USAF Space Weather Modeling Needs and V&V

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Lt Col Christopher Smithtro
Commander, 16th Weather Squadron
Air Force Weather Agency

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Overview

- "Requirements"
- Models used at AFWA
- Ensembles
- Validation and Verification
- AFWA-CCMC Partnership

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Warfighter Impacts

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X-Rays, EUV, Radio Bursts

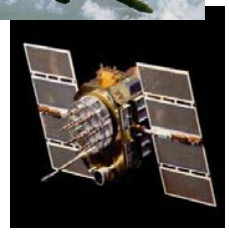
- SATCOM Interference
- Radar Interference
- HF Radio Blackout
- Geolocation Errors
- Satellite Orbit Decay

Scintillation

- Degraded SATCOM
- Dual Frequency GPS Error
  - Positioning
  - Navigation
  - Timing

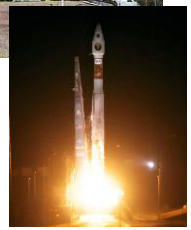
Proton Events

- High Altitude Radiation Hazards
- Spacecraft Damage
- Satellite Disorientation
- Launch Payload Failure
- False Sensor Readings
- Degraded HF Comm (high latitudes)



Geomagnetic Storms

- Spacecraft Charging and Drag
- Geolocation Errors
- Space Track Errors
- Launch Trajectory Errors
- Radar Interference
- Radio Propagation Anomalies
- Power Grid Failures

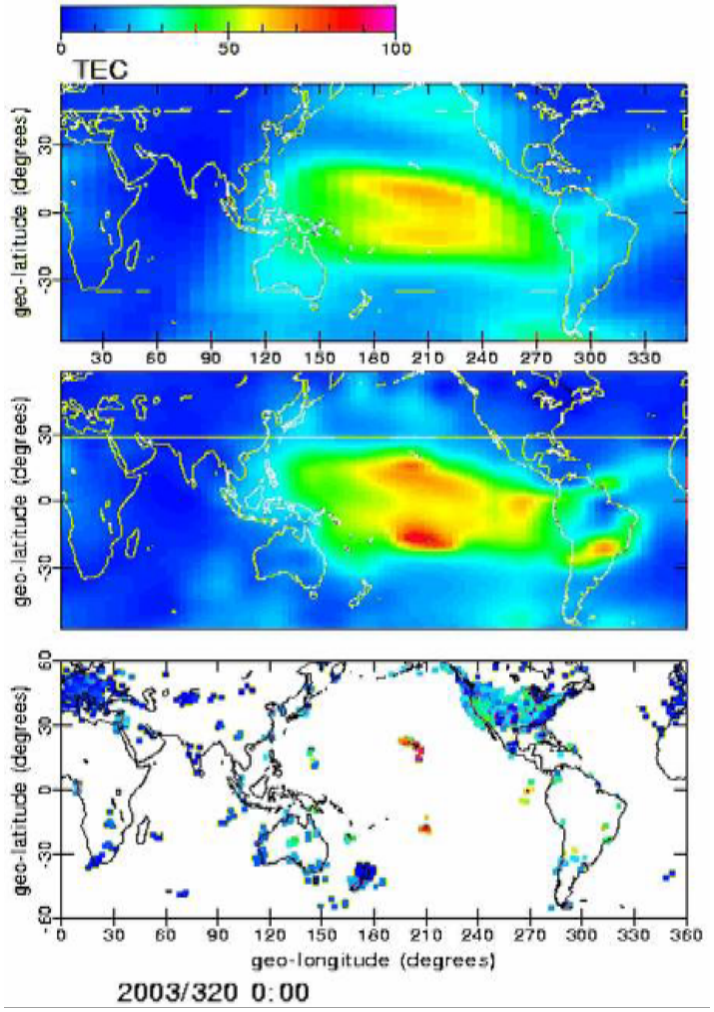


Model "Requirements"

- Impacts drive requirements
  - Mitigate or leverage impact using knowledge/forecasting of space environment
- Forecasts must be: Timely, Accurate, and Relevant
  - Timely – climatology, post-analysis, 5 days lead-time
  - Accurate – What do the users really need? What is a realistic end-goal?
  - Relevant – How do we translate *flux, density, magnetic field*, etc. into *impacts*
- Cost of transitioning new models must be justified by benefit

Modeling Challenges

- Do we know the physics?
- Do we have the data?
  - Quality, quantity, availability
- Can we depict/communicate the results in a meaningful way?
- Are we sure we've made an improvement?
  - Defining and quantifying impacts
- Can we afford to use/implement it?
  - Budget/personnel
  - Portability, optimization, robustness
  - Common formats



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Operational Models

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- **Global Assimilation of Ionospheric Measurements (GAIM)**
- **Solar Wind/Interplanetary Shock**
  - e.g. Hakamada-Akasofu-Fry (HAF) Model
- **Proton event prediction**
- **Radiation Belts**
  - e.g. Relativistic Electron Prediction, Radiation Belt Environment (RBE), Magnetospheric Specification & Forecast Model (MSFM)
- **Auroral Oval:** Hardy Oval, Ovation
- **Real-time & predicted Dst, Kp**
- **Impact Products**
  - e.g. HF Illumination, GPS Single Frequency Error, D-Region Absorption, WBMOD Scintillation, High Flyer Radiation Dose

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Modeling Needs

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- **Solar**
  - Solar wind speed
  - Flare
  - Coronal Mass Ejection
  - Proton Event
  - Solar Cycle
- **IMF**
  - Solar wind speed
  - Coronal Mass Ejection
  - Proton Event
- **Magnetosphere**
  - Magnetopause boundary
  - Particle acceleration
- **Magnetosphere (cont.)**
  - Radiation Belt energy/density
  - Energy deposition in I/T
  - Currents
- **Ionosphere**
  - Electron density/temperature
  - Scintillation
  - Currents
- **Thermosphere/ Mesosphere/Stratosphere**
  - Neutral densities
  - Winds
  - Radiation dose

Stochastic Forecasting

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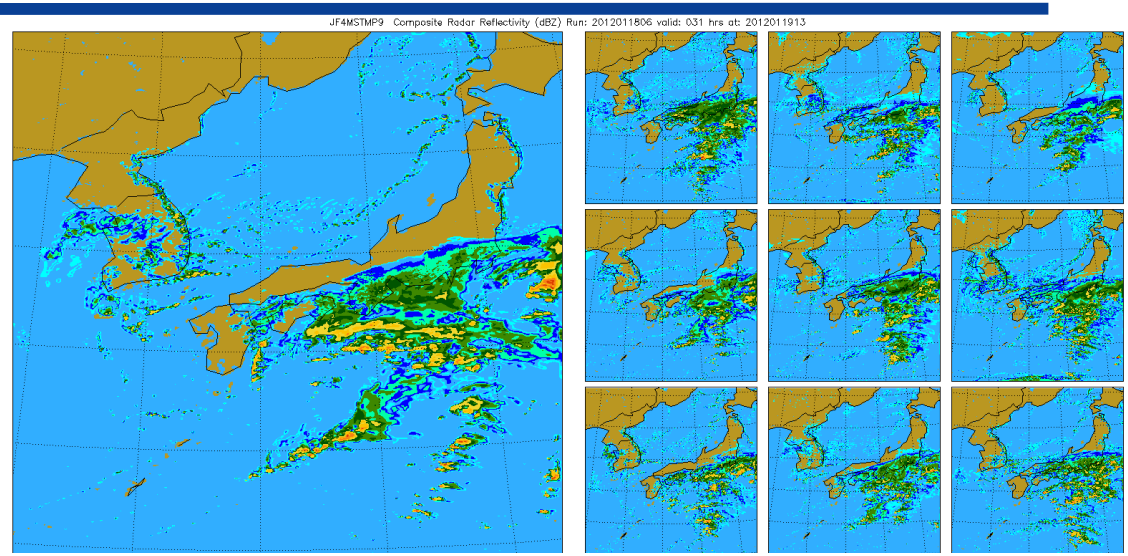
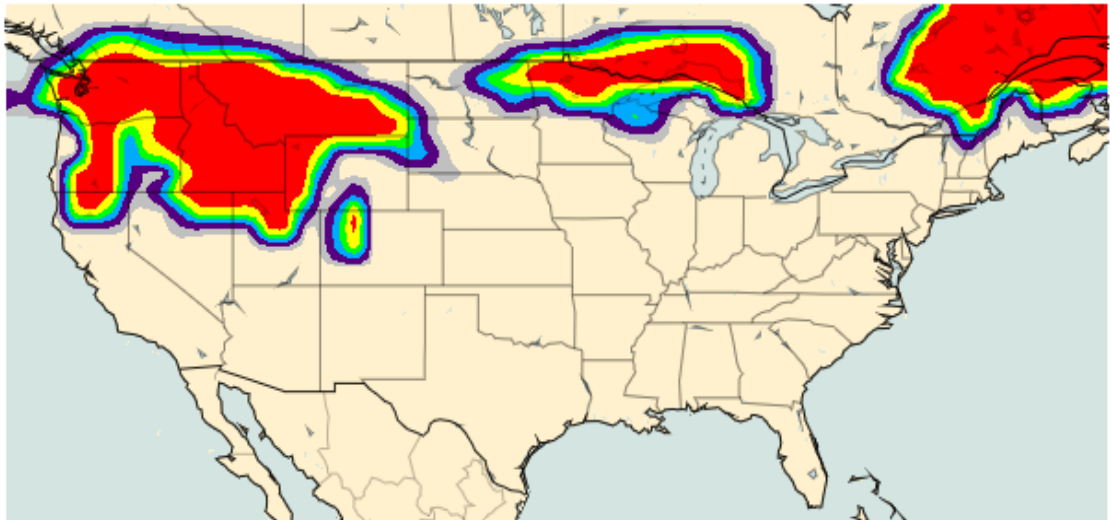
- AF moving to ensembles
- Products
  - Stamp charts
  - Probability plots
  - Point probabilities
  - Near Future – customized thresholds, joint probabilities
- Issues:
  - Computational resources
  - Education
  - Machine-to-machine
  - Legacy products





Provide decision making tools

Bridging the Gap

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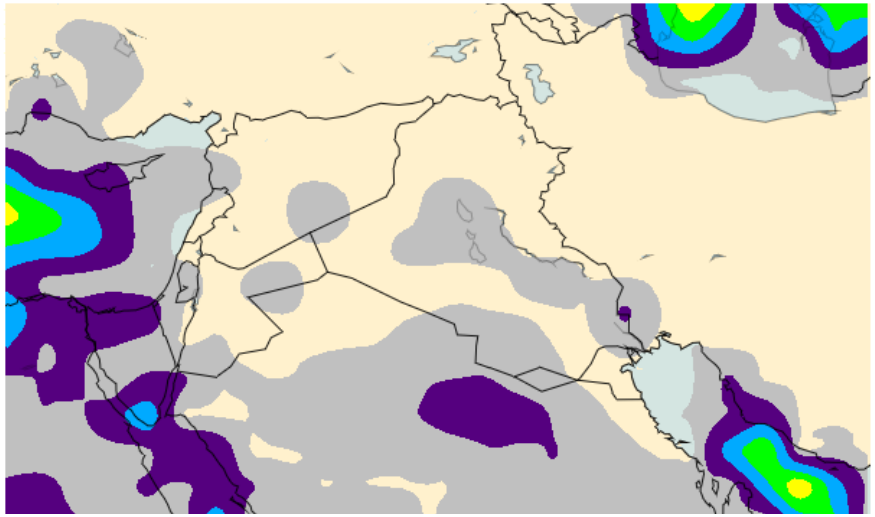
Stochastic Forecast



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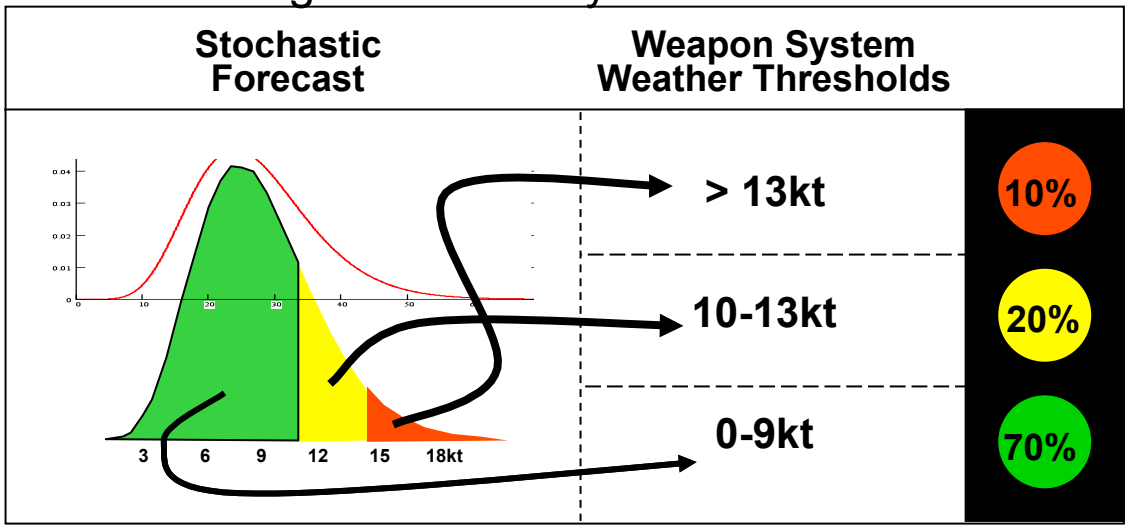
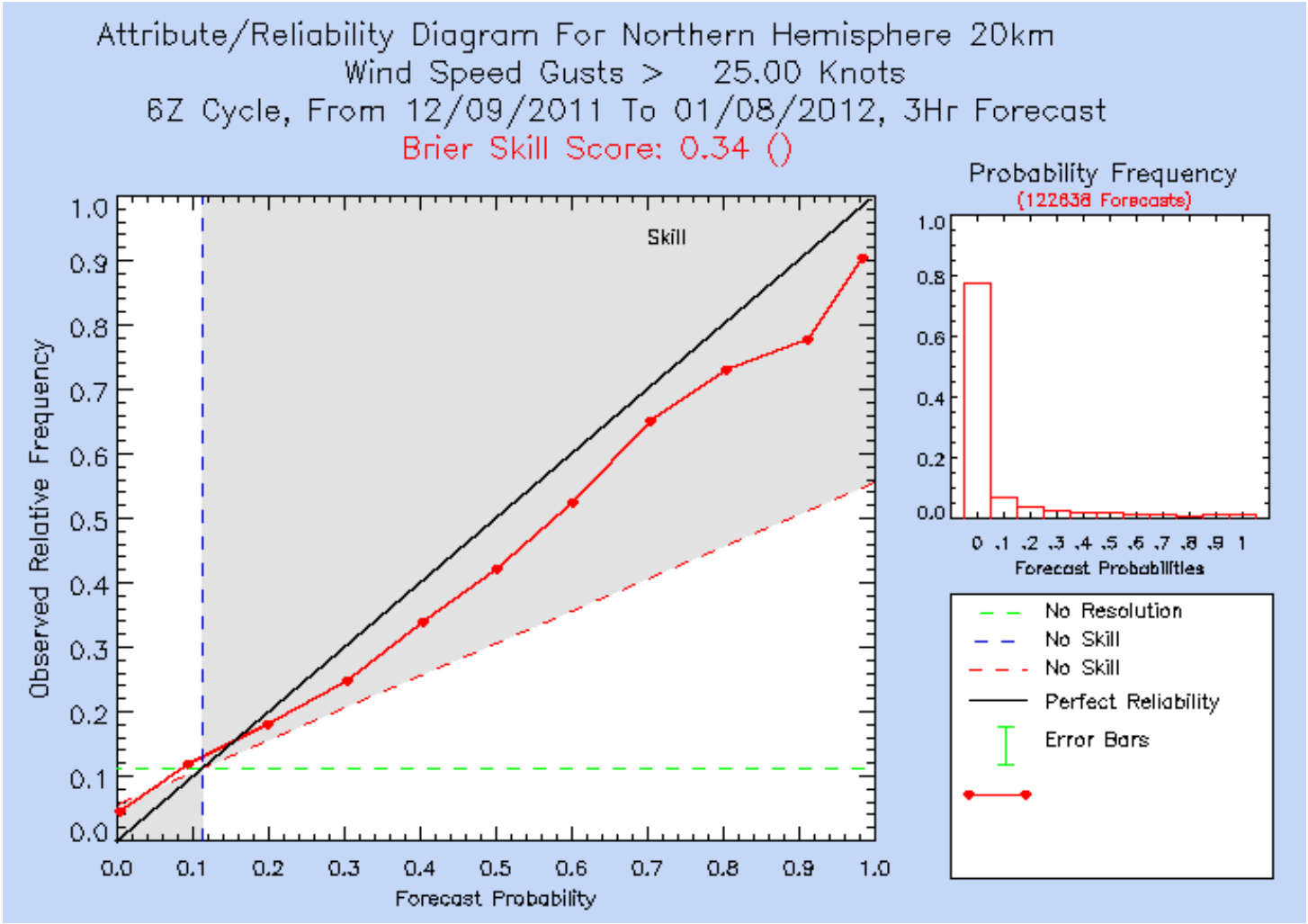
Binary Decisions/Actions

Using PDFs and System Thresholds



*Probabilistic Decision Aids — a tool for Operational Risk Management (**ORM**)*

Stochastic Verification



V&V Definition

Validation: A determination, based on performance, that a model is ready for operational use

- **Used to decide whether to implement a model into operations**

Verification: The continuous process of measuring the performance of an operational model to determine how well its performing

- **Used for forecaster awareness and to identify areas for model improvement**

AFWA Use of V&V

- Robust V&V supports *Advocacy*, *Acquisition*, and *Operations*
- Advocacy: Metrics needed to quantify the benefit of new and existing models
- Acquisition: Select/prepare models for operations
  - Model-to-model 'fly-offs'
  - Document strengths, weaknesses, and biases
  - Processing requirements, efficiency, storage needs
  - Transition decision: real-time inputs, automated/hands-off runs
- Operations: Real-time metrics to track longer term biases and daily variations in performance
  - Daily performance statistics critical to model confidence
  - Identify and prioritize model improvements
  - Tuning efforts

AFWA - CCMC Partnership

- CCMC can provide assistance with all levels of V&V
  - Identify & test candidate metrics
  - Advocacy for adoption of community standards
  - Conduct model fly-offs as honest broker
  - Document model performance/biases and communicate with developers
- CCMC can lead the way into stochastic modeling
  - Shock propagation
  - Flare and proton event prediction

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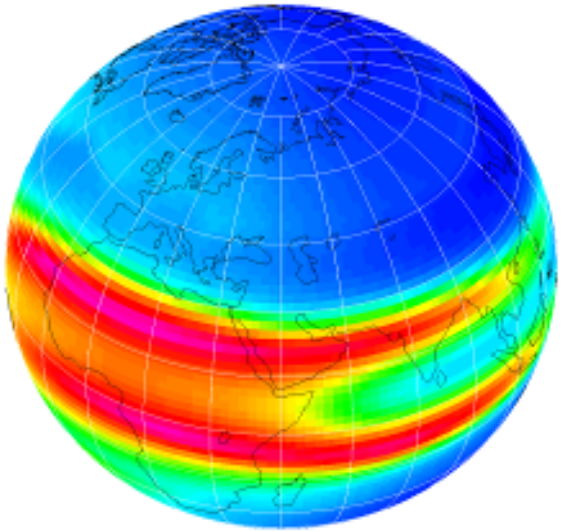
Summary

- Impacts drive requirements
- What do the users need/want?
  - Risk management (ORM)
- What can we reasonably expect to provide?
  - Budget; available data
- Stochastic forecasting
- V&V
- Continue close relationship with CCMC

Questions?



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