

METEOR[®]: A Dice-Based Method for Uniform Random Bearing Generation and Geodesic Landfall Determination

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Abstract

When a METEOR[®] coordinate lies at sea (“in the soup”), a physical dice roll selects a compass bearing. The implementation divides the full circle into 36 ten-degree sectors with a D36 and selects one of 10,000 positions within the chosen sector using four D10 digits. This yields 360,000 equally likely bearings at 0.001-degree spacing, assuming fair and independent rolls. The program follows a geodesic on the World Geodetic System 1984 (WGS84) reference ellipsoid from the sea coordinate and searches for an intersection with mapped land. This paper specifies both stages, explains the conditions for angular uniformity, and documents the numerical landfall search and its limitations.

1 Introduction

The companion coordinate-generation paper describes a dice method for choosing a location across the Earth’s surface. If that location is at sea, METEOR[®] offers a second, independent draw: a direction in which to seek land. The bearing is a clockwise azimuth measured from true north: 0° points north, 90° east, 180° south and 270° west. A uniform direction is useful for making the choice of direction independent of the operator’s preferences. It does not imply that every coastline, island or country has an equal chance of being reached.

2 Bearing generation

Dice required

One D36 and four D10 rolls, each D10 read as a digit from 0 to 9.

Procedure

Let $n \in \{1, \dots, 36\}$ denote the D36 result and let $a, b, c, d \in \{0, \dots, 9\}$ denote the four D10 results in order. Calculate

$$B = 10(n - 1) + a + \frac{b}{10} + \frac{c}{100} + \frac{d}{1000} \quad \text{degrees.} \quad (1)$$

Thus the D36 selects a ten-degree sector and the D10 sequence forms the offset $a.bcd$ degrees inside it. The result ranges from 0.000° to 359.999°; north is represented by 0.000°, without duplicating it as 360.000°.

For example, $n = 14$ and $(a, b, c, d) = (7, 2, 4, 6)$ give

$$B = 10(14 - 1) + 7.246 = 137.246^\circ.$$

At the other end, $n = 36$ and $(9, 9, 9, 9)$ give 359.999°.

Uniformity and resolution

The D36 has 36 outcomes, each equally likely if the die is fair. The four D10 rolls jointly have 10^4 digit sequences. The mapping from the $36 \times 10^4 = 360,000$ roll sequences to bearings is one-to-one. Therefore each bearing has probability $1/360,000$, provided all rolls are independent and their outcomes are equiprobable. Each ten-degree sector contains 10,000 bearings, so any union of complete sectors has the expected share of outcomes. The spacing is 0.001° , or approximately 17.45 microradians. Physical dice fairness remains an empirical assumption; the algorithm alone cannot guarantee it.

3 Geodesic projection

The program uses `pyproj.Geod(ellps="WGS84")` to solve the forward geodesic problem. Given initial latitude ϕ_0 , longitude λ_0 , azimuth B , and distance s in metres, its forward operation gives

$$(\lambda(s), \phi(s), \alpha_{\text{back}}) = \text{Geod.fwd}(\lambda_0, \phi_0, B, s).$$

Distances supplied in kilometres are multiplied by 1,000 before the call. The output path is a geodesic on the WGS84 reference ellipsoid. The azimuth specifies the *initial* direction; a constant numerical compass heading is not maintained along the path.

4 Landfall search

Mapped land is assembled from polygon geometries. A projected point counts as land when the land union **covers** that point, including a represented boundary. The search evaluates the geodesic at 10, 20, 30, $\dots$, 20,000 km from the sea start. When a sample first lies on land, its distance is the upper end of a 10-km bracket; the preceding sample is its lower end. Forty iterations halve that bracket: a midpoint classified as land becomes the new upper end, otherwise it becomes the new lower end. The returned point is the upper (land-classified) end, with its distance along the geodesic.

If no sampled point lies on land by 20,000 km, the function returns no landfall. With an ideal monotone sea-to-land transition within the detected bracket, the remaining distance interval after 40 halvings is $10/2^{40}$ km, approximately 9 nanometres. That figure describes arithmetic bracketing alone: it is *not* a claim of shoreline accuracy. Polygon resolution, geodesic calculations and the classification of coastal points dominate the practical uncertainty.

5 Interpretation and limitations

The first *sampled* land point identifies the bracket, but a 10-km step can cross a narrow island or peninsula and return to sea before the next sample. Consequently the algorithm does not mathematically guarantee the first land intersection along the continuous path. Binary refinement likewise assumes that the detected bracket has a single relevant sea-to-land transition. Where multiple coastline crossings occur within one bracket, it may converge to a later transition. Landfall is therefore relative to the supplied land polygon dataset and the program's sampling procedure, rather than an exact physical shoreline.

Uniform angular sampling does not yield uniform landfall locations: coast geometry, distance, island size, and the chosen starting point shape the resulting distribution. The bearing is generated with physical dice; landfall calculation requires the software, map data and a computing device. The method can be reproduced by retaining the starting coordinates, dice results, map dataset and software version.

6 Conclusion

METEOR[®] produces an exactly uniform *discrete* set of 360,000 bearings under fair, independent rolls. It turns a sea result into a reproducible geographic route by following the selected initial azimuth on a WGS84 geodesic and seeking mapped land. The reported landfall should be read as the result of a finite-step numerical search against a particular land dataset.

Keywords

Random bearing; geodesic; WGS84; dice; landfall; geographic sampling.

Implementation note

This description is based on the METEOR[®] Python source supplied by the author, specifically `roll_bearing`, `project_point`, `find_landfall_along_bearing` and `point_is_on_land`. The companion paper is *METEOR: A Dice-Based Method for Uniform Random Sampling of Geographic Coordinates* (April 2026).

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