

## The Challenges of a Public Data Release: behind the scenes of SDSS DR13

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**Abstract.** The Sloan Digital Sky Surveys (SDSS) have been collecting imaging and spectroscopic data since 1998. These data as well as their derived data products are made publicly available through regular data releases, of which the 13th took place summer 2016. Although public data releases can be challenging to manage, they significantly increase the impact of a survey, both scientifically and educationally.

### 1. Introduction

The Sloan Digital Sky Survey (SDSS) started observing in 1998, with the goal to image the Northern hemisphere in five optical wavelength bands (York et al. 2000), using the dedicated 2.5m Sloan Foundation Telescope (Gunn et al. 2006) at Apache Point Observatory (APO), New Mexico, US. Since then, SDSS has hosted several dedicated surveys, adding optical, infrared and integral-field spectroscopy to its original imaging survey (e.g. Eisenstein et al. 2011). The current SDSS-IV (Blanton et al. in prep) consists of three spectroscopic surveys: i) APOGEE-2 (Apache Point Observatory Galaxy Evolution Experiment), obtaining infrared spectra of stars to unravel the chemical and dynamical formation history of the Milky Way (Majewski et al. in prep), ii) MaNGA (Mapping Nearby Galaxies at APO), an integral-field spectroscopic survey to study the formation, growth and evolution of galaxies (Bundy et al. 2015), and iii) eBOSS (extended Baryon Oscillation Spectroscopic Survey), measuring redshifts of  $\sim 1.5$  million galaxies and quasars from optical spectra to map the structure of the Universe and determine its expansion history (Dawson et al. 2016). In 2017, SDSS will for the first time observe from the Southern hemisphere at Las Campanas Observatory (LCO), Chile, as part of APOGEE-2. The SDSS collaboration includes more than 50 member institutes spread over 4 continents, with close to 1000 scientists registered as members.

SDSS has from its beginnings been dedicated to making its data publicly available through data releases. The first early data release was made public in 2002 (Stoughton et al. 2002), and in summer 2016 the Thirteenth SDSS data release (DR13) became publicly available (Albareti et al. 2016). These public data releases have significantly

widened the impact of the SDSS beyond its collaborations: more than 7000 papers have been published based on SDSS data. The 2015 National Research Council report “Optimizing the U.S. Ground-Based Optical and Infrared Astronomy System” notes that within this US system the SDSS has a publication rate three times higher than any other telescope. In addition, SDSS data has been incorporated in various educational (e.g., Voyages<sup>1</sup>) and public engagement activities (e.g., Galaxy Zoo; Lintott et al. 2008). In the field of data science, SDSS public data releases have been cited as the most influential data source ahead of any other source in any field of science (Stalzer & Mentzel 2016). In this proceeding we discuss the mechanisms of an SDSS public data release, with a focus on the latest release - SDSS-IV’s DR13.

## 2. Data and Data Products

The main components of a data release are the data products. The raw SDSS data is transferred daily from APO to the Center for High Performance Computing (CHPC) at the University of Utah, where it is reduced by dedicated data reduction pipelines. Each survey within SDSS-IV has a survey data team that is responsible for this part of the process. Once the data is reduced and the relevant data products have been vetted by the survey data teams, they are copied to the Science Archive Server (SAS)<sup>2</sup> where they remain as proprietary data for the SDSS-IV collaboration, until they are incorporated in a public data release (average time scale  $\sim 1.5$  year).

The SAS offers a file-based system that allows for low-level bulk data access and off line analysis. The SAS can also be accessed through a specialised web application, to visualise spectra. In addition, the Catalog Archive Server (CAS)<sup>3</sup>, hosted at the Johns Hopkins University, offers Web browser-based graphical and SQL query interfaces to the catalog data that permit casual synchronous data retrieval (SkyServer; Szalay et al. 2002) as well as batch-mode server-side analysis (CasJobs; Li & Thakar 2008) with advanced capabilities like a server-side personal SQL database, data upload and data sharing via groups. There is also a command-line tool to submit CasJobs queries, and as of DR13, a jupyter notebook interface to retrieve catalog data from SkyServer and CasJobs within a docker container. Both the SAS and the CAS offer public data access, with the SAS hosting 267 TB of data products, as of DR13. All data releases are cumulative, in that they also contain data products from previous data releases. By accessing the latest SDSS data release, users will therefore always have access to all available SDSS public data.

## 3. Documentation

Making data publicly available is a necessary but not sufficient condition for generating impact: in addition, the data has to be *accessible*. Users need to know where to find the data, and how to work with the data. Documentation is essential, and each SDSS

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<sup>1</sup><http://voyages.sdss.org>

<sup>2</sup><http://data.sdss.org/sas>

<sup>3</sup><http://skyserver.sdss.org>

data product therefore has a detailed data model. Each data release is also described in detail in an accompanying data release paper (for DR13, see Albareti et al. 2016).

However, a public data release serves many different audiences. Although for astronomers familiar with the SDSS data format the data model may be sufficient, novel users and students require more documentation. The SDSS website<sup>4</sup> therefore offers a portal with more information on how to access the data (including links to the SAS, CAS and web application), as well as background information, links to technical papers, examples and tutorials. As teachers and instructors also use SDSS data in their classrooms, the website also offers links to education and public engagement activities. Finally, users can e-mail the SDSS helpdesk if they have any questions or encounter any problems when working with SDSS data.

#### **4. Data Release Management**

The SDSS-IV data team is led by the Science Archive Scientist, the Catalog Archive Scientist and the Data Release Coordinator. The latter is responsible for managing the data release and keeping it on schedule. Planning for a public data release typically starts one year in advance. First the data products are generated by the survey data teams, and vetted for quality control by the survey science teams. Once the data products are finalised, catalogs are generated and loaded into the CAS.

Most of the documentation is written during a one-week documentation workshop (“DocuFeest”), ~four months before the data release. Several members of the data team, the survey teams and the education and public engagement team meet to generate most of the website content, as well as a comprehensive draft of the data release paper. Descriptions and tutorials for new data products have to be added into the documentation hierarchy: for DR13 this meant a redesign of the website to include the new MaNGA survey. The website and paper are finalised in the weeks after the DocuFeest. Meeting in person has proved crucial for efficient writing of documentation, as both the website and paper require input from all teams across SDSS-IV, and communication is key.

As the date for the data release approaches, a plan is drafted for the announcement of the data release. SDSS-IV has a strong social media presence, with a general and survey-specific Twitter accounts, a Facebook page, and a blog aimed at the general public. For DR13, we issued a Facebook announcement and tweeted in almost all languages spoken within the collaboration (thanks to a team-wide effort to translate the tweets). A description of the content of DR13 was given in a multilingual blog post. Announcements were also issued over mailing lists aimed at professional astronomers.

#### **5. Conclusion**

The impact of an astronomical survey is set by the reach of its data distribution system. If the data does not reach the astronomers for their research projects to make new discoveries, the teachers to teach their students how to work with astronomical data, and the general public to increase their awareness of astronomy and science, then impact will be limited to a small core survey team. A successful public data release, especially

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<sup>4</sup><http://www.sdss.org/>

one aimed at a variety of end users, therefore needs to ensure that the data is not only freely available, but also clearly documented and in accessible formats.

Managing a public data release is challenging: it involves keeping track of a myriad of different data products and their documentation, which includes data models, descriptions and tutorials, all aimed at different user audiences. Quality control of both the data products and the documentation is crucial. Good communication between different teams within the collaboration is key, given that the data release requires input from everyone. But despite the challenges and work involved, public data releases are worthwhile: they increase the impact of the survey, allow for more science output beyond the collaboration, and provide accessible data products not only for astronomical research, but also for education and public engagement.

**Acknowledgments.** AW acknowledges support of a Leverhulme Trust Early Career Fellowship. The authors would like to thank the Center for Data Science at New York University for their hospitality during DocuFeest 2016. Funding for the Sloan Digital Sky Survey IV has been provided by the Alfred P. Sloan Foundation, the U.S. Department of Energy Office of Science, and the Participating Institutions. SDSS-IV acknowledges support and resources from the Center for High-Performance Computing at the University of Utah. The SDSS web site is [www.sdss.org](http://www.sdss.org). SDSS-IV is managed by the Astrophysical Research Consortium for the Participating Institutions of the SDSS Collaboration including the Brazilian Participation Group, the Carnegie Institution for Science, Carnegie Mellon University, the Chilean Participation Group, the French Participation Group, Harvard-Smithsonian Center for Astrophysics, Instituto de Astrofísica de Canarias, The Johns Hopkins University, Kavli Institute for the Physics and Mathematics of the Universe (IPMU) / University of Tokyo, Lawrence Berkeley National Laboratory, Leibniz Institut für Astrophysik Potsdam (AIP), Max-Planck-Institut für Astronomie (MPIA Heidelberg), Max-Planck-Institut für Astrophysik (MPA Garching), Max-Planck-Institut für Extraterrestrische Physik (MPE), National Astronomical Observatory of China, New Mexico State University, New York University, University of Notre Dame, Observatório Nacional / MCTI, The Ohio State University, Pennsylvania State University, Shanghai Astronomical Observatory, United Kingdom Participation Group, Universidad Nacional Autónoma de México, University of Arizona, University of Colorado Boulder, University of Oxford, University of Portsmouth, University of Utah, University of Virginia, University of Washington, University of Wisconsin, Vanderbilt University, and Yale University.

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