Towards a synthesis definition of the TTL

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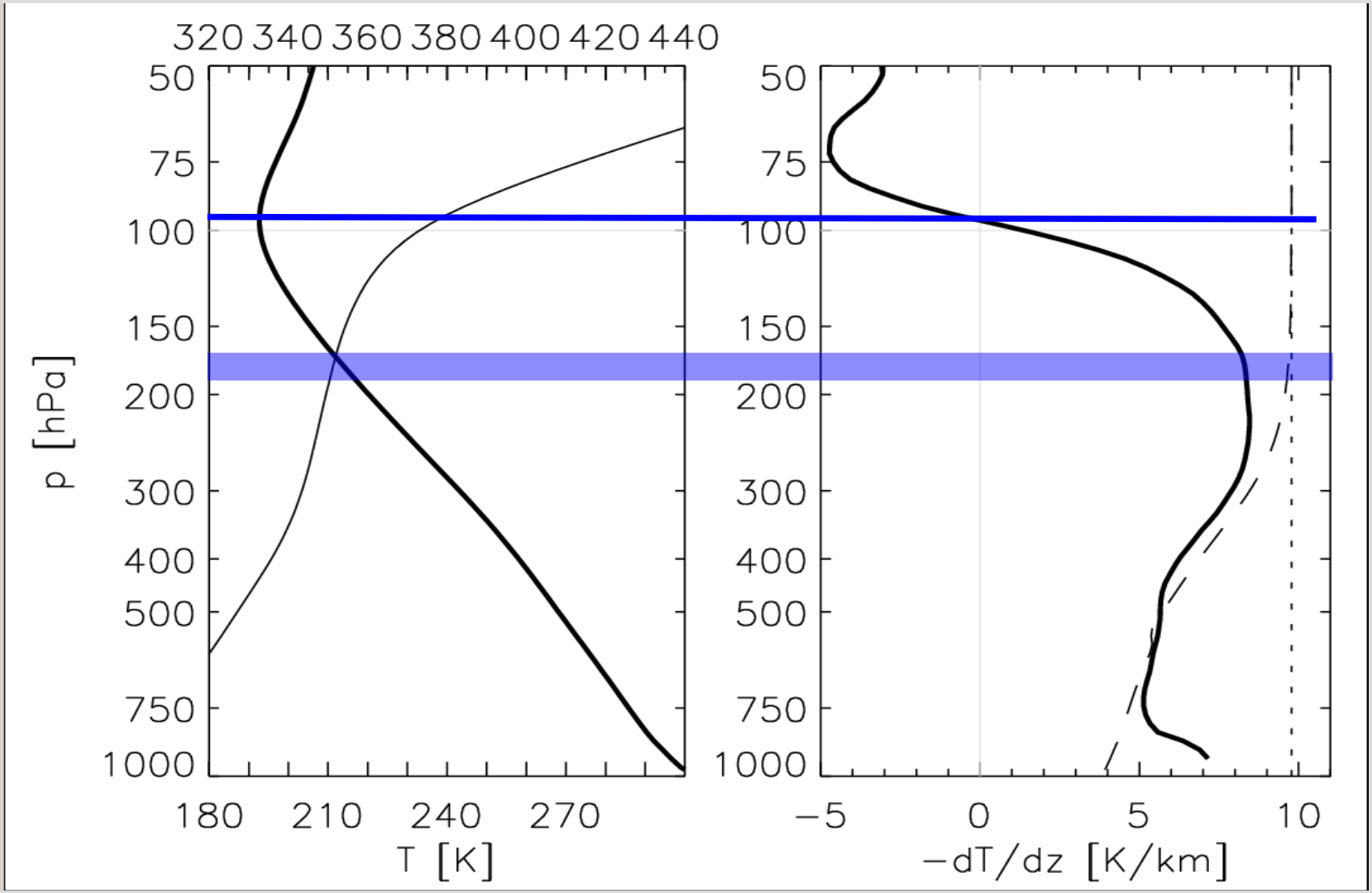
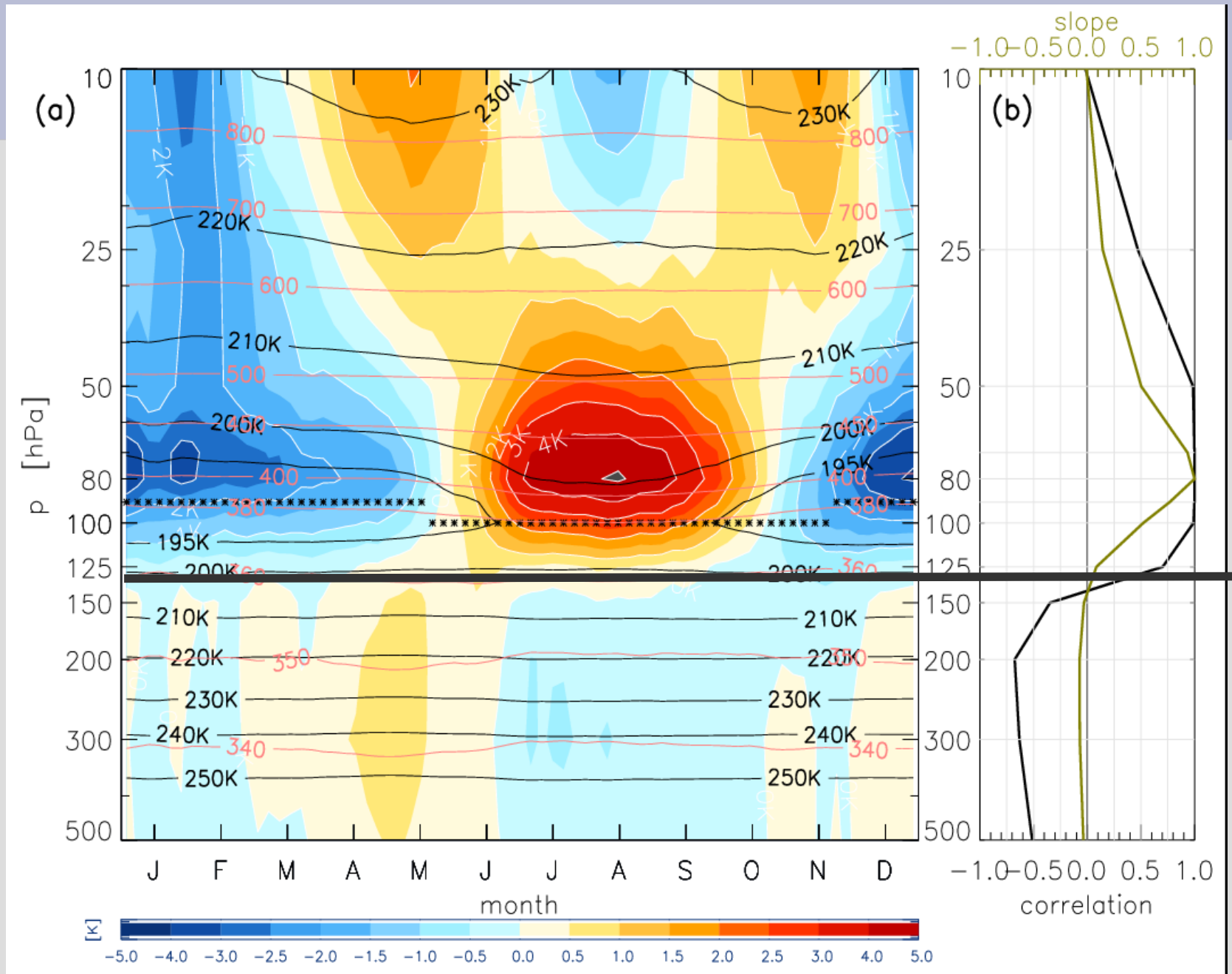
Goal: synthesize observed and derived quantities

- Principle: TTL the region with both (5-95%) stratospheric and tropospheric properties
- Temperature profiles and variability
- Ozone and other trace constituents
- Clouds
- Dynamical and radiative considerations

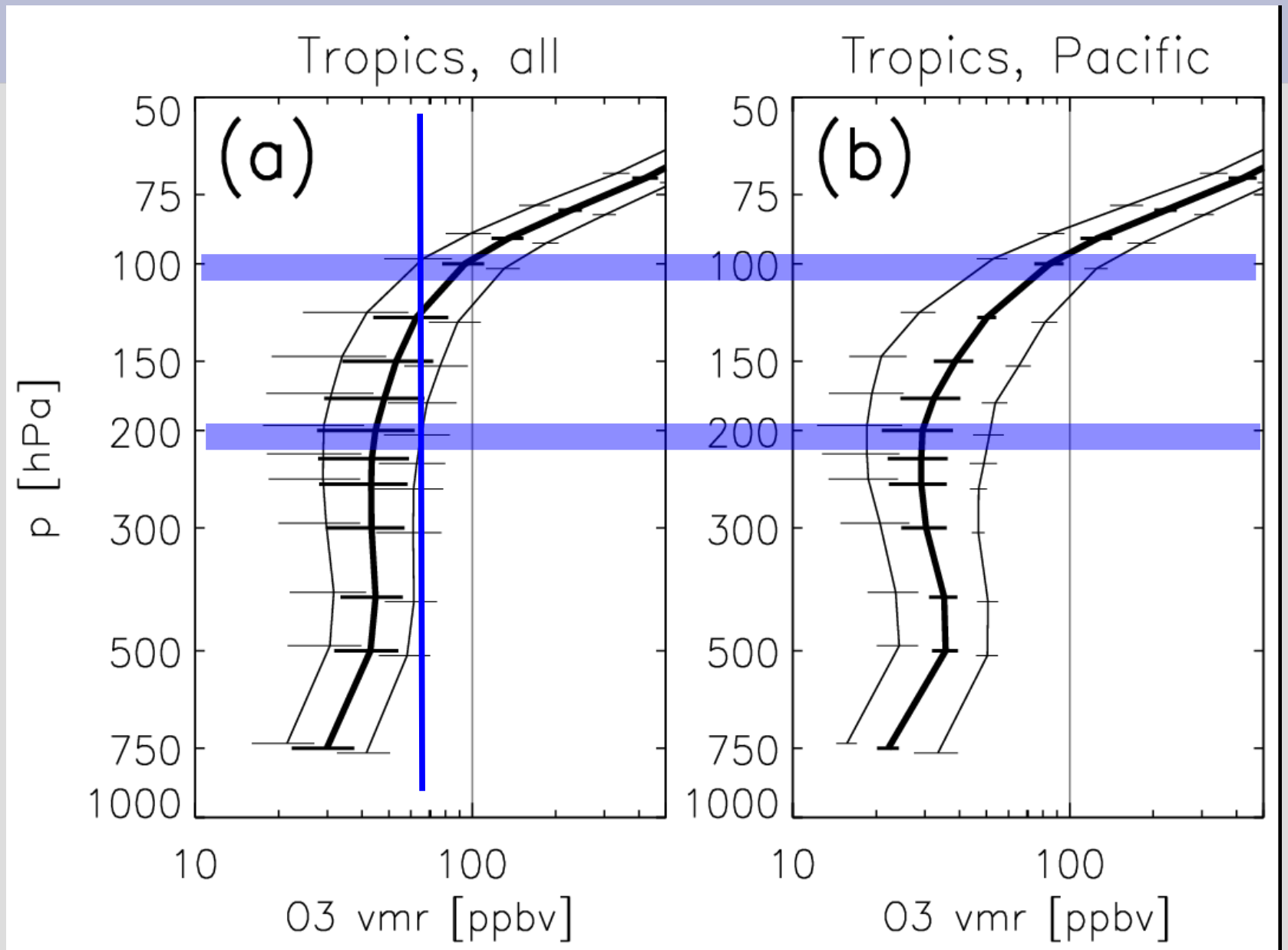
Temperature



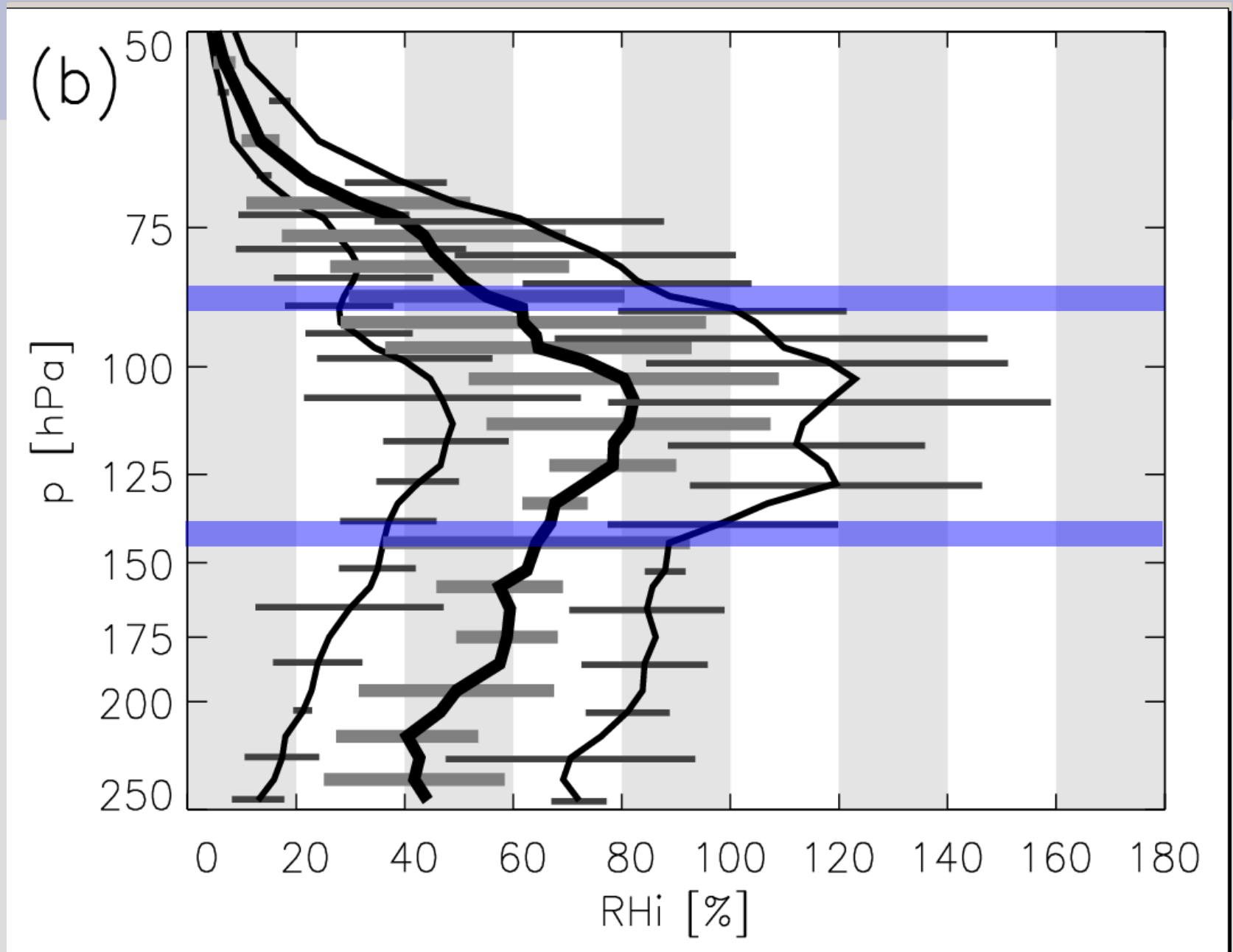
Temperature variability



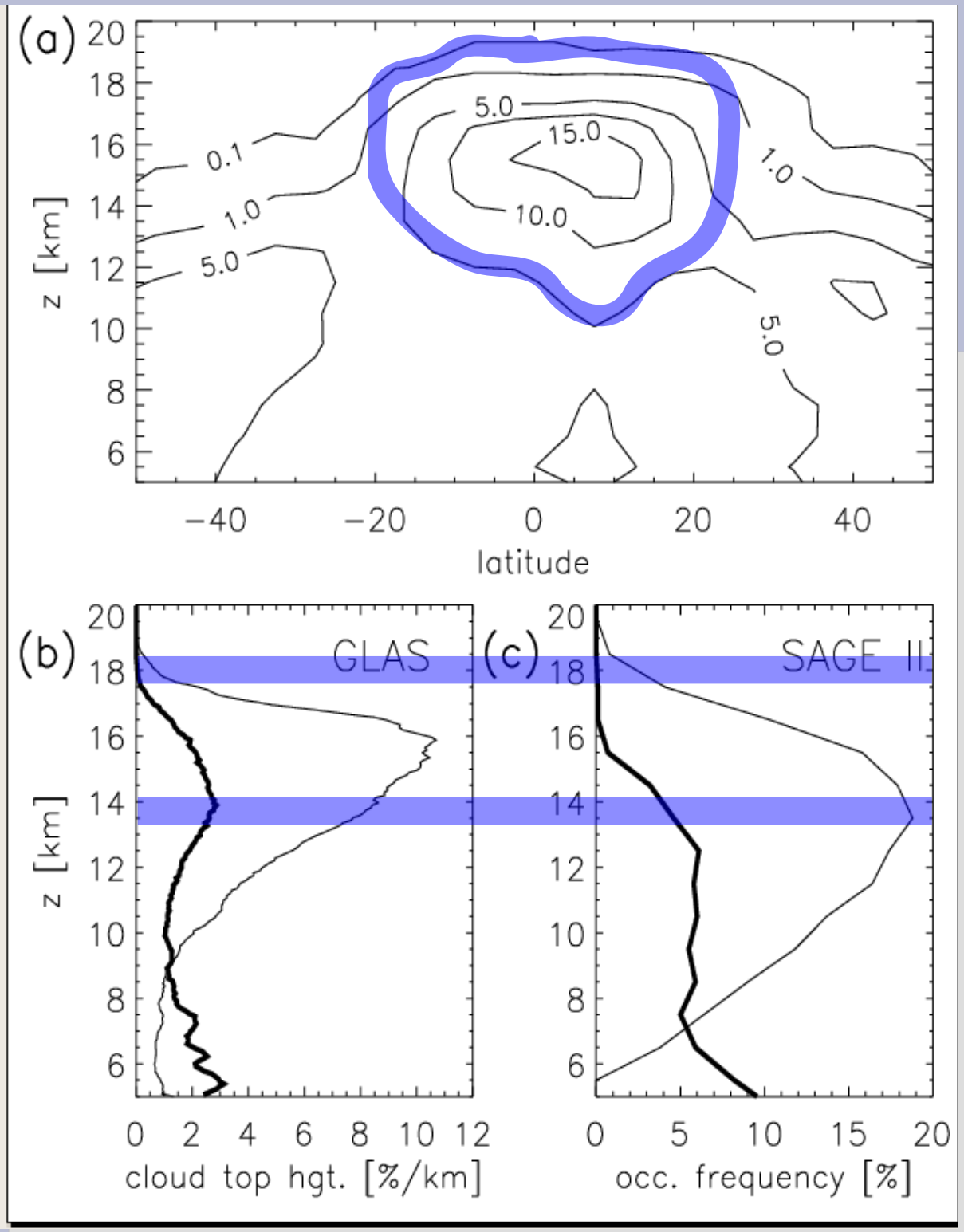
Ozone


Tropics, all
Tropics, Pacific
(a)
(b)
p [hPa]
50
75
100
150
200
300
500
750
1000
10
100
O3 vmr [ppbv]

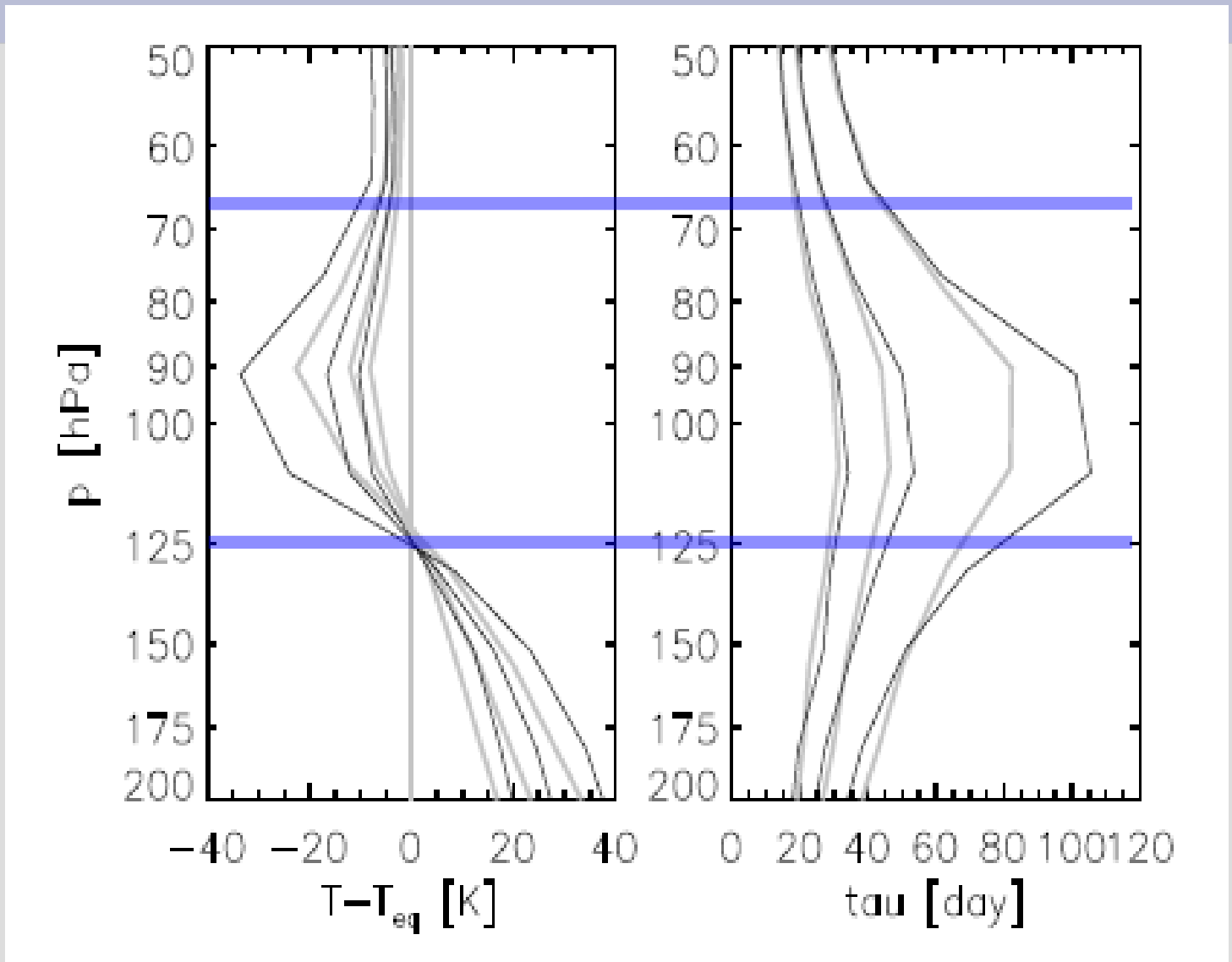
Relative humidity



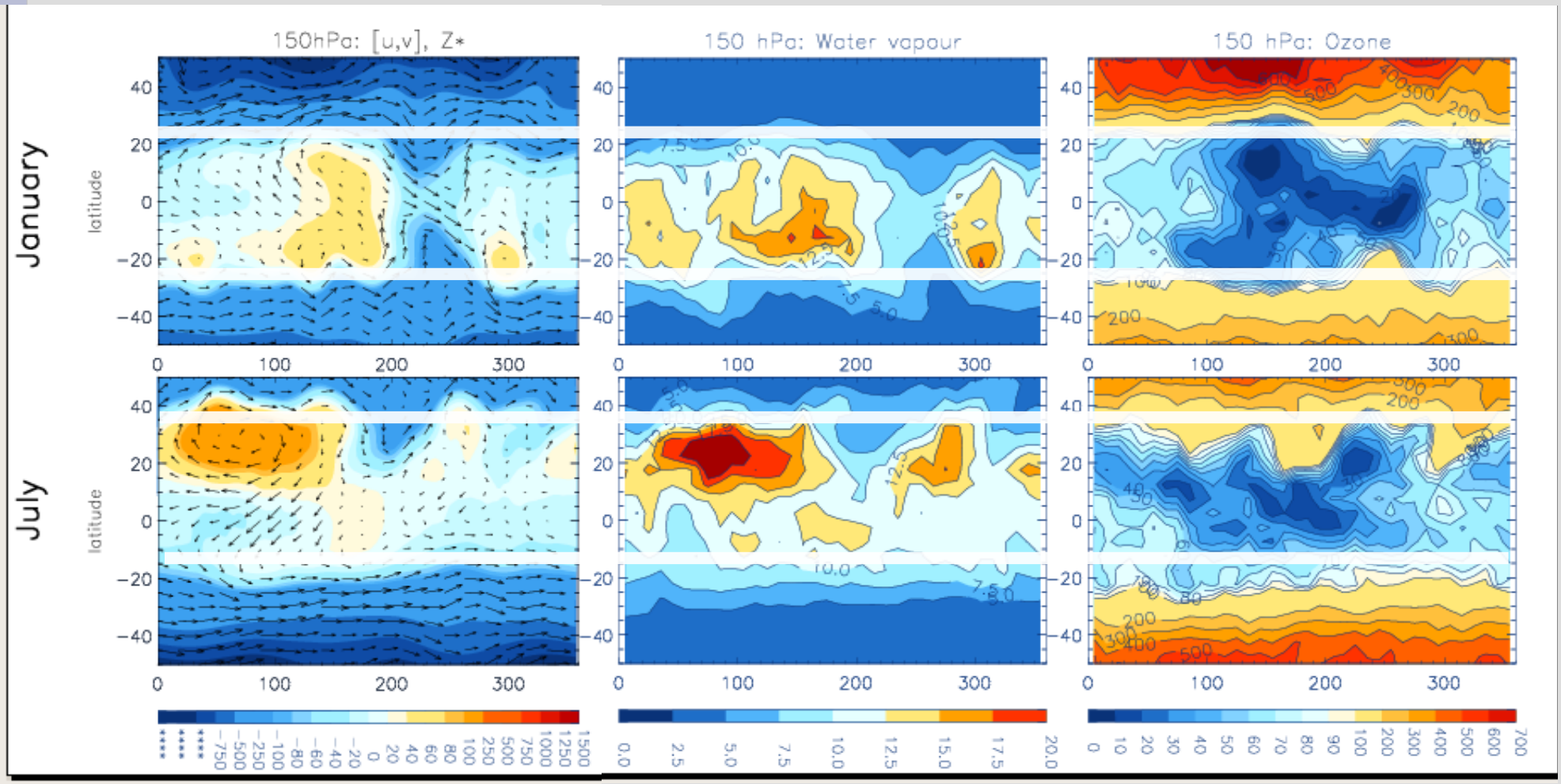
Clouds


(a)
z [km]
latitude
5.0
15.0
10.0
0.1
1.0
5.0
1.0
5.0
(b)
GLAS
cloud top hgt. [%/km]
(c)
SAGE II
occ. frequency [%]

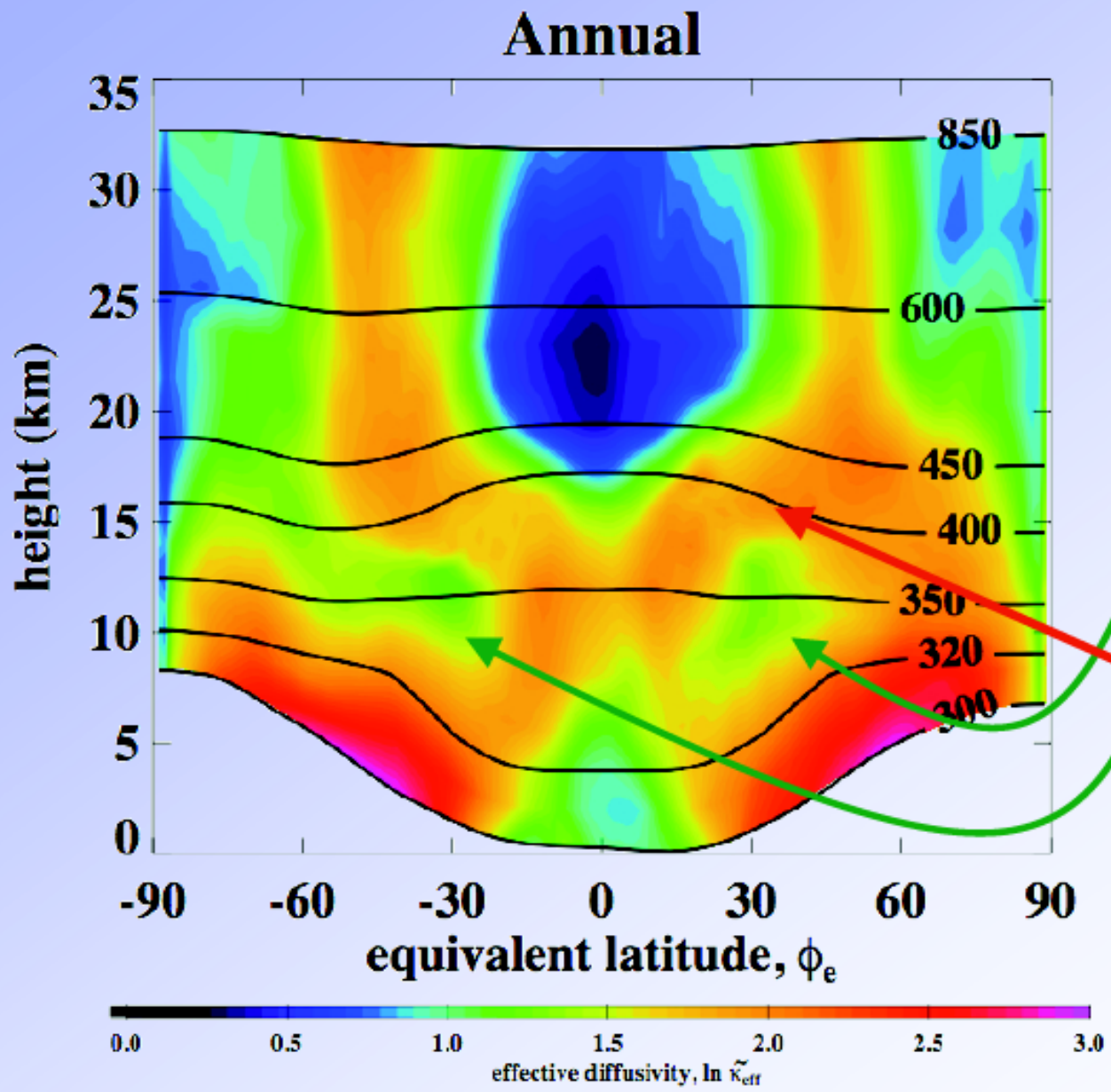
Radiative heating/cooling



Lateral bounds?



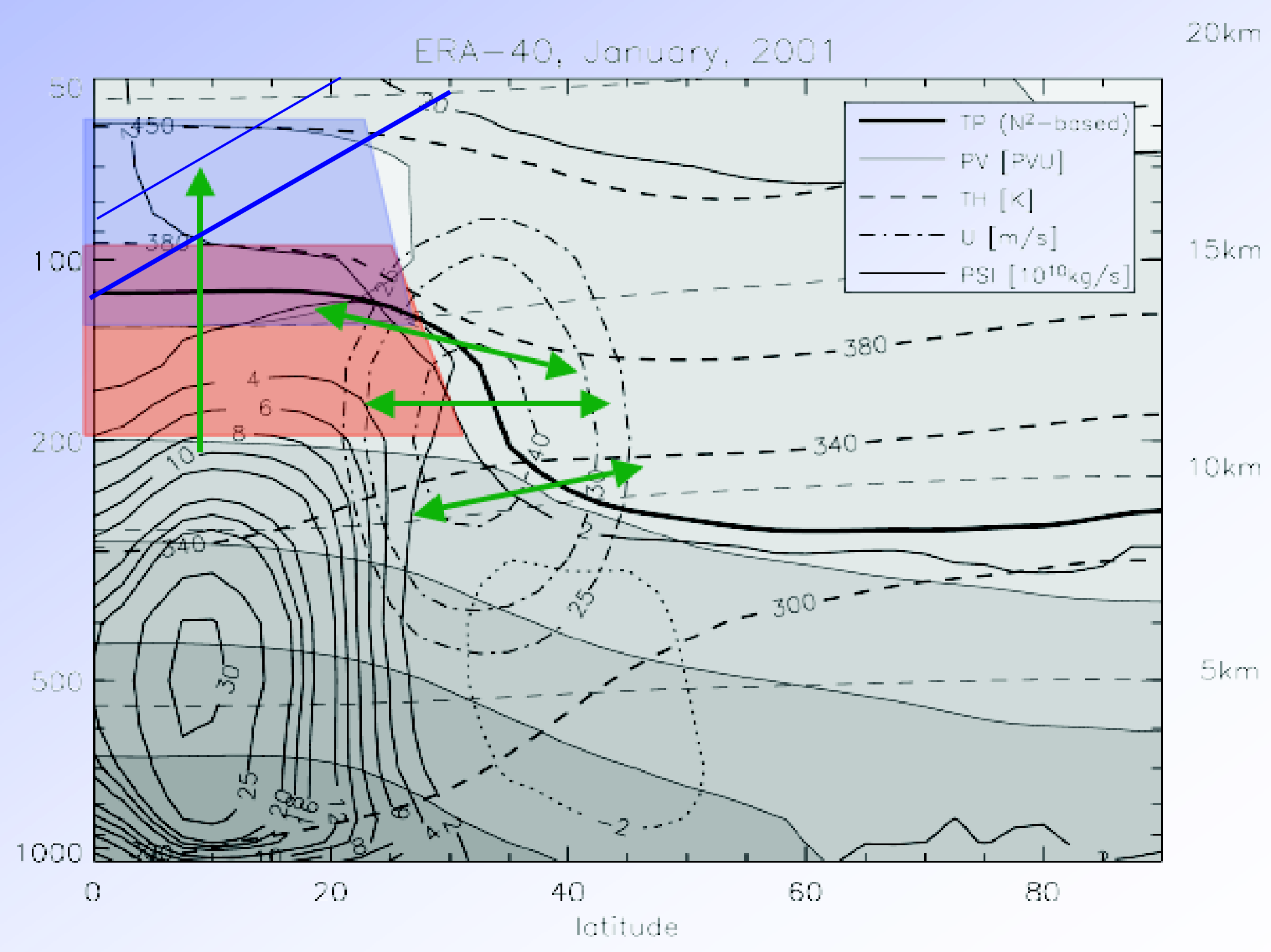
Lateral bounds?



Minima at subtropical jet level -> 'mixing barrier' (see H_2O and O_3 maps), lateral TTL bounds?

BUT: Just above TP strong mixing! (Readily seen in, e.g., H2O)

[Haynes and Shuckburgh, 2000]


ERA−40, January, 2001
TP (N²−based)
PV [PVU]
TH [K]
U [m/s]
PSI [10¹⁰kg/s]
20km
15km
10km
5km
50
100
200
500
1000
0
20
40
60
80
latitude
450
380
340
300
30
25
20
15
10
8
6
4
2
1

Quantity		*Trop. value*	*transition ht*	*TTL value*	*transition ht*	*strat. value*
T	lapse rate	moist adiabatic	~200 hPa	<<adiabatic	85-100 hPa	positive
	ampl	<1 C	150 hPa	>1 C	100 hPa	>>1 C
	phase	varies	150 hPa	max Jul/Aug	--	max Jul/Aug
ozone		95% <60ppb	200 hPa	$dO_3/dz > 0$	100 hPa	95% >60 ppb
ozone ann. cy.		max ~Oct	-	--	--	max ~Aug
CO, N2O		constant	125 hPa	--	--	decreasing
rel. humidity		10-100%	140 hPa	frq. supersat.	85 hPa	<< 50%
clouds		variety	~250 hPa	abundant, esp. subv Ci	~80 hPa	no clouds
rad. heating		<0	125 hPa	>0, dom. by H_2O	85-10 hPa	>0, dom. by O_3
Convection		frequent	~200 hPa	occasional	70 hPa	never
HDO depletion		increases with height	200 hPa	~ const	-	~const
Radon		detectable	--	--	90 hPa	not detectable

Summary

- Considering a range of observed and derived quantities, the base of the TTL can be placed about 125-150 hPa and the top at 70-80 hPa
- Lateral boundaries at equatorward flank of subtropical jet
- Boundaries fuzzy and fluctuate with longitude and season