Abstract
One of the first concerns of global change was climate change and so it remains today. With the inherent uncertainties in projecting future climate change and impacts, it is now recognized that studies of the impact of climate variability is an acceptable avenue for exploring the impacts of future climate change. Research teams in the Caribbean have been studying climate variability and impacts for the last 10 years. Much of this effort has been concentrated on analyzing and understanding climate variability so as to predict seasonal climate. However there have been efforts to link climate prediction to applications in the human dimension. Three climate outlook forums have been held in the Caribbean region at which potential users of climate prediction have been invited. This report is concerned primarily with the English-speaking Caribbean, particularly with Jamaica. A survey of the benefits of the first 2 forums was carried out to assess their impacts. The main success has been the ability to use the predictions to access greater funds for disaster preparedness. Impediments to the application of climate predictions were due primarily to the poor flow of information from the source of prediction to the potential users, the inherent uncertainties in the prediction and the lack of media interest. The use of the national meteorological offices as interpreters of climate predictions for users was seen as the necessary way forward. This would require an investment in training of meteorological officers. A need for pilot projects in climate prediction applications was also identified. The Caribbean now has at least one project in climate change. This project entitled The Threat of Dengue Fever – Assessment of the Impacts and Adaptation to Climate Change in Human Health in the Caribbean is funded by the Assessment of the Impacts and Adaptation to Climate Change (AIACC) initiative of TWAS and START. The project has been in existence for 1 year, during which time activities were mainly devoted to the training of researchers. Field work has now begun and preliminary results will be presented as well as the assessment of the climate outlook forums described above.

Introduction
Global Climate Change
Global change encompasses all significant changes associated with anthropogenic processes. Global climate change was one of the first concerns and remains a significant cause of concern. This paper is particularly concerned with climate change and human health.

Assumptions
We start with 2 premises. Firstly, while it is impossible to predict daily weather beyond 10 days, it is possible to predict future climate if we accept a stationary state. Secondly, studies of the impact of climate variability or departures from the mean in the short term is an avenue for exploring the impacts of future climate change.
Contents of paper

- Experience of activities in the Caribbean to predict seasonal (short term) climate and apply the predictions – Climate Outlook Forums
- Climate change project on dengue fever, including a socio-economic study
- Design of a Pilot Project for early warning of dengue outbreak

Previous Activities

Three Caribbean Climate Outlook Forums have been held to date, the first in Kingston, Jamaica, from May 21-22, 1998, the second in St. James, Barbados from April 22-23, 1999 and the third in Santo Domingo, Dominican Republic from May 3-5, 2000. Sponsors have included USAID/Office of Foreign Disaster Assistance (OFDA), NOAA/Office for Global Programs (OGP), World Meteorological Organization (WMO), Inter-American Institute (IAI) for Global Change Research, International Research Institute (IRI), the University of the West Indies, Mona (UWI), Office of Disaster Preparedness and Emergency Relief Management (ODPEM) Caribbean Meteorological Institute (CMI), now the Caribbean Institute of Meteorology and Hydrology (CIMH) and Oficina Nacional de Meteorologia (ONAMET).

Main players involved and attendees

Support, in terms of providing resource personnel, has always come from IRI, NOAA/AOML Hurricane Research Division, Florida State University, UWI, CIMH, OPDEM and Caribbean Disaster Emergency response Agency (CDERA) and occasionally from NOAA/Climate Diagnostic Center (CDC), NOAA/Climate Prediction Center (CPC) and Center for Ocean Land Atmosphere Studies (COLA). Representatives of most NMS’s in the Caribbean and potential users in the field of emergency management, water resources, agriculture, health and tourism have attended the forums.

The process before, during and after the Forums

During Forecaster involvement

At the forum proper, resource persons made presentations, which included descriptions of the climatology of the region and the development of hurricanes, followed by descriptions of the present state of the background conditions affecting the climate, particularly of sea surface temperatures, and current forecasts of climate and hurricanes from organizations such as IRI, ECMWF, NOAA/AOML and Florida State University. Next the National Meteorological Services (NMS’s) in the region gave their assessment of the past and present climate. This together with the assessment of previous forecasts by CIMH, was an important activity in the Second and Third Forums. Finally 3-month forecasts for countries with similar climatology were discussed by all until a consensus outlook was arrived at. The forecasts are made in tercile format.

User involvement
After

At the first Forum it was agreed that the three-month outlook, produced at the Forum, would be updated every month so there would always be a three-month running climate forecast for the Caribbean. The Caribbean Institute of Meteorological and Hydrology (CIMH) gratefully volunteered to be the regional headquarters for updating the regional forecast. For this purpose it was agreed that numerical model forecasts will be regularly provided by the IRI, COLA and NCEP/CPC, and all relevant agencies (NMS’s, Climate Studies Group (at the University of the West Indies), Mona (CGSM) and the Instituto de Meteorologia, Cuba) would communicate with the CIMH via Internet or Fax on a monthly basis to provide local input and update for the modification of the outlook. Following the first Forum, the forecast has been updated every one or two months and made available on CIMH website: inacs.com.bb/carimet.

Forecast assessment

The main forecast assessment is done by CIMH. These assessments are discussed at the succeeding forums. Assessments for individual islands are also presented by the respective NMS’s at the succeeding forum. CIMH has adopted a simple approach to verify the probability outlooks by computing the anomalies (difference between the actual three-month average and the long-term average) to determine whether the observed rainfall fell within the near-, above-, or below normal categories as given in the projections. The exercise indicates that while there may be some skill (subjective) in the forecasts, much work is needed to improve their reliability.

Forecast Dissemination

At the 2nd Forum it was agreed that the NMS’s would pass on the forecasts, including the updated forecasts from CIMH, in a meaningful manner to local committees comprising the meteorological services, water resource management, agriculture, tourism, national emergency management agency and the media. The NMS’s were also expected to answer queries on the forecasts from consulting agencies. It was the view of SC, 3rd Forum that a greater degree of implementation of these agreements was needed.

Links generated with the application side

The link with the application side, following a recommendation at the 2nd Forum, should be through the NMS’s who are to pass on the forecasts to users, once they have been issued by CIMH. There is also expected to be some interaction between the NMS’s and the users in that the NMS’s should explain the forecast to the users and answer relevant questions. Links have also been developed by the research group CSGM with the National Drought Committee and with the Sugar Research Institute in Jamaica.

Lessons learnt

The Steering Committee (SC), 3rd Forum noted that although much “inroad had been made in achieving the objectives of the forums (i) improve climate forecasting activities, (ii) identify and meet existing knowledge gaps in climate
forecasting, (iii) facilitate research cooperation and the exchange of data, and (iv) encourage the use of climate information in management decision-making) …a lot remains to be done in order to fully realize these goals…. Improvements are particularly needed in the following areas: (i) producing, verifying and disseminating the consensus climate outlooks, (ii) educating and training users in interpreting and using seasonal forecasts, and (iii) maintaining communication between and among producers and users of seasonal forecasts outside the COF...

SC, 3rd Forum also noted that, from a survey done by NOAA/OGP, although most individuals, who were familiar with the climate outlooks, had participated in a COF, very few non-participants had received the outlooks, indicating that they had not been widely distributed. Although requested, details on the factors which prevented participants from sharing the outlooks, were not provided.

**Forecast assessment as viewed by the users**

Building of credibility for the forecasts among users will depend on how accurate they perceive the forecasts to be. For this reason, review of previous forecasts and their accuracy should be an integral part of each forum. Analysis of why the forecasts were correct (or incorrect) and how closely the forecast approached reality should be carried out among users and forecasters. Problems which arose because of inaccurate forecasts should be aired and discussed. It is essential that users understand variations as they will have to defend the continued use of the forecasts.

Users will also need to know how confident forecasters are in the forecasts. Again, participation of users in the forum, the ability to interact, ask questions and have explanations in easily understood terms will allow this. The level of confidence will necessarily influence how the forecasts are used by disaster managers and other users. Forecasts which do not mention that there are associated uncertainties are likely to be interpreted as if they have a high level of certainty. Forecasts with high uncertainty are not necessarily useless. However the user may wish to limit knowledge of its use to a technical or scientific personnel who understand error and uncertainty. At higher levels of confidence, policy makers can be made aware of forecast use. Users may, however wish to involve the public only at high levels of confidence, as issues of credibility now become important.

**Benefits achieved**

As above, this section is extracted from SC, 3rd Forum:

“Working group reports from past meetings and preliminary results of a survey\(^1\) assessing climate information use in decision-making by personnel from the agriculture, water resources and disaster management sectors, indicated that the most notable achievements of the COF were the following:

- Facilitating dialogue between users and producers of climate forecasts (The format of the fora in which users were able to interact with forecasters and to actively participate in the process was considered to be one of its most positive aspects).
- Contributing to the building of an interdisciplinary community sharing the common objective of increasing our understanding and ability to cope with climate fluctuations

\(^1\) Based on 38% of total responses
• Increasing awareness of the potential value of climate information to strategic planning, resource management and disaster mitigation and preparedness
• Advancing climate forecasting activities in the region

Survey responses also indicated that respondents viewed seasonal climate information as a potentially valuable management tool. However, reasons supporting this view were not given in most cases. Respondents were keenly interested in receiving seasonal climate forecasts on a regular basis and participating in training workshops and pilot projects exploring how to apply forecast information in their respective sectors.

All COF participants surveyed were supportive of having the meetings continued. Individuals who had not attended either COF were interested in becoming involved in future meetings.

The survey revealed that the consensus climate outlooks produced at the COF were used to:
• Lobby for additional funding from government officials in the disaster management and water resources sectors (In Jamaica the first practical use to which the Outlook was put was management of the 1997-1998 drought. Scientists involved in the forecasts were invited to be members of the National Drought Management Committee and explained the forecasts and how they are generated to the group. Based on the forecasts additional funds for providing household water and running public awareness programmes was requested and received.)
• Catalyze organization of national drought and flood monitoring committees
• Increase awareness of managers within the agriculture, water resources and disaster management sectors of predicted drought conditions
• Create applied seasonal climate forecast tailored for use in agriculture by combining with local data

Views on the future
At the 3rd Forum it was noted that the Caribbean COFs are really only at the beginning stages, i.e., forecasts are made and disseminated in a rudimentary form, and some agencies, but not many, make use of the forecasts. Moving from the present stage to an advanced stage obviously will require an enormous effort. In moving forward, it is suggested that networks be augmented or created 1) to serve as a mechanism for carrying out operational procedures, 2) serve as a communication conduit to allow members to keep in touch and exchange ideas, and provide encouragement for each other, 3) encourage new initiatives and new partners, 4) report on progress.

The specific networks mentioned were a Forecasting and Disseminating Network (consolidation of the present informal arrangement), Applications Network (e.g., in Hydro-electricity and Sugar Industry), Disaster Management Network and a Climate Research Network.

In addition expansion of the forecast to other elements, such as temperature, will increase the potential applicability. Questions on whether future efforts should be towards increasing accuracy of forecasts or expanding the forecasts to other potential
users will have to be examined, thus inferring that a method of measuring usefulness of forecasts and their social benefits may have to be found.

New (AIACC) Project

The first major project to be undertaken is one in climate and dengue fever entitled *The Threat of Dengue Fever - Assessment of Impacts and Adaptation to Climate Change in Human Health in the Caribbean – SIS06*. The project is funded by Assessments of Impacts and Adaptations to Climate Change (AIACC), which is a global initiative developed in collaboration with the UNEP/WMO, Intergovernmental Panel on Climate Change (IPCC) and funded by the Global Environment Facility to advance scientific understanding of climate change vulnerabilities and adaptation options in developing countries. AIACC is implemented by the UNEP and executed jointly by START and the Third World Academy of Sciences (TWAS). SIS06 is a collaborative project between University of the West Indies, Mona, and the Caribbean Epidemiology Centre, Trinidad.

**Project description:** The impetus for this project was initiated by (i) recent increases in the incidence of dengue fever in the Caribbean and (ii) a seeming relationship between some peaks in dengue occurrence and increases in air temperature, some of which occurred in El Niño years. Research has revealed that the occurrence of dengue is sensitive to factors such as temperature increase and rainfall, and scenarios in which temperature is projected to increase with a possible change in the hydrological cycle are therefore a cause for serious concern.

The starting point of this proposed investigation is the construction of databases of past and present data of climate and dengue indicators for the Caribbean region. These databases, continually maintained and updated, will be made available to all interested parties after the life of project. The databases will be analyzed for linkages between climate and dengue after isolating other dominant and confounding factors, and by the use of sophisticated statistical techniques.

Concurrently personnel will be trained in statistical downscaling. Projections of climate for the Caribbean will then be downscaled from model outputs using SRES emission scenarios. These projections together with (i) scenarios of future population and income on a national scale consistent with SRES scenarios and (ii) the knowledge gathered from the database analyses will then form the basis for an analysis of the impact of and adaptation strategy for climate change induced dengue. Also concurrent with these will be a study to determine the socio-economic impact of dengue fever. Based on the above findings adaptation strategies will be developed. The adaptation strategy will be two-fold, consisting firstly of a pilot project for managing (climate related) dengue in the near term (next 10 years), and secondly of adaptation strategies for the longer term, based on knowledge gained in the AIACC project and experience to be gained in the pilot project.

Capacity building, including graduate training, will be an integral part of the project. This will ensure that research on the threat of dengue due to climate change will continue, self financed and otherwise, at the research institutions involved in the project. The project team will therefore be expected to play a significant role in
enlightening and enlivening future discussions on climate change in the Caribbean and will be able to make invaluable inputs into necessary decision making. Countries and Sectors covered: All 21 Caribbean Epidemiology Centre (CAREC) Member Countries (CMCs) will be included for general observations, but 4 countries – Jamaica, Barbados, Trinidad and Tobago and St. Kitts – will be targeted for specific study. These countries are of varying size and possess varying levels of complexity of ecology. The socio-economic study will be done in Jamaica.

**Socio-economic Study**

The aim of this study is to develop socioeconomic scenarios to for analysing the vulnerability of communities in Jamaica to possible increase in the transmission of dengue and to propose actions that can mitigate the effects. Research questions which need to be answered are

- What areas of the country are vulnerable?
- What are the characteristics of the individuals and households that are vulnerable?
- What are the factors that are associated with vulnerability?
- How will climate change impact on transmission?
- What modifications can effect change?
- How can community based interventions be encouraged and supported?

Answers to some of the above questions will come from a study of the impact of dengue and the preparedness of communities to respond to warnings. Field work is taking place at the moment and the investigation is proceeding from country to local level, measuring adaptive capacity both at the generic and specific levels and the constraints on the choice of adaptation measures. Expert interviews have been conducted with policy implementers in the Ministry of Health, officials in local government as well as with Public Health Inspectors. Based on the pattern of the 1998 outbreak a local area was selected for in-depth study and questionnaires administered to a sample of population in three districts.

**Preliminary Results of Socio-economic study**

Preliminary analysis of the expert interviews shows that a resource problem limits the ability of the MOH to respond adequately to present conditions and there is no long-term planning to meet the possibility of increased transmission. There is little routine surveillance but rather, knee-jerk responses to outbreaks and citizens’ complaints. The philosophy is that communities must take the responsibility for vector control. But the public education programme that could empower communities is also a victim of financial constraints and knowledge at the community level is generally quite low. Besides, the community structures that would facilitate collective action are nonexistent in squatter communities where the problem is greatest.

**Pilot Project**

Based on the predictability of climate and the linkage between climate and dengue we can attempt to mitigate the incidences of dengue. The process of mitigation may consist of destroying the vector by spraying or destroying the habitat by removing discarded containers capable of collecting rainfall, covering tanks, etc. How can this be effected?
The following shows a schematic for predicting climate consisting of a network of regional organizations working in climate prediction (CSGM, IM, CIMH) which will downscale global forecasts from IRI, ECMWF, etc. Climate predictions are then channeled to a climate/health committee, which will determine the risk based on knowledge of climate health linkages. Alerts will be passed on to the media and public health officials who will then disseminate them to public health officers and to sanitation officers, etc.

Several problems will be encountered concerned with (i) the usefulness of climate forecasts, (ii) deciding how to use the climate forecast to issue a dengue alert, (iii) dissemination of the alert, (iii) acceptance of the alert by the population, (iv) determining the value of the process. Firstly, the major problem in applying climate forecasts is the level of uncertainty in the forecast and from that stems a number of problems. A climate forecast is useful only if it is sufficiently skilful and relevant and is made early enough so that the sector can take appropriate action. Relevance relates to the climate parameters forecasted and the details of the forecast. For mitigation of dengue fever, temperature and precipitation forecasts would be most useful, as well as wind direction and wind speed. Magnitudes of these values, which are difficult to predict, would be needed.

Secondly, uncertainties in the linkage between climate and dengue will dictate caution in issuing alerts based on climate information only. Field surveillance will also be necessary. Thirdly dissemination of the forecast will required a network or smooth chain of command. Fourthly, acceptance of the alert will depend on the propaganda medium and the content of the message. Inertia and previous biases of the user and his or her knowledge of climate will also affect the efficacy with which the forecast will be applied. To overcome this problem of biases, it necessary to
educate a user as to how the alert was arrived at. It is also necessary to educate the user about the extent of uncertainty in the forecasts and alerts.

Lastly, the value of a forecast/alert must be demonstrated. Even if the forecast/alert is of some use, Government or Funding agency will want to know if they could have better spent the funds and manpower resources on other pressing problems. This question is particularly relevant in tight budgetary situation, which many of the Governments of the Caribbean find themselves in.

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Appendix (Acronyms):
CDERA - Caribbean Disaster Emergency response Agency
CIMH - Caribbean Institute of Meteorology and Hydrology, formerly Caribbean Meteorological Institute (CIM)
COF – Climate
CSGM – Climate Studies Group (UWI) Mona
IAI - Inter-American Institute for Global Change Research
IM – Institute of Meteorology of Cuba
IRI - International Research Institute
NMS - National Meteorological Service.
NOAA – National Oceanographic and Atmospheric Agency
ODPEM - Office of Disaster Preparedness and Emergency Relief Management
OGP - Office for Global Programs
OFDA - Office of Foreign Disaster Assistance
ONAMET - Oficina Nacional de Meteorologia, Dominican Republic
SC, 3rd Forum – Steering Committee to plan 3rd Forum
USAID – US Agency for International Development
UWI - University of the West Indies, Mona
WMO - World Meteorological Organization