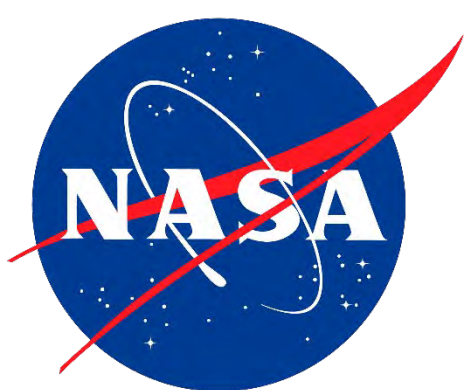


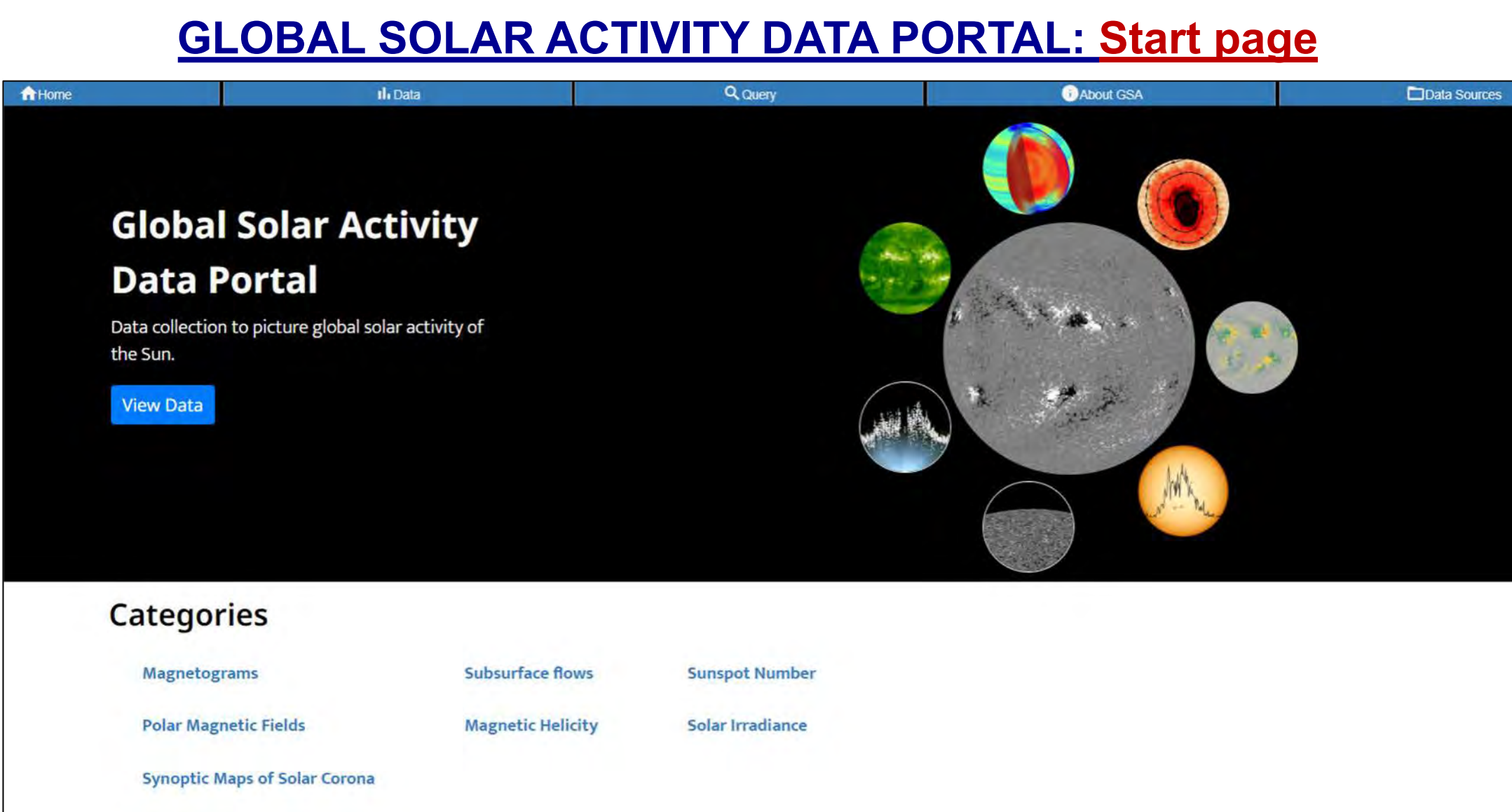


Enabling Solar Variability Studies Through Global Solar Activity Data Portal

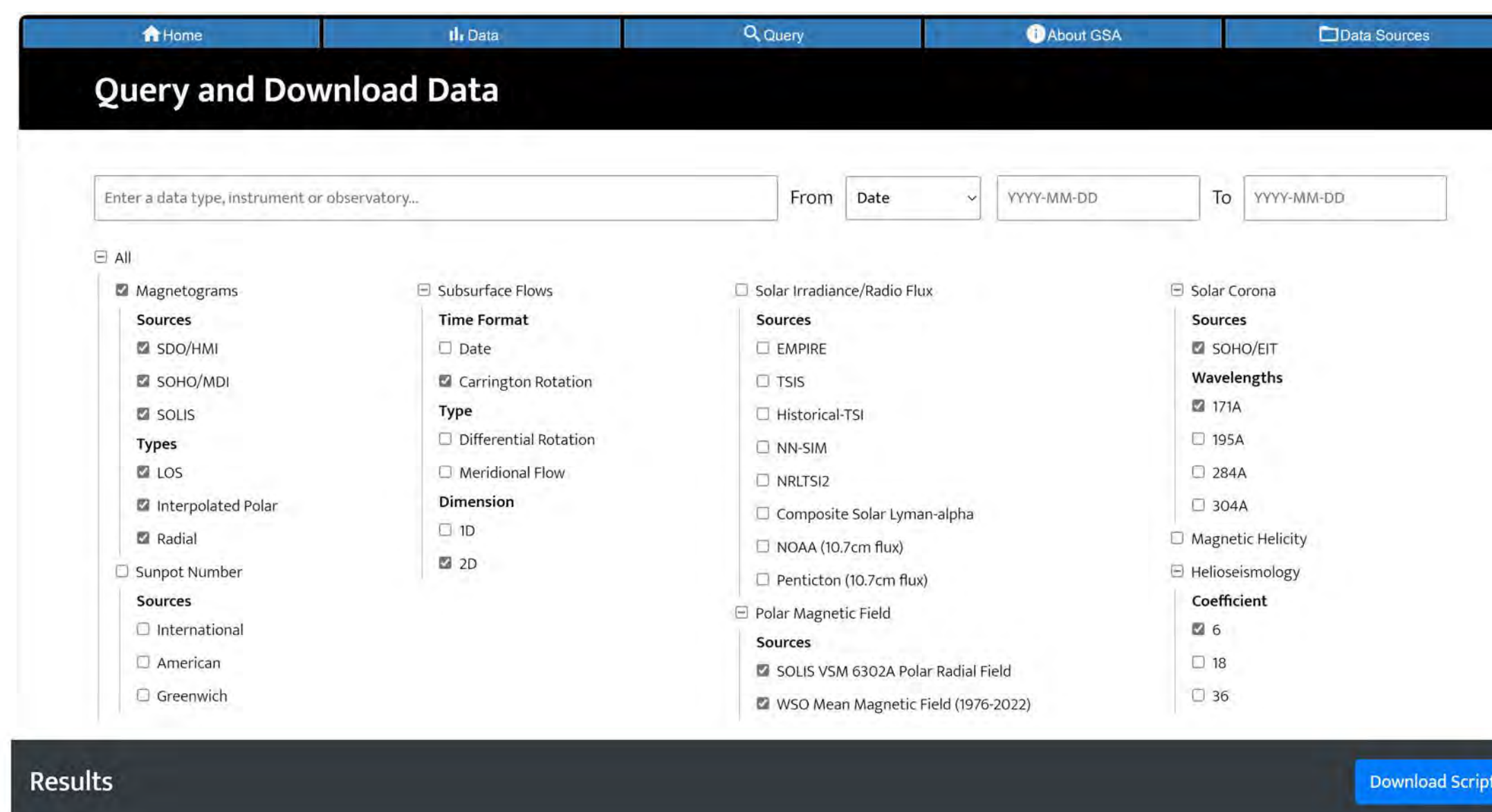
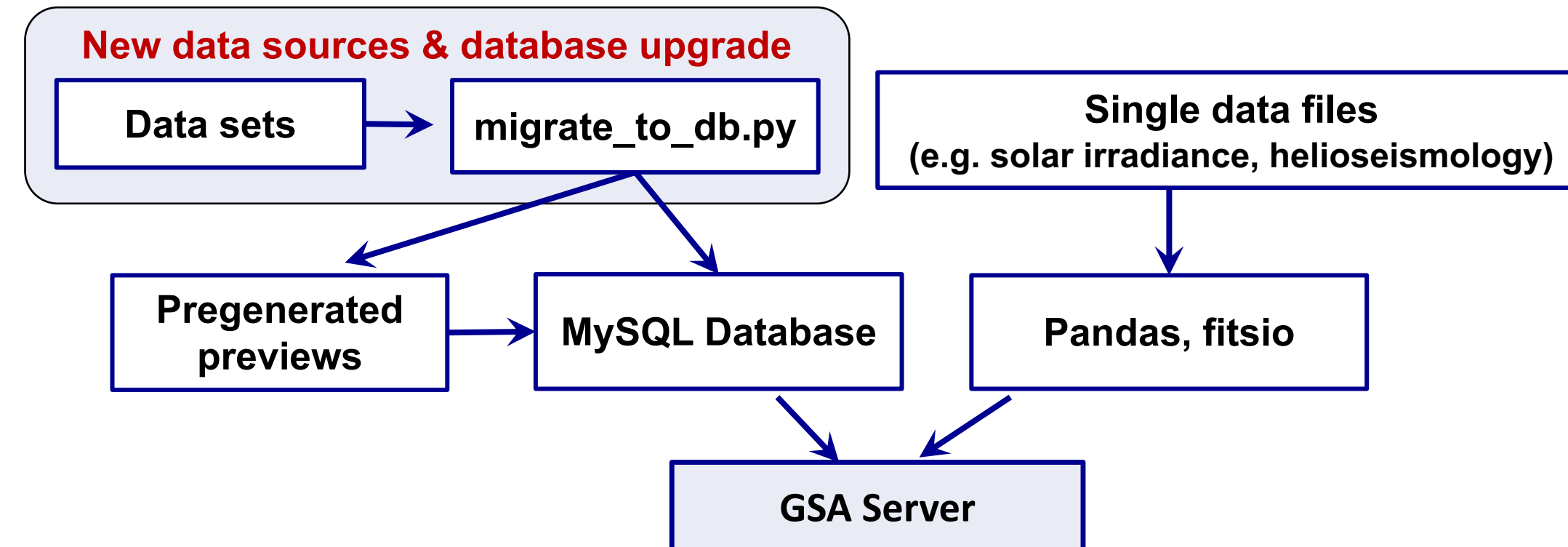
Irina N. Kitiashvili¹, Vincent Wang^{1,2}, Matthew Vu^{1,3}, Arthur Foy^{1,4}, Zoe Fischer^{1,5}, Andrew Ngo^{1,6}, Hannah Suresh^{1,7}, Shubha S. Ranjan¹, Ryan C. Spaulding¹, Donald G. Deardorff¹

¹NASA Ames Research Center, ²Purdue University, ³George Mason University, ⁴University of California, ⁵University of Minnesota, ⁶University of Delaware, ⁷University of Maryland

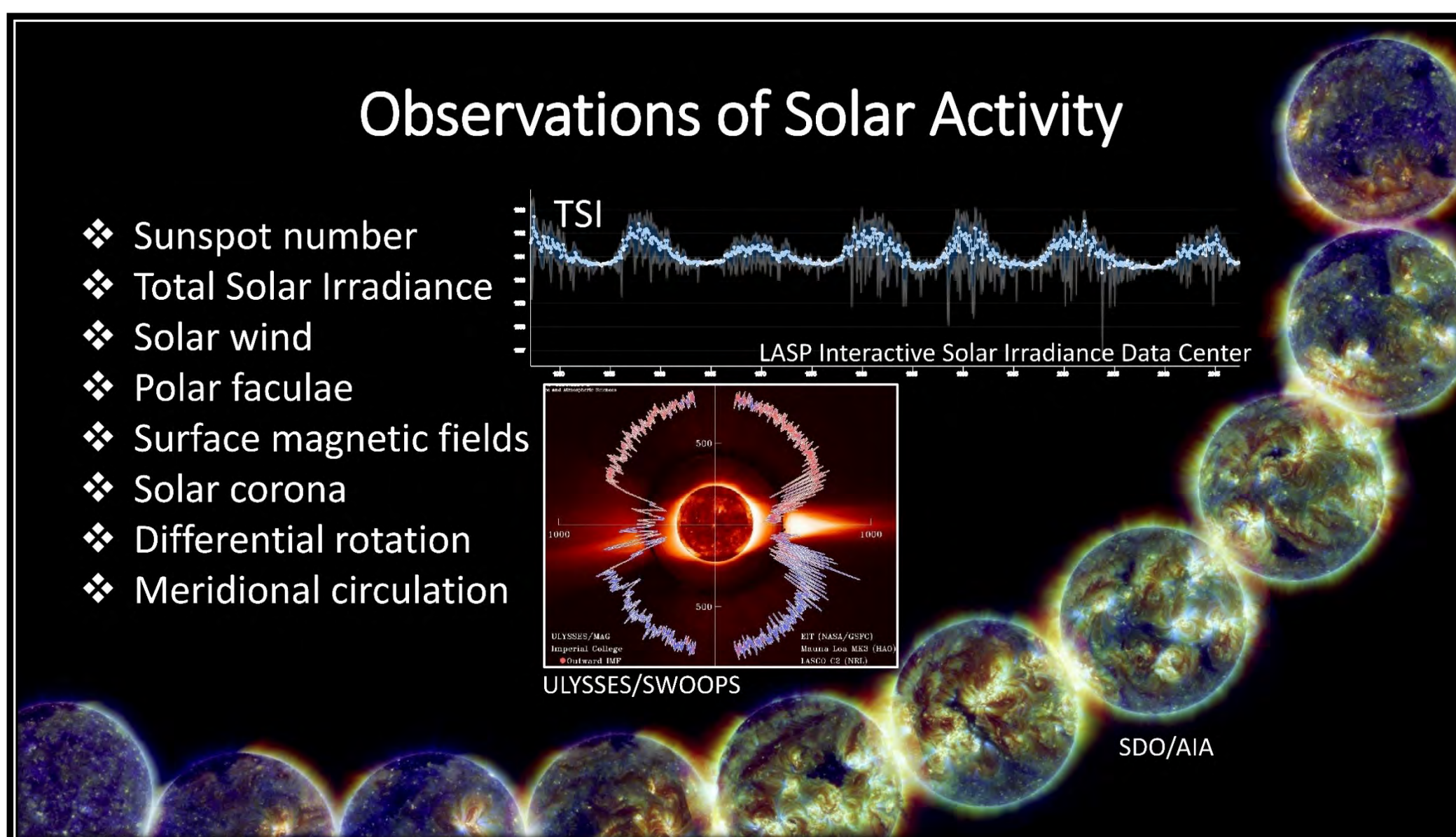
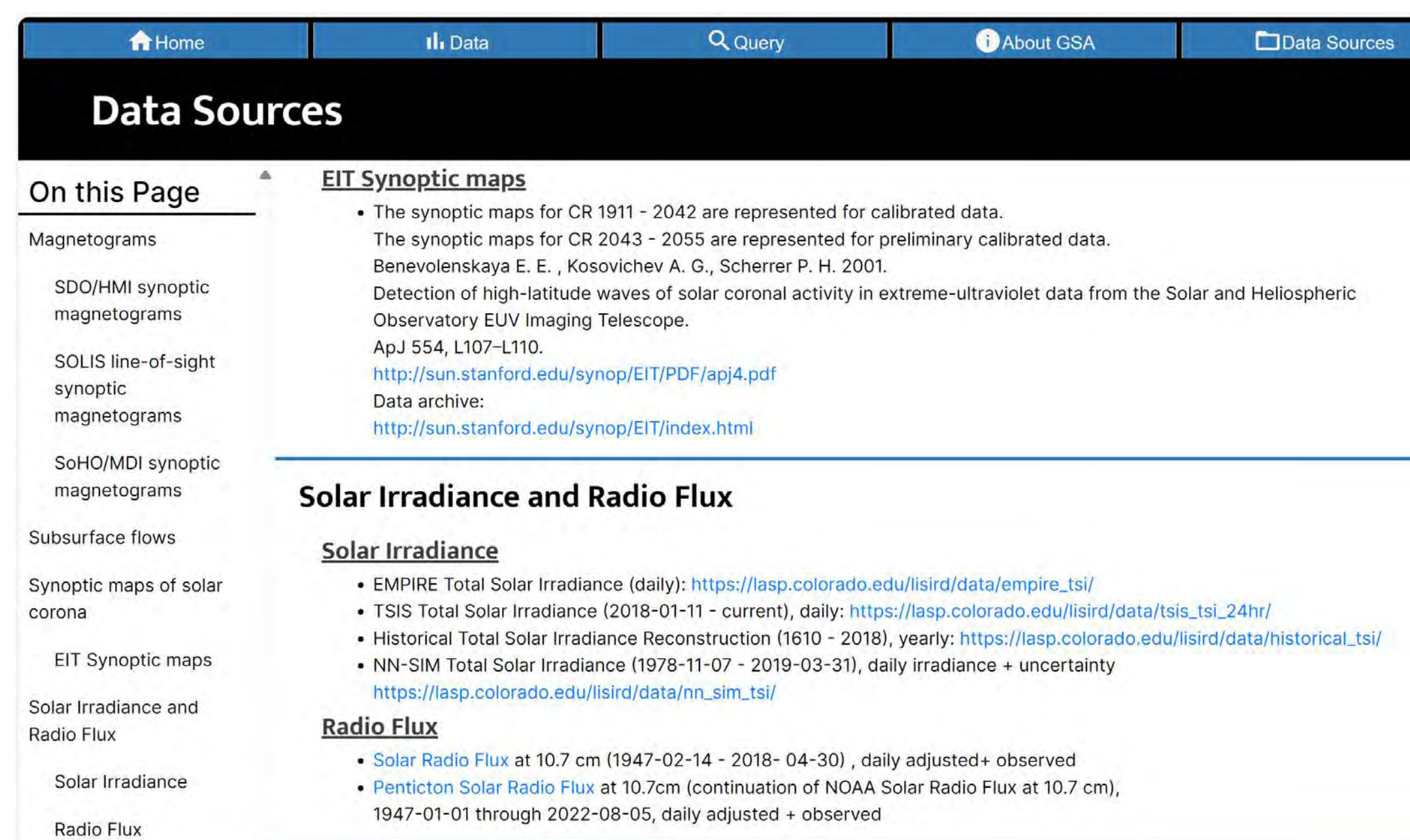
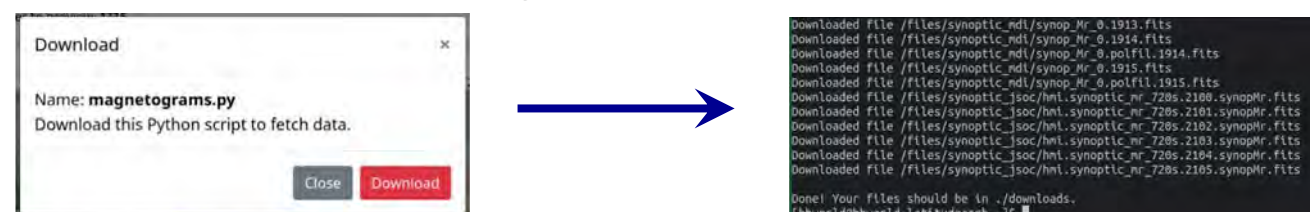
The complex processes that drive solar variability and magnetic activity make it challenging to study the progression of the current activity cycle and to predict future cycles. The currently available observational data provide crucial information about the global evolution of the Sun from the deep interior to the corona. However, the data are scattered over various databases, making it difficult to obtain a complete picture of global solar dynamics and activity. The associated knowledge gaps can inhibit the development of new physics-based models. In addition, it is important to use historical observational data for many studies, such as model calibration and machine-learning techniques for solar activity forecasting. Therefore, we initiated the development of the Global Solar Activity (GSA) Data Portal, which accumulates diverse data relevant to global solar dynamics and activity. The data portal collects observations from space- and ground-based instruments, including raw observational and processed data, as well as helioseismic inferences. The portal allows users to review data, perform various searches, and download data products. The data portal provides brief descriptions of the data sources, including references to detailed documentation. The user-friendly interface allows users to identify specific data sets and generate scripts for convenient data retrieval.



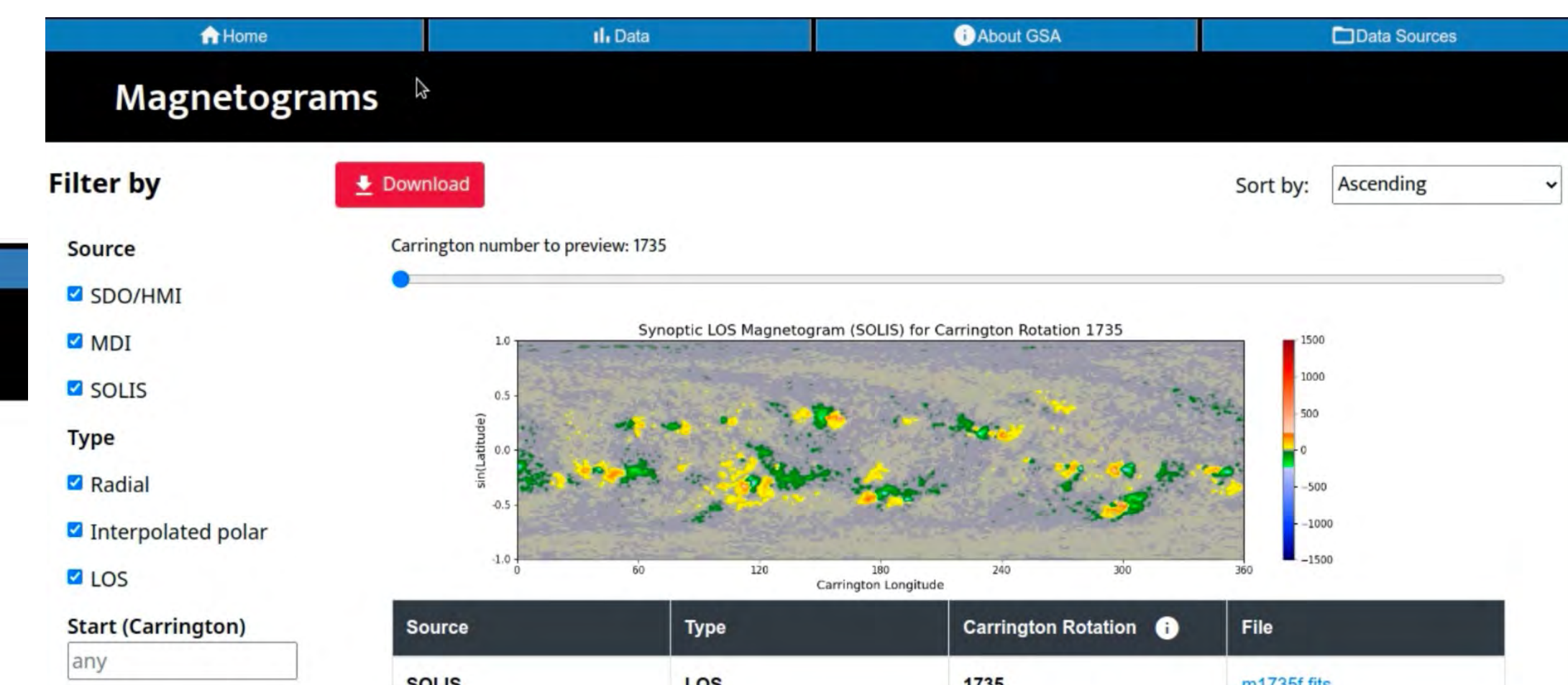
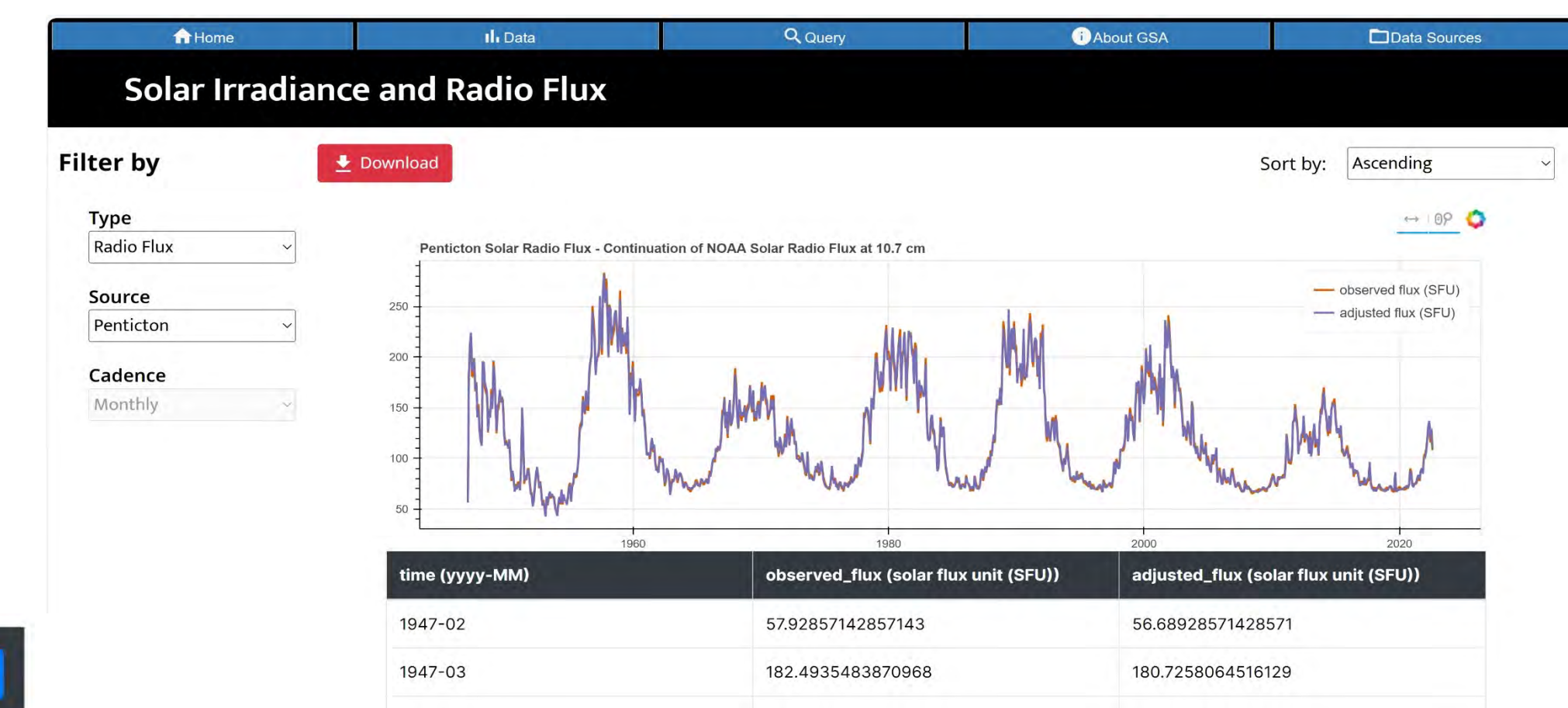
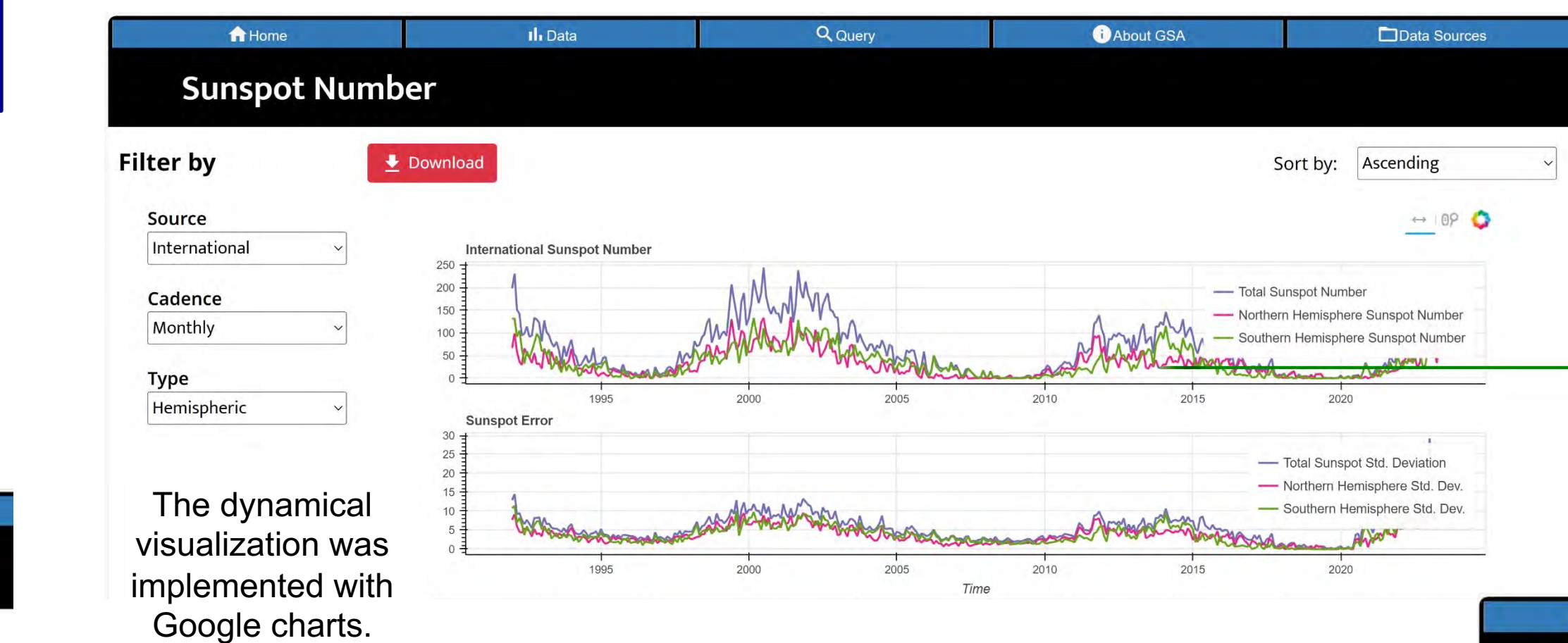
Data Flow:



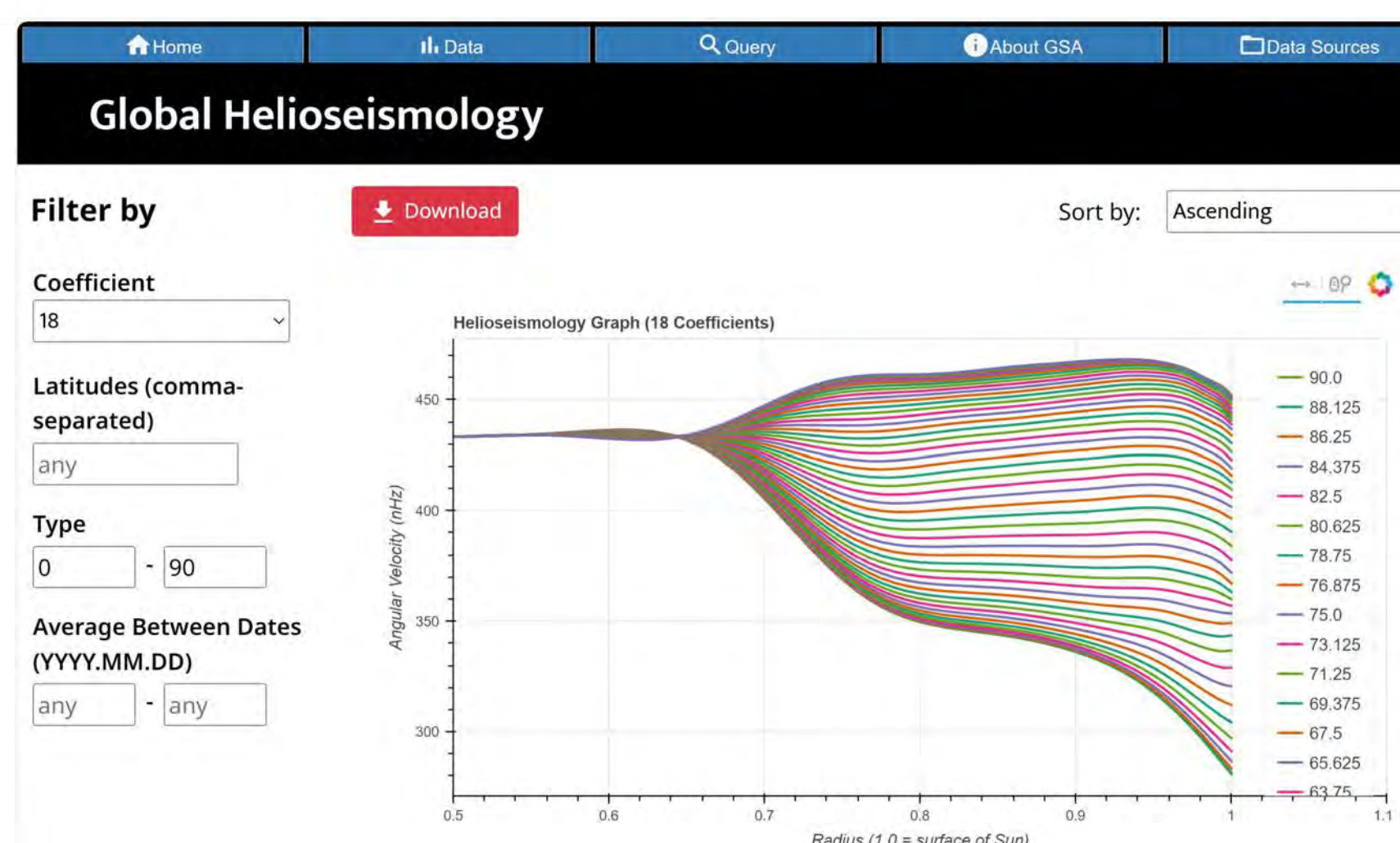
A Python script is automatically generated for selected data sources and time range to download the data sets.



Data Visualization



time (yyyy-MM)	total Sunspot number (SN)	North SN	South SN	Std dev total	Std dev North	Std dev South	# of obs total	# of obs North	# of obs South
1992-01	188.3	67.0	131.3	12.9	7.7	10.8	566.0	-1.0	-1.0
1992-02	230.7	98.8	131.9	14.5	9.2	11.4	590.0	-1.0	-1.0
1992-03	151.0	59.1	91.9	9.2	6.0	7.0	537.0	-1.0	-1.0
1992-04	142.2	36.8	105.4	9.5	4.6	8.2	660.0	-1.0	-1.0
1992-05	84.3	29.8	64.5	7.7	4.3	6.5	748.0	-1.0	-1.0
1992-06	98.5	66.0	32.5	6.6	5.4	3.7	706.0	-1.0	-1.0
1992-07	114.2	54.2	60.0	7.7	5.2	6.0	761.0	-1.0	-1.0
1992-08	91.9	46.5	45.4	6.7	4.7	4.8	794.0	-1.0	-1.0



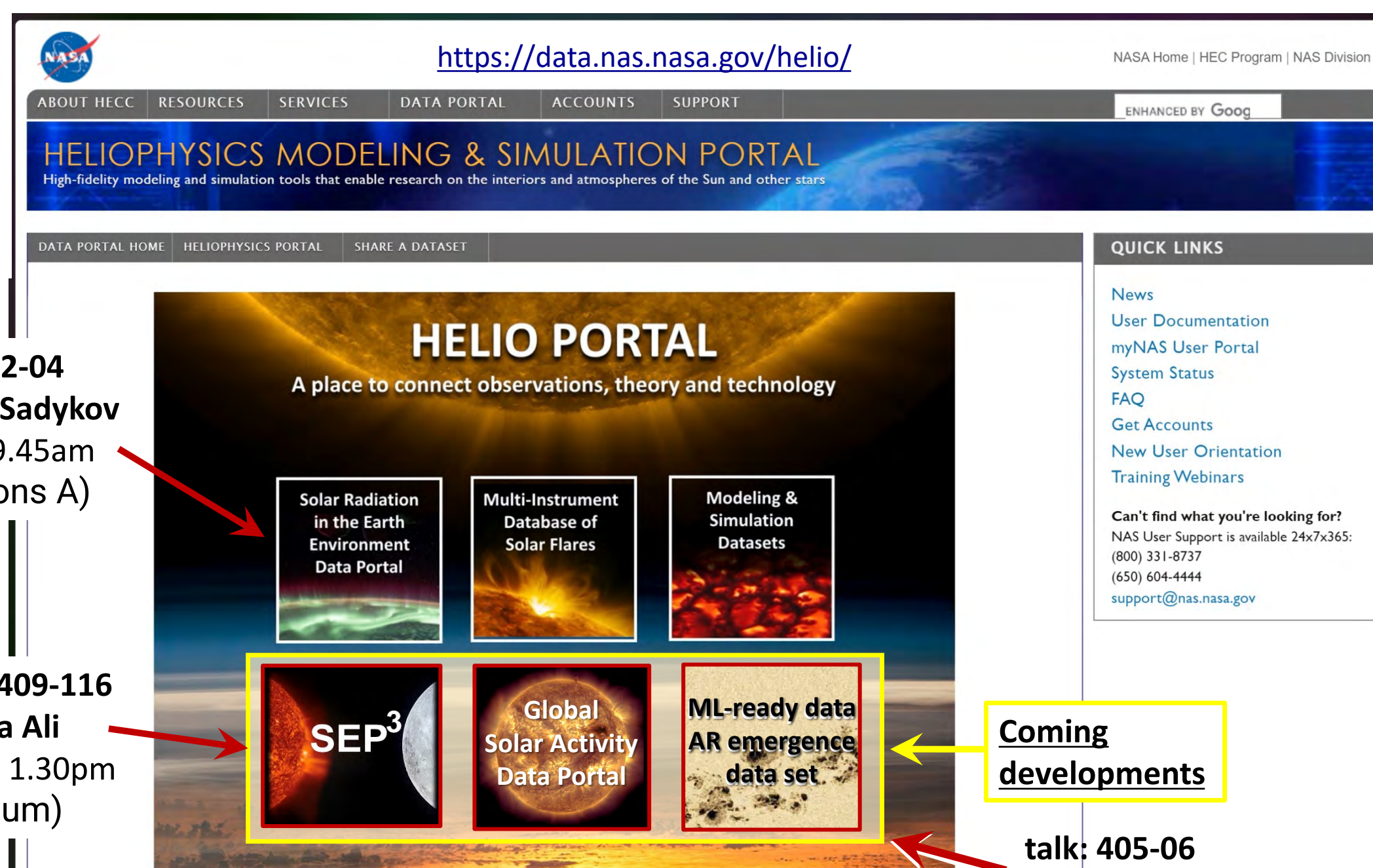
NASA Ames Supercomputing Facility



The Global Solar Activity data portal will be hosted at the NASA Ames Supercomputing Facility, which enables convenient access to observational and processed data, both current and historical, from NASA space missions and ground observatories.

talk: 402-04
Viacheslav Sadykov
April 12, 9.45am
(Stemmons A)

poster: 409-116
Aatia Ali
April 12, 1.30pm
(Atrium)



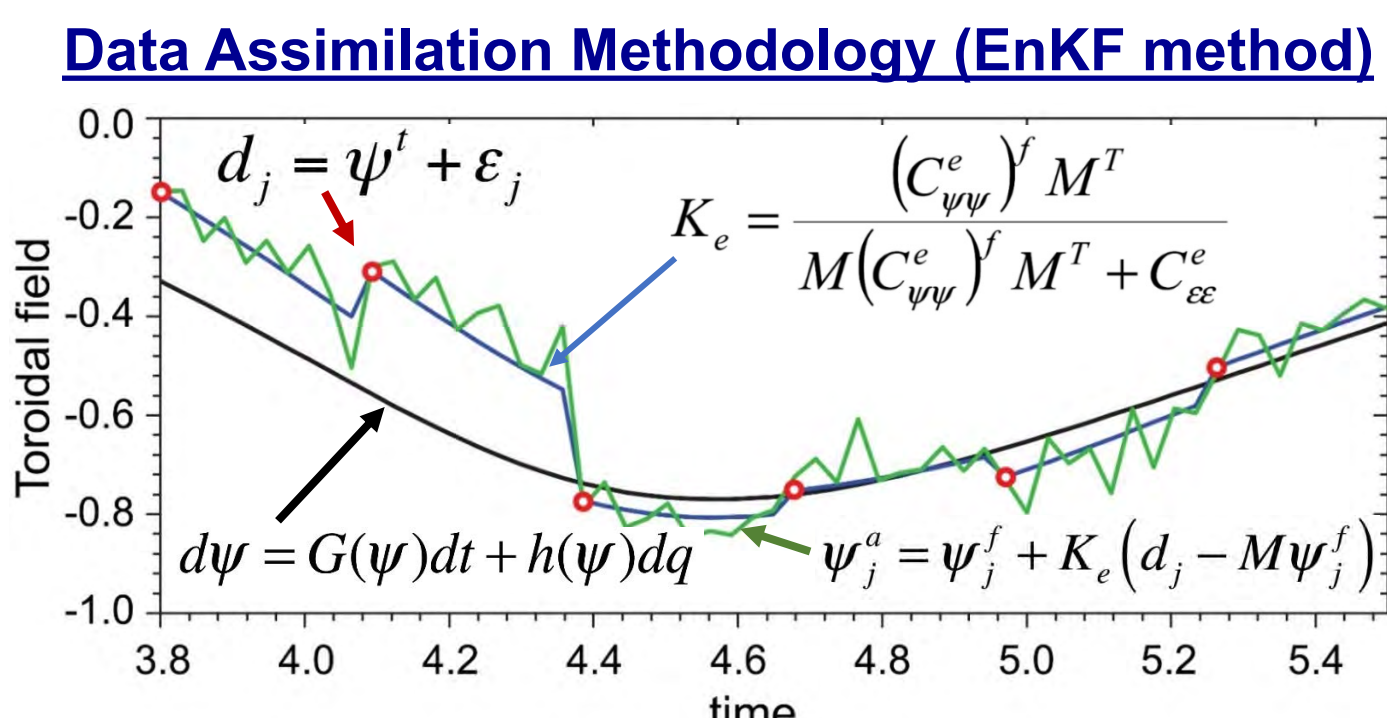
talk: 405-06
Spiridon Kasapis
April 12, 1.15pm (Stemmons B/D)

Challenges to build a reliable forecast of solar activity

Dynamo model:

Parker 1955, Kleeorin & Ruzmaikin, 1982; Kitiashvili & Kosovichev 2009

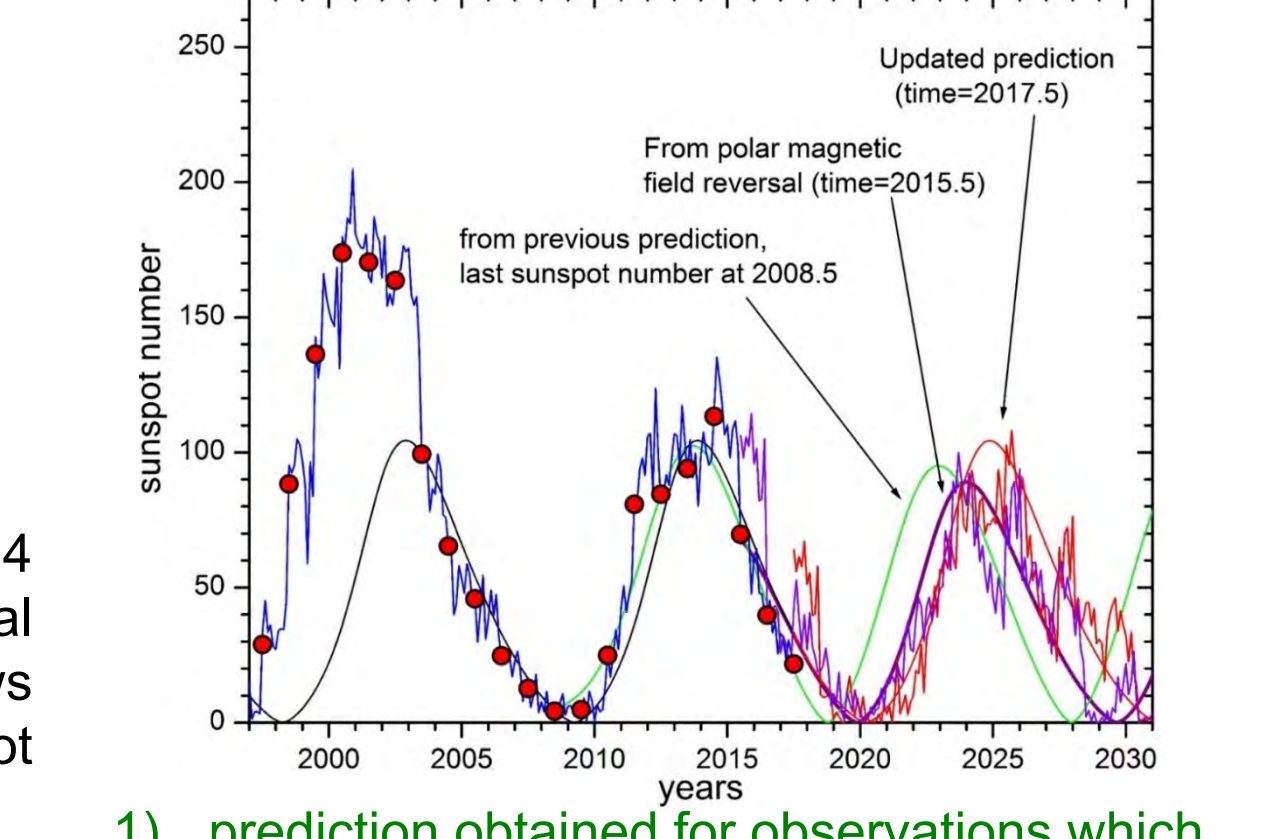
$$\begin{aligned} \frac{\partial A}{\partial t} &= \alpha B + \eta \nabla^2 A & \alpha_k &= -(\tau/3) \mathbf{u}(\nabla \times \mathbf{u}) \\ \frac{\partial B}{\partial t} &= G \frac{\partial A}{\partial z} + \eta \nabla^2 B & \alpha_m &= (\tau/12\pi p) \mathbf{h}(\nabla \times \mathbf{h}) \\ \frac{\partial \alpha_m}{\partial t} &= \frac{\mu}{4\pi\rho} \left(\mathbf{B} \cdot (\nabla \times \mathbf{B}) - \frac{\alpha B^2}{\eta} \right) - \frac{\alpha_m}{\tau_a} \end{aligned}$$



Comparison of the sunspot number prediction for Solar Cycle 24 (red curve, Kitiashvili & Kosovichev, 2008) and actual observations of monthly sunspot number. The blue curve shows the corrected dynamo solution according to annual sunspot number (green diamonds).

Comparison of hemispheric sunspot numbers, observed and inferred from magnetograms. The plot shows the sunspot number over time, with a blue curve for observed data and a green curve for inferred data.

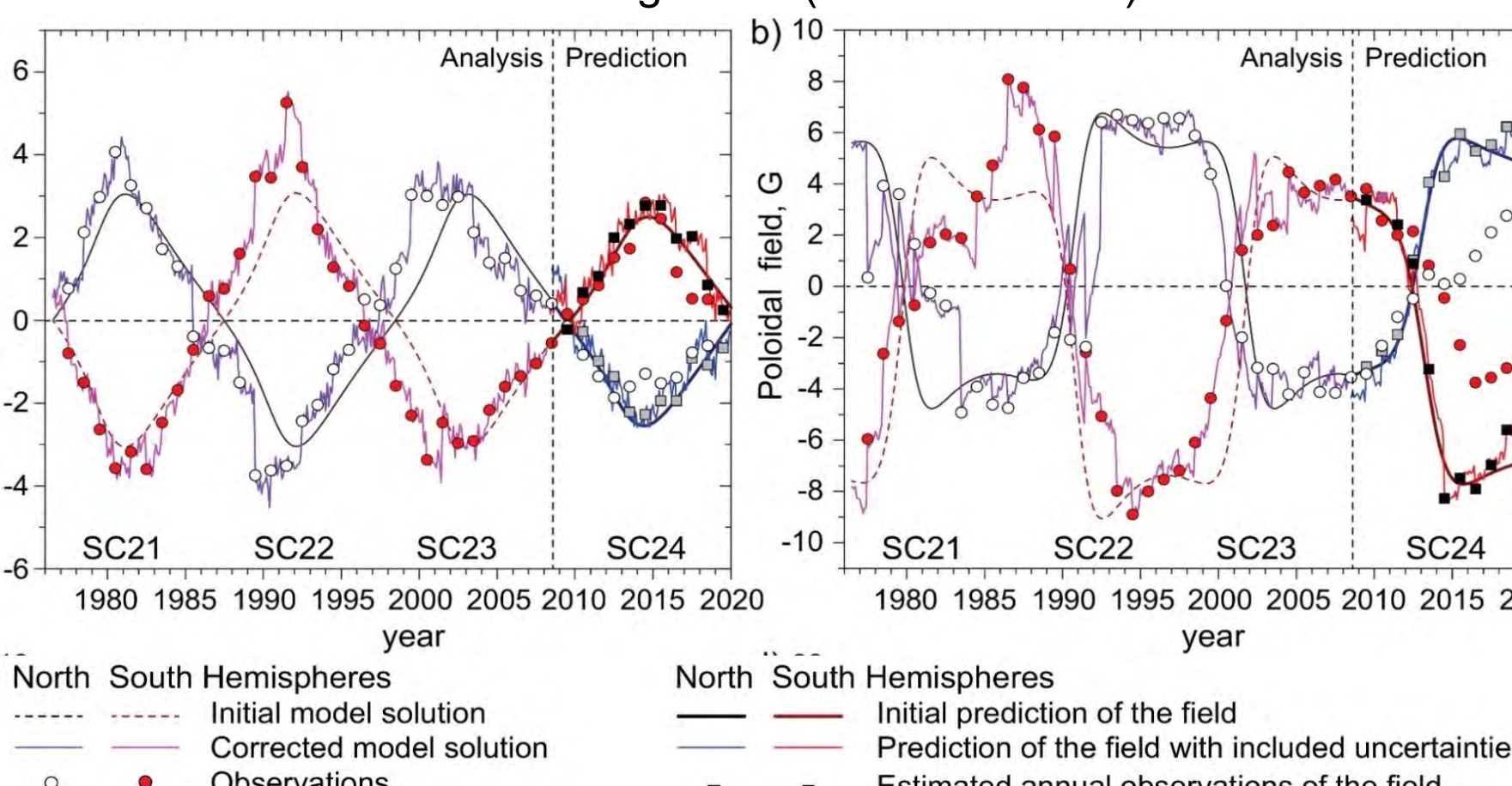
Early estimates of the properties of Solar Cycle 25



1) prediction obtained for observations which include the sunspot number data up to the solar minimum in 2008 (green curve);
2) prediction obtained for the last observation during the polar magnetic field reversal (purple/violet);
3) prediction obtained using all currently available observations up to 2017 (red curve).
Blue curve shows the best EnKF estimates of the previous cycles based on the dynamo model and all available sunspot observations (red circles).

Prediction of the magnetic activity based on synoptic magnetograms

Evolution of the mean toroidal (panel a) and poloidal (b) fields in the Northern and Southern hemispheres based on field observations for three solar cycles, and prediction of the mean toroidal and poloidal field component variations during SC24 (Kitiashvili 2020).



References

Evansen G. Data Assimilation. Springer, 2007.
Kitiashvili I.N. 2016. ApJ 831, article id. 15.
Kitiashvili I. N. & Kosovichev A. G. 2008. ApJ 688, L49-L52.
Kitiashvili I.N. & Kosovichev A.G. 2009. GAFF 103, 53-68.

Current work & future developments:

- Preparation of the data portal for public release
- Inclusion of new data sets
- Decomposition of magnetic fields into the poloidal and toroidal field components
- Inclusion of magnetic and kinetic helicity maps
- Inclusion of solar model solutions
- Implementation of automatic updates to the database

Conclusions

To address the need to reconstruct the past and current solar activity states, we are developing the Global Solar Activity data portal, which collects observations from multiple sources, such as space missions (SOHO and SDO), ground observations, and historical data. The developed data portal will be publicly available as a part of the NASA Helio Portal. The developed data resources and new capabilities that are under development will improve the predictive capabilities of existing data-driven models and data analysis techniques, such as data assimilation and machine learning, to build more reliable forecasts of global solar activity.

References

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Kitiashvili I.N. 2016. ApJ 831, id. 15, 8 pp.
Kitiashvili I.N., 2020, ApJ, 890, Issue 1, id.36, 15 pp
Kitiashvili I.N., 2021, MNRAS 505, Issue 4, pp.6085-6102
Kleeorin N.I., Ruzmaikin A.A. 1982. Magnetohydrodynamics, 18, 116.
Pipin V.V., Pevtsov A.A., Liu Y., Kosovichev A.G. 2019. ApJL 877, L36