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Making rain with lasers

May 2, 2010 4 comments

Could lasers help make rain?

Firing extremely powerful laser pulses through humid air can stimulate the formation of clouds, according a team of European scientists. They say that the effectiveness of this method is much easier to gauge than traditional cloud-seeding techniques and that it could provide a practical means of triggering rainfall.

Cloud seeding is practised in many countries around the world and usually involves adding small particles to the atmosphere from ground stations, aircraft or rockets, in order to increase rainfall or reduce hail. This can be done by using molecules of silver iodide as nuclei around which supercooled water in higher-altitude clouds freezes, forming ice crystals that fall from the sky when heavy enough. Alternatively, compounds such as sodium, lithium and potassium salts can be released into lower altitude clouds in order to encourage the aggregation of small water droplets.

Although cloud seeding could have major practical benefits, it remains controversial because scientists have not been able to establish whether it really does change rainfall significantly. Among the many uncertainties are limitations in both our understanding of natural rainfall fluctuations and our knowledge of the extent to which pollutant aerosols stimulate precipitation.

Filaments of light

Philipp Rohwetter of the Free University of Berlin and colleagues in Germany, Switzerland and France believe that they can overcome these problems to some extent by seeding clouds using laser beams. To demonstrate their idea they used the portable Teramobile infrared laser with beam pulses lasting just 10^{-13} s and a power of 5×10^{12} W. Such pulses are intense enough to modify the refractive index of air, which causes the beam to focus itself. This further increases the intensity, producing filaments of light that are intense enough to ionize the air and initiate condensation.

The researchers fired the laser into both the atmosphere and into a controlled environment – a cloud chamber filled with ambient air. In both cases they illuminated the trajectory of the beam with a second, lower-powered laser, which would experience greater scattering if more droplets were present.

That is indeed what they found – the scattering of the second laser increased each time a pulse from the first laser was fired. They observed this pattern in over 900 laser flashes, providing, they say, a clear proof of the pulsed laser's cloud seeding capability that cannot be established for traditional seeding techniques.

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Nature Photonics
doi:10.1038/nphoton.2010.115

Sweeping the beam

According to team member Jerôme Kasparian of the University of Geneva, several years will be needed to turn this physical demonstration into a practical technique. In particular, he says, a more powerful laser will probably need to be developed to take advantage of a sweeping effect that they have noted – that ionization continues for a few seconds after the laser has stopped flashing and so by sweeping the beam it should be possible to seed a larger volume of air.

More importantly, the researchers need to establish the physics behind the effect in order to know how to optimize the laser's wavelength, pulse duration and other parameters. They are certain that the ions in the laser-induced plasma contribute to condensation but they also believe that condensation might occur on molecules of sulphuric acid and nitric acid, which are formed when electrons from the plasma generate the OH radical that then oxidizes sulphur dioxide and nitrogen, respectively.

The experiments, however, do not convince other researchers. Bill Cotton of Colorado State University in the US describes the results as "intriguing" but maintains that Rohwetter and colleagues have "grossly overstated their case for impacts on real cloud formation and, especially, on precipitation". In particular, he points out that the air in the cloud chamber had a relative humidity of 230% whereas that in the atmosphere rarely exceeds 101%, meaning that droplet formation in the chamber would not necessarily imply droplet formation in the atmosphere.

This view is supported by Dan Breed of the National Center for Atmospheric Research in Colorado, who says that, on the other hand, laser-enhanced condensation in air with a relative humidity of less than 100% would be very transient and therefore unlikely to generate significant amounts of new cloud droplets, let alone precipitation. "The leap to modifying clouds and even larger jump to influencing precipitation is very speculative and I believe fairly unrealistic," he claims.

The research is described in *Nature Photonics* doi:10.1038/nphoton.2010.115.

About the author

Edwin Cartlidge is a science writer based in Rome

4 comments

Add your comments on this article

1 **nateburd**
May 3, 2010 6:49 PM
San Diego, United States

Ionization and Rain Drops

I didn't get a good sense of how the laser would ionize the air. My assumption would be that Nitrogen would be ionized and act as a nucleation site for the water molecules.

The picture at the top of the article is based on a misconception about the way water experiences free fall. Water drops are nearly spherical as they experience free fall.

Reply to this comment Offensive? Unsuitable? Notify Editor

2 **John Duffield**
May 4, 2010 2:36 PM
United Kingdom

I found I could follow the link and read the paper, Nate. They talk about ionising the oxygen and go on to say:

"The exceptionally high charge density could also result in a production rate of oxidizing molecules such as O3 and †OH radicals that is orders of magnitude above the natural rates found in the atmosphere. The resulting †OH, together with the O2- ions mentioned above, will rapidly produce Wilson clusters, oxidize SO2 and NO2 into H2SO4 and HNO3 respectively, and assist their heterogeneous nucleation as well as that of volatile organic species."

Sounds interesting stuff.

Edited by John Duffield on May 4, 2010 2:37 PM.

Reply to this comment Offensive? Unsuitable? Notify Editor

3 **mindmire**
May 5, 2010 12:44 AM
Richmond, United States

The article describes an interesting experiment but to imply the technique would avoid the controversy of cloud seeding is terribly simplistic. The politics of seeding concern more than the uncertainty of the outcome. No matter the method, successfully triggering condensation will always steal water from downwind locations

that might have benefited from natural precipitation. Will we fail to consider unintended consequences as we did not so long ago when damming rivers?

Reply to this comment Offensive? Unsuitable? Notify Editor

4 **gjw284**
May 5, 2010 10:27 PM

Quote:

> *Originally posted by* ***nateburd***
> I didn't get a good sense of how the laser would ionize the air. My assumption would be that Nitrogen would be ionized and act as a nucleation site for the water molecules.
>
> The picture at the top of the article is based on a misconception about the way water experiences free fall. Water drops are nearly spherical as they experience free fall.

When in free fall Water droplets are only spherical at relatively low speeds, at higher velocities of free fall they are not entirely spherical. The area to the underside of the droplet is flattened as a result of friction with the atmosphere which is enough to distort the usual spherical surface tension shape of said droplet. it would appear spherical from above or below but from left or right handside view they would appear hemispherical if falling in the vertical, if there was an angle to the descent the droplets would be skewed to compensate for this.

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