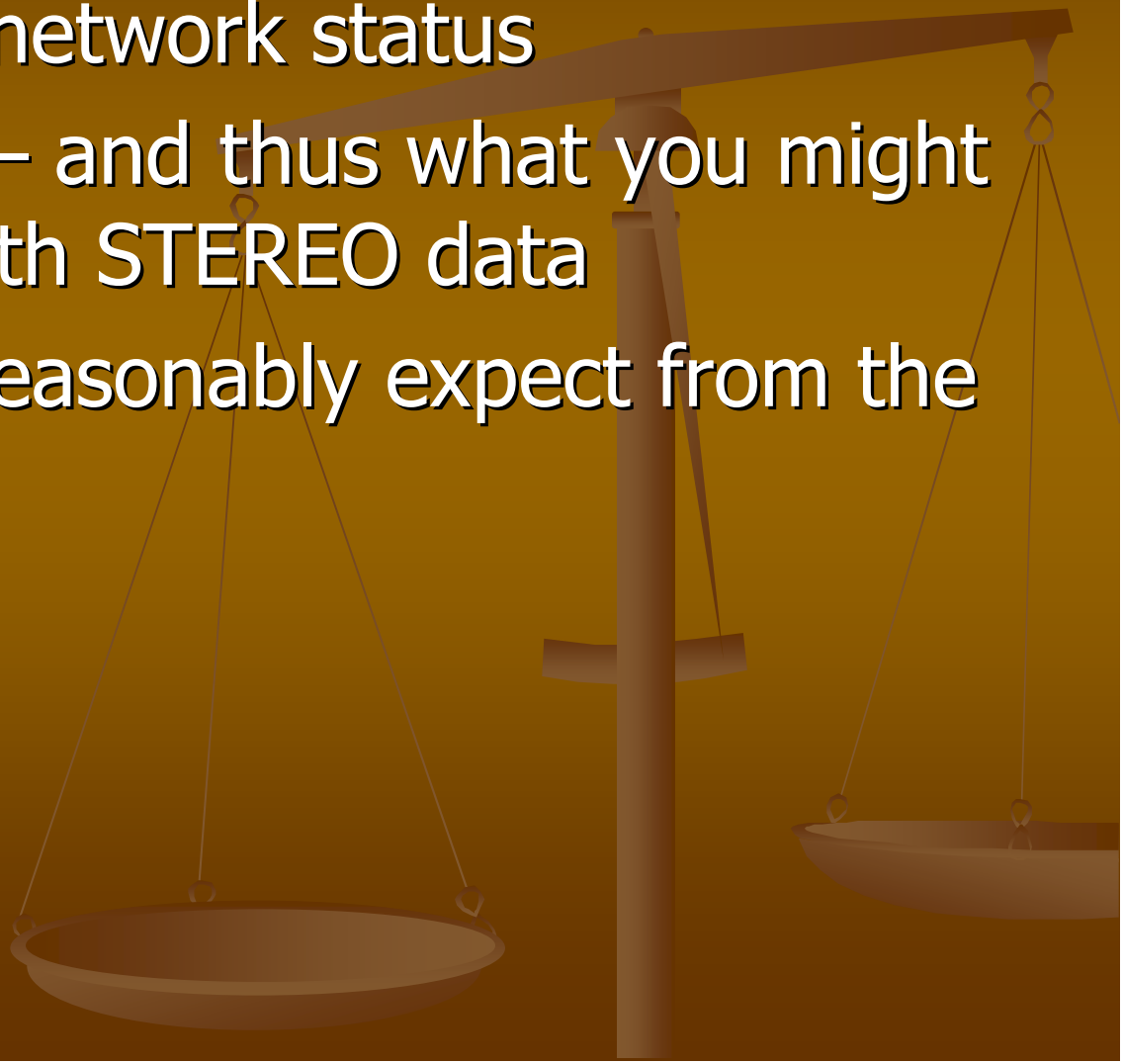
STEREO Space Weather Beacon:
March 2004

D.A. Biesecker

NOAA/SEC

Outline

- Ground station network status
- SEC's priorities – and thus what you might choose to do with STEREO data
- What SEC can reasonably expect from the STEREO data



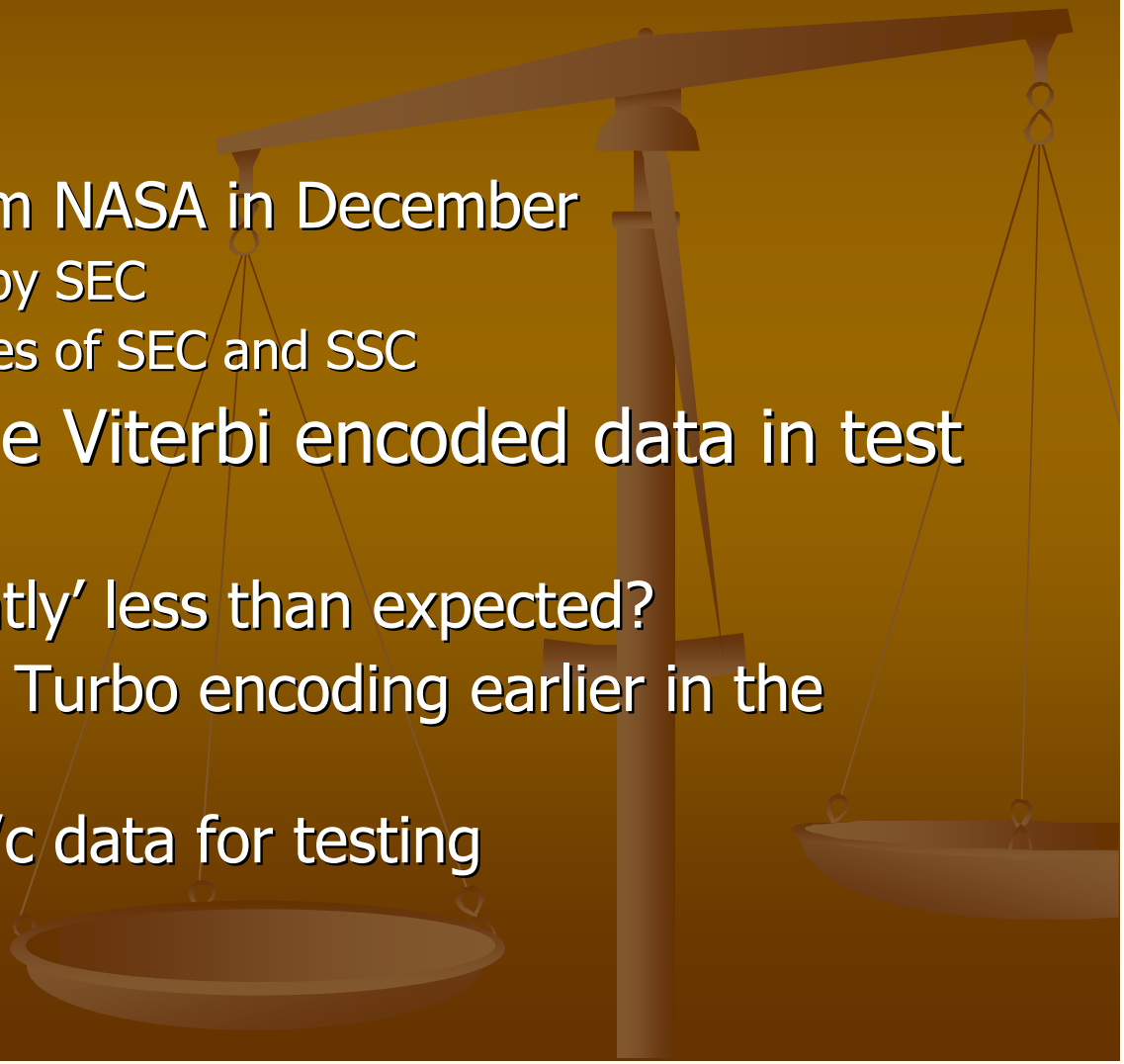
Ground Station Partners

- Earliest Beacon Mode operation April, 2006
  - End of phasing for 'B' s/c ~ 60 days after launch
- None have yet signed on the bottom line
  - Moving along nicely
    - Probables would give us the coverage we need
    - Looking for redundancy wherever possible
  - Probables are NOAA (Fairbanks), NOAA (Wallops)*, RAL* (UK), CNES (France), and CRL (Japan)
  - Possible is USAF (California), ACRES (Australia), NOAA (Boulder)*
  - Others?
  - * primary tracking target is ACE

Ground Station Particulars

- NOAA/Wallops and NOAA/Fairbanks (13m)
  - Formal request not yet made – needs to be a high priority
  - Informal contacts indicate antenna availability likely
- CNES (9m near Toulouse)
  - Should receive confirmation soon
  - Performance of antenna recently tested and additional upgrades being considered to increase link margin
  - Technical exchange on-going
- RAL (12m, 2.4m and 3.7m)
  - ACE is primary here – use smaller dishes for ACE?
- CRL (6m) – now 7m
  - Expect decision on funding on April 1, 04. Preliminary word is favorable
  - Valley Forge (PA) Composite Technologies building new antenna
    - Technical exchange to start when budget approved

Other beacon issues

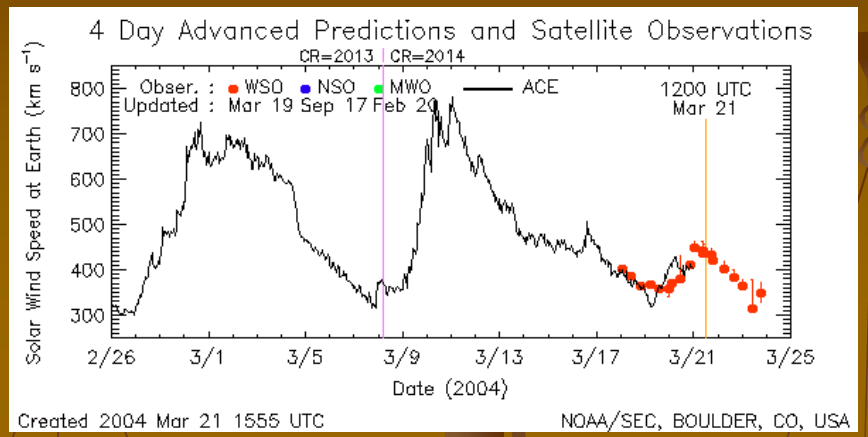


- MOU with NASA
  - Draft received from NASA in December
    - Still needs action by SEC
    - Formalizes the roles of SEC and SSC
- Software to decode Viterbi encoded data in test (Phil Karn)
  - Performance 'slightly' less than expected?
  - Might force use of Turbo encoding earlier in the mission
  - Still need actual s/c data for testing

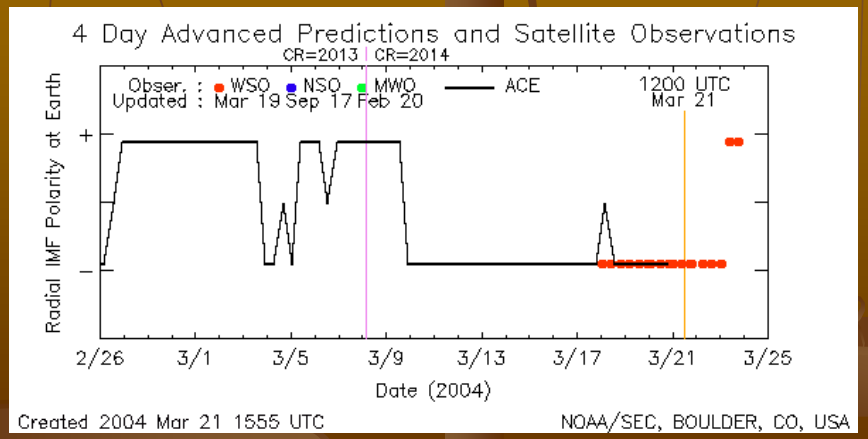
N. Arge promises the following from Wang-Sheeley work

- Given the s/c position in heliographic coord.
  - Solar wind and IMF radial polarity (Bx) forecasts (1-7 days)
- In time for STEREO?
  - |B|, density, other B components

Predicted Solar Wind Speed at Earth

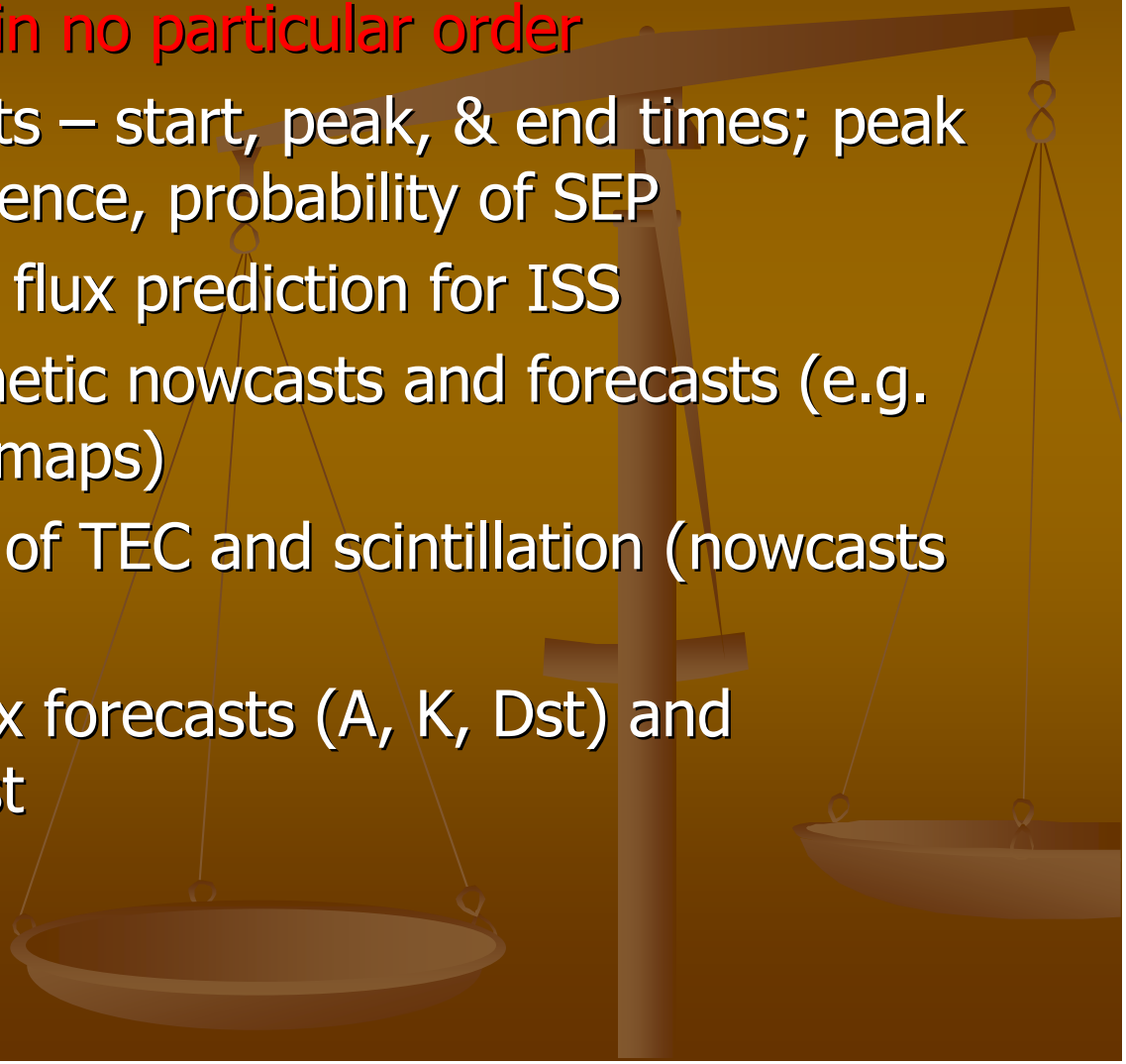


Predicted IMF Polarity at Earth



SEC's Identified Needs: I

- Highest priority – in no particular order
  - SEP event forecasts – start, peak, & end times; peak flux, spectrum, fluence, probability of SEP
  - Energetic electron flux prediction for ISS
  - Regional geomagnetic nowcasts and forecasts (e.g. Auroral electrojet maps)
  - Ionospheric maps of TEC and scintillation (nowcasts and forecasts)
  - Geomagnetic index forecasts (A, K, Dst) and probability forecast



SEC's Identified Needs: II

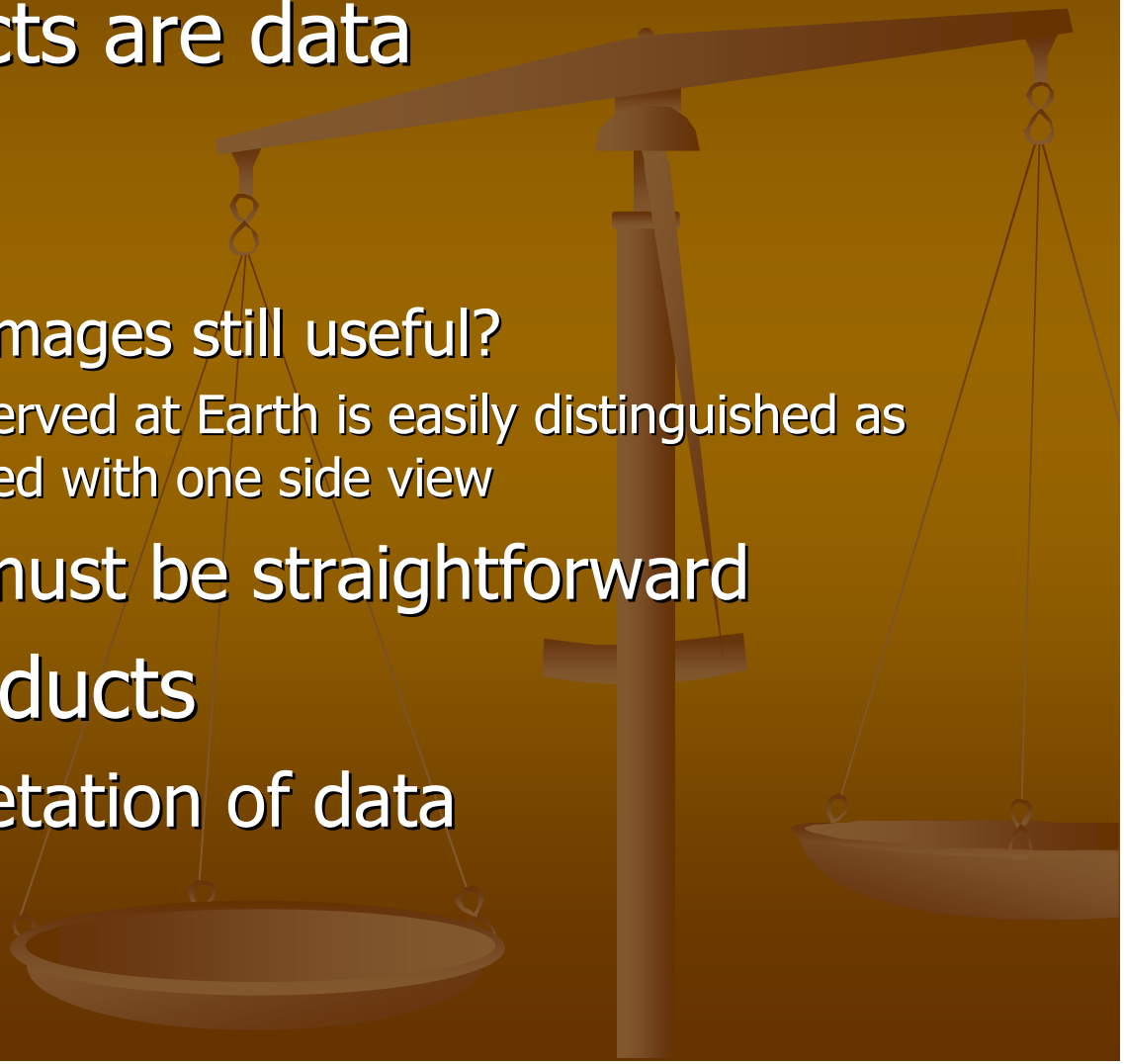
- High Priority – in no particular order
  - Geomagnetic activity predictions (1-7 days): CME's, coronal holes, solar magnetic observations; and ACE/EPAM
  - Geomagnetic storm end time forecast
  - Real-time estimates of geomagnetic indices
  - Improved image analysis capability (e.g. SXI, STEREO, SMEI)
  - Short-term (days) F10.7 forecast
  - Short-term (days) X-ray flare forecast
  - Geosynch. magnetopause crossing forecasts
  - EUV index
  - Real-time quality diagnostics (verification) of all warning/watch/forecast products
  - Routine statistical/numerical guidance for all forecast quantities

NOAA/SEC use of STEREO

- Based on success of transitioning missions such as ACE and SOHO into operations; expectations are high
  - Most important lesson is probably the time it took to integrate into forecast center
  - Expect STEREO to be faster just because we'll receive beacon data from start
    - It needs to be faster due to changing geometry and thus changing capabilities

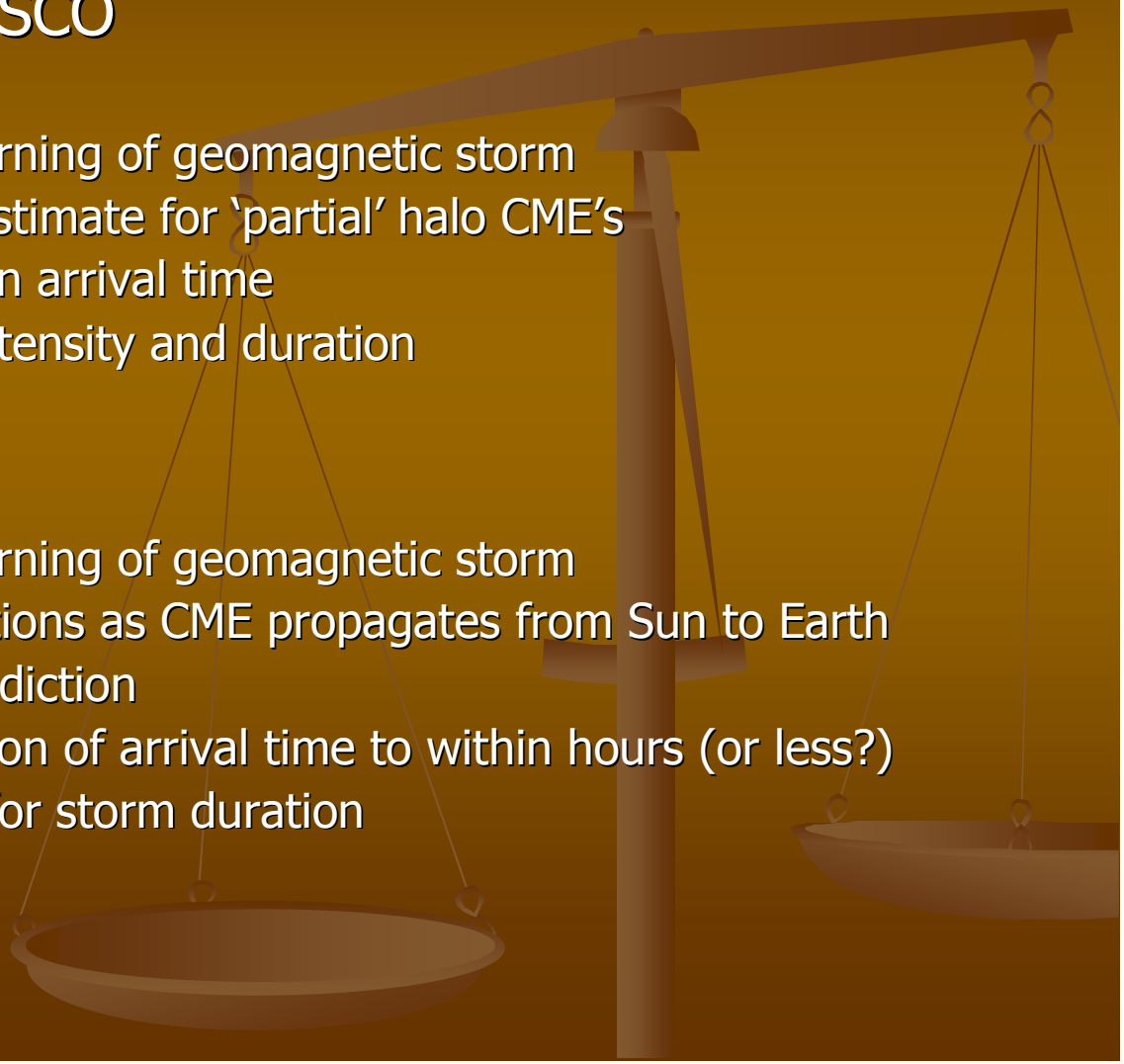
Transition to operations

- `Easiest' products are data
  - How to display
    - 3-d graphics
    - Single s/c 2-d images still useful?
      - Halo CME observed at Earth is easily distinguished as front/back sided with one side view
  - Interpretation must be straightforward
- Higher level products
  - Require interpretation of data



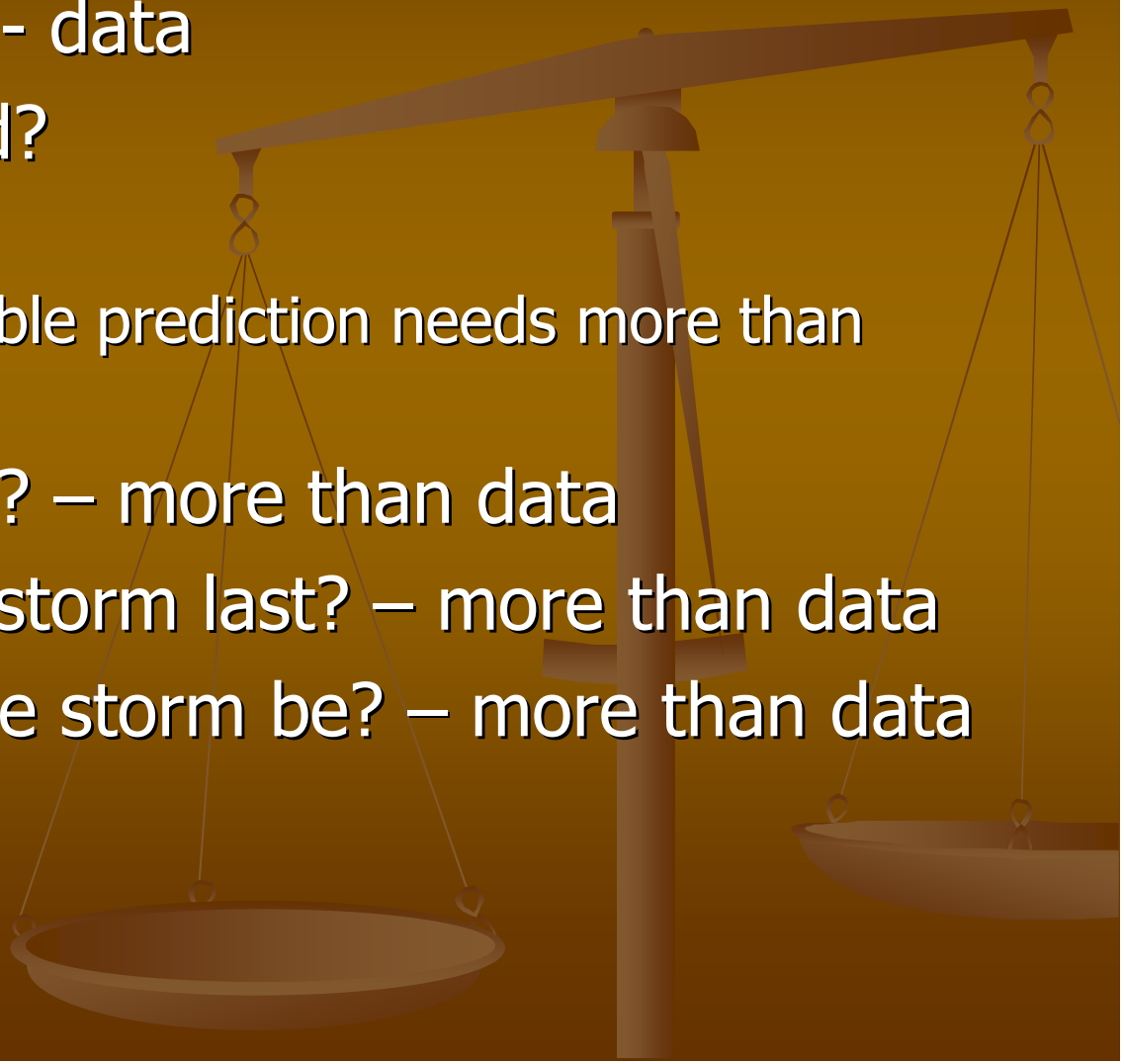
Coronal Mass Ejections

- Currently – SOHO/LASCO
  - Halo CME's
    - 1-3 day advance warning of geomagnetic storm
    - Uncertain hit/miss estimate for 'partial' halo CME's
    - error of ±11 hours in arrival time
    - rough estimate of intensity and duration
- STEREO
  - 3-d views of CME's
    - 1-3 day advance warning of geomagnetic storm
    - Continuous observations as CME propagates from Sun to Earth
    - Reliable hit/miss prediction
    - Potential for prediction of arrival time to within hours (or less?)
    - Improved estimate for storm duration



e.g. CME related geomag storm

- Did a CME occur? - data
- Is it Earth directed?
  - Halo – data
  - Partial halo – reliable prediction needs more than data
- When will it arrive? – more than data
- How long will the storm last? – more than data
- How strong will the storm be? – more than data



STEREO beacon CME detection

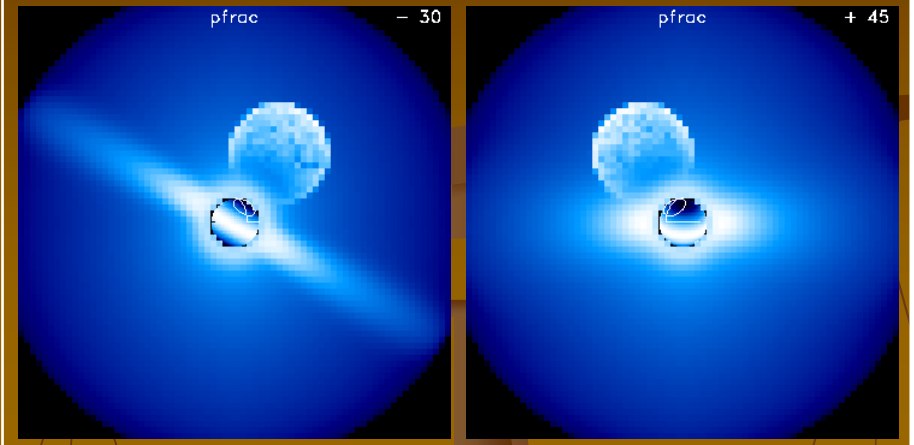
OVERVIEW

Objective:
Use near-real-time STEREO beacon data to infer direction, speed, extent, and mass of Earth-directed CMEs

Application:
Advance warning of oncoming CMEs affecting geospace

Forecast Gain:
Immediate, High

GRAPHIC



APPROACH

Strategy:
Forward modeling study to develop understanding of stereo images, then construction of ops analysis tools

Uniqueness:
Only N-R-T beacon analysis underway, is based upon triangulation

Context:
Complements tomographic approaches

PROGRAMMATICS

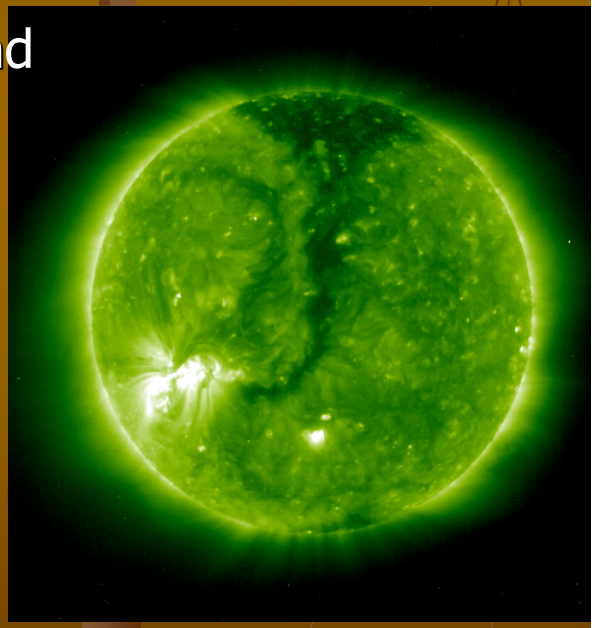
Resources Needed:
0.2 FTE level of effort

Development Time:
2-3 years at 0.2 FTE

Current Status: Basic LOS routines done, analysis not yet started

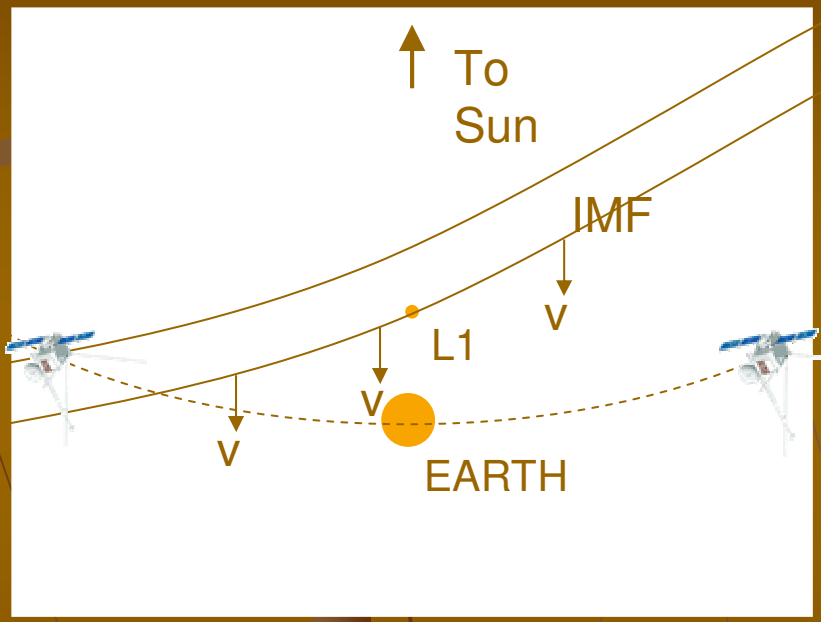
Recurring Solar Wind Streams

- Currently
  - For first time stream – estimate from longitude
  - Recurring stream – use previous occurrence and changes in coronal hole since then – 27 days
- STEREO – Lagging spacecraft
  - Use actual observation from ~few days earlier
  - Improved start time of high speed wind
  - Improved end time of high speed wind
  - Determination of high speed wind properties (*e.g.* velocity)



Solar Wind Discontinuities (and more)

- Currently
  - In-situ observation at L1
  - ~1 hour warning of
    n, V, B

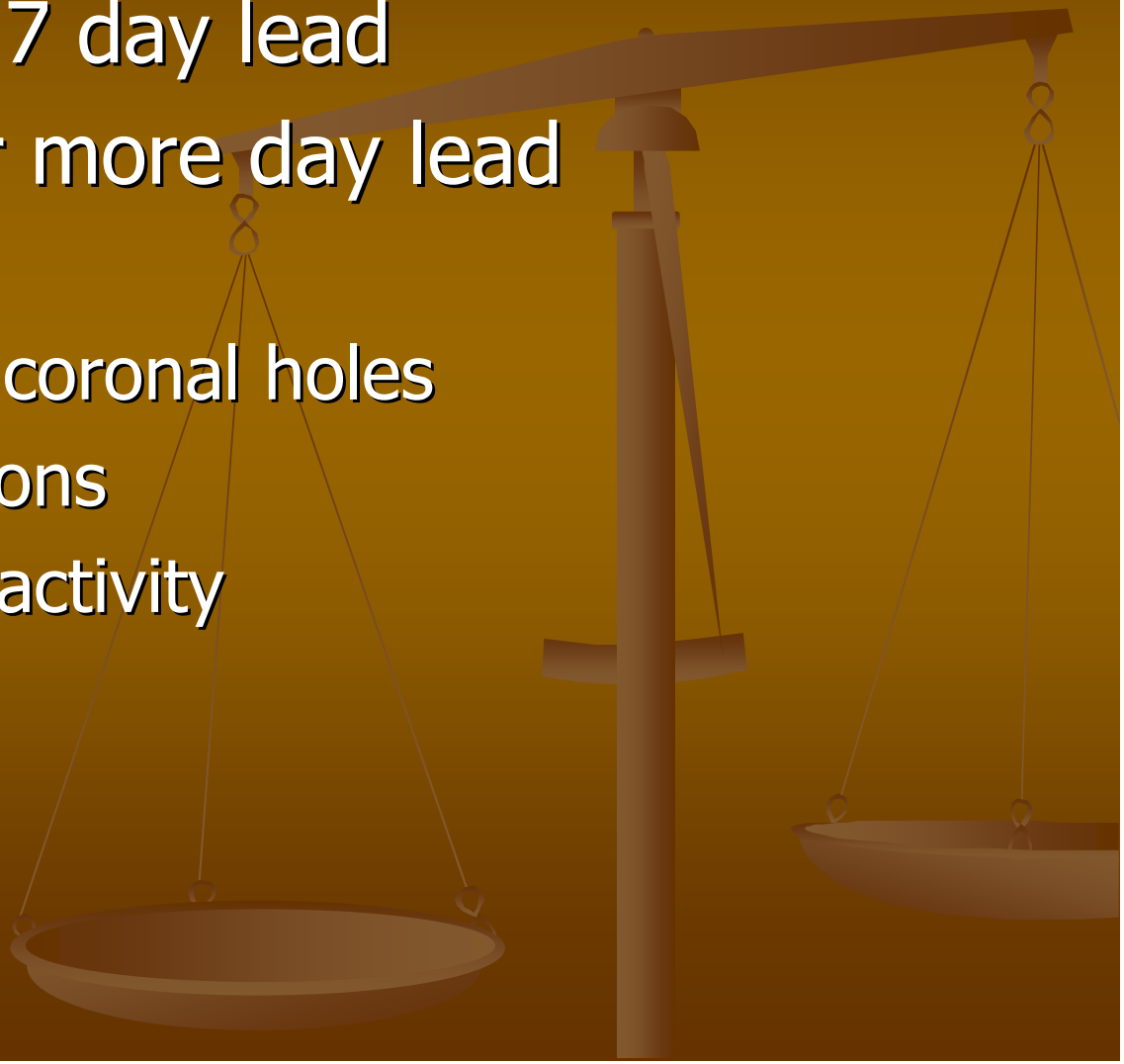


- STEREO
  - Either spacecraft, depending on heliosphere
    - May potentially provide ~ 1 day warning of V, B

    Weimer *et al.* (2003)

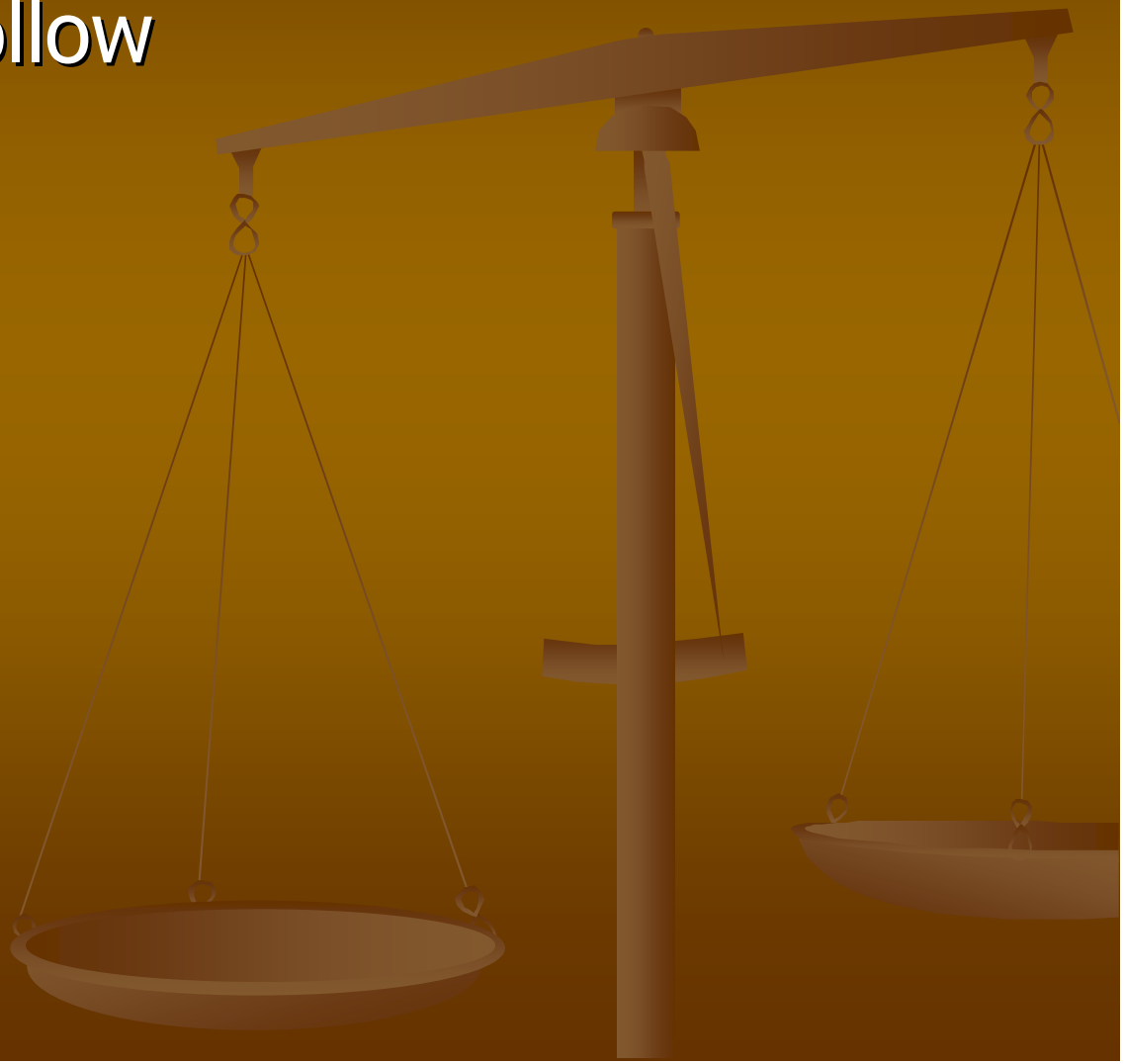
Long-term Forecasts

- Current – up to 7 day lead
- STEREO – 14 or more day lead
  - EUV Flux
  - New equatorial coronal holes
  - New active regions
  - Level of flaring activity



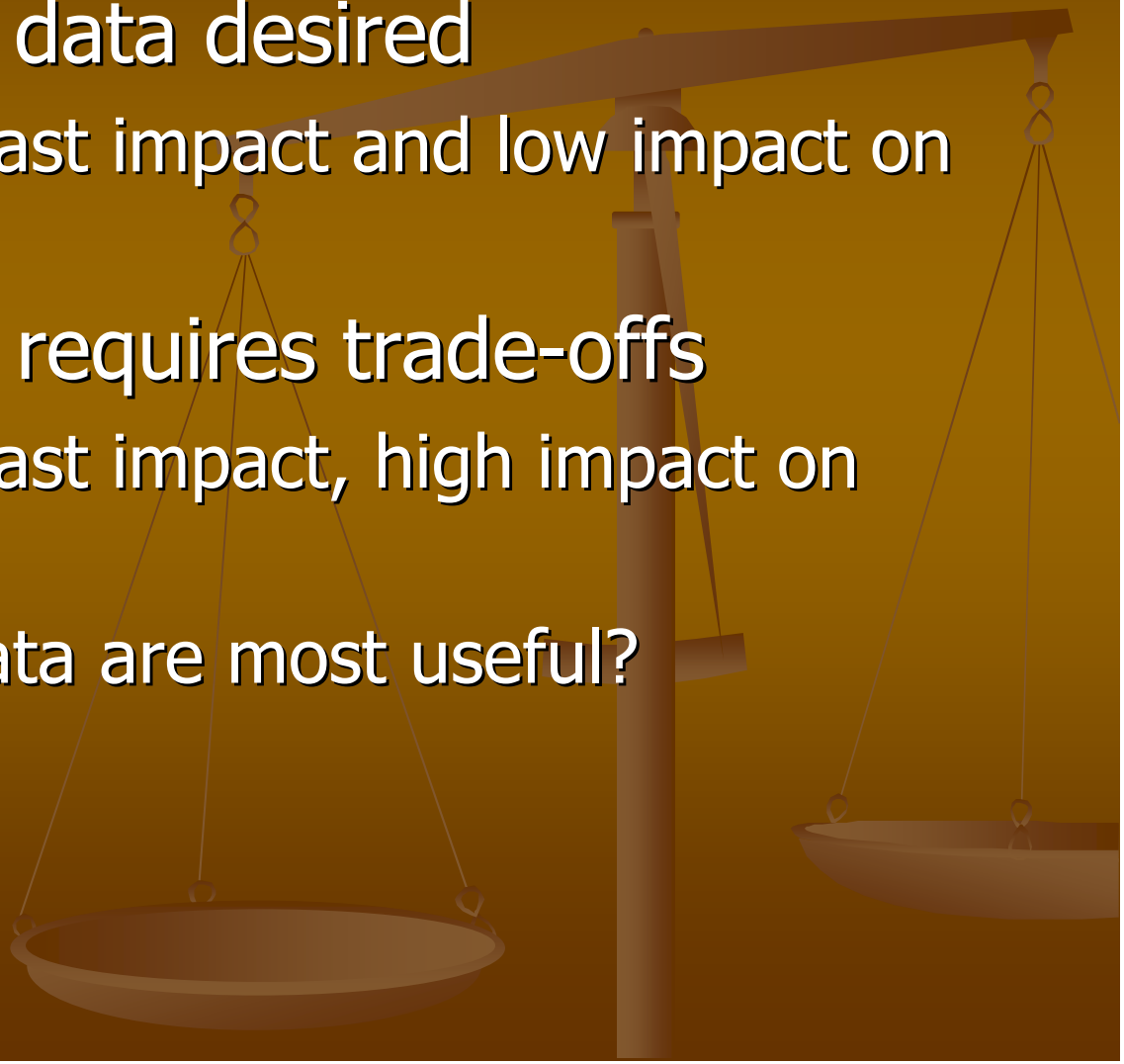
Done

- Backup slides follow



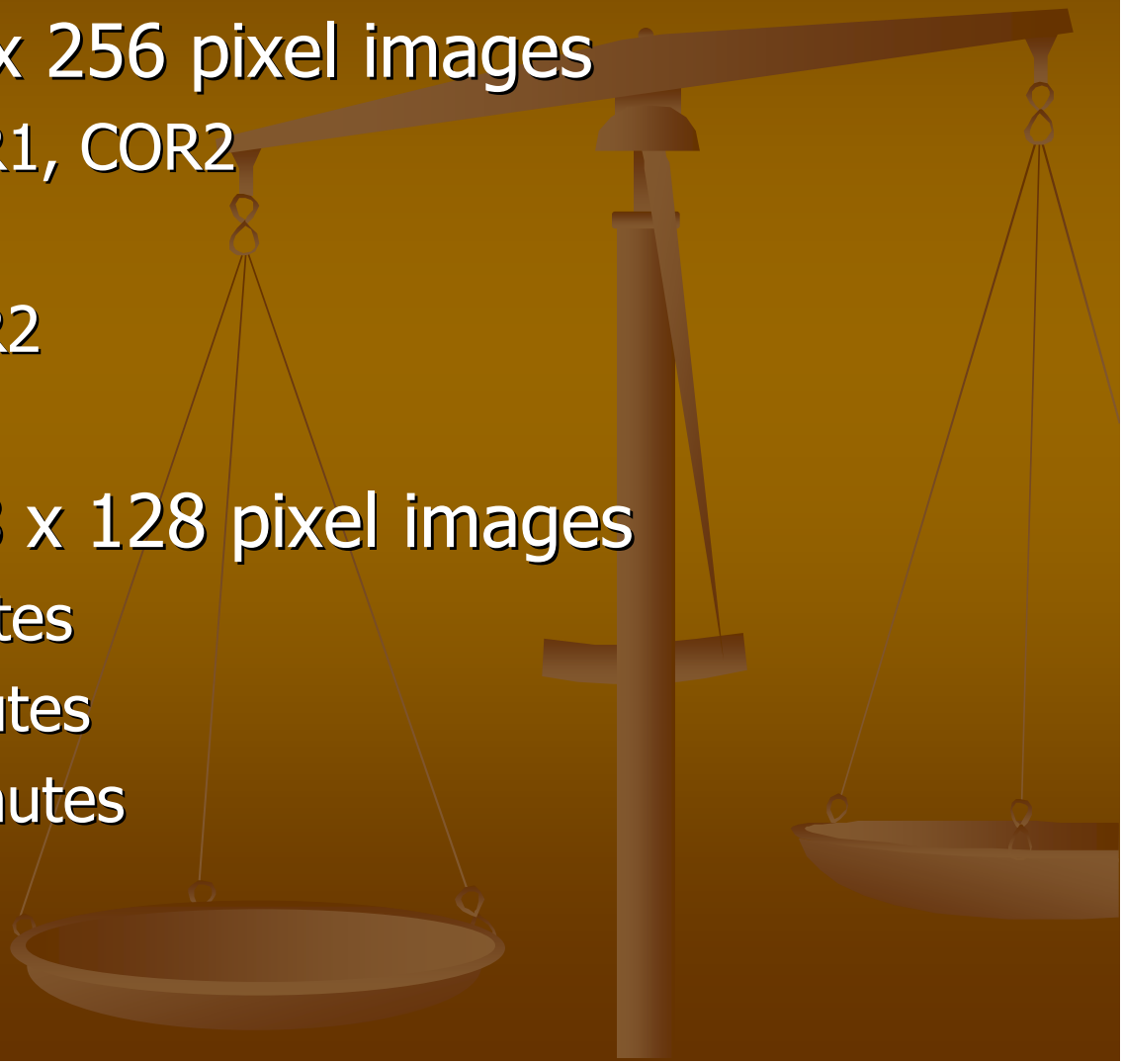
Space Weather Beacon Data

- All non-imaging data desired
  - High SWx forecast impact and low impact on telemetry
- The image data requires trade-offs
  - High SWx forecast impact, high impact on telemetry
  - Which image data are most useful?



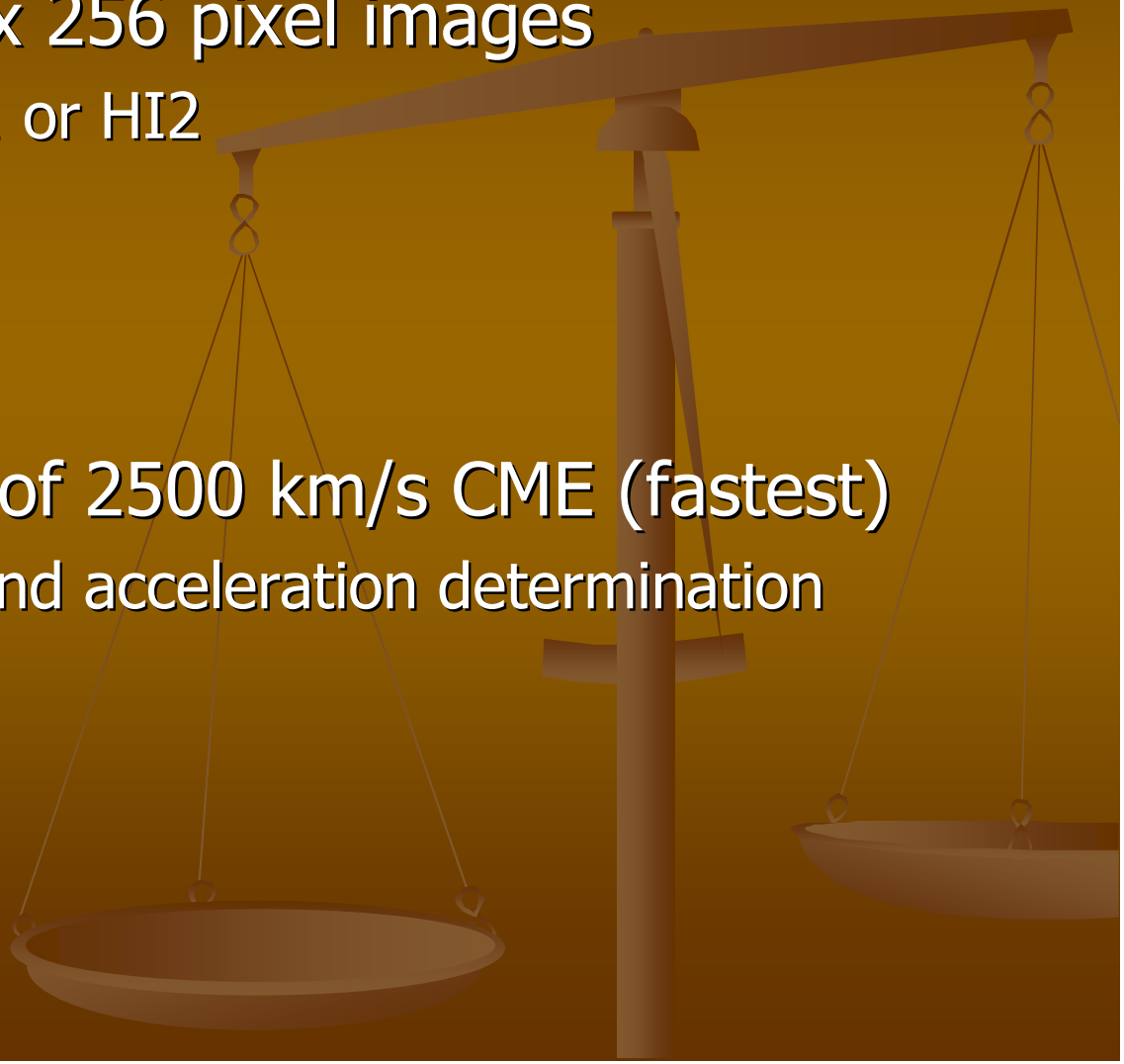
SECCHI Draft Observing Plans

- Hourly Plan 7 256 x 256 pixel images
  - 00 mins EUVI, COR1, COR2
  - 15 mins COR2
  - 30 mins EUVI, COR2
  - 45 mins COR2
- Hourly Plan 28 128 x 128 pixel images
  - EUVI every 5 minutes
  - COR1 every 6 minutes
  - COR2 every 10 minutes

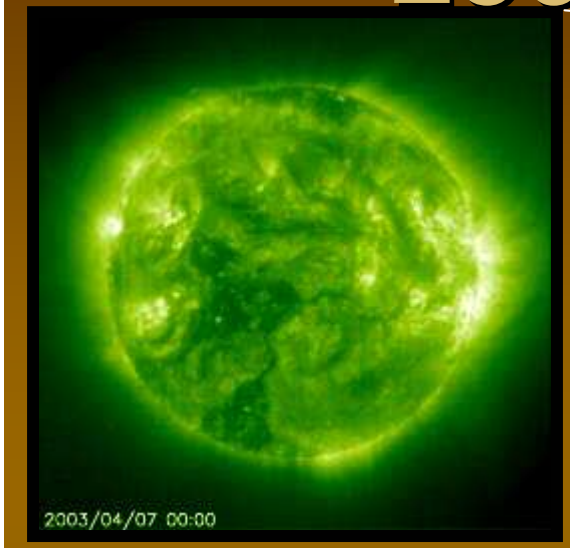


SEC Preferred Observing Plans

- Hourly Plan 7 256 x 256 pixel images
  - 00 mins COR2, HI1 or HI2
  - 15 mins COR2
  - 30 mins COR2
  - 45 mins COR2
- Provides 4 images of 2500 km/s CME (fastest)
  - 'Reliable' velocity and acceleration determination

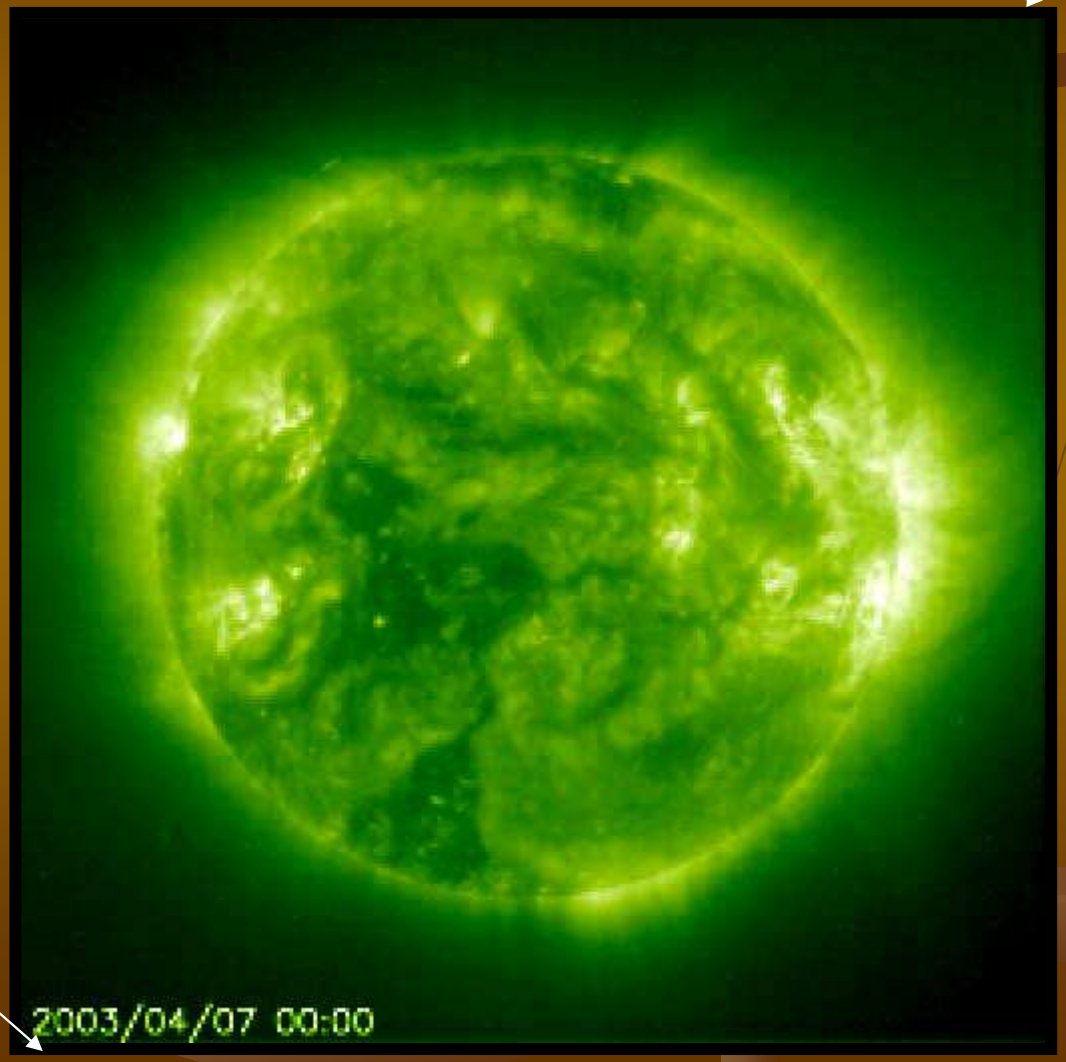


256 x 256 EIT Images

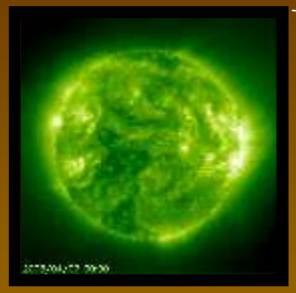


12 min cadence
10.4”/pixel

2x Enlargement

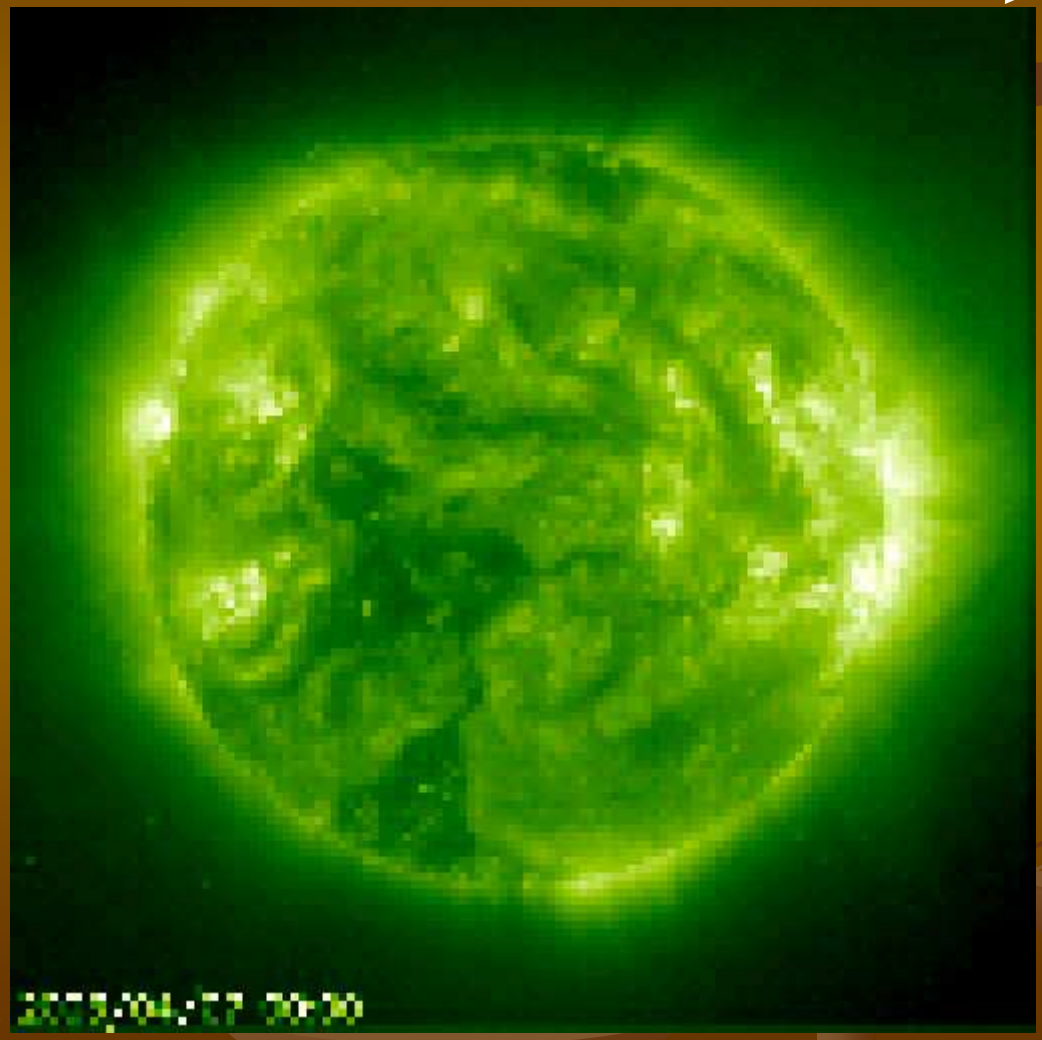


128 x 128 EIT Images

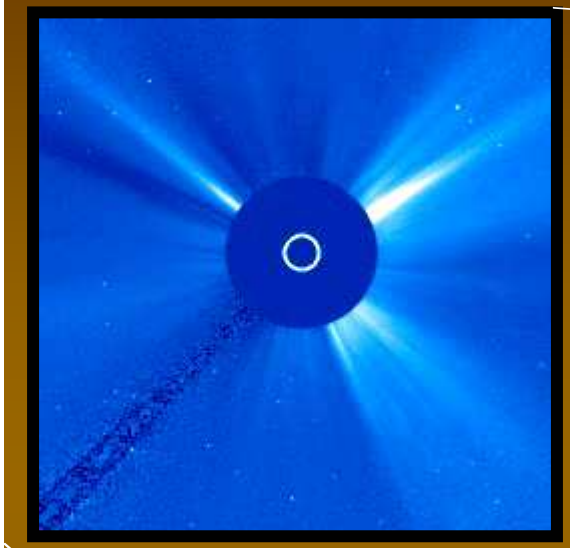


12 min cadence
20.8”/pixel

4x enlargement



256 x 256 LASCO C3 Images



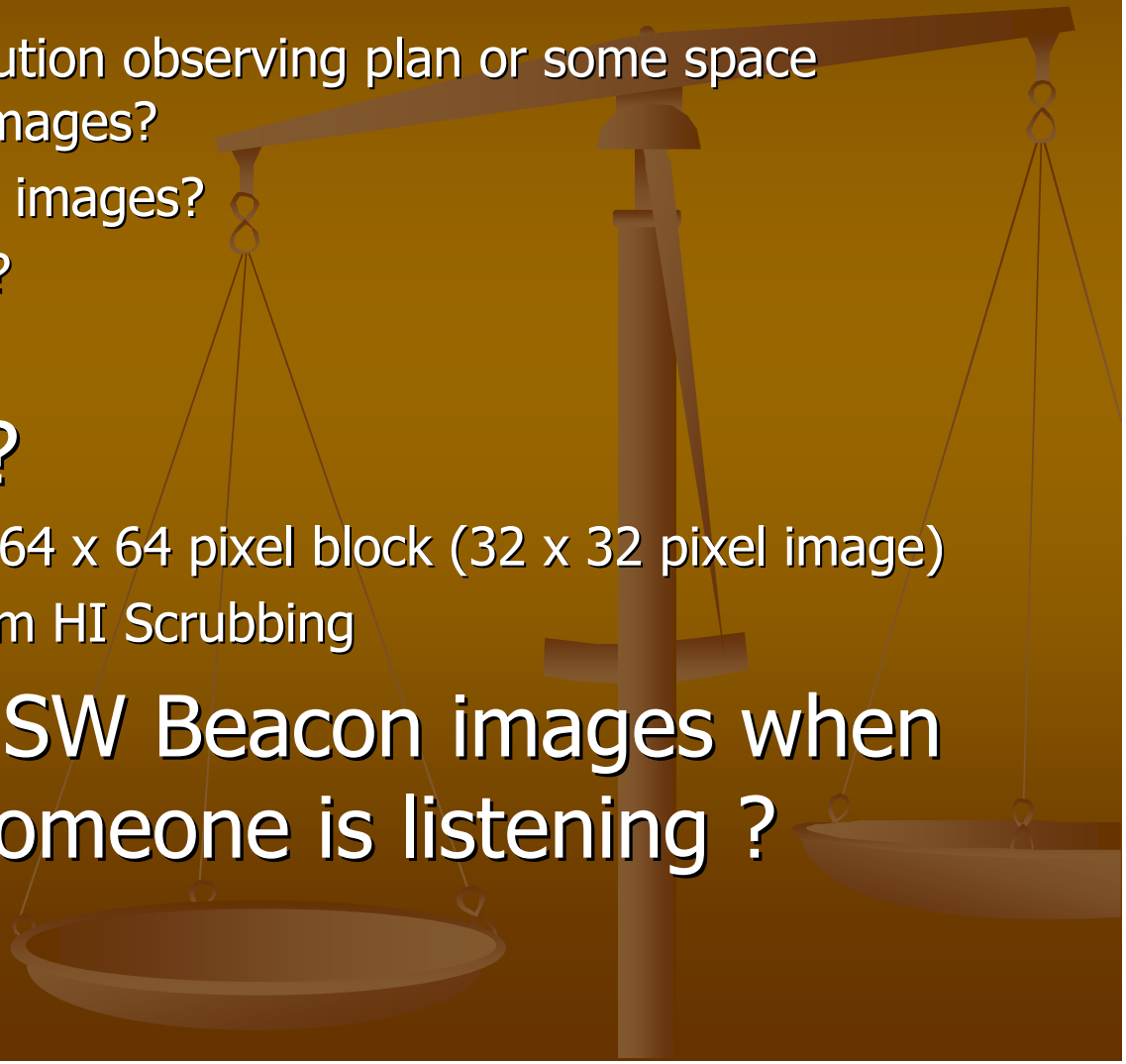
~30 min cadence
224”/pixel

2x Enlargement

128 x 128 LASCO C3 Images

~30 min cadence
448”/pixel

4x enlargement

Space Weather Beacon Questions

- Observing plan
  - Piggyback on full resolution observing plan or some space weather beacon only images?
  - Brightness or polarized images?
  - EUVI wavelength scan?
  - HI-1 or HI-2 data?
- Non-image data?
  - Brightest pixel in each 64 x 64 pixel block (32 x 32 pixel image)
  - Cosmic Ray Counts from HI Scrubbing
- Do we generate SW Beacon images when we don't know someone is listening ?