# Output Domains in the AMPS Wizard: Points, Trajectories, and Spherical Shells

AMPS Interface Documentation

February 22, 2026

## 1 Concept: what is an "Output Domain"?

The Output Domain (Step 7) defines *where* AMPS evaluates geomagnetic cutoffs, particle access, and flux. Conceptually, AMPS evaluates a map

$$\left(\mathbf{r}, \hat{\mathbf{v}}, t, E\right) \; \mapsto \; \text{allowed/forbidden}, \; R_c, \; J(E), \; \Phi(E > E_0), \; \dots \tag{1}$$

for a set of sampling locations $\mathbf{r}$ (and optionally directions $\hat{\mathbf{v}}$) at one or more times $t$.

**Coordinate system**   Unless stated otherwise, the interface assumes **GSM** coordinates. If you provide data in another frame (GSE, GEO, SM), convert before upload.

**Units**   The wizard UI labels distances in $R_E$ (Earth radii) for geospace problems. If your data are in kilometers, convert using $1 \, R_E \approx 6371 \, \text{km}$.

## 2 Mode 1: Individual Points (POINTS)

Use POINTS when you have a small set of discrete locations (stations, grid points, spacecraft points-of-interest).
- Provide $N$ points, each as $(x, y, z)$ in GSM.
- Optional metadata (label, altitude) may be included but is ignored by the simplest parser.
- Best for: validation, site-specific cutoffs, "spot checks".

### 2.1 Example point list (space-delimited)

```
# x(Re)    y(Re)    z(Re)     label
 6.60     0.00     0.00      GEO
 1.05     0.00     0.00      LEO_equator
 1.00     0.00     0.50      LEO_midlat
```

## 3 Mode 2: Trajectories (TRAJECTORY)

Use TRAJECTORY when you want sampling along an orbit or path (e.g., Van Allen Probes, ISS, a flight segment). A trajectory is a time-ordered list of positions.
- Each row provides time + position.
- Time is used when Temporal Mode is TIME_SERIES; otherwise it may be ignored.
- Positions should be monotonic in time (no backward jumps).

## 3.1 Trajectory file formats: recommended options

To keep the interface robust, support a small set of easy-to-parse ASCII formats. All formats below are **plain text**, one sample per line.

### 3.1.1 Format A (Gregorian columns) — recommended

```
# YYYY MM DD HH MM SS    x(Re)    y(Re)    z(Re)
2017 09 07 00 00 00      4.12     -0.52    0.80
2017 09 07 00 01 00      4.10     -0.50    0.81
...
```

**Notes:** seconds may be omitted if your cadence is 1 minute; if omitted, assume SS=0.

### 3.1.2 Format B (ISO-8601 timestamp)

```
# ISO_TIME_UTC               x(Re)    y(Re)    z(Re)
2017-09-07T00:00:00Z         4.12     -0.52    0.80
2017-09-07T00:01:00Z         4.10     -0.50    0.81
...
```

**Notes:** include a trailing `Z` to indicate UTC.

### 3.1.3 Format C (positions only; steady-state only)

```
# x(Re)    y(Re)    z(Re)
4.12     -0.52    0.80
4.10     -0.50    0.81
...
```

**Use only** when Temporal Mode is STEADY_STATE and you do not need time tagging.

## 3.2 Validation tips

- Plot $r = \sqrt{x^2 + y^2 + z^2}$ versus time to catch unit mistakes (km vs $R_E$).
- Verify GSM orientation: in GSM, +X points sunward.
- If you see discontinuities, check that your time column is strictly increasing.

# 4 Mode 3: Spherical Shells (SHELLS)

Use SHELLS when you want a global (or regional) map at fixed altitude(s).
- Define one or more radii $r = R_E + h$ (or directly $r$ in $R_E$).
- Choose angular resolution (e.g., $\Delta\lambda$, $\Delta\phi$ or number of points).
- Best for: global cutoff maps, exposure maps, "LEO shell" diagnostics.

## 4.1 Example shell specification

```
# shell radii (Re)
1.02
1.05
1.10
# grid: 1-degree lat/lon
LAT_STEP_DEG 1
LON_STEP_DEG 1
```

# 5  How sampling is used in the calculations

For each sample (point/trajectory location/shell node), AMPS computes a cutoff rigidity (or access) by backtracing trajectories in the configured fields. Once $R_c$ is known, the chosen upstream spectrum $J(E)$ is filtered to produce local flux and integral quantities.

# 6  References (starting points)

- Smart, D. F., and Shea, M. A. (2009): trajectory tracing and cutoffs.
- Example mission: Van Allen Probes ephemeris products (for realistic trajectories).