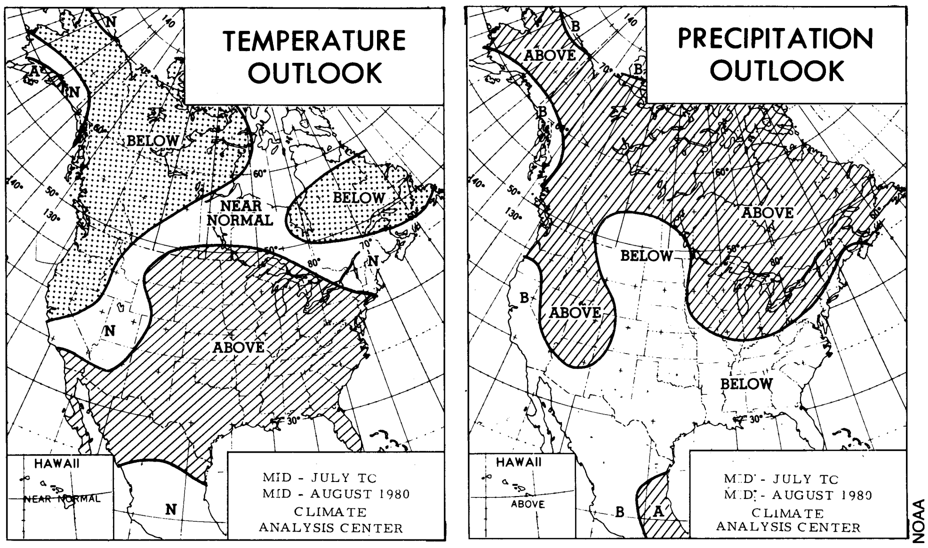
The Heat Wave: What Happened?

Triple-digit temperatures continued to sizzle the southern and central United States and moved eastward last week, claiming more than 1,200 lives since the searing reign began June 22. With no immediate end in sight, the National Weather Service last week forecast more of the same at least until mid-August. For meteorologists, the unpredicted, protracted heat wave and associated drought has brought the additional discomfort of defeat, though in hindsight much is being learned.



Mid-July to mid-August thirty-day outlook offers no relief from heat, drought.

The scene was set last May, according to Robert Livezey of the Long Range Prediction Group of the National Oceanic and Atmospheric Administration. At that time, he says, the predominate air flow over the United States at 10,000 feet was moving strongly eastward from the Pacific Ocean. These westerly winds were forced straight across the country in part by a very strong and stationary clockwise-circulating air mass (high) over south-central Canada.

When the Canadian high began to break up, the system that had been maintaining the westerlies collapsed. As a result, a strong but previously suppressed high pressure system in the Pacific began to swell, says Livezey. In response, a series of alternating lows (counterclockwise-circulating air masses) and highs set up, including the very strong, stationary high — and its accompanying heat and dryness — that took up residence over the south-central United States.

The "wavy" alternating pattern of highs and lows, the position of the high over the south-central states and even the longevity of the entire pattern are not unusual, Livezey says. But the strength of the south-central U.S. high is rare: "We don't see an anomaly of this magnitude in the 33 years of data that we have," he says.

Just why the high pressure system is so strong and so persistent is unclear. In part, such a "blocking" high—so called because it is strong enough to deflect any smaller scale weather events such as fronts and storms — is maintained by the circulation system it creates. According to Jerome Namais of the Climate Research Group at Scripps Institution of Oceanography, the air within a high pressure system sinks very slowly — about 500 meters per day — which causes compression and drying of the air. This dehumidification essentially eliminates cloud-building, which increases heating of the air due to solar radiation. This expands the air column, which in turn amplifies the high pressure area.

"But the real causal mechanism is unclear," says Namais. Livezey agrees: "We don't know if the system sets up due to internal forcing [causes] or external forcing." Namais suggests, however, that the key may be an interaction between the sea and the air. The Pacific Ocean surface, cooled by last year's strong westerly winds, may have caused reduced air drag and allowed the clockwise-circulating air mass to slow and build.

"Realistically, no one could have forecast the extreme extent and strength" of the high over the south-central states, says Namais. But in hindsight, he says, had forecasters — who usually watch for longer-scale events — been watching the development of the rapidly growing Pacific high, they might have forecast the formation of the heat wave-producing high. What they're looking for now, says Livezey, is a weakening of the Pacific high that may signal a collapse of the entire system. □

Beauty bottoms out: Fifth quark found

Pinning down the existence of a new variety of quark and making it available so its properties can be studied is one of the experimental milestones of particle physics these days. Theory proposes the existence of six varieties or "flavors" of quarks and six varieties of the particles called leptons as the basic constituents of all other forms of matter. Firmly establishing the existence and identity of the fifth quark in order of discovery is now reported accomplished by work done at the Cornell Electron Storage Ring (CESR) at Ithaca, N.Y. The reports caused a certain satisfaction at the 20th International Conference on High Energy Physics held this week at the University of Wisconsin in Madison.

Nature is not kind to those who would seek to identify and study quarks. Current theory decrees that quarks may not exist as free particles, but only as constituents, bound and confined inside the structures they make. Those structures are the particles seen in experiments such as protons, neutrons, mesons and hyperons of various kinds. In spite of one or two reported exceptional exceptions nature seems to behave as theory expects.

The thing that would-be quark hunters have to do is to go and find particles in which the sought-after quark plays a role and try to study the quark in the relations and behavior of these particles. Three flavors of quark (named up, down and strange) were available for study in particles well known from the late 1950s and early '60s, but the three varieties of heavy or unstable quark, called charm, bottom or beauty and top or truth, can be found only in extremely heavy particles. Such particles could not be made experimentally at the energies available in those days.

The fourth flavor, charm, came over the horizon and began to have its identity established in 1974 with the discovery of the psi particles. The fifth flavor, bottom or beauty, requires work with the heaviest particles known to physics, the upsilon particles, whose masses lie around 10 billion electron-volts.

Upsilons were first discovered in 1977. Gradually it has become clear that there are at least four of them, designated upsilon, upsilon prime, upsilon double prime and upsilon triple prime. The CESR colliding beam apparatus is particularly