

2020 Oct 10

Wind Vector Mapping and Animation in QGIS

This posting is on how to map wind vector (i.e. speed/magnitude and direction) and create an animation using QGIS. This is written for my friend, Jim at PacIOOS. Check them out for some awesome oceanographic data that are open and very accessible. I used their GeoServer services all the time for my tutorials.

What you'll need if you want to follow along with this short tutorial.

Requirements:

- QGIS software installed - (I'm using version 3.14 on Windows OS)
- Wind data in netCDF format - you can download the sample below or use your own
- Crayfish plugin for QGIS - if you want to do animation, otherwise it's optional

For those who are not familiar with the netCDF format. It stands for network Common Data Form and is a file format for storing multi-dimensional scientific data, such as temperature, salinity, wind speed and direction. These data or variables can be mapped through time (a dimension) in GIS by making a layer from the netCDF file.

Download Wind Data

I am using the [PacIOOS ERDAP](#) (Environmental Research Division's Data Access Program) server to download my data. To download the exact data I used here, you can click the direct data download link below, or use your own data. The data set I'm using is the Regional Ocean Modeling System for the main Hawaiian Islands.

These are the parameters I used to query the data, which can be saved to a URL and shared for downloading: To use the same dataset for this tutorial, click this link: [Direct Data Download](#).

ERDDAP > griddap > Data Access Form

Dataset Title: **Regional Ocean Modeling System (ROMS): Main Hawaiian Islands: 3-D Variables**  

Institution: Pacific Islands Ocean Observing System (PacIOOS) (Dataset ID: roms_hiig)

Information: [Summary](#) | [License](#) | [FGDC](#) | [ISO 19115](#) | [Metadata](#) | [Background](#) | [Make a graph](#)

Dimensions	Start	Stride	Stop	Size	Spacing
☒ time (UTC)	2020-09-14	1	2020-09-15	16028	3h 0m 25s (uneven)
☒ depth (m)	0.25	1	100	36	157.1357 (uneven)
☒ latitude (degrees_north)	17.01843	1	23.98239	195	0.0358967 (even)
☒ longitude (degrees_east)	-163.8307	1	-152.5193	295	0.03847415 (even)

Grid Variables (which always also download all of the dimension variables)

- ☒ temp (potential temperature, Celsius)
- ☒ salt (salinity, 1e-3)
- ☒ u (u-velocity component, meter second-1)
- ☒ v (v-velocity component, meter second-1)

File type: [\(more info\)](#)

.nc - Download a NetCDF-3 binary file with COARDS/CF/ACDD metadata.

Just generate the URL: https://pae-paha.pacioos.hawaii.edu/erddap/griddap/roms_hiig.

[\(Documentation / Bypass this form\)](#)

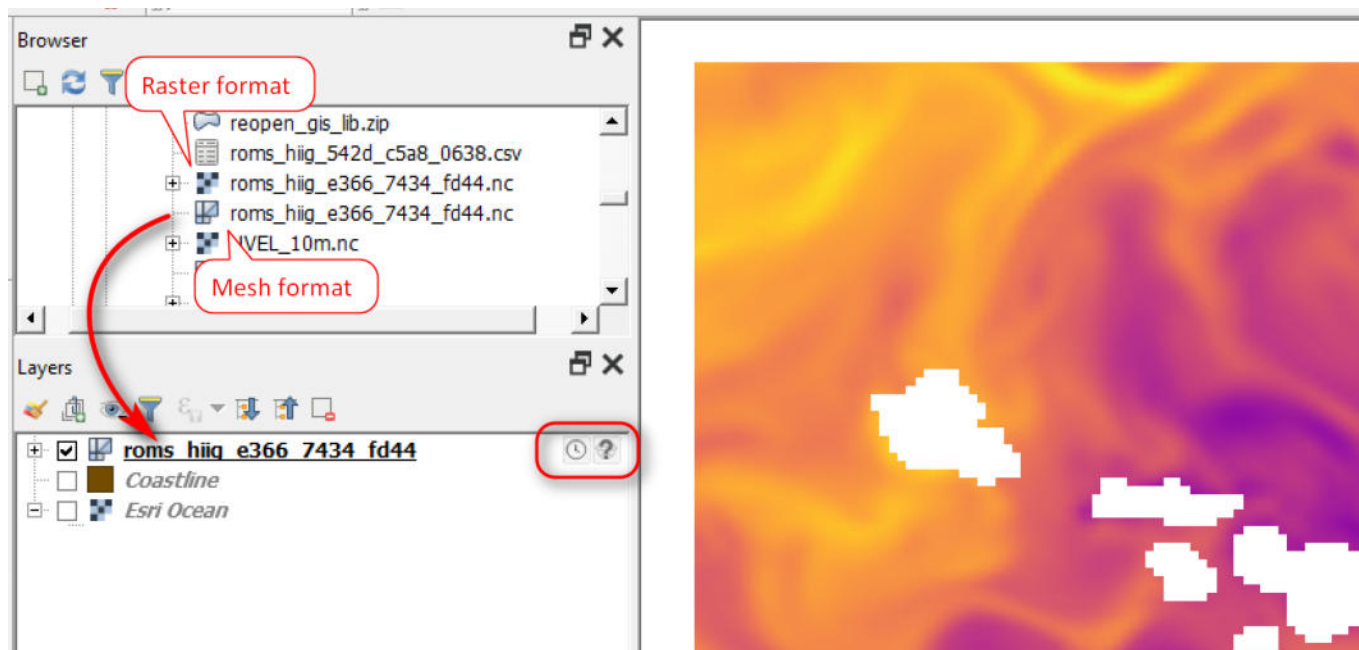
Submit (Please be patient. It may take a while to get the data.)

Viewing netCDF data as a mesh

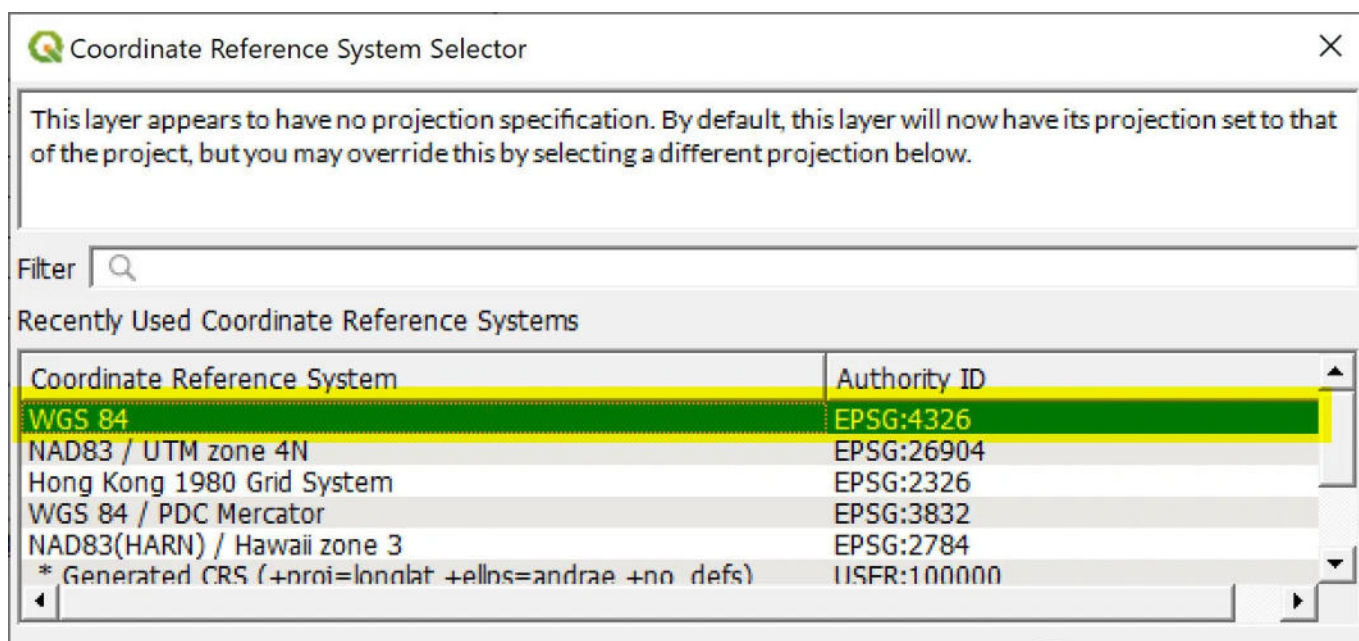
NetCDF data can be viewed in QGIS either as a raster or as a mesh. The mesh method is much more elegant and easy. Find more information about working with mesh data in the [QGIS user manual](#).

Here's how.

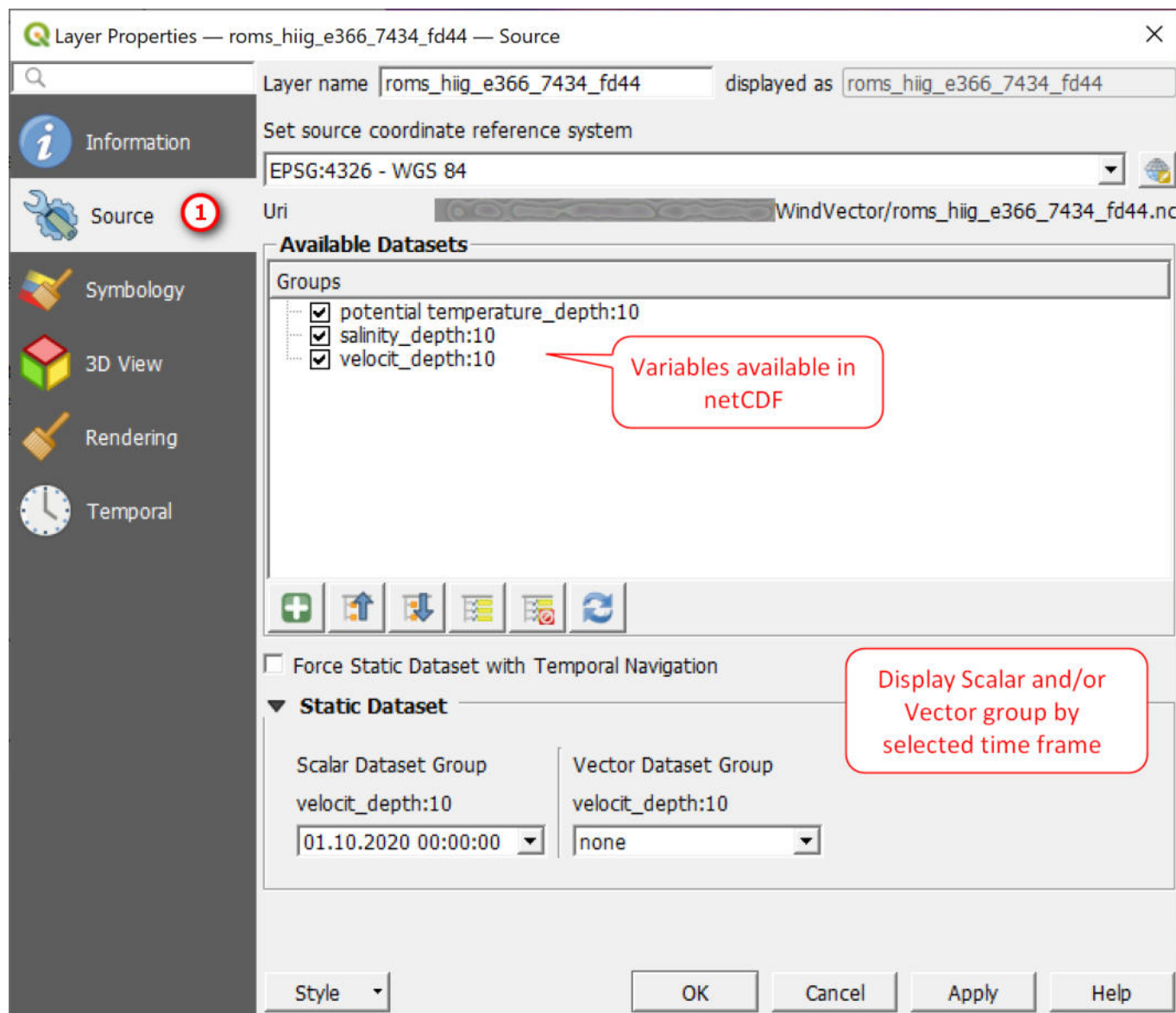
1. Open up QGIS
2. Browse to when you saved the netCDF data. Then either double click on the mesh data or drag and drop it into your TOC.



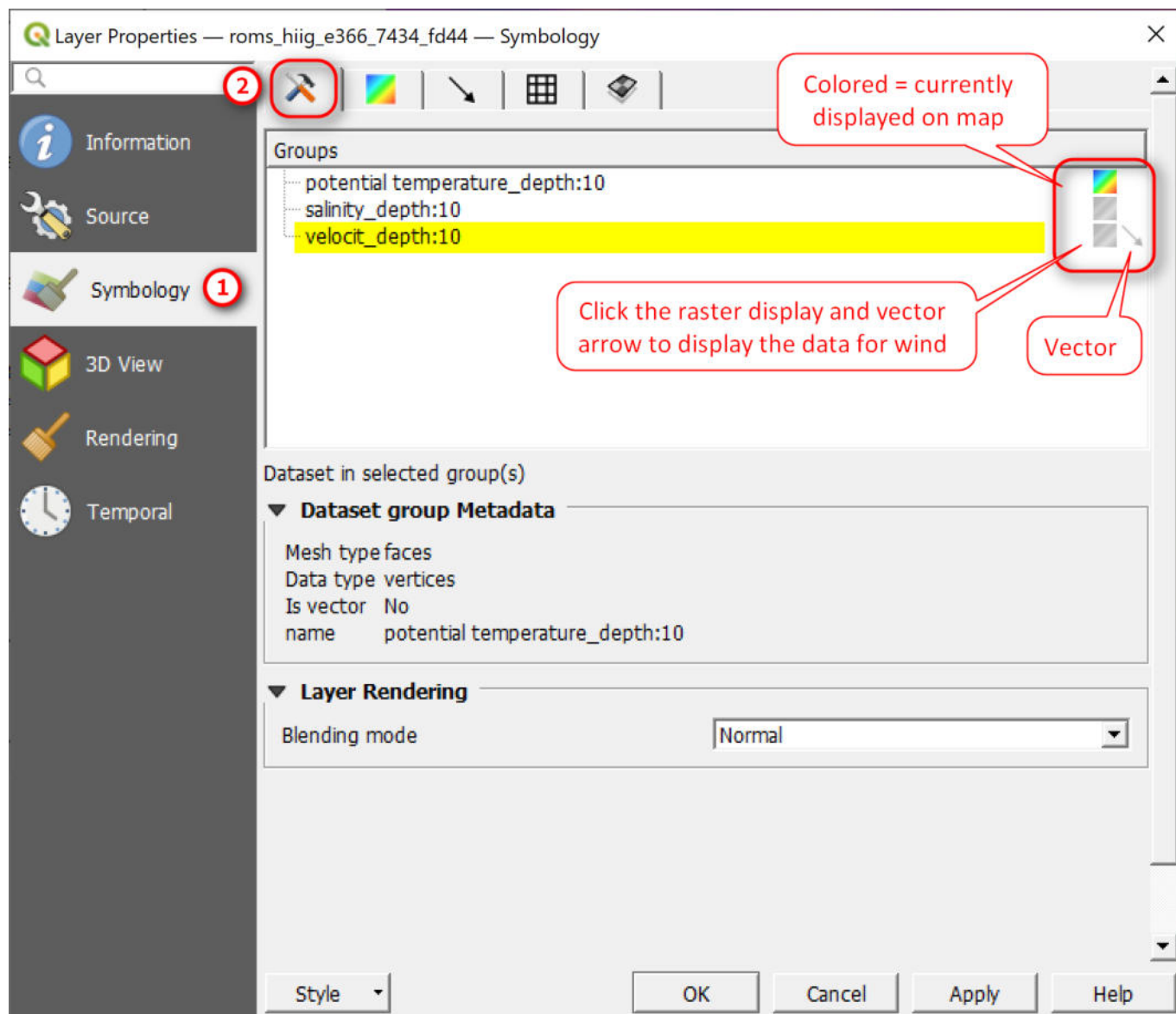
3. Notice in the TOC to the left of the filename there's a clock to indicated that the netCDF is a temporal dataset. There's also a question mark - if you hover on it will say layer has no coordinate reference system set. Click on the question mark to bring up the CRS selector window, define the coordinate system as WGS 84.



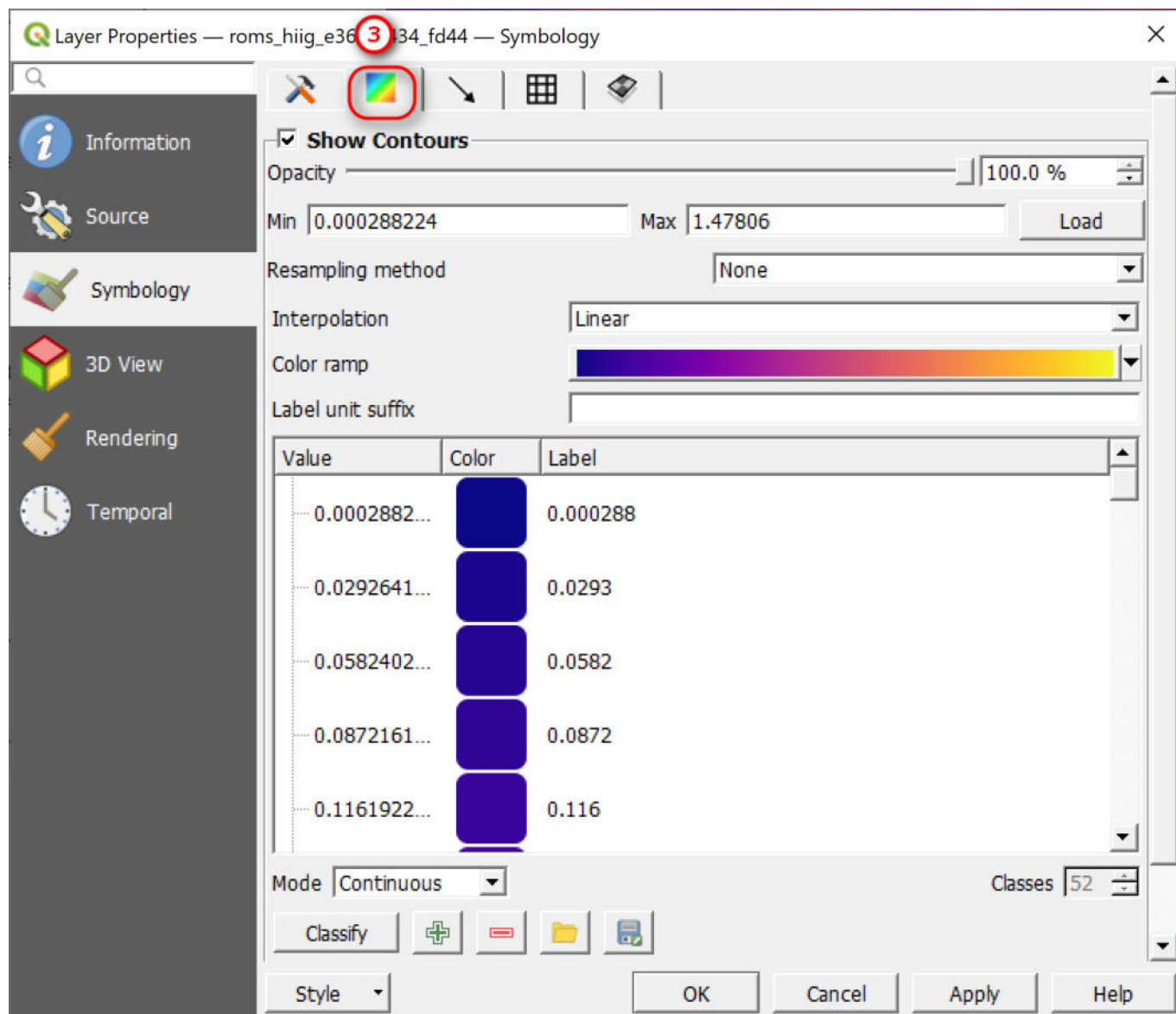
4. Open up the layer's property window (right click layer name >> Properties). If you go to Source section to view information about available datasets in the netCDF



5. Go to Symbology section, then click on the Setting tab and display the wind contour (raster) and vector. You'll notice there are 3 layers (temperature, salinity, wind velocity) in the netCDF file. By default QGIS will display the first layer in the group. You can change these settings. Don't forget to click Apply button to see your changes.



6. Go to the Contour tab to change how you want to change the way the wind contour is displayed. Make your changes then click Apply to see your changes. I'm using the default settings with transparency of 50%.



7. Go to the Vector tab (arrow) to change how you want the vector to display as either an arrow, streamlines or traces. Try instead of showing the arrows as a single color, try changing it to Color Ramp Shade. I'm using a default settings. Click Apply when done making your change.

Layer Properties — roms_hiig_e366_7434_f4 — Symbology

Information
Source
Symbology
3D View
Rendering
Temporal

Show Vectors

Symbology
Arrows

Line Width and Color
0.26 Coloring Method: Color Ramp Shader

Color Ramp Shader
Min: 0.000288224 Max: 1.47806

Interpolation: Linear
Color ramp: [Color Ramp]
Label unit suffix: [Empty]

Value	Color	Label
0.0002882...	[Dark Blue]	0.000288223678522393
0.0292641...	[Dark Blue]	0.0292641504032482
0.0582402...	[Dark Blue]	0.0582402249055253
0.0872161...	[Dark Blue]	0.0872161516302511
0.1161922...	[Dark Blue]	0.116192226132528

Mode: Continuous Classes: 52

Classify [Add] [Remove] [Folder] [Save]

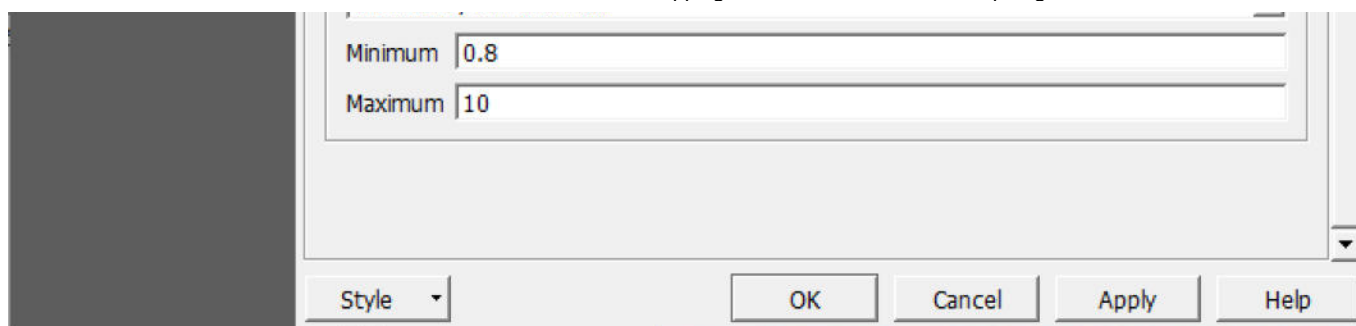
☐ Clip out of range values

Filter by Magnitude
Min: [Empty] Max: [Empty]

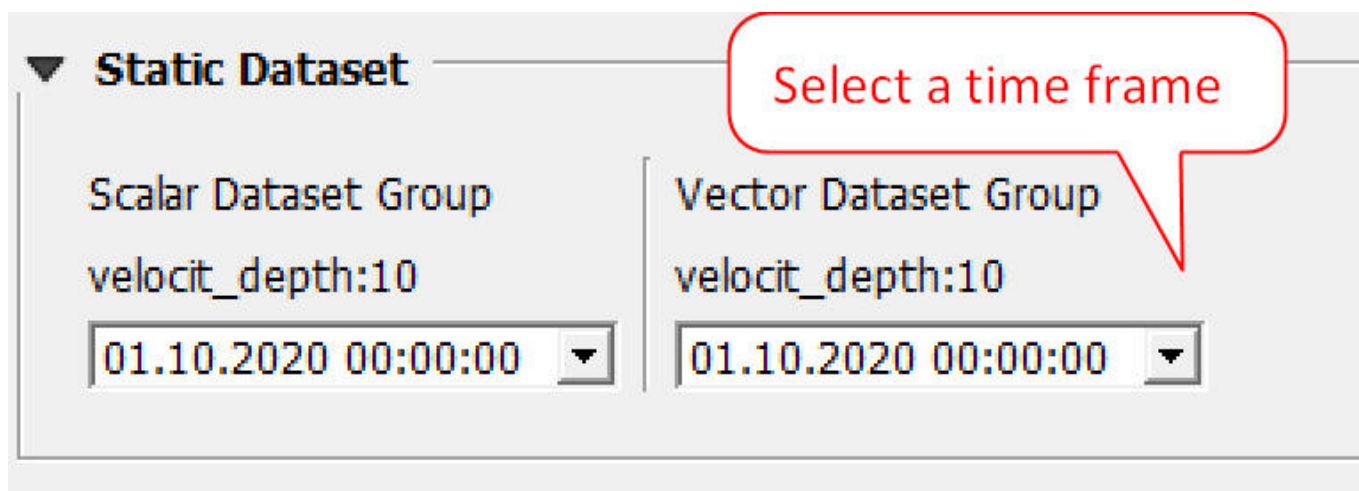
☐ **Display on User Grid**
X Spacing: 10 px
Y Spacing: 10 px

Head Options
Width: 15 % of shaft length
Length: 40 % of shaft length

Arrow Length
Defined by Min and Max

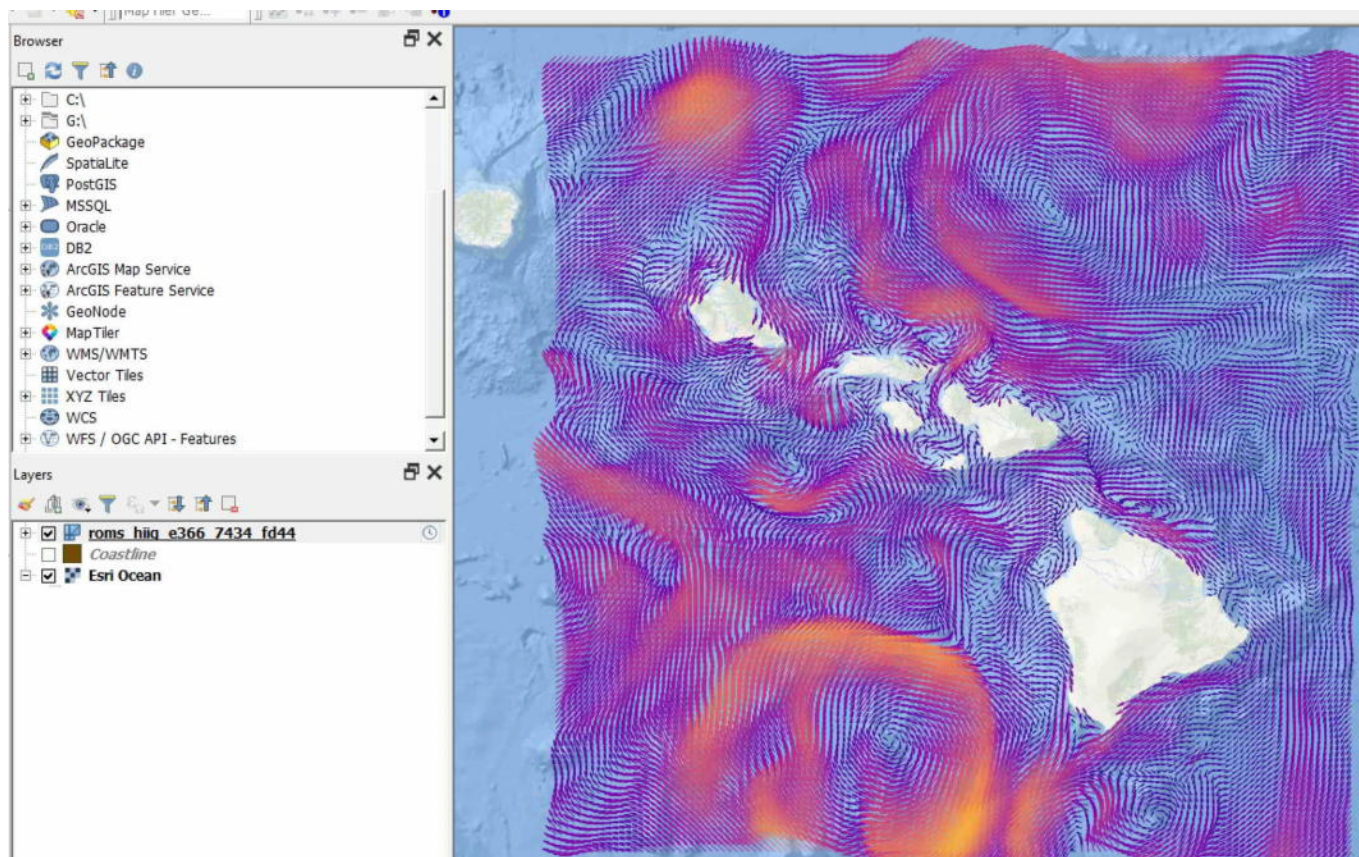


Note: if you do not see the vector arrows displayed on your map after making your changes here, go back to the Source section (#1 above) and select a time frame for the vector. Select none for the Scalar Dataset Group if you only want to view the vector on the map — see my display below.



Feel free to explore the mesh rendering tab (regular square grid or triangular faces) and vertical layer stacking.

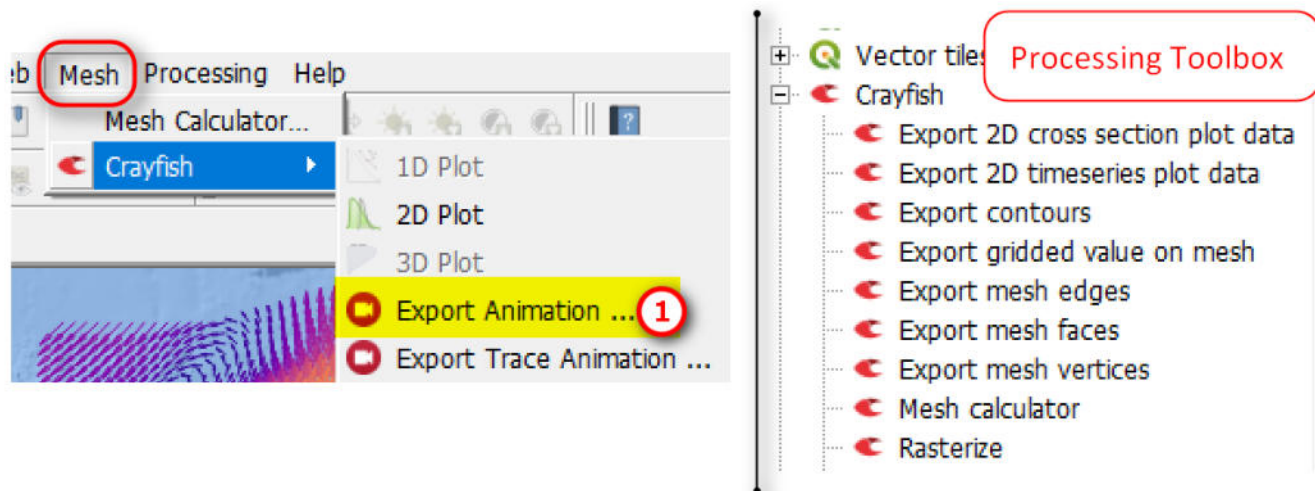
This is how my wind vector look likes. My display is showing only the vectors overlaid on top an ESRI bathymetry (ocean) basemap.



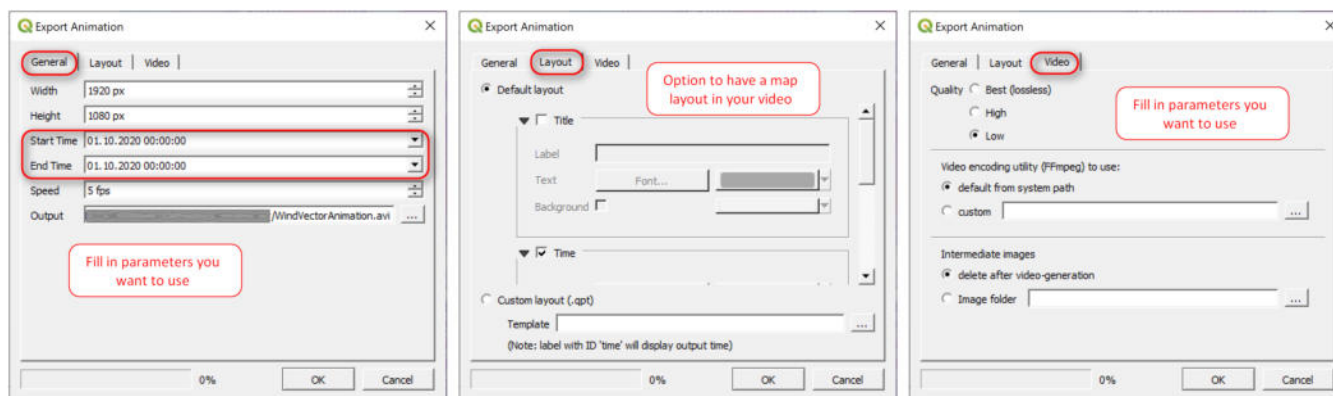
Animate vector using Crayfish plugin

If you want to animate your vector, you can do this using the [Crayfish plugin](#). This plugin gives you more functionalities with mesh data. Here I'm using just to create an animation for my vector data. The video created will be in avi format.

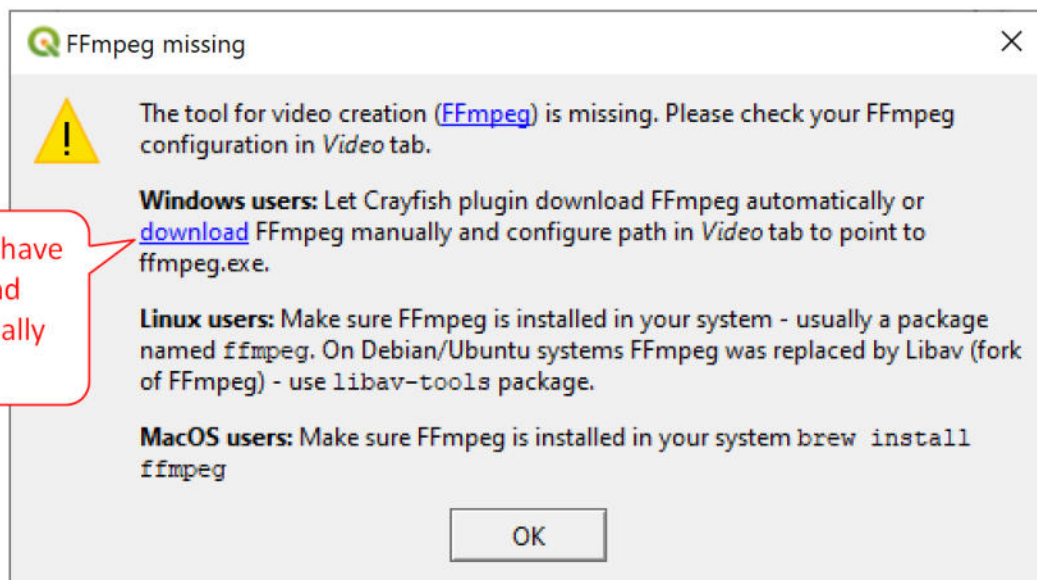
1. Install the Crayfish plugin. Go to the Plugin menu >> Manage and Install Plugins. In the Plugins window, search for Crayfish and install it.
2. Once you have the plugin installed - you can access the tool in the Mesh menu >> Cray >> Export Animation. For other tools, you can access them in the Processing Toolbar panel



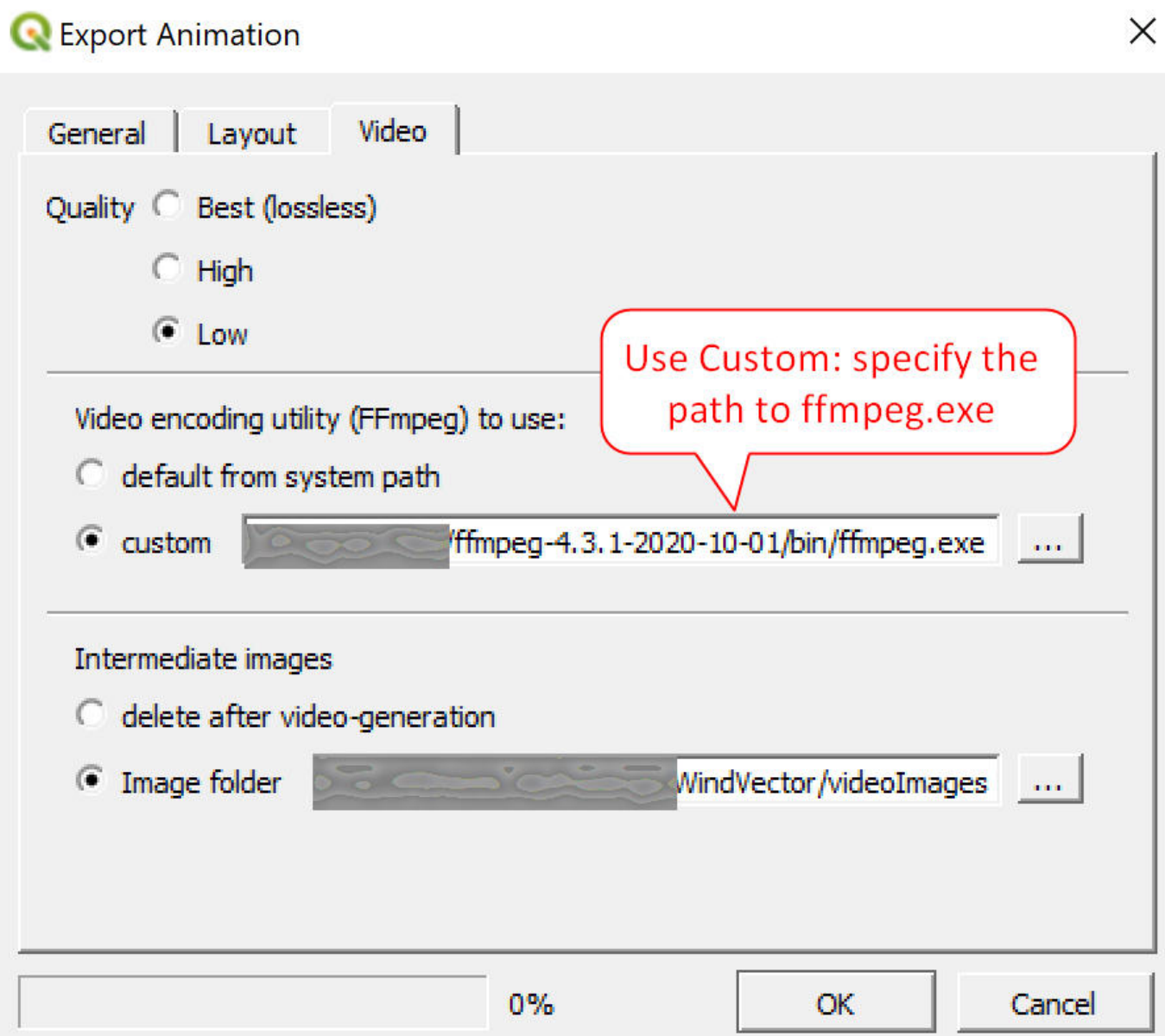
3. In the Export Animation window, enter the parameters you want. I'm using mostly the default settings. Don't forget to select a **Start Time and End Time**. You have the option to save the images as well to create animated gif.



NOTE: if you get an error about **FFmpeg is missing**. You need to [download FFmpeg](#) and extract it to your computer then specify the path to FFmpeg.exe in the Export Animation window.

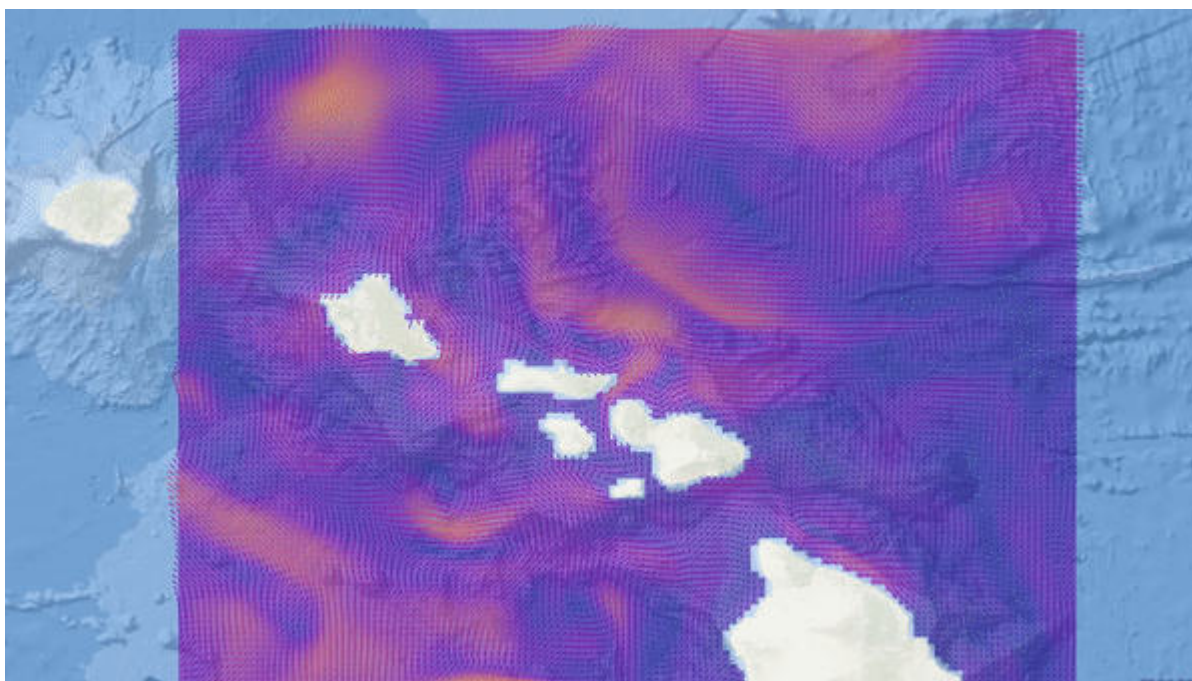


Using the option to have
Crayfish download
FFmpeg automatically
DID NOT work



Use Custom: specify the
path to ffmpeg.exe

Here is my vector animation shown as a gif.



Converting raster wind vector to a point layer with u, v, speed and direction

So, what if you have raster(s) containing the u (eastward x-axis) and v (northward y-axis) components and you want to convert to a point layer (e.g. shapefile) and use arrows to show the wind speed and direction (wind vectors). This section will show you how to do that. But first, you'll need to do some calculations. See this [wind direction quick reference](#) for calculating wind direction and speed and other tips. Also keep in mind that wind direction is described differently for oceanography and meteorology. Oceanographers describe the wind in the direction that it's flowing towards and meteorologist describes wind in the direction that it's flowing from.

$$\text{Wind Speed (magnitude)} = \sqrt{u * u + v * v}$$

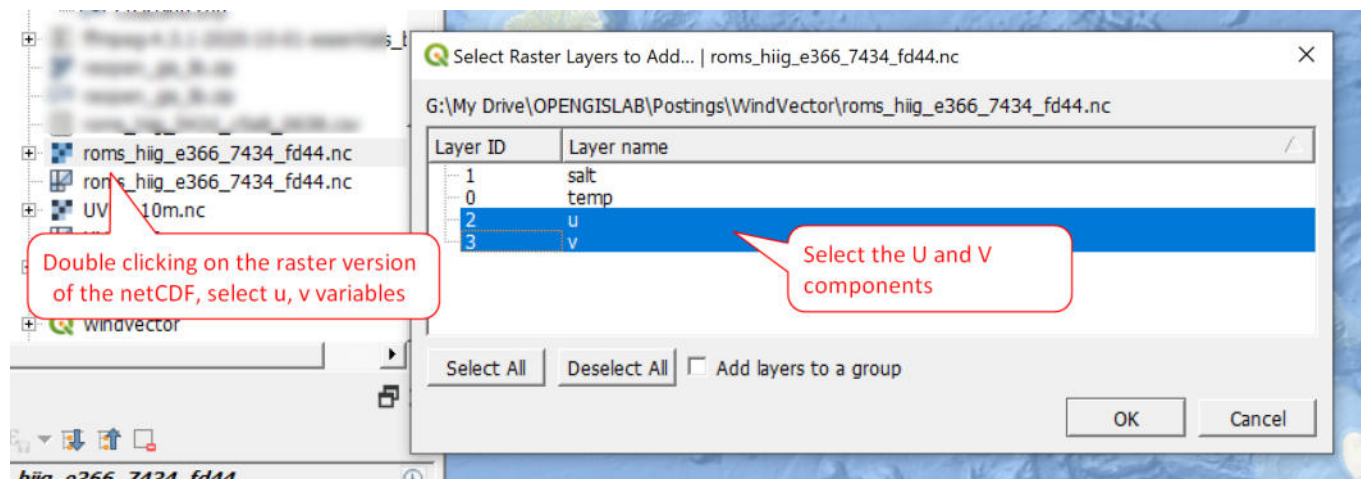
$$\text{Wind Direction} = \text{Atan2}(v, u) \text{ is the same as } \text{Atan2}(y, x)$$

If you read the quick referenced guide linked above, there is tip on some software, especially spreadsheets using the $\text{Atan2}(x, y)$, where x and y are switched. QGIS uses the $\text{atan2}(y, x)$, which return values in radians. To convert radians to degrees (symbol rotation), multiply it by $180/\pi$.

$$\text{Oceanographic Convention: } (180/3.14) * \text{Atn2}(v, u)$$

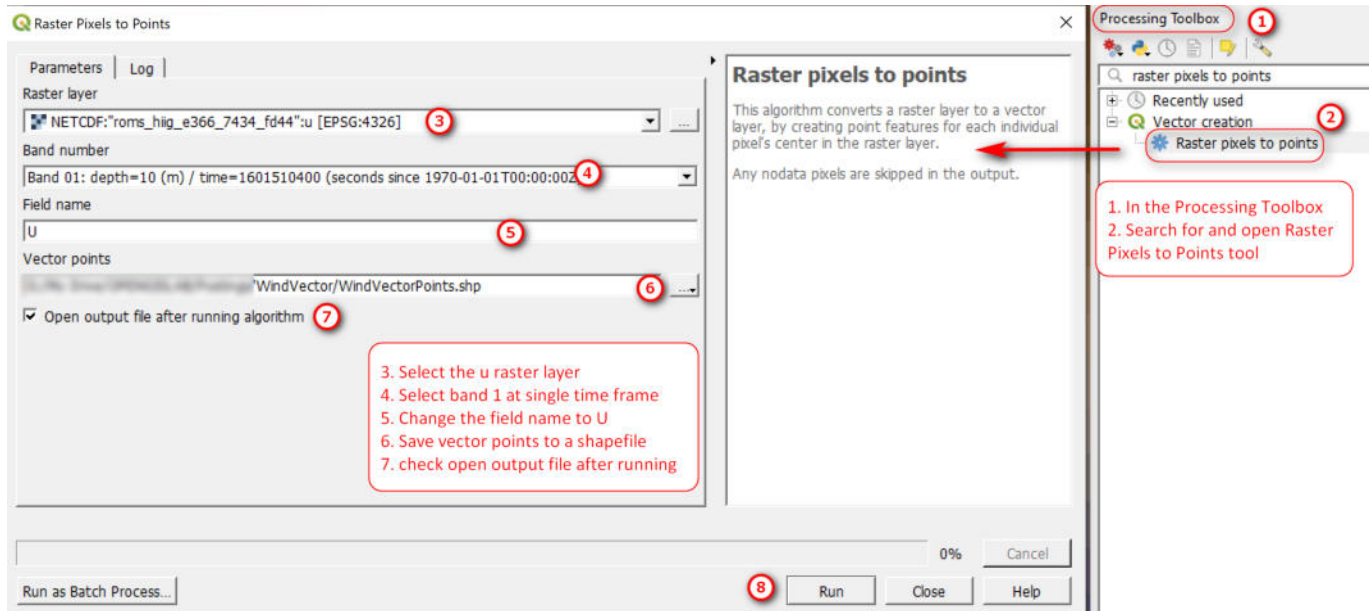
$$\text{Meteorological Convention: } (180/3.14) * \text{Atn2}(v, u) + 180$$

1. Instead of using the mesh version of the netCDF data, add the raster version of it into your map. When you double click on the netCDF raster, QGIS will ask you to select variables you want to view. Select the u and v components and add to your map

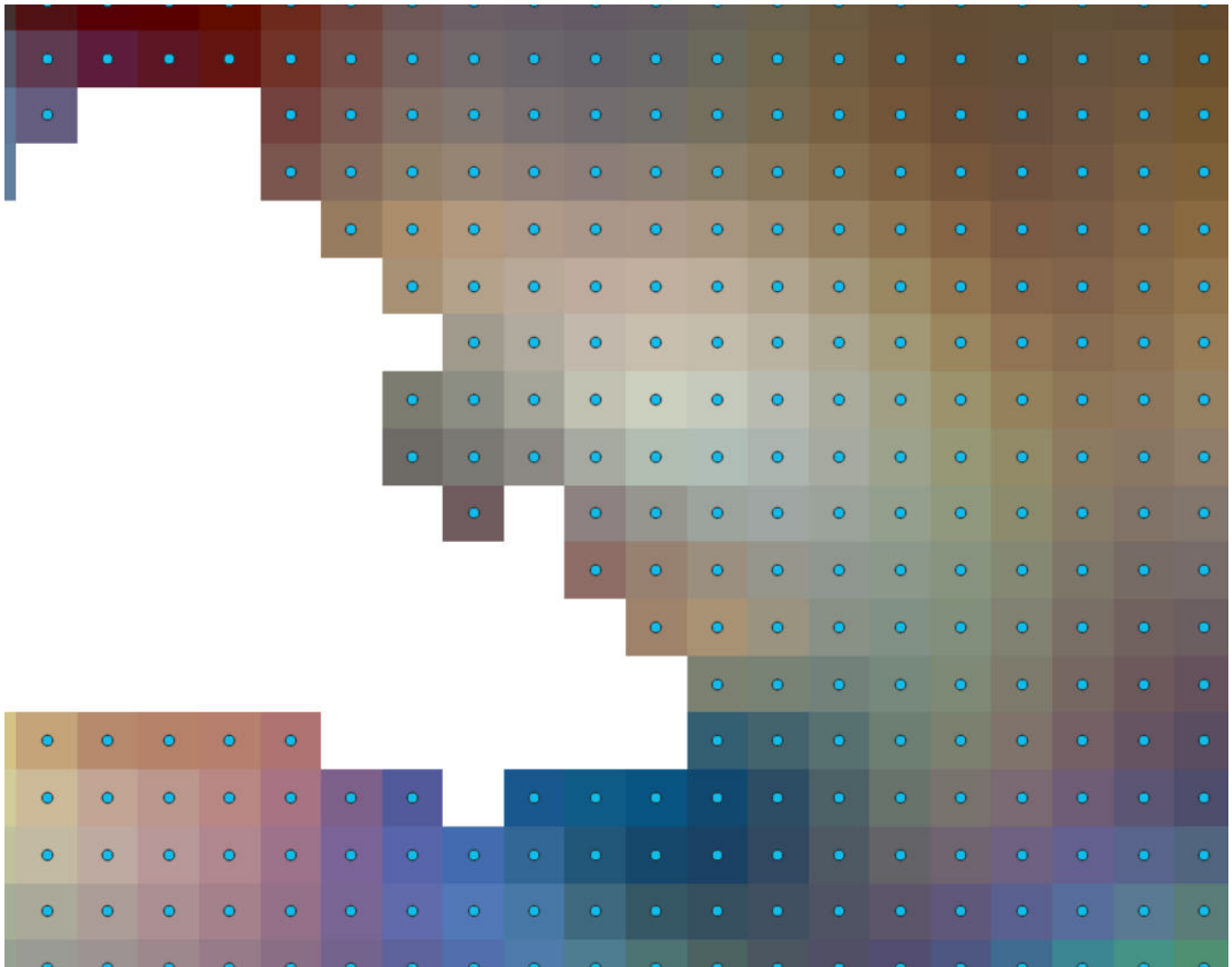


2. Using the u raster grid, create a point

- Go to the Processing Toolbar >> Vector Creation >> Raster Pixels to Points
- In the Raster Pixels to Points window:
 - Select the u raster grid
 - Band 1 band/time frame combo
 - Field name: change to U (u values from the raster will be written out to this field)
 - Vector points: Save as a permanent layer (e.g. WindVectorPoints.shp)
 - Check the box, Open output file after running
 - Run the process



You should get a point layer that is the centroid of each raster cell of your grid.



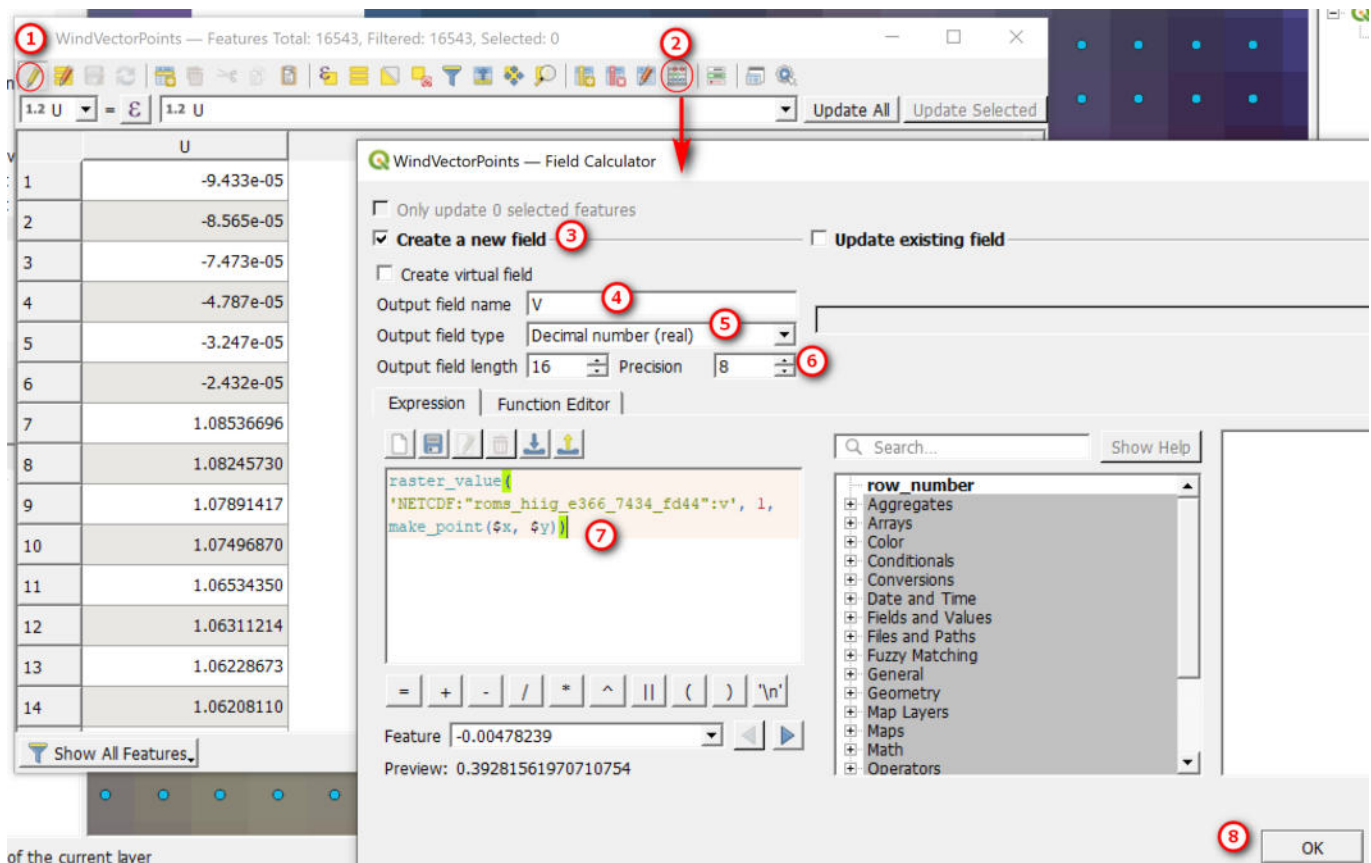
3. Open up the attribute table of your point layer just created. You should see the U values from raster grid. Using the Raster Calculator add the v values from the v grid.

- Toggle on table editing (pencil button)
- Open Field Calculator
 - Check Create a new field
 - Output field name: V
 - Output field type: Decimal number
 - Output field length and Precision: 16 and 8
 - In the Expression text box: type in the following

`raster_value('NETCDF:"roms_hiig_e366_7434_fd44":v', 1, make_point($x, $y))`

The syntax: `raster_value('raster', 1, make_point($x, $y))` where raster is the filename of your v raster grid

- Click Run



4. Keep your attribute table open and calculate wind speed using the the field calculator. Remember $\text{speed} = \sqrt{uu + vv}$

WindVectorPoints — Field Calculator

☐ Only update 0 selected features

☒ **Create a new field** 1 ☐ Update existing field

☐ Create virtual field

Output field name: 2

Output field type: 3

Output field length: Precision: 4

Expression | Function Editor

`sqrt( u * u + v * v )` 5

Feature:

Preview: 0.3928447308671665

you can search for the function

Search:

- Geometry
 - make_square
- Math
 - sqrt
- Record and Attributes
 - sqlite_fetch_and_increment
- + Recent (fieldcalc)

5. Calculate the wind direction using the formula given above. Don't forget to convert radians to degrees

WindVectorPoints — Field Calculator

☐ Only update 0 selected features

☒ **Create a new field** 1 ☐ Update existing field

☐ Create virtual field

Output field name: 2

Output field type: 3

Output field length: Precision: 4

Expression Function Editor

📄 💾 ✍️ 🗑️ ⬇️ ⬆️

5 `(180/3.14)*atan2(v,u)`

= + - / * ^ || () "\n"

Feature: ⬅️ ➡️

Preview: 90.74352430828684

Show Help

Math

- atan2
- Recent (fieldcalc)

function atan2

Returns the inverse tangent of the ratio of the y coordinate to the x coordinate, using the signs of the coordinates to determine the quadrant of the result.

Syntax

`atan2 ( dy, dx )`

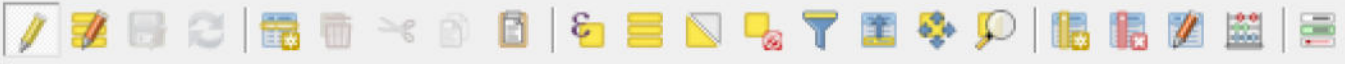
Arguments

dy y coordinate
dx x coordinate

Examples

Save your table and don't forget to toggle off editing. Your point layer should now have values for u, v, speed, and direction.

WindVectorPoints — Features Total: 16543, Filtered: 16543, Selected: 0



1.2 U = €

	U	V	Speed	Direction
1	0.52986795	0.00024614	0.52986801	0.02662915
2	0.45019665	0.00028719	0.45019674	0.03656873
3	0.38733453	-0.00027875	0.38733463	-0.04125451
4	0.12653731	9.834e-05	0.12653735	0.04455068
5	0.31774315	0.00032474	0.31774332	0.05858714
6	0.52179712	-0.00056295	0.52179742	-0.06184589
7	0.49436462	0.00054876	0.49436492	0.06363232
8	0.39165133	0.0004424	0.39165158	0.06475275
9	0.3909145	0.00046285	0.39091477	0.06787364
10	0.34248731	0.00046399	0.34248762	0.07766167
11	0.24673505	0.00040005	0.24673537	0.09294497
12	0.38077778	0.00072059	0.38077846	0.10848232
13	0.24980983	0.00049413	0.24981032	0.1133898

Mapping the wind vector using the point layer

Now that you have all the information you can map the wind vector using the point layer you just created.

1. Open the Properties window of your point layer. The following this guide below to display the points as arrows in the direction of the wind (rotated using the direction values)

- Go to Symbology section
- Change the Single symbology to Graduated style
- Value: Select Speed
- Click on the point Symbol

- Click on Simple Marker
 - Symbol layer type: select Font maker
 - Choose an arrow character (must be point up or north)
 - For Rotation: click the custom variable button >> Field type >> Direction
 - Optional - change font symbol size if you want
 - Click OK to Symbol Settings
- Back in the main symbology window, select a color ramp
 - Mode: Use Equal Interval
 - Click Classify (change the number of classes if you want)
 - Click Ok when done

Here's what my point vector map looks like (zoomed in a bit to show the arrows and overlaid on to of ESRI basemap). Yours may look differently depending on how you choose to symbolize the point vectors.

Here's a comparison of the point vector map and the mesh vector - the mesh version is much more refined and more efficient for mapping vectors. You can also view the mesh as a 3D map, but that's for another time.

Point wind vector map (left) and mesh wind vector map (right).

Hopefully, this tutorial provides a brief guide on how to map and animate wind vectors. There are lots of options for how you want to view wind vectors, so play around with the settings. Thanks for reading. Until my next post.

Comments (9)

Newest First

Daniel 5 years ago · 0 Likes

Hello,

Thanks a lot for this article, you helped me a lot;

Still have one question. I have 2760 grid values for 11520 hours in "u" "v" vectors (total values: $2760 \times 11520 \times 2$). When I convert raster to pixel my attribute table only gives me 2760 values. I checked my Excel and the velocities of the attribute table are not a mean of all the 11520 hours for each grid. What happens to time when I use "Raster Pixels to Points"?

Stephanie Saephan 5 years ago · 0 Likes

Hi Daniel,

The Raster Pixels to Points function - for the Band Number parameter (see above in tutorial) - you are selecting for a single time frame. If you have 2760 grid cells then you should have the same number of points -- but only for a single time frame that you've chosen (e.g hour X as specified by Band X). In the tutorial I show, I choose to create a point layer using U grid (U values at Band 1 written to my points) then use the Raster Calculator to add the corresponding (same time/Band 1 as U) V values from V grid to the existing point layer's attribute table then I calculate speed and direction. In other words, the point layer should contain U,V values for a single time period.

Also note that if you are using Excel to do your calculations, see <https://www.eol.ucar.edu/content/wind-direction-quick-reference> - there is a note about

"Spreadsheets, including Microsoft Excel, LibreOffice Calc and Google Docs switch the arguments, so that $\text{atan2}(x,y)$ is the arctangent of y/x ."

Hope this helps and good luck.

Daniel 5 years ago · 0 Likes

I'm sorry, In the first line I wanted to say "total values: 2760x11520x2", I used asteriks ldk what happened :D

Thank you in advance, Stephanie!

Orla Osborne 6 years ago · 0 Likes

Hi Stu,

I was wondering if you've encountered NetCDF files being mapped in the "wrong" location by QGIS? I'm using QGIS 3.16 and I've tried 2.18 too. I think it has to do with the longitude units being in degrees east. When I add other layers (vector or raster) they map correctly to my area of interest. My map display is set to WGS 84 (EPSG: 4326) and as per your instructions I import my file.nc as a mesh layer (I've tried raster too to no avail) and set the CRS of the mash layer to WGS 84 (4326) too. The NetCDF file imports and visualizes without any problems, it's just in the wrong place. When I zoom into the mesh layer, The Coordinate box at the bottom of the display gives the longitude (degrees east, approx. 225), latitude (approx 50), and then when I zoom to a vector layer in my study area the coordinate box shows the longitude (approx. -128) and latitude (approx. 50)

I don't think the problem lies with the NetCDF file, I think it is how QGIS is reading it that may be the problem, like it doesn't know how to convert the longitude degrees east.

The NetCDF has a single variable (Chlorophyll), with 4 dimensions (time, altitude, longitude and latitude). Also, I have tried mapping it in ArcPro, using the NetCDF to raster tool, and it works perfectly. Unfortunately I need to be able to use it in QGIS as my ArcPro trial is about to expire.

Any advice you have is much appreciated,

Orla

Stephanie Saephan 6 years ago · 0 Likes

Hi Orla,

I'm Stephanie (not Stu :)) and I run this blog. Yes, you are correct the issue is which the projections of the basemap and your netCDF file. Your netCDF file is in WGS 84 (epsg 4326) and the web basemaps are in WGS 84/Pseudo Mercator (epsg 3857). What you can do is add the basemap (e.g. OSM or ESRI Topo) to your QGIS project. This will set the project CRS to epsg 3857 (the first layer you add to your project will set the project/global CRS). Then add your netCDF file - it will come in with Unknown CRS), so set its CRS to epsg 4326. QGIS will then project your netCDF file to that of the basemap and you should be able to see your layer. Note though projection on the fly of mesh data produce distortions so you're layer may look weird. I was able to see your sample netCDF as being something off the coast of British Columbia between Graham Island and Vancouver Island.

I think ArcGIS handles projection on the fly much better than QGIS. Maybe you could re-project your netCDF using ArcGIS/Pro then bring into QGIS if you need to.

Hope this helps :)

Stephanie Saephan 6 years ago · 0 Likes

Hi Stu,

I'm sorry you are having trouble with the netcdf file. I saw your question posted on Stack Exchange. I have basically the same setup as you. I even tested it on another computer and had no problem. I think it may be some sort of netcdf dll conflict with QGIS installation, but I'm not sure. Can you try this and let me know if it works for you.

See if netcdf.dll is in these two places.

..Windows/System32

..Windows/SysWOW64

If so, make a backup copy first (just in case) then delete it. Restart your computer then try opening the nc file. There should only be one netcdf.dll file and it should be in the OSGeo4W64/bin folder (if you are using the OSGeo4W installation method to install QGIS).

Good luck. I hope this will work for you.

Stu Smith 6 years ago · 0 Likes

Hi Stephanie,

I'm trying to add the file from the "Direct Data Download" link in this article: roms_hiig_e366_7434_fd44.nc

No matter how I try (double-click, drag & drop, ...) I get the "...not a valid or recognized data source" error.

Because of this error, no layer (raster or mesh) is added to the Table of Contents.

Stephanie Saephan 6 years ago · 0 Likes

Hi -

Are you trying to add the netCDF (.nc) file as a mesh file to QGIS? If you are seeing the not valid data source error - it could be that your file is corrupt or that it only contains only variable - in which case only the raster version of the *.nc will be valid. Not sure why or if this is the case for you.

Try adding the raster version of your .nc file and see if it show up on your map. I hope this helps.

Stu Smith 6 years ago · 0 Likes

When I try to load the netCDF file, QGIS 3.14.16 responds with "...not a valid or recognized data source."

I've asked this question on Stack Exchange GIS, at:

<https://gis.stackexchange.com/questions/376435/qgis-error-loading-netcdf-files>

but have not yet received a solution. Does anyone here have a solution?

< Introduction to QGIS - GIS
Day 2020 Virtual Workshop

Exploring MapStore as an
Opensource Web Mapping
Framework >

open.gis.lab



