

Hurricanes and Climate Change

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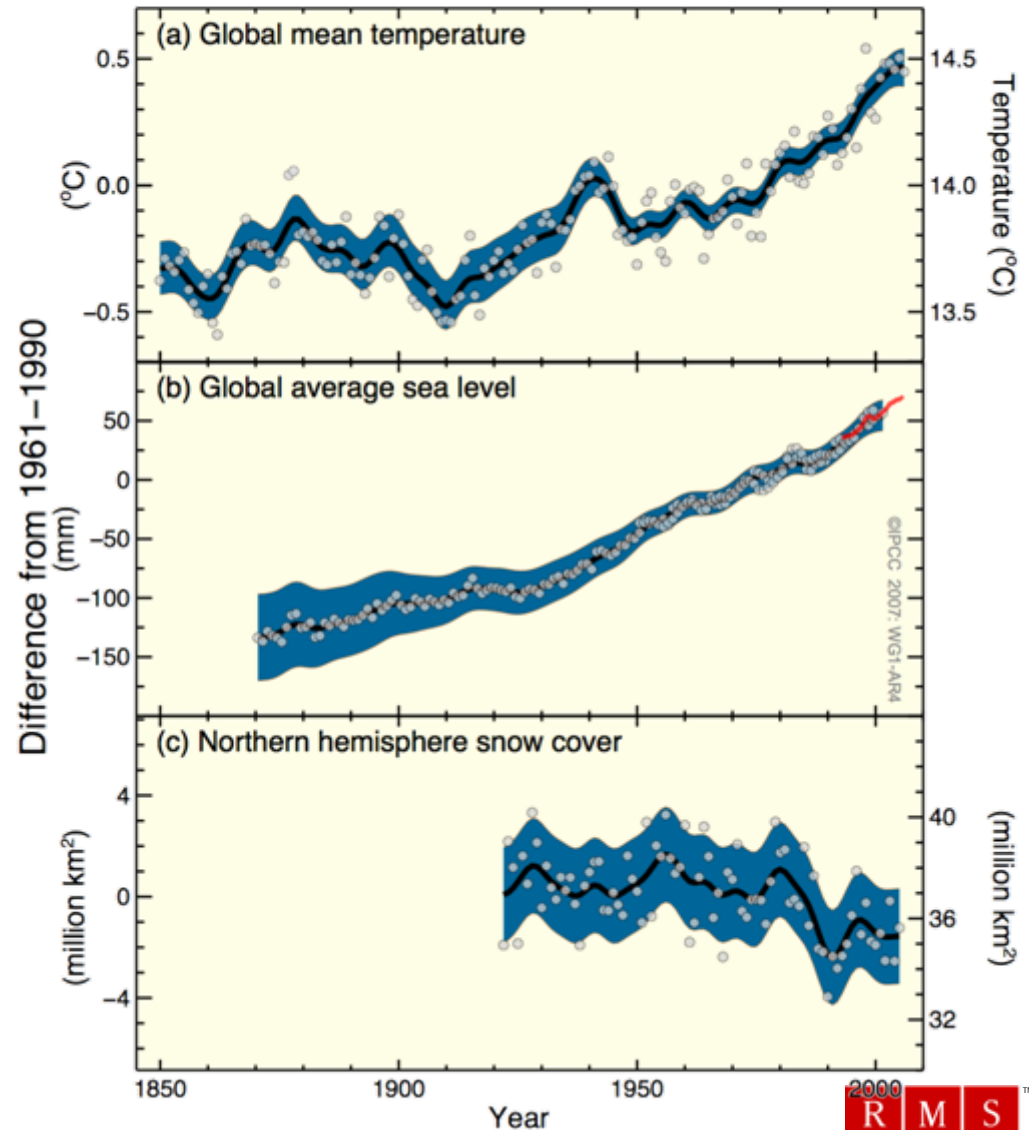
Agenda

- The scientific evidence for climate change
- Implications of the change in climate on the occurrence and intensity of Atlantic hurricanes
- Significance of climate change for insurance rating

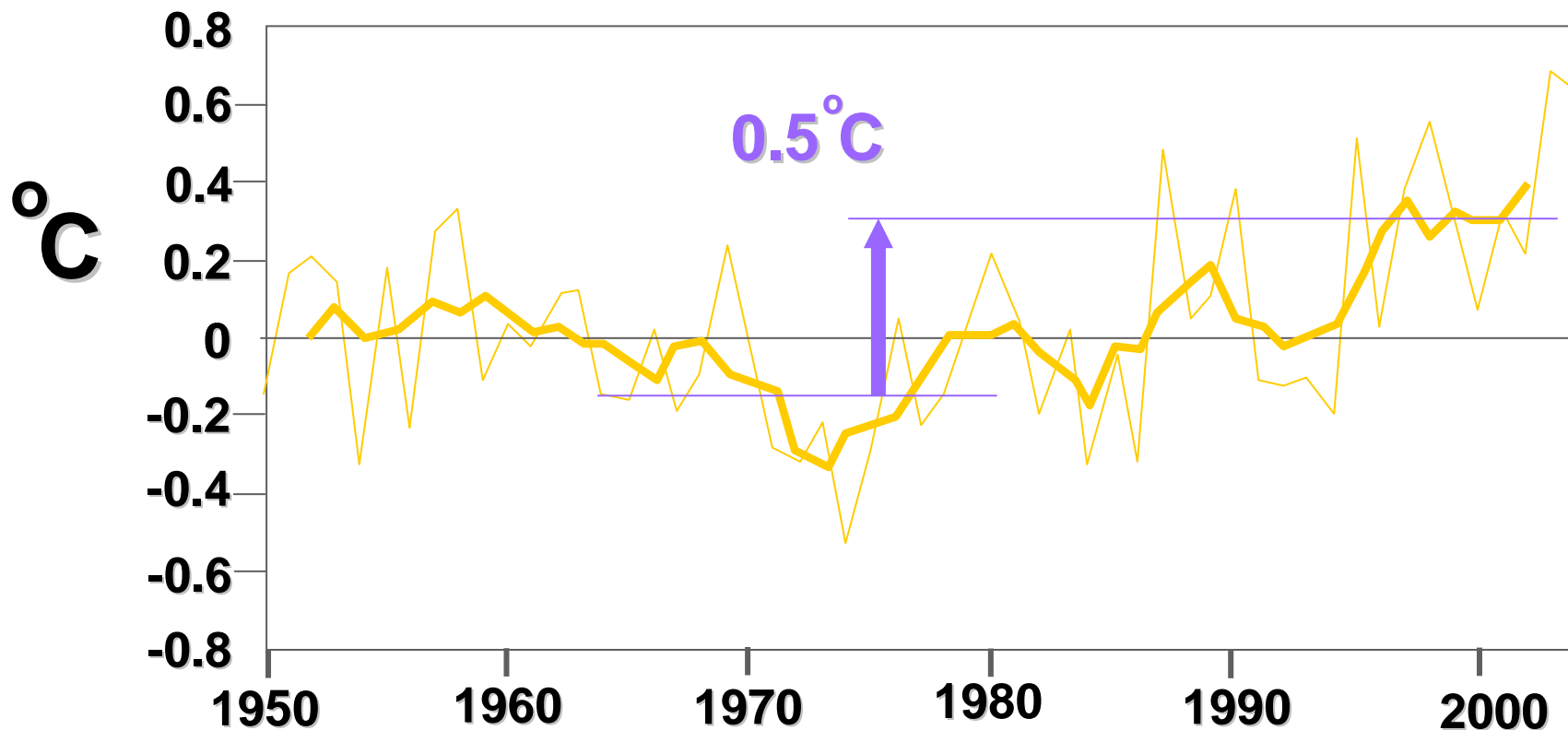
The current state of evidence on Climate Change: IPCC 2007

- Global warming is 'unequivocal' on land, ocean.
- Broad system change: sea level rise, snow cover, water vapor, atmospheric circulation, glaciers.
- "Very unlikely due to known natural causes alone..." likely due to observed increase man-made greenhouse gases.

Changes in Temperature, Sea Level and Northern Hemisphere Snow Cover



Tropical Atlantic Sea Surface Temperature Departures (C) During Aug-Oct (1951-2000 Base Line)



IPCC extremes v Cat Modeling extremes

- If the climate is changing, then so is the occurrence of catastrophic events driven by that climate.
 - climate-related cat risk is 'dynamic' and complex
- The question is – what is the nature of the change and can it be demonstrated?
- Climate change is already underway – and the change relative to the pre-1970 period is increasing year by year.

Factors contributing to TC genesis

- Landsea (1999) lists 6 necessary (but not sufficient) conditions for TC genesis:
 - Warm sea surface;
 - Atmospheric instability;
 - A moist mid-troposphere;
 - Sufficient planetary vorticity;
 - Pre-existing environmental vorticity/convergence;
 - Low values of shear.
- All but the planetary vorticity can be significantly impacted by changes in the climate, and therefore genesis and genesis patterns are likely to see an impact.

UN IPCC Report (February 2007)

- Regarding tropical cyclone activity - as SSTs warm, the water vapor in the lower atmosphere increases, and so does the moist static energy fueling convection.
- As storms form over water exceeding 26°C, the regions of formation may change as warmer SSTs cover greater regions.
- However - many other processes affect storm formation and development, including the phase of ENSO, for example.
- Whether the thermodynamic environment becomes more favorable depends on changes in the large-scale circulation, which have significant uncertainty attached to them.

Potential impacts of climate change on Atlantic hurricanes

- The question is not whether Climate Change will effect Atlantic hurricanes but what is the magnitude of the effect?
- Key climatological factors such as SSTs and wind shear that determine the life cycle of Atlantic hurricanes are known to be impacted by climate change.
- Therefore hurricane formation, intensification and predominant tracks can all be expected to change.
- Strong evidence that there have already been significant increases in intensity and frequency in the Atlantic – attributed by several researchers to climate change.
- Explanation of larger signature in Atlantic – that this is a relatively cool basin marginal to tropical cyclone formation.
- Modeling studies suggest increases in intensity can be expected and some also suggest increases in frequency.
 - Increases in shear may influence formation and intensification.

Recent published studies

- A number of studies attempting to expand tropical cyclone records by using activity proxy (Frappier et al., 2007; Donnelly and Woodruff, 2007; Nyberg et al., 2007).
- Those studies usually observe variability in landfall records over periods of decades to century.
 - Frappier (2007): “to the extent that TCs are a manifestation of shifting climatic changes, the spectrum of recurrence interval risk is non-stationary”
- Holland and Webster (2007): The Atlantic activity has responded with significant step-like increases to changes in the climate of the 20th century.
 - The last change has occurred in 1995, and we may not have reached a stable level yet.
- Vecchi and Soden 2007: For long term predictions, IPCC AR4 climate models show increased vertical windshear in the tropical North Atlantic basin over the 21st Century that may offset the tendency for increased hurricane activity in the tropical Atlantic due to warming SSTs. However, results looked mixed, and rely on predictions of mean changes in the Walker circulation - a feature currently not robustly simulated by climate models, unlike future tropical Atlantic SSTs.

RMS position – modeling US risk over a five-year forward looking time window

- Even without the theory and forecasts of global warming, based on what has been observed empirically RMS would be employing a dynamic medium term perspective on hurricane activities
- The strength of the accumulating evidence for climate change in the Atlantic hurricane basin means that it is now inappropriate to employ a long term historical perspective for determining hurricane activities for insurance rate making
- RMS has committed significant research to exploring how climate change can be expected to change future hurricane activities
 - However annual revisit of medium term activities is principally driven by empirical evidence to date rather than climate models

Summary

- The science around the expected impact of climate change on hurricanes is rapidly changing.
- All published theories point to the fact that activity changes with time, and that current activity in the Atlantic basin is higher than the long term average.
- Different theories for the drivers of the post 1995 period of higher activity predict similar levels of activity for the next 5 years.
- However if climate change is the principal driver of the changes in Atlantic activity already seen, then for the foreseeable future we will not return to the conditions that prevailed in the first half of the 20th Century.
- In a time of change it becomes more difficult to define what is the mean and the uncertainty around the mean increases.
 - Emphasizes the need to explore all available evidence and forecasting models in an expert elicitation

Significance of climate change for insurance rating

- Climate Change means that one cannot assume 'a priori' that the occurrence of weather extremes today is the same as the occurrence of extremes in history
- Many regions and perils worldwide where there is clear evidence that the occurrence of extremes has already changed
 - Other areas and perils where it can be suspected that extremes may have changed – but insufficient data to prove the case
- Changes can include shifts in intensity, frequency and geography
- Change in Atlantic Hurricane activity impacts Florida