Locating Activity Nests in Solar Cycle 24 using Data from the Helioseismic Magnetic Imager

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Abstract

We analyze data from the SPEAR (Solar Plage, Ephemeral & Active Region) Catalog created from Spaceweather HMI Active Region Patch (SHARP) data. We identify the activity nest locations in each hemisphere during Solar Cycle 24 to examine how prevalent nests are in structuring the Sun's magnetic flux emergence. From 2010 to 2019, we identify 54 (56) activity nests in the North (South) Hemisphere containing ~80% of all sunspot magnetic flux, which is higher than previously reported. On average, there were 7 active region members in each nest with a nest lifetime of 6 months and with the nest rotating slightly faster than the average Carrington Rotation rate.

Introduction

Active region nests are locations on the Sun where sunspots repeatedly emerge month after month. Other stars show similar nesting behavior of magnetic activity[1]. The precise physical mechanism that causes nests is unknown but it could be an instability acting on the magnetic field in the interior of the Sun or it could be due to low fields such as giant convection cells[2] causing preferred locations of magnetic flux emergence. Activity nests host a great majority of solar energetic events and as such, are crucial to our understanding of space weather.

Methods

The criteria that must be met to be an activity nest[3] is as follows:

1) At least 3 sunspot groups emerge,
2) Within 15˚ longitude and 10˚ latitude of each other,
3) With a nest lifetime that is a minimum of 4 months.

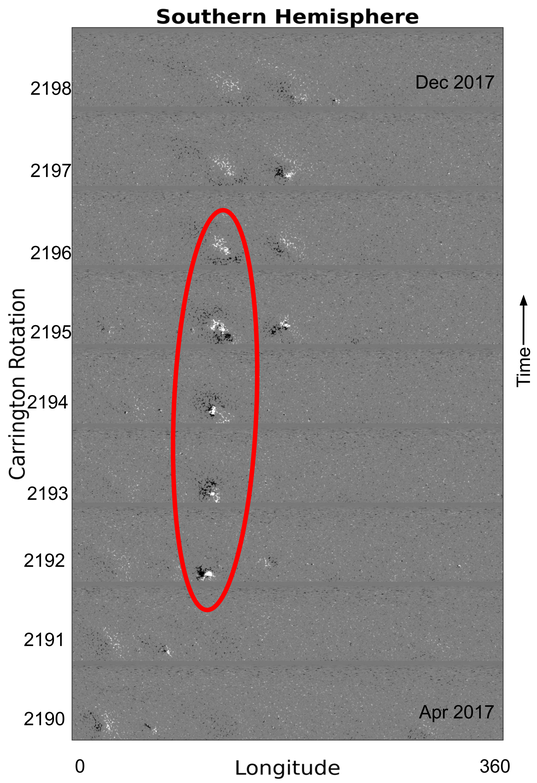

Figure 1. Synoptic magnetograms from HMI/SDO data stacked in time that feature the sunspots comprising the last activity nest in the southern hemisphere for Solar Cycle 24. There are 5 sunspot members over a lifetime of 5 Carrington Rotations (CRs) with a prograde rotation of 3.8˚ per CR.

Results

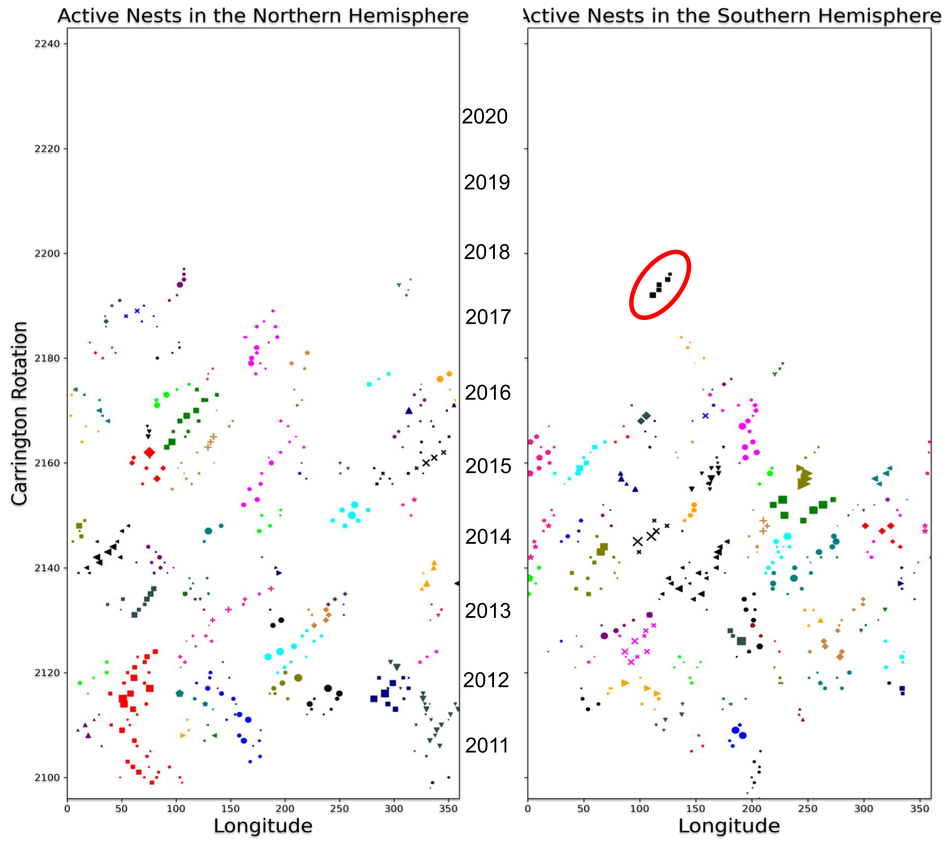

Figure 2. Plots separating the Northern and Southern hemispheres show unique activity nests which are grouped by color and symbol and plotted as a function of longitude (x-axis) and Carrington Rotation number (y-axis). Each point on the plots represents an active region with a NOAA number. The symbol size is proportional to the magnetic flux in the region. The nest noted by the red ellipse correlates to the nest shown in the grayscale magnetogram maps in Figure 1.

Conclusions

- We identified over 50 activity nests in each hemisphere with 80% (83%) of sunspot flux being associated with the activity nests in the North (South). This confirms that the Sun strongly prefers certain locations for flux emergence.
- Active nests in the North (South) hemisphere contained an average of 8.2 (6.6) active regions.
- The average lifetime for each activity nest in the North (South) hemisphere was 6.4 (5.3) Carrington Rotations (CR).
- Active regions associated with nests contained higher flux than active regions not associated with a nest.
- In the North (South), 61% (68%) of the nests had a prograde rotation, rotating on average 3.5˚ (3.3˚) faster per CR than the CR rate. This suggests that the mechanism creating nests has a faster rotation rate than the solar surface, which giant convection cells do[2].

Future Work

- Search for active regions that have returned for a second rotation and remove them from the catalog.
- Include data from the Michelson Doppler Imager from 2009-10 to have all data from Solar Cycle 24. Possibly analyze data from Cycle 23.
- Explore the correlation between nest rotation rates and latitude.
- Determine if stricter criteria for nests makes sense at Solar Maximum.

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