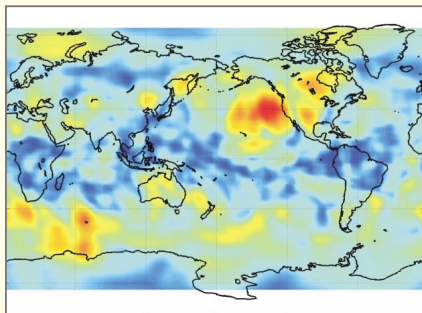


PHYSICS UPDATE

▶ ALL DATA ON THE WEATHER MAP ARE NOT EQUAL.

Researchers usually assume that all spots on a weather map are equally chaotic, meaning that small uncertainties in initial conditions lead to unpredictably different results. A realistic model of Earth's atmosphere must be high dimensional—there are a great many degrees of freedom—which further complicates the art of forecasting. Now, a multidisciplinary team of scientists at the University of Maryland has shown that, locally, the finite-time dynamics of the atmosphere is often low dimensional. They developed a statistic called the bred vector (BV) dimension that characterizes the differences be-



tween a model atmospheric state (the initial condition) and several perturbations of that state that evolve for a finite time. Using real “ensemble forecasts” from the National Weather Service, they mapped

the atmosphere's BV dimension globally, as shown in the figure, where red is low dimensionality and blue is high. The team says that the low BV-dimension regions might be particularly important for obtaining accurate weather forecasts; atmospheric data obtained there will tend to evolve only along the subspace spanned by the few dominant bred vectors. (D. J. Patil et al., *Phys. Rev. Lett.* **86**, 5878, 2001) —BPS

▶ TWO-PATH QUANTUM INTERFERENCE IN A LIQUID.

Interference experiments have unequivocally shown the quantum wave nature of photons, electrons, neutrons, atoms, molecules, and even Bose–Einstein condensates. Now, a team of physicists at the University of California, Berkeley, has demonstrated quantum interference for superfluid helium-3. They built an interferometer analogous to a dc SQUID (superconducting quantum interference device) consisting of a loop of hollow tube filled with superfluid ^3He and interrupted by two superfluid Josephson “weak links.” Each weak link consists of an array of thousands of submicron apertures in a 50-nm thick silicon nitride window on a Si chip. The group used a membrane to monitor both the pressure head across the interferometer and the mass current through it. Theory predicts—again similar to SQUIDS—that the total mass current depends on the superfluid phase winding. To adjust the quantum phase in the uncharged superfluid ^3He , the team varied the loop's orientation with respect to Earth's rotation vector. The physicists found precisely the quantum interference pattern they expected for the current. Because the interferometer responds to rotation rather than magnetic field, poten-

tial applications include a superfluid quantum interference gyroscope (R. W. Simmonds et al., *Nature* **412**, 55, 2001.) —SGB

▶ SEMICONDUCTING HIGH-TEMPERATURE MAGNETS?

In recent years, calcium hexaboride (CaB_6) doped with lanthanum has puzzled magnetism researchers, in large part because it retains a modest ferromagnetism even at 900 K—a surprisingly high Curie temperature for a compound that does not contain traditional magnetic metals such as nickel or iron. Electronic structure calculations based on density functional theory led to several possible explanations: CaB_6 might be a semimetal or an excitonic insulator; doped CaB_6 might be a doped excitonic insulator, a conventional magnetic material, or even an example of the long-sought, low-density spin-polarized electron gas. Now, however, physicists in the Netherlands have performed more accurate calculations, using the so-called GW approximation, which suggest that CaB_6 is actually a semiconductor with a bandgap of 0.8 eV. If that is true, important applications await the compound in the field of spintronics, in which an electron's spin and not just its charge carries information. Thus far, combining semiconductors with magnetic metals has been difficult, especially at or above room temperature. In addition, new magnetic sensor and memory applications might be possible. (H. J. Tromp et al., *Phys. Rev. Lett.* **87**, 016401, 2001) —PFS

▶ A “SPIN BATTERY” has been demonstrated by researchers at the University of California, Santa Barbara, and Pennsylvania State University. They have shown that a persistent coherent spin current can flow across an interface between two n-doped semiconductor materials, at a temperature of 5 K. The discovery is a positive step in the quest for spintronic semiconductor devices that manipulate electron spins rather than charges. (See the article by David D. Awschalom and James M. Kikkawa in *PHYSICS TODAY*, June 1999, page 33.) Putting an external electric field across the interface between a gallium arsenide spin reservoir and a zinc selenide layer increased the efficiency of spin transfer by a factor of 5 over that with no electrical bias. The characteristics of the spin signal in the ZnSe layer were surprisingly representative of the spin properties of the GaAs layer. When the same team replaced the n-doped GaAs reservoir with p-doped GaAs, they found up to 40 times greater efficiency of spin transfer, facilitated by the internal field at the p–n interface. The findings show promise for multifunctional spintronic devices, such as spin transistors, in which the amplitude and phase of a coherent spin current can be controlled by either electric or magnetic fields. (I. Malajovich, J. J. Berry, N. Samarth, D. D. Awschalom, *Nature* **411**, 770, 2001.) —BGL ■