Comment on "Impact of Shifting Patterns of Pacific Ocean Warming on North Atlantic Tropical Cyclones"

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ABSTRACT

Kim et al. (Reports, 3 July 2009, p.77) claim that central Pacific warming events in 1969, 1991, 1994, 2002 and 2004 are associated with greater-than-average cyclone activity along the Gulf of Mexico coast and Central America. Here we show that only 1969 has significantly greater-than-average activity, which is likely due to the presence of a very large Atlantic warmpool in that year.

The so-called central Pacific warming (CPW) phenomenon has received some attentions in recent years (*1-4*). Since the CPW tends to occur more frequently since the 1990s, it has been claimed to be associated with anthropogenic global warming (*4*). It is well known that the canonical eastern Pacific warming (EPW) pattern associated with El Niño can suppress Atlantic cyclone activity (*5*). A recent study by Kim et al. (KWC09) (*6*) claimed that, in contrast to the EPW events, the CPW episodes are associated with an increased frequency and landfall potential along the Gulf of Mexico coast and Central America.

KWC09 used a criterion of detrended Niño4 warming exceeding 1 standard deviation to identify five CPW events in 1969, 1991, 1994, 2002 and 2004. Their conclusion is based on the five-year average of tropical storm data. Table 1 shows detrended hurricane indices for the five individual years. The last column is the number of tropical storms that either form inside or move into the Gulf of Mexico and Caribbean Sea. This is referred to as Intra Americas Sea (IAS) cyclone activity hereafter. Also included in this table are the detrended Niño4 and the size of Atlantic warm pool (AWP), which is defined as the tropical Atlantic sea surface area of its temperature exceeding 28.5^{o}C (*8*), both averaged for the Atlantic hurricane season of June to November.

All of the five hurricane indices, including IAS cyclone activity, indicate that Atlantic cyclone activity is either below average or neutral in 1991 and 1994. In both 2002 and 2004, the number of cyclones formed in or moved into the IAS is 6.7, which is slightly greater than the 57-year (1950-2006) mean of 5.8. However, the difference is statistically insignificant at 99% confidence (*9*). Therefore, among the five CPW years, 1969 was the only year of significantly greater-than-average cyclone activity in the IAS.

To have a better perspective of the potential relationship between the CPW events and IAS cyclone activity, it is useful to examine other cyclone indices. According to the tropical storm index, for instance, only 1969 and 2004 can be characterized with a greater-than-average frequency of tropical storm, whereas 1991, 1994 and 2002 have either a neutral or a lesser-than-average frequency. The number of hurricanes, the number of major hurricanes, and the accumulated cyclone energy (ACE) index also show the same result. The five-year averaged tropical storm index is slightly above the climatological mean mainly because of 1969 and 2004, which were quite active years. It is immediately noticed that the AWP is significantly larger than average in both 1969 and 2004, whereas it is smaller than average in 1991, 1994 and 2002 (*8*). Earlier studies have shown that local sea surface temperature (SST) in the tropical North Atlantic can greatly influence the cyclone activity (*8*, *10*). Therefore, it is quite logical to presume that the spread of tropical storm frequency among the five CPW years can be readily explained by the local SST index of the AWP without invoking a remote influence from the tropical Pacific.

The presence of a very large AWP in 1969 and 2004 makes it difficult to attribute the increased cyclone frequency to the CPW events. Therefore, in an effort to isolate the remote influence of the 1969 and 2004 CWP events from the local SST effect, we perform multiple sets of ensemble model experiments using the NCAR atmospheric general circulation model coupled to a slab mixed layer ocean model (*11*). The model experiments are performed by prescribing the evolutions of SSTs only in the tropical Pacific (15^{o}S-15^{o}N; 120^{o}E–coast of the Americas) for 1969 and 2004, and for a typical EPW year of 1987, while predicting the SSTs outside of the tropical Pacific using the slab ocean model. The detailed methodology is described in (*11*).

Figure 1 shows the simulated vertical wind shear change for the 1969, 1987 and 2004 cases. The simulated vertical wind shear for the 1987 EPW case is greatly increased over the main development region for hurricane (MDR), suggesting that the 1987 EPW event is responsible for significantly reduced cyclone activity in that year: the detrended tropical storm index for 1987 is 6.3, which is significantly less than the climatological mean of 10.7. However, the simulated MDR vertical wind shear for the 1969 CPW event is nearly unchanged from the climatology, and thus indicates that the 1969 CPW event is not responsible for increased cyclone activity in 1969. The 2004 CPW case is quite interesting because the MDR vertical wind shear is increased as much as in the 1987 EPW case. The simulated vertical wind shear response in the 1969 and 2004 cases suggests that it could be misleading to generalize the remote influence of the CPW events on Atlantic cyclone activity.

In summary, our independent data analysis of tropical cyclone activity in the five CPW years and the modeling experiments suggest that KWC09 may be falsely associating CPW events to an increased frequency of cyclone activity in the Gulf of Mexico and Caribbean Sea. Nevertheless, we still cannot disregard KWC09's claim that the CWP events can influence Atlantic hurricane activity. Here, we simply point out that such a claim must be supported by a much longer time series data (or many more cases of CPW event), with the effect of tropical North Atlantic SST removed, to achieve a statistically significant result.

References and Notes

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Table 1. Detrended hurricane indices for the five CPW years (1969, 1991, 1994, 2002 and 2004), the five-year mean and the climatological mean for 1950 - 2006 period. The 4th, 5th and 6th columns represent the number of tropical storm, hurricane and major hurricane (categories 3 - 5). The 7th column is the accumulated cyclone energy (ACE). The 8th column is US landfalling hurricanes. The last column is the number of tropical storms that either form inside or move into the Gulf of Mexico and Caribbean Sea. This is referred to as Intra Americas Sea (IAS) cyclone activity. The Gulf of Mexico is represented as the box region of 100^{o}W - 80^{o}W and 20^{o}N - 30^{o}N, while the Caribbean Sea is represented as the box region of 90^{o}W - 60^{o}W and 10^{o}N - 20^{o}N. Also included in this table are the detrended Niño4 and the size of Atlantic warm pool (AWP), both averaged for the Atlantic hurricane season of June to November. To construct this table, the hurricane reanalysis database of HURDAT for the period of 1950 - 2006 (http://www.aoml.noaa.gov/hrd/darta_sub/reanalysis.html) and the improved extended reconstructed SST data (*7*) for 1950-2006 are used. All data values are detrended. Any value higher (lower) than the climatological mean with above the 99% significance is in bold (italic).

Year	Niño4	AWP	TS	HR	MH	ACE	USL	IAS
1969	**0.62**	**68.9**	**18.7**	**12.1**	**4.9**	**159.3**	2.1	**10.1**
1991	**0.59**	*-33.8*	*7.0*	*3.8*	2.1	*32.2*	*0.9*	*1.8*
1994	**0.70**	*-54.6*	*5.8*	*2.8*	*0.2*	*29.8*	*0.0*	*3.8*
2002	**0.69**	-7.0	10.1	*3.6*	2.2	*62.7*	*0.8*	6.7
2004	**0.51**	**51.3**	**13.0**	**8.6**	**6.3**	**220.4**	**5.8**	6.7
CPW mean	-	-	10.9	6.2	3.1	100.9	1.9	5.8
Climatology	-	-	10.7	6.2	2.7	101.9	1.6	5.8

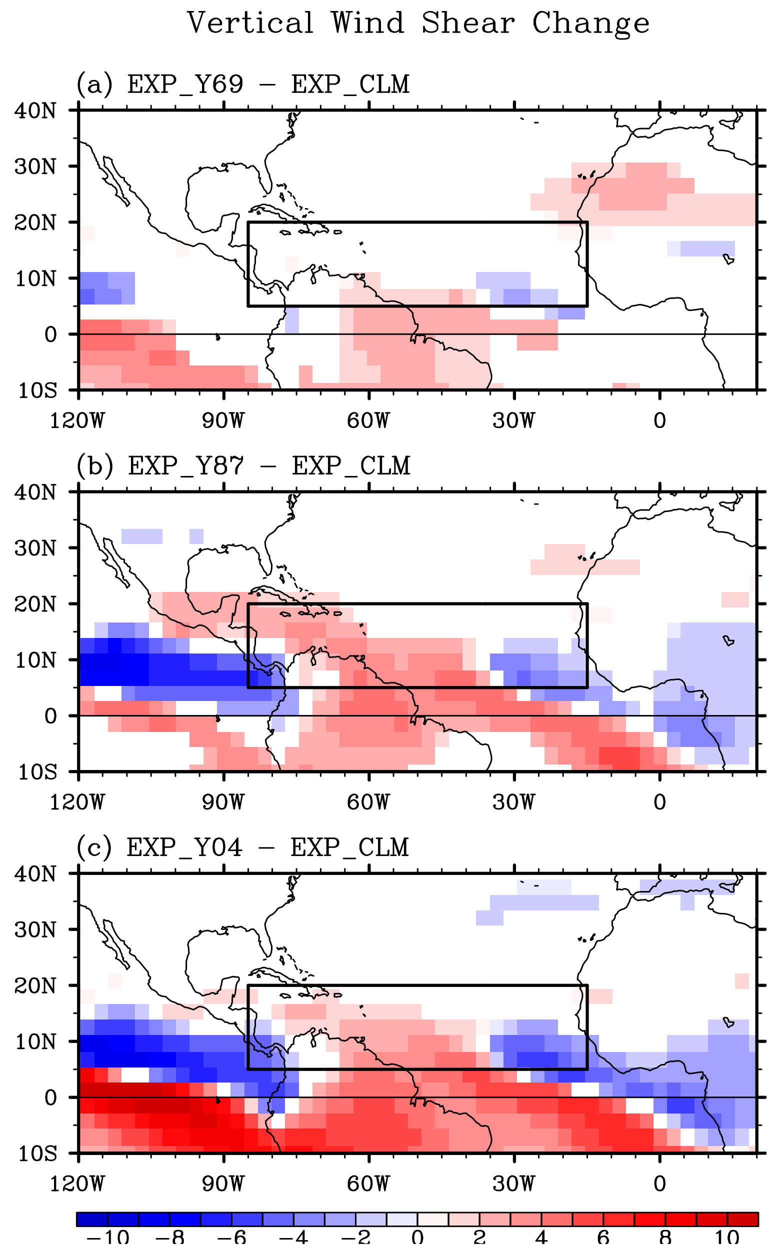

Figure 1. Tropospheric vertical wind shear (200mb minus 850mb) difference (ms^{-1}) in June-November between (a) EXP_Y69 and EXP_CLM, between (b) EXP_Y87 and EXP_CLM, and between (c) EXP_Y04 and EXP_CLIM. For EXP_Y69, EXP_Y87, EXP_Y04 and EXP_CLM, the SSTs in the tropical Pacific region (15^{o}S-15^{o}N; 120^{o}E–coast of the Americas) are prescribed with those of 1969, 1987, 2004 and climatology, respectively, while predicting the SSTs outside of the tropical Pacific using the slab ocean model. Each experiment consists of ten model

integrations that are initialized with slightly different conditions to represent internal atmospheric variability. The shading denotes a statistical confidence at the 95% or above based on a student-t test.