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Census of Environment: Spatial information products

Statistical Ecosystem Register grid system reference files: Data product specifications

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1 Overview

1.1 Title

Census of Environment Statistical Ecosystem Register grid system reference files: Data product specifications

1.2 Reference date

2025-05-13

1.3 Responsible party

Census of Environment

Environment Accounts and Statistics Division, Statistics Canada

150 Tunney's Pasture Driveway
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1.4 Language

eng – English

fra – French

1.5 Terms and definitions

Statistical Ecosystem Register: A framework developed and used by Statistics Canada's Census of Environment for organizing spatial data to support the compilation of ecosystem accounts following the System of Environmental-Economic Accounting Ecosystem Accounting. The Statistical Ecosystem Register includes a spatial grid system, which will be linked to statistical ecosystem types and other relevant data.

1.6 Abbreviations and acronyms

CoE	Census of Environment
CRS	Coordinate reference system
DGGS	Discrete Global Grid System
EA	Ecosystem Accounting
EEZ	Exclusive economic zone
GeoTIFF	Geographic Tagged Image File Format
GIS	Geographic Information Systems
ISO	International Organization for Standardization
SEEA	System of Environmental-Economic Accounting
WKT	Well-known text

1.7 Informal description of the data product

This product contains reference files that define the nested spatial grid system used by the Census of Environment (CoE) at Statistics Canada. The Census of Environment reports on the extent and condition of ecosystems in Canada and provides information about ecosystem services. It organizes data using the System of Environmental-Economic Accounting (SEEA) international statistical standard.

The files contain no thematic data, only placeholder values. They can be used as templates for integrating data from multiple sources into a single gridded spatial reference system. This grid system can therefore support a common approach to integrating, producing and disseminating spatial data. The grid system was developed as part of the Statistical Ecosystem Register, which will organize and integrate spatial data to support the production of environmental-economic accounts following the SEEA Ecosystem Accounting (EA) framework. This will enable a spatial approach to accounting for ecosystems and natural capital described in the SEEA EA.

The Statistical Ecosystem Register grid system includes multiple resolutions, which are all defined from the same reference point, so they are aligned and nested: cells in each grid are subdivided to generate the cells of the next smaller resolution. There are two exceptions (100 m, 30 m), which are defined as variants of the main system. These two resolutions are aligned with, but not nested in between, other grid resolutions (see section 4.1 for details).

The grid covers an area that includes all of Canada's land, freshwater and ocean (to the limits of the exclusive economic zone [EEZ]), and the Great Lakes (including portions in the United States), plus a 100 km buffer. This ensures that the grid covers not only the geographic scope of Canadian environmental-economic accounts, but also adjacent areas that are useful for certain analyses.

The files were generated using the terra package in the R language and environment for statistical computing (section 11.1). The product will be updated as necessary.

2 Specification scope

In these specifications, only one scope is used.

2.1 Scope identification

Main

2.2 Level

Product

2.3 Level name

Main scope of the Census of Environment Statistical Ecosystem Register grid reference files

2.4 Level description

Empty reference files defined with key parameters of the Statistical Ecosystem Register grid system, which can be used as templates for integrating gridded data for Canada's land, freshwater and ocean areas.

2.5 Extent

2.5.1 Description

This product is a series of two-dimensional reference files with no elevation, temporal or thematic data associated. Each file has a different spatial resolution (grid cell size) and covers the same horizontal extent, except for the 30 m resolution grid, which is 10 m shorter along the eastern (right) edge of the grid extent (see section 2.5.3 below).

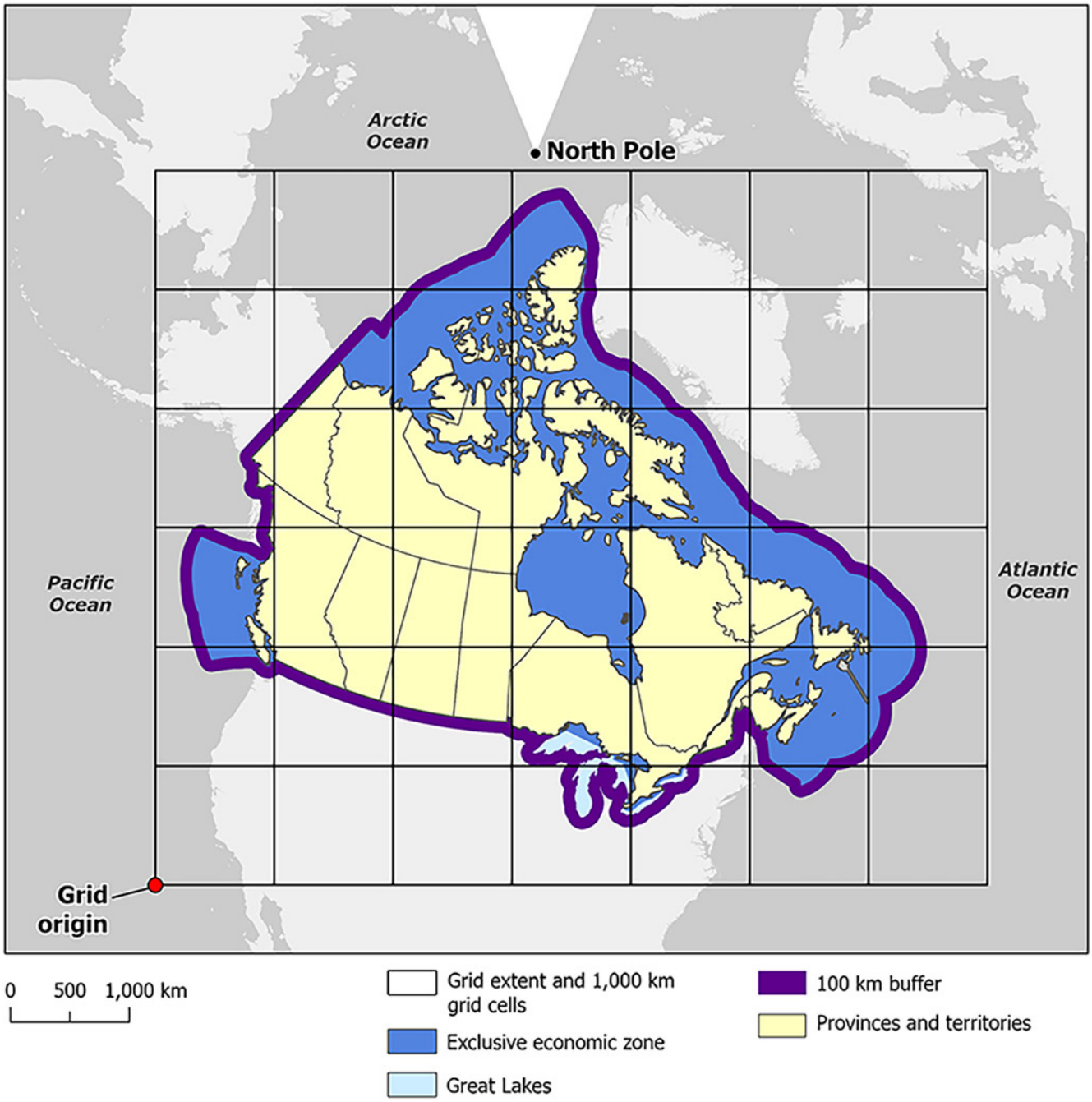
2.5.2 Vertical extent

Not applicable. The grid is two-dimensional. There is no elevation (z) associated with the grid itself or the reference files in this product. Nevertheless, elevation data from other sources may be associated to the same grid cells by users.

2.5.3 Horizontal extent

The Statistical Ecosystem Register grid system was chosen to cover Canada's land, freshwater and oceans (to the limits of the EEZ), and the Great Lakes (including portions in the United States), plus a 100 km buffer (Map 1). This ensures that the extent covers all areas necessary for compiling environmental-economic accounts for Canada, with a buffer to allow for certain models and analyses that require data from neighbouring areas. Most datasets based on this grid system will not cover the full extent of the grid, but the grid system was defined to ensure that all necessary areas could be easily captured.

Map 1
Statistical Ecosystem Register grid extent, origin and 1,000 km grid cells



Sources: Statistics Canada, 2021 Census of Population, Cartographic and digital boundary files, and calculations; Fisheries and Oceans Canada, Federal Marine Bioregions; and Great Lakes Commission, Great Lakes Shorelines.

The grid is defined from an origin point at the bottom-left (southwest) corner of the extent, rounded down to the next 1,000 km (the size of the largest cells in the grid system) to simplify calculations: this is 3,000,000 m east and 0 m north in the projected coordinate reference system (CRS) (section 5.1).

All grid resolutions cover the same extent as shown in Map 1, with one exception: the 30 m grid (see sections 4.1 and 10.2) excludes a strip that is exactly 10 m wide along the eastern (right) edge of the grid extent. This area could not be captured by a whole number of 30 m cells starting from the same grid origin without extending beyond the limits of the other grids.

While the grid system was defined to ensure the coverage of desired areas (Canada's land, freshwater and oceans, plus a buffer), the shape of that area means that large portions of the rectangular grid outside Canada are not normally used. Therefore, the latitude and longitude boundaries include only the areas where the projected coordinate system and grid system are intended for use (Table 1).

Table 1 Longitude and latitude boundaries

	Degrees
West bounding longitude	-145
East bounding longitude	-44
South bounding latitude	39
North bounding latitude	88

2.5.4 Temporal extent

Not applicable. There is no temporal dimension associated with the grid itself or the reference files in this product. Nevertheless, data from other sources may be associated to the same grid cells by users, which may include a temporal dimension.

2.6 Coverage

The information applies to all coverages.

3 Data product identification

Table 2
Data product identification for the Statistical Ecosystem Register grid reference files

Title	Statistical Ecosystem Register grid reference files
Alternate title	CoE_grid_2025
Abstract	Empty reference files defined with key parameters of the Statistical Ecosystem Register grid system, covering Canada's land, freshwater and ocean areas, plus a buffer. The files contain no elevation, temporal or thematic data.
Purpose	This product includes empty reference files that can be used as templates for integrating gridded data from multiple sources into a single coherent grid system, including multiple nested resolutions. The grid system was developed to support the production of environmental-economic accounts following the SEEA EA. These reference files allow consistent reproduction of the grid system across multiple analyses and derived products. This enhances the reproducibility and interoperability of the data produced using this grid system.
Topic category	Environment, location
Spatial representation type	Grid
Spatial resolution	1,000 km, 100 km, 10 km, 1 km, 500 m, 250 m, 100 m, 50 m, 30 m, 10 m
Geographic description	Authority: International Organization for Standardization (ISO)
	ISO 3166-1:1997 – Codes for the representation of names of countries and their subdivisions – Part 1: Country codes
	Reference date of the ISO 3166-1 standard: 1997-10-01
	Data type: Publication
	Code: CA – Canada
	Extent type code: 1 – Inclusion
Specification scope	Main

4 Data content and structure

4.1 Description

This product is composed of a series of 11 raster files, plus a text file in well-known text representation of CRSs (WKT-CRS 2) format containing a detailed definition of the projected CRS (with a .prj extension) (see section 5.1). A reference grid at each resolution (cell size) is stored as a separate file, resulting in 11 files (section 10.2). This enables users to choose the grid resolution they require for their analytical purposes.

The Statistical Ecosystem Register grid system uses a series of resolutions defined by subdividing each "parent" level into a whole number of smaller cells, as described in Table 3. The reference files contain two additional grids, defined as variants: one with 30 m grid cells and another with 100 m grid cells. A 30 m grid was defined to work with Landsat and similar imagery at this resolution, defined by aggregating the 10 m grid into 30 m cells (so the 10 m grid nests within both the 50 m and the 30 m grids). A 100 m grid was defined as a variant level in between 50 m and 500 m; much remote sensing data are available at a 250 m resolution (e.g., MODIS imagery), but some flexibility was desired in this range, and a 100 m grid was chosen as a variant subdivision of the 500 m grid.

Table 3
Nested cell sizes used in the Statistical Ecosystem Register grid system, which define the resolution of associated data

Grid level	Cell size (side length, metres)	Number of cells per parent	Number of cells required to cover minimum extent[1] × 1,000,000
0	1,000,000	…	…
1	100,000	100 (10 × 10)	…
2	10,000	100 (10 × 10)	…
3	5,000	4 (2 × 2)	< 1
4	1,000	25 (5 × 5)	16
5	500	4 (2 × 2)	64
6	250	4 (2 × 2)	256
variant	100	…	1,598
7	50	25 (5 × 5)	6,392
variant	30	…	17,754
8	10	25 (5 × 5)	159,788

... not applicable
1. The minimum extent is Canada's land, freshwater and oceans (to the limits of the EEZ), and the Great Lakes (see section 2.5.3).

4.2 Feature information

Not applicable

4.3 Coverage information

4.3.1 Description

Technical description: The rasters contain placeholder values of 1 in each cell. Grid cell size and position information are also encoded in the files.

Type of coverage content: thematicClassification

4.3.2 Coverage type

Discrete quadrilateral grid coverage

4.3.3 Specification

4.3.3.1 Domain extent

Refer to section 2.5.

4.3.3.2 Range type

The files contain placeholder values of 1.

Value data type: 1-bit integer (0-1)

4.3.3.3 Common point rule

Not applicable

4.4 Reference to the specification scope

Main

5 Reference systems

5.1 Spatial reference system

The spatial reference system is based on EPSG:3347, with the following key differences:

- It uses Albers equal-area conic projection.
- The second standard parallel is at 90° (i.e., the North Pole).

An equal-area projection is used to ensure that each grid cell covers the same area and to better support area-based statistics. A standard parallel at the North Pole reduces shape distortion in the region and allows the North Pole to be projected to a single point in the spatial reference system, rather than an arc. This projected CRS results in a triangular “wedge” area above the North Pole that is not on the Earth’s surface—the grid system described here does not extend into this area.

The spatial reference system is defined using the WKT-CRS 2 (ISO 19162:2019). This is a portable open standard that is compatible with many software applications. The following is the WKT-CRS 2 representation of the projected CRS used to create the reference files, which is also included as a text file (with a .prj file extension):

```
PROJCRS["NAD83 / Statistics Canada Statistical Ecosystem Register Albers",
    BASEGEOGCRS["NAD83",
        DATUM["North American Datum 1983",
            ELLIPSOID["GRS 1980",6378137,298.257222101,
                LENGTHUNIT["metre",1]]],
        PRIMEM["Greenwich",0,
            ANGLEUNIT["degree",0.0174532925199433]],
        ID["EPSG",4269]],
    CONVERSION["Statistics Canada Statistical Ecosystem Register Albers",
        METHOD["Albers Equal Area",
            ID["EPSG",9822]],
        PARAMETER["Latitude of false origin",63.390675,
            ANGLEUNIT["degree",0.0174532925199433],
            ID["EPSG",8821]],
        PARAMETER["Longitude of false origin",-91.8666666666667,
            ANGLEUNIT["degree",0.0174532925199433],
            ID["EPSG",8822]],
        PARAMETER["Latitude of 1st standard parallel",49,
            ANGLEUNIT["degree",0.0174532925199433],
            ID["EPSG",8823]],
        PARAMETER["Latitude of 2nd standard parallel",90,
            ANGLEUNIT["degree",0.0174532925199433],
            ID["EPSG",8824]],
        PARAMETER["Easting at false origin",6200000,
            LENGTHUNIT["metre",1],
            ID["EPSG",8826]],
        PARAMETER["Northing at false origin",3000000,
            LENGTHUNIT["metre",1],
            ID["EPSG",8827]]],
    CS[Cartesian,2],
        AXIS["(E)",east,
            ORDER[1],
            LENGTHUNIT["metre",1,
                ID["EPSG",9001]]],
        AXIS["(N)",north,
            ORDER[2],
            LENGTHUNIT["metre",1,
                ID["EPSG",9001]]],
    USAGE[
        SCOPE["Spatial data management and analysis for environmental-economic
accounting."],
        AREA["Canada - onshore and offshore; Alberta; British Columbia; Manitoba; New
Brunswick; Newfoundland and Labrador; Northwest Territories; Nova Scotia; Nunavut;
Ontario; Prince Edward Island; Quebec; Saskatchewan; Yukon."],
        BBOX[39.11,-144.23,87.30,-44.86]],
    REMARK["Developed by Statistics Canada's Census of Environment for the Statistical
Ecosystem Register."]
    ]
```

5.2 Linear reference system

Not applicable

5.3 Temporal reference system

Not applicable

5.4 Reference to specification scope

Main

6 Data quality

6.1 Completeness

Not applicable

6.2 Logical consistency

6.2.1 Conceptual consistency

Not applicable. The files are filled with placeholder values (section 4.3).

6.2.2 Domain consistency

Not applicable. The files are filled with placeholder values (section 4.3).

6.2.3 Format consistency

The rasters were generated by open-source software (section 11.1), which ensures format consistency for product distribution.

6.2.4 Topological consistency

The rasters were generated by open-source software (section 11.1), which controlled projection and pixel alignment.

6.3 Positional accuracy

The rasters were generated by open-source software (section 11.1), which controlled pixel position and encoding in the files.

6.4 Temporal accuracy

Not applicable. There is no temporal dimension associated with the grid reference files.

6.5 Thematic accuracy

Not applicable. There are no thematic data included in the grid reference files.

6.6 Reference to the specification scope

Main

7 Data capture

7.1 Description

The Statistical Ecosystem Register grid system was designed to cover Canada's land, freshwater and oceans (to the limits of the EEZ), and the Great Lakes (including portions in the United States), plus a 100 km buffer (Map 1, section 2.5.3). The boundaries for these areas were based on the following sources (Table 4):

Table 4
Boundaries used to derive the minimal extent of the Statistical Ecosystem Register grid system

Boundaries	Source	Comments
Land and freshwater	Census of Population cartographic boundaries	Provincial boundaries; Census of Population digital boundaries were used in some areas for administrative (international) boundaries
Ocean (to limits of exclusive economic zone)	Federal Marine Bioregions (Fisheries and Oceans Canada)	Excluding areas outside Canada (Saint Pierre and Miquelon)
Great Lakes	Great Lakes Shorelines (Great Lakes Commission)	Including portions within Canada and the United States

A 100 km buffer was added to the exterior of these combined boundaries to ensure that neighbouring areas could be included for certain analyses. The grid origin and extent were chosen to cover this combined area, with some additional rounding to simplify calculations.

7.2 Reference to the specification scope

Main

8 Data maintenance

8.1 Description

The reference files are updated as needed. No updates are currently planned, but the grid system may be updated in terms of resolution, extent or other parameters, based on the requirements of the CoE program.

8.2 Reference to the specification scope

Main

9 Portrayal

Not applicable

10 Data product delivery

10.1 Delivery format information

Geographic Tagged Image File Format (GeoTIFF)

10.1.1 Format name

GeoTIFF

10.1.2 Version

GeoTIFF 1.1 (TIFF 6.0 compliant)

10.1.3 Specification

GeoTIFF is a format extension for storing georeference and geocoding information in a TIFF 6.0 compliant raster file by tying a raster image to a known model space or map projection.

10.1.4 File structure

Not applicable

10.1.5 Language

eng – English

10.1.6 Character set

utf8

10.2 Delivery medium information for static files

10.2.1 Units of delivery

Each file in the series is delivered by resolution using these naming conventions:

CoE_grid_2025_[grid level]_[cell size].tif

E.g., grid file for 10 km resolution (level 3): CoE_grid_2025_3_10km.tif

10.2.2 Transfer size

File size increases with resolution (i.e., smaller cells). Files are filled with placeholder values, as required for a valid file format. File size was reduced using the following data and compression options in the terra package for R, which uses the GTIFF driver in GDAL to write the files (see section 11.1):

- Data type="INT1U" (unsigned 1 byte integer)
- NBITS=1 (1-bit data values)
- COMPRESS=DEFLATE, PREDICTOR=1, ZLEVEL=12 ("DEFLATE" compression with no predictor [1] and a compression level of 12)

Table 5
File names and sizes of reference files for the Statistical Ecosystem Register grid system

Grid level	Cell size (side length, metres)	File size (kb)	File name
0	1,000,000	1	CoE_grid_2025_0_1000km.tif
1	100,000	1	CoE_grid_2025_1_100km.tif
2	10,000	2	CoE_grid_2025_2_10km.tif
3	5,000	2	CoE_grid_2025_3_5km.tif
4	1,000	27	CoE_grid_2025_4_1km.tif
5	500	113	CoE_grid_2025_5_500m.tif
6	250	447	CoE_grid_2025_6_250m.tif
variant	100	3,166	CoE_grid_2025_6a_100m.tif
7	50	7,395	CoE_grid_2025_7_50m.tif
variant	30	14,846	CoE_grid_2025_7a_30m.tif
8	10	77,346	CoE_grid_2025_8_10m.tif

10.2.3 Medium name

File transfer

Open Government Portal

GEO.CA

10.2.4 Other delivery information

Information regarding the use of the data is defined in the Statistics Canada Open Licence.

10.3 Reference to specification scope

Main

11 Additional information

Statistics Canada's Census of Environment's (CoE) aims to deliver a full picture of the complex relationship between ecosystems, the economy, society and human well-being in one easily accessible location. More information is available in "Methodological Guide: Canadian System of Environmental-Economic Accounting."

The CoE considered alternative spatial grid definitions, including alternate grid cell shapes, such as squares, triangles or hexagons, as well as Discrete Global Grid Systems (DGGSs). Hexagonal grids have a consistent topology (all neighbours are equidistant) and a lower perimeter to surface area ratio. These characteristics make them useful for certain applications, including analyzing connectivity and movement, or grouping point data in areas with curved boundaries such as coastlines (Birch et al., 2007; Koropatnick & Coffen-Smout, 2020; Strimas-Mackey, 2020). Nevertheless, hexagons are not congruent, meaning that they cannot be subdivided into a whole number of smaller cells that are enclosed by the parent, which is a disadvantage for integrating data from multiple sources and resolutions (Bowater & Stefanakis, 2018). The CoE program also relies on remote sensing data, which are most often provided in square grids (e.g., sensor images). Therefore, square cells were preferred to reduce the amount of resampling needed to work with input data and to allow perfect nesting (congruency) of grid resolutions (section 4.1).

Although DGGSs show promise for organizing geospatial data with equal-area cells on a global scale, software tools to facilitate their use are not widely available and require further development (Béjar et al., 2023; Kmoch et al., 2022; Robertson et al., 2020). Only one DGGS with square cells was identified: rHEALPix. This DGGS uses a Collignon equal-area projection in polar regions (Gibb, 2016)—where the vast majority of Canada is located—which is unusual and not supported by some popular Geographic Information System (GIS) software applications.

11.1 Software used

The software was used to produce the files in this product are listed in Table 6:

Table 6
Software versions used to produce the Statistical Ecosystem Register grid reference files

Software	Version	Citation
R	4.3.3	R core team, 2024
terra	1.7-78	Hijmans, 2024
GEOS	3.12.1	GEOS contributors, 2024
GDAL	3.8.5	Rouault et al., 2024
PROJ	9.4.0	PROJ contributors, 2024

The files were produced using an R package named coeGridR (version 0.12.002), developed and executed internally using the software above.

11.2 References

Béjar, R., Lacasta, J., Lopez-Pellicer, F. J., & Nogueras-Iso, J. (2023). Discrete Global Grid Systems with quadrangular cells as reference frameworks for the current generation of Earth observation data cubes. *Environmental Modelling & Software, 162.* 10.1016/j.envsoft.2023.105656

Birch, C. P. D., Oom, S. P., & Beecham, J. A. (2007). Rectangular and hexagonal grids used for observation, experiment and simulation in ecology. *Ecological Modelling, 206*(3), 347–359. 10.1016/j.ecolmodel.2007.03.041

Bowater, D., & Stefanakis, E. (2018). The rHEALPix Discrete Global Grid System: considerations for Canada. *Geomatica, 72*(1), 27–37. 10.1139/geomat-2018-0008

GEOS contributors (2024). *GEOS computational geometry library.* Open Source Geospatial Foundation.

Gibb, R. G. (2016). The rHEALPix Discrete Global Grid System. *IOP Conference Series: Earth and Environmental Science, 34*(1), 12012–12019. 10.1088/1755-1315/34/1/012012

Hijmans, R. (2024). *terra: Spatial Data Analysis.* R package version 1.7-78.

Kmoch, A., Matsibora, O., Vasilyev, I., & Uuemaa, E. (2022). Applied open-source Discrete Global Grid Systems. *AGILE: GIScience Series, 3,* 1–6. 10.5194/agile-giss-3-41-2022

Koropatnick, T., & Coffen-Smout, S. (2020). *Atlantic Canadian Protocol on Mapping Fishing Activity.* (No. 3348). Dartmouth, N.S. https://waves-vagues.dfo-mpo.gc.ca/library-bibliotheque/40844018.pdf

PROJ contributors (2024). *PROJ coordinate transformation software library.* Open Source Geospatial Foundation.

R Core Team (2024). *R: A Language and Environment for Statistical Computing.* R Foundation for Statistical Computing, Vienna, Austria.

Robertson, C., Chaudhuri, C., Hojati, M., & Roberts, S. A. (2020). An integrated environmental analytics system (IDEAS) based on a DGGS. *ISPRS Journal of Photogrammetry and Remote Sensing, 162,* 214–228. 10.1016/j.isprsjprs.2020.02.009

Rouault, E., Warmerdam, F., Schwehr, K., Kiselev, A., Butler, H., Łoskot, M., Szekeres, T., Tourigny, E., Landa, M., Miara, I., Elliston, B., Chaitanya, K., Plesea, L., Morissette, D., Jolma, A., Dawson, N., Baston, D., de Stigter, C., & Miura, H. (2024). *GDAL (v3.8.5).* Zenodo.

Strimas-Mackey, M. (2020). *Fishnets and Honeycomb: Square vs. Hexagonal Spatial Grids.* Retrieved 2023-06-16.

12 Metadata

Not applicable

12.1 Reference to specification scope

Main