

# L1 Solar Wind, Kp, Aurora and GNSS Error Alerts



INSTITUT FÜR  
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L1 based short-term warnings of extreme space weather and its effects

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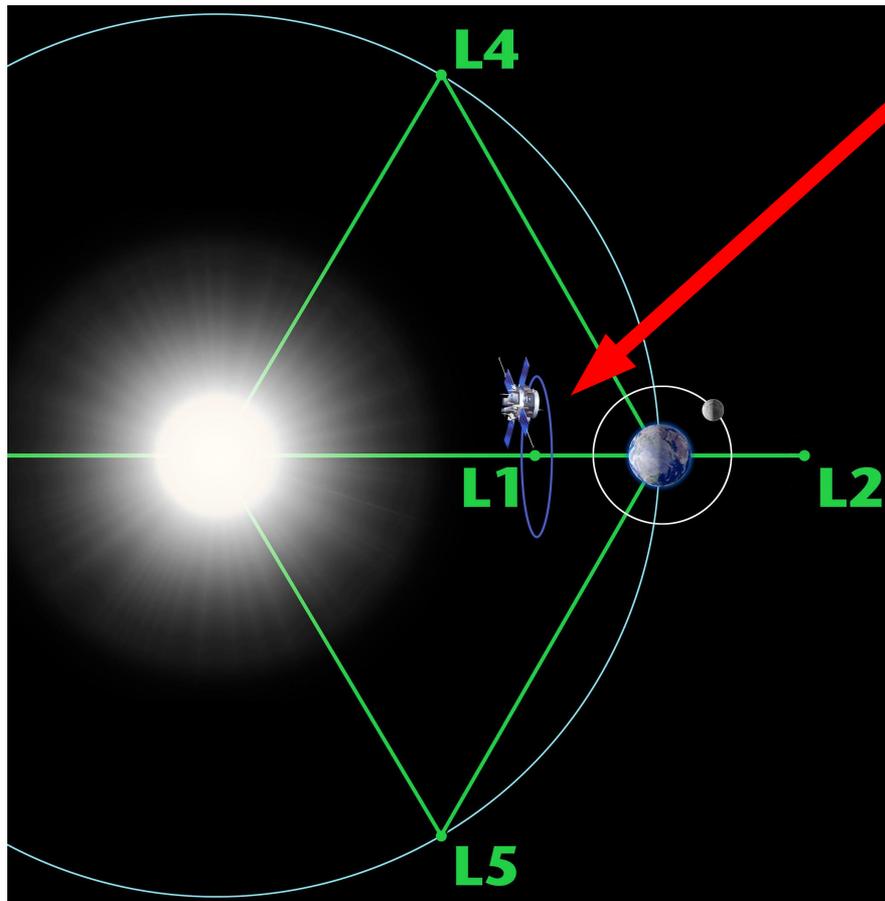
# Overview



Provision of short-time warnings of severe space weather effects via RSS feeds

- L1 ACE solar wind data
- RSS feed alerts:
  - L1 Solar Wind Alert (established)
  - L1 Kp Alert (preliminary)
  - L1 Aurora Alert (preliminary)
  - L1 GNSS Error Alert (in progress)

# L1 ACE solar wind data



Advanced Composition Explorer  
(ACE)

Spacecraft at L1 since 1997

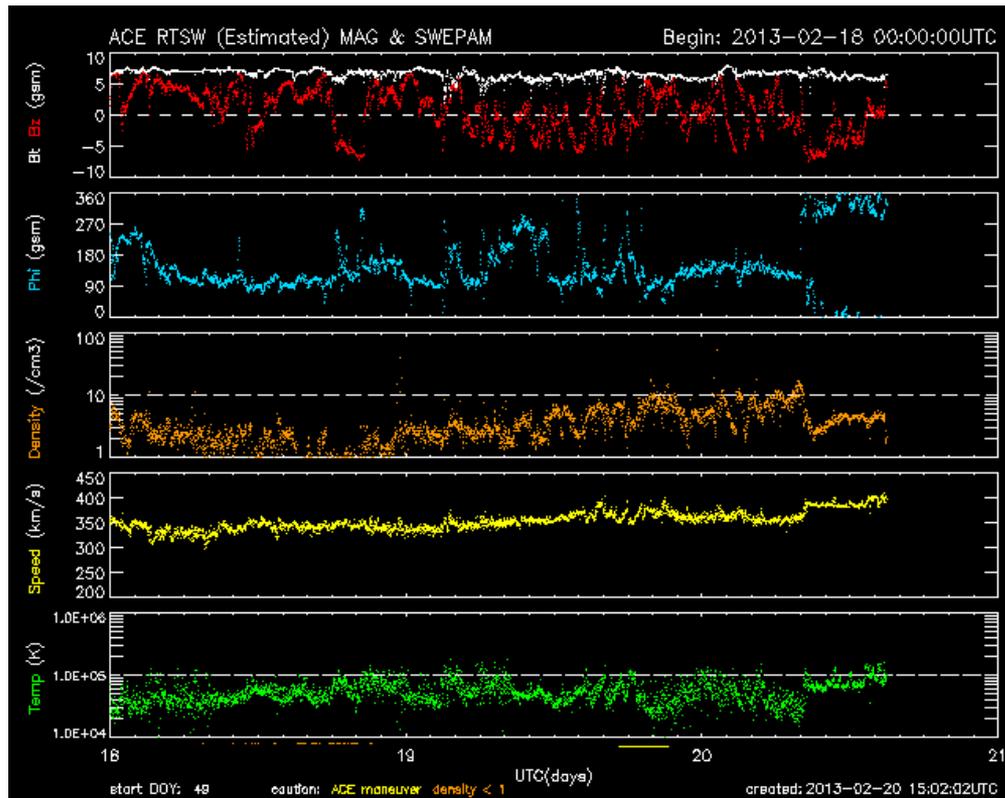
Provides real-time data online

In-situ solar wind parameters allow  
short-term forecast (> 10 min):

- ~3 min data delay to availability  
at SWPC server
- L1 to Earth travel time 12 - 60 min  
depending on speed (2000 - 400 km/s)

ACE satellite position around Lagrange 1.  
Credit: NASA/H. Zell

# ACE solar wind data



ACE dynamic real-time solar wind plot for the last 3 days.  
Credit: SWPC/NOAA

Measured solar wind parameters by  
MAG and SWEPA M instruments:

- Magnetic field strength
- Magnetic field orientation
- Proton density
- Bulk speed
- Ion temperature

Real-time data available from SWPC/NOAA:  
<http://www.swpc.noaa.gov/ftpmenu/lists/ace.html>

# L1 Solar Wind Alert



RSS feed: L1 Solar Wind Alert

Creates a new alert if thresholds of specified solar wind parameters are exceeded.

Uses 1-minute real-time data from ACE  
Update interval: 5 minutes

Actual thresholds:  $|B| = 15$  nT,  $B_z = 10$  nT and  $V = 600$  km/s  
- 31 warnings triggered since September 2012

Example warning:

**2013-02-19 17:45 Solar Wind Alert**

02/19/2013 06:51 PM

Last 2 hour extreme values:  $|B| = 7.7$  nT,  $B_z = -4.9$  nT and  $V = 401.8$  km/s. With current threshold values:  $|B| > 1$  nT,  $B_z < -10$  nT and  $V > 600$  km/s.

RSS subscription link:

[www.astro.physik.uni-goettingen.de/~mvvenzmer/rssfeed/rssfeed.xml](http://www.astro.physik.uni-goettingen.de/~mvvenzmer/rssfeed/rssfeed.xml)

# L1 Kp Alert



RSS feed: L1 Kp Alert

Extreme solar wind **affects** the Earth's magnetosphere.

Kp is a geomagnetic disturbance index, introduced by Bartels in 1948 at the Institute for Geophysics, Göttingen University.

Feed provides warnings of possible strong Kp conditions.

Creates a new alert if the estimated Kp exceeds a specified threshold.

Actual threshold: Kp = 7-

- No alerts since October 2012

Kp scale ranges from 0 to 9 with +/- substeps:

0    1    2    3    4    5    6    7    8    9  
0 + - 0 + - 0 + - 0 + - 0 + - 0 + - 0 + - 0 + - 0

Example warning:

**2013-02-19 16:12 Kp Alert**

02/22/2013 12:13 PM

Empirical Kp estimate from last 2 hour extreme solar wind values: Kp = 4- (ap = 22; 12 < ap < 32 with 68.3 % probability; 7 < ap < 67 with 95.4 % probability). With a current threshold value of Kp = 3.

RSS subscription link:

[www.astro.physik.uni-goettingen.de/~mvvenzmer/rssfeed\\_kp/rssfeed\\_kp.xml](http://www.astro.physik.uni-goettingen.de/~mvvenzmer/rssfeed_kp/rssfeed_kp.xml)



# L1 GNSS Error Alert



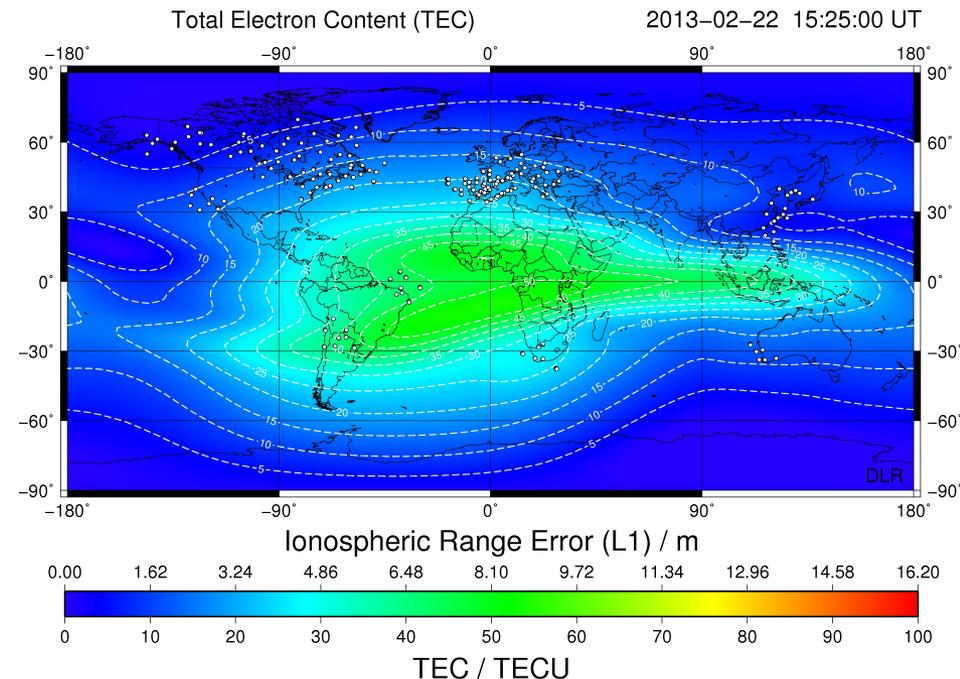
RSS feed: L1 GNSS Error Alert

Global navigation satellite system (GNSS)  
- Ionosphere positioning error is up to 30 m

Error scales with Total Electron Content (TEC)

TEC data is provided by DLR

Work on RSS alert is in progress



Global map of the total electron content.  
Credit: DLR/SWACI

# RSS feeds



RSS icon

Rich Site Summary (RSS) web feeds:

- They are used to publish frequently updated news.
- Their standardized XML file format can be viewed by many different feed readers.
- The RSS reader automatically checks the user's subscribed feeds regularly for new content.
- RSS allows users to avoid manually inspecting all of the websites they are interested in

# New RSS message



- Script:
- download of real-time data
  - processing of data
  - writes to XML file

```
#!/bin/sh
# Script for downloading the latest 2 h ACE real-time MAG + SWPM data files and writing alerts into a RSS file.

set -e

# Parameters
MAG=1
SWPM=1

# Download ACE data
wget -q -O- http://www.swpc.noaa.gov/products/ace/mag/mag_1m.txt > mag.txt
wget -q -O- http://www.swpc.noaa.gov/products/ace/swpm/swpm_1m.txt > swpm.txt

# Process data
python process_ace.py mag.txt swpm.txt > ace_data.txt

# Write to RSS file
python write_rss.py ace_data.txt > rssfeed.xml
```

## XML-RSS file

```
<?xml version="1.0" encoding="utf-8"?>
<channel>
  <title>L1 solar wind alert</title>
  <link>http://www.astro.physik.uni-goettingen.de/~avenzner/rssfeed4.xml</link>
  <description>L1 real-time ACE data alerts - ap prediction. Creates a new alert if the predicted ap value exceeds the threshold of ap > 111 (kp > 7) and the last two hour extrema. ap is estimated from the product VdBz (The magnetic field component Bz and the proton speed V from ACE). http://www.astro.physik.uni-goettingen.de/~avenzner/description/
  </description>
  <language>en</language>
  <copyright>2013, Malte Venzner</copyright>
  <pubDate>Thu, 10 Jan 2013 11:52:26 UTC</pubDate>
  <lastBuildDate>Thu, 10 Jan 2013 11:52:26 UTC</lastBuildDate>
  <docs>http://www.rssboard.org/rss-specification/docs</docs>
  <atom:link href="http://www.astro.physik.uni-goettingen.de/~avenzner/rssfeed4/rssfeed4.xml" rel="self" type="application/rss+xml" />
  </channel>
  <!-- insert the new item here -->
  <item>
    <title>Begin of automatic L1 solar wind alerts v4</title>
    <link>http://www.astro.physik.uni-goettingen.de/~avenzner/rssfeed4.xml</link>
    <description>The current threshold value is: ap = 111 (corresponds to kp = 7).</description>
    <pubDate>Thu, 10 Jan 2013 16:15:26 UTC</pubDate>
    <source url="http://www.astro.physik.uni-goettingen.de/~avenzner/">avenzner</source>
    <guid>http://www.astro.physik.uni-goettingen.de/~avenzner/420130110113794c/guid</guid>
  </item>
  <item>
    <title>2013-01-10 16:14 Solar wind alert</title>
    <link>http://www.astro.physik.uni-goettingen.de/~avenzner/rssfeed/alert_charts/20130110_161442_pngc</link>
    <description>Last 2 hour extreme values: ap = 3.69653, |B| = 5.7 nT, Bz = -5.1 nT, V = 336.5 km/s and VdBz = -1658.52 nTkm/s (threshold value: ap > 1)</description>
    <pubDate>Thu, 10 Jan 2013 16:14:42 UTC</pubDate>
    <source url="http://www.astro.physik.uni-goettingen.de/~avenzner/">avenzner</source>
    <guid>http://www.astro.physik.uni-goettingen.de/~avenzner/420130110161442c/guid</guid>
  </item>
  <item>
    <title>L1 solar wind ACE data</title>
    <link>http://www.astro.physik.uni-goettingen.de/~avenzner/realtimeacedata.php</link>
    <description>Current ACE data plotted</description>
    <pubDate>Thu, 10 Jan 2013 14:06:58 UTC</pubDate>
    <source url="http://www.astro.physik.uni-goettingen.de/~avenzner/">avenzner</source>
    <guid>http://www.astro.physik.uni-goettingen.de/~avenzner/41c/guid</guid>
  </item>
  <item>
    <title>Real-time space weather overview</title>
    <link>http://www.astro.physik.uni-goettingen.de/~avenzner/realtimepaceweather2.php</link>
    <description>Collection of the latest images/data relating to space weather</description>
    <pubDate>Thu, 20 Sep 2012 12:56:02 UTC</pubDate>
    <source url="http://www.astro.physik.uni-goettingen.de/~avenzner/">avenzner</source>
    <guid>http://www.astro.physik.uni-goettingen.de/~avenzner/41c/guid</guid>
  </item>
</channel>
```

## RSS feed reader

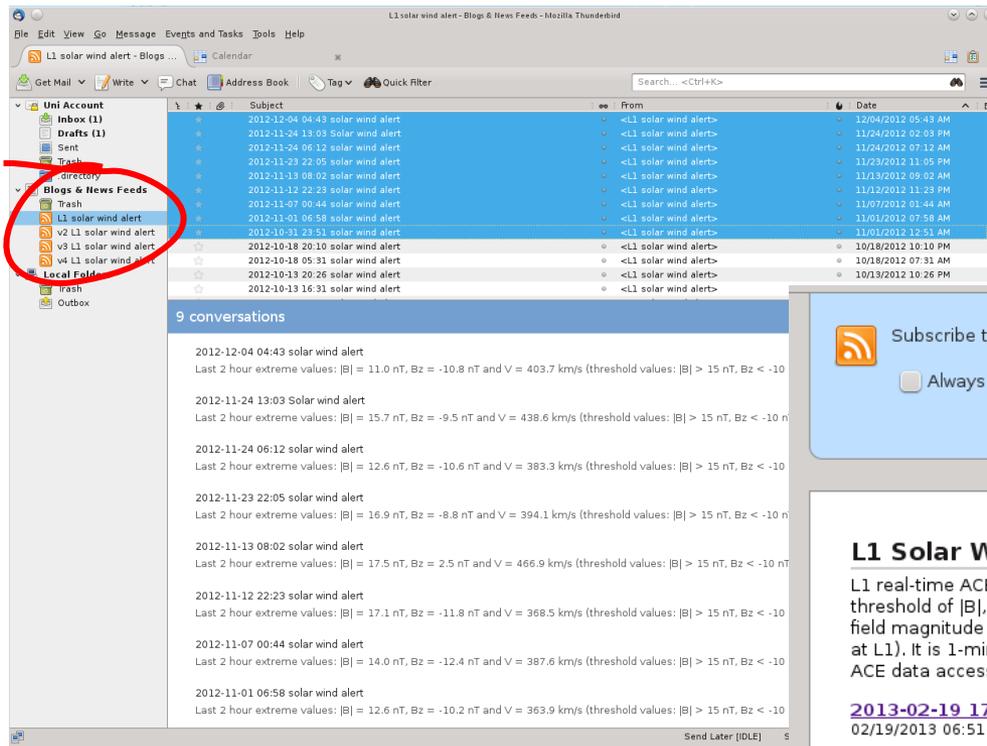
- L1 Solar Wind Alert**  
L1 real-time ACE data - L1 Solar Wind Alert. Creates a new alert if at least one threshold of |B|, Bz or V is exceeded by the last two hour extrema. (The magnetic field magnitude |B|, the magnetic field component Bz\_GSM and the proton speed V at L1). It is 1-minute data from MAG and SWEPAM instruments on the ACE satellite. ACE data accessed from SWPC/NOAA (<http://www.swpc.noaa.gov/ace/>).
- 2013-02-19 17:45 Solar Wind Alert**  
02/19/2013 06:51 PM  
Last 2 hour extreme values: |B| = 7.7 nT, Bz = -4.9 nT and V = 401.8 km/s. With current threshold values: |B| > 1 nT, Bz < -10 nT and V > 600 km/s.
- 2013-02-16 15:06 solar wind alert**  
02/16/2013 04:06 PM  
Last 2 hour extreme values: |B| = 12.2 nT, Bz = -10.4 nT and V = 440.1 km/s (threshold values: |B| > 15 nT, Bz < -10 nT and V > 600 km/s)
- 2013-02-01 07:21 solar wind alert**  
02/01/2013 08:21 AM  
Last 2 hour extreme values: |B| = 5.7 nT, Bz = -2.5 nT and V = 943.0 km/s (threshold values: |B| > 15 nT, Bz < -10 nT and V > 600 km/s)
- 2013-01-26 20:40 solar wind alert**  
01/26/2013 09:40 PM  
Last 2 hour extreme values: |B| = 12.1 nT, Bz = -10.5 nT and V = 543.6 km/s (threshold values: |B| > 15 nT, Bz < -10 nT and V > 600 km/s)
- 2013-01-26 14:28 solar wind alert**  
01/26/2013 03:28 PM  
Last 2 hour extreme values: |B| = 15.9 nT, Bz = -9.2 nT and V = 548.6 km/s (threshold values: |B| > 15 nT, Bz < -10 nT and V > 600 km/s)
- 2013-01-26 07:07 solar wind alert**  
01/26/2013 08:07 AM  
Last 2 hour extreme values: |B| = 11.4 nT, Bz = -10.2 nT and V = 518.8 km/s (threshold values: |B| > 15 nT, Bz < -10 nT and V > 600 km/s)
- 2013-01-25 17:44 solar wind alert**

# RSS subscription



Subscription via mobile feed reader, browser or email-client

Can be accessed with Thunderbird



Subscription in Firefox

Subscribe to this feed using   Always use Live Bookmarks to subscribe from feeds.

### L1 Solar Wind Alert

L1 real-time ACE data - L1 Solar Wind Alert. Creates a new alert if at least one threshold of  $|B|$ ,  $B_z$  or  $V$  is exceeded by the last two hour extrema. (The magnetic field magnitude  $|B|$ , the magnetic field component  $B_z$  and the proton speed  $V$  at L1). It is 1-minute data from MAG and SWEPAM instruments on the ACE satellite. ACE data accessed from SWPC/NOAA (<http://www.swpc.noaa.gov/ace/>).

**2013-02-19 17:45 Solar Wind Alert**  
02/19/2013 06:51 PM

Last 2 hour extreme values:  $|B| = 7.7$  nT,  $B_z = -4.9$  nT and  $V = 401.8$  km/s. With current threshold values:  $|B| > 1$  nT,  $B_z < -10$  nT and  $V > 600$  km/s.

**2013-02-16 15:06 solar wind alert**  
02/16/2013 04:06 PM

Last 2 hour extreme values:  $|B| = 12.2$  nT,  $B_z = -10.4$  nT and  $V = 440.1$  km/s (threshold values:  $|B| > 15$  nT,  $B_z < -10$  nT and  $V > 600$  km/s.)

# Thanks!



Questions?

## Summary

We provide short-time warnings of severe space weather effects via different RSS feed alerts:

- L1 Solar Wind Alert
- L1 Kp Alert
- L1 Aurora Alert
- L1 GNSS Error Alert