Satellite-based Mapping of Water in Fields

Satellite data is a time-efficient and inexpensive source for identifying and mapping waterlogged fields. With a particular specialization in agriculture, we develop solutions and applications for processing and analyzing satellite and weather data with machine learning and computer vision.

Stinna Susgaard Filsø [A], Lotte Nyborg [B]

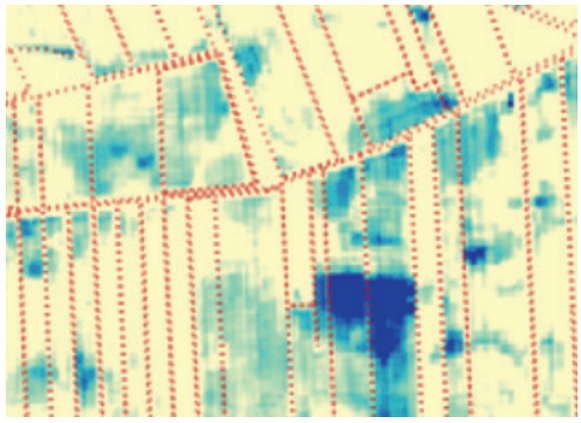
A: SEGES B: DHI GRAS

The challenge

Since the systematic monitoring of climate observations in Denmark started in the late 1800s, the mean precipitation at the national level has increased annually by more than 100 mm, with an accelerated trend in precipitation increase since 1940. At the same time, the rainfall events have increased in intensity, leading to challenges with flooded and waterlogged fields. Flooded or wet fields challenge the optimal timing of crop sowing because the soil is too wet and cold to support germination and growth. This reduces the crop root development, which results in a loss of yield as well as a loss of unused nitrogen. Thus, it is essential for the farmer to have well-drained soil to maintain an optimal production and to reduce the environmental impact from the agricultural soil. In order to allow the farmer to accommodate floods, it is necessary to know the extent of affected areas with drainage problems. Such an overview is normally difficult and time-consuming to obtain. Here, high-resolution satellite data provides a unique opportunity to cost-effectively map wet areas in the field.

The space-based solution

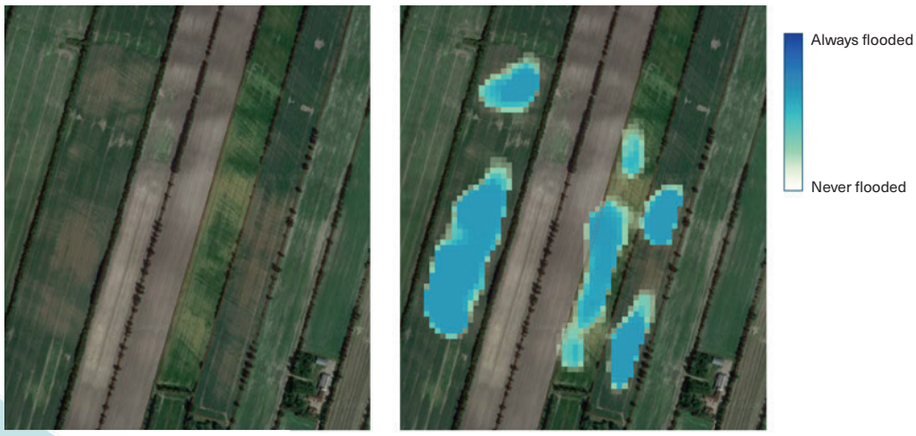
Large quantities of Sentinel-1 and Sentinel-2 data have been processed and analyzed to investigate and present different methods for mapping waterlogged soils in selected fields in Denmark. The optical time series from Sentinel-2 provide a good overview of the spatial distribution of water



The darker the blue, the more wet the area was during the season from September to April. Copyright: DHI GRAS, contains modified Copernicus Sentinel data [2019].

in fields, but the quality of the products is dependent on the cloud cover. The SAR-based data from Sentinel-1 has the obvious advantage of being independent of cloudless conditions and thus providing a more homogeneously distributed annual time series.

Time series of Sentinel-2 data can be analyzed and visualized in frequency maps, showing which areas are waterlogged during a growing season. Time series of Sentinel-1 data can be used to map larger areas with water issues and floods by using an automated method developed by DHI GRAS. Furthermore, the soil surface moisture at field level can be derived from Sentinel-1 observations, thereby mapping the annual relative development for independent fields. This can provide important in-



Flood-frequency map based on Sentinel-1 radar data. Copyright: DHI GRAS, contains modified Copernicus Sentinel data [2019].

formation for the farmers concerning the need for irrigation and the presence of waterlogged areas.

Further validation in relation to the observations made by the farmers is needed, but satellite-based methods provide a good opportunity to help understand which areas are prone to waterlogging and when the problems occur.

> **Mapping of waterlogged areas in fields provides important knowledge on where to improve drainage conditions – and where to minimize fertilizer and crop protection application.**
>
> *Jens Elbæk, farmer*

Benefits to Citizens

Mapping areas with drainage problems provides a way to focus and improve the efficiency of tools to secure a better drainage of cultivated areas.

Sufficient drainage of cultivated areas is key to an economically sustainable production of crops meanwhile securing a better utilization of nitrogen. This limits the risk of losing nitrogen from cultivated areas to the groundwater and surface water. Furthermore, the climate benefits because the risk of emission of the potent greenhouse gas nitrogen oxide (NO2) is reduced. The application benefits of developing satellite-based tools for mapping waterlogged farmland extend beyond agricultural interests.

The mapping will also be useful for governments, municipalities, and other stakeholders involved in climate adaptation, river management, and management of wetland areas.

Outlook to the future

Using satellite-based technology for mapping soils will only become more relevant in the future because of climate change invoking increased precipitation with more frequent incidences of intense rainfall. Additionally, artificial intelligence has the potential to contribute to the automatization of workflows even further in the future, hereby securing continuous monitoring of waterlogged fields.

Acknowledgements

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