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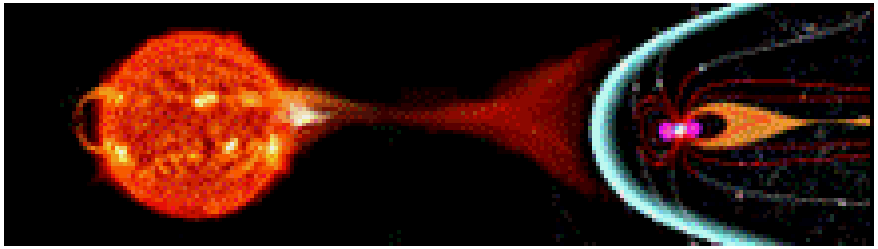

Space Weather Users Workshop
The University of Sydney, 16-17 November 2017

Auroras: How do we forecast them in reality ?

Rakesh Panwar

16 November 2017

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Auroras: Mythology to space weather

- Gods/supernatural creatures dancing
- Dead friends trying to contact the living ones
- Fire by ancient voyagers signalling to relatives
- Bad omen, children not allowed outside
- Ghosts dancing, huge fires, active volcanoes
- Tycho Brahe (1546-1601): Precise description of position of auroral corona
- Modern knowledge: Space weather

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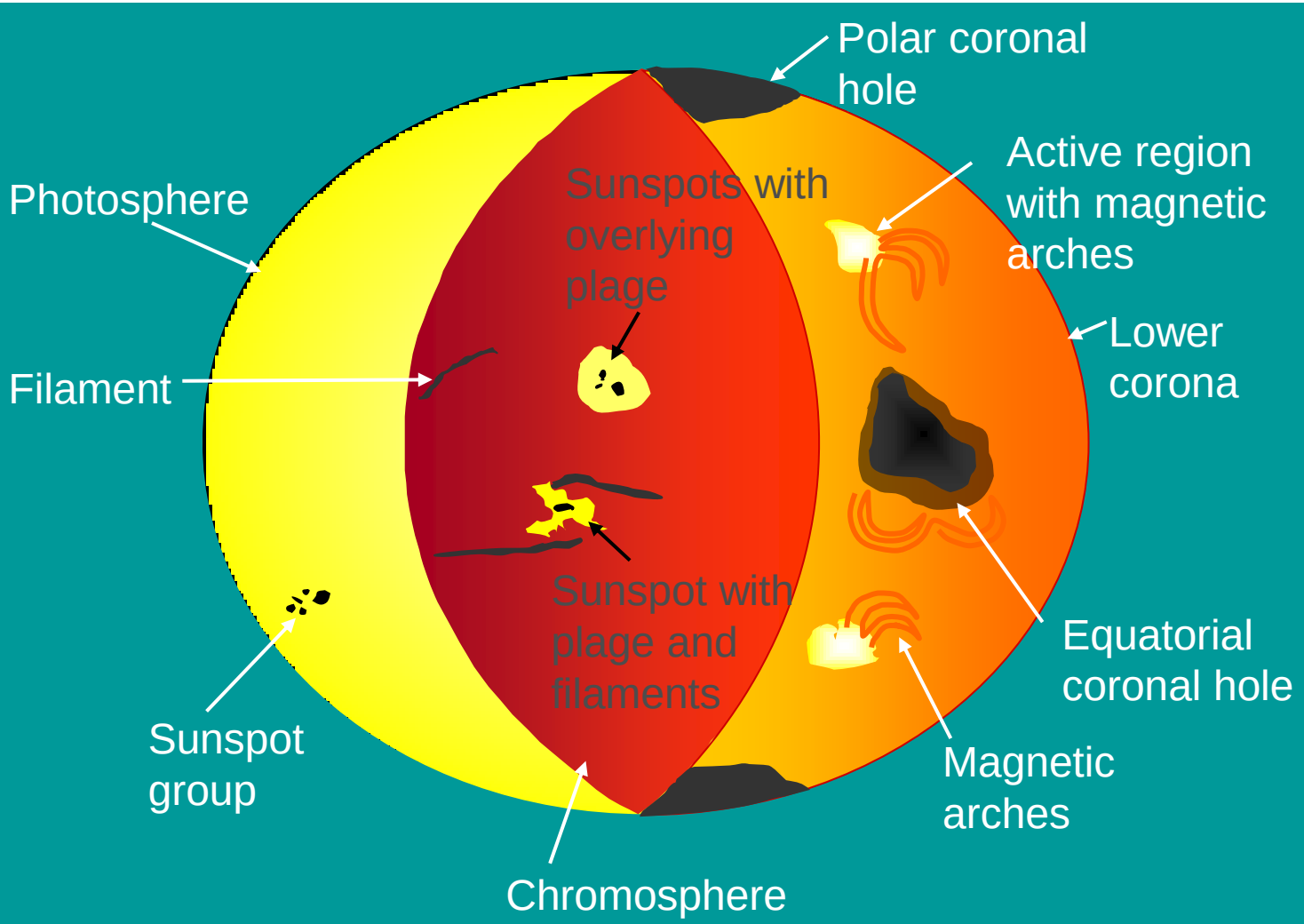
Solar features to observe



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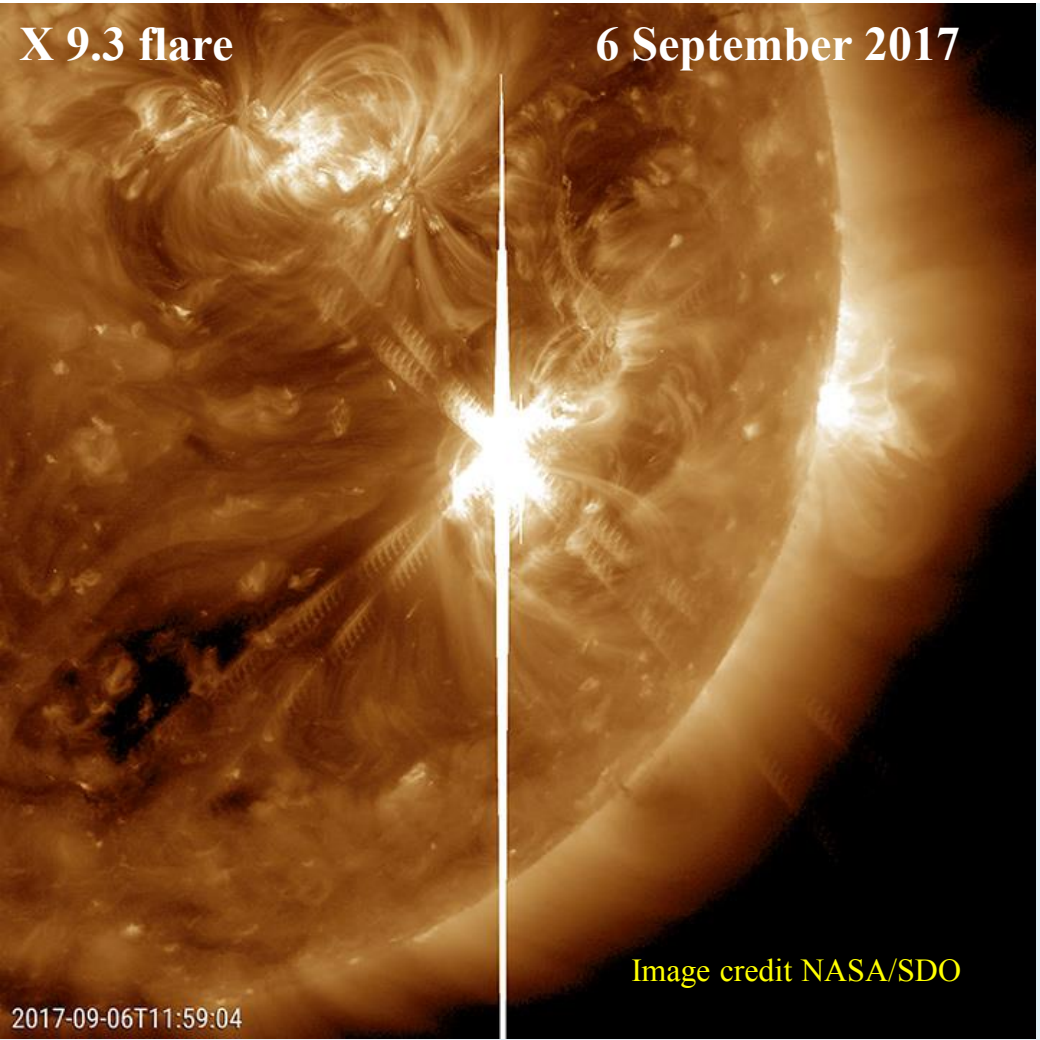
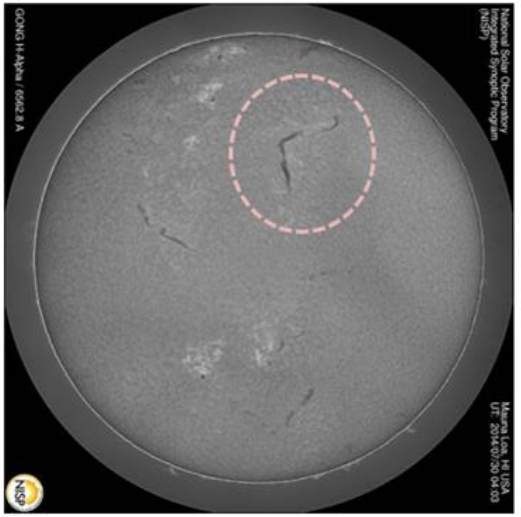
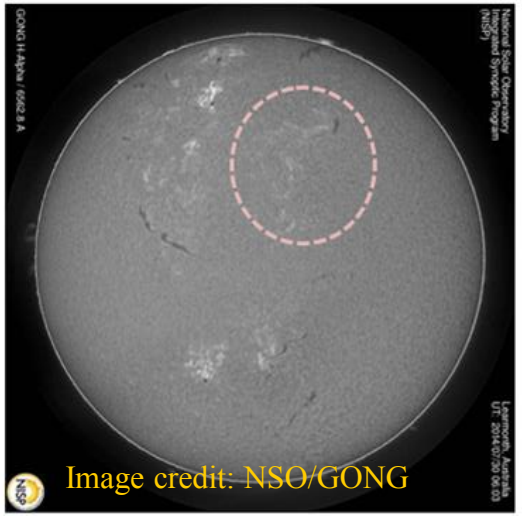
Main solar activities to observe







H-alpha image of a disappearing solar filament

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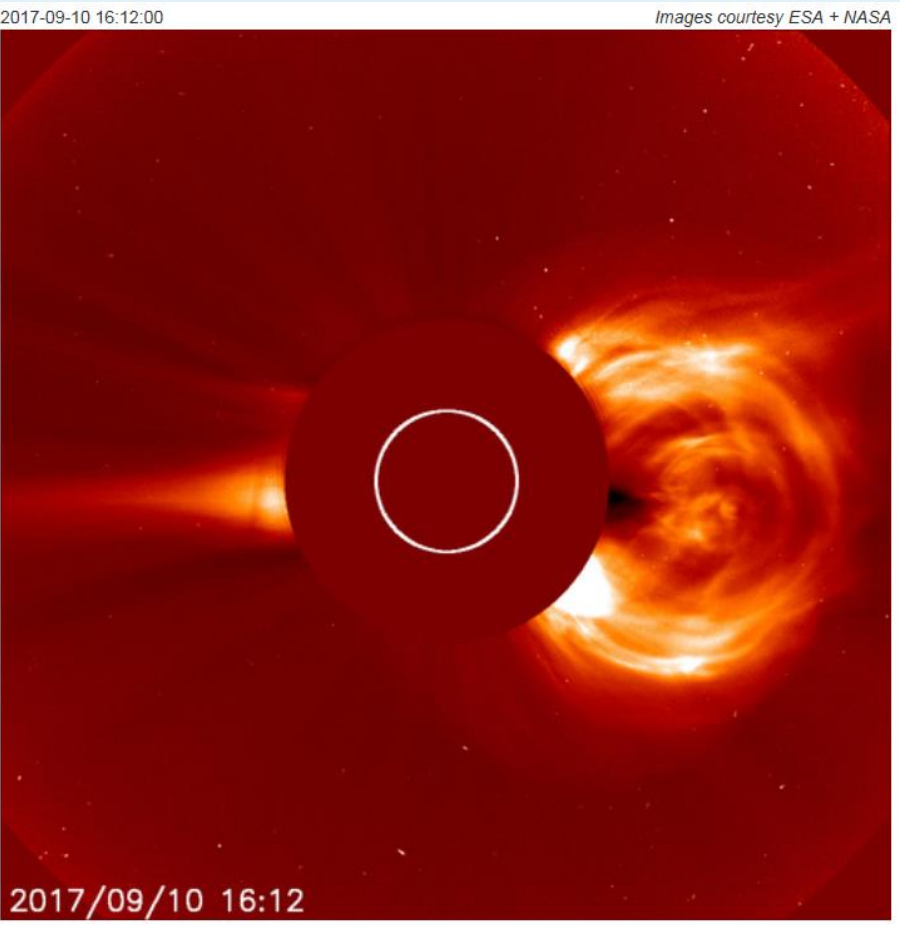
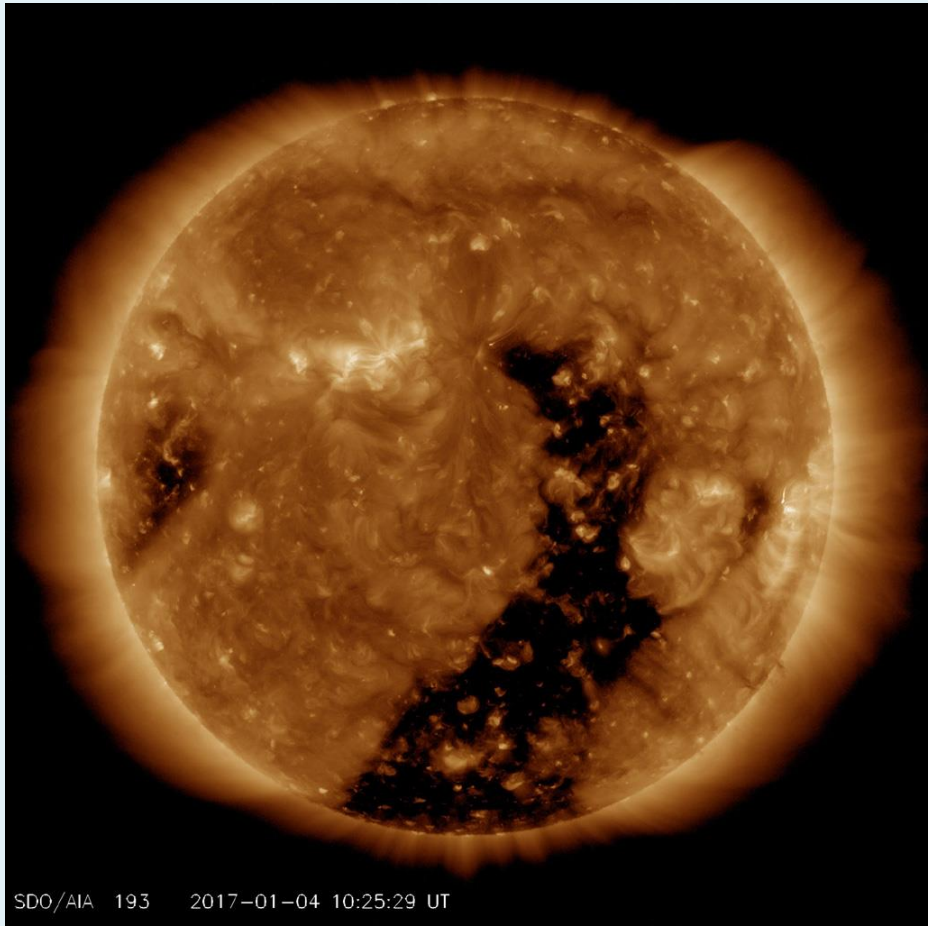
Main solar activities to observe

A coronal mass ejection, 10 September 2017.
Image courtesy NASA



A coronal hole, 1 January 2017.
Image courtesy NASA



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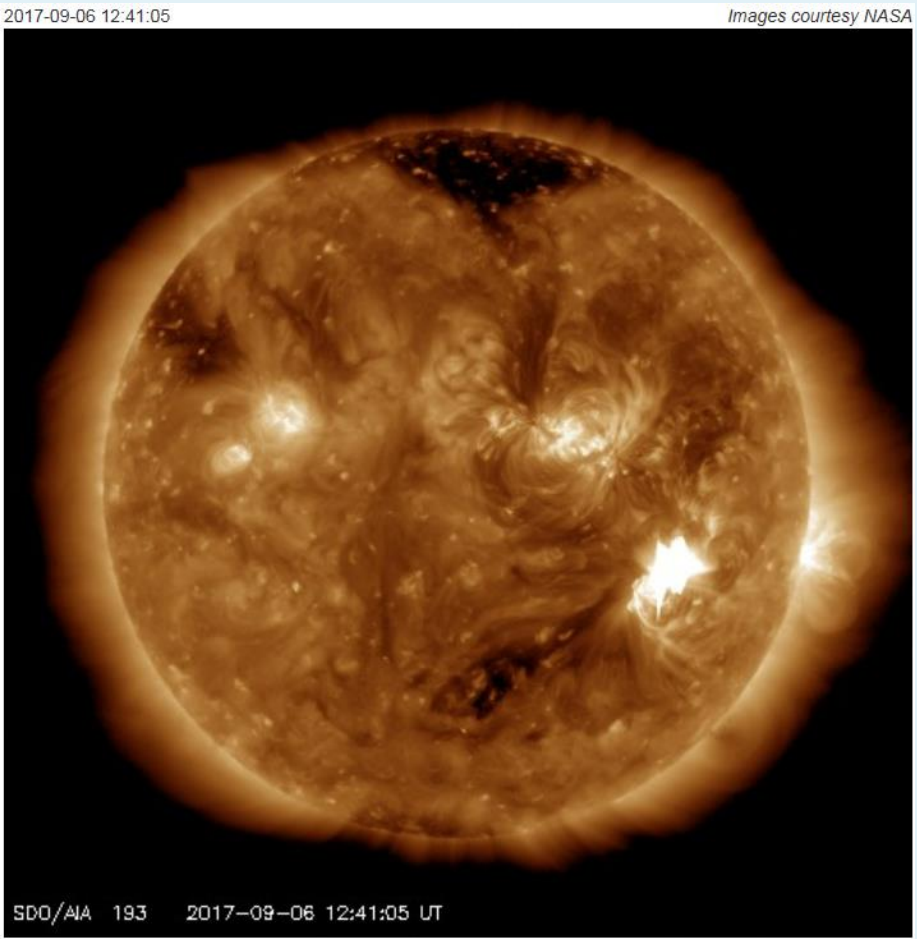
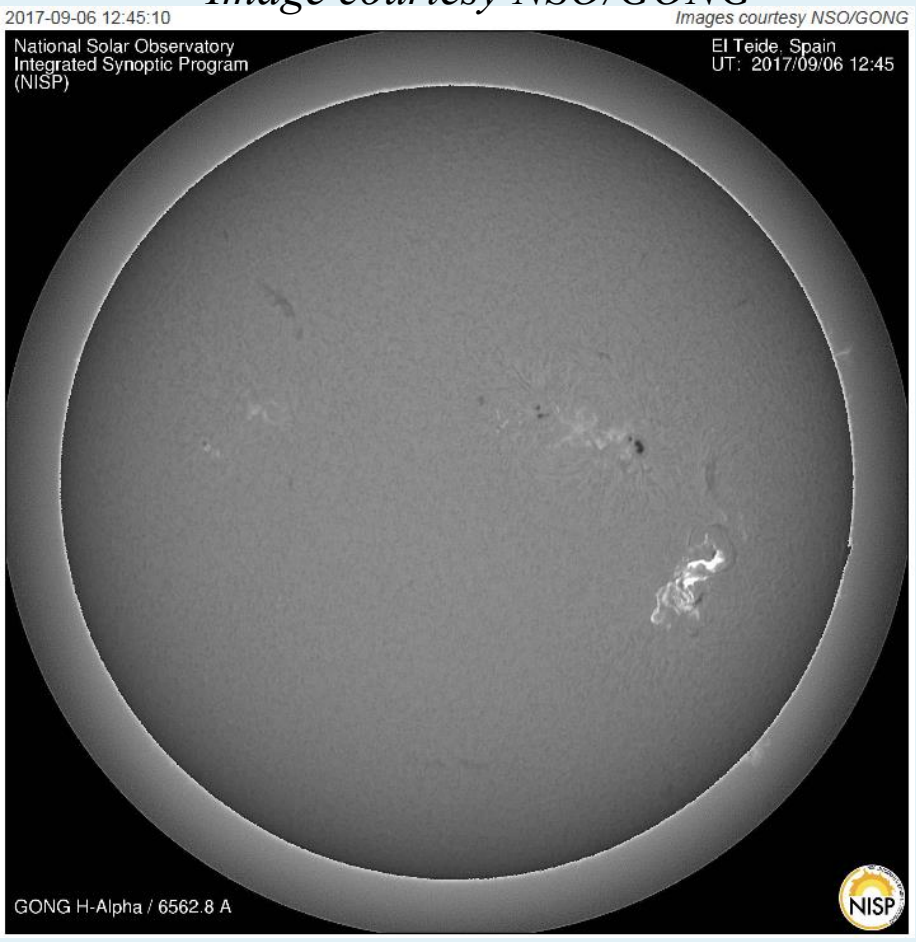
Solar activities on 6 September 2017

Solar flare 12:41:05 UT *Image courtesy NASA*



GONG H-alpha/6562.8 A, 12:45 UT
Image courtesy NSO/GONG



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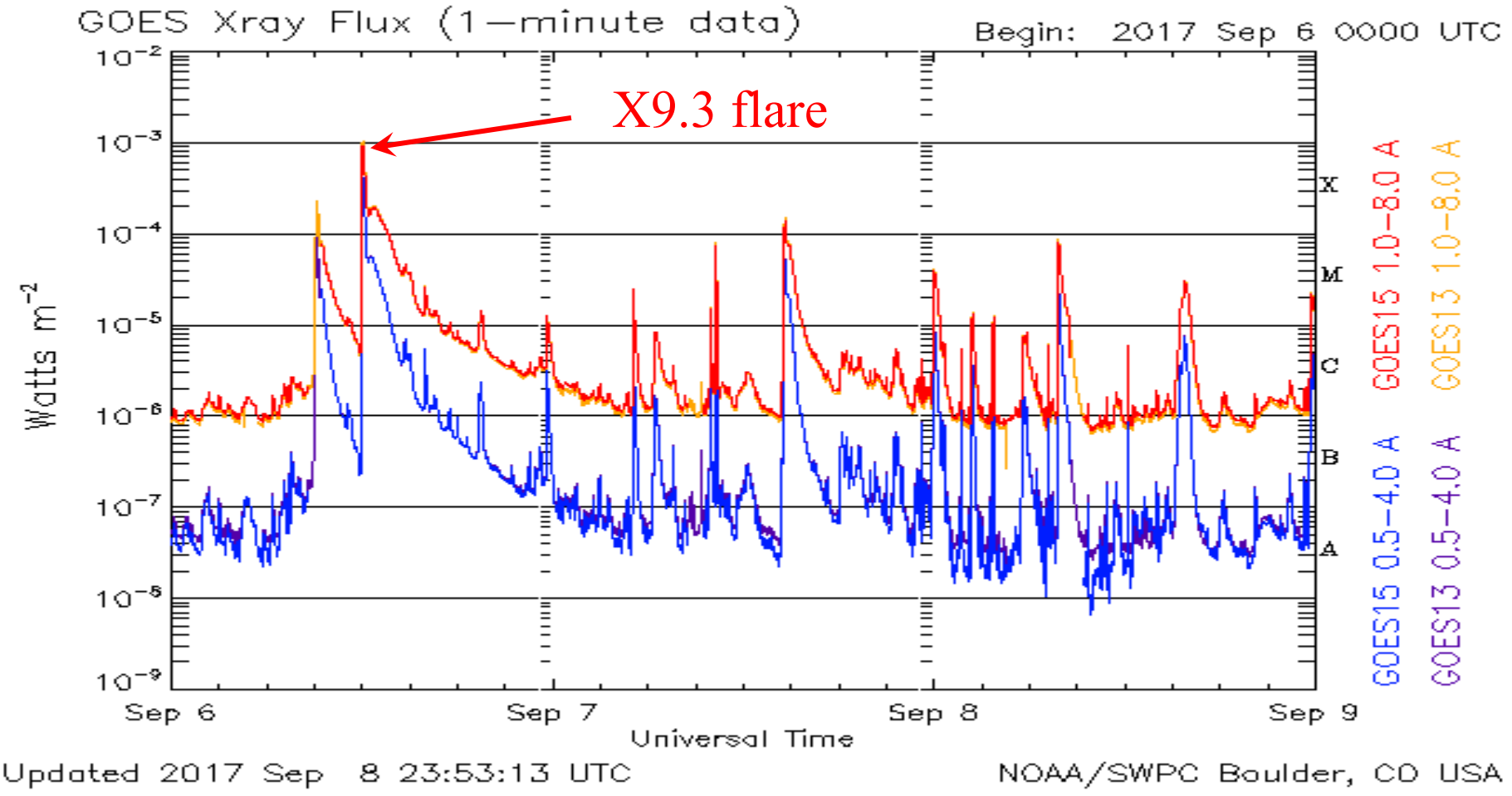
Solar activities on 6 September 2017

Image courtesy SWPC



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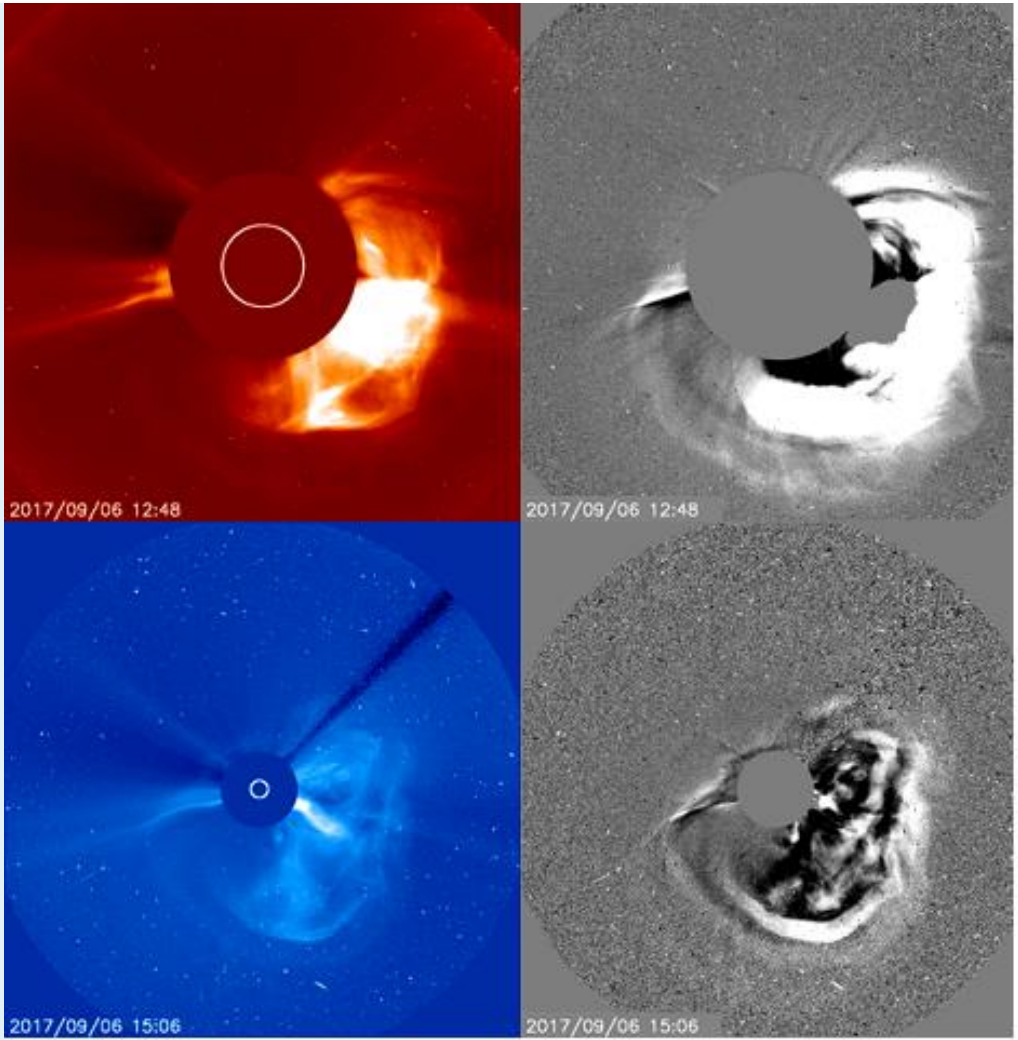
CME observed with X9.3 flare on 6 September 2017



CAT *(CME Analysis Tool)*

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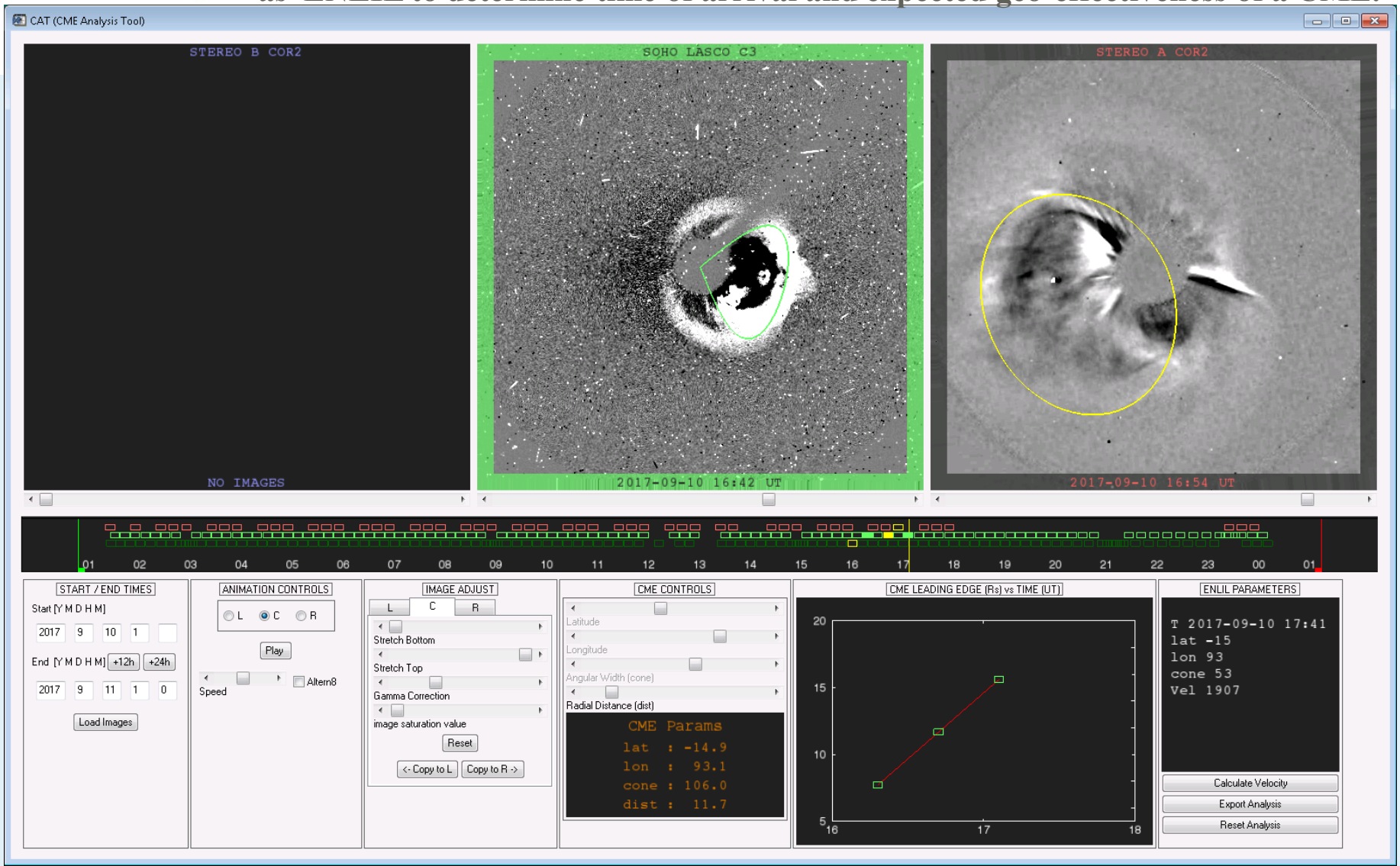
Determines key parameters (speed, direction of motion and angular width) of CME. Parameters used as input for computational models of the heliosphere such as ENLIL to determine time of arrival and expected geo-effectiveness of a CME.



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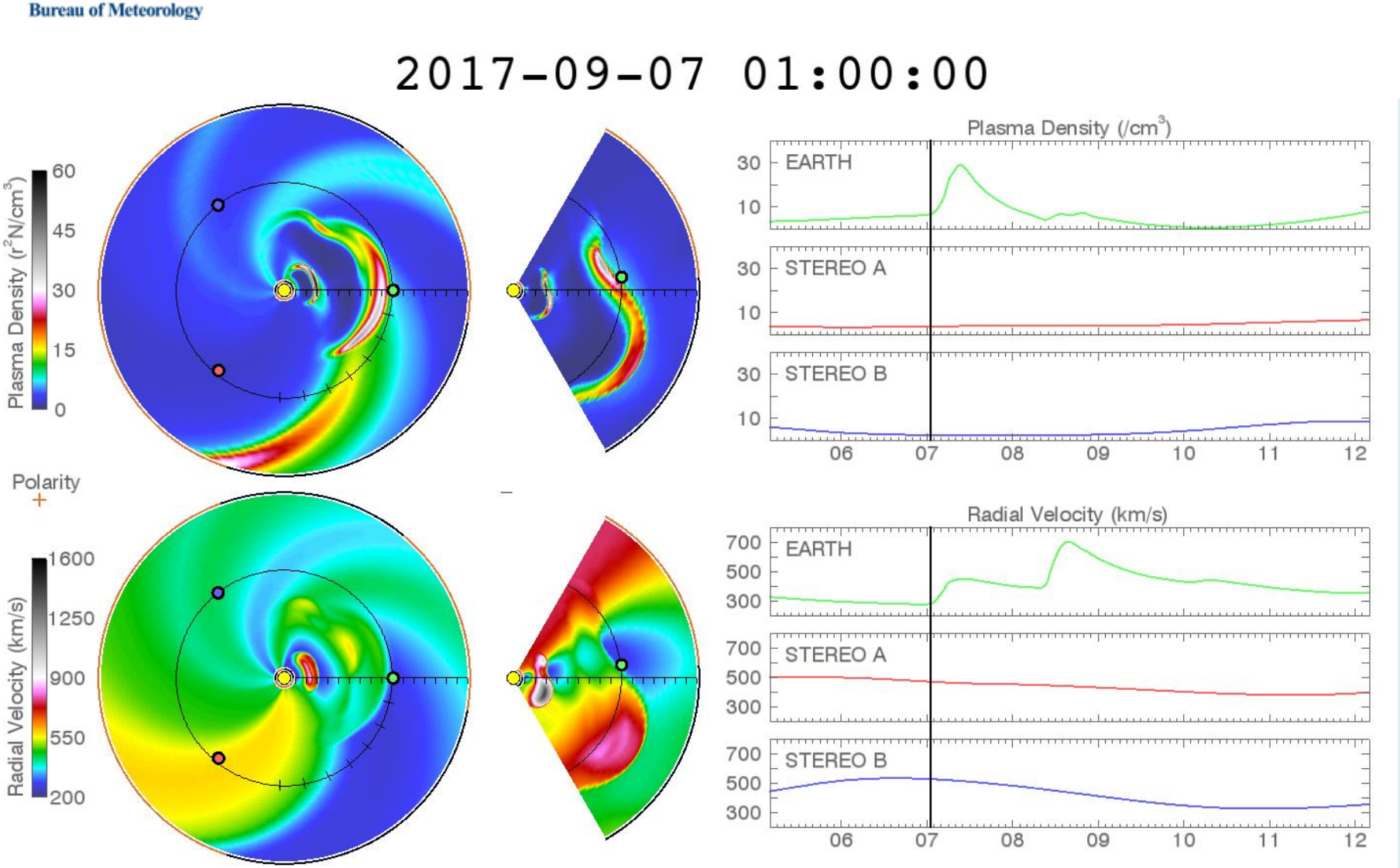
ENLIL run at SWS, 7 September 2017



BoM/SWS Run Time: 2017-09-07 04:00 UT Mode: CME Image Created: 2017-09-07 05:58 UT

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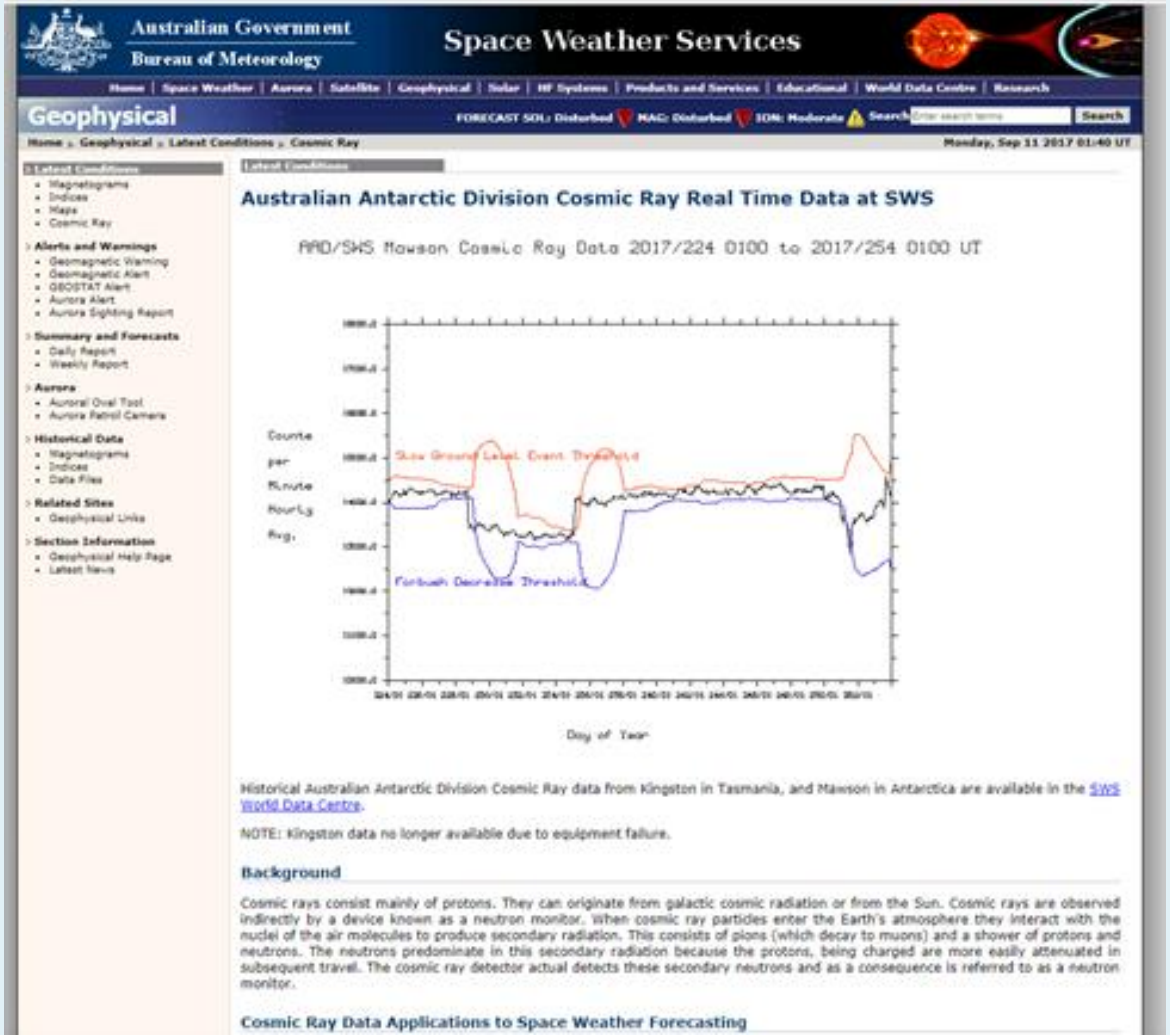
Forbush decrease



Shielding of Galactic Cosmic Rays by the magnetic field of the CME

Reduction (typically 3 to 20%) in the count of secondary neutrons

Reduction time scale: hours to days

Forbush alert threshold: decrease >= 3%

Reliable indicator of geomagnetic storm

Warning time of up to 24 hours or more possible

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K and A index

- **K Index:** A three hourly index of geomagnetic activity relative to an assumed quiet day curve for the recording site. K index values range from 0 (very quiet) up to 9 (extremely disturbed).
- **A Index:** Location specific linear index for measuring the disturbance level in the Earth's magnetic field. The index is defined over a period of one day.
- **quiet:** A < 8 — usually no K indices >2
- **unsettled:** 8 <= A < 16 — usually no K indices >3
- **active:** 16 <= A < 30 — a few K indices of 4
- **minor storm:** 30 <= A < 50 — K indices mostly 4 and 5
- **major storm:** 50<=A< 100 — some K indices >=6
- **Severe storm: A>=100** — **some K indices >=7**
- **Ap Index:** The planetary index for measuring the strength of a disturbance in the Earth's magnetic field. The index is defined over a period of one day from a set of standard stations around the world.

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Forecast after the solar events on 6 September 2017

2B. MAGNETIC FORECAST

Date	Ap	Conditions
07 Sep	50	Active to Major Storm
08 Sep	30	Active to Minor Storm
09 Sep	75	Major to Severe Storm

COMMENT: SWS Geomagnetic Warning 42 was issued on 6 September and is current for 6-8 Sep. Magnetic conditions were quiet across the Australian region during the UT day, 06 September. The arrival of a CME late in the UT day 06 Sep will increase geomagnetic conditions over the early part of the UT day (07 Sep). Expect Active to Major Storm conditions with possible cases of Severe Storm conditions at higher latitudes for 7 September.

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Aurora Outlooks

- Warnings with lead times of 3-7 days.
- Issued in response to the presence of a large active solar region expected to rotate into a position that is favourable for CMEs, and similarly for significant coronal holes.

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Aurora Watch

- Are warnings with lead times of up to 48 hours.
- Issued in response to a significant CME or coronal hole likely to be geo-effective.

Aurora Watch issued on 7 September 2017

SUBJ: SWS AURORA WATCH

ISSUED AT 0326 UT ON 07 Sep 2017 by Space Weather Services

FROM THE AUSTRALIAN SPACE FORECAST CENTRE

A coronal mass ejection is expected to impact the Earth within the next 48 hours, possibly resulting in significant geomagnetic activity and visible auroras during local night time hours. Aurora alerts will follow if significant geomagnetic activity actually occurs.

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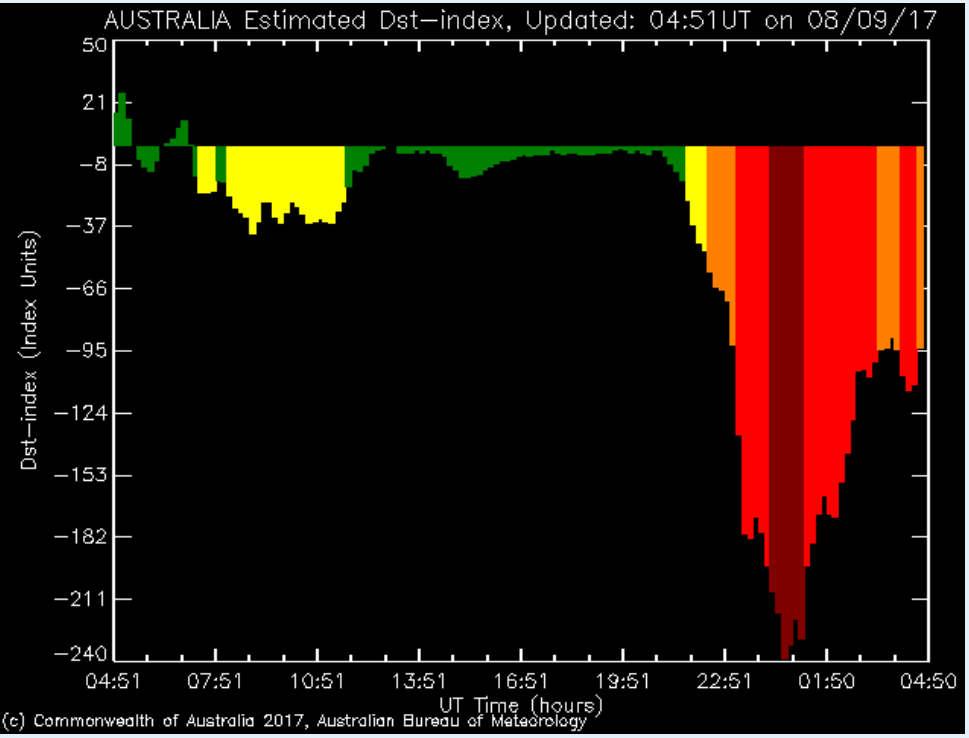
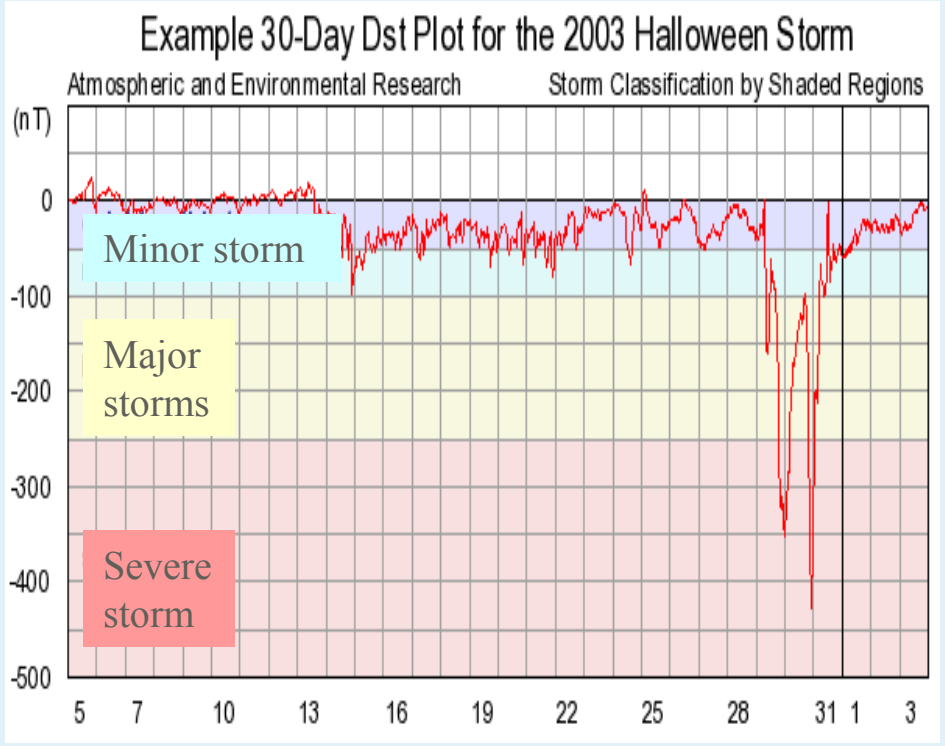
The Dst index

Disturbance Storm Time (Dst) index: is a measure of the decrease in the horizontal component of the Earth's magnetic field near the magnetic equator due to increase in the magnetospheric ring current.

Values less than −50 nanotesla (nT) indicate high geomagnetic activity.





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Aurora Alert

- Issued when space weather activity favourable for viewing aurora is in progress.
- Indicates the latitudinal range in terms of high, middle, low and equatorial regions where aurora may be visible under good observing conditions.

Criteria: Dst -100 nT or more negative; Kp >= 6 and local night;
Average Bz -15 nT or more negative for 4 hours

Aurora Alert issued on 8 September 2017

SUBJ: SWS AURORA ALERT HIGH LATITUDES

ISSUED AT 1323 UT ON 08 Sep 2017 BY SPACE WEATHER SERVICES

FROM THE AUSTRALIAN SPACE FORECAST CENTRE GEOMAGNETIC STORM IN PROGRESS. AURORA MAY BE OBSERVEDDURING LOCAL NIGHT TIME HOURS IN GOOD OBSERVING CONDITIONS AT HIGH LATITUDES.

Follow the progress of this event on the IPS web site by following the links to the Space Weather Status Panel, Home > Space Weather

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Forecasting coronal hole effect

Geo-effective location of coronal hole

Australian Government
Bureau of Meteorology

Image animator

hide filters | show url

Product

sdo

Source

aia_193

From **To**

Latest **Refresh every**

400 N minutes

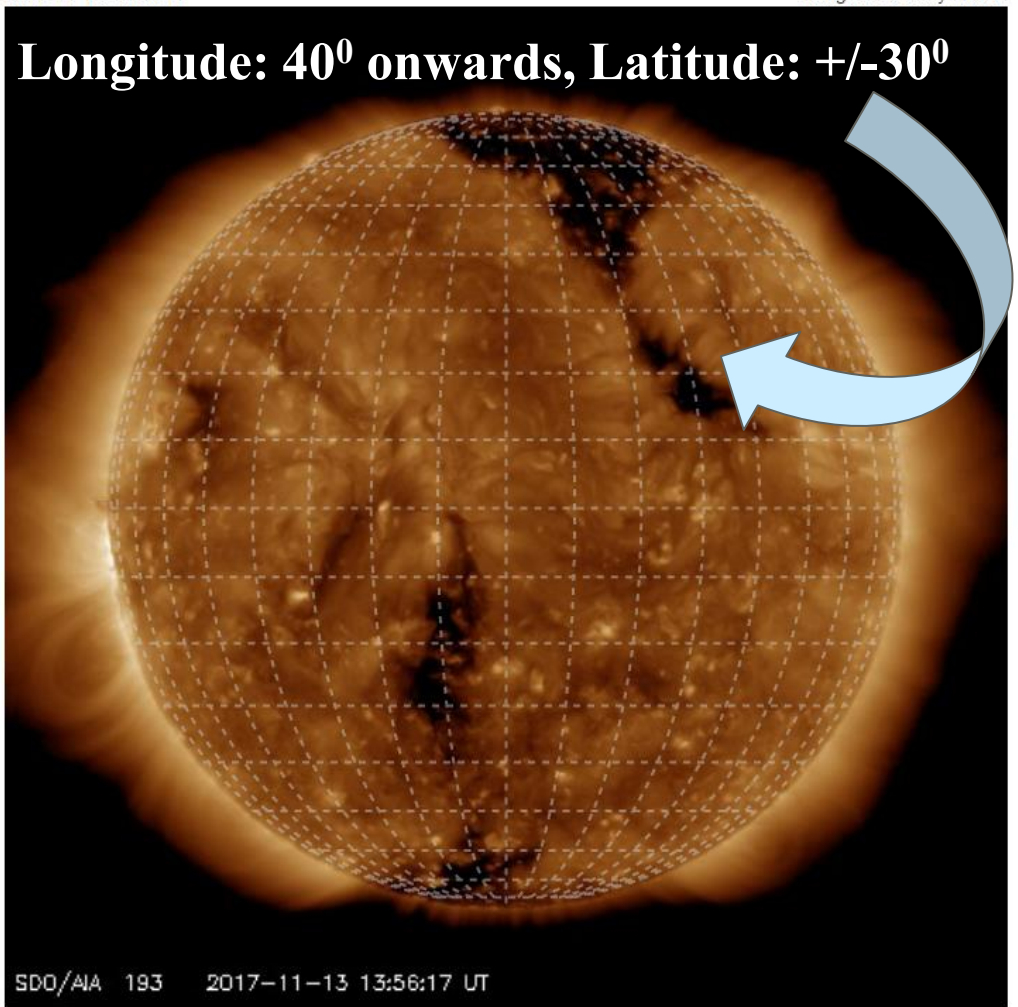
Stonyhurst **Scale**

280

Refresh (animations are limited to 500 images)

Keep

2017-11-13 13:56:17 *Images courtesy NASA*



Australian Government

Recurrence Board

Recurrence board

+1	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	-10
19 Dec 2017	22 Nov 2017	26 Oct 2017 Ap: 18	29 Sep 2017 Ap: 11	02 Sep 2017 Ap: 26	06 Aug 2017 Ap: 12	10 Jul 2017 Ap: 10	13 Jun 2017 Ap: 6	17 May 2017 Ap: 9	20 Apr 2017 Ap: 30	24 Mar 2017 Ap: 5	25 Feb 2017 Ap: 5
18 Dec 2017	21 Nov 2017	25 Oct 2017 Ap: 18	28 Sep 2017 Ap: 44	01 Sep 2017 Ap: 17	05 Aug 2017 Ap: 16	09 Jul 2017 Ap: 26	12 Jun 2017 Ap: 8	16 May 2017 Ap: 8	19 Apr 2017 Ap: 17	23 Mar 2017 Ap: 11	24 Feb 2017 Ap: 17
17 Dec 2017	20 Nov 2017	24 Oct 2017 Ap: 14	27 Sep 2017 Ap: 37	31 Aug 2017 Ap: 28	04 Aug 2017 Ap: 22	08 Jul 2017 Ap: 3	11 Jun 2017 Ap: 17	15 May 2017 Ap: 10	18 Apr 2017 Ap: 6	22 Mar 2017 Ap: 23	23 Feb 2017 Ap: 9
16 Dec 2017	19 Nov 2017	23 Oct 2017 Ap: 4	26 Sep 2017 Ap: 4	30 Aug 2017 Ap: 5	03 Aug 2017 Ap: 10	07 Jul 2017 Ap: 4	10 Jun 2017 Ap: 4	14 May 2017 Ap: 9	17 Apr 2017 Ap: 3	21 Mar 2017 Ap: 24	22 Feb 2017 Ap: 10
15 Dec 2017	18 Nov 2017	22 Oct 2017 Ap: 5	25 Sep 2017 Ap: 5	29 Aug 2017 Ap: 11	02 Aug 2017 Ap: 4	06 Jul 2017 Ap: 6	09 Jun 2017 Ap: 3	13 May 2017 Ap: 5	16 Apr 2017 Ap: 4	20 Mar 2017 Ap: 2	21 Feb 2017 Ap: 4
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13 Dec 2017	16 Nov 2017	20 Oct 2017 Ap: 8	23 Sep 2017 Ap: 6	27 Aug 2017 Ap: 9	31 Jul 2017 Ap: 2	04 Jul 2017 Ap: 4	07 Jun 2017 Ap: 6	11 May 2017 Ap: 6	14 Apr 2017 Ap: 12	18 Mar 2017 Ap: 1	19 Feb 2017 Ap: 9
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Show

Ap

- Ap
- Aaus
- Tdiff
- Solar wind
- CMEs
- Solar activity

Key

- Quiet: < 8
- Unsettled: < 16
- Active: < 30
- Minor storm: < 50
- Major storm
- (missing data)

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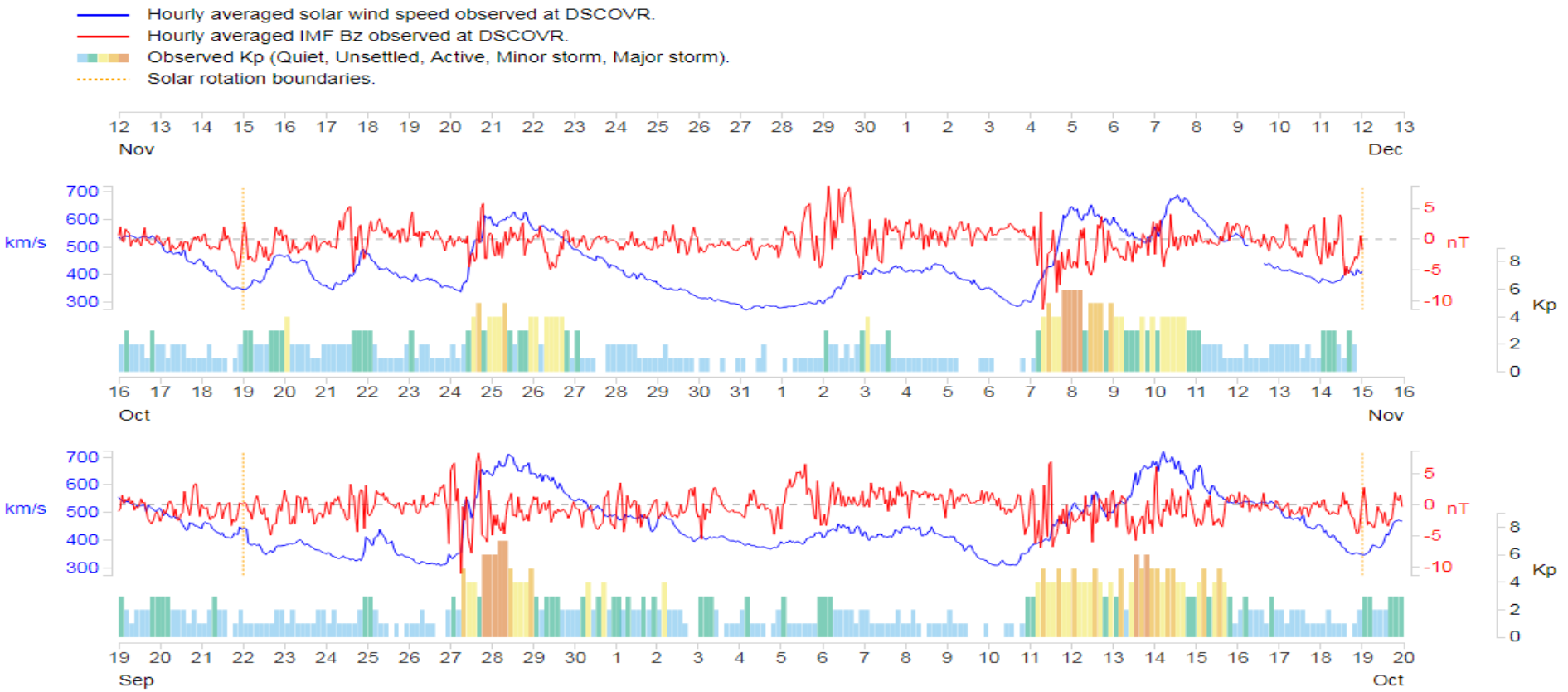
Variation of Kp with solar wind speed and IMF Bz

Solar wind

Show

Solar wind + Bz vs Kp

Comparison of DSCOVR hourly averaged solar wind speed and Bz with Kp (over 2 rotations).



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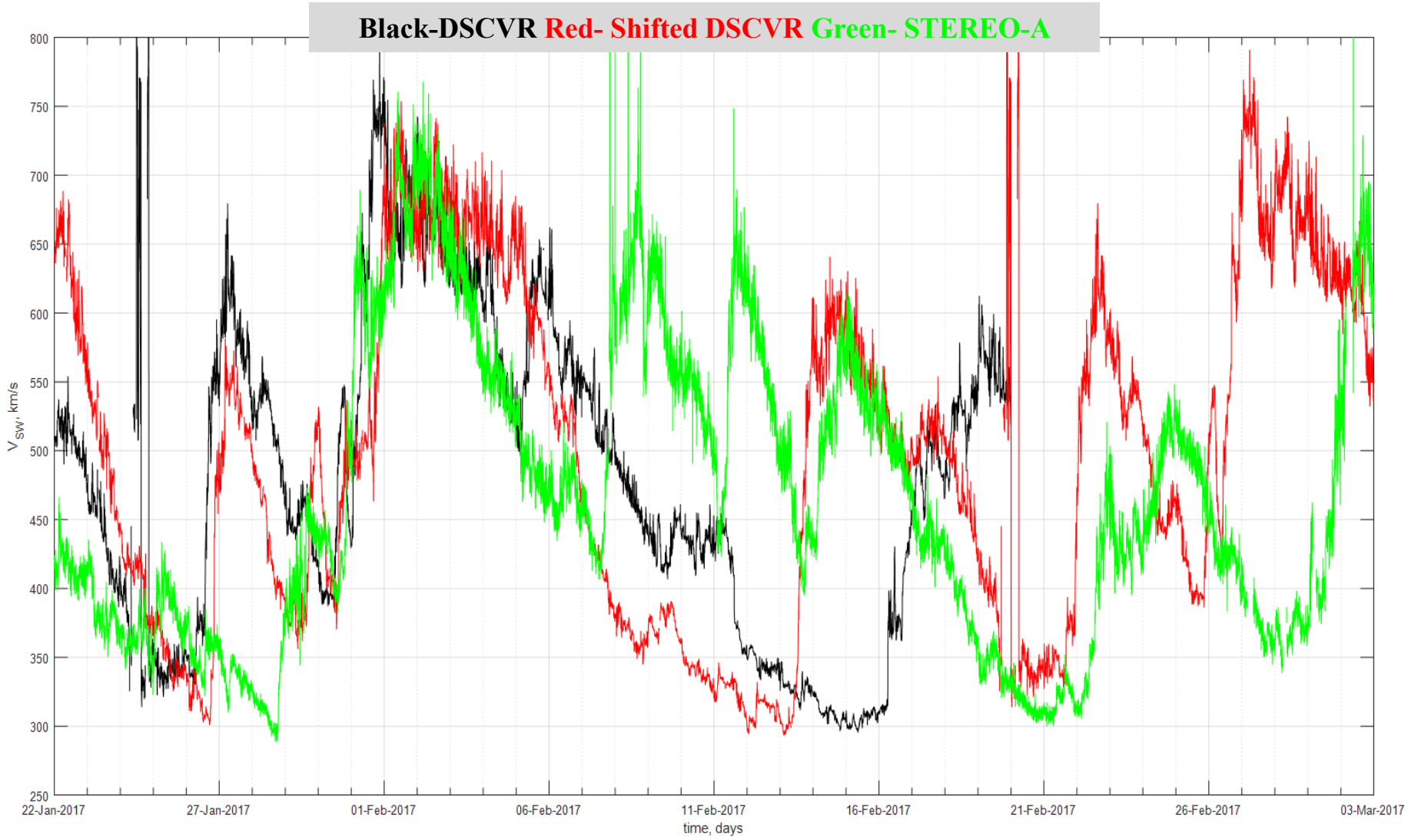
Solar wind speed data from DSCVR and STEREO-A



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Some aurora related products of SWS/BOM

http://www.sws.bom.gov.au/Products_and_Services

- **Possibility of Auroral Event** (available by SMS)
- Magnetic Alert (available by SMS)
- GEOmagnetic STorm Alert Tracking System (available by SMS)
- Solar Wind Shock Alert
- Solar Wind geomagnetic activity precursor Alert
- Forbush Decrease Alert
- **Geophysical Warning**
- Summary Forecast
- Daily Solar and Geophysical Report

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THANKS FOR YOUR ATTENTION !!