CloudSat mission

Cloud vertical structure and OCO-2 A-band retrievals of droplet number concentration in marine boundary layer clouds

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Jet Propulsion Laboratory
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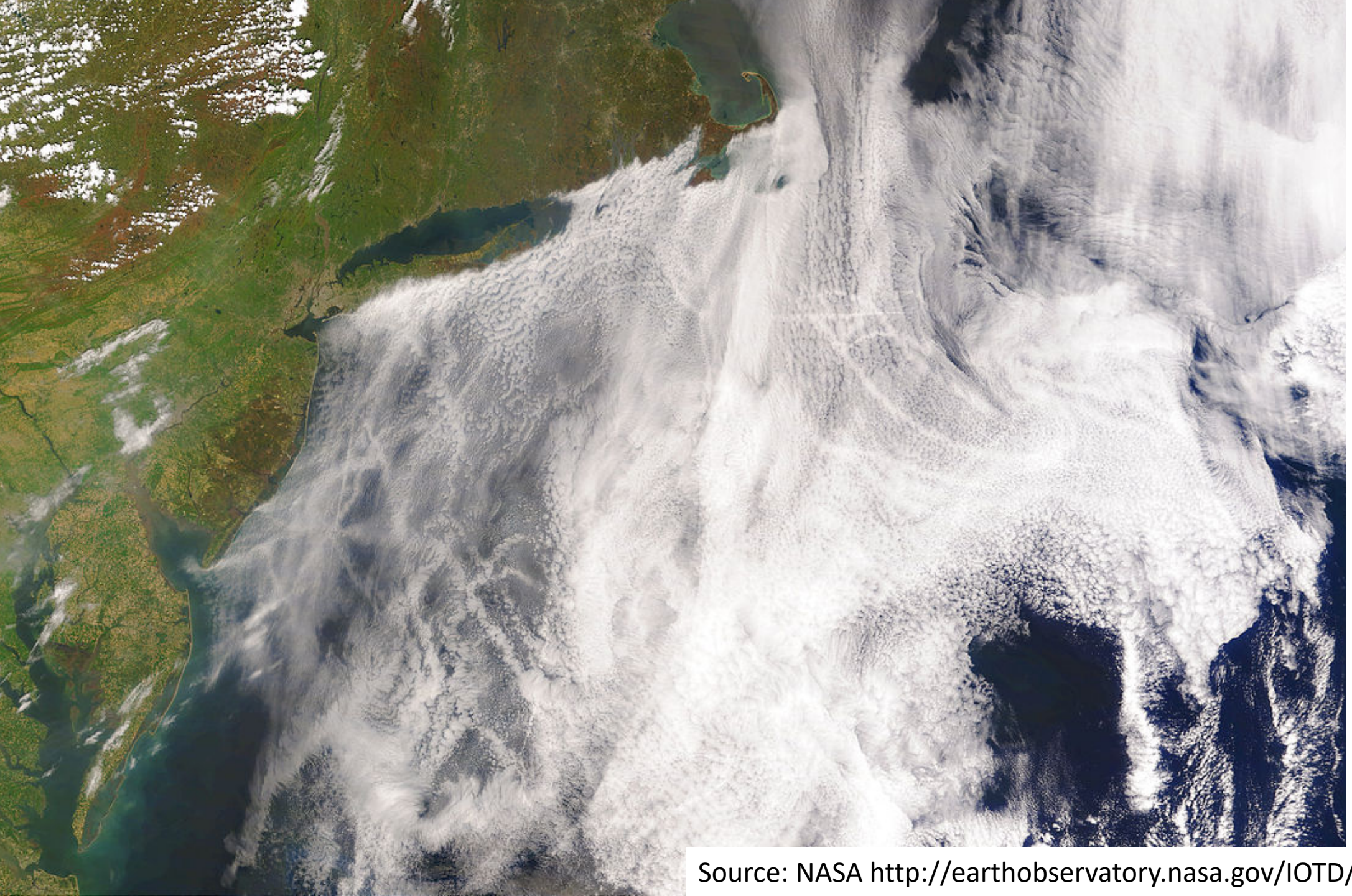
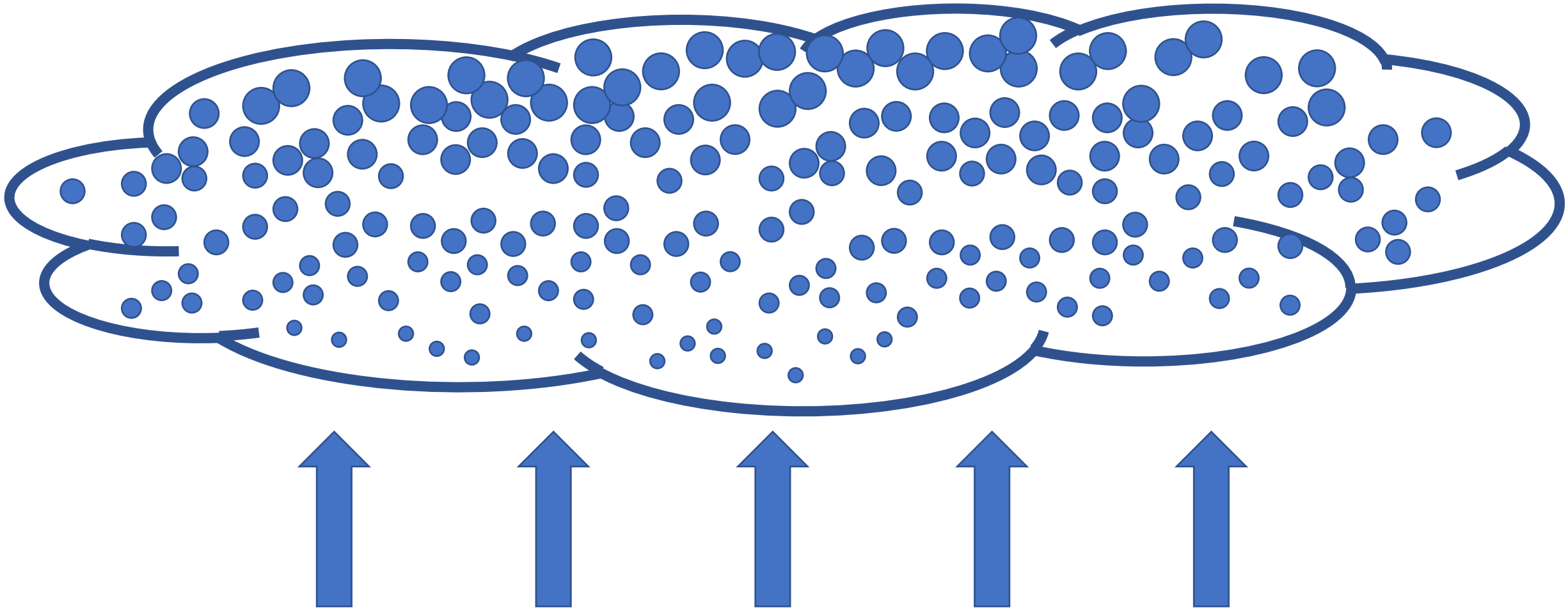


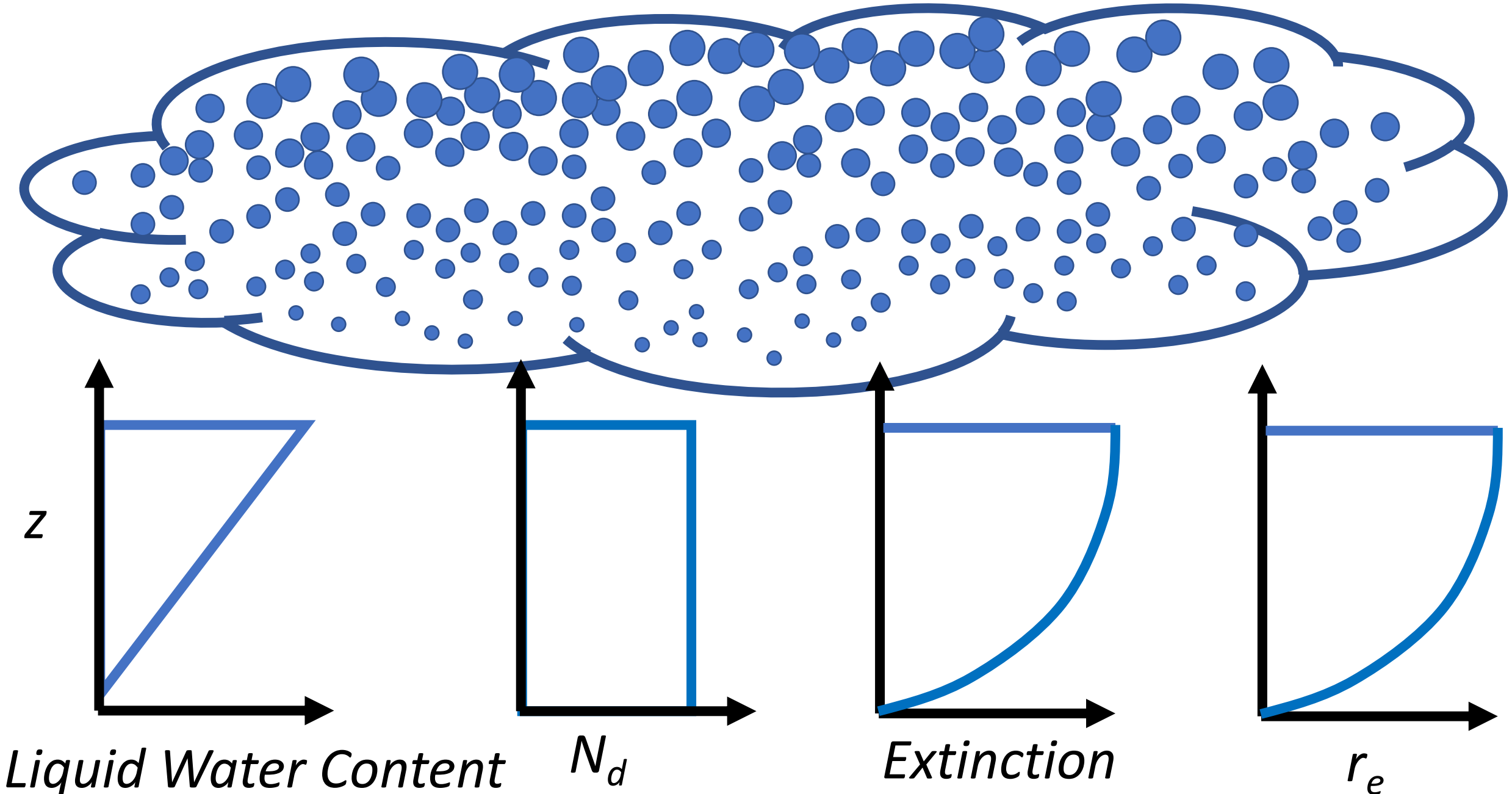
Source: NASA http://earthobservatory.nasa.gov/IOTD/view.php?id=5488

“Aerosol-driven droplet concentrations dominate coverage and water of oceanic low-level clouds” – Rosenfeld et al., *Science* (2019)

“Weak average liquid-cloud-water response to anthropogenic aerosols” – Toll et al. *Nature* (2019)

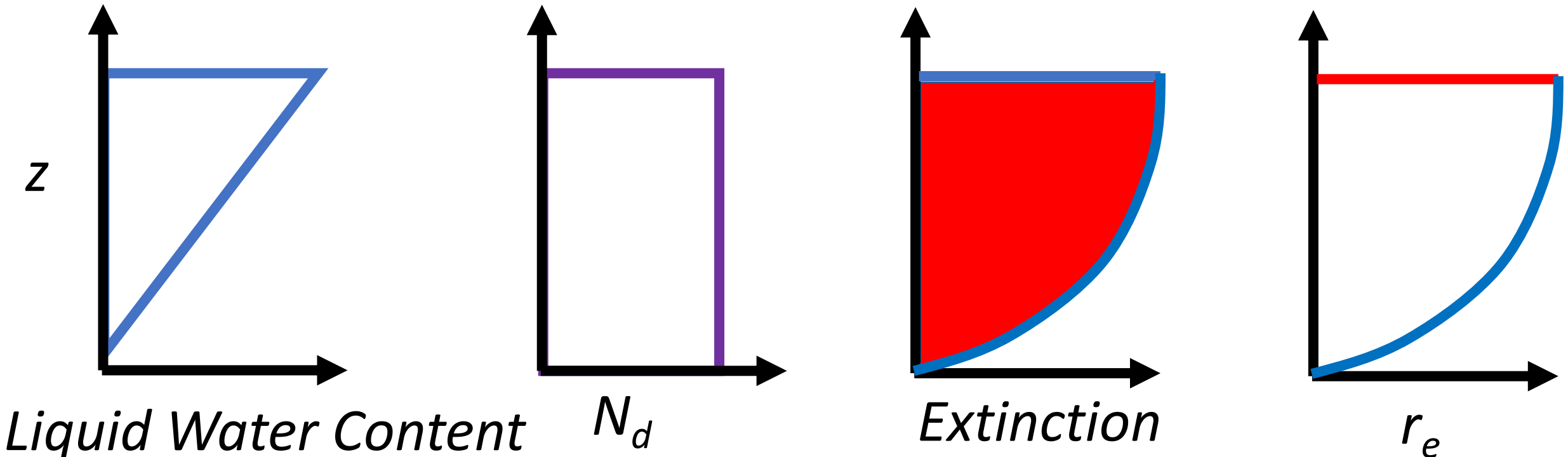


Updraft


z
Liquid Water Content
N_d
Extinction
r_e

These profiles + MODIS $\boldsymbol{\tau_c}$ and $\boldsymbol{r_e}$ → $\boldsymbol{N_d}$

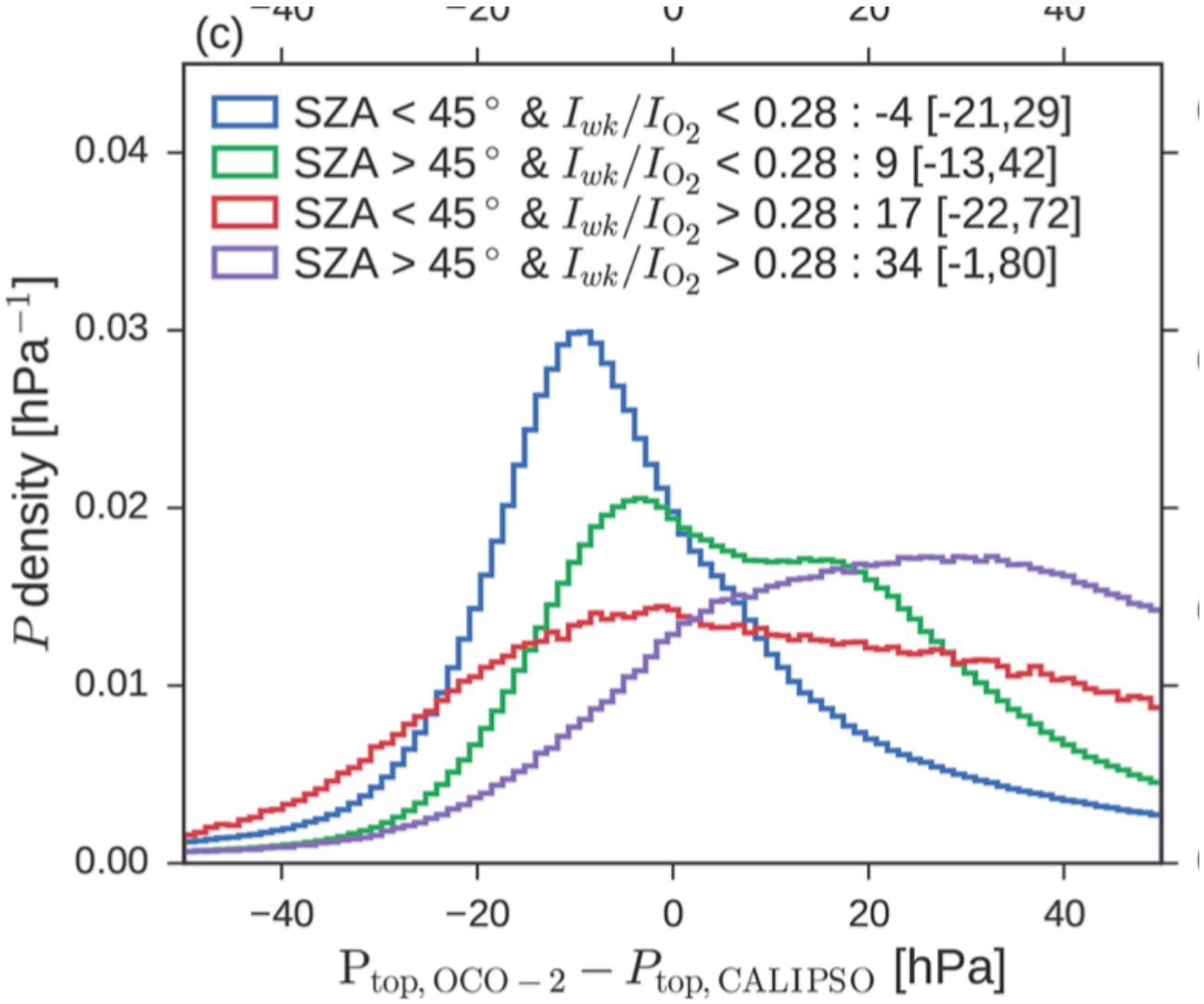
$$\boldsymbol{N_d} = \frac{\sqrt{5}}{2\pi k}\sqrt{\frac{f_{ad} c_w \boldsymbol{\tau_c}}{Q_{ext}\rho_w \boldsymbol{r_e^5}}}$$



f_{ad} is "adiabatic fraction" from 0—1
Not measured by MODIS, so you must assume a value

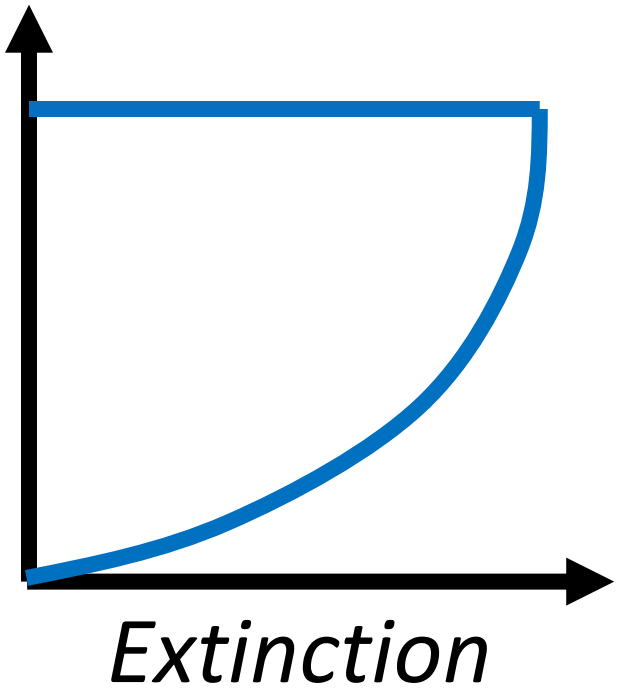
$$\boldsymbol{N_d} = \frac{\sqrt{5}}{2\pi k}\sqrt{\frac{f_{ad} c_w \boldsymbol{\tau_c}}{Q_{ext}\rho_w \boldsymbol{r_e^5}}}$$

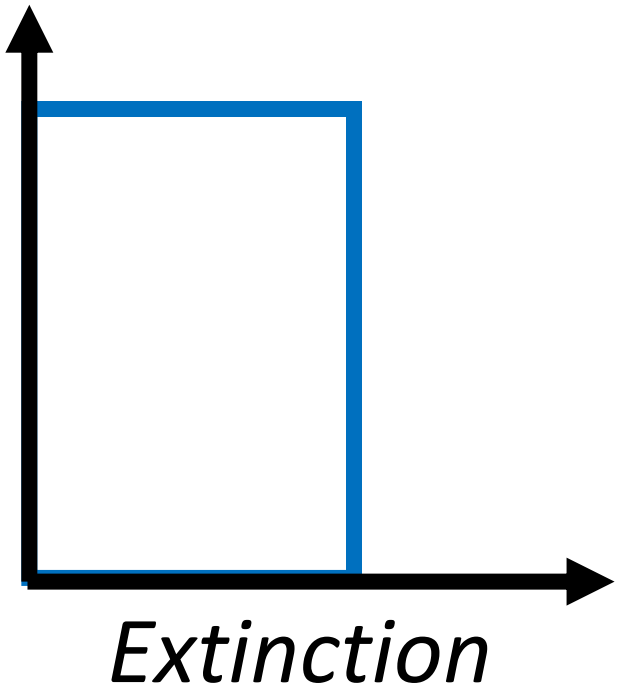
OCO2CLD-LIDAR-AUX



Hypothesis: vertical extinction structure of cloud matters.

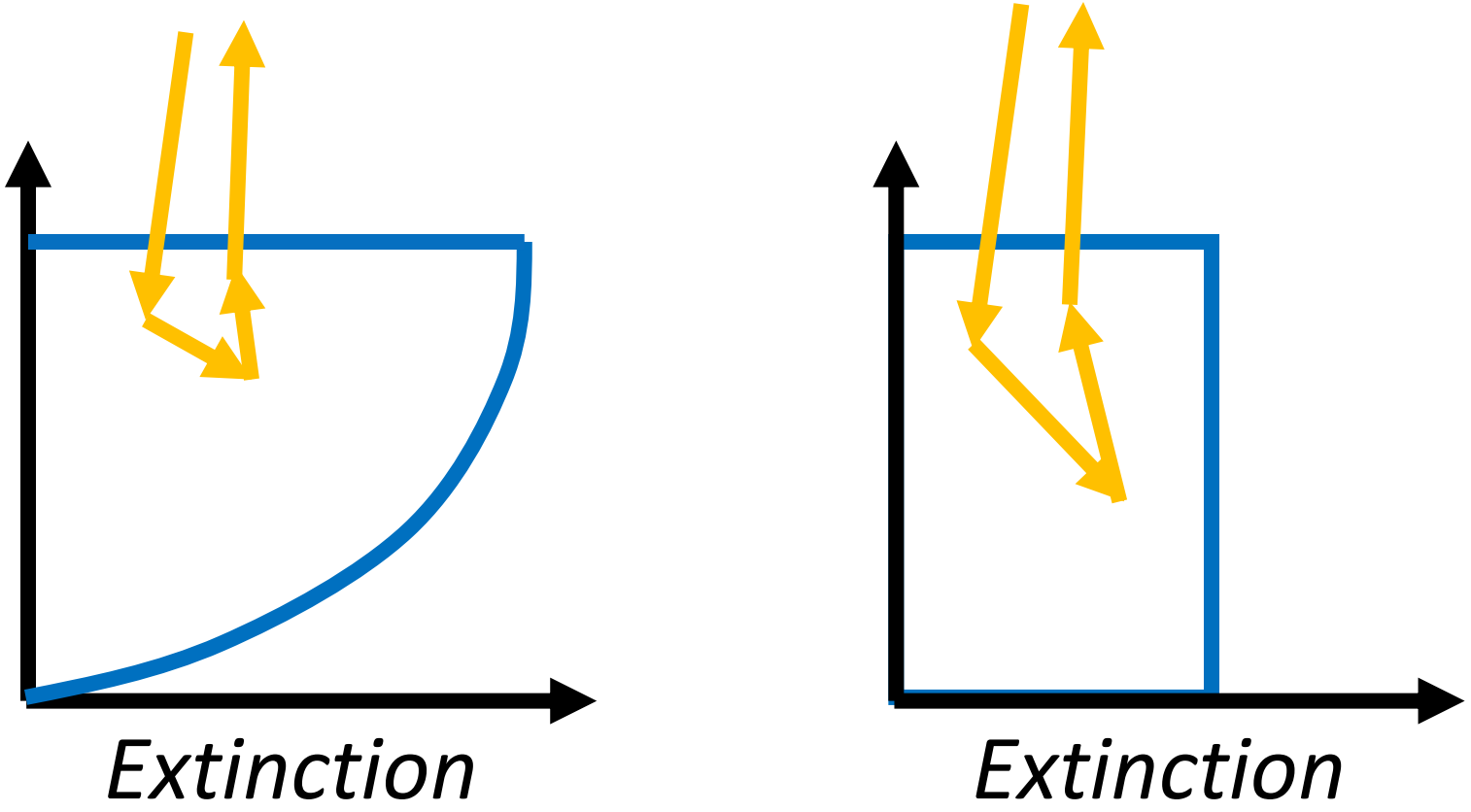
(explored in Rozanov & Kokhanovsky 2004, but only for very thick clouds)

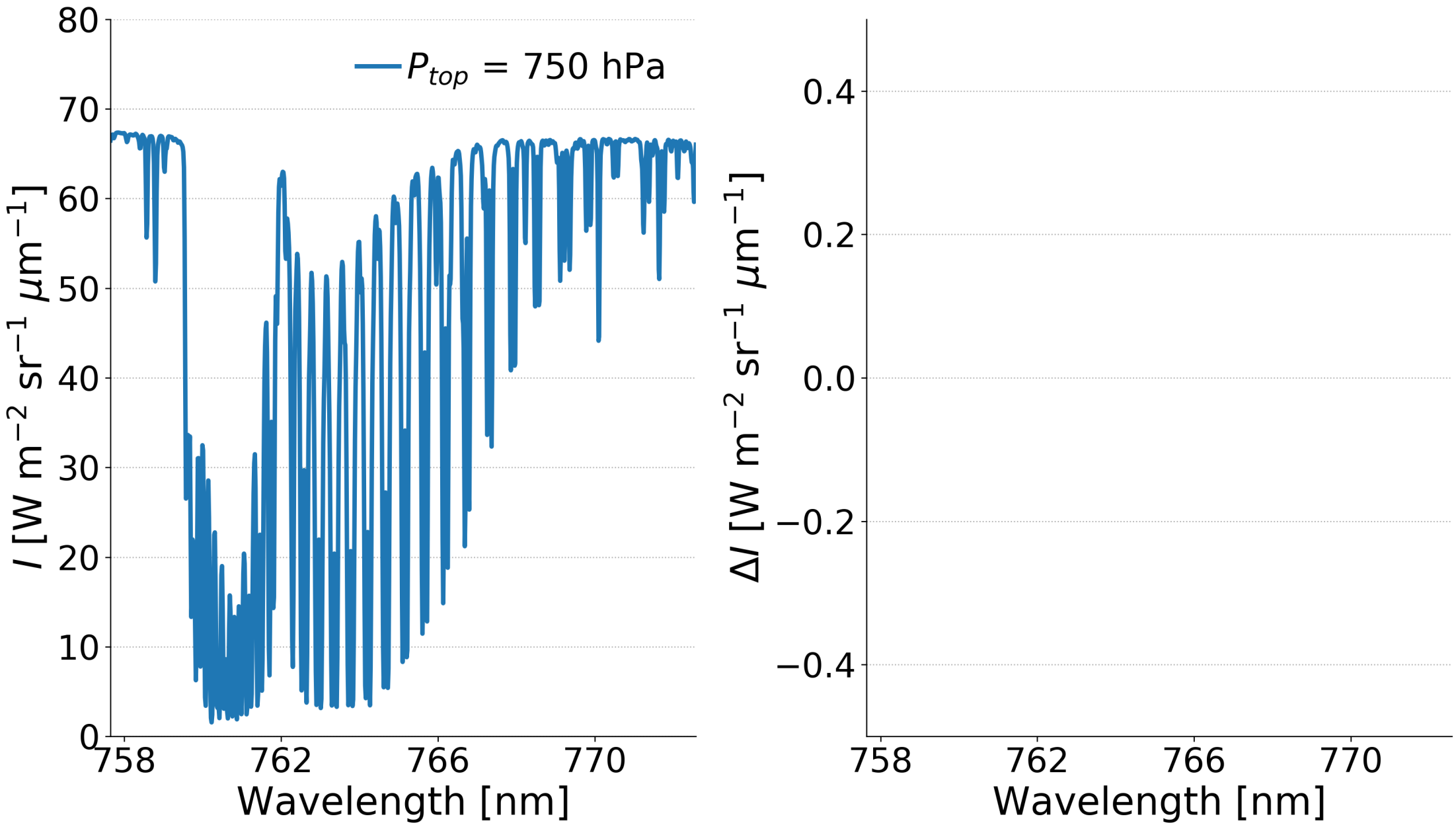


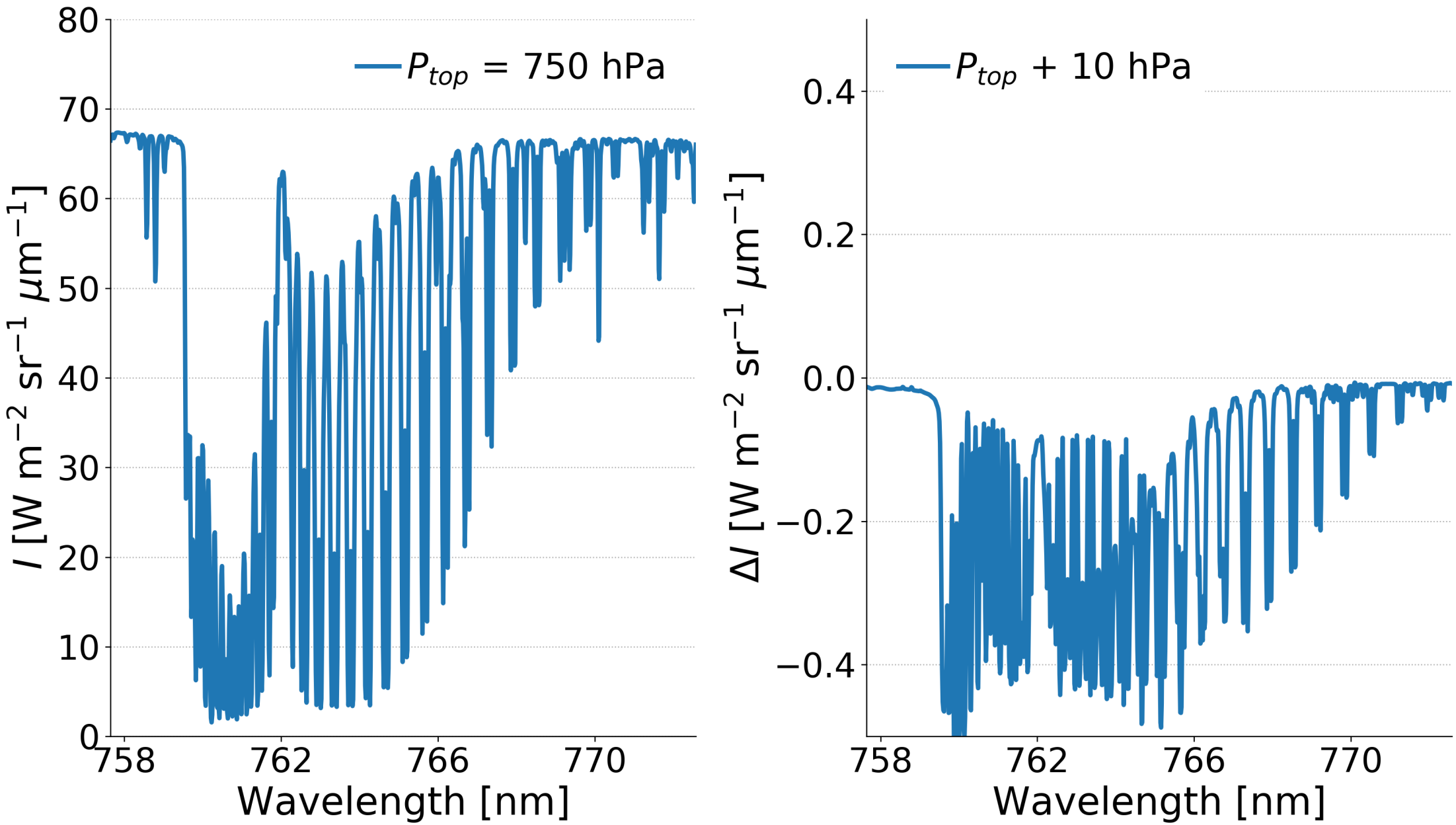


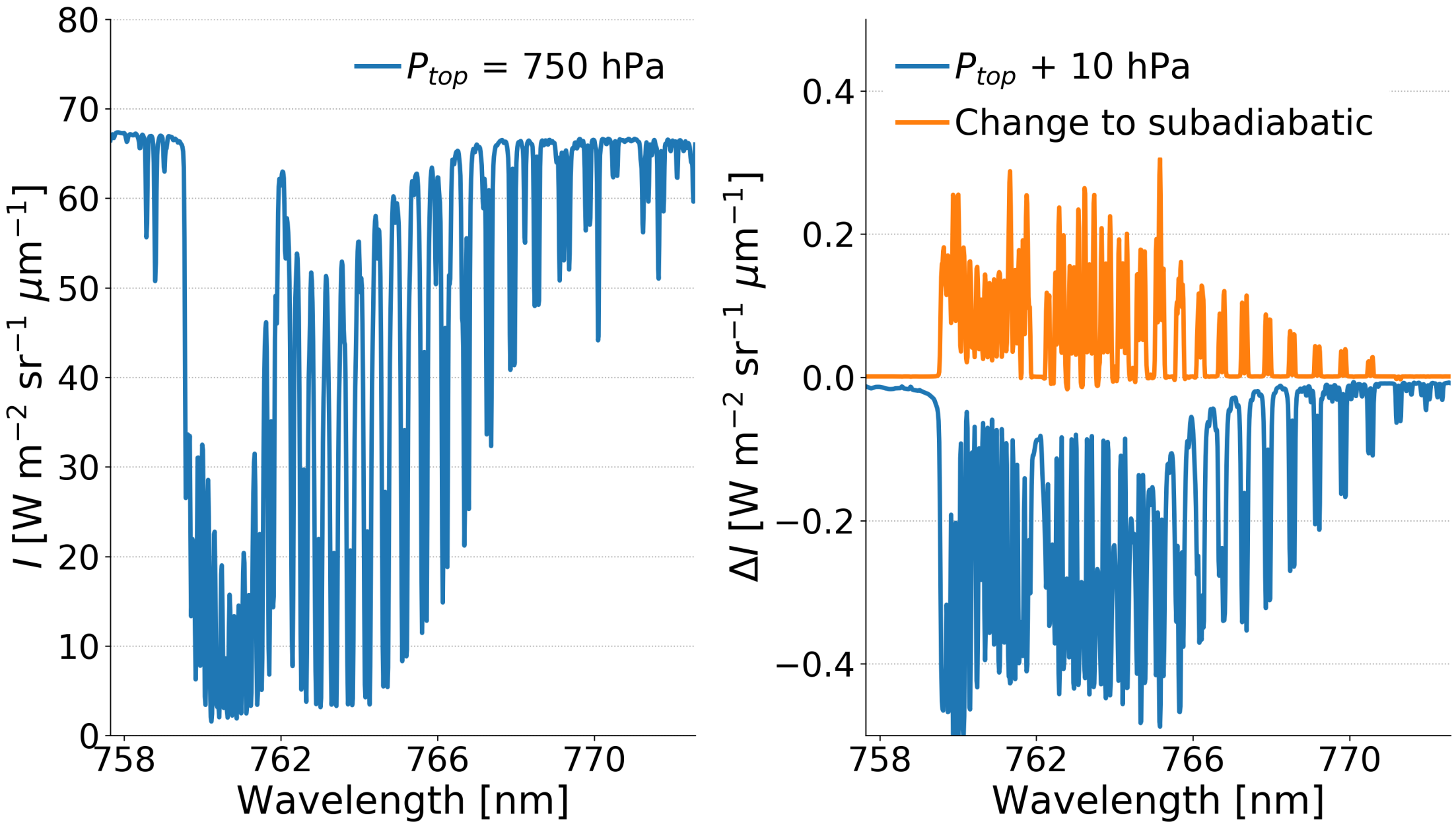
Real clouds have shorter within-cloud path.

Retrieval biases both P_{top} and thickness to compensate.



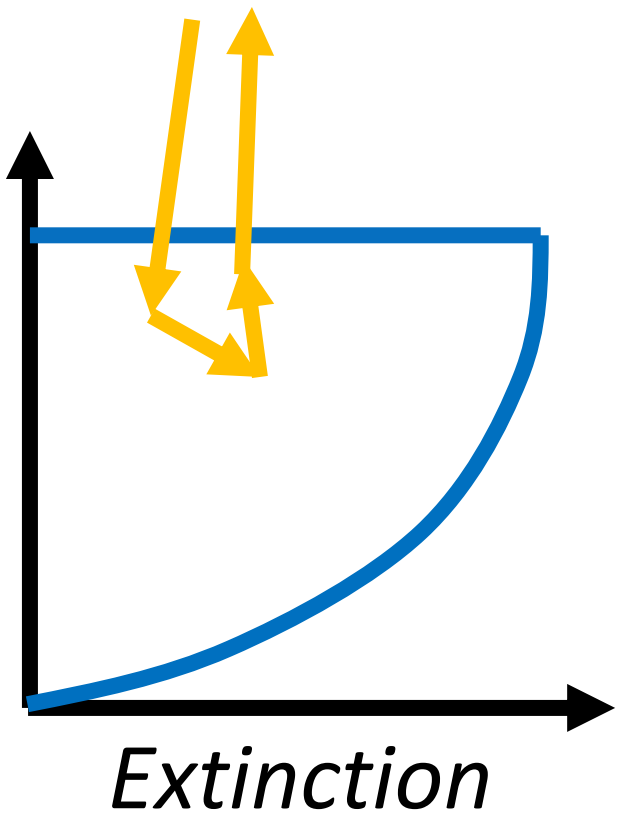

P_{top} = 750 hPa
I [W m^{-2} sr^{-1} μm^{-1}]
0
10
20
30
40
50
60
70
80
758
762
766
770
Wavelength [nm]
ΔI [W m^{-2} sr^{-1} μm^{-1}]
−0.4
−0.2
0.0
0.2
0.4
758
762
766
770
Wavelength [nm]


P_{top} = 750 hPa
I [W m^{-2} sr^{-1} μm^{-1}]
Wavelength [nm]
P_{top} + 10 hPa
ΔI [W m^{-2} sr^{-1} μm^{-1}]
Wavelength [nm]

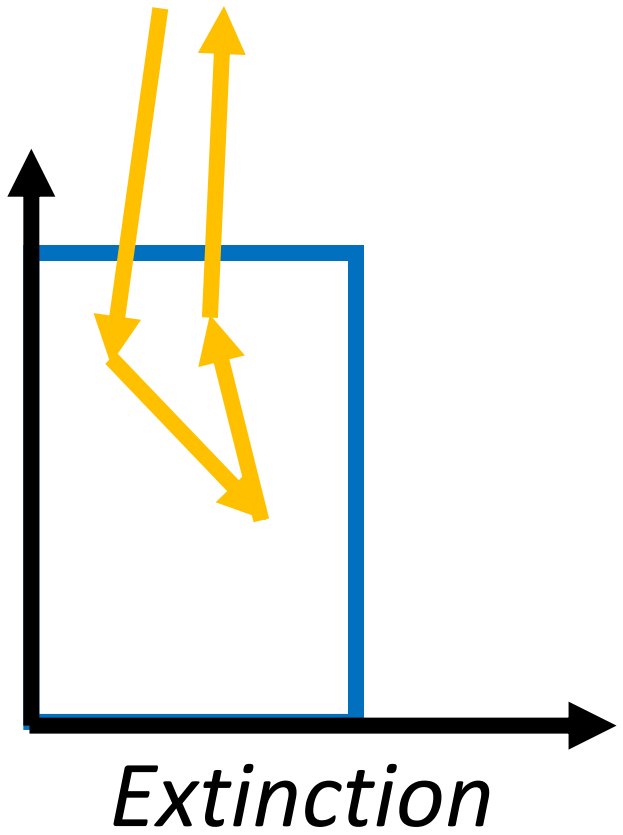

P_{top} = 750 hPa
I [W m^{-2} sr^{-1} μm^{-1}]
Wavelength [nm]
P_{top} + 10 hPa
Change to subadiabatic
ΔI [W m^{-2} sr^{-1} μm^{-1}]
Wavelength [nm]

Run retrievals of simulated cloud scenes

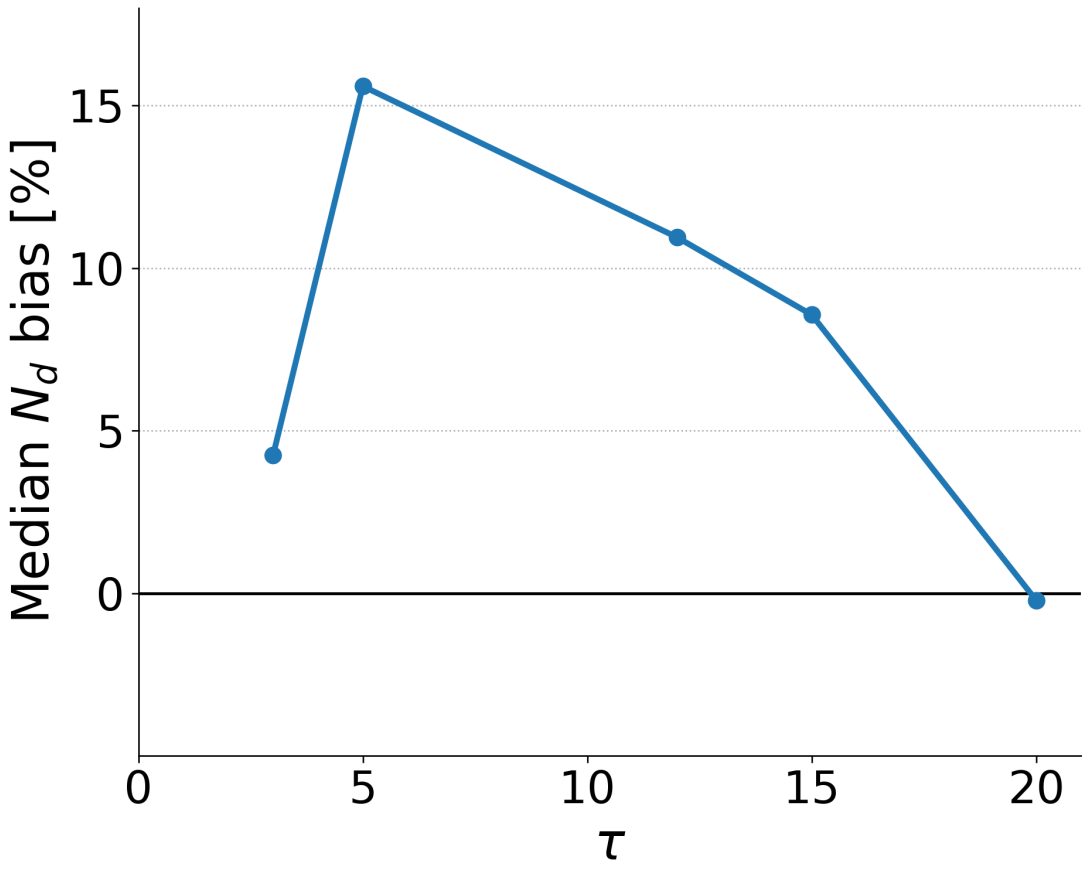
"Real" clouds to simulate I_{obs}



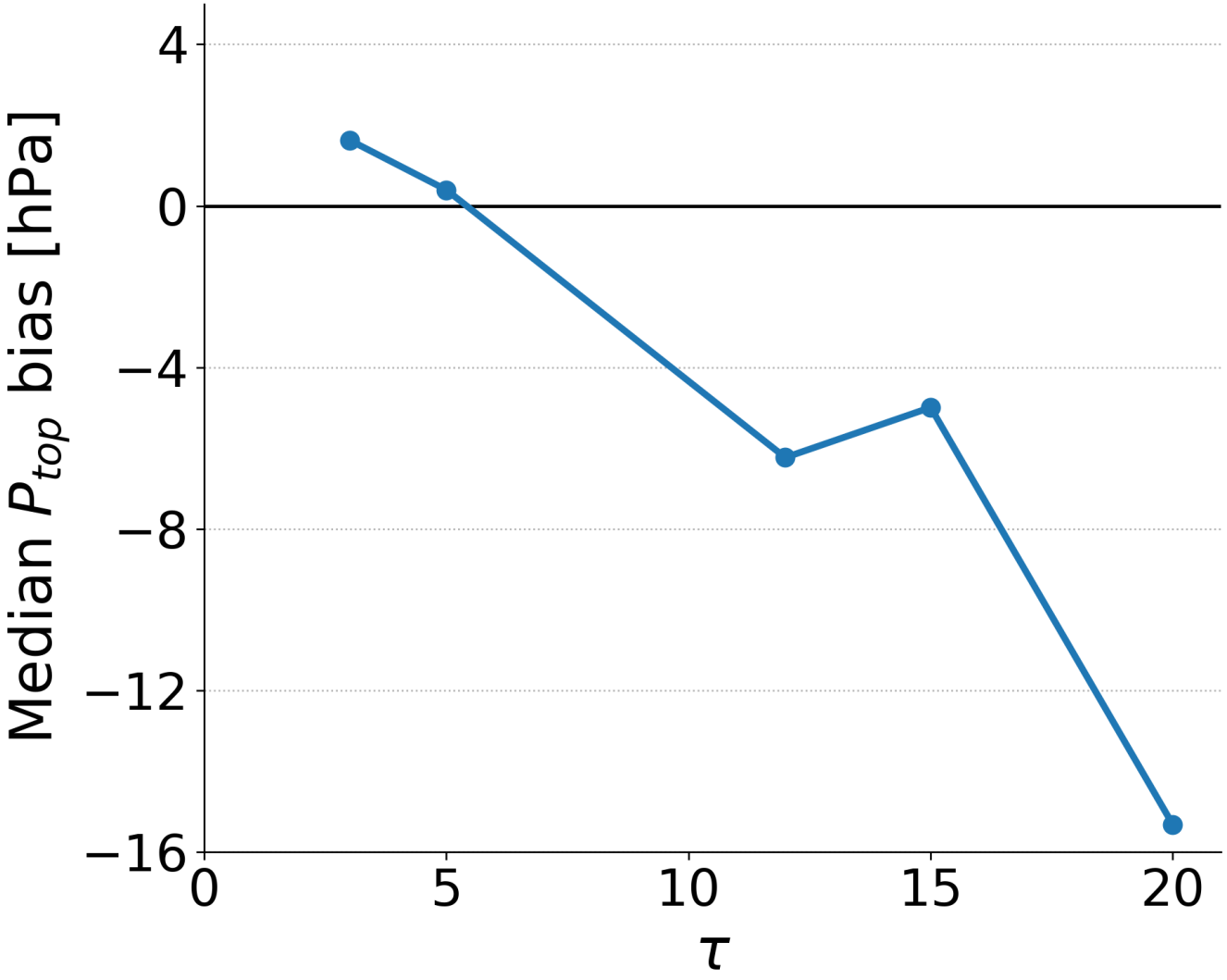
"Retrieval" clouds



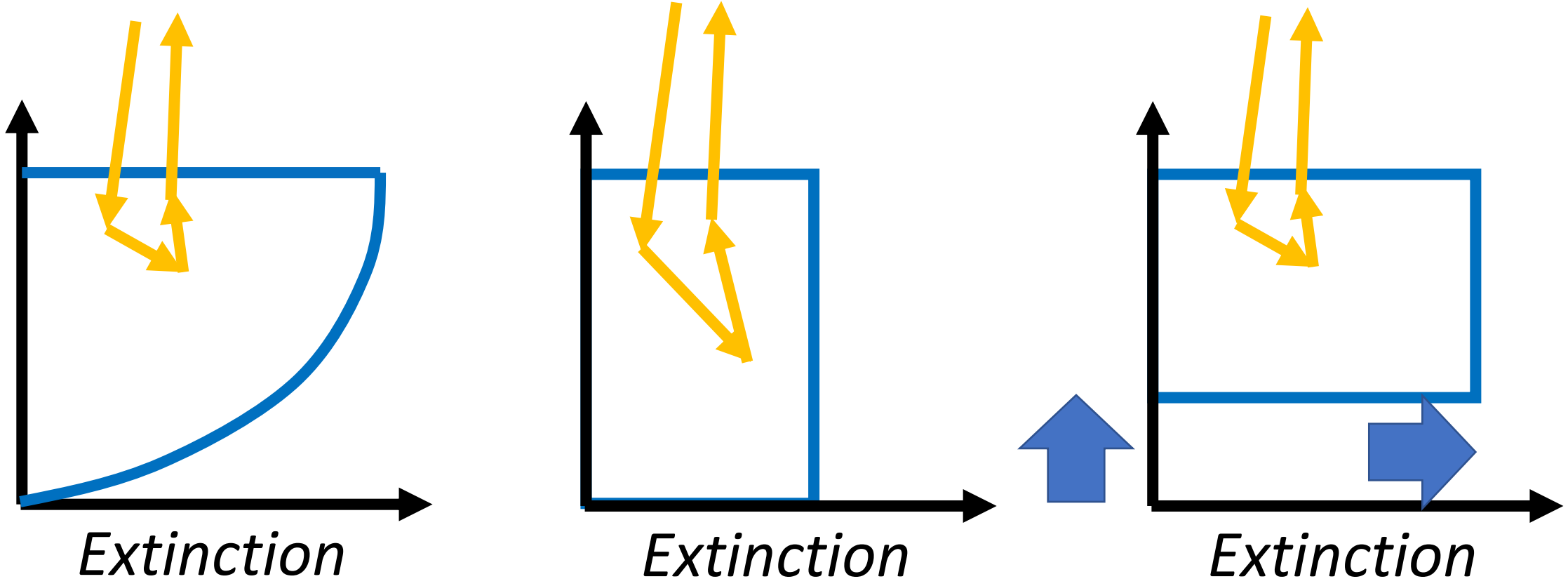
N_d retrieval bias from subadiabatic structure



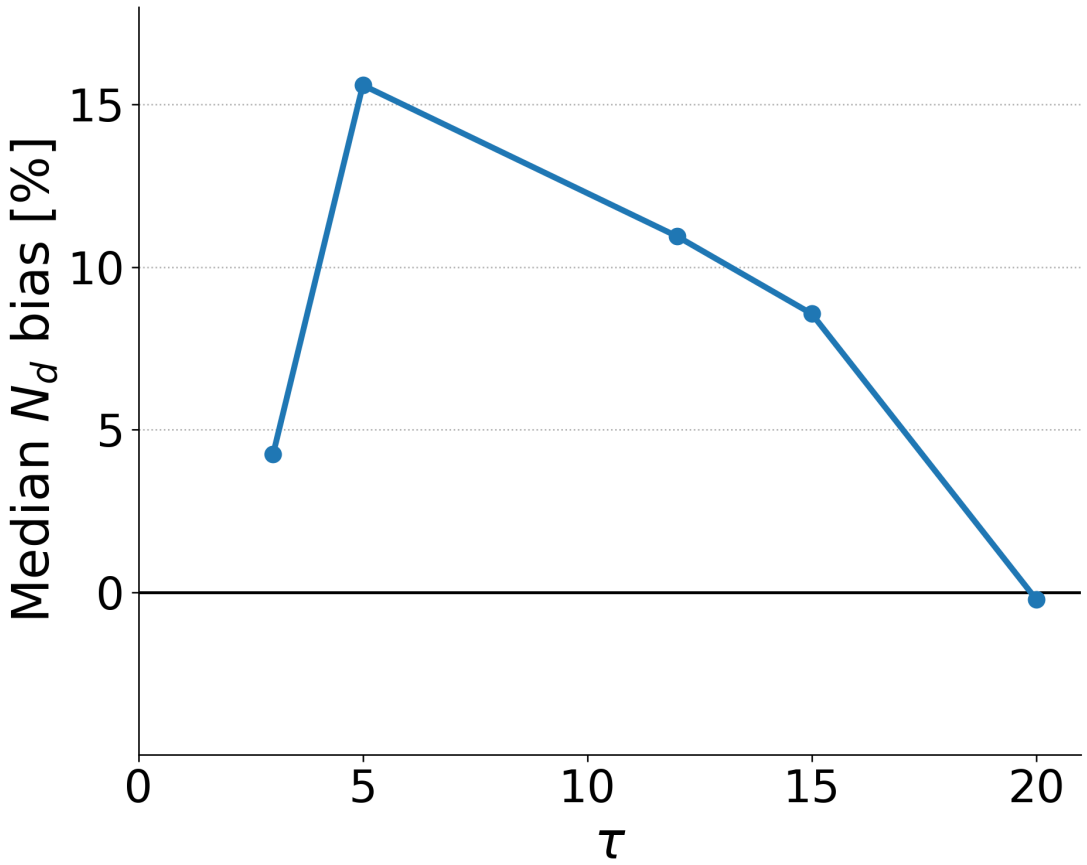
P_{top} retrieval bias from subadiabatic structure

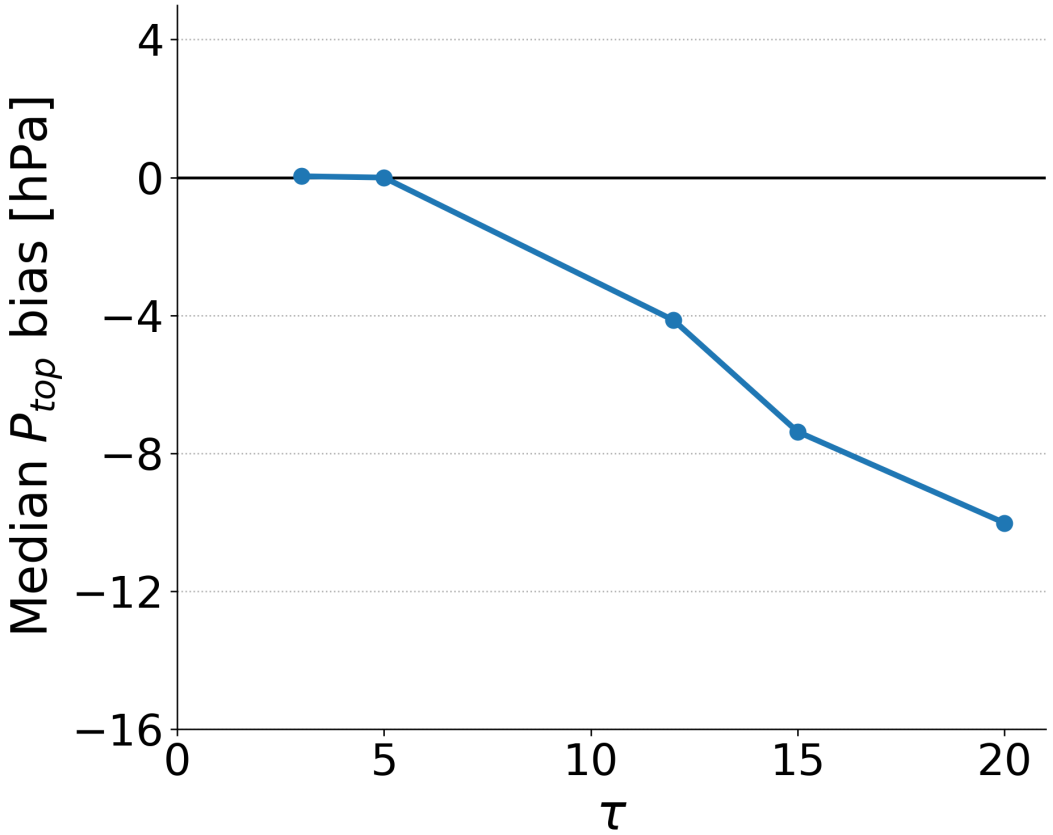


One approach to correction: squish homogeneous profile to give similar mean extinction near cloud top

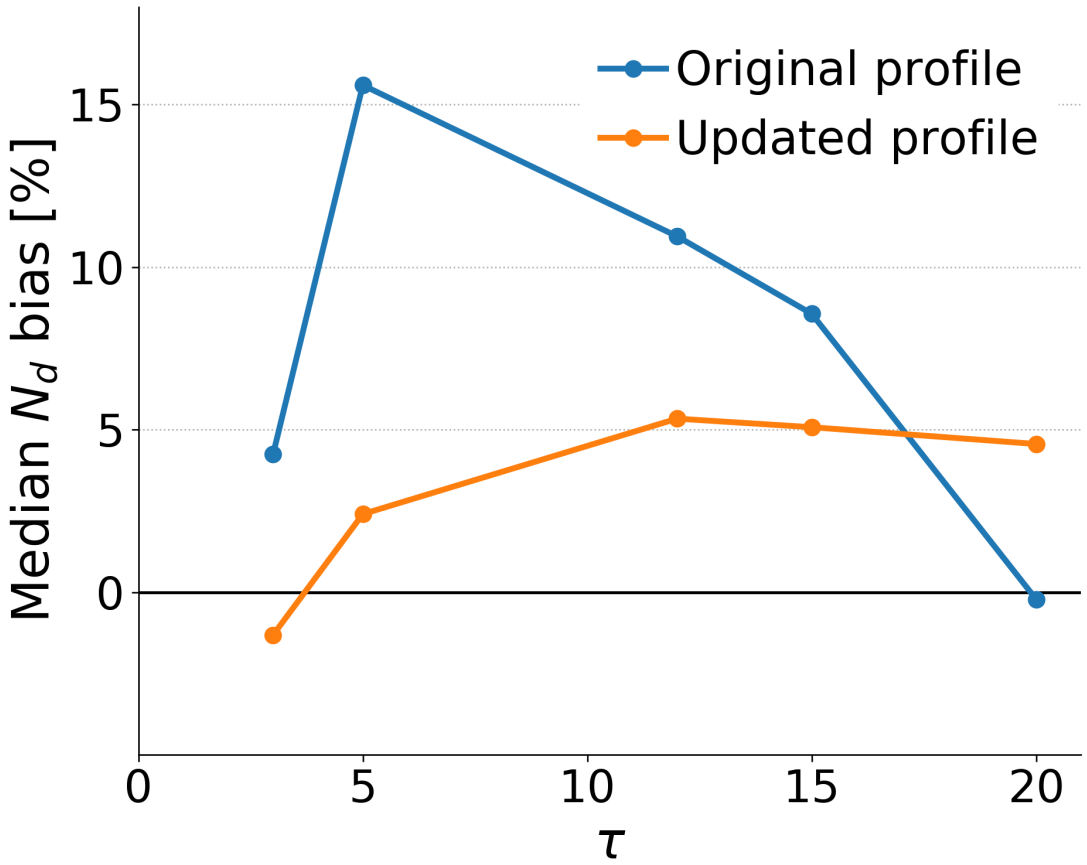


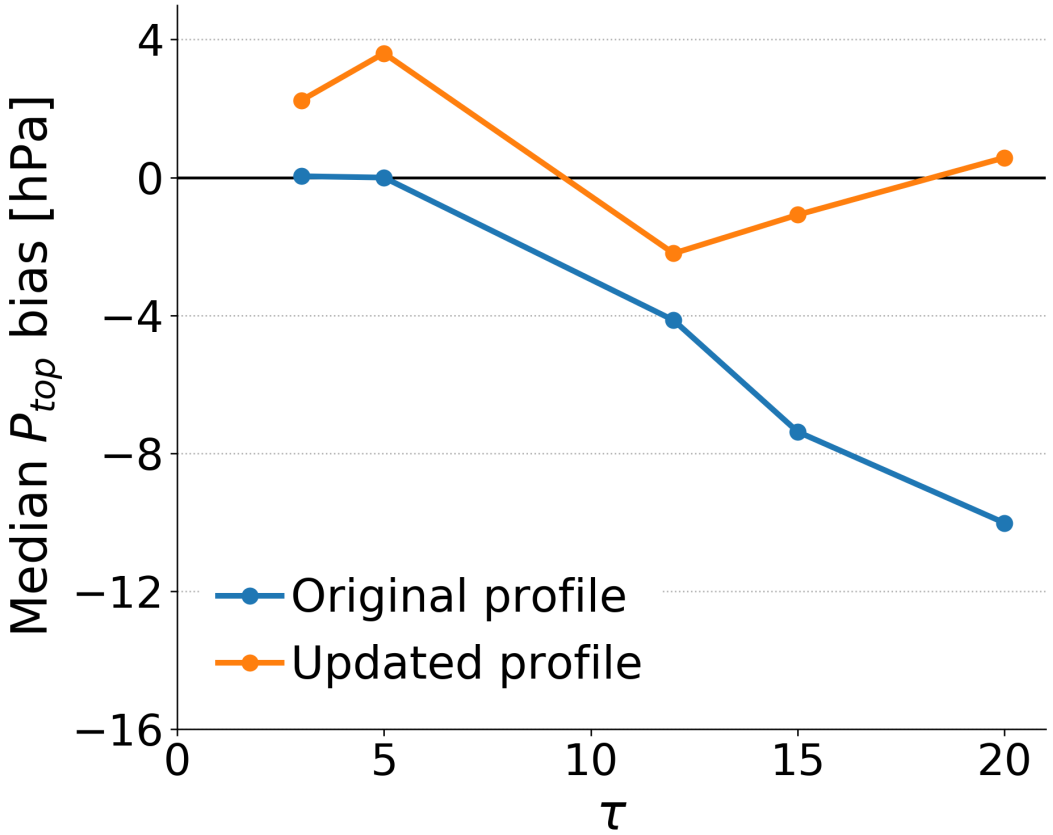
Trade-offs which depend on τ





Trade-offs which depend on τ





Conclusions

- Vertical structure adds a *bias*, not just random error to A-band retrievals of P_{top} and N_d
- May affect *any* cloud retrieval method that relies on differential absorption
- We are now trying corrections for the “vertical structure bias” for next version of OCO-2 cloud retrieval, it varies with SZA, optical depth and cloud-top pressure.