EMISSION SCENARIOS FROM INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC)

Presented by
Jorge E. Gonzalez, Ph.D.
1. INTRODUCTION …CONTINUE

- The atmospheric constituents are fundamental to maintain life on our planet by means of the Greenhouse Effect (GHE).

- GHE: Short-wave radiation from the sun passes through the atmosphere with little energy loss. The surface radiates energy back as long wave radiation. Most of the long-wave radiation is absorbed by the atmospheric constituents and then the energy is radiated both to the atmosphere and to the surface. As a consequence a thermal equilibrium is established.

- The CO₂, after water vapor, is the Greenhouse Gases (GHG) of greater concentration in the atmosphere, contributing approximately 25% of the GHE and playing a principal role in determining the Earth’s climate.

- Without an atmosphere, the temperature of the earth would be -18⁰C. The difference is because of the greenhouse effect [1].
The Greenhouse Effect
Earth’s Heat Budget

Incoming Solar Radiation +100 units

-30 units of solar radiation reflected back to space

Outgoing radiation lost to space -100 units

-58 units emitted to space by the atmosphere

-12 units of longwave radiation to which the atmosphere is transparent

+20 units absorbed by atmosphere and clouds

+7 units absorbed by the atmosphere

+23 units released to the atmosphere by condensation (latent heat)

+8 units of longwave radiation absorbed by the atmosphere

Longwave energy exchange between Earth’s surface and the atmosphere

+50 units of solar radiation absorbed by Earth’s surface

-7 units lost from Earth’s surface by conduction and convection

-23 units lost by evaporation

-20 units lost by longwave radiation

= -50 units of energy lost by Earth’s surface

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Atmospheric Energy Balance

Shortwave portion of the budget

- Earth's albedo -31
-7 Diffuse reflection and scattering
-21 Reflected by clouds
-3 Reflected by surface
+20 Diffuse by surface
Direct and diffuse radiation absorbed by Earth's surface
+45 Direct and diffuse radiation absorbed by Earth's surface

Solar energy input +100

Stratospheric absorption by ozone +3

Atmospheric heat input +21

Absorbed by clouds +3

Longwave portion of the budget

Energy radiated to space -69

Radiated by ozone layer to space -3

Energy gained and lost by the atmosphere

Energy gained and lost by the Earth's surface

Latent heat transfer (evaporation) +19

Convective (turbulent) transfer +4

Infrared radiation and reradiation +110 -96

Greenhouse effect

Direct heat loss to space +8

+66 (21 + 23 + 14 + 8 = 66)
INTRODUCTION

- Global heat balance, where the earth and ocean are not to warm [1].
- The albedo of the earth is about 30% (scattering and reflection). 50% is available for heating the land, ocean, and ice.
- Although the sun is the primary energy source, 70% of this energy is transferred to the atmosphere from the earth, then the primary energy source for heating the atmosphere is the earth and not the sun.
2. CURRENT CLIMATE CHANGE … CONTINUE

• The atmospheric concentrations of the GHG have grown significantly since pre-industrial times (about 1750 A.D.) [2]:
  – CO₂ from ~ 280 to 360 ppmv.
  – CH₄ from ~700 to 1720 ppbv.
  – N₂O from ~275 to 310 ppbv.

• These trends can be attributed largely to human activities, mostly fossil-fuel use, land-use change and agriculture.

• The anthropogenic emissions of these gases have contributed about 80% of the additional climate forcing. The contribution of CO₂ is about 60% of this forcing, about four times that from CH₄.

• During the decades of 1940 and 1950, studies were carried out correlating the global warming with the increase of CO₂ attributed mostly to the burning of fossil fuels[3].
CURRENT CLIMATE CHANGE

• The surface temperature has increased 0.6 ± 0.2°C from the end of the XIX century to date, where the warming has been greater in land than in ocean [2].

• From 1950 to 1993, the minimum daily surface temperatures have increased at a rate almost twice the value of the maximum temperatures (0.2 to 0.1°C/decade).

• Since the 1950s, the water temperature increased by 0.04°C/decade inside 300 m of depths.

• The annual precipitation during the 20th century [4]:
  – Middle and high latitudes has been increasing at ~0.5 to 1%/decade.
  – In the subtropics (from 10°N to 30°N) has decreased in 0.3%/decade.
  – In the tropics (from 10°S to 10°N) has increased at 0.2 to 0.3%/decade.

• The sea level in the world during the 20th century has risen between 1.0 and 2.0 mm/year.
3. INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE HISTORY CONTINUE

- Due to these indications of climate changes and of the anthropogenic CO₂ increase, the World Meteorological Organization and the United Nations Environment Programme established in 1988 the Intergovernmental Panel on Climate Change (IPCC) [2].

- The goals of the IPCC are:
  - Assess available scientific information on climate change.
  - Assess the environmental and socio-economic impacts of climate change.
  - Formulate response strategies.

- The IPCC has formed three working groups to study various aspects of climate change [5].
  - Working Group I: Climate System and Climate Change.
  - Working Group II: Climate Change: Impacts, Adaptation, and Vulnerability.
  - Working Group III: Mitigation of Climate Change.
The first assessment report of the IPCC was completed in August 1990 and served as the basis for negotiating the UN Framework Convention on Climate Change [2].

Following a resolution of the Executive Council of the World Meteorological Organization (July 1992), the IPCC decided to include an examination of approaches to Article 2, the Objective of the UN Framework Convention on Climate Change (UNFCCC), in its work programme.

- Article 2: “... stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a timeframe sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner”.
4. 1990 EMISSION SCENARIOS FROM IPCC

- What are scenarios? [6]
  - Scenarios are alternative images of how the future might unfold.
  - The main driving forces of future greenhouse gas trajectories are demographic change, social and economic development, and the rate and direction of technological change.
  - They represent a tool to analyze how driving forces may influence future emission outcomes and to assess the associated uncertainties.

- The first report of the IPCC in 1990 was concentrated in the increase of the GHG concentration

<table>
<thead>
<tr>
<th>1990 IPCC ESCENARIOS [7]</th>
<th>DESCRIPTION</th>
</tr>
</thead>
</table>
| Business as Usual (BAU) | • Modest controls and efficiency improvements over industrial emissions.  
                           | • Uncontrolled agricultural emissions.  
                           | • Depletion of tropical forests at the present rate. |
| B                       | • Lower use of carbon fuels and natural gas.  
                           | • Large increase in efficiency.  
                           | • Carbon Monoxide control.  
                           | • Reversal of deforestation. |
| C                       | • Like scenario B plus phasing out of CFCs.  
                           | • Limitation of agricultural emissions.  
                           | • Renewable and nuclear energy is used in the second half of the 21st century. |
| D                       | • Renewable and nuclear energy is used immediately. |
The IPCC model had shortcomings, predicting a temperature rise of 1°C in the last 100 years, whereas the actual temperature increase was of 0.5°C[7].

<table>
<thead>
<tr>
<th>Location</th>
<th>Season</th>
<th>Temperature</th>
<th>Rainfall</th>
<th>Soil moisture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central N. America</td>
<td>Winter</td>
<td>+2–4°C</td>
<td>+0–15%</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>Summer</td>
<td>+2–3°C</td>
<td>−5–10%</td>
<td>−15–20%</td>
</tr>
<tr>
<td>India</td>
<td>Winter</td>
<td>+1–2°C</td>
<td>−</td>
<td>−</td>
</tr>
<tr>
<td></td>
<td>Summer</td>
<td>annually</td>
<td>+5–15%</td>
<td>+5–10%</td>
</tr>
<tr>
<td>Sahel</td>
<td>Winter</td>
<td>+1–3°C</td>
<td>Changes marginal and regularly variable</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Summer</td>
<td>annually</td>
<td>−</td>
<td>+5–10%</td>
</tr>
<tr>
<td>Southern Europe</td>
<td>Winter</td>
<td>+2°C</td>
<td>Some increase</td>
<td>−</td>
</tr>
<tr>
<td></td>
<td>Summer</td>
<td>+2–3°C</td>
<td>−5–15%</td>
<td>−15–25%</td>
</tr>
<tr>
<td>Australia</td>
<td>Winter</td>
<td>+2°C</td>
<td>−</td>
<td>−</td>
</tr>
<tr>
<td></td>
<td>Summer</td>
<td>+1–2°C</td>
<td>+10%</td>
<td>−</td>
</tr>
</tbody>
</table>

IPCC numerical model result assuming a doubling CO₂ for the period 1985 to 2050
5. 1992 EMISSION SCENARIOS (IPCC) … CONTINUE

- In 1992 the IPCC issued six forcing scenarios (A-F) [7].

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>IS92a or BAUS</td>
<td>11.3 billion by 2100</td>
<td>2.3%</td>
<td>1500</td>
<td>12 000 Exajoules (EJ) conventional oil, 13 000 EJ natural gas, Solar costs fall to $0.075/kWh, 191 EJ of biofuels available at 70/barrel.</td>
</tr>
<tr>
<td>IS92b</td>
<td>as IS92a</td>
<td>as IS92a</td>
<td>1430</td>
<td>As IS92a but with CO₂ Stabilization, like the Kyoto Protocol</td>
</tr>
<tr>
<td>IS92c</td>
<td>6.4 billion by 2100</td>
<td>1.2%</td>
<td>770</td>
<td>8 000 EJ conventional oil, 7300 EJ natural gas, nuclear costs decline by 0.4% annual</td>
</tr>
<tr>
<td>IS92d</td>
<td>6.4 billion by 2100</td>
<td>2.0%</td>
<td>980</td>
<td>Oil and gas same IS92c, solar costs fall to 0.065/kWh, 72 EJ of biofuels available at $50/barrel.</td>
</tr>
<tr>
<td>IS92e</td>
<td>11.3 billion by 2100</td>
<td>3.0%</td>
<td>2190</td>
<td>18 000 EJ conventional oil Gas same as IS92a, b. Phase out of Nuclear by 2075.</td>
</tr>
<tr>
<td>IS92f</td>
<td>17.6 billion by 2100</td>
<td>as IS92a</td>
<td>1830</td>
<td>Oil and gas same as IS92e. Solar costs fall to $0.083/kWh, nuclear costs increase to $0.09/kWh.</td>
</tr>
</tbody>
</table>
1992 EMISSION SCENARIOS (IPCC) …CONTINUE
1992 EMISSION SCENARIOS (IPCC)

- In 1992 the IPCC models were modified to take into account [7]:
  - The cooling effect of anthropogenic sulphate aerosols.
  - A possible slowdown of the thermohaline circulation.
  - An upper mixed ocean layer with 90 m deep.
  - Revised estimations of differences between land and sea.
  - An improved feedback assumptions (cloud covers).

- Current estimates for sea-level change predict a rise of about 45 cm by 2080. The most serious effect of this would be coastal flooding, with consequent displacement of populations and loss of wetland habitats [11].
6. SPECIAL REPORT ON EMISSIONS SCENARIOS (IPCC) …CONTINUE

• Much has changed since the IS92 scenarios in our understanding of possible future greenhouse gas emissions and climate change. In 1996 the IPCC decided to develop the Special Report on Emissions Scenarios (SRES), a new set of emissions scenarios [11].

• SRES includes:
  – improved emission baselines.
  – latest information on economic restructuring throughout the world.
  – examine different rates and trends in technological change.
  – expand the range of different economic-development pathways
  – include the tendency decrease the economic unbalance between developed and developing countries.

• In June 1998, the IPCC Bureau agreed to make the unapproved, preliminary scenarios available to climate modelers, who could use the scenarios as a basis for the assessment of climatic changes in time for consideration in the IPCC’s Third Assessment Report [11].

• In this report the scenarios do not include the implementation of the United Nations Framework Convention on Climate Change (UNFCCC) or the emissions targets of the Kyoto Protocol.
• Four different narrative storylines were developed. Each storyline represents different demographic, social, economic, technological, and environmental developments [11].
• All the scenarios based on the same storyline constitute a scenario “family”.

<table>
<thead>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Population (billion)</td>
<td>5.3</td>
<td>7.6 (7.4-7.8)</td>
<td>7.5 (7.2-7.9)</td>
<td>7.6 (7.4-7.8)</td>
<td>8.2 (7.5-8.2)</td>
<td>7.6 (7.4-7.8)</td>
<td>7.6 (7.4-7.8)</td>
</tr>
<tr>
<td></td>
<td>World GDP (10^12 1990 US$ / yr)</td>
<td>21</td>
<td>58 (53-67)</td>
<td>66 (48-61)</td>
<td>79 (52-57)</td>
<td>87 (57-61)</td>
<td>87 (67-63)</td>
<td>93 (91-98)</td>
</tr>
<tr>
<td></td>
<td>Per capita income ratio: developed countries and economies in transition (Annex-I) to developing countries (Non-Annex-I)</td>
<td>16.1</td>
<td>7.5 (5.7-7.8)</td>
<td>6.4 (5.2-7.0)</td>
<td>6.2 (5.7-8.4)</td>
<td>8.4 (7.5-10.7)</td>
<td>7.7 (5.7-12.3)</td>
<td>7.5 (5.7-12.3)</td>
</tr>
</tbody>
</table>

*For some driving forces, no range is indicated because all scenario runs have adopted exactly the same assumptions.
• The A1 storyline and scenario family [11]:
  – future world of very rapid economic growth.
  – global population that peaks in mid-century and declines thereafter.
  – rapid introduction of new and more efficient technologies.

• The A2 storyline and scenario family:
  – continuous increasing of the global population.
  – per capita economic growth and technological change are more fragmented and slower than in other storylines.

• The B1 storyline and family:
  – rapid changes in economic structures.
  – introduction of clean and resource-efficient technologies.

• The B2 storyline and scenario family:
  – continuous increase of the global population at a rate lower than A2,
  – less rapid and more diverse technological change than in the A1 and B1.
SPECIAL REPORT ON EMISSIONS SCENARIOS (IPCC)

• The globally averaged surface temperature is projected to increase by 1.4 to 5.8°C (greater than IS92, ~1.0 to 3.5°C) over the period 1990 to 2100 [12].

• By the second half of the 21st century, it is likely that precipitation will have increased over northern mid- to high latitudes and Antarctica in winter. At low latitudes there are both regional increases and decreases over land areas.

• Global mean sea level is projected to rise by 0.09 to 0.88 meters between 1990 and 2100, for the full range of SRES scenarios.

The multi-AOGCM ensemble annual change of the precipitation (unit %) over globe for the SRES scenario A2 for the years 2071 to 2100 relative to the period 1961 to 1990 [13].
Climate Change 2007: Synthesis Report

-ATTRIBUTION OF CHANGES-

Global and continental temperature change

- Observations
- Models using only natural forcings
- Models using both natural and anthropogenic forcings
Large-scale relative changes in annual runoff (water availability, in percent) for the period 2090-2099, relative to 1980-1999. Values represent the median of 12 climate models using the SRES A1B scenario. White areas are where less than 66% of the 12 models agree on the sign of change and hatched areas are where more than 90% of models agree on the sign of change. The quality of the simulation of the observed large-scale 20th century runoff is used as a basis for selecting the 12 models from the multi-model ensemble [1].
Estimated economic mitigation potential by sector and region using technologies and practices expected to be available in 2030. The potentials do not include non-technical options such as lifestyle changes [1].
Global climate models in which the atmosphere and ocean components have been coupled together are also known as Atmosphere-Ocean General Circulation Models (AOGCMs) [14].

The climate system is represented in submodels (atmosphere, ocean, land surface, cryosphere and biosphere).

Many physical processes, such as those related to clouds or ocean convection, take place on much smaller spatial scales than the model grid. Their average effects are approximately included by means of parametrizations.
# CLIMATE MODELS

Survey of available SRES Scenarion Runs for TAR GCM data [14]

<table>
<thead>
<tr>
<th>Center</th>
<th>Acronym</th>
<th>Model</th>
<th>SRES Scenario Runs</th>
<th>Additional data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max Planck Institute für Meteorologie</td>
<td>MPIfM</td>
<td>ECHAM4/OPYC3</td>
<td></td>
<td>A2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>B2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6-h data (local)</td>
</tr>
<tr>
<td>Hadley Centre for Climate Prediction and Research</td>
<td>HCCPR</td>
<td>HADCM3</td>
<td>A1F1</td>
<td>A2, A2b, A2c, B1, B2</td>
</tr>
<tr>
<td>Australia's Commonwealth Scientific and Industrial Research Organisation</td>
<td>CSIRO</td>
<td>CSIRO-Mk2</td>
<td>A1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>National Centre for Atmospheric Research</td>
<td>NCAR</td>
<td>NCAR-CSM</td>
<td></td>
<td>A2</td>
</tr>
<tr>
<td></td>
<td>NCAR</td>
<td>NCAR-PCM</td>
<td></td>
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<tr>
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<td></td>
</tr>
<tr>
<td>Geophysical Fluid Dynamics Laboratory</td>
<td>GFDL</td>
<td>R30</td>
<td></td>
<td>A2</td>
</tr>
<tr>
<td>Canadian Center for Climate Modelling and Analysis</td>
<td>CCCma</td>
<td>CGCM2</td>
<td></td>
<td>A2, A2b, A2c, B2, B2b</td>
</tr>
<tr>
<td>Center for Climate System Research National Institute for Environmental Studies</td>
<td>CCSR / NIES</td>
<td>CCSR/NIES AGCM + CCSR OGCM</td>
<td>A1, A1T, A2, B1, B2</td>
<td></td>
</tr>
</tbody>
</table>

**Importantly notice** concerning the CSRIO data sets!
8. INVENTORY OF AOGCM STUDIES

...CONTINUE

Runs using historical forcing from the last century to present and IPCC scenario IS92a thereafter [15].

<table>
<thead>
<tr>
<th>Institution / Investigators</th>
<th>Available runs / Stabilisation scenario experiments.</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSIRO - Hal Gordon, (Peter Whetton) CSIRO Division of Atmospheric Research</td>
<td>Historical forcing run from 1880 to present and then IS92a up to 3xCO2 (up to 2083).</td>
<td>Hirst AC, Gordon HB, O'Farrell SP, (1996).</td>
</tr>
<tr>
<td>CCCMA - George Boer Canadian Centre for Climate Modelling &amp; Analysis</td>
<td>Historical/future runs from 1900 to 2100 using the current coupled model.</td>
<td></td>
</tr>
<tr>
<td>Atmospheric Environment Service University of Victoria</td>
<td></td>
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</tbody>
</table>
### INVENTORY OF AOGCM STUDIES …CONTINUE

<table>
<thead>
<tr>
<th>Institution</th>
<th>Description</th>
<th>References</th>
</tr>
</thead>
</table>
| GFDL - Ronald Stouffer  
Geophysical Fluid Dynamics Laboratory Princeton University | Three experiments from 1766-2065: CO2 only. CO2 + aerosols. aerosols only | Haywood et al, (1997) Geo. Research |
| LMD/IPSL - Hervé Le Treut  
Laboratoire de Météorologie Dynamique | Integrations within the IPCC criteria for 1998 | |
| DKRZ/MPI - Ulrich Cubasch  
| Hadley Centre - John Mitchell  
| IAP - Qing-Cun Zeng  
Institute of Atmospheric Physics Chinese Academy of Sciences | Transient AOGCM simulation (gradual increase of CO2) | Integrations within IPCC criteria |
9. THE CARIBBEAN CASE

• There is a high tendency of a possible future global climate change and the importance of determining its possible impact in the Caribbean is of major interest to society. Thus, our scientific questions for the present research are:

  – How the climatological characteristics of the Caribbean region will be affected as consequence of a future global climate changes due to increases of anthropogenic CO$_2$ concentrations?
OBJECTIVES

• To solve adequately our scientific problem, the following goals are established:

  – To determine the effects of the future global warming over the climatology of the Caribbean region due to the CO$_2$ concentration increases.

  – To analyze the interaction between oceanic and atmospheric variables to determine their predominance in the spatial and temporal variability in climatological variables under the effects of an increasing CO$_2$ concentration.
METHODOLOGY - PARALLEL CLIMATE MODEL (PCM) …

<table>
<thead>
<tr>
<th>COMPONENT MODEL</th>
<th>RESOLUTION (DEGREES)</th>
<th>RESOLUTION (KILOMETERS)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LATITUDE</td>
<td>LONGITUDE</td>
</tr>
<tr>
<td>LAND</td>
<td>T42</td>
<td>T31</td>
</tr>
<tr>
<td>ATMOSPHERE</td>
<td>~2.8</td>
<td>~3.75</td>
</tr>
<tr>
<td>OCEAN</td>
<td>~0.3</td>
<td>~0.9</td>
</tr>
<tr>
<td>SEA-ICE</td>
<td>~0.3</td>
<td>~0.9</td>
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</table>

Parallel Ocean Model mesh
RAMS – PCM COUPLING
CARIBBEAN CLIMATOLOGY ...
CURRENT CARIBBEAN CLIMATE SIMULATED BY PCM ...
CURRENT CARIBBEAN CLIMATE SIMULATED BY PCM
CURRENT CARIBBEAN CLIMATE SIMULATED BY PCM
FUTURE CARIBBEAN CLIMATE CHANGE SIMULATED BY PCM ...
FUTURE CARIBBEAN CLIMATE CHANGE SIMULATED BY PCM ...
FUTURE CARIBBEAN CLIMATE CHANGE SIMULATED BY PCM ...
Monthly average daily total solar resource for the Caribbean basin simulated by PCM. The future Caribbean rainfall season is divided in (a) DS, (b) ERS and (c) LRS.
FUTURE CARIBBEAN WIND POWER DENSITY 2041-2055 SIMULATED BY PCM

Wind Power density from PCM for (a) DS, (b) ERS and (c) LRS.
REGIONAL ATMOSPHERIC MODELING SYSTEM (RAMS)

- $\sigma_z$ terrain-following coordinate system
- NCEP-RALPH2-V-format
- Convective Parameterization
- Radiation Parameterization
- Multilayer Soil Model
- RAMS uses a nudging technique for its 4DDA scheme

\[
\frac{\partial \phi}{\partial t} = \left( \phi_{\text{obs}} - \phi_{\text{m}} \right) \\
\tau_l = \frac{(x - x_l)^2}{(x_l - x_B)^2}
\]
RAMS CONFIGURATION ...

Grid 1: 11.5° N to 25.5° N and 83° W to 50.5° W.

Grid 2: 7.61° N to 18.65° N and 67.63° W to 64.99° W.
FUTURE CARIBBEAN CLIMATE SIMULATED BY THE COUPLED MODELS RAMS-PCM

Grid 1, RAMS-PCM 2048 outputs for the air temperature in the (a) DS, (b) ERS and (c) LRS, and the Caribbean rainfall for the (d) DS, (e) ERS and (f) LRS.
Surface air temperature RAMS-PCM in the finer grid. The difference between the respective month and the average monthly values is calculated for the year 2048 for (a) January, (b) February, (c) March, (d) April, (e) May, (f) June, (g) July, (h) August, (i) September, (j) October, (k) November and (l) December.
Puerto Rico rainfall RAMS-PCM. The difference between the respective monthly average and the hourly monthly rainfall is calculated for the year 2048 for (a) January, (b) February, (c) March, (d) April, (e) May and (f) June, (g) July, (h) August, (i) September, (j) October, (k) November and (l) December.
What future work on emissions scenarios would be useful?

• Establishment of a programme for on-going evaluations and comparisons of long-term emissions scenarios, including a regularly updated scenario database;
• Capacity building, particularly in developing countries in the area of modeling tools and emissions scenarios;
• Multiple storyline, multi-model approaches in future scenario analyses;
• New research activities to assess future developments in key GHG driving forces in greater regional, subregional, and sectoral detail which allow for a clearer link between emissions scenarios and mitigation options;
What future work on emissions scenarios would be useful?

- Development of additional gridded emissions for scenarios which would facilitate improved regional assessment;
- Improved specification and data for, and integration of, the non-CO2 GHG and non-energy sectors, such as land use, land-use change and forestry, in models, as well as model inter-comparison to improve scenarios and analyses;
- Integration into models emissions of particulate, hydrogen, or nitrate aerosol precursors, and processes, such as feedback of climate change on emissions, that may significantly influence scenario results and analyses;
What future work on emissions scenarios would be useful?

• Assessment of strategies that would address multiple national, regional, or global priorities;
• Assessment of specific adaptation, vulnerability, and mitigation strategies on a sectorial and regional basis including determination of economic risks and benefits.
• Development of regional integrated approaches to address the above.
10. REFERENCES …CONTINUE

REFERENCES


