Aurorasaurus and the St Patrick's Day storm

Nathan A Case, Elizabeth A MacDonald and Kasha G Patel
examine the spectacular response of citizen scientists to a once-in-a-decade geomagnetic storm.

1 An aurora photo taken by an Aurorasaurus user near Berlin, Germany.

The recent St Patrick's Day geomagnetic storm provided a rare chance for the public to witness a dazzling auroral display, even from mid-latitudes. An unprecedented number of people reported their sightings to the citizen-science project Aurorasaurus, offering an exciting opportunity for future study.

The geomagnetic storm of 17–19 March 2015, colloquially known as the St Patrick's Day storm, is the largest storm of solar cycle 24 to date. A fortuitous combination of an Earthward directed, southward oriented coronal mass ejection (CME) and a high-speed stream meant that the solar wind buffeted the Earth's magnetic field to create a once-in-a-decade event.

At its peak, the storm registered as "severe" (G4) on the National Oceanographic and Atmospheric Administration (NOAA) storm scale (Poppe 2000). Geomagnetic indices reached their highest levels in many years, with a maximum real-time Kp index of 8 and a minimum real-time Dst index of –228 nT, all of which meant a high chance of auroral visibility even at mid-latitudes (evidenced by photographs such as that in figure 1). Figure 2 shows preliminary real-time values of the Kp (Bartels *et al.* 1939) and Dst (Sugiura 1964) indices.

"Geomagnetic indices reached their highest in years, meaning a high chance of visibility"

The CME arrived slightly earlier than expected, with arrival estimates averaging at around 12:00 UTC but actual arrival at 04:05 UTC. The arrival time originally looked unfavourable for aurora hunters in Europe and North America, as daylight would soon be approaching. Aurora hunters in New Zealand and Australia, however, were in luck. Indeed, aurora sightings in New Zealand started appearing on Twitter by early morning (UTC). Fortunately, strongly disturbed geomagnetic conditions continued throughout the day and, as darkness approached, Twitter was abuzz with talk of auroras across Europe, including from countries such as Germany, Poland and Romania, where sightings are a rarity. Conditions remained strong, though not quite as elevated as earlier, well into 18 March, allowing auroral sightings from the northern-mid US, including Ohio, Pennsylvania and Virginia.

Internet reports

Throughout the storm, the public reported sightings of the aurora on various platforms. Reports were made on social media (e.g. Twitter, Facebook, Instagram) and via Aurorasaurus (MacDonald *et al.* 2014).

Aurorasaurus is aimed at both collecting observations of auroras by the interested

WEBSITE
Aurorasaurus http://www.aurorasaurus.org

public – or "citizen scientists" – and improving the public's understanding of auroras and space weather in general. Visitors to the site are able to report observations of the aurora (both positive and negative) and provide details such as auroral activity, colour and height in the sky along with a photo. The site also combs Twitter for tweets that are likely to be aurora sightings and visitors are encouraged to verify these. All of these citizen-science data are shown on a Google map (figure 3) alongside an estimated auroral oval – based on the empirical model of Roble & Ridley (1987).

During the peak of the storm, Aurorasaurus saw a 50% increase in the number of registered members – a staggering increase in just one day for a site that has been live since October 2014. Such an increase demonstrates that the public is clearly interested in the aurora, wants to share sightings with others and is keen to receive alerts of when an aurora might be visible nearby.

More than 170 auroral sightings were reported by Aurorasaurus users during the St Patrick's Day storm – nearly a quarter of all observations received thus far. Additionally, Aurorasaurus users verified more than 420 tweets as being auroral sightings. These sightings spanned the globe, encompassing several different countries and continents, as shown in figure 4.

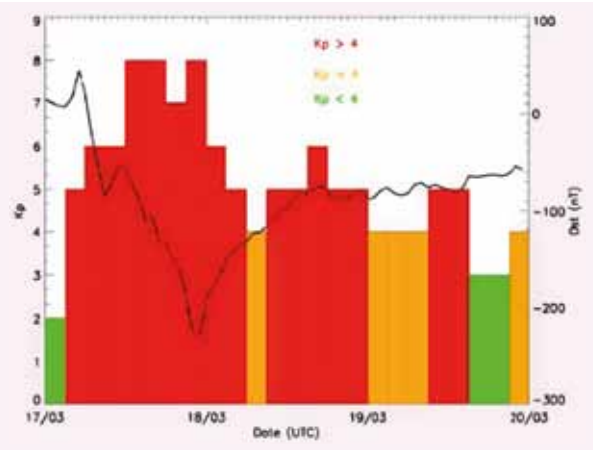
By combining multiple sightings in the same region, Aurorasaurus can produce alerts of when an aurora might be seen near a member (Lalone *et al.* 2015). During this storm, Aurorasaurus sent more than 300 alerts to users (via email and Twitter), demonstrating the power of citizen-science observations in aiding event notification.

Auroral oval models

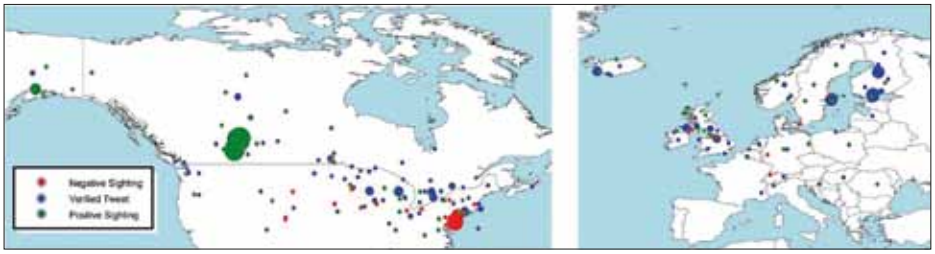
The citizen-science observations are useful not just for alerting other users to nearby aurora, but also to improve our understanding of the aurora and our ability to predict when, and from where, they will be visible. This is especially true for auroral oval models; these have not been extensively tested during extreme auroral events, because of their rarity.

While detailed investigation of the accuracy of the auroral sightings and their use in improving auroral models continues, early results suggest that model developers may benefit from exploiting the Aurorasaurus dataset (and citizen-science data in general). During the St Patrick's Day storm, significant differences were noted between the locations of the modeled auroral ovals of Newell *et al.* (2010) and Roble & Ridley (1987). Aurorasaurus can offer groundtruth observations to help address such discrepancies and, perhaps, lead to further improvements of these models.

2 Real-time Kp and Dst values for the storm period, provided by NOAA's Space Weather Prediction Center and the World Data Center for Geomagnetism, respectively.



3 A screenshot of the Aurorasaurus map, showing a positive sighting from as far south as southern Virginia (time is UTC-4). Positive sightings are represented by green "+" symbols, negative sightings by red "–" symbols and verified tweets by the blue Twitter icon (blue bird).



4 Locations of sightings reported by Aurorasaurus users and of verified Twitter sightings. Red circles indicate the location of a negative sighting (no aurora), green circles indicate a positive sighting and blue circles indicate a verified Twitter sighting. The size of circle represents the density of sightings in the area.

It is clear that this geomagnetic storm provided an extraordinary chance to see the aurora for those outside of the usual auroral ovals and that many people took advantage of such disturbed conditions. Although viewing was hampered by local weather conditions in some cases, citizen scientists reported their aurora observations at unprecedented levels.

These observations are already showing promise in improving our future modelling abilities and are sure to offer some exciting insights in subsequent analyses. Overall, this storm proved to be a great success for citizen science! ●

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REFERENCES

Bartels J *et al.* 1939 *Terr. Magn. Atmos. Electr.* **44(4)** 411
Lalone N *et al.* 2015 in *Proceedings of the ISCRAM 2015 Conference*
MacDonald E A *et al.* 2014 *IN42A-07* presented at 2014 Fall Meeting, AGU, San Francisco, Calif., 15–19 Dec.
Newell P T *et al.* 2010 *J. Geophys. Res.* **115** A03216
Poppe B B 2000 *Eos Trans. AGU* **81(29)** 322
Roble R G & E C Ridley 1987 *Ann. Geophys.* **5** 369
Sugiura M 1964 *Annals of the International Geophysical Year* **35** 9