igate the corner flow collapse hypothesis, which explains how near-surface rotation is quickly intensified into a tornado. Traditional radar measurements in the corner flow region are heavily contaminated by ground clutter; however, the AIR has superior clutter suppression through the application of adaptive beam nulling techniques and longer dwell times since no beam steering (mechanical or electronic) is needed.

The high temporal resolution capabilities of the AIR will facilitate investigating what causes tornadoes to strengthen and weaken, and what causes temporal variations of the tornado wind field. The AIR can exploit recent advances in cross beam wind retrievals to measure the cross beam wind, shear, and turbulence. Suction vortices within a tornado have been rarely observed using mobile radar because they require very high temporal and spatial resolution. However, when the tornado is sufficiently close, the AIR can make dozens of measurements throughout the short lifetime of a suction vortex. Hence, the full evolution of this rapidly evolving phenomenon can finally be studied.

The AIR is currently being fabricated at the ARRC and is scheduled to be ready for testing by May 2010 and deployment in fall 2010. Currently, numerical simulations of the AIR in a phased-array radar simulator are being performed to study the capabilities of the radar and develop the adaptive beam-forming algorithms. The AIR and future imaging radars could be the next generation of weather radars, providing much better temporal resolution and clutter suppression capabilities than today’s mobile radars.—David Bodine (University of Oklahoma), B. Isom, R. Palmer, and B. L. Cheong. "A New Frontier for Mobile Weather Radar—The Atmospheric Imaging Radar: Meteorological Implications and Requirements," presented at the 34th Conference on Radar Meteorology, 5–9 October 2009, Williamsburg, Virginia.

**PAPERS OF NOTE**

**Precipitation Simulations Using WRF as a Nested Regional Climate Model**

Initially, the Weather Research and Forecasting (WRF) model was developed and tested for regional simulation and forecasting the weather. However, as regional climate modeling has become more prevalent for dynamical downscaling of simulations from global climate models (GCMs) to finer resolution, use of WRF as a regional climate model is increasing. Despite this, little has been reported on the performance of the WRF in longer-term (e.g., seasonal) simulations, even though some responses of the model to specific setup options may not be apparent in shorter simulations. We examined the sensitivity of simulated U.S. summer precipitation to variations in model setup in the WRF, when it is used as a nested regional climate model, and determined that there indeed are some concerns.

Our research grew out of a GCM downscaling project. Many WRF options were tested in search of a setup that would give reasonable results in a feasible amount of computational time. During this process, numerous WRF sensitivities were found, some of which we documented. Specifically, the impacts on precipitation of the choice of land-surface model, convective parameterization, time-varying sea surface temperature, WRF version (2.2 vs. 3.0.1), and nest to parent-domain feedback are regionally dependent, highly diverse, and in some cases, much greater than expected. We learned that there is a clear issue with two-way nesting in both WRF versions that may not be easily diagnosed in short simulations. In addition, while one would expect to see differences in precipitation given changes in physical parameterizations, one may not expect that changing to a different version of the WRF with an otherwise identical setup would have a considerable impact on precipitation—but we found that it does in this case. In fact, average precipitation is about 44% greater using WRF version 3.0.1 than it is using version 2.2 in our 90-km domain setup, and about 27% greater in our 30-km nest.

Our goal with these observations is not to provide comprehensive guidance, but to inform any user of the WRF of potential impacts that certain setup options may have on their simulations, whether or not the impacts are obvious during the time frame of their model runs. It also serves to remind us that blind use of the WRF (or any model) is not recommended.—Melissa S. Bukovsky (University of Oklahoma), and D. J. Karoly. "A Note
on Precipitation Simulations using WRF as a Nested Regional Climate Model,” in a forthcoming issue of the Journal of Applied Meteorology and Climatology.

**DO GRAVITY WAVES TRANSPORT ANGULAR MOMENTUM AWAY FROM TROPICAL CYCLONES?**

Recent studies claim that gravity waves can transport a significantly large amount of angular momentum away from tropical cyclones—as much as 10% of the core angular momentum per hour. These previous studies used the shallow water equations to model gravity waves radiating outward from rapidly rotating inner-core asymmetries. However, gravity waves propagating away from tropical cyclones are internal waves in a stratified atmosphere and behave differently than shallow water waves. Hence, we reinvestigated this phenomenon using a three-dimensional, nonhydrostatic, linear numerical model of the vortex-anelastic equations, which we found better represented the transport of angular momentum by gravity waves.

Rotating asymmetric heat sources are used to generate radiating gravity waves in idealized but realistic tropical cyclone vortices. Calculations confirm that gravity waves do transport angular momentum away from the core of tropical cyclones, but at a rate that is several orders of magnitude smaller than recent estimates. Sensitivity tests indicate that the rate at which gravity waves transport angular momentum away increases with decreasing static stability of the environment but decreases with increasing inertial stability associated with the tropical cyclone wind field. In other words, as the environmental temperature drops more slowly with height and the winds outside the radius of maximum wind decay more rapidly, the ability of tropical cyclones to shed angular momentum from the core through gravity waves is enhanced. In addition, the angular momentum loss rate is closely related to the speed at which convective heat sources rotate around the storms. Note, however, that for all parameter spaces considered in this study, the rate at which gravity waves transport angular momentum away from tropical cyclones remains significantly smaller than recent estimates.

Our results reveal that angular momentum transport by gravity waves does occur in tropical cyclones, but plays an insignificant role in a storm’s angular momentum budget.—Yumin Moon (University of Miami), and David S. Nolan. “Do Gravity Waves Transport Angular Momentum Away from Tropical Cyclones?” in a forthcoming issue of the Journal of the Atmospheric Sciences.

**GREAT WESTERN HEAT WAVE IN 2006 PROVIDES A GLIMPSE OF FUTURE EXTREMES**

In July, 2006, California and Nevada were impacted by a great heat wave, unprecedented in its magnitude, duration, areal extent, and high humidity levels. A moist air mass exacerbated the stressful effects of the heat and decisively contributed to maintaining record-high nighttime temperatures during the event. Enormous demands were placed on water and energy resources. Californians, human and cattle...

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**ECHOES**

“It is an astonishing number.”

—RON KWOK of NASA’s Jet Propulsion Laboratory, commenting on the fact that the thickness of Arctic sea ice has diminished 53% since 1980. Kwok coauthored a study recently published in Geophysical Research Letters that used sonar profiles of Arctic ice dating back to 1958 that were taken by U.S. Navy submarines. Comparing these profiles and other records to more recent data from NASA’s Ice, Cloud, and Land Elevation Satellite (ICESat), they determined that the mean thickness of Arctic ice declined from 3.64 m in the winter of 1980 to 1.89 m in the winter of 2007. The long-term series of data suggest that “this decline for more than three decades does not appear to be cyclical,” according to the University of Washington’s Drew Rothrock, who coauthored the research.

The study was published just as two German container ships were in the middle of the first-ever voyage by Western commercial vessels through the Arctic’s Northeast Passage. The Beluga Fraternity and the Beluga Foresight each carried 2,000-ton cargoes from Ulsan, South Korea, to Rotterdam in the Netherlands. The voyage was 3,000 miles shorter than the normal journey, which takes ships through the Gulf of Aden and the Suez Canal. The vessels were accompanied by ice-breakers, but those were hardly necessary. “I was slightly surprised by what we saw,” explained Valeriy Durov, captain of the Foresight. “There was virtually no ice on most of the route. Twenty years ago, when I worked in the eastern part of the Arctic, I couldn’t even imagine something like this.”

(SOURCES: NASA/Goddard Flight Center; BBC News)
In a study that could influence the public’s opinion on climate change more than any other, researchers have found that warmer temperatures are threatening the quality of beer. A team led by Martin Mozny of the Czech Hydrometeorological Institute compared data on weather patterns, crop yield, and hop quality in the Czech Republic from 1954 to 2006 to determine the effects of climate on the quality of Saaz hops, which are used to make pilsner lagers. They found that the concentration of alpha acids in the hops had decreased by 0.06% per year during the period studied. Alpha acids give the Saaz hops their unique bitter taste, and the scientists attribute their decline to changing growing conditions and other effects they relate to increasing temperatures in the region. The study was recently published in Agricultural and Forest Meteorology.

**WARM BEER**