

Tuesday, April 14 / 14:30 - 15:30

From Satellites to Smartphones: Opportunities for Digital Agriculture in Apple Orchards

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The Semear Digital project represents a nationwide initiative in Brazil that aims to foster digital agriculture through the establishment of ten Agrotechnological Districts (DATs) across diverse production systems. Among them, the DAT of Vacaria, located in the state of Rio Grande do Sul, stands out as a strategic area for temperate fruit production, particularly apples. This DAT is recognized as one of the most important apple-producing regions in Brazil and plays a key role in both national and international markets. This makes the district an exemplary case to explore the opportunities of integrating remote sensing, artificial intelligence, and field data collection for agricultural innovation. Apple production in Vacaria faces significant challenges, especially related to climate risks. Hailstorms are recurrent in the region and impact orchard productivity. As a result, anti-hail nets have become increasingly widespread as a protection strategy. However, scientific studies addressing how to map and monitor these protective structures through remote sensing remain limited. Identifying the presence and extent of anti-hail nets is crucial for improving the understanding of production systems, assessing the impacts of climate risks, and guiding management practices. Recent approaches developed within the DAT Vacaria have tested the combination of satellite imagery (Sentinel-2 and Harmonized Landsat-Sentinel-HLS) with machine learning and deep learning algorithms. These efforts enabled the mapping of apple orchards covered and uncovered by anti-hail nets. In parallel, ground-based data collection using mobile devices has provided new perspectives. Mobile phones images of Fuji and Gala apples are being used to evaluate the performance of neural networks for fruit detection, which can serve as the basis for developing future mobile applications not only for fruit detection but also for the assessment of different characteristics and parameters, such as size, color, or quality. Such applications may support farmers and technicians by offering practical and low-cost tools for monitoring orchard conditions. The integration of multisource data, from satellites, field surveys, and mobile devices, highlights the potential of the DAT approach for bridging scientific research and local agricultural practices. The case of Vacaria illustrates how digital agriculture can enhance resilience, productivity, and sustainability in fruit production. Moreover, the challenges observed, such as climate risks and the need for efficient monitoring of protective practices, are shared by other fruit-producing regions worldwide. Therefore, the methodologies and experiences developed in the Brazilian context offer insights and potential applications with international relevance.

Funding: São Paulo Research Foundation (FAPESP), grants 2022/09319-9, 2024/05205-4 and 2024/13150-5; and by the National Council for Scientific and Technological Development (CNPq/PQ), grant 302963/2025-1.