IONOSPHERIC MODELS

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OUTLINE

• CURRENT MODELS

• INPUTS REQUIRED

• PRODUCTS AND OUTPUTS FOR USERS

• HOW NASA CAN HELP

• WHAT LWS SHOULD SUPPLY
# CURRENT IONOSPHERIC MODELS

## RESEARCH

- Global Theoretical Ionospheric Model (GTIM)
- Field Line Interhemispheric Plasma Model (FLIP)
- USU model of the global ionosphere
- A Coupled Thermosphere-Ionosphere-Plasmasphere Model (CTIP)
- Thermosphere-Ionosphere-Mesosphere-Electrodynamical-General Circulation Model (TIME-GCM)

## OPERATIONAL

- Parameterized Real-time Ionospheric Specification Model (PRISM)
- Ionospheric Forecast Model (IFM)
- Coupled Ionosphere-Thermosphere Forecast Model (CITFM)
### MODEL INPUT REQUIREMENTS

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Future Data: IMAGE Satellite

NASA Explorer Series Satellite Operational in February, 2000

- Energetic Neutral Atom Imagers
- Far Ultraviolet Imager
- Extreme Ultraviolet Imager
- Radio Plasma Imager

Multiple Ground Stations to Provide Real-Time Data

Products from IMAGE

- Auroral Oval - Situational Awareness
- Auroral Oval - Energy Deposition
- Magnetopause and Plasma-pause Locations
- Ring Current Ion Flux
Identify Users and Define User Needs (Parallel Efforts in DoD)
- NASA Manned Space Mission
- NASA Low-Earth-Orbit Satellites
- Electric Power Companies
- FAA Navigation
- Global Telecommunications
- Global Navigation

Requirement Areas
- Orbital Drag
- Ionospheric Effects and Scintillation
- Satellite Design and Anomaly Resolution

NPOESS Measurement Requirements
- Auroral Boundary: In-situ Plasma Temperature
- Auroral Energy Deposition: Ionospheric Scintillation
- Auroral Imagery: Neutral Density Profile
- Electric Field: Medium Energy Charged Particles
- Electron Density Profile: Energetic Ions
- Geomagnetic Field: Supra-thermal to Auroral Energy Particles
- In-situ Plasma Fluctuations: Neutral Winds
Future Data: COSMIC
(Constellation Observing System for Meteorology, Ionosphere, and Climate)
Measurements of TEC and Electron Density Profiles

An international (NSPO (Taiwan), UCAR, JPL) fleet of
8 low-Earth-orbit spacecraft with GPS receivers to be
launched in 2001

• Using occultation of the GPS signal as it passes through the ionosphere, height profiles of electron densities will be obtained.

• During a 24 hour period, 8 spacecraft will obtain 4014 ionospheric soundings

• Data products will be global Total Electron Content (TEC) and Electron Density Profiles

24HR GPS/MET soundings (4014) with 8 LEO's
THE FUTURE:

Data Assimilation Approach for Ionospheric Products

**Observations**

- Solar EUV or F10.7 Proxy
- Kp Magnetometer NOAA/TIROS
- NOAA CORS GPS TEC COSMIC
- DISS DMSP

**Products**

- Previous Forecast of Ionospheric Conditions
  - Assimilation of Available Driving Parameters and Ionospheric Observations
    - Forecast Input Conditions
      - Forecast of Ionospheric Conditions
        - Ionospheric Specification Products
        - Ionospheric Forecast Products
An Example of Model Implementation
Coupled Thermosphere-Ionosphere Model (CTIM)

- Solar EUV, UV
- Magnetosphere Electric Fields
  - Auroral Particles
- Lower Atmospheric Tides
- Coupled Thermosphere Ionosphere Model
  - Neutral Winds
  - Composition
  - Temperatures
  - Density
- Thermosphere
  - Ion/Electron Density
  - Total Electron Content
  - Ion Temperatures
  - Ion Drifts
- Ionosphere
- Specification Forecast
- Product Areas
  - Communications
  - Navigation
  - Satellite Drag
Product:
Ionospheric Variability Maps

- Hourly maps of ionospheric variability created from modeled predictions
- Shows the deviation from the average quiet condition
- Can be easily modified to a number of specific applications such as GPS position errors
- Similar maps of NmF2 can be used to produce HF propagation predictions
**Product:**
Equatorial Scintillation Forecast

**Problem:**
- Ionospheric irregularities near the magnetic equator produce some of the largest errors in the GPS signals. These irregularities are quite sporadic.

**Solution:**
- Nightly predictions of scintillation based on ground-based ionospheric digital sounders to measure the post-sunset upward drift of the ionosphere.
- The faster the upward drift of the ionosphere, the more likely scintillation will occur.

**Product:**
- The S4 index - a measure of scintillation activity
- Presented as **Red-Yellow-Green** Alert/Warning
WHAT NASA CAN PROVIDE

• Satellites in equatorial, C/NOFS (Communication/Navigation Outage Forecast System) type orbits, with sensors to understand, specify and forecast, at all longitudes, ionospheric scintillation activity

• COSMIC-type GPS receivers in Low Earth Orbit (LEO) providing near real-time electron density profiles, globally, for ionospheric data assimilation models

• Critical ionospheric observations for model validation
WHAT LWS SHOULD PROVIDE

- Provide state-of-the-art assimilation models with sufficient, near real-time data from sensors such as ionospheric imagers and COSMIC-type GPS receivers.

- Development of a global, ionospheric TEST-BED model capable of SIMULATING ground-based and satellite-borne sensor observations for all levels of geomagnetic and solar activity conditions.