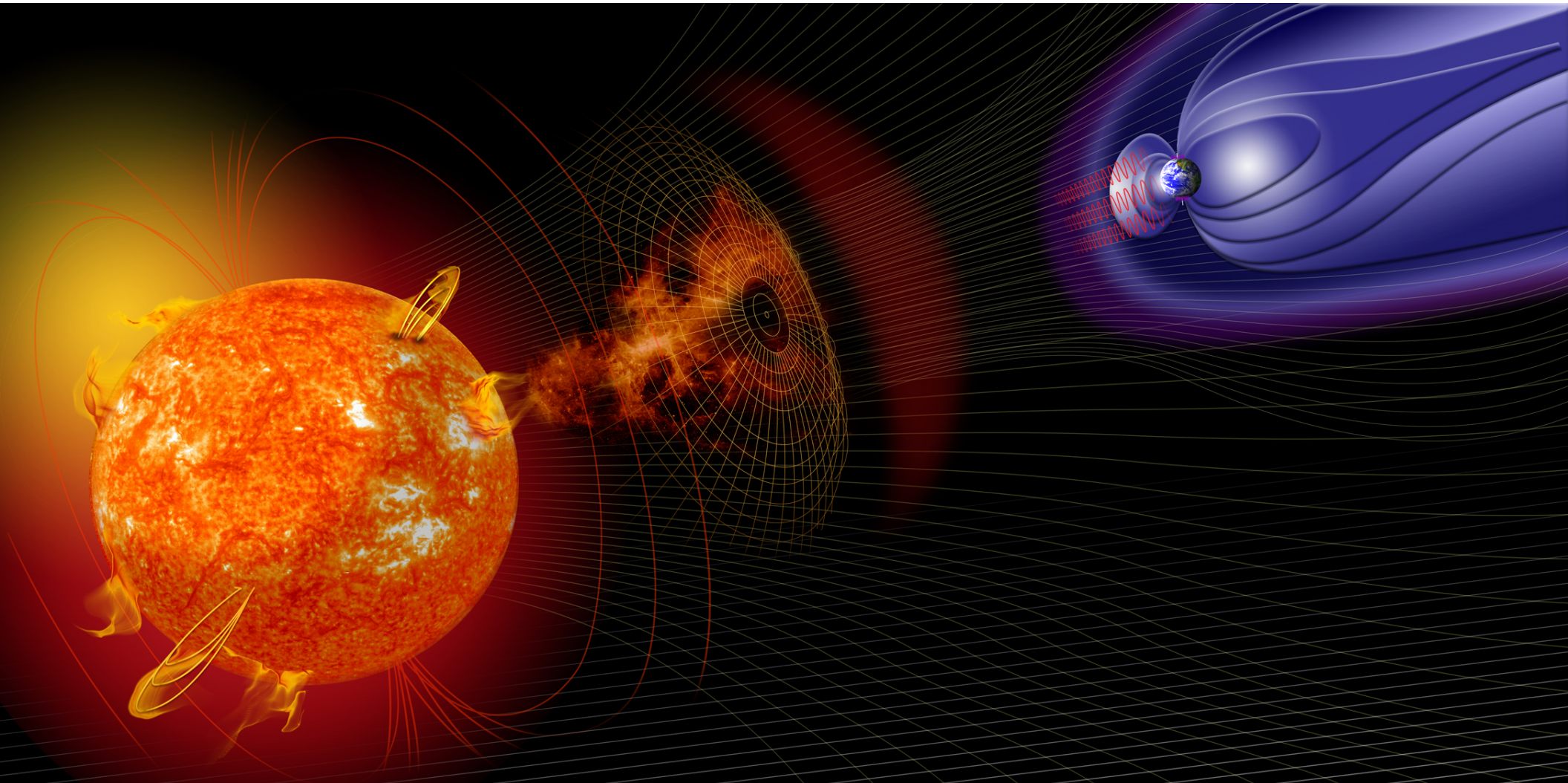


# Heliophysics Science Mission Drivers

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# Broadly 4 Heliophysics Mission Lines

1. Living With a Star (LWS) - Solar Dynamics Orbiter (SDO), Radiation Belt Storm Probes (RBSP - Van Allen Probes), Solar Probe Plus, **Geospace Dynamics Coupling (GDC)**  
*Now \$1B, Center led*
2. Solar Terrestrial Probes (STP) - MMS, STEREO, Hinode, TIMED, **IMAP, DYNAMIC, MEDICI**  
*Now \$500M, PI led*
3. Explorers - ICON, IBEX, IRIS, RHESSI, THEMIS, FAST, SAMPEX, TRACE, etc.  
*SMEX (\$105M) and MIDEX (\$200M), PI led*
4. H-TIDeS - “sub-orbital”  
*<\$4M, PI led*

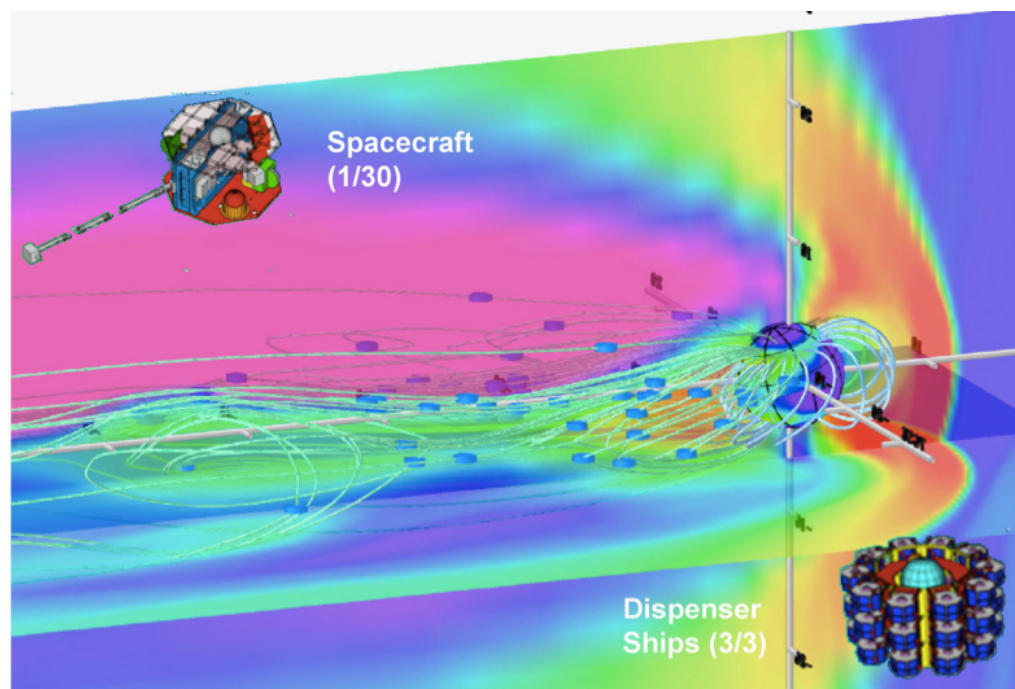
SmallSats are applicable to all mission lines  
but with very different risk postures



# Utilizing SmallSat's disruption for "Big Science"

1. Provide the capability to deliver **compelling science** that can best or **only be realized** by mission architectures that incorporate small spacecraft
2. **More efficiently implement** larger or "traditional" spaceflight missions, through **demonstration, displacement, or disaggregation.**

## Constellations



**Demonstration** - Test new tech  
**Displacement** - Same with less  
**Disaggregation** - Break it apart

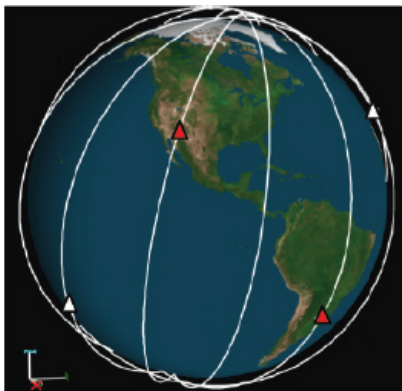


# GDC \$1B Decadal Mission - SmallSats?

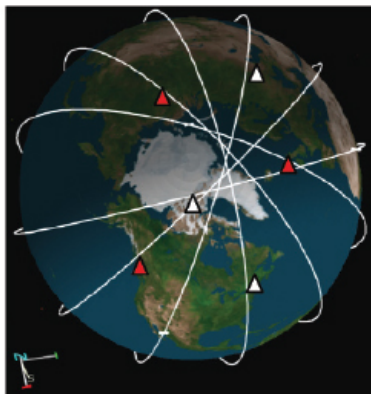
6 large spacecraft

vs.

25-100 smallsats



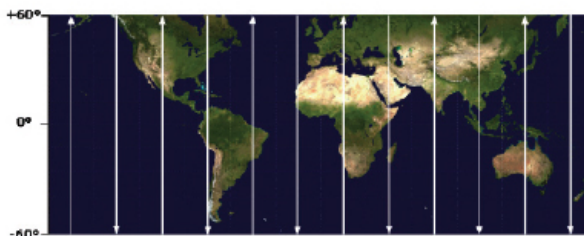
(a) Full global coverage



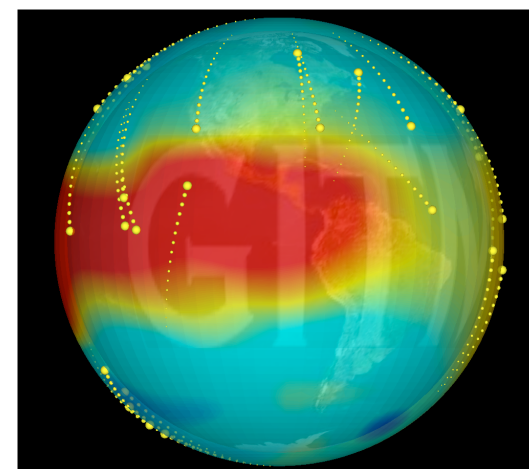
(b) 6-spacecraft high-latitude "armada"



(c) 3 spacecraft simultaneously sampling each pole



(d) 6 s/c cross the equator every 45 min.

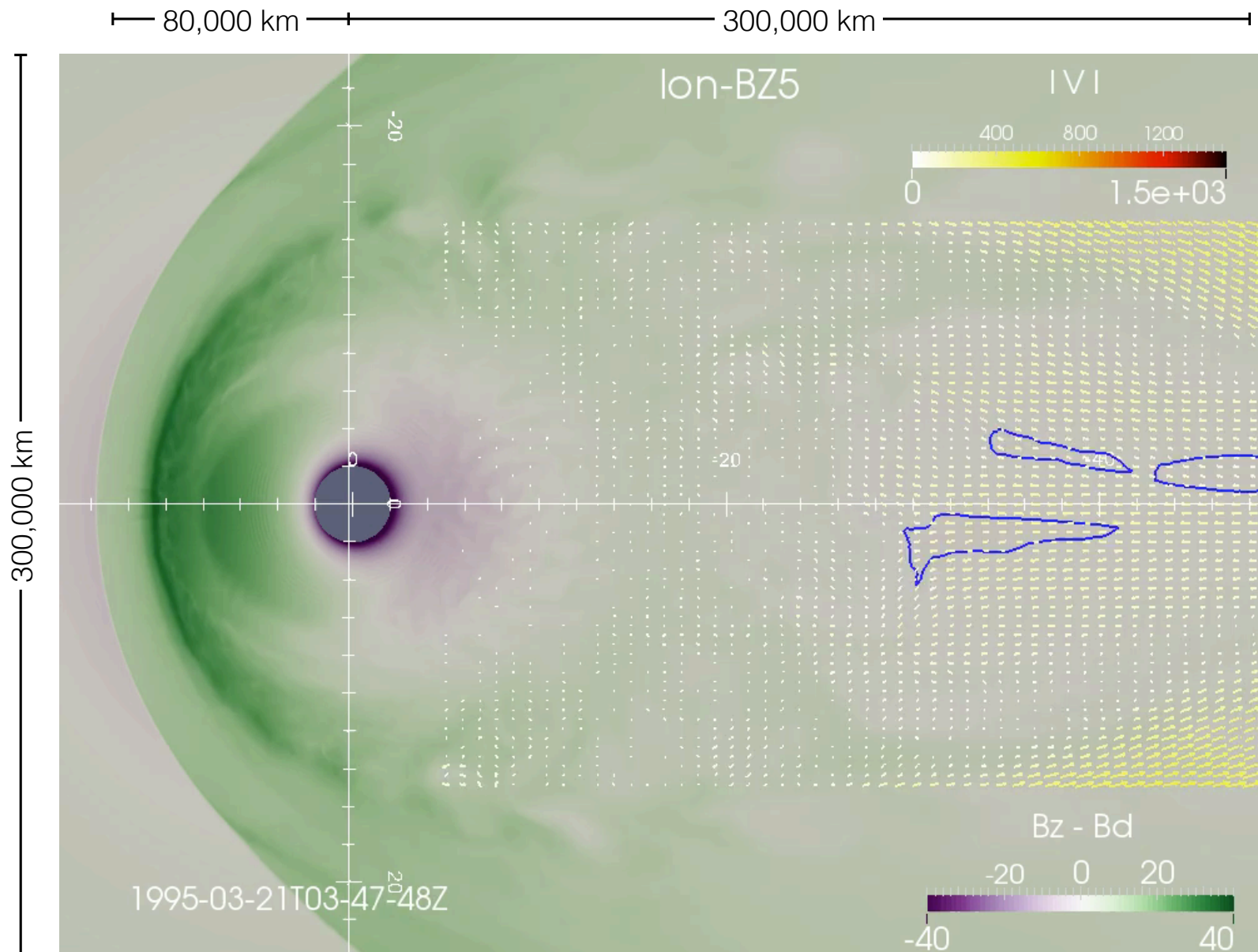


"Armada" Decadal mission concept

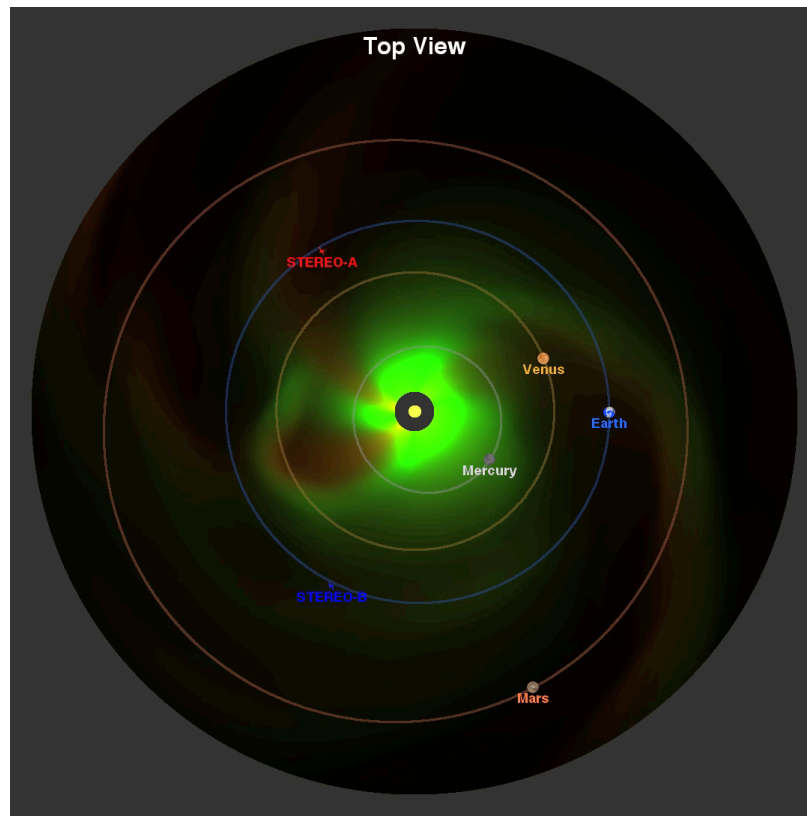


“Most of the important phenomena involve simultaneous variations in space and time. In some cases simultaneous measurements made at two well-chosen locations will provide unambiguous results. In other cases, it may be necessary to make *simultaneous measurements at several hundred locations.*”

- C.E. McIlwain [1967]



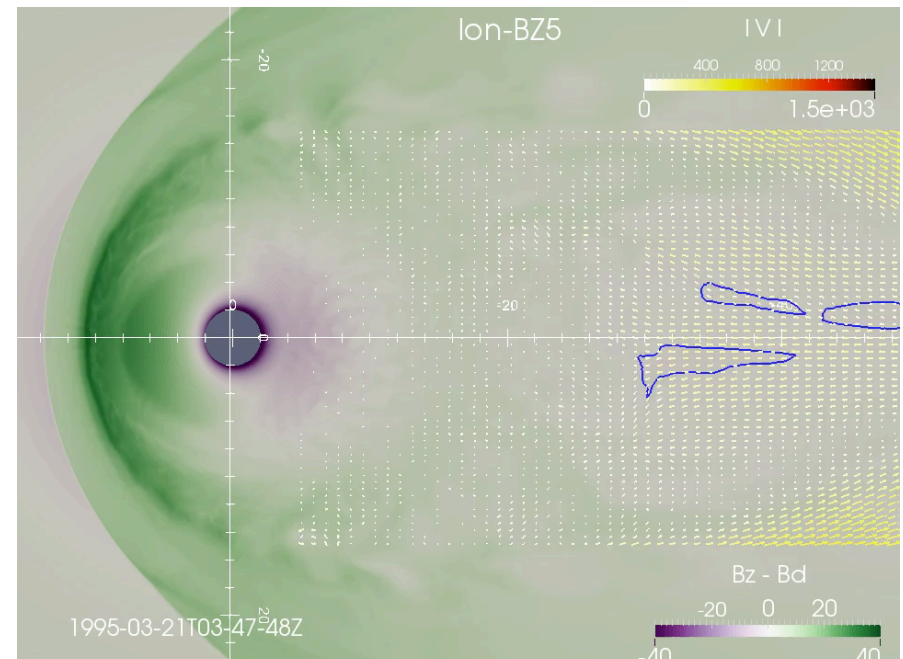
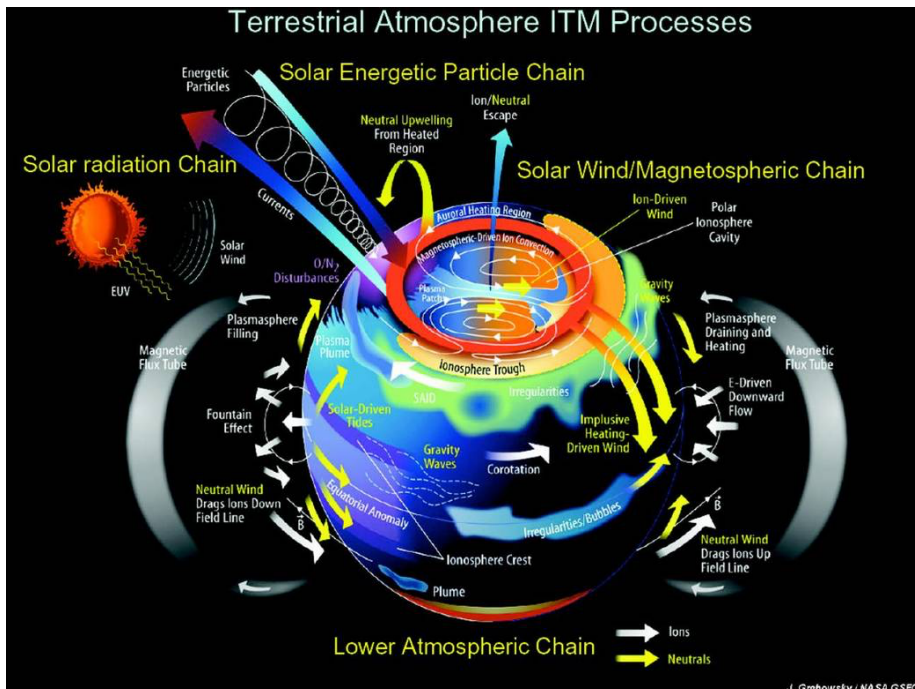
# Three broad regions of study



Heliosphere - LI/  
L4, GCR

LEO - benign radiation; eclipses

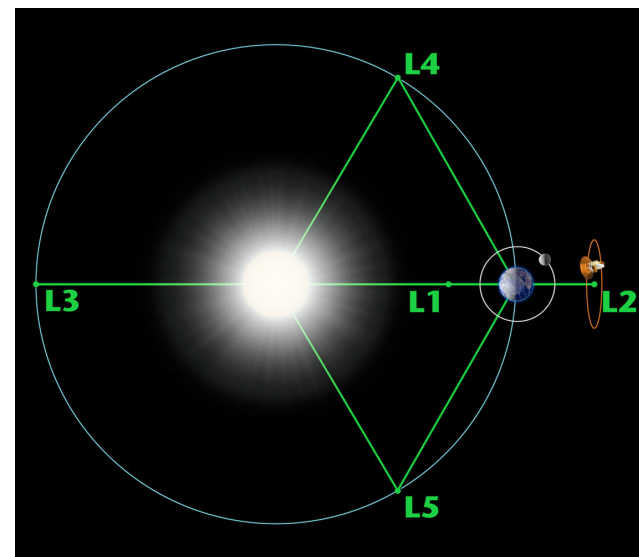
Magnetosphere - elliptical orbit, spinners, radiation



# The Nation has operational space weather needs

The 2013-2022 Heliophysics decadal survey called for a space weather flight program (L1, coronagraph, L5, LEO)

- No extra funding at this moment.
- Not feasible if we need dedicated launchers and large satellites
- Smallsats & Venture Class LV



Congressional Bill S.141, “To improve understanding and forecasting of space weather events, and for other purposes.”

(2)CONSIDERATIONS.—In developing the strategy under paragraph (1), the Director of the Office of Science and Technology Policy shall *consider small satellite options*, hosted payloads, commercial options, international options, and prize authority.





# Heliophysics Science Drivers - Take Aways

- Broad range of reliability needs, from “do no harm” to Class C/7120.5
  - Ideal if the spacecraft product line was a continuum
- Strong need for “System Science” (original LWS)
  - Simultaneous measurements from LI, LEO (aurora, particle precipitation, atmospheric response), and magnetosphere
- Strong need for constellations, particularly high inclination LEO and magnetospheric
  - Many constellation missions enabled with 30 kg spacecraft
- Potential and need for operational space weather line
  - Requires rapid, inexpensive smallsat capability to LI, L4, LEO, inner magnetosphere.

