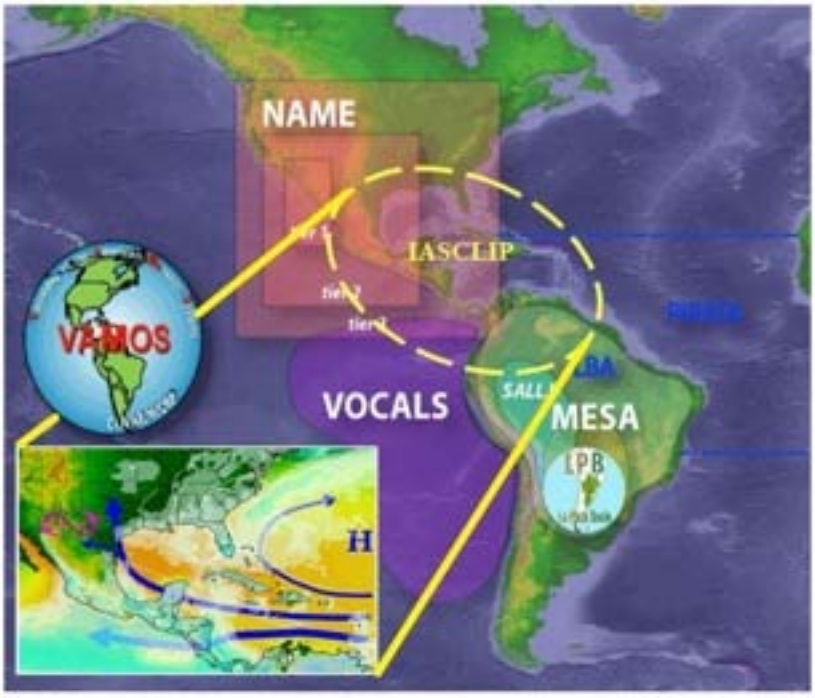
The IASCLiP Modeling Plan



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Executive summary

The modeling plan recognizes that the state-of-the art global models have very large mean bias and erroneous variability over the Intra-Americas Seas Climate Processes (IASCLiP) region. Furthermore it is recognized that the warm pool of the Intra-Americas Seas (IAS) forces atmospheric anomalies both in-situ and in remote locations that can affect climate extremes including tropical cyclone activity, droughts and floods in the Caribbean region and in the two American continents. The variations in the IAS have interannual, inter-decadal and long term linear trends that can influence the climate variations in the region, which offers a unique opportunity to understand these variations and their impact on local and remote climate. The proposed modeling plan intends to capitalize on this feature of the IAS.

This IASCLiP modeling plan is driven by phenomenology, based on the idea that unraveling and understanding modes of variability, including their physical mechanisms and interactions, may lead to discovery of predictable climate signals and improvement in their prediction. The modeling plan has charted a roadmap, which includes conducting a comprehensive model intercomparison study to ascertain pathology of the errors and possibly define appropriate metrics for model evaluation and improvement. Several mechanistic studies to understand the influence of remote and local forcing on the IASCLiP region is suggested including anthropogenic influence in way of land cover and land use change (for example the widespread deforestation of the Amazonian forests). In addition some sensitivity studies are also proposed to understand the role of resolution changes, especially when steep orography in the two continents presents a challenge for climate models in the region and dictates the large-scale land-ocean temperature contrasts that can exert influence on the low level atmospheric features like jets. While many of these studies would help in understanding the climate variability in the region, separate seasonal to interannual climate predictability studies are also proposed including a co-ordinated multi-model comparison study, for isolating errors in the forecast system. Observed system simulation experiments are also suggested to isolate the importance of observations for initializing the forecast system.

An IASCLiP forecast forum is already underway in its second year, with the overarching objective to compliment our research and development efforts in an operational setting. Despite the overwhelming biases in the operational models over the region, our first year of forecast forum indicate that reasonable forecast skill can be harvested, based on simple bias correction and our current understanding of the teleconnections in the region. This forum offers an opportunity for modeling groups to bring their forecast tools for further scrutiny, comparison with other models, and feedback from an expert group.

The IASCLiP modeling plan compliments the observational monitoring plan for the region with the intent that progress in either or both will help in the understanding and implementation of the overall IASCLiP objective, which is to improve the forecast skill at all spatio-temporal scales. The multi-scale, multi-tiered and integrated modeling approach of this plan conforms to the cherished goals of the VAMOS modeling plan as well. It is anticipated that the concerted effort to implement this plan will lead to a significant contribution from improved forecast skills of climate extremes to NOAA's climate services.

Contents

1. Introduction

This document describes an Intra-Americas Seas Climate Processes (IASCliP) modeling strategy to address the key science issues raised in the science plan of the IASCLiP. The IASCLiP (cover picture) covers a broad region in the western hemisphere including northern South America, Caribbean Sea, Gulf of Mexico, northwestern tropical Atlantic and northeastern tropical Pacific Oceans, and continental US and Central America. A unique aspect of this region is that in the boreal summer and early fall seasons it hosts the warmest pool of warm water (>28.5^{0}C) in the western hemisphere. Therefore it is termed as the Western Hemisphere Warm Pool (WHWP). The Intra-Americas Seas (IAS), which includes the Caribbean Sea, the Gulf of Mexico, and the tropical northwestern Atlantic Ocean (Fig. 1) is a subset of the larger WHWP and also interchangeably referred in this document as the Atlantic Warm Pool (AWP).

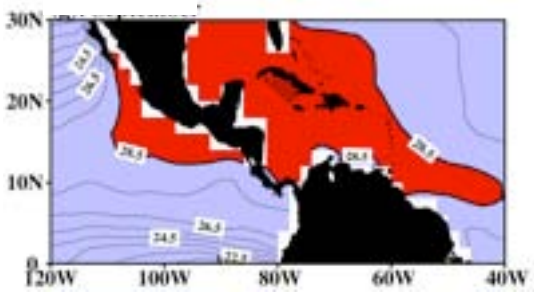

Figure 1: Western Hemisphere Warm pool.

The IASCLiP is proposed as a natural step forward to integrate our understanding from the North American Monsoon Experiment (NAME; http://www.cpc.ncep.noaa.gov/products/precip/monsoon/) and the Monsoon Experiment in South America (MESA; http://www.clivar.org/organization/vamos/vamos.php/MESA_ImplementationPlan_April_2009.doc) to provide a holistic framework for the variability of the monsoon of the two American continents as it progresses from one hemisphere to the other. Furthermore, the complex variations in the intervening WHWP and its local and remote interactions with land and atmosphere makes IASCLiP a challenge to model.

The IASCLiP region is vulnerable to climate variability across many spatio-temporal scales and including long-term climate change. Tropical cyclone activity has enormous impacts in the IASCLiP region, and is modulated by both oceanic and large-scale atmospheric conditions on intra-seasonal (Maloney and Hartmann 2000a, b), seasonal to interannual (Elsner et al. 2006; Wang and Lee 2007), decadal time scales (Goldenberg et al. 2001, Bell and Chelliah 2006), and also potentially by climate change (Knutson et al. 2010; Bender et al. 2010). Rainfall and severe convective storms in the North American Monsoon and in the mid-west US are also modulated by the strength and location of the of the North Atlantic subtropical high and the related Caribbean low level jet and Great Plains low level jet wind enhancements on its rim (Wang and Enfield 2001; Wang and Enfield 2003; Wang et al. 2006; Wang and Lee 2007; Wang et al. 2008a). The variability of these low level wind features is partly correlated to changes in WHWP size (the area enclosed by the 28.5^{0}C isotherm in the IAS region), but is undoubtedly modulated by remote influences as well.

Theoretical and modeling studies have suggested that this region has self regulating meridional circulations in the atmosphere (Hadley cell) that are interhemispheric, generated by the significant diabatic heat release that alternates in the Amazon in boreal winter to the WHWP in the boreal summer (Lee et al. 2009; Wang and Lee 2010). This atmospheric response in the region is shown to also apply to diabatic heating anomalies in the Amazon and in the WHWP.

This IASCLiP modeling plan is driven by phenomenology, based on the idea that unraveling and understanding modes of variability, including their physical mechanisms and interactions, may lead to discovery of predictable climate signals and improvement in their prediction. The specific scientific goals outlined in the IASCLiP science plan (http://www.eol.ucar.edu/projects/iasclip/documentation/iasclip_prospectus_latest.pdf) are to promote better understanding and prediction of these linked phenomena:

i) The oceanic variability of the Western Hemisphere Warm Pool (WHWP), including inter-relationships between its Eastern North Pacific (ENP) and the Atlantic Warm Pool (AWP) components
ii) The variability of rainfall over the WHWP and neighboring continental regions of North and South America
iii) Low level moisture transport in the IAS region
iv) The relationship between IAS variations and tropical cyclone activity
v) The decadal variation of the WHWP (more specifically the AWP) from natural and/or anthropogenic changes in the Atlantic Meridional Overturning Circulation (AMOC)
vi) The influence of continental rainfall and thereby river discharge on stratification in the IAS
vii) Mid-summer drought of the (broadly defined) North American Monsoon and its relation to WHWP variability
viii) The influence of Amazonian rainfall on AWP variations
ix) Influence of WHWP on diurnal variations
x) The influence of IAS observations on climate prediction

The effort to understand some of the above phenomena may be attempted through mechanistic and sensitivity studies while their influence on prediction may be channeled through predictability studies. In many ways, this modeling plan compliments the corresponding plan of the VAMOS (http://www.clivar.org/organization/vamos/Publications/Vamos_Modeling_Plan_Jun08.pdf). The VAMOS modeling approach emphasizes on multi-scale approach of monitoring, modeling and diagnosis at local, regional, and continental scales. The IASCLiP modeling plan embodies these principles of VAMOS modeling plan, in that it seeks to understand the low frequency variations at the meso, synoptic and large-scales. The proposed plan is an integrated multi-tiered modeling plan with specific roles delineated for atmospheric GCM's, coupled ocean-atmosphere GCM's and regional atmospheric and oceanic models, which again conforms to one of the cherished VAMOS modeling goals.

The modeling plan also compliments the proposed observational monitoring program for IASCLiP, which is promoting enhanced observations of the ocean and the atmosphere in the IASCLiP region. There is a growing consensus that this is one of the

most poorly observed oceans besides the polar oceans. Furthermore, Misra and Chan (2009) clearly demonstrate that seasonal prediction models suffer from poor ocean initialization from such lack of sub-surface ocean observations. In addition lack of in-situ observations of rainfall, precipitable water make for uncertain calibration of remotely sensed products.

2. Modeling issues

i) Basic state

The fidelity of the climate models over the IASCLiP region is relatively poor. Fig. 2 shows the seasonal mean SST in ASO season (which marks the observed annual peak of AWP) from some of the climate forecast models run routinely in the U.S. for research and

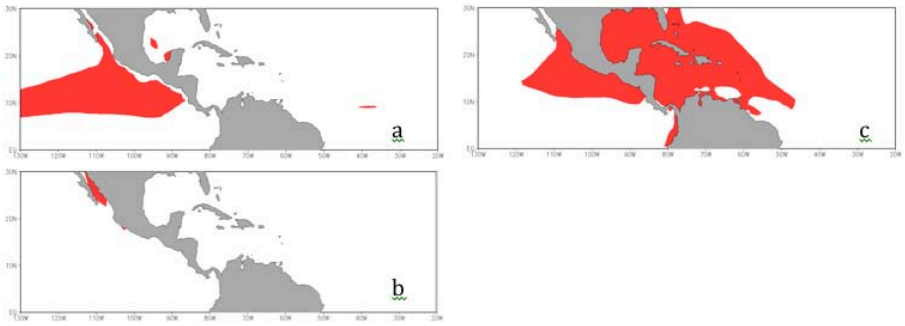

Figure 2: Climatological Western Hemisphere Warm Pool (WHWP) defined by the area enclosed by the 28.5^{0}C isotherm (shaded in red) in Aug-Sep-Oct (ASO) in some of the seasonal forecast climate models at zero month lead like a) NASA GMAO CGCMv1 (http://gmao.gsfc.nasa.gov/research/modeling/cgcm), b) CCSM3 (Kirtman and Min 2009), and c) NCEP CFS (Saha et al. 2006).

operations in seasonal to interannual variations. Similarly, the IPCC class of models (Fig. 3) has a very poor simulation of mean SST in the IASCLiP region with cold biases predominant. Some models have no >28.5C water at all in the Atlantic (Fig. 2b). On the other hand there are a minority of models (e.g. UKMET HADCM3, MPI ECHAM5) which have a warm bias over the AWP region. Cross-comparing these models with the ones that have cold bias may provide some useful insight in to the cause of these biases.

As a consequence of severe cold biases, merely defining the AWP and WHWP becomes problematic. However, quantile thresholds rather than absolute T >28.5 or SST anomaly field approaches should still permit meaningful work to be done.

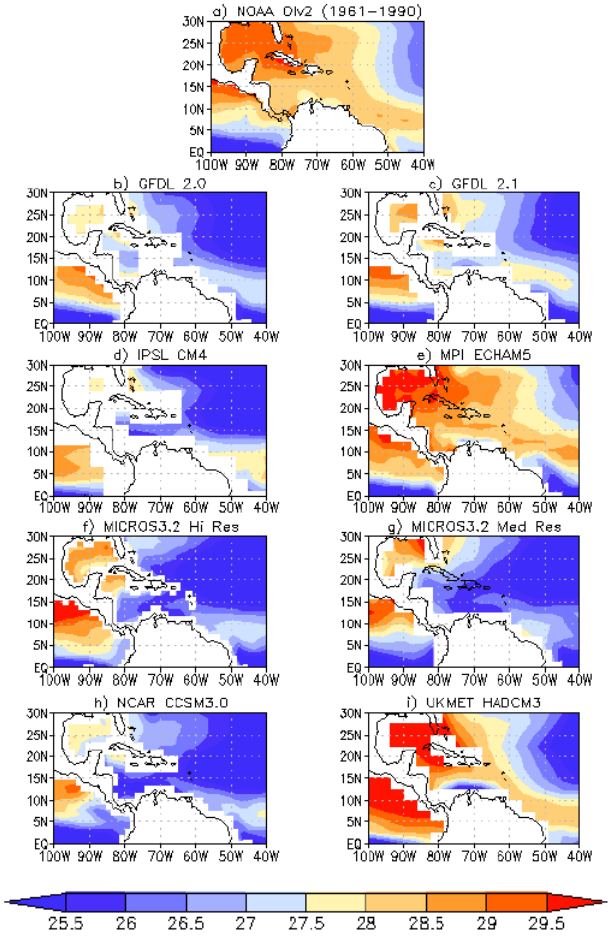

Figure 3: The Jul-Aug-Sep climatological mean SST bias from a) observations, and b, c, d, e, f, g, h, i) eight IPCC AR4 models. From Misra et. al. (2009).

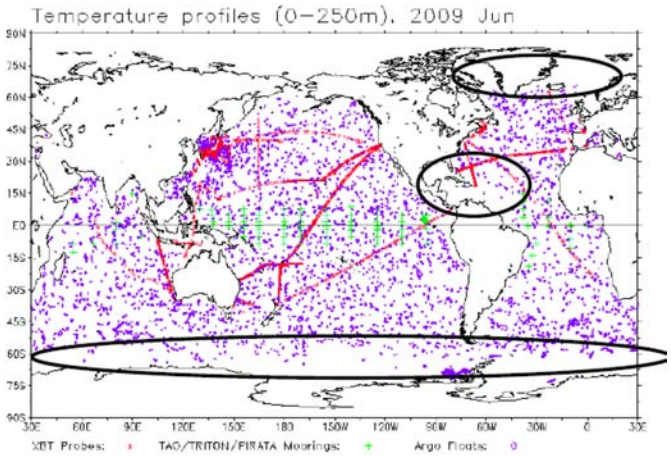

Figure 4: A snap shot of the ocean observations for June 2009. The circled areas in black show the data sparse regions of the global oceans, with the observational coverage over the AWP area being comparable to that in the polar oceans.

ii) Seasonal to interannual time scale

Despite the low bias of NCEP CFS (comparing Fig. 2c and Fig. 1), Misra et al. (2009) show that the model's seasonal prediction skill is rather poor. In fact the seasonal prediction skill of the AWP in the NCEP CFS is shown to vary from one decade to another. This feature apparently stems from the lack of sub-surface ocean observations in the IAS region, which affects the quality of the ocean initialization. In fact, the sub-surface ocean observational coverage in the IAS region is almost as sparse as that over the polar oceans (Fig. 4).

In addition, most of these climate models struggle with aspects of the time structure of climatology, such as the mid-summer drought in the NAM region and in the Caribbean islands. Over the IASCLiP area's continents too,

boreal summer and fall rainfall and temperature prediction are relatively poor compared to other seasons.

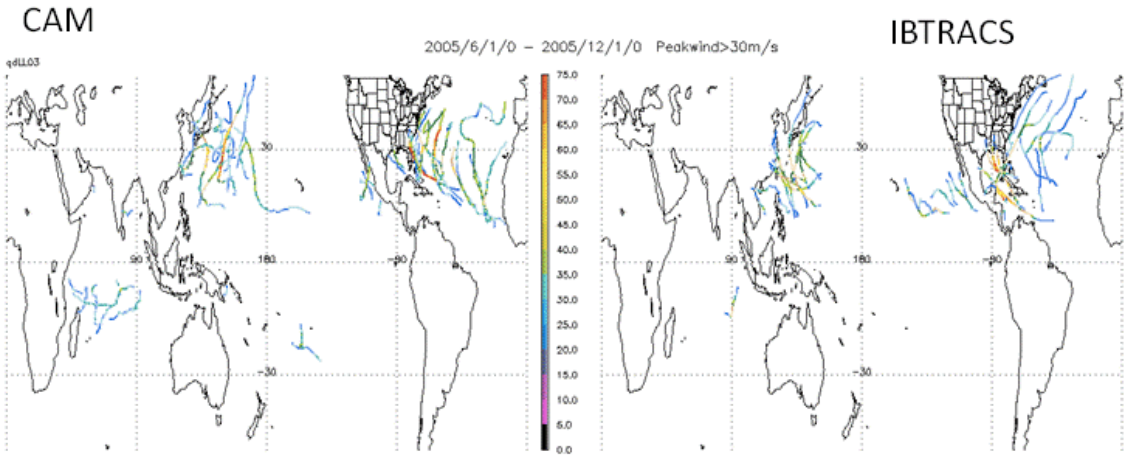

Figure 6: Simulation of the Atlantic tropical cyclone tracks for the 2005 season from quarter degree resolution of the Community Atmosphere Model version 5 (CAM5) on the left and International Best Track Archive for Climate Stewardship (IBTRACS).

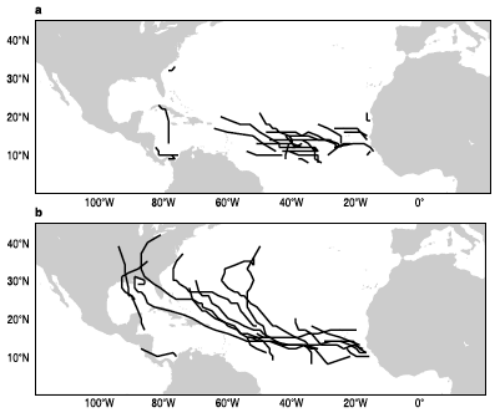

Figure 7: An example of an ensemble of trajectories of tropical cyclones for seasonal forecasts starting June 1, 2000 in a) a coarse (~200km) and b) a finer resolution (~100km) ECMWF seasonal forecast model. From Vitart et al. (2007).

The summer season is also well known for climate extremes like tropical cyclones, droughts, and floods. While there is moderate success in the seasonal prediction of tropical cyclone counts (Figs. 5a and b; Vitart et al. 2007; LaRow et al. 2009), the seasonal prediction skill of the tracks (Fig. 6), probability distribution of the intensity of the storm, and the region of cyclogenesis still remain as very strong challenges. For example Vitart et al. (2007) find that in the ECMWF seasonal forecast model, the simulated tracks are unrealistically short (Fig. 7a) and the strength of the tropical storms are weaker than observed values. They attribute this feature to the coarse resolution of the climate models. By raising the horizontal resolution from 200km to 100km of this model, they showed considerable improvement in the tracks of the Atlantic storms (Fig. 7b). Increasingly the

benefits of increasing the resolution of the model for seasonal and long-term prediction of tropical cyclones are being uniformly realized.

ii) Intraseasonal time scale

The Madden-Juilan oscillation (MJO), though centered in the Indo-Pacific sector, modulates conditions across the world in the western Atlantic. For example, Fig. 8 shows a May-Oct. TRMM rainfall composite of MJO phases from the CLIVAR MJO Working Group (CLIVAR 2009, figure from http://climate.snu.ac.kr/mjo_diagnostics/obs_level_2.htm)

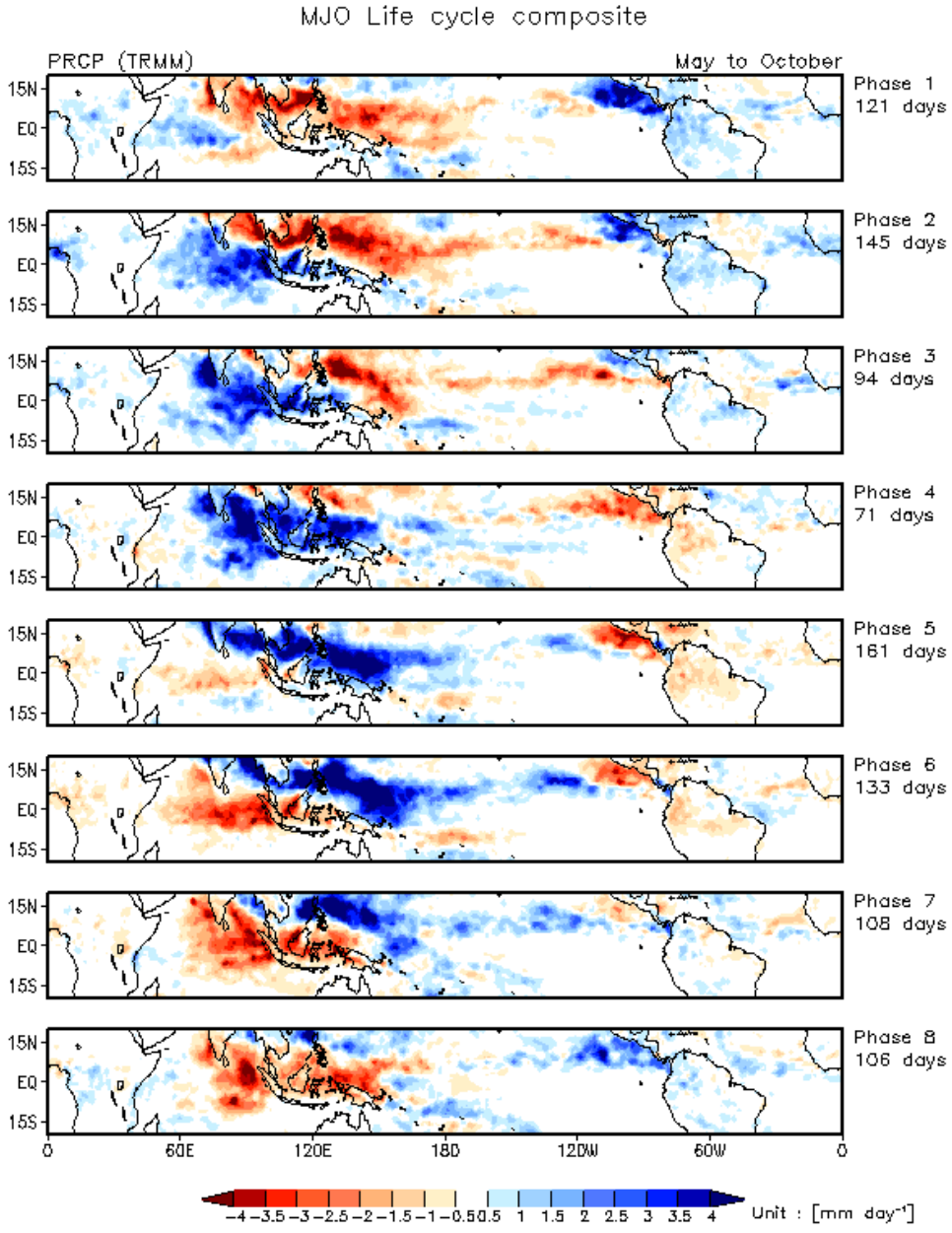

Figure 8: May-Oct. TRMM rainfall composite of MJO phases from the CLIVAR MJO Working Group (from http://climate.snu.ac.kr/mjo_diagnostics/obs_level_2.htm)

It seems clear that the Western Hemisphere participates in the global MJO, although it must be cautioned that the method for defining the MJO here (a global EOF analysis) may pull in weakly correlated variance.

iii) Decadal time scale

The AWP multidecadal variability coincides with the signal of the Atlantic Multi-decadal Oscillation (AMO); that is, the warm (cool) phases of the AMO are characterized by repeated large (small) AWPs. Since the climate response to the North Atlantic SST anomalies is primarily forced at the low latitudes, the well-known influence of the AMO on the U.S. drought and Atlantic hurricane activity may operate through the mechanism of the AWP-induced atmospheric changes (Wang et al. 2008b; Mo et al. 2009). Coupled numerical models consistently show that warm (cool) AMO phases occur in concert with increases (decreases) in the Atlantic Meridional Overturning Circulation (AMOC)

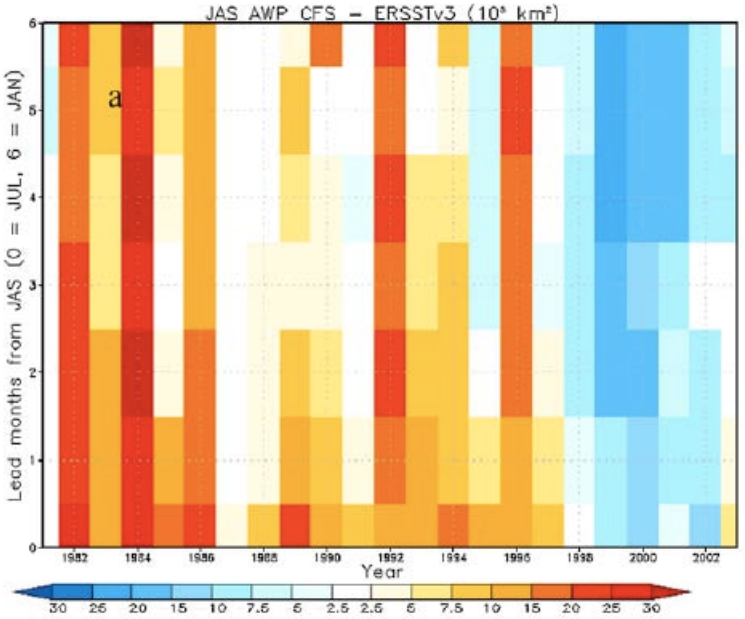

Figure 9: July-August-September (JAS) seasonal mean errors of the area of the AWP in the NCEP CFS seasonal hindcasts at zero month lead computed using ERSSTV3 (Smith et al. 2008). From Misra and Chan 2009).

(Delworth and Mann 2000; Knight et al. 2005; Latif et al. 2004). Given the apparent coherent relation among the AMOC, AMO and AWP, decadal climate predictability over North and Central Americas depends critically on predictability of the AMOC. The National Centers for Environmental Prediciton (NCEP) Climate Forecast System (CFS) seasonal hindcasts (Saha et al. 2006) show a distinct change in its magnitude of the seasonal prediction errors (Fig. 9) since 1997 when the AMO shifted from a negative to a positive phase. Misra and Chan (2009) suggest that ocean initialization in the NCEP CFS for lack of observations in the sub-surface ocean does not carry this information of the shift of phase in the AMO resulting in the decadal variation of the seasonal errors in the AWP.

iv) Climate change

Global climate model simulations forced by future greenhouse warming, project that the AWP SST will increase, but at a slower rate than the tropical Indo-Pacific SST in the 21st century as indicated in Fig. 10. This is consistent with projections of a weakened Atlantic thermohaline circulation. Lee et al. (2010) used a suite of atmospheric general circulation model experiments to illustrate that the preferential warming of the tropical Indo-Pacific induces a warming of the global tropical troposphere, via a fast tropical

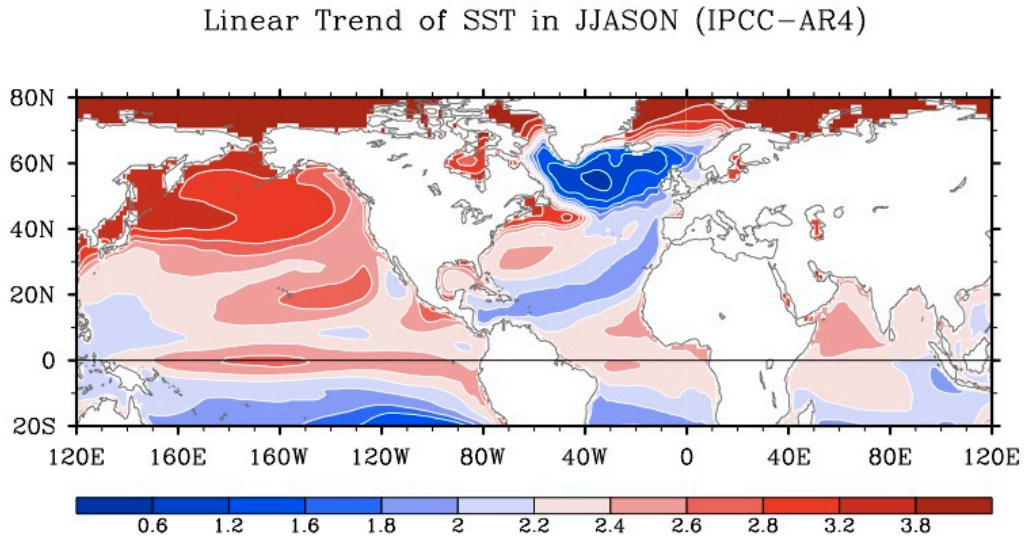

Figure 10: Linear trend of SST (in unit of ^{0}C per 100 years) in JJASON computed over the period of 2000-2100 from the ensemble average of 21 IPCC-AR4 climate simulations under SRESA1B scenario.

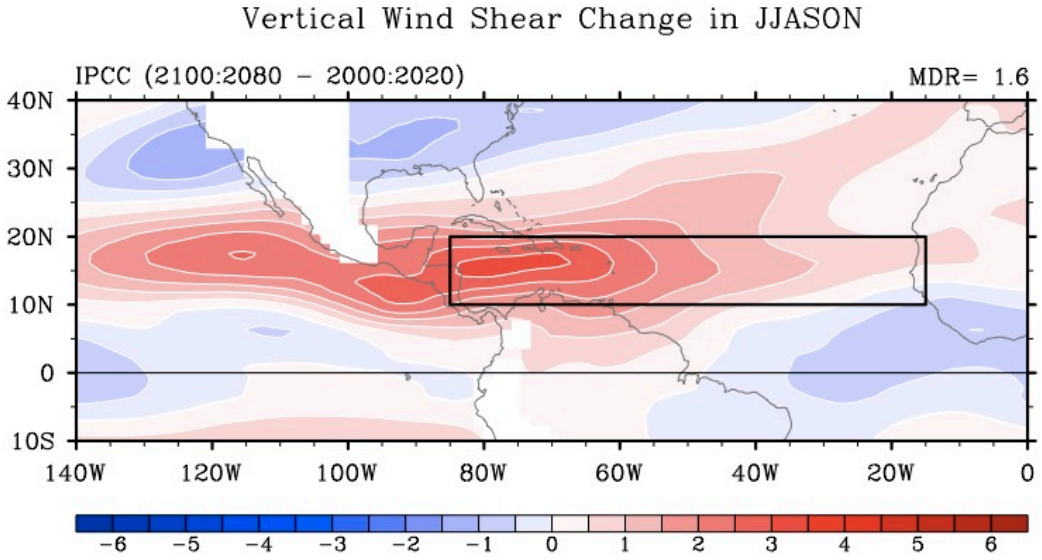

Figure 11: Vertical wind shear (200mb minus 850mb) difference in JJASON between 2080-2100 and 2000-2020 periods computed from the ensemble average of 11 IPCC-AR4 climate simulations under the SRESA1B scenario.

teleconnection mechanism. This increases atmospheric static stability and decreases convection over the suppressed warming region of the AWP. The anomalous diabatic-cooling, in turn, forces the formation of a stationary baroclinic Rossby wave northwest of the forcing region in such a way as to induce a secular increase of the maximum development region vertical wind shear (Fig. 11), and thus decrease overall Atlantic hurricane activity in the 21st century. Therefore, the threshold SST of 28.5^0C for defining the AWP may not be appropriate to measure the AWP's impact on changing climate. However as illustrated in Fig. 3, improving the fidelity of these climate projection models in their fidelity of the AWP remains a challenge.

3. Roadmap

The overarching objective of this effort is to realize an improved prediction at Seasonal to Interannual (SI) time scales through an improved understanding of the processes, teleconnections and feedbacks in the IASCLiP region. The success of this enterprise will significantly improve our capability of seasonal forecasting of tropical cyclones, droughts and floods in the region. Since IASCLiP is also co-incident with significant decadal variations and is susceptible to the potential influence of climate change from anthropogenic forcing, the SI modeling effort will also span across the longer time scales as well to be relevant in a changing global climate. The roadmap for the modeling implementation of the IASCLiP is classified into 5 different categories of model diagnostics, mechanistic studies, sensitivity studies, predictability studies and the IASCLiP forecast forum.

i) Model diagnostics

As a first step, a thorough diagnosis of the SST bias in the climate models over the IASCLiP region is warranted. It is not clear if the pathological SST bias in these models over the IASCLiP region is a result of similar pathology in the:

a) Low bias due to too-strong easterly winds bias resulting from stronger NASH that then results in stronger wind-induced surface evaporation. This could in turn result from interaction of the models' tropical North Atlantic cold bias with the known positive SST bias in the tropical South Atlantic.
b) A bias in the air-sea humidity difference that results in stronger evaporation.
c) Erroneous cloud radiative feedback leading to bias in surface radiative fluxes
d) Remote influence of erroneous east-west or local meridional circulation in the atmosphere
e) Erroneous ocean dynamical process including bias in ocean mixing, thermocline depth, salinity etc.
f) All of the above

These errors are coupled, not exclusive, as indicated by item f), so the ultimate source of model error needs to be conjectured at a higher level. One hypothesis centers around the idea that the WHWP's relatively clear skies (given how warm it is) are maintained by dynamical influences which keep the mid-tropospheric humidity too low

for widespread deep convection. Convection schemes in global models tend to lack sensitivity to midlevel dry air (Derbyshire et al. 2004), so they may produce excessive clouds and perhaps wind gusts and downdrafts, leading to cool SST biases in a coupled model setting. Other hypotheses might center on ocean mixing biases, land-based biases, etc. A diagnosis of regional biases in multiple models might already cast light on the hypotheses, provide some clarity, and define metrics and targets to try to improve upon. Systematic model experimentation will ultimately be needed, and changes to major physics will have global (not just regional) effects, so IASCLiP global modeling work must be viewed as an aspect of broader global efforts. Still, the IASCLiP region appears to offer both important impacts to motivate such work, and especially critical tests of challenging aspects of model physics, and thus serves as an ideal testbed for model work.

ii) Mechanistic studies

Air-sea coupling: Component models of coupled GCM's have to be separately forced and compared with fully coupled ocean-atmosphere version of the model to understand the role of air-sea coupling to the simulated WHWP bias. Careful model experiments have to be designed so that logical conclusions can be deduced from these experiments. It is necessary that in such design of experiments, care are taken to only include the component models that come from the same climate model to isolate the role of air-sea coupling.

Land cover and albedo changes: Changes in the land cover in the surrounding continental regions have to be assessed in coupled climate models to understand their influence on the atmospheric circulations and their potential influence on SST in the AWP region. These kind of mechanistic studies become quite relevant in the context of widespread land cover changes in the Amazon (Skole and Tucker 1993) and may be relevant to a bias in the Amazon convection that occurs in many models and which in turn affects the tropical South Atlantic SST.

Fresh water discharge: Fresh water discharge from some of the major rivers in the region like the Orinoco, Amazon, Mississippi can change the salinity profile and cause barrier layer formation. There is some preliminary evidence that the barrier layer formation in the AWP is sensitive to the river discharge from Orinoco and Amazon rivers (e.g. Vizy and Cook 2010). The formation of the barrier layer and its variability can have potential impact on the air-sea interaction and the consequent atmospheric response. Experiments using OGCM's, regional ocean models for the region, coupled GCM's can be designed to understand the barrier layer formation and their impacts on air-sea interaction.

iii) Sensitivity studies

Resolution experiments: The potential influence of the Amazon convection both from forcing the atmospheric wind field and also through the fresh water discharge into the oceans, raises an important possibility of modulating the WHWP simulation by changing horizontal and even vertical resolutions. These resolution changes to the atmospheric model would imply changes to the steep orography of the Andes and therefore, e.g. changes in the convection associated with an altered South American Low Level Jet and the moisture it imports from the Atlantic. By reducing the entrainment parameter in the

convection scheme, Zhao et al. (2010) showed from their AGCM simulations, that the dry bias over the Amazon region can be reduced significantly. Similar reductions in the dry bias were also seen when substantial increases in horizontal resolution of the AGCM was made. An increase in convection should decrease the positive SST bias in the tropical South Atlantic and perhaps as a result, the negative SST bias in the North Atlantic. Therefore, what implications would these resolution changes have on the WHWP will be of great interest. Likewise high resolution modeling experiments have helped in discerning the impact of climate change on tropical cyclone variability in the Atlantic (Knutson et al. 2010). Knutson et al. (2010) show that the likelihood of the overall number of tropical cyclones may decrease, the frequency of the most intense categories of hurricanes may increase in a warm world at the end of this century. These results are needed to be further vetted with higher resolution and improved models. Furthermore, given that IAS SST anomalies carry interannual, decadal and climate change signals, its relationship with the Atlantic tropical cyclone activity can be further dissected. For example, Wang and Lee (2010) show that the out of phase relationship in the hurricane activity between the tropical Atlantic and eastern north Pacific was related to the atmospheric vertical shear anomalies in the two ocean basins forced by the IAS SST anomalies.

Inter-basin relationship: The WHWP extends both in the tropical northeastern Pacific and in the Atlantic Ocean. In addition both of these ocean basin components of the WHWP have a distinct seasonal cycle with the northeastern Pacific component peaking in SST around June while the Atlantic component peaking around September. There is a notion that interannual variations in the northeastern Pacific component can lead to modulations in the interannual variations in the AWP as can variations in the South Atlantic SST. These connections can be verified in POGA, AOGA, and GOGA type modeling experiments (Goddard and Graham, 1999), but with coupled GCM's.

iv) Predictability studies

Diagnosing potential predictability: Co-ordinated seasonal reforecast experiments conducted separately with multiple AGCM's forced with observed SST, OGCM's forced with observed atmospheric fluxes for the boreal summer and fall seasons may be designed to compare the potential seasonal predictability of the atmospheric and oceanic response for anomalous AWP years from other years. These experiments can be complimented with coupled ocean-atmosphere models to understand the role of feedbacks in the seasonal predictability. Carefully crafted seasonal predictability experiments in different phases of AMO/PDO can also help in understanding the decadal modulation of the seasonal predictability.

Observed System Simulation Experiment (OSSE): These OSSE's would specifically be designed to test the importance of the sub-surface ocean observations of temperature, currents, and possibly salinity in the AWP region to seasonal to interannual prediction problem. As indicated in Fig. 3, the observational coverage of the oceans in the AWP region is scarce and comparable to the coverage over the polar oceans.

Downscaling: There are many sovereign countries in the general area of the WHWP. Some of these countries are extremely small to resolve many of our current GCM's. The

local implication of the large-scale circulation changes and SST over these small island countries is not very well known. From a dynamic downscaling study over the Caribbean region, Chan et al. (2010) indicate that majority of the islands in the Lesser Antilles undergo a modulation of the local diurnal cycle from AWP variations. High resolution dynamic downscaling also appears to reduce the dry bias in the global reanalyses over the Lesser Antilles region (Chan et al. 2010). Vizy and Cook (2010) using a regional atmospheric model were able to show the impact of the fresh water discharge from Amazon and Orinoco rivers on the Atlantic tropical cyclone activity.

v) IASCLiP forecast forum

The intent of this forecast forum is to gather available global and regional (over the Americas and Intra-Americas Seas) boreal summer and autumn seasonal prediction integrations to provide

i) Seasonal outlook of Atlantic tropical cyclone activity (Metric: Accumulated cyclone energy, number; vertical wind shear anomaly in the MDR region, start of the TC season)
ii) Size of the Western Hemisphere Warm Pool (WHWP), Atlantic warm pool (AWP), and the East Pacific Warm Pool (EPWP), which will have implication on the strength of the trades, Atlantic tropical cyclone activity, LLJ strengths and Great Plains region seasonal precipitation anomaly in Jun-Jul-Aug (Metric: Area of the 28.5C isotherm)
iii) Ocean heat content anomalies of the Western Hemisphere Warm Pool (WHWP)
iv) The start, strength and duration of mid-summer drought
v) Anticipated transition from South American to North American Monsoon (Metric: Monitor/predict indices of the respective monsoons)
vi) Timing of transition from south American to north American monsoons
vii) Intra-seasonal tropical cyclone activity in the east Pacific and western Atlantic Oceans (Metric:
viii) The strength of the Caribbean Low Level Jet (CLLJ) and the Great Plains Low Level Jet
ix) Seasonal precipitation anomaly over central America, mid-western and southwestern United States (Metric: anomaly defined on seasonal reforecast climatology)

However, these objectives will be further modified and expanded as we gain experience with the models and interact with the stakeholder base of this forum.

It is anticipated that the concerted effort in implementing this plan will lead to refinement in our understanding and eventual improvement in the forecast skill at seasonal to interannual time scales over the IASCLiP region. This effort will also pave a way to develop a mutually gainful relationship with the Met offices in several of the small sovereign countries in the IASCLiP region who in all likelihood will provide routine operational maintenance of the observational instrumentation placed in their countries as part of the IASCLiP monitoring program.

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