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Press Release

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GULF STREAM LEAVES ITS SIGNATURE 7 MILES HIGH

Honolulu, HI –The Gulf Stream's impact on climate is well known, keeping Iceland and Scotland comfortable in winter compared to the deep-freeze of Labrador at the same latitude. That cyclones tend to spawn over the Gulf Stream has also been known for some time. A new study reveals that the Gulf Stream anchors a precipitation band with upward motions and cloud formations that can reach 7 miles high and penetrate the upper troposphere. The discovery, announced by a Japan–US team of scientists, shows that the Gulf Stream has a pathway by which to directly affect weather and climate patterns over the whole Northern Hemisphere, and perhaps even world wide. The study is published in the March 13 issue of *Nature* as the cover article.

"Our findings gain even more significance by the fact that the Gulf Stream is the upper limb of the Atlantic portion of the ocean conveyor belt that drives the global ocean circulation," says co-author Shang-Ping Xie, a research team leader at the International Pacific Research Center and professor of meteorology at the University of Hawai'i at Mānoa. "The conveyor belt is predicted to slow down with global warming, which implies that changes in the Gulf Stream will modulate spatial patterns of future climate change."

Xie has been curious for some time about the response of the atmosphere to warm currents flowing within cold ocean water, such as the Gulf Stream or its Pacific counterpart, the Kuroshio. Xie says, "It has been a challenging task to isolate the climatic influence of the Gulf Stream from energetic weather variations by using conventional observations, which are spatially and temporally sporadic. Our findings were only possible because of the availability of high-resolution satellite data, an operational weather analysis, and an atmospheric circulation model."

The first hint that these warm ocean currents have a significant effect on the atmosphere came from high-resolution NASA satellite data. These images show a narrow rain band hovering frequently over the warm flank of the currents; wind accelerates and converges over the warm flank and diverges and decelerates on the cold flank.

The satellite images, however, do not allow accurate measurements of upward motions and divergence of air in the upper troposphere, which are necessary to understand the link between the current and large-scale climate. This is where the European Center for Medium-Range Weather Forecasts (ECMWF) analysis provided the missing data. "It is remarkable to see how the diverging winds 7 miles high show a structure similar to the converging winds and the rain clouds, all meandering with the Gulf Stream," says lead author Shoshiro Minobe, a professor at the Division of Earth and Planetary Sciences at Hokkaido University.

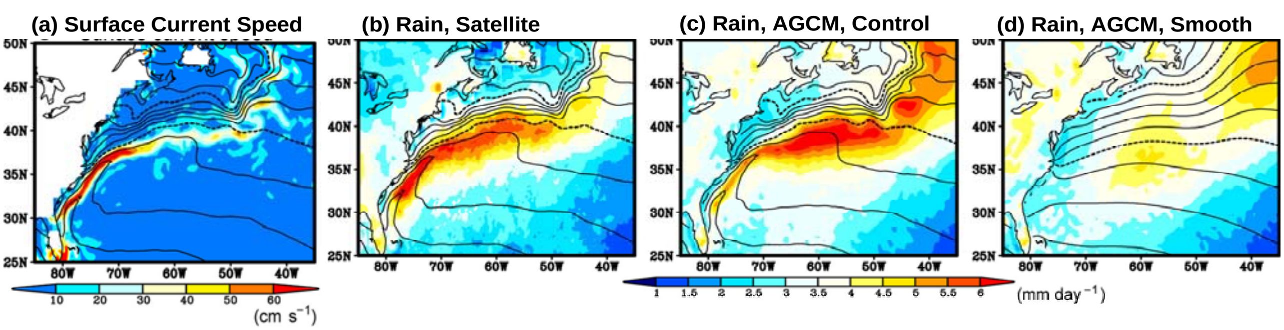

Figure 1. Annual climatology: (a) satellite observation of surface geostrophic current speed with sea surface temperature (SST) (contours; 2℃ interval and dashed contours for 10℃ and 20℃) and rain rate and SST from (b) satellite (c) AGCM control, and (d) AGCM smoothed SST.

The upward wind velocity is strongest about the first mile above the surface, but the Gulf Stream-following structure is clearly visible at 4 miles and still discernible at 7 miles and above. The band of diverging winds in the upper troposphere follows the meandering Gulf Stream front.

The findings from the operational weather analysis pointed to the warm flank of the Gulf Stream as the cause of the strong upward winds. "We wanted more evidence, though," says team member Akira Kuwano-Yoshida of the Japan Agency for Marine-Earth Science and Technology (JAMSTEC), "and turned to the high-resolution Atmospheric Model for the Earth Simulator (AGCM) at JAMSTEC. We drove the model first with the actual Gulf Stream temperatures. The model successfully captured the rain band and the signature in the upper troposphere. Then we removed the sharp sea surface gradient from the Gulf Stream front by smoothing the temperature in the model. The narrow rain band disappeared."

Finally, the team used outgoing longwave radiation satellite data to measure the cloud top temperatures. The narrow cloud band, associated with lightning, extends 7 miles high above the Gulf Stream meanders and has temperatures below freezing. All this is further evidence that the Gulf Stream influence on the atmosphere extends far above the lower atmosphere.

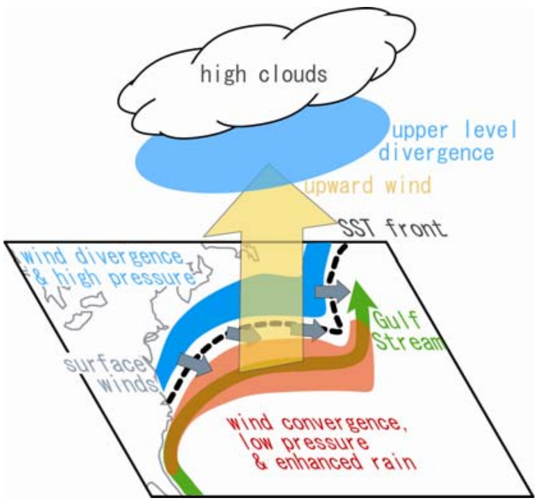

Figure 2. A schematic of the climatic responses to the Gulf Stream. The warm Gulf Stream (green arrow) creates a sharp sea surface temperature front (black dashed line) in the cold Atlantic. The surface winds flow toward the warm Gulf Stream (gray arrows) and the warm air rises (yellow arrow), creating a region of rain (orange band). The upward motion over the Gulf Stream penetrates into the upper troposphere, creating high clouds. In the upper troposphere, the winds branch out (blue oval), forming planetary waves that travel eastward toward Europe.

The Gulf Stream's strength has changed markedly in the past as Earth has switched between warm periods and ice ages. Closely linked to these changes have been climate changes around the globe—not only in the Atlantic, but also in the Pacific and even in the Southern Hemisphere. Scientists have been puzzled at how the changes in the Atlantic thermohaline circulation (the conveyor belt) lead to climate anomalies in other regions in the Northern Hemisphere. The new study discovers a direct pathway, the Gulf Stream's deep heating of the atmosphere. This heating generates planetary waves that can induce quite rapid changes in Earth's atmospheric circulation and alter climate over Europe and beyond by riding on the westerly jet stream in the upper troposphere.

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