Space Weather Observatory Network: Science Topics and Motivation

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How to make "progress"

- In order to make progress on something, there needs to be a goal
- What is the goal?
  - Better understand the near-Earth space environment?
- How to quantify "understand"
  - Space weather gives us a good way to quantify our ability to predict the environment
  - Is the ability to predict a good proxy for understanding?
  - By codifying our knowledge in models, we express our understanding
    - There are a lot of caveats in this, since models are not just equations, but are grids and numerics and all sorts of other stuff.

Space Weather

- The National Science Foundation is tasked with improving our understanding of space weather
  - Does not include actually doing space weather operations
  - Or even making operational models
  - But, understanding the basic science behind space weather
- Our goal aligns with this goal
  - We want to better understand the basic science behind space weather that enables more accurate prediction of different phenomena
  - Can we quantify this improvement in understanding?

Science Topics to Address

- Aurora
  - While this is not one of the Space Weather objectives, it is one of the most visible aspects of our field.
- Thermospheric Expansion
  - As the atmosphere expands, satellite drag changes, which then can change the probability of collision between objects.
- Ionospheric Disturbances
  - Structures in the ionosphere cause radio waves propagation changes and signal loss.
- Geomagnetically Induced Currents
  - Electromagnetic induction caused by large disturbances can drive strong currents in power lines and pipeline, causing failures and degradation.

Science Topics to Address - 2

- Aurora
  - What processes control the location, strength, and dynamics within the aurora?
- Thermospheric Expansion
  - What processes control the thermospheric absorption and dissipation of energy and momentum?
- Ionospheric Disturbances
  - What processes create small-, meso-, and large-scale structure in the ionosphere?
- Geomagnetically Induced Currents
  - What processes cause large dB/dt on the ground?

Why These Topics?

- Balance between magnetosphere and ionosphere/ thermosphere communities
  - Aurora and GICs are fundamentally GEM topics
  - Ionospheric disturbances and thermospheric expansion are CEDAR topics
- Societal relevance
  - There is basic science to understand
  - Findings can probably be used to improve space weather predictions
  - Congress has called on NSF to address these topics explicitly
- Instrumentation that leads to better understanding of one topic may lead to understanding of other topics
  - Possibly significant overlap in instrumentation needed to make progress in these topics
  - Specifically did not include solar component, since instrumentation would probably be very different

Objectives for Each Topic

- Define the goals of prediction
  - What do we really want to predict for each topic?
- Determine what gaps in our knowledge must be filled to enable understanding and predictive simulation ability
  - What do we not know or understand?
- Determine data-model fusion advances needed for specification and improved prediction
  - Data assimilation? Bias removal? Parameter specification?
- Determine what observations are necessary to provided the basis for understanding and model improvement
  - What measurements will allow us to gain understanding and prove that by codifying it?
- Define the instrumentation necessary and the placement of those instruments to provide those observations
  - Do we need to create new instruments? Chains of instruments? What do we need to do to actually make a real difference?

Discussion

- Are these appropriate science topics?
  - Aurora, Ionospheric Disturbances, GICs, Thermospheric Expansion
  - Basic science behind space weather?
  - Quantification of progress through modeling?
- Are these appropriate objectives?
  - Goals of prediction, ID gaps in knowledge, data-model fusion, ID observations, ID instruments and placement