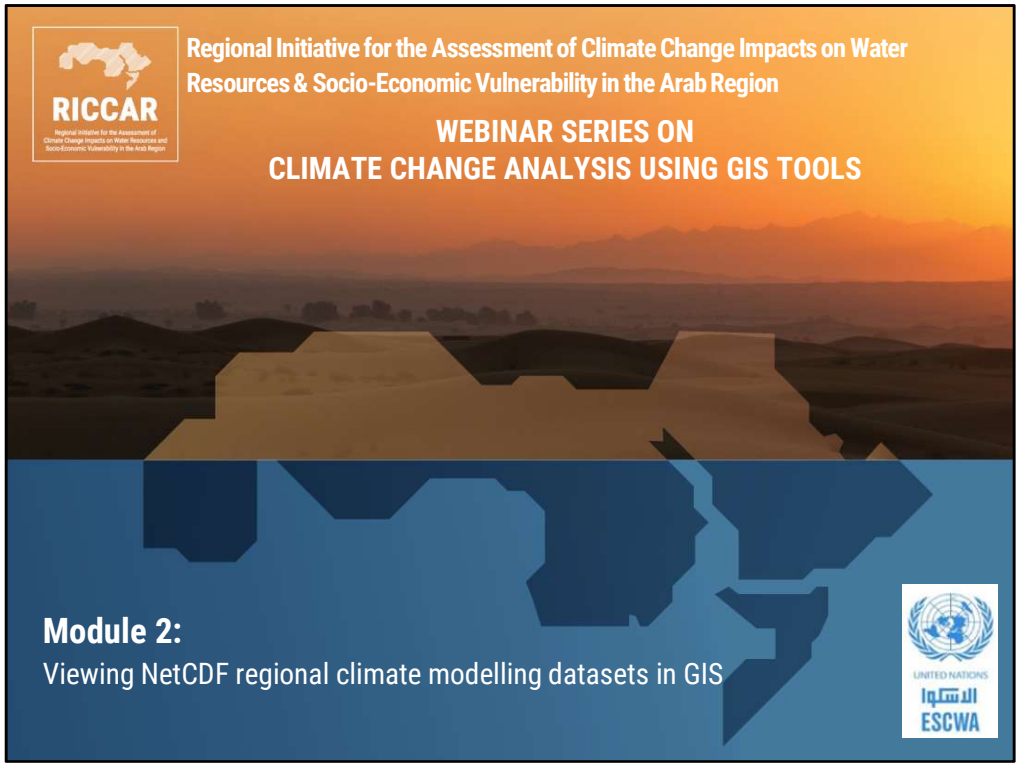
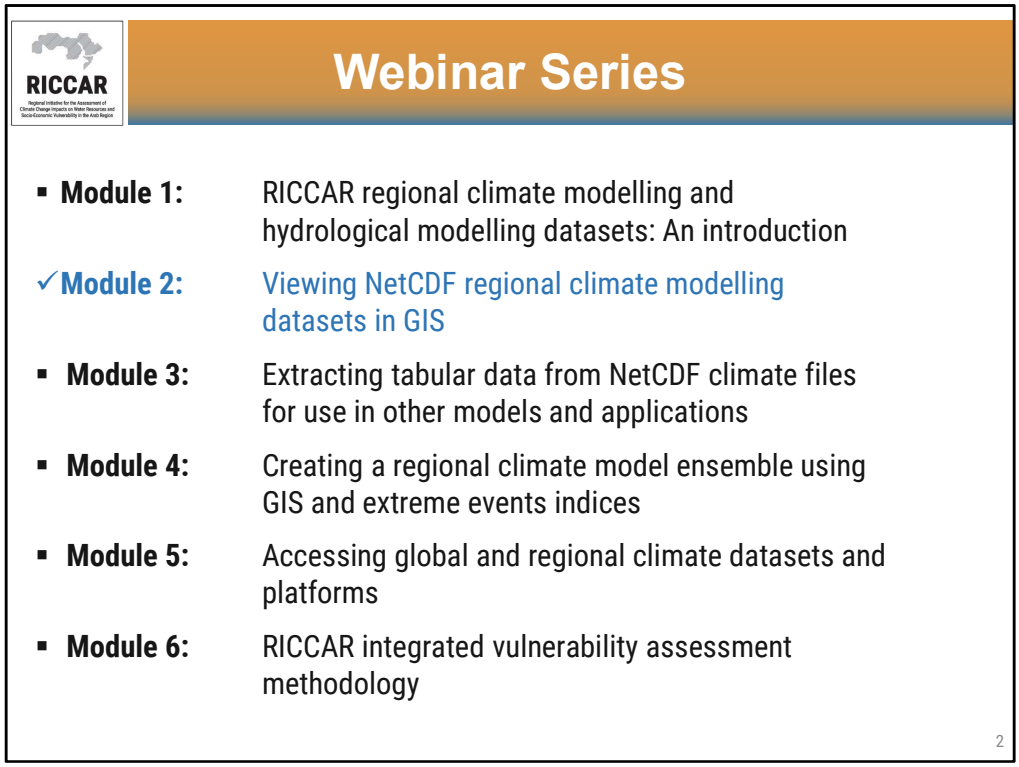
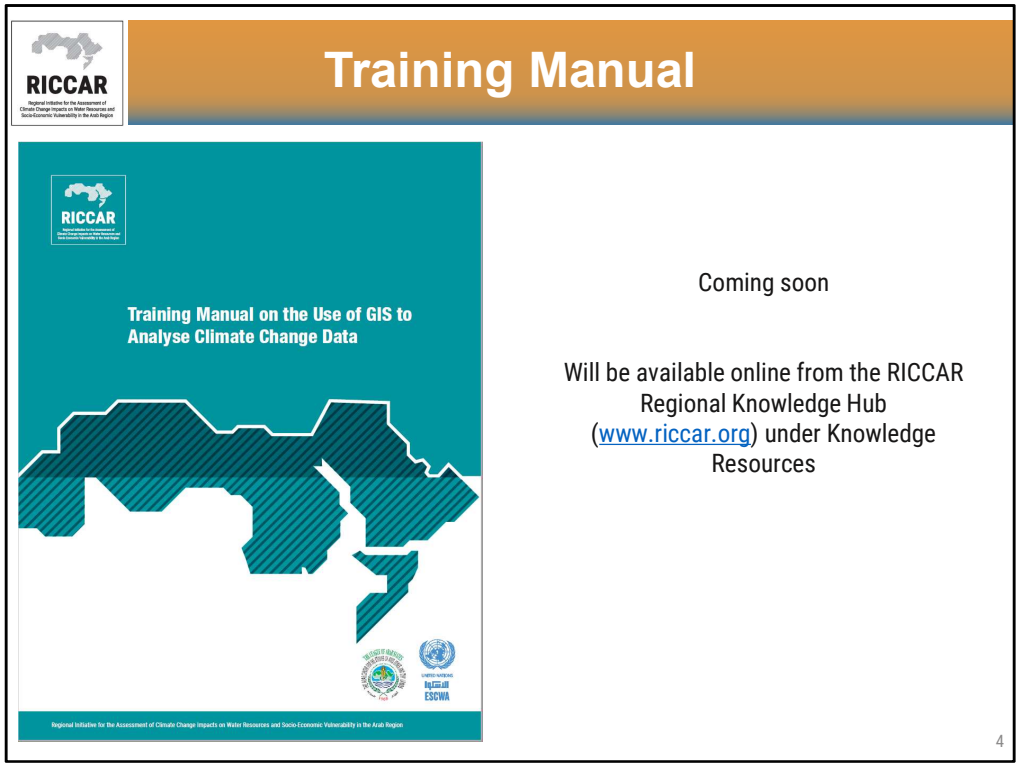

RICCAR
Regional Initiative for the Assessment of Climate Change Impacts on Water Resources & Socio-Economic Vulnerability in the Arab Region
WEBINAR SERIES ON
CLIMATE CHANGE ANALYSIS USING GIS TOOLS
Module 2:
Viewing NetCDF regional climate modelling datasets in GIS
UNITED NATIONS
ESCWA


RICCAR
Webinar Series
Module 1: RICCAR regional climate modelling and hydrological modelling datasets: An introduction
✓Module 2: Viewing NetCDF regional climate modelling datasets in GIS
Module 3: Extracting tabular data from NetCDF climate files for use in other models and applications
Module 4: Creating a regional climate model ensemble using GIS and extreme events indices
Module 5: Accessing global and regional climate datasets and platforms
Module 6: RICCAR integrated vulnerability assessment methodology
2

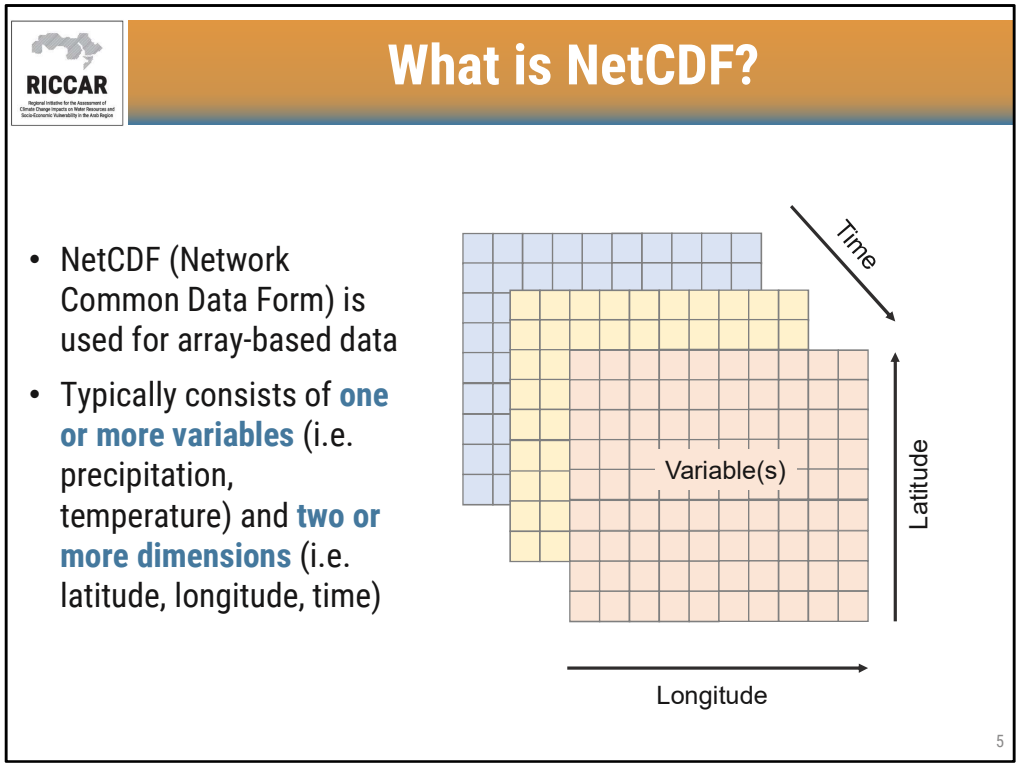
Module 2: Contents

- What is NetCDF
- Multidimension tools: Working with NetCDF files in a GIS platform
- Visualizing NetCDF files

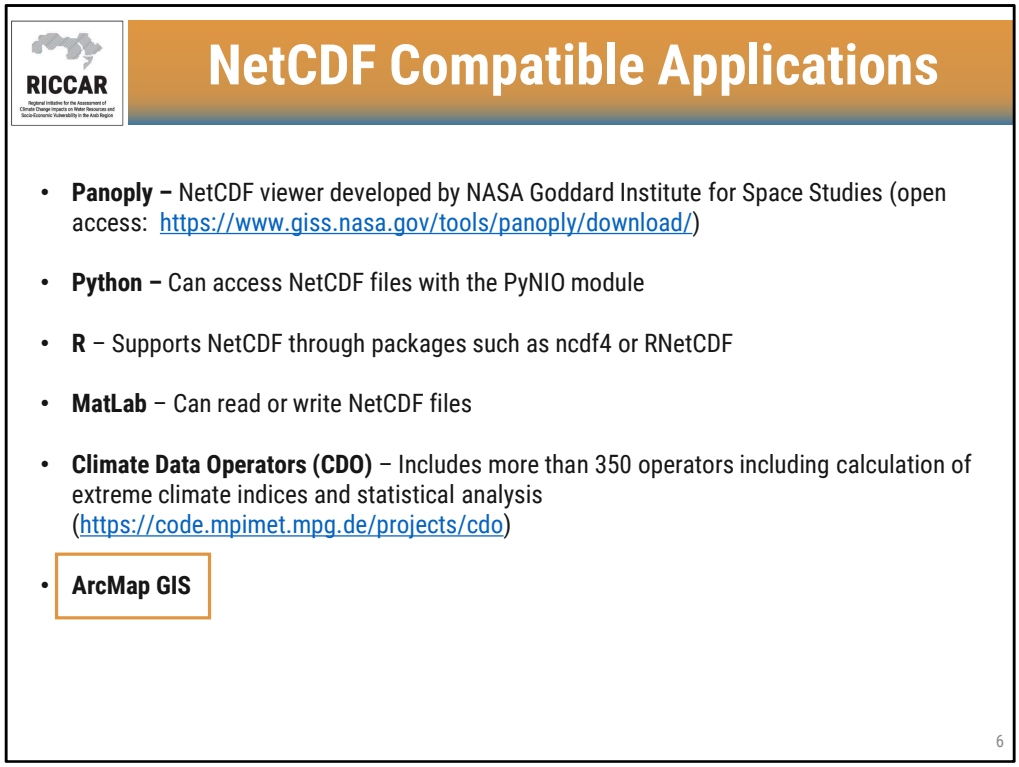
3



- Information included in this module is detailed in this training manual and relevant sections will be referenced.
- Manual is currently being finalized and will be available online. We will let participants know when it becomes available. It will be available in both English and Arabic.



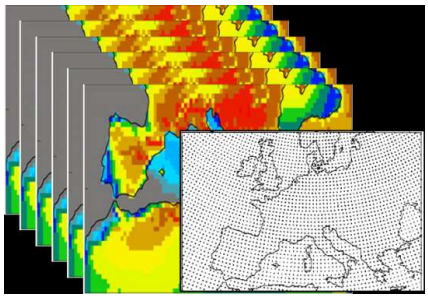
- Most climate datasets (including RICCAR) are in NetCDF format (designated with a .nc suffix)
- Used for array-based data – allows for the application of an entire set of values at once
- NetCDF files are used for climate, oceanography, air pollution and other datasets and lessons from this module can be applied to other .nc datasets beyond RICCAR
- RICCAR Training Manual on the Use of GIS to Analyse Climate Change Data Section 3.1



- Listed are a few of the common software platforms that work with NetCDF files

Advantages of Using ArcMap GIS for NetCDF

- Software familiarity
- Ability to visualize data
- Allows for comparison of other geospatial datasets



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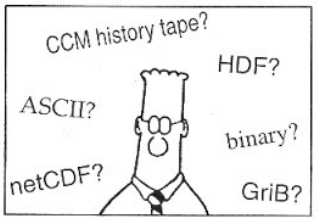
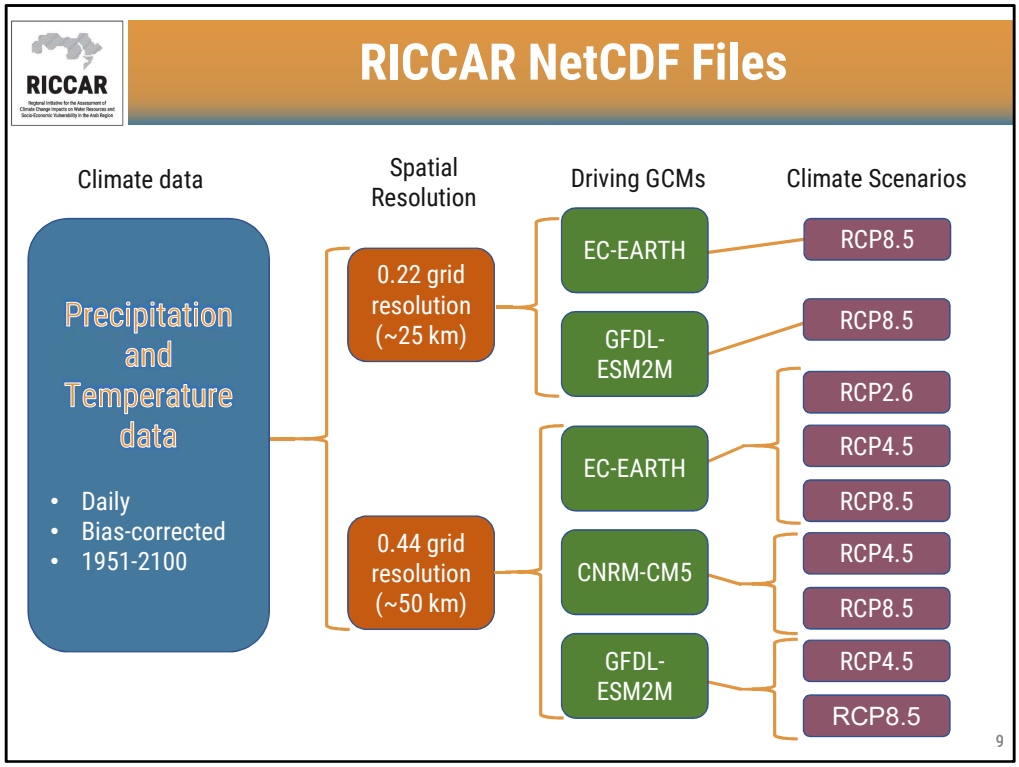
Disadvantages of Using ArcMap GIS for NetCDF

- Limited functions
  - Cannot "clip" data
  - Cannot perform certain analyses
- Not compatible with all NetCDF files
  - Must be netcdf 4 format
  - Must have geospatial data included

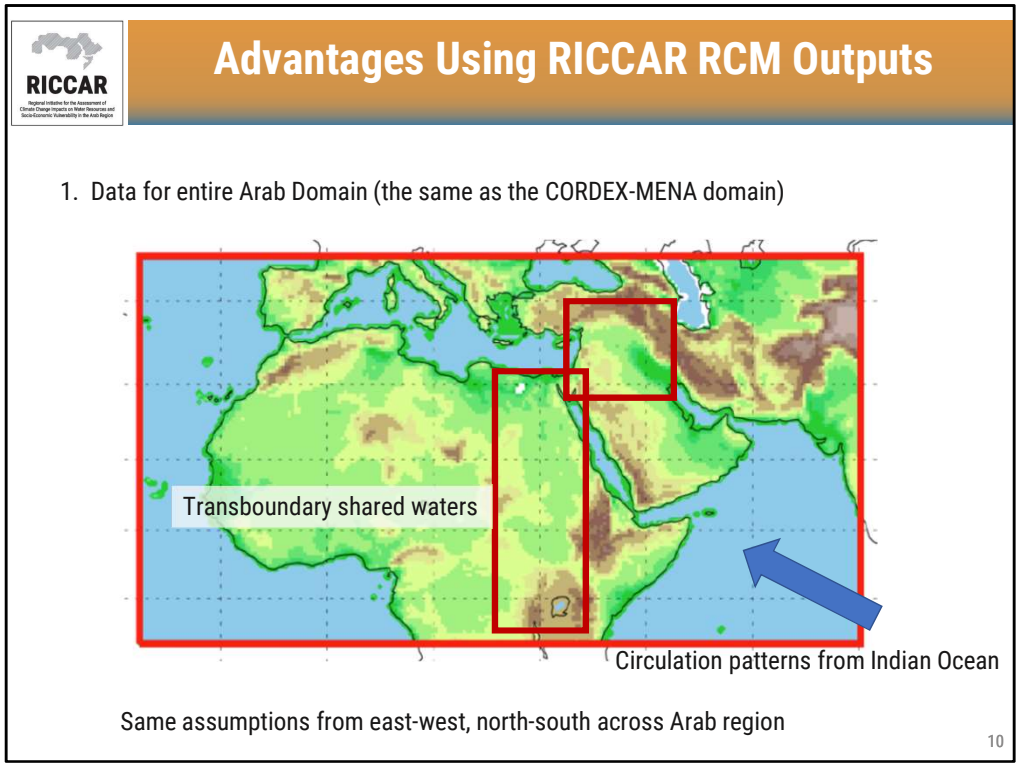


8

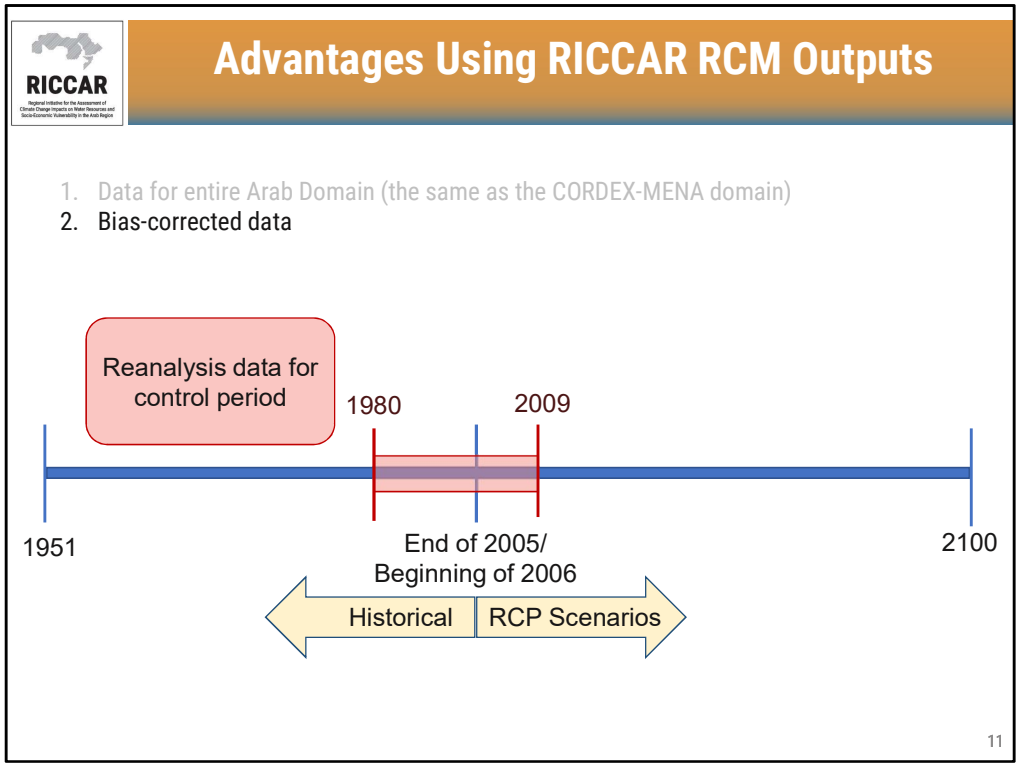
- Cannot "clip" or extract data based on a shapefile such as country
- Cannot perform analyses such as calculation of extreme climate indices



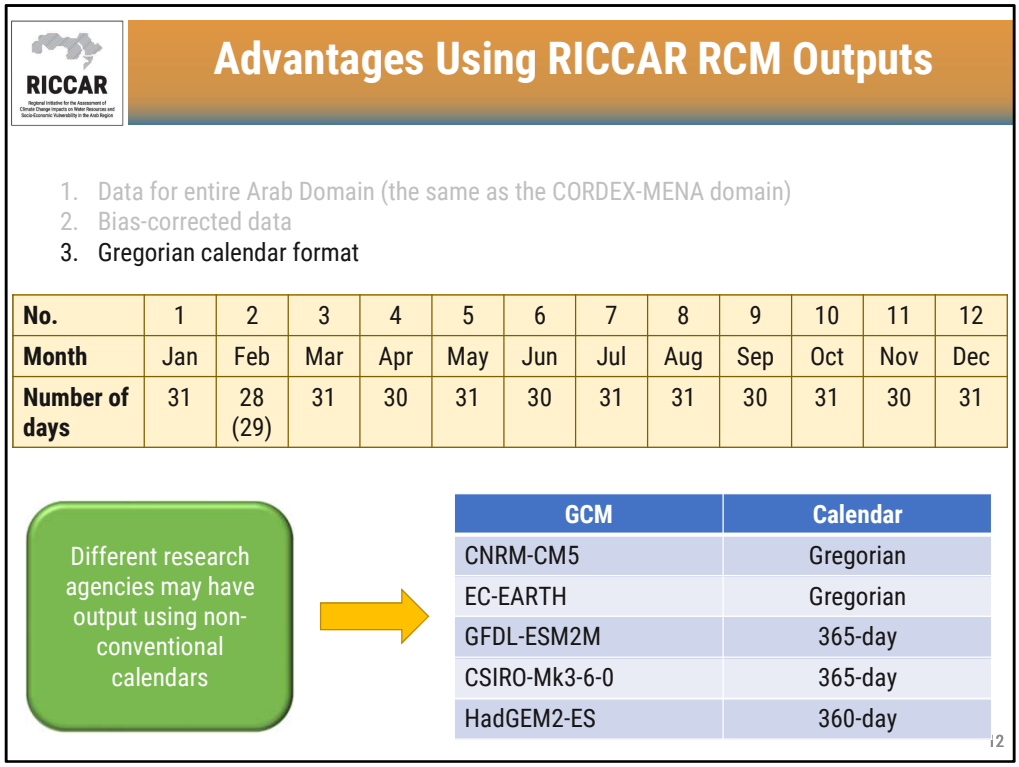
- RICCAR NetCDF data contain the outputs from the Regional Climate Modelling (RCM)
- RCMs are downscaled from three different Global Climate Models (GCM)
- It is recommended to present data as an ensemble mean – meaning over a 20-year period, using outputs based on the 3 driving GCMs (thus limiting data availability to the 0.44 grid/50 km)
- Other datasets (25 km grid, RCP2.6) are available as shown for comparative analysis- but should not be presented as an ensemble mean



- The Coordinated Regional Climate Downscaling Experiment (CORDEX) is a unified framework to conduct regional climate modelling for differing domains around the world. The Arab Domain was established as part of CORDEX (described as Middle East-North Africa)
- RCM outputs for the Arab/Middle East-North Africa domain are available from CORDEX (as well as other domains) but are not bias-corrected data
- More information on CORDEX datasets, how to access, and reasons to access will be covered in webinar module 5



- GCM and RCM modelling outputs have systemic biases which result in some inaccuracies in results, such as unexpected colder temperatures or heavier precipitation. Bias-correction attempts to reduce these inaccuracies by incorporating reanalysis data based on historical meteorological observations
- Note that although bias-correction is widely used, it is still controversial and has some limitations. This is why raw (not-bias-corrected) RCM outputs are still available directly from CORDEX.
- Bias-corrected data is recommended for use in hydrological applications and impact studies which is why used for RICCAR data.
- CORDEX data describes historical data as those modelling outputs through the end of 2005. The RCP scenarios (RCP4.5, RCP8.5) start at the beginning of 2006.
- The reanalysis data (based on observed data) used for the bias-correction included a control period from 1980-2009
- Because of the bias-correction, the “historical” outputs (2005 and before) will very slightly differ based on the RCP scenario. Thus is it important to compare “projected” RCP4.5 outputs to “historical” RCP4.5 outputs; similarly for RCP8.5 “historical” vs “projected”.



- RICCAR RCM outputs use a Gregorian calendar format which is the current international standard based on 365 days per year with 366 days every four years (leap year)
- Other climate modelling outputs may have differing calendars. Note that GFDL-ESM2M outputs on CORDEX are based on a 365-day calendar (including leap year) but the outputs available from RICCAR have been corrected to the Gregorian calendar format. HadGEM2-ES models use a 360-day calendar such that every month (including February) has 30 days.

Advantages Using RICCAR RCM Outputs

1. Data for entire Arab Domain (the same as the CORDEX-MENA domain)
2. Bias-corrected data
3. Gregorian calendar format
4. Extreme climate indices

Index	Long Name	Definition
SU	Number of summer days	Number of days (annually or seasonally) when daily maximum temperature ≥ 25°C
SU35	Number of hot days	Number of days (annually or seasonally) when daily maximum temperature ≥ 35°C
SU40	Number of very hot days	Number of days (annually or seasonally) when daily maximum temperature ≥ 40°C
TR	Number of tropical nights	Number of days (annually or seasonally) when daily minimum temperature ≥ 20°C

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- Extreme climate indices are not readily available from CORDEX or other climate modelling output datasets and need to be calculated using CDO (climate data operators) or other software platforms

Advantages Using RICCAR RCM Outputs

1. Data for entire Arab Domain (the same as the CORDEX-MENA domain)
2. Bias-corrected data
3. Gregorian calendar format
4. Extreme climate indices

Index	Long Name	Definition
CDD	Maximum length of dry spell	Maximum number of consecutive days when daily precipitation < 1 mm
CWD	Maximum length of wet spell	Maximum number of consecutive days when daily precipitation ≥ 1 mm
R10	Number of 10 mm precipitation days	Number of days when daily precipitation ≥ 10mm
R20	Number of 20 mm precipitation days	Number of days when daily precipitation ≥ 20mm
SDII	Simple precipitation intensity index	Ratio of total precipitation (annually or seasonally) the number of wet days

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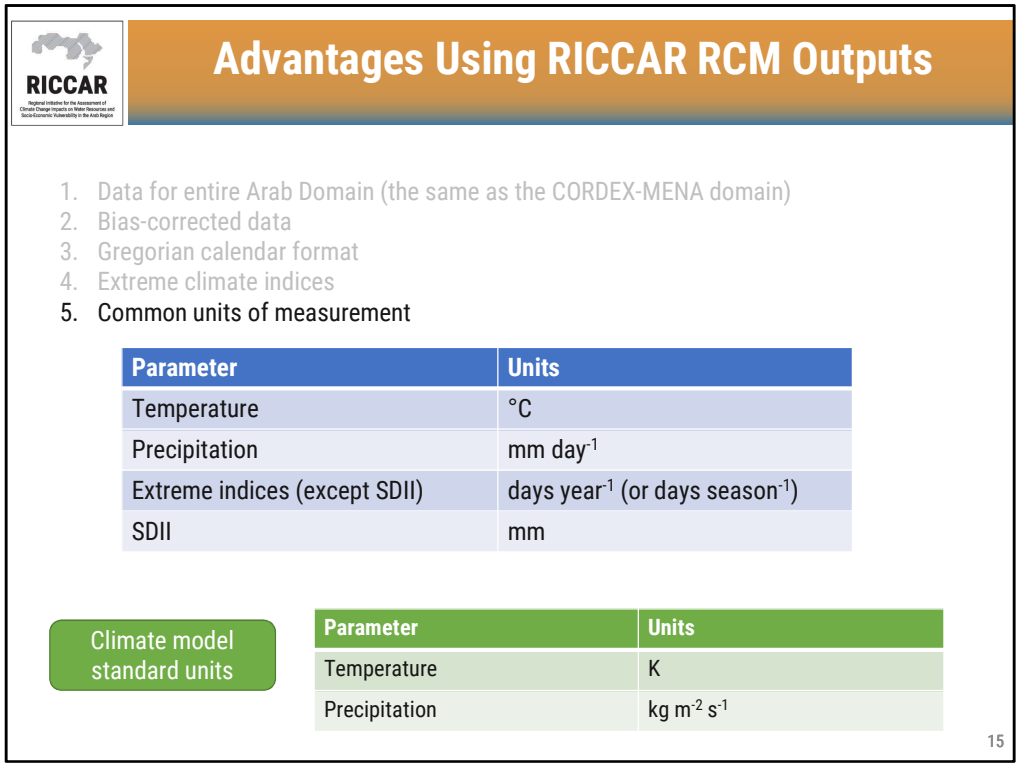
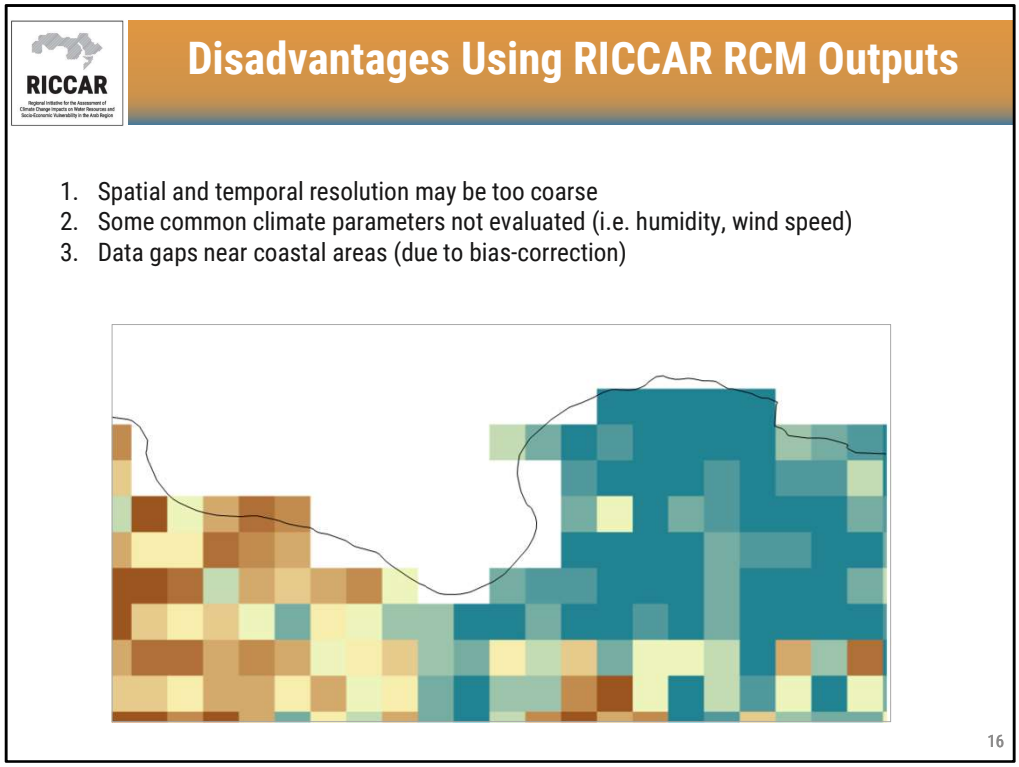
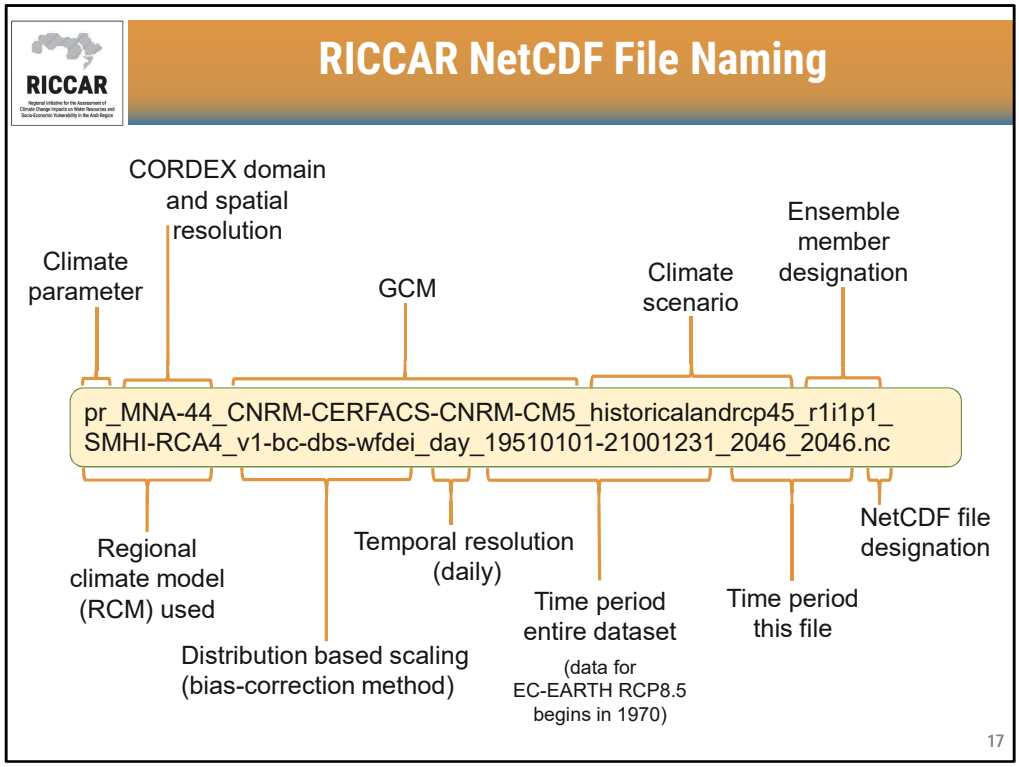


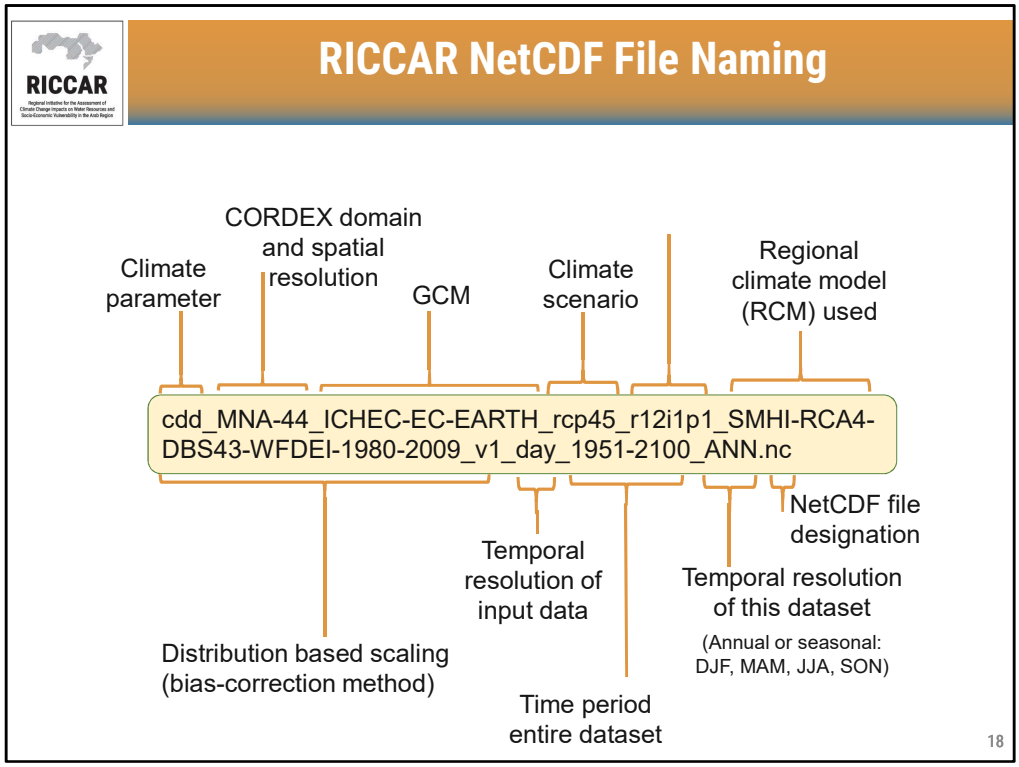
- CORDEX and other climate modelling outputs use units of measurements such as K for temperature and kg/m2/s for precipitation. However, RICCAR RCM outputs use more commonly used units of measurement



- RICCAR modelling outputs were based on a regional analysis. Certain requirements may need finer spatial (less than 25 or 50 km) or temporal (less than 1 day) resolution, such as basin analysis
- Differing modelling output requirements may be met using CORDEX data



- Note that RICCAR datasets follow a similar naming convention as CORDEX
- This is for a sample precipitation NetCDF file. It will be similar for temperature data
- Note that although EC-EARTH data for RCP8.5 begins in 1970, the file name will still show 19510101-21001231 to designate the time period, like the remaining RICCAR NetCDF files



- This naming convention is for the extreme climate indices
- Extreme climate indicates have annual data (designated as ANN) or seasonal data based on 3-month seasons (DJF: December, January, February; MAM: March, April, May; JJA: June, July, August; SON; September, October, November)

NetCDF File Climate Parameter Abbreviations

Climate parameter	Abbreviation in NetCDF File
Near-surface air temperature	tas
Daily maximum near-surface air temperature	tasmax
Daily minimum near-surface air temperature	tasmin
Precipitation	pr
Maximum length of dry spell	cdd
Maximum length of wet spell	cwd
Count of 10 mm precipitation days	pr10
Count of 20 mm precipitation days	pr20
Simple precipitation intensity index	sdii
Number of summer days	su
Number of hot days	su35
Number of very hot days	su40
Number of tropical nights	tr

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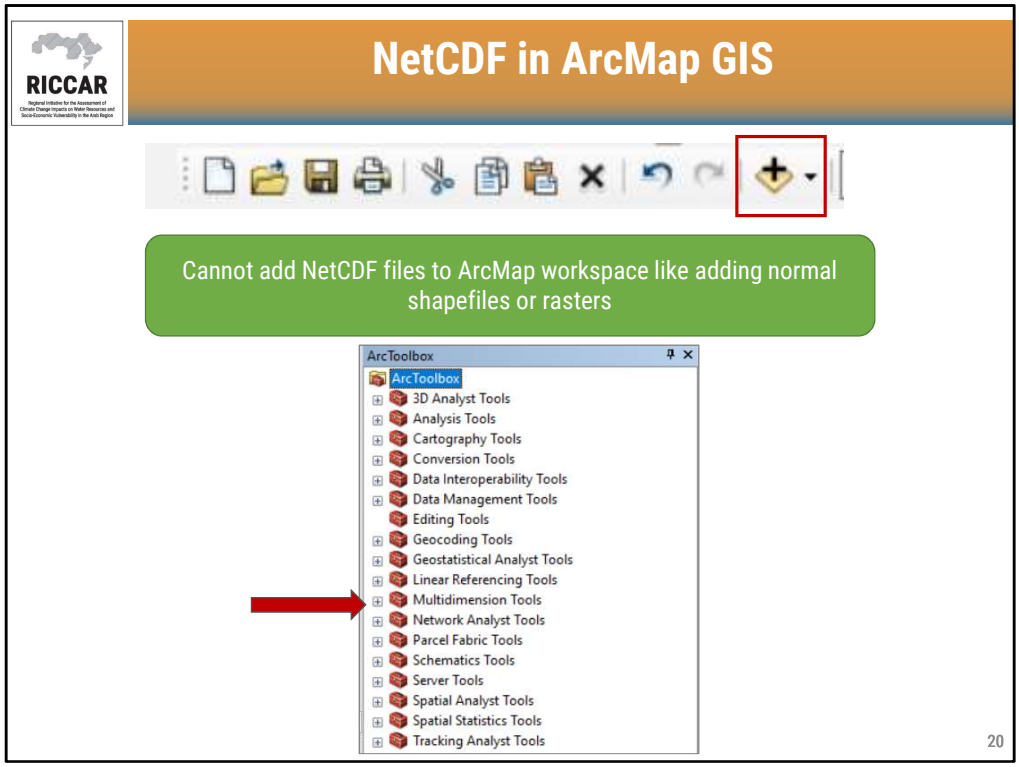
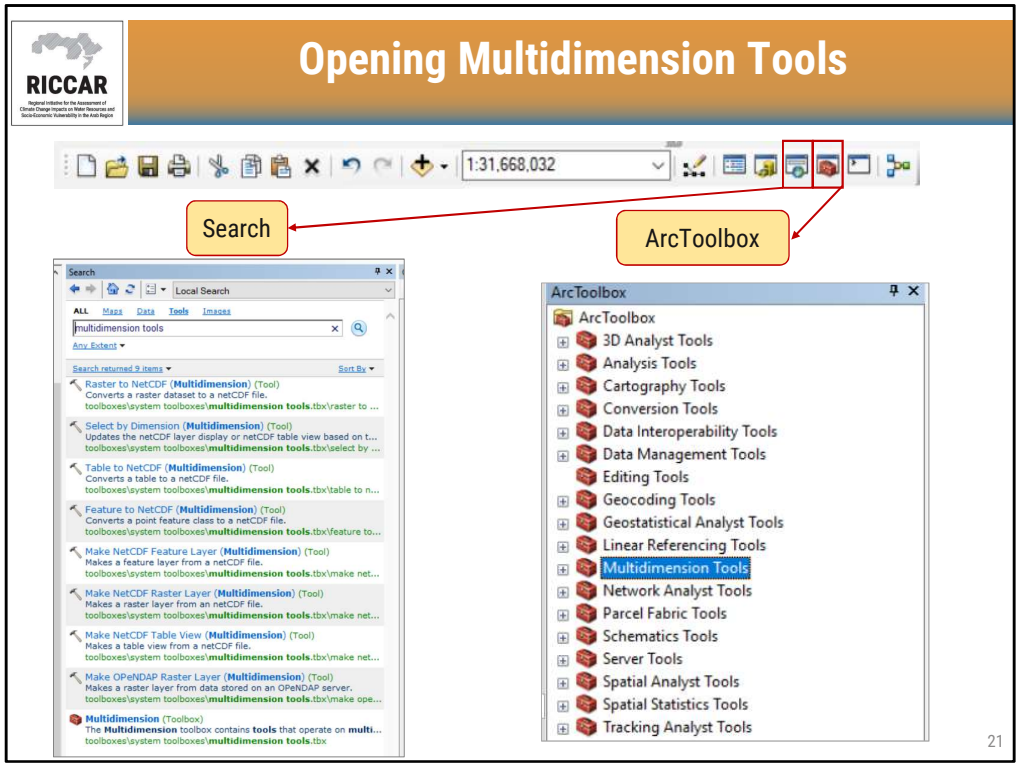
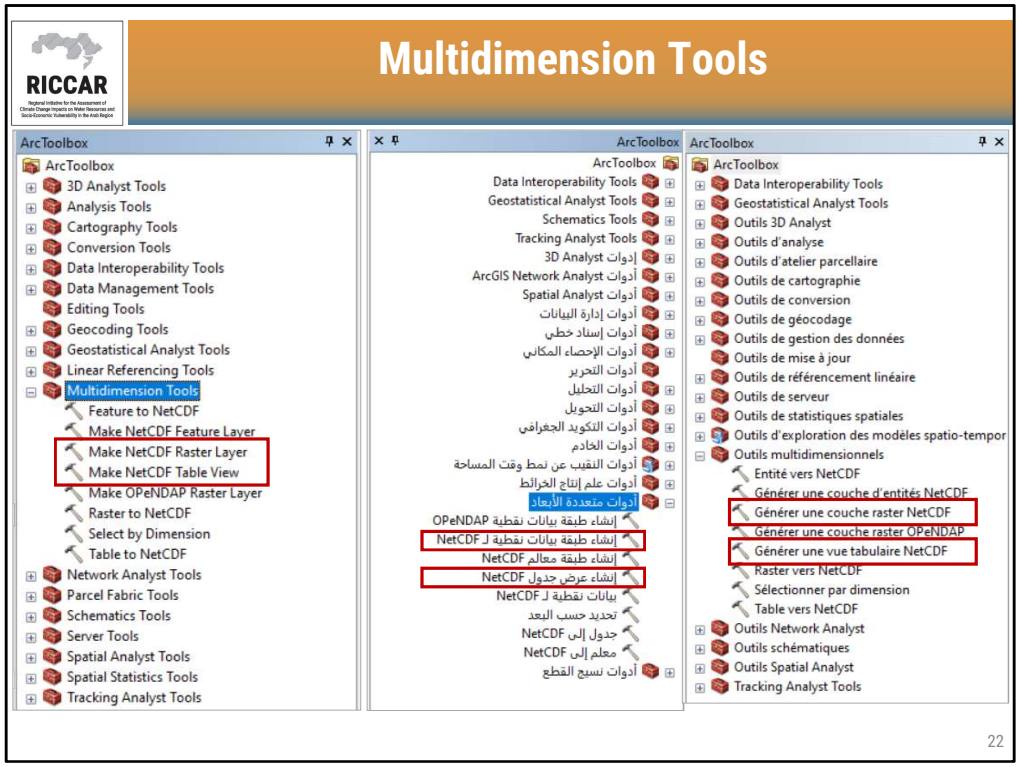
- These abbreviations may differ from the index. (For example, pr10 in file name is for the R10 index).



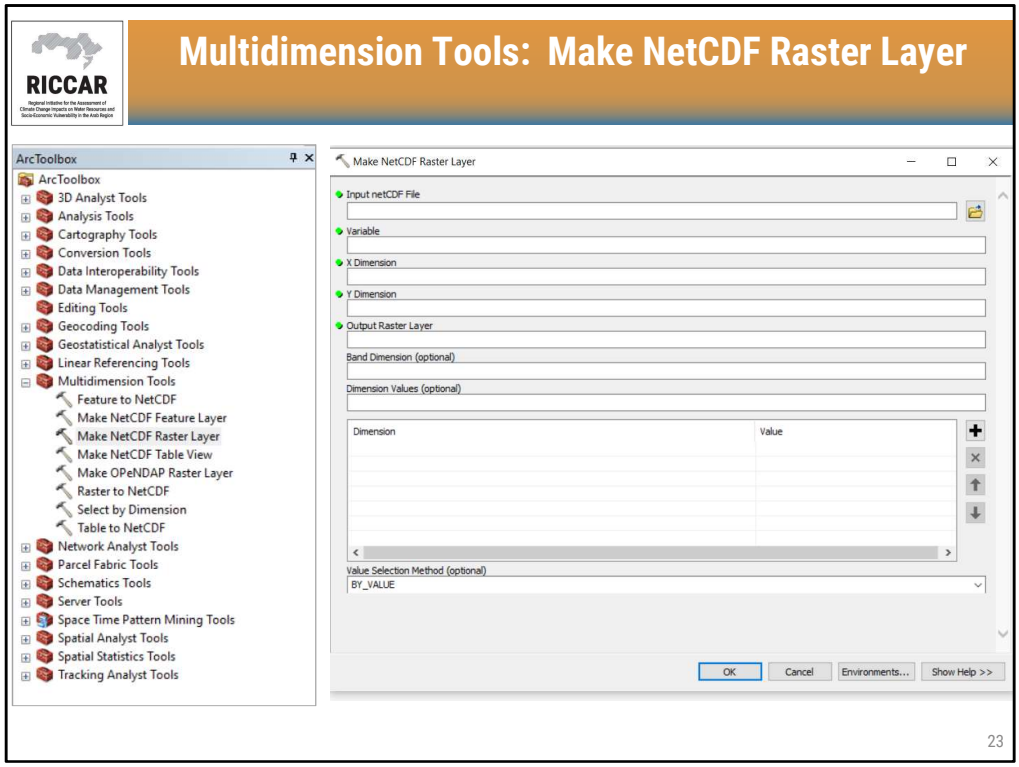
- Normally add data (shapefiles and rasters) to ArcMap workspace using "+" icon. (If this toolbar is not shown, it can be added to GIS by selecting "Customize" and then "Toolbars". There is an option to select differing toolbars including this one, which is the "standard" toolbar.)
- However, cannot add NetCDF files to ArcMap GIS using the "+" icon. They must be added using the "Multidimension Tools" available from the ArcToolbox
- Note that this webinar series will use an English version of ArcMap GIS. There will be occasional references to the Arabic and French versions to help locate tools.



- Opening the “Multidimension Tools” can be done using the “Search” tool or from the “ArcToolbox” depending on personal preference.

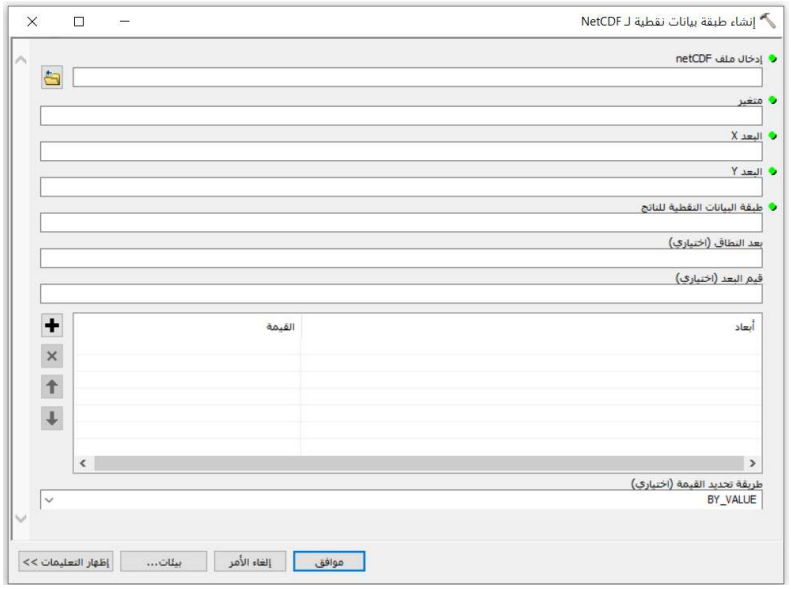


- Multidimension tools have multiple functions. The 2 most commonly used (covered in this webinar series) are shown.
- Available from ArcMap version 10.2 or later.



- RICCAR Training Manual on the Use of GIS to Analyse Climate Change Data Section 3.2.

Multidimension Tools: Make NetCDF Raster Layer (Tool in Arabic)



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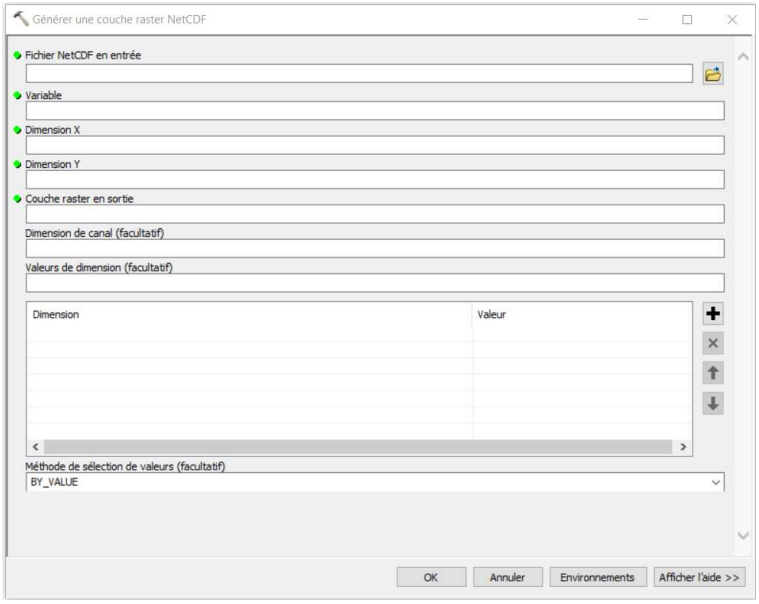
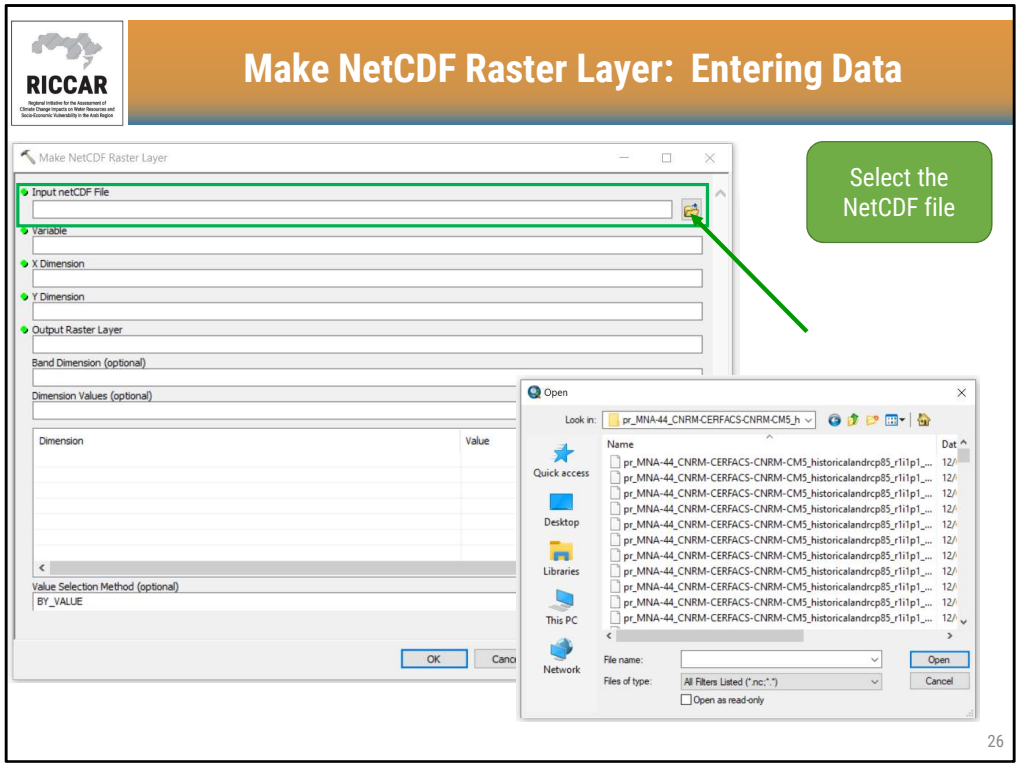
Multidimension Tools: Make NetCDF Raster Layer (Tool in French)

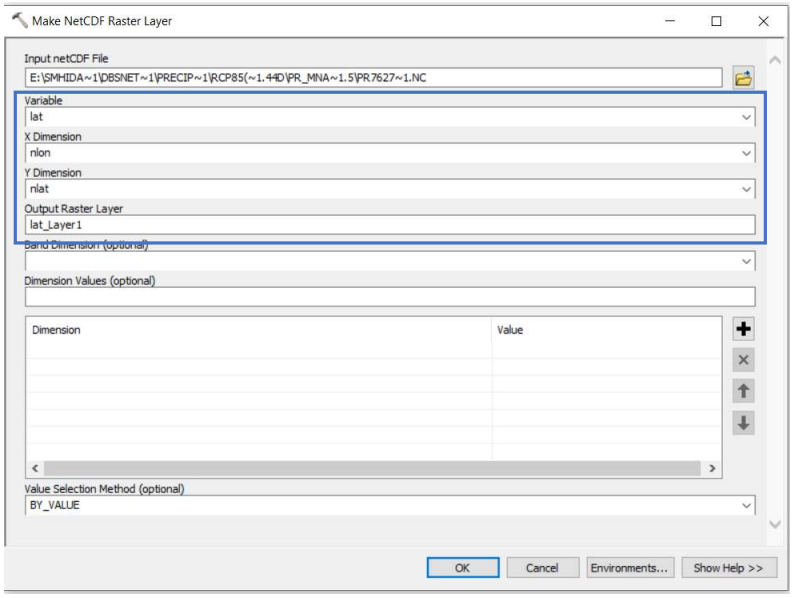




- Select the NetCDF file by clicking on the folder icon and picking the folder where you have saved NetCDF files to your computer.

RICCAR

Make NetCDF Raster Layer: Entering Data



Default entries (must be manually changed)

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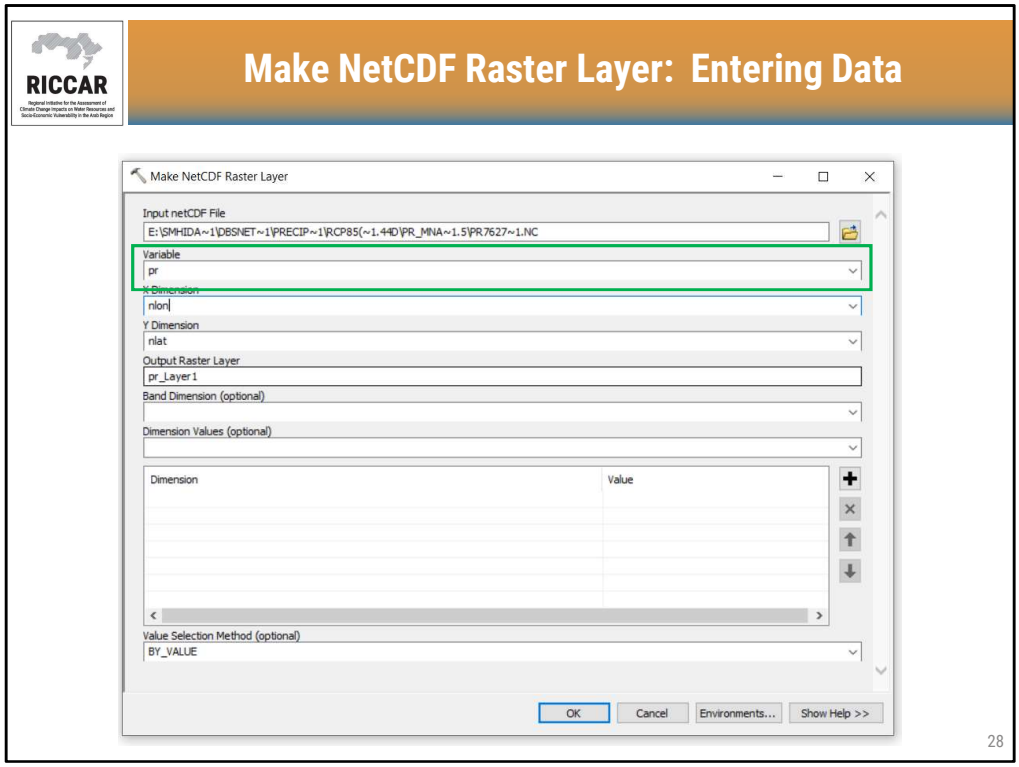
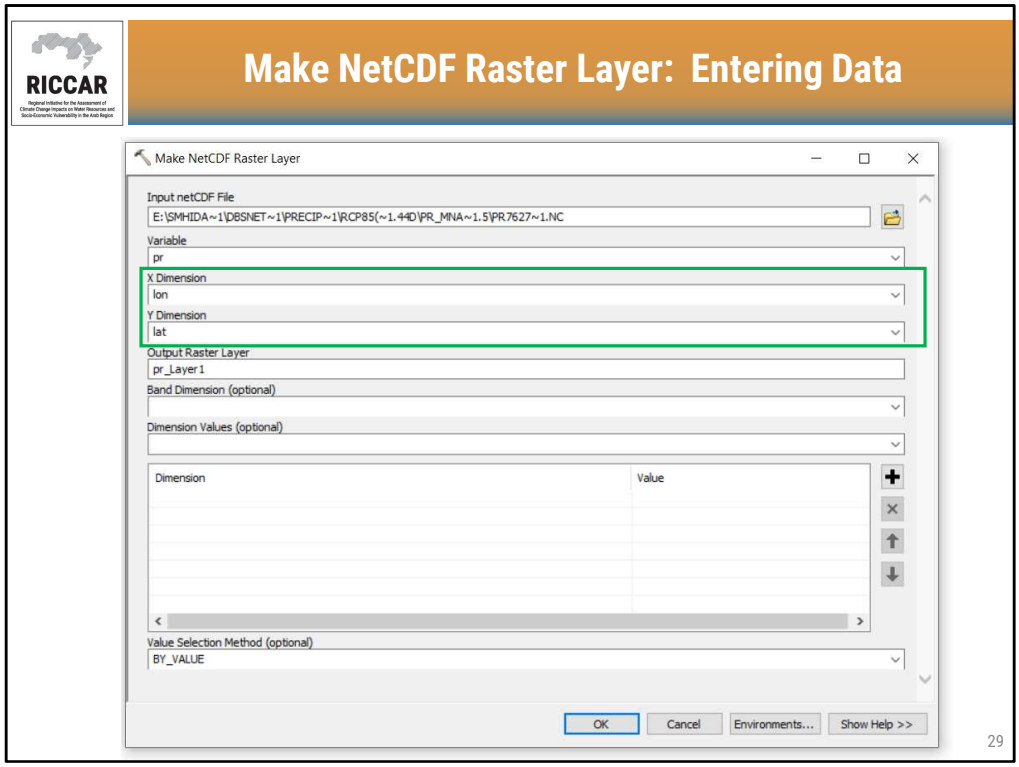
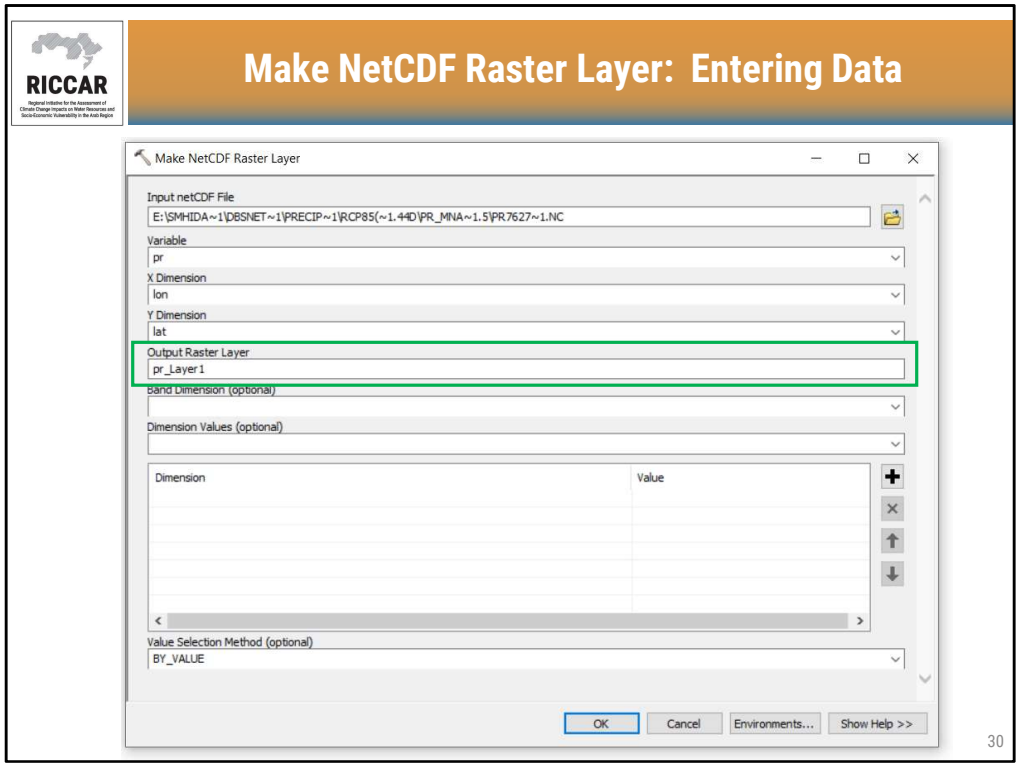


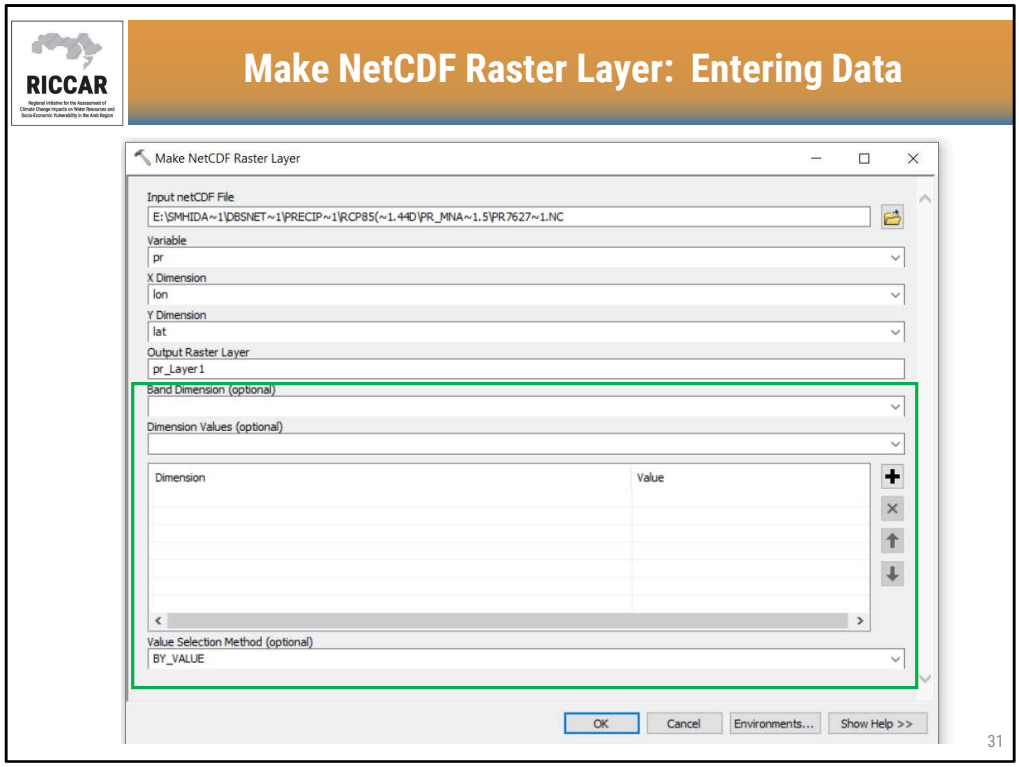
- For “Variable”, pick the climate parameter abbreviation. In this example, “pr” is selected for precipitation. All climate parameter abbreviations for RICCAR data is on slide 19 of this module.



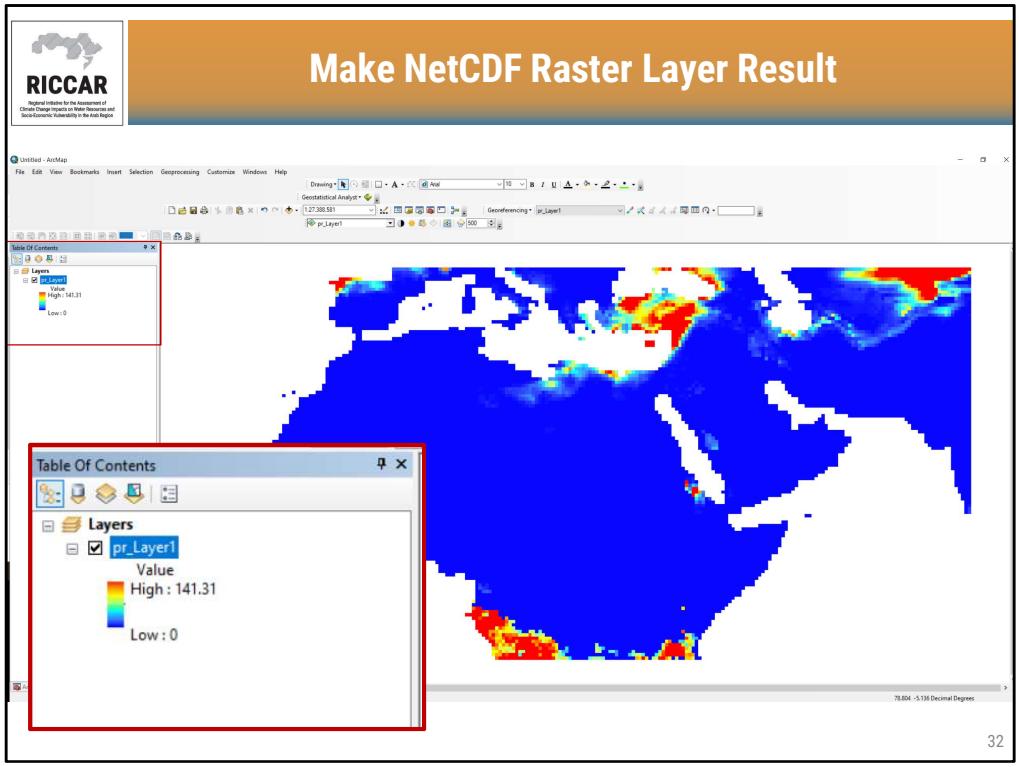
- For the “X Dimension” and “Y Dimension”, select “lon” (for longitude) and “lat” (for latitude), respectively.
- The nlon and nlat dimensions will be discussed in Webinar Module 3.
- If default nlon and nlat are used, the resultant raster layer will be georeferenced incorrectly and not match up with shapefiles and other GIS datasets.



- For the “Output Raster Layer”, the default name can be left as is or user defined.



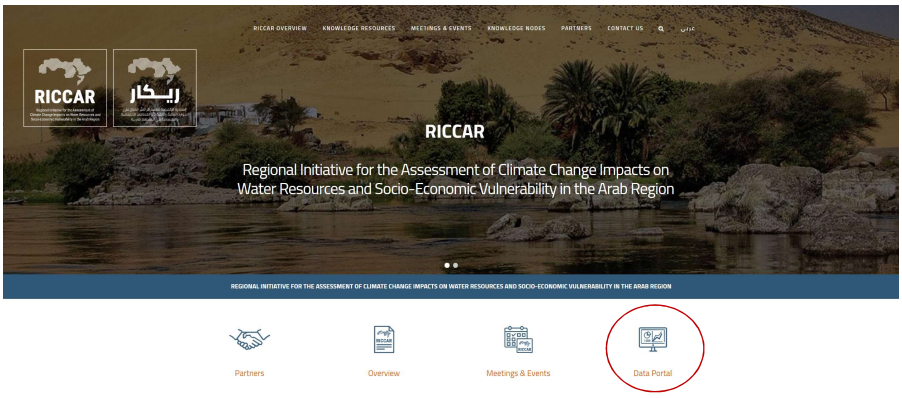
- Remaining entries are optional and not used for RICCAR data as well as most climate datasets.
- Once all entries are complete, click “OK”.



- Result will be a raster layer as shown
- Note that color scheme is automatically determined by ArcMap and may be different for other language versions.

Notes on NetCDF Files

- NetCDF file provided to participants and available on Webinar series event website is an extracted file based on Morocco (to reduce file size)
- Complete NetCDF files are available from the RICCAR Regional Knowledge Hub data portal (www.riccar.org) or upon request



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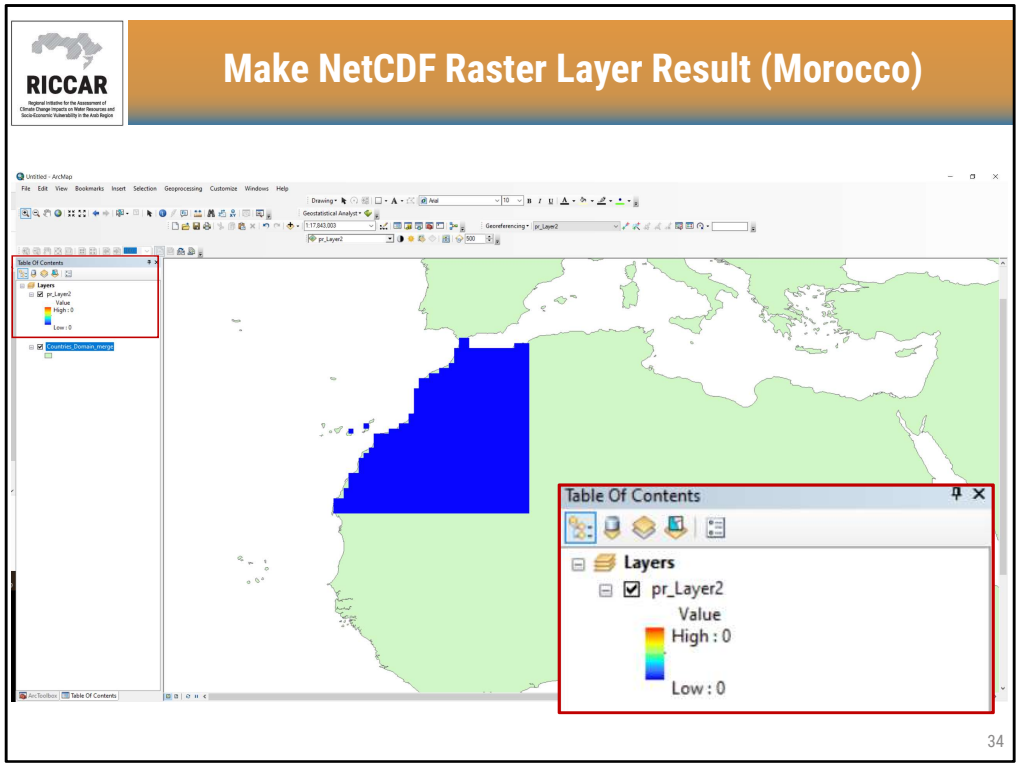
- The NetCDF file for Morocco is obtained from RICCAR NetCDF file and was extracted using CDO (Climate Data Operators).
- More information about the RICCAR Regional Knowledge Hub (RKH) data portal will be discussed in Module 5.



- Arab Domain shapefile is included in background to give spatial reference.

Notes on NetCDF Raster Layers

- Each NetCDF file contains multiple “time slices”
  - Temperature and precipitation files have 365 time slices (one for each day of the year) except for leap years which have 366 time slices
  - Extreme climate indices have 150 time slices (one for each year 1951-2100)
- By default, the first time slice is shown in the raster layer
  - January 1 for temperature and precipitation data
  - 1951 for extreme climate indices

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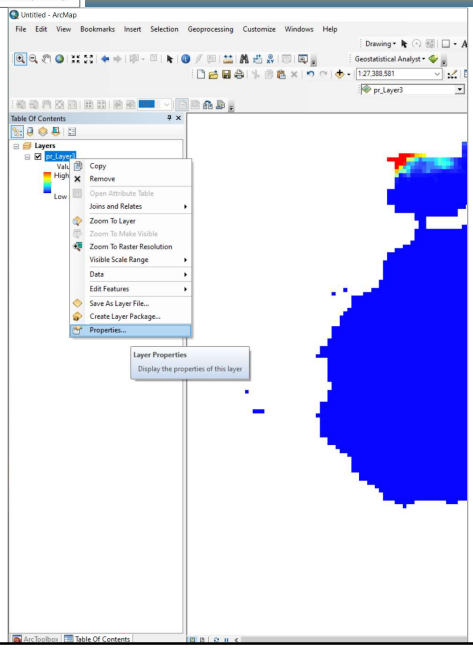
Select Other "Time Slices"



Right click on layer name in Table of Contents to display layer properties

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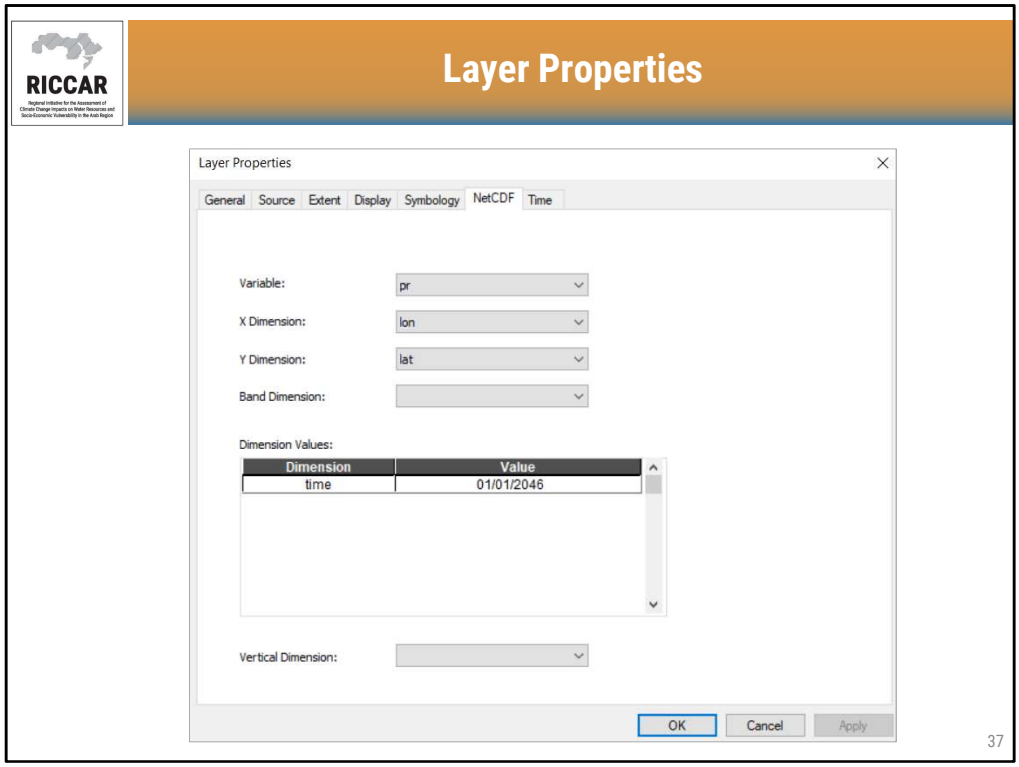
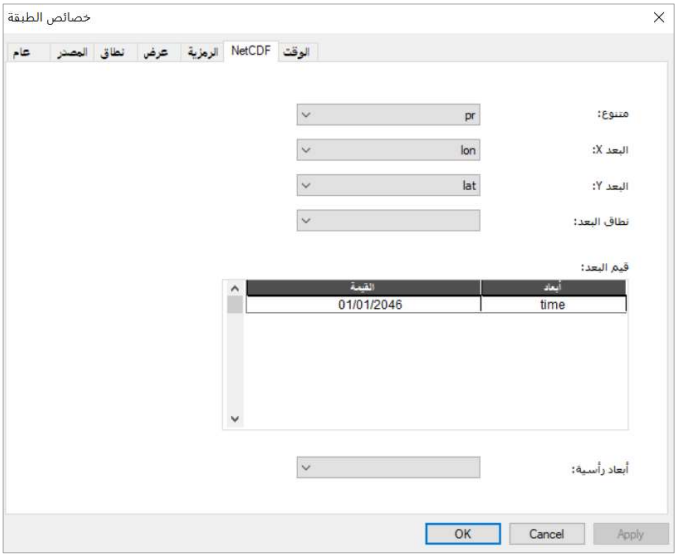


- Multiple tabs are available under Layer Properties. The NetCDF properties are found in the “NetCDF” tab, including the current raster layer time slice (i.e. date, year).

RICCAR

Layer Properties (in Arabic)



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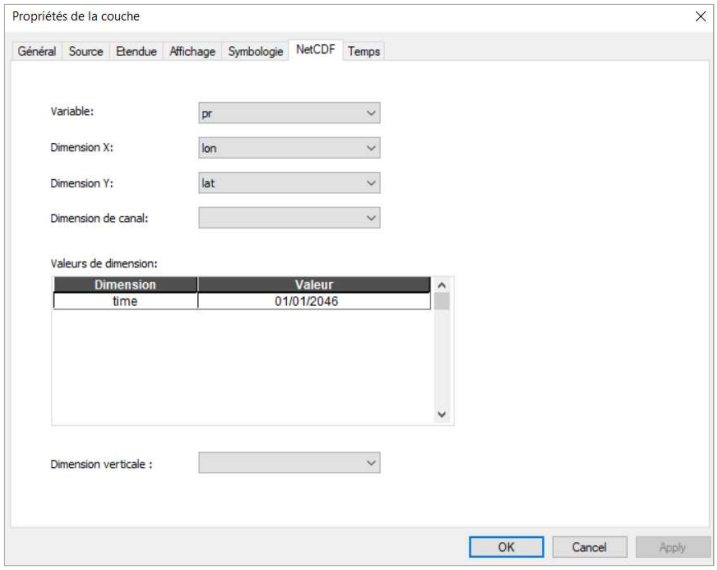
Layer Properties (in French)



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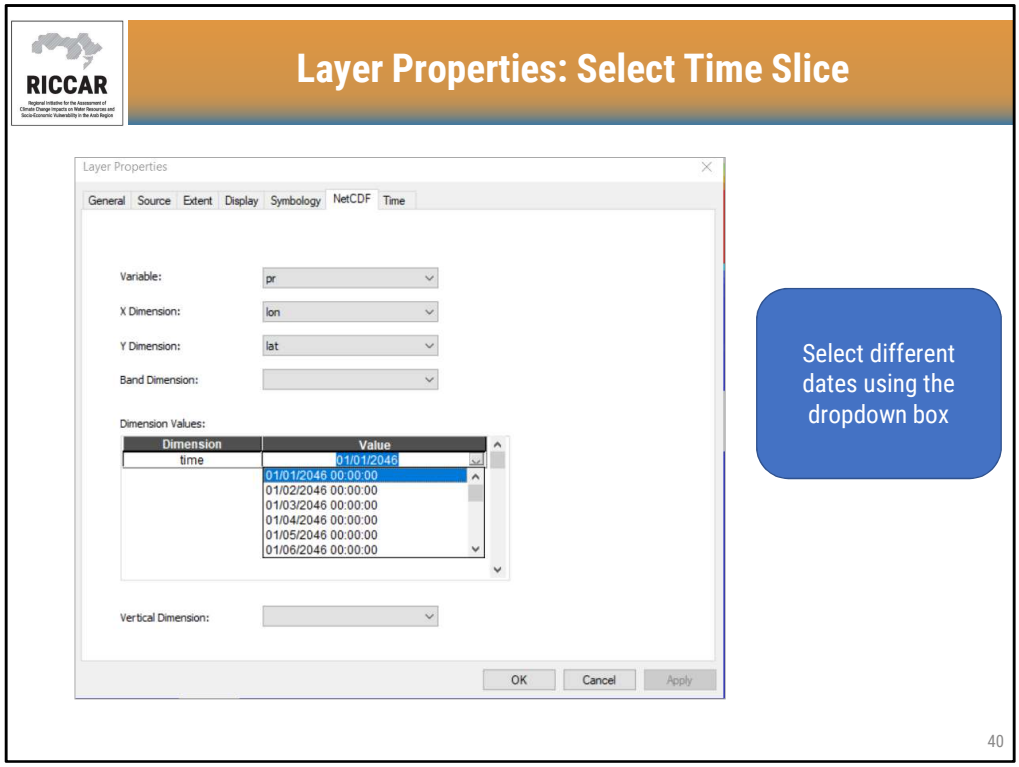
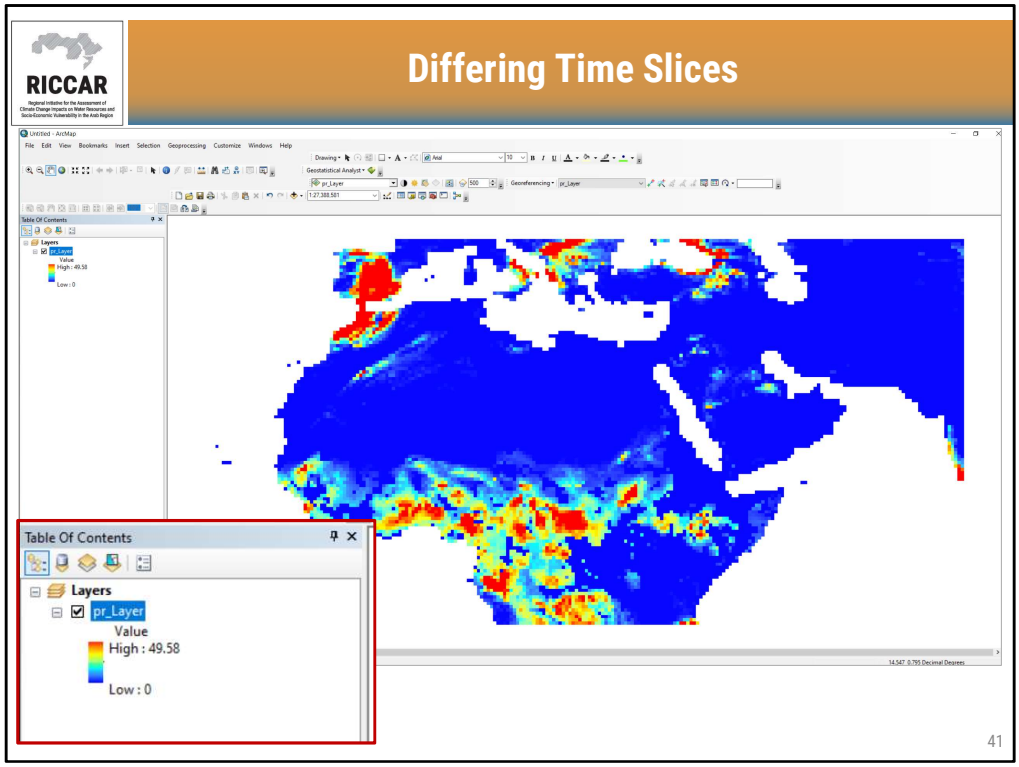
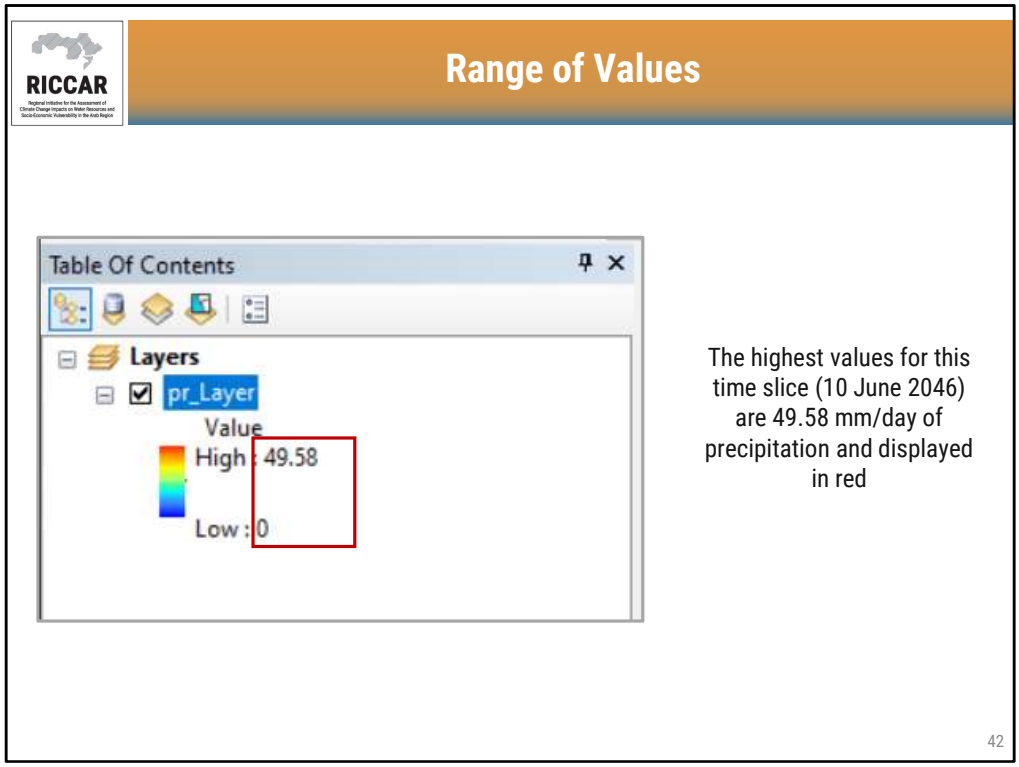


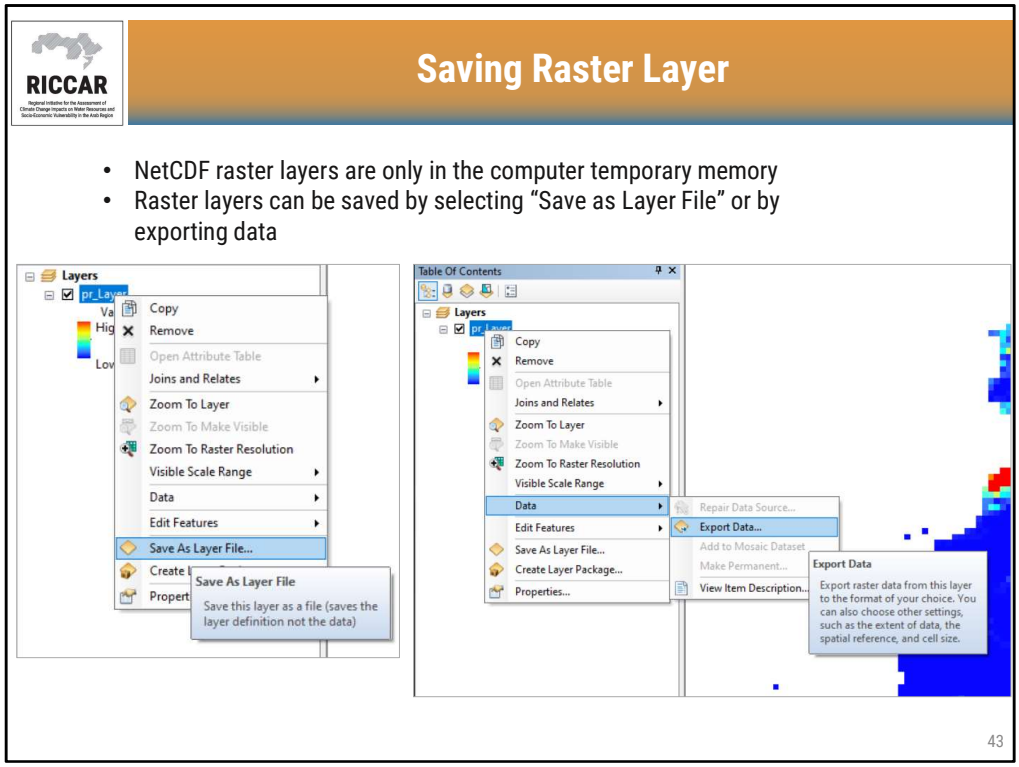
- Note that ArcMap may have differing ways the time slices are shown. Users may have month-day-year and time like shown. The time is shown but is not applicable in this case because there is only value per day.
- Some users may have day-month-year and no time shown. Also, other users may not have the ability to use the dropdown box and may have to enter differing dates manually. This may require trial to determine whether dates are entered as month-day-year or day-month-year.



- By selecting differing time slices, the raster shown and the values will adjust accordingly. This example is 10 June 2046.



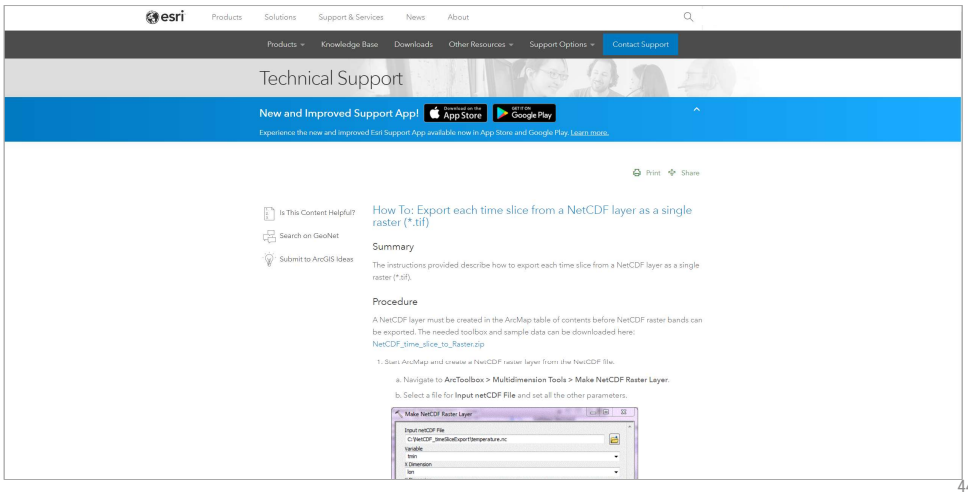
- Users must consider the temporal resolution of the NetCDF file. Because RICCAR precipitation NetCDF files are daily, the units of measurement are mm/day.



- Exporting data will only export the currently displayed raster time slice.

Extract Multiple Time Slices

- Users can automatically extract every time slice in the NetCDF file
- Instructions and tool download is available from the following website: https://support.esri.com/en/technical-article/000011318



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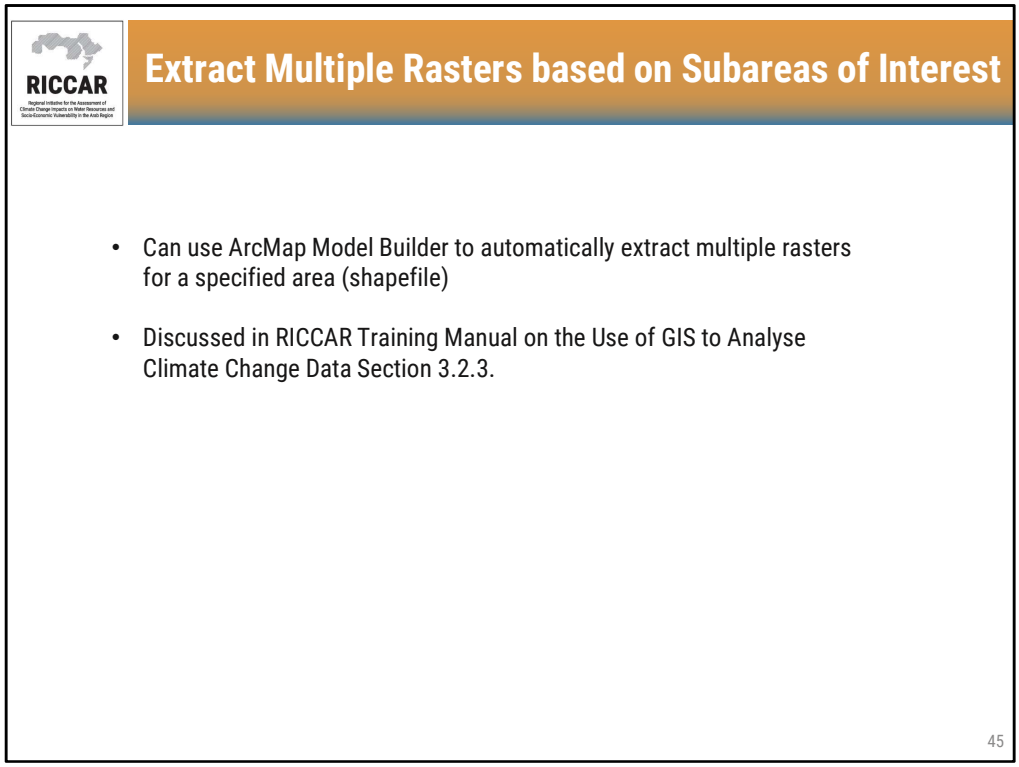

- Model Builder will be discussed in Module 3.


RICCAR
Thank You
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