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# ***Space Weather and Its Impacts on Polar Aviation***

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**USA**

*18<sup>th</sup> Cross Polar Working Group*  
*ICAO EUR/NAT, Paris*  
*December 16-19, 2014*

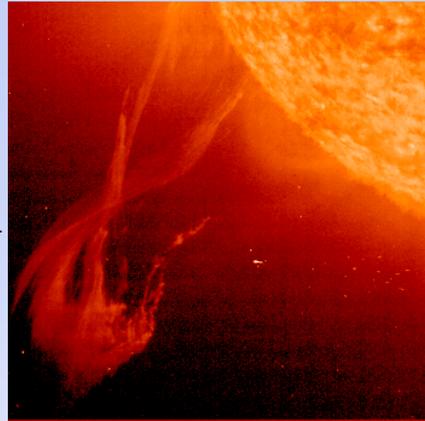
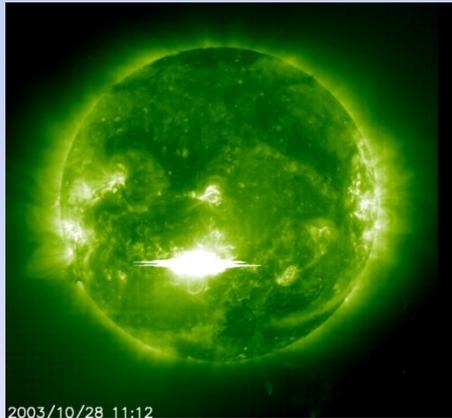
# A Brief History of Polar Flights and Space Weather

- 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

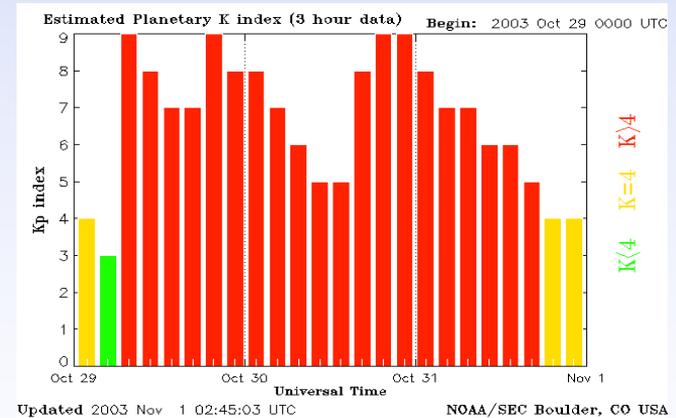
## Brief History.... (Part 2)

- 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

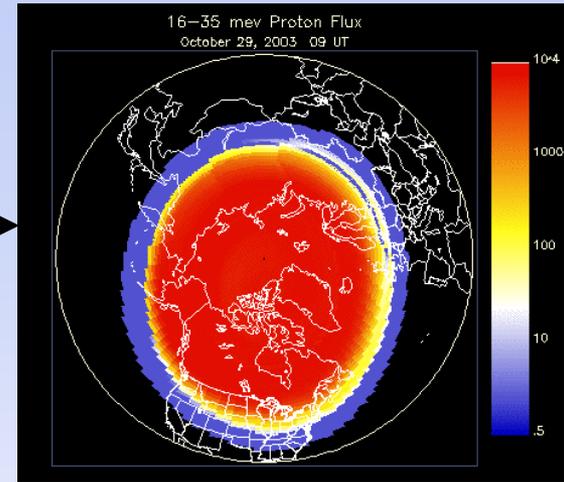
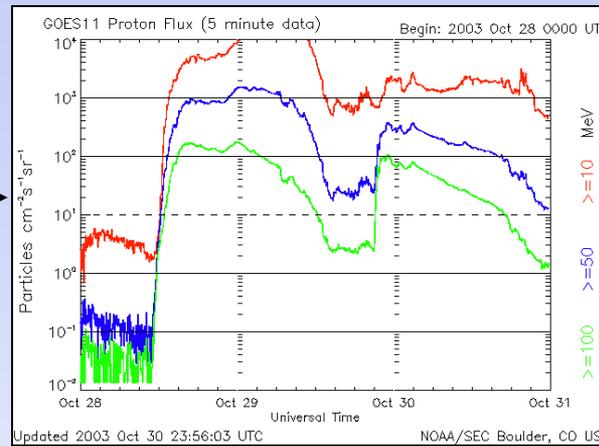
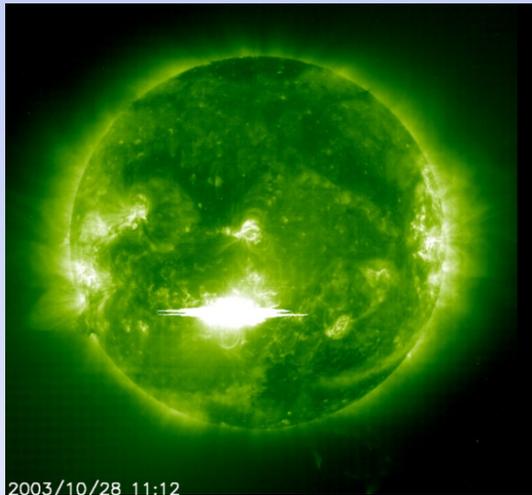
# Geomag Storms = Degraded Comm



- Ionospheric disturbances often occur in concert with geomagnetic disturbances.
- The reflection of VHF signals will occur on occasion during strong geomagnetic storms.



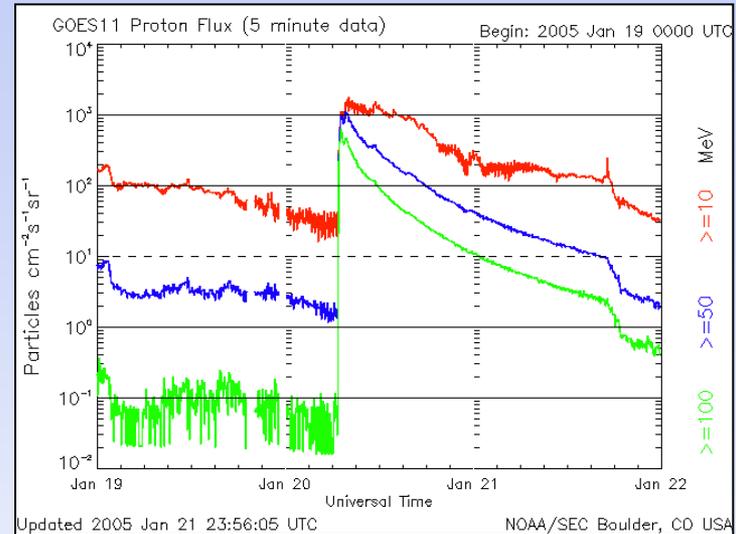
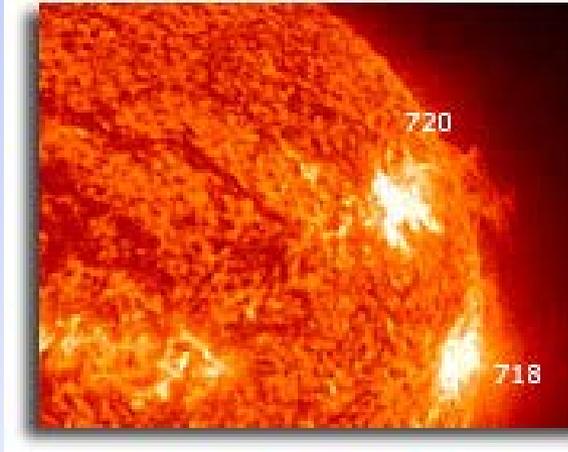
# Radiation Storms = Blacked-Out Comm



- Radiation storms (proton events) can cause extended periods of HF blackout at higher latitudes.
- 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.**

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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](#)

The sunspot, which is 129,000 kilometres across, is known as active region (AR) 12192. It rotated into view on Oct. 18, NASA says. (NASA/SDO)

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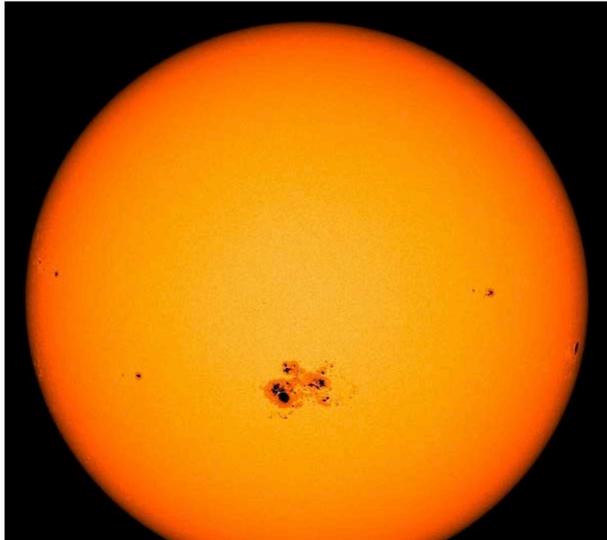
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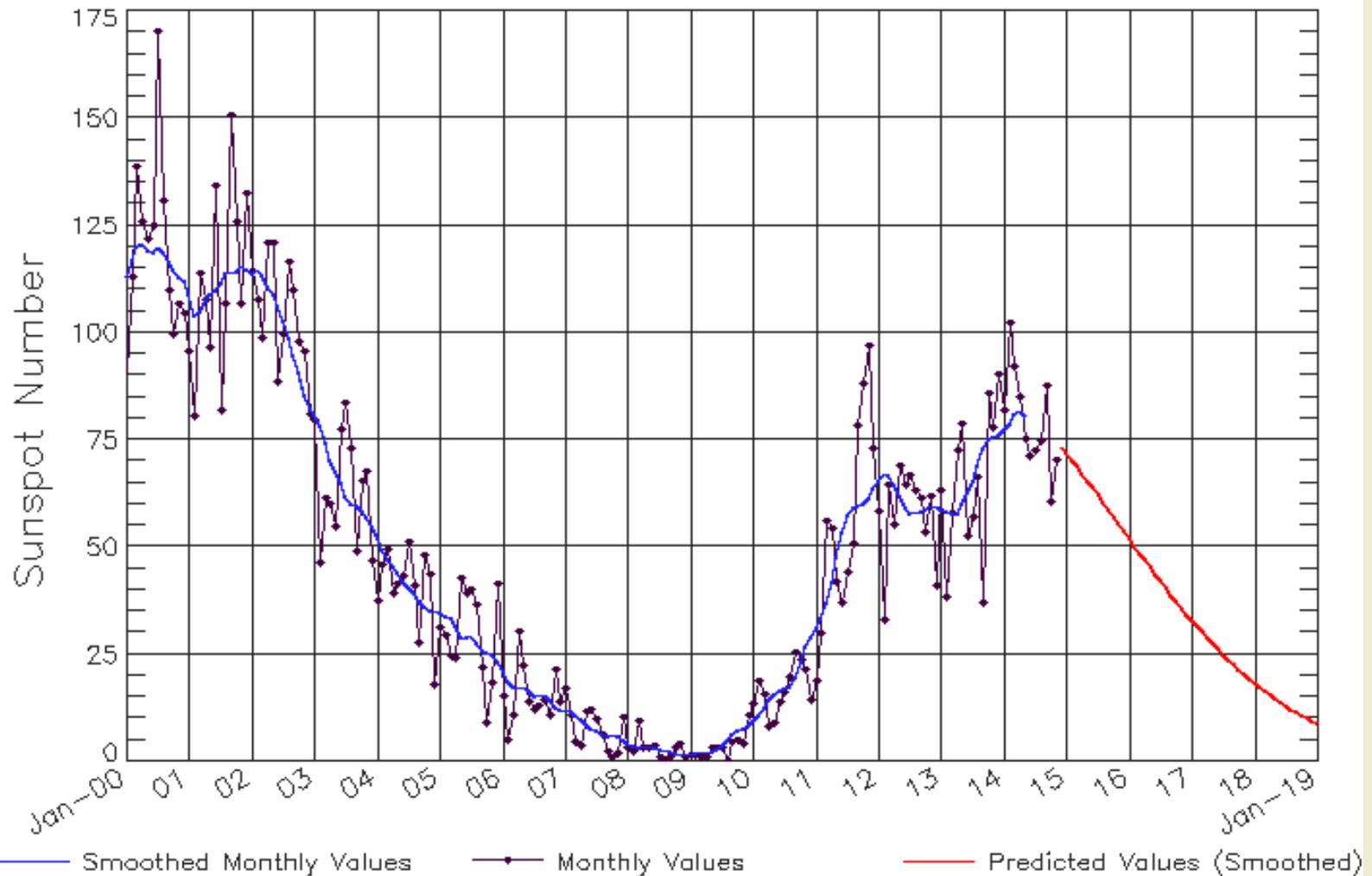
OCTOBER 24, 2014  
 BY RASIM VAN NIEROP

**A Massive Sunspot Brewing Solar Flares Threatening Earth**

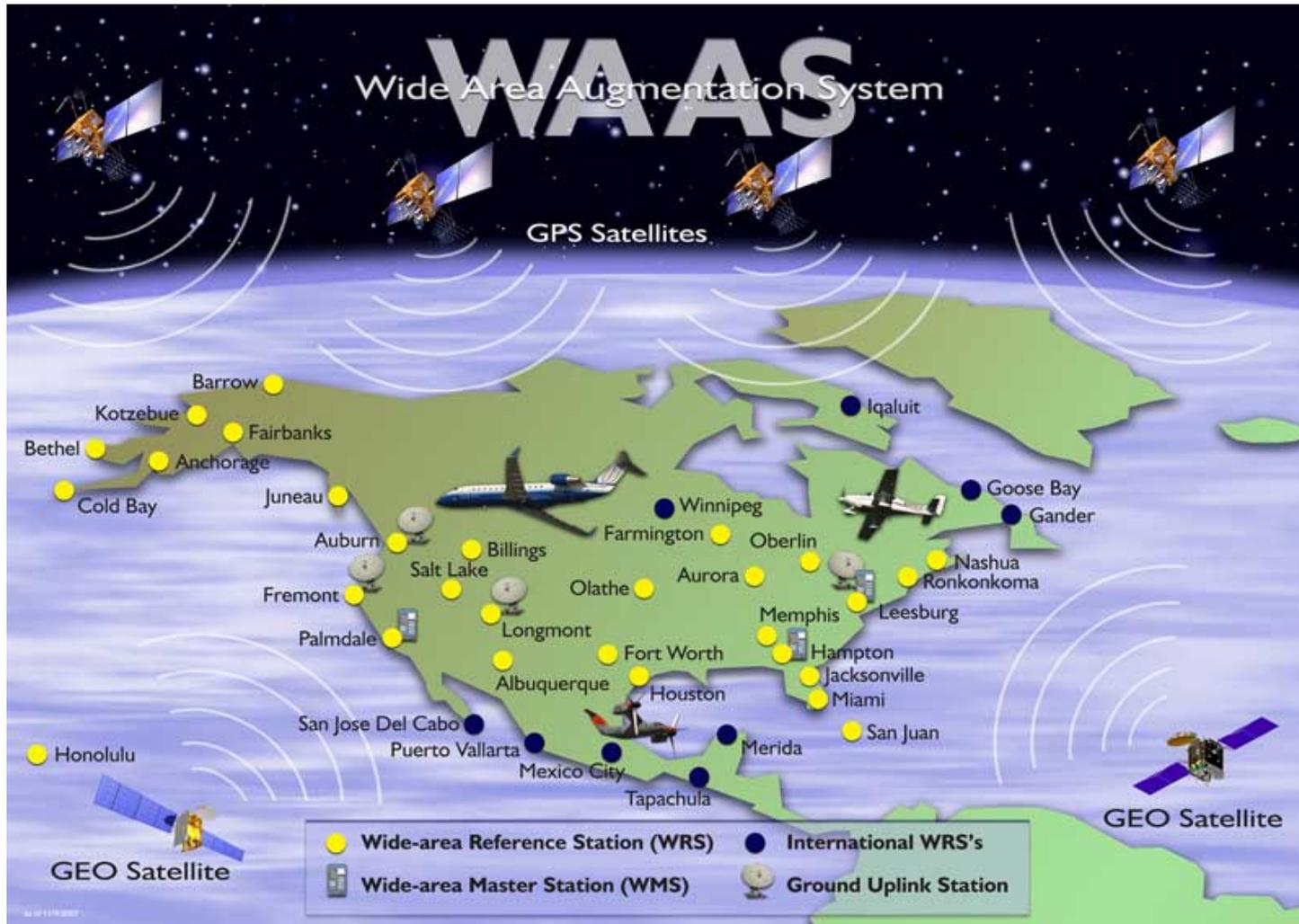


## ISES Solar Cycle Sunspot Number Progression

Observed data through Nov 2014



# SBAS (WAAS) Infrastructure



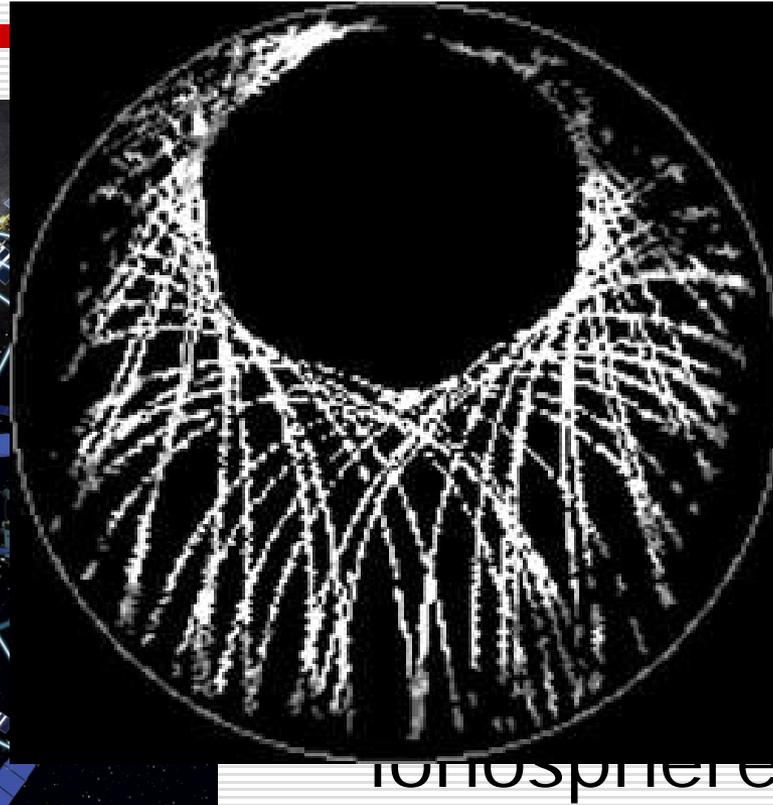
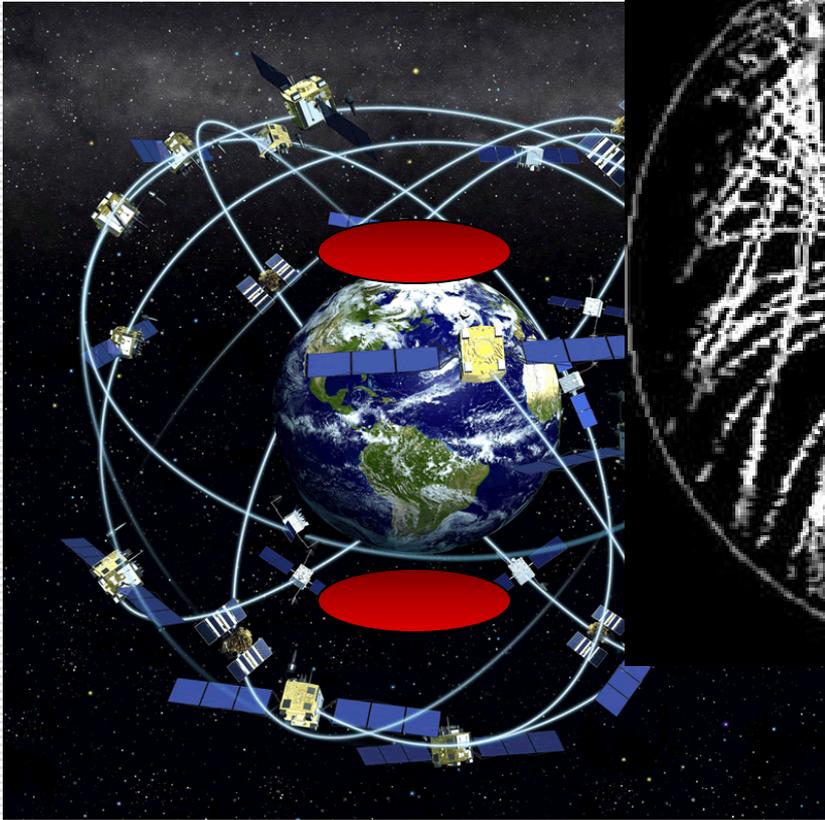
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# *GPS: Consequences of a 55° Inclination*



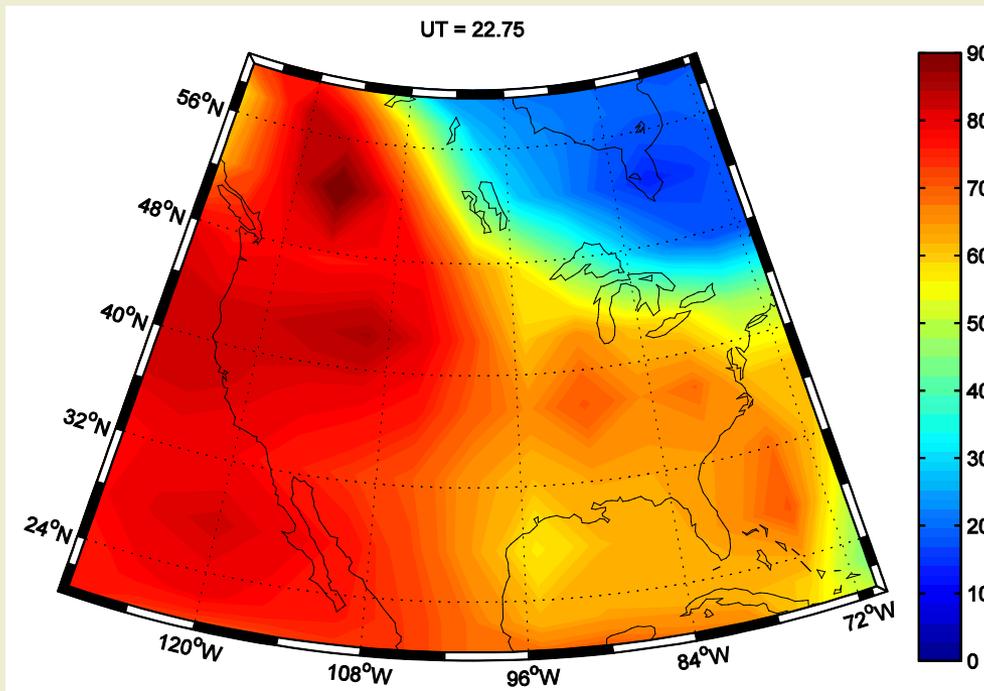
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ionosphere



# Recent Impact to WAAS

“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.” **FAA**



Moderate Kp = 6 Storm

# ASTRA: Overview

❖ Science

❖ Technology

❖ Applications

*Bringing It All Together*



## Modeling

Physics-Based Modeling  
(TIMEGCM)

Real-Time Specification of Ionosphere/Thermosphere

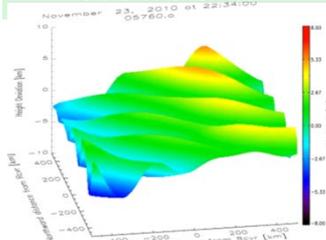
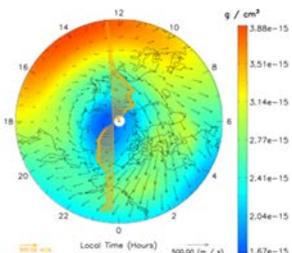
## Data Assimilation

High-latitude Electrodynamics (AMIE)

Global Ionosphere (IDA4D)

Thermospheric Neutral Density (ADAM)

Satellite Drag & Ballistic Coefficients



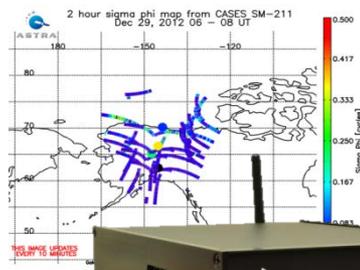
## Data Services

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

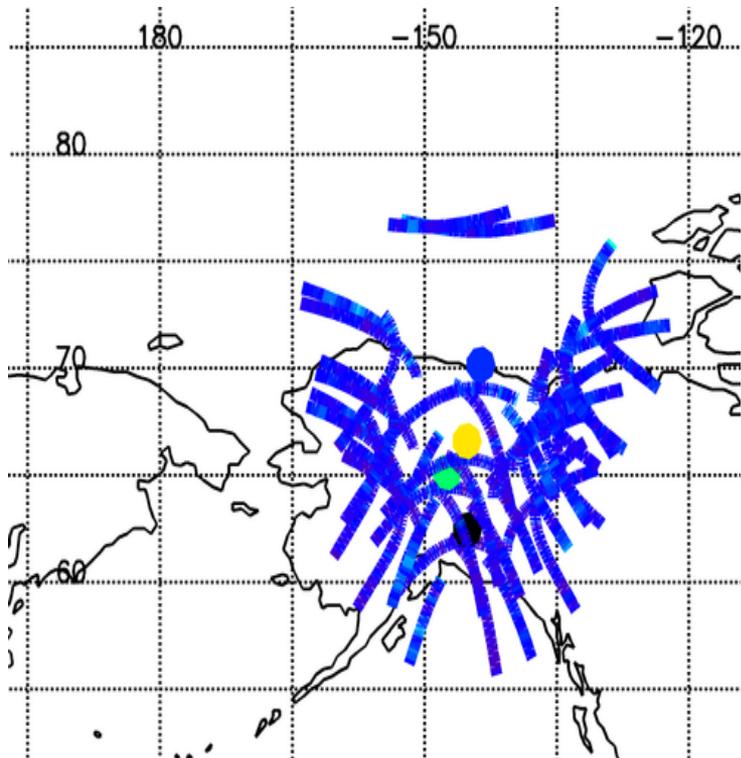
Wind Profiler

GPS-based Space Weather Monitor

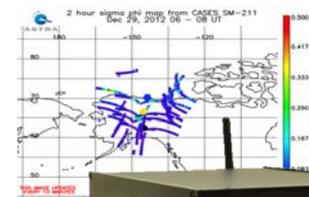
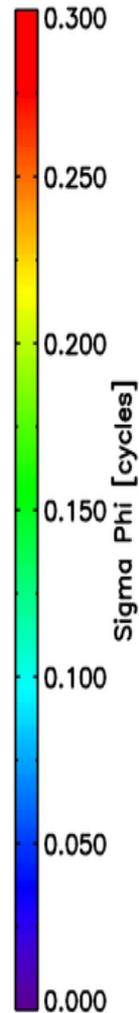
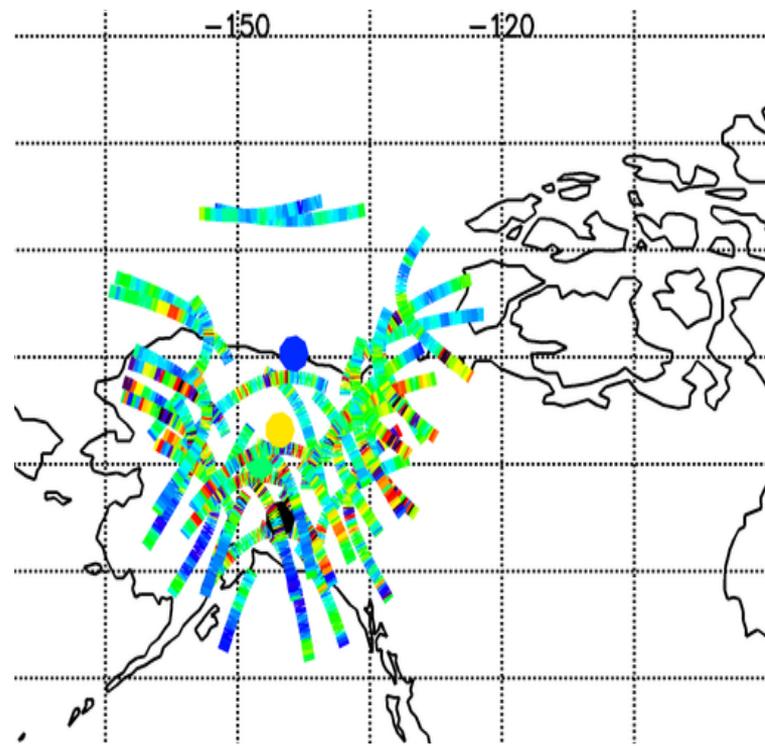
Satellite Aerodynamics

# Real Time Alaska GPS Data

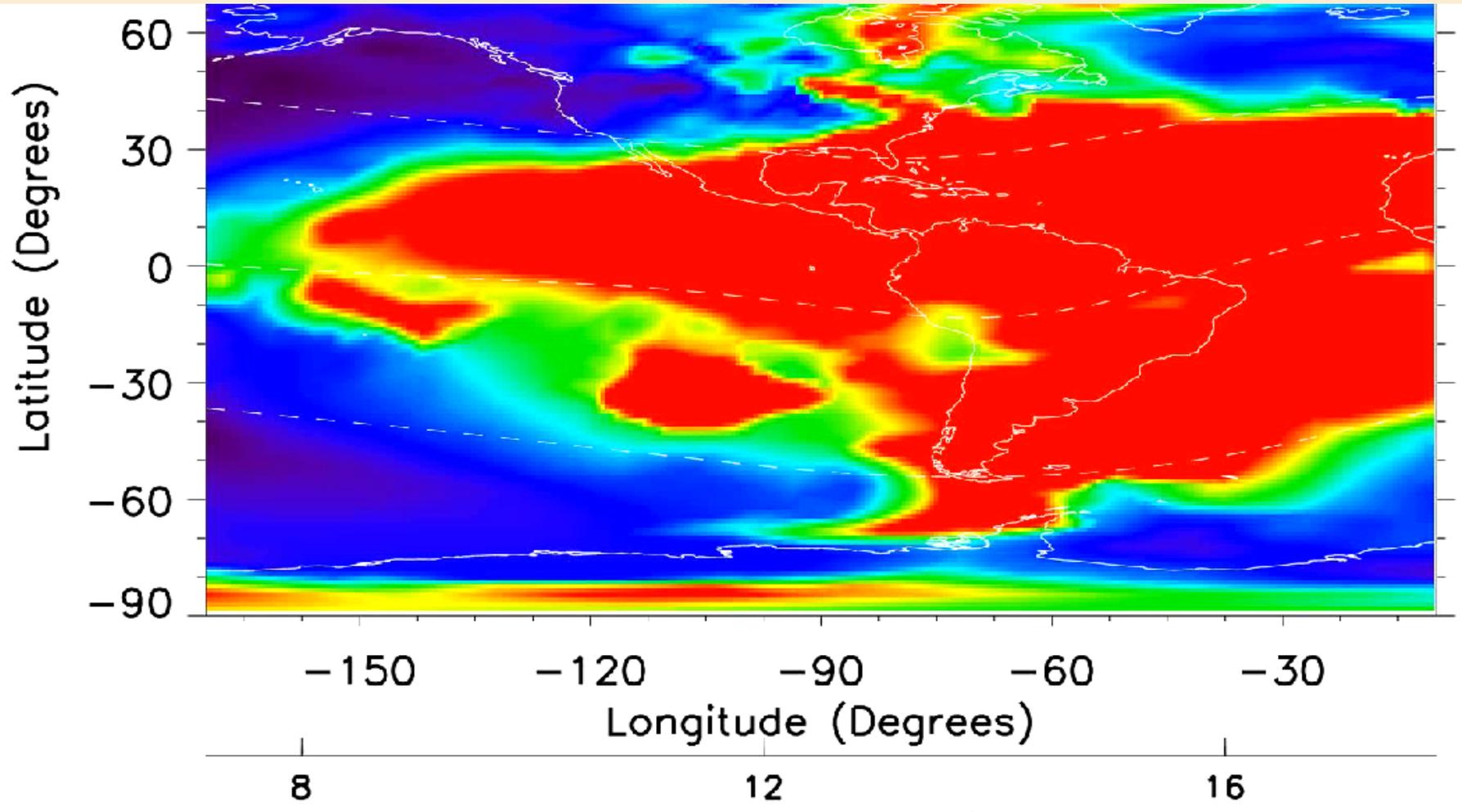
## Quiet Conditions



## Active Conditions



# ASTRA Real Time Ionospheric Data Assimilation



# Summary

- Communications and navigation performance prime issues
- Space weather benign lately ,i.e., SWPC alerts, but disruptive activity still occurring
- ASTRA offers forward-looking, tailored products and services for ANSPs and airlines