The National Space Weather Program and the Role of SuperDARN

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Overview

- The NSF view of SuperDARN
- Review of the National Space Weather Program
- Real-time products
  - Convection
  - Ionospheric conditions
- Science topics that may eventually lead to Space Weather products
  - Improving information about currents and Joule heating
  - Data assimilation for ionospheric and magnetospheric modeling

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NSF and SuperDARN

- NSF supports SuperDARN activities at JHU/APL, including operation and maintenance of selected sites, data analysis, and science
- Funding contributions to SuperDARN are divided between three programs: Upper Atmospheric Facilities, Aeronomy, and Magnetospheric Physics
- NSF funding to JHU/APL is administered through the Upper Atmospheric Facilities Program (UAF)

UAF

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Elements of the Upper Atmospheric Facilities Program

- Four incoherent scatter radar facilities
- Partial funding for SuperDARN
- Half of CEDAR Program
  - CEDAR instrumentation
    - Lidars
    - Passive optical instrumentation
    - Radio-wave instrumentation
  - The Resolute Bay Observatory

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NSF Funding for SuperDARN

- A five year award to JHU/APL was initiated in FY99
- Level of support will increase 25 per cent over five years (no growth in core NSF program budgets anticipated)
- Small supplement in FY2000 for upgrade to Goose Bay site
- Possibility for additional support in FY2001 from the National Space Weather Program

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The UAF View of SuperDARN

- UAF views SuperDARN as an international network of observatories serving the world-wide space science community
- SuperDARN is an essential element in the UAF-supported chain of upper atmospheric observing facilities, providing high-quality, globally distributed measurements of ionospheric parameters
- The UAF program will continue efforts to work with other U. S. government agencies and the international space science community to ensure continued
  - operation of SuperDARN sites,
  - timely processing, analysis, and distribution of data,
  - high-quality scientific output, and
  - expansion of the SuperDARN network

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Space Weather

refers to conditions on the sun and in the solar wind, magnetosphere, and ionosphere/ thermosphere that can influence the performance and reliability of space-borne and ground-based technological systems, and endanger human life. Space weather storms can cause disruption of satellites, communications, navigation, and electric power distribution grids.

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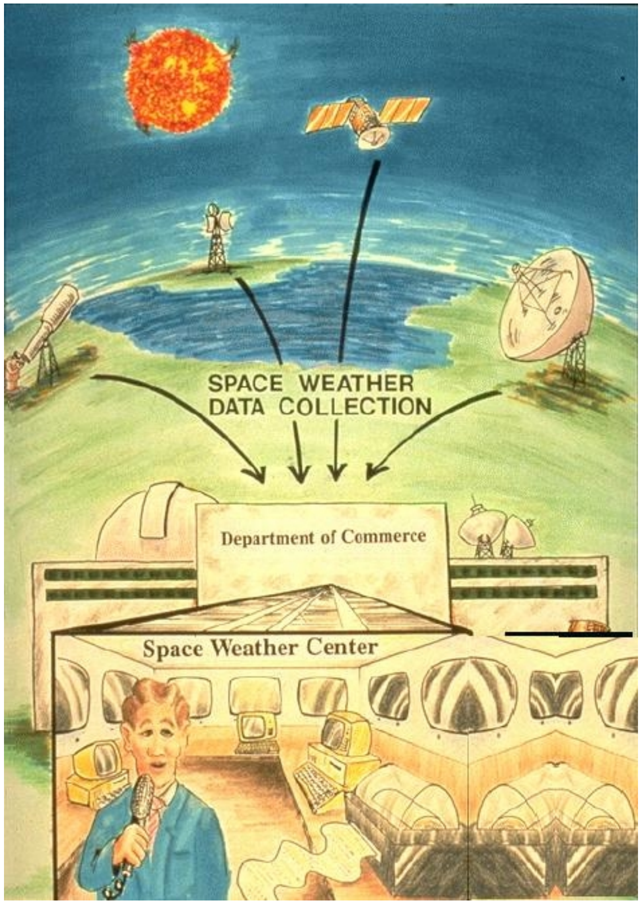
National Space Weather Program VISION

An active, synergistic, interagency, "single-minded" system to achieve the goal of timely, accurate, and reliable space environment observations, specifications, and forecasts in the next 10 years



<u>US Agencies</u>: DOD, NASA, NOAA, NSF, DOI, DOE, FAA

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National Space Weather Program Goals

- *To advance*
  - ➜ observing capabilities
  - ➜ fundamental understanding of processes
  - ➜ numerical modeling
  - ➜ data processing and analysis
  - ➜ forecasting accuracy and reliability
  - ➜ space weather products and services
  - ➜ education on space weather effects
- *In order to prevent*
  - ➜ under- or over-design of technical systems
  - ➜ regional blackouts of power utilities
  - ➜ early demise of multi-million dollar satellites
  - ➜ disruption of communications via satellite, HF, and VHF radio
  - ➜ errors in navigation systems
  - ➜ excessive radiation doses dangerous to human health

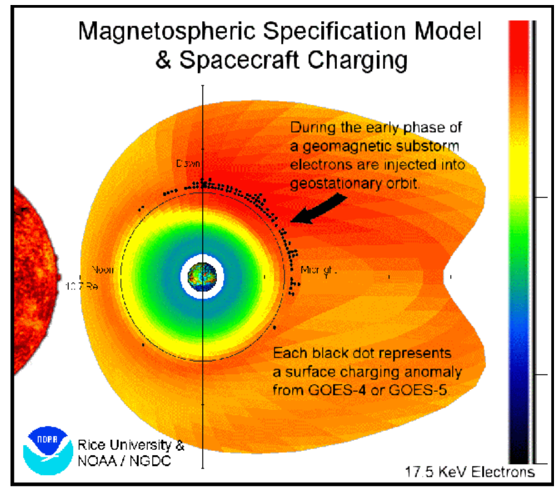
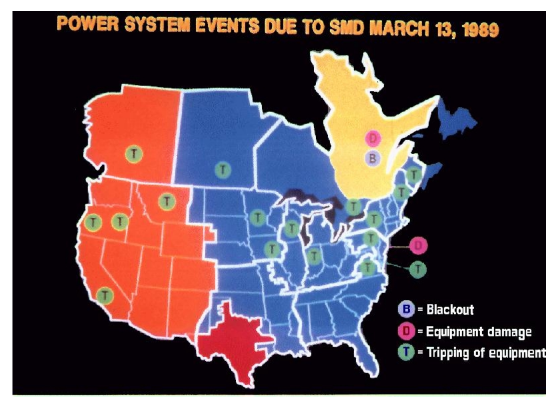


Figure courtesy of The National Geophysical Data Center



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Real-Time Products

- The high level of connectivity we have in the Northern hemisphere makes SuperDARN one of the best sources for real-time space weather data.
- What are the competitors?
  - Real-time magnetometer data
  - Real-time solar wind monitor
  - Real-time solar monitor
  - NASA Living With a Star initiative may provide a lot more real-time data, BUT NASA is not an agency that is supposed to provide operational system for Space Weather.

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Real-Time Convection

- **SuperDARN**
  - **Advantages**
    - **Large area of coverage**
    - **Short delay (~10 minutes)**
    - **Direct measurement of the quantity**
  - **Disadvantages**
    - **Don’t always have a lot of scatter**
    - **Don’t fully cover all MLT time sectors**
    - **Polar cap may expand to be equatorward of radar fields of view**

rtAMIE

- **Real-time AMIE**
  - **Advantages**
    - **Large area of coverage**
    - **Magnetometer data almost always available**
    - **Short delay (~10 minutes)**
    - **Provides Joule heating and field-aligned currents**
  - **Disadvantages**
    - **Not a direct measurement of convection**
      - **Requires conductance model**
    - **Don’t fully cover all MLT sectors – BUT it may be more likely to get Russian magnetometers in real-time than that we will get new radars in that sector with real-time connectivity.**

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LiMIE

- **IZMEM/DMSP linear regression model**
  - Advantages
    - Only needs solar wind data – Can be used for prediction!
    - No delay
  - Disadvantages
    - Statistical model, not a real measurement

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Real-Time MHD

- **Dartmouth group will begin running the Lyon-Fedder-Mobary code in real-time**
  - **Advantages**
    - **Only needs solar wind data – Predictive Capability**
    - **Provides a lot more than just ionospheric convection**
      - **But does not provide realistic information on radiation belts or ionospheric conditions**
  - **Disadvantages**
    - **Not a measurement, so quality of the result is difficult to determine**
    - **Questions of stability and accuracy still to be determined**

Real-time Ionospheric Conditions

- SuperDARN
  - Provides information on location of ionospheric irregularities
    - Scintillation is an important Space Weather quantity
    - But SD irregularities are not what cause scintillations, so this is an indirect inference
  - Use of radars as oblique sounders can provide information about high-latitude radio propagation
  - But we are not doing this yet and there are still issues and problems to be worked out

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SD

Currents and Joule Heating

- SuperDARN does not currently provide information on ionospheric currents, field-aligned currents and Joule heating
  - Using curl(V) gives you some information about FAC (Sofko et al)
  - To really get all the information we need to have accurate conductance information
    - From a Space Weather point of view SD would be helped by improved conductance information almost as much as AMIE technique
  - Improved conductance models would help, but would not completely solve the problem

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SD

Improving Conductance Models

- Conductance is very difficult to measure
- To derive conductance we need to know electric field (SuperDARN) and the currents
- To get the currents we need to invert magnetometer data (AMIE)
- Although we often see AMIE as a rival to SuperDARN there is a natural way for the two to work together to provide a product that both need and that is needed by many others in the Space Weather community as well

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Other possible collaborations

- Other collaborations are possible for improving conductance models
  - SuperDARN + MHD models
  - SuperDARN + Ionospheric models (e.g. TIME-GCM)
  - Global Image data + SuperDARN
    - NOTE: It is likely that SRI and Alaska will collaborate on a study of Sondrestrom radar data and UVI data to improve conductance models

Data Assimilation for Space Weather Modeling

- **Data assimilation is critical to successful terrestrial weather forecasting. We can expect the same to be true of space weather.**
- **Data assimilation for MHD modeling of the magnetosphere is going to be very difficult.**
  - **MHD equations give you wave solutions.**
  - **MHD modelers have an inner boundary around 3 Re.**
  - **The electric potential in the ionosphere is propagated along magnetic field lines to that inner boundary.**
  - **SuperDARN could provide an improved inner boundary.**

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SD

MSM

- The Magnetospheric Specification Model (an operational version of the Rice Convection Model) is used to provide now-casting of the state of the inner magnetosphere.
- The MSM uses the polar cap potential drop as an important parameter in the model. It is currently derived from Kp. SuperDARN could provide a much superior value for the total potential drop and could provide additional spatial detail for improved versions of MSM.

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Ionospheric modeling

- Data assimilation for ionospheric modeling is less problematical than for magnetospheric modeling.
  - A wide variety of data can probably be assimilated into ionospheric models
  - An important aspect of ionospheric modeling is the role of convection. It should therefore be possible to assimilate SuperDARN convection data into the ionospheric models.

Conclusion

- **SuperDARN will continue to play a vital role in the basic scientific research that is important to the NSWP**
- **SuperDARN will play a critical role in now-casting of space weather.**
- **SuperDARN data is likely to be useful in both ionospheric and magnetospheric now-casting and forecasting.**
  - **SuperDARN needs to consider how it will provide Space Weather products to the community**

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