SDDS – An Automated System for Space Experiment Data Processing, Storage, and Distribution*

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The ultimate goal of research in space weather is to create complex operational magnetosphere-ionosphere models which allow predicting the radiation risk for space satellites in different orbits, and also estimating the occurrence risk of technological disasters due to magnetic storms and charged particle precipitation. The solution to this problem is to collect all relevant space-related data sets acquired by multiple satellites of various purposes and capabilities as well as ground stations and develop the operational services that use space weather models and collected data to produce forecasts.

There are several centers around the world which provide such kind of services: Space Monitoring Data Center (SMDC) of SINP MSU [1], Space Weather Prediction Center (SWPC / NOAA) [2], iNTEGRATED Space Weather Analysis System (iSWA) [3], and Space Situation Awareness (SSA) Space Weather Service Network [4]. Besides space missions such as GOES, POES, SDO, ACE, STEREO which are used as the primary data source, Space Monitoring Data Center of SINP MSU is using also the data from Russian satellites such as Electro-L, Meteor-M, and Lomonosov. Each center provide access to satellite data, space weather models, and forecasts online through their websites. Data is available through either an FTP server or an HTTP server. However, each center provides analyses based only on its own data set and its own set of implemented operational models. Each set of data and models of a center is unique in its own way, but it only shows a part of the whole picture of space weather. There is no possibility to automatically compare real-time data obtained from satellites at similar orbits collected at different centers, furthermore, to apply a third-party space weather model to domestic data. It is possible to customize a provided model to suit our needs, but this possibility is limited by the functionalities of the web interfaces. Currently, the only way to overcome all these difficulties is to manually download data to a local computer, convert it into a proper format, and then feed it to an operational model. Such task is challenging and time-consuming because data formats, storage methods, datasets and values of registered factors differ between satellites. There is a high demand for creating an automated system for collecting data from various satellites, converting it to a unified canonical form and making it available in a standardized machine-readable format. Such system should provide correctly processed data and a unified access form to the data either by a web interface or API, thus allow physicists to focus on building their models and forecasts.

To solve the problem described above a system for space experiment data processing, storage, and distribution called SDDS has been created at SINP MSU. The system automatically connects to different data storage servers of various satellites, downloads real-time data whenever available, decodes binary telemetry, processes decoded data and stores it in a unified archive. SDDS supports the following protocols: FTP, HTTP(S), and FTP/HTTP(S) over IPsec or PPTP. SDDS has been tested in production with real scenarios. During 12 months of operation, SDDS has demonstrated its effectiveness and stability. At the moment of writing, SDDS is used at SMDC SINP MSU as the main data provider for space weather operational models. SDDS monitors all stages of work in each data processing cycle of each satellite in real-time and shows them on a web interface. When an error occurs in any stage of data processing, it will be shown immediately on the web interface and sent to operators. It is one of the most important features of SDDS that help us identify errors in data processing quickly, hence fix them in the future and prevent incorrect data to be used in forecasts. Another important feature of SDDS is its data access API. One can retrieve satellite data either locally using the Python library or remotely using the RESTful API with JSON used as the data exchange format. Based on the SDDS's API several space weather web services. Two important ones are Data Access, which allows users to retrieve combined data from different satellites in one data file, and Data Constructor, which allows users to compose customized charts using data provided by SDDS.

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Currently, satellites are processed in parallel, but the data processing cycle of a satellite is a sequential synchronous process. To improve the performance of SDDS, we're going to redesign the architecture of SDDS to imply the task level parallelism: each work of the cycle of data processing will be treated as a task and tasks will be distributed over all available computing nodes. Moreover, tasks will be distributed in an asynchronous event-driven manner to reduce the idle time of computing nodes between them. Within a task, the same instructions are applied on multiple data (SIMD), so to improve the performance further, we will use the CUDA technology to map the computation to GPU.

References

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