

From NDVI to N application map (agriculture)

Lecture notes preparation - about conceptual framework

(Education purpose)

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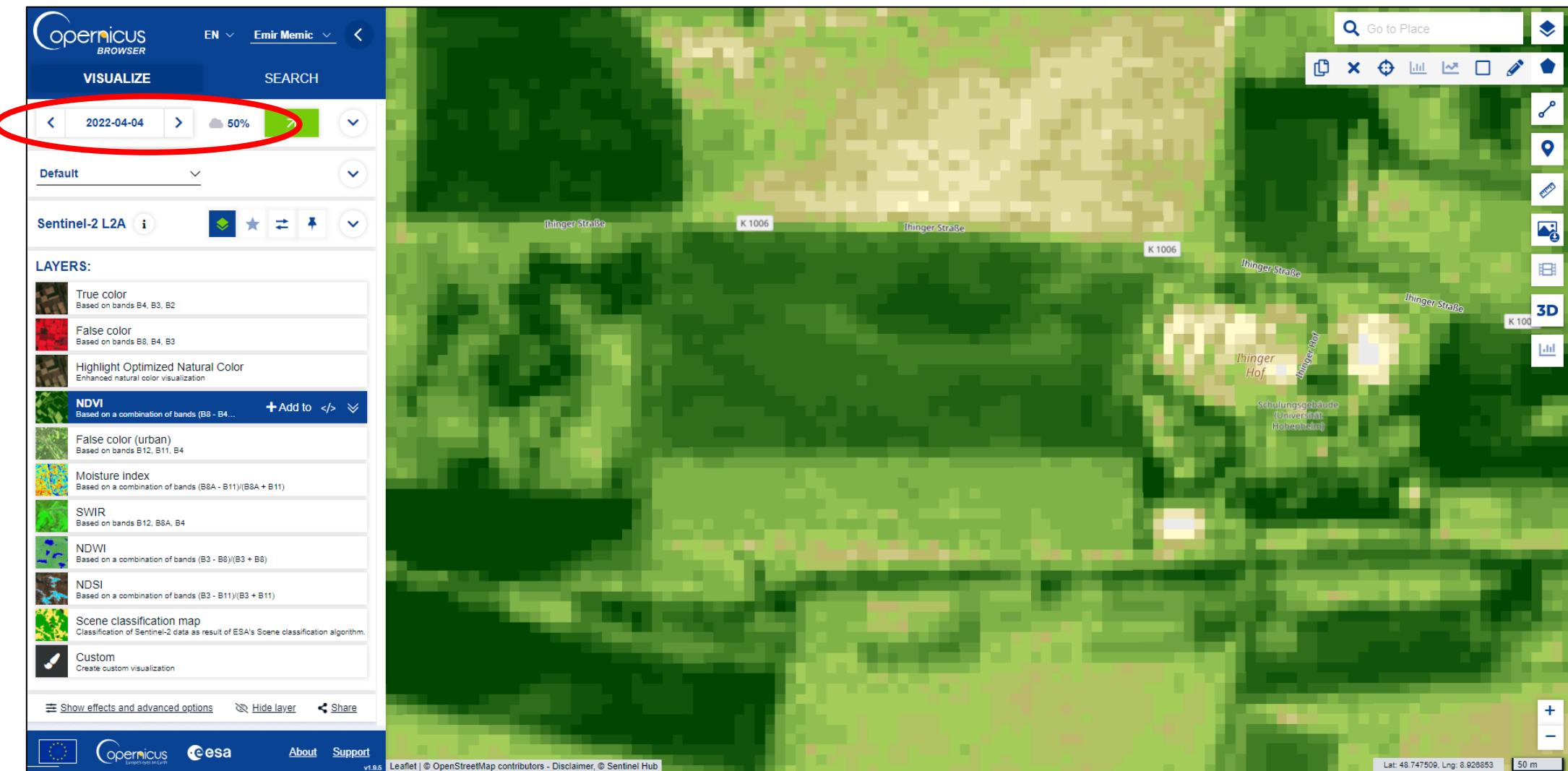
(University of Hohenheim)

Feb 2024

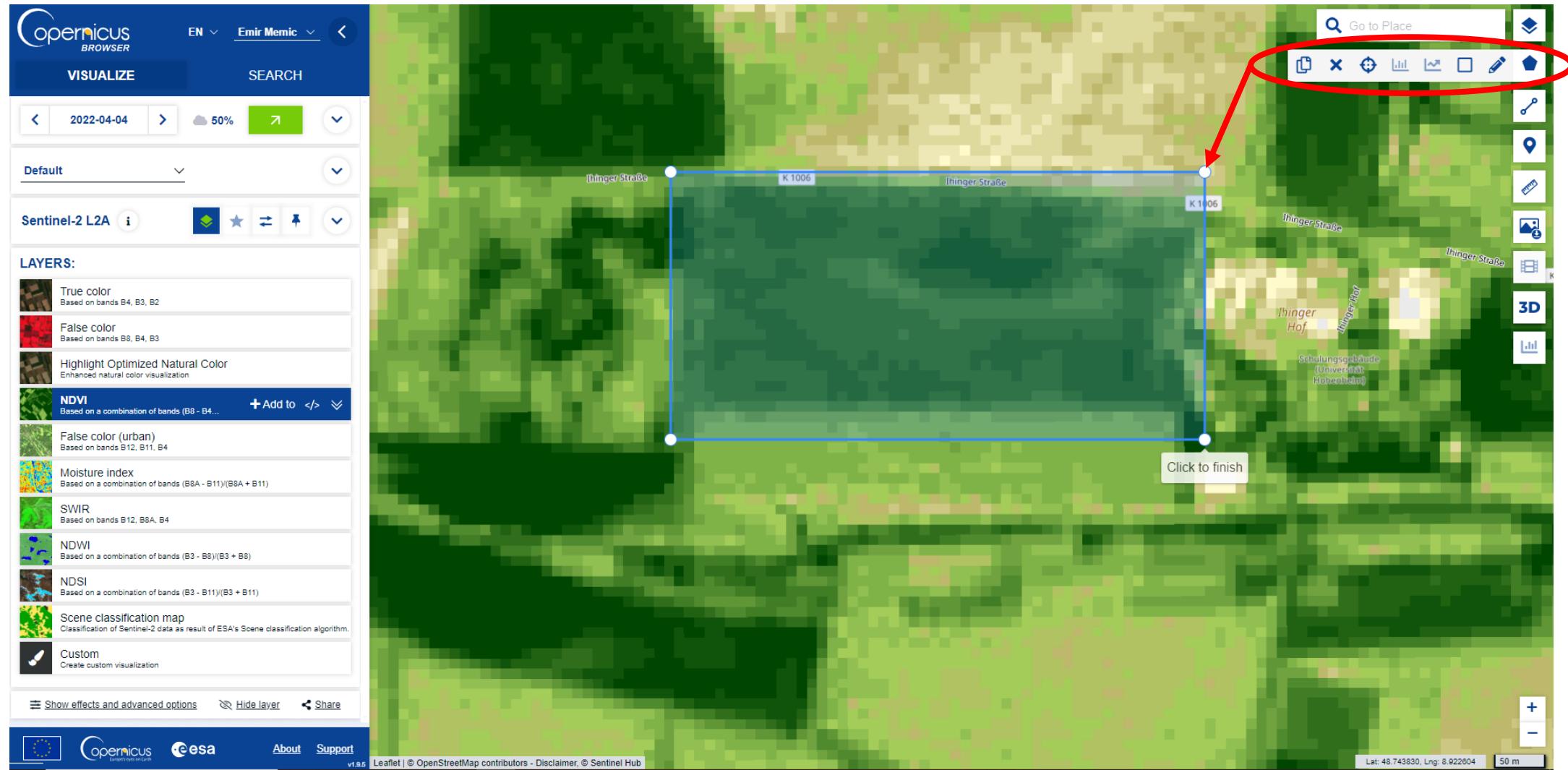
Outline

- Satellite images download – Copernicus Browser
 - Copernicus Data Space Ecosystem (CDSE), Modified Copernicus Sentinel data 2024 processed in Copernicus Browser. <https://browser.dataspace.copernicus.eu/>
- QGIS-based NDVI analysis and N prescription map processing
 - QGIS 2024. QGIS.org, Geographic Information System. QGIS Association. <http://www.qgis.org>
- Discussion

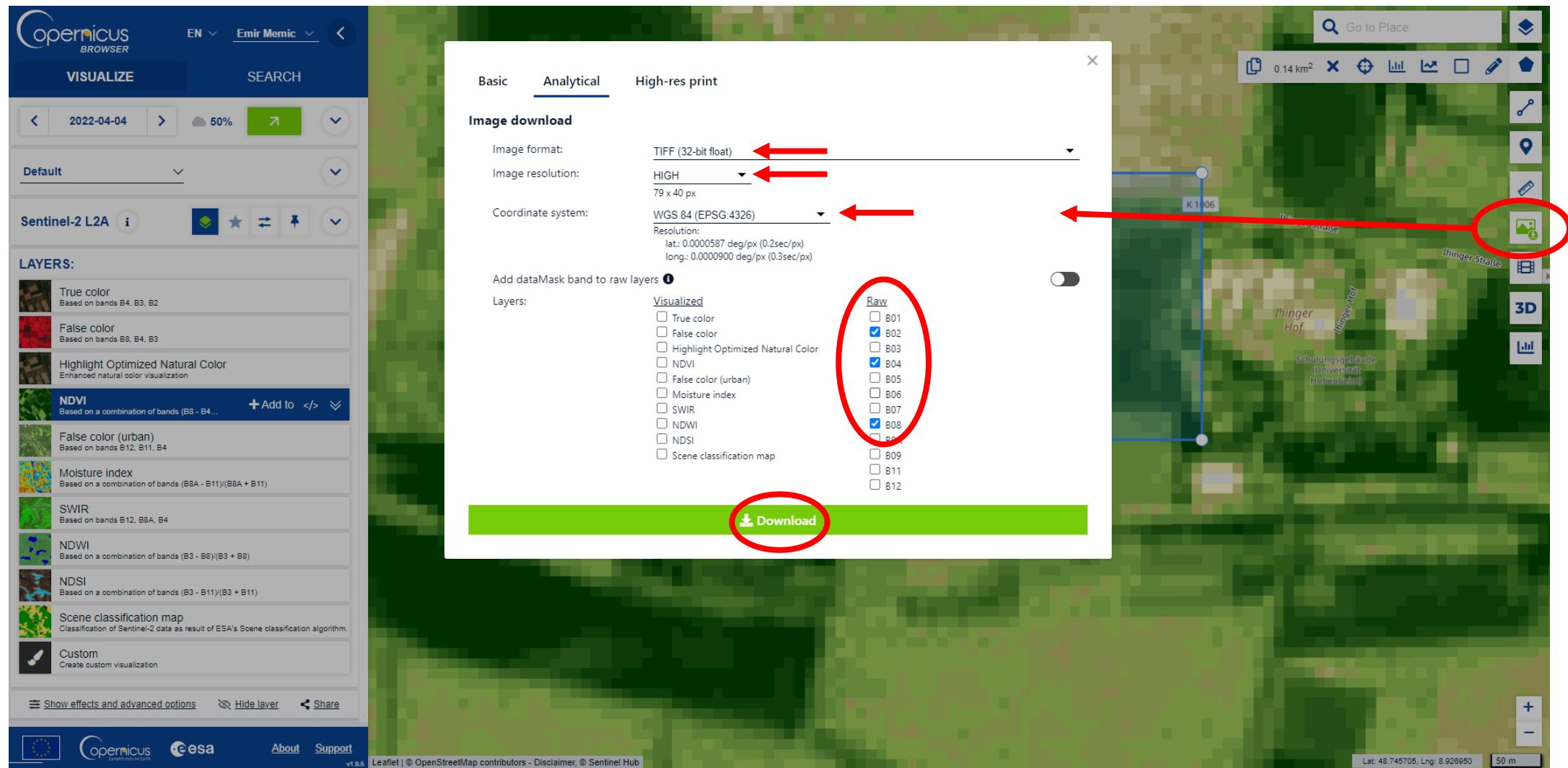
Acquiring satellite images via Copernicus Browser



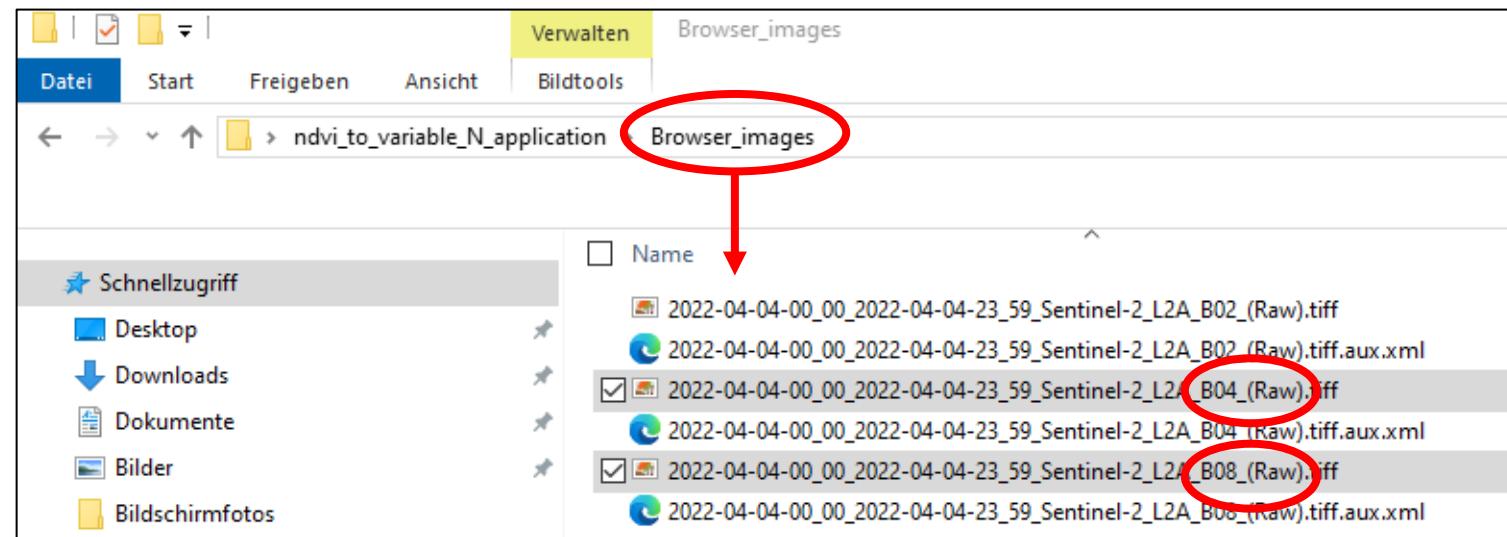
Delineating area of interest (polygon) for downloading



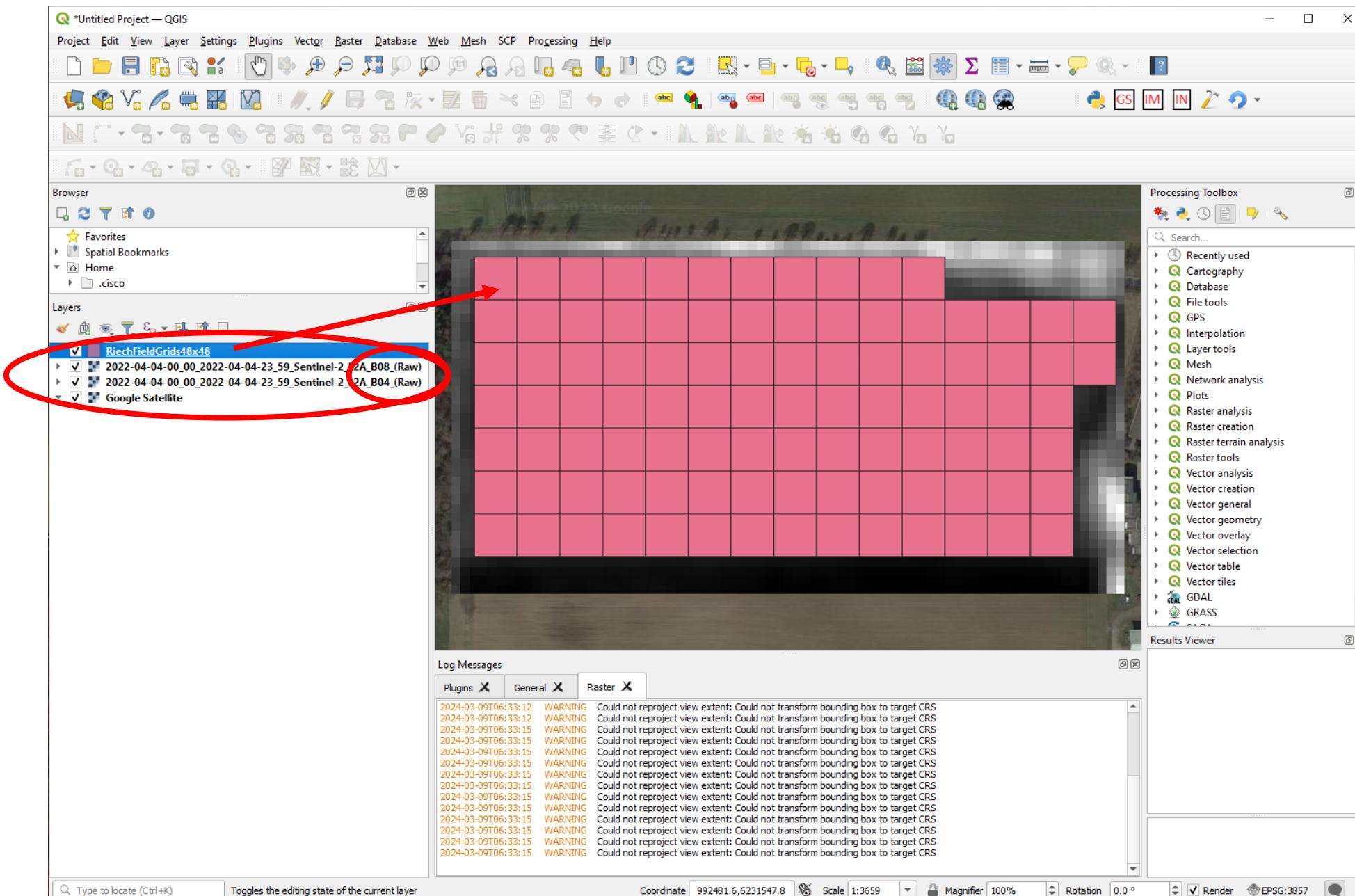
Downloading bands of interest – B02 (Blue), B04 (Red) and B08 (NIR)



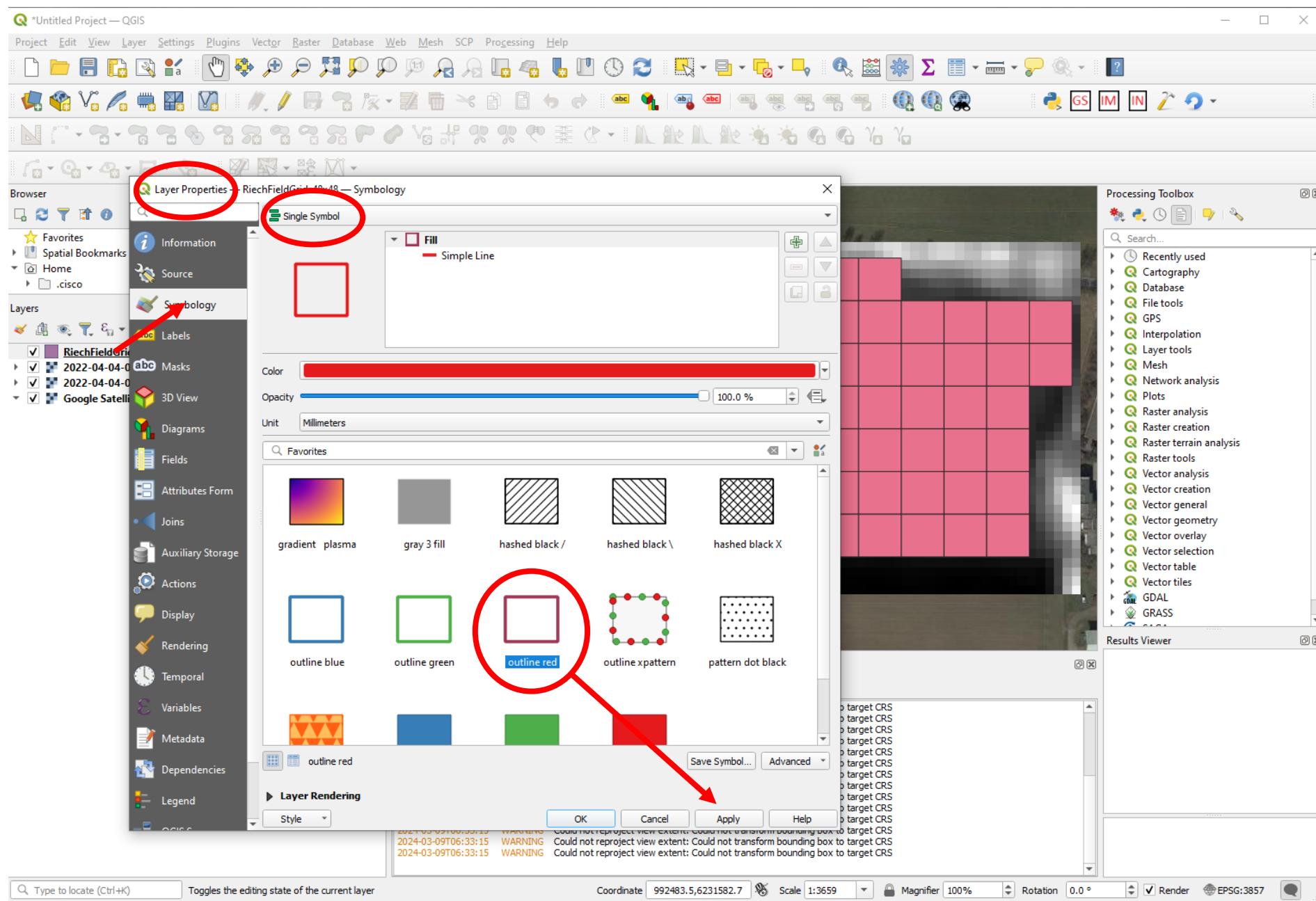
Downloaded and unzipped row data – for this example only B04 and B08 required for NDVI calculation



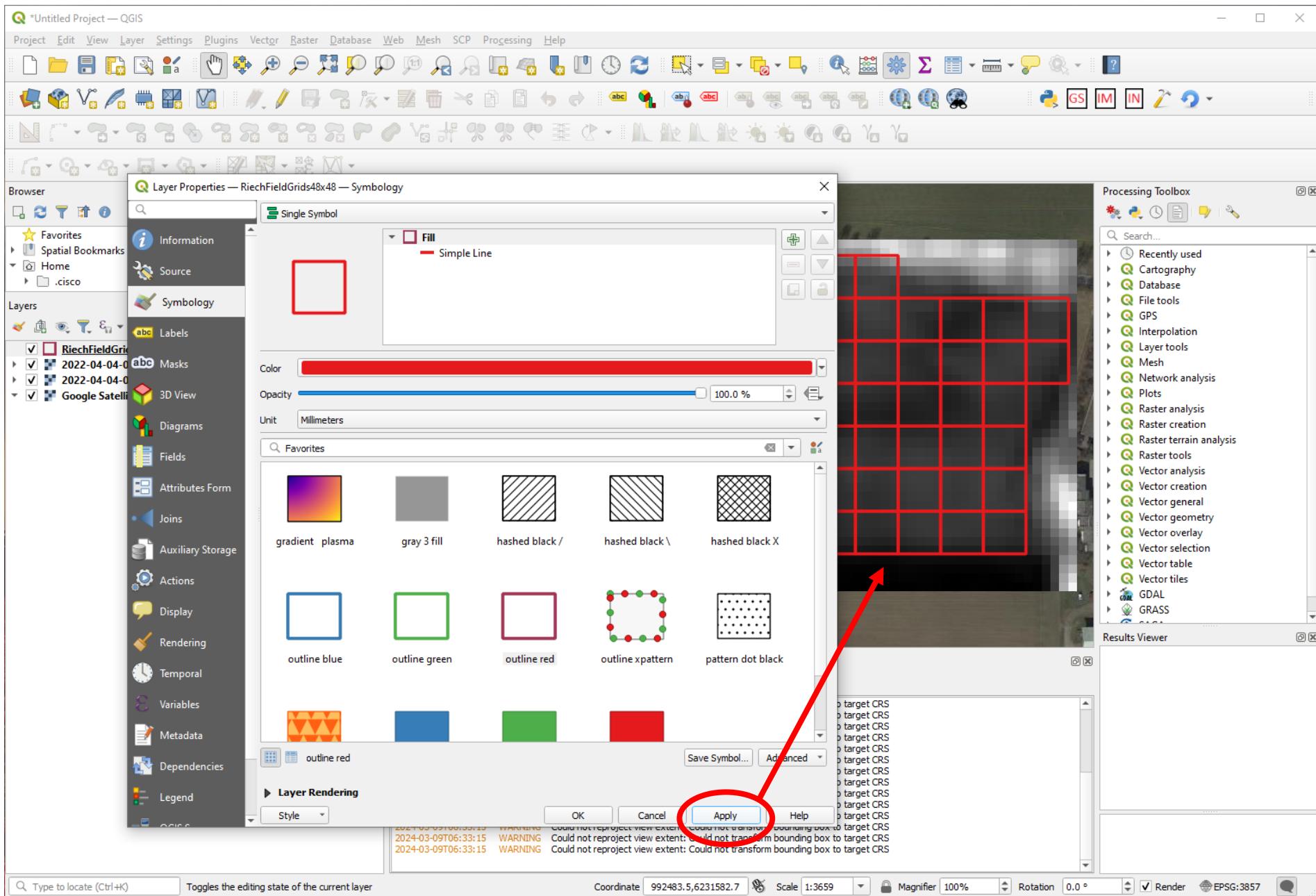
Uploading required data into QGIS (drag and drop): georeferenced images and raster grid of area of interest



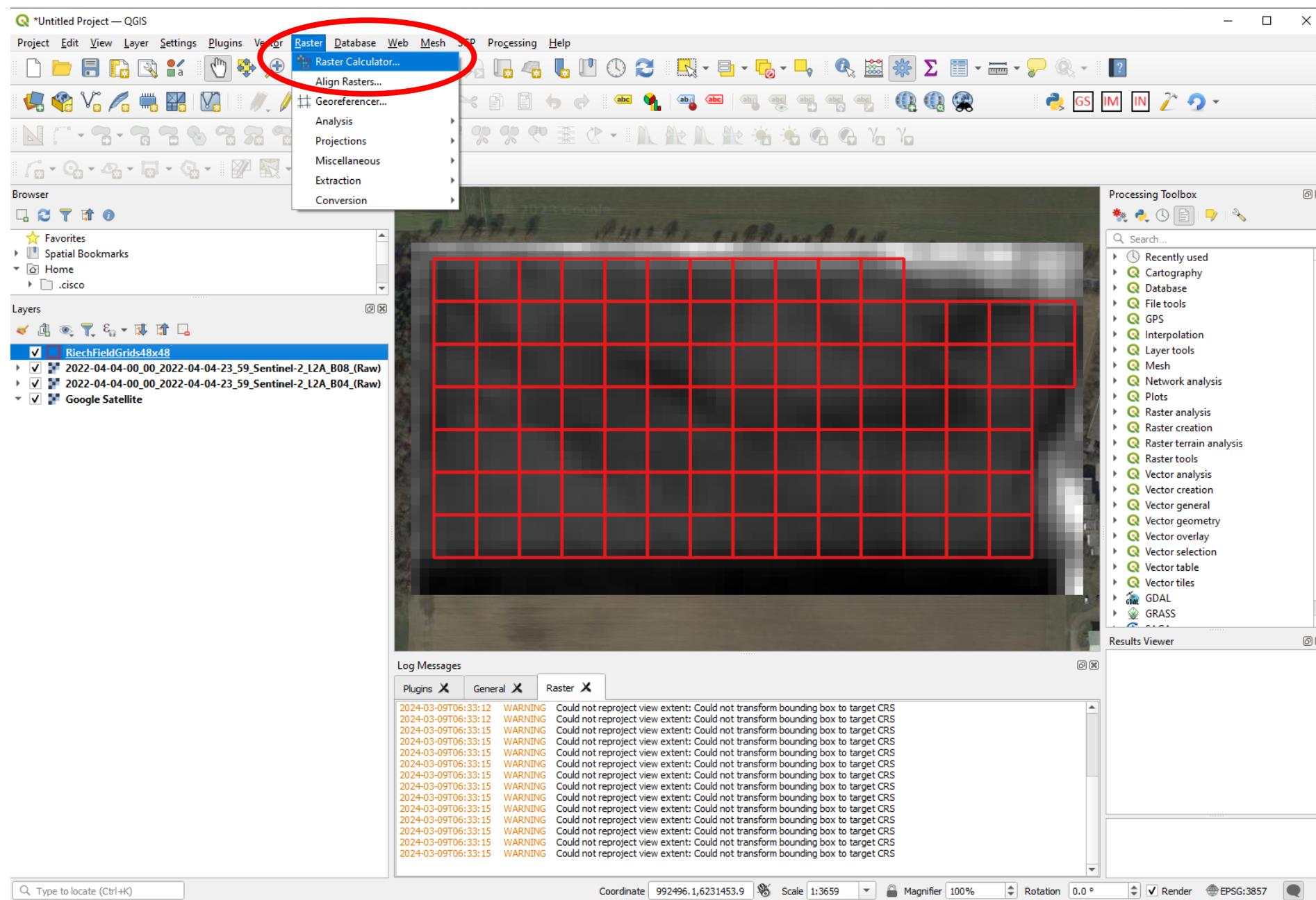
Modifying of the girds to get transparent background – Layer Properties -> Symbology -> Single Symbol



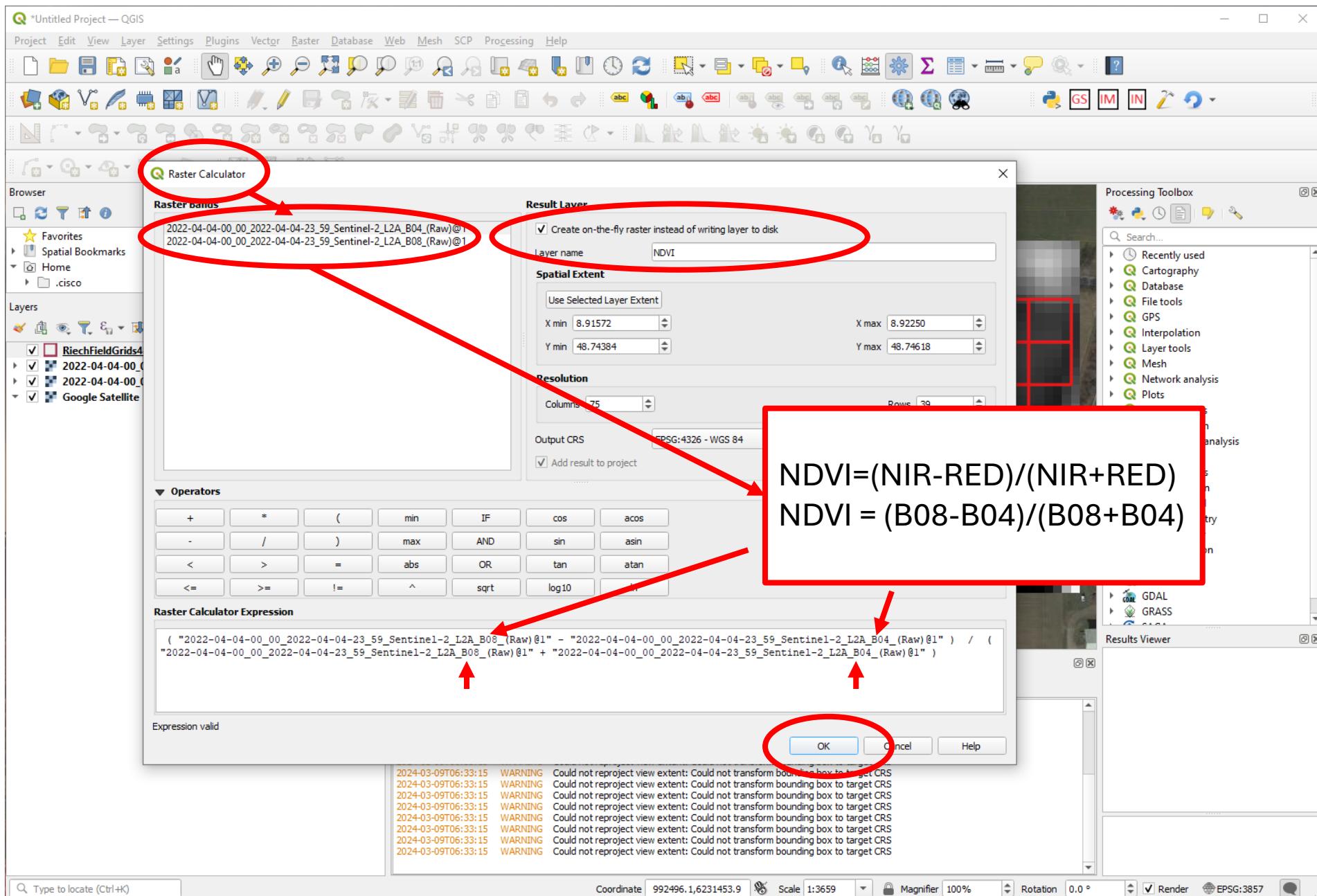
Modifying of the girds to get transparent background – when executed



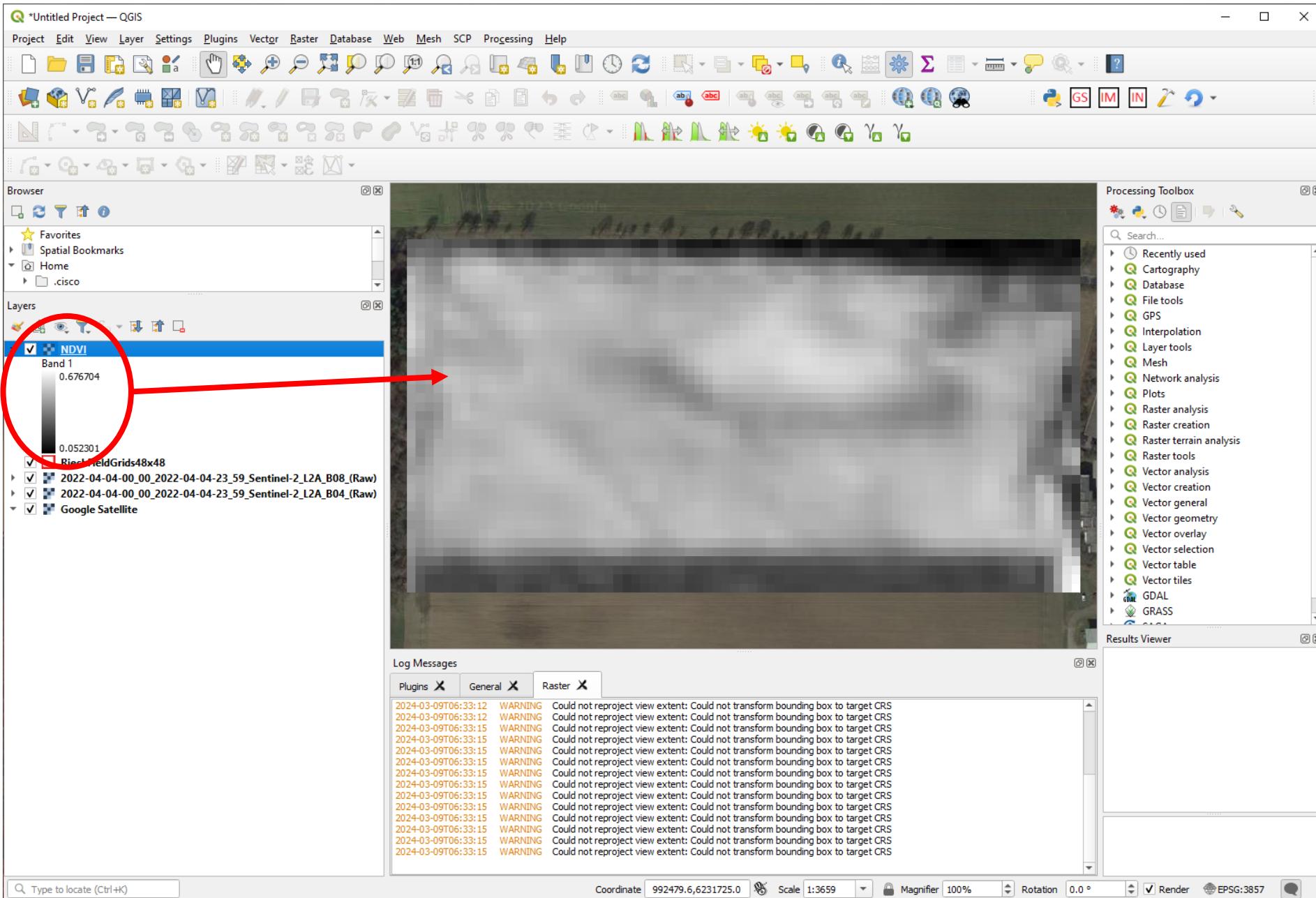
Calculating NDVI is conducted with Raster Calculator – Raster -> Raster Calculator



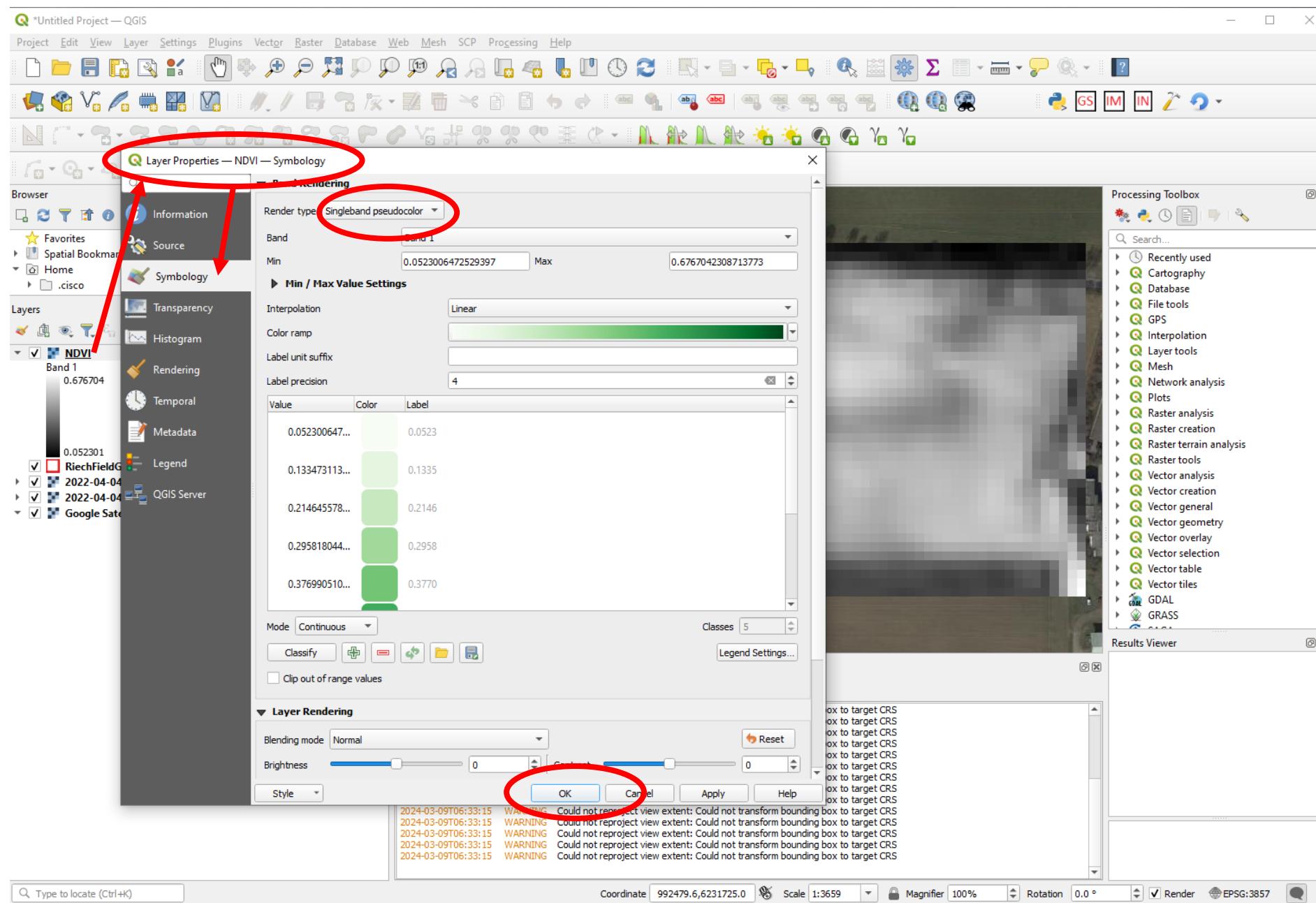
In Raster Calculator – minimum action required to calculate NDVI is indicated with red circles and arrows



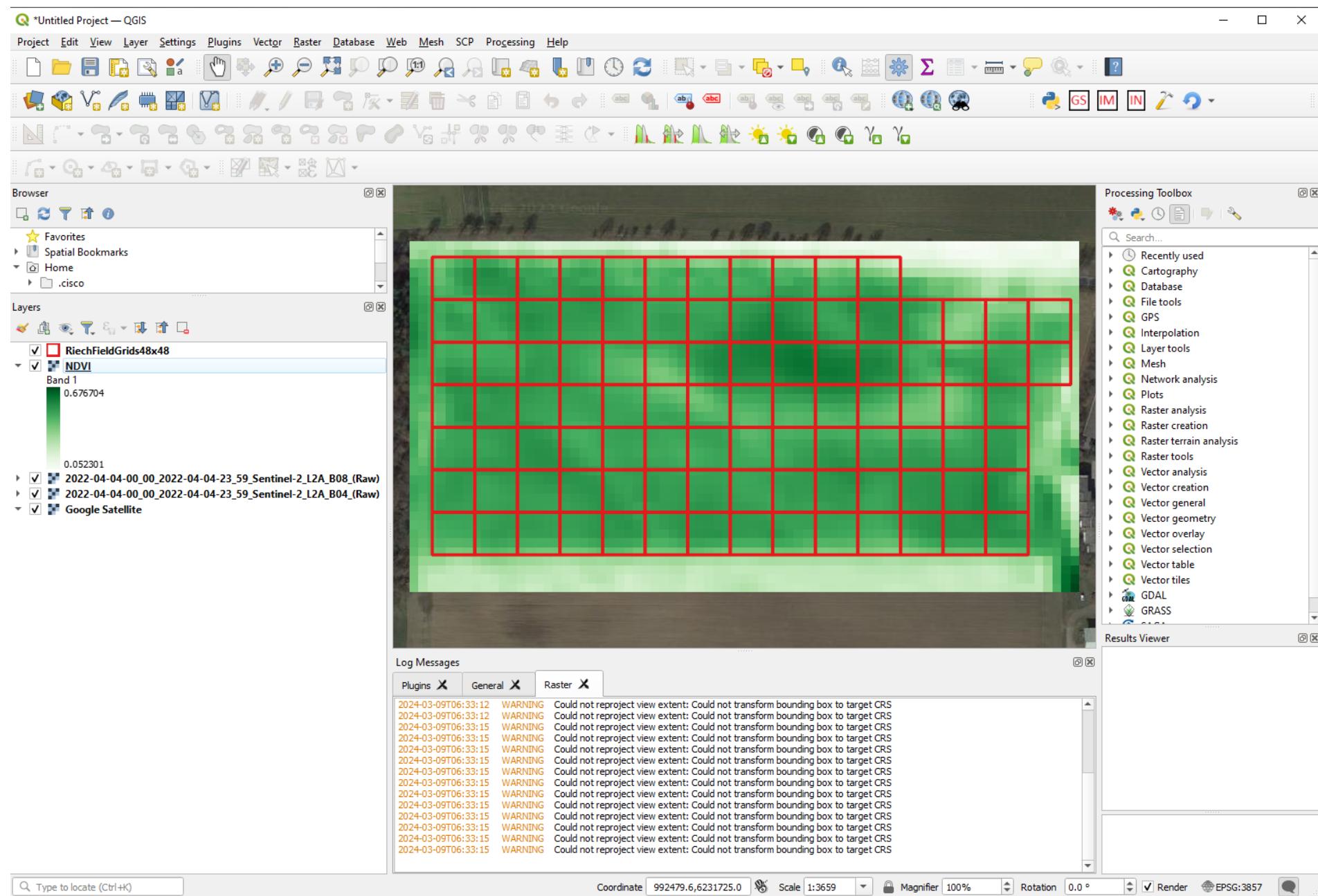
After Raster Calculator calculations are conducted a user gets NDVI layer in QGIS



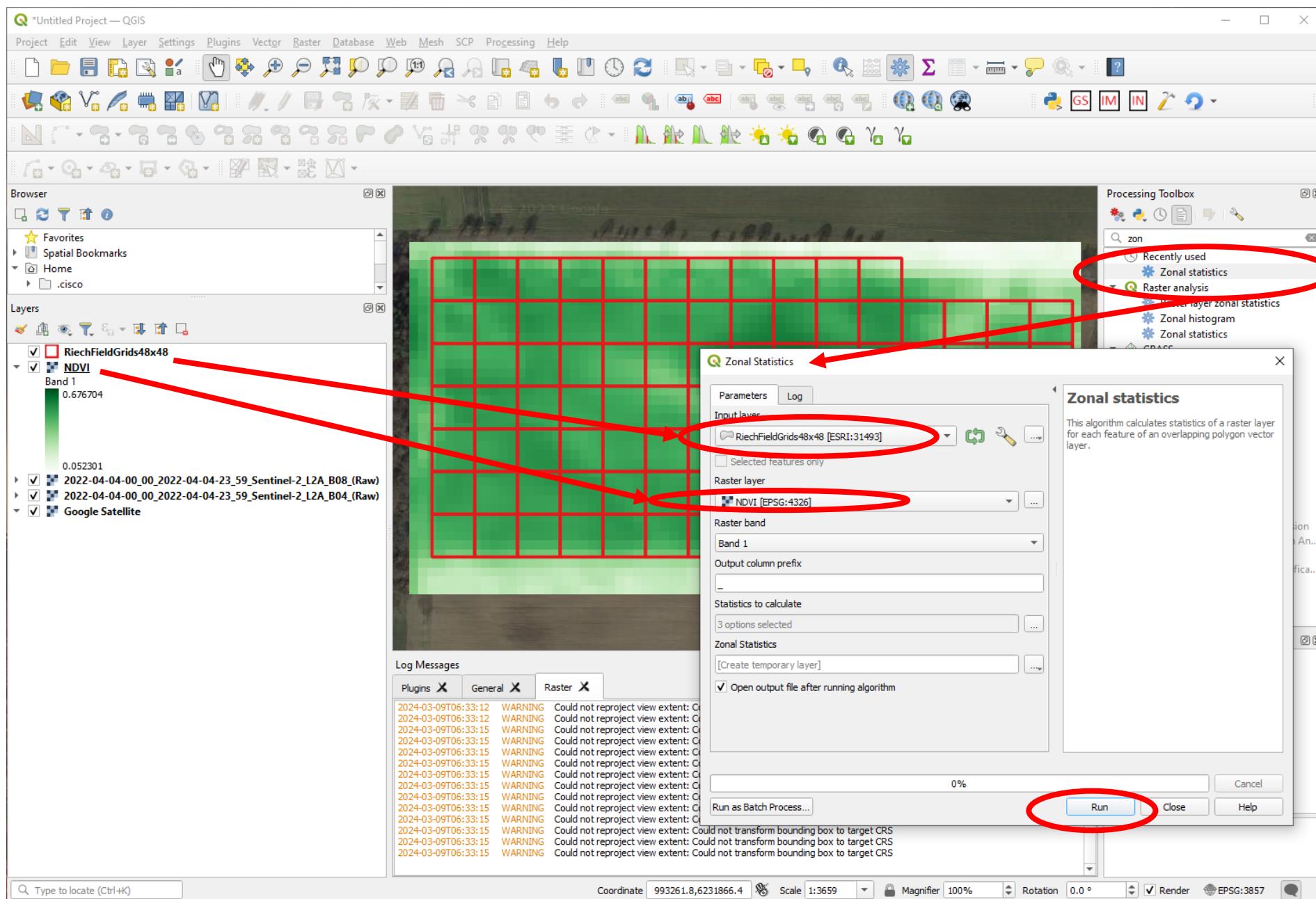
NDVI layer (in gray by default) can be changed to green – Layer Properties -> Symbology -> Singleband Pseudocolor



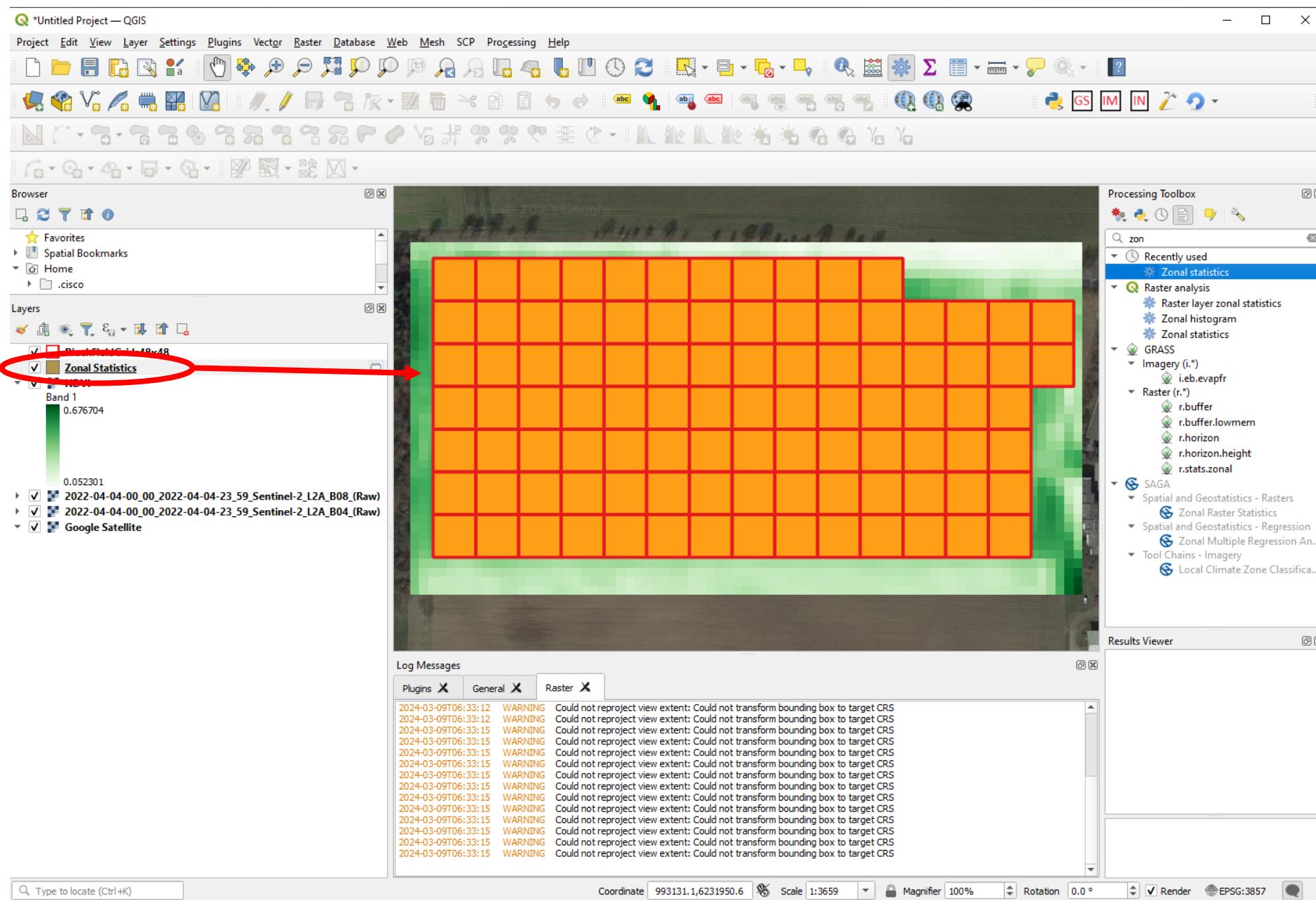
NDVI layer in green



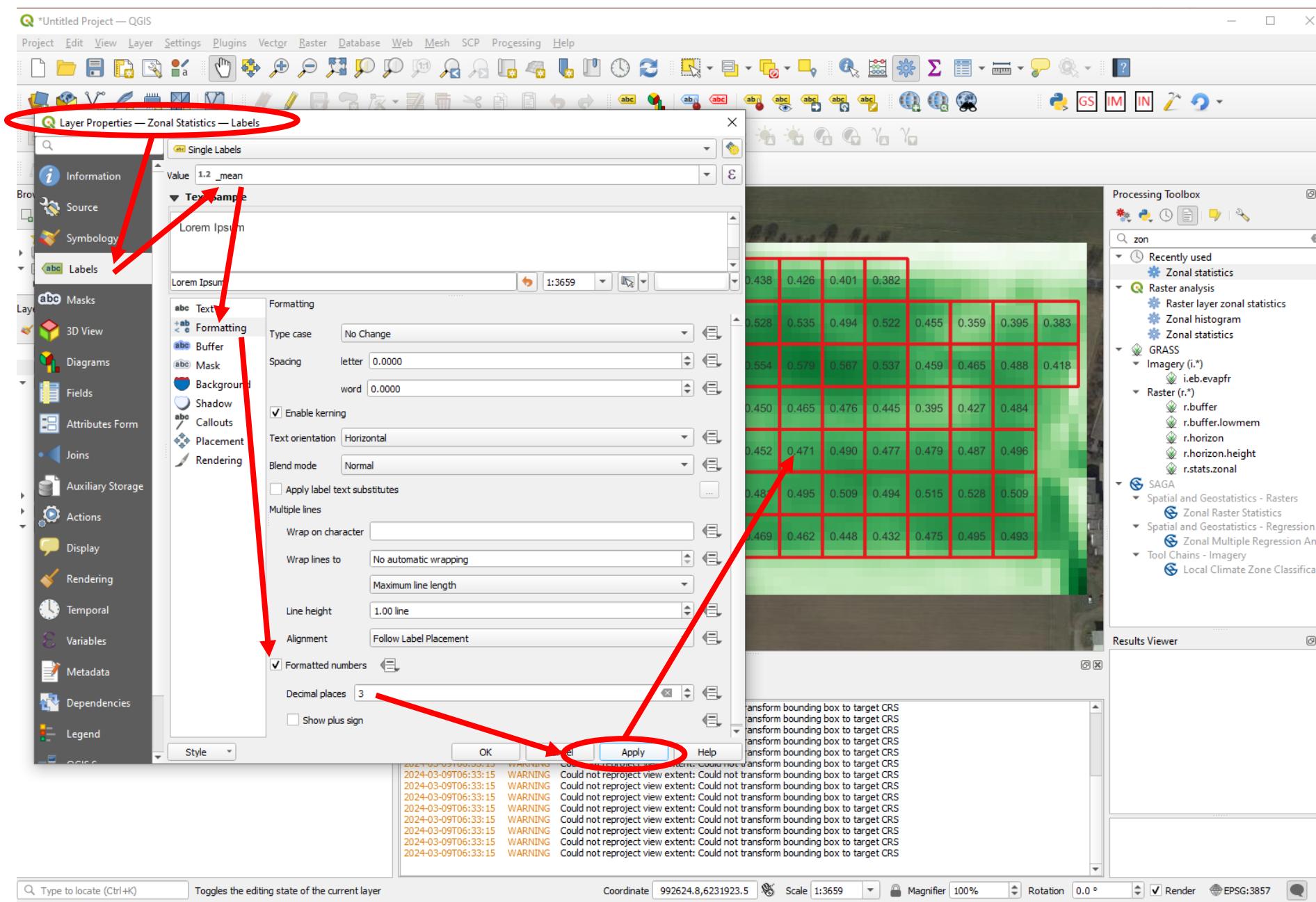
Calculating NDVI for each grid – based on Grid layer and NDVI layer with Zonal Statistics



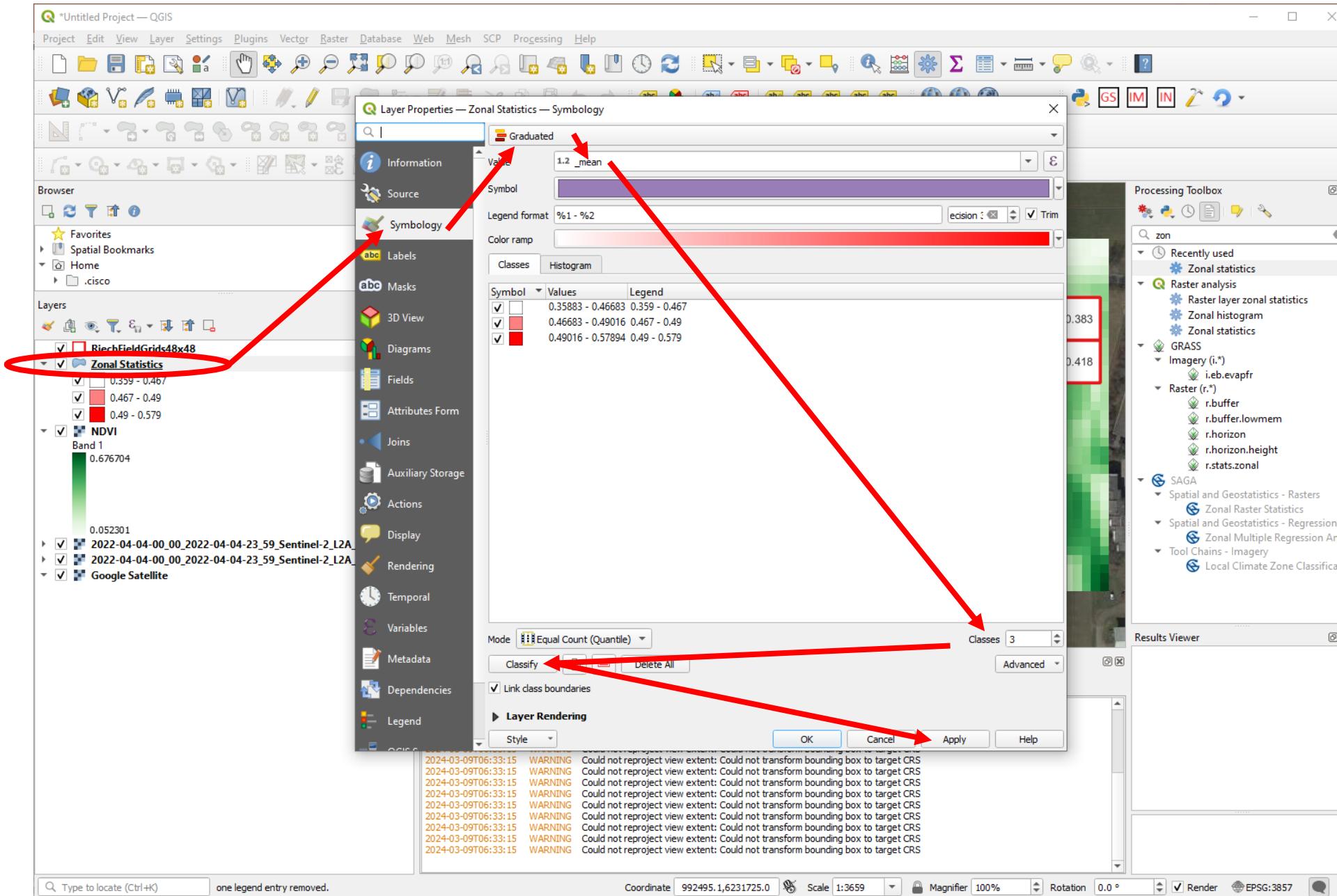
Zonal Statistics after execution produce Zonal Statistics (temporary layer)



Zonal Statistics layer – to show NDVI for each grid – Layer Properties -> Labels -> Single Labels -> _mean (value select)



Zonal Statistics layer – create 3 NDVI categories – Symbology -> Graduated -> _mean -> Classes (3) -> Classify



Zonal Statistics layer – setup of previous slide when executed will produce heat map of index variability (3 categories)

The screenshot shows the QGIS application interface with several panels:

- Project Bar:** Standard QGIS menu bar with options like Project, Edit, View, Layer, Settings, Plugins, Vector, Raster, Database, Web, Mesh, SCP, Processing, and Help.
- Toolbar:** A large set of icons for various spatial analysis and editing tools.
- Browser Panel:** Shows the project structure. A red circle highlights the "Zonal Statistics" entry under the "RiechFieldGrids40x40" layer.
- Layers Panel:** Displays the layers in the project, including "RiechFieldGrids40x40", "Zonal Statistics" (selected), "NDVI", and several raw Sentinel-2 L2A bands.
- Main Canvas:** Shows a raster map with a grid overlay. The grid cells contain numerical values ranging from 0.444 to 0.499, color-coded by category. A legend on the left indicates three categories: 0.359 - 0.467 (light green), 0.467 - 0.49 (medium green), and 0.49 - 0.579 (dark green).
- Processing Toolbox:** Shows the "zon" tool selected under "Recently used". Other tools include "Raster layer zonal statistics", "Zonal histogram", "Zonal statistics", "GRASS Imagery", "Raster", and "SAGA".
- Log Messages Panel:** Displays warning messages related to reprojection issues.
- Results Viewer:** Currently empty.
- Bottom Status Bar:** Includes a search bar, coordinate information (992479.6, 6231588.5), scale (1:3659), magnifier, rotation, render checkbox, EPSG code (3857), and a speech bubble icon.

This example was oversimplified with 3 NDVI categories (low, medium, high) for later 3 N-application amounts (low, medium, high) – for educational purpose

Zonal Statistics layer – Properties -> Open Attribute Table (shows statistics for each grid, including number of pixels per grid – count)

The screenshot shows the QGIS interface with several panels:

- Project Bar:** Standard QGIS menu items like Project, Edit, View, Layer, Settings, Plugins, Vector, Raster, Database, Web, Mesh, SCP, Processing, Help.
- Toolbar:** Various tools for selection, measurement, and analysis.
- Browser Panel:** Shows layers: RiechfieldGrids40_10, Zonal Statistics (circled in red), NDVI, Band 1, 0.676704, 0.052301, 2022-04-04_00_00_2022-04, 2022-04-04_00_00_2022-04, Google Satellite.
- Processing Toolbox:** Contains sections for Recently used, Raster analysis (Raster layer zonal statistics, Zonal histogram, Zonal statistics), GRASS (Imagery (i.*), Raster (r.*)), and SAGA (Spatial and Geostatistics - Rasters, Spatial and Geostatistics - Regression, Tool Chains - Imagery).
- Attribute Table:** "Zonal Statistics — Features Total: 97, Filtered: 97, Selected: 0" showing columns id, _count, _sum, _mean. The data is as follows:

| id | _count | _sum | _mean |
|----|--------|-------------------|-------------------|
| 1 | 16 | 7.26533224302356 | 0.454083265188... |
| 2 | 20 | 9.561190362974... | 0.478059518148... |
| 3 | 20 | 9.64982833645304 | 0.482491416822... |
| 4 | 20 | 9.7433026494669 | 0.487165132473... |
| 5 | 16 | 7.729688096652... | 0.483105506040... |
| 6 | 20 | 9.987119150445... | 0.499355957522... |
| 7 | 20 | 8.885069083774... | 0.444253454188... |
| 8 | 20 | 10.16147149656... | 0.508073574828... |
| 9 | 25 | 12.18572898793... | 0.487429159517... |
| 10 | 25 | 11.96224975064... | 0.478489990025... |
| 11 | 25 | 12.63730946743... | 0.505492378697... |
| 12 | 20 | 9.914615602144... | 0.495730780107... |
| 13 | 25 | 12.25410090718... | 0.490164036287... |
| 14 | 25 | 11.77746172654... | 0.471098469061... |
| 15 | 20 | 9.336695751450... | 0.466834787572... |
| 16 | 25 | 12.86960526978... | 0.514784210791... |
| 17 | 25 | 12.45027138085... | 0.498010855234... |
| 18 | 25 | 12.25743391055... | 0.490297356422... |
| 19 | 20 | 10.36852047105... | 0.518426023552... |
| 20 | 25 | 12.53953562042... | 0.501581424816... |

- Processing History:** Shows a series of transformations: transform bounding box to target CRS, repeated multiple times.
- Coordinate Bar:** 993264.7, 6231471.4, Scale 1:3659, Magnifier 100%, Rotation 0.0°, Render checked, EPSG:3857.
- Search Bar:** Type to locate (Ctrl+K).

Zonal Statistics layer –Attribute Table tool -> Add Field (will create a place holder to populate later with corresponding N application kg)

The screenshot shows the QGIS interface with the following components:

- Top Bar:** Project, Edit, View, Layer, Settings, Plugins, Vector, Raster, Database, Web, Mesh, SCP, Processing, Help.
- Toolbar:** Various icons for selection, measurement, analysis, and processing.
- Layers Panel:** Shows layers like "RiechFieldGrids48x48", "Zonal Statistics", and "NDVI".
- Processing Toolbox:** Contains tools under categories like "Recently used", "Raster analysis", "GRASS", and "SAGA".
- Results Viewer:** Displays a log of recent operations.
- Main Window:** Shows a map with a grid overlay and a "Zonal Statistics" dialog box.
- Zonal Statistics Dialog:** Shows features total: 97, filtered: 97, selected: 0. It has columns: id, _count, _sum, _mean. A red circle highlights the "Update All" button.
- Add Field Dialog:** A modal window where a new field "agrYieldMax" is being added. The "Name" field is highlighted with a red circle. Other fields include Comment (empty), Type (Whole number (integer)), Provider type (integer), Length (10), OK, and Cancel buttons.
- Map View:** A 48x48 pixel grid where each cell contains a numerical value representing a statistic. The values range from 0.359 to 0.554.

Zonal Statistics layer –Attribute Table – new field added: agrYieldMax

*Untitled Project — QGIS

Project Edit View Layer Settings Plugins Vector Raster Database Web Mesh SCP Processing Help

Browser

Layers

- RiechFieldGrids48x48
- Zonal Statistics
 - 0.359 - 0.467
 - 0.467 - 0.49
 - 0.49 - 0.579
- NDVI
 - Band 1 0.676704
 - 0.052301
- 2022-04-04_00_00_2022-04
- 2022-04-04_00_00_2022-04
- Google Satellite

Zonal Statistics — Features Total: 97, Filtered: 97, Selected: 0

| | id | _count | _sum | _mean | agrYieldMax |
|----|----|--------|-------------------|-------------------|-------------|
| 1 | 1 | 16 | 7.26533224302356 | 0.454083265188... | NULL |
| 2 | 2 | 20 | 9.561190362974... | 0.478059518148... | NULL |
| 3 | 3 | 20 | 9.64982833645304 | 0.482491416822... | NULL |
| 4 | 4 | 20 | 9.7433026494669 | 0.487165132473... | NULL |
| 5 | 5 | 16 | 7.729688096652... | 0.483105506040... | NULL |
| 6 | 6 | 20 | 9.987119150445... | 0.499355957522... | NULL |
| 7 | 7 | 20 | 8.885069083774... | 0.444253454188... | NULL |
| 8 | 9 | 20 | 10.16147149656... | 0.508073574828... | NULL |
| 9 | 10 | 25 | 12.18572898793... | 0.487429159517... | NULL |
| 10 | 11 | 25 | 11.96224975064... | 0.478489990025... | NULL |
| 11 | 12 | 25 | 12.63730946743... | 0.505492378697... | NULL |
| 12 | 13 | 20 | 9.914615602144... | 0.495730780107... | NULL |
| 13 | 14 | 25 | 12.25410090718... | 0.490164036287... | NULL |
| 14 | 15 | 25 | 11.77746172654... | 0.471098469061... | NULL |
| 15 | 17 | 20 | 9.336695751450... | 0.466834787572... | NULL |
| 16 | 18 | 25 | 12.86960526978... | 0.514784210791... | NULL |
| 17 | 19 | 25 | 12.45027138085... | 0.498010855234... | NULL |
| 18 | 20 | 25 | 12.25743391055... | 0.490297356422... | NULL |
| 19 | 21 | 20 | 10.36852047105... | 0.518426023552... | NULL |

Show All Features

2024-03-09T06:33:15 WARNING Could not reproject view extent: Could not transform bounding box to target CRS

Coordinate 993264.7, 6231471.4 Scale 1:3659 Magnifier 100% Rotation 0.0° Render EPSG:3857

Processing Toolbox

zon

- Recently used
 - Zonal statistics
- Raster analysis
 - Raster layer zonal statistics
 - Zonal histogram
 - Zonal statistics
- GRASS
 - Imagery (i.*)
 - i.eb.evapfr
 - Raster (r.*)
 - r.buffer
 - r.buffer.lowmem
 - r.horizon
 - r.horizon.height
 - r.stats.zonal
- SAGA
 - Spatial and Geostatistics - Rasters
 - Zonal Raster Statistics
 - Spatial and Geostatistics - Regression
 - Zonal Multiple Regression An...
 - Tool Chains - Imagery
 - Local Climate Zone Classifica...

Results Viewer

Zonal Statistics layer –Attribute Table – Field Calculator setup – based on the grid NDVI value the grid is allocated N application value (kg)

The screenshot shows the QGIS interface with the following components:

- Top Bar:** Project, Edit, View, Layer, Settings, Plugins, Vector, Raster, Database, Web, Mesh, SCP, Processing, Help.
- Toolbar:** Various icons for selection, measurement, analysis, and processing.
- Layers Panel:** Shows layers: RiechiFieldGrids48, Zonal Statistics, and NDVI.
- Attribute Table:** Shows a table with columns: id, _count, _sum, _mean, and agrYieldMax. The agrYieldMax column contains NULL values.
- Processing Toolbox:** Shows recently used items: Zonal statistics, Raster analysis, Raster layer zonal statistics, and Zonal histogram.
- Field Calculator Dialog:**
 - Checkboxes: Only update 0 selected features, Create a new field (unchecked), Create virtual field (unchecked).
 - Checkboxes: Update existing field (checked), Output field name: agrYieldMax, Output field type: Whole number (integer), Output field length: 10, Precision: 3.
 - Expression Editor: CASE WHEN "_mean" >= 0.359 and "_mean" < 0.467 THEN 50 WHEN "_mean" >= 0.467 and "_mean" < 0.490 THEN 70 WHEN "_mean" >= 0.490 and "_mean" <= 0.579 THEN 90 END
 - Feature: 1, Preview: 50.
 - Buttons: OK, Cancel, Help.

A red arrow points from the 'Update existing field' checkbox in the Field Calculator to the 'agrYieldMax' column in the Attribute Table. A green arrow points from the 'CASE' expression in the Field Calculator to the 'agriYieldMax' column in the Attribute Table.

This code when added into Field Calculator consol to allocate N kg value: If NDVI is **bigger or equal to 0.359** and **less then 0.467** in the field in Attribute Table agriYieldMax 50 value is added. 50 -> low N application rate etc.

CASE

WHEN "_mean" >= 0.359 and "_mean" < 0.467 THEN 50

WHEN "_mean" >= 0.467 and "_mean" < 0.490 THEN 70

WHEN "_mean" >= 0.490 and "_mean" <= 0.579 THEN

90

END

Zonal Statistics layer – based on grid NDVI values and categories the N-application values are allocated

The screenshot displays the QGIS interface with several windows open, illustrating a spatial analysis workflow.

Project Bar: Standard QGIS menu items: Project, Edit, View, Layer, Settings, Plugins, Vector, Raster, Database, Web, Mesh, SCP, Processing, Help.

Toolbars: Standard QGIS toolbars for selection, measurement, and analysis.

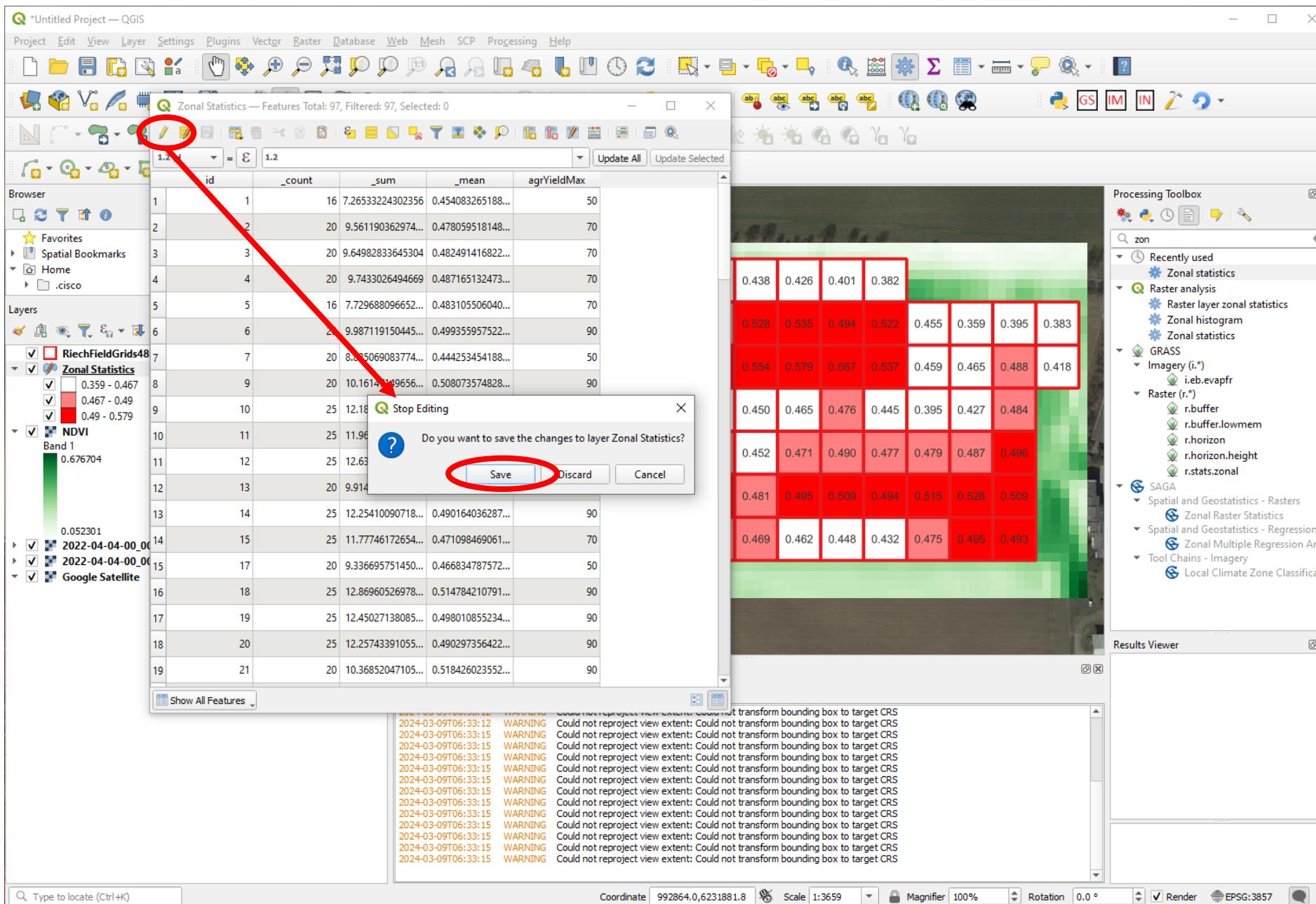
Zonal Statistics Window: Shows a table of results for "RiechFieldGrids48" layer. The table includes columns: id, _count, _sum, _mean, and agrYieldMax. The last column is highlighted with a red arrow pointing to it. The results show varying values across different grid features.

| | id | _count | _sum | _mean | agrYieldMax |
|----|----|--------|-------------------|-------------------|-------------|
| 1 | 1 | 16 | 7.26533224302356 | 0.454083265188... | 50 |
| 2 | 2 | 20 | 9.561190362974... | 0.478059518148... | 70 |
| 3 | 3 | 20 | 9.64982833645304 | 0.482491416822... | 70 |
| 4 | 4 | 20 | 9.7433026494669 | 0.487165132473... | 70 |
| 5 | 5 | 16 | 7.729688096652... | 0.483105506040... | 70 |
| 6 | 6 | 20 | 9.987119150445... | 0.499355957522... | 90 |
| 7 | 7 | 20 | 8.885069083774... | 0.444253454188... | 50 |
| 8 | 8 | 20 | 10.16147149656... | 0.508073574828... | 90 |
| 9 | 9 | 25 | 12.18572898793... | 0.487429159517... | 70 |
| 10 | 11 | 25 | 11.96224975064... | 0.478489990025... | 70 |
| 11 | 12 | 25 | 12.63730946743... | 0.505492378697... | 90 |
| 12 | 13 | 20 | 9.914615602144... | 0.495730780107... | 90 |
| 13 | 14 | 25 | 12.25410090718... | 0.490164036287... | 90 |
| 14 | 15 | 25 | 11.77746172654... | 0.471098469061... | 70 |
| 15 | 17 | 20 | 9.336695751450... | 0.466834787572... | 50 |
| 16 | 18 | 25 | 12.86960526978... | 0.514784210791... | 90 |
| 17 | 19 | 25 | 12.45027138085... | 0.498010855234... | 90 |
| 18 | 20 | 25 | 12.25743391055... | 0.490297356422... | 90 |
| 19 | 21 | 20 | 10.36852047105... | 0.518426023552... | 90 |

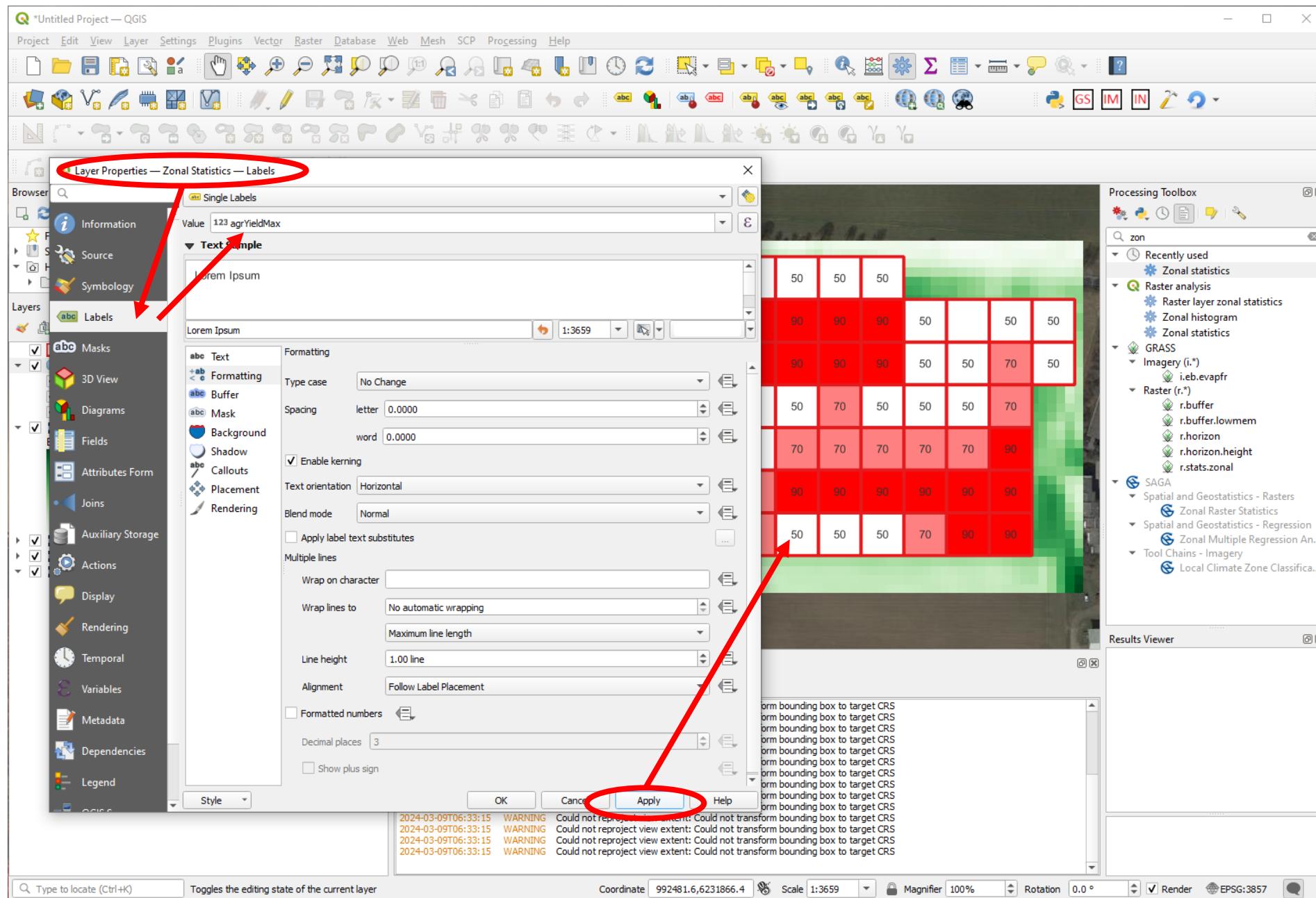
Processing Toolbox: Shows the "zon" search term. Results include "Recently used", "Raster analysis", "GRASS", "Raster (r.)", "SAGA", and "Tool Chains - Imagery".

Results Viewer: Displays a heatmap visualization of the raster data, where each pixel's value corresponds to the "agrYieldMax" value from the Zonal Statistics table. The colors range from red (low values) to green (high values).

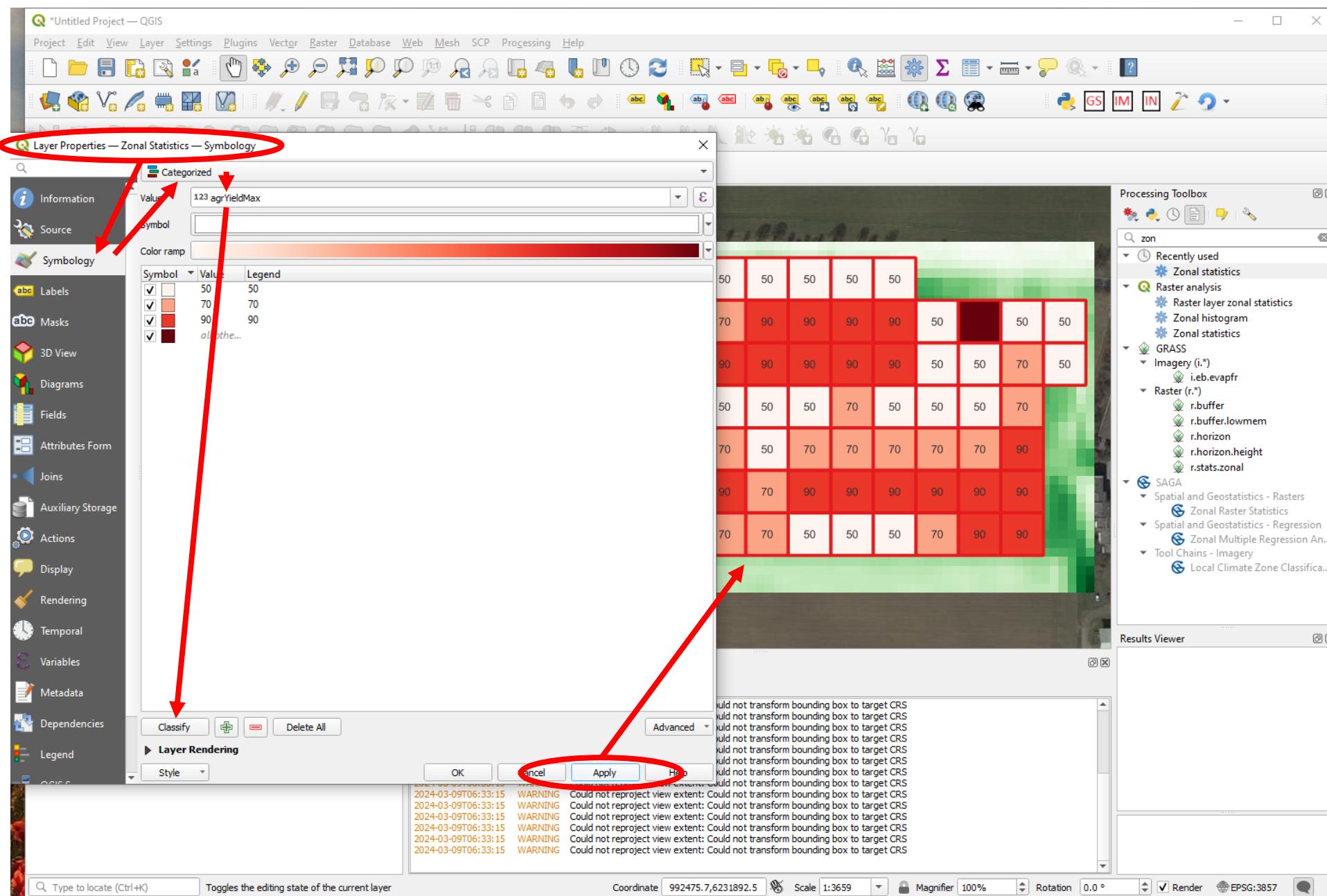
Zonal Statistics layer – based on grid NDVI values and categories the N-application values are allocated – stop editing and save!



Zonal Statistics layer – Labels -> Single Labels -> agrYieldMax (value) -> will N application values to each corresponding grid



Zonal Statistics layer – Symbology -> Categorized -> agrYieldMax -> Classify



Zonal Statistics layer – N application mat generated!

The screenshot shows the QGIS interface with a raster layer named "RiechFieldGrids48x48" in the layers panel. A specific feature in the "Zonal Statistics" layer is highlighted with a black arrow pointing to its entry in the layers panel. The entry shows a color swatch corresponding to a value of 90 and includes a numerical value of 0.67704. A callout box contains the following text:

None defined category was result of non detailed setup of NDVI categories.

A code block in the Log Messages panel shows the zonal statistics query:

```
CASE
    WHEN "_mean" >= 0.359 and "_mean" < 0.467 THEN 50
    WHEN "_mean" >= 0.467 and "_mean" < 0.490 THEN 70
    WHEN "_mean" >= 0.490 and "_mean" <= 0.579 THEN 90
END
```

The Processing Toolbox panel shows the "Zonal statistics" tool under the "Raster analysis" section. The Log Messages panel displays several warning messages about reprojecting view extent.

These ranges have to be defined carefully!

Discussion