## Chapter 3

# Random Numbers

Three subroutines serve to fill a CM array with pseudo random numbers:

```
CALL CMF_RANDOMIZE( SEED )

CALL CMF_RANDOM( DEST, LIMIT )

CALL CMF_RANDOM_LONG_S_INTEGER( DEST, LIMIT )
```

**CMF_RANDOMIZE** sets a seed for the random number generator used by the other two subroutines. **CMF_RANDOM** and **CMF_RANDOM_LONG_S_INTEGER** use the initialized random number generator to store a pseudo random number in each element of the **DEST** array. For **CMF_RANDOM**, the **DEST** array can be of type **INTEGER*4**, **INTEGER*8**, **REAL**, **DOUBLE PRECISION**, **COMPLEX**, or **DOUBLE COMPLEX**. For **CMF_RANDOM_LONG_INTEGER**, the **DEST** array must be of type **INTEGER*8**.

**LIMIT** is of type **INTEGER*4** for **CMF_RANDOM** and **INTEGER*8** for **CMF_RANDOM_LONG_S_INTEGER**. The **LIMIT** argument should always be specified as 1.0 for floating-point values. For integers, the argument serves as the exclusive upper bound of the values generated. If you do not want to set a limit for integer values, specify the **LIMIT** argument as 0.

The random number generator algorithm used by these routines is Wolfram's Rule 30 Cellular Automaton, described in Stephen Wolfram, "Random Sequence Generation by Cellular Automata," *Advances in Applied Mathematics* **7**, pp. 123−69 (1986). This paper may be more readily available as a reprint in Stephen Wolfram, *Theory and Application of Cellular Automata*, World Scientific (1986).


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The cellular automaton is run on a finite string of bits, i=0,...,N−1, with periodic boundary conditions (so that site N is equivalent to site 0). In the CM implementation N = 59.

- For integer values, **CMF_RANDOM** generates the random numbers by running the automaton for 32 generations. (If **DEST** is of type **INTEGER*8**, only 32 of the 64 bits are filled.) **CMF_RANDOM_LONG_S_INTEGER** runs the automaton for 64 generations.

- For real, double-precision real, complex, or double-precision complex values, the random numbers are generated by running the automaton for *s* generations (where *s* is the mantissa length), and setting the exponent bits and sign bit so that the values are uniformly distributed between 2.0 and 1.0. Then 1.0 is subtracted from the results to yield numbers that are uniformly distributed between 0.0 and 1.0.

## 3.1 Language Comparison

No comparable language feature.




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## CMF_RANDOMIZE

Initializes the random number generator with a seed.

---

### Syntax

```
INCLUDE '/usr/include/cm/CMF_defs.h'

CALL CMF_RANDOMIZE( SEED )
```

---

### Arguments

| | |
|---|---|
| **SEED** | An **INTEGER** scalar (*4 only) specifying the seed value with which to initialize the random number generator. |

### Result

None.

### Description

This subroutine uses **SEED** to initialize the random number generator used when **CMF_RANDOM** or **CMF_RANDOM_LONG_S_INTEGER** is called.

The random number generator algorithm used by **CMF_RANDOM** and **CMF_RANDOM_LONG_S_INTEGER** is Wolfram's Rule 30 Cellular Automaton. For more information, see the descriptions of those subroutines.

### Restriction

- On the CM-5, the Wolfram random number generator cannot be seeded with −1 or 0.


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### See Also

**CMF_RANDOM**
**CMF_RANDOM_LONG_S_INTEGER**


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## CMF_RANDOM

Places a different pseudo random number in each element of an array **DEST**.

---

### Syntax

```
INCLUDE '/usr/include/cm/CMF_defs.h'

CALL CMF_RANDOM( DEST, LIMIT )
```

---

### Arguments

**DEST** A CM array of one of the following types:

- **INTEGER*4**
- **INTEGER*8**
- **REAL**
- **DOUBLE PRECISION**
- **COMPLEX**
- **DOUBLE COMPLEX**

**LIMIT** A scalar **INTEGER*4** specifying the exclusive upper bound for the range of random numbers generated. For floating-point values this number should be 1.0. For integers only, to specify no upper bound, **LIMIT** should be 0.

### Result

None.

### Description

This subroutine places a pseudo random number in each element of the **DEST** array.


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The random number generator algorithm used by this procedure is Wolfram's Rule 30 Cellular Automaton. For **INTEGER** values the random numbers are generated by simply running the automaton for 32 generations. (If **DEST** is of type **INTEGER*8**, only 32 of the 64 bits are filled.) For **REAL**, **DOUBLE PRECISION**, **COMPLEX**, and **DOUBLE COMPLEX** values, the random numbers are generated by running the automaton for **s** generations (where **s** is the mantissa length), and setting the exponent bits and sign bit so that the result is uniformly distributed between 2.0 and 1.0. Then 1.0 is subtracted from the result to yield numbers that are uniformly distributed between 0.0 and 1.0. This automaton is run on a finite string of bits, i=0,...,N-1, with periodic boundary conditions (so that site N is equivalent to site 0). In the CM implementation N = 59.

The primary reference for the Rule 30 Cellular Automaton is Stephen Wolfram, "Random Sequence Generation by Cellular Automata," *Advances in Applied Mathematics* **7**, pp. 123−69 (1986). This paper may be more readily available as a reprint in Stephen Wolfram, *Theory and Application of Cellular Automata* (including selected papers 1983−1986), World Scientific (1986).

### Restrictions

- The CM Fortran Utility Library procedures do not operate on arrays that have been aligned with other arrays of greater rank or with other arrays of the same rank but with offsets for the individual axes.
- The **INTEGER*8** type is supported only on CM-5 systems with vector units.

### See Also

**CMF_RANDOMIZE**
**CMF_RANDOM_LONG_S_INTEGER**


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## CMF_RANDOM_LONG_S_INTEGER

Places a different pseudo random number in each element of a 64-bit integer array **DEST**.

---

### Syntax

```
INCLUDE '/usr/include/cm/CMF_defs.h'

CALL CMF_RANDOM_LONG_S_INTEGER( DEST, LIMIT )
```

---

### Arguments

| | |
|---|---|
| **DEST** | A CM array of type **INTEGER*8**. |
| **LIMIT** | An **INTEGER*8** specifying the exclusive upper bound for the range of random numbers generated. To specify no upper bound, **LIMIT** should be 0. |

### Result

None.

### Description

This subroutine places a pseudo random number in each element of the **DEST** array.

The random number generator algorithm used by this procedure is Wolfram's Rule 30 Cellular Automaton. The random numbers are generated by simply running the automaton for 64 generations. This automaton is run on a finite string of bits, i=0,...,N-1, with periodic boundary conditions (so that site N is equivalent to site 0). In the CM implementation N= 59.

The primary reference for the Rule 30 Cellular Automaton is Stephen Wolfram, "Random Sequence Generation by Cellular Automata," *Advances in Applied Mathematics* **7**, pp. 123−69 (1986). This paper may be more readily available as a reprint in Stephen Wolfram, *Theory and Application of Cellular Automata* (including selected papers 1983−1986), World Scientific (1986).


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### Restrictions

- The CM Fortran Utility Library procedures do not operate on arrays that have been aligned with other arrays of greater rank or with other arrays of the same rank but with offsets for the individual axes.
- The **CMF_RANDOM_LONG_S_INTEGER** procedure is supported only on CM-5 systems with vector units.

### See Also

**CMF_RANDOM**
**CMF_RANDOMIZE**


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