



Supplement of

The 2009–2010 step in atmospheric CO₂ inter-hemispheric difference

R. J. Francey and J. S. Frederiksen

Correspondence to: R. J. Francey (roger.francey@csiro.au)

The copyright of individual parts of the supplement might differ from the CC-BY 3.0 licence.

Coherence of NH DC signals:

To check if Figure 1(a) is specific to *mlo*, we use NOAA data to check the NH spatial extent of the 2009/10 step in Figure S1. Figure S1 shows residuals from linear regressions through ΔC at each site using 1992-2012 mean annual average concentration differences between NH NOAA baseline sites and *cgo* using NOAA flask data. While Alert (alt) is more variable than mid-latitude sites, all sites show increases from 2009 to 2010, and, save *gmi*, are of similar large amplitude.

The next most obvious coherence between sites occurs between 2002 and 2003 (when IH transport through the equatorial duct is normal, but record NH drought and Boreal fires occurred).

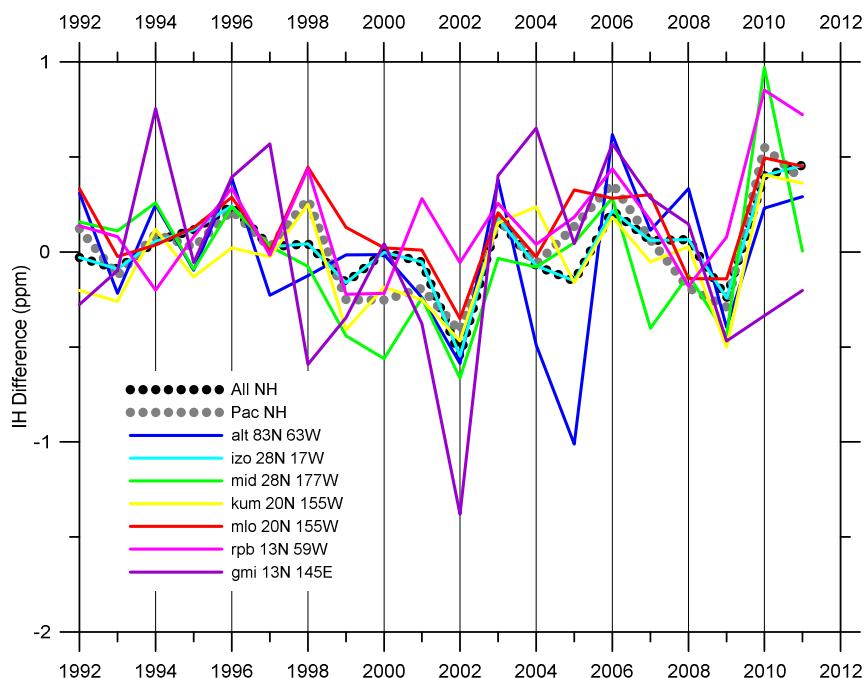


FIGURE S1: NOAA network (NH site minus *cgo*) using annual average baseline data (calendar year, plotted at the beginning of the year). Latitude and Longitude of sites are provided in the legend.

Dependence of IH duct transport on seasonality of trace gases:

The timing of seasonality is determined by sources and sinks in each hemisphere and average seasonality for the 1992-2013 period is shown in Figure 2S. For CO₂ (top panel) *mlo* concentrations exceed *cgo* carbon dioxide concentrations at times when IH mixing through the equatorial duct is most vigorous; at other times of the year the IH difference is mainly reversed but the duct is generally closed.

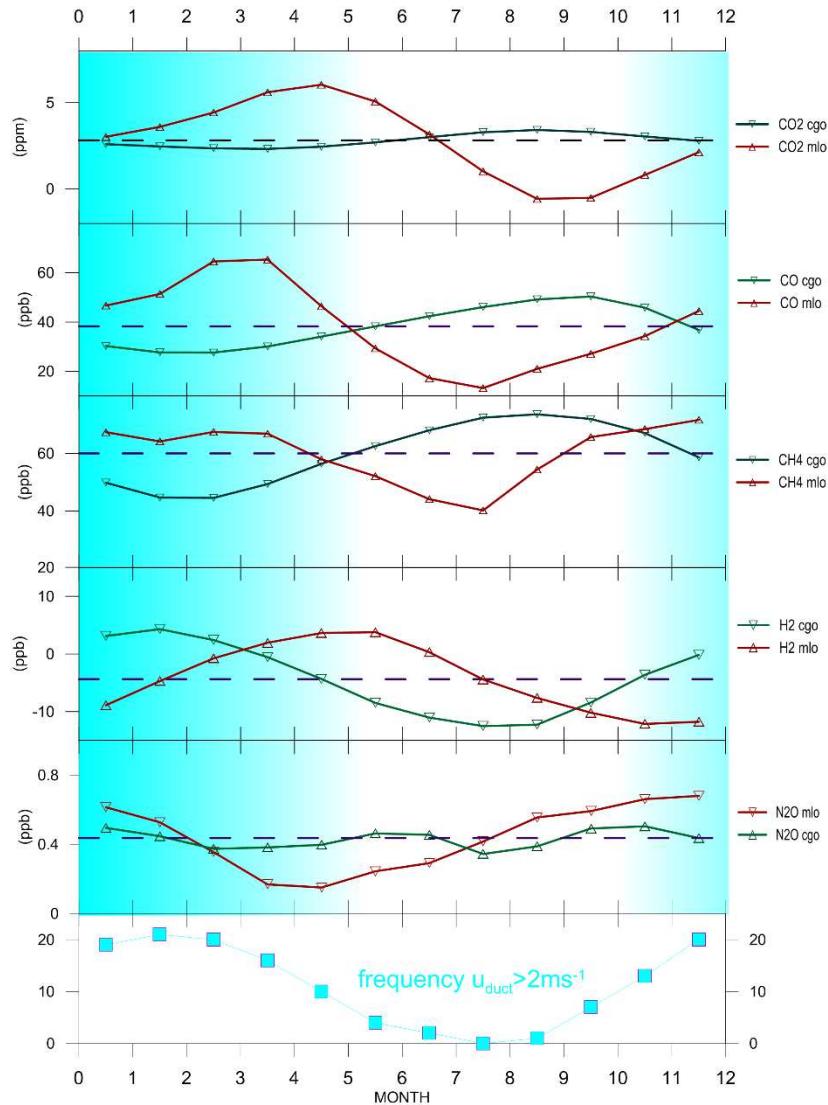


FIGURE S2: Average seasonal cycles added to mean annual average difference (since 1992) at mlo (red) and cgo (green) from CSIRO flasks and analysed for CO₂, CO, CH₄, H₂ and N₂O. Shading represents periods when IH exchange through the equatorial upper troposphere duct is most active (indicated in the bottom panel by the frequency of occurrence of westerly zonal winds $> 3 \text{ ms}^{-1}$).

CSIRO CO₂ data:

Monthly CSIRO baseline data for CO₂ and δ¹³C at Cape Grim, South Pole and Mauna Loa.
Calibration details are in Francey et al. (2015).

Dec Date	cgo CO ₂ (ppm)	cgo δ ¹³ C (‰)	spo CO ₂ (ppm)	spo δ ¹³ C (‰)	mlo CO ₂ (ppm)	mlo δ ¹³ C (‰)
1991.452	353.66	-7.77	353.64	-7.80		-7.99
1991.534	353.93	-7.80	354.15	-7.81		-7.89
1991.619	354.20	-7.85	354.35	-7.83	352.75	-7.78
1991.704	354.21	-7.84	354.27	-7.83	352.11	-7.68
1991.786	354.02	-7.84	354.25	-7.83	352.63	-7.69
1991.871	353.77	-7.82	354.27	-7.83	354.39	-7.76
1991.953	353.66	-7.80	354.19	-7.83	355.78	-7.82
1992.038	353.45	-7.81	353.83	-7.82	356.89	-7.87
1992.123	353.34	-7.82	353.37	-7.81	357.74	-7.94
1992.202	353.27	-7.79	353.29	-7.81	358.89	-8.02
1992.287	353.44	-7.78	353.50	-7.80	359.56	-8.05
1992.369	353.82	-7.79	353.68	-7.80	359.89	-8.05
1992.454	354.26	-7.82	354.13	-7.80	359.26	-7.99
1992.536	354.72	-7.83	354.76	-7.82	356.87	-7.87
1992.620	354.85	-7.80	355.04	-7.84	354.93	-7.80
1992.705	354.96	-7.82	355.21	-7.86	353.94	-7.74
1992.787	355.02	-7.85	355.30	-7.86	353.91	-7.72
1992.872	354.79	-7.86	355.05	-7.85	354.71	-7.77
1992.954	354.53	-7.85	354.81	-7.84	356.05	-7.85
1993.038	354.20	-7.81	354.63	-7.82	357.45	-7.91
1993.123	354.13	-7.80	354.42	-7.80	358.14	-7.93
1993.200	354.34	-7.80	354.40	-7.79	358.65	-7.95
1993.285	354.27	-7.79	354.51	-7.81	359.35	-7.99
1993.367	354.25	-7.80	354.63	-7.82	359.92	-8.03
1993.452	354.68	-7.82	354.91	-7.82	359.55	-8.00
1993.534	355.15	-7.83	355.38	-7.83	357.84	-7.89
1993.619	355.57	-7.84	355.81	-7.85	355.06	-7.75
1993.704	355.79	-7.86	356.01	-7.86	353.34	-7.68
1993.786	355.82	-7.86	355.96	-7.85	353.96	-7.72
1993.871	355.73	-7.86	355.82	-7.84	355.49	-7.80
1993.953	355.40	-7.85	355.77	-7.84	356.97	-7.87
1994.038	355.03	-7.85	355.75	-7.85	357.75	-7.88
1994.123	355.03	-7.85	355.57	-7.85	358.02	-7.88
1994.200	355.34	-7.85	355.51	-7.85	359.18	-7.94
1994.285	355.62	-7.83	355.68	-7.84	360.94	-8.03
1994.367	355.85	-7.82	355.75	-7.83	361.52	-8.08
1994.452	356.11	-7.83	355.92	-7.83	360.78	-8.03
1994.534	356.58	-7.85	356.44	-7.84	359.61	-7.94
1994.619	357.15	-7.87	357.00	-7.86	357.74	-7.84
1994.704	357.47	-7.88	357.42	-7.87	355.45	-7.73
1994.786	357.47	-7.89	357.55	-7.88	355.12	-7.73
1994.871	357.37	-7.89	357.43	-7.87	356.83	-7.82
1994.953	357.33	-7.89	357.48	-7.88	358.52	-7.89
1995.038	357.39	-7.90	357.59	-7.88	359.78	-7.93
1995.123	357.49	-7.90	357.49	-7.88	361.08	-8.00
1995.200	357.51	-7.89	357.48	-7.88	362.15	-8.08
1995.285	357.49	-7.88	357.66	-7.88	362.94	-8.11
1995.367	357.77	-7.87	357.84	-7.87	364.12	-8.14
1995.452	358.17	-7.88	358.14	-7.87	363.10	-8.08
1995.534	358.46	-7.91	358.59	-7.89	360.41	-7.94
1995.619	358.80	-7.92	358.95	-7.90	360.41	-7.92
1995.704	359.08	-7.92	359.26	-7.91	360.21	-7.90
1995.786	359.19	-7.92	359.47	-7.91	358.78	-7.84
1995.871	359.27	-7.93	359.53	-7.91	359.38	-7.87
1995.953	359.53	-7.94	359.55	-7.91	360.63	-7.91
1996.038	359.42	-7.94	359.53	-7.92	361.63	-7.96
1996.123	359.09	-7.94	359.45	-7.93	362.71	-8.03
1996.202	359.08	-7.91	359.34	-7.92	363.59	-8.07
1996.287	359.13	-7.88	359.31	-7.91	364.34	-8.09
1996.369	359.32	-7.89	359.30	-7.89	365.00	-8.11
1996.454	359.82	-7.90	359.34	-7.88	364.66	-8.09
1996.536	360.24	-7.91	359.71	-7.91	362.74	-7.98
1996.620	360.58	-7.93	360.22	-7.93	360.75	-7.87

1996.705	360.72	-7.94	360.52	-7.93	359.49	-7.80
1996.787	360.59	-7.94	360.69	-7.93	359.26	-7.80
1996.872	360.44	-7.93	360.58	-7.94	360.60	-7.86
1996.954	360.32	-7.92	360.49	-7.94	362.36	-7.94
1997.038	360.34	-7.92	360.52	-7.95	363.13	-7.98
1997.123	360.47	-7.90	360.36	-7.94	363.40	-8.00
1997.200	360.51	-7.88	360.24	-7.93	364.84	-8.06
1997.285	360.57	-7.90	360.37	-7.94	366.62	-8.16
1997.367	360.74	-7.91	360.61	-7.96	366.80	-8.17
1997.452	360.95	-7.92	360.92	-7.95	365.51	-8.10
1997.534	361.34	-7.95	361.25	-7.94	363.96	-8.00
1997.619	361.81	-7.95	361.59	-7.95	362.26	-7.89
1997.704	362.07	-7.93	361.95	-7.97	360.44	-7.79
1997.786	362.19	-7.96	362.12	-7.98	360.74	-7.81
1997.871	362.17	-7.96	362.14	-7.98	362.86	-7.93
1997.953	362.08	-7.96	362.18	-7.97	364.37	-8.00
1998.038	362.02	-7.97	362.24	-7.97	365.13	-8.02
1998.123	362.16	-7.97	362.31	-7.97	366.02	-8.09
1998.200	362.47	-7.98	362.53	-7.96	367.61	-8.18
1998.285	362.75	-7.99	362.87	-7.95	369.36	-8.26
1998.367	363.11	-7.98	363.19	-7.96	369.77	-8.26
1998.452	363.54	-7.99	363.62	-7.98	368.44	-8.17
1998.534	364.06	-7.99	364.18	-8.01	366.95	-8.06
1998.619	364.70	-7.98	364.66	-8.04	365.50	-7.98
1998.704	365.05	-8.00	365.03	-8.05	363.81	-7.90
1998.786	365.05	-8.01	365.24	-8.04	364.03	-7.90
1998.871	364.95	-8.01	365.16	-8.03	365.81	-7.99
1998.953	364.88	-8.03	365.13	-8.04	367.17	-8.06
1999.038	365.02	-8.02	365.18	-8.04	368.03	-8.07
1999.123	365.08	-8.01	365.04	-8.03	368.61	-8.09
1999.200	364.89	-8.00	364.93	-8.01	369.71	-8.17
1999.285	364.95	-7.98	365.01	-8.02	370.82	-8.24
1999.367	365.19	-7.99	365.19	-8.02	370.47	-8.21
1999.452	365.35	-8.00	365.52	-8.01	369.77	-8.16
1999.534	365.63	-8.01	365.87	-8.02	368.86	-8.10
1999.619	366.08	-8.02	366.21	-8.02	366.76	-7.99
1999.704	366.45	-8.02	366.51	-8.03	364.98	-7.91
1999.786	366.60	-8.03	366.69	-8.03	365.21	-7.91
1999.871	366.53	-8.03	366.81	-8.02	366.71	-7.98
1999.953	366.54	-8.02	366.81	-8.03	368.03	-8.04
2000.038	366.61	-8.01	366.67	-8.04	369.28	-8.09
2000.123	366.43	-8.00	366.48	-8.03	370.33	-8.14
2000.202	366.19	-7.99	366.35	-8.02	371.15	-8.18
2000.287	366.11	-7.98	366.33	-8.01	371.70	-8.20
2000.369	366.33	-7.98	366.45	-8.00	371.82	-8.19
2000.454	366.77	-7.98	366.74	-8.00	371.51	-8.15
2000.536	367.19	-8.00	367.09	-8.01	370.09	-8.08
2000.620	367.45	-8.00	367.42	-8.03	368.17	-7.99
2000.705	367.68	-8.02	367.73	-8.04	366.81	-7.92
2000.787	367.80	-8.03	367.85	-8.04	367.13	-7.93
2000.872	367.73	-8.01	367.80	-8.02	368.56	-8.00
2000.954	367.64	-8.01	367.84	-8.01	369.57	-8.04
2001.038	367.59	-8.00	367.78	-8.01	370.64	-8.08
2001.123	367.54	-7.99	367.52	-8.02	371.81	-8.14
2001.200	367.53	-8.00	367.49	-8.04	372.95	-8.21
2001.285	367.69	-8.00	367.76	-8.04	374.16	-8.27
2001.367	367.94	-7.99	368.04	-8.01	374.48	-8.27
2001.452	368.20	-7.99	368.32	-8.01	373.40	-8.19
2001.534	368.62	-8.01	368.71	-8.03	371.35	-8.07
2001.619	369.17	-8.04	369.19	-8.04	369.29	-7.97
2001.704	369.66	-8.05	369.63	-8.05	368.00	-7.90
2001.786	369.74	-8.05	369.84	-8.07	368.41	-7.92
2001.871	369.46	-8.04	369.69	-8.07	370.24	-8.02
2001.953	369.29	-8.03			371.56	-8.08
2002.038	369.37	-8.03			371.95	-8.09
2002.123	369.44	-8.03			372.53	-8.13
2002.200	369.49	-8.02	369.39		373.57	-8.19
2002.285	369.65	-8.01	369.71		374.87	-8.24
2002.367	369.91	-8.02	370.00	-8.03	375.83	-8.26
2002.452	370.37	-8.04	370.43	-8.05	375.44	-8.21
2002.534	370.94	-8.07	370.92	-8.07	373.62	-8.12
2002.619	371.43	-8.08	371.39	-8.08	371.32	-8.02
2002.704	371.77	-8.08	371.83	-8.08	370.29	-7.97

2002.786	371.90	-8.09	371.99	-8.09	371.31	-8.02
2002.871	371.79	-8.09	371.90	-8.10	372.60	-8.08
2002.953	371.60	-8.09	371.93	-8.10	373.96	-8.15
2003.038	371.57	-8.09	371.96	-8.09		
2003.123	371.65	-8.08	371.86	-8.08		
2003.200	371.85	-8.08	371.89	-8.08		
2003.285	372.13	-8.07	372.17	-8.08		
2003.367	372.43	-8.07	372.47	-8.09	379.07	-8.35
2003.452	372.77	-8.08	372.81	-8.10	378.18	-8.29
2003.534	373.22	-8.11	373.22	-8.11	376.53	-8.20
2003.619	373.77	-8.13	373.71	-8.11	374.73	-8.11
2003.704	374.06	-8.13	374.07	-8.12	373.16	-8.05
2003.786	373.98	-8.13	374.01	-8.13	373.18	-8.06
2003.871	373.77	-8.12	373.87	-8.13	374.57	-8.11
2003.953	373.59	-8.12	373.94	-8.12	375.90	-8.15
2004.038	373.55	-8.11	374.04	-8.12	376.72	-8.17
2004.123	373.69	-8.11	374.10	-8.11	377.58	-8.22
2004.202	373.78	-8.11	374.13	-8.11	379.10	-8.31
2004.287	373.90	-8.11	374.18	-8.11	380.64	-8.38
2004.369	374.30	-8.10	374.49	-8.12	380.80	-8.36
2004.454	374.78	-8.11	374.90	-8.13	379.69	-8.30
2004.536	375.18	-8.13	375.27	-8.14	377.65	-8.19
2004.620	375.53	-8.13	375.64	-8.15	375.55	-8.08
2004.705	375.68	-8.13	375.87	-8.14	374.18	-8.02
2004.787	375.69	-8.14	375.86	-8.14	374.46	-8.06
2004.872	375.69	-8.14	375.67	-8.14	376.31	-8.13
2004.954	375.53	-8.13	375.63	-8.13	377.72	-8.17
2005.038	375.38	-8.13	375.47	-8.14	378.67	-8.21
2005.123	375.41	-8.12	375.22	-8.14	379.48	-8.24
2005.200	375.43	-8.11	375.39	-8.14	380.57	-8.29
2005.285	375.56	-8.11	375.76	-8.13	382.33	-8.39
2005.367	376.17	-8.13	376.12	-8.13	382.91	-8.40
2005.452	376.93	-8.15	376.62	-8.15	382.13	-8.34
2005.534	377.29	-8.16	377.12	-8.17	380.79	-8.26
2005.619	377.59	-8.17	377.51	-8.17	378.15	-8.14
2005.704	377.86	-8.18	377.82	-8.18	376.23	-8.05
2005.786	377.92	-8.18	377.95	-8.18	376.92	-8.06
2005.871	377.87	-8.17	377.99	-8.18	378.38	-8.13
2005.953	377.76	-8.17	378.06	-8.18	379.83	-8.20
2006.038	377.84	-8.16	377.94	-8.19	381.17	-8.25
2006.123	377.98	-8.15	377.69	-8.18	382.00	-8.29
2006.200	378.00	-8.15	377.75	-8.17	382.90	-8.33
2006.285	378.05	-8.16	378.01	-8.15	384.47	-8.42
2006.367	378.18	-8.15	378.18	-8.14	385.38	-8.45
2006.452	378.42	-8.15	378.37	-8.15	384.21	-8.37
2006.534	378.80	-8.16	378.74	-8.16	382.20	-8.25
2006.619	379.26	-8.16	379.18	-8.17	380.36	-8.16
2006.704	379.48	-8.16	379.52	-8.18	379.04	-8.11
2006.786	379.40	-8.18	379.62	-8.18	379.00	-8.10
2006.871	379.37	-8.18	379.55	-8.19	380.33	-8.16
2006.953	379.44	-8.18	379.59	-8.20	381.98	-8.24
2007.038	379.36	-8.18	379.62	-8.20	383.02	-8.29
2007.123	379.34	-8.17	379.49	-8.20	383.62	-8.31
2007.200	379.44	-8.17	379.54	-8.20	384.78	-8.37
2007.285	379.63	-8.18	379.88	-8.20	386.38	-8.45
2007.367	380.01	-8.18	380.15	-8.20	386.89	-8.45
2007.452	380.40	-8.18	380.41	-8.20	386.13	-8.39
2007.534	380.90	-8.19	380.86	-8.22	383.93	-8.28
2007.619	381.32	-8.19	381.32	-8.24	381.62	-8.18
2007.704	381.53	-8.21	381.66	-8.24	380.75	-8.14
2007.786	381.65	-8.23	381.78	-8.23	381.08	-8.14
2007.871	381.63	-8.22	381.77	-8.23	382.39	-8.20
2007.953	381.59	-8.23	382.01	-8.24	383.83	-8.28
2008.038	381.64	-8.24	382.18	-8.25	385.37	-8.36
2008.123	381.73	-8.22		-8.26	385.97	-8.38
2008.202	381.74	-8.21		-8.25	385.76	-8.36
2008.287	381.82	-8.22		-8.24	386.86	-8.39
2008.369	382.10	-8.21	382.61	-8.23	388.54	-8.46
2008.454	382.60	-8.21	382.78	-8.22	388.49	-8.44
2008.536	382.92	-8.23	383.06	-8.23	386.50	-8.34
2008.620	383.30	-8.25	383.32	-8.25	384.10	-8.22
2008.705	383.71	-8.26	383.61	-8.26	382.92	-8.16
2008.787	383.66	-8.25	383.73	-8.26	383.15	-8.18

2008.872	383.51	-8.25	383.58	-8.28	384.08	-8.22
2008.954	383.59	-8.25	383.54	-8.27	385.41	-8.26
2009.038	383.83	-8.25	383.46	-8.25	386.76	-8.33
2009.123	383.80	-8.24			387.46	-8.37
2009.200	383.47	-8.22			387.96	-8.38
2009.285	383.36	-8.20			388.95	-8.45
2009.367	383.60	-8.21	383.71	-8.24	389.84	-8.50
2009.452	383.89	-8.23	384.29	-8.25	389.24	-8.43
2009.534	384.28	-8.24	385.03	-8.26	387.72	-8.33
2009.619	384.75	-8.25	385.09	-8.27	385.85	-8.23
2009.704	384.98	-8.25	384.98	-8.27	384.27	-8.16
2009.786	385.10	-8.27	385.04	-8.27	384.61	-8.18
2009.871	385.08	-8.27	385.06	-8.27	386.25	-8.27
2009.953	385.00	-8.26	385.38	-8.27	387.63	-8.33
2010.038	384.96	-8.24	385.47	-8.27	389.04	-8.37
2010.123	384.71	-8.23	385.00	-8.24	390.09	-8.42
2010.200	384.61	-8.23	384.82	-8.24	390.76	-8.47
2010.285	384.90	-8.23	384.90	-8.26	392.41	-8.54
2010.367	385.29	-8.24	385.15	-8.25	393.44	-8.56
2010.452	385.79	-8.26	385.75	-8.25	392.29	-8.49
2010.534	386.45	-8.27	386.41	-8.27	390.42	-8.39
2010.619	387.10	-8.28	387.03	-8.30	387.82	-8.27
2010.704	387.44	-8.28	387.41	-8.30	386.11	-8.19
2010.786	387.43	-8.29	387.46	-8.29	387.07	-8.24
2010.871	387.29	-8.29	387.46	-8.29	388.69	-8.30
2010.953	387.05	-8.30	387.59	-8.30	390.37	-8.35
2011.038	386.90	-8.30	387.51	-8.30	391.71	-8.42
2011.123	386.98	-8.29	387.00	-8.29	392.13	-8.45
2011.200	387.02	-8.27	386.81	-8.27	392.99	-8.49
2011.285	387.02	-8.25	387.14	-8.25	394.28	-8.54
2011.367	387.29	-8.26	387.38	-8.24	394.31	-8.51
2011.452	387.71	-8.27		-8.25	393.58	-8.47
2011.534	388.06	-8.29		-8.29	392.28	-8.41
2011.619	388.51	-8.29	388.77	-8.30	390.01	-8.29
2011.704	389.00	-8.30	388.93	-8.30	388.71	-8.23
2011.786	389.13	-8.30	389.01	-8.31	389.12	-8.24
2011.871	388.94	-8.28	388.91	-8.34	390.55	-8.30
2011.953	388.81	-8.29	388.96	-8.34	392.08	-8.37
2012.038	388.68	-8.30	388.93	-8.30	392.68	-8.39
2012.123	388.66	-8.28	388.80	-8.28	393.00	-8.39
2012.202	388.69	-8.27	388.92	-8.29	394.47	-8.46
2012.287	388.85	-8.27	389.12	-8.30	396.61	-8.56
2012.369	389.15	-8.26	389.26	-8.29	396.72	-8.57
2012.454	389.58	-8.27	389.64	-8.31	395.43	-8.50
2012.536	390.23	-8.30	390.26	-8.33	394.35	-8.45
2012.620	390.91	-8.32	390.78	-8.33	392.73	-8.38
2012.705	391.33	-8.33	391.16	-8.34	391.02	-8.27
2012.787	391.37	-8.33	391.31	-8.36	391.08	-8.25
2012.872	391.18	-8.33	391.35	-8.34	392.48	-8.32
2012.954	391.09	-8.34	391.49	-8.33	394.30	-8.41
2013.038	391.13	-8.33	391.43	-8.33	396.09	-8.50
2013.123	391.39	-8.31	391.12	-8.33	396.62	-8.51
2013.200	391.77	-8.31	391.17	-8.33	397.01	-8.50
2013.285	391.99	-8.31	391.72	-8.33	398.40	-8.55
2013.367	392.28	-8.32	392.28	-8.32	399.45	-8.60
2013.452	392.72	-8.34	392.69	-8.33	398.88	-8.55
2013.534	393.21	-8.35	393.14	-8.35	397.21	-8.45
2013.619	393.67	-8.36	393.68	-8.36	395.17	-8.36
2013.704	393.92	-8.36	394.04	-8.37	393.56	-8.29
2013.786	393.97	-8.36	394.15	-8.38	393.59	-8.28
2013.871	393.85	-8.36	394.29	-8.39	395.19	-8.35
2013.953	393.75	-8.35	394.31	-8.38	397.32	-8.44
2014.038	393.77	-8.34			398.18	-8.46
2014.123	393.70	-8.34			398.02	-8.44
2014.200	393.65	-8.33			399.20	-8.51
2014.285	393.91	-8.33			401.45	-8.61
2014.367	394.22	-8.34			402.30	-8.64
2014.452	394.63	-8.34			400.97	-8.56
2014.534	395.21				398.62	-8.50
2014.619	395.54				396.97	