**SWIGS Annual Workshop, British Antarctic Survey, Cambridge, 2nd – 4th September 2019**

Please be ready to upload your talks from USB stick to the meeting laptop ahead of your session. Use of individual laptops is also possible (HDMI and VGA connections only) but we will ask if we can put a copy of your presentation on the meeting website (full access for project partners only, but with a short summary of discussions placed on the public part of the website: [swigs.bgs.ac.uk/](http://swigs.bgs.ac.uk/)).

A reminder of last year’s emergent ‘themes’ where we felt at the time, there was collaboration potential:

* Theme 1 = “What causes the Eskdalemuir dB/dt anomalously large return level/period” (WP 1, 2, 4)
* Theme 2 = “Better modelling of the expansion of auroral oval” (WP 1, 2, 3)
* Theme 3 = “Reversals/longer scale core field changes and implications for SW impacts” (WP 1, 3, 4)
* Theme 4 = “Carrington event: modelling the chain of solar wind to GIC processes” (WP 1, 2, 3, 4)

For UK team members only: please consider commenting during your presentation if/how/where your work in the past year or so touches on any of these themes.

**Monday 2nd September: Day 1**

**12:30 – 13:15 Arrival and lunch**

BAS has a display area and coffee in the reception area, which may be of interest to any particularly early arrivers. Meeting room access may also be possible before 12:30 – please ask Mervyn. Lunch is at own expense in the BAS canteen.

**13:15 – 13:30 Welcome, local information and introductions**

**13:30 – 15:00 Session 1 (Chair: Mark Clilverd)**

13:30 – 13:50 The Directionality of Extreme Geomagnetic Field Fluctuations. Neil Rogers.

13:50 – 14:10 Extreme Value Statistics. Phil Livermore.

14:10 – 14:30 The influence of substorms on extreme rates of change of the surface horizontal magnetic

field in the U.K. and at other latitudes. Mervyn Freeman.

14:30 – 15:00 **Invited**: GIC Monitoring and Space Weather Impacts on the New Zealand Power Grid: Summary of the Solar Tsunamis project. Craig Rodger, University of Otago.

**15:00 – 15:20 Coffee break & informal discussion**

**15:20 – 17:00 Session 2 (Chair: Mervyn Freeman)**

15:20 – 15:40 Data mining for information on UK sub-surface conductivity structure. Kathy Whaler.

15:40 – 16:00 Validating GIC Modelling through Differential Magnetometer Measurements in the UK High-

Voltage Power Grid. Juliane Huebert.

16:00 – 16:20 Geoelectric modelling using the thin-sheet approximation and validation against UK

Observatory measurements. Ciaran Beggan.

16:20 – 16:50 **Invited**: Power System Disruption. Trevor Gaunt, University of Cape Town.

16:50 – 17:00 Short discussion around day 1 results and issues & setting up discussions for days 2 and 3.

**17:00 Close of Day 1**

**Evening Free – we may suggest a local pub to meet for informal drinks for those interested**

**Tuesday 3rd September: Day 2**

**09:30 – 11:00 Session 3 (Chair: Ciaran Beggan)**

09:30 – 09:50 Mid-latitude magnetic field perturbations and geomagnetically induced currents during the

September 2017 solar storm. Mark Clilverd.

09:50 – 10:10 Global Magnetospheric Modelling of GIC Risk: Introduction to Gorgon. Jonathan

Eastwood.

10:10 – 10:30 Understanding Space Weather Impact on the UK Gas Pipeline Network. Alan Thomson.

10:30 – 11:00 **Invited**: Update on Irish Activities Related to SWIGS. Peter Gallagher.

**11:00 – 11:30    Coffee break & informal discussion**

**11:30 – 12:15 Discussion 1: Lessons from First Two Years of SWIGS (Chair: Alan Thomson)**

This meeting marks the midpoint of the project. It is therefore timely to look back and have a discussion around what progress has been made, where things have been slow or completed OK, what logjams there are (if any), interaction between groups, ways of working, etc. Anything and everything. All participants are invited to comment and share experiences.

**12:15 – 13:30    Lunch, covered by SWIGS**

**13:30 – 15:00    Session 4 (Chair: Juliane Huebert)**

13:30 – 13:50 The Influence of Sudden Commencements on the Rate of Change of the Surface Horizontal

Magnetic Field in the United Kingdom. Andy Smith.

13:50 – 14:10 Global Magnetospheric Modelling of GIC Risk: Sensitivity to Onset Time and Internal Field,

Jonathan Eastwood.

14:10 – 14:30 Bounding the evolution of the geomagnetic dipole for space weather purposes.

Stefano Maffei.

14:30 – 15:00 **Invited**: The Importance of Geoelectric Fields. Mike Hapgood, RAL Space.

**15:00 – 15:30 Coffee break & informal discussion**

**15:30 – 16:45 Discussion 2: Odds and Ends (Chair: Alan Thomson)**

*Short discussions (10 mins approx.) on specific items raised by the consortium. Showing 1 or 2 slides might be possible.* *\*\*\* Any further suggestions for “Odds and Ends”? \*\*\**

Mike Hapgood: ‘Promoting a shift in UK risk assessment of GIC risk: from dB/dt to the geoelectric field’

Mike Hapgood: ‘Opinions on AGU’s latest data policy developments?’

Phil Livermore: ‘Implications of the recent shift in the north magnetic pole?’

Craig Rodger: ‘What do the power grid operators want from Space Weather researchers?’

David Jackson: ‘Update on Implementing the Space Weather Modelling Framework’

Alan Thomson/Mike Hapgood: ‘SWIGS at Royal Society Summer Science Exhibition 2020/2021? Other outreach opportunities? ‘

Alan Thomson: ‘For info: ESA Space Weather Week 2019 – Topical discussion meeting on GIC’

Alan Thomson: ‘Let’s make an early decision on date of next annual meeting’

Alan Thomson: ‘Any lessons from the recent UK local grid blackout: the aftermath of a severe space weather event?’

**16:45-ish Close of Day 2**

**19:00 Group Dinner**

 Rajbelash Fine Indian Dining

36-38 Hills Rd, Cambridge CB2 1LA, UK

Tel: 01223-354679

<https://www.rajbelash.co.uk/>

Please remember your order! <https://www.rajbelash.co.uk/menus>

**Wednesday 4th September: Day 3**

**09:30 – 11:00 Session 5 (Chair: Neil Rogers)**

**Followed by short breakout session for small groups and individuals to plan research, etc**

09:30 – 09:50 Update on Rail Anomaly Analysis. Mike Hapgood.

09:50 – 10:10 Summary of activities at Reading. Alan Thomson, on behalf of Mike Lockwood and Matt Owens.

10:10 – 10:40 **Invited**: What do the power grid operators want from Space Weather researchers?

Discussions with the New Zealand operator Transpower. Craig Rodger.

10:40 – 11:00 Breakout for separate group and individual discussions and planning

**11:00 – 11:20     Coffee break & informal discussion**

**11:20 – 12:00 Discussion 3: Next Steps and Future Plans (Chair: Alan Thomson)**

**OR more “Odds and Ends” (as required)**

All participants to outline their next steps and use this opportunity to indicate where collaborative efforts are needed, if not already agreed.

Perhaps you can ask yourself

* What/where are the upcoming meetings and research opportunities that we should be aiming for?
* What are the bright new ideas we should work on, even looking beyond SWIGS?
* How do we make SWIGS more than just the sum of the various parts?
* Is/could anything from one WP be useful to another WP?
* Is anything emerging that is useful to end users, besides improved understanding?

Anticipating mainly a discussion but if you have a slide or two to show, that can probably be accommodated.

*Depending on whether more “Odds and Ends” are suggested as discussion items, this discussion session #3 may be rolled up with #1 to leave this slot free for more “Odds and Ends”.*

**12:00-ish      End of Meeting**

The BAS canteen is open for any delegates who want lunch prior to departure, at own

expense.

Abstracts

**The Directionality of Extreme Geomagnetic Field Fluctuations**

Neil Rogers1, Jim Wild1, and Emma Eastoe2

1. Space & Planetary Physics, University of Lancaster.
2. Dept. of Maths and Statistics, University of Lancaster.

From a large archive of SuperMAG field measurements at 125 locations, we have developed a global statistical model of high-percentiles and extremes of the horizontal geomagnetic field fluctuation, *R* = |*dBH/dt*|. This model predicts the likely return levels (RL) over periods from 5 to 500 years as functions of magnetic latitude. The RLs may be refined by considering patterns of occurrence likelihood of *R* exceeding the 99.97th percentile, *P99.97*, to which we have fitted analytical functions of magnetic local time (MLT), month, and/or the compass direction of *R*. These patterns of occurrence are partially explained by reference to sudden commencements (SC), Pc5 ULF waves, magnetotail-lobe reconnections, and auroral substorm onsets. The patterns depend on the time-scale, *dt*, of the fluctuation (which we have analysed on scales from 1 to 60 minutes) and change according to the prevailing interplanetary magnetic field orientation (*Bz* and *By*).

*R* values have been resolved along a range of compass bearing axes from 0° to 180° and this reveals strong (up to +/- 100%) changes in *P99.97*, RL, and fitted tail-distribution parameters between the N-S and E-W axes. The directional distribution of (*R > P99.97*) occurrences are most strongly anisotropic in the low-latitude regions. Interesting directional dependences have emerged from the data at latitudes up to $\pm $40°, showing clear asymmetries with regard to hemisphere and between narrow pre- or post-noon MLT bands. The drivers of these perturbations – perhaps a combination of Chapman-Ferraro and field-aligned currents – have yet to be fully explained

**Extreme value statistics**

Phil Livermore, University of Leeds

Abstract expected

**The influence of substorms on extreme rates of change of the surface horizontal magnetic field in the U.K. and at other latitudes**

Mervyn P. Freeman1, Colin Forsyth2, I. Jonathan Rae2, Andrew. W. Smith2

1British Antarctic Survey, Cambridge, U.K.

2Mullard Space Science Laboratory, UCL, Dorking, Surrey, U.K.

We investigate how statistical properties of the rate of change *R* of the surface horizontal magnetic field differ during substorm expansion and recovery phases compared with other times. *R* is calculated from one-minute magnetic field data from the three U.K. INTERMAGNET observatories – Lerwick, Eskdalemuir, and Hartland, and between 1996 and 2014 – nearly two solar cycles. Substorm expansion and recovery phases are identified from the SML index using the SOPHIE method. The probability distribution of *R* is decomposed into categories of whether during substorm expansion and recovery phases, in enhanced convection intervals, or at other times. From this, we find that 54-56% of all extreme *R* values (defined as above the 99.97th percentile) occur during substorm expansion or recovery phases. By similarly decomposing the MLT variation of the occurrence of large *R* values (> 99th percentile), we deduce that 21-25% of large *R* during substorm expansion and recovery phases are attributable to the DP1 magnetic perturbation caused by the substorm current wedge. This corresponds to 10-14% of all large *R* in the entire dataset. These results, together with asymptotic trends in occurrence probabilities, may indicate the two-cell DP2 magnetic perturbation caused by magnetospheric convection as the dominant source of hazardous *R* > 600 nT/min. The analysis is currently being extended to lower and higher latitudes in Europe with initial results showing broadly similar behaviour, the details of which will be reported at the meeting.

**GIC Monitoring and Space Weather Impacts on the New Zealand Power Grid: Summary of the Solar Tsunamis project**

Craig Rodger, University of Dunedin

In the last few years we have undertaken a GIC-focused research project in the New Zealand electrical grid. Our project was entitled 'Solar Tsunamis: Mitigating Emerging Risks to New Zealand's Electrical Network', and was funded by the New Zealand Ministry of Business, Innovation and Employment, from late 2015 to late 2018. The project was quite SWIGS-like in some sense, and as well as the main New Zealand institutions (Otago Univ., and Victoria Univ.) it included strong collaboration with both BGS and BAS. New Zealand is at very similar magnetic latitudes when compared with the United Kingdom, and is also (obviously) an island nation. We have been fortunate to have unusually strong support from Transpower New Zealand Ltd., the national grid operator. They have provided us with large amounts of measurements, including >10 years of DC measurements from ~30-60 transformers and case study periods with nation wide harmonic distortion measurements. I will provide an overview of the 'Solar Tsunamis' research findings and hope to stimulate discussions and more collaboration with our SWIGS-friends.

**Data mining for information on UK sub-surface conductivity structure**

Kathy Whaler1 and Juliane Hübert 1, 2

1University of Edinburgh

2British Geological Survey

There have been a number of campaigns to collect DC resistivity sounding and magnetotelluric (MT) data in the UK, dating back at least to the 1960s, providing information on the sub-surface resistivity structure. Much of it remains unpublished, including in MSc dissertations. In at least one instance, boreholes have been used to calibrate the results. Although the quality is variable and, especially for the DC resistivity soundings, penetration depth is shallow, it is worth collecting and documenting during this project. We will present the locations of most of the known MT sites, and comment on their quality, and present a possible structure for the database that should allow us to characterise resistivity ranges of rock types from the legacy data. These can be compared with the resistivity values assigned to UK geology in previous studies. Eventually, we intend to update the resistivity model used for GIC prediction, which will require a discussion of resolution, model cell sizes, depth requirements etc. We will also present the history of the ‘Eskdalemuir anomaly’ as documented by MT and magneto-variational studies.

**Validating GIC Modelling through Differential Magnetometer Measurements in the UK High-Voltage Power Grid**

Juliane Hübert, British Geological Survey

Modelling GICs requires knowledge about the source magnetic field and the electrical conductivity structure of the Earth to calculate the electric fields generated during enhanced geomagnetic activity.

The electric field in combination with detailed information about an electrical network’s topology and resistance parameters enable the derivation of GICs flowing in HV power lines.

Directly monitoring of GICs at the ground neutral in substations is possible using a Hall probe, but scarcely implemented. Therefore, we have used the differential magnetometer method (DMM) to measure GICs at six sites in the UK power grid. The setup of the DMM includes the installation of two fluxgate magnetometers, one directly under a HV power line (400 kV) affected by GICs, and one as a remote site further away a few hundred metres away. The difference in the recorded magnetic field between the instruments allows for the inference of GICs in the line, via the Biot-Savart law, during geomagnetically enhanced periods.

Data from several storm events during 2018 and 2019 are presented. These show a good match to Hall probe measurements available from one transformer site in Scotland. Comparing the measured GIC at the DMM sites to the computed ones will allow us to validate the UK model and to monitor GICs in real-time.

**Geoelectric modelling using the thin-sheet approximation and validation against UK observatory measurements**

Ciarán Beggan, British Geological Survey

Various methodologies for modelling the geoelectric field exist. The simplest approximation of the electric field is a magnetic transfer function using a 1D conductivity profile in the frequency domain. The most complete is 3D modelling using finite element analysis. A 1D transfer function is quick to compute but inaccurate when the regional conductivity is complex. Finite element modelling is much more accurate though very computationally expensive.  Between these two methods is the thin-sheet approximation which can reproduce much of the spatial complexity of the surface electric field while being relatively quick to compute.

Globally, there are few long-term monitoring sites of the geoelectric field so validation is difficult, but three sites exist in the UK to make comparisons against. In addition, the models can be compared to proxy measurements such as Geomagnetically Induced Currents in high voltage transformers. We compare the modelled outputs to measurements of the geoelectric field.

**Power System Disruption**

CT Gaunt, University of Cape Town

The justification for studying space weather and its effects arises from two views: that it is good and useful to improve generally our knowledge of science, and that it is important to understand how to mitigate the societal consequences of severe and extreme events.

One of the potential consequences of severe space weather is disruption of electric power systems, such as by initiating insulation degradation leading to failure of transformers; causing protection systems to fail or to operate incorrectly, and reducing the power transfer capability of power lines, which separately or together can lead to interruptions and even widespread, extended blackouts.

Most disruptions start with the transformer response to the geomagnetically induced currents. Therefore, I will discuss the testing we have carried out on model transformers, the development of an equivalent circuit, testing in FEM models calibrated by the practical tests, and then the testing of simple power systems with GICs flowing in the transformers. I will comment on the shortcomings of some published research, outline some of our present thinking and summarize some of the paths to power system disruption by GICs.

Arising from these descriptions, I will identify some aspects of space weather information that could be useful for the power system engineers and offer brief comments on the implications for engineering science.

**Mid-latitude magnetic field perturbations and geomagnetically induced currents during the September 2017 solar storm**

Mark Clilverd, British Antarctic Survey

A period of intense geomagnetic storm activity during 07-08 September 2017 occurred after the arrival of a strong solar wind shock. Half a day after the shock, a long-lasting, large, GIC period of up to 30 minutes in duration was detected in Dunedin, South Island, New Zealand. About 5 hours later Scotland experienced its peak GIC event of the storm. We analyse magnetic field data from mid-latitude sites around the world to better understand the large-scale and smaller scale current structures that were developed during the storm interval, and compare GIC observations from the same regions. We address the question of whether the immediate impact of solar wind shock events, or more delayed magnetospheric storming events, are more significant for electrical power systems at mid-latitudes.

**Global Magnetospheric Modelling of GIC Risk: Introduction to Gorgon**

Jonathan Eastwood, Lars Mejnertsen, Joe Eggington, Ravi Desai, Jerry Chittenden, Imperial College London

Global simulations of the interaction between the magnetised solar wind plasma and the Earth’s magnetosphere are crucial for placing satellite observations in the proper context and for providing a better understanding of magnetospheric structure and dynamics under all possible input conditions. Furthermore, magnetospheric simulations are a key component in efforts to predict space weather. The magnetosphere occupies a large volume relative to typical plasma scale lengths and so fluid codes are typically used to model its behaviour. Here we describe the work we have accomplished at Imperial College London developing global simulations of the solar wind – magnetosphere interaction. This work is based on the Gorgon MHD code developed in the Plasma Physics group at Imperial, which has been used to successfully model a variety of different laboratory plasma devices such as wire array Z-pinches and inertial confinement fusion experiments. The code uses a unique explicit formalism which enables efficient parallel scaling, and employs other numerical techniques and approaches that are different from other codes used to perform similar modelling, but which may provide important capability.

**Understanding Space Weather Impact on the UK Gas Pipeline Network**

Gemma Richardson, Alan Thomson, British Geological Survey

Research into space weather impacts on the UK high voltage power network has resulted in a sophisticated model of the electrical transmission network and a detailed conductivity model of the landmass and surrounding offshore geology. However, there has been limited study of impacts on other ground-based systems in the UK, particularly impacts within the high-pressure gas transmission and railway signaling networks. We describe an initial electrical model of the UK gas transmission network and examine the pipe-to-soil potential (PSP) - the enhanced corrosion hazard - in this network, in response to hypothetical and historical geomagnetic storms. We find that, for example, during the March 1989 geomagnetic storm the PSP could readily have exceeded 50V in parts of the UK, well in excess of the typical level of active cathodic protection potential on a gas pipeline (~1V). We then outline where the model needs improvement and other next steps to provide a useful tool for industry.

**Update on Irish Activities Related to SWIGS**

Peter Gallagher, Dublin Institute of Advanced Studies

Abstract expected.

**The Influence of Sudden Commencements on the Rate of Change of the Surface Horizontal Magnetic Field in the United Kingdom**

Andy Smith, Jonny Rae, University College London

Sudden commencements (SCs) are rapid increases in the northward component of the surface geomagnetic field, related to sharp increases in the dynamic pressure of the solar wind. Large rates of change of the geomagnetic field can induce damaging currents in ground power networks. In this work, the effect of SCs on the (one minute) rate of change of the surface magnetic field (R) at three UK stations is investigated. The distributions of R during SCs are shifted to higher values than the data set as a whole. Rates of change greater than 10 nT/min are 30 - 100 times more likely during SCs, though less than 8% of the most extreme R (> 99:99th percentile) are observed during SCs. SCs may also precede geomagnetic storms, another potential source of large R. We find that the probability of observing large R is greatly enhanced for three days following an SC. In the 24 hours following an SC it is 10 times more likely than at any given time to observe rates of change between 10 and several hundred nT/min. Additionally, between 90 and 94% of data (depending on station) above the 99.97th percentile is recorded within three days of an SC. All values of R >200 nT/min in the UK have been observed within three days of an SC. These results suggest that accurately predicting sudden commencements is critically important to identify intervals during which power networks at similar geomagnetic latitudes to the UK are at risk from large GICs.

**Global Magnetospheric Modelling of GIC Risk: Sensitivity to Onset Time and Internal Field**

Jonathan Eastwood\*, Lars Mejnertsen, Joe Eggington, Ravi Desai, Jerry Chittenden, Phil Livermore, Jon Mound, Mervyn Freeman, Jim Wild, Alan Thomson \*Imperial College London

Geomagnetically Induced Currents (GICs) represent a significant pathway for space weather risk because of their effects on power grids, as observed and documented in a variety of historical events. Mitigating GIC impact risk depends on accurate forecast of impact footprint. Global magnetospheric simulations provide an important tool to better model and understand the likely spatial footprint particularly for extreme events which are known to have occurred, but which happened prior to the availability of modern observations. Using the global magnetospheric model Gorgon, we examine extreme individual substorm events. Since current forecast capability is limited in arrival time error of solar wind drivers, we firstly examine the sensitivity of the GIC-relevant magnetospheric and ionospheric response to this uncertainty, for a range of drivers. Secondly, we examine the role that variation in the internal field may play, since it may change significantly over the return period of the most severe events. This variation includes the strength of the internal field, its orientation, and the significance of higher order terms; the effects of these different terms is discussed.

**Bounding the evolution of the geomagnetic dipole for space weather purposes**

Stefano Maffei, University of Leeds

In this talk we will present the current state of the geomagnetic field of internal origin (the main field) and it's possible evolution in future years. The main field has an important influence on the modulation of space weather hazard given its fundamental effect on the shape of the magnetosphere and on the strength of the currents in the magnetosphere-ionosphere system. Current forecasts are either based on linear extrapolations of the present field or on the evolution of numerical models that are potentially not capturing the real physical balances of the Earth's outer core. We will approach the problem from an alternative point of view and attempt to bound the evolution of key geomagnetic quantities, namely the geomagnetic dipole tilt and strength. We do so by deriving optimal flows on the top of the core that maximize/minimize the growth rate of these quantities. Our results will be compared with the current forecasts and their applications to space weather discussed.

**The Importance of Geoelectric Fields**

Mike Hapgood, RAL Space

The UK national risk assessment of GIC impacts is primarily parameterised via dB/dt, the rate of change of the geomagnetic field. This reflects the state-of-the-art when the original assessment was made in 2012, but is now arguably well behind that state given international scientific progress over the past seven years. That progress has firmly shifted the focus from dB/dt to use of the geoelectric field as the key parameter in specifying the space weather environment that drives GIC. This talk aims to stimulate discussion on whether and how to promote a shift in UK risk assessment. It will explore a number of points for discussion including: (a) most importantly, does use of geoelectric fields give more insight into regional variations of GIC risk? (b) does the UK need to keep up the international state-of-the-art? (c) can we improve the historical evidence base for large geoelectric fields in the UK? (d) how does this fit with current UK capabilities as being developed via SWIGS? & (e) how do we communicate the changing state-of-the-art to a wider UK audience? In the course of discussion it may also be helpful to touch on evolution of the UK power grid since 2012, especially the ongoing shift to low-carbon generation and the ever-growing importance of HVDC interconnects, both internal to the UK and with European partners.

**Update on Rail Anomaly Analysis**

Mike Hapgood, RAL Space

Network Rail has kindly provided two sets of rail anomaly reports for days around recent geomagnetic storms: one covering the whole of Great Britain during the storms of March 2015 and September 2017, and the other covering Wales and the Marches during storms in 2003, 2004 and 2005. An initial analysis reported at the 2018 SWIGS meeting was suggestive, but not conclusive, of a correlation between dH/dt and anomalies in track circuits and signalling systems. More recently, a case study focused on the Halloween storm has added weight to this conclusion – in that a major rail anomaly was well correlated with large rotating perturbations in the geomagnetic field. To take this work forward the anomaly reports and geomagnetic data is being consolidated into a database that will enable more rigorous statistical analyses, e.g. against varying thresholds of dH/dt, also dX/dt and dY/dt, and perhaps a parameter based on rotating perturbations. In parallel with this data analysis, a literature survey has been undertaken to better understand the technologies used on rail systems, in particular the typical electrical characteristics of track circuits and signalling systems, and hence to better understand how GIC could influence those systems.

**Reading University Update**

Mike Lockwood, Mathew Owens. Presented by Alan Thomson

A brief summary of research, results and publications, under SWIGS to date, will be given.

**What do the power grid operators want from Space Weather researchers? Discussions with the New Zealand operator Transpower**

Craig Rodger, University of Dunedin

Following the end of our MBIE funded Solar Tsunamis project in late 2018, we developed a new research proposal submitted to New Zealand funding bodies. This funding project was not successful. However, the preparation for it involved a lot of discussion with New Zealand's national grid operator, Transpower New Zealand Ltd - discussions which have continued into recent months. Transpower is developing a business case around mitigating the hazard posed by GIC. In this presentation, I will discuss what Transpower told us they want, and how they have proposed to use the knowledge we produce as space weather researchers, to develop mitigation plans and strategies. I am hoping this presentation will stimulate discussion.