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Solar Numbers and Amateur Radio Propagation

What the heck are these numbers (and should I care)

- Solar Flux Index (SFI)
- K Index
- A Index
- G1 – G5 Solar storms
- Sunspot number
- X-Rays
- Solar Bulletins

Solar Flux Index (SFI)

- A measure of ionizing radiation from the sun
- Ranges from 50 – 300
- Measured by detecting the level of radio noise emitted by the sun at 2800 MHz (10.7 cm)
- Units are Solar Flux Units, which is 10^{-22} watts per square meter per Hertz
- Proportional to sunspot activity (number of sunspots, grouping of sunspots)

Solar Flux Index (SFI)

- The higher this number is, the better radio waves bounce off the upper atmosphere (F region)
- The longer this number stays high, the better ionized the upper atmosphere is, which results in better propagation.

K Index

- K index is a measure of the **variation** of the Earth's magnetic field over a three hour period, compared to a quiet day.
- Measurement is nano-Teslas, which is converted to a K index (logarithmic scale)
- Range is 0 – 9
- Measurements are taken around the world and vary by location

Kp Index

- Kp is the Planetary K index
- Average of K index readings from around the world.
- Range from 0 – 9
- For amateur radio purposes, the lower this number is, the better the propagation.
- Values above 5 indicate a geomagnetic storm.

A Index

- Daily average on a linear scale of magnetometer variations
- Kp index is converted to a linear scale to create the A index
- **The A index is the average of 8 consecutive Kp readings** (24 hours)
- Range from 0 – 400 (sometimes higher)
- Ap is Planetary A index
- Lower is better for propagation

K and A index Relationships

Ap Index	Kp Index	nTeslas	NOAA G scale	Description
0	0	0-5	G0	Quiet
4	1	5-10	G0	Quiet
7	2	10-20	G0	Unsettled
15	3	20-40	G0	Unsettled
27	4	40-70	G0	Active
48	5	70-120	G1	Minor Storm
80	6	120-200	G2	Moderate
132	7	200-330	G3	Strong
208	8	330-500	G4	Severe
400	9	>500	G5	Extreme

Geomagnetic Storms

- NOAA "G" scale
- Measure of severity of magnetic storms
- Can affect power systems, satellites, and other utilities
- Directly related to Kp Index
- Caused by Coronal Mass Ejections (CMEs)

G1, Kp = 5, Minor

- **1700 storms per cycle**
- **Power systems:** weak power grid fluctuations can occur.
- **Spacecraft operations:** minor impact on satellite operations possible.
- **Other systems:** migratory animals are affected at this and higher levels; aurora is commonly visible at high latitudes (northern Michigan and Maine)

G2 , Kp = 6, Moderate

- **600 storms per cycle**
- **Power systems:** high-latitude power systems may experience voltage alarms, long-duration storms may cause transformer damage.
- **Spacecraft operations:** corrective actions to orientation may be required by ground control; possible changes in drag affect orbit predictions.
- **Other systems:** HF radio propagation can fade at higher latitudes, and aurora has been seen as low as New York and Idaho (typically 55° geomagnetic lat.)

G3 , Kp = 7, Strong

- **200 storms per cycle**
- **Power systems:** voltage corrections may be required, false alarms triggered on some protection devices.
- **Spacecraft operations:** surface charging may occur on satellite components, drag may increase on low-Earth-orbit satellites, and corrections may be needed for orientation problems.
- **Other systems:** intermittent satellite navigation and low-frequency radio navigation problems may occur, HF radio may be intermittent, and aurora has been seen as low as Illinois and Oregon (typically 50° geomagnetic lat.)

G4 , Kp = 8, Severe

- **100 storms per cycle**
- **Power systems:** possible widespread voltage control problems and some protective systems will mistakenly trip out key assets from the grid.
- **Spacecraft operations:** may experience surface charging and tracking problems, corrections may be needed for orientation problems.
- **Other systems:** induced pipeline currents affect preventive measures, HF radio propagation sporadic, satellite navigation degraded for hours, low-frequency radio navigation disrupted, and aurora has been seen as low as Alabama and northern California (typically 45° geomagnetic lat.)

G5 , Kp = 9, Extreme

- **4 storms per cycle**
- **Power systems:** widespread voltage control problems and protective system problems can occur, some grid systems may experience complete collapse or blackouts. Transformers may experience damage.
- **Spacecraft operations:** may experience extensive surface charging, problems with orientation, uplink/downlink and tracking satellites.
- **Other systems:** pipeline currents can reach hundreds of amps, HF (high frequency) radio propagation may be impossible in many areas for one to two days, satellite navigation may be degraded for days, low-frequency radio navigation can be out for hours, and aurora has been seen as low as Florida and southern Texas (typically 40° geomagnetic lat.)

Sunspots

- Sunspots are areas where there is intense magnetic activity.
- The number of sunspots on the Sun has a considerable effect on the levels of radiation emitted and hence impacting on the ionosphere.
- Sunspot number usually correlates well to SFI

Sunspot numbers

- Estimation of the number of sunspots.
- As a rule of thumb, if you divide either of the official sunspot numbers by 15, you'll get the approximate number of individual sunspots visible on the solar disk if you look at the Sun by projecting its image on a paper plate with a small telescope.

Solar X-ray emissions

- Very high X-rays emissions result in HF blackouts!
- X-ray bursts caused by solar flares
- If the band fades quickly, it was likely caused by a solar flare.
- Scale:
  - A is the lowest level,
  - B is 10 times more powerful than A,
  - C is 10 times more powerful than B,
  - M is 10 times more powerful than C,
  - X is 10 times stronger than M.

Maximum Usable Frequency (MUF)

- MUF does not correlate to daily SFI numbers
- MUF directly related to smoothed (monthly) solar flux
- There must be several consecutive days of sustained high solar radiation with the absence of solar disturbances (low A and K) for high MUFs for HF band radio communications.

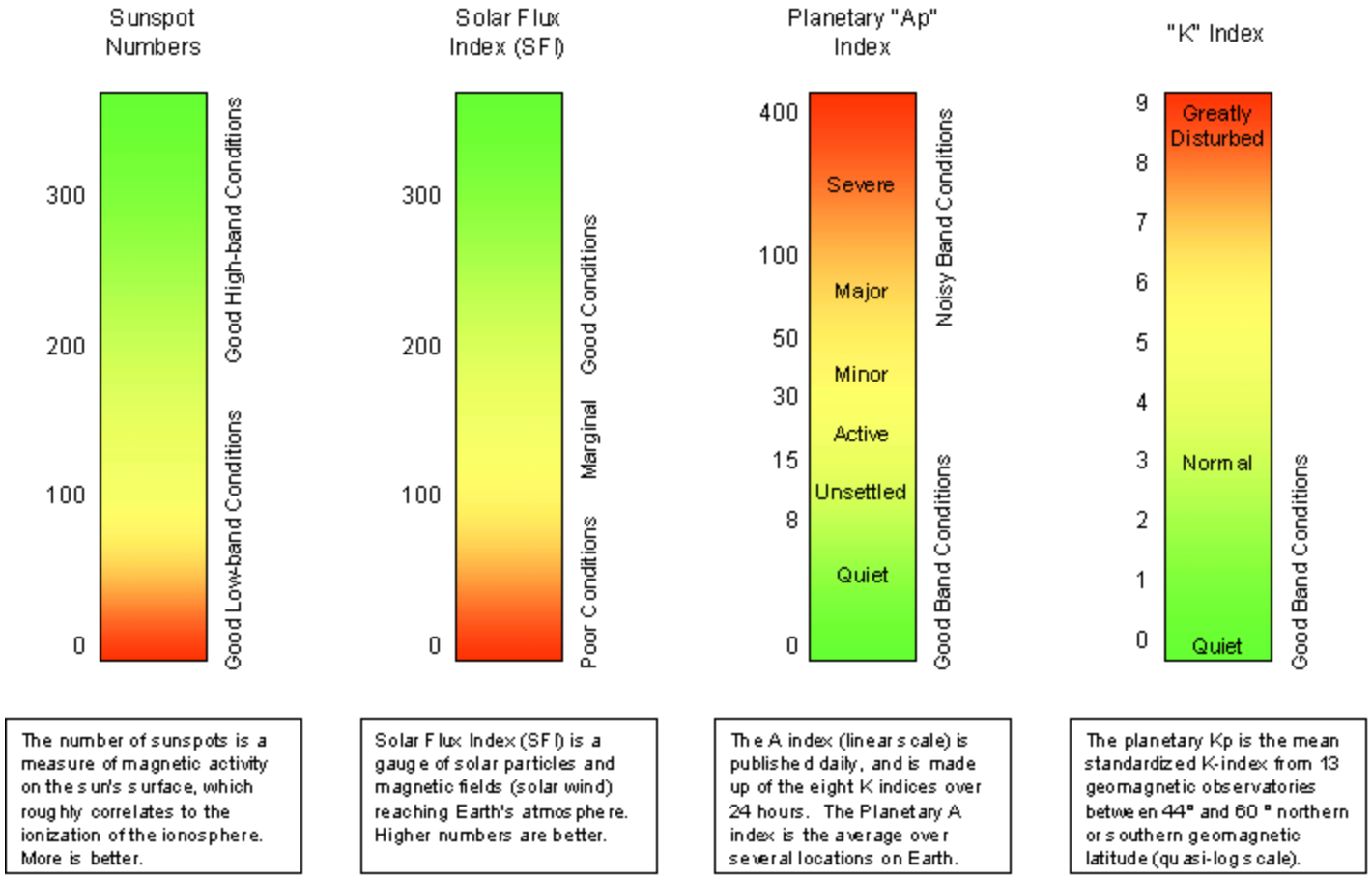
RN7A's Ratings

- **K index [LOW is GOOD]**
  - 0 or 1 is BEST
  - 2 is OK
  - 3 or more is BAD
  - 5 is VERY VERY BAD
- **The A index [LOW is GOOD]**
  - 1 to 6 is BEST
  - 7 to 9 is OK
  - 11 or more is BAD
- **SFI index [HIGH is GOOD]**
  - 70 NOT GOOD
  - 80 GOOD
  - 90 BETTER
  - 100+ BEST

RN7A's Ratings

- A lower K-Index generally suggests better propagation on the 10, 12, 15, 17, & 20 Meter Bands; a low & steady Kp-Index generally suggest good propagation on the 30, 40, 60, 80, & 160 Meter Bands.

N2LVI's Propagation Chart



http://www.qsl.net/w2vtm/hf_solar.html

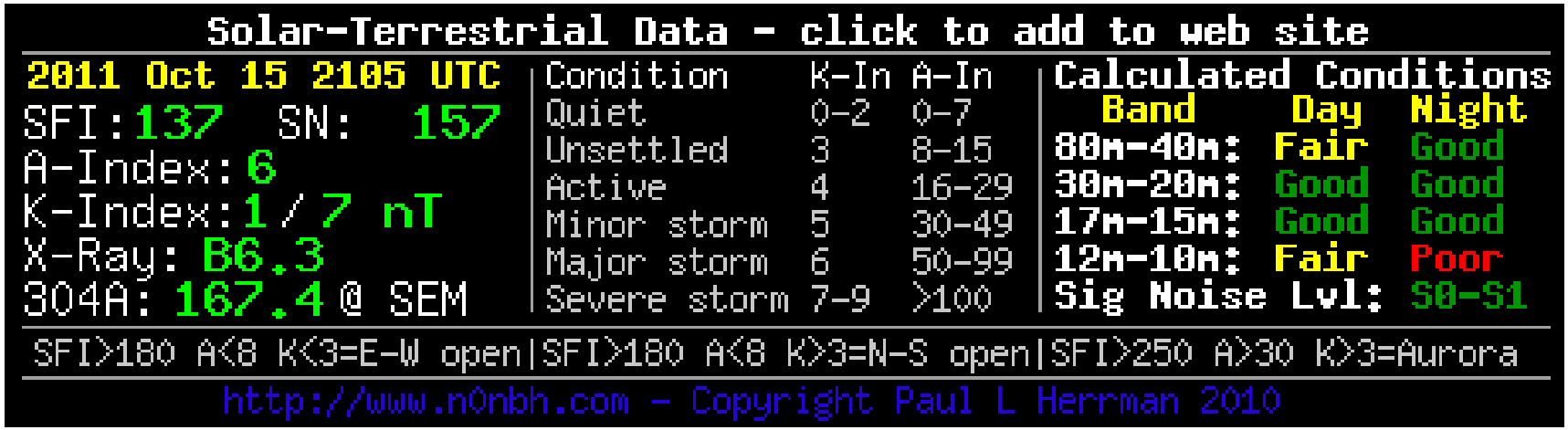
WWV Alert

- http://www.swpc.noaa.gov/ftpdir/latest/wwv.txt

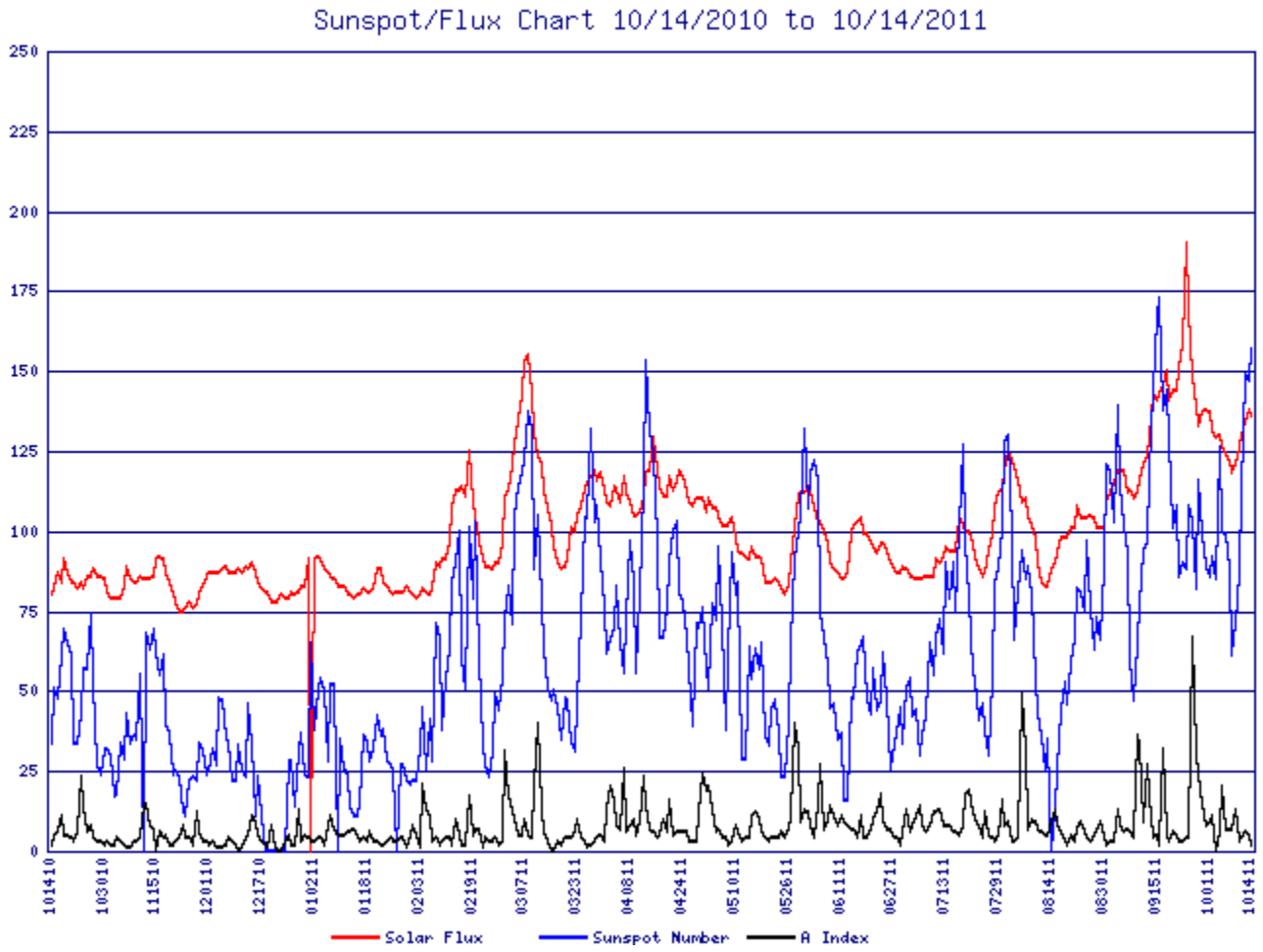
```
:Product: Geophysical Alert Message wwv.txt
:Issued: 2011 Oct 15 2105 UTC
# Prepared by the US Dept. of Commerce, NOAA, Space Weather
   Prediction Center
#
# Geophysical Alert Message
#
Solar-terrestrial indices for 15 October follow.
Solar flux 138 and estimated mid-latitude A-Index 6.
The mid-latitude K-index at 2100 UTC on 15 October was 1 (7 nT).
No space weather storms were observed for the past 24 hours.
No space weather storms are predicted for the next 24 hours.
```

Solar Report

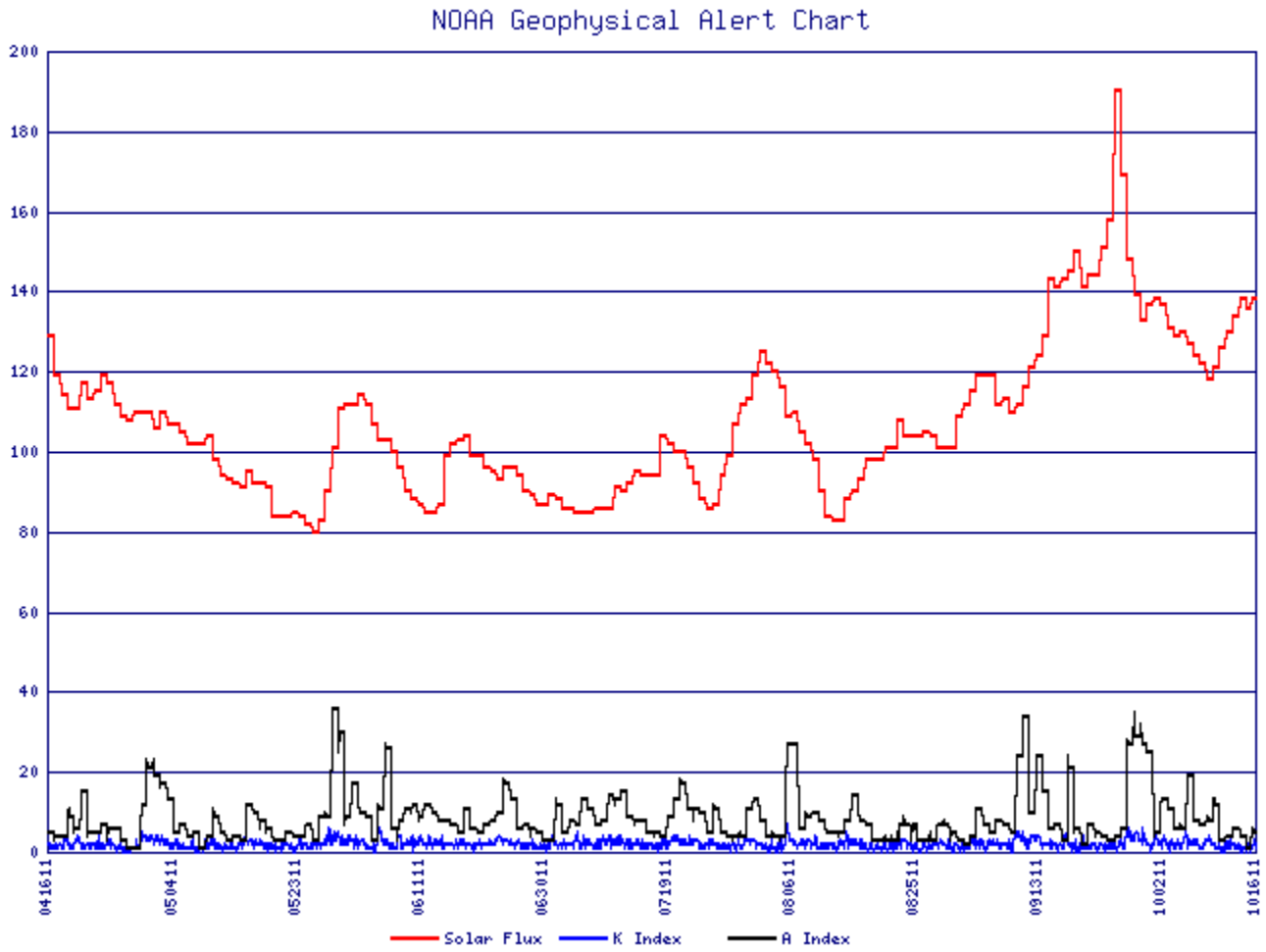
- http://www.k7pt.com/solarphp.php



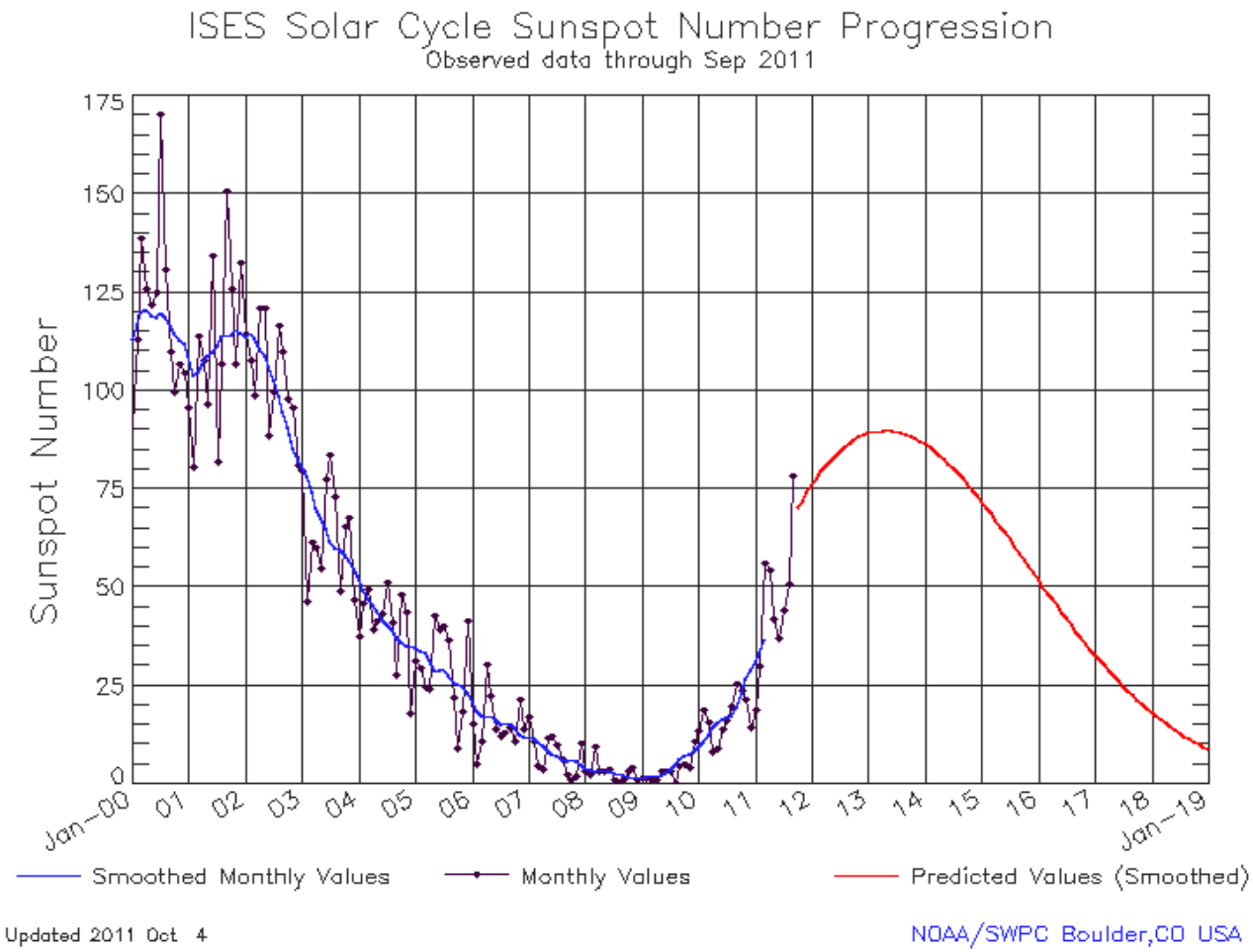
Solar Flux, Sunspots, A Index



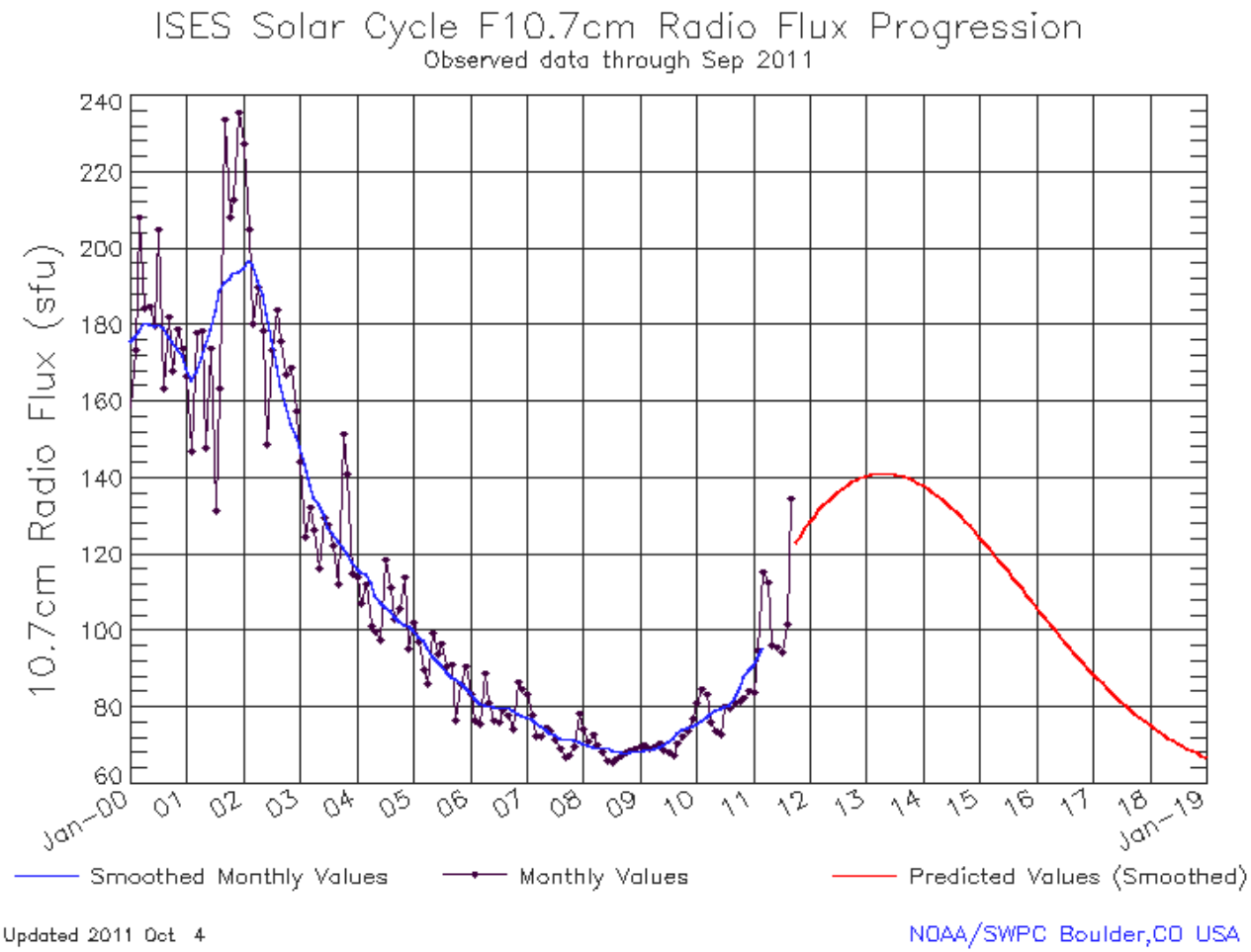
Solar Flux, K index, A Index



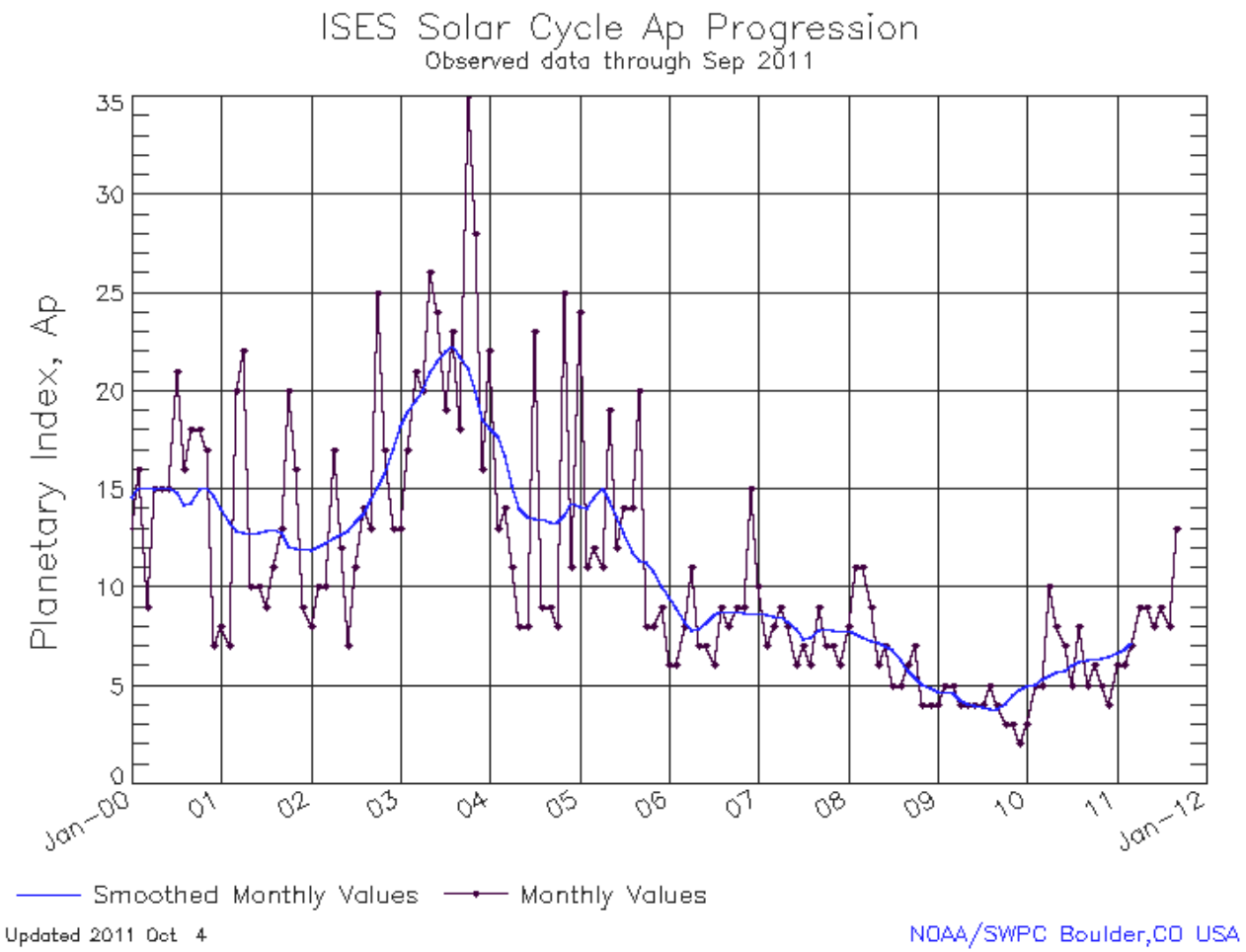
Sunspot number progression



Solar Flux Progression



Ap Progression



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Questions / Discussion

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