Concerns and Devil's Advocate Comments

David Webb

ISR, Boston College, USA

- How I use SSN
- Comments & Concerns:
  - Older data archive
  - "Modern" data
  - What Next?

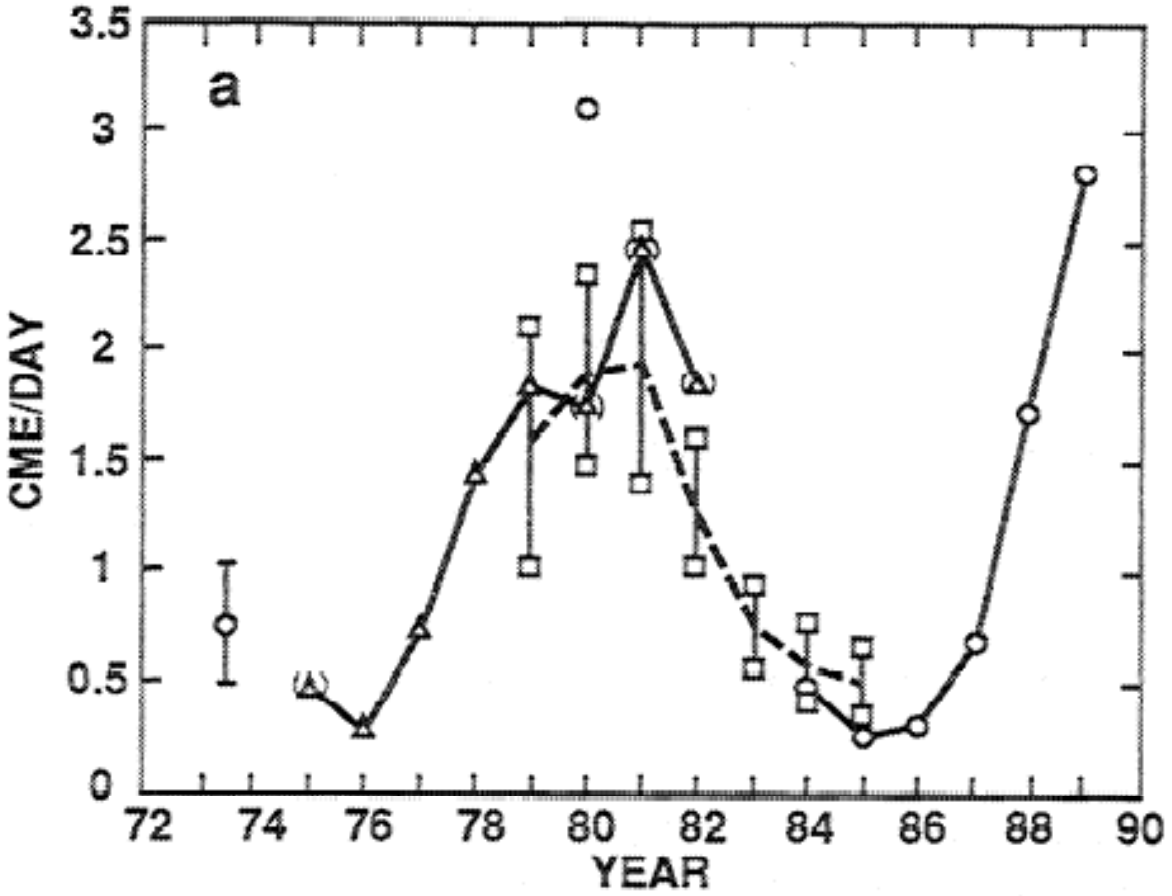
3rd SSN Workshop

NOAO, Tucson

25 January 2013

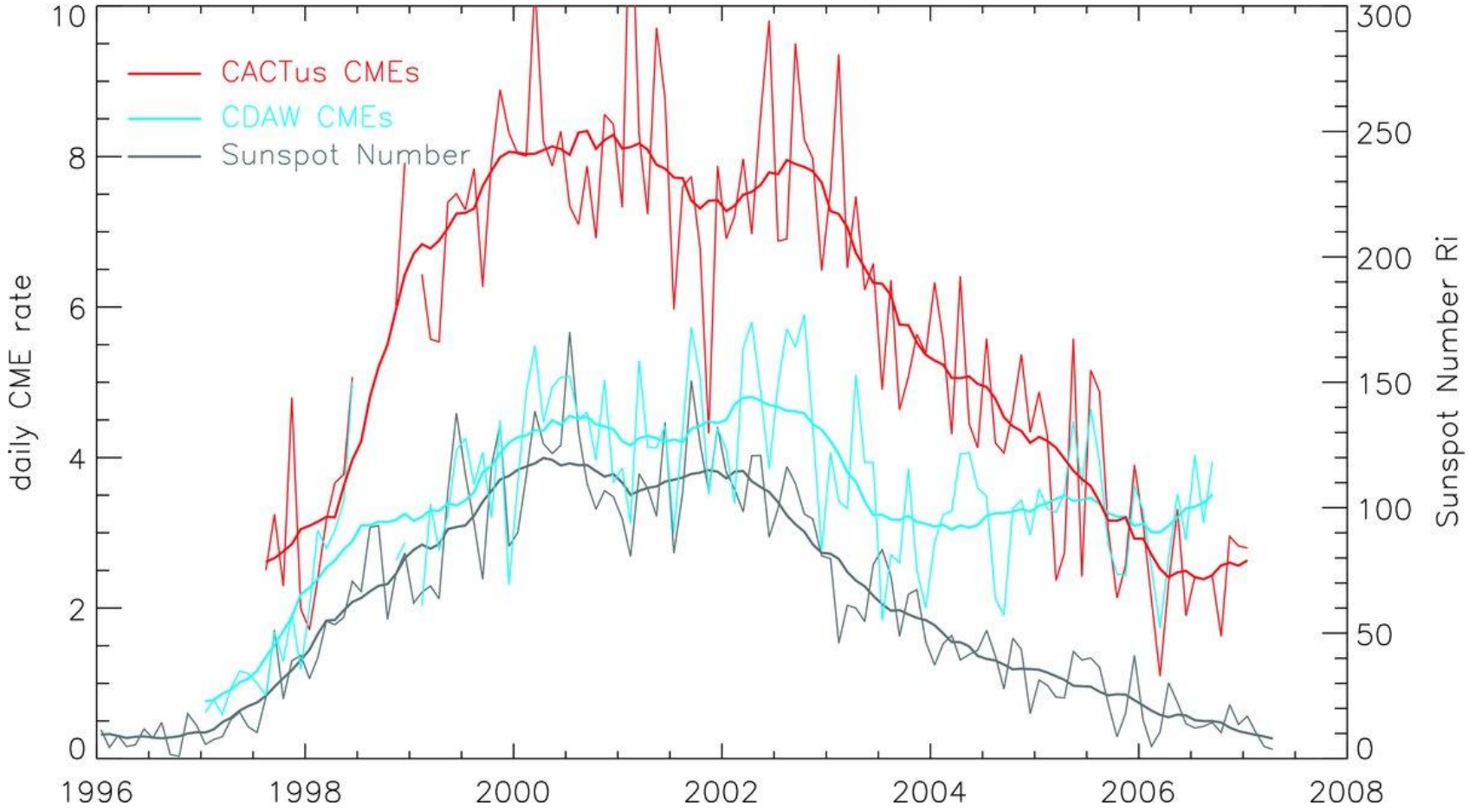
WL CME Rates; SC 21 & 22 Rise

Webb & Howard, 1994



CME rate measurements derived from the Skylab, SMM and P78-1 coronagraphs and the Helios photometers.

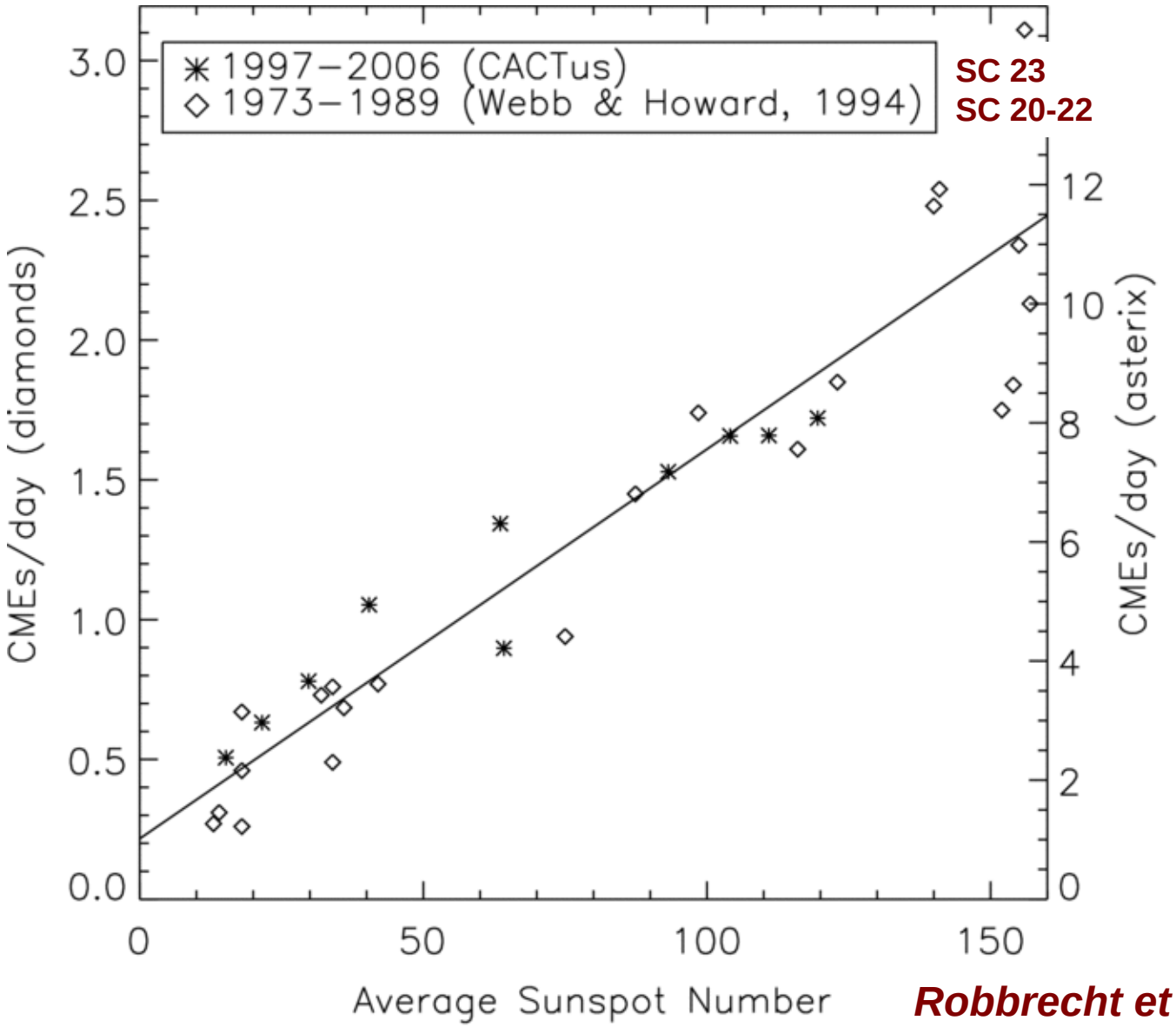
LASCO CME & SSN Rates - SC 23



CDAW rates are manual counts by observers.
CACTus rates are from automatic program; tend to be 2X higher.
SSN rates are from NOAA SWPC.

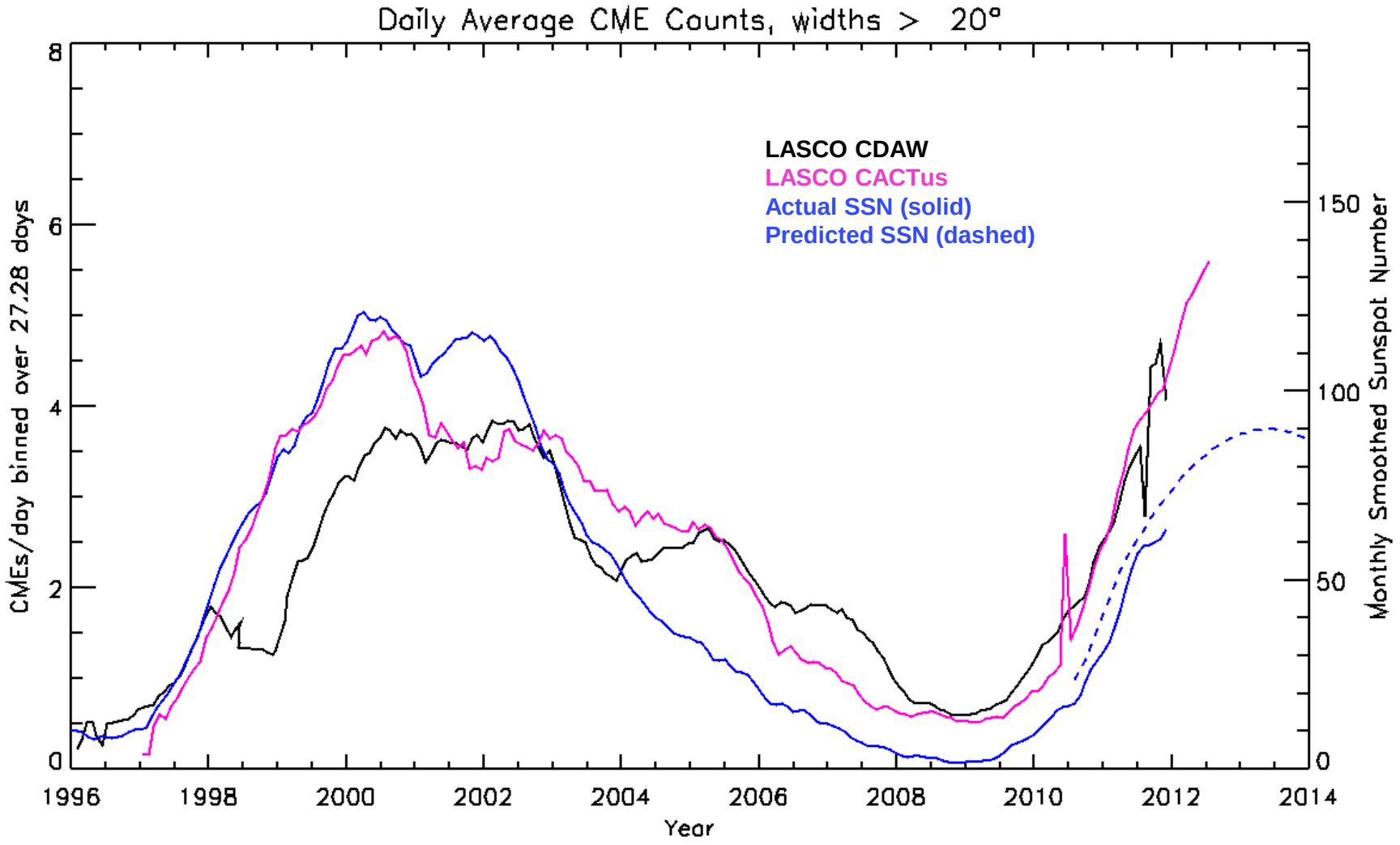
Robbrecht et al. (2009)

Annual CME & SSN Rates Remain Well Correlated (r~0.9)



Robbrecht et al. (2009)

Extended LASCO CME Rates minus Narrow CMEs



Conclusions: SSN vs CME Rate

- WL CME rate continues to track solar cycle (SSN) in both phase and amplitude
  - Over last 4 SCs & through minimum & rise of Cycle 24
- Observations of CMEs now extend over all or parts of 5 solar cycles
  - Complete for SCs 21 and 23; Rise phases of SCs 22 & 24
  - SC 21-22 → WL coronagraphs on Skylab, SMM, P78-1, Helios
  - SC 23-24 → LASCO obs. complete for Cycle 23 and through rise phase of Cycle 24
- Have now observed CMEs at 4 solar SC minima
  - CME rate at minima constant at ~0.3/day → 1 CME every 3-4 days
  - True even for recent SC 23/24 minimum despite extended decline & min. w/ low SSN.
- Have observed CMEs at or near 3 solar SC maxima (SC 21 – 23)
  - CME rate at maximum ranged from 2.5 – 4.75/day
  - LASCO SC 23 rate higher than for earlier coronagraphs
  - Likely due to better sensitivity BUT SSN-CME rates still well correlated.
- Cycle 23 had an unusually long decline and flat minimum
  - We can now count & track CMEs into the heliosphere, both manually & automatically.
- Both CME & SSN rates reveal double cycle peaks
  - CME peak lags sunspots by ~1/2 year to over a year.
  - Related to: 1) CMEs have 2 sources: active regions (SSN) & PC (high lat.) filaments,
    2) Offset or lag between hemispheres.

Coming-in Knowledge about SSN

- **Assumed SSN was a (mostly) well-understood quantity even back to 1800s**
  - Less known about Maunder Minimum and earlier
  - Little knowledge about details of SSN
  Probably typical of SSN users

- **Starting in Solar Physics much of my knowledge/interpretations of Solar activity variations, AR evolution, CHs, esp. in corona, came from Waldmeier papers!**

Older Data Archive

- **Group no. vs R_I**
  Have seen multipliers of 10.8, 13.5, 12.08, 13.06
  - Y'day Leif showed spots/group ranging from 7-12 and Andras showed Debrecen data → ≤ 5 spots/group!
  - Variation in SS/group- Tlatov/Pevtsov
  - So what formula do we use to get homogeneous SSN over time?!
- **K factors to correct for subjectivity; do we need a standard station?**
- **Need error bars or uncertainty limits**
  - weighting by no. of observers, no. of observations, time scale
- **Use (Wolf) of geomag data to "adjust" SSN**
- **ROG SS record very important bridge between older and modern data**
  - **Problems with it are disturbing**
  - **Why aren't Hoyt and Schatten more involved?**
- **Advocated "adjustments" to the Wolf, ROG, etc. data can be large**
  - ~50%
  - Trends in data sets are worrisome; esp. when comparing one data set to another.

“Modern” Data

- **I was concerned about the old data, but now I am concerned about getting consistent, reproducible results for modern SSN!**
  - **k factors, spot sizes (when is a SS measurable/reportable), lifetime vs size, when is a spot a group, etc.**

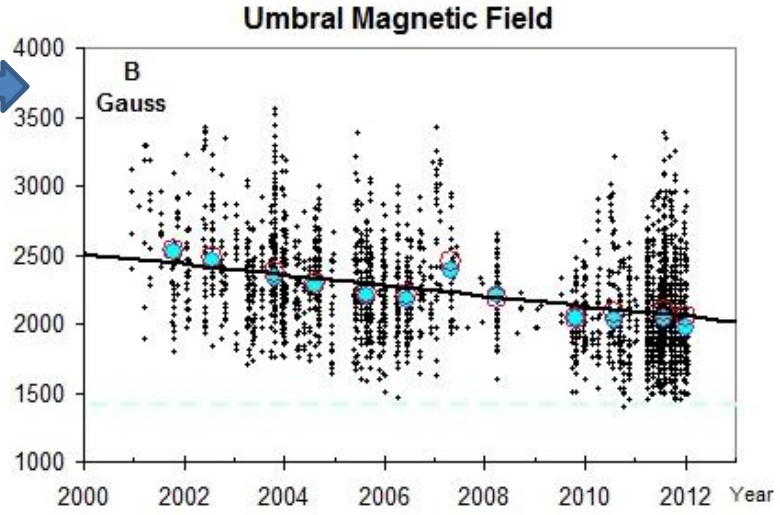
- **Use of digital techniques and pattern recognition software on images to detect and analyze SSs**

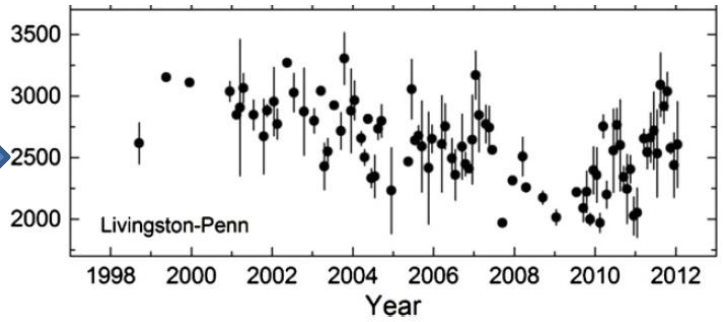
- **Remove the human element as much as possible**
  - **Calibration with spacecraft data; MDI & HMI: talks by Laure and Fraser**

- **Livingston-Penn “effect”**
  - **Interpretation of slope into SC 24**
  - **Confirm with independent data**
  - **Extend series at least until ATST; crucial support needed for next year or so; can/should we endorse this?**
  - **How about proxies for prior SCs?**

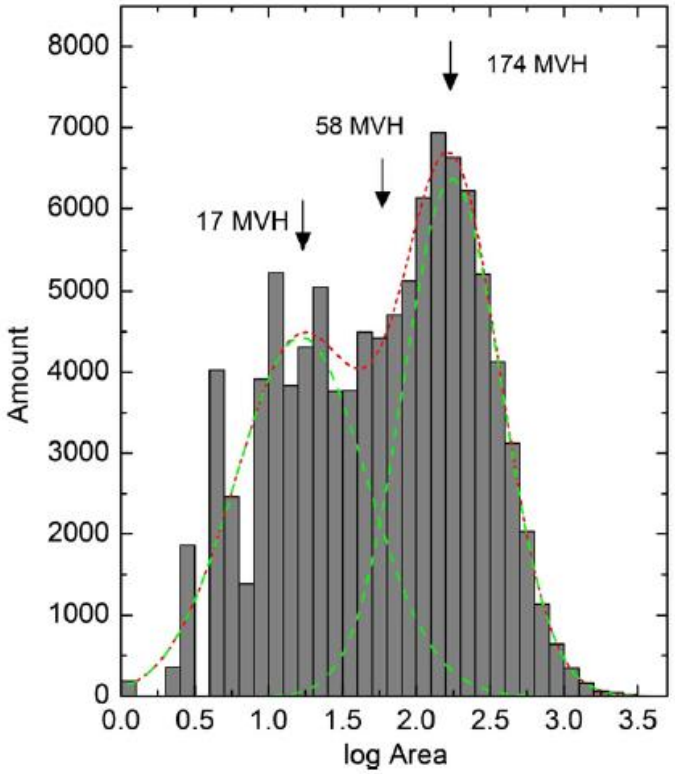
How about LP-effect?

Average of all measurements





Average of daily strongest measurements



Change in fractional distribution of sunspots can explain both trends

Nagovitsyn et al (2012, ApJL)

Next Steps?

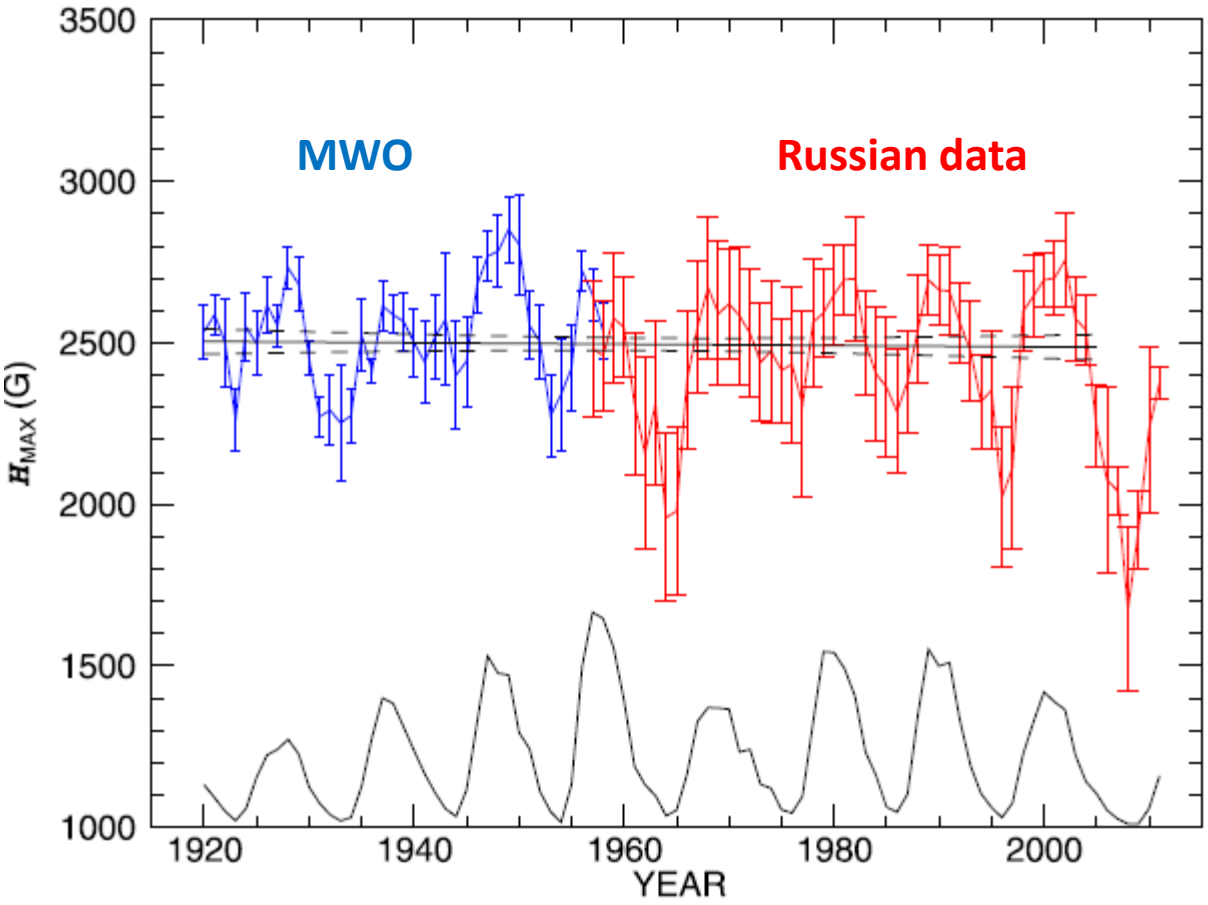
- **Exciting and fun workshop!**
  - **I have learned a lot, including that the SSN calibration is even worse than I thought!**
  - **We absolutely need to make adjustments to SSN**

- **New agreed upon calibrated SSN**
  - **Proper backboning; including ERRORS/UNCERTAINTIES**
  - **Keep and document previous SSN archives**
  - **Careful documentation of purpose and construction details of new archive**

- **Possibly develop new SSN series based on modern data and techniques**
  - **e.g., spacecraft calibration, digital imagery and pattern recognition**

- **Recovery of very old SS data (Vaquero)**

- **Parallel effort to recalibrate geomag. series for comparison with SSN, CRs, cosmogenic data, etc.**



Pevtsov et al (2013, Solar Physics)

How I use SSN

• Occurrence rate of CMEs obs. in white light (WL) tracks solar cycle in both phase & amplitude

• Observations of WL CMEs now extend over last four solar cycles

• LASCO observed entire Cycle 23 and continues to observe through rise phase of Cycle 24

• Cycle 23 had an unusually long decline and flat minimum

- During this period we have been able to image and count CMEs in the heliosphere
- Can determine rates from both LASCO and STEREO coronagraphs and from the Solar Mass Ejection Imager (SMEI; 2003-2011) and the SECCHI Heliospheric Imagers (since 2006) in the heliosphere.
- Manual rates made by observers
- Rates from IDs made by automatic programs → SEEDS, CACTus & ARTEMIS catalogs

• Despite differences in amplitude, CME rate continues to track SSN through minimum & rise of Cycle 24. I will discuss these rate estimates, both for the Cycle 23-24 period and over the last four cycles for which we have WL CME observations.

• Both CME rate and sunspot no. (SSN) have double cycle peaks

- CME peak lags sunspots by many months.
- Related to obs. that high lat. CMEs arise from polar crown filaments → "rush to the poles" near max and disappear (erupt) at rate that slightly lags SSN at low latitudes