

## *Open solar data, data products, and tools at MEDOC*

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IHDEA 2024, Madrid, 2024-10-17

# What is MEDOC? <https://idoc.osups.universite-paris-saclay.fr/MEDOC/>

A *data and operations center* for *solar physics space missions* :

- ▶ Created in 1996, as *European SoHO data and operations center*
- ▶ Since then, *many other solar data sets* (STEREO, SDO...), but also *derived data products* and *tools* to use data → facilitate data exploitation
- ▶ SoHO/GOLF and Solar Orbiter/SPICE *operations*



▶ Funding from CNES, CNRS, and Université Paris-Saclay

▶ Projects/collaborations with ESA, EC, CNES, CDPF...

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## *Officially CNRS-recognized "observation services" for heliophysics data*



- ▶  : space solar/heliospheric data (remote-sensing observations)
- ▶  : solar system natural plasmas (in-situ measurements)
- ▶ *3SOLEIL* : ground solar data (VL, radio, cosmic rays)
- ▶ APIS (planetary auroral observations), MASER (radio), CLIMSO, STORMS, ISGI.

...offering :

- ▶ Access to data and products derived from observation data
- ▶ Tools and services to access and exploit data

...in an effort to make data and metadata

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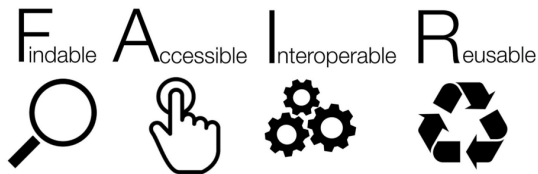
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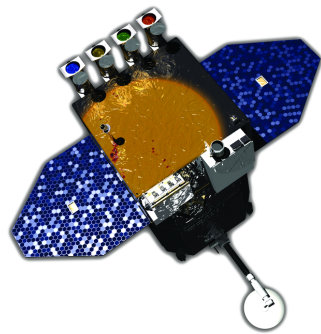
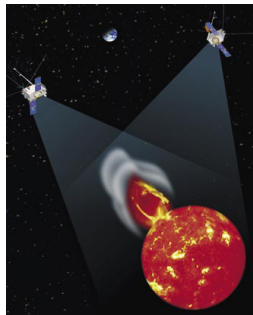
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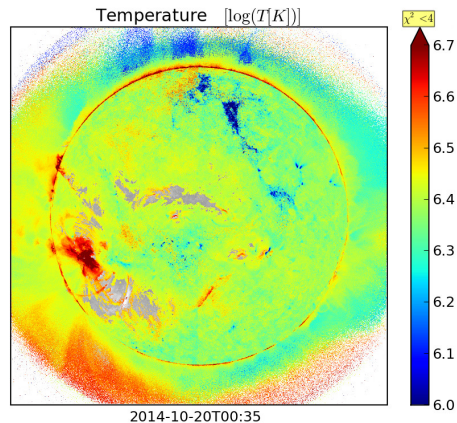
# What does MEDOC provide ? Observation data



- ▶ *Current missions* : SoHO (1995–), STEREO/SECCHI (2006–), SDO (2010–) : > 700 TB  
Coming soon : Solar Orbiter (2020–)
- ▶ PICARD (2010–2014 ; [CNES main archive](#)), TRACE (1998–2010)...

## *Derived data products (computed from observation data)*

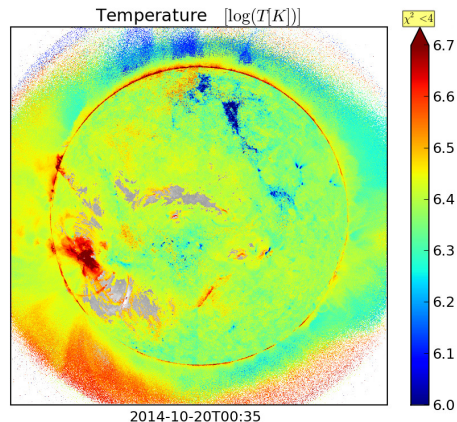
- ▶ Thermal structure of the corona (DEM parameters)
- ▶ Synchronous synoptic maps of the corona and photosphere
- ▶ Electric currents in active regions
- ▶ Movies, spectral atlases, catalogs...





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Some of these are computed *several times per day*, just a *few hours after the observation*.

# Main interface : *SiTools2*

- ▶ Developed (2010–2017) by AKKA for CNES, Java, ExtJS
- ▶ REST API, for which we have developed IDL and Python clients
- ▶ Web interface
- ▶ Not maintained anymore by CNES → migration needed.

The screenshot displays the SiTools2 web interface. The top navigation bar includes links for 'Explore data', 'Search forms', 'Tools', 'Medoc News', 'Help', 'Credits', and 'Missions'. The main area is divided into two panels: 'AIA: build your query' on the left and 'AIA : results' on the right.

**AIA: build your query**

**DATE**: 2019-03-30 18:14:54 to 2019-04-04 18:14:54

**Wavelength**: A list of values (304, 211, 193, 171, 131, 94) with 171 selected.

**CADENCE**: 1 h

**Quick Start**:

1. Select dates  
Format must be: YYYY-MM-DD HH:MM:SS
2. Select cadence
3. Select a wavelength
4. Click Search

**Search** **Reset**

**AIA : results**

**Filter** **MultiSort** **Columns**

	series_name	date_obs	wavelnth
<input type="checkbox"/>	aia.lev1	2019-03-30 19:00:21	171
<input type="checkbox"/>	aia.lev1	2019-03-30 20:00:21	171
<input type="checkbox"/>	aia.lev1	2019-03-30 21:00:18	171
<input type="checkbox"/>	aia.lev1	2019-03-30 22:00:21	171
<input type="checkbox"/>	aia.lev1	2019-03-30 23:00:21	171
<input type="checkbox"/>	aia.lev1	2019-03-31 00:00:21	171
<input type="checkbox"/>	aia.lev1	2019-03-31 01:00:21	171
<input type="checkbox"/>	aia.lev1	2019-03-31 03:00:21	171
<input type="checkbox"/>	aia.lev1	2019-03-31 03:00:21	171

Display 1 - 10 to 101

## New interface : REGARDS

- ▶ Developed by CS for CNES
- ▶ Built on Spring microservices, implements OAIS recommendation
- ▶ REST API (for which we have developed a Python client)
- ▶ Web interface (React+Redux)

Catalogue

Solar-Orbiter

19/06/2023 20:50:25 UTC

Connexion

Solar-Orbiter

Résultats

RAFRÂCHIR

FILTRES

TRI

COLONNES

RECHERCHER





























TOUT SÉLECTIONNER

500/5054 résultats

TELESCOPE

DETECTOR

Instrument = SPICE

	Observatory	Instrument	Date-obs	Scientific objective	Observation mode	X-center [arcsec]	Y-center [arcsec]	Data type				
<input type="checkbox"/>		Solar Orbiter	SPICE	15/12/2021 11:19:11	L_FULL_LRES_MCAD_Cor...	CAL_SPECTRAL-RESPON...	-79.700035	-66.704124	SCI			
<input type="checkbox"/>		Solar Orbiter	SPICE	01/03/2022 13:34:35	None	CAL_SPECTRAL-RESPON...	44.505917	-73.63908	SCI			
<input type="checkbox"/>		Solar Orbiter	SPICE	12/01/2022 17:42:58	None	CAL_SPECTRAL-RESPON...	-30.632143	-70.33096	SCI			
<input type="checkbox"/>		Solar Orbiter	SPICE	12/01/2022 17:23:33	None	CAL_SPECTRAL-RESPON...	13.301798	-73.59341	SCI			
<input type="checkbox"/>		Solar Orbiter	SPICE	17/11/2020 08:17:45	None	CAL_FOCUS-COLD_TS_SL...	-85.20438	-77.45922	SCI			
<input type="checkbox"/>		Solar Orbiter	SPICE	06/03/2022 22:38:31	R_BOTH_HRES_HCAD_Na...	SCI_HIGH-CAD_SS_SL04_...	-755.7152	-530.342	SCI			
<input type="checkbox"/>		Solar Orbiter	SPICE	18/11/2020 15:03:07	None	SCI_DYN-QS-MEDIUM-1A...	-84.17502	-77.36724	SCI			

## How we are migrating to REGARDS

- ▶ *Setting up all datasets* : displayed columns, query forms, filters....  
Now using a single data model.
- ▶ *Ingesting* data :
  - Build OAIS SIP packets from pre-existing databases (SOHO, STEREO, SDO...) or from TAP interface (ESA Solar Orbiter archive).
  - Submit them to the ingestion queue using AMQP (RabbitMQ)
  - After ingestion, the products are harvested into ElasticSearch
- ▶ REGARDS can in principle ingest data using *OpenSearch*, but is this supported by another heliophysics archive ?

### Some challenges :

- A lot of "hidden" work before datasets are migrated or ingested.
- Currently no good technical solution for ingesting our > 300M SDO records
- REGARDS, as a generic CNES tool, doesn't support heliophysics API standards out-of-the-box.

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# EPN-TAP VO services

- ▶ A few MEDOC-specific datasets are available through EPN-TAP using a **DaCHS** server
- ▶ Then they are available from *Virtual Observatories* : **VESPA** and **Solar-VO**
- ▶ Maybe soon in VSO, or waiting for VSO 2.0 ?


**VESPA** Virtual European Solar and Planetary Access
 Help ▾

Refine your search
 ADQL Query
[Back To Services Results](#)

### Main Parameters

Target Name

Target Class

Dataproduct Type

Instrument Host Name

Instrument Name

= ▾

Processing level

Time

Location

### Results in service Gaia-DEM

**Gaia-DEM - Thermal structure maps of the solar corona from SDO**

GAIA-DEM is a database of Differential Emission Measure (DEM) maps. The DEM is a measure of the thermal structure of the coronal plasma, representing the quantity of light emitting plasma along the line of sight, at different temperatures. In GAIA-DEM, the DEM is modelled by a specific function of temperature, namely a Gaussian of the logarithm of electron temperature. GAIA-DEM maps are then maps of the DEM maximum temperature, of the DEM integral (total Emission Measure), and DEM width (in temperature). These maps are obtained by inversion from the SDO/AIA EUV images in 6 coronal channels (9.4, 13.1, 17.1, 19.3, 21.1, and 33.5nm). In addition, maps of the  $\chi^2$  for the inversion are provided. GAIA-DEM is available from the MEDOC interface at <https://idoc-medoc.ias.u-psud.fr/> based on the CNES SiTools2 framework. GAIA-DEM is also available from IDL and Python scripts, using a specialization of the generic SiTools2 IDL and Python clients developed by MEDOC. Fits files are not currently supported by ds9 but can be opened in fv and other fits viewers.

**Credits:**  
Creators: Karin Dassas, Eric Buchlin  
Contributors: IDOC  
Publisher: Institut d'Astrophysique Spatiale - IDOC

Column visibility Show all Hide all

Select All in current page Reset Selection

granule_uid	dataproduct_type	target_name	time_min (d)	time_max (d)	access_url
DEM-AIA-width_2023-06-14 23:34:51.622000	image	Sun	2023-06-14T23:34:51.621	2023-06-14T23:34:51.621	<a href="https://idoc-me">https://idoc-me</a>
DEM-AIA-width_2023-06-14 23:05:05.125000	image	Sun	2023-06-14T23:05:05.125	2023-06-14T23:05:05.125	<a href="https://idoc-me">https://idoc-me</a>

Products for the ESA Space Weather Portal <https://swe.ssa.esa.int/>

MEDOC provides 4 products (maps derived from data) to ESA's Space Weather network portal (ESA contract numbers 4000128012/19/D/MRP and 4000134036/21/D/MRP) :

- ▶ Web apps with well-determined functionalities and layout
- ▶ API (freely specified — HAPI was not ready when we started)
- ▶ All datasets have a SPASE description file submitted to ESA (not in any registry yet?)





















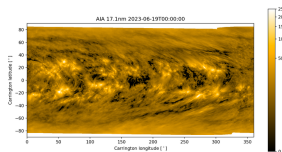

Federated products from the [Multi Experiment Data & Operation Center \(UPSaclay\)](#)


[Help](#) • [Related products](#) • [Latest](#) • [Query](#)

## UV/EUV synchronous synoptic maps

This service provides maps of the radiance in different UV and extreme-UV (EUV) bands on the full solar sphere, in heliographic Carrington coordinates, for a given reference time. These maps are derived from SOI/IA observations.

EUV 17.1nm nowcast synoptic map [Download](#)



This map, generated from a series of SDO/AIA observations, represents the intensity in the AIA 17.1 nm channel as a function of Carrington longitude and latitude, at the specified date (in UTC).



**THE EUROPEAN SPACE AGENCY**


**Welcome to the ESA Space Weather Service Network**  
 Please note that all ESA-SWE Services are under review/transition

[Expert Service Centres](#) / [ESC Solar Weather](#) / [radio-SSC-Informatics](#) /

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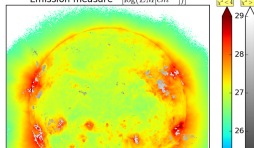

[Help](#) • [Related products](#) • [Latest](#) • [Query](#)

**Maps of thermal properties of the corona**

This service provides maps of parameters of a Differential Emission Measure (DEM) model as a function of temperature: temperature [T], Emission Measure [EM], width of the DEM, and coodnats of R[ $\lambda$ ]. Those maps are derived from SDO/AIA observations.

☒ Emission Measure      ☐ Temperature      ☐ DEM width      ☐ Goodness of fit

Gray scale:  $\chi^2 > 4$  White pixels: less than 6 bands! See user manual for interpretation.

Emission measure  $[\log(EM[\text{cm}^{-5}]])$ 

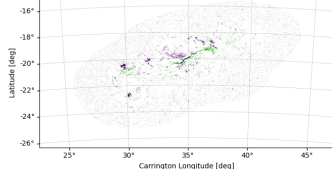

[Help](#) \* [Related products](#) \* [Latest](#) [Query](#)

### Maps of electric currents in Active Regions

This service provides maps of the radial component of the electric current density vector in Active Regions, in Cylindrical Equal Area coordinates. These maps are derived from science-level and near-real-time SDO/HMI data.

Observation date	Data type	Version	HARP number	NOAA Active Region number(s)	Download FITS file
2011-02-15T03:58:12 UTC	sci	1	377	11158	<a href="#">Download</a>

2011-02-15T03:58 jr [A / m2] HARP377

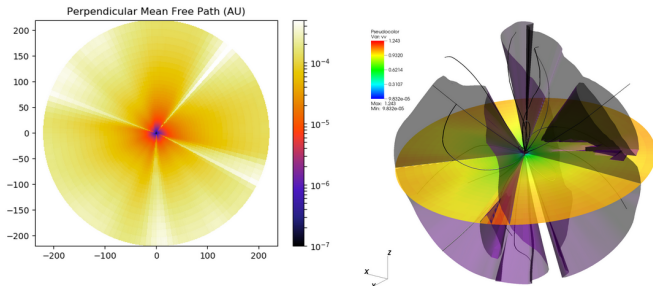


## Data from numerical simulation runs

- ▶ Solar wind profiles (VP code, 1D hydrodynamics)
- ▶ Solar eruption (OHM code, 3D MHD)
- ▶ Solar wind with cosmic rays scattering (PLUTO code, 3D MHD).

Will soon be provided through the new MEDOC node of Galactica (CEA/AIM, OP/VO-PDC, Heidelberg)

Galactica is built following IVOA Theory Data Model, and uses Django, Celery, RabbitMQ



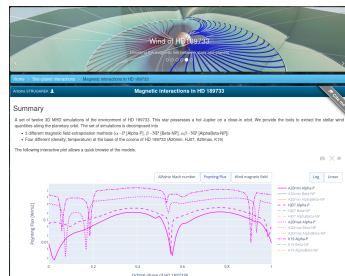
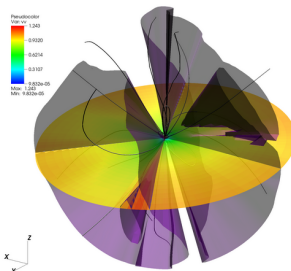
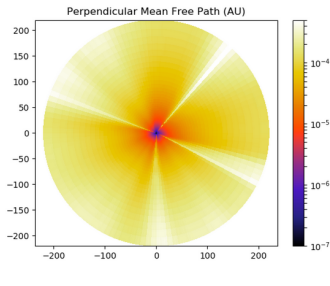


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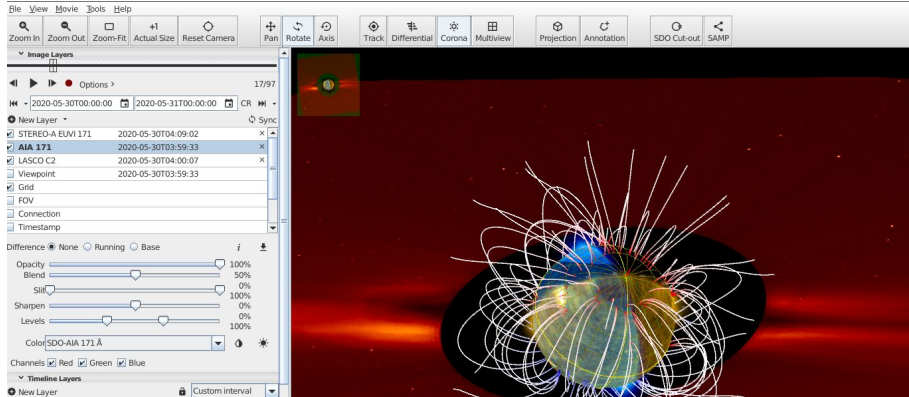
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# Data exploration / visualization : HelioViewer (ESA and NASA)

- ▶ HelioViewer JPIP (JPEG2000) server at MEDOC. New (ESA, ROB) : HAPI interface.
- ▶ Full mirror of NASA-GSFC HelioViewer data (100TB data).
- ▶ JHelioViewer SAMP interface, can be used e.g. to get FITS data from ESA Solar Orbiter archive



# Conclusion

- ▶ MEDOC provides data and tools for the community
  - All are open, available with no registration
- ▶ Efforts to provide APIs, complete metadata, DOIs... as well as to adopt standards (in particular IVOA ones)

➤ But many tools are not fully compliant with these standards... Still much work to do.

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