

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

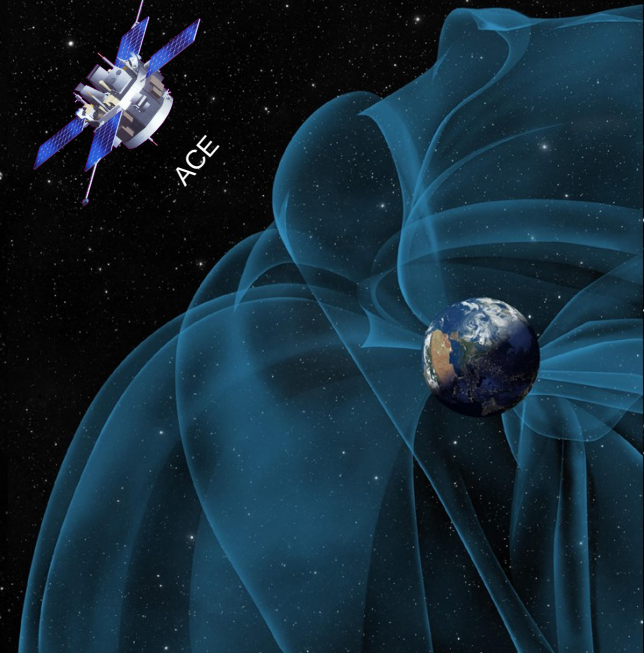


INSTITUT FÜR  
ASTROPHYSIK  
GÖTTINGEN

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

M. Venzmer, V. Bothmer, J. Hesemann, E. Bosman  
Institute for Astrophysics, Göttingen University, Germany

Contact:  
0049 551 39 5062  
[mvenzmer@astro.physik.uni-goettingen.de](mailto:mvenzmer@astro.physik.uni-goettingen.de)

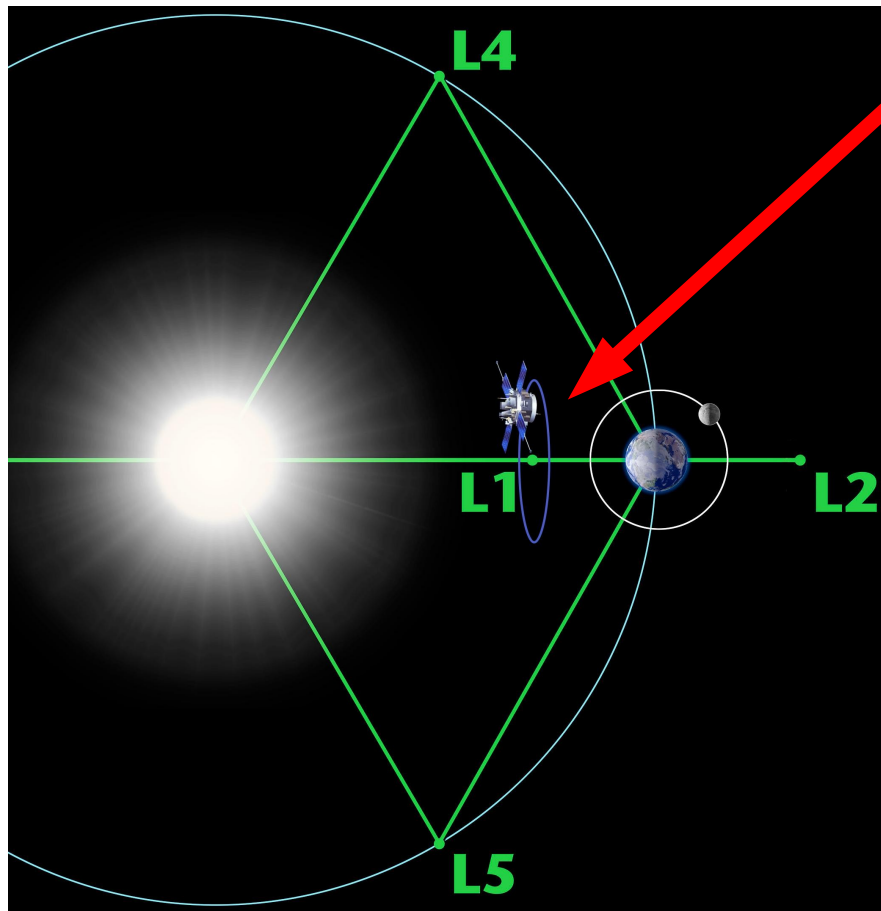




Provision of short-time warnings of severe space weather effects via RSS feeds

- 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

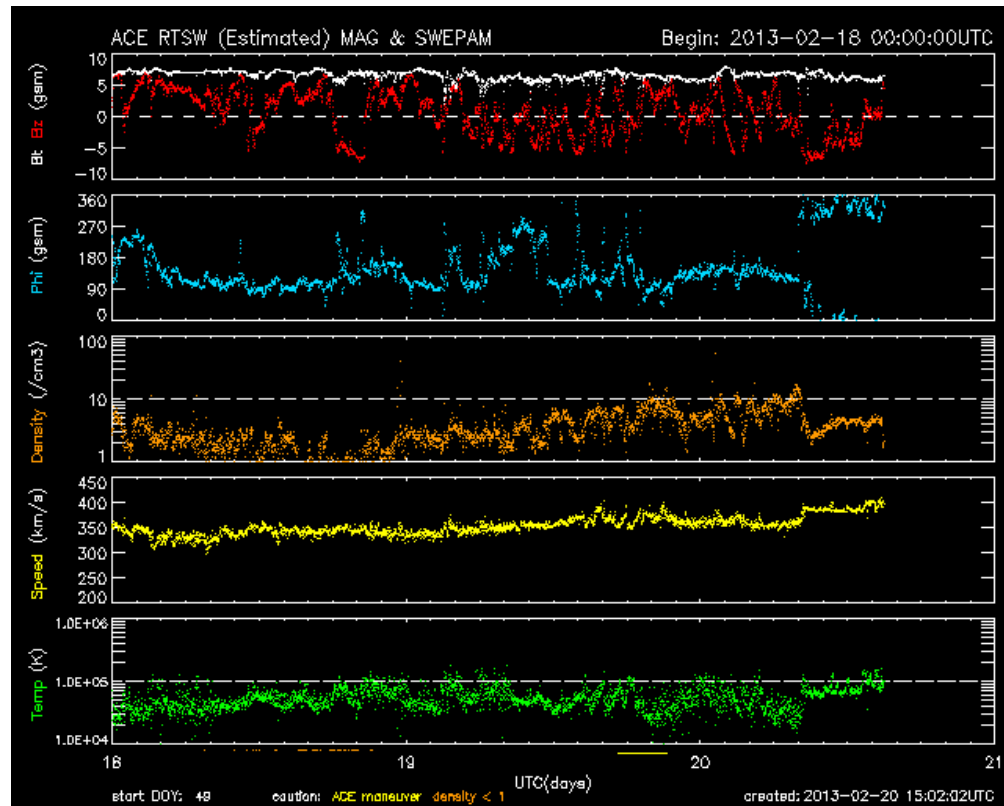
In-situ solar wind parameters allow  
short-term forecast (> 10 min):

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

# L1 Aurora Alert

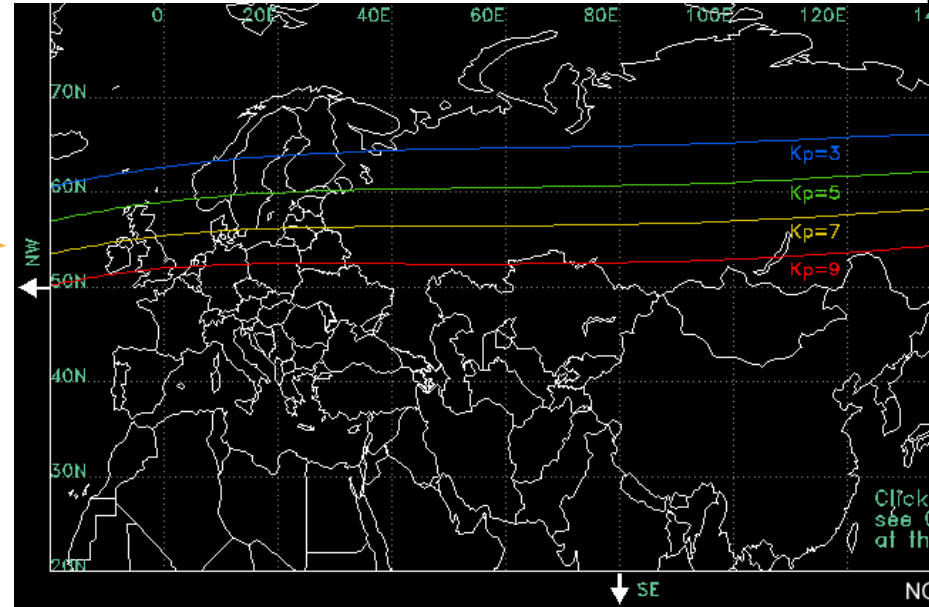


RSS feed: L1 Aurora Alert

Equatorward auroral boundary position correlates with Kp

Auroral position derived via estimated Kp index from solar wind data

Current threshold: 52.2° geomagnetic latitude  
- No alerts since January 2013



Map of midnight equatorward auroral boundaries for a Kp of 3, 5, 7 and 9. Credit: NOAA/SEC Boulder CO

Example warning:

## 2013-02-19 16:58 Aurora Alert

02/22/2013 12:17 PM

Southern auroral boundary estimate from last 2 hour solar wind extreme values. With a current threshold value of 64.5 deg geomagnetic latitude. Corrected magnetic latitude of the auroral boundary at local midnight: 58.3 deg. Corresponding NOAA POES Auroral Activity Level (1 to 10++): 7. Possible viewing locations in Europe: Trondheim

RSS subscription link:

[www.astro.physik.uni-goettingen.de/~mvenzmer/rssfeed\\_aurora/rssfeed\\_aurora.xml](http://www.astro.physik.uni-goettingen.de/~mvenzmer/rssfeed_aurora/rssfeed_aurora.xml)

# L1 GNSS Error Alert



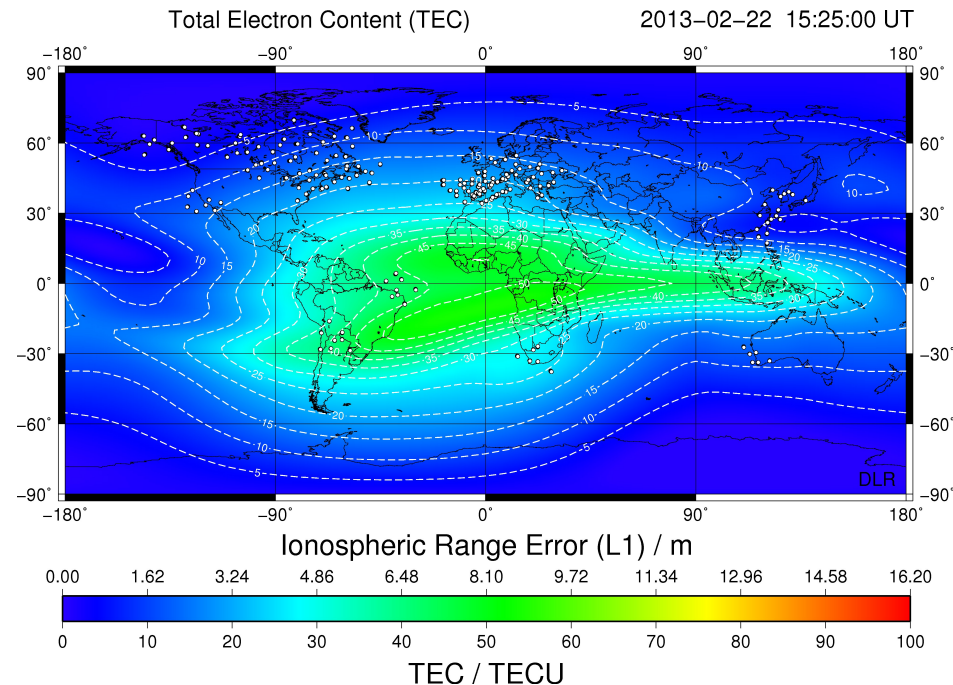
RSS feed: L1 GNSS Error Alert

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 1 h ACE real-time data + SWPM data files and writing alerts into a RSS file.

set -e

# Download ACE data
ACE=$(curl -s http://www.swp.noaa.gov/ftpdir/1/realtime/ace_mag_1m.txt)
ACE=$(cat $ACE)

# Download SWPM data
SWPM=$(curl -s http://www.swp.noaa.gov/ftpdir/1/realtime/swpm_mag_1m.txt)
SWPM=$(cat $SWPM)

# Process data and write to XML file
python process_data.py $ACE $SWPM
```

## XML-RSS file

```
<?xml version="1.0" encoding="utf-8"?>
<rss version="2.0" xmlns:atom="http://www.w3.org/2005/Atom">
  <channel>
    <title>L1 solar wind alert</title>
    <link>http://www.astro.physik.uni-goettingen.de/~avvenzner/rssfeed4/rssfeed4.xml</link>
    <description>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/~avvenzner/
    <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>
    <atom:link href="http://www.astro.physik.uni-goettingen.de/~avvenzner/rssfeed4/rssfeed4.xml" rel="self" type="application/rss+xml" />
  </channel>
  <item>
    <title>2013-01-10 16:14 Solar wind alert</title>
    <link>http://www.astro.physik.uni-goettingen.de/~avvenzner/rssfeed4/rssfeed4.xml</link>
    <description>The current threshold value is: ap = 111 (corresponds to Kp > 7-).</description>
    <pubDate>Thu, 10 Jan 2013 16:14:42 UTC</pubDate>
    <source>http://www.astro.physik.uni-goettingen.de/~avvenzner/rssfeed4/rssfeed4.xml</source>
    <guid>http://www.astro.physik.uni-goettingen.de/~avvenzner/420130110161442/guid</guid>
  </item>
  <item>
    <title>2013-01-10 16:14 Solar wind alert</title>
    <link>http://www.astro.physik.uni-goettingen.de/~avvenzner/rssfeed4/rssfeed4.xml</link>
    <description>The current threshold value is: ap = 111 (corresponds to Kp > 7-).</description>
    <pubDate>Thu, 10 Jan 2013 16:14:42 UTC</pubDate>
    <source>http://www.astro.physik.uni-goettingen.de/~avvenzner/rssfeed4/rssfeed4.xml</source>
    <guid>http://www.astro.physik.uni-goettingen.de/~avvenzner/420130110161442/guid</guid>
  </item>
  <item>
    <title>Real-time space weather overview</title>
    <link>http://www.astro.physik.uni-goettingen.de/~avvenzner/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>http://www.astro.physik.uni-goettingen.de/~avvenzner/realtimepaceweather2.php</source>
    <guid>http://www.astro.physik.uni-goettingen.de/~avvenzner/41</guid>
  </item>
</rss>
```

## 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<sub>y</sub> B<sub>z</sub> or V is exceeded by the last two hour extrema. (The magnetic field magnitude |B|, the magnetic field component B<sub>z</sub> 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, B<sub>z</sub> = -4.9 nT and V = 401.8 km/s. With current threshold values: |B| > 1 nT, B<sub>z</sub> < -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<sub>z</sub> = -10.4 nT and V = 440.1 km/s (threshold values: |B| > 15 nT, B<sub>z</sub> < -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, B<sub>z</sub> = -2.5 nT and V = 943.0 km/s (threshold values: |B| > 15 nT, B<sub>z</sub> < -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, B<sub>z</sub> = -10.5 nT and V = 543.6 km/s (threshold values: |B| > 15 nT, B<sub>z</sub> < -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, B<sub>z</sub> = -9.2 nT and V = 548.6 km/s (threshold values: |B| > 15 nT, B<sub>z</sub> < -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, B<sub>z</sub> = -10.2 nT and V = 518.8 km/s (threshold values: |B| > 15 nT, B<sub>z</sub> < -10 nT and V > 600 km/s)

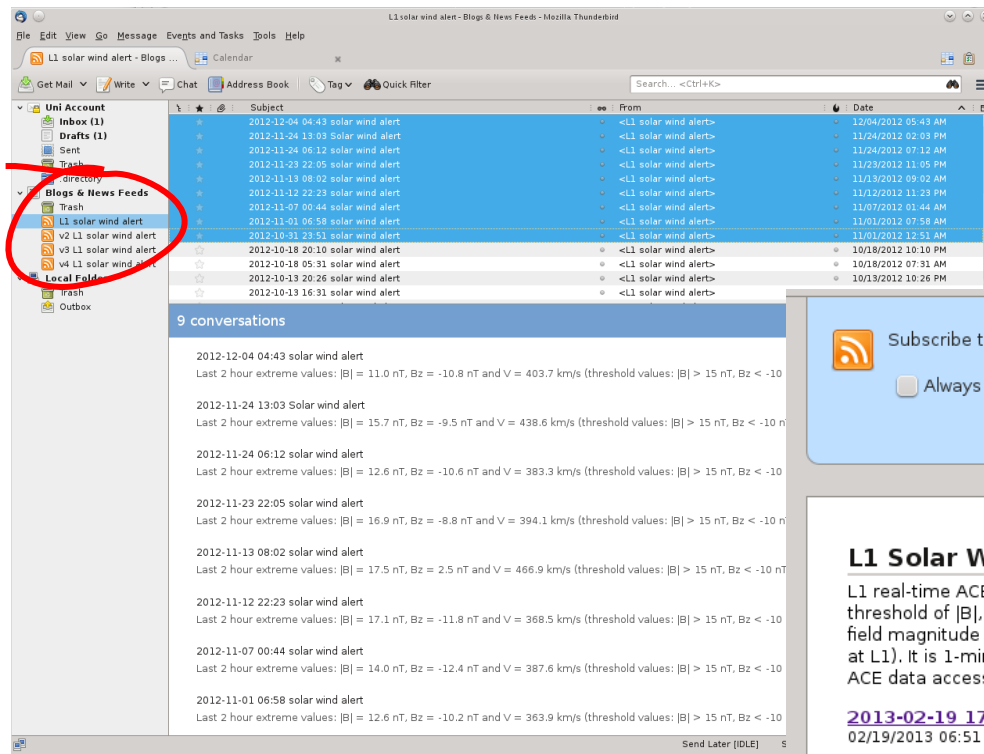
#### 2013-01-25 17:44 solar wind alert

# RSS subscription

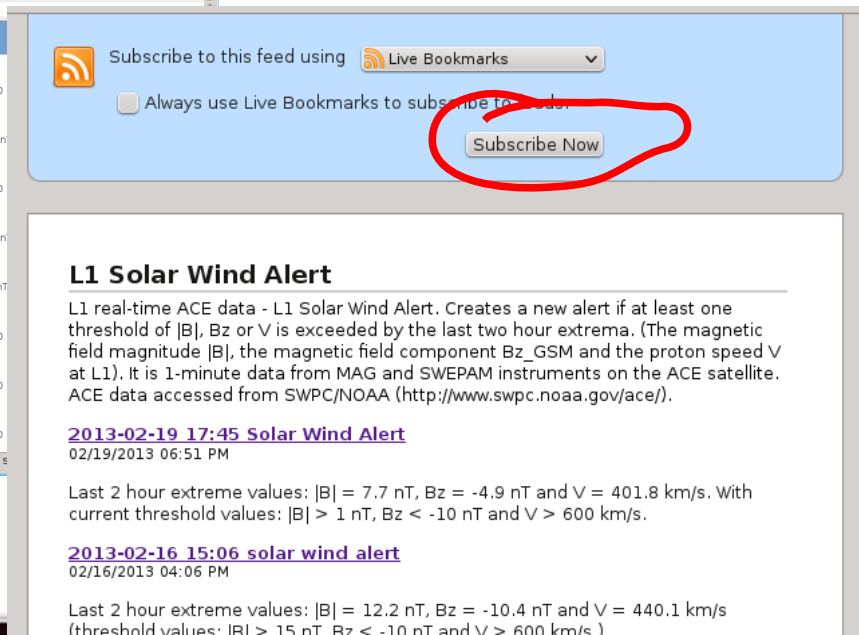


Subscription via mobile feed reader, browser or email-client

Can be accessed with Thunderbird



Subscription in Firefox



# 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