

A Catalog of Bipolar Active Regions Violating the Hale's Polarity Law

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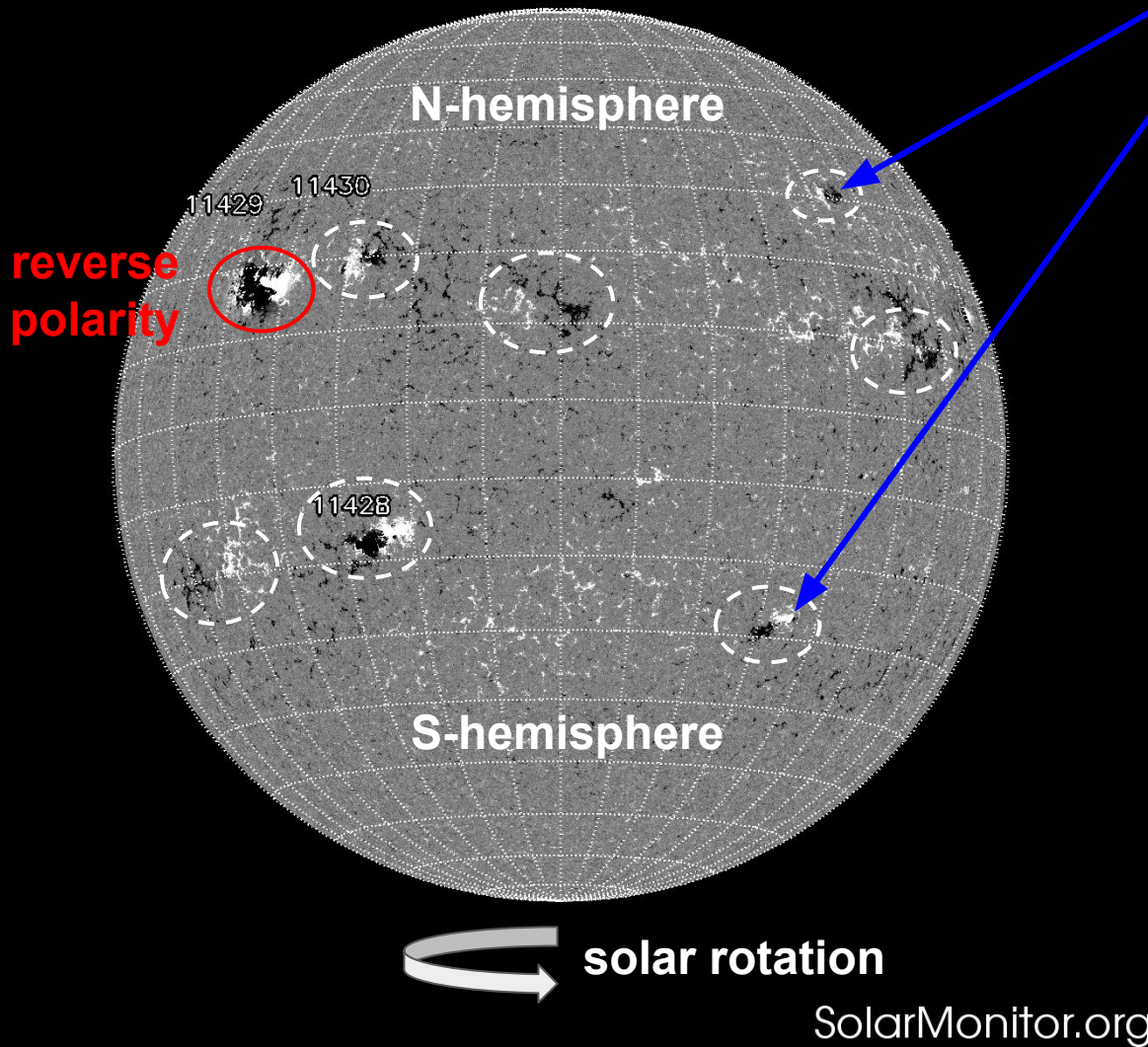
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The Hale's polarity law

SDO HMI Magnetogram 5-Mar-2012 18:30:18.000

Solar cycle 24



Leading polarities
of active regions:

even solar cycles

N-hemisphere "-"

S-hemisphere "+"

odd solar cycles

N-hemisphere "+"

S-hemisphere "-"

Active regions with
reverse polarity

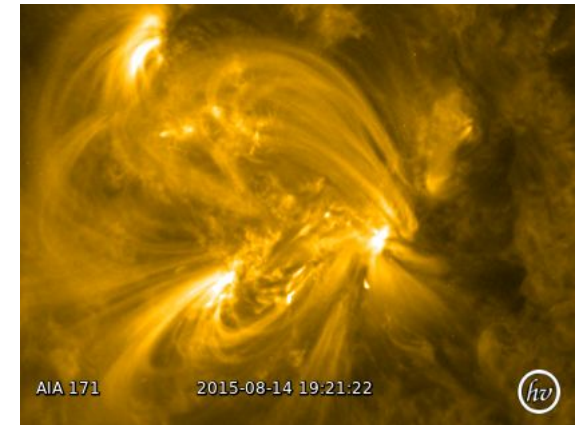
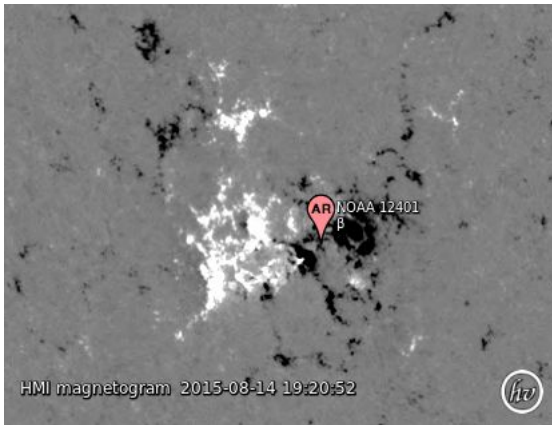
~2-9 %

Data and method

We studied ~8600 active regions from 1989 to 2018

- Visual inspection of solar data using web applications:
 - *Debrecen Photoheliographic Data (DPD)*
 - *Solarmonitor*
 - *Heliviewer*
- Sunspot drawing of the Mount Wilson Observatory
- Catalogs of sunspot groups:
 - *Mount Wilson Observatory*
 - *Crimean Astrophysical Observatory*
 - *USAF/NOAA Solar Region Summary*
 - *DPD*

The basic criteria of active regions violating the Hale's law



- The active region forms a **bipole reverse to the Hale's law** with sunspots or pores of both polarities.
- The opposite polarities are connected by **stable magnetic loops** (when EUV data are available).

The additional criteria of active regions violating the Hale's law

- **Small active regions** (stable tilt, sunspot area >4 MSH)
- **Equatorial active regions** (area-weighted center and midpoint between the sunspots of opposite polarities located in the same hemisphere)
- **Magnetic fluxes emerging at the existing active regions** (>3 days)
- **“ δ -sunspots”** (individual and strong structure)

The solar cycle boundaries *McClintock, Norton, Li (2014)*

Unipolar sunspots and multipolar active regions **were not considered**

275 active regions with reverse polarity for 1989-2018

~3 % of all active regions

Catalog contents

1. Parameters of active region at the evolutionary maximum:

- NOAA number
- Date
- Coordinates
- Sunspot area
- Most complex magnetic class
- Tilt

- USAF/NOAA Solar Region Summary
- DPD database

2. Special marks related to the peculiarities of the active regions

Active region: **C** – decaying | **S** – small short-lived | **E** – equatorial

“ δ -sunspot”: **D** – individual | **W** – with surrounding sunspots or pores

Tilt: **T** – close to 90° | **R** – rotation axis

...

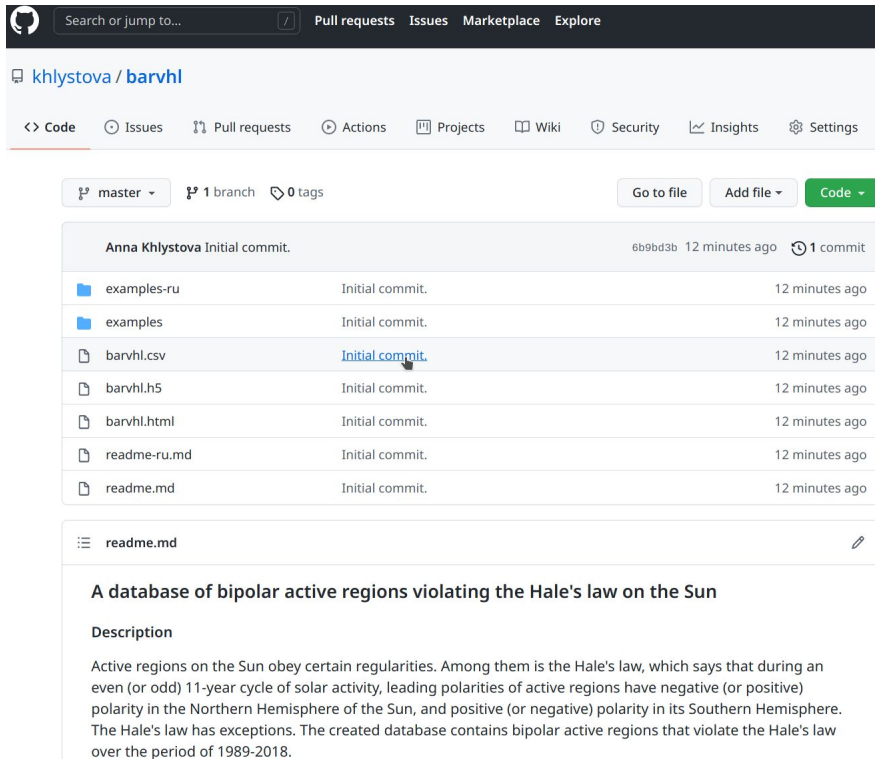
Conclusions

- We studied ~8600 active regions from 1989 to 2018.
- Criteria for identification of reverse polarities in ambiguous active regions have been formulated.
- 275 active regions violate the Hale's law.

*For details, see [Zhukova et al. \(2020\)](#)
[Solar Physics, Volume 295, Issue 12, article id 165. arXiv](#)*

The catalog is available

- website of the Crimean Astrophysical Observatory
<https://sun.crao.ru/databases/catalog-anti-hale>
- GitHub
<https://github.com/khlystova/barvhl>



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File	Commit	Time
Anna Khlystova Initial commit.	6b9bd3b	12 minutes ago
examples-ru	Initial commit.	12 minutes ago
examples	Initial commit.	12 minutes ago
barvhl.csv	Initial commit.	12 minutes ago
barvhl.h5	Initial commit.	12 minutes ago
barvhl.html	Initial commit.	12 minutes ago
readme-ru.md	Initial commit.	12 minutes ago
readme.md	Initial commit.	12 minutes ago

readme.md

A database of bipolar active regions violating the Hale's law on the Sun

Description

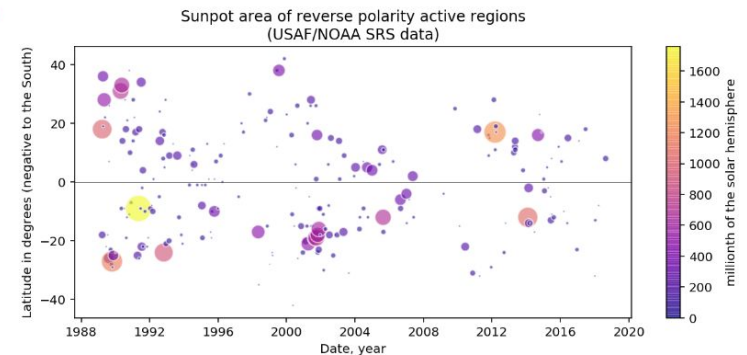
Active regions on the Sun obey certain regularities. Among them is the Hale's law, which says that during an even (or odd) 11-year cycle of solar activity, leading polarities of active regions have negative (or positive) polarity in the Northern Hemisphere of the Sun, and positive (or negative) polarity in its Southern Hemisphere. The Hale's law has exceptions. The created database contains bipolar active regions that violate the Hale's law over the period of 1989-2018.

Time-latitude diagram of the sunspot areas in active regions violating the Hale's law

```
In [2]: fig, ax = plt.subplots()
ax1 = dat.plot.scatter(x='datetime_u',
                      y='lat_u',
                      s=dat['area_cor_u']/4,
                      c=dat['area_cor_u'], colormap='plasma',
                      edgecolors='white', alpha=0.6,
                      figsize=(10, 4), ax=ax)

plt.axhline(y=0.0, color='black', linestyle='-', linewidth = .5)
l1=ax1.set_xlabel('Date, year')
l2=ax1.set_ylabel(d_usaf.loc['lat_u'][0])
re=plt.title('Sunspot area of reverse polarity active regions
(USAF/NOAA SRS data)')
f = plt.gcf()
cax = f.get_axes()[1]
ct=cax.set_ylabel('millionth of the solar hemisphere')
```

Out[2]:



Thanks for your attention!