Whatever the crystallization procedure, finding the right initial concentration requires crystallizers to set up dozens or even hundreds of samples, each with a slightly differing concentration. Juan García-Ruiz, of the CSIC-University of Granada, Spain, hopes to bypass this tedious process by varying the protein concentration along the length of a capillary tube using what he calls the gel acupuncture technique.

The technique involves inserting a protein-filled capillary tube into a layer of gel placed in the bottom of a vessel. Crystallizing agent is then poured into the vessel. The agent diffuses down through the gel and up into the capillary, mixing with the protein. The gel serves to hold the capillary, and the depth of penetration can be varied to control how quickly the agent diffuses into the protein. The diameter of the capillary minimizes convection. And if sedimentation of the growing crystals is a worry, sealing the vessel and placing it on its side prevents developing crystals from sliding down the tube.

As the crystallizing agent diffuses through the protein, it creates a gradient of concentrations. The hope is that the gradient, at some point, includes the condition of supersaturation that initiates crystal growth. "Unlike other crystallization methods, where you only have one set of conditions in one experiment, [in gel acupuncture] you can scan many, many different conditions of solubility," he says.

García-Ruiz has obtained crystals of several different proteins, some big enough to fill the capillary tube. He believes this approach could be particularly useful for growing larger protein crystals, if he can find a way to control the wave of supersaturation as it travels along the length of the capillary. One possibility is varying the initial conditions so that the speed of the supersaturation wave is slowed to match the rate of crystal growth. In theory, the result would be crystals stretching from the point of initial nucleation to the end of the tube.

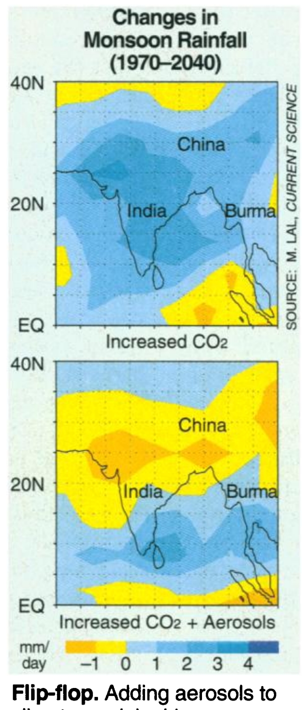
But that's a long way off. "We don't know yet how to do it," García-Ruiz confesses. Indeed, Komatsu says that crystallographers are constantly searching for "the guiding principle" of crystal growth. In the meantime, he says, any improvements in trial-and-error methods are "very important."

–Dennis Normile

CLIMATE CHANGE

Monsoon Shrinks With Aerosol Models

NEW DELHI, INDIA—Sulfur compounds spewing into the atmosphere from burning fossil fuels have long been implicated in acid rain and smog. But it's only recently that climate modelers have also viewed them, along with greenhouse gases such as carbon dioxide, as major determinants of global change. Last month a team of Indian and German scientists showed just how important the aerosols that form from the sulfur compounds may be in affecting climate on a regional scale. Their computer climate model predicts that the cooling effect of aerosols will combine with an increasing greenhouse effect to cause a significant drop in monsoon rainfall over India and parts of China by the middle of the next century.



Flip-flop. Adding aerosols to climate models dries up monsoon rainfall predictions.

That's a switch from earlier projections based on carbon dioxide alone. "The inclusion of the aerosol effect reverses the rainfall scenario on the Indian subcontinent," says Murari Lal, chief scientific officer at the Indian Institute of Technology (IIT) Center for Atmospheric Sciences and lead author for the study, published in the Indian journal *Current Science* (10 November, p. 752). The research, done jointly with a team at the Max Planck Institute (MPI) for Meteorology in Hamburg, Germany, implies that the combination could reduce rainfall by as much as 10% or more, harming Indian agriculture. The results are similar to those obtained independently by a modeling team at Britain's Hadley Center for Climate Prediction and Research, which are mentioned in last month's report from Working Group I of the Intergovernmental Panel on Climate Change (*Science*, 8 December, p. 1565) but have not yet been published.

The South Asian monsoon is a unique annual atmospheric phenomenon driven by heat differences between the south Asian land mass and the Indian Ocean. During April and May, the land heats up faster than the ocean, creating a land-sea gradient in temperature and pressure that drives the monsoon circulation across the Indian subcontinent. Rainfall during the 4-month monsoon accounts for more than 70% of the annual precipitation over the subcontinent.

A greenhouse warming might be expected to amplify the temperature gradients and the resulting rainfall. But even as greenhouse gases increase, industrialization in China and India is blanketing south Asia in an aerosol haze. The cooling effect of the haze could reduce the land-sea temperature contrast, weakening the monsoon. In addition, a cooler land surface could mean less evaporation and reduced water vapor in the atmosphere.

That's just what the IIT-MPI group found when they ran their model assuming both a 1.3% per year increase in carbon dioxide and a fivefold increase in peak aerosol levels over India by midcentury. The projected decrease in the monsoon ranges from 0.5 millimeters to 1.0 millimeters a day over the fertile north and central Indian plains. That represents a possible drop of 7% to 14% in the average rainfall of 88 centimeters for the 120-day monsoon season. Anything below 10% is considered a threat to agriculture. The monsoon will increase over south India, but by an amount smaller than predicted by models based only on greenhouse gases.

Results from the new model compare well with some observed climate trends. The prediction of a rise of 0.33 degrees Celsius in average near-surface temperatures over India during the past century is close to the 0.4 degrees published recently by the Indian Meteorological Department. The total average predicted rainfall, says Lal, is "marginally lower" than the historical mean.

Beyond its importance to agriculture, the results from the improved model also carry political overtones. "It shows that China can have an important impact on India," says MPI's Ulrich Cubasch, a co-author on the paper. "Specifically, what it suggests is that greater industrialization in China will mean less food for India."

The next step for both groups is joint research on the effect of aerosols—their migration patterns and influence on clouds, for example—and on probable future emission levels. Scientists hope to incorporate that knowledge into improved models of how the rainfall is likely to be distributed during the monsoon, the biggest factor in determining agricultural output.

Despite its uncertainties, the new work is recognized as underscoring the central role of aerosols in climate change. "Two independent groups working with different models and arriving at similar results helps boost confidence in the projections," says Tom Wigley of the U.S. National Center for Atmospheric Research in Boulder, Colorado. "The figures might need to be revised, but the crucial point is that regional models are different when aerosols are included."

–Ganapati Mudur

Ganapati Mudur is a science writer in New Delhi.