Quantifying the deep convective temperature signal within the Tropical Tropopause Layer (TTL)

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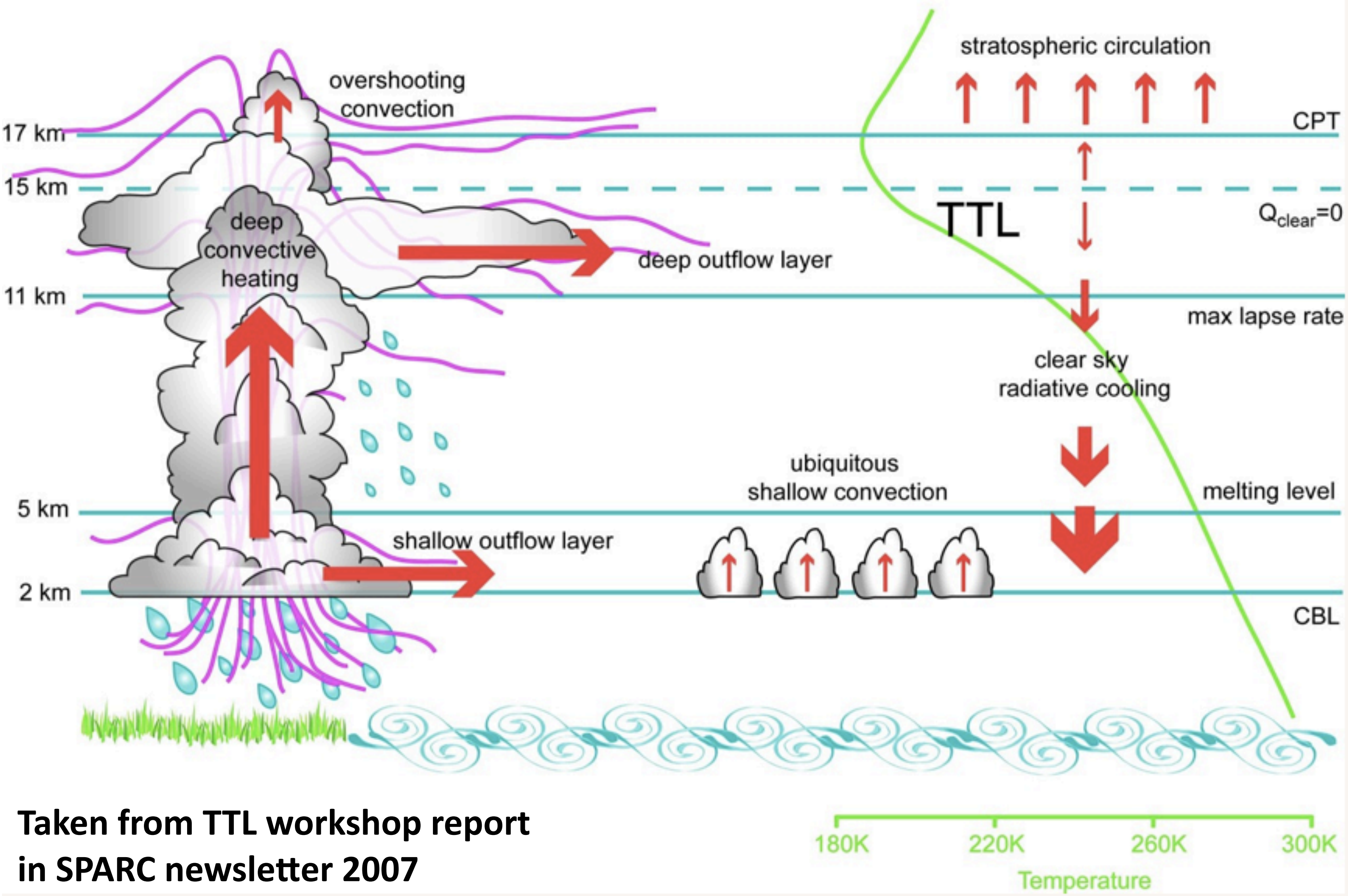
Tropical Tropopause Layer and Deep Convection



Taken from TTL workshop report in SPARC newsletter 2007

Deep Convection: The Large-Scale Response

Indirect Response to Latent Heating

Direct Response to Latent Heating

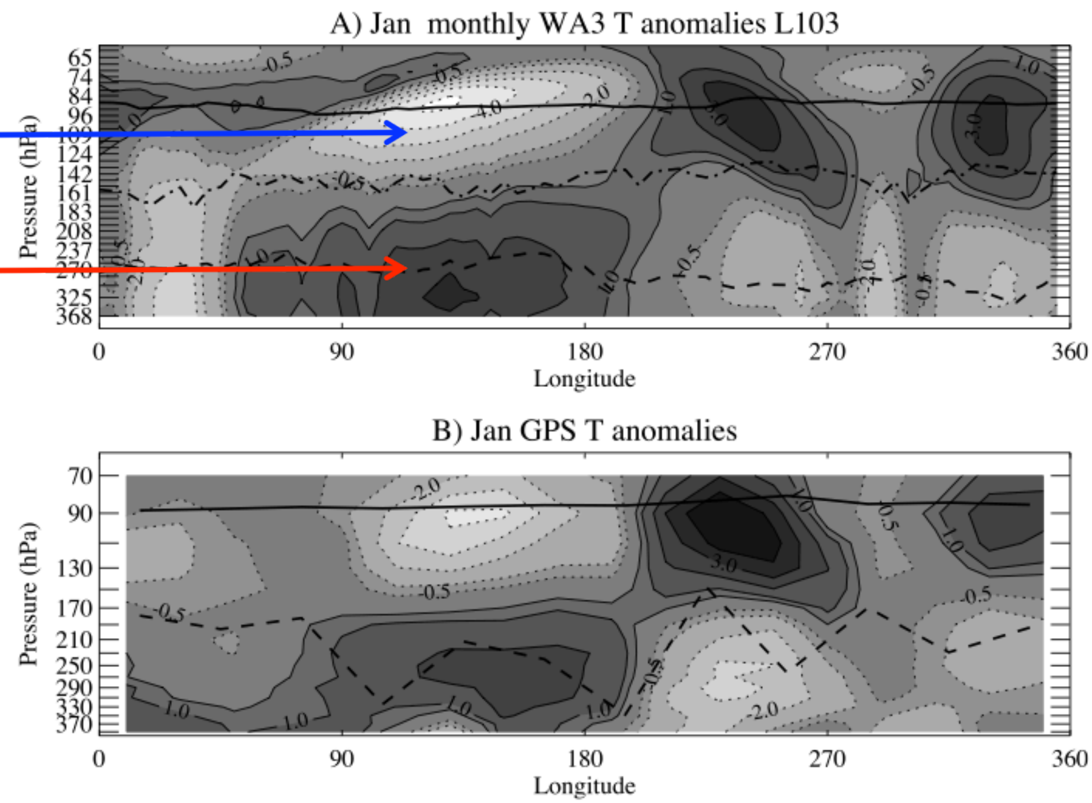


Figure 9. January tropical (25S–25N) temperature anomalies (deviations from the zonal mean) as a function of longitude and height from () WACCM L103 simulation and (b) GPS. Positive anomalies are solid; negative anomalies are dotted. Contour interval of ±1 K with ±0.5 K values added. Also shown is the meridional (25S–25N) average of the Cold Point Tropopause pressure (solid), the level of zero heating (dot-dash), and the level of the minimum lapse rate (dashed).

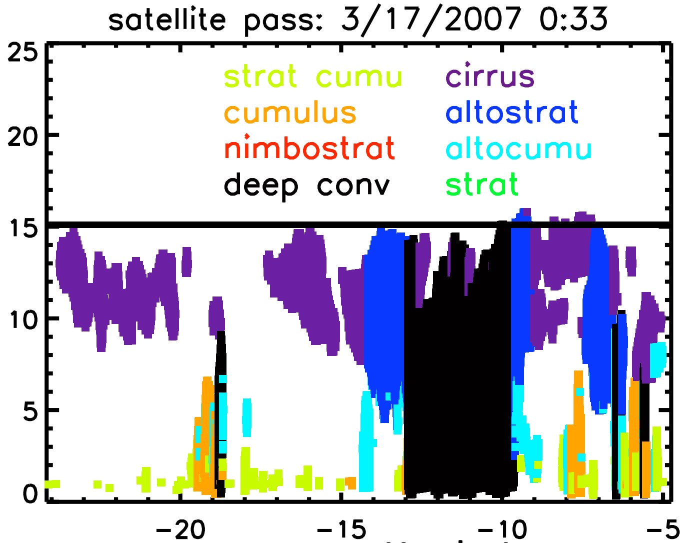
Gettelman and Birner 2007

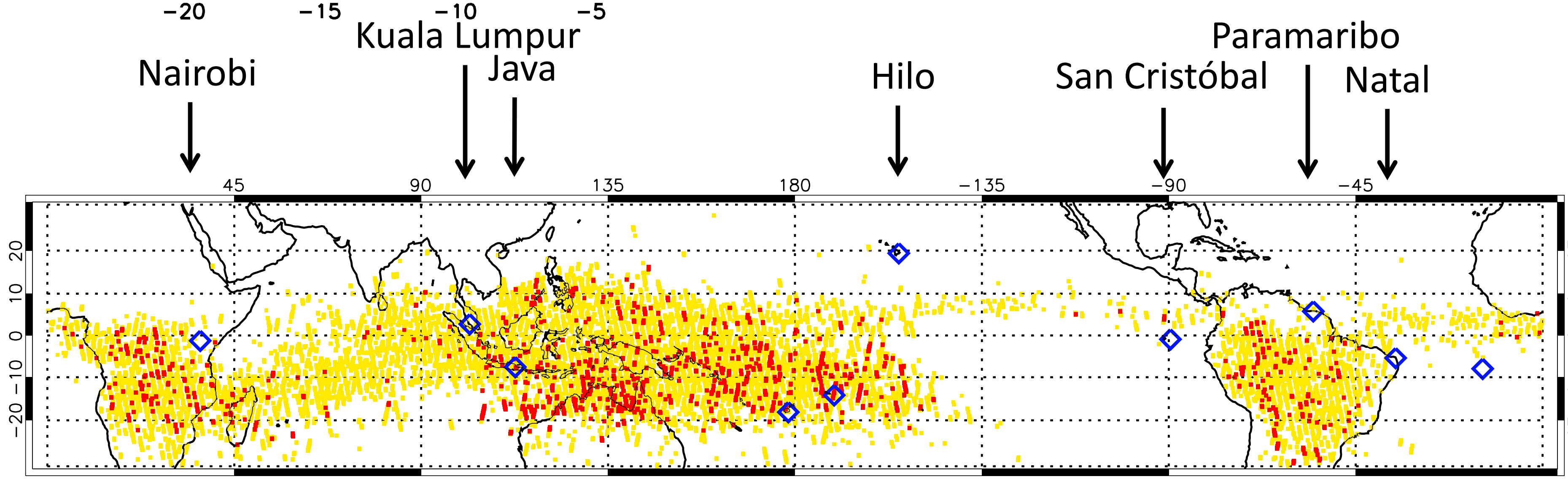
"Convective Cold Top":
a natural response to the latent heating.
(Holloway and Neelin 2006)

DJF Deep Convective Cloud Top Pixels Identified from CloudSat 2B-CLDCLASS:

> 15 km (Yellow), > 17 km (Red)

(Stephens et al. 2002, Sassen and Wang 2008)

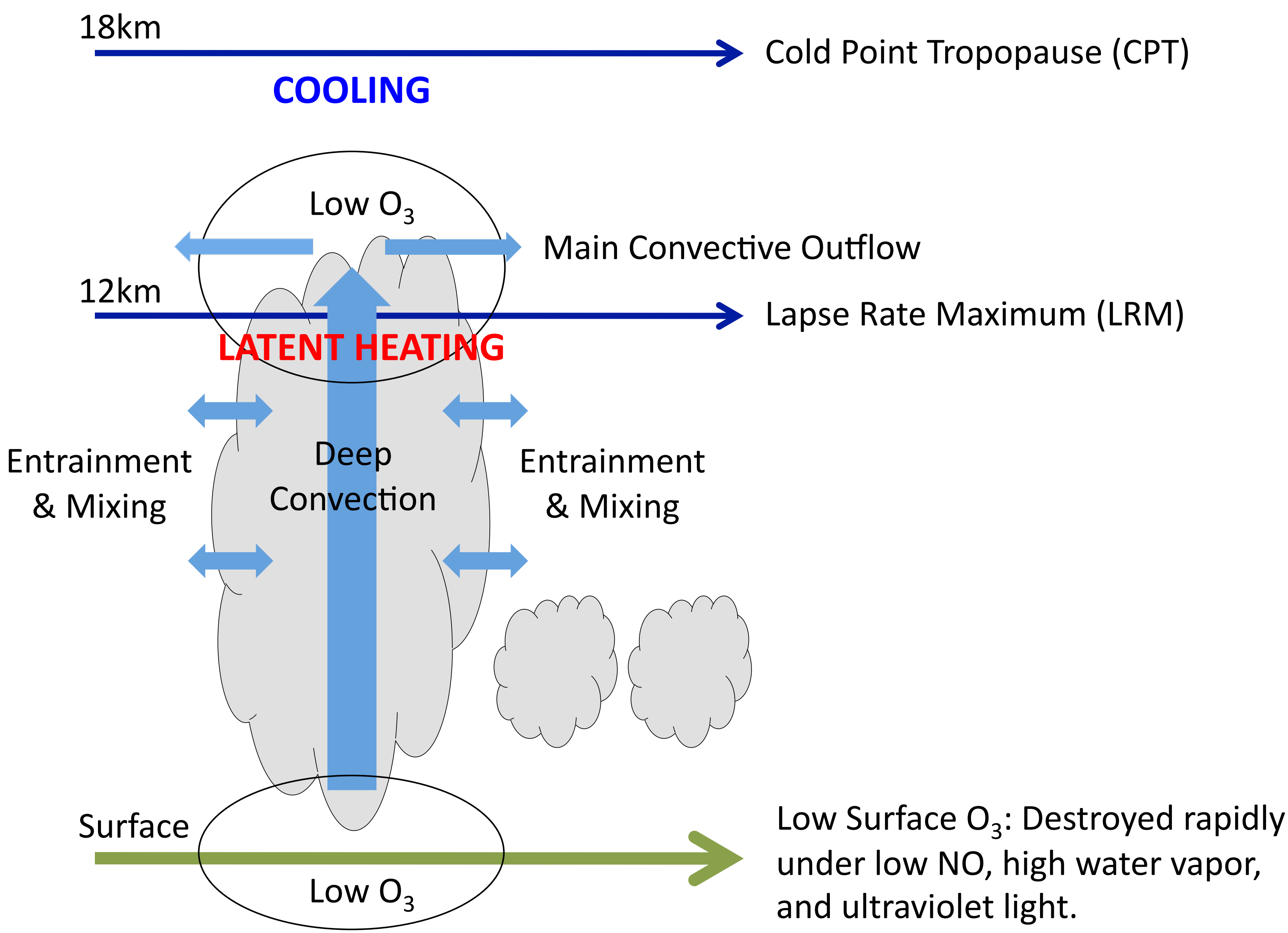




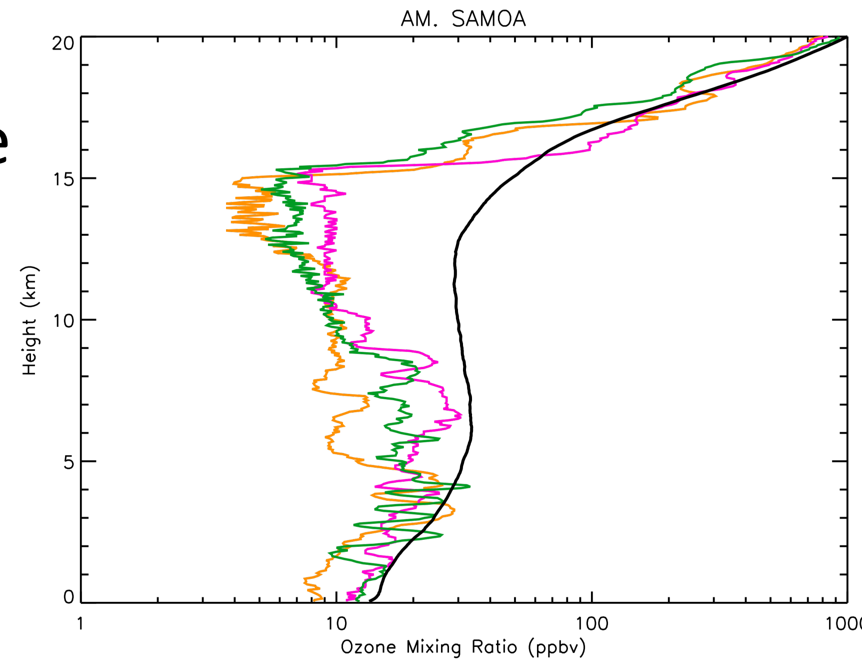
Southern Hemisphere Additional Ozonesondes (SHADOZ) stations

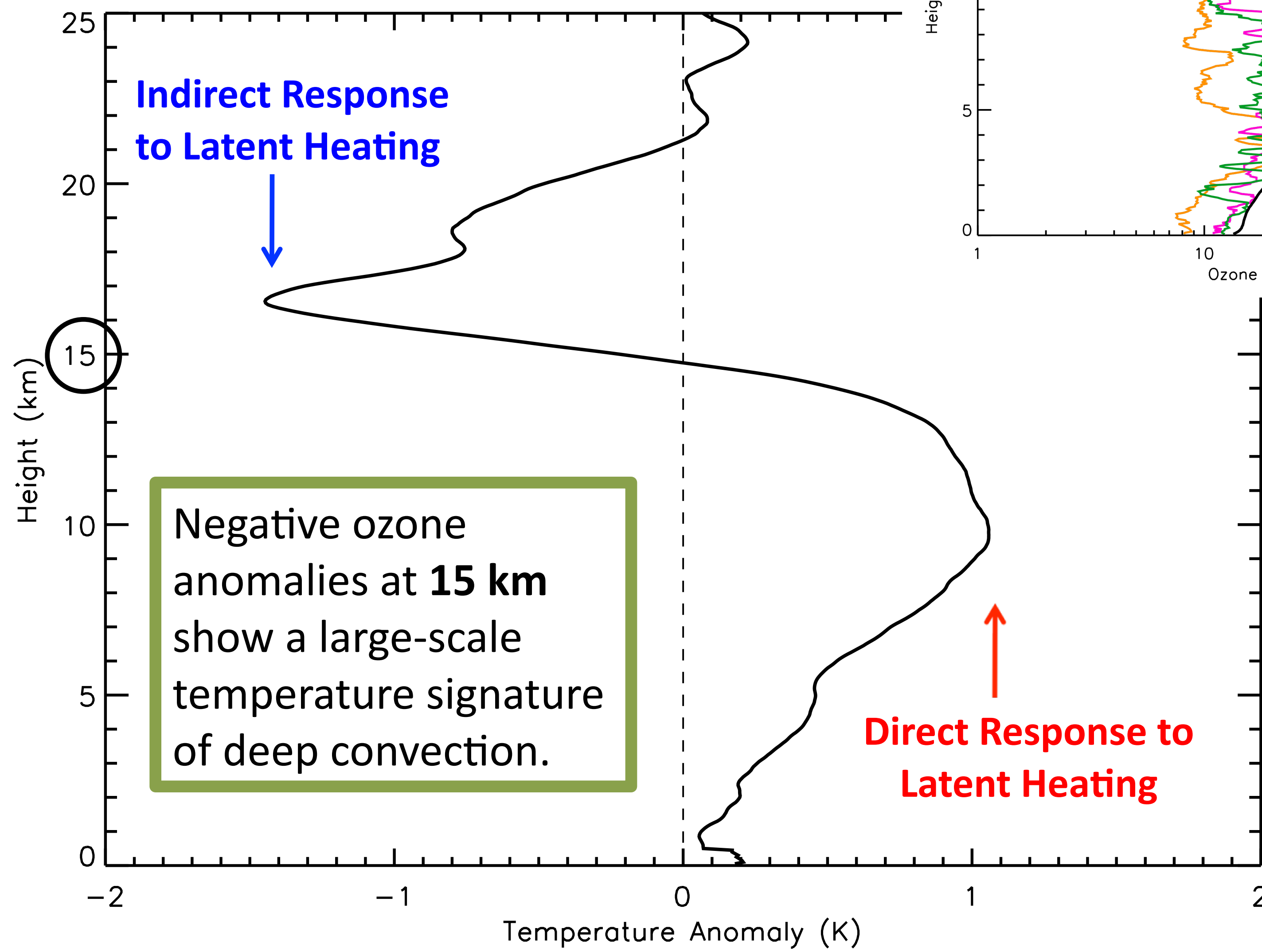
(Thompson et al. 2003a, 2003b)

Ozone as a Tracer for Deep Convection:



Investigating Negative Ozone Anomalies:





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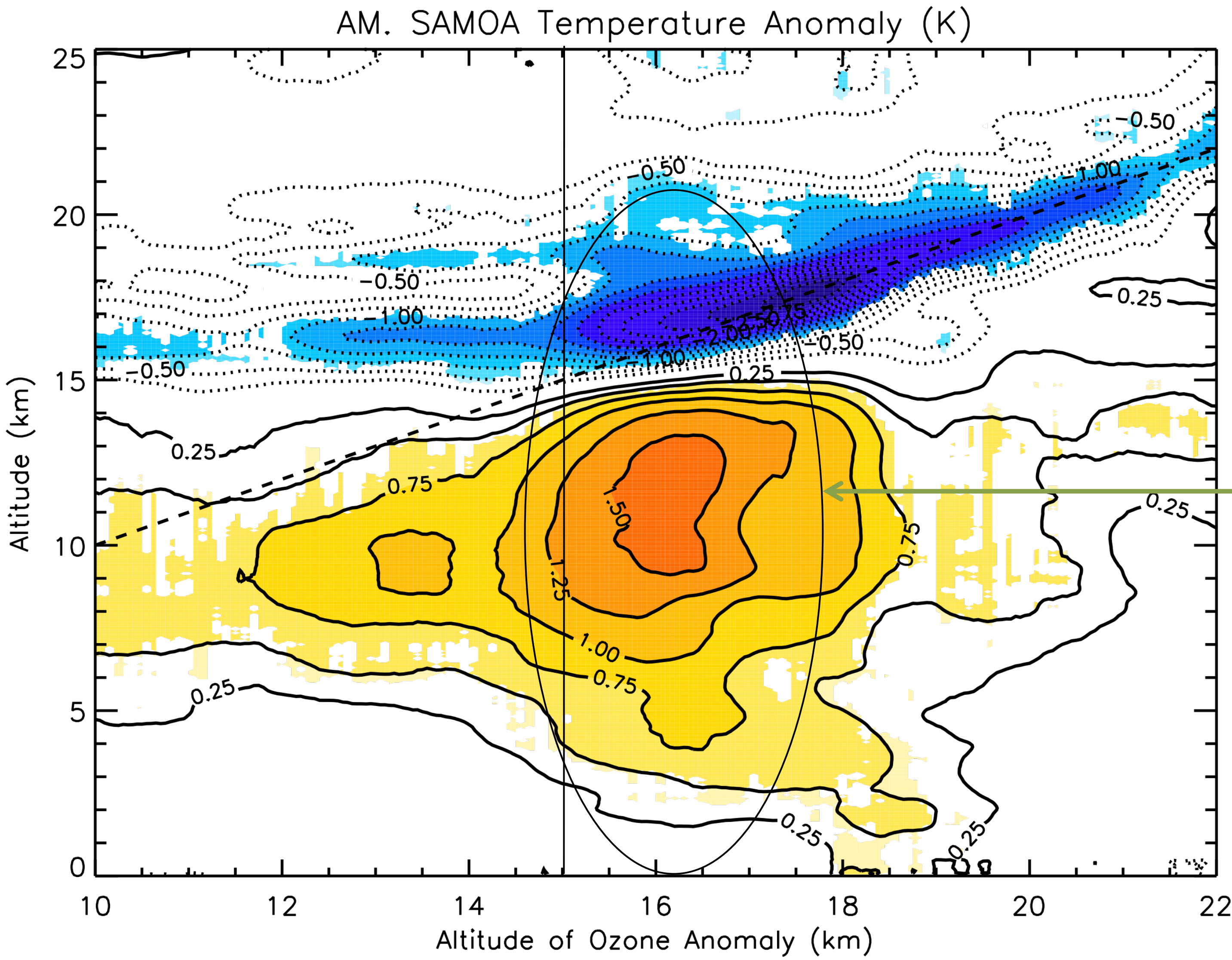
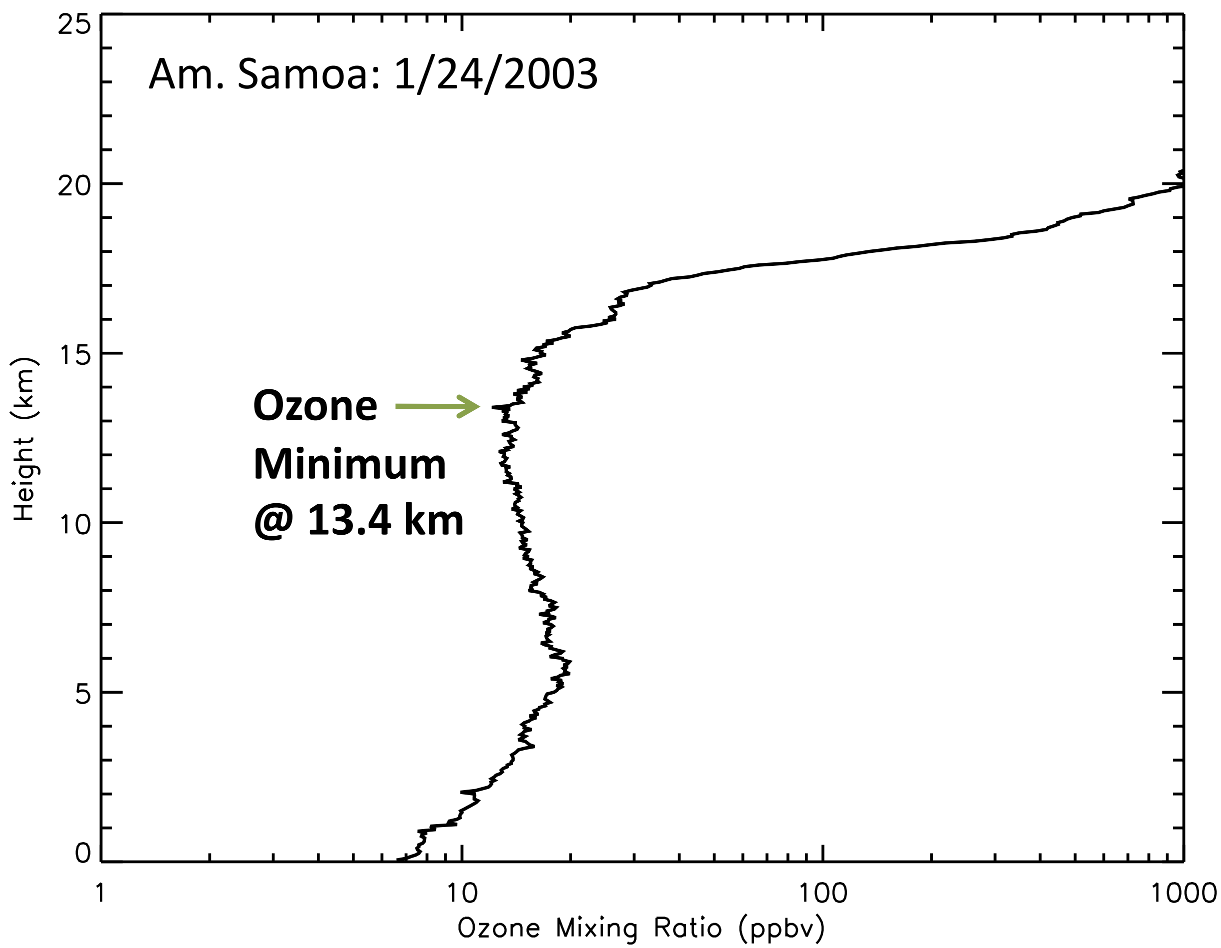


Negative ozone anomalies between 12-18 km show the large-scale temperature signature of deep convection.

Defining the Upper Tropospheric Ozone Minimum:

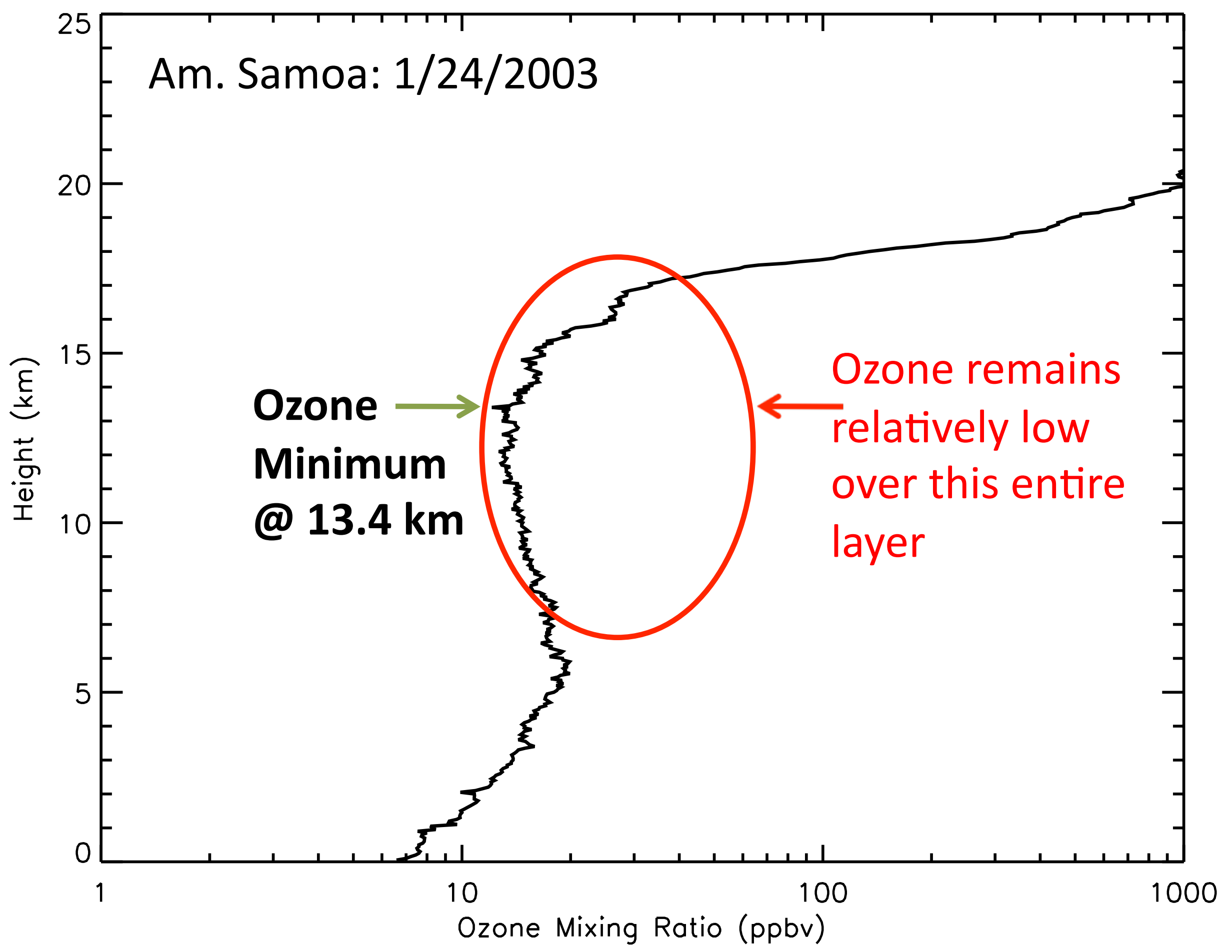


Minimum ozone concentration above 6.5 km was quantified for each profile, as well as the height at the ozone minimum.

Gettelman and Forster 2002; Gettelman and Birner 2007

Is this the best way to approach the problem?

Defining the Upper Tropospheric Ozone Minimum:



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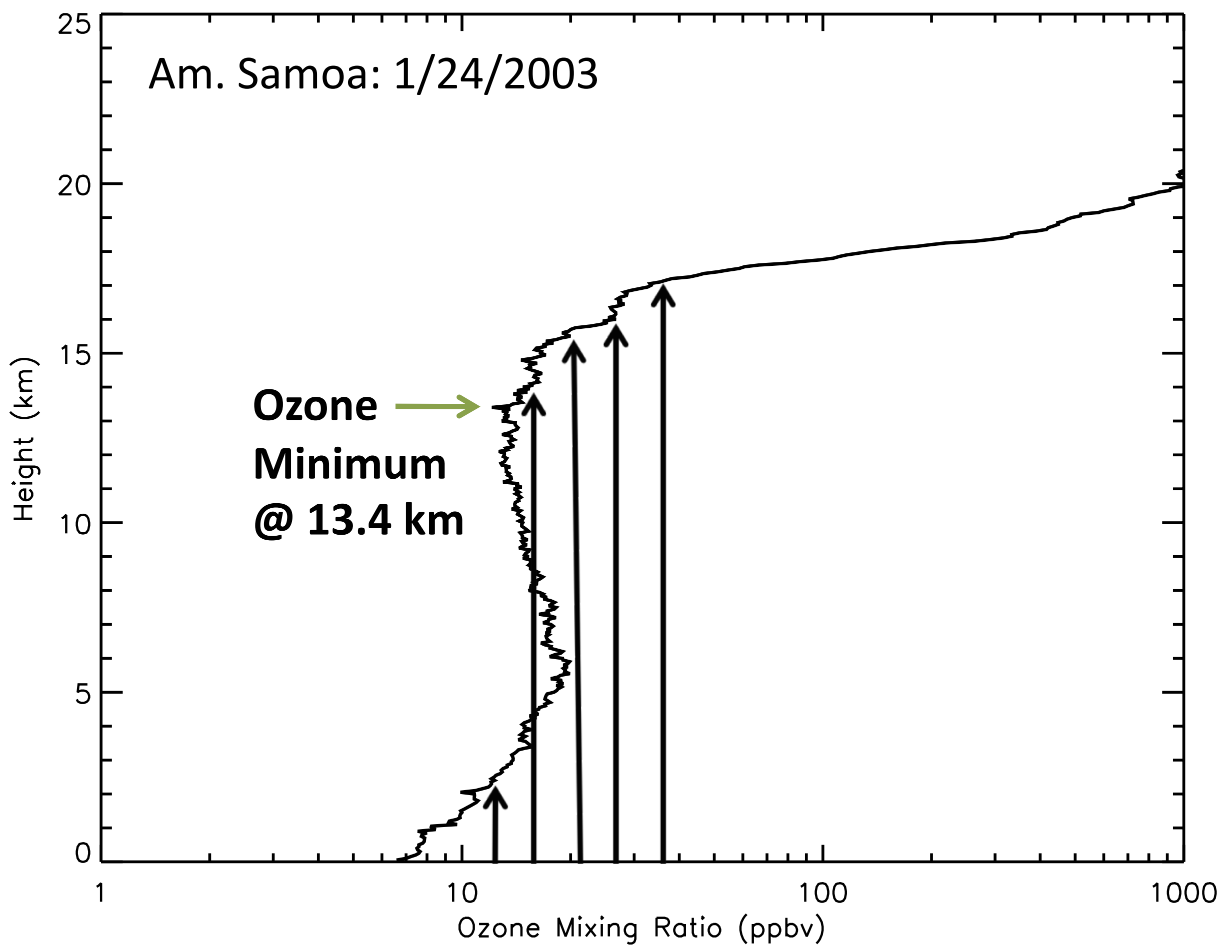

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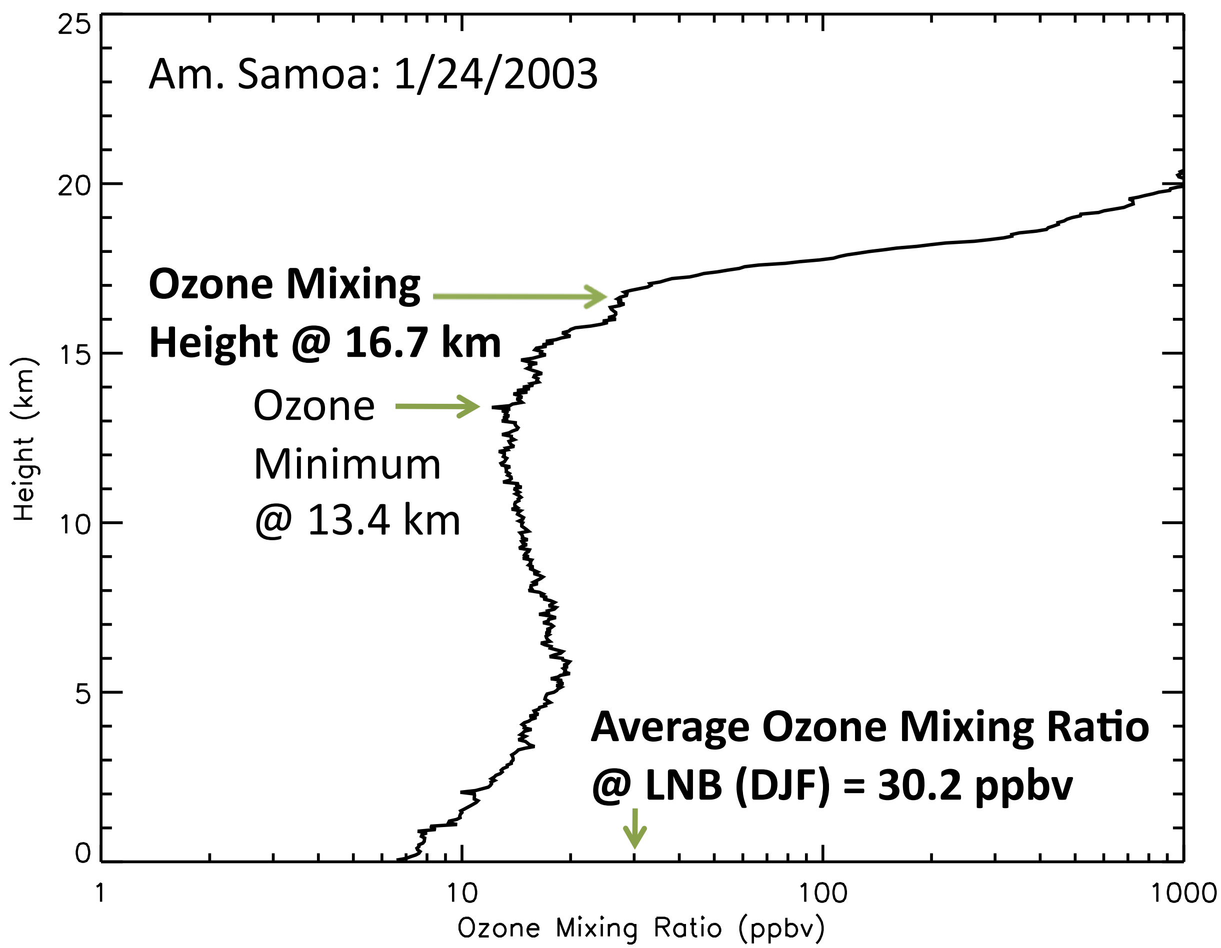
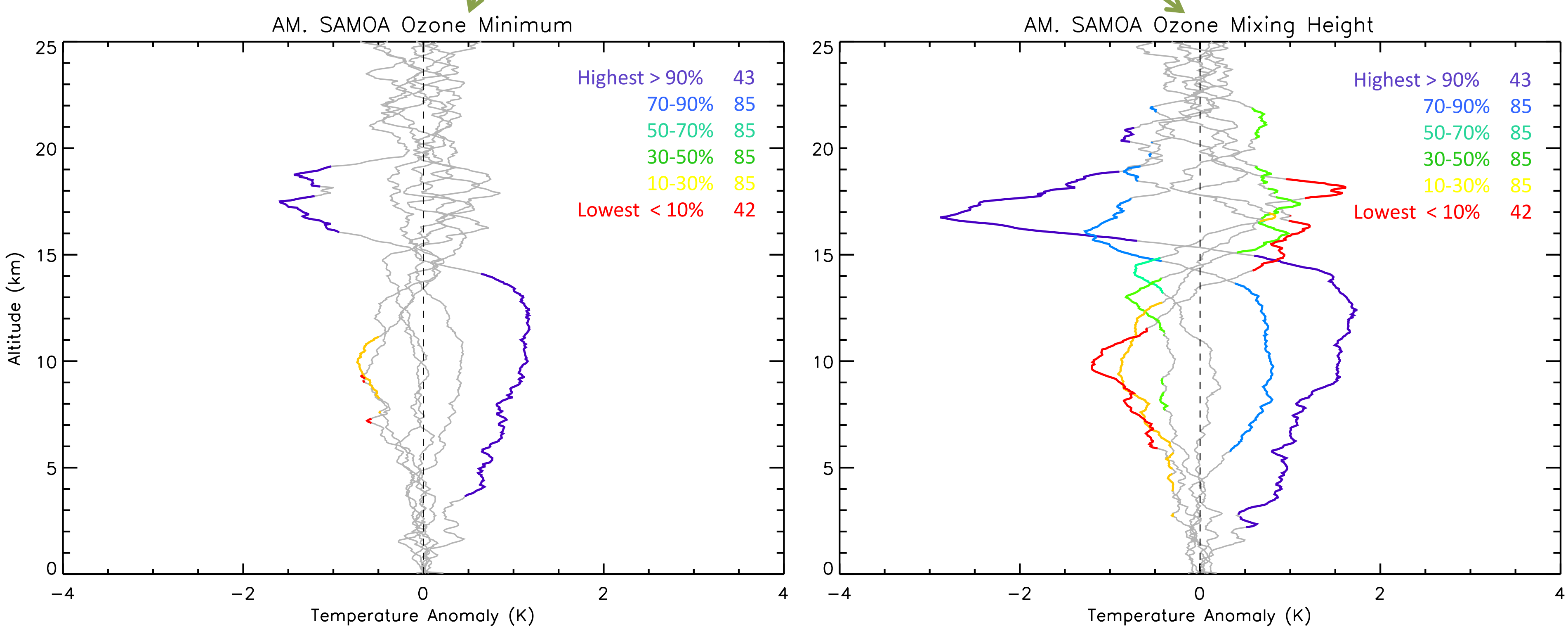
Defining the Ozone Mixing Height:



The maximum height that the an ozone mixing ratio is less than the average ozone mixing ratio at the LNB.

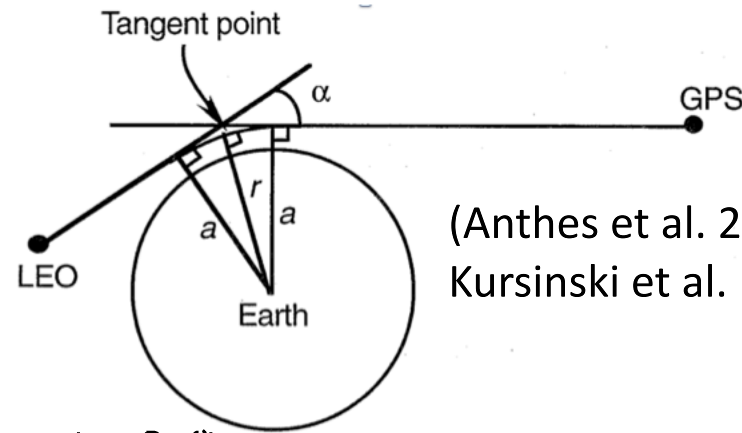
The Level of Neutral Buoyancy (LNB): "level at which an air parcel, rising or descending adiabatically, attains the same density as its environment" (AMS Glossary)

Ozone Minimum vs. Ozone Mixing Height:



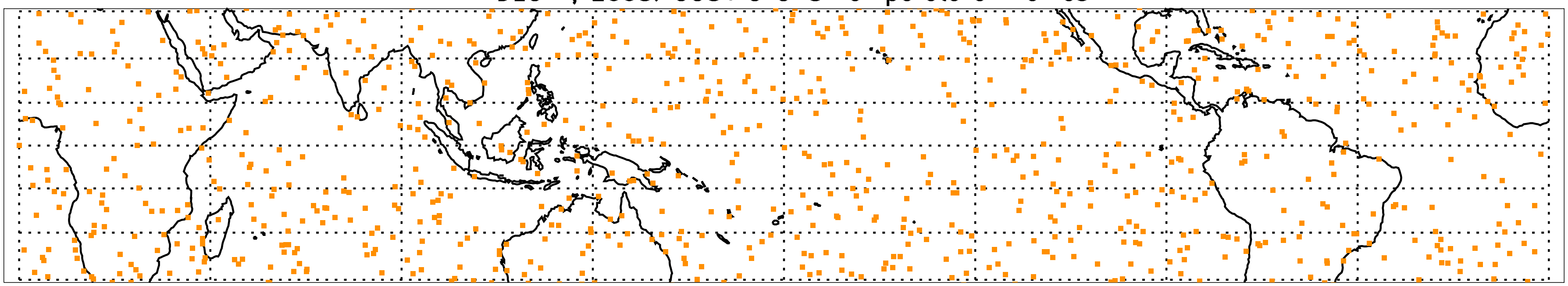
More Distinct Convective Signal

COSMIC GPS and CloudSat 2B-CLDCLASS Collocation:

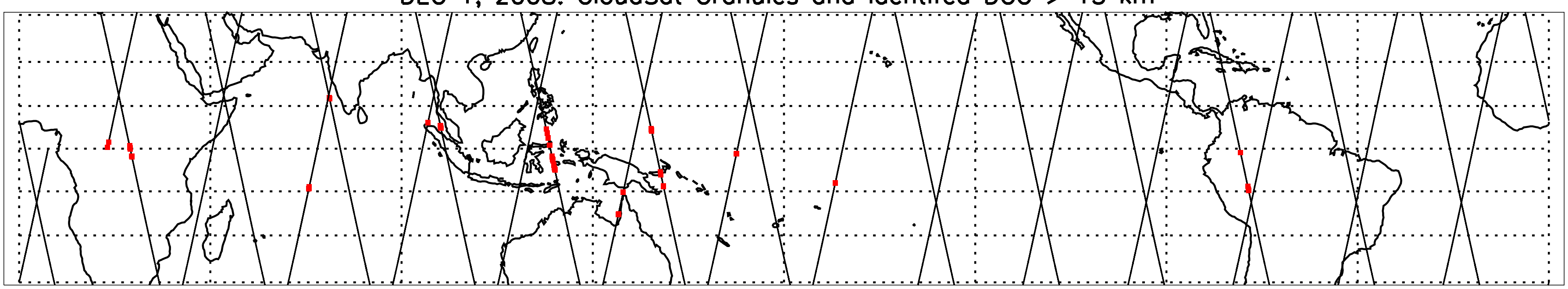


(Anthes et al. 2008, Kursinski et al. 1996)

DEC 1, 2008: COSMIC GPS Temperature Profiles



DEC 1, 2008: CloudSat Granules and Identifed DCC > 15 km

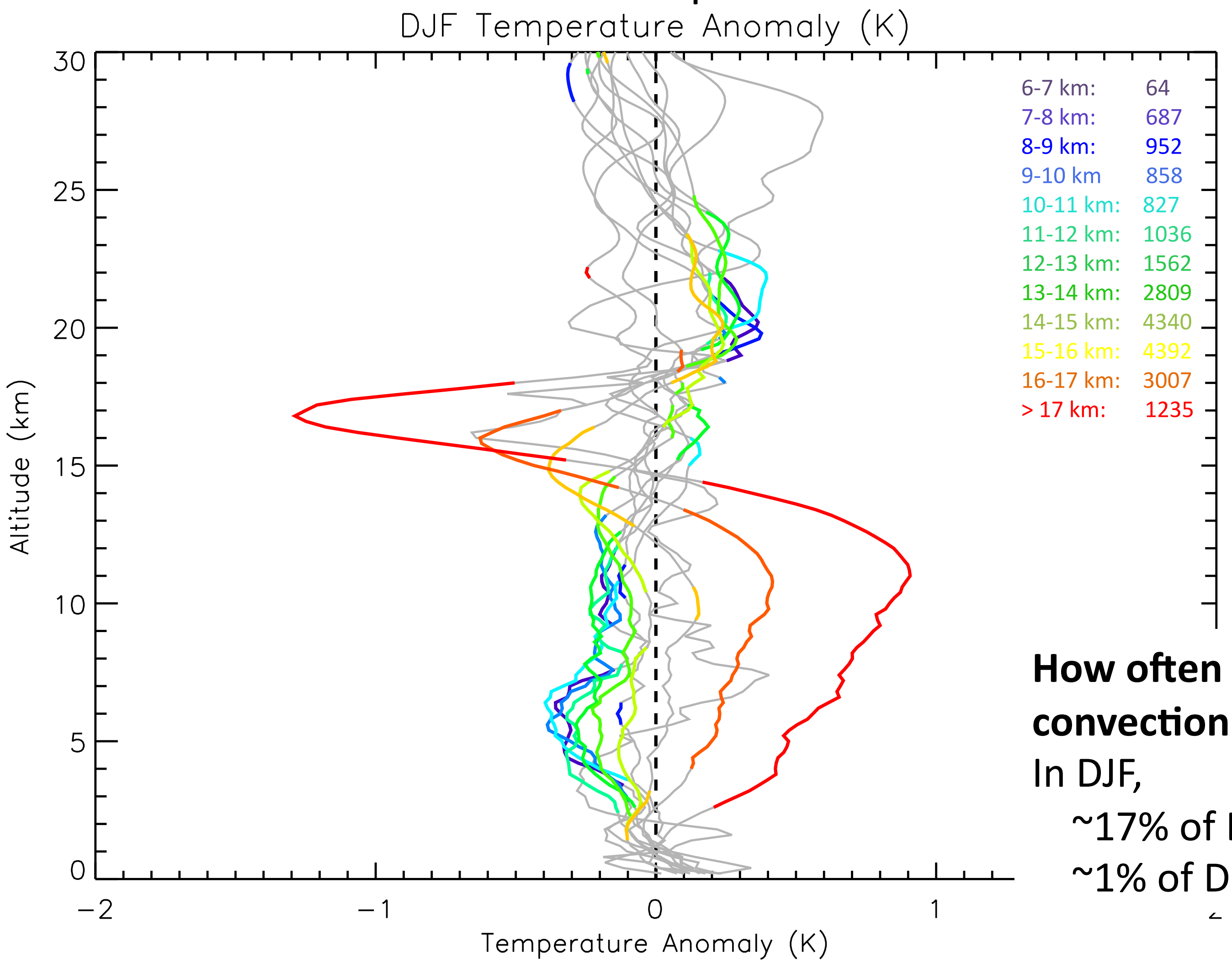


Temperature anomalies are created by subtracting the monthly mean temperature profile interpolated to the position of the sounding.

The distance between deep convective clouds and temperature profiles is computed using the Great Circles Distance Formula.

Dependence of Temperature Signal on DCC Top Height:

The convective temperature signal is only evident for deep convective clouds top pixels > 15 km



How often does the deepest convection occur?

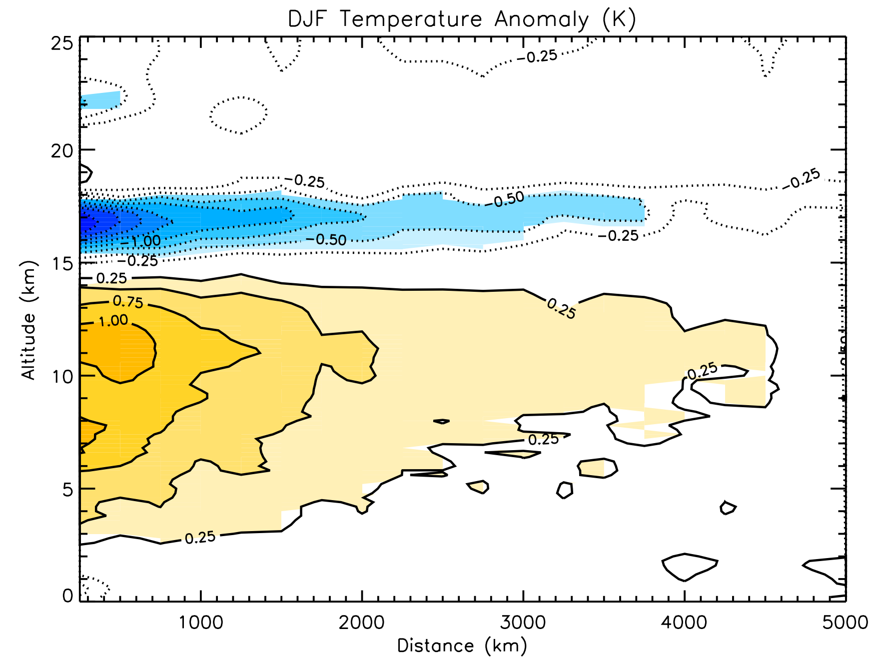
In DJF,

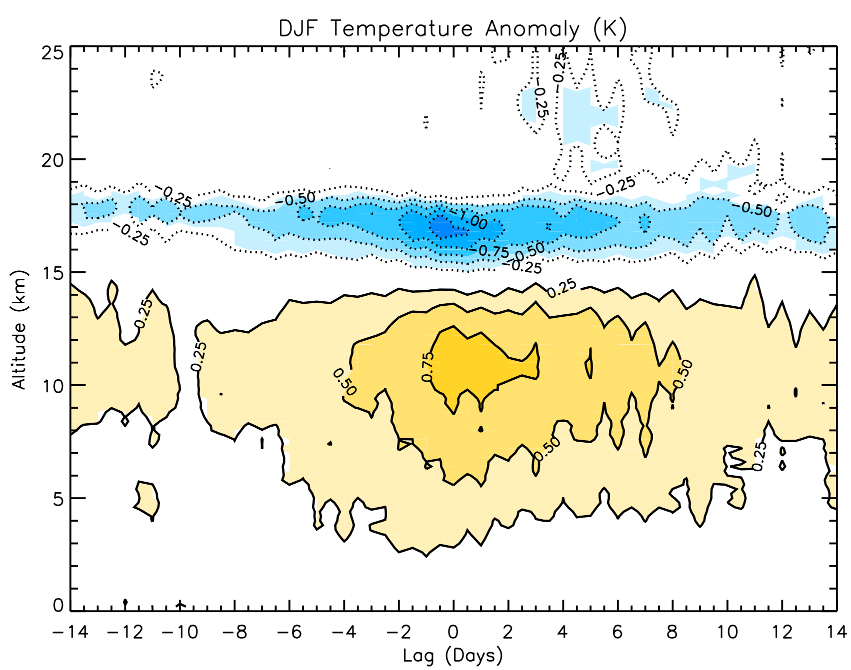
~17% of DCC top pixels > 15 km

~1% of DCC top pixels > 17 km

Dependence of Temperature Signal on Distance:

temperature signal decays with increasing distance





Time Evolution of Temperature Signal:

temperature strongest at lag 0, and persistent in time

Conclusions:

1. Confirmed the usefulness of ozone as an indicator of deep convection.

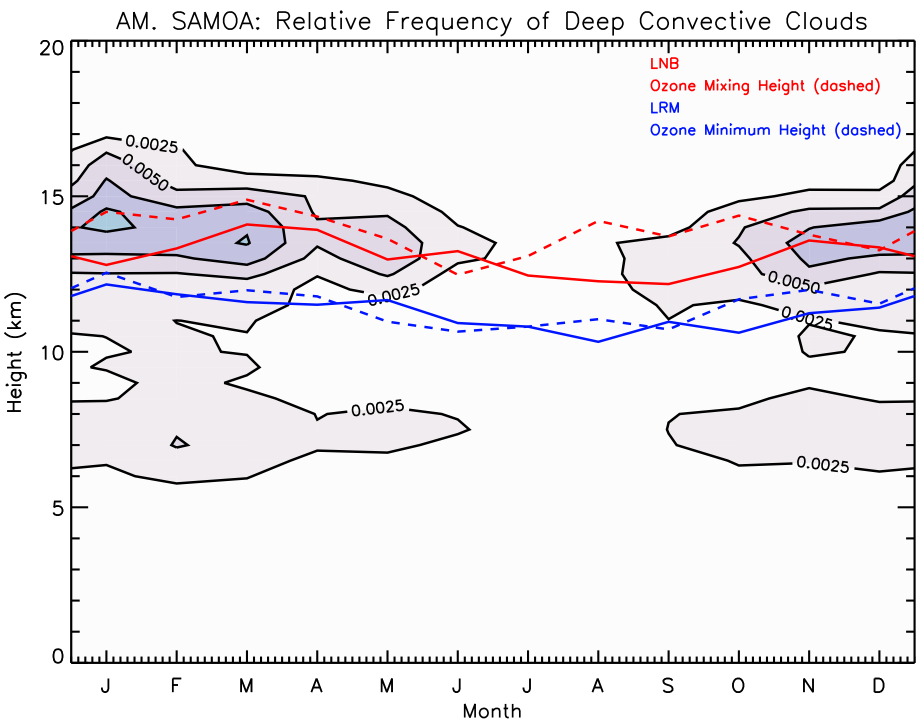
2. Revealed convective signals in temperature (deep upper tropospheric warm anomaly/ cold CPT anomaly) associated with reduced ozone events.

3. Using ozone in connection with the Level of Neutral Buoyancy (i.e. "Ozone Mixing Height" diagnostic) is more useful for determining deep convective influence when compared to the "Ozone Minimum" diagnostic.

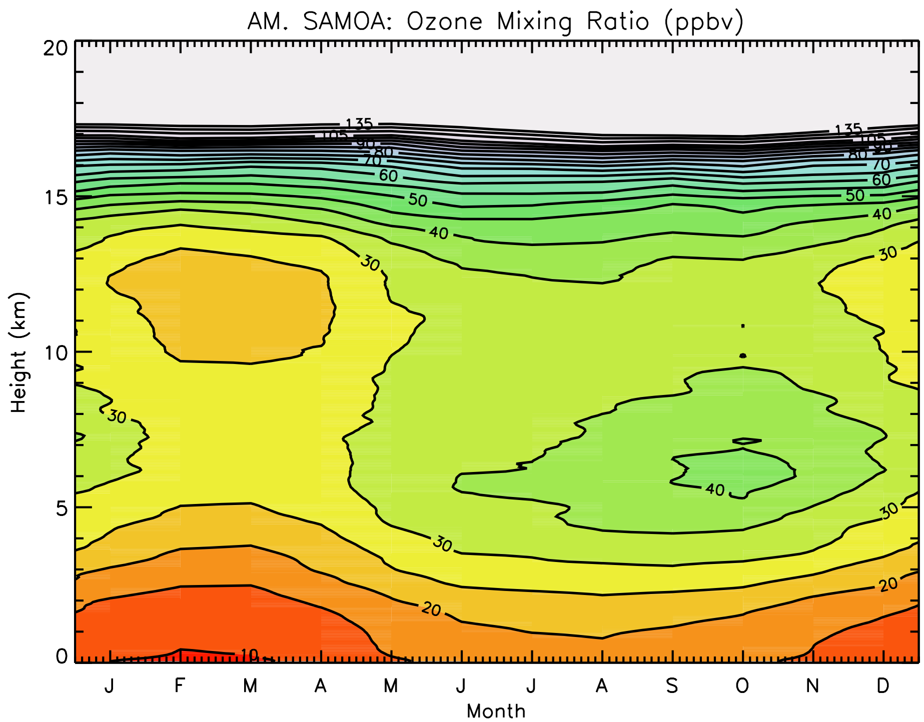
4. Revealed a convective temperature signal for COSMIC GPS profiles in proximity to deep convective cloud top pixels greater than 15 km.

5. The strongest temperature signal is evident when distance in time and space is minimized.

Deep Convective Cloud Climatology: American Samoa



The LNB (solid red) much better represents the top of convection when compared to the LRM (solid blue).



Deep convection is significant in determining composition up to 15 km during convective season.