Latitudinal dependence of the ExTL from *in-situ* observations

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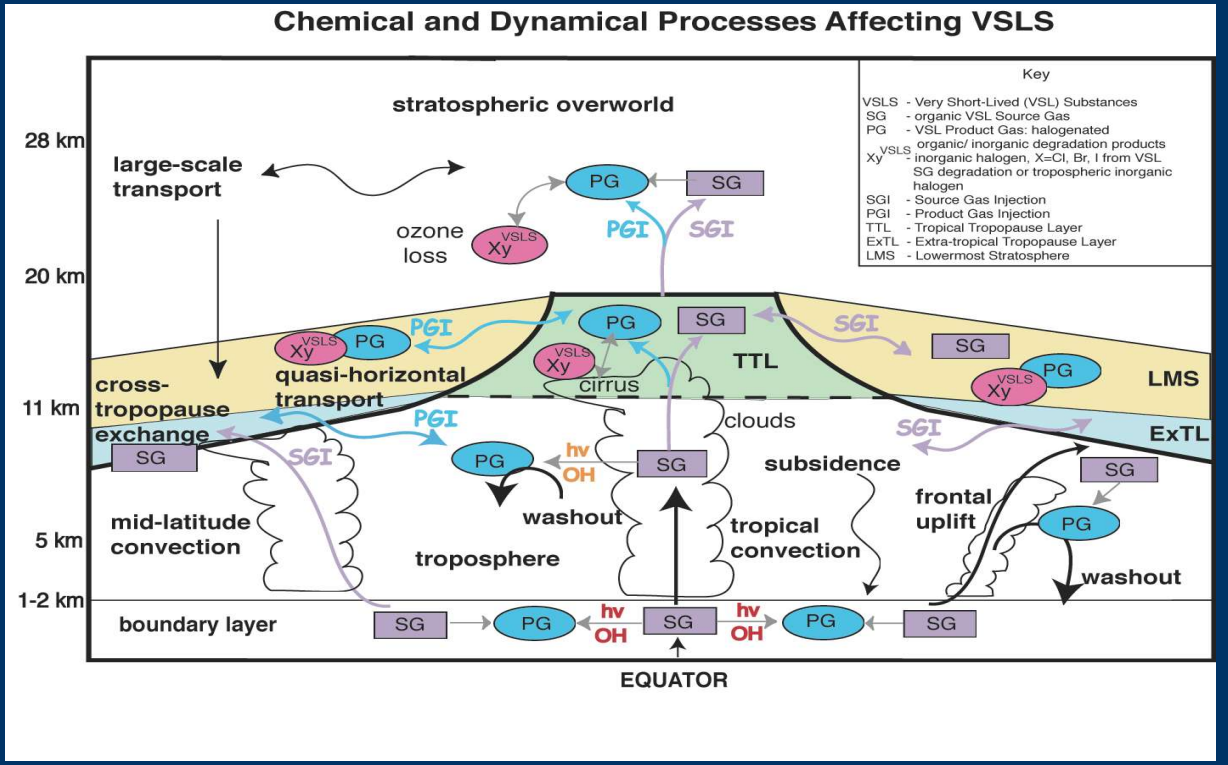
Introduction

Where air is transported between troposphere and stratosphere, how is chemically processed during its passage through the transition layers and how CCMs represent these processes?

Convection, tropical upwelling and extratropical downwelling
Isentropic transport / barriers
Frontal uplift

Links between local and global scales
Different methodologies



Law, Haynes & Cox, WMO (2007), Chapter 2 on Very Short-Lived Halogenated Substances (VSLS)

Plan

In situ measurements: harmonising different sources to produce a global picture

Vertical coordinates

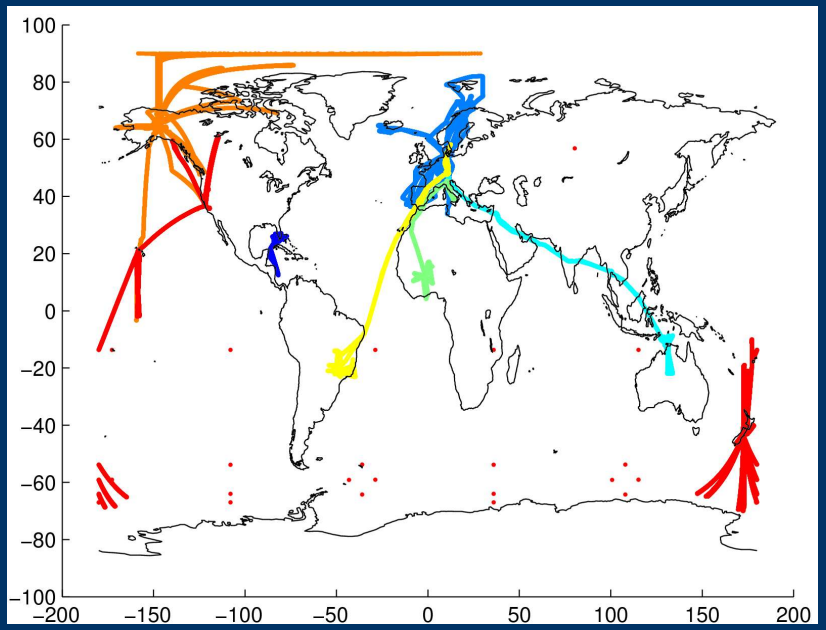
Tracer gradients

A Lagrangian perspective

Summary and outlook

In-situ measurements

Development of an algorithm to integrate individual campaigns into a composite dataset of in situ measurements and then consistently calculate dynamical diagnostics from analysed winds.



ASHOE-MAESA, Polaris, Crystal-Face, SPURT, Hibiscus-Troccinox, AMMA and SCOUT-O3. More in progress

In-situ measurements

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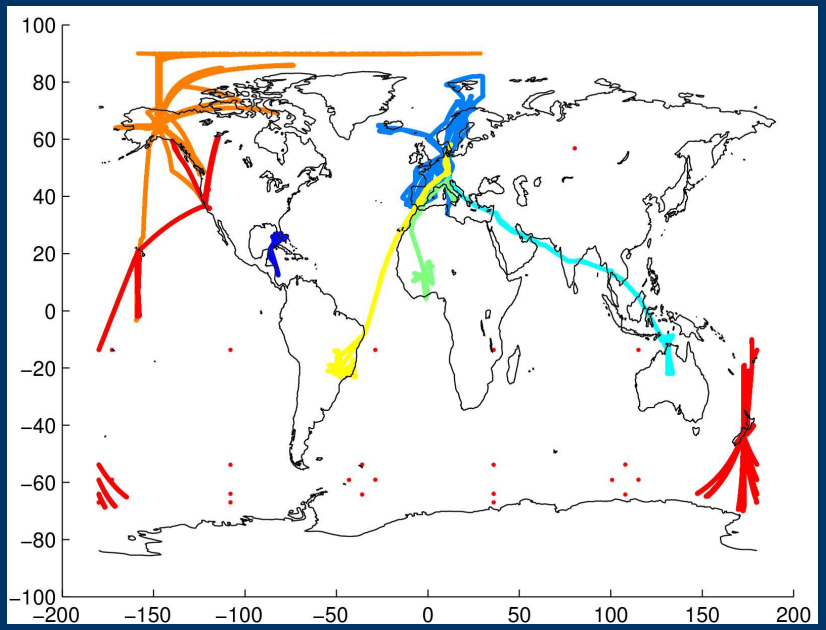


Based on ECMWF analysis

Time
Latitude
Longitude
Pressure
Temperature

O3
Water
TotalWater
CO
CH4
CO2
N2O

Potential temperature
Potential vorticity
Equivalent latitude

Tropopause theta (2 PV definition)
Tropopause theta (WMO definition)
Cold point theta

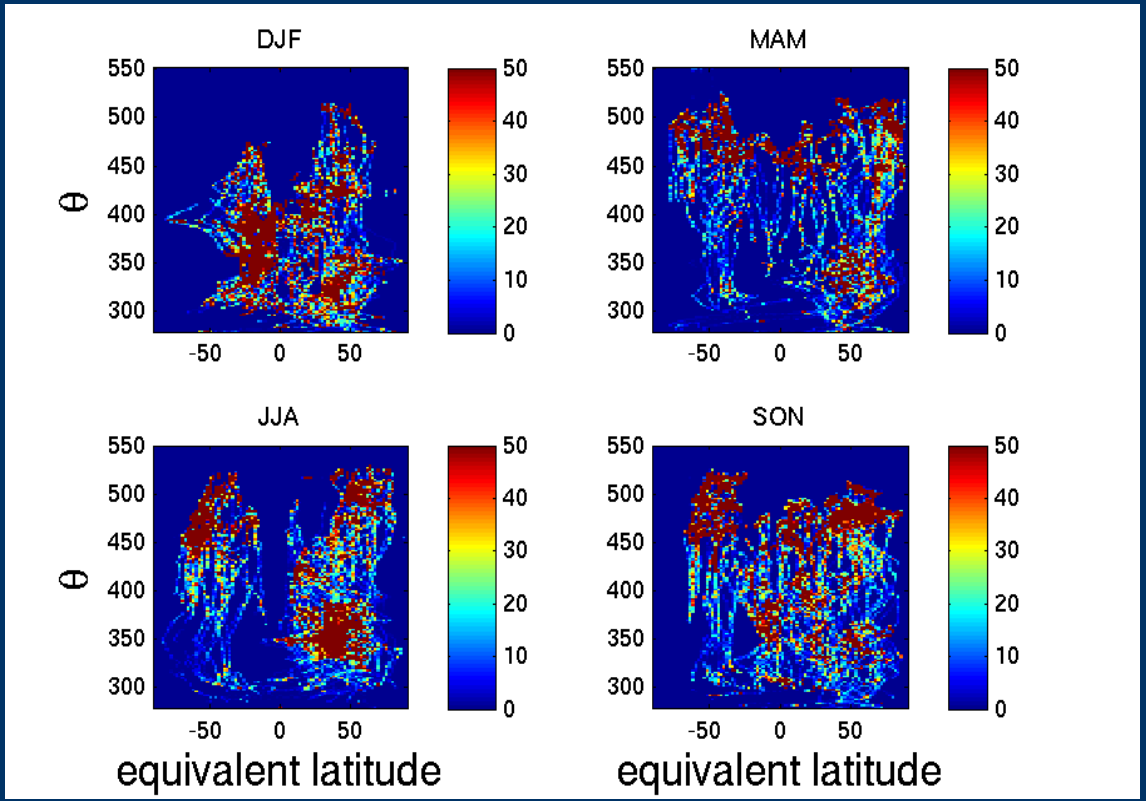
ASHOE-MAESA, Polaris, Crystal-Face, SPURT, Hibiscus-Troccinox, AMMA and SCOUT-O3. More in progress

In-situ measurements

1 234 241 measurement points

seasonal distribution:

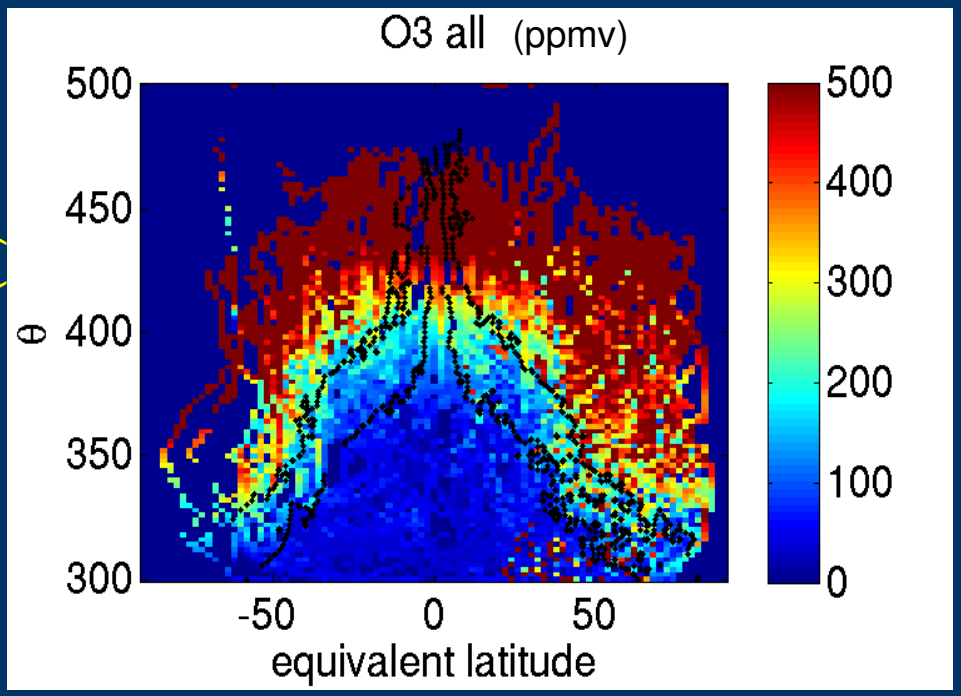
DJF	331 661
MAM	265 607
JJA	313 054
SON	323 919

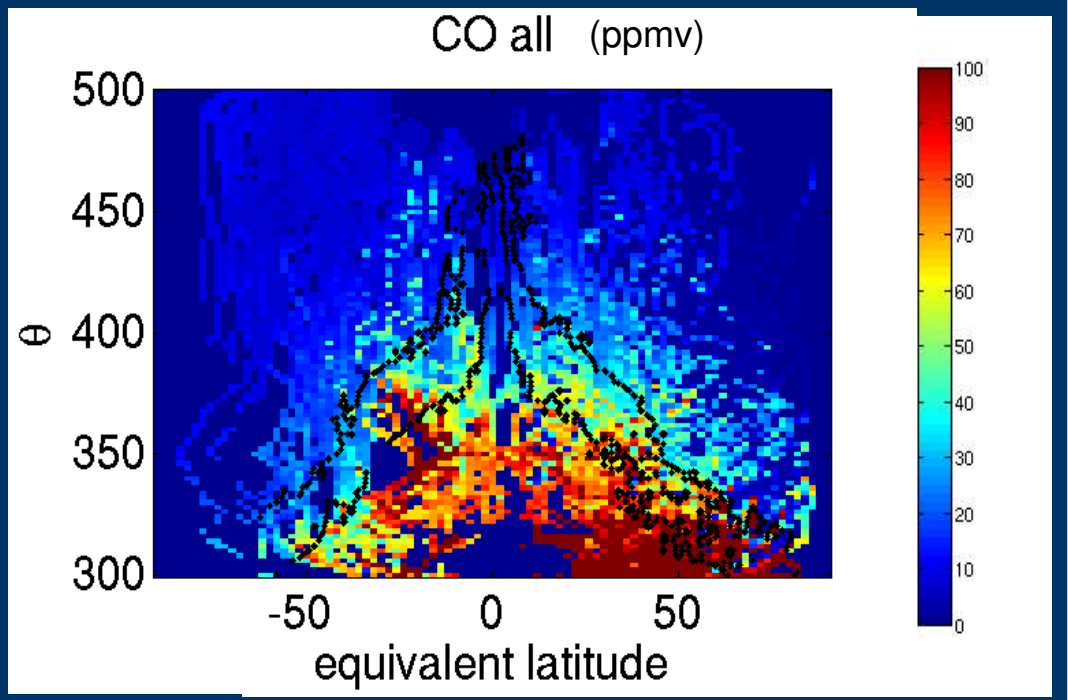


Data points histogram in 2° x 2K bins

In-situ measurements

Composite of O3 and CO *in-situ* measurements

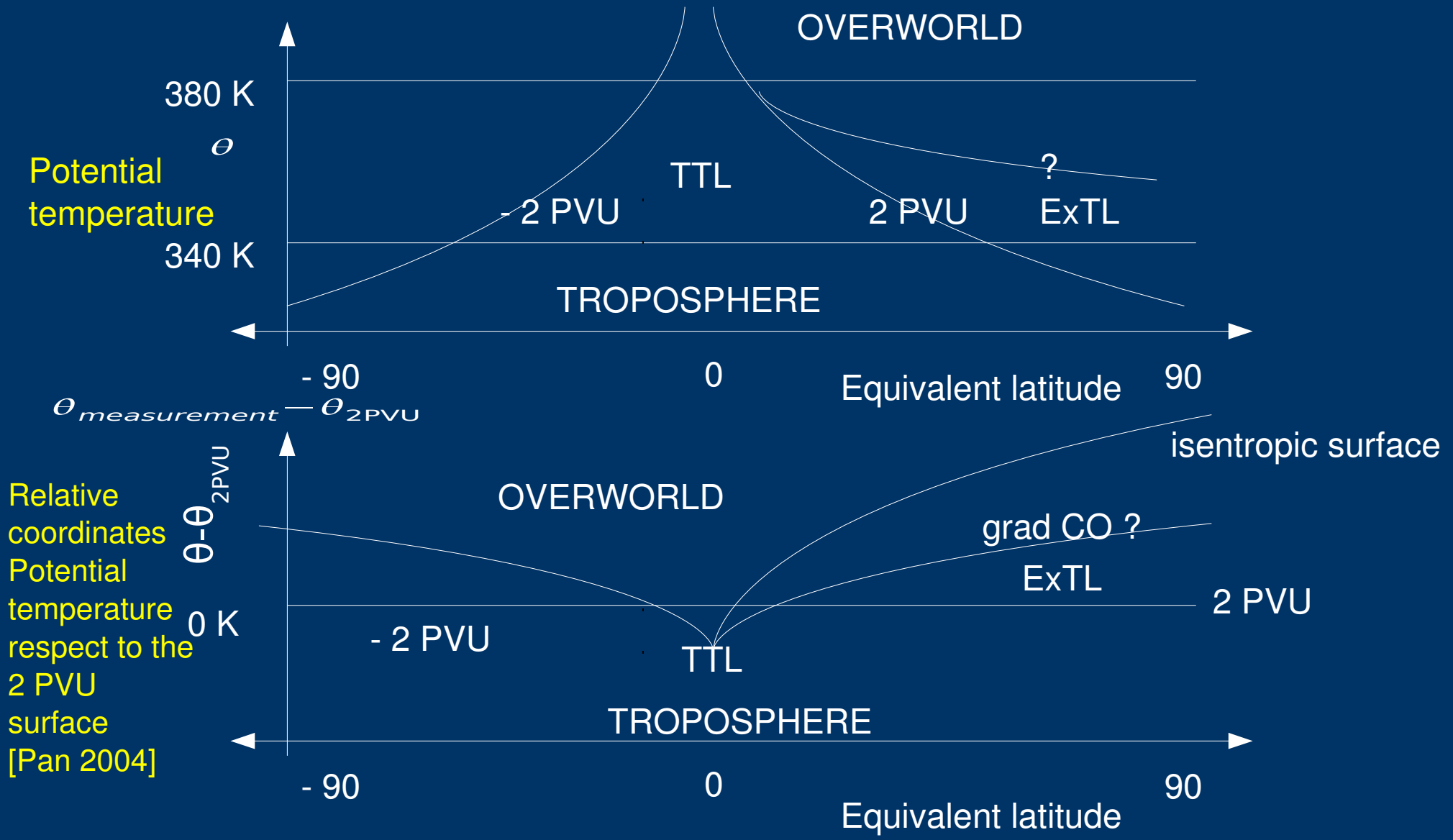




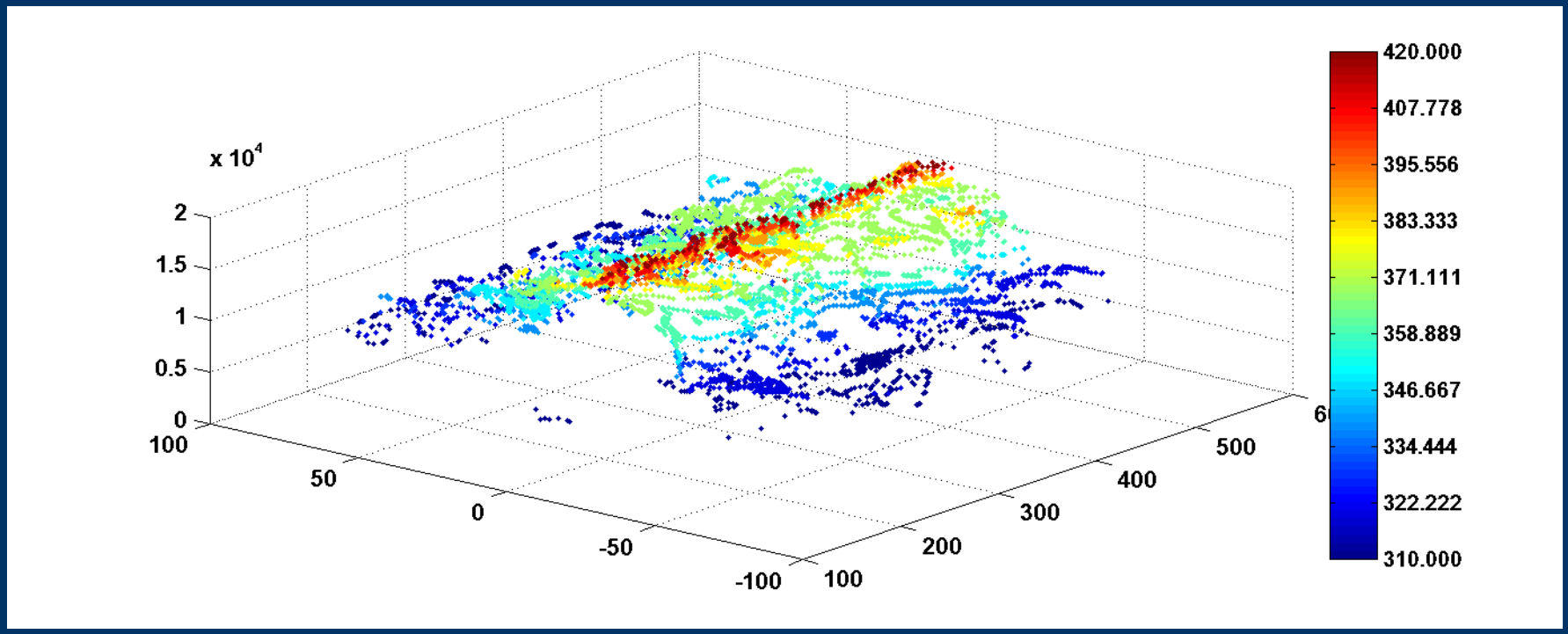
theta (K)

equivalent latitude

Change of vertical coordinates

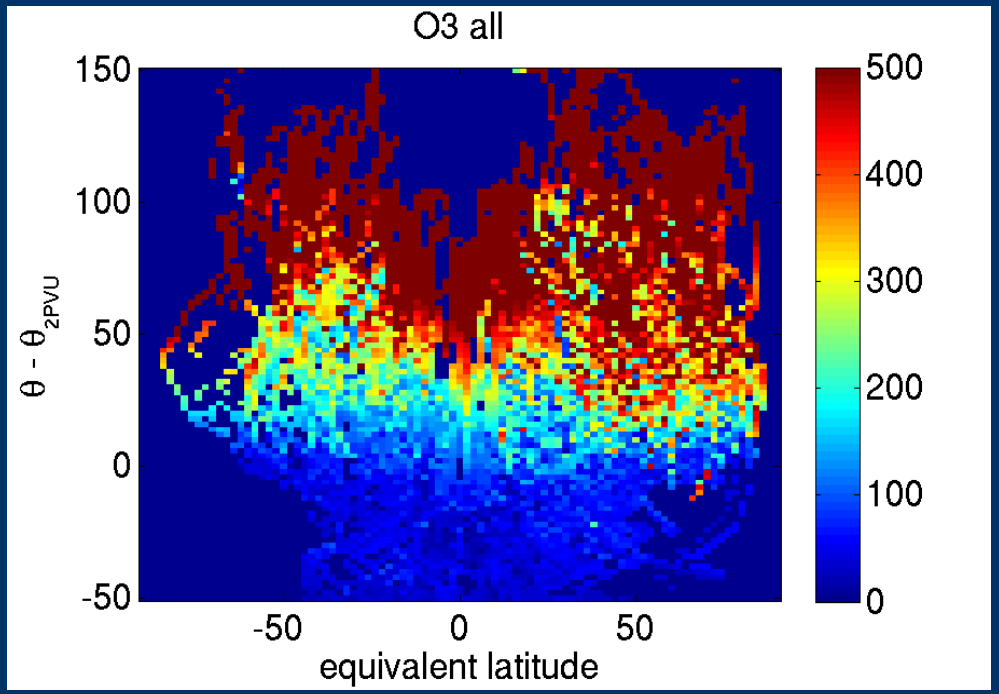


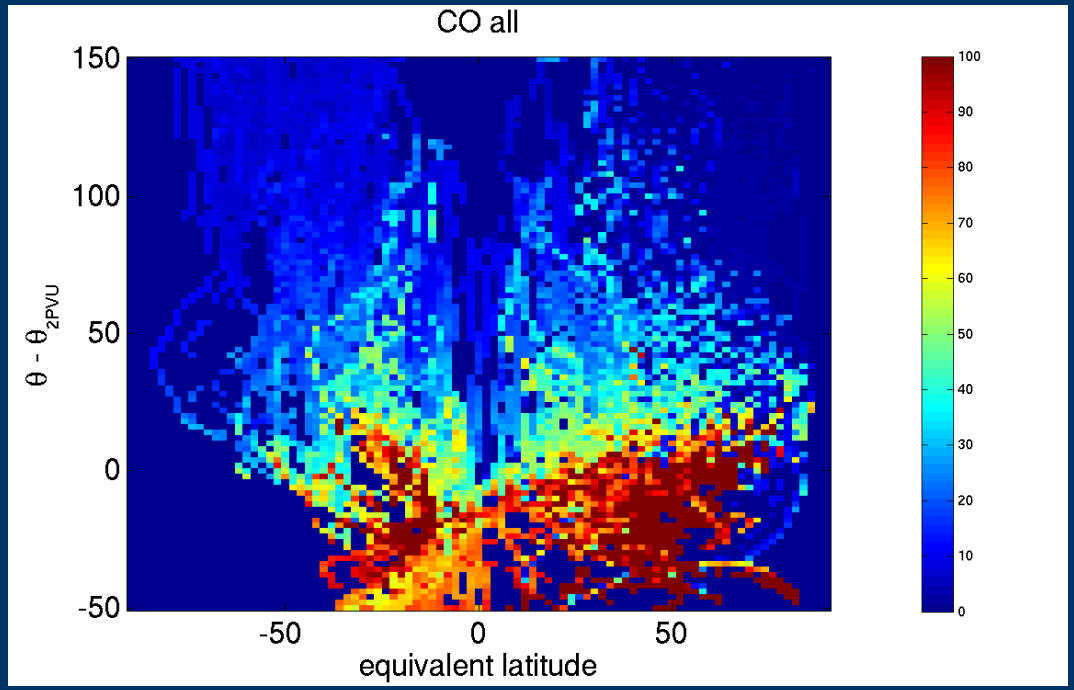
Height and θ of the 2 PVU surface



2 PVU surface height in meters .Color indicates potential temperature. A latitude circle of this surface intersects different isentropic levels.

Composite tracer data

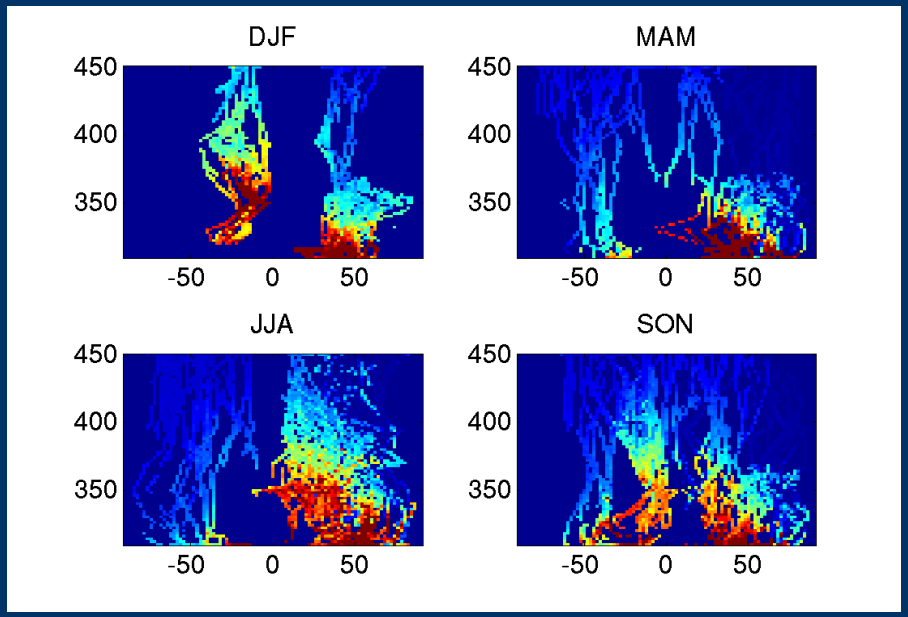


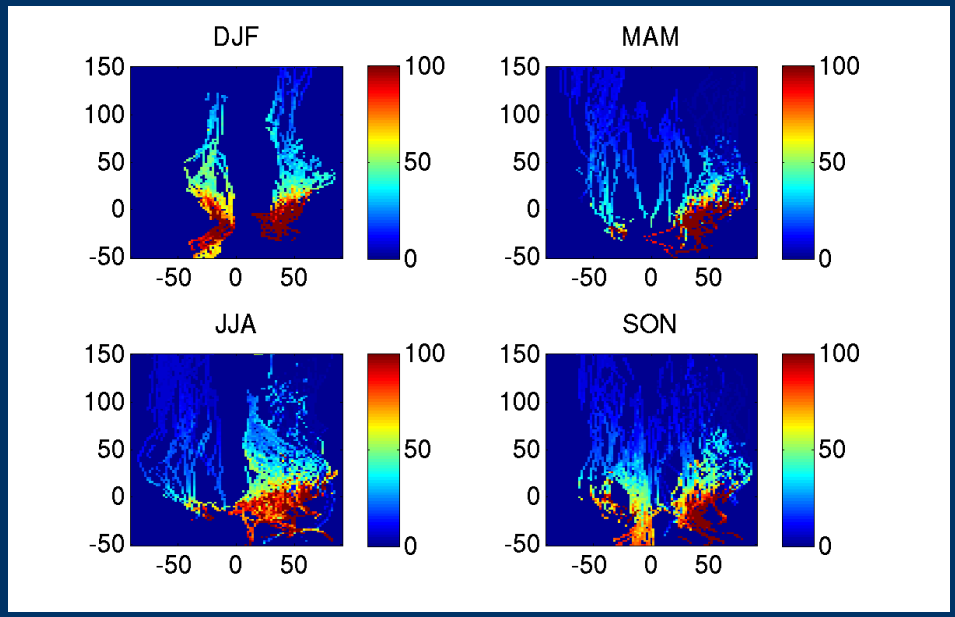


Composite of O3 and CO *in-situ* measurements (ppbv)
in relative coordinates respect to the local 2 PVU surface.
For CO the NH is more regular (landmasses-pollution-forest fires).
SH two extrema: ASHOE on the Pacific+Troccinox over the Amazon in summer

CO seasonal variation

Seasonal composites of CO *in-situ* measurements





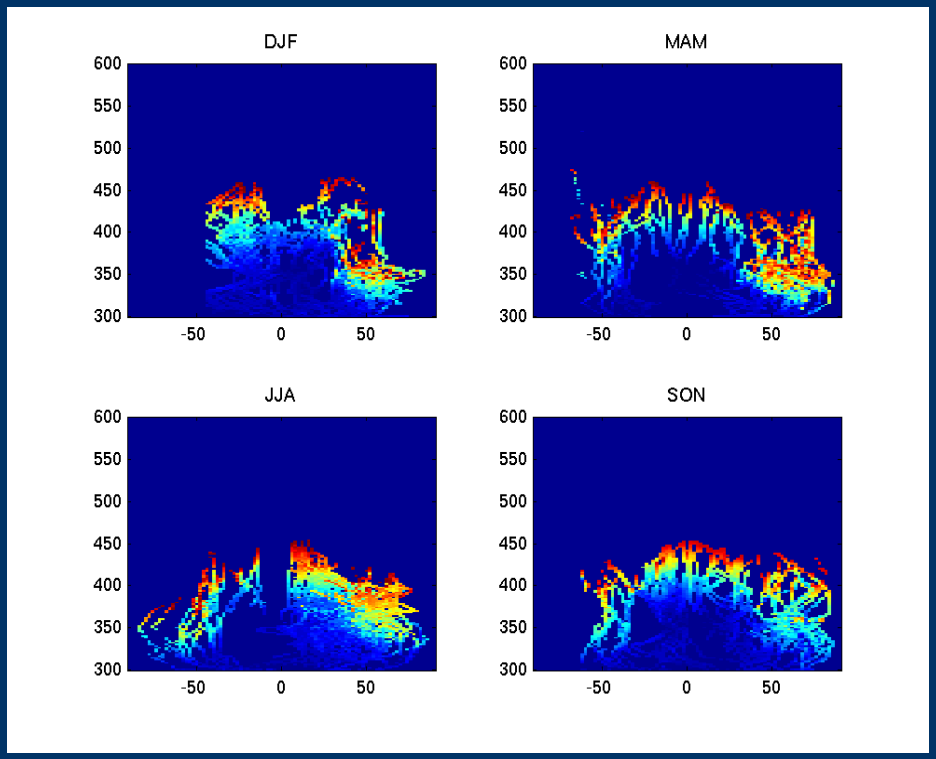
In theta coordinates

in relative coordinates respect to the local 2 PVU surface

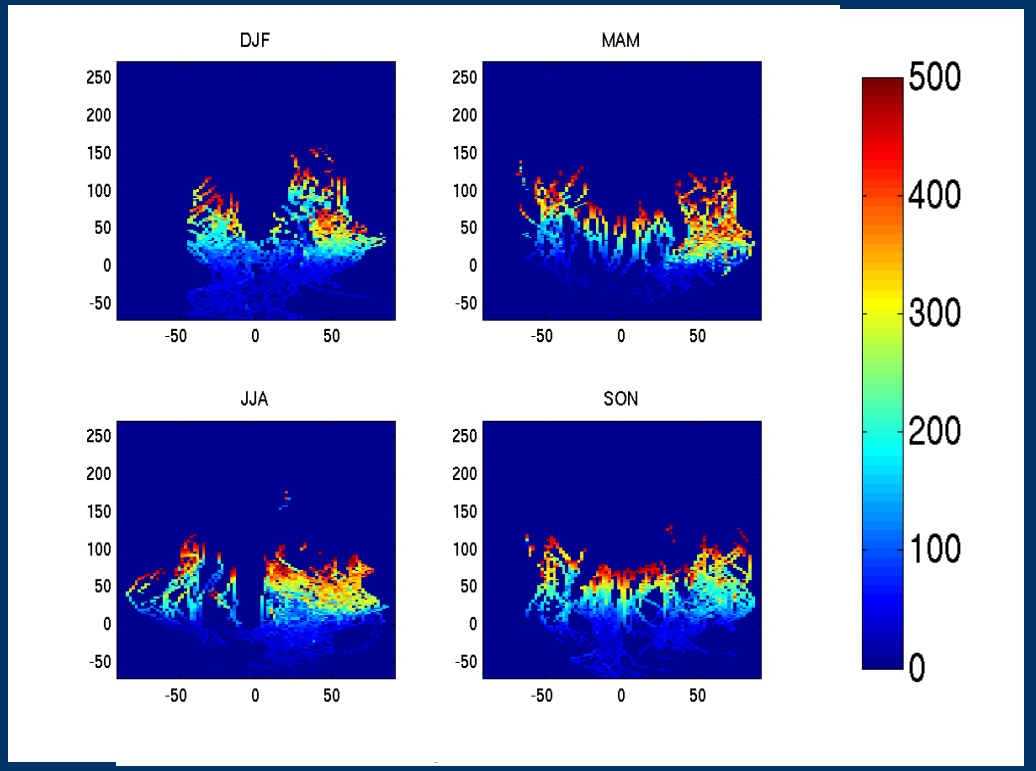
Less seasonal variation in delta theta coords.

O3 seasonal variation

Seasonal composites of O3 *in-situ* measurements



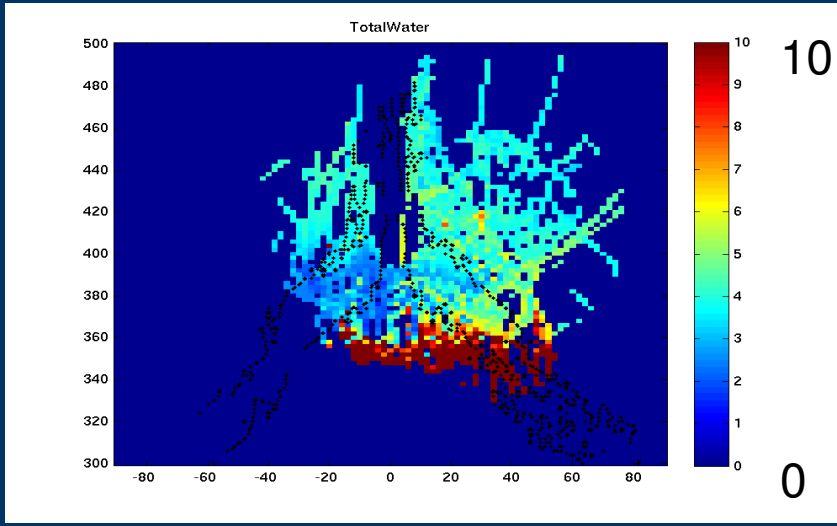
In theta coordinates

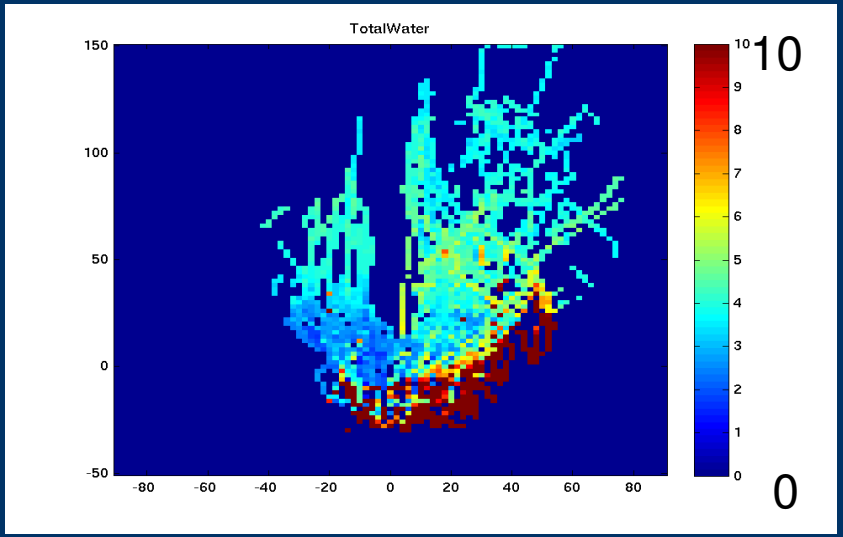


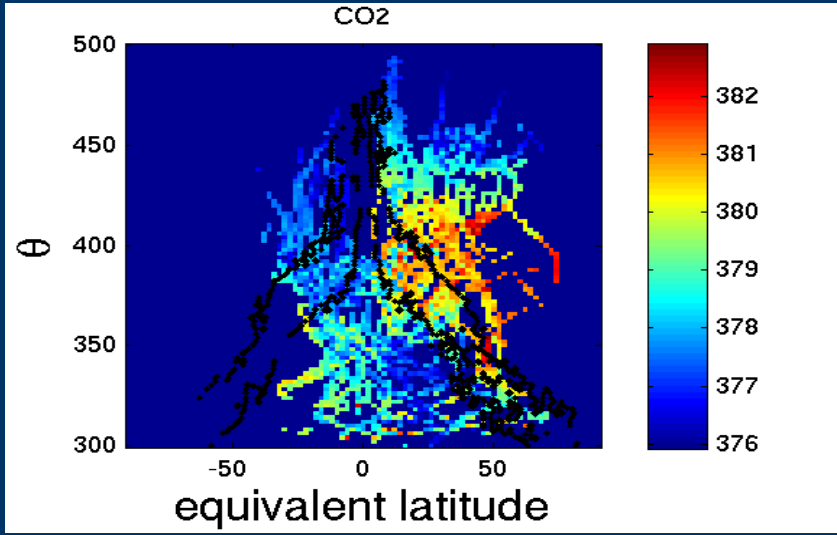
in relative coordinates respect
to the local 2 PVU surface

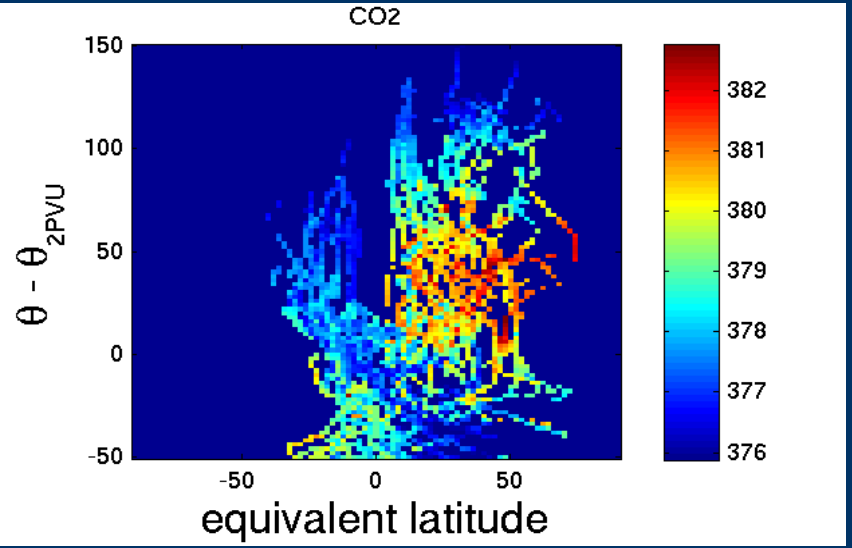
CO2 and H2O

Water similar to CO. For CO2 there is no reason to follow the same pattern. Much longer lived

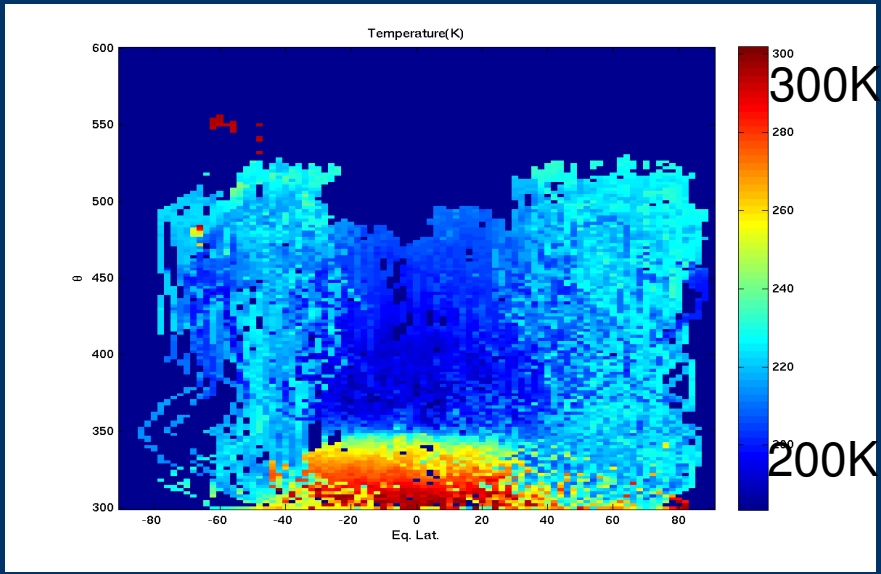


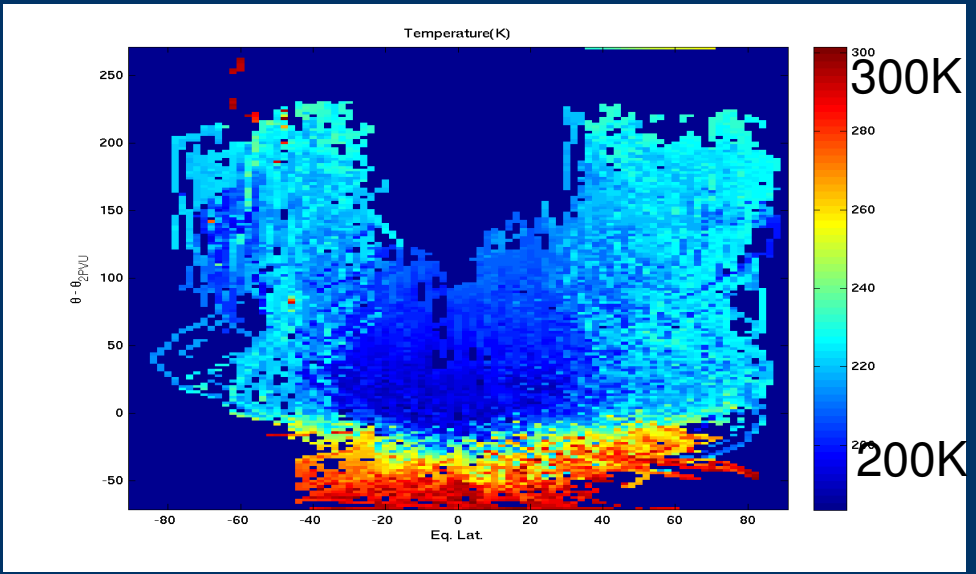






Temperature

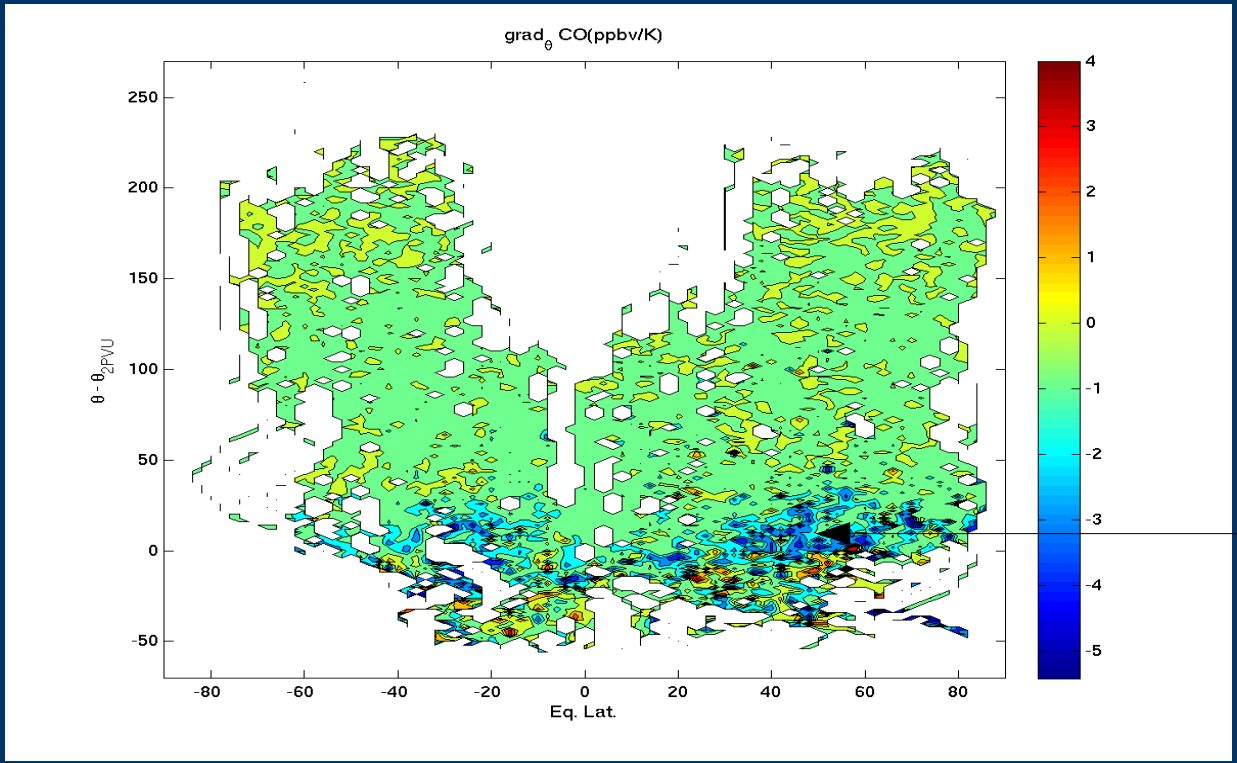




In theta coordinates

In delta theta
consistent with Hegglin 2009

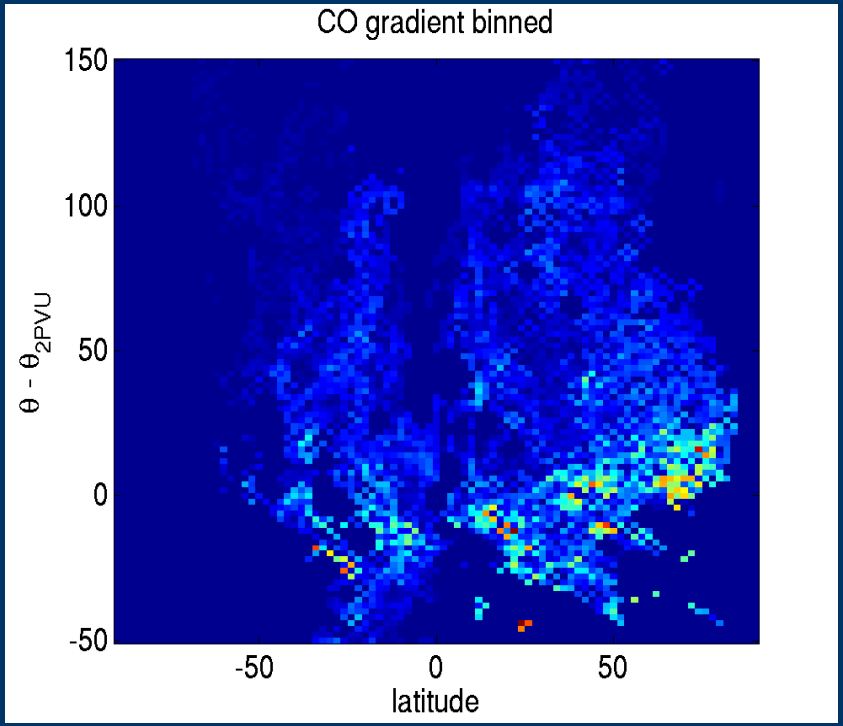
CO cross isentropic gradient (calculated along flight tracks)



Gradient (calculated along the flight tracks) of CO in delta theta coordinates
Suggests strong gradients associated with the transition region

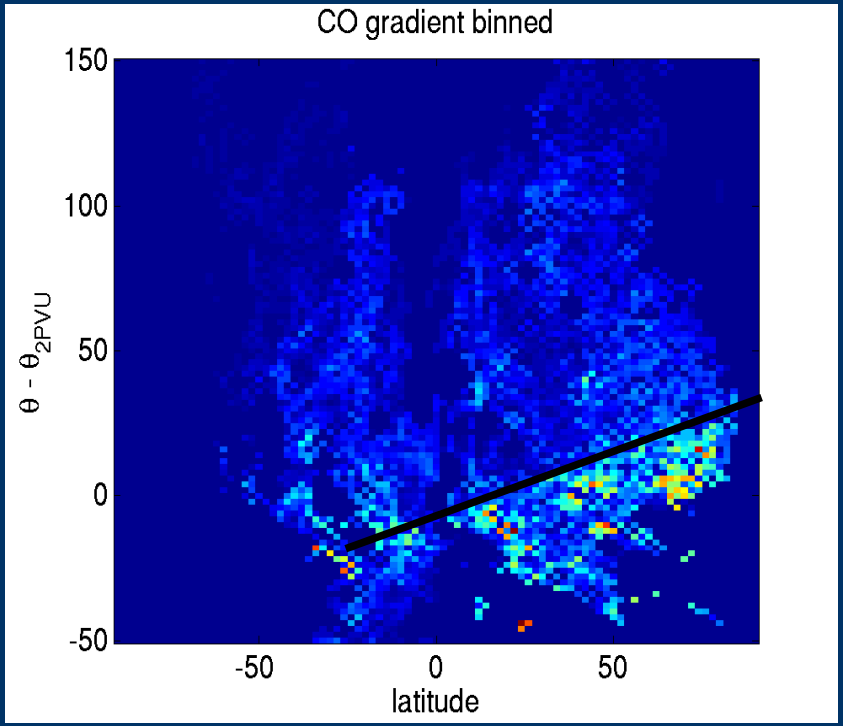
Grad CO = $\Delta CO/\Delta\theta$ along flight path

CO gradients and theta surfaces



Total gradient CO (theta + eq. latitude arbitrary units)

CO gradients and theta surfaces



Total gradient CO (theta + eq. latitude arbitrary units)

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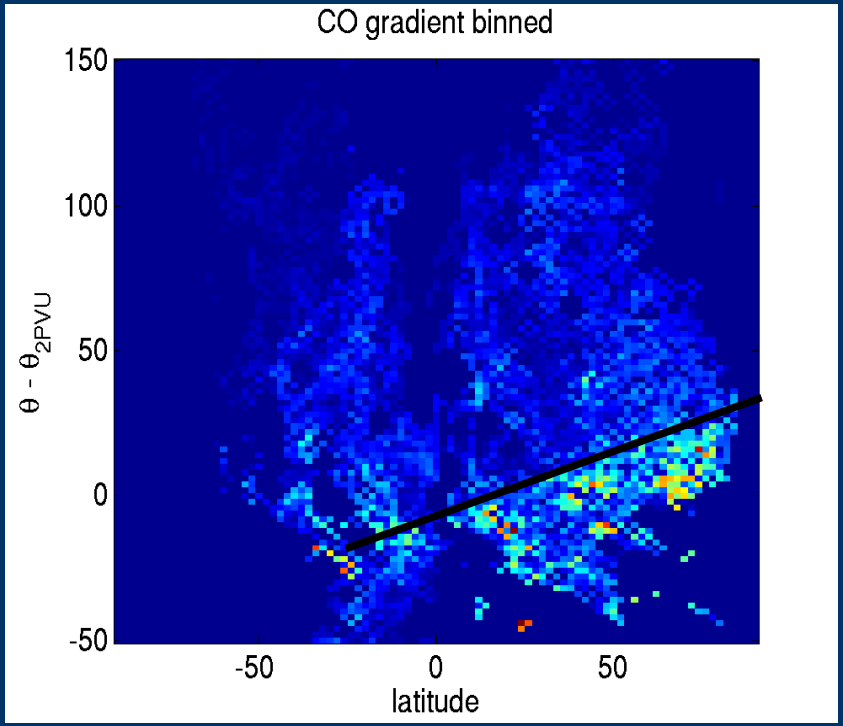
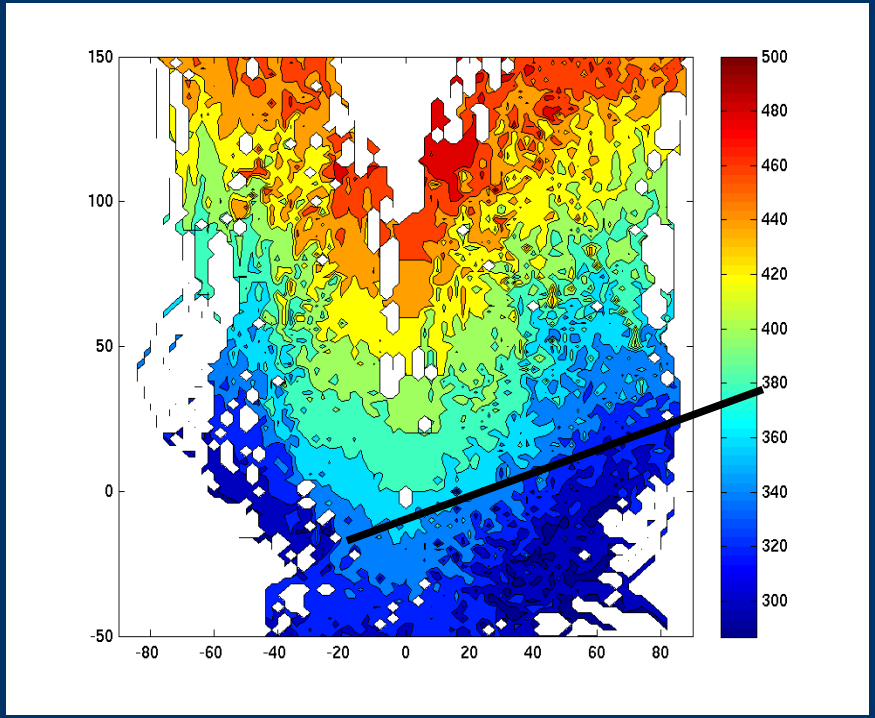
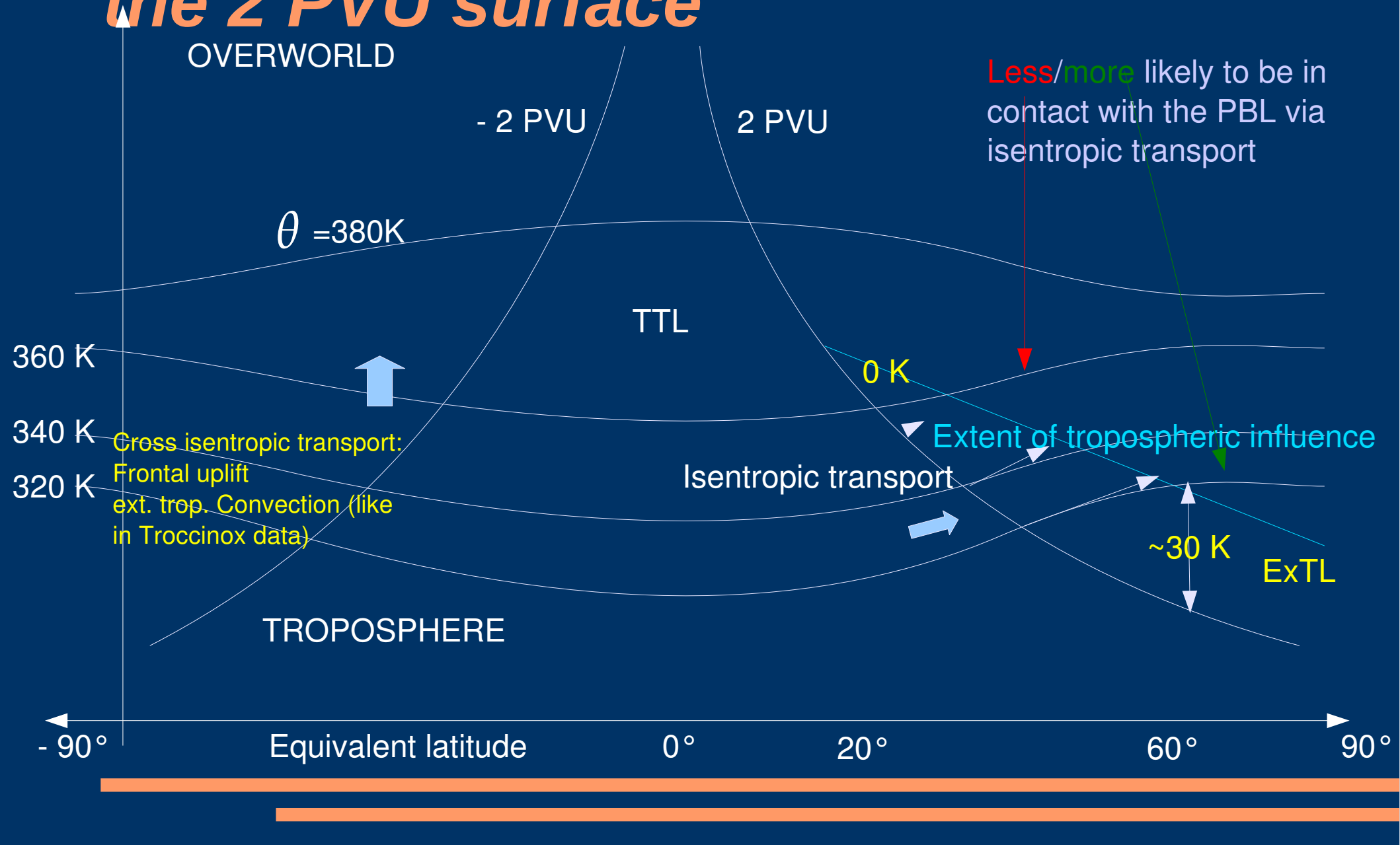




Total gradient CO (theta + eq. latitude arbitrary units)

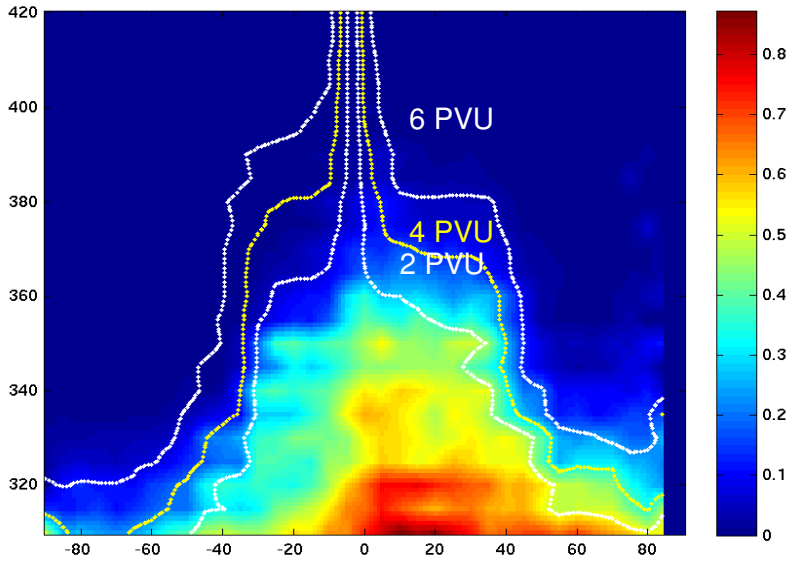
Theta in relative coordinates
In northern extratropics at 50k above the 2 PVU surface
theta ~ 340 K

Conclusion 1: extent of isentropic + cross isentropic transport across the 2 PVU surface

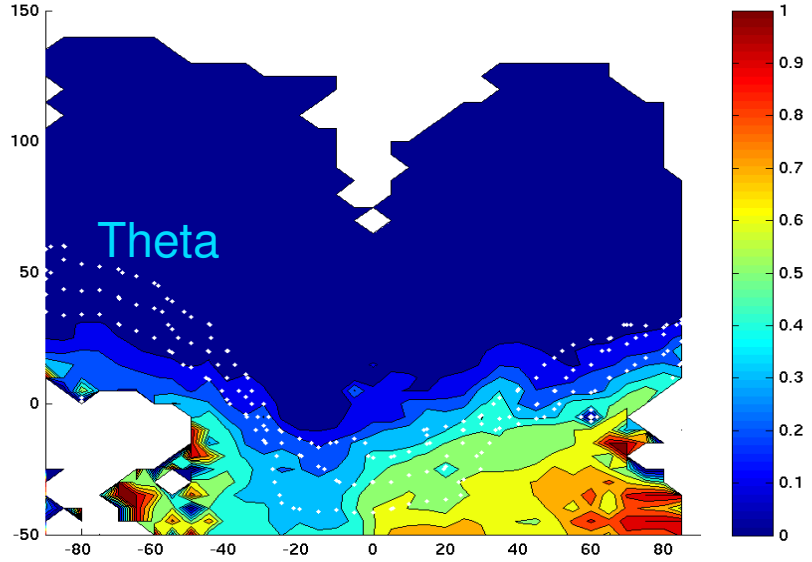


Discussion: consistent with the Lagrangian perspective

Chi: proportion of air in contact with the PBL within 1 month as in Berthet et al. 2007



Chi in theta coordinates



Chi in delta theta coordinates

Pure transport also displays isolines sloping between the constant PV and constant theta surfaces. The tilt respect to constant PVU surfaces is due mainly to isentropic transport but the iso chi does not seem to follow the isentropes as CO

CONCLUSIONS

Reduced seasonal variability and regular distribution in relative coordinates.

The SH data evidences impact of convection (Troccinox over Brazil) and tracer sources (less CO over the pacific -- more homogeneous in NH in space and time).

Extract information from small scale (well resolved in in situ measurements) to general features

Application to global model validation: alternative to pointwise comparison.

CONCLUSIONS

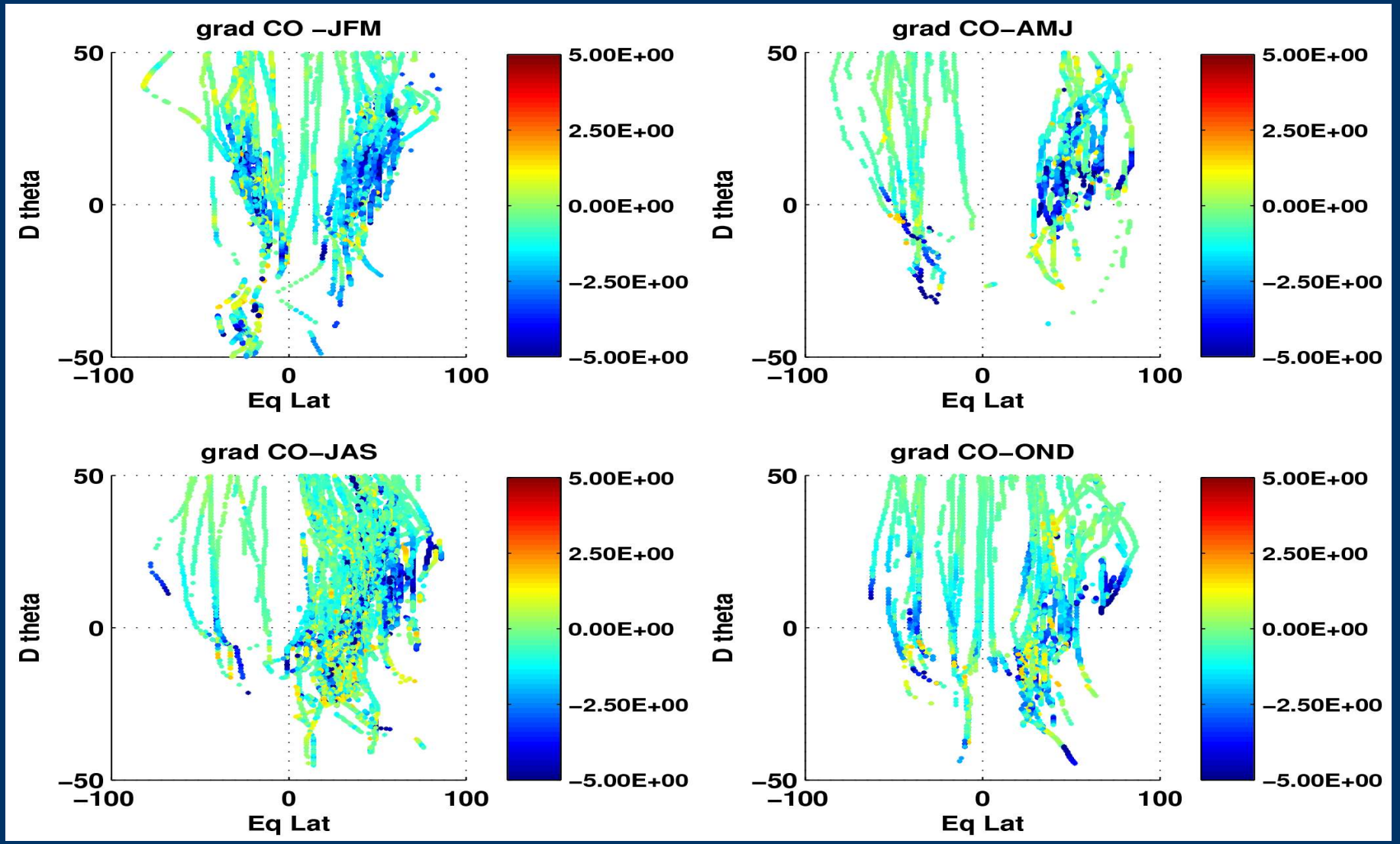
Increase of the thickness of the ExTL towards the poles:

~0 K above the 2 PVU surface at 20° to

~30 K in higher latitudes 60°/70°. Consistent with [Hoor 2004].

Similar pattern observed in T (c.f. [Hegglin 2009]) and H2O

Isentropic transport across constant PV surfaces also present in chi (pure transport). Tracer (CO-chi) isolines do not necessarily follow isentropes nor iso-PV surfaces as all of them intersect.


grad CO –JFM
grad CO–AMJ
grad CO–JAS
grad CO–OND
D theta
Eq Lat
50
0
−50
−100
0
100
5.00E+00
2.50E+00
0.00E+00
−2.50E+00
−5.00E+00