MRNatCat*POSTER*51 for EWC III

Multidecadal climate oscillation in the North Atlantic as predictor for long-term hurricane risk

Storm surge effects of Hurricane Katrina

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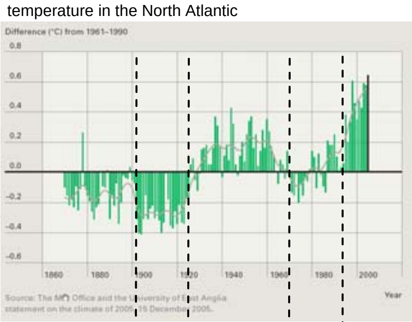
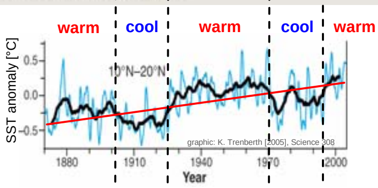
The 2004 hurricane season with four landfalls in and around Florida and the highest cyclone-related loss ever for the insurance industry already raised the question whether or not the hurricane risk in the North Atlantic changed systematically in comparison with the situation 10 – 15 years ago. The 2005 season, with even higher insured and economic losses, has given this question added urgency. If put together all insured hurricane market losses of the years 2004 and 2005 which occured on the coastlines at the western edges of the North Atlantic (United States, Caribbean, Mexico) sum up to **approx. US$ 115 bn**. Hurricane Katrina alone brought about insured market losses of **approx. US$ 60 bn** and more than double in terms of economic losses. Recent findings of climate research confirm the principal change in the hazard situation in a way that people at the western edges of the North Atlantic should be aware of a continuation of the high risk level for many years.

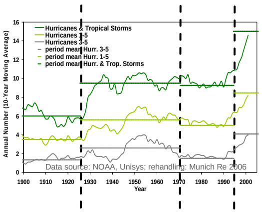
Annual average sea surface temperature in the North Atlantic



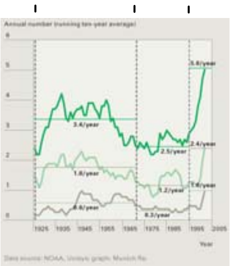


Annual average sea surface temperature in the tropical North Atlantic (excluding the Carribean west of 80°W) –
Anomalies (°C) relative to 1961 to 1990

Annual number of tropical cyclones formed in the North Atlantic and annual means over climatic phases



Annual number of tropical cyclone US landfalls and annual means over climatic phases



There are alternating phases each lasting for several decades with exceptionally warm or exceptionally cool sea surface temperatures in the North Atlantic (*upper graphic on left-hand side*) and especially in the tropical part of the North Atlantic (*second graphic on left-hand side*). In these tropical regions most of the tropical cyclones develop („main development region" MDR). After removal of the trend the margin of deviation is about 0.5°C.

This natural climatic fluctuation is most probably driven by the ocean's large-scale thermohaline circulation (THC). By this super-dimensional water conveyor belt in the ocean – the so-called meridional overturning – warm, saline water from the tropical North Atlantic, the Caribbean, and the Gulf of Mexico is transported by the Gulf Stream and the North Atlantic Current in the upper sea layers towards the north and the east. Having discharged its heat to the atmosphere the water, which is very dense due to ist salt concentration, sinks to the depths in parts of the Labrador Sea and off the coasts of Europe between Greenland and Scotland.The churning process is completed by a current flowing south in deeper layers.

The greater the churning effect of the THC, which crosses the equator in the south, the more heat is transported from the tropical latitudes into northern latitudes, meaning that sea surface temperatures rise in the North Atlantic and a warm phase is approaching. Climate model simulations conducted at the Hadley Centre show that a large-scale oscillation involving the evaporation rates and hence salinity in the subtropical and tropical North Atlantic, the position of the Intertropical Convergence Zone (ITCZ) which regionally counteract salinity by convective rainfalls and the impacts of these variables on the strength of the THC makes up the alteration of the multidecadal climatic phases in the North Atlantic.

Warm phases produce a distinct increase in hurricane frequency and also more intense storms, whereas cold phases have the opposite effect. Hence in the current warm phase since the mid-1990s, for example, 4.1 major hurricanes have already occured on average per year while in the previous cold phase from 1971 to 1994 this figure only was 1.5 (major hurricanes correspond to Saffir-Simpson categories 4 – 5) . This means an increase by about 170% (*third graphic on left-hand side, grey curve*).

At the same time, the natural fluctuation between these cold and warm phases seems to be intensified by a superimposed long-term warming process, so that sea surface temperature and the level of hurricane activity increase from warm phase to subsequent warm phase and form cold phase to subsequent cold phase. The increase in the number of major hurricanes per year from 2.6 to 4.1 from the previous warm phase (mid-1920s to 1970) to the current warm phase since the mid-1990s means an increase by about 60% (*third graphic on left-hand side*). There are strong arguments in favour of climate change as the long-term warming agent (Barnett et al. [2005], Science 309; Tourre and White [2006], GRL). The current unusually high level of activity is most probably due to the warm phase prevailing since the mid-1990s, which is supposed to continue for several years, if not decades, and is also intensified by the long-term process of anthropogenic global warming.

The climatic oscillation determines also landfalls and subsequent damages. With regard to major hurricanes the mean annual landfall frequency increased since the last cold phase (approx. 1971 – 1994) by about 230%, since the foregoing warm phase (approx. 1926 – 1970) by about 70% (*lowest graphic on left-hand side, grey curve*). Insurance-related analyses showed that annual aggregate losses increased in similar ways, if normalized by developments in wealth, population and inflation, however (not shown).

So as a consequence an understanding of multidecadal climate oscillations in the North Atlantic fosters long-term understanding and preparedness for the hurricane risk at the western edges of the North Atlantic including the coastlines of the Gulf of Mexico and throughout the Carribean. Judged from the fact that the periodicity of the respective oscillation was found to be about 65 years in the 20th century we have to expect another 10 or more years with the potential of high tropical cyclone risk in this region.

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Further Reading

Munich Re [2006], Hurricanes – More intense, more frequent, more expensive. Insurance in a time of changing risks

Knight, J.R. et al. [2005], A signature of persistent natural thermohaline circulation cycles in observed climate, GRL 32

Vellinga, M./Wu, P. [2004], Low-latitude freshwater influence on centennial variability of the atlantic thermohaline circulation, J. Clim. 17.

Webster, P. J. et al. [2005], Changes in tropical cyclone number, duration and intensity in a warming environment, Science 309.

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