Configuring Steady-State vs. Time-Varying Runs in the AMPS Wizard

AMPS Interface Documentation

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1 Why the "Temporal Mode" matters

In AMPS geospace transport calculations, the particle equation of motion depends on the background fields

$$\frac{d\mathbf{p}}{dt} = q\left(\mathbf{E}(\mathbf{r},t) + \mathbf{v}\times\mathbf{B}(\mathbf{r},t)\right), \tag{1}$$

so any time variability in $\mathbf{E}$ and/or $\mathbf{B}$ must be represented consistently. The wizard provides a *Temporal Mode* (Step 6) that selects how t enters the problem.

2 Temporal modes supported by the interface

2.1 STEADY_STATE (single epoch snapshot)

Use this mode when you want a static field configuration.

- Choose one epoch (date/time) and a field model in Step 3.
- AMPS uses *one* set of geomagnetic driving parameters for the entire run.
- Best for: cutoff maps, parameter sweeps, and controlled comparisons.

Wizard behavior: the time-series form is hidden; the output preview prints `TEMPORAL_MODE = STEADY_STATE`.

2.2 TIME_SERIES (driven by an external time history)

Use this mode when you need storm-time dynamics (changing pressure/IMF/Dst, etc.).

- The field model is updated at a cadence `FIELD_UPDATE_DT`.
- Particle injection (or evaluation) occurs at `INJECT_DT`.
- `INJECT_DT` must be an integer multiple of `FIELD_UPDATE_DT`.

Wizard behavior: Step 6 shows a timeline illustration of the relationship between the two cadences. The interface warns when `INJECT_DT < FIELD_UPDATE_DT`.

2.3 MHD_COUPLED (planned / placeholder)

This mode represents fully time-dependent fields supplied by an MHD model (e.g., BATS-R-US or GAMERA). It is included in the UI as a forward-looking option; the implementation depends on the field I/O pipeline and is typically not available in early CCMC prototype deployments.

3 Driving sources for TIME_SERIES

The interface provides multiple ways to specify time histories:

1. **OMNIWeb auto-fetch (UI simulation):** the wizard demonstrates the intended pipeline (fetch solar wind, fetch indices, merge, produce a driving file). In production, a back-end service performs the actual fetch on submission.
2. **Upload a driving file:** you supply a text file with one epoch per row.
3. **Scalar input (debug):** use a constant set of scalars but still exercise the time-series code path.

4 Time-series driving file format (`ts05_driving.txt`)

For TS05-style scalar-driven models, AMPS expects one line per epoch. A common format is:

```
# YYYY MM DD HH MM  Dst[nT]  Pdyn[nPa]  Bz[nT]  Vx[km/s]  Nsw[cm^-3]  By[nT]  Bx[nT]
2017 09 07 00 00   -20.0     2.3       -3.5     -420      6.1         2.0     1.0
2017 09 07 00 05   -21.0     2.4       -3.7     -430      6.2         2.1     1.0
...
```

Rules and recommendations

- Timestamps must be strictly increasing.
- Use UTC unless explicitly stated otherwise.
- If your cadence is coarser than `FIELD_UPDATE_DT`, AMPS must interpolate or hold values. Prefer to provide data at the intended update cadence.
- If gaps exist, document how they were filled (linear interpolation is common).

5 Choosing cadences: practical guidance

- **Field update cadence (`FIELD_UPDATE_DT`):** choose based on how quickly the field model changes. For storm-time studies, 1 min to 5 min is typical.
- **Injection cadence (`INJECT_DT`):** choose based on how often you want new particles injected (or how often you want diagnostics written). 15 min to 60 min is common.
- Make `INJECT_DT` a multiple of `FIELD_UPDATE_DT` to avoid ambiguous partial steps.

6 Worked configuration examples

6.1 Example A: steady-state cutoff map

- Temporal Mode: **STEADY_STATE**
- Field model: T96 or T15 snapshot at a single epoch
- Output domain: spherical shells at multiple altitudes

6.2 Example B: Sep 2017 storm time-series

- Temporal Mode: **TIME_SERIES**
- `FIELD_UPDATE_DT = 5 min`, `INJECT_DT = 30 min`
- Driving: `ts05_driving.txt` generated from OMNI + Dst
- Trajectory evaluation: along a spacecraft ephemeris (see the Output Domain doc)

7 References (starting points)

- Tsyganenko, N. A., and Sitnov, M. I. (2005): TS05 storm-time geomagnetic field model.
- Smart, D. F., and Shea, M. A. (2009): Geomagnetic cutoff rigidities and trajectory tracing.