Supplemental Material for

Statistical regularization for trend detection: An integrated approach for detecting long-term trends from sparse tropospheric ozone profiles

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Table S-1: Trends and 2-sigma variabilities [in units of ppb decade^{-1}] based on the separated fit and integrated fit methods, with a reference to different starting year, above Hilo, Hawaii and Trinidad Head (THD), California.

		Separated fit			Integrated fit		
		Trend	2-sigma	p-value	Trend	2-sigma	p-value
Hilo	700-300hPa	1.11	0.83	0.01	1.12	0.78	0.01
Since 1982	950-250hPa	0.89	0.68	0.01	0.96	0.63	<0.01
	950-800hPa	-0.25	0.70	0.47	0.02	0.56	0.95
	400-300hPa	2.31	1.10	<0.01	1.87	1.03	<0.01
	650hPa	0.21	0.86	0.63	0.70	0.67	0.05
Hilo	700-300hPa	0.70	1.43	0.34	0.64	1.33	0.35
Since 1994	950-250hPa	0.63	1.11	0.27	0.59	1.07	0.29
	950-800hPa	0.29	0.98	0.56	0.30	0.92	0.52
	400-300hPa	1.11	1.73	0.21	0.98	1.61	0.24
	650hPa	-0.05	1.34	0.94	-0.03	1.22	0.96
Hilo	700-300hPa	0.07	2.01	0.95	0.04	1.83	0.96
Since 2000	950-250hPa	0.02	1.50	0.98	-0.03	1.41	0.97
	950-800hPa	0.07	1.12	0.91	0.09	1.11	0.87
	400-300hPa	0.19	2.49	0.88	-0.19	2.17	0.86
	650hPa	-0.45	2.01	0.66	-0.09	1.64	0.91
		Separated fit			Integrated fit		
		Trend	2-sigma	p-value	Trend	2-sigma	p-value
THD	700-300hPa	-2.46	2.45	0.06	-2.45	2.19	0.04
Since 1998	950-250hPa	-1.85	1.70	0.04	-1.85	1.53	0.03
	950-800hPa	-0.81	0.90	0.09	-0.82	0.79	0.05
	400-300hPa	-5.65	5.73	0.06	-5.46	5.02	0.04
	650hPa	-0.48	1.46	0.52	-0.71	1.05	0.19
THD	700-300hPa	-0.12	1.76	0.90	-0.22	1.47	0.76
Since 2000	950-250hPa	-0.25	1.28	0.70	-0.33	1.09	0.55
	950-800hPa	-0.47	1.05	0.38	-0.52	0.92	0.28
	400-300hPa	-0.19	3.90	0.93	-0.32	3.04	0.84
	650hPa	-0.32	1.72	0.71	-0.41	1.19	0.50
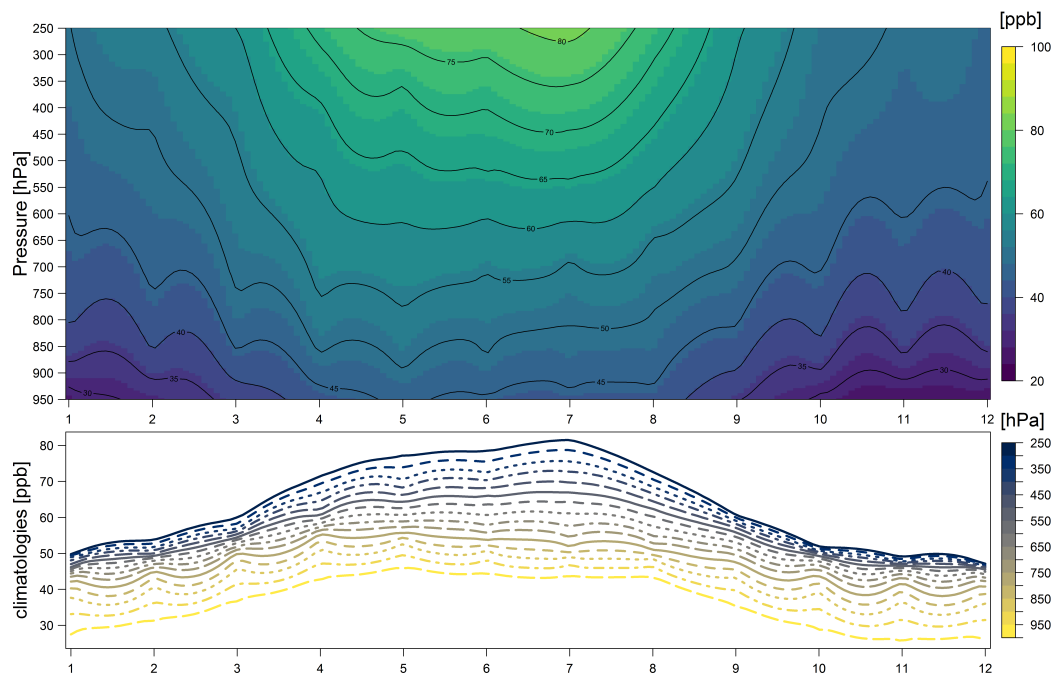
(a) Seasonal component
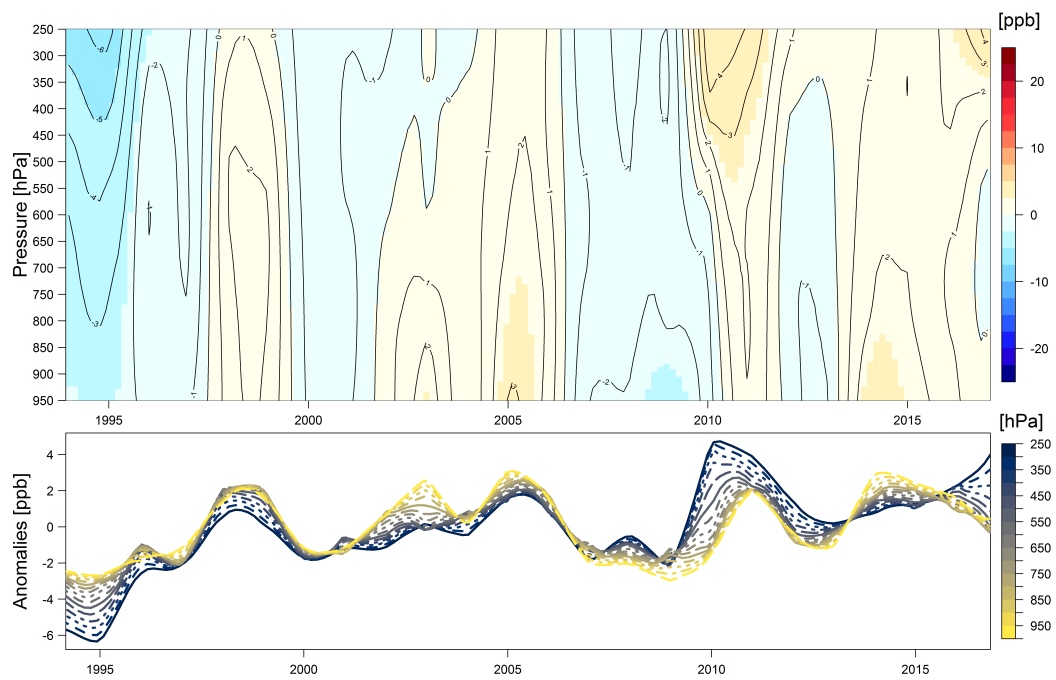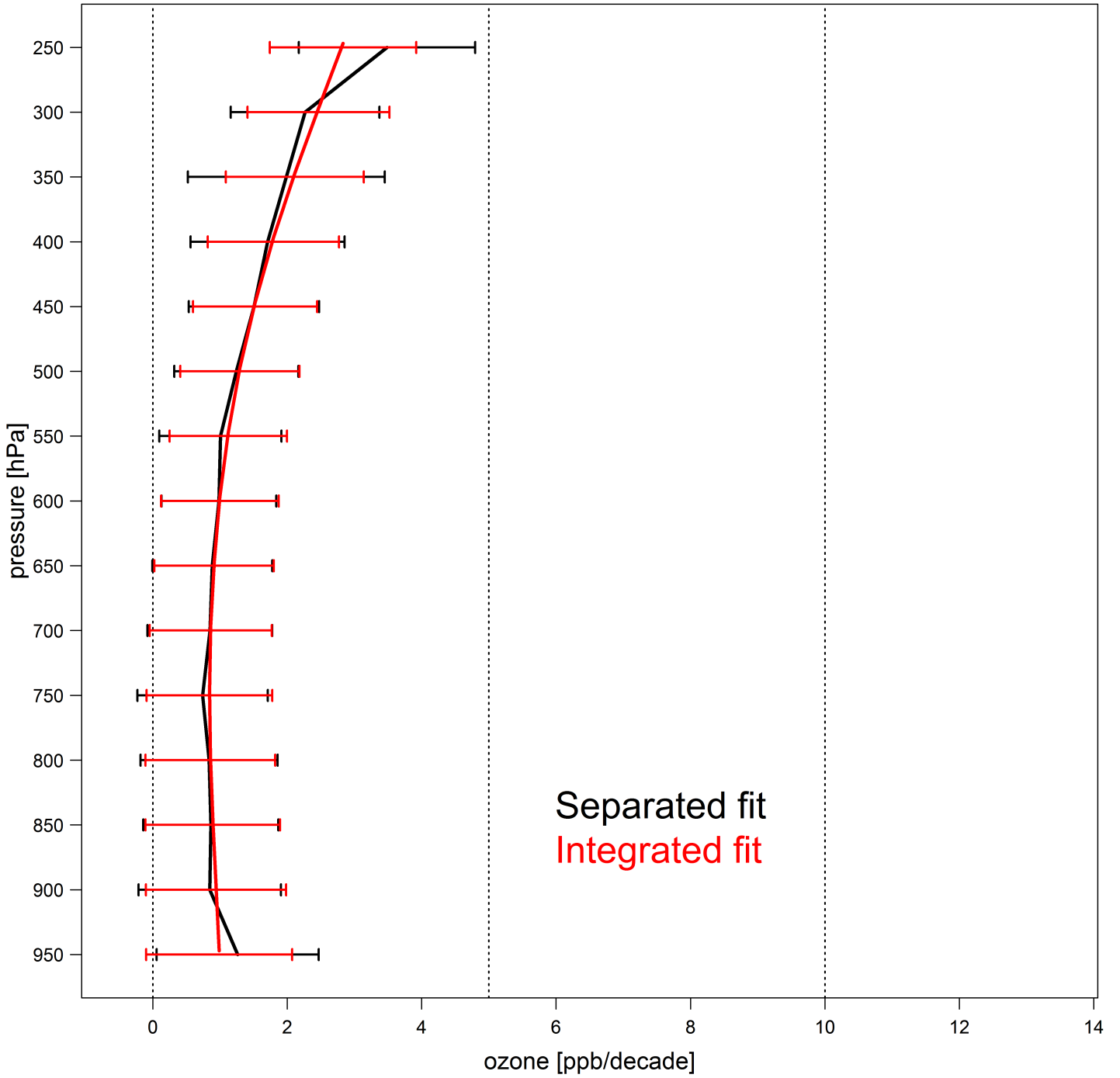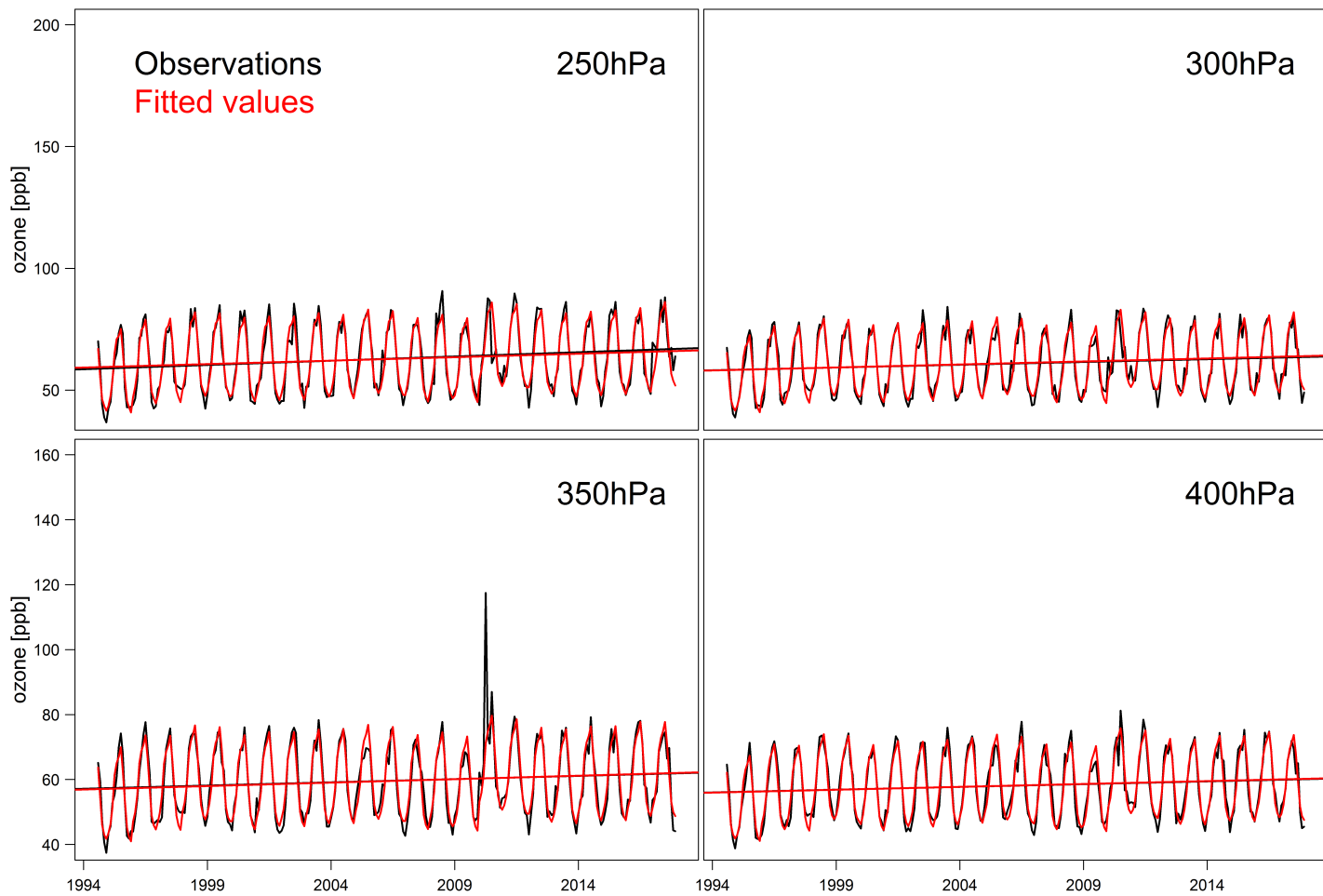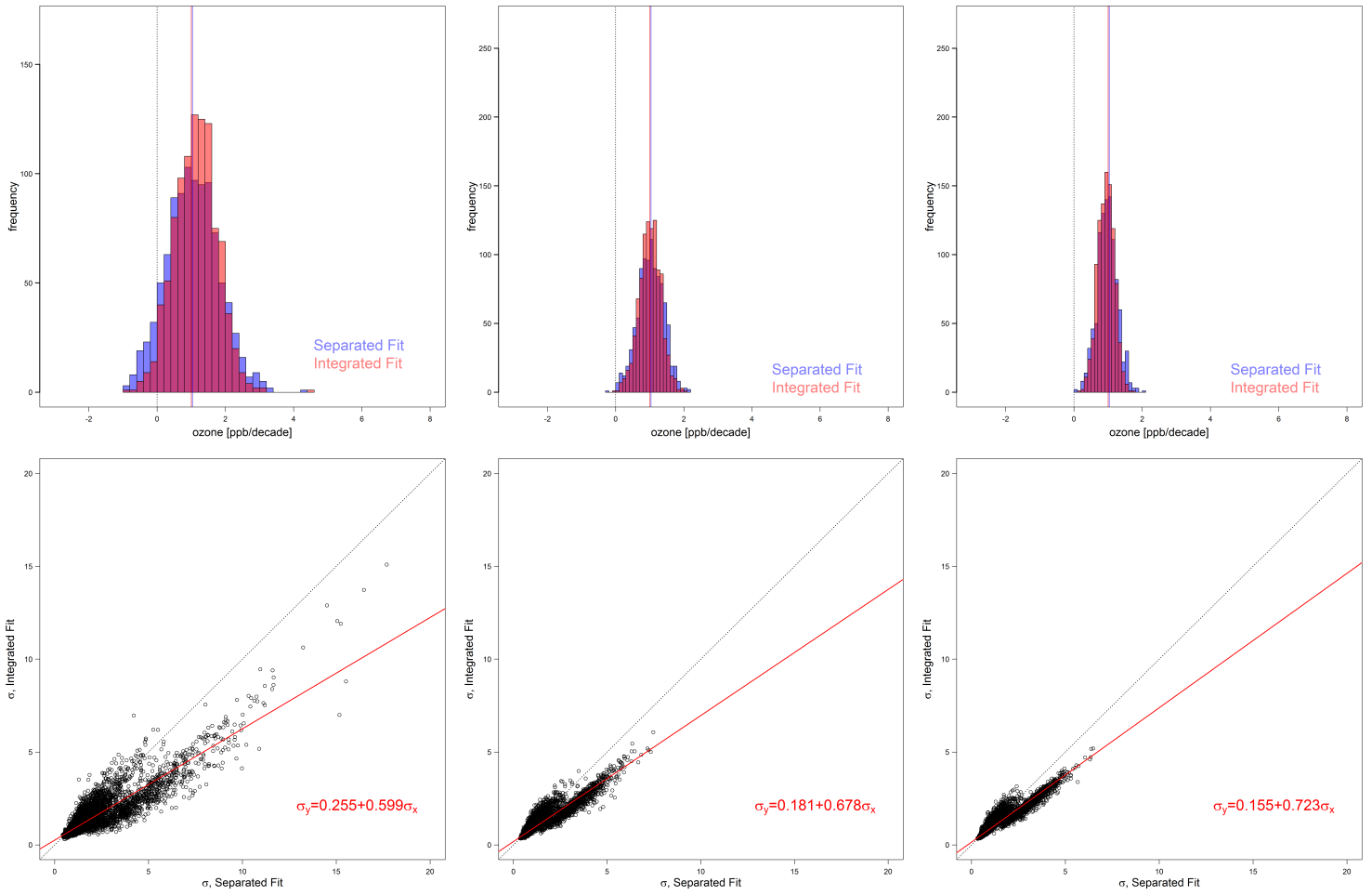

(b) Interannual component

Figure S-1: As in Figure 2, but all observations made in the stratosphere have been removed.

Figure S-2: As in Figure 4, but all observations made in the stratosphere have been removed.

Figure S-3: As in Figure 5, but all observations made in the stratosphere have been removed.

Figure S-4: Sensitivity analysis at 550 hPa based on 1000 random samples of 1 (left), 5 (middle) and 9 (right) selected profiles per month. Shown are the sampled trend distributions with vertical lines indicating the trend values derived from the full data set (top), and the corresponding matched trend uncertainties based on the separated and integrated fits (bottom).
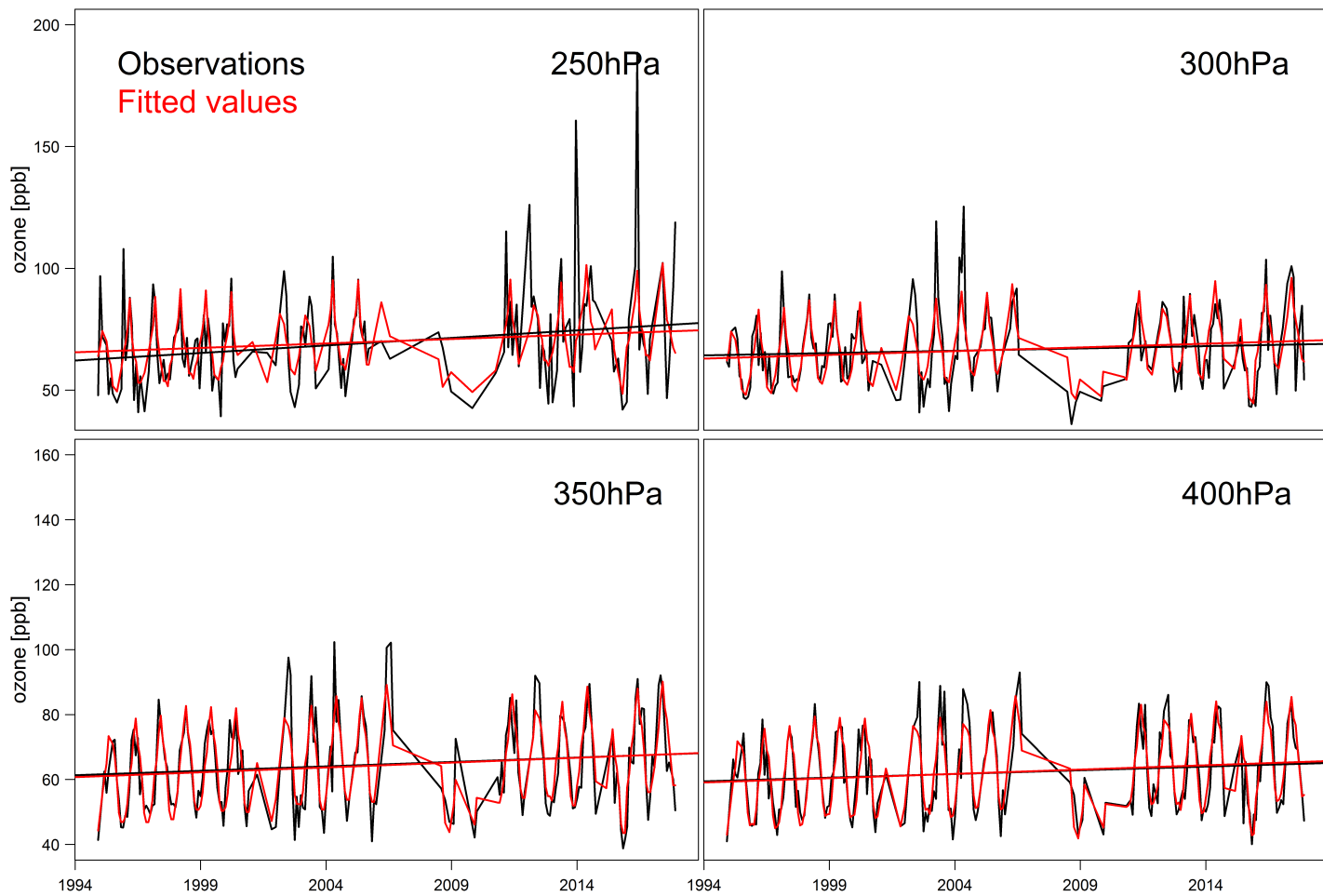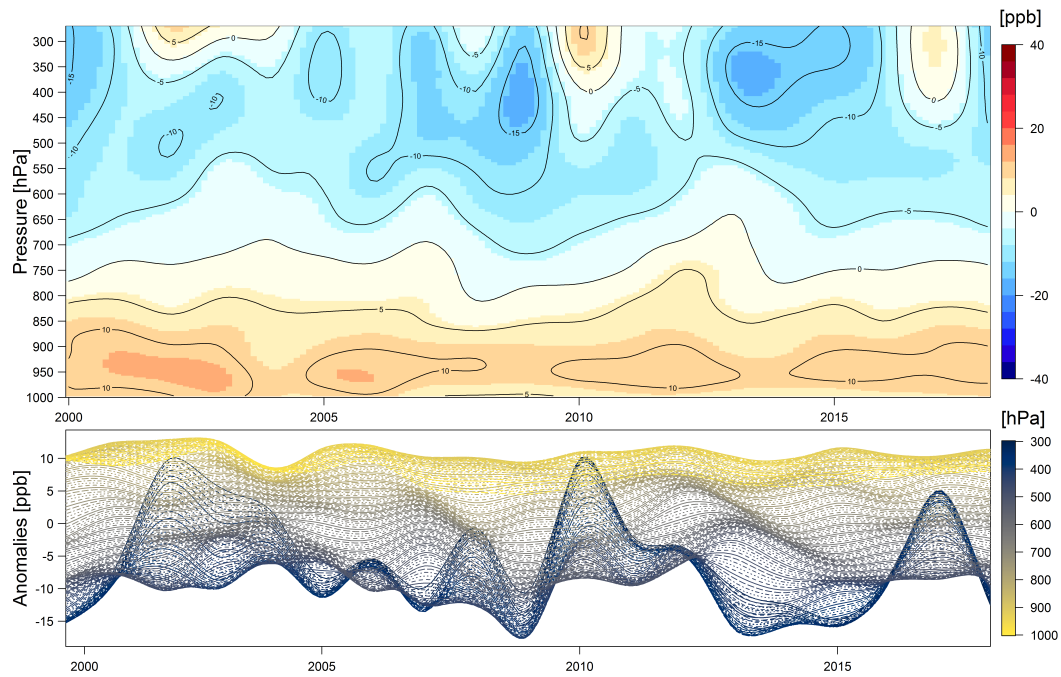
Figure S-5: Monthly mean ozone time series and model fitted values on 4 upper-level layers above NE China.
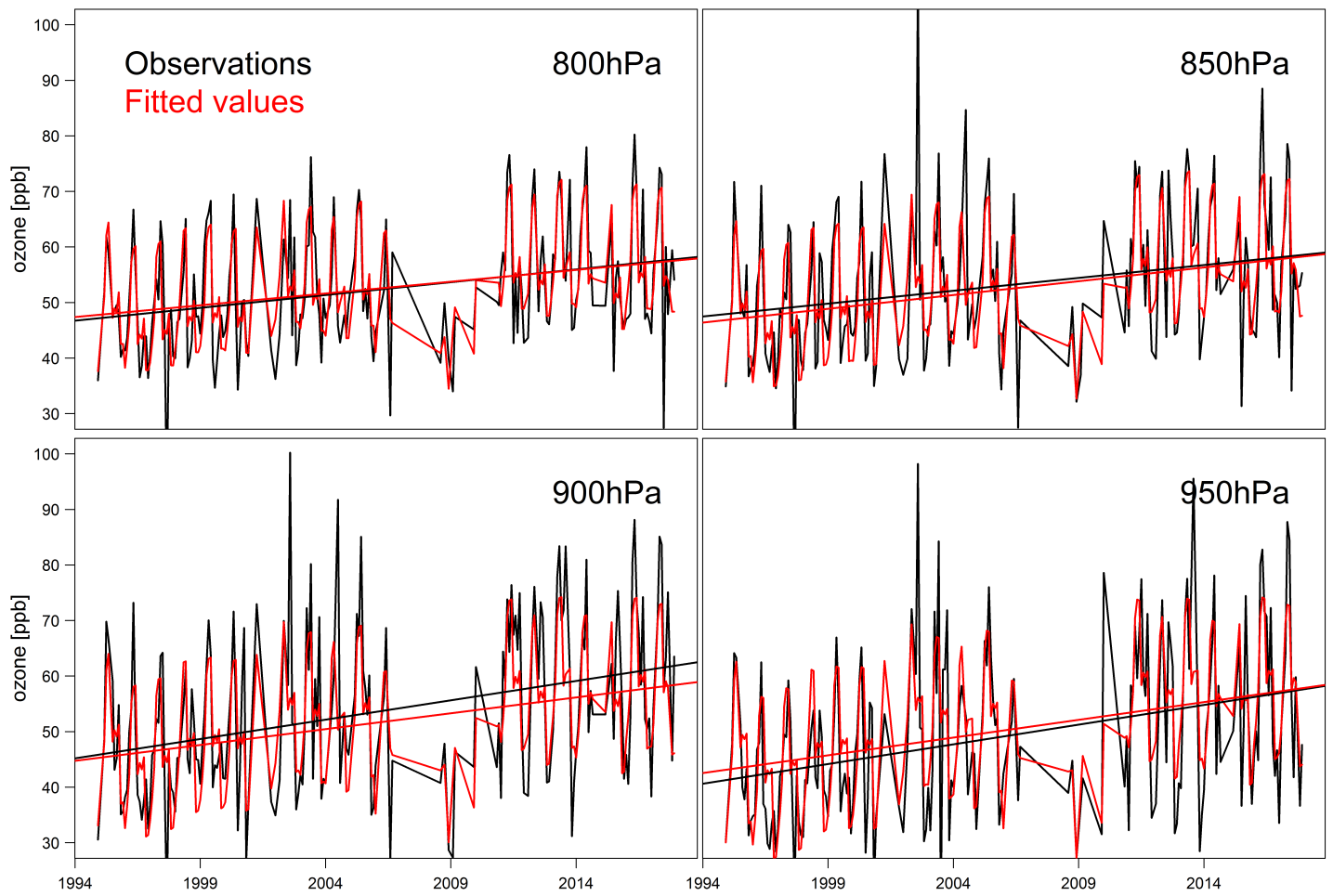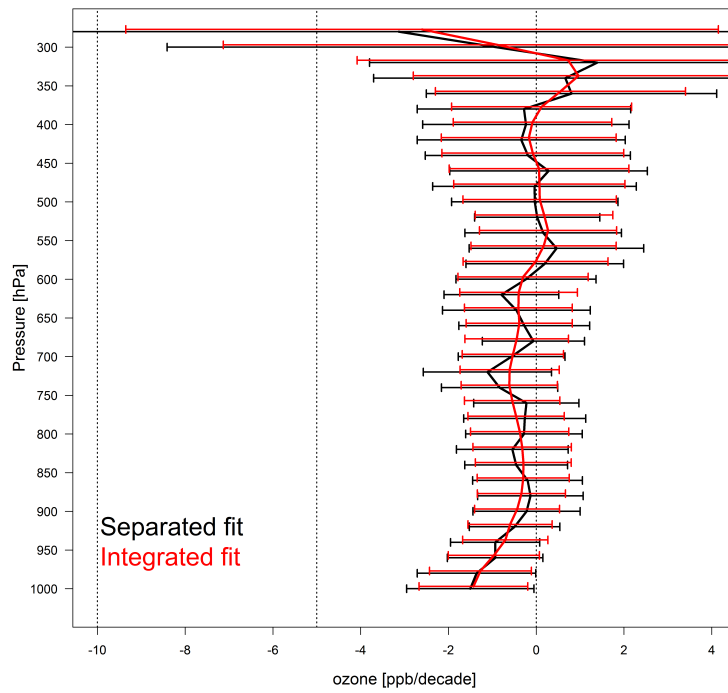
Figure S-6: Monthly mean ozone time series and model fitted values on 4 lower-level layers above NE China.
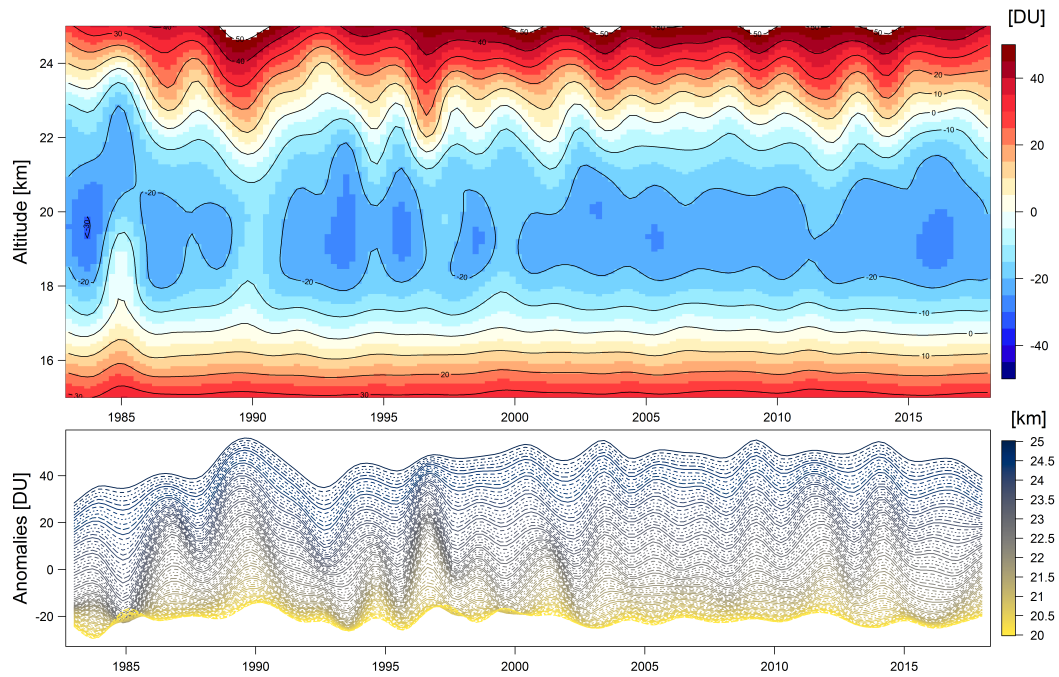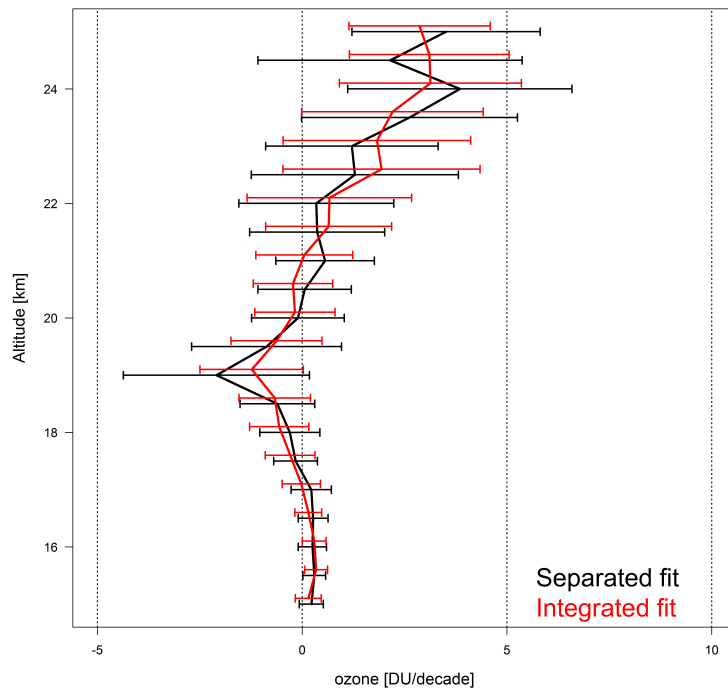
(a) Interannual component

(b) Trend estimates (2000-2018)

Figure S-7: (a) Interannual component for the ozone distribution and (b) trend estimates and associated 2-sigma variabilities at 20 hPa vertical resolution, based on the separated fit and integrated fit methods above Trinidad Head, California.

(a) Interannual component

(b) Trend estimates (1982-2018)

Figure S-8: (a) Interannual component for stratospheric ozone observation and (b) trend estimates and associated 2-sigma variabilities at 0.5 km vertical resolution, based on the separated fit and integrated fit methods above Hilo, Hawaii.