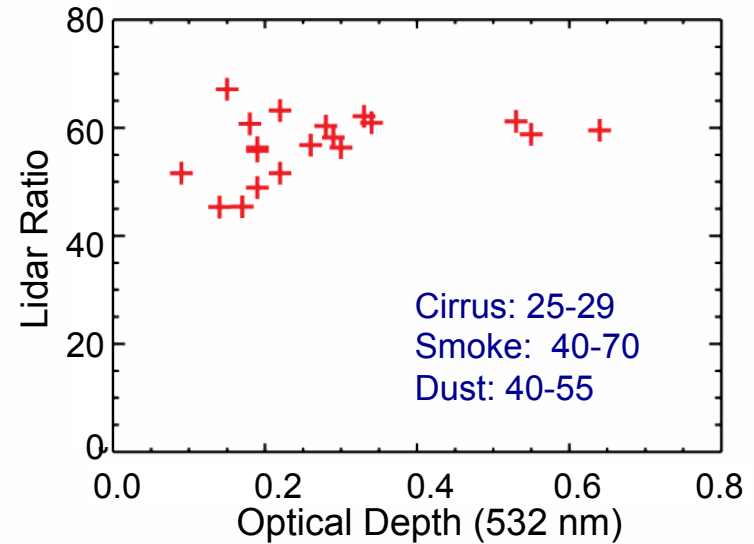
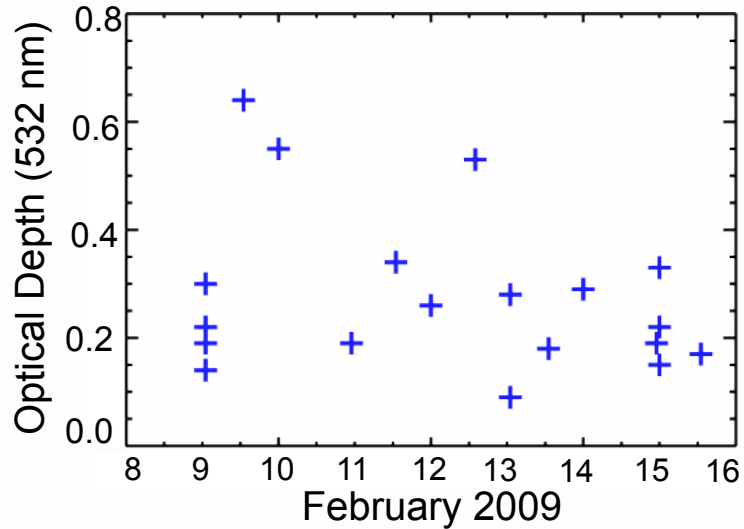
- Typical values near tropopause < 1.05
- Peak values exceed 80 (532 nm) and 200 (1064 nm)
- Very 'clean' below and above layer
- Direct measure of optical depth permitted from ratio of R above and below layer*.

February 9, 2009 13:28 UTC
Averaged from 27°S to 31°S



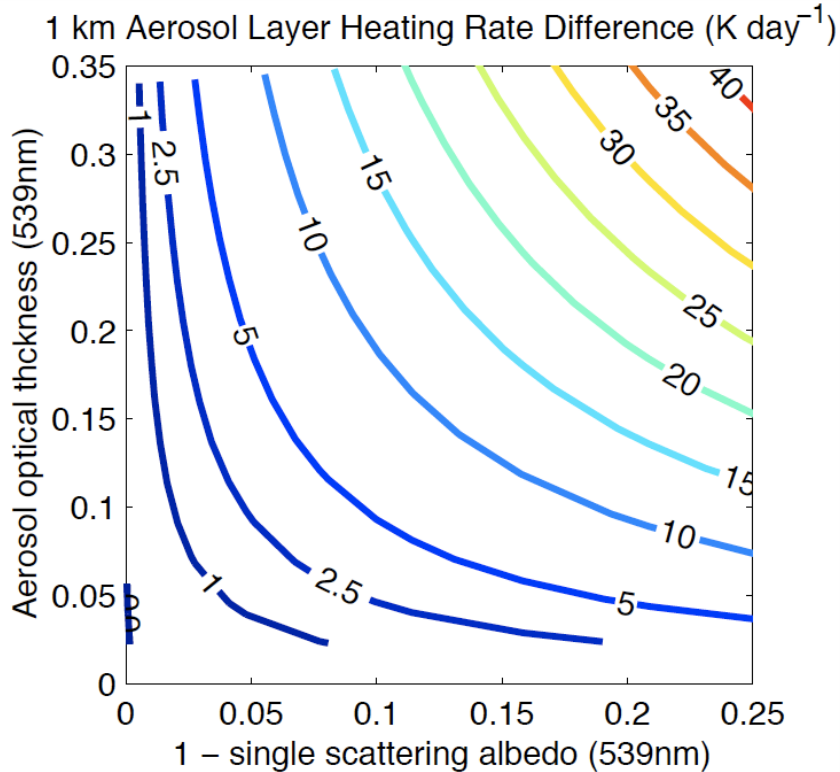
* References: P.A. Davis, Appl. Opt. 2099-2102 (1969)

Optical Properties from 18 Averaged Segments

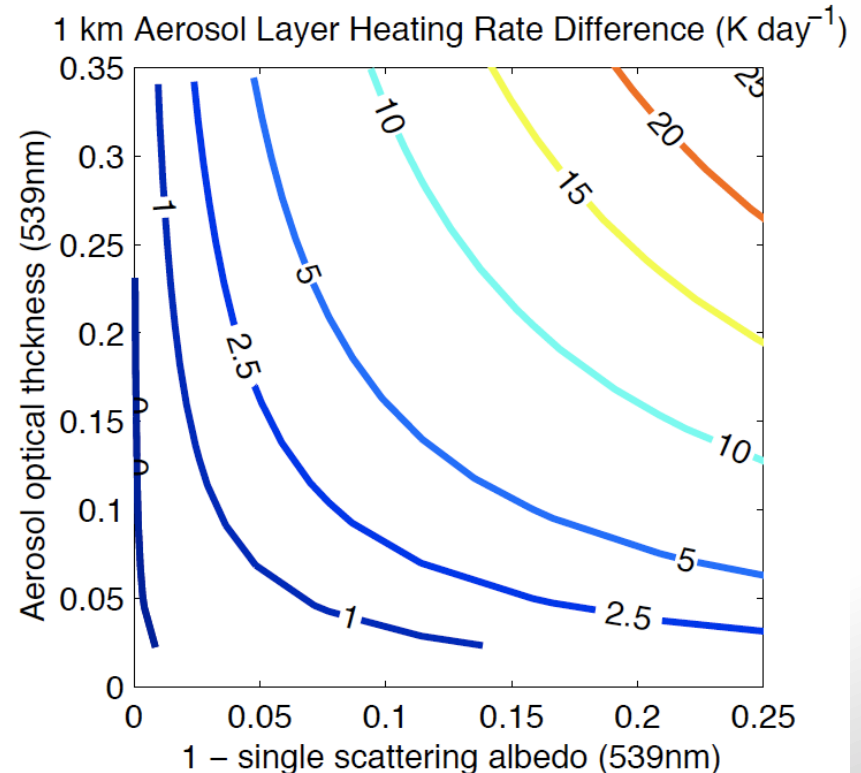


Aerosol Layer Heating Rates

With boundary layer overcast clouds



Clear-sky

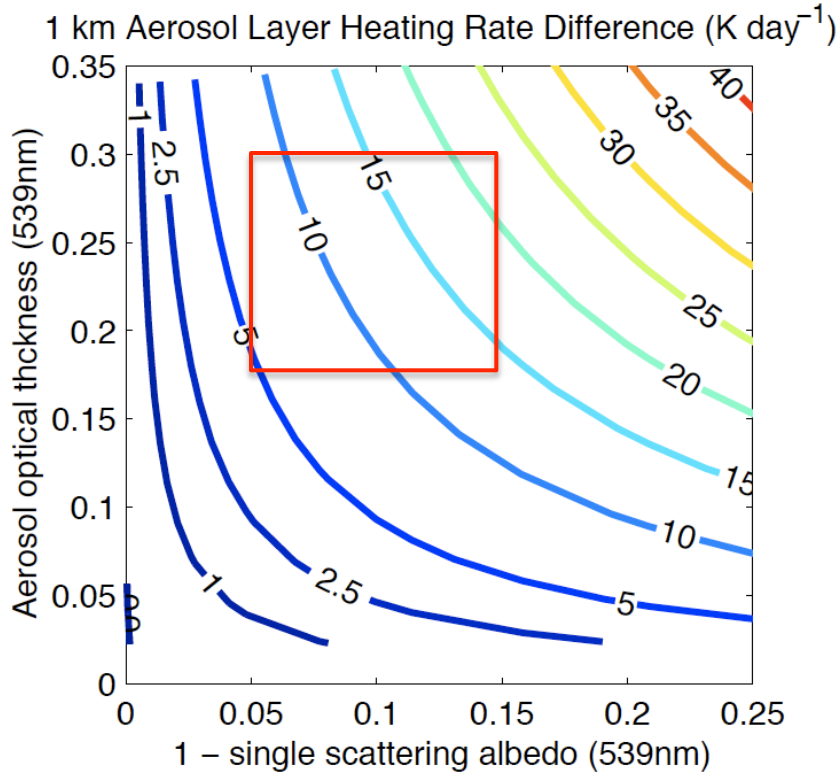


Ascent of layer of ~ 50 K/week (90 K/month) needs heating rate of ~ 7 K/day (3 K/day).

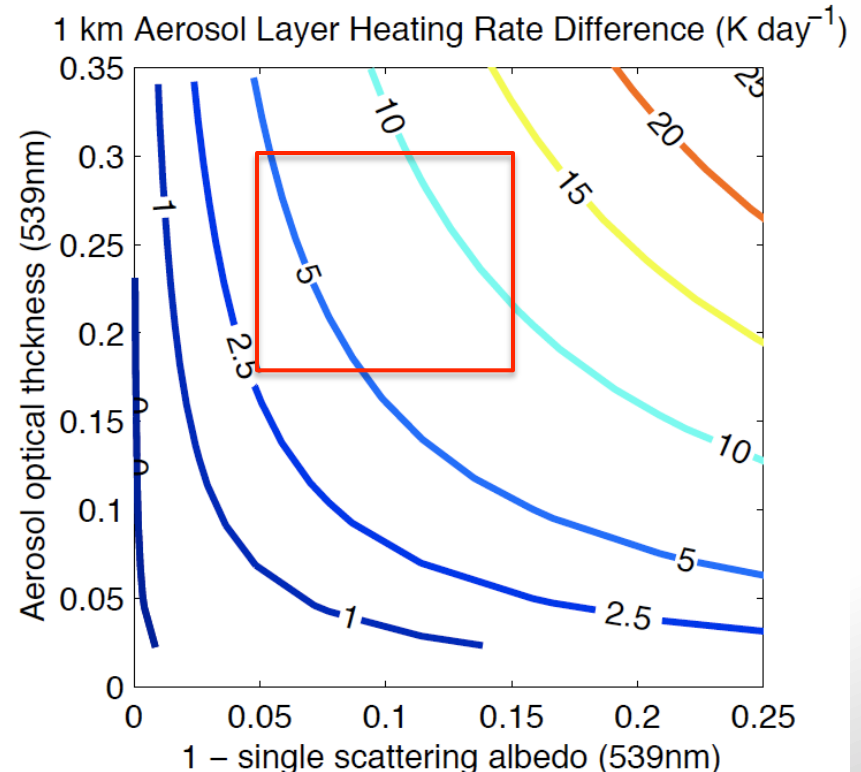
Range of single scattering values for smoke: 0.95 – 0.82 (Leahy, 2007, GRL: 1029/2007GL029697,)
Simulated solar zenith angles are at 30°S on Feb. 12, 2009 for a tropical standard atmosphere.

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Summary

CALIPSO observed elevated layers of smoke from February 9 -16, 2009 and from March 12-29, 2009.

Highest smoke layer ascended ~ 1.5 km during the first week of CALIPSO observations.

Intensive optical properties were consistent over the period.

Measured optical depths ranged $\sim 0.15 - 0.6$.

- Inferred heating rates are consistent with the observed ascent rate.