**SWIGS annual meeting 11-12 Sept – Lancaster. Wrap up discussion, Session 5.**

Discussion took place on the bullet points on the following slide.



Gemma – This is a record of the comments and discussion made.

Alan - Emergent themes from the discussion are **highlighted**. For those who have an interest in these cross-WP themes please supply comments and indicate your interest in being a part of taking these forward.

* Theme 1 = “The Eskdalemuir dB/dt anomaly” (WP1, 2, 4)
* Theme 2 = “Modelling expansion of auroral oval” (WP1, 2?, 3)
* Theme 3 = “Reversals/longer scale core field changes” (WP1, 3, 4)
* Theme 4 = “Carrington event: solar wind to GIC link” (WP1, 2, 3, 4)

1. Reflections, plans, cross-WP activities

Mervyn – what are the possible causes of anomalous return period at Esk? Ideas from wider group may be helpful to formulate a cross-WP research **theme**

* Large conductivity anomaly at Esk – does that contribute to large dB/dt?
* The Thomson et al paper 2011 – looks like there is a slow increase with geomagnetic latitude but there are some outliers around 55-58 geomag latitude
* Could be a place to bring internal fields into the Space weather challenges – i.e. if you shift peak latitude by a little bit that changes what you see in the UK in terms of GIC
* But…there are some caveats to this
	+ All the stations have different lengths of records
	+ Some reassurance – it’s only a few points
	+ If you plot the 4 points they are (magnetic) latitudinally organised – is it related to the auroral oval, or underlying solid earth? Is there a relation between conductivity at Esk and BFE (Brorfelde, Denmark)?
	+ From Neil’s global study if you look at 99.97 percentile Esk doesn’t stand out but as you increase the return levels Esk increases (potentially related to the shape parameter – heavy tailed)
	+ Eyrewell worth investigating – very similar (south) geomagnetic latitude to Esk – might help to dig out if the Esk bit is geology related (Gemma note – when I checked the work we had done on extending the European study to include worldwide geomagnetic observatories Eyrewell did not stand out in the same way as Esk.)
* David – when they (with Nikitina) looked at EVS they couldn’t find much relation between shape parameters – e.g. are auroral ones all similar?

Phil – how should we try to work to maximise collaboration between work packages?

* 2 extreme models for the research program – each institute either works separately – or- everyone works on everything – ideally we want to be somewhere in between
* Suggest to create a living document – who is working on what – open to allow people to add in where they have expertise to help on other work packages/tasks – add to project website
* With projects we already have – make sure there is a mechanism to allow people to help/work on what they want/are most useful on

Kathy – this should be the last meeting organised by work package – next time it would be good to work more by theme (e.g. Esk – theme 1).

David – expansion of the auroral oval – don’t really know of a good model for that – interesting to see that Neil’s work (EVS) shows that a bit. We need to get a better understanding of the expansion of the auroral oval (useful before we jump into internal field stuff too much).

* Ciaran – is Rob shore working on this?
* Mervyn – yes – depends on what time scale you are looking at
* David – limit of the expansion of the auroral oval is really important in trying to understand the GIC risk. E.g. with Quebec the auroral oval was over Quebec when the 1989 storm happened – then later it expanded further equatorward – which is when US got clobbered
* Could be a good candidate for another **theme** to look at
* Mike Hapgood – some case studies would be a good idea – intense events it can do odd things
* Mervyn – during the growth phase you should be able to model the expansion fairly well, but when a substorm kicks off it becomes much much harder – could potentially do a simulation to see if that works
* Alan – October 2003 event – aurora was directly overhead in Edinburgh
* Jim – Steve Milan has a model parameterised by SYM-H to give auroral location
* Phil – Leeds have collaboration with China – they are creating a database of aurora sightings for the last ~300 years. Could build upon the database Mike Lockwood has made for UK sightings and look at historical data.
* Alan – this is sounding quite WP3 based – WP4 useful for testing a model once there is one. WP2 could help in terms of conductivity – particularly for that Esk anomaly
* Mervyn – we’ve now got quite a lot of variometers on fairly small scales – with MT measurements and DMMs – can we now start to use this to look at the sorts of effects Mark was talking about with the Swampy summit and EYR relation to GIC in Dunedin (i.e. small scale fluctuations in magnetic field)

Definitely seems like a living document is useful (a google doc that everyone can edit?)

David – can we bring conductivity into the extremes study – dB/dt is still a hard sell to users – can we convert to E-field (e.g. in N America – used the Quebec as the standard conductivity model). Then when there are different conductivities then develop a scaling factor. Statistics of electric fields are easier to talk to engineers with

David – option for stats – instead of using sunspot number try F10.7

Neil – hoping to work a bit more with WP1 to help with identifying substorms, sudden commencements etc in the statistics.

Reaching a point where the WPs are now off the ground – but now slightly switch focus to themes/projects which cross work package themes. Something to think about as something that will develop to link work packages (Alan gave good path of linkages between the 4…)

Jim - WP3 so far has been more about making models of dB/dt but will need that step to get GIC (so some collaboration with WP4)

Jim – getting external expertise has been really useful this last week to help move the DGA work forwards.

Reversals/longer scale core field changes as a **theme**:

* Phil – lot of people are interested in is geomag reversals – one thing the Post-doc will have time to look at is reversals – look at shortest possible time scale until a reversal. Want to try and quantify that. Can we then say what might happen during a geomagnetic reversal?
* Ciraran – has anyone modelled a magnetosphere during a reversal?
* There are some papers on e.g. quadrupole magnetosphere
* If the magnetic field is weak – does that mean that geomagnetic variations are smaller? Or could you get more rapid variation because of the complexity of the ionosphere? Ring current probably doesn’t exist
* David – if field gets stronger or weaker does that expand or shrink the auroral oval?
* Mervyn – it certainly changes the rate of expansion of the auroral oval (David suggested to write that up as a paper)
* David - What was main field in 1859? Can we compare what happened then with now – if that happened now would we get a larger or smaller impact? (see follow up note from Phil at the end of this document)
* Alexis – for nuclear – interested in 1 in 10,000 year – so if we get a reversals are definitely interesting

Mervyn – potential gap – we have the GIC modelling but what are the failure modes of systems – how can we tailor the work to address that, maybe as another theme, but probably more internal to WP4.

* Alan – how can we assist with identifying/testing mitigation procedures – stress test procedures
* Michael – DGA – if you only concentrate on the peaks you might be missing the accumulation of stress on the transformers – so that might change the 1 in 100 year type failure. Stefan Lotz at SANSA trying to look at that.
* Alan – I did some work on trying to show cumulative GIC impact for a European SWW meeting, where I plotted i2R across a storm as well as its time integral, where i=GIC and R=1, but what I would have liked to have had is some measure of transformer response (Jim suggested trying this for some transformer for which we have time series DGA data) to try and capture any correlation or at least indicate when peak transformer heating was occurring
* David – NERC (America) starting to think about accumulated heating - Sample waveform from Mar 1989 – quite large oscillations – continued heating for hours after the event
* Luke – other work going on with looking at peak or some integrated dose (sorry I missed exactly what research area…) – could try doing that in the EVS studies – e.g. integrated B over an hour?

Ciaran – BGS could do some analysis for a couple of storms and give that to Jim – do some of the transformers show vulnerability and does that match with what Jim is seeing in the DGA – e.g. sites where you don’t see anything, is that because they aren’t experiencing GIC?

2. Bigger picture

Alan - How does SWIGS relate to the ‘bigger picture’ are there things we need to change (within scope of the project) to stay relevant?

Mike Hapgood – BEIS have woken up to start saying we need to do something about this – there will be more space weather exercises. Need to talk to N. America more? Try and get people to understand what’s occurring and get a consistent message.

A UK project but need to be aware of how this relates to international activities. Any potential collaborations?

David – on the right track with all this (i.e. with SWIGS). Few places where we’re hitting issues that he’s pleased to see we’re hitting. E.g. Dst – is way over used but it isn’t right for GIC studies – Quebec is a good example – the blackout happened before the large value of Dst but it’s often presented as related. Important to make sure papers get written on e.g. the work Yulia has been doing to help in countering that argument

Also the railway stuff is great – be really good if we can take this all the way through to get to a tangible model – can then take that to network rail and get them to take notice. Hoping for opportunities to do some measurements on railways

Ciaran - Are there other big projects going on that we should be aware of?

Going on all over the place – Mike – starting to see a lot of engineers (mainly in US) throwing a lot of maths at the problem but maybe still missing some of the physics.

Mike - Internationally there are several groups in Spain looking at GIC, and a group in Ireland, but will the group in Austria continue? Maybe there is also interest in GIC from a group in Italy, Japan and China. Mexico starting to get very interested in space weather.

Juliane – re US electric hazard maps – should we be doing something similar? In principle, we already have this capability (Alan). Alan – post meeting - Might make for an interesting live display on the project website.

David – direction of the electric field is important – maybe look into statistics of that too (in EVS)

3. Website and publications

Website – will have a members only area (e.g. for all the talks for this meeting) but there will be a public facing part too – can people send in something about what they are doing. (Kathy) best way to do that is to send round an example to everyone and ask for something similar. Agreed by all.

Kathy – publications should also be on there (BGS - will need people to let us (Juliane) know and we’ll try and remember to ask periodically too)

4. Meetings schedule, DMPs and reporting

Alan - WPs have had telecons and occasional face-to-face. This is the first time in a year that we’ve all met together. Is yearly enough? Is 6-month too much? Agreement that annually, for a whole-team meeting is OK.

Kathy – annual meeting good, then some WP or breakout meetings (based on some of those themes we’ve identified) in between

Jim - we have the flexibility to have meetings organically

Alan – could be good to get a paragraph for the website from those WP and theme meetings just to help let people know what’s going on and what’s been discussed

Kathy - IUGG next year – we could/should contribute to that under any hazards sessions

Malcolm – publications – is there some statement of funding we need to put on those?

Put grant number in. SWIGS in brackets to help with searchability. Alan – doesn’t appear to be mandatory from NERC’s point of view, but I think it good practise (grant number + ‘SWIGS’) as it helps us in searching.

Alan - NERC need annual report – 1-page report – so WP leaders will be asking for highlights soon.

Alan - Next year’s meeting – should be more towards start of summer next year? – will be looking for someone to host. Alan – *post meeting comment* – the WP leaders discussed this and it was felt that 1st week of September was as good as any and we would try to do this again next year. For universities other dates would have to be pre-summer hence only ~8 months from now, so not much time for advances.

*Post meeting email from Phil Livermore (13/9/18):*

“One idea that came out of the SWIGS meeting was to run a simulation of the 1859 event (using the Earth’s internal field structure of 1859) and an equivalent event but using today’s internal field structure.

Although I realise that it may take some computational effort, I think being able to mine the model files for diagnostics would be really useful.

Lars mentioned that there is a BATSRUS model of this event - did they apply it to GICs? If Gorgon can’t do this (easily), could we use BATSRUS to generate the datasets that we would need?

Alan - more broadly, this is also something that we could all (i.e. everyone in SWIGS) contribute to - we could (presumably) feed the model output into a model of the conductivity and national grid, to see what the UK GIC effect would be.

I wonder whether there is some merit in trying to create such a model of the Carrington event soon - with a view to updating it in a few years in the light of SWIGS developments.

I can see it might serve to bring everyone together early on in the project - and it would be good to aim for a publication with everyone’s name on it.

Sorry for not suggesting this earlier, but it only just came to me!”

Alan comments sent to Phil: “We did discuss something along these lines. I recall that I mentioned that a thread through all the WPs for me could be doing something similar: WP1 research tells us how to improve M-I components of geospace models, which are then coupled to better models of Earth conductivity developed in WP2, which is then combined with solar wind data to forecast dB/dt in WP3 and finally fed into a grid model in WP4 to see what GIC we get. However what you propose would likely have more impact as it is the 'biggest storm' we know of. Whether Gorgon or BATSRUS can do this maybe someone else could comment on?”

This is included as **theme 4**.

*Post meeting email from Malcolm Dunlop (25/9/18):*

*“*I contacted Neil Rogers and Jim to see if there is mileage in comparing the FAC correlation distributions and current sheet orientations with the vector dH/dt. I guess this might develop into a cross WP1 and WP3 activity if feasible (I have a small amount of time allocated to WP3 anyway).”