HEIBRIDS
Helmholtz Einstein International
Berlin Research School in Data Science

Admission Round 2019

Project Title	**Facilitating Machine Learning on Super-High-Resolution Earth Observation Data for Detecting and Quantifying Arctic Permafrost Thaw Dynamics**
Project leads / supervisors	Prof. Dr. Guido Grosse (AWI, Helmholtz) Prof. Johann-Christoph Freytag, PhD (HU Berlin, ECDF)

Project description

Permafrost, covering one quarter of Earth's landmass, is undergoing significant change in a rapidly warming Arctic. Ground ice melt results in dramatic landscape reconfiguration in many regions due to soil volume loss, geomorphic change, and re-routing of hydrology. Permafrost soil carbon is mobilized and impacts the global carbon cycle by adding greenhouse gases to the atmosphere. In this PhD project, super-high resolution (<20cm) airborne stereo imagery and LiDAR point cloud data acquired with the AWI Polar-5 airplane in the Arctic will be processed and analyzed with machine learning methods to (1) **map ground ice distribution** and to (2) **detect and quantify the presence and abundance of thaw-related landforms**. Resulting data will be (3) used to **train deep learning algorithms such as convolutional neural networks (CNN)** to quantify such features in satellite imagery covering very large Arctic permafrost regions. Available datasets include tens of thousands of images captured with the innovative DLR MACS camera onboard Polar-5 in summer 2018 over Canada. Multi-year airborne LiDAR datasets exist for Alaska and Canada and additional data will be acquired in 2019-2021. The airborne data will be complemented by very high resolution (<50 cm) satellite imagery available at AWI. Their large spatial coverage results in raw datasets of tens of TB size that require processing and subsequent analysis with machine learning.

The project will result in a) the **development of methods for handling huge very high resolution imagery** datasets for Arctic landscapes, b) **new machine learning algorithms** to quantify ground ice and thaw-related features, c) the **detection of early warning signs of rapid permafrost thaw** in large regions of the Arctic using high resolution image and elevation datasets, and d) a **prototypical implementation using current Data Science concepts** for *data integration*, *data cleaning*, *data analysis*, *data visualization*, and *metadata management*. Potential platforms forming the basis for a **scalable implementation environment** in this project could be Apache Spark (UC Berkeley), Apache Flink (Berlin), or Apache Kafka. The experience gained in GeoMultiSens, one of the 10 BMBF-funded Big Data projects could help to advance rapidly in the current context. The work will be supervised by a team from AWI Potsdam, U Potsdam, HU Berlin, and DLR Berlin.

Candidate requirements:

The position requires a MSc or equivalent degree in Data Sciences, Remote Sensing, Geo-Informatics, or data-driven Earth Sciences. A strong background in handling and analysis of large datasets or highly automated remote sensing data processing is required. Solid skills in programming and geospatial statistics are highly advantageous. Experience in working with scalable cluster systems or similar processing environments/systems will be beneficial. Experiences in the application of machine learning / deep learning algorithms and the visualization of geospatial data are highly welcome. The candidate should be familiar with current Data Science concepts for *data integration*, *data cleaning*, *data analysis*, *data visualization*, and *metadata management*.

Fluency in English language (written and spoken) is required for this work in an interdisciplinary and international research group. Generally good communication, teamwork, and writing skills are required. Participation in multi-week field campaigns in the Arctic to collect additional airborne data is an option, but not required.

References

Liljedahl AK, **Boike J**, Daanen RP, Fedorov AN, Frost GV, **Grosse G**, et al. (2016): Pan-Arctic ice-wedge degradation in warming permafrost and its influence on tundra hydrology. *Nature Geoscience*, 9: 312–318.

Zhang W, Witharana C, Liljedahl AK, Kanevskiy M (2018): Deep Convolutional Neural Networks for Automated Characterization of Arctic Ice-Wedge Polygons in Very High Spatial Resolution Aerial Imagery. *Remote Sensing*, 10, 1487.

Nitze I, **Grosse G**, Jones BM, Romanovsky VE, **Boike J** (2018): Remote sensing quantifies widespread abundance of permafrost region disturbances across the Arctic and Subarctic. *Nature Communications*, 9: 5423.

Antonova S, Sudhaus H, Strozzi T, Zwieback S, Kääb A, Heim B, **Langer M**, Bornemann N, **Boike J** (2018): Thaw subsidence of a yedoma landscape in northern Siberia, measured in situ and estimated from TerraSAR-X interferometry. *Remote Sensing*, 10(4) (494).

Abolt, C.J., Young, M.H., Atchley, A.A., Wilson, C.J., 2018. Brief communication: Rapid machine learning-based extraction and measurement of ice wedge polygons in airborne lidar data, *The Cryosphere Discuss.*, https://doi.org/10.5194/tc-2018-167.