The View from SWPC: Utilizing the Diversity of the Commercial Space Weather Industry

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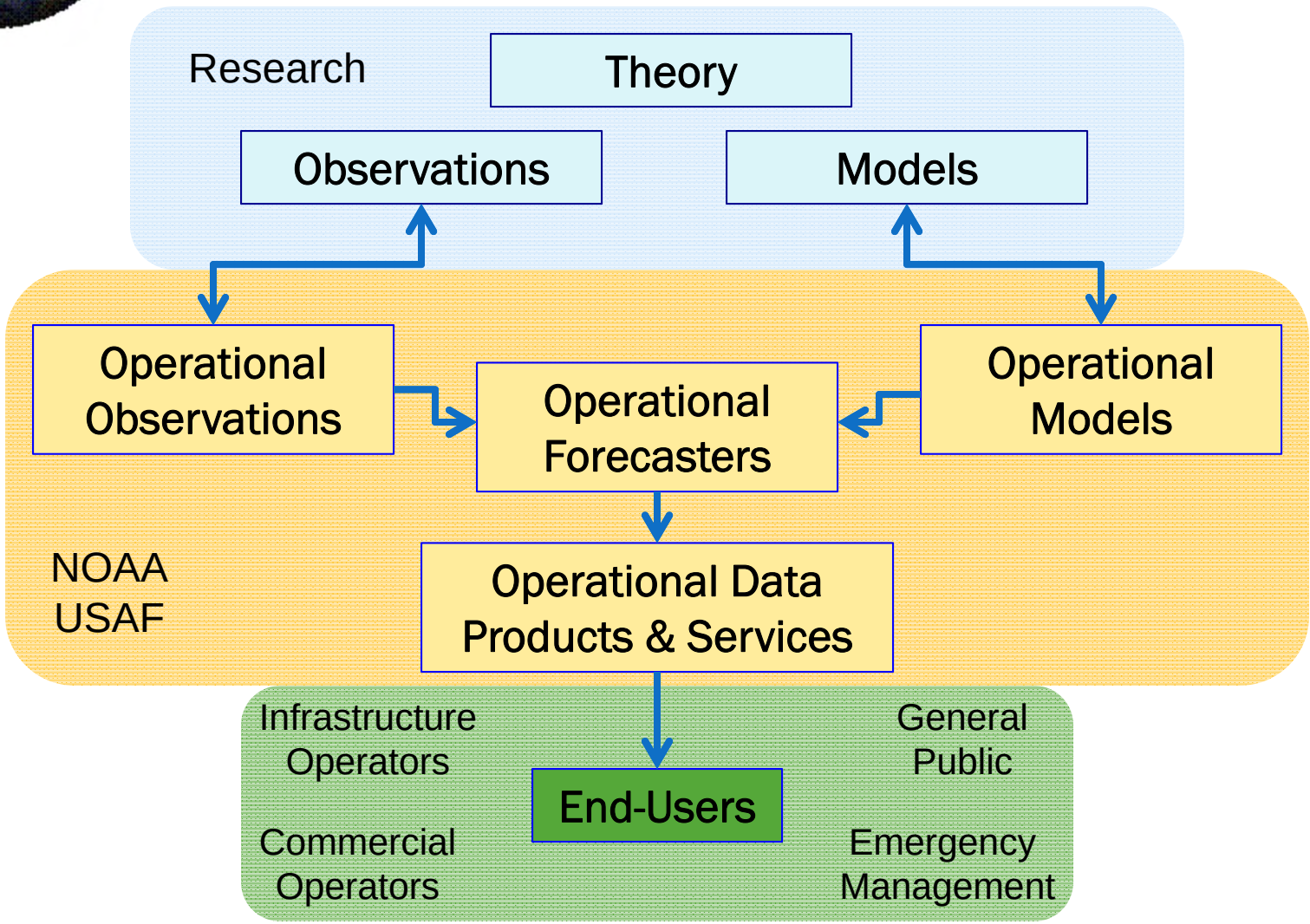
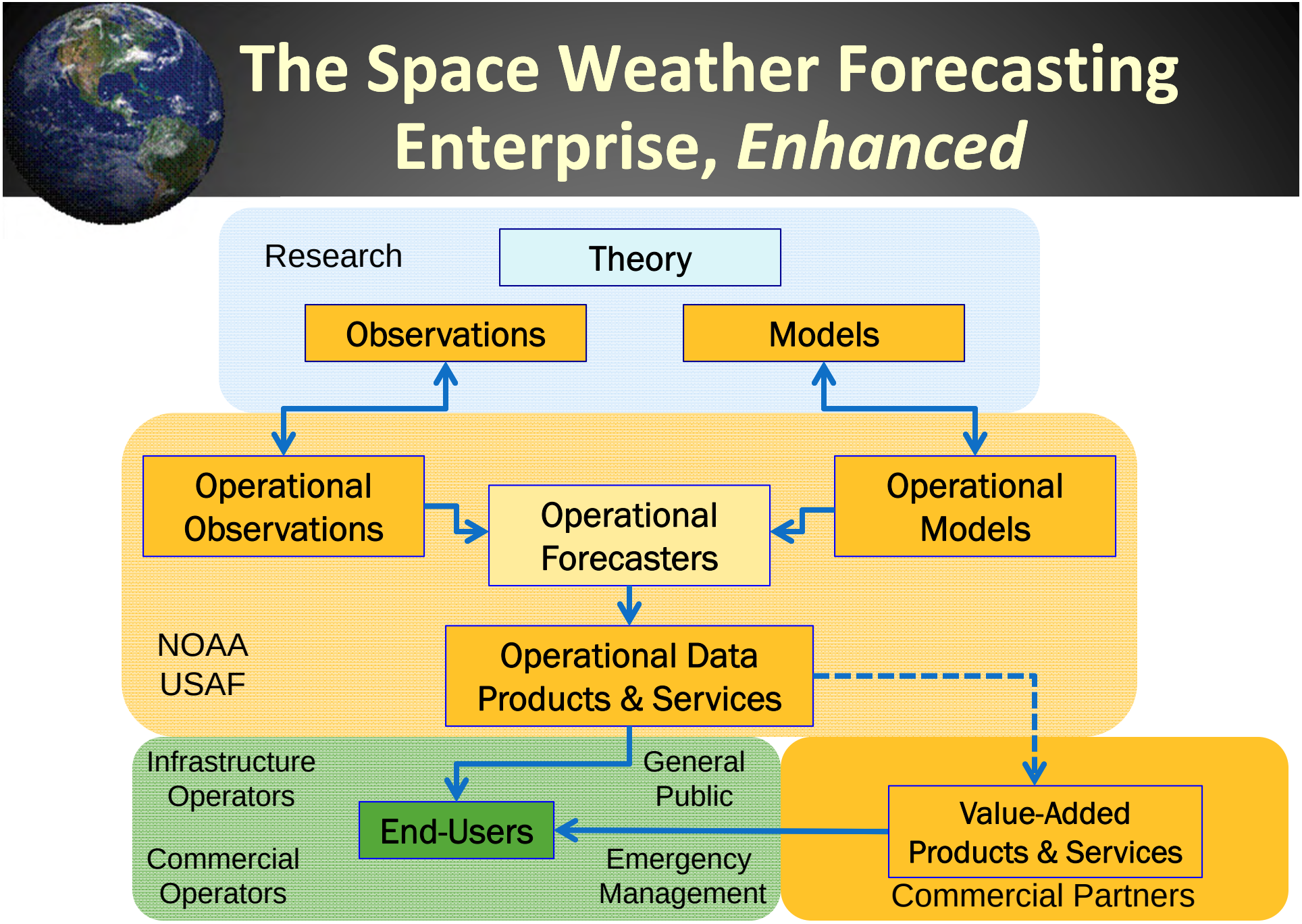
Space Weather Enterprise Forum, Washington, DC
October 20, 2015

The Space Weather Forecasting Enterprise



The Space Weather Forecasting Enterprise, *Enhanced*



Drivers:
NWS Weather Ready Nation

- NOAA: "A science-based *service* organization"
- NWS mandate: protect life & property while enhancing commerce
- NWS strategic outcome:

  "Ready, responsive, resilient"

- Extreme weather events arena remains the focus
- "Impact-based Decision Support Services" (IDSS)

"There is no intrinsic value in a forecast – only in how it is used"

Drivers:
The National Space Weather Strategy

- Space Weather Operations Research and Mitigations (SWORM) task force
- Prepare the nation for an extreme space weather event
  - Establish benchmarks for events
  - Enhance response and recovery capabilities
  - Improve protection and mitigation efforts
  - Improve assessment, modeling, and prediction of impacts on infrastructure
  - Advance observations and research to improve forecasting
  - Increase international collaboration

"Enabling a Space Weather Ready Nation"

Drivers: Global Transportation

Global Commerce

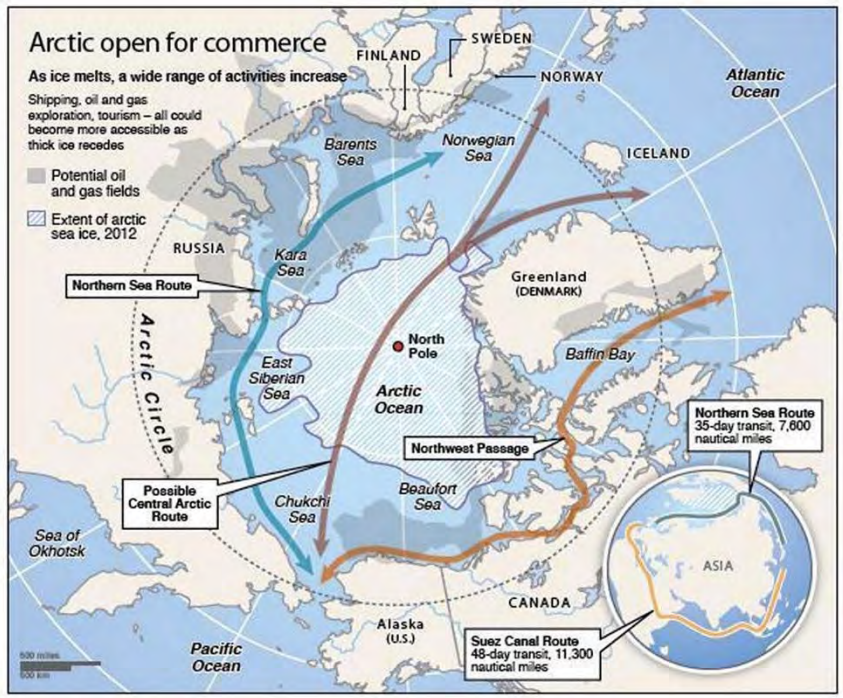
- 87,000 daily commercial flights.
- 3500 commercial shipping vessels over the course of a year.
- 1 Billion vehicles on the roads.

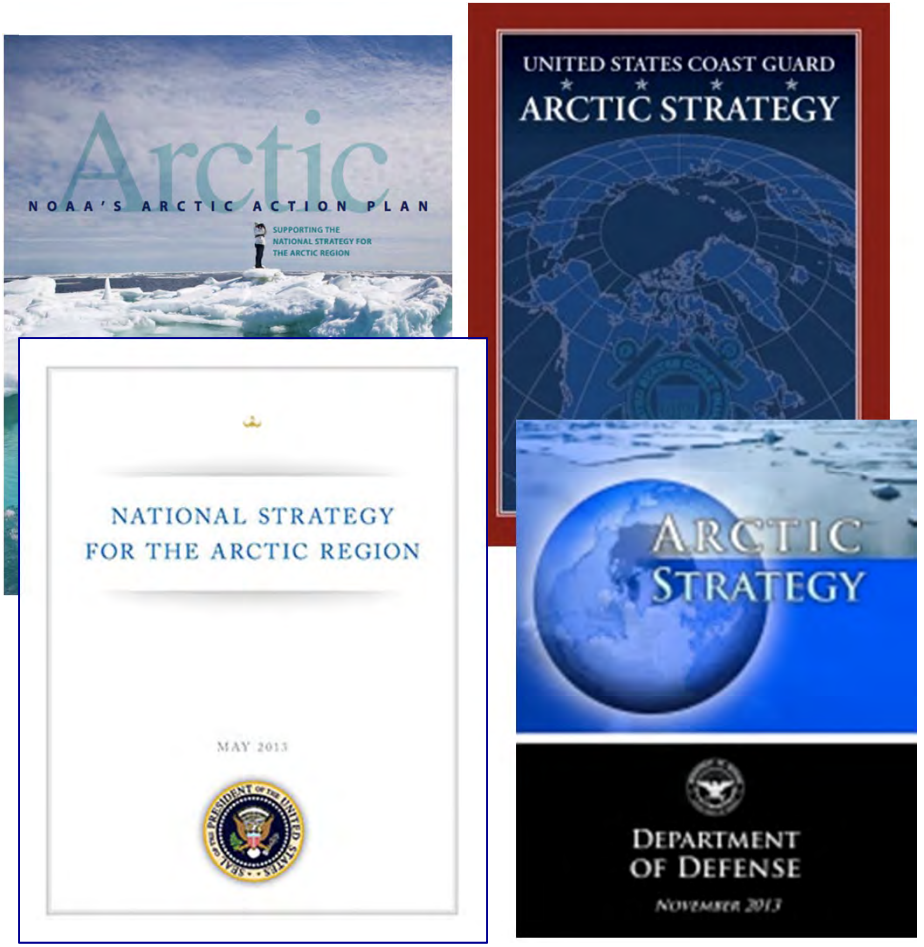
Position, Navigation, and Timing services are foundational to this web of global commerce.

Drivers:
Evolving Needs for Services

Arctic exploration, stewardship, and development

Space weather services to aid safe and efficient navigation, search & rescue, and exploration in a highly impacted region





Drivers:
Evolving Needs for Services

Evolving the National Airspace System

Satellite-based navigation requires
Space weather services to ensure
Accuracy and reliability

FAA NextGEN "Gate to Gate"

Commercial UAVs

Drivers:
Evolving Needs for Services

Commercial Space

Space weather services to ensure passenger and crew safety

Commercial Space Stations

Space Tourism

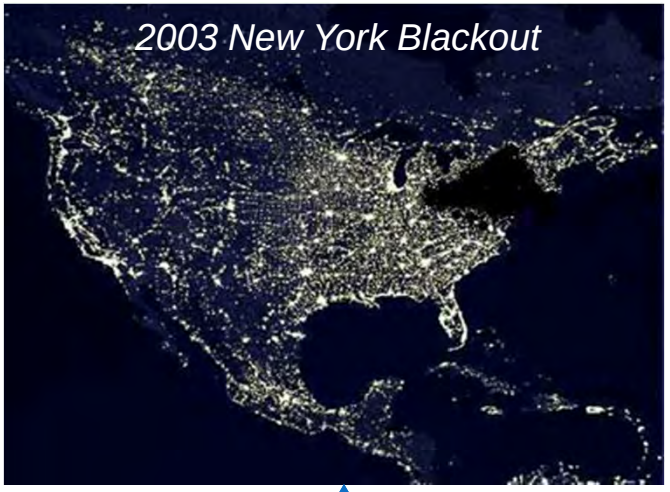
Opportunities: Impact Models and Forecast Products

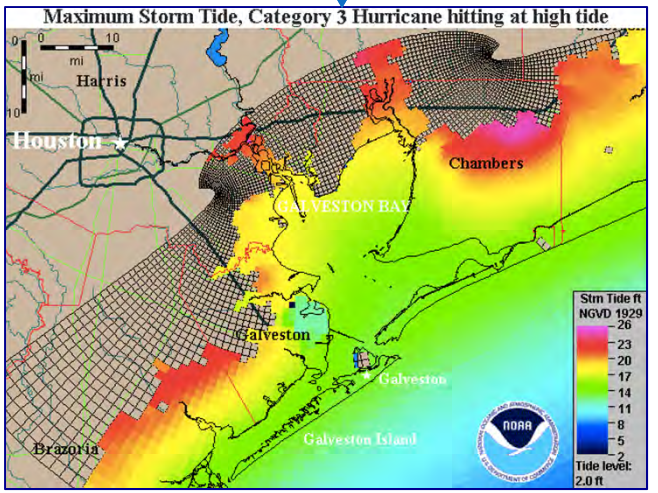
National Space Weather Strategy goal

- **Critical infrastructure impact models will be operationalized to allow forecasts and nowcasts of space weather effects.**
- ***"Beyond space weather phenomenology..."***
- **Analogous to hurricane storm surge impact models for mitigation planning.**

> *"Wind speed doesn't matter – it's the storm surge that does 90% of the damage."*

- **Blue sky opportunities for new products and services to both operational forecast centers and emergency managers.**



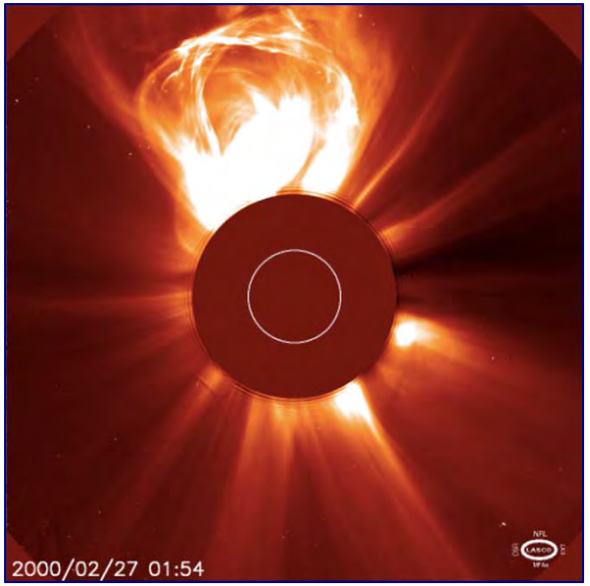


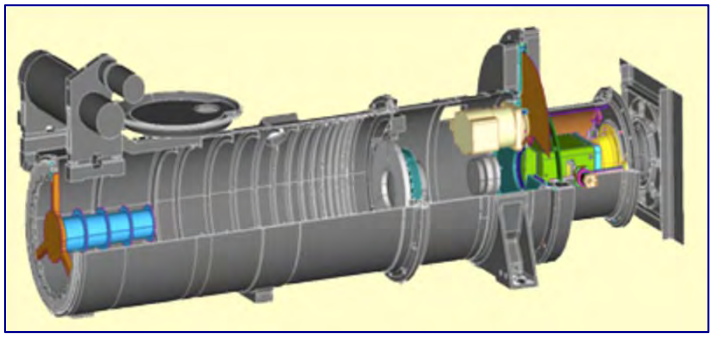
Tailored Support for Infrastructure

Opportunities: Baseline Operational Observing System

National Space Weather Strategy goal

- Will be defined as part of the Action Plan.
- Will specify the optimal mix of ground-based and satellite observations to enable continuous and timely watch, warning, and alert data.
- A top priority will be an operational coronagraph to replace the 20 year-old SOHO/LASCO at L1.



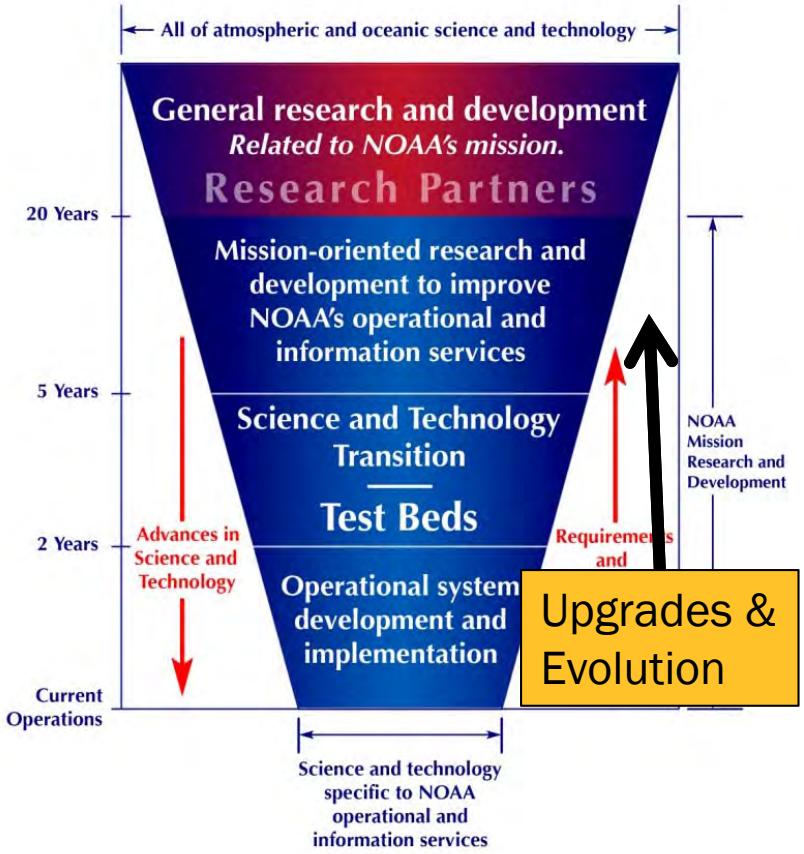


Next generation Coronagraph

Opportunities: Operations to Research (O2R) Challenge

SWx Operational Models…

- Heavily modified from research models.
- Run on 24/7 Weather & Climate Operational Supercomputer System (WCOSS).
- Require proven innovations to maintain relevancy. Therefore…
- …require a mechanism for engaging the research community in operational code upgrades.
  - Terrestrial weather enterprise examples: DTC, JCSDA, etc.

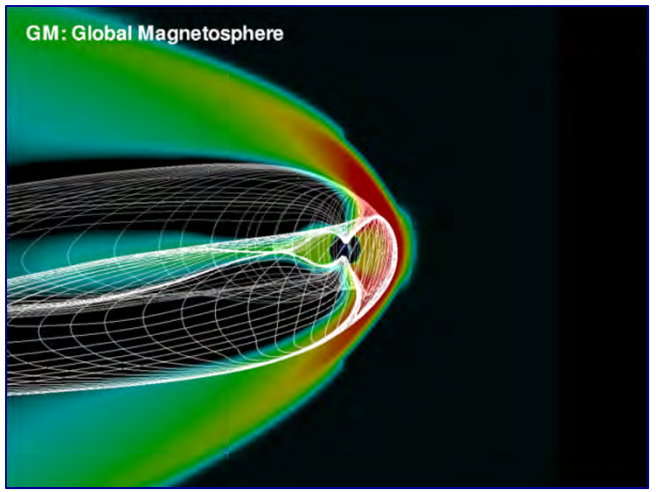


…must have Research Engagement

Opportunities: New Space Weather Models

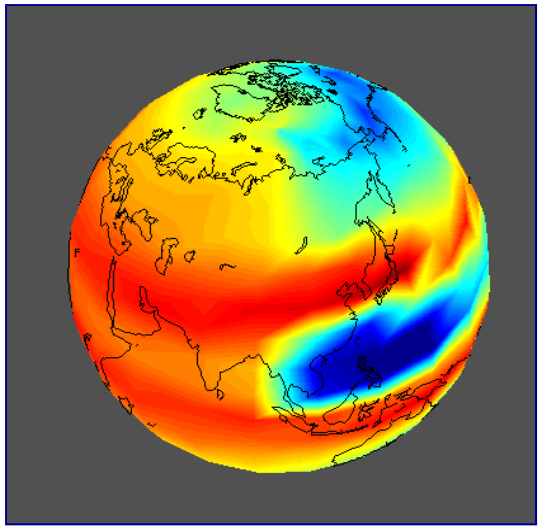
U. Michigan "Geospace" Model

- Dynamic 3-D model of Earth's magnetosphere.
- Driven by solar wind data from L1 to give 20—30 minute lead time on ***regional*** geomagnetic storm forecasts.
- Opportunities for products for localized customer bases.



Whole Atmosphere Model (WAM)

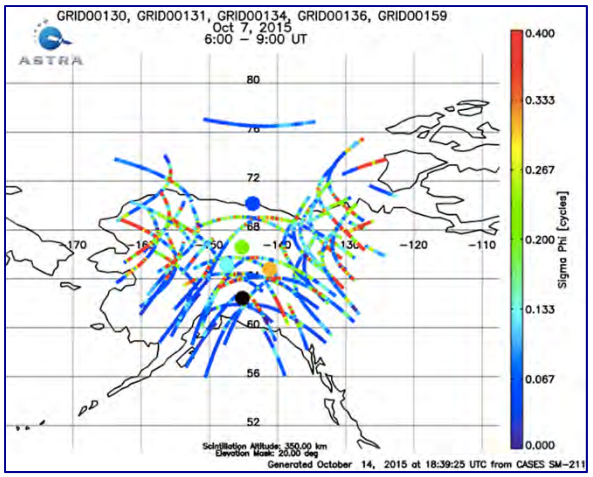
- Operational GFS forecast model extended to 600 km. Full physics ionosphere (IPE) model coupled in by 2019.
- Data assimilation via GPS Radio Occultation (RO) measurements.



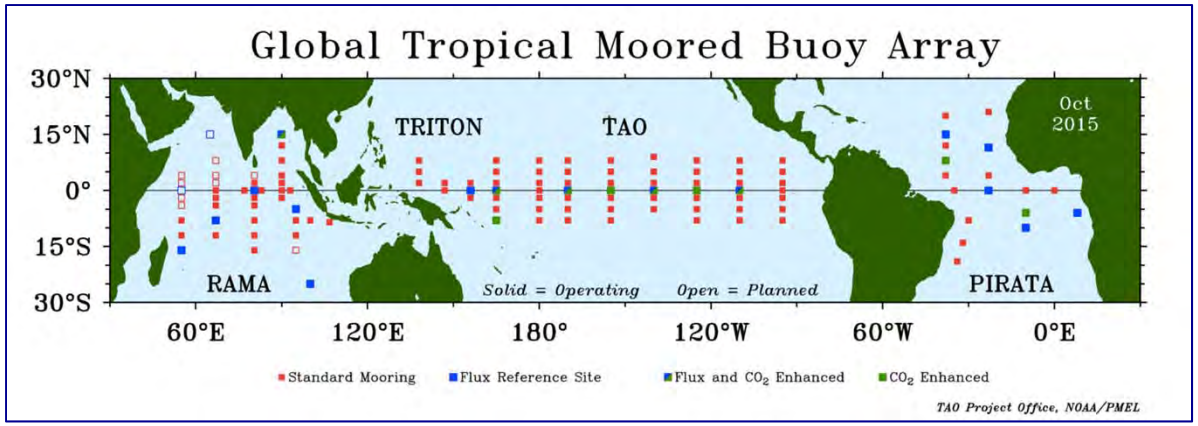
Opportunities: Commercial Capabilities

GPS scintillation monitoring in Alaska and on Tau Buoys

- CRADA with ASTRA Inc.
- Alaska array could enable GPS reception monitoring in critical Arctic region.
- Tau buoy array could enhance equatorial ionospheric data assimilation into new models.



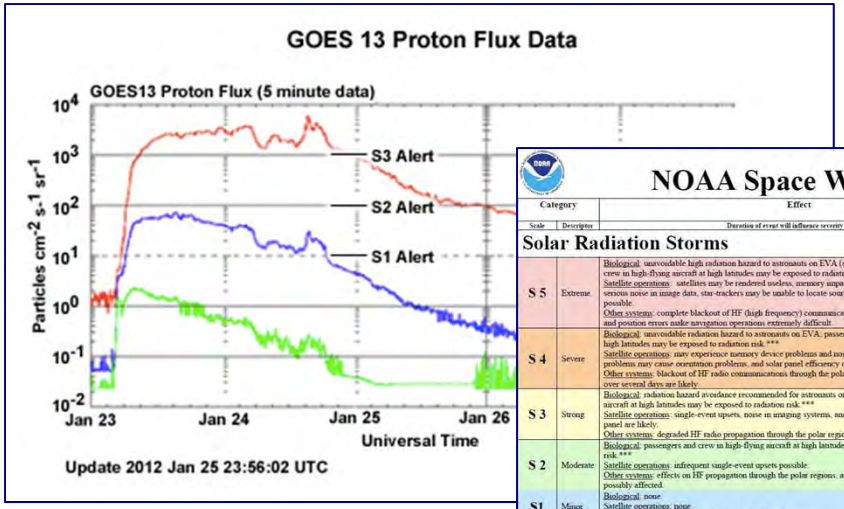
Alaskan Scintillation Array



Opportunities: Commercial Capabilities

Airborne Radiation Monitoring

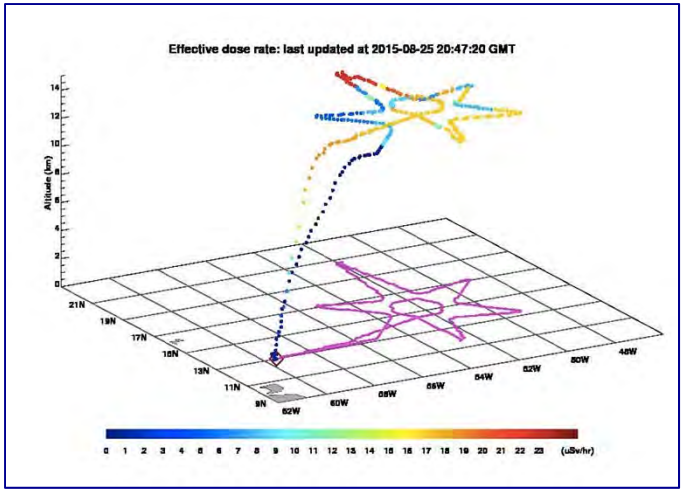
- Collaboration with SET Inc. for particle radiation dose monitoring at aviation altitudes.
- Potential for analog to terrestrial weather data inputs from commercial aircraft.



NOAA Space Weather Scales

Category: Scale	Category: Descriptor	Effect: Duration of event will influence severity of effect	Physical measure	Average Frequency (1 cycle = 11 years)
Solar Radiation Storms			Flux level of ≥ 10 MeV particles (ions)*	Number of events when flux level was met**
S 5	Extreme	Biological: unavoidable high radiation hazard to astronauts on EVA (extra-vehicular activity); passengers and crew in high-flying aircraft at high latitudes may be exposed to radiation risk. *** Satellite operations: satellites may be rendered useless, memory impacts can cause loss of control, may cause serious noise in image data, star-trackers may be unable to locate sources; permanent damage to solar panels possible. Other systems: complete blackout of HF (high frequency) communications possible through the polar regions, and position errors make navigation operations extremely difficult.	10^5	Fewer than 1 per cycle
S 4	Severe	Biological: unavoidable radiation hazard to astronauts on EVA; passengers and crew in high-flying aircraft at high latitudes may be exposed to radiation risk.*** Satellite operations: may experience memory device problems and noise on imaging systems; star-tracker problems may cause orientation problems, and solar panel efficiency can be degraded. Other systems: blackout of HF radio communications through the polar regions and increased navigation errors over several days are likely.	10^4	3 per cycle
S 3	Strong	Biological: radiation hazard avoidance recommended for astronauts on EVA; passengers and crew in high-flying aircraft at high latitudes may be exposed to radiation risk.*** Satellite operations: single-event upsets, noise in imaging systems, and slight reduction of efficiency in solar panel are likely. Other systems: degraded HF radio propagation through the polar regions and navigation position errors likely.	10^3	10 per cycle
S 2	Moderate	Biological: passengers and crew in high-flying aircraft at high latitudes may be exposed to elevated radiation risk.*** Satellite operations: infrequent single-event upsets possible. Other systems: effects on HF propagation through the polar regions, and navigation at polar cap locations possibly affected.	10^2	25 per cycle
S1	Minor	Biological: none. Satellite operations: none. Other systems: minor impacts on HF radio in the polar regions.	10	50 per cycle

* Flux levels are 5 minute averages. Flux in particles·s^{-1}·ster^{-1}·cm^{-2}.Based on this measure, but other physical measures are also considered.
** These events can last more than one day.
*** High energy particle (>100 MeV) are a better indicator of radiation risk to passenger and crews. Pregnant women are particularly susceptible.

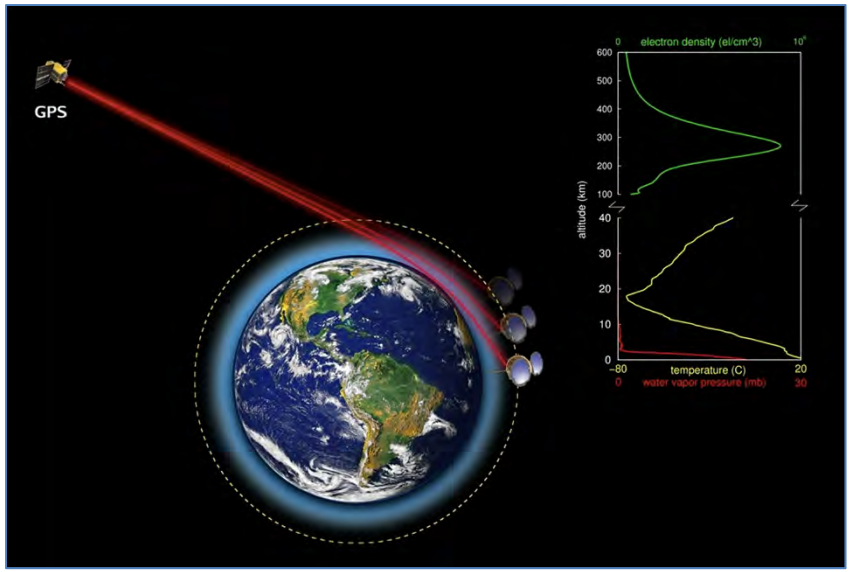


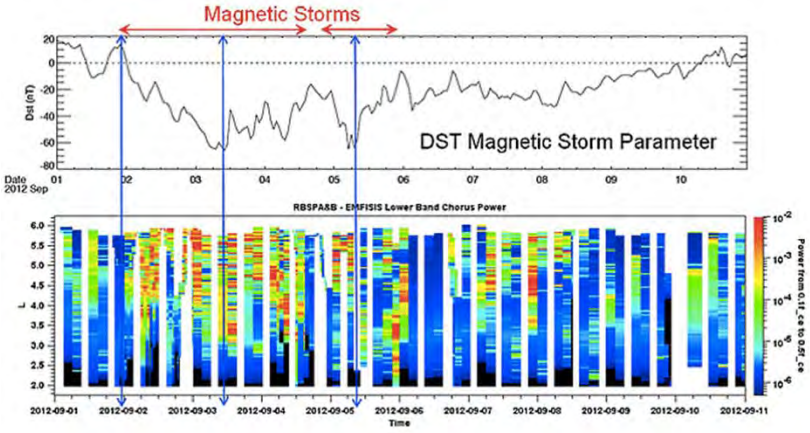
NOAA G4 ARMAS flight

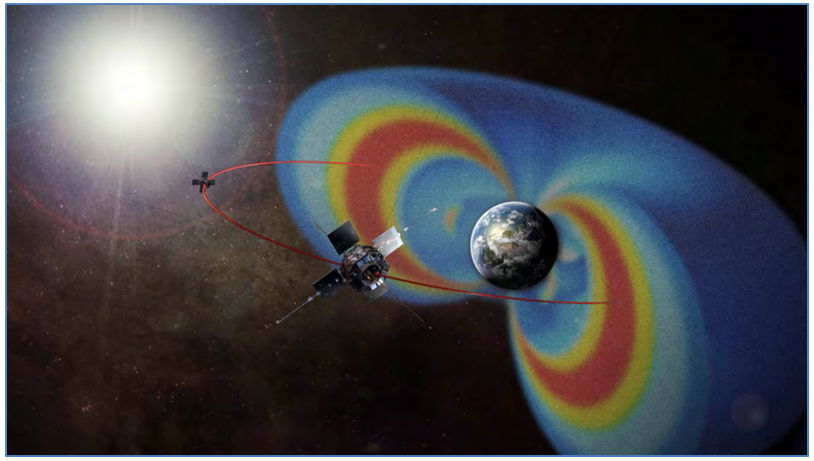
Opportunities: Commercial Capabilities

CubeSats and SmallSats for Near-Earth Space Weather Observations

- Ionospheric model data assimilation inputs from GPS radio occultation, expanding on COSMIC-2 constellation inputs.
- Potential for magnetospheric data in operational follow-ons to Van Allen Probes radiation belt monitoring.





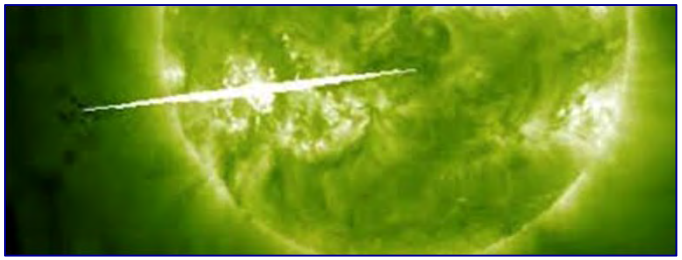


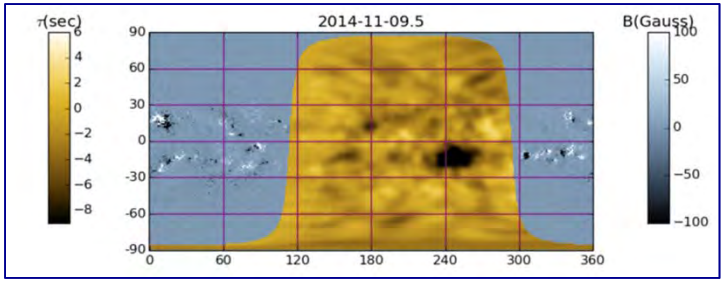
Mechanisms for Cooperation: CRADAs, SBIRs, Direct Grants

SWPC is active in CRADA and SBIR grants

- **Cooperative Research And Development Agreements** protect intellectual property of commercial partners while allowing government agencies to explore products.
- **Small Business Innovation Research** grants are a strength of SWPC. Recent projects:
  - Ionospheric ROTI product: PRA Inc.
  - Solar flare forecasting: NWRA
  - Solar far-side imaging: NWRA, NSO, JPL, & Stanford

  New SBIRS coming out in 2015:
  - Real-time deep space satellite ground-stations
  - Satellite radiation environment monitoring
- **Direct Grants** via new O2R facility in 2016++





techpartnerships.noaa.gov

Mechanisms for Cooperation: AMS and Space Weather Workshop

- The AMS Annual Meeting has included a Space Weather Enterprise session chaired by NWS for the past 10 years.

  Next Meeting: January 10—14, 2016

  New Orleans, LA

www2.ametsoc.org/cwwce

- NOAA/SWPC's annual Space Weather Workshop facilitated by UCAR includes sessions on commercial sector engagement.

  Next Meeting: April 25—29, 2016
  Boulder, CO

spaceweather.gov/content/annual-meeting

THANK YOU!