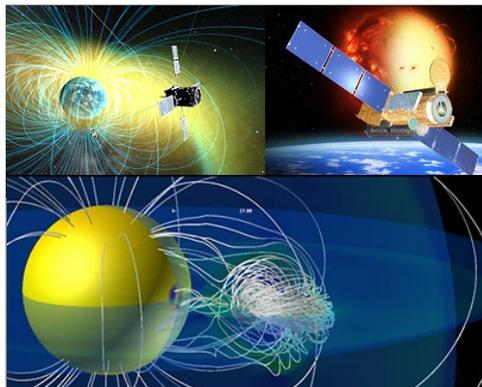


## Center for Integrated Data Science (CIDAS)



- Hinode Science Center
- ERG Science Center
- Research and development of advanced simulations (SUSANOO, CReSS, Monte Carlo simulations for high-precision age calculations)
- Construction of various databases (IUGONET, WDS-CR)
- Operation of CIDAS supercomputer system
- Membership activity of HPCI consortium

The Center for Integrated Data Science (CIDAS) aimed to construct infrastructure and conduct research and development to perform a cutting-edge scientific study of the space–Earth environmental system through integrated analyses using various observational data and advanced computer simulations. CIDAS operates many projects in cooperation with ISEE research divisions and centers and other universities and institutes.

### Science centers for space missions: Hinode and ERG

The Hinode Science Center is operated as a joint project with the NAOJ and developed a database and analytical environment for the data provided by the Japanese solar observation satellite Hinode, and plays an important role in considering the research topics of oncoming solar missions such as Solar-C EUVST. In addition, the ERG Science Center operates as a joint research center in cooperation with the ISAS/JAXA, which releases data files from ERG (Arase) and ground-based observations. The ERG Science Center also develops the data analysis software. The CIDAS computer system was used for the data analysis environment for the Hinode and ERG projects.

### Cooperative research program for database construction and supercomputing

CIDAS produces various databases for space–Earth environmental research and provides supercomputing facilities in collaboration with the Information Technology Center of Nagoya University and other universities and institutes. CIDAS mints DOIs for ISEE research data to ensure permanent accessibility and promote the reusability of the data. CIDAS has also joined the inter-university network project (Inter-university Upper atmosphere Global Observation NETwork: IUGONET) with Tohoku University, NIPR, Kyoto University, Kyushu University, and Nagoya University to develop a metadata server and data analysis software. CIDAS is responsible for activities in ISEE as a member of the High-Performance Computing Infrastructure Consortium (HPCI) in Japan.

### Research and development of advanced simulations

CIDAS plays a leading role in researching and developing the following advanced computer simulation models: Space Weather Forecast Usable System Anchored by Numerical Operations and Observations (SUSANOO), CReSS, and Monte Carlo simulations for accurate Th-U-Pb dating. The CReSS model was designed for all types of parallel computers to simulate the detailed structure of clouds and storms. CReSS is free to use for the scientific community. It has been used for meteorological research and real-time weather forecast experiments, such as simulation experiments of tropical cyclones, heavy rainfall events, snow clouds, tornados, and downscaling experiments of future tropical cyclones.

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## Main Activities in FY2020

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### Development of a data analysis system for the ERG (Arase) project

Scientific data from the ERG (Arase) satellite, ground-network observations, and modeling/simulations were archived at the ERG Science Center, which is operated by ISAS/JAXA and ISEE/Nagoya University. The format of these data files is CDF, and includes the metadata of each file. This is a de facto format in the solar–terrestrial physics community. The Space Physics Environment Data Analysis System (SPEDAS), a commonly used software in the solar–terrestrial physics community, can easily read and manipulate CDF files. The ERG Science Center has developed CDF files and SPEDAS plug-in software for the ERG project. We also joined the International Heliosphere Data Environment Alliance to discuss common data formats in the international framework. The ERG Science Center has organized training sessions for SPEDAS in Japan and Taiwan, providing important opportunities to learn to use SPEDAS and ERG data. The ERG Science Center is also developing a data analysis environment for the CIDAS system. Users can access the CIDAS system via the internet and analyze ERG project data using SPEDAS (<https://ergsc.isee.nagoya-u.ac.jp/research/index.shtml.en>).

### Energy-consistent finite difference schemes for compressible (magneto-)hydrodynamics

When the magnetic or kinetic energies overwhelm the internal energy of the plasma, numerical simulations of the (magneto-)hydrodynamic equations become strongly unstable, sometimes causing unphysical solutions. Unfortunately, such situations can be found all over the universe, for example, in the solar atmosphere above sunspots. A new finite difference formulation has been proposed to overcome this difficulty, focusing on the consistency among the internal, kinetic, and magnetic energy equations in the discrete sense. Traditionally, the total energy equation is solved. The time variation of the internal energy was calculated by subtracting the kinetic and magnetic energies from the total energy. However, the resultant internal energy can be erroneous from the discretization error in stringent situations, such as the solar corona. In this study, the discrete versions of the product rule were effectively used to implicitly satisfy the internal, magnetic, and kinetic energy equations without directly solving them. The resultant formulation was implemented as spatial second- and fifth-order schemes. The numerical tests showed the extremely high robustness of these schemes for most stringent problems under high Mach number and low plasma beta conditions (Iijima, 2021, *Journal of Computational Physics*).

### Activity of IUGONET

IUGONET has been promoting the use and application of upper atmospheric observation data by providing database and analysis tools in collaboration with other institutions (e.g., the Research Organization of Information and Systems (ROIS)) and has been developing a foundation for a universal infrastructure to disclose and cite data. IUGONET has held several international data analysis workshops in collaboration with several international organizations, such as SCOSTEP and the World Data System (WDS) affiliated with the International Science Council (ISC) and supported the construction of infrastructure for disclosing data and data integrity (<http://www.iugonet.org/>).

### Operation of the CIDAS supercomputer system

A new computer system for integrated data analysis (CIDAS computer system) was installed on April 2021. The system consists of 16 compute nodes, each of which has two Intel Xeon Gold 6230R CPUs and 384 GiB memory. In FY2020, 190 researchers/students were registered as users of the CIDAS supercomputer system. Data analyses related to the Hinode Science Center and ERG/Arase Science Center and computer simulation studies were conducted.

### Development of the CReSS model

The CReSS model was developed and improved for physical processes. It is available for scientific research from CIDAS. The CReSS model was used for the simulation experiments and daily weather forecasts. The simulated daily forecast data were openly available from the meteorological laboratory website. CIDAS also plans to make available the simulation output data from the CReSS model.