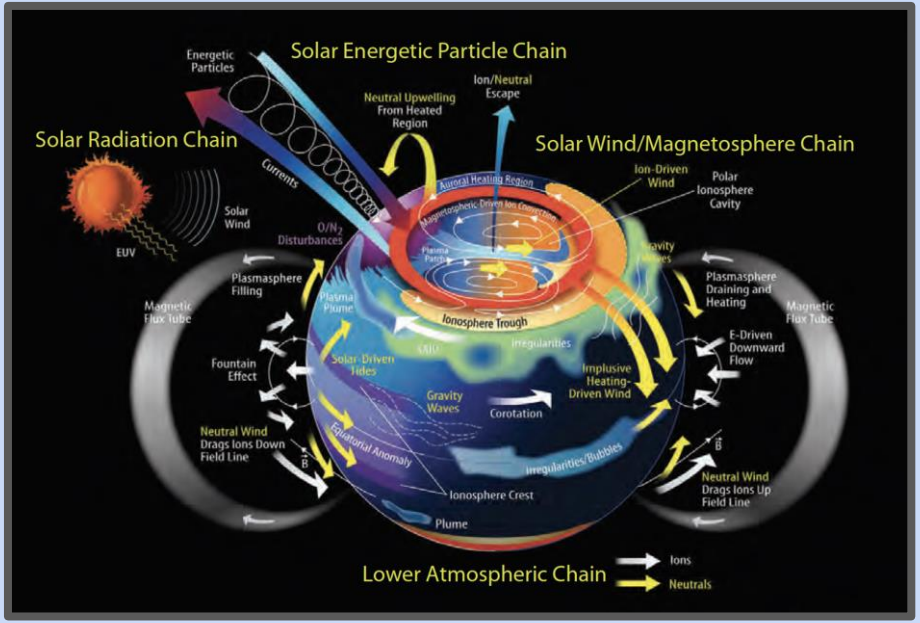
GDC STDT
Mid-term Report

Allison Jaynes and Aaron Ridley
STDT Co-chairs

Heliophysics Advisory Committee Meeting
December 19, 2018

Overview

- STDT Charge and Motivation
- STDT Schedule to Now
- STDT Organization & Subgroups
- GDC Goals and Objectives
- GDC Potential Implementations and Constraints
- STDT Report Timeline
- STDT Recommendations
- Conclusions



Charge & Motivation

- Making sure that the mission is focused enough to have achievable objectives, but broad enough to engage the IT community and exciting enough to engage the Heliophysics community.
  - Mitigation: Make sure both IT and non-IT people on committee are happy.
  - Mitigation: Pinpoint the exciting science that everyone can rally behind.
- Schedule is aggressive. This is a massive undertaking and people are doing it in their “spare time”.
  - Mitigation: Weekly telecons and trying to make sure that we stick to our schedule. Keep people informed.
- Keeping our eyes on the forest and not the trees.
  - Mitigation: Stop discussions when we get down into the weeds. Balance.
  - Mitigation: Strong leadership to steer conversations and keep groups focused.

GDC STDT Schedule to Current Day

- May 15 - 18, First in person meeting
  - First rough cut of Goals and Objectives
- July 31 - August 3, Second in person meeting
  - Second cut of Goals and Objectives
  - First cut of implementation plans
- Subgroups formed to work on details of different topics
  - More on that in a minute
- November 27 - 30, Third in person meeting
  - In depth discussions on each objective to clarify intent
  - Started writing report
  - Write text surrounding each objective, and gather references and figures
  - Gather information on implementation needs

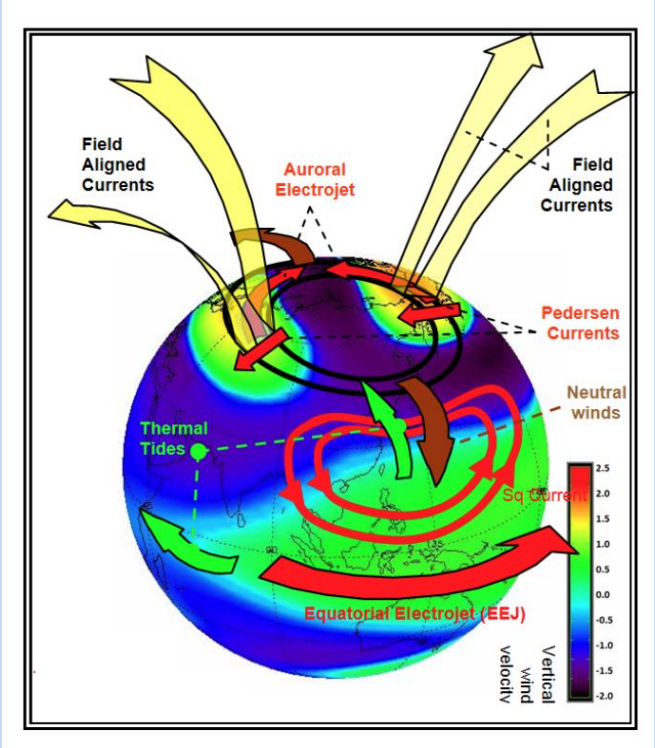
Organization & Subgroups

- Subgroups formed to divide and conquer
- At least one co-chair on each subgroup - overseeing all progress
- Each subgroup brings their decisions to the larger STDT for review and comment
- Subgroups
  - Goals and Objectives - refine and finalize
    - Almost done!
  - Implementation - mature the original four ideas and determine cost/benefit of each
    - Requested tables from flight dynamics experts
    - General information, such as delta-V needed to change altitudes and such
  - Measurements - discuss and decide measurement requirements needed to close each objective
  - Modeling Support - specify modeling studies needs by CCMC to determine if objectives can be closed with measurements and implementation plans

Current GDC Goals

1. Understand how the dynamic high latitude ionosphere-thermosphere responds to solar wind/magnetospheric forcing from quiet to disturbed conditions

1. Understand how internal processes in the global ionosphere/thermosphere system redistribute mass, momentum, and energy.



Goal 1 Objectives

Understand how the dynamic high latitude ionosphere-thermosphere responds to solar wind / magnetospheric forcing from quiet to disturbed conditions

1. Determine how high-latitude plasma convection and auroral precipitation drive thermospheric neutral winds
2. Determine how neutral winds, auroral precipitation, and collisional heating drive high-latitude neutral density structures.
3. Determine how mesoscale plasma density and convection features in the ionosphere structure the thermospheric winds and densities.
4. Determine how atmospheric gravity and tidal waves influence the IT response to magnetospheric inputs.
5. Determine how localized, coherent ion density features arise and evolve. (pending)

Goal 2 Objectives

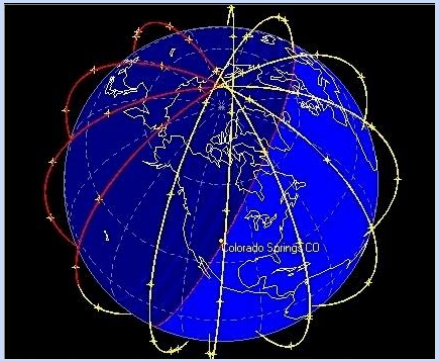
Understand how internal processes in the global ionosphere/thermosphere system redistribute mass, momentum, and energy.

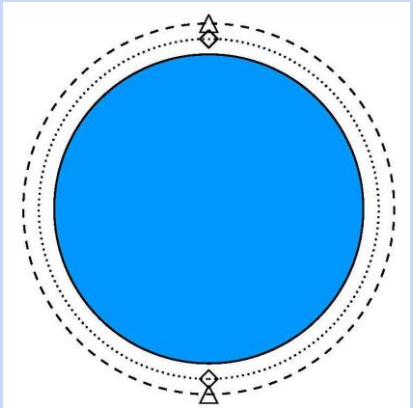
1. Determine how hemispheric asymmetries in the Earth's magnetic field, seasonal variations, and magnetospheric input affect the ionosphere-thermosphere system.
2. Identify the processes that create and dissipate propagating structures within the ionosphere and thermosphere during active and storm conditions.
3. Determine the connections between winds and neutral density/composition variations at mid- and low-latitudes during geomagnetic storms.
4. Determine the relative importance of penetration electric fields and disturbance winds in driving plasma density variations at mid- and low-latitudes during geomagnetic storms.
5. Characterize the spatial and temporal variability in IT parameters that results from the transfer of momentum and energy from atmospheric tidal and gravity waves.
6. Quantify the roles of radiative cooling and neutral winds in dissipating thermospheric energy.

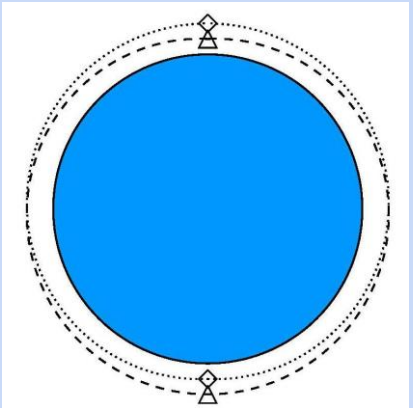
Implementation Architectures

1. N x M: Having M different localtime planes with N satellites in each plane
2. With CubeSats: Having M motherships with N “sacrificial” CubeSats
3. High-Low Circular: Having satellites at two different altitudes
4. Over-Under: Having slightly elliptical orbits offset by 180°

Can mix these if desired! Report will include constraints and trade studies for various aspects of architectures, and all information to easily find total flight dynamics effort required.







Timeline

- Given end of April as an ending date.
- January:
  - Finish goals and objectives write-up for the report
  - Finalize figures for goals and objectives section of the report
  - Start artwork for report (i.e., illustrations for general concepts and overall mission)
- February:
  - Work on implementation write-ups
  - Rough drafts for Implementation, Introduction, Relationships to past, present, and future missions
  - Artwork, figures, and references for these sections started
- March:
  - Finalize Implementation, Introduction, and relationships sections
  - Work on flow with the goals and objectives
  - Figures, artwork, and references completed

Timeline Continued

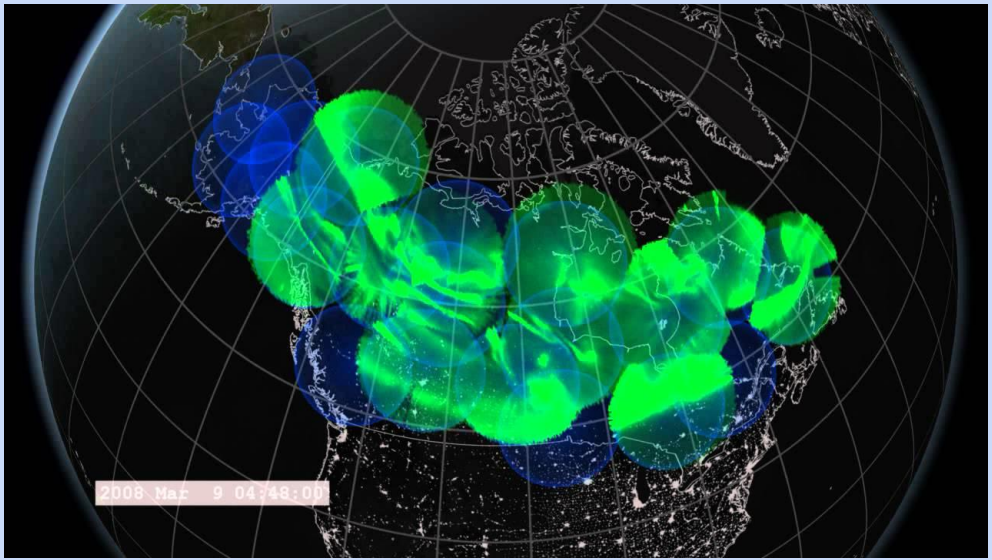
- April:
  - Recommendations and Executive Summary finished
  - Internal review by committee members
  - Editing fun with Aaron, Allison, and Jared
  - Team review final document
  - Delivery

Technology Development Needed!

- GDC is a constellation mission
  - This means that smaller satellites are fundamentally better than larger satellites when cost and mass to orbit are drivers.
    - Smaller satellites means more satellites/dollar (or /kg) which means better coverage, more planes, tighter spacing, etc.
- Satellite size is strongly driven by size, mass, and power requirements of instruments
- Typically, NASA would like high TRL instruments to be selected for flight
  - Need a few flights for this to occur since there are often failures to begin with
  - While flight opportunities are pretty regular now, it can still take multiple years to get a small sat together and launch it
- We recommend that Heliophysics is proactive in flowing funds into technology development in support of GDC. Sooner, rather than later.
  - We are not advocating for any particular instrument type, but the report will outline what the measurement requirements are for each of the objectives.

Ground-based complements

- GDC measurements will benefit greatly from conjunction observations by ground-based assets
- The THEMIS mission ground-based instrumentation allowed for closure of important science topics
- GDC should consider including a ground-based component in the primary mission concept
    - Constant observation at one geographic point
    - Large fields-of-view of various parameters (e.g. imagers on THEMIS)



Summary

- Goals and objectives are nearly finalized
- Have good ideas for implementation
- Report has been started
- Have an aggressive timeline for completion in April
- Technology development is needed to support large constellation missions