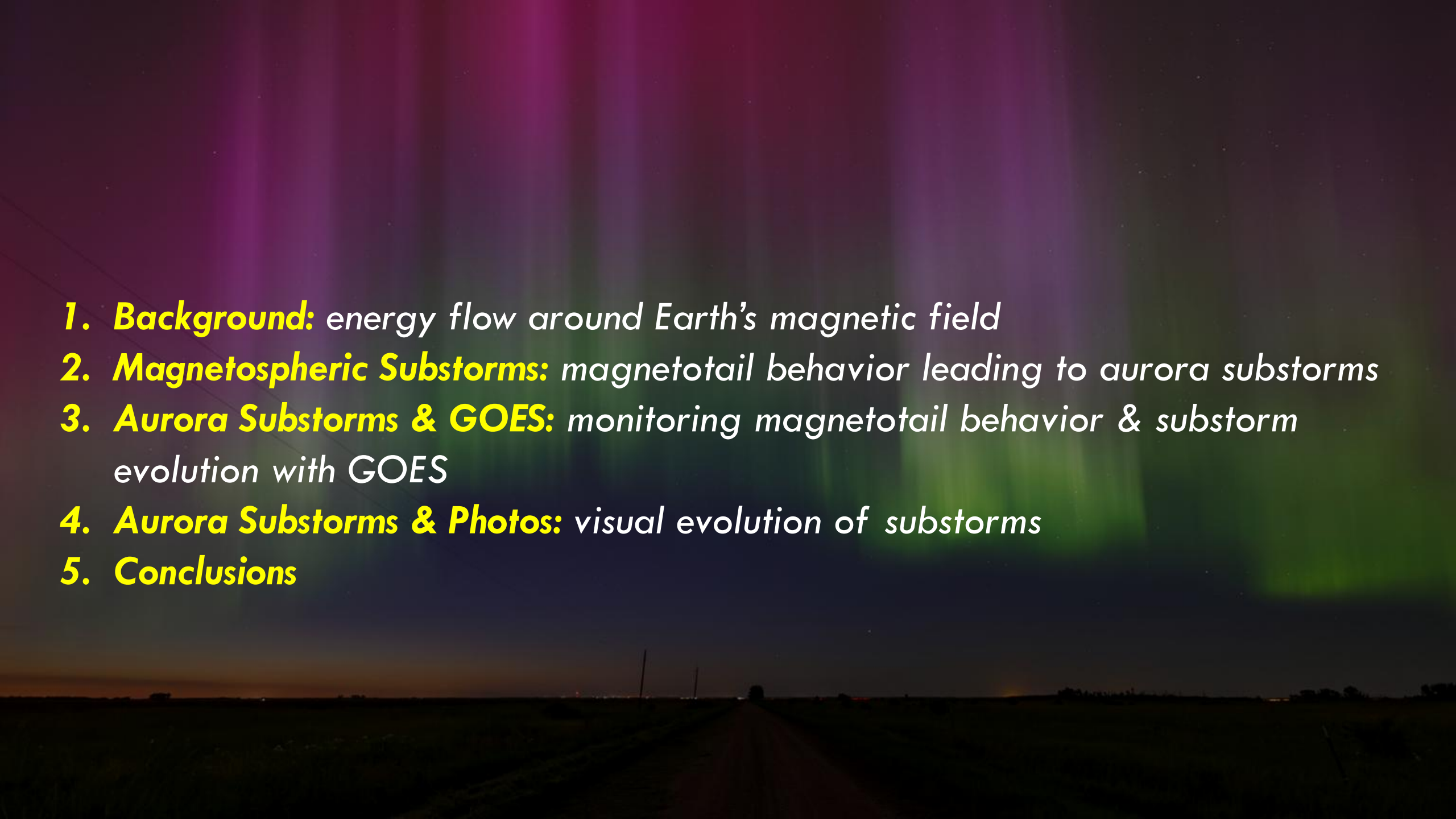
A simple guide to northern lights forecasting

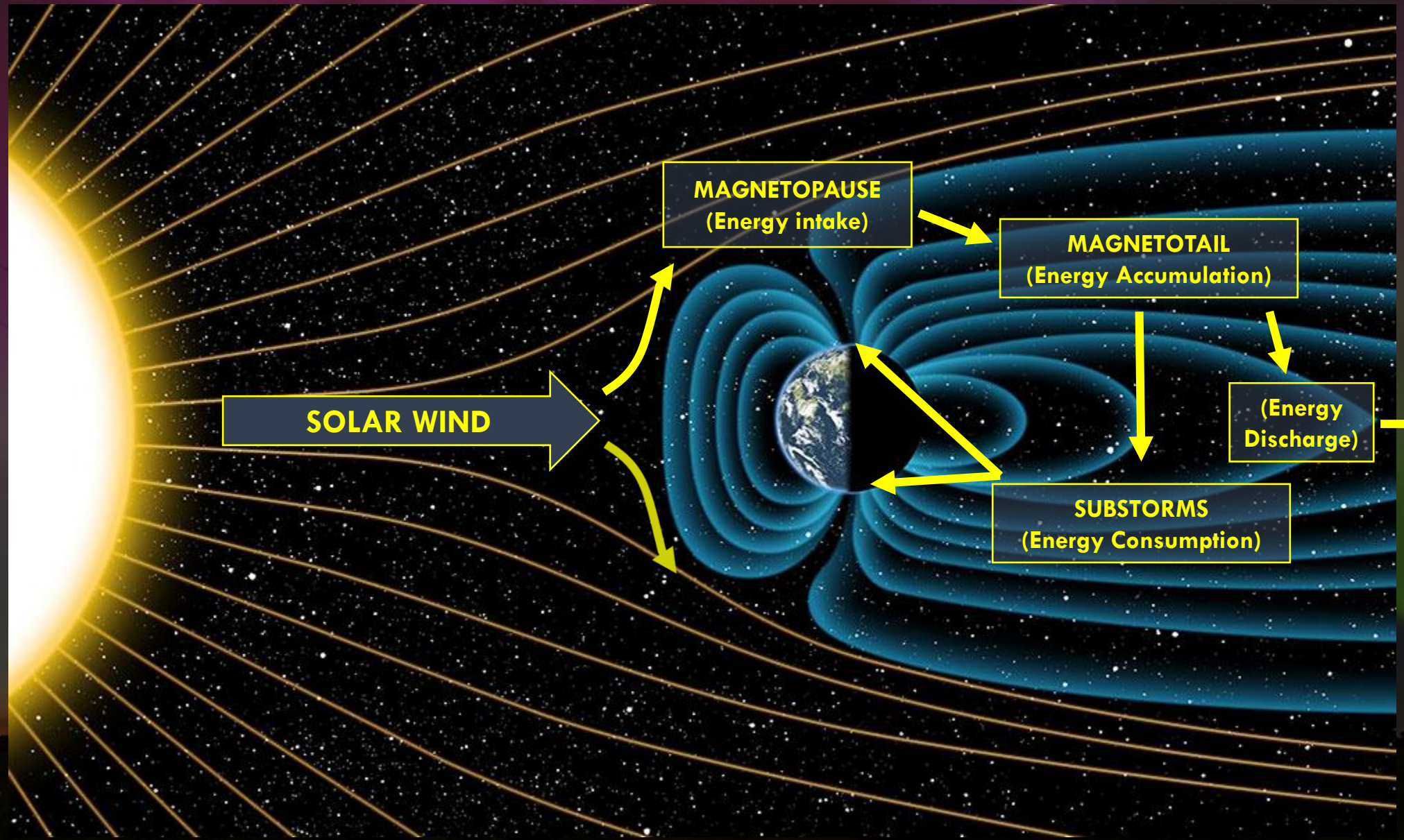
with Auroral Substorms

SCALAR – University of North Dakota – May 1st, 2025 – Kyle J Gillett



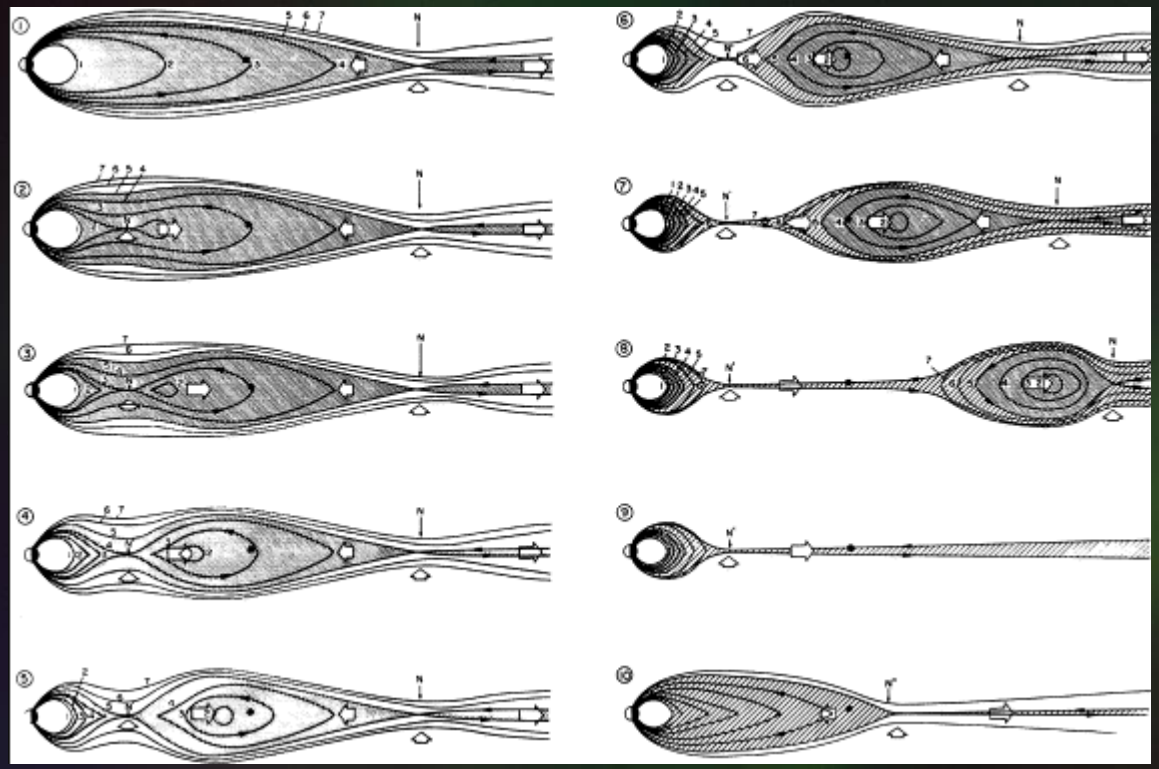
1. ***Background:*** *energy flow around Earth's magnetic field*
2. ***Magnetospheric Substorms:*** *magnetotail behavior leading to aurora substorms*
3. ***Aurora Substorms & GOES:*** *monitoring magnetotail behavior & substorm evolution with GOES*
4. ***Aurora Substorms & Photos:*** *visual evolution of substorms*
5. ***Conclusions***

BACKGROUND: ENERGY FLOW AROUND EARTH'S MAGENTIC FIELD



MAGNETOSPHERIC SUBSTORMS

Making aurora chasing a little more predictable



The Dungey Cycle - Rostoker 1998

Over the course of the night, Earth's magnetotail undergoes periods of stretching.

Eventually, this stretching of magnetotail forms closed loops in the magnetic field lines.

As this happens, charged particles are ejected back towards the poles.

When those particles reach the poles, aurora rapidly expands

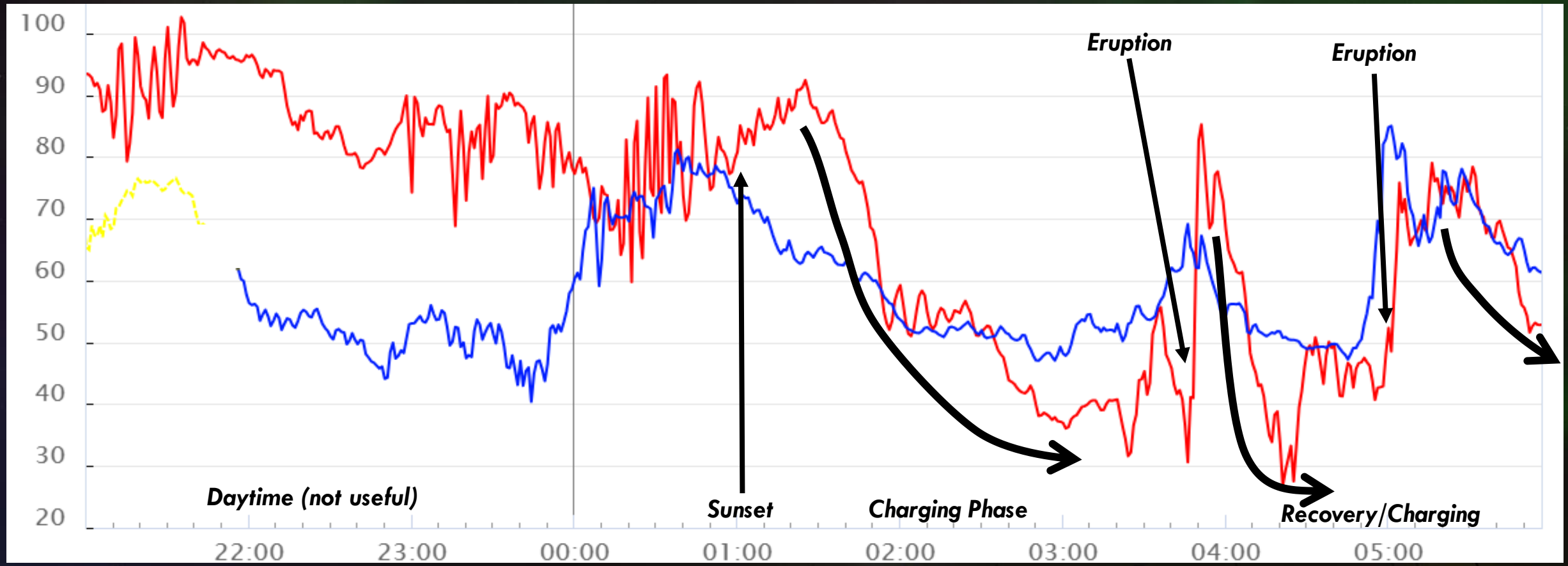
Thankfully GOES can help us visualize this in real time!

SUBSTORM EVOLUTION

Typical event evolution & the GOES Magnetometer

Pre-Substorm "charging-phase" → *Substorm "erupting-phase"* → *Post-Substorm "recovery-phase"*

GOES measures the z-component of the (height) of the magnetic field



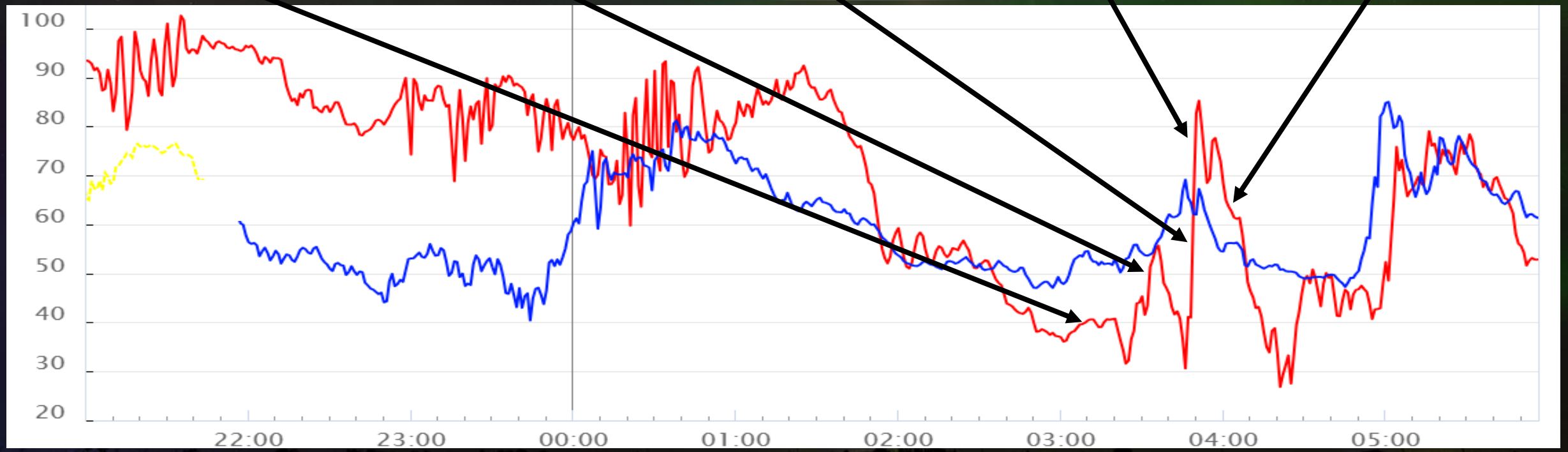
SUBSTORM EVOLUTION

Typical substorm evolution

Early Pre-Substorm "charging phase"	*Pre-Substorm "charging phase"*	*Early Substorm "erupting phase"*	*Peak Substorm "erupting phase"*	*Post-Substorm "recovery phase"*
				
• *Dim/diffuse* • *Starts north* • *Very little motion* • *Arc or bands*	• *Gradually brightens* • *Advances southward* • *May become more active* • *May develop more structure* • *Arc, developing curtains, a few pillars*	• *Rapid brightening* • *Sudden development of vertical structure* • *Can rapidly become more dynamic/active* • *Can rapidly advance south* • *Pillars, curtains*	• *Maximum vertical structure* • **Usually*, maximum brightness* • **Usually*, Maximum movement* • *Pillars, curtains, corona*	• *May advance even further south* • *"Blob" or "patchy" aurora* • *Can be very active* • *Pulsing aurora* • *S.T.E.V.E. aurora* • *Eventually dims, slows down, recedes north*

4. SUBSTORMS

Early Pre-Substorm "charging-phase" → *Pre-Substorm "charging-phase"* → *Early Substorm "erupting-phase"* → *Peak Substorm "erupting-phase"* → *Post-Substorm "recovery-phase"*



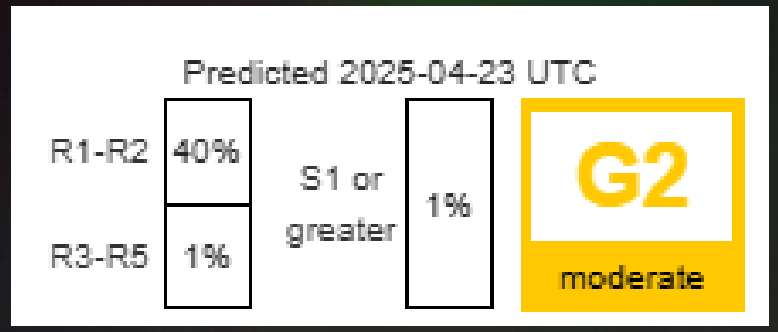
WHY IS THIS IMPORTANT?

If you go out and see this…

Check GOES and wait for this…

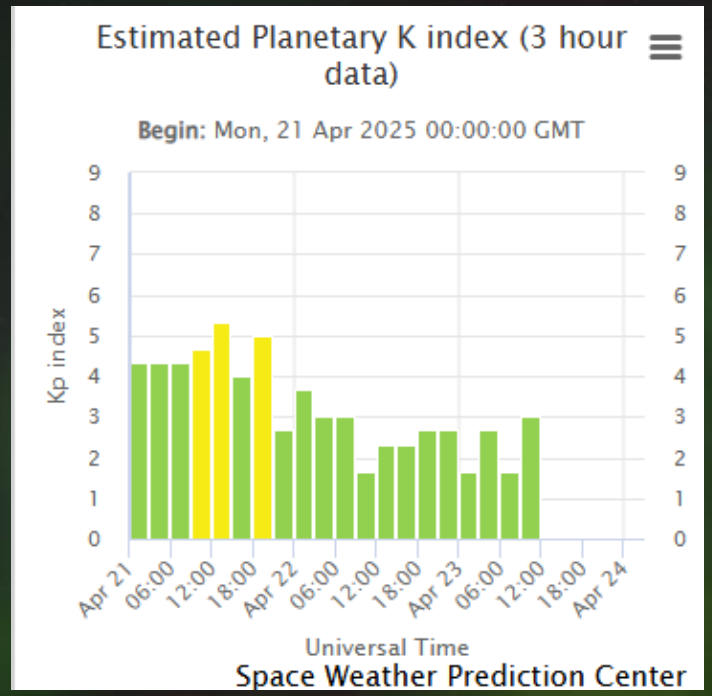
DON'T BE A KP CHASER

Geomagnetic Storm Watches



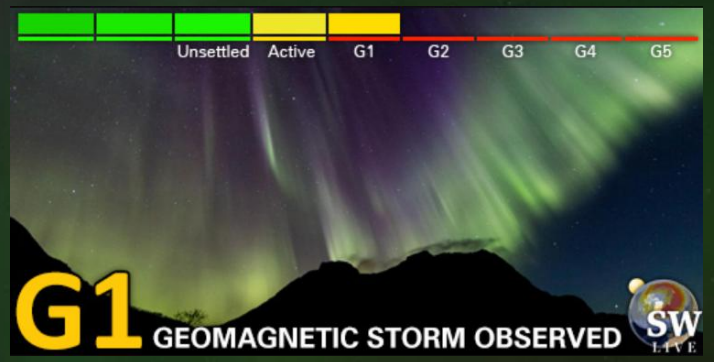
These are ok, its a forecast …but for geomagnetic storming, not aurora

KP Index



This is a bad observation metric

"Observed G-level"



This is based on a 3hr avg of a bad observation metric


Kyle Gillett Photography
GILLETT

SITES FOR DATA

spaceweatherlive.com

swpc.noaa.gov

stevepy.anvil.app

norlys.live/rtsw

theauroraguy.com/pages/webcams

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On X