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Supplement of

The 2009–2010 step in atmospheric CO₂ interhemispheric difference

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SUPPLEMENTARY INFORMATION

Dependence of IH duct transport on seasonality of trace gases:

The timing of seasonality in trace gas baseline concentrations relative to equatorial duct closure is shown in Figure 1S. For CO₂ (top panel) *m/o* concentrations exceed *cgo* carbon dioxide concentrations at times when IH mixing through the equatorial duct is vigorous; at other times of the year the IH difference is mainly reversed and/or mixing through the duct is blocked. The measurement techniques are described by Francey et al. (1996).

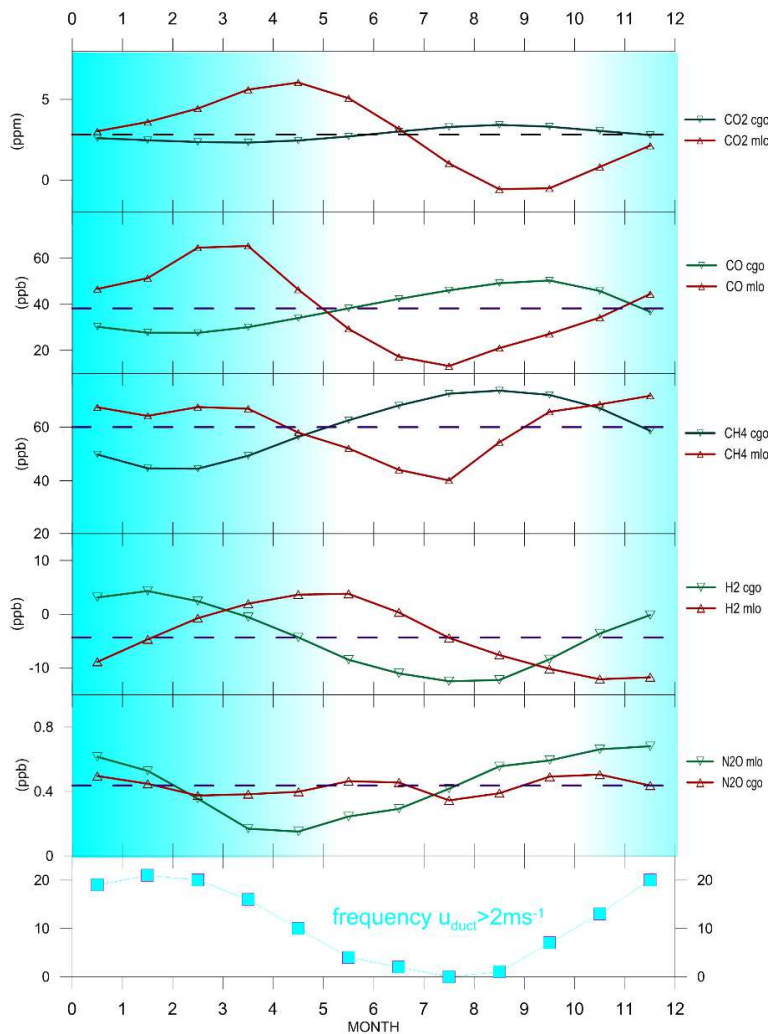


Figure 1S: CSIRO GASLAB average seasonality between 1992 and 2013 (red lines, upright triangles, show *m/o*, and green lines, inverted triangles, show *cgo*), plotted around the average inter-hemispheric difference ΔC (*m/o*-*cgo*) over the period (blue dashed line). Different trace gas species are indicated to the right. The frequency of occasions when $u_{duct} > 3 \text{ m s}^{-1}$, enhancing interhemispheric, is shown in the bottom panel and also indicated by blue shading in the trace gas plots.

Note: N₂O is not further considered in our article due to complexities associated with the sources and transport of N₂O exchange (Kort et al., 2011).

YU et al. modelling of the 2009–2010 step in CO₂ interhemispheric difference:

Results are sourced from a presentation at the 2014 Annual Cape Grim Science Meeting by Xingjie Lu, Ying-Ping Wang and Rachel Law (Ying-Ping Wang, Rachel Law, personal communications).

The Community Atmosphere Biosphere Land Exchange model (CABLE, Law 2014) was used to simulate Net Ecosystem Production anomalies over the 2001 to 2012 period. CABLE biospheric fluxes were used to predict $\Delta C_{mlo-cgo}$ using CO₂ response functions from the CCAM atmospheric model.

The left panel appears to show good agreement between the magnitudes of reconstructed and observed IH CO₂ differences (mlo-cgo). However, while the observations refer to baseline data, the reconstruction is for all wind speeds and directions at cgo. (Note that the characteristic rapid recovery from the 2010/11 biosphere response to the climate anomaly in the reconstruction is not apparent in the measured ΔCO_2).

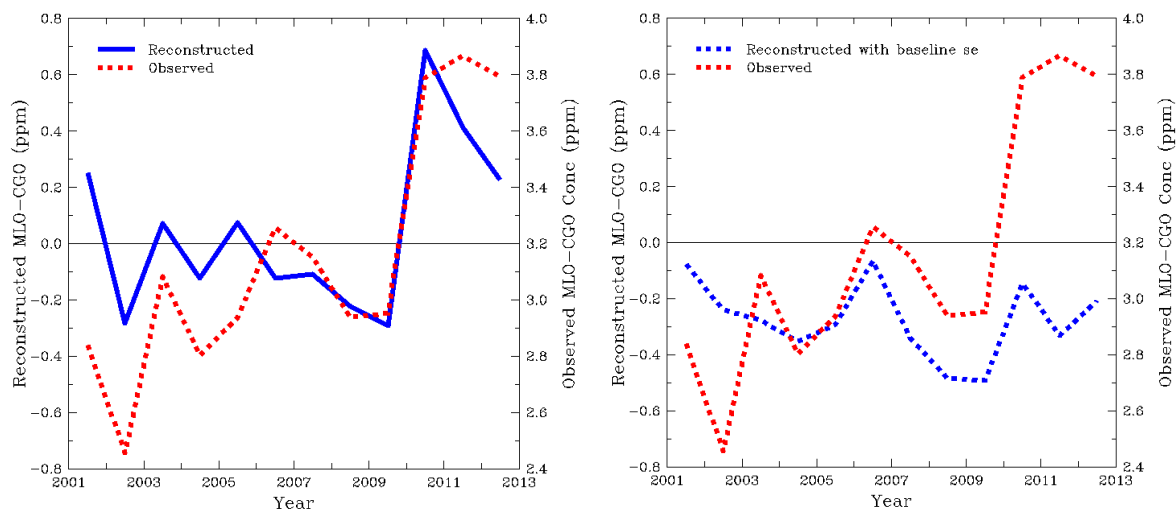


Figure 2S: Both panels compare measured annual average mlo-cgo CO₂ differences with differences reconstructed using climate sensitive biospheric fluxes introduced into a global atmospheric transport model. The measurements use selected baseline data. The left panel reconstruction is for continuous times, the right panel only uses times (via transport model response functions) when stations are experiencing baseline conditions.

A more valid comparison is shown in the right panel, where CO₂ response functions from the CCAM model are selected for baseline, there is no significant agreement between observations and the reconstruction implying the Australian fluxes are too small to impact on the near-hemispheric scale represented by cgo baseline.

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Monthly baseline CO₂ and δ¹³CO₂ from the CSIRO GASLAB flask network

The data used in this paper (BG-2015-404) are described in Francey et al. (1996).

CO₂ data are on the WMO 2007 Mole Fraction Scale.

δ¹³CO₂ data are in the CSIRO 2005 Scale (Allison and Francey, 2007).

Data were accessed from the CSIRO database on January 2015.

Dec Date	cgo CO2 (ppm)	cgo C13(‰)	spo CO2 (ppm)	spo CO2C13(‰)	mlo CO2 (ppm)	mlo CO2C13(‰)
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

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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

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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		373.50	-8.19
2002.285	369.65	-8.01	369.71		374.80	-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

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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

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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

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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				398.60	-8.50
2014.619	395.54				396.90	