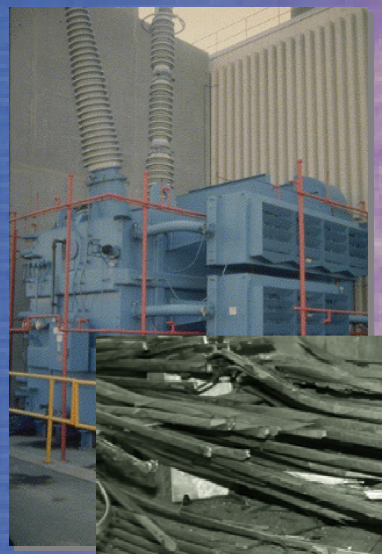
Geomagnetically Induced Currents

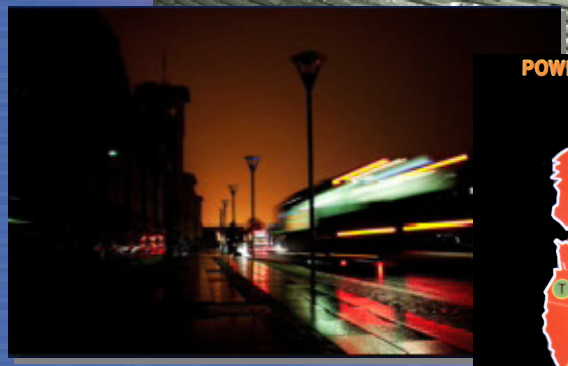
Antti Pulkkinen

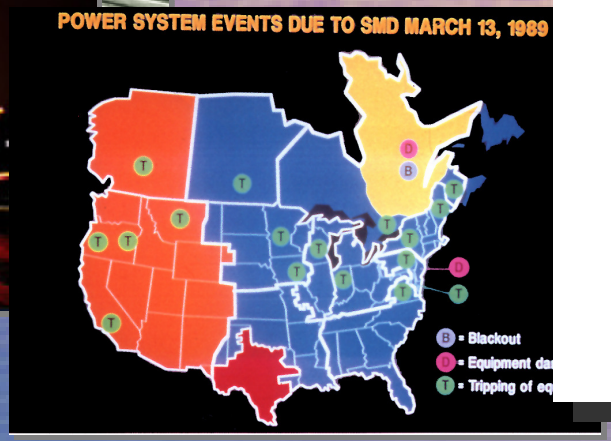
[1]The Catholic University of America & [2]NASA Goddard Space Flight Center

[1]Washington, DC, USA [2]Greenbelt, MD, USA

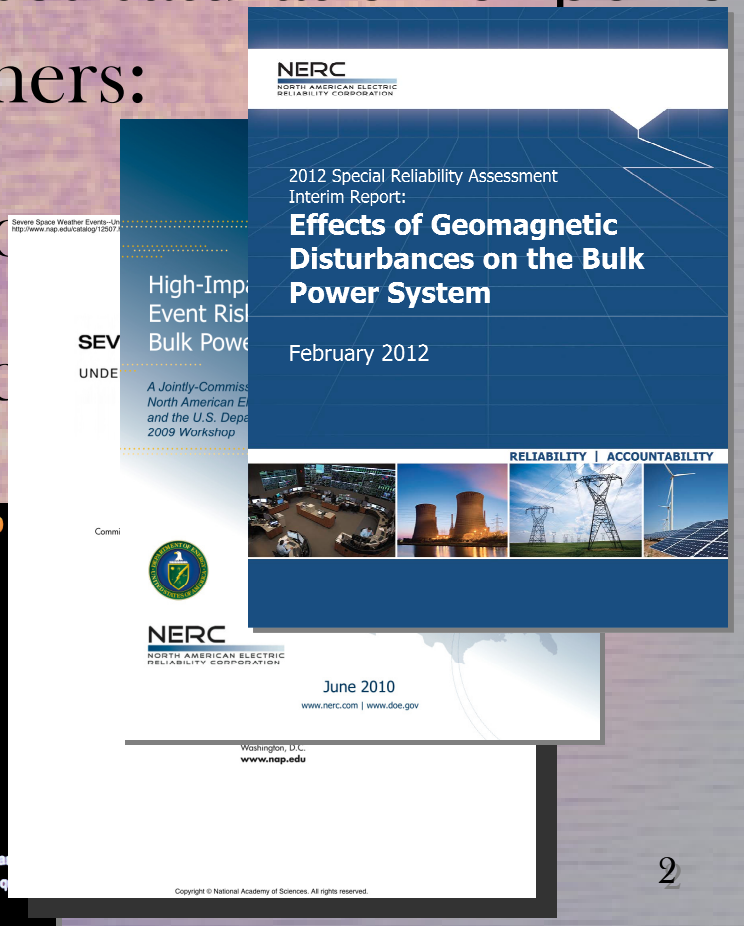
Why do we care?

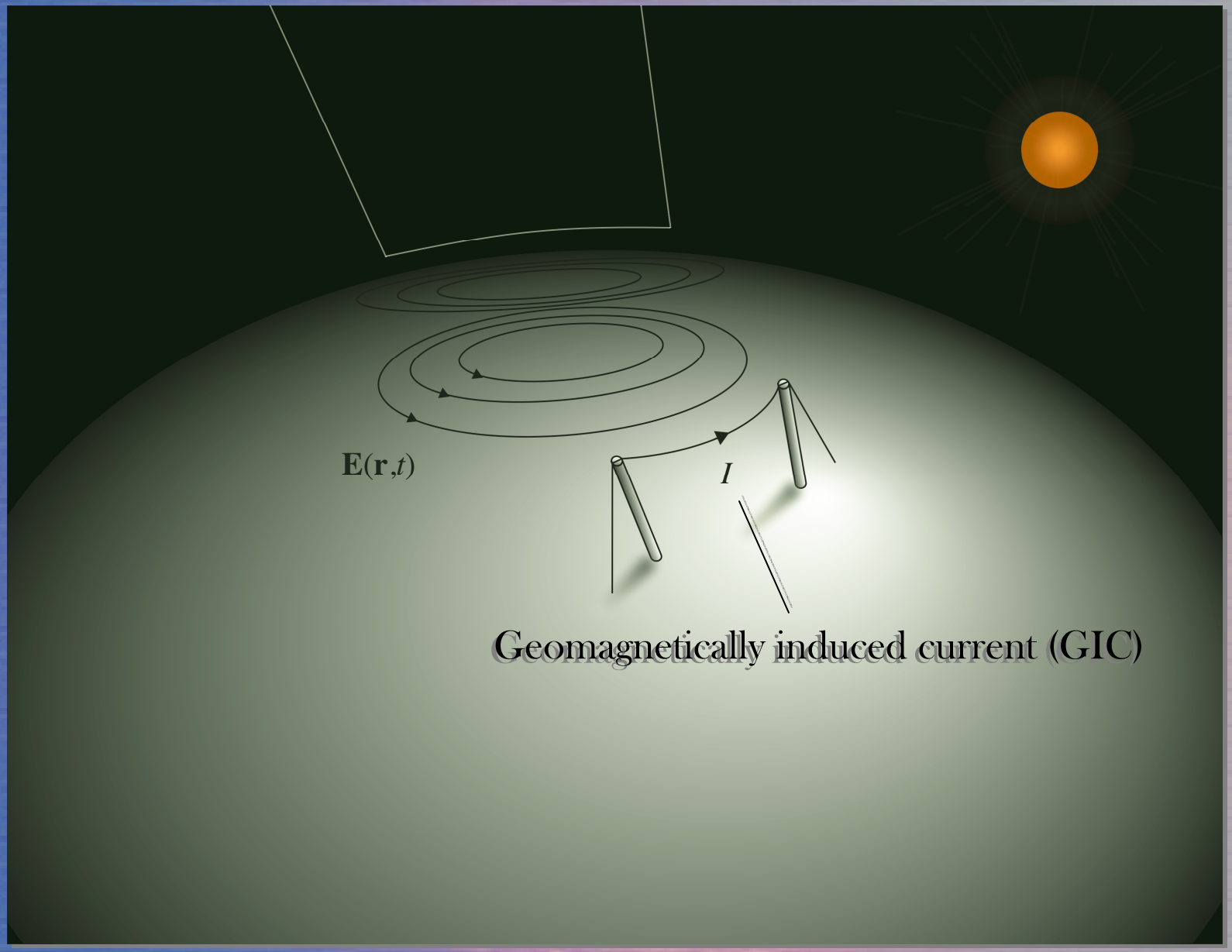






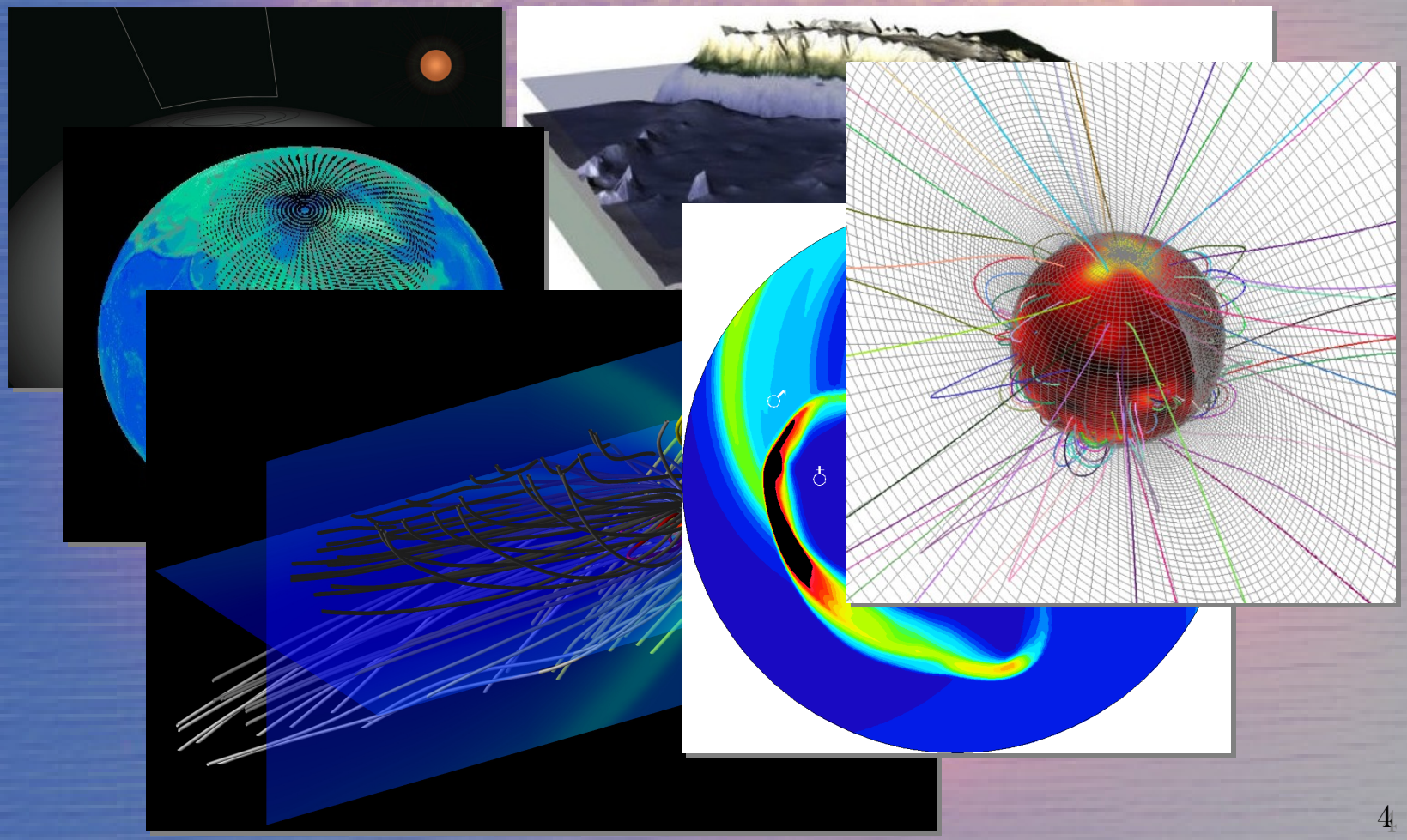
- GIC causes saturation of power transformers:
  - Transfo
  - Electric





Geomagnetically induced current (GIC)

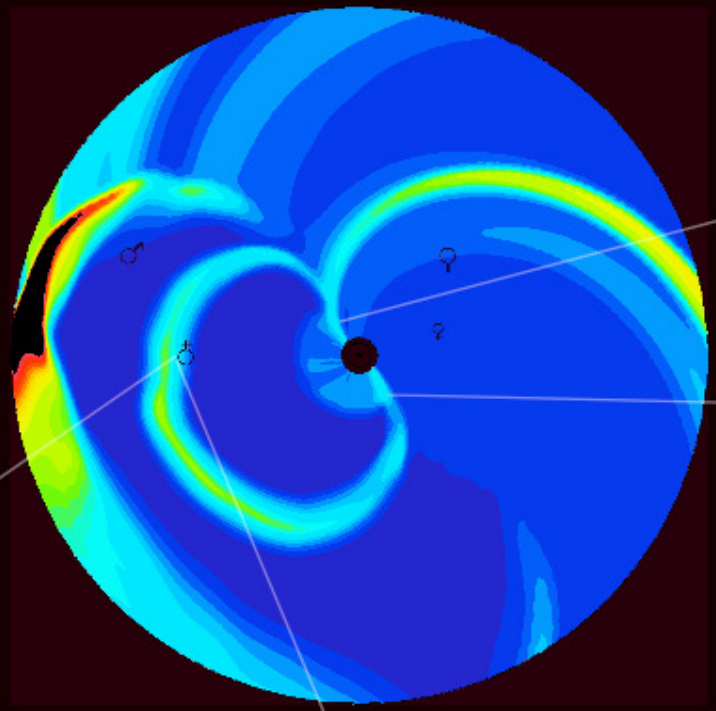
Overview of the GIC problem

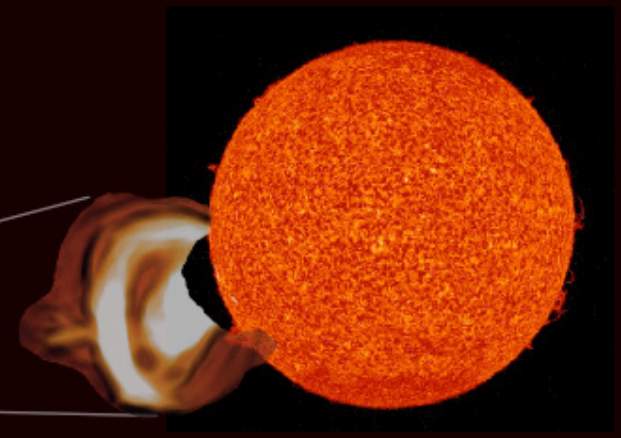


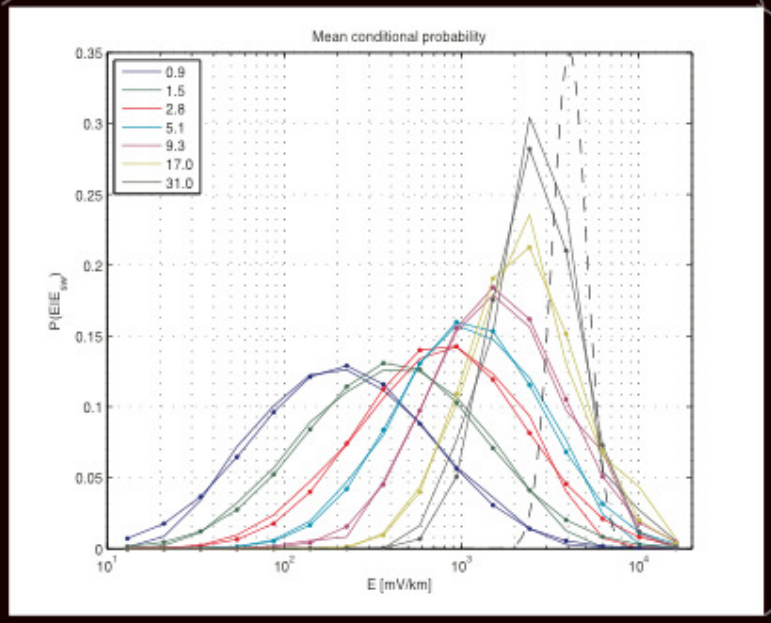
How NASA GSFC and CUA address these issues?

- Developing next generation forecasting capacity.
- Providing scientific analyses of extreme space weather conditions. These are being fed into further engineering analyses.

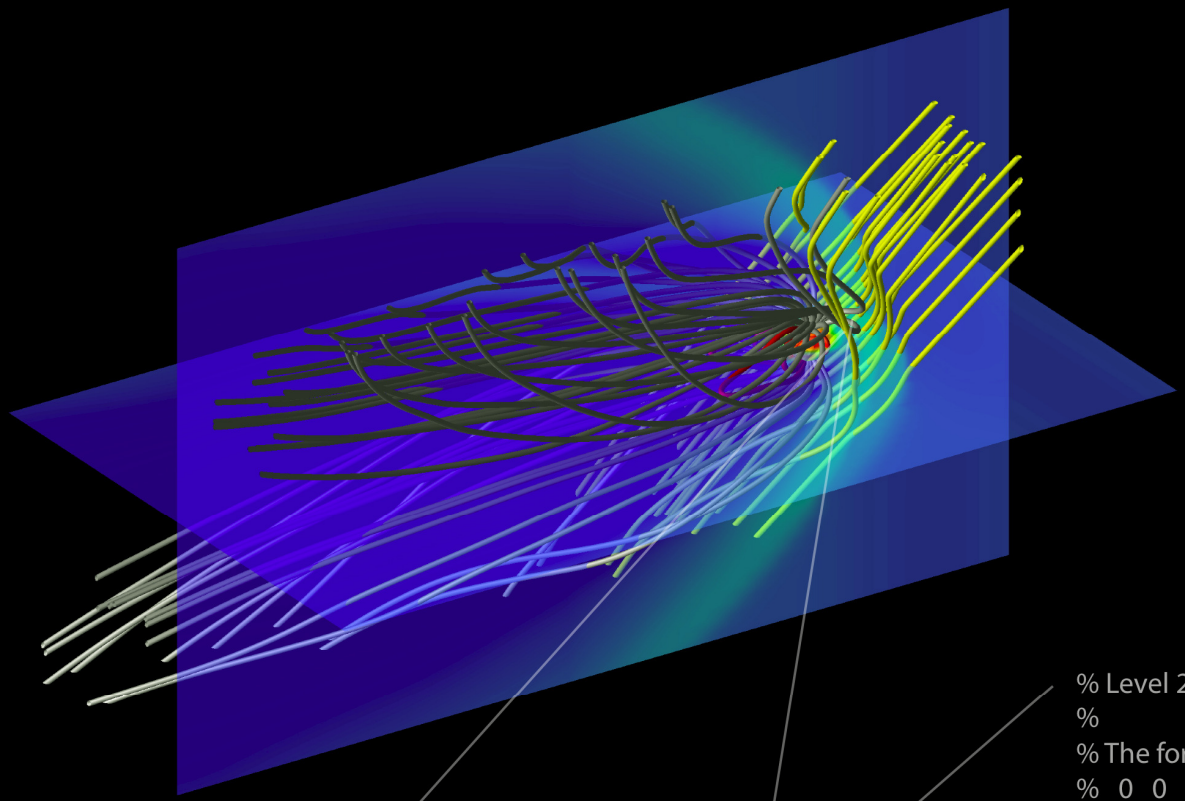
Next generation space weather forecasting

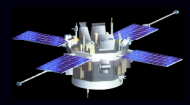


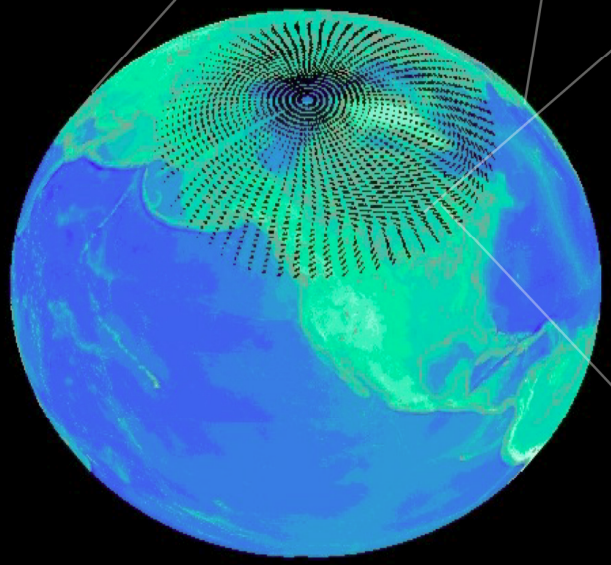





```
% Level 1 GIC forecast produced by REALTIMEGIC_LEVEL1
%
% The format of the data is as follows:
%  0  0  0  0  0 lat1    lon1     lat2    lon2     ...
% yy mm dd hh mi GIC1low GIC1high GIC2low GIC2high ...
%
  0 0 0 0    53.16  -99.29  45.39  -68.53
2006 12 14 14      6     76     15     153
```

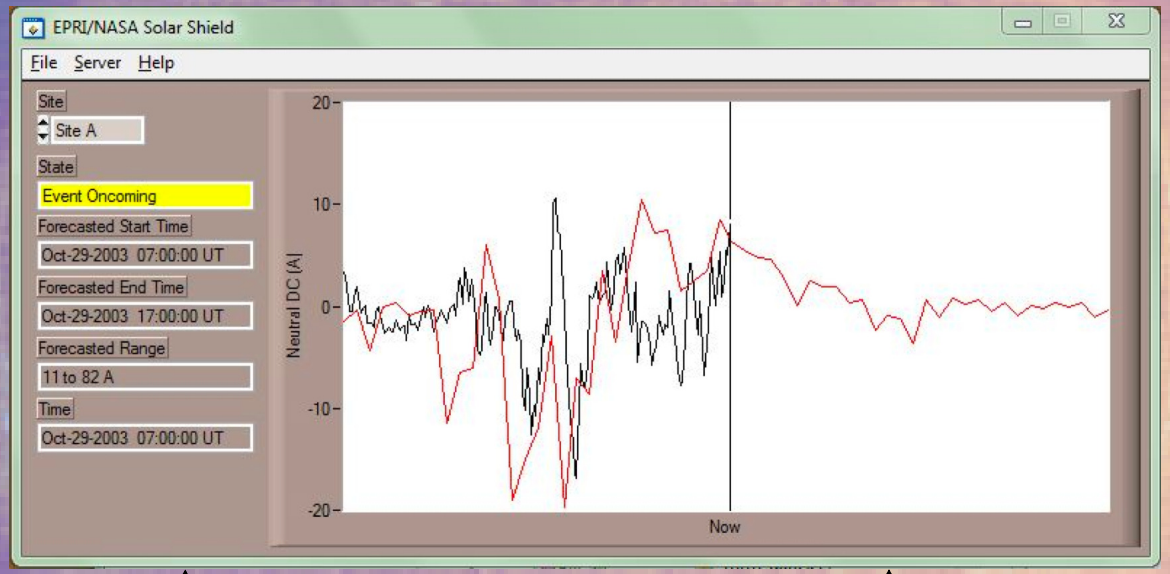






```
% Level 2 GIC forecast produced by REALTIMEGIC_LEVEL2
%
% The format of the data is as follows:
%  0  0   0  0  0  0 lat1   lon1   lat2   lon2     ...
% yy1 mm1 dd1 hh1 mi1 ss1 GIC1     0   GIC2     0     ...
% yy1 mm1 dd1 hh1 mi1 ss1 GIC1     0   GIC2     0     ...
%   . . . . . . .    .    .    .    ...
%   . . . . . . .    .    .    .    ...
%   . . . . . . .    .    .    .    ...
%
  0 0 0 0 0 0    53.16  -99.29  45.39  -68.53
2008 03 19 11 02 31    -0.11    0.00    0.13    0.00
2008 03 19 11 04 31     0.02    0.00    0.03    0.00
2008 03 19 11 06 31    -0.02    0.00    0.04    0.00
2008 03 19 11 08 31     0.00    0.00    0.01    0.00
2008 03 19 11 10 31     0.01    0.00   -0.03    0.00
2008 03 19 11 12 31     0.00    0.00    0.02    0.00
2008 03 19 11 14 31     0.02    0.00    0.04    0.00
2008 03 19 11 16 31    -0.00    0.00   -0.05    0.00
2008 03 19 11 18 31    -0.01    0.00   -0.07    0.00
2008 03 19 11 20 31     0.03    0.00    0.00    0.00
```

Coupling to the SUNBURST research support tool



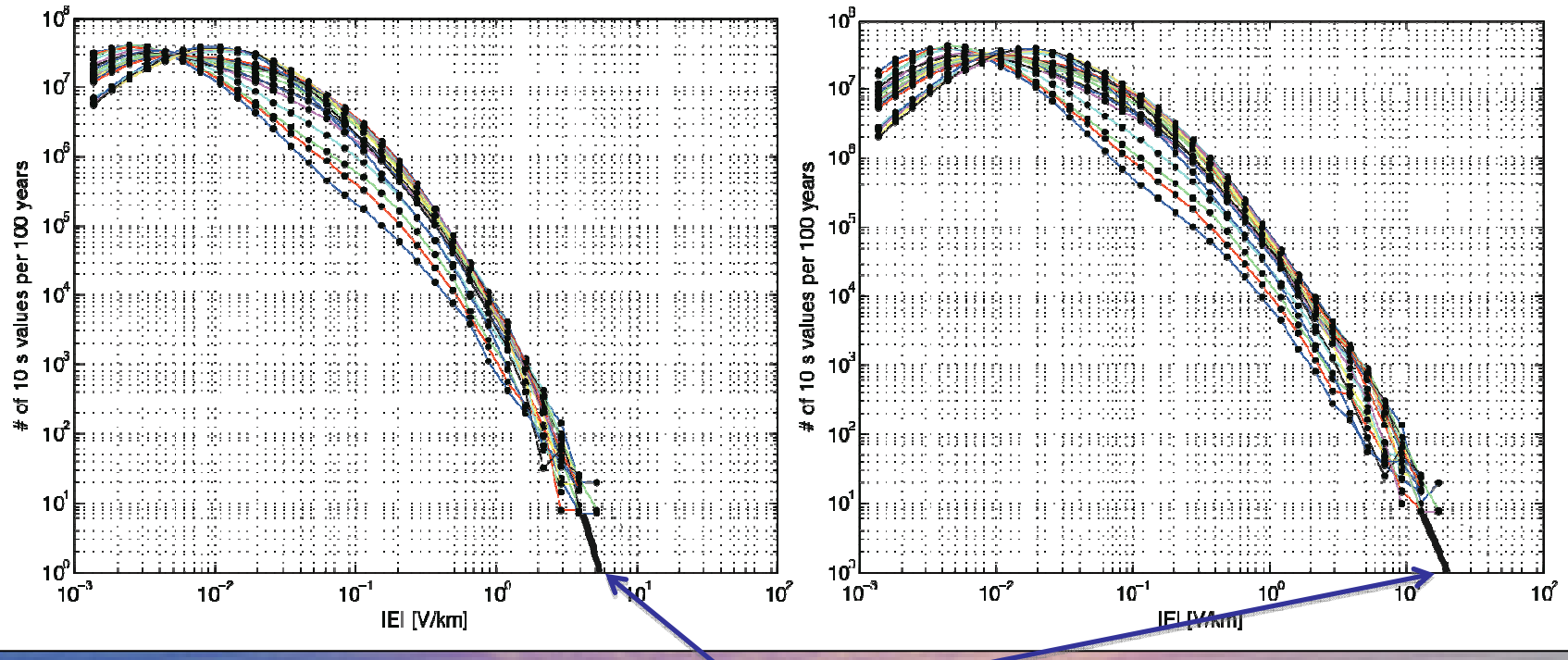

```
% Level 1 GIC forecast produced by REALTIMEGIC_LEVEL1
%
% The format of the data is as follows:
%  0  0  0  0  0  0 lat1    lon1     lat2     lon2     . . .
% yy mm dd hh mi GIC1low GIC1high GIC2low GIC2high . . .
%
  0 0 0 0    53.16  -99.29  45.39  -68.53
2006 12 14 14      6     76     15     153
```

```
% Level 2 GIC forecast produced by REALTIMEGIC_LEVEL2
%
% The format of the data is as follows:
%  0  0   0  0  0  0 lat1   lon1   lat2   lon2     . . .
%
  0 0 0 0 0 0    53.16  -99.29  45.39  -68.53
2008 03 19 11 02 31    -0.11    0.00    0.13    0.00
2008 03 19 11 04 31     0.02    0.00    0.03    0.00
2008 03 19 11 06 31    -0.02    0.00    0.04    0.00
2008 03 19 11 08 31     0.00    0.00    0.01    0.00
```

Analyses of extreme space weather conditions

a) British Columbia

b) Quebec

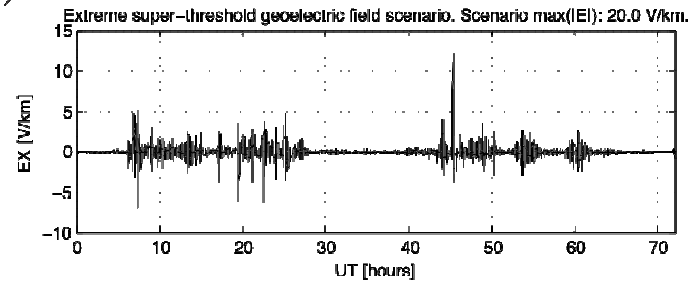


Data for 1993-2006

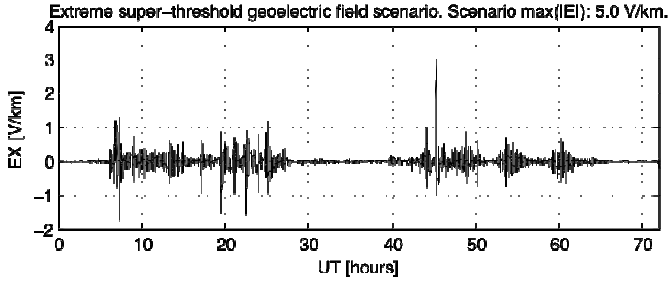
Visual extrapolation to 100-year amplitudes (well-justified if physics of the process remains the same)

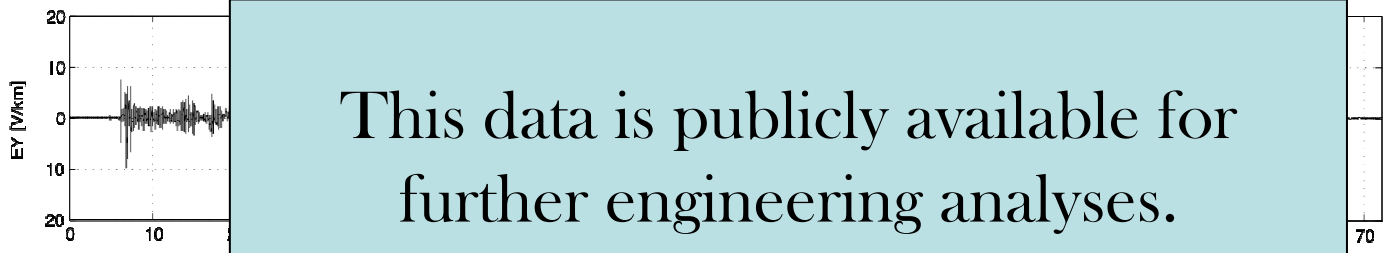
Resistive ground | Conducting ground

a)



b)

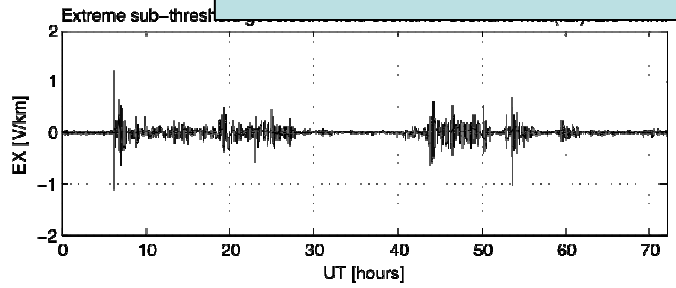


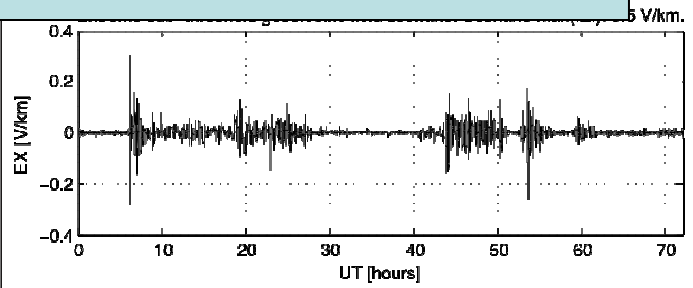


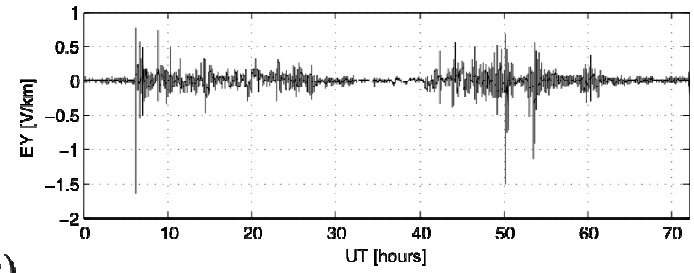
This data is publicly available for further engineering analyses.

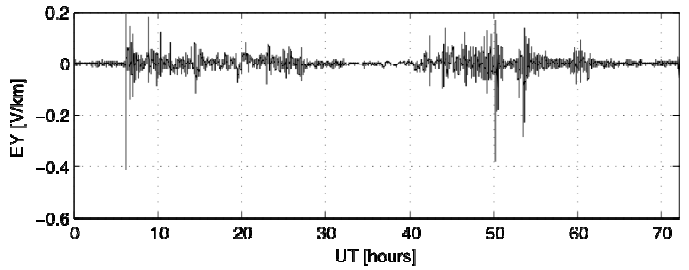
Above threshold geo-magnetic latitude

Below threshold geo-magnetic latitude









c)

d)

Summary

- GIC is a problem that needs to be addressed.
- Phenomenon the end link in the chain of complex space physical interactions.
- NASA GSFC and CUA address the problem both from the forecasting and extreme conditions analysis viewpoints.