Economic and Social Commission for Western Asia

Overview of Climate Change Impacts on Water Resources in Africa and the Region

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ICID African Young Water Professionals Forum (Af-YWPF) Webinar

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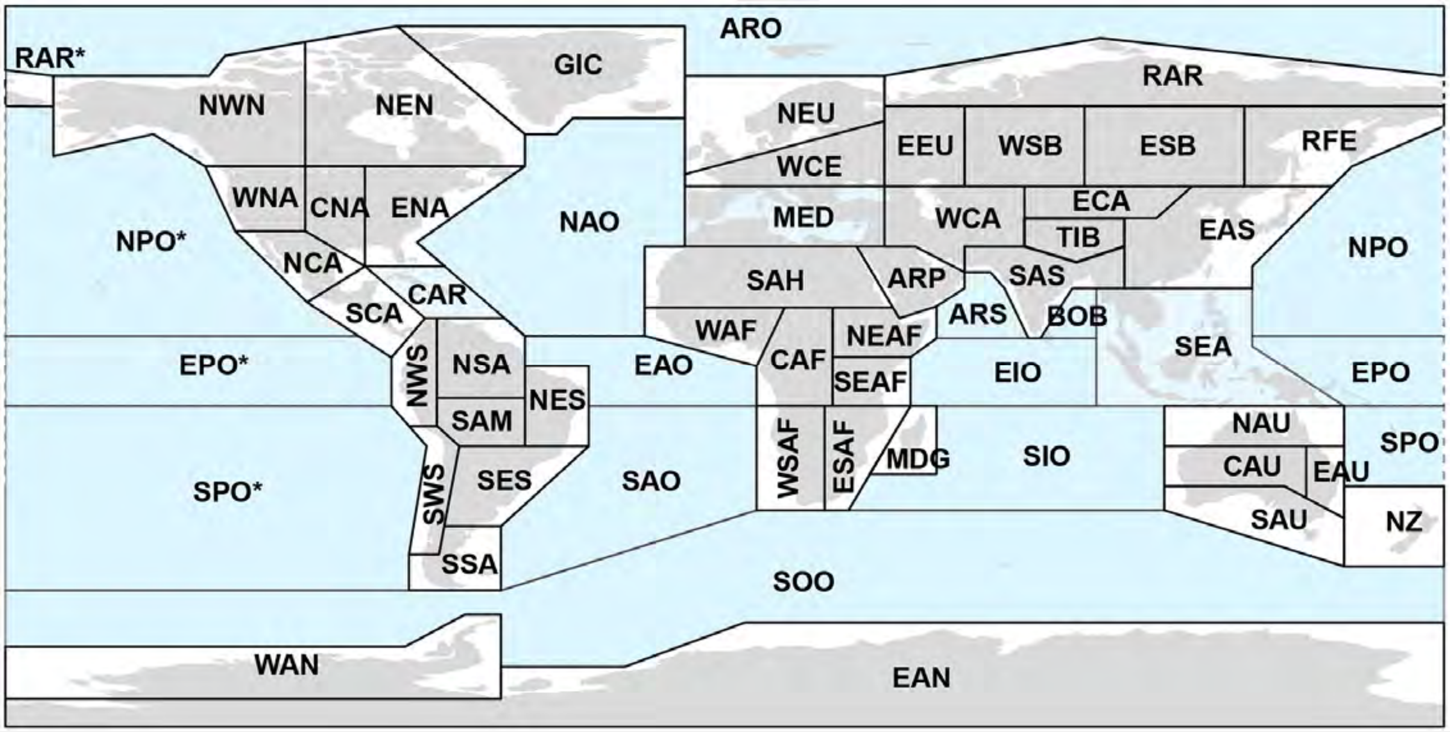
RICCAR
Regional Initiative for the Assessment of Climate Change Impacts on Water Resources and Socio-Economic Vulnerability in the Arab Region

THE LEAGUE OF ARAB STATES
THE ARAB CENTER FOR THE STUDIES OF ARID ZONES AND DRY LANDS
ACSAD 1968 أكساد

Summary of findings from IPCC AR6

IPCC WGI reference regions



MED:	Mediterranean
SAH:	Sahara
WAF:	Western Africa
CAF:	Central Africa
NEAF:	N Eastern Africa
SEAF:	S Eastern Africa
WSAF:	W Southern Africa
ESAF:	E Southern Africa
MDG:	Madagascar
WCA:	W Central Asia
ARP:	Arabian Peninsula

IPCC: Intergovernmental Panel on Climate Change

Summary of findings from IPCC AR6

- Projected decrease in mean precipitation, increases in fire weather conditions and decreases in mean wind speed
- Observed and projected increases in droughts

- Projected increase in heavy precipitation and pluvial flooding

- Observed increase in river flooding
- Observed increase in drying and droughts
- Projected increase in mean wind speed
- Projected increase in heavy precipitation and pluvial flooding

Summary of findings from IPCC AR6

- Observed decrease in mean precipitation
- Observed decrease in SPI (deficit of precipitation)
- Observed increase in droughts
- Projected increase in heavy precipitation and pluvial floodings
- Projected increase in riverine flooding

- Observed decrease in mean precipitation
- Observed and projected decrease in snow and glaciers
- Projected increase in heavy precipitation and pluvial flooding
- Projected decrease in meteorological drought at 4 °C warming

- Projected increase in frequency and intensity of heavy precipitation and pluvial flooding
- Observed and projected decreases in snow and glaciers
- Projected increase of average tropical cyclone wind speeds with heavy precipitation and increased cyclone intensity

Summary of findings from IPCC AR6

- Observed decrease in mean precipitation
- Observed increase in heavy precipitation and pluvial flooding
- Observed and projected increase in drought
- Projected increase in dryness from 1.5 °C
- Projected increases in mean wind speed and fire weather conditions

- Observed increase in aridity
- Projected increase in drought, particularly at higher warming
- Projected increase in heavy precipitation and pluvial flooding
- Projected increase of average tropical cyclone wind speeds and associated heavy precipitation

- Observed decrease in precipitation
- Observed and projected increase in heavy precipitation and pluvial flooding
- Observed and projected increase in drought
- Projected increase in fire weather conditions
- Projected increase of average tropical cyclone wind speeds and associated heavy precipitation

Summary of findings from IPCC AR6

- Observed increase in drought frequency and intensity since the 1980s
- Observed increase in extreme precipitation, mostly in elevated areas
- Mountain permafrost degradation at high altitudes has increased the instability of mountain slopes over the last decade
- Observed reduction in snow cover
- Projected increase in precipitation volume, intensity and frequency
- Projected increase in precipitation spatiotemporal variability
- Projected decrease in precipitation during summer with increase during winter

A common theme?

Climate change expected to significantly impact surface and groundwater resources driven by increased drought <u>and</u> flood events

How can we adapt?

As water resources engineers and managers, we can use hydrological models to help project impacts and provide results to policymakers and planners

- Trend analysis based on observed data
- Analysis using climate modelling outputs ★

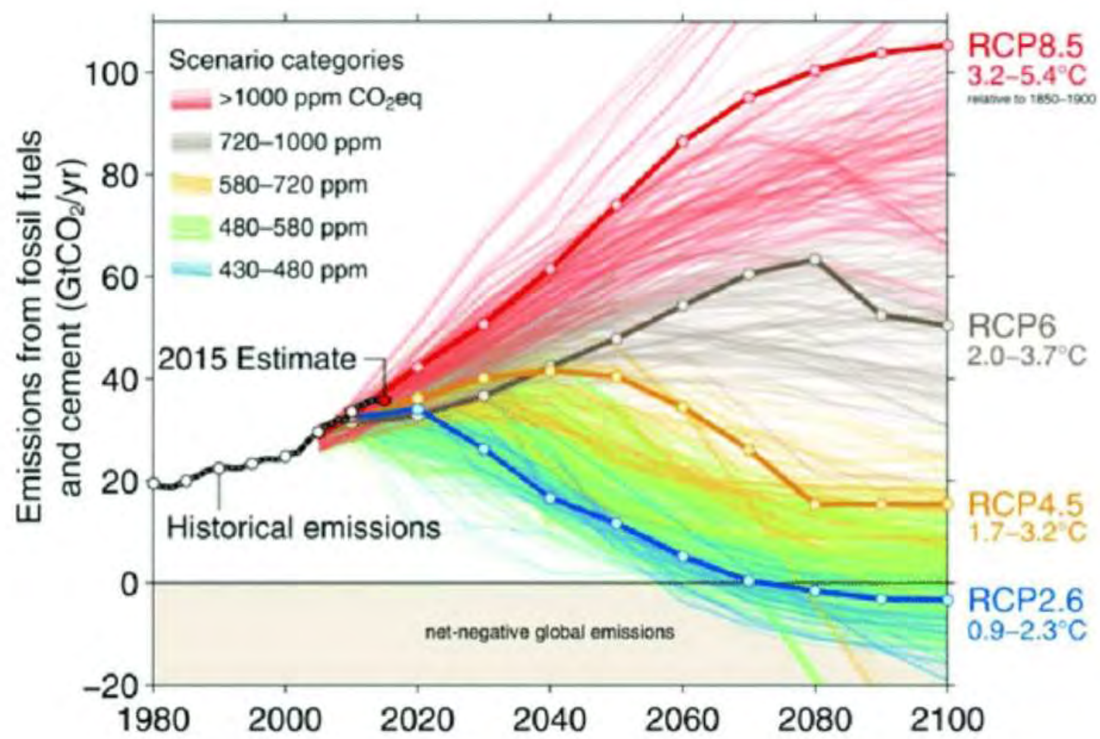
Trend Analysis	Climate modelling outputs
Pros: • Simple • Common approach	Pros: • Considers changing climate
Cons: • Based on the past	Cons: • Unfamiliar method

Today's webinar aims to fix this

How to project future climate

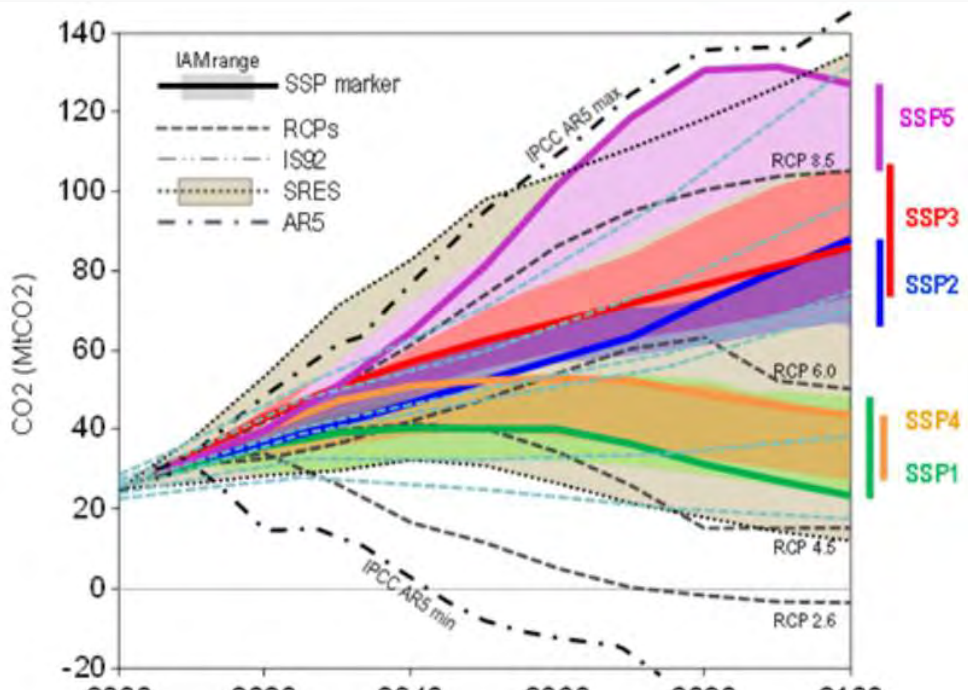
Representative Concentration Pathways (RCPs)

- Greenhouse gas concentrations (not emissions) trajectory
- Presented in IPCC AR5
- Coupled Model Intercomparison Project, Fifth Phase (CMIP5) climate models



https://climatenexus.org/

How to project future climate



Shared socio-economic pathways (SSPs)

- Considers greenhouse gas trajectories with differing climate policy scenarios

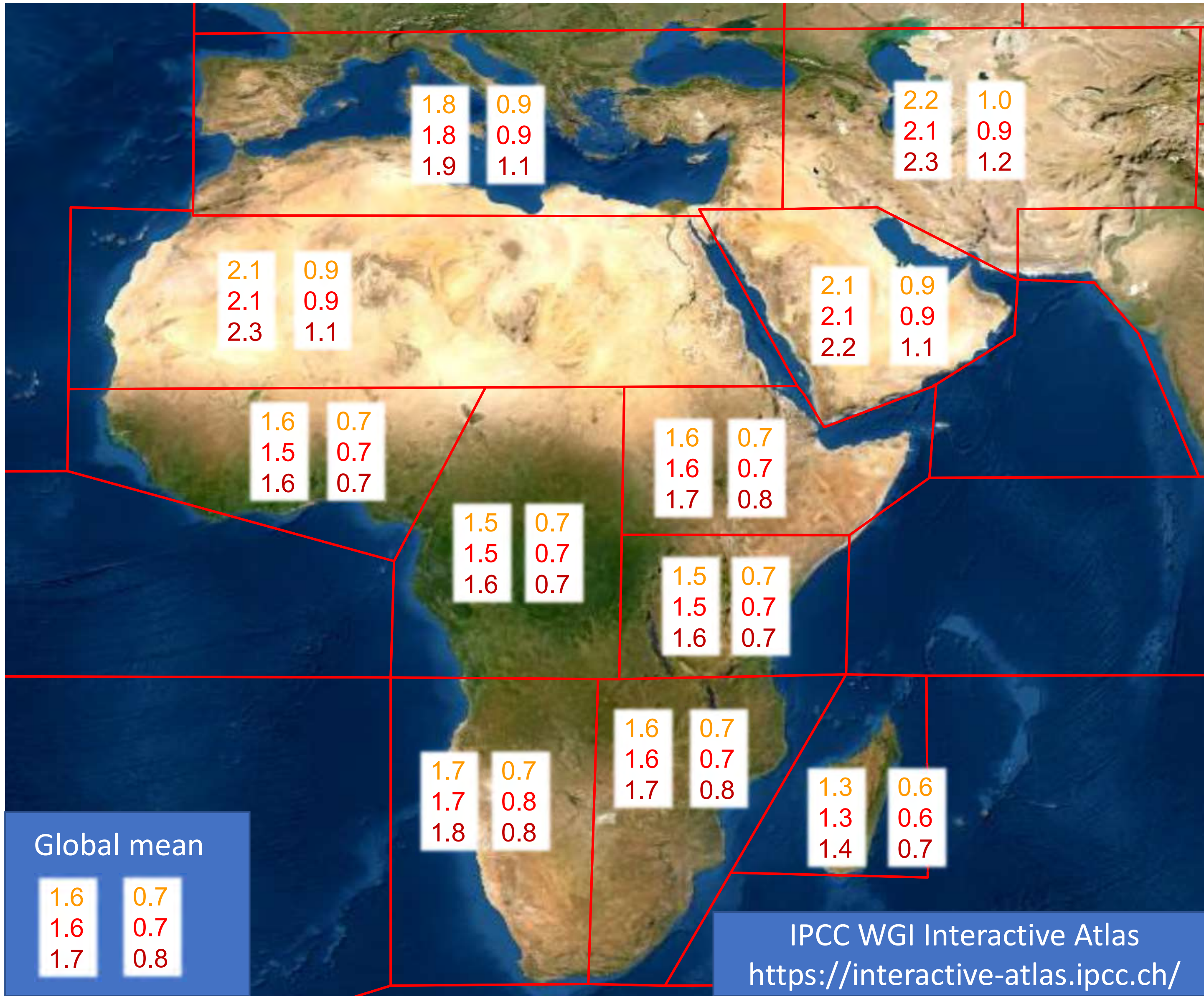
SSP5	Fossil-fueled development (rapid and unconstrained growth in economic output and energy use)
SSP4	Inequality (ever-increasing global inequality)
SSP3	Regional rivalry (fragmented resurgent nationalism)
SSP2	Middle of the road (trends loosely follow historical patterns)
SSP1	Sustainability (sustainability-focused growth and equality)

https://climatenexus.org/

Projected Change in Temperature (°C) Near-term (2021-2040)

SSP1-2.6
SSP3-7.0
SSP5-8.5

Compared to reference period
1st column: 1850-1900
2nd column: 1995-2014



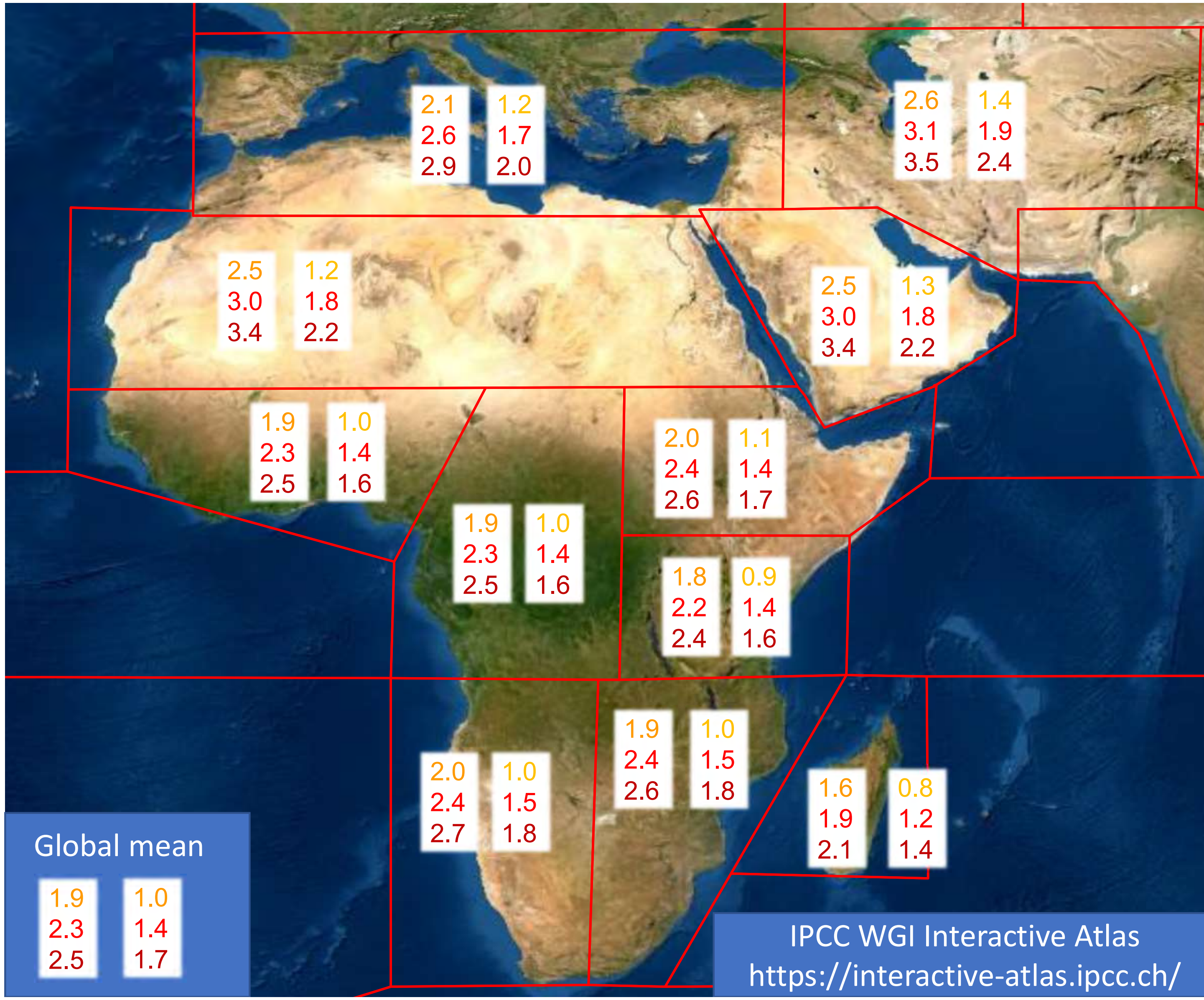
Note: Climate modelling outputs are evaluated over 20-year (or greater) period to minimize uncertainties

Projected Change in Temperature (°C) Mid-term (2041-2060)

SSP1-2.6
SSP3-7.0
SSP5-8.5

Compared to reference period
1st column: 1850-1900
2nd column: 1995-2014

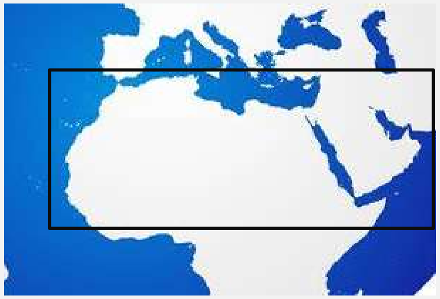
Most of the region (especially N Africa & W Asia) are warming at a faster rate than the globe



From Global Climate Models [General Circulation Models] to Regional Climate Models

GCMs

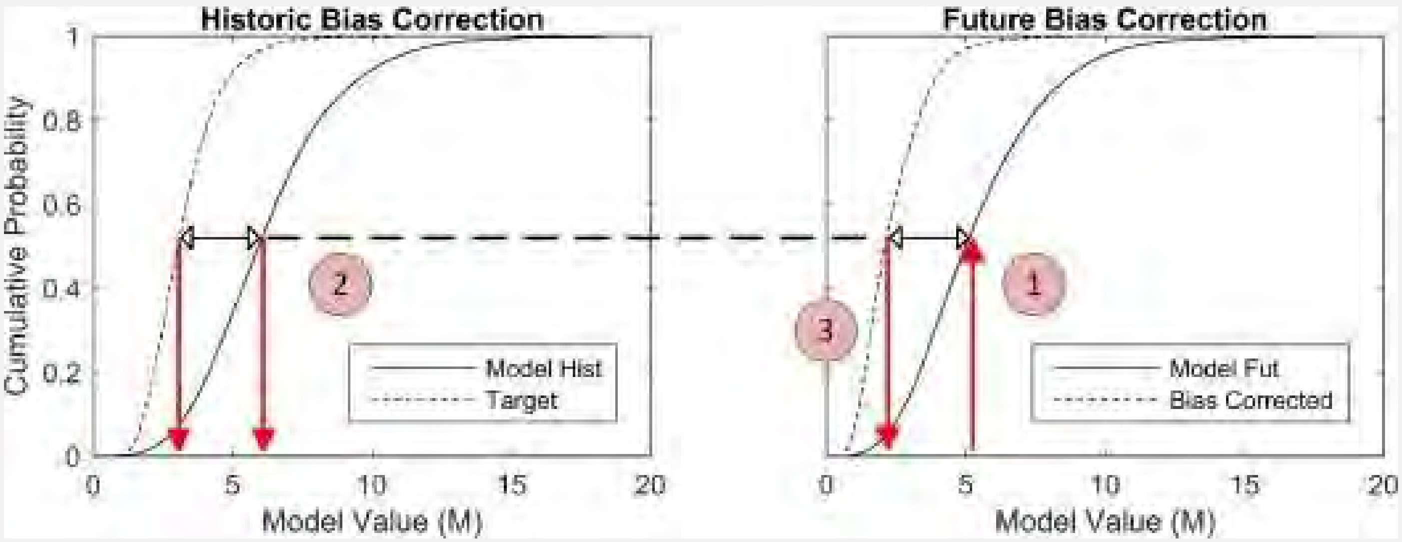
- Simulate climate based on well-established physical principles
- Have demonstrated the ability to reproduce observed recent past climate
- But are limited in simulating certain regional features (i.e. precipitation, mid-latitude storms, organized tropical convection, ecosystem dynamics)



RCMs

- RCMs are nested within GCMs
- Simulate climate based on regional specifications
- Small spatial (i.e. 50 km for CMIP5 and 10 km for CMIP6) and temporal scales

Bias-corrected RCMs



Parker, K., & Hill, D. F. (2017). Evaluation of bias correction methods for wave modeling output. Ocean Modelling, 110, 52-65.

Bias correction incorporates observed data into RCM outputs

- Not available for all RCM domains
- Limited to few parameters (i.e. temperature, precipitation)
- Application reserved for hydrological and impact studies
- Detailed process using 30-year period of historical data across the entire domain (cannot be properly done for small subdomain like a basin)

Where to get RCM outputs

- CORDEX (Coordinated Regional Climate Downscaling Experiment)
  - https://cordex.org/
  - ESGF: https://esg-dn1.nsc.liu.se/search/esgf-liu/

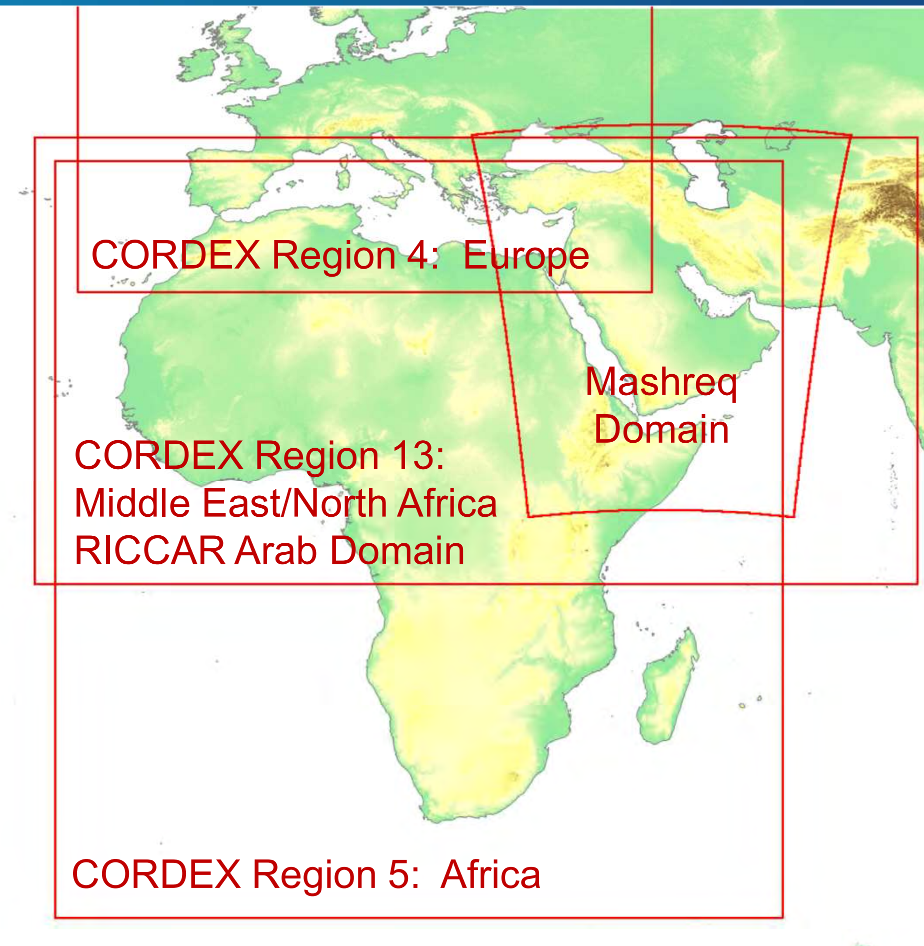
- RICCAR (Regional Initiative for the Assessment of Climate Change Impacts on Water Resources and Socio-Economic Vulnerability in the Arab Region)
  - https://www.riccar.org/
  - Data portal and knowledge resources

CORDEX and RICCAR Domains

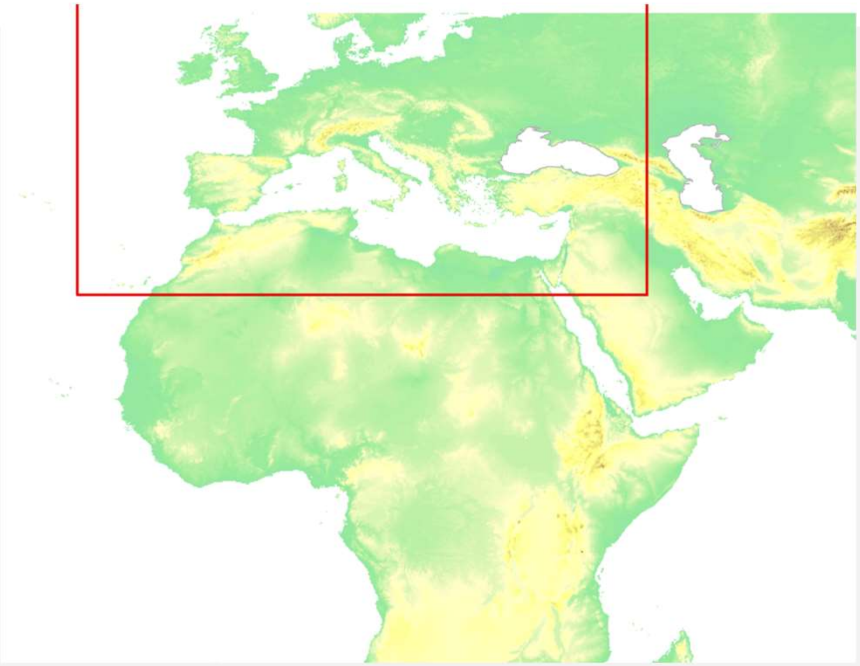
CORDEX (Coordinated Regional Climate Downscaling Experiment)

Currently, all available RCMs completed as part of CORDEX are based on CMIP5 GCMs; updates based on CMIP6 in progress

The newly available Mashreq Domain is based on CMIP6 models

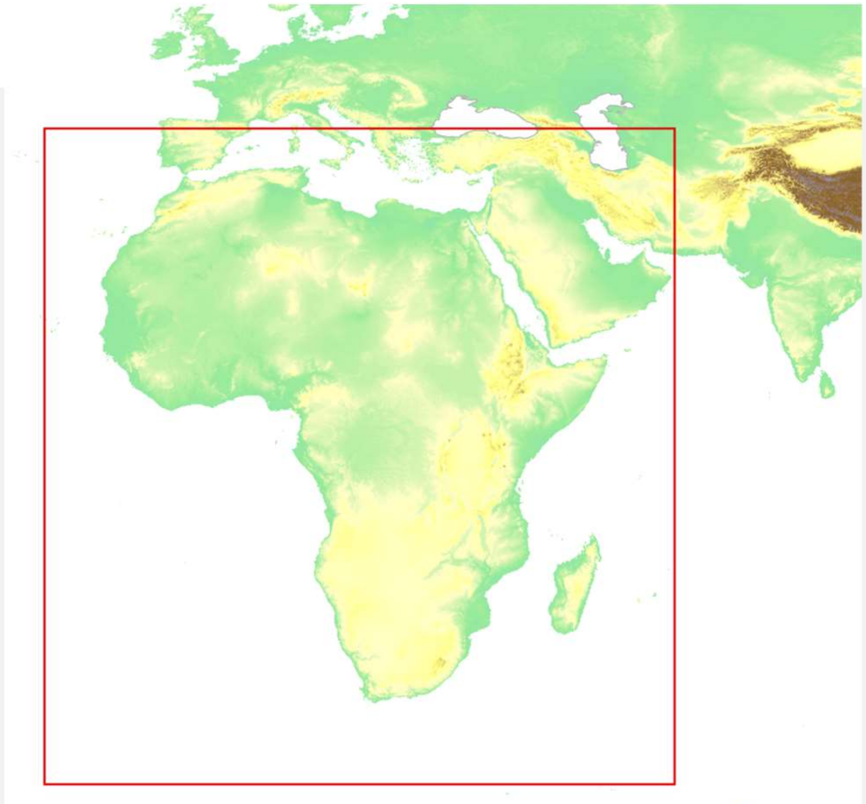


CORDEX Region 4: Europe “Euro-CORDEX”



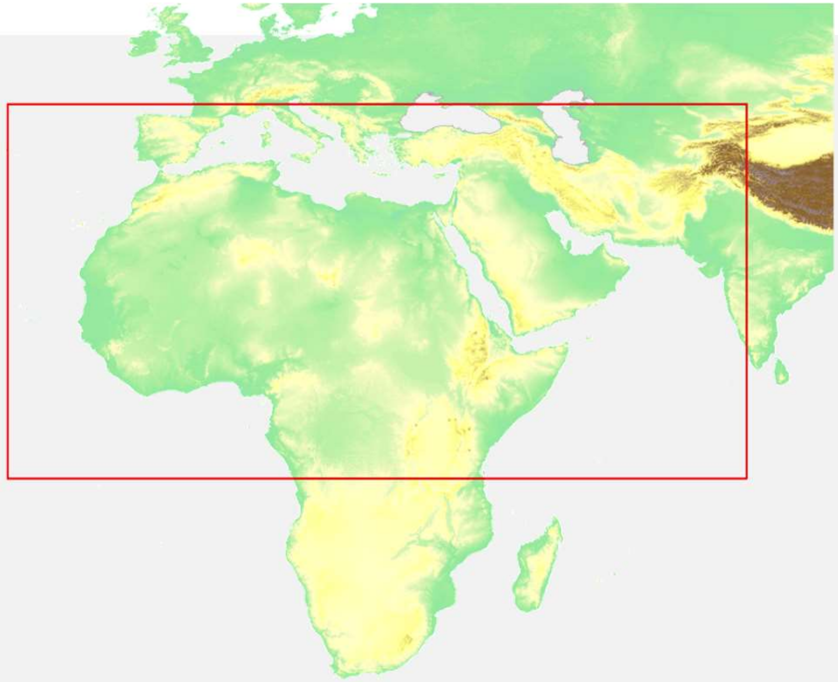
- Available at 0.11° (~12.5 km^2), 0.22° (~25 km^2) and 0.44° (~50 km^2)
- Raw and bias-corrected RCM outputs
- RCP2.6, RCP4.5, RCP8.5
- Driving models (selected GCMs):
  - CNRM-CERFACS-CNRM-CM5
  - ICHEC-EC-EARTH
  - IPSL-IPSL-CM5A-LR
  - IPSL-IPSL-CM5A-MR
  - MIROC-MIROC5
  - MOHC-HadGEM2-ES
  - MPI-M-MPI-ESM-LR
  - NCC-NorESM1-M
  - NOAA-GFDL-GFDL-ESM2G
- Selected RCMs:
  - ALADIN63
  - CCLM4-8-17
  - COSMO-crCLIM-v1-1
  - HIRHAM5
  - HadREM3-GA7-05
  - RACMO22E
  - RCA4
  - REMO2015
  - RegCM4-6

CORDEX Region 5: Africa



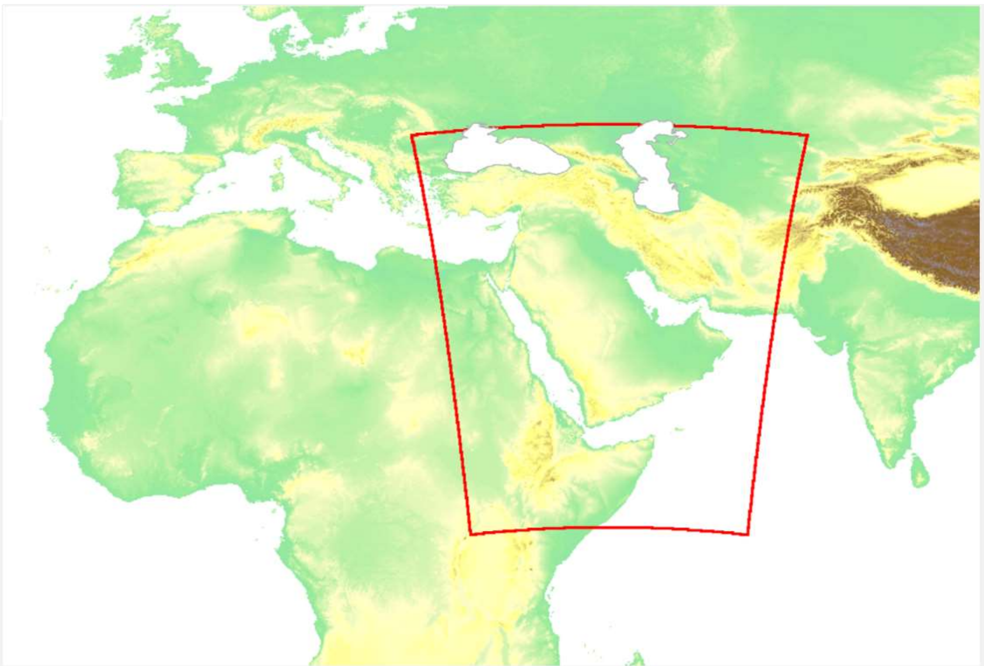
- Available at 0.22° (~25 km^2) and 0.44° (~50 km^2)
- Raw RCM outputs only
- RCP2.6, RCP4.5, RCP8.5
- Driving models (selected GCMs):
  - CCCma-CanESM2
  - CNRM-CERFACS-CNRM-CM5
  - CSIRO-Mk3-6-0
  - IPSL-IPSL-CM5A-LR
  - IPSL-IPSL-CM5A-MR
  - MOHC-HadGEM2-ES
  - MPI-M-MPI-ESM-LR
  - NCC-NorESM1-M
  - NOAA-GFDL-GFDL-ESM2G
  - NOAA-GFDL-GFDL-ESM2M
- Selected RCMs:
  - CCLM4-8-17
  - CRCM5
  - CanRCM4
  - HIRHAM5
  - HadGEM3-RA
  - HadRM3P
  - RACMO22T
  - RCA4
  - REMO2000
  - RegCM4-3

CORDEX Region 13: Middle East/North Africa "Arab Domain"



- Available at 0.22° (~25 km^2) and 0.44° (~50 km^2)
- Raw and bias-corrected RCM outputs
- RCP2.6, RCP4.5, RCP8.5
- Driving models (selected GCMs):
  - CNRM-CERFACS-CNRM-CM5
  - ICHEC-EC-EARTH
  - NOAA-GFDL-GFDL-ESM2M
- RCM:
  - RCA4
- Other model runs hosted by The Cyprus Institute

Mashreq Domain



- Available at 0.10° (~10 km^2)
- Raw and bias-corrected RCM outputs
- SSP5-8.5 (CMIP6 models)
- Driving models (selected GCMs):
  - CMCC-CM2-SR5
  - CNRM-CERFACS-CNRM-ESM2-1
  - ICHEC-EC-EARTH3-Veg
  - MPI-ESM1-2-LR
  - MRI-ESM2-0
  - NCC-NorESM2-MM
- RCM:
  - HCLIM-ALADIN-38

So many models….

More models are better to facilitate an “ensemble” analysis

Model for each domain are carefully selected based on:

- Time frames of the project
- Resources provided
- Availability of boundary forcing data
- GCM resolution
- Representative spread of climate sensitivity

Frequently asked questions

1. Which model should I use for my area of study?

   It is recommended to use several modelling outputs (at least 3) of same spatial resolution and same climate scenario

2. Can I do my own bias-correction?

   No, bias-correction reduces systemic errors but requires detailed methodology and long range data across the entire domain

3. Input climate data is daily. How should I present my results?

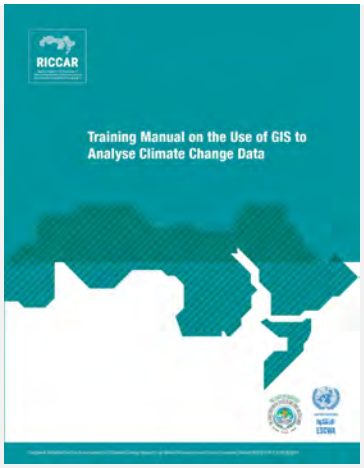
   It is recommended to hydrological modelling outputs as an ensemble mean (20-year mean from all climate input models) but can present time series analysis data for each climate model to illustrate the variability

Frequently asked questions

4. How do I extract climate data?

Climate data is commonly available in netCDF format. Daily data can be extracted using differing methodologies:

- GIS (see RICCAR training manual and on-demand webinar series [https://riccar.org/index.php/events/riccar-webinar-series-climate-change-analysis-using-gis-tools])
- CDO (webinar coming late July 2022)



5. Can I use observed data with climate modelling outputs?

Observed data can be used for calibrating hydrological models before rerunning the model using RCM outputs. However, comparing the future to the past should always be based on RCM outputs.

Thank You

www.riccar.org

https://www.unescwa.org/acccp

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