TOWARDS A SCIENCE DATA CENTER FOR EST

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European Data Provider & Training Event
Heidelberg, June 27th & 28th 2018

KIS
Kiepenheuer-Institut
für Sonnenphysik

Contents

- Solar physics and ground-based solar observation
- Upcoming solar telescopes → EST
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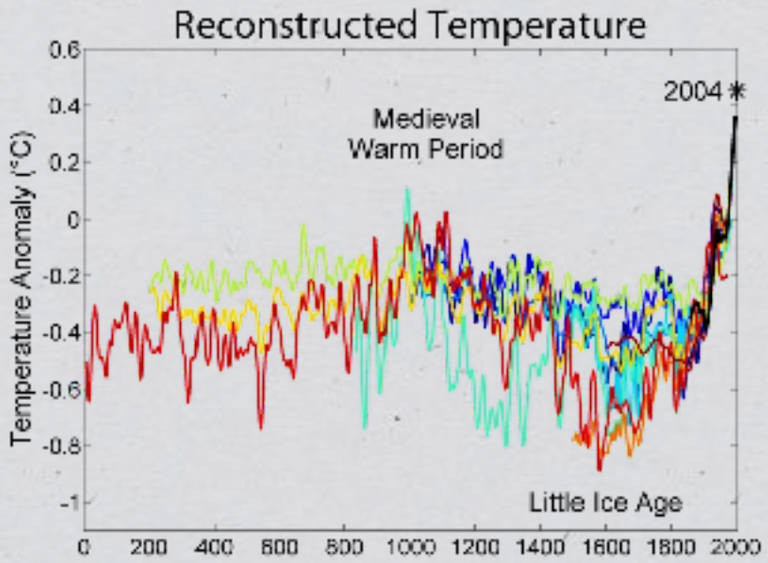
- Summary

Solar Physics

- The Sun has a significant impact on Earth's daily life
  - Solar cycle, sunspot number and solar activity



http://en.wikipedia.org

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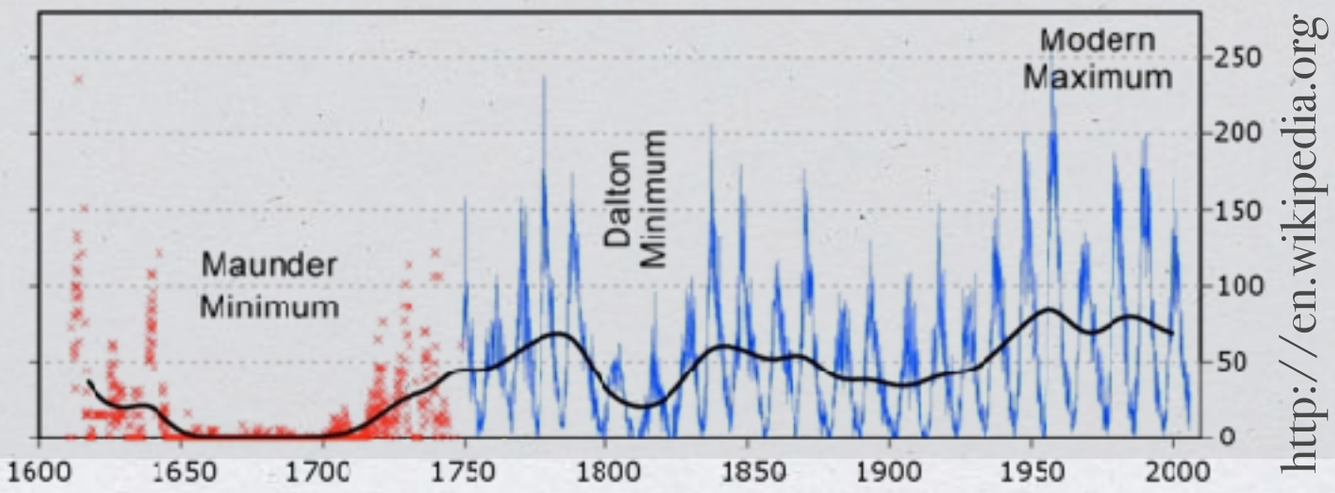
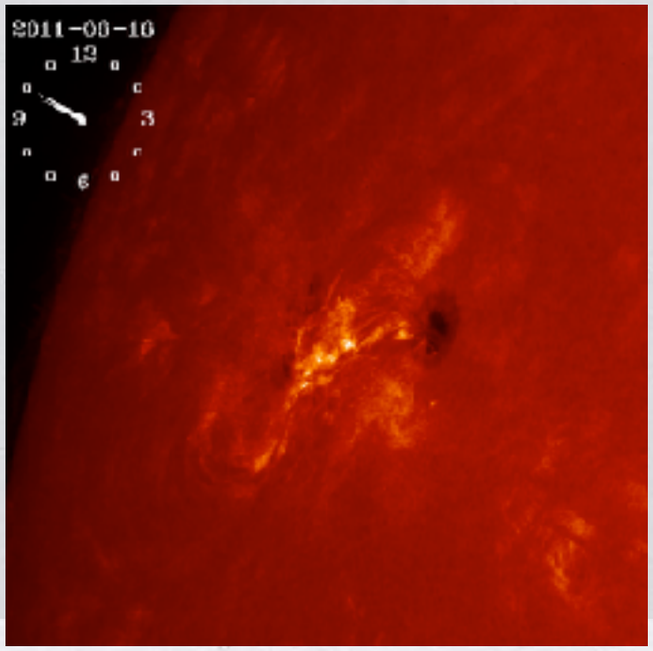


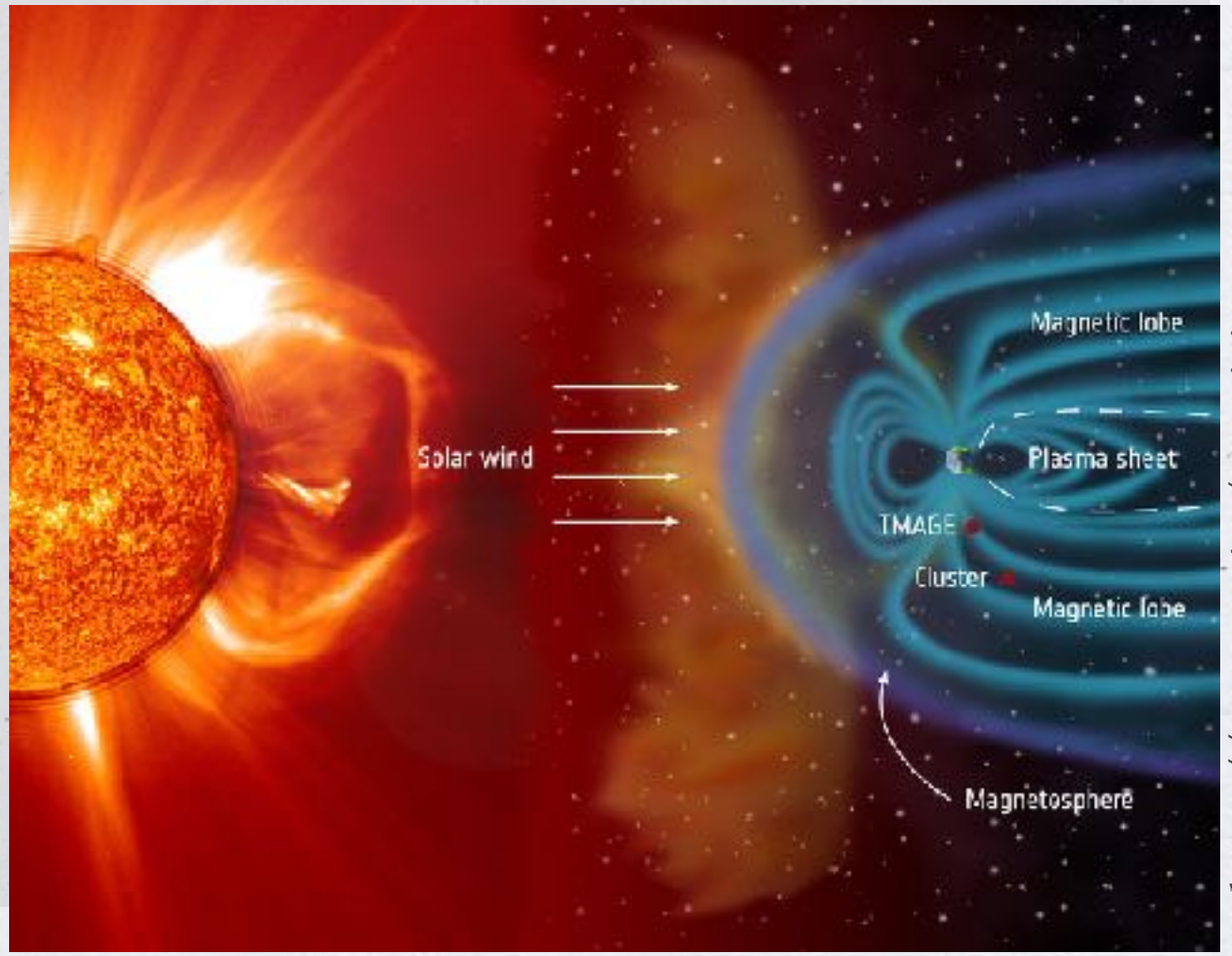
http://en.wikipedia.org

Solar Physics

- The Sun has a significant impact on Earth's daily life
  - Solar cycle, sunspot number and solar activity
- Space weather has an impact on Earth and its magnetosphere
  - Consequences for satellites, i.e. GPS
  - Rerouting of commercial flights
  - Power grid failure

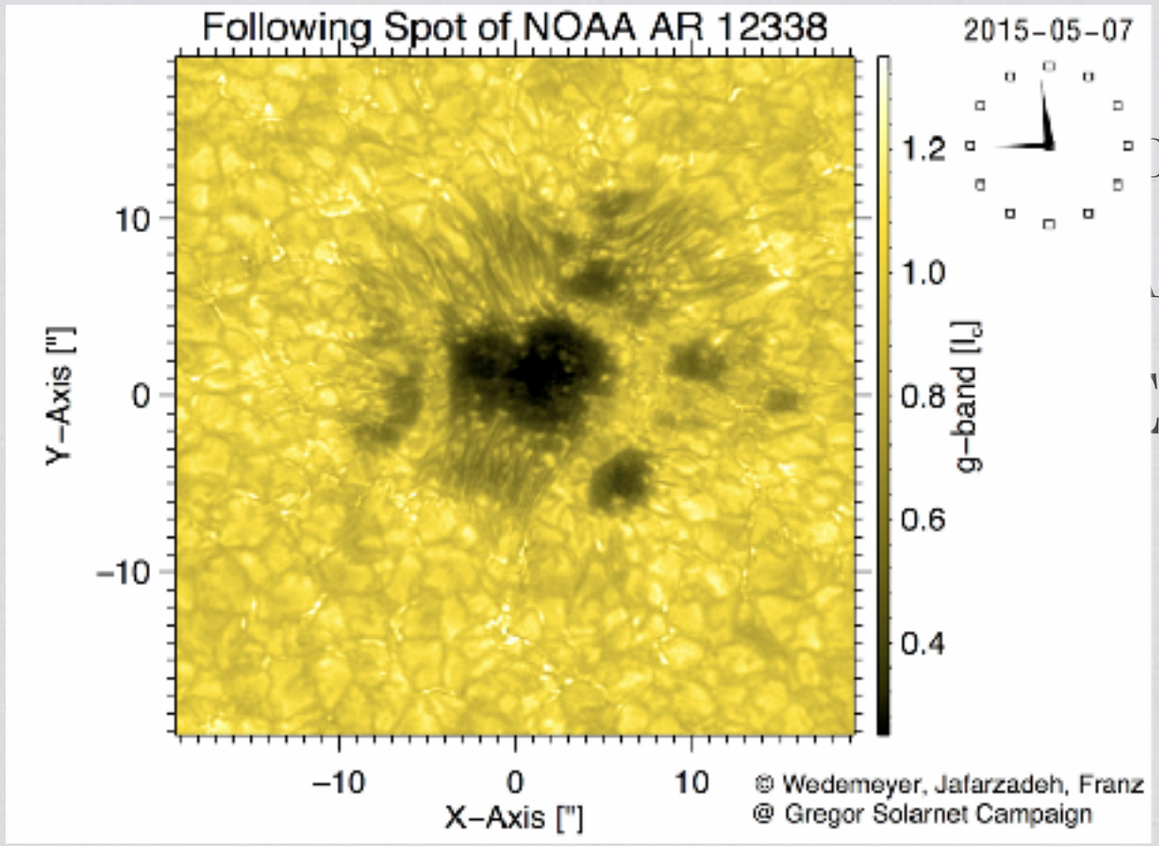


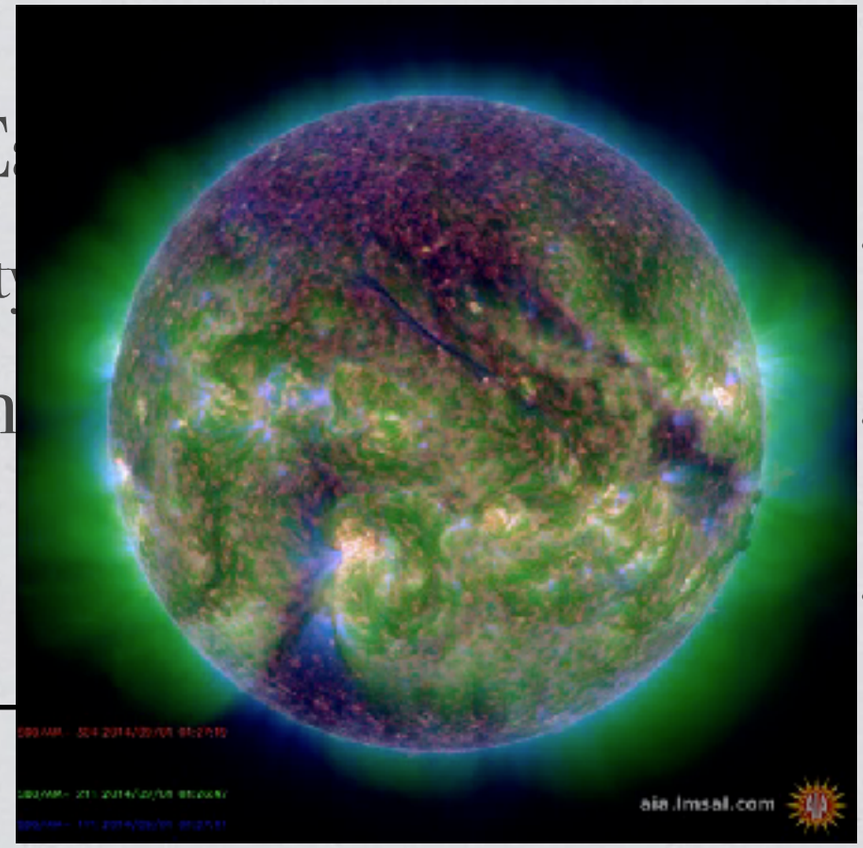
AIA 304 Å & AIA 4500 Å @ SDO



https://www.esa.int/spaceinimages

Solar Physics





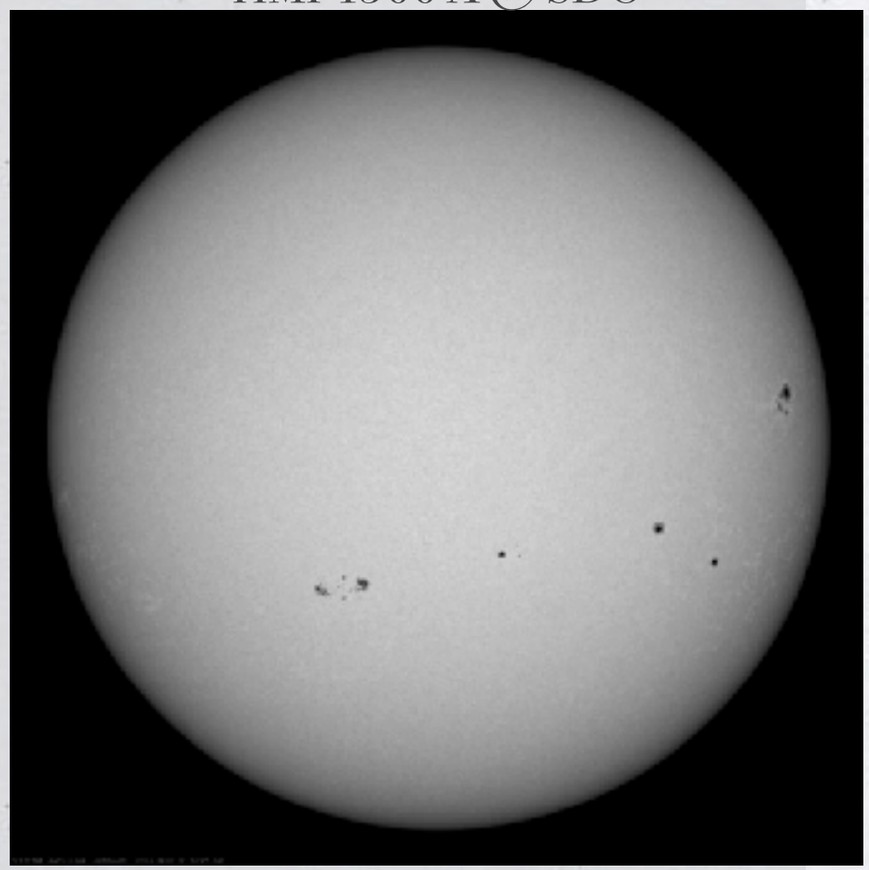
AIA 171 Å & 211 Å & 304 Å@ SDO

- Solar physics provides valuable input to the more general field of astrophysics
  - Sun is ‘Rosetta‘ stone: Only star for which surface structures can be resolved in detail
  - Unique laboratory for magnetohydrodynamics
  - Abundance of elements

Space-based vs. ground-based

* Advantages of space-based observation
  - ☑ Uninterrupted
  - ☑ Uninfluenced by Earth's atmosphere
  - ☑ Fixed observation modes
  - ☑ Homogeneity of observational data
* Disadvantages of space-based observation
  - ↯ Inflexibility of observation
  - ↯ Inaccessibility of hardware
  - ↯ Limited in size
  - ↯ Extensive costs

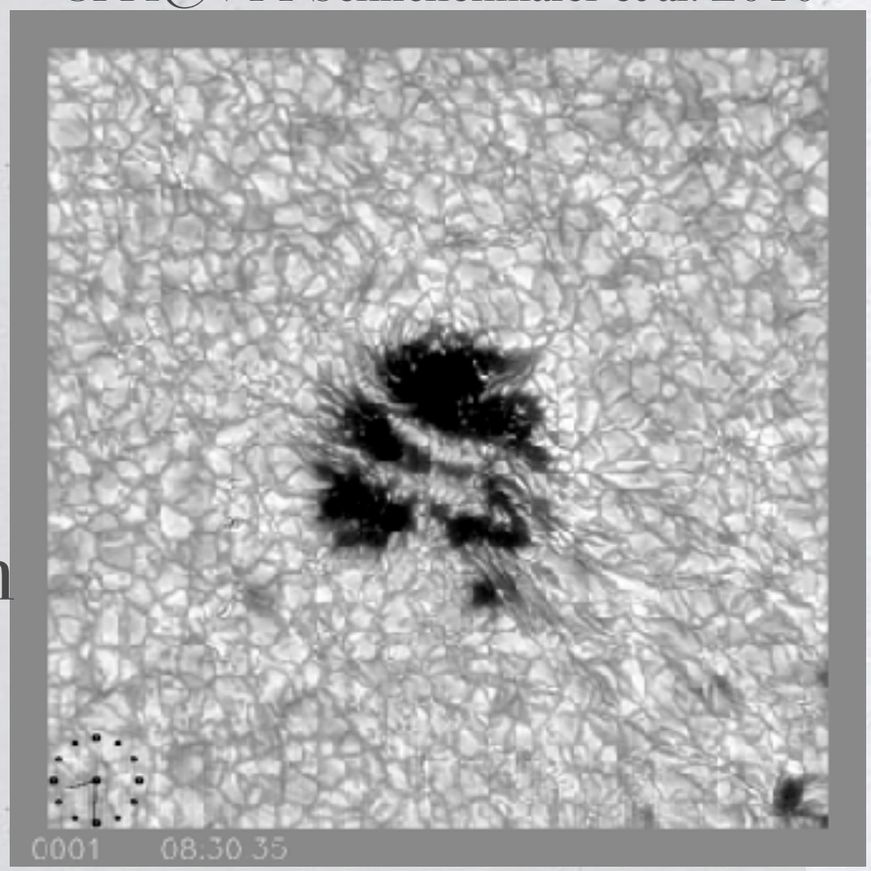
HMI 4500 Å @ SDO



Space-based vs. ground-based

* Advantages of ground-based observation
  - ☑ Flexibility of observation
  - ☑ Hardware development during operational phase
  - ☑ Cheap and easy maintenance
  - ☑ Large facilities realizable at affordable cost
* Disadvantages of ground-based observation
  - ⚡ Interrupted by day-night cycle
  - ⚡ Influenced by Earth's atmosphere
  - ⚡ Currently PI based and run without standardized observing modes
  - ⚡ Heterogeneity of data

GFPI@VTT Schlichenmaier et al. 2010



Upcoming Solar Telescopes

DKIST 2020

GST

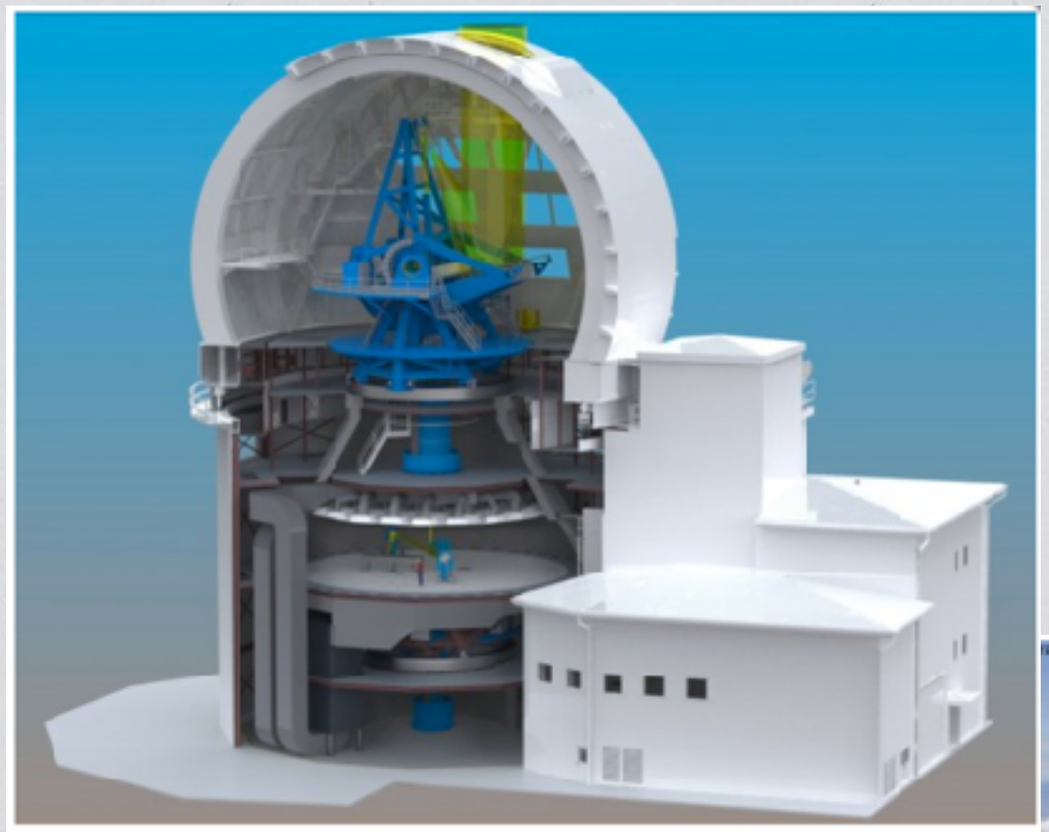
EST 2027

GREGOR, VTT, SST, Themis

Sayan Solar Telescope Coronograph

CGST 2030

Upcoming Solar Telescopes



DKIST
DANIEL K. INOUYE SOLAR TELESCOPE

Daniel K. Inouye Solar Telescope,
Hawaii, USA

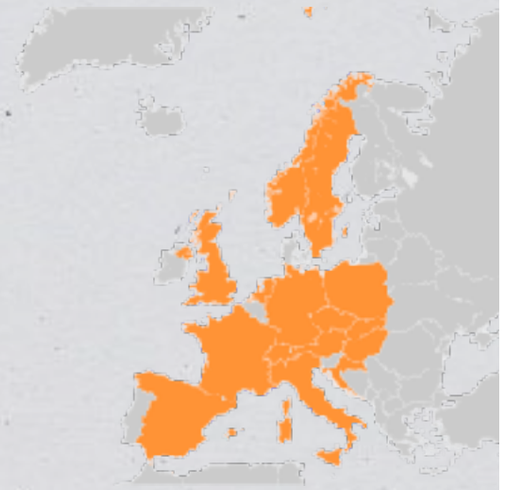
Upcoming Solar Telescopes

Daniel K. Inouye Solar Telescope,
Hawaii, USA

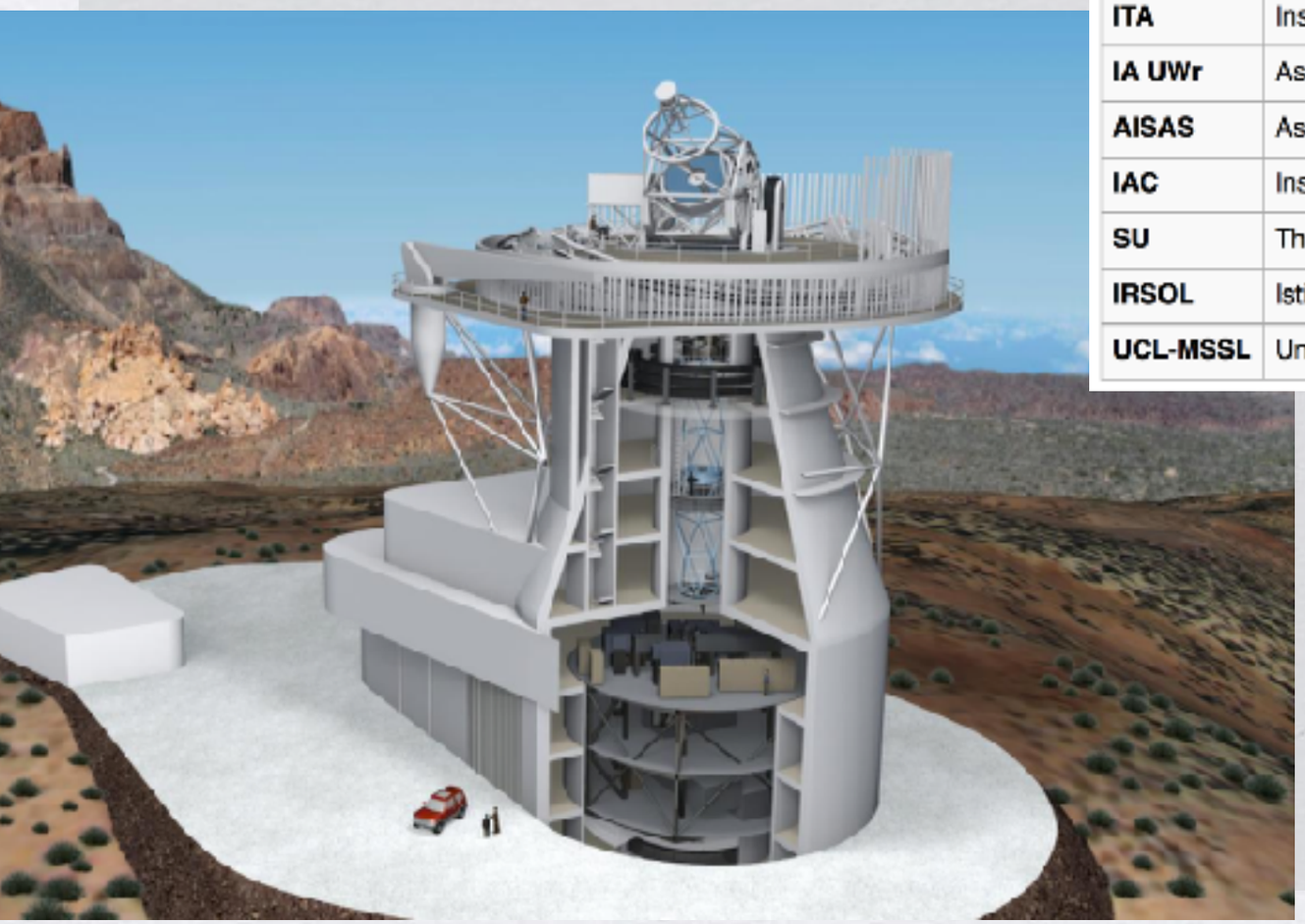
UK and Germany are contributing to the DKIST project with detectors and the VTF 2D spectro-polarimeter

European access to observation and data

Upcoming Solar Telescopes



	Institute	Location
IGAM	Institutsbereich Geophysik, Astrophysik und Meteorologie	Graz
HVO	Hvar Observatory	Hvar
AIASCR	Astronomical Institute AS CR	Ondrejov
THEMIS	THEMIS S.L.,[note 1] INSU-CNRS, CNR	Paris
KIS	Kiepenheuer-Institut für Sonnenphysik	Freiburg
UniDeb	Heliophysical Observatory Debrecen	Debrecen
INAF	Istituto Nazionale di Astrofisica	Rome
UU	Ultrecht University, Sterrekundig Instituut	Utrecht
ITA	Institute of Theoretical Astrophysics	Oslo
IA UWr	Astronomical Institute of the Wroclaw University	Wroclaw
AISAS	Astronomical Institute of the Slovak, Academy of Sciencees	Tatranská Lomnica
IAC	Instituto de Astrofisica de Canarias	La Laguna
SU	The Institute for Solar Physics	Stockholm
IRSOL	Istituto Ricerche Solari	Locarno
UCL-MSSL	University College London - MSSL	London



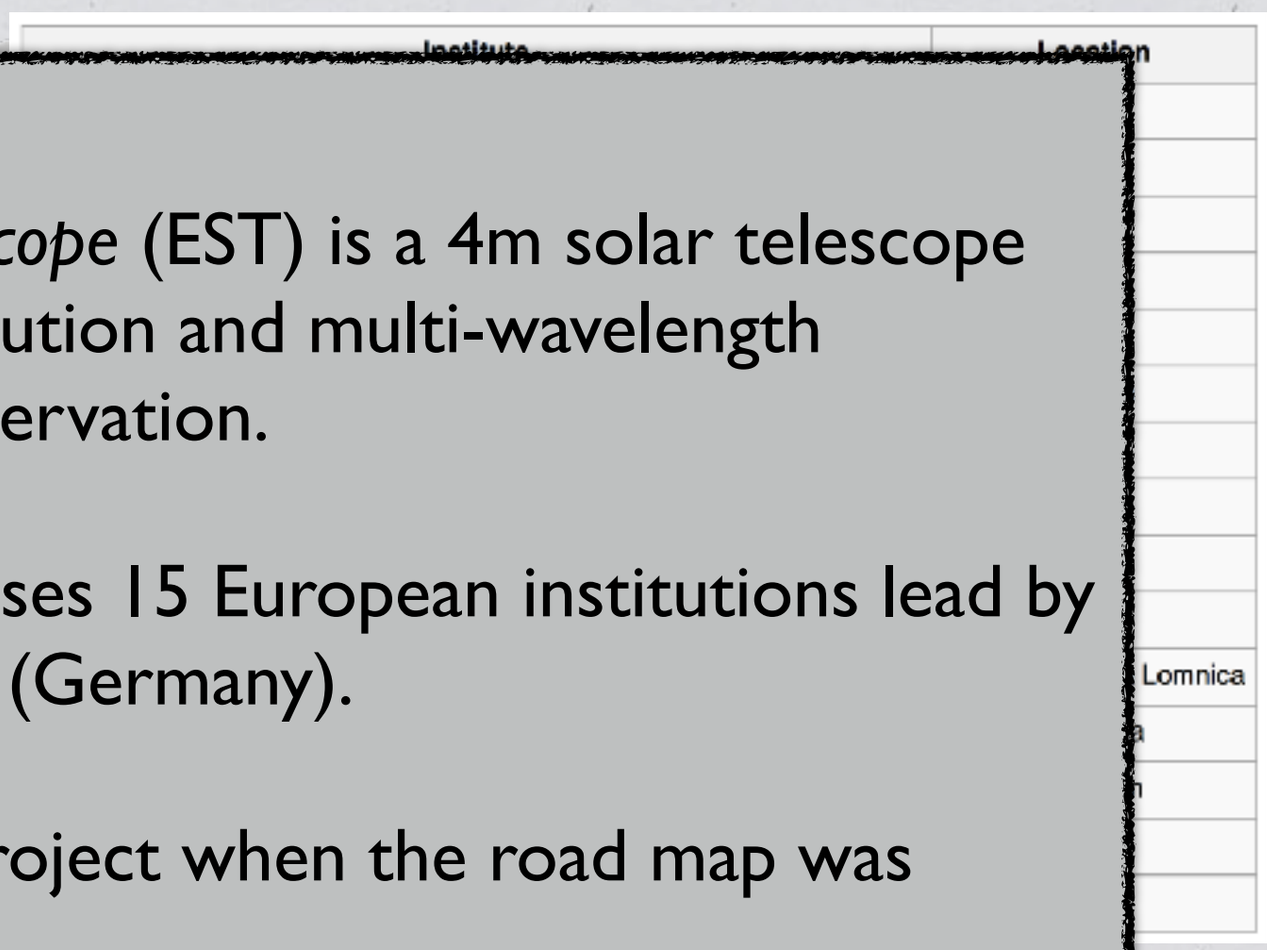
Upcoming Solar Telescopes

The *European Solar Telescope* (EST) is a 4m solar telescope optimized for high-resolution and multi-wavelength spectropolarimetric observation.

The EST project comprises 15 European institutions lead by the IAC (Spain) and KIS (Germany).

EST became an ESFRI project when the road map was updated in 2016.

KIS will join the ASTERICS network as a representative for the EST community.

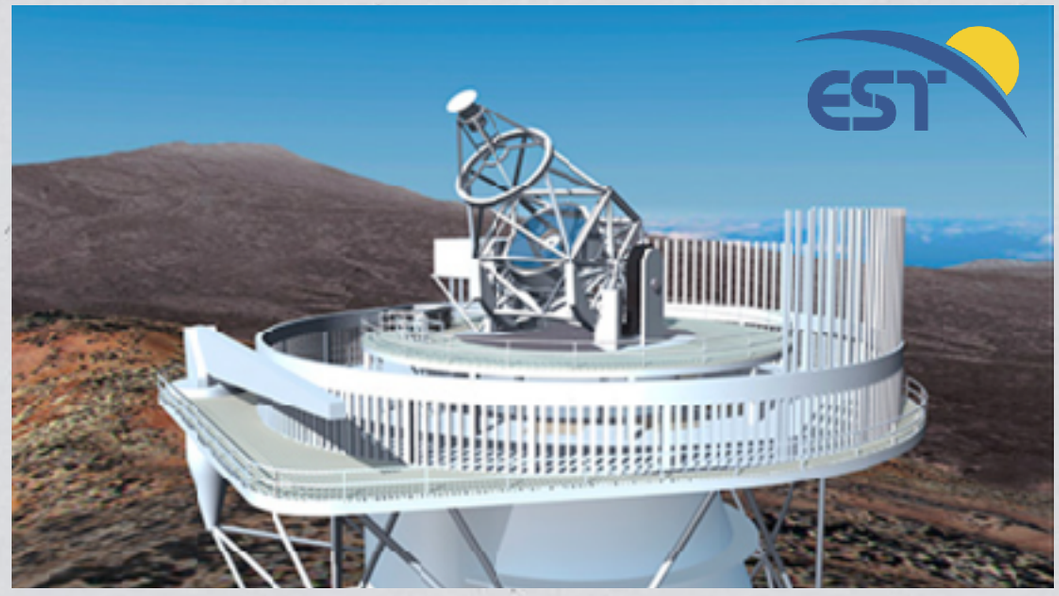


Upcoming Solar Telescopes

* Type: Single-sited
* Coordinating country: Spain
* Timeline

2011 - 2021	2021 - 2026	2027
Preparatory Phase	Construction phase	Operation start

* Estimated Cost
  - Preparation: 10M€
  - Construction: 200M€
  - Operation: 9M€/year
* Location
  - EST will be built on the Canary Islands
  - Headquarters will be at the Instituto de Astrofisica de Canarias, Tenerife, Spain



Upcoming Solar Telescopes

[...]

EST Science Data Center: EST SDC

Apart from the EST Telescope Operation and Science Centre on the Canary Islands, it is also planned to have the EST Science Data Centre in Germany, to provide data access and online services to the solar physics community. This center will provide a storage area to be accessed online through a data management system. Furthermore remote-observing facilities will be installed here.

Costs related to the installation of the telescope at the observatory form an integral part of the EST project budget. However, the construction or use of those spaces at sea-level and at mainland Europe for the EST TOSC and the EST SDC are planned to be covered by additional sources and agreements.

[...]

Online submission form: Research Infrastructure proposal to the 2016 ESFI Roadmap

Upcoming Solar Telescopes

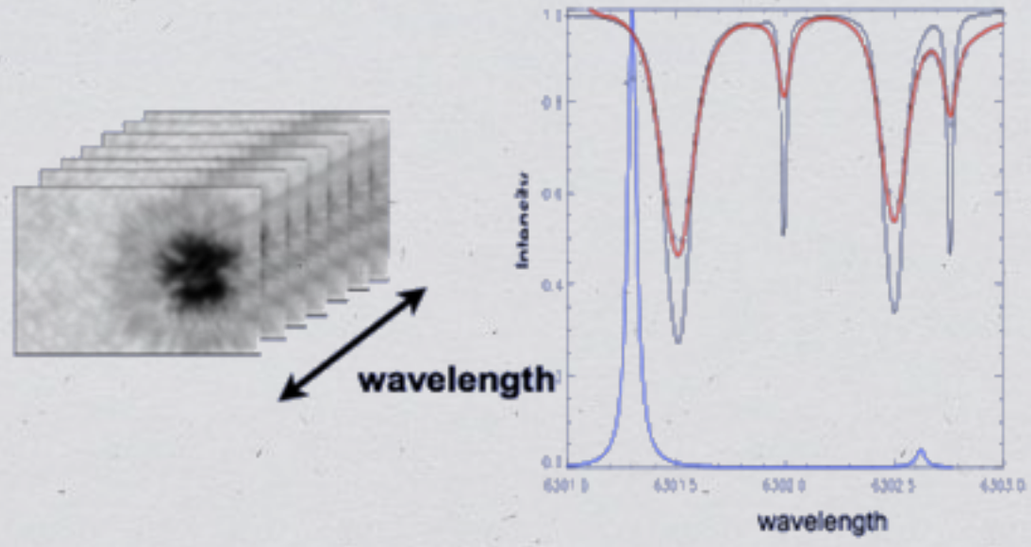
[...]
The EST Science Data Centre (EST SDC) will gather all expertise for producing EST science-ready data. Science-ready data will be moved or duplicated from the processing centre to the mainland Europe Virtual Observatory Compliant Data-Base (VOCDB). The SDC will be the nucleus of the scientific life of EST, where scientists are expected to come for a full data analysis and share results. If communication bandwidth allows, remote control of the infrastructure shall also be possible from the SDC. The SDC will also be in charge of the long-term data storage and the VO-diffusion of EST data. The VOCDB shall take charge of the interoperability with the VOCDB from other facilities.

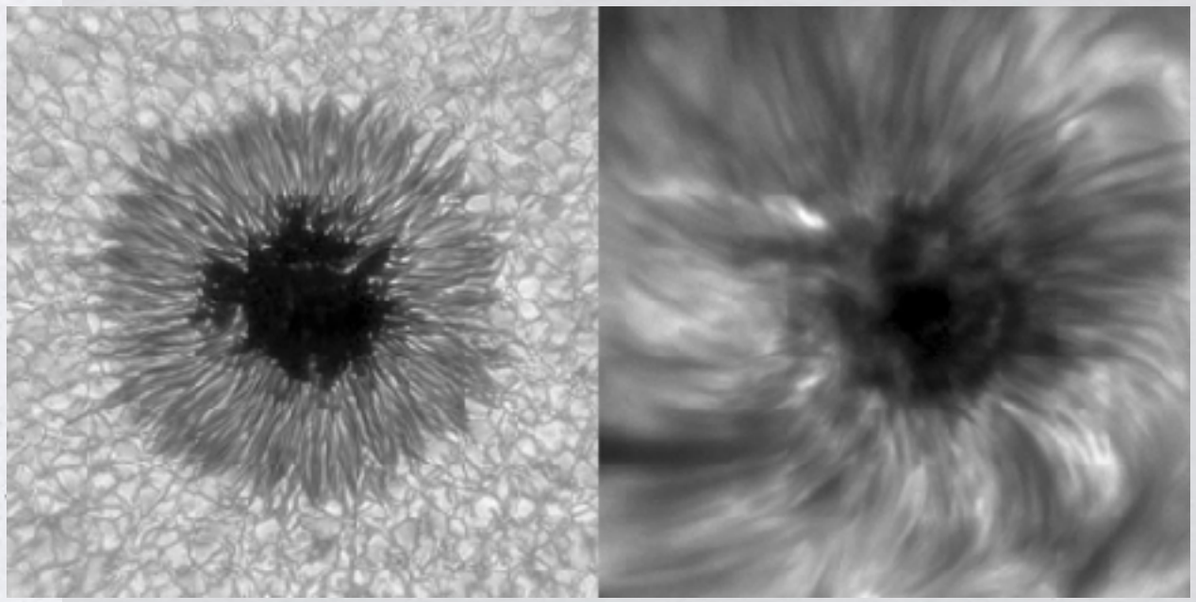
The SDC shall have offices for specialized staff in data reduction and analysis and for visiting astronomers to work on, and get familiar with, the EST data. Computing and storage capacities will be enough to guarantee the successful handling of EST data to generate innovative results.

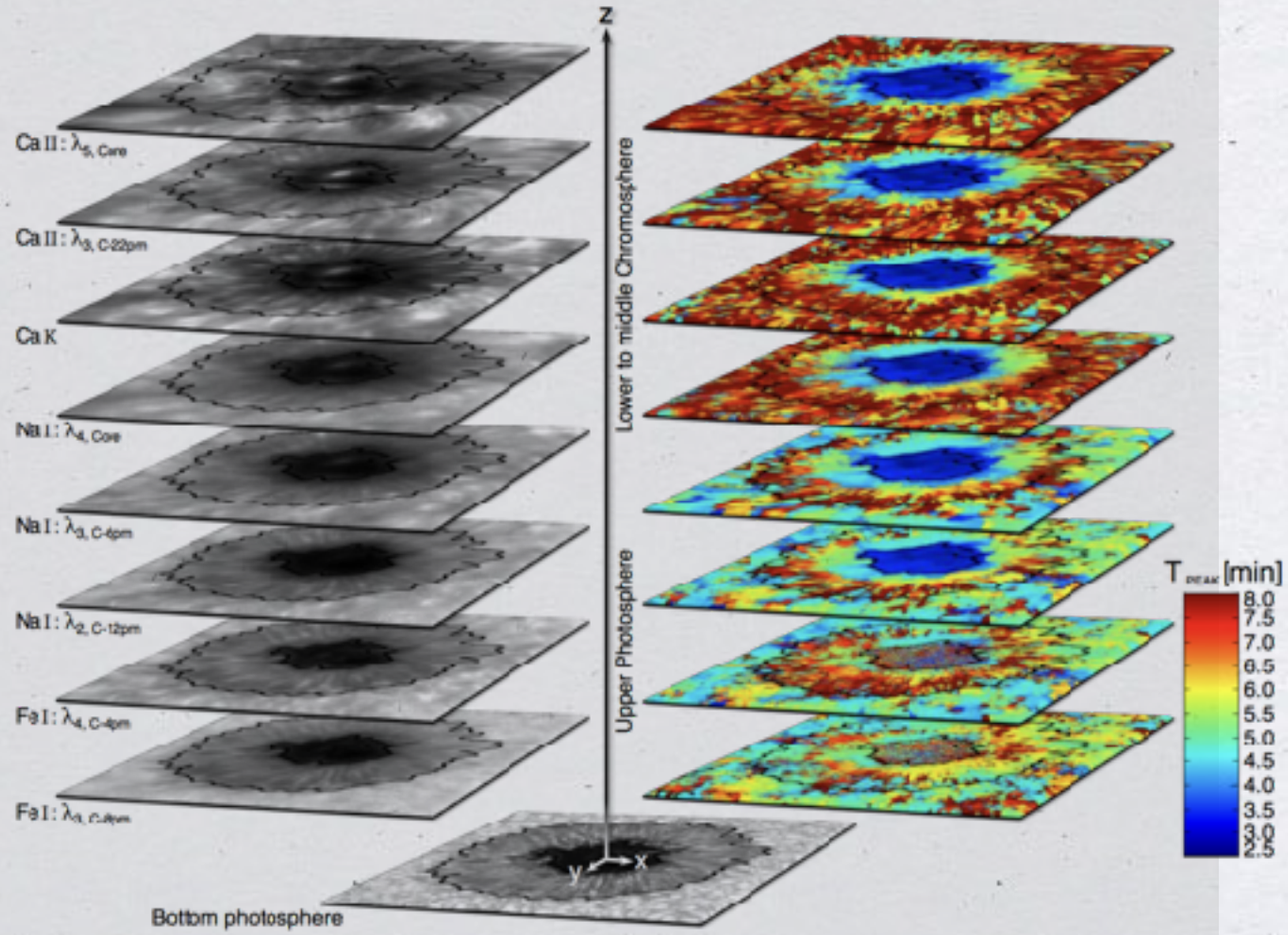
The SDC will organize special events to gather scientific visitors there to foster discussion forums and workshops based on EST data and results.
[...]

Online submission form: Research Infrastructure proposal to the 2016 ESFI Roadmap

A Flavor of Solar Data





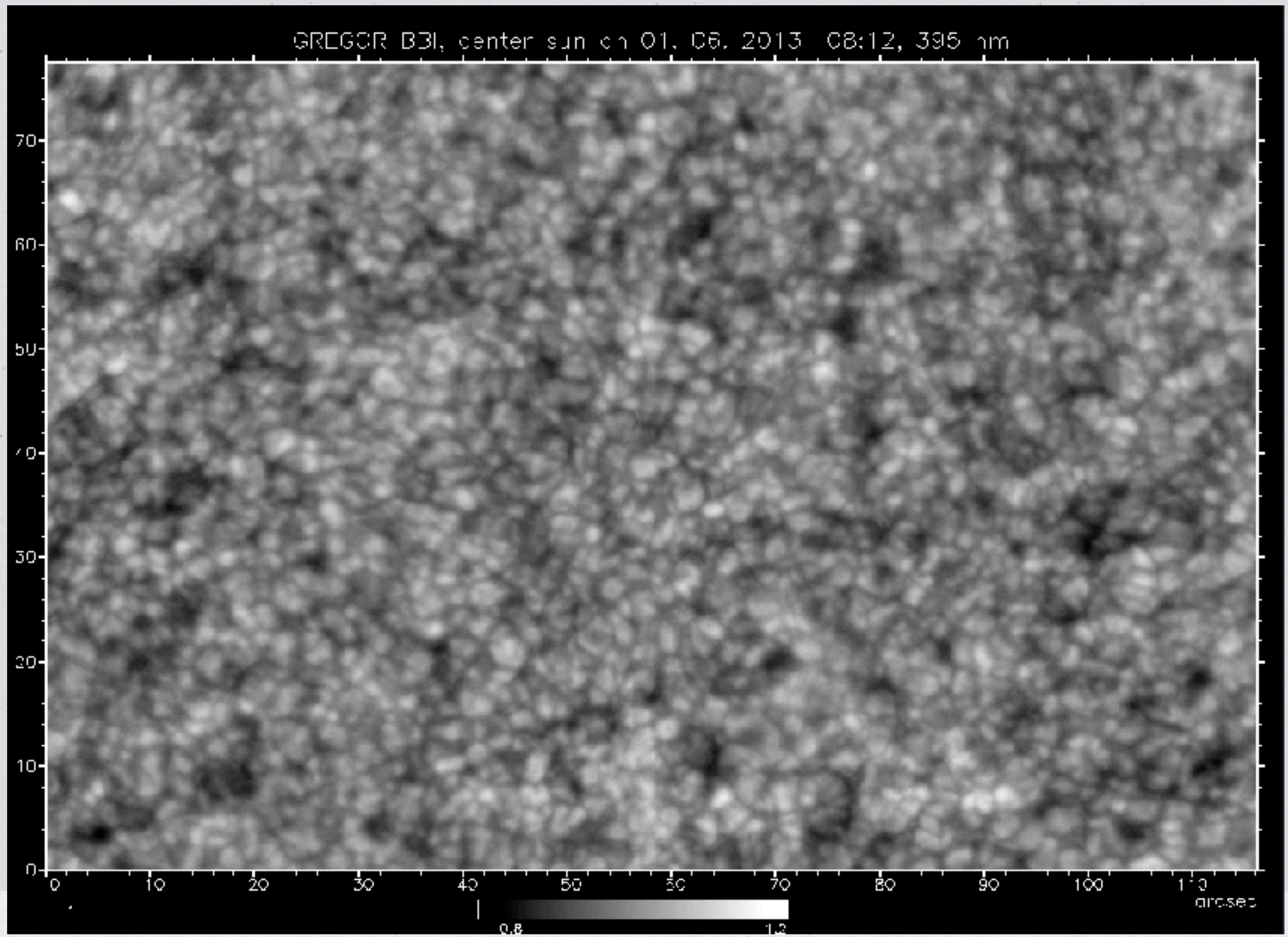


IBIS & ROSA@DST Löhner-Böttcher 2016

A Flavor of Solar Data

- Some characteristics of ground-based solar observation:
  - Varying atmospheric observing condition (seeing).

A Flavor of Solar Data



A Flavor of Solar Data

- Some characteristics of ground-based solar observation:
  - Varying atmospheric observing condition (seeing).
  - Target based (quiet Sun, sunspots, pores, plages, faculae, etc.) with a limited FOV. Pointing information become important.
  - Versatile and non-standardized observing modes as well as novel science (multi-wavelength, ...) make it difficult to unify data pipelines.
  - Upgrade might change the data characteristics for a given (upgraded) instrument.

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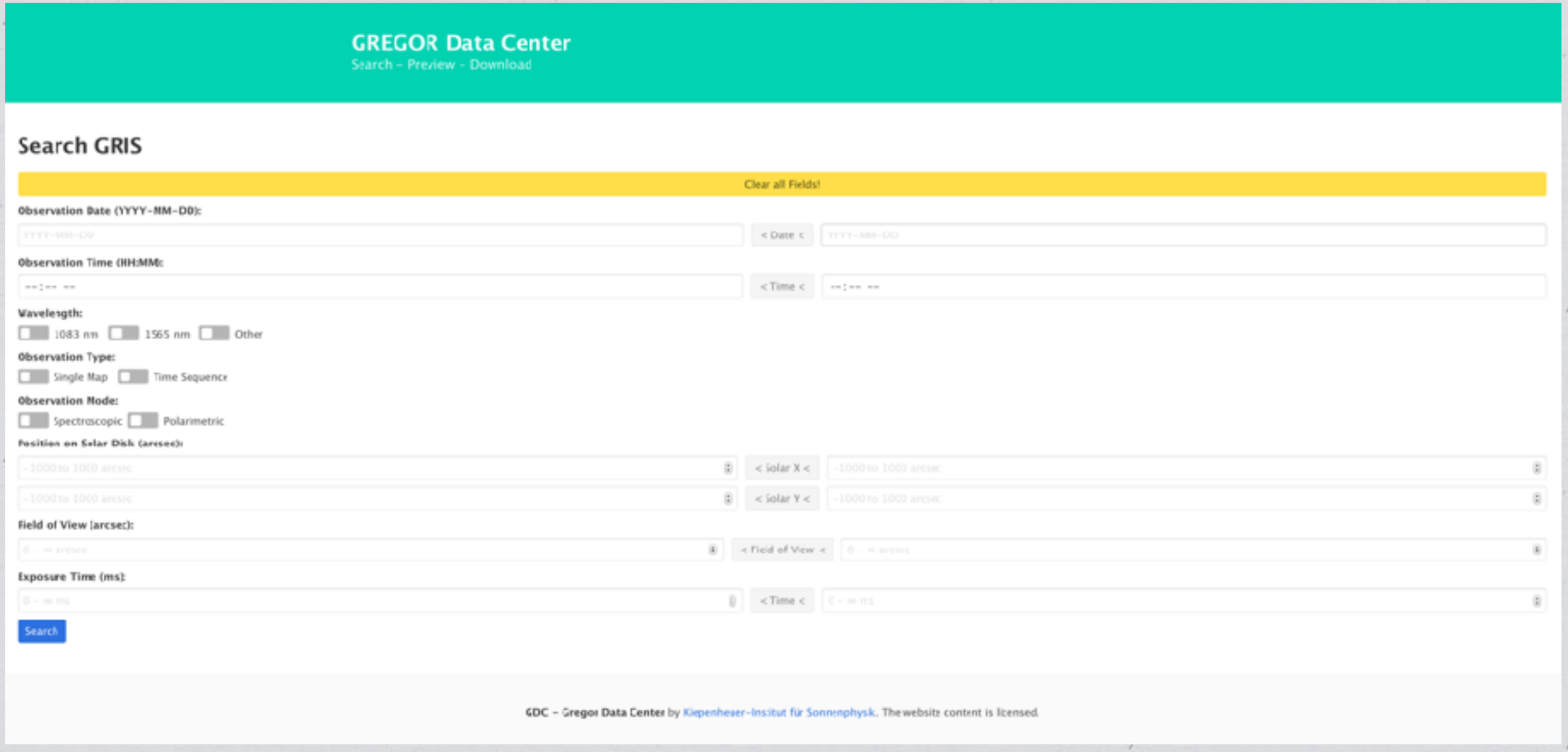
The major challenge for the archiving and dissemination of ground-based solar observation is the inherent heterogeneity of the data

A Flavor of Solar Data

* GRIS archive 2.0 (unofficial beta version)



Hederer, Schaffer, Franz 2018

A Flavor of Solar Data

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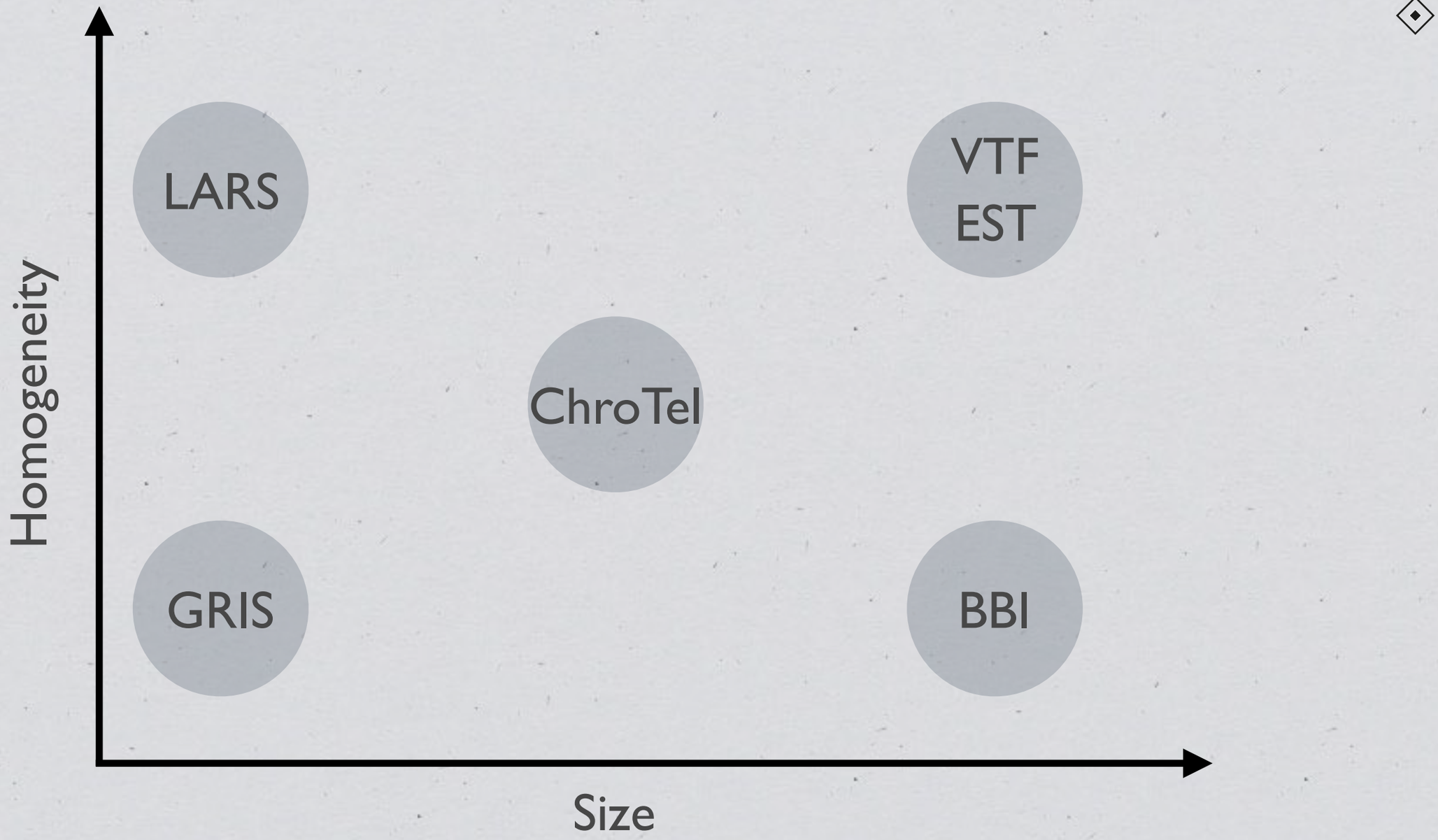
GREGOR Data Center

The result of your search:

No.	Date Obs.	UT Start	UT End	λ [nm]	Scan Type	Mode	Exp. Time [ms]	FOV [arcsec]	Target	Solar X [arcsec]	Solar Y [arcsec]	Θ [°]	Location	Map	Log File	LVL 0	LVL 1	LVL 2	Mark
1	2014-05-01	08:00:34.0	08:10:03.0	1565	Single Map	polar.	30.0	40,5	Filament/Prominence	-332	133	22,027	NO IMAGE AVAILABLE						
2	2014-05-01	08:26:27.0	08:14:26.0	1565	Single Map	polar.	30.0	27	Filament/Prominence	8	-184	11,139							
3	2014-05-02	15:05:41.0	15:33:25.0	1565	Single Map	polar.	30.0	40,5	Filament/Prominence	-228	75	14,587							
4	2014-05-02	13:27:23.0	13:15:12.0	1565	Single Map	polar.	30.0	27	Filament/Prominence	389	-153	26,01							
5	2014-05-02	11:35:12.0	11:53:00.0	1565	Single Map	polar.	30.0	27	Filament/Prominence	96	61	6,854							
6	2014-05-02	12:07:56.0	12:26:18.0	1565	Single Map	polar.	30.0	27	Filament/Prominence	-168	151	13,71							
7	2014-05-02	14:16:47.0	14:32:14.0	1565	Single Map	polar.	30.0	40,5	Filament/Prominence	213	104	14,401							

Hederer, Schaffer, Franz 2018

A Flavor of Solar Data



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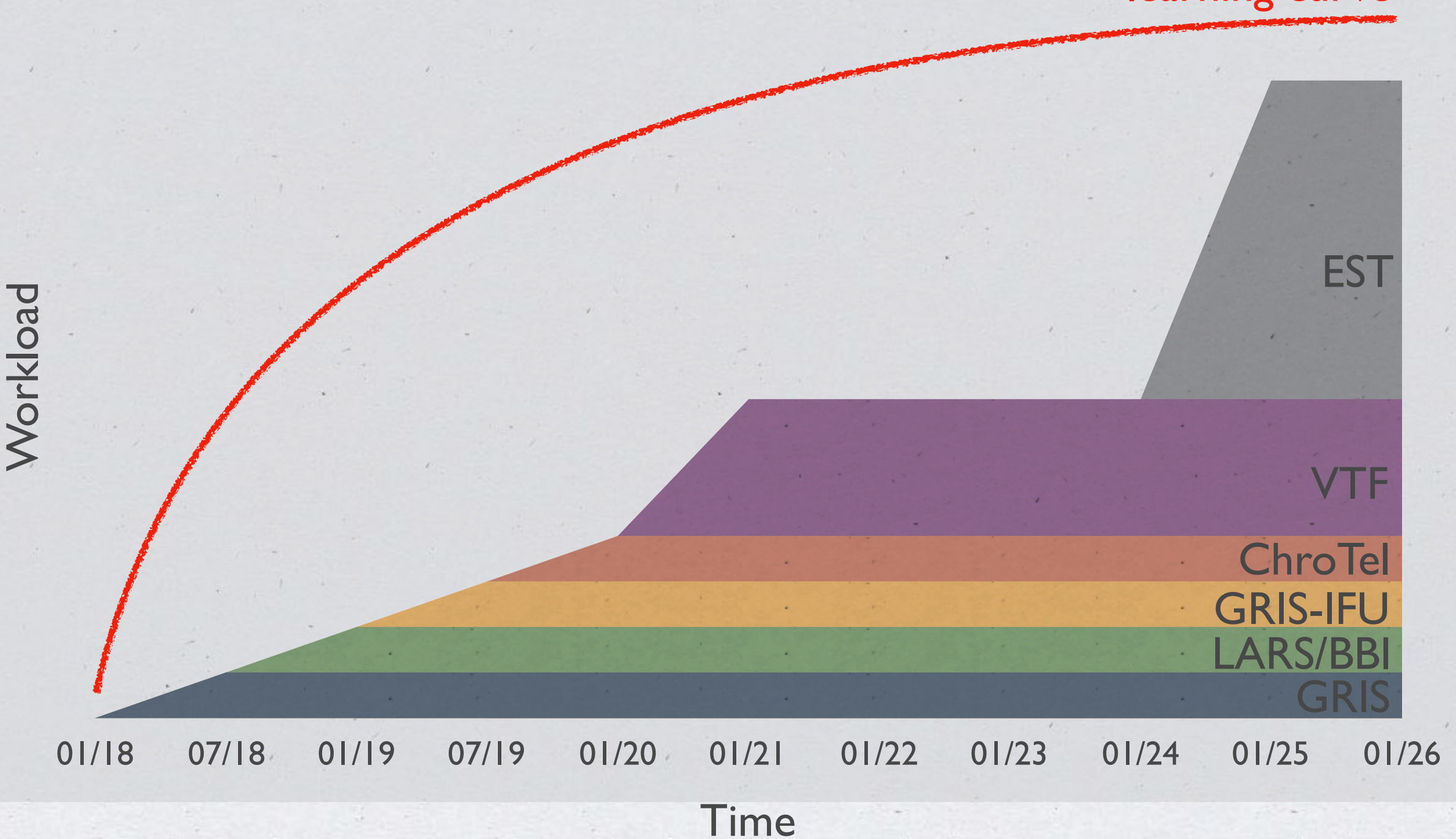

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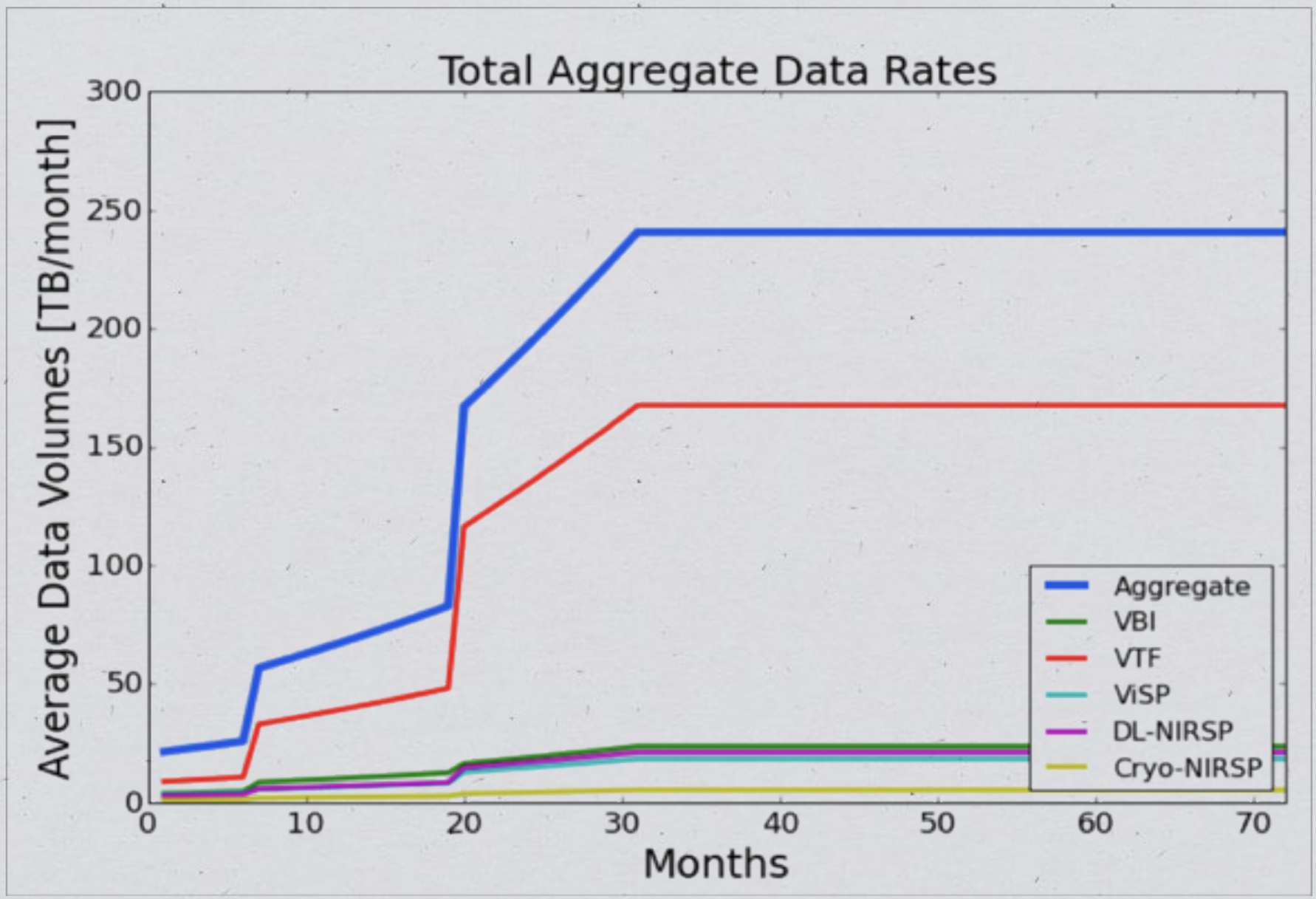
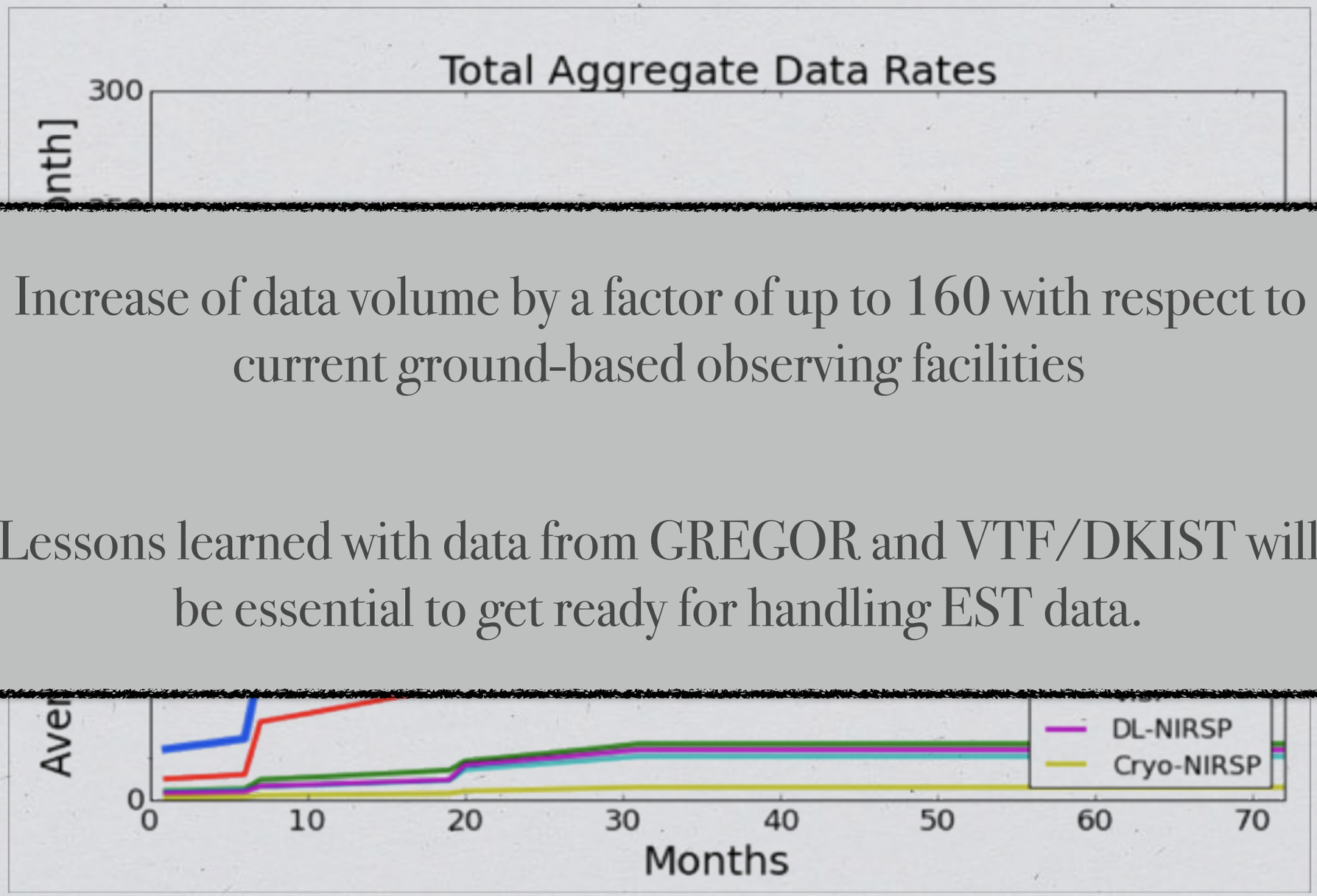


DKIST Solar Data Center

A Flavor of Solar Data



Increase of data volume by a factor of up to 160 with respect to current ground-based observing facilities

Lessons learned with data from GREGOR and VTF/DKIST will be essential to get ready for handling EST data.

DKIST Solar Data Center

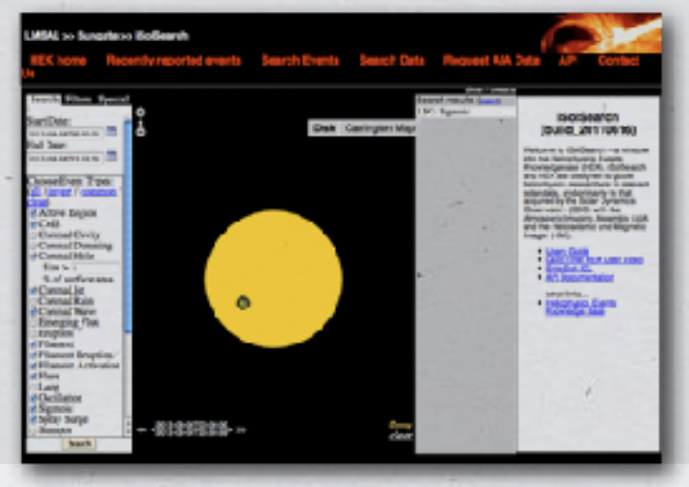
A Flavor of Solar Data

* There is a need to make distribution and discovery of data as easy as possible, especially for ground based solar observation

Data archives, e.g., VSO

Browsing tools, e.g., (j)Helioviewer

Event searching, e.g., HEK



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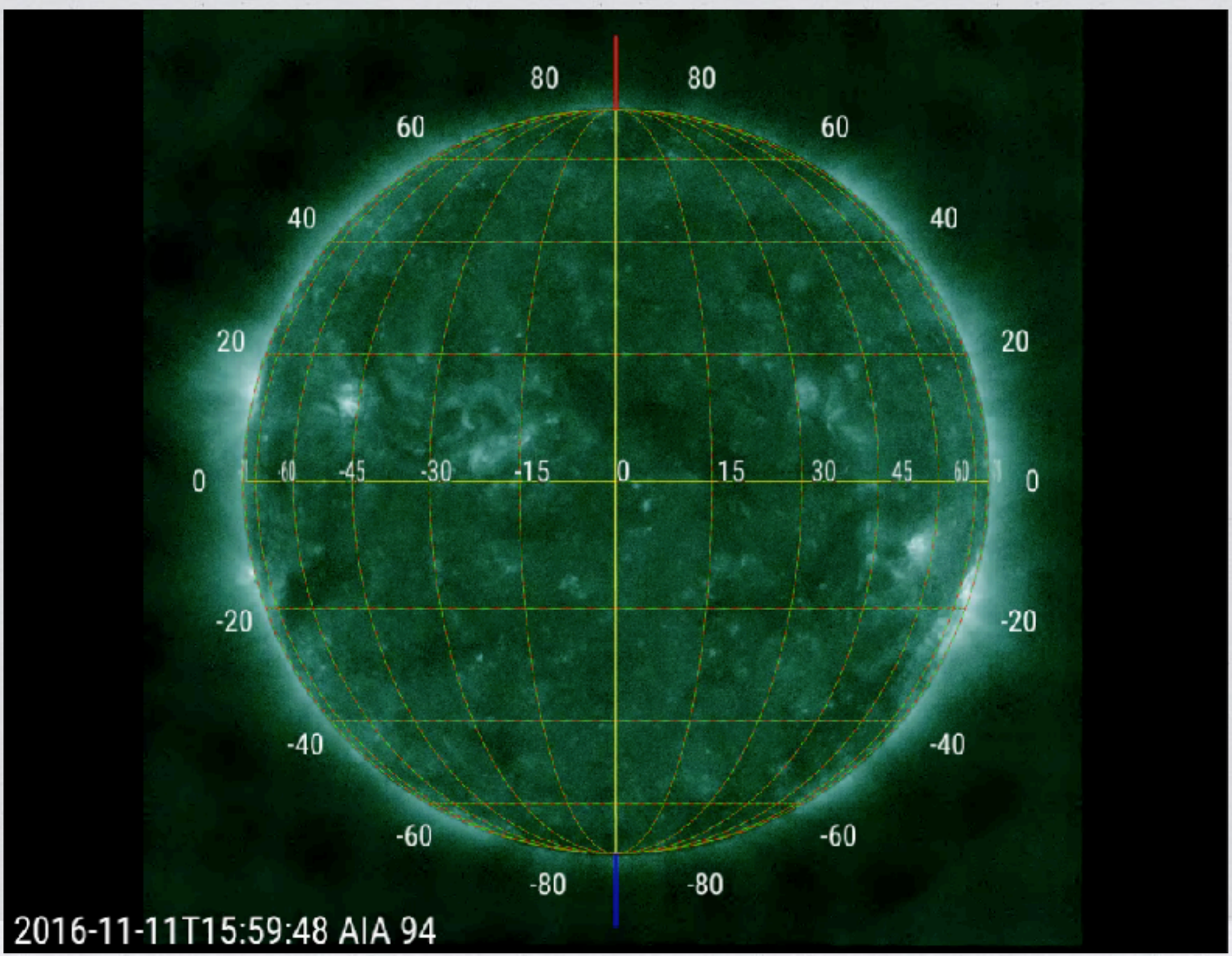


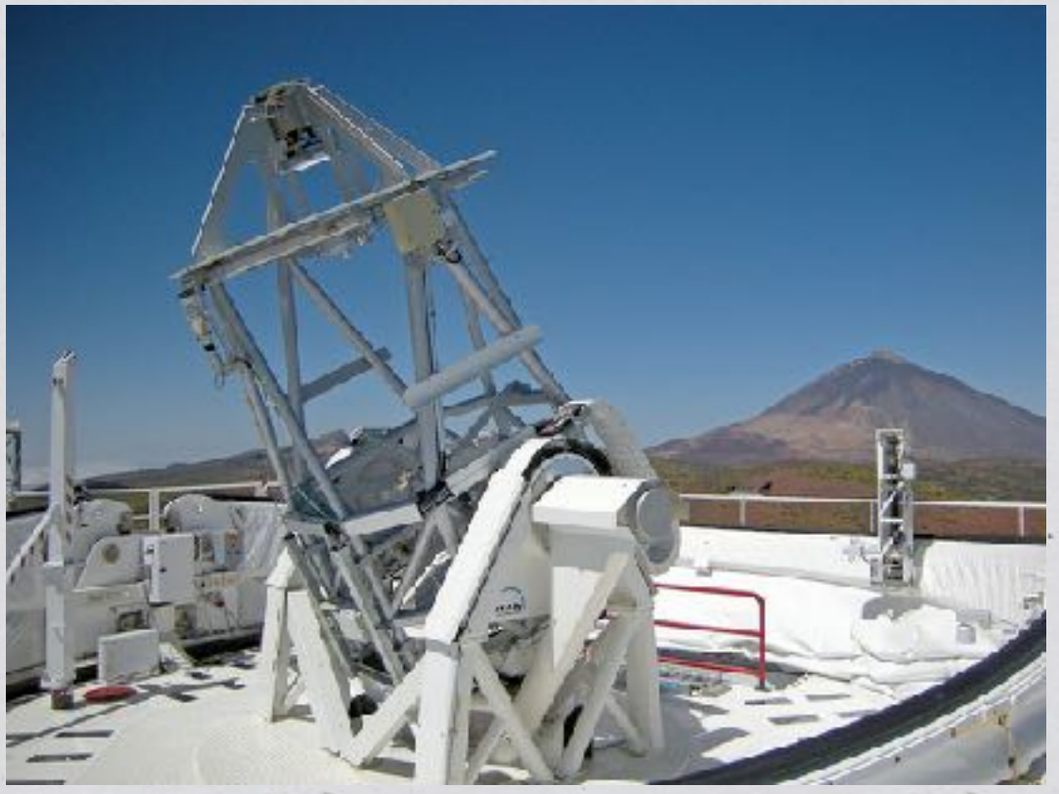
Royal Observatory of Belgium

Summary

- Solar physics provides input to a number of research disciplines.
- Space- and ground-based observatories provide complementary types of information.
- A new class of ground-based Solar Telescopes is on the horizon.
- Size and data volume of these telescopes require service mode observation and pre-defined standards for (meta)data.
- Challenges are the flexibility of the facilities and the subsequent heterogeneity of the data. Efforts to overcome these problems are undertaken, e.g. within the framework of the SOLARNET project.
- Adopting existing (meta)data standards from the astronomical community (IVOA) will be of great help for the solar community.

Acknowledgements

- Thomas Hederer
- Manolo Collados
- Peter Caligari
- Nazaret Bello Gonzalez
- Carl Schaffer
- Philip Lindner
- Christian Bethge
- Ikrima bin Saeed
- Alexander Bell
- Andreas Lagg
- Svetlana Berdyugina
- etc.



The 1.5-meter GREGOR solar telescope was built by a German consortium under the leadership of the Kiepenheuer-Institut für Sonnenphysik in Freiburg with the Leibniz-Institut für Astrophysik Potsdam, the Institut für Astrophysik Göttingen, and the Max-Planck-Institut für Sonnensystemforschung in Göttingen as partners, and with contributions by the Instituto de Astrofísica de Canarias and the Astronomical Institute of the Academy of Sciences of the Czech Republic.