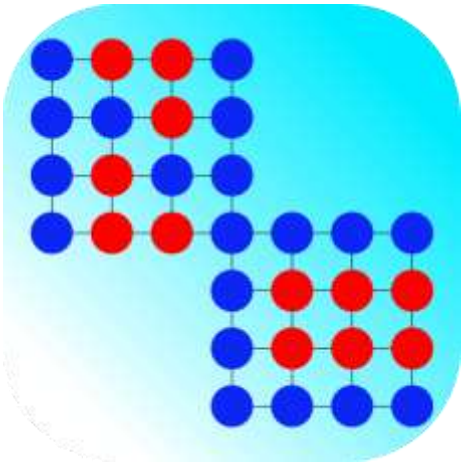
ncPick- A Toolkit for Extracting, Analyzing, and Visualizing Copernicus ERA5 NetCDF Reanalysis Climate Datasets



User manual & testing documentation

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About the software

ncPick is a software tool for extracting, analyzing, and visualizing Copernicus ERA5 Reanalysis Climate Datasets. It was developed to make Copernicus NetCDF data more accessible to researchers, students, and professionals who may not be familiar with the NetCDF format but require access to vast climatological and meteorological datasets.

At its core, ncPick bridges the gap between Copernicus data and more commonly used analytical tools such as Microsoft Excel, Python, JASP, R, and similar software (Figure 1). With this in mind, ncPick was designed to be highly intuitive and easy to use, even for users with limited technical backgrounds.

The software offers a range of functions, including data selection, visualization, basic descriptive statistics, interpolation, and time-of-day heatmap generation. In addition, it provides specialized features for preparing final datasets-such as merging CSV files on a time axis, formatting data for labeling, and downsampling-making it easier to integrate Copernicus ERA5 data into broader analytical workflows.

By combining accessibility, usability, and powerful data processing tools, ncPick enables users to efficiently transform raw reanalysis data into ready-to-use formats for further research, teaching, or operational applications.

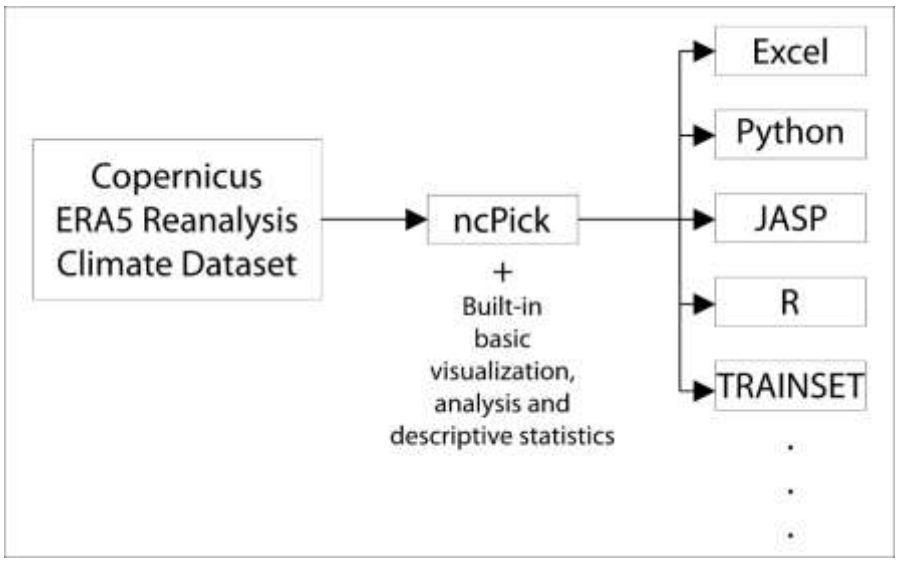

Figure 1. Position of ncPick within the data processing pipeline, from Copernicus ERA5 Reanalysis Climate Datasets to commonly used data analysis software.

The software was developed by Filip Arnaut (main developer), Sreten Jevremović and Aleksandra Kolarski of the Institute of Physics Belgrade, University of Belgrade, Republic of Serbia. The software was entirely developed in Python v3.12.

Who is this software for?

ncPick is designed for anyone who wishes to work with NetCDF files from the Copernicus ERA5 Reanalysis. While it is fully capable for use by climatologists and meteorologists, its conceptualization and development were primarily aimed at researchers and professionals from other disciplines who may not have prior experience with NetCDF data.

Fields such as agriculture, forestry, geosciences, physics, traffic engineering, and geography can all benefit from the wealth of information contained in Copernicus ERA5 datasets. However, professionals in these areas often lack the time-or the specialized technical skills-needed to navigate the complexities of the NetCDF format and extract the data they require.

By providing a streamlined, user-friendly interface, ncPick removes these barriers, enabling users to access, process, and visualize high-quality climatological and meteorological data without deep technical expertise. In short, whether you are an experienced scientist, a student, or a professional from another field, ncPick offers a simple and efficient way to unlock the potential of Copernicus ERA5 reanalysis data.

License

Installation/usage

Installation:

1. Download the ncPick v1.0 folder and place it in a location of your choice (e.g., Downloads, C:\, or another preferred directory).
2. Inside the folder, locate the ncPick application file (.exe).
3. Create a shortcut to the application file and place it on your Desktop for quick access.
4. The software can be directly run from the ncPick v1.0 folder if you prefer, but using a Desktop shortcut is generally more convenient.

In the event of any bugs or problems with the ncPick software please contact: Filip Arnaut, Institute of Physics Belgrade, University of Belgrade at: filip.arnaut@ipb.ac.rs

Brief note of the existing software landscape

In the domain of Copernicus-recommended software for working with NetCDF data, Panoply and SNAP are among the most widely cited tools. While they are capable and versatile, they are not always entirely intuitive or user-friendly-particularly for individuals who are not deeply experienced with technical workflows or data processing software. Users can accomplish a great deal with these tools, but navigating their interfaces often requires trial and error, and those who are less technically inclined can quickly encounter obstacles that interrupt their workflow.

We developed ncPick with these challenges in mind. The software is aimed at people who may have little to no prior experience with NetCDF data, who do not wish to learn programming languages or adopt new technical methods, and who simply want to extract and use their data without unnecessary complexity. Whether users have no coding background or only basic knowledge but lack the confidence or time to experiment, ncPick is designed to provide an approachable, intuitive, and efficient solution-allowing them to focus on their actual work rather than on learning a new tool from scratch.

A broader examination of available NetCDF-related tools from UniData “Software for manipulating or Displaying NetCDF data” shows that most existing solutions fall into two categories: command-line utilities and programming libraries. Many of these require substantial technical expertise to install and operate, and a significant portion are developed primarily for Linux environments. Very few combine a graphical user interface with a focus on usability, and even fewer are optimized for Windows, despite it being the most widely used operating system among potential users. With ncPick, we aimed to address this gap-delivering a Windows-based, GUI-driven, and highly intuitive application that enables users to work with Copernicus ERA5 NetCDF data without technical barriers.

Description of the user interface

The user interface (UI) was designed to be simple (Figure 2), featuring the primary functionalities in the top ribbon, alongside the map window, time-series window, and descriptive statistics window, which occupy the central area of the UI. Upon data loading, the map window exhibits the basemap and the locations of the data points, while the time-series window and the descriptive statistics window present data upon the selection of a data point.

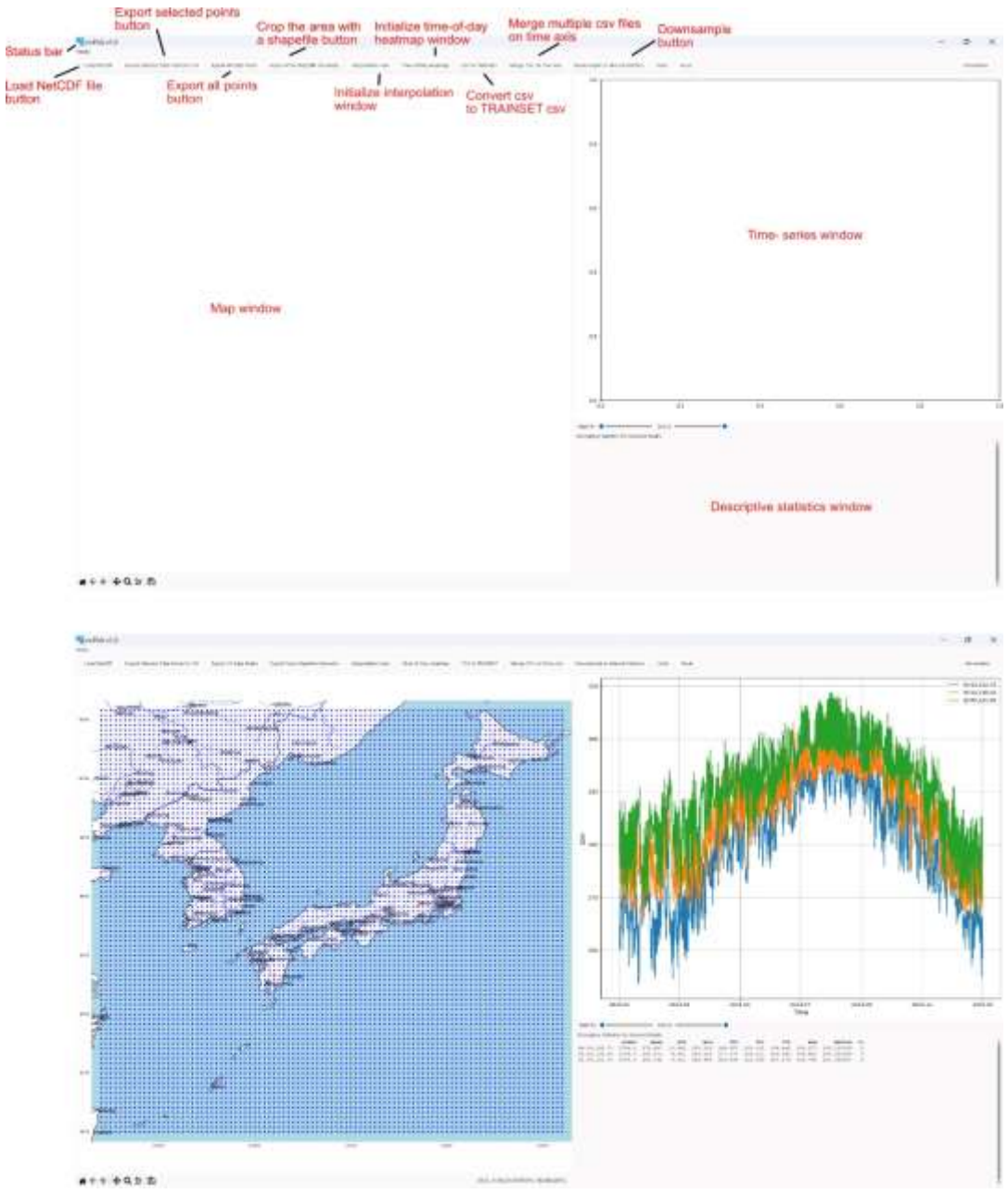

Figure 2. Display of the ncPick UI (upper panel) and display of the ncPick UI with loaded data (lower panel)

ncPick workflow

Initialization and Basemap Setup

The initialization process for ncPick begins when the user starts the software by double-clicking the application icon or its desktop shortcut. A temporary loading screen is displayed while, in the background, the basemap layer is loaded (Figure 1).

The basemap layer is composed of the following elements:

1. Road network - Natural Earth 10m roads.
2. River network - Natural Earth 10m rivers and lake centerlines.
3. Urban centers - Natural Earth 10m urban areas (LandScan).
4. Water layer - Global water bodies.
5. Administrative boundaries - World administrative boundaries from Opendatasoft.

All these layers have been combined into a single basemap GeoPackage file. The use of a static, local basemap ensures that ncPick can function without relying on an internet connection or online map services, while still providing essential geographic orientation for the selected region. This approach keeps startup times reasonable-around 10 seconds from launch to interface readiness-while maintaining a built-in global basemap.

Two optimizations were applied to the original datasets from Natural Earth and Opendatasoft to improve performance:

1. The road network was filtered to retain only Major Highway, Secondary Highway, and Road categories, removing all other road types to reduce memory usage.
2. The urban centers layer was filtered to include only cities with populations above 100,000, omitting smaller urban areas to further conserve resources.

For users who wish to further optimize ncPick performance, the basemap GeoPackage file can be manually edited. The file is located at:

ncPick v1.0_internal\basemap_data\basemap_main.gpkg

It can be opened in GIS software such as QGIS, where the attribute table for the urban areas layer can be filtered to retain only locations meeting specific criteria (e.g., cities with populations over 1 million). Reducing the number of displayed urban areas can decrease memory usage and improve loading speed.

Loading and Viewing NetCDF Files

Once the software has initialized, the user can load a NetCDF (.nc) file. The left panel will display the basemap overlaid with data points (typically in a grid pattern). The user can either proceed directly to the interpolation view-where all data points are included-or select specific points of interest.

Points of interest can be selected in three ways:

1. Manual Point Selection - The user clicks individual points directly on the map. Any number of points may be selected. Once at least one point is chosen, the visualization interface is enabled, showing a time series graph for the selected point(s) with two adjustable time sliders for zooming into specific periods (forward and backward sliders). Descriptive statistics are automatically calculated for the selection. Users can export selected points to CSV, where the first column contains timestamps and subsequent columns are labeled by latitude and longitude. The time-of-day heatmap function is also enabled for manually selected points.
2. Shapefile-Based Selection - The Export from Shapefile function filters the NetCDF dataset to retain only points within a user-specified polygon (e.g., country boundaries or a custom research area created in QGIS). The output consists of both a filtered .nc file and a CSV containing only the points within the shapefile's geometry. This filtered dataset can be reloaded into ncPick for further analysis.
3. Export All Points - This option exports every data point from the loaded NetCDF file into a CSV. Large exports-whether due to extensive spatial coverage or long-time spans-can create very large files that may be difficult to open in applications like Excel. It is recommended to segment large datasets before export.

Descriptive Statistics Module

The descriptive statistics module provides the following measures for selected data: count, mean, standard deviation, minimum, first quartile (Q1), median, third quartile (Q3), maximum, and the count of values below 1.

Interpolation Modules

General Interpolation - Implemented using SciPy's interpolate library with linear interpolation on a 200×200 grid. The playback speed can be set to slow (1000 ms), medium (200 ms), or fast (20 ms) per time step. Processing is sequential, meaning each frame is generated on demand, and actual playback speed may vary depending on system performance.

Time-of-Day Heatmap - Displays the day of the year on the x-axis and the time of day on the y-axis, with values interpolated using cubic interpolation from SciPy's interpolate. The user must first select one or more points, then specify the correct UTC offset so that the heatmap reflects local time rather than UTC. This tool is particularly useful for identifying diurnal patterns in parameters such as temperature.

CSV Processing Modules

CSV to TRAINSET Conversion- Converts a standard CSV into a TRAINSET-compatible format for use with the TRAINSET online data labeling tool. The input file must have a time column in YYYY-MM-DD or YYYY-MM-DD HH:MM:SS format and one or more value columns. The user specifies the time column and value column(s) upon loading. If two value columns are provided, the first is labeled series_a and the second series_b. All entries are initially labeled as "Normal," with labeling adjustments performed later in TRAINSET.

Merge CSV Files on Time Axis- Merges two CSV files by aligning their time columns and retaining only overlapping periods. Time columns must be in YYYY-MM-DD or YYYY-MM-DD HH:MM:SS format. The user selects which value columns to keep, and the output contains only the intersecting time range with the chosen values.

Downsample to Interval-Specific Statistics- Reduces the resolution of a CSV file by aggregating values over a user-specified time interval (e.g., 24 hours, 6 hours). The user specifies the time column, value columns, and desired interval. The output CSV contains aggregated statistics for each interval, including count, mean, median, minimum, maximum, and standard deviation, along with the number of data points used for each aggregated value and the 25^{th} and 75^{th} percentile for the data.

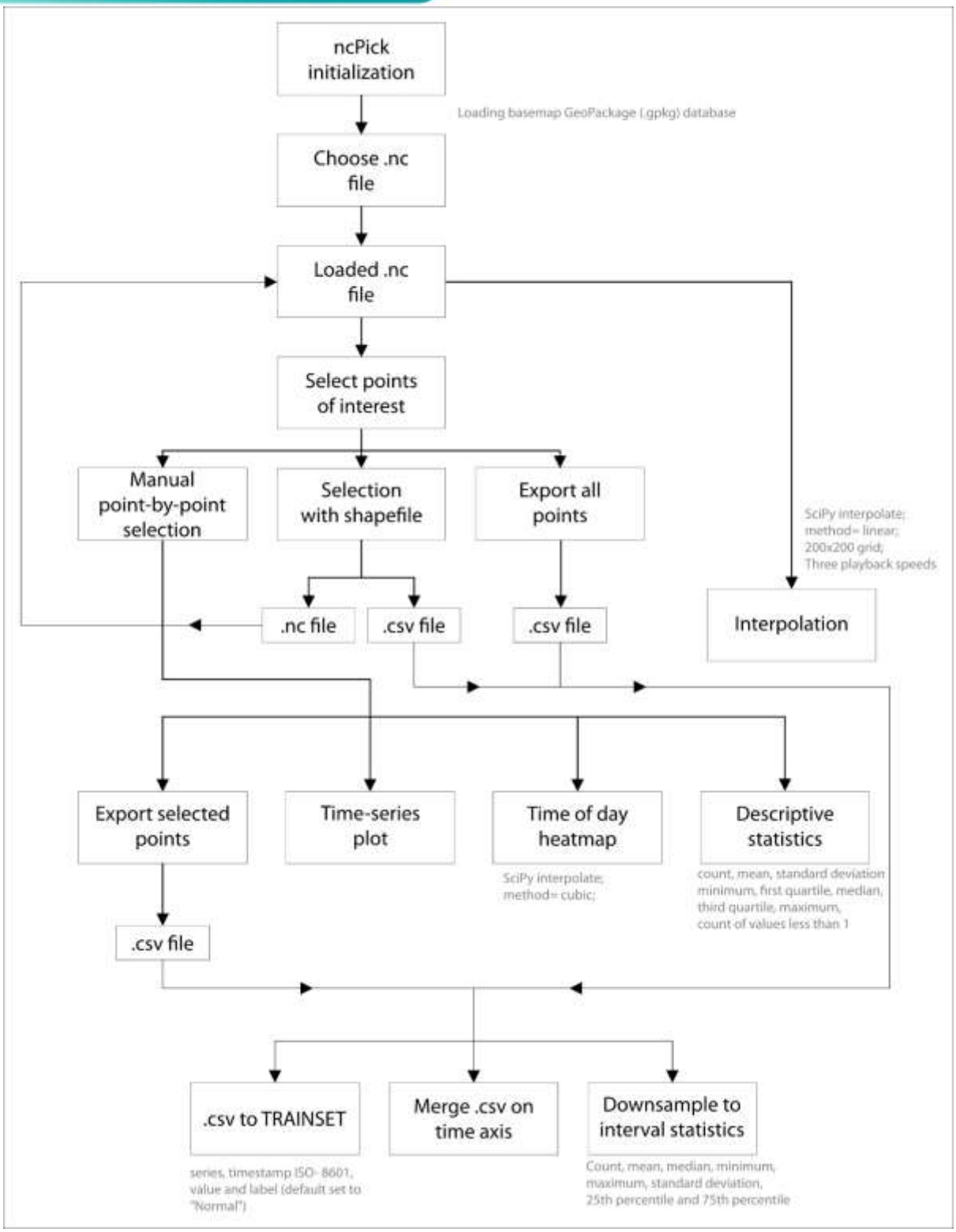

Figure 3. Structure and workflow of ncPick, showing the main functional components and their interactions within the software.

Testing and quality control

Testing was carried out to ensure that all functions of ncPick operated correctly and produced the expected results. This process involved checking the accuracy of outputs, verifying that all features worked as intended, and ensuring overall software stability. The following section outlines the testing workflow and presents the results of these procedures.

Functions that underwent testing:

- Load NetCDF,
- Export selected points to CSV,
- Export all data points,
- Export from Shapefile Geometry,
- Visualization interface,
- Descriptive statistics for selected points,
- Interpolation View,
- Time-of-day heatmap,
- CSV to TRAINSET,
- Merge CSV on time axis,
- Downsample to interval statistics.

Load NetCDF and Export selected points to CSV

Load NetCDF function objective: Load a NetCDF data file and display the data points on the basemap.

Export Selected Points to CSV function objective: When the user selects specific data point(s) and exports them to CSV, the resulting file contains a time column and *n* value columns corresponding to the selected points.

Test: Load a NetCDF file, select five random data points, and export them to CSV.

Verification: Cross-reference the exported CSV file from ncPick with the same exported values from Panoply. Calculate any discrepancies between the two outputs.

Test Workflow:

1. Load the PBL_2020.nc data file (Planetary Boundary Layer parameter) for the area above Serbia.
2. Export five random points.
3. Load the same file in Panoply and export the same five data points.
4. Calculate the Absolute Percentage Error (APE) between the outputs.
5. Repeat the process for the MSL_Slovenia.nc file (Mean Sea Level Pressure parameter for Slovenia).

Test Results: The results were satisfactory, showing an error rate of less than 0.5% in both cases. This minor discrepancy can be attributed to rounding differences.

The detailed results are available in:
ncPick v1.0\test_files\1_Load_NetCDF_and_export_selection_test

Export all data points

Export all data points function objective: Export all data points contained within the selected .nc file.

Test: Load a NetCDF file and use the Export All Data Points function.

Verification: Cross-reference the exported CSV file from ncPick with five random points exported from Panoply, and calculate the discrepancy. Additionally, verify that the total number of data points in the .nc file matches across ncPick, Panoply, and the exported CSV file.

Test Workflow:

1. Load the Percip_Slovenia.nc file.
2. In ncPick, export all data points to CSV.
3. Load the same file in Panoply, select five random points, and export them to another CSV file.
4. Calculate the Absolute Percentage Error (APE) and Mean Absolute Percentage Error (MAPE) for the known exported points.
5. Compare the total number of data points reported by ncPick, Panoply, and the exported CSV file. All values should match.

Test Results: For the five selected points, the maximum APE value did not exceed 5%, and the MAPE did not exceed 1%. The higher APE values for individual points can be attributed to the nature of precipitation data-where values often have a very small order of magnitude-and the fact that percentage-based error metrics can become disproportionately large in such cases. Despite this, the discrepancies are minimal and within acceptable limits. Furthermore, ncPick, Panoply, and the exported CSV file each reported a total of 98 data points, confirming complete and consistent export functionality. The Export All Data Points function is therefore deemed satisfactory.

The detailed results are available in: ncPick v1.0\test_files\2_Export_all_data_points

Export from Shapefile Geometry

Export from shapefile geometry function objective: Retain only the data points from a .nc file that are located within the boundaries defined by a given shapefile (e.g., a country polygon). This allows users to filter data spatially based on a defined geographic area.

Test: Load a .nc file and apply the Export from Shapefile function using a shapefile of a given country.

Verification: Perform a visual inspection to confirm that only data points within the shapefile boundaries are retained in the resulting .nc file.

Test Workflow:

1. Download a .nc file from Copernicus encompassing Japan, including its numerous islands.
2. Obtain a shapefile of Japan and process it in QGIS to remove distant islands, retaining only mainland Japan and several nearby islands.
3. Load the original .nc file into ncPick.
4. Apply the Export from Shapefile Geometry function using the processed Japan shapefile.
5. Visually compare the original and exported .nc files to ensure proper filtering of data points.

Test Results: Visual inspection (Figure 4) confirmed that only the points within the shapefile boundaries were retained in the exported .nc file. Additionally, when all points from the cropped .nc file were exported using the Export All Data Points function, the resulting CSV contained the same number of points (598) as the shapefile-based export, confirming that the filtering process preserved the correct dataset. The function is deemed to perform as intended.

The detailed results are available in:
ncPick v1.0\test_files\3_Export_from_shapefile_geometry

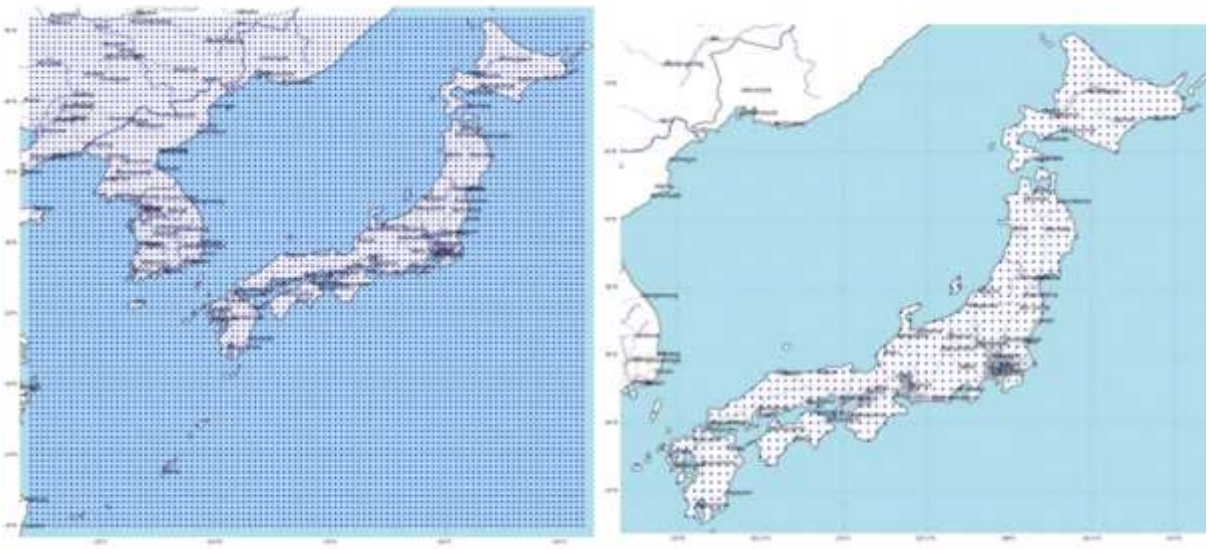

Figure 4. Original .nc file obtained from Copernicus with all data points (left) and .nc file obtained from ncPick after selecting the export from shapefile geometry function (right)

Visualization interface and descriptive statistics for selected points

Visualization Interface and Descriptive Statistics for Selected Points Functions Objective: When a user selects a data point from the map view, its time series is displayed in the graph view, and descriptive statistics are calculated for that location's dataset.

Test: Load a .nc file, select a data point, export that same point to CSV, and plot it in Microsoft Excel. Visually compare the resulting graph with the one generated by ncPick. Additionally, select four points to trigger the descriptive statistics calculation, export them to CSV, manually compute the same parameters in Excel, and compare the results with those generated by ncPick.

Verification: Visual comparison of time-series graphs and numerical comparison of descriptive statistics values.

Test Workflow:

1. Load the Japan_temp.nc file into ncPick.
2. Select a single data point and set the time slider to a shorter time range. Take a screenshot of the time-series graph.
3. Export the same data point to CSV and plot it in Excel for the same time range. Compare the two graphs visually.
4. Select four data points to trigger the descriptive statistics calculation in ncPick.
5. Export these four points to CSV and manually compute the descriptive statistics in Excel. Compare the results with the ncPick output.

Test Results: Visual inspection (Figure 5) confirmed that the graphs generated by ncPick and Excel are identical, verifying the correctness of the visualization interface. Likewise, the descriptive statistics computed by ncPick matched the manually calculated values from Excel, confirming the accuracy of the descriptive statistics module.

The detailed results are available in: ncPick v1.0\test_files\ 4_Visualization_interface

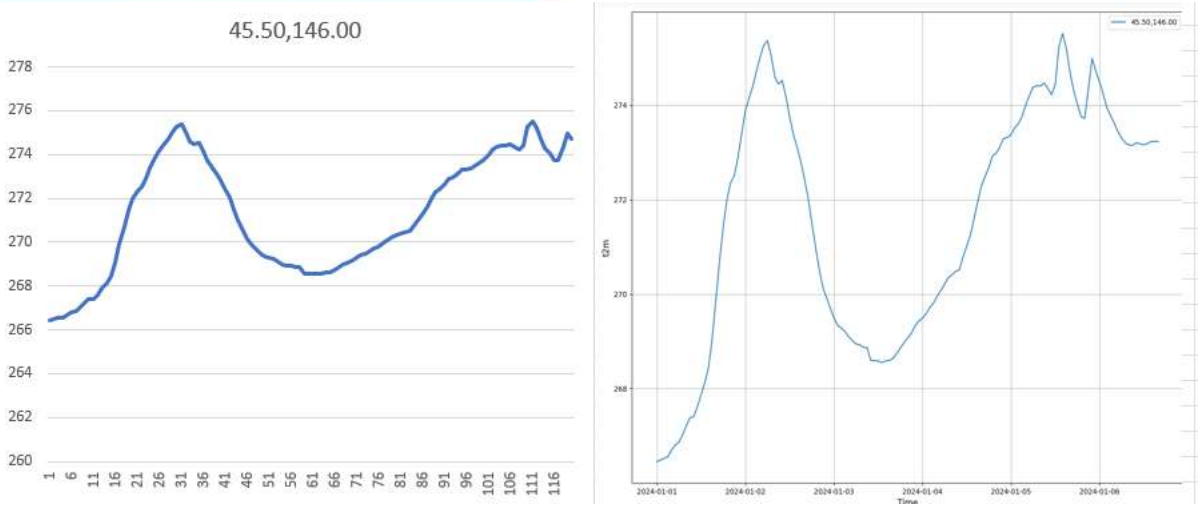

Figure 5. Visualization of Temperature for coordinates 146 and 45.5 in MS Excel (left) and in ncPick (right)

Interpolation View

Interpolation View Function Objective: Display all data from the imported .nc file using interpolation, overlaid with country borders for spatial context.

Test: Compare the interpolation results from ncPick with those generated by Panoply.

Verification: Visual inspection of interpolated features at different time steps.

Test Workflow:

1. Load the Percip_Slovenia.nc data file into ncPick.
2. Select the Interpolation View option.
3. For five randomly chosen time steps, visually compare the interpolated output from ncPick with the corresponding interpolation in Panoply.

Test Results: Visual comparison (Figure 6) showed that the interpolations generated by ncPick closely matched those produced by Panoply. The interpolation function is therefore deemed satisfactory.

The detailed results are available in: ncPick v1.0\test_files\ 5_Interpolation_verification

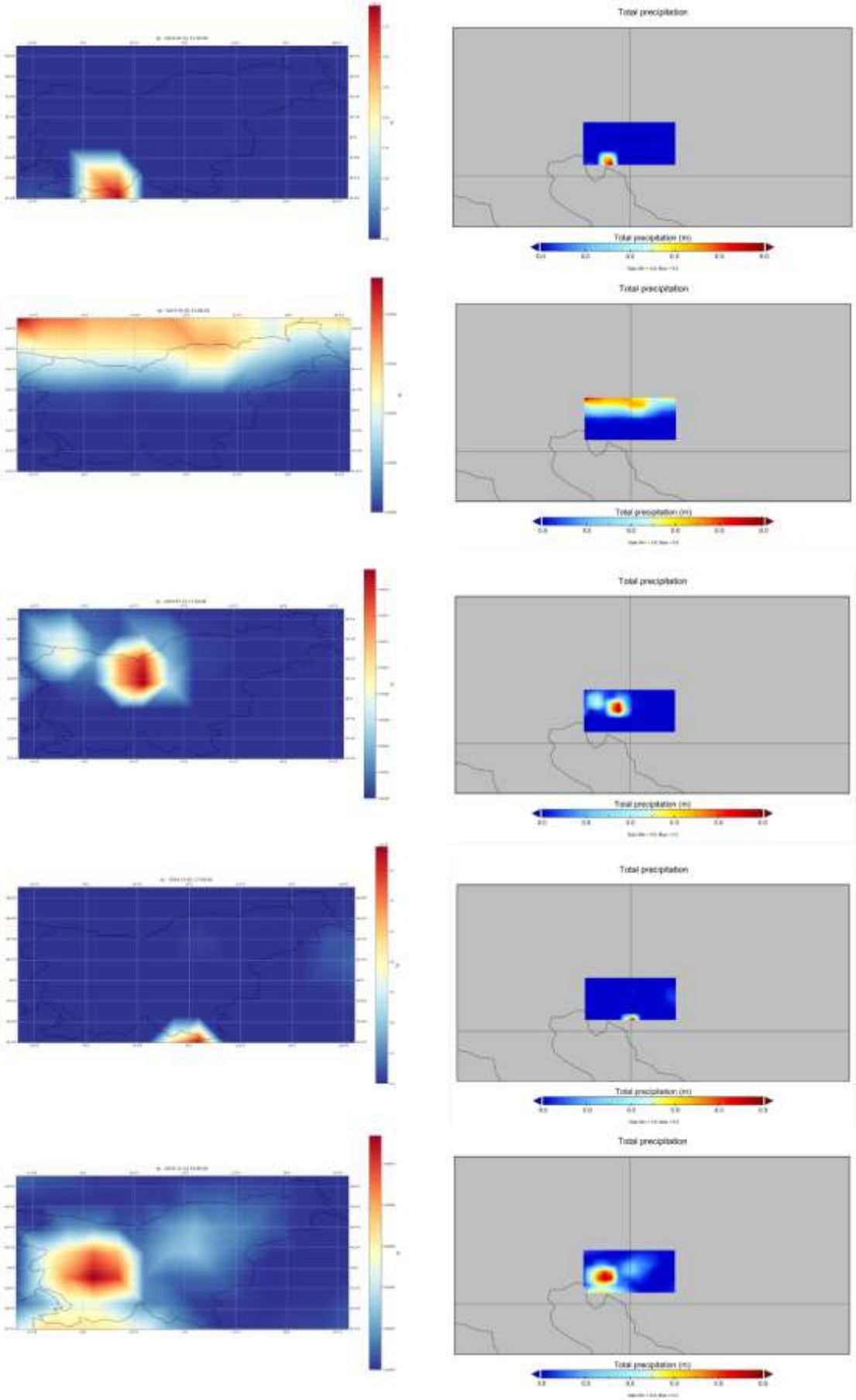

Figure 6. Interpolation validation; ncPick (left) and Panoply (right)

Time-of-day heatmap

Time-of-Day Heatmap Function Objective: Generate a time-of-day heatmap for the entire time period for one or more selected locations.

Test: Run an independent script with the same objective and compare its output with the heatmap generated by ncPick.

Verification: Visual comparison between the ncPick heatmap and the independently generated heatmap. Additionally, interpret the results based on the known physical properties of the selected parameter.

Test Workflow:

1. Using the Temp_Japan.nc file, select four locations.
2. Generate a time-of-day heatmap in ncPick for each location and export the underlying data to CSV.
3. Run an independent script on the exported data to produce the same type of heatmap.
4. Visually compare the heatmap output from ncPick with the one produced by the script.
5. Interpret the results in the context of the known seasonal and diurnal characteristics of temperature (e.g., warmest in summer months during midday, coldest in winter months during early morning).

Test Results: The visual comparison confirmed that the outputs from ncPick and the independent script were identical. Furthermore, the seasonal and daily patterns observed in the heatmap were consistent with the expected behavior of temperature over the year, supporting the correctness of the function.

The detailed results are available in: ncPick v1.0\test_files\ 6_time_of_day_heatmap_test

CSV to TRAINSET

CSV to TRAINSET Conversion Function Objective: Convert any CSV file into a TRAINSET-compatible CSV file format.

Test: Convert a synthetic CSV file and run it in TRAINSET.

Verification: Confirm compatibility by loading the converted file into TRAINSET and comparing it with the original synthetic CSV file.

Test Workflow:

1. Create two synthetic CSV files, each with a time column and two value columns (value1 and value2).
2. For the first file:

- Time column: 1 January 2025 00:00:00 to 2 January 2025 00:00:00.
- value1: sequential integers from 1 to 25.
- value2: integers from 1 to 5, repeated cyclically.

3. For the second file:

- Same structure, but with a total of 745 data points.
- value1: sine wave values.
- value2: step function values.

4. Use ncPick to convert both files into TRAINSET-compatible CSV format.
5. Load the converted files into TRAINSET to confirm proper recognition and formatting.

Test Results: Both synthetic CSV files were successfully converted into TRAINSET-compatible format. The converted files loaded correctly into TRAINSET, confirming that the conversion process worked as intended and the outputs were ready for data labeling.

The detailed results are available in: ncPick v1.0\test_files\ 7_CSV_TRAINSET

Merge CSV on time axis

Merge Two CSV Files Function Objective: Merge two CSV files containing a time column, producing a resulting CSV file that starts and ends where the time ranges of both input files overlap.

Test: Create two CSV files, run the merge function, and check the output for validity.

Verification: Compare the exported merged file with the two original input files to confirm correct alignment and inclusion of all expected columns.

Test Workflow:

1. Create two CSV files:

- File 1: 1 January 2023 to 31 January 2023.
- File 2: 10 January 2023 to 20 January 2023.

2. Run the Merge Two CSV Files function in ncPick.
3. The resulting CSV should span from 10 January to 20 January (the overlapping period) and contain all value columns from both input files.

Test Results: The resulting CSV file was successfully merged, with the time range correctly matching the overlapping period of the two input files and all value columns from both sources present.

The detailed results are available in: ncPick v1.0\test_files\ 8_Merge_on_time_axis_test

Downsample to interval statistics

Downsample CSV File Function Objective: Downsample any CSV file based on a user-specified time interval (e.g., 24 hours, 12 hours, 6 hours, etc.).

Test: Create a synthetic CSV file and test the function using various user-specified intervals.

Verification: Compare the output file's calculated statistics with manually computed statistics for the same intervals.

Test Workflow:

1. Create a synthetic CSV file containing:
- A time column.
- A value column with values ranging from 1 to 24 for each time step, repeating daily.
2. Run the Downsample CSV File function in ncPick using intervals of 24, 12, and 6 hours.
3. Manually calculate the downsampled statistics for each interval.
4. Cross-check the manually calculated statistics with those from the ncPick output.

Test Results: The results confirmed that the downsampling function produced statistics identical to the manually calculated values for all tested intervals, indicating that the function operates as intended.

The detailed results are available in: ncPick v1.0\test_files\ 9_Downsample_test

The ncPick software has undergone extensive internal testing to ensure that its features, calculations, and outputs operate as intended under a wide variety of scenarios. Based on the results of these tests, we believe the software functions correctly and delivers accurate results within the intended scope of use. However, given the complexity of geospatial and climatological datasets, and the diverse ways in which the software may be applied, it is possible that unexpected issues or edge cases may arise. Should you encounter any problems, irregularities, or unexpected results, please contact us at the email address provided above so that we can investigate and, where appropriate, provide guidance or corrective updates.

While every reasonable effort has been made to ensure the reliability of ncPick, we cannot accept responsibility for any errors, inaccuracies, or consequences arising from its use. All outputs should be independently verified by the user to ensure suitability for their specific application. By using ncPick, you acknowledge and agree that you do so at your own discretion and risk.

Stress test

Since limitations are to be expected when working with large NetCDF files, it was deemed advisable to provide users with rule-of-thumb guidelines on when certain functions may become slow, delayed, or even temporarily unresponsive.

The stress test involved downloading a large NetCDF file from Copernicus. The file size was approximately 500 MB and covered a 50° × 50° region over North America (Figure 7), containing hourly 2 m temperature data for the entire year of 2024. At the native Copernicus resolution (0.25° × 0.25°), this domain corresponds to about 40,000 grid points and roughly 350 million data values in total.

The procedure consisted of loading the dataset into ncPick and systematically testing various functions provided by the software:

- Loading and basic operations: The NetCDF file loaded successfully. Selecting a few data points, generating time-series visualizations, and computing descriptive statistics all worked as expected.
- Data export: Exporting individually selected points also functioned normally. The Export all data points option was not attempted, as exporting ~40,000 points (350 million values) would be of little practical benefit and would likely stall the system.
- Interpolation view: Interpolation view may freeze on very large datasets because interpolation is generated on request; for practical use, apply interpolation on smaller regions.
- Heatmap visualization: The time-of-day heatmap function operated without issues.
- Shapefile export: Exporting data for the state of Texas (1,054 grid points, ~9.26 million data values) was successful, though slower than for smaller areas. The resulting CSV was ~85 MB, and despite the longer processing time, the function completed correctly.
- CSV-related post-processing: These functions were not tested in this scenario.

The key finding is that, for ERA5 NetCDF data, the primary performance limitation lies in spatial coverage rather than temporal extent. Although Copernicus enforces temporal restrictions (typically ≤2 years even for small 10° × 10° areas, ~100 deg^2), these do not pose major problems for ncPick. By contrast, very large spatial domains (e.g., 50° × 50°, ~2,500 deg^2) can strain memory and responsiveness, affecting some modules such as interpolation and large-scale exports.

In this extreme case, ncPick remained functional overall, but certain features were slower or limited. Users are therefore advised to restrict spatial areas to smaller regions

than this test case in order to preserve the full responsiveness and capability of the software.

Memory vs. speed: ncPick opens NetCDF files with lazy loading, so even very large datasets typically keep memory below ~1 GB during interactive use. Heavy operations (e.g., interpolation or bulk exports) are usually CPU/I/O-bound and may feel slow on large spatial domains, despite low RAM usage. *During such tasks, the operating system may briefly mark ncPick as "Not Responding"; this does not indicate a crash and can generally be disregarded until the operation finishes.*

Tip: If interpolation feels slow on big areas, tile the region (e.g., 10°×10°). For small/medium regions, performance is generally smooth on most operating systems.

For most users, who typically work with smaller regions, such performance issues are unlikely to be encountered; for power users requiring interpolation or other large-scale operations on very large files, specialized tools outside of ncPick are recommended.

The detailed results are available in:
ncPick v1.0\test_files\10_stress_test

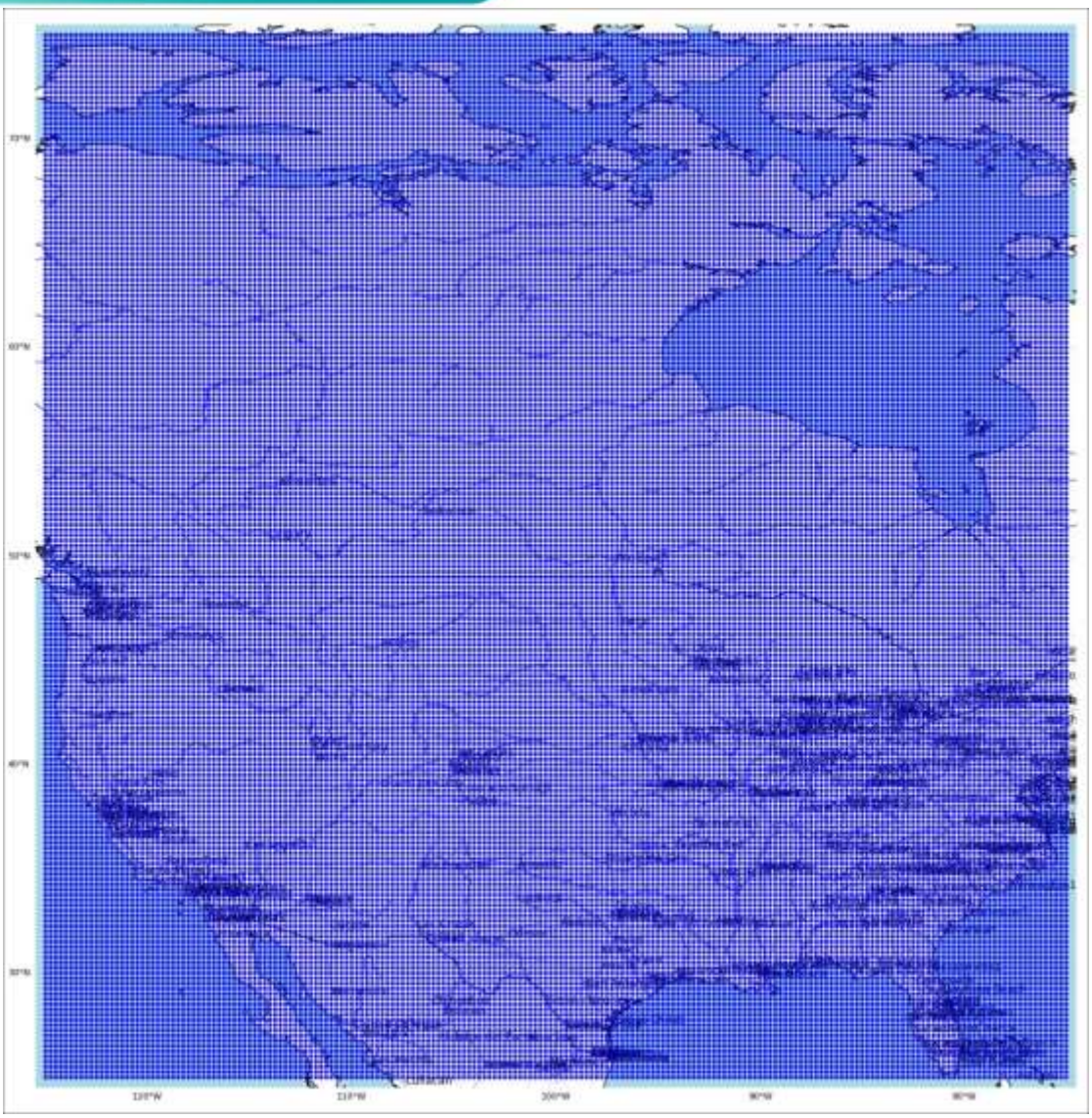

Figure 7. The 50° × 50° area over North America utilized for the stress test

Testing on other Windows systems

Testing of ncPick was carried out on a range of Windows-based systems to evaluate its stability and functional consistency across different computing environments. The objective was to identify any system-specific issues that might affect performance, user interface behavior, or compatibility with underlying libraries and dependencies. In all cases, the software executed its intended operations without producing errors or anomalous outputs.

These observations suggest that ncPick exhibits a high degree of portability and operational stability within the Windows ecosystem. While the scope of testing was limited to a subset of possible hardware and software configurations, the absence of discrepancies or failures in these trials provides preliminary evidence that the software is likely to function as intended on comparable Windows systems. Further testing on a broader set of configurations would strengthen these findings and help identify any edge cases.

Limitations

May stall under larger files- When working with large Copernicus ERA5 NetCDF files, ncPick may experience performance slowdowns or temporary unresponsiveness, particularly during interpolation, or bulk export operations. To avoid such issues, it is recommended to segment the data into smaller, more manageable subsets before loading them into the software. This approach can significantly improve responsiveness.

May potentially not work under some Windows systems- ncPick has been tested extensively on Windows 10 and Windows 11 systems. Functionality on older or alternative Windows versions (e.g., Windows 7, Windows 8, or certain specialized enterprise builds) has not been verified and may lead to compatibility issues. Users running non-tested versions of Windows should proceed with caution and may need to explore compatibility mode settings.

Can be flagged as a virus by Windows Defender- The standalone executable version of ncPick may occasionally be flagged as a potential threat by Windows Defender or other antivirus software. This is a common occurrence for software distributed as unsigned executables. In such cases, it is recommended to manually add an exception for the ncPick .exe file in the antivirus settings. The software has been tested and contains no malicious code.

File format constraints- ncPick is designed specifically for handling Copernicus ERA5 NetCDF file formats. While it may be able to open other NetCDF files, compatibility and correct operation are not guaranteed, as these formats can vary significantly in structure, variable naming, and metadata conventions. The software has not been tested on datasets outside of Copernicus ERA5 Reanalysis, and results with other NetCDF sources may be unpredictable.

Visualization limitations- The basemap rendering in ncPick relies on static vector datasets for displaying country borders and geographic features. As these datasets are not updated dynamically, they may not reflect recent geopolitical changes, boundary adjustments, or newly recognized territories. Users requiring the most current boundary information should update the underlying shapefiles manually before use.

No built-in data download- ncPick does not include integrated functionality to download datasets directly from the Copernicus Climate Data Store (CDS) or other repositories. Users must obtain and download ERA5 NetCDF files manually before they can be loaded into the software. This limitation ensures simplicity and offline usability but requires additional steps in the workflow.

Data size and export limitations- Exporting large datasets, particularly when using the "Export All Data Points" function on high-resolution ERA5 files, can result in very large CSV files. Such files may be slow to open in standard spreadsheet software (e.g., Microsoft Excel) or may exceed application row limits. Users handling large exports should consider using more capable data analysis tools (e.g., Python, R) for post-processing.

Rounding and precision- Small numerical discrepancies (typically less than 0.5%) may occur when comparing ncPick outputs with results from other software. These differences can arise from variations in rounding, interpolation algorithms, or floating-point precision handling. While the examples tested in this manual confirmed minimal discrepancies, results from other datasets or parameters may differ. Users who encounter unexpected differences are encouraged to report them for further investigation.

Other limitations beyond those described here have not been identified or tested. As ncPick has primarily been evaluated on a specific set of datasets and system configurations, its behavior in other environments or with other data sources may vary. Users who encounter unexpected issues, discrepancies, or errors are encouraged to report them so that they may be reviewed in future updates. The developers disclaim any liability for problems, data loss, or other consequences arising from the use of the software, and it is the user's responsibility to ensure that outputs are verified and suitable for their intended application.

Maintenance and future features

The maintenance of ncPick will be carried out on an as-needed basis. This means that if errors, performance issues, or other problems are identified-either internally or through user feedback-a corrected and updated version will be developed and released. While routine updates are not scheduled, the software will be maintained to ensure its continued reliability and compatibility when necessary.

Looking ahead, several potential features are currently under consideration. These include automation capabilities for retrieving data directly from relevant sources, support for additional file formats, and the development of new modules such as an anomaly detection module or spatial analysis tools. These features remain in the conceptual stage and will be implemented selectively, based on identified needs, technical feasibility, and the overall direction of the software's development.

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data used in the basemap, rbende for the Sun Valley theme utilized in ncPick, and opendatasoft for making the World Administrative Boundaries - Countries and Territories dataset freely available. Without such openly accessible datasets and resources, software solutions like ncPick would not be possible.

References and data sources

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