GWOSC:

Gravitational Wave Open Science Center

Kent Blackburn

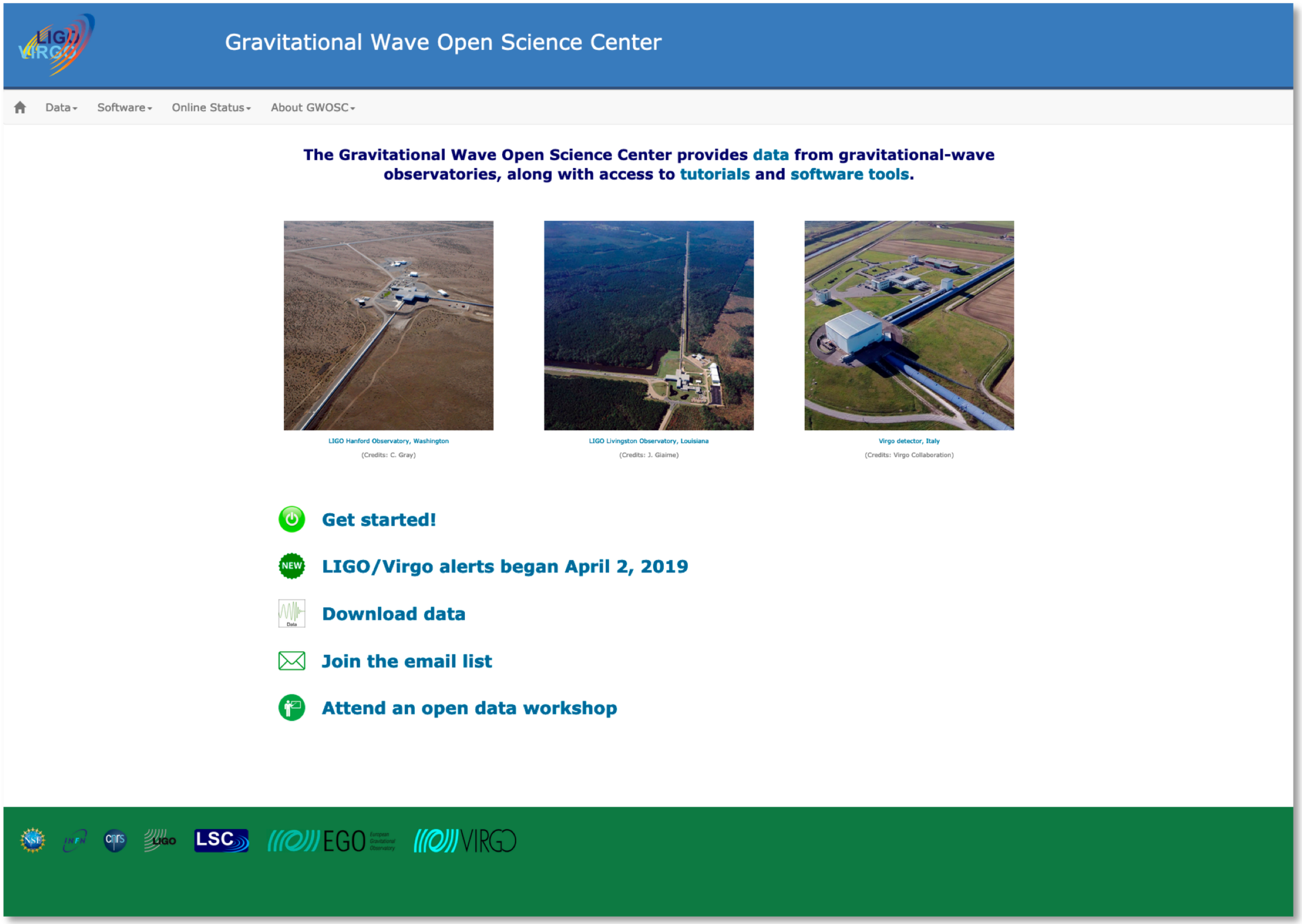
on behalf of the GWOSC Team and the LIGO/Virgo Collaboration

AstroInformatics 2019

Caltech
Pasadena, CA
June 24th – 27th, 2019

GWOSC: Public Web Presence

https://www.gw-openscience.org



LIGO and Virgo GW strain, data quality and hardware injection time series.
Documentation, tutorials, software, publications, projects, detector status and more.

Gravitational Wave Open Data

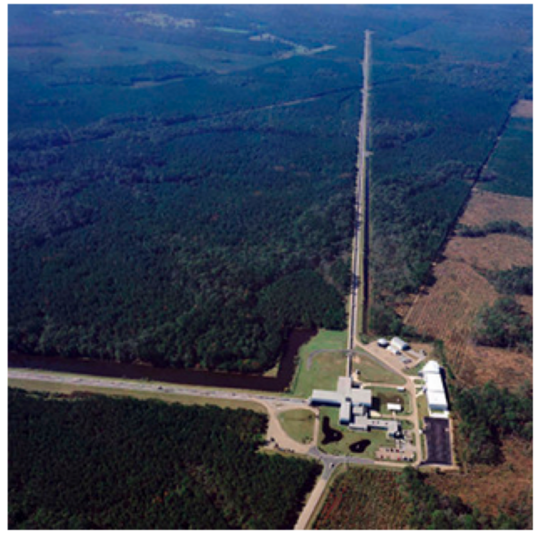
- *Open data is data that can be freely used, re-used and redistributed by anyone – subject only, at most, to the requirement to attribute and share alike.*

- The GWOSC open data release policy is documented within the LIGO Data Management Plan (https://dcc.ligo.org/LIGO-M1000066/public).
- Two primary types of open data releases:
  - Comprehensive [O(TBs)] bulk data sets for "observing runs".
    - *Releases will occur every 6 months, in blocks of 6 months of data, with a latency of 18 months from the end of acquisition of each observing block.*
    - *The first 6 months of O3 data will be releases ~ April 2021.*
  - Roughly one hour data blocks [O(GBs)] tied to "events".
    - *Released at the time of publication(s) for the event(s).*
  - Data releases are supplemented by documentation, tutorials and software to facilitate use outside the LIGO/Virgo Collaboration.
- Data sets are time series in several formats (HDF5, GWF, GZIP ASCII for events).

Gravitational Wave Data Products

LIGO Hanford Observatory, Washington

(Credits: C. Gray)



LIGO Livingston Observatory, Louisiana

(Credits: J. Giaime)

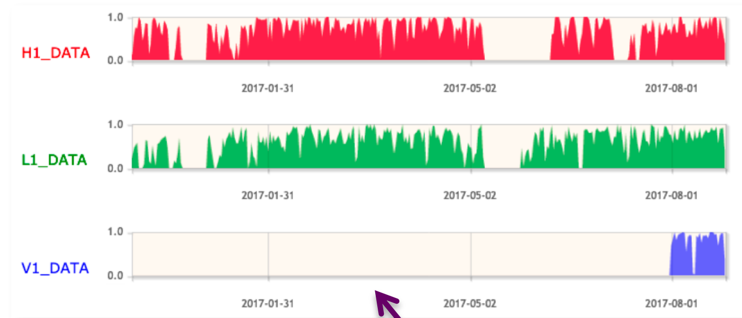
Virgo detector, Italy

(Credits: Virgo Collaboration)

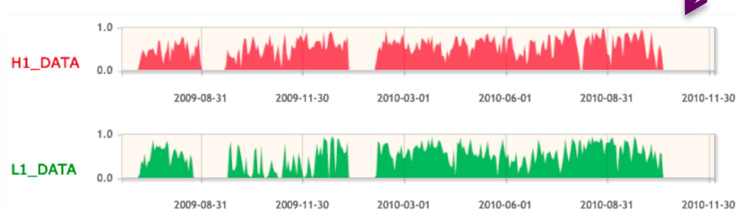
- Data from LIGO's 2(3) detectors available for Initial LIGO S5 and S6 science runs and Advanced LIGO's **O1** and **O2** observation runs.
- Data from Advanced Virgo is ***now*** available starting with their participation in **O2**.

Released Data

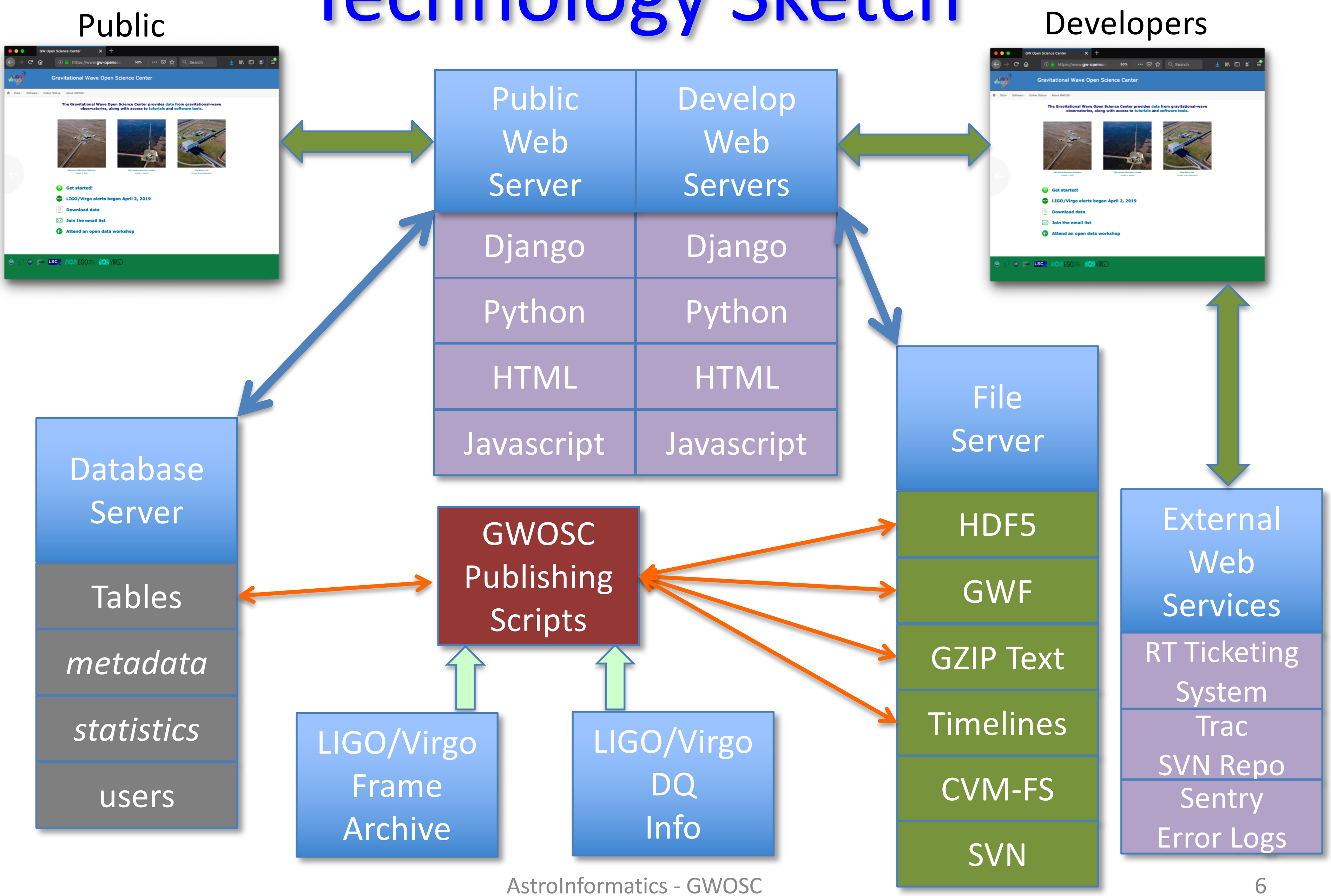
(timelines – "good" strain data!)



	RUNS			
	S5	**S6**	**O1**	**O2**
Detectors	**H1 H2 L1**	**H1 L1**	**H1 L1**	**H1 L1 V1**
Start	**2005-11-04**	**2009-06-21**	**2015-09-12**	**2016-11-30**
End	**2007-10-01**	**2010-12-05**	**2016-01-19**	**2017-08-25**

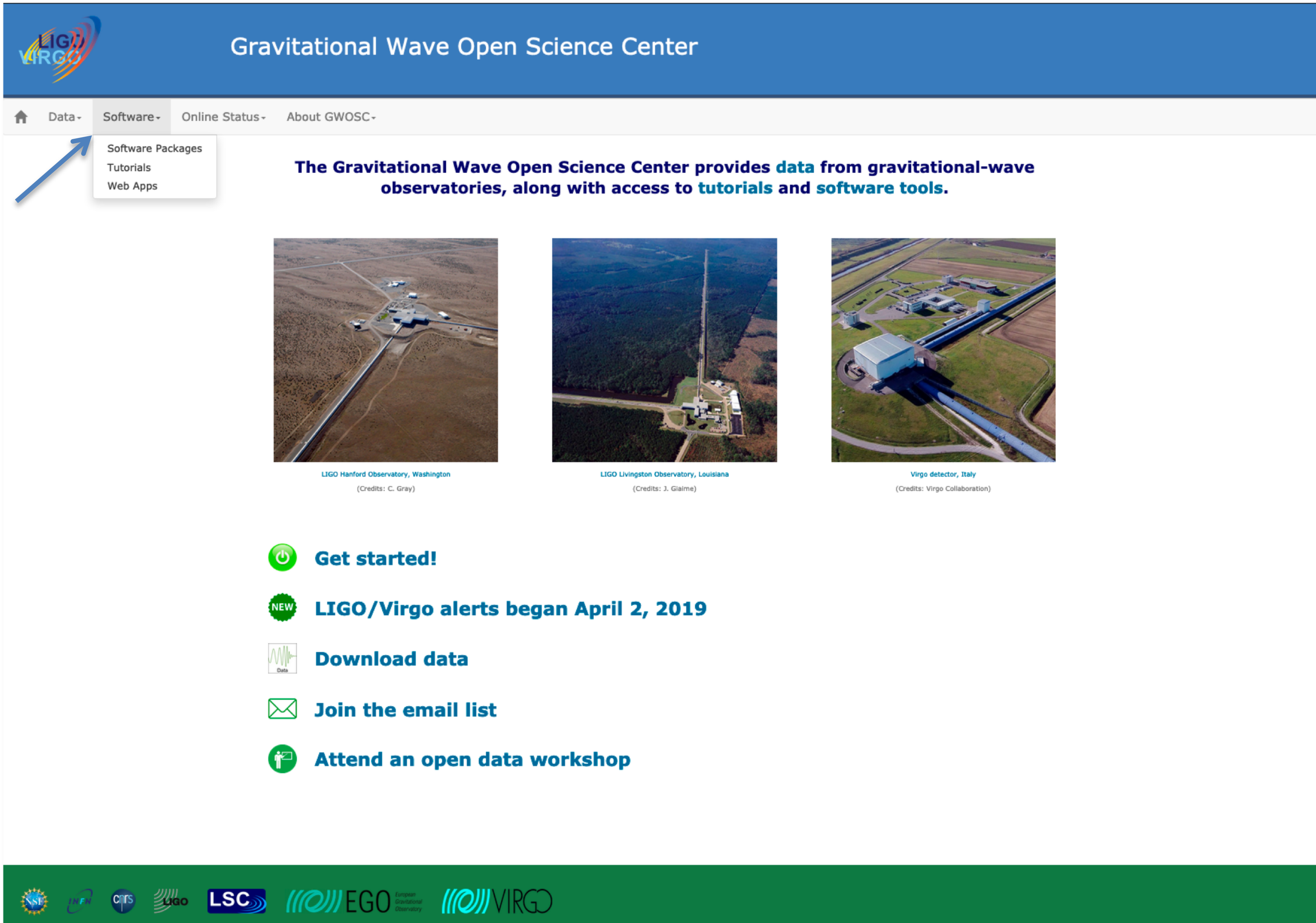


Technology Sketch



Menu Navigation

Menu Navigation



Menu Navigation

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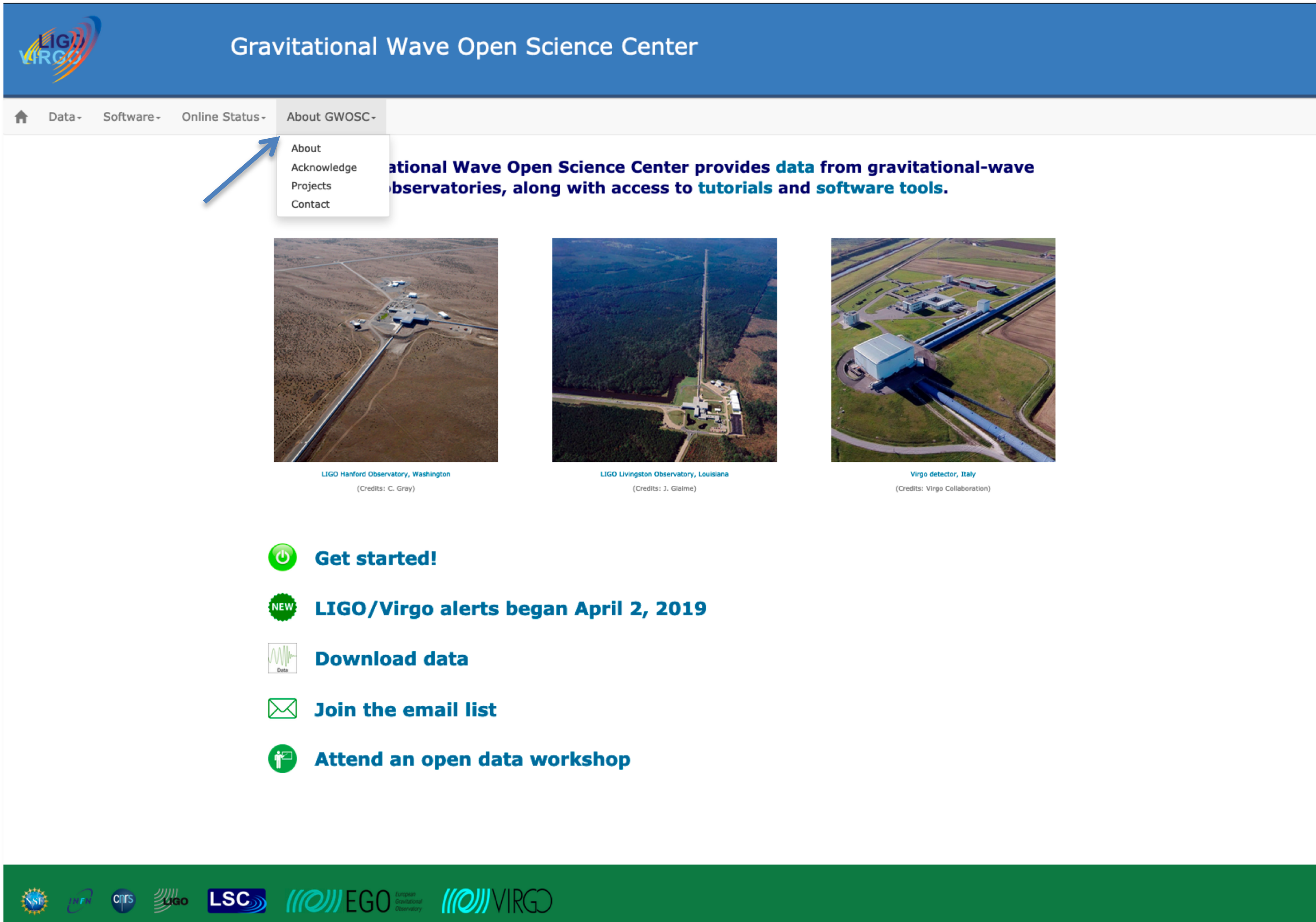

TIMELINES …

Timelines – when and what data are available

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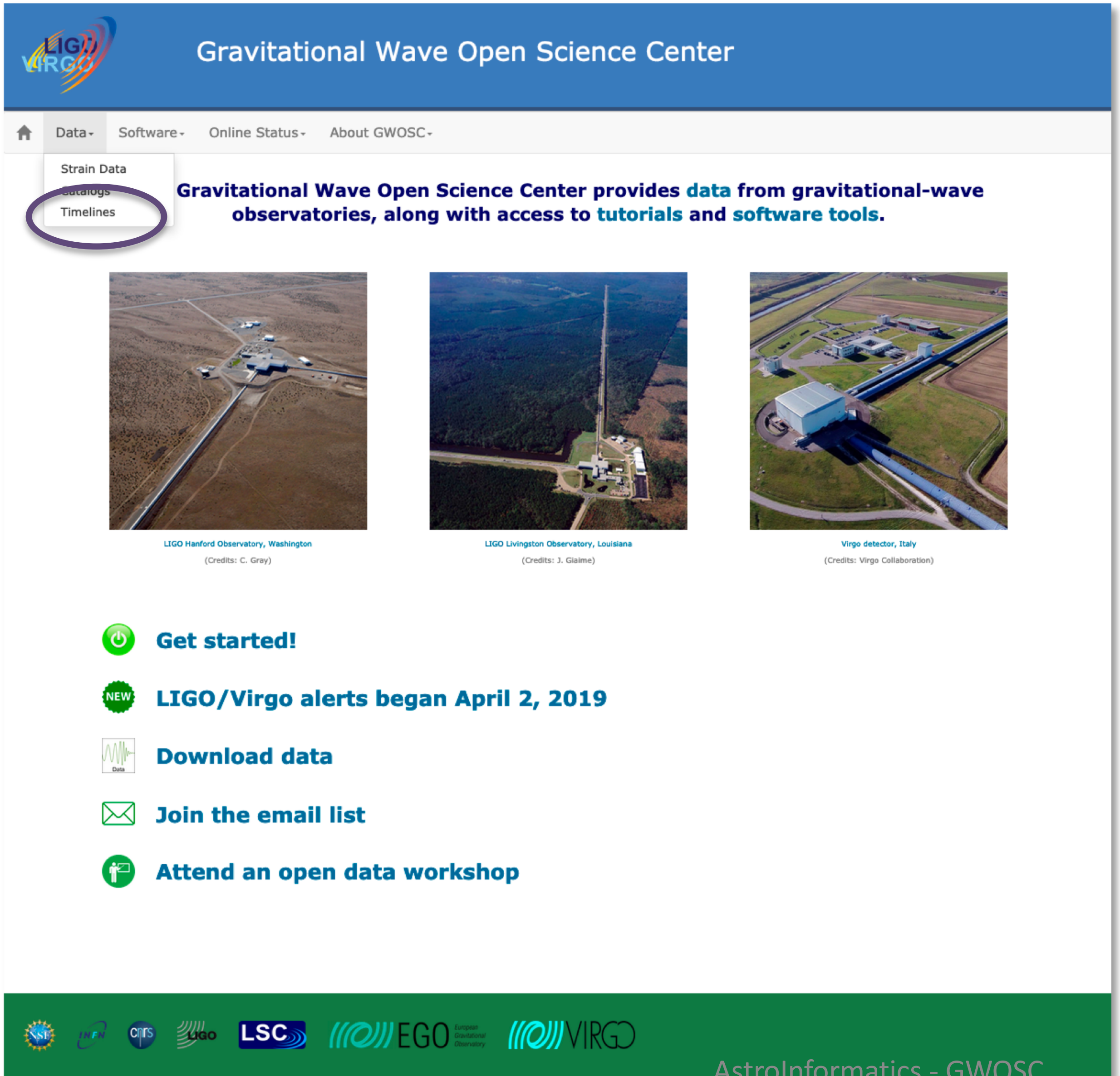
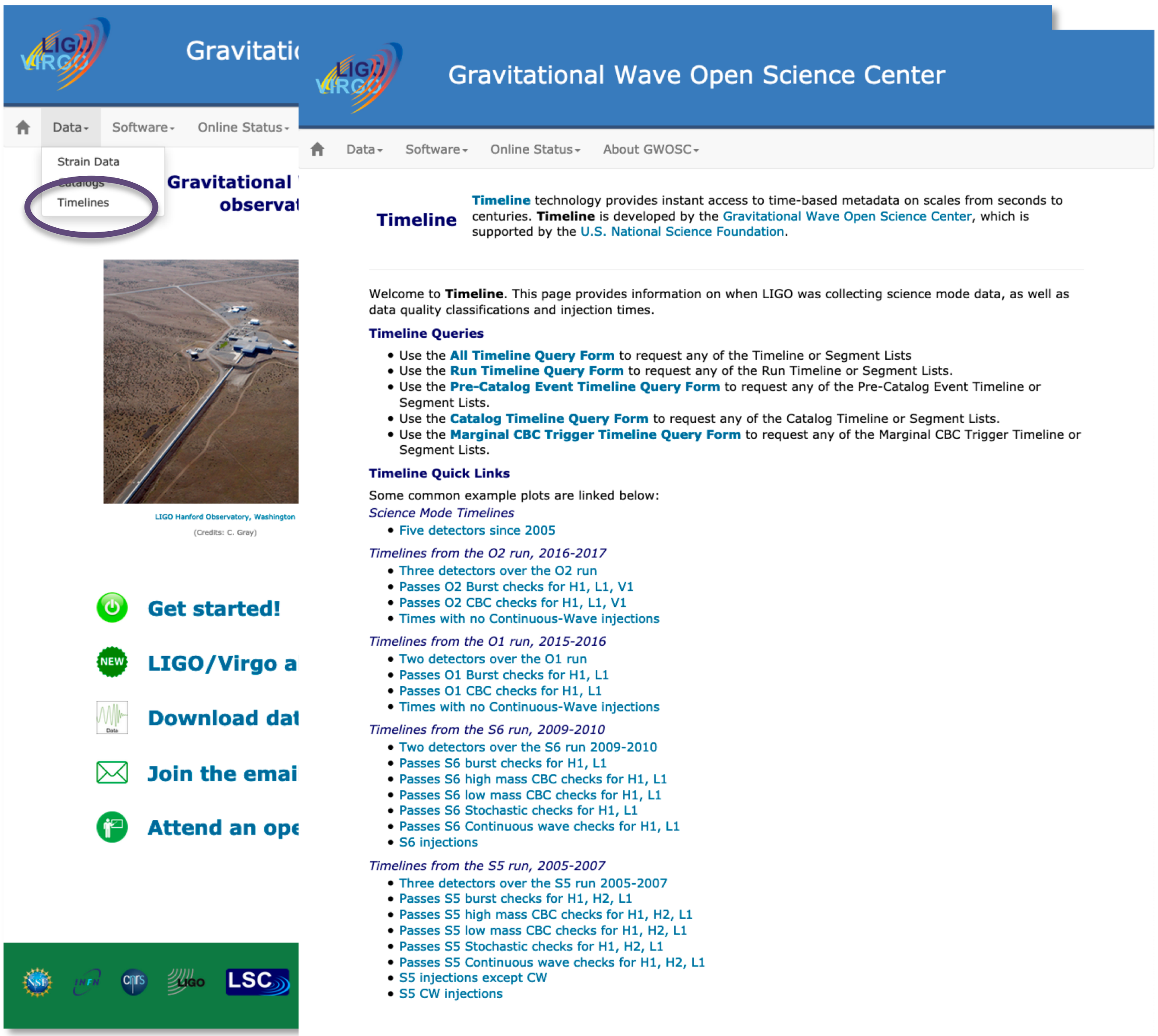
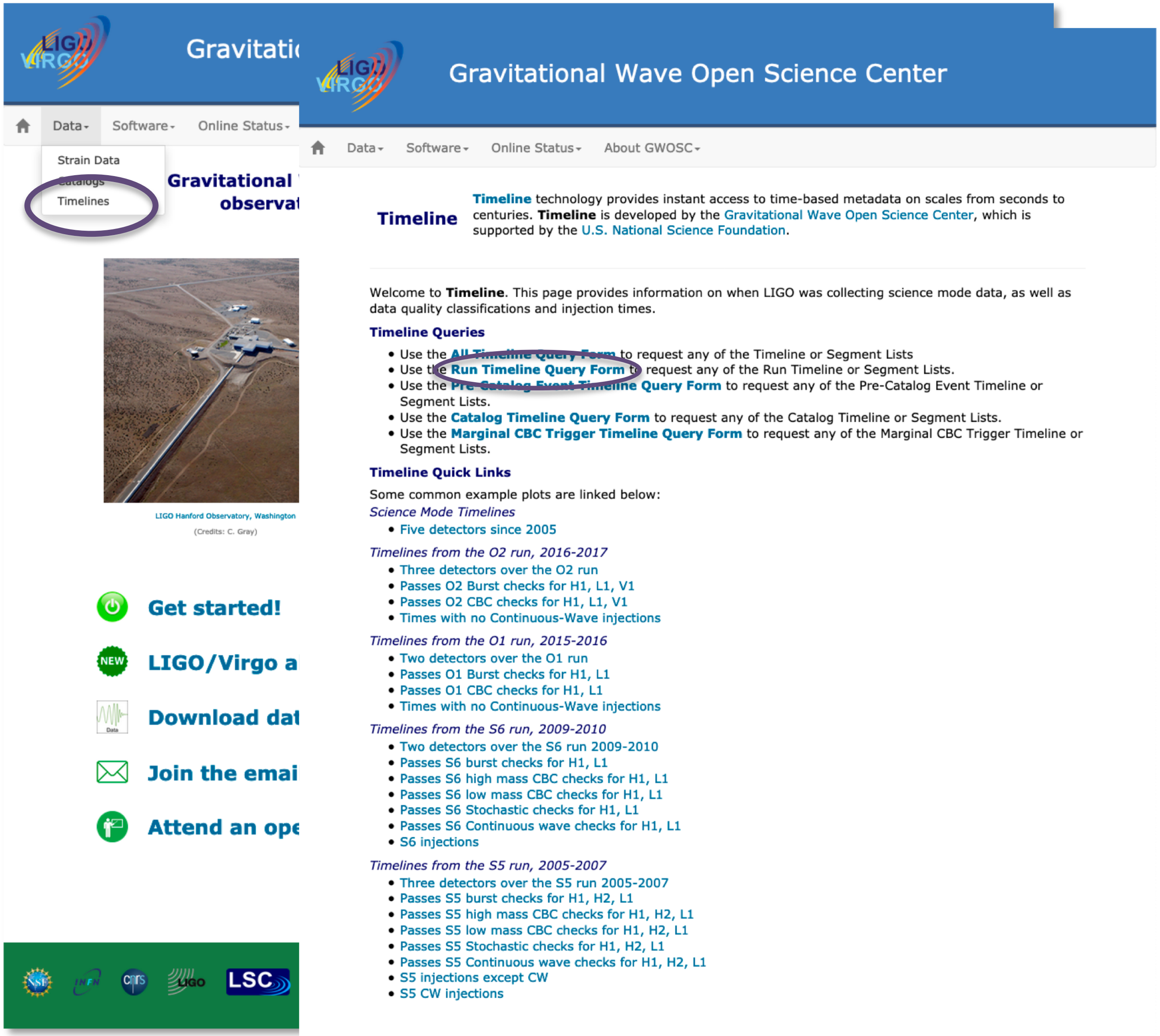


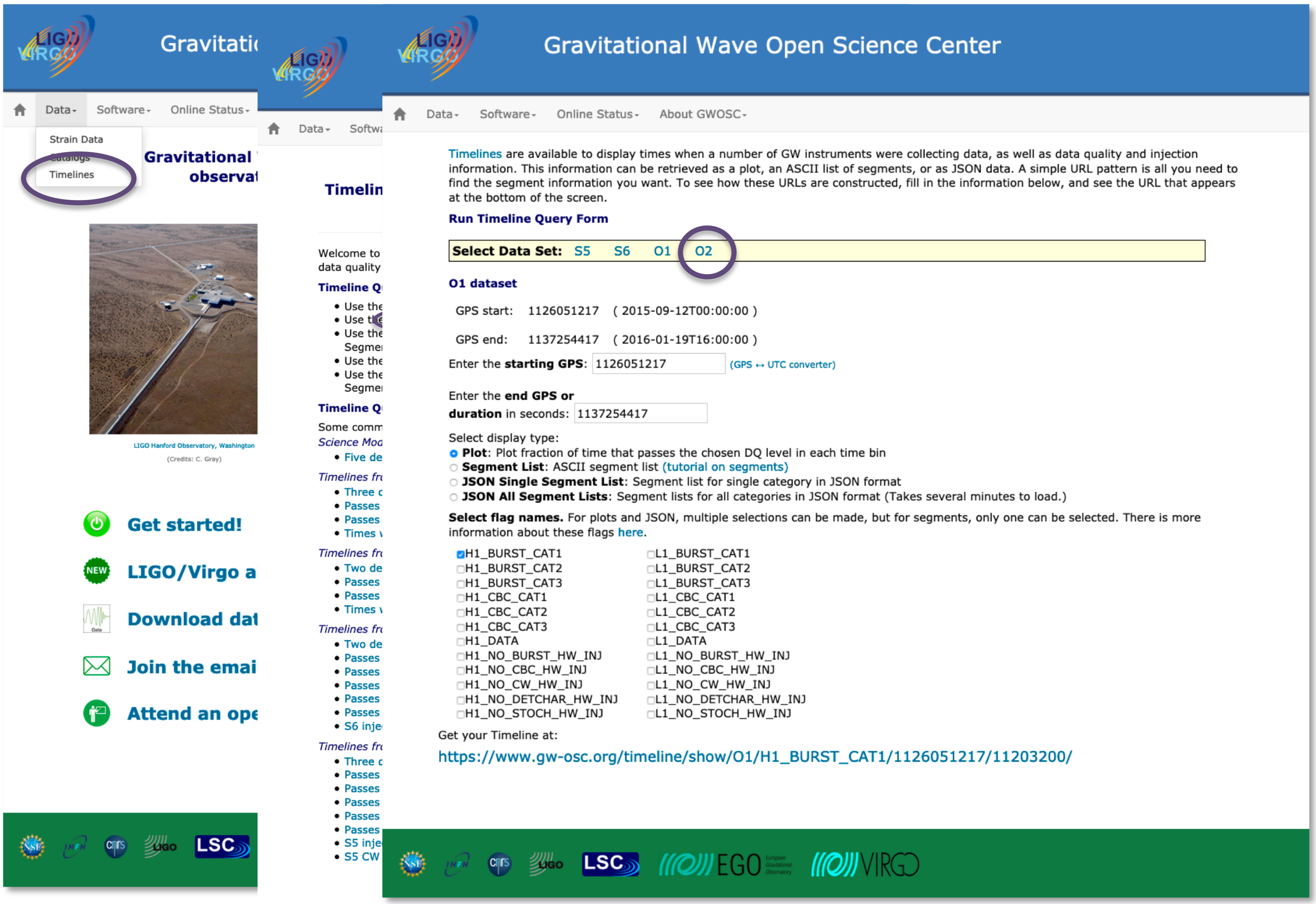
Timelines – when and what data are available



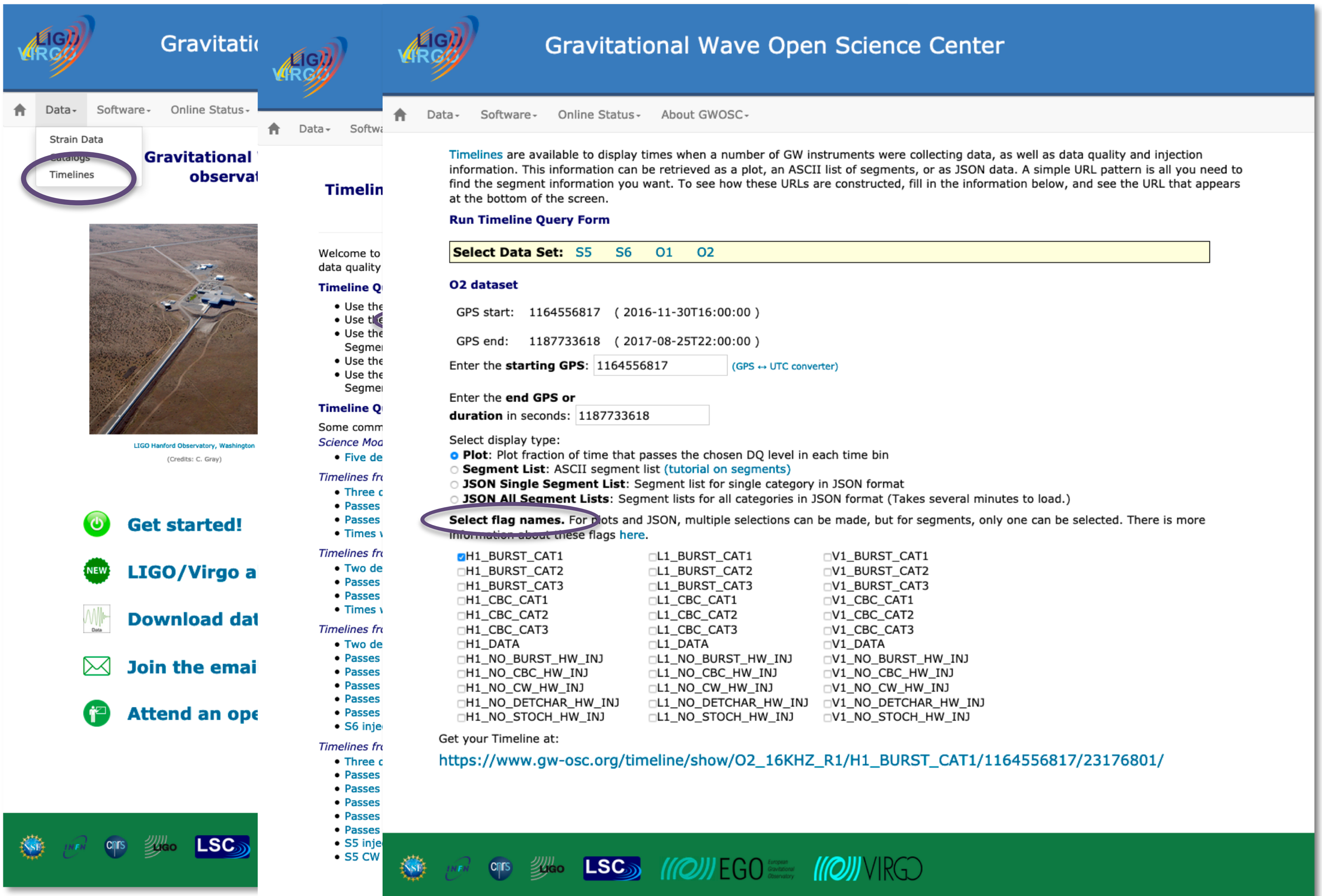
Timelines – when and what data are available



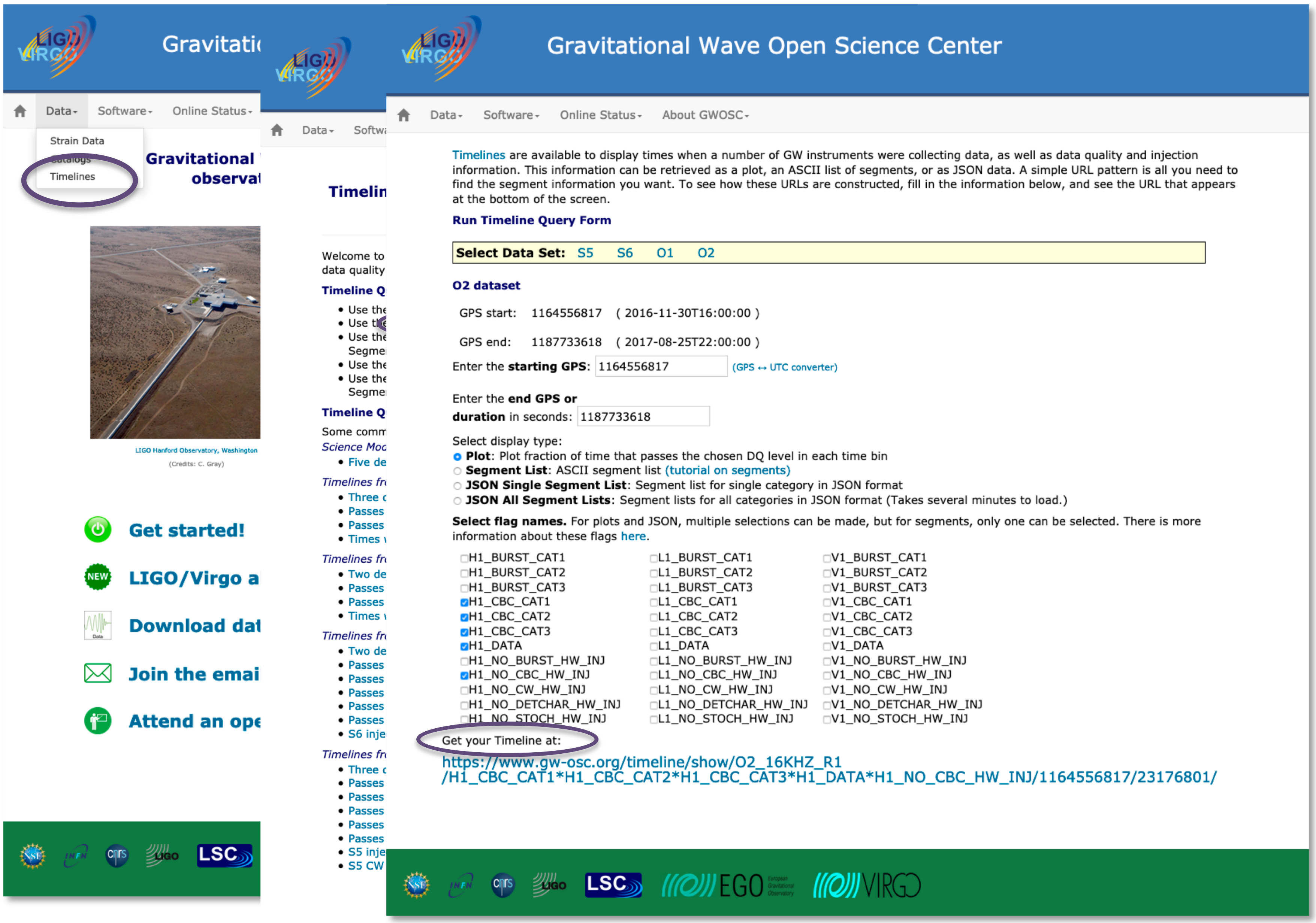
Timelines – when and what data are available



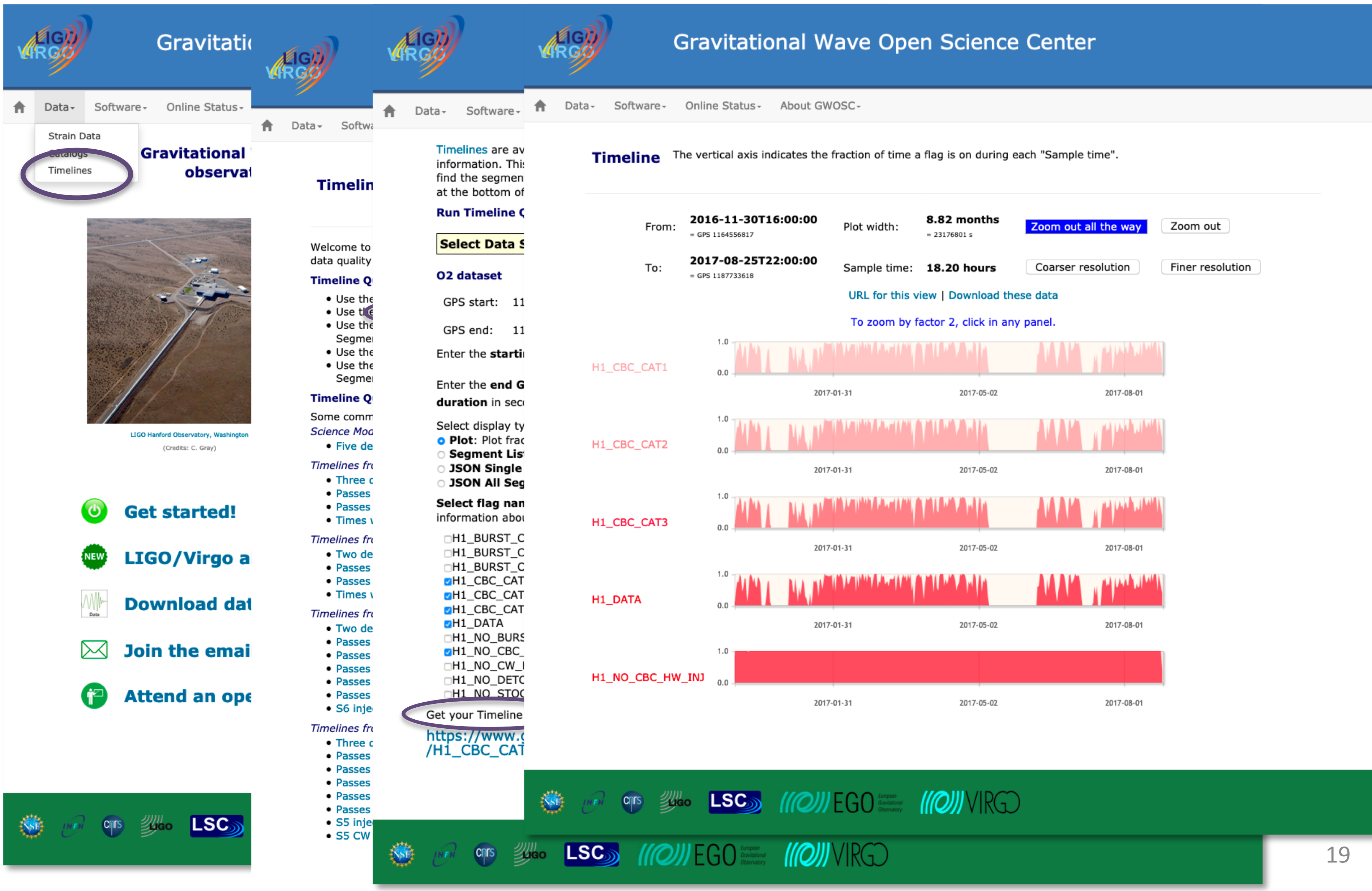
Timelines – when and what data are available



Timelines – when and what data are available

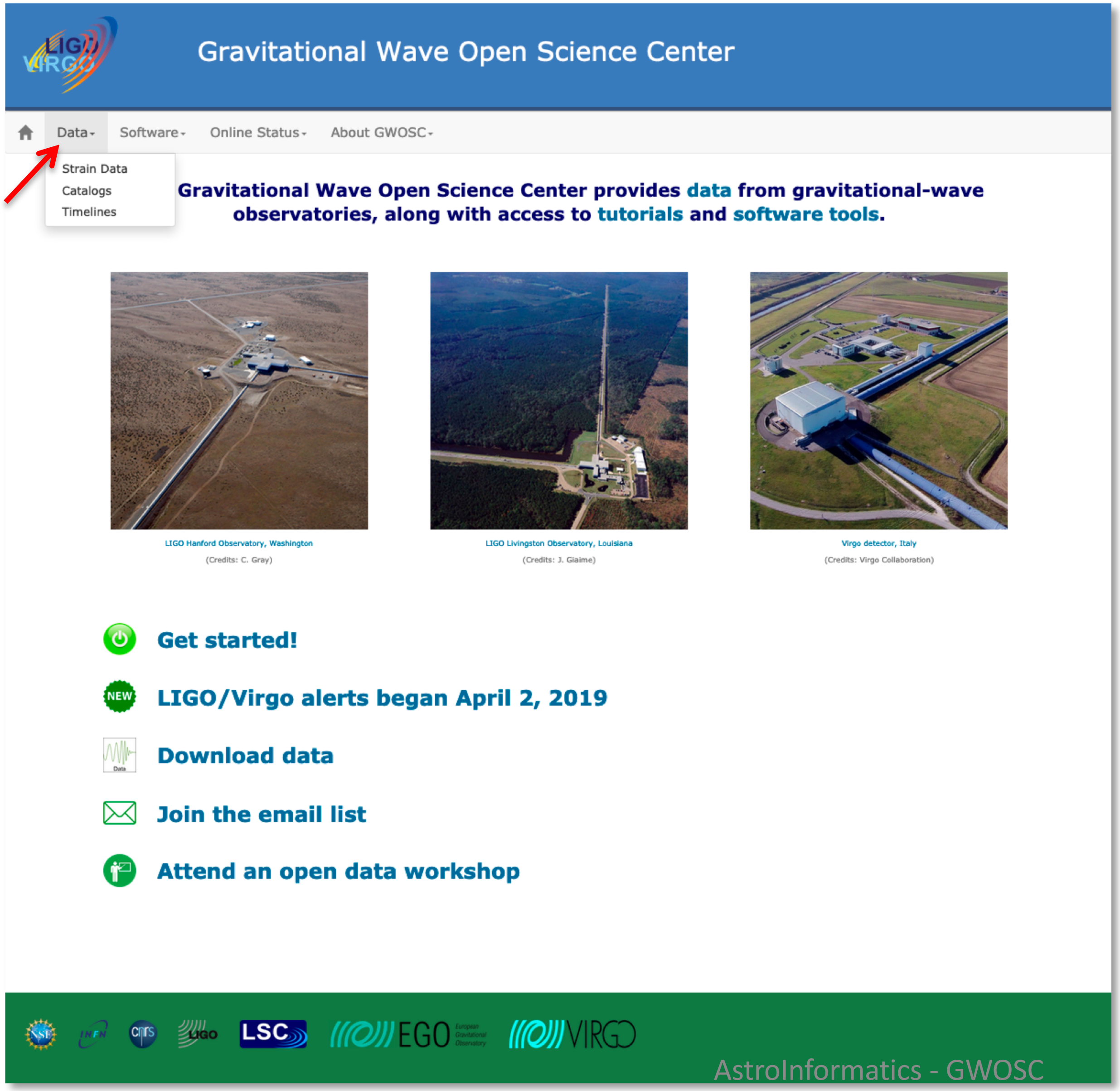


Timelines – when and what data are available

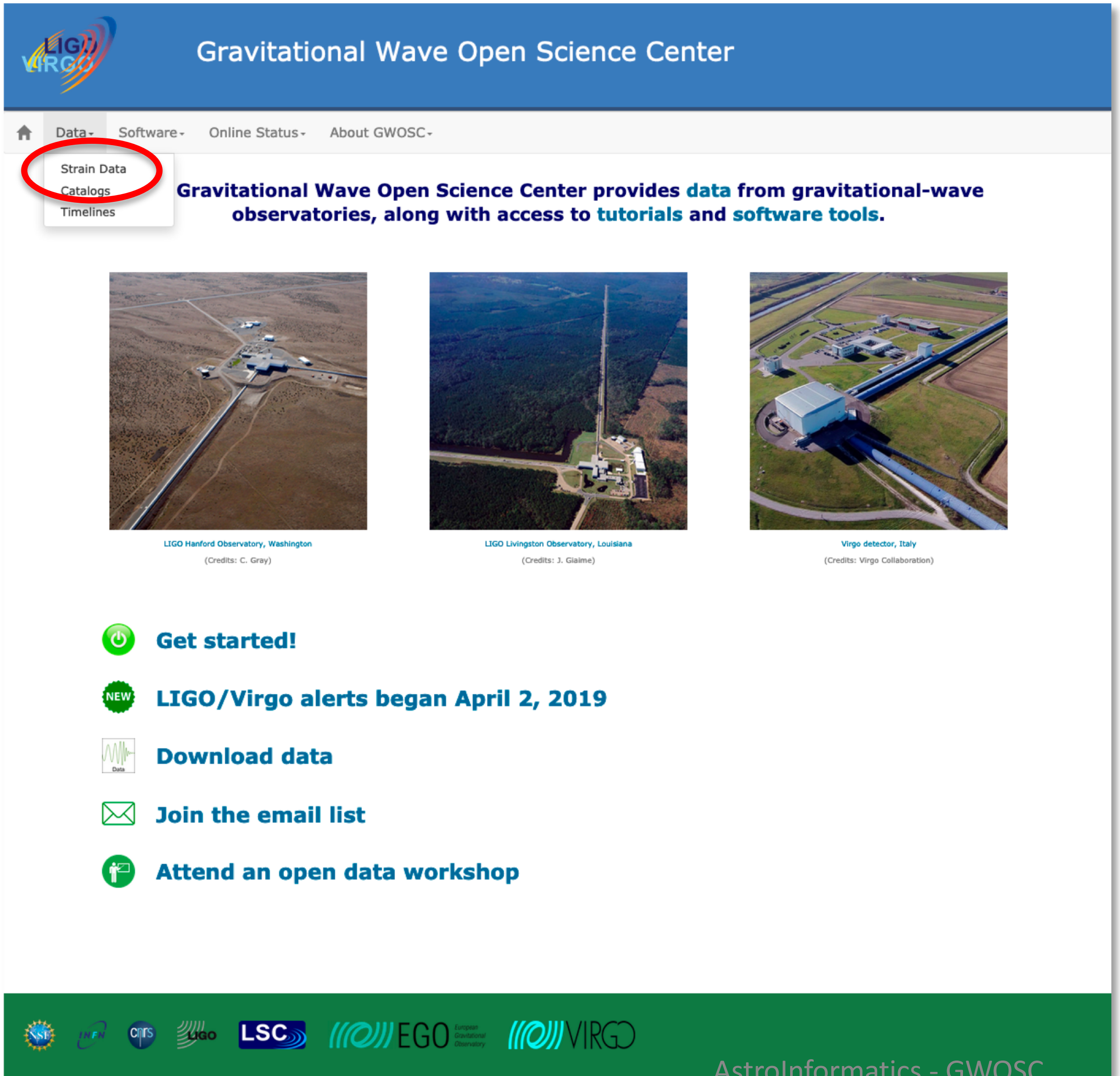


GW STRAIN DATA …

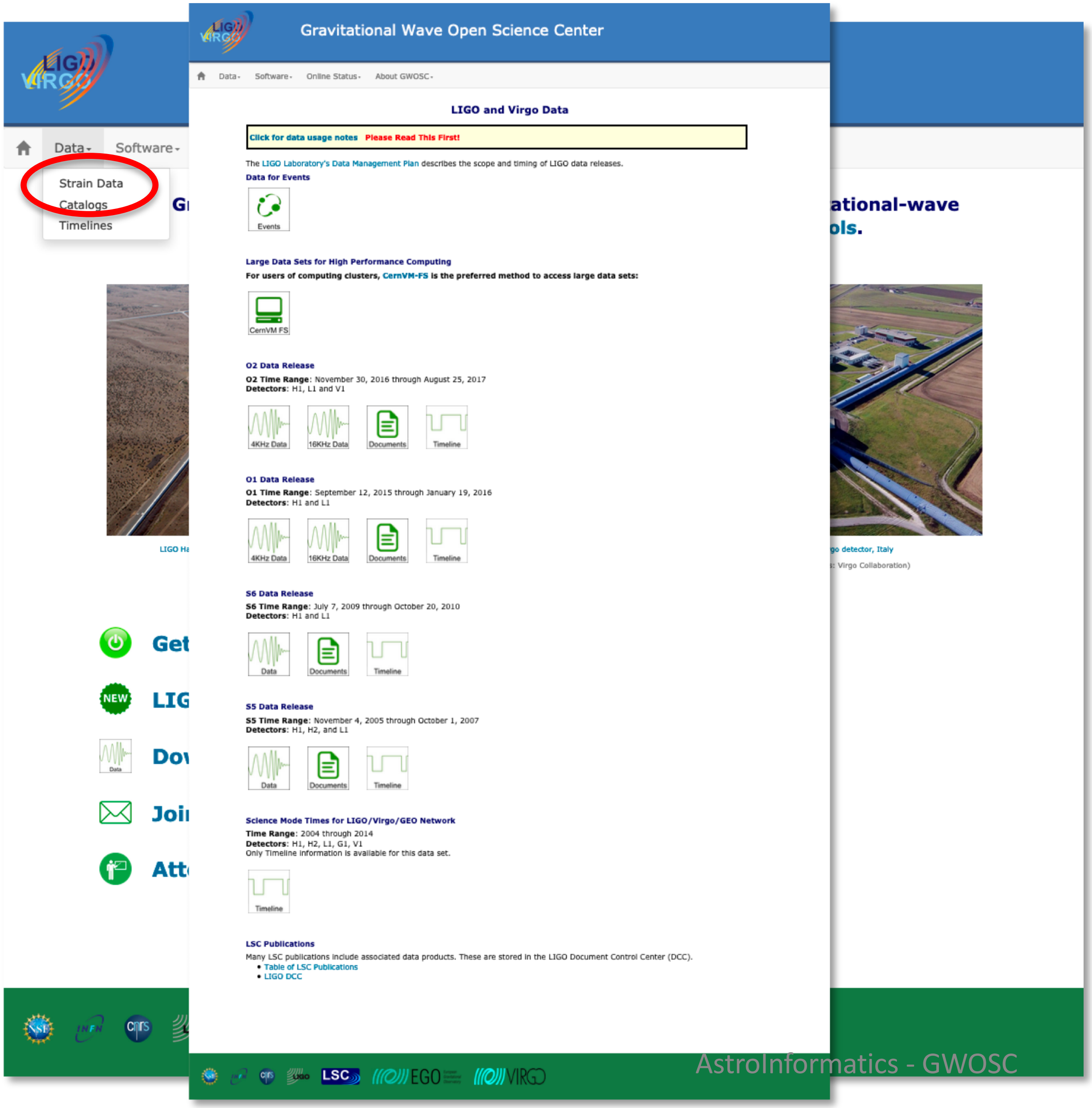
Data Downloads via **Web**



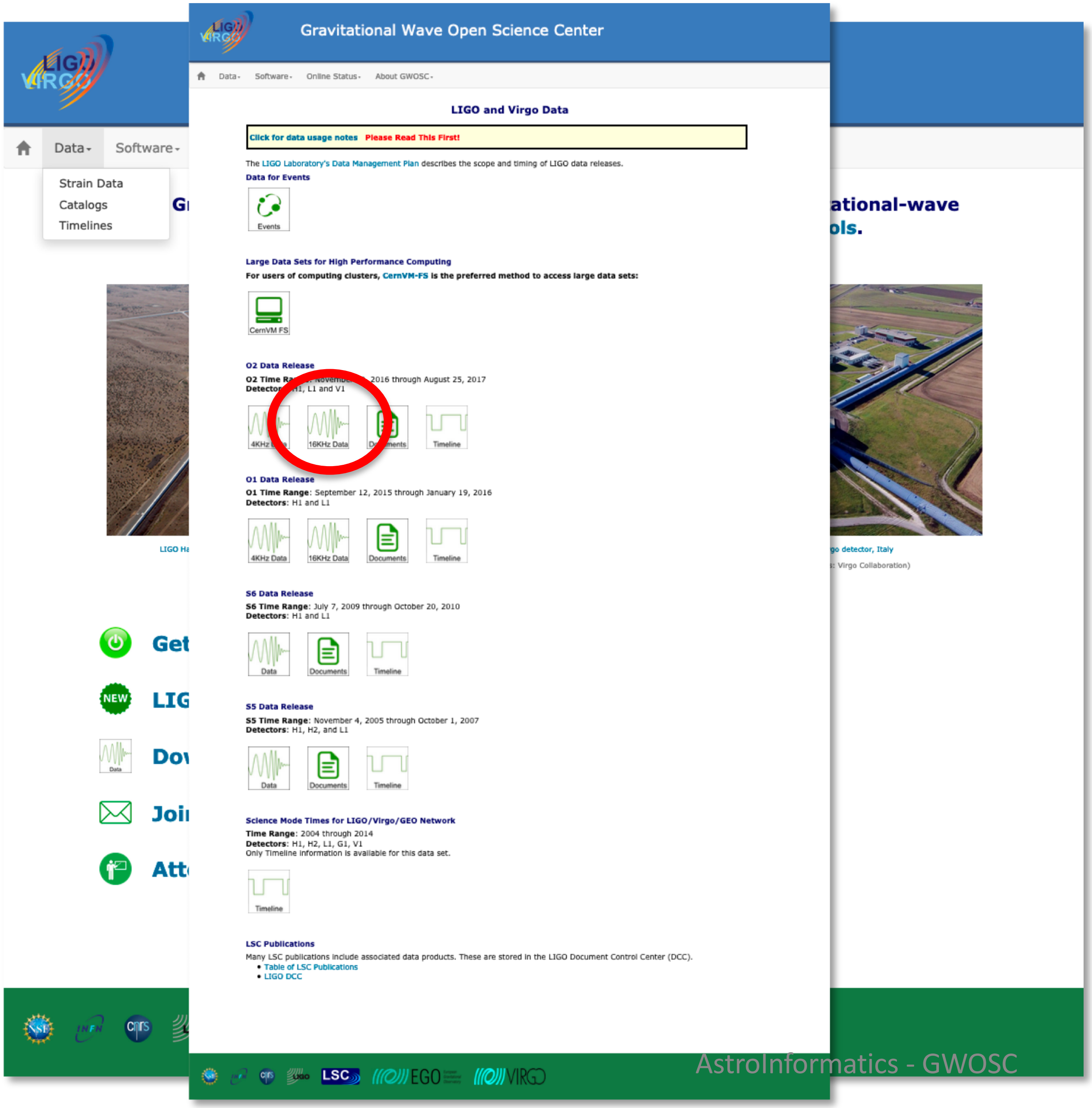
Data Downloads via **Web**



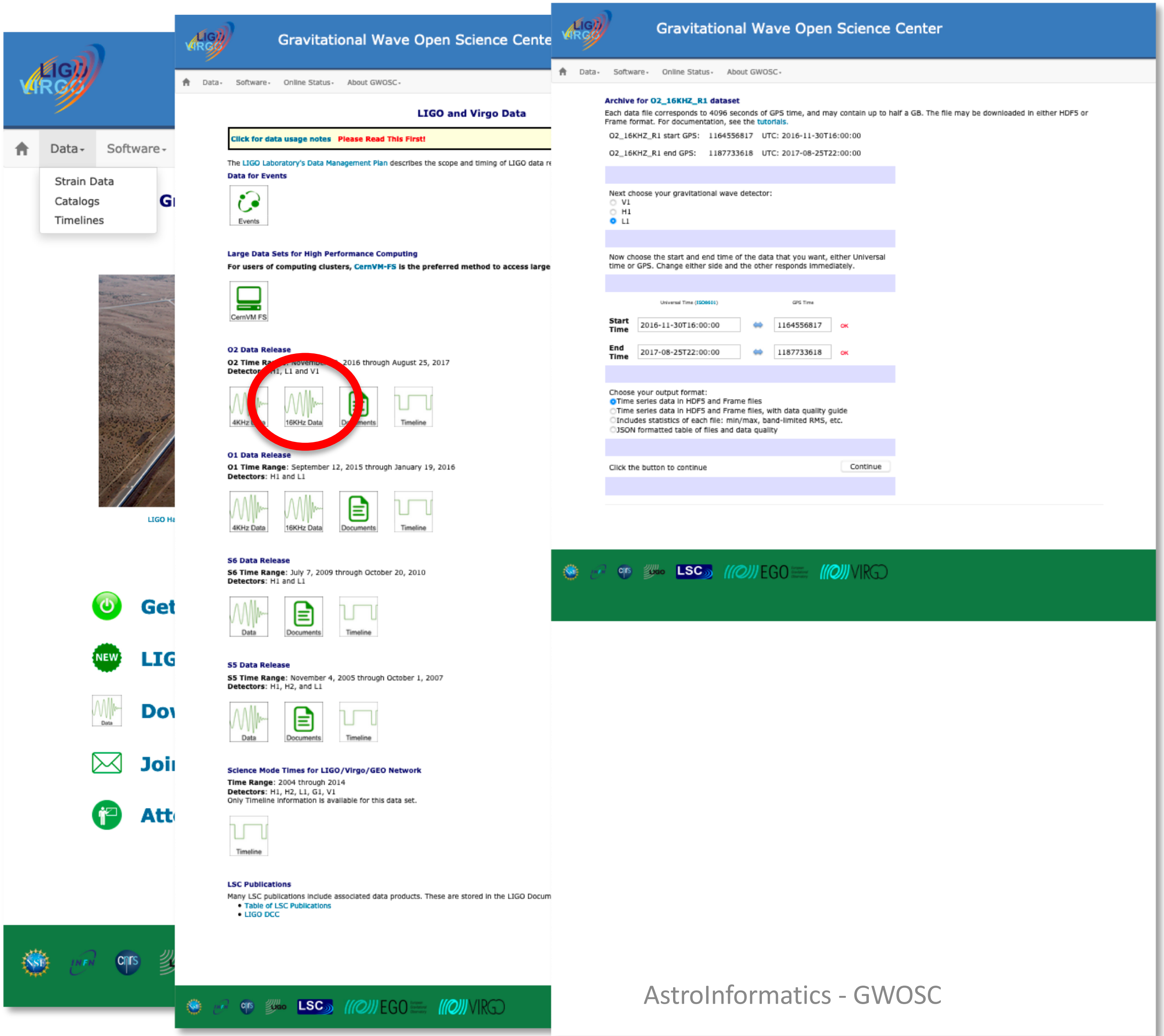
Data Downloads via **Web**



Data Downloads via **Web**



Data Downloads via **Web**



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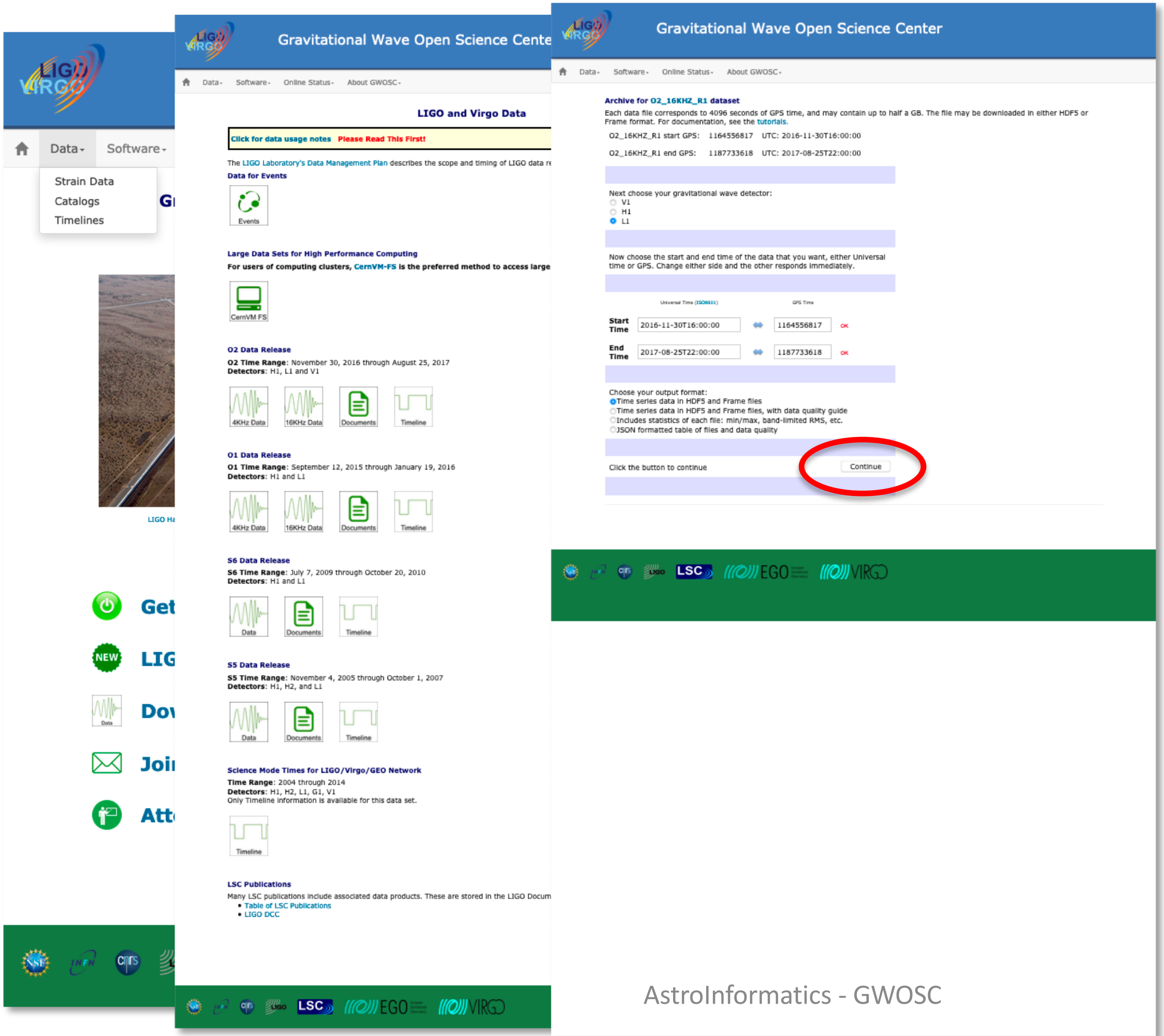

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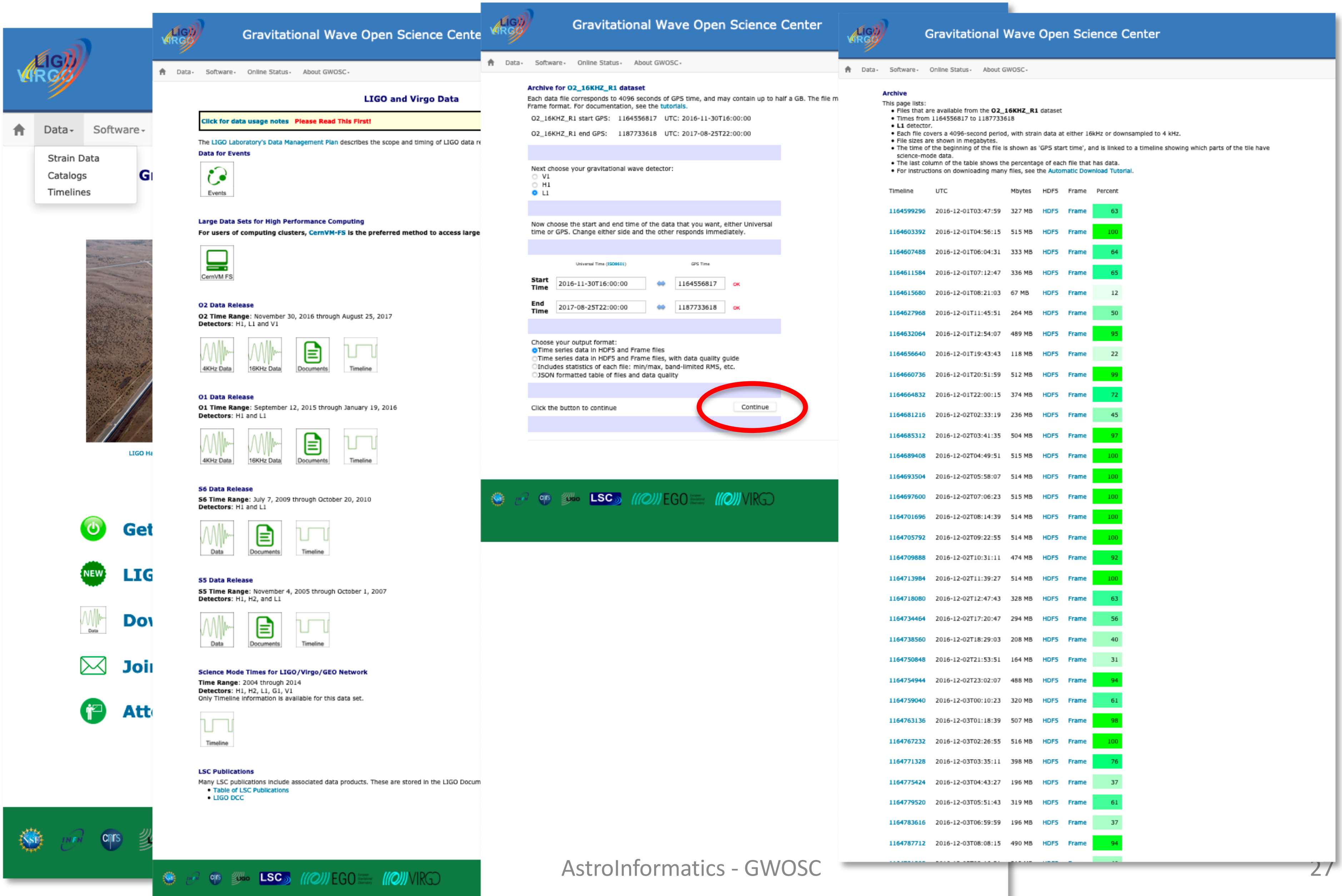

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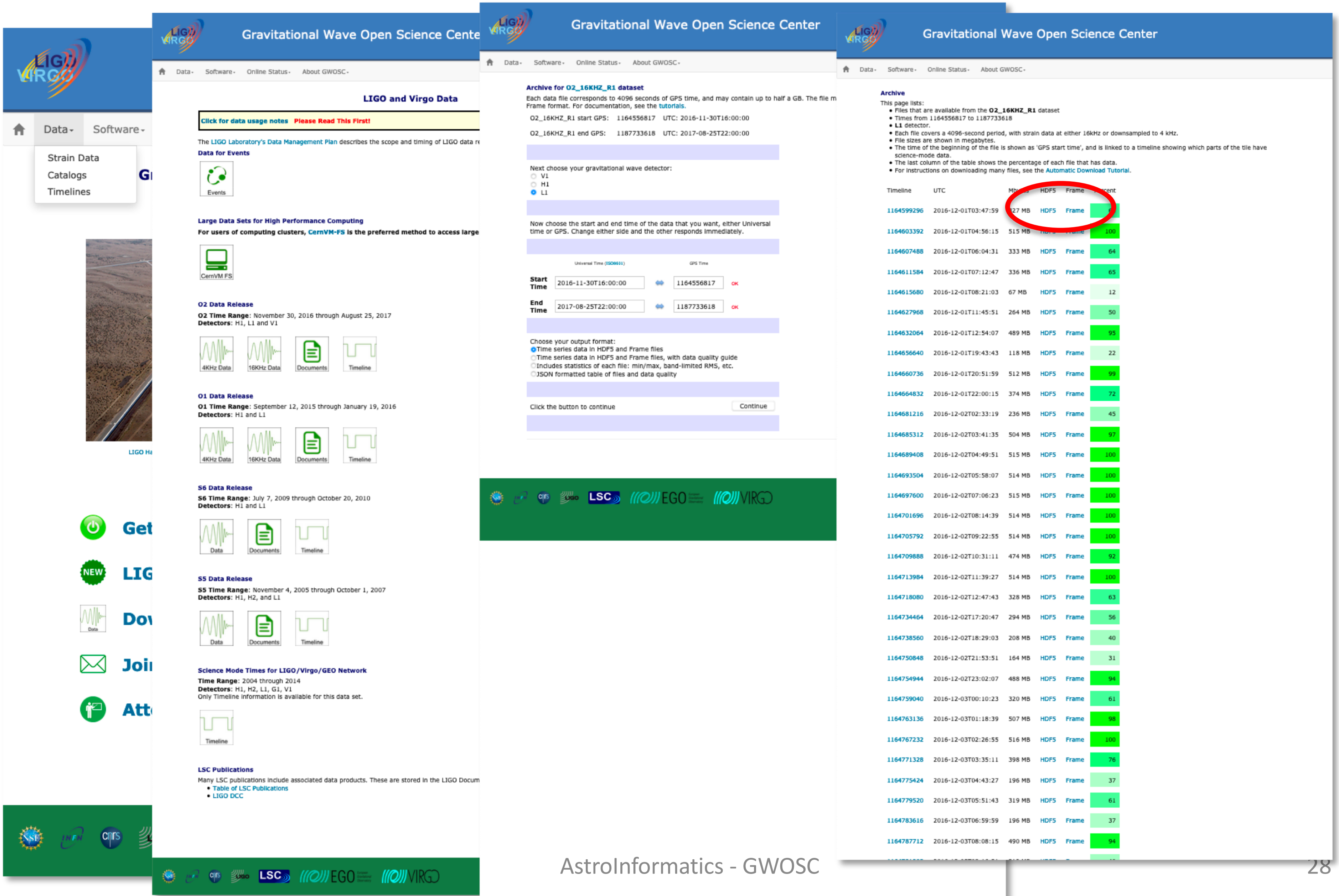
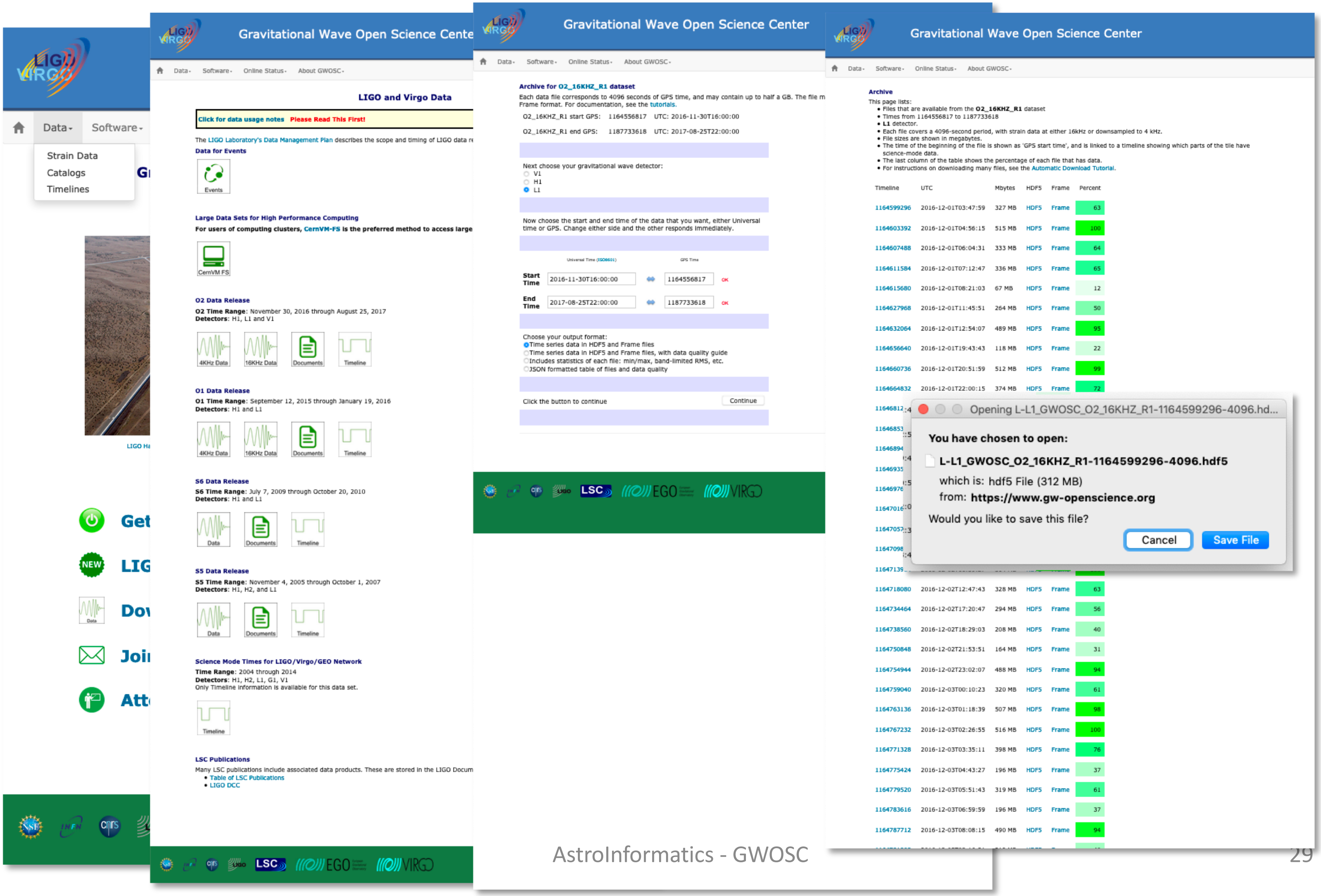
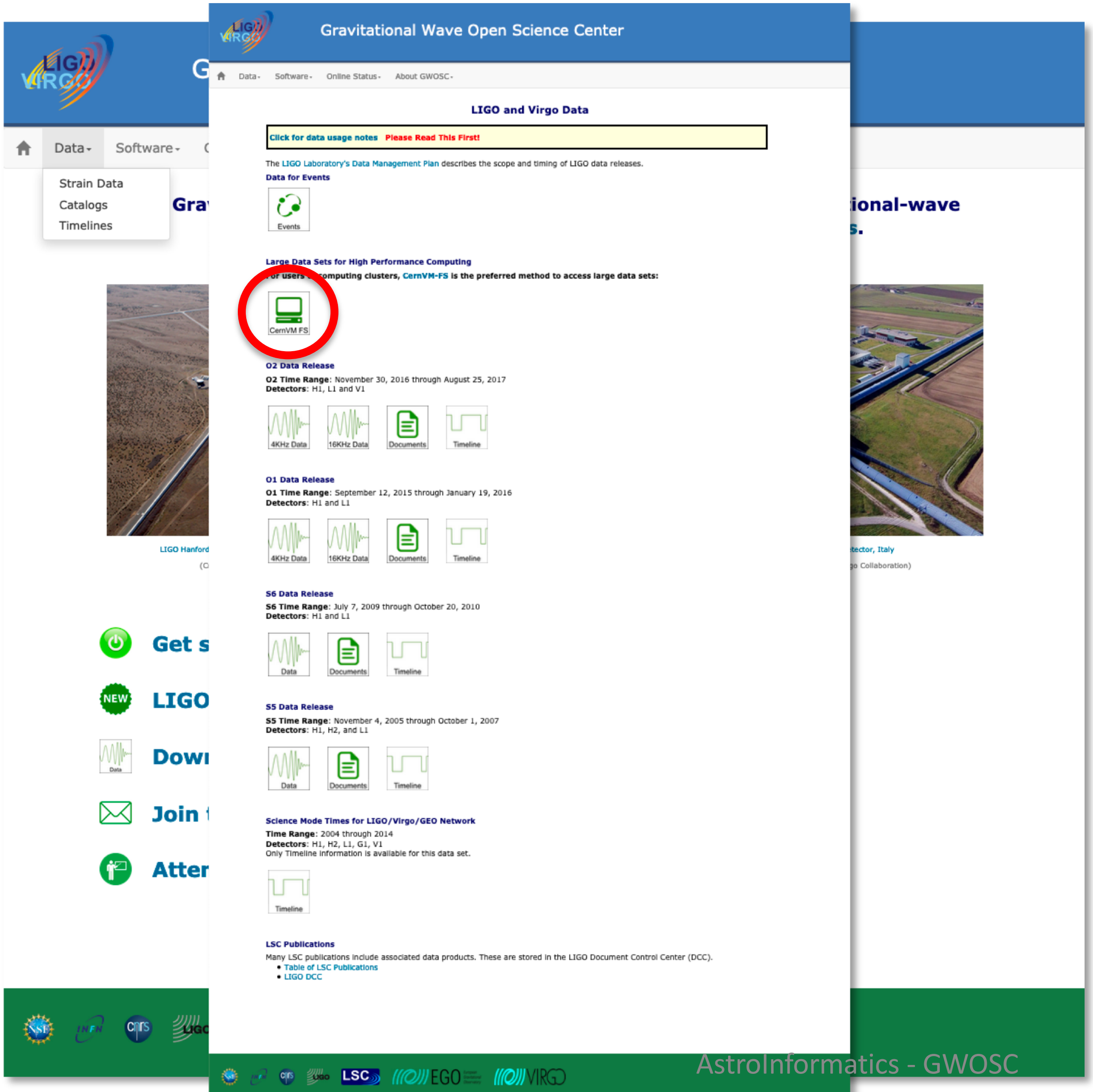


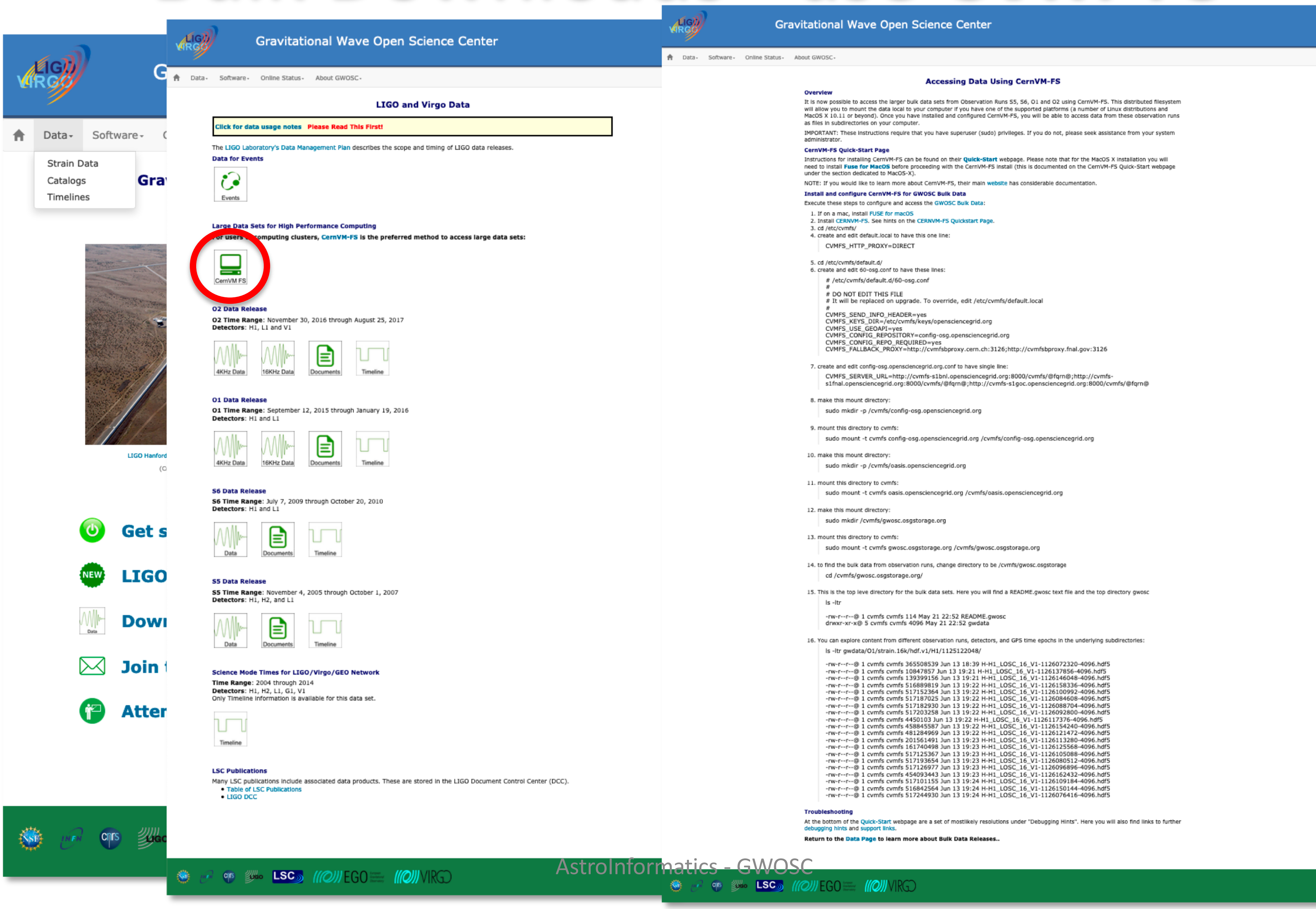
Data Downloads via **Web**



Bulk Downloads - use **CVM-FS**

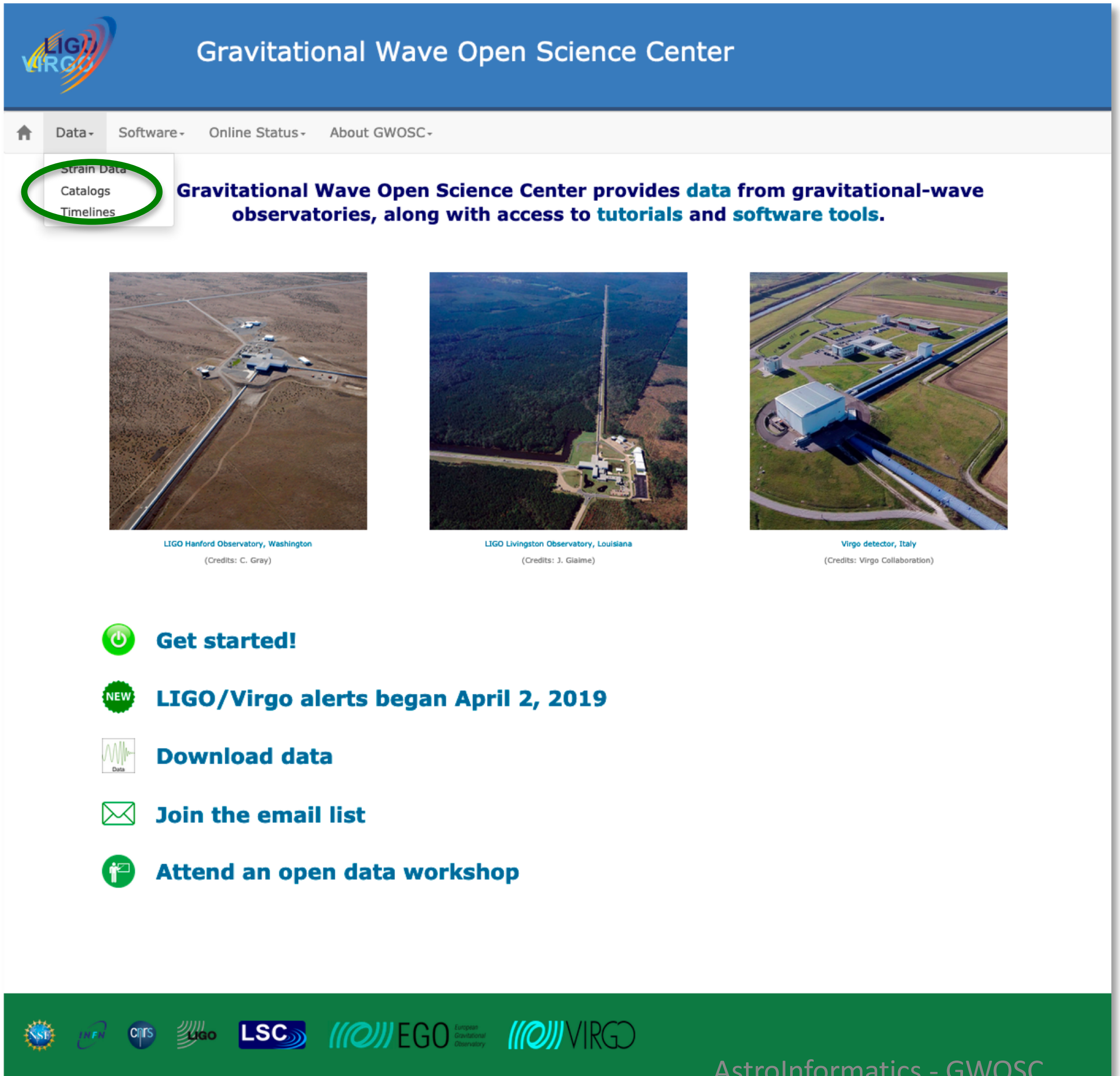


Bulk Downloads - use **CVM-FS**

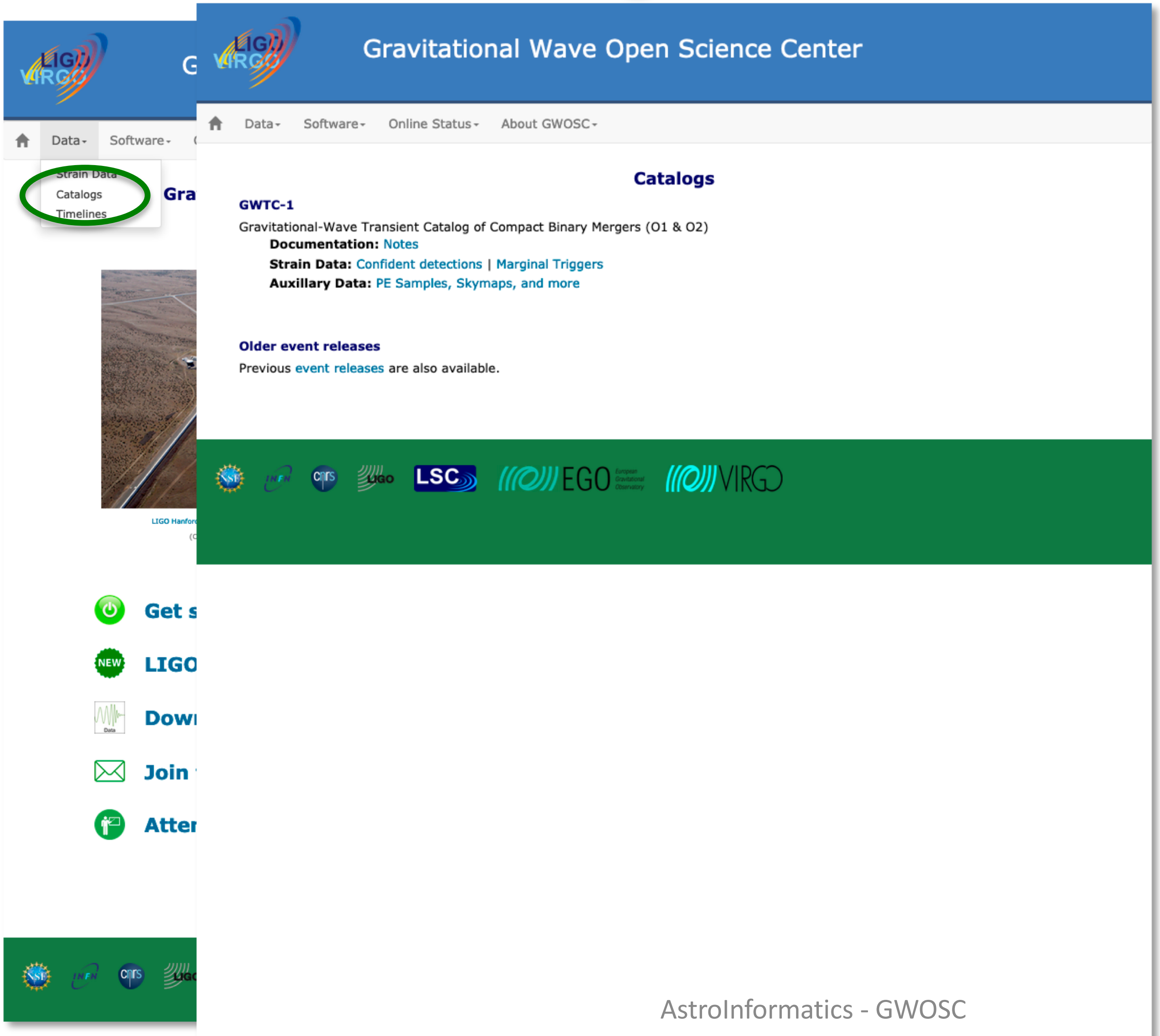


GW TRANSIENT CATALOGS …

Catalog Data: **GWTC-1**



Catalog Data: **GWTC-1**



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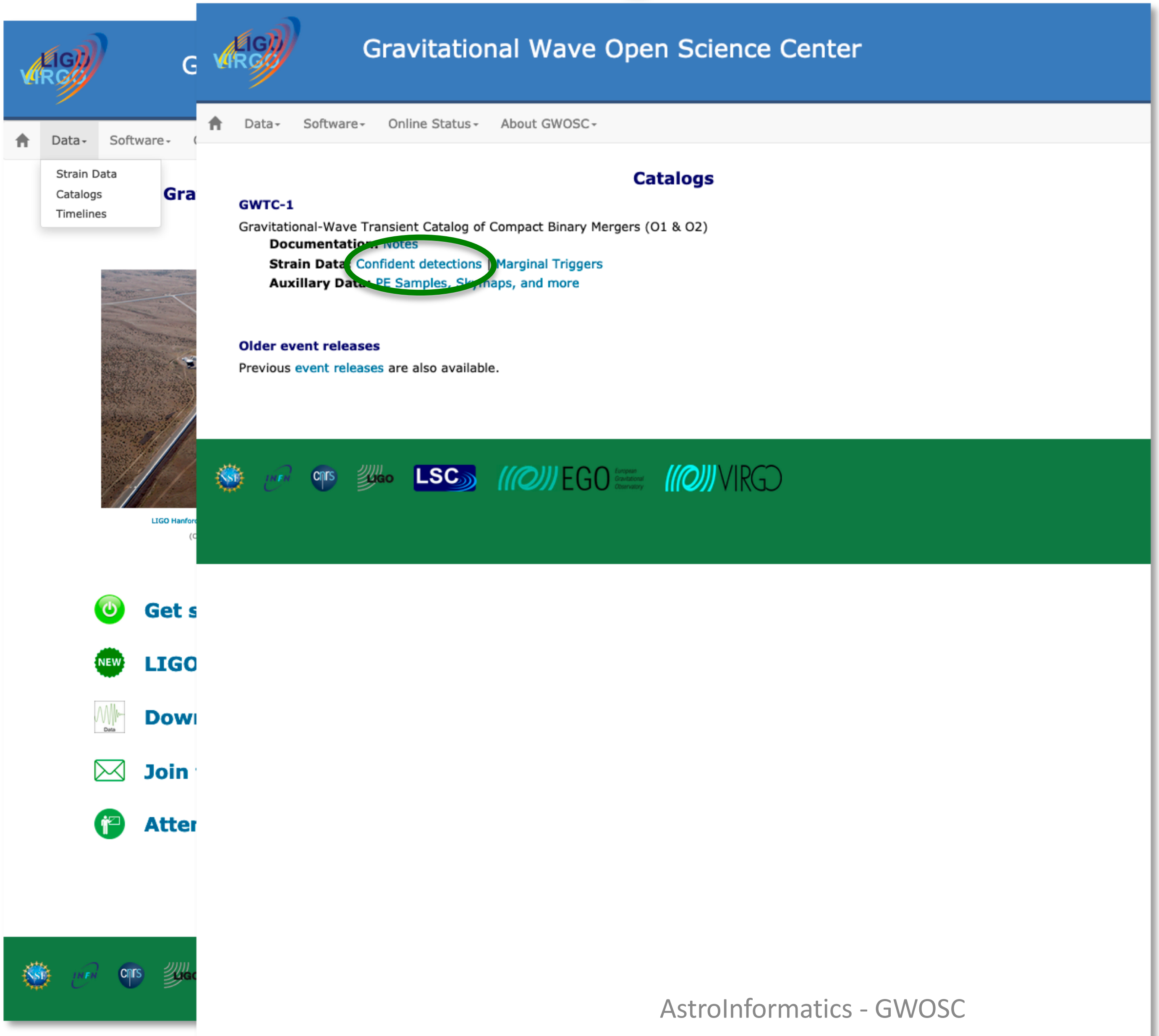
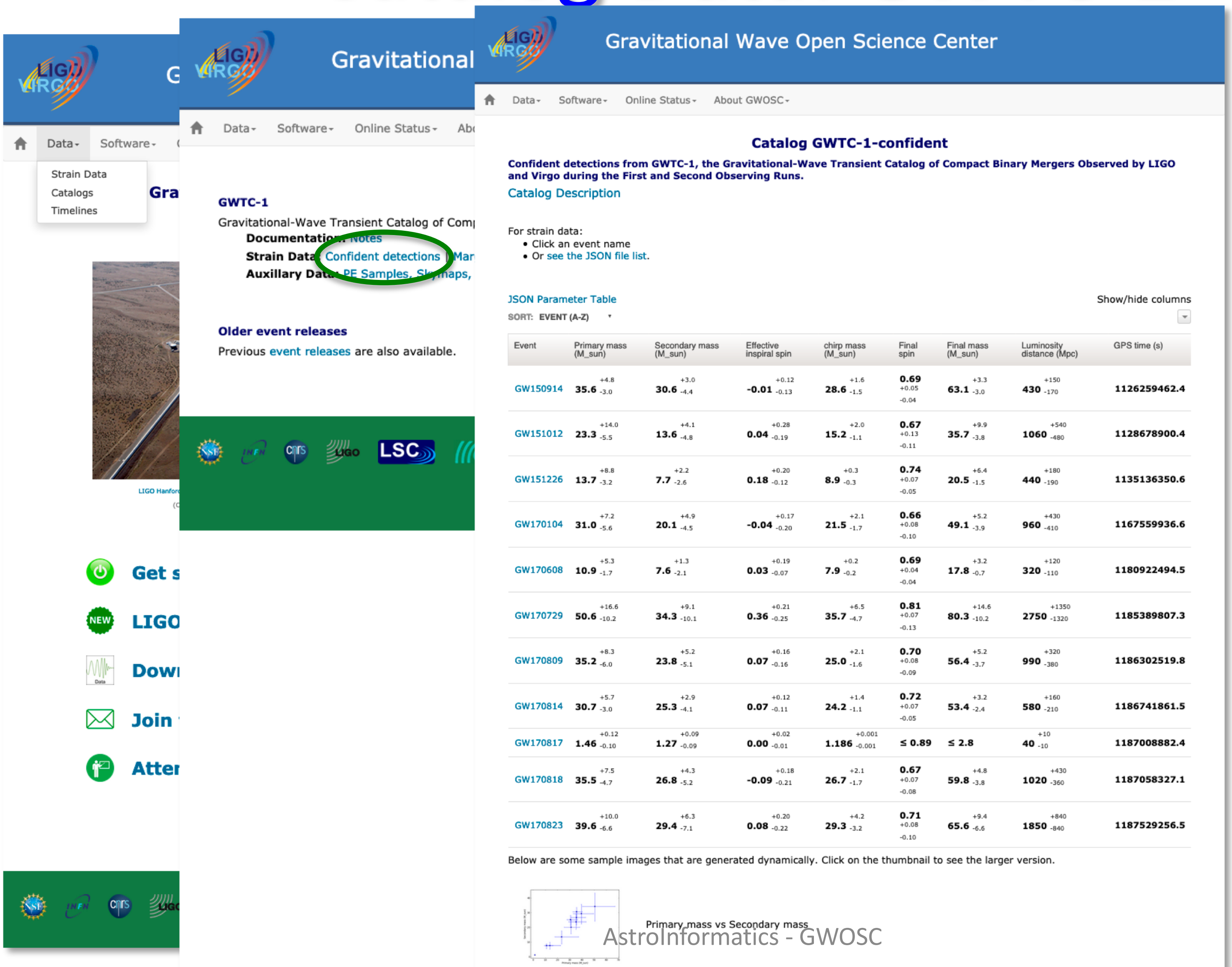
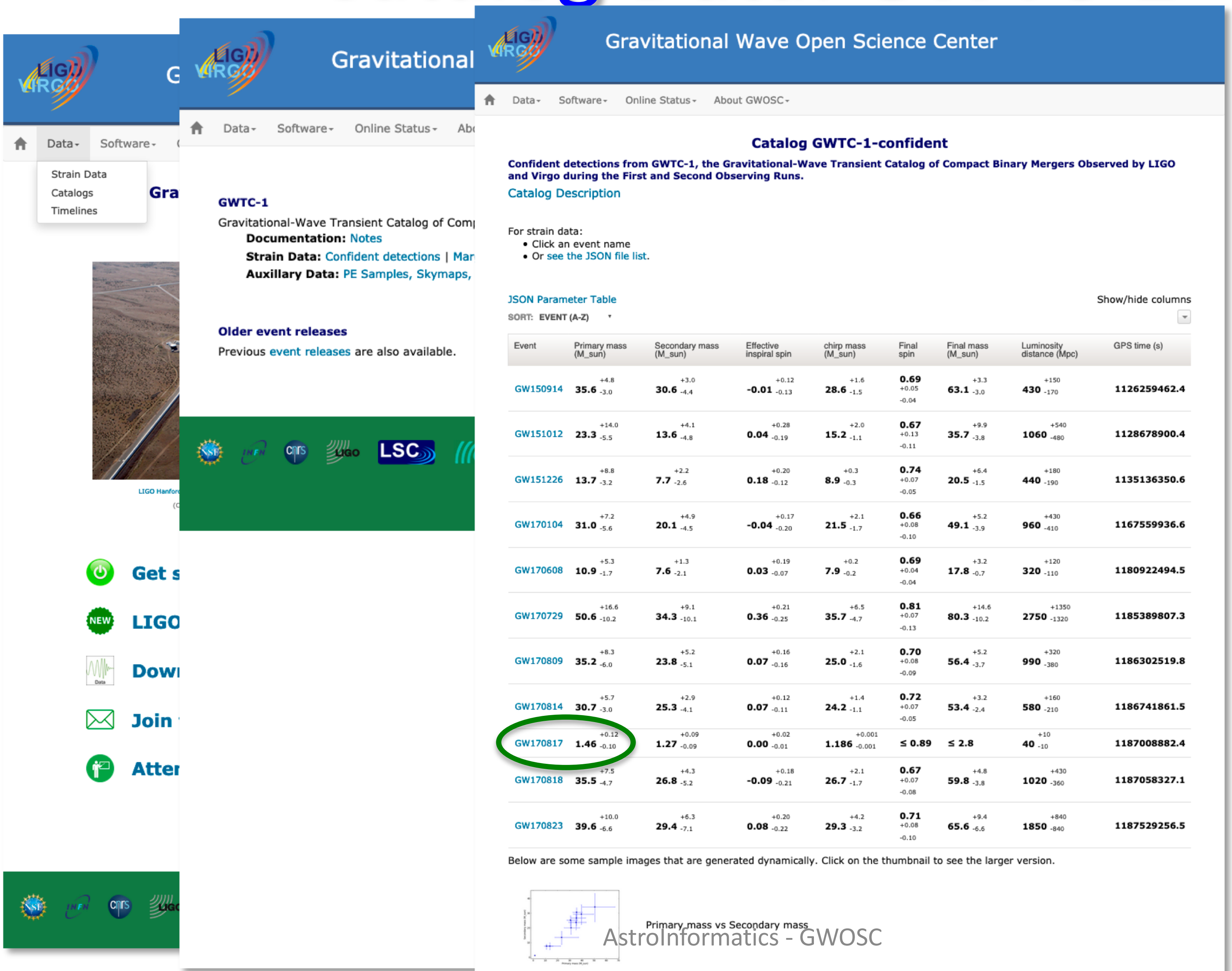


Catalog Data: **GWTC-1**



Event	Primary mass (M_sun)	Secondary mass (M_sun)	Effective inspiral spin	chirp mass (M_sun)	Final spin	Final mass (M_sun)	Luminosity distance (Mpc)	GPS time (s)
GW150914	$35.6^{+4.8}_{-3.0}$	$30.6^{+3.0}_{-4.4}$	$-0.01^{+0.12}_{-0.13}$	$28.6^{+1.6}_{-1.5}$	$0.69^{+0.05}_{-0.04}$	$63.1^{+3.3}_{-3.0}$	430^{+150}_{-170}	1126259462.4
GW151012	$23.3^{+14.0}_{-5.5}$	$13.6^{+4.1}_{-4.8}$	$0.04^{+0.28}_{-0.19}$	$15.2^{+2.0}_{-1.1}$	$0.67^{+0.13}_{-0.11}$	$35.7^{+9.9}_{-3.8}$	1060^{+540}_{-480}	1128678900.4
GW151226	$13.7^{+8.8}_{-3.2}$	$7.7^{+2.2}_{-2.6}$	$0.18^{+0.20}_{-0.12}$	$8.9^{+0.3}_{-0.3}$	$0.74^{+0.07}_{-0.05}$	$20.5^{+6.4}_{-1.5}$	440^{+180}_{-190}	1135136350.6
GW170104	$31.0^{+7.2}_{-5.6}$	$20.1^{+4.9}_{-4.5}$	$-0.04^{+0.17}_{-0.20}$	$21.5^{+2.1}_{-1.7}$	$0.66^{+0.08}_{-0.10}$	$49.1^{+5.2}_{-3.9}$	960^{+430}_{-410}	1167559936.6
GW170608	$10.9^{+5.3}_{-1.7}$	$7.6^{+1.3}_{-2.1}$	$0.03^{+0.19}_{-0.07}$	$7.9^{+0.2}_{-0.2}$	$0.69^{+0.04}_{-0.04}$	$17.8^{+3.2}_{-0.7}$	320^{+120}_{-110}	1180922494.5
GW170729	$50.6^{+16.6}_{-10.2}$	$34.3^{+9.1}_{-10.1}$	$0.36^{+0.21}_{-0.25}$	$35.7^{+6.5}_{-4.7}$	$0.81^{+0.07}_{-0.13}$	$80.3^{+14.6}_{-10.2}$	2750^{+1350}_{-1320}	1185389807.3
GW170809	$35.2^{+8.3}_{-6.0}$	$23.8^{+5.2}_{-5.1}$	$0.07^{+0.16}_{-0.16}$	$25.0^{+2.1}_{-1.6}$	$0.70^{+0.08}_{-0.09}$	$56.4^{+5.2}_{-3.7}$	990^{+320}_{-380}	1186302519.8
GW170814	$30.7^{+5.7}_{-3.0}$	$25.3^{+2.9}_{-4.1}$	$0.07^{+0.12}_{-0.11}$	$24.2^{+1.4}_{-1.1}$	$0.72^{+0.07}_{-0.05}$	$53.4^{+3.2}_{-2.4}$	580^{+160}_{-210}	1186741861.5
GW170817	$1.46^{+0.12}_{-0.10}$	$1.27^{+0.09}_{-0.09}$	$0.00^{+0.02}_{-0.01}$	$1.186^{+0.001}_{-0.001}$	≤ 0.89	≤ 2.8	40^{+10}_{-10}	1187008882.4
GW170818	$35.5^{+7.5}_{-4.7}$	$26.8^{+4.3}_{-5.2}$	$-0.09^{+0.18}_{-0.21}$	$26.7^{+2.1}_{-1.7}$	$0.67^{+0.07}_{-0.08}$	$59.8^{+4.8}_{-3.8}$	1020^{+430}_{-360}	1187058327.1
GW170823	$39.6^{+10.0}_{-6.6}$	$29.4^{+6.3}_{-7.1}$	$0.08^{+0.20}_{-0.22}$	$29.3^{+4.2}_{-3.2}$	$0.71^{+0.08}_{-0.10}$	$65.6^{+9.4}_{-6.6}$	1850^{+840}_{-840}	1187529256.5

Catalog Data: **GWTC-1**



Catalog GWTC-1-confident

Confident detections from GWTC-1, the Gravitational-Wave Transient Catalog of Compact Binary Mergers Observed by LIGO and Virgo during the First and Second Observing Runs.

Catalog Description

For strain data:
- Click an event name
- Or see the JSON file list.

JSON Parameter Table

Show/hide columns

SORT: EVENT (A-Z)

Event	Primary mass (M_sun)	Secondary mass (M_sun)	Effective inspiral spin	chirp mass (M_sun)	Final spin	Final mass (M_sun)	Luminosity distance (Mpc)	GPS time (s)
GW150914	$35.6^{+4.8}_{-3.0}$	$30.6^{+3.0}_{-4.4}$	$-0.01^{+0.12}_{-0.13}$	$28.6^{+1.6}_{-1.5}$	$0.69^{+0.05}_{-0.04}$	$63.1^{+3.3}_{-3.0}$	430^{+150}_{-170}	1126259462.4
GW151012	$23.3^{+14.0}_{-5.5}$	$13.6^{+4.1}_{-4.8}$	$0.04^{+0.28}_{-0.19}$	$15.2^{+2.0}_{-1.1}$	$0.67^{+0.13}_{-0.11}$	$35.7^{+9.9}_{-3.8}$	1060^{+540}_{-480}	1128678900.4
GW151226	$13.7^{+8.8}_{-3.2}$	$7.7^{+2.2}_{-2.6}$	$0.18^{+0.20}_{-0.12}$	$8.9^{+0.3}_{-0.3}$	$0.74^{+0.07}_{-0.05}$	$20.5^{+6.4}_{-1.5}$	440^{+180}_{-190}	1135136350.6
GW170104	$31.0^{+7.2}_{-5.6}$	$20.1^{+4.9}_{-4.5}$	$-0.04^{+0.17}_{-0.20}$	$21.5^{+2.1}_{-1.7}$	$0.66^{+0.08}_{-0.10}$	$49.1^{+5.2}_{-3.9}$	960^{+430}_{-410}	1167559936.6
GW170608	$10.9^{+5.3}_{-1.7}$	$7.6^{+1.3}_{-2.1}$	$0.03^{+0.19}_{-0.07}$	$7.9^{+0.2}_{-0.2}$	$0.69^{+0.04}_{-0.04}$	$17.8^{+3.2}_{-0.7}$	320^{+120}_{-110}	1180922494.5
GW170729	$50.6^{+16.6}_{-10.2}$	$34.3^{+9.1}_{-10.1}$	$0.36^{+0.21}_{-0.25}$	$35.7^{+6.5}_{-4.7}$	$0.81^{+0.07}_{-0.13}$	$80.3^{+14.6}_{-10.2}$	2750^{+1350}_{-1320}	1185389807.3
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GW170814	$30.7^{+5.7}_{-3.0}$	$25.3^{+2.9}_{-4.1}$	$0.07^{+0.12}_{-0.11}$	$24.2^{+1.4}_{-1.1}$	$0.72^{+0.07}_{-0.05}$	$53.4^{+3.2}_{-2.4}$	580^{+160}_{-210}	1186741861.5
GW170817	$1.46^{+0.12}_{-0.10}$	$1.27^{+0.09}_{-0.09}$	$0.00^{+0.02}_{-0.01}$	$1.186^{+0.001}_{-0.001}$	≤ 0.89	≤ 2.8	40^{+10}_{-10}	1187008882.4
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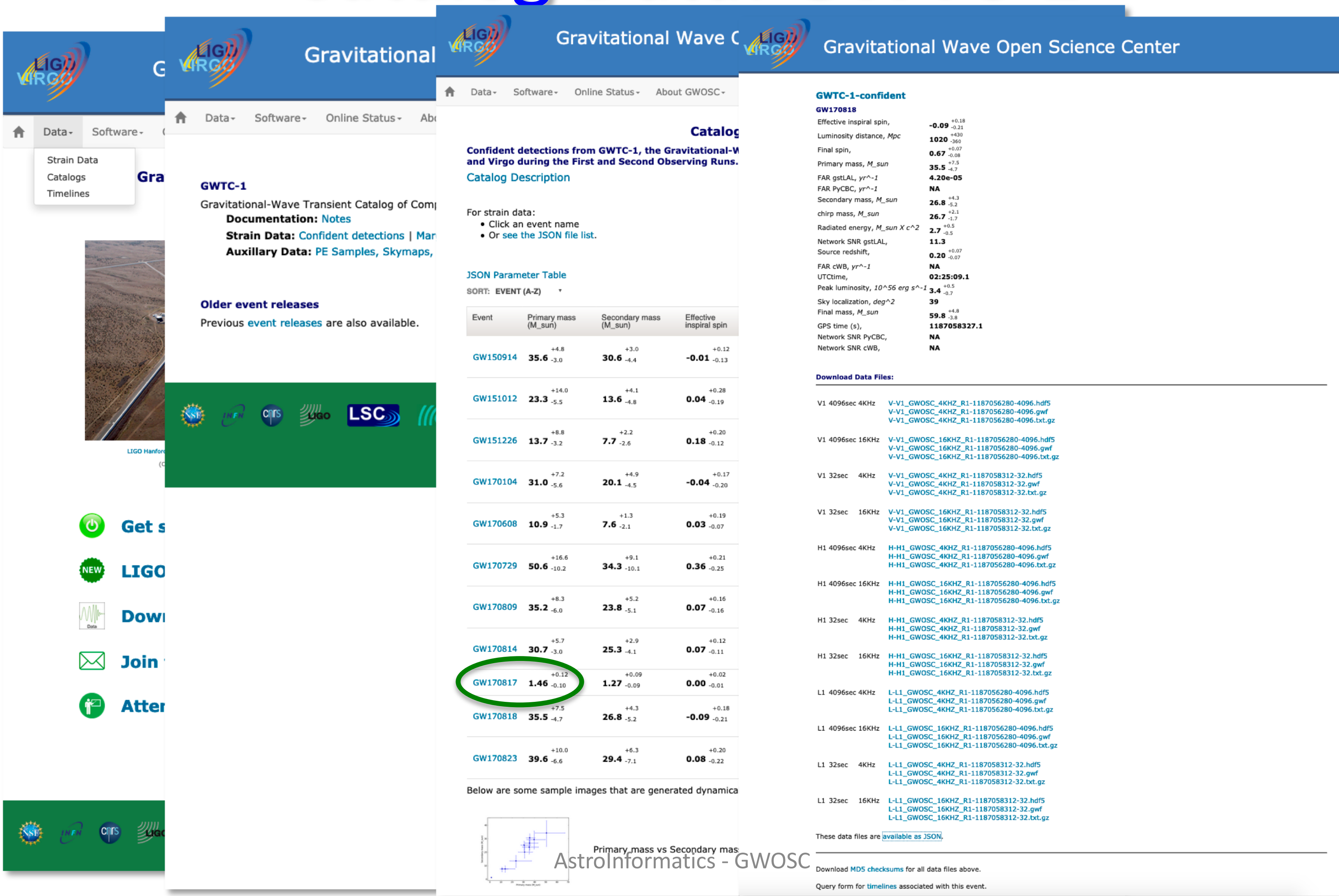
GW170823	$39.6^{+10.0}_{-6.6}$	$29.4^{+6.3}_{-7.1}$	$0.08^{+0.20}_{-0.22}$	$29.3^{+4.2}_{-3.2}$	$0.71^{+0.08}_{-0.10}$	$65.6^{+9.4}_{-6.6}$	1850^{+840}_{-840}	1187529256.5

Below are some sample images that are generated dynamically. Click on the thumbnail to see the larger version.

Primary mass vs Secondary mass

Catalog Data: **GWTC-1**



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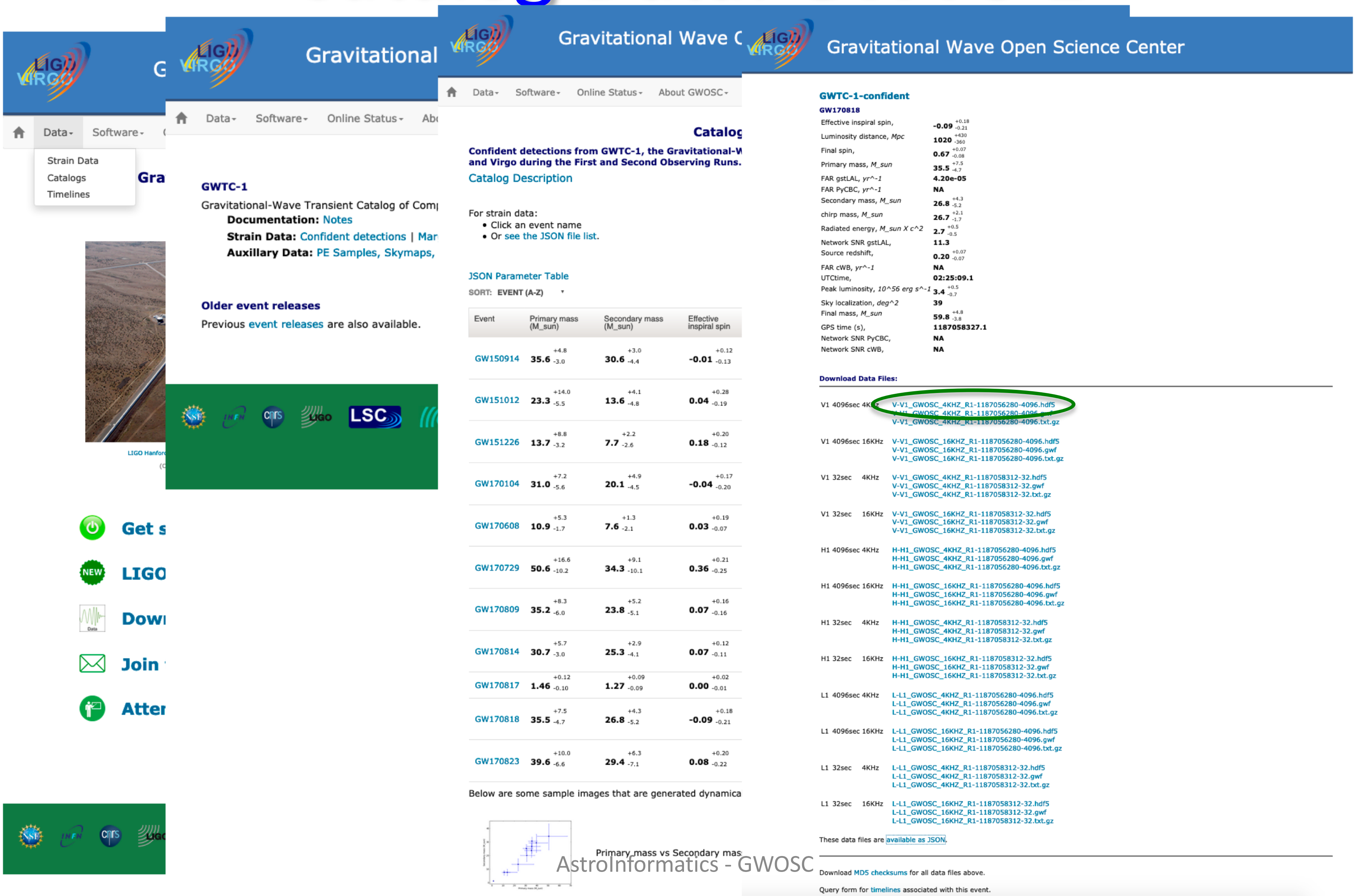

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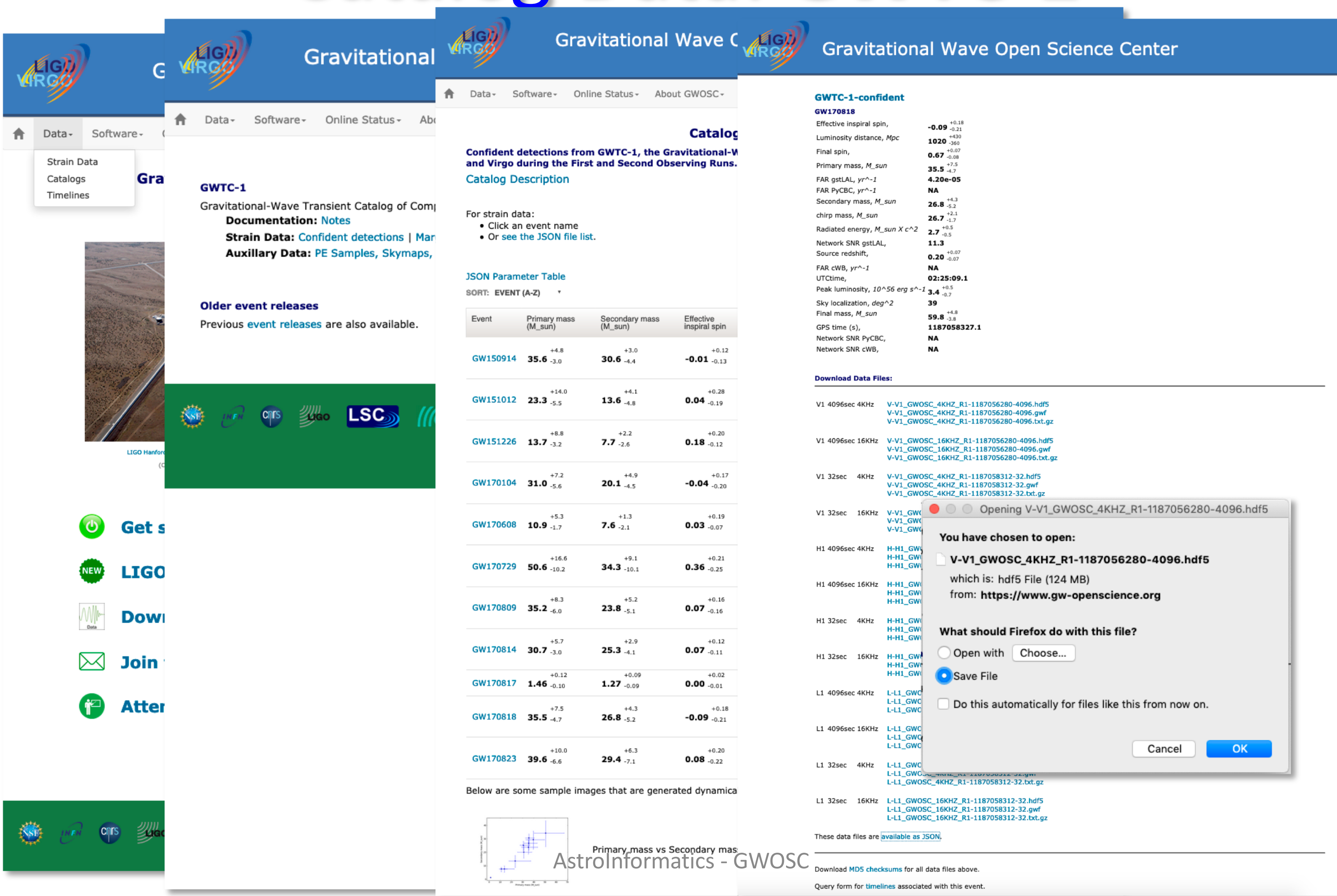

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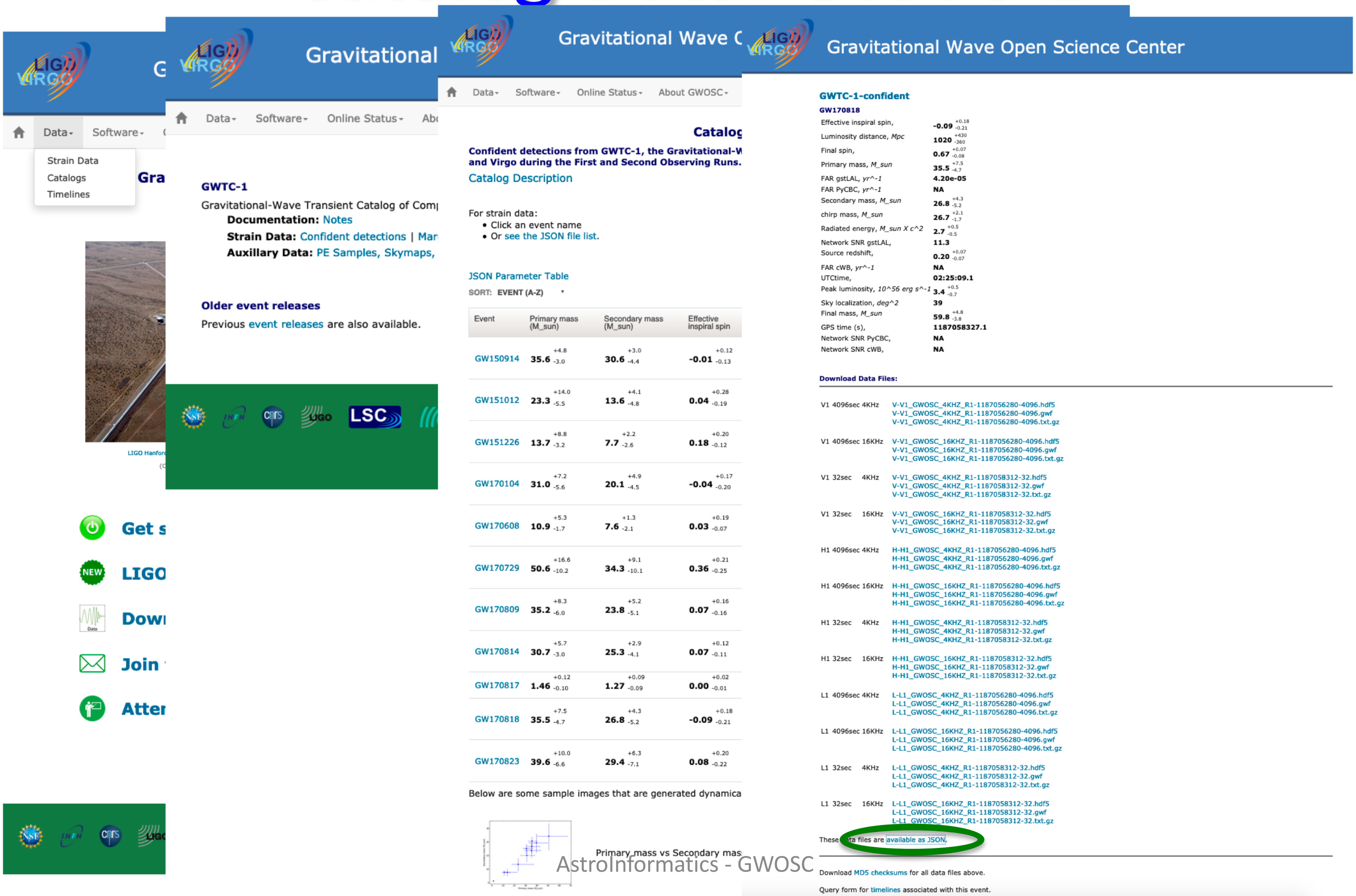

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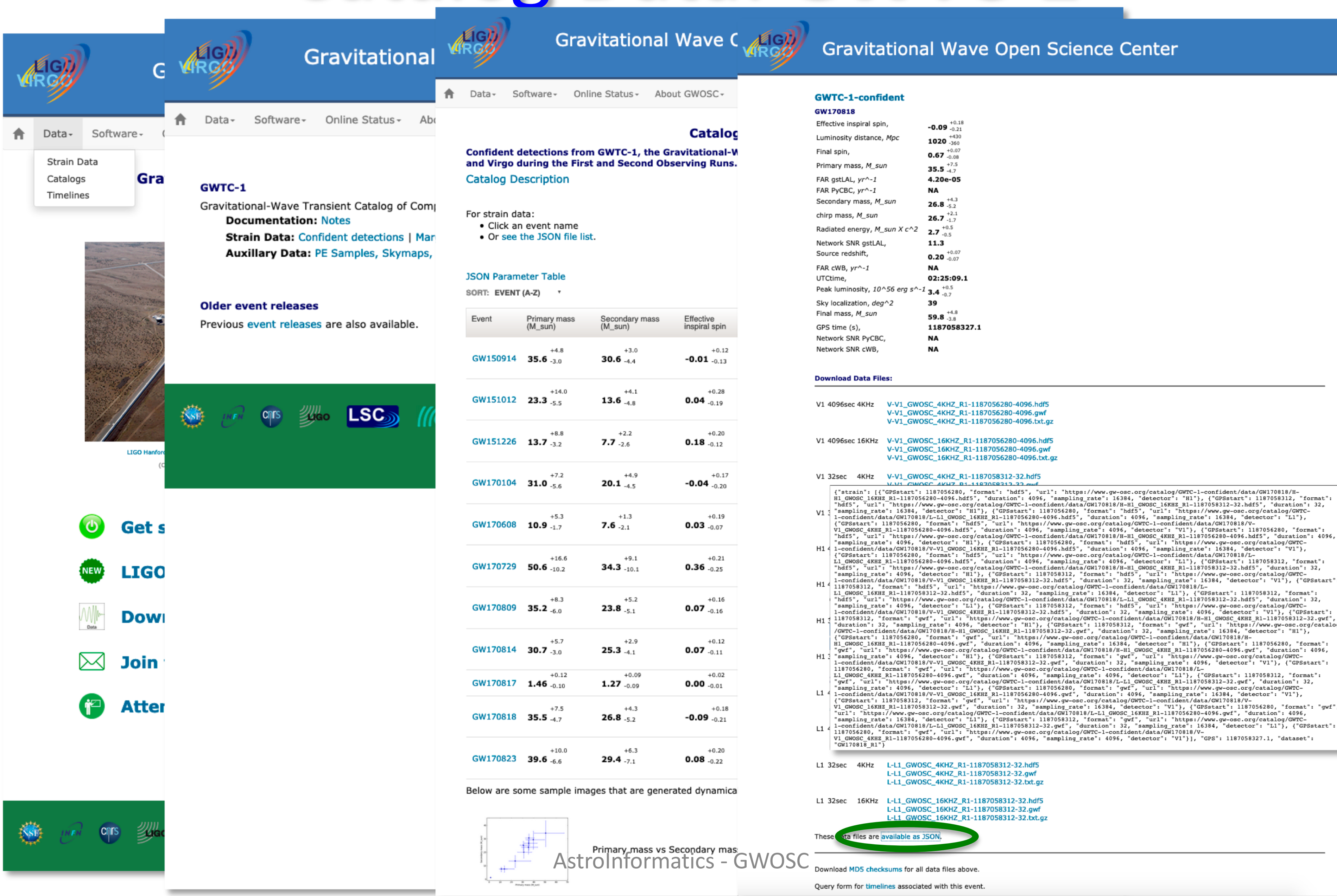
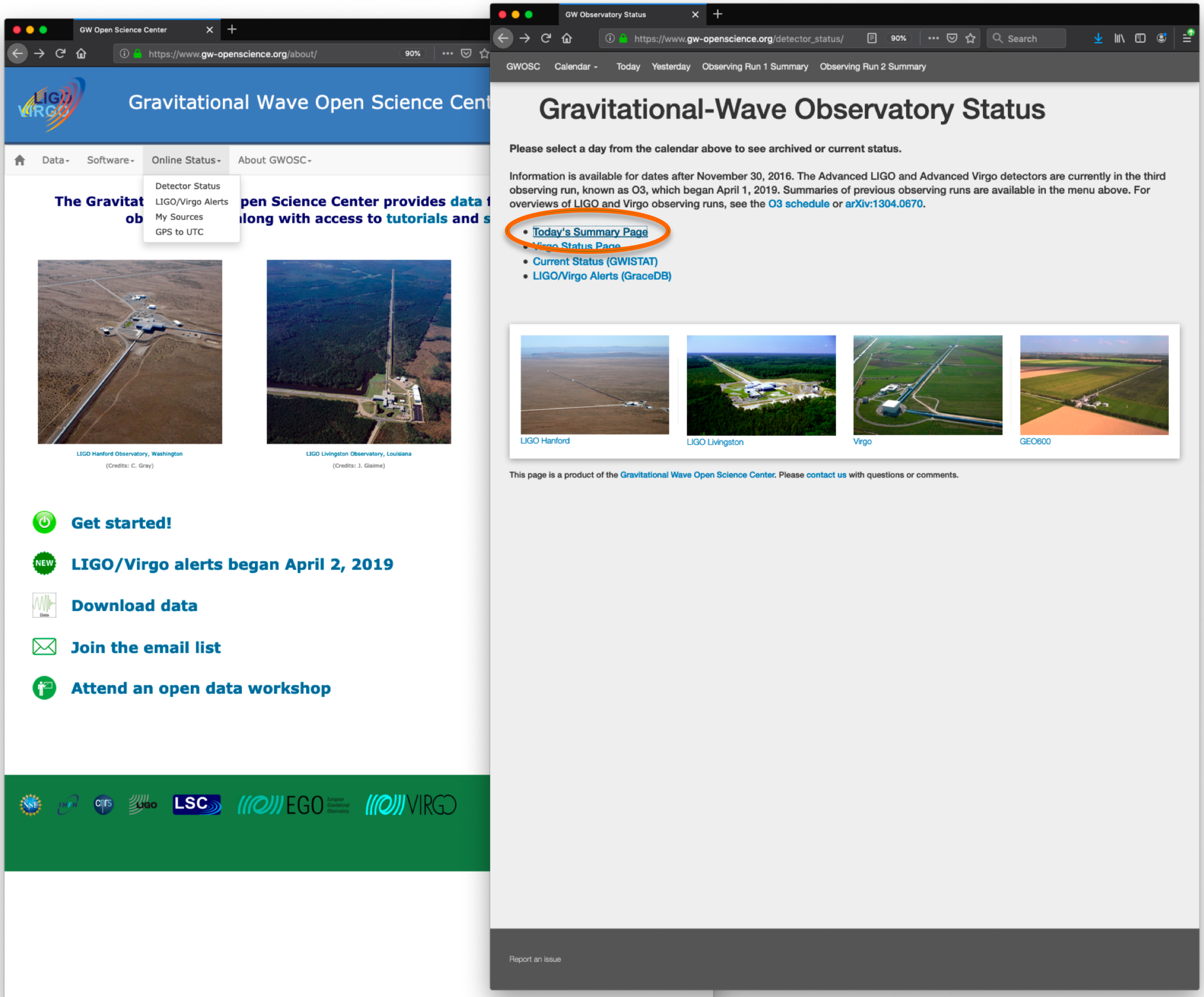


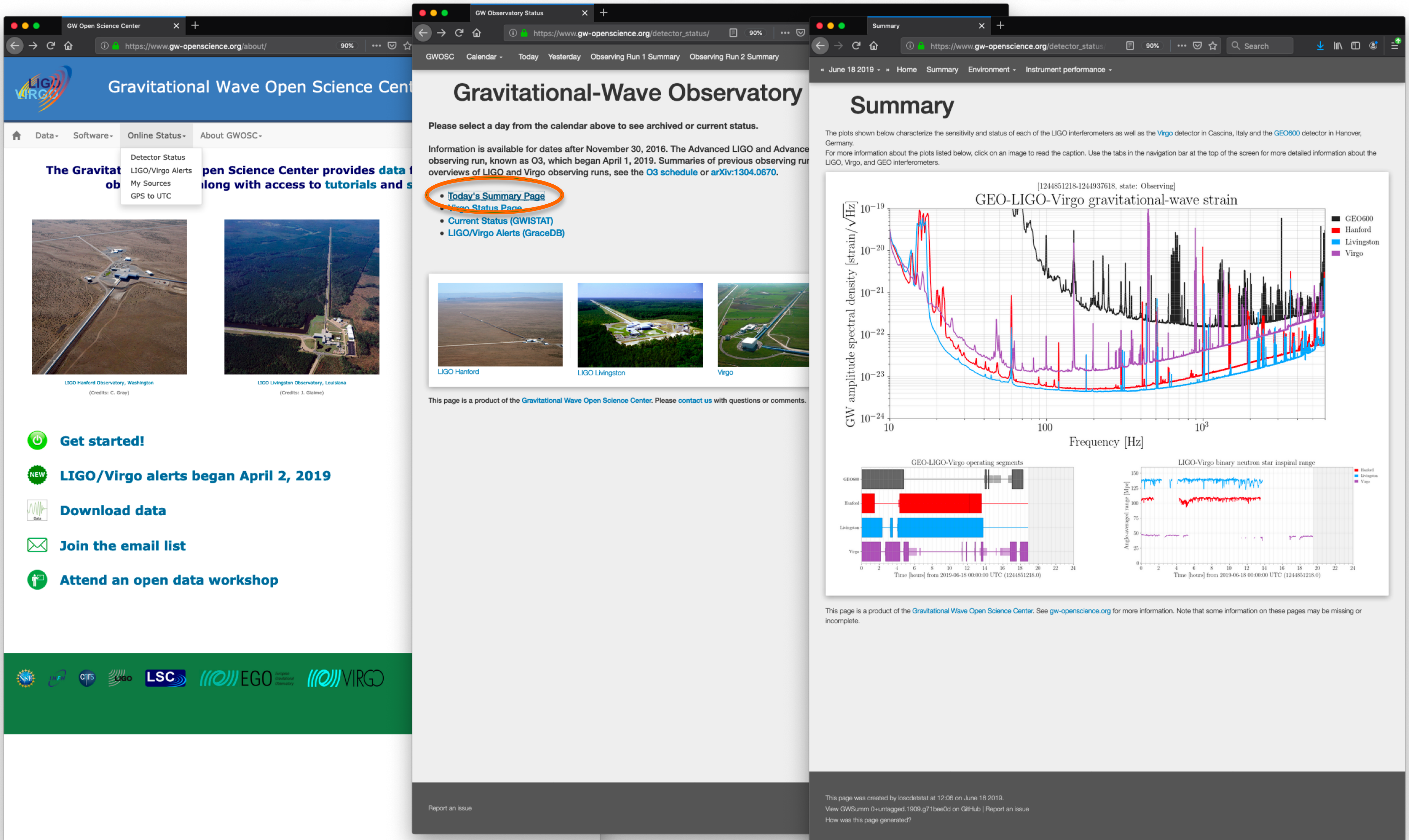
DETECTOR STATUS, SOFTWARE, TUTORIALS, PROJECTS, WORKSHOPS …

Current Detector Status

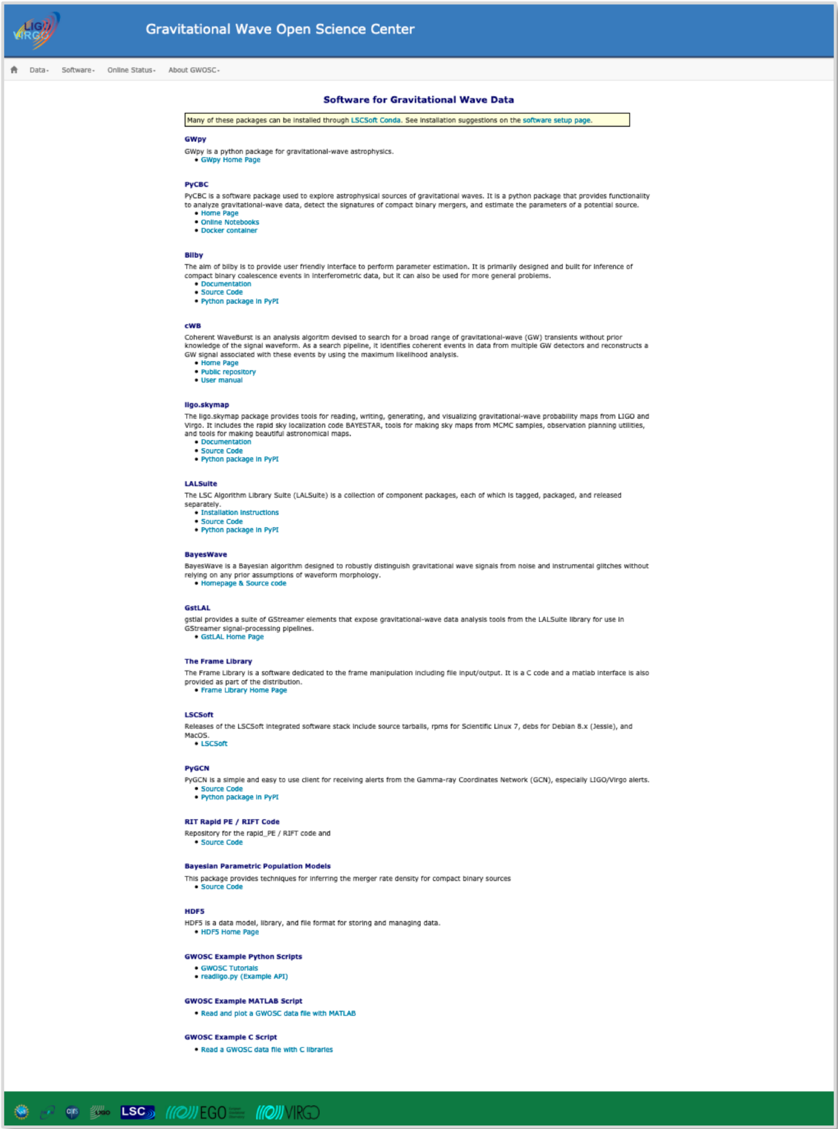
Current Detector Status

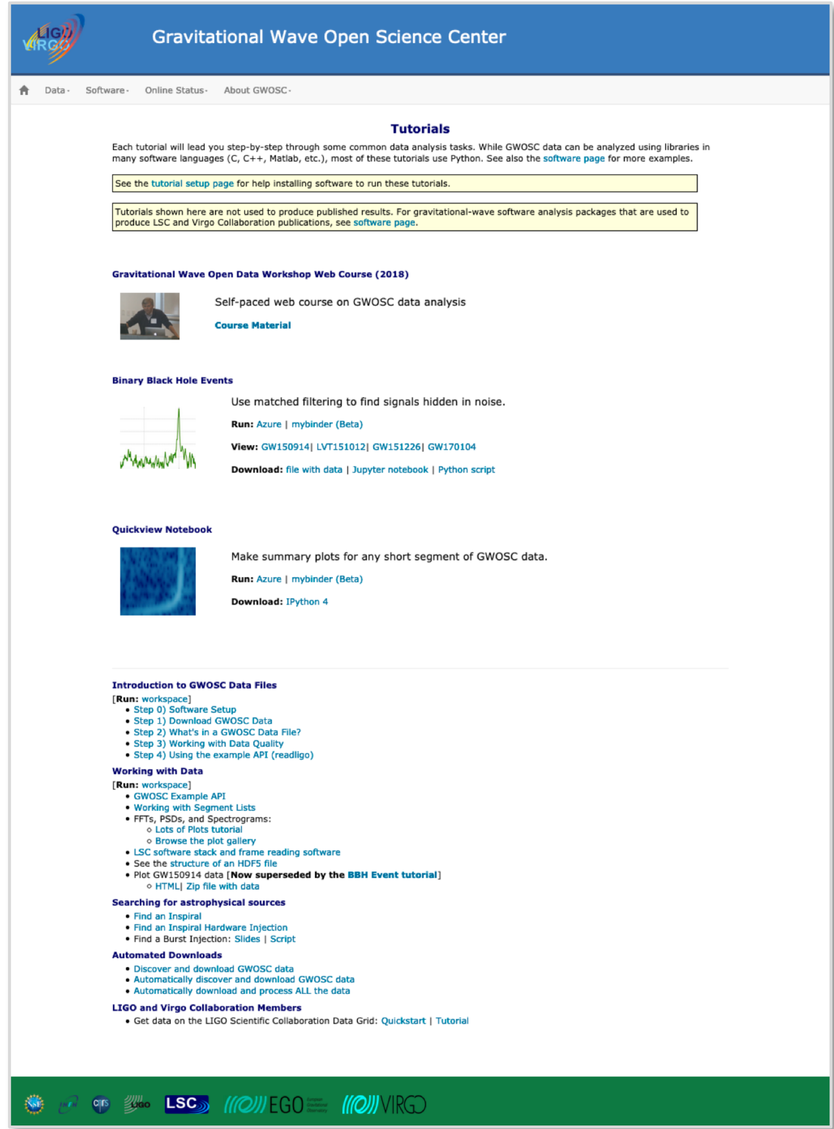


Current Detector Status



Software and Tutorials

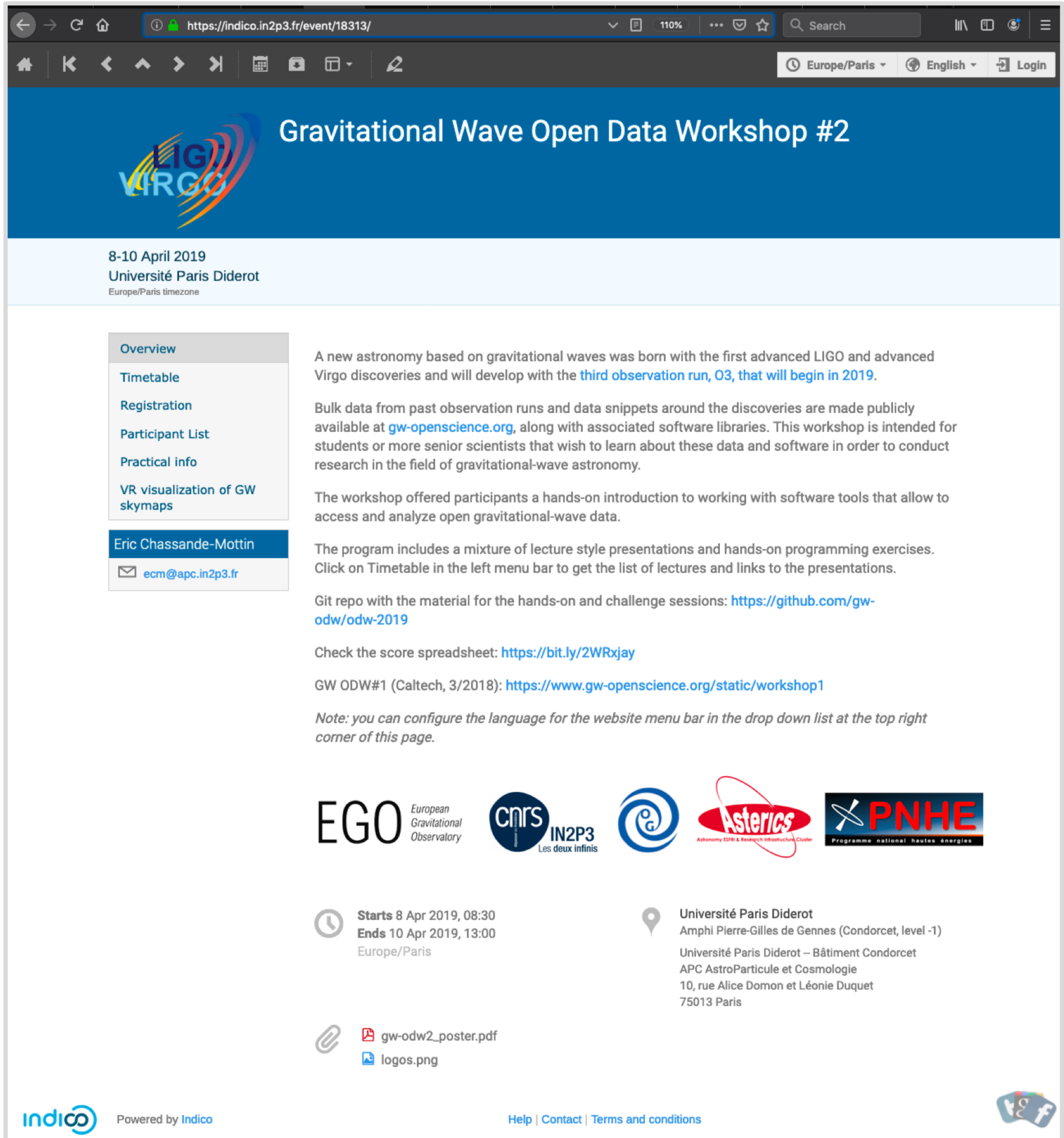




Projects with GWOSC Data

Yearly GWOSC Workshops

April, 2019: https://indico.in2p3.fr/event/18313 (Paris, France)



Looking towards the **Future**

- Current focus on releasing events as catalogs and bulk data associated with observation runs.
  - Catalogs are a new way of presenting data so we are still learning what's features to include.
  - First 6 months of O3 data slated for public release in April 2021.
- Specifics of what, when and how are moving targets driven by the collaboration.
- Constantly learning better ways to do things
  - Detection rates grow cubically with sensitivity … must meet the scale.
  - Existing technologies rapidly become outdated and require migration.
- Will continue to host workshops and improve tutorials and example code for users.

https://www.gw-openscience.org

THANK YOU!