

How much Earth Potential Allowance is really needed for Submarine Systems?

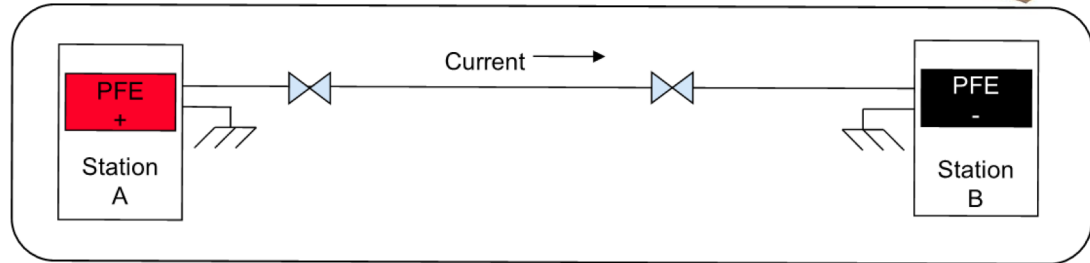
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Powering Undersea Systems

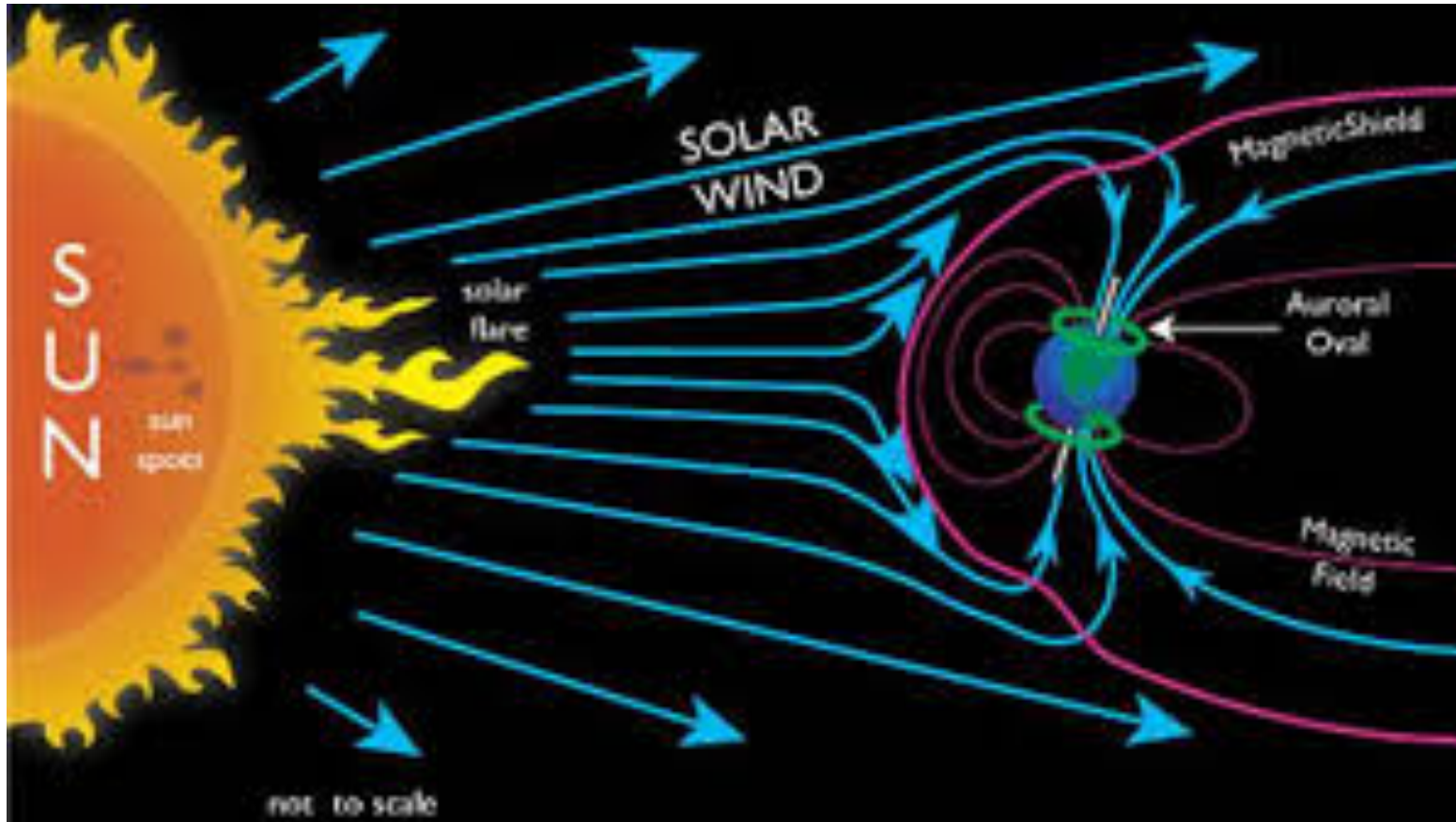


- Large DC Power sources feed systems from shore
- System Voltage consists of 3 components:
 - IR drop of Cable
 - Voltage drop across each repeater
 - Earth Potential variations

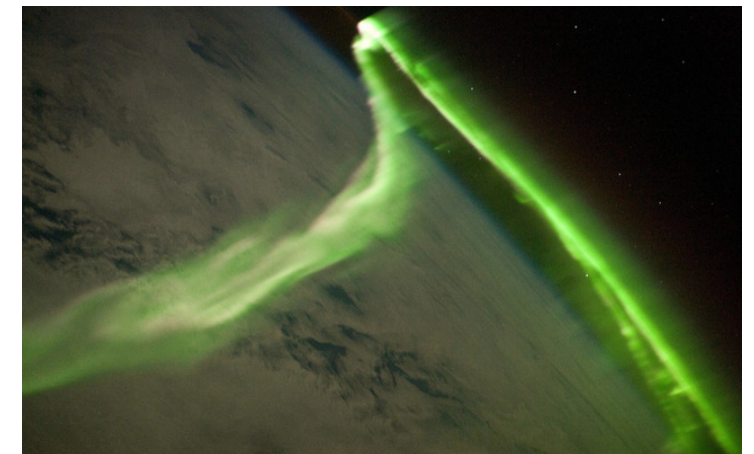


- ~ 15,000 volts @ 0.75A
- ~7,500V = 10,000km * 1Ω/km * 0.75A
- ~6,500V for repeaters
- ~1,000V earth potential (0.1 V/km)

What Causes Earth Potential Variations ?



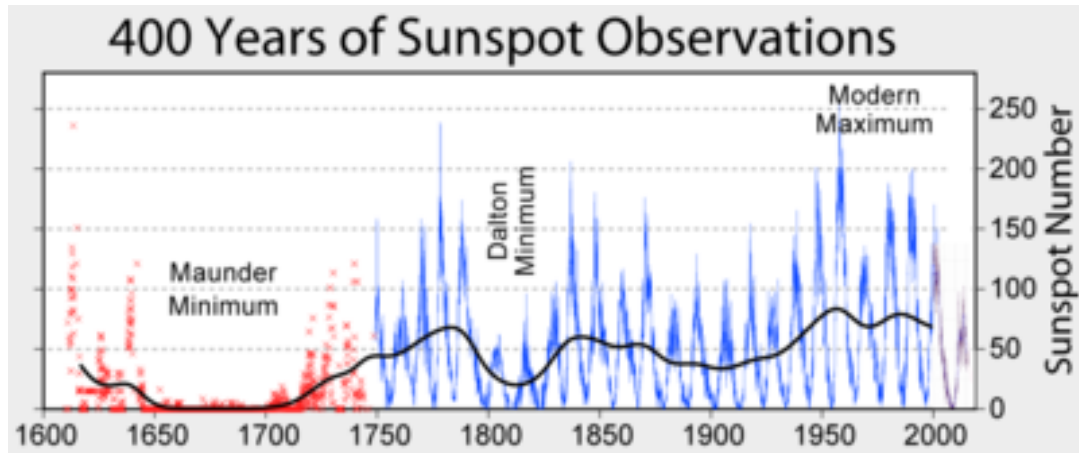
- Sun continuously emits a stream of charged particles
- The charged particles interact with the Earth's magnetic field
- Variations in the magnetic field and Auroral electrojet induce current along long conductors (Pipelines, power systems and submarine cables and even the ground)



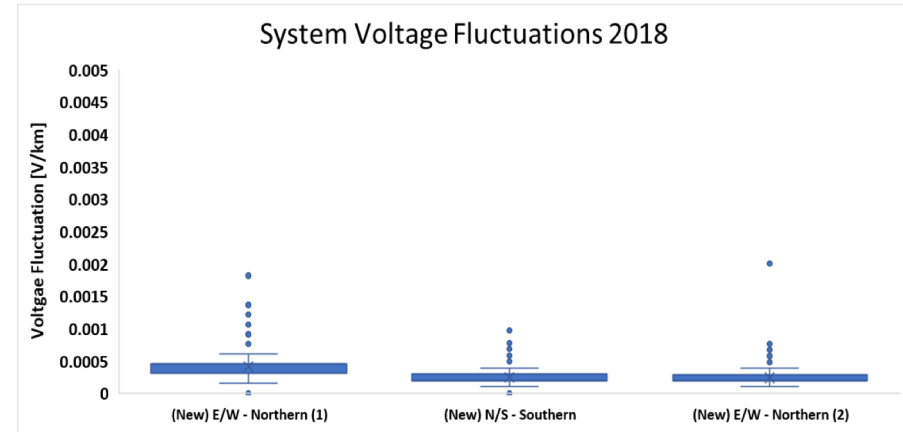
How big are the variations and should we worry ?

Magnitude of Earth Potential Variations

Solar activity follows a cycle



Ordinarily Geomagnetic impact is very low even at maxima

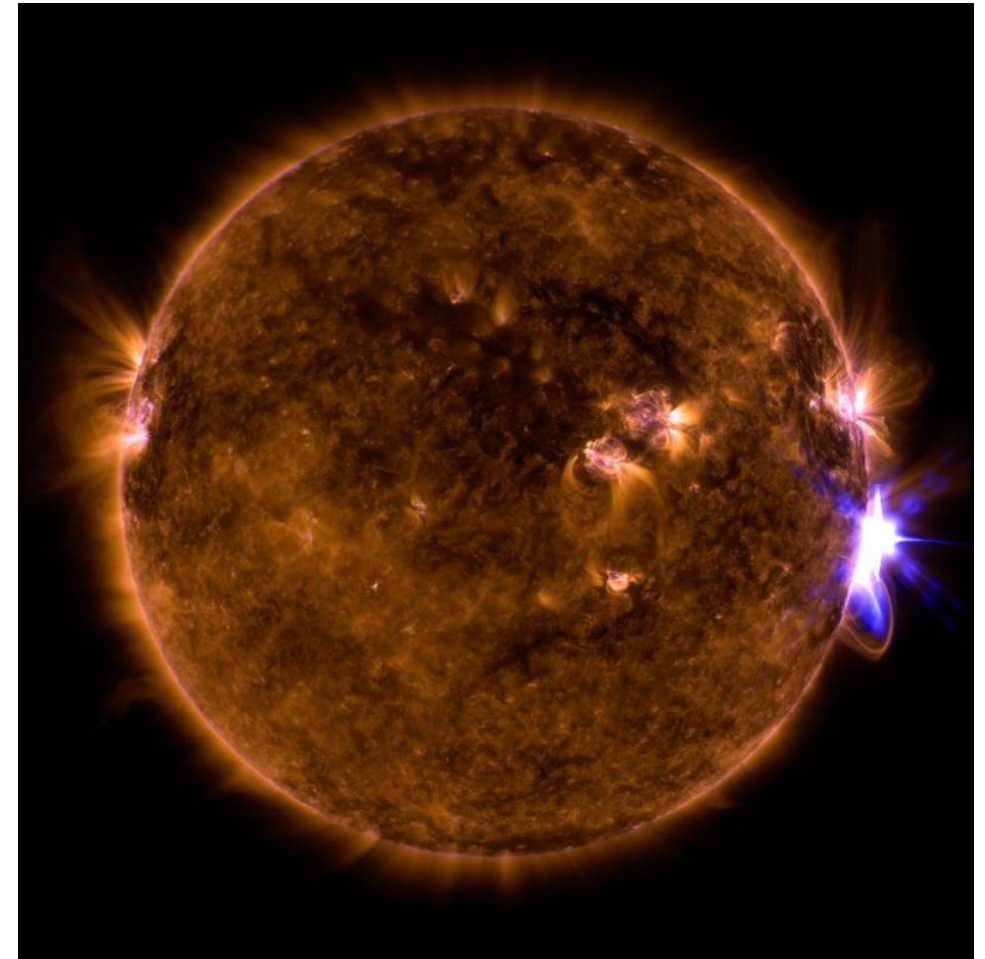


However

- Several Historical disruptive events have been recorded
 - Carrington -1859
 - L4 outage 1972
 - Quebec Blackout 1989

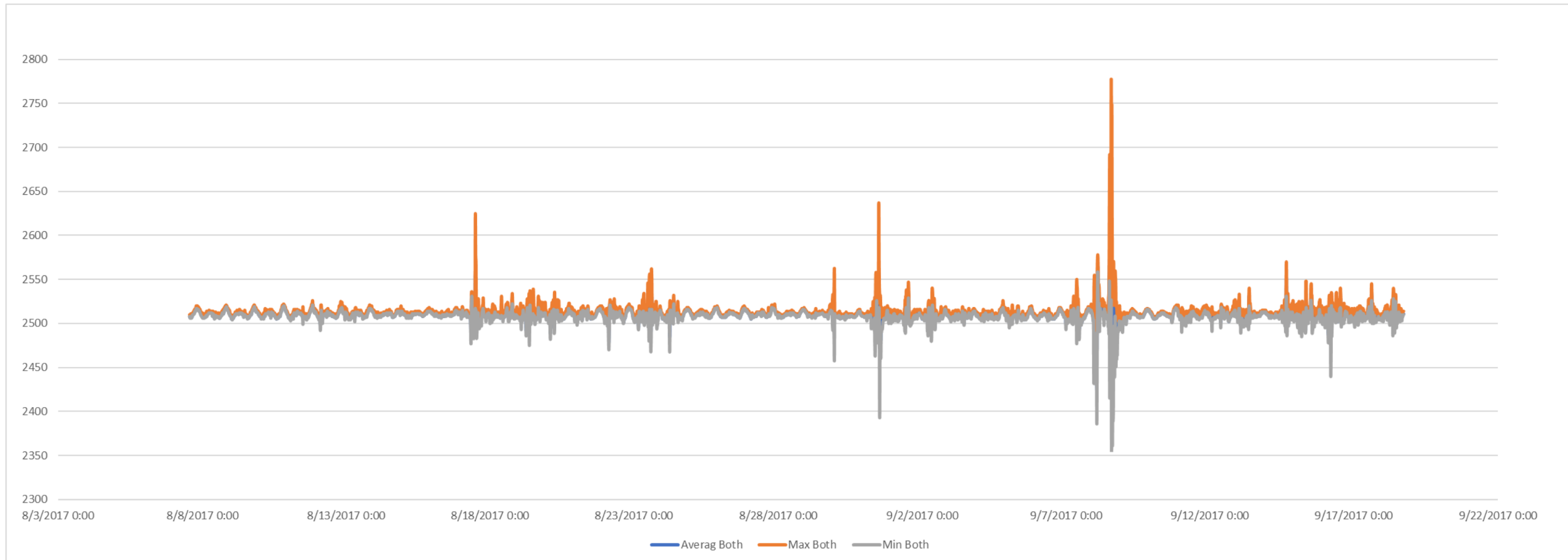
Impact of a Recent High Magnitude CME on Submarine Systems

- On September 11, 2017 an X8.2 magnitude solar flare was observed
 - X is highest class of flare, magnitude is exponential (like Richter scale). The last flare of similar magnitude occurred in 2006 and the one previous was 30 years prior
- Submarine System Electrical Powering Data was pulled to examine impact
 - Systems were selected in all hemispheres and system orientations (East-West or North South)

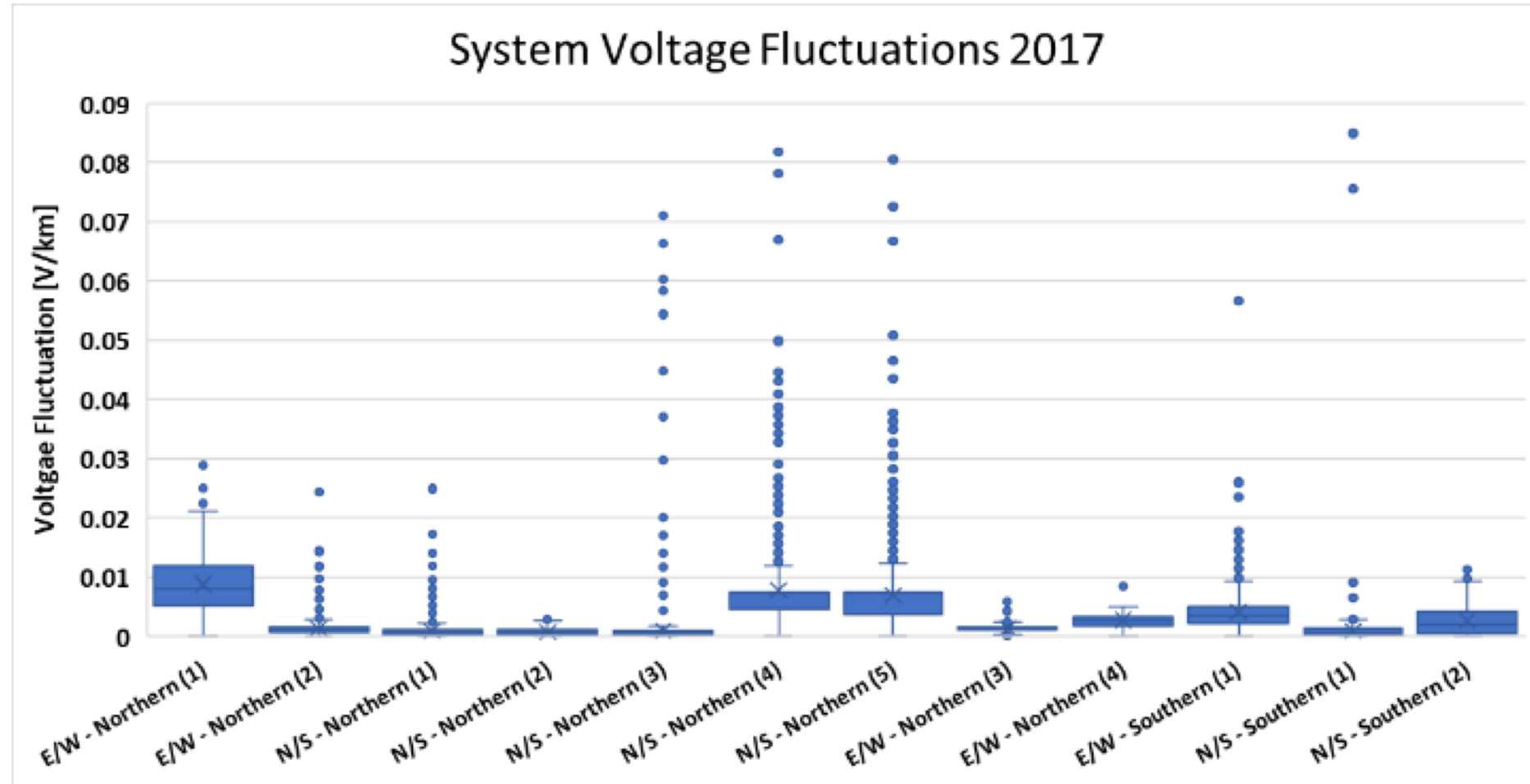


The Results: Activity detected on Systems

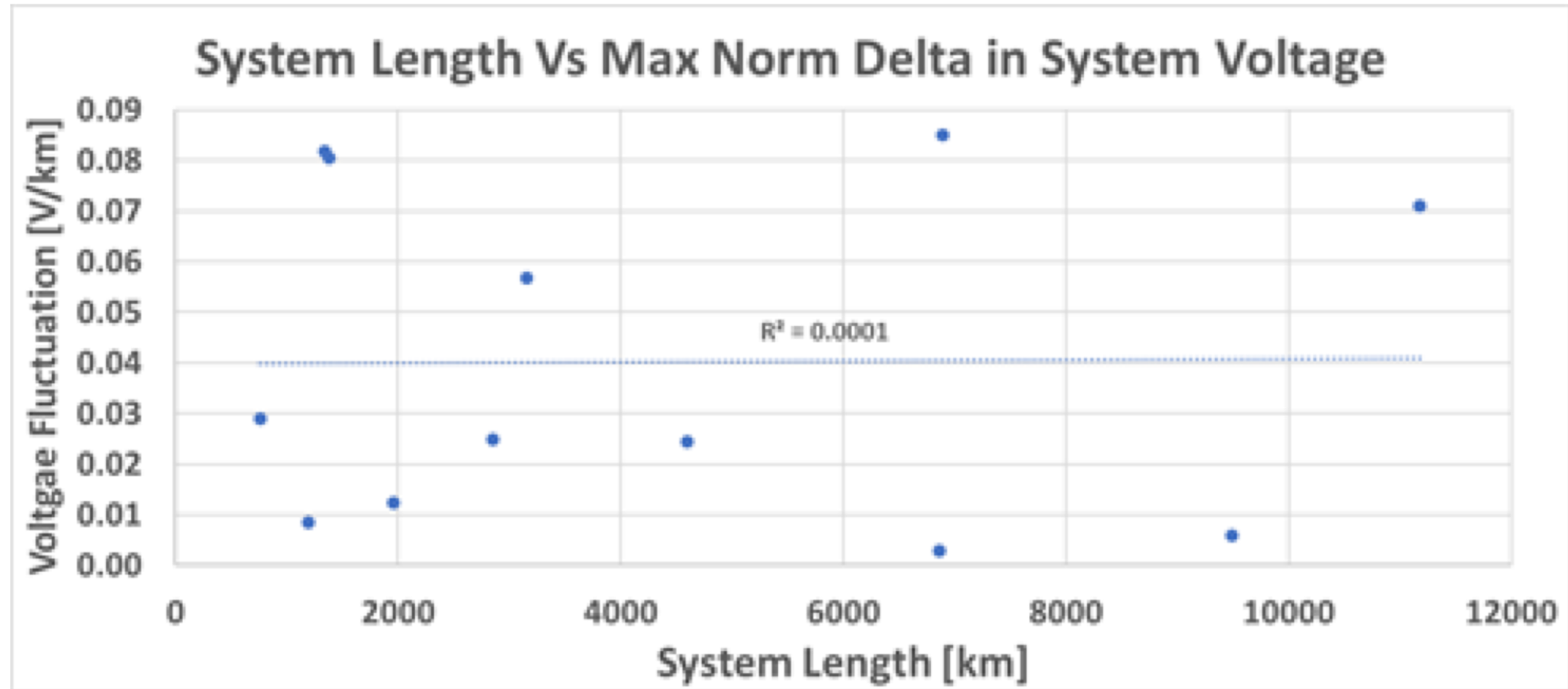
A North-South Oriented System at high latitude



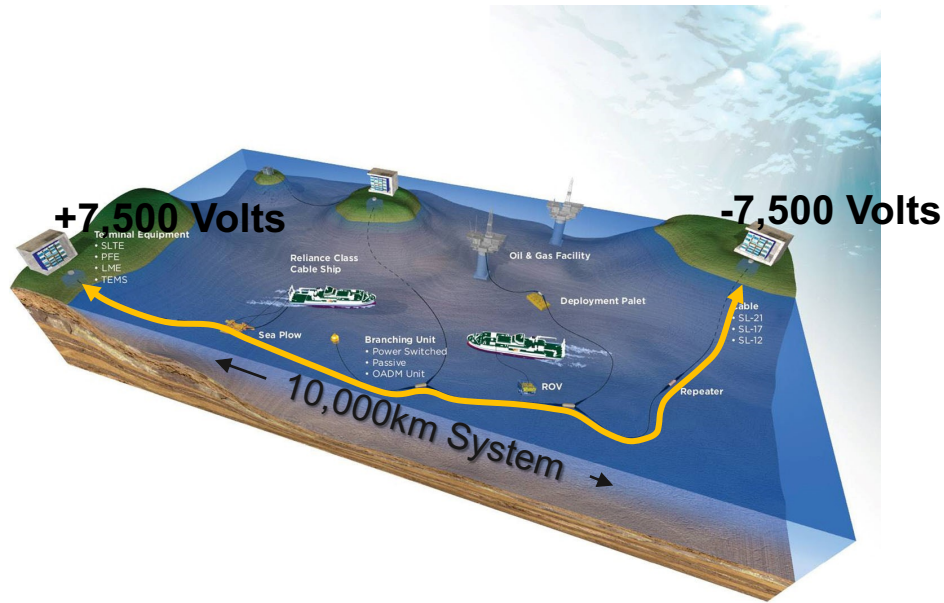
The Results: Magnitudes very low



The Results: No Correlation to system length !



A Bad Day !



- Most modern systems are rated for Single end feeding
 - During normal operation *PFE are only at half power*
 - This provides a *large Voltage headroom* for the system
 - Only in the *very rare and extreme* case of a shunt fault at the far end does the system go into single end feeding
 - *The likelihood of a Massive CME aimed directly at Earth during this period is vanishingly small*

- **Recommendation**

- The allocation of EPA in system voltage margins could be better used to improve system performance such as extending Single-end feed reach or increasing available optical power
- Suggest the EPA rule of thumb of 0.1 V/km be reduced to 0.01 V/km if not eliminated entirely

Thank you !!

