Ken Stroech/EPA

A Legacy of War

By JOHN TRAVIS

As the Gulf region chokes, the global climate breathes easier

As a helicopter ferries EPA Administrator William K. Reilly toward his destination dozens of miles away, he spots a roiling plume of smoke rising into the desert sky. Closer still, thick oily clouds obscure the sun, turning day into night. Waves of heat wash the chopper and its occupants, still half a mile from their destination.

The searing temperatures transform the desert sand into a black, glassy surface, and thundering noise fills the air. Finally, the cause comes into view — a half-dozen of the nearly 600 raging Kuwait oil wells set afire by the army of Saddam Hussein. Each blaze, a hypnotic mixture of red, orange and yellow flames, burns 24 hours a day.

"If hell had a national park, it would be those oil fires," Reilly told reporters last month after his environmental survey of war-wrecked Kuwait. With fewer than 200 of its wells capped, Kuwait loses as many as 6 million barrels of petroleum to these flames each day — an amount equal to one-third of the United States' daily oil consumption. Some of the wells may continue to burn unchecked for years, say those battling the blazes.

But even as the flames continue to pour smoke into the atmosphere, it appears the fires do not threaten global climate, as some scientists had once feared. A number of new studies instead suggest that the serious consequences of the Kuwait blazes will remain confined to the Persian Gulf region.

Even before television crews began transmitting images of the blazing wells, even before the armies of the Coalition Forces and Iraq clashed, many atmospheric scientists began worrying about the threat of worldwide damage from smoke plumes in the event Kuwait's rich oil fields ended up ablaze. Would this soot remain in the lower atmosphere, or would it ascend into the stratosphere and spread around the planet, potentially altering climate on a global scale?

One major concern centered on India's monsoon winds, which from May through September bring crucial rains to an agricultural area that feeds billions. These seasonal winds are driven by a temperature gradient in which air over the hotter landmass of the subcontinent rises and draws in air from the surrounding, cooler ocean. Some scientists speculated that a haze of smoke clouding enough of India to reduce the land temperature — the wind's driving force — might weaken or eliminate this year's monsoon (SN: 2/2/91 p.71). So far, reports an Indian Embassy science officer, 1991 has seen a slightly weaker than usual monsoon, but one well within normal variation.

Under an even more dire scenario, if the wells burned long enough and their plumes rose high enough, dense, spreading soot clouds might ultimately shroud large portions of the planet from the sun's warming rays. Unseasonably cool weather — perhaps even regional frigid zones similar to those proposed under nuclear-winter scenarios — might develop.

However, simulations using atmospheric computer models of the region, described in the May 30 NATURE, seem to dismiss this chilling scenario and the demise of India's monsoon. Two groups — one British, one German — predict that the majority of the smoke will remain in the lower atmosphere. The German group, for instance, calculates that just 0.3 percent of it would reach all the way to the stratosphere, "where soot can survive for several years," according to Klaus F. Hasselmann and his colleagues at the Max Planck Meteorology Institute in Hamburg.

The two computer analyses conclude that India's monsoon appears safe. Indeed, both groups project that the fires' slight heating of the atmosphere might actually increase this year's monsoon rains. Their simulations also forecast an unseasonal cooling in the Persian Gulf area — an accurate prediction, according to those back from the region. Bahrain has just experienced its coldest May in 35 years, more than 7°F below the normal average temperature for the month.

Remote-sensing and on-site data appear to confirm the models' conclusions. "The smoke is mainly confined to the lower atmosphere, rendering highly unlikely the possibility of a nuclear-winter scenario," says atmospheric scientist Christopher Velden of the University of Wisconsin-Madison. His team's analysis of early satellite data, described in the June 14 SCIENCE, indicates that most of the well fires' smoke remains within 3 to 5 kilometers of Earth's surface, though some of the plume does extend up to 7 km.

A "self-raining system" provides one explanation for why the sooty smoke has not reached the stratosphere, Velden says. Satellite images show large cumulus clouds, fed by the fires' strong, heated updraft, forming over the burning wells. These clouds scavenge the smoke, removing the soot from the atmosphere and often depositing it in rain.

A surprising aspect of the soot aids in this process. The smoke particles are attracted to water, not repelled by it as many predicted, explains Lawrence Radke of the National Center for Atmospheric Research in Boulder, Colo. This allows the easy formation of rain droplets and contributes to the short lifespan (7 to 10 days) of the soot in the atmosphere, he says. At this point, Radke and his coworkers have not determined whether the soot has increased the acidity of the rain falling in the region.

From mid-May through mid-June, Radke and 26 other federally supported scientists completed 35 flights through the smoke plumes with two instrument-laden aircraft. Not only did their studies confirm most of the conclusions reached earlier by climate modelers and Velden's remote-sensing group, but the effort also provided some unanticipated insights.

The researchers discovered that the plumes were not as black as expected. To their surprise, they saw white and gray smoke rising skyward with the black. Scientists are still debating why the fires emit lighter smoke, Radke says. But in any case, the color difference limits the extent to which solar heating of the plume can help loft soot into the stratosphere. Since a paler plume absorbs less solar energy than a black one, its smoke is not as buoyant. None of the plumes they flew through extended to the stratosphere, Radke reports. These preliminary results from the mission were presented at a National Science Foundation briefing in late June.

Air currents "blowing the top off the plume" also restrain the soot's upward climb, Velden says. Seasonal spring winds along the Gulf tend to propel the smoke more horizontally, limiting its vertical rise. But these winds usually die down during summer. If and when they do so, the smoke may rise much higher, Velden warns — though still probably not high enough to alter the global climate.

An initial worry that the smoke might rise too high has given way to concern about what type of threat the low-drifting pollution poses to those living around the Persian Gulf. As the summer doldrums set in, stagnant air may trap more of the noxious sooty emissions close to the ground, exacerbating the fire-related air pollution.

The region's air is already unhealthy. EPA measurements in and around Kuwait show that high levels of dust-sized particles pollute the air. Such particulates, predominantly soot, have recently been linked to increased mortality rates in U.S. cities (SN: 4/6/91, p.212). Moreover, satellite observations and airplane measurements indicate the smoke particulates are of the smaller, more dangerous variety. No more than 10 microns in size, they can easily penetrate deep into the lungs.

Such fine particulates pose an increased health hazard to elderly people, children and anyone with chronic respiratory problems such as asthma or em-

Below: Daytime shot of an oil well fire. While nearly 200 of the damaged wells have been capped, those wells include some that never caught fire and some whose blazes were relatively easy to put out.

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Above: Researchers are still puzzling over the presence of white and gray smoke along with the expected black plumes. Below: Red Adair's firefighting company battles the blazes. Adair recently told a Senate committee it may take five years to extinguish all the fires and cap the damaged wells.

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physema. A recent study by The Analytic Sciences Corp. in Reading, Mass., estimates that within the first two months of their exposure to the smoky conditions, more than 10 percent of the people living in southeast Kuwait have become sick or experienced a worsening of chronic respiratory symptoms. Indeed, the Reuters news agency reported on April 30 that a hospital in Ahmadi, a Kuwaiti port close to the fires, was handling 40 new cases of respiratory problems a day and that admissions for breathing difficulties had risen from the usual 150 per day to more than 350.

The threat from other pollutants contaminating Kuwait's skies remains unclear. Petroleum fire experts expected the burning oil to generate smoke with high concentrations of sulfur dioxide, since Kuwait's crude contains more than 3 percent sulfur. They also feared the fires might taint the air with dangerous levels of other toxic substances, including hydrogen sulfide and heavy metals.

However, the U.S. Interagency Air Monitoring Team, which began its assessments of the Gulf region's air quality in mid-March, has found no such concentrations. "Limited sampling did not reveal the existence of high levels of sulfur dioxide or hydrogen sulfide near the burning wells or in population areas in the path of the oil well emissions," the team stated in its interim report, released in April. Nor did the investigators detect airborne heavy metals.

The recent aircraft measurements made by Radke and his colleagues appear to support this assessment. Radke says that while the fires are producing large amounts of sulfur dioxide, diluted levels of the gas 650 km downwind resemble those of any large urban area. Confirming reports that the smoke plume contains large quantities of oil in micro-droplets, the researchers who conducted the May-June flights suggest that incomplete combustion of the oil may account for the lower sulfur levels.

Findings about sulfur concentrations remain preliminary, according to Richard D. Small, a fire-effects expert at Pacific-Sierra Research Corp. in Los Angeles. While praising the speed with which the scientific community began its investigations of the oil fires, Small notes that the vast quantities of data may take years to understand.

"I really think the verdict is still out [on the extent of the atmospheric pollutants]," adds Robert R.P. Chase, an atmospheric scientist at Analytic Sciences.

Small and others note that acid rain and "black snow," which can result from atmospheric sulfur dioxide, have been reported over parts of Iran. One computer simulation by the British Meteorological Office predicted acid rain and petrochemical smog up to 2,000 km downwind of the fires. Another simulation by Analytic Sciences predicted that sulfur dioxide from the fires should essentially have destroyed all crops and vegetation in southeast Kuwait after just two months. "Recent reports of plant mortality in that area tend to bear out these predictions," states the company's report, presented in May to the American Geophysical Union.

Despite the unanswered questions about local effects, hard data confirming the theoretical models should produce a sigh of relief about the global climate. And on the local level, EPA experts "continue to be moderately confident that there are no undue risks to the population in Kuwait as a result of those oil fires," Reilly reported after his return.

Other atmospheric scientists do not share EPA's optimism at this stage, and they emphasize the need for additional local monitoring. As acrid smoke continues to spew into Kuwait's sky month after month, they believe the Gulf's environmental prospects grow only cloudier.

"Environmentally and ecologically," says Chase, "I think this will rank as one of the greatest tragedies of the 20th century." □