Influence of cosmic rays on cloud droplet formation explored in a global climate model

February 12 2013

Above the clouds.

A research team from the State University of New York-Albany and Pacific Northwest National Laboratory used a global atmospheric model to estimate that charged ions produced by cosmic rays in the atmosphere increase new atmospheric particles formed by a factor of ten when compared with particles formed by a corresponding neutral, non-charged, mechanism. Though cosmic rays ionization is important in forming aerosol particles and altering the make-up of clouds, the team determined that the changes during the solar cycle are insufficient to

produce a measurable change in the Earth's energy balance.

It's not the stuff of Buck Rogers. Scientists want to know: do cosmic rays alter clouds and climate? Some studies show a connection between measured variations in cosmic radiation, such as solar flares coming from the sun's surface, and climate, but establishing a physical mechanism remains elusive. One proposed mechanism is a chain of events that form new particles which affect clouds. In this scenario, cosmic radiation influences the concentration of ions in the atmosphere, which provokes new particles forming from the ions. Then, as the particles collide and condense on other gasses in the atmosphere, the new particles grow until they are large enough to form cloud droplets. Finally, the cloud droplets' surface area is thus altered affecting the energy balance of the planet. Although all of these mechanisms are plausible, the scientists in this study tackled a key question: whether the variations during solar cycles are large enough to produce a measurable influence on climate. Their verdict: not so much.

For this study, researchers from SUNY-Albany and PNNL added an ion-mediated nucleation mechanism to a global climate model that already represented other mechanisms for new particle formation. In the model, they first compared the total nucleation rates, cloud droplet numbers and the Earth's energy balance calculated with and without the presence of ionization. Then, they simulated variations in those quantities using measured changes in cosmic rays during different phases of the eleven-year solar cycle. The average change in the global energy balance between the solar minimum and solar maximum was smaller than 0.06 Wm-2. This is more than ten times smaller than changes due to increases in carbon dioxide or aerosol particles resulting from human activity over the last one hundred years.

The estimate of the solar cycle ionization effect on the Earth's energy balance is uncertain because of random variations in the simulated

clouds. To isolate the cosmic signal from the noise of random cloud variations, the group will repeat the simulations but nudge the simulated winds toward the same winds in all simulations. Further research is also needed to reduce uncertainties in the model representation of key aerosol particle and aerosol-cloud interaction processes.

More information: Yu, F. et al. Indirect Radiative Forcing by Ion-mediated Nucleation of Aerosol. *Atmospheric Chemistry and Physics* 12, 11451-11463. DOI:10.5194/acp-12-11451-2012.

Provided by Pacific Northwest National Laboratory