# Monitoring Space Weather with iSWA

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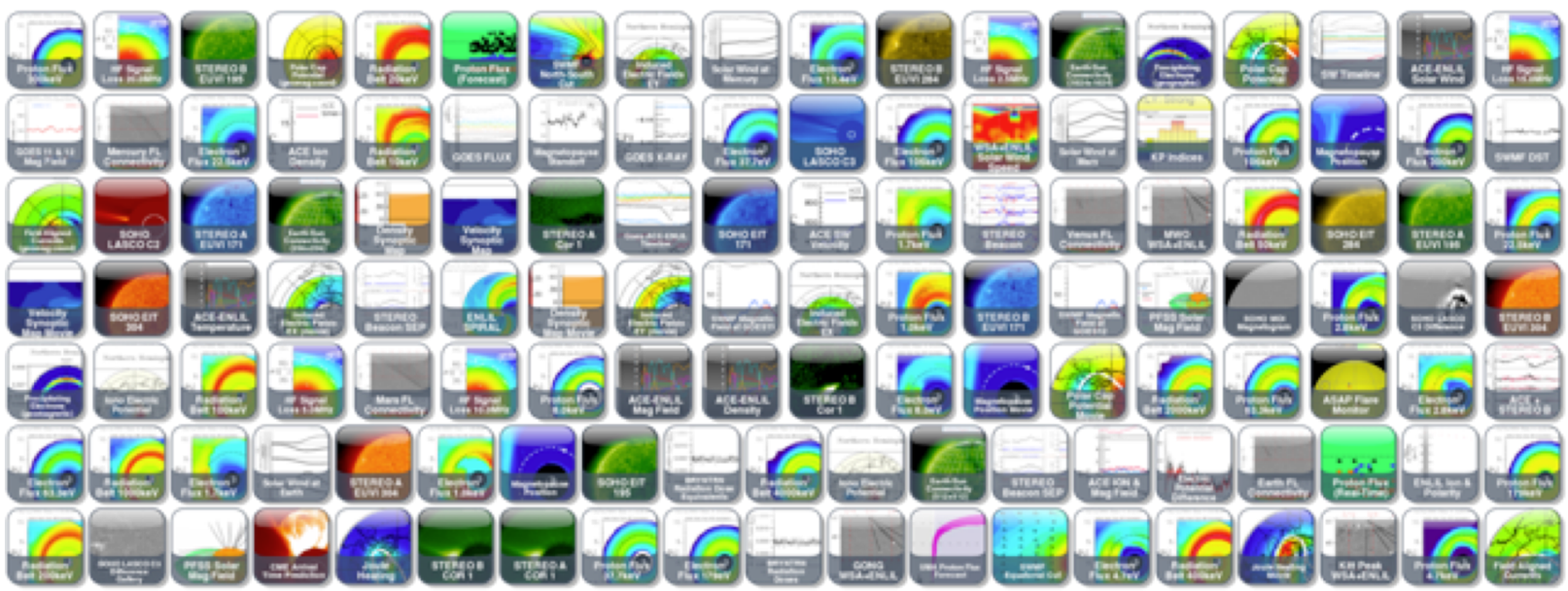
SW REDI Bootcamp 2019

Acknowledge: Alex Wold, Mary Aronne and Hayley Austin

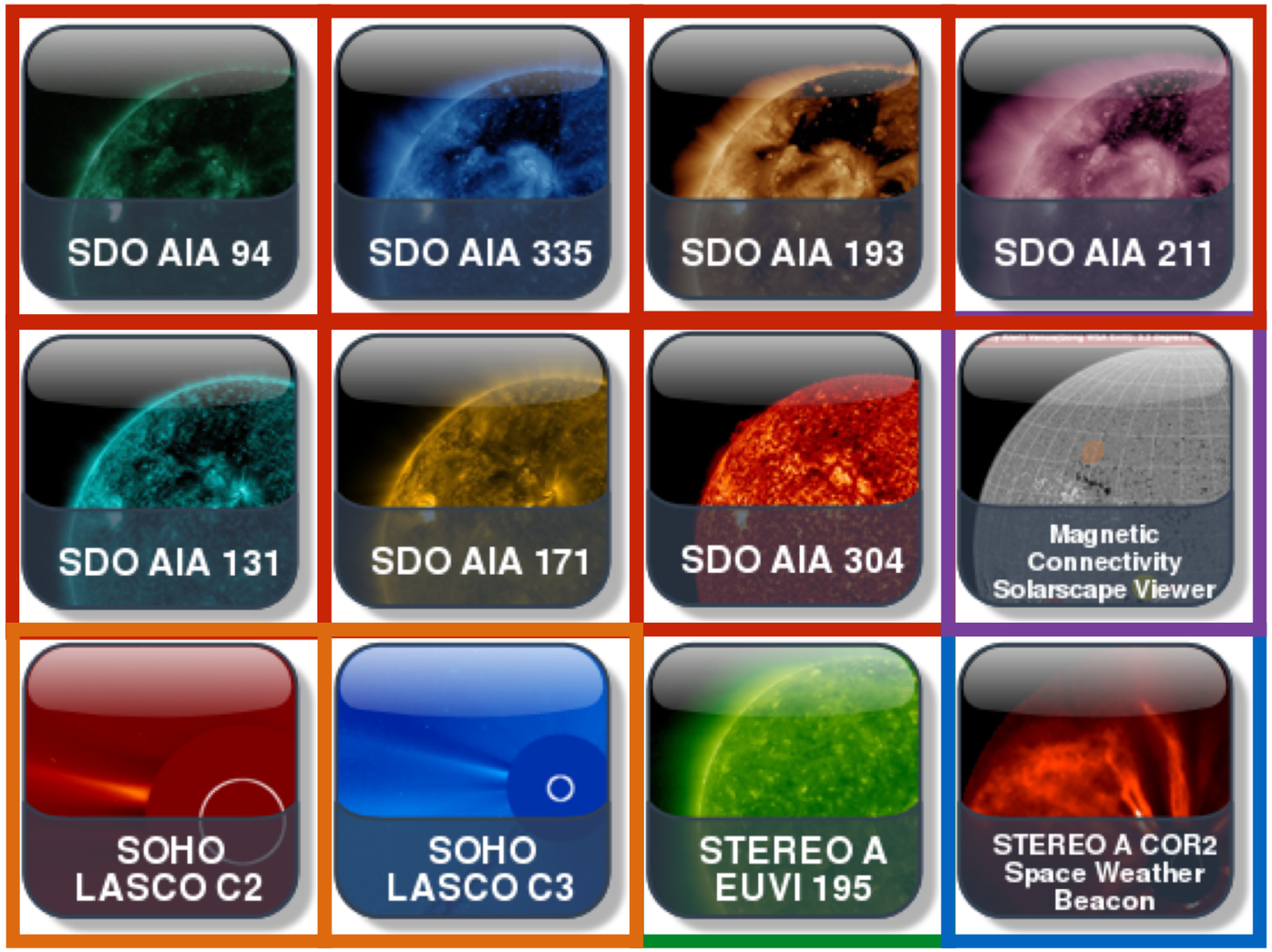
# Introduction
# Monitoring Space Weather with iSWA

- iSWA — Integrated Space Weather Analysis System
- Allows forecasters to customize a space weather monitoring layout
- https://iswa.gsfc.nasa.gov



# Introduction
# iSWA Imagers

- **SDO AIA for the earth facing solar surface**
- **SOHO LASCO coronagraphs for CMEs**
- **STEREO-A EUVI for far-sided solar surface**
- **STEREO-A coronagraphs**
- **Magnetic Connectivity Solarscape Viewer**




https://www.nasa.gov/content/goddard/how-sdo-sees-the-sun

https://www.nasa.gov/mission_pages/sunearth/news/light-wavelengths.html

# Introduction
# iSWA Graphs/Timelines

- **GOES (X-ray, Proton, & Electron Fluxes)**
- **SOHO/COSTEP Proton Flux (Real-time & Forecast)**
- **DSCOVR Solar Wind (Speed, Magnetic Field, Temperature, & Density)**
- **SWMF Magnetopause Standoff Position**
- **Kp (Observed & Predicted)**
- **STEREO Beacon (Solar Wind & SEPs)**
- **…and more!**

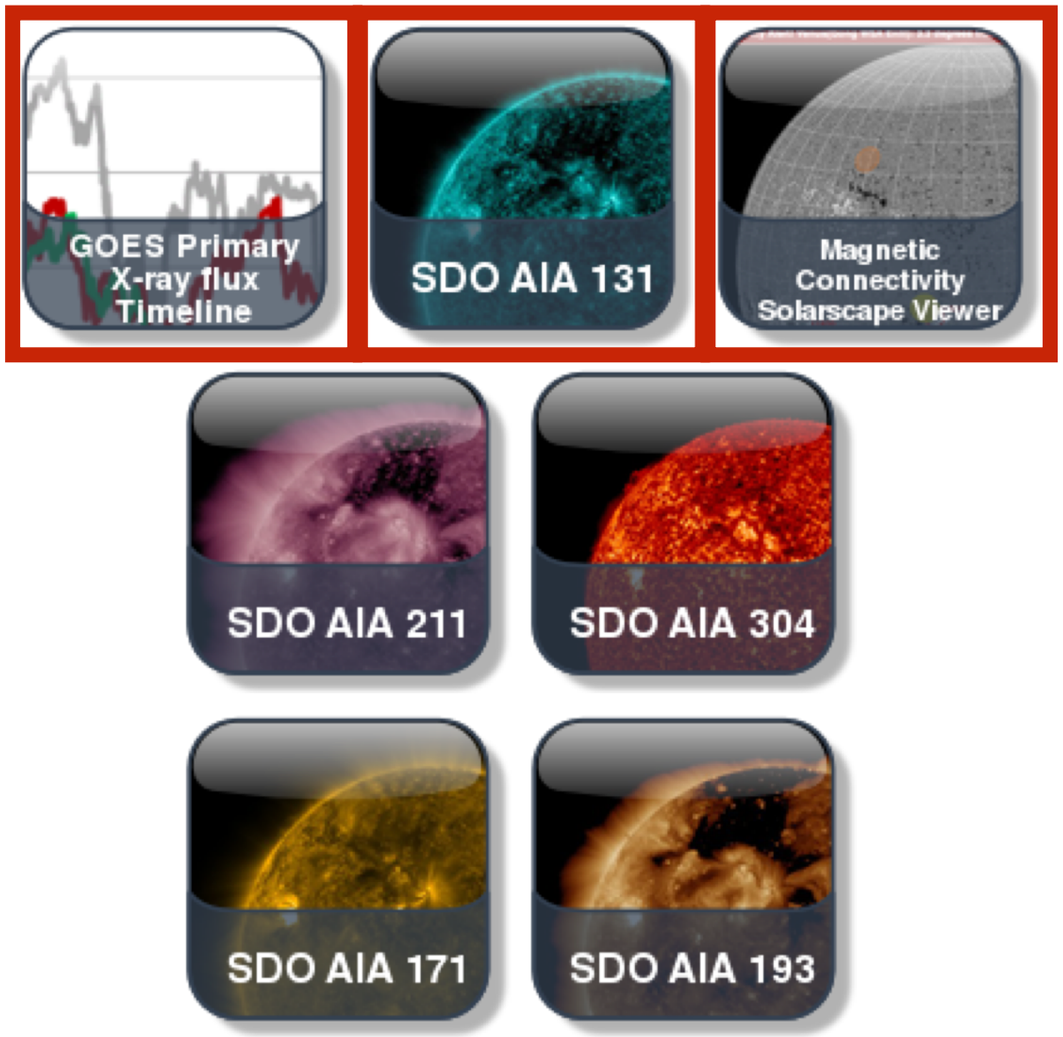

Super Timeline under ‘bETA’ tab

# Outline

- Solar Cygnets
  - Monitoring flares, eruptions, & CMEs
- Heliosphere Cygnets
  - Monitoring solar energetic particles, CME arrivals, and high speed stream arrivals
- Magnetosphere Cygnets
  - Monitoring geomagnetic storms, radiation belt enhancements, and magnetopause crossings
- Demonstration
  - Following the course of the June 21st 2015 CME

# Solar Cygnets:
# Solar Flares

- **GOES 0.1-0.8 nm X-rays — flares**
  - **Threshold: $5 \times 10^{-5}$ W/m$^2$ (M5.0)**
- SDO AIA imagery — flares, eruptions, & coronal holes
  - 193 Å — 1 million Kelvin, EUV waves, dimming, post-eruption arcades, off limb (field lines), coronal holes
  - 171 Å — off limb (field lines), post-eruption arcades
  - **131 Å — flares (10 million Kelvin)**
  - 211 Å — 2 million Kelvin, active region (coronal holes)
  - 304 Å — 50K kelvin, filaments
- **Magnetic Connectivity Solarscape Viewer**
  - **SDO backgrounds, lat/lon grid, active region labels, and magnetic connectivity**




A strong flare can exhibit signatures in all wavelengths
e.g, the X9 class flare on 2017-09-06

# Solar Cygnets: Eruptions & Coronal Holes

- **GOES 0.1-0.8 nm X-rays — flares**
  - **Threshold: $5 \times 10^{-5}$ W/m$^2$ (M5.0)**
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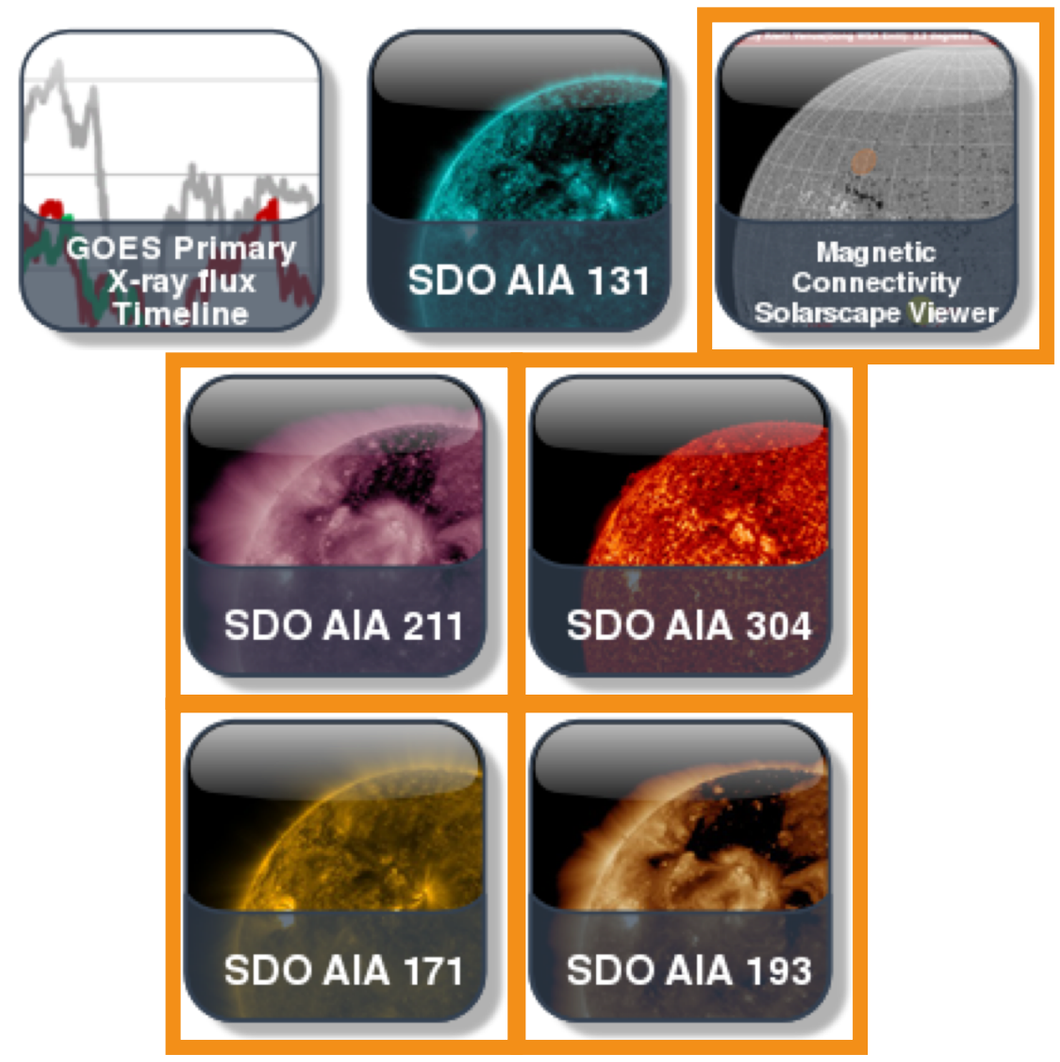

# Solar Cygnets:
# Coronal Mass Ejections (CMEs)

- **SOHO LASCO C2 & 3 imagery — CMEs**
  - **C2 — 1.5 to 6 solar radii**
  - **C3 — 3.7 to ~30 solar radii**
  - **Threshold: measured >=500 km/s and modeled to impact Earth OR measured >= 800 km/s and modeled to impact other location**
  - **Any CME heading towards Parker Solar Probe**
- STEREO A EUVI 195 Å imagery — flares, eruptions, & coronal holes
- STEREO A COR2 imagery — CMEs
  - Threshold: measured >=500 km/s and modeled to impact Earth OR measured >= 800 km/s and modeled to impact other location
  - Any CME heading towards Parker Solar Probe
- www.SolarMonitor.org (not on iSWA)
  - lat/lon grid and active regions

# Solar Cygnets: STEREO-A

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  - **C2 — 1.5 to 6 solar radii**
  - **C3 — 3.7 to ~30 solar radii**
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  - **Any CME heading towards Parker Solar Probe**
- STEREO A EUVI 195 Å imagery — flares, eruptions, & coronal holes
- STEREO A COR2 imagery — CMEs
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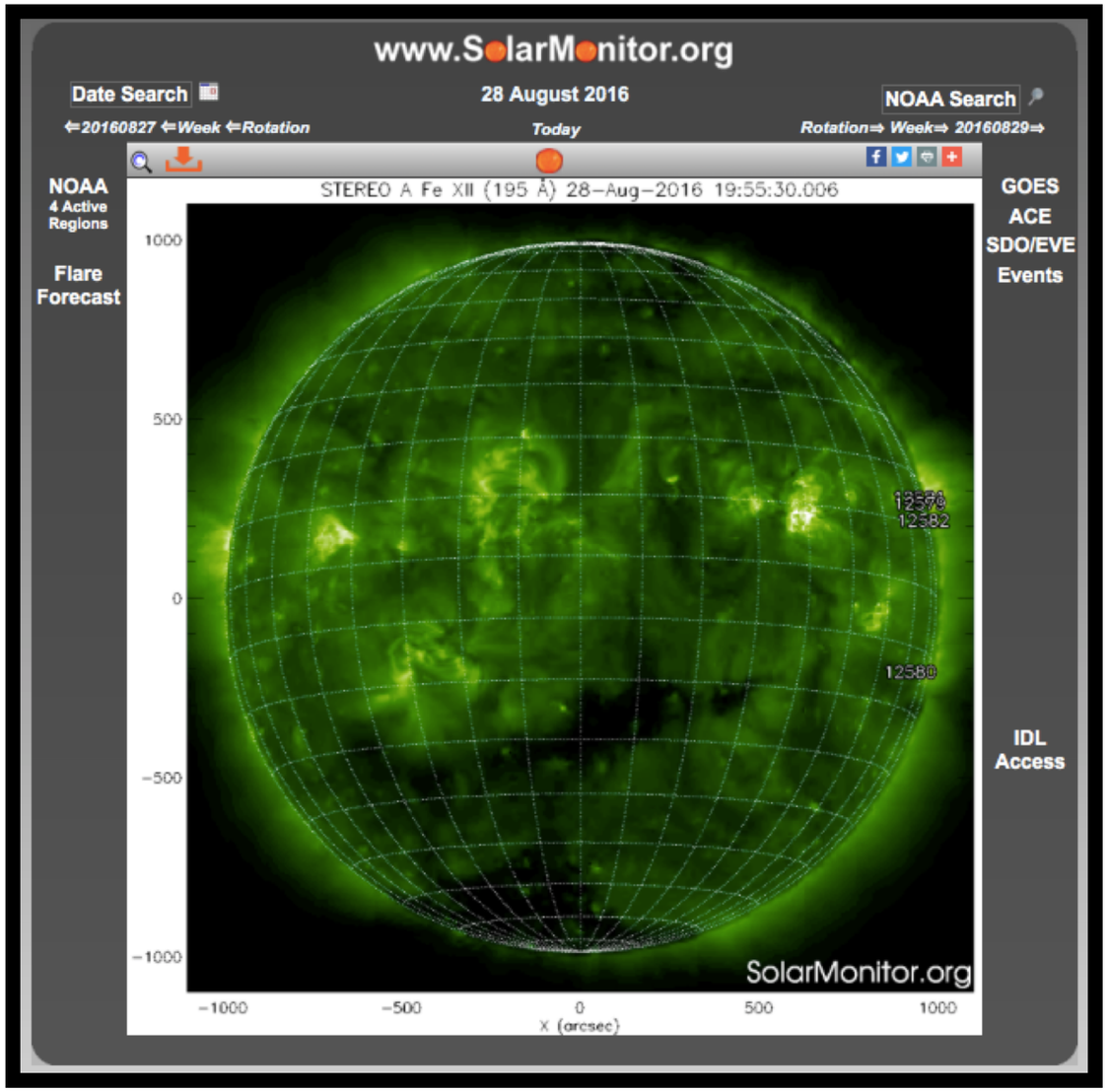
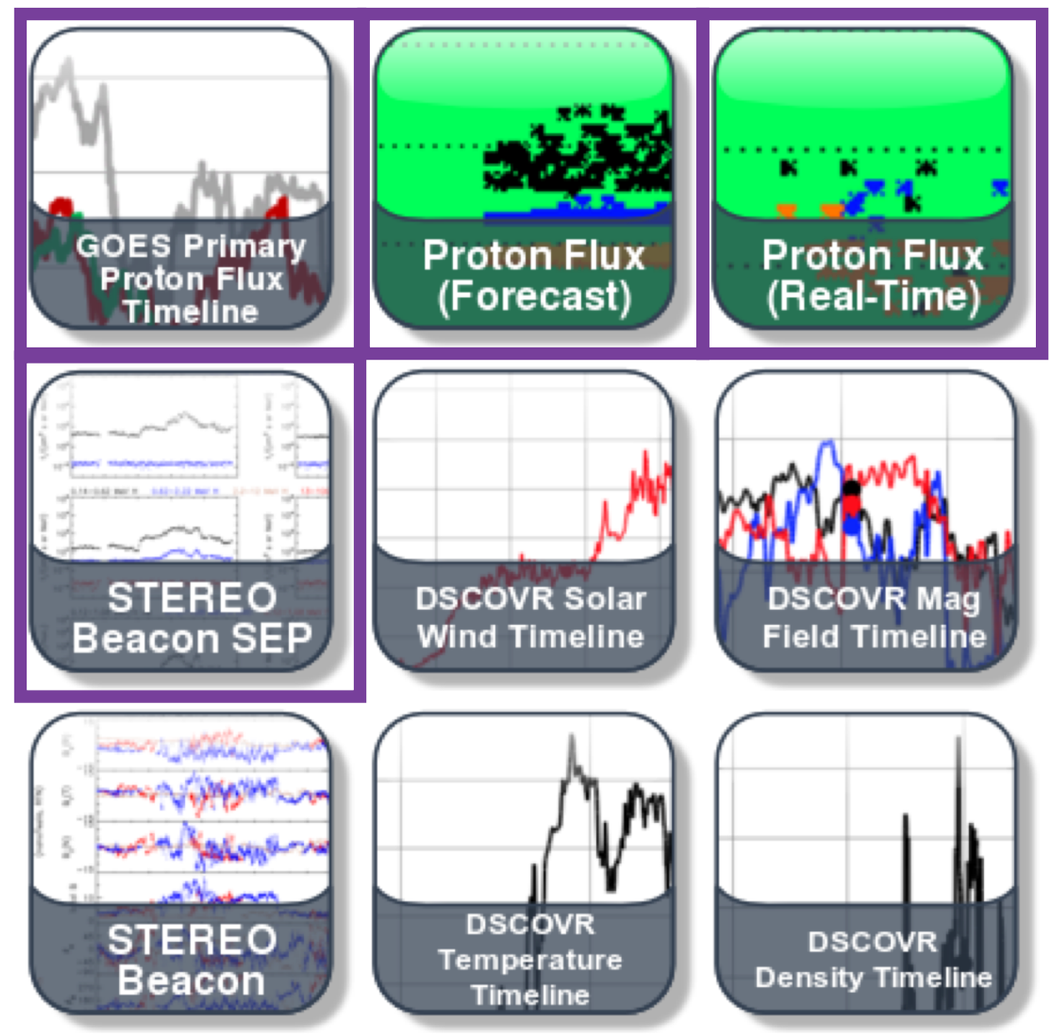


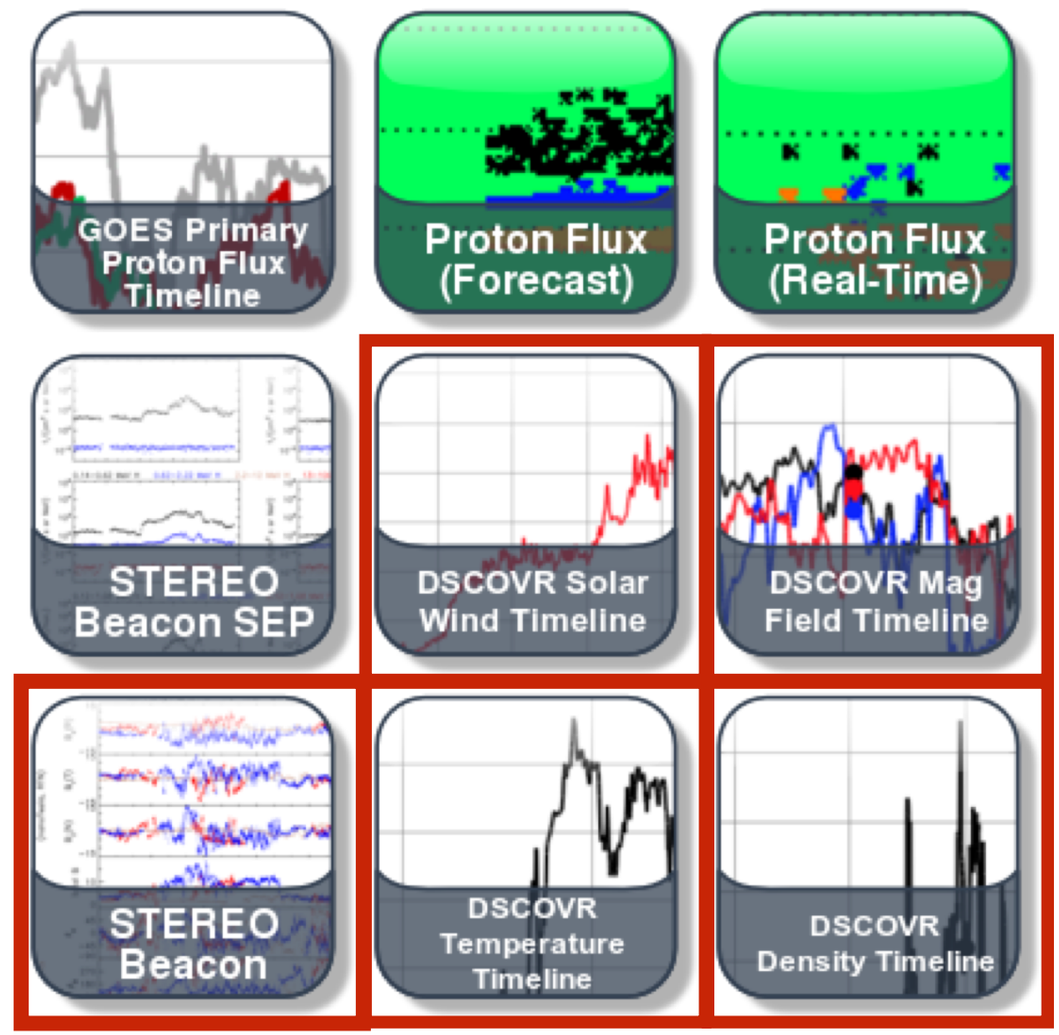
# Heliosphere Cygnets: Solar Energetic Particles

- GOES > 10 MeV and > 100 MeV protons
  - Threshold: > 10 MeV above 10 pfu and/or > 100 MeV above 1 pfu
- SOHO COSTEP > 15.8 MeV proton channels
  - Threshold: 10^(-1) pfu/MeV
- RELEASE forecast for > 15.8 MeV proton channels
  - Threshold: 10^(-1) pfu/MeV
- STEREO A and B 13-100 MeV protons
  - Threshold: 10^(-1) pfu/MeV



# Heliosphere Cygnets: Interplanetary Shocks/Arrivals

- **DSCOVR/ACE**
  - **speed, magnetic field, temperature, & density**
  - **Threshold: significant shock passage at L1 (about >=10 nT amplitude jump)**
- **STEREO A IMPACT/PLASTIC**
  - **speed, magnetic field, temperature, & density**



# Magnetosphere Cygnets: Geomagnetic Storms

- **Kp index**
  - **level (0 to 9) of geomagnetic activity in the Earth's magnetosphere**
  - **Threshold: >=6 (or larger than previous alert)**
- GOES > 0.8 MeV electrons
  - state of the Earth's outer radiation belt
  - Threshold: $10^5$ pfu (or 70-80 % from the threshold two days after)
- Modeled magnetopause standoff distance
  - location of the boundary between magnetospheric and solar wind plasma
  - Threshold: 6.6 Re

# Magnetosphere Cygnets: Radiation Belt Enhancement

- Kp index
  - level (0 to 9) of geomagnetic activity in the Earth's magnetosphere
  - Threshold: >=6 (or larger than previous alert)
- **GOES > 0.8 MeV electrons**
  - **state of the Earth's outer radiation belt**
  - **Threshold: $10^5$ pfu (or 70-80 % from the threshold two days after)**
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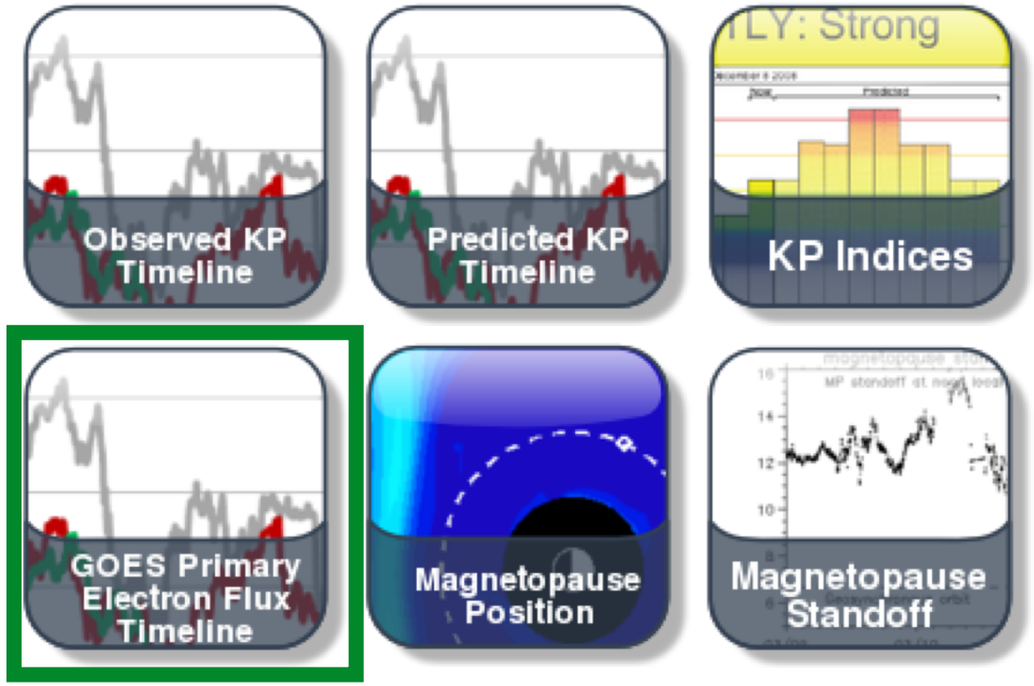
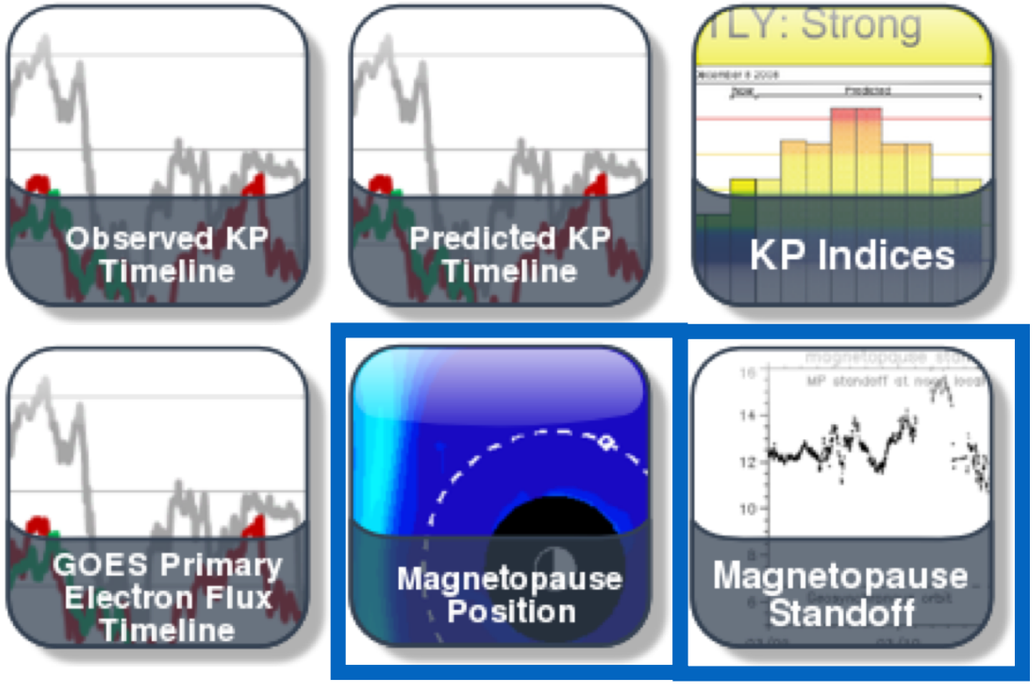


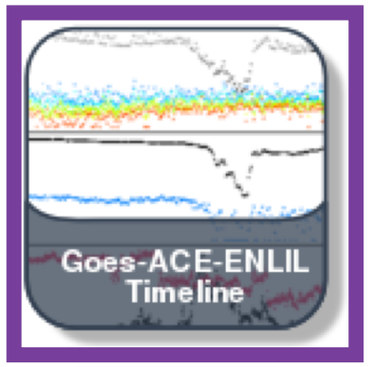
# Magnetosphere Cygnets: Magnetopause Crossing

- Kp index
  - level (0 to 9) of geomagnetic activity in the Earth's magnetosphere
  - Threshold: >=6 (or larger than previous alert)
- GOES > 0.8 MeV electrons
  - state of the Earth's outer radiation belt
  - Threshold: $10^5$ pfu (or 70-80 % from the threshold two days after)
- **Modeled magnetopause standoff distance**
  - **location of the boundary between magnetospheric and solar wind plasma**
  - **Threshold: 6.6 Re**



# Other Useful Cygnets

- **CCMC SWAN Space Weather Timeline Ensemble**
  - **Quick check of flare, SEP, radiation belt, and solar wind conditions**
- iSWA Super Timeline
  - Make interactive plots of static cygnets
  - Plot SWMF Magnetopause Standoff Position with geosynchronous orbit
  - Plot CCMC-Predicted Kp with NOAA-Kp

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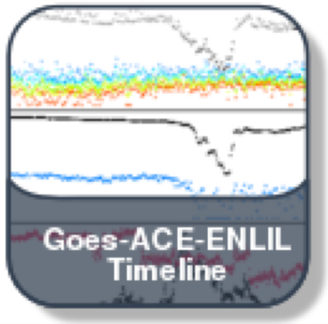


# Activities

- iSWA basics demo
  - adding cygnets and navigating category tabs, using the super timeline, setting time periods locally and globally, and saving your layout
  - Event walkthrough/chain of events