Modern climate has roots in Early Devonian

The clay-filled cast of a 390-million-year-old root shows up as a dark, branching pattern in sandstone.

New fossils show that sapling-size plants with substantial roots grew on land at least 10 million years earlier than paleobotanists had thought. The advent of such deep-rooted land plants drastically reduced atmospheric concentrations of carbon dioxide, scientists believe, thereby turning down the greenhouse effect and cooling the climate.

Plants 2 to 3 meters tall with roots almost 1 m long lived 390 million years ago near what is now Gaspé Bay in Quebec, report scientists from the University of Tennessee-Knoxville in the February GEOLOGY. The researchers found fossil traces of the above-ground portions of plants attached to roots.

"We assumed we would find maybe some roots. . . and lo and behold, we came across these traces that were just wild—they were just huge," says Jennifer M. Elick, a coauthor of the report. "These root systems are larger than anything that has been previously documented [for this period]."

Land plants with water-conducting vessels appeared even earlier, more than 410 million years ago. Those early plants, only 5 centimeters tall, shared the land with a variety of arthropods (SN: 11/10/90, p. 292). Vertebrates did not clamber onto land until 60 or 70 million years later.

Around 390 million years ago, many plants were still primitive and leafless, says paleobotanist William A. DiMichele of the National Museum of Natural History in Washington, D.C. Typical vegetation was "creeping ground cover, like a *Pachysandra* without any leaves," he says, "just branching sticks." Most plants were thought to be rootless and restricted to wet habitats, he says.

The recently found fossils have more complex structures, however. Elick says the deep-rooted plants lived along seasonal streams and had to tolerate prolonged dry periods. Fossils of these plants exist today because the streams sometimes flooded, flattening the plants and burying them in sediment. As the plants decayed, clay replaced the roots and stems, yielding a cast of the plant.

"The environment was pretty harsh," Elick says. Having large roots helped the plants withstand such severe conditions, she adds.

Several researchers have suggested that by accelerating the weathering of soil, deep-rooted plants drew down the atmospheric concentration of carbon dioxide and changed the climate (SN: 12/9/89, p. 376).

As plants grow, they capture carbon dioxide from the atmosphere and release some of it via their roots into the soil. There, carbon dioxide combines with water to form carbonic acid, which leaches out calcium, forming either insoluble calcium carbonate or soluble calcium and bicarbonate ions that dissolve into the groundwater and ultimately end up at the bottom of the ocean. Either way, the carbon dioxide in the carbonate is removed from the atmosphere.

"This is what made the Earth a habitable place—changed an intolerably steamy greenhouse climate. . . into one that is tolerable to humans," says Gregory J. Retallack of the University of Oregon in Eugene.

Computer simulations by Robert A. Berner of Yale University show that burgeoning vegetation would have produced a big drop in carbon dioxide concentrations. Estimates of ancient concentrations, derived from analysis of fossil soils, agree with those predictions.

Finding such large roots at an early time validates his model, Berner says, noting that plants' ability to alter soil is the key to the carbon dioxide decrease predicted by the model.

Berner's findings may receive an additional boost when the Tennessee researchers analyze the fossil soils found with the root casts. Elick says her next step is to determine the ratio of carbon-12 to carbon-13 isotopes in carbonates from the ancient soil (SN: 8/28/93, p. 140). That ratio is a clue to the atmospheric concentration of carbon dioxide 390 million years ago, when the fossil roots were part of a small streamside forest. —*M. Jensen*

As globe warms, hurricanes may speed up

Climbing ocean temperatures during the next century could raise the speed limit for hurricane winds, leading to more intense tropical storms, according to computer simulations of a warmer world.

Hurricanes draw their power from the heat within tepid tropical waters, and theory suggests that greenhouse warming could pump up the winds in such storms. Meteorologists, however, have debated whether hurricanes would respond in any obvious way.

The new study describes the most detailed simulations of future hurricanes to date, say Thomas R. Knutson and his colleagues at the National Oceanic and Atmospheric Administration's (NOAA) Geophysical Fluid Dynamics Laboratory in Princeton, N.J. The researchers used a global climate model to simulate storms in a world gradually warmed by increasing carbon dioxide in the air. They focused on storms in the northwest Pacific Ocean, where the most intense hurricanes occur, and compared 51 in the warming scenario with an equal number in simulations of the present climate.

Because the global model covers such a large area, its resolution is limited and it produces only fuzzy versions of hurricanes. To sharpen the picture, the researchers reran each of the 102 simulated storms on a smaller-scale, higher-resolution model. Meteorologists use this technique for tracking actual hurricanes.

When tropical sea surface temperatures in the model increased by 2.2°C, the wind speeds in the strongest storms were 5 to 12 percent higher than in the strongest storms of the control runs, the researchers report in the Feb. 13 SCIENCE. That amounts to a surge of 7 to 16 miles per hour.

With this enhanced power, such storms could batter coastal regions with unprecedented force. "If the strongest ones get stronger by about 10 miles per hour, that might double their damage," comments Christopher W. Landsea, a meteorologist at NOAA's Hurricane Research Division in Miami.

The simulations do not examine what would happen to hurricanes outside the northwest Pacific or whether the frequency of hurricanes would change. Hurricanes in the Atlantic Ocean could occur less frequently if global warming caused El Niños to appear more often in the Pacific, says Landsea. El Niños inhibit hurricane formation in the Atlantic.

If a small proportion of hurricanes grows stronger, most people may not notice the shift, says Kerry A. Emanuel of the Massachusetts Institute of Technology. Hurricane behavior varies tremendously from year to year and decade to decade, tending to drown out subtle changes in strength.

Common sense might suggest that the spawning grounds of hurricanes should expand as ocean temperatures climb, but researchers say the physics of the atmosphere argues otherwise. "The broad geographic regions of cyclogenesis, and therefore also the regions affected by tropical cyclones, are not expected to change significantly," reports a group of 11 storm specialists in the January BULLETIN OF THE AMERICAN METEOROLOGICAL SOCIETY. —*R. Monastersky*