R Documentation

Rotation and shift of spatial coordinates

**Description**

Functions to apply (random) rotation and/or shift of a set of spatial coordinates preserving their relative spatial distribution (i.e. distance matrix) on a rectangular area or on a sphere. The resulting spatial coordinates can be constrained to fit within a defined range of X-Y or latitude-longitude coordinates. Optionally, one coordinate can also be reversed to obtain the mirror image.

Three main functions aim to help programming null models of realistic spatial predictors (e.g. climate data) defined over a continuous area (raster of environmental layers, globe). They return a set of moved spatial coordinates.

Three additional functions used by the main functions aim to convert spatial coordinates on a sphere between Cartesian (X, Y, Z) and polar (latitude, longitude) coordinate systems, and to rotate a set of coordinates on a sphere around a single axis.

shiftrotXY() performs (random) rotation and/or shift on a rectangular area where position is defined by Cartesian X, Y coordinates. It can be applied using latitude and longitude but will not correct for Earth curvature, so that it is not recommended outside the inter-tropical zone and for an area spanning over several tens of degrees longitude or latitude.

shiftrotGlobe() performs (random) rotation and/or latitude and longitude shifts of spatial coordinates on a sphere, possibly within a limited window. Adapted to situations where the set of coordinates to move spans over less than 90° longitude and latitude.

rrotGlobe() performs multiple random rotations of latitude and longitude coordinates around at least three random axes of a sphere, possibly until the set of coordinates fall within a limited window. Adapted to situations where the range of latitude and longitude is not too small (large or unlimited window), and performs well even when the set of coordinates to move are widely distributed around the globe (i.e. spanning more than 90° longitude and latitude).

LatLon2XYZ() converts latitude, longitude coordinates in degrees into Cartesian XYZ coordinates (where X points to 0° latitude and 0° longitude, Y points to 0° latitude and +90° longitude, Z points to 90° latitude).

XYZ2LatLon() converts Cartesian XYZ coordinates on a sphere (satisfying X^2 + Y^2 + Z^2 = 1) into latitude ([-90°, 90°]) and longitude ]-180°, 180°] coordinates in degrees.

shiftrotGlobe() rotate a set of latitude, longitude coordinates around a given axis by a given angle.

**Usage**

shiftrotXY(coord, X.range = c(-180, 180), Y.range = c(-30, 30), rotation = T, X.shift = T, Y.shift = T, mirror = c("random", "no", "yes"), verbose = T, MAXtrial = 1000)

shiftrotGlobe(coord, Lat.range = c(-90, 90), Lon.range = c(-180, 180), rotation = T, Lat.shift = T, Lon.shift = T, mirror = c("random", "no", "yes"), verbose = T, MAXtrial = 1000)

rrotGlobe(coord, Lat.range = c(-90, 90), Lon.range = c(-180, 180), mirror = c("random", "no", "yes"), verbose = T, MAXtrial = 1000, MINtrial = 3)

LatLon2XYZ(coord)

XYZ2LatLon(XYZ)

RotLatLongAxis(coord, axis, angle)

**Arguments**

coord matrix with the latitude (first column) and longitude (second column) of a set of spatial coordinates, given in degrees (-90 to 90 and -180 to 180)

X.range, Y.range vectors with the minimal and maximal coordinates along the X and Y axes, defining a window within which the set of coord are to be randomly moved. Default values correspond to a window where latitude and longitude coordinates could be used for Y and X, respectively, with reasonably limited spatial deformation.

Lat.range, Lon.range vectors with the minimal and maximal latitude and longitude, defining a window within which the set of coord are to be randomly moved. Default values correspond to unlimited window (free rotations and latitudinal or longitudinal shifts).

rotation either a logical indicating whether the set of coord should be rotated around their centroid by a random angle (TRUE) or not (FALSE), or a numerical value giving the angle (in degrees) of the rotation to apply to the set of coord.

X.shift, Y.shift either a logical indicating whether the set of coord should be shifted along the X or Y axis by a random value (TRUE) keeping the set of coord within the window defined by X.range and Y.range, or not (FALSE), or a numerical value giving the shift to apply to the set of coord along the X or Y axis.

Lat.shift, Lon.shift either a logical indicating whether the set of coord should be shifted in latitude or longitude by a random angle (TRUE) or not (FALSE), or a numerical value giving the angle (in degrees) used to rotate the set of coord around an equatorial axis perpendicular to the centroid of coord (Lat.shift) or around a polar axis (Lon.shift).

mirror a string, one of “yes”, “no” or “random”, defining whether a mirror image of the set of coord is taken systematically (yes), never (no) or with a probability of 0.5 (random). Only the first letter of the string matters. A logical will be interpreted as well, with TRUE for “yes” and FALSE for “no”.

verbose a logical defining if warning messages should be printed to the I/O. Warning messages appear (i) if some of the set of coord fall outside the window defined by Lat.range, Lon.range or X.range, Y.range, (ii) if after up to MAXtrial trials, random movements failed to bring the moved set of coord into the window. Note that message (i) does not stop the algorithm, which will attempt to move the set of coord into the window.

MAXtrial integer giving the maximal number of random rotation or shift trials until the set of coord fall into the window

MINtrial minimal number of successive random rotations to move the set of coord

XYZ a three column matrix with Cartesian coordinates of point situated on a sphere of unit radius along the X, Y and Z axes (must satisfy X^2 + Y^2 + Z^2 = 1)

axis, angle axis is a vector with the latitude and longitude pointing to an axis around which a set of coord is to be rotated by an angle angle in degrees

### Value

For LatLon2XYZ, a matrix with 3 columns giving the X, Y, Z coordinates corresponding to the latitude, longitude coordinates given in coord.

For the other functions, a matrix with 2 columns corresponding to the latitude [-90, 90] and longitude [-180, 180] of the moved set of coordinates defined in coord, or corresponding to the X, Y, Z coordinates given in XYZ in the case of XYZ2LatLon.

NULL is returned when a function fails to bring the set of coord within the window defined after MAXtrial random rotations or shifts (see notes for details).

### Note

shiftrotXY() successively (i) reverses or not the Y coordinates (mirror image), (ii) rotates the set of coordinates around their centroid by a defined or random (uniform 0° to 360°) angle, (iii) shifts the set of coordinates along the X and Y axes by defined amplitudes or randomly to keep the set of coordinates within the defined X and Y ranges (window). If the window is too narrow, it tries again from step (ii), a limited number of times.

shiftrotGlobe() successively (i) reverses or not the longitude coordinates (mirror image), (ii) rotates the set of coordinates around their controid axis by a defined or random (uniform 0° to 360°) angle, (iii) rotates the set of coordinates around an equatorial axis perpendicular to the previous axis by a defined or random angle (latitudinal shift), (iv) rotates the set of coordinates around a polar axis by a defined or random angle (longitudinal shift). When limited latitudinal and/or longitudinal ranges are defined (window), random shifts aim to bring the set of coordinates within the window, and if the latter appears too narrow, the algorithm is repeated from step (ii), a limited number of times. In the absence of range constrains, random longitudinal shifts are uniformly distributed (angle 0° to 360°) while latitudinal shifts are non-uniformly distributed to satisfy that the centroid of the moved coordinates is uniformly distributed around the sphere. These random distributions are truncated when a limited window is defined.

rrotGlobe() (i) reverses or not the longitude coordinates (mirror image), (ii) rotates the set of coordinates around a randomly chosen axis (unit vector uniformly distributed on the sphere) by a random angle (uniform 0° to 360°), (iii) repeat operation (ii) on the coordinates moved previously at least MINtrial times and up to MAXtrial times when a limited ranges of latitude and longitude are defined (window) until the set of moved coordinates fall within the window.

### References

### See Also

### Examples