RÉPUBLIQUE FRANÇAISE
Liberté
Égalité
Fraternité

INRAE

Press release – 18 July, 2024

Predicting a crop field's weather

As the world tries to adapt to climate change, a major challenge is accurately predicting local-level meteorological conditions, such as those found in agricultural landscapes. INRAE researchers recently made a significant step forward: using a supercomputer, they simulated a forest plot's micrometeorological conditions in the early morning. This time period has rarely been modelled at such fine scales, yet it plays a crucial role in predicting the functioning of cultivated ecosystems. Published on July 18 in the *Journal of Atmospheric Sciences*, this work demonstrates that meteorological forecasts can be obtained at an extremely high level of resolution (~1 metre), making it possible to develop targeted agricultural strategies for mitigating the effects of climate change on crops.

The countryside is a mosaic of croplands, forests, hedgerows, and roads. This landscape heterogeneity gives rise to spatial variability in fluxes of heat, water vapour, and carbon dioxide, as well as in air movement, at scales ranging from millimetres to kilometres. These exchanges have a local influence on the climate, creating zones that may be better or worse off in the case of extreme climatic conditions.

Understanding this complexity is essential if we wish to develop agricultural strategies that can exploit micrometeorological patterns to mitigate extreme climatic situations. For example, agroforestry systems combine trees and field crops, the result is a reduction in soil evaporation, wind speed, and heat spikes–conditions that favour crop growth. Studying microclimatic variability requires the ability to make extremely fine-scale meteorological predictions that account for exchanges between the vegetation and the atmosphere.

INRAE researchers set out to simulate micrometeorological dynamics within agricultural landscapes using a 5-by-5 km forest plot. Thanks to the Juliot-Curie supercomputer provided by France's Alternative Energies and Atomic Energy Commission (CEA), the researchers generated 7.5 TB of data over several months (~26 days of continuous computing) to produce a simulation that recreated mass and energy exchanges on the plot over a 5-hour period. This massive amount of information made it possible to obtain an extremely fine level of spatial and temporal resolution (metres and milliseconds, respectively).

The simulation was used to represent mass and energy fluxes at the top of the forest canopy during the early morning–from 4 to 9 am. This complex period of the day has been little studied because of its high degree of temporal variability, which is linked to surface warming. Indeed, the morning is when the atmospheric boundary layer[1] develops and grows, subsequently mixing all the compounds emitted by the surface, including pollutants. The researchers identified differences in exchanges of heat, water vapour, and carbon dioxide between the forest and the atmosphere under conditions of low versus high wind flow. Using this simulation, the researchers reproduced, for the first time ever, the massive early-morning release of carbon dioxide by the forest under conditions of low wind, a dynamic that results from the gas's nocturnal accumulation within the forest.

---

[1]Lowest part of the atmosphere directly affected by exchanges between the earth's surface and the atmosphere.

This research lays the groundwork for improving how surface exchanges are represented in meteorological and climatic models. Indeed, when models fail to account for surface heterogeneity, they may yield faulty predictions of meteorological conditions at regional scales.

Doctoral research is underway to expand this simulation approach to more complex landscapes, with the goal of studying micrometeorological dynamics in hilly environments where crops and forests are grown together, as well as in agroforestry systems. The aim is to understand how landscape heterogeneity affects microclimatic conditions and to identify strategies for managing agricultural landscapes so as to mitigate the effects of climate change on crops.

Reference

Dupont S., R. Irvine M., Bidot C. et al. (2024). Morning transition of the coupled vegetation canopy and atmospheric boundary layer turbulence according to the wind intensity. *Journal of Atmospheric Sciences*, https://doi.org/10.1175/JAS-D-23-0201.1

Scientific contact

Sylvain Dupont - sylvain.dupont@inrae.fr
Joint Research Unit for Soil-Plant-Atmosphere Interactions