**CEOS Demonstrator - Concept Paper:** Ecosystem Extent Mapping Using Earth Observation Data over Wapusk National Park in Manitoba, Canada.

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**Introduction**

The Hudson Bay Lowland, located in northeastern Canada, stands as a remarkable region of global importance for both carbon storage and biodiversity. This vast area, encompassing approximately 324,000 square kilometers, is characterized by its unique blend of wetlands, peatlands, and boreal forests. In addition to its importance to indigenous people on this traditional territory, it plays a crucial role in mitigating climate change by serving as a significant carbon sink and harboring diverse ecosystems that support a wide array of plant and animal species. The conservation and preservation of the Hudson Bay Lowland are not only essential for maintaining the delicate balance of global carbon cycles but also for safeguarding the rich biodiversity and ecological services that it offers. Understanding the intricate interplay between carbon storage and biodiversity within this region is paramount for devising effective conservation strategies and sustainable land management practices.

**Demonstrator Goal and Objectives**

The overarching purpose for the demonstrator is to convey how satellite remote sensing is essential for mapping and monitoring ecosystems. To achieve this, three specific objectives will be pursued:

* To estimate the extent of each ecosystem class and ecotype within the ecozone, providing valuable information for biodiversity assessments, carbon cycling studies, and conservation planning.
* To generate a detailed ecosystem map of Wapusk National Park by combining a variety of Earth Observation and other data sources with advanced Machine Learning Classifiers
* To estimate the extent of each ecosystem and ecotype within the park, providing valuable information for conservation and management purposes and a foundation for future research and monitoring initiatives focused on ecosystem dynamics and changes.

**Approach**

The work will use advanced AI algorithms and other methods to combine data from several satellite sensors, *in situ* biodiversity data, and data from other sources. It will utilize the CEOS Analytics Laboratory (running on an Open Data Cube, ODC) developed by the CEOS System Engineering Office, which will provide technical assistance in setting up that infrastructure. The following technical steps are planned:

a) Data Acquisition and Ingestion:

* In addition to the ODC core datasets, obtain hyperspectral satellite data (ENMAP), ALOS L-Band, and TerraSAR-X data covering Wapusk National Park. It is hoped that JAXA and DLR can assist with obtaining the data.
* Preprocess the data, including atmospheric correction, radiometric calibration, and geometric alignment, to ensure data consistency and quality.
* Ingest the preprocessed data into the selected datacube platform, ensuring metadata integration and proper organization.

b) Data Storage and Indexing:

* Design and implement a data storage infrastructure within the datacube platform to efficiently store the preprocessed hyperspectral, radar and DEM data.
* Develop indexing techniques and data structures to optimize data access, retrieval, and visualization capabilities of the datacube platform.

c) AI Model Development:

* Develop and train AI models, such as deep learning architectures (e.g., CNNs or RNNs), specifically tailored to hyperspectral data analysis and ecotype classification.
* Utilize training datasets consisting of labeled samples and ground truth data to teach the AI models to recognize and classify different ecotypes within the Hudson Bay Ecozone.

d) Data Fusion and Analysis:

* Fuse the hyperspectral satellite data (ENMAP) and ALOS L-Band data, leveraging data fusion techniques to exploit their complementary spectral and spatial information.
* Incorporate the high resolution DEM data into the analysis, integrating topographic characteristics as additional input features to enhance the accuracy and precision of ecosystem extent estimation.

e) Mapping and Extent Estimation:

* Generate a final ecosystem and ecotype map for the entire Wapusk National Park by applying the trained AI models to the fused hyperspectral and DEM data within the datacube platform.
* Quantify the extent of each ecosystem class and ecotype within the Park, to link to information for biodiversity assessments, carbon cycling studies, and conservation planning.

**Partners and Roles**

* Environment and Climate Change Canada (ECCC)
* CEOS
* Parks Canada
* JAXA, DLR, CSIRO

**Expected Outcomes and Significance**

By utilizing a datacube platform in combination with multi-sensor satellite data, advanced AI algorithms, and incorporating a high-resolution DEM, this project aims to provide a comprehensive ecosystem and ecotype map of Wapusk National Park and lay the groundwork for maps of the entire Hudson Bay Ecozone. The project's technical approach, including data preprocessing, advanced AI model development, and fusion with DEM data, should enable more accurate and detailed mapping results. The incorporation of high-resolution topographic information will enhance the understanding of how landscape characteristics influence ecosystem distribution and functioning within the ecozone.

The outcomes of this project will enhance our understanding of the park's ecological composition for biodiversity assessments and monitoring, support targeted conservation efforts, and serve as a valuable resource for ongoing monitoring and management initiatives. As such it is an ideal way to demonstrate to both CEOS agencies and the biodiversity community the essential nature of satellite data for monitoring biodiversity—and thus for supporting its management and benefits to society. Lastly, the project's methodology and findings will support future research and monitoring initiatives that have a strong dependency on satellite remote sensing, and likely be of particular value for wetland ecosystems.Top of Form

**Challenges**

Key challenges include analysis of data sources unfamiliar to the project partners. For example, ECCC has expertise in hyperspectral remote sensing, but not with ENMAP platform and the application of neural networks to hyperspectral and SAR fused datasets is a new area of research for most of the EO community.

**Schedule**

* September 2023 – Confirmation of data availability (JAXA, DLR)
* December 2023 – CEOS Analytics Lab – Data Cube prepared.
* Winter/Spring/Summer 2024 – Analysis and Write up.
* Fall 2024 – demonstration and delivery at CEOS Plenary