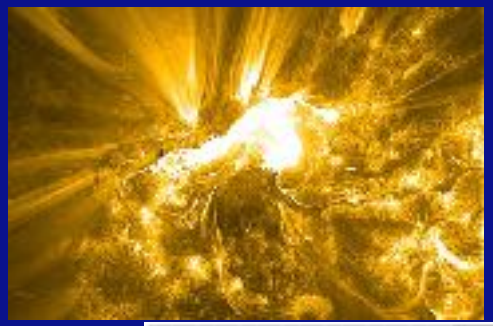
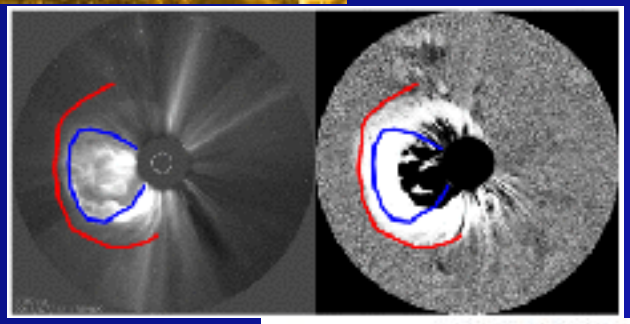
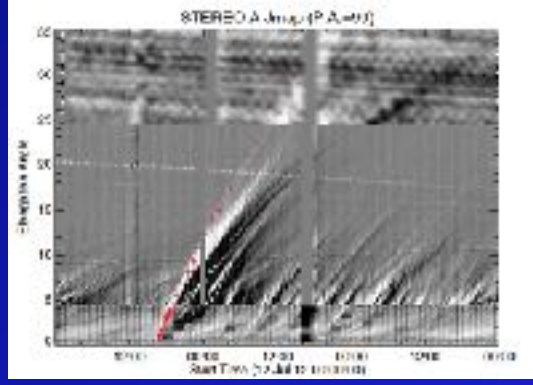
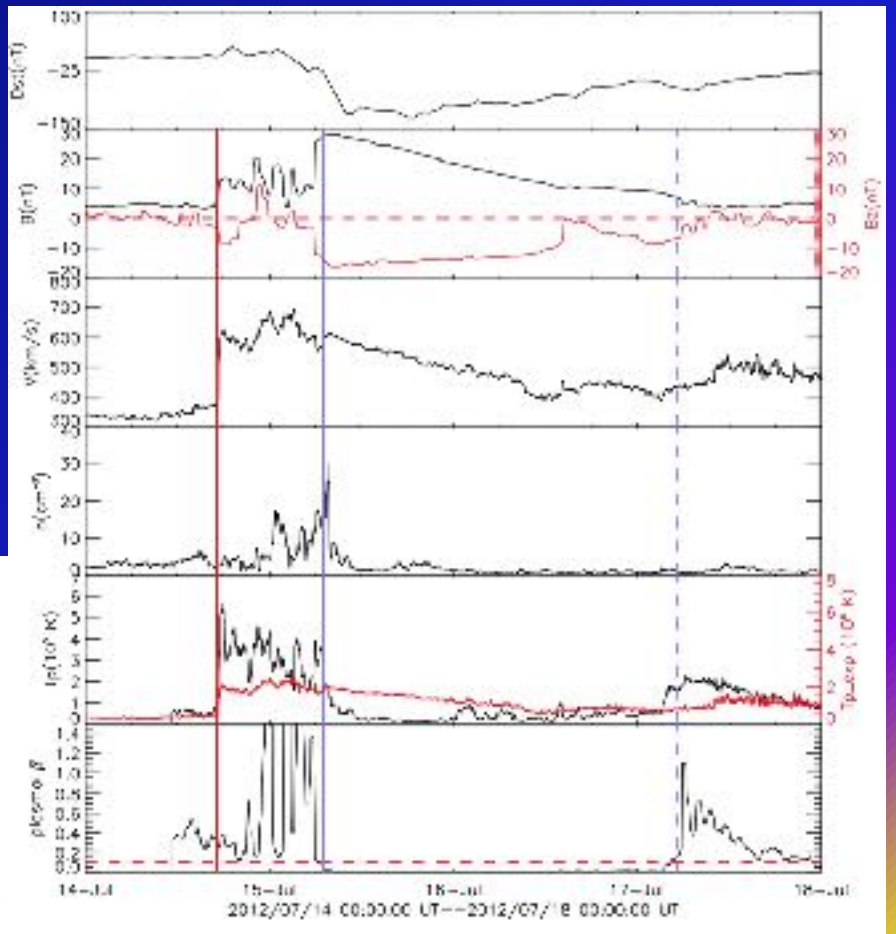
ISEST WG1 Report: Data Group (Jie Zhang)









Content

- WG Tasks
  - Event Catalogs and Database
  - Measurement and Issues

- Scientific Objectives
  - On Evolution of Ejecta and Shock.
  - On Predicting HIT/MISS
  - On Predicting TOA (Time of Arrival)
  - On Predicting Intensity (Dst) or Category (Kp) of Geomagnetic Storm

- Items in this workshop

WG Tasks

1. Identify all Earth-Affecting solar transient events, CMEs and CIRs, during the STEREO era (2007 - 2017)

2. Track selected events from the Sun to the Earth, and fully measure, characterize and quantify their evolutional properties from the Sun to the Earth

- SEPs (WG6)

Data could….

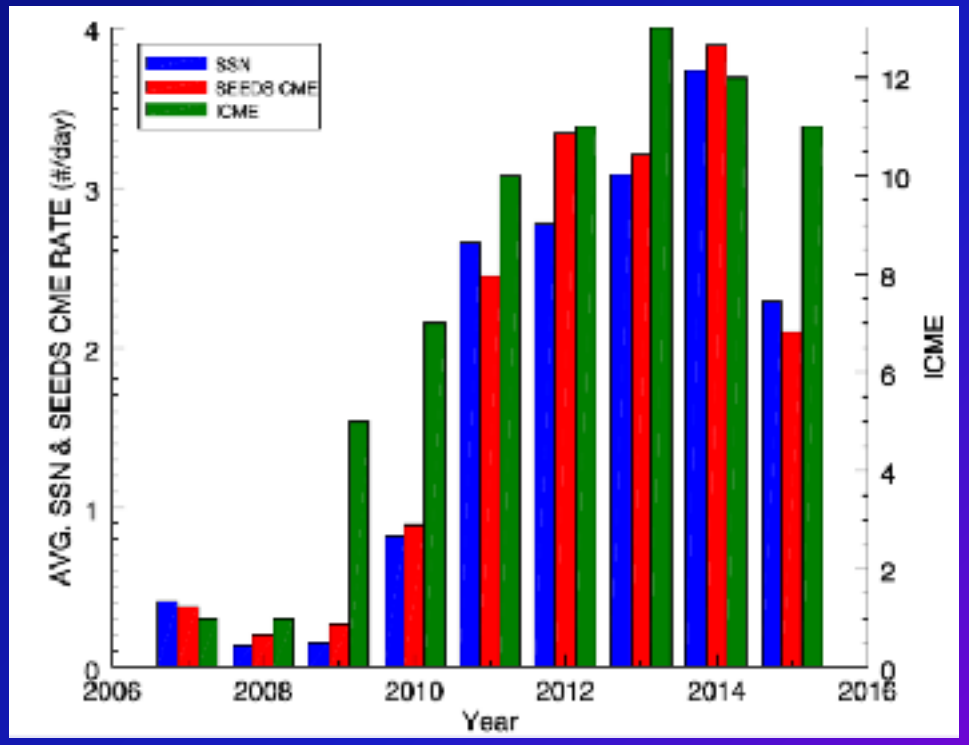
Provide a comprehensive event **database** which are valuable and necessary for a variety of scientific studies:

- Statistical studies of events and new findings
- Create empirical evolution models
- Create prediction models
- Improve theoretical understanding and models
- Constrain and validate numerical models

— an invaluable data asset for the community for studying Sun-Earth Connection and predicting space weather—

Event Catalog

- **Hess & Zhang CME-ICME catalog**
  - Available at http://solar.gmu.edu/heliophysics/index.php/GMU_CME/ICME_List/
  - 72 ICME events between 2006 and 2016 inclusive based on in-situ observations of ACE
  - Solar sources are mostly identified, thanks to STEREO

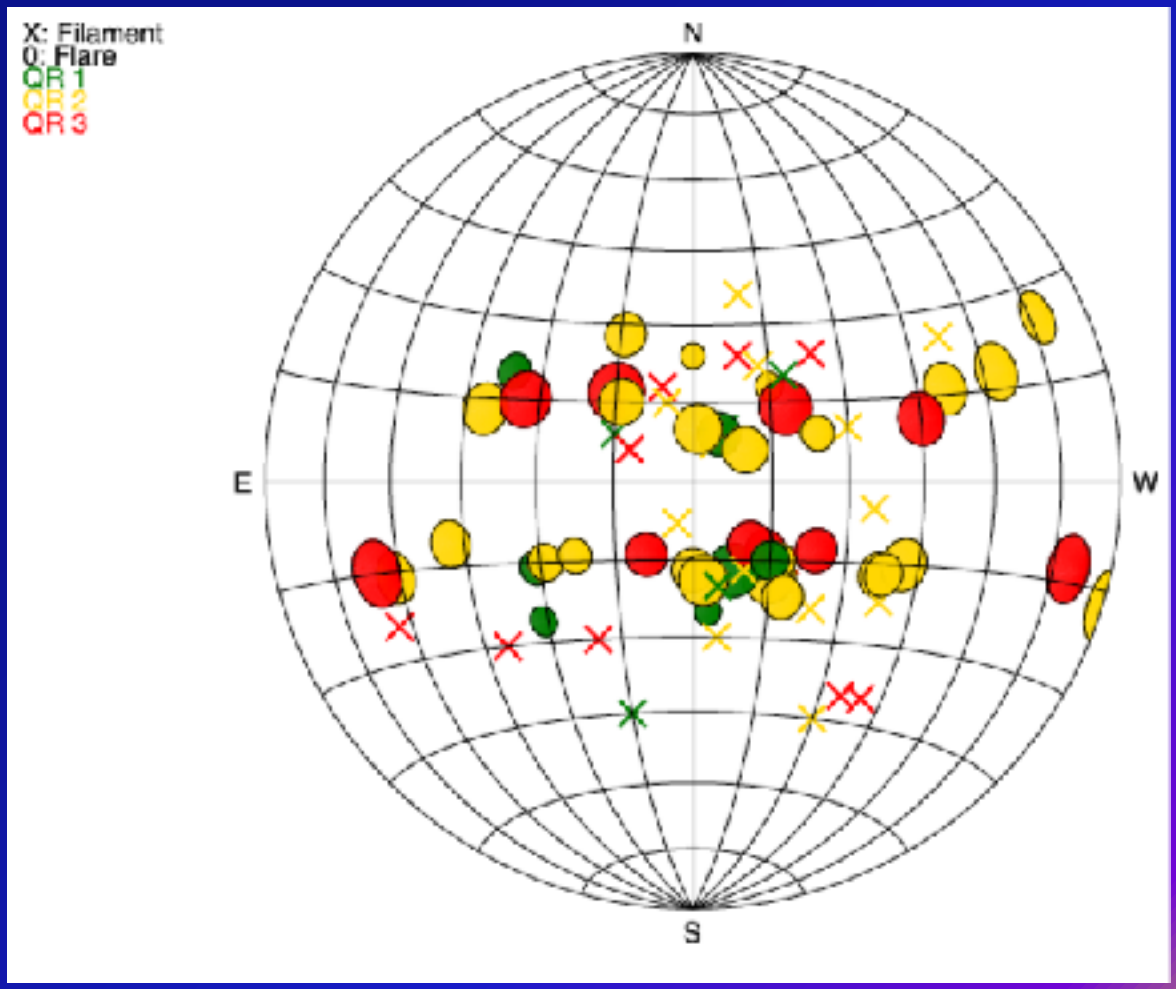


(Hess & Zhang, 2017 in Solar Physics Topical Issue)

Event Catalog

- **Hess & Zhang CME-ICME catalog**

1. **28 (40%) major flares (M & X)**
2. **13 (19%) minor flares (B & C)**
3. **29 (41%) quiet Sun region filament or filament channel ("stealth" events)**

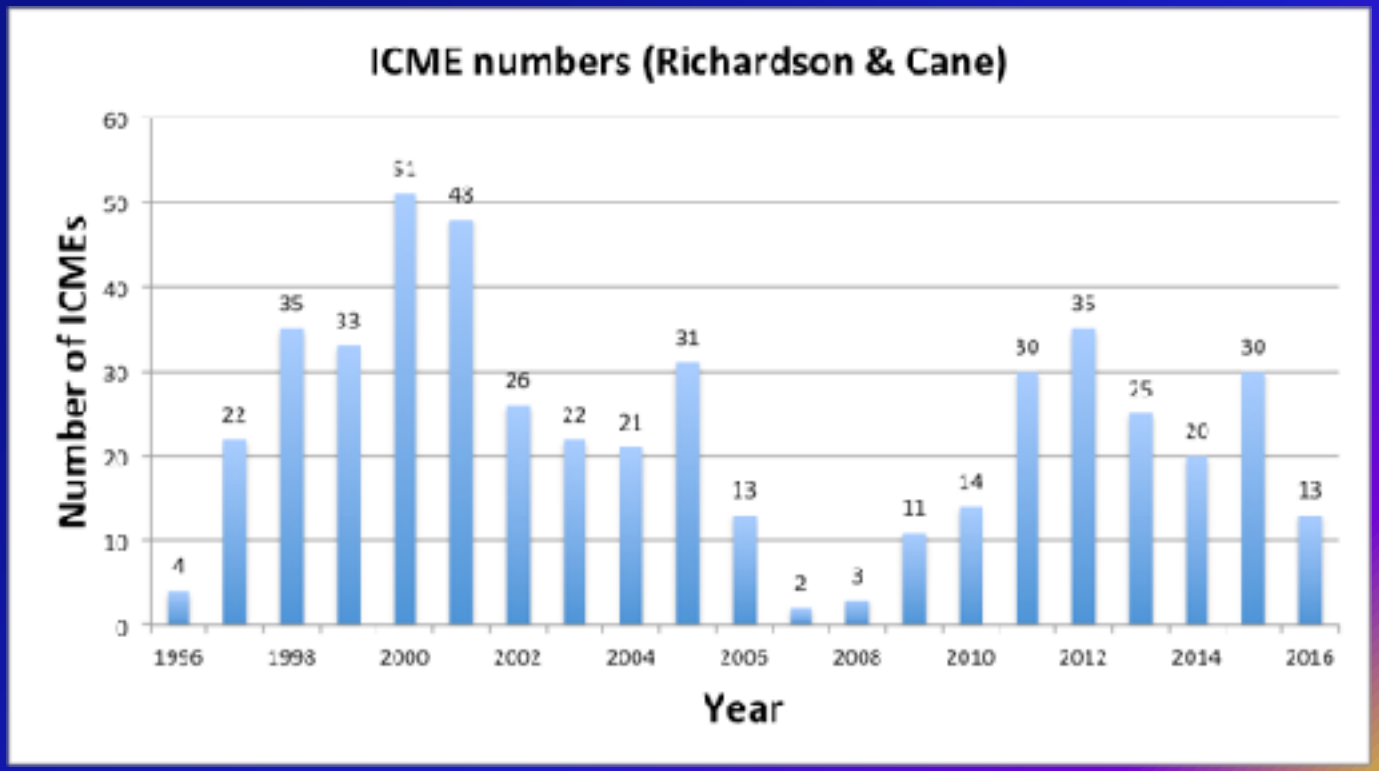


1. **34 (49%) full halo**
2. **20(29%) partial halo**
3. **11 (15%) non halo**
4. **5 (7%) can not be identified**

(Hess & Zhang, 2017 in Solar Physics Topical Issue)

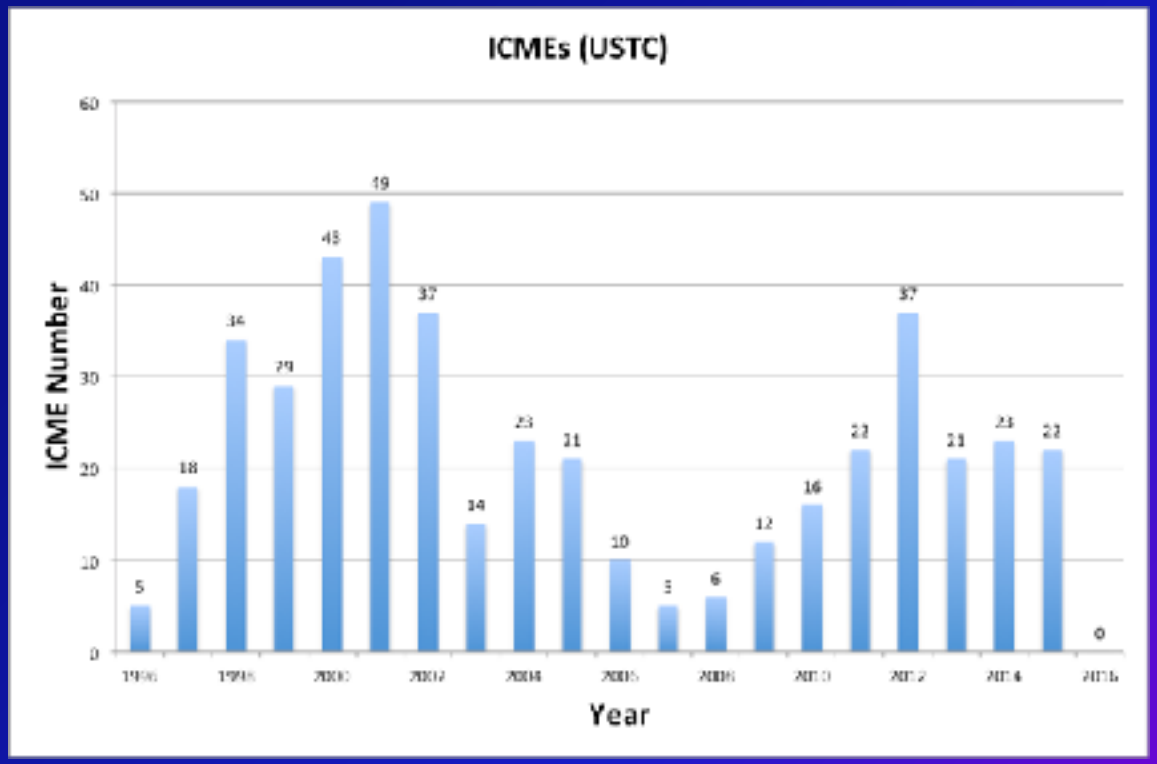
Event Catalog

- Richardson & Cane ICME Catalog
  - Available at http://www.srl.caltech.edu/ACE/ASC/DATA/level3/icmetable2.htm
  - **196 ICMEs from 2006 to 2016** based on ACE and WIND
  - 306 ICMEs from 1996 to 2006 in solar cycle 23rd
  - Refer to Cane & Richardson 2003; Richardson & Cane 2010.



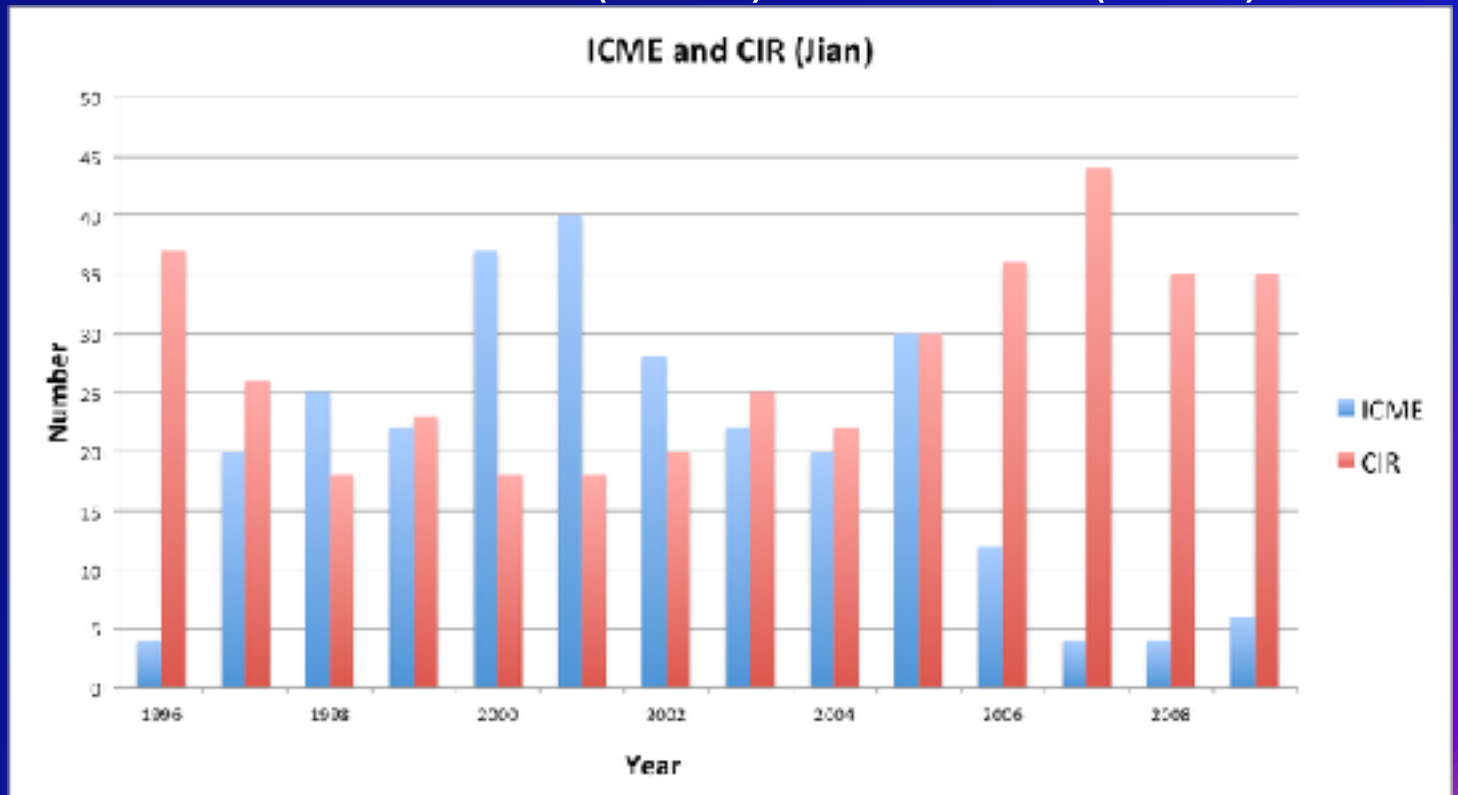
Event Catalog

- USTC ICME Catalog
  - Available at http://space.ustc.edu.cn/dreams/wind_icmes/
  - **174 ICMEs from 2006 to 2016** based on ACE and WIND
  - 283 ICMEs from 1996 to 2006 in solar cycle 23rd
  - Refer to Chi, Shen, Wang etc (2016)



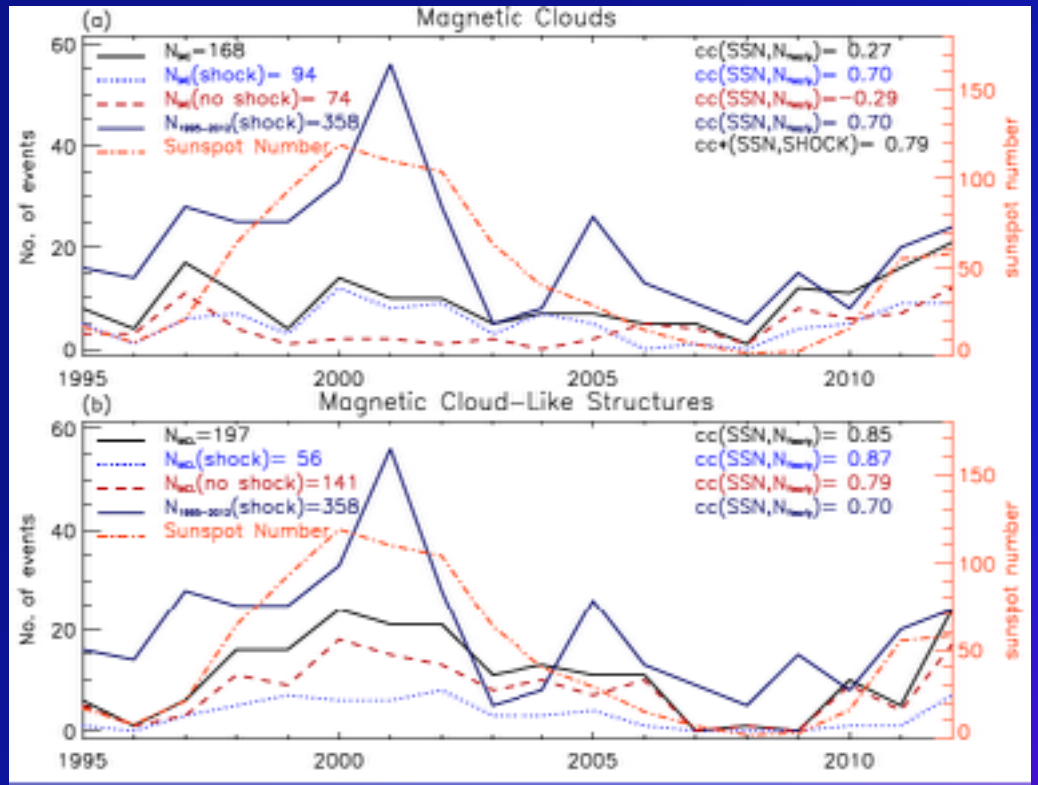
Event Catalog

- Jian's ICME and CIR Catalogs
  - Available at http://www-ssc.igpp.ucla.edu/~jlan/ACE/Level3/
  - Only up to 2009 based on WIND and ACE
  - 260 **ICMEs from 1996 to 2006**
  - **273 CIRs from 1996 to 2006**
  - Refer to Jian et al. (2009); Jan et al. (2011)



Event Catalog

- Lepping & Wu MC and MCL lists
  - MC from 1995-2007 at https://wind.nasa.gov/mfi/mag_cloud_pub1.html
  - MC from 2007-2010 (Lepping et al. 2011)
  - MC from 2010-2012 (Lepping et al. 2015)
  - MC-like events from 1995-2012 (Wu & Lepping 2015; 2016)

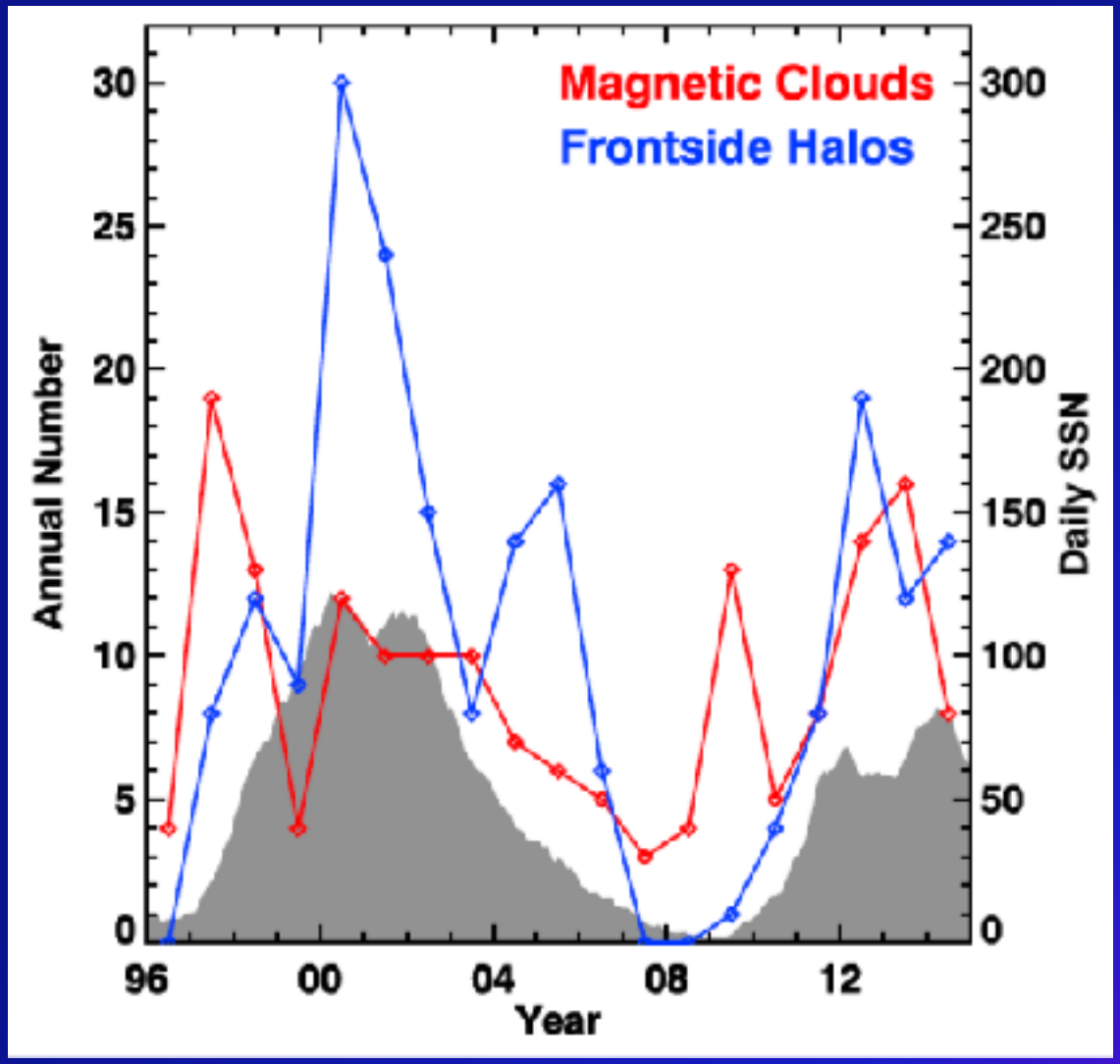


Wu & Lepping 2016

MC: 168
MCL: 197

Event Catalog

- MC study in solar cycle 23 and 24 (Gopalswamy et al. 2015)



Rise 1996-1998: 36
Max 1999-2002: 32
Total: 68

Rise 2008- 2010: 27
Max 2010-2014: 33
Total: 61

Event Catalog

Yermolaev's large scale solar wind phenomena catalog

- include HCS, SLOW, FAST, CIR, EJECTA, MC, RARE, IS, ISA
- from 1976 to 2016 based on OMNI database
- Available at ftp://www.iki.rssi.ru/pub/omni/
- Refer to Yermolaev et al. (2009) in Cosmic Research

Type of event	Total number	Minimum number per year	Maximum number	Average number	Standard deviation
HCS	1449	17	219	57.96	46.12
CIR	884	21	55	35.4	9.04
SHEATH	740	10	51	29.6	13.9
EJECTA	1567	36	123	62.68	23.45
MC	136	0	15	5.44	4.19
RARE	18	0	8	0.72	1.8
IS	319	2	43	12.8	10.2
ISA	14	0	5	0.56	1.3

solar wind phenomena from 1976 to 2000(Yermolaev et al. 2009)

Event Catalog

- **Y.-Liu List (NSSC, China) for highly selected events (2006-2010)**
  - **Available at http://sprg.ssl.berkeley.edu/~liuxying/CME_catalog.htm**

- **MostI ICME List**
  - Available at http://www.uni-graz.at/~moestlc/events/chris_list_v1.htm
  - 24 events from 2008 to 2012-July

Action Items on Catalogs Recommended in 2015

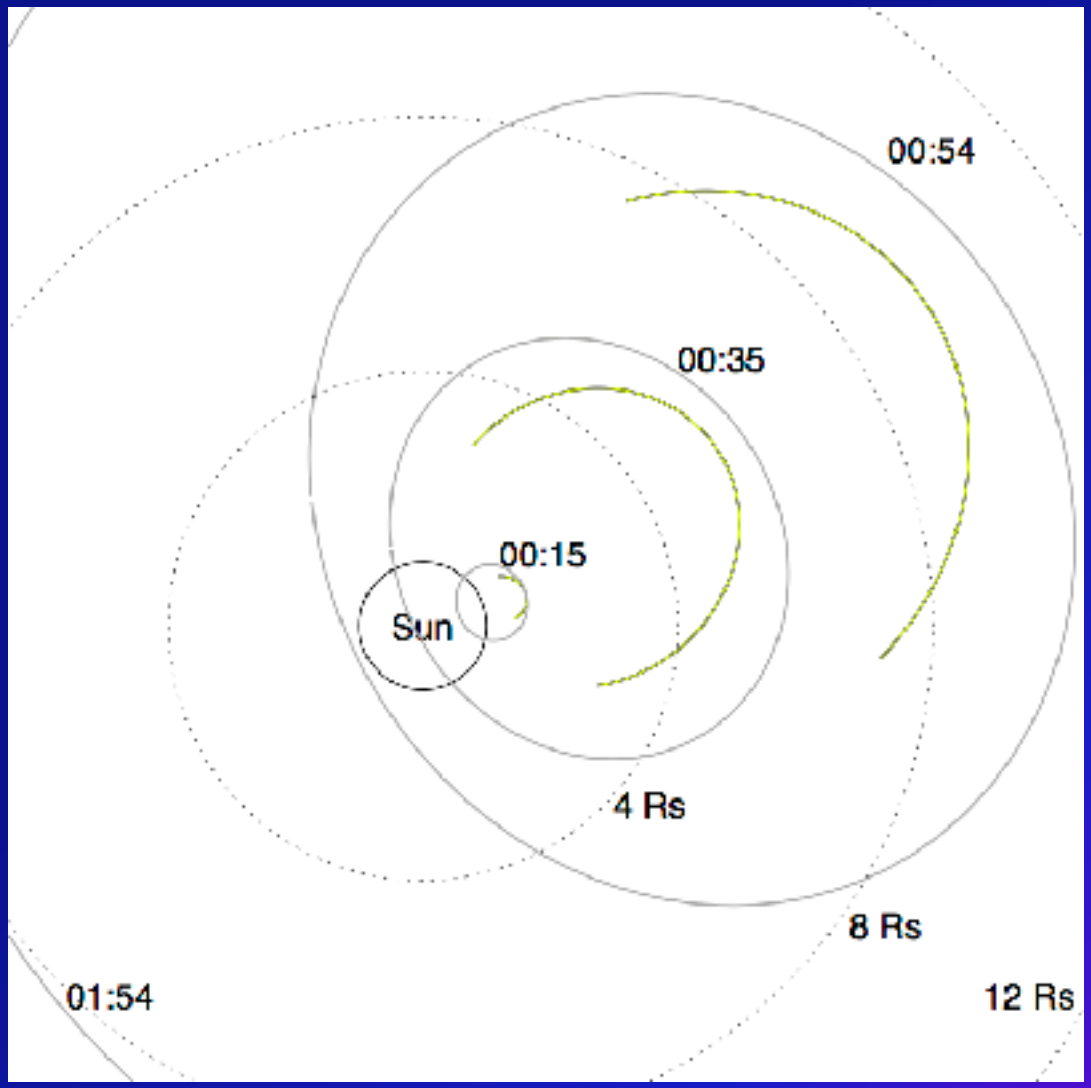
- Merge and clean the catalogs to make a unified ISEST ICME/CME catalog
  - ICME events at the Earth
  - Solar sources of these ICMEs

- Did a united ISEST catalog for events from 2006 to 2013 as a group in the 2013 Workshop
- Probably not applicable to have an ISEST endorsed catalog
- GMU group has populated this ICME/CME catalog from 2006 to 2016
- GMU group welcomes other groups to provide comments/inputs

CME Sun-to-Earth Tracking

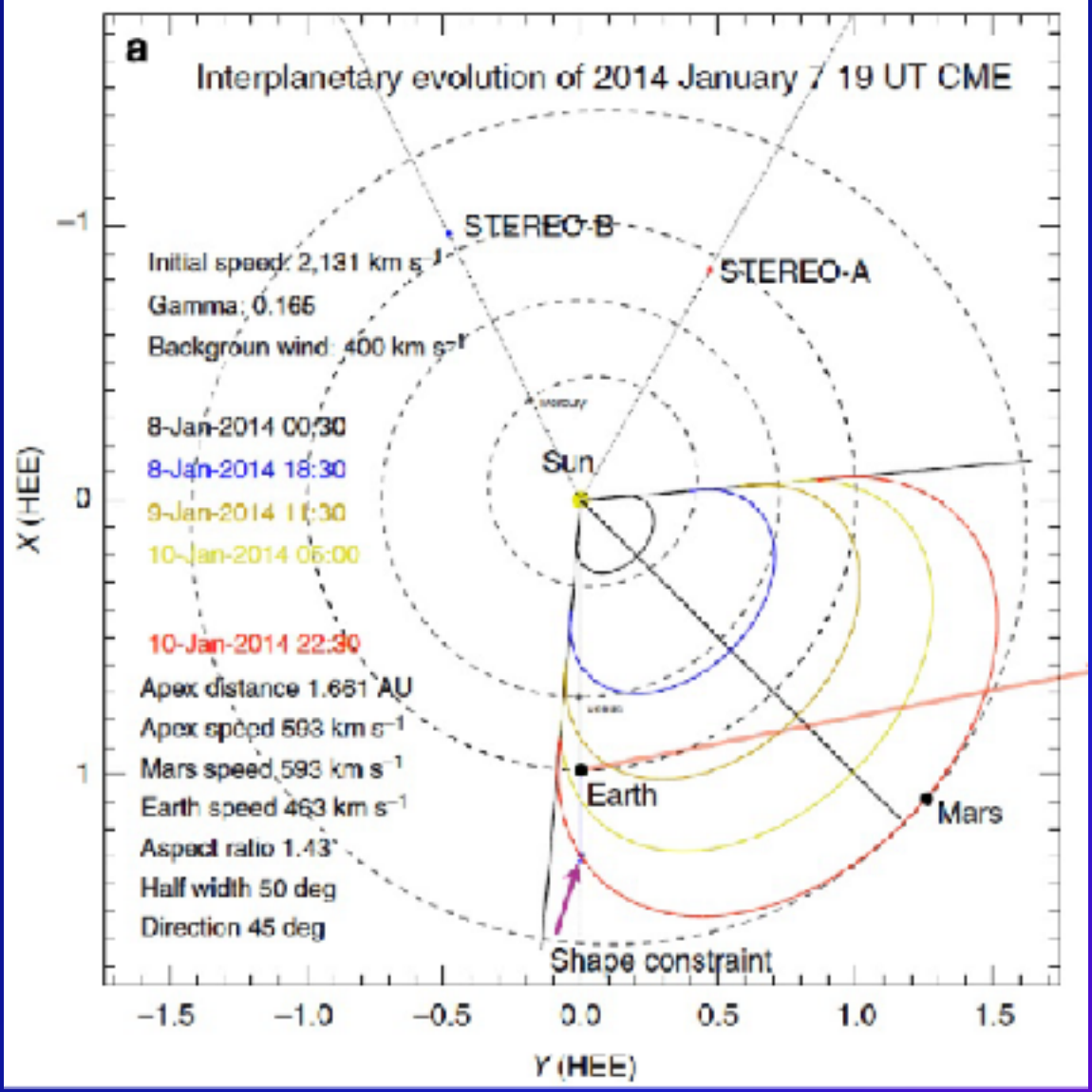
- Track the evolution from the Sun to Earth in 3D for as many events as possible (but will be a small number)
  - Kinematic evolution in 3D (free of projection effect): distance-time profile, velocity-time profile, acceleration time profile
  - Morphological evolution of ejecta: angular width and 3D shape
  - Morphological evolution of shock: angular width and 3D shape, and the standoff distance

CME Sun-to-Earth Tracking



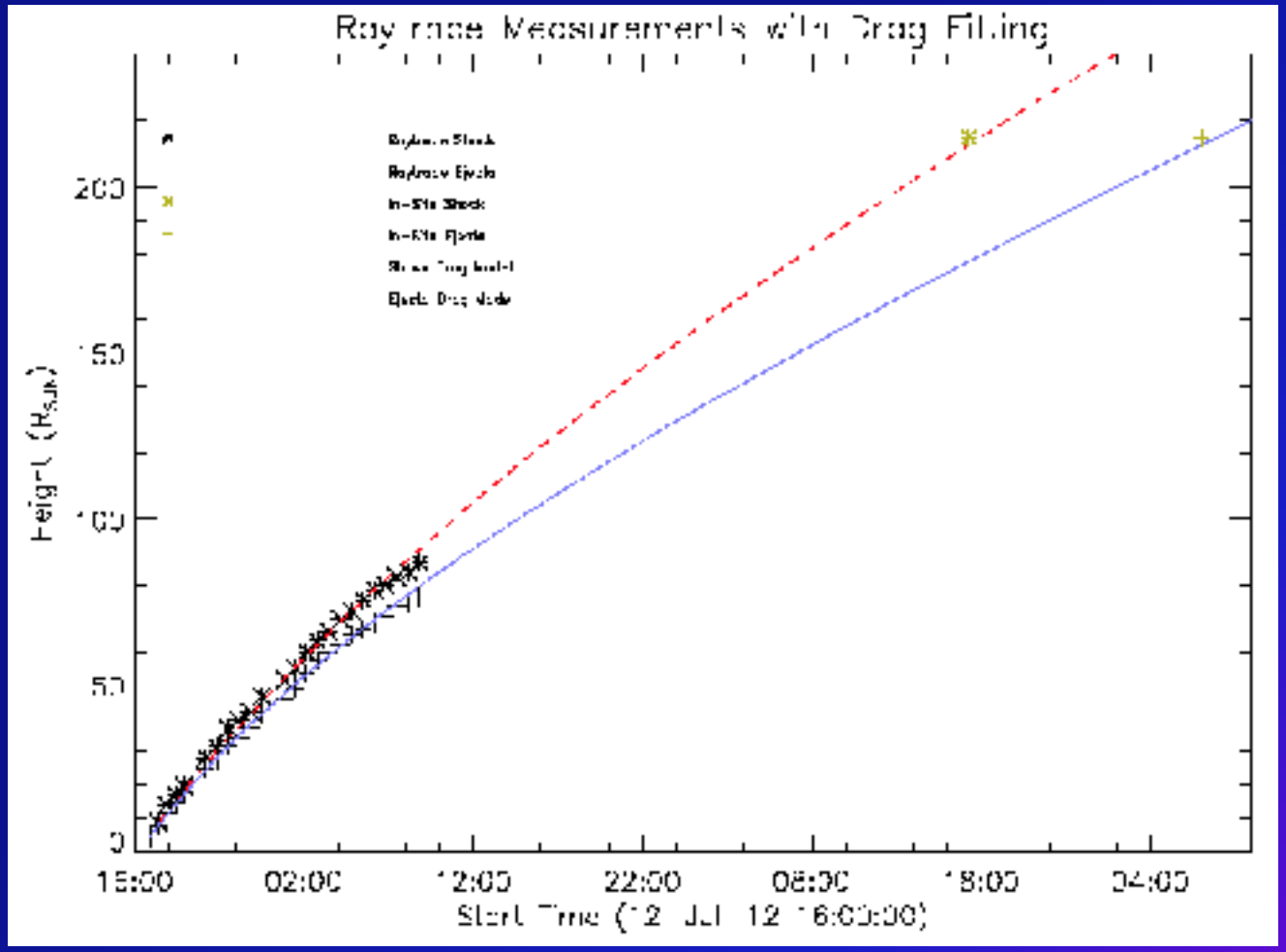
Ejecta and Shock (Kwon et al. 2014)

CME Sun-to-Earth Tracking



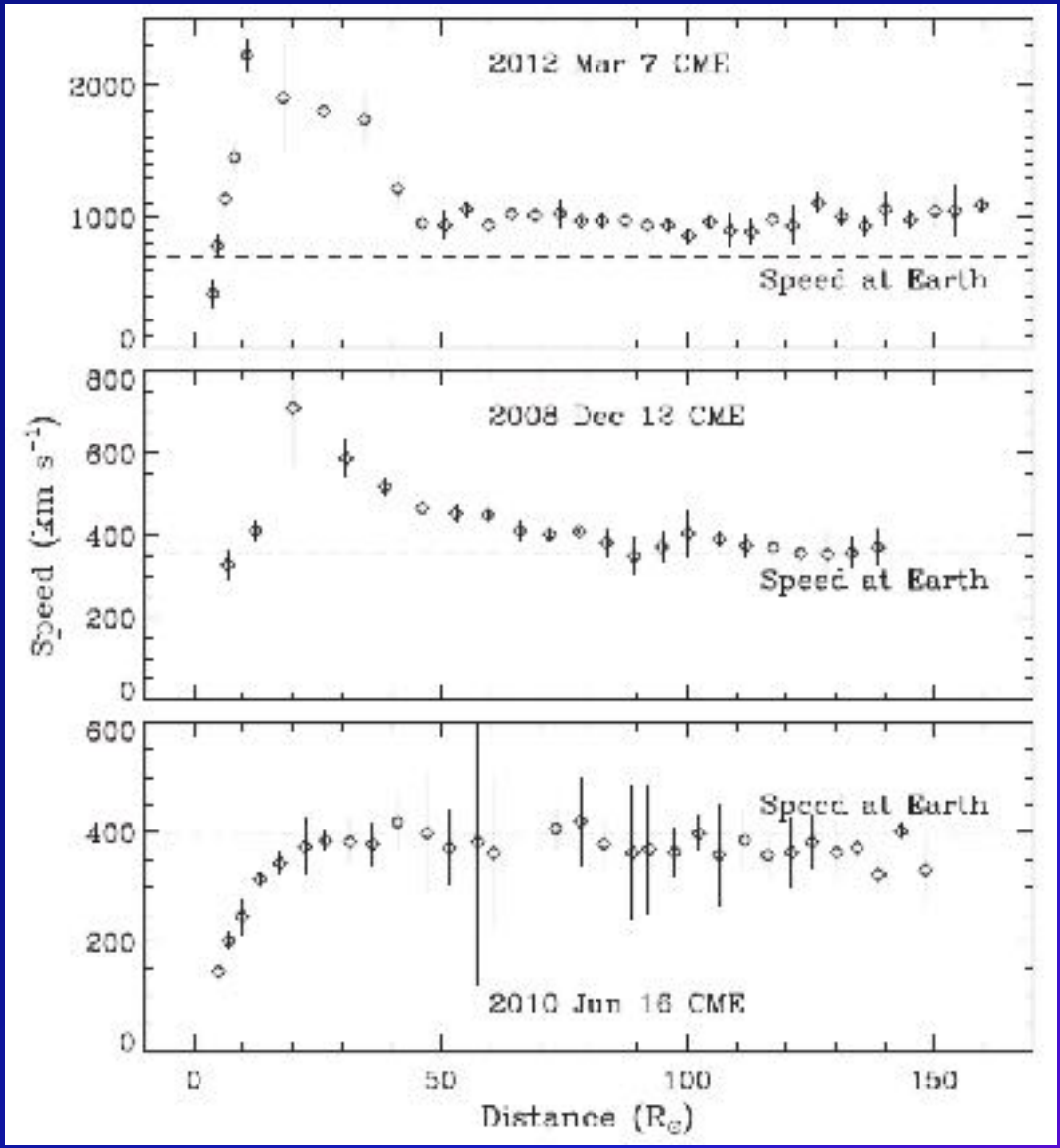
Ellipse evolution model (Most et al. 2015)

CME Sun-to-Earth Tracking



Ejecta and Shock (Hess & Zhang, 2014)

CME Sun-to-Earth Tracking



Liu et al (2016)

CME Sun-to-Earth Tracking The appropriate methods?

- For ejecta and shock near the Sun (COR2, C3, HI-1)
  - GCS model (Thernisien et al. 2006)
  - GCS + spherical model (Hess et al. 2014)
  - GCS + spheroid/ellipse model (Kwon et al, 2014, Mostle 2015)
- For shock in the interplanetary space (HI-2) (single versus double)
  - J-map: fixed-ϕ (Rouillard et al. 2008)
  - J-map: harmonic mean (Lugaz et al. 2010)
  - J-map: Self-similar expansion (SSE) (Davies et al. 2012)
  - J-map: fixed-ϕ and triangulation (Liu et al. 2010) for using double HI-2 images

CME Sun-to-Earth Tracking: Action Item recom.ed in 2015

cross-comparison between different observers for a selected number of events

- Time and Velocity at 5 Rs, 10 Rs, 20 Rs, 40 Rs, 80 Rs, 160 Rs, 1 AU and Earth

Will pursue this in 2018

Scientific Questions?

How do CMEs propagate from the Sun to Earth?

- **How do CMEs accelerate or decelerate in the interplanetary space through interaction with the ambient solar wind?**
- **How does the CME morphology change, e.g., pancaking?**
- **How does the shock front separate from the ejecta front, i.e., the evolution of the standoff distance with time?**
- **Effects of CME interaction with preceding CME?**
- **Effects of CME interaction with preceding and trailing CIRs?**
- **CME erosion due to magnetic reconnection**

Scientific Questions?

What kind of CMEs would reach the Earth?
i.e., predicting HIT/MISS from near-Sun observations?

- **Source location distribution on the solar disk?**
- **Why so many halo CMEs missed the Earth?**
- **What is the true nature of halo CMEs? Is merely a projection effect?**
- **How significant is the CME deflection?**
- **What are the causes of CME deflection?**
- **What about the effect of CME rotation?**
- **Stealth CMEs?**
- **Problem ICMEs?**

Scientific Questions?

How well could we predict the time of arrival (TOA) of CME ejecta and driven shocks?

- **How accurately can we predict the TOA of an ICME?**
- **How accurately can we predict the TOA for shocks and ejecta separately ?**
- **How can we further improve the prediction of TOA?**

Scientific Questions

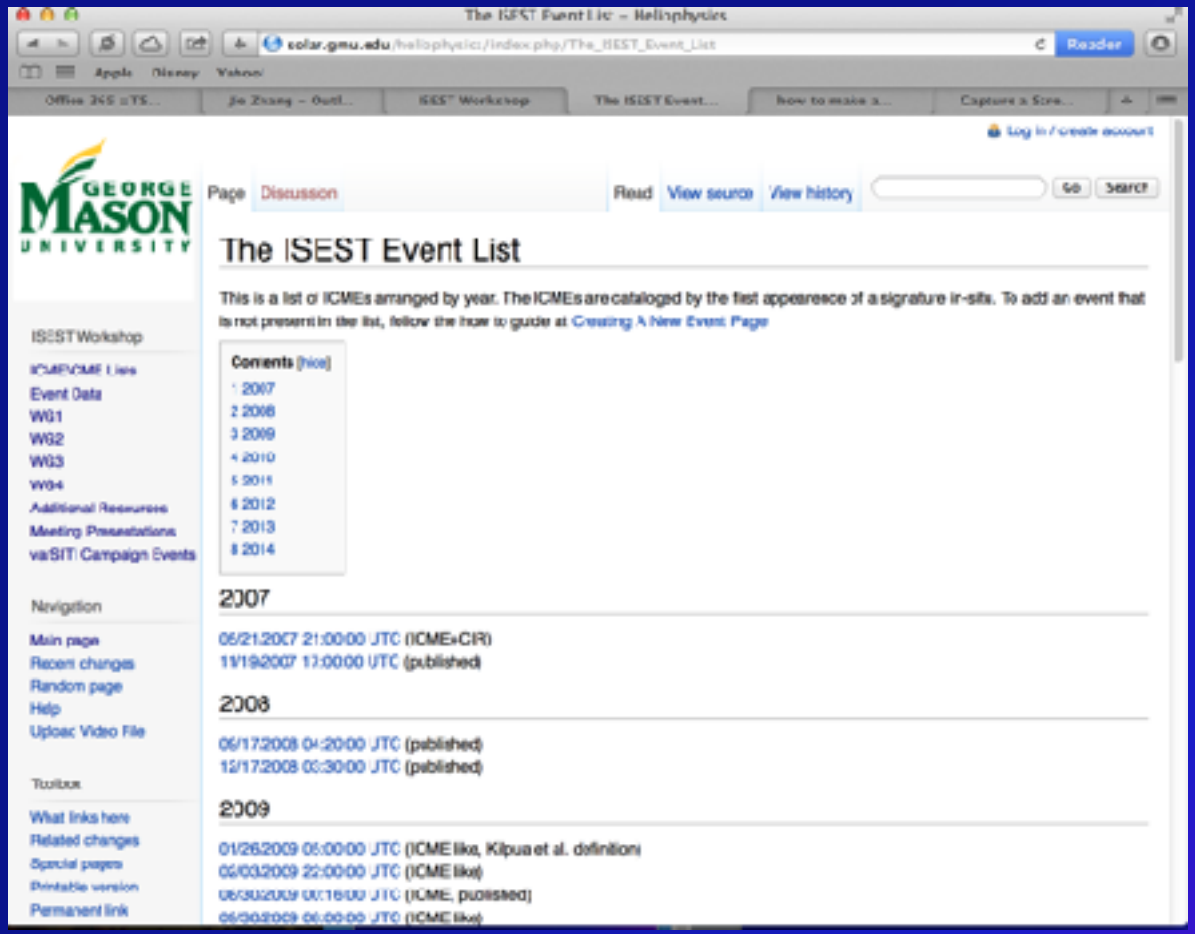
How can we predict the potential geoeffectiveness of an arriving ICME?

- **The big problem is the Bz issue, or the magnetic field topology in magnetic flux ropes (WG5).**

Use the ISEST WiKi

http://solar.gmu.edu/heliophysics/

Access data/information and provide your contribution



Without your input, it won't work

Items in this workshop

From the perspective of WG1

- On the geoeffectiveness of ICMEs?
- On the evolution of shock and ejects?
- On the prediction of CME geoeffectiveness?
- On the prediction of TOA?

Thanks