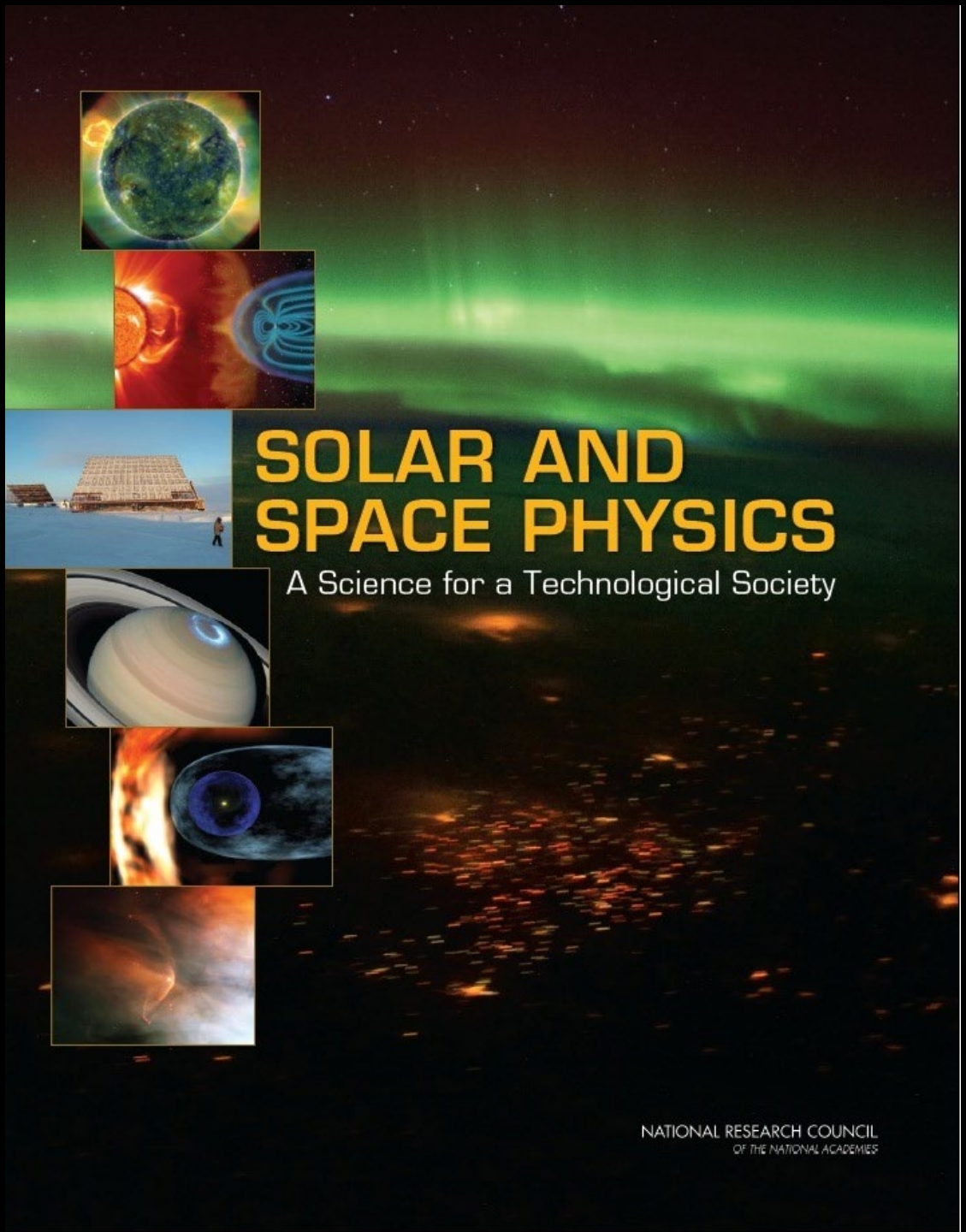
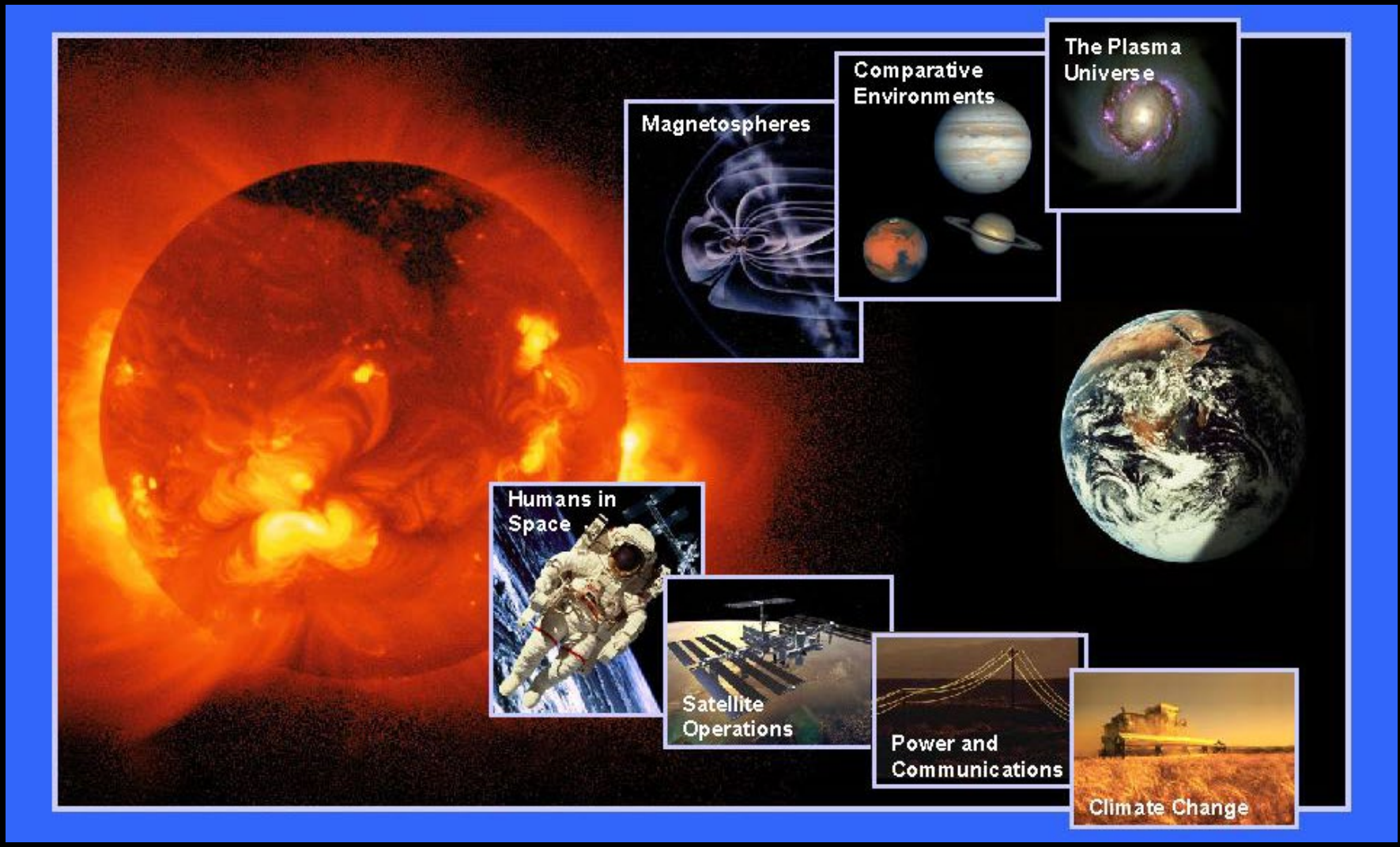



# Space Weather and Space Climate Recommendations

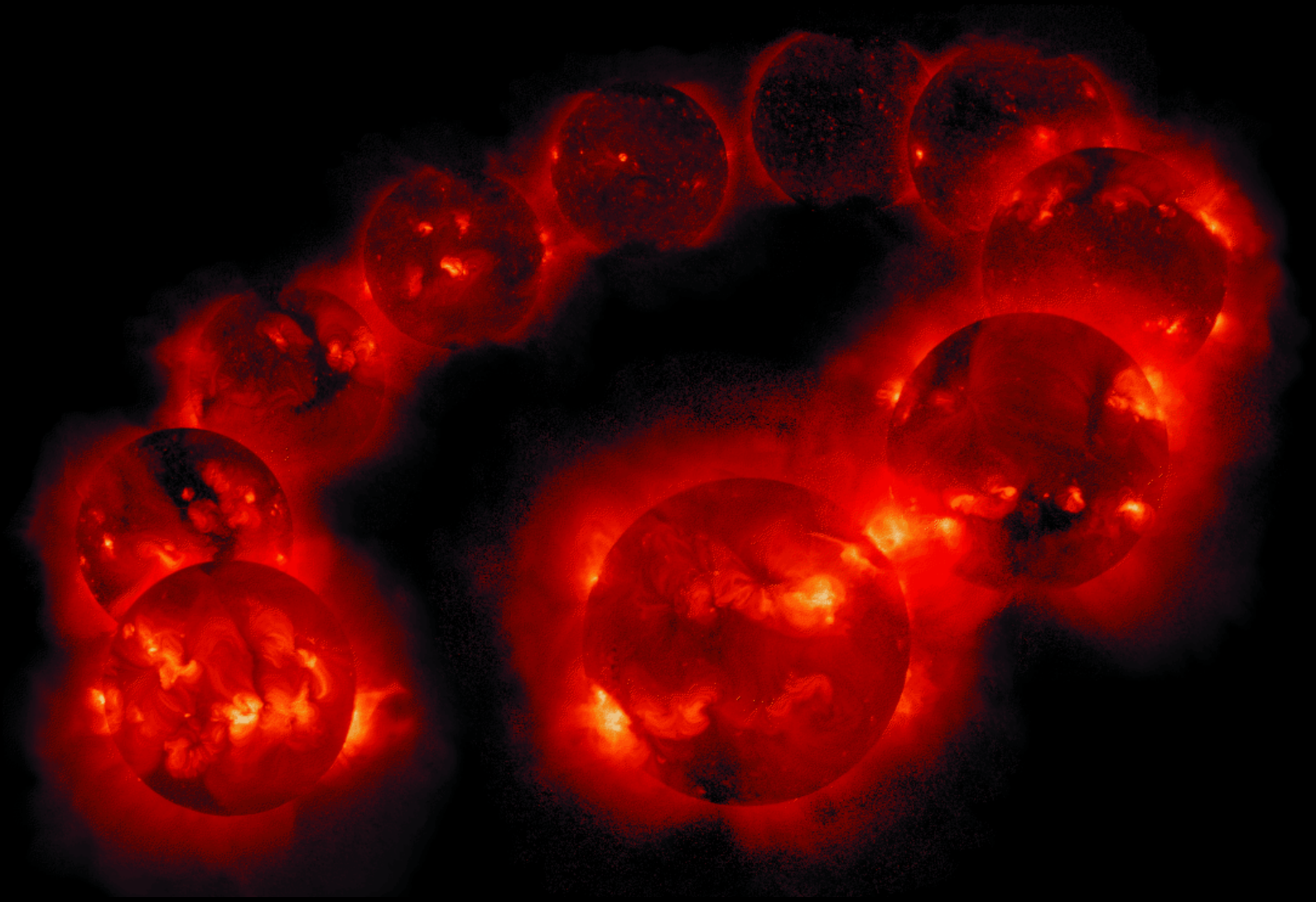
## The 2013-2022 NRC Decadal Survey

Daniel N. Baker, Chair
NRC Decadal Survey
Steering Committee

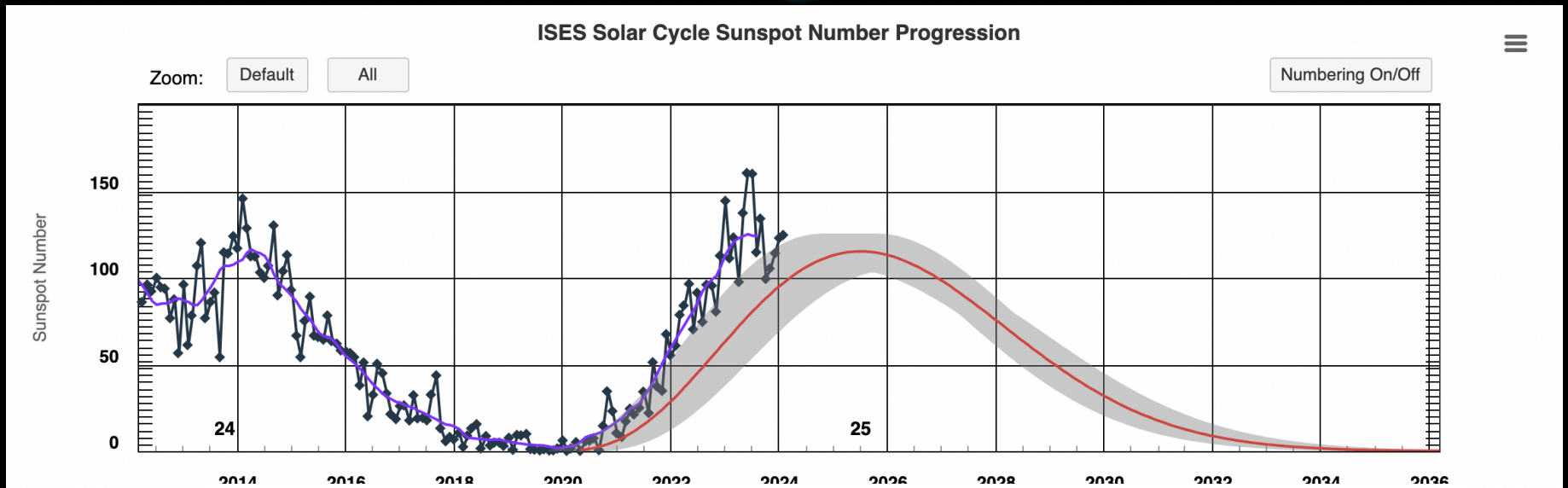
# Understanding Solar-Planetary Connections



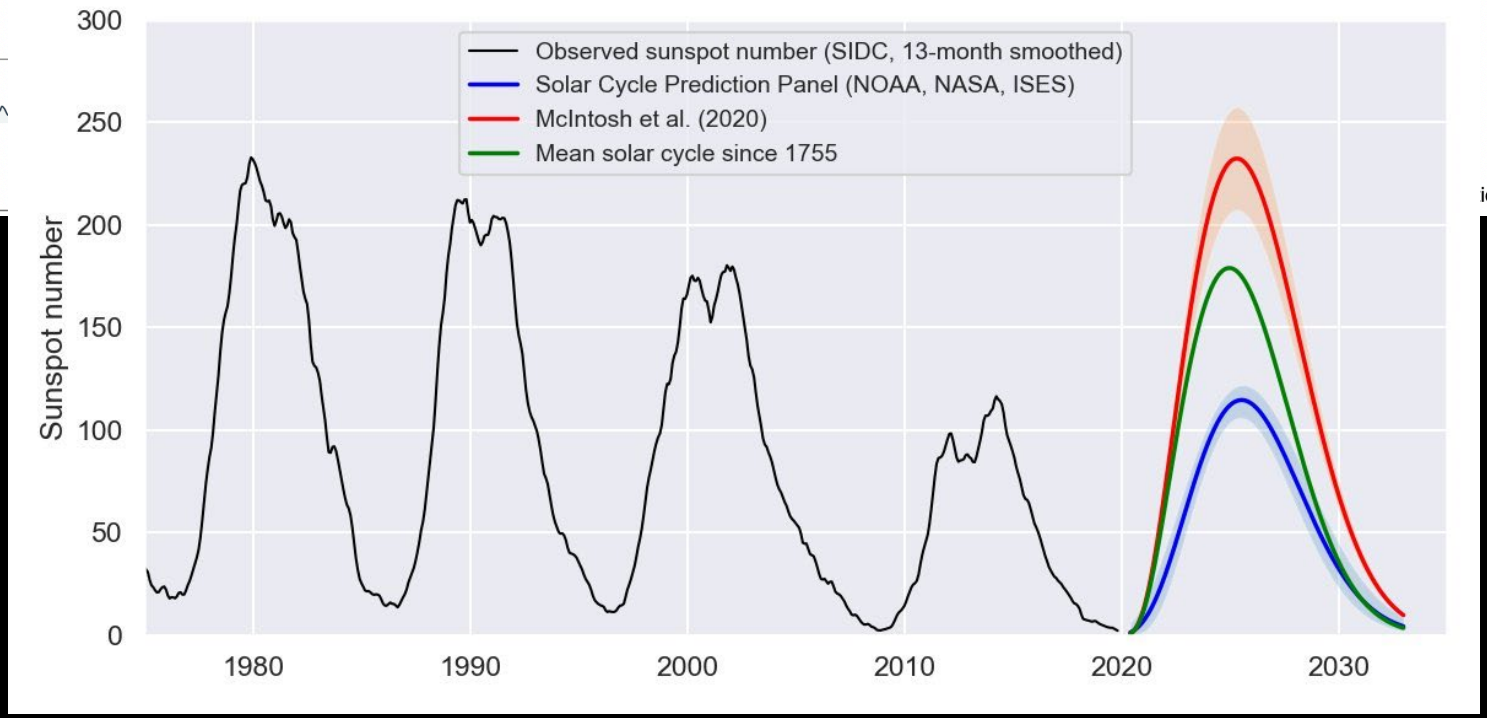
# Yohkoh Soft X-rays:  11-Year Solar Activity Cycle



# Solar Cycle 25



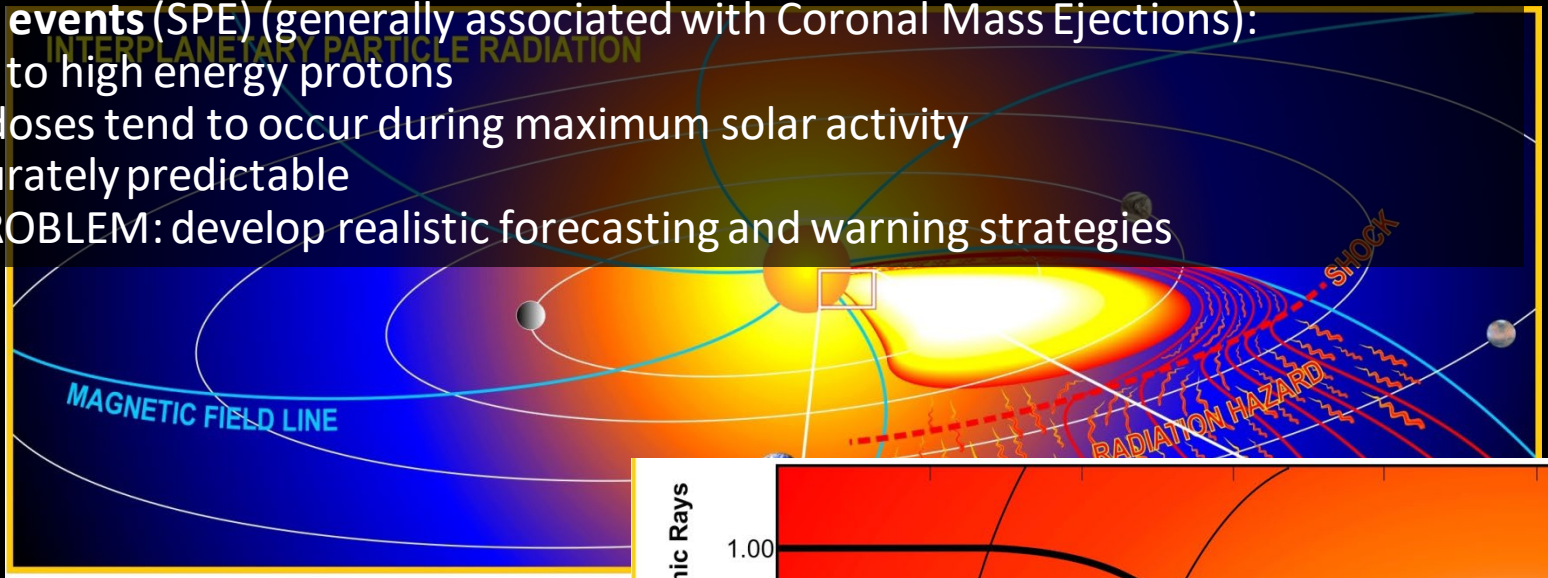


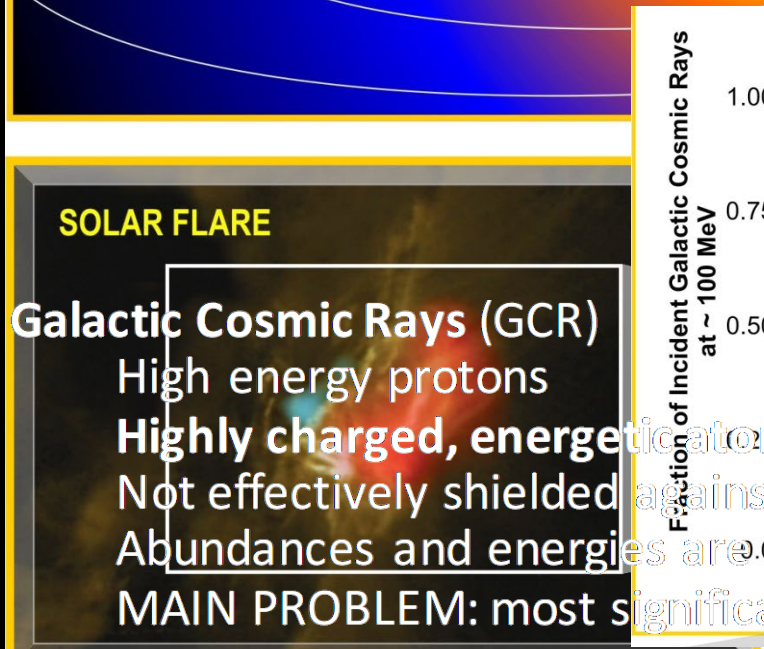



ion Center

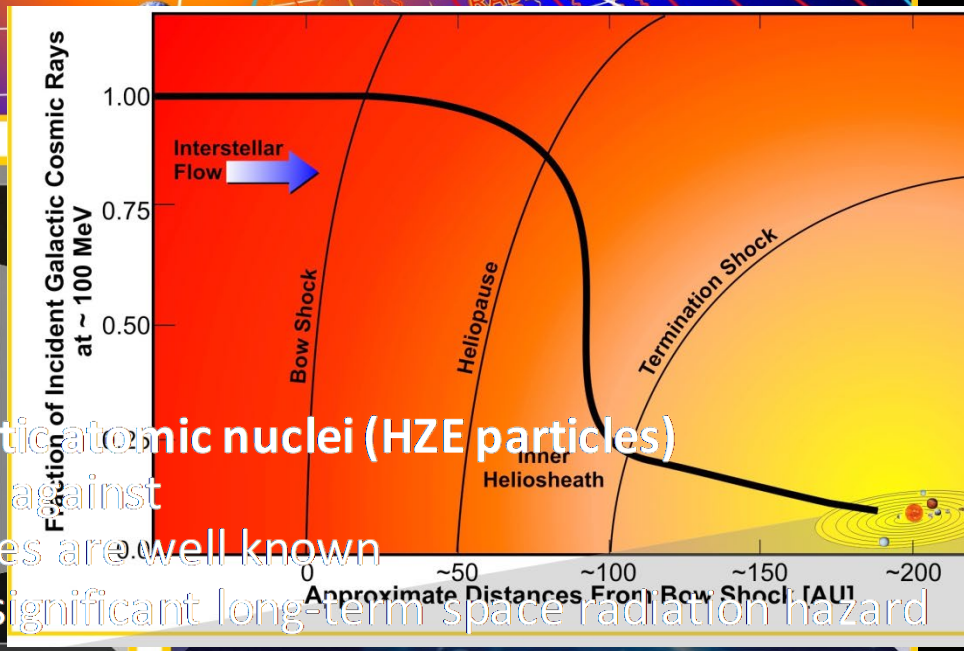
# Space Radiation Drivers

**Solar particle events** (SPE) (generally associated with Coronal Mass Ejections):
- Medium to high energy protons
- Largest doses tend to occur during maximum solar activity
- Not accurately predictable
- MAIN PROBLEM: develop realistic forecasting and warning strategies

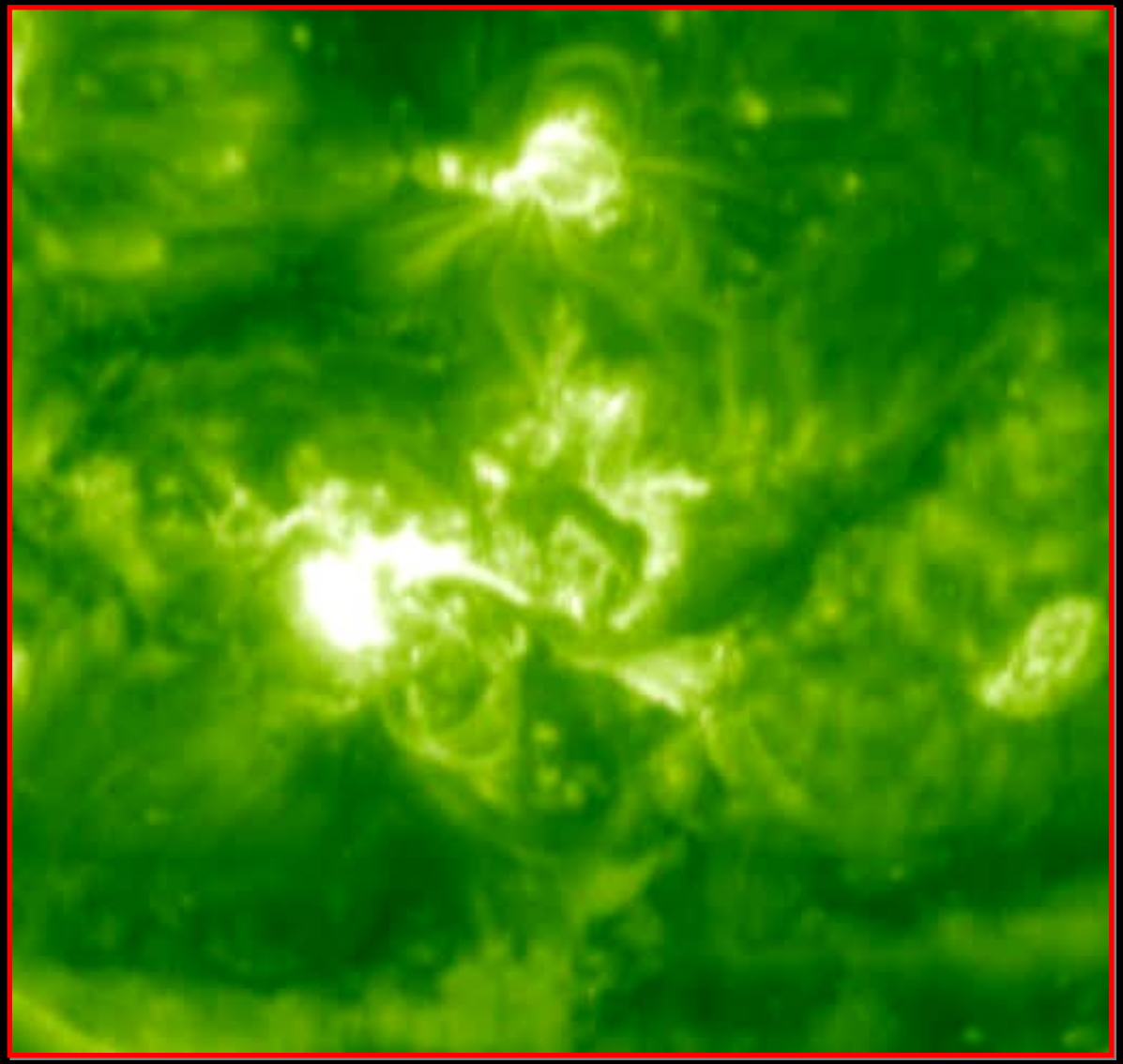


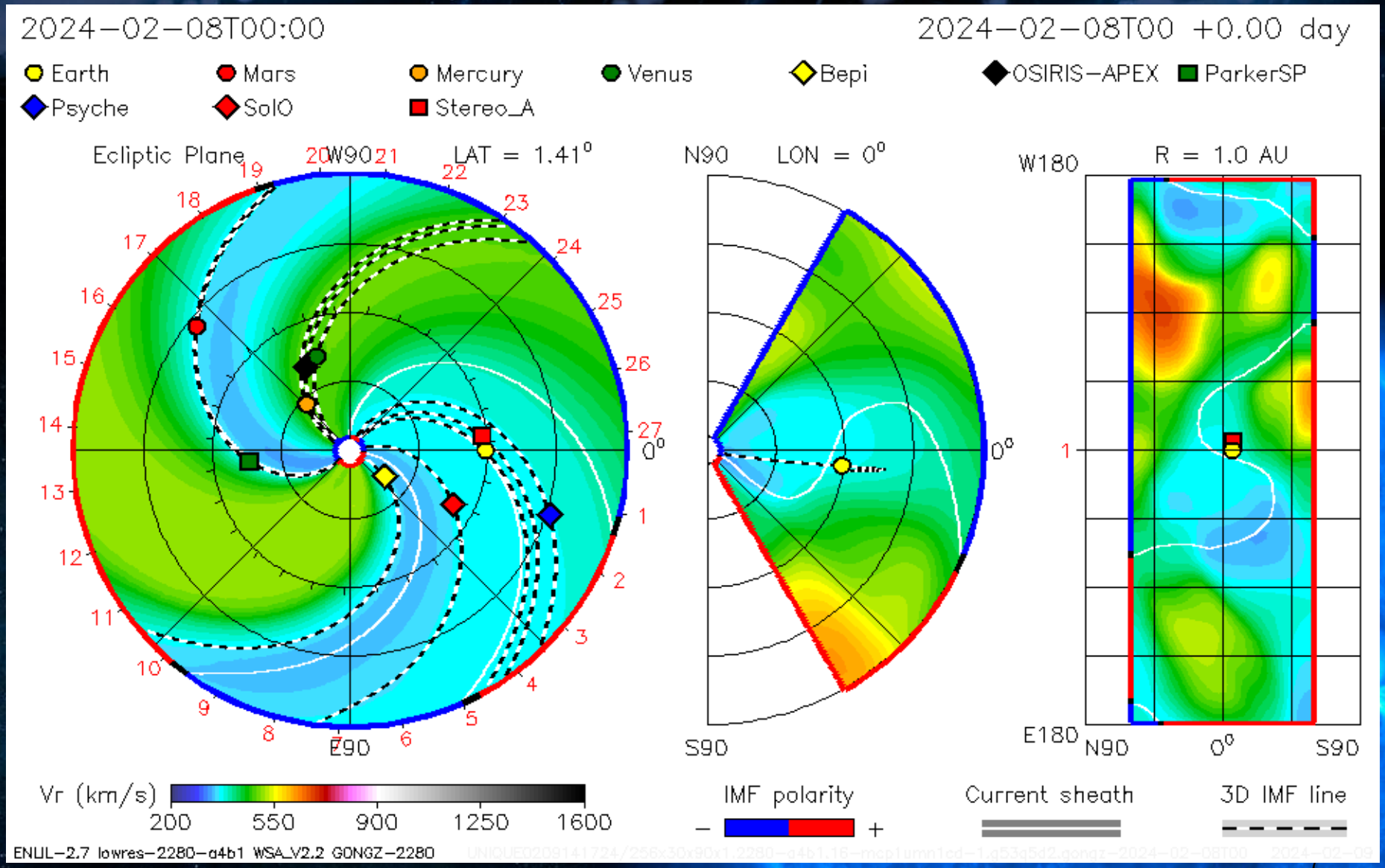

**Galactic Cosmic Rays** (GCR)
- High energy protons
- **Highly charged, energetic atomic nuclei (HZE particles)**
- Not effectively shielded against
- Abundances and energies are well known
- MAIN PROBLEM: most significant long-term space radiation hazard



# SOHO Solar Images—October 2003



# NASA Moon-to-Mars Modeling



# Human Space Flight

- ISS missions and EVAs require particular attention. Note: ***The EVA-1 hr briefing is the last opportunity to abort an EVA due to space weather. (>30 MeV events are primary concern)***


**NASA SRAG will report to Mission Control when:**

**>K6 observed *(One 3-hr period after decay)***

**>M5 observed**

**Protons (All >100 MeV events).**

- Electron belt enhancements can delay or postpone an EVA.

  Solar protons events can shut down robotic arm and cause aborts to human activities

# Space Radiation Hazards and the Vision for Space Exploration

## Report of a Workshop

Ad Hoc Committee on

the Solar System Radiation Environment

and NASA's Vision for Space Exploration: A Workshop

Space Studies Board

Division on Engineering and Physical Sciences

National Research Council of the National Academies

Radiation Risks

- Carcinogenesis
  - Leukemia
  - Solid Cancers
  - Age/Gender Differences
- Degenerative Tissue Effects
  - Heart Disease
  - Cataracts
  - Respiratory Disease
  - Digestive Diseases
- Damage to the Central Nervous
  - Motor Skills
  - Behavior
  - Accelerated Aging
- Acute Risks
  - Death
  - Vomiting/Nausea

Potential Outcomes

- Mortality: Reduced Lifespan
- Mortality: In-flight (Acute from SEP Events)
- Performance Degradation:
- Morbidity: Post-Flight

Figure 1.2

[Baker et al., ***Nat. Academy Space Radiation Report***, 2004]

# New Drivers for SWx Forecasts

## *2024-2030*

*An evolving landscape: new technologies and capabilities will drive demand for space weather products*

- Next Generation Air Transportation System
- Space Tourism
- Exploration Missions to the Moon and beyond