SAMPEX Attitude/Orbit (PS Set) Data

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These data are derived from the SAMPEX PS Set data, documented in the SAMPEX Master Data File Description.

For an overview of SAMPEX pointing modes, see the SAMPEX Pointing Modes and History.

The data are instantaneous values at the given timestamp, measured every 6 seconds.

Note on attitude data quality flag

Users of the attitude data should pay particular attention to the **Att_flag**, which is documented near the end of this web page.

Notes on the time-stamps for these data

The time-stamps for these attitude/orbit (PS Set) data have been synced (in ground data processing) with the time-stamps for the 6-second rates (RS Set) data, and with the time-stamps for the 6-second Intensities data. On the spacecraft, the PS Set and RS Set time-stamps start each day in sync. However, they can drift by a second-or-so relative to each other during each day (they run on different spacecraft clocks...)

The RS Set time-stamps are preferred, so each PS Set record has been assigned the time-stamp of its associated RS Set, whenever possible. This is not always possible, because there are sometimes gaps in the RS Set data. We provide a flag (flag_rstime) for each record to indicate whether the time-syncing was possible.

In addition, the 6-second intensity, attitude/orbit (PS Set), and rates (RS Set) data have been filled so that they all contain the same number of records per day.

Thus, the timestamps in these data sets may be used to associate the appropriate attitude/orbit data with each 6-second-averaged intensity or rates data record.

Description of each data field

- **Year:**
  Four-digit year
- **Day-of-year:**
  Day of year, starting at 1
- **Sec_of_day:**
  Second of day, synced RS Set time-stamp when Flag_rstime is 1
- **Sec_of_day_psset:**
  Second of day contained in the original PS Set data record - see time-stamp notes above.

- **Flag_rstime:**
  Flag indicating whether the time-stamp for the data record has been synced to its corresponding RS Set time-stamp - see time-stamp notes above. 1=synced, 0=not synced.
- **Orbit_Number:**
  SAMPEX Orbit Number
- **GEO_Radius:**
  Range in GEO coordinate system (km). In the GEO system, the X-axis is in the Earth's equatorial plane but is fixed with the rotation of the Earth so that it passes through the Greenwich meridian (0 degrees longitude). The Z-axis is parallel to the rotation axis of the Earth, and the Y-axis completes a right-handed orthogonal set.
- **GEO_Long:**
  Longitude in GEO coordinate system (0 to 360 degrees).
- **GEO_Lat:**
  Latitude in GEO coordinate system (-90 to +90 degrees).
- **Altitude:**
  Altitude above surface of Earth (km).
- **GEI_X, GEI_Y, GEI_Z:**
  Position coordinates in GEI coordinate system (km). In the GEI system, the X axis points toward the first point of Aries (i.e. the vernal equinox), and the Z axis is parallel with the Earth's rotation axis. The Y-axis completes a right-handed orthogonal set. When expressed in terms of longitude and latitude, this is the well known celestial coordinate system of right ascension and declination.
- **GEI_VX, GEI_VY, GEI_VZ:**
  Velocity coordinates in GEI coordinate system (km/s).
- **ECD_Radius:**
  Eccentric Dipole (offset tilted dipole) range (km). ECD is a coordinate system centered on and aligned with a ficticious dipole that approximates Earth's actual magnetic field.
- **ECD_Long:**
  Eccentric Dipole longitude (0 to 360 degrees).
- **ECD_Lat:**
  Eccentric Dipole latitude (-90 to +90 degrees).
- **ECD_MLT:**
  Eccentric Dipole local time (hr).
- **L_Shell:**
  L-shell parameter.
- **B_Mag:**
  Model field magnitude (gauss).
- **MLT:**
  Local time at magnetic equator along current field line (hr) ECD.
- **Invariant_Lat:**
  Invariant latitude (degrees).
- **B_X, B_Y, B_Z:**
  Magnetic field vector, Cartesian GEI coordinates.
- **B_R, B_Theta, B_Phi:**
  Magnetic field vector, spherical geographic coordinates (GEO) (r, theta, phi).
- **Declination:**
  Magnetic declination (degrees).
- **Dip:**
  Magnetic dip angle (degrees).
- **Magnetic_Radius:**
  Algebraic magnetic radial distance (km).

- **Magnetic_Lat:**
  Algebraic magnetic latitude (degrees).
  Note: Algebraic magnetic radius and latitude are computed using the dipole relationship between B, L, and latitude but with values for B and L generated from the IGRF model.
- **Loss_Cone_1:**
  Loss cone 1/2 angle (degrees) for particles mirroring below 100 km along the current field line in same hemisphere as spacecraft.
- **Loss_Cone_2:**
  Loss cone 1/2 angle (degrees) for particles mirroring below 100 km along the current field line in either hemisphere.
- **Dipole_Moment_X, Dipole_Moment_Y, Dipole_Moment_Z:**
  Dipole moment vector. Cartesian geographic coordinates (GEO).
- **Dipole_Disp_X, Dipole_Disp_Y, Dipole_Disp_Z:**
  Dipole moment displacement vector. Cartesian geographic coordinates (GEO).
- **Mirror_Alt:**
  Geographic altitude (km) of conjugate mirror point (the point in opposite hemisphere along current field line for particle mirroring at the spacecraft).
- **Mirror_Long:**
  Geographic longitude (degrees) of mirror point.
- **Mirror_Lat:**
  Geographic latitude (degrees) of mirror point.
- **Equator_B_Mag:**
  Magnitude of field (gauss) at magnetic equator along current field line.
- **Equator_Alt:**
  GEO altitude (km) at magnetic equator along current field line.
- **Equator_Long:**
  GEO longitude (degrees) at magnetic equator along current field line.
- **Equator_Lat:**
  GEO latitude (degrees) at magnetic equator along current field line.
- **North100km_B_Mag:**
  Magnitude of field (gauss) at north 100km point (point at 100 km in northern hemisphere along current field line).
- **North100km_Alt:**
  GEO altitude (km) at north 100km point. Should generally be ~100km, but is included to indicate accuracy of the numerical calculation involved.
- **North100km_Long:**
  GEO longitude (degrees) at north 100km point.
- **North100km_Lat:**
  GEO latitude (degrees) at north 100km point.
- **South100km_B_Mag:**
  Magnitude of field (gauss) at south 100km point (point at 100 km in southern hemisphere along current field line).
- **South100km_Alt:**
  GEO altitude (km) at south 100km point. Should generally be ~100km, but is included to indicate accuracy of the numerical calculation involved.
- **South100km_Long:**
  GEO longitude (degrees) at south 100km point.
- **South100km_Lat:**
  GEO latitude (degrees) at south 100km point.
- **Vertical_Cutoff:**
  Nominal vertical cutoff (1980) at 20 km altitude at subsatellite location (GV). (Shea and Smart, 1983, Bangalore ICRC, Paper MG10-3).

- **SAA_Flag:**
  South Atlantic Anomaly Flag. 0=not in SAA, 1=within SAA.
- **A11, A21, A31, A12, A22, A32, A13, A23, A33:**
  9-element attitude direction cosine array for rotating from GEI coordinates to body fixed coordinates. Z-axis in body fixed is along instrument bore sights.
  Derived from the (corrected) attitude quaternions, this matrix is used to map a vector from GEI coordinates into spacecraft coordinates. Let V, with elements V(1), V(2), V(3), be a GEI vector; to obtain the vector in the spacecraft coordinate frame, say v with elements v(1), v(2), v(3), use

  $$v(1) = A11 * V(1) + A12 * V(2) + A13 * V(3)$$
  $$v(2) = A21 * V(1) + A22 * V(2) + A23 * V(3)$$
  $$v(3) = A31 * V(1) + A32 * V(2) + A33 * V(3)$$

  So, for example, the pitch angle of a particle going down the instruments' boresights is the angle between the magnetic field vector and the spacecraft (-z) axis; this means that, if B is the magnetic field vector in GEI coordinates,

  $$\cos(\text{pitch}) = (-1) * (A(3,1) * B(1) + A(3,2) * B(2) + A(3,3) * B(3)) / |B|$$

  where |B| is the norm of B.
- **Pitch:**
  Pitch angle of a particle heading down the instrument boresight (i.e., angle between S/C z-axis and (-1) times the local magnetic field vector), in degrees
- **Zenith:**
  Angle between instrument boresight (S/C z-axis) and local zenith, in degrees
- **Azimuth:**
  Azimuth of projection of boresight into plane normal to zenith, in degrees, with 0 = east, 90 = north, 180 = west, 270 = south
- **Att_Flag:**
  Flag, data quality flag indicating source of attitude information (attitude direction cosines, pitch, zenith, azimuth).
  Executive summary: flag =0,1,100, or 101 means attitude is OK. Other values indicate attitude is not OK. For more details, READ THIS.

Andrew Davis, SAMPEX Data Center Technical Lead