FERC TM: Panel 3: Monitoring and future work

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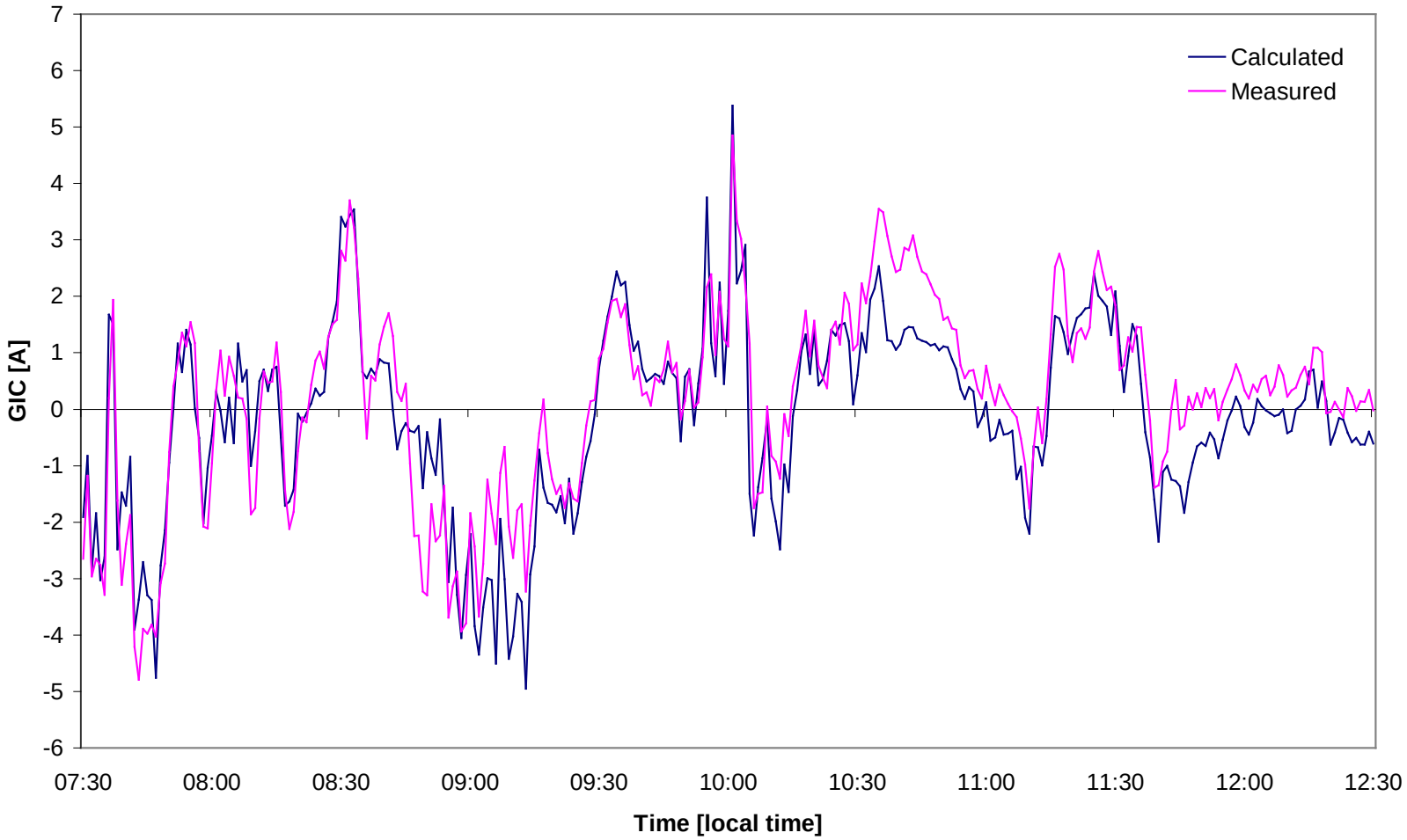
3.1 Present monitoring

- Extent of monitoring existing and in development, including GIC, geomagnetic fields, and geoelectric fields.
- Uses of monitored data (e.g. model validation, near-real time situational awareness).

Measurements test models

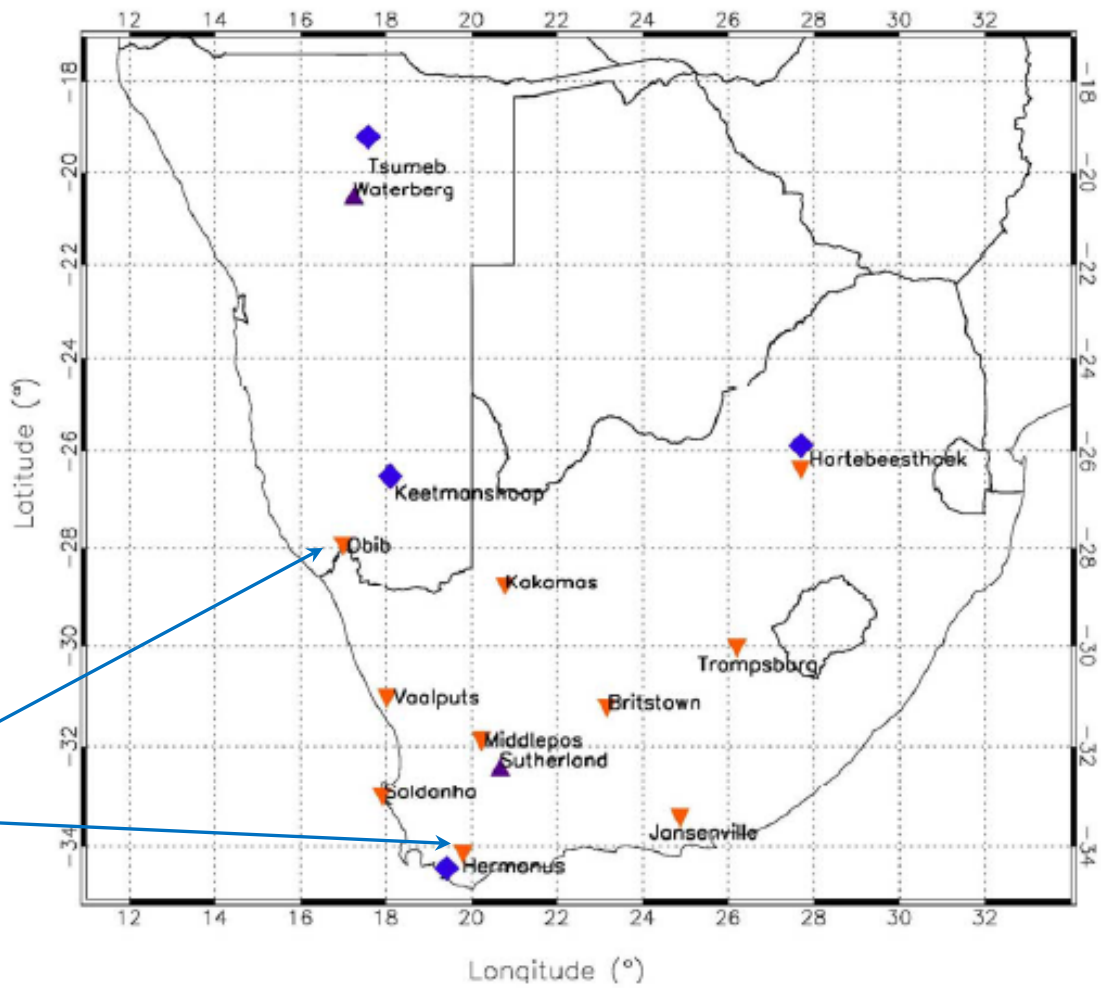


EPRI Sunburst tests GIC calculation in SA

[Koen & Gaunt, 2002]

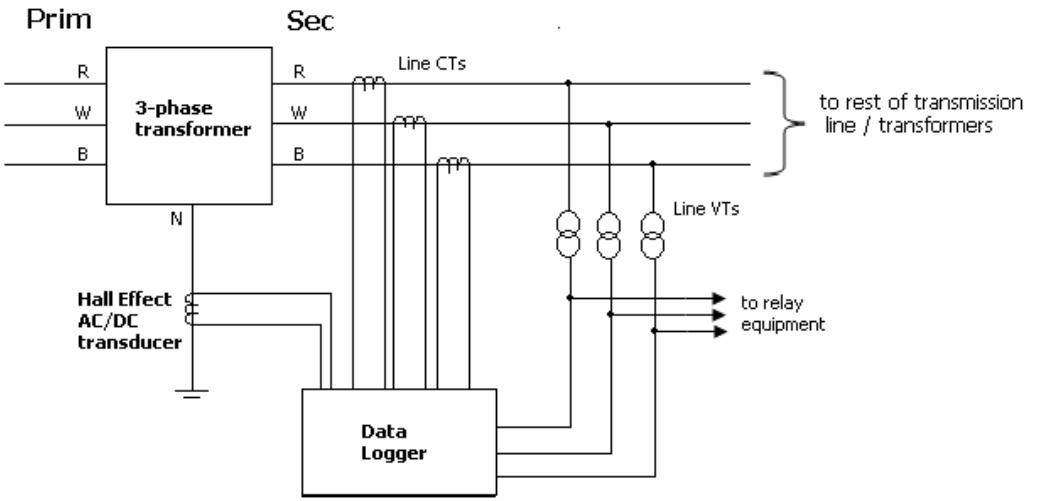
SANSA magnetometer and MT stations

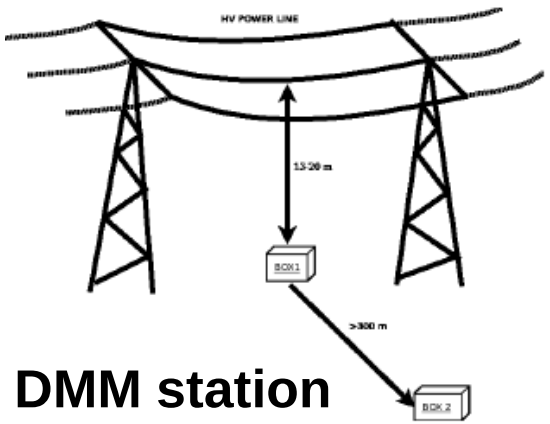
+2 DMM stations



GMD, GIC and Q measurements

- **B-field + GICs measured in line and substations → model back-fitting to derive effective ground resistivity, and …**
- **Measure Q vs GIC**



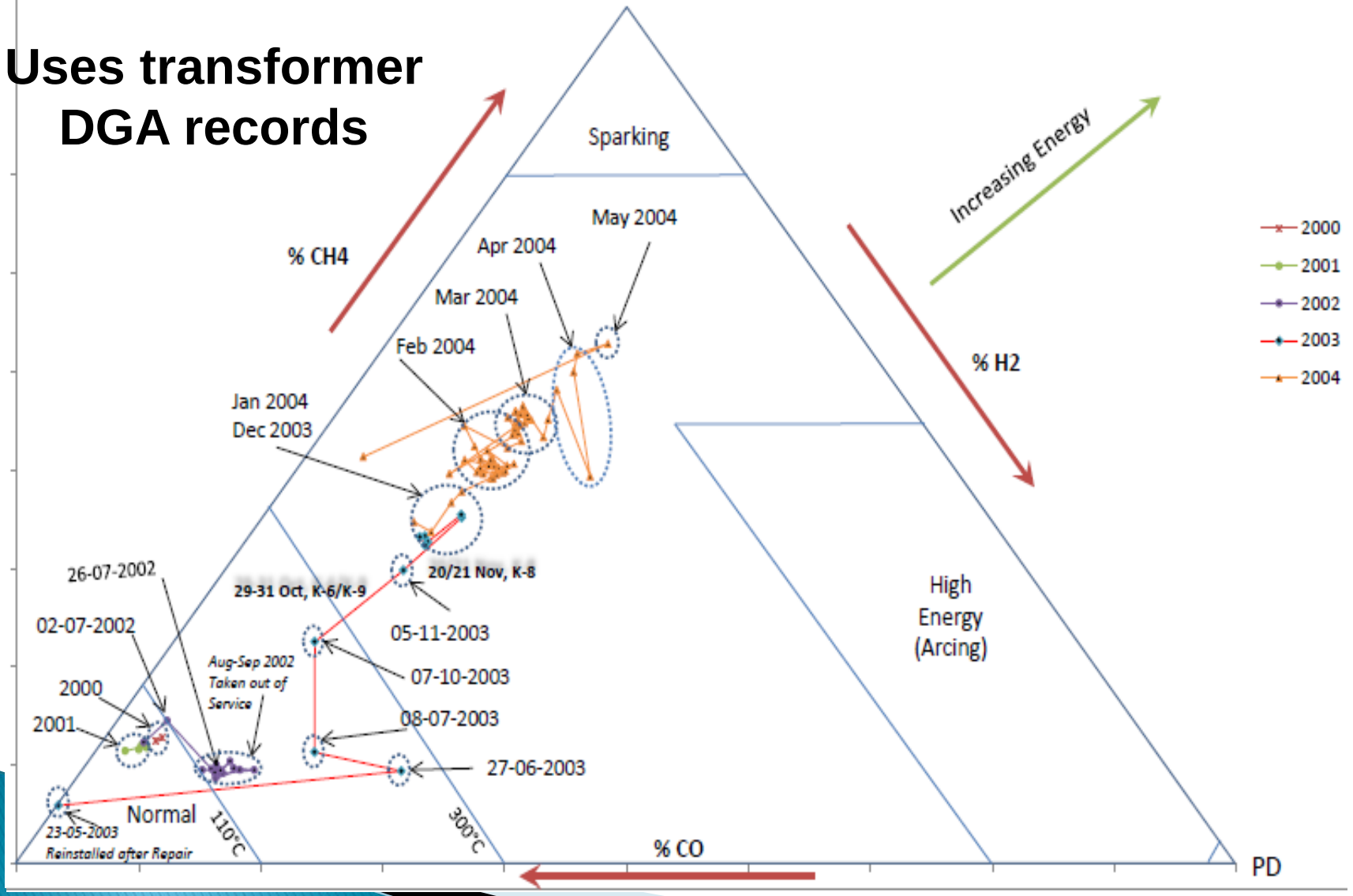


DMM station

Measurements easiest under single lines and at terminal substations.

Low Energy Degradation Triangle

Uses transformer DGA records

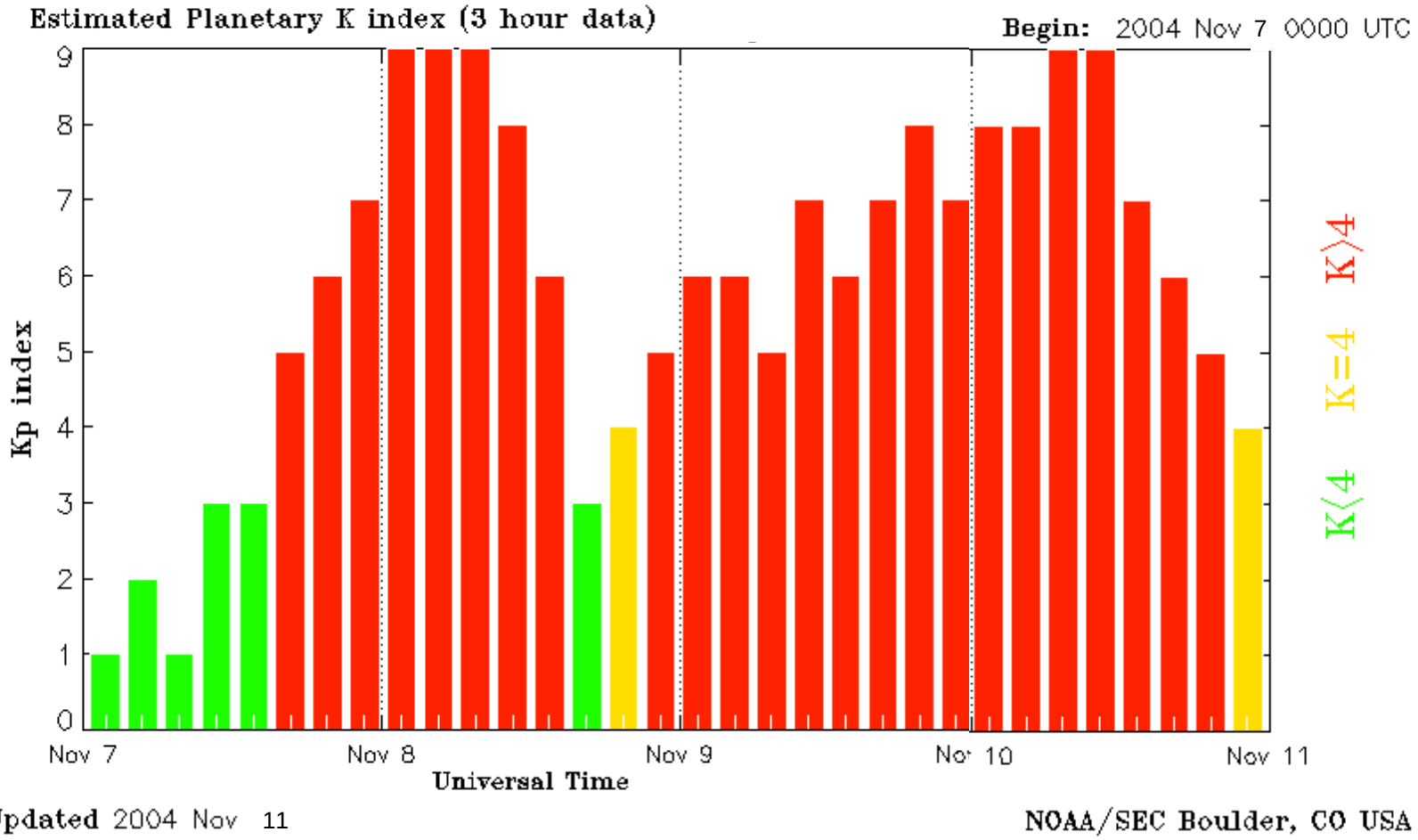


3.2 Potential for more monitoring

- Useful additional monitoring and process of selecting locations.
- Techniques to ensure maximum benefit of data (e.g., cadence).
- Costs and other factors to consider in installing, operating and maintaining monitoring devices for GIC, geomagnetic fields and geoelectric fields, including opportunities to collaborate.

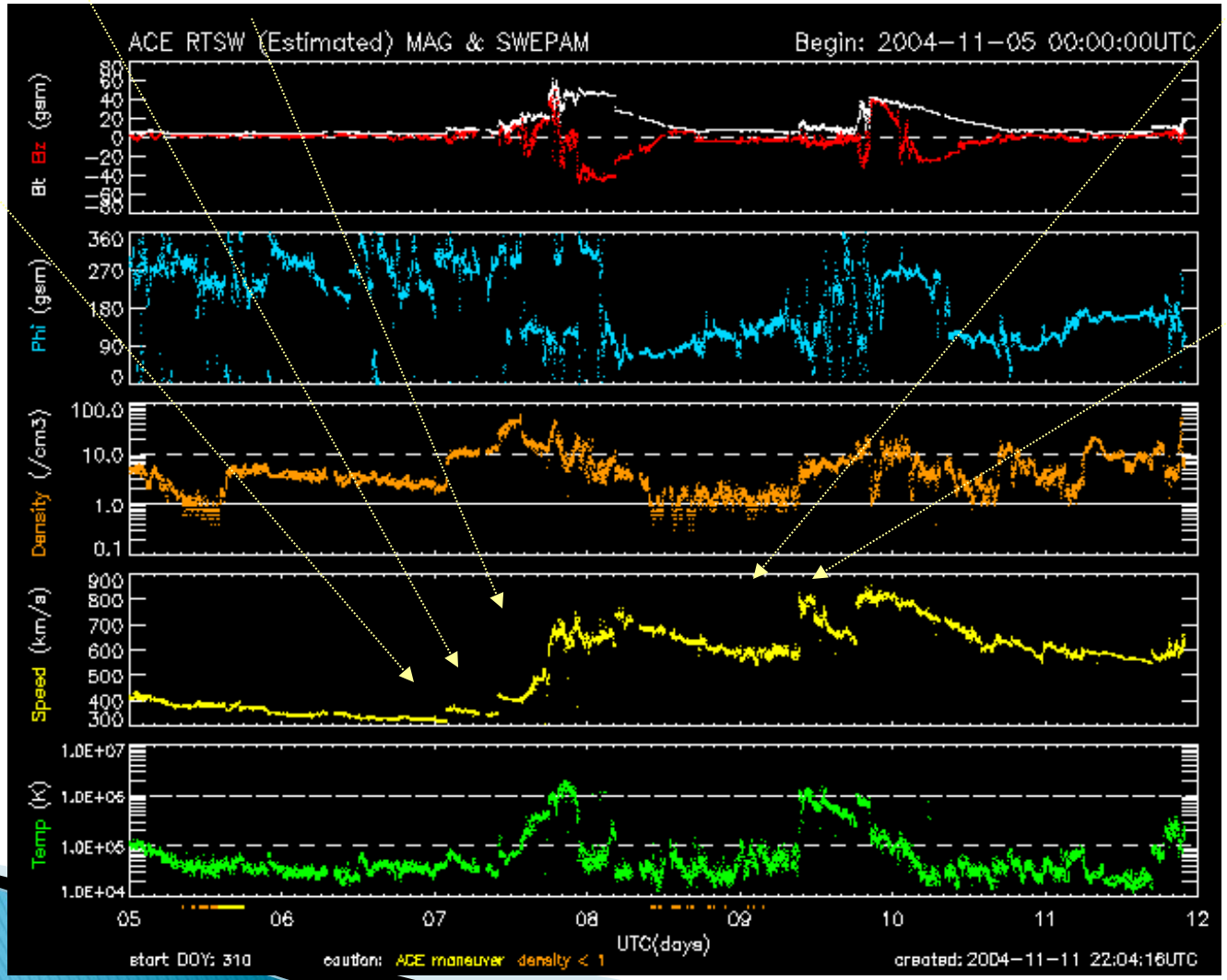
Multiple events: GMD 8-10 Nov 2004

NOAA estimated Kp-index



Carrington event (1859) lasted 5 days!

9 Earth-directed CMEs resulted in at least 5 shocks at ACE



Co-located, simultaneous data

To develop GMD models:

- **Solar wind data and local *B*-field data**

For ground conductivity data:

- **MT measurements and/or simultaneous GIC and *B*-field measurements**

For system response:

- **GIC, $Q_{(GPT)}$, P, V and I measurements**

For transformer response:

- **GIC and Q measurements, DGA records, failures**

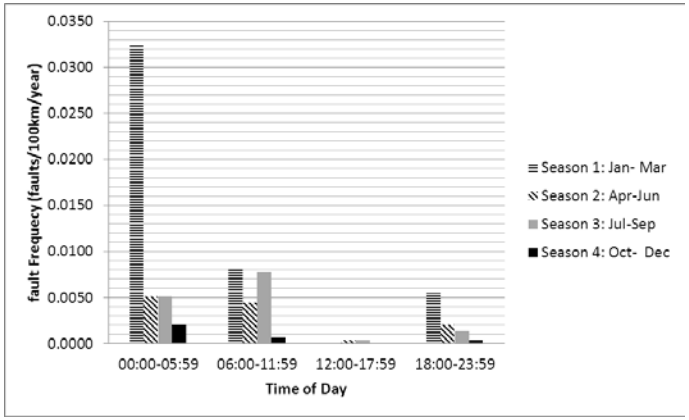
Weather, failure and CIC data

<u>GIC events occur at same time as ‘normal’ system faults.</u>

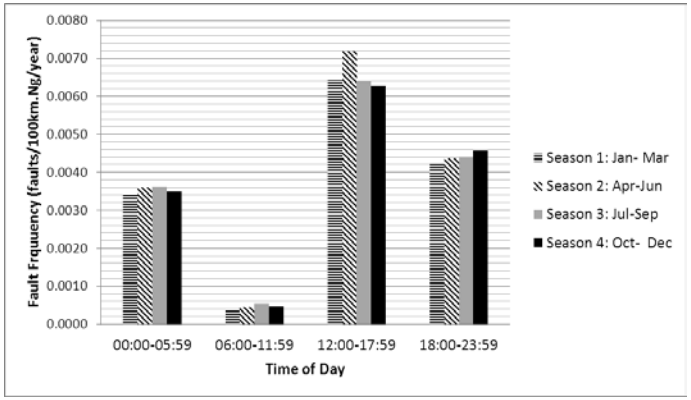
‘Public benefit’ and mitigation depend on ‘value at risk’ - V@R.

Requires:

- **Characteristic failure data**
- **Cost of interruption data**



Pollution



Lightning
(Ng=1)

Real-time data

Main data requirement is for model testing and research.

Limited data used in real-time – so far.

Real-time data for operations requires:

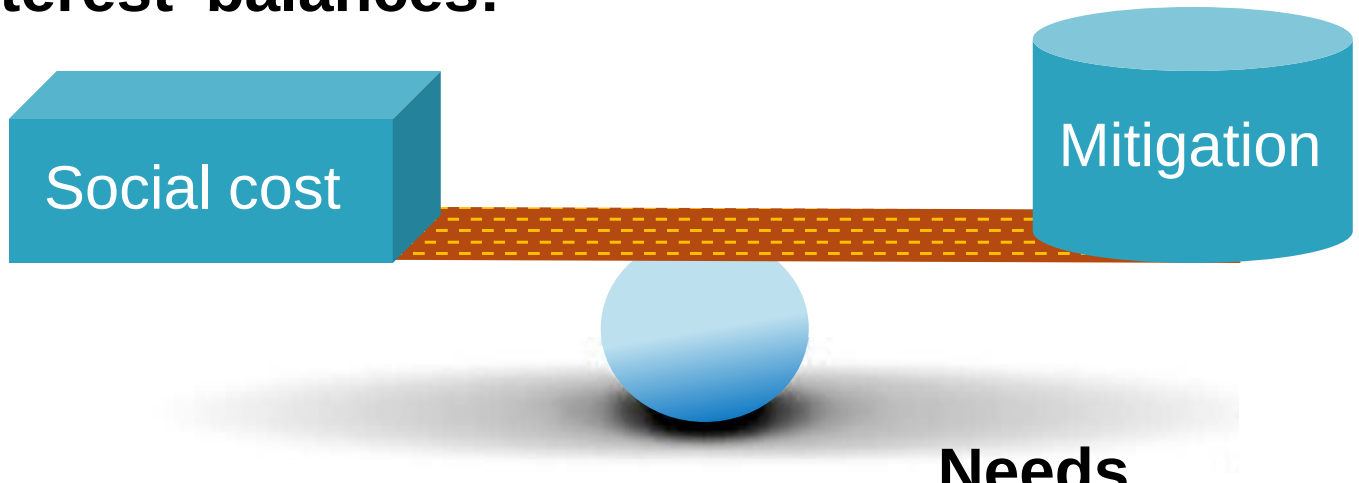
- **Communication channels**
- **Error checking**
- **Interpretation and user-friendly display**
- **Response plans**

Future research

Probabilistic

- **GMD and GIC phenomena, esp. extreme event models**
- **disruption of supply system,**
- **condition monitoring and**
- **costs of interruptions.**

‘Public interest’ balances:



Needs collaboration

3.3 Availability of data

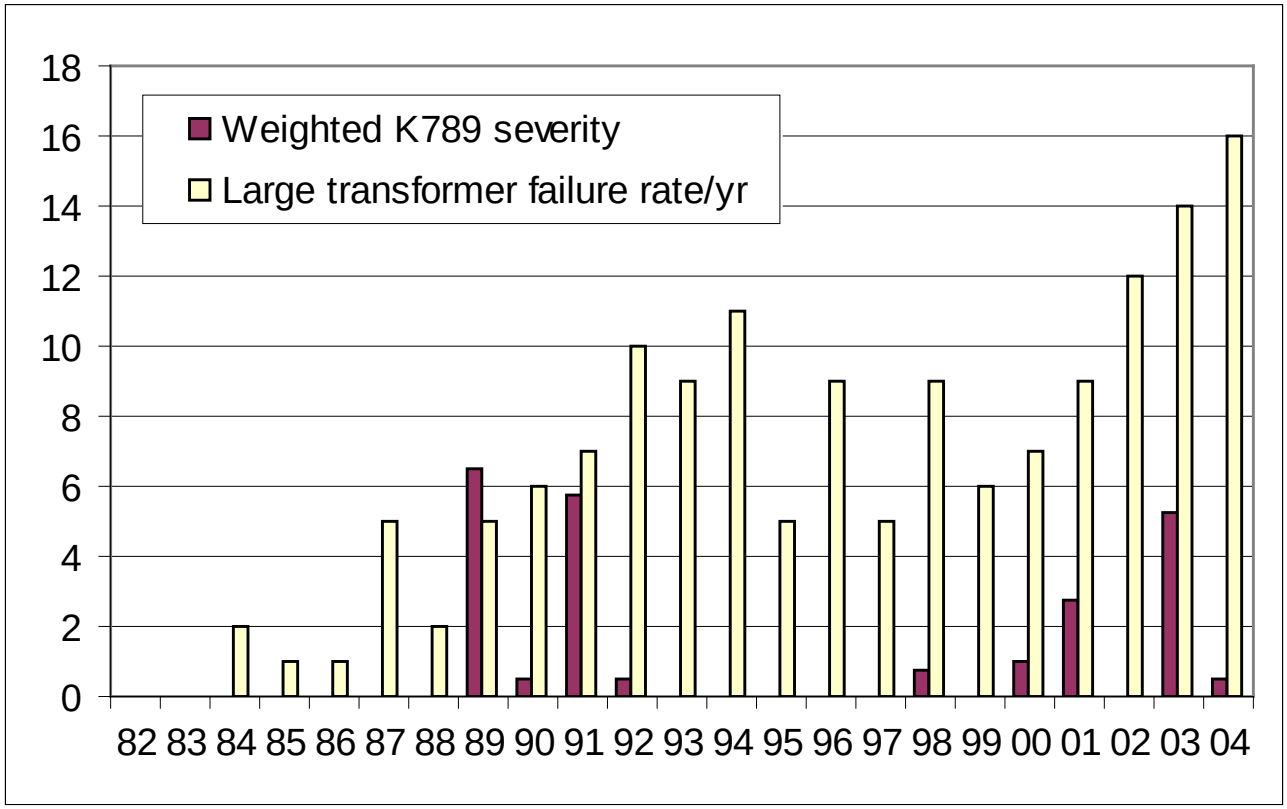
(e.g. today and future,
need for protection,
methods for sharing).

Transformer failures

Eskom 1984-2004, filtered

Also:

IEEE PES survey of GSU failures 1980-1994



Cigré transformer failure rate surveys [1983 and 2015] do not collect year of failure → no profiles.

Collecting data

LEDT and GIC research has shown many utilities:

- **will not provide data,**
- **claim data is confidential and sensitive, and**
- **even state their transformers do not fail.**

~1% of large transformers fail each year, on average.

Basic asset information is on the Web.

Most data has no value until analyzed.

Summary

Knowledge and techniques have been

- and are being - developed,

… but data for rigorous testing, planning and operations is scarce,

… and (mostly) techniques and data are neither shared nor received.