

# ISTPNext and Heliophysics Great Observatories

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And the COSPAR task group on Establishing an International Geospace Systems Program (IGSP)  
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and

The many members of the Heliophysics community who have been joining the movement



# Heliophysics has had 4 primary eras

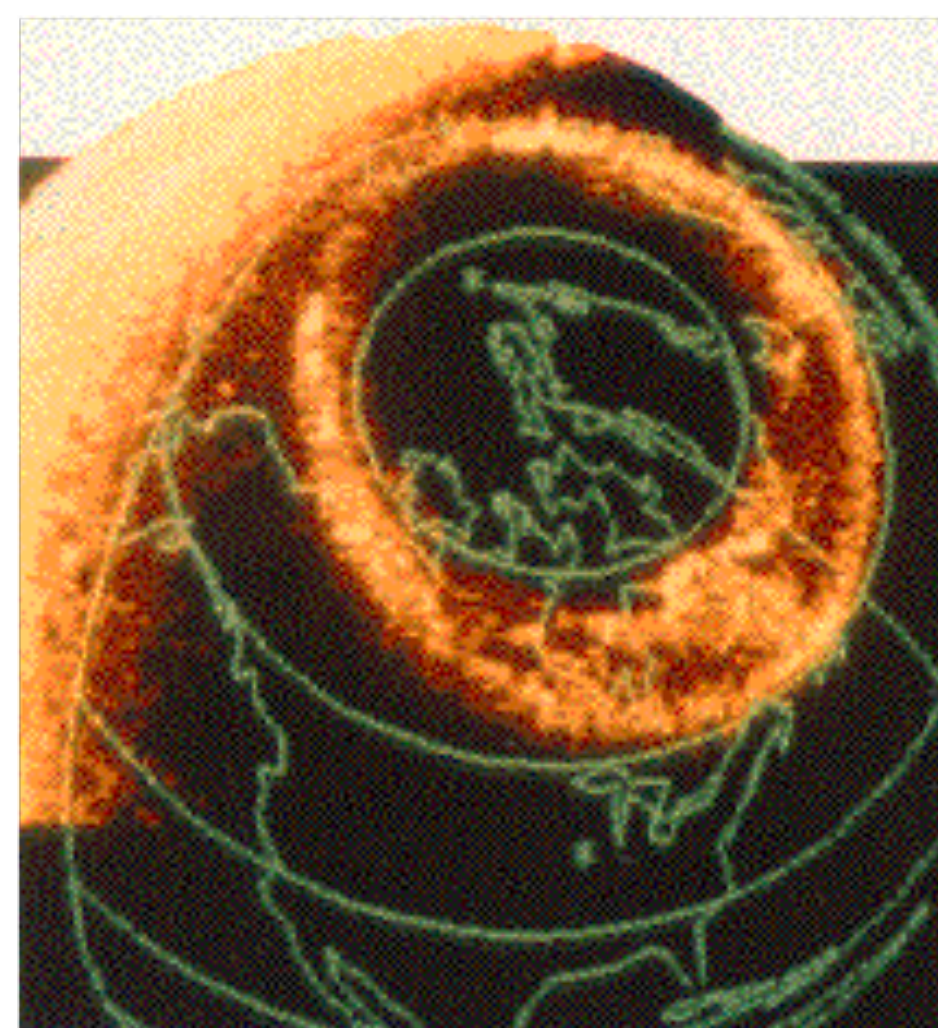
*The 5th era is up to us to define*

Discovery era - Regions



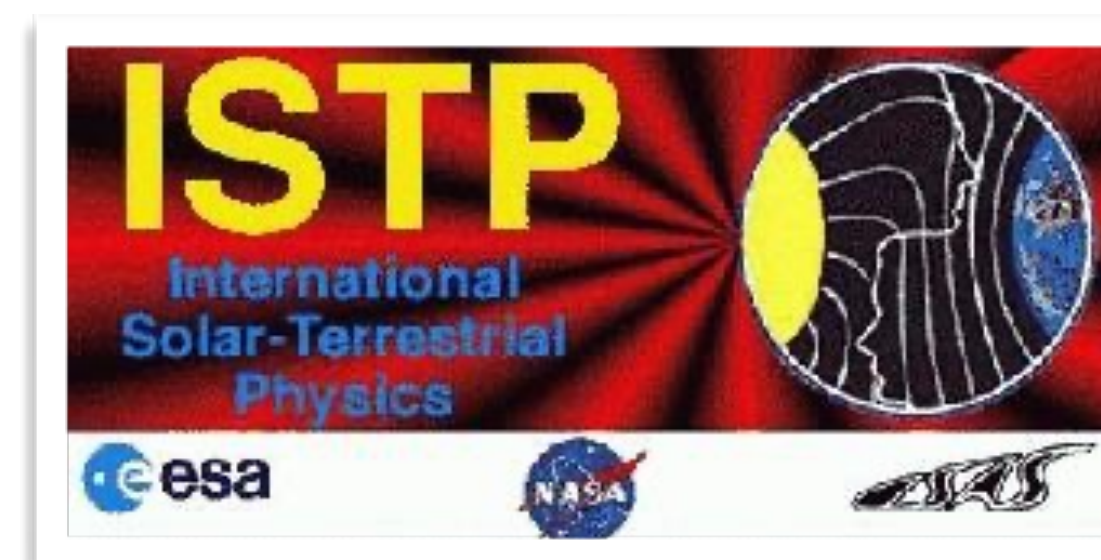
1958 - ~1975

Discovery era - Dynamics



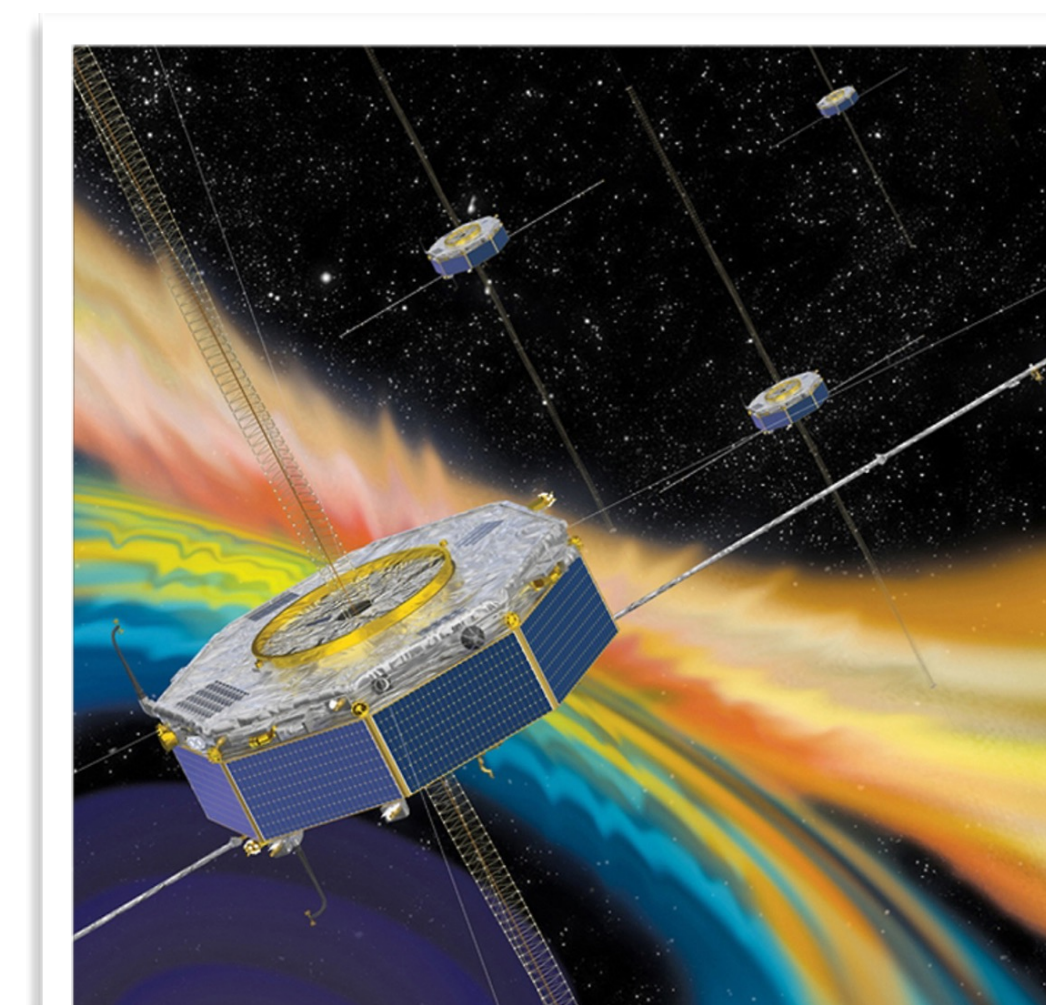
~1975-1990

Era of coarse system science (ISTP)



~1990-2005

Era of microscales



~2005-present

There is a 'pre-history' - here we focus on the space age.



# Era of Coarse System Science (~1990-2005)

*The International Solar Terrestrial Physics Program (ISTP)*



OPEN (Origin of Plasmas in the Earth's Neighborhood) competed in 1980; descoped from 4 spacecraft to 2 (**Wind and Polar**), turned into GGS program. International contributions turned this into ISTP:

- ISAS contributed Geotail
- EQUATOR descoped, Germany launched Equator-S
- SoHO added (joint ESA/NASA)
- Cluster II, Akebono, SAMPEX, INTERBALL, LANL, GOES, etc. all participated.

Core spacecraft

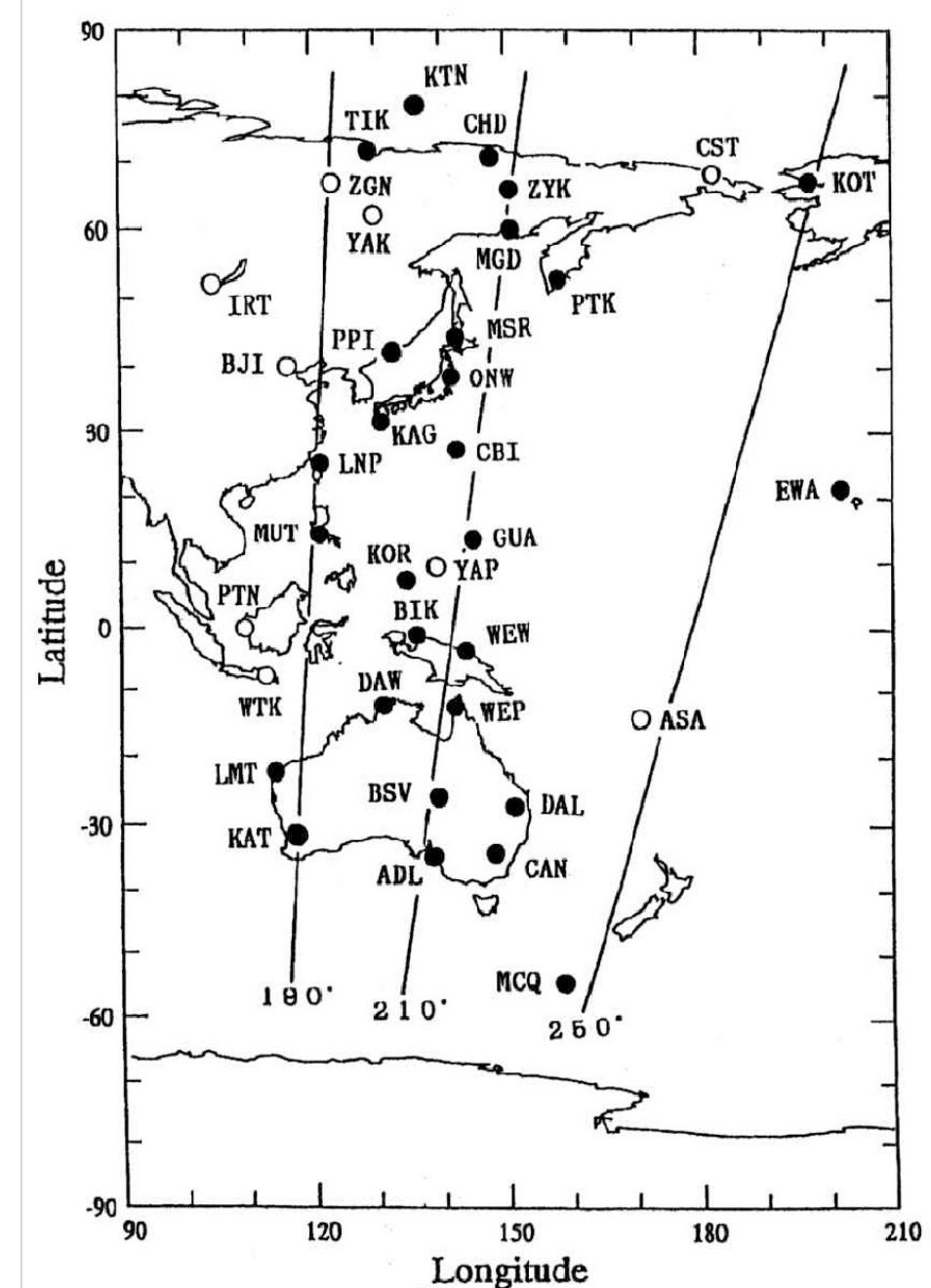
Core program endorsed by the Interagency Consultative Group (IACG), *ISTP unified the worldwide space physics community under a **common scientific objective*** of acquiring detailed, quantitative information about the flow of energy, mass, and momentum from Sun to Earth with a distributed system of measurements.

ISTP was much more than spacecraft:

- Theory & modeling component (Ashour-Abdalla, Papadopoulos, Hudson, Rees)
- Ground-based (Rostoker, Dudeney, Kelly, Greenwald). Fun fact #1: First funding for SuperDARN (KapusKasing) came from NASA! Fun fact #2: CANOPUS grew out of OPEN/GGS/ISTP.
- International data standards & spirit of data sharing that continues today (CDAWeb)

ISTP is a shining example of how coordinated, worldwide efforts can be brought to bear on otherwise intractable problems.

210° MM NETWORK STATIONS

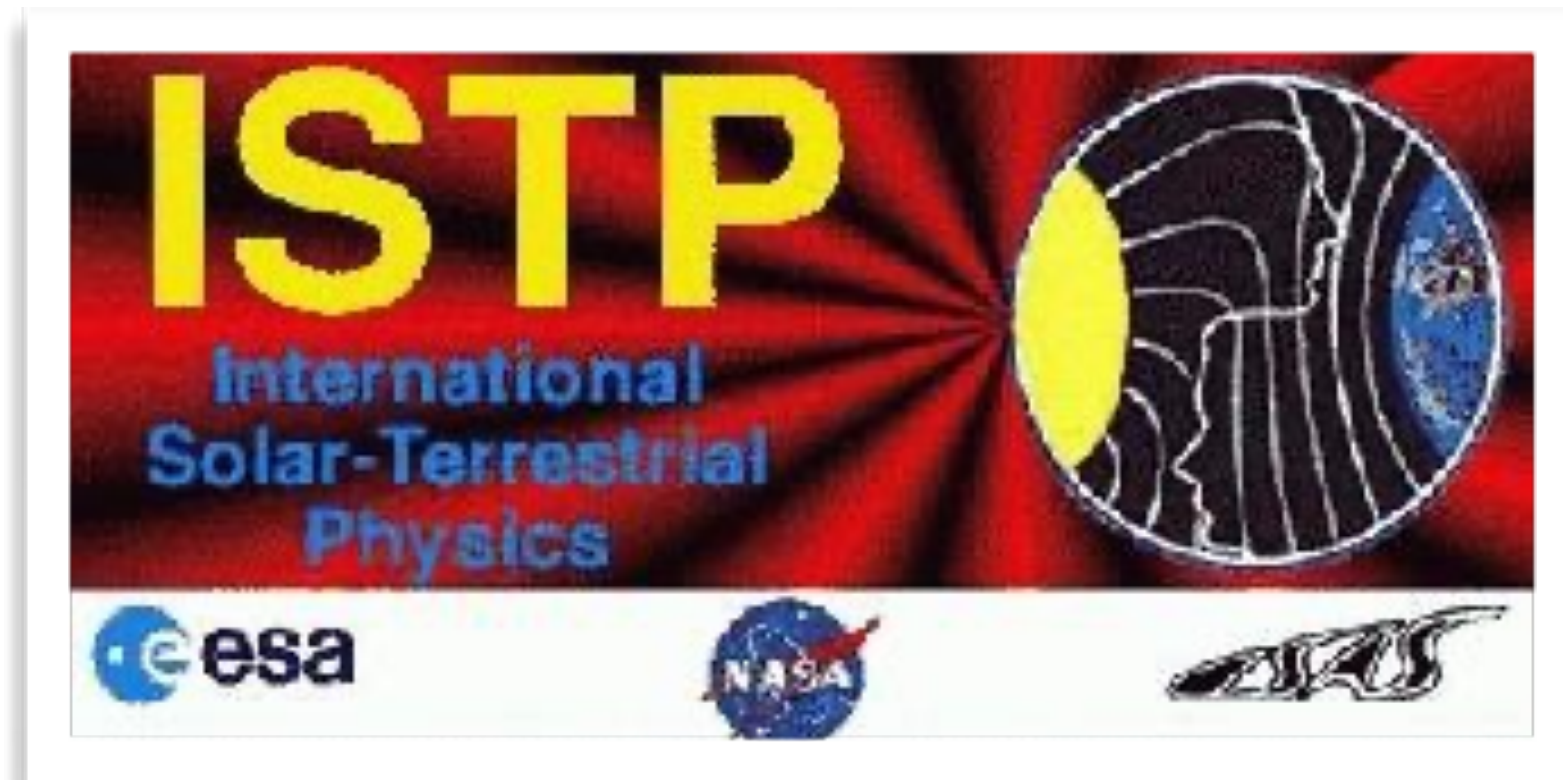




# We have studied both ends of the scale extensively

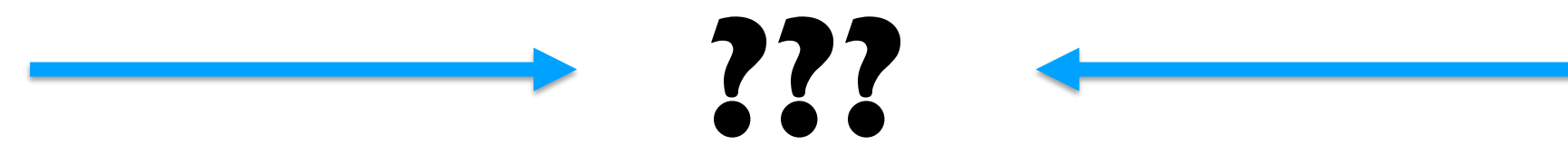
## Large Scale

Era of coarse system science (ISTP)



~1990-2005

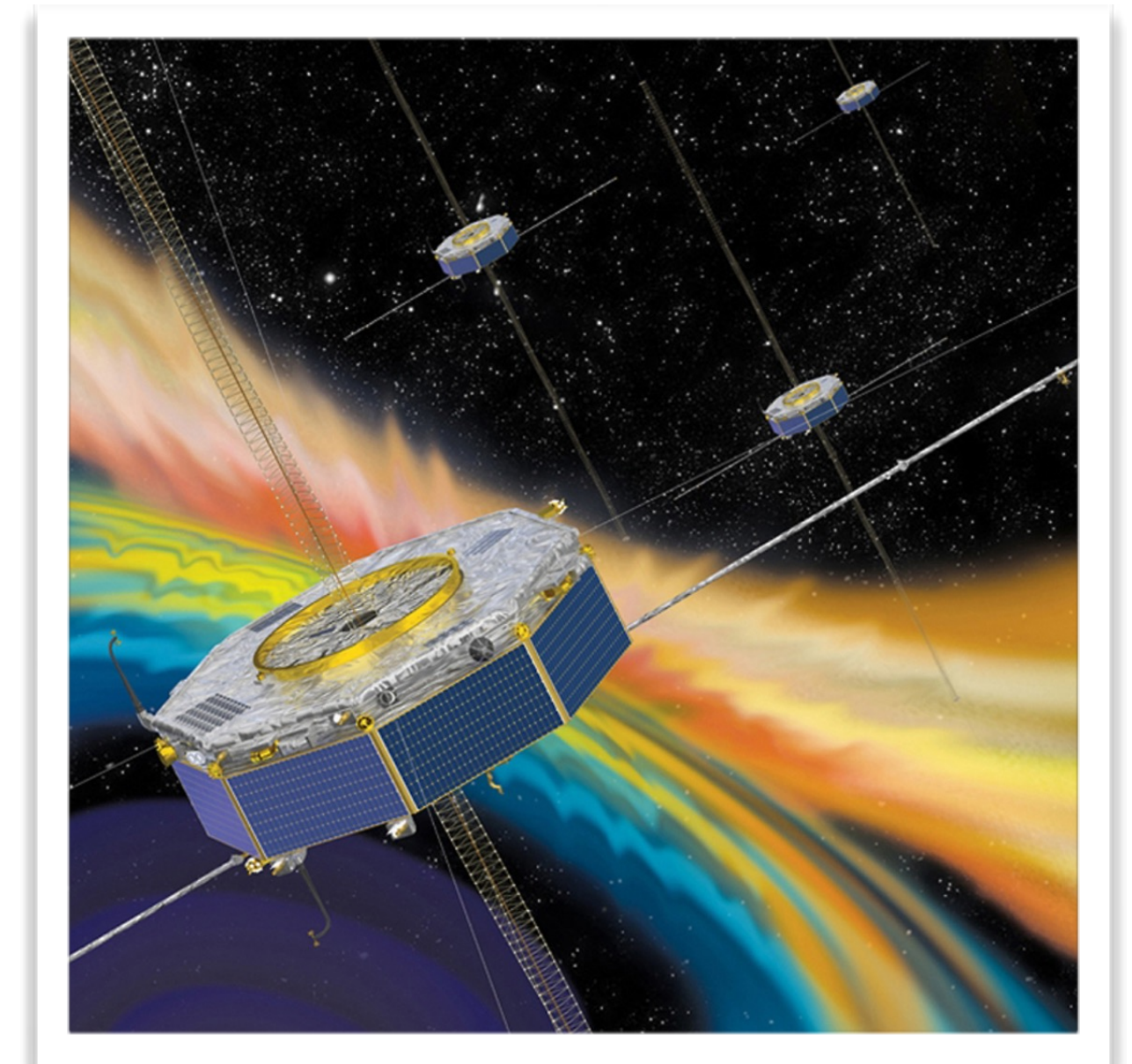
## Cross-scale and cross-system coupling



The “Missing Middle” of Mesoscales

## Small Scale

Era of microscales



~2005-present

The 5th era could focus on Geospace (ITM+Mag) and SIH, each as a **System of Systems**, with a key goal of observing at mesoscale resolution and connecting micro<->meso<->macro



Everything we study is a system of systems

# Sun

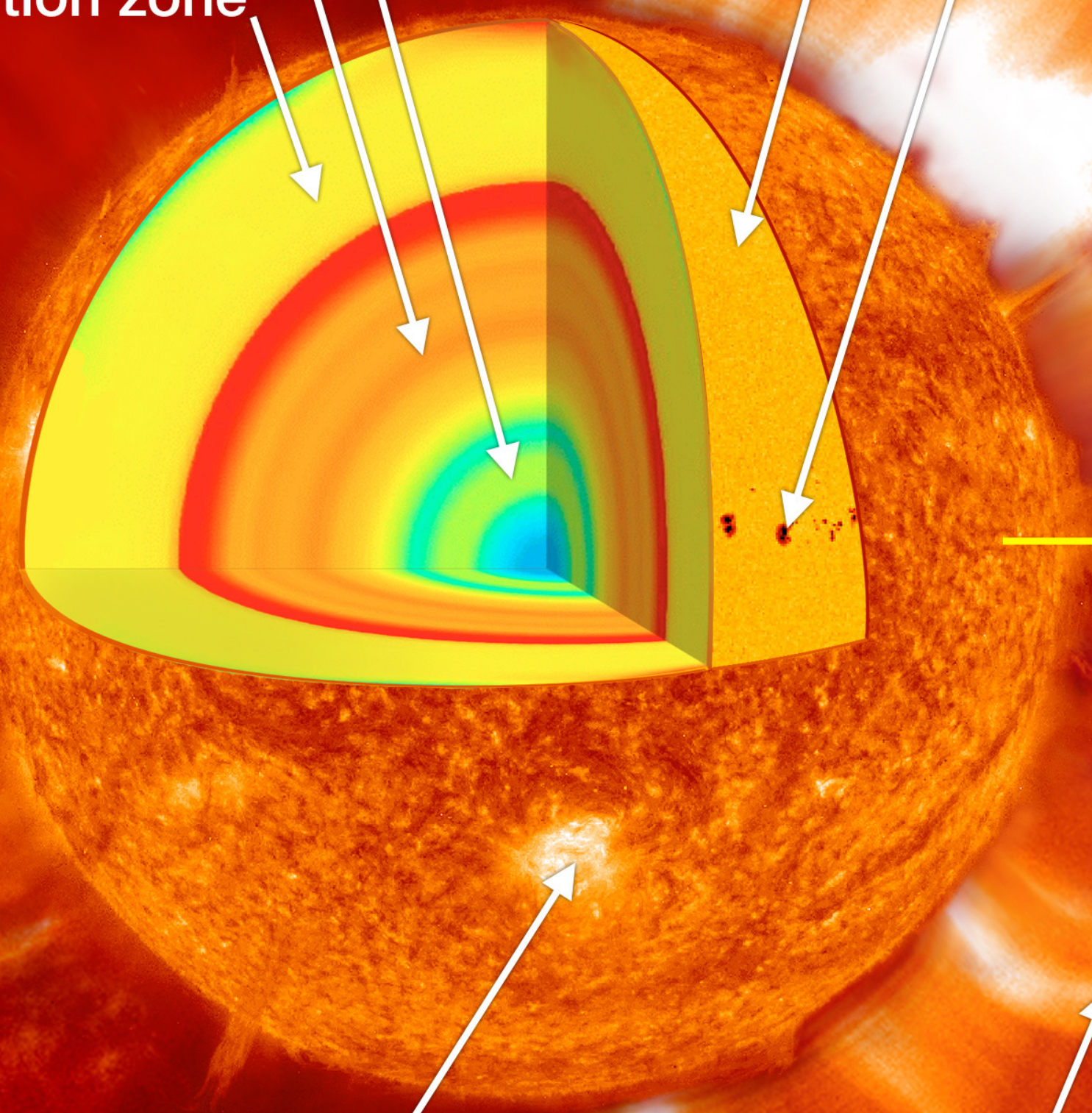
# Earth

## Internal Structure:

- inner core
- radiative zone
- convection zone

photosphere

sunspot



plage

coronal mass ejection

corona

*solar wind*

photons

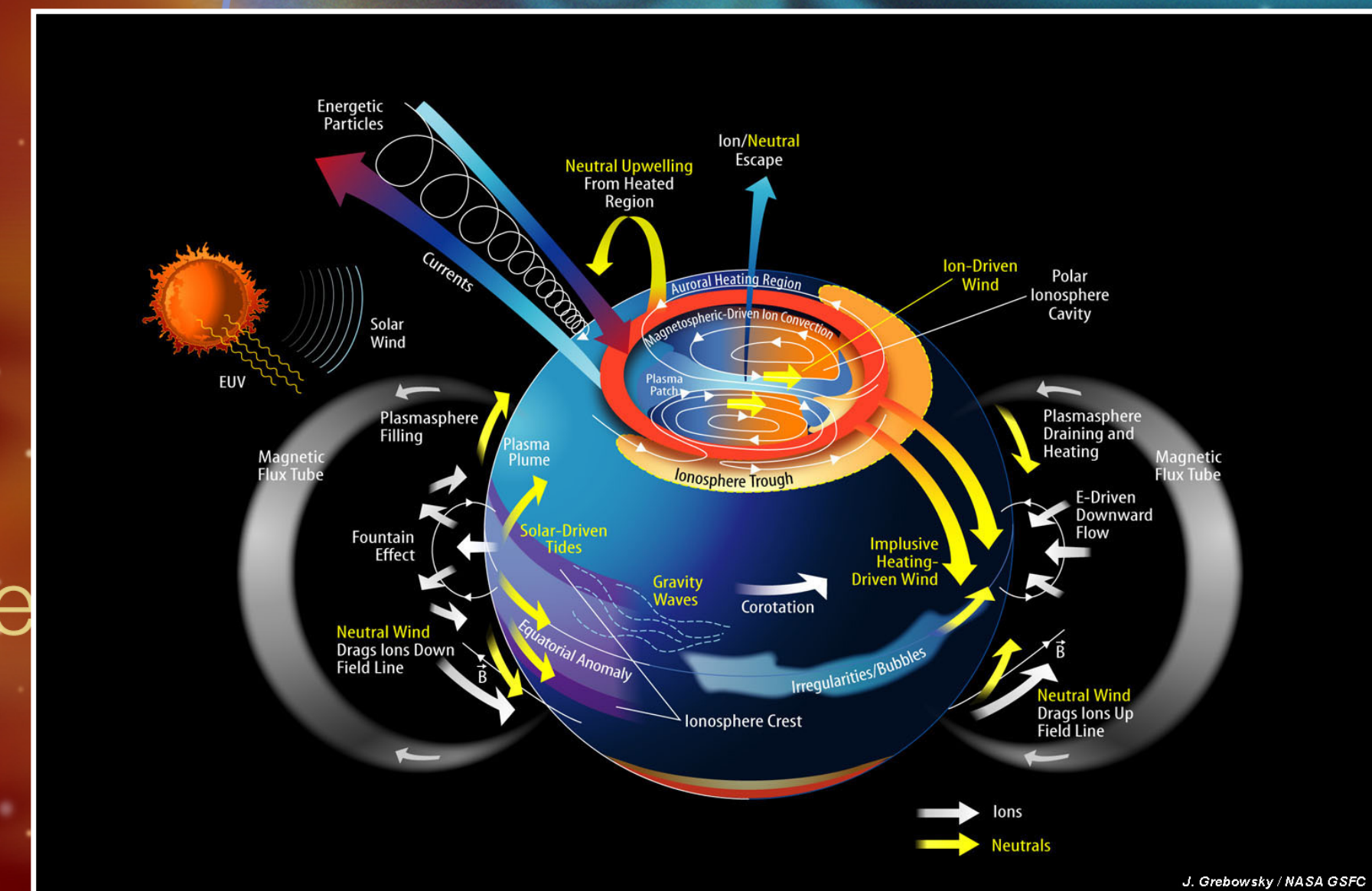
magnetosphere

incoming solar wind particles

polar cusp

plasmasphere

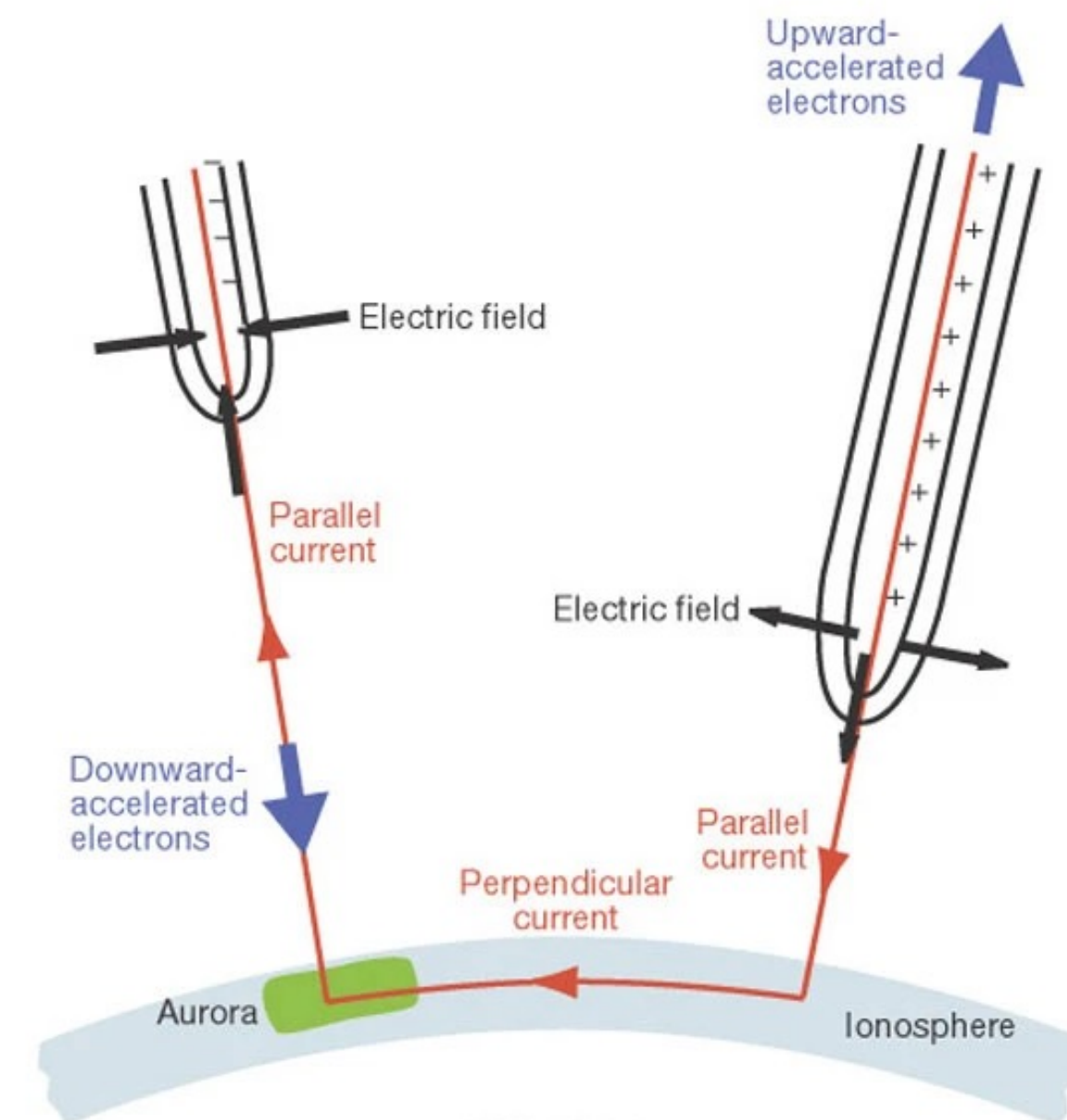
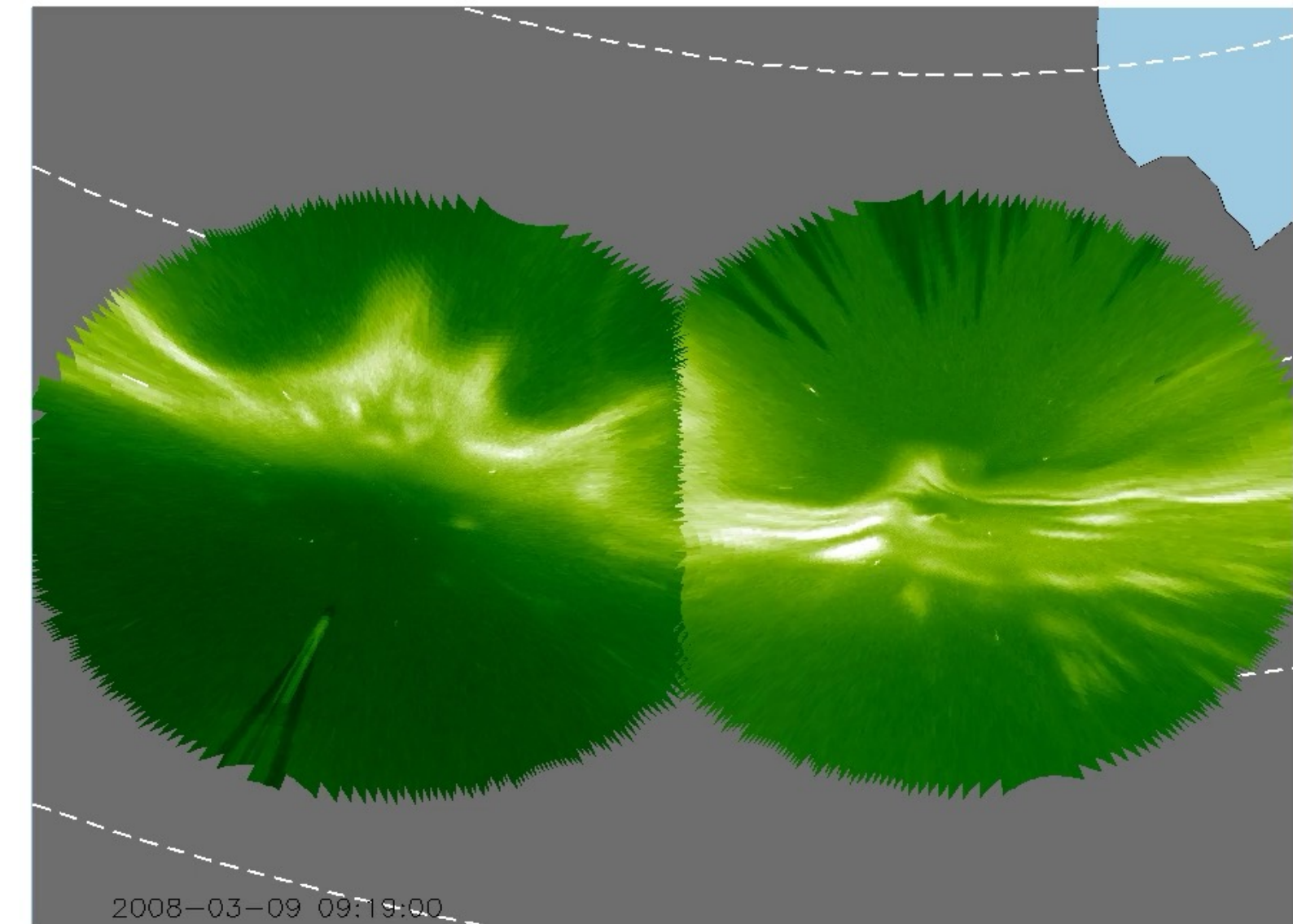
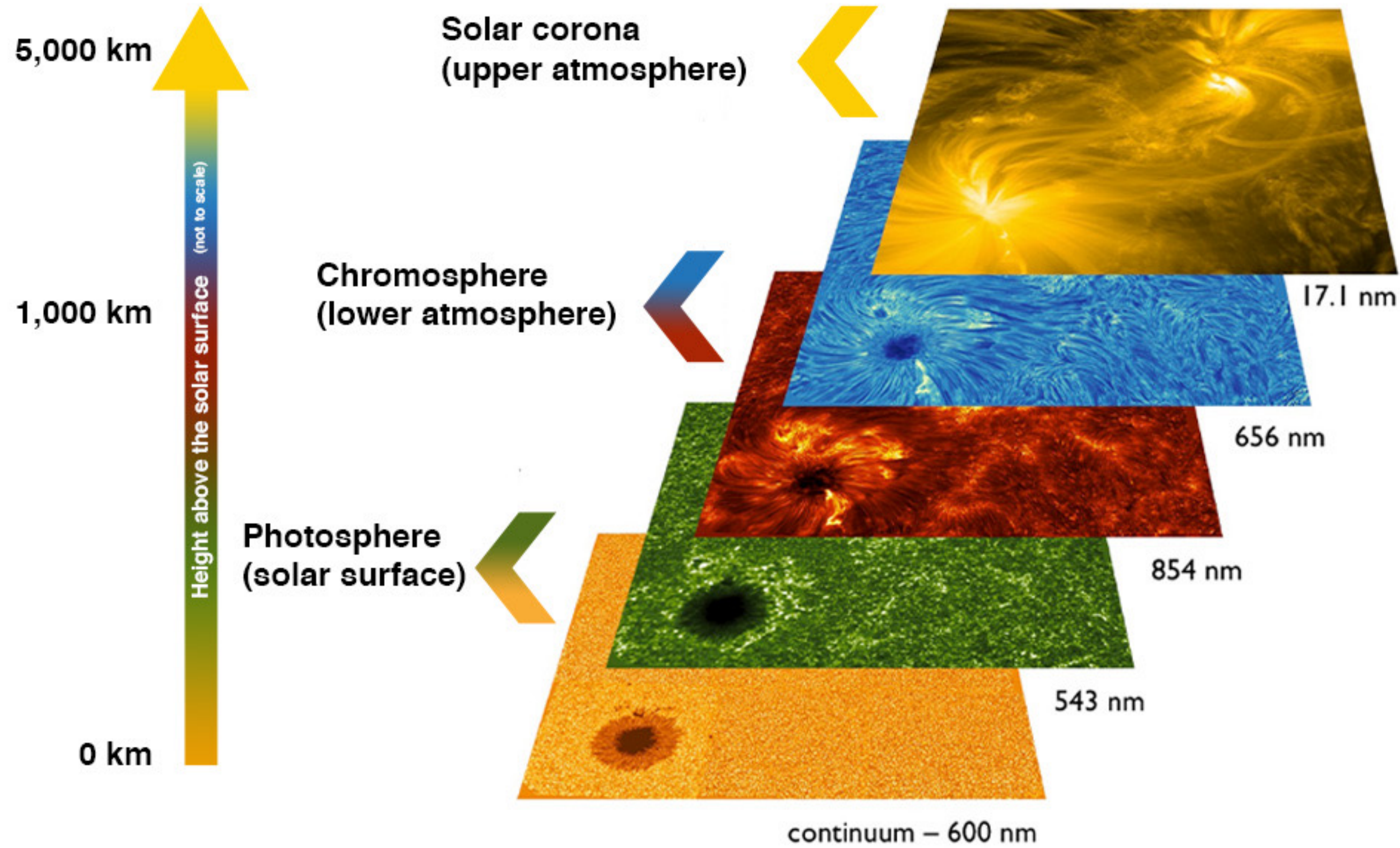
atmosphere



he



# Connecting layers of the system-of-systems can cross discipline boundaries and observational techniques



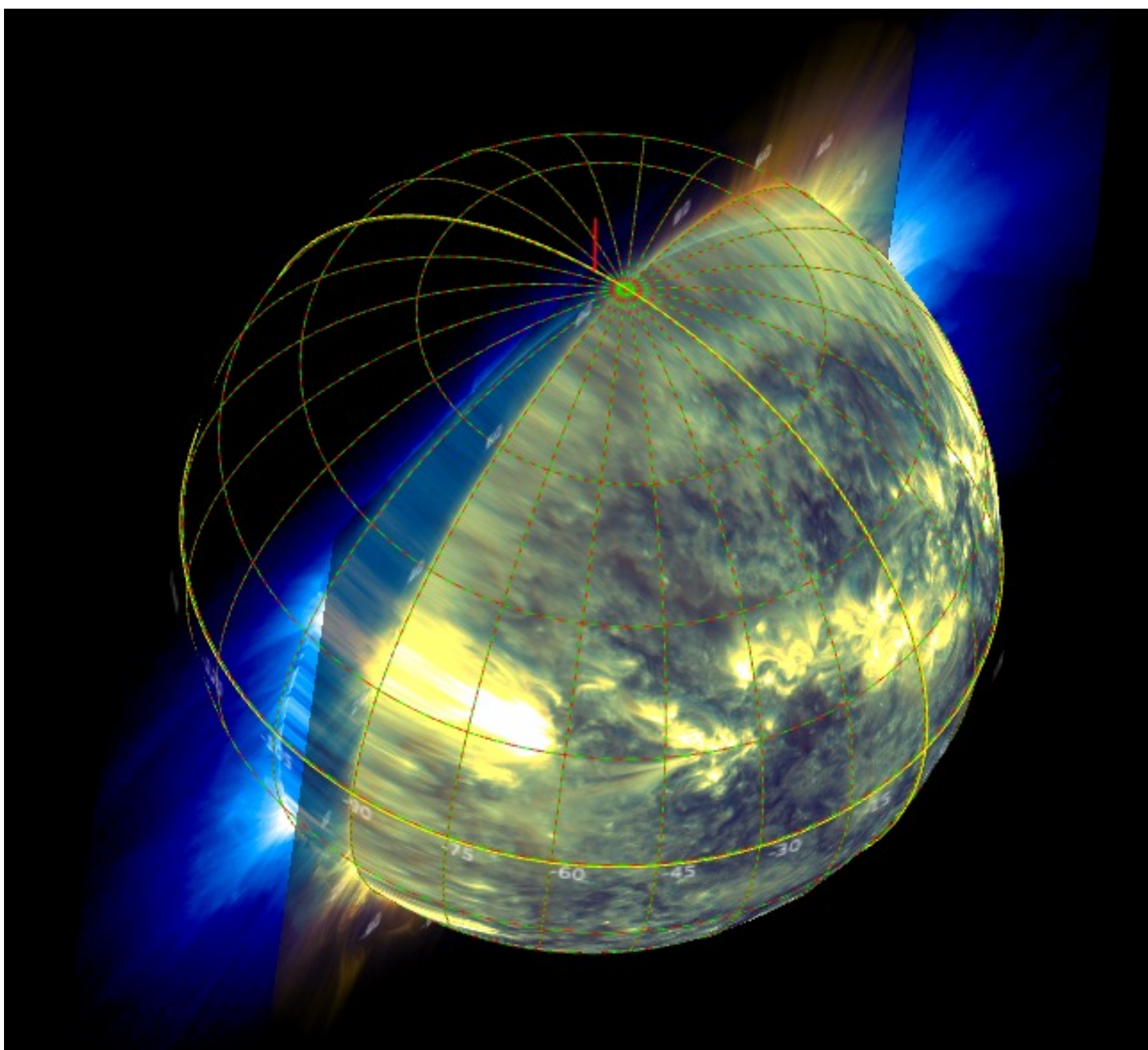
Series of images representing the view of a sunspot at different layers in the solar atmosphere. Layers include the photosphere (yellow, green), and the chromosphere (red, blue), all of which were taken with the IBIS instrument on NSF's Dunn Solar Telescope. The corona is represented as the topmost layer, with an image taken from NASA's Solar Dynamic's Observatory AIA imager. NSO/AURA/NSF & NASA/SDO



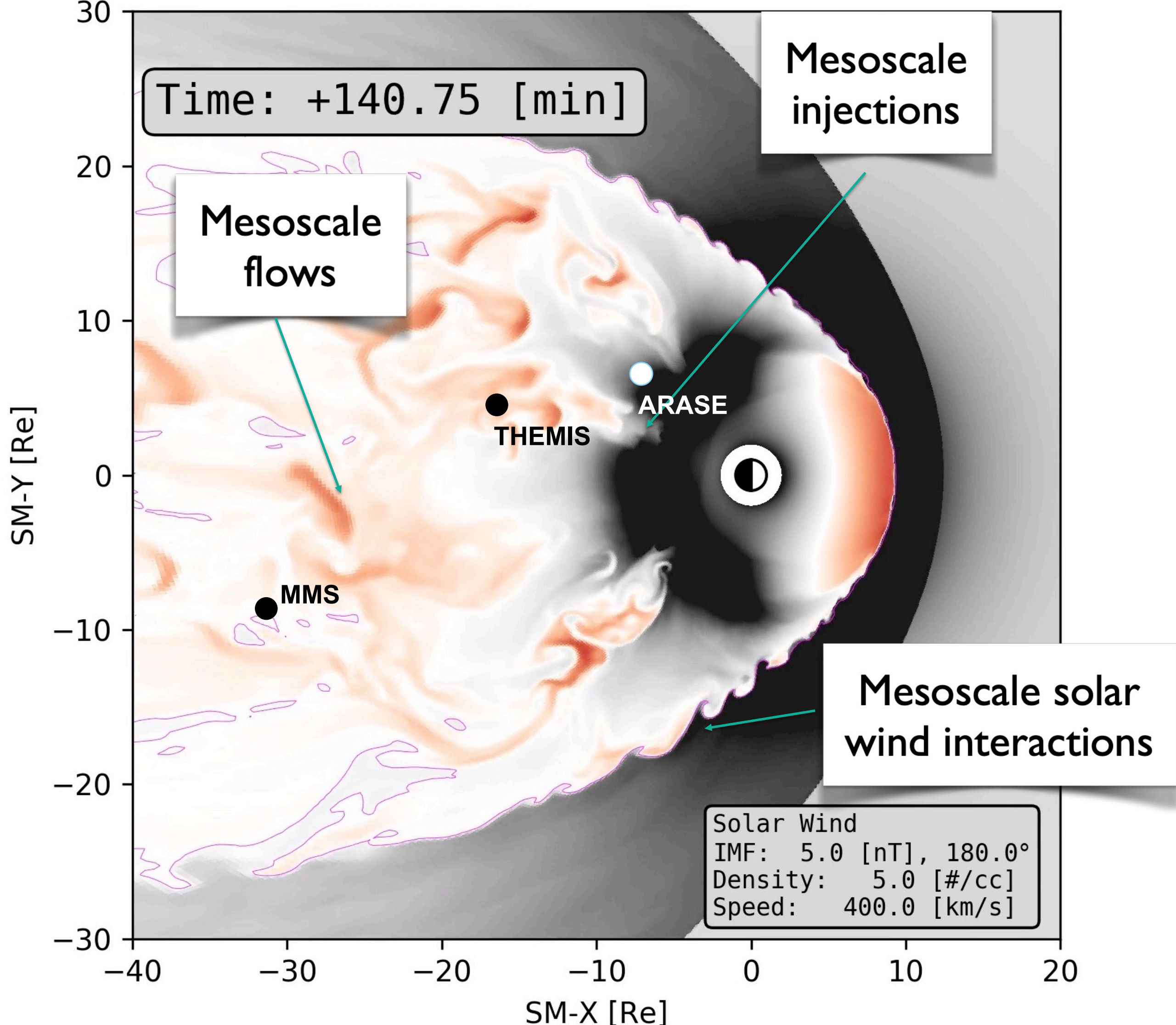
# Current observational approach is not designed for system-of-system studies

Coordination is ad-hoc, often accidental, and inadequate for mesoscales.

Sparse measurements, even if coordinated, are **inadequate to fully capture the system.**



Sparse measurements, even if coordinated, are **inadequate to fully capture the mesoscales.**





# The cross-scale, cross-system science of our (5th) era requires a new approach

We need both a new **intentional, forward-thinking coordination mechanism & a new worldwide effort** that:

- Resolves cross-scale coupling – simultaneously, across System of Systems
  - For magnetosphere, mesoscales are particularly important.
- Monitors the state variables
  - L1, EUV imagery, auroral imagery, cross polar cap potential, radiation belt content, etc.
- Advances next generation numerical modeling
- Organizes the ground- and space-based communities around *programs*, not missions.
- Embrace & utilize ‘big data’, AI/ML techniques, & universal standards

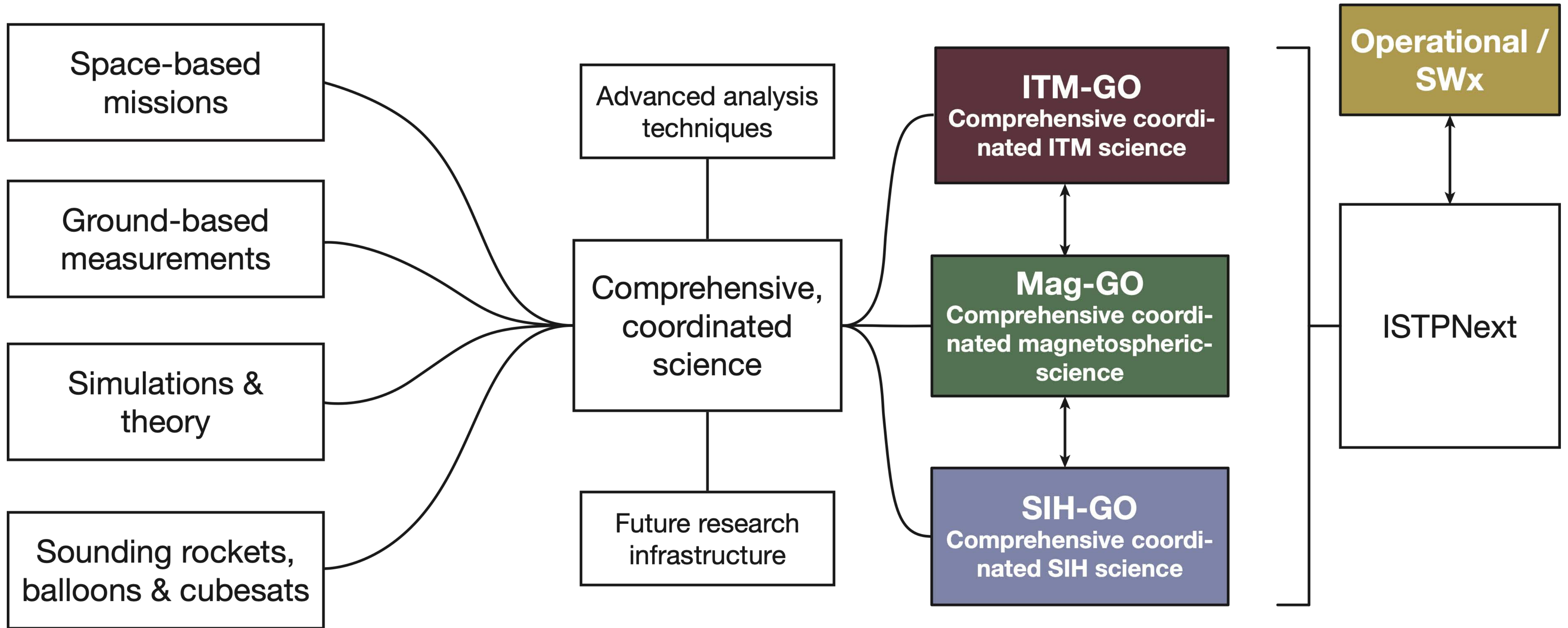
All activities and initiatives are globally *coordinated* and *working together* to study Geo and S-IH holistically, as systems, *at the scale sizes that we now know are driving the overall dynamics.*

A next generation ISTP-type program



# Great Observatories would form ISTPNNext

*System of systems & mesoscales/cross-scale coupling creating the common scientific thread*



*Science architecture is independent of the mission implementations*



**SIH-GO**  
Comprehensive coordinated SIH science



Many assets today, more coming online.

**ITM-GO**  
Comprehensive coordinated ITM science



GDC+DYNAMIC is an opportunity

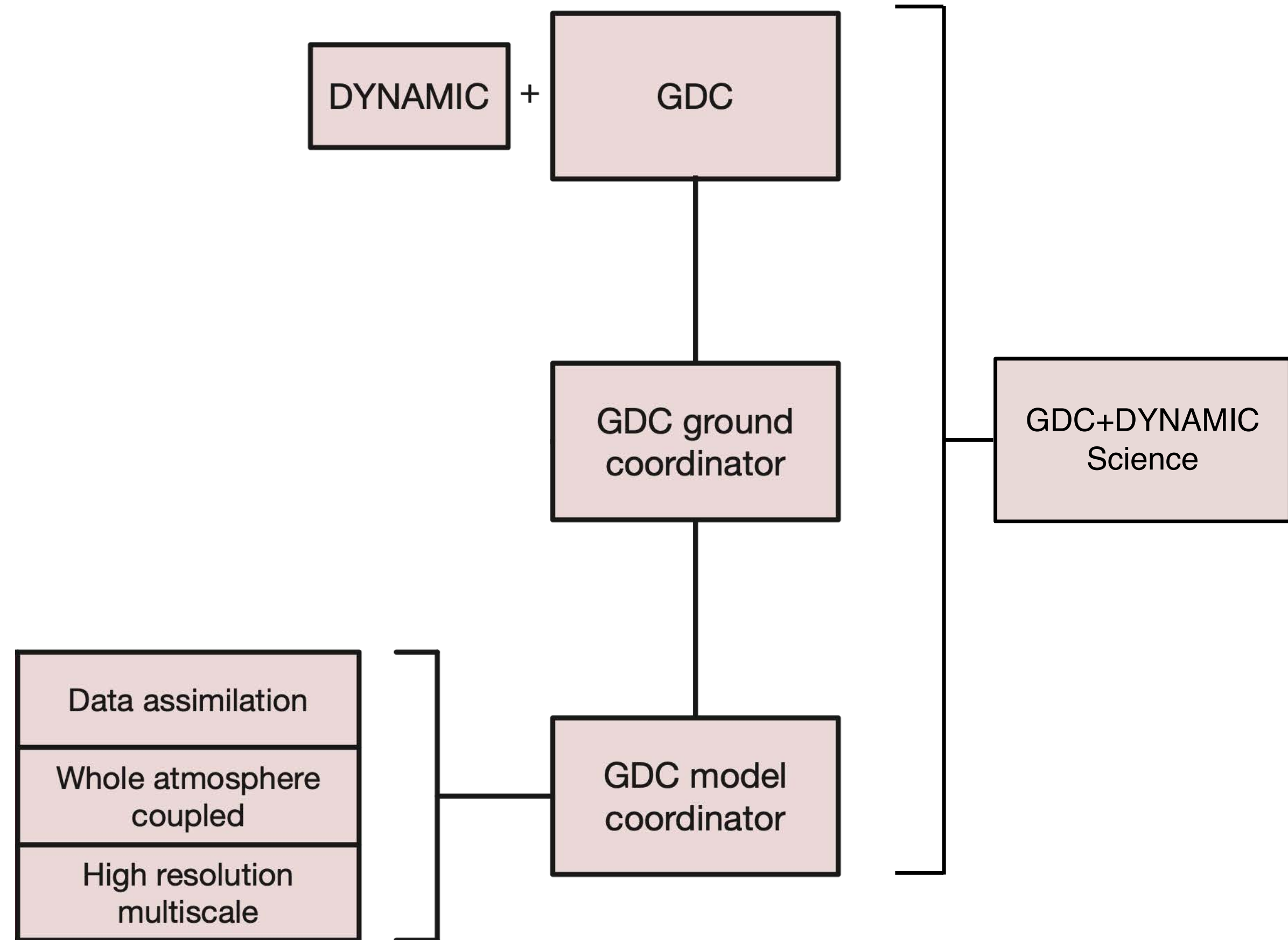
**Mag-GO**  
Comprehensive coordinated magnetospheric science



Many small pieces today; needs decadal guidance (and a strategic mission or 2)



# GDC+DYNAMIC





# Component

# Resources

# GDC+DYNAMIC

Space-based missions

- AMPERE
- AWE
- AIM
- TIMED
- GOLD
- Future SMEX/MIDEX
- EZIE
- SNIFE
- ROKITS
- TRACERS
- SWARM
- Other agencies

Ground-based measurements

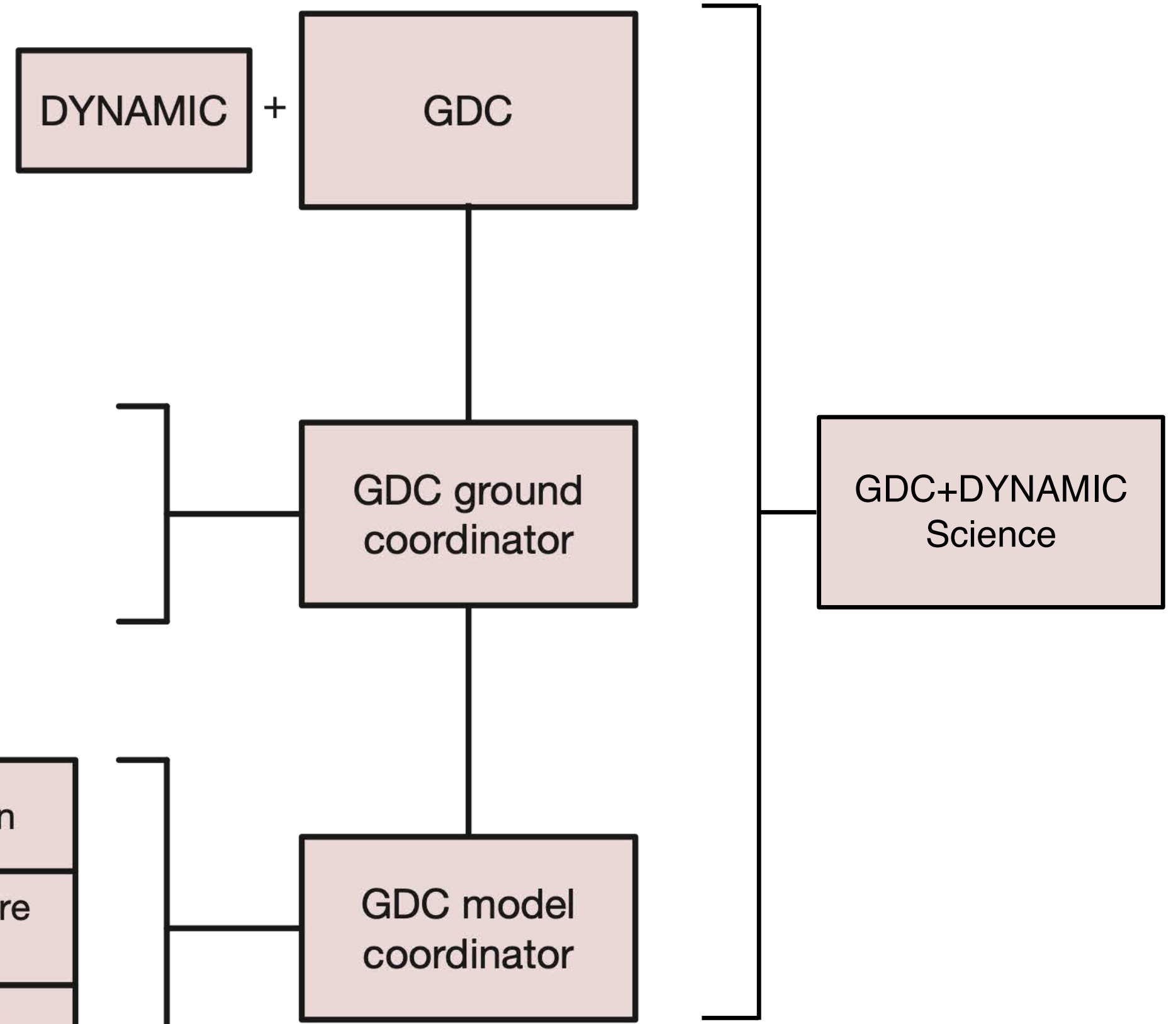
- SuperDARN
- FPI
- ISR
- Meteor Radars
- ASI
- Mag
- GPS

Simulations & theory

- NASA DRIVE Science Centers
- Community developed models
  - Data assimilation
  - Whole atmosphere coupled
  - High resolution multiscale

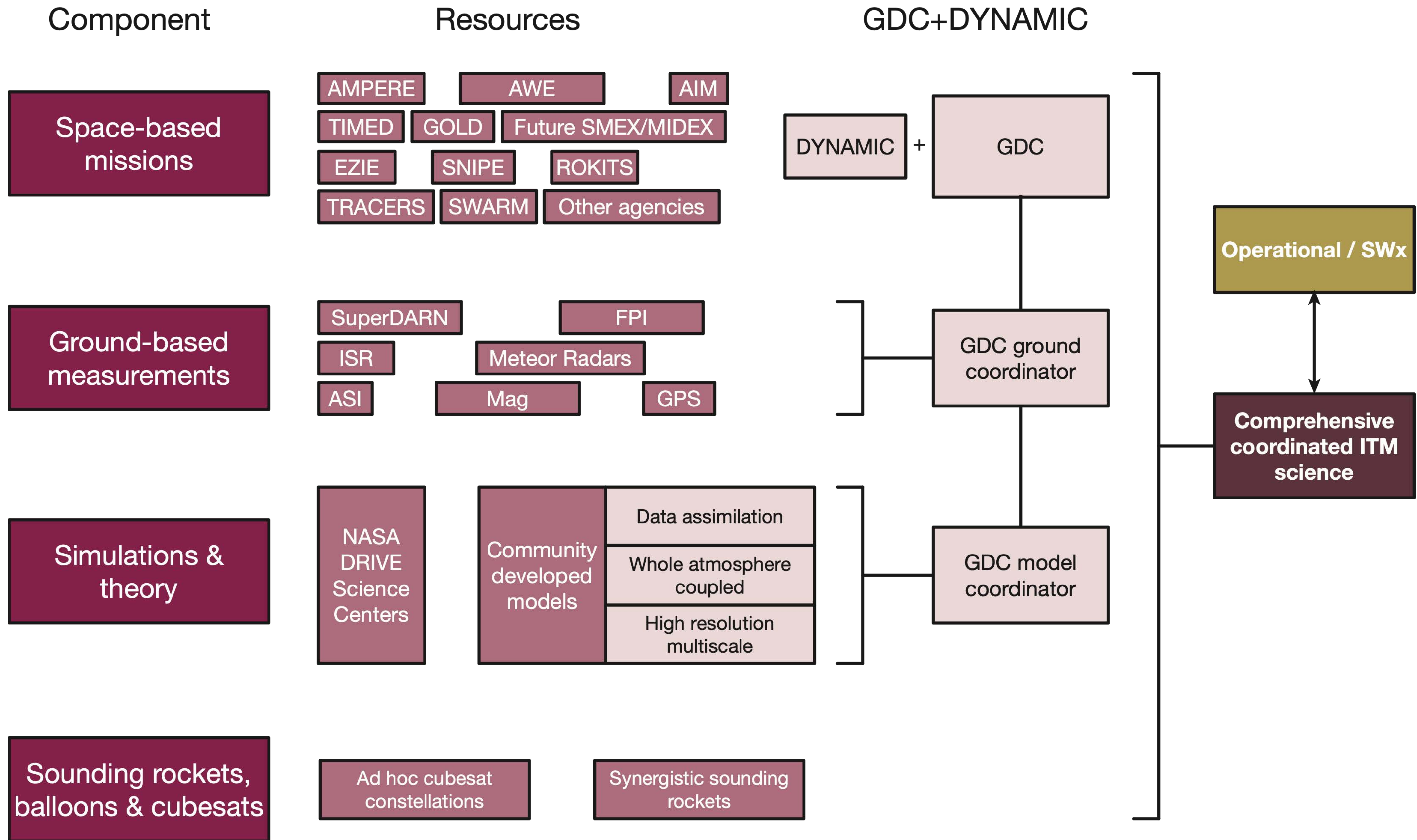
Sounding rockets, balloons & cubesats

- Ad hoc cubesat constellations
- Synergistic sounding rockets





# ITM Great Observatory



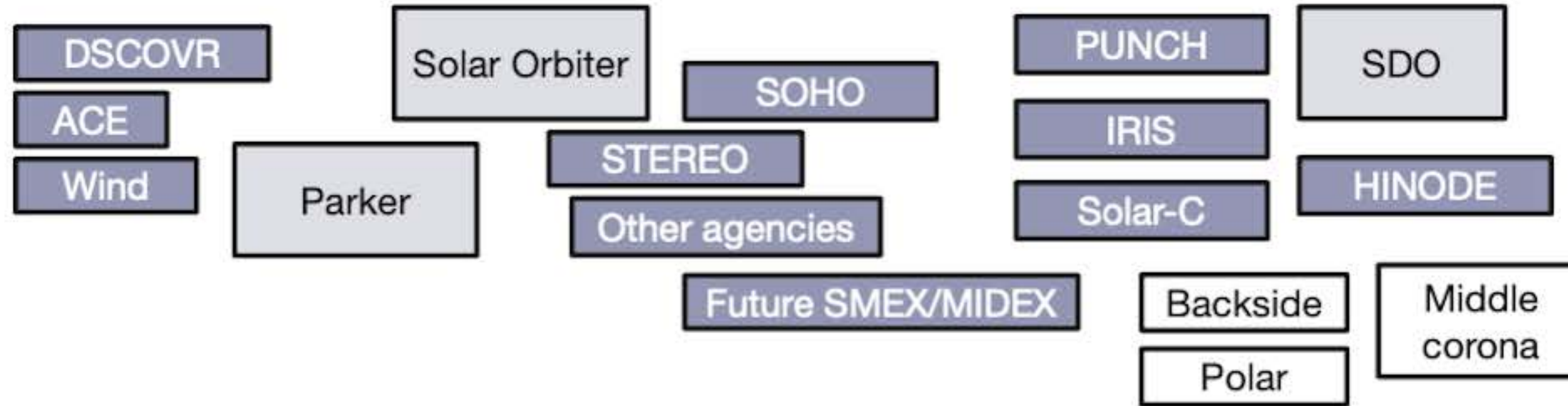


# SIH Great Observatory

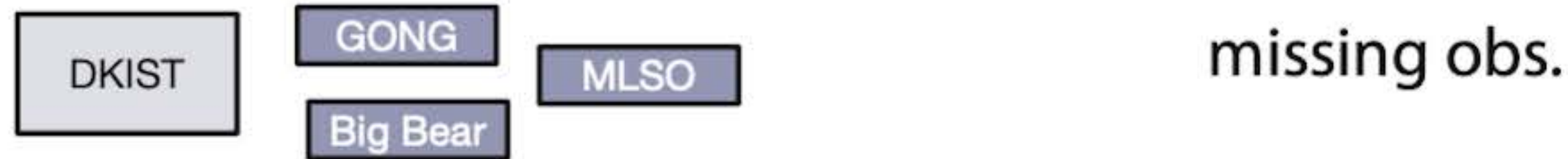
Component

In Situ ← → Remote

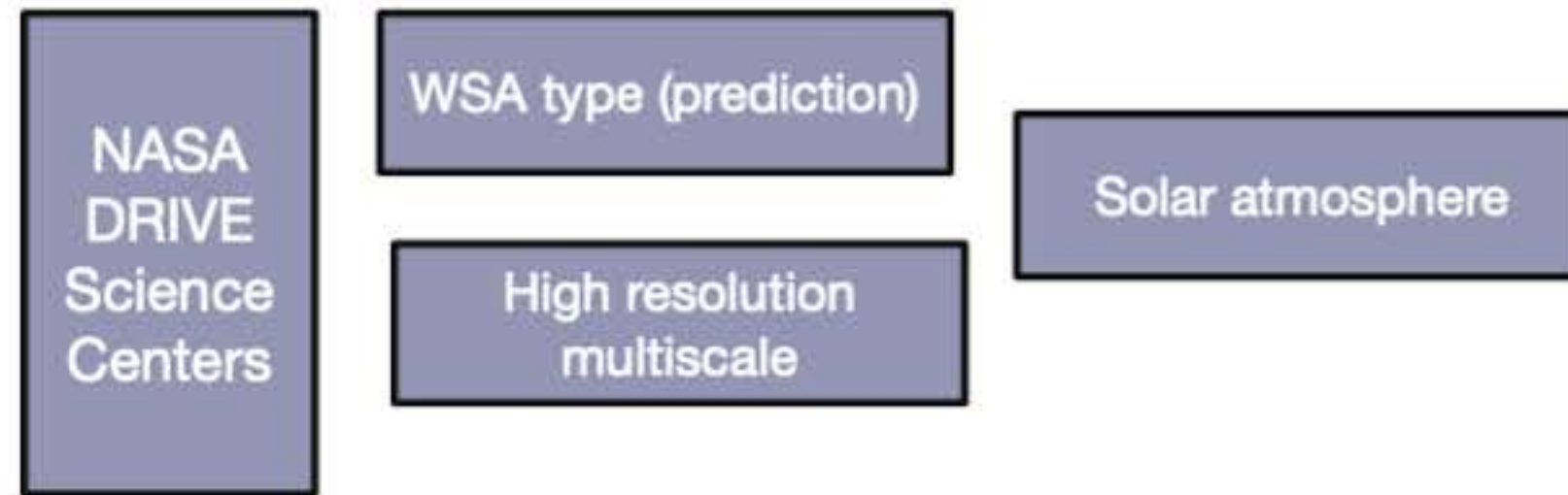
Space-based missions



Ground-based measurements



Simulations & theory



Sounding rockets, balloons & cubesats



Operational / SWx

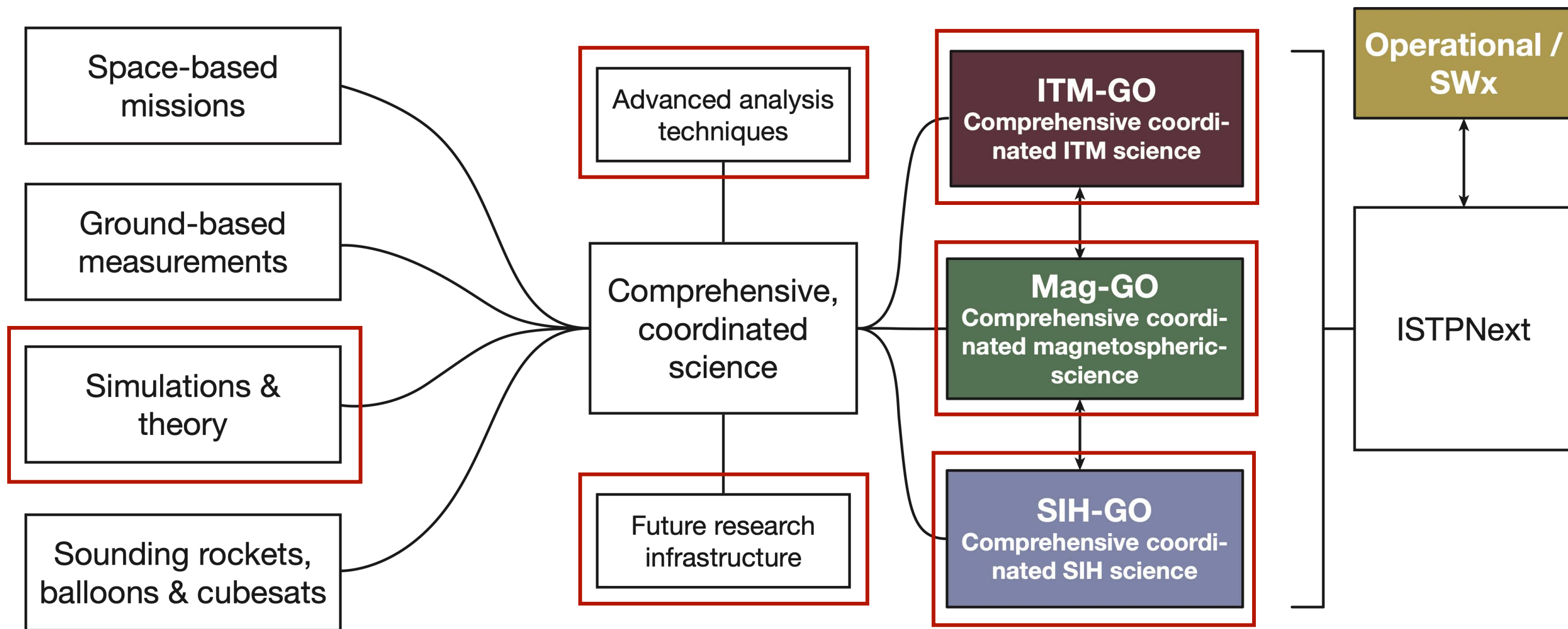
Comprehensive coordinated SIH science

Comprehensive coordinated ITM science

Comprehensive coordinated Mag science







Breakout sessions on:

- Ground ASI/simulation comparisons (see CGS session Friday)
- Heliophysics branding
- Issues affecting the community
- SIH coordination

202 total registered attendees  
85 in person, 117 remote





**ISTPNext Workshop Report**  
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[https://bit.ly/ISTPNext\\_report](https://bit.ly/ISTPNext_report)



Will keep same link as report is updated



# The best way to predict the future is to create it

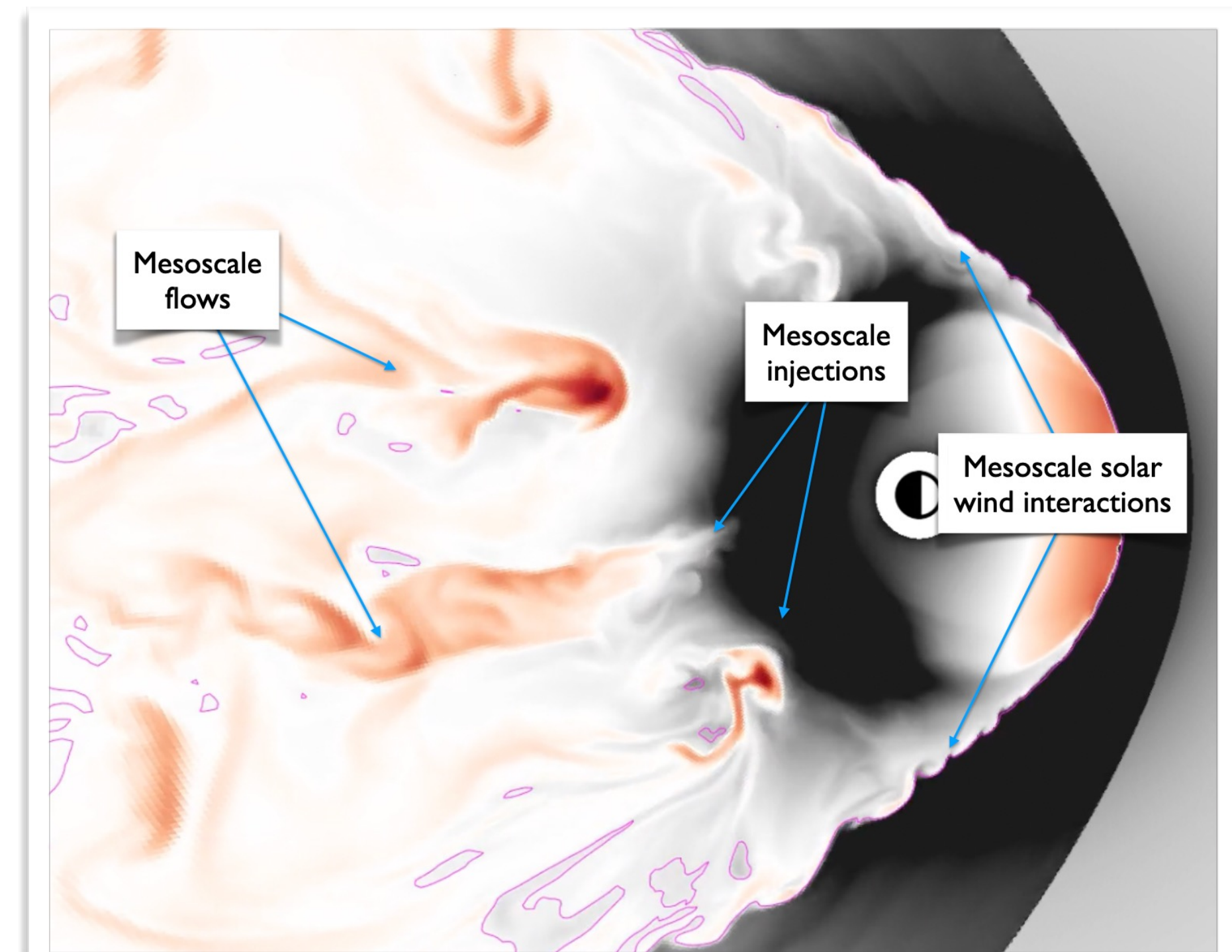
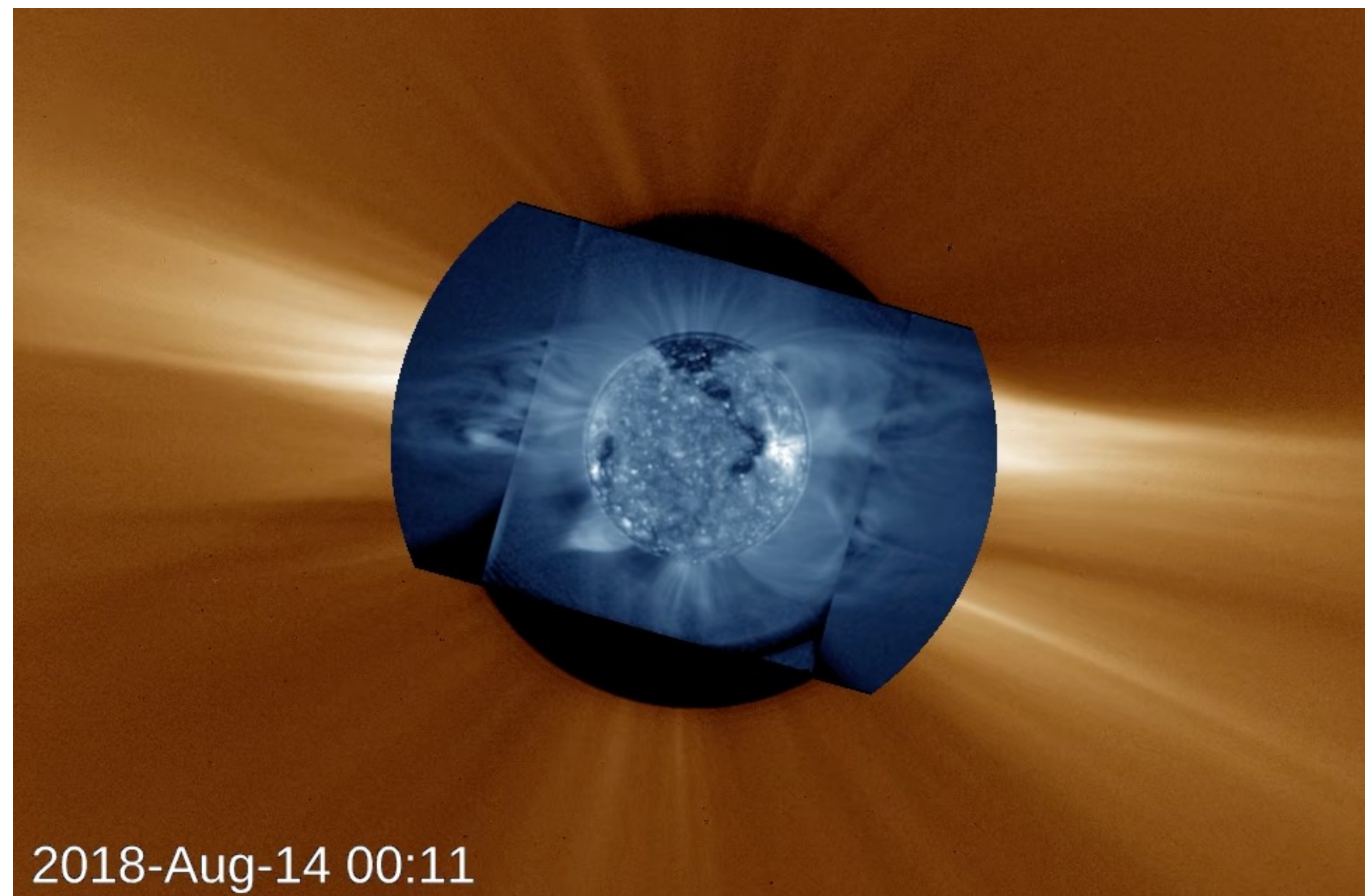
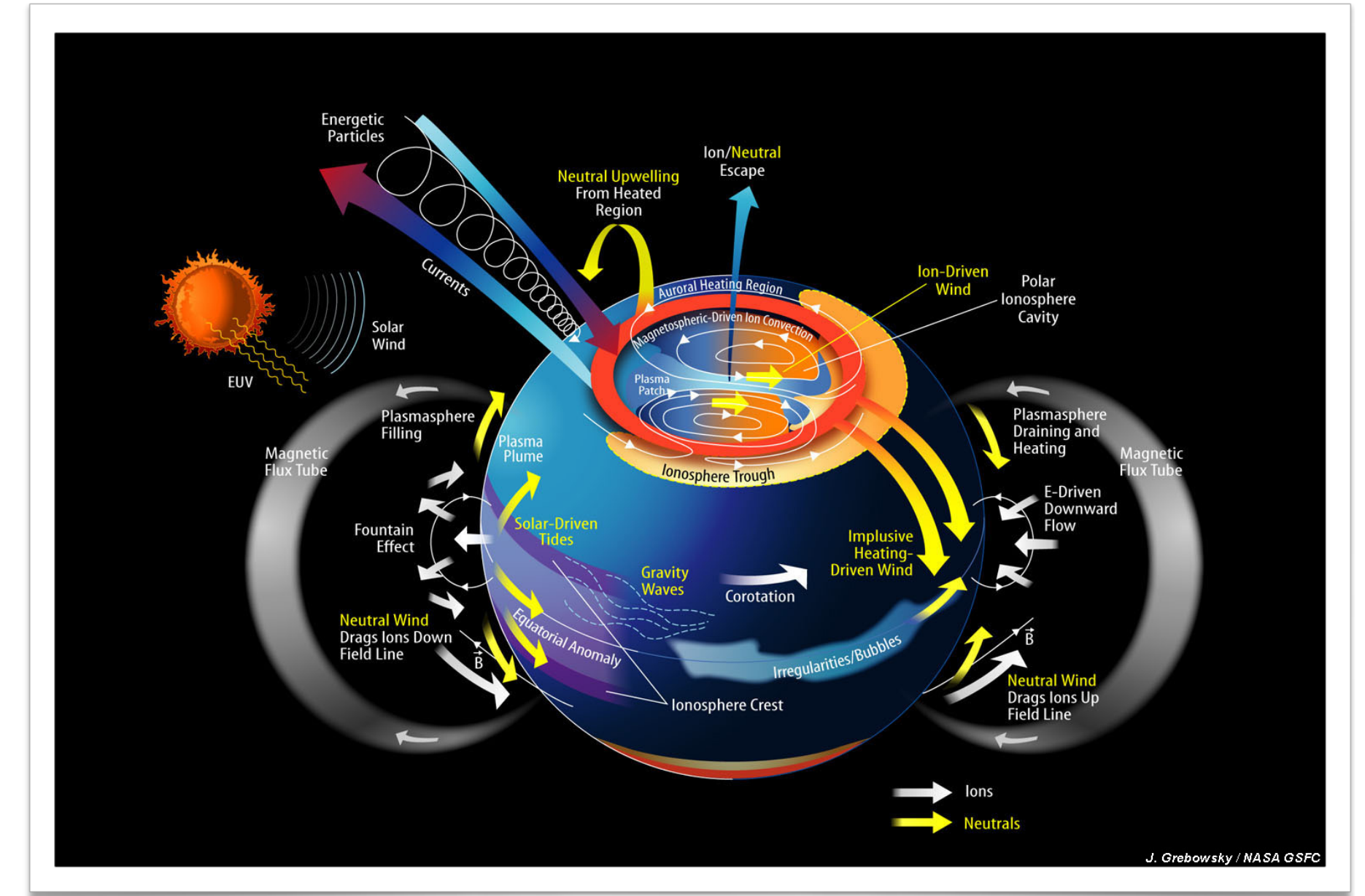
- **We are all heliophysicists**
  - With specialization in aurora, or radiation belts, or space weather, or the sun, e.g.
- **If large-scale coordination like ISTPNNext is what we want, then we can make it happen.**
- **Leverage GDC+DYNAMIC missions to jumpstart the vision, and then help establish a new method of collaboration coordination.**
- **Resist the trance of scarcity**
  - Particularly the next few years when budgets may tighten.
- **Advocate for the community**
  - For the future health and vibrancy of our unified field.
  - Important to speak with a common community voice. “Heliophysics”. “System of Systems”. “Mesoscales”/“Messengers”/“Connectors”
  - Speak in solidarity. Internecine warfare can have impacts beyond our community (everybody loses).

**We are all on “Team Science”**



Mag, ITM & SIH are focused on “System of Systems” understanding, mesoscale dynamics, & cross-scale coupling

One could imagine a common scientific framework, like ISTP had, with mesoscales & system of systems as a common focal point across SIH, ITM, and Mag.





ISSI team selection  
Nov 2020

Helio2050  
May 3-7, 2021

COSPAR TGIGSP  
Fall 2021

ISTPNext WP  
Summer 2022

GDC



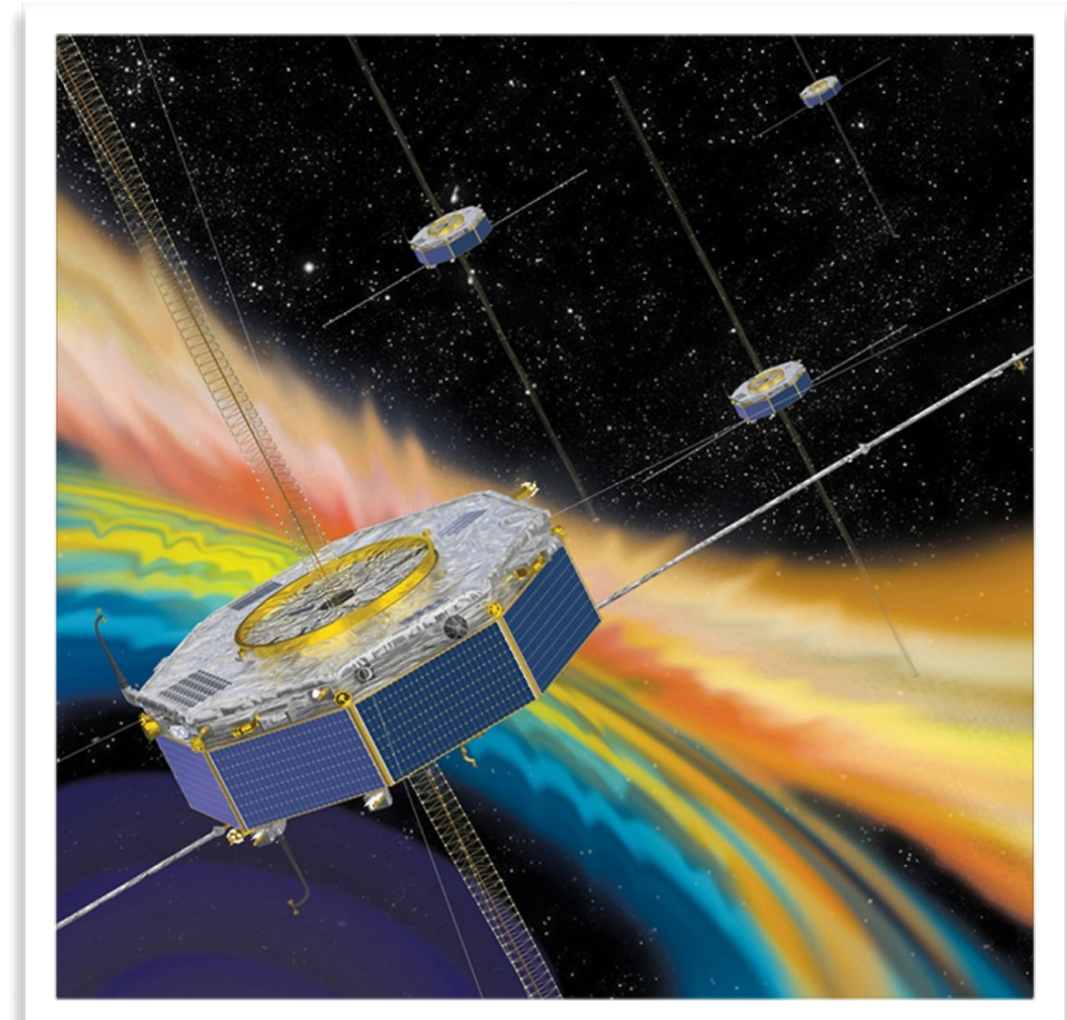


# Era of Microscales (~2005-present)

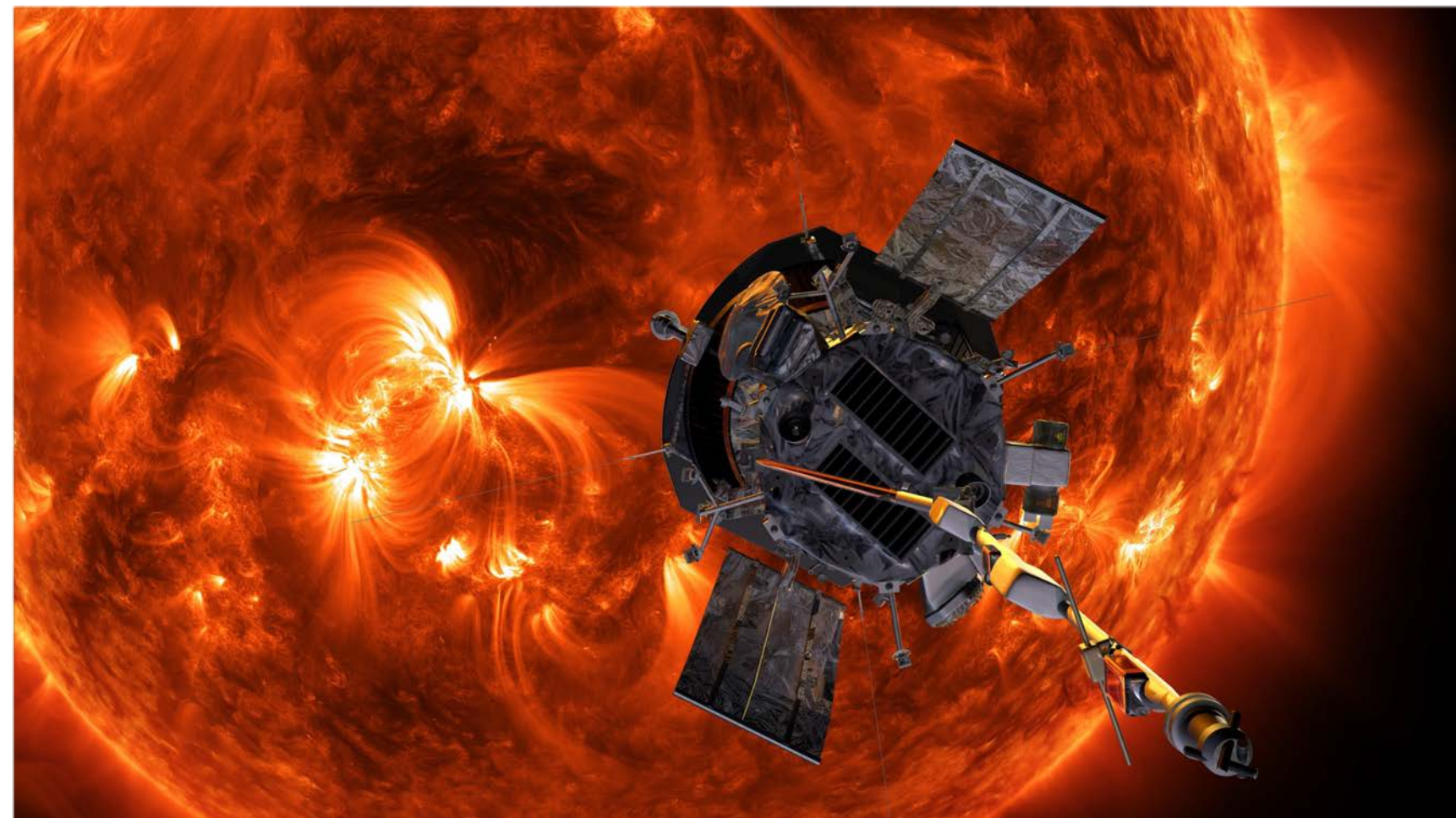
*Focused on basic plasma physics*

Van Allen Probes + Arase - Physics of acceleration & transport of radiation belt particles (wave particle interactions)

Magnetospheric Multiscale (MMS) - Physics of magnetic reconnection (electron scale)



Parker Solar Probe - kinetic plasma physics of the solar corona; SoHO - “complex scientific laboratory”







WORKSHOP

# INTERNATIONAL SOLAR TERRESTRIAL PROGRAM (ISTP) NEXT

MAY 8-10 2023

 **JOHNS HOPKINS**  
APPLIED PHYSICS LABORATORY







ISTPNext poster session for very, very early career scientists



“Why does vinegar and baking soda make bubbles”

