# Geospace Missions for Space Weather and the Next Scientific Challenges

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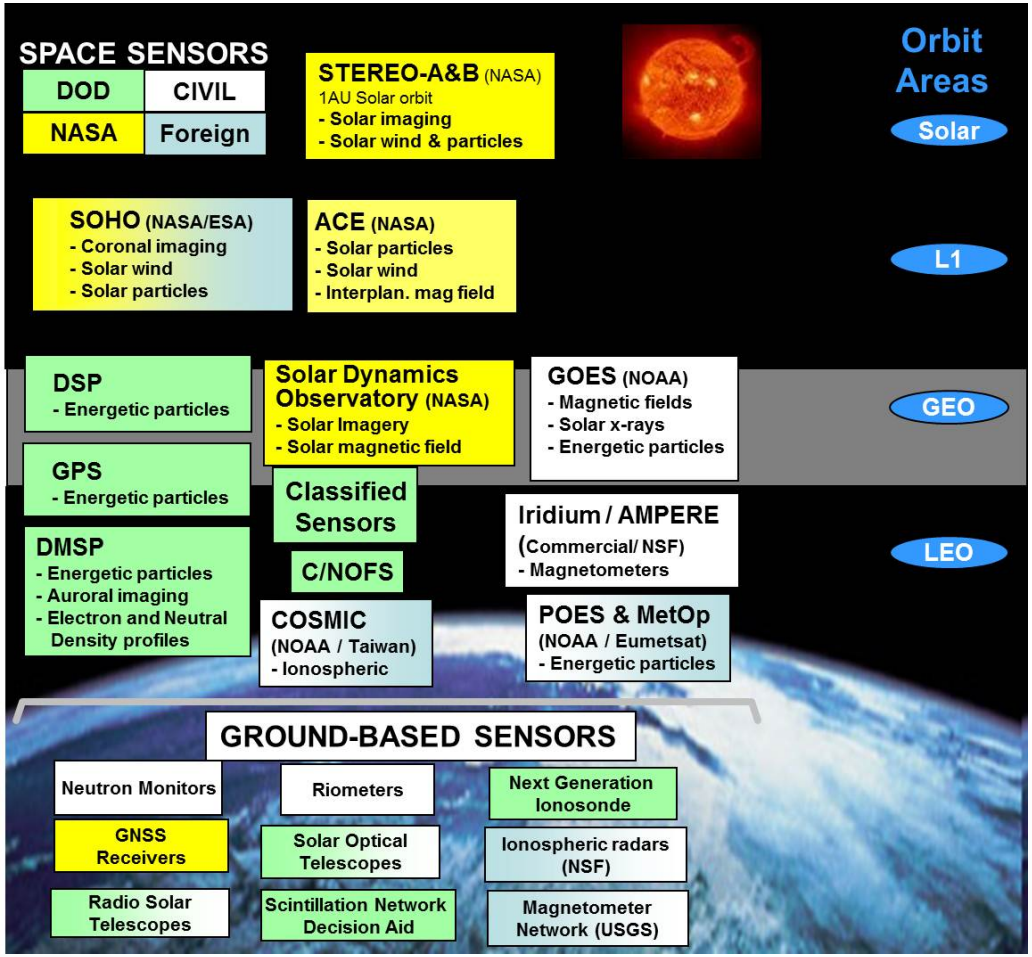
- Geospace Missions
  - Observation Requirements
  - Space-Based
  - Ground-Based
- Next Major Science Challenges
  - Geoeffectiveness of Space Storms – interplanetary magnetic field
  - Ubiquitous Impact – ionospheric variability

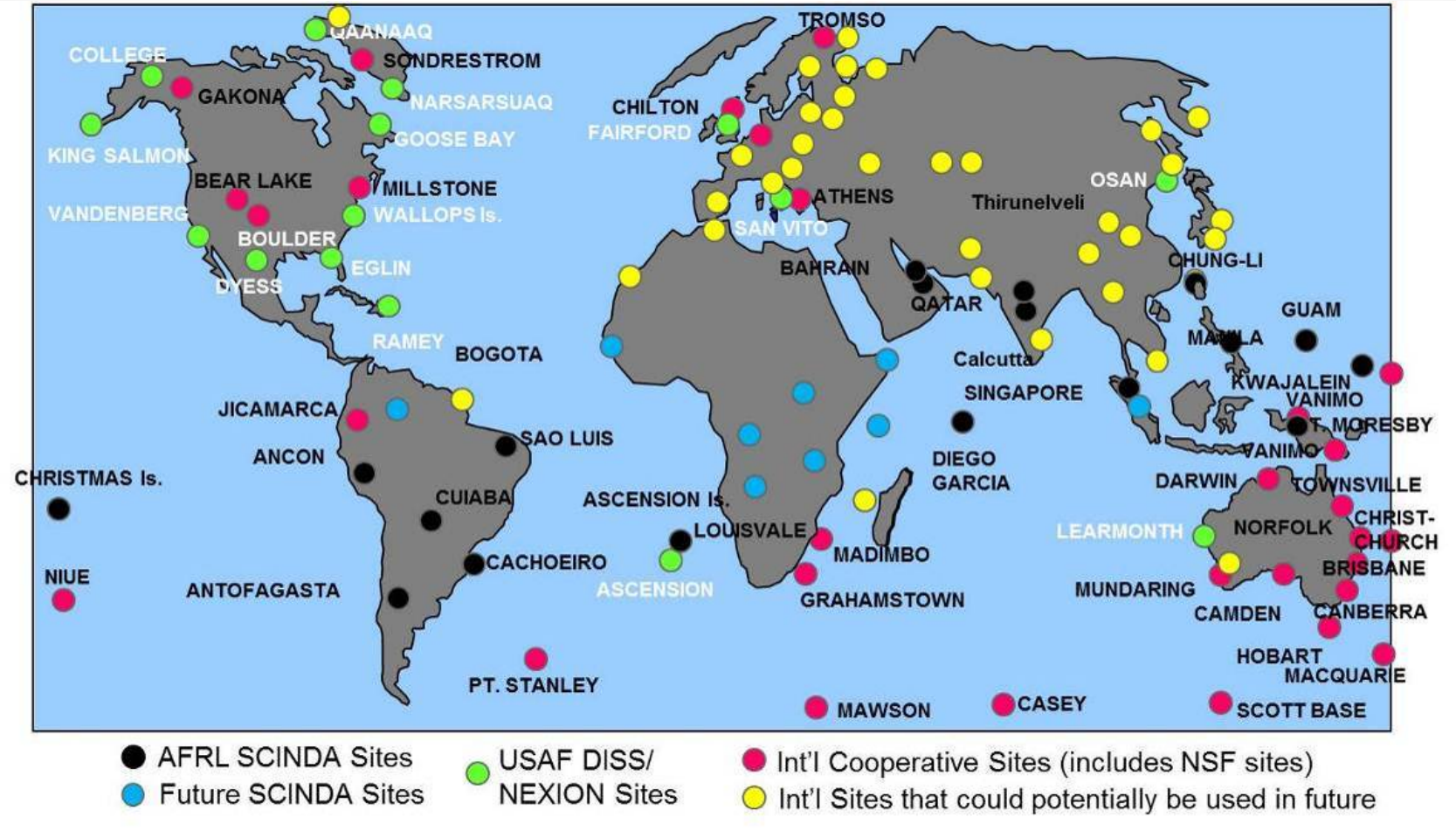
# Observation Requirements

| Solar | Heliosphere | Magnetosphere | Aurora | Ionosphere | Upper Atmosphere |
|---|---|---|---|---|---|
| Solar EUV &UV Flux | Solar Wind: 3D Mag. Field Components | Energetic Ions and Protons: Energy & Flux | Auroral Boundaries (Equatorial and Polar) | Ionospheric Scintillation: Phase and Amplitude | Mesospheric Temperature |
| Solar EUV and UV Imagery | Solar Wind Plasma Components: Composition, Density and Temperature | Medium Charged Particles: Total Flux and Energy | Auroral Energy Deposition | Plasma Fluctuations | Mesospheric Wind Speed and Direction |
| Solar Magnetic Field | Solar Wind: Speed and Direction (3D Plasma Velocity Components | Trapped Particles: Protons, Electrons, Waves | Auroral Emissions & Imagery: UV, Visible and IR | Plasma Temperature: Te & Ti Plasma Temps | Neutral Winds (Speed & Direction) |
| Solar Radio Emissions: (Total and spectral flux) | Sun-Earth line Heliospheric Imagery | Supra-thermal through Auroral Energy Particles: Diff. Dir., Energy, Flux | Precipitating Particles: Electrons; 20eV-1KeV; 1KeV-50KeV | Ionospheric Characterizations: Layer Height & Freq. | Neutral Density, Composition, and Temperature |
| Solar Radio Burst: (Location, Type, Polarization) | Off-angle Heliospheric Imagery | Magnetic Field Strength and Direction | | Energetic Ions 1-500MeV | Neutral Density Profile |
| Solar Imagery IR and Optical | Solar Wind Radio Emissions | Earth Surface Geomagnetic Fields | | Total Electron Content | |
| Solar Coronagraph | Relativistic Electrons | | | Electric Field | |
| Solar X-Ray Flux (total and discrete Freq.) | Solar High Energy Protons and Cosmic Rays | | | D Region Absorption | |
| Solar X-Ray Imagery | Off-angle Solar Wind In Situ Parameters | | | Electron Density Profile: Density, Features, Composition | |
| Off-angle Solar Imagery | | | | | |
| Helio-seismology | | | | | |

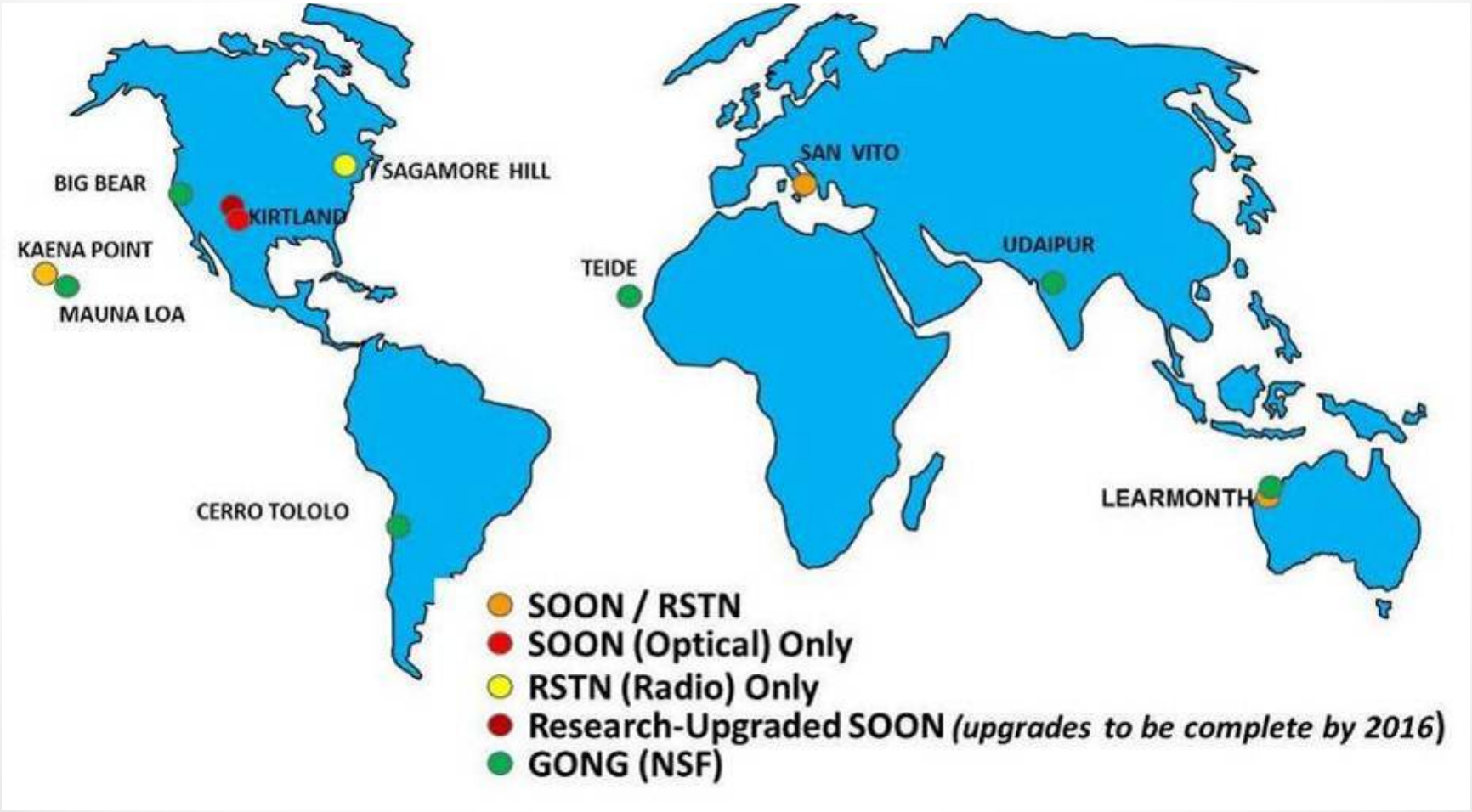
# Space Weather Observing Systems



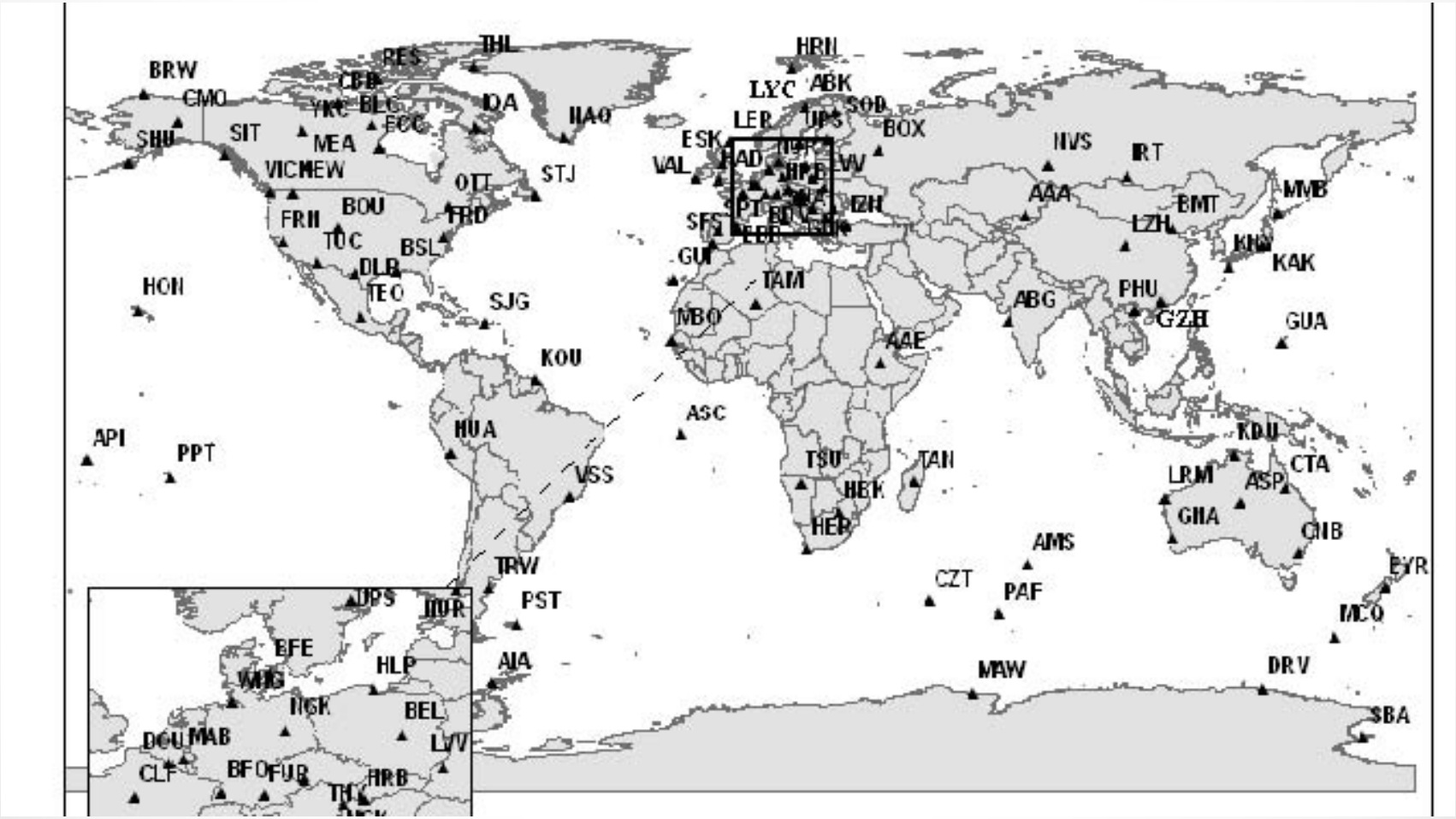
# Ground-Based Ionospheric Sensors



# Ground-Based Solar Telescopes



# INTERMAGNET Sites



# Geoeffectiveness Scientific Challenge #1

- Significant progress predicting arrival time of space storms
- How geoeffective will a storm be?
  - Sometimes yes, sometimes no
- Orientation of magnetic field is the first order determinant
- Have magnetic field orientation, and magnitude at L1 with in situ monitors
- Goal: measure the orientation of the magnetic field as it evolves on its way to Earth

# A concept to measure the inner solar system magnetic field

- Zodiacal light is scattered sunlight off interplanetary dust grains
- Dust grains rotate when illuminated, and become charged when exposed to UV and charged particles

- A rotating charged grain will align itself with mag field
- Alignment of a cloud of dust grains will produce polarized scattered light when illuminated
- Using polarimetry measurements and knowledge of optical extinction coefficient, the mag field direction can be inferred

# Ionospheric Variability Scientific Challenge #2

- Ionospheric variability is arguably the most ubiquitous of all space weather effects on society
- Understanding the nature of the variability is very difficult
- Remote observations of the variability is elusive, but possible on large and small scales
- To make progress, in situ and large scale observations are needed