Climate Change, Water Resources and Adaptation

Climate Change Policies in the Arab Middle East
Challenges for Decision Makers and Activists

A Regional Conference
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Amman - Jordan

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Ramallah, Palestine

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What is Climate Change?

- Climate change is the change in the magnitude of a single climate parameter such as temperature.

- Is it really confirmed that some areas are shifting to colder, wetter, cloudier, and windier conditions and other areas shift to the opposite direction?!!

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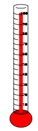
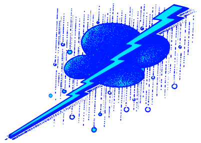
Parameters of Climate Change

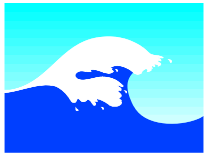
Climate Changes



Temperature



Precipitation



Sea Level Rise

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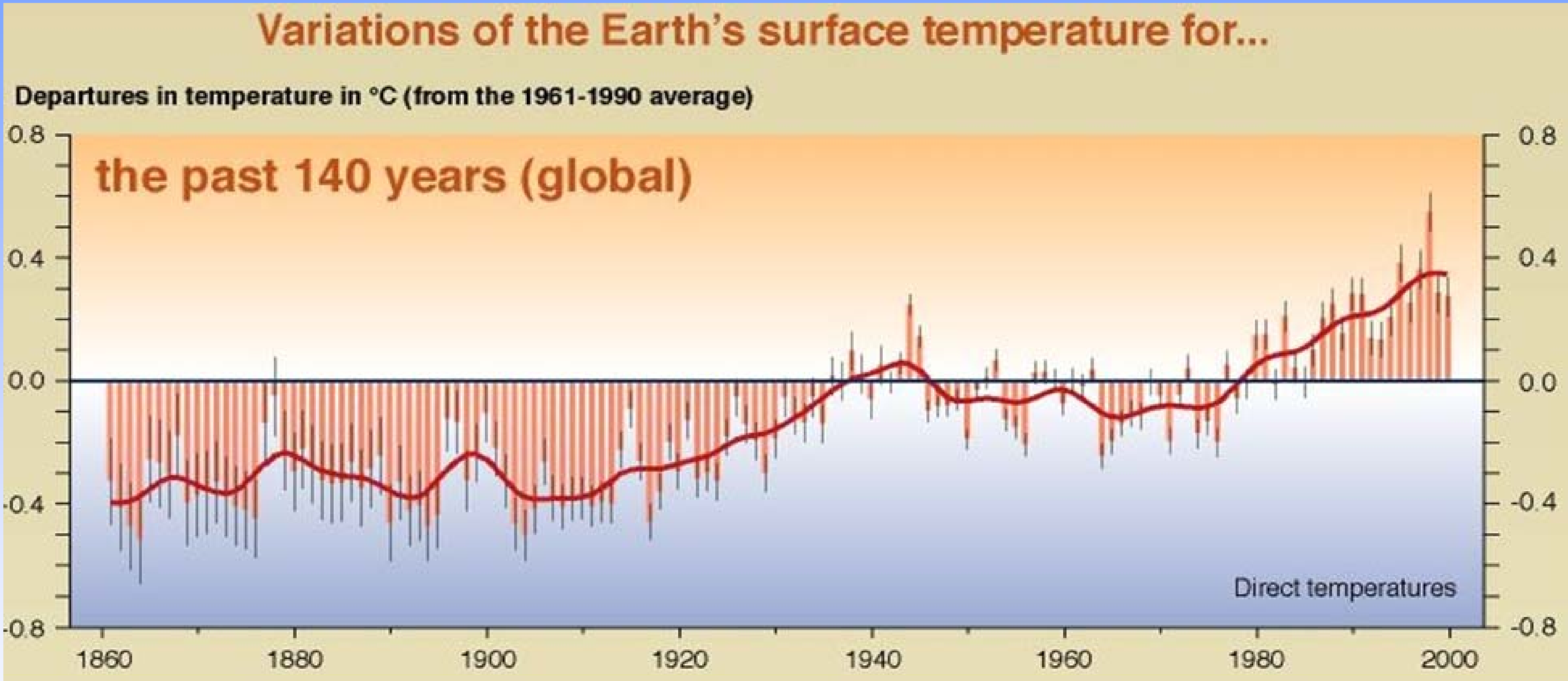
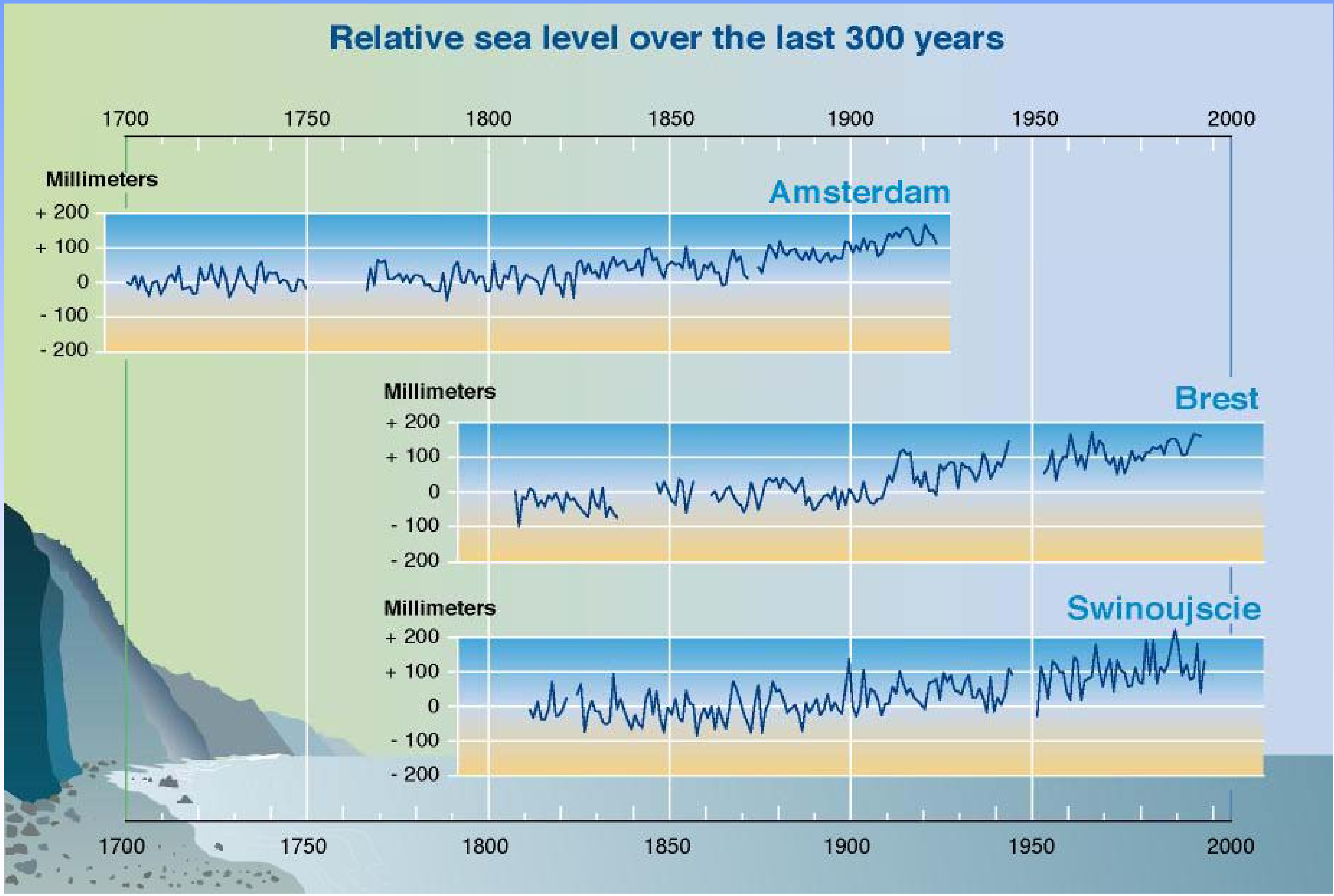
Variation of the Earth's Surface Temperature for the Past 140 years

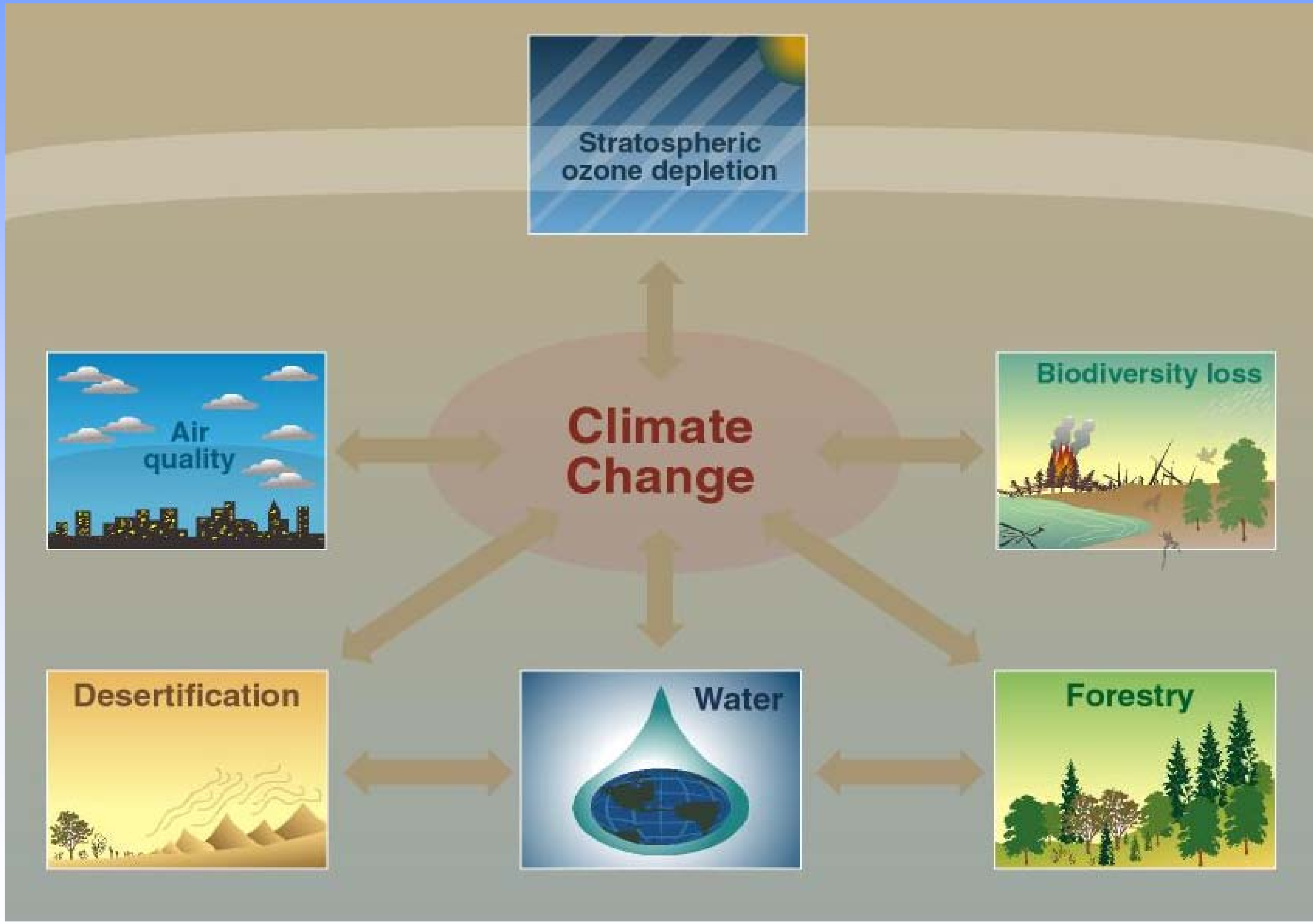


Global mean surface temperatures have increased

Sea Levels have Risen



Pathways of Climate Change Impacts



Climate Change: a threat for water resources in our region

- Lower rainfall.
- Increase in the intensity and distribution of precipitation.
- An increase of floods.
- A rise of temperature.
- It will add pressure on
  - water resources.
  - environment resources
  - coastal system

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Climate Change: a threat for water resources in our region

- Temp warmining will lead to more demand on water.
- Evaporation will increase and this will reduce the available water supply.
- Water quality will deteriorate due to high concentration of agriculture chemicals in lower flows.
- Intensification of rainfall will be responsible for soil erosion, leaching of agriculture chemicals and runoff of urban wastes and nutrients into water bodies.

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Potential Climate Change Impacts on Water Resources

- Change in average precipitation
- Change in the character of precipitation (rainfall intensity)
- Changes in amount, timing and distribution of floods and droughts
- With a warmer land and atmosphere:
    - More precipitation falls as rain
    - Winter runoff is increased
    - Winter starts later (or earlier?) and ends earlier (or later?)
    - Spring runoff pulse is earlier (or later)
    - Summer runoff (if any) is decreased

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Extreme Events

- 1991/2 - Wettest year recorded over the century, with annual mean precipitation above 200% in most areas.
- Water levels in aquifers returned to the levels of 1950's in many places.
- 1995, 1998 - While most spring and fall khamasin events (hot, dry cyclone) occur in May-June and in September-October, respectively, the first ever recorded khamasin as late as July (accompanied by a severe forest fire in the West Bank mountains) and as early as April in 1998 (causing severe agricultural damage) occurred in 1995 and 1998, respectively.

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- 1998 - Hottest summer recorded.

- 1999 – First khamasin ever recorded in December, accompanied by severe forest fires on Mt. Carmel.

- 1998/9 and 1999/2000 - two consecutive years of extreme drought and the longest drought ever recorded in the south (leading to widespread mortality of trees).

- 2000 - Heaviest snowfall in the northern Negev.

- 2000 - Hottest July in the last 50 years, with a mean temperature 4^{o}C higher than average. Highest recorded temperature (41^{o}C) in Jerusalem since 1888.

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Potential Climate Change Impacts on Water Resources

- Surface water
- Groundwater
- Availability of water supplies

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Potential Climate Change Impacts on Water Resources

- Drinking and agricultural waters (less rainfall)
- Coastal property and infrastructure (sea level rise)
- Economic activity

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Precipitation Intensity Increases

- More intense precipitation
- Precipitation increases are due to the strong events

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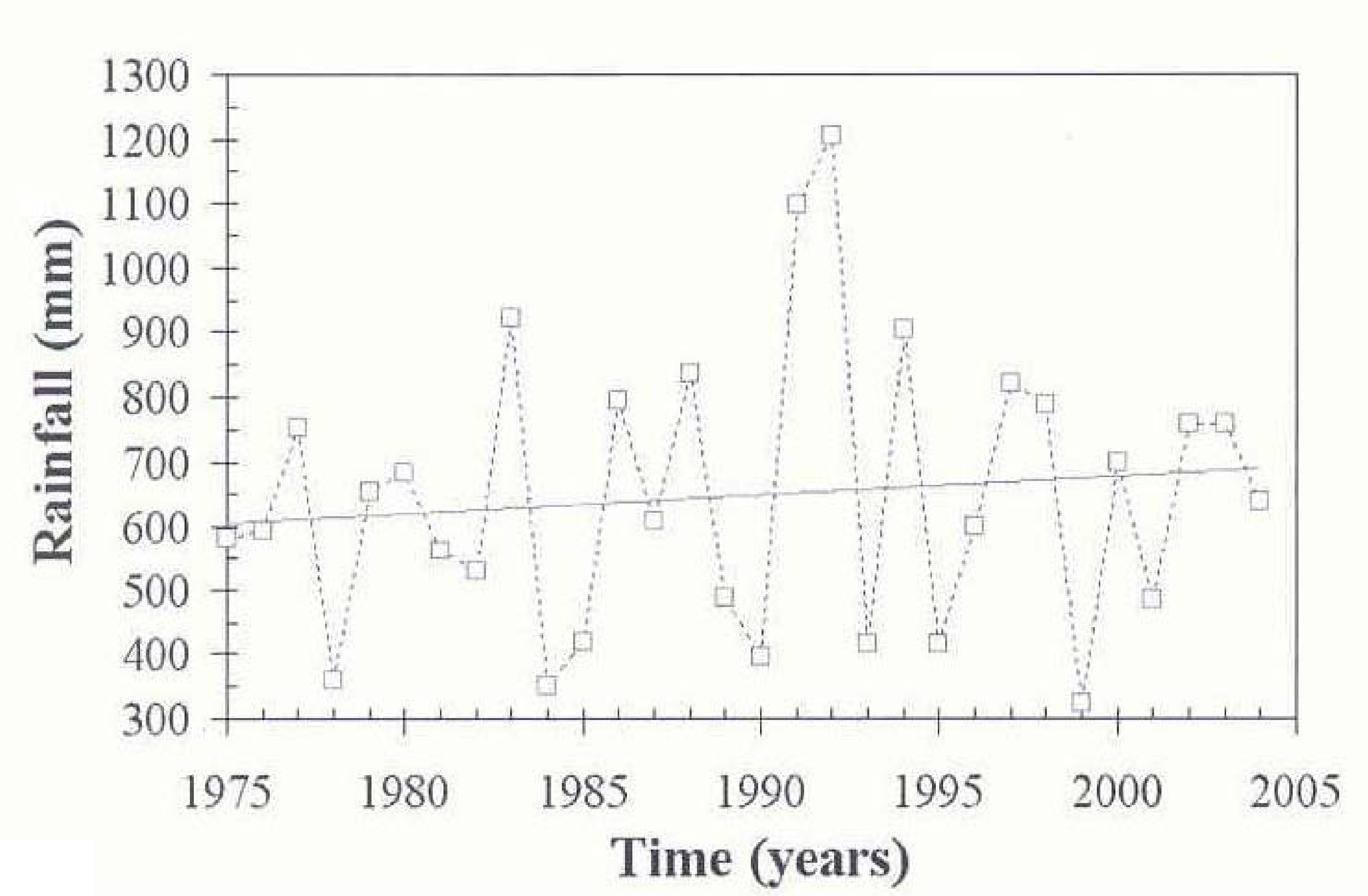
Rainfall of Nablus City – Annual amount



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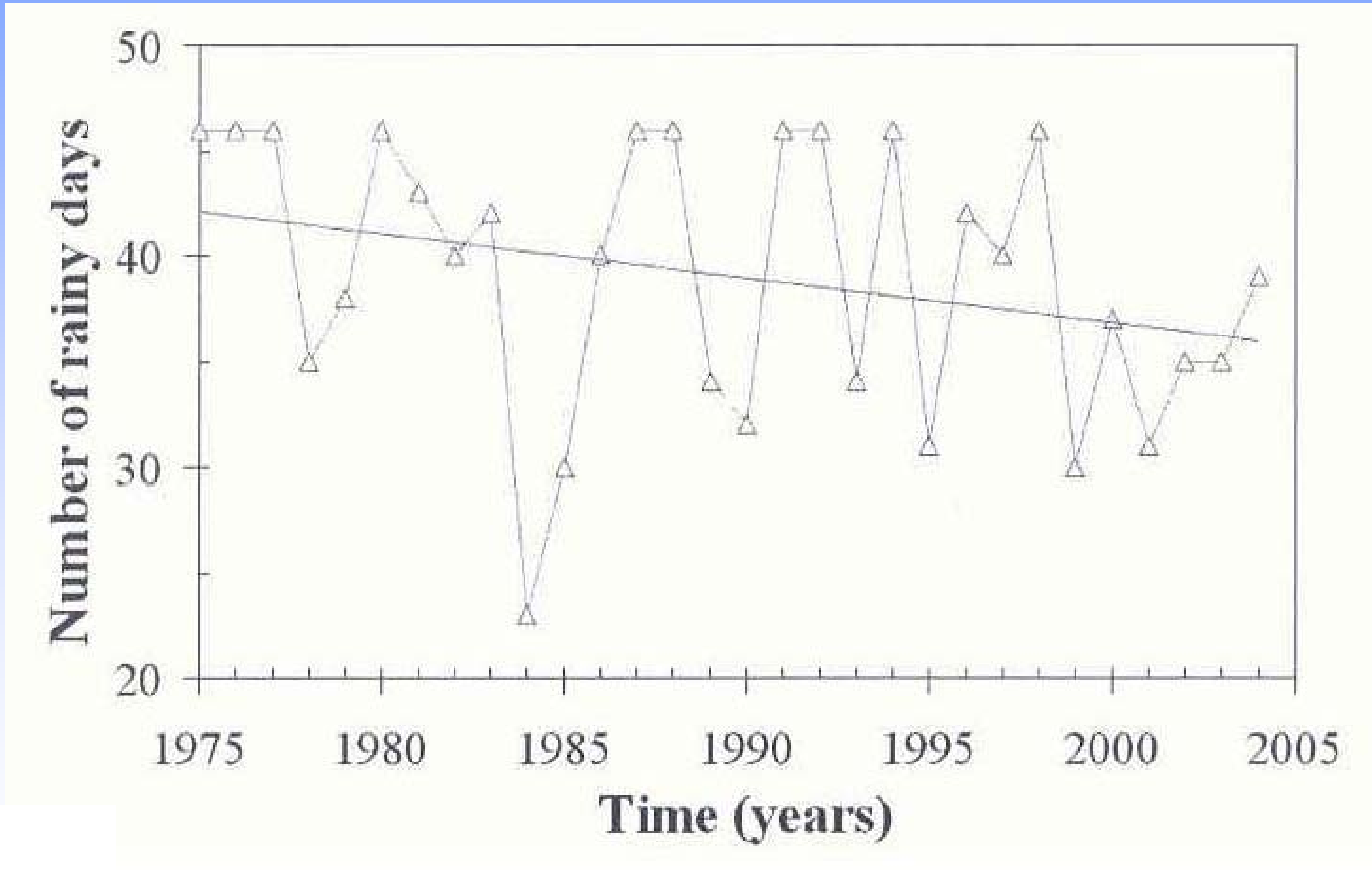
Rainfall of Nablus City – Number of Rainy Days



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Minimum and Maximum Numbers of Rainy Days

- The minimum and maximum numbers of rainy days per year for the past 30 years are 23 and 46 days, respectively with an average of 39 days per year.

- It can be inferred that the rainfall amount per a rainy day is increasing while the frequency of rainy days is decreasing.

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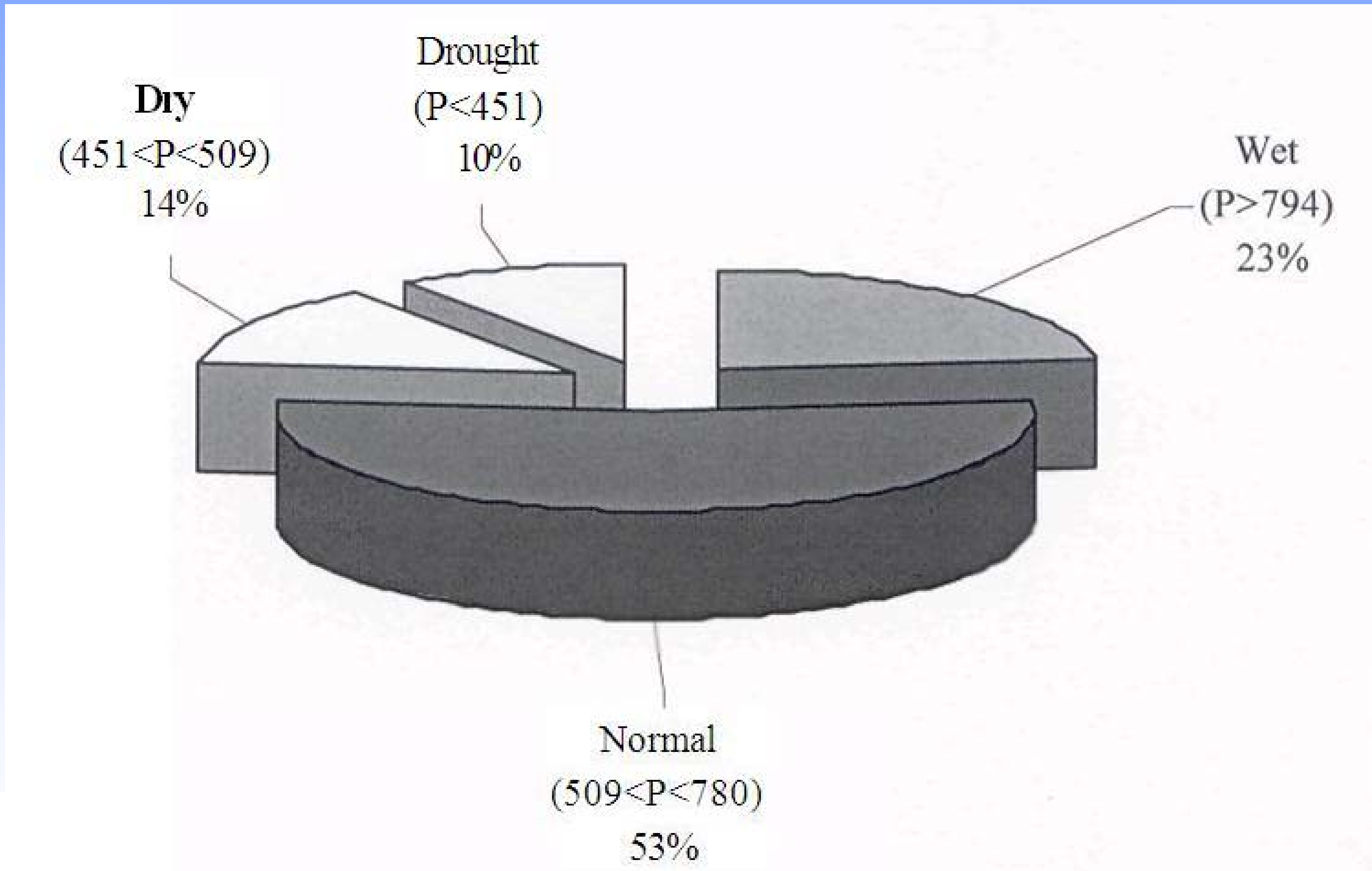
Distribution of drought, dry, normal and wet years



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Surface runoff and flush floods

Increased risk of floods due to sea level rise and heavy rainfall events

- The vegetation in the semi-arid and arid parts of Palestine significantly reduces the permeability of the underlying soil.
- The projected reduced precipitation processes, will expand the dryness of the top soil.
- In addition to the 2 points above, the projected increased rain intensity, the surface runoff will increase.

Thus, climate-change induced increased surface runoff will exacerbate desertification.

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Surface runoff and flush floods

- The increased rainfall intensity will also increase surface runoff from urban areas.

- This, together with the increased runoff from open areas will generate more frequent and more powerful flash floods that beside damage to infrastructures and life will lead to an increased water loss, either to the Mediterranean or to the Dead Sea.

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Surface runoff and flush floods

- The increased runoff, coupled with sea level rise and increased rain intensity may cause flooding leading to the creation of swamps.

- A decrease in the hydraulic slope between drainage systems and sea level reduces the efficiency of water transfer and increases the probability of flooding. This may result in a relatively high vulnerability to projected increases in rain intensity and surface runoff.

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Impact of Climate Change on Water Availability

- One third of the world's population is now subject to water scarcity
- Climate change is projected to decrease water availability in many arid- and semi-arid regions

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Impact of Climate Change on Water Availability

- In Palestine 40 % of the communities do not have access to water supply
- This translates to 35% of the population
- 67% of the Palestinians do not have safe sanitation

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Climate Change: Impact on Recharge

- The variations in the amount of precipitation, the timing of precipitation events, and the form of precipitation are all key factors in determining the amount and timing of recharge to aquifers.

- Droughts result in declining water levels not only because of reduction in rainfall, but also due to increased evaporation and a reduction in infiltration that may accompany the development of dry top soils.

- Extreme precipitation events (e.g., heavy rainfall and storms) may lead to less recharge to groundwater because much of the precipitation is lost as runoff.

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Climate Change Impact on Groundwater Flow

- Climate variability and change may be important considerations for overall changes to the groundwater flow.

- Coastal aquifers are sensitive to changes in water budget due to the interaction between fresh and salt water in the subsurface along the coast.

- When recharge is lowered, the position of the freshwater-saltwater interface will move inland.

- Similarly, a rise in sea level that might accompany climate change will move this interface inland.

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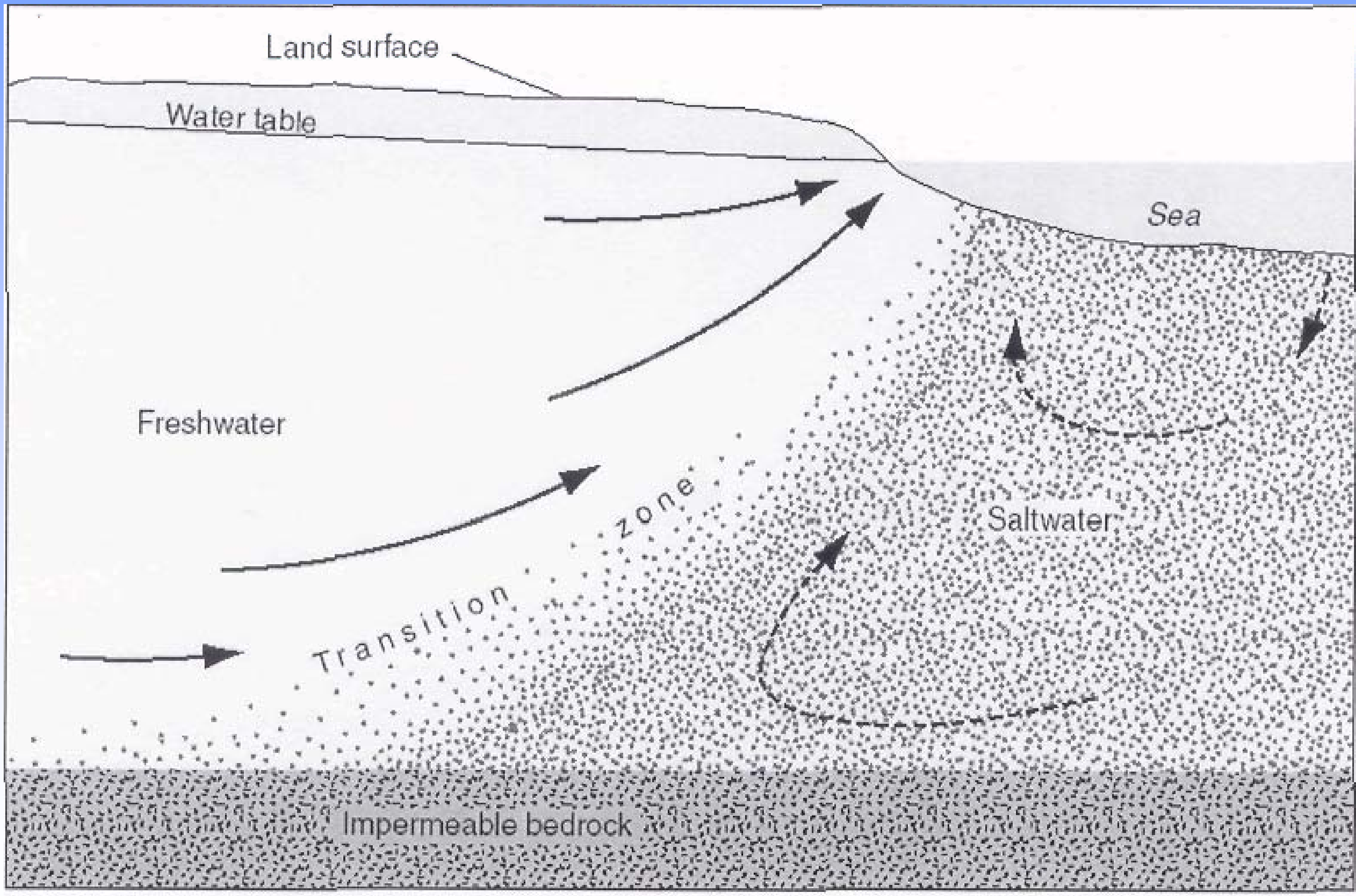
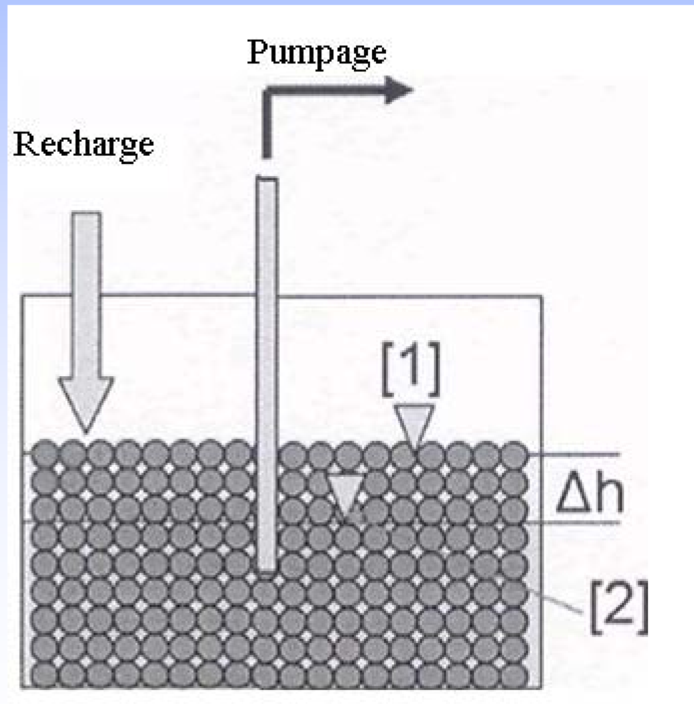
Climate Change Impact on Flow



Climate Change Impact on GW Storage

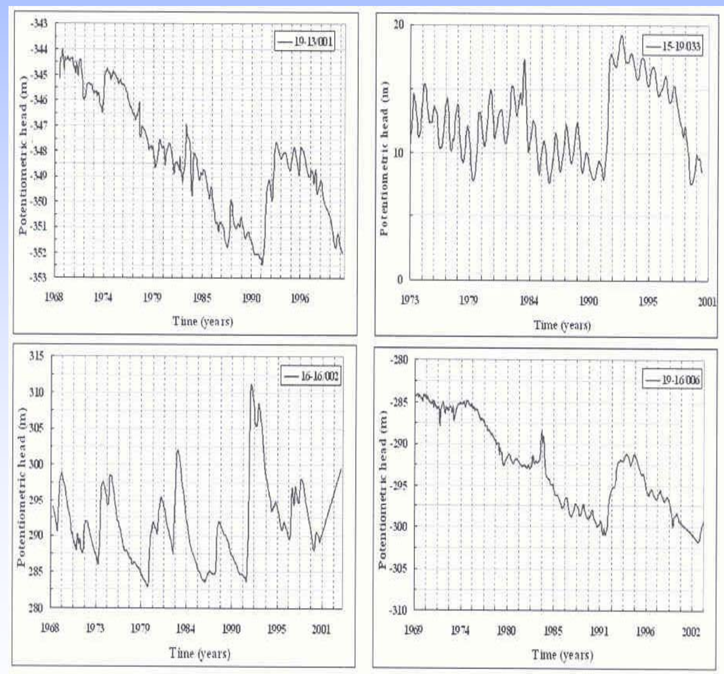
- Less recharge will mean less storage of groundwater in an aquifer.

- When groundwater is removed from storage of aquifer with less recharge, water levels in the aquifer will drop in multiple orders.



Impact of less recharge

- A long-term decline in groundwater storage.
- Increased frequency and severity of groundwater droughts.
- Higher concentration of pollutants.
- Saline intrusion in coastal aquifers, due to sea level rise and drop in water levels.



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Climate Change in Palestine: Some results from the SUSMAQ Project

Variability of rainfall is crucial for recharge

- spatial: topography, permeability of surface
- temporal: intensity, seasonality

Major concerns for future recharge:

- climate change: global warming
- observed downward trend in annual rainfall

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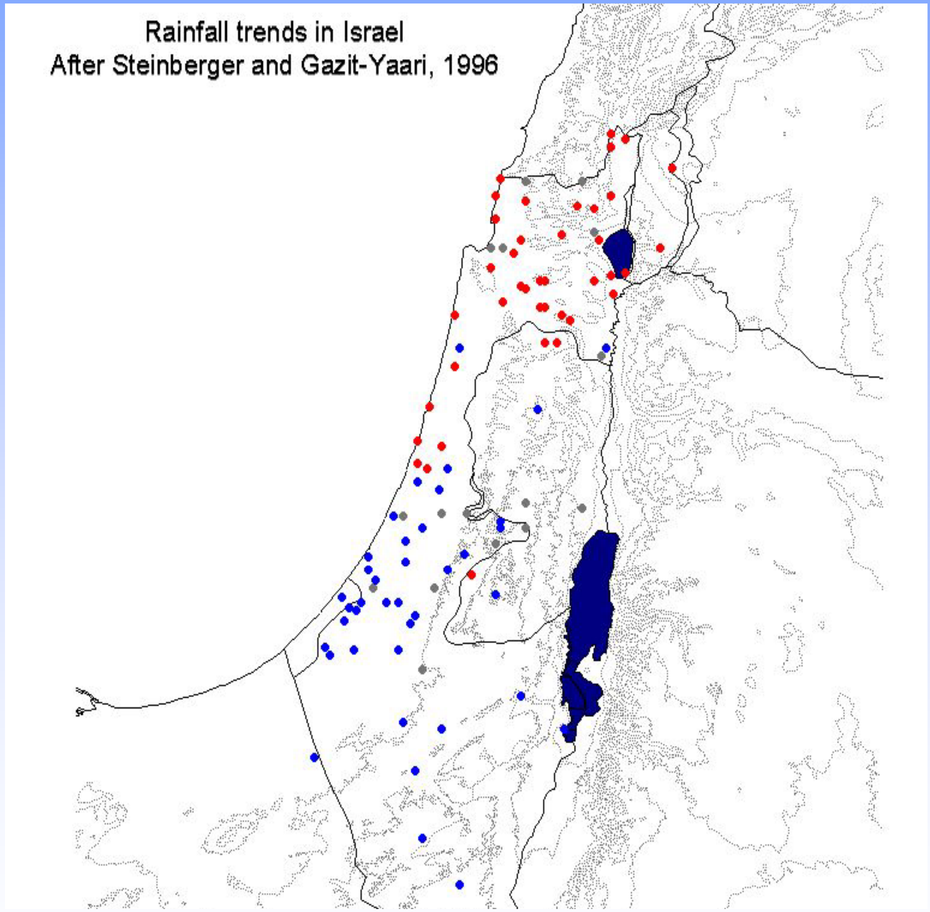
Background – observed trends (1961-90)



- **Decreasing** (red)
- **Increasing** (blue)

Background – global warming

Current predictions are for:

- decreases in annual rainfall by the 2050s
- increase in temperatures, causing higher losses from evaporation
- changes in snow accumulation and melt

A possible further issue is the effect of variations in rainfall intensity on groundwater recharge.

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Available rainfall data

Daily stations	78
Monthly stations	110
Annual stations	110

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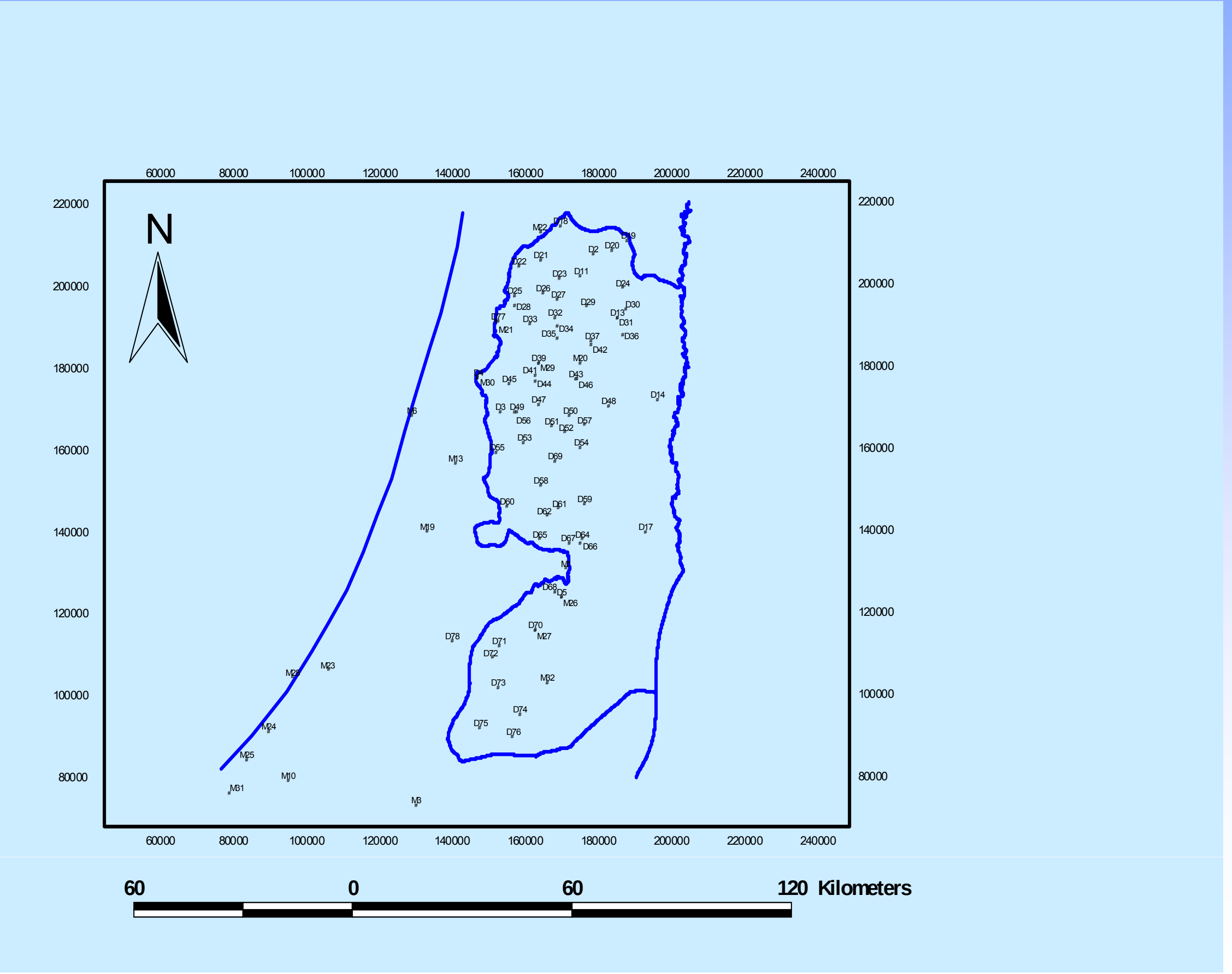
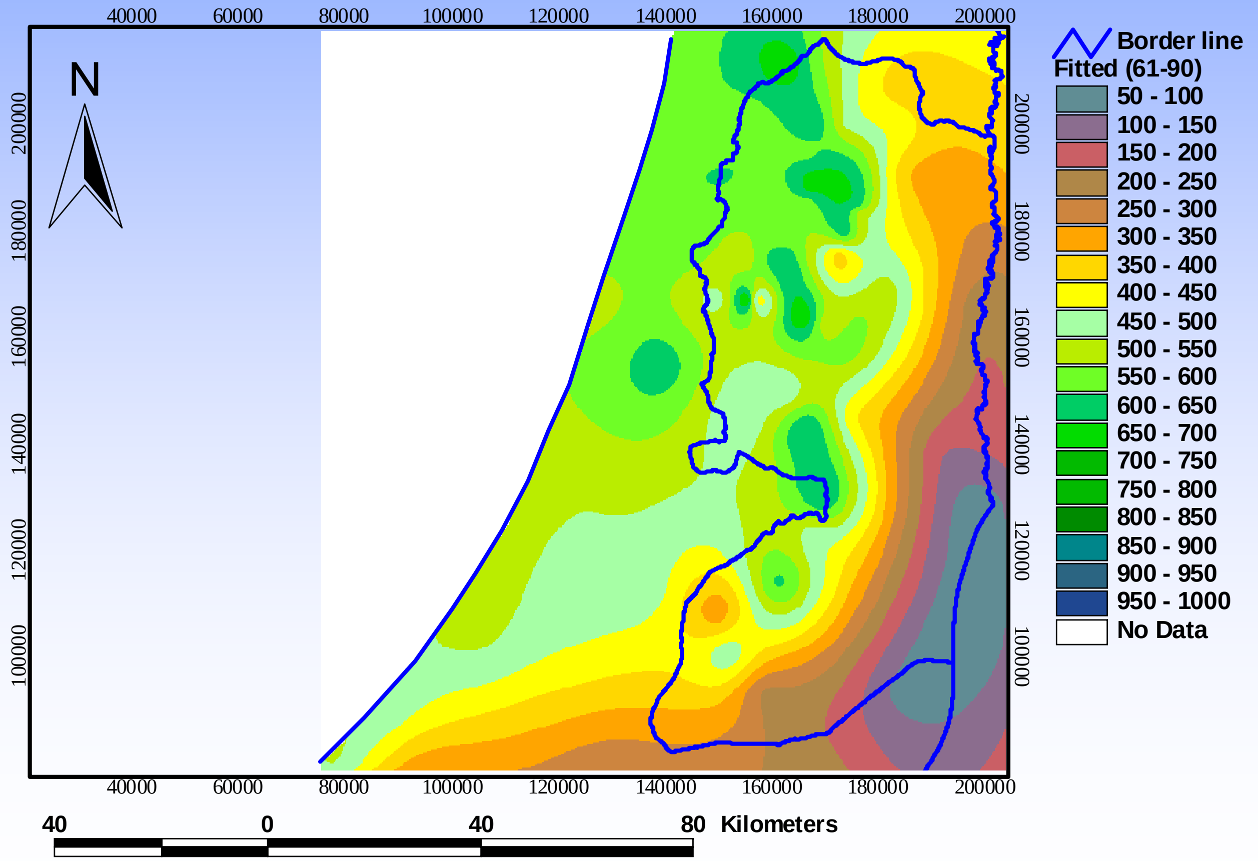
Available Data

- Annual, monthly and daily stations



Available Data

- Annual average rainfall – fitted surface for the period 61-90



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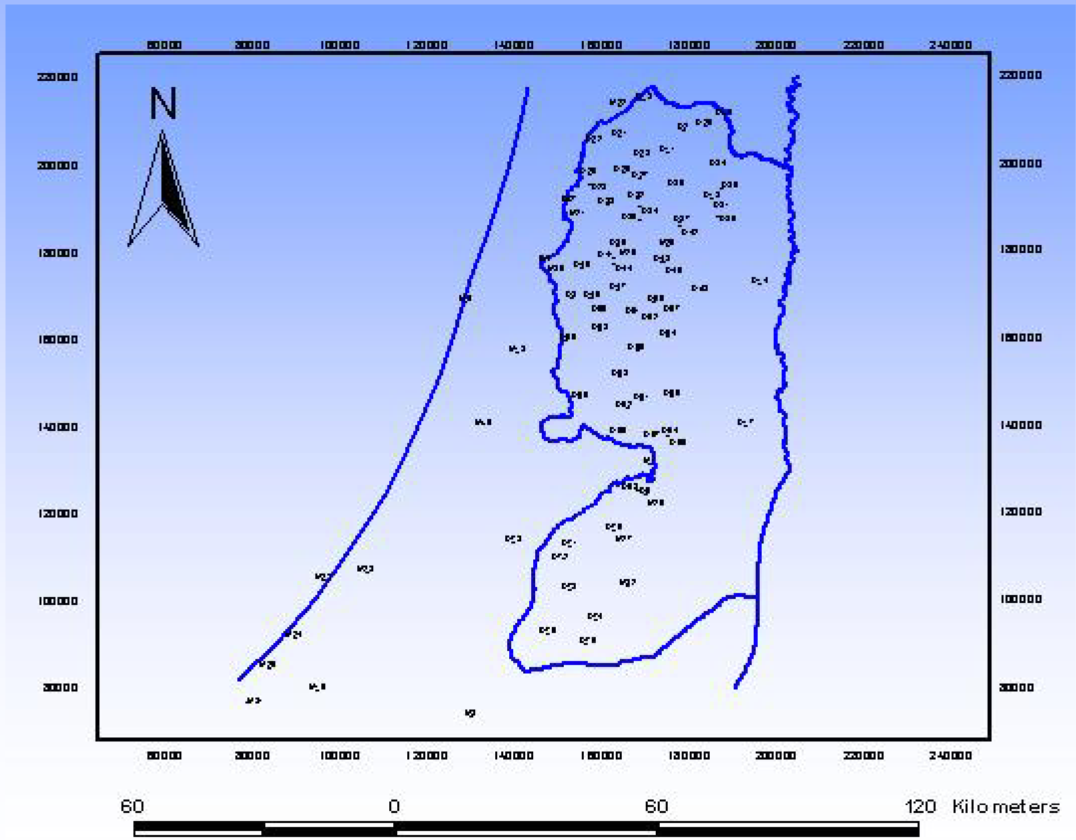
Available Data

- Location of the daily rainfall stations adopted for the spatial correlation analysis



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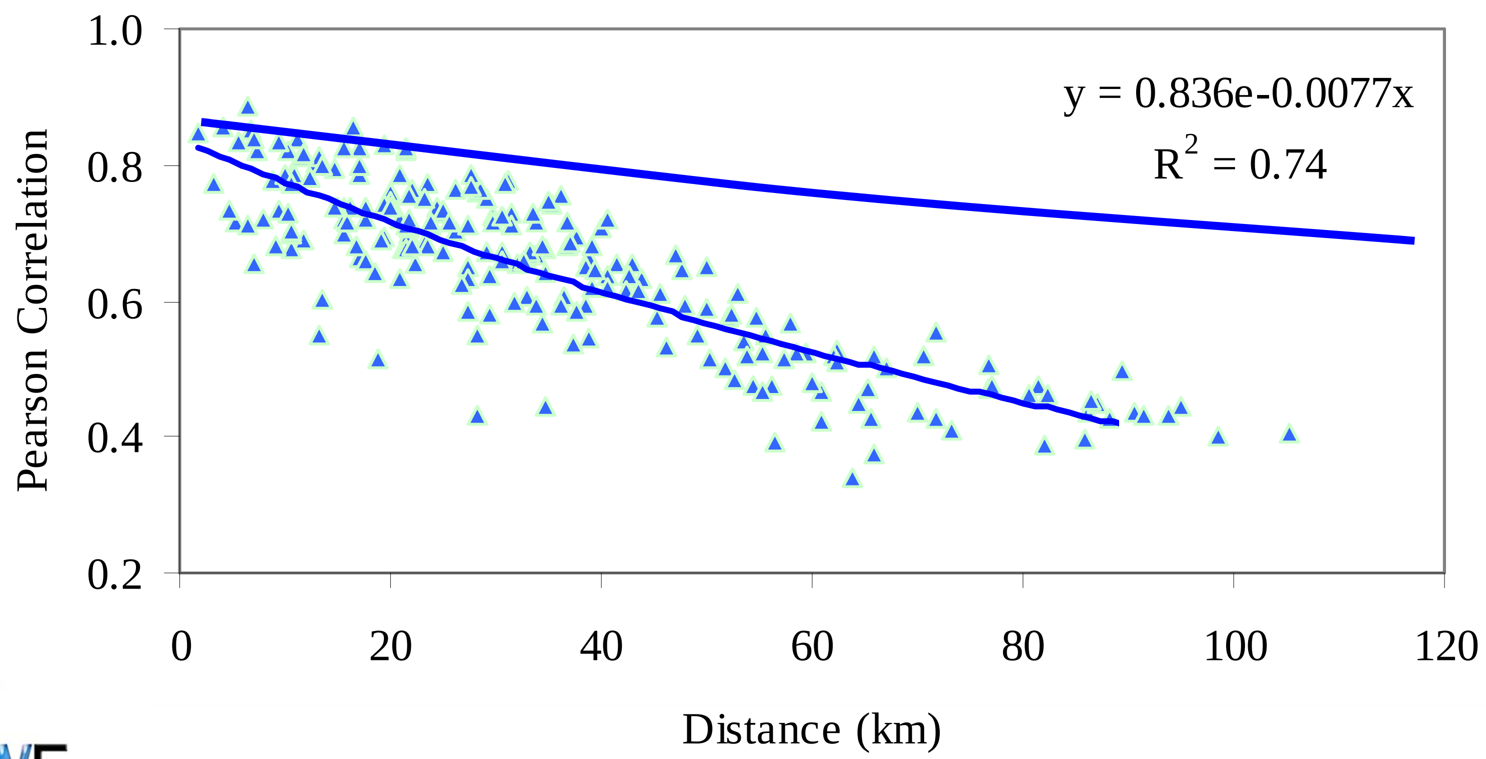
Available Data

- Correlation of daily rainfall plotted against distance for the selected rainfall stations in the WB. (A comparison with the Portuguese case)



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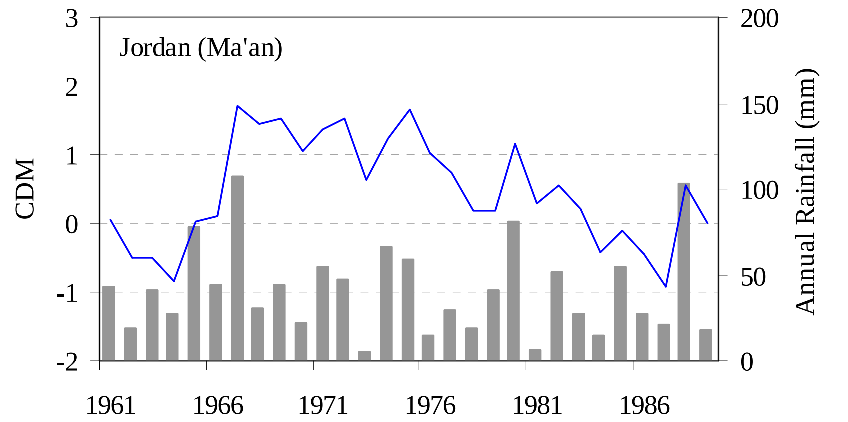
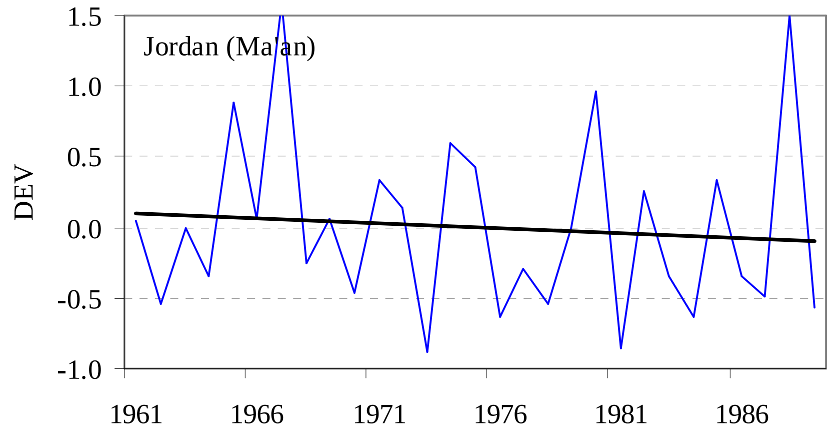
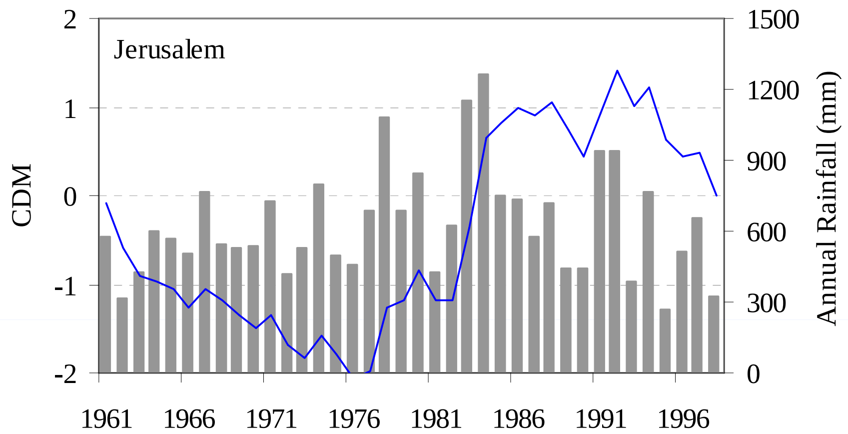
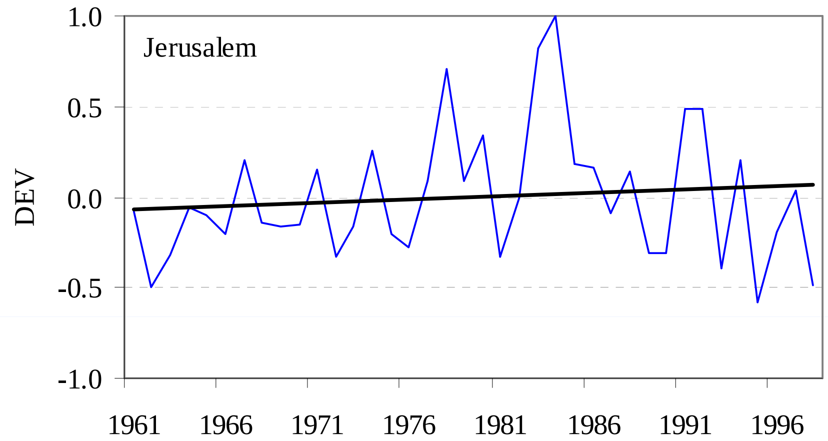
Trends in annual rainfall

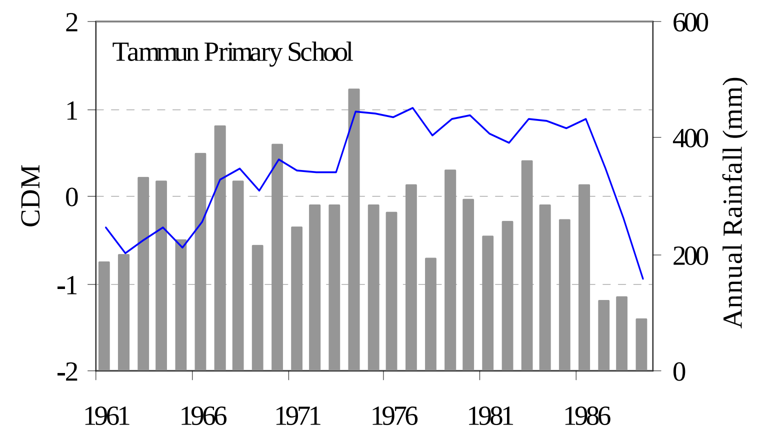


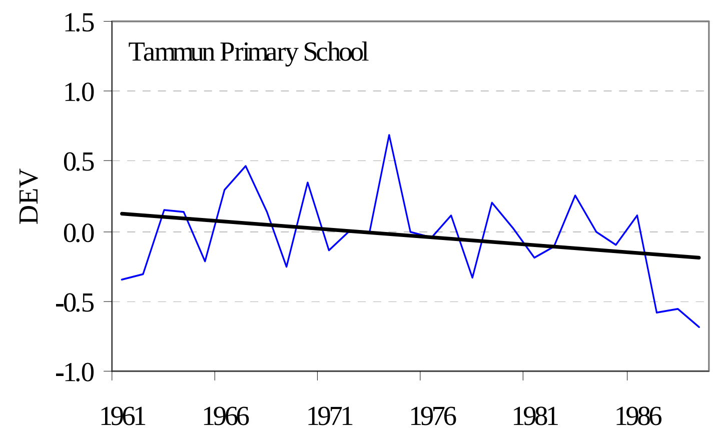


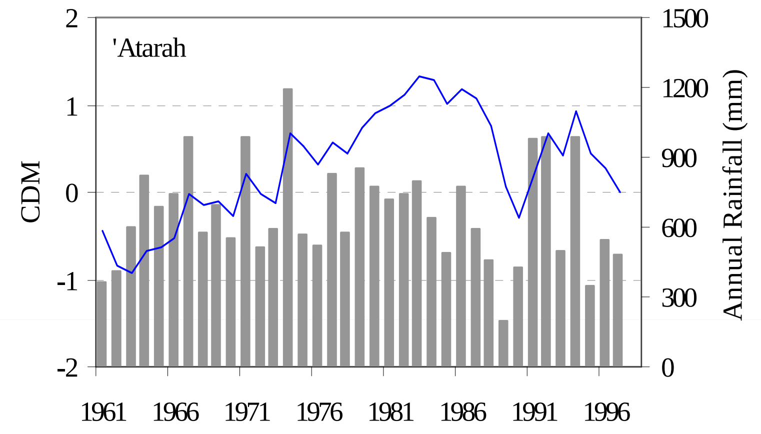


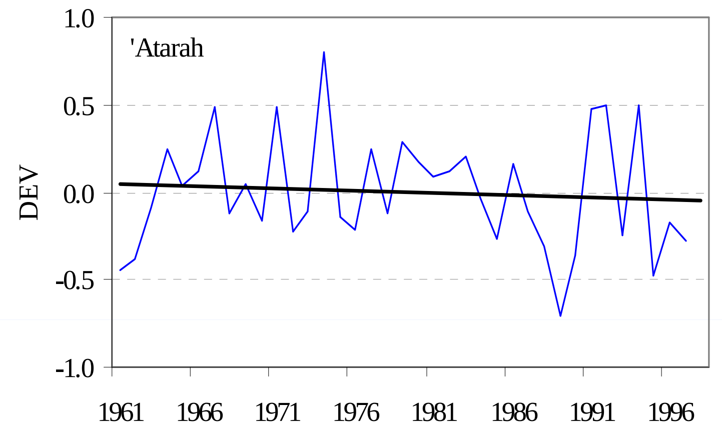


Trends in annual rainfall









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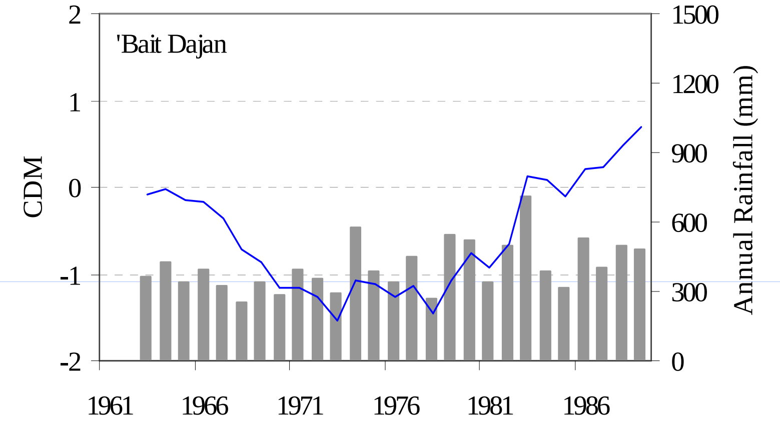
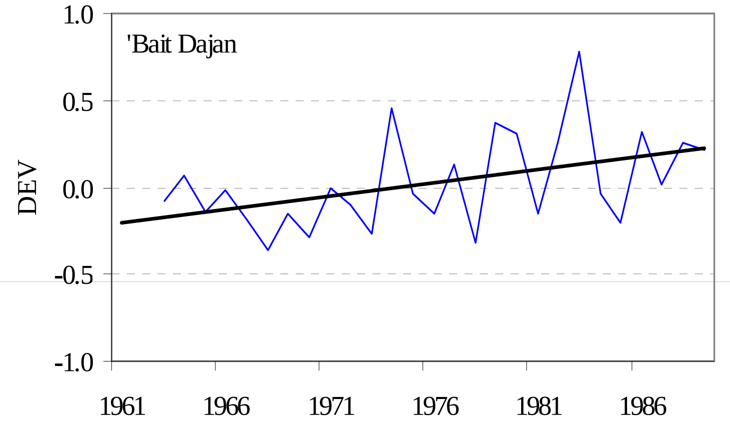
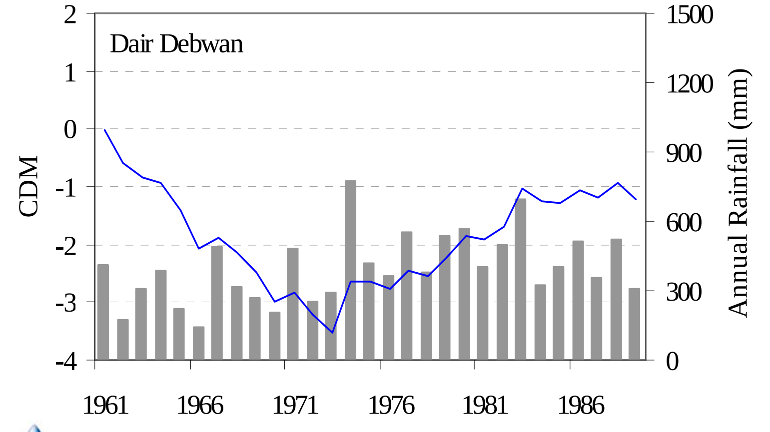
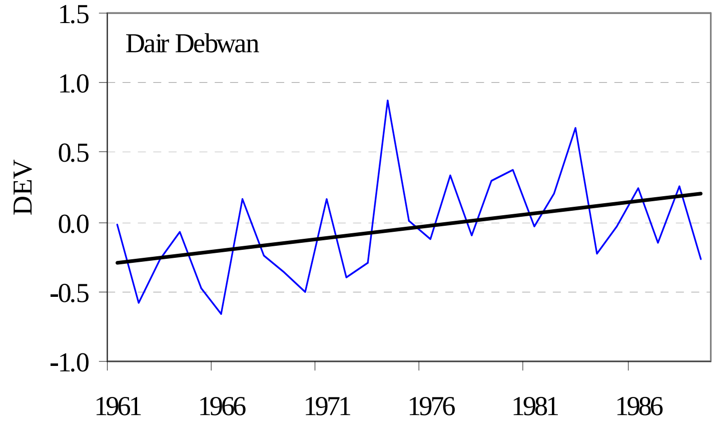
Trends in annual rainfall









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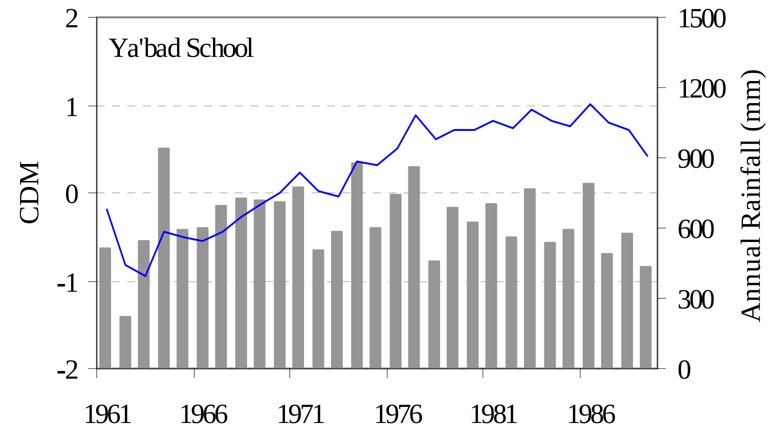
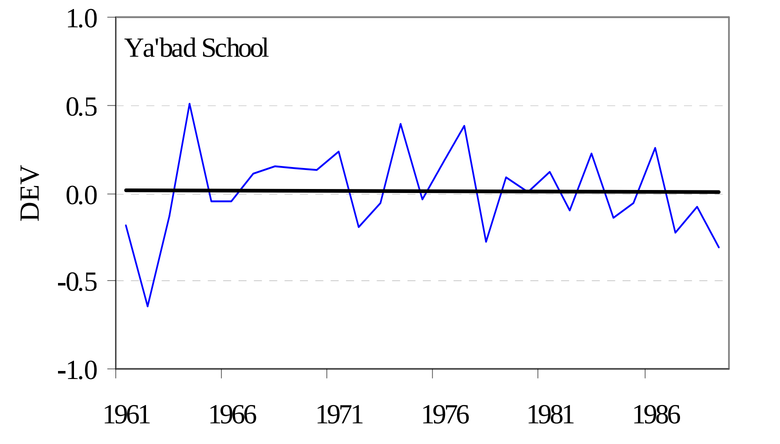
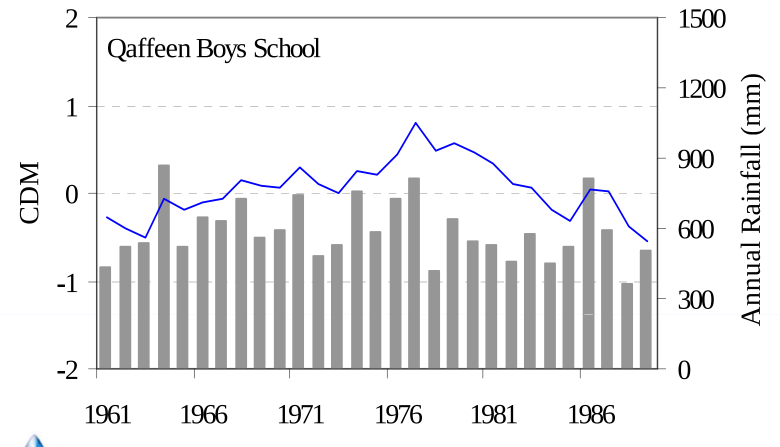
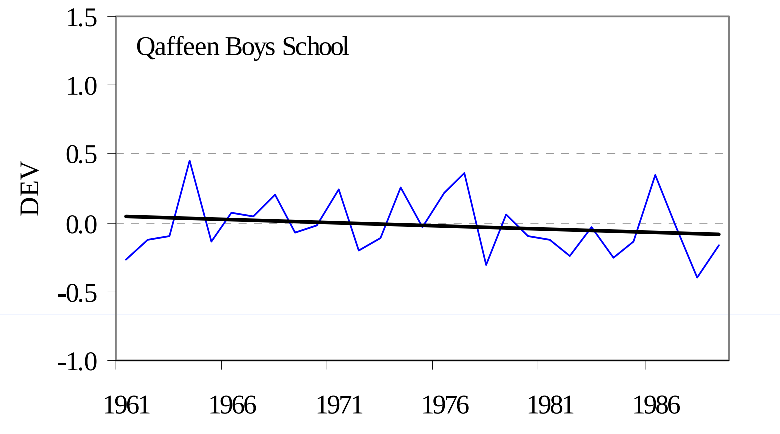
Trends in annual rainfall









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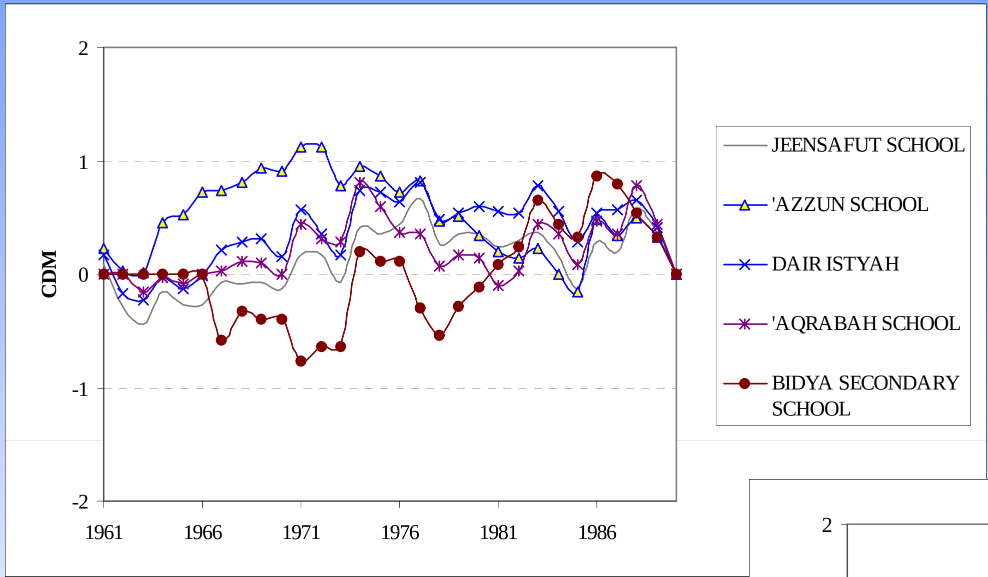
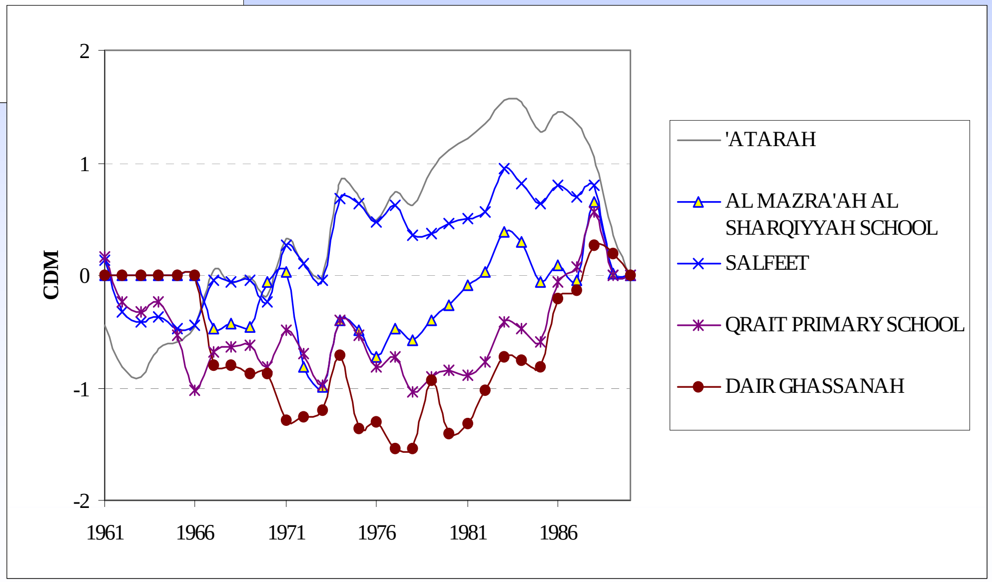
Cumulative departure from the mean (CDM)





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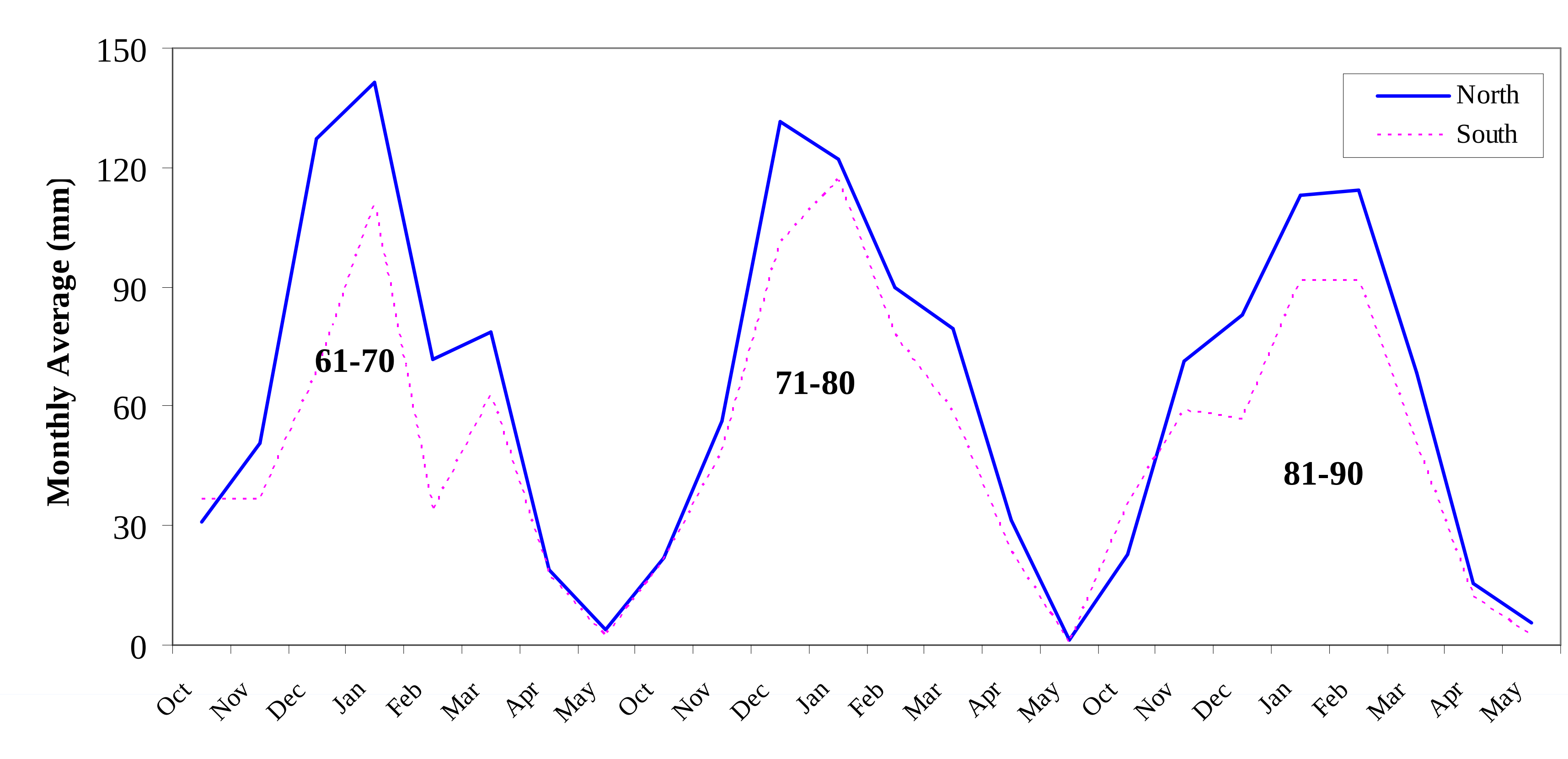
Seasonal pattern of rainfall over the 3 decades



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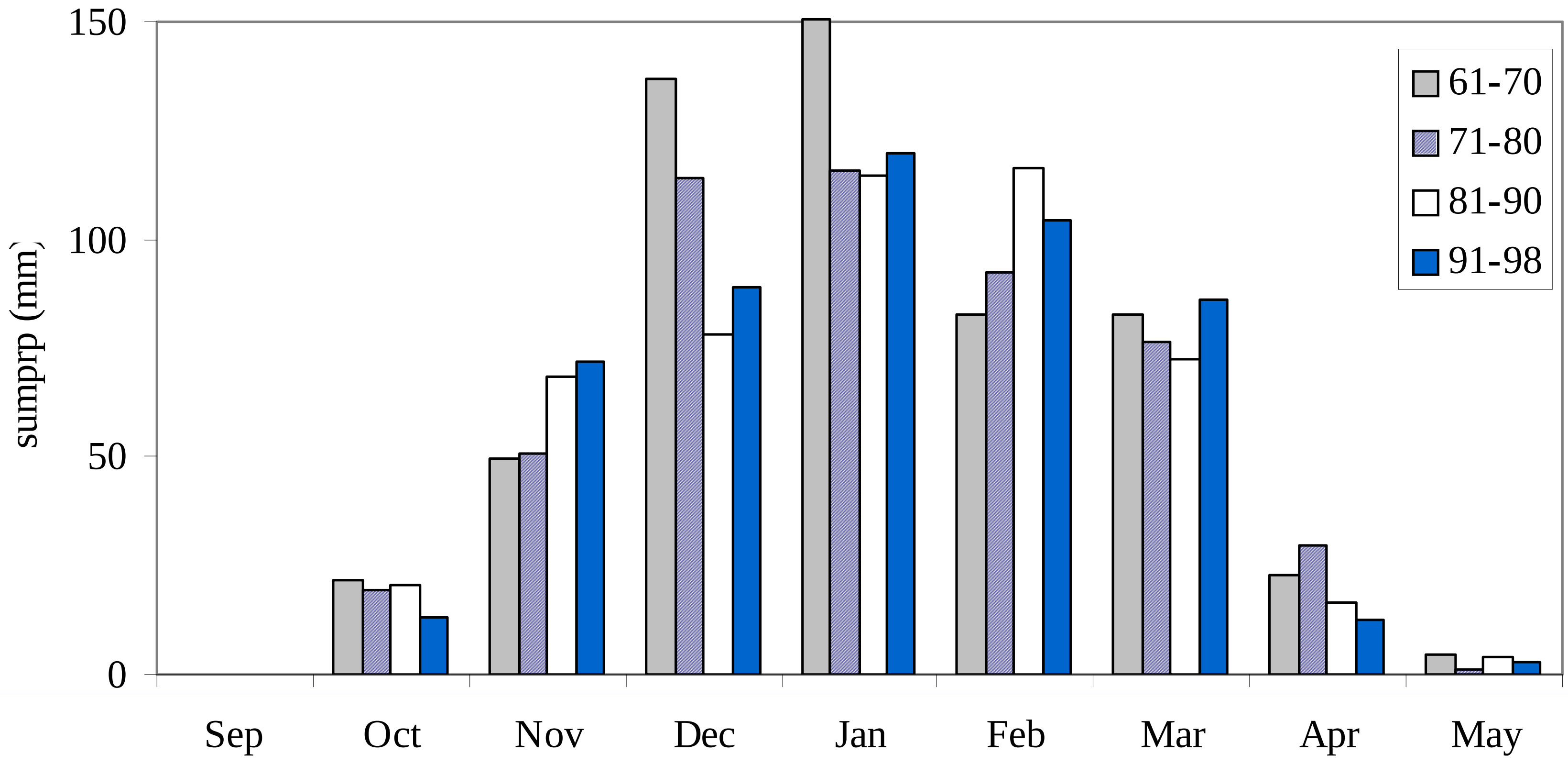
Monthly mean rainfall for the four recent decades



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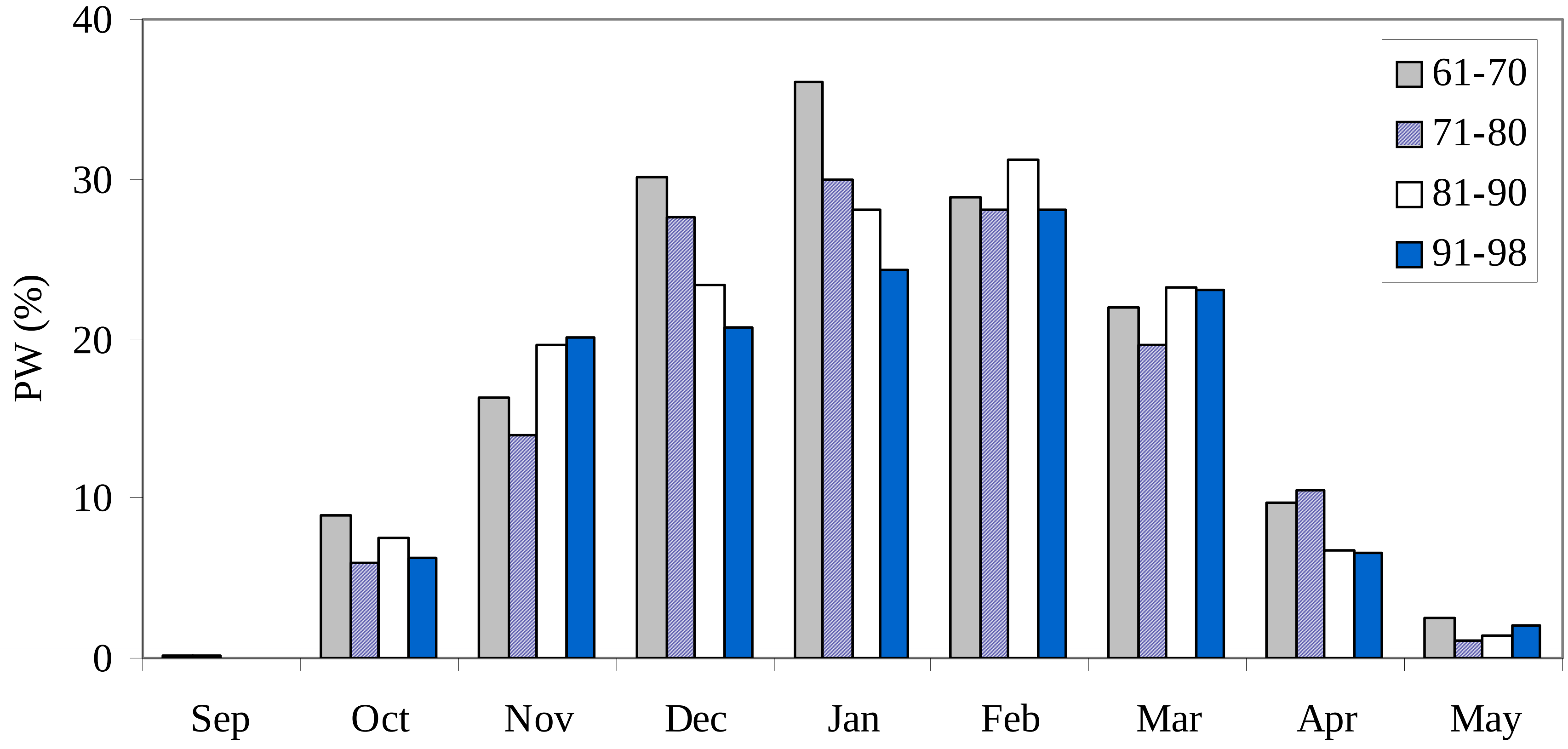
Proportion of wet days for the four recent decades



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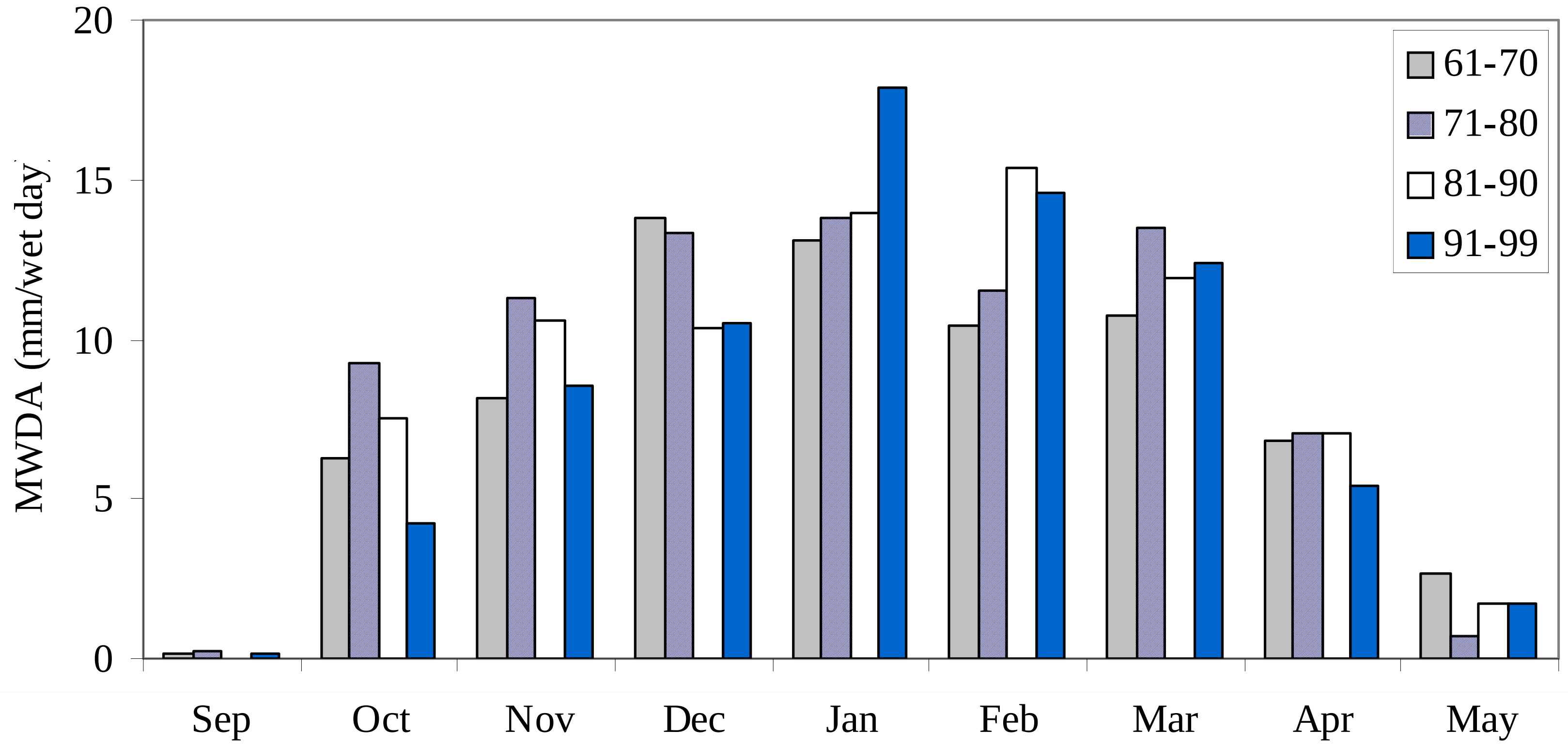
Mean Wet Day Average for the four recent decades



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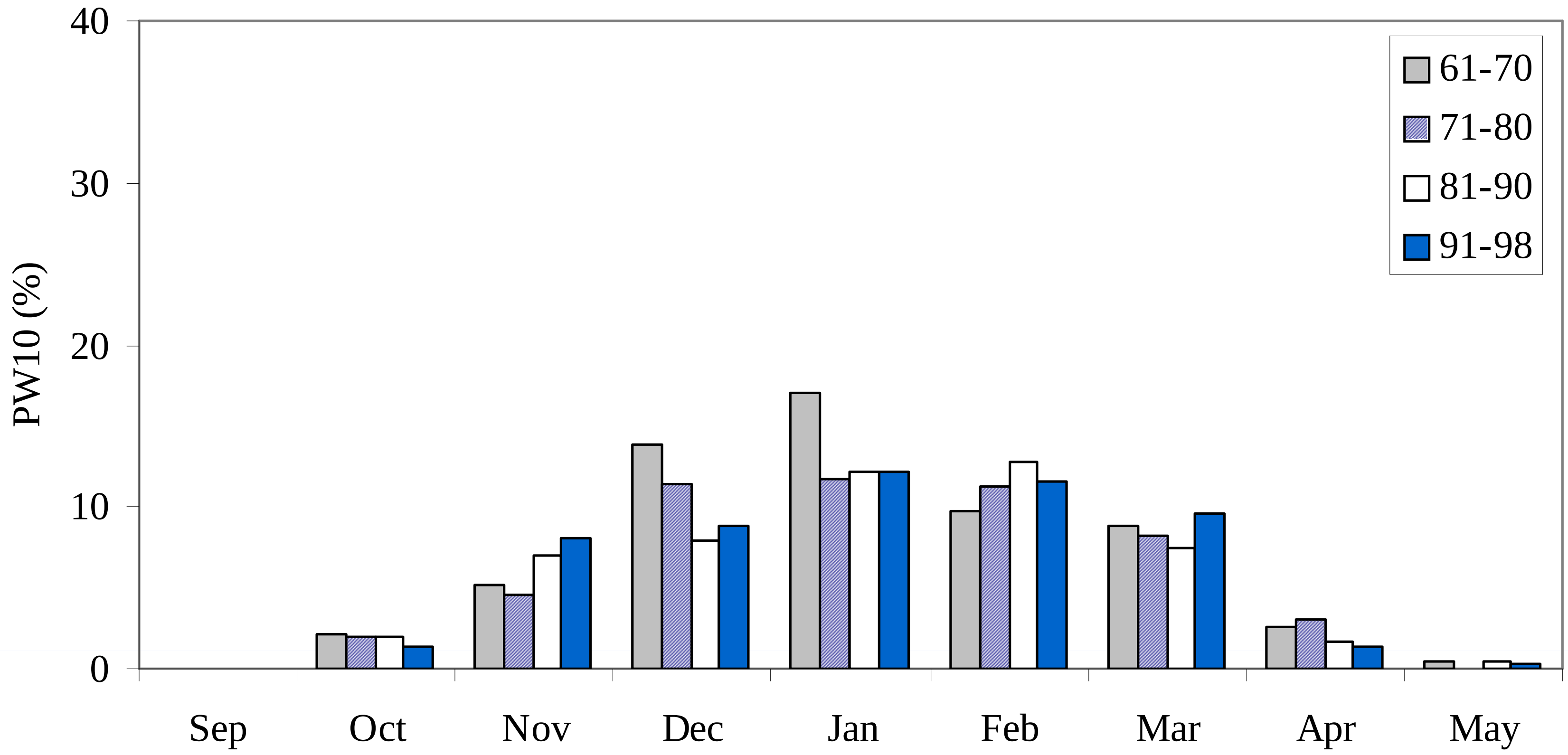
Proportion of days with rainfall greater than 10 mm



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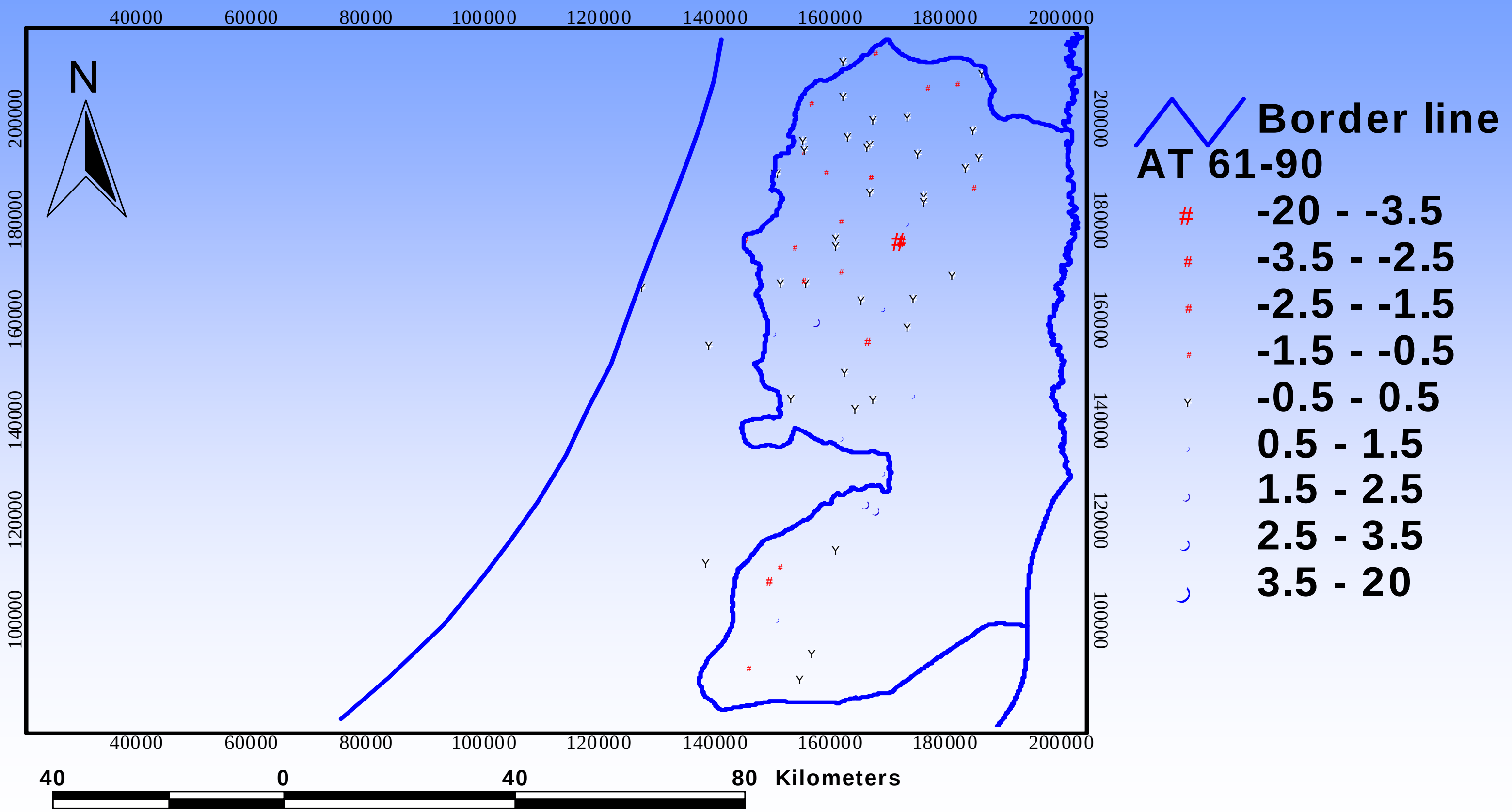
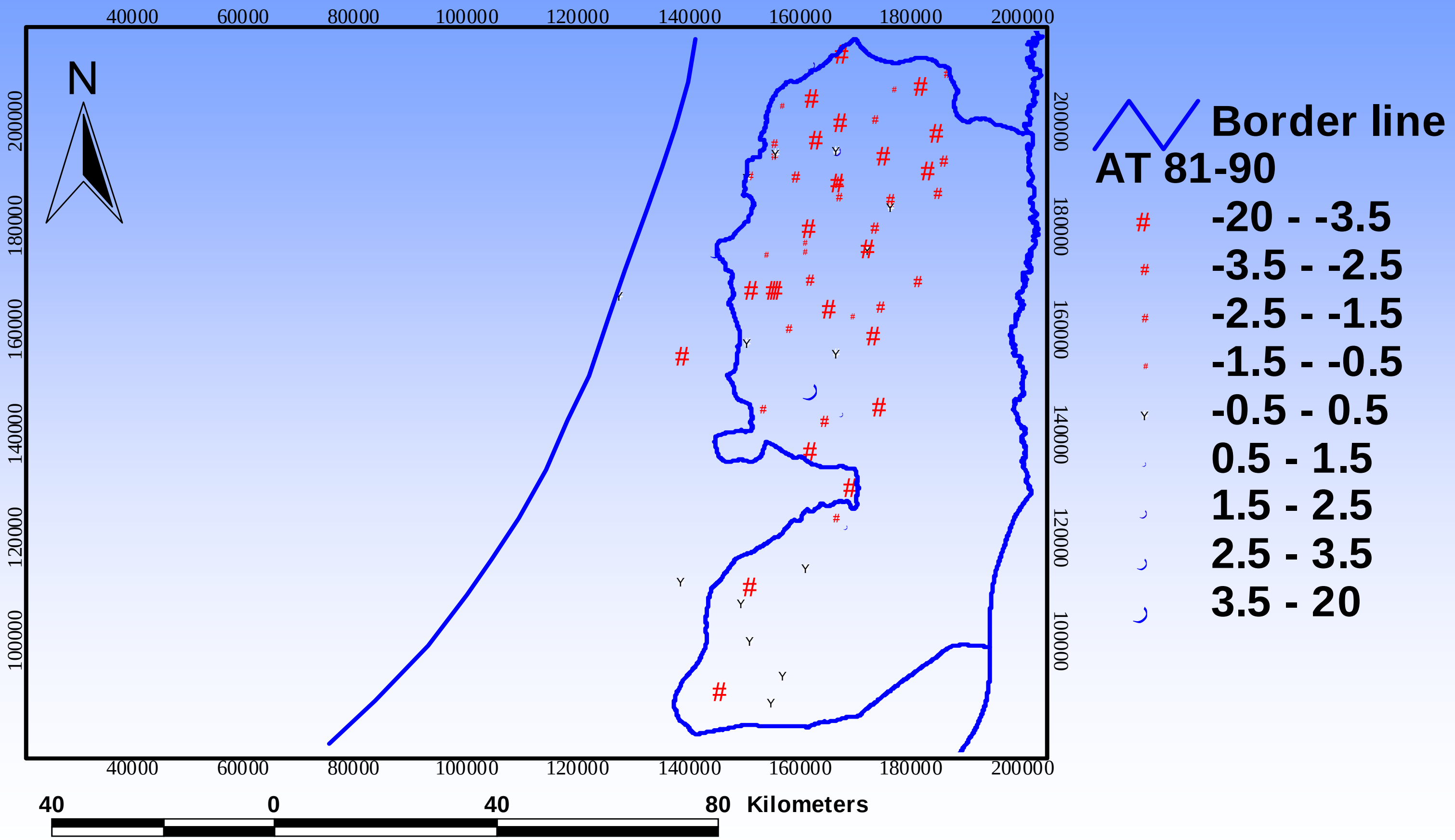
Annual trend observed for the period of 61-90



Annual trend observed for the period of 81-90



Future Climate – Modelling Rainfall in Palestine

- Future climate predictions derived from output from **HadCM3**:
  - the Hadley Centre coupled ocean-atmosphere General Circulation Model (GCM).
- Output is averaged across grid-squares of 300 km x 300 km in size
- Rainfall output is indicative only

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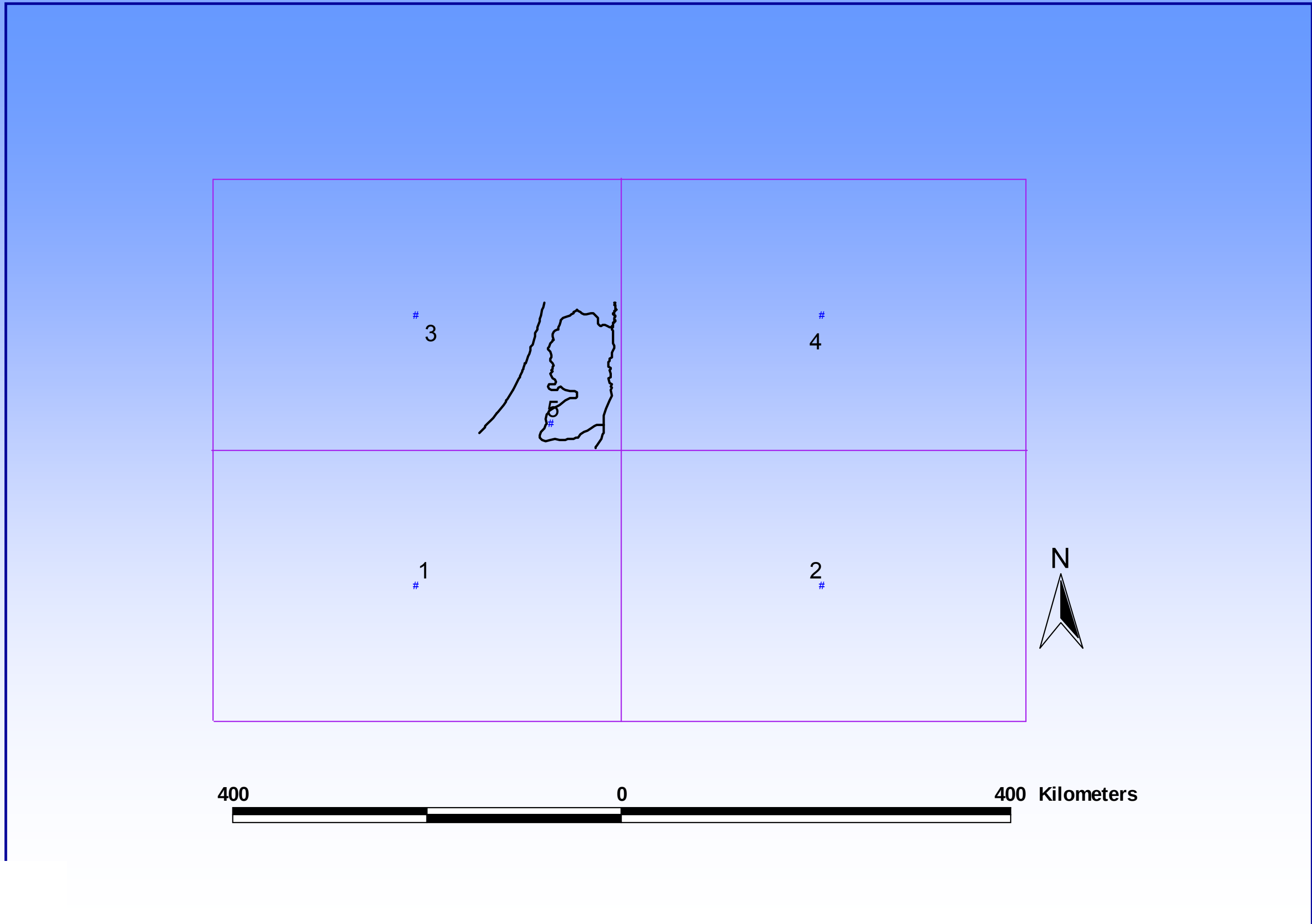
The nearest GCM grid points in the study region



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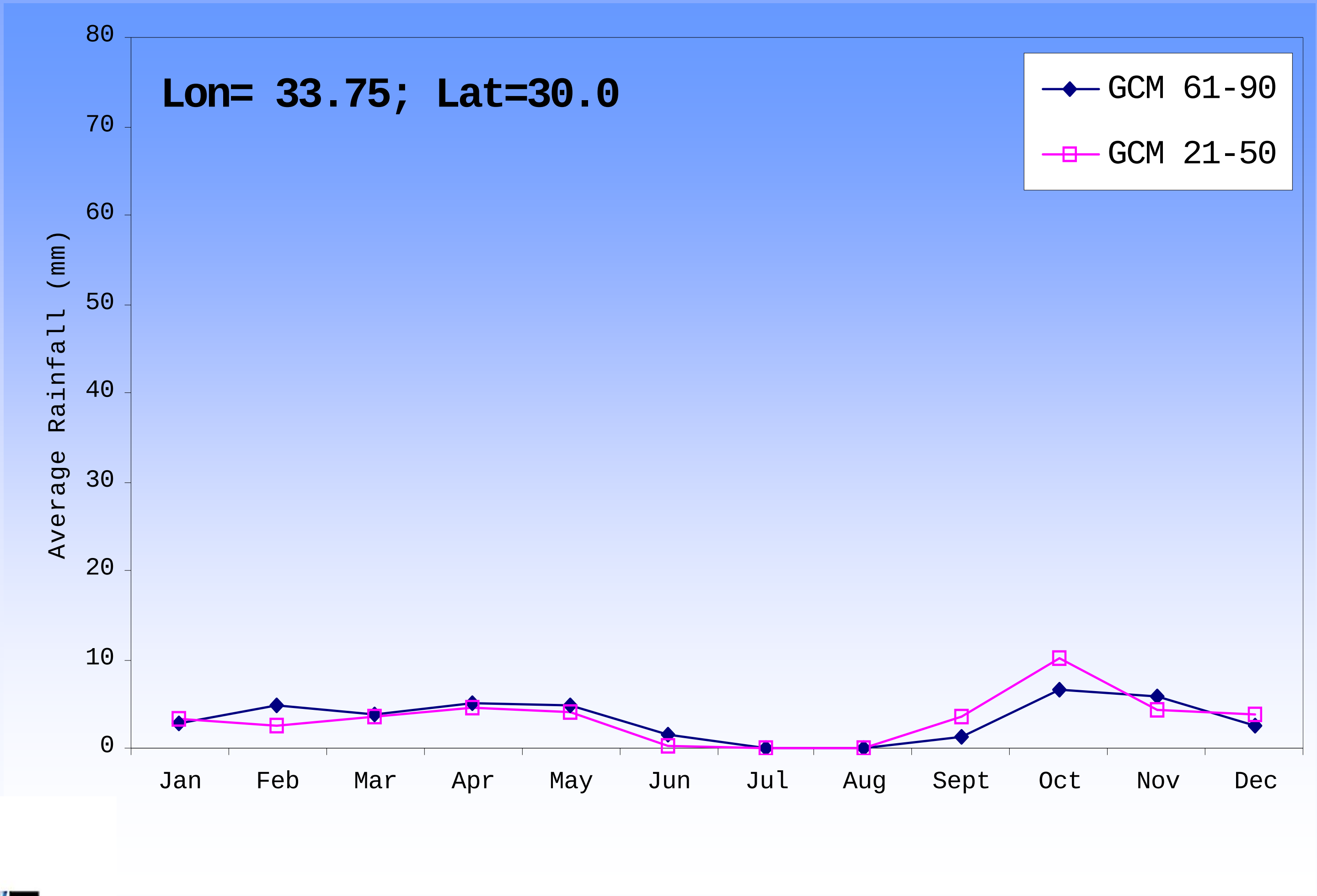
GCM grid point 1



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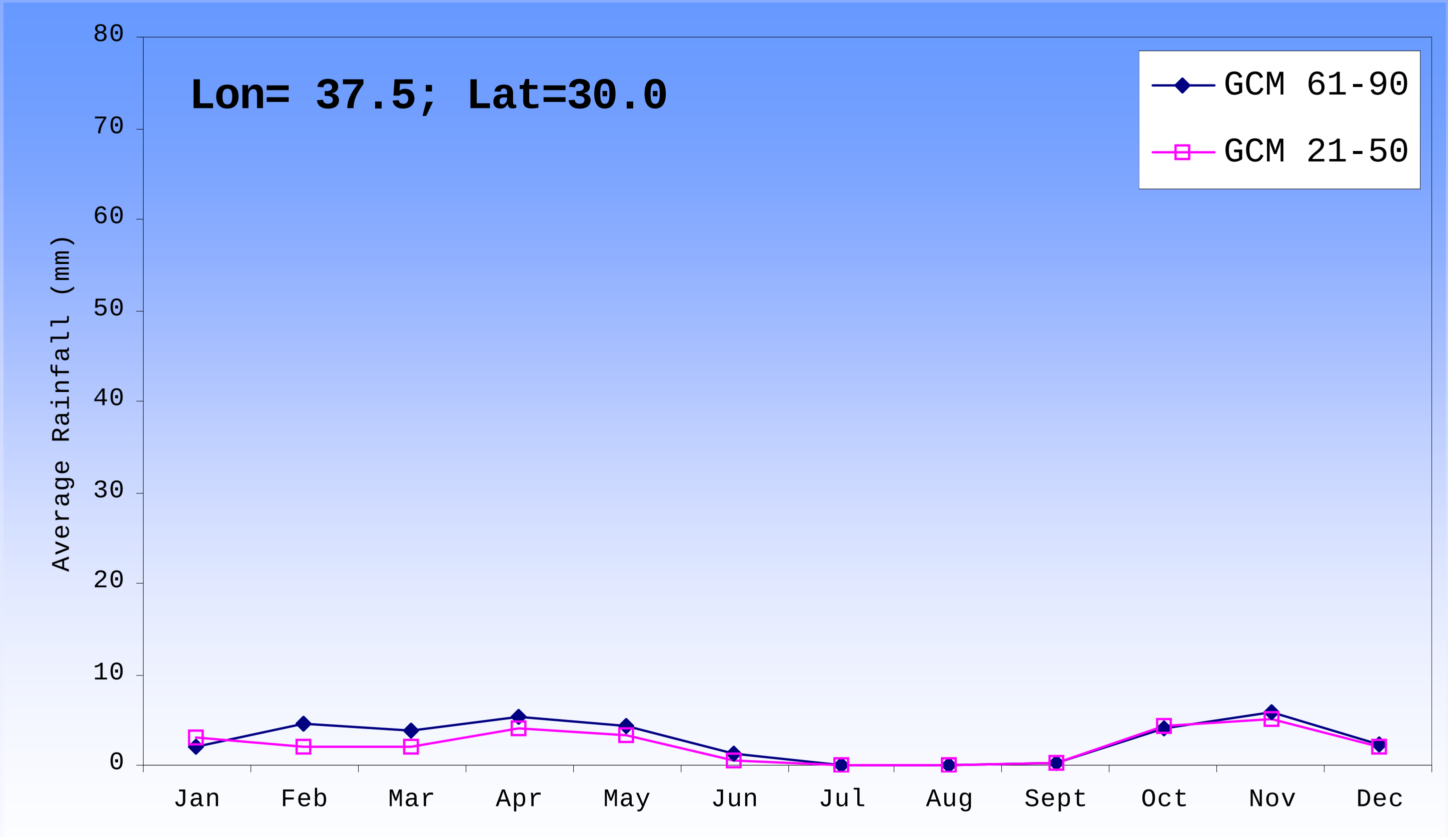
GCM grid point 2



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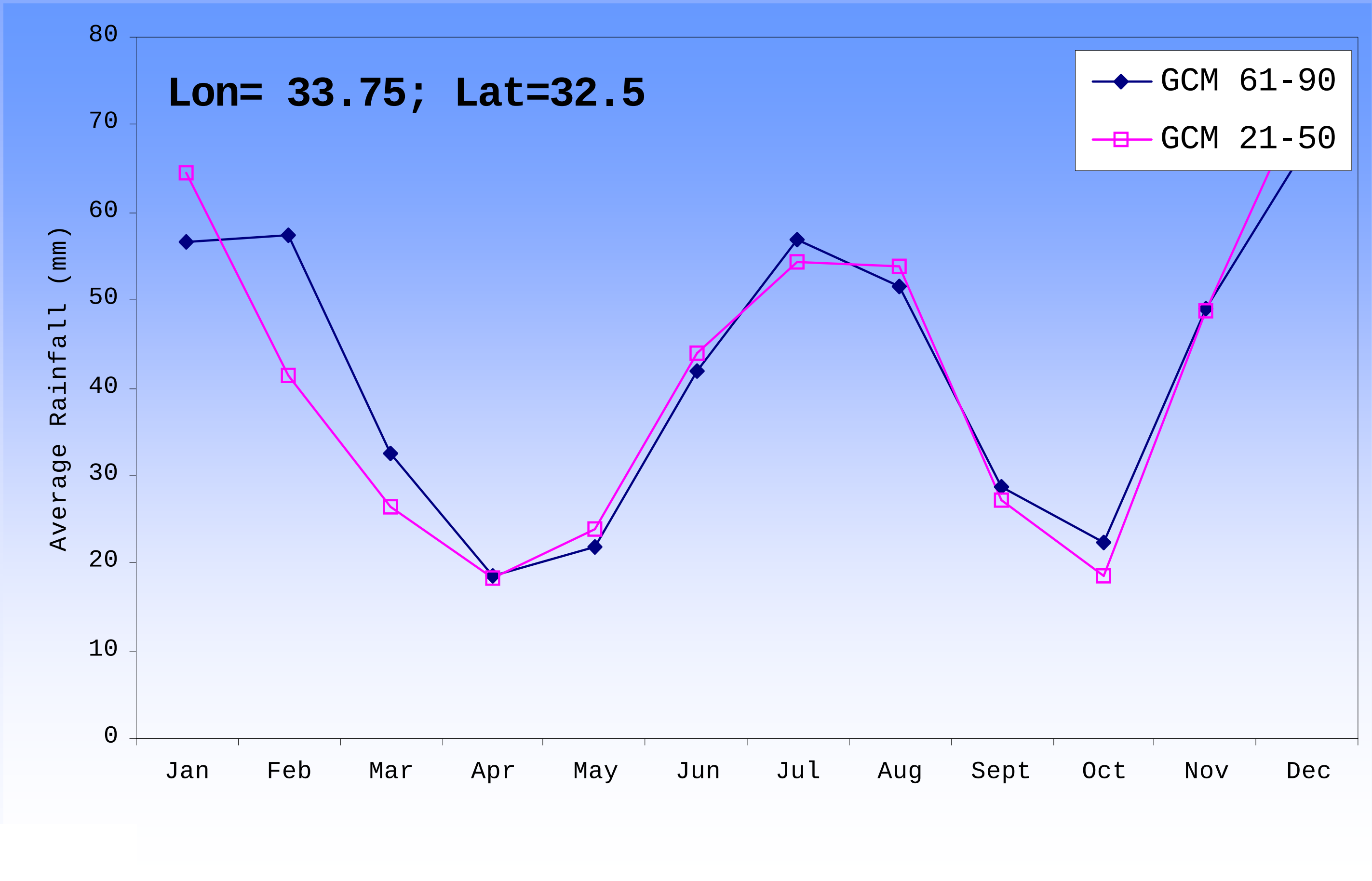
GCM grid point 3



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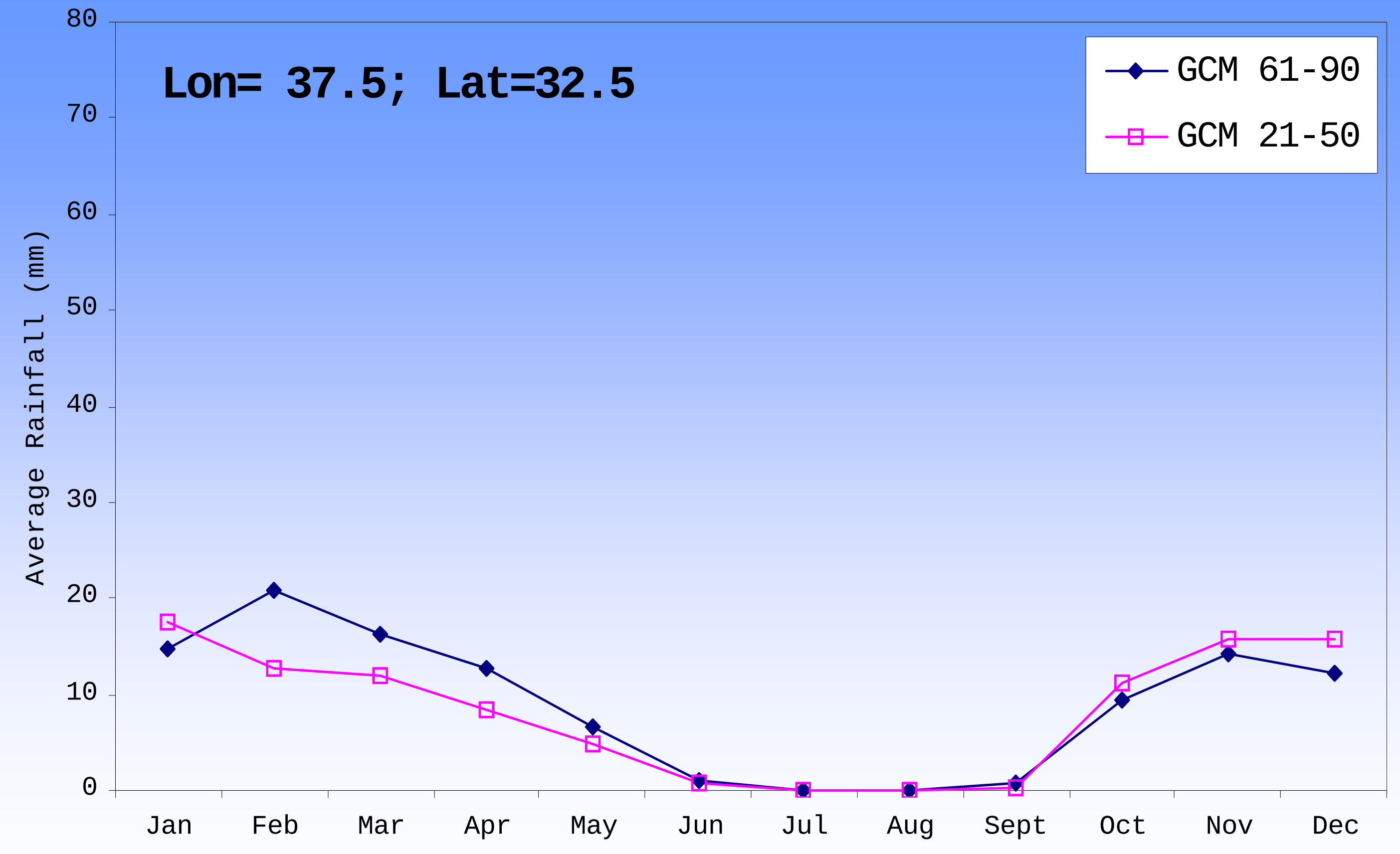
GCM grid point 4



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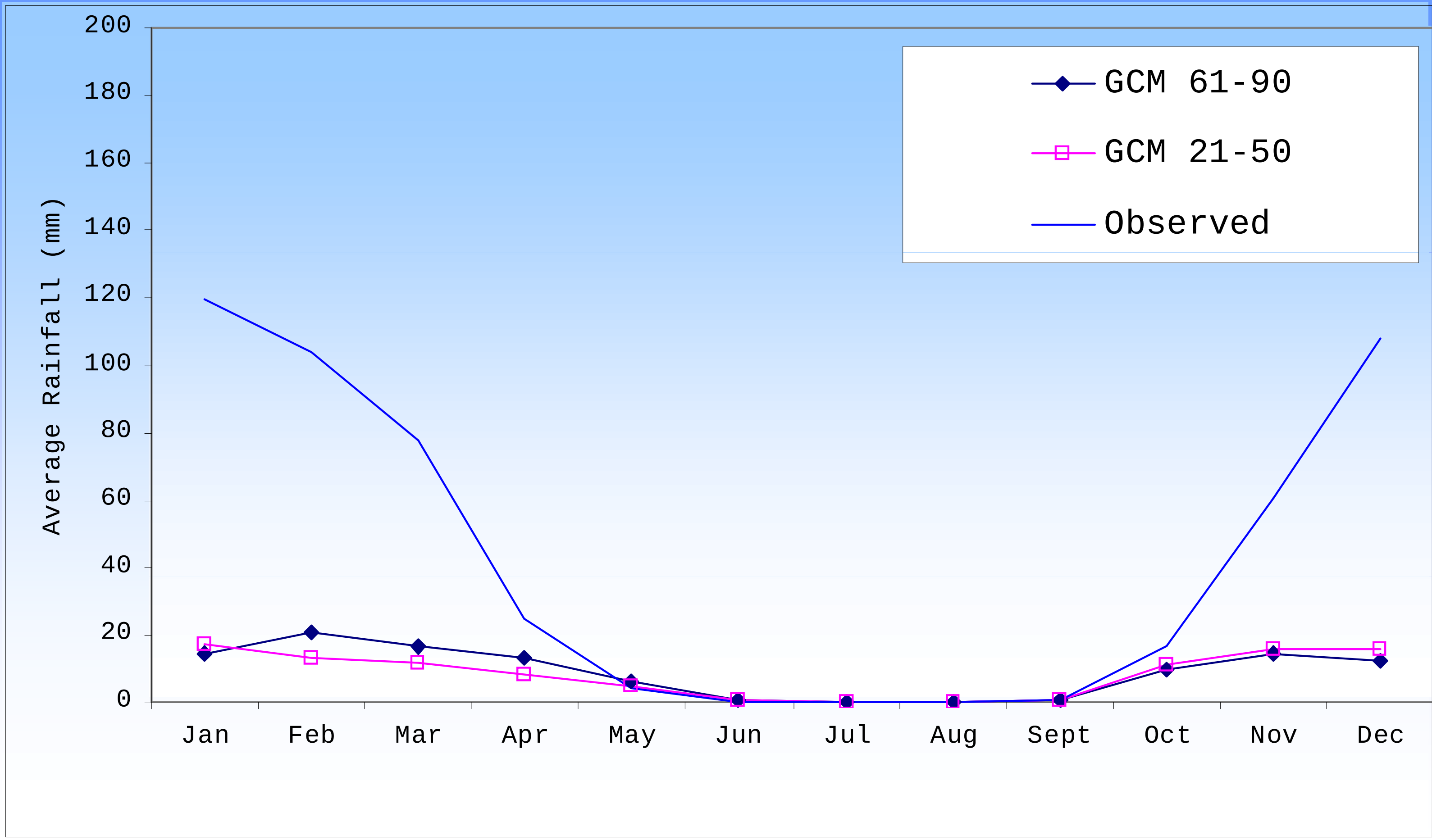
Observed and GCM rainfall – point 5



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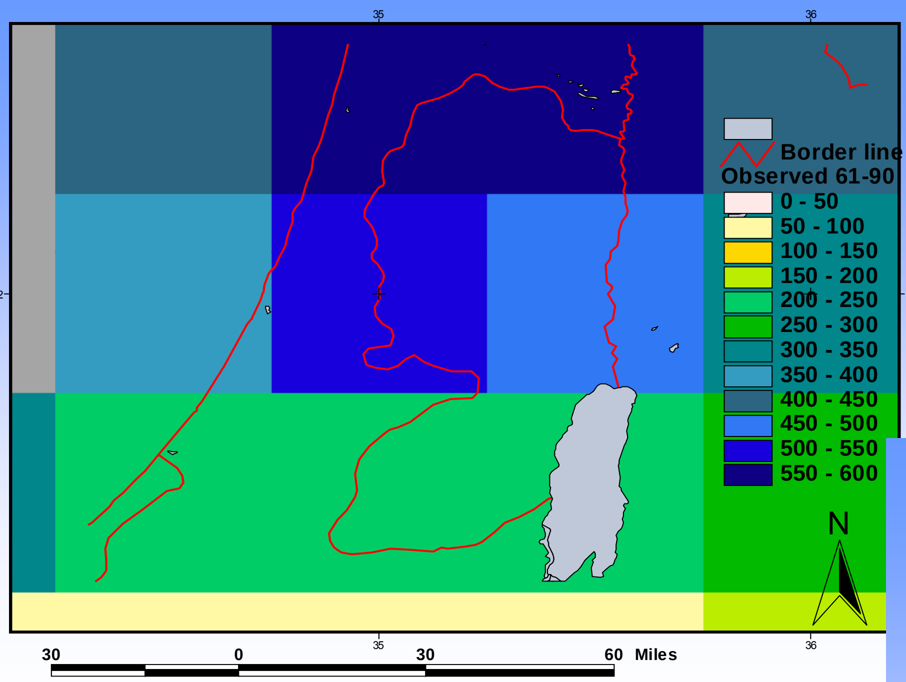
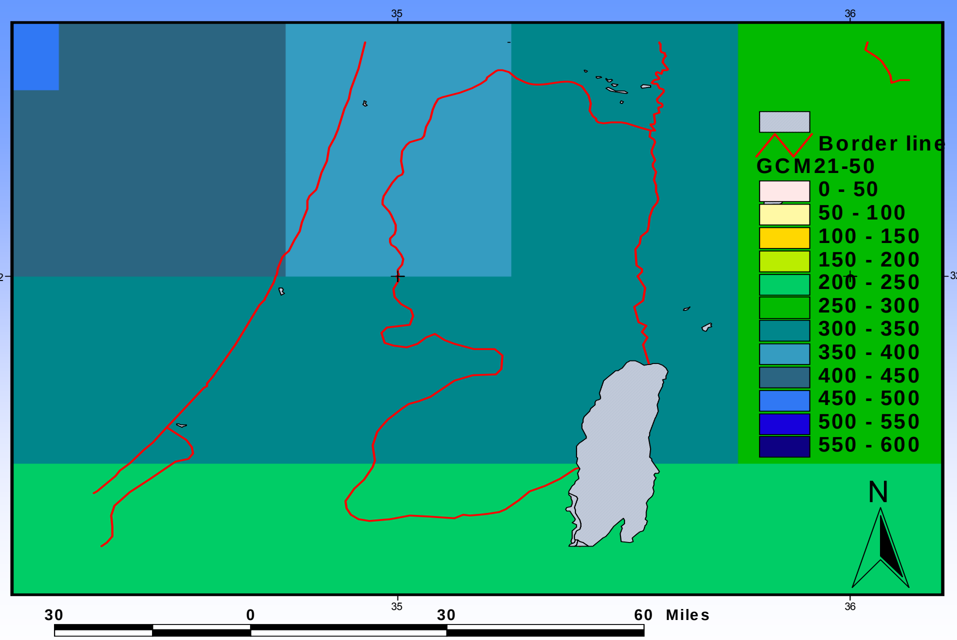
Observed annual rainfall (1961-90)



GCM future annual rainfall (2021-50)



Remarks about modelling rainfall in Palestine

1. ***Spatial and temporal variability of rainfall***

A stochastic space-time rainfall model is required to generate rainfall with required spatial and temporal resolutions

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Remarks (continued)

2. *Trends in rainfall*

- Significant evidence of trends in past rainfall occurrence, amounts and intensities; downwards trend in last decade.

- Predictions for GCMs indicate significant reductions in WB rainfall and increases in evapotranspiration but prediction at large scale.

- The scale needs to be refined for accuracy.

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Remarks (continued)

3. Climate and land use change impact assessment

- Causes of observed changes in rainfall not well understood: possible links between climate and land use changes (such as the Israeli National Carrier which diverted the Jordan River to the Negev).

- Major changes in economy and agriculture likely; can impact rainfall.

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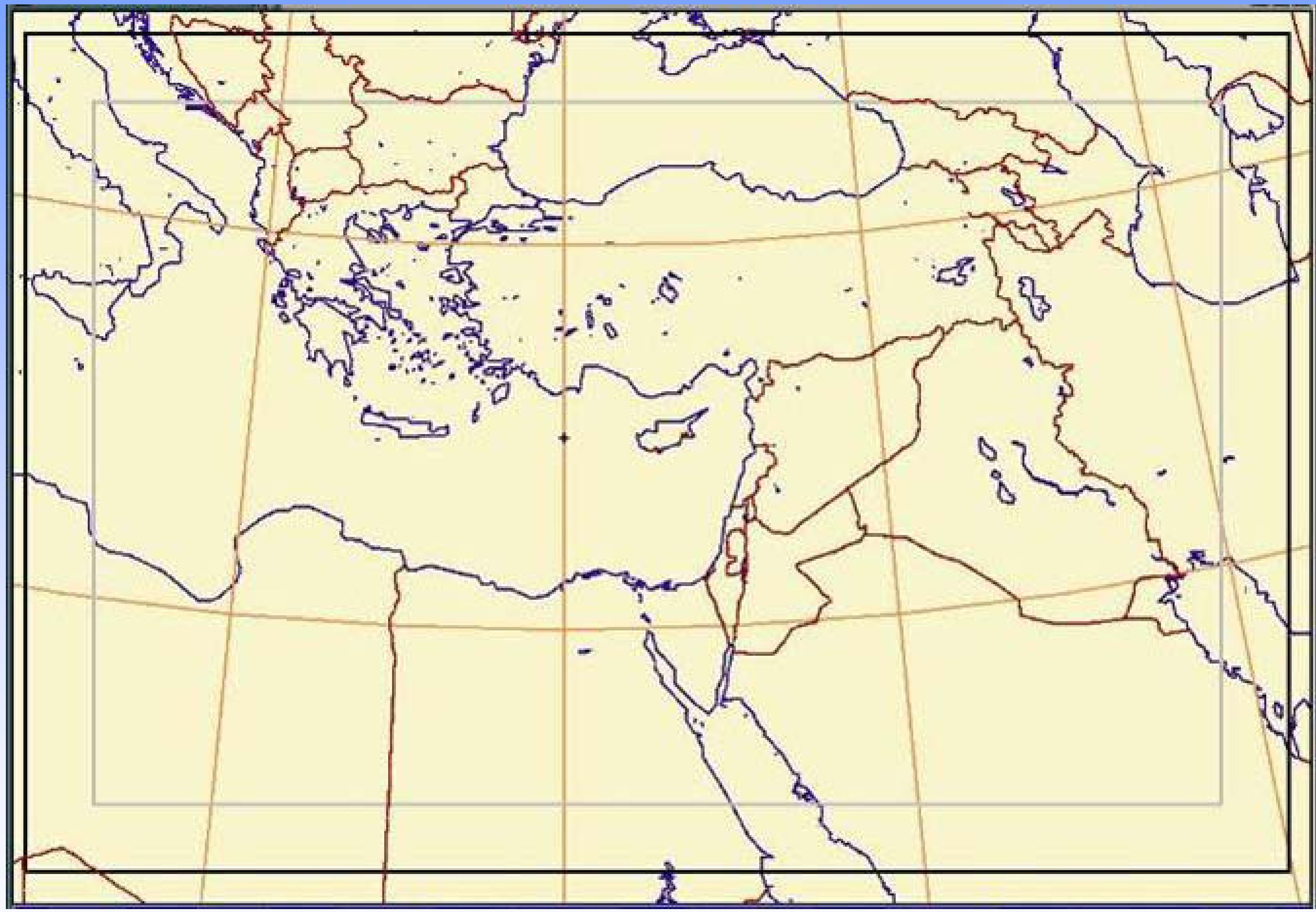
West Bank PRECIS domain



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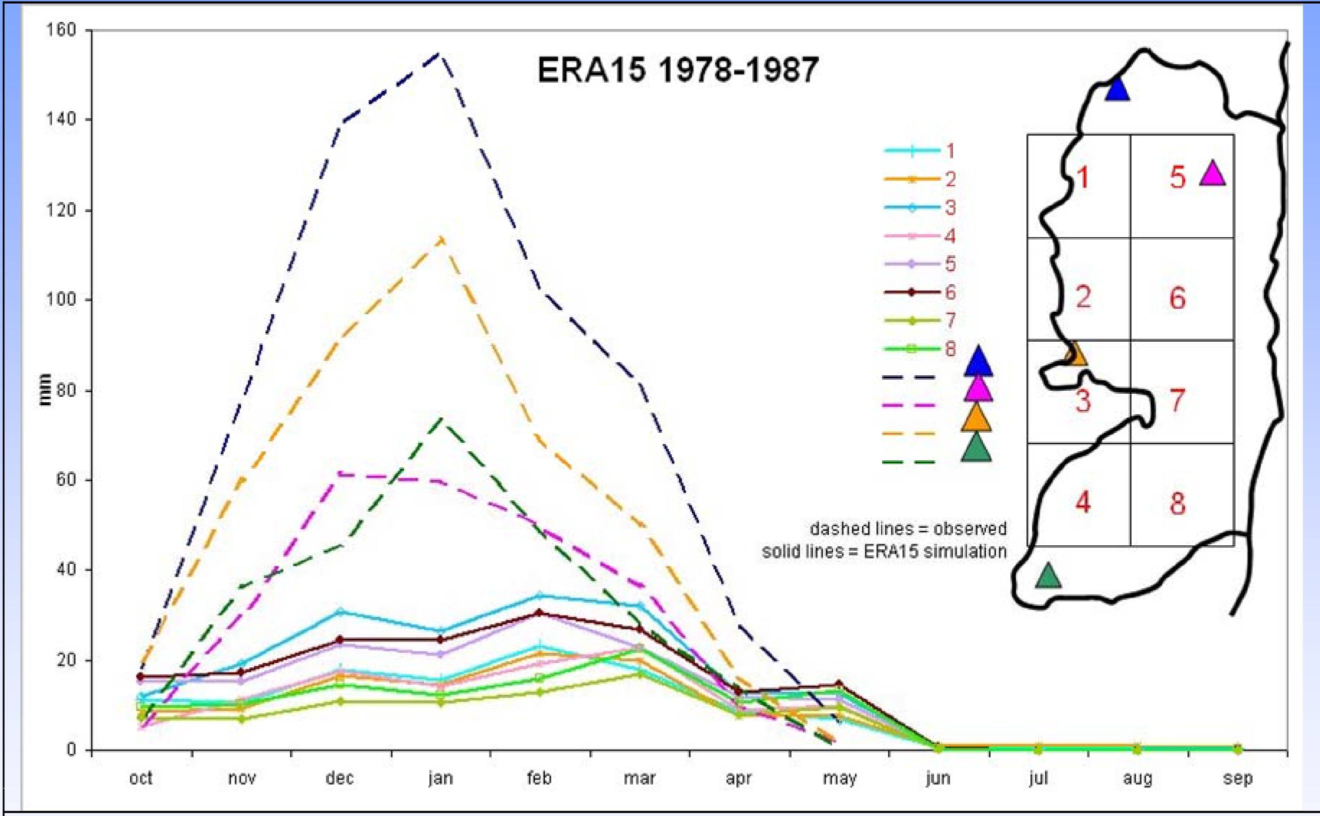
Validation for Control for PRECIS: West Bank Rainfall



Average total precipitation per month (Oct to Sep)

Graph showing observed data (dashed) and location (triangles) compared to simulated ERA15 re-analysis results (solid lines) for grid boxes over the West Bank (numbered)

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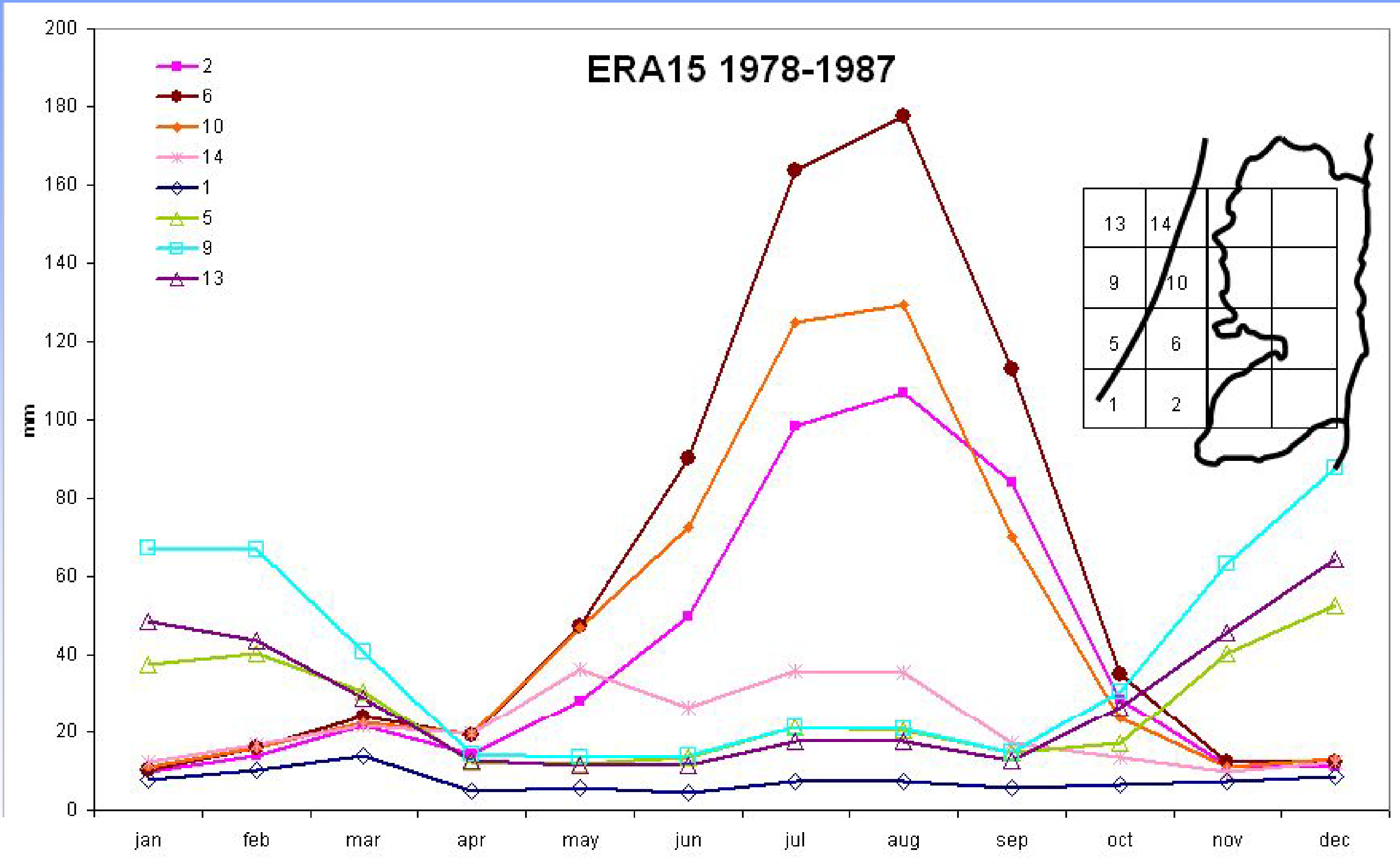
Validation for Control for PRECIS: Coastal Rainfall



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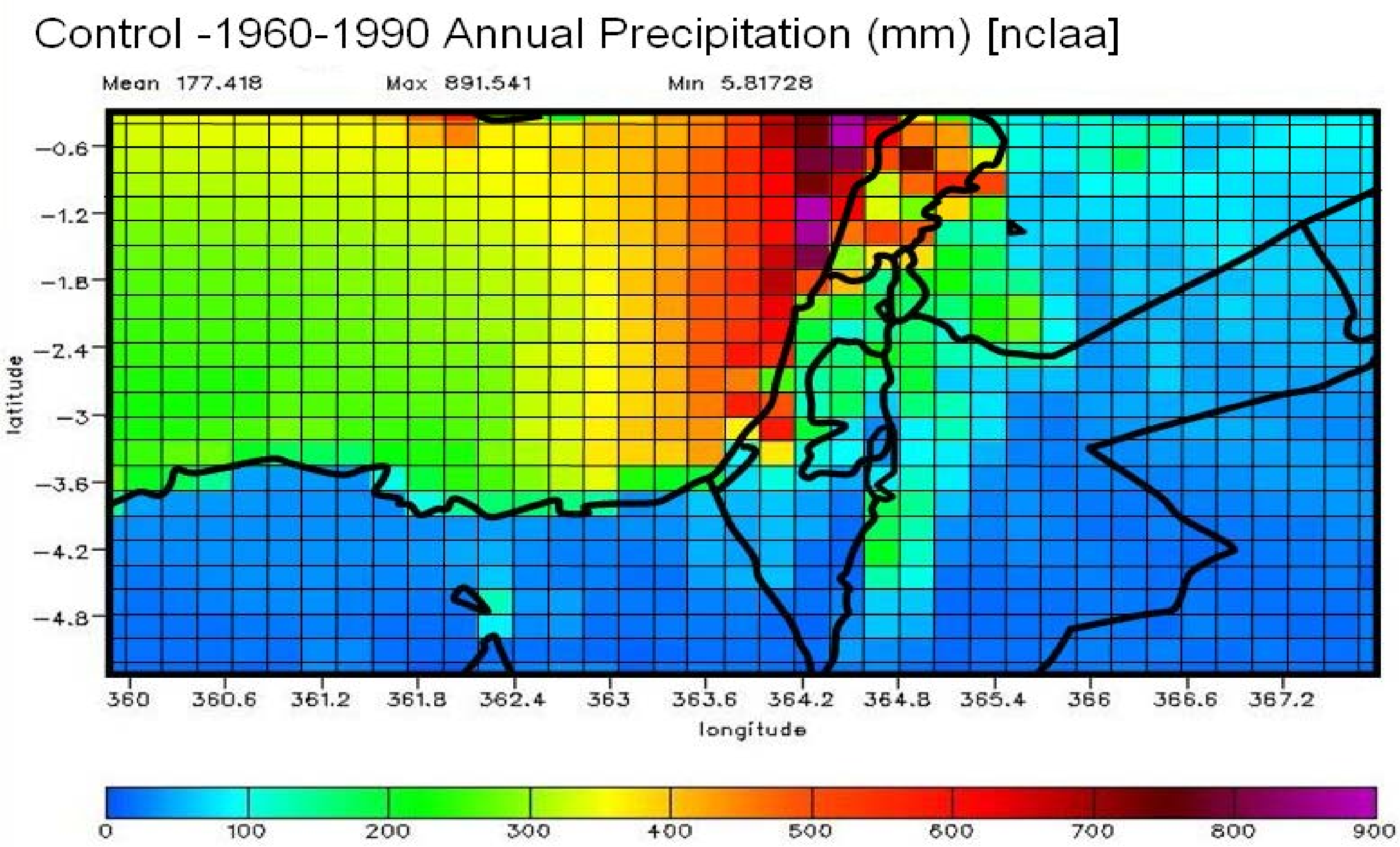
Validation for Control for PRECIS



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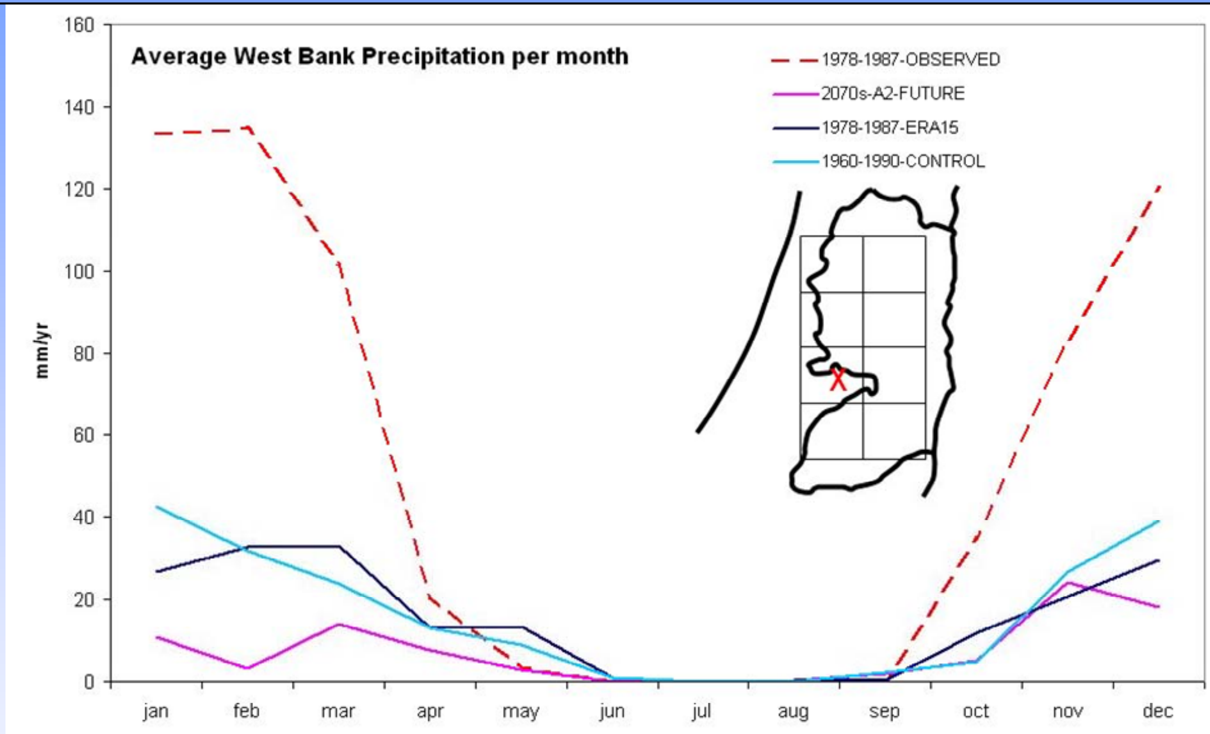
Future simulation from PRECIS



Average total precipitation per month

Comparisons of Observed , ERA15, Control and A2 Future

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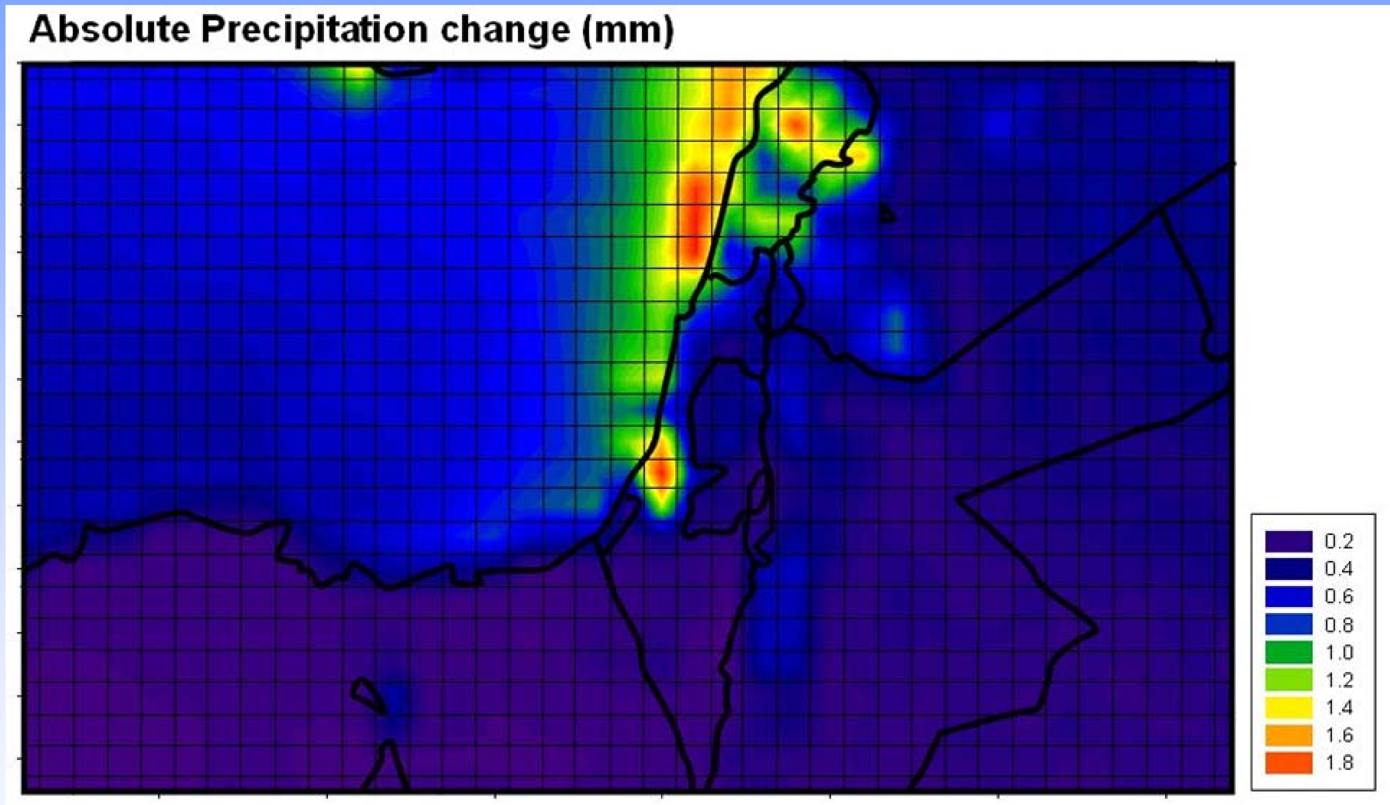
Land Use change simulation from PRECIS



Land use change (precipitation)

a) ERA15-land use change simulation (nclab) b) Absolute differences (mm) for precipitation between ERA15 (nclah) and ERA15 land use change (nclab) simulations

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Impacts and adaptations

- In general, most of the impacts of climate change are expected to amplify projected impacts of anthropogenic stresses resulting from accelerated population growth and a higher standard of living;

- The relative contribution of climate change to the overall impact is not known.

- Therefore, measures to reduce the overall impact are, by default, adaptations to climate change, whose implementation represents a potential win-win strategy.

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Impacts and adaptations

- Increased rain intensity plus a reduction in overall precipitation will diminish vegetation cover and increase surface runoff and desertification.

- Rainfed agricultural fields will become more saline from increased evapotranspiration.

- Measures for combating desertification, such as afforestation, and methods for rehabilitating and regenerating natural vegetation are also adaptations for climate change.

Impacts and adaptations

- Increased surface runoff will increase flash floods during peak waterflows, damaging human structures and crops.
- Possible adaptations include water-sensitive urban planning to reduce surface runoff and promote water infiltration into the soil, and conservation and rehabilitation of natural vegetation in rural areas.

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Impacts and adaptations

- Water supply may fall to 60% of current levels by 2100, due to sedimentation in reservoirs, salinization and reduced aquifer recharge. Increased surface runoff will reduce aquifer recharge; and sea level rise and the intrusion of seawater into the coastal aquifer will further damage groundwater.
- The quality of stored water will degrade due to salinization, and the increased surface runoff will transport dissolved pollutants to waters reservoirs, often causing algal blooms.
- Adaptation: water conservation, reuse of treated wastewater, desalination, cloud seeding etc will serve as future adaptations necessitated by climate change.

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Impacts and Adaptations

- The need to collect and save water for drought years will increase with greater temporal uncertainty. Sufficient adaptation includes better use of recycled water and use of additional water resources.

- In Palestine storage is still far from existence but in a few years time Palestine will face severe drought problems. It is unless we act now we will work without planning.

- Better management of aquifer recharge through water-sensitive urban planning may reduce surface runoff.

- Urban development greatly decreases aquifer recharge and increases the chances of flash flooding and decreases the quantity and quality of freshwater supplies. Using infiltration basins reduces surface runoff and enables aquifer recharge employing relatively inexpensive measures.

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Impacts and Adaptations

- For example, roof-collected water serves both to recharge the aquifer and to reduce the load of municipal drainage systems.
- Since natural vegetation traps soil moisture and reduces surface runoff, conservation of natural and man-made forests may also serve as an adaptation to the projected increase in flash flooding due to climate-change.
- Adaptation to more frequent flooding is improving drainage systems and flood-sensitive urban planning.

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Developing countries are the most vulnerable to climate change

- Impacts are worse - already more flood and drought prone and a large share of the economy is in climate sensitive sectors.
- Lower capacity to adapt because of a lack of financial, institutional and technological capacity and access to knowledge.
- Net market sector effects are expected to be negative in most developing countries.

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Thank you