

Mapping of Wet Areas in Denmark using Sentinel-1 and Sentinel-2

Time series analysis of Sentinel-1 and Sentinel-2 images is useful for mapping wet areas in Denmark. This includes the mapping of permanent and temporary lakes as well as flooded areas caused by extreme weather events.

Eva Bøgh ^A, John Kamper ^A, Lotte Nyborg ^B, Mads Christensen ^B, Georg Bergeton Larsen ^A

A: Agency for Data Supply and Efficiency B: DHI GRAS

The Challenge

Denmark is a lowland being frequently exposed to storm surges and floods from heavy rain and increasing groundwater levels. National scale temporal mapping of wet areas is important to support climate adaptation, agricultural and land use planning, environmental management, infrastructure planning and financial investments.

At the same time, a concrete challenge of Agency for Data Supply and Efficiency (SDFE) is to decide whether the many small lakes of the country include new lakes or not. SDFE monitors and maps lakes at very high spatial resolution using aerial orthoimagery acquired each year in spring. However, it is uncertain whether the identified lakes are in fact lakes, or whether the water will disappear after a few days.

The space-based solution

Remote sensing based temporal maps of wet areas using Sentinel-1 and Sentinel-2 time series are valuable for mapping both permanent and temporary lakes as well as the flood frequency of open areas.

There is also a large potential for validating and improving hydrological models and prognostic flood forecasts using Sentinel-1 based real time flood

maps in combination with the national elevation model.

How are satellite data applied?

Copernicus provides data for both lake and flood mapping.

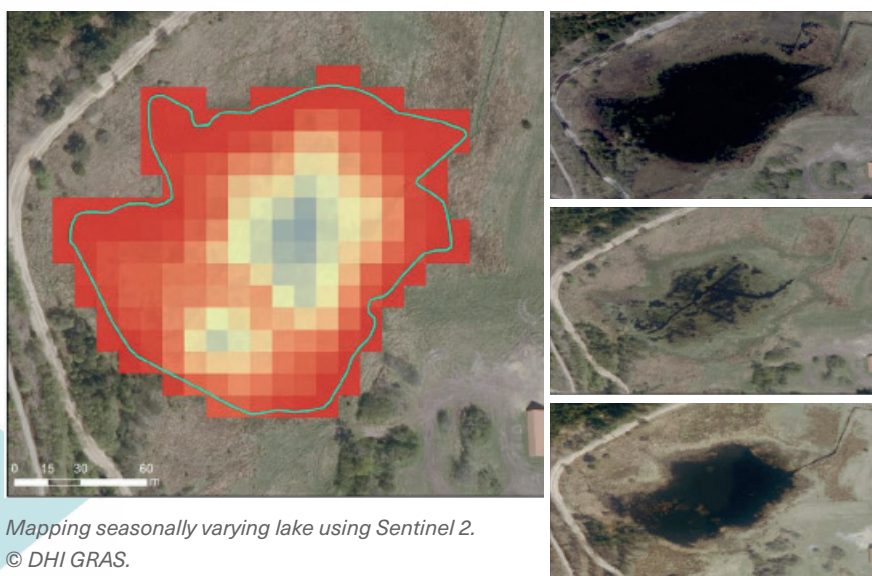
Flood mapping and modelling / Sentinel1 (S1):

The application of S1-data is not limited by cloud cover. This makes these data very valuable as event data for floods during overcast weather which is typical for "extreme-wet-events".

S1-data can be acquired in 10 m resolution before, during and after the flood event. Flood maps can be used as snapshot views of exposed areas and compared with hydrological model simulations. The combination of Sentinel flood maps and hydrological modelling is particularly useful if the satellite acquisition time does not correspond to the time of peak flooding.

Temporary lakes / Sentinel2 (S2): S2-data are optical data and therefore applicable during cloud-free weather conditions. Cloud-free S2 data can be composited over a period (weeks, months, etc.) to give cloud-free national scale dataset.

Using composite data, different indices can be cal-



Mapping seasonally varying lake using Sentinel 2.
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culated. This includes the NDWI which is related to the wetness of land surfaces and highly sensitive to open water. Using time series analysis of NDWI, the fractional water cover of each pixel is mapped. The water fractions give information about the wetness of pixels during a certain period, e.g. a year. The results are classified in terms of “wetness classes”, e.g. open land, meadow or moist grass. Using “ground-truth-data”, the wetness classes are related to land cover types and upscaled to national level to identify permanent and temporary lakes.

NDWI is calculated using the near-infrared and green spectral band of S2-data in 10 m resolution.

SDFE has completed two projects in collaboration with DHI-GRAS to assess the potential of Sentinel-1 and Sentinel-2 for mapping floods and seasonal lakes in Denmark.

Benefits to Citizens

SDFE can use these results to assess whether a lake is completely dry in periods and therefore should be deleted from the lake database, or whether the wetness class suggests that the lake should be reclassified as meadow or other wet land surface types. Changes in the spatial extent of wet areas can also be mapped.

SDFE can use the same wetness classes to map areas that are flooded over shorter periods due

to storm surges, cloudburst or high groundwater levels. For this purpose, it is also possible to use S1-data, as described above.

Perspectives and possibilities

SDFE expects that the methods also can be applied to map the dynamics of coastlines in tidal areas. This is particularly relevant in areas where tidal water fluctuates by more than 10 meters. Another perspective is to use Sentinel-1 and Sentinel-2 data in combination with SDFE's elevation model to map flooded areas.



Mapping of floods from Sentinel 1 data. Odense Å december 2015 © DHI GRAS.