Monitoring Landscape Inundation Dynamics for Supporting Characterization of the Carbon Cycle of Northern Eurasia

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Project Summary:

Wetlands exert major impacts on global biogeochemistry, hydrology, and biological diversity. The sensitivity of wetlands to changes in global precipitation and temperature patterns and their ability to produce large quantities of methane gas are key global change questions. Rapidly rising temperatures across the northern high latitudes threaten to accelerate climate change through the release of carbon from the region's permafrost soils and ubiquitous lakes and surface waters. Northern Eurasia is characterized by large carbon storages and seasonal fluxes, through both sinks and sources, and is thought to be particularly susceptible to climatic change. Satellite remote sensing of global inundation dynamics thus can support the ability for a complete synoptic view of past and current inundation dynamics over large areas that otherwise could not be assessed. Coarse-resolution (~25km) data from satellite-borne passive and active microwave remote sensing instruments are well suited for the regional, continental, and global observation of large-scale inundation patterns. These data are primarily sensitive to the associated dielectric properties of the landscape and cover large areas within a relatively short amount of time (up to daily repeat in high latitudes). We are assembling a global-scale Earth System Data Record (ESDR) of natural Inundated Wetlands to facilitate investigations on the role of wetlands in climate, biogeochemistry, hydrology, and biodiversity. The ESDR includes global coarse-resolution (~25 km), multi-temporal mappings of inundated area fraction (Fw) across multiple years.

We present details of remote sensing data collections, algorithm application, and cross-product harmonization. Surface water and inundated vegetation is classified at 100m resolution using Advanced Land Observing System (ALOS) Phased Array type L-band Synthetic Aperture Radar (PALSAR) imagery. We combine AMSR-E and SeaWinds-on-QuikSCAT passive/active microwave data sets to quantify Fw at 25 km resolution with ~weekly temporal composites from 2002-2009. We compare information content and accuracy of the coarse resolution data sets relative to the SAR-based data sets. This ESDR will provide the first high-resolution, accurate, consistent and comprehensive global-scale data set of wetland inundation and vegetation.

Our LCLUC project is employing these data to support a synthesis of data sets to characterize carbon cycling of North Eurasian Earth Science Partnership Initiative (NEESPI) region. The wetlands datasets will be employed within a set of linked models to estimate the magnitude, potential future changes, and associated uncertainties in carbon sinks and sources.

ESDR Components:

The Inundated Wetlands ESDR will consist of two complementary components: 1) Fine-resolution (100m) maps of wetland extent, vegetation type, and seasonal inundation dynamics, derived from ALOS PALSAR, for continental-scale areas covering crucial wetland regions.

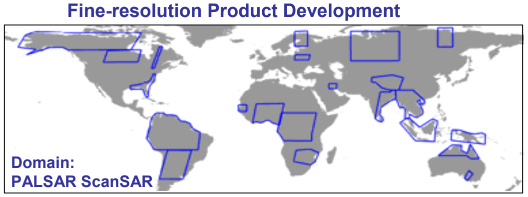
2) Global mapping of inundation extent at ~25 km resolution and high temporal fidelity for 1992-2009, derived from multiple satellite observations.

Comparison and validation of these data sets will ensure self-consistency within the ESDR. Accuracy assessment of the fine-scale regional wetlands data sets takes advantage of high-resolution wetlands maps to be made available through K&C Initiative collaborators.

I. Regional inundated wetlands data sets from Synthetic Aperture Radar (SAR)
- Spatial coverage: Major global wetland regions, 100m resolution
- Temporal coverage: 1-2 year time series at 17-to-46 day intervals during 2006-2009 † ‡
- Retrospective 1990's-era from archived JERS data covering Alaska, Canada, Amazon
1. Wetland extent (maximum inundatable area, including water bodies).
2. Wetland vegetation type (Non-vegetated, Herbaceous, Shrub, Woodland, Forest).
3. Inundation state (Flooded, Non-flooded; 17-46 day intervals) ‡
4. Annual inundation duration

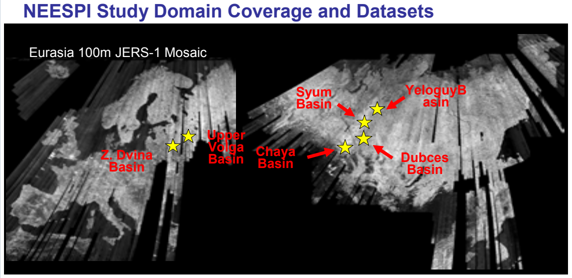
II. Global inundation data sets derived from multiple satellite data sources, daily and monthly composites
- Spatial coverage: Global, 25 km resolution
- Temporal coverage: Monthly monitoring with annual summaries, 1992-2009
1. Globally gridded (25km) inundated area fraction
2. Globally gridded (25km) annual inundation duration

Fine-resolution Product Development

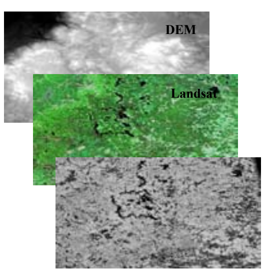


Regions for which ALOS PALSAR repeat acquisitions in ScanSAR HH-polarization mode (descending node) were planned (ref: ALOS Kyoto & Carbon Science Plan, v.2.0, 2006). We focus generation of the regional fine-resolution inundated wetlands data sets ESDR on regions covered by these ScanSAR polygons. **Selected to enable consistent, repeat coverage across large wetland regions, all of these regions receive at least one year of coverage with a 45-day repeat cycle, allowing mapping and monitoring of major wetland regions at 100-meter resolution**. All areas also receive PALSAR coverage in fine-resolution mode (ascending node) at least once.

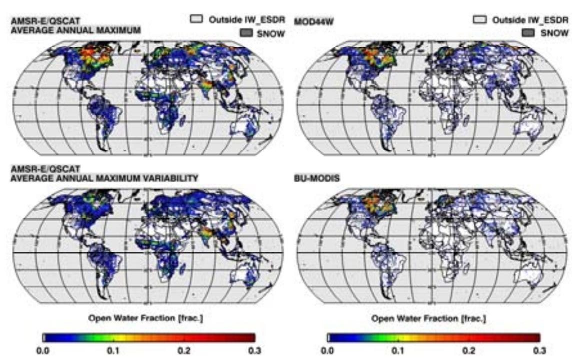
NEESPI Study Domain Coverage and Datasets



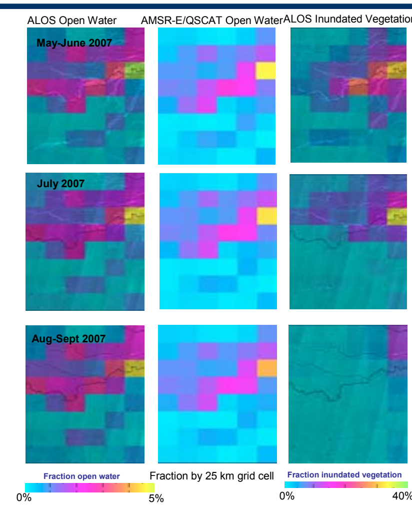
Multi-temporal high and low resolution microwave remote sensing data spanning the beginning of the seasonal non-frozen period through the end of summer was assembled over selected hydrologic basins (illustrated above) within the Northern Eurasia Earth Science Partnership Initiative (NEESPI) domain. Datasets employed include multi-temporal PALSAR data (L-band, 30 m resolution, HH and HV-polarizations) and combined QuikSCAT (Ku-band, ~25 km) and AMSR-E (C-band, ~25 km) of overlapping timeframes to map wetland distribution and inundation state within sub-regions of the NEESPI domain at multiple spatial and temporal scales. A digital elevation model (DEM), derived slope, and LANDSAT data were used where available as ancillary datasets (example on the right).

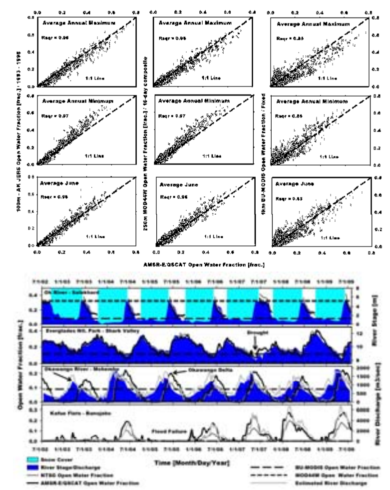


Coarse Resolution Products: Assembly and Comparison



Global mappings of inundation extent at ~25 km grid postings and high temporal fidelity (daily to monthly) are derived from multiple satellite observations (AMSR-E, QuikSCAT). Cross-product comparison with MODIS and harmonization with JERS and PALSAR products allows assessment of the relative accuracy and sensitivity of the coarse resolution products to wetlands components mapped at SAR resolutions. Comparison with basin-scale discharge measurements (far right) allow assessment of regional-scale performance.





Methodology:

SAR Data Classification- Decision Tree Classifier: Random Forest

Random forest operates by generating a large number of decision trees (a "forest") based on training data and using all input layers. Each decision tree is built through an iterative process where nodes are split according to the training pixel values in each input layer. This occurs until nodes can no longer be split. Each pixel is then classified by running it through every decision tree in the forest and assigning the pixel to the class selected by most decision trees. Ancillary datasets included a DEM, derived slope, optical datasets, and derived NDVI. The flow chart on the right shows the series of steps leading to the final classification product.

Assemble data layers

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Mutually co-register data layers to common projection and 30 meter resolution

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Derive ancillary products such as slope, ndvi, fusion of radar and optical

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Create training file based on ground truth data

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Mask data layers to exclude open water

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Set operating parameters and run Random Forest

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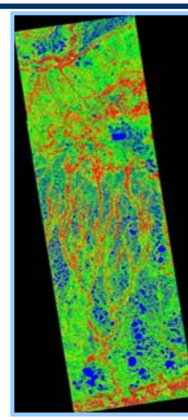
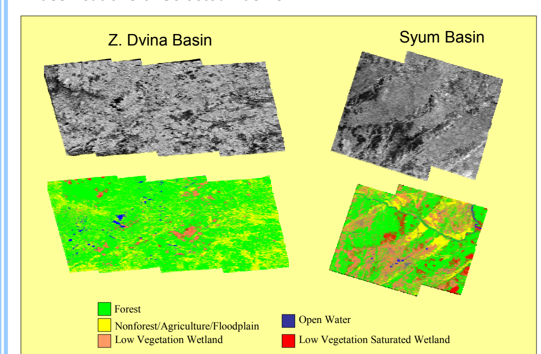
Wetlands classification →



Wetland Classification of Servut Basin, Northern Siberia

- Open water
- Inundated Vegetation
- Saturated Soil
- Vegetation

Classifications of Selected Basins



Development of the global Inundated wetlands Earth System Data Record is supported under the NASA Making Earth Science Data Records for Use in Research Environments (MEaSUREs) program. This work was carried out in part within the framework of the ALOS Kyoto & Carbon Initiative. PALSAR data were provided by JAXA/EORC and the Alaska Satellite Facility. Portions of this work were conducted at the Jet Propulsion Laboratory, California Institute of Technology under contract to the National Aeronautics and Space Administration.