Solar Observation, Space Weather and the Computation of Sunspot Dynamics

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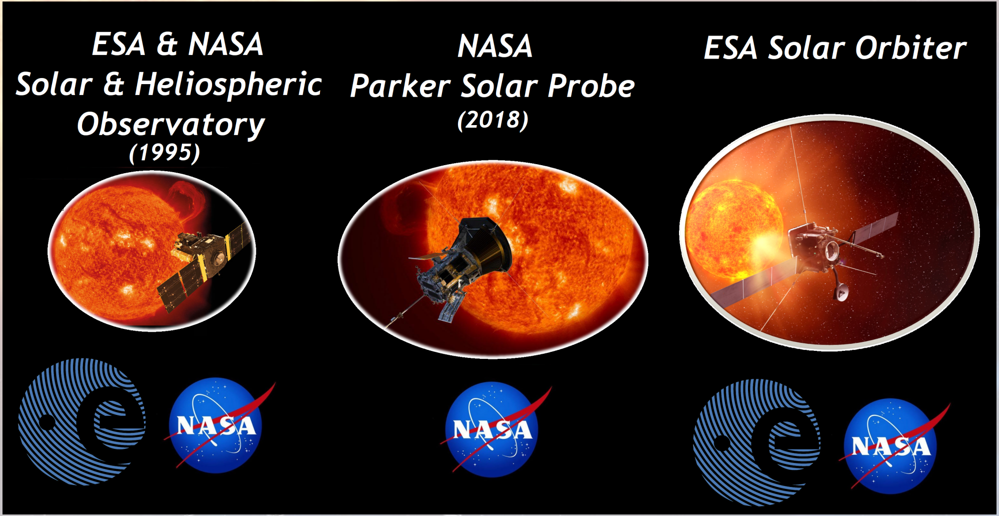
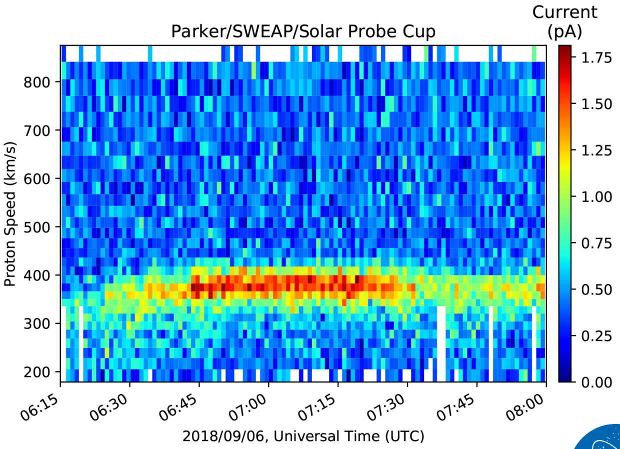
Solar Observation Part I: Global Interest



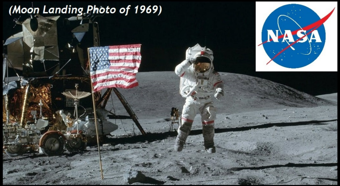
Solar Observation Part II: Parker Probe Early Data



https://svs.gsfc.nasa.gov/13072

Solar Observation Part III: Why Do We Care?

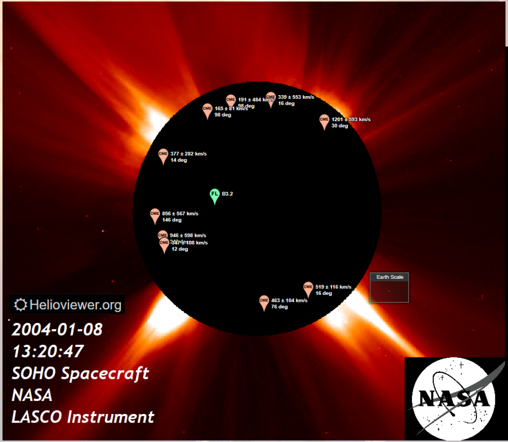
Current Dependence on Satelite & Spacecraft Technology

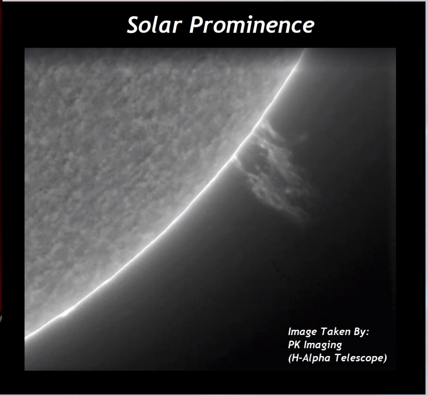


NASA: Artemis Mission

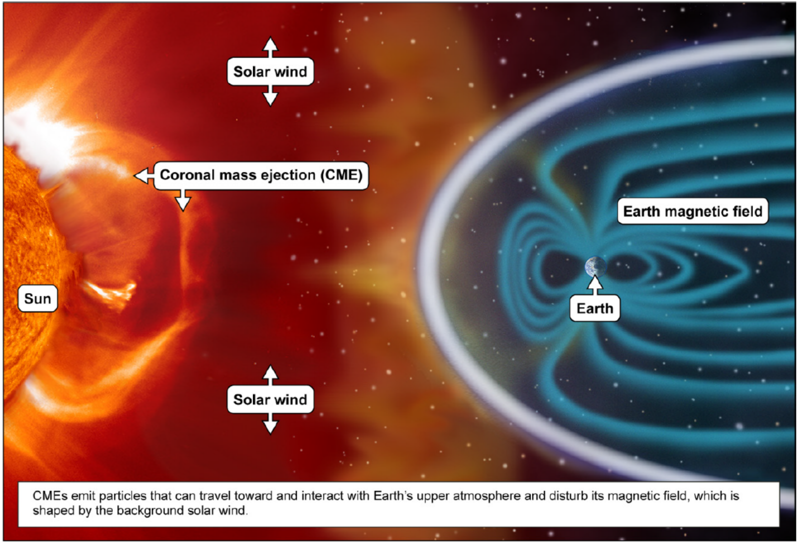
SpaceX: Mars Misson

Space Weather Part I: Solar Variances





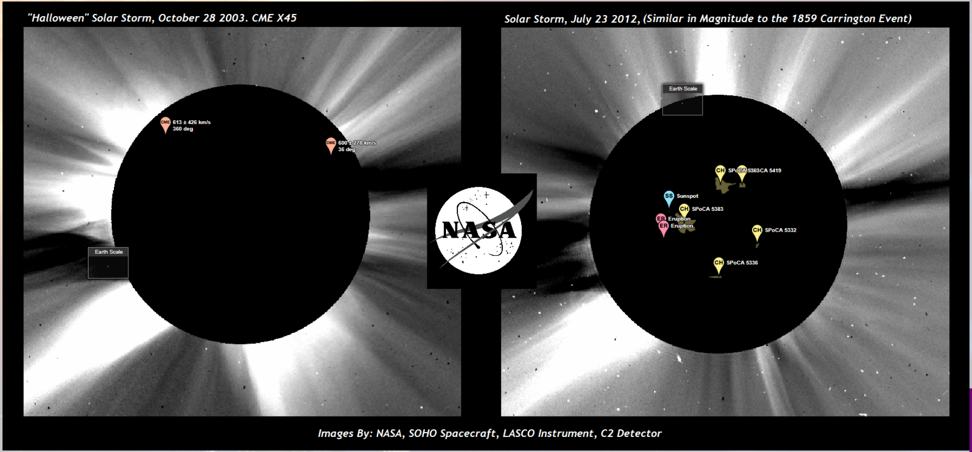
Space Weather Part II: Geomagnetic Storms



CMEs emit particles that can travel toward and interact with Earth's upper atmosphere and disturb its magnetic field, which is shaped by the background solar wind.

Source: National Aeronautics and Space Administration (illustration). | GAO-19-98

Space Weather Part III: Historical Solar Storms



NWU Solar Observation Part I: Our Telescopes

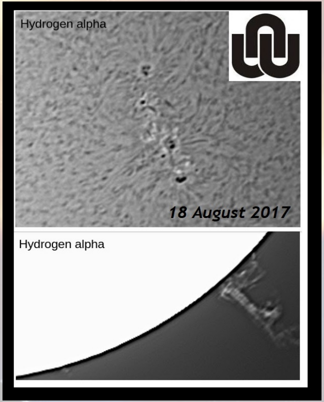
NEXSTAR 8SE COMPUTERIZED TELESCOPE

(White Light Telescope)

50MM H-ALPHA PRESSURE TUNED SOLAR TELESCOPE

(Hydrogen Alpha Telescope)

NWU Solar Observation Part II: Hydrogen-Alpha Telescope

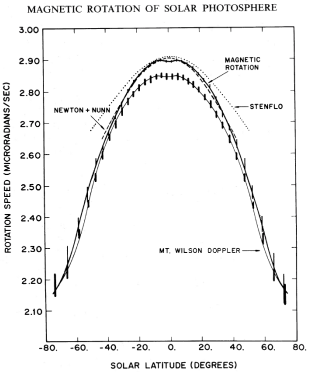


- Aperture Size: 50 mm
- Focal Length: 350 mm
- Focal Ratio: 7

NWU Solar Observation Part III: White Light Telescope

- Schmidt-Cassegrain Telescope
- Aperture Size: 203.2mm (8")
- Focal Length: 2032mm (80")
- Focal Ratio: 10

Sunspot Dynamics Part I: Solar Magnetic Differential Rotation



MAGNETIC ROTATION OF THE SOLAR PHOTOSPHERE

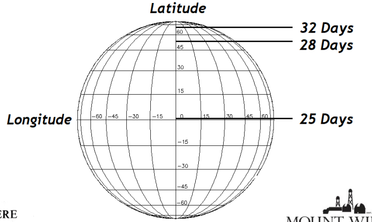
Herschel B. Snodgrass
Mount Wilson and Las Campanas Observatories of the Carnegie Institution of Washington

Received 1982 October 15; accepted 1982 December 9

Magnetic Rotation for Polar Latitudes Averaged from 1967 January 1 to 1981 December 31 Based on Yearly Averaged Correlations

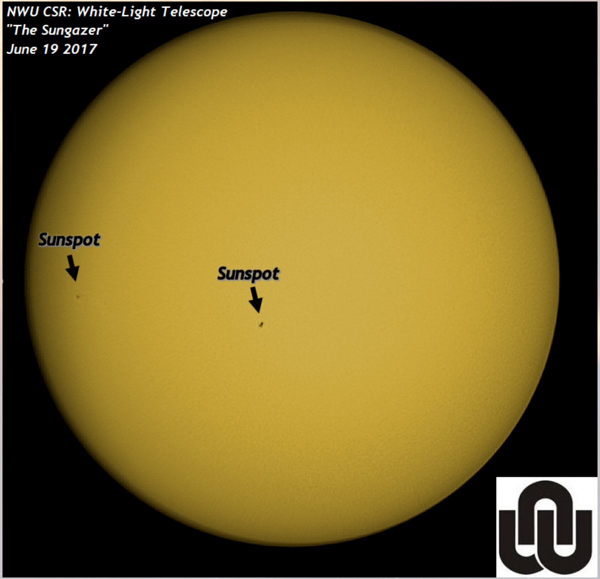
	1 Day Lag		2 Day Lag		3 Day Lag		4 Day Lag		Average over Lags		
Latitude	$\omega_l(1)$	$\sigma_l(1)$	$\omega_l(2)$	$\sigma_l(2)$	$\omega_l(3)$	$\sigma_l(3)$	$\omega_l(4)$	$\sigma_l(4)$	ω_l	σ_l	$\bar{\Delta}_l$
South:											
1 −72.8	2.174	0.045	2.210	0.057	2.202	0.069	2.095	0.038	2.172	0.026	0.056
2 −65.8	2.331	0.046	2.253	0.019	2.249	0.028	2.233	0.038	2.274	0.022	0.039
3 −58.5	2.359	0.023	2.372	0.023	2.367	0.016	2.327	0.024	2.356	0.013	0.023
4 −52.6	2.498	0.013	2.487	0.013	2.446	0.012	2.457	0.010	2.472	0.012	0.016
5 −47.3	2.568	0.009	2.560	0.007	2.531	0.008	2.597	0.006	2.564	0.016	0.015
North:											
30 47.3	2.567	0.008	2.557	0.008	2.571	0.008	2.507	0.010	2.562	0.015	0.010
31 52.6	2.485	0.010	2.486	0.014	2.477	0.013	2.454	0.012	2.478	0.009	0.014
32 58.5	2.404	0.018	2.367	0.010	2.361	0.019	2.365	0.011	2.377	0.012	0.017
33 65.8	2.272	0.032	2.220	0.024	2.253	0.026	2.244	0.023	2.249	0.019	0.029
34 72.8	2.187	0.054	2.091	0.059	2.137	0.068	2.188	0.015	2.148	0.023	0.059

$$\omega(\phi) = 2.902 - 0.464 \sin^2 \phi - 0.328 \sin^4 \phi \ \mu rad \ s^{-1}$$



MOUNT WILSON OBSERVATORY

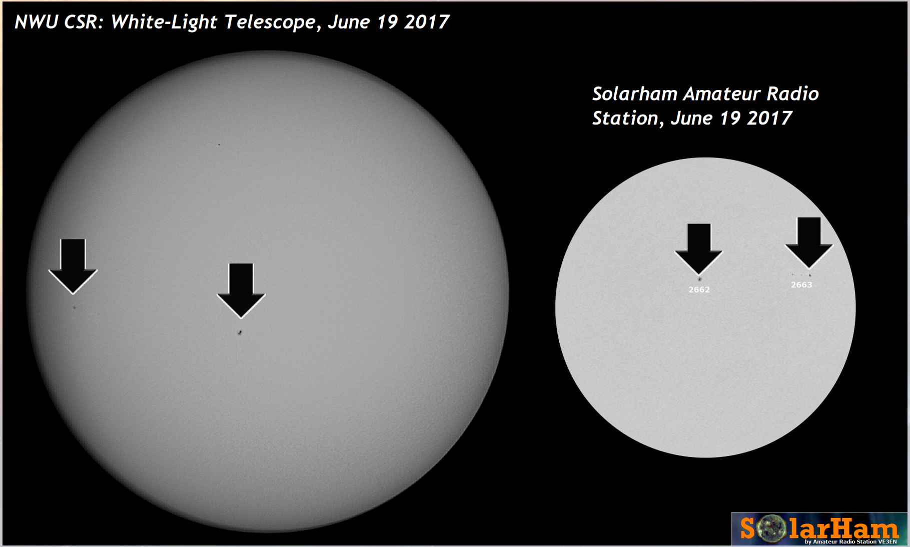
Sunspot Dynamics Part II: Which Way is "Up"?



Why can't we tell which way is "up"? (How the image should be oriented.) Calculations and comparisons require a fixed universal coordinate system. Why are two images never the same? The factors:

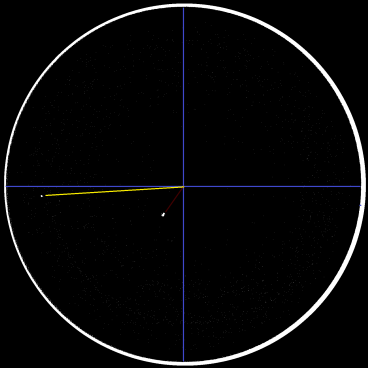
- #1 Hemispherical position.(Image perspective)
- #2 Time delay. (Snodgrass differential rotation)
- #3 Instrumental / handling errors. (Unique orientation)

Sunspot Dynamics Part III: Orienting Images to Match

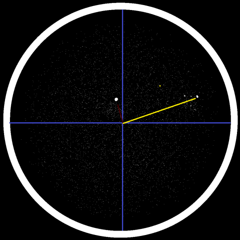


Sunspot Dynamics Part III: Orienting Images to Match

NWU CSR: White-Light Telescope, June 19 2017



Solarham Amateur Radio Station, June 19 2017



Steps of the program:

#1 Use colour detection to threshold the images to black and white images - identifying the possible sunspot regions.

#2 Use tolerance settings to differentiate actual sunspots from static. (Define a minimum & maximum size)

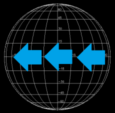
#3 Calculate coordinates of these sunspots (cartesian) and arrange in terms of size.

#4 Define position vectors in terms of each image's largest sunspot. (Vectors ensure that size and quality isn't an issue)

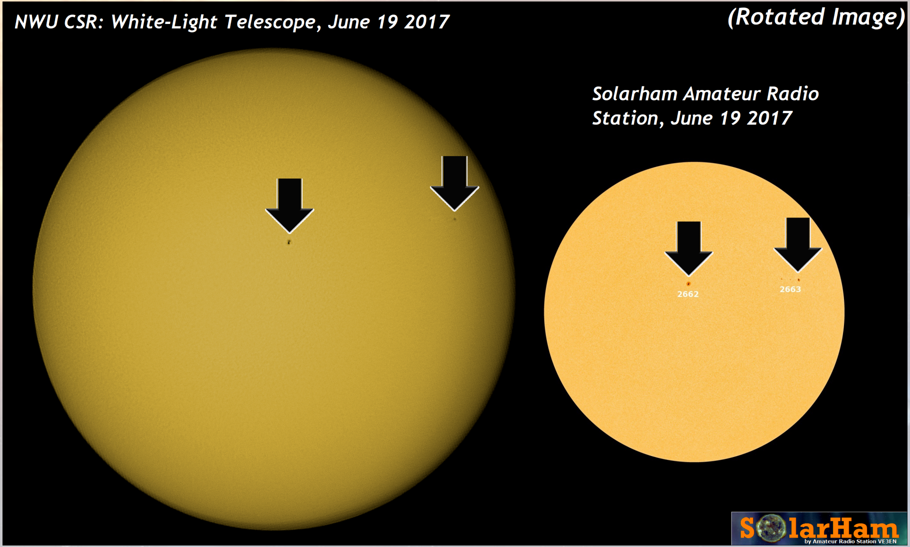
#5 Calculate the angle between these two position vectors.

#7 Rotate 1st image through this angle and test if the sunspots share the same latitude & longitude coordinates. (Which is a universal coordinate system, where as cartesian coordinates aren't)

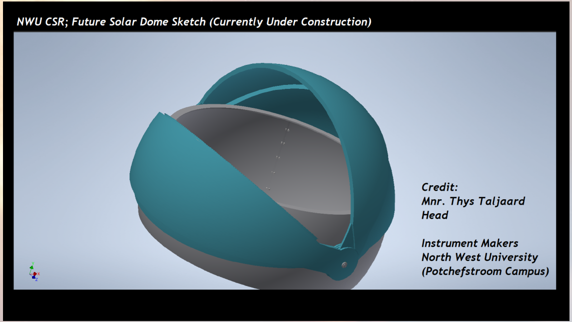
#8 If the longitude / latitude coordinates aren't the same. Shift the coordinates of the reference image along the line of latitude and repeatedly test if the images will then match. (This ensures that the time delay between the two images are taken into account & this can actually be calculated using Snodgrass' equation)



Sunspot Dynamics Part III: Orienting Images to Match



The Future in Mind: NWU CSR Solar Dome



- Plan: Use the program to calculate how the telescope should be rotated / oriented & Use the solar dome to easily rotate and fix the positions of the telescopes.
- Result: Minimal handling errors and a the capability to compare data with other scientists within solar observation.

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