Transport in the extratropical UTLS as revealed by chemical tracers during the START08 campaign

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INTRODUCTION

- Climate is sensitive to the distribution of chemical tracers in the UTLS. This distribution is influenced by chemical and dynamical processes.

- The START08 campaign (April – June 2008) provided a unique opportunity to study transport pathways that influence the distribution of chemical tracers in the extratropical UTLS.

- In this study, we investigate the impact of transport processes such as tropospheric and stratospheric intrusions, on the chemical composition of the extratropical UTLS.

DATA

- We use data from the following instruments that flew during the START08 campaign:

  NOAA O_3; QCLS CO_2, N_2O, and CH_4; RAF CO; VXL H_2O

- Thermal tropopause properties and potential vorticity are derived using the NCEP Global Forecast System (GFS) operational analysis (4 times daily, 35 km horizontal resolution, 47 vertical levels).

RESULTS AND DISCUSSION

- The START08 campaign provided a unique opportunity to sample a wide range of latitudes over North America and a wide range of altitudes, with focus in the extratropical UTLS (Figure 1).

- Both tropospheric and stratospheric intrusions show distinct signatures in the chemical composition of the UTLS (Figures 2, 3, and 4). Of all tracers, H_2O showed the least distinctive evidence for these transport pathways in vertical profile frequency plots.

- Figures 3 and 4 show tropospheric and stratospheric intrusions in various tracer-tracer correlations. In this space, H_2O clearly shows the distinction between the different types of intrusions when plotted against O_3.

- Figure 5 shows clear signatures of both tropospheric and stratospheric intrusions in chemical (O_3) and dynamic (PV) space. In addition, air of different age or mixing level in tropospheric intrusions cases (RF07 versus RF14) as evidenced by the different static stability and O_3 mixing ratios also show distinct signatures in PV.

- Figure 6 shows the frequency distribution and the O_3-PV relation during START08, where tight correlations are observed in the UTLS. Previous studies have used these tracers to identify stratospheric intrusions in the UT [e.g., Newell *et al.*, *Geosphys. Res. Let.,* 1997; Browell *et al., J. Geophys. Res.*,2003] as well as seasonal dependences in their relation [Krebsbach *et al.*, *ACP*, 2006]. The START08 data show that both tropospheric and stratospheric intrusions can alter the O_3-PV relation, and are thus necessary to characterize in order to better understand changes in the climate system.

ACKNOWLEDGEMENTS

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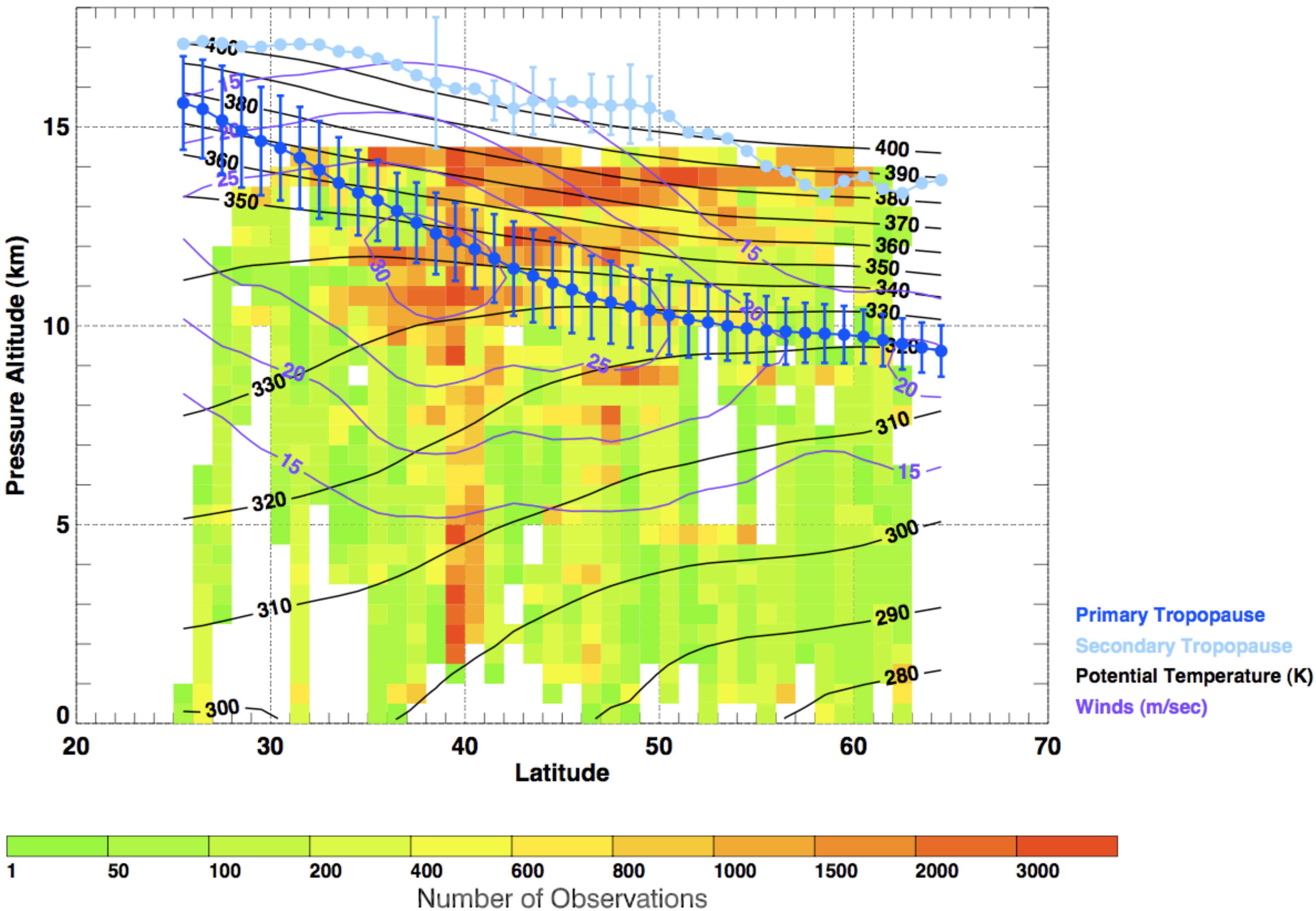


Figure 1. Frequency distribution of aircraft measurements during START08.

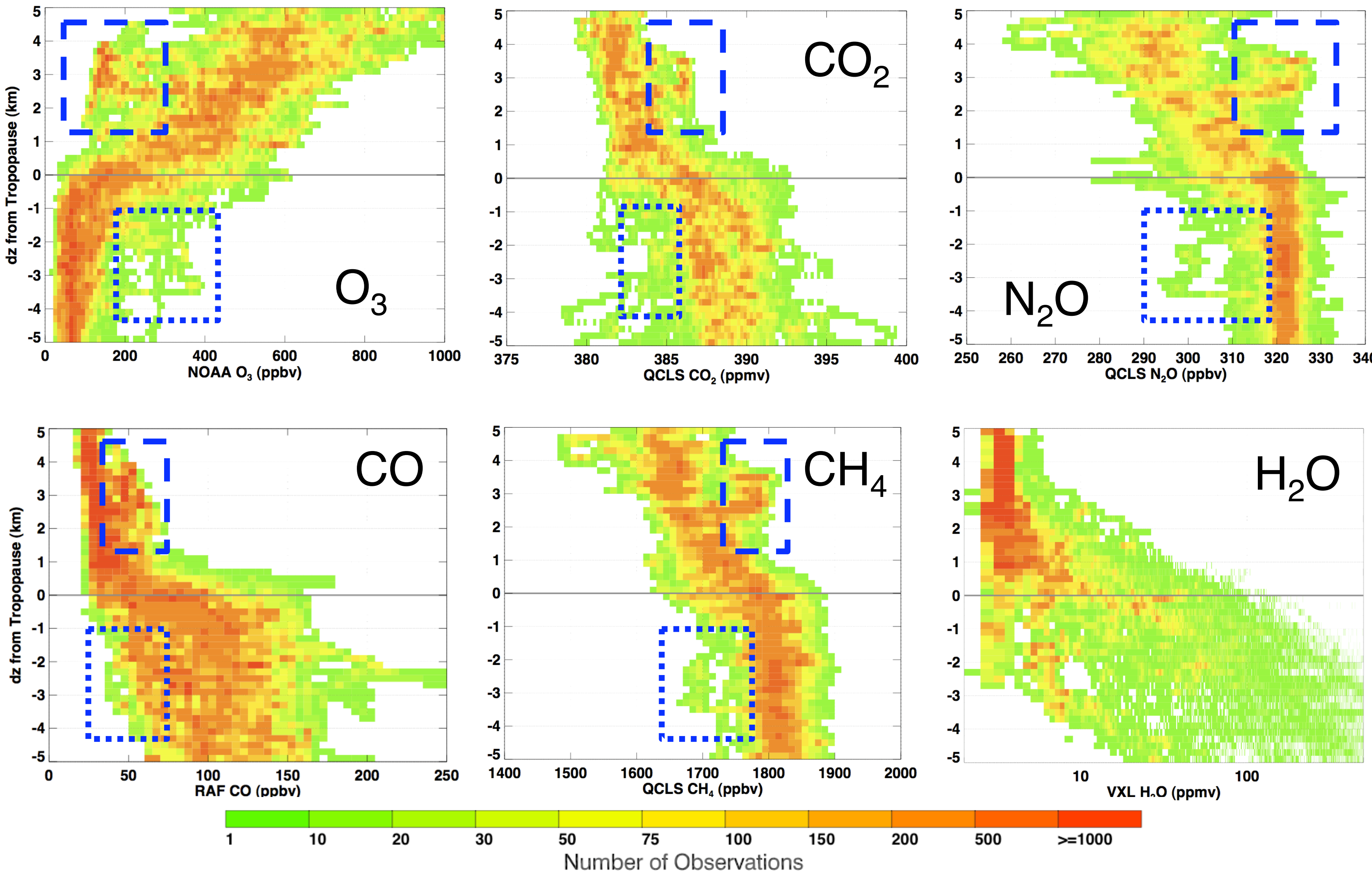


Figure 2. Frequency distributions of chemical tracer mixing ratios as a function of distance from the thermal tropopause. Highlighted are mixing ratios during tropospheric (blue dashed squares) and stratospheric intrusions (blue dotted squares).

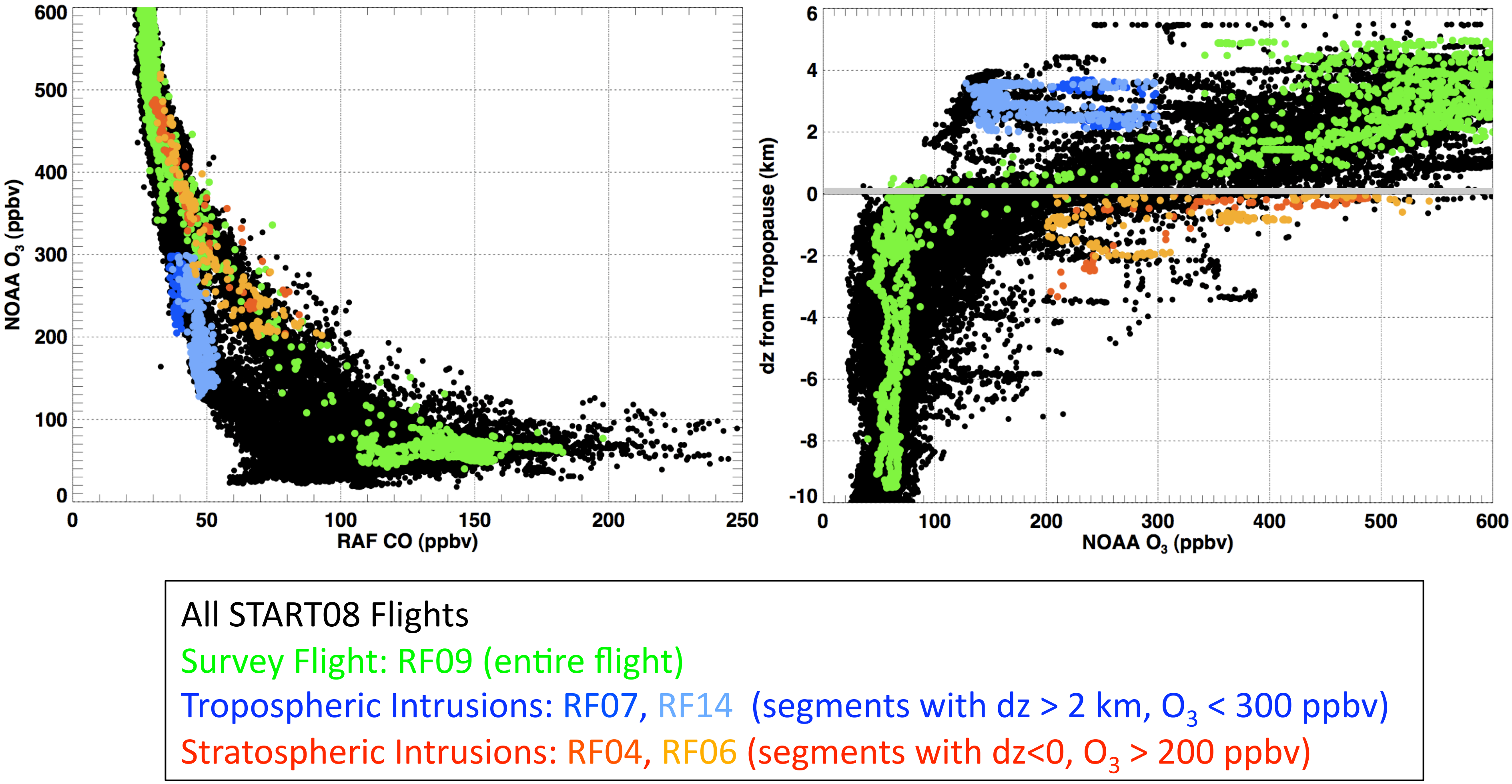


Figure 3. Signature of transport processes on O_3-CO correlations and O_3 vertical profiles as a function of distance from the thermal tropopause.

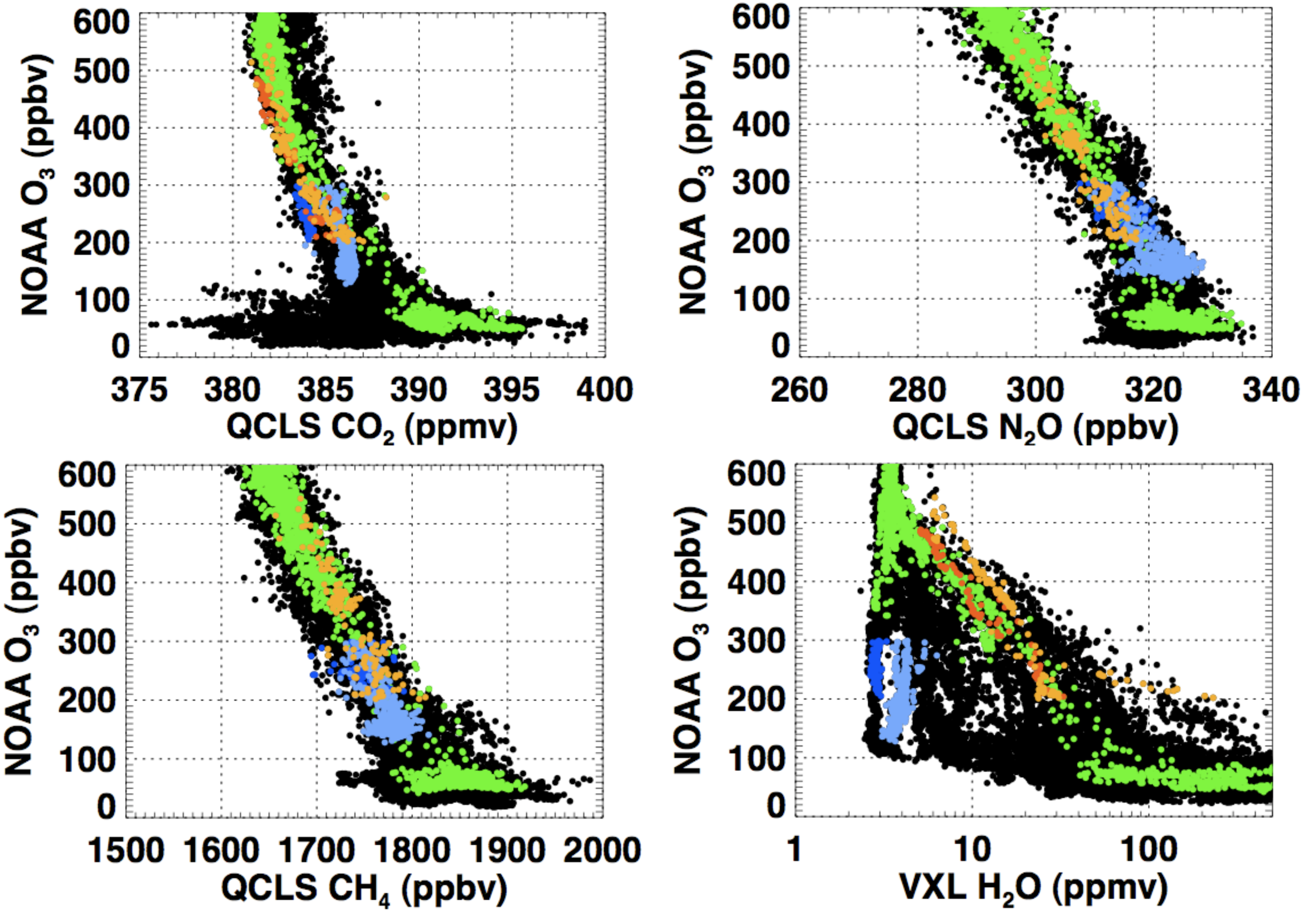
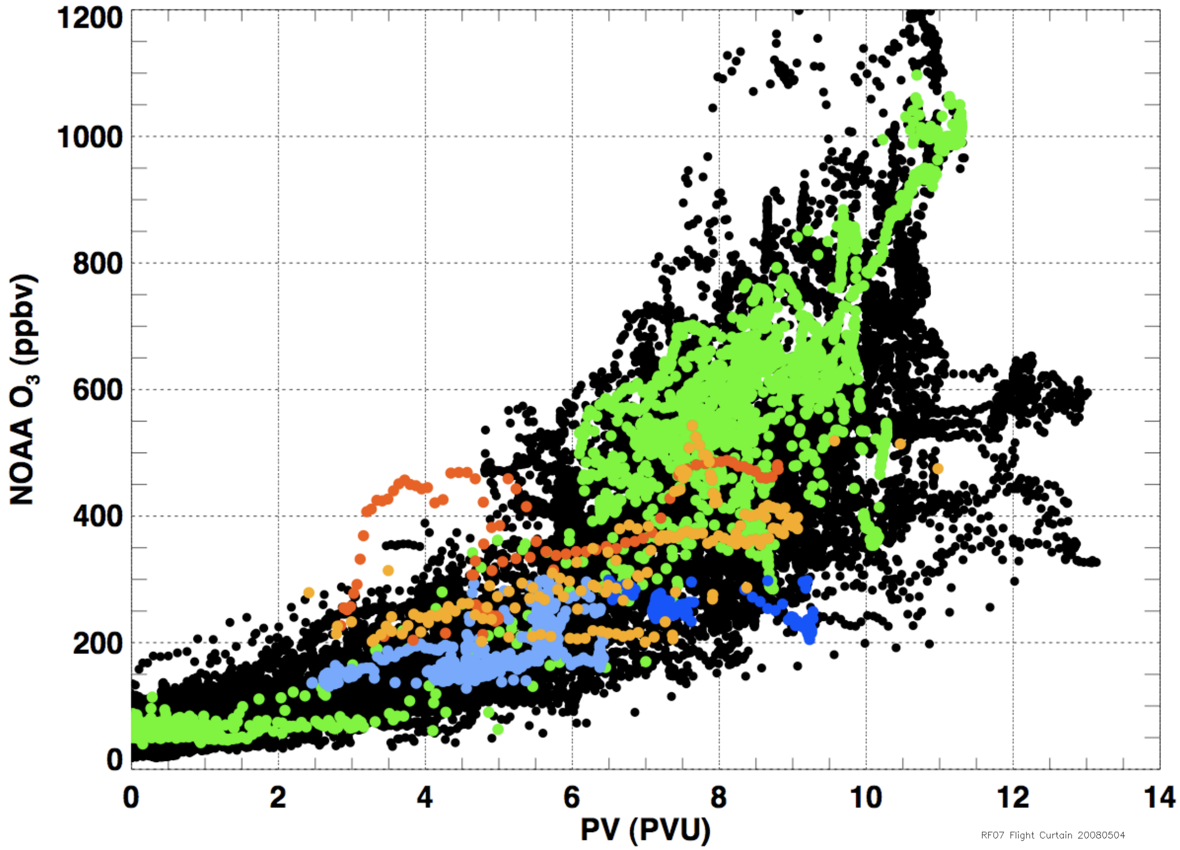


Figure 4. Signature of transport processes on tracer correlations. Color coding is same as in Fig. 3.



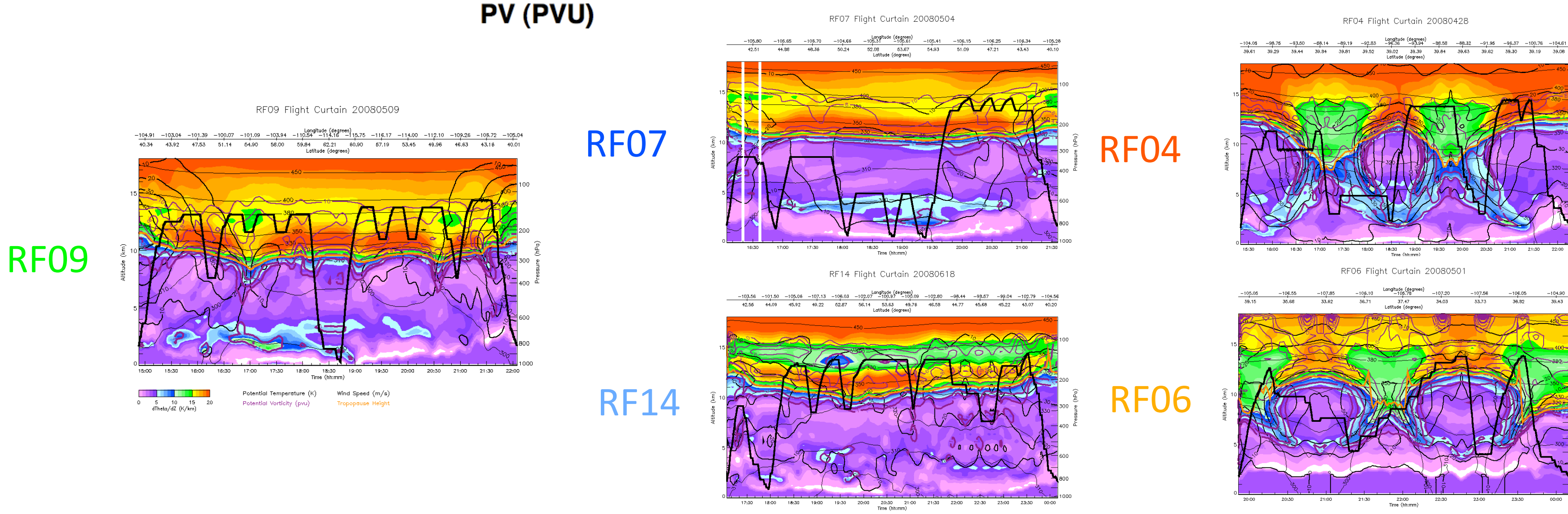


Figure 5. Signature of transport processes in PV-O_3 space. Color coding is same as in Fig. 3. Shown at the bottom are static stability curtains for the colored flights. In tropospheric intrusions, we find lower PV in more recent intrusions (lower stability air).

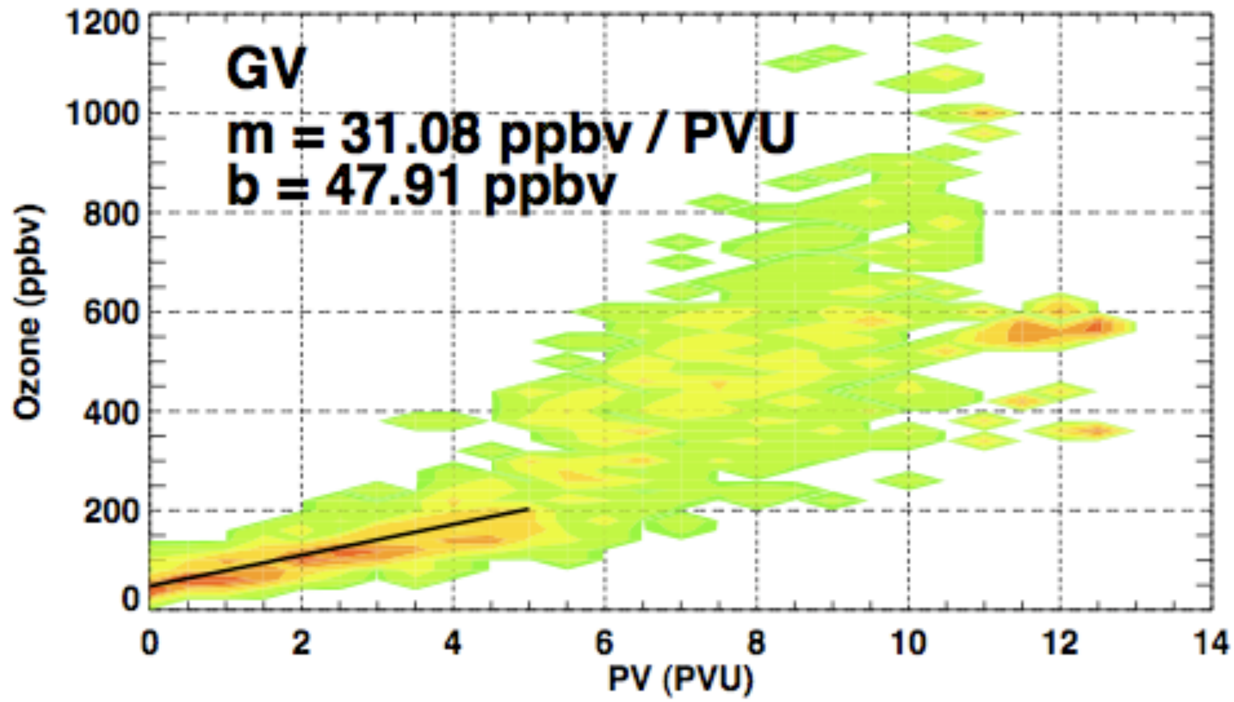


Figure 6. Frequency distribution of PV and O_3 for the START08 campaign. Also shown is the linear fit (with slope *m* and intercept *b*) for data in the UTLS (0 to 5 PVU).