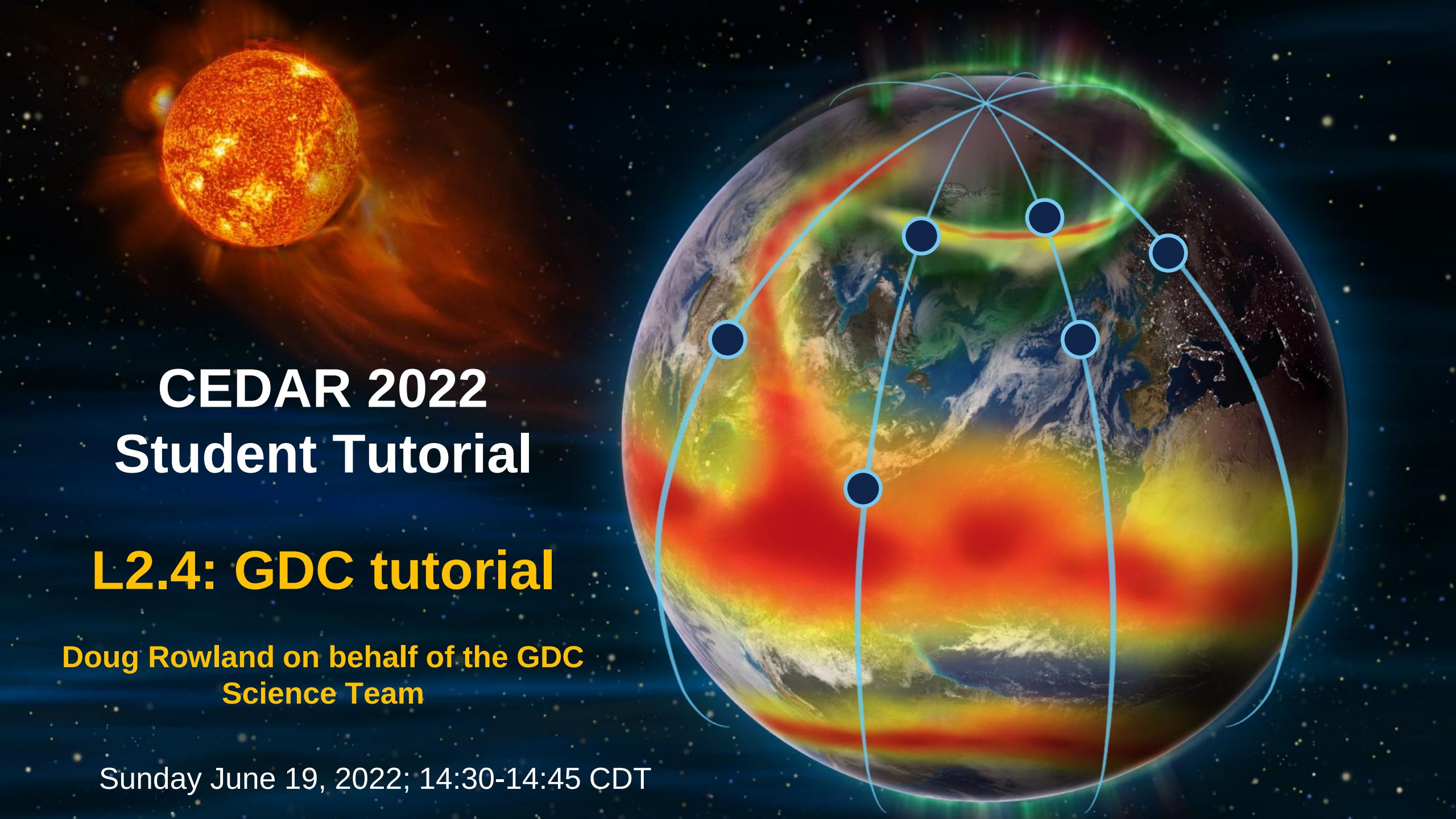


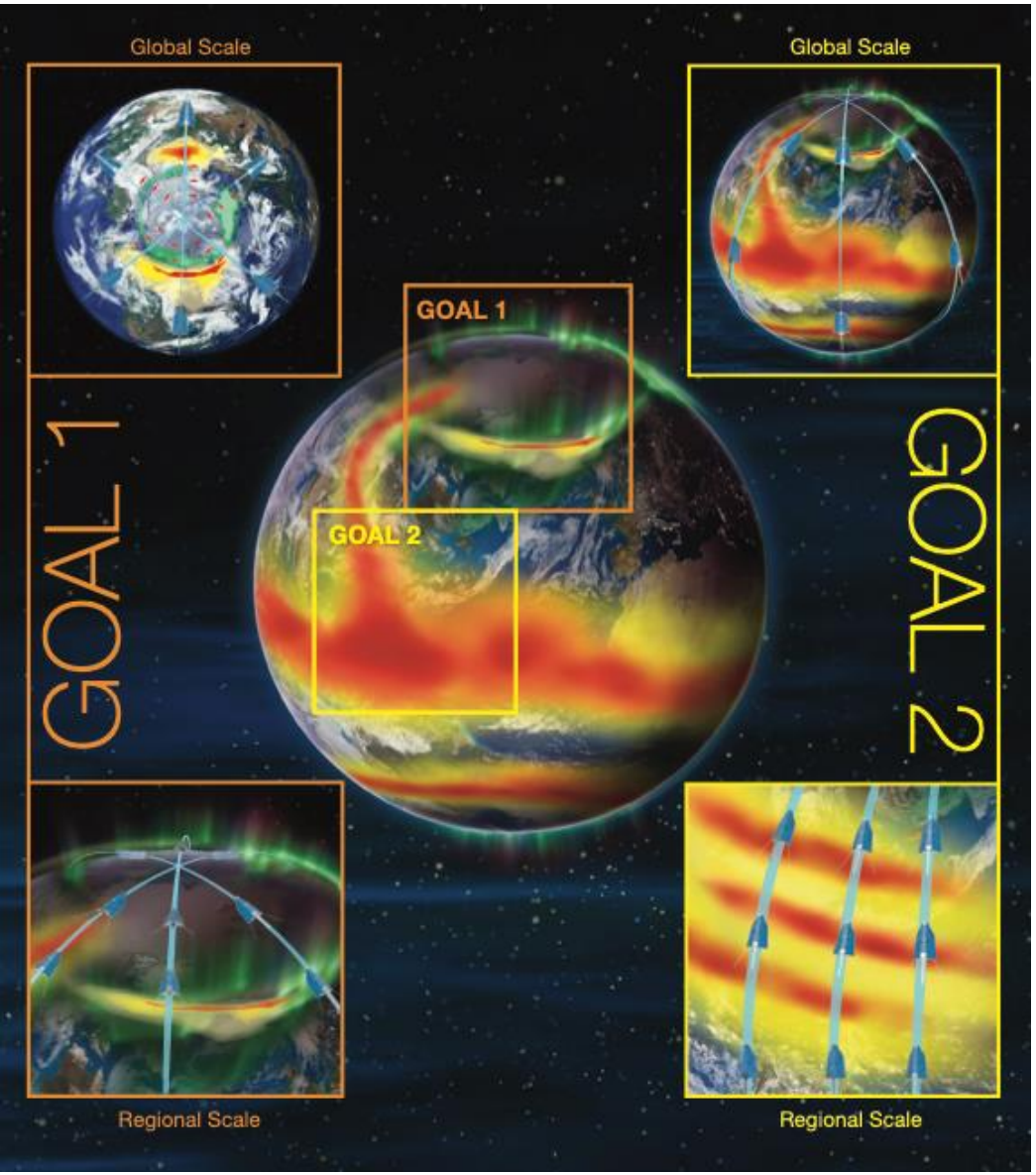
# CEDAR 2022 Student Tutorial

## L2.4: GDC tutorial

**Doug Rowland on behalf of the GDC Science Team**

Sunday June 19, 2022; 14:30-14:45 CDT

# GDC focuses on IT response to magnetospheric forcing




**GDC Goal 1**

Understand how the high latitude ionosphere-thermosphere system responds to variable solar wind/magnetosphere forcing

(see tutorials by **Lamarche**, **Zou**)

**GDC Goal 2**

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

(see tutorials by **Yamazaki**)

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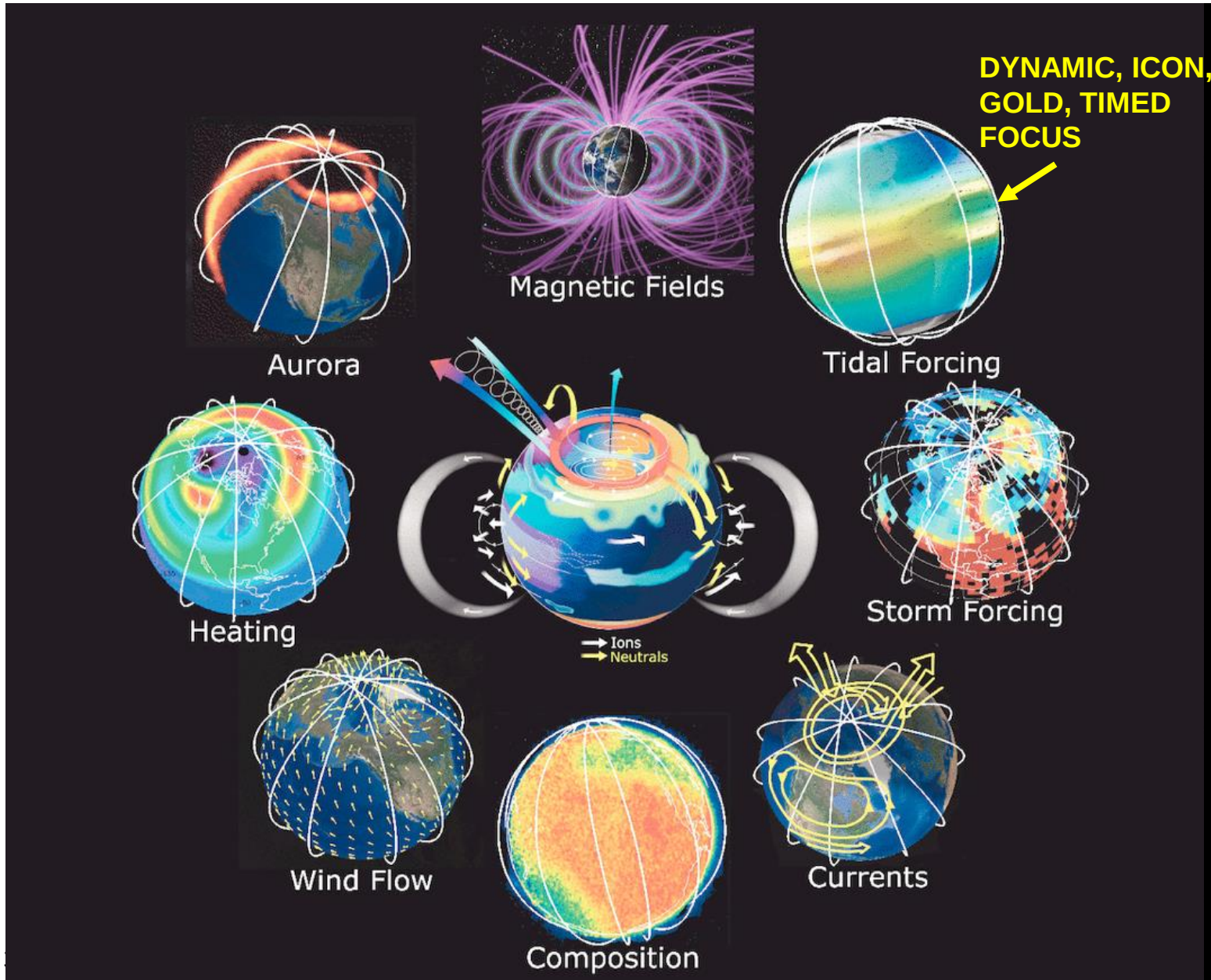
# GDC's comprehensive measurements fully track energy flow through this complex system




GDC will characterize the global upper atmospheric dynamics for the first time. GDC will provide critical new observations of spatiotemporal variations in drivers and responses on **local-** and **regional-scales**.

Energy Inputs

- Solar EUV (measured by other assets)
- Electromagnetic energy flux
- Energetic charged particle flux

Atmospheric Responses:

- Neutral gas: wind, temperature, density, composition
- Ionized gas: "wind", temperature, density, composition

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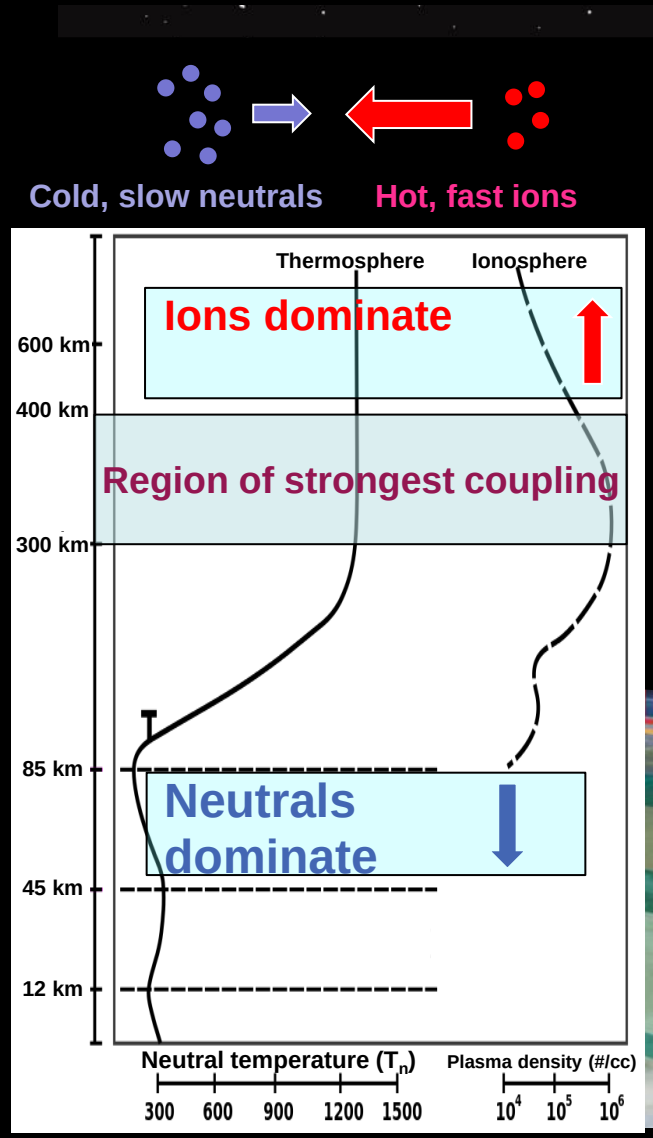
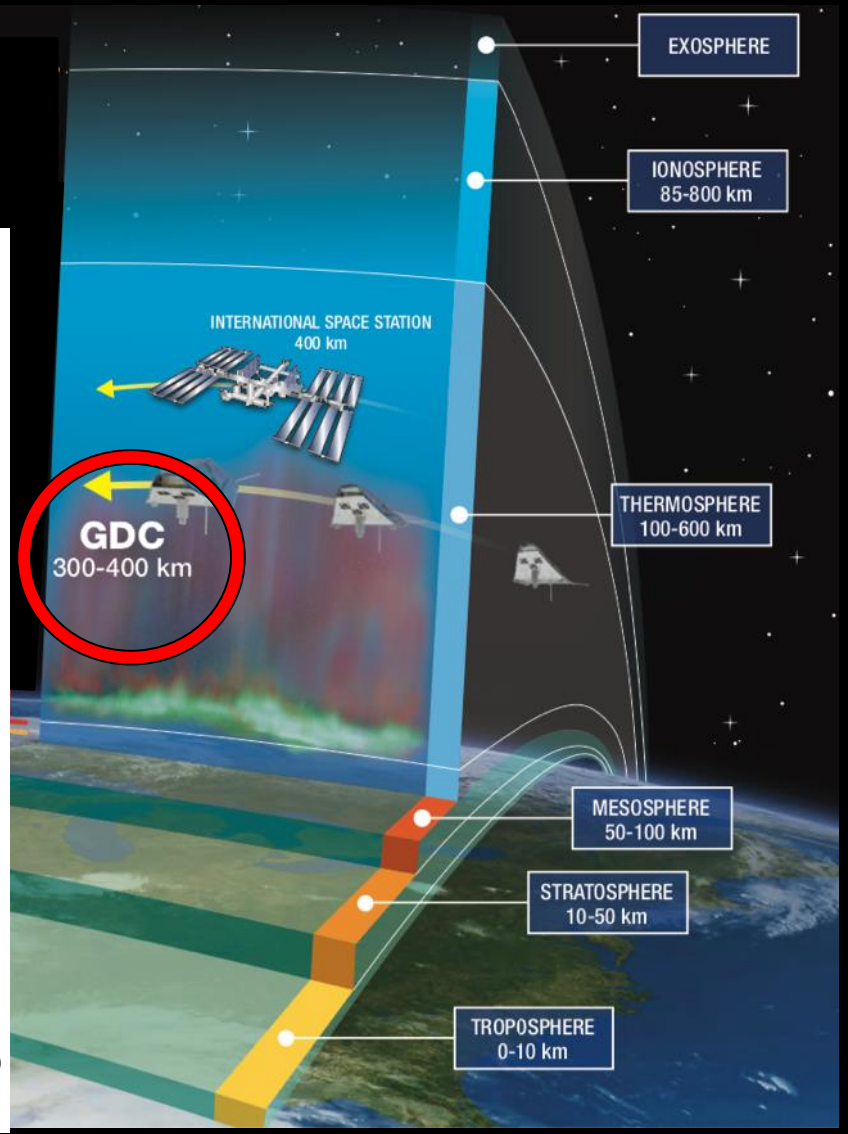
# GDC will focus on the critical 300-400 km region where ions and neutral gas couple most strongly




At GDC altitudes, ionized and neutral gases coexist

There are more neutrals, but the ions typically are hotter and move faster

The two gases move in different directions – neutrals respond to pressure, ions respond to pressure and electric and magnetic fields

Temperature and composition can vary widely

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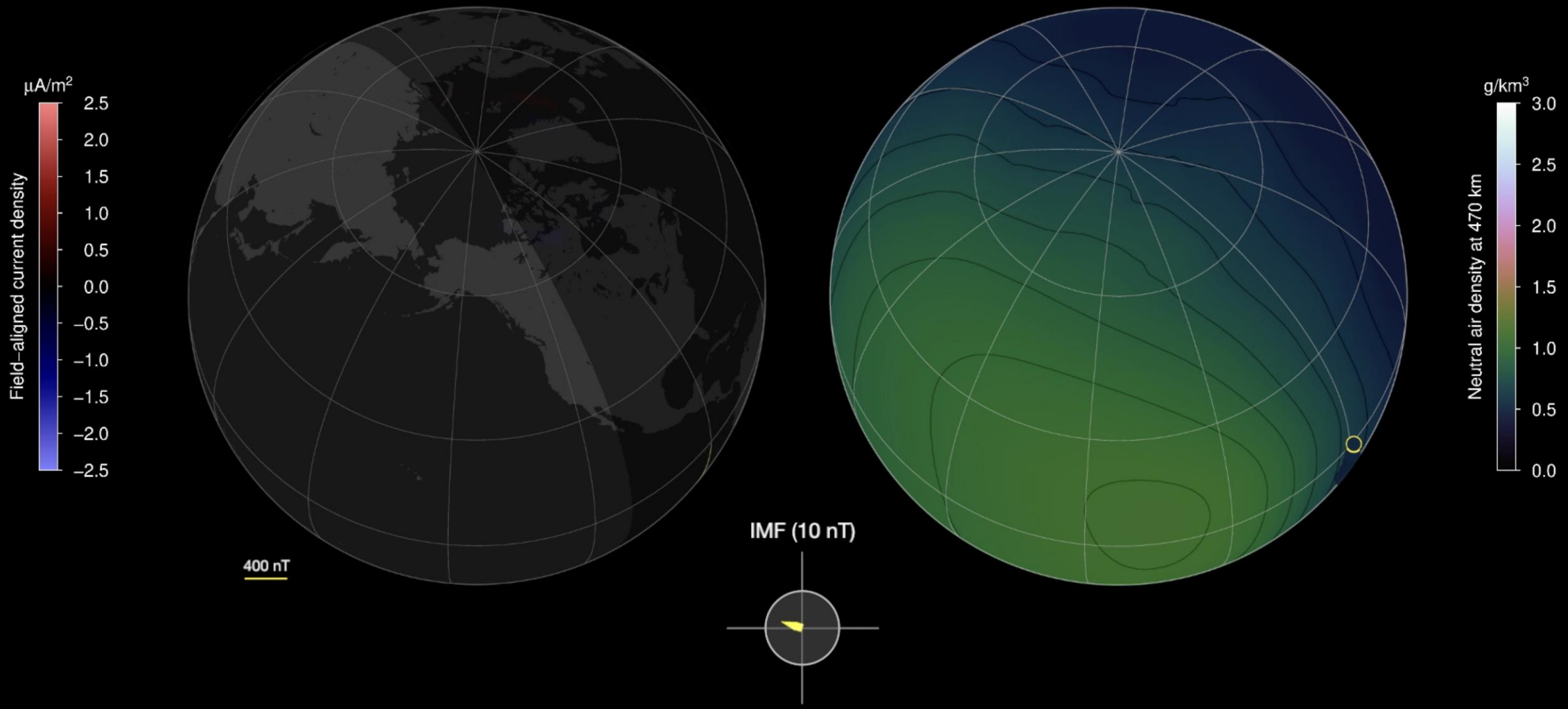
## Field-aligned currents (energy input)

## Simulated neutral air density (thermospheric response)

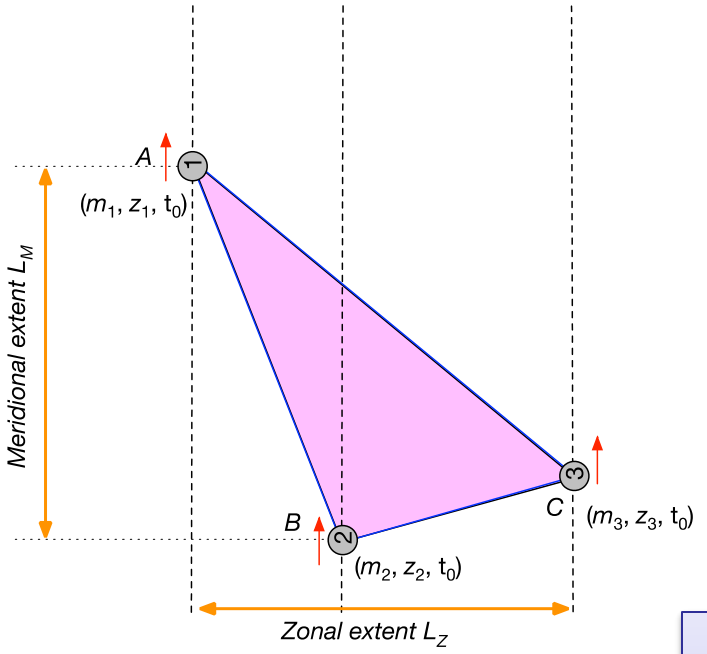


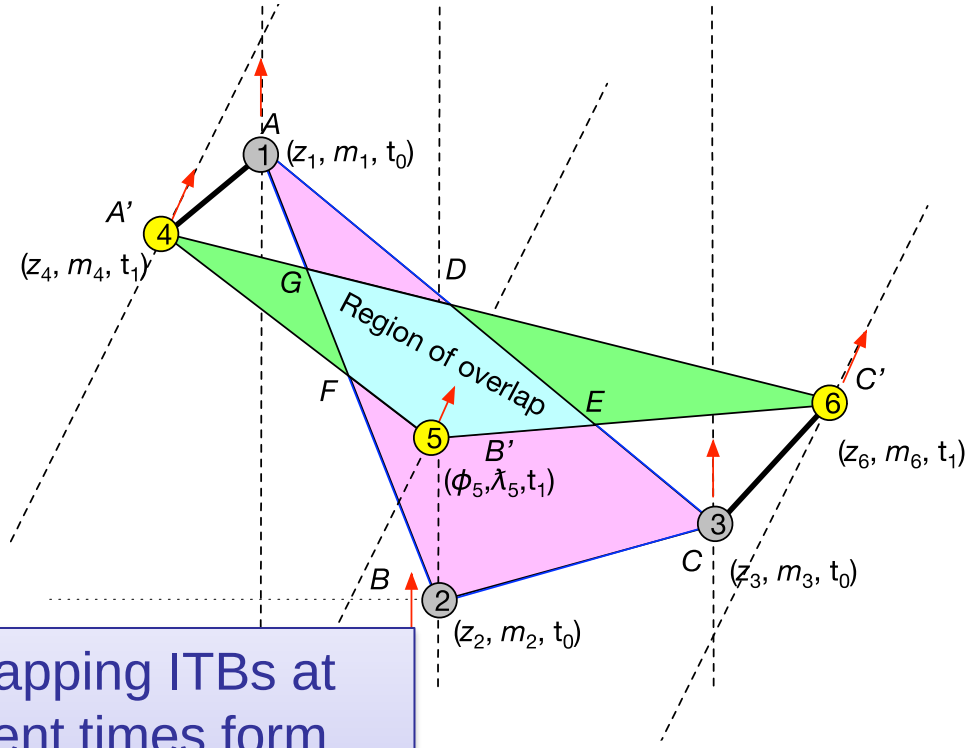

2015–03–17 01:35

ESA Swarm mission
Animation courtesy of Eelco Doornbos, TU Delft
AMIE and TIE-GCM simulations courtesy of Gang Lu, NCAR
http://m.esa.int/spaceinvideos/Videos/2018/04/St._Patrick_s_Day_storm

# GDC uses multipoint measurements to measure spatiotemporal variations

Three observatories (**Instantaneous Triangular Baseline, or ITB**) measure the horizontal gradient at a single scale size.




Overlapping ITBs at different times form **Temporal Variation assessment Baselines (TVBs)** to provide temporal rates of change.

GDC will adjust its configuration throughout the mission to cover the full range of spatial and temporal scales

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# GDC Basics

- GDC is the first NASA Strategic Mission (”large mission”) in the Ionosphere-Thermosphere since TIMED (2002) and before that Dynamics Explorer-2 (1981)
- GDC consists of **six identical observatories**. Each observatory carries the same set of instruments
  - **AETHER** (PI: Laila Andersson / CU/LASP)– Langmuir probe to measure plasma density, electron temperature, and small-scale electric field and density structures
  - **CAPE** (PI: Dan Gershman / NASA GSFC) – dual top-hat electrostatic analyzer to measure ion and electron energy-pitch angle / energy distributions in ”auroral” energy ranges
  - **MoSAIC** (PI: Mehdi Benna / UMBC) – ion/neutral mass spectrometer with the capability to measure temperatures and drift/wind vectors, as well as detailed mass composition information
  - Still in competitive phase A: magnetometer and thermal plasma instrument

# GDC Basics

- GDC will be in **high-inclination orbits**, ~81 degrees
- **GDC orbits will be nearly circular in the 350-400 km** altitude range
- Launch expected **by the end of this decade**
- GDC will use onboard propulsion to adjust and maintain the altitudes and orbits of the individual observatories
- GDC has a **three-year prime mission**, and currently holds enough expendables (i.e. propellant) for two additional years of operation
- GDC will carry a “space weather” beacon that will **broadcast real-time space weather data** for reception by operational agencies / organizations

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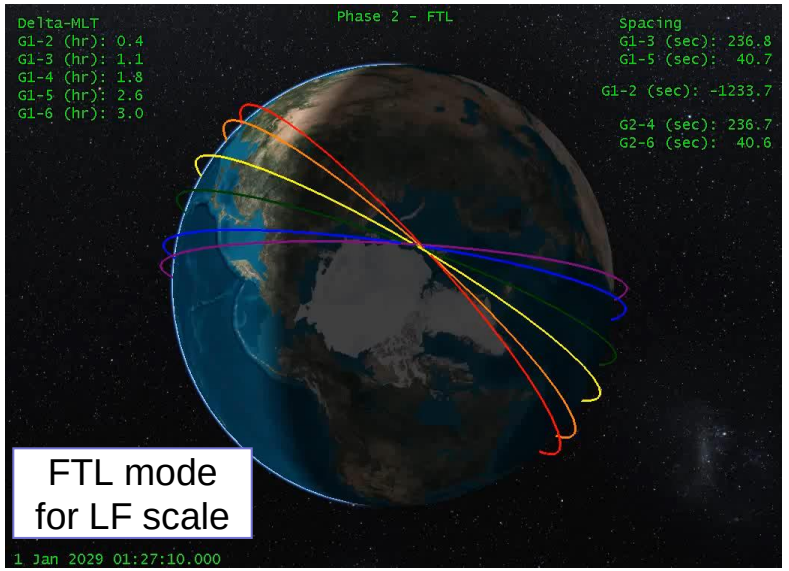
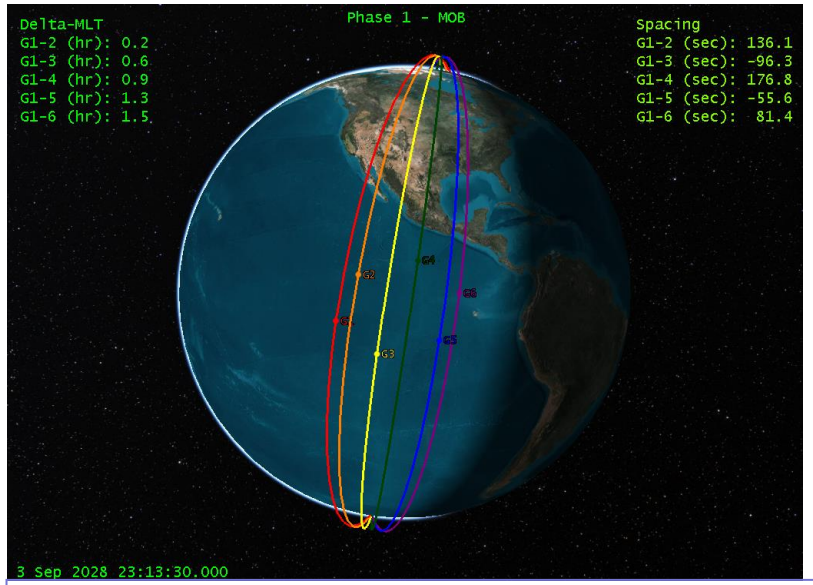
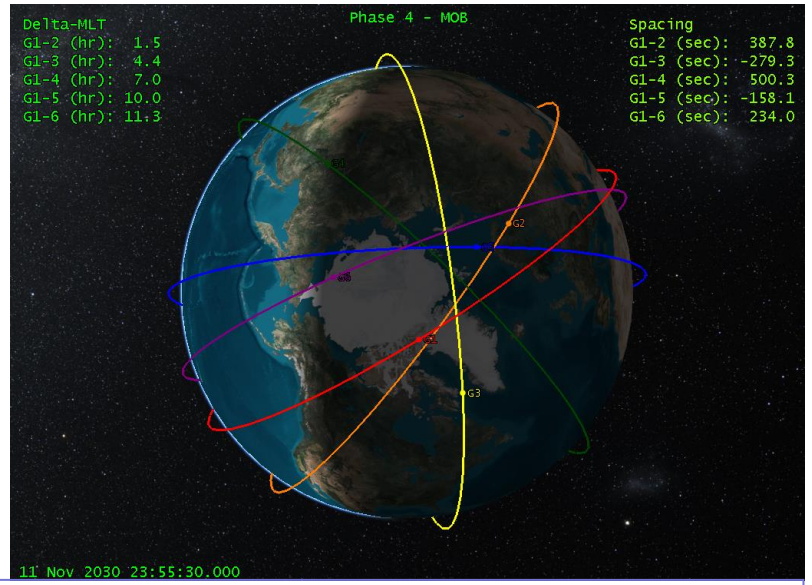
# Orbits

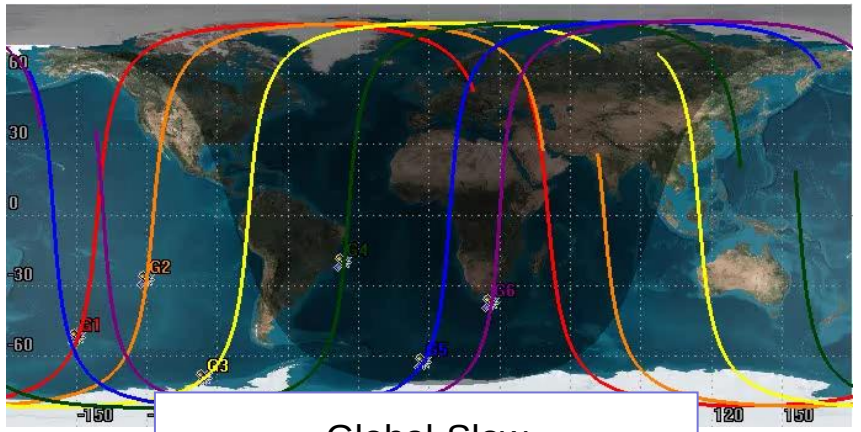
- On-board propulsion / LV puts observatories in different inclinations between 81-82 degrees, “400 km circular”
- Differential precession separates the orbit planes as they all precess in local time




FTL mode for LF scale




Global-Slow

Examples of ”MOB” mode – (left) early in the mission, measuring “Local-fast” scales; (right) later in the mission, measuring “Global-fast” scales (3 spacecraft in each hemisphere)

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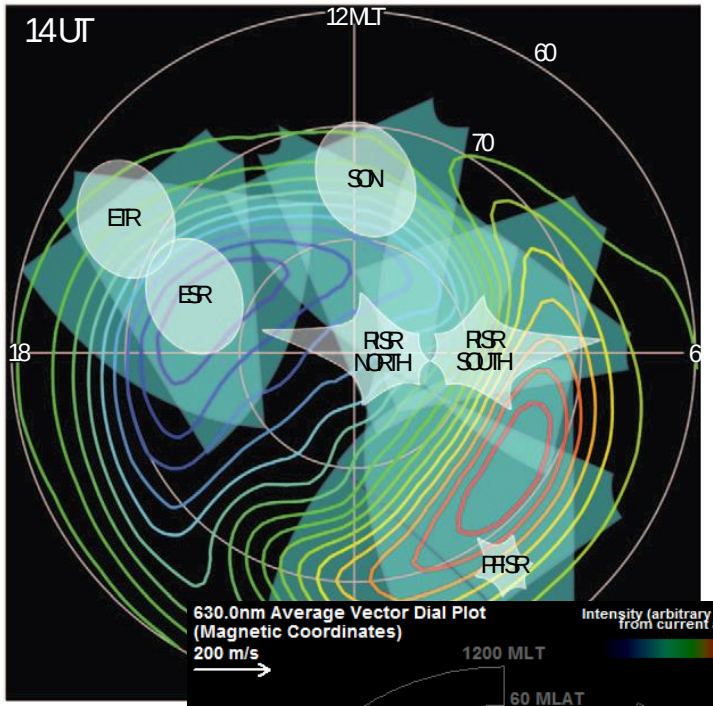
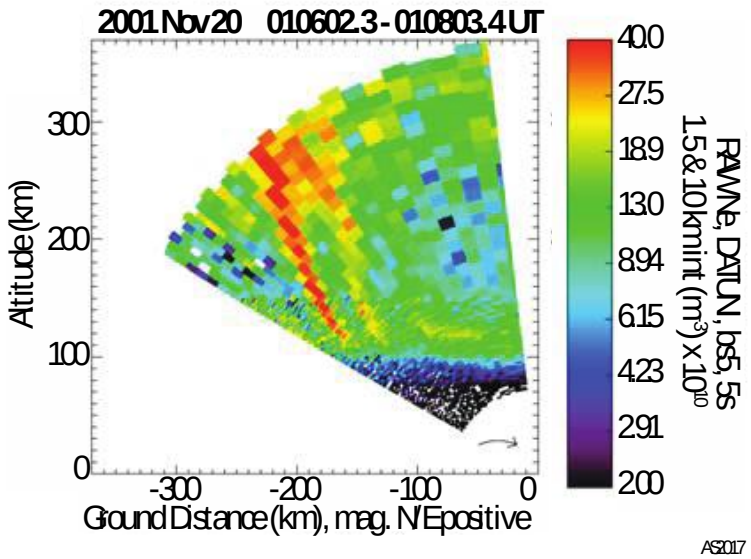
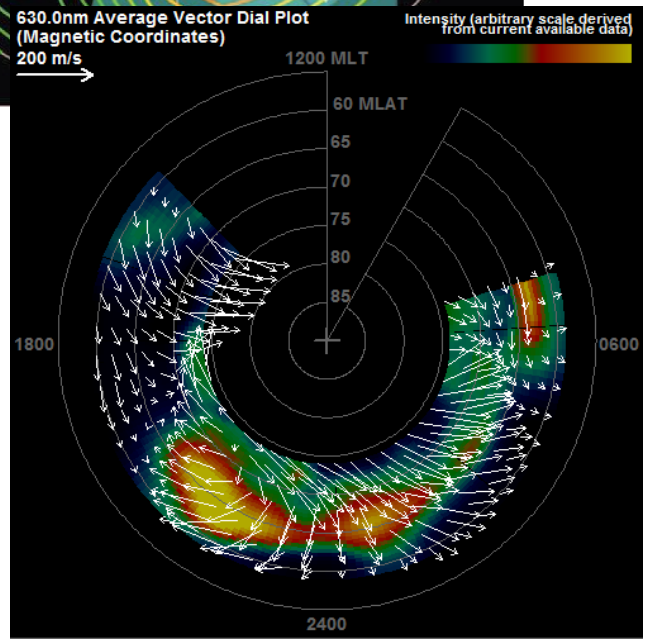
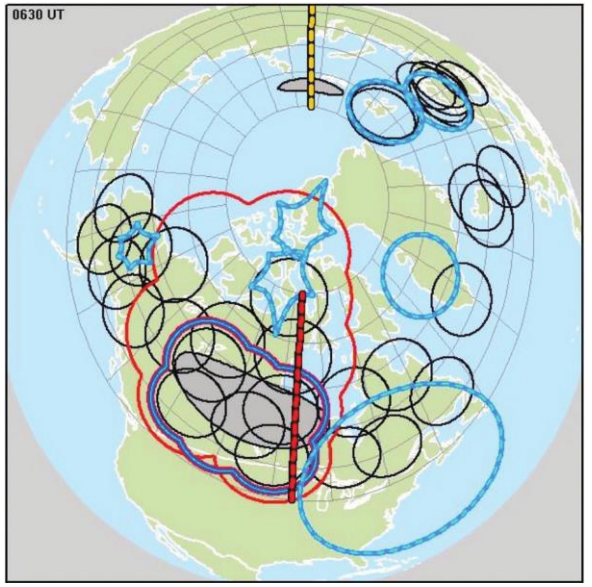
# GDC leverages complementary ground-based measurements where available

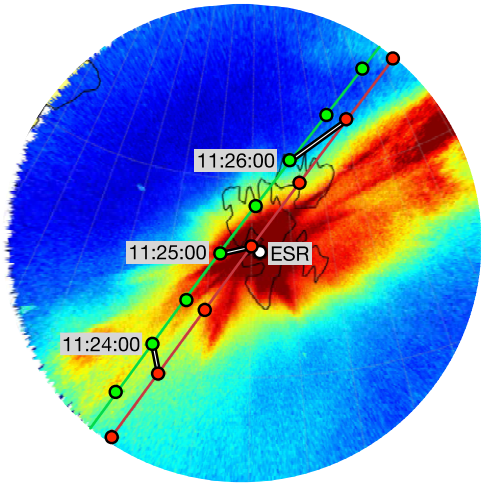



**GDC will continue to coordinate with ground-based observers, through existing and new domestic and international partnerships**

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# GDC as a community mission

- GDC's data, science, and tools are meant to be **open, accessible, reproducible, and extensible** by the community. The same tools used by the science team will be available for use, extension, modification, etc. GDC is the first strategic Heliophysics mission to be developed under SMD's "open science" policies from day 1.
- As a Center-led strategic mission with independent PI-led investigation and IDS teams, GDC is inherently open and democratic, and well suited for community engagement and open dialog and coordination.
- GDC will help to strengthen, rebuild, recruit, and retain a NASA-funded community of ITM researchers, which has not had a new **strategic** mission in over two decades (TIMED / remote sensing, launch 2002) or four decades (Dynamics Explorer-2 / in situ sampling, launch 1981).

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# GDC as a community mission

- GDC has a *scientific* focus as a NASA investigation of Earth's upper atmosphere
- GDC has a major *system-science* focus as the next NASA LWS mission, providing a critical "missing link" in the Heliophysics System Observatory (of high interest to ITM and magnetospheric researchers) and a critical window into the science of space weather phenomena that have by far the most impact on our technological society
- GDC is a *strategic* focus as a "**community mission**" that will lay the groundwork for future science investigations and capabilities. GDC can serve as an "anchor / hub" to provide synergistic opportunities for a range of related and complementary Heliophysics and partner agency / international investigations and missions.

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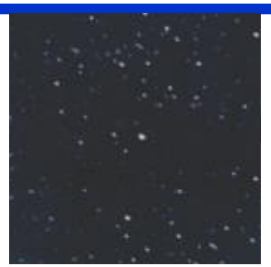
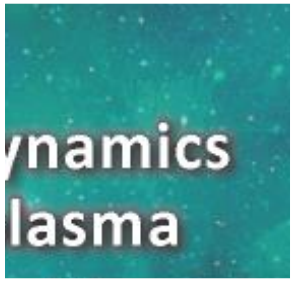
# Community involvement in GDC as of June 2022
# we seek to expand and strengthen collaborations across the CEDAR and GEM communities







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# Joint CEDAR+GEM workshop TOMORROW

- Joint CEDAR+GEM workshop TOMORROW June 20
  - **Community Science Enabled by the Upcoming GDC Mission**
  - 4-6 PM Austin time – in Onyx ballroom – GEM session starts at 330 with EZIE+TRACERS discussion, and we will be connected to their session via Webex

  - **GDC dedicated Slack channel: # GDC-Community**
    - https://join.slack.com/t/gdc-community/shared_invite/zt-1afbt5m7r-FmPZPjoLFrMNkPOQKFXBIw
  - Workshop Slack channel for discussion/questions:
    - #cedar-gem-2022-gdc-workshop

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# Getting engaged with GDC

## GDC is a community mission!

- Now is the time to strategize for synergistic activites
- CEDAR Community endorsement letter (thank you, CEDAR!):
  - https://docs.google.com/document/d/1khh1kVnITd6f-Ffg_2dBXPqrS-sgJ8R2/edit

## How to Connect with GDC:

- AGU Fall 2022 Chicago: “Leveraging Multi-Point and Multi-Source Observations to Advance Frontier ITM Science” + 2-hour community workshop
- Get the latest NASA information & announcements for GDC:
  - https://lws.larc.nasa.gov/gdc/
- Checkout the GDC mission video!
  - https://www.youtube.com/watch?v=W0dmXzyhIeA
- GDC dedicated Slack channel: # GDC-Community
  - https://join.slack.com/t/gdc-community/shared_invite/zt-1afbt5m7r-FmPZPjoLFrMNkPOQKFXBIw

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# NASA Postdoctoral Program

- NASA holds annual applications for NASA Postdoctoral positions (2-3 year appointments) March, July, November each year
- Applications consist of 15 page research proposal + references
- Next applications are due July 1, then November 1
- Wide variety of potential projects and mentors

- How to apply:
  - https://npp.orau.org (includes list of potential mentors and general project areas)
  - Email douglas.e.rowland@nasa.gov – I can help find a NASA mentor for your desired research area
  - Best to make contact with mentor and work with them as you develop your research proposal

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# References

- The official NASA website for GDC can be found here.
  - (https://science.nasa.gov/heliophysics/resources/stdts/geospace-dynamics-constellation)
- The Science, Technology Definition Team report can be found here.
  - (https://science.nasa.gov/science-pink/s3fs-public/atoms/files/GDC STDT Report FINAL.pdf)
- "GDC Science Planning Resources" are available here -- this includes among other things the GDC predicted ephemeris (Rev C from March 2022 is the latest), a description of the predicted ephemeris, and several GITM model runs that may be of general use for planning experiments with GDC.
  - (https://ccmc.gsfc.nasa.gov/mission-planning/GDC/)
- The NASA GDC blog can be found here.
  - https://blogs.nasa.gov/gdc/
- NASA's Scientific VIsualization Studio has produced a "Welcome to GDC" video that can be found here. The direct link to the video is here.
  - https://svs.gsfc.nasa.gov/13969
- A "kiosk" presentation from the 2020 Fall AGU meeting about GDC can be found here.
  - https://www.youtube.com/watch?v=CedFqFg1PII
- The press release describing the selected instrument investigations can be found here.
  - https://www.nasa.gov/press-release/nasa-selects-investigation-teams-to-join-geospace-dynamics-mission