ACE Data from the ACE Science Center

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Abstract

The purpose of the ACE Science Center (ASC) is to perform level 1 processing of data from the nine science instruments aboard the Advanced Composition Explorer (ACE) spacecraft and to facilitate access to all ACE data by both the instrument investigators and the space physics community. We describe the ACE data products available from the ASC and the methods by which users may access the data.

1 Introduction

ACE measures the elemental, isotopic, and ionic charge-state composition of energetic nuclei in interplanetary space, at energies ranging from ∼1 keV/nucleon (solar wind) to ∼0.5 GeV/nucleon (cosmic radiation), including ions accelerated in the Sun, in interplanetary space, at the edge of the heliosphere, and in the galaxy. In addition, solar wind and magnetic field parameters, and electrons from solar wind energies up to ∼300keV are measured. These measurements are being made from orbit about the L1 Lagrangian point, ∼0.01 astronomical units sunward of the Earth. The spacecraft was launched successfully on August 25th, 1997. ACE includes six high-resolution spectrometers and three monitoring instruments that characterize the environment in which a given composition measurement is made. The mission, the spacecraft, each of the nine instruments, and the Science Center are described in detail in a special issue of *Space Science Reviews* (Russell et al. 1998).

The following sections describe the flow of the data from the spacecraft to the scientific community, the contents of the data available from the ASC, the methods by which users may access the data, and plans for long-term archiving of the ACE data.

2 Data Processing

Science data from the spacecraft flows from NASA to the ASC where it undergoes level 1 processing, in which the data from each instrument are decompressed, formatted, and supplemented with ancillary data, including spacecraft ephemeris data and onboard clock calibrations. The level 1 data are then distributed by the ASC to the instrument teams and to the National Space Science Data Center (NSSDC) for archiving. Generally, the data are less than 1 week old by this time. These level 1 data are not likely to be useful to the general community, since significant higher-level processing by the instrument teams is required.

In parallel with the level 1 processing, the ASC produces browse parameters, a subset of ACE measurements which allow monitoring of the solar wind and large-scale particle and magnetic field behavior. They also allow the selection of time intervals of particular interest for more intensive study. Since it is considered important to distribute first-order ACE results as soon as possible, the browse parameters are delivered to the public domain immediately, at the expense of full verification. The ACE browse parameters are described in detail in Garrard et al. (1998). They are available from the ASC web site http://www.srl.caltech.edu/ACE/ASC and are also being incorporated into the International Solar Terrestrial Physics (ISTP) Key Parameter dataset, available from http://cdaweb.gsfc.nasa.gov.

The ASC also coordinates the archiving and distribution of the level 2 data produced by the instrument teams from the level 1 data. Level 2 processing includes such operations as application of calibration data and detector response maps, organization of data into appropriate energy and time bins, and conversion of vector data to useful coordinate systems using the spacecraft ephemeris data.

Each instrument team is required to deliver level 2 data back to the ASC, which then makes the data available to the other instrument teams, the space physics community (as required by NASA), and the NSSDC for archiving. Once the instrument teams have had time to evaluate the performance of their instruments, and

develop and gain confidence in their level 2 production software, roughly a three month lag time is expected between their receipt of level 1 data and delivery of level 2 data back to the ASC. However, the level 2 dataset is intended to be evolutionary, in the sense that an instrument team may enhance their level 2 data with additional products in the future, as the sophistication of their analysis increases. The quality of ACE level 2 data is such that it is suitable for serious scientific study.

3 Data Available to the Scientific Community

ACE level 2 data include galactic cosmic ray, anomalous cosmic ray, and solar energetic particle fluxes, and solar wind and interplanetary magnetic field parameters. Examples of the types of measurements available in the level 2 data are shown in Figure 1. Hourly, daily, and Bartels rotation averages of the data from each instrument are available. (A Bartels rotation corresponds roughly to a solar rotation period.) In addition, higher time resolution data are available from some of the instruments, as described below. Instrument acronyms are defined in Stone et al. (1998). Note that the instrument teams may elect to add new data items to the level 2 data in the future.

3.1 CRIS Data: Galactic cosmic ray fluxes for 24 elements (B to Ni), in seven energy bands. For B, these seven energy bands span the range 49–173 MeV/nuc, while for Ni the energy range is 131–498 MeV/nuc.

3.2 EPAM Data: Solar ion and electron fluxes from five telescope apertures of three different types:
LEMS30: Ions at 30° from the spacecraft spin axis, in eight energy bands in the range 0.047–4.75 MeV.
DE30: Electrons at 30° from the spacecraft spin axis, in eight energy bands in the range 0.038–0.315 MeV.
CA60: Fluxes of He, CNO, and Fe, at 60° from the spacecraft axis, in two energy bands. For He, the energy bands are 0.39–1.28 MeV/nuc and 1.28–6.98 MeV/nuc.
LEFS60: Ions and electrons at 60° from the spacecraft axis. Electrons are measured in four energy bands in the range 0.045–0.312 MeV. Ions are measured in three energy bands in the range 0.546–4.97 MeV.
WARTD60: Integral fluxes of four ion species above certain energy thresholds, at 60° from the spacecraft axis.
LEMS120: Ions at 120° from the spacecraft spin axis, in eight energy bands in the range 0.047–4.75 MeV.
LEFS150: Ions and electrons at 150° from the spacecraft axis. Electrons are measured in four energy bands in the range 0.045–0.312 MeV. Ions are measured in three energy bands in the range 0.54–4.94 MeV. Note: data from the lower three electron energy bands are unavailable after 19 March 1998.

3.3 MAG Data: Interplanetary magnetic field vector, in RTN and GSE coordinate systems, in 16-second, 4-minute and hourly time averages. Since individual vector components on timescales longer than 1 hour are potentially misleading, for daily and Bartels rotation averages only the magnitude of the magnetic field is provided.

3.4 SEPICA Data: Solar energetic particle fluxes for the elements H, He, C, O, and Fe. For H and He, 2-minute time resolution data are available in addition to the standard hourly, daily and Bartels rotation data. The energy bands are different for each element: for He, there are six energy bands, spanning the range 0.1–7.5 MeV/nuc.

3.5 SIS Data: Solar energetic particle, low-energy galactic cosmic ray, and anomalous cosmic ray fluxes, for the elements C, N, O, Ne, Mg, Si, S, and Fe, in eight energy bands. For C, these eight energy bands span the range 6.1–76.3 MeV/nuc, while for Fe the energy range is 10.5–168 MeV/nuc. 256-second time resolution data are available in addition to the standard hourly, daily and Bartels rotation data. For the 27-day Bartels rotation averages, two kinds of averages are provided: 1) Quiet-time flux averages, where data from solar energetic particle event time periods have been excluded, and 2) flux averages computed using all the data.

3.6 SWEPAM Data: Solar wind plasma ion and electron parameters. 64-second (ions) and 128-second (electrons) data are available in addition to the standard hourly, daily and Bartels rotation data.
Ion data: Proton density, proton temperature, and proton velocity vector in RTN and GSE coordinates.
Electron data: Electron temperature

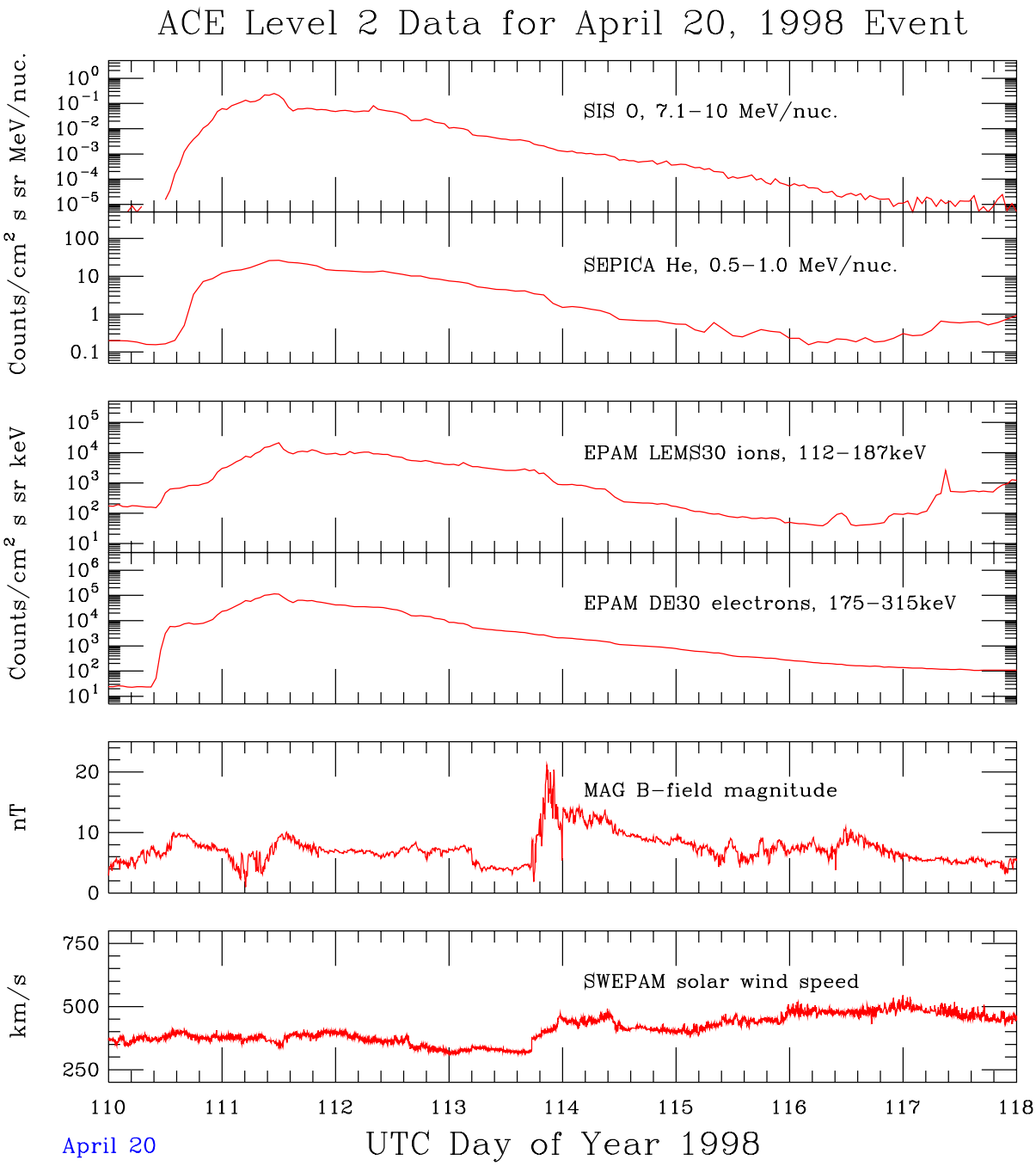

Figure 1: Examples of level 2 data from some of the ACE instruments, for the April 20, 1998 solar energetic particle event. SIS, SEPICA and EPAM data are hourly averages. MAG data are 4-minute averages, and SWEPAM data are 64-second averages.

3.7 SWICS and SWIMS Data: Solar wind bulk and thermal ion speeds and solar wind species ratios.
Bulk and Thermal ion Speeds: H^{+1}, He^{+2}, O^{+6}, Mg^{+10}, and Fe^{+11}.
Element Ratios: $^{4}He^{+2}/O$, $^{20}Ne^{+8}/O$, $^{24}Mg^{+10}/O$, and $^{56}Fe^{+(7\text{ to }12)}/O$.
Charge State Ratios: C^{+5}/C^{+6}, O^{+7}/O^{+6}, and Fe^{+9}/Fe^{+11}.
Isotope Ratios: $^{3}He^{+2}/^{4}He^{+2}$, $^{22}Ne^{+8}/^{20}Ne^{+8}$, and $^{26}Mg^{+10}/^{24}Mg^{+10}$

3.8 ULEIS Data: Solar supra-thermal and energetic charged particle fluxes for the following seven species: H, ^{3}He, ^{4}He, C, O, Ne-S and Fe. The energy bands are slightly different for each species - for H, six energy bands are provided, covering the range 0.16–7.24 MeV/nuc.

4 Data Access Options

ACE level 2 and browse data are available from the ASC web site: http://www.srl.caltech.edu/ACE/ASC. The ASC has selected the Hierarchical Data Format (HDF), version 4.1r2, as the standard data format for archiving ACE data, and all ACE data is stored in HDF format. However, the web interface to the HDF data files allows users to download data as ASCII text, HDF, or as simple online plots. This interface also provides point-and-click access to data documentation and a wide degree of flexibility in the selection of time periods and data items for download. The HDF format is supported by many commercial data analysis and visualization packages, and the ASC provides a library of routines which allow easy access to ACE HDF data files from within C programs.

Long term archiving of ACE data will be undertaken by the NSSDC, and the ASC will soon begin delivery of ACE level 2 data to the NSSDC for that purpose. After the end of the ACE mission, the NSSDC will become the primary site for distribution of ACE data.

Acknowledgments

The web interface to HDF data files used at the ASC is a customized version of the DIAL Experimental Data Server (http://dial.gsfc.nasa.gov), jointly developed by the National Center for Supercomputing Applications and Raytheon ITSS, under contract to NASA/GSFC.

This work was supported by NASA under contract NAG5-6912.

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