

# Collaboration Priorities to Improve Space Weather Services



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# Main Topics



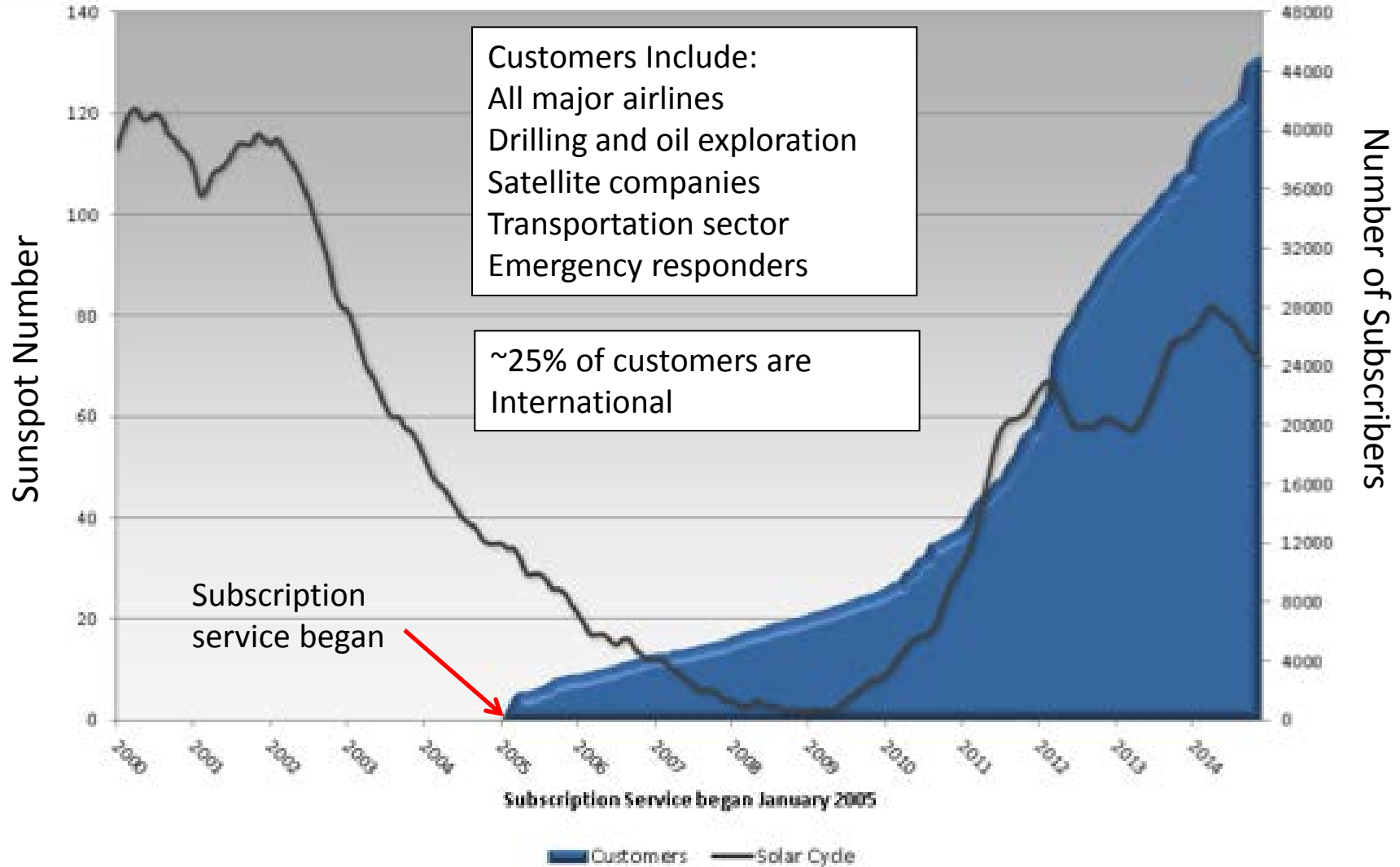
- Operational service focus
- Research and data needed
- Available observations and model output
- Additional collaboration possibilities





# Growth in Subscribers to Space Weather Products

Customer Growth  
SWPC Product Subscription Service





# Major Forecast Center Products

## **Daily Forecasts (1-3 day):**

- Solar flares
- Solar energetic particles
- Geomagnetic activity
- 10.7 cm radio flux

## **Event-Driven Warnings and Alerts:**

- Warnings: geomagnetic storms, proton events
- Alerts: solar flare, proton event, geomagnetic storm, electron event, solar radio burst

## **Numerical Models:**

- Enlil – background solar wind and CMEs
- Relativistic Electron Forecast Model
- D-Region Absorption Product
- U.S. Total Electron Content
- Ovation Aurora Model

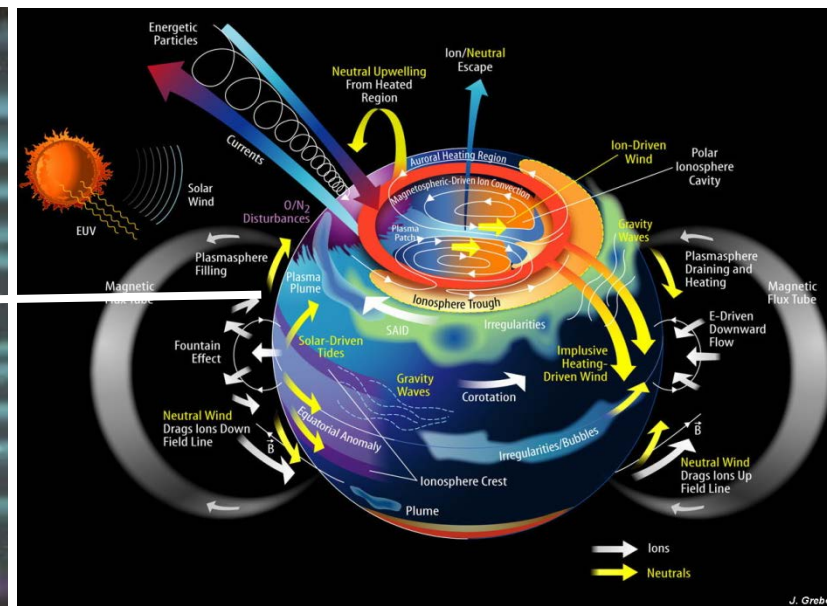
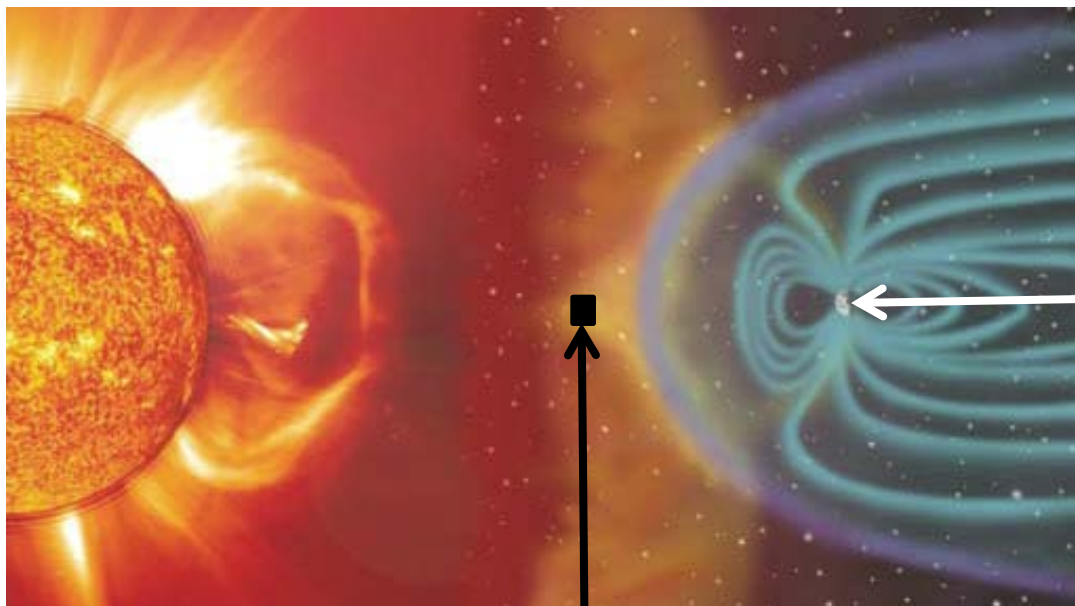


# Components of NOAA's Numerical Space Weather Modeling Effort

Solar /Solar Wind

Magnetosphere/  
Ionosphere

Atmosphere/  
Ionosphere



L1 Satellite Location – ACE and now DSCOVR



# Research and Modeling Priorities

- Improved accuracy of 1-4 day forecasts of geomagnetic storms
- Localized specifications and forecasts of the impacts of geomagnetic storms at ground level
- Forecasts of ionospheric conditions relevant to GNSS users
- Specifications and forecasts of the radiation environment for satellites and commercial aircraft
- Improved probability of solar active-region eruption, including flare x-rays and energetic particles



# High-Priority Needs for Real-Time Data In Approximate Priority Order

- Back-up of space-based solar and solar wind measurements
  - Receiving antennas for real-time data (e.g., DSCOVR, STEREO, etc.)
  - Coronagraph, solar E/M emissions, solar wind plasma and mag field
- Off Sun-Earth-line coronagraph (e.g., L5)
- Ionospheric measurements (ground-based and space-based)
  - Global TEC, scintillation, FUV images, electron density profile
- Magnetospheric in-situ measurements
  - Energetic electrons and protons, low energetic electrons, mag field
- Earth-surface magnetic field
  - Global ground magnetometer data



# Deep Space Climate Observatory (DSCOVR) Solar Wind Mission



- Launched February, 2015
- Space weather is the primary mission; climate is secondary
- Faraday cup: solar wind density, speed, temperature
- Electron electrostatic analyzer
- Magnetometer
- International network of real-time receiving antennas: Germany, Japan, South Korea, U.S.
- Real-time data processed and provided by NOAA





# Geostationary Operational Environmental Satellites (GOES)

GOES-R is planned to launch in 2016

- Extreme Ultraviolet and X-ray Irradiance Sensors (EXIS): X-ray sensor, expanded dynamic range and flare location
- Solar Ultraviolet Imager (SUVI) – Full-disk extreme ultraviolet imager: Active region characterization, filament eruption, and flare detection
- Space Environment In-Situ Suite (SEISS): Electrons, protons, heavy ions – Surface charging, internal charging, single-event upsets
- Magnetometer: Detection of geomagnetic storms and magnetopause crossing, energetic particle products, model validation



Requirements workshop for future geostationary measurements planned for April 13, 2015, before Space Weather Workshop



# Evolution of GOES Charged Particle and Magnetometer Coverage

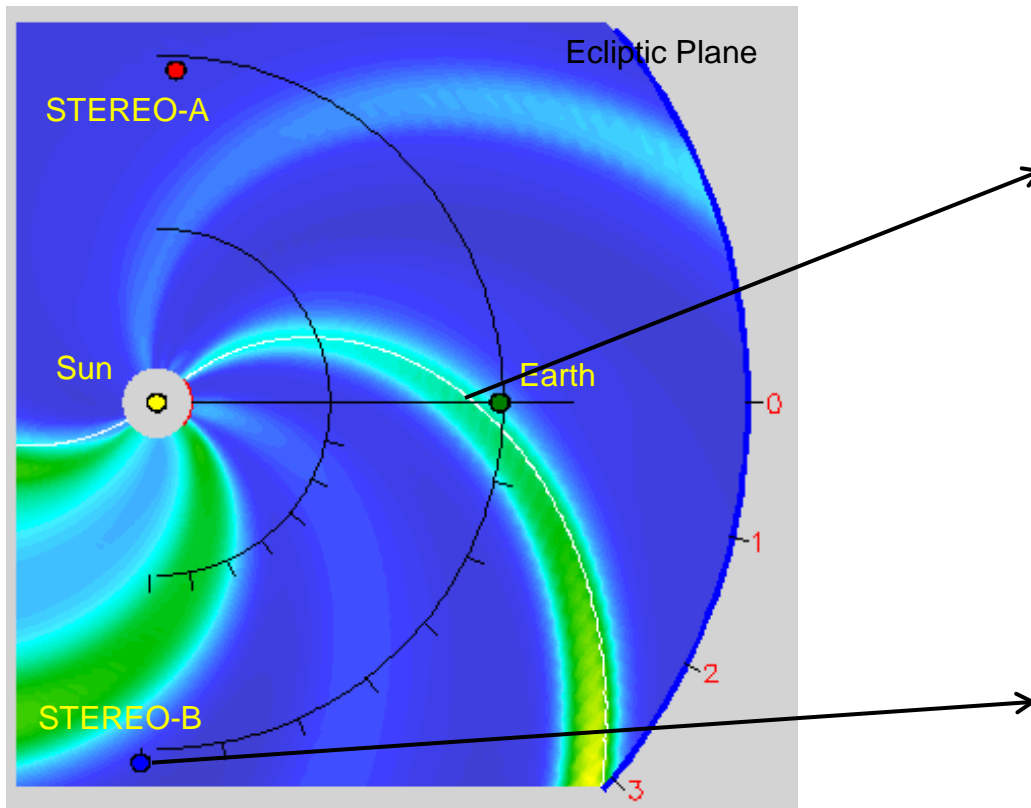
Satellite Series	Electrons >800 keV	Electrons 30-600 keV	Electrons 0.03-30 keV	Protons >740 keV	Protons 80-800 keV	Protons 0.03-30 keV	Solar Heavy Ions, >10 MeV/n	Magnetometer
GOES 8-12	√			√			He	√
GOES 13-15	√	√		√	√		He	√
GOES R	√	√	√	√	√	√	He, Z=4-29 (Be-Cu)	√
Radiation effects application	Interior charging, human radiation	Surface and interior charging	Surface charging and charging signatures	Single event effects, HF comm., human radiation	Surface damage (e.g., solar arrays)	Surface charging signatures	Single event effects	Charging, calculation of n and T, orientation anomalies

- Daily Forecasts (1-3 day):
  - Solar x-rays and **energetic protons**
  - Geomagnetic activity
  - 10.7 cm radio flux
- Event-Driven Warnings and Alerts:
  - Warnings: geomagnetic storms, **proton events**
  - Alerts: solar flares, **proton events**, geomagnetic storms, **electron events**, solar radio bursts
- Also: Continuous real-time data and input for numerical models



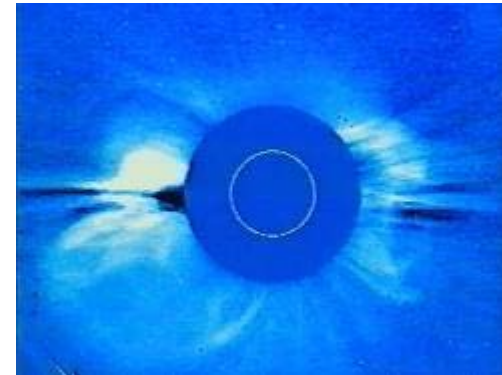
# Determining the Initial Properties of CMEs is Important for Predicting Their Arrival

WSA-Enlil Model of Background Solar Wind

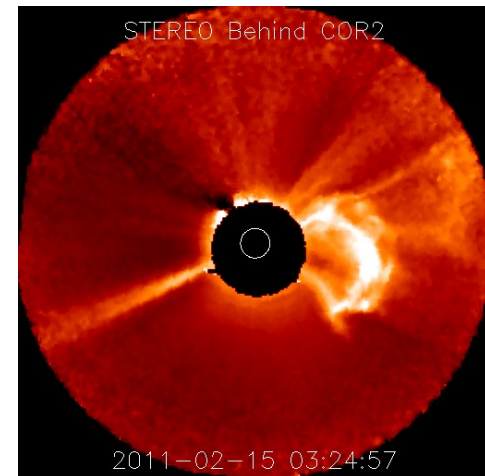


D. Odstrcil

SOHO LASCO Coronagraph



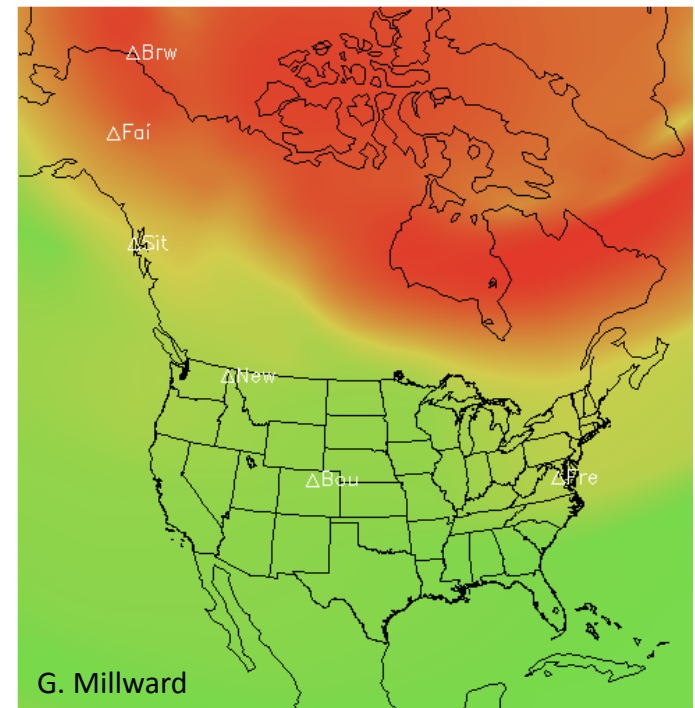
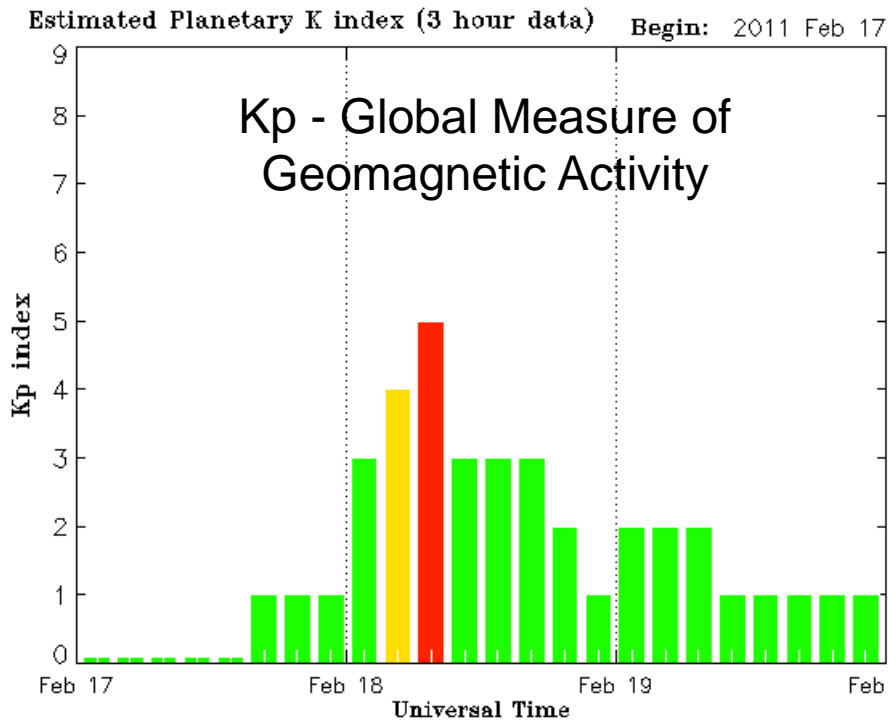
NASA STEREO Coronagraph





# Regional Predictions of Geomagnetic Disturbances

- Current forecasts do not resolve regional differences in activity
- Evaluation of geomagnetic activity models is occurring – involving NOAA, CCMC, MHD modelers, and empirical modelers
- Transition to operations could begin in 2013

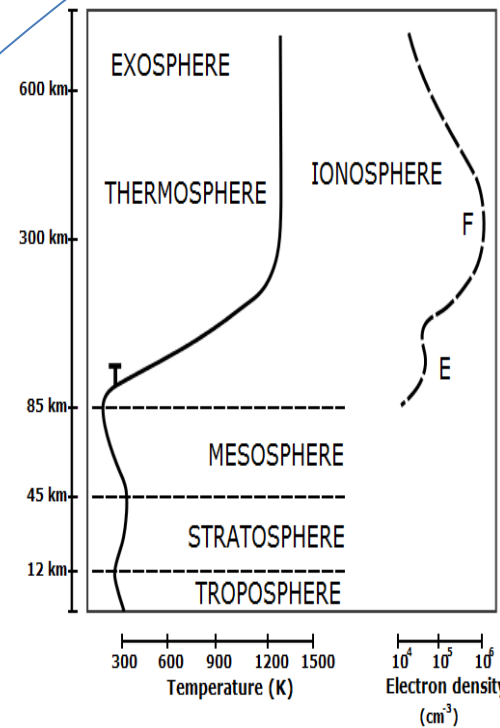
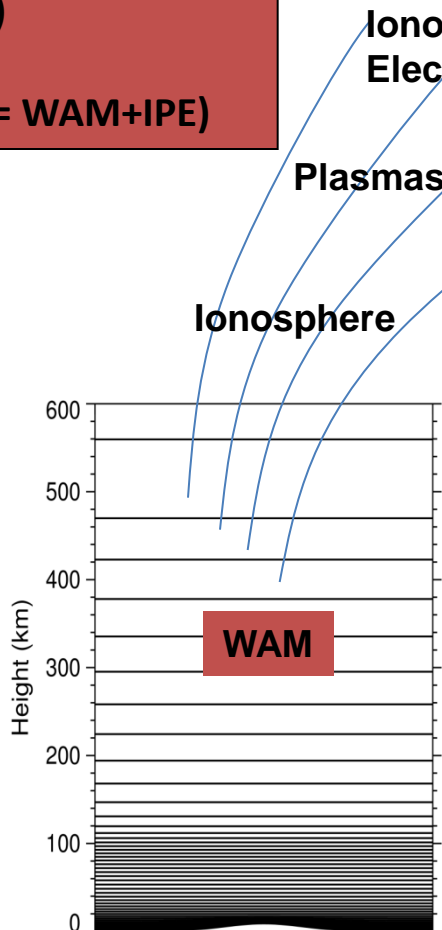
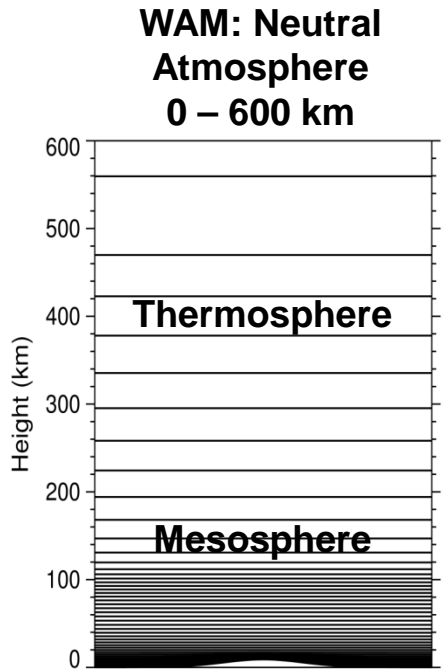
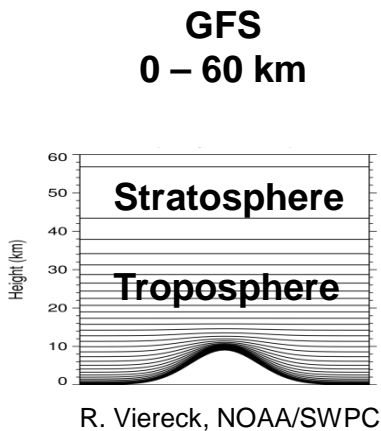




# Coupling of Atmospheric Dynamic to the Ionosphere System

Model development includes collaboration with UK researchers and the UK Met Office

**Whole Atmosphere Model (WAM = Extended GFS)**  
**Ionosphere Plasmasphere Electrodynamic (IPE)**  
**Integrated Dynamics in Earth's Atmosphere (IDEA = WAM+IPE)**





# Additional Information Sharing with Service Partners

- Alert notifications
- Customer requirements
- Customer impacts
- National contingency plans
- Verification methods and results
- Research/product development progress



# Space Weather Services to Build Global Resilience

Expert Meeting on Space Weather Services  
February 3, 2015 – UNCOPUOS STSC Assembly

Goal: Foster greater global participation in space weather service activities

- How can members benefit from information and services available today?
- What types of services are likely to be needed in various regions?
- How can members expand from a research/education capability to a service capability?
- How can members contribute local data and expertise to the global effort?

Supporting the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS)  
Scientific and Technical Subcommittee (STSC) Agenda Item on Space Weather

