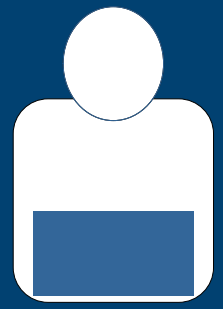
VirES

Earth Observation Scientists



DEMPO

Development,
Maintenance & Pre-Operations

VirES for Swarm – Virtual Research Environment

Martin Pačes, Daniel Santillan Pedrosa, Ashley Smith

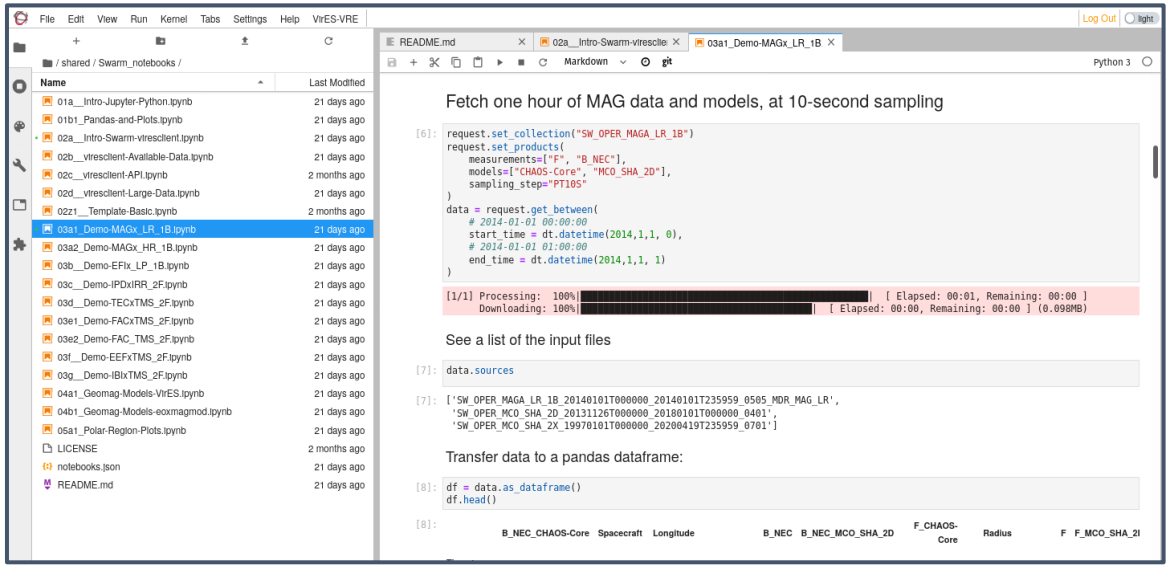
EGU2020-19908

Session EMRP2.2

Wednesday, 6 May 2020, 08:30–12:30

Virtual Research Environment (VRE)

https://vre.vires.services

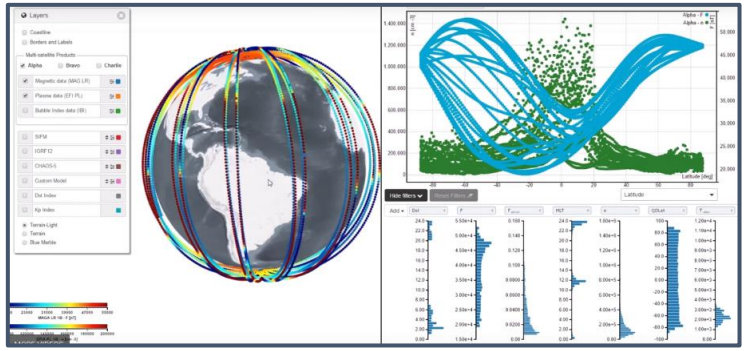


What is it?

Free-to-use Jupyter environment in the cloud to easily access Swarm products

Evolution of VirES for Swarm

https://vires.services



Integrated notebooks to help new users (intro to Swarm products and Python tools)

VirES for Swarm

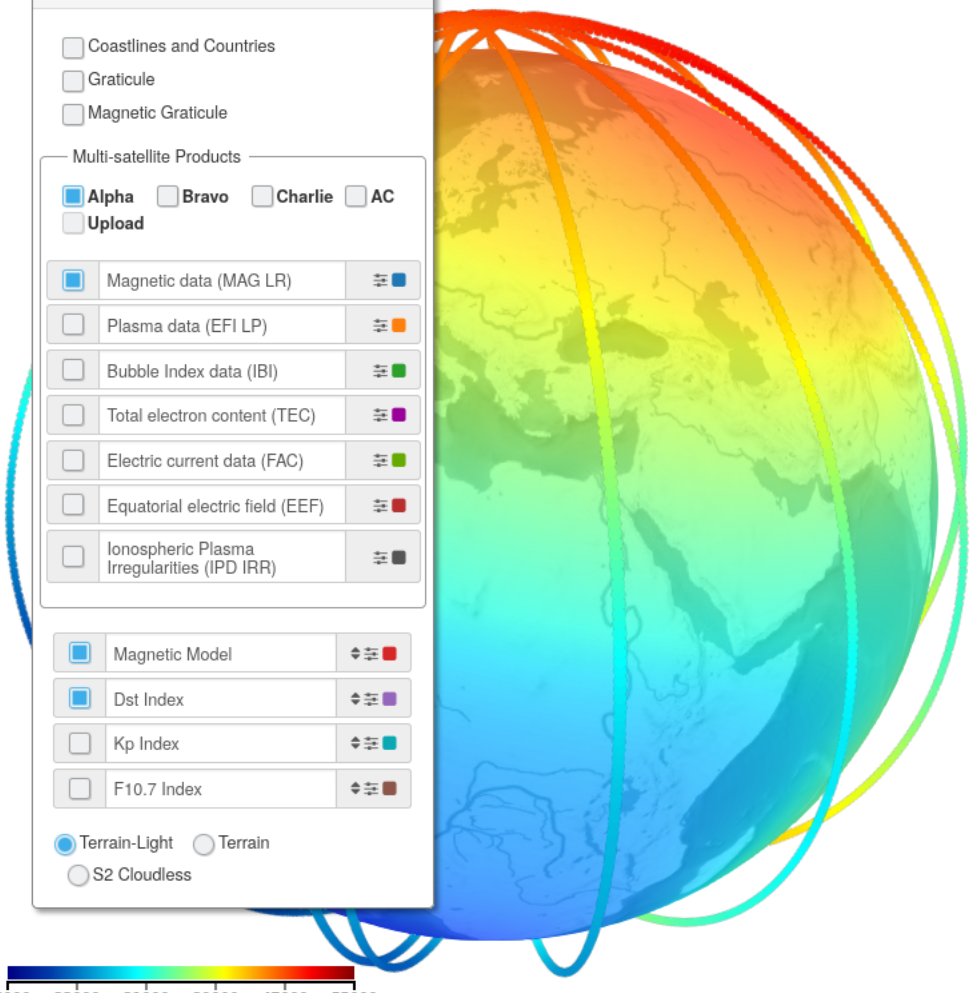
EGU2020-19908

VirES for Swarm – Web GUI

data visualization platform

- on-line data exploration
- data filtering and subset download
- products synchronized to the latest available versions :
  - Swarm measurements (MAG, EFI, IBI, TEC, FAC, EEF, IPD)
  - auxiliary data (Kp, Dst, F10.7, QD lat/lon, MLT, Sun position)
  - magnetic models
    (IGRF13, CHAOS-7, LCS-1, MF7, Swarm L2 SHC, AMPS)

Globe View | Select Area | Save as Image



Layers

- Coastlines and Countries
- Graticule
- Magnetic Graticule

Multi-satellite Products

- Alpha
- Bravo
- Charlie
- AC
- Upload

- Magnetic data (MAG LR)
- Plasma data (EFI LP)
- Bubble Index data (IBI)
- Total electron content (TEC)
- Electric current data (FAC)
- Equatorial electric field (EEF)
- Ionospheric Plasma Irregularities (IPD IRR)

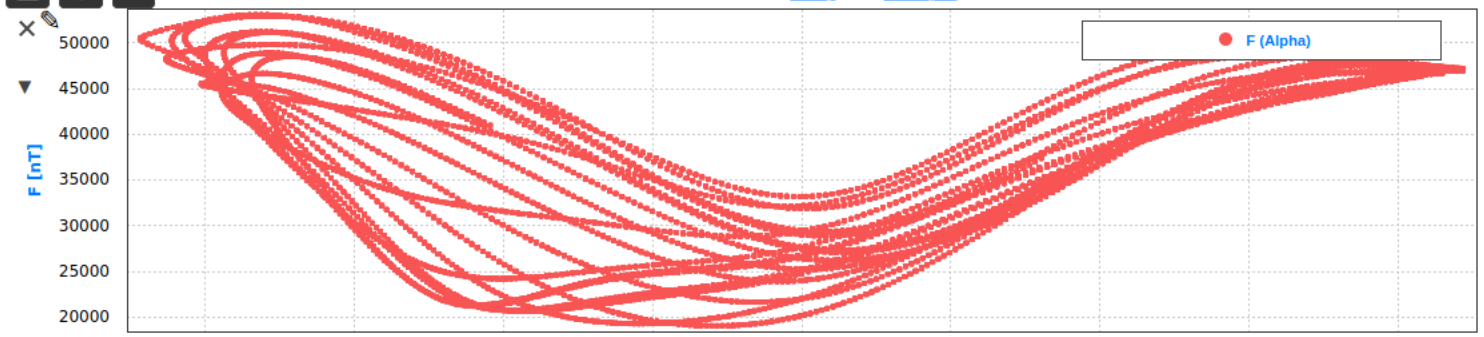
- Magnetic Model
- Dst Index
- Kp Index
- F10.7 Index

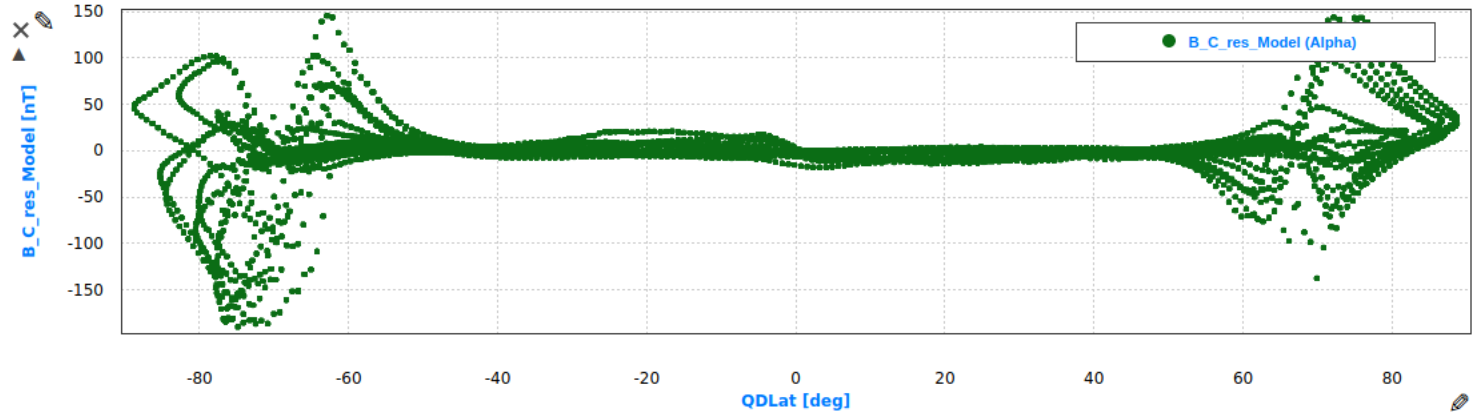
- Terrain-Light
- Terrain
- S2 Cloudless

15000 23000 31000 39000 47000 55000
Model - F [nT]

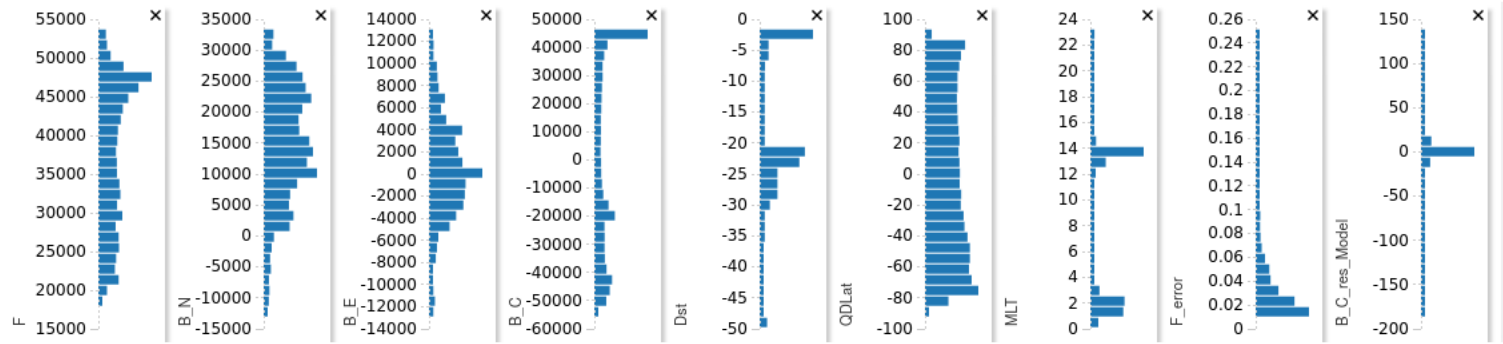
15000 23000 31000 39000 47000 55000
MAGA LR 1B - F [nT]

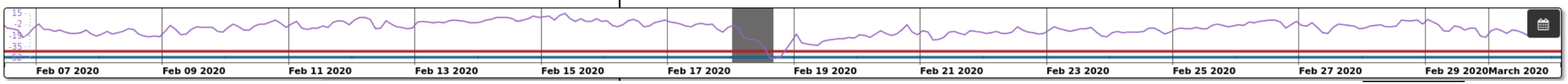
Config | + Add plot





Reset filters | Add filter





VirES for Swarm | Layers | Download | Upload | Views | Tutorials | Workspace | About | demo-user

Globe View | Select Area | Save as Image

Layers

- Coastlines and Countries
- Graticule
- Magnetic Graticule

Multi-satellite Products

Alpha | Bravo | Charlie | AC | Upload

- Magnetic data (MAG LR)
- Plasma data (EFI LP)
- Bubble Index data (IBI)
- Total electron content (TEC)
- Electric current data (FAC)
- Equatorial electric field (EEF)
- Ionospheric Plasma Irregularities (IPD IRR)

- Magnetic Model
- Dst Index
- Kp Index
- F10.7 Index

Terrain-Light | Terrain | S2 Cloudless

100000 120000 140000 160000 180000 200000
EFIA LP 1B - Ne [cm -3]

Config | + Add plot

Ne [cm -3]: 700000, 600000, 500000, 400000, 300000, 200000, 100000, 0
Ne (Alpha)
Add parameter ...

Te [K]: 5000, 4500, 4000, 3500, 3000, 2500, 2000, 1500, 1000, 500, 0
Te (Alpha)
Add parameter ...

03:00 | 06:00 2020-02-18T06:00:00 | 09:00 | 12:00 2020-02-18T12:00:00 | 15:00
Timestamp

Reset filters | Add filter

Dst: 0, -5, -10, -15, -20, -25, -30, -35, -40, -45, -50
QDLat: 100, 80, 60, 40, 20, 0, -20, -40, -60, -80, -100
MLT: 24, 22, 20, 18, 16, 14, 12, 10, 8, 6, 4, 2, 0
Je: 2×10⁵, 1.5×10⁵, 1×10⁵, 50000, 0, -50000, -1×10⁵, -1.5×10⁵
Ne: 8×10⁵, 7×10⁵, 6×10⁵, 5×10⁵, 4×10⁵, 3×10⁵, 2×10⁵, 1×10⁵, 0

EGU2020-19906

(cc) BY

VirES for Swarm | Layers | Download | Upload | Views | Tutorials | Workspace | About | demo-user

Globe View | Select Area | Save as Image

Layers

- Coastlines and Countries
- Graticule
- Magnetic Graticule

Multi-satellite Products

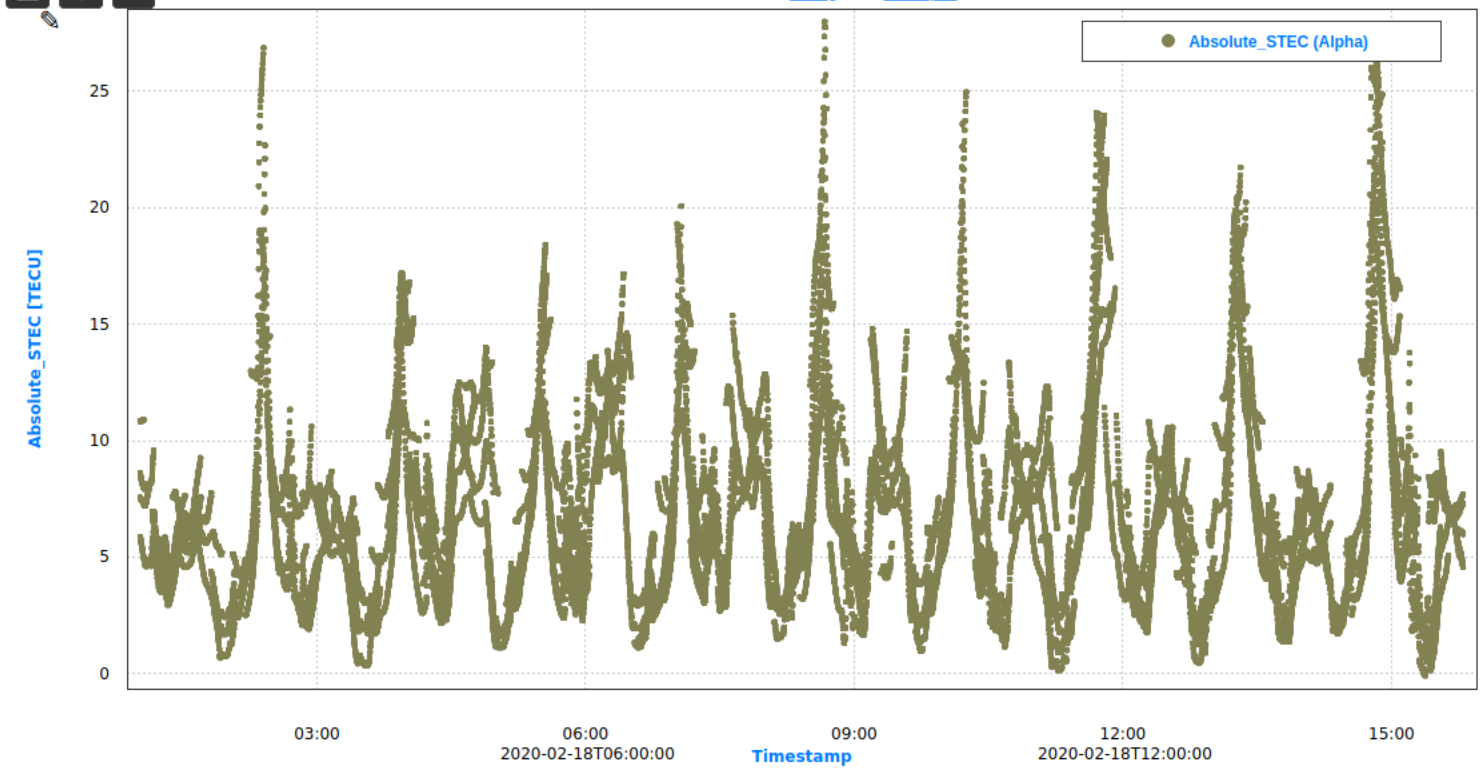
Alpha | Bravo | Charlie | AC | Upload

- Magnetic data (MAG LR)
- Plasma data (EFI LP)
- Bubble Index data (IBI)
- Total electron content (TEC)
- Electric current data (FAC)
- Equatorial electric field (EEF)
- Ionospheric Plasma Irregularities (IPD IRR)

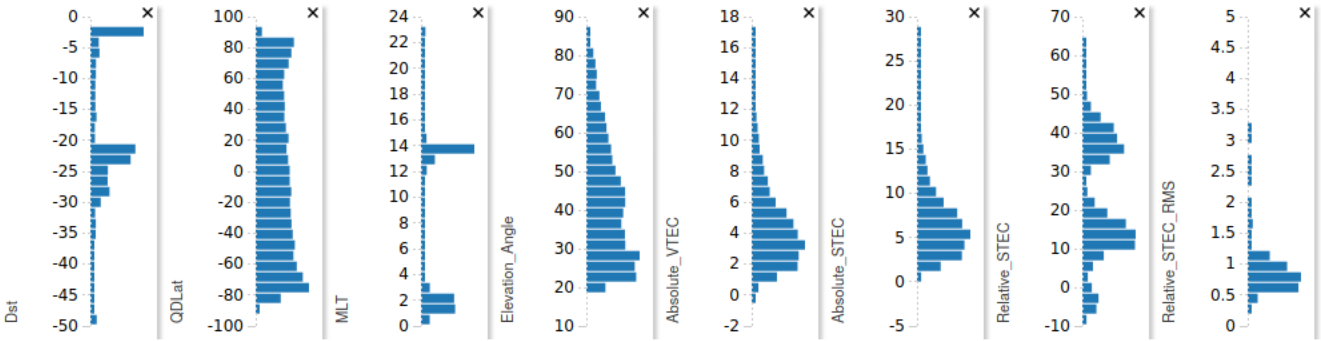
- Magnetic Model
- Dst Index
- Kp Index
- F10.7 Index

Terrain-Light | Terrain | S2 Cloudless

Config | + Add plot



Reset filters | Add filter

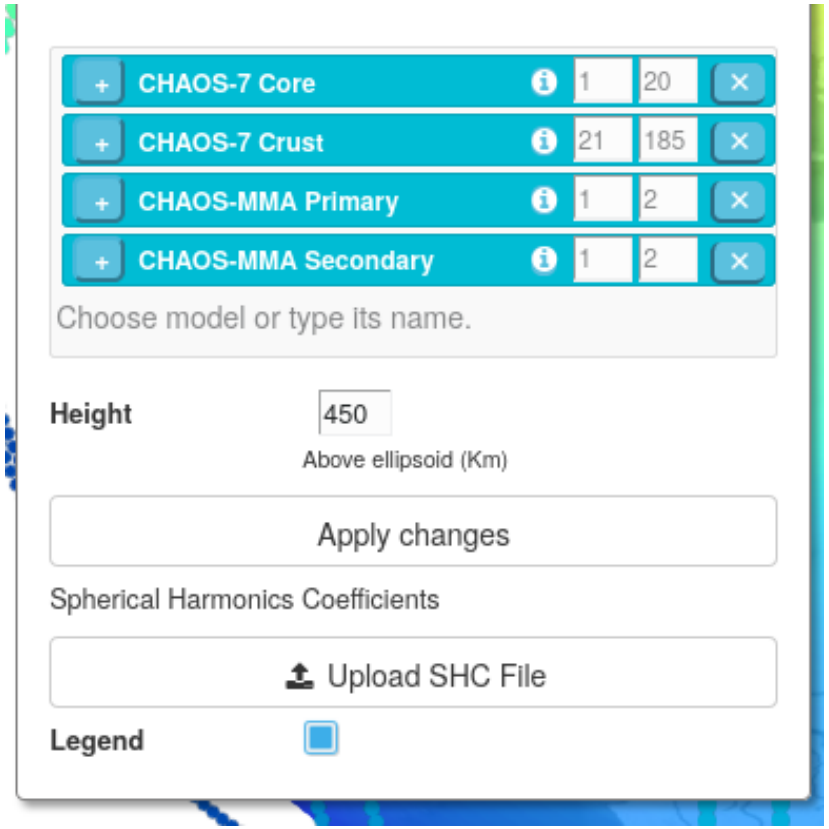



VirES for Swarm
Layers
Download
Upload
Views
Tutorials
Workspace
About
demo-user
Config
+ Add plot
Layers
Coastlines and Countries
Graticule
Magnetic Graticule
Multi-satellite Products
Alpha
Bravo
Charlie
AC
Upload
Magnetic data (MAG LR)
Plasma data (EFI LP)
Bubble Index data (IBI)
Total electron content (TEC)
Electric current data (FAC)
Equatorial electric field (EEF)
Ionospheric Plasma Irregularities (IPD IRR)
Magnetic Model
Dst Index
Kp Index
F10.7 Index
Terrain-Light
Terrain
S2 Cloudless
Ne [cm-3]
Ne (Alpha)
Background_Ne (Alpha)
Foreground_Ne (Alpha)
Te (Alpha)
Te [K]
ROD [cm-3/s]
ROD (Alpha)
RODI10s (Alpha)
RODI20s (Alpha)
delta Ne [cm-3]
delta_Ne10s (Alpha)
delta_Ne20s (Alpha)
delta_Ne40s (Alpha)
grad Ne [cm-3/m]
Grad_Ne_at_20km (Alpha)
Grad_Ne_at_50km (Alpha)
Grad_Ne_at_100km (Alpha)
grad Ne [cm-3/m]
Grad_Ne_at_PCP_edge (Alpha)
PCP_flag (Alpha)
PCP flag
IPIR index
IPIR_index (Alpha)
Add parameter ...
03:50
03:51
2016-01-01T03:51:00
03:52
03:53
03:54
03:55
03:56
03:57
03:58
03:59
2016-01-01T03:59:00
04:00
Timestamp
Reset filters
Add filter
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00

VirES for Swarm – Data Upload

- **Upload of custom data (time-series) is possible (e.g., ground measurements)**
- **Supported formats: CDF and CSV**
- **On-line format specification:**
  https://vires.services/accounts/custom_data_format_description/

VirES for Swarm – Composed Models



- Multiple SH models can be combined
- Model degree ranges can be constrained
- A custom model can be uploaded and combined with other models.
- The new model can be displayed on the globe and MAG residuals are calculated.

Globe View | Select Area | Save as Image

Magnetic Model Settings

Parameter: Total field intensity

Style: jet

15000 23000 31000 39000 47000 55000

nT

15000 — 55000

Opacity

- CHAOS-7 Core (1 – 20)
- CHAOS-7 Crust (21 – 185)
- CHAOS-MMA Primary (1 – 2)
- CHAOS-MMA Secondary (1 – 2)

Choose model or type its name.

Height: 450

Above ellipsoid (Km)

Apply changes

Spherical Harmonics Coefficients

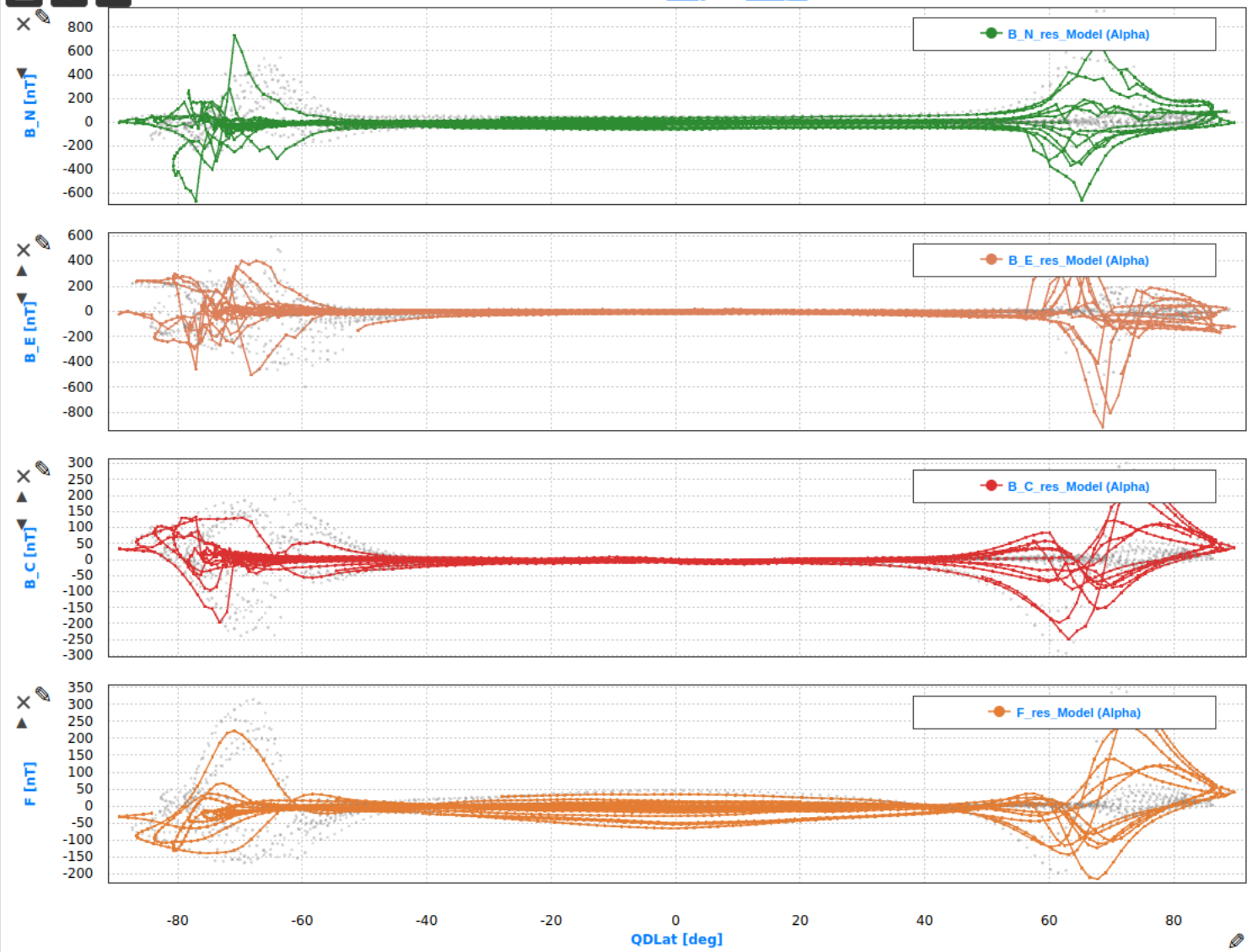
Upload SHC File

Legend

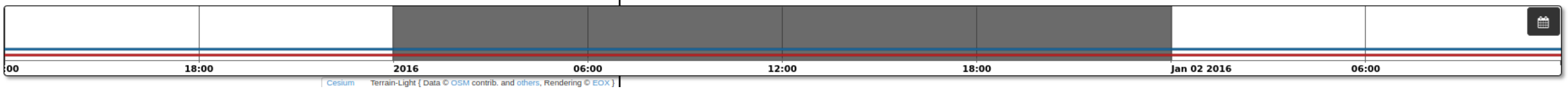
15000 23000 31000 39000 47000 55000
Model - F [nT]

15000 23000 31000 39000 47000 55000
MAGA LR 1B - F [nT]

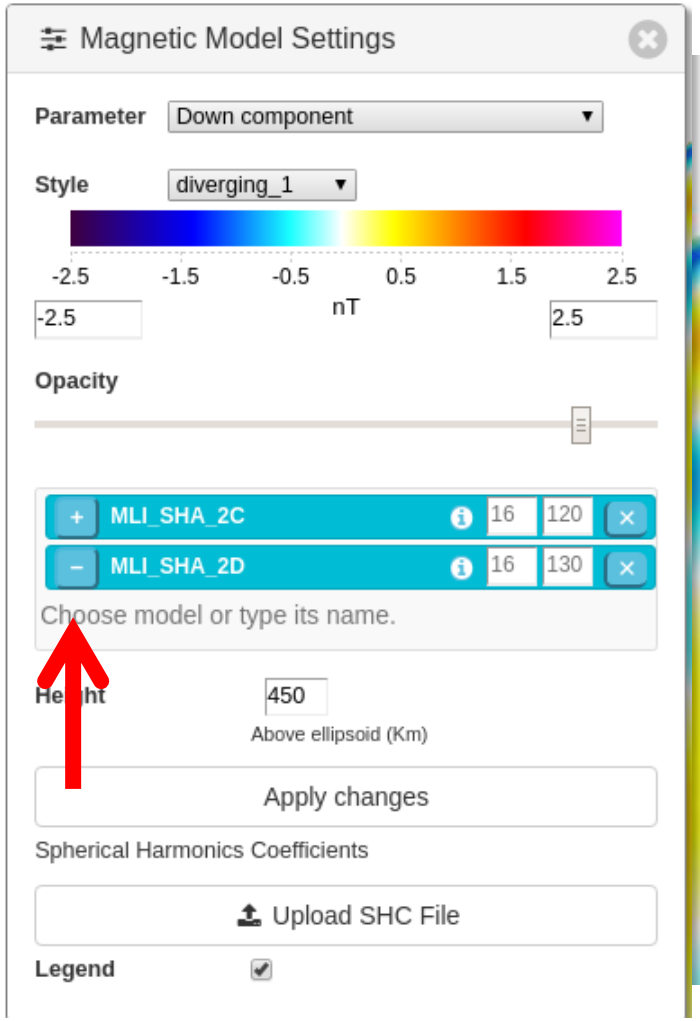
Config | + Add plot

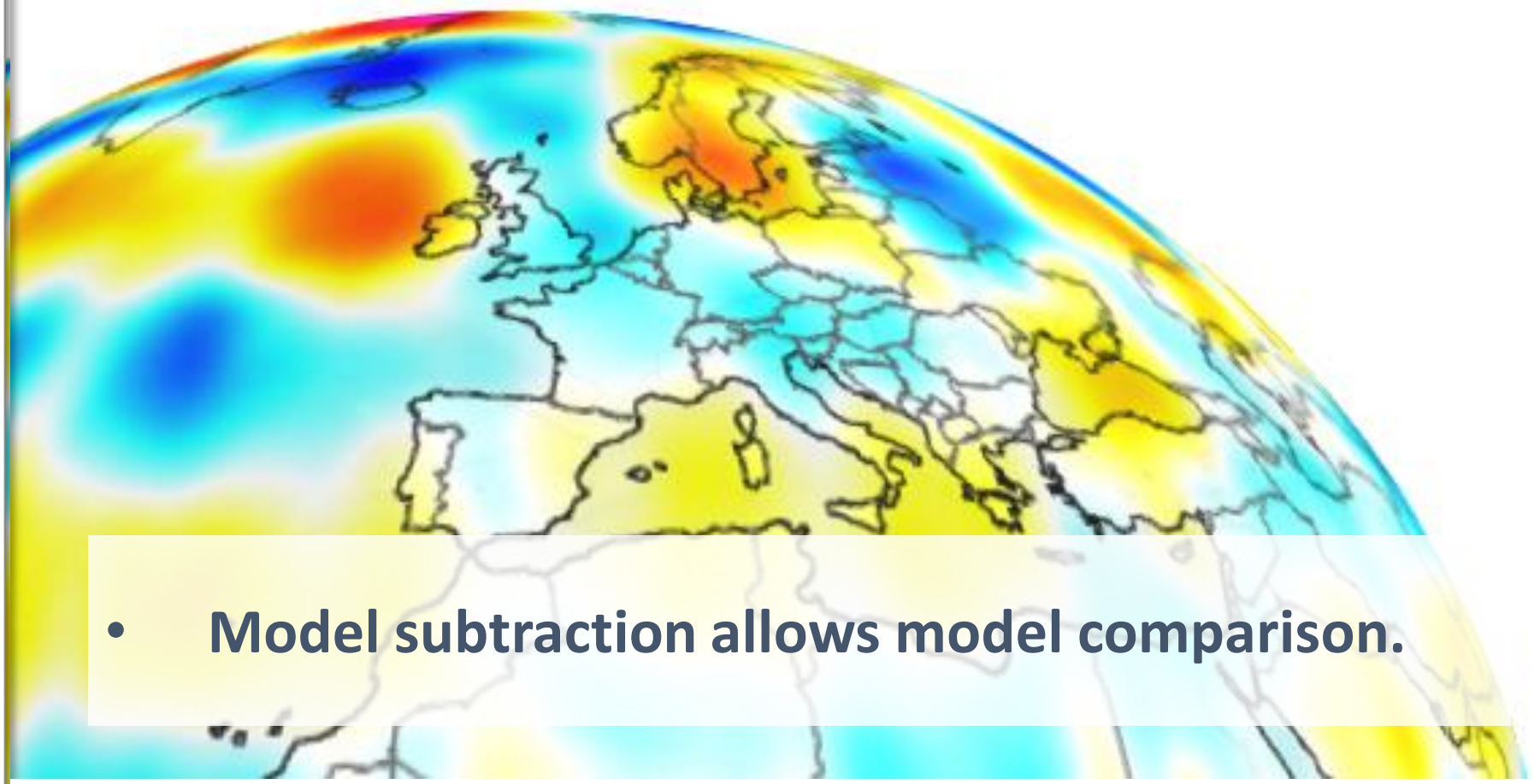


Reset filters | Add filter



VirES for Swarm – Composed Models

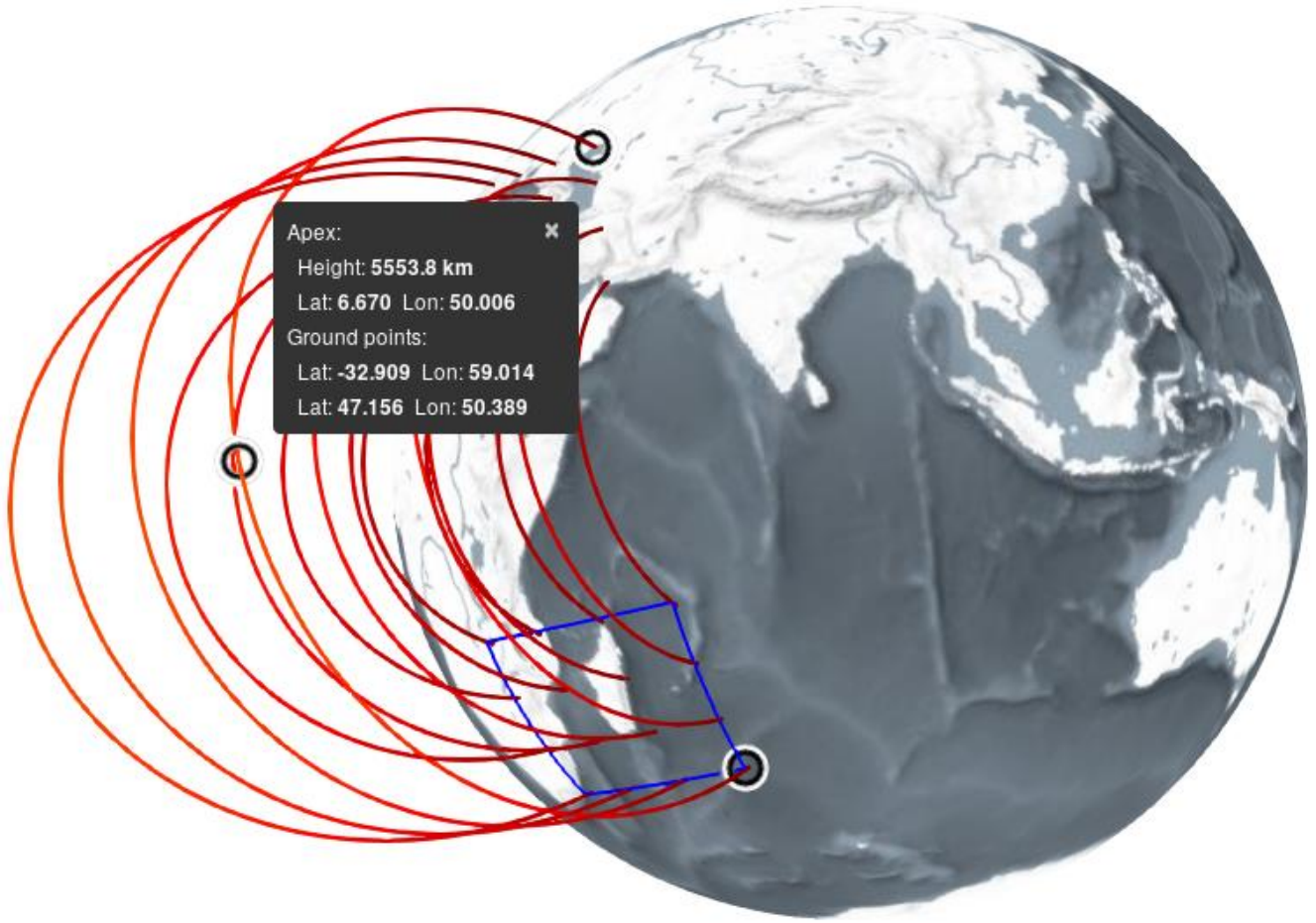




- **Model subtraction allows model comparison.**

VirES for Swarm – Model Fieldlines

- **The Apex and ground points are displayed when a field line is clicked**



Explore VirES for Swarm at:

https://vires.services

VirES for Swarm – Server API

Swam data accessible via the server API (Python client)

- retrieval the time series of the Swarm data
  (e.g., measurements and quality flags)
- easy temporal and spatial subsetting
- filtering by parameter values.
- evaluation of magnetic models along the Swarm orbit
- all Swarm products and models offered by VirES web GUI

  + MAGx_HR_1B (not available via web GUI)

VirES Python Client

Access to the VirES API.

Retrieves data as pandas/xarray

https://viresclient.readthedocs.io

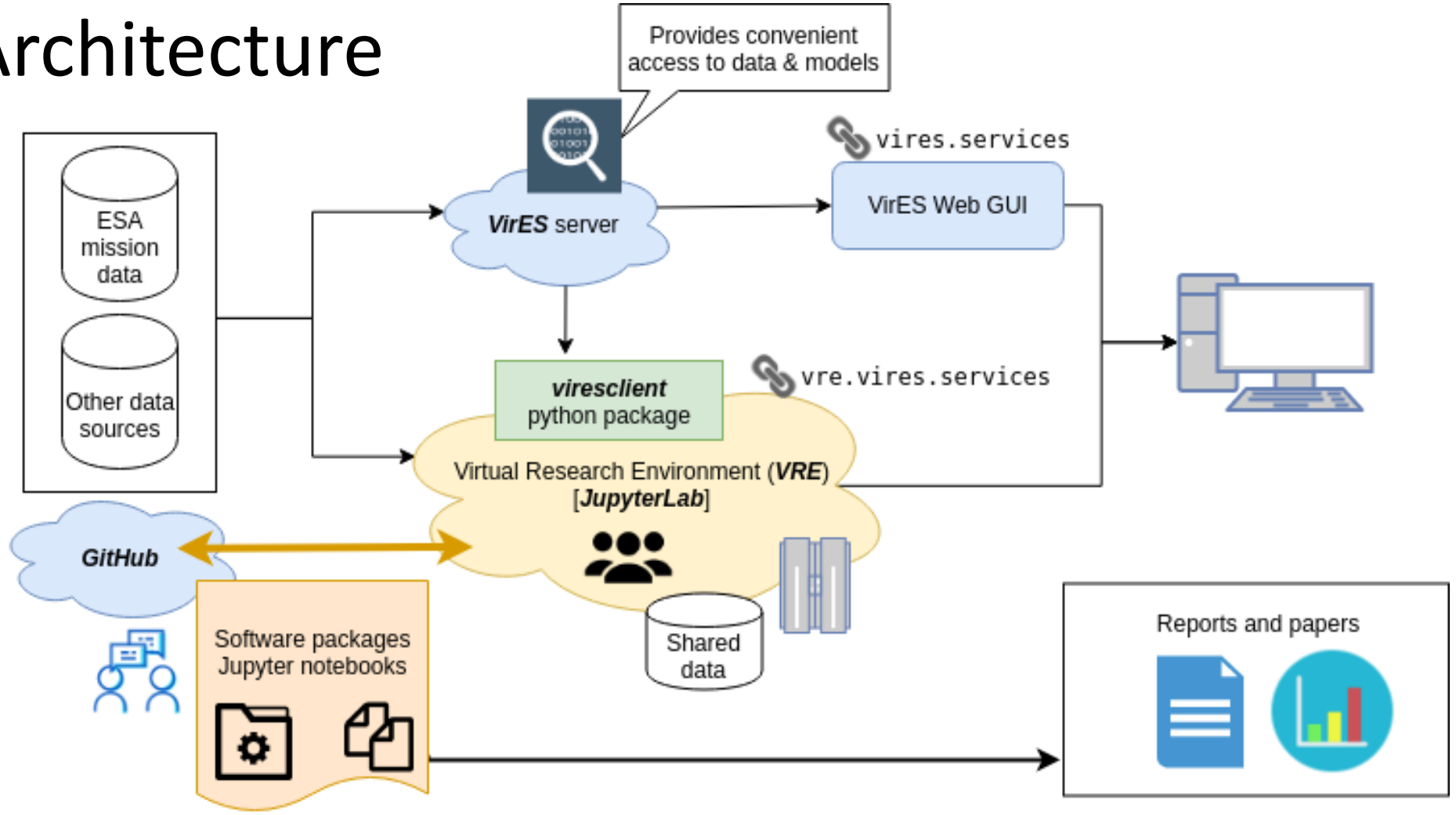
```
from viresclient import SwarmRequest

request = SwarmRequest()
request.set_collection("SW_OPER_MAGA_LR_1B")
request.set_products(
    measurements=["B_NEC"],
    models=["CHAOS-Core"],
    residuals=True,
    auxiliaries=["MLT", "QDLat", "SunZenithAngle"])
data = request.get_between("2019-01-01", "2019-01-02")
ds = data.as_xarray()
ds
```

```
[1/1] Processing:  100%|██████████|  [ Elapsed: 00:05, Remaining: 00:00 ]
      Downloading: 100%|██████████|  [ Elapsed: 00:00, Remaining: 00:00 ] (7.004MB)
<xarray.Dataset>
Dimensions:                (NEC: 3, Timestamp: 86400)
Coordinates:
  * Timestamp              (Timestamp) datetime64[ns] 2019-01-01 ... 2019-01-01T23:59:59
  * NEC                    (NEC) <U1 'N' 'E' 'C'
Data variables:
    Spacecraft             (Timestamp) object 'A' 'A' 'A' 'A' ... 'A' 'A' 'A' 'A'
    MLT                    (Timestamp) float64 14.82 14.82 14.82 ... 2.445 2.445
    Radius                 (Timestamp) float64 6.819e+06 6.819e+06 ... 6.809e+06
    QDLat                  (Timestamp) float64 -13.94 -13.88 ... 39.74 39.67
    SunZenithAngle         (Timestamp) float64 40.87 40.89 40.91 ... 141.1 141.2
    B_NEC_res_CHAOS-Core   (Timestamp, NEC) float64 -13.44 -18.83 ... 4.656 7.37
    Latitude               (Timestamp) float64 -17.03 -16.97 -16.9 ... 44.0 43.93
    Longitude              (Timestamp) float64 -136.0 -136.0 ... 40.88 40.88
Attributes:
    Sources:          ['SW_OPER_MAGA_LR_1B_20190101T000000_20190101T235959_050...
    MagneticModels:   ["CHAOS-Core = 'CHAOS-Core'(max_degree=20,min_degree=1)"]
    RangeFilters:     []
```

Swarm Virtual Research Environment (VRE)

EGU2020-19908

VRE Architecture



File Edit View Run Kernel Tabs Settings Help VirES-VRE

Log Out light

/ Swarm_notebooks /

Name	Last Modified
00a1_Quicklooks-L1b.ip…	2 hours ago
00b1_Outreach-Report.I…	an hour ago
01a__Intro-Jupyter-Pyth…	a month ago
01b1_Pandas-and-Plots.…	a month ago
02a__Intro-Swarm-viresc…	a month ago
02b__viresclient-Availabl…	a month ago
02c__viresclient-API.ipynb	a month ago
02d__viresclient-Large-D…	a month ago
02z1__Template-Basic.ip…	a month ago
03a1_Demo-MAGx_LR_…	a month ago
03a2_Demo-MAGx_HR_…	a month ago
03b__Demo-EFIx_LP_1…	a month ago
03c__Demo-IPDxIRR_2…	a month ago
03d__Demo-TECxTMS_…	a month ago
03e1_Demo-FACxTMS_…	a month ago
03e2_Demo-FAC_TMS_…	a month ago
03f__Demo-EEFxTMS_2…	a month ago
03g__Demo-IBIxTMS_2…	a month ago
04a1_Geomag-Models-V…	a month ago
04b1_Geomag-Models-e…	a month ago
05a1_Polar-Region-Plots…	a month ago
LCS-1.shc	2 months ago
LICENSE	2 months ago
notebooks.json	a month ago
README.md	a month ago
src.py	an hour ago
test_file.cdf	2 months ago

README.m | 02a__Intro- | 03a1_Demo | Untitled.ipyr | 00b1_Outre | Launcher | 04b1_Geom | 05a1_Polar- | src.py

Notebook

Python 3 | VirES template | Octave | py37

Other

Python 3 | Terminal | Text File | Markdown File | Show Contextual Help

Introduction

Intro to Jupyter & Python | Pandas: plot stats, errors... | Intro to Swarm viresclient | Available data & models | viresclient API document | Working with large data

Swarm Product Demos

MAGx_LR_1B: 1Hz Magnetic | MAGx_HR_1B: 50Hz Magnetic | EFIx_LP_1B: 2Hz Langmuir | IPDxIRR_2F: 1Hz Plasma data | TECxTMS_2F: Total e-count | FACxTMS_2F: (Single-sat) FAC | FAC_TMS_2F: (Dual) + 2D-plot

0 12

Launcher

Explore Swarm VRE at:

https://vre.vires.services

Live Demo

For a live Swarm VRE demo between 4th – 8th May 2020 drop by

https://meet.google.com/kkw-nqqs-wep

or email to ashley.smith@ed.ac.uk

Additional links:

- Main GitHub repos:
  - VRE user documentation github.com/ESA-VirES/Swarm-VRE
  - Swarm example notebooks github.com/Swarm-DISC/Swarm_notebooks
  - viresclient github.com/ESA-VirES/VirES-Python-Client
  - VirES Server github.com/ESA-VirES/VirES-Server
  - VirES Web GUI github.com/ESA-VirES/WebClient-Framework
  - eoxmagmod library github.com/ESA-VirES/MagneticModel
- Planned dedicated webinars: https://swarm-vre.readthedocs.io/en/latest/help.html
- See also: magneticearth.org