UK Risk Assessment and Economic Impact Study

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Inputs from: Ed Oughton (University of Cambridge, UK), Mark Gibbs and Catherine Burnett (Met Office, UK), Mike A. Hapgood (STFC RAL Space, UK), and Enrico Biffis (Imperial College, London).
This is just a snapshot of some of the key past and current activities with some outline plans going forward – it is not all-encompassing…
Space weather arises (mainly) from solar ejecta impacting the Earth, in particular plasma and particle radiation.

Need to understand energy flow:
Source (Sun) and transmission (solar wind), processing by the Earth’s own magnetically-confined system (magnetosphere, ionosphere/atmosphere, lithosphere).
Our modern world is highly inter-connected with many dependencies across many systems. Space weather can impact many of these systems simultaneously, and severe space weather can cause several of these systems to fail resulting in both primary and secondary (knock-on) impacts. These can do so across the world, subsequently amplifying the impact of space weather.

Potential overstretched resources for recovery.

Figure to come taken from USA Department of Homeland Security (DHS).

Interconnected Systems with Wide-Scale Impacts (1)
Interconnected Systems with Wide-Scale Impacts (2)

EVERYTHING'S CONNECTED

All the different services we depend on every day also depend on each other. To keep a service running smoothly means keeping other services running smoothly too – which can be tricky...

CLIMATE CHANGE

ROADS

HEAT WAVES

FLOODS

HEAVY SNOW

HIGH WINDS

SNOW

WASTE

WATER

AIR

WIND

ELECTRICITY

KEEPPING THE LIGHTS ON

Avoiding problems as energy use goes up and down each day

KEY TO ARROWS

A

B

A disrupts B!

DINORWIG

A hydro-electric dam in Snowdonia, North Wales. If the system is unable to keep up with demand, energy from Dinorwig may help top up the grid. That's why it's so important to keep just a little bit of storage, like gas, ready to help out when extra power is needed.

CO-LOCATION of different services

This is a concept developed by the National Grid in the UK. It's the idea that different services can be located close to each other to make them easier to manage and more resilient. For example, if you have a wind farm and a solar array nearby, you can use the output from both sources to create a more stable power supply.

AND FINALLY

LATEST UPDATE

If you're interested in further disruption of the grid, we recommend you check out our latest update on the website.

SCIENCE: David Alderson
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• Assessing the Risk

• UK’s National Risk Register (NRR: 2015 edition; 2018 updated version in preparation)...

• Severe space weather has been on the UK’s NRR since 2011.

• This, along with other additional risks, were brought to the government’s attention following the problems caused by the Iceland volcano ‘Eyjafjallajökull’ ash clouds in 2010.

• UK also practices responses!

• UKSA funded a socio-economic study on space-weather impacts (IPSP) reporting to government.
Optimising the Risk Equation

• Who Bears the Risk?
• Who Benefits from Resilience?
Socio-Economic Studies (1)

- UKSA IPSP Study undertaken with substantial results in favour of needing increased forecast capability, not just in maintaining the status quo:
  - Started with a literature study later published (see: Eastwood *et al.*, Risk Analysis, doi:10.1111/risa.12765, 2017);
  - Included comprehensive space-weather sub-storm impact studies based on historical severe geomagnetic storms of varying impacts (1-in-10, 1-in-30, 1-in-100 year cases);
  - Included comprehensive studies on both the power grid and aviation sectors ONLY;
  - Many learning outcomes on how we improve the studies, to look at the wider (secondary impacts and quantify them), and how we tackle other sectors similarly/differently…
Socio-Economic Studies (2)

• UKSA IPSP Study economic approach:
  – Footprinting - Physical footprinting, impact table, resilience table, and evidence on comparative man-made (explosion, fire, terrorism) and natural (windstorms, quakes) impacts;
  – Bottom-up analysis - Value of Lost Load (VoLL) emerging across the footprint (timestamp, location, severity, and duration of sub-storm), and physical damage and business interruption; and
  – Spillovers - International spillovers via Input-Output (I-O) Model, and reallocation of costs across countries and sectors.

• Looked at three types of recovery to severe space-weather events: Immediate recovery; No recovery; and Linear recovery.

• In a reasonable worst-case scenario, losses up to €5B expected.
The University of Cambridge EPSRC study concentrated on quantifying the daily economic impact of extreme space weather due to failure in electricity transmission infrastructure:

- Concentrated on the US grid infrastructure and regionalised:
  - Focus was on the USA for a number of reasons including absolute economic size, insurance penetration, regulatory emphasis, etc…; and
  - Can learn how to apply similar studies to Europe and UK.

Daily economic losses depending on the severity of the event (how far South it reached across the continental USA states) ranged from $7B per day to $48.5B per day as total combined direct losses in the USA and globally including both upstream and downstream effects.
Conclusions

- The risk has to be regularly monitored and updated, and in the UK this is advised and guided by the Space Environment Impacts Expert Group (SEIEG – chaired by Mike Hapgood, STFC RAL Space) who input to UK Government.
- All aspects of society are interconnected making this a difficult task!
- Many lessons learned from completed socio-economic studies (e.g. UKSA IPSP, University of Cambridge, etc.), and these are and will be applied to the current and upcoming additional studies (one of which is again being led by the University of Cambridge).
- A clear financial benefit is derived from space weather forecasting.
- The IPSP wider economic impact for UK was €5B, but across Europe (including Scandinavia) suggested reasonable impacts of up to €82B.
- Costs relating from the loss of power far outweigh the costs incurred by civil aviation – but other sectors need greater study.
- Similar such impact costs were derived by an ESA study.

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If you want to know more…

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- Also, please see session SH012 at the upcoming Fall AGU in New Orleans in December of this year “Space Weather Forecasting: Science, Operations, Future Missions, Missing Information, and the Economic Case” – abstract-submission deadline of 2nd August (Wednesday!): https://goo.gl/6QqYft or https://agu.confex.com/agu/fm17/preliminaryview.cgi/Session23441