RadLab: A Comprehensive Database and Graphical and Programming Interfaces for Space Radiation Data

Biological and Physical Sciences

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NASA Transform to Open Science (TOPS)

"Closed science, hoarding information and resources, silos of knowledge holds science back by limiting who can participate. We need more voices that work together and share knowledge and resources. [...]

NASA's Transform to Open Science (TOPS) initiative will allow us to create a scientific culture that is ready for 21st century challenges.

Open Science will broaden participation, increase accessibility to knowledge, and embrace new technologies that can respond to these changes at scale."

science.nasa.gov/open-science/
nasa.github.io/Transform-to-Open-Science/about/

NASA Open Science Data Repository

Open Science Projects

Open Science Projects primary goals aim to increase collaborative scientific data sharing, analysis and more rapid scientific advancement.

GeneLab

GeneLab, an open science multi-omics repository, covering transcriptomics, metagenomics, epigenomics, proteomics, and metabolomics. Studies comprise of data from model organisms including microbes, plants, fruit flies, rodents and humans.

Learn more GeneLab

BSP

The NASA Space Biology Biospecimen Sharing Program (BSP) collects biospecimens to maximize the scientific return from biological spaceflight and associated ground investigations and to encourage and broaden participation from the scientific community in space biology-related research.

Learn more about BSP

ALSDA

Ames Life Sciences Data Archive (ALSDA) collects, curates, and makes available space-relevant higher-order phenotypic datasets. Datasets that enable scientists to perform retrospective analysis across missions, experiments, life science disciplines, research subjects, and species.

Learn more about ALSDA

NBISC

NASA Biological Institutional Scientific Collection (NBISC) is a biorepository of non-human samples collected from NASA-funded spaceflight investigations and correlative ground studies. The purpose of NBISC is to receive, store, document, preserve, and make the collection available to the scientific community.

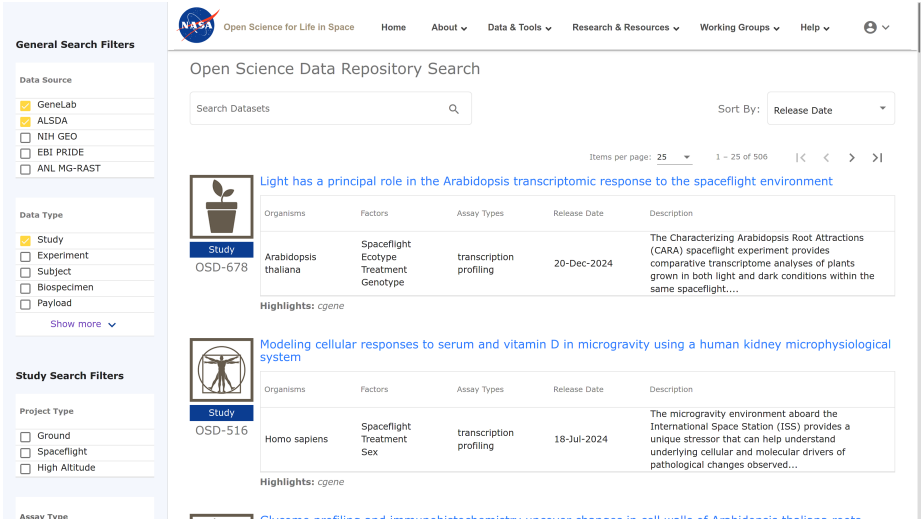
Learn more about NBISC

FAIR Guiding Principles

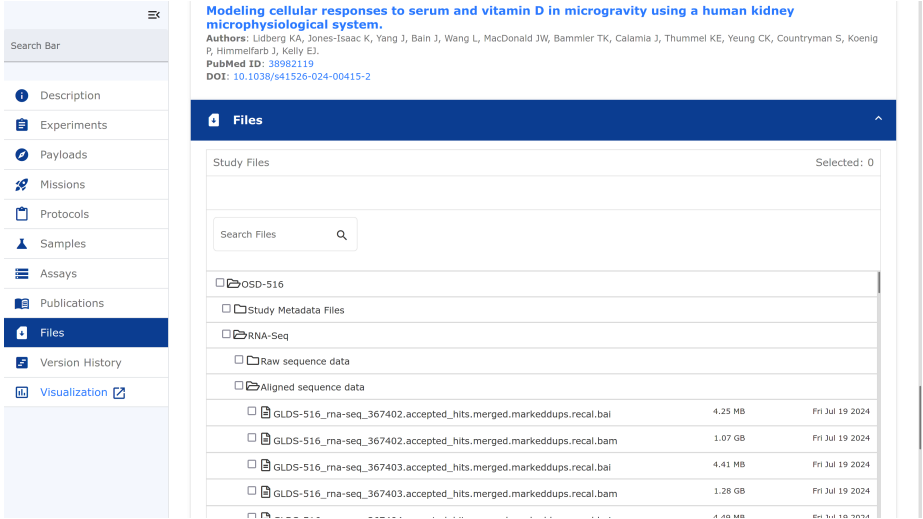
"[...] all research objects should be
Findable, Accessible, Interoperable and Reusable (FAIR)
both for machines and for people."

Wilkinson, M., Dumontier, M., Aalbersberg, I. *et al*.
"The FAIR Guiding Principles for scientific data management and stewardship" (2016)
doi.org/10.1038/sdata.2016.18

OSDR: GeneLab and ALSDA



OSDR: GeneLab and ALSDA



OSDR: GLOpenAPI

Generated URL:

```
https://visualization.genelab.nasa.gov/GLOpenAPI/samples/?id=
OSD-37|OSD-48&file.datatype=unnormalized%20counts&format=csv
```

Retrieval of entries with metadata field values

Follow generated URL

The search can be constrained to only the samples that are annotated with specific **value(s)** of an ISA field.

- The logical AND of several conditions is achieved by passing them at the same time (`x=a&y=b`).
- The logical OR for a *single* condition is achieved by passing the target values joined by a vertical pipe (`x=a|b`).
- Under view levels "assays" and "samples", the values of target field(s) will be reported in table columns.

Example: `/samples/?study.characteristics.genotype=WT`
Example: `/samples/?study.characteristics.genotype=WT|TK6`

Retrieval of files or data

- ☐ & `file.filename=` `/.*/`
- ☐ & `file.datatype`
- ☑ & `file.datatype=` `unnormalized c...` *OR*

For the resultant queried datasets, assays, and samples, there may be files associated.

- All files with recognized datatypes can be queried by passing `file.datatype`.
- The query can be constrained to files of particular datatypes by specifying these datatypes in the query (`file.datatype=pca`).

OSDR: GLOpenAPI

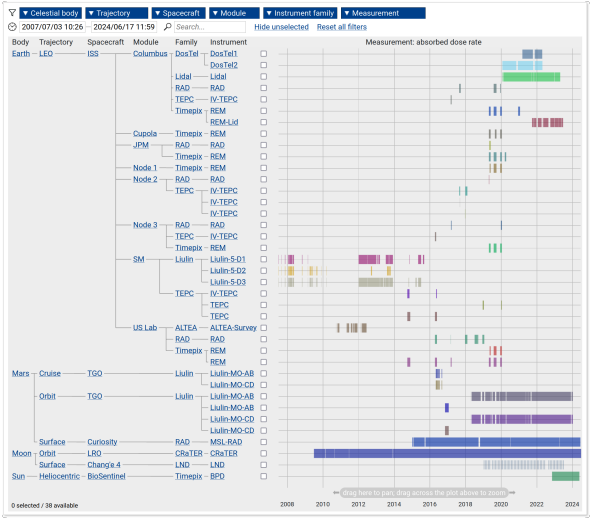
Navigate: (Shift-)click headers to sort. Hover to highlight equal values. Toggle crosshairs.
Download: as csv, tsv, json, gct. Switch view level: assays, samples, data.

*	GLDS-21 gse65943_transcription_profiling_RNA_Sequencing_(RNA-Seq)				GLDS-127 e-geod-84582_transcription_pr
index	Hsap_TK6cells_LCL_1G_Rep1	Hsap_TK6cells_LCL_1G_Rep2	Hsap_TK6cells_LCL_suG_Rep1	Hsap_TK6cells_LCL_suG_Rep2	Hsap_IMR90iPSCs_CPCs_1G_F
ENSG00000000003	0	0	0	0	2626
ENSG00000000005	0	0	0	0	1
ENSG00000000419	8626	8795	7877	10306	543
ENSG00000000457	949	972	1041	1095	358.29
ENSG00000000460	1519	1583	1387	1620	327.71
ENSG00000000938	2048	1881	1675	1745	0
ENSG00000000971	2	3	1	0	0
ENSG00000001036	1250	1315	1239	1534	577.56
ENSG00000001084	961	988	1046	1194	348.96
ENSG00000001167	3102	3102	2909	3149	1342
ENSG00000001460	2	2	4	1	204
ENSG00000001461	141	131	143	121	492
ENSG00000001497	6047	6088	5433	6249	1058
ENSG00000001561	749	848	843	859	95
ENSG00000001617	1	1	1	0	764
ENSG00000001626	0	2	3	0	380
ENSG00000001629	2523	2755	2639	2638	1116.84
ENSG00000001630	7438.87	8272.86	8505.75	9655.86	833.4
ENSG00000001631	2124.14	2269.97	2063.21	2337.41	687.57
ENSG00000002016	863	932	944	846.09	355.05
ENSG00000002079	1	6	4	2	2
ENSG00000002330	325	356	296	419	426.27
ENSG00000002549	2830	3108	2554	3022	679
ENSG00000002586	2451	2523	2227	2349	4079
ENSG00000002587	0	1	0	1	179
ENSG00000002726	35	43	37	34	2

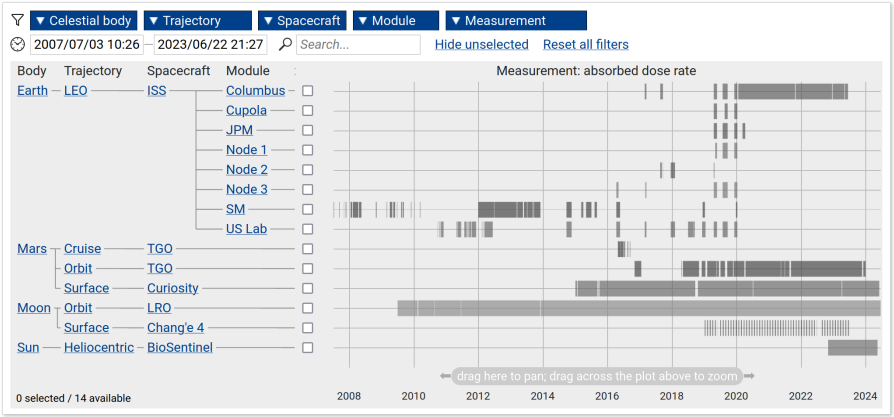
OSDR: Impact

- Analysis Working Groups (AWGs)
- GeneLab-derived publications
- Educational initiatives (GL4U, GL4HS)

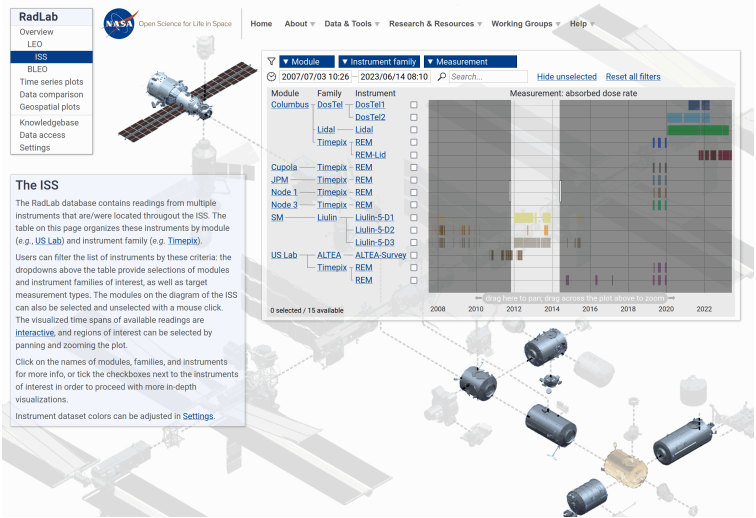
RadLab: Current State



RadLab: Current State

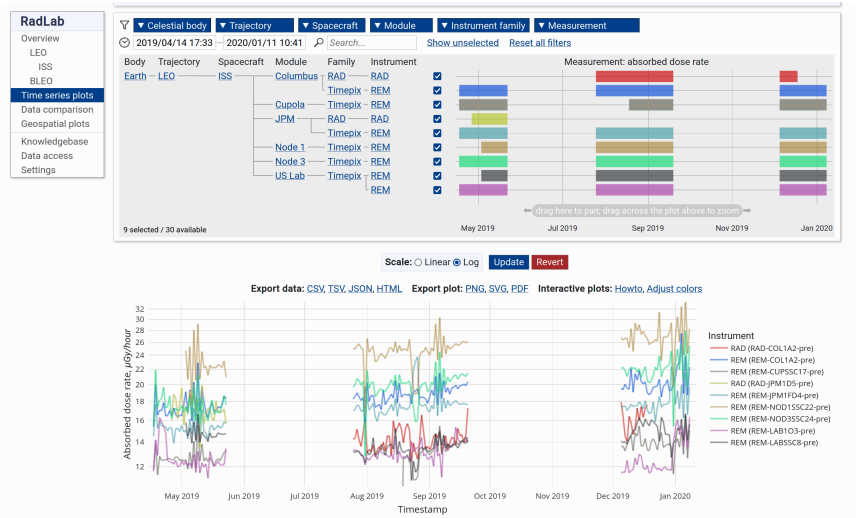


RadLab: GUI (Bells and Whistles)

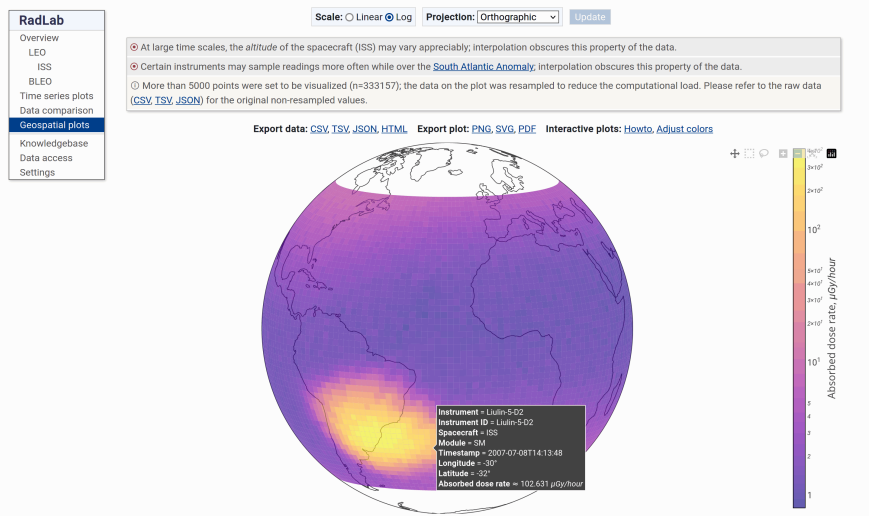


RadLab: GUI (Time Series Plots)

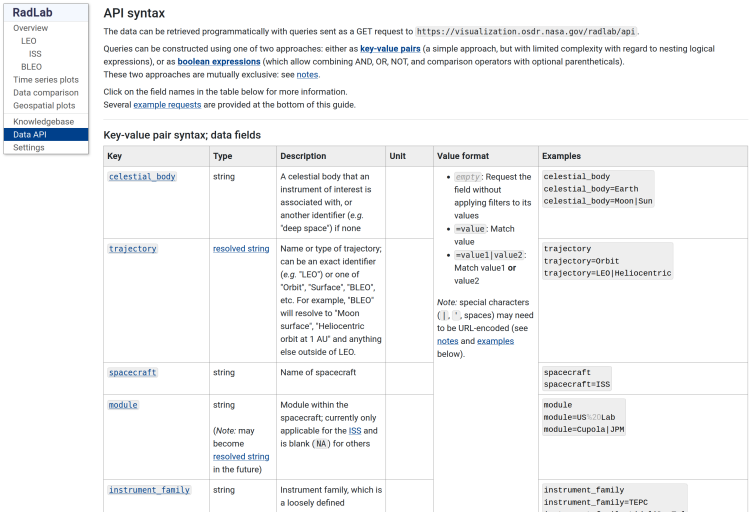
RadLab: GUI (Time Series Plots)



RadLab: GUI (Geospatial Plots)



RadLab: API



RadLab
- Overview
- LEO
  - ISS
  - BLEO
- Time series plots
- Data comparison
- Geospatial plots
- Knowledgebase
- Data API
- Settings

API syntax

The data can be retrieved programmatically with queries sent as a GET request to `https://visualization.osdr.nasa.gov/radlab/api`.

Queries can be constructed using one of two approaches: either as **key-value pairs** (a simple approach, but with limited complexity with regard to nesting logical expressions), or as **boolean expressions** (which allow combining AND, OR, NOT, and comparison operators with optional parentheticals).
These two approaches are mutually exclusive: see notes.

Click on the field names in the table below for more information.
Several example requests are provided at the bottom of this guide.

Key-value pair syntax; data fields

Key	Type	Description	Unit	Value format	Examples

`celestial_body`	string	A celestial body that an instrument of interest is associated with, or another identifier (*e.g.* "deep space") if none		• `empty`: Request the field without applying filters to its values
				• `=value`: Match value
				• `=value1|value2`: Match value1 **or** value2
				
				Note: special characters (`|`, `%`, spaces) may need to be URL-encoded (see notes and examples below).
					`celestial_body`
					`celestial_body=Earth`
					`celestial_body=Moon|Sun`

`trajectory`	resolved string	Name or type of trajectory; can be an exact identifier (*e.g.* "LEO") or one of "Orbit", "Surface", "BLEO", etc. For example, "BLEO" will resolve to "Moon surface", "Heliocentric orbit at 1 AU" and anything else outside of LEO.			`trajectory`
					`trajectory=Orbit`
					`trajectory=LEO|Heliocentric`

`spacecraft`	string	Name of spacecraft			`spacecraft` `spacecraft=ISS`

`module`	string
	
	(*Note:* may become resolved string in the future)
		Module within the spacecraft; currently only applicable for the ISS and is blank (`NA`) for others			`module`
					`module=US%20Lab`
					`module=Cupola|JPM`

`instrument_family`	string	Instrument family, which is a loosely defined			`instrument_family` `instrument_family=TEPC`

RadLab: API

`instrument_id`	string	**Note: case-sensitive**. A specific ID of an instrument, detector, or configuration; this is guaranteed to be unique in the database. *E.g.*: REM-Lid, the REM instrument affixed to the lid of Lidal and included in the DORELI project; or Liulin-5-D2, the second detector of the Liulin-5 instrument. **Note:** is always returned, even when not explicitly requested. The ID can be used to look up the specifics of the instrument and the dataset in the knowledgebase.			`instrument_id`
					`instrument_id=ALTEA-Survey`
					`instrument_id=DosTel1|DosTel2`

`timestamp`	ISO-formatted string (or Unix timestamp)	Timestamp of recorded value(s). **Note: case-sensitive** if passed as an ISO-formatted string.		• `empty`: Request the field without applying filters to its values
				• `<value`: Match any less than value
				• `<=value`: Match any less or equal to value
				• `=value`: Match value
				• `>=value`: Match any greater or equal to value
				• `>value`: Match any greater than value
				Note: can be used more than once in a single query
					`timestamp`
					`timestamp=2021-01-01T15:25`
					`timestamp>=2022-01-01&timestamp<2023-01-01`
					`timestamp>1683786900`

`absorbed_dose_rate`	number	Absorbed radiation dose rate	µGy/hour		`absorbed_dose_rate` `absorbed_dose_rate>=2`
`dose_equivalent_rate`	number	Dose equivalent rate	µSv/hour		`dose_equivalent_rate` `dose_equivalent_rate<=20`
`flux`	number	Particle flux	$cm^{-2}sr^{-1}s^{-1}$		`flux` `flux<1`
`latitude`	number	Latitude of a spacecraft at given timestamp, where available. This and the values below are currently only tracked for the ISS and are blank (`NA`) for others.	deg		`latitude` `latitude<-10`

RadLab: API

Examples

- **Key-value pair syntax**
  - Dose rate and flux readings from DosTel-type instruments on the ISS between 11 PM on 01 Apr 2022, inclusive, and 1:05 AM on 02 Apr 2022, non-inclusive, only where the dose rate is above 2 μGy/hour, together with the spatial and magnetic coordinates of the ISS, formatted as HTML:
    - Conceptually:

```
https://visualization.osdr.nasa.gov/radlab/api/
?spacecraft=ISS
&instrument=DosTel
&timestamp>=2022-04-01T23:00
&timestamp<2022-04-02T01:05
&absorbed_dose_rate>2
&flux
&latitude
&longitude
&altitude
&b
&l
&format=html
```

    - URL-encoded *(may not be necessary)*:

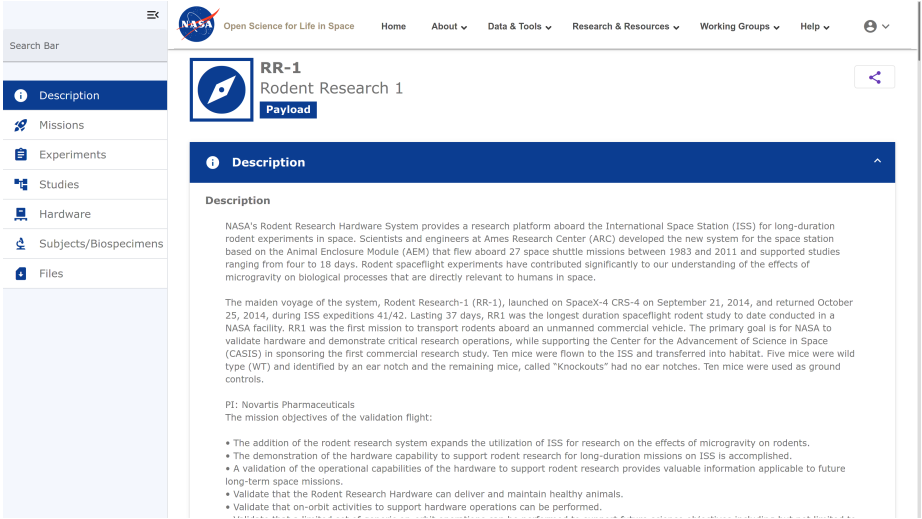
```
https://visualization.osdr.nasa.gov/radlab/api/
?spacecraft=ISS
&instrument=DosTel
&timestamp%3E=2022-04-01T23%3A00
&timestamp%3C2022-04-02T01%3A05
&absorbed_dose_rate%3E2
&flux
&latitude
&longitude
&altitude
&b
&l
&format=html
```

    - Full URL: https://visualization.osdr.nasa.gov/radlab/api/?spacecraft=ISS&instrument=DosTel&timestamp%3E=2022-04-01T23%3A00&timestamp%3C2022-04-02T01%3A05&absorbed_dose_rate%3E2&flux&latitude&longitude&altitude&b&l&format=html
    - Full URL without encoding (should work in most browsers, Python, ...): https://visualization.osdr.nasa.gov/radlab/api/?spacecraft=ISS&instrument=DosTel&timestamp>=2022-04-01T23:00&timestamp<2022-04-02T01:05&absorbed_dose_rate>2&flux&latitude&longitude&altitude&b&l&format=html
- **Boolean expression syntax**
  - Dose rate readings from all detectors in either the Cupola or JPM modules, between 5 Dec 2019 inclusive and 25 Dec 2019, non-inclusive; also retrieve the value of 'instrument_family' for each reading and format the output as TSV:

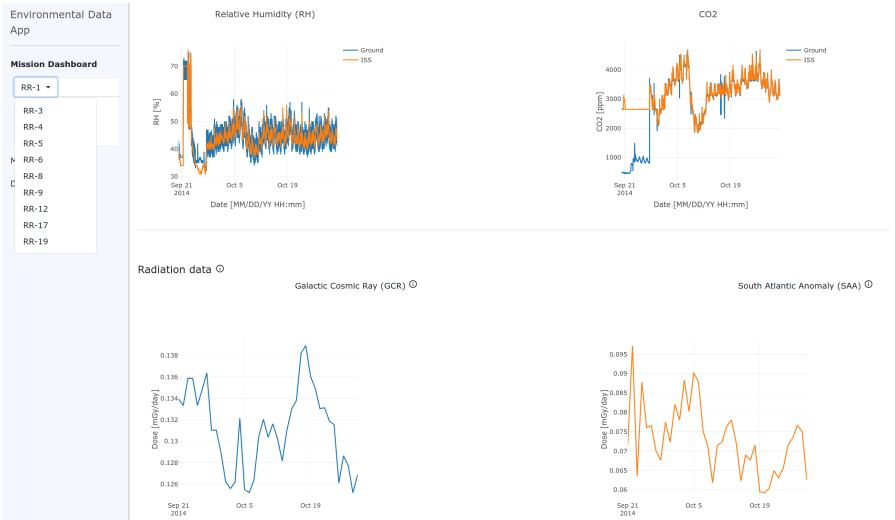
RadLab: API

timestamp	instrument_id	absorbed_dose_rate	altitude	b	flux	l	latitude	longitude	module	spacecraft
2022-04-01T00:00:00	REM-Lid	0.9107814	416.851987	32511.1	0.0731268…	1.09344	-8.324694	162.94325	Columbus	ISS
2022-04-01T00:00:00	DosTel2	2.368557	416.851987	32511.1	0.1394459…	1.09344	-8.324694	162.94325	Columbus	ISS
2022-04-01T00:00:00	DosTel1	1.99686266666667	416.851987	32511.1	0.1160901…	1.09344	-8.324694	162.94325	Columbus	ISS
2022-04-01T00:00:00	Lidal	2.2391858088147	416.851987	32511.1	0.0982921…	1.09344	-8.324694	162.94325	Columbus	ISS
2022-04-01T00:05:00	REM-Lid	2.0818824	415.176415	27547.8	0.1663191…	1.02651	6.951546	173.790418	Columbus	ISS
2022-04-01T00:05:00	DosTel2	2.08211030188679	415.176415	27547.8	0.1343182…	1.02651	6.951546	173.790418	Columbus	ISS
2022-04-01T00:05:00	DosTel1	1.87163492307692	415.176415	27547.8	0.1053458…	1.02651	6.951546	173.790418	Columbus	ISS
2022-04-01T00:05:00	Lidal	2.0517677736311	415.176415	27547.8	0.0981521…	1.02651	6.951546	173.790418	Columbus	ISS
2022-04-01T00:10:00	REM-Lid	2.291432	416.22943	28879	0.1320885…	1.15888	21.89461	-174.5494…	Columbus	ISS
2022-04-01T00:10:00	DosTel2	2.46097266666667	416.22943	28879	0.1473333…	1.15888	21.89461	-174.5494…	Columbus	ISS
2022-04-01T00:10:00	DosTel1	2.18748766666667	416.22943	28879	0.1266577…	1.15888	21.89461	-174.5494…	Columbus	ISS
2022-04-01T00:10:00	Lidal	2.42490397146081	416.22943	28879	0.1122379…	1.15888	21.89461	-174.5494…	Columbus	ISS
2022-04-01T00:15:00	REM-Lid	3.86292	419.150222	34088	0.2971092…	1.52678	35.576278	-160.0008…	Columbus	ISS
2022-04-01T00:15:00	DosTel2	3.78154447435897	419.150222	34088	0.2223902…	1.52678	35.576278	-160.0008…	Columbus	ISS
2022-04-01T00:15:00	DosTel1	4.11190379487179	419.150222	34088	0.2051074…	1.52678	35.576278	-160.0008…	Columbus	ISS
2022-04-01T00:15:00	Lidal	3.94472706410343	419.150222	34088	0.1846939…	1.52678	35.576278	-160.0008…	Columbus	ISS
2022-04-01T00:20:00	REM-Lid	10.904088	422.420509	40921.5	0.4180964…	2.36792	46.397315	-139.8094…	Columbus	ISS
2022-04-01T00:20:00	DosTel2	7.48317466666667	422.420509	40921.5	0.4153514…	2.36792	46.397315	-139.8094…	Columbus	ISS
2022-04-01T00:20:00	DosTel1	7.80761766666667	422.420509	40921.5	0.3730812…	2.36792	46.397315	-139.8094…	Columbus	ISS
2022-04-01T00:20:00	Lidal	6.11440798239105	422.420509	40921.5	0.2980769…	2.36792	46.397315	-139.8094…	Columbus	ISS
2022-04-01T00:25:00	REM-Lid	11.048988	424.567687	45611.9	0.5415207…	3.89651	51.663254	-112.4683…	Columbus	ISS
2022-04-01T00:25:00	DosTel2	10.6957077435897	424.567687	45611.9	0.5561581…	3.89651	51.663254	-112.4683…	Columbus	ISS
2022-04-01T00:25:00	DosTel1	11.0199630897436	424.567687	45611.9	0.5182704…	3.89651	51.663254	-112.4683…	Columbus	ISS
2022-04-01T00:25:00	Lidal	6.96877643785163	424.567687	45611.9	0.3478796…	3.89651	51.663254	-112.4683…	Columbus	ISS
2022-04-01T00:30:00	REM-Lid	11.574072	424.812496	45307.7	0.5625323…	3.85842	49.120498	-83.450832	Columbus	ISS
2022-04-01T00:30:00	DosTel2	10.6151193333333	424.812496	45307.7	0.5378740…	3.85842	49.120498	-83.450832	Columbus	ISS
2022-04-01T00:30:00	DosTel1	10.8238516666667	424.812496	45307.7	0.5084686…	3.85842	49.120498	-83.450832	Columbus	ISS
2022-04-01T00:30:00	Lidal	6.38013989877022	424.812496	45307.7	0.3076296…	3.85842	49.120498	-83.450832	Columbus	ISS
2022-04-01T00:35:00	REM-Lid	7.364856	423.385667	39608.2	0.3250669…	2.25814	39.968035	-60.605414	Columbus	ISS
2022-04-01T00:35:00	DosTel2	7.15227441025641	423.385667	39608.2	0.3641040…	2.25814	39.968035	-60.605414	Columbus	ISS
2022-04-01T00:35:00	DosTel1	6.20494814102564	423.385667	39608.2	0.3208913…	2.25814	39.968035	-60.605414	Columbus	ISS

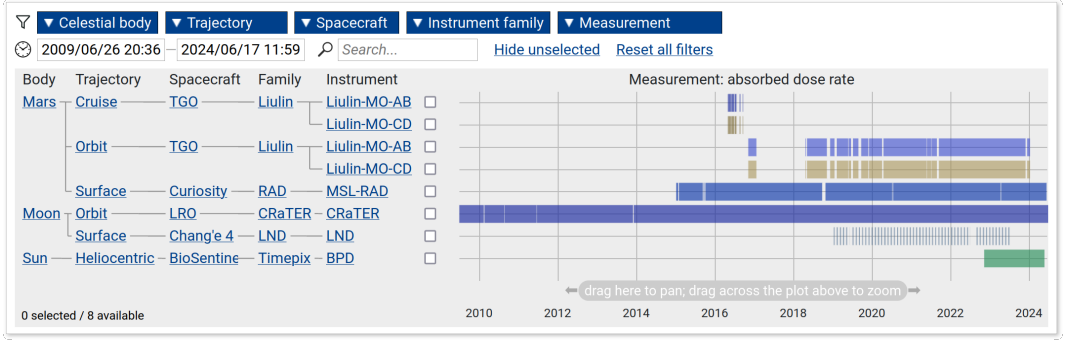
RadLab: GeneLab/ALSDA Applications



RadLab: GeneLab/ALSDA Applications



RadLab: Modeling Applications



RadLab: Modeling Applications

Frontier Development Labs: FDL-X Heliolab 2024 Challenge
"Forecasting Radiation Exposure for Human Space Flight"

Team: Elena Massara, Xiaomei Song, Rutuja Gurav, Kimberly Sinclair
Faculty: Matt Kusner, Atılım Güneş Baydin, Bala Poduval
Advisors: Sylvain Costes, Jack Miller, Kirill Grigorev

Resources used: GOES, SDO, RadLab (BioSentinel + CRaTER)

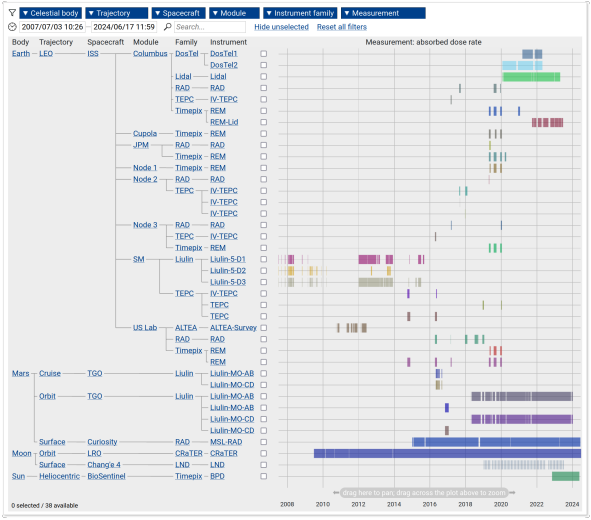
Training an early warning model

frontierdevelopmentlab.org/fdl2024
youtube.com/watch?v=VYe9wpx8PXQ

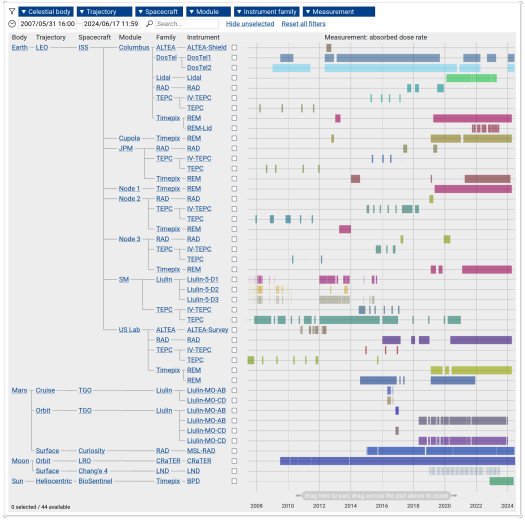
RadLab: Modeling Applications

- Synthetic datasets
  - For payloads
  - For arbitrary locations / timespans
  - Combining data from multiple sources

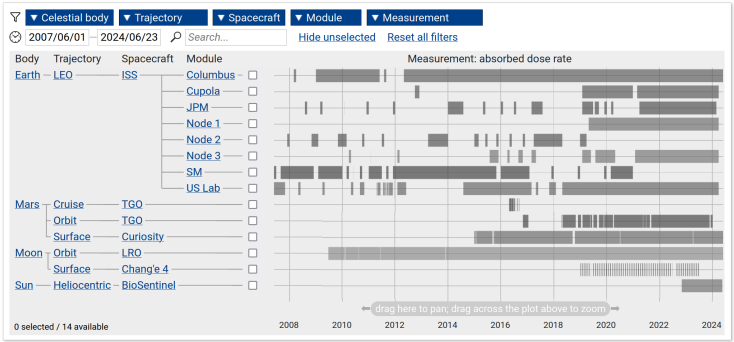
RadLab: Current State



RadLab: Goals

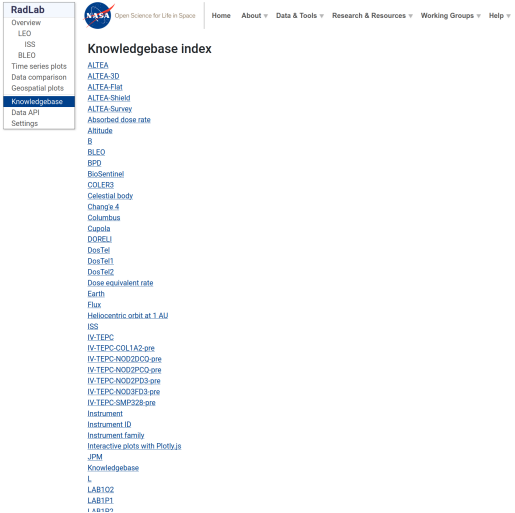


RadLab: Goals

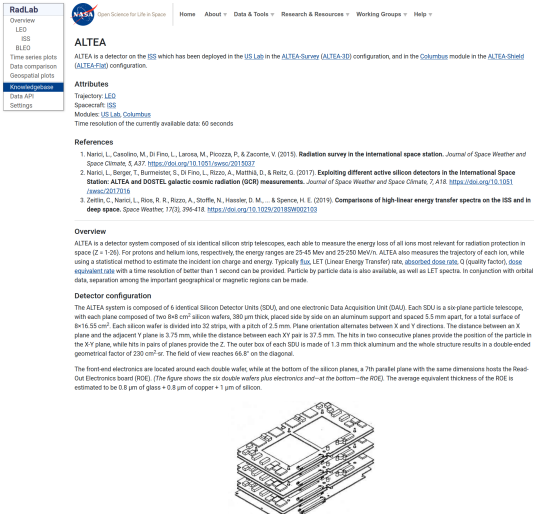


+ Known historical SPE annotations (in both the API and the GUI)
+ Federated GOES and POES data
+ Integration with other resources (*e.g. Space Radiation Intelligence System a.k.a. SPRINTS*)

RadLab: Knowledgebase



RadLab: Knowledgebase



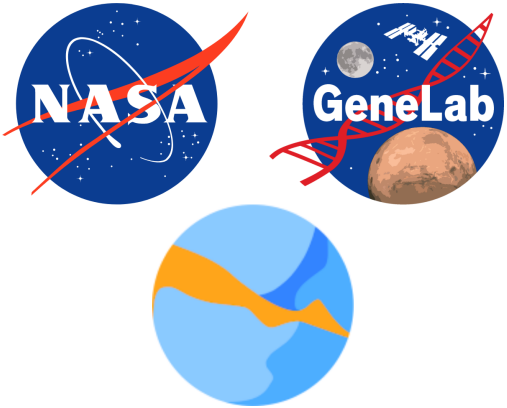
RadLab: Roadmap

- Ingest and make public the currently staged datasets (more DosTel, TEPC, TriTel, …)
- Integrate known historical SPE annotations
- Expand the knowledgebase
- Working Group objectives (next slide)

The RadLab Working Group (RLWG)

- Fostering collaboration
- Integration of new datasets
- Development of data harmonization standards
- Guiding the development of the platform
- Establishing the use of RadLab in radiation and biology research

Thank you!



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