Whole Heliosphere and
Planetary Interactions

1st WHPI virtual colloquium

The Making of WHPI

Sarah Gibson and Barbara Thompson
(and a cast of hundreds)

Whole Heliosphere and Planetary Interactions

Outline

Why study solar minimum?

What did we learn from the Whole Sun Month (WSM)?

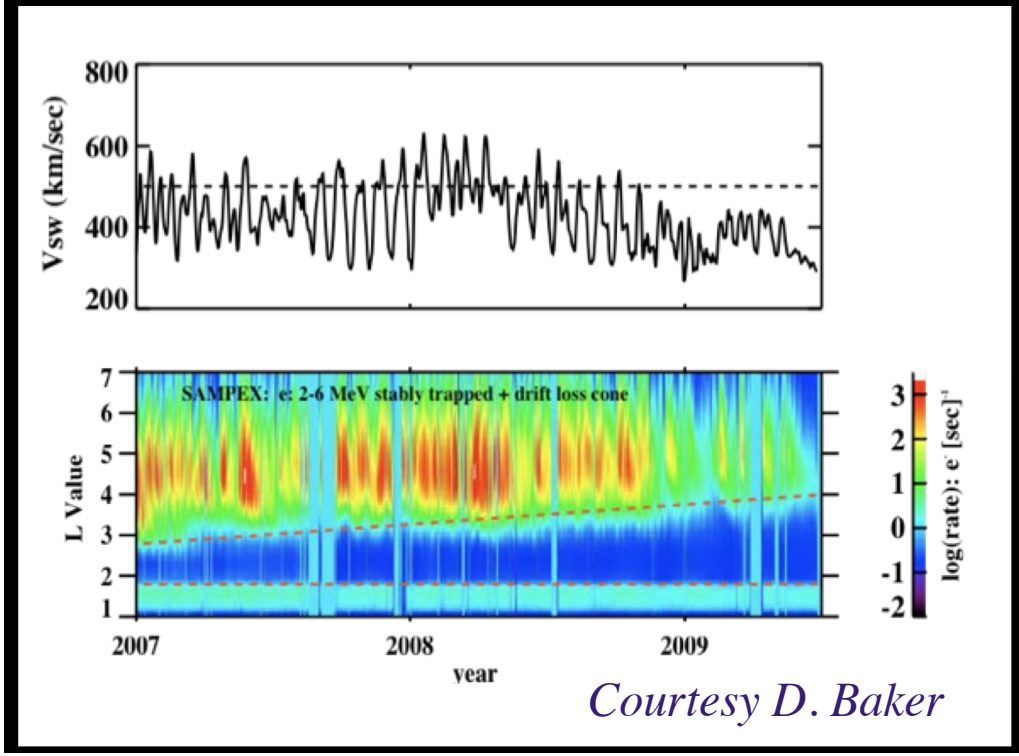
What did we learn from the Whole Heliosphere Interval (WHI)?

Where are we going with WHPI?

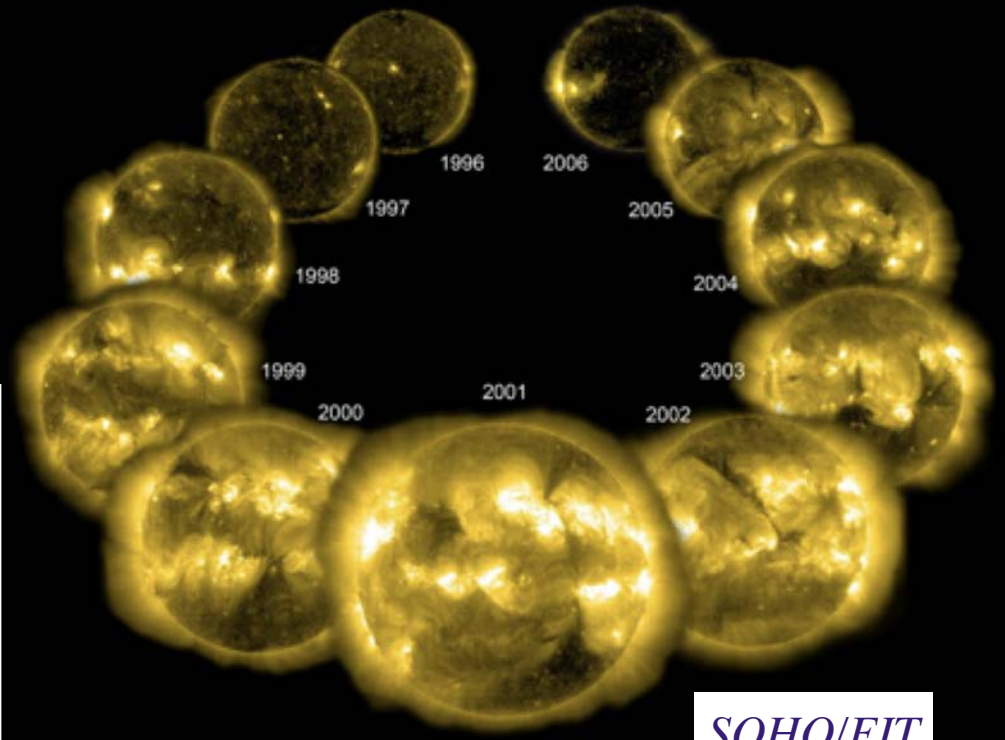
Whole Heliosphere and Planetary Interactions

Why Study Solar Minimum?

Isn't it boring?



Courtesy D. Baker



SOHO/EIT

Solar activity is slow

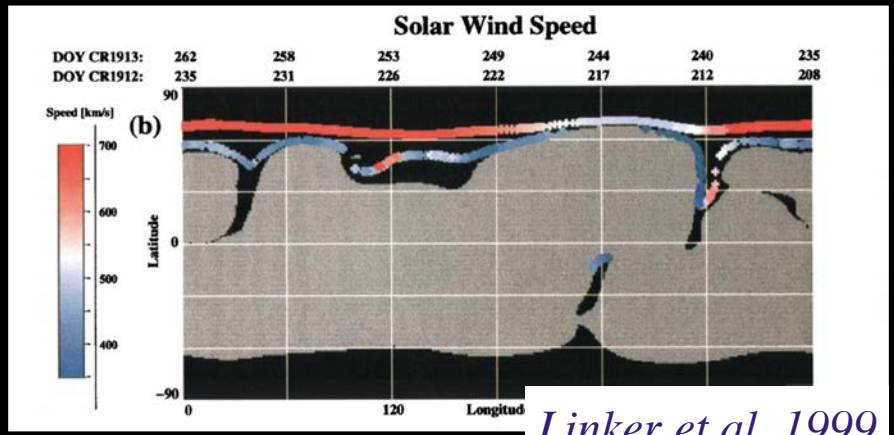
The solar wind is slower and less variable

The space environment is less energized

Whole Heliosphere and Planetary Interactions

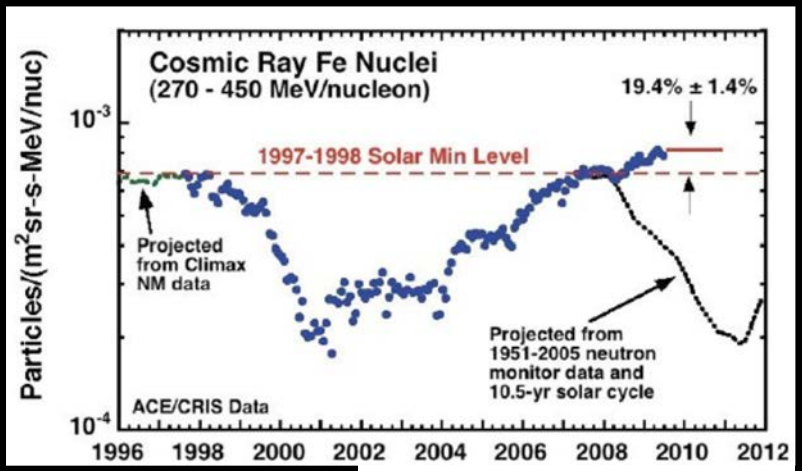
Why Study Solar Minimum?

Solar minimum is the perfect time to trace events "end to end".



Linker et al. 1999

Solar minimum is the perfect time to characterize the "baseline" system.



Mewaldt et al., 2010

No two solar minima are the same.

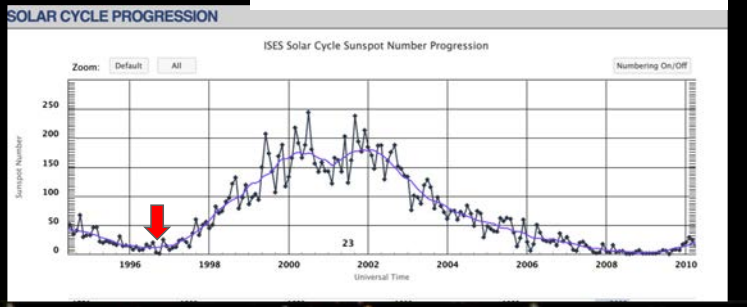
Whole Heliosphere and Planetary Interactions

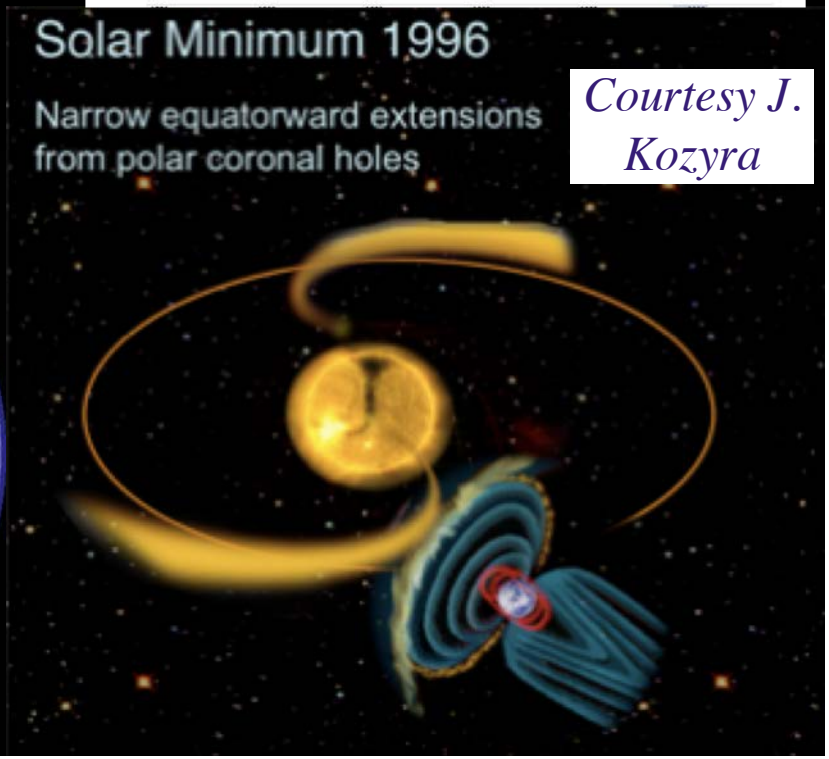
Why Study Solar Minimum?

Cycle 22: Whole Sun Month (WSM)

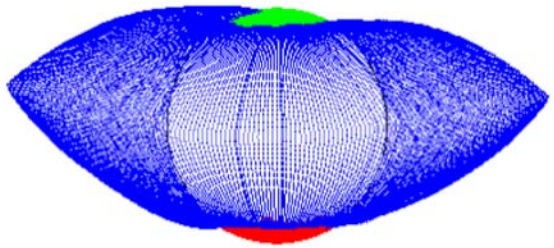
- August 10 - September 8, 1996
- 11 solar and 7 solar wind/heliosphere instruments
- ~50 participants

ISES SSN NOAA-SWPC

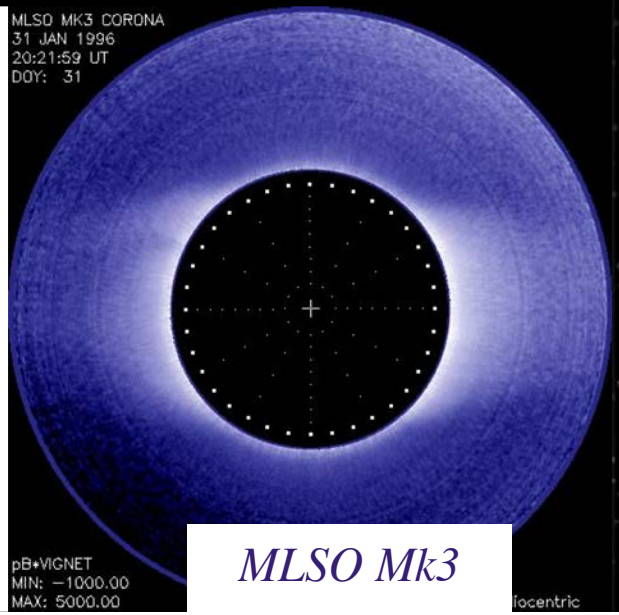




Courtesy J. Kozyra



NSO GONG PFSS



MLSO Mk3

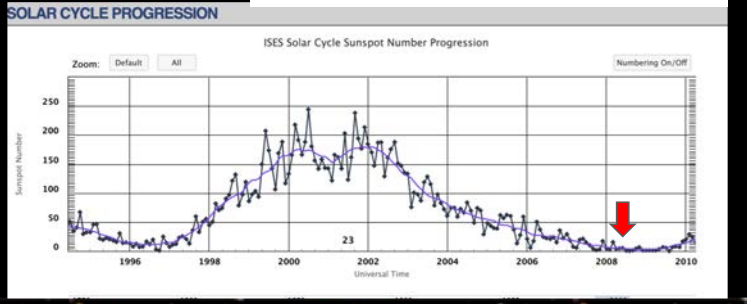
Whole Heliosphere and Planetary Interactions

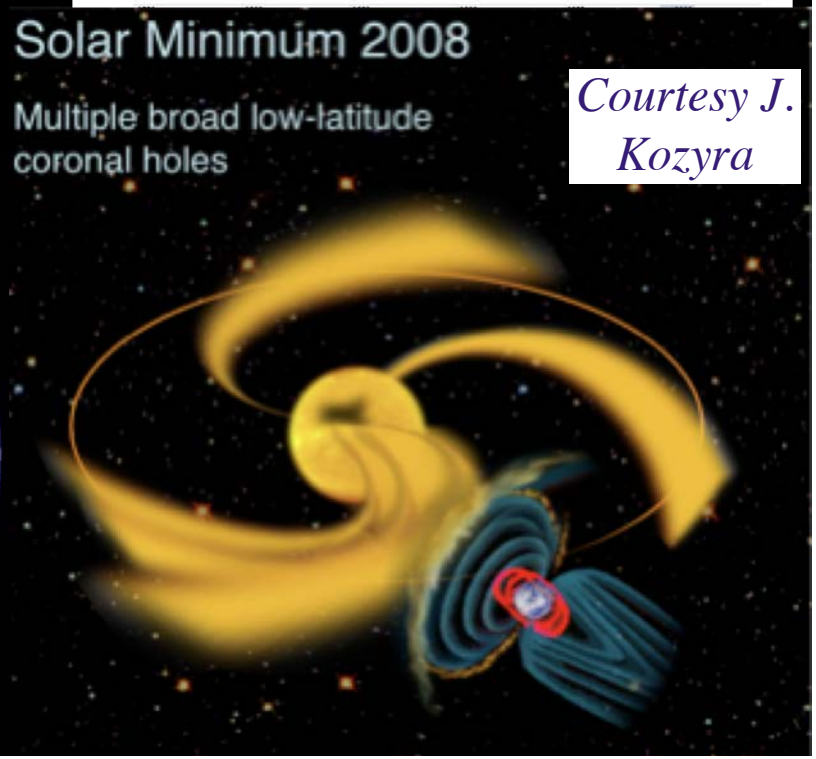
Why Study Solar Minimum?

Cycle 23: Whole Heliosphere Interval (WHI)

- Carrington Rotation 2068: March 20 - April 16, 2008
- 27 solar, 19 heliospheric, and 21 geospace instruments
- ~200 participants

ISES SSN NOAA-SWPC





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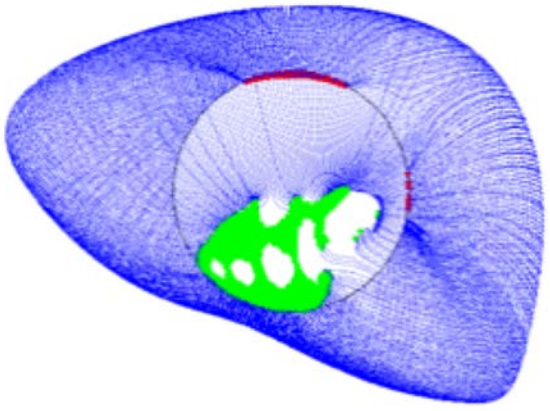

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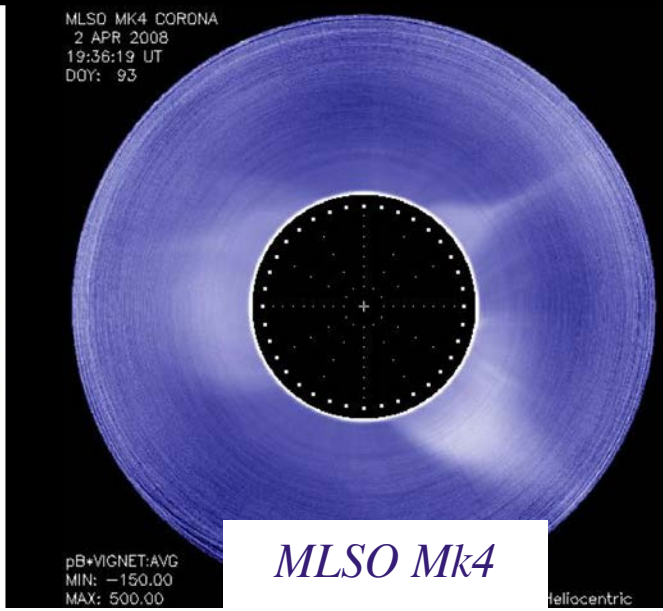
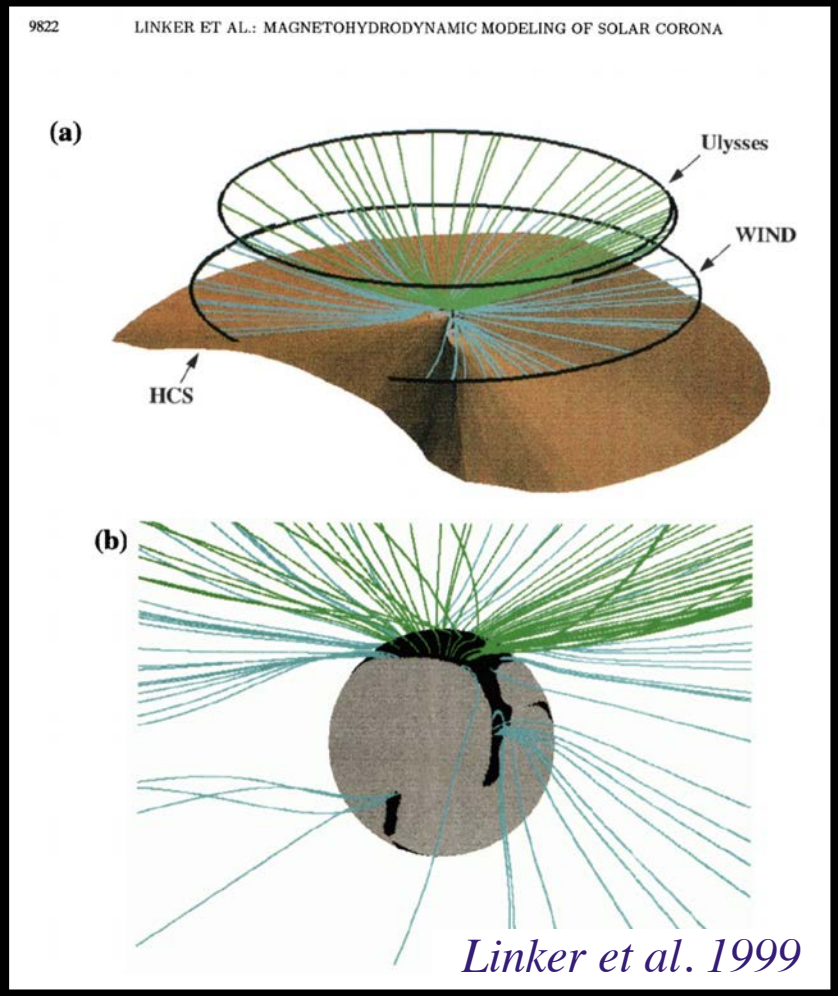


MLSO Mk4

Whole Heliosphere and Planetary Interactions

What did we learn from WSM?



Linker et al. 1999

WSM was the ~first major coordinated campaign driven by modeling goals: observations were designed to provide constraints and boundary conditions.

It was challenging! But extremely worthwhile.

WSM was the most comprehensive (to date) global study of solar-heliospheric defining structures.

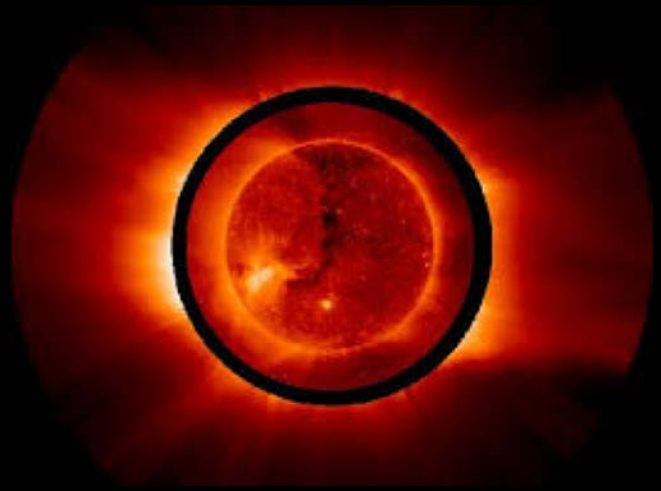
WSM set the stage for several significant future efforts.

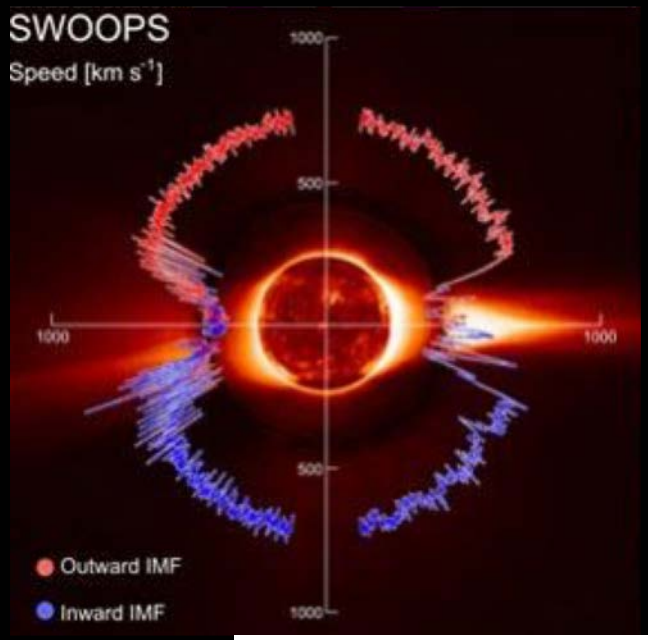
Whole Heliosphere and Planetary Interactions

What did we learn from WSM?

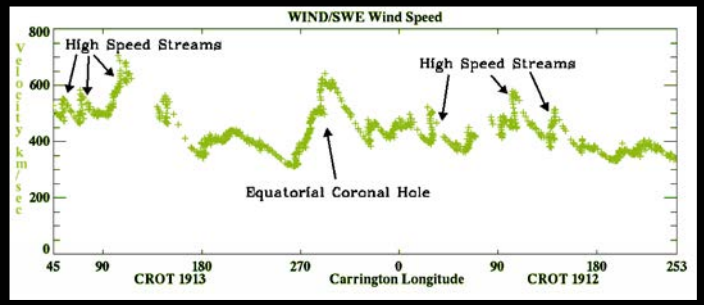
The internet was changing the way we interacted and shared data.

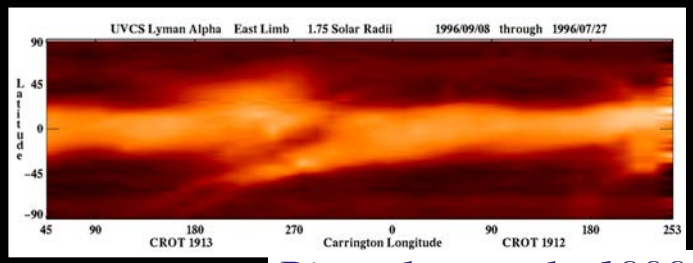
The team* devised innovative new ways to represent and combine data sets that are still in use today.





McComas et al. 1998





Biesecker et al., 1999

* WSM was the origin of several career-changing collaborations!

Whole Heliosphere and Planetary Interactions

What did we learn from WSM?

New ways of looking at the data

East		Limb				West	Limb	
5 Solar Radii	2.25/2.5 Solar Radii	1.75 Solar Radii	1.15 Solar Radii	Central Meridian	1.15 Solar Radii	1.75 Solar Radii	2.25/2.5 Solar Radii	5 Solar Radii
LASCO C3	LASCO C2	LASCO C1	EIT 171 Å	EIT 171 Å	EIT 171 Å	LASCO C1	LASCO C2	LASCO C3
	UVCS Lyman Alpha	UVCS Lyman Alpha	EIT 195 Å	EIT 195 Å	EIT 195 Å	UVCS Lyman Alpha	UVCS Lyman Alpha	
	UVCS Ovygen VI	UVCS Oxygen VI	EIT 284 Å	EIT 284 Å	EIT 284 Å	UVCS Ovygen VI	UVCS Oxygen VI	
		HAO/Mauna Loa MK III	HAO/Mauna Loa MK III	EIT 304 Å	HAO/Mauna Loa MK III	HAO/Mauna Loa MK III		
			Yohkoh SXT	Yohkoh SXT	Yohkoh SXT			
			NSO/Sac Peak Fe XIV	CDS O V 630 Å	NSO/Sac Peak Fe XIV			
			NSO/Sac Peak Fe X	CDS He I 584 Å	NSO/Sac Peak Fe X			
			LASCO C1	CDS Mg IX 368 Å	LASCO C1			
				MDI Magnetogram				
				Nobeyama Radioheliograph				
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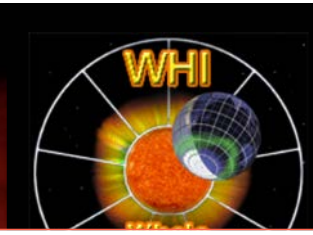
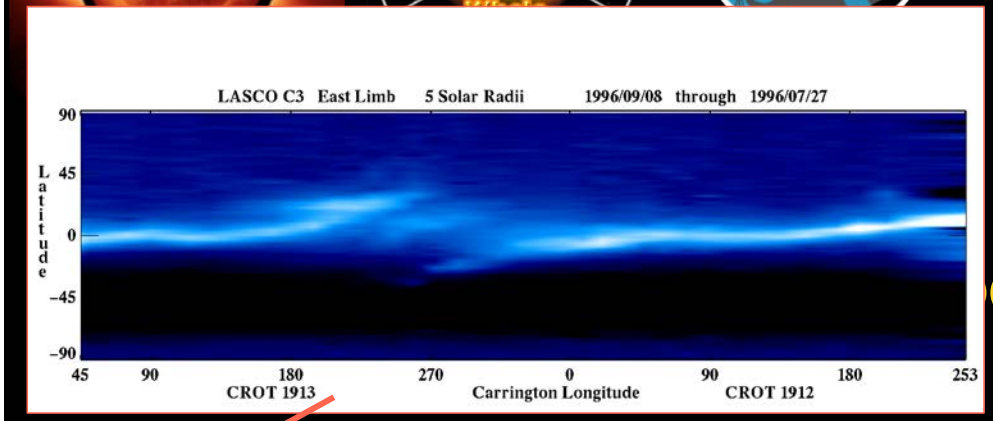
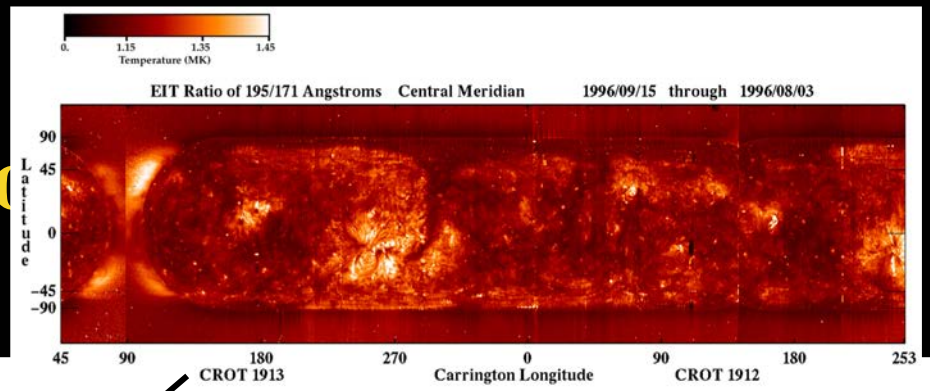
	East	Limb				West	Limb	



What did we learn from WSM?





East Limb					West Limb			
5 Solar Radii	2.25/2.5 Solar Radii	1.75 Solar Radii	1.15 Solar Radii	Central Meridian	1.15 Solar Radii	1.75 Solar Radii	2.25/2.5 Solar Radii	5 Solar Radii
LASCO C3	LASCO C2	LASCO C1	EIT 171 Å	EIT 171 Å	EIT 171 Å	LASCO C1	LASCO C2	LASCO C3
	UVCS Lyman Alpha	UVCS Lyman Alpha	EIT 195 Å	EIT 195 Å	EIT 195 Å	UVCS Lyman Alpha	UVCS Lyman Alpha	
	UVCS Ovygen VI	UVCS Oxygen VI	EIT 284 Å	EIT 284 Å	EIT 284 Å	UVCS Ovygen VI	UVCS Oxygen VI	
		HAO/Mauna Loa MK III	HAO/Mauna Loa MK III	EIT 304 Å	HAO/Mauna Loa MK III	HAO/Mauna Loa MK III		
			Yohkoh SXT	Yohkoh SXT	Yohkoh SXT			
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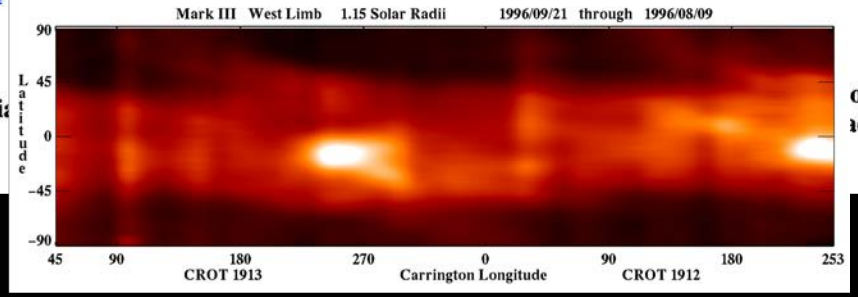
	East Limb							



Whole Heliosphere and Planetary Interactions

What did we learn from WSM?

WSM consisted of several phases:

- Preliminary planning phase
- First observation pl
- "First W semble data sets and
- "Second ve working groups an

Outstanding ditional intervals:

- Whole Sun , 1998
- Whole Sun paign: August 18 – September 14, 1999
- WSM-U: Ulysses fast equatorial scan May 2001 coordinated observations

We learned:

1) Solar minimum is interesting and complicated!

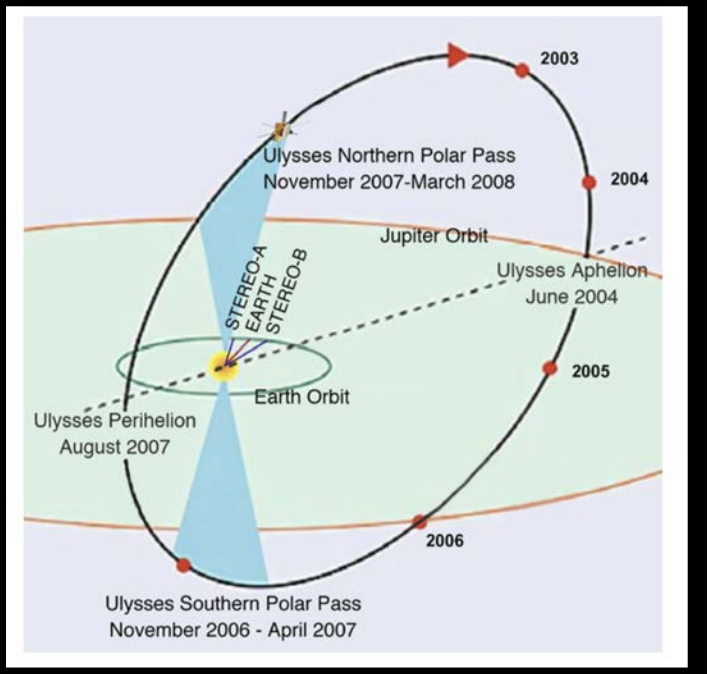
2) A strong grasp of the solar minimum corona can form the basis of studies of more active stages of the solar cycle.

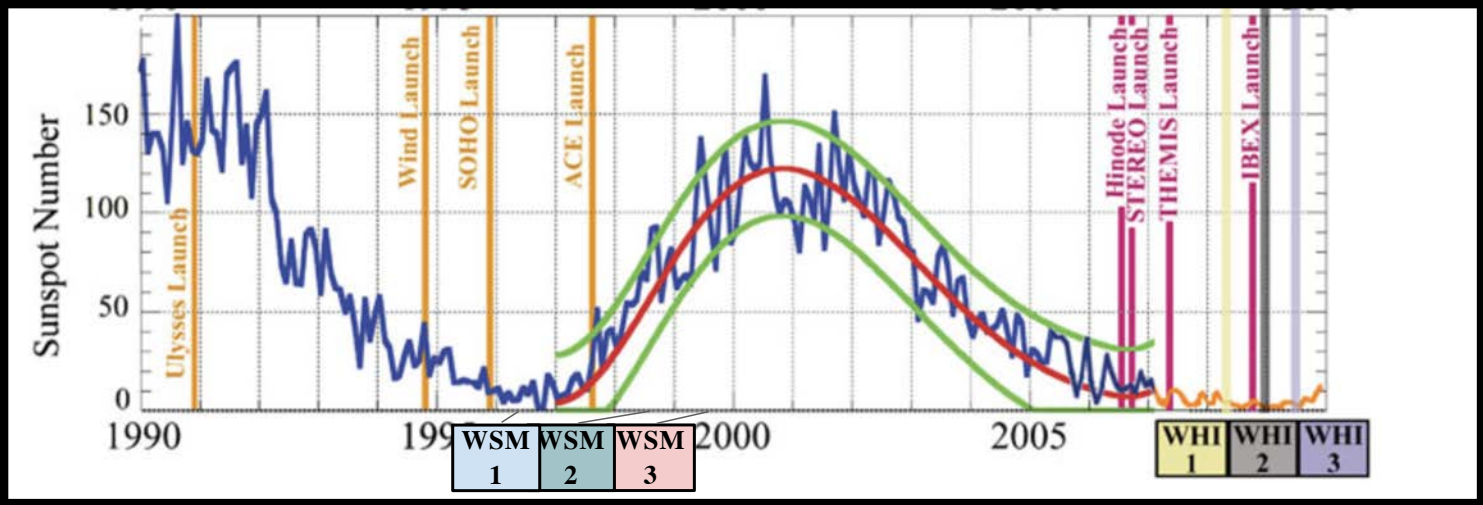
Whole Heliosphere and Planetary Interactions

We learned we wanted WHI!

Better heliospheric coverage (Ulysses + STEREO + Wind + ACE + SOHO)

Exciting new geospace capabilities (THEMIS, Global ground-based chains, ITM models)





Whole Heliosphere and Planetary Interactions

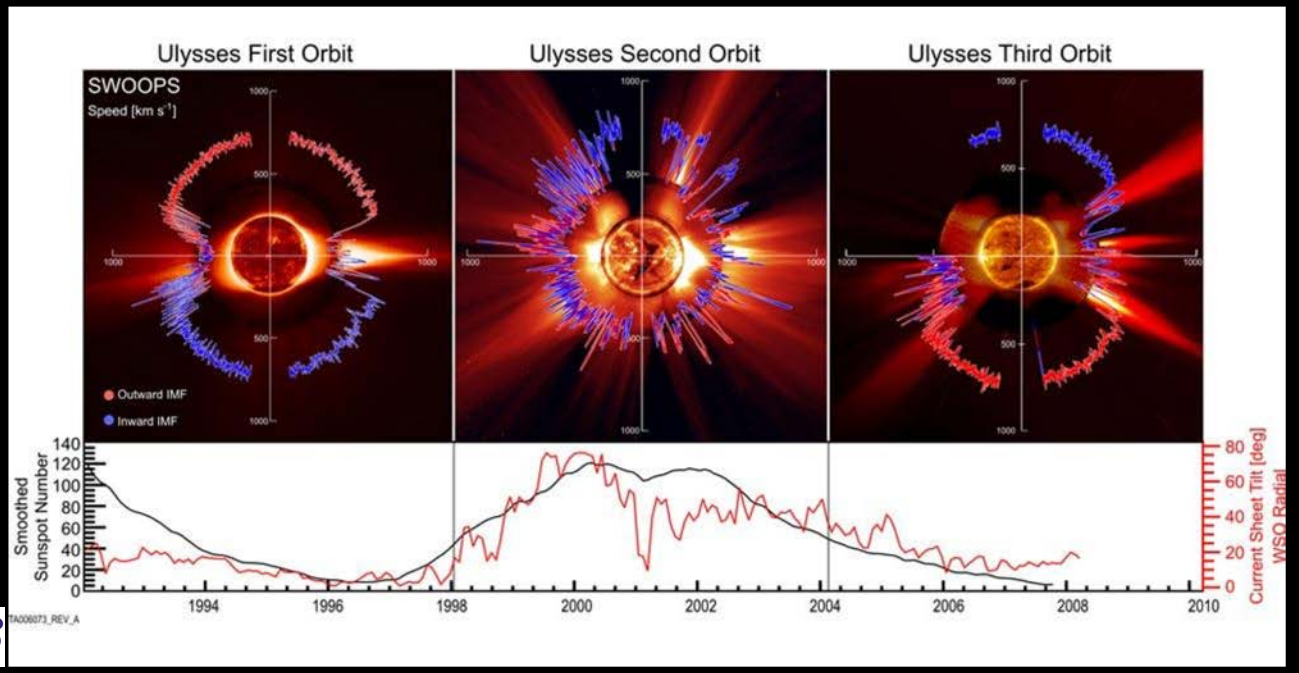
What did we learn from WHI?

WHI happened during the **deepest and widest solar minimum of the space age.** Serendipitously, the observing and modeling campaigns were already being planned, with hundreds of participants around the globe.

It resulted in the largest assembly of co-mapped data sets ever! (or at least we think so)

27 solar, 19 heliospheric, 21 geospace instruments, and many models

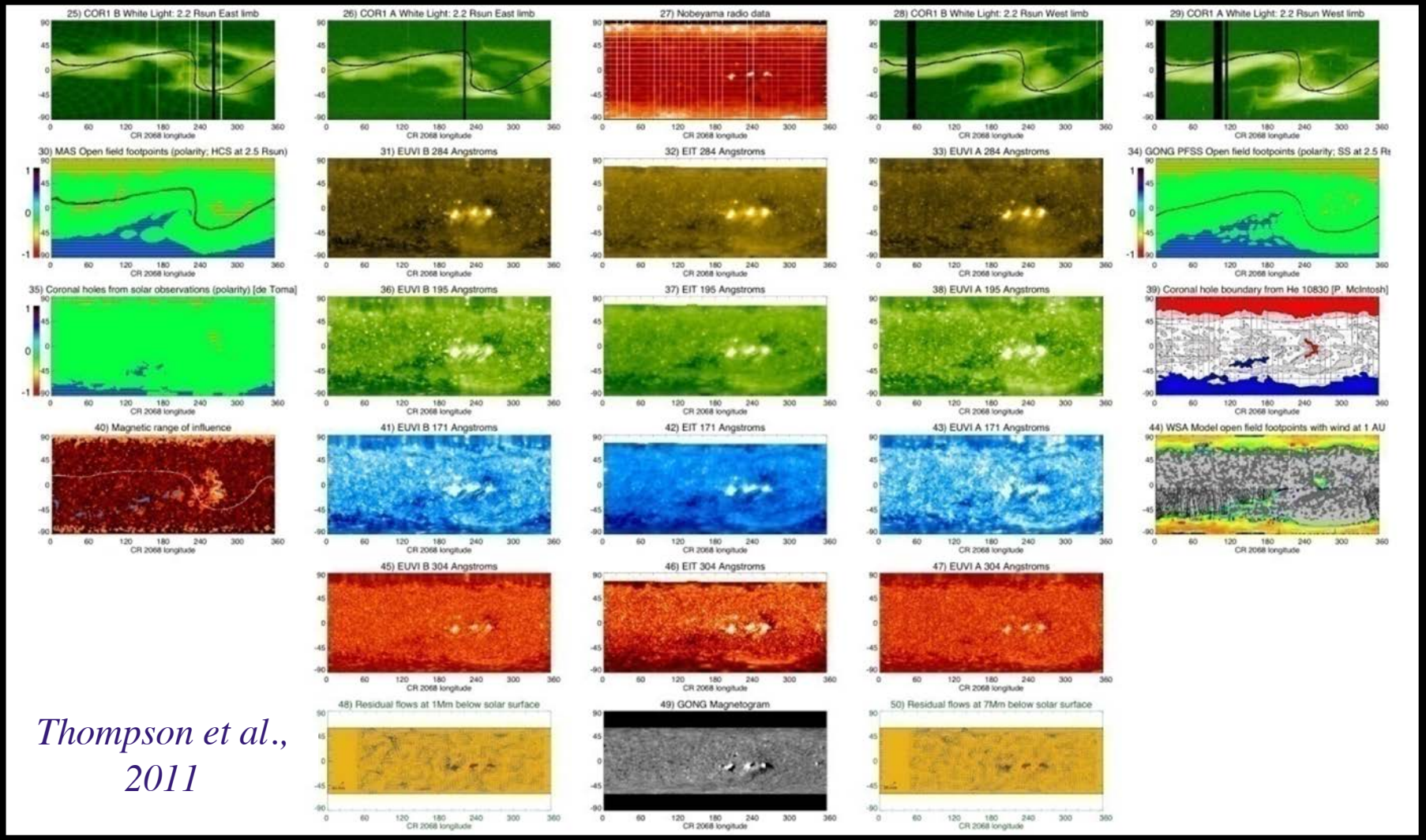
- Huge special journal issue
- Special Sessions at meetings



McComas et al. 1998; 2003; 2008

Whole Heliosphere and Planetary Interactions

What did we learn from WHI?



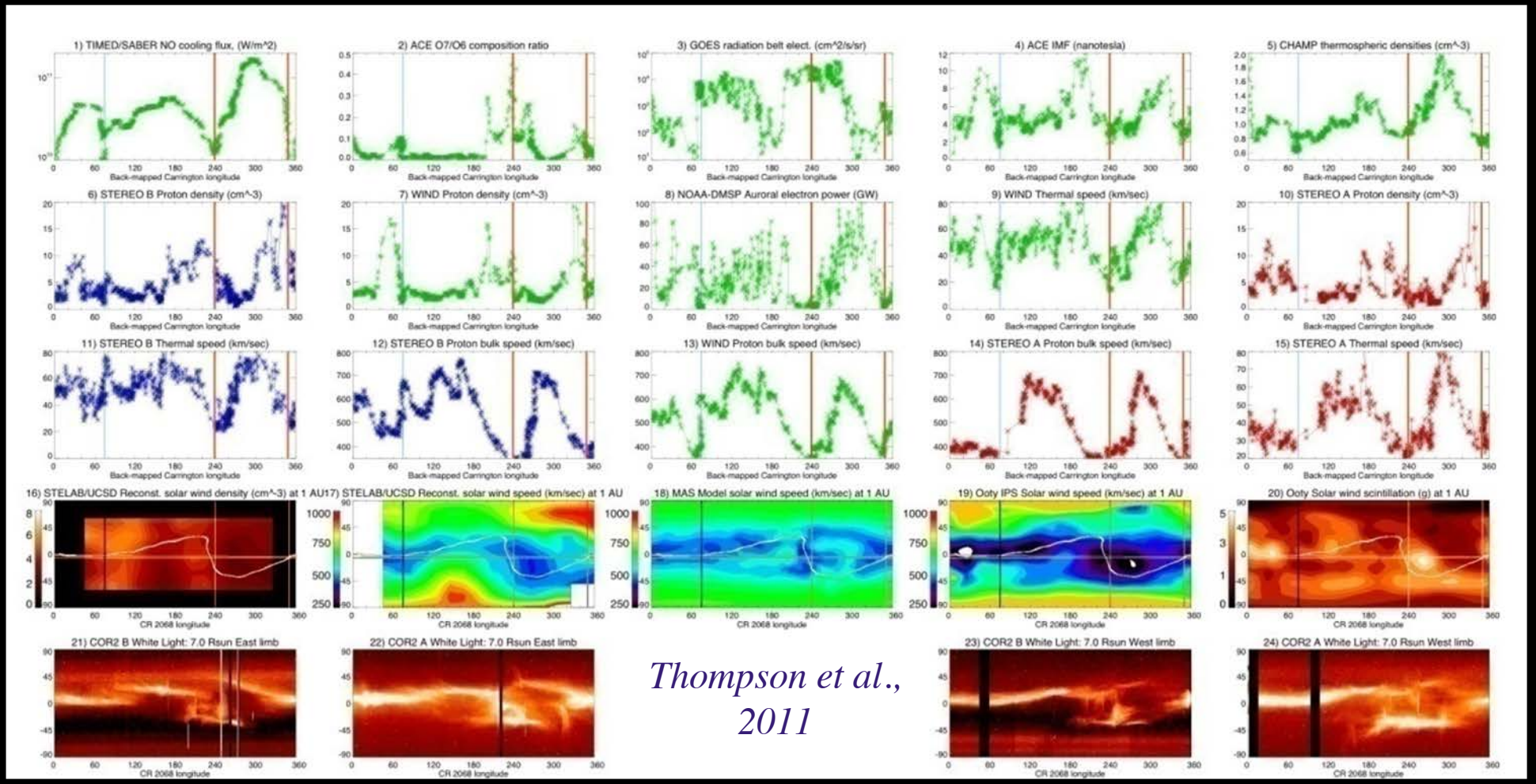
Thompson et al., 2011

WSM
Whole Sun Month

WHI
Whole Heliosphere Interval

WHPI
Whole Heliosphere and Planetary Interactions

What did we learn from WHI?



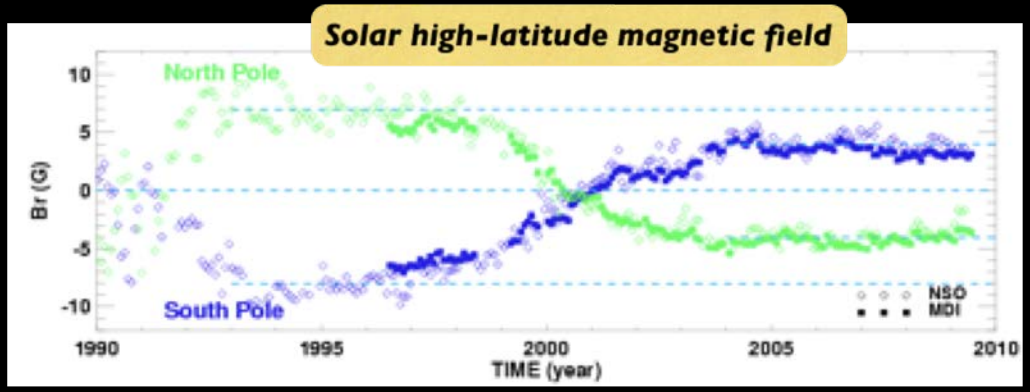
Thompson et al., 2011

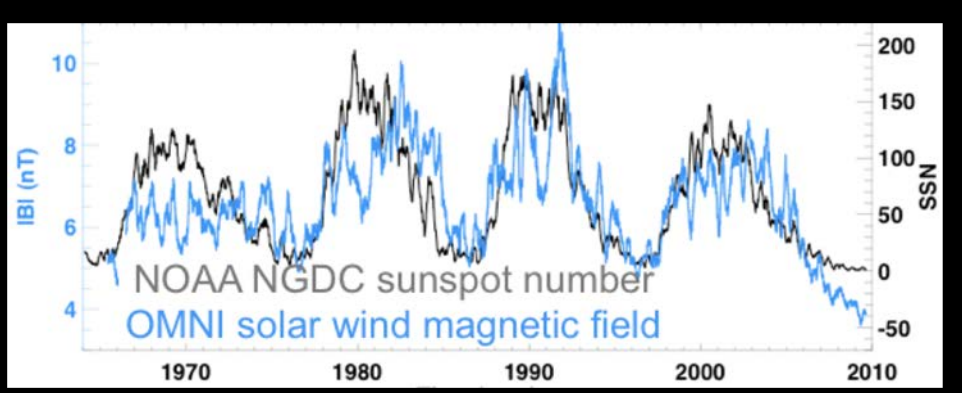
Whole Heliosphere and Planetary Interactions

What did we learn from WHI?

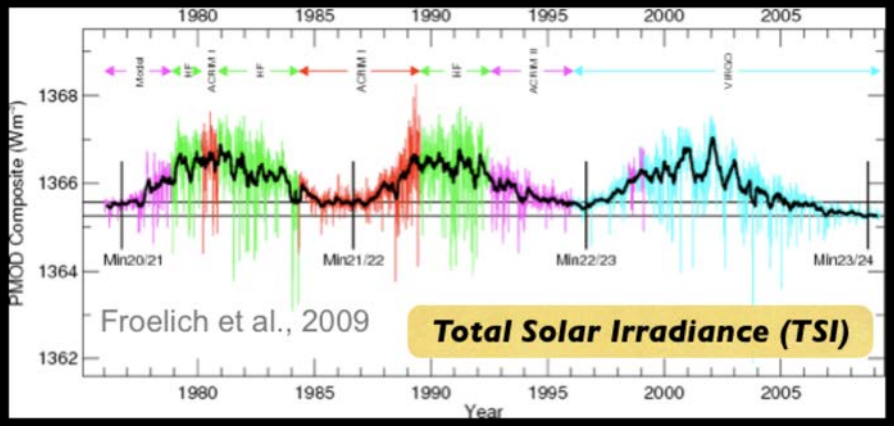
A deep and long solar minimum

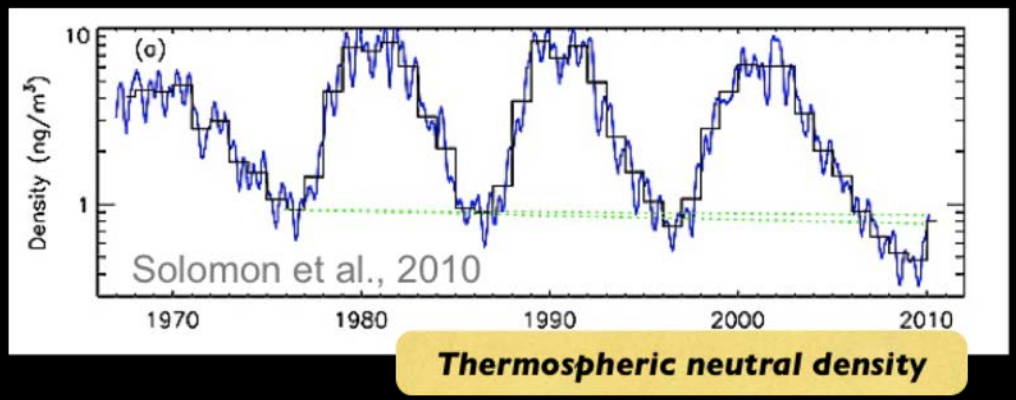
Weak magnetic fields - at the sun and in the solar wind





Depth of minimum affects Earth's upper atmosphere

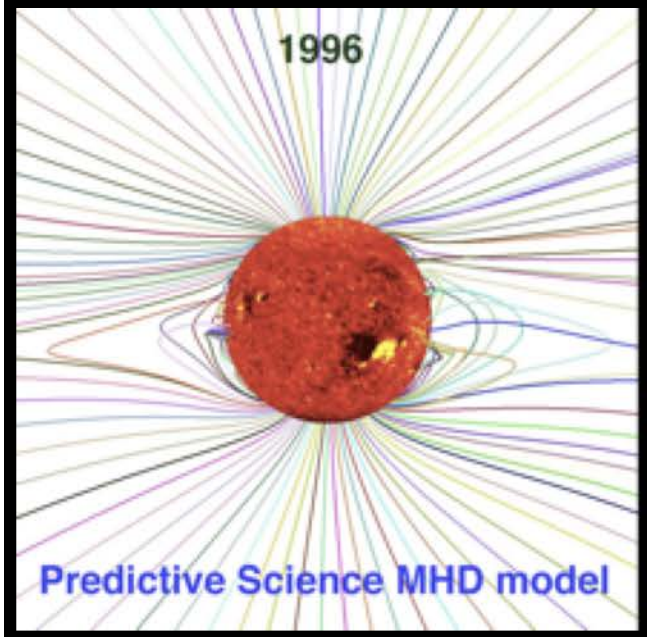


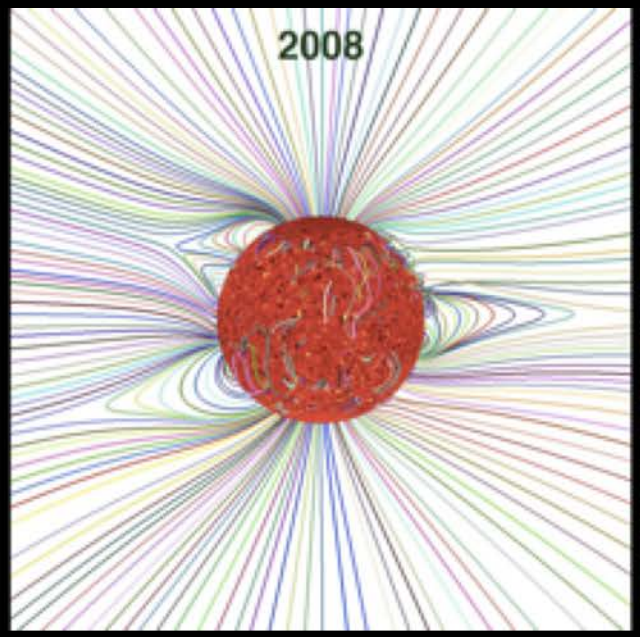


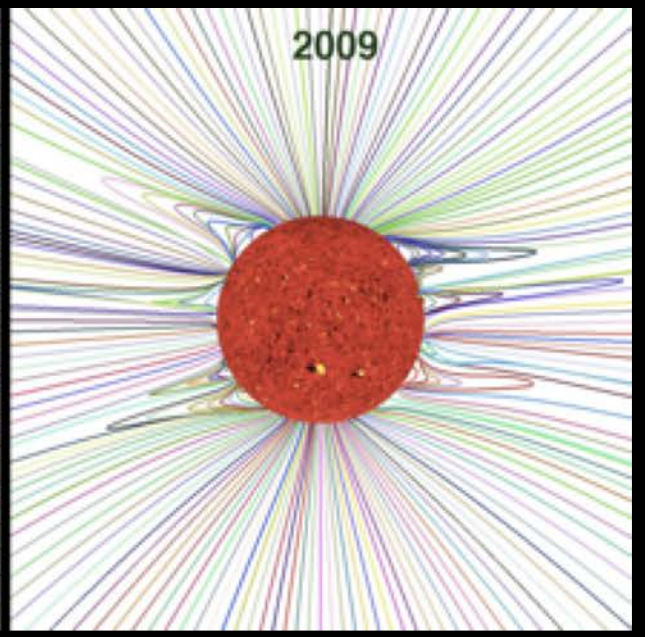
Whole Heliosphere and
Planetary Interactions

What did we learn from WHI?

Our whole concept of solar minimum changed.







Whole Heliosphere and Planetary Interactions

What did we learn from WHI?

WHI consisted of several phases:

- Preliminary planning pha
- First observati
- "WHI Da Boulder, Colorado, USA. The yst for the assembly of the data and an alysis efforts between the WHI community
- The second W 10 – 13 November 2009 in Boul on the generation of s results.

Learning from WSM, we planned two separate workshops:
First: a data and model "assessment" to compare and combine our products.
Then: Science meeting focusing on producing major results

Similar to WSM, we decide to add a

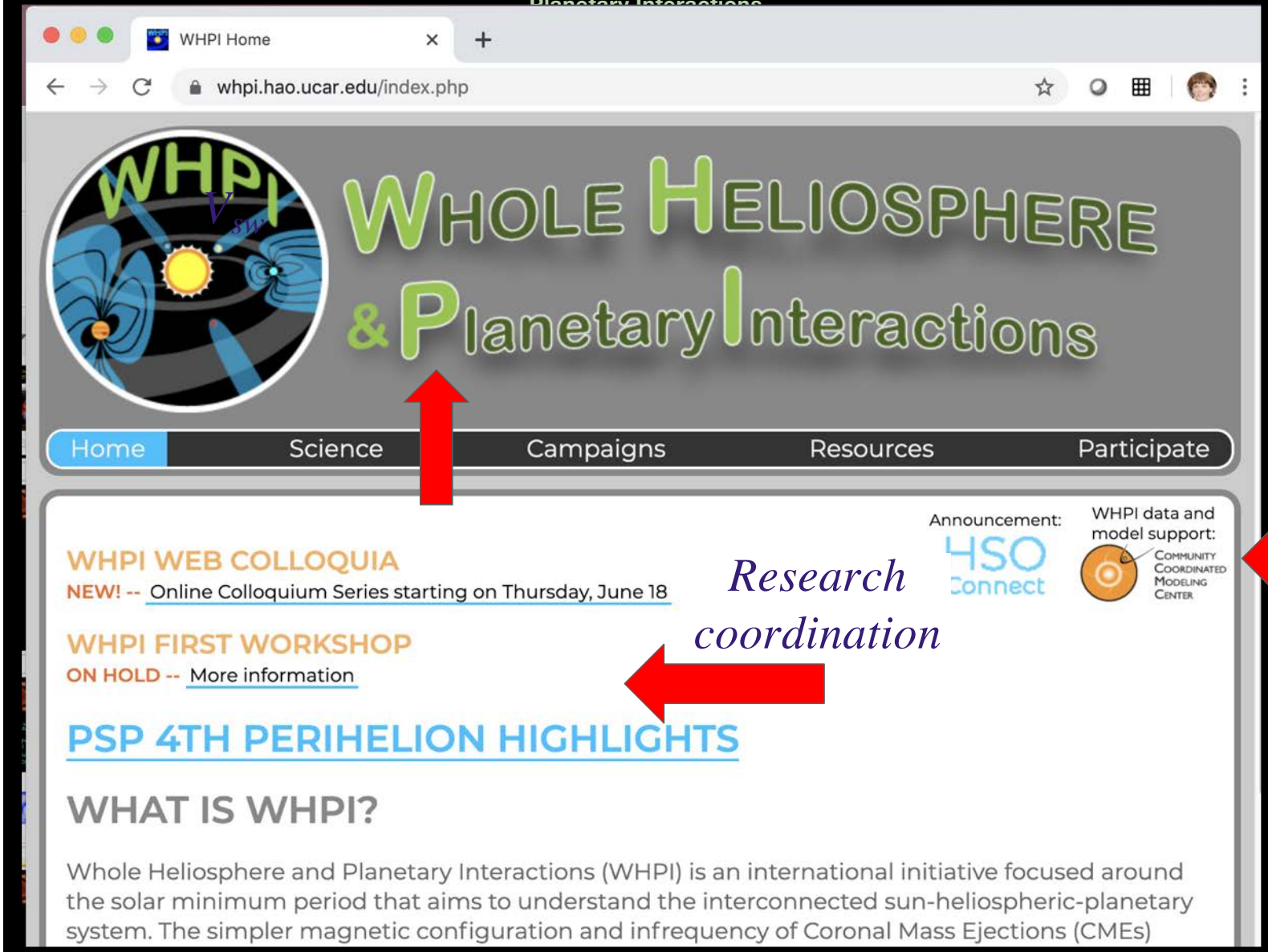
- WHI 2 (corresponding to CR anuary 2009)
- WHI 3 (corresponding to CR 2 22 July 2009).

Originally, WHI focused on a single interval and didn't plan additional campaigns.

Once again, solar minimum required more - we learned our lesson!

Whole Heliosphere and

Where are we going with WHPI?



Data archive

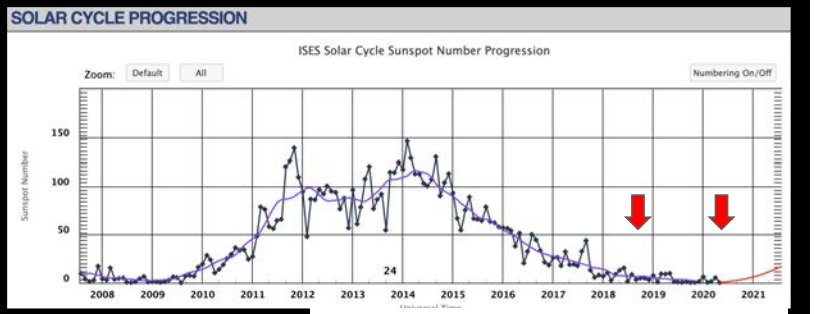
Research coordination

Whole Heliosphere and Planetary Interactions

Where are we going with WHPI?

Cycle 24: Whole Heliosphere and Planetary Interactions (WHPI)

- Spans period from late 2018 to early 2020
- 33 solar, 7 heliospheric, 15 geospace, and 3 planetary **missions/projects**
- ~600 participants



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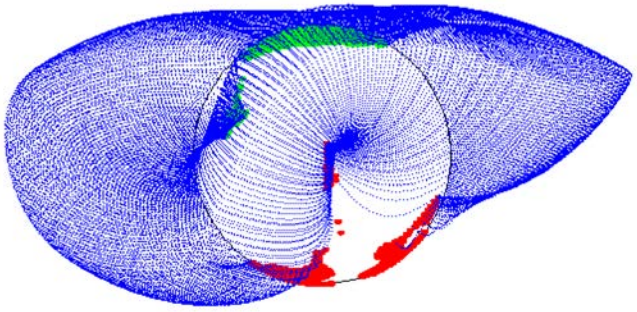

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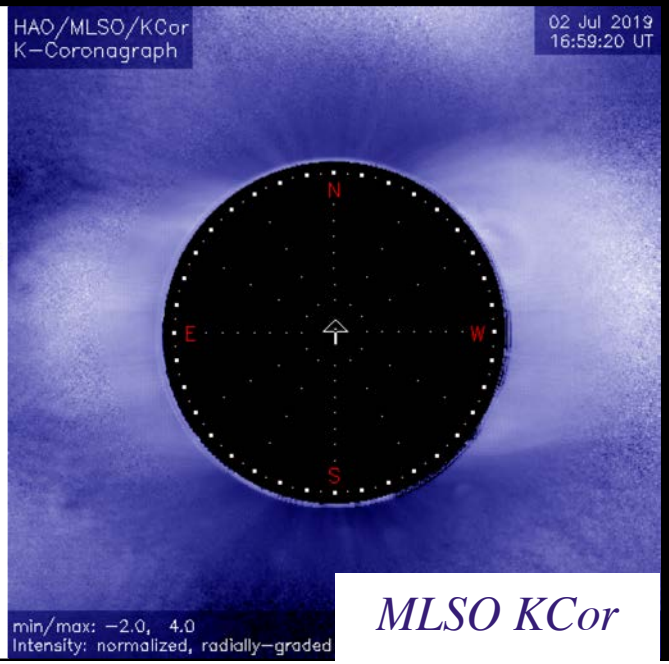

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Whole Heliosphere and Planetary Interactions

Where are we going with WHPI?

CAMPAIGN PERIODS:

Planet positions during campaign periods

"Recurrent Coronal Holes/High Speed Solar Wind Streams" Mar 12 - Apr 8 2019, Carrington Rotation **2215**

"Total Solar Eclipse Campaign" Jun 29 - Jul 26 2019, Carrington Rotation **2219**

"Parker Solar Probe 4th Perihelion Campaign" Jan 15 - Feb 11 2020

OTHER INTERESTING TIME INTERVALS

"Parker Solar Probe First Perihelion" Oct 31 - Nov 11, 2018, Carrington Rotation **2210**

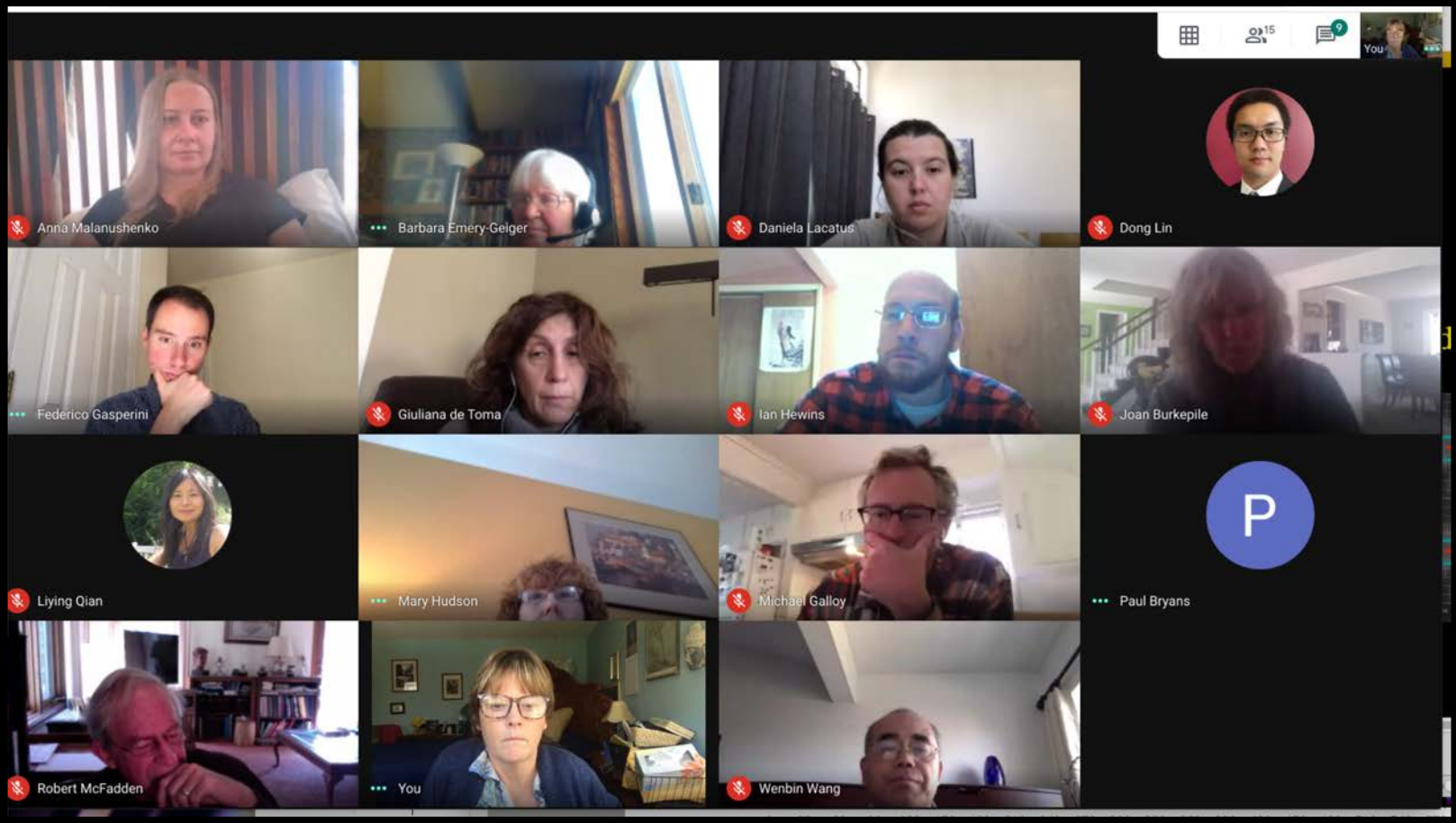
"Parker Solar Probe Third Perihelion Campaign" Aug 22 - Sep 19, 2019, Carrington Rotation **2221**

"PSP and STEREO-A Closest Approach" Oct 16 - Nov 12 2019, Carrington Rotation **2223**

"Parker Solar Probe Venus Flyby Campaign" Dec 10 2019 - Jan 6 2020, Carrington Rotation **2225**

Whole Heliosphere and Planetary Interactions

Where are we going with WHPI?



A virtual WHPI sprint...

Whole Heliosphere and Planetary Interactions

Conclusions

Why study solar minimum?

- To characterize the baseline system and the connections within it
- No two minima are the same!

What did we learn in WSM and WHI?

- Global insight into the origins and impacts of the solar wind
- The nature of a quiet solar minimum

Why an international interdisciplinary initiative?

- Catalyst for new analysis approaches
- Builds an enduring cohort of scientific collaborators

Where are we going with WHPI?

- New science, new connections
- New data-model interpretation schema
- Virtual WHPI: potential to be more global and inclusive than ever!