Director's Note

We are pleased to bring to you this fourth issue of the Tree-Ring Times. This issue highlights Dr. Katie Hirschboeck's research in "synoptic dendroclimatology," and a new Tree-Ring Lab archive. Katie's research reflects her commitment to improving knowledge and understanding of broad-scale climate mechanisms. Katie's focus on fundamentals and mechanisms is also characteristic of her teaching. She has become a renowned teacher on campus, particularly in her leadership in implementing and improving the undergraduate General Education Program. Katie teaches a freshman course for non-science majors called "Introduction to Global Change," where she uses state-of-the-art classroom technologies and hands-on, group exercises to inspire learning.

Our new archive in a building we are calling "Tree-Ring West" has stimulated our thinking about the future of our entire, priceless collection of tree-ring specimens. We expect to occupy a larger space, including room for the rest of our collections, in a new building to be constructed on campus in 2004 and 2005. The article on page 4 highlights some of the values of our enormous tree-ring collection, and our need for support to develop the potential of this unique archive of environmental and cultural history.

Here's wishing you all Happy Holidays and a productive New Ring (Year)!

COVER: *Bristlecone pine trees, such as the one on the cover growing in the White Mountains of California, can live more than 4,000 years. Thousands of samples from these trees have been used in dendroclimatic studies, and they helped fill the Tree-Ring Lab's archive.*
Photo by Thomas P. Harlan

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Hirschboeck

• *By Melanie Lenart*

While most dendrochronologists keep their feet on the ground, matching records of surface temperature, rainfall and snowpack to variations in tree-ring widths, Laboratory of Tree-Ring Research Associate Professor Katherine Hirschboeck has her head in the clouds.

She and some of her students at the University of Arizona consider air pressure between roughly 8,000 and 10,000 feet and other lofty variables when seeking to explain fluctuations in tree-ring records. This allows them to consider the overarching weather and climatic processes that influence regional temperature and precipitation patterns along with the growth of annual tree rings.

"We're so married to temperature and precipitation because they've been so consistently collected," Dr. Hirschboeck said. "Yet there are all kinds of other weather-related variables that trees may be responding to that haven't traditionally been looked at in a systematic way."

Hirschboeck calls this branch of study "synoptic dendroclimatology," with "synoptic" alluding to the use of information from weather balloons sent out simultaneously around the globe (see sidebar on page 6 for more details) and "dendroclimatology" referring to using tree-ring patterns over time to infer climatic conditions.

The concepts behind synoptic dendroclimatology have been developing since at least the 1970s publications by LTRR Professor Emeritus Harold Fritts and others connecting spatial patterns of tree growth to seasonal pressure fields, Hirschboeck said.

Other researchers have considered the influence on tree rings of both sea-level and

Focuses On Synoptic Dendroclimatology

upper-level atmospheric circulation, including linkages to circulation patterns associated with the El Niño phenomenon, Hirschboeck noted in a 1996 paper introducing "synoptic dendroclimatology" as a useful name for the budding specialty. The paper, written with co-authors Fenbiao Ni, Michelle Wood and Connie Woodhouse for the Radiocarbon publication "Tree Rings, Environment and Humanity," reviews important contributions to this new field and proposes that standard dendrochronological reconstructions could also benefit from looking at the bigger picture.

The dozens of variables she and her team examine include: the 700-millibar height, which is the height at which the atmospheric pressure is about 70% of sea level pressure; relative humidity at this height; and the number of days the system can be described as being in a "ridge" or "trough" as the 700-millibar height respectively towers above or plunges below its average height.

"Sometimes the 700-millibar circulation level is actually at or below the ground level, where you've got tall mountains, hence it's a good indicator of the environment at those high elevations," she noted.

As it happens, tall mountains tend to favor long-lived trees, such as bristlecone pine, which eke out a living for millennium living at high altitudes and low pressure. Because one tree can produce 4,000 annual rings or more during its lifetime, bristlecone are the source of some of the longest tree-ring-based climatic reconstructions.

In some situations, the regional patterns captured by the 700-millibar height can reflect a tree's reality more than the nearest weather station, which may be 100 miles away as the crow flies and, perhaps worse, a mile down as the stone drops. Temperature rises on average by more than 3 degrees Fahrenheit for every 1,000 vertical feet down a mountain, while precipitation tends to decrease.

Also, surface rainfall may be spotty, with thunderstorms inundating the weather station or the forest, but not necessarily both. In contrast, atmospheric circulation conditions tend to be regionally consistent at the 700-millibar height.

As an example of how fluctuations at the 700-millibar height can affect tree growth, Hirschboeck displayed some results linking trees at Keen Camp Summit with conditions above San Diego, the nearest weather balloon site. During 1961, a year of slow growth as evidenced by a narrow annual ring, upper-level ridges dominated throughout the growing season window, she pointed out.

"And this was a wet year," she said of 1973, a year of abundant growth with a wide ring to prove it. She indicated a graphic showing the abundance of troughs passing overhead during the growing season.

"Now we're linking the wide ring to the dynamics of what's delivering temperature

Continues on page 6

LTRR Associate Professor Katherine Hirschboeck, above, matches tree-ring widths with upper-level atmospheric conditions, as described in the poster behind her.

syn·op·tic den·dro·cli·ma·tol·o·gy

synoptic *relating to or displaying conditions (as of the atmosphere or weather) as they exist simultaneously over a broad area*

dendroclimatology *referring to using tree ring patterns to infer climatic conditions over time*

Synoptic Dendroclimatology

Continued from page 3

and precipitation," Hirschboeck said. LTRR Principal Research Specialist David Meko also contributed to the project, as did several graduate students, including Fenbiao Ni, Gregg Garfin and Matthew Salzer, all of whom have since completed their Ph.D. requirements and taken positions at the University of Arizona.

The research team followed similar procedures for six other sites throughout the western United States, selected because preliminary analyses indicated they might reflect different regional responses to upper-level circulation patterns.

Using a statistical program refined by Dr. Meko, the researchers first pinpointed the specific months that influence tree-ring widths for each site. Then they considered atmospheric circulation patterns during the crucial growing season windows for the past 40 years or so of the chronologies. From there, they created spatial correlation fields for each site, and compared them with composite maps showing the typical atmospheric circulation pattern for years in which tree rings were narrow, wide or average.

"Basically, the same precipitation-related circulation patterns are showing up at each site but they sometimes operate in different seasons," Hirschboeck said. "Luckily we found things were geographically consistent and you could explain them meteorologically. Even the patterns for average years made meteorological sense. I didn't know if they would."

The success of the project has made her eager to examine other tree-ring data sets with an eye to linking the climatic responses to atmospheric circulation. So there's a good chance Dr. Hirschboeck will be looking skyward for the answers for many years to come as she explores her LTRR niche more thoroughly.

WEATHER BALLOONS AND TREE RINGS

• *By Melanie Lenart*

The opportunity to use upper-level atmospheric circulation patterns to consider their influence on tree-ring growth goes back only to the 1940s, when meteorologists around the world agreed upon a system for collecting the necessary information.

Basically, they agreed to send up weather balloons twice a day at exactly the same moment from hundreds of stations all over the world. The balloons go up every 12 hours, sending down details on air pressure, moisture and temperature as they ascend into the clouds.

From these thousands of snapshots of the atmosphere, meteorologists can piece together a moving picture of global circulation patterns. In Arizona, weather balloons arising from only two locations, Tucson and Flagstaff, can capture fluctuations occurring across the state in combination with neighboring stations.

Forecasters rely on this "synoptic weather mapping," as it is known, to predict movement of cold and warm fronts and the probability of seeing rain or snow in specific locations.

This technique works because air is a fluid that moves in waves. Air molecules go with the flow, riding the crests and troughs like surfers. Or perhaps they are like skiers rushing downslope into the troughs of low-pressure systems, such as in areas where the 700-millibar height – the height where atmospheric pressure is about 70% of sea level pressure – may be 1,000 feet lower than the 700-millibar height of the closest high-pressure system.

From a ground-based point of view, the low pressure can allow a hovering air mass to rise high enough in the atmosphere to become a storm cloud, with its water vapor condensing into droplets only if it reaches the cooler regions high above the Earth's relatively warm surface.

While low-pressure systems tend to promote precipitation, high-pressure systems tend to prevent it, creating deserts when they consistently linger over an area as they do in the Southwest.

The proportion of time a piece of ground spends under troughs vs. ridges during the growing season affects the productivity of the trees on the landscape, as described in the main story. This translates into measurable differences in tree-ring widths because of the precipitation and temperature patterns that are associated with the ridges and troughs.