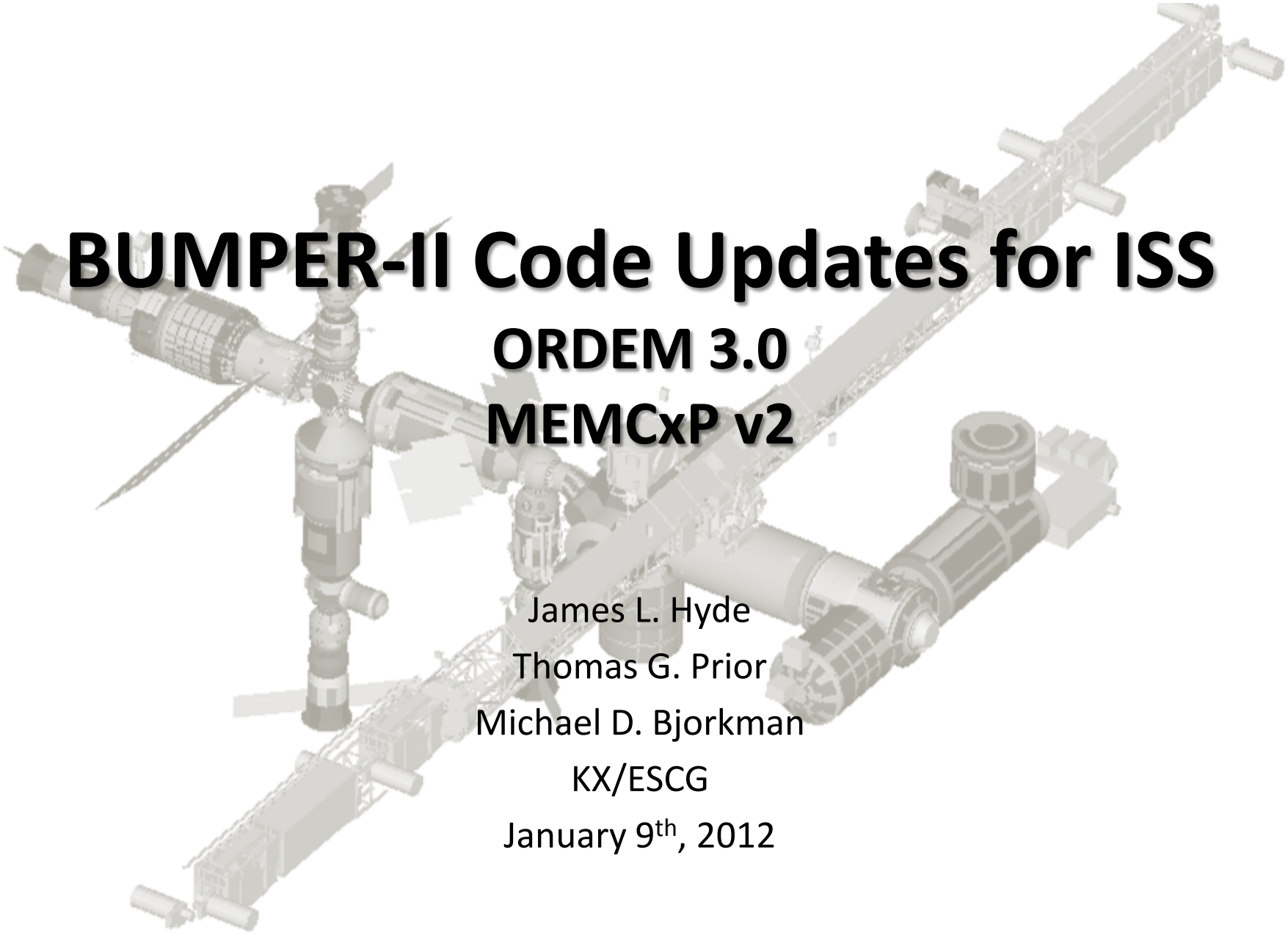

# BUMPER-II Code Updates for ISS

## ORDEM 3.0

## MEMCxP v2

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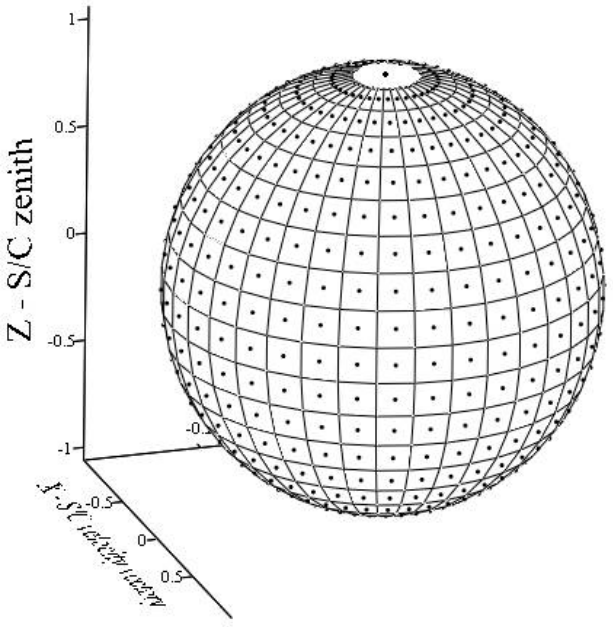
# Introduction

- BUMPER-II has been updated to version 1.95j
  - Updated source code will be provided to RSC-E and Khrunichev
- New environments implemented as external data files
  - Orbital Debris: ORDEM 3.0
  - Micrometeoroid: MEMCxP v2

# ORDEM 3.0: Background

- Model Populations
  - RORSAT NaK coolant droplets
  - Low-density fragments
  - Medium-density fragments and degradation/ejecta
  - Intact objects
  - High-density fragments and degradation/ejecta
- Density Bins
  - NaK = 1.0 g/cm$^3$
  - Low = 1.4 g/cm$^3$
  - Medium = 2.8 g/cm$^3$
  - High = 8.0 g/cm$^3$




- Altitude range: 100 to 40,000 km
- Time Range: 1995 to 2035
- Threats originate from 612, 10$^o$ x 10$^o$, patches on the sky sphere plus a north and south pole patch, for a total of 614 patches.
- The discrete closing speed distribution has 23 speed bins, from 0 to 1 km/s, 1 to 2 km/s, … 22 to 23 km/s
- Total number of fluence integration steps for each element of analysis FEM: 614 threats x 23 speed bins = 14,122 steps.

# ORDEM 3.0: Data Files (1/2)

- ORDEM 3 application produces three intermediate files
  - IGLOOFLUX_SC.OUT
    - igloo patch fluxes
    - 14,122 rows: 614 threats x 23 speeds
    - 55 columns: 11 sizes x 5 populations
  - IGLOOFLUX_SIGMAPOP_SC.OUT
    - Correlated population uncertainty estimates (for future use)
  - IGLOOFLUX_SIGMARAN_SC.OUT
    - Random uncertainty estimates (for future use)
- Files are processed by an external utility
  - >95% of the 776,710 entries in the IGLOOFLUX_SC.OUT file are zeros
  - Generate an index to the non-zero values (*.key file)
  - Compress the file by removing the zeros (*.daf file)
  - Reduces the amount of RAM required

# ORDEM 3.0: Data Files (2/2)

- The final version of ORDEM 3.0 is expected to be released in mid 2012.
- NASA will provide a sample ORDEM 3.0 ".key" & ".daf" environment file for demonstration and benchmarking BUMPER-II v1.95j installation.
- After the final release, NASA will provide 27 ORDEM 3.0 output file sets at 400 km altitude & 51.6$^{o}$ inclination.
  - Individual years 2012 through 2035 (24 .key & .daf file sets)
  - Combined 2012 thru 2022 (current + 10yr)
  - Combined 2012 thru 2027 (current + 15yr)
  - Combined 2012 thru 2032 (current + 20yr)

ORDEM Debris flux through spacecraft 'igloo'.
Igloo Debris Populations Flux in Bin (no./km^2/yr)
Year: 2012 Elements: 14122 Populations: 55 a = 6778.136 e = 0.000000 inc = 51.60

| Element | az_low | az_high | el_low | el_high | vel_low | vel_high | Flux NK10 | Flux NK15 | Flux NK20 | Flux NK25 | Flux NK30 | Flux NK35 | Flux NK40 | Flux NK45 | Flux NK50 | Flux NK |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | -180.000 | 180.000 | -90.000 | -85.000 | 0.000 | 1.000 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+ |
| 2 | -180.000 | 180.000 | -90.000 | -85.000 | 1.000 | 2.000 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+ |
| 3 | -180.000 | 180.000 | -90.000 | -85.000 | 2.000 | 3.000 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+ |
| 4 | -180.000 | 180.000 | -90.000 | -85.000 | 3.000 | 4.000 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+ |
| 5 | -180.000 | 180.000 | -90.000 | -85.000 | 4.000 | 5.000 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+ |
| 6 | -180.000 | 180.000 | -90.000 | -85.000 | 5.000 | 6.000 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+ |
| 7 | -180.000 | 180.000 | -90.000 | -85.000 | 6.000 | 7.000 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+ |
| 8 | -180.000 | 180.000 | -90.000 | -85.000 | 7.000 | 8.000 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+ |
| 9 | -180.000 | 180.000 | -90.000 | -85.000 | 8.000 | 9.000 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+ |
| 10 | -180.000 | 180.000 | -90.000 | -85.000 | 9.000 | 10.000 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+ |
| 11 | -180.000 | 180.000 | -90.000 | -85.000 | 10.000 | 11.000 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+ |
| 12 | -180.000 | 180.000 | -90.000 | -85.000 | 11.000 | 12.000 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+ |
| 13 | -180.000 | 180.000 | -90.000 | -85.000 | 12.000 | 13.000 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+ |
| 14 | -180.000 | 180.000 | -90.000 | -85.000 | 13.000 | 14.000 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+ |
| 15 | -180.000 | 180.000 | -90.000 | -85.000 | 14.000 | 15.000 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+ |
| 16 | -180.000 | 180.000 | -90.000 | -85.000 | 15.000 | 16.000 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+ |
| 17 | -180.000 | 180.000 | -90.000 | -85.000 | 16.000 | 17.000 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+ |
| 18 | -180.000 | 180.000 | -90.000 | -85.000 | 17.000 | 18.000 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+ |
| 19 | -180.000 | 180.000 | -90.000 | -85.000 | 18.000 | 19.000 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+ |
| 20 | -180.000 | 180.000 | -90.000 | -85.000 | 19.000 | 20.000 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+ |
| 21 | -180.000 | 180.000 | -90.000 | -85.000 | 20.000 | 21.000 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+ |
| 22 | -180.000 | 180.000 | -90.000 | -85.000 | 21.000 | 22.000 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+ |
| 23 | -180.000 | 180.000 | -90.000 | -85.000 | 22.000 | 23.000 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+00 | 0.0000000E+ |

# ORDEM 3.0: BUMPER-II Execution

- GEOMETRY
  - Altitude and inclination prompts for ORDEM 3.0 option removed
  - Execution time for ISS model with 708,392 elements ≈ 6 hours
  - File size ≈ 1.8 GB
- SHIELD
  - Prompts removed for the altitude, inclination, start date or duration. The altitude and inclination are implicit in the ORDEM3 ".daf" file and the start date and duration are read from the header in the ".key" file
  - Prompt added for the root file name of the ".daf" and the ".key" files
  - Execution time for ISS model with 708,392 elements ≈ 13 minutes
  - Output includes subtotals for each population:

| RANGE | STARTING | ENDING | PENETRATIONS | NaK | LOW DENSITY | MEDIUM DENSITY | HIGH DENSITY | INTACTS | AREA (M^2) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 20001 | 24858 | 0.396887E-04 | 0.107567E-06 | 0.719892E-06 | 0.249733E-04 | 0.127364E-04 | 0.115151E-05 | 180.6006077 |
| 2 | 20001 | 20500 | 0.195207E-05 | 0.510211E-38 | 0.268951E-07 | 0.141834E-05 | 0.385058E-06 | 0.121776E-06 | 11.6261567 |

# MEMCxP v2: Background

- Calculates directionality of 1 microgram meteoroids
- Uses Grun flux to calculate other sizes
- Model Populations
  - Asteroids
  - Jupiter family comets
  - Short period comets
  - Long period comets
- Density = constant 1.0 g/cm$^3$
- Threats originate from **equal area** patches (like the blocks of ice in an igloo) on the sky sphere similar to the SSP 30425 micrometeoroid threats.
  - 21 speed bins: 0 to 5 km/s, 5 to 15 km/s, 15 to 25 km/s, … 95 to 105 km/s
  - 1,652 threat directions
  - Note: ORDEM 3.0 uses **equal angular** patches, like lines of latitude and longitude on a globe.

# MEMCxP v2: Data File

Flux distributed by speed bins, speed bin labels are midpoints of speed range

| ID | I | J | PHI1B(I) | PHI2B(I) | THETA1B(IJ) | THETA2B(IJ) | PHIavg | THETAavg | 0 | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | -90.00 | -85.00 | 0.00 | 120.00 | -87.50 | 60.00 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 2 | 1 | 2 | -90.00 | -85.00 | 120.00 | 240.00 | -87.50 | 180.00 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 3 | 1 | 3 | -90.00 | -85.00 | 240.00 | 360.00 | -87.50 | 300.00 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 4 | 2 | 1 | -85.00 | -80.00 | 0.00 | 40.00 | -82.50 | 20.00 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 5 | 2 | 2 | -85.00 | -80.00 | 40.00 | 80.00 | -82.50 | 60.00 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 6 | 2 | 3 | -85.00 | -80.00 | 80.00 | 120.00 | -82.50 | 100.00 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 7 | 2 | 4 | -85.00 | -80.00 | 120.00 | 160.00 | -82.50 | 140.00 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 8 | 2 | 5 | -85.00 | -80.00 | 160.00 | 200.00 | -82.50 | 180.00 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 9 | 2 | 6 | -85.00 | -80.00 | 200.00 | 240.00 | -82.50 | 220.00 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 10 | 2 | 7 | -85.00 | -80.00 | 240.00 | 280.00 | -82.50 | 260.00 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 11 | 2 | 8 | -85.00 | -80.00 | 280.00 | 320.00 | -82.50 | 300.00 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 12 | 2 | 9 | -85.00 | -80.00 | 320.00 | 360.00 | -82.50 | 340.00 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 13 | 3 | 1 | -80.00 | -75.00 | 0.00 | 22.50 | -77.50 | 11.25 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 14 | 3 | 2 | -80.00 | -75.00 | 22.50 | 45.00 | -77.50 | 33.75 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 15 | 3 | 3 | -80.00 | -75.00 | 45.00 | 67.50 | -77.50 | 56.25 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 16 | 3 | 4 | -80.00 | -75.00 | 67.50 | 90.00 | -77.50 | 78.75 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 17 | 3 | 5 | -80.00 | -75.00 | 90.00 | 112.50 | -77.50 | 101.25 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 18 | 3 | 6 | -80.00 | -75.00 | 112.50 | 135.00 | -77.50 | 123.75 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 19 | 3 | 7 | -80.00 | -75.00 | 135.00 | 157.50 | -77.50 | 146.25 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 20 | 3 | 8 | -80.00 | -75.00 | 157.50 | 180.00 | -77.50 | 168.75 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 21 | 3 | 9 | -80.00 | -75.00 | 180.00 | 202.50 | -77.50 | 191.25 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 22 | 3 | 10 | -80.00 | -75.00 | 202.50 | 225.00 | -77.50 | 213.75 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 23 | 3 | 11 | -80.00 | -75.00 | 225.00 | 247.50 | -77.50 | 236.25 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 24 | 3 | 12 | -80.00 | -75.00 | 247.50 | 270.00 | -77.50 | 258.75 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 25 | 3 | 13 | -80.00 | -75.00 | 270.00 | 292.50 | -77.50 | 281.25 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 26 | 3 | 14 | -80.00 | -75.00 | 292.50 | 315.00 | -77.50 | 303.75 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 27 | 3 | 15 | -80.00 | -75.00 | 315.00 | 337.50 | -77.50 | 326.25 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 28 | 3 | 16 | -80.00 | -75.00 | 337.50 | 360.00 | -77.50 | 348.75 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 29 | 4 | 1 | -75.00 | -70.00 | 0.00 | 16.36 | -72.50 | 8.18 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 30 | 4 | 2 | -75.00 | -70.00 | 16.36 | 32.73 | -72.50 | 24.55 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 31 | 4 | 3 | -75.00 | -70.00 | 32.73 | 49.09 | -72.50 | 40.91 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 32 | 4 | 4 | -75.00 | -70.00 | 49.09 | 65.45 | -72.50 | 57.27 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 33 | 4 | 5 | -75.00 | -70.00 | 65.45 | 81.82 | -72.50 | 73.64 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 34 | 4 | 6 | -75.00 | -70.00 | 81.82 | 98.18 | -72.50 | 90.00 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 35 | 4 | 7 | -75.00 | -70.00 | 98.18 | 114.55 | -72.50 | 106.36 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 36 | 4 | 8 | -75.00 | -70.00 | 114.55 | 130.91 | -72.50 | 122.73 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 37 | 4 | 9 | -75.00 | -70.00 | 130.91 | 147.27 | -72.50 | 139.09 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 38 | 4 | 10 | -75.00 | -70.00 | 147.27 | 163.64 | -72.50 | 155.45 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 39 | 4 | 11 | -75.00 | -70.00 | 163.64 | 180.00 | -72.50 | 171.82 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 40 | 4 | 12 | -75.00 | -70.00 | 180.00 | 196.36 | -72.50 | 188.18 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 41 | 4 | 13 | -75.00 | -70.00 | 196.36 | 212.73 | -72.50 | 204.55 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 42 | 4 | 14 | -75.00 | -70.00 | 212.73 | 229.09 | -72.50 | 220.91 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 43 | 4 | 15 | -75.00 | -70.00 | 229.09 | 245.45 | -72.50 | 237.27 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 44 | 4 | 16 | -75.00 | -70.00 | 245.45 | 261.82 | -72.50 | 253.64 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 45 | 4 | 17 | -75.00 | -70.00 | 261.82 | 278.18 | -72.50 | 270.00 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 46 | 4 | 18 | -75.00 | -70.00 | 278.18 | 294.55 | -72.50 | 286.36 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 47 | 4 | 19 | -75.00 | -70.00 | 294.55 | 310.91 | -72.50 | 302.73 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 48 | 4 | 20 | -75.00 | -70.00 | 310.91 | 327.27 | -72.50 | 319.09 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 49 | 4 | 21 | -75.00 | -70.00 | 327.27 | 343.64 | -72.50 | 335.45 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 50 | 4 | 22 | -75.00 | -70.00 | 343.64 | 360.00 | -72.50 | 351.82 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 51 | 5 | 1 | -70.00 | -65.00 | 0.00 | 12.86 | -67.50 | 6.43 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 52 | 5 | 2 | -70.00 | -65.00 | 12.86 | 25.71 | -67.50 | 19.29 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 53 | 5 | 3 | -70.00 | -65.00 | 25.71 | 38.57 | -67.50 | 32.14 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 54 | 5 | 4 | -70.00 | -65.00 | 38.57 | 51.43 | -67.50 | 45.00 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 55 | 5 | 5 | -70.00 | -65.00 | 51.43 | 64.29 | -67.50 | 57.86 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 56 | 5 | 6 | -70.00 | -65.00 | 64.29 | 77.14 | -67.50 | 70.71 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 57 | 5 | 7 | -70.00 | -65.00 | 77.14 | 90.00 | -67.50 | 83.57 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 58 | 5 | 8 | -70.00 | -65.00 | 90.00 | 102.86 | -67.50 | 96.43 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 59 | 5 | 9 | -70.00 | -65.00 | 102.86 | 115.71 | -67.50 | 109.29 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |
| 60 | 5 | 10 | -70.00 | -65.00 | 115.71 | 128.57 | -67.50 | 122.14 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 | 0.000000E+000 |

# MEMCxP v2: BUMPER-II Execution

- MEMCxP application produces one output file for BUMPER-II
  - Based on random draws from an input file of state vectors describing the spacecraft trajectory. (Doesn't need to be a closed orbit.)
  - Default filename: AvgMEMIglooDist.out (Igloo patch fluxes in 21 speed bins)
  - 1,652 rows (igloo patches) x 30 columns (speed bins & threat direction info)
- NASA will provide a 400 km MEMCxP v2 environment file for BUMPER-II
- GEOMETRY
  - Prompts removed for the altitude & inclination
  - Prompt added for the file name of the MEM data file
  - Execution time for ISS model with 708,392 elements ≈ 12 hours
  - File size = 4.9GB
- SHIELD
  - Prompt added for the file name of the MEM data file
  - Execution time for ISS model with 708,392 elements ≈ 5 minutes

# BUMPER-II Run Time Comparison

| Environment | Threats | Geometry (min) | Shield (min) |
|---|---|---|---|
| OD2k | 90 | 34 | 11 |
| OD3 | 614 | 360 | 13 |
| MEMCxP v2 | 1652 | 720 | 5 |

- Code: BUMPER-ISS v1.95j
  - Uses ASCII formatted OD3 input files (not binary)
  - 32 bit build using Intel FORTRAN compiler v10.1.013
- Hardware: Dell Precision T7500
  - Dual Quad Core Xeon E5530 (2.4GHz) w/12GB RAM
  - Windows XP Professional 64bit
- Model: ITA12-Stage2014,2-revE-FIN.unv
  - 708,392 elements
  - Run times based on 3 concurrent single threading Perl scripts

# ITA-12 Stage 2014-2

**905 Property IDs**
**708,392 Elements**