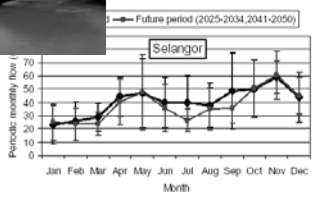
# MALAYSIAN EXPERIENCE IN FINE RESOLUTION REGIONAL CLIMATE PROJECTION FOR VULNERABILITY ASSESSMENT AND ADAPTATION IN THE WAKE OF CLIMATE CHANGE




by

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**National Hydraulic Research Institute of Malaysia (NAHRIM)**

**4 – 7 March 2008, Mexico City**



# OUTLINE

- **INTRODUCTION**
- **MALAYSIAN 2ND NATIONAL COMMUNICATION (NC2)**
- **NAHRIM CLIMATE CHANGE STUDY**
- **RESULTS**
- **WHAT IS NEXT ?**

**UNFCCC Expert Meeting on Methods and Tools and on Data and Observations Under the Nairobi Work Programme on Impacts, Vulnerability and Adaptation to Climate Change**

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# INTRODUCTION

- **Malaysian Initial National Communication for UNFCCC (2000) recommend the need for a Regional Model for finer resolution of global climate simulations.**


Annual rainfall (Peninsular Malaysia) - 2470 mm or 324 billion m3
10.8 billion m3 per annum consumed for domestic, industry and agriculture

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# Observed Climate Change

| | GLOBAL* | | MALAYSIA** |
|---|---|---|---|
| | **1906-2005** | | **1968-2002** |
| **Surface temperature (ºC)** | **0.74** | | **0.49 – 0.91** |
| | 1961-2003 | 1993-2003 | 1986-2006 |
| **Sea level rise (mm/yr)** | **1.8** | **3.1** | **1.25** |

* IPCC 4TH ASESSMENT REPORT (AR4), 2007
** INITIAL NATIONAL COMMUNICATION, 2000
** NATIONAL COASTAL VULNERABILITY INDEX STUDY,DID, 2007



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## National Communication 2 (NC2) [2007-2009]

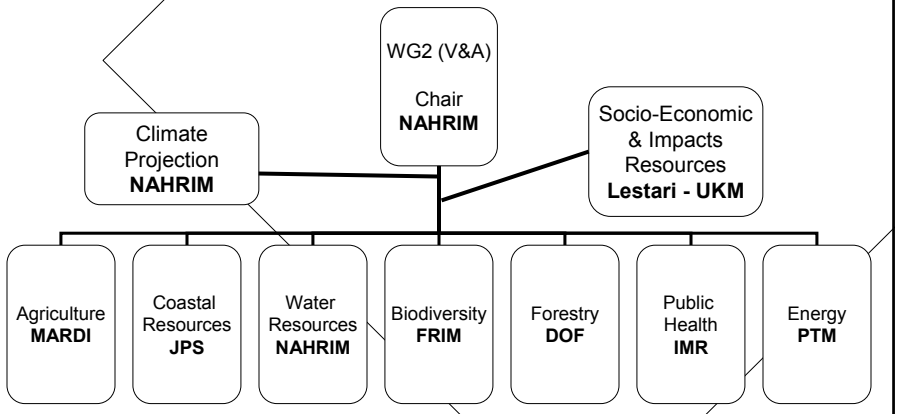
- Preparation of NC2 - to further integrate climate change issues and impacts into the national and local strategic and development plans.

- 3 Working Groups (WG) under NC2:
  - WG 1 - Greenhouse Gases (GHGs) Inventory
  - WG 2 - Vulnerability Assessment & Adaptation (V&A)
  - WG 3 - Mitigation



WG2 (V&A) - chaired by NAHRIM

- to undertake an assessment of potential impacts of climate change on several vulnerable sectors
- to formulate corresponding adaptation measures

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- **Malaysia climate projections in the coming years required in assessing vulnerability and adaptation for various sectors:**
  - **NAHRIM, Malaysian Meteorological Department (MMD) and UKM actively looking at climate change projections in Malaysia.**
  - **RegHCM-PM - NAHRIM's Regional Hydro-climate Model of Peninsular Malaysia (completed in 2006) will be the current basis for the vulnerability assessment and consequent adaptation measures for the 7 vulnerable sectors.**
  - **Similar study started for East Malaysia (Sabah and Sarawak) - July 2007**



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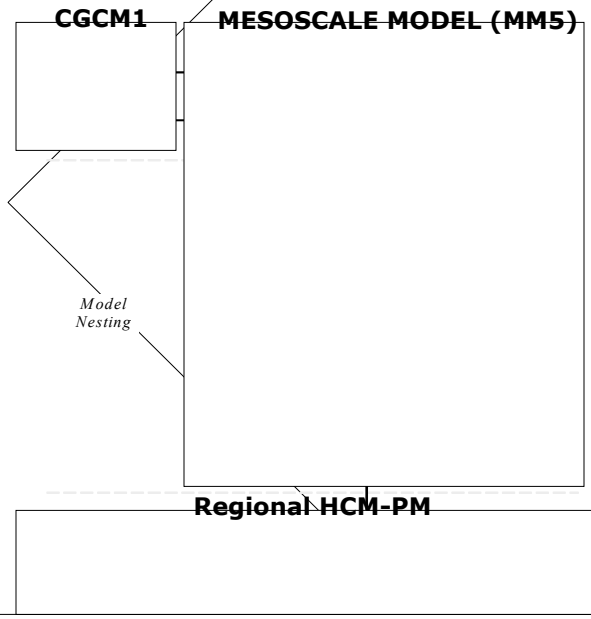
# NAHRIM REGIONAL HYDROCLIMATE MODEL

- A regional hydrologic-atmospheric model of Peninsular Malaysia called as '**Regional Hydroclimate Model of Peninsular Malaysia (RegHCM-PM)'** was developed
- Downscaling global climate change simulation data (Canadian GCM1 current and future climate data) that are at very coarse resolution (~ 410km), to Peninsular Malaysia at fine spatial resolution (~9km).
- Able to quantify the impact of the complex topographical and land surface features of Peninsular Malaysia on its climate conditions.



## NAHRIM Regional Scale Model Configuration

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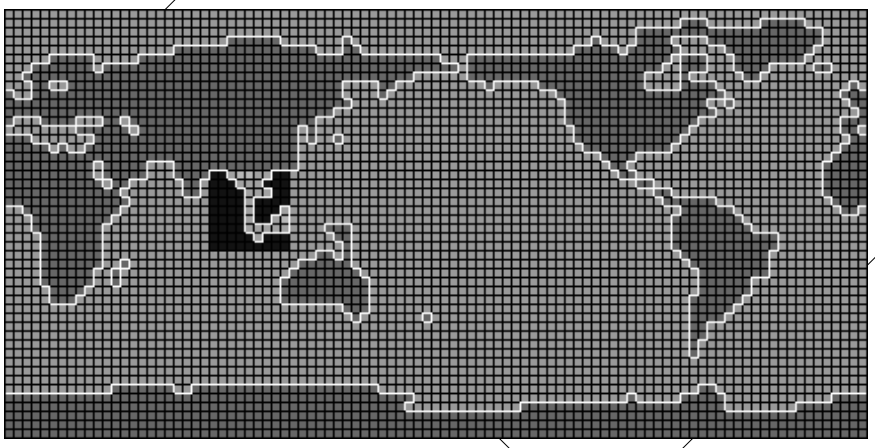
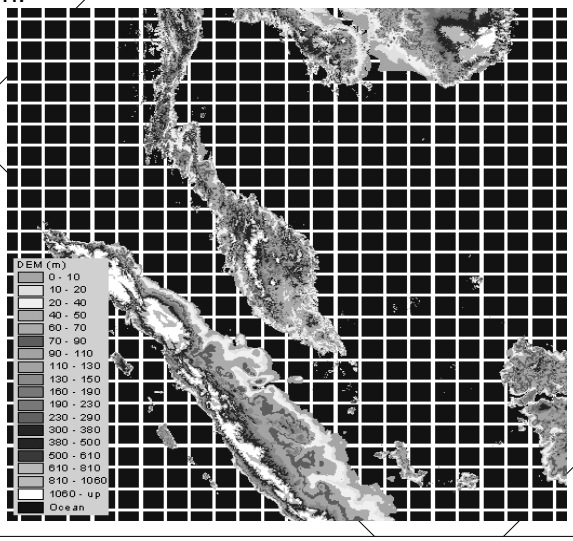
**Data grid of CGCM1 that were used in the RegHCM-PM. The ocean grids which are used in the RegHCM-PM are shown as blue. The land grids which are used in the RegHCM-PM are shown as green.**





The grid layout for the outer domain (1st Domain, 26x28 grids, 81 km resolution) of the RegHCM-PM under Mercator projection.



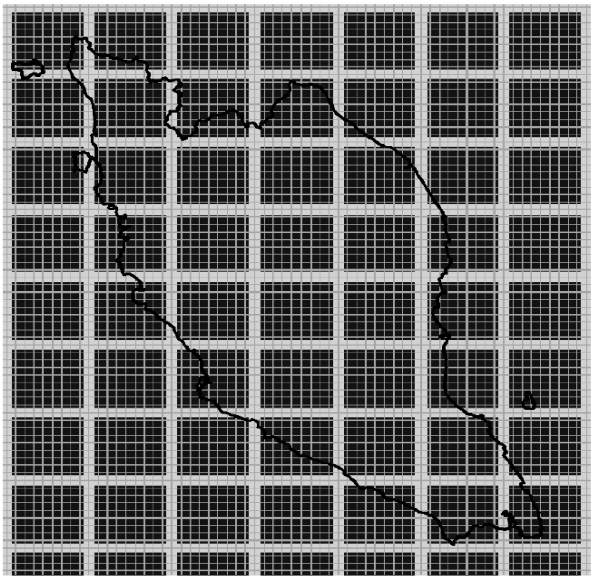
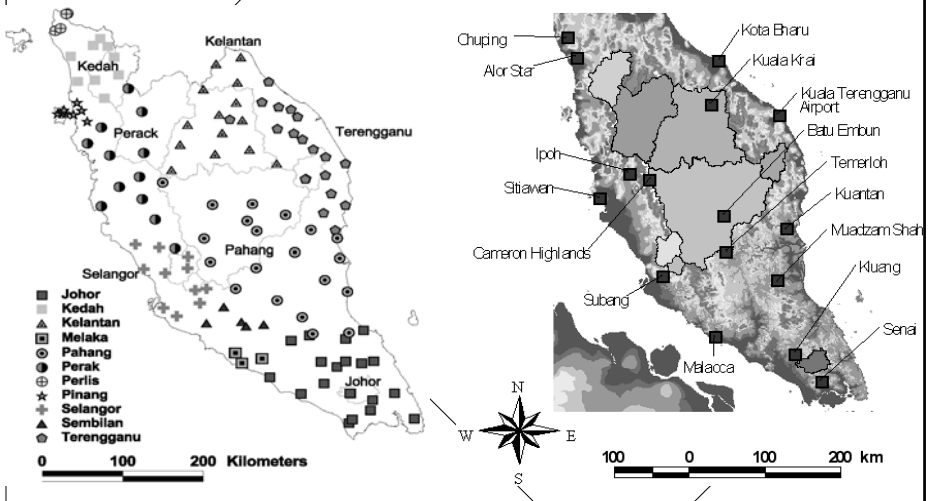


Figure 17 - Nested grids of the inner and the outer domains of RegHCM-PM under Mercator projection. The boundaries of the Peninsular Malaysia and nearby islands are overlaid on the grids.



The Map in the left shows the rain gages that were used in the validation, and the map on the right shown the locations of weather station at which the temperature data were used for validation

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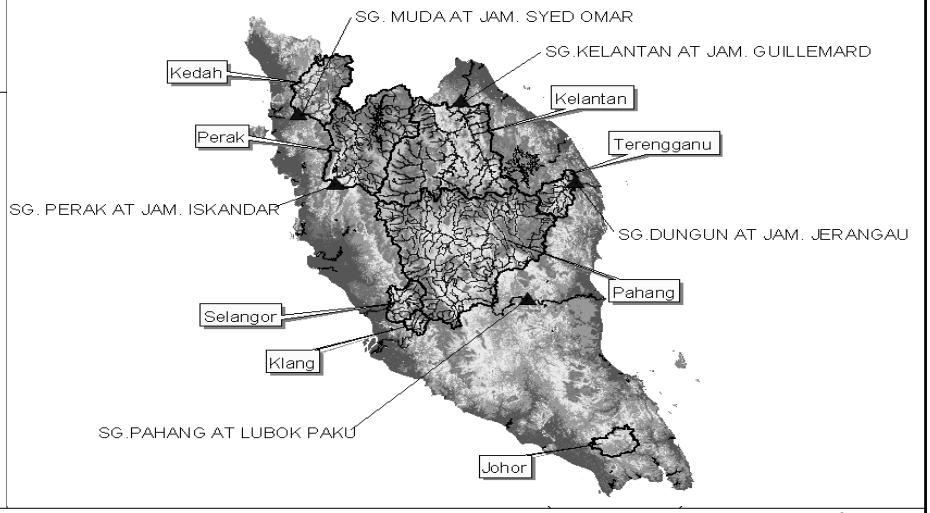
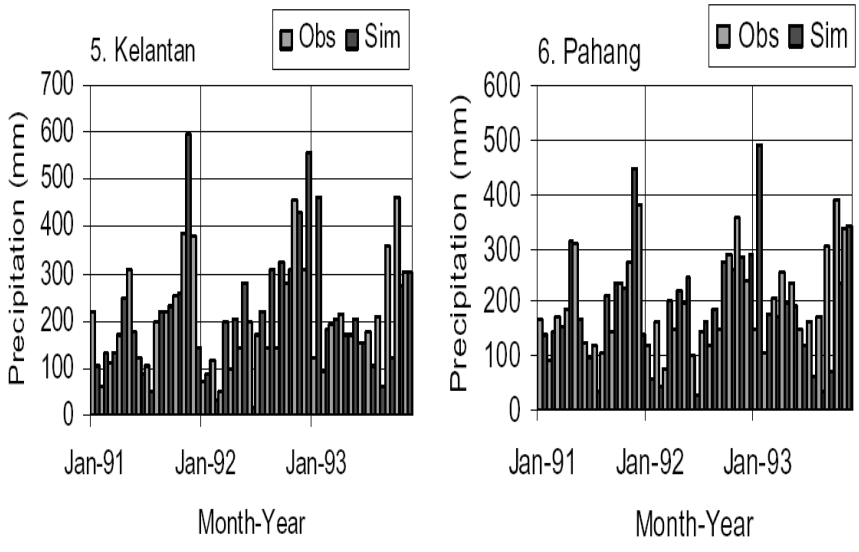
# Locations of the selected stream gauging stations and watersheds






## Validation of Simulated Precipitation with Observed Precipitation



## Validation of Simulated Streamflow with Observed Streamflow

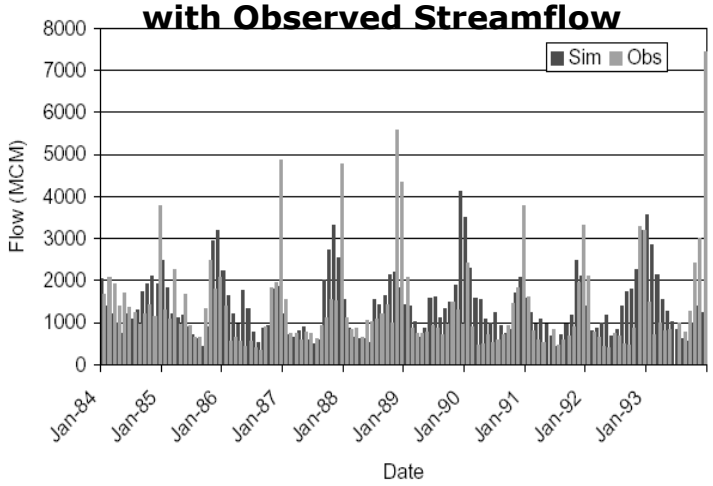



Figure 58 - Observed monthly mean flow and simulated monthly mean flow at Jam. Guillemard, Kelantan (region no. 5).



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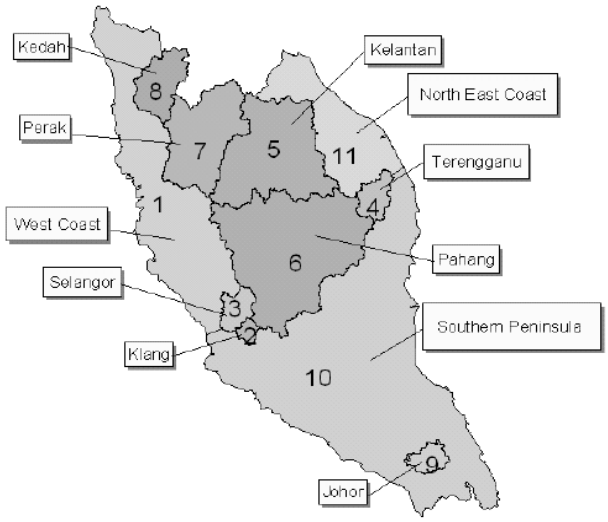
# Selected Sub-regions in Peninsular Malaysia






# Table A: Summary of Monthly Air Temperature

| Subregion Name | | West Coast | Klang | Selangor | Teren-gganu | Kelan-tan | Pahang |
|---|---|---|---|---|---|---|---|
| Maximum Monthly Air Temp (deg C) | Historical | 28.9 | 27.7 | 27.7 | 28.2 | 28.0 | 28.3 |
| | Future | 30.7 | 29.7 | 29.5 | 29.9 | 29.6 | 29.9 |
| | Increase | 1.8 | 2.0 | 1.8 | 1.7 | 1.6 | 1.6 |
| | % Increase | 6.2% | 7.2% | 6.5% | 6.0% | 5.7% | 5.7% |
| Mean Monthly Air Temp (deg C) | Historical | 27.3 | 26.5 | 26.4 | 25.5 | 25.3 | 26.1 |
| | Future | 28.6 | 27.9 | 27.8 | 26.8 | 26.5 | 27.4 |
| | Increase | 1.3 | 1.4 | 1.4 | 1.3 | 1.2 | 1.3 |
| | % Increase | 4.7% | 5.3% | 5.3% | 5.1% | 4.7% | 5.0% |
| Minimum Monthly Air Temp (deg C) | Historical | 24.9 | 24.8 | 24.7 | 21.9 | 21.0 | 22.8 |
| | Future | 26.2 | 25.5 | 25.4 | 23.1 | 22.4 | 24.1 |
| | Increase | 1.3 | 0.7 | 0.7 | 1.2 | 1.4 | 1.3 |
| | % Increase | 5.2% | 2.8% | 2.8% | 5.5% | 6.7% | 5.7% |

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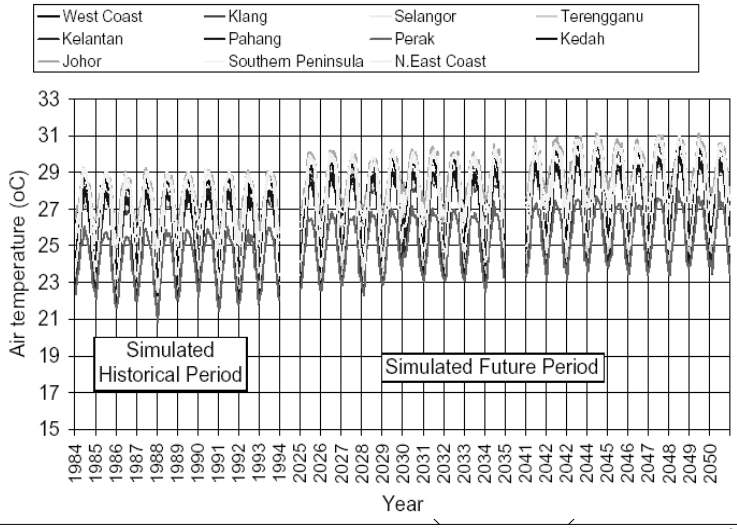
## Table A.1: Average Annual Mean Temperature

| REGIONS | SUB-REGIONS | HISTORICAL (1984-1993) | FUTURE (2025-2024) & (2041-2050) | INCREASE |
|---|---|---|---|---|
| North West Region | West Coast | 27.25 | 28.61 | 1.36 |
| | Perak | 24.14 | 25.43 | 1.29 |
| | Kedah | 26.01 | 27.31 | 1.30 |
| North East Region | Northeast Coast | 26.39 | 27.60 | 1.21 |
| | Terengganu | 25.53 | 26.76 | 1.23 |
| | Kelantan | 25.32 | 26.54 | 1.22 |
| Central Region | Klang | 26.48 | 27.87 | 1.40 |
| | Selangor | 26.44 | 27.82 | 1.39 |
| | Pahang | 26.13 | 27.41 | 1.28 |
| Southern | Johor | 27.69 | 29.07 | 1.38 |



Simulated monthly mean air temperatures at every subregion of Peninsular Malaysia during the simulated historical (1984-1993) and future (2025-2034 and 2041-2050) periods

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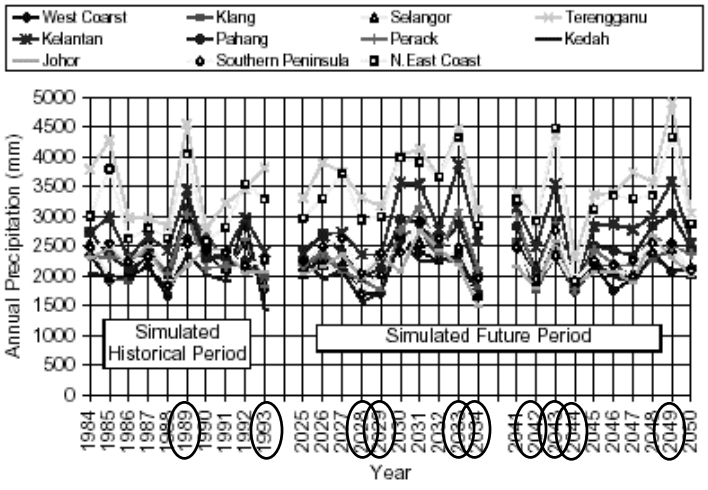
# Table B: Summary of Monthly Precipitation

| Subregion Name | | West Coast | Klang | Selan-gor | Teren-ggau | Kela-ntan | Pahang | Perak | Kedah | Johor |
|---|---|---|---|---|---|---|---|---|---|---|
| Maximum Monthly Precip (mm) | Historical | 600.0 | 436.2 | 564.1 | 1271.2 | 929.7 | 633.6 | 722.9 | 626.7 | 591.7 |
| | Future | 560.3 | 601.3 | 525.7 | 1913.9 | 1128.5 | 684.6 | 767.8 | 705.3 | 538.2 |
| | Diff. | -39.7 | 165.1 | -38.4 | +642.7 | +198.8 | +51.0 | +44.9 | +78.3 | -53.5 |
| | (%) | -6.6 | +37.8 | -6.8 | +50.6 | +21.4 | +8.0 | +6.21 | +12.5 | -9.0 |
| Mean Monthly Precip (mm) | Historical | 179.2 | 190.1 | 190.2 | 289.0 | 221.8 | 198.5 | 192.9 | 173.6 | 187.3 |
| | Future | 176.2 | 182.3 | 180.9 | 299.0 | 239.5 | 208.4 | 199.4 | 176.6 | 180.0 |
| | Diff. | -3.0 | -7.8 | -9.3 | +10.0 | +17.7 | +9.9 | +6.5 | +3.0 | -7.3 |
| | (%) | -1.7 | -4.1 | +4.9 | +3.5 | +7.9 | +4.9 | +3.4 | +1.7 | -3.9 |
| Minimum Monthly Precip (mm) | Historical | 12.4 | 12.8 | 12.2 | 33.6 | 15.4 | 24.5 | 9.0 | 2.1 | 13.3 |
| | Future | 7.9 | 5.9 | 8.3 | 14.0 | 10.9 | 16.6 | 4.1 | 1.1 | 5.2 |
| | Diff. | -4.5 | -6.9 | -3.9 | -19.6 | -4.5 | -7.9 | -4.9 | -1.0 | -8.1 |
| | (%) | -36.3 | -53.9 | -32 | -58.3 | -29.2 | -32.2 | -54.4 | -50 | -60.9 |



Simulated annual rainfall (historical and future period) at sub regions of Peninsular Malaysia

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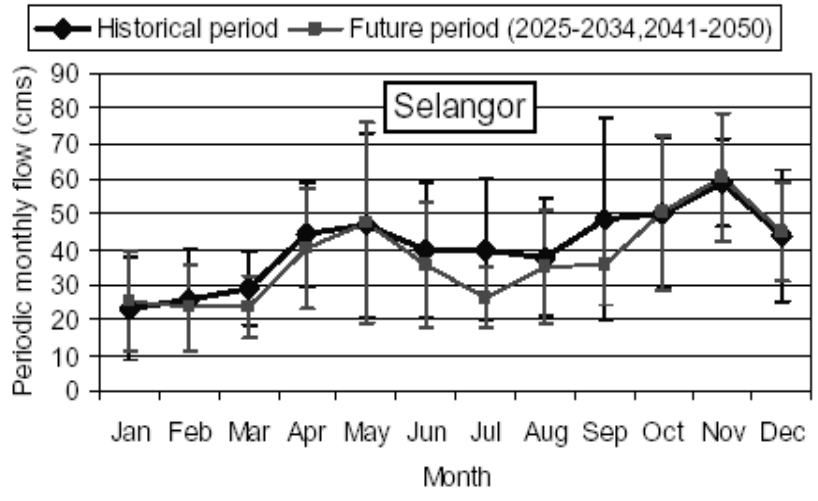
# Table C: Summary of Monthly River Flows

| River | | Klang | Selangor | Dungun | Kelan-tan | Pahang | Perak | Muda | Johor |
|---|---|---|---|---|---|---|---|---|---|
| Maximum Monthly Flows (cms) | Historical | 31.2 | 107.9 | 398.4 | 1535.1 | 1697.4 | 523.7 | 307.4 | 82.7 |
| | Future | 45.8 | 108.5 | 569.5 | 1950.7 | 2176.6 | 578.2 | 340.0 | 94.0 |
| | Diff. | +14.6 | +0.6 | +171.1 | +415.6 | +479.2 | +54.5 | +32.6 | +11.3 |
| | (%) | +46.8 | +0.6 | +42.9 | +27.1 | +28.2 | +10.4 | +10.6 | +13.7 |
| Mean Monthly Flows (cms) | Historical | 14.4 | 40.7 | 93.4 | 535.9 | 669.6 | 286.4 | 105.6 | 32.7 |
| | Future | 13.3 | 37.5 | 98.3 | 601.7 | 718.1 | 299.7 | 104.0 | 31.8 |
| | Diff. | -1.1 | -3.2 | +4.9 | +65.8 | +48.5 | +13.3 | -1.6 | -0.9 |
| | (%) | -7.6 | -7.9 | +5.2 | +12.3 | +7.2 | +4.6 | -1.5 | -2.8 |
| Minimum Monthly Flows (cms) | Historical | 2.6 | 7.1 | 13.1 | 158.4 | 156.3 | 183.6 | 25.3 | 9.8 |
| | Future | 3.5 | 0.5 | 10.8 | 125.8 | 122.7 | 139.2 | 5.3 | 6.8 |
| | Diff. | +0.9 | -6.6 | -2.3 | -32.6 | -33.6 | -44.4 | -20 | -3 |
| | (%) | +34.6 | -93.0 | -17.6 | -20.6 | -21.5 | -24.2 | -79.1 | -30.6 |



# Figure C1: Simulated Monthly River Flow Periodic Means and Standard Deviations

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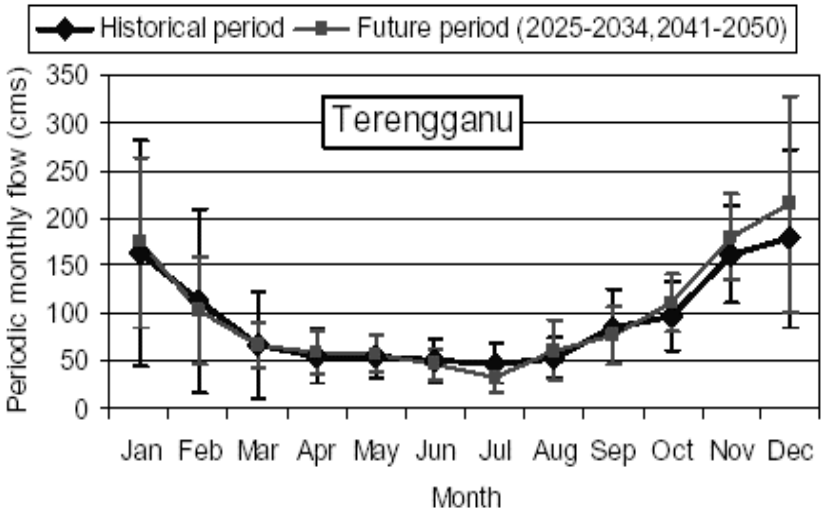
## Figure C2: Simulated Monthly River Flow Periodic Means and Standard Deviations



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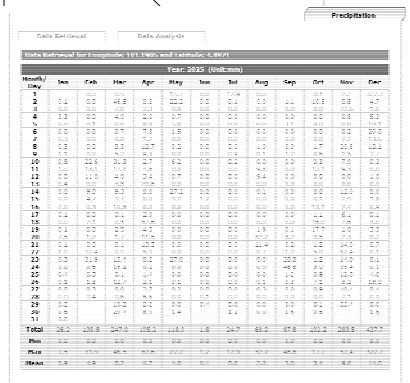
# INTRODUCTION TO FUTURE HYDROCLIMATE DATABASE

- 5 main modules/parameters:
  - Precipitation
  - Evapotranspiration
  - Soil Water Storage
  - Surface Temperature
  - Streamflow



# Data Retrieval – Single Point

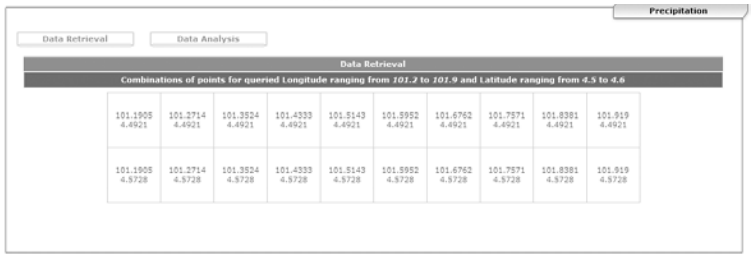
- **Query Criteria:**
  - **Single Point Query Interface**


- **Single Point Query Result**

# Data Retrieval – Multiple Points

- **Query Criteria:**
  - **Multiple Points Query Interface**

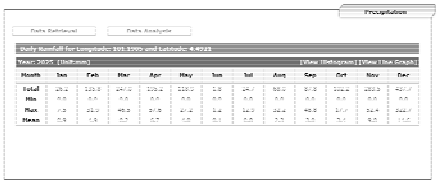

  - **Multiple Points Query Result (pixels are arranged accordingly)**

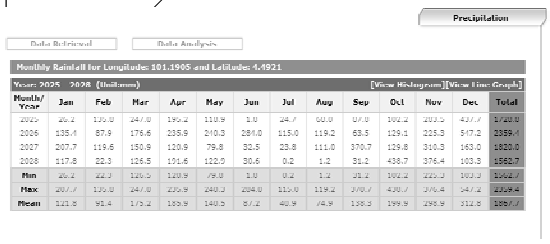


# Data Analysis

**Sample1: Daily Rainfall –**

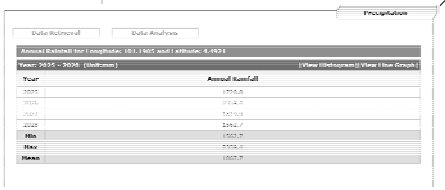
- **Query Type:**



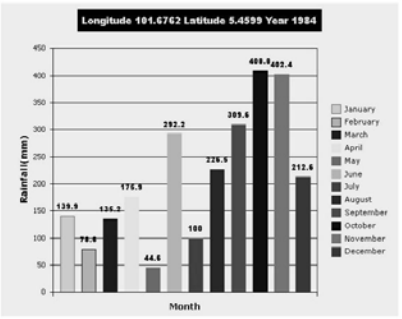

- Sample2: Monthly Rainfall

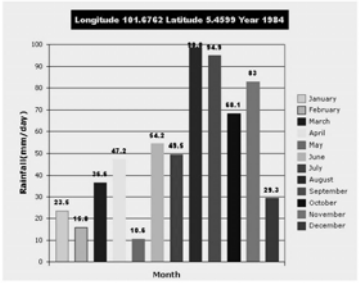
**Sample3: Annual Rainfall –**



# Graph – Histogram

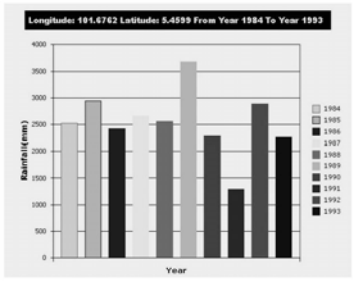
**Sample1: Max Daily Rainfall –**




**Sample2: Monthly Rainfall**

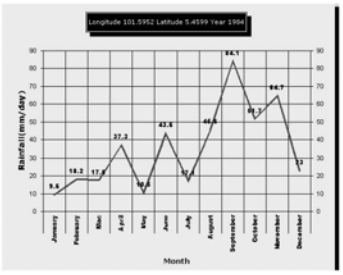
**Sample3: Annual Rainfall –**

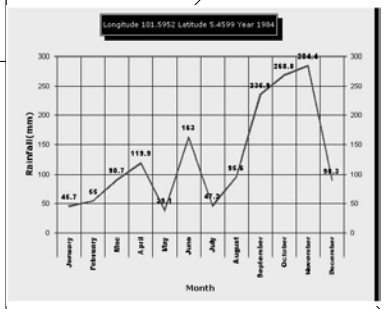





# Graph – Line Graph

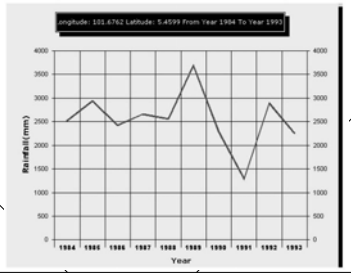
**Sample1: Max Daily Rainfall –**




**– Sample2: Monthly Rainfall**

**Sample3: Annual Rainfall –**



# Water Resources Sector

*Membership*

1. National Hydraulic Research Institute of Malaysia (NAHRIM)
2. Ministry of Energy, Water and Communication (KTAK)
3. Ministry of Agriculture (MOA)
4. Public Works Department (JKR)
5. Department of Mineral and Geoscience (JMG)
6. Department of Environment (DOE)
7. Department of Town and Country Planning (JPBD)
8. National Power Company (TNB)
9. Department of Irrigation and Drainage (JPS)
10. Muda Agricultural Development Authority (MADA)



# Proposed assessments

| | |
|---|---|
| Irrigation | MOA (Barat Laut Selangor)<br>MADA (Muda) |
| Domestic water supply | KTAK, JBA (Klang Valley, Johor, Negeri Sembilan) |
| Hydropower | TNB (Kenyir, Temenggong, Cenderoh, Cameron Highland) |
| Flooding | JPS (Frequency analysis)<br>NAHRIM (River flooding) |

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# Proposed assessments (contd)

| | |
|---|---|
| Groundwater | JMG (Selangor) |
| Drought | NAHRIM |
| River water quality | DOE, KTAK |
| Sedimentation /erosion | NAHRIM |



Thank You

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