3.2

Lecture 3.2 Correlations among scaling exponents

There are some unexpected correlations among scaling exponents, with potentially important consequences.

Correlations in the scaling exponents.

* There are five correlations among the scaling exponents that emerge when appropriate grand averages are resolved on a flight-by-flight basis:-

[1] *H* for wind speed and temperature with measures of jet stream strength, in the ‘horizontal’ from ER-2 observations.

[2] *H* for the vertical scaling of the horizontal wind speed with jet stream strength, taken from ‘vertical’ dropsonde observations.

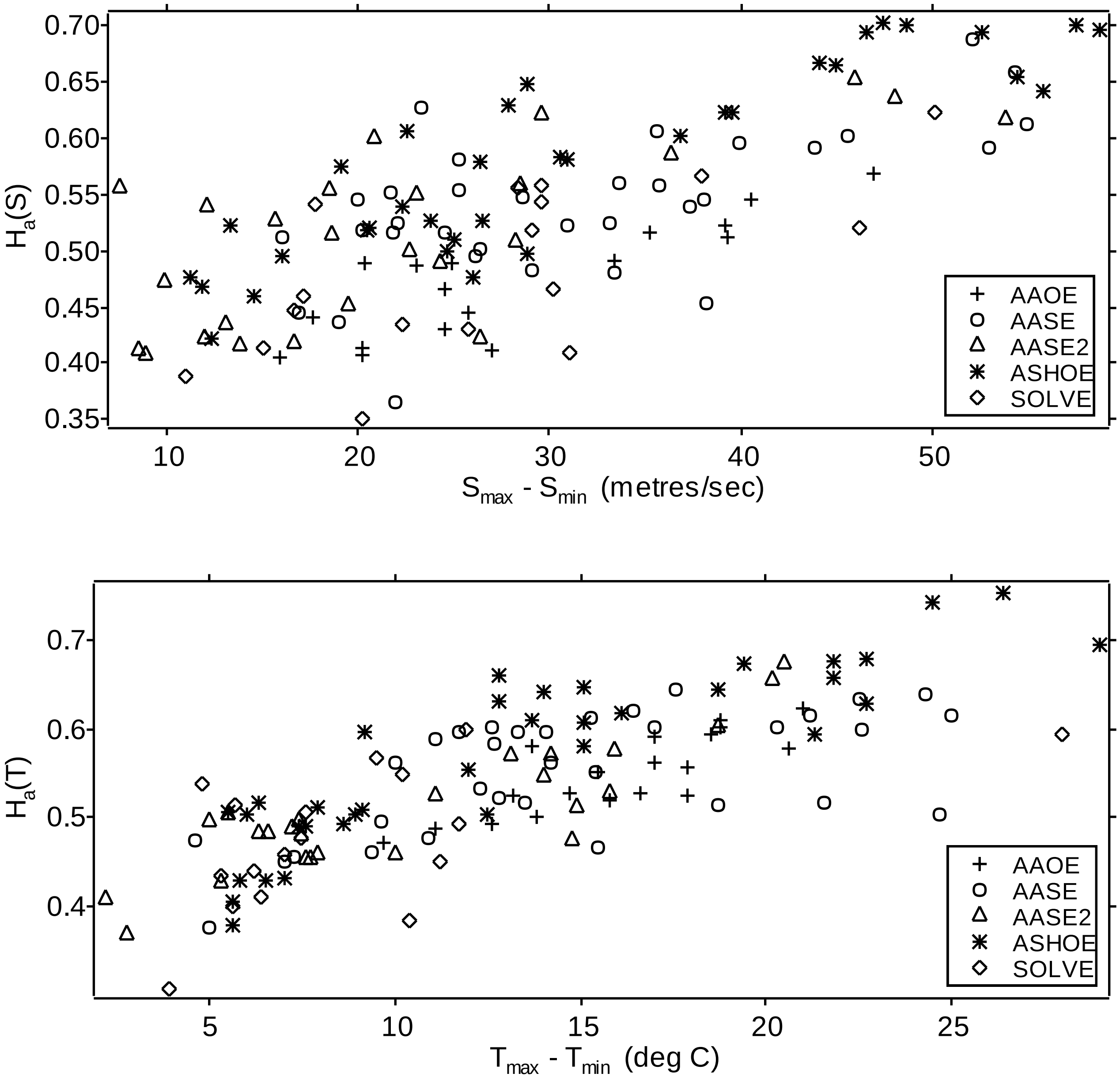
[3] $C_1(T)$, the intermittency of temperature, with the ozone photodissociation rate during ER-2 flights in Arctic summer and winter.

[4] $H(O_3)$ and $\alpha(O_3)$ - the conservation and multifractality exponents- in the lower stratospheric polar vortex during ER-2 flights in late winter and early spring.

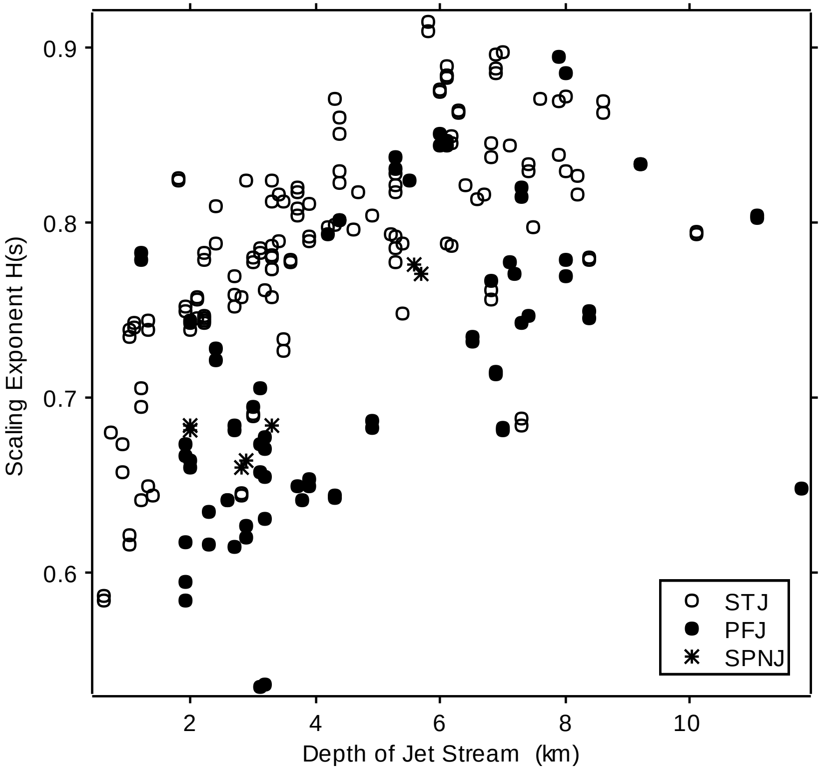
[5] Chemical values of $H > 0.56$ show source behaviour, $H = 0.56$ are tracers, $H < 0.56$ show sink behaviour.

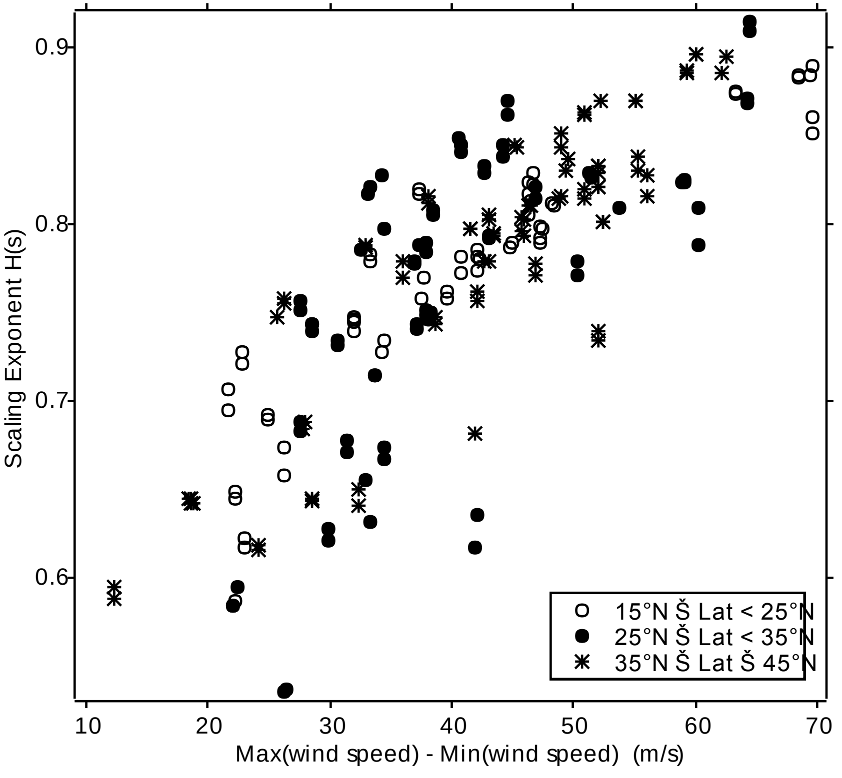
What do these correlations imply?
None are predicted by current theory.

Correlation of *H* for ER-2 wind speed and temperature with jet strength

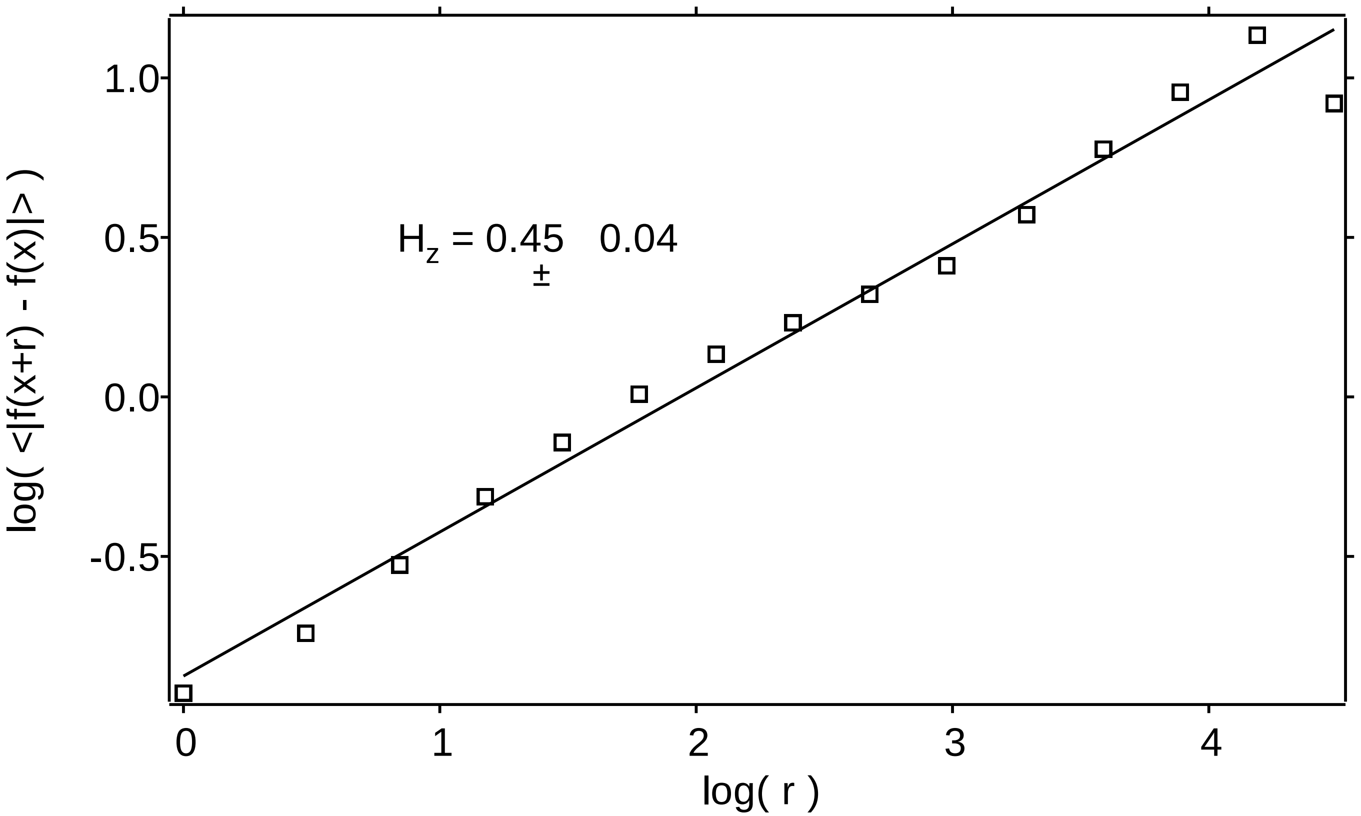


Correlation of *H* for dropsonde wind speed with jet strength, WS 2004

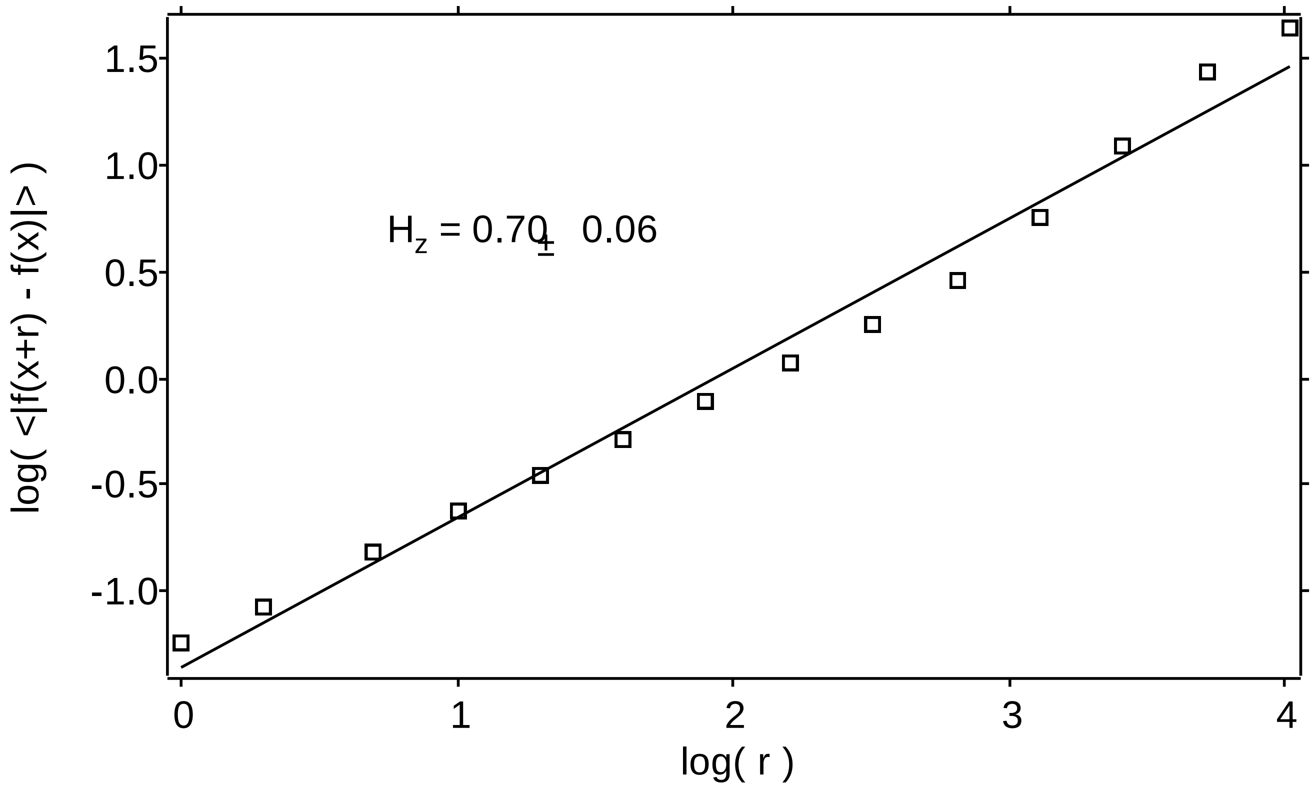




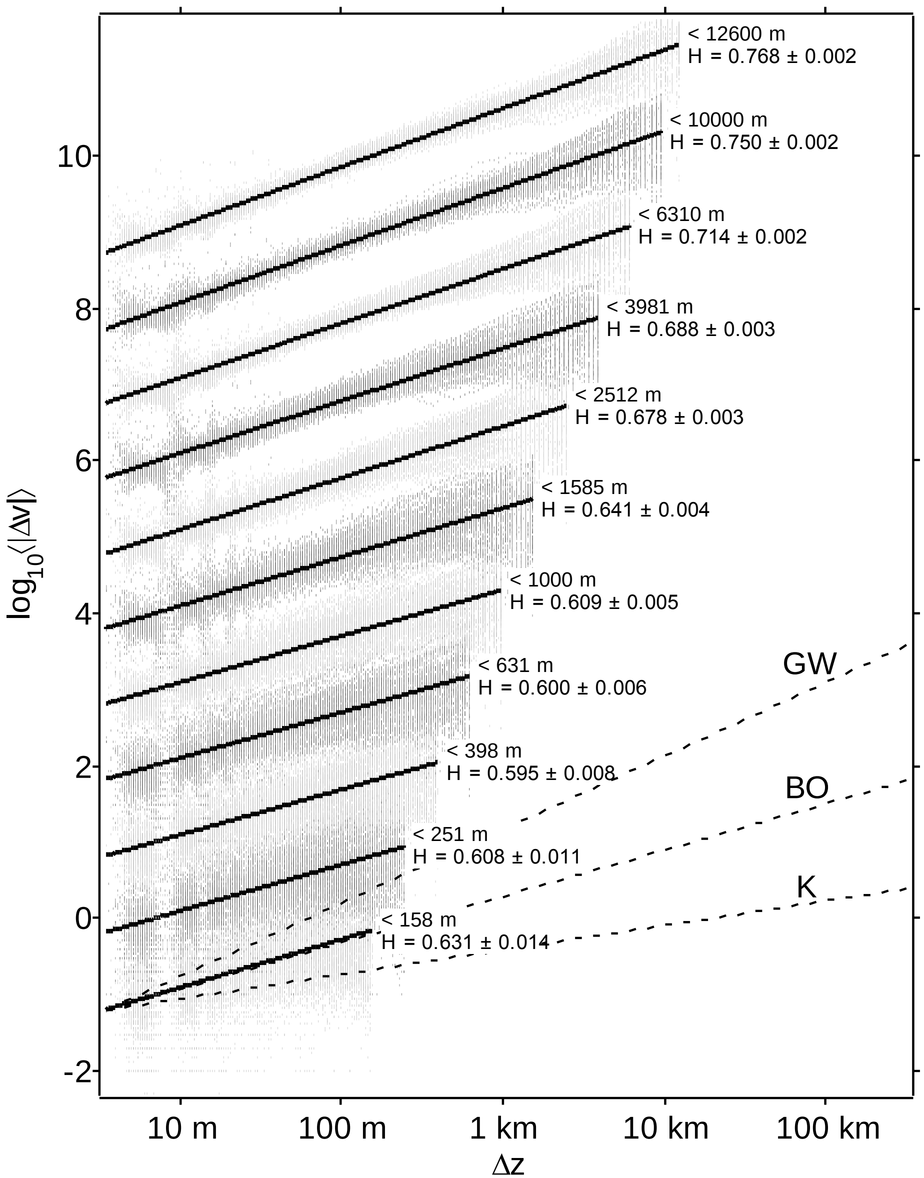
Scaling Calculation for 19890220 Wind Speed



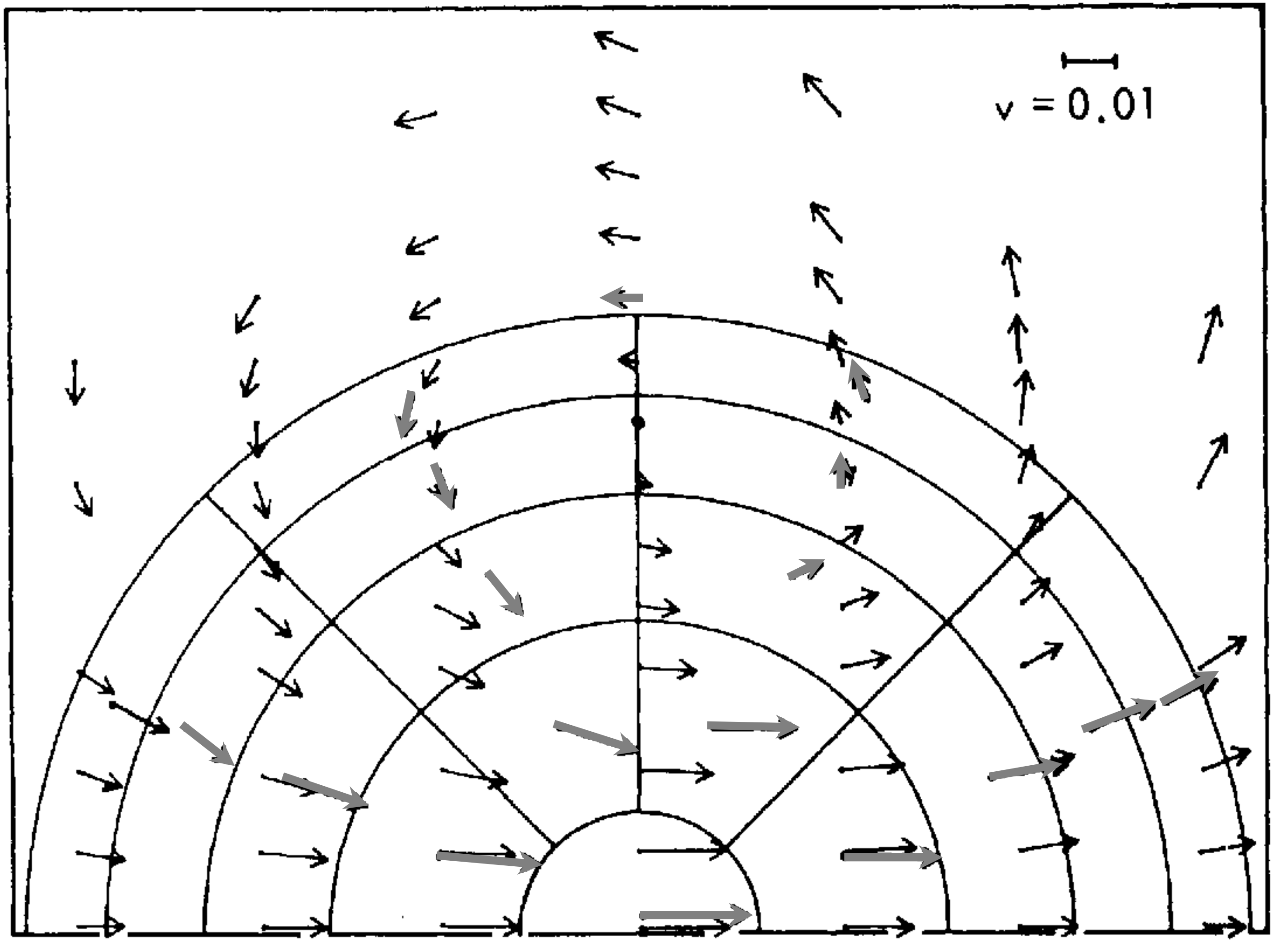
Scaling Calculation for 19941005 Wind Speed (44° S,173° E) to (65° S,180° E)



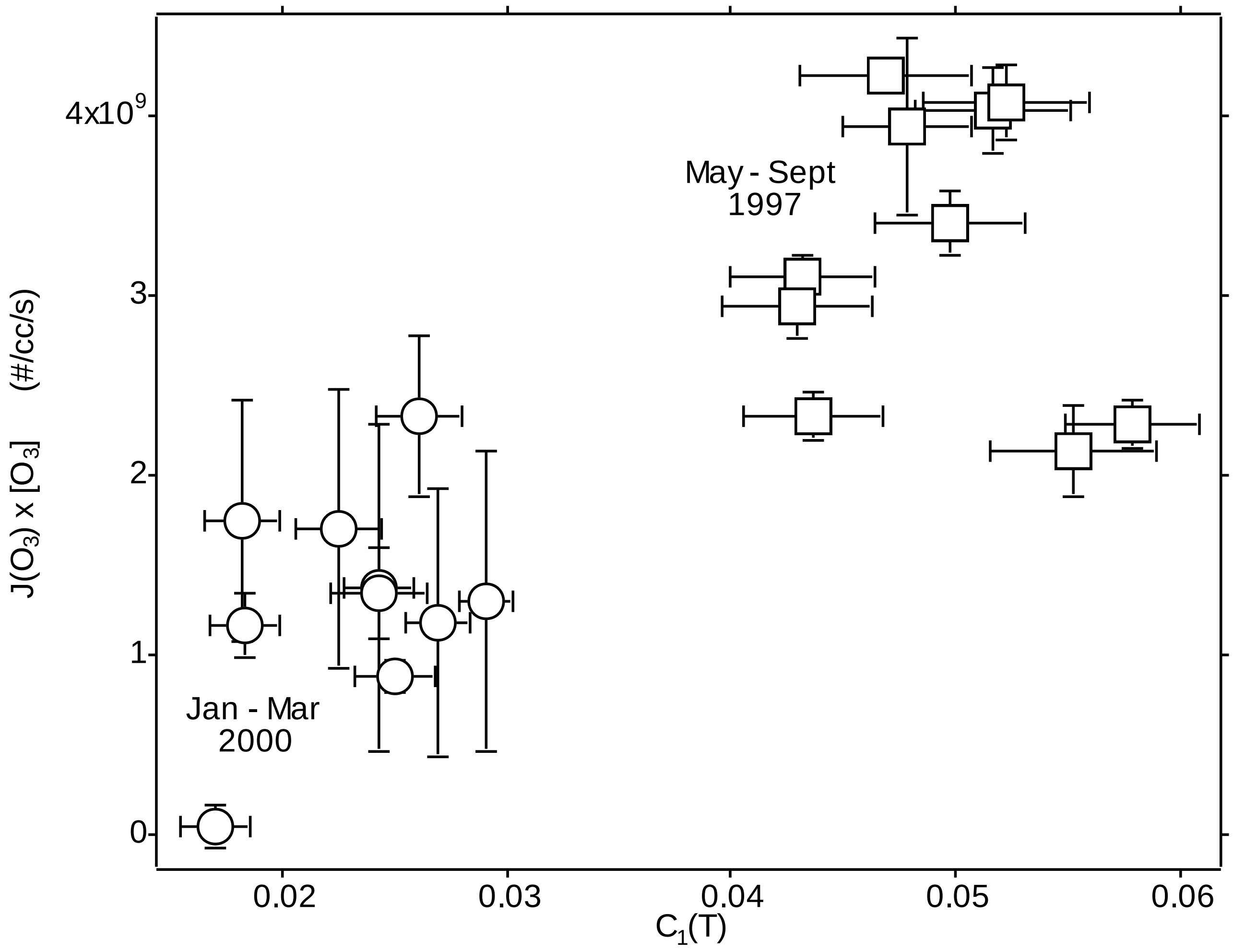
Vertical scaling of horizontal wind, 235 dropsondes, Winter Storms 2004. Scaling is not Kolmogorov or gravity wave; Bolgiano-Obukhov applies in lower troposphere, but none are correct at jet altitudes.



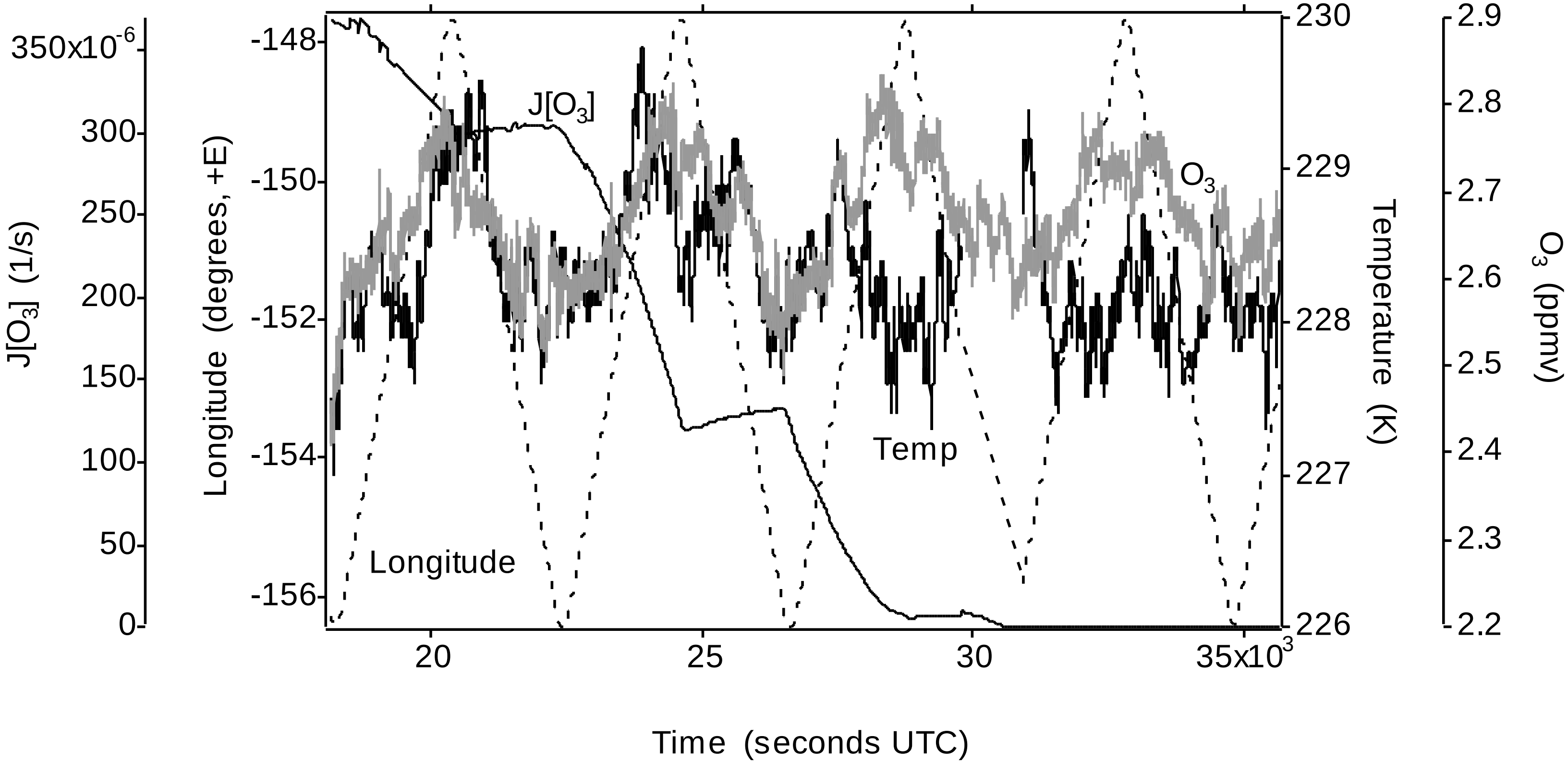
Alder & Wainwright (1970): A flux applied to an equilibrated population of Maxwellian molecules. Vortices and fluid flow emerge in 10^{-12}s and 10^{-9} m.



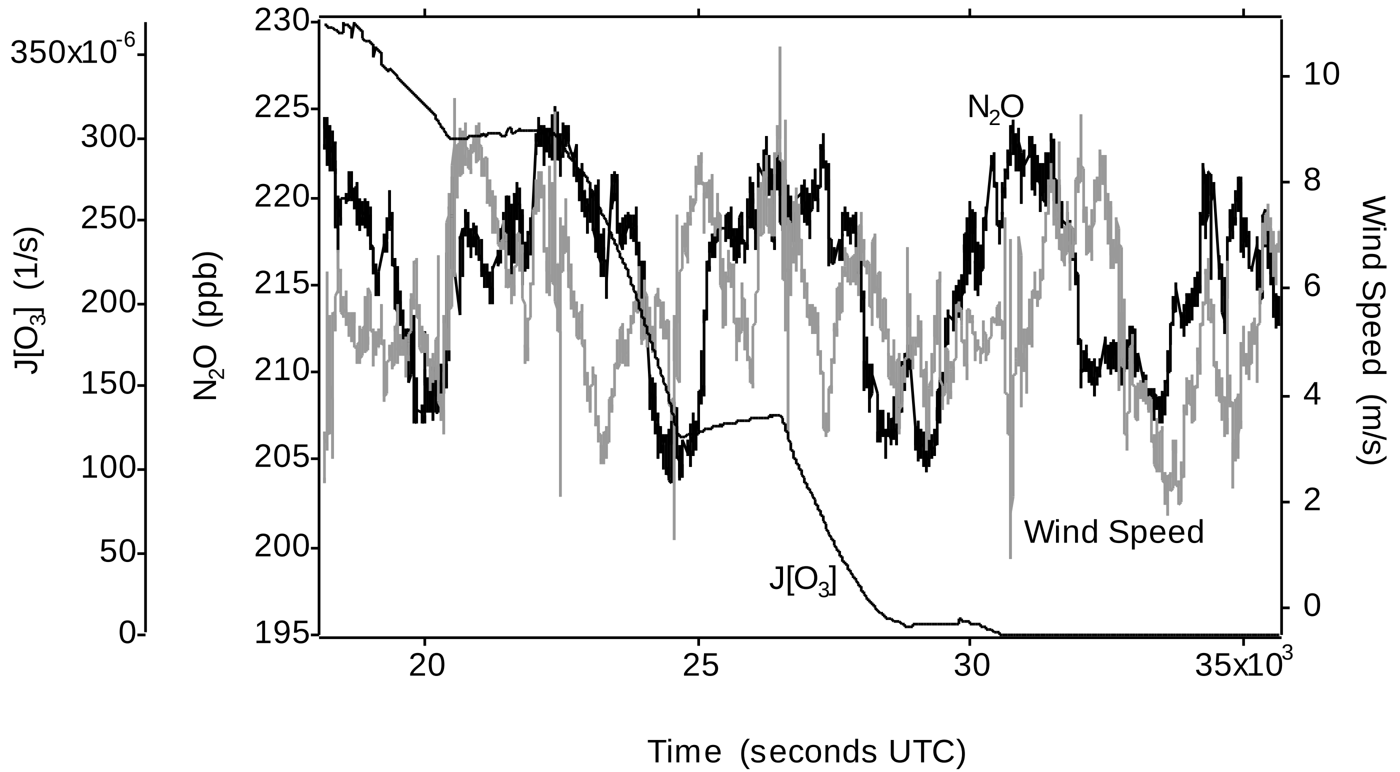
Correlation of the observed photodissociation rate of ozone with the intermittency of observed temperature. Arctic summer 1997 and winter 2000.



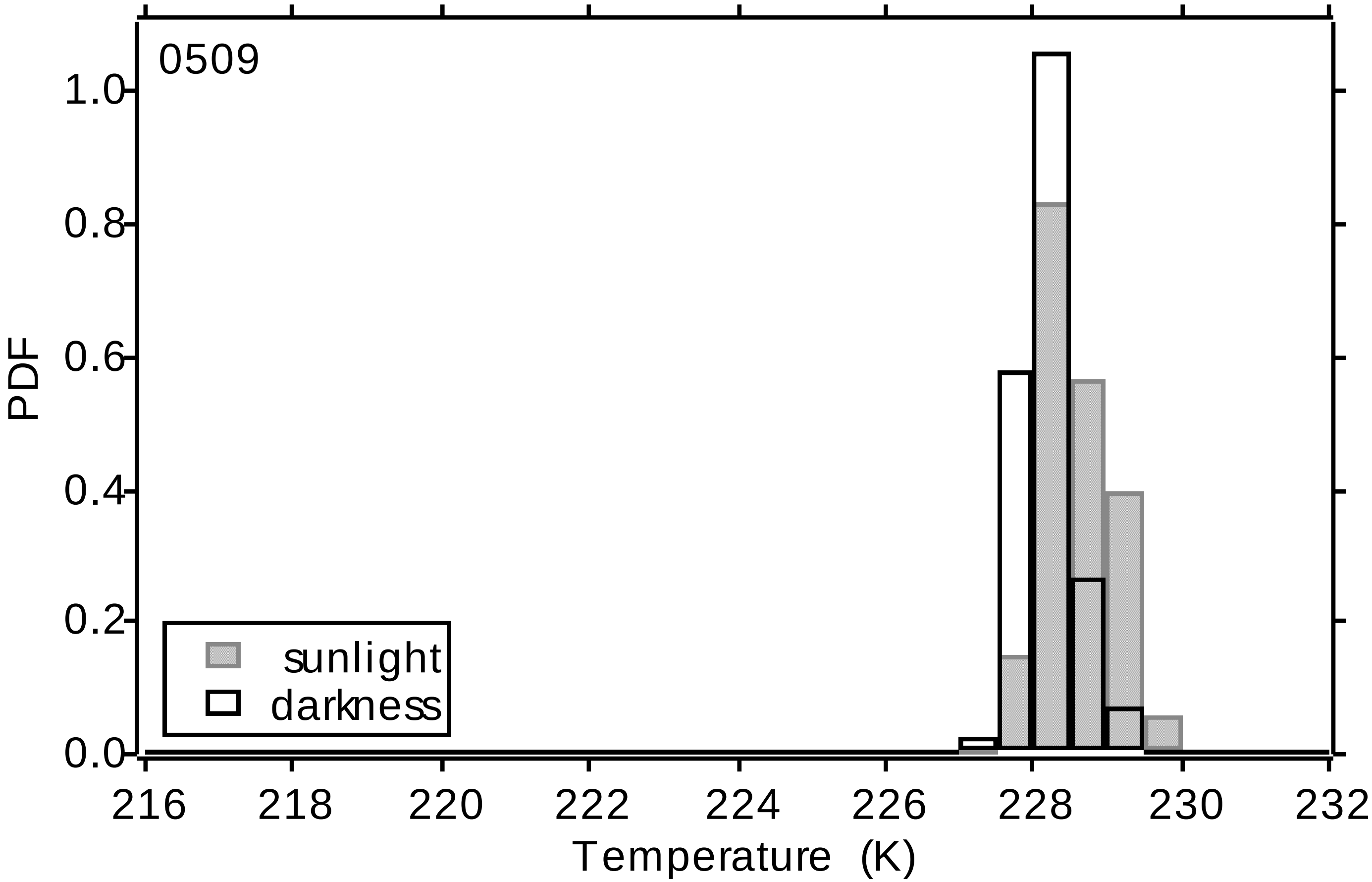
ER-2, Arctic summer 1997. Racetrack segments in static air mass, crossing terminator. Temperature changes between night and day, nothing else does.



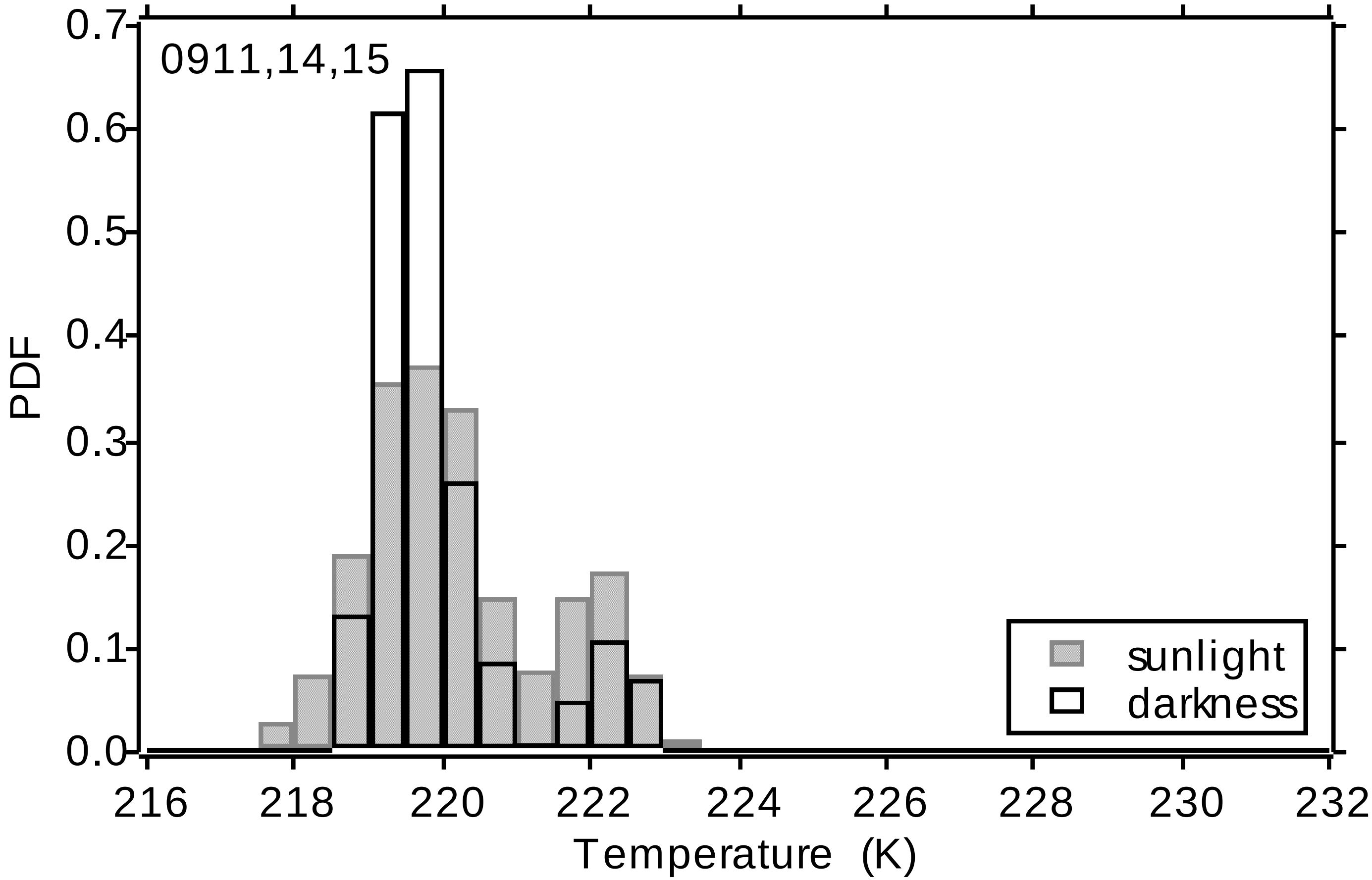
ER-2, Arctic summer 1997. Unlike temperature, wind speed and nitrous oxide do not change across the terminator.



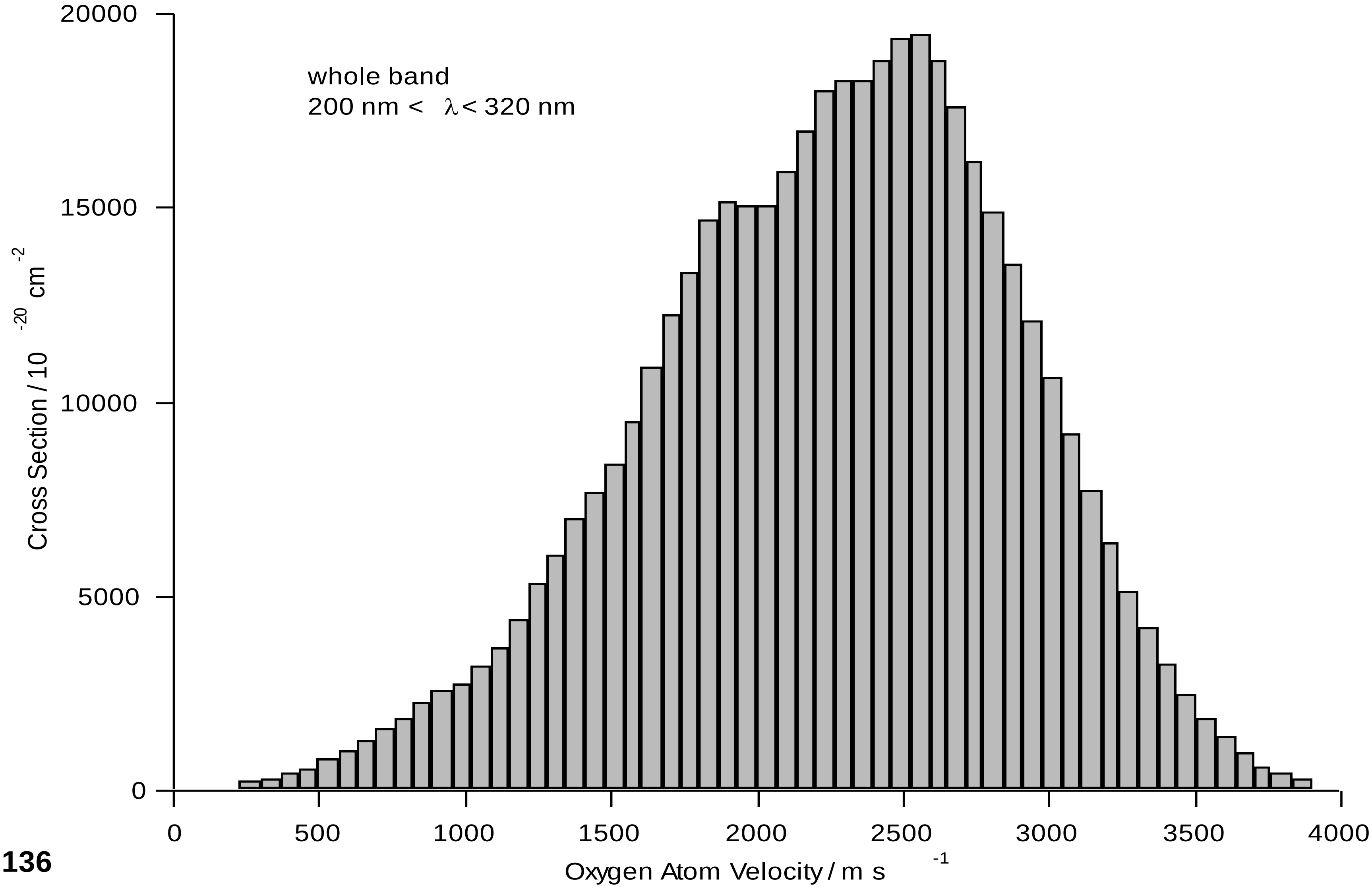
Shift to warmer temperatures on sunlit side of terminator, ER-2 racetrack flights in static air mass, Arctic summer 19970509.



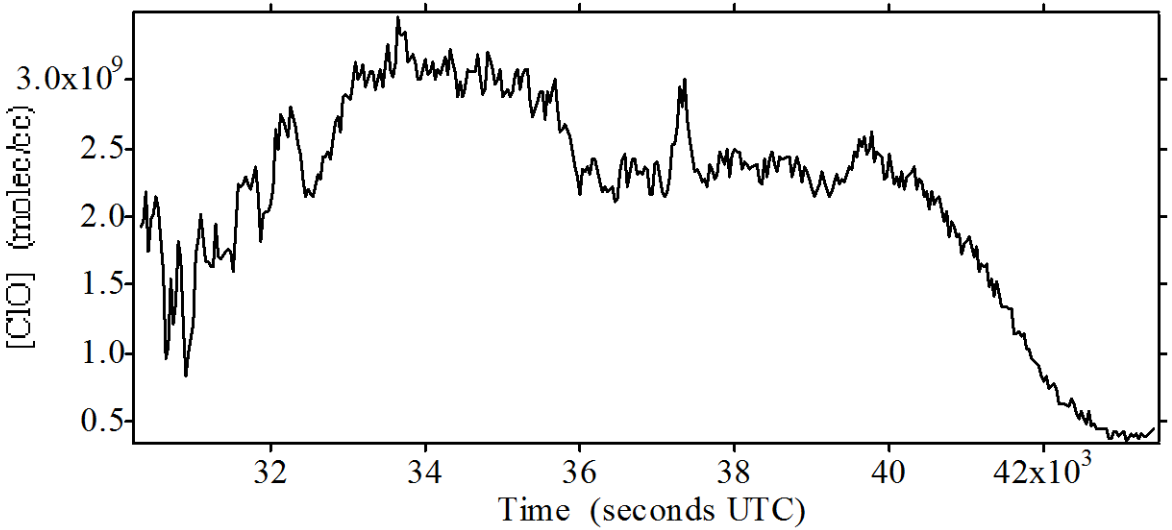
Shift to warmer temperatures, sunlit side of terminator, ER-2 racetrack flights in static air mass, Arctic summer 19970911,14,15.

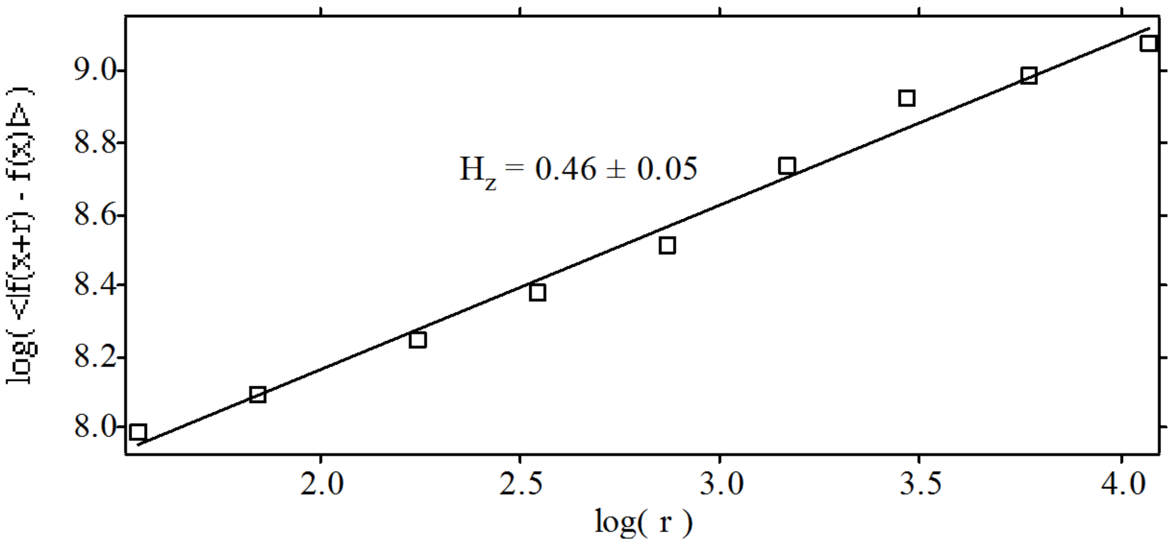


Baloïtcha & Balint-Kurti (2005), *PCCP, 7,* 3829-3833. Speed distribution of photofragments, O_3 photodissociation, Hartley band.

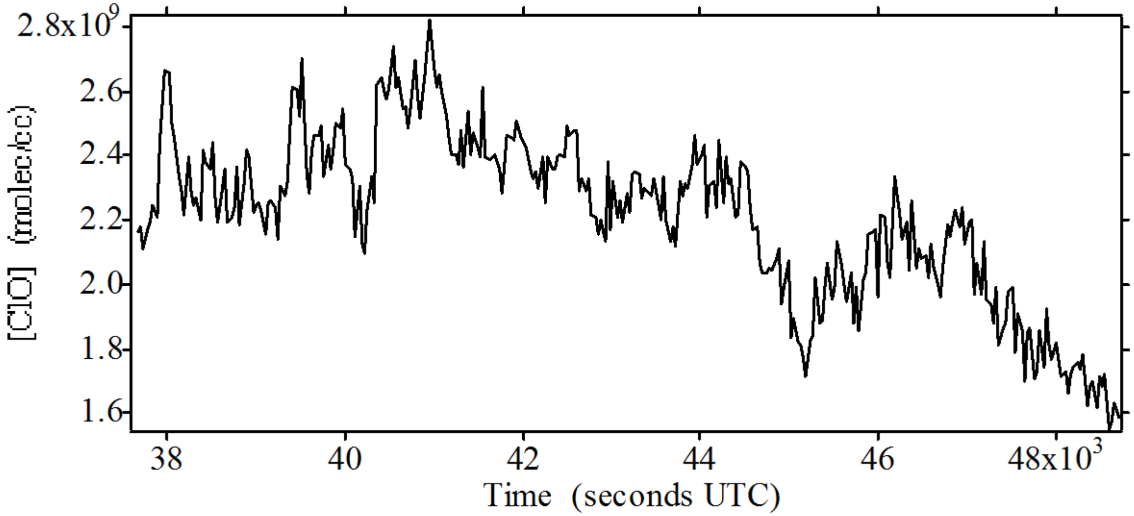


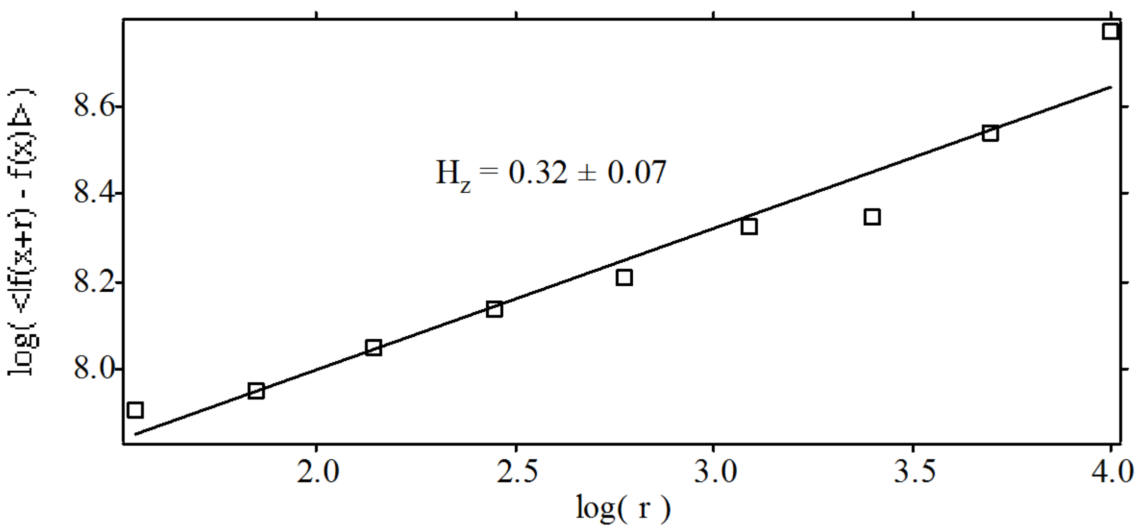
Scaling of ER-2 ClO, Arctic vortex, 20000226. Source no longer operative.



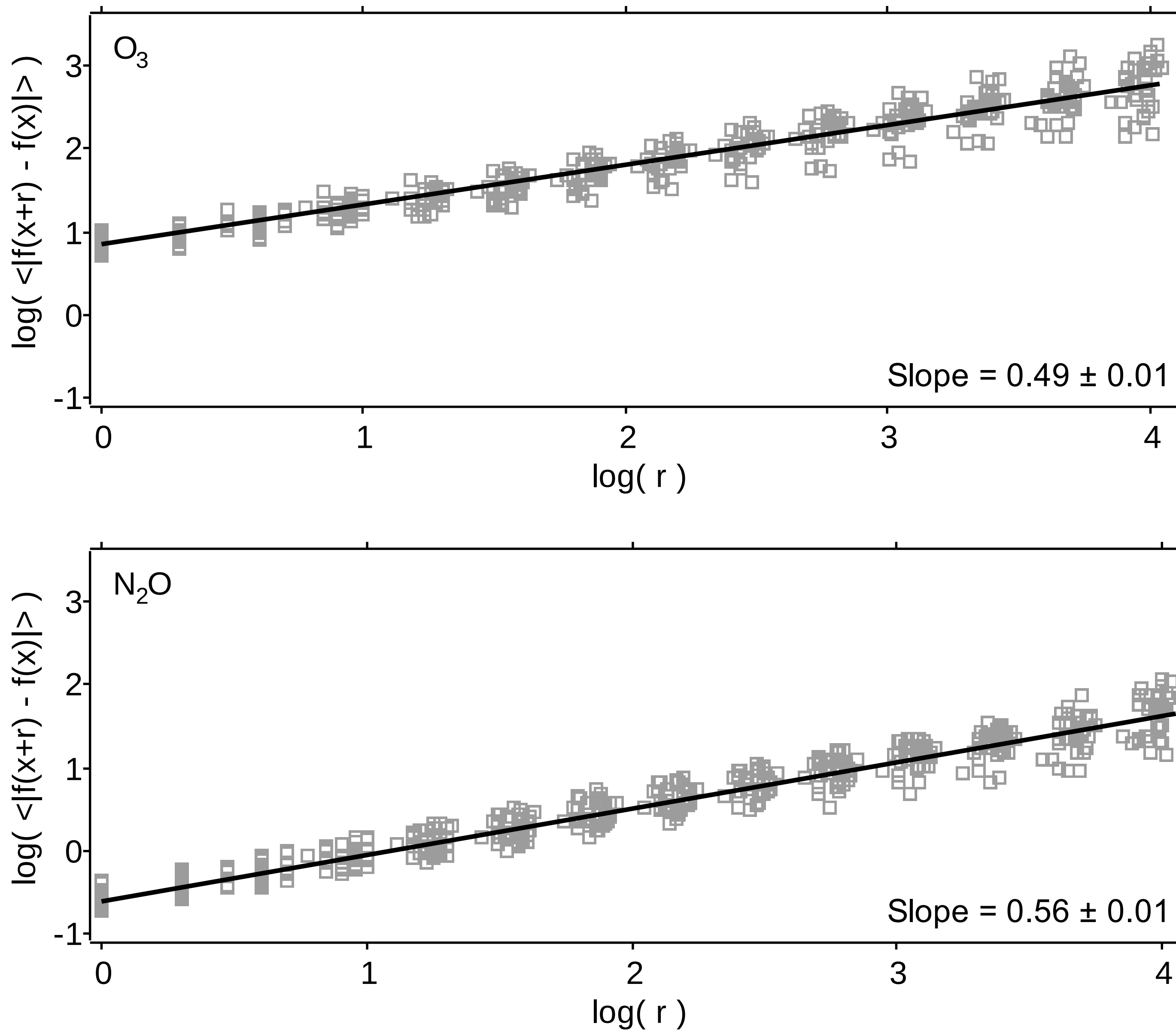


Scaling of ER-2 ClO, Arctic vortex, 20000312. A sink is operative, *H*[ClO] < 0.56.

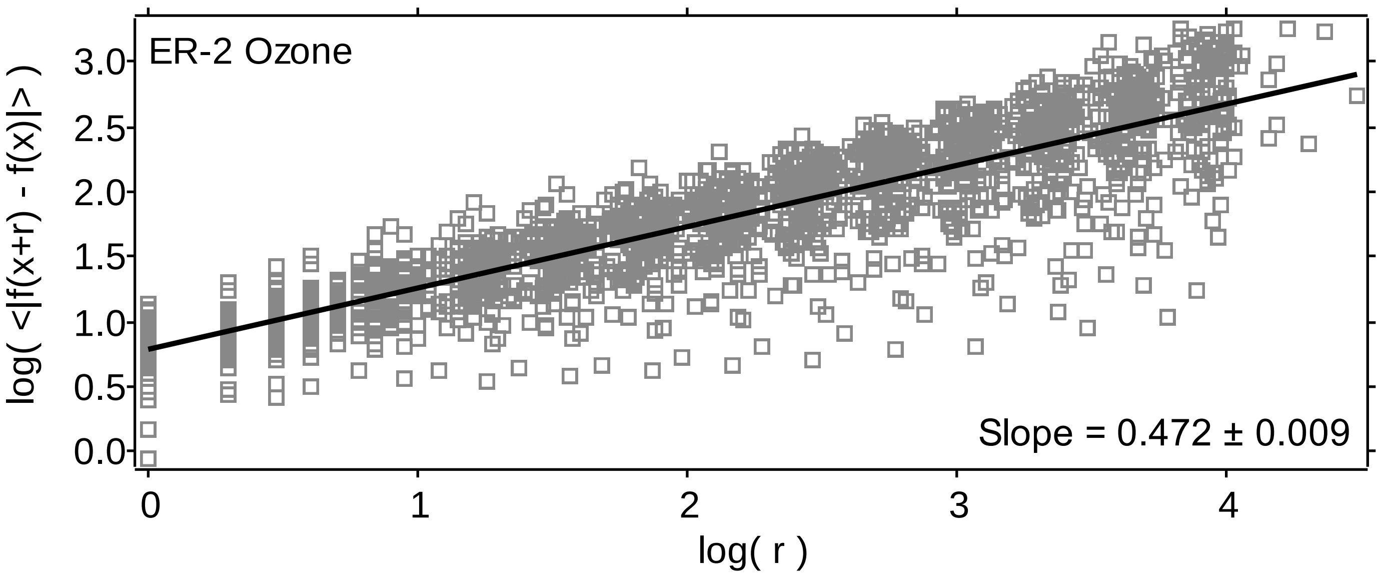




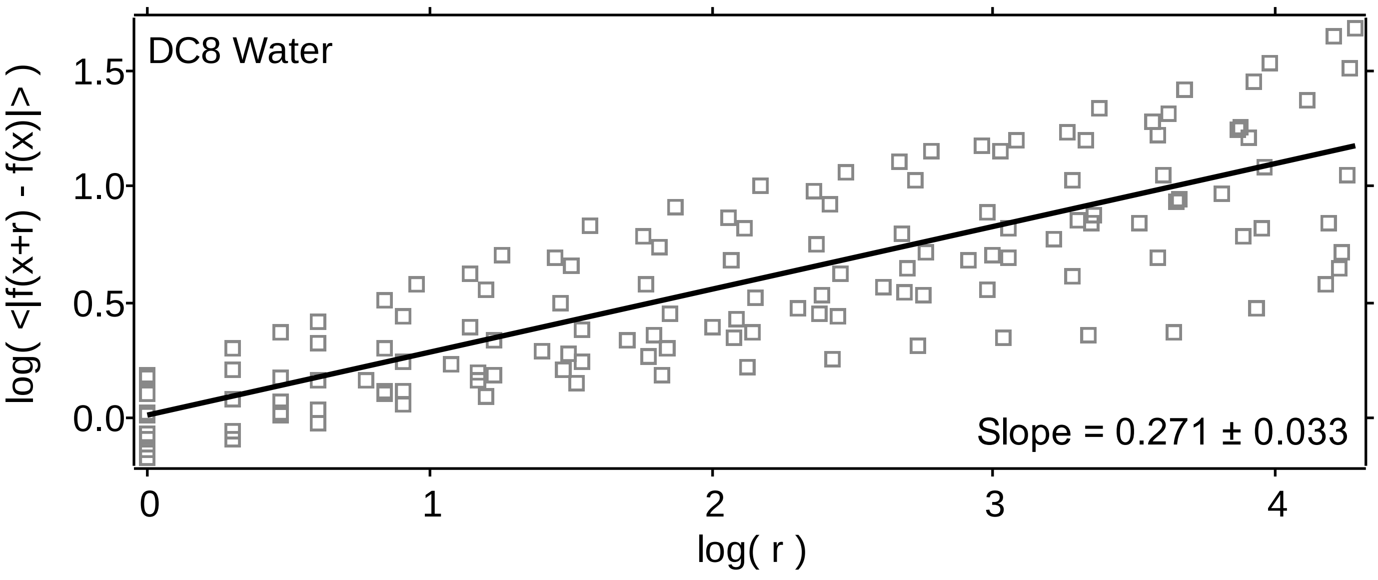
All ER-2 ozone & nitrous oxide, 59˚N-70˚S, heavy SH weighting



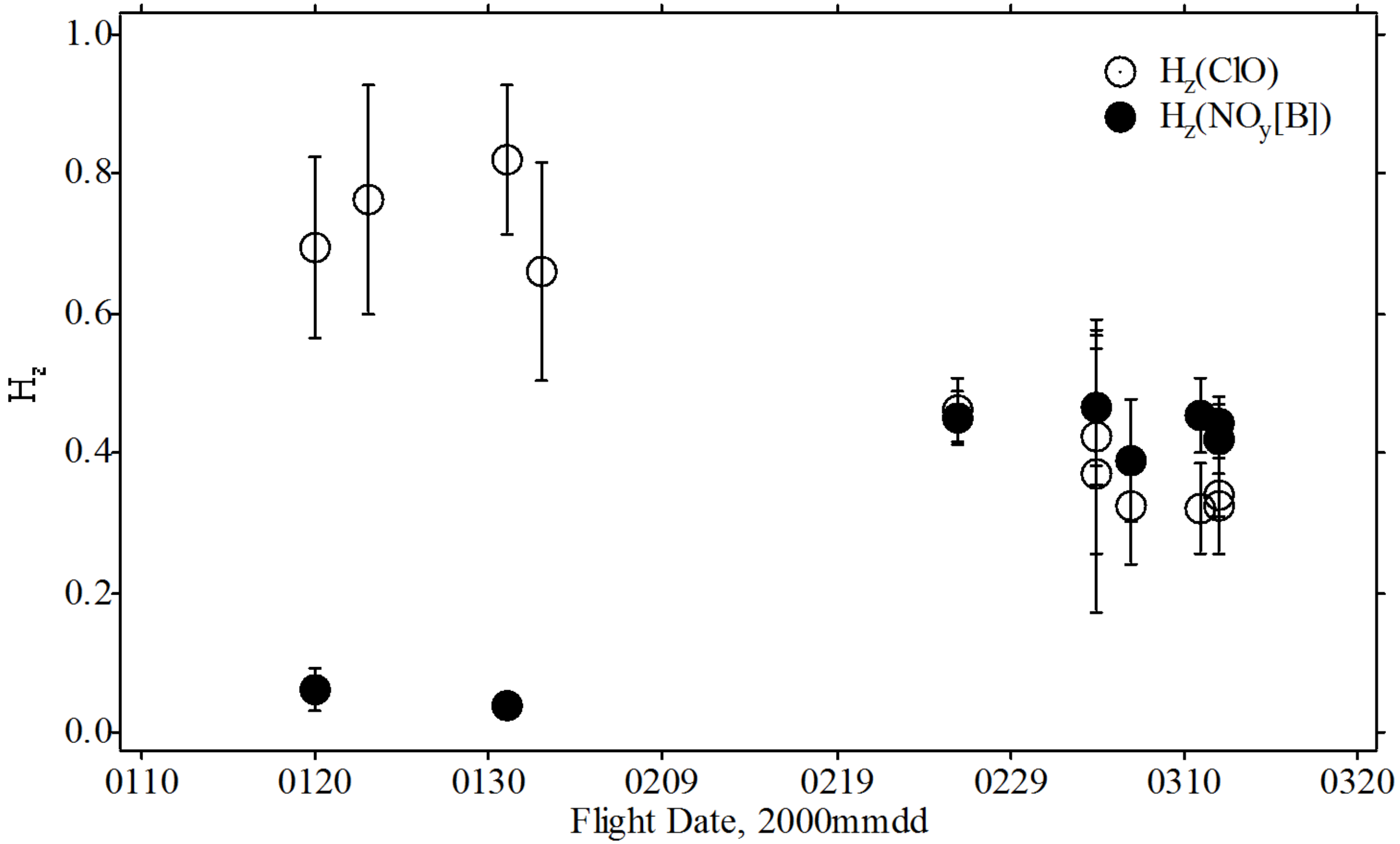
All ER-2 'horizontal' segments >2000 s, 1987-2000



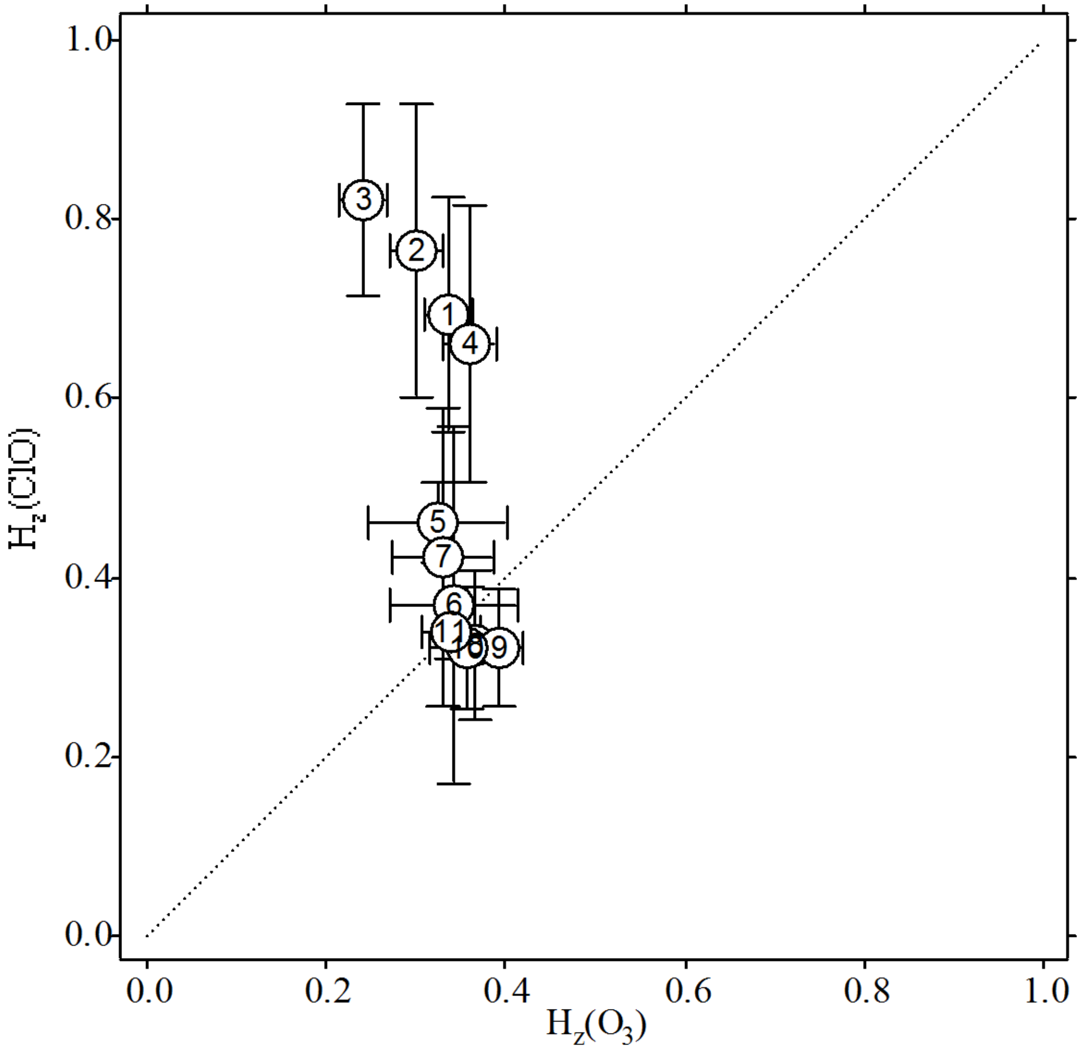
All DC-8 total water, ‘horizontal’, 44˚S - 90˚S, Aug-Sep 1987



ER-2 scaling exponents for ClO and NO_y, Arctic vortex, January - March 2000. An early ClO source & NO_y sink from PSCs evolve to a sink and to a passive scalar (tracer) respectively.



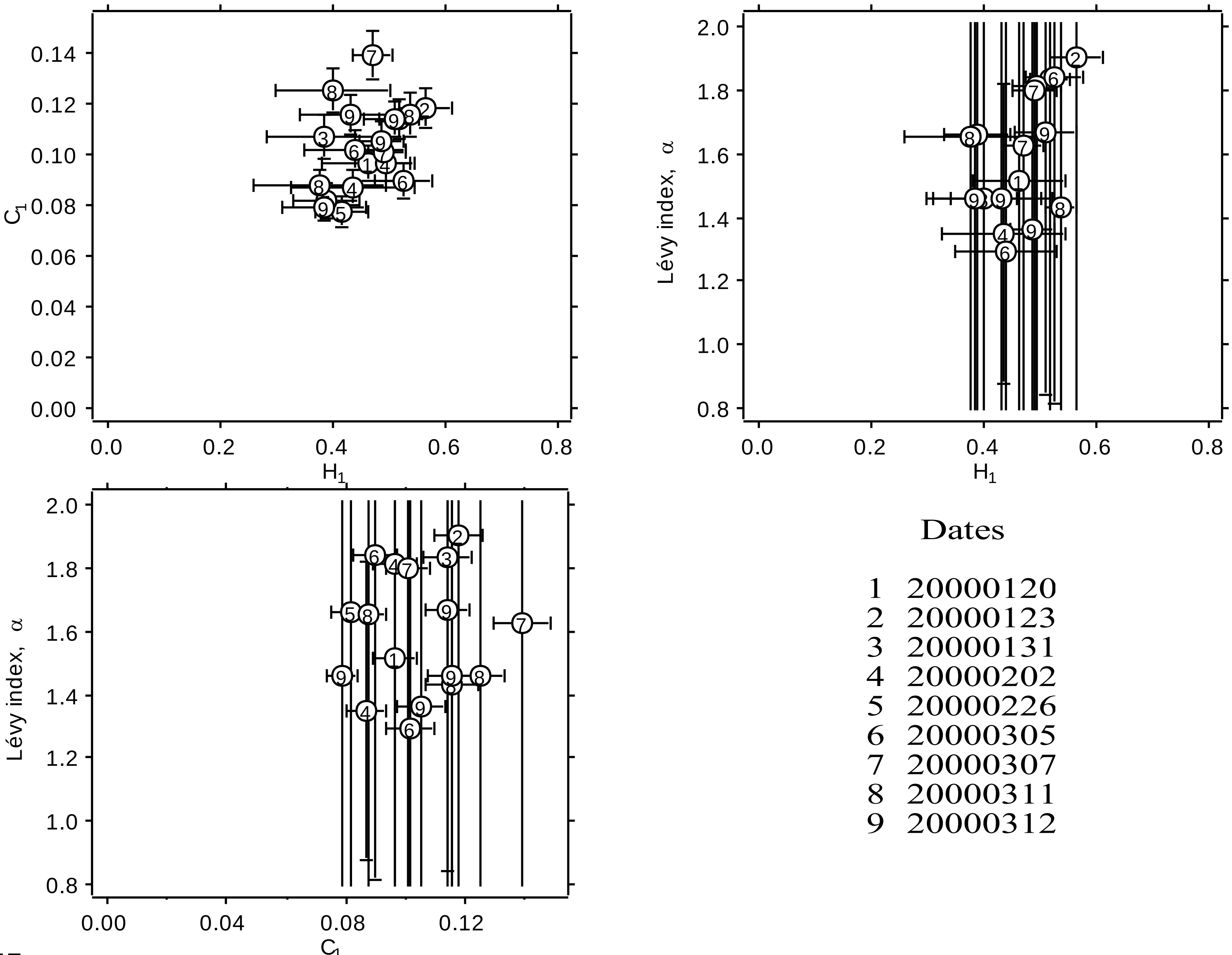
Scatterplot, scaling exponents of ClO & O_3, Arctic vortex 2000. 1 = 20000120, 11 = 20000312. Ozone sink was present 20000120.



H_1 scaling exponents for chemical species ER-2 during SOLVE

Date	Time Interval	$H_z(ClO)$	$H_z(NO_y[B])$	$H_z(O_3)$	$H_z(M)$
20000120[1]	37553-47828	0.69±0.13	0.06±0.03	0.34±0.03	0.50±0.05
20000123[2]	31017-38648	0.76±0.16		0.30±0.03	0.49±0.05
20000131[3]	38199-43249	0.82±0.11	0.04±0.01	0.24±0.03	0.51±0.05
20000202[4]	35869-53229	0.66±0.15		0.36±0.03	0.52±0.07
20000226[5]	30303-43443	0.46±0.05	0.45±0.04	0.32±0.08	0.48±0.07
20000305[6]	35567-39442	0.37±0.20	0.47±0.08	0.34±0.07	0.43±0.04
20000305[7]	52392-57922	0.42±0.17	0.47±0.11	0.33±0.06	0.44±0.07
20000307[8]	28834-43679	0.32±0.08	0.39±0.09	0.37±0.02	0.54±0.07
20000311[9]	46765-52389	0.32±0.07	0.46±0.06	0.39±0.03	0.52±0.08
20000312[10]	37649-48709	0.32±0.07	0.44±0.04	0.36±0.04	0.47±0.06
20000312[11]	51342-58549	0.34±0.03	0.42±0.05	0.34±0.03	0.46±0.06

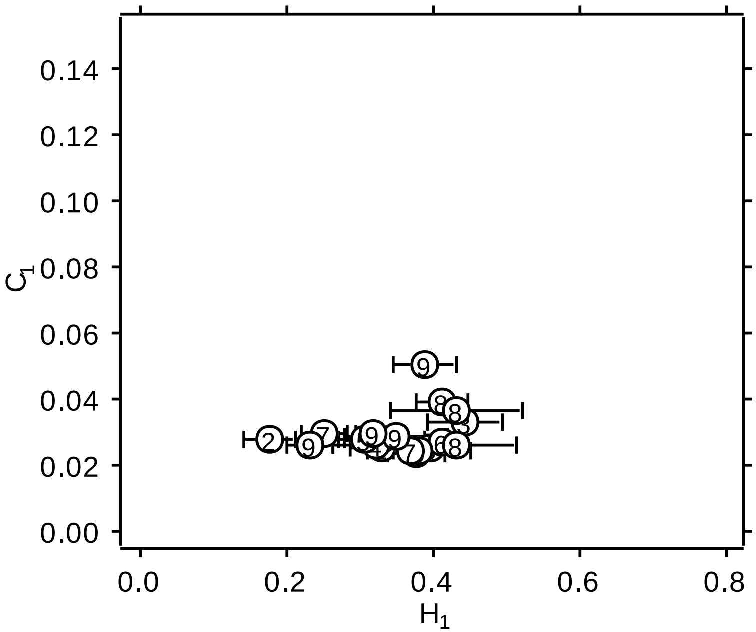
ER-2 temperature data from SOLVE, Arctic Jan-Mar 2000. H_1, C_1 and α. Archived (truncated) data spoils calculation of $\alpha(T)$.

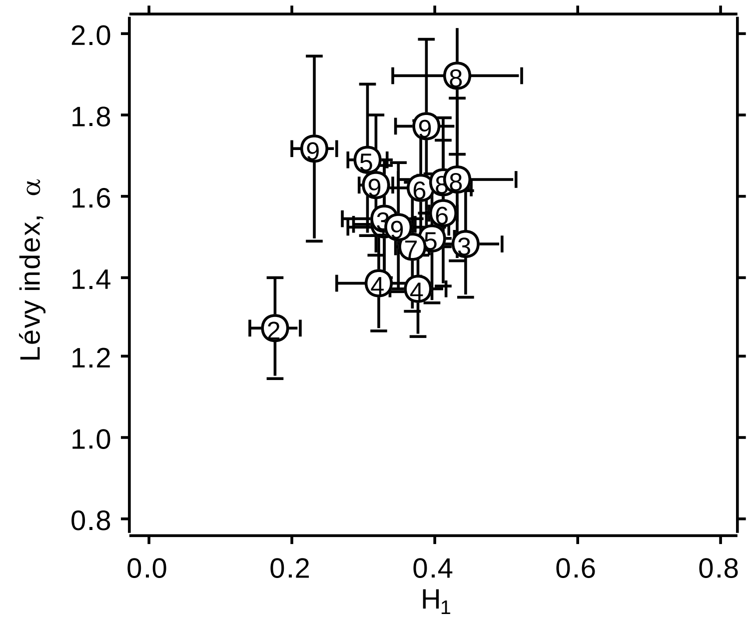


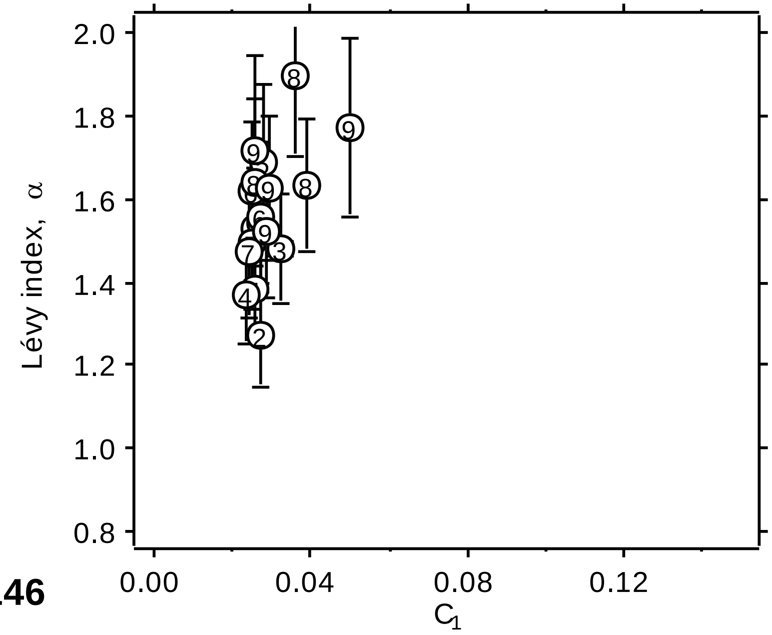
Dates

1 20000120
2 20000123
3 20000131
4 20000202
5 20000226
6 20000305
7 20000307
8 20000311
9 20000312

ER-2, O_3 SOLVE data. Scaling exponents H_1, C_1 and α.



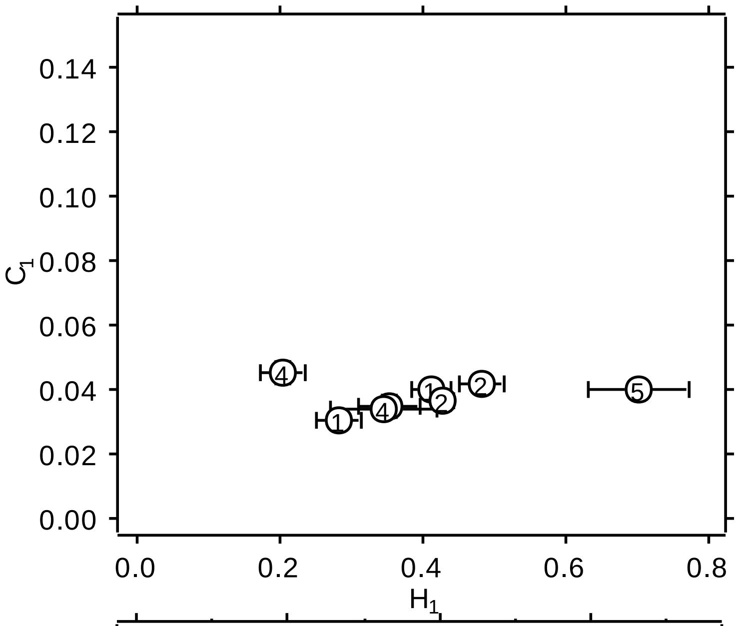


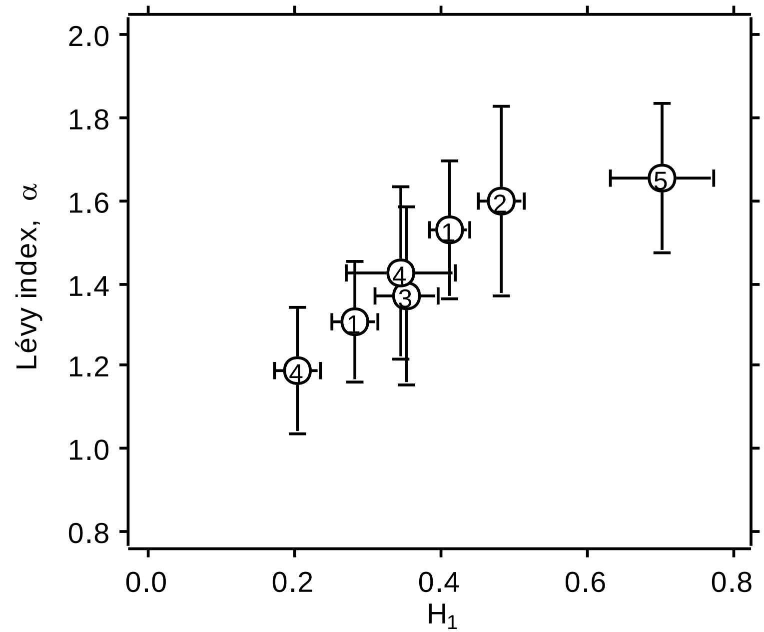


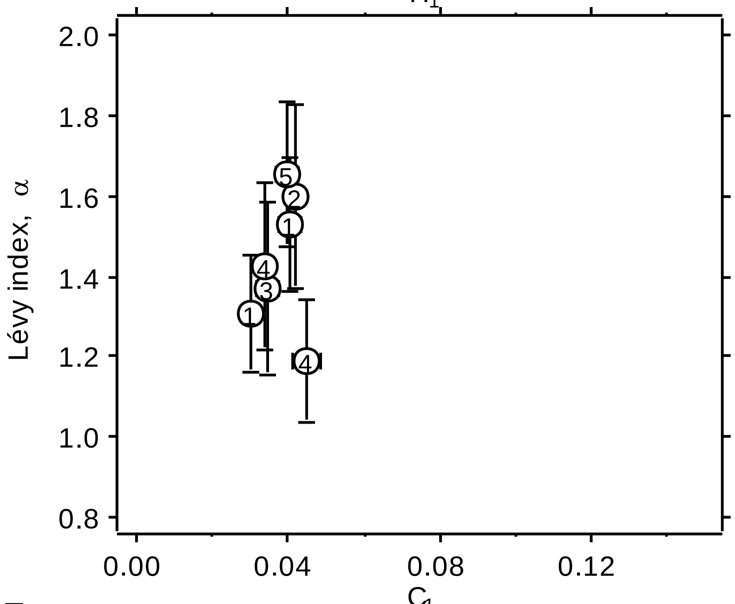
Dates

1	20000120
2	20000123
3	20000131
4	20000202
5	20000226
6	20000305
7	20000307
8	20000311
9	20000312

ER-2, O_3 scaling exponents, AAOE, Antarctic vortex, Aug-Sep 1987.







Dates

1 19870830
2 19870902
3 19870904
4 19870909
5 19870922

Summary, Lecture 3.2, Correlations.

*In both horizontal and vertical, *H*(windspeed) is correlated with jet stream strength. Why? Recall the Alder-Wainwright mechanism, and that observed winds breach Navier-Stokes assumptions.

* Correlation of intermittency of temperature with ozone photodissociation rate. Fast O atoms + Alder-Wainwright breach local thermodynamic equilibrium assumption.

* Correlation of *H* and α exponents for ozone in the winter polar vortex can only be of chemical origin.

* Correlation of *H* for molecular species, including water, with source, tracer and sink behaviour with values greater than, equal to and less than 5/9 (0.56). Is the interpretation in the statistical thermodynamic formulation of scale invariance?