



ATMOSPHERIC & SPACE TECHNOLOGY RESEARCH ASSOCIATES

SCIENCE + TECHNOLOGY + APPLICATIONS // *Bringing it all together*

Space Weather and Its Impacts to Polar Aviation

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ICAO EUR/NAT, Paris
December 16-19, 2014

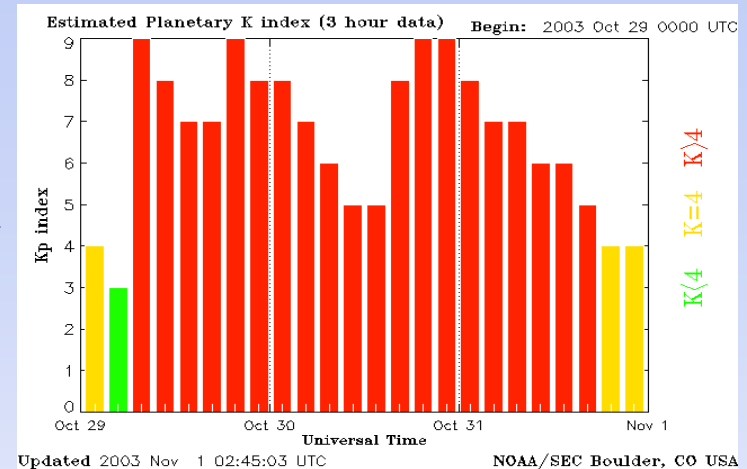
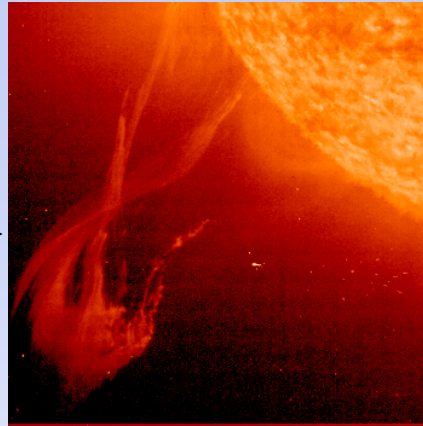
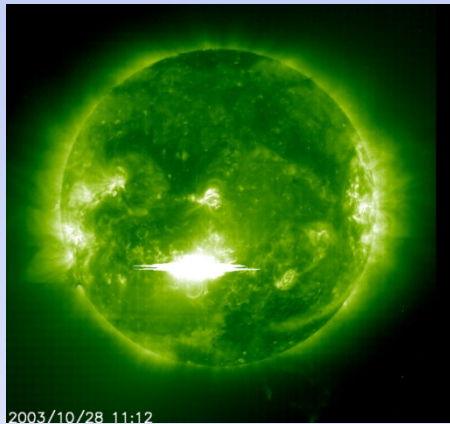
A Brief History of Polar Flights and Space Weather

- Polar flying matured and prospered in the decade starting in late '90's (*Cameron, CPWG 10*)
- In parallel, solar activity also grew in the maximum phase of Solar Cycle 23, i.e., 2001-2006
 - Motivated the definition of procedures and actions based on level of activity
- Solar Cycle 24 began January 2009

Brief History.... (Part 2)

- Compared to Cycle 23, the current Cycle 24 has been very weak
 - Flares and CMEs are about 1/3 as frequent
 - Geomagnetic storm activity affected similarly
- There are suggestions that the next Cycle – Cycle 25 – will be even less eruptive
- Mostly good news for the airlines, but not completely
 - Weak solar activity means more galactic radiation at aircraft altitudes

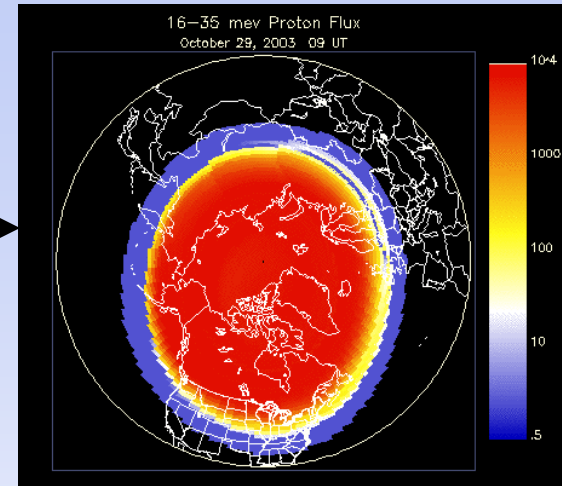
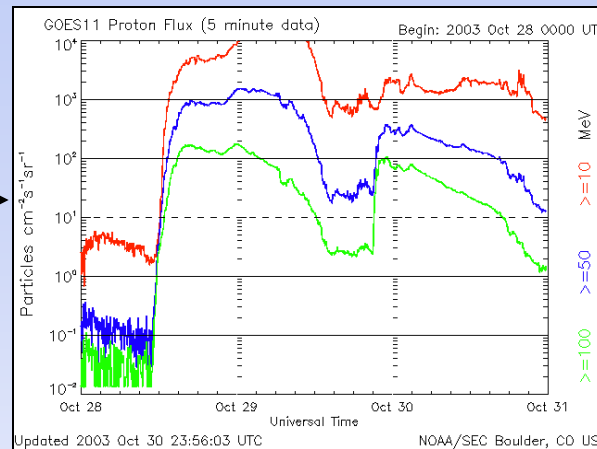
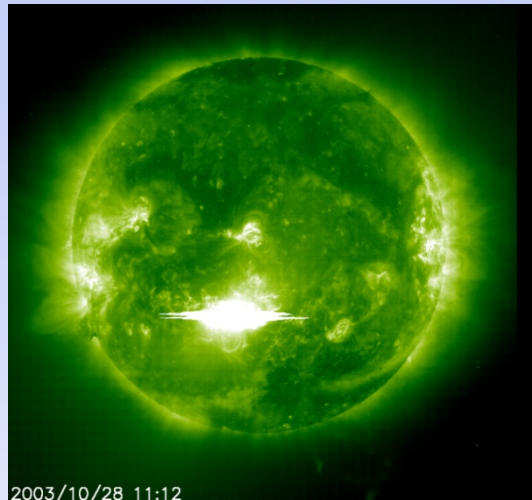
Geomag Storms = Degraded Comm



Ionospheric disturbances often occur whenever geomagnetic disturbances do, but not always. The relationship between the two is complex with no one-to-one relationship between a magnetic disturbance, and the level of ionospheric disturbance as measured by communications disruption.

The reflection of VHF signals will occur on occasion during strong geomagnetic storms.

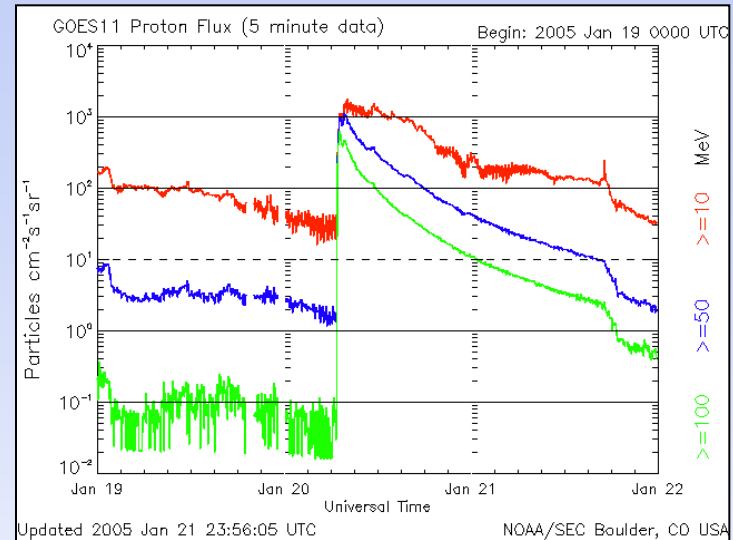
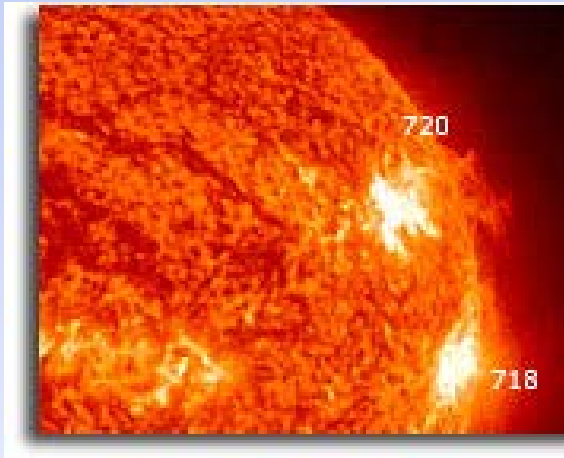
Radiation Storms = Blacked-Out Comm



Radiation storms (proton events) can cause extended periods of HF blackout at higher latitudes. MacRelay reported over 100 hours of HF blackout in the Antarctic during the “Halloween Storms” of 2003.

The onset of these storms is difficult to predict, but once they begin, forecasters can predict the duration with some accuracy.

Radiation Storms and the Biological Threat



Radiation storms can quickly follow the onset of a large solar flare. Highest energy protons (>100 MeV) travel fastest (up to a third the speed of light!).

Jan 2005: X7 flare began at 20/0636 UT and peaked at 20/0701 UT. The Intense >100 MeV radiation storm peaked at 20/0710 UT. This storm was short-lived, but did exceed the FAA Solar Radiation Alert at Flight Altitudes for about 1.5 hours.

Recent Space Weather News

World News &... NOAA / NWS Space Weather Prediction Center noaa 12192 - Google Search Sun turns biggest sunspot

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Sun turns biggest sunspot in 24 years toward Earth

CBC News Posted: Oct 24, 2014 3:39 PM ET | Last Updated: Oct 27, 2014 8:59 AM ET

371 shares

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The sun is staring us down with a dark spot 10 times as wide as the Earth – the biggest sunspot in more than two decades.

The sunspot, which is 129,000 kilometres across, is known as AR 12192. It rotated into view on Oct. 18, NASA says.

It was clearly visible in many photographs of the Oct. 23 partial solar eclipse.

Partial solar eclipse: Your photos of the crescent sun

Sunspots are active regions of the sun where solar explosions called solar flares and coronal mass ejections often erupt. The spots appear dark because they are cooler than other parts of the sun's surface.

The facts on solar storms

Not only is the new giant sunspot the largest of the current solar cycle that began in 2008, but according to [NOAA's Space Weather Prediction](#)

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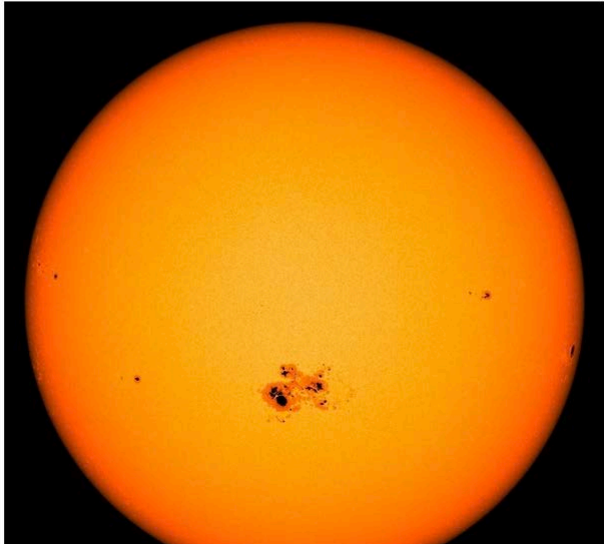
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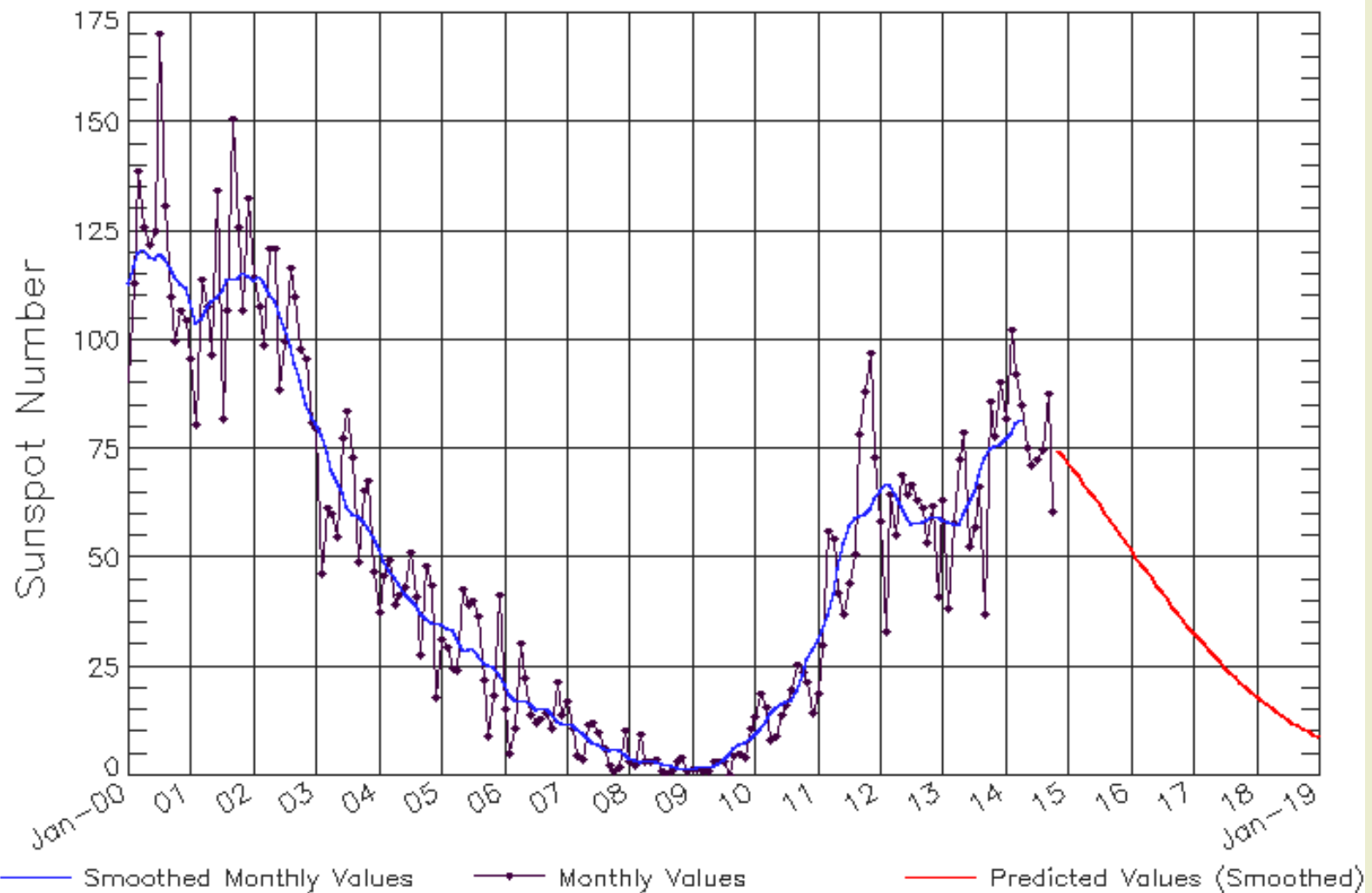
OCTOBER 24, 2014
BY RASIM VAN NIEROP

A Massive Sunspot Brewing Solar Flares Threatening Earth

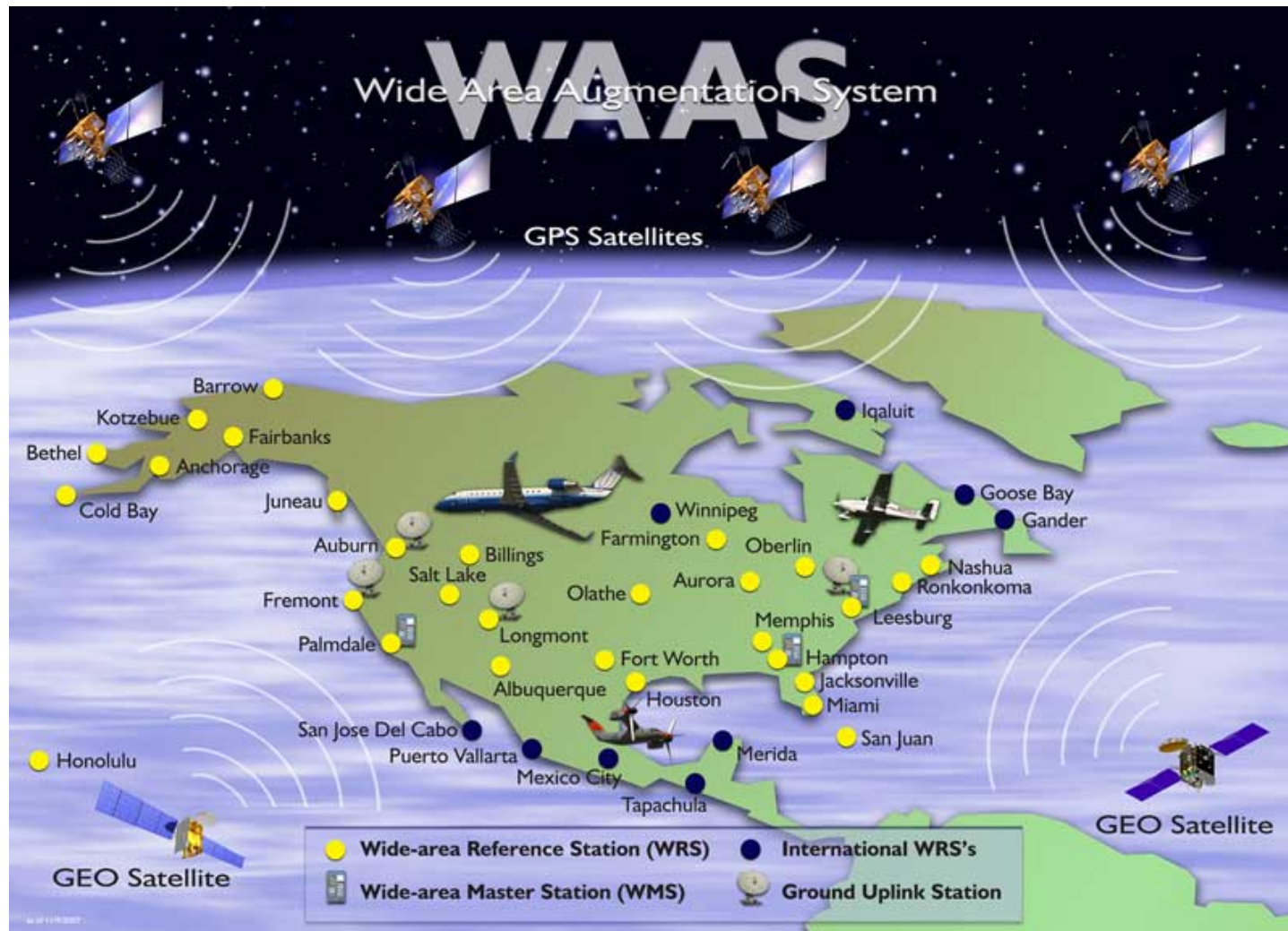


ISES Solar Cycle Sunspot Number Progression

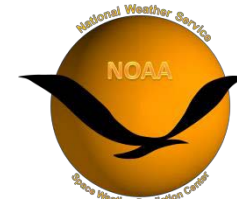
Observed data through Oct 2014



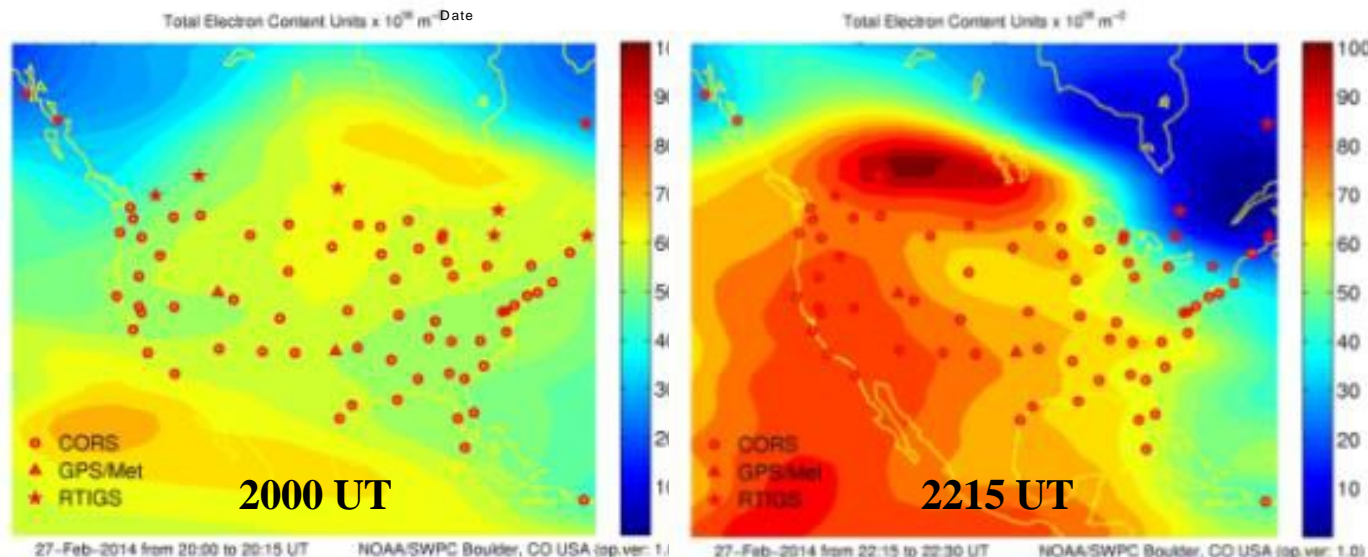
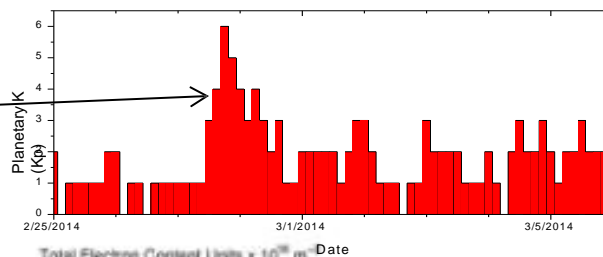
SBAS (WAAS) Infrastructure



Impact of a Moderate Geomagnetic Storm



Moderate Geomagnetic Storm:
Kp of 6 on a scale of 0-9



FAA Msg to SWPC

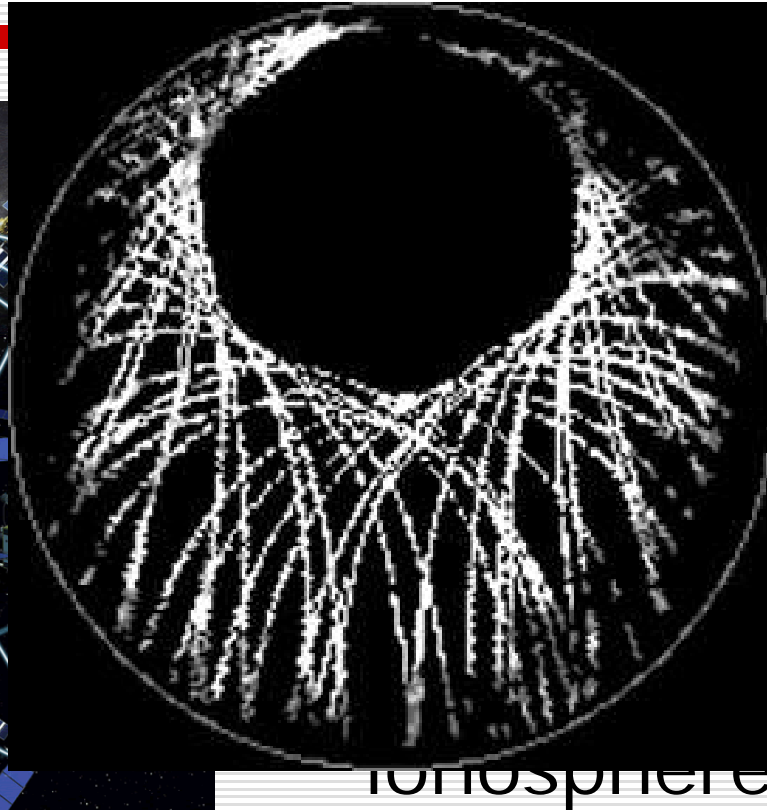
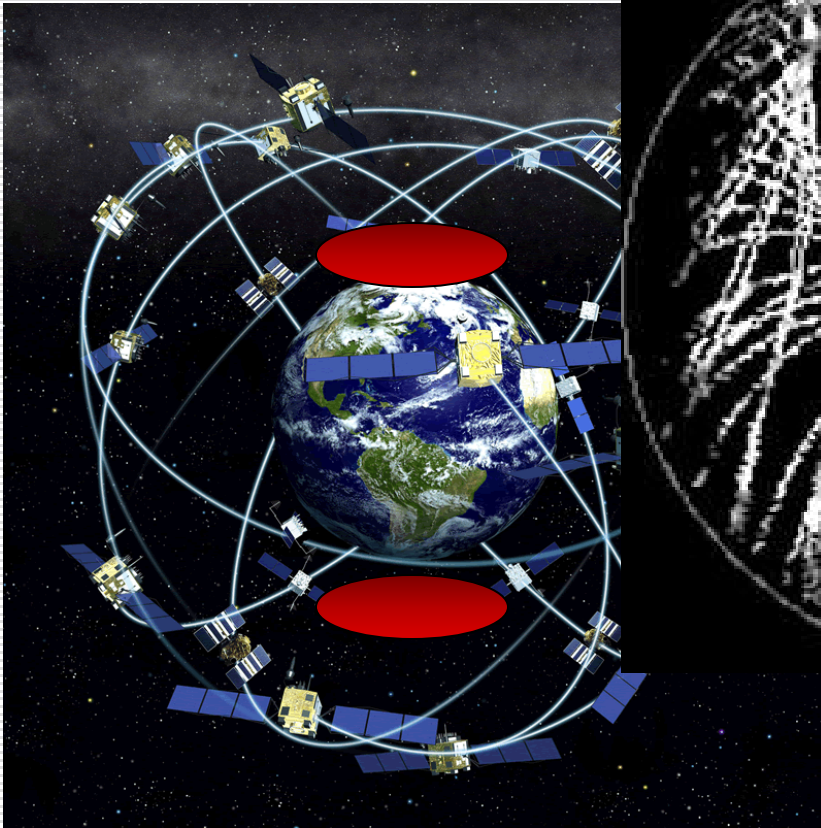
“An Ionospheric Storm began on 2/27/14. The Satellite Operations Specialists were alerted at the WAAS O&M by a Significant Event 757 at 2120 Zulu. So far, LPV and LPV200 service has not been available in Eastern Alaska and Northeastern CONUS. At times, North Central CONUS and all of Alaska have lost LPV and LPV200 Service.”

Note: LPV is Localizer Performance with Vertical Guidance which takes the aircraft down to 250 ft altitude

9 Sept 2014

11 R. Viereck, SWPC

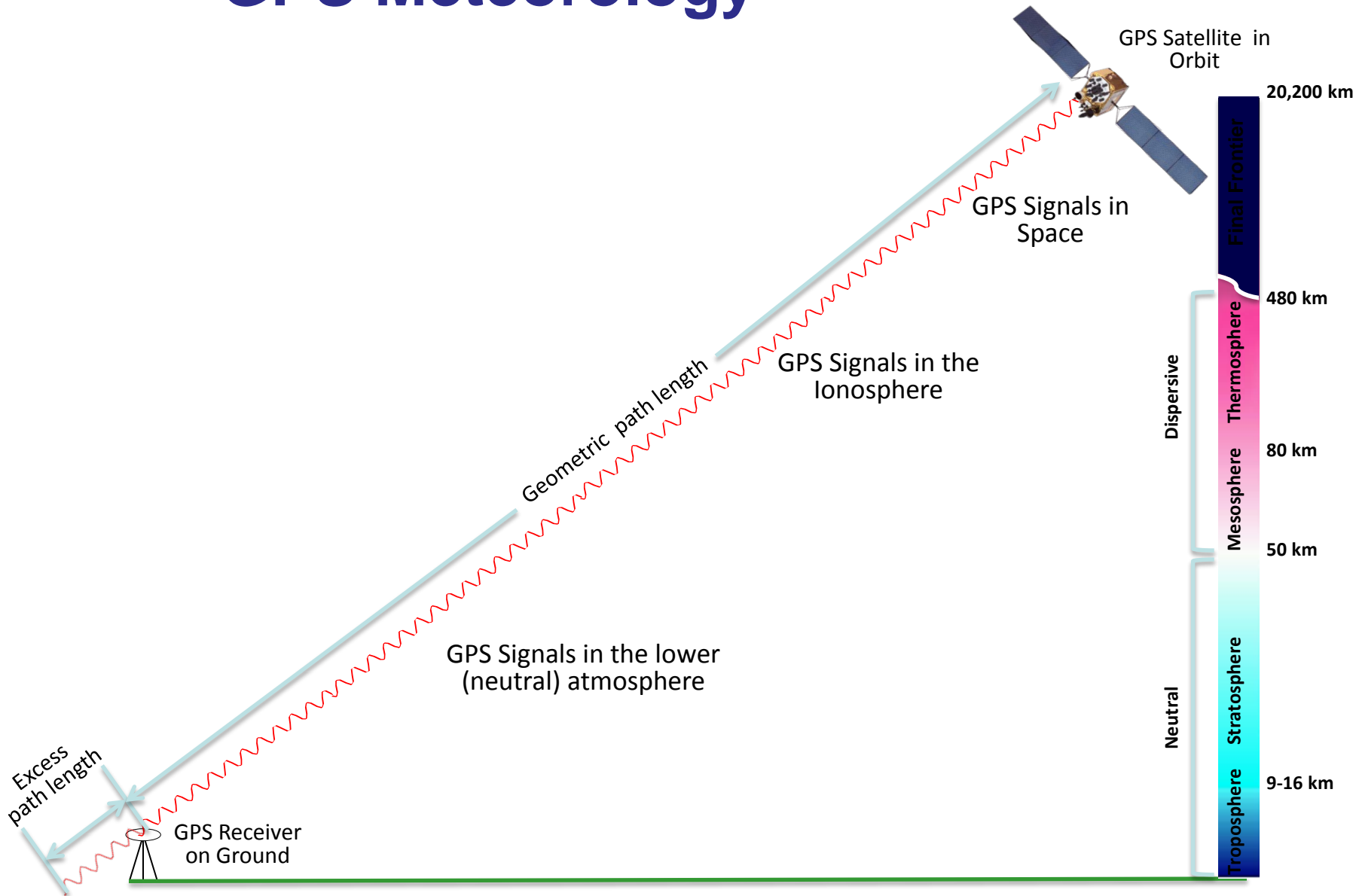
GPS: Consequences of a 55° Inclination



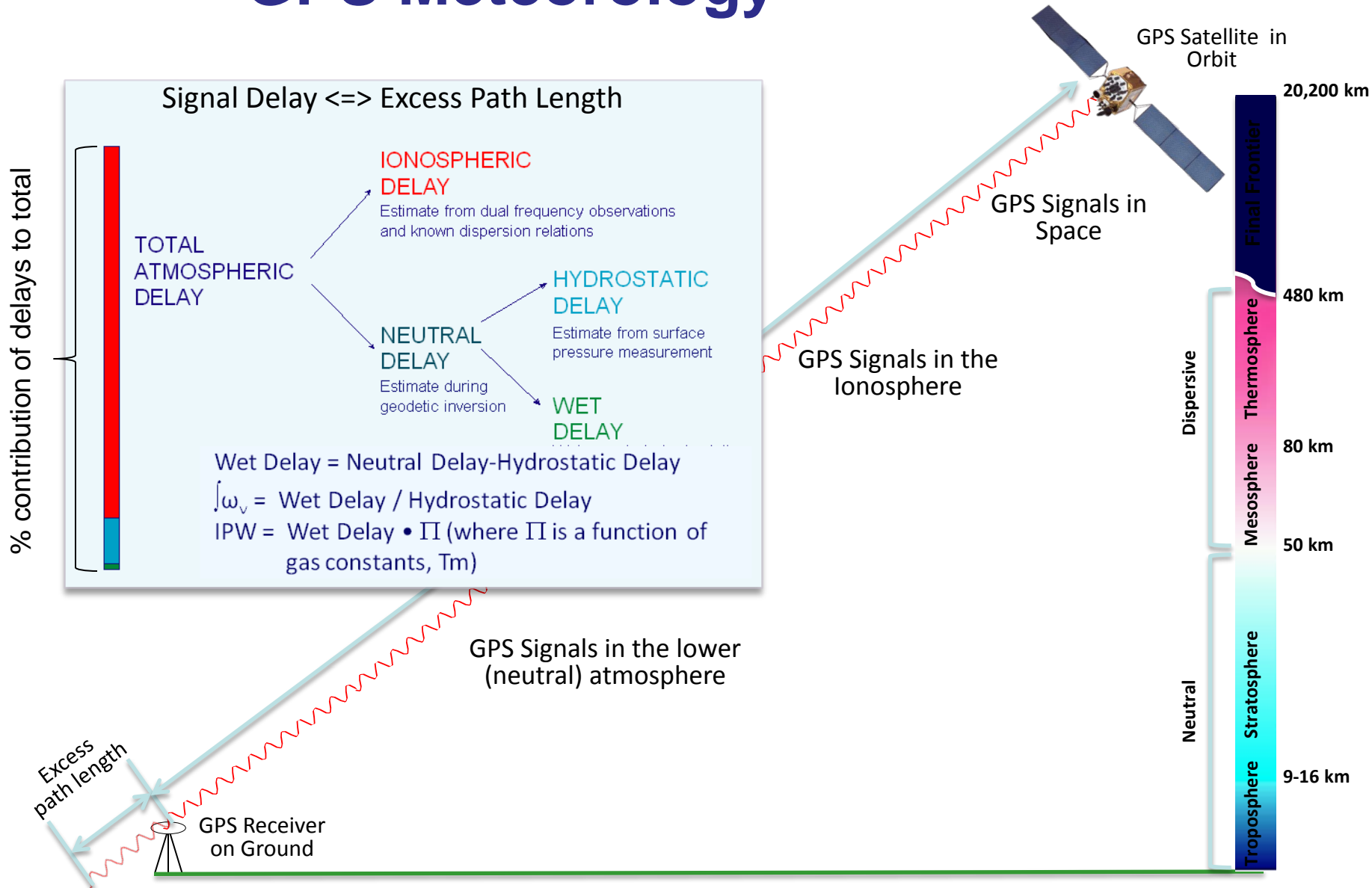
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GPS Meteorology



GPS Meteorology



ASTRA: Overview

❖ Science

❖ Technology

❖ Applications

Bringing It All Together



Modeling

Physics-Based
Modeling
(TIMEGCM)

Real-Time
Specification
of
Ionosphere/
Thermosphere

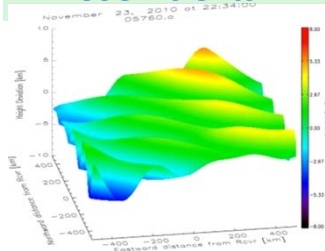
Data Assimilation

High-latitude
Electrodynamics
(AMIE)

Global Ionosphere
(IDA4D)

Thermospheric
Neutral Density
(ADAM)

Satellite Drag & Ballistic Coefficients



Data Services

Space Based
Data

Ground Based
Data

Forensic Space
Weather
Analysis

Space weather
Phone Apps

Ground-based Instrument Development

GPS-based Space
Weather Monitor

Low Power
Ionospheric
Sounder

HF TID Mapper

Laser Bathymetry

Lidar Systems

Space Systems

CubeSat Missions

NSF DICE Cubesat

SMC SENSE

AF DIME Cubesat

Plug-N-Play Avionics

CubeSat Instruments

Scanning
UV Photometer

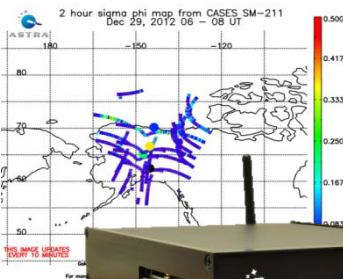
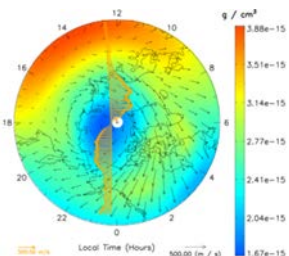
E-field Double Probe

Topside Sounder

Wind Profiler

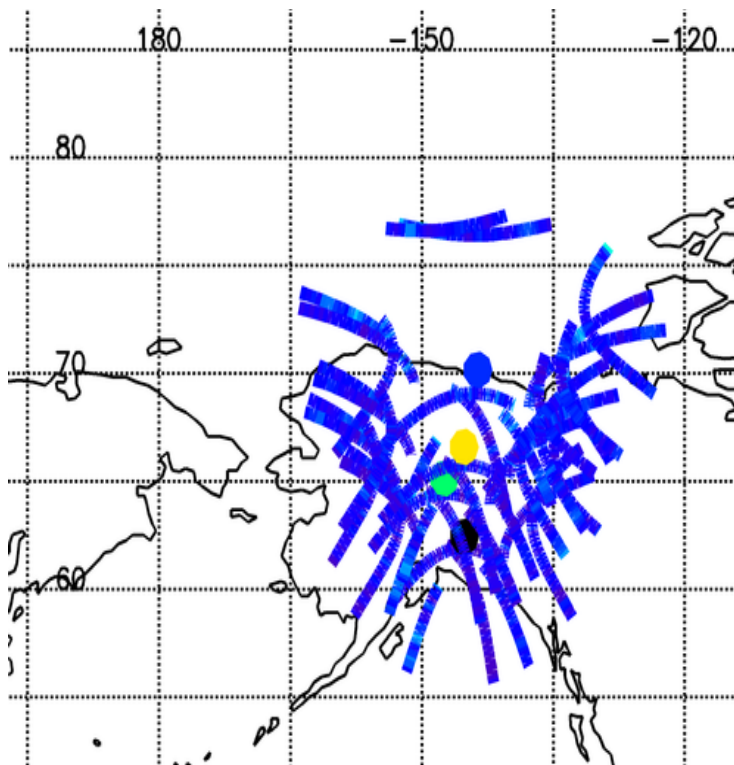
GPS-based Space
Weather Monitor

Satellite
Aerodynamics

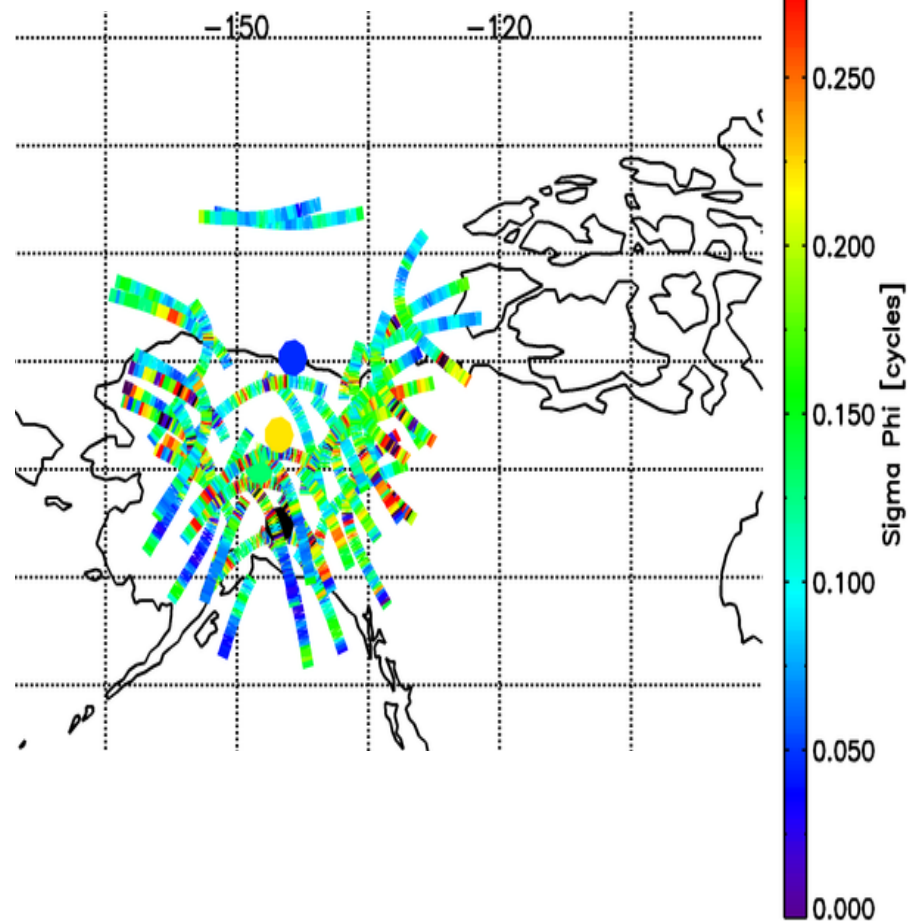


<http://www.youtube.com/4spaceweather>

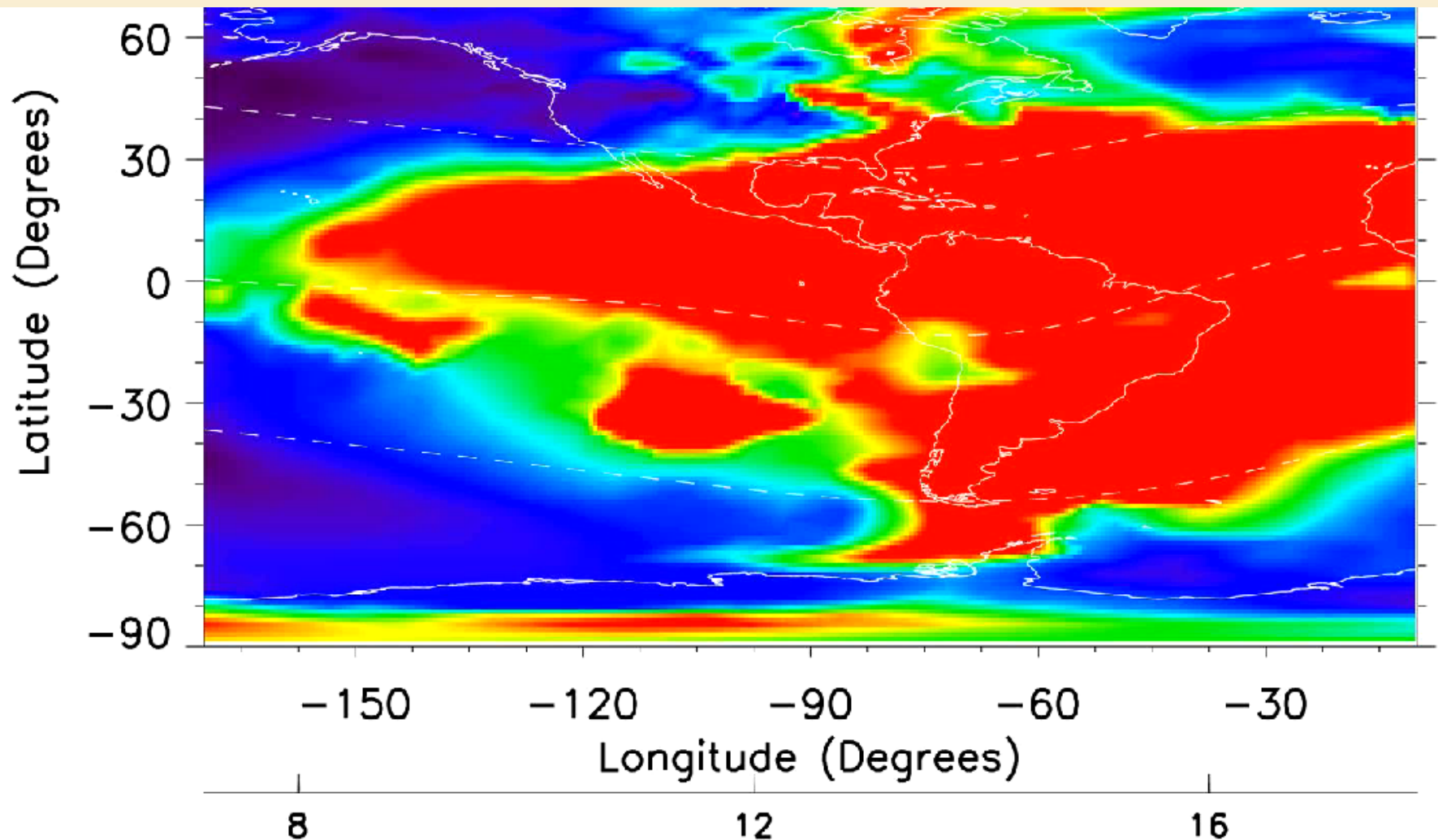
Quiet Conditions



Active Conditions

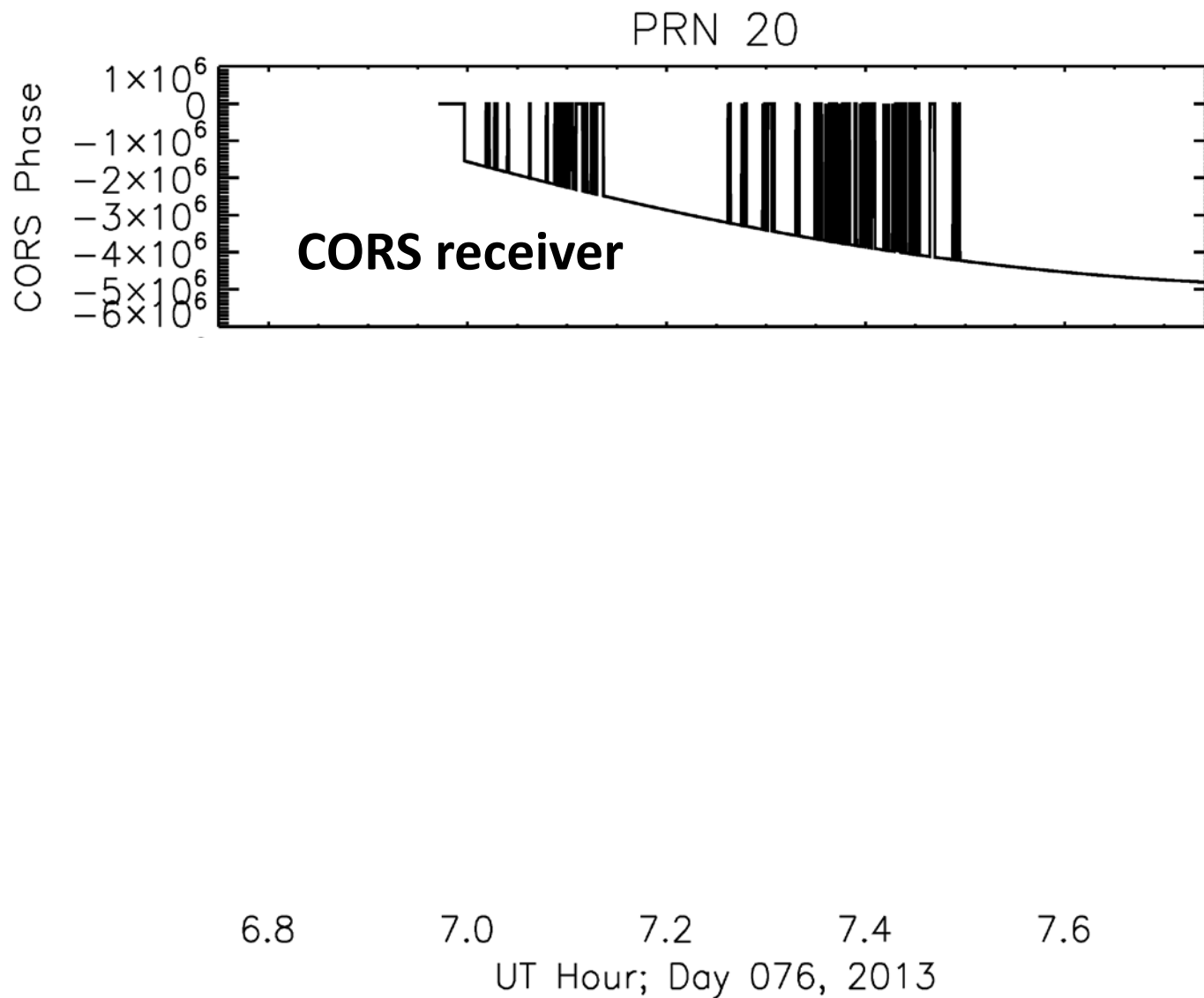


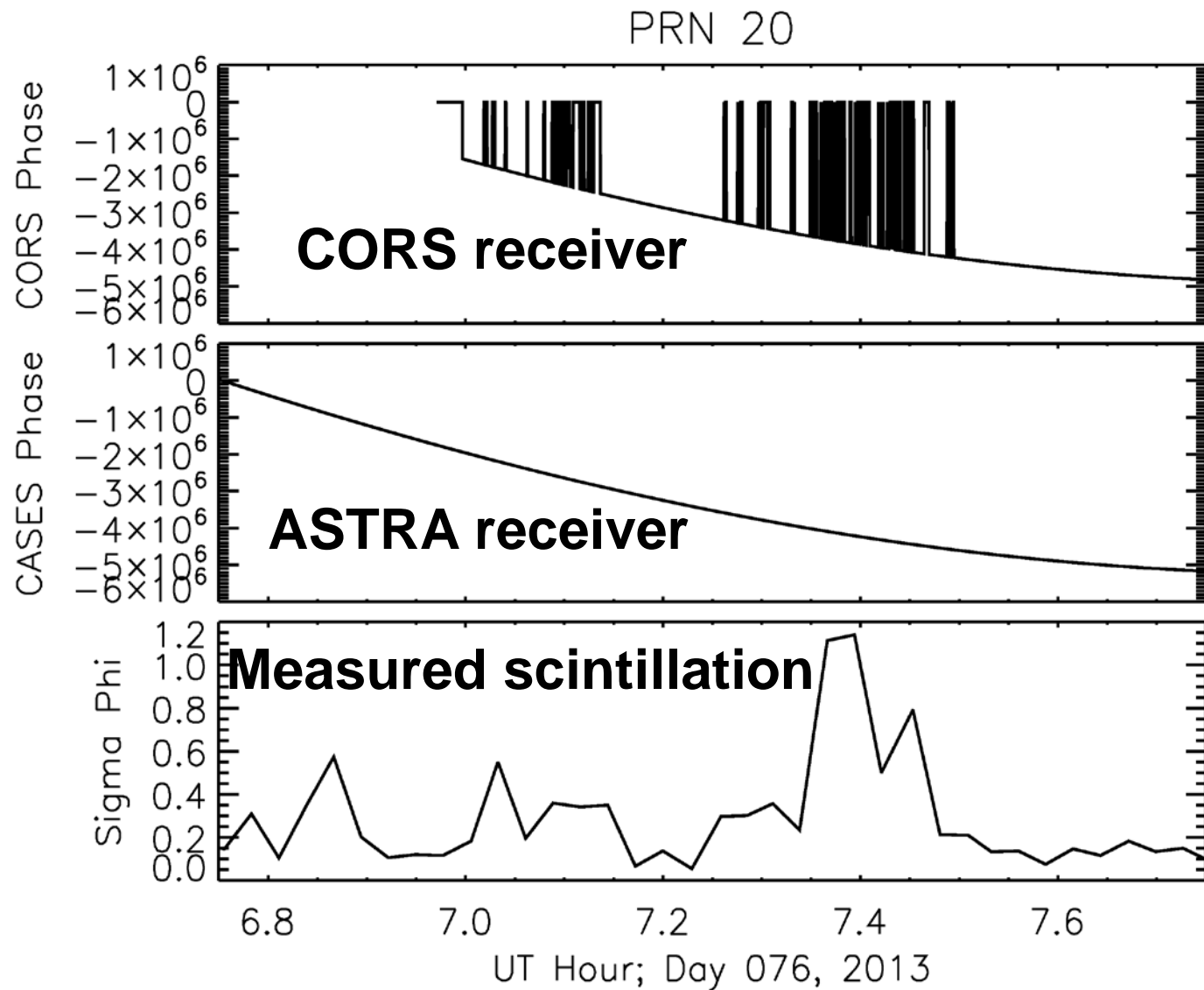
ASTRA IDA4D Model





Scintillation of GPS signals can disrupt critical services





Summary

- Space weather benign lately, may stay that way for the next few years
- Communications and navigation performance prime issues
- Surprisingly, radiation exposure may increase
- ASTRA offers forward-looking products and services for ANSPs and airlines