Where is Ulysses Today?
Earth-Sun-Ulysses Quadratures & Longitude Alignments
STEREO A/B-Sun-Ulysses Quadratures & Longitude Alignments

Including: (1) The position angles around the Sun for 2006-2014. (2) Detailed information for the Winter 2007 & 2008 5-month quadratures.

Steve Suess
(steven.t.suess@nasa.gov)

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1. The Ulysses and STEREO A & B Orbits

Ulysses is in a solar polar orbit of inclination 80.2°, perihelion 1.34 AU, aphelion 5.4 AU, and period 6.2 years (Fig. 1). Fig. 2 shows the orbital radius and heliographic latitude, along with a plot of the sunspot number since launch in late 1990.

The orbit is highly elliptic. Considering the time between north and south polar passages, Ulysses spends about five times as long in the aphelion portion of the orbit than in the perihelion portion of the orbit. For this reason, the south-to-north passage containing the perihelion is called the 'fast latitude scan,' while the north-to-south passage containing the aphelion is called the 'slow latitude scan.' The slow latitude scan takes ~5.4 years and the fast latitude scan (FLS) takes ~1 year.

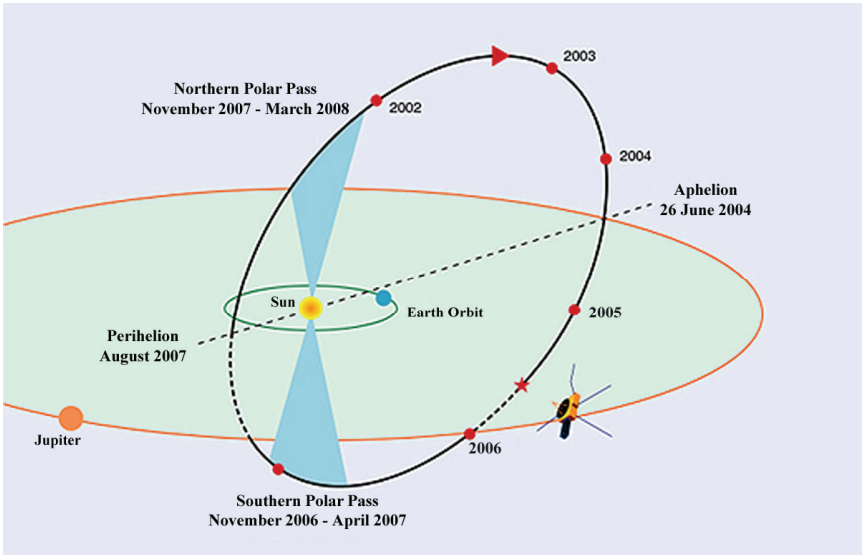

Figure 1. Ulysses' orbit, 2002-2008.

Fig. 1 also shows the orbit of the Earth. For the present purposes, SOHO, WIND, ACE, Cluster, Hinode, etc. are at the same location as Earth on this scale, so they will be treated so from here on. Earth is in 'quadrature' with respect to Ulysses and the Sun when the Earth-Sun-Ulysses included angle is 90°. Inspecting this figure indicates that quadratures will normally occur twice each year as Earth revolves around the Sun. This is especially true during the slow latitude scan because Ulysses is moving very slowly relative to the motion of Earth around the Sun and therefore is approximately fixed in space over a 20 day interval.

Fig. 2 shows the radius and heliographic latitude throughout the life of the mission and onward through 2014. In this figure, Ulysses' orbits and fast latitude scans are highlighted and labeled (O-I, -II, -III, -IV; FLS I, II, III, IV). By good fortune, FLS I and III have occurred around sunspot minimum and FLS II occurred around sunspot maximum. This produced rapid cuts in latitude through the inner heliosphere at extreme times in the solar cycle. At the bottom of Fig. 2 is shown the sunspot number through October 2007 and the prediction for solar cycle 24,through 2014. The prediction is extended backward to the beginning of cycle 23 to show that the prediction for the last cycle was quite good. The 5% and 95% confidence limits of the prediction are shown by the green lines.

Superimposed on the sunspot number plot is the launch date for Ulysses and several other heliospheric missions, along the anticipated launch dates for IBEX and SDO. Finally, the typical morphology of the corona is shown by the superimposed cartoons at various times over the sunspot cycle.

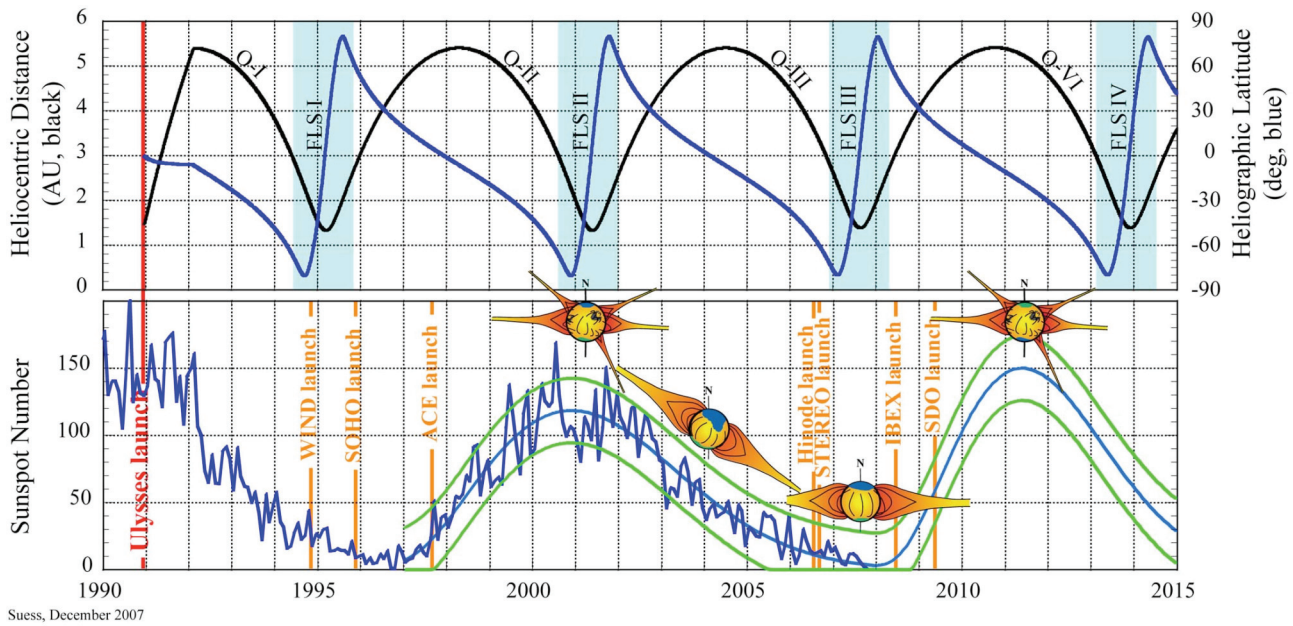

Figure 2. Ulysses radius and heliographic latitude (top). The observed and predicted sunspot number (blue, with green 1-sigma uncertainties – Hathaway) (bottom). Superimposed are some past and expected launch dates and schematics of the appearance of the corona over the sunspot cycle. 'N' shows heliographic north in the schematics.

STEREOs A and B were launched late in 2006. After using the Moon for a gravitational assist, STEREO-A (-B) began moving ahead of (behind) the Earth. As they separate from the Earth, they provide an improving perspective for 3-dimensional viewing of mass ejections. This is especially true during the winter 2008 extended quadrature that is described below. The locations of STEREOs A and B relative to Earth are shown in Fig. 3. The orbital locations of STEREO A/B were taken from the GSFC web site:
http://cohoweb.gsfc.nasa.gov/helios/heli.html

The STEREO A and B missions were designed to be stand-alone, not depending on any other mission. Their approximately 22°/year separation rate from Earth at the beginning of cycle 24 is meant to give a range of viewing angles of solar activity and *in situ* sampling of ejecta. Nevertheless, it happens that the spacecraft will be very conveniently located for a variety of observations involving other spacecraft. The bottom panel in Fig. 3 shows their separation from Earth and all the spacecraft in near-Earth orbits. This provides both another solar viewing position and another location for *in situ* sampling of observed ejections. Similarly, Ulysses offers yet another location for *in situ* sampling of observed ejections. In the following sections, some of the observing opportunities will be described.

The other panels in Fig. 3 are the heliographic latitude or Earth and STEREO A/B (top) and the heliocentric radius of Earth, STEREO A, and STEREO B (middle). The orbit information at the above web site only provided two significant figures after the decimal for the radius, so the plot looks somewhat jagged on this exaggerated scale.

In all three panels of Fig. 3, the orbit information from the above web site stopped at the end of 2009. Therefore, the orbital parameters shown here were estimated starting in 1 January 2010.

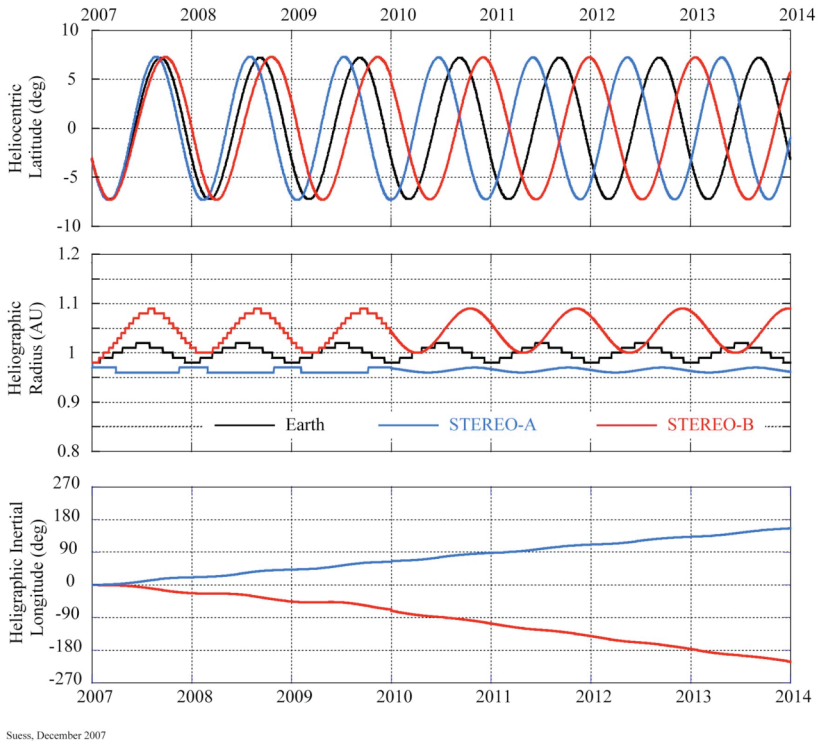

Fig. 3. Relative positions of Earth, STEREO A, and STEREO B, from 1 January 2007 through 31 December 2013. The radius plot appears 'jagged' because the STEREO values are only given to three significant figures. Data is from: http://cohoweb.gsfc.nasa.gov/helios/heli.html which only gives orbits through 2009. Therefore, STEREO orbits here are estimated after 31 December 2009.

3. Quadratures, 2006-2014

Fig. 4 shows the Earth-Sun-Ulysses included angle (IA) from 1 January 2006 to 31 December 2013 (the red line). The general occurrence of quadratures twice per year is illustrated here. Earth moves around the Sun about 1°/day. Therefore, Ulysses is within +/- 10° of the limb for a period of 20 days centered on the quadrature date and time. 10° is close enough to the limb to expect that Ulysses will usually sample activity occurring on the limb. Feature tracking of phenomena rotating past the limb can be used to refine the relationship between activity and phenomena near the limb and what is detected at Ulysses. It is important to realize that the Sun is rotating during a 20 day interval. Over this time, the Sun will rotate through more than 180°.

There are times in Fig. 4 when quadratures do not occur twice per year. In 2006-2007 and 2007-2008, two quadratures effectively merge. The IA lingers near 90° for extended intervals. The is happening at the beginning and of FLS III and is due to the high latitude of Ulysses and its relatively rapid motion. FLSs are when Ulysses can no longer be considered to be moving slowly, causing the unusual behavior in the IA. The 2006-2008 cases work in favor of quadrature observations.

STEREO A and B quadratures have been added to Fig. 4, leading to several additional curves due to the various possible pairings. In all cases, the included angle is with respect to the Sun. The new pairings shown here are Earth:STEREO-A, Earth:STEREO-B, and STEREO-A:STEREO-B. Since STEREO A and B are both near 1 AU in the ecliptic, moving slowly in opposite directions away from the Earth, they only rarely come into quadrature . This is shown by the purple line in Fig. 4. Making observations at these quadrature times is one of the STEREO mission objectives. The STEREO-A:STEREO-B quadratures occur in 2009 and 2012.

With respect to Ulysses, STEREO quadratures are about the same as for Earth near the beginning of the mission, in 2007 and early 2008 (Fig. 4, blue and green lines, respectively). In fact, the quadrature geometry places STEREO-A observing slightly closer to the limb than, e.g., Earth for the extended Winter 2008 quadrature.

Later, as STEREO A and B separate, the quadrature opportunities multiply and better distributed throughout the year in the years 2008.5 through 2012. There are 27 additional quadratures from 2008.5 through early 2013. Some of them, as in mid-2012, have multiple quadrature observing geometries at differing latitudes and longitudes around the Sun, increasing the possibilities for catching a desired type of solar phenomenon.

Table 3.1 lists the dates of all 31 quadratures from late 2006 through early 2013, along with the position angle and limb. It is done chronologically, with the pairing for each case being identified. In this table, the PA for STEREO-A & B is defined as the PA counterclockwise from solar north in a fixed STEREO-A - Sun or STEREO-B - Sun frame of reference, respectively. Thus, it is the PA as if viewing the Sun from the spacecraft, not from Earth.

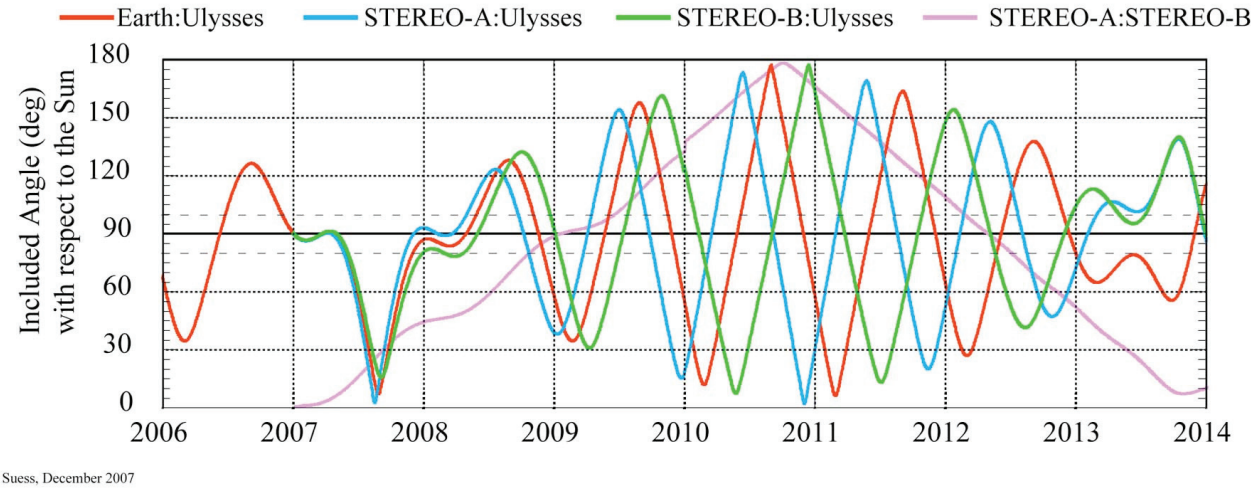

Figure 4. Earth(SOHO, etc.)-Sun-Ulysses, STEREO A/B-Sun-Ulysses and STEREO A-Sun-STEREO B included angles from 1 January 2006 to 31 December 2013. STEREO orbits are estimated starting in 2010, accounting for the discontinuity in the STEREO A:B included angle at 2010.00. Quadrature occurs when this angle is 90°. The longer dashed lines are +/-10° from 90°, bracketing the quadrature by approximately +/- 10 days.

Table 3.1
Quadratures, 2006 - 2013
(Earth:Ulysses, STEREO-A:Ulysses, STEREO-B:Ulysses, STEREO-A:STEREO-B)

Fractional Yr.	Date	Pairing	Ulysses Position Angle	Ulysses Latitude, Limb	Heliocentric Distance To Ulysses
2007.00 → 2007.36	<2007 Dec 1 → 2007 May 13	STR-A:Ulysses	<193° → 215° (in progress at start of mission)	>77S → 55S, West limb	2.63AU → 1.76AU
2006.96 → 2007.38	2006 Dec. 17 → 2007 May 19	Earth:Ulysses	195.6° → 217.2° (Fig. 5, center)	74.4S → 52.8S, West limb	2.72AU → 1.72AU
2007.00 → 2007.39	<2007 Dec 1 → 2007 May 23	STR-B:Ulysses	<193.5° → 220° (in progress at start of mission)	>76.5S → 50S, West limb	2.63AU → 1.69AU
2007.86 → 2008.33	2007 Nov. 10 → 2008 Apr. 30	STR-A:Ulysses	29° → 27° (in progress at start of mission)	61N → 63N, East limb	1.66AU → 2.78AU
2007.92 → 2008.41	2007 Dec. 2 → 2008 May 28	Earth:Ulysses	20° → 33° (Fig. 5, center)	70N → 57N, East limb	1.79AU → 2.96AU
2007.99 → 2008.48 **	2007 Dec. 29 → 2008 Jun. 25	STR-B:Ulysses	8° → 36°	82N → 54N, East limb	1.96AU → 3.13AU
2008.77	2008 Oct. 8	STR-A:Ulysses	309°	39N, West limb	3.70AU
2008.89	2008 Nov. 20	Earth:Ulysses	305.5°	35.5N, West limb	3.91AU
2009.01	2008 Jan. 5	STR-B:Ulysses	301°	31N, West limb	4.12AU
2009.07	2009 Jan. 26	STR-A:STR-B	NA	NA	NA
2009.26	2009 Apr. 5	STR-A:Ulysses	65°	25N, East limb	4.47AU
2009.39	2009 May 23	Earth:Ulysses	68.9°	21.1N, East limb	4.63AU
2009.53	2009 Jul. 14	STR-B:Ulysses	72°	18N, East limb	4.79AU
2009.74	2009 Sep. 26	STR-A:Ulysses	283°	13N, West limb	4.98AU
2009.91	2009 Nov. 27	Earth:Ulysses	279.7°	9.7N, West limb	5.11AU
2010.11 *	2010 Feb. 11	STR-B:Ulysses	276°	6N, West limb	5.24AU
2010.21 *	2010 Mar. 18	STR-A:Ulysses	86°	4N, East limb	5.29AU
2010.40	2010 May 28	Earth:Ulysses	89.8°	0.2N, East limb	5.36AU
2010.67 *	2010 Sep. 3	STR-B:Ulysses	95°	5S, East limb	5.41AU
2010.69 *	2010 Sep. 8	STR-A:Ulysses	265°	5S, West limb	5.41AU
2010.92	2010 Dec. 1	Earth:Ulysses	260.9°	9.1S, West limb	5.41AU
2011.16 *	2011 Feb. 28	STR-A:Ulysses	103°	13S, East limb	5.36AU
2011.23 *	2011 Mar. 27	STR-B:Ulysses	256°	14S, West limb	5.33AU
2011.42	2011 Jun. 1	Earth:Ulysses	108.3°	18.3S, East limb	5.25AU
2011.64 *	2011 Aug. 21	STR-A:Ulysses	247°	23S, West limb	5.12AU
2011.79 *	2011 Oct. 16	STR-B:Ulysses	116°	26S, East limb	5.00AU
2011.93	2011 Dec. 5	Earth:Ulysses	241.3°	28.7S, West limb	4.88AU
2012.11 *	2012 Feb. 11	STR-A:Ulysses	123°	33S, East limb	4.68AU
2012.32 *	2012 Apr. 25	STR-A:STR-B	NA	NA	NA
2012.35 *	2012 May 8	STR-B:Ulysses	232°	38S, West limb	4.39AU
2012.43	2012 Jun. 6	Earth:Ulysses	131.2°	41.2S, East limb	4.28AU
2012.59 *	2012 Aug. 5	STR-A:Ulysses	224°	46S, West limb	4.02AU
2012.91 *	2012 Nov. 30	STR-B:Ulysses	149°	59S, East limb	3.45AU
2012.95	2012 Dec. 15	Earth:Ulysses	210.3°	59.7S, West limb	3.37AU
2013.09 *	2013 Feb. 4	STR-A:Ulysses	156°	66S, East limb	3.07AU

STR-A = STEREO-A
STR-B = STEREO-B
* STEREO orbits are estimated starting in 2010.
** Inlcudes a short interval in 2008 for which the included angle is 78-79 degrees (see plot).
There are two quadratures in this time period, between STEREO-A:Earth and STEREO-B:Earth that are not listed here.

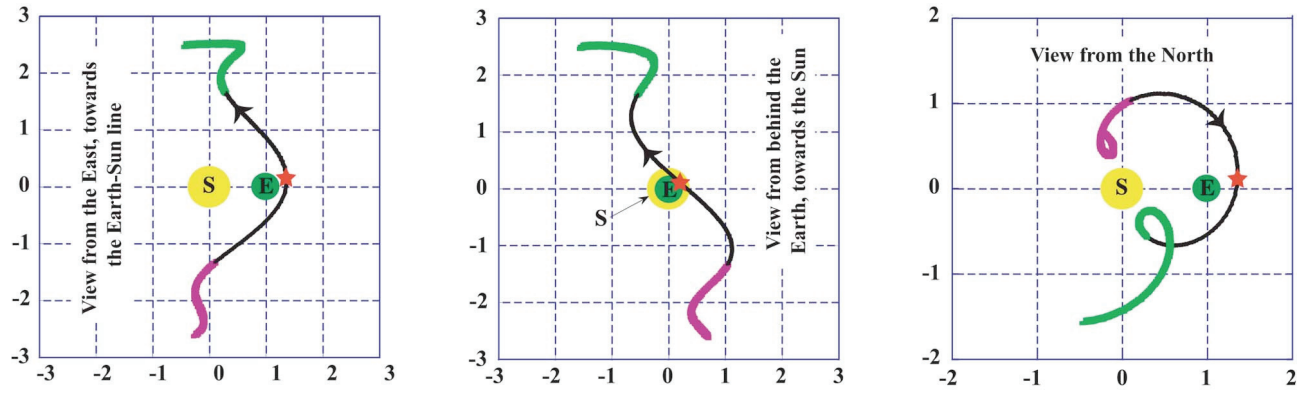

Fig. 5. Ulysses' motion from 19 December 2006 through 28 May 2008, as viewed in the Earth-Sun fixed frame of reference. Left: viewed from east of the Earth-Sun line. The red start at the equator crossing shows a radial alignment with Earth. Middle: viewed from behind Earth, towards the Sun. Right: viewed from above the heliographic equatorial plane. Axis units are AU. Maroon is the winter 2007 quadrature and green is the winter 2008 quadrature.

3. The Winter 2007 & Winter 2008 Extended Quadratures

In Fig. 4, there are two times when the IA dwells near 90º for an extended time, in winter 2007 and again in winter 2008. This happens when Ulysses is at high latitudes (Fig. 2) and is due to both that and the relatively rapid motion of Ulysses.

The first of these two quadratures (referred to from here on as the W2007 and W2008) starts as Ulysses is at 74.4º S and approaching its maximum southern latitude and continues until Ulysses moves back down to ~52.8º S off the west limb. The dates are 19 December 2006 to 19 May 2007. The distance to Ulysses begins as 2.72 AU and decreases to 1.72 AU. Typically, it will take one to two weeks for the solar wind to reach Ulysses at these distances. This lag must be taken in to account when comparing solar phenomena to Ulysses data. Ulysses will be within +/- 5º of the limb over this entire interval.

W2008 is much the same as W2007, except that it occurs after Ulysses has passed its perihelion and has begun moving back away from the Sun over the north pole. W2008 begins on 2 December 2007 and lasts until 28 May 2008, while Ulysses moves from 69.8º N to its maximum northern latitude and then back down to 56.8º N. The distance to Ulysses varies from 1.79 AU out to 2.96 AU. Conditions are not quite so ideal during W2008, with Ulysses only being within +/- 10º of the limb over this interval. However, Ulysses is closer to the limb as viewed from STEREO-A (Fig. 4).

It is a little difficult to visualize the motion of Ulysses in W2007 and W2008. To help, views of the Ulysses orbit in a frame of reference fixed in the Earth(SOHO)-Sun frame of reference are shown in Fig. 5. The left panel shows the orbit viewed from east of the Earth-Sun line, the center panel is the view from behind Earth looking towards the Sun, and the third panel is the view from heliographic north. The red star is just a marker for the near-radial alignment of Ulysses with near-Earth spacecraft as it passes the plane of the ecliptic in summer 2007. This is of interest for propagating disturbance and energetic particle transport studies. In these three panels, the arrow shows the motion of Ulysses, the maroon portion shows W2007, and the green portion shows W2008. The axes are in AU.

The center panel of Fig. 5 is especially helpful for solar reference. Since it shows the location of Ulysses is viewed when looking towards the Sun from behind Earth, the East limb is to the left and the West limb is to the right. Ulysses is in the south off the West limb throughout the W2007 quadrature and is in the north off the East limb throughout the W2008 quadrature.

Ulysses' Position Angle (PA) During the Winter 2007 and Winter 2008 Quadratures:

The PA is computed as the angle, moving counter-clockwise, from heliographic north in the plane shown in the center panel of Fig. 5. Its variation throughout W2007 and W2008 is shown in Fig. 6, along with IA and the heliocentric distance to Ulysses. In this plot, the date is given across the bottom and the fractional day of year (DoY) is shown across the top. The dates are for 12:00:00 on each day. The DoY is shown to four decimal places and is accurate to this value. It is probably more accurate than using the dates across the bottom.

A tabular listing of the PA, along with date (centered on noon), fractional day of year, IA, and radius to Ulysses is in the Appendix I. These are given at 4-day intervals. A simple linear extrapolation between these values gives more accuracy than generally required for extrapolations to Ulysses. Appendix II gives STEREO locations in tabular form at the same 4-day interval done for the Ulysses PA.

A final note: Ulysses is presently scheduled for shut-off on 31 March 2008, before the end of W2008. An extension is under consideration be NASA to keep the mission running through the end of March 2009. This extension has already been approved by ESA. Ulysses will propose in the 2008 Senior Review of Heliophysics Operating Missions for continuation beyond both 31 March 2008 and March 2009.

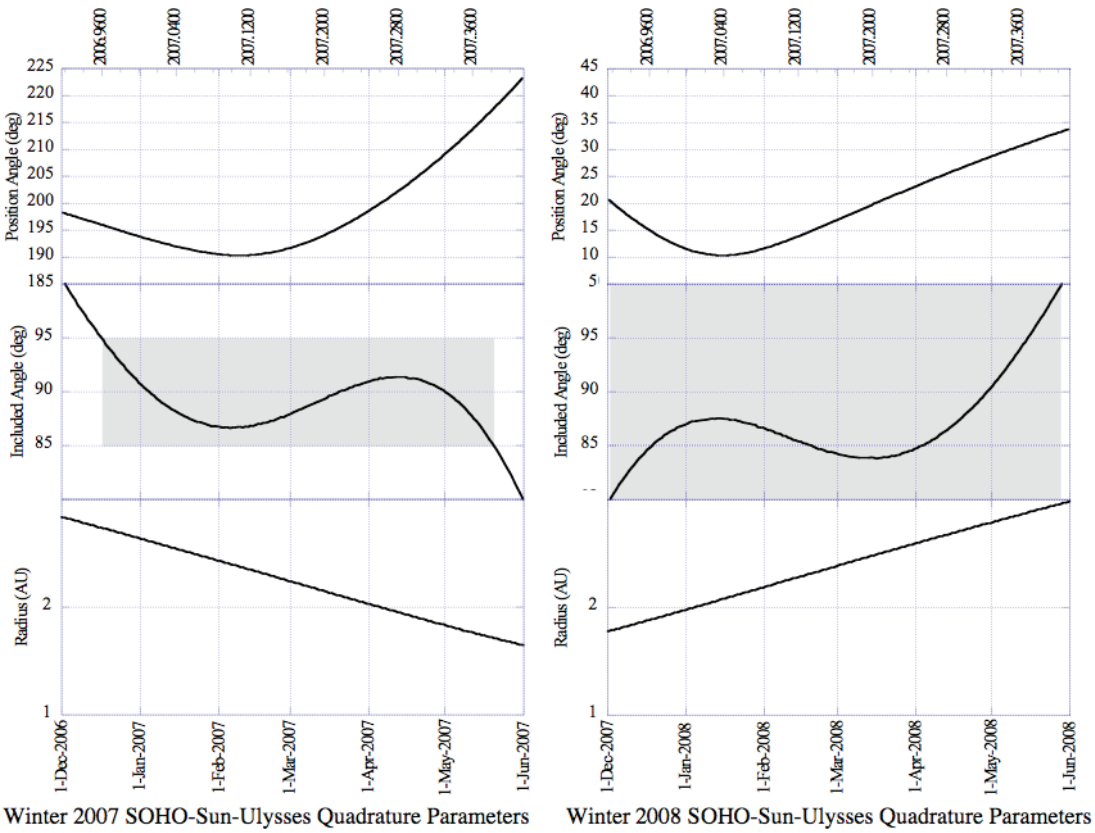

Figure 6. Position angle, Ulysses-Sun-Earth/SOHO included angle, and radius to Ulysses during winters 2007 and 2008. The gray areas of the included angle mark when the angle is ≤5° (W2007) and ≤10° (W2008),

4. Alignments in Longitude

Just as with quadratures, alignments in longitude multiply with the presence of STEREO-A and B added to the Great Heliospheric Observatory. Fig. 7 shows the heliographic intertial longitude of Ulysses in 2008-2013 along with that of several other heliosphysics missions in the top panel. Thirteen longitude alignments are seen to occur over this interval. This is in addition to the very fortuitous radial (not just longitude) alignment that occurred in August 2007 between Earth and Ulysses.

Most of these longitude alignments occur at widely differing latitudes for the two (or more, as in early 2012) observing points. The difference in latitudes generally decreases to small values, or even zero, as Ulysses approaches the ecliptic plane in 2010. At this time, the Great Observatory becomes a very powerful tool for evaluating the three dimensional structure and radial evolution of travelling and corotating interplanetary structures.

There are no longitude alignments between Voyagers 1 and 2 and Ulysses. Their longitudes are fixed in intertial space and do not overlap except when Ulysses is at the very highest heliographic latitudes. Alignments in longitude are not particularly useful, though, for extrapolating solar wind from the inner/mid-heliosphere to the heliosheath. Instead, it is important to know the character of the solar wind at the latitudes of Voyagers 1 and 2. The lower panel in Fig. 7 shows that Ulysses crosses the latitudes of Voyages 1 and 2 around 2009.0 and 2012.0, respectively, when it is moving fairly slowly in latitude. These are ideal times for comparing the response of the heliosheath to the observed wind, with ~1-year delay due to the transit time from a few AU to the termination shock.

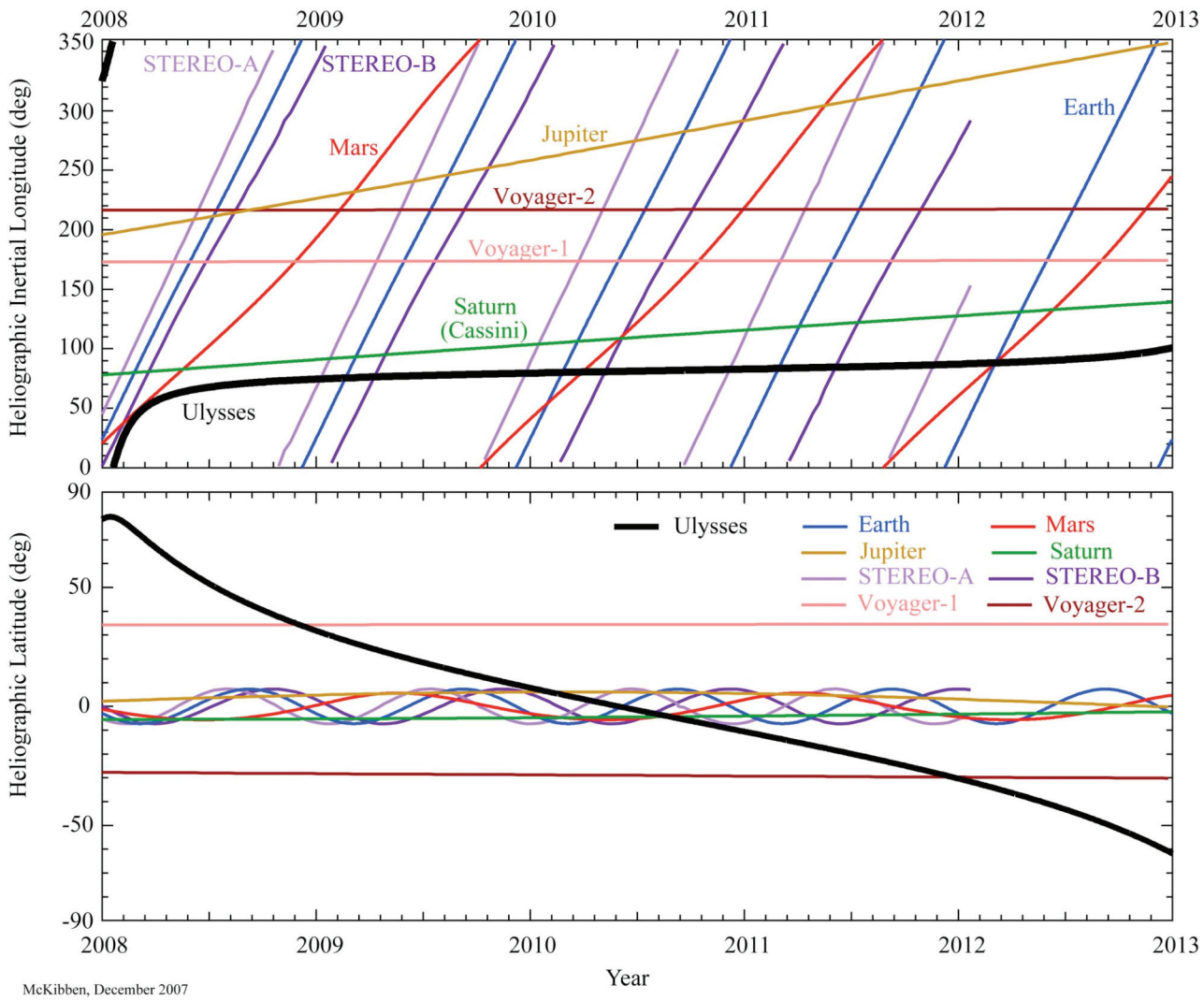

Fig. 7. Top: Heliographic longitude of Ulysses and several other missions/observing points in 2008-2013. These STEREO data are accurately represented (as opposed to the extrapolation used in earlier plots), but the data stops at the end of 2011. Where the heavy, black curve for Ulysses crosses the orbit of another spacecraft, an alignment in longitude occurs. The latitudes of the two observing points/spacecraft can be read off the bottom panel. Bottom: Heliographic latitude of the same missions/observing points shown in the top panel.

6. Appendix I: Ulysses' orbital parameters during the winter 2007 and winter 2008 extended quadratures.

Winter 2007

Frac. Year	Date	Radius	Latitude	Incl.Ang.	PositionAngle
2006.9164	01-Dec-2006	2.8300	-71.800	100.29	198.20
2006.9247	04-Dec-2006	2.8200	-72.200	99.166	197.80
2006.9274	05-Dec-2006	2.8100	-72.400	98.815	197.60
2006.9384	09-Dec-2006	2.7800	-73.000	97.373	197.00
2006.9493	13-Dec-2006	2.7600	-73.500	96.080	196.50
2006.9603	17-Dec-2006	2.7300	-74.100	94.801	195.90
2006.9712	21-Dec-2006	2.7100	-74.700	93.554	195.30
2006.9822	25-Dec-2006	2.6800	-75.300	92.436	194.70
2006.9932	29-Dec-2006	2.6500	-75.900	91.370	194.10
2007.0042	02-Jan-2007	2.6300	-76.500	90.399	193.50
2007.0150	06-Jan-2007	2.6000	-77.000	89.617	193.00
2007.0260	10-Jan-2007	2.5700	-77.500	88.839	192.50
2007.0370	14-Jan-2007	2.5500	-78.000	88.230	192.00
2007.0480	18-Jan-2007	2.5200	-78.400	87.709	191.60
2007.0590	22-Jan-2007	2.4900	-78.800	87.266	191.20
2007.0698	26-Jan-2007	2.4700	-79.100	87.032	190.90
2007.0808	30-Jan-2007	2.4400	-79.400	86.826	190.60
2007.0918	03-Feb-2007	2.4100	-79.600	86.706	190.40
2007.1028	07-Feb-2007	2.3900	-79.700	86.657	190.30
2007.1136	11-Feb-2007	2.3600	-79.700	86.765	190.30
2007.1246	15-Feb-2007	2.3300	-79.600	86.906	190.40
2007.1356	19-Feb-2007	2.3100	-79.300	87.110	190.70
2007.1466	23-Feb-2007	2.2800	-79.000	87.408	191.00
2007.1576	27-Feb-2007	2.2500	-78.500	87.770	191.50
2007.1685	03-Mar-2007	2.2200	-78.000	88.175	192.00
2007.1794	07-Mar-2007	2.2000	-77.300	88.610	192.70
2007.1904	11-Mar-2007	2.1700	-76.600	89.015	193.40
2007.2014	15-Mar-2007	2.1400	-75.700	89.416	194.30
2007.2123	19-Mar-2007	2.1100	-74.800	89.841	195.20
2007.2233	23-Mar-2007	2.0900	-73.800	90.225	196.20
2007.2343	27-Mar-2007	2.0600	-72.800	90.603	197.20
2007.2452	31-Mar-2007	2.0300	-71.600	90.915	198.40
2007.2561	04-Apr-2007	2.0100	-70.400	91.138	199.60
2007.2671	08-Apr-2007	1.9800	-69.200	91.327	200.80
2007.2781	12-Apr-2007	1.9500	-67.800	91.344	202.20
2007.2891	16-Apr-2007	1.9300	-66.500	91.254	203.50
2007.3000	20-Apr-2007	1.9000	-65.000	91.168	205.00
2007.3109	24-Apr-2007	1.8700	-63.500	90.786	206.50
2007.3219	28-Apr-2007	1.8500	-62.000	90.364	208.00
2007.3329	02-May-2007	1.8200	-60.300	89.745	209.70
2007.3439	06-May-2007	1.8000	-58.700	89.016	211.30
2007.3547	10-May-2007	1.7700	-56.900	88.000	213.10
2007.3657	14-May-2007	1.7500	-55.100	86.960	214.90
2007.3767	18-May-2007	1.7200	-53.300	85.566	216.70
2007.3877	22-May-2007	1.7000	-51.400	84.151	218.60
2007.3987	26-May-2007	1.6800	-49.400	82.507	220.60
2007.4095	30-May-2007	1.6500	-47.300	80.616	222.70

Winter 2008

Frac. Year	Date	Radius	Latitude	Incl.Ang.	PositionAngle
2007.9164	01-Dec-2007	1.7800	69.400	79.860	20.600
2007.9274	05-Dec-2007	1.8000	71.000	81.383	19.000
2007.9384	09-Dec-2007	1.8300	72.400	82.644	17.600
2007.9493	13-Dec-2007	1.8600	73.800	83.809	16.200
2007.9603	17-Dec-2007	1.8800	75.000	84.766	15.000
2007.9712	21-Dec-2007	1.9100	76.200	85.603	13.800
2007.9822	25-Dec-2007	1.9300	77.200	86.266	12.800
2007.9932	29-Dec-2007	1.9600	78.000	86.753	12.000
2008.0042	02-Jan-2008	1.9900	78.700	87.163	11.300
2008.0150	06-Jan-2008	2.0100	79.200	87.319	10.800
2008.0260	10-Jan-2008	2.0400	79.500	87.473	10.500
2008.0369	14-Jan-2008	2.0700	79.700	87.516	10.300
2008.0479	18-Jan-2008	2.1000	79.600	87.376	10.400
2008.0587	22-Jan-2008	2.1200	79.400	87.242	10.600
2008.0697	26-Jan-2008	2.1500	79.100	87.010	10.900
2008.0806	30-Jan-2008	2.1800	78.600	86.676	11.400
2008.0916	03-Feb-2008	2.2000	78.100	86.415	11.900
2008.1024	07-Feb-2008	2.2300	77.400	86.068	12.600
2008.1134	11-Feb-2008	2.2600	76.700	85.679	13.300
2008.1243	15-Feb-2008	2.2900	76.000	85.358	14.000
2008.1353	19-Feb-2008	2.3100	75.200	85.037	14.800
2008.1461	23-Feb-2008	2.3400	74.400	84.683	15.600
2008.1571	27-Feb-2008	2.3700	73.600	84.407	16.400
2008.1626	29-Feb-2008	2.3800	73.200	84.261	16.800
2008.1708	03-Mar-2008	2.4000	72.600	84.091	17.400
2008.1816	07-Mar-2008	2.4300	71.800	83.932	18.200
2008.1926	11-Mar-2008	2.4600	71.000	83.876	19.000
2008.2035	15-Mar-2008	2.4800	70.100	83.869	19.900
2008.2145	19-Mar-2008	2.5100	69.300	83.938	20.700
2008.2255	23-Mar-2008	2.5400	68.500	84.023	21.500
2008.2363	27-Mar-2008	2.5600	67.800	84.345	22.200
2008.2473	31-Mar-2008	2.5900	67.000	84.700	23.000
2008.2582	04-Apr-2008	2.6200	66.200	85.064	23.800
2008.2692	08-Apr-2008	2.6400	65.400	85.621	24.600
2008.2800	12-Apr-2008	2.6700	64.700	86.304	25.300
2008.2910	16-Apr-2008	2.6900	63.900	87.010	26.100
2008.3019	20-Apr-2008	2.7200	63.200	87.889	26.800
2008.3129	24-Apr-2008	2.7500	62.500	88.771	27.500
2008.3237	28-Apr-2008	2.7700	61.800	89.791	28.200
2008.3347	02-May-2008	2.8000	61.100	90.900	28.900
2008.3456	06-May-2008	2.8200	60.400	92.044	29.600
2008.3566	10-May-2008	2.8500	59.700	93.368	30.300
2008.3674	14-May-2008	2.8700	59.000	94.631	31.000
2008.3784	18-May-2008	2.9000	58.400	96.093	31.600
2008.3894	22-May-2008	2.9200	57.700	97.539	32.300
2008.4003	26-May-2008	2.9500	57.100	99.109	32.900
2008.4113	30-May-2008	2.9700	56.400	100.66	33.600

7. Appendix II: The locations of Earth, STEREO-Ahead, and STEREO-Behind from 1 January 2007 through 30 May 2008, in heliographic inertial coordinates.

Fractional Year	Radius Earth	Latitude Earth	Radius STEREOA	Latitude STEREOA	D-Long. Earth-A	Radius STEREOB	Latitude STEREOB	D-Long. Earth-B
2007.001370	0.98000	-3.0000	0.98000	-3.1000	0.20000	0.98000	-3.0000	0.20000
2007.012329	0.98000	-3.4000	0.97000	-3.5000	0.20000	0.98000	-3.5000	0.099998
2007.023288	0.98000	-3.9000	0.97000	-4.0000	0.30000	0.98000	-3.9000	0.099998
2007.034247	0.98000	-4.3000	0.97000	-4.4000	0.30000	0.98000	-4.4000	0.10000
2007.045205	0.98000	-4.7000	0.97000	-4.8000	0.30000	0.98000	-4.7000	0.0000
2007.056164	0.98000	-5.1000	0.97000	-5.2000	0.40000	0.98000	-5.1000	0.0000
2007.067123	0.98000	-5.4000	0.97000	-5.6000	0.40000	0.98000	-5.3000	-0.099998
2007.078082	0.98000	-5.8000	0.97000	-5.9000	0.40000	0.99000	-5.6000	-0.099998
2007.089041	0.99000	-6.1000	0.97000	-6.2000	0.40000	0.99000	-5.9000	-0.10000
2007.100000	0.99000	-6.3000	0.97000	-6.5000	0.60000	0.99000	-6.2000	0.0000
2007.110959	0.99000	-6.6000	0.97000	-6.7000	0.60000	0.99000	-6.5000	-0.10001
2007.121918	0.99000	-6.8000	0.97000	-6.9000	0.70000	1.0000	-6.7000	-0.099998
2007.132877	0.99000	-6.9000	0.97000	-7.1000	0.80000	1.0000	-6.9000	0.0000
2007.143836	0.99000	-7.1000	0.97000	-7.2000	0.90000	1.0000	-7.0000	-0.099998
2007.154795	0.99000	-7.2000	0.97000	-7.3000	1.0000	1.0000	-7.1000	-0.20000
2007.165753	0.99000	-7.2000	0.97000	-7.3000	1.1000	1.0000	-7.2000	-0.20000
2007.176712	0.99000	-7.2000	0.97000	-7.3000	1.3000	1.0100	-7.3000	-0.20000
2007.187671	0.99000	-7.2000	0.97000	-7.3000	1.4000	1.0100	-7.3000	-0.30000
2007.198630	0.99000	-7.2000	0.97000	-7.2000	1.5000	1.0100	-7.3000	-0.30000
2007.209589	1.0000	-7.1000	0.97000	-7.1000	1.7000	1.0100	-7.2000	-0.39999
2007.220548	1.0000	-7.0000	0.97000	-7.0000	1.9000	1.0200	-7.1000	-0.39999
2007.231507	1.0000	-6.8000	0.97000	-6.8000	2.1000	1.0200	-7.0000	-0.50000
2007.242466	1.0000	-6.7000	0.96000	-6.6000	2.2000	1.0200	-6.8000	-0.60000
2007.253425	1.0000	-6.4000	0.96000	-6.3000	2.4000	1.0200	-6.7000	-0.80000
2007.264384	1.0000	-6.2000	0.96000	-6.1000	2.7000	1.0300	-6.4000	-0.90000
2007.275342	1.0000	-5.9000	0.96000	-5.7000	2.9000	1.0300	-6.2000	-1.0000
2007.286301	1.0000	-5.6000	0.96000	-5.4000	3.1000	1.0300	-5.9000	-1.1000
2007.297260	1.0000	-5.3000	0.96000	-5.0000	3.4000	1.0400	-5.7000	-1.3000
2007.308219	1.0100	-5.0000	0.96000	-4.6000	3.7000	1.0400	-5.3000	-1.4000
2007.319178	1.0100	-4.6000	0.96000	-4.2000	3.9000	1.0400	-5.0000	-1.6000
2007.330137	1.0100	-4.2000	0.96000	-3.7000	4.2000	1.0400	-4.7000	-1.8000
2007.341096	1.0100	-3.8000	0.96000	-3.3000	4.5000	1.0500	-4.3000	-2.1000
2007.352055	1.0100	-3.4000	0.96000	-2.8000	4.8000	1.0500	-3.9000	-2.2000
2007.363014	1.0100	-2.9000	0.96000	-2.3000	5.1000	1.0500	-3.5000	-2.5000
2007.373973	1.0100	-2.5000	0.96000	-1.8000	5.5000	1.0600	-3.1000	-2.7000
2007.384932	1.0100	-2.0000	0.96000	-1.2000	5.8000	1.0600	-2.7000	-2.9000
2007.395890	1.0100	-1.6000	0.96000	-0.70000	6.2000	1.0600	-2.2000	-3.1000
2007.406849	1.0100	-1.1000	0.96000	-0.20000	6.5000	1.0600	-1.8000	-3.5000
2007.417808	1.0100	-0.6000	0.96000	0.40000	6.9000	1.0700	-1.4000	-3.8000
2007.428767	1.0100	-0.1000	0.96000	0.90000	7.2000	1.0700	-0.90000	-4.1000
2007.439726	1.0100	0.40000	0.96000	1.4000	7.6000	1.0700	-0.50000	-4.4000
2007.450685	1.0200	0.80000	0.96000	2.0000	8.0000	1.0700	0.0000	-4.7000
2007.461644	1.0200	1.3000	0.96000	2.5000	8.5000	1.0700	0.40000	-4.9000
2007.472603	1.0200	1.8000	0.96000	3.0000	8.9000	1.0800	0.80000	-5.3000
2007.483562	1.0200	2.3000	0.96000	3.4000	9.3000	1.0800	1.3000	-5.6000
2007.494521	1.0200	2.7000	0.96000	3.9000	9.7000	1.0800	1.7000	-6.0000
2007.505479	1.0200	3.1000	0.96000	4.4000	10.100	1.0800	2.1000	-6.4000
2007.516438	1.0200	3.6000	0.96000	4.8000	10.500	1.0800	2.5000	-6.7000
2007.527397	1.0200	4.0000	0.96000	5.2000	10.900	1.0800	3.0000	-7.1000
2007.538356	1.0200	4.4000	0.96000	5.5000	11.400	1.0800	3.3000	-7.5000
2007.549315	1.0200	4.7000	0.96000	5.9000	11.800	1.0800	3.7000	-7.9000
2007.560274	1.0200	5.1000	0.96000	6.2000	12.200	1.0800	4.1000	-8.3000

2007.571233	1.0200	5.4000	0.96000	6.5000	12.600	1.0900	4.4000	-8.8000
2007.582192	1.0100	5.7000	0.96000	6.7000	13.000	1.0900	4.8000	-9.2000
2007.593151	1.0100	6.0000	0.96000	6.9000	13.500	1.0900	5.1000	-9.6000
2007.604110	1.0100	6.3000	0.96000	7.1000	13.800	1.0900	5.4000	-10.100
2007.615068	1.0100	6.5000	0.96000	7.2000	14.300	1.0900	5.7000	-10.400
2007.626027	1.0100	6.7000	0.96000	7.3000	14.600	1.0900	5.9000	-10.900
2007.636986	1.0100	6.9000	0.96000	7.3000	15.000	1.0800	6.2000	-11.400
2007.647945	1.0100	7.0000	0.96000	7.3000	15.400	1.0800	6.4000	-11.800
2007.658904	1.0100	7.1000	0.96000	7.3000	15.800	1.0800	6.6000	-12.200
2007.669863	1.0100	7.2000	0.96000	7.2000	16.100	1.0800	6.8000	-12.700
2007.680822	1.0100	7.2000	0.96000	7.1000	16.500	1.0800	6.9000	-13.100
2007.691781	1.0100	7.2000	0.96000	7.0000	16.800	1.0800	7.1000	-13.500
2007.702740	1.0100	7.2000	0.96000	6.8000	17.000	1.0800	7.2000	-14.100
2007.713699	1.0000	7.2000	0.96000	6.5000	17.400	1.0800	7.2000	-14.500
2007.724658	1.0000	7.1000	0.96000	6.3000	17.700	1.0700	7.3000	-14.900
2007.735616	1.0000	6.9000	0.96000	6.0000	17.900	1.0700	7.3000	-15.400
2007.746575	1.0000	6.8000	0.96000	5.7000	18.200	1.0700	7.3000	-15.700
2007.757534	1.0000	6.6000	0.96000	5.3000	18.400	1.0700	7.2000	-16.200
2007.768493	1.0000	6.4000	0.96000	4.9000	18.700	1.0700	7.2000	-16.500
2007.779452	1.0000	6.1000	0.96000	4.5000	18.800	1.0600	7.1000	-17.000
2007.790411	1.0000	5.8000	0.96000	4.1000	19.000	1.0600	7.0000	-17.400
2007.801370	1.0000	5.5000	0.96000	3.6000	19.200	1.0600	6.8000	-17.700
2007.812329	0.99000	5.2000	0.96000	3.2000	19.400	1.0600	6.7000	-18.100
2007.823288	0.99000	4.8000	0.96000	2.7000	19.500	1.0500	6.5000	-18.400
2007.834247	0.99000	4.4000	0.96000	2.2000	19.700	1.0500	6.2000	-18.800
2007.845205	0.99000	4.0000	0.96000	1.7000	19.800	1.0500	6.0000	-19.100
2007.856164	0.99000	3.6000	0.96000	1.1000	19.900	1.0500	5.7000	-19.500
2007.867123	0.99000	3.1000	0.96000	0.60000	20.100	1.0400	5.4000	-19.800
2007.878082	0.99000	2.7000	0.97000	0.10000	20.200	1.0400	5.1000	-20.100
2007.889041	0.99000	2.2000	0.97000	-0.40000	20.300	1.0400	4.7000	-20.300
2007.900000	0.99000	1.7000	0.97000	-1.0000	20.400	1.0300	4.3000	-20.600
2007.910959	0.99000	1.2000	0.97000	-1.5000	20.500	1.0300	3.9000	-20.800
2007.921918	0.99000	0.70000	0.97000	-2.0000	20.500	1.0300	3.5000	-21.200
2007.932877	0.99000	0.20000	0.97000	-2.5000	20.600	1.0300	3.1000	-21.400
2007.943836	0.98000	-0.3000	0.97000	-3.0000	20.800	1.0200	2.7000	-21.600
2007.954795	0.98000	-0.8000	0.97000	-3.5000	20.800	1.0200	2.2000	-21.900
2007.965753	0.98000	-1.4000	0.97000	-3.9000	20.900	1.0200	1.7000	-22.000
2007.976712	0.98000	-1.9000	0.97000	-4.4000	21.000	1.0200	1.2000	-22.200
2007.987671	0.98000	-2.3000	0.97000	-4.8000	21.000	1.0100	0.80000	-22.400
2007.998630	0.98000	-2.8000	0.97000	-5.2000	21.200	1.0100	0.30000	-22.500
2008.009563	0.98000	-3.3000	0.97000	-5.5000	21.200	1.0100	-0.20000	-22.700
2008.020492	0.98000	-3.7000	0.97000	-5.9000	21.200	1.0100	-0.70000	-22.900
2008.031421	0.98000	-4.2000	0.97000	-6.2000	21.400	1.0100	-1.2000	-23.000
2008.042350	0.98000	-4.6000	0.97000	-6.4000	21.400	1.0100	-1.7000	-23.100
2008.053279	0.98000	-5.0000	0.97000	-6.7000	21.500	1.0000	-2.2000	-23.300
2008.064208	0.98000	-5.3000	0.97000	-6.9000	21.600	1.0000	-2.7000	-23.300
2008.075137	0.98000	-5.7000	0.97000	-7.0000	21.700	1.0000	-3.2000	-23.400
2008.086066	0.99000	-6.0000	0.97000	-7.2000	21.800	1.0000	-3.6000	-23.500
2008.096995	0.99000	-6.2000	0.97000	-7.3000	21.800	1.0000	-4.0000	-23.600
2008.107923	0.99000	-6.5000	0.97000	-7.3000	22.000	1.0000	-4.5000	-23.600
2008.118852	0.99000	-6.7000	0.97000	-7.3000	22.100	1.0000	-4.9000	-23.700
2008.129781	0.99000	-6.9000	0.97000	-7.3000	22.200	1.0000	-5.2000	-23.800
2008.140710	0.99000	-7.0000	0.97000	-7.2000	22.300	1.0000	-5.6000	-23.800
2008.151639	0.99000	-7.1000	0.97000	-7.2000	22.400	1.0000	-5.9000	-23.800
2008.162568	0.99000	-7.2000	0.96000	-7.0000	22.600	1.0000	-6.2000	-23.800
2008.173497	0.99000	-7.2000	0.96000	-6.8000	22.700	1.0000	-6.4000	-23.900
2008.184426	0.99000	-7.2000	0.96000	-6.6000	22.900	1.0000	-6.7000	-23.800
2008.195355	0.99000	-7.2000	0.96000	-6.4000	23.000	1.0000	-6.8000	-23.800
2008.206284	0.99000	-7.1000	0.96000	-6.1000	23.100	1.0000	-7.0000	-23.900

2008.217213	1.0000	-7.0000	0.96000	-5.8000	23.300	1.0100	-7.1000	-23.900
2008.228142	1.0000	-6.9000	0.96000	-5.5000	23.500	1.0100	-7.2000	-23.900
2008.239071	1.0000	-6.7000	0.96000	-5.1000	23.700	1.0100	-7.3000	-23.800
2008.250000	1.0000	-6.5000	0.96000	-4.7000	23.900	1.0100	-7.3000	-23.800
2008.260929	1.0000	-6.3000	0.96000	-4.3000	24.100	1.0100	-7.3000	-23.900
2008.271858	1.0000	-6.0000	0.96000	-3.8000	24.300	1.0200	-7.2000	-23.800
2008.282787	1.0000	-5.7000	0.96000	-3.3000	24.500	1.0200	-7.1000	-23.900
2008.293716	1.0000	-5.4000	0.96000	-2.9000	24.800	1.0200	-7.0000	-23.900
2008.304645	1.0000	-5.1000	0.96000	-2.4000	25.100	1.0200	-6.9000	-23.900
2008.315574	1.0100	-4.7000	0.96000	-1.9000	25.300	1.0300	-6.7000	-24.000
2008.326503	1.0100	-4.3000	0.96000	-1.3000	25.600	1.0300	-6.5000	-24.000
2008.337432	1.0100	-3.9000	0.96000	-0.80000	26.000	1.0300	-6.3000	-24.000
2008.348361	1.0100	-3.5000	0.96000	-0.30000	26.200	1.0300	-6.0000	-24.100
2008.359290	1.0100	-3.1000	0.96000	0.30000	26.600	1.0400	-5.7000	-24.100
2008.370219	1.0100	-2.6000	0.96000	0.80000	26.900	1.0400	-5.4000	-24.300
2008.381148	1.0100	-2.2000	0.96000	1.3000	27.300	1.0400	-5.1000	-24.400
2008.392077	1.0100	-1.7000	0.96000	1.9000	27.700	1.0400	-4.7000	-24.500
2008.403005	1.0100	-1.2000	0.96000	2.4000	27.900	1.0500	-4.4000	-24.700

8. **Appendix UV:** Sources for the data used here.

Orbital data used here were taken from:
http://cohoweb.gsfc.nasa.gov/helios/heli.html

Orbital data for STEREO in Fig. 7 are from:
http://stereo-ssc.nascom.nasa.gov/where/

Ulysses data is accessed at NSSDC and through the Ulysses Data System (UDS). Web sites are:

(UDS) http://helio.esa.int/ulysses/data_archive.html
(UDS mirror) http://ulysses-ops.jpl.esa.int/ulysses/data_archive.html
(NSSDC) http://nssdc.gsfc.nasa.gov/database/MasterCatalog?sc=1990-090B

Typical solar wind parameters that are available from the SWOOPS instrument include solar wind proton and electron densities, flow speeds, and temperatures. The vector magnetic field is available at a higher cadence than the plasma. Solar wind composition and ionization state data is available from the SWICS instrument. There is a large amount of energetic particle and radio data.