METER
ENVIRONMENT

SOIL MOISTURE AND TEMPERATURE SENSORS AID LANDMINE DETECTION

Anti-personnel landmines are one of the most dangerous environmental hazards worldwide. Each year thousands of people are injured by landmines buried in eighty different countries. Ben Wallen, Ph.D. candidate and active military officer at the Colorado School of Mines, is using soil moisture and temperature sensors to model, simulate, and predict how environmental conditions affect landmine detection performance.

LANDMINE DETECTION

Anti-personnel landmines are difficult to detect. They are small and often contain very little metal. It is difficult to differentiate between a landmine and, for example, a rock.

Success depends on many factors, including the landmine's physical composition and how long it's been in the ground. The numerical and analytical models used to find the mines rely on detailed data about conditions in the subsurface. Wallen and his Ph.D. advisor, Dr. Kate Smits, realized that changing environmental conditions—particularly changes in soil moisture content—were commonly overlooked in developing these models. By gaining a greater understanding of these dynamic environmental conditions, Wallen thought he could better calibrate the numerical models used in detection technologies such as ground penetrating radar.

COMPARISONS

The goal of Wallen's research was to improve understanding of the complex flow processes of water, water vapor, and air in the shallow subsurface. He installed METER soil moisture and temperature sensors in a field site in order to understand how landmines buried at different depths affect spatial patterns of soil moisture. He compared holes with mines at a shallow depth (2.5 cm) to more deeply buried mines (10 cm). He also measured the environmental response to shallow empty

holes roughly the size that you'd dig for the placement of a mine. He realized if there was an identifiable response between a disturbed hole with nothing in it and a hole with a mine buried, researchers would be able to do experiments with different soils in a lab without needing a buried landmine in order to investigate the environmental response associated with a buried landmine.

RESULTS

Wallen was able to see differences in the "with mine" and "without mine" treatments. He says, "The soil moisture in the disturbed soil 2.5 cm below the surface with no landmine inserted matched very well to a shallow-buried mine. The only time it really deviated was when there was a saturation event. At that point, there was a break from that relationship, but then, in 36 hours, the soil moisture returned to matching very closely between the disturbed soil hole and the shallow-buried mine." Wallen says there was also a relationship in the case of the more deeply buried mine. He adds, "For a deeply buried mine, both the soil moisture and temperature in the disturbed soil 2.5 cm below the surface had a strong correlation with the response to the dug, disturbed hole."

TEROS 12 soil moisture and temperature sensor

AN ARRAY OF SENSORS IS CRUCIAL

Ben says it was important to his study to use a suite of measurement tools that complimented each other. In addition to soil moisture sensors, he used an IR camera to detect surface temperature differences prior to the saturation event, during saturation event, and then afterward, helping identify the different scenarios of

shallow-buried mines, deep buried mines, and the disturbed soil. He comments, "There are numerous global climate models that may be used to predict evaporation from energy balances in order to understand what is occurring. By combining the sensors in this minefield detection scenario, we were able to really understand what was going on at different depths with soil moisture and temperature, and that enabled us to better understand how the system responds."

THE NEXT STEP

Now that Wallen has done a soil characterization of the site, he wants to incorporate the data into a 3D model to ensure that the model accurately represents the actual physical conditions he's observed. The next step is modeling under different climatic conditions: seeing what the environmental response is for various mine scenarios in a different soil environment.

MAKING THE WORLD A SAFER PLACE

The goal, according to Wallen, is to provide pertinent information that will improve landmine detection technologies. Understanding how temperature contrast impacts remote sensing technology and understanding how the soil moisture signature impacts ground penetrating radar. Ben says, "Ideally, this information takes us one step farther in being able to identify potential locations for landmines, but there is a long way to go. This is just one piece of the pie, but every step forward moves us toward the goal of making the world a little bit safer for everyone."

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