

# NOAA SWPC Proton Prediction Model

- Operational proton prediction model currently used by the NOAA SWPC forecast office (Balch 99, Balch 08).
- Statistical model based on the association of flares with SEP events (>1 pfu for >10 MeV protons measured at GOES). Trained on events from 1986 to 2004.
- Input parameters:
  - peak soft X-ray flux
  - integrated soft X-ray flux
  - flare location
  - occurrence of metric Type II and Type IV radio bursts.
- Model output: probability of proton event, predicted max flux at 10 MeV and time of max flux.
- Prediction of max flux from statistical relationship between log integrated X-ray flux of the associated flare with log peak flux of proton event.
- Rise time prediction (time difference between the X-ray max and proton max) from empirical relationship with the location of the flare on the solar disk.

# Model results: July 2017

Proton Prediction Model
X

Flare Max Date: July 14 2017

Flare Max Time: 0209 UT

Flare Location: S06W29

X-ray Class: M2

Optical Class: 1N

Integrated Flux: 0.1300

Current Ap: 5 Connecting Longitude = 75

Radio Sweep

Type II  Type IV  Both  Neither  Unknown

Type IV Duration: [ ] minutes

Type IV Importance: [ ]

Previous Flare from this region?  N  Y or N

Previous flare integrated flux: [ ]

Print Save Exit

Help

For a flare with the following parameters:  
 0209UT 14 July 2017 Location S06W29  
 X-ray class: M2 Optical class: 1N Integrated Flux: 0.1300  
 Previous Flare: none  
 Radio Sweep type: unknown

The probability of protons as a result of the flare is **2%**  
 Should a proton enhancement occur, the following values

| Integral |        |         |         |         |         |          |
|----------|--------|---------|---------|---------|---------|----------|
| >1 MeV   | >5 MeV | >10 MeV | >15 MeV | >30 MeV | >50 MeV | >100 MeV |
| 200.2    | 120.6  | 82.8    | 61.9    | 32.4    | 16.8    | 5.1      |

| Differential |        |         |         |         |         |          |
|--------------|--------|---------|---------|---------|---------|----------|
| @1 MeV       | @5 MeV | @10 MeV | @15 MeV | @30 MeV | @50 MeV | @100 MeV |
| 137.1        | 43.1   | 20.1    | 13.1    | 3.5     | 1.2     | 0.5      |

Delay time to start of 10 MeV protons is 3.5 to 13.2 hours  
 (0540/14 Jul to 1522/14 Jul)

Rise time to 10 MeV flux max is 7.0 to 26.4 hours  
 (0912/14 Jul to 0436/15 Jul)

Predicted PCA (dB): Daytime 3.70  
 Night 0.92

SST Peak Dose Rate at 65000 Ft is 0.36 Millirems per Hr  
 Hours to onset: 3.3 Hours to max: 6.2

The probability of a sudden commencement is 0%  
 Delay time until the SSC is 42 to 60 hours  
 (2009/15 Jul to 1409/16 Jul)

The predicted Ap for 24 hours following the SSC is 44

| Probability, in percent, of seeing aurora overhead/at all |       |     |       |     |       |     |       |
|---|-------|-----|-------|-----|-------|-----|-------|
| SEA   | 10/60 | RPD | 40/90 | CHI | 40/90 | NY  | 40/90 |
| POR   | 0/30  | BOU | 0/30  | STL | 10/60 | WAS | 10/60 |
| SF  | 0/10  | ABQ | 0/0   | LRK | 0/0   | CHR | 0/0   |
| LA  | 0/0   | ELP | 0/0   | NOR | 0/0   | MIA | 0/0   |

- MISS
- Probability of proton event: 2%

# Model results: September 2017

## Sept 6<sup>th</sup> 2017

- **HIT**
- Probability of proton event: 45%
- 10 MeV max: 49.7 pfu
- Time to start: 3.3 – 12.3 hours

For a flare with the following parameters:  
 1202UT 06 September 2017 Location S08W33  
 X-ray class: X9 Optical class: 2B Integrated Flux: 0.5700  
 Previous Flare: Yes Previous Flare Integrated Flux: 0.1300  
 Radio using Type II/IV: Type IV Duration: 194 Importance: 2

The probability of protons as a result of the flare is 45%  
 Should a proton enhancement occur, the following values

Integral

|        |        |         |         |         |         |          |
|--------|--------|---------|---------|---------|---------|----------|
| >1 MeV | >5 MeV | >10 MeV | >15 MeV | >30 MeV | >50 MeV | >100 MeV |
| 424.6  | 282.5  | 208.8   | 165.3   | 98.2    | 57.9    | 22.2     |

Differential

|        |        |         |         |         |         |          |
|--------|--------|---------|---------|---------|---------|----------|
| @1 MeV | @5 MeV | @10 MeV | @15 MeV | @30 MeV | @50 MeV | @100 MeV |
| 286.4  | 99.0   | 49.7    | 34.0    | 10.5    | 4.1     | 2.0      |

Delay time to start of 10 MeV protons is 3.3 to 12.3 hours  
 (1519/06 Sep to 0021/07 Sep)  
 Rise time to 10 MeV flux max is 6.6 to 24.6 hours  
 (1836/06 Sep to 1240/07 Sep)

Predicted PCA (dB): Daytime 5.87  
 Night 1.47  
 SST Peak Dose Rate at 65000 Ft is 1.99 Millirems per Hr  
 Hours to onset: 2.0 Hours to max: 3.7

The probability of a sudden commencement is 86%  
 Delay time until the SSC is 30 to 42 hours  
 (1802/07 Sep to 0602/08 Sep)  
 The predicted Ap for 24 hours following the SSC is 74

Probability, in percent, of seeing aurora overhead/at all

|     |       |     |       |     |       |     |       |
|-----|-------|-----|-------|-----|-------|-----|-------|
| SEA | 40/90 | RPD | 90/95 | CHI | 90/95 | NY  | 90/95 |
| POR | 10/60 | BOU | 10/60 | STL | 40/90 | WAS | 40/90 |
| SF  | 0/30  | ABQ | 0/10  | LRK | 0/10  | CHR | 0/10  |
| LA  | 0/10  | ELP | 0/0   | NOR | 0/0   | MIA | 0/0   |

## Sept 10<sup>th</sup> 2017

- **HIT**
- Probability of proton event: 30%
- 10 MeV max: 64.4 pfu
- Time to start: 2.1 – 7.8 hours

For a flare with the following parameters:  
 1606UT 10 September 2017 Location S09W90  
 X-ray class: X8 Optical class: 1N Integrated Flux: 1.4000  
 Previous Flare: Yes Previous Flare Integrated Flux: 0.0690  
 Radio using Type II/IV: Type IV Duration: 31 Importance: 2

The probability of protons as a result of the flare is 30%  
 Should a proton enhancement occur, the following values

Integral

|        |        |         |         |         |         |          |
|--------|--------|---------|---------|---------|---------|----------|
| >1 MeV | >5 MeV | >10 MeV | >15 MeV | >30 MeV | >50 MeV | >100 MeV |
| 1020.6 | 738.7  | 581.4   | 482.9   | 319.5   | 210.1   | 98.2     |

Differential

|        |        |         |         |         |         |          |
|--------|--------|---------|---------|---------|---------|----------|
| @1 MeV | @5 MeV | @10 MeV | @15 MeV | @30 MeV | @50 MeV | @100 MeV |
| 413.1  | 131.4  | 64.4    | 34.3    | 10.1    | 4.2     | 2.3      |

Delay time to start of 10 MeV protons is 2.1 to 7.8 hours  
 (1811/10 Sep to 2353/10 Sep)  
 Rise time to 10 MeV flux max is 4.2 to 15.6 hours  
 (2015/10 Sep to 0740/11 Sep)

Predicted PCA (dB): Daytime 9.80  
 Night 2.45  
 SST Peak Dose Rate at 65000 Ft is 13.37 Millirems per Hr  
 Hours to onset: 1.0 Hours to max: 1.7

The probability of a sudden commencement is 0%  
 Delay time until the SSC is 66 to 96 hours  
 (1006/13 Sep to 1606/14 Sep)  
 The predicted Ap for 24 hours following the SSC is 32

Probability, in percent, of seeing aurora overhead/at all

|     |      |     |       |     |       |     |       |
|-----|------|-----|-------|-----|-------|-----|-------|
| SEA | 0/30 | RPD | 10/60 | CHI | 10/60 | NY  | 10/60 |
| POR | 0/10 | BOU | 0/10  | STL | 0/30  | WAS | 0/30  |
| SF  | 0/0  | ABQ | 0/0   | LRK | 0/0   | CHR | 0/0   |
| LA  | 0/0  | ELP | 0/0   | NOR | 0/0   | MIA | 0/0   |

# Discussion questions

- How did your optimized run results differ from the initial run?
  - Single run based on flare parameters.
- What aspects of the event does your model capture well, and what aspects were more difficult to capture?
  - Used only for proton event prediction at Earth.
  - Flares occurring behind the limb automatically count as a miss.
  - POD: 0.57, FAR: 0.55
- What are the next steps for your modeling technique?
  - Many potential improvements could be made to the model.
  - Currently investigating a machine learning classification approach for probability of event occurrence. Includes more features than original model.
  - Extension of statistics to the current solar cycle.

# Probabilistic S1 Forecasts - September 2017 (Earth\*)



