

National Aeronautics and
Space Administration



EXPLORE EARTH



CALIPSO

Ocean Derived Column Optical Depths

Rob Ryan, Mark Vaughan, Dave Winker
10 March 2021

Motivation

- CALIOP only retrieves extinction coefficients and optical depths where clouds or aerosols are detected.
- The detection limit of the retrievals means background aerosol is not detected.
- The missing aerosol is important.

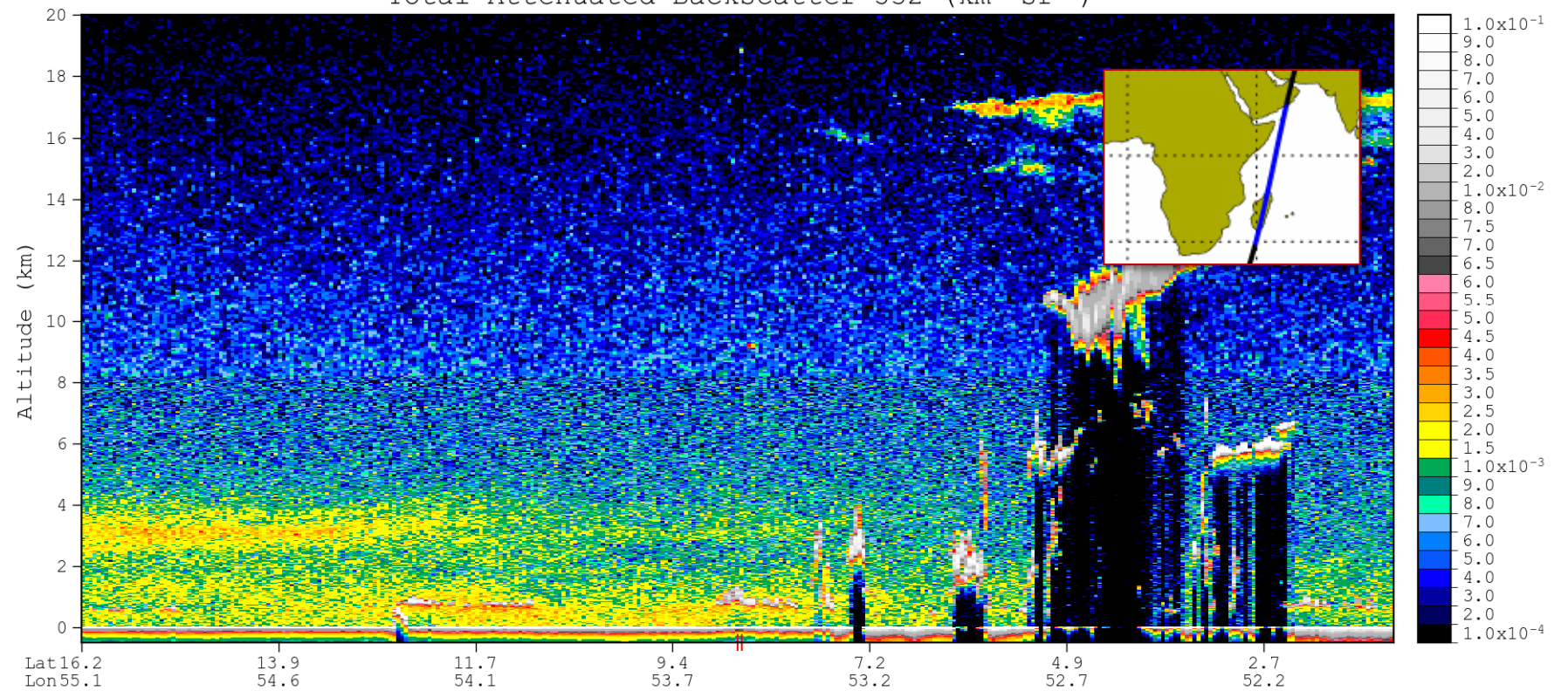
Thorsen et. al. [2017]; Watson-Parris et. al. [2018]; etc.

Thorsen, T. J., R. A. Ferrare, C. A. Hostetler, M. A. Vaughan, and Q. Fu (2017), The impact of lidar detection sensitivity on assessing aerosol direct radiative effects, *Geophys. Res. Lett.*, 44, 9059–9067, doi:10.1002/ 2017GL074521.

Watson-Parris, D. et al., 2018: On the Limits of CALIOP for Constraining Modeled Free Tropospheric Aerosol, *Geophys. Res. Lett.*, 45, 9260–9266. <https://doi.org/10.1029/2018GL078195>

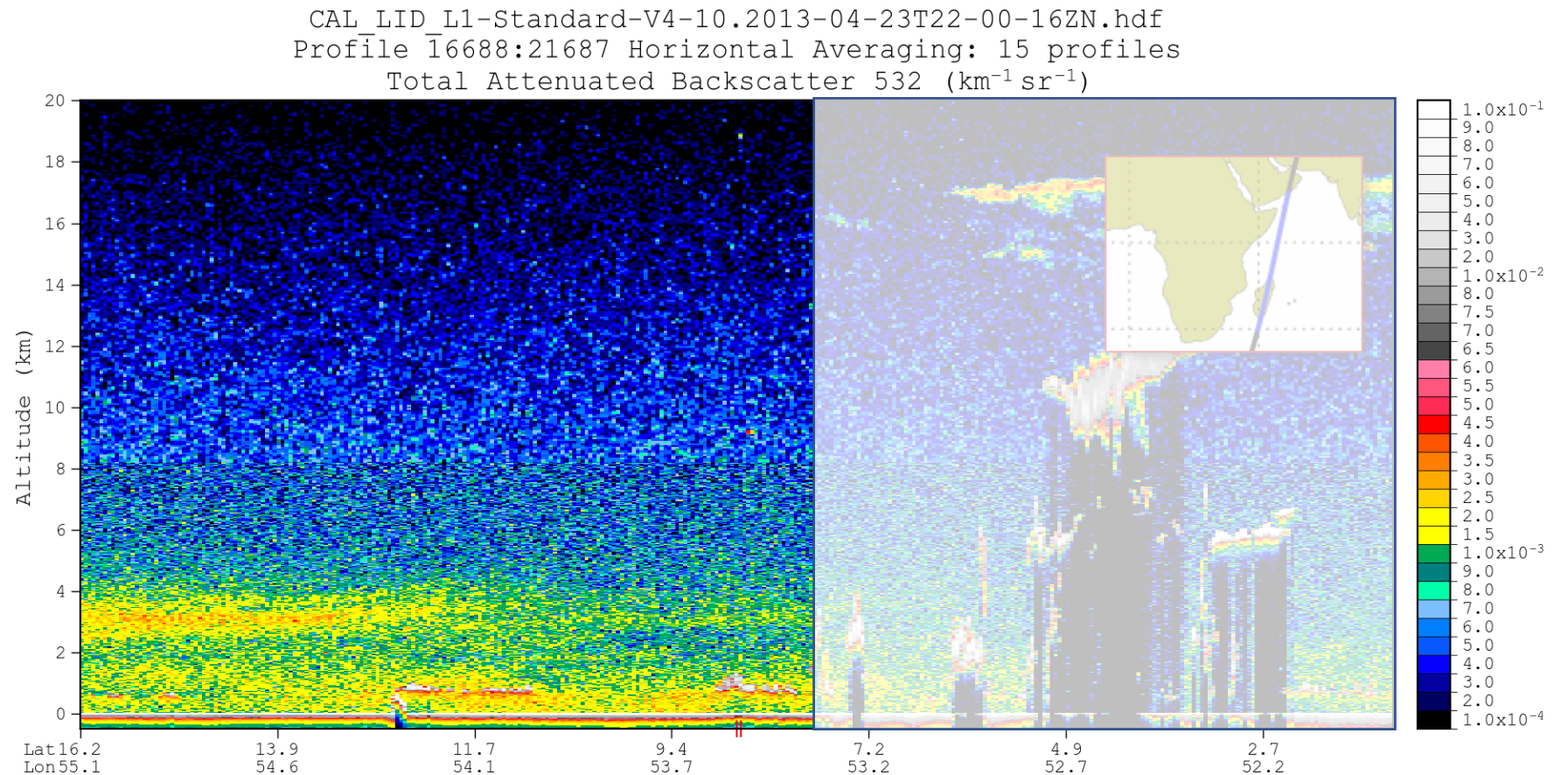
The Technique

CAL_LID_L1-Standard-V4-10.2013-04-23T22-00-16ZN.hdf
Profile 16688:21687 Horizontal Averaging: 15 profiles
Total Attenuated Backscatter 532 ($\text{km}^{-1} \text{sr}^{-1}$)



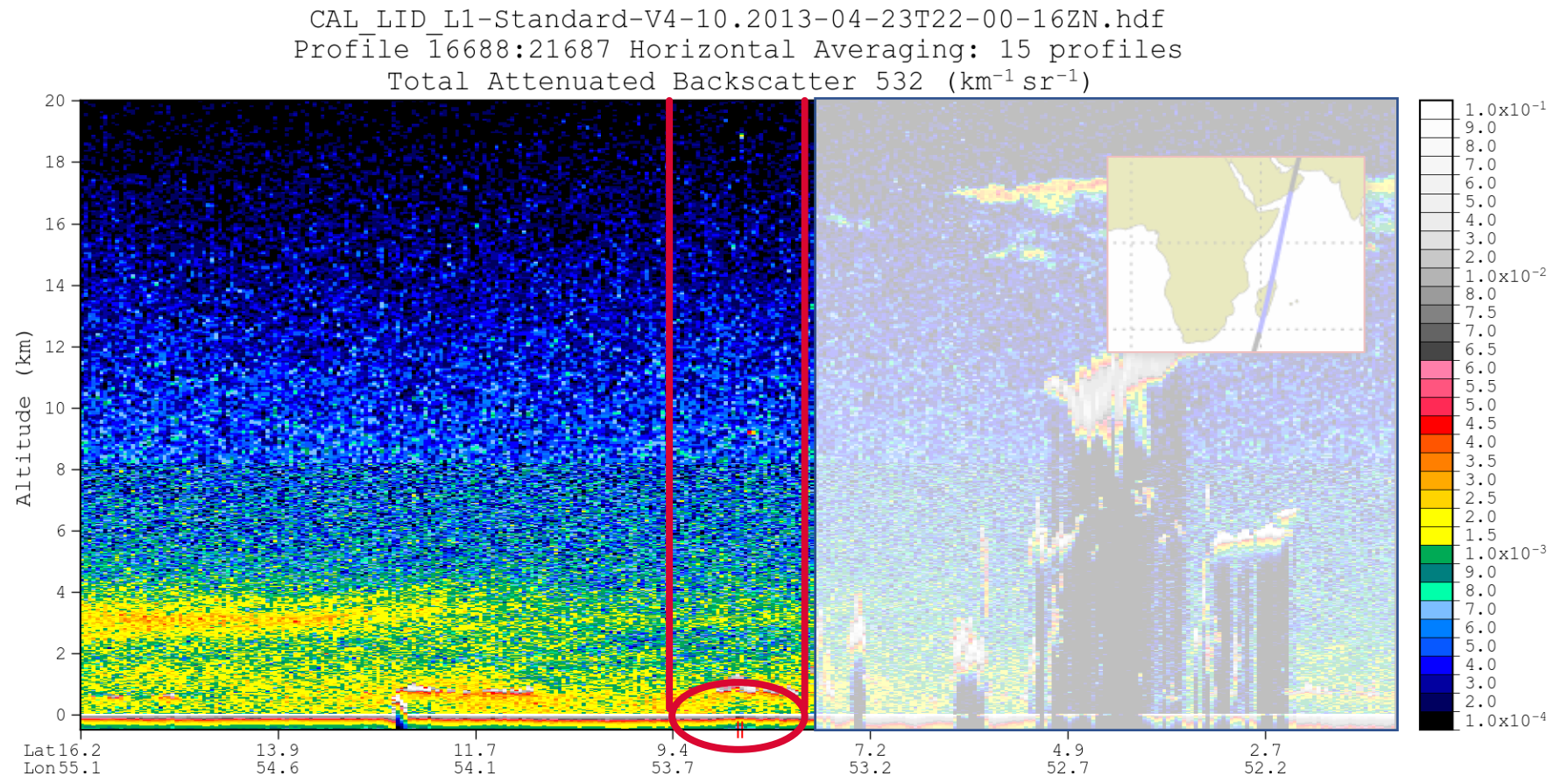
The Technique

When skies above are relatively clear, backscatter from the ocean surface is very high.



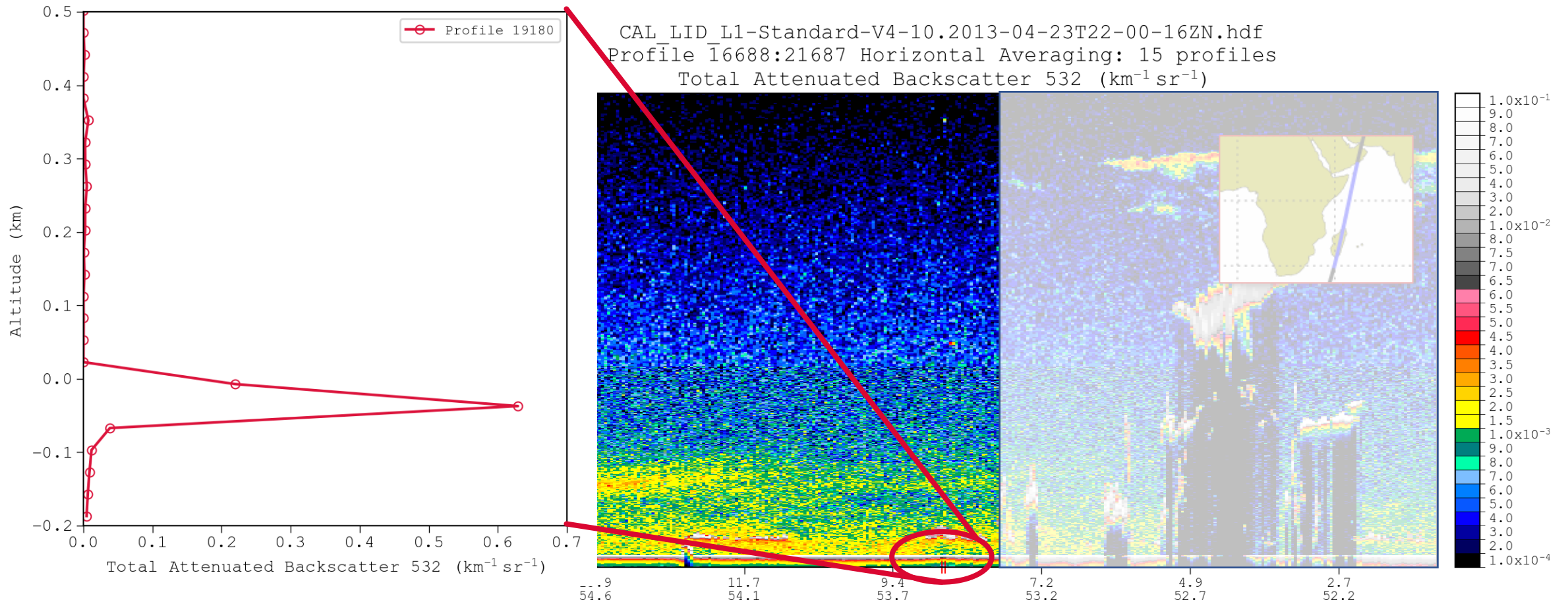
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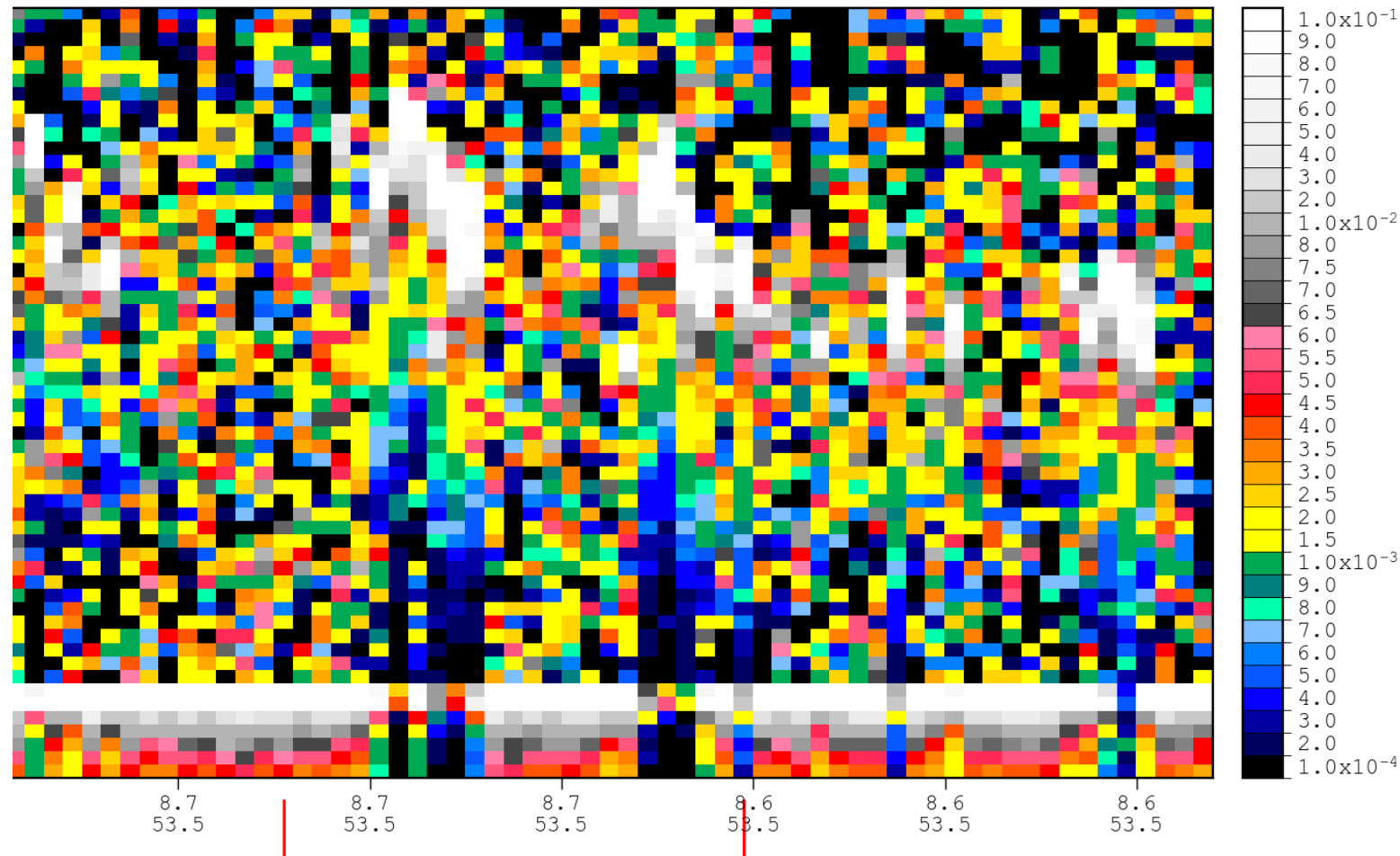
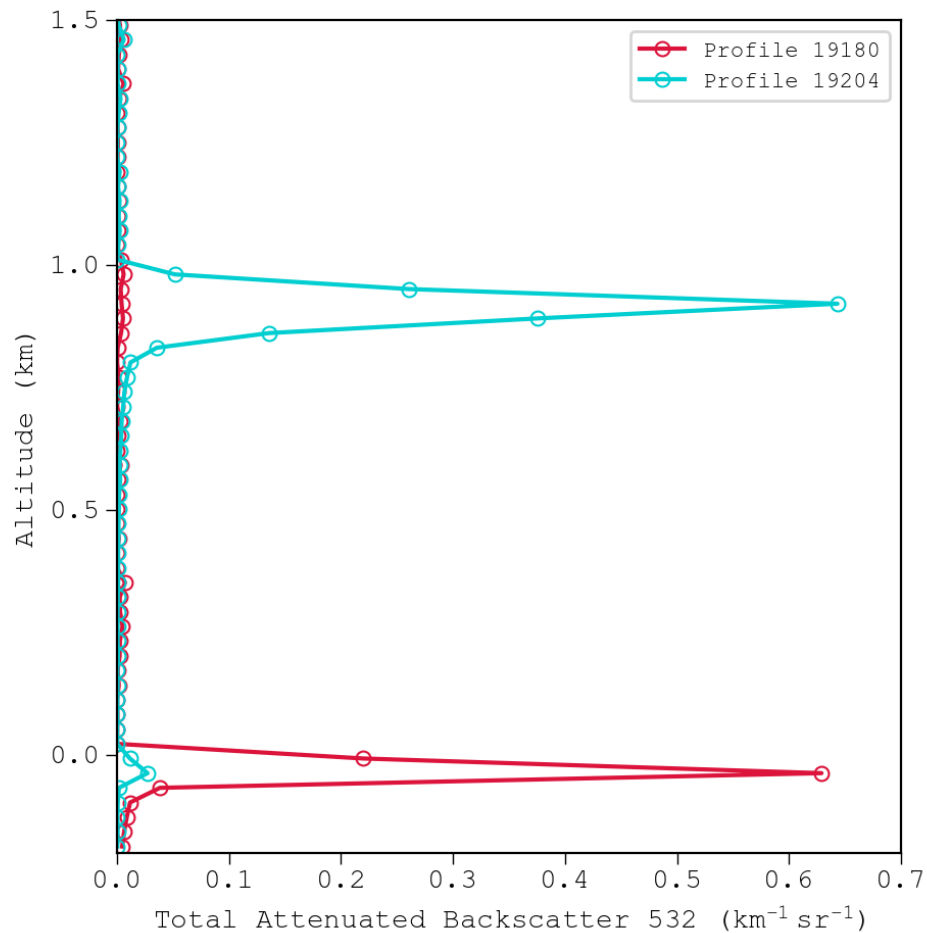
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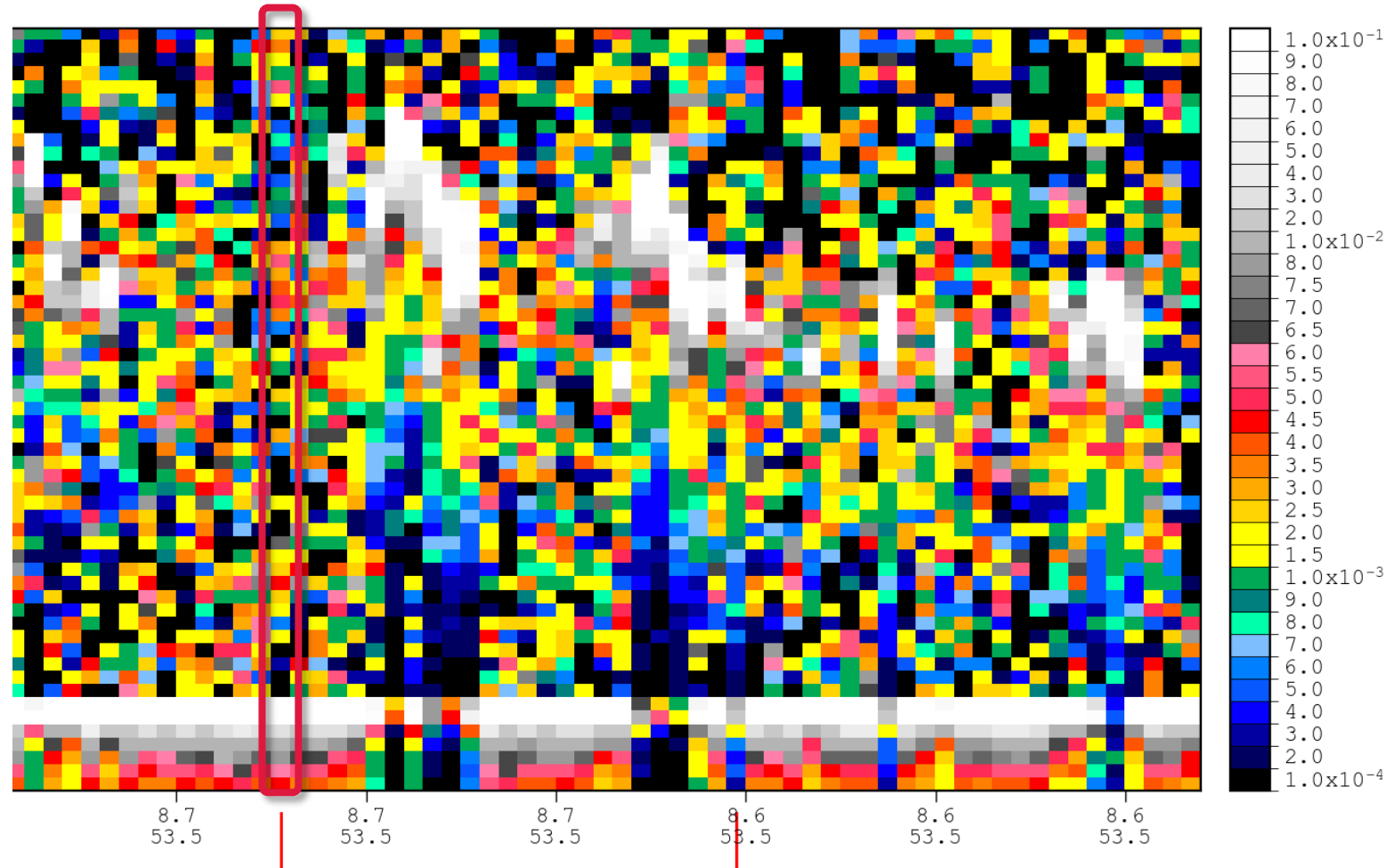
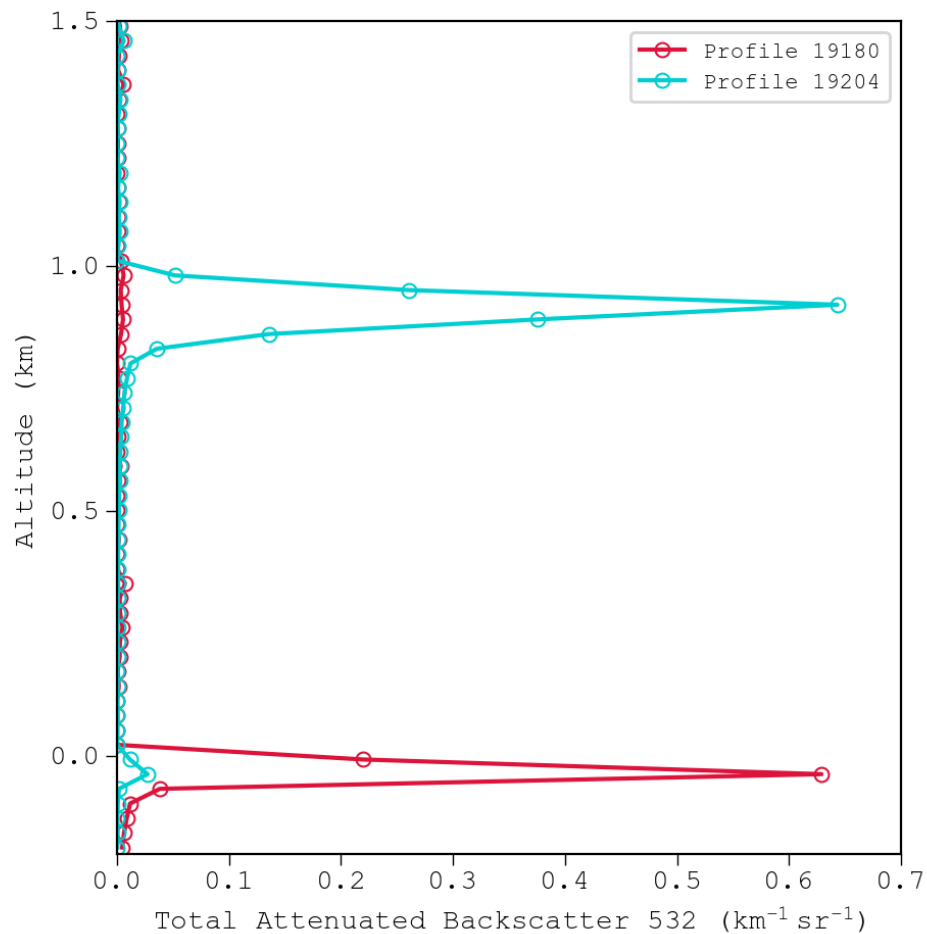
The Technique

Clouds and/or aerosols above the surface attenuate the signal, resulting in a notably smaller ocean backscatter return.



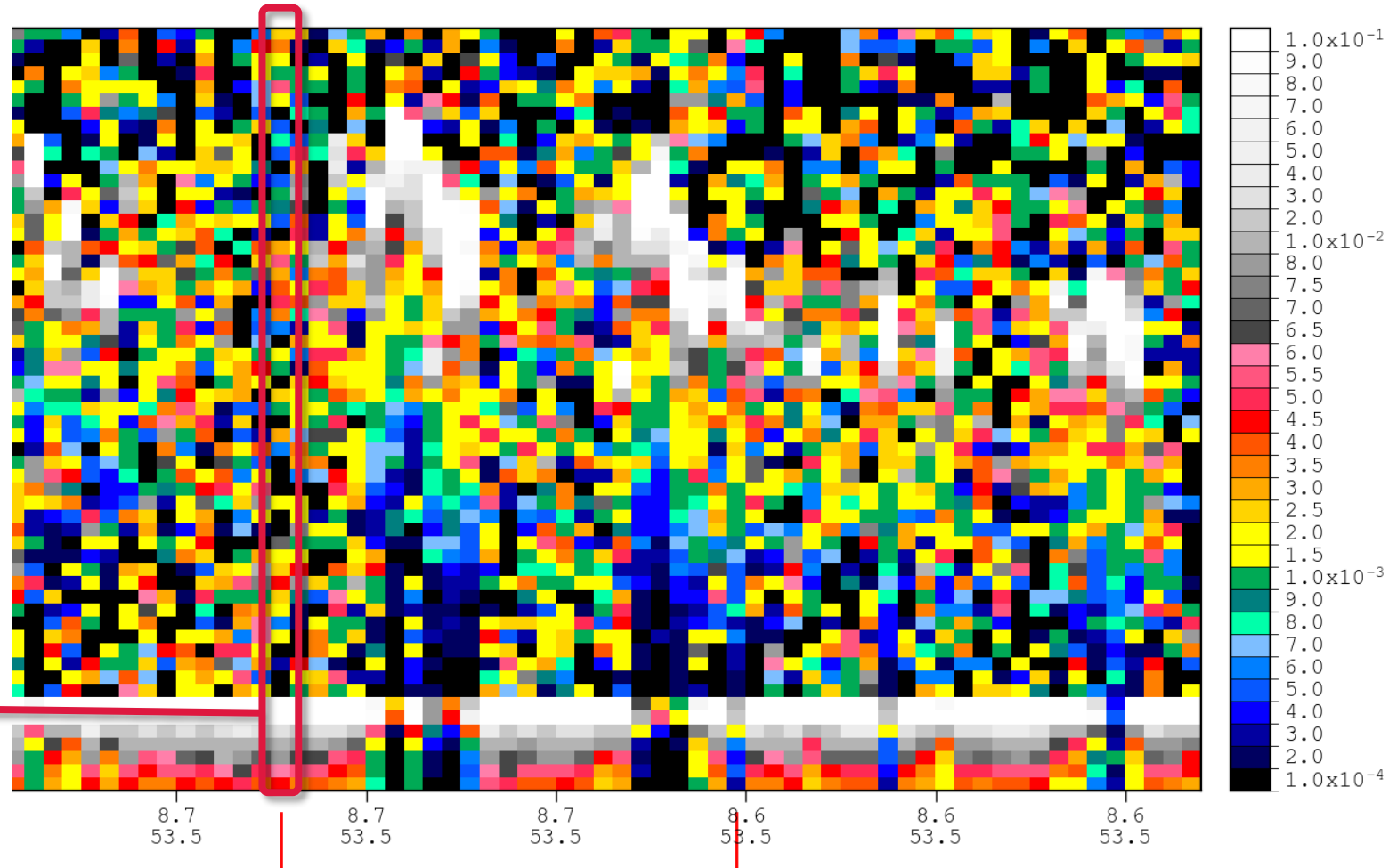
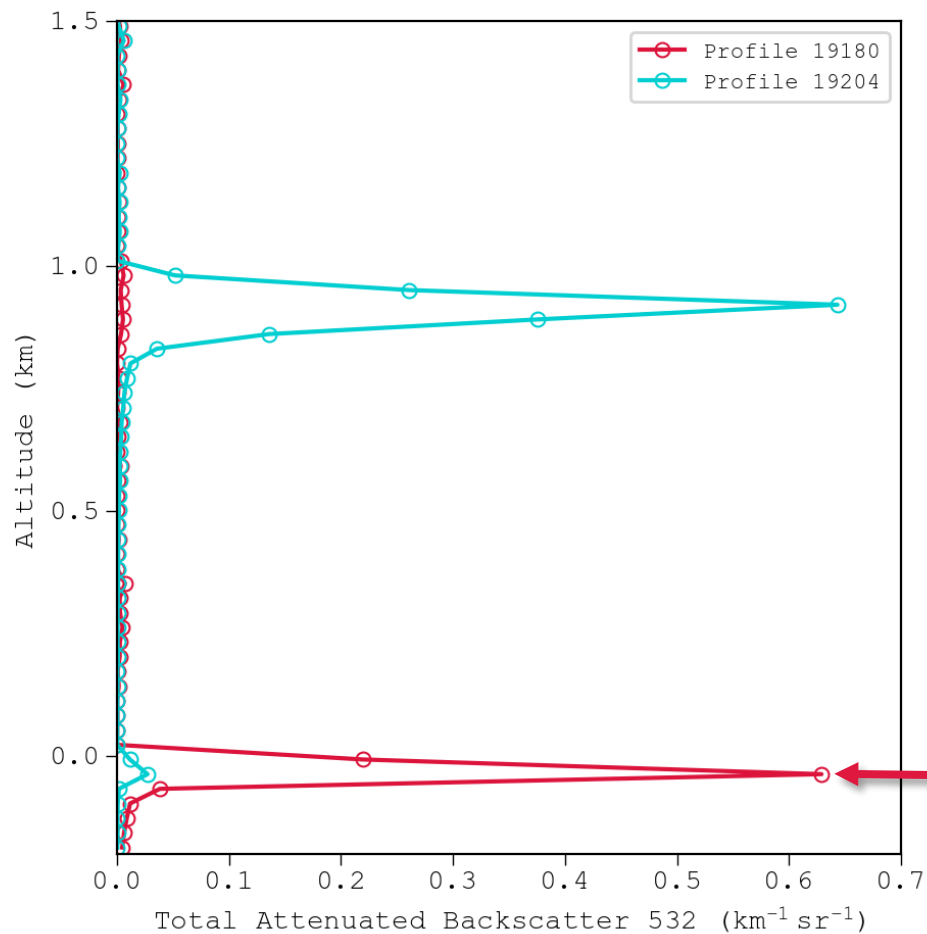
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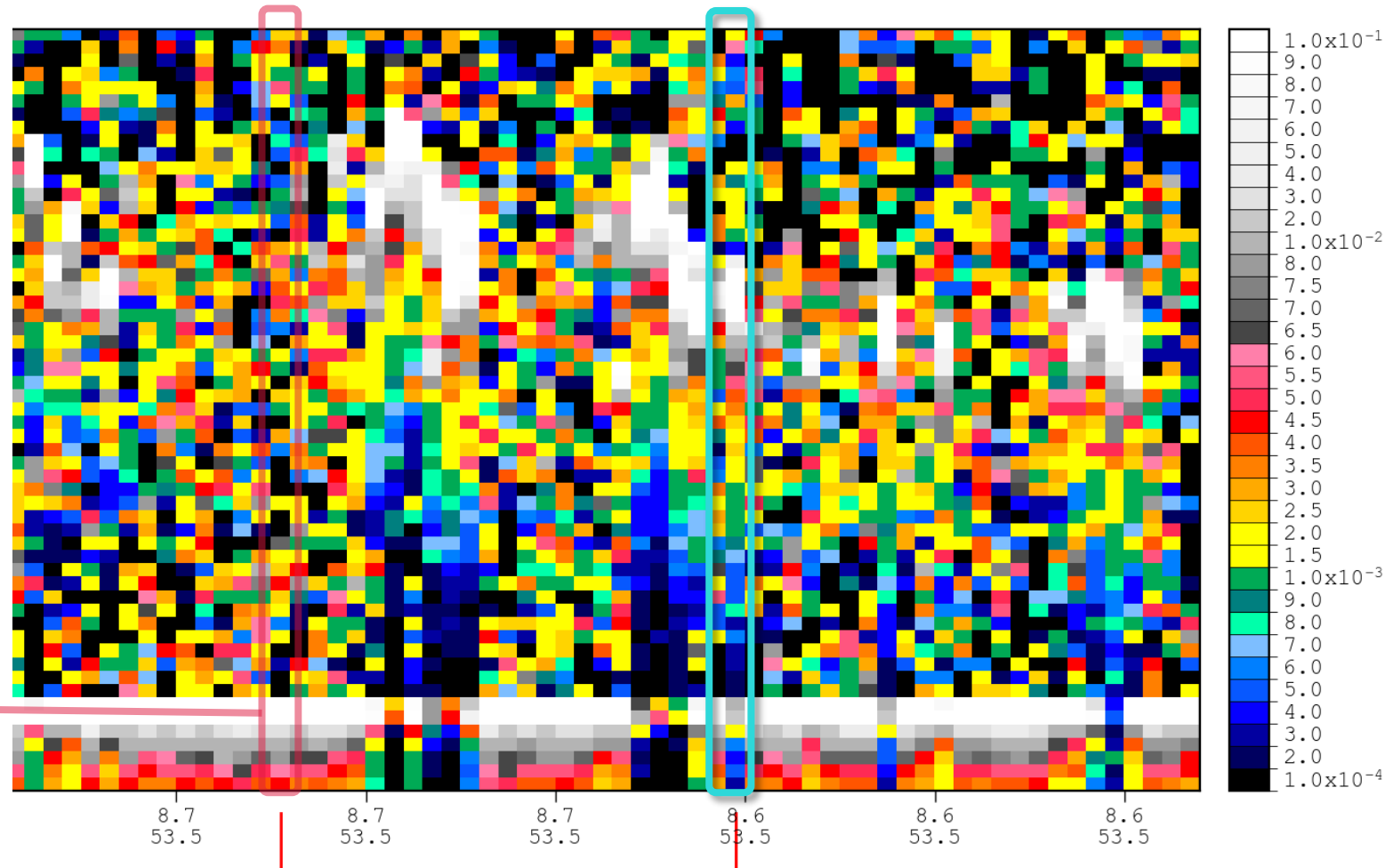
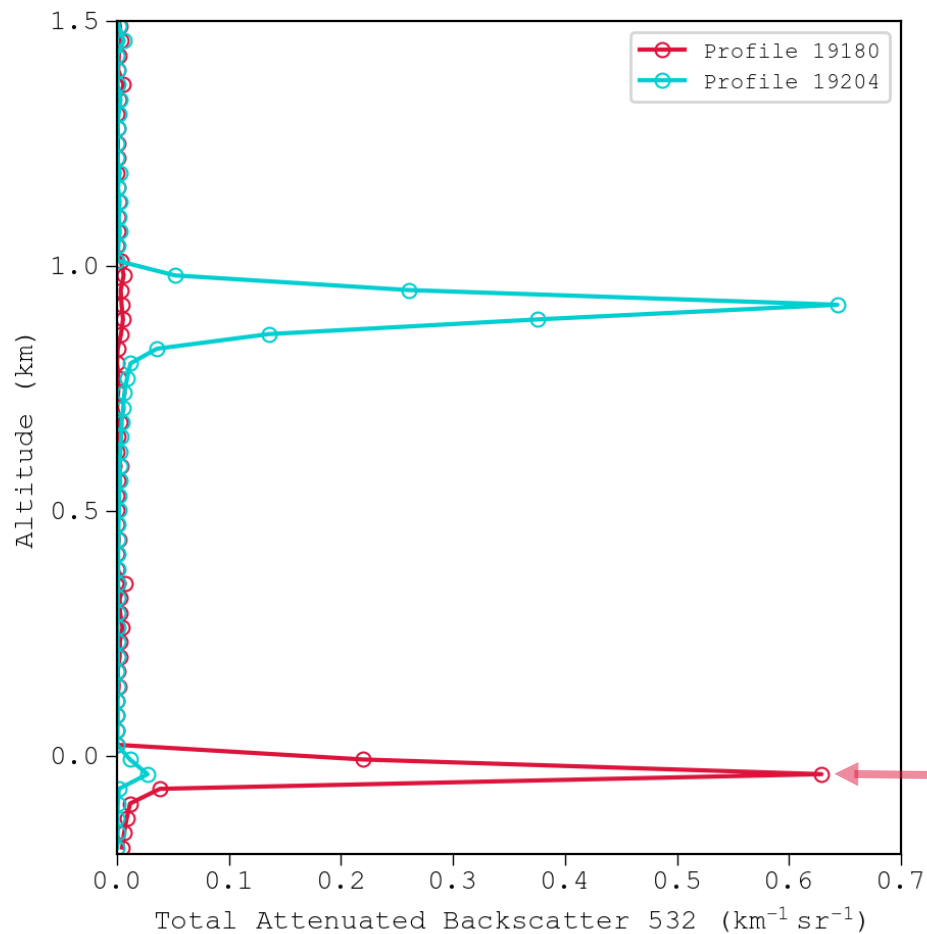
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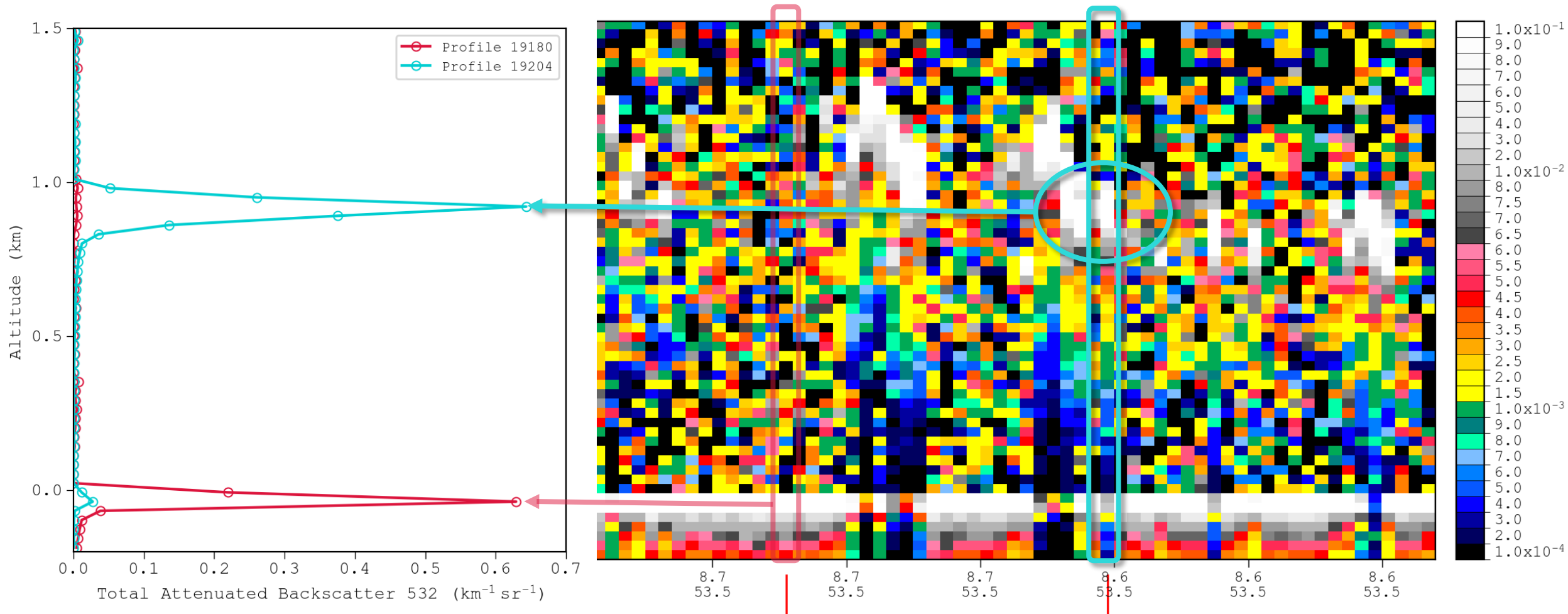
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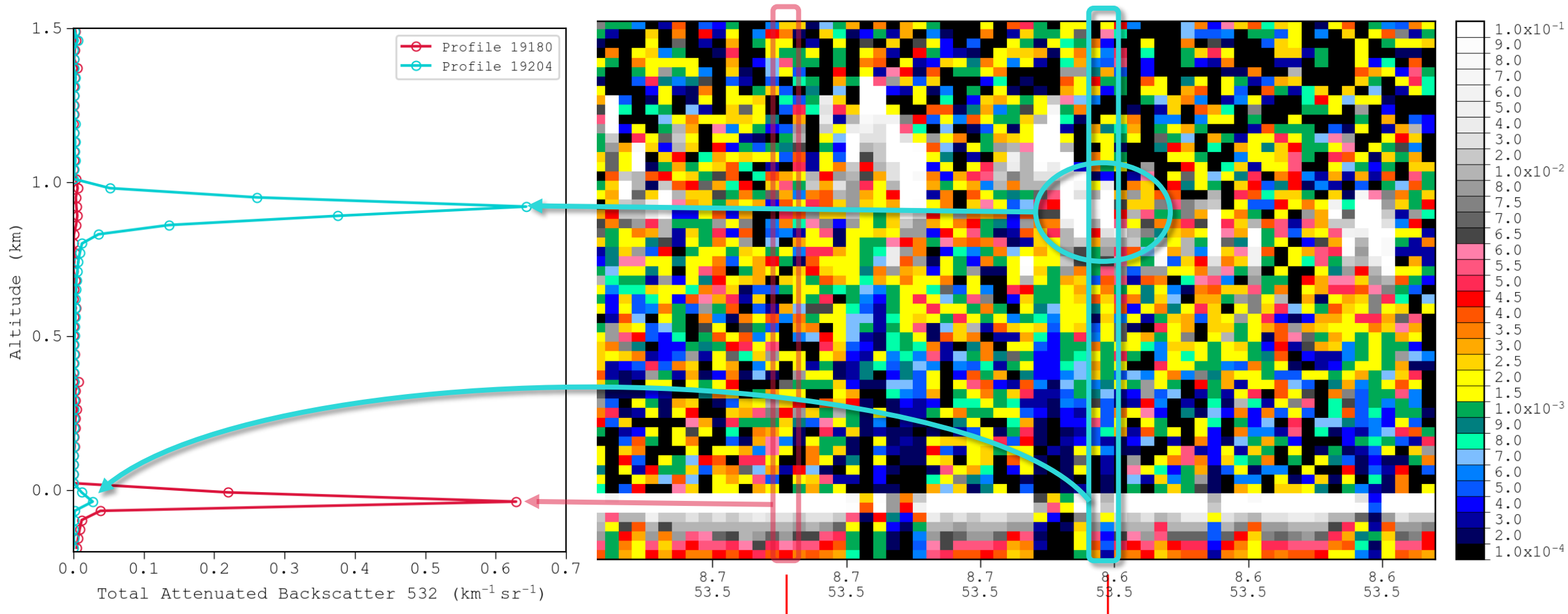
The Technique

Clouds and/or aerosols above the surface attenuate the signal, resulting in a notably smaller ocean backscatter return.



The Technique

Clouds and/or aerosols above the surface attenuate the signal, resulting in a notably smaller ocean backscatter return.





The Technique

- The ocean backscatter return is modeled from lab measurements by a fit function.
- The data is **ALIGNED** with the model and **SCALED** to match.
- The area under the modeled curve is only a function of the scale factor used to fit the surface spike which is found iteratively.

The Technique

- The two-way transmittance is a function of the area and the ocean surface retro reflectance (OSRR).

$$T^2 = \frac{2 \cdot A_C}{c \cdot O_{SRR} \cdot T_{mol}^2 \cdot T_{O_3}^2}$$

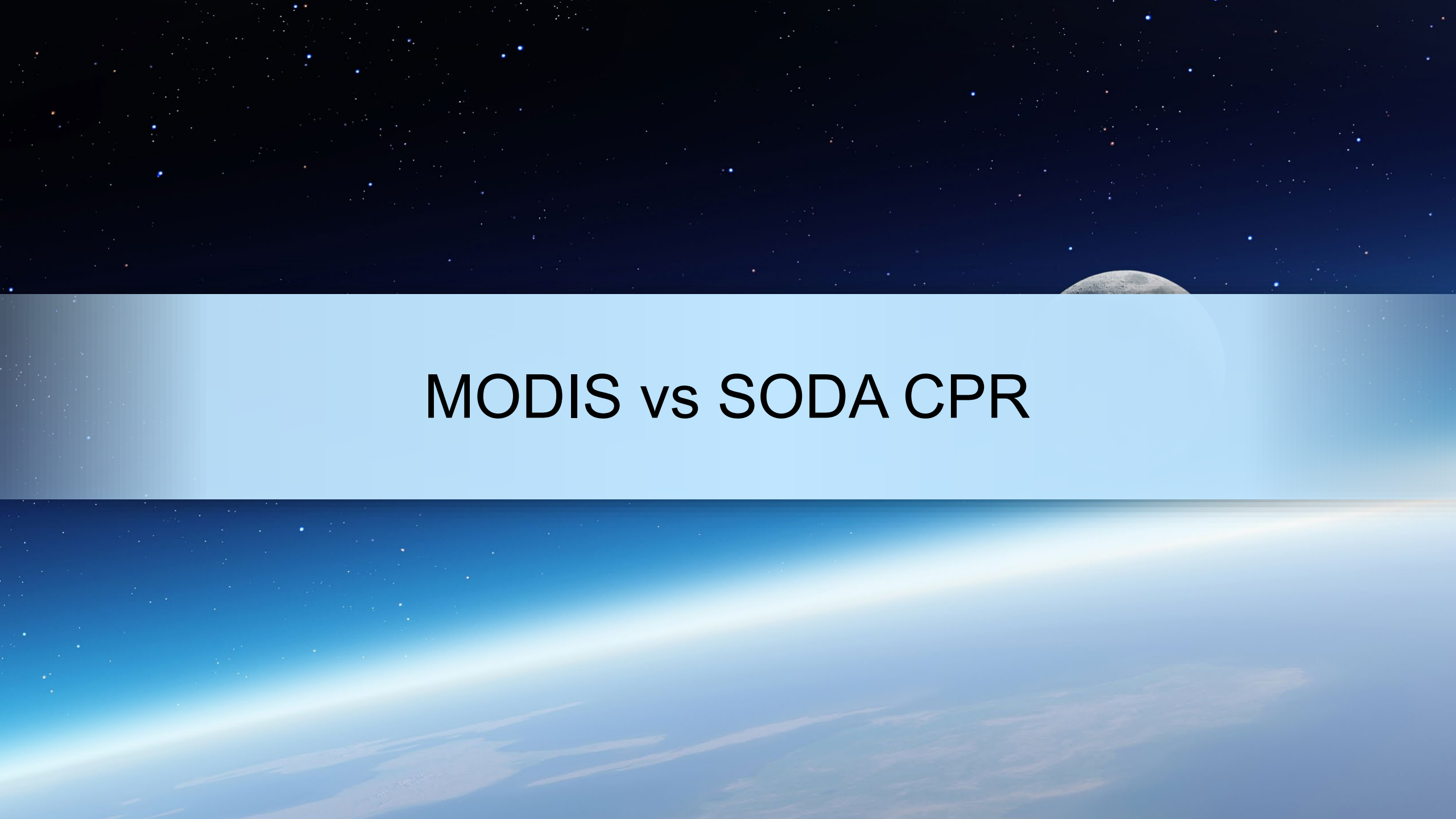
- The OSRR is a function of the whitecap fraction (W), and the Fresnel Reflectance of the Ocean Surface (R_λ).

$$O_{SRR} = (1 - W)R_\lambda + 0.2W$$

The Technique

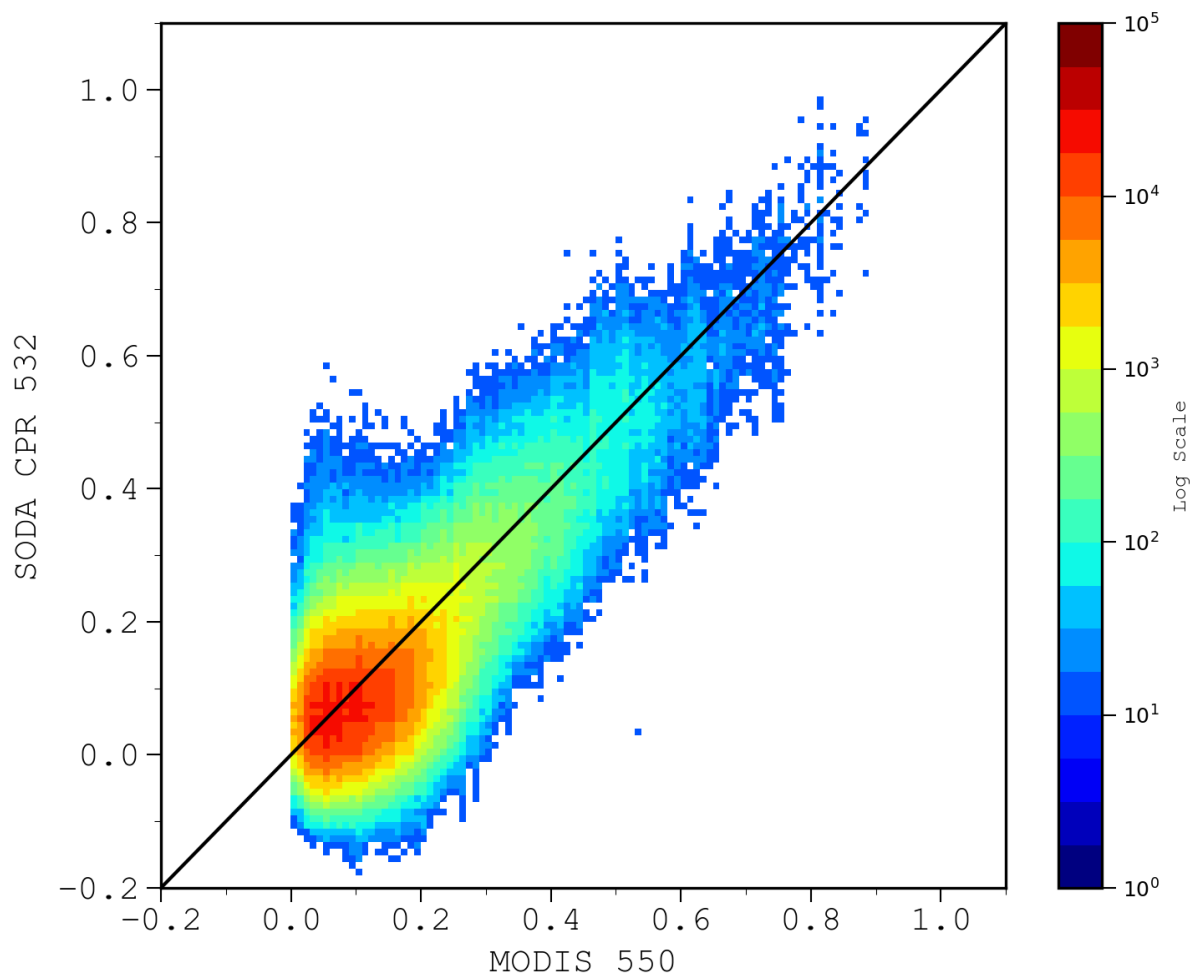
- W and R_λ are only a function of wind speed (obtained from MERRA-2).
- Optical depth is calculated from two-way transmittance.

Venkata, S. and Reagan, J.: Aerosol Retrievals from CALIPSO Lidar Ocean Surface Returns Remote Sens., 8, 1006, <https://doi.org/10.3390/rs8121006>, 2016.

The background of the slide is a composite image of space. The top half shows a dark blue sky filled with numerous small, distant stars. A thin, grey crescent moon is visible on the right side, partially obscured by the light blue banner. The bottom half of the image shows the Earth's horizon, with a bright blue atmospheric glow and a view of the planet's surface, including landmasses and clouds.

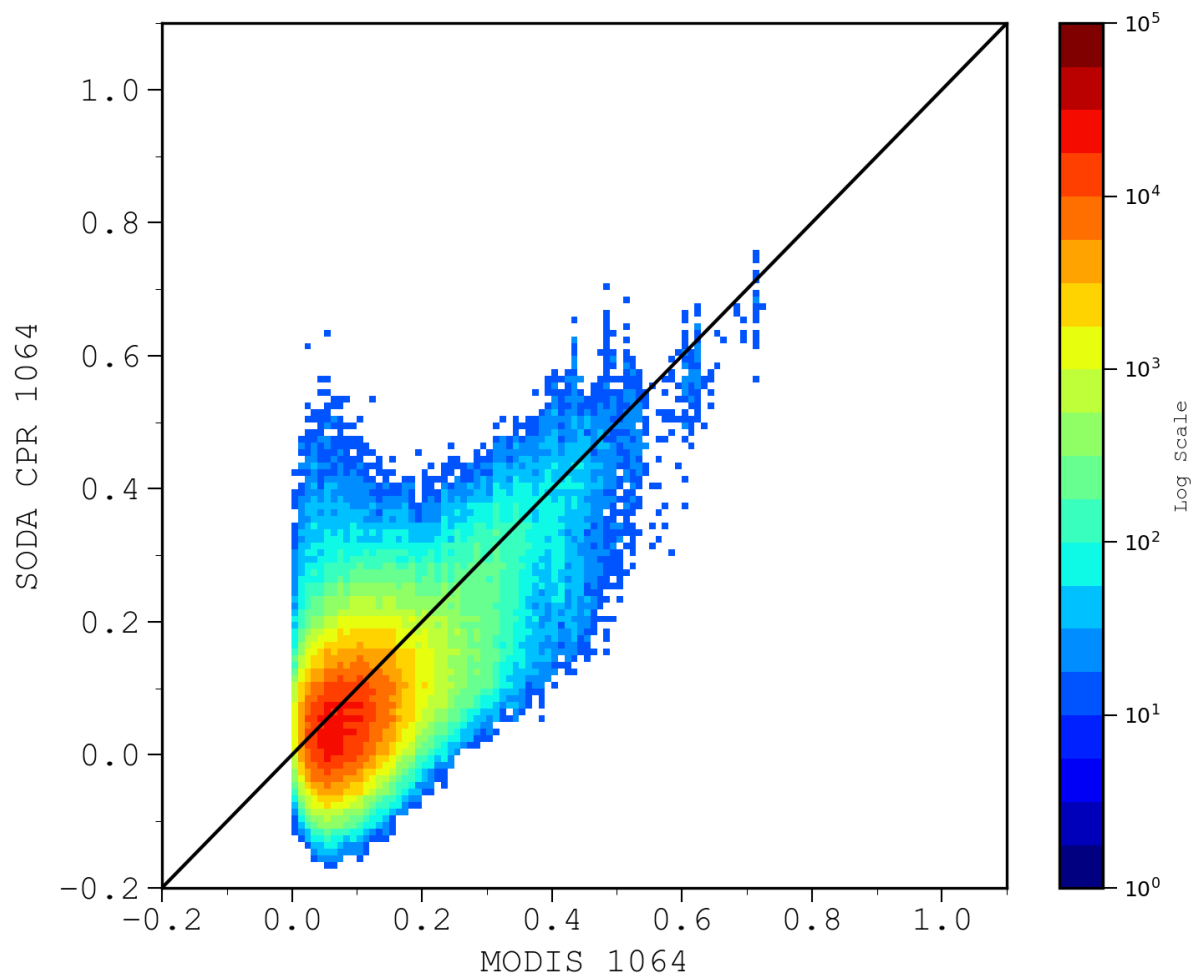
MODIS vs SODA CPR

MODIS 550 compared to SODA CPR 532
(Daytime Clear Air and Aerosols Only)



Created on: 2021-04-03T15:16:53
Created by: CALIPSO_Workshop/plot_hists:makeSpecialModis()

MODIS 1064 compared to SODA CPR 1064
(Daytime Clear Air and Aerosols Only)



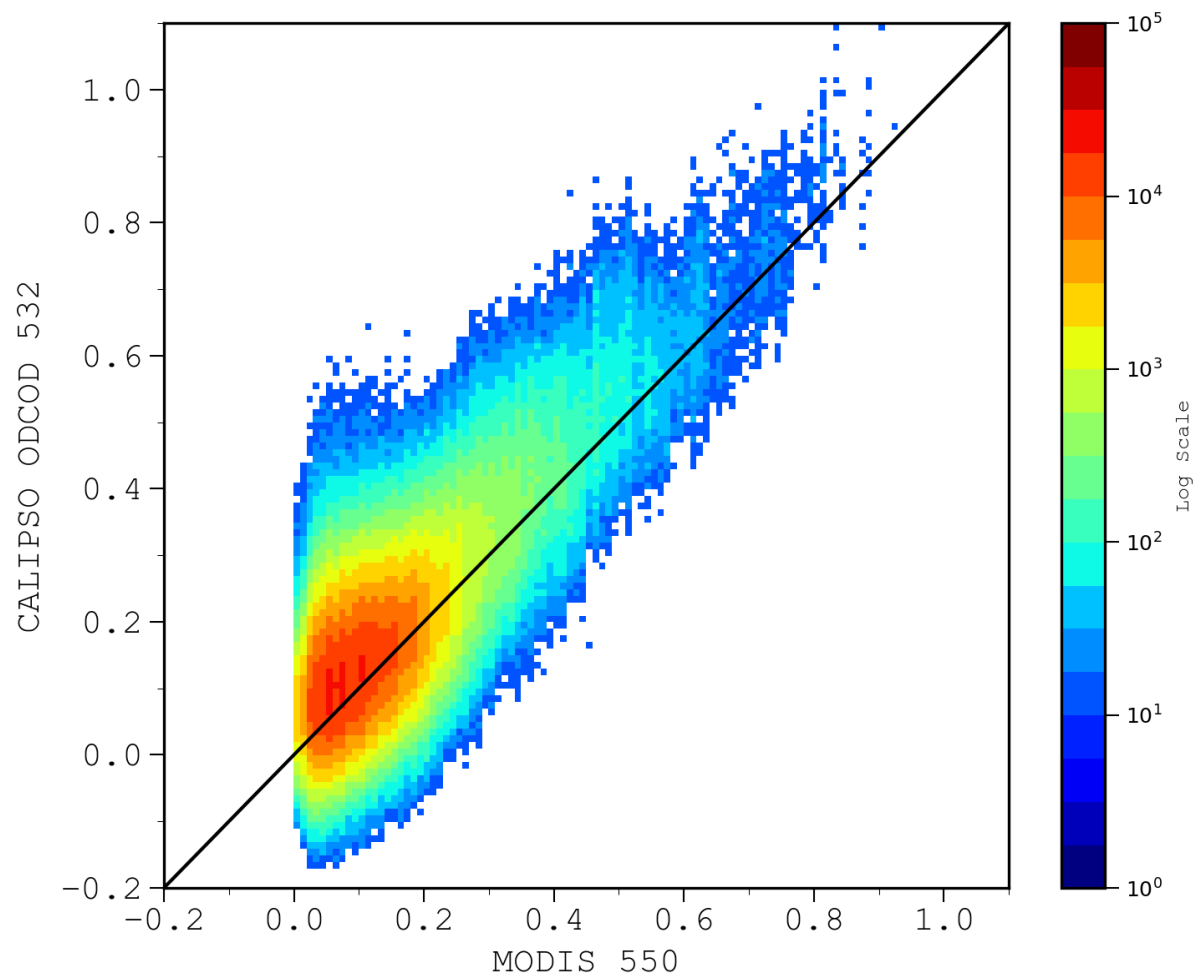
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May, June, July, and August 2008 All Single Shot Profiles

The background of the slide is a composite image of space. The top half shows a dark blue sky filled with numerous small, distant stars. A thin, grey crescent moon is visible on the right side, partially obscured by the top edge of a light blue horizontal band. The bottom half of the slide shows the Earth's horizon, with a bright blue atmospheric glow and a view of the planet's surface, including landmasses and clouds, seen from space.

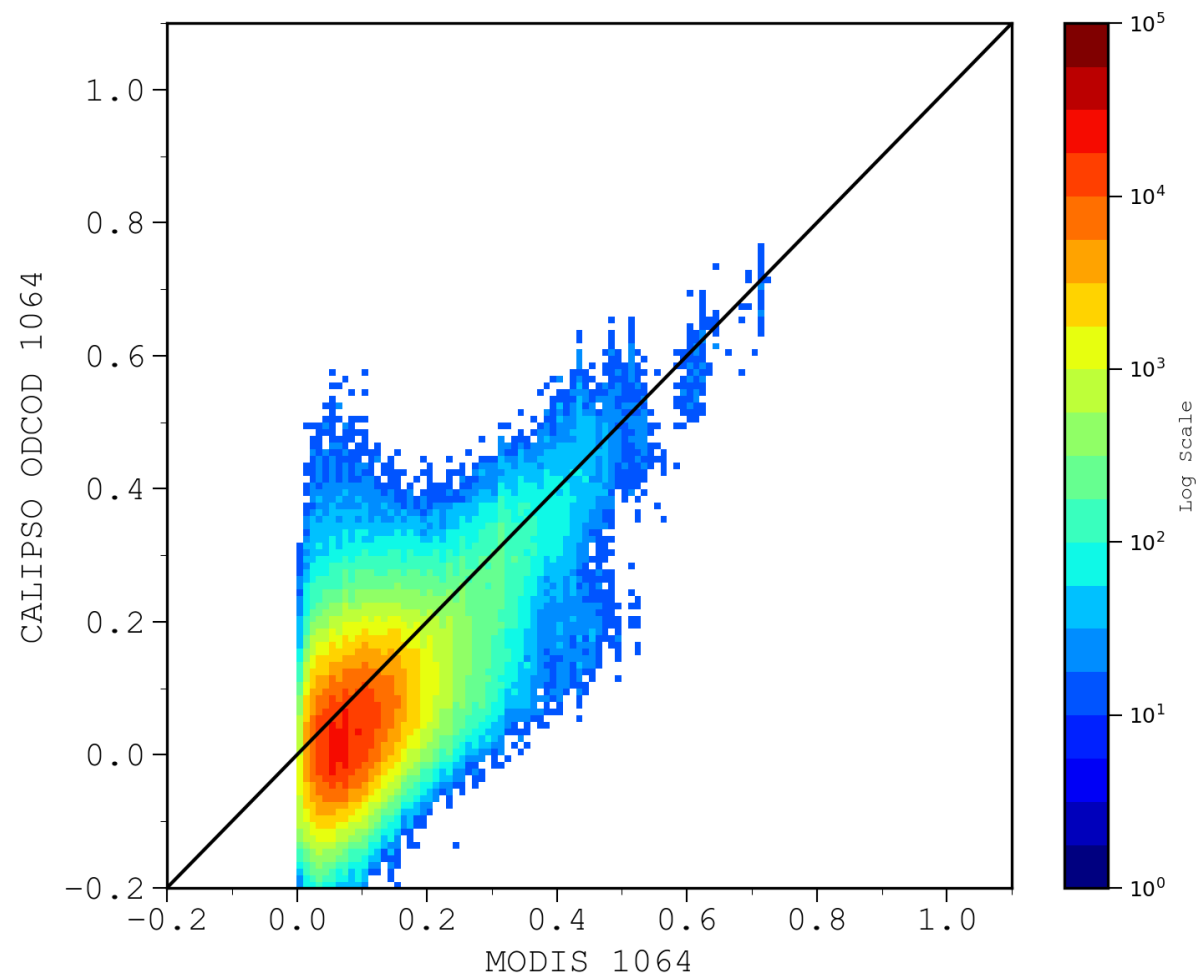
MODIS vs CALIPSO ODCOD

MODIS 550 compared to CALIPSO ODCOD 532
(Daytime Clear Air and Aerosols Only)



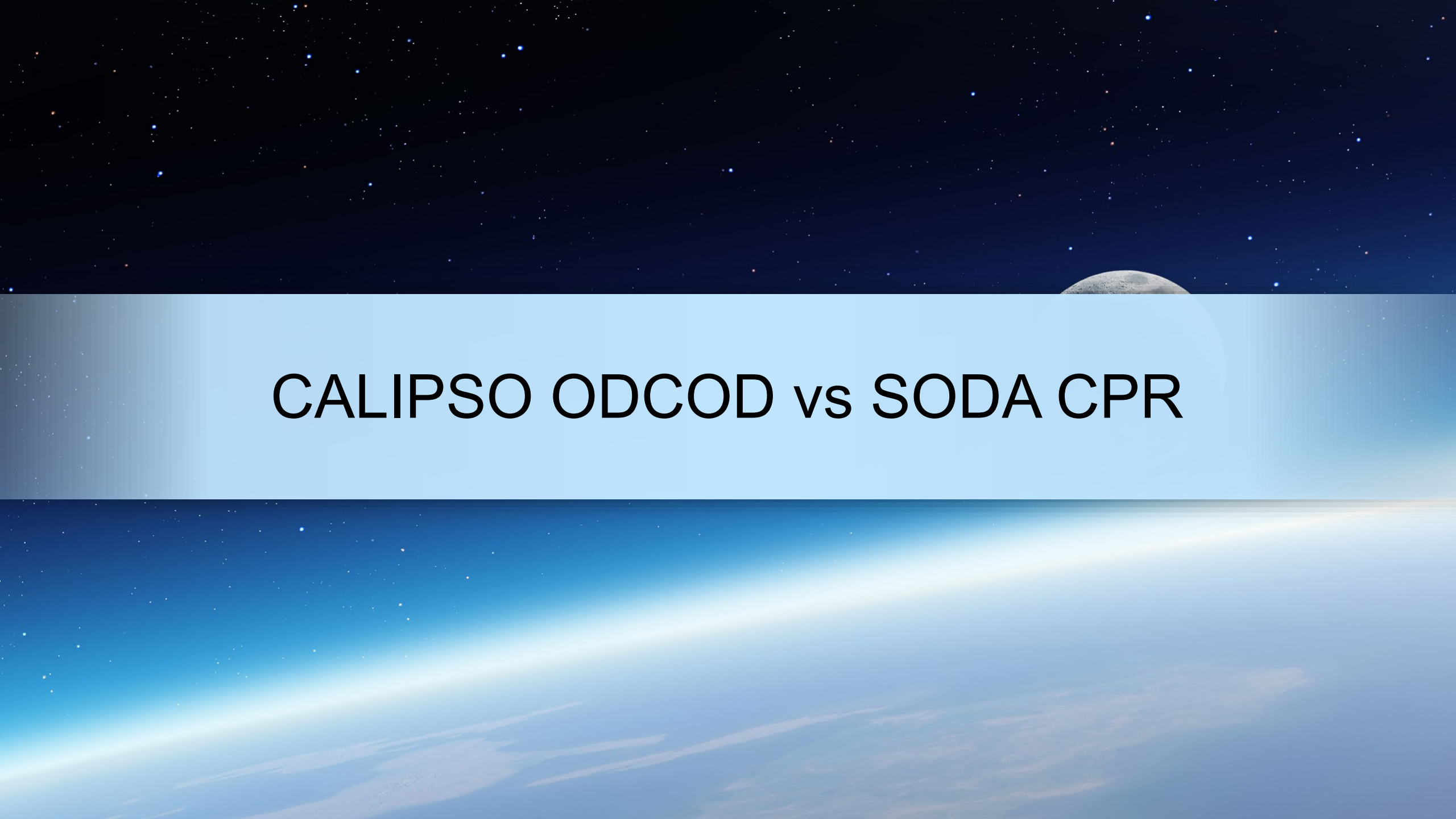
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MODIS 1064 compared to CALIPSO ODCOD 1064
(Daytime Clear Air and Aerosols Only)



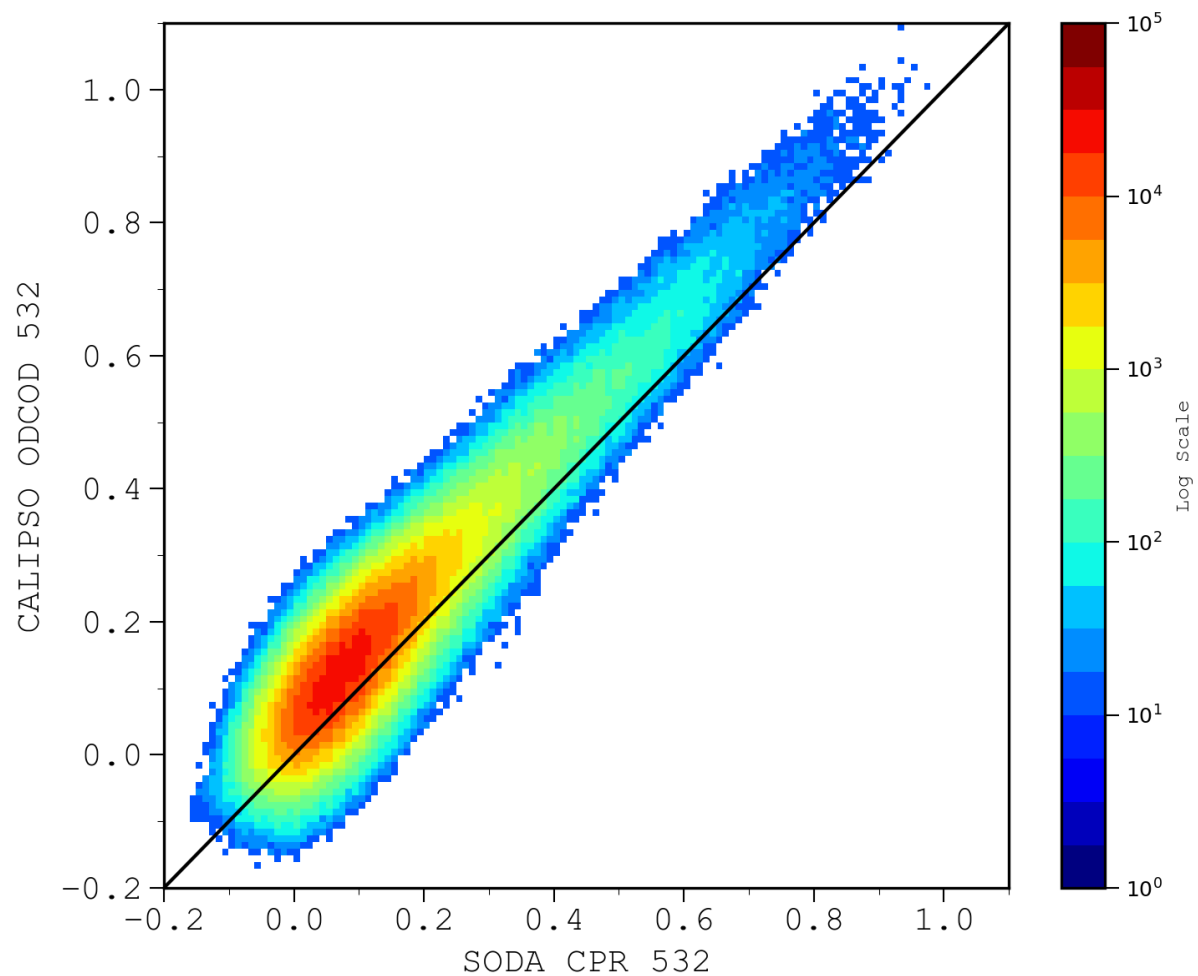
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May, June, July, and August 2008 All Single Shot Profiles

The background of the slide is a composite image of space. The top half shows a dark blue night sky filled with numerous small, distant stars. On the right side, the grey, cratered surface of the Moon is partially visible. The bottom half of the image shows the bright blue horizon of Earth, with white clouds and the curvature of the planet visible against the blackness of space.

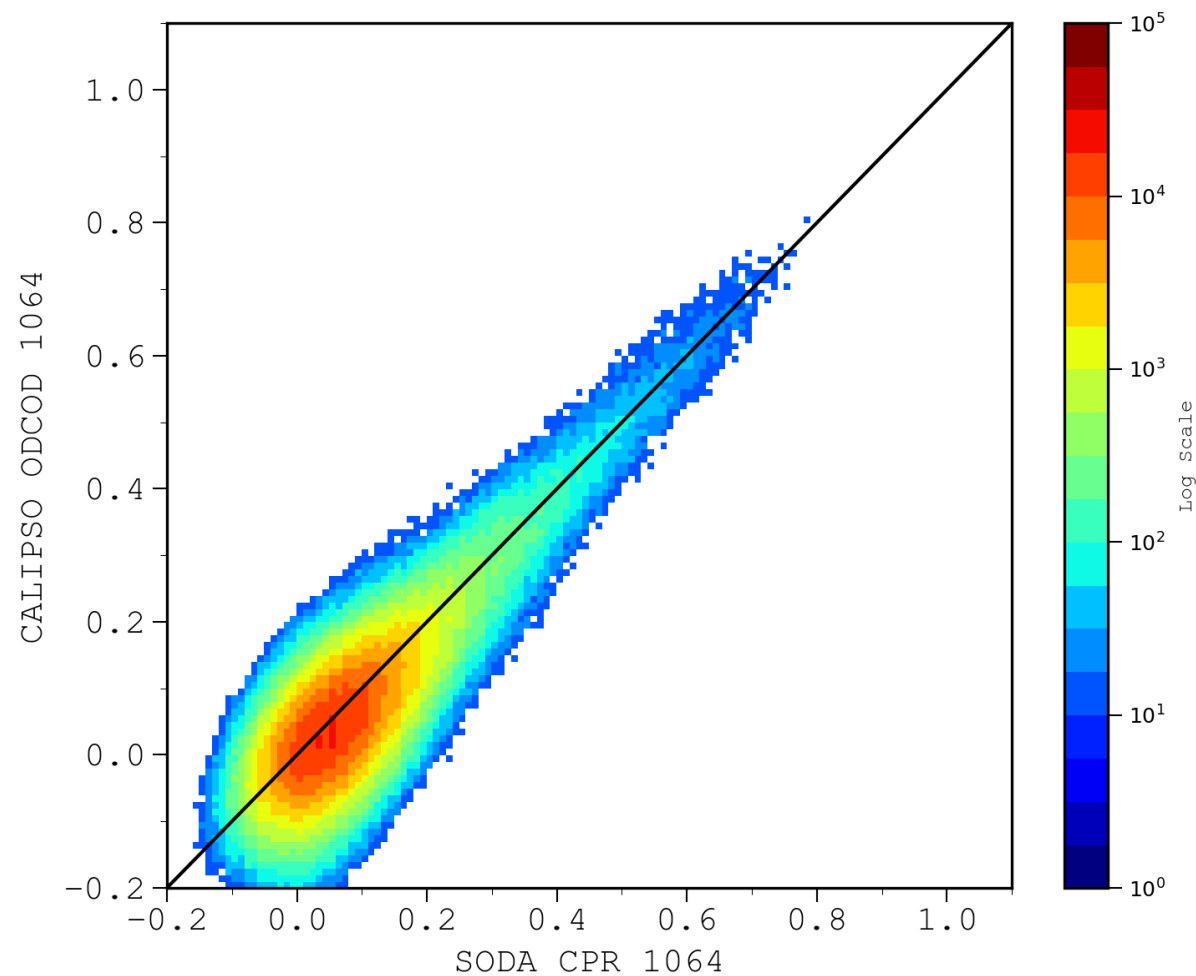
CALIPSO ODCOD vs SODA CPR

SODA CPR 532 compared to CALIPSO ODCOD 532
(Daytime Clear Air and Aerosols Only)



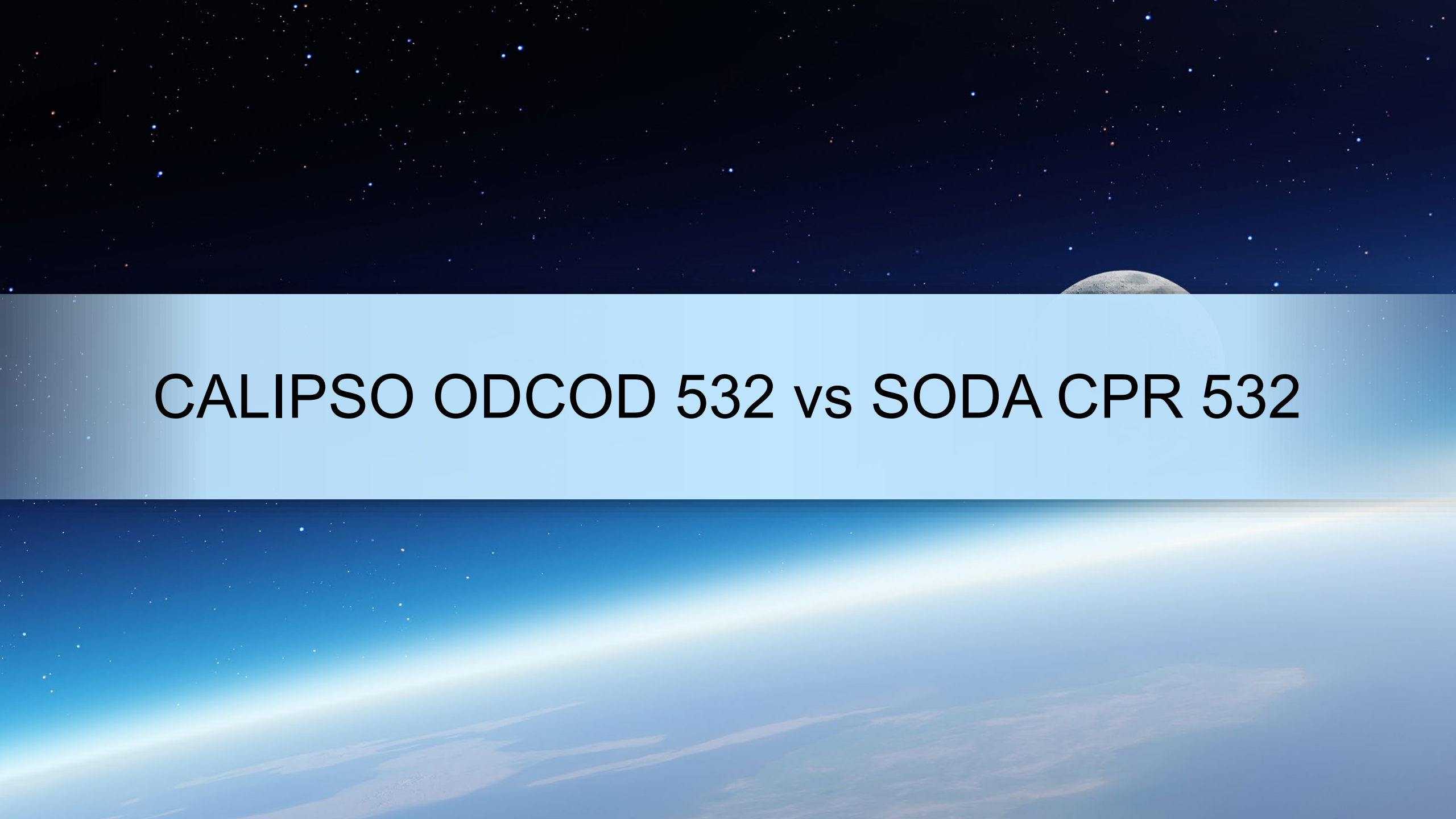
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SODA CPR 1064 compared to CALIPSO ODCOD 1064
(Daytime Clear Air and Aerosols Only)



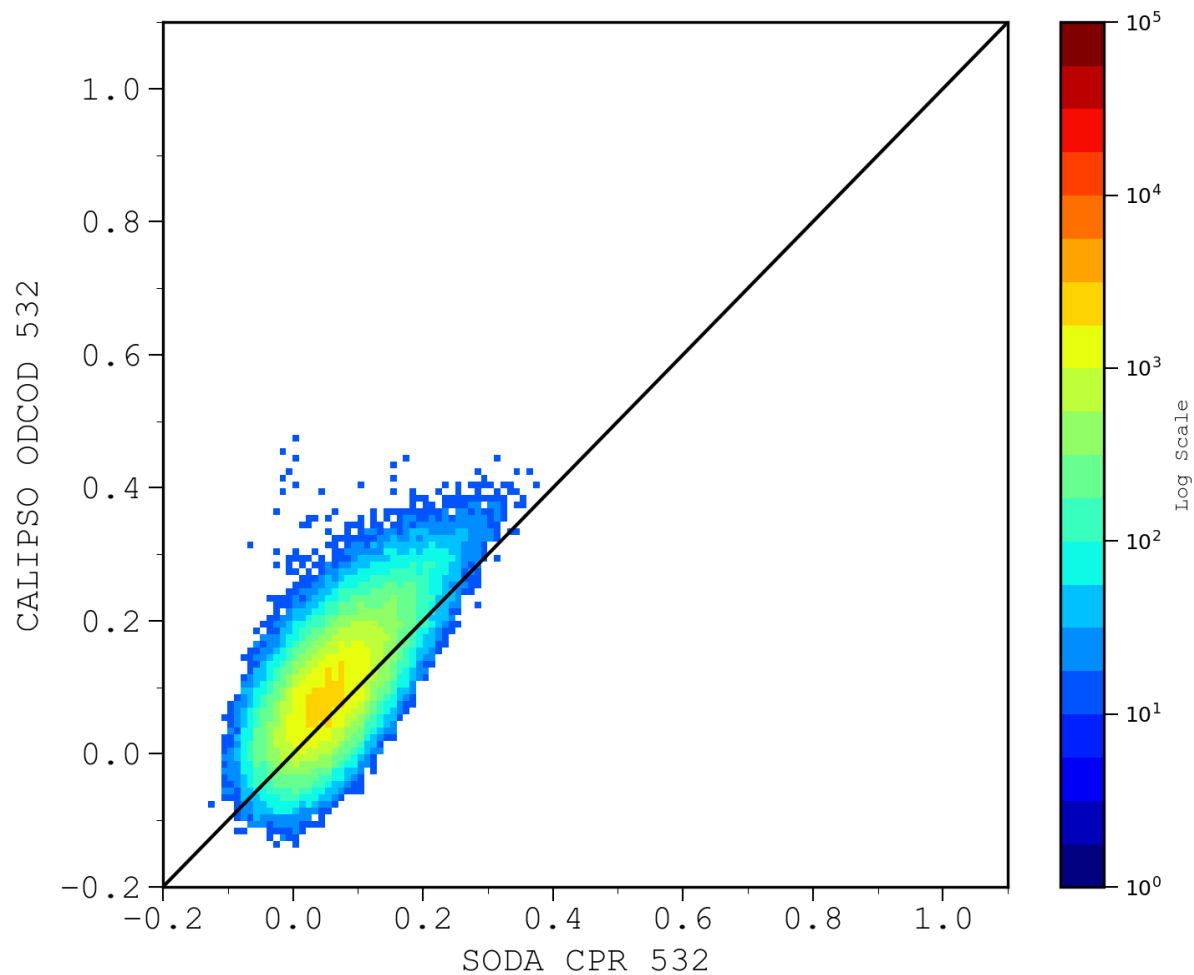
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May, June, July, and August 2008 All Single Shot Profiles

The background of the slide is a composite image of space. The top half shows a dark blue sky filled with numerous small, distant stars. A thin, grey crescent moon is visible on the right side, partially obscured by the light blue banner. The bottom half of the slide shows the Earth's horizon, with a bright blue glow from the sun or moon just below the horizon line, creating a lens flare effect. The Earth's surface is visible as a mix of blue oceans and brownish-green landmasses.

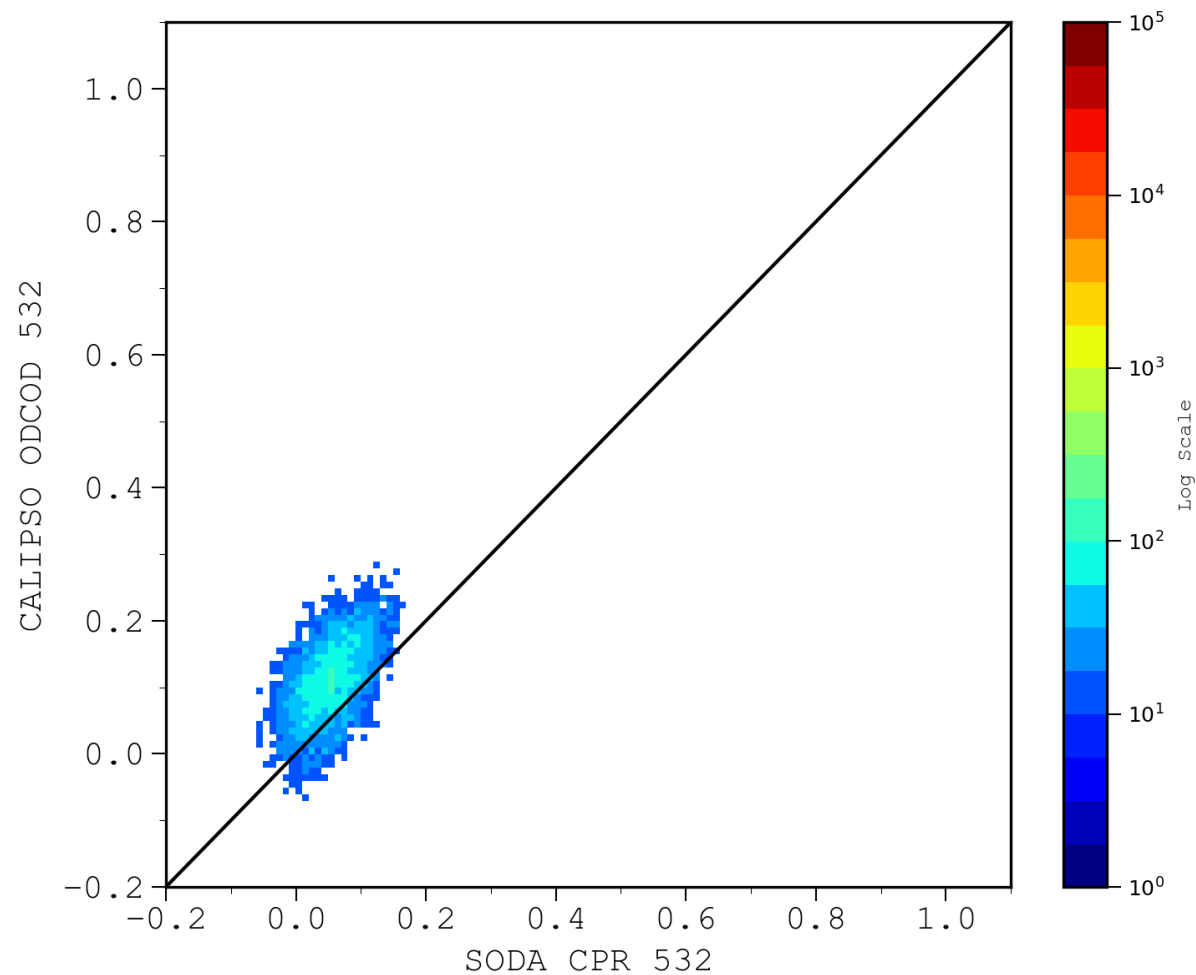
CALIPSO ODCOD 532 vs SODA CPR 532

SODA CPR 532 compared to CALIPSO ODCOD 532
(Daytime Clear Air)



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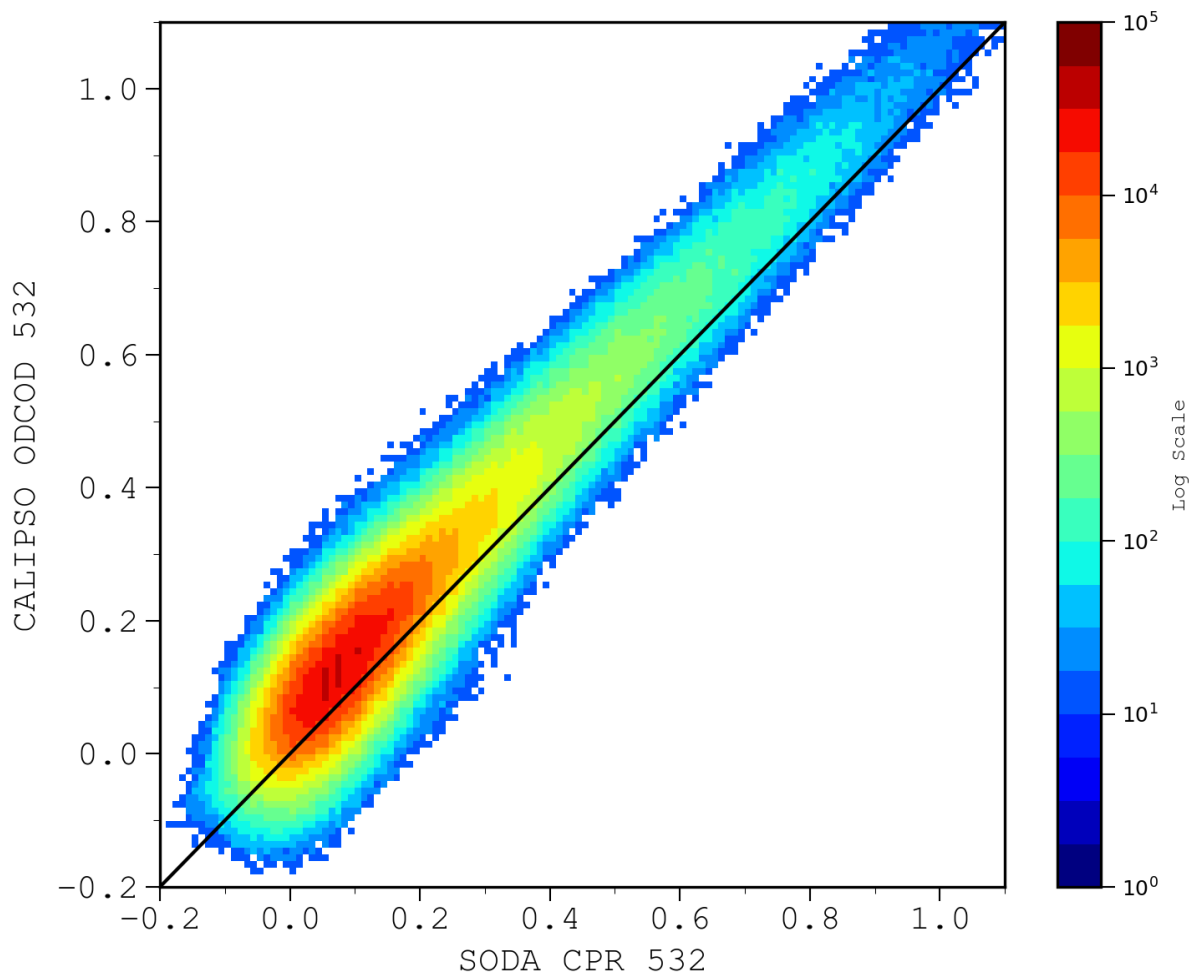
SODA CPR 532 compared to CALIPSO ODCOD 532
(Nighttime Clear Air)



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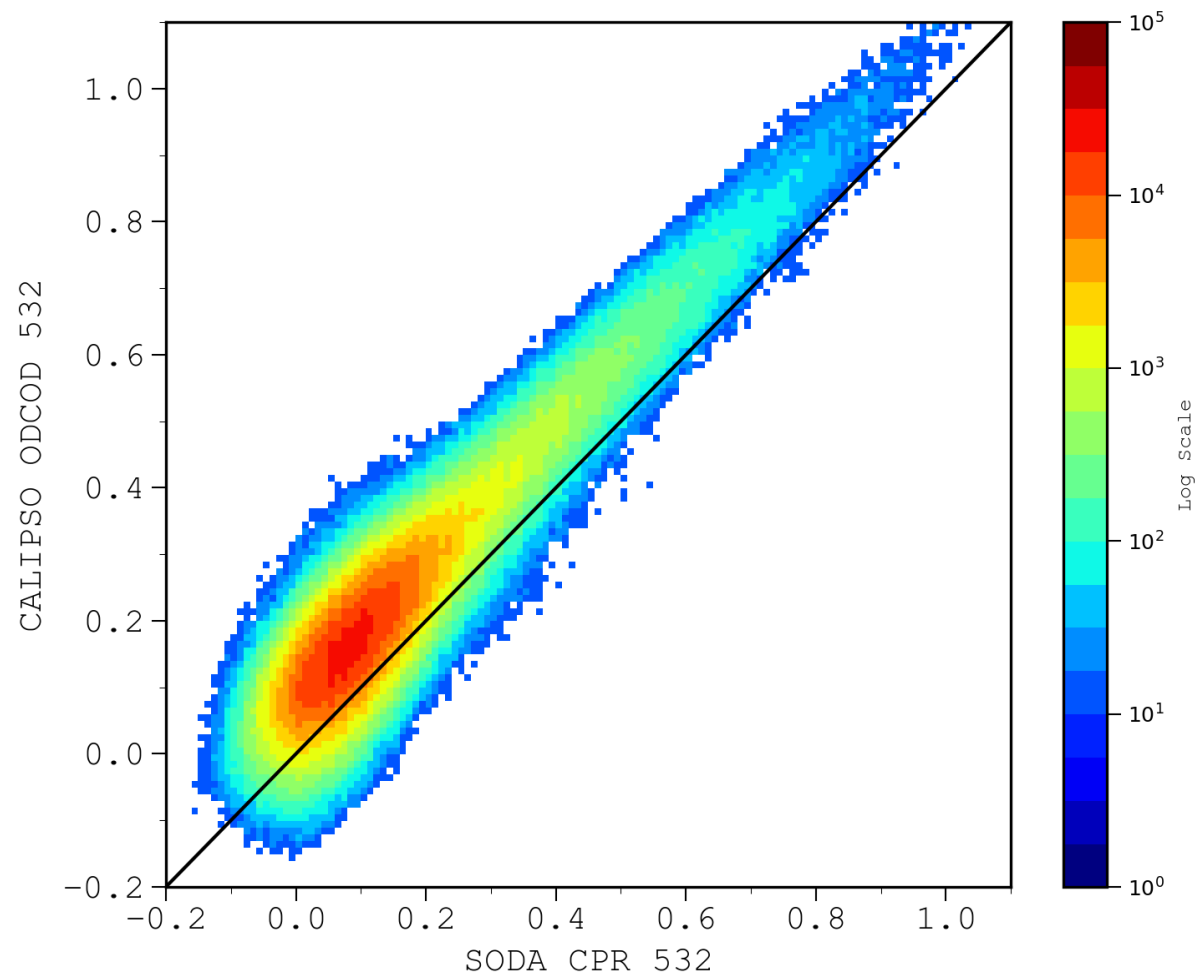
May, June, July, and August 2008 All Single Shot Profiles

SODA CPR 532 compared to CALIPSO ODCOD 532
(Daytime Aerosols Only)



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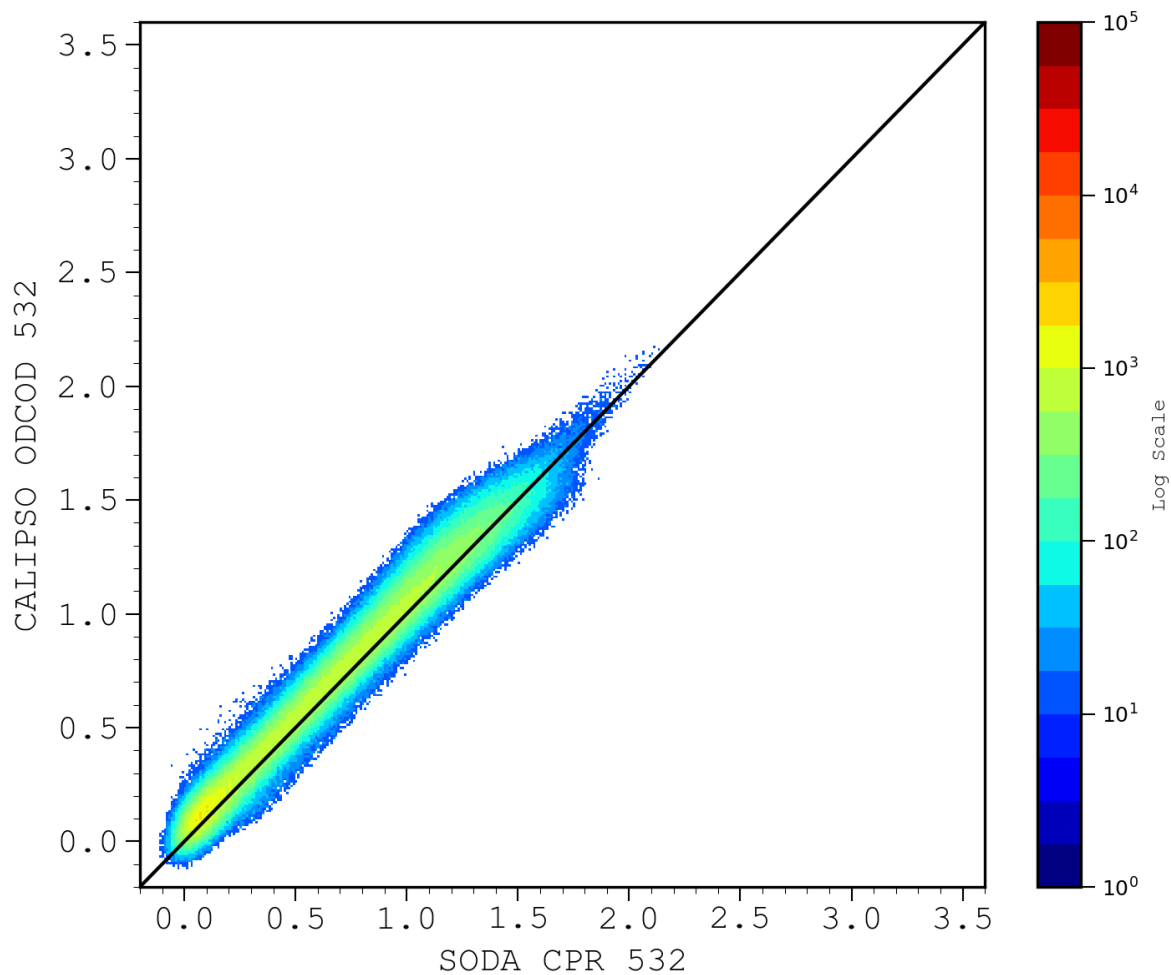
SODA CPR 532 compared to CALIPSO ODCOD 532
(Nighttime Aerosols Only)



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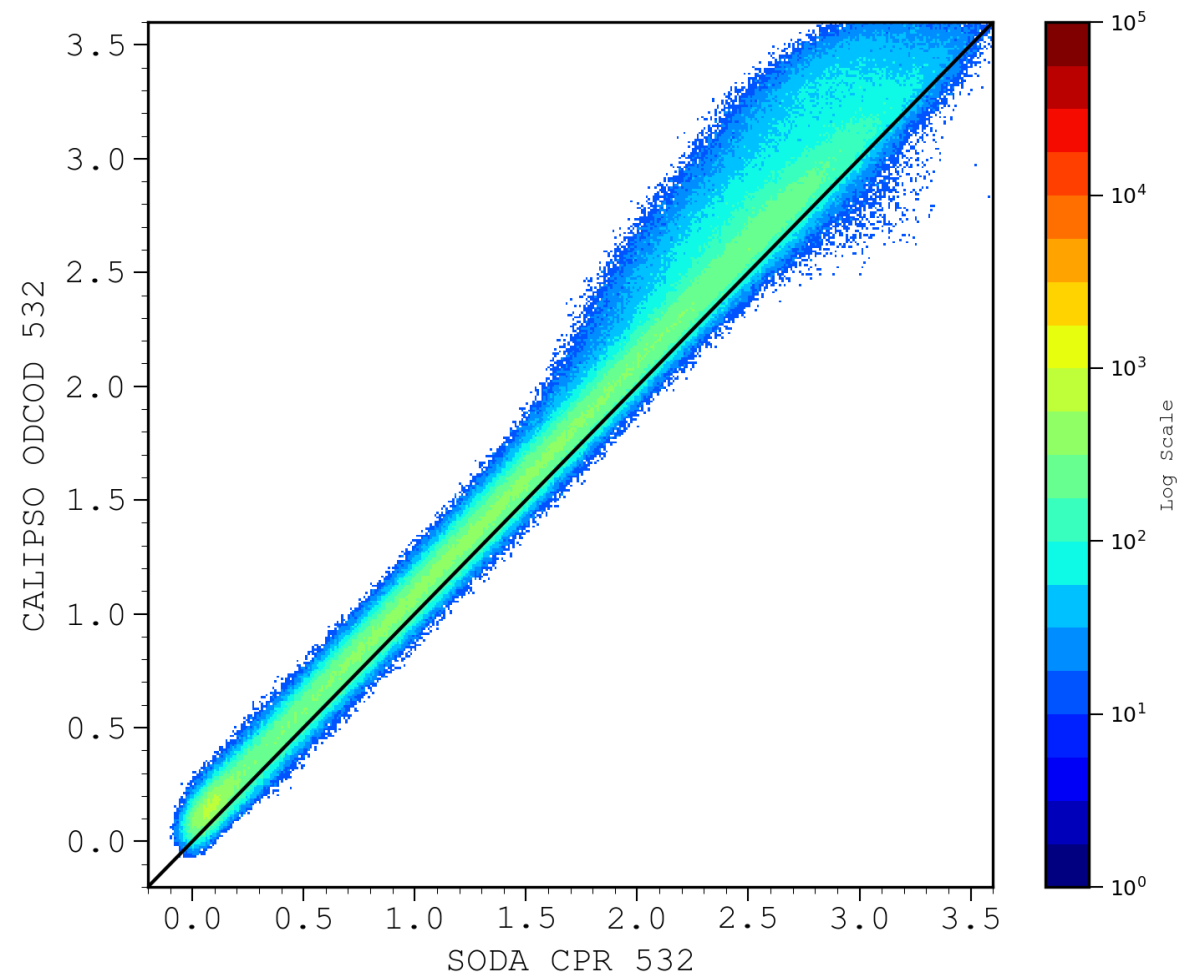
May, June, July, and August 2008 All Single Shot Profiles

SODA CPR 532 compared to CALIPSO ODCOD 532
(Daytime Clouds Only)



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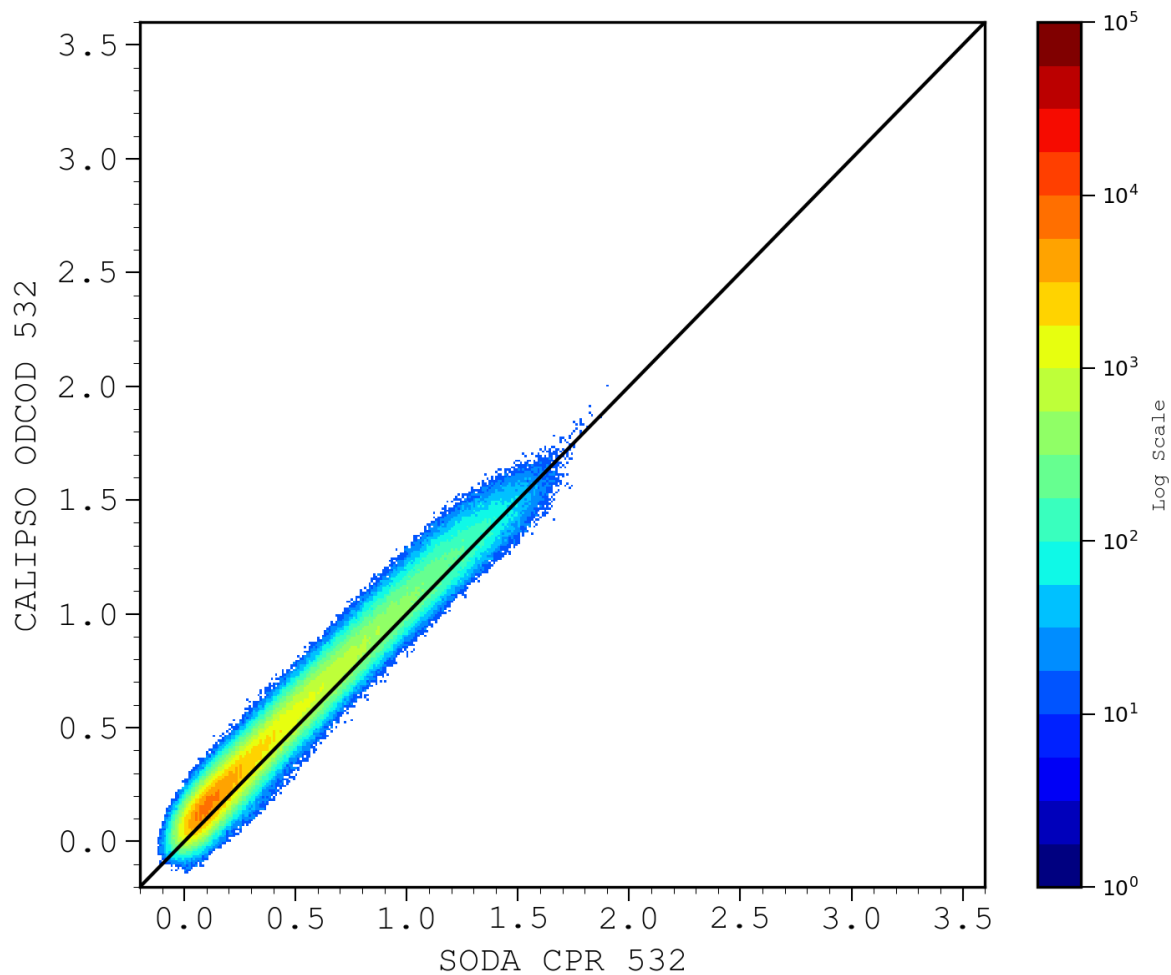
SODA CPR 532 compared to CALIPSO ODCOD 532
(Nighttime Clouds Only)



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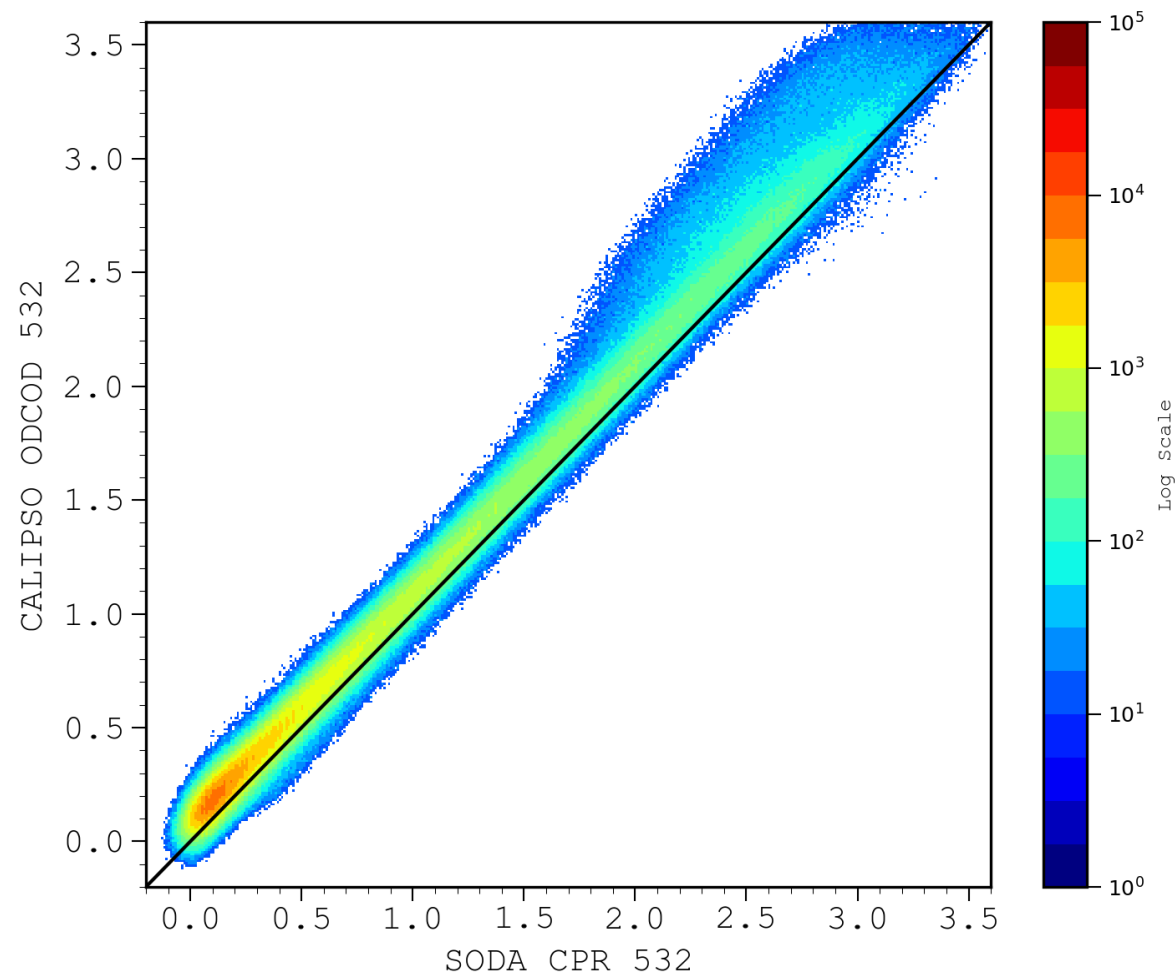
May, June, July, and August 2008 All Single Shot Profiles

SODA CPR 532 compared to CALIPSO ODCOD 532
(Daytime Clouds and Aerosols)



Created on: 2021-04-03T
Created by: CALIPSO_Workshop/plot_hists::makeSpecia

SODA CPR 532 compared to CALIPSO ODCOD 532
(Nighttime Clouds and Aerosols)



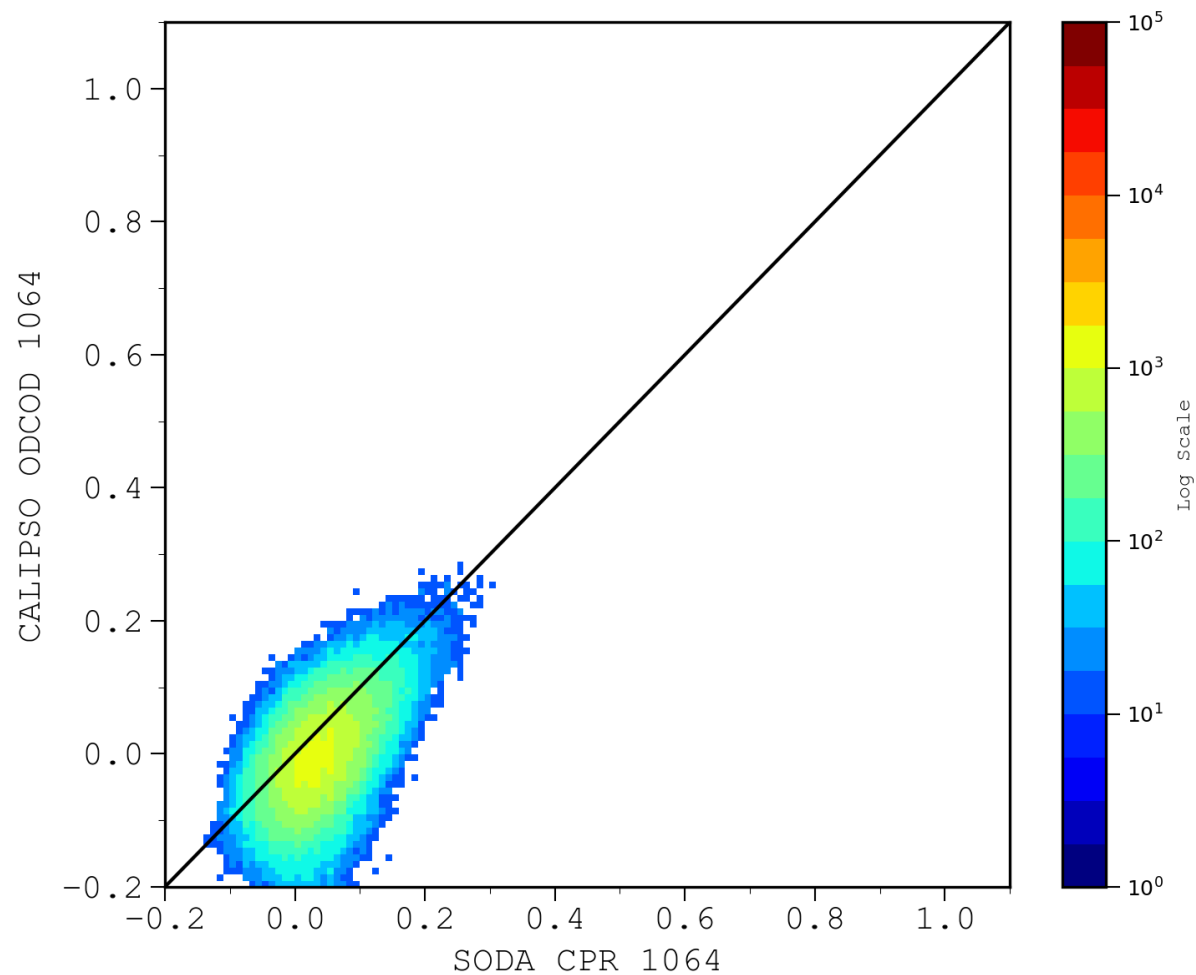
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May, June, July, and August 2008 All Single Shot Profiles

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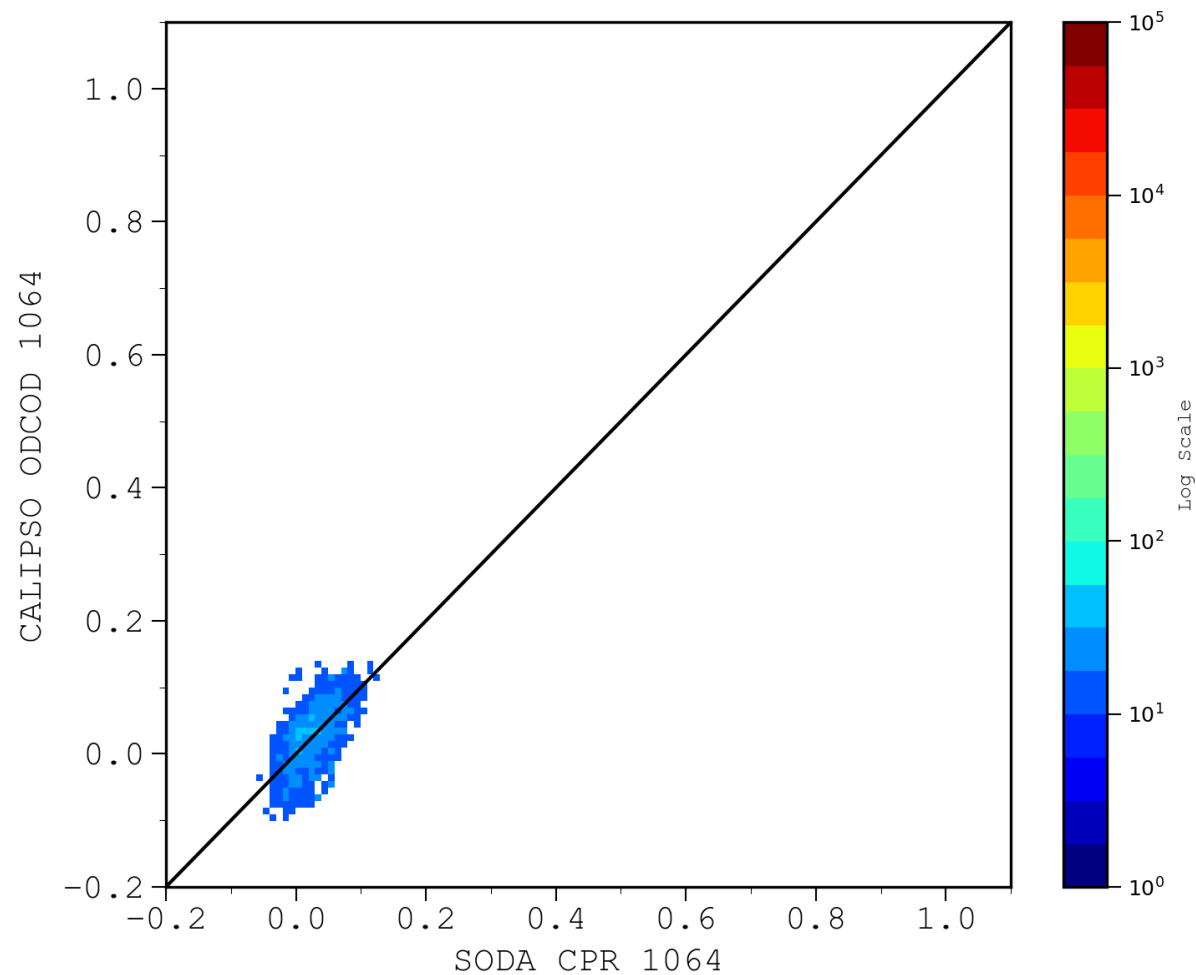
SODA CPR 1064

SODA CPR 1064 compared to CALIPSO ODCOD 1064
(Daytime Clear Air)



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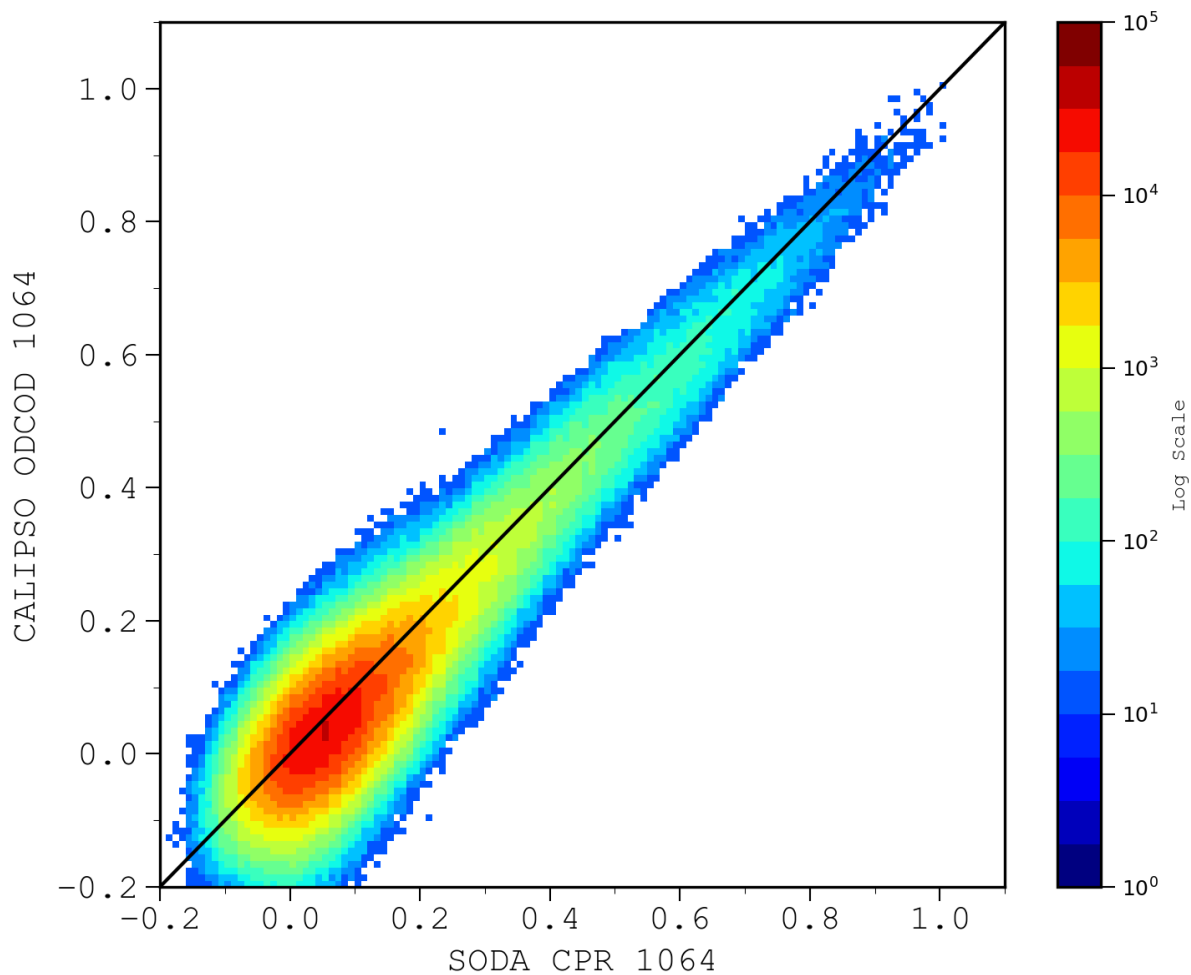
SODA CPR 1064 compared to CALIPSO ODCOD 1064
(Nighttime Clear Air)



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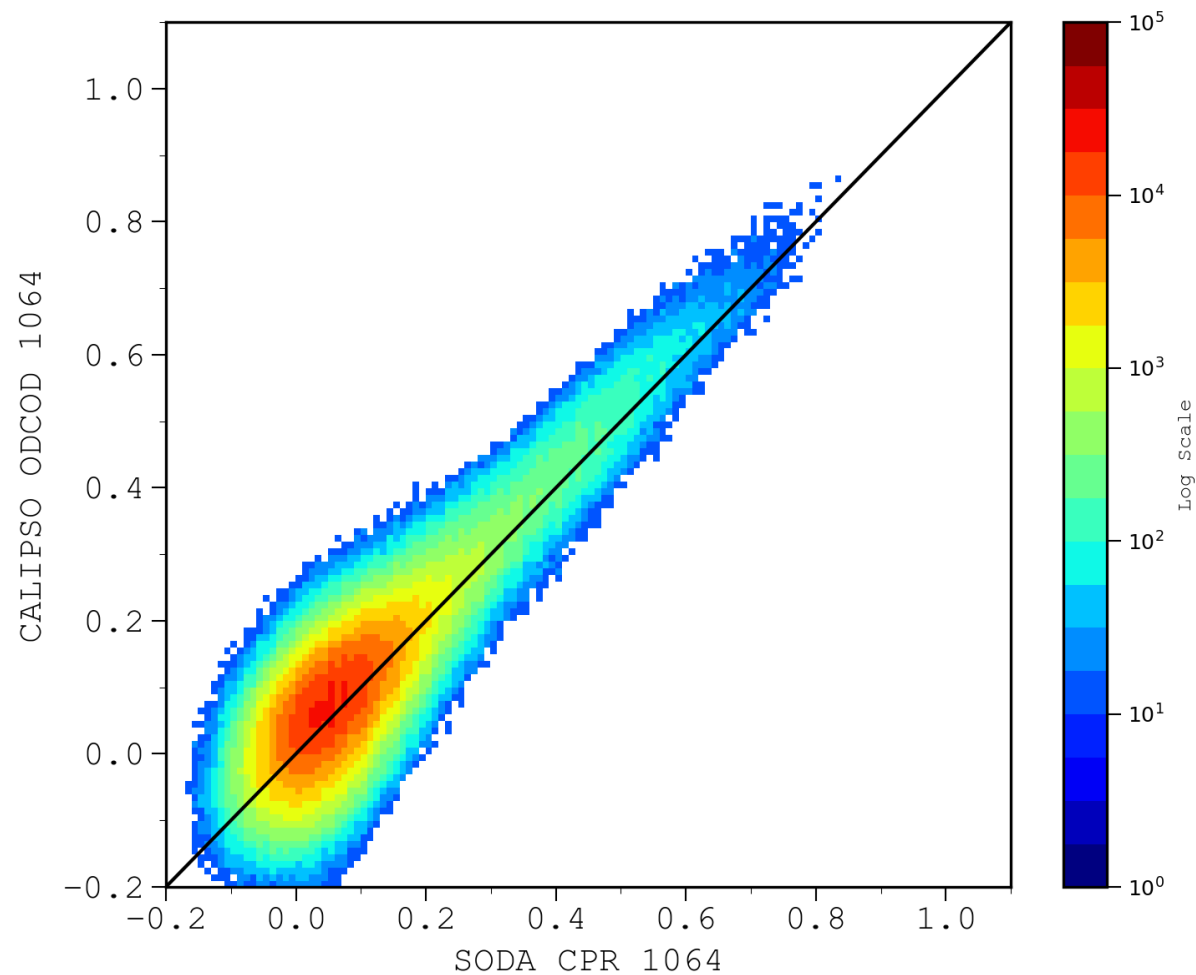
May, June, July, and August 2008 All Single Shot Profiles

SODA CPR 1064 compared to CALIPSO ODCOD 1064
(Daytime Aerosols Only)



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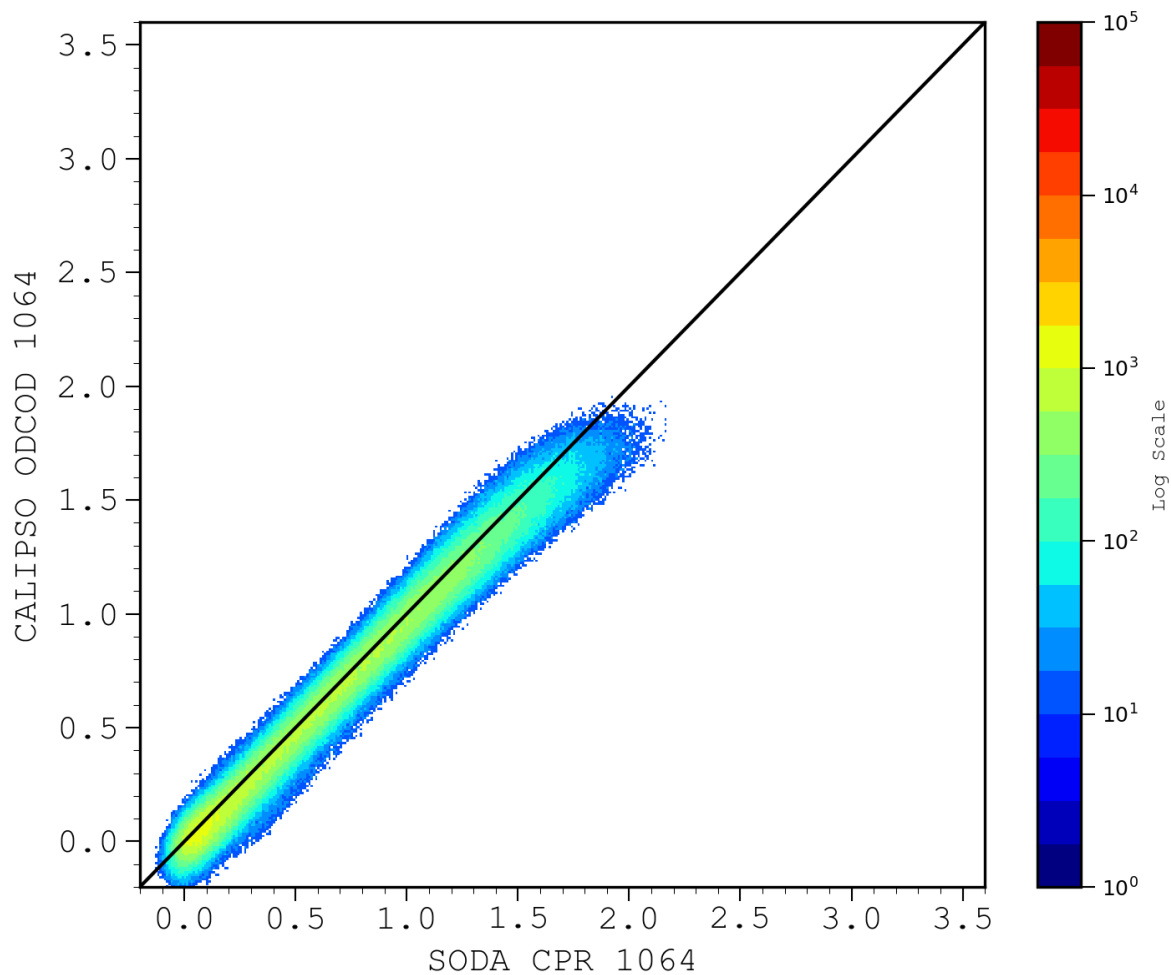
SODA CPR 1064 compared to CALIPSO ODCOD 1064
(Nighttime Aerosols Only)



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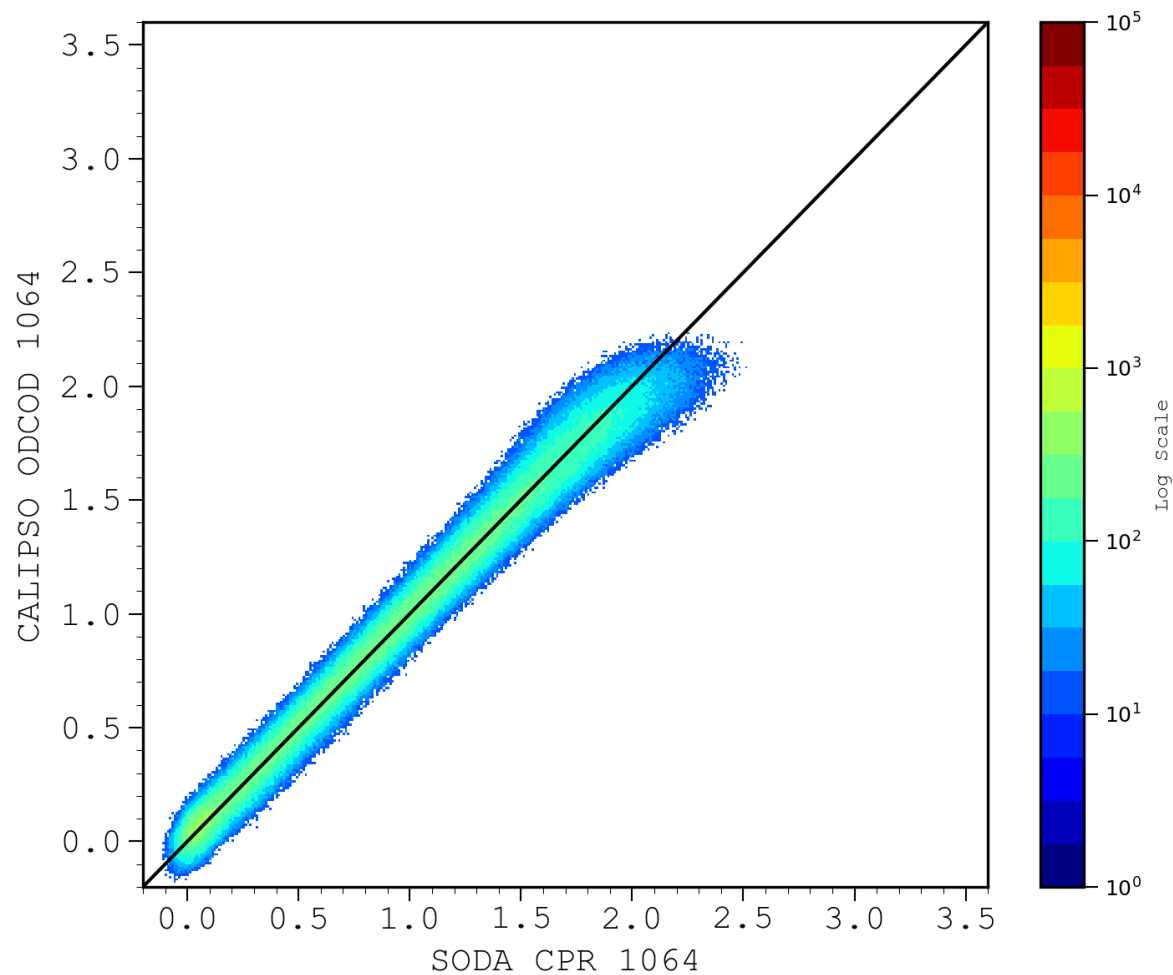
May, June, July, and August 2008 All Single Shot Profiles

SODA CPR 1064 compared to CALIPSO ODCOD 1064
(Daytime Clouds Only)



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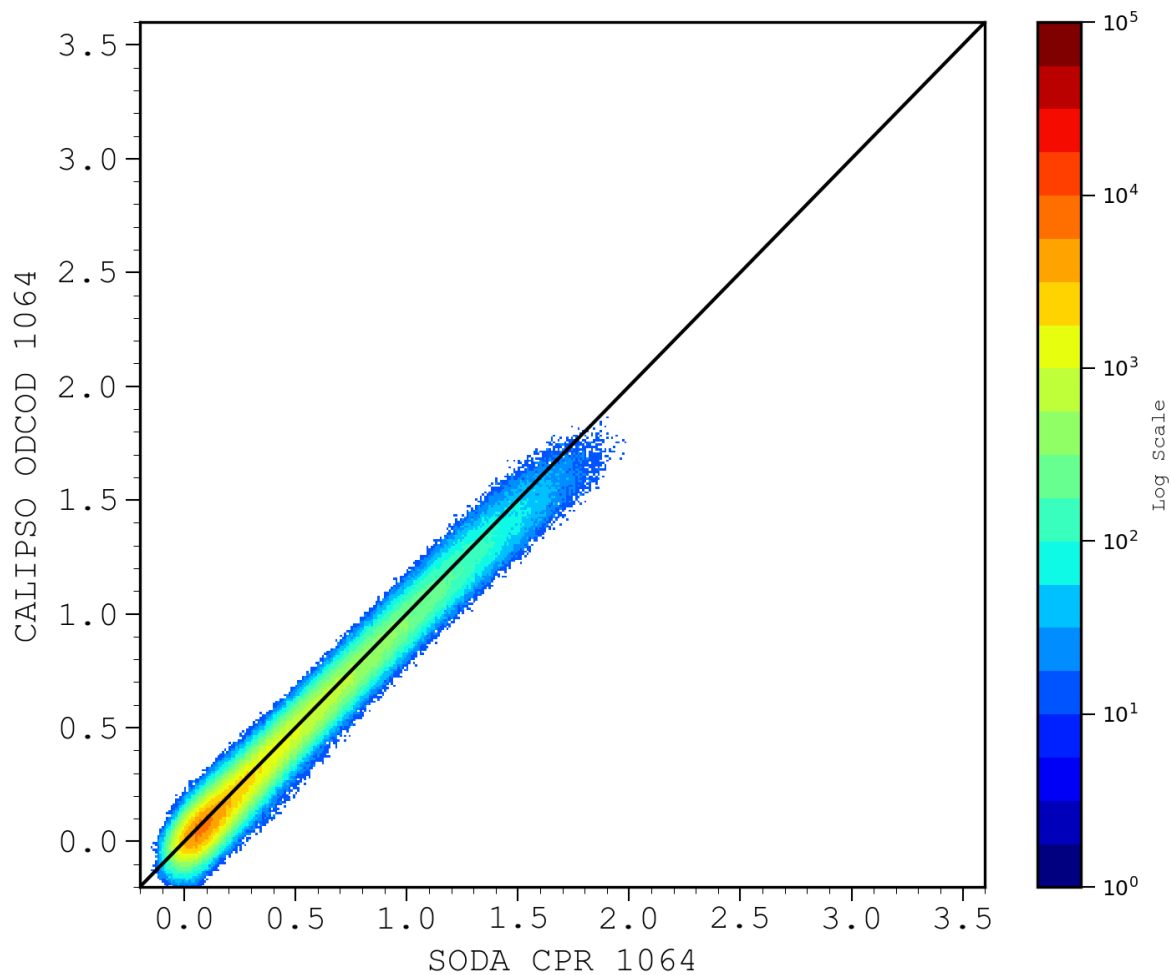
SODA CPR 1064 compared to CALIPSO ODCOD 1064
(Nighttime Clouds Only)



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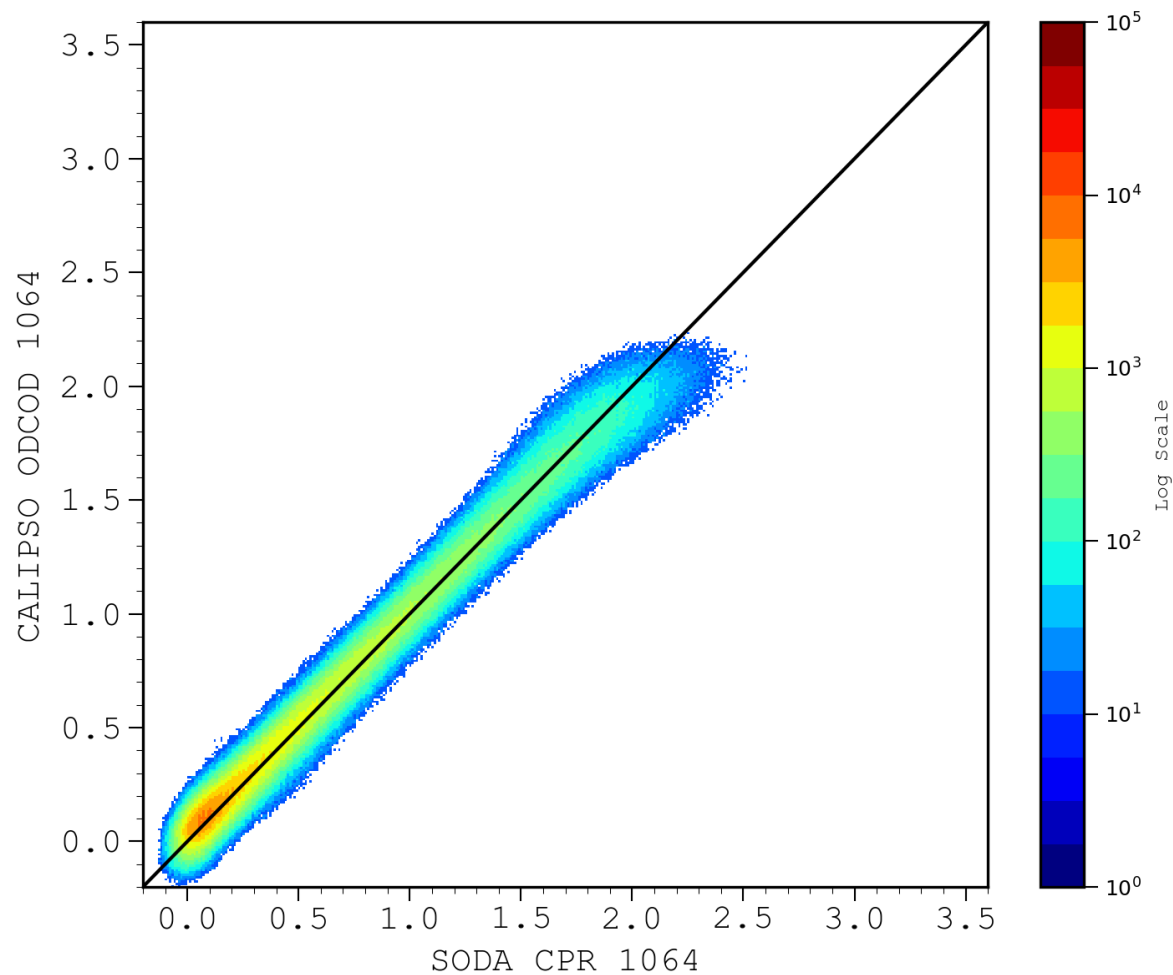
May, June, July, and August 2008 All Single Shot Profiles

SODA CPR 1064 compared to CALIPSO ODCOD 1064
(Daytime Clouds and Aerosols)



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SODA CPR 1064 compared to CALIPSO ODCOD 1064
(Nighttime Clouds and Aerosols)



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Created by: CALIPSO_Workshop/plot_hists::makeSpecialMod

May, June, July, and August 2008 All Single Shot Profiles



Conclusion

- CALIPSO Ocean Derived Column Properties will be in the upcoming Version 4.5 release.
- This new single instrument retrieval shows agreement with MODIS and SODA CPR Optical Depths.
- This new product will help us improve the existing CALIPSO dataset by providing an additional independent method of finding column OD and an additional constraint for finding extinction.