WORLD METEOROLOGICAL ORGANIZATION

RA IV HURRICANE COMMITTEE

THIRTY-THIRD SESSION

GRAND CAYMAN, CAYMAN ISLANDS

(8 to 12 March 2011)

FINAL REPORT

1. ORGANIZATION OF THE SESSION

At the kind invitation of the Government of the Cayman Islands, the thirty-third session of the RA IV Hurricane Committee was held in George Town, Grand Cayman from 8 to 12 March 2011. The opening ceremony commenced at 0830 hours on Tuesday, 8 March 2011.

1.1 Opening of the session

1.1.1 Mr Fred Sambula, Director General of the Cayman Islands National Weather Service, welcomed the participants to the session. He urged that in the face of the annual recurrent threats from tropical cyclones that the Committee review the technical & operational plans with an aim at further refining the Early Warning System to enhance its service delivery to the nations.

1.1.2 Mr Arthur Rolle, President of Regional Association IV (RA IV) opened his remarks by informing the Committee members of the national hazards in RA IV in 2010. He mentioned that the nation of Haiti suffered severe damage from the earthquake in January. He thanked the Governments of France, Canada and the United States for their support to the Government of Haiti in providing meteorological equipment and human resource personnel. He also thanked the Caribbean Meteorological Organization (CMO), the World Meteorological Organization (WMO) and others for their support to Haiti. The President spoke on the changes that were made to the hurricane warning systems at the 32nd session of the Hurricane Committee in Bermuda. He mentioned that the changes may have resulted in the reduced loss of lives in countries impacted by tropical cyclones. In particular, he cited the damages in Saint Lucia and St Vincent and the Grenadines from Hurricane Tomas.

1.1.3 The Chairman of the Hurricane Committee, Mr Bill Read, welcomed all participants and stated that he looked forward to a productive session with the active participation of all those attending this year's session. He expressed his hope that collaboration and cooperation among the Members will be further strengthened through this session.

1.1.4 On behalf of Mr. Michel Jarraud, Secretary-General of the World Meteorological Organization (WMO), Mr Koji Kuroiwa, Chief of Tropical Cyclone Programme, expressed the sincere appreciation of WMO to the Government of the Cayman Islands for hosting the thirty-third session of the Committee. He extended his particular gratitude to Mr Fred Sambula, Director General of the National Weather Service of the Cayman Islands for his earnest effort in the arrangements for this session. Referring to the increasing role of the Hurricane Committee to play as the platform for various regional projects to develop multi-hazard early warning systems, Mr Kuroiwa stressed that the proactive action taken by the Committee for those projects will extend the scope of its activities and, eventually, allow it to enhance the regional framework and cooperation to reduce the loss of lives and properties from the hurricane-related disasters.

1.1.5 The Honourable Juliana O'Connor-Connolly, JP, Deputy Premier and Minister of District Administration, Works, Lands and Agriculture, in her address, spoke on the "Strengthening of Regional Collaboration on early Warning" with major emphasis on the enhancement of regional met services collaboration such that citizens receive the most timely, credible and reliable information for the protection of life and property.

1.1.6 In his remarks, Mr Tyrone Sutherland, Permanent Representative of the British Caribbean Territories, thanked the Deputy Premier and the Government of the Cayman Islands for their strong support for meteorological services, locally, regionally and internationally. He extended his warmest welcome to all delegations and experts participating in the 33rd session of the Committee and thanked the sponsors for partnering with the Weather Service and the

Ministry of District Administration, Works, Lands and Agriculture in supporting this very first time that the Hurricane Committee held a session in the Cayman Islands.

1.1.7 The session was attended by 52 participants, including 39 from RA IV Member States of the Committee, observers from Spain and four Regional and International Organizations. The list of participants is given in **Appendix I**.

1.2 Adoption of the agenda

The Committee adopted the agenda for the session as given in **Appendix II**.

1.3 Working arrangements for the session

The Committee decided on its working hours and the arrangements for the session.

2. REPORT OF THE CHAIRMAN OF THE COMMITTEE

2.1 The Chairman reported to the Committee that during the 2010 hurricane season, RSMC Miami included in the Tropical Weather Outlook the likelihood of tropical cyclone formation in percents. RSMC Miami also increased the watch and warnings issuance times as described in the operational plan and improved the Tropical Cyclone Public Advisory format. Information about changes on the RSMC Miami web is included in: http://www.nhc.noaa.gov/pns_index.shtml

2.2 During the 2010 season, Mr. Akil Nancoo from the Trinidad and Tobago, and Mr. Lorne Terry Salmon from Antigua and Barbuda, respectively, participated in the WMO/RSMC Miami attachment program. The meteorologists helped with hurricane warning coordination in the region during the tropical cyclone events while they gained valuable training in hurricane forecasting. RSMC Miami and WMO strongly encouraged WMO RA-IV Permanent Representatives to continue to support this program. The announcement requesting candidates for 2011will be send by the Region IV President in late March. The program will be shortened to two weeks.

2.3 Three meteorologists from the Mexican Air Force were stationed at the RSMC Miami during2010. Capitan Julio Diaz Ramirez, Capitan Alejandro Campos Solorzano and Mayor Felipe Sanchez Mejia helped coordinate timely clearances for hurricane surveillance and reconnaissance flights over Mexico during tropical cyclone events that had the potential to make landfall. Their efforts helped improve the overall efficiency of the Hurricane Warning Program. The Chairman urged the continuation of this program in 2011 and a letter of invitation has been sent to the Mexican Air Force.

2.4 This year's WMO RA-IV Workshop on Hurricane Forecasting and Warning and Public Weather Services was scheduled to be held at RSMC Miami 21 March to 1 April 2011. This year's workshop will be conducted in English only. The Chairman strongly supports that the workshop continues to be offered in English and Spanish every other year due to the importance to the region’s hurricane program.

2.5 The Latin America Caribbean Hurricane Awareness Tour (LACHAT) will take place from 20 to 27 March 2011. The U.S. Air Force C-130 (J-model) Hurricane Hunter plane will visit Cabo San Lucas and Chiapas, Mexico, Grand Cayman, Curacao, Saint Lucia and Puerto Rico. As in past years, the LACHAT is expected to increase public awareness of the hurricane threat and will serve to recognize and strengthen national and international teamwork for storm warning and emergency response. The LACHAT had enhanced the visibility of the participating country's weather forecasting and emergency management offices. Over 15 thousand people toured the plane in 2010. A Hurricane Awareness Tour (HAT) would take place along the United States east coast from 1 to7May 2011.

2.6 Reconnaissance aircraft continues to play an important role in monitoring the track and intensity of tropical cyclones. During the 2010 season, the U.S. Air Force and NOAA Reconnaissance Hurricane aircraft provided valuable meteorological data not available from any other sources. The NOAA P-3 and NOAA-Gulf stream jet aircraft missions were primarily devoted to collecting data for the Intensity Forecasting EXperiment (IFEX) project lead by NOAA's Hurricane Research Division. IFEX seeks to improve operational forecasts of tropical cyclone intensity, structure, and rainfall by providing more accurate data to the operational numerical modelling system (HWRF) and by improving understanding of tropical cyclone physical processes. Several other experiments occurred simultaneously and in partnership with NOAA. NASA collaborators conducted the Genesis and Rapid Intensification Processes (GRIP) experiment to better understand the processes important in tropical cyclone genesis and rapid intensification. The NSF conducted the PRE-Depression Investigation of Cloud systems in the Tropics (PREDICT) experiment to understand the processes governing the transition of easterly waves into tropical depressions, with a focus on the mesoscale and synoptic-scale environment supportive of tropical cyclogenesis. These observations collected, no doubt, aid researchers in understanding the processes that contribute to hurricane intensification, ultimately leading to better forecasts.

2.7 RSMC Miami and the Chairman greatly appreciated the radar imagery received operationally from RA-IV members during the hurricane season primarily the new radars from Trinidad and Belize. The Chairman encouraged NMHSs to continue to make radar imagery from the region available operationally via the Internet or any other possible way.

2.8 Surface and upper air observations are very important to the operational forecasts of the RSMC Miami. The Chairman appreciated the members' efforts to maintain their observation and communication systems, especially the data received from country members during hurricanes.

2.9 The Chairman thanked the members affected by tropical cyclones for the submission of their post-storm country reports. These reports are vital to the preparation of the RSMC Miami Tropical Cyclone Report.

2.10 Coordination between RSMC Miami and the U.S. Department of State Crisis Operations Center during hurricane events in 2010 was helpful in communicating forecasts with the U.S. Embassies in the RA-IV countries.

2.11 As part of the United States Weather Research Program (USWRP), the Joint Hurricane Testbed (JHT) is one of the primary avenues to evaluate research projects with the goal of transitioning successful projects into operations. There are 11 on-going projects which will be evaluated during the upcoming 2011 hurricane season.

2.12 The NOAA Hurricane Forecast Improvement Program (HFIP) is a multi-agency effort to improve tropical cyclone track and intensity forecast accuracy by 50% over a ten-year period. Some promising preliminary results were noted in 2010 when Doppler radar data were assimilated into a high resolution model. The output showed potential to provide better intensity forecast guidance, though much more developmental work and testing are required. RSMC Miami is actively involved in leading the aspects of HFIP. A procedure whereby promising output will be made available in real or near real time for the Specialists in place, allowing for interaction through the season between research and operations scientists. As of 19 January, HFIP was still awaiting official notification of funding for the 2011 season.

2.13 The Seventh International Workshop on Tropical Cyclones (IWTC-VII) was held at RSMC La Reunion, France during 12-20 November, 2010. In addition to 4 participants from RSMC Miami, there were 8 participants from Region IV. A summary of the IWTC-VII activities and recommendations will be provided during the hurricane committee meeting. Dr. Lixion Avila continues as the RA-IV International Organizing Committee representative.

3. COORDINATION WITHIN THE WMO TROPICAL CYCLONE PROGRAMME

3.1 The Committee was informed by the WMO Secretariat of the basic principles of the Tropical Cyclone Programme (TCP) in implementation of the Programme's activities as follows;

- To enhance support measures for TC forecasters; e.g. update of the "Global Guide to Tropical Cyclone Forecasting" and its linkage to the "Tropical Cyclone Forecaster's website".
- To transfer research and development results into operational forecasting through promoting the collaboration between operational forecasters and researchers.
- To establish Storm Surge Watch Schemes (SSWSs) and strengthen the storm-surge warning capabilities of National Meteorological and Hydrological Services (NMHSs).
- To continue to put high priority on capacity building.

3.2 The Committee was informed that the various international forums were organized by TCP in cooperation with the World Weather Research Programme (WWRP) of WMO such as the Second International Workshop on Typhoon Landfall Processes (IWTCLP-II; Oct 2009, Shanghai, China), the Third International Conference on QPE/QPF & Hydrology (Oct 2010, Nanjing, China) and the Seventh International Workshop on Tropical Cyclones (IWTC-VII; Nov 2010, La Reunion). These forums promoted interaction between forecasters and researchers and thus contributed significantly to the application of research achievements to operational forecasting.

3.3 From this perspective, TCP also plans to organize the International Workshop on Satellite Analysis of Tropical Cyclones (IWSATC) in Honolulu in April 2011 with a view to improving the operational procedures of the satellite analysis, including Dvorak analysis. In view of the great relevance with the best track data in each region, the workshop will be held in conjunction with the second workshop of the International Best Tracks Archive for Data Stewardship (IBTrACS) which is organized by the World Data Center (WDC) for Meteorology maintained by NOAA. IWSATC will focus particularly on the objective satellite-based TC analysis methods and is expected to make a recommendation toward a more standardized and objective procedures of the satellite analysis of tropical cyclones.

3.4 The Committee was please to note that as part of the Storm Surge Watch Scheme, TCP and the Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM) jointly held the 6th Storm Surge and Wave Forecasting Workshop from 21 to 25 February 2011 in Santo Domingo, Dominican Republic for the Committee Members, with the support of NOAA. At the workshop, it was identified that marine forecasting capabilities including storm surge are very limited in many of the Committee Members. Recognizing that improvement of the capabilities on coastal/marine hazards forecasting based on meso-scale and small-scale models/products is essential to island countries, the workshop recommended that efforts be made for capacity building in this field with high priority.

3.5 Typhoon Landfall Forecast Demonstration Project (TLFDP) and the NW Pacific Tropical Cyclones Ensemble Forecast Project (NW-P/TCEFP) are the tangible outcomes of the IWTCLP-II, which were launched jointly by TCP and World Weather Research Programme (WWRP) in 2009 targeting at the Members of the Typhoon Committee and have been implemented successfully. NW-P/TCEFP established a website in August 2010 to examine the utility of the ensemble forecast products in tropical cyclone forecasting. It is envisaged that the project will be extended to other regional TC bodies in phases and will eventually develop its status from research to operation.

3.6 The Committee was informed that update of the Global Guide to Tropical Cyclone Forecasting will be completed by the middle of 2011. It will provide comprehensive guidance on tropical cyclone forecasting from a multi-hazard point of view. Also, the new Guide will be web-based with a view to timely update and easier access. The WMO Tropical Cyclone Forecaster's Website has been developed to provide a readily accessible source of forecast tools and analytical data necessary for operational forecasting. These two information sources will be linked with the TCP Website to serve as a comprehensive source of information/material/data that is expected to be of great value to operational forecasters. In light of the online format for publication, the Committee requests that the WMO Secretariat make the Chapters available online, as they are completed & approved.

3.7 In answer to the inquiry about the unestablished links in the Forecaster's Website, WMO Secretariat acknowledged that the website is still on the way to enhance its practical utility. A questionnaire will be sent to the forecasters of national and regional warning centers with a view to increasing the usefulness of the website for operational forecasting.

3.8 The Committee noted with satisfaction that the study on suitable conversion factors between the wind speeds of different time ranges was completed and its outcome was distributed as a WMO Technical Document (WMO/TD-No.1555) to the WMO Members including those of the Committee in October 2010. It has been proposed by WMO/TCP to include a summary of the study in the Hurricane Operational Plan (see para 6.4).

4. REVIEW OF THE PAST HURRICANE SEASON

4.1 Summary of the past season

4.1.1 A report of the 2010 hurricane season in the North Atlantic basin and in the Eastern North Pacific was presented to the Committee by Dr Lixion Avila, Senior Hurricane Specialist, on behalf of RSMC Miami - Hurricane Center.

RSMC Miami 2010 North Atlantic Hurricane Season Summary

4.1.2 The 2010 Atlantic hurricane season was significantly more active than the 2009 season. The active season likely resulted from very warm sea surface temperatures in the tropical Atlantic between the Lesser Antilles and Africa, combined with La Nina conditions in the Pacific in 2010. Nineteen tropical storms developed, tying 1995 for the third highest number of storms on record. Twelve of the storms became hurricanes - the second highest total on record behind the fifteen observed in 2005. Five of the hurricanes became major hurricanes, category 3 or higher on the Saffir-Simpson Hurricane Wind Scale. There were two additional tropical depressions. The accumulated cyclone energy (ACE) index was 190% of the long-term median. The Accumulated Cyclone Energy (ACE) index is a measure of the collective strength and duration of all tropical storms and hurricanes during the year, calculated by adding up the squares of the maximum wind speeds (in knots) at six-hour intervals for each storm. The active season likely resulted from very warm sea surface temperatures in the tropical Atlantic between the Lesser Antilles and Africa, combined with the change in Pacific Ocean conditions from El Niño in 2009 to La Niña in 2010. There were a series of experiments involving research aircraft from NOAA, NASA, and the National Science Foundation that monitored the life cycles of several Atlantic storms from beginning to end. The data collected during the experiments was of great value to the National Hurricane Center both during and after the storms.

RSMC Miami 2010 Eastern North Pacific Hurricane Season Summary

4.1.3 The 2010 Eastern North Pacific hurricane season was historically the least active season on record. Only seven tropical storms developed, which is the lowest number observed since routine satellite reconnaissance of that basin began in 1971. Furthermore, only three of those storms became hurricanes, which is also the lowest number of hurricanes ever observed in a season. Only two of the hurricanes became category 3 or higher on the Saffir-Simpson Hurricane Wind Scale (SSHWS) which was 50% of the long-term average. There were five additional tropical depressions that did not reached tropical storm intensity. The accumulated cyclone energy (ACE) index was only 46% of the long-term median. This is the third lowest ACE value, ahead of the 2007 and 1977 seasons.

4.1.4 The detailed report on the 2010 hurricane season provided by the RSMC is given in **Appendix III.**

4.2 Reports on hurricanes, tropical storms, tropical disturbances and related flooding during 2010

4.2.1 Members provided the Committee with reports on the impact of tropical cyclones and other severe weather events in their respective countries in the 2010 hurricane season. In addition to its country report the Cuban delegate also presented a history of Cayman Islands first weather observation programme that was setup by Cuba in the 1930s (see **Appendix VI**). The summary of the reports is given in **Appendix V**.

4.2.2 A discussion arose as to the warning arrangement made by RSMC Miami and NMHSs for Hurricane Tomas which rapidly intensified into a hurricane and caused significant damage to the Member countries peculiarly to Saint Lucia and Barbados. The cyclone also produced heavy rains in Haiti, which killed an estimated 50 people and complicated the ongoing earthquake relief efforts in that country. Noting that this subject contains significant relationship with institutional and coordinative matters in the regional warning system, the Committee decided to discuss this issue under the agenda item 5.

4.2.3 The Committee recommend that all presentations and documents submitted by the Members related to meteorological severe events indicated the type of wind speeds (1 min-, 2 min- and 10 min-average) to which they are referring.

5. COORDINATION IN OPERATIONAL ASPECTS OF THE HURRICANE WARNING SYSTEM AND RELATED MATTERS

5.1 Mr Tyrone Sutherland (BCT) agreed to serve as rapporteur on this agenda item. This agenda item allows Committee members to raise matters that have an impact on the effectiveness of the Hurricane Warning System.

5.2 During the discussions on the 2010 hurricane season, the Committee discussed a few examples where the regional coordination of warnings may not have been totally satisfactory to all the Meteorological Services concerned. One example raised by Cuba related to the passage in September of Tropical Storm Nicole over Cuba. During its lifetime before landfall, there had been some difficulties in identifying the centre of Nicole using satellite imagery as its major convection was, most of the time, displaced quite some distance from the centre. Not long after the system was upgraded to a tropical storm, its centre moved over Cuba, where surface observations suggested that Nicole was not at tropical storm strength as the strongest winds then appeared to be quite some distance from the centre. The system was then downgraded from tropical storm status to a depression. The Cuban representative on the Committee suggested that when there is a change in classification of a system while over the territory or waters of a Member State, there was need for much greater coordination between the RSMC and the State concerned to avoid confusion with the public.

5.3 The Committee also discussed the effect on population of differences in local warnings for islands in close proximity. This occurred in the case of Hurricane Earl as it passed near the Northern Leeward and Virgin Islands, in which the timing of warnings differed significantly between the two sides of the French/Dutch island of Saint Martin/Sint Maarten. The Committee called for greater coordination between all NMHSs concerned in conjunction with the RSMC. Regarding this matter, the Representatives have agreed to organize a meeting to discuss the warning system with the relevant stakeholders including Antigua and Barbuda.

5.4 Hurricane Tomas crossed the Windward Islands in late October 2010, causing a swath of destruction from Barbados and St. Vincent and the Grenadines, northward to Dominica, with destruction and loss of life being particularly severe in Saint Lucia. Tomas had been classified as an intense tropical wave as it approached the islands, but upon investigation by a hurricane reconnaissance aircraft, it was immediately upgraded to a tropical storm. Tomas impacted Barbados only 14-hours after it was named. Concern had been expressed about the timing of the aircraft investigation of Tomas when the system was already within 24-hours of the Windward Islands. It was generally felt in the Eastern Caribbean that there were enough signs to suggest the possible intensification of the system above that of a tropical wave at least 24-hours before the aircraft flew into the system, which should have warranted an earlier aircraft investigation and which would have greatly contributed to a more appropriate alert, preparation and possible reduction in the loss of life among the islands.

5.5 In this regard, the Committee recalled that it had discussed some requests in the past few years for reconnaissance aircraft to investigate systems in the Atlantic that had the potential to make landfall in the Eastern Caribbean when the system is further east of 55°W, which was the existing eastern limit in the RA IV Hurricane Operational Plan. RSMC Miami will task reconnaissance aircraft to systems west of 52.5 degrees longitude when resources permit. The RSMC and the United States representatives on the Committee indicated that this matter had indeed been under consideration and that it would be further studied. RSMC Miami and member countries request that radar outage information be provided to the region during the hurricane season. Information should include estimated repair time, if known.

5.6 The British Caribbean Territories briefed the Hurricane Committee of the formalities within the Caribbean Meteorological Organization (CMO) that led to the existing arrangements for weather forecast and warning services of its Member States, which were reflected in Chapter 2 of the Hurricane Operational Plan. These arrangements were also reflected in similar arrangements under the auspices of the International Civil Aviation Organization (ICAO). The BCT also drew attention to the back-up arrangements between States for normal NMHS operations and specifically, the backup arrangements for Watches, Warnings and agreed-upon essential products, as contained in Chapter 2 of the Operational Plan and in arrangements under the auspices of ICAO. Specifically, for the CMO Member States, the backup arrangements are:

① Antigua will provide backup services for Barbados with respect to the island and coastal waters of Dominica;

② Barbados will provide backup services for Antigua and/or Saint Lucia;

③ Barbados will provide backup services for Trinidad and Tobago;

④ Jamaica will provide backup services for the Cayman Islands;

⑤ Trinidad and Tobago will provide backup services for Barbados with respect to the islands and coastal waters of Barbados and St. Vincent and the Grenadines;

⑥ The USA will provide backup services for Jamaica.

5.7 These backup arrangements were discussed in light of the operational impact of the passage of Hurricane Tomas across the Caribbean in 2010. In the process, it became very evident that there was a real possibility of a "double whammy" situation occurring in that a Forecast and Warning Office in one State and its designated backup in another State could both be “taken out of operations” by the same weather system. For example, Saint Lucia and its backup Barbados or the Cayman Islands and its backup Jamaica could be knockout together since hurricanes can and do hit both States with the track that hurricanes generally take. The BCT representative indicated that the CMO requested the Hurricane Committee to discuss this matter within its Operational Plan with a view to producing an improved backup arrangement. The results of the Hurricane Committee’s deliberations on the matter would be taken into account by the CMO at its next review of its overall backup arrangements.

5.8 In the process of its deliberation on the matter, the Hurricane Committee recognized that there was no backup arrangement for Belize and some other States. The Committee initiated a discussion among the NMHSs on the matter and came up with the following preliminary proposal, which would need to be decided upon formally on a bilateral basis:

① Antigua will provide backup services for Barbados with respect to the island and coastal waters of Dominica;

② Barbados will provide backup services for Antigua and/or Saint Lucia;

③ Barbados will provide backup services for Trinidad and Tobago;

④ Jamaica will provide backup services for the Cayman Islands;

⑤ Trinidad and Tobago will provide backup services for Barbados with respect to the islands and coastal waters of Barbados and St. Vincent and the Grenadines. Trinidad and Tobago will serve as a secondary backup to Barbados with respect to Saint Lucia;

⑥ The USA will take provide backup services for of Jamaica;

⑦ The Cayman Islands will take over responsibility for Belize, with Jamaica serving as a secondary backup to the Cayman Islands with respect to Belize.

5.9 The Committee urged the other countries in RA IV without backup arrangements for Watches, Warnings and other essential products, including those under the auspices of ICAO, to consider this matter on a bilateral basis and inform the Committee accordingly. The RSMC also informed the Committee that it was prepared to serve as a further backup for any Member State with respect to tropical cyclone forecasts and warnings, but not for other products. At the same time, the Committee suggested that States with more than one operational office might also consider the ability to transfer forecast and warning operations to those offices as a first measure to try to maintain national responsibilities as much as possible.

5.10 The RSMC briefed the Committee on a new Internet-based method for undertaking coordination of watches and warnings. The system was an "Internet Chat" for the region, based on a similar system used by the U.S. NWS for coordination with emergency managers within the USA. The software used in the Chat included a map with the ability to overlay satellite and radar images. The RSMC planned to begin experimenting with the Internet Chat for coordination within RA IV in the 2011 hurricane season. Coordination by this Chat method would be controlled and carried out at specific times. NMHSs would be required to register in order to be able to login to the system for participation. While the RSMC indicated that many users could be on the system at the same time, including several from one country, there was the general view among many Committee members that only the senior operational staff that were normally involved in coordination with the RSMC should be allowed to use the system. There were questions about the language to be used in the Chat. The Committee suggested that those States with forecast and warning responsibilities for other States, as reflected in Chapter 2 of the Operational Plan, could set up similar Chat systems for their coordination with these other States.

5.11 The representative of the US Air Force reconnaissance team, Lt. Col. David Borsi, briefed the Committee on the status of the diplomatic clearances for hurricane reconnaissance flights in the airspace of Member States. He pointed out that as of March 2011, several of the clearances had expired and that new diplomatic clearances were being sought. The Committee made it clear that the hurricane reconnaissance flights were an essential component of the warning system for the benefit of all countries. It therefore urged the Meteorological Services to make contact with the appropriate authorities in their countries to ensure that the requests for diplomatic clearances were acted upon.

5.12 The Committee recalled that at its 32nd session (Bermuda, 2010), it decided to adopt into the Operating Plan, the same changes to lead times for tropical storm and hurricane watches and warnings that were to be introduced at RSMC Miami, in which hurricane watches and warnings would generally be timed to provide 48 and 36 hours notice respectively, before the onset of tropical storm force winds. The Committee reviewed how the system was applied in its first season by the States that issued tropical cyclone watches and warnings. It was found that some NMHSs had not yet introduced the changes into their internal operations and had not made the changes known to the public and relevant authorities at the national level; therefore they had not utilized the new lead times in 2010. It was recognized that the longer lead times were clearly very advantageous for some States, particularly the larger and more populous ones and those with a large number of islands, while the longer lead times may not always be necessary for smaller States. The Committee agreed that the new definitions and lead times would remain as agreed in 2010. It reiterated that the issuance of watches and warnings was a national responsibility, in which the lead time to be used should be decided upon based on national assessment of each individual system. It pointed out, however, that variations in lead times could occasionally lead to confusion among officials and the public, especially if different lead times were used by neighbouring States.

5.13 RSMC requests additional coastal watch/warning breakpoints for portions of the region. Member countries should provide additional breakpoints to RSMC as soon as possible.

6. REVIEW OF THE RA IV HURRICANE OPERATIONAL PLAN

6.1 Under this agenda item, the Committee designated Dr Mark Guishard (Bermuda; English-speaking Vice-chairman) and Dr José Rubiera Torres (Cuba; Spanish-speaking Vice-chairman) to serve as rapporteurs. Mr John Parker (Canada) agreed to serve as a coordinator for Attachment 8A (List of Telephone Numbers of National Meteorological Services and Key Officials) to the RA IV Hurricane Operational Plan.

6.2 The Committee reviewed in depth the Operational Plan, taking into account changes and additions that came out from this and the other agenda items.

6.3 Changes were made to the RSMC products in Chapter 1 according to the RSMC Miami's proposal, which included:

(i) Addition of the pronunciation for some storm names;
(ii) New format for the header of RSMC bulletins;
(iii) Revise the wording for overall tropical cyclone MAX WIND location in the remarks section of the VORTEX message;
(iv) Use of the abbreviation of "KM/H";
(v) Inclusion of intensity in mph in the Tropical Cyclone Discussion;
(vi) Inclusion of accents in Spanish

6.4 A proposal was made by the WMO Secretariat to include in the Plan a summary of the study on suitable conversion factors between the wind speeds of different time ranges as a guideline for the conversion. The study was undertaken by the Systems Engineering Australia Pty Ltd (SEA) to arrive at suitable conversion factors between the WMO 10-minute standard average wind and 1-minute, 2-minute and 3-minute "sustained" winds. The final report was submitted to the TC RSMCs/TCWCs Technical Coordination Meeting and was endorsed at its 6th session in Brisbane, Australia in October 2009. Noting the significance of setting guidelines for converting the maximum wind speeds of tropical cyclones, the Committee accepted the proposal and decided to include the summary in the Chapter I as given in the **Appendix VI**.

6.5 Update of Chapter 5 (Satellite Surveillance) was also proposed by the WMO Secretariat (Space Programme) and adopted. Most of the updates are related to operationalization and rearrangement of the polar-orbiting, geostationary and environmental R&D satellites which were carried out during 2010.

6.6 In Chapter 9, the Committee considered retirement of the names of tropical cyclones of significant strength or impact during the previous season. From the Atlantic list, at the request of Saint Lucia, Curaçao and Costa Rica, "Tomas" and, at the request of Canada, "Igor" were retired and replaced by "Tobias" and "Ian", respectively on the 2016 list.

6.7 Considering that the Operational Plan was only available in English and Spanish, the Committee requested the Secretariat to provide Météo-France with all the changes to the Plan and a French version of the wind conversion document to facilitate Météo-France's internal French version. The Committee also urged Météo-France to continue to make copies available to Haiti as soon as it was updated.

6.8 The Committee recommended to the President of RA IV the approval of the amendments to the text of the Plan. The Committee urged the WMO Secretariat to ensure that the amendments and changes made to the Plan are posted to the TCP Web site both in English and Spanish, before commencement of the 2011 hurricane season.

6.9 The Committee agreed to remove 1.3 International Hurricane Scale Table from the 2011 version of the Hurricane Operational Plan (Document 6)

6.10 At the request of Cuba, the table of names in the Operational Plan will include properly accented characters for the Spanish and French names. RSMC Miami will continue to use the unaccented characters in its bulletins and will provide phonetic pronunciations for the yearly lists.

7. REVIEW OF THE COMMITTEE'S TECHNICAL PLAN AND ITS IMPLEMENTATION PROGRAMME FOR 2011 AND BEYOND

7.0.1 The Committee designated Dr Mark Guishard (Vice-chairman of English-speaking members) and Dr José Rubiera Torres (Vice-chairman of Spanish-speaking members) to serve as rapporteurs.

7.0.2 A detailed review of all components of the Technical Plan and its Implementation Programme was carried out, taking into account the development and progress made by Members since the thirty-first session of the Committee.

7.0.3 The Committee recommended to the President of RA IV the approval of the updated RA IV Hurricane Committee's Technical Plan and its Implementation Programme, which is given in Appendix VII.

7.0.4 The Committee has agreed that the Vice Chairs, in collaboration with a small drafting group from the Committee, will restructure the Appendix of Document 7, the Technical Plan and its Implementation Programme, in an effort to provide clear separation between long term objectives, and specific activities tasked to the Members.

7.1 Meteorological Component

Regional Basic Synoptic Network (RBSN)

7.1.1 The Committee considered the availability of observations and noted the results of the most recent monitoring. In particular, there was a reduction to 538 surface stations from 539 stations in 2009 and to 133 upper air stations from 135 in 2009. Although of concern, this fluctuation is within the variability seen in the monitoring over several years. The meeting also noted there continues to be a number of "silent stations". There are multiple reasons for both the variability and silent stations including administrative issues of reporting, costs of supplies and telecommunications problems or interruptions. There was consensus there is a sustainable level of availability of these observations at this time but also recognition that this situation could easily change. The meeting stressed the importance of continuing the monitoring of and attention to the availability of observations including in the future to those from new sources. The meeting also highlighted the need for all Members to be able to access the observations including those from automated monitoring and observation networks and strongly encouraged increased efforts on data sharing.

7.1.2 The Committee also took note of and welcomed the outcome from the Sixth RA-III/IV TECO held the previous week in Costa Rica for RA-III/IV Members to make available the observational data from automated weather stations, rain gauges, etc which they already have as well as new systems which will be implemented.

7.1.3. The Committee noted with regard to upper air observations that given widespread budget concerns, upper air rawinsonde programs of Members may be under threat, as they are an expensive aspect of NMHS operations. Sometimes governments have trouble understanding the benefits, especially in light of improving remote sensing technologies and AMDAR. Some Members are already reducing the number of launches and in some cases launches are done only at the duty meteorologists' discretion. The Meeting strongly stressed the continuing importance of rawinsonde upper air programmes and the maintenance of launches in accordance with the Hurricane Operations Plan.

7.1.4 The Committee also stressed that along with observations, the availability of the metadata was essential to the utilization of the data especially with regard to data quality and integration of data from many different sources. It also noted that standardizing metadata in accordance with WIGOS and WIS was critical especially for newer data handling and sharing systems as well as NWP. It echoed strong support for the RA-IV WIGOS/WIS activities and encouraged all those countries involved in the Hurricane Committee to actively engage in providing standard metadata and improving the sharing of the data (including radar data) they have available. These activities will help in the integration of upper air and surface data from different sources.

7.1.5 The Committee took note of the information provided by Fred Branski, the President of CBS, regarding the advances in AMDAR technology with regard to humidity and access to this improved AMDAR for the area of concern to the Hurricane Committee. The AMDAR data websites were provided as well as examples of recent AMDAR profiles into Santo Domingo, Dominican Republic and Miami, Florida. The Meeting discussed the ongoing improvements regarding the installation of newer sensors which allow the measurement and reporting of humidity as well as temperature and wind for enroute, ascent and descent. A map of some the existing routes was made available and a comparison of rawinsonde and AMDAR generated profiles. This data is generally available within 5 minutes of generation to registered users of the website. The meeting welcomed these advances but also highlighted it is still early to consider AMDAR as a full replacement for rawinsonde data. Several studies have been undertaken in this regard and the following web links were made available for several of those studies done in Europe:
Available through MADIS: http://madis.noaa.gov/
Available through GSD Web Page: http://amdar.noaa.gov/java/

Additional Information:
GSD web Page: http://amdar.noaa.gov/
WMO AMDAR Program: http://www.wmo.int/amdar/AMDARResources.html

7.1.6 The meeting noted there must be a data requirements-based approach, rather than a technology-based approach for observational data needs. In this regard, users and NMHSs need to assess what the requirements are - users don't need rawinsondes, they need the data they produce. So as costs rise and budgets are cut, if we can use alternative means for generating the same data, then this may be one avenue for development of a multi-platform system but only if the requirements are met and if the data is fully available to all Members and users.

WMO Information System (WIS)

7.1.7 In RA IV, the telecommunications services required to meet on-going operational needs of the WMO Regional Meteorological Telecommunications Network (RMTN) were provided by a new NOAA-Net Multi-Protocol Label Switching (MPLS). NOAA also maintain a satellite distribution system for aviation services known as the "International Satellite Communication System" (http://www.nws.noaa.gov/iscs/pdf/Poster02v10.pdf). This service is referred to as the ISCS Generation 2 Extended, or ISCS-G2e, and will operate from Mid 2010-June 2012. The new NOAA-Net MPLS at 64 Kbps is several times faster than the ISCS data transmission rate. Performance, requirements, and funding will be re-evaluated to determine the System Requirements beyond June 2012.

7.1.8 Following the 2010 extraordinary meeting of the Commission for Basic Systems (CBS) in Namibia, it is now clear that WIS has moved from its development stage and into implementation. Three candidate GISCs (Offenbach, Beijing and Tokyo) along with 15 DCPCs are now in preoperational mode. These and several other GISCs, including Washington, will be operational following endorsement from Congress XVI. The project to upgrade the Main Telecommunication Network (MTN) component of the GTS has now completed, and this improved MTN based on the same MPLS technology as NOAA-Net will form the core network of WIS connecting all GISCs. The Manual on WIS (WMO No. 1060) was prepared by CBS, along with the draft amendments to include WIS in the Technical Regulations (WMO No. 49) which will all be presented to Congress XVI for approval. These combined with a Guideline to WIS (WMO No. 1061) and guidelines for WMO Metadata for WIS (http://wis.wmo.int) will allow all Members to begin to implement the new WIS functionality. It is expected that GISC Washington will take the leading role in ensuring Members in RA IV also implement and benefit from the new functionality of WIS.

7.1.9 CBS Extraordinary 2010 also updated the Manual on GTS (WMO No. 386) and Manual on Codes (WMO No. 306) to allow the exchange of information in the form of Common Alerting Protocol (CAP) between WMO Members. This is in line with the decision of the WMO Council that recognized the benefits of using the Common Alerting Protocol (CAP, ITU Recommendation X.1303), which is a content standard designed for all-hazards and all-media public alerting, for the dissemination of weather, climate and water related alerts and warnings. Thus CAP will now be supported in the virtual all hazards network within the WIS-GTS.

7.1.10 To benefit fully from WIS, it was recommended that the Committee Members make plans to implement WIS functionality in their programme plans and the Hurricane Committee work with the GISC Washington and WMO secretariat to ensure their programmes include WIS implementation as a priority activity over this coming WMO 16th financial period.

WAFS Internet File Service (WIFS)

7.1.11 The Committee, on behalf of the International Civil Aviation Organization (ICAO), reminded its members that with the transition from ISCS-G2 (satellite broadcasts), there was an urgent need for the Caribbean States and Territories (CAR) to register to access the WAFS Internet File Server (WIFS) and to start download tests. The ISCS/WAFS broadcasts via satellite will end in June 2012 but users could already access the WIFS. It was pointed out that access to the WIFS is restricted; therefore it was necessary for authorization to be granted to the NMHSs since they provide direct support to flight planning for international air operations. To begin WIFS-download tests, it was only necessary to have a suitable internet terminal (internet speed 64kbps bursting to 512 kbps). Special software may be required to display meteorological graphics, as indicated in the NOAA-FAA WIFS Users Guide that was provided.

7.1.12 The Committee noted that ICAO sent out a circular letter to that effect in August 2010, but in March 2011, only one CAR user was registered. The Committee urged RA IV Member States and Territories to register immediately in the manner indicated by ICAO.

7.2 Hydrological Component

7.2.1 The Committee was informed that in December 2010 a meeting of hydrology experts had been held in the Dominican Republic to consider the recommendations of the Management Group for Hydrology, and to propose regional priorities on that basis. The experts who met in the Dominican Republic recommended that the RA IV Management Group set up a Task Team so that during 2011, in collaboration with the Commission for Hydrology and the WMO Secretariat, through the Hydrology and Water Resources Programme and the WMO Office for North America, Central America and the Caribbean, an action plan could be developed to tackle the following tasks:

- Help develop projects relating to flash flood guidance systems and those concerning Multi-Hazard Early Warning Systems (MHEWS), elaborating a comparative analysis of the results that could be expected from the use of the system in those countries where pilot projects are being developed, including developing and promoting the use of the Flash Flood Guidance System User Manual and other flood-related material.
- Identify and coordinate with WMO regional training centres training requirements in the field of hydrology and the adaptation of existing hydrology-related courses.
- Request National Hydrological Advisers to update the hydrological component of the Hurricane Committee's Technical Plan.
- Prepare an evaluation report on the sustainability of the hydrological observing systems and National Hydrological Services, including the establishment of Carib-HYCOS.

7.2.2 The Task Team to be established according to the aforementioned objectives will support the activities of the RA IV Task Team on Disaster Risk Reduction and the implementation of WIS/WIGOS in this Region.

7.2.3 Furthermore, since the last session of Regional Association IV (Bahamas, 2009), there were several discussions on the work of a task team on Hydrology. Four distinct goals to strengthen regional capacity:

a) Providing assistance and advice to the President of the regional association on all issues relating to the regional aspects of hydrology and water resources;
b) Determining the best way to meet the Region's needs in terms of hydrology and water resources;
c) Cooperating with the Commission for Hydrology (CHy) and other WMO bodies on projects relating to hydrology and water resources:
d) Collaborating on he creation and developments HYCOS components in RA IV.

7.2.4 Regarding the hydrological component of the Hurricane Committee's Technical Plan, the RA IV Hydrological Adviser initiated consultations with National Hydrological Advisers in order to fulfil the mission to:

a) update the hydrological component of the Hurricane Committee's Technical Plan with the active participation of the National Hydrological Services;
b) establish a regional mechanism for monitoring the hydrological component of the Hurricane Committee's Technical Plan;
c) increase coordination between the National Meteorological and Hydrological Services, in all their activities;
d) strengthen the system for the communication and transfer of hydrological data between National Hydrological Services during severe weather events; and
e) continue to improve the hydrological information and data in the hurricane season report.

7.2.5 After considering the information presented by the Regional Hydrological Adviser, the Committee recognized the importance of establishing a coordination mechanism for the hydrological component of the Hurricane Committee's Technical Plan and:

1. invited the Management Group to consider the changes to the regional priority tasks in the field of hydrology and to set up a Task Team to carry out these tasks;
2. invited member countries to study the hydrological component of the Hurricane Committee's Technical Plan carefully;
3. reiterated the importance of the Hydrological Adviser's attendance at the meeting of the Committee.

7.3 Disaster Prevention and Preparedness Component

7.3.1 Following extensive consultations in RA IV for Central America and the Caribbean, with a multi-stakeholder approach, a potential project concept was discussed for phase-I Caribbean Initiative for strengthening Risk Assessment and MHEWS based on discussions and consultations at this Meeting, including:

(i) Facilitate national policy/legislation dialogues and risk management workshops for strengthening of meteorological, hydrological and climate services and identification of roles and responsibilities of National Meteorological and Hydrological Services as reflected in national policy, legal framework and institutional coordination mechanisms, within a comprehensive Disaster Risk Management Framework;

(ii) Develop and demonstrate operational capacities in EWS for severe weather (heavy precipitation) and flooding (flash floods and coastal inundation) spanning all components of regional cooperation and all components of national EWS including monitoring and forecasting, risk analysis, dissemination and communication and development Standard Operating Procedures for emergency contingency planning and activation of emergency plans based on warnings issued on the levels of risks.

7.3.2. This preliminary project concept was presented by the Chairs of the RA IV DRR Task Team during a special session on Disaster Risk Management for further consultation with the participants. The concept was endorsed and the Meeting noted that the design of the proposal should be carried out with consideration for a number of factors, including:

(i) The concept should be consulted with the DRM agencies and other regional and international partners for further development and buy-in. It was noted that consultation with these stakeholders are planned in Q2 and early Q3 2011;

(ii) The alignment of the project with the elements of the Caribbean Disaster Management (CDM) Framework;

(iii) Development and implementation of a multi-stakeholder and transparent mechanism for project/proposal development, implementation planning, resource mobilization and establishment of project governance engaging Members and key partners. It was discussed that a proposal document for both components should be developed with a clear project management framework and implementation planning with consideration for the roles and responsibilities of different stakeholders, to leverage technical, operational, coordination and funding capacities within WMO and with other partners. The following issues should also be considered;

    (a) Criteria for country/territory selection for implementation of the project should be based on multiple benefits and governments' and agencies' receptivity for active participation in and contributions to the project;

    (b) Relevant partners (national, regional, international) should be identified and engaged in the planning, implementation, and resource mobilization and development of project governance mechanism;

    (c) Concrete experiences and lessons learnt from the good practices in Multi-Hazard EWS documented by WMO, from the region and globally such as France/French West Indies, Cuba, Italy, the USA, Japan, Bangladesh, etc. would provide significant insight and expertise in all aspects of the projects;

    (d) Mapping of all relevant existing projects in the region and determining leveraging opportunities should be explored, particularly highlighting the following projects:

        i. Finish and Canadian QMS/SOP development

        ii. OAS/CDEMA/UNDP DRR Legislative/planning/governance initiative

        iii. CIMH/UNDP/CDEMA/Italian Cooperation project on risk identification for EWS purposes

iv. The EU funded Regional Risk Reduction Initiative (R3I) project of OCTs being implemented by UNDP
v. CIMH/CCRIF project on indexing of floods for Flood insurance products
vi. Caribb WIGOS, Caribb HYCOS, and the Radar projects;

(iv) Consideration of funding opportunities;
(v) Establishment of an annual Regional forum or meeting for monitoring, discussions, evaluations and improvements within the context of these multi-stakeholder projects, leveraging relevant annual meetings in the region.
(vi) The outcomes and progress in 2011/2012 timeframe for the development of the DRR project proposals will be presented to the next 34th HC to determine concrete areas of cooperation as relevant to each tier of the projects.

7.3.3 In this context, the Committee discussed that,

(a) There is need for establishment of a regional website that would list all the DRR related projects, trainings, and related meetings and that whether the UN-ISDR could be consulted with to host such a website, in collaboration with the regional and international agencies concerned. Given the discussion in the Committee and the DRR Workshop about the significant need for engagement between the meteorologists and disaster management communities, at this level, and despite progress made to date by various regional agencies, the membership took note of concerns regarding the coordination of DRR-related workshops, meetings and activities organized by various agencies, and encouraged that these agencies work collectively to ensure that communication with the disaster management community regarding upcoming events is clear, inclusive and unambiguous. It stressed the importance of such a regional portal.
(b) Furthermore, potential areas of collaboration with ICG- Tsunami EWS for the Caribe and Adjacent Seas were discussed. The meeting noted that there are areas of convergence among the meteorological and tsunami systems, its important to keep in mind the following;
    - The models that are used to determine tsunami inundation vs storm surges are different, given the difference in the source (seismic and mass movement displacement vs wind/pressure). Areas indicated to be under threat from tsunami inundation might be greater or smaller than those predicted from storm surge models.
    - While the need for sea level monitoring is important for both meteorological and tsunami needs, the requirements for location of stations may vary.
    - Expressed concern regarding recent loss of some sea level observing capability and reiterated the importance of maintaining the existing network of sea level monitoring stations including DART buoys. It encouraged Members to work to increase sea level monitoring capabilities.
    - Because of the nature of tsunamis, much expertise is required is the field of seismology, and therefore a major component of the professionals that are required for a tsunami warning center are Seismologists, followed by Oceanographers.
    - Recall the recommendation of the ICG that a Regional Tsunami Warning Center be established in the region to deliver the timeliest and effective tsunami products for the decision makers.
    - Short lead times between first warning and impact, minutes vs days for tropical cyclones and storm surges.
    - Recalled that for different reasons (operational, technical capabilities), less than 50% of the national Tsunamis Warning Focal Points are not met offices,

but Emergency Management, Seismological Institutions, Security Agencies (Police, Fire).

c) Three key areas should receive attention form the Members, in support of national & regional DRR activities to address Coastal Inundation due to Storm Surge & Tsunami:
1) Generation and availability of Bathymetry and coastal topography data, with a view towards developing inundation maps for Disaster Management use;
2) Procurement, installation & improvement of Sea Level monitoring systems;
3) Development of Physical Oceanography & modelling expertise. This also incidentally leverages national level support for activities on the following areas, and others: wave forecasting, coastal geomorphology studies, shipping and navigation, coral reef ecology, marine biology and fisheries sustainability.

d) A work plan towards strengthening these activities would include the following approaches
   i. Bathymetry:
      - Airborne LIDAR
      - Multibeam scanning instruments mounted on marine vessels. Leveraging can
      - be sourced from shipping, cruise ship, oil and/or fishing industries.
      - Digitising of existing charts
   ii. Sea Level Stations: Perhaps some technical advice can be given by those jurisdictions which already have extensive Sea Level Networks in the region, particularly the US. The ideal scenario is to facilitate an integrated network that is compatible with existing systems and data.
   iii. Physical oceanography expertise: This is one of the more significant challenges, given the problems the NMHSs already face in the development of meteorological & hydrological expertise in the region. These challenges include funding, staffing resources, training/education resources.

7.4 Training Component

7.4.1 Under this agenda item, the Committee requested Dr David Farrell (CIMH) to serve as a rapporteur.

7.4.2 The Committee noted with appreciation that Fellowships for long-term and short-term training totalling 102 person X month were granted to the Member States of RA IV under various WMO programmes. This represented a noticeable increase from the 58.5 person X month reported in the 2009 and indicates that greater use of the fellowship by the Region. However, it was noted that in spite of this increase, Fellowship opportunities available to the region remain under utilized. As a result, the membership was encouraged to further increase its usage of the fellowship program.

7.4.3 It was brought to the attention of the Committee that fellowship opportunities to attend some academic institutions in the Region were under threat due to the high cost of tuition and the high cost of living. It was suggested that one solution to this problem was for the membership to seek opportunities for sharing of training costs through funding agencies or grants programs.

7.4.4 The Committee noted the request made by the WMO ETR for the region to identify its training needs and appreciated the information template supplied by the ETR which will be translated into the various languages of the Region to allow the full membership to respond effectively. It was noted that some of the information requested mirrored that recently provided to the WMO as part of its Disaster Risk Reduction initiative in the region and, as a result, this information already exists at WMO. As part of the request, the ETR requested that a small ad hoc working group be formed to support this activity. It was agreed that the matter would be brought to the RA IV Management Group.

7.4.5 The Committee expressed the need for increased opportunities in the areas of online and distance education given the high costs and often inconvenience associated with having persons travel abroad for training. In this regard, the need for an online B.Sc. program in Meteorology was emphasized. The Committee was informed of the various global and regional initiatives that were being undertaken to support the online and distance learning needs of the region. In particular, CIMH informed the Committee of it had initiated work with COMET on a suite of online and distance learning courses aimed at supporting the continuous professional development of the meteorological personnel in the Region. Training materials developed under this effort will be made available to the global community. This effort is supported by WMO and the US Weather Service. The Committee was also informed that the WMO ETR, CIMH and COMET along with other collaborators were also looking into the development of an online B.Sc. program in Meteorology. The Committee appreciated the update provided with regards to these initiatives but noted that certification of online programs, especially the proposed B.Sc. program, will require careful attention.

7.4.6 The Committee discussed the matter of specialized training in relation to managing the effective and accurate dissemination of critical information through the media. Two approaches for addressing this issue were considered by the Committee: (i) provide specialized training to the media to improve their understanding of the information provided by the Meteorological Services and the approach to developing the information; and (ii) providing specialized training on media interactions to media liaison officers in meteorological services. It was proposed that consideration be given by the Regional Association IV Communications Focal Point, Mr. Mario Sánchez from Costa Rica, to having a specialized regional workshop for liaison offers to address this regional problem. It was also suggested that national training opportunities be sought for small national meteorological services that do not have a structured approach and trained personnel for interacting with the media.

7.4.7 The Committee noted the request of specialized radar training by the membership. This was prompted by the increasing number of radars present and planned for RA IV (Central America and the Caribbean) and the limited technical expertise of meteorological personnel to adequately utilize the data and information products produced by these systems. The Committee was informed that one of the online distance learning courses being prepared by COMET and CIMH will focus on the use of radar data and products to support meteorological forecasting. While this course will address some of the needs of the National Meteorological Services in this area, other courses will be required.

7.4.8 The Committee was informed that careful attention needs to paid to the training needs of Aeronautical Forecasters in the region, especially given the increasing trend of Meteorological Services hiring recent university graduates who have little or no prior experience working in Meteorological Services. The Committee was informed that CIMH had recognized this as a concern for Caribbean Meteorological Organization (CMO) Member States and had developed a competency based course for recent graduates to address this problem. The first offering of this 3-month course commenced in May 2010. The employers of these graduates were quite pleased with their technical skills.

7.4.9 The Committee considered the request for forecaster internships during the hurricane season. In particular, the request was made to determine if Cuba and Mexico could support such a program. Cuba and Mexico responded positively to the request noting that it has supported such activities in the past. The Committee was further informed that such a program exists at the NHC but is poorly utilized. The Membership is encouraged to take greater advantage of the opportunities available.

7.4.10 The CIMH, through the Committee, expressed its gratitude to WMO and the international community, in particular, the USA, Canada, the UK, Finland and Japan, for the many training opportunities and technical assistance offered to the staff and students of the CIMH. Areas of support included instrument calibration, quality assurance and quality control, marine forecasting, storm surge modelling, flood mapping and the design and implementation of flood early warning systems, statistical analysis of climate data, drought forecasting and the interpretation of radar data and products among others. These opportunities have significantly improved the ability of the Institute to effectively serve its stakeholders and RA IV as a whole.

7.4.11 A workshop was hosted by the USA to provide training on the EMWIN system, which included:

- understanding of EMWIN in comparison to other communication tools,
- understanding of recent EMWIN system transitions (particularly related to GOES N),
- setup and maintenance of the EMWIN ground station (hardware), and
- installation and operation of EMWIN software.

The goal was to increase regional capabilities to use and maintain EMWIN, which is accompanied with a distribution of EMWIN stations. The outcome was trained personnel from the NMHS and emergency management community, who are now skilled in EMWIN installation, maintenance, and operation. Very soon, as a side outcome, the US will distribute EMWIN stations. Another hopeful outcome is a persistent community of EMWIN users. A long-term goal is for this program is for the US to continue to provide technical assistance and support, as possible, to ensure EMWIN stations are utilized.

7.5 Research Component

7.5.1 The Committee was informed that the Seventh International Workshop on Tropical Cyclones (IWTC-VII) was successfully held in La Réunion, France from 15 to 20 November 2010. Chaired by Chris Velden (USA) and Jeff Kepert (Australia), the quadrennial workshop brought together tropical cyclone researchers and operational experts (forecasters and warning specialists). Workshop participants reviewed and examined recent developments in the science of tropical cyclone forecasting and sorted out priorities for future research and operational activities with special regard to the varying needs of different regions. It was attended by 128 tropical cyclone experts from 38 WMO Members with the RA IV Hurricane Committee being represented by its Chairman Mr Bill Read and 21 operational forecasters. Twenty-eight tropical cyclone research experts from the region, mostly from the USA, also attended the workshop.

7.5.2 The Third International Conference on Quantitative Precipitation Estimation (QPE) and Quantitative Precipitation Forecasting (QPF) was successfully held in Nanjing, China from 18 to 22 October 2010. The five-day conference, attended by 107 experts covered a wide range of issues relation to QPF including new observational approaches and technique development for QPE, advances in data assimilation, modelling and verification for QPF, user needs and the challenges of operational QPF. One of the foci of the 2010 conference is on QPF for tropical cyclones and monsoons. The conference report is currently being finalized and will be available for download at the WGTMR/WWRP webpage.

7.5.3 Prof. R. Elsberry, Chair of the Tropical Cyclone Panel of the WWRP Working Group on Tropical Meteorology Research (WGTMR) provided a detailed report on the IWTC-VII. He summarized the primary workshop recommendations: To WMO/WWW/TCP and to the WGTMR;

Those forecaster-related recommendations in which the Region IV Hurricane Committee is also active; and workshop recommendations that the Hurricane Committee might take a lead role, including direct or indirect rainfall related to tropical cyclones and extratropical transitions, coupled hydrological-meteorological models, and intraseasonal predictions of tropical cyclones.

7.5.4 Prof. Elsberry also reported on tropical cyclone-related presentations at the Third International WMO Conference on QPE/QPF held in October 2010. Prof. Elsberry recommended a number of presentations that described heavy rainfall events that appeared similar to events in Region IV reported at HC33.

7.5.5 There are three organized projects on tropical cyclones which are currently underway namely:

a) NW Pacific Tropical Cyclone Ensemble Forecast Project for Typhoon Committee members (Lead: Japan Meteorological Agency);
b) Typhoon Landfall Forecast Demonstration Project (Lead: Eastern China Regional Meteorological Center/CMA);
c) Severe Weather Forecast Demonstration Project (SWFDP) for Southern Africa (2008-2011; Lead: RSMC Pretoria) and for the South Pacific Islands (2009-2011; Lead: RSMC Wellington).

7.5.6 The book "Global Perspectives on Tropical Cyclones: From Science to Mitigation", edited by Johnny C.L. Chan (HK, China) and Jeffrey D. Kepert (Australia) was published in April 2010. The book is a completely rewritten, updated and expanded new edition of "Global Perspectives on Tropical Cyclones" (published in 1995) which in turn was a revision of "A Global View of Tropical Cyclones" (published in 1988). It presents a comprehensive review of the state of the science and forecasting of tropical cyclones together with the application of this science to disaster mitigation.

7.5.7 WGTMR's Expert Team on Climate Change Impacts on Tropical Cyclones is organizing the Second International Conference on Indian Ocean Tropical Cyclones and Climate Change tentatively in New Delhi, India in September 2011. The broad thematic areas of the conference includes: current status of the operational tropical cyclone forecasting and warning system, progress on the understanding of tropical cyclone genesis, climate change and tropical cyclone activity, tropical cyclone risk and vulnerability assessment and tropical cyclone disaster preparedness, management and reduction.

8. ASSISTANCE REQUIRED FOR THE IMPLEMENTATION OF THE COMMITTEE'S TECHNICAL PLAN AND STRENGTHENING OF THE OPERATIONAL PLAN

8.1 The Committee reviewed the assistance, pertinent to the implementation of the Technical Plan or strengthening of the operational plan, provided to Members since the Committee's thirty second session and considered the plan for future action.

8.2 The Committee expressed its satisfaction that WMO, through the Development and Regional Activities Department (DRA) with the support of the WMO Office for North America, Central America and the Caribbean (NCAC), has continued the development of technical cooperation activities to ensure cost-effective services to Members. The NCAC Office has also provided support to regional activities and assisted in the implementation of WMO Programmes in the Region.

Regional activities

8.3 The Committee was informed that:

- During 2010 the WMO has continued its Project Office in Mexico to support the National Water Commission in achieving integrated, sustainable management of water and the PREMIA project aimed to, as outlined in the agreement between the WMO and the Government of Mexico, the efficient management of water, technical support in the fields of hydrology, meteorology, climate variability and change and their effects on water availability, in particular ground water reserves, prevention of floods will be also another area to be covered.

- The Meeting of NMS's Directors of Iberoamerican Countries was held in Santiago, Chile, in November 2010 with the attendance of the Spanish speaking members of the RA III and RA IV. The action plan for the next three years (2011-2013) was discussed and will be approved in early March 2011 in a meeting in Costa Rica. The main lines of action of the three-year Action Plan include, institutional strengthening of NMHS and resource mobilization; development of climate services through pilot projects; education and training; and development of sub-regional virtual centres for the prevention and monitoring of extreme events.

- The RAMSDIS System that provides, in real time, high resolution satellite imagery and products to Central American countries, continue its execution with great success. The system is expected to be upgraded sometime during 2011. The System is supported by the United States Government, Costa Rica's Institute of Meteorology and the Universidad de Costa Rica, assisted by the WMO.

Training

8.4 The Committee was also informed that:

- The RA IV Workshops on Hurricane Forecasting and Public Weather Services took place in Miami, U.S.A, in the first quarter of 2010. These very important workshops are organized on an annual basis at the National Hurricane Centre in Miami, USA, with strong support of WMO and the U.S.A.

- Focus Group of WMO's Virtual Laboratory on Satellite Meteorology, using Internet and Visit View software, has continued with great success. Discussion takes place 3 or 4 times a month and an every other day presence under the threat of a hurricane. These discussions also keep in close monitoring of the evolution of ENSO. The group is lead by NOAA, US National Weather Service at Comet, Barbados and Costa Rica RMTCs and Colorado State University.

- WMO, through the fund in deposit from Spain, support during 2010 several different courses in automatic weather stations, data processing, climate change, administration of meteorological and hydrological services, flood management, seasonal forecast, hydrology, statistic forecast tools, use of forecast products and satellites, and other topics. Additional a series of seminars and workshops were also supported especially in hydrological forecast, seasonal forecast, coastal flooding, and telecommunications interaction.

- The WMO Disaster Risk Reduction Programme (DRR) organized a Training Workshop on Multi-hazard Early Warning Systems with focus on Institutional Partnership and Coordination in San Jose, Costa Rica, 22-26 March 2010 and a Technical Workshop for the Development of the Caribbean Regional MHEWS Programme in Barbados in

November 2010. These Workshop were cosponsored by different local, regional and international agencies and Representatives of most of the RA IV NMHSs and National Civil Agencies attended the workshops.

- The Master Degree Programme in Hydrology with strong distance and computed aided learning components has continued with great success at the WMO/RMTC of Costa Rica, with the participation of students from RA IV countries.

Assistance to NMHS

8.5 The Committee took note that:

- The Central American Project on Multi-Hazard Early Warning System to develop an end to end early warning system for Central America, financed by the World Bank and executed by WMO, is ready to start its execution. The Project will start its implementation in Costa Rica in the first months of 2011.

- After the earthquake that impact Haiti on January 12, 2010, the WMO and some members of RA IV took actions carried out to coordinate efforts, assess how the collaborating countries can help (provision of information, products or staff on secondment) and ways and means to organize the support to be provided to Haiti for the coming rainy and hurricane seasons.

- The WMO Haiti Task Team has continued coordinating the different actions and efforts for the development of the Haiti NMHS. Immediate assistance in 2010 included an assessment WMO mission to Haiti which defined a plan for short and medium term actions to assist the NMHS of Haiti. Short term actions included among others, the donation of seven automatic weather stations from the WMO VCP Programme; five fellowships for an ongoing training course of 12 months in Toulouse, France supported by WMO and MétéoFrance; the provision of two EMWIN systems and training by the USA; development of a web site for the Haiti NMHS and donation of computer equipment by Environment Canada. An important step taken was the establishment of a forecasting unit in Martinique with the support from MétéoFrance, Environment Canada and the UK MetOffice, including the secondment of experts from these 3 countries to support Haiti with daily forecasts and information on extreme events. The Oficina Nacional de Meteorología (ONAMET), Dominican Republic, has also been supporting Haiti with data, weather products and experts assisting the installation of automatic weather stations.

- The WMO also is seeking support for a medium term project proposal to support the development of the NMHS of Haiti, formulated using the findings and recommendations from the WMO assessment mission carried out in Haiti in April 2010.

VCP projects

8.6 During 2010 the WMO VCP programme received in total six requests from the region from five different countries. The requesting countries were Bahamas, Dominica, El Salvador, Guyana and Suriname. The VCP Programme has been able to support or find a suitable donor for three of these requests and has provided expert services in telecommunications for Suriname and Guyana to link the NMSs with the rest of the RAIII countries and expert services for Suriname to repair or upgrade the existing weather radar.

National Weather Service/International Activities Office

8.7 NOAA/NWS has been engaged in capacity-building efforts within the region. NWS IAO supports capacity-building, education and outreach activities in RA-IV through the WMO's Voluntary Contribution Program (VCP). Many of the projects are in support of the monitoring and warning of hurricanes operations of RSMC Miami, but the activities also support the routine forecasting and operations of NMHSs in the region.

8.8 NOAA Tropical Training Desk: NOAA trains six fellows from Central America and the Caribbean each year at the Tropical Desk at the NCEP HPC. Fellows are trained on operational skills, including numerical weather prediction techniques

8.9 Contribution to the WMO Tropical Cyclone Program in support of the 33rd WMO Region IV Hurricane Committee Conference.

8.10 WMO Participants attending the Hurricane Attachment Program: Located at NOAA's National Hurricane Center/Tropical Prediction Center, this program brings weather service personnel from vulnerable Members States to train on forecasting, preparedness, and public outreach during hurricane season. Three participants will be trained the hurricane season.

8.11 Support the organization of an RA III/RA IV Workshop on Implementing Competency Assessment for Aeronautical Meteorological Personnel as part of the activities of the RAIV Task Team on Aviation. The workshop is *tentatively* scheduled for 20- 24 June 2011, in Trinidad and Tobago.

8.12 WMO AMDAR Panel: Capacity-building activities to improve upper air observations and data collection using commercial airplanes with a pilot project in Mexico. AMDAR Workshop in Mexico City, Fall 2011. Travel funding for experts to provide technical support and coordination with air carrier management and WMO for the installation of observation platforms in aircrafts.

8.13 NOAA is sponsoring a Disaster Risk Reduction project in Mexico. The project has to two parallel objectives: 1) to set up a river flood forecasting system using the new CHPS approach 2) working with the Mexican government to expand and document their Early Warning System for river flooding. This project is expected to go on two to three years.

8.14 In view of the continued difficulties in meteorological services faced by Haiti, the Committee strongly recommended that three to five Haitian forecasters, recently trained at MeteoFrance, participate in the 2012 RA IV Workshop on Hurricane Forecasting and Warning and Public Weather Services, in Miami, Florida. The Committee also requested that the WMO and RSMC Miami look into the possibly of having a one week Workshop in lieu of their participation in the two week workshop. This specific and condensed workshop may also include training on FFGS. Both options would provide for French translation of course materials and on-site interpretation.

9. OTHER MATTERS

Tsunami Early Warning System for the Caribbean

9.1 The Committee noted that the next ICG meeting would be held from 26 to 29 in April 2011 in the Dominican Republic. It requested the WMO Secretariat to take an action to facilitate participation of the representative of the Committee in the meeting.

9.2 The Committee requested Members to ensure that their list of Tsunami Warning Focal Points and Tsunami National Contacts is up to date. A TWFP and TNC Nomination form is given in **Appendix VIII.**

9.3 In conjunction with ICG activities, a the first ever Caribbean Tsunami Exercise entitled CARIBE WAVE 11 / LANTEX 11 will be conducted to assist tsunami preparedness efforts in the region on 23 March 2011. The Members States have been notified of this exercise via communications from the WMO and from the IOC/ICG.

Assistance to Haiti

9.4 A side meeting to review the recent activities carried out to support the NMS of Haiti was held during the session with the participation of Members who have provided continuous support to Haiti and international organizations who have also been involved in the process. During the meeting, a summary of the urgent assistance and support provided to the NMS of Haiti in 2010 and the status of present and ongoing activities were reviewed. The meeting also considered the plans for 2011 (in each of the key areas: monitoring, telecomm, forecasting, forecast and warning services) and the challenges and opportunities for capacity building and sustainability of the NMS (institutional and operational issues). Finally, funding and cooperation opportunities for capacity development of the NMS in Haiti were discussed and analyzed. A complete report will be submitted to all participants.

9.5 The Committee notes the recent successes evident from the solicitation of private sponsorship and contributions to the hosting of the Meetings in the last few years. Given the recent pressure on budgets for hosting such activities in recent years, the Committee requests the Management such Meetings.

10. SCIENTIFIC LECTURES AND DISCUSSIONS

Hurricane Preparedness & Business Continuity Seminar was held under this agenda item. This seminar was supported by scientific lectures from meteorologist, Emergency Management, the Insurance Sector, aimed at delivering best quality and timely warning information to the business sector for proper planning towards greater resiliency & quick return to normalcy. The following presentations were proffered.

1) National Hurricane Center Operation

- Tracking tropical disturbances and forecasting genesis
  - *Dr. Dan Brown, NHC/NOAA*
- Forecasting track, intensity and size
  - *Dr. Lixion Avila, NHC/NOAA*
- Forecasting & Public Response
  - *Mr. Bill Read, NHC/NOAA*

2) Canadian Hurricane Centre Operation

- The Canadian Hurricane Centre; An Essential Component in Canada's Emergency Preparedness and Response Capability
  - *Dr. David Grimes, Canada*
- Catastrophe Insurance and Business Continuity in the Cayman Islands
  - *Mr. John Cameron/BritCay*

3) Hurricane Hunter Operations

- Challenges for Hurricane Hunter Mission
  - *Lt. Col. David Borsi, USAF*

4) Cayman Islands national Operations

- The role of CINWS before and during a hurricane – Improvements & The Future of CINWS
  - *CINWS*
- The role of the Emergency Managers & Interaction with Media
  - *McCleary Frederick, HMCI*
- Climate change and tropical cyclones
  - *Prof. Russ Elsberry*

11. DATE AND PLACE OF THE THIRTY-FOURTH SESSION (Agenda item 10)

The Committee was informed that the United States would consider hosting the thirty-fourth session of the RA IV Hurricane Committee in Florida in 2012.

12. CLOSURE OF THE SESSION (Agenda item 11)

The report of the thirty-third session of the Committee was adopted at its final meeting at 11:30 hours on 12 March 2011.

LIST OF APPENDICES

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AGENDA

1. ORGANIZATION OF THE SESSION

    1.1 Opening of the session
    1.2 Adoption of the agenda
    1.3 Working arrangements for the session

2. REPORT OF THE CHAIRMAN OF THE COMMITTEE

3. COORDINATION WITHIN THE WMO TROPICAL CYCLONE PROGRAMME

4. REVIEW OF THE PAST HURRICANE SEASON

    4.1 Summary of the past season
    4.2 Reports of hurricanes, tropical storms, tropical disturbances and related flooding during 2010

5. COORDINATION IN OPERATIONAL ASPECTS OF THE HURRICANE WARNING SYSTEM AND RELATED MATTERS

6. REVIEW OF THE RA IV HURRICANE OPERATIONAL PLAN

7. REVIEW OF THE COMMITTEE'S TECHNICAL PLAN AND ITS IMPLEMENTATION PROGRAMME FOR 2011 AND BEYOND

8. ASSISTANCE REQUIRED FOR THE IMPLEMENTATION OF THE COMMITTEE'S TECHNICAL PLAN AND STRENGTHENING OF THE OPERATIONAL PLAN

9. OTHER MATTERS

10. SCIENTIFIC LECTURES AND DISCUSSIONS

11. DATE AND PLACE OF THE THIRTY-FOURTH SESSION

12. CLOSURE OF THE SESSION

SUMMARY OF THE PAST SEASON

2010 Atlantic and Eastern North Pacific Hurricane Season Summary

(*Submitted by the RSMC Miami*)

Atlantic

The 2010 Atlantic hurricane season was significantly more active than the 2009 season. Nineteen tropical storms developed, tying 1995 for the third highest number of storms on record. Twelve of the storms became hurricanes - the second highest total on record behind the fifteen observed in 2005. Five of the hurricanes became major hurricanes, category 3 or higher on the Saffir-Simpson Hurricane Wind Scale. There were two additional tropical depressions. The accumulated cyclone energy (ACE) index was 190% of the long-term median. The Accumulated Cyclone Energy (ACE) index is a measure of the collective strength and duration of all tropical storms and hurricanes during the year, calculated by adding up the squares of the maximum wind speeds (in knots) at six-hour intervals for each storm. The active season likely resulted from very warm sea surface temperatures in the tropical Atlantic between the Lesser Antilles and Africa, combined with the change in Pacific Ocean conditions from El Niño in 2009 to La Niña in 2010.

There were a series of experiments involving research aircraft from NOAA, NASA, and the National Science Foundation that monitored the life cycles of several Atlantic storms from beginning to end. The data collected during the experiments was of great value to the National Hurricane Center both during and after the storms.

In the individual storm descriptions that follow, all dates and times are based on Universal Coordinated Time (UTC).

Hurricane Alex

Alex's genesis does not appear to be directly associated with a tropical wave that can be traced back to the coast of Africa. Instead, the tropical cyclone originated from a perturbation within the Inter-tropical Convergence Zone that was first identified on 17 June at very low latitudes over the central Atlantic. Over the next few days this feature moved west-northwestward and by 20 June, the system had crossed the Windward Islands and produced a large area of disturbed weather that affected much of the southeastern Caribbean Sea. The disturbed weather area moved west-northwestward across the Caribbean and became a tropical depression by 1800 UTC June25 about 100 miles north-northeast of Puerto Lempira, Honduras. It then strengthened into a tropical storm around 0600 UTC June 26 and reached of 65 mph shortly before the center made landfall very near Belize City around 0000 UTC June 27.

Alex crossed Belize and the southern Yucatan Peninsula of Mexico, entering the southwestern Gulf of Mexico on June 28. Over the Gulf, the cyclone grew in both strength and size, and it reached hurricane strength on 30 June. The hurricane made landfall around 0200 UTC July 1 near Soto la Marina, Mexico with sustained winds of 110 mph – Category 2 on the Saffir-Simpson Hurricane Wind Scale. This made Alex the strongest June hurricane since Alma of 1966. Alex weakened after landfall and dissipated over central Mexico the next day.

There were no official observations from the landfall area in Mexico. Port Isabel, Texas, reported sustained winds of 51 mph and a peak gust of 62 mph. The main impact of Alex was heavy rainfall, with widespread estimates of 20 inches or more over northeastern Mexico and 5 to 10 inches in Texas. These rains caused widespread flooding, especially in the Mexican state of Nuevo León where the city of Monterey was hard hit. Severe flooding also occurred along the Rio Grande River. In addition, the hurricane produced nine tornadoes in Texas. Alex directly caused twelve deaths in Mexico, and the estimated damage to property in Mexico is $ 1.5 billion.

Tropical Depression Two

This short-lived system formed from a tropical wave early on July 8 about 290 miles southeast of Brownsville, Texas, and it made landfall near Port Isabel, Texas near 1400 UTC that day. Thereafter, the cyclone moved into northeastern Mexico where it dissipated on July 10. The depression caused locally heavy rains over southern Texas and northeastern Mexico, which aggravated the ongoing flooding in these areas started by Hurricane Alex.

Tropical Storm Bonnie

A tropical wave spawned a low pressure area early on July 22 near the southeastern Bahamas, and soon thereafter a tropical depression formed near Acklins Island in the central Bahamas. The cyclone became a tropical storm early the next day and maximum sustained winds peaked at 45 mph as the center passed over Andros Island in the northwestern Bahamas. Bonnie made landfall around 1430 UTC July 23 near Elliot Key, Florida, and it weakened to a tropical depression over southern Florida. Unfavorable upper-level winds over the Gulf of Mexico caused Bonnie to degenerate into a low pressure area on July 25 over the northern Gulf, with the low dissipating over eastern Louisiana later that day.

Fowey Rocks, Florida, reported sustained winds of 47 mph and a peak gust of 56 mph, at a height of 144 ft/44 m ASL while Mangrove Cay in the Bahamas reported sustained winds of 43 mph. Bonnie caused minor impacts in the Bahamas and southern Florida.

Tropical Storm Colin

Two tropical waves and a surface trough of low pressure interacted to produce Colin. The cyclone started on August 2 and gradually intensified into a tropical storm early the next day. Strengthening stopped, and later on August 3 the storm degenerated to a trough of low pressure, even though it retained tropical-storm force winds. The trough passed to the northeast of the Leeward Islands on August 4, then a closed circulation re-formed the next day. The re-formed Colin reached a peak intensity of 60 mph later that day, after which it gradually weakened. It became a tropical depression early on August 8, and it again degenerated to a trough later that day about 115 miles southwest of Bermuda. Some squally weather occurred on Bermuda before the trough dissipated on August 9.

Tropical Depression Five

A decaying frontal system spawned a low pressure area over the western Atlantic, which crossed the Florida Peninsula into the eastern Gulf of Mexico. The low became a tropical depression for about 12 hours on August 9 and 10 before degenerating back to a low pressure area. The low then followed a looping track over the northern Gulf of Mexico and the Gulf Coast states before finally dissipating over southwestern Mississippi on August 18. The system caused locally heavy rains over portions of the northern Gulf coast, with total rainfalls up to 10 inches in parts of eastern Louisiana and southwestern Mississippi.

Hurricane Danielle

Danielle had a complex origin over the eastern tropical Atlantic involving a tropical wave and an active ITCZ. The two systems combined to form a large low pressure area on August 20, which in turn spawned a tropical depression the next day about 520 miles west-southwest of the Cape Verde Islands. The depression became a tropical storm about 12 hours later and a hurricane on August 23. After an encounter with an upper-level trough which halted development, Danielle intensified again on August 26, reaching an estimated peak intensity of 135 mph late on August 27. The cyclone recurved into the westerlies during August 28 and 29 and weakened to a tropical storm on August 30. Extratropical transition occurred the next day, and the former hurricane dissipated several hundred miles east-southeast of southern Greenland on September 3.

Danielle did not directly impact land. However, swells from the hurricane reached the east coast of the United States and caused one death.

Hurricane Earl

A strong tropical wave spawned a low pressure system southeast of the Cape Verde Islands on August 24. The low developed into a tropical depression and then a tropical storm on August 25. Gradual strengthening over the next several days lead to Earl becoming a hurricane on August 29 as it approached the Leeward Islands. Rapid intensification ensued, and Earl became a major hurricane just north of the northern Leeward Islands on August 30. After undergoing an eyewall replacement cycle, the hurricane reached its peak intensity of 145 mph on September 1.

On September 3, Earl moved northeastward parallel to, but offshore of, the east coast of the United States. The system briefly weakened to a tropical storm, but it strengthened back to a Category 1 hurricane before making landfall near Liverpool, Nova Scotia around 1500 UTC September 4. Earl then crossed Prince Edward Island as a tropical storm and became extratropical over the Gulf of St. Lawrence early on September 5. The extratropical low it merged with another low over the Labrador Sea the next day.

NOAA buoy 41046 reported sustained winds of 82 mph with a peak gust of 100 mph as the eye of Earl passed over it on September 3. In Nova Scotia, McNabs Island and Osbourne Head reported sustained winds near 65 mph. Tropical-storm force winds were also reported in the northern Leeward Islands, the Virgin Islands, and Puerto Rico. The storm also produced locally heavy rains over the Caribbean islands and portions of the U. S. east coast.

Earl caused five deaths by drownings in dangerous surf conditions – four along the U. S. east coast and one in Nova Scotia. The total property damage is estimated at $ 45 million, with $18 million of that in the United States.

Tropical Storm Fiona

Fiona formed from a large and convectively active tropical wave which slowly developed over the tropical Atlantic. On August 30 a tropical depression formed about 1035 miles east of the Lesser Antilles and became a tropical storm later that day. Fiona's center passed about 65 miles northeast of Barbuda in the Leeward Islands on September 1 just before the storm reached an estimated peak intensity of 65 mph. After that, outflow from the much larger Hurricane Earl caused Fiona to weaken. The cyclone degenerated to a post-tropical low about 110 miles south of Bermuda on September 4, and the low dissipated the next day northeast of Bermuda.

Tropical Storm Gaston

A tropical wave spawned Gaston, which was a minimal tropical storm for only 12 hours over the tropical Atlantic on September 1. The cyclone degenerated to a remnant low the next day. National Research Foundation flight data suggest Gaston's demise may have been due to ingestion of very dry air.

Tropical Storm Hermine

Hermine developed from the remnants of eastern Pacific Tropical Depression Eleven-E, which made landfall on the Pacific coast of Mexico on September 4. The remnants moved into the southern Bay of Campeche and re-developed into a tropical depression late on September 5, and strengthened to a tropical storm early the next day. Hermine reached an estimated peak intensity of 70 mph at landfall in northeastern Mexico around 0200 UTC September 7. The storm crossed the Rio Grande into the United States a few hours later and maintained tropical-storm intensity until the center reached central Texas early on September 8. The cyclone then weakened to a depression, and it subsequently degenerated to a remnant low over Oklahoma. The low dissipated over southeastern Kansas early on September 10.

Harlingen, Texas, reported sustained winds of 59 mph and a peak gust of 72 mph. The storm produced locally heavy rains over portions of Texas and Oklahoma, with a storm total of 16.27 inches reported at Georgetown Lake, Texas. In addition, the storm caused two tornadoes in central and northern Texas. Six people died due to Hermine, including one drowning in a coastal rip current and five drownings in freshwater flooding. Hermine was the costliest U. S. tropical cyclone of 2010, with property damage estimated at $240 million.

Hurricane Igor

The monstrous Igor first became a tropical storm on September 8 southeast of the southern Cape Verde Islands. The cyclone briefly weakened to a tropical depression on September 9 before regaining tropical-storm strength the next day. Igor strengthened to a major hurricane on September 12, and maintained this status for the next five days with a peak intensity of 155 mph on September 15. The storm also grew in size, with the associated tropical-storm-force winds covering an area about 500 miles in diameter by September 17 and about 850 miles in diameter by September 20. Igor passed about 40 miles west of Bermuda early on September 20, at which time it had become a Category 1 hurricane. The hurricane accelerated toward Newfoundland on September 20 and 21, and the center passed over the southeastern end of the Avalon Peninsula around 1500 UTC September 21. Shortly thereafter, Igor became a hurricane-force extratropical low over the Labrador Sea, and it was finally absorbed into another low pressure system early on September 23.

St. David's on Bermuda reported sustained winds of 91 mph and a gust of 117 mph at an elevation of 159 feet. Hurricane conditions also occurred in Newfoundland, where Cape Pine reported sustained winds of 81 mph and a gust of 107 mph. Widespread wind and flooding damage estimated at $ 200 million was reported in Newfoundland, and one death was reported there. Minor damage to property was reported on Bermuda.

Hurricane Julia

A tropical depression formed early on September 12 about 290 miles south-southeast of the southernmost Cape Verde Islands, and became Tropical Storm Julia 12 hours later. Julia reached hurricane intensity on September 14, and then rapidly strengthened to an estimated peak intensity of 140 mph the next day. After peaking, Julia weakened as it encountered an upper-level low and the outflow of the vastly larger Hurricane Igor. Julia recurved to the east of Igor, and by September 17 it was down to tropical-storm strength. The cyclone degenerated to a convectionless low late on September 20 about 1100 miles west of the Azores Islands. The low slowly weakened for several more days while it turned southward and then westward, finally degenerating into an open trough on September 24.

Julia is the strongest Atlantic hurricane on record east of 40°W. However, it is unlikely that its peak intensity or its 1.25 day duration as a major hurricane would have been observed for a hurricane in this location before the advent of regular satellite imagery and the Dvorak intensity analysis system in the 1970s. While there were no reliable reports of tropical-storm-force winds from Julia, it is possible they occurred in the southern Cape Verde islands.

Hurricane Karl

The first signs of the development of Karl were on September 9, when a tropical wave interacted with a trough of low pressure extending northeastward from northeastern South America. The resulting low pressure area crossed the Caribbean Sea and became a tropical depression on September 14 about 375 miles east of Chetumal, Mexico. The cyclone became a tropical storm six hours later, and the maximum sustained winds increased to 65 mph before Karl made landfall on the Yucatan Peninsula around 1245 UTC September 15.

Karl remained well organized over land until reaching the Bay of Campeche early on September 16. It then rapidly intensified, and became a hurricane later that day, reaching a peak intensity of 120 mph on September 17. The Category 3 hurricane made landfall just northwest of Veracruz, Mexico around 1645 UTC September 17. Post-landfall weakening led to Karl dissipating completely over the mountains of central Mexico on September 18.

An automated station in the harbor at Veracruz reported sustained winds of 66 mph and a gust of 94 mph. Karl is responsible for 22 deaths, and major damage occurred in the landfall area in the northwestern portions of Veracruz.

Hurricane Lisa

A broad low pressure area associated with a tropical wave was noted southwest of the Cape Verde Islands on September 18. Slow development followed, and a tropical depression formed on September 20 about 460 miles west of the Cape Verde Islands. The cyclone fluctuated in strength for a couple of days, becoming a tropical storm on September 21 and weakening to a depression the next day. Lisa regained tropical storm strength on September 23 and it became a hurricane the next day with the estimated maximum winds reaching 85 mph. Rapid weakening then took place, and Lisa degenerated to a remnant low by the end of September 26. The remnants moved northward and northwestward before dissipating south-southwest of the Azores on September 29.

Tropical Storm Matthew

The southern portion of the tropical wave that spawned Hurricane Julia moved into the Caribbean Sea and spawned another low pressure area on September 22. On September 24, this became a tropical depression about 565 miles east of Cabo Gracias a Dios on the Nicaragua/Honduras border. Matthew reached a peak intensity of 60 mph before making landfall about 25 miles south of Cabo Gracias a Dios near 1900 UTC September 24. It then crossed northeastern Nicaragua and Honduras into the Gulf of Honduras. A final landfall occurred about 15 miles north-northeast of Monkey River Town, Belize, about 1500 UTC September 25. Matthew weakened to a remnant low over eastern Mexico on September 26, and the surface circulation dissipated later that day.

Puerto Lempira, Honduras, reported 10-min mean winds of 46 mph at 2300 UTC September 24. The main impact of Matthew was widespread heavy rains that caused flooding and mudslides. A storm total of 16.73 inches fell at Acayucan in the Mexican state of Veracruz, and 5 to 10 inch totals were common elsewhere in eastern Mexico. Storm totals of 4 to 8 inches occurred over portions of Nicaragua and Honduras. Matthew, the deadliest storm of the 2010 season, caused 73 deaths, consisting of 65 in Nicaragua, 7 in Mexico, and 1 in El Salvador.

Tropical Storm Nicole

A broad low pressure area became evident on September 26 in a very vigorous ITCZ or monsoon-type trough over the western Caribbean Sea and became a tropical storm south of western Cuba on September 28 while heading toward the northeast. The center of Nicole lost organization as it crossed central Cuba on September 29, and the cyclone degenerated into a low pressure area over the Straits of Florida. The low became extratropical near south Florida and the northwestern Bahamas on September 30 and dissipated later that day.

Nicole more resembled a monsoon cyclone of the Indian Ocean or western North Pacific Ocean than a typical Atlantic tropical cyclone, with the strongest winds and heaviest rains well removed from the center. The main impact from Nicole was widespread heavy rains over southern Florida, central and eastern Cuba, Jamaica, and the Cayman Islands. The associated flooding killed 14 people in Jamaica.

Hurricane Otto

A tropical wave interacting with an upper-level trough was the origin of Otto. A well-defined surface circulation formed under the upper-level trough on October 6 about 265 miles north-northwest of San Juan, Puerto Rico, resulting in the formation of a subtropical depression which strengthened to a subtropical storm shortly thereafter. Otto evolved from a subtropical to a tropical storm on October 7 and became a hurricane on October 8, reaching an estimated peak intensity of 85 mph later that day. The cyclone weakened to a tropical storm late on October 9 and lost tropical characteristics on October 10 about 1035 miles east-northeast of Bermuda. The remnants of Otto gradually weakened over the eastern Atlantic for the next several days before dissipating on October 18.

Otto and its precursor disturbance caused widespread heavy rains over the islands of the northeastern Caribbean, with storm totals exceeding 15 inches. The rains caused damaging flooding and mudslides in portions of Puerto Rico, the U. S. Virgin Islands, and the British Virgin Islands.

Hurricane Paula

A complex series of weather systems caused the formation of a tropical depression early on October 11 about 115 miles southeast of Cabo Gracias a Dios. The depression strengthened to a tropical storm before the center crossed over Cabo Gracias a Dios at about 1200 UTC that day. Moving into the northwestern Caribbean, Paula became a hurricane on October 12, and it reached a peak intensity of 105 mph later that day. After that, a weakening Paula moved into the Yucatan Channel. The cyclone made landfall as a 65-mph tropical storm in the Pinar del Rio province of Cuba around 1500 UTC October 14. The system rapidly weakened as it moved through western Cuba, and it completely dissipated by the end of October 15.

La Palma, Cuba, reported sustained winds of 51 mph and a peak gust of 68 mph, and Bahía Honda in Pinar del Rio reported 7.32 inches of rain. The storm caused one fatality, a drowning in rough surf at Cancun, Mexico. The property damage from Paula was relatively minor.

Even at peak intensity, Paula was a small hurricane. The eye of Paula passed within 60 miles of NOAA buoy 42056, and the buoy did not report tropical-storm-force winds even in gusts.

Hurricane Richard

A long-lived area of disturbed weather over the Caribbean and a tropical wave spawned a low pressure area north of Cabo Gracias a Dios on October 19. The next day, the low became a tropical depression about 195 miles north of Gracias a Dios. While finishing a half-loop, the depression became a tropical storm on October 21. Richard subsequently became a hurricane on October 24 before passing just north of the Bay Islands of Honduras. The hurricane made landfall as a Category 2 hurricane with estimated 100 mph winds near Gales Point, Belize, around 0040 UTC October 25. The cyclone weakened over land and eventually dissipated over the Bay of Campeche on October 26.

An observer near Orange Walk, Belize, reported sustained winds of 52 mph and a gust of 92 mph. Roatan in the Bay Islands reported a storm total rainfall of 7.64 inches. Richard directly caused one death when a boat capsized in the landfall area in Belize. Property and agricultural damage in Belize is estimated at near $ 80 million.

Hurricane Shary

The interaction of a frontal system and an upper-level trough caused the formation of a broad area of low pressure, which in turn formed into a tropical depression about 520 miles south-southeast of Bermuda on October 28. The depression reached tropical storm strength a few hours later, and it became a hurricane for a short time on October 30 before merging with a cold front. The system completely dissipated soon thereafter.

Hurricane Tomas

An area of disturbed weather associated with a tropical wave first showed signs of organization over the tropical Atlantic on October 27, and a tropical depression formed two days later about 350 miles southeast of Barbados. The cyclone rapidly intensified into a hurricane before the center reached the Windward Islands late on October 30. Tomas reached an estimated peak intensity of 100 mph over the southeastern Caribbean early on October 31, then it weakened due to increasing shear and dry air entrainment. Tomas weakened to a tropical storm on November 1, and it meandered across the central Caribbean for the next couple of days.

Late on November 4, Tomas re-intensified. It regained hurricane strength as the center passed between Jamaica and the southwestern peninsula of Haiti, with the maximum winds reaching 85 mph a few hours later. The center then moved through the Windward Passage between Haiti and Cuba. Tomas weakened to a tropical storm as the center moved through the southeastern Bahamas and the Turks and Caicos Islands early on November 6. After passing the Bahamas, it then re-gained hurricane status for the third time. Tomas again weakened to a tropical storm before merging with a cold front on November 8, and the resulting extratropical low persisted over the western Atlantic until it was absorbed into another low south of Newfoundland on November 11.

Tomas caused hurricane conditions in the Windward Islands, which caused significant damage to property on St. Lucia and Barbados. The cyclone produced heavy rains in Haiti, which killed an estimated 50 people and complicated the ongoing earthquake relief efforts in that country.

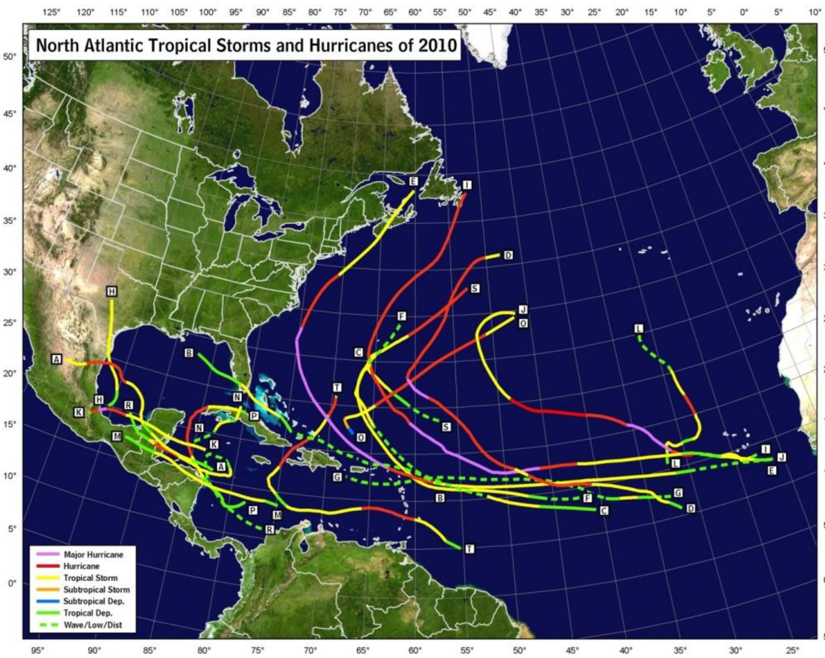
Summary of activities of the 2010 Atlantic Hurricane Season.

Storm Name	Class*	Dates**	Max. Winds (mph)	Min. Pressure (mb)	Deaths	U. S. Damage ($million)
Alex	H	June 25 - July 2	110	946	12	<25
Two	TD	July 8 – 9	35	1005		
Bonnie	TS	July 22 - 24	45	1005		
Colin	TS	August 2 - 8	60	1005		
Five	TD	August 10 - 11	35	1008		
Danielle	MH	August 21 - 30	135	942	1	
Earl	MH	August 25 – September 4	145	927	5	18
Fiona	TS	August 30 – September 3	65	998		
Gaston	TS	September 1 - 2	40	1005		
Hermine	TS	September 6 - 8	70	989	6	240
Igor	MH	September 8 - 21	155	925	1	
Julia	MH	September 12 - 20	140	948		
Karl	MH	September 14 - 18	120	957	22	
Lisa	H	September 20 - 26	85	982		
Matthew	TS	September 23 - 26	60	998	73	
Nicole	TS	September 28 - 29	45	995	14	
Otto	H	October 6 - 10	85	976		
Paula	H	October 11 - 15	105	981	1	
Richard	H	October 20 - 25	100	977		
Shary	H	October 28 - 30	75	989		
Tomas	H	October 29 – November 7	100	982	50	

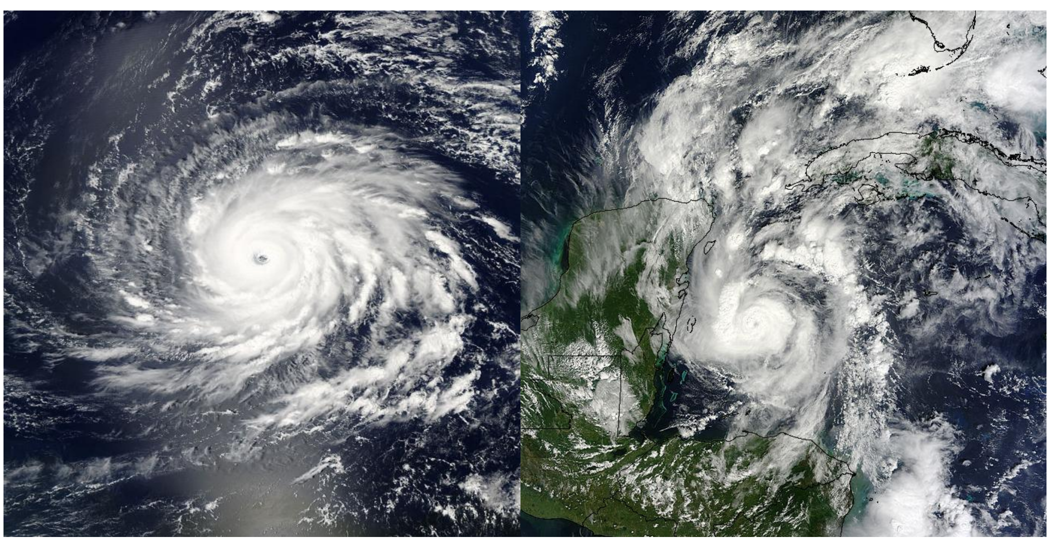
* TD - tropical depression maximum sustained winds 38 mph or less; TS - tropical storm, winds 39-73 mph; H - hurricane, winds 74-110 mph; MH - major hurricane, winds 111 mph or higher.

** Dates based on UTC time and include tropical depression stage

Tracks of Atlantic tropical storms and hurricanes during 2010.



MODIS image of Hurricane Igor over the open Atlantic on September 13 and Hurricane Paula over the northwestern Caribbean on October 12. Image courtesy of NASA.



Eastern North Pacific

The 2010 Eastern North Pacific hurricane season was historically the least active season on record. Only seven tropical storms developed, which is the lowest number observed since routine satellite reconnaissance of that basin began in 1971. Furthermore, only three of those storms became hurricanes, which is also the lowest number of hurricanes ever observed in a season. Only two of the hurricanes became category 3 or higher on the Saffir-Simpson Hurricane Wind Scale (SSHWS) which was 50% of the long-term average. There were five additional tropical depressions that did not reached tropical storm intensity. The accumulated cyclone energy (ACE) index was only 46% of the long-term median. This is the third lowest ACE value, ahead of the 2007 and 1977 seasons.

In the individual storm descriptions that follow, including Table 1, all dates and times are based on Universal Coordinated Time (UTC).

Tropical Storm Agatha

The primary contributor to the development of Agatha was a tropical wave that moved westward from the coast of Africa on May 8 and crossed Central America and into the eastern North Pacific on May 21. The associated shower activity increased on May 24 a few hundred miles west of Costa Rica, and a broad low pressure area formed the next day along the wave axis. Little development occurred over the next couple of days as the low drifted slowly westward to a position a few hundred miles south of the Gulf of Tehuantepec. A tropical depression formed near 0000 UTC May 29 about 180 miles southwest of Tapachula, Mexico and moved northeastward in deep-layer southwesterly flow between a mid-tropospheric trough over the Gulf of Mexico and a high pressure ridge over the western Caribbean Sea. The depression strengthened into a tropical storm about six hours later, and Agatha reached a peak intensity of 45 mph at 1800 UTC May 29. The cyclone made landfall with the same intensity near Champerico, Guatemala a few hours later at 2230 UTC. Agatha weakened as it moved northeastward across the Sierra Madre Mountains, and it dissipated on May 30 over western Guatemala.

Tropical cyclone landfalls in Guatemala are rare events. During the period of reliable records in the eastern North Pacific, only one other tropical storm has made landfall in Guatemala --Simone on October 19, 1968. In addition, Tropical Storm Barbara made landfall just west of the Mexico-Guatemala border -- not far from where Agatha made landfall -- on June 2, 1997.

The main impact from Agatha was widespread heavy rain through portions of Central America. Rainfall totals of 4-8 inches occurred over southern Guatemala on May 29, with Montufar reporting a 24-hour total of 16.78 inches. Similar heavy rains occurred in El Salvador with Ilopango reporting a total of 8.17 inches. The rains from Agatha were part of a prolonged period of heavy rain in Central America from May 25-30. During this period, Mazatenango, Guatemala, reported 22.27 inches of rain. Agatha's heavy rains caused widespread flooding and mudslides in Guatemala, Honduras, and El Salvador. Although there is some uncertainty as to exactly how many direct deaths are due to the Agatha, official reports indicate there were at least 160 fatalities in Guatemala-- 18 in Honduras, and 12 in El Salvador. An additional 47 people were officially listed as missing in Guatemala. Floods and mudslides caused an estimated US$1.1 billion in total property damage -- US$982 million in Guatemala and US$112 million in El Salvador. A spectacular example of damage documented by various news media was a 65-ft diameter sinkhole that opened up in Guatemala City, damaging or destroying several buildings in the process.

Tropical Depression Two-E

Tropical Depression Two-E formed around 0600 UTC June 16 about 110 miles south of Salina Cruz, Mexico and moved slowly west-northwestward. It became disorganized by 0000 UTC June17and the surface circulation dissipated a few hours later south of Puerto Angel, Mexico. The depression brought heavy rainfall to portions of the Pacific coast of Mexico. Media reports indicate rain-induced floods caused damage to 70 to 80 homes in San Juan Bautista Tuxtepec, 40 homes in Rio Grande, and 20 homes in Santa Gertrudis.

Tropical Storm Blas

Blas developed from a tropical wave that moved across Central America on June 9-10. An area of low pressure formed along the wave axis over the Gulf of Tehuantepec by June 13, and moved slowly west-northwestward a couple hundred miles south of the Mexican coast over the next four days. A tropical depression formed around 0600 UTC that day about 300 miles south-southwest of Manzanillo, Mexico. A ship reported tropical-storm-force winds near the center at 1500 UTC that day, indicating that the depression had become a tropical storm by 1200 UTC. Blas accelerated toward the northwest and then west-northwest as a strong subtropical ridge to its north built westward from Mexico over the eastern North Pacific waters. Moderate vertical wind shear prevented the cyclone from strengthening over the next day or so. By 1800 UTC June 18, the shear weakened slightly, and Blas intensified reaching its peak intensity of 65 mph by 1200 UTC 19 June. Shortly thereafter, the cyclone move into a region of unfavorable environmental conditions and over cooler waters, which caused associated shower and thunderstorm activity to decrease sharply. Blas weakened to a tropical depression around 0000 UTC June 21 and then degenerated into a remnant low pressure system.

Hurricane Celia

Celia originated from a tropical wave that entered the eastern North Pacific basin on June 17. Showers and thunderstorms associated with the slow-moving wave increased later that day, and a surface low pressure area formed along the wave axis early on June 18. Thunderstorm activity increased and became better organized, and a tropical depression formed late that same day about 370miles southeast of Acapulco, Mexico. After a brief hiatus early on 19 June, the organization of the convective cloud pattern improved and the depression reached tropical storm status around 1200 UTC while centered about 290 n mi south-southeast of Acapulco.

Celia moved slowly west-southwestward to westward over the next few days and steadily intensified reaching hurricane strength by 1800 UTC June 20 while centered about 330miles south of Acapulco. Thereafter, Celia moved into a region of decreasing vertical shear by June24 and it began a period of explosive deepening. The hurricane strengthened from 105 to 160 mph in just 18 hours – an intensity change more than double the typical rapid intensification rate of 35 mph in 24 hours. The conclusion of this strengthening phase early on June 25 also corresponded with Celia's peak intensity when the category 5 hurricane was located about 775 miles south-southwest of Baja California.

Almost as quickly as Celia strengthened, the cyclone underwent a rapid weakening trend over the next couple of days as the hurricane moved over progressively cooler waters. The cyclone weakened to a tropical storm by 0000 UTC June 27 while centered about 950 miles west-southwest of the southern tip of Baja California. The weakening cyclone abruptly slowed down later that day and drifted west-southwestward to southwestward in weak low-level steering flow before becoming embedded in deep low-level westerly flow early on June 28. After completing a tight counter-clockwise loop, Celia turned east-northeastward and quickly weakened from a tropical storm to a remnant low pressure system late that same day about 1030 miles west-southwest of the southern tip of Baja California. Celia's remnants drifted northward for another day and then dissipated.

Hurricane Darby

The vigorous tropical wave that spawned Hurricane Darby moved off the west coast of Africa on June 8 and reached the far eastern North Pacific eleven days later on June 19. The next day, a small low pressure system developed along the wave axis southwest of Costa Rica as the disturbance slowed and began moving toward the west-northwest. Thunderstorm activity steadily increased and became better organized, and a tropical depression formed early on June 23about 380 miles south-southeast of Salina Cruz, Mexico. The relatively small tropical cyclone continued in a west-northwestward direction for the next three days accompanied by a gradual decrease in forward speed. Darby became a tropical storm by 0600 UTC June 23 and a hurricane by 0600 UTC 24 June while moving west-northwestward motion about a couple hundred miles off of the coast of Mexico. During this time, the cyclone remained in a low vertical wind shear environment and underwent two separate periods of rapid intensification -- from 35 to 70 mph on June 23-24 and then from 85 to 120 mph on June 24-25. Even at Darby's peak intensity of 120 mph, tropical-storm-force winds only extended outward about 70milesto the northeast of the center. After Darby reached its peak intensity about 250 miles south-southwest of Acapulco, Mexico, the hurricane turned westward and its forward speed slowed. Early on June 27, a long fetch of low- to mid-level westerly winds flowing into the large circulation of Atlantic basin Hurricane Alex, which was located well to the northeast over the Gulf of Mexico, briefly caused Darby to become stationary about 285 miles south-southwest of Zihuatanejo, Mexico. Later that day, Darby reversed its course and began moving slowly to the east-northeast as it was drawn into the circulation of Alex. During this time, Darby began to weaken due to the northeasterly vertical wind shear created by the massive upper-level outflow from Hurricane Alex. Darby became a tropical storm early on June 27 and weakened to a tropical depression the next day around 1200 UTC June 28 when it was located more than 170 miles south of Acapulco. The cyclone degenerated into a remnant low pressure system a few hours later as strong vertical shear conditions stripped away deep convection from the circulation.

Tropical Depression Six-E

The depression formed at 1200 UTC July 14, when a low pressure had acquired sufficient organized convection about 325 miles south-southwest of Manzanillo, Mexico. The cyclone moved parallel to the Mexican coast a few hundred miles offshore. Moderate to strong easterly vertical wind shear prohibited the depression from strengthening. The system moved over cooler waters on July 16 and thunderstorm activity dissipated later that day, which resulted in the depression degenerating to a remnant low pressure system by 1800 UTC.

Tropical Storm Estelle

A weak low pressure system developed along a tropical wave axis just south of the Gulf of Tehuantepec on September 4. The low moved west-northwestward and by 0000 UTC August 6, a tropical depression had formed about 140 miles southwest of Acapulco, Mexico. Twelve hours later, the depression became a tropical storm and slowly intensified. Early on August 7, the center of Estelle reformed to the southwest of its previous position, but the overall system continued moving toward the west and west-northwest. Tropical Storm Estelle reached its peak intensity of 65 mph by 0000 UTC August 8. Thereafter, the cyclone gradually decreased in strength due to cooler waters, unfavorable environmental conditions, and moderate southeasterly vertical wind shear.

Tropical Depression Eight-E

Thunderstorm activity gradually increased with a tropical wave that moved westward just to the south of Mexico. The convection became better organized near a well-defined surface circulation center, and it is estimated that a tropical depression formed by 0600 UTC August 20 about 185miles west-southwest of Manzanillo, Mexico. The depression moved west-northwestward, meanwhile, strong northeasterly vertical wind shear prevented the tropical cyclone from strengthening. Early on August 21, the depression moved over cooler waters and weakened.

Hurricane Frank

Showers and thunderstorms increased as a tropical wave crossed Central America on August 19, but the activity did not become concentrated until the morning of August 21 over the Gulf of Tehuantepec after an area of low pressure had formed along the wave axis. The system developed curved convective outer bands while thunderstorm activity increased near a circulation center, and a tropical depression formed from this system at 1800 UTC August 21 about 205 miles southeast of Salina Cruz, Mexico. As the cyclone drifted slowly westward, the cloud pattern gradually became better organized and the depression became a tropical storm at 1200 UTC August 22. Frank strengthened slightly as it moved westward on a track parallel to the coast of Mexico. However, strong northeasterly vertical wind shear eroded the central deep convection, and the cyclone weakened on August 23.

There was a resurgence of the thunderstorm activity on August 24 and cloud pattern gradually improved. Early on August 25, microwave satellite imagery revealed a closed ring of convection resembling an eyewall, and it is estimated that Frank became a hurricane around 1200 UTC that day. The eye was visible intermittently in conventional satellite imagery during the next day or so, but additional microwave data clearly showed that the eye persisted underneath the thick cirrus cloud canopy. Frank reached its peak intensity of 90 mph at 1800 UTC August 26 when it was located about 380 miles south of the southern tip of Baja California. At that time, visible and microwave satellite images showed a small but distinct eye embedded within a circular area of strong thunderstorm activity. A couple of hours later, however, the cloud pattern quickly deteriorated and the eye noted earlier was no longer evident, indicating that Frank had started to weaken. The hurricane moved toward the northwest and gradually as it approached cooler waters and encountered strong vertical shear.

Tropical Depression Ten-E

A weak tropical wave crossed Central America and entered the eastern North Pacific Ocean on August 26. Over the course the next several days, shower and thunderstorm activity remained disorganized and displaced to the west of the wave axis due to strong easterly vertical wind shear. Deep convection increased and became better organized, and the system developed a well-defined circulation center late on September 2. The low pressure system continued to acquire sufficient organized convection for it to be classified a tropical depression at 0000 UTC September 3, when it was located about 250 miles south-southeast of the southern tip of Baja California. The depression moved over cooler waters early on September 4 and dissipated.

Tropical Depression Eleven-E

Tropical Depression Eleven-E developed from part of a tropical wave that spawned Hurricane Danielle in the far eastern tropical Atlantic Ocean. The southern portion of the wave continued westward at a low latitude across the Atlantic and northern South America, and reached the eastern North Pacific on August 29. A surface circulation gradually developed along the wave axis over the next few days, and it is estimated that a tropical depression formed around 1800 UTC September 3 about 115 miles southeast of Salina Cruz, Mexico. The depression moved west-northwestward and then northwestward across the Gulf of Tehuantepec, and made landfall near Salina Cruz around 0700 UTC 4 September. After landfall occurred, the cyclone turned northward and degenerated into a remnant low pressure system later that day over the Isthmus of Tehuantepec. The low continued on a rare northward track into the Bay of Campeche on September 5, where it re-developed and became Atlantic Tropical Storm Hermine.

No reports of casualties or damages directly related to the depression were received. However, after the remnant low moved into the southwestern Gulf of Mexico, very moist southwesterly flow on the south side of the system producing heavy rains over portions of Central America. These rains produced mud slides that caused 38 deaths in Guatemala.

Tropical Storm Georgette

The formation of Georgette was associated with a tropical wave that also triggered the genesis of Atlantic Hurricane Karl on September 14. The wave continued westward and crossed Mexico on September 17-18, and entered the eastern North Pacific on September 19. Thunderstorm activity increased and became organized about a well-defined surface circulation center on September 19-20, and a tropical depression formed about 240 miles south-southeast of Cabo San Lucas, Mexico. Although the depression reached tropical storm status just 6 hours later, moderate to strong easterly vertical wind shear inhibited any further development. Tropical Storm Georgette maintained its 35-kt intensity for the next day or so as the cyclone moved north-northwestward around the western periphery of a subtropical ridge anchored over northern Mexico. On September 21, Georgette approached the southern tip of Baja California and made landfall around 1800 UTC near San Jose del Cabo in the state of Baja California Sur as a 35-kt tropical storm. After landfall, Georgette turned northward across southeastern Baja California and weakened to a tropical depression around 0000 UTC September 22. Shortly thereafter, the system moved into the Gulf of California and continued northward with no change in strength. Around 2200 UTC that day, the cyclone made a second landfall – this time along the west coast of mainland Mexico near San Carlos, west of Guaymas, in the state of Sonora. After landfall, the ill-defined depression moved inland and dissipated by 0600 UTC September 23.

Flooding was reported in Empalme, Etchojoa, Navojoa, and Guaymas in the state of Sonora, and 500,000 people were evacuated in those areas. Flooding was also reported in the city of Los Mochis in Sinaloa. No monetary damage estimates are available, and there were no casualties reported in association with Georgette.

Acknowledgements

Much of the international data in this report was provided by the National Meteorological Services of the countries affected by the 2010 tropical cyclones, and also from various media sources.

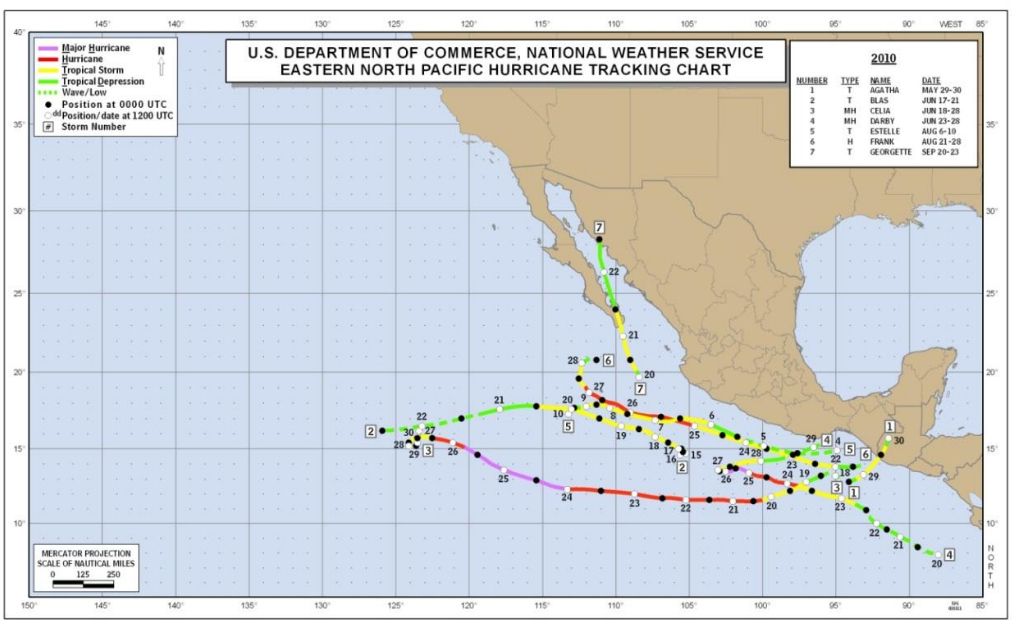
Summary of activity of the 2010 Eastern North Pacific Hurricane Season.

Storm Name	Class*	Dates**	Max. Winds (mph)	Min. Pressure (mb)	Deaths	U.S. Damage ($million)
Agatha	TS	May 29 - 30	45	1001	160	1100
Two-E	TD	June 16 - 17	35	1007		
Blas	TS	June 17 - 21	65	994		
Celia	MH	June 18 - 28	160	921		
Darby	MH	June 23 - 28	120	959		
Six-E	TD	July 14 - 16	35	1006		
Estelle	TS	August 6 - 10	65	994		
Eight-E	TD	August 20 - 21	35	1003		
Frank	H	August 21 - 28	90	978		
Ten-E	TD	September 3 - 4	35	1003		
Eleven-E	TD	September 3 - 4	35	1004		
Georgette	TS	September 20 - 23	40	999		

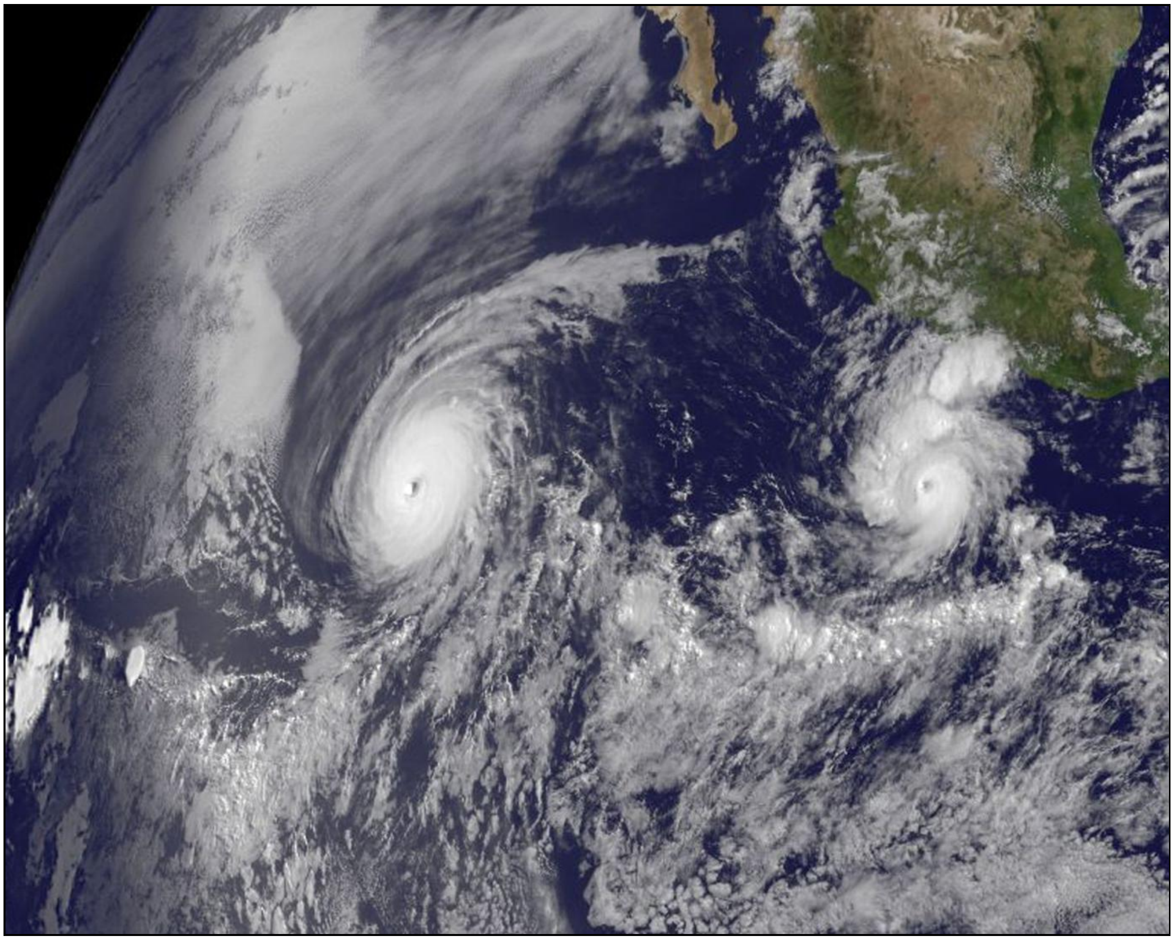
* TD - tropical depression maximum sustained winds 38 mph or less; TS - tropical storm, winds 39-73 mph; H - hurricane, winds 74-110 mph; MH - major hurricane, winds 111 mph or higher.

** Dates based on UTC time and include tropical depression stage

Tracks of Eastern North Pacific tropical storms and hurricanes during 2010.



MODIS image of major Hurricanes Celia (left) and Darby (right) over the eastern North Pacific on June 25, 2010. Image courtesy of NASA.



Large sink hole that developed in Guatemala City on May 31, 2010 due to floods triggered by heavy rainfall from Tropical Storm Agatha. Picture courtesy of Associated Press.

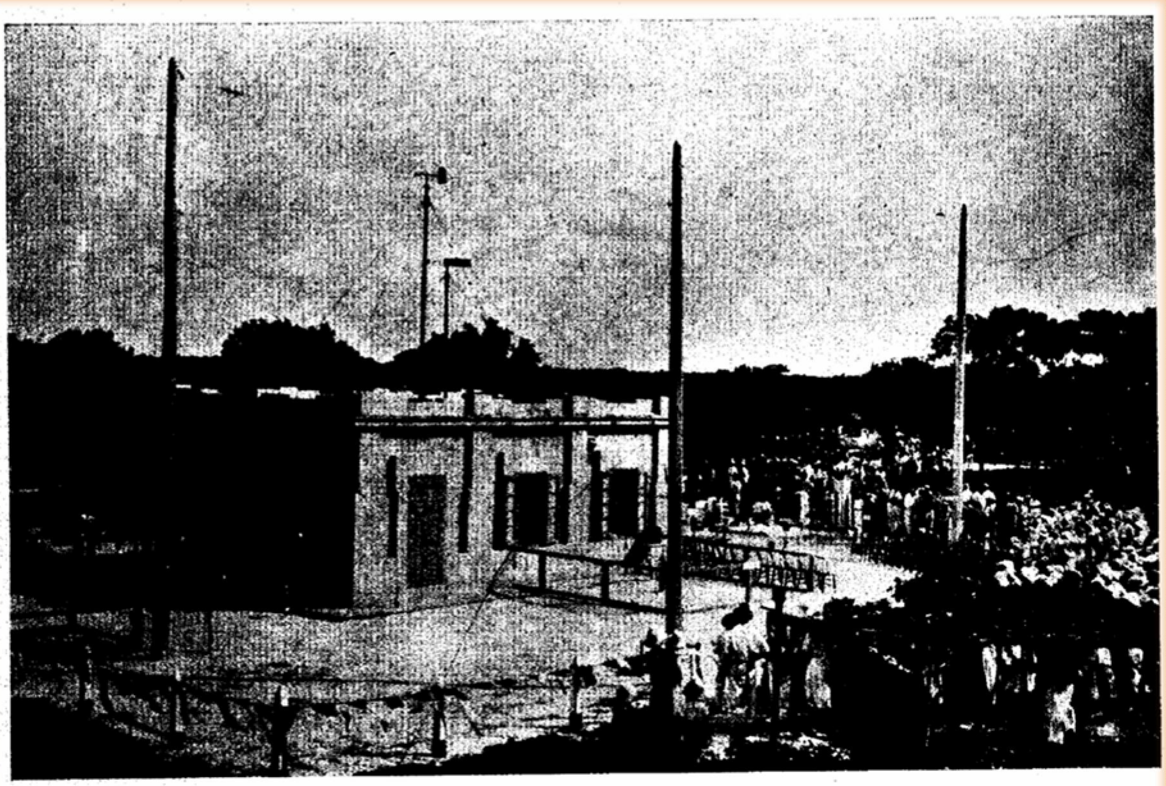
Deep crater that swallowed up a 3-story building and utility poles in Guatemala City on May 31, 2010 due to a large sink hole created by heavy rainfall from Tropical Storm Agatha. Picture courtesy of National Geographic.

APPENDIX IV

The first meteorological station in the Cayman Islands

Dr. José Rubiera of Cuba led the Committee in paying a tribute to the former Director of the Cuban National Observatory, ***Eng. José C.Millás***, and to ***Hon. Allen Wolsy Cardinall***, former Commissioner of the Cayman Islands, as well as to all other persons that participated in the establishment of a radiotelegraphic and meteorological station in the Cayman Islands on the 23rd of November, 1935, as shown in the photograph below. It was the first meteorological station in the Cayman Islands, completely built and operated by Cubans, while the radiotelegraphic station was installed and operated by Caymanians. The radio station, with calling letters GGC for “Georgetown, Cayman Island”, transmitted the observations to Havana where they were retransmitted to Washington, linking the Cayman Island to the World.

Those who made this achievement possible set the foundation of the international cooperation that we now have in modern meteorology, mainly within the Hurricane Committee in this region, as Eng. Millas pointed out by saying, “…and let us rejoice also over the fact that the splendid cooperation between two nations has made possible the establishment of this station, which will serve science, and render a great benefit to Mankind”.



La Estación Meteorológica y Radiotelegráfica de Georgetown, Caimán Grande.
(Fotografía de T. I. Rees).

REVIEW OF THE PAST HURRICANE SEASON

REPORTS OF HURRICANES, TROPICAL STORMS, TROPICAL DISTURBANCES AND RELATED FLOODING DURING 2010

(Submitted by Members of the RA IV Hurricane Committee)

Reports are posted on the WMO/TCP Website along with the main report.

GUIDELINES FOR CONVERTING BETWEEN VARIOUS WIND AVERAGING PERIODS IN TROPICAL CYCLONE CONDITIONS

This note is based on recommendations from Harper et al. (2010) and extracts from Knaff and Harper (2010), providing advice on why, when and how “wind averaging conversions” can be made.

a) Why Convert Wind Speeds?

From the observational perspective, the aim is to process measurements of the wind so as to extract an estimate of the **mean** wind at any time and its **turbulence** properties. From the forecasting viewpoint, the aim is, given a specific wind speed metric derived from a process or product, to usefully predict other metrics of the wind. Typically these needs revolve around the concept of the mean wind speed and an associated peak gust wind speed; such that the statistical properties of the expected level of wind turbulence under **different exposures** can be used to permit useful conversions **between peak gust wind speed** estimates.

b) When to Convert Wind Speeds?

Wind speed conversions to account for varying averaging periods only apply in the context of a maximum (peak gust) wind speed of a given duration observed within some longer interval. Simply measuring the wind for a shorter period of time at random will not ensure that it is always higher than the mean wind (given that there are both lulls and gusts). It is important that all wind speed values be correctly identified as an estimate of the **mean wind** or an estimate of a **peak gust**.

Once the mean wind is reliably estimated, the random effects of turbulence in producing higher but shorter-acting wind gusts, typically of greater significance for causing damage, can be estimated using a “gust factor”. In order for a gust factor to be representative, certain conditions must be met, many of which may not be exactly satisfied during a specific weather event or at a specific location:

- Wind flow is turbulent with a steady mean wind speed (**statistically stationary**);
- Constant surface features exist within the period of measurement, such that the boundary layer is in equilibrium with the underlying surface roughness (**exposure**);
- The conversion assumes the mean wind speed and the peak gust wind speed are at the same **height** (e.g. the WMO standard observation height +10 m) above the surface.

c) How to Convert Individual Point-Specific Wind Speeds

Firstly, the mean wind speed estimate V should be explicitly identified by its averaging period T_o in seconds, described here as V_{To} , e.g.

V_{600} is a 10-min averaged mean wind estimate;
V_{60} is a 1-min averaged mean wind estimate;
V_3 is a 3-sec averaged mean wind estimate.

Next, a peak gust wind speed should be additionally prefixed by the gust averaging period τ, and the time period over which it is observed (also termed the **reference period**), described here as $V_{\tau,To}$, e.g.

$V_{60,600}$ is the highest 1-min mean (peak 1-min gust) within a 10-min observation period;
$V_{3,60}$ is the highest 3-sec mean (peak 3-sec gust) within a 1-min observation period.

The “gust factor” $G_{\tau,To}$ then relates as follows to the mean and the peak gust:

$$V_{\tau,To} = G_{\tau,To}\, V \,,$$

where the (true) mean wind V is estimated on the basis of a suitable sample, e.g. V_{600} or V_{3600}.

On this basis, Table 1 provides the recommended near-surface (+10 m) conversion factors $G_{\tau,To}$ between typical peak gust wind averaging periods, which are a strong function of the exposure class because the turbulence level varies depending on the surface roughness. Table 1 only provides a range of indicative exposures for typical forecasting environments and Harper et al. (2010) or WMO (2008) should be consulted for more specific advice regarding particular types of exposures - especially if it is intended to calibrate specific measurement sites to "standard exposure".

Table 1 Wind speed conversion factors for tropical cyclone conditions (after Harper et al. 2010).

Exposure at +10 m		Reference Period T_o (s)	Gust Factor $G_{\tau,To}$				
			Gust Duration τ (s)				
Class	Description		*3*	*60*	*120*	*180*	*600*
In-Land	Roughly open terrain	3600	1.75	1.28	1.19	1.15	1.08
		600	1.66	1.21	1.12	1.09	1.00
		180	1.58	1.15	1.07	1.00	
		120	1.55	1.13	1.00		
		60	1.49	1.00			
Off-Land	Offshore winds at a coastline	3600	1.60	1.22	1.15	1.12	1.06
		600	1.52	1.16	1.09	1.06	1.00
		180	1.44	1.10	1.04	1.00	
		120	1.42	1.08	1.00		
		60	1.36	1.00			
Off-Sea	Onshore winds at a coastline	3600	1.45	1.17	1.11	1.09	1.05
		600	1.38	1.11	1.05	1.03	1.00
		180	1.31	1.05	1.00	1.00	
		120	1.28	1.03	1.00		
		60	1.23	1.00			
At-Sea	> 20 km offshore	3600	1.30	1.11	1.07	1.06	1.03
		600	1.23	1.05	1.02	1.00	1.00
		180	1.17	1.00	1.00	1.00	
		120	1.15	1.00	1.00		
		60	1.11	1.00			

Some example applications of the above recommendations are:

- To estimate the expected "off-land" 3-sec peak gust in a 1-min period, multiply the estimated "off-land" mean wind speed by 1.36
- To estimate the expected "off-sea" 3-sec peak gust in a 10-min period, multiply the estimated "off-sea" mean wind speed by 1.38
- To estimate an "at-sea" 1-min peak gust in a 10-min period, multiply the estimated "at-sea" mean wind speed by 1.05

Note that it is not possible to convert from a peak gust wind speed back to a **specific** time-averaged mean wind – only to the **estimated true mean** speed. Hence to estimate the "off-sea" mean wind speed given only a peak observed gust of 1-min duration (τ = 60 s) measured in a 10-min period (T_o = 600 s), multiply the observed 1-min peak gust by (1/1.11) = 0.90. This does not guarantee that the estimated mean wind will be the same as the 10-min averaged wind at that time but, because the 10-min average is normally a reliable estimate of the true mean wind, it will likely be similar. In all cases, measurement systems should aim to reliably measure the mean wind speed and the standard deviation using a sample duration of not less than 10-min (WMO 2008), i.e. V_{600}. Additional shorter averaging periods and the retaining of peak information should then be targeted at operational needs.

d) Converting Between Agency Estimates of Storm Maximum Wind Speed *Vmax*

This is a slightly different situation from converting a point specific wind estimate because the concept of a storm-wide maximum wind speed *Vmax* is a metric with an associated spatial context (i.e. anywhere within or associated with the storm) as well as a temporal fix context (at this moment in time or during a specific period of time). While it may be expressed in terms of any wind averaging period it remains important that it be unambiguous in terms of representing a mean wind or a peak gust. Agencies that apply the WMO standard 10-min averaged *Vmax* wind have always applied a wind-averaging conversion to reduce the maximum "sustained" 1-min wind value (a 1-min peak gust) that has been traditionally associated with the Dvorak method (Dvorak 1984, Atkinson and Holliday 1977)[1]. As noted in the previous section, it is technically not possible to convert from a peak gust back to a specific time-averaged mean wind – only to the estimated true mean wind speed. However, in Harper et al. (2010) a practical argument is made for nominal conversion between $Vmax_{60}$ and $Vmax_{600}$ values via an hourly mean wind speed reference, and the recommendations are summarised in Table 2.

It can be noted that the recommended conversion for at-sea exposure is about 5% higher than the "traditional" value of 0.88 (WMO 1993), which is more appropriate to an off-land exposure. This has special implications for the Dvorak method because "at sea" is the typical exposure of interest where such conversions have been traditionally applied.

Table 2 Conversion factors between agency estimates of maximum 1-min and maximum 10-min averaged tropical cyclone wind speed *Vmax*. (after Harper et al. 2010).

$Vmax_{600}=K\ Vmax_{60}$	At-Sea	Off-Sea	Off-land	In-Land
K	0.93	0.90	0.87	0.84

e) References

Atkinson, G.D., and C. R. Holliday, 1977: Tropical cyclone minimum sea level pressure/maximum sustained wind relationship for the Western North Pacific. *Mon. Wea. Rev.,* **105**, 421-427.

Dvorak, V.F., 1984: Tropical cyclone intensity analysis using satellite data. NOAA Tech. Rep. NESDIS 11, *National Oceanic and Atmospheric Administration*, Washington, DC, 47 pp.

Knaff, J.A. and B.A. Harper, 2010: Tropical cyclone surface wind structure and wind-pressure relationships. In: Proc. WMO IWTC-VII, *World Meteorological Organization* , Keynote 1,La Reunion, Nov.

Harper, B.A.,, J. D. Kepert, and J. D. Ginger, 2010: Guidelines for converting between various wind averaging periods in tropical cyclone conditions. *World Meteorological Organization*, TCP Sub-Project Report, WMO/TD-No. 1555.

WMO 1993: Global guide to tropical cyclone forecasting. Tropical Cyclone Programme Report No. TCP-31, *World Meteorological Organization*, WMO/TD – No. 560, Geneva.

WMO 2008: Guide to meteorological instruments and methods of observation. *World Meteorological Organization* , WMO-No. 8, 7th Ed, 681pp.

[1] As detailed in Harper et al. (2010), this traditional assumption is without a firm basis.

RA IV HURRICANE COMMITTEE'S TECHNICAL PLAN AND ITS IMPLEMENTATION PROGRAMME

I. METEOROLOGICAL COMPONENT

TASKS		TIMESCALE					BY WHOM	RESOURCES		COMMENTS	
		2011	2012	2013	2014	2015					
1.1 DEVELOPMENT OF METEOROLOGICAL SERVICES											
1.1.1	Development and provision of adequate staff and equipment to enable the national Meteorological Services in the area to meet their responsibilities in the provision of hurricane warning services						Members	National and external assistance			
1.1.2	Full implementation of the observing, telecommunication and data-processing systems of the World Weather Watch in the hurricane area						Members	National and external assistance		With advice of WMO, where needed	
1.1.3	Implementation of Quality Management Systems in support of Meteorological Services and associated activities						Members	National and external assistance		With advice of WMO, where needed	

I. METEOROLOGICAL COMPONENT

TASKS		TIMESCALE					BY WHOM	RESOURCES	COMMENTS
		2011	2012	2013	2014	2015			
1.2 METEOROLOGICAL OBSERVING SYSTEM									
1.2.1	**Manned surface stations**								
1.2.1.1	Assignment of the highest priority to the removal of deficiencies in the synoptic observation programmes at 0000 and 0600 UTC at stations of the RA IV regional basic synoptic network lying in the area between latitudes 5°N and 35°N, and between longitudes 50°W and 140°W*						Members	National	
1.2.1.2	Investigation of the possibilities of establishing simple stations which may be operated by volunteers and would supply hourly observations of direction and measured wind speed and atmospheric pressure only during periods (hours) that a hurricane is within about 200 km of the stations						Members with large land masses	National	Such stations could suitably be placed where stations of the WWW network are more than 200 km apart.

*During 2011-2012 items with an asterisk to be given priority attention

TASKS		TIMESCALE					BY WHOM	RESOURCES	COMMENTS
		2011	2012	2013	2014	2015			
1.2.1.3	Introduction of the practice of requesting stations along the shore to provide observations additional to those in the regular programme during hurricane periods, in particular when required by the RA IV Hurricane Operational Plan*						Members	National	
1.2.1.4	Expand the synoptic observation network of the RAIV in the area between latitudes 5ºN and 35º and longitude 50ºW and 140ºW.						Members	National	

*During 2011-2012 items with an asterisk to be given priority attention

APPENDIX VII

I. METEOROLOGICAL COMPONENT

TASKS		TIMESCALE					BY WHOM	RESOURCES	COMMENTS
		2011	2012	2013	2014	2015			
1.2.2	**Upper-air stations**								
1.2.2.1	Establishment of the following upper-air stations:								
	Guatemala						Guatemala	) National and	
	80400 Isla de Aves - radiosonde						Venezuela	) external assistance	
1.2.2.2	Implementation of two rawinsonde observations per day at all rawinsonde stations throughout the hurricane season*						Members concerned	National and external assistance	
1.2.2.3	Maintaining two rawinsonde observations per day whenever a named hurricane is within 1,000 km of the station, until the requirements of paragraph 1.2.2.2 above can be accomplished*						Members	National	
1.2.2.4	Implementation of the upper-air observations required at 0000 GMT under the World Weather Watch plan to enable a sufficient coverage during night hours						Members concerned	National and external assistance	

*During 2011-2012 items with an asterisk to be given priority attention

I. METEOROLOGICAL COMPONENT

TASKS		TIMESCALE					BY WHOM	RESOURCES	COMMENTS
		2011	2012	2013	2014	2015			
1.2.3	**Ships' weather reports**								
1.2.3.1**	Continuation of efforts to recruit ships for participation in the WMO Voluntary Observing Ship Scheme, in particular by :								
	• Recruiting selected and supplementary ships plying the tropics*								
	• Designating Port Meteorological Officers*						Members	National	
							Members	National	
1.2.3.2	Improvement of liaison between Meteorological Services and Coastal Radio Stations and arrangements for specific requests for ships' reports from any area of current hurricane activity even if such reports have to be transmitted in plain language*						Members operating coastal radio stations	National	

*During 2011-2012 items with an asterisk to be given priority attention

APPENDIX VII

I. METEOROLOGICAL COMPONENT

TASKS		TIMESCALE					BY WHOM	RESOURCES	COMMENTS
		2011	2012	2013	2014	2015			
1.2.4	**Automatic weather stations**								
1.2.4.1	Exploration of the possibility of installing automatic reporting devices at stations with insufficient staff for operation throughout the 24 hours; such stations might then be operated during daylight hours as manned stations and during night-time as unattended automatic stations, possibly with a reduced observing programme						Members concerned	National and external assistance	
1.2.4.2	Exploration of the possibility of installing automatic weather stations at locations which may be considered critical for the hurricane warning system for operation at least during the hurricane season						Members concerned	National and external assistance	

I. METEOROLOGICAL COMPONENT

TASKS		TIMESCALE					BY WHOM	RESOURCES	COMMENTS
		2011	2012	2013	2014	2015			
1.2.4.3	Establishment of automatic weather stations at the following locations:								
	Dominican Republic (8) remainder to be installed in 2011						Dominican Republic	National & USA	The USA requested that countries planning to install automatic weather stations which use the GOES satellite for collection consult early with NOAA concerning details of the station configuration and transmission code formats which should be in WMO formats if possible
	Panama 9 installed 2010, 10 more in 2011, 30 more auto stations available on the web						Panama	National and external assistance	
	Guatemala (31)						Guatemala		
	Cuba (30)						Cuba		
	Trinidad (3)						Trinidad		
	Jamaica 3 installed, 2 more in 2011 (12 total remaining to be installed)						Jamaica		
	Belize(1)						Belize(1)		
	Mexico 17 installed 2010, 18 more for installation						Mexico		
	El Salvador – 5 stations						El Salvador	national funds with the program PNRR	
	Curacao installed 3 last year, 5 more for 2011						Curacao		
1.2.4.4	Ensure the sharing of AWS weather data to the international met community.						Members		

I. METEOROLOGICAL COMPONENT

TASKS		TIMESCALE					BY WHOM	RESOURCES	COMMENTS
		2011	2012	2013	2014	2015			
1.2.5	**Radar stations**								
1.2.5.1	Promotion of the establishment and operation of a sub-regional network of 10 cm/5.6 cm wavelength radar stations, including replacement of unserviceable radars*	shaded	shaded	shaded	shaded	shaded		National & European Union	Being implemented
	Installation of radar in Cayman Islands	shaded	shaded				BCT (Cayman Islands)		
1.2.5.2	Establishment and operation of 10 cm/5.6 cm wavelength radar stations at the following locations or nearby:							National and external assistance	
	El Salvador 3 X-band radars + purchase of 2 more	shaded							
	Honduras (1)	shaded	shaded				Honduras		
	Guatemala (1)	shaded	shaded				Guatemala		
	Venezuela (3 more)	shaded					Venezuela		

*During 2011-2012 items with an asterisk to be given priority attention

I. METEOROLOGICAL COMPONENT

TASKS		TIMESCALE					BY WHOM	RESOURCES	COMMENTS
		2011	2012	2013	2014	2015			
1.2.5.3	Speedy availability of 10 cm/5.6 cm radar data in the hurricane area in accordance with the Hurricane Operational Plan for Region IV*						Members operating 10 cm/5.6 cm radar stations	National	
1.2.5.4	Development of pictorial radar information sharing programme including composites among all RA IV countries in the hurricane area in accordance with the Hurricane Operational Plan*						France	USA and France	France produces composites based on 5 radars**; USA provide the telecommunication facilities.

TASKS		TIMESCALE					BY WHOM	RESOURCES	COMMENTS	
		2011	2012	2013	2014	2015				
1.2.6	**Air reconnaissance flights**									
1.2.6.1	Continue provision of aircraft reconnaissance when required in accordance with the Hurricane Operational Plan for Region IV and dissemination of the information obtained to all concerned*, whenever this activity is not in violation of the sovereignty of the countries concerned.						USA	USA		

*During 2011-2012 items with an asterisk to be given priority attention

I. METEOROLOGICAL COMPONENT

TASKS		TIMESCALE					BY WHOM	RESOURCES	COMMENTS
		2011	2012	2013	2014	2015			
1.2.7	**Meteorological satellite systems**								
1.2.7.1	Maintaining and operating the LRIT stations for the reception of cloud pictures from GOES and near-polar-orbiting satellites, including any modified or new equipment necessary for the reception of information from the POES series of satellites*						Members	National	
1.2.7.2	Installation and operation of direct read-out satellite reception facilities, in view of their great utility in hurricane tracking and forecasting*						Members able to do so	National and external assistance	
	Dominican republic hopes to revert to GOES 12 - having problems with receiving GOES 13 data						Dominican Republic		
	El Salvador - update of Metlab								
	Panama GOES Satellite receiving station installation								

*During 2011-2012 items with an asterisk to be given priority attention

I. METEOROLOGICAL COMPONENT

TASKS		TIMESCALE					BY WHOM	RESOURCES	COMMENTS
		2011	2012	2013	2014	2015			
1.2.8	**Storm surges *****								
1.2.8.1	Establishment of a network of tide-gauge stations in coastal areas where storm surges are likely to occur, and in coordination with tsunami mitigation activities						Members able to do so	National	Data should be provided in near real-time
1.2.8.2	Bahamas - wave buoys being repaired and will become operational						Bahamas	National	
1.2.8.3	Panama - more wave buoys are planned for deployment						Panama	National	
1.2.8.4	Deployment of a wave buoy off east coast of Bermuda						Bermuda	National	In support of wave energy assessment - data provided to NMHS

I. METEOROLOGICAL COMPONENT

TASKS		TIMESCALE					BY WHOM	RESOURCES	COMMENTS
		2011	2012	2013	2014	2015			
1.2.9	**Lightning detection systems**								
1.2.9.1	Installation of a high resolution lightning network for the Lesser Antilles						France, CMO	To be identified	1st phase explore networks available to find one best suited for the region to be upgraded or installed.
1.2.9.2	Cayman Islands Lightning detection system						Caymans, UK	UK Met Office	
1.2.9.3	Bahamas 2 Lightning detectors						Bahamas	National	

I. METEOROLOGICAL COMPONENT

TASKS		TIMESCALE					BY WHOM	RESOURCES	COMMENTS
		2011	2012	2013	2014	2015			
1.3 METEOROLOGICAL TELECOMMUNICATION SYSTEMS									
1.3.1	National telecommunication networks								
1.3.1.1	Provision of suitable telecommunication facilities for the collection at NMCs of all observational data from stations in the regional basic synoptic network in accordance with the requirements of the WWW (i.e. 95% of reports to reach the collecting centre within 15 minutes of the observing station's filing time)*						Members	National and external assistance	Take urgent action
1.3.2	Special hurricane telecommunication arrangements								
1.3.2.1	Implementation, where necessary, of communication links to enable direct contact between warning centres to permit direct communication between forecasters						Members	National	Use of systems such as VSAT is recommended

I. METEOROLOGICAL COMPONENT

TASKS		TIMESCALE					BY WHOM	RESOURCES	COMMENTS
		2011	2012	2013	2014	2015			
1.3.2.2	Implementation, where necessary, of national and international communication links for distribution of warnings and advisories						Members	National and external assistance	
1.3.3	Regional telecommunication network								
1.3.3.1	Continue to improve and upgrade telecommunication systems in accordance with the RA IV Regional Meteorological Telecommunication Plan,*						Members		
1.3.3.2	Promote installation of EMWIN systems						USA Members able to do so	External Assistance & National budget EMWIN Workshop was held in Puerto Rico Feb 2011– 53 participants from RAIV	

I. METEOROLOGICAL COMPONENT

TASKS							BY WHOM	RESOURCES	COMMENTS
		2011	2012	2013	2014	2015			
1.4 HURRICANE AND STORM SURGE SIMULATION, FORECASTING AND WARNING									
1.4.1	Storm surge project activities								
1.4.1.1	Develop storm surge maps and undertake hazard assessment activities*						Members	National and external assistance including TCDC	With advice of WMO; IOC
							Members		
							Bahamas		Digitized format ; Resolution 0.1 to 1.0 nautical mile
							Members		
							CIMH		
1.4.1.2	Undertake bathymetric and topographic data collection for vulnerable areas*								
	Bahamas – atlases of coastal inundation are being updated						Bahamas		
1.4.1.3	Enhance storm surge map coverage by using SLOSH								

*During 2011-2012 items with an asterisk to be given priority attention

I. METEOROLOGICAL COMPONENT

TASKS							BY WHOM		COMMENTS
		2011	2012	2013	2014	2015			
1.4.1.4	Include the tsunami and other coastal hazards early warning system community in storm surge modelling and hazard assessment activities								
1.4.1.5	CIMH in collaboration with UWI and the World Bank will develop a series of storm surge hazard maps for the Caribbean Region								
	Provide bathymetric data towards the development of a local circulation model and inundation risk maps, which will facilitate assessment and real time forecasting of impacts from storm surge, tsunami and other coastal hazards.								

II. HYDROLOGICAL COMPONENT

TASKS		TIMESCALE					BY WHOM	RESOURCES	COMMENTS
		2011	2012	2013	2014	2015			
2.1 SUPPORT TO HYDROLOGICAL SERVICES AND FACILITIES									
2.1.1	Strengthening the national Hydrological Services and, in particular, improvement of the hydrological observing networks and data transmission and processing facilities**						Members concerned	National and external assistance	**This would include promoting the use of quantitative precipitation information from precipitation forecasts, surface radar networks and satellites, as considered in the meteorological component of the Technical Plan
2.1.2	Establishment and development of national and/or sub-regional hydrological workshops to repair and maintain hydrological instruments, and promotion of the establishment of sub-regional facilities for the calibration of these instruments						Members concerned	National and external assistance	

II. HYDROLOGICAL COMPONENT

TASKS		TIMESCALE					BY WHOM	RESOURCES	COMMENTS
		2011	2012	2013	2014	2015			
2.2 HYDROLOGICAL FORECASTING									
2.2.1	Establishment, improvement and/or expansion of hydrological forecasting (including flash floods) and warning systems in flood-prone areas, and in particular: (a) The countries indicated to be invited to consider the establishment/ expansion of systems in the:							National	
	• YAQUE DEL SUR river basin						Dominican Republic		
	• YAQUE DEL NORTE river basin						El Salvador and Honduras		
	• RIO LEMPA						Guatemala		
	• International river, RIO GRANDE (RIO BRAVO) river basin						Mexico & USA		Additional data required
	• VIEJO,COCO and TUMA river basins						Nicaragua		
	• RIO PARRITA and RIO SARAPIQUI						Costa Rica		

II. HYDROLOGICAL COMPONENT

TASKS		TIMESCALE					BY WHOM	RESOURCES	COMMENTS
		2011	2012	2013	2014	2015			
2.2.1 (cont'd)	Establishment, improvement and/or expansion of hydrological forecasting (including flash floods) and warning systems in flood-prone areas, and in particular: (b) Establishment of flash flood warning systems in flood-prone areas; (c) Promote the use of hydrological models to forecast the behaviour of rainfall and run-off characteristics, paying special attention to the use of radar and satellite information.						Members concerned Members concerned	National National	
2.3 BASIC SUPPORTING STUDIES AND MAPS									
2.3.1	Determination of flood-prone areas; compilation of an inventory of existing hydrological observing, transmission and processing facilities in these areas; and determination of requirements for related meteorological services						Members concerned	National and external assistance	For these studies, use should be made insofar as possible, of previous experience of Member countries of the Committee
2.3.2	Implementation of hydrometeorological and rainfall-runoff studies (including depth-area duration-frequency analyses of rainfall) for use in planning and design						Members concerned	National and external assistance	

II. HYDROLOGICAL COMPONENT

TASKS		TIMESCALE					BY WHOM	RESOURCES	COMMENTS
		2011	2012	2013	2014	2015			
2.3.3	Carry out surveys as soon as possible, immediately following flood events for the purpose of delineating the limits of flooding. The survey should include if possible aerial and satellite imagery						Members concerned	National	
2.3.4	Preparation of flood risk maps in flood-prone areas for their use in: (a) Planning and undertaking preventive measures and preparations for flood mitigation; (b) Long-term planning covering land use						Members concerned	National	Members sharing basins encouraged to standardize the scales of these maps
2.3.5	Assessment of quantitative precipitation information from precipitation forecast, satellite, radar and raingauge networks for flood forecasting						Members concerned	National and external assistance including TCDC	

TASKS		TIMESCALE					BY WHOM	RESOURCES	COMMENTS
		2011	2012	2013	2014	2015			
2.3.6	Initiation of research studies and operational data collection for analysis and forecasting of combined effects of storm surge and river flooding phenomena** ** WMO Operation Hydrology Report No. 30 "Hydrological Aspects of Combined Effects of Storm Surges and Heavy Rainfall on River Flow"						Members	National and external assistance	For these studies, use should be made, insofar as possible, of previous experience of Member countries of the Committee

II. HYDROLOGICAL COMPONENT

TASKS		TIMESCALE					BY WHOM	RESOURCES	COMMENTS
		2011	2012	2013	2014	2015			
2.3.7	Basic studies on the vulnerability of the monitoring networks to damage caused by tropical storms, taking into account also the problems which might be generated when stations become inoperative, both with regard to the interruption of the available historical series and to the provision of observations and data of subsequent events						Interested Members	National and TCDC	
2.3.8	Basic studies on the intensity and spatial variability of rainfall produced by all tropical storms during the tropical cyclone season, as well as on the optimal density of the recording rainfall network required						Interested Members	National and TCDC	
2.3.9	Preparation of flood-risk maps of zones susceptible to flooding caused by tropical storms, separating floods resulting from local rains from those resulting from rainfall in the headwaters of the basins						Interested Members		
2.3.10	Basic studies on the problems of operation of reservoirs when their basins are affected by rainfall produced by tropical storms and decisions to be made with respect to the water impounded						Interested Members	National and TCDC	
2.3.11	Initiation of a GIS-based database to be used by all countries of the region						Interested Members	National and TCDC	

II. HYDROLOGICAL COMPONENT

TASKS		TIMESCALE					BY WHOM	RESOURCES	COMMENTS
		2011	2012	2013	2014	2015			
2.3.12	Establishment of a regional project to generalize the hydrological impact knowledge of tropical storms and hurricanes**						Interested Members	National and TCDC	
2.4 TRANSFER OF HYDROLOGICAL TECHNOLOGY									
2.4.1	Attention to the availability through HOMS of components and sequences containing hydrological technology suitable for the hydrological component of the technical plan*						Members	National and TCDC	With advice of WMO
2.4.2	Undertaking a promotional effort among Member countries, so that they may develop HOMS components reflecting in particular experiences in regions affected by tropical storms; the Committee to encourage the inclusion of the components in the HOMS Reference Manual						Hurricane Committee in cooperation with its Members	National and TCDC	

* These HOMS components include instrumentation and hydrological models for monitoring and forecasting the floods caused by all tropical storms during the tropical cyclone season. HOMS components also relate to flood damage estimation extent of flooding and flood-plain mapping.

** The meeting expressed a desire for the hydrology and meteorology group to be compatible and for the Working Group on Hydrology (RA IV) to consider technical plan for RA IV.

III. DISASTER REDUCTION AND PREPAREDNESS

TASKS		TIMESCALE					BY WHOM	RESOURCES	COMMENTS
		2011	2012	2013	2014	2015			
3.1 DISASTER REDUCTION									
3.1.1	Drawing the attention of national authorities of the principal role of meteorological and hydrological factors in carrying out vulnerability analyses in the fields of physical and urban planning, land-use zoning, public works and building codes						Members	National, regional and international	
3.1.2	Promote public awareness of the hurricane risk and the associated risks prior to each hurricane season						Members	National, regional and international	Members are encouraged to collaborate with ISDR
3.1.3	Participate actively in appropriate conferences and activities related to natural hazard mitigation and multi-hazard warning systems. The Hurricane Committee will nominate a representative to attend meetings of the Sessions of the Intergovernmental Coordination Group for the Tsunami and Other Coastal Hazards Warning System for the Caribbean and Adjacent Regions (ICG)						Members	National, regional and international	
3.1.4	Participate actively in the preparation and on-going review of the national disaster prevention and preparedness plans						Members	National	

TASKS		TIMESCALE					BY WHOM	RESOURCES	COMMENTS
		2011	2012	2013	2014	2015			
3.1.5	Cooperate with all national and regional agencies in their annual pre-hurricane season exercises. Where these do not exist meteorological services should promote their implementation						Members	National and regional	
3.1.6	Promote good relationship with the media and make full use of their services to disseminate information prior to and during the hurricane season						Members	National, regional and international	
3.1.7	Arranging for the early transmission of forecasts of hurricanes and flooding to the central coordinating agency responsible for the organization of protective and relief measures, and to similar coordinating agencies at regional level, to allow the timely dissemination of warning by such agencies						Members	National and regional	
3.1.8	Participate in ensuring that official advisory statements concerning forecasts, warnings, precautionary actions or relief measures are only to be made by authorised persons and to be disseminated without alteration						Members	National, regional and international	
3.1.9	Advising on and contributing to training programmes to support preparedness programmes to include disaster administrators, disaster control executives and rescue/relief groups and workers in all counter-disaster authorities and agencies						Members	National, regional and international	

III. DISASTER REDUCTION AND PREPAREDNESS

TASKS		TIMESCALE					BY WHOM	RESOURCES	COMMENTS
		2011	2012	2013	2014	2015			
3.2 REVIEWS AND TEST EXERCISES									
3.2.1	Participating in periodic reviews of both disaster prevention and disaster preparedness plans to ensure that they are active and up to date						Members	National and external assistance	With advice of OCHA/IFRC/ CDERA
3.2.2	Conducting of periodic staff checks and test exercises to test the adequacy of NMHSs disaster preparedness plans, preferably on a progressive annual basis prior to the expected seasonal onset of natural disaster threats but also, in respect of plans to meet sudden impact disasters, on an occasional no-warning basis						Members	National	

IV. TRAINING COMPONENT

TASKS		TIMESCALE					BY WHOM	RESOURCES	COMMENTS
		2011	2012	2013	2014	2015			
4.1 TRAINING OF METEOROLOGICAL PERSONNEL									
4.1.1	Assessment of current and expected future needs for the training of specialized staff to man their warning systems at all levels under the following headings:								
	(a)Those capable of being met through training facilities already available in Member countries*						Members	National	
	(b)Those for which assistance from external sources is needed*						Members	National	With advice of WMO
	Take appropriate steps to organize such training programmes*						Members	National and external assistance	
4.1.2	Support as appropriate and make full use of the training facilities offered at the WMO Regional Training Centres at the CIMH, Barbados, and the University of Costa Rica, San José, as well as at the Tropical Desk in Washington.						Members	National and external assistance	

*During 2011-2012 items with an asterisk to be given priority attention

IV. TRAINING COMPONENT

TASKS		TIMESCALE					BY WHOM	RESOURCES	COMMENTS
		2011	2012	2013	2014	2015			
4.1.3	Arrangements for short courses of approximately 2 to 3 weeks duration on topics related to storm rainfall estimation and to hurricane forecasting to be organized at the RSMC Miami Hurricane Center and the Regional Training Centres at the CIMH and the University of Costa Rica*						Regional centres	Regional, national and external assistance	These events should be conducted in English and Spanish
4.1.4	Arrangements for periodic seminars or workshops on specific topics of particular interest for hurricane prediction and warning purposes, priority being given in the first instance to operational techniques for the interpretation and use of NWP products, satellite and radar data and to storm surge prediction						Members, Hurricane Committee	National and external assistance	
	Storm surge and coastal hazards training is a vital need for the region, and must be continued following the outcomes of the wkshp in DR								

*During 2011-2012 items with an asterisk to be given priority attention
** Workshop proposed to be held in the Dominican Republic during November or December 2010

TASKS		TIMESCALE					BY WHOM	RESOURCES	COMMENTS
		2011	2012	2013	2014	2015			
4.1.5	Arrangements for exchange working visits of Staff between operational and training centres						Members, training centres	National and external assistance, regional projects, TCDC	
4.1.6	Specific training for forecasters from Haiti Ongoing training for techinicians should also be implemented						France, USA	To be determined	

IV. TRAINING COMPONENT

TASKS		TIMESCALE					BY WHOM	RESOURCES	COMMENTS
		2011	2012	2013	2014	2015			
4.2 TRAINING OF HYDROLOGICAL PERSONNEL									
4.2.1	Assessment of current staff availability and capabilities and future needs for training hydrologists in specific subjects concerning hydrological forecasting and warning and of hydrological technicians, to promote and take appropriate steps to organize and disseminate information on training courses, workshops and seminars, and in particular to support the following: (a) The establishment of a sub-regional centre in the Central American Isthmus for hydrological technicians' training; (b) The training of operational hydrological personnel at the sub-regional (training) centre in the Caribbean; (c) The organization of a course for training in tropical cyclone hydrology and flood forecasting. Courses and workshops on hydrological forecasting techniques or data acquisition, processing and analysis						Members concerned USA or other Members concerned	National and external assistance National and external assistance	

TASKS		TIMESCALE					BY WHOM	RESOURCES	COMMENTS
		2011	2012	2013	2014	2015			
4.2.2	Arrangements for exchange working visits of staff between national hydrology and flood forecasting centres and regional hydrological training centres						Members, training centres	National and external assistance, regional projects, TCDC	

V. RESEARCH COMPONENT

TASKS		TIMESCALE					BY WHOM	RESOURCES	COMMENTS
		2011	2012	2013	2014	2015			
5.1 RESEARCH									
5.1.1	Making readily available information on research activities and results carried out in Member countries to other Members of the Committee with a view for transfer to operational application as appropriate *						Members	National	*WMO, when requested, to facilitate the exchange of information on these activities as well as on sources of data available for research
5.1.2	Formulation of proposals for consideration by the Committee for joint research activities to avoid duplication of effort and to make the best use of available resources and skills						Members	National	

*During 20112012 items with an asterisk to be given priority attention

TASKS		TIMESCALE					BY WHOM	RESOURCES	COMMENTS
		2011	2012	2013	2014	2015			
5.1.3	Arrangements for exchange visits of staff between national research centres						Members	National and external assistance, regional projects, TCDC	

APPENDIX VIII

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