EMERGING RESEARCH FRONTS - 2009

February 2009

PDF

Paul J. DeMott talks with *ScienceWatch.com* and answers a few questions about this month's Emerging Research Front Paper in the field of Geosciences.

Article: African dust aerosols as atmospheric ice nuclei
Authors: DeMott, PJ;Sassen, K;Poellot, MR;Baumgardner, D;Rogers, DC; Brooks, SD;Prenni, AJ;Kreidenweis, SM
Journal: GEOPHYS RES LETT, 30 (14): art. no.-1732 JUL 17 2003
Addresses: Colorado State Univ, Dept Atmospher Sci, Ft Collins, CO 80526 USA.
Colorado State Univ, Dept Atmospher Sci, Ft Collins, CO 80526 USA.
Univ Alaska Fairbanks, Inst Geophys, Fairbanks, AK 99775 USA.
Univ N Dakota, Dept Atmospher Sci, Grand Forks, ND 58201 USA.
Univ Nacl Autonoma Mexico, Mexico City 04510, DF, Mexico.
Natl Ctr Atmospher Res, Boulder, CO 80307 USA.

SW: Why do you think your paper is highly cited?

I think the paper highlighted a growing recognition that mineral dusts may play complex roles in affecting climate, due not only to their impacts on radiative transfer but also due to their action as favored nuclei for forming warm and cold clouds. Our paper confirmed, through actual airborne measurements, the particular action of mineral dusts as nuclei for the formation of ice in clouds, even after transport for thousands of kilometers.

The paper is one of the first that demonstrates this via field measurements and not through only theoretical or modeling arguments. This behavior of dusts is not yet explicitly accounted for in climate change assessments and requires consideration also in the context of net impacts (thermodynamic and microphysical) of dust plume ingestion by hurricanes in their formative stages. Yet, mineral dusts travel widely in the atmosphere at all times of the year and so it is vital to understand their microphysical interactions with all types of clouds.

SW: Does it describe a new discovery, methodology, or synthesis of knowledge?

Previous knowledge on the ice nucleation behavior of mineral dusts in the atmosphere came from measurements of composition of the central nuclei of snow crystals and from laboratory studies of specific minerals or mixes of these. It stood to reason that if one encountered a concentrated dust plume, such as that we encountered within the Saharan aerosol layer near Florida, the number concentrations of ice nuclei would be greatly elevated, but until recently these ice nuclei number concentrations could not be measured in real-time from aircraft.

Our measurements confirmed that ice nuclei concentrations increased when the aircraft penetrated the dust layers. Together with other measurements of cloud properties, we showed that the dust particles help ice particles to form at warmer temperatures and in greater numbers in dust-affected clouds. The newness involved was the technological capability to reliably measure the relatively small number concentrations of ice nuclei (sometimes only 1 in 10,000 of cloud condensation nuclei) in real-time, to collect the nuclei to confirm their nature, and to have enough supporting measurements (lidar, other aerosol measurements) along to clearly associate the ice nuclei with the transported dust layer. We were the only group able to make these types of measurements at that time.

SW: Would you summarize the significance of your paper in layman's terms?

This research made it crystal clear that the emission and transport through the atmosphere of mineral dusts is a major global source for particles that form ice in clouds, a process that is a necessary first step in precipitation formation for many clouds on earth. By implication, such particles represent a large potential lever on the hydrologic cycle, so new measurements are needed and models ultimately need to carefully consider their sources and sinks in the context of human impacts and climate change.

SW: How did you become involved in this research and were any particular problems encountered along the way?

My involvement in this research came about through my interests in ice nucleation and cloud microphysics, which led us naturally from studies in the laboratory to ones on aircraft in the atmosphere. Our goals in the experiment discussed in the paper were to understand the mechanisms by which aerosols in the lower atmosphere impact clouds through the depth of the troposphere. We approached this through detailed measurements of the aerosols entering clouds and through similar analyses of particles that had activated to form ice; those collected directly as ice crystals (and evaporated to release the nuclei) from within the colder regions of clouds.

The measurements themselves involved 10+ years of team development of an instrument to measure ice nuclei with fast response by exposing aerosol to similar conditions as might be encountered in a cloud. As any atmospheric experimentalist knows, instrument development efforts are oftentimes works in progress. Each campaign brings its stress, defeats, and successes, and one can only hope that over time the trend is firmly toward the latter. The dust layer measurements we made were conducted within the last two days of a month-long project that began with an inoperable instrument. We left exhausted, but delighted that on return to our flight base on these last two days, we were able to obtain a unique data set that has stimulated long-term interest.

SW: Where do you see your research leading in the future?

The period of time following the paper release has seen an explosion of research into the impacts of aerosols on clouds and precipitation. Much new effort has been expended in laboratories throughout the world to investigate the behaviors of collected mineral dusts and their specific components as cloud nuclei. Simultaneously, many more investigators have now fashioned new instrumentation for obtaining measurements of ice nucleating aerosols in the laboratory and in the atmosphere. I see a period in which these measurements will be made widely and tied closely to documenting real effects on clouds. This information will be assimilated toward developing and improving theoretical and parametric descriptions that can be put in models that account for source emission through atmospheric and climate impacts.

This also largely describes where my own research is leading. At the same time, mineral dusts are not the only players. We need to understand direct and indirect human contributions to the populations of cloud-active aerosols via our land and energy usages, and we need to understand the dynamic contribution that may come also from biological particles, certain of which represent some of the best ice nucleators known to man. Therefore, I am pursuing and anticipate more cross-disciplinary research in this area.

SW: Do you foresee any social or political implications for your research?

The influence of man's activities on climate is something that has long been of concern to scientists, and is now increasingly of concern to many people around the world. As an example of implications of our work, activities that result in desertification of larger regions of the earth could lead to increased emissions of dusts active as ice nuclei in clouds, with unknown consequences for the global hydrological cycle. Changes in precipitation pattern and amounts might serve to moisten dry areas, or might lead to additional drying of arid regions, or might have no discernable impact.

Particles in the air know no boundaries, so changes in natural emissions or actions in other regions that

"The influence of man's activities on climate is something that has long been of concern to scientists, and is now increasingly of concern to many people around the world."

alter human sources of aerosols can influence clouds at long distances. As we increase our understanding of these complex processes and improve models by incorporating details on aerosol impacts at the cloud or storm scale, we will better have the ability to enter discussions across national and political boundaries about strategies to minimize or mitigate climate impacts.

Dr. Paul J. DeMott
Senior Research Scientist/Scholar
Department of Atmospheric Science
Colorado State University
Fort Collins, CO, USA

Keywords: UNITED-STATES; MINERAL DUST; DESERT DUST; TRANSPORT; ISRAEL.

PDF

back to top

2009 : February 2009 - Emerging Research Fronts : Paul J. DeMott