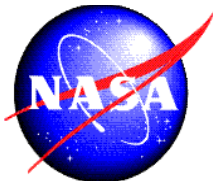


CALIPSO
Data Products: progress and status

Dave Winker, Jason Tackett

NASA Langley Research Center

With help from:

Mark Vaughan, Stuart Young, Jay Kar, Ali Omar, Zhaoyan Liu, Brian Getzewich, Kam-Pui Lee, Bill Hunt, Chip Trepte, Travis Toth, Pat Lucker, Sharon Rodier, Jim Lambeth, Brian Magill, Rob Ryan, Josh Phillips, Shan Zeng, Xia Cai, Tim Murray, Ken Beaumont, Paula Detweiler

Outline

- V4 Level 1
  - Released in 2015
  - Minor update underway
- Level 1.5
- V3 Level 3
  - New sky conditions
  - Additional aerosol types
- V4 Level 2
  - Many improvements

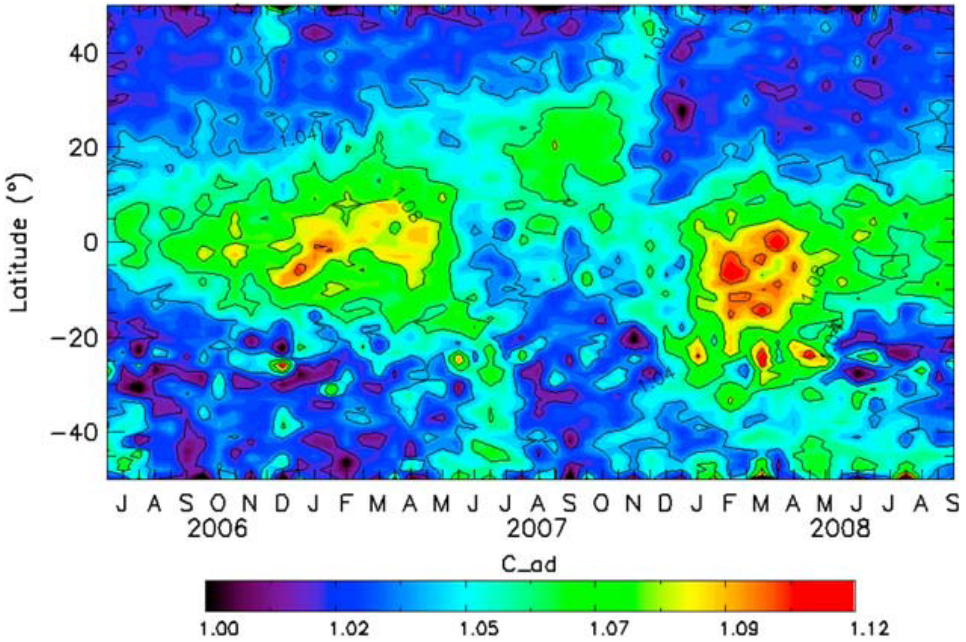
Version 4 Level 1

- **Level 1 V4.0 development completed in April 2014**
  - Improved stability: removed day-night, seasonal, and volcanic biases
  - Removed biases in 1064/532 color ratio; aids L2 classification algorithms
  - V4 Level 1 processed from the beginning of the mission
  - Both V3.30 and V4 Level 1 produced until V4 Level 2 is available
- **Version 3 biases are corrected in Version 4:**
  - 532 calibration biases from stratospheric background aerosol
  - Intra-orbit 1064 nm calibration biases
  - Flagged 'negative signal' anomalies at surface
- **Minor update now underway (V4.1)**
  - Replace Version 3 DEM with new CloudSat DEM
  - Update meteorology products from GMAO to MERRA-2
  - Snow/Ice data not included in V4.0 surface types
  - Several minor bug fixes

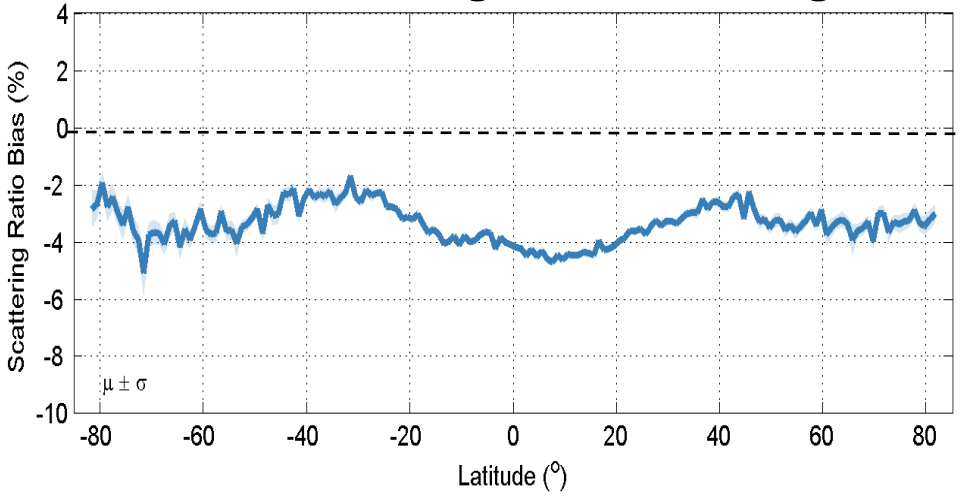
V4 L1: 532 nm Night Calibration

- Normalization altitude moved from 30-34 km (V3) to 36-39 km (V4) to avoid aerosol biases
- Lower SNR at 36-39 km requires averaging over multiple orbits
  - Product latency increases from 'days' to 'weeks'
  - Implications for expedited products

Scattering Ratio at 30 – 34 km



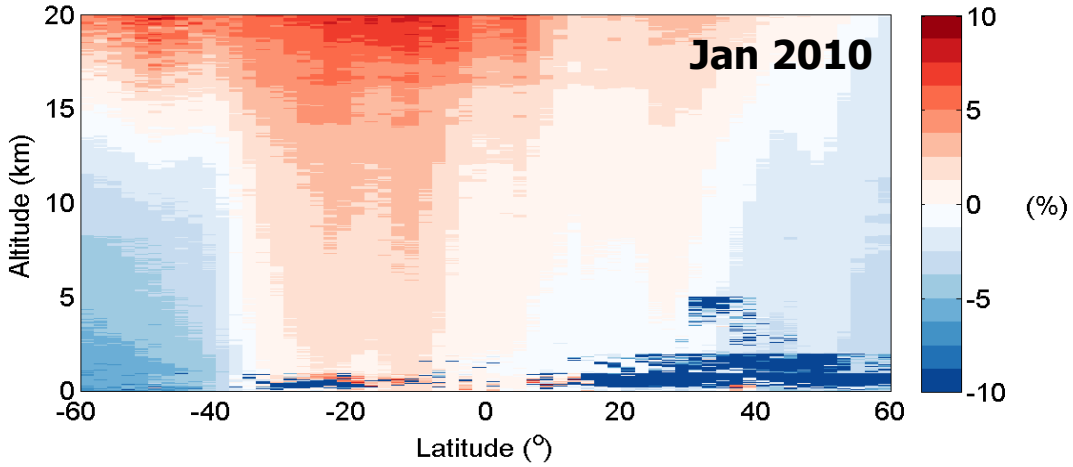
V3 scattering ratio bias, night



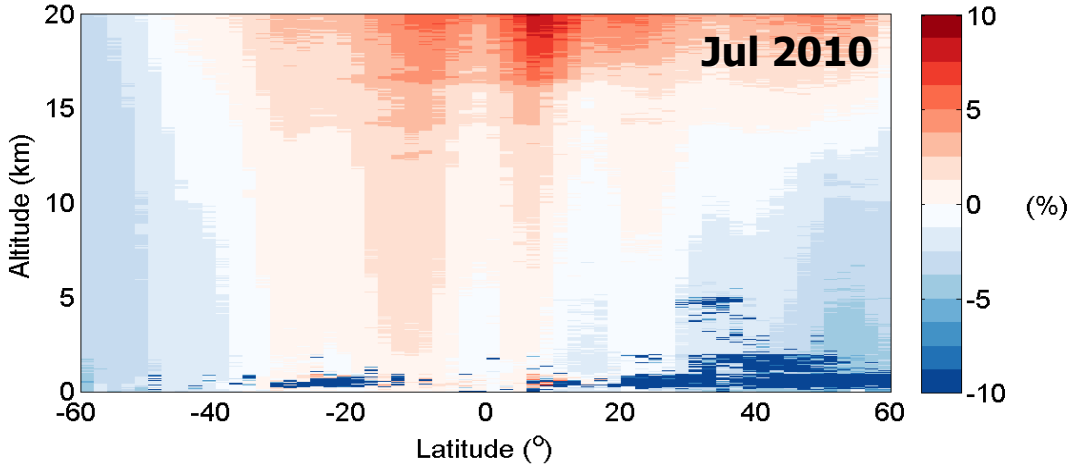
Vernier et al., 2009

V4 L1: 532 nm Day Calibration

V3 clear-air R'_{day} bias (compared to V4)



V3 clear-air R'_{day} bias (compared to V4)



slope corrections

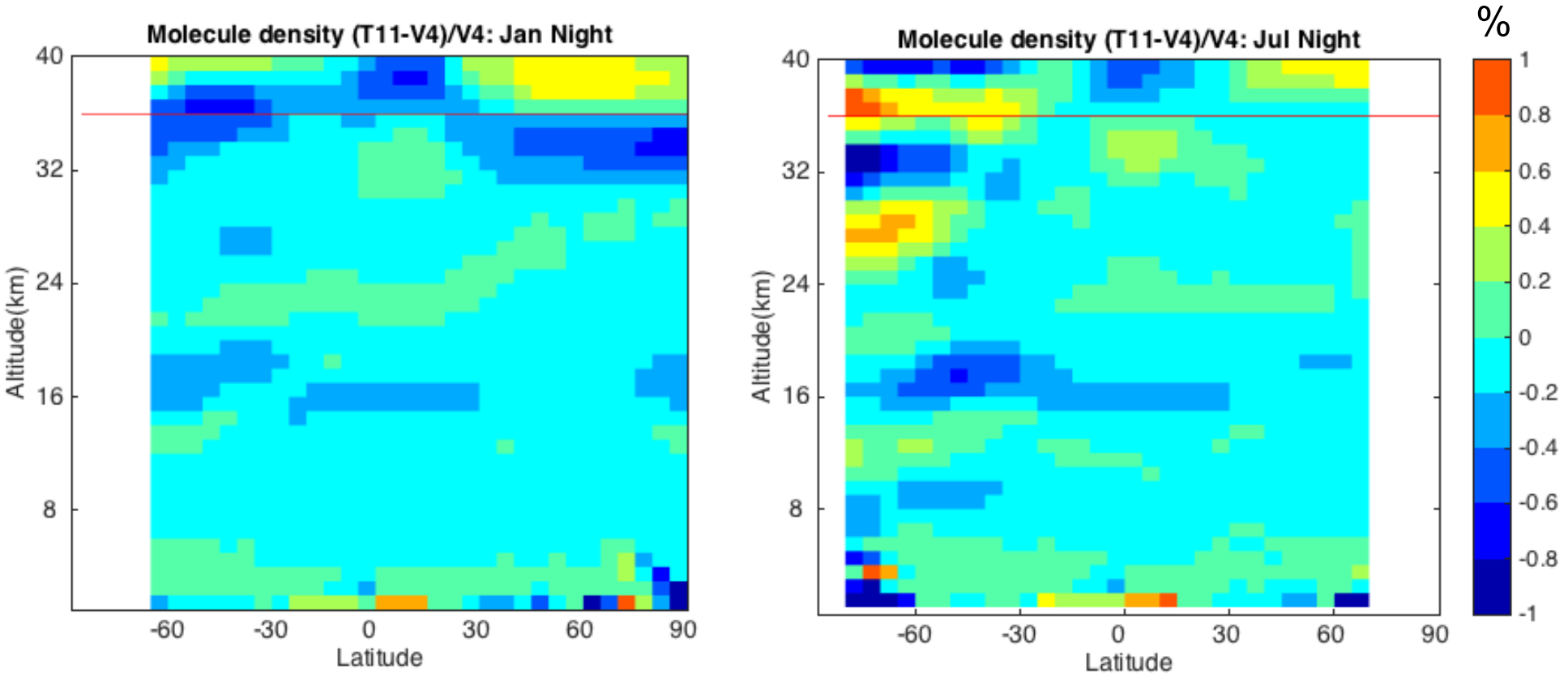
Small altitude-dependent bias in V3 daytime scattering ratio (R') corrected for first time in V4.

Below 2 km at mid-latitudes, the absolute bias is about 2%.

Level 1 V4.1 Update (1)

- Replacing GMAO FP-IT with MERRA-2

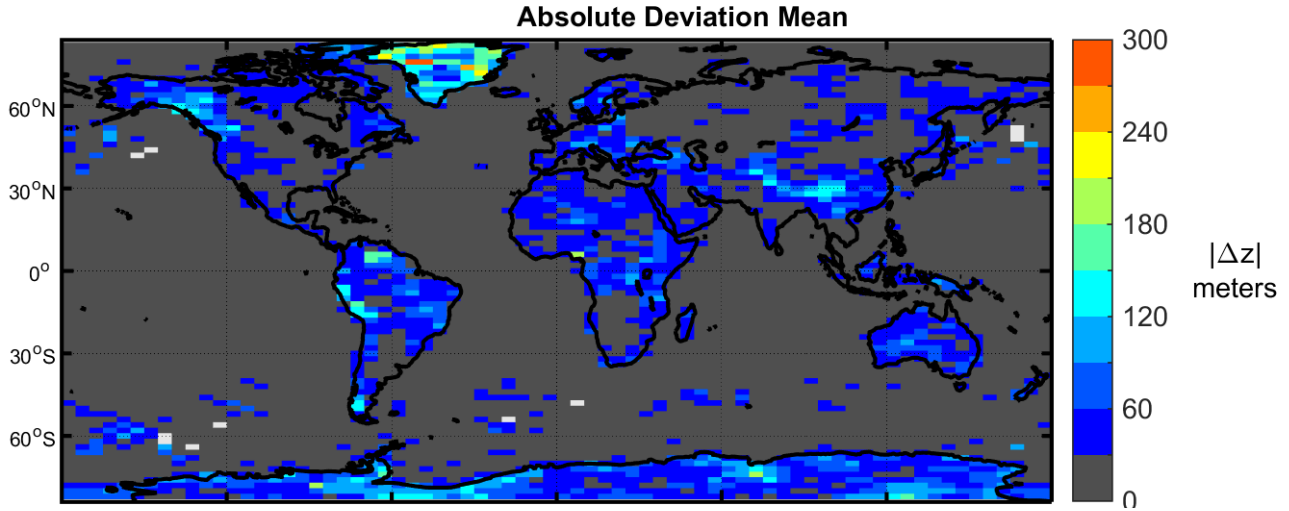
Molecular density: MERRA-2 minus FP-IT, Jan & July 2008



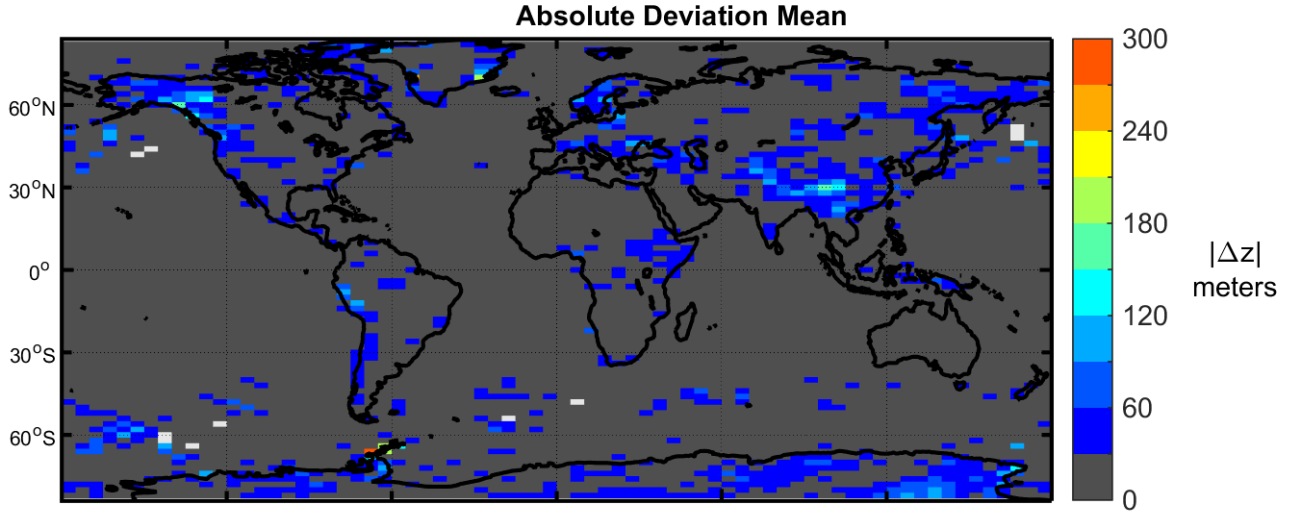
Level 1 V4.1 Update (2)

- Replacing GTOPO30 DEM (c. 1996) with new DEM used in CloudSat R05

CALIOP lidar sfc elevation vs. GTOPO30



CALIOP lidar sfc elevation vs. CloudSat DEM



Level 1.5

- Production of NRT Level 1.5 continues (based on V3 Expedited products)

- New: Level 1.5 ‘re-analysis’ product (L1.5RA)
  - Based on V4 Level 1 and V3 VFM (cloud mask)
  - Atmospheric state from MERRA-2
  - Have recently processed entire mission
  - Will be the ‘target’ for a CALIPSO aerosol simulator (CFMIP COSP)

- Will update L1.5RA using V4 VFM after V4 Level 2 release

Revised Level 3 Aerosol Product

- New Level 3 aerosol product released fall 2015
- New aerosol types added
- Sky conditions changed (improved)
- Several significant algorithm bugs corrected

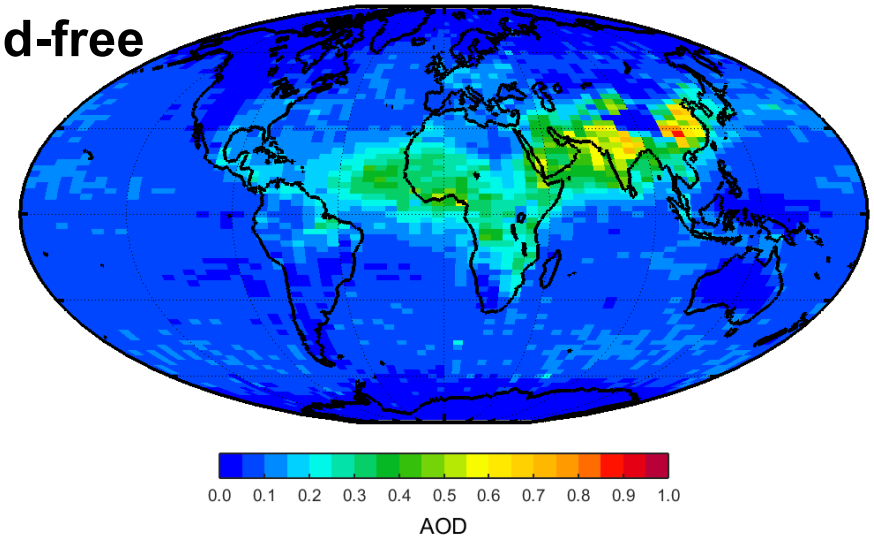
Changes	Beta Version	"Version 3"
Revised sky conditions	All-sky Cloud-free Above-cloud Combine (cloud-free + above-cloud)	All-Sky Cloud-Free Cloudy-Sky, Transparent Cloudy-Sky, Opaque
Add profiles of individual species	All species Dust	All species Dust Polluted Dust Smoke
Correct the way single-species averages are calculated	Ignored	Assign extinction = 0.0 /km
Correct computation of column AOD	Average of column AODs	Integral of average extinction
Extinction scale height (63%, 90%)	n/a	Included

Annual mean AOD (new L3 product)

Annual 2008 Mean AOD

Day, Cloud Free

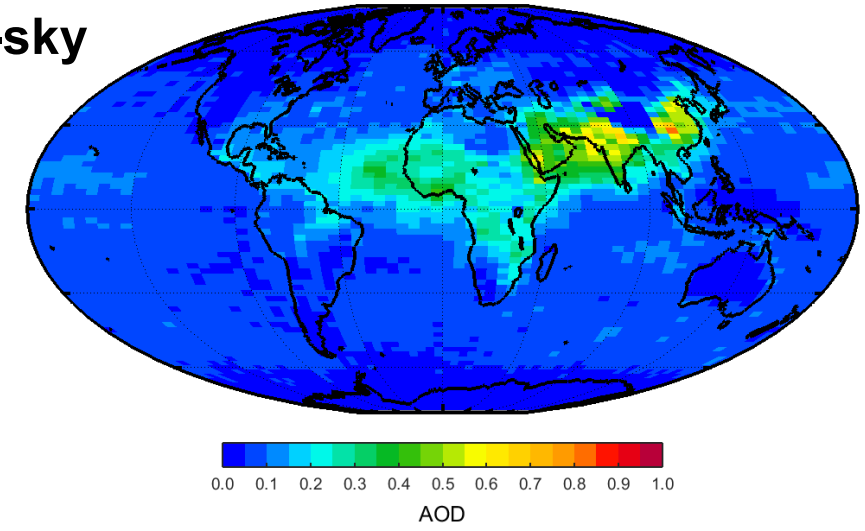
Cloud-free



Annual 2008 Mean AOD

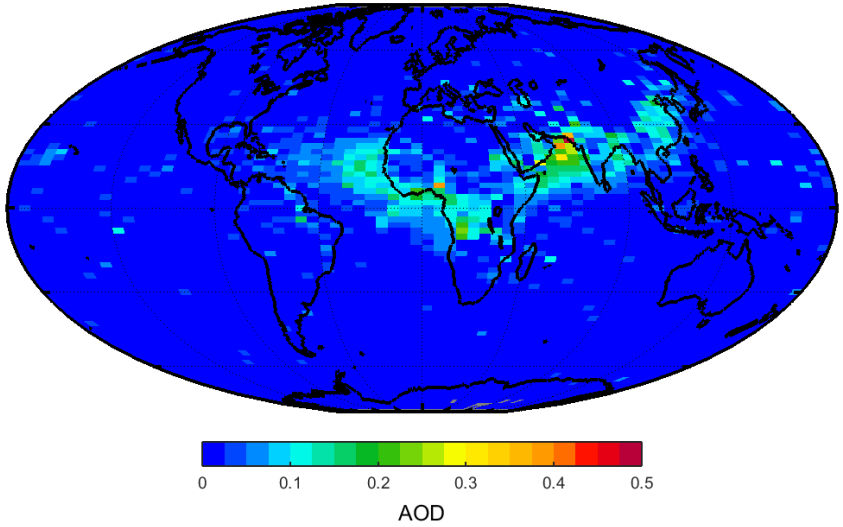
Day, All Sky

All-sky



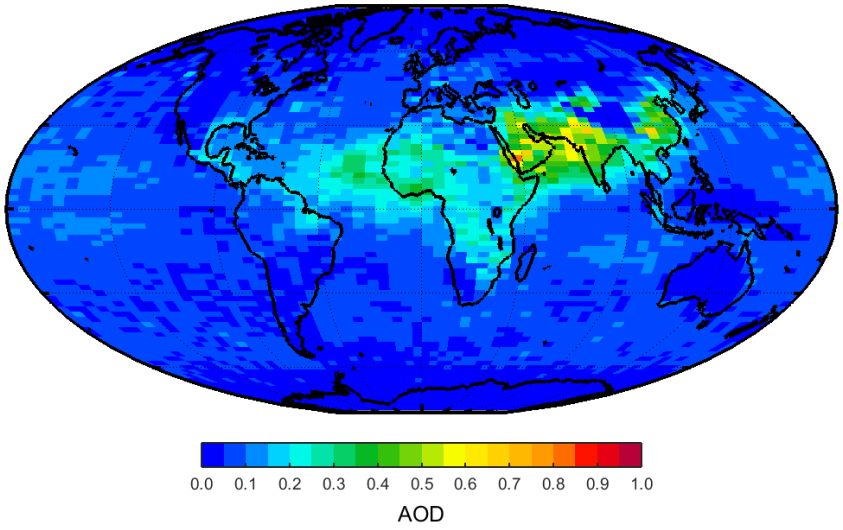
Cloudy-opaque

Day, Opaque Cloudy Sky



Cloudy-semitransparent

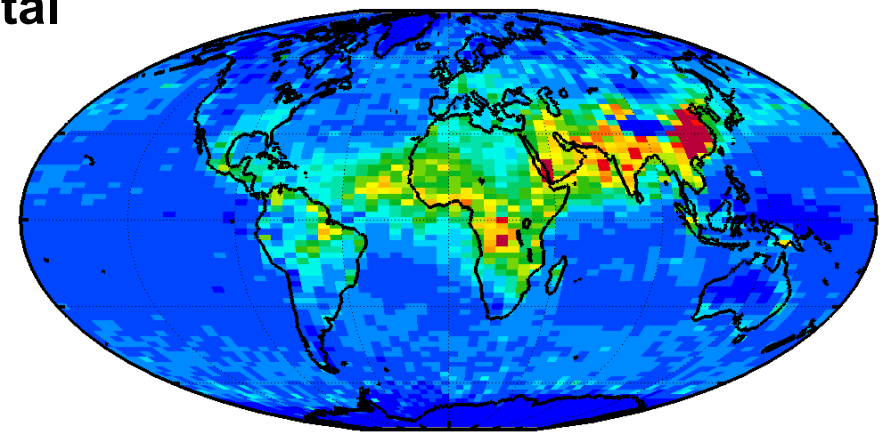
Day, Transparent Cloudy Sky



Aerosol Species (annual mean, cloud-free)

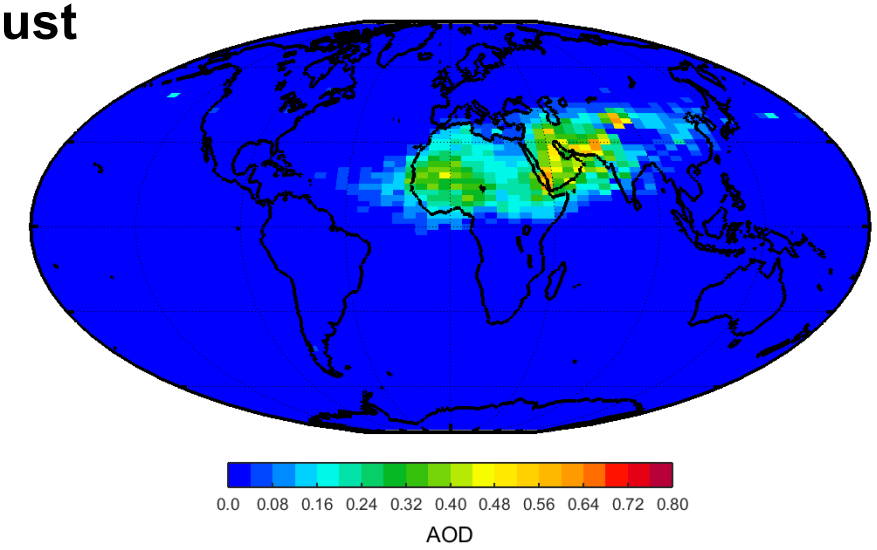
Annual 2008 Mean AOD — Night, Cloud Free

Total



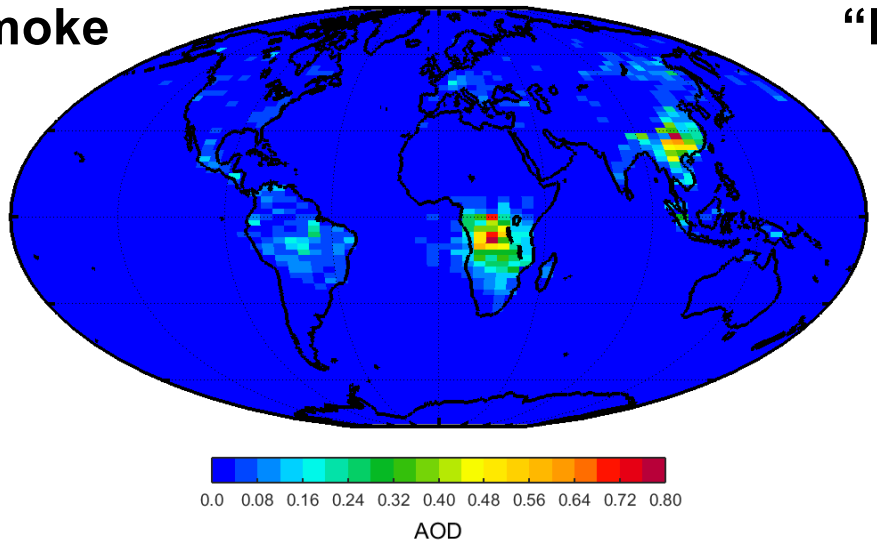
Annual 2008 Mean Dust AOD — Night, Cloud Free

Dust



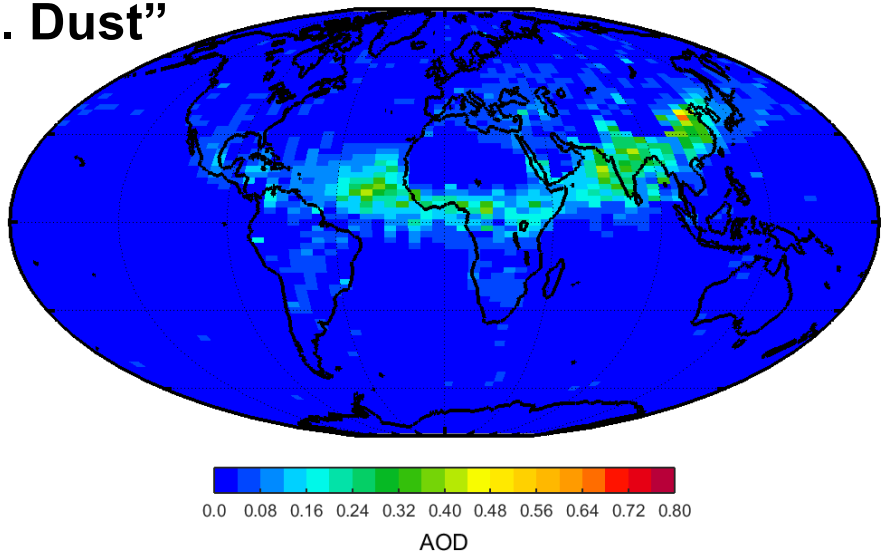
Annual 2008 Mean Smoke AOD — Night, Cloud Free

Smoke



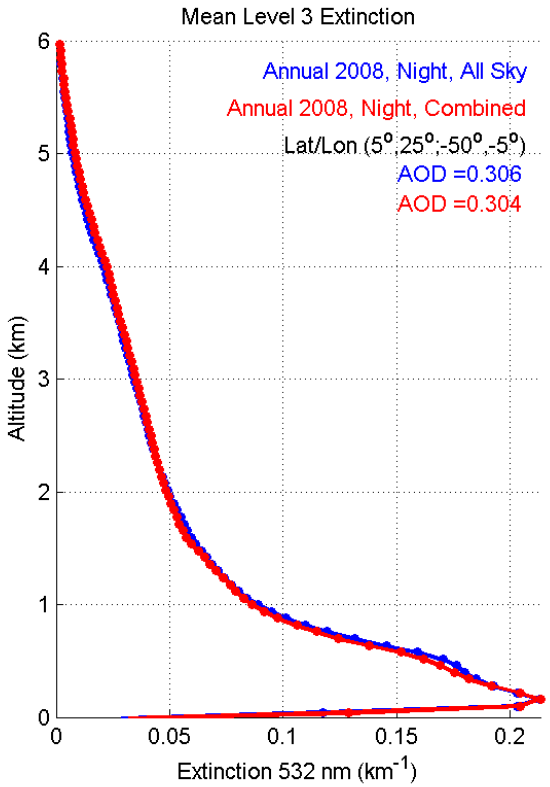
Annual 2008 Mean Polluted Dust AOD — Night, Cloud Free

"Poll. Dust"

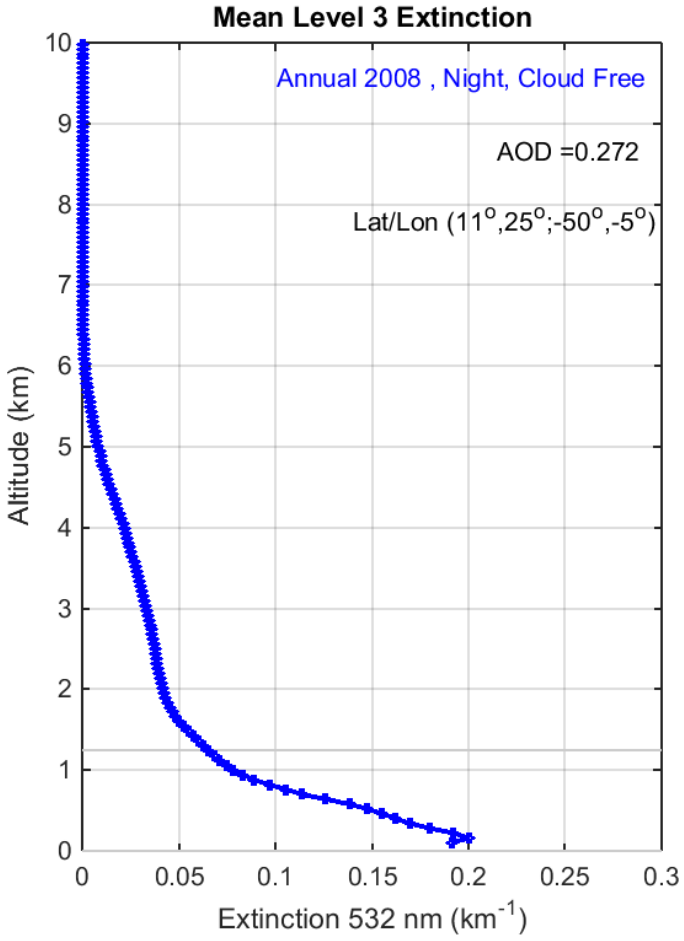


V3 vs. β version

β

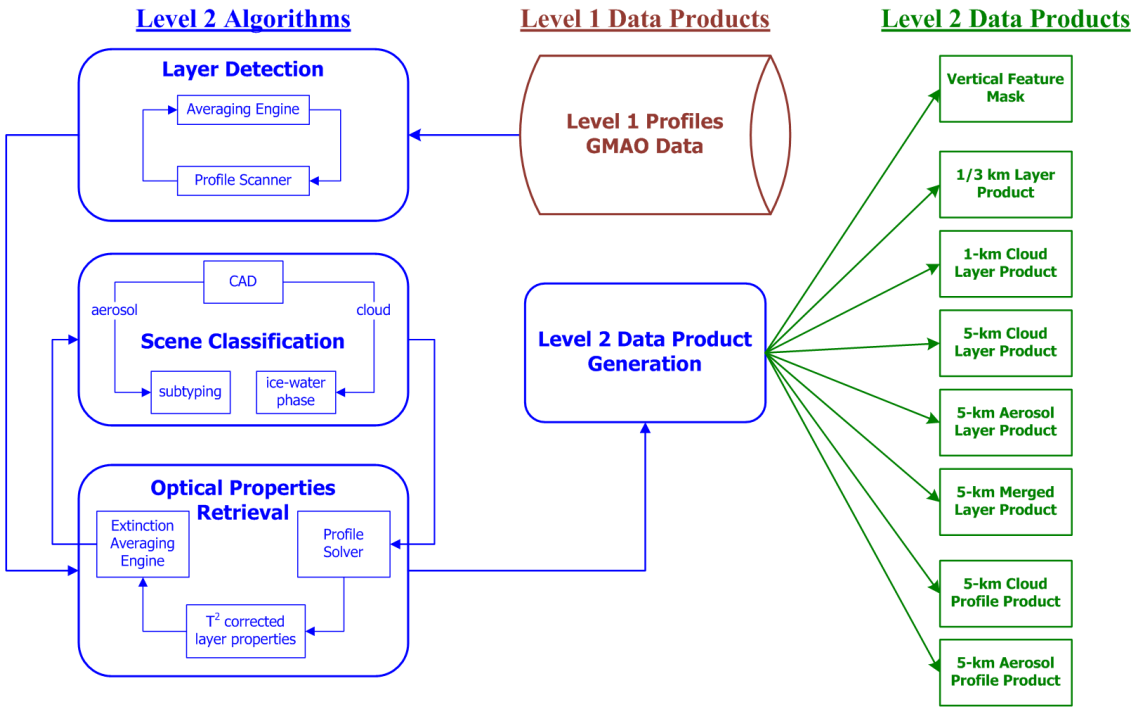


V3



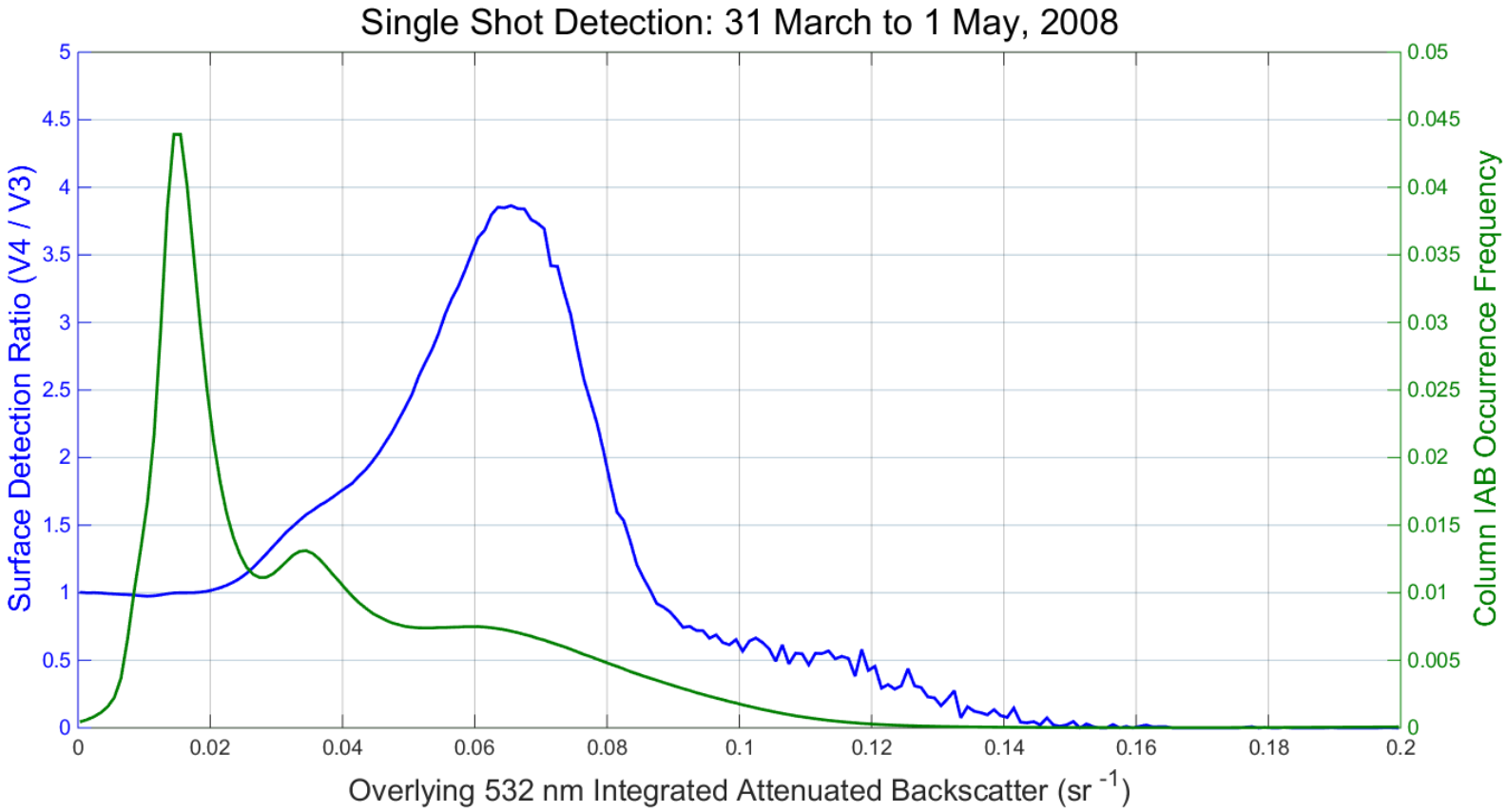
L2 Product Developments

1. New Surface Detection Alg.
2. Cloud-Aerosol Discrimination
   1. New PDF's
   2. Now at 1/3 km
   3. Now in stratosphere
3. Stratospheric Aerosol Classification
4. Tropospheric Aerosol Classification
5. Revised Aerosol Lidar Ratios
6. Ice-Water Content
7. Cirrus Multiple Scattering
8. Opaque Extinction Retrieval



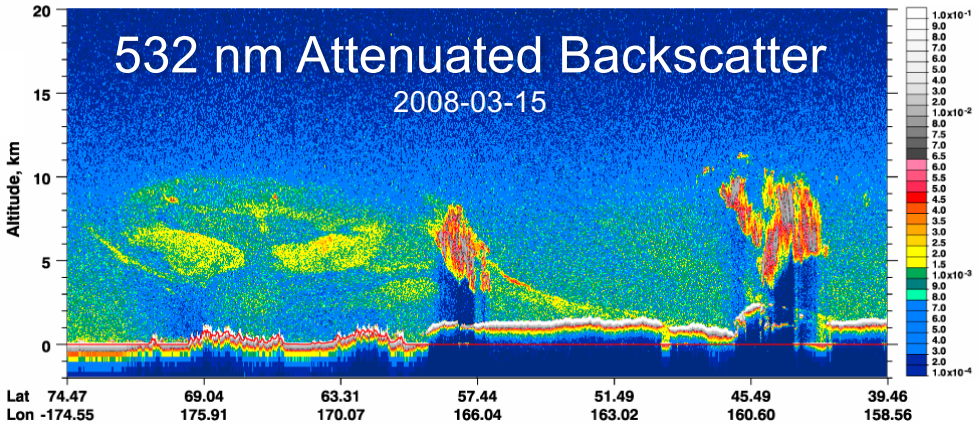
Surface Detection

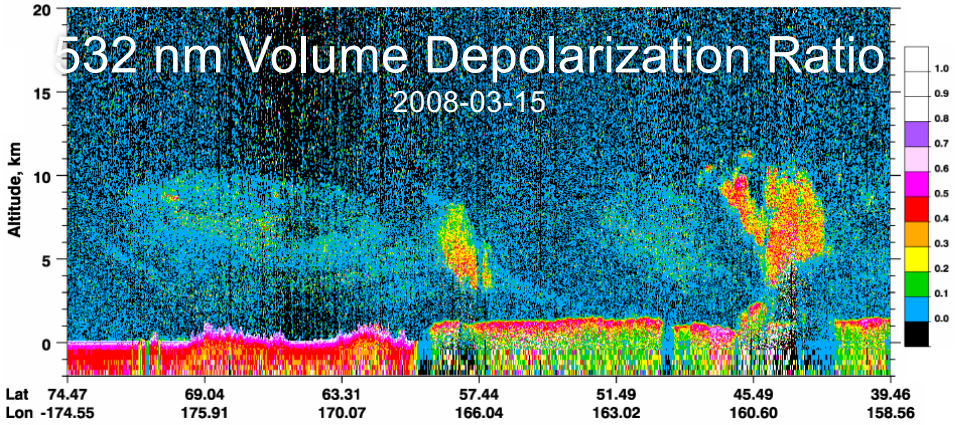
- New surface detection algorithm developed
- Starts below surface rather than at top of atmosphere
- Frequency of surface detection under clouds is increased

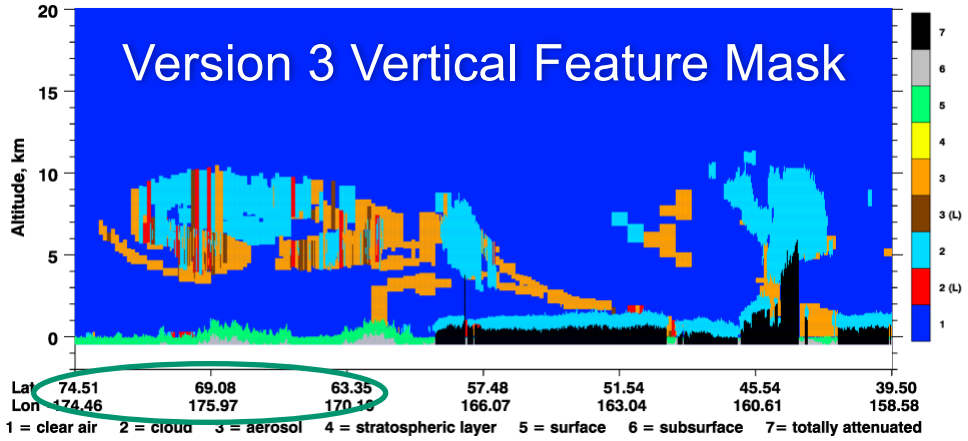


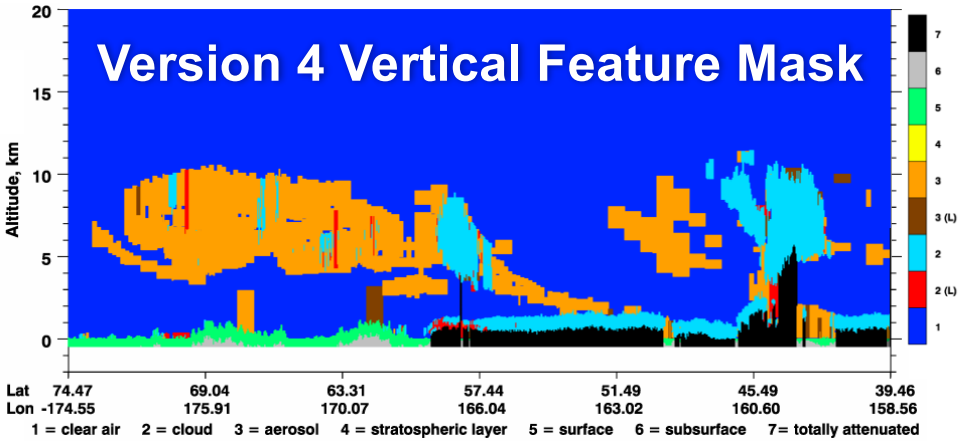
Cloud-Aerosol Discrimination (CAD)

- Revised CAD algorithm required to accommodate new (V4) calibration
- Also fixes several V3 problems (misclassification of high-latitude dust)





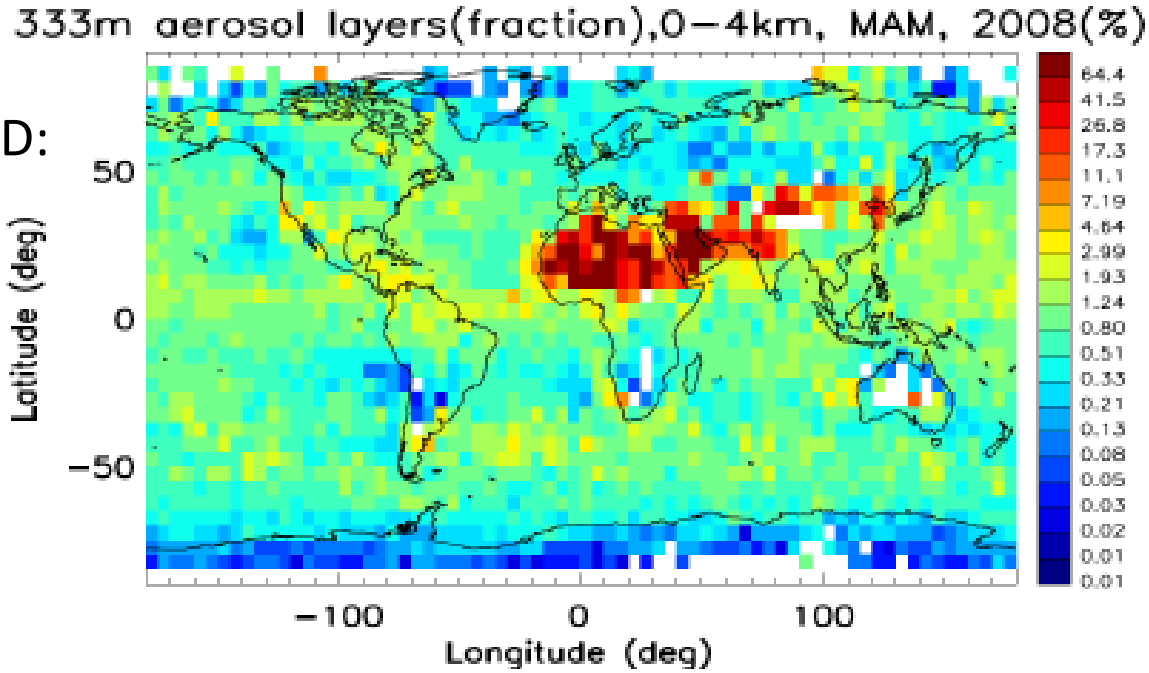




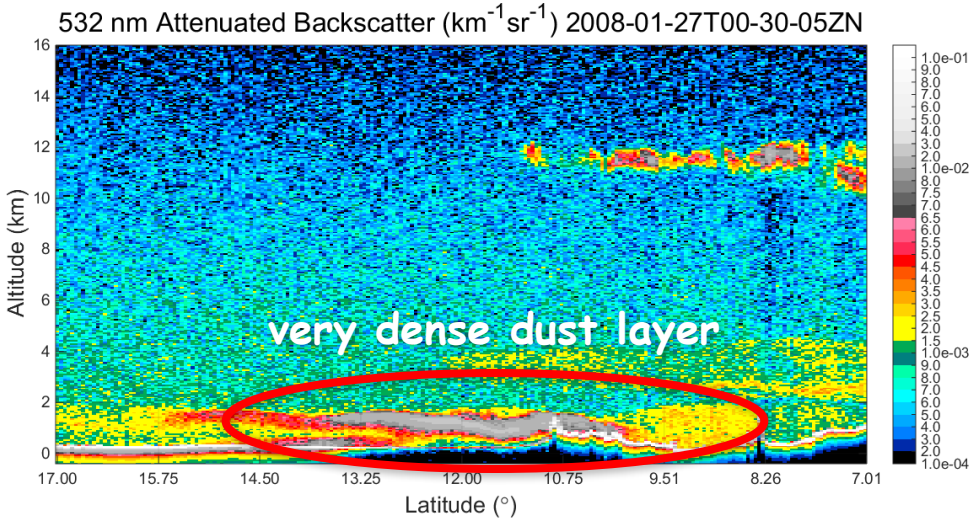
CAD on 1/3 km profiles

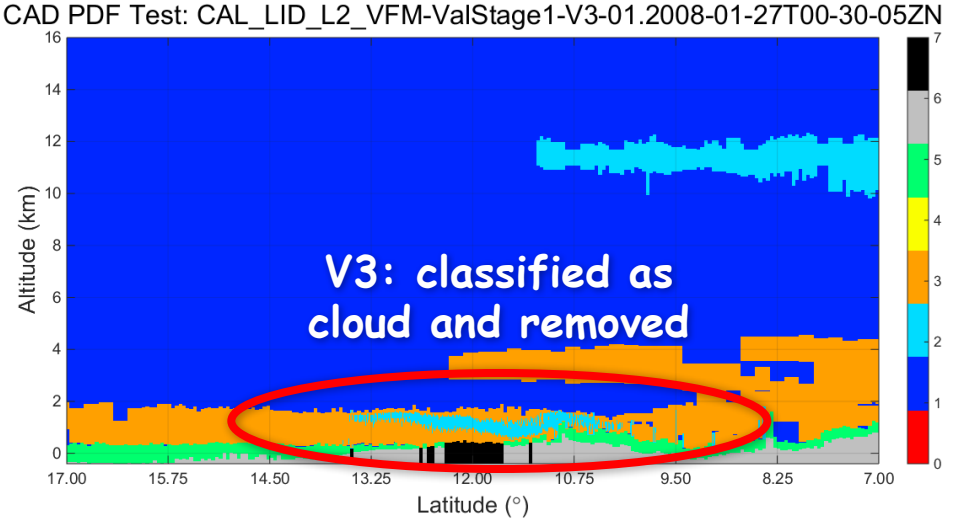
- In Version 3, anything detected on single-shots was classified as cloud
  - Dense smoke and dust layers often classified as cloud
- In Version 4, Cloud-Aerosol Discrimination (CAD) algorithm will be applied to single-shot profiles

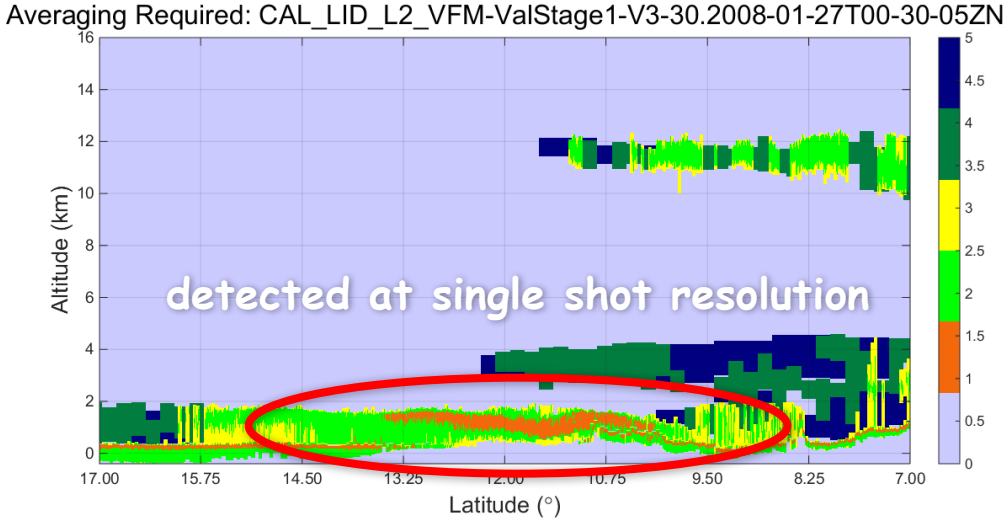
Preliminary results from 1/3 km CAD:
Most 1/3 km aerosol layers correspond to dense dust

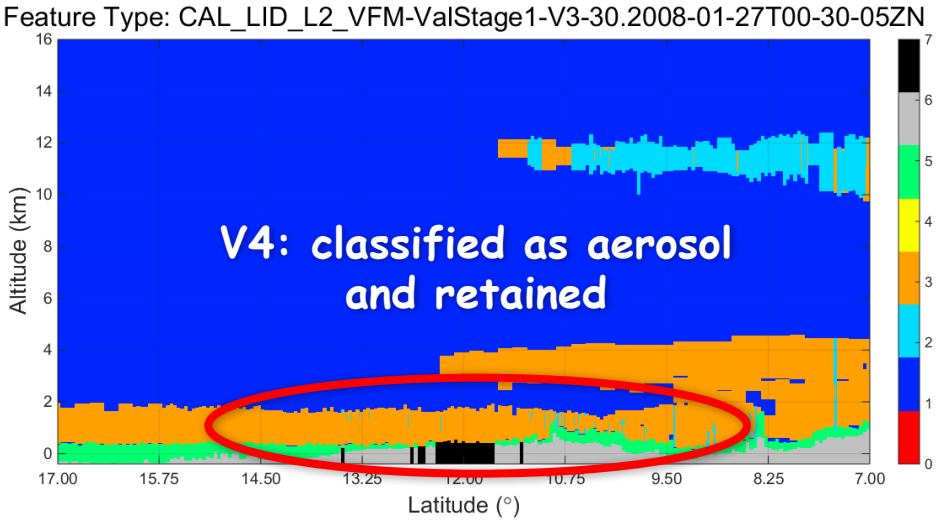


V4: Implement CAD at 1/3 km



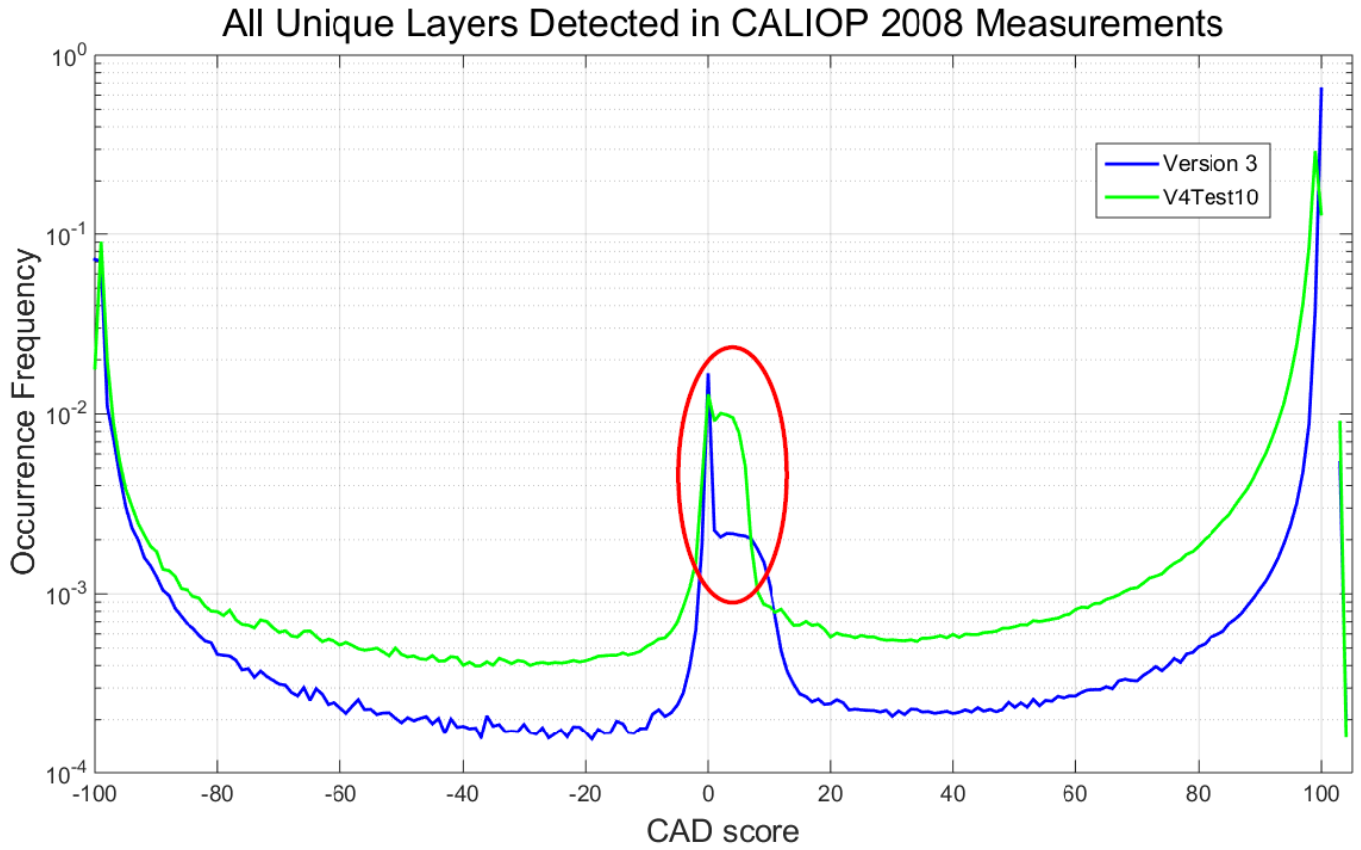






CAD Scores are changing!

- V4 CAD scores tend to be lower than in V3
  - V4 scores probably more realistic, but requires new interpretation

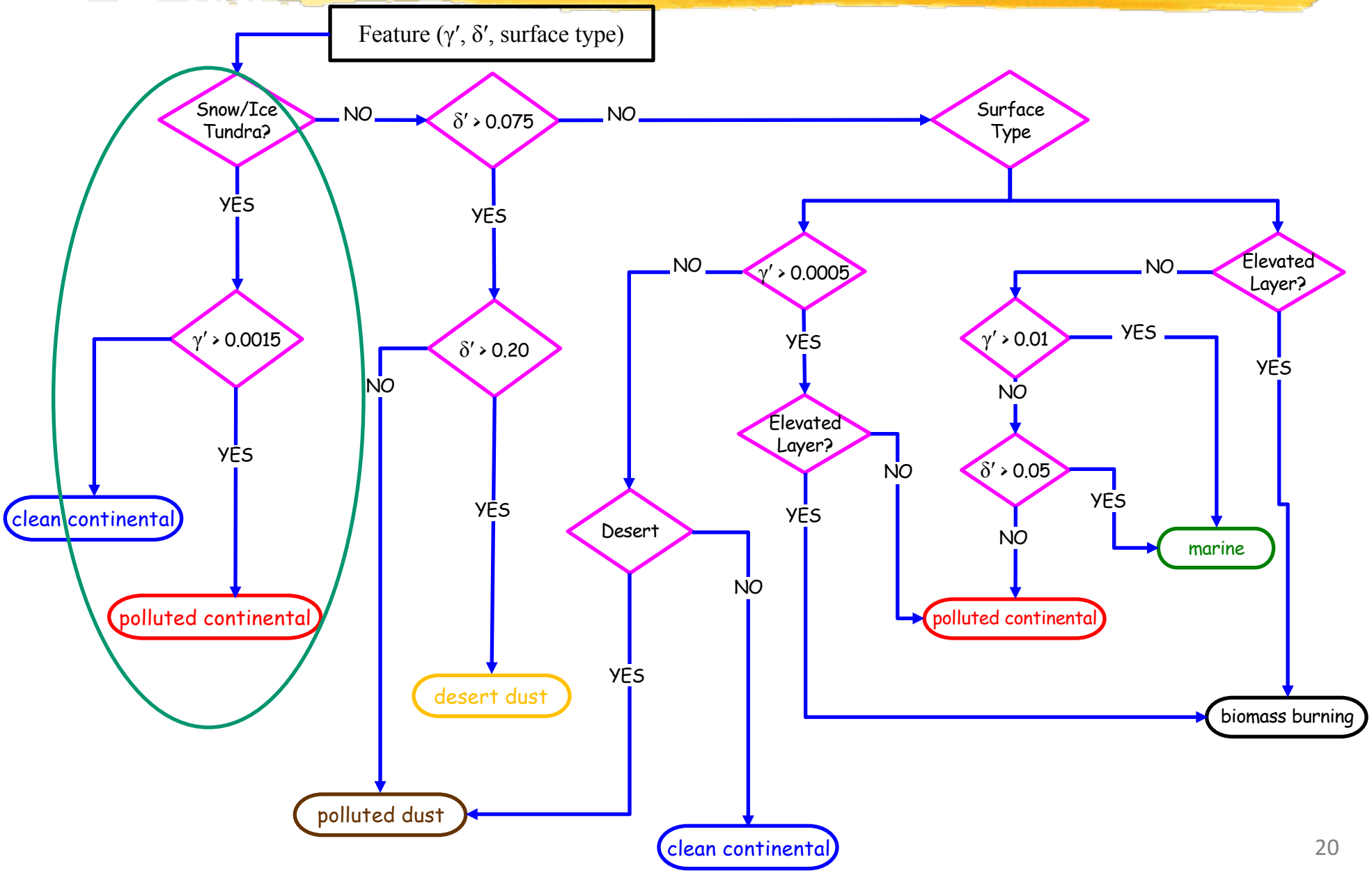


Aerosol Subtyping

Many Subtyping Revisions …

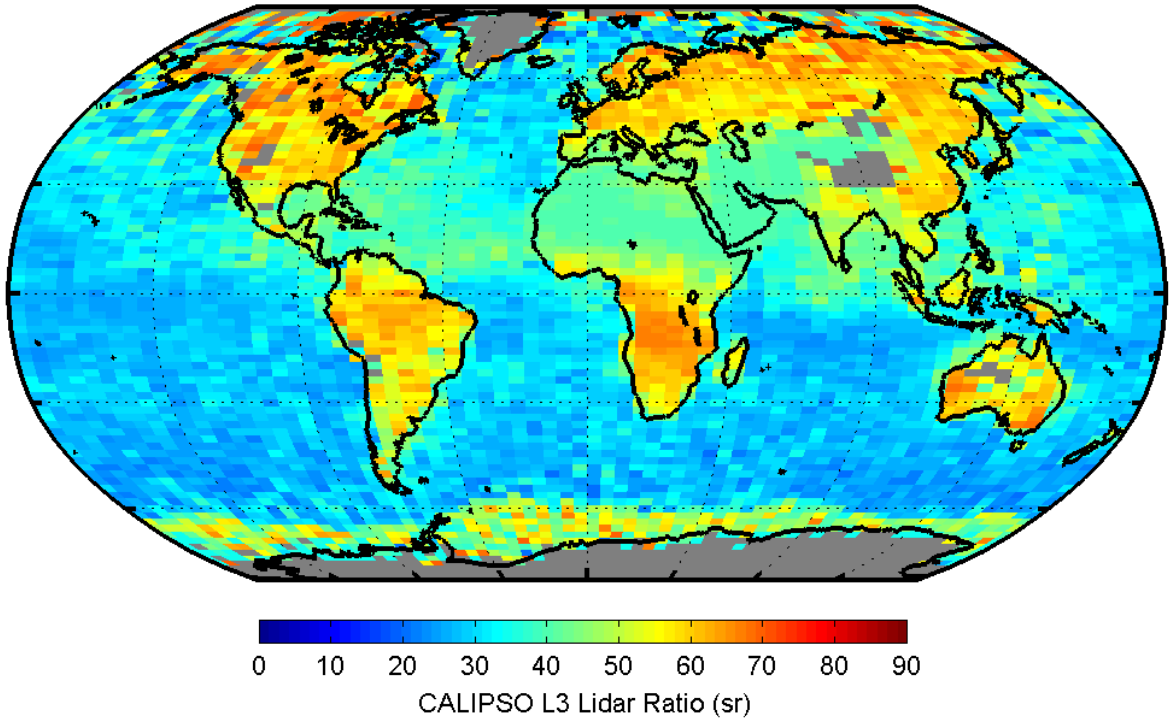
1. **Reduce/eliminate smoke misclassified as marine over ocean**
2. **Smoke vs polluted continental.**
   - Rename “smoke” and “polluted continental” to “elevated smoke” and “polluted continental or smoke”
3. **Added stratospheric aerosol typing**
4. **Disallow polluted continental over Antarctica**
5. **Improved dust/polluted dust classification**
   - Correct for overlying transmittance in δ_p calculation
   - Adjust δ_p thresholds for day/night
6. **Add Dusty Marine aerosol type**
7. **Better CAD for high-latitude dust**
8. **Revised polar aerosol classification (removed “Arctic haze”)**

V3 Tropospheric Aerosol Classification



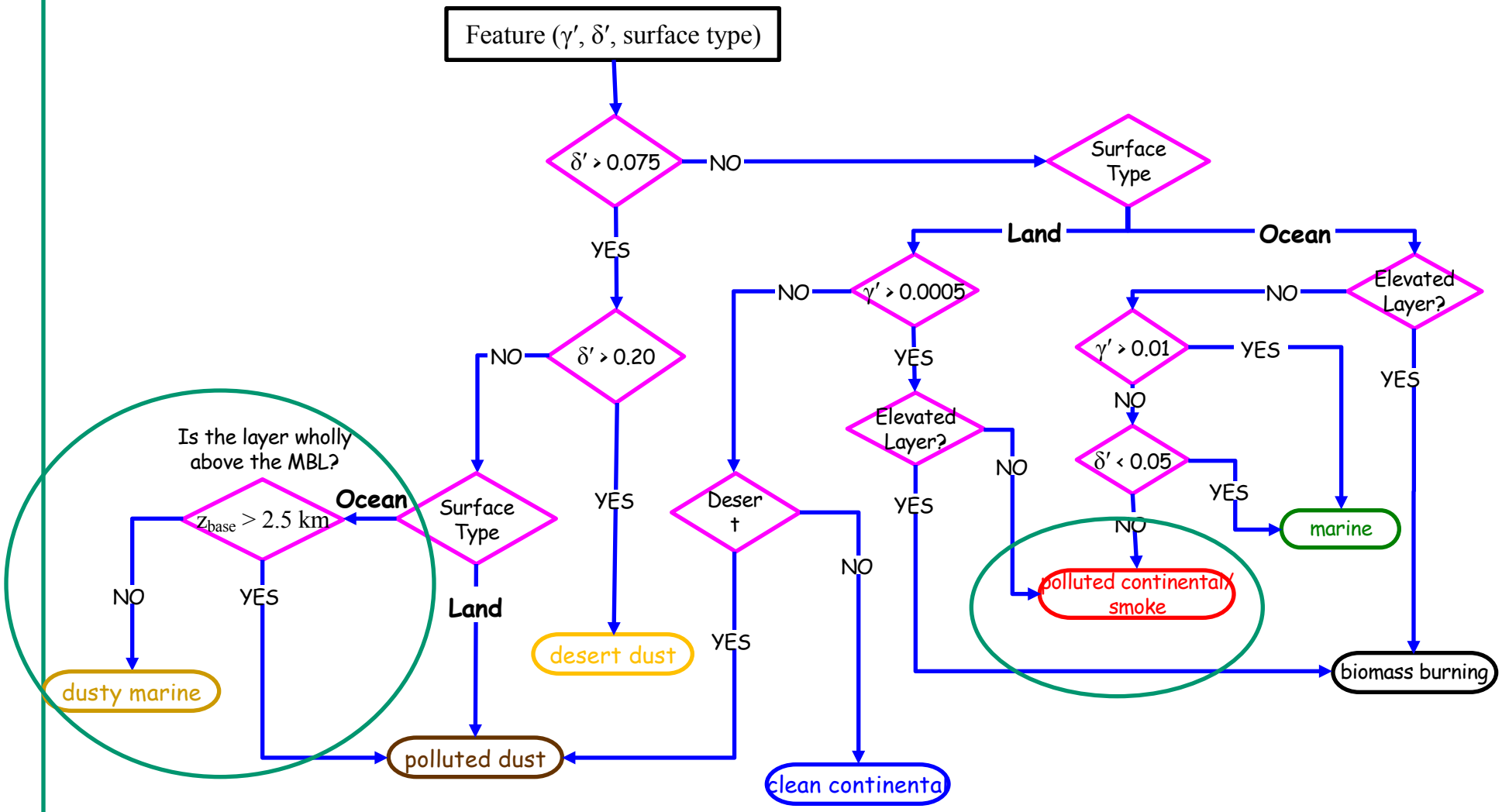
V3: Typing artifact near Antarctica

Average Lidar Ratio, Jun-Aug 2008, Daytime, AllSky. Layers < 2 km



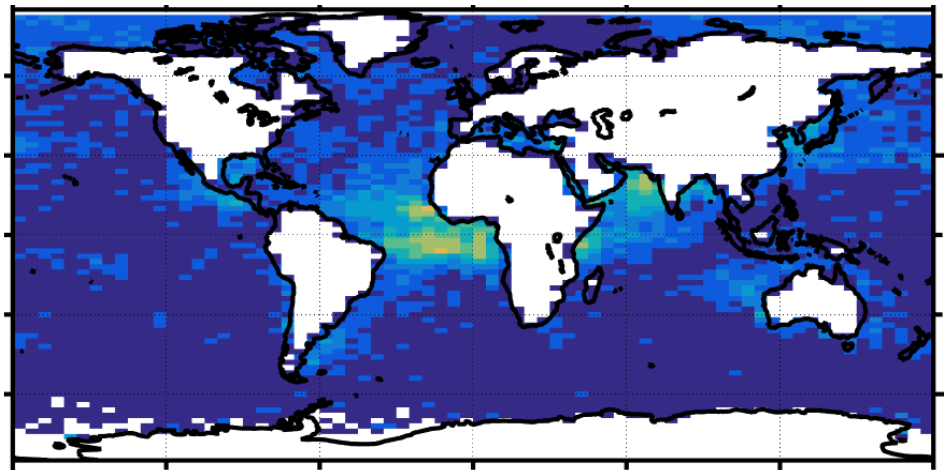
V4 Tropospheric Aerosol Classification

Removed tests over snow, added Dusty Marine type

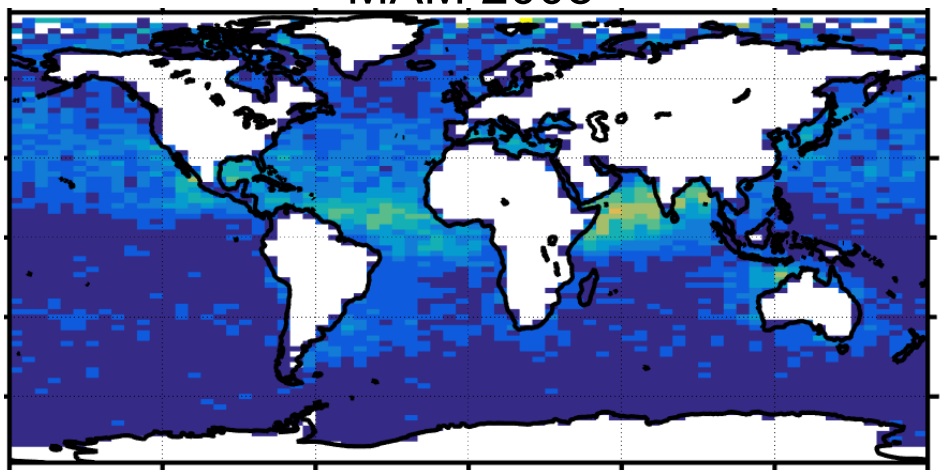


Dusty Marine – V4 Test 10, Night

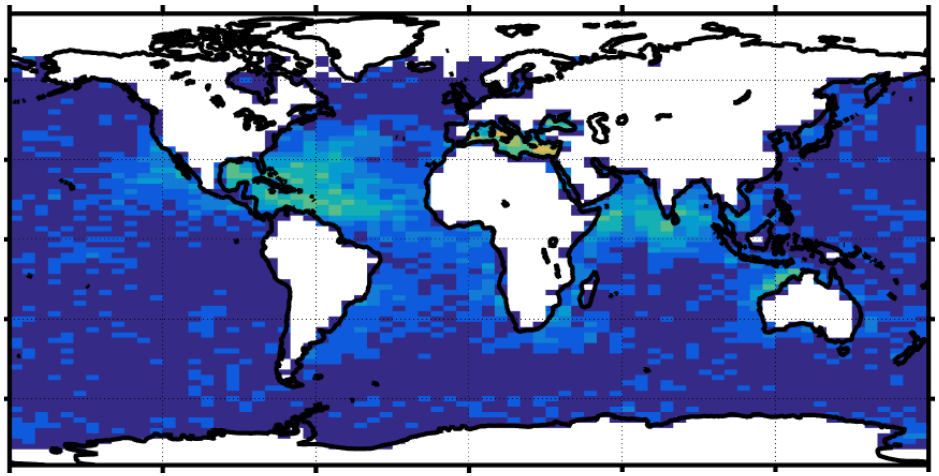
DJF 2008



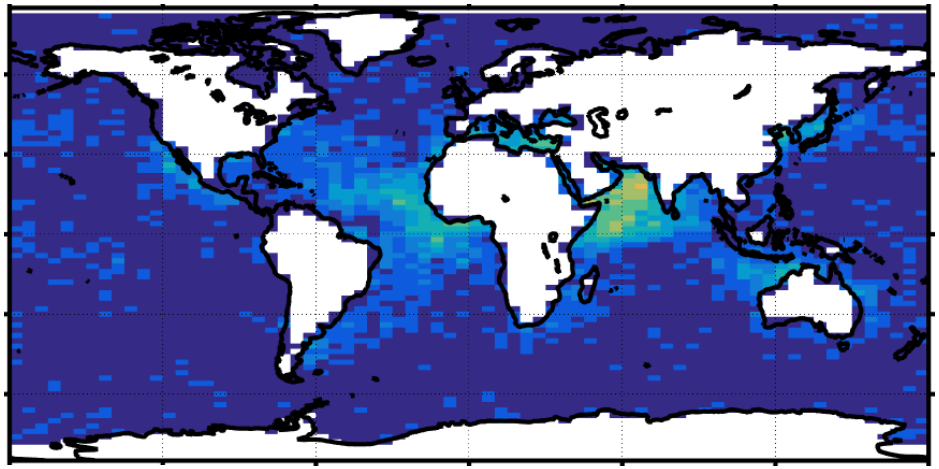
MAM 2008



JJA 2008

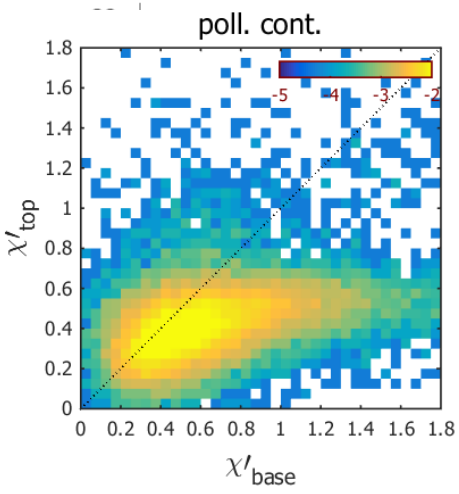


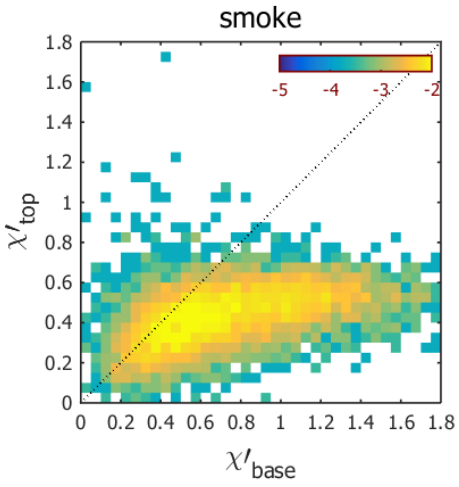
SON 2008

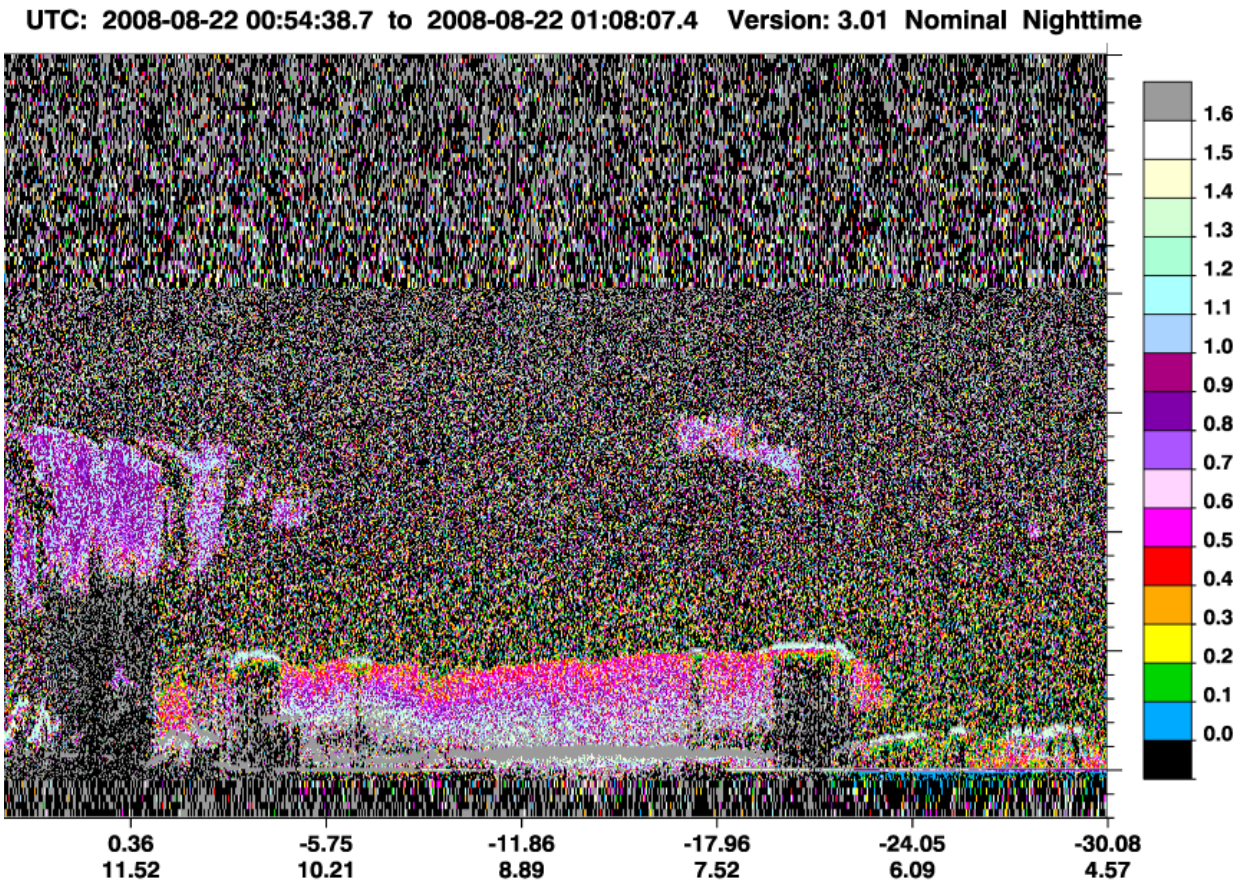


Smoke vs. Polluted Continental
new interpretation in V4

Can we use attenuated color ratio to discriminate between smoke and polluted continental?

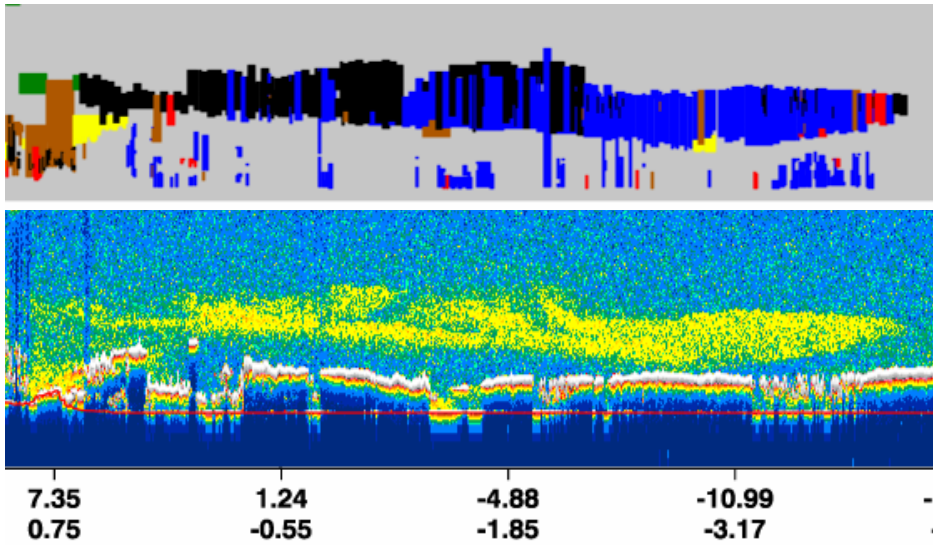




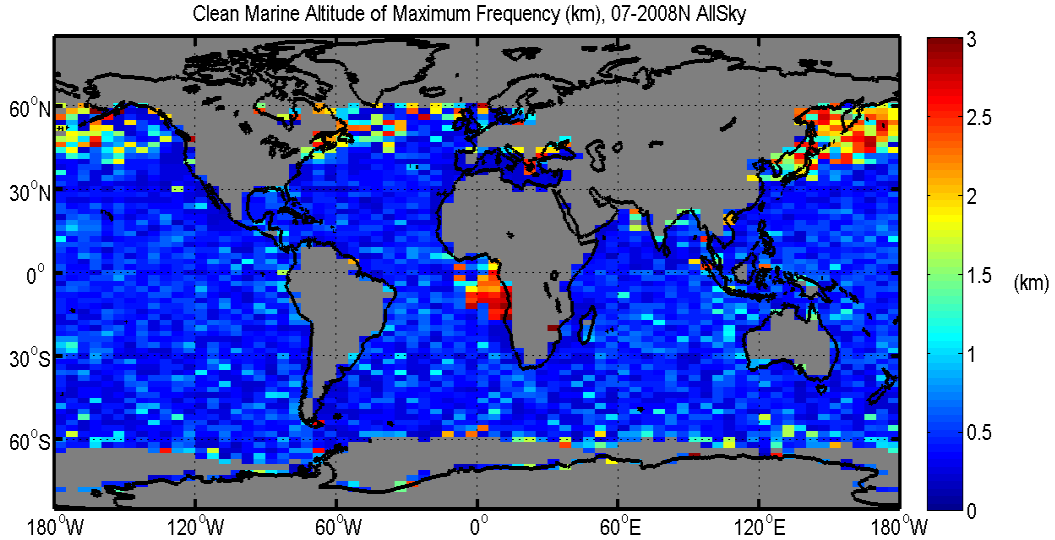


"Elevated marine"

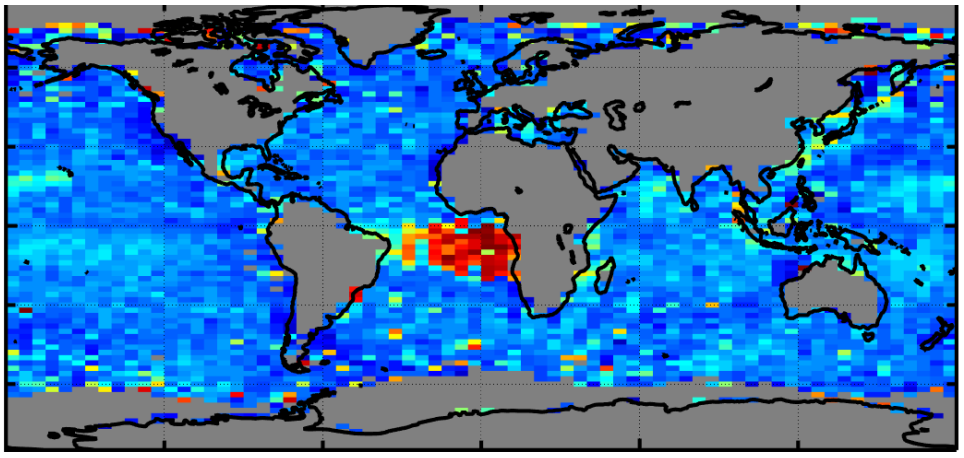
AerTypeProfiles_southAf_global.png



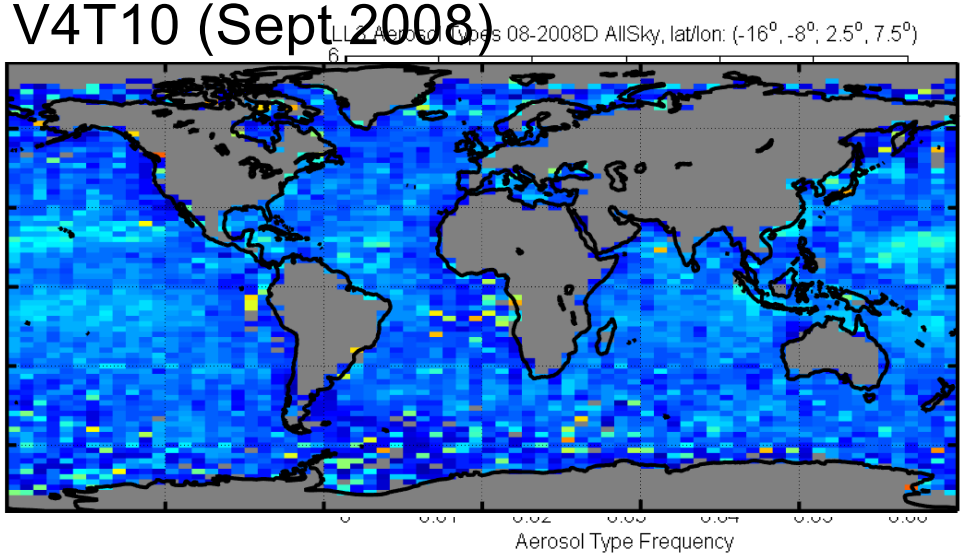
V3: altitude of max freq (July)



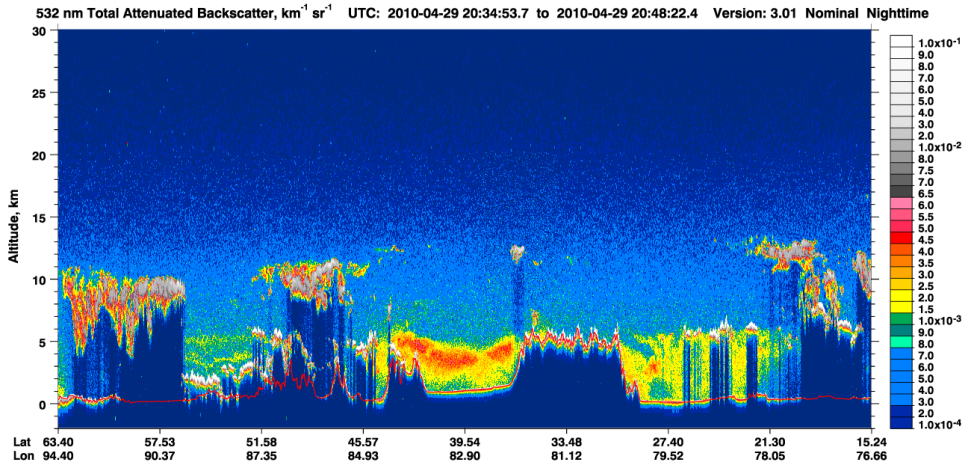
V3 (Sept 2008)

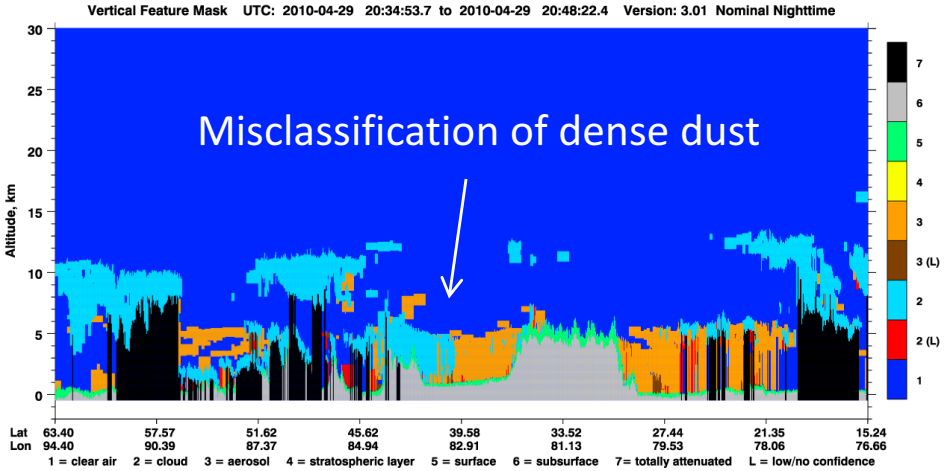


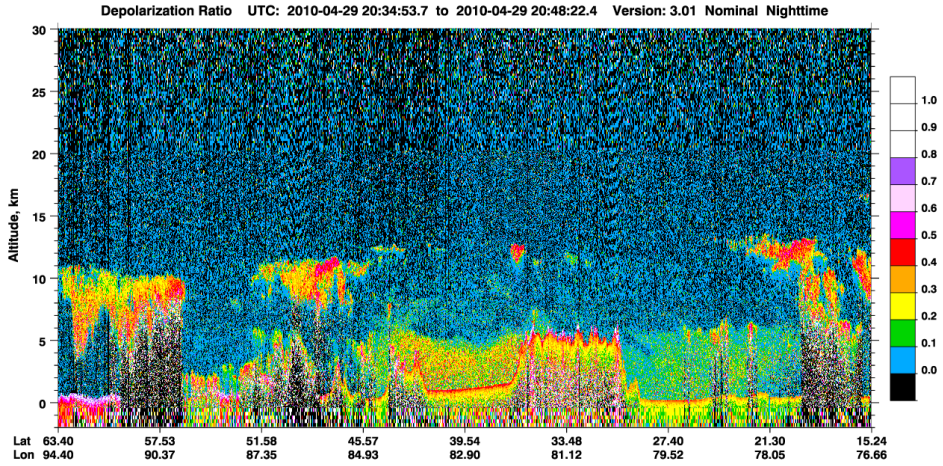
V4T10 (Sept 2008)

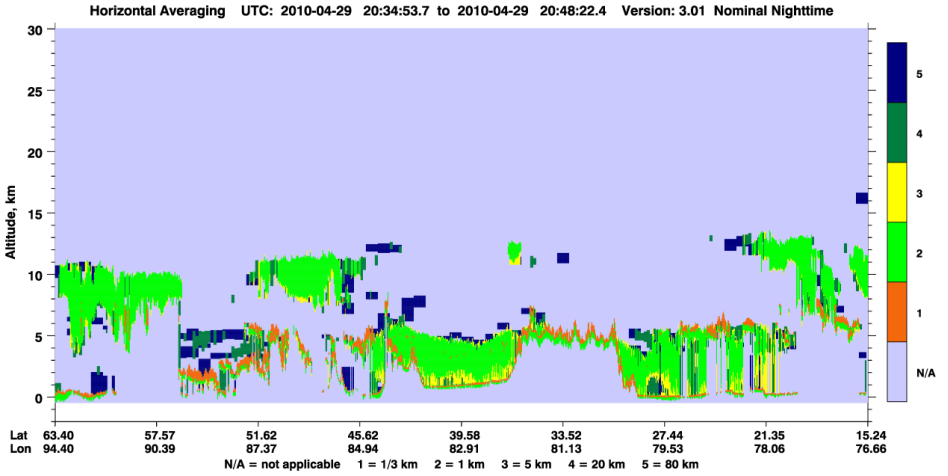


Dust → Cirrus at high latitudes



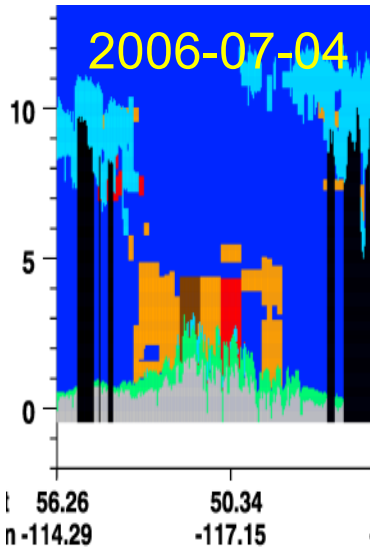


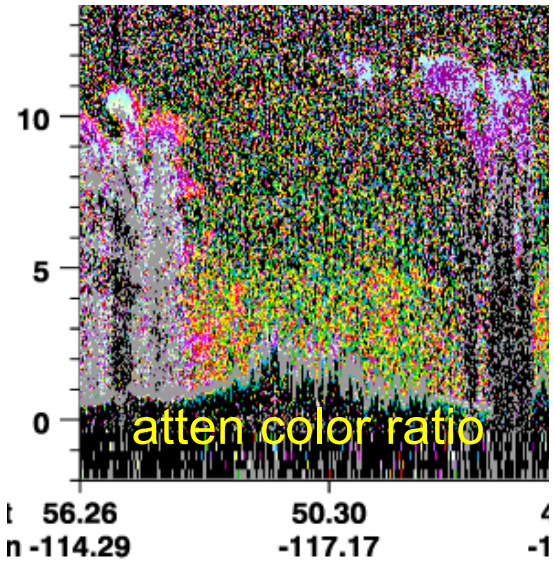


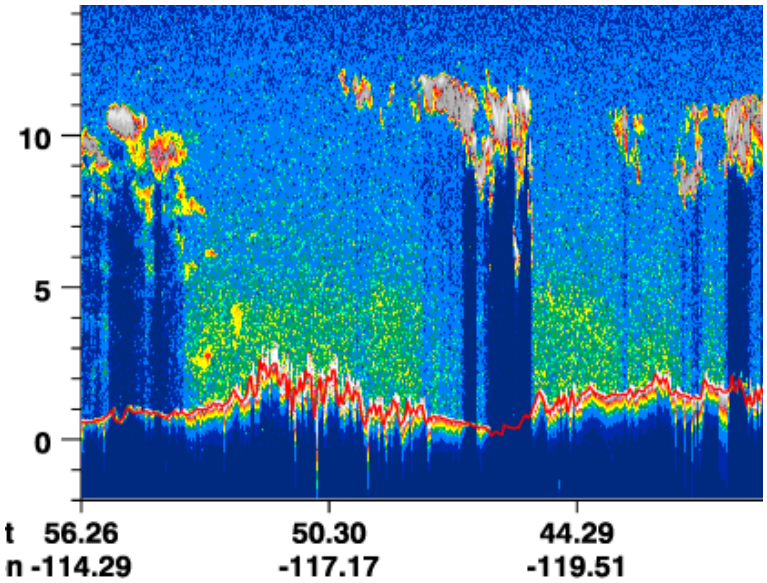


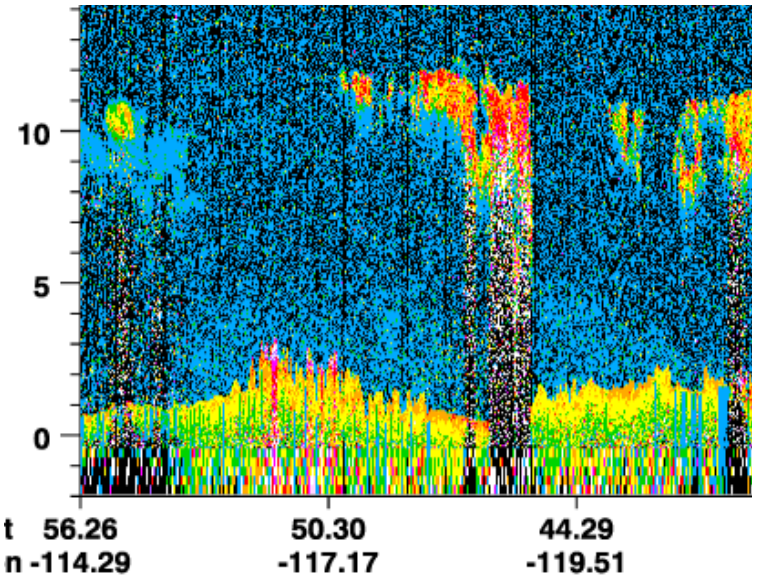
Misclassification of dense dust layers north of 40°N over the Taklimakan Desert.
Improved with modified V4 PDFs.

Smoke → Cirrus at high altitudes

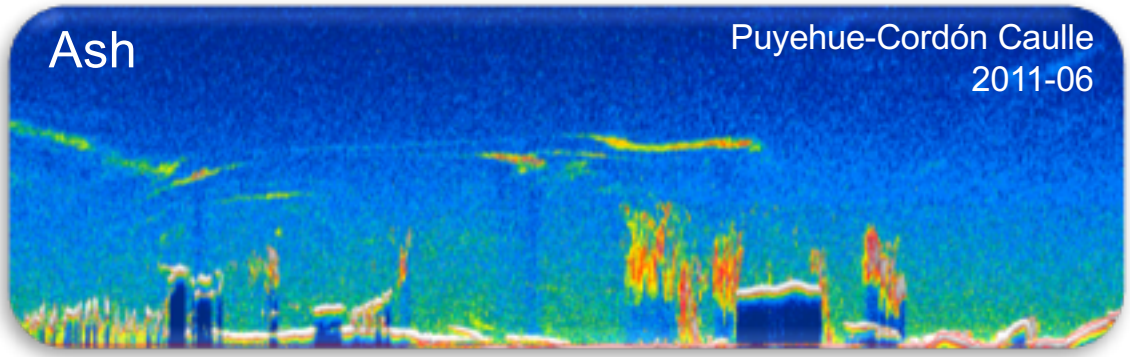


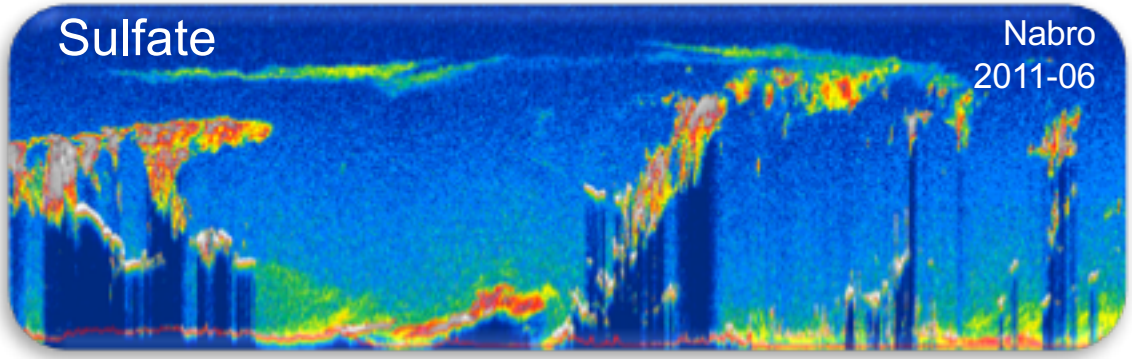


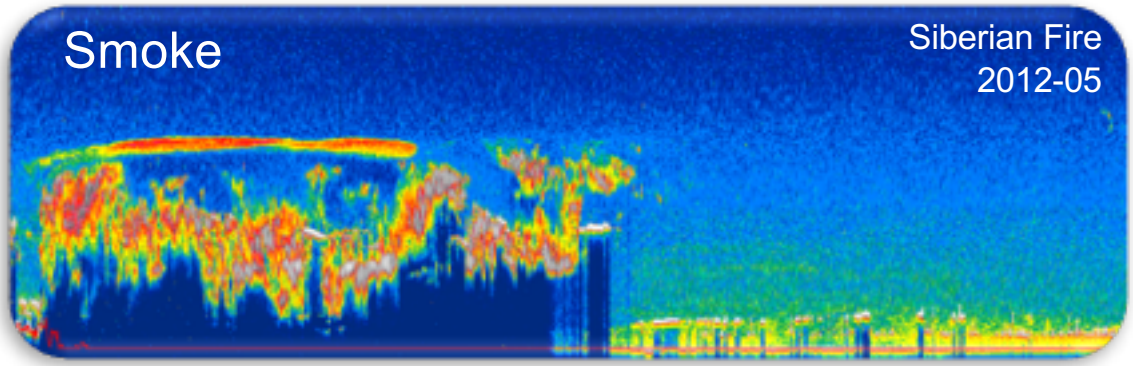


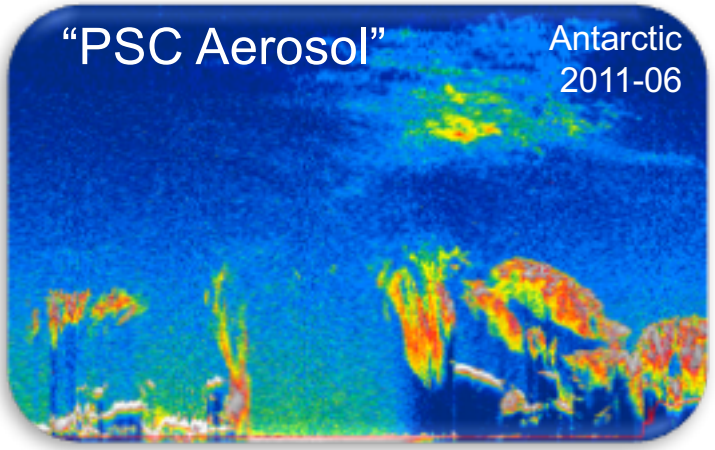


New: Stratospheric CAD and Typing









Aerosol Lidar Ratio Updates

Troposphere	V3	V4
Clean Marine	20	23
Clean Continental	35	53
Dust	40	44
Dusty Marine	---	37
Polluted Continental	70	70
Smoke	70	70
Polluted Dust	55	55

Stratospheric Types	V4
'aerosol' PSC	50
Volcanic Ash	44
Smoke	70
Sulfate/other	70
Undetermined	50

Some 1064 lidar ratios modified – highly uncertain (validation!!)

Remaining Aerosol Issues

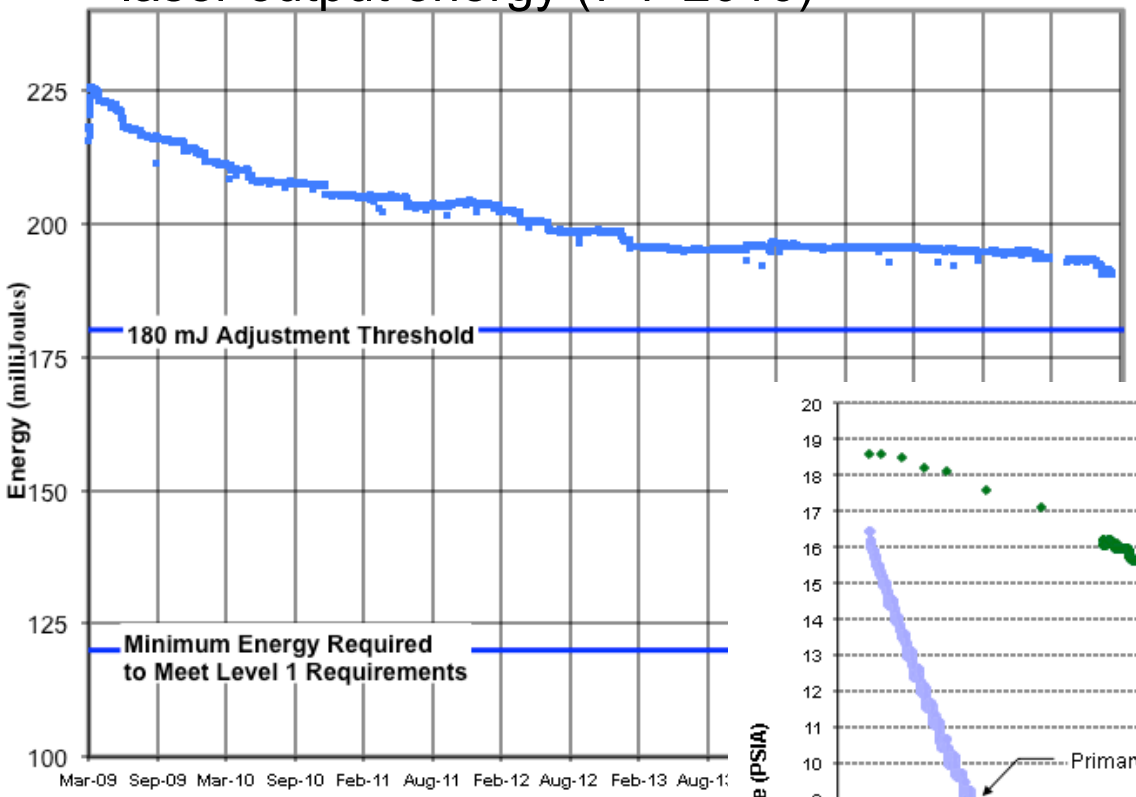
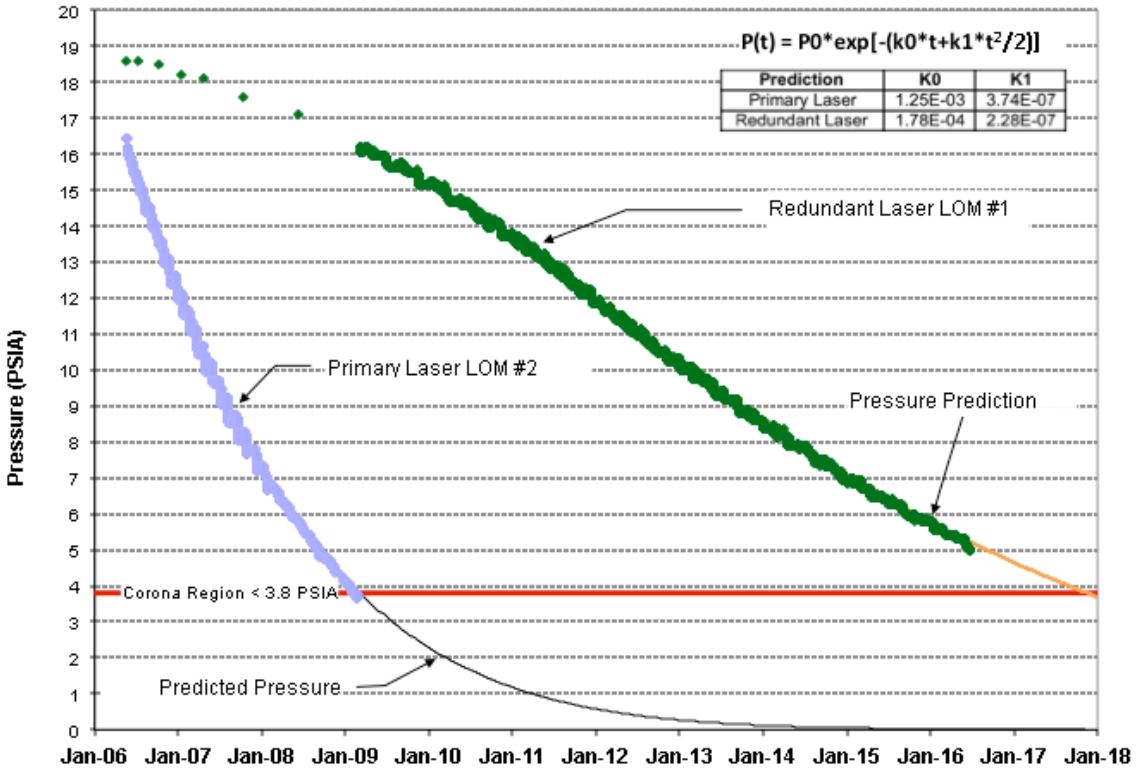
- Smoke mixed into MBL is still an issue
- High altitude smoke → cirrus not completely fixed
- Need to replace Dust/Polluted Dust with a depol-based retrieval
- Dust needs a 10% adjustment for MS

Lidar Data Products Summary

- Level 1 Version 4 released since spring 2014.
  - Minor updates underway for release in mid-2016 (V4.1)
- Level 1.5 ‘re-analysis product’
  - Based on V4 Level 1 and V3 cloud mask, full mission
- Level 2 Version 4 release planned for summer 2016.
- Revised Level 3 aerosol product released fall 2015
  - Will be updated after release of V4 L2 product
- Stratospheric aerosol product in development.
  - Release to follow V4 L2.
- Level 3 cloud product - Initial release in 2016, based on V3 L2
- Ocean subsurface product
  - Recently funded under CC science team

Brief CALIPSO status …
2nd laser now at 4.3 billion shots!

laser output energy (7-7-2016)



laser canister pressure