FINAL AGENDA 27 May, 2022

SCERIN-9 Virtual Workshop

Focus: Satellite remote sensing for forest management and ecosystem health -

floods, droughts, and wildfires in the context of climate change

SCERIN web pages: https://www.scerin.eu/

Proceedings of the SCERIN-9 Workshop

FG 1: Forest monitoring:

Baban Gabriela
Transilvania University of Brașov
Romania
Can spaceborne and terrestrial LiDAR technology be used to map forest structure?
The need for better and more detailed information on the three-dimensional structure of forest vegetation has been pointed out for decades (Hurtt et al., 2010). Forest structure impacts forest succession, the carbon cycle, primary productivity, and fauna and flora (Brokaw & Lent, 1999), and helps provide a better estimation of aboveground biomass (Torano Caicoya et al., 2015). Monitoring this type of data through traditional field studies is labor-intensive, costly, and prone to bias (Curtis & Marshall, 2005), especially for large areas. A promising alternative is spaceborne LiDAR, such as the Global Ecosystem Dynamics Investigation (GEDI) and the Advanced Topographic Laser Altimeter System (ATLAS) mounted on the Ice Cloud and land Elevation Satellite (ICESat-2). We extract parameters from the two on a patch of forest in Dealul Lempeș, Romania, and we validate the product with the point clouds obtained from a field inventory with a terrestrial laser scanner (TLS). The purpose of this study is to assess the performance of GEDI and ICESat-2 in taking forest structure measurements with the help of a TLS and use the obtained parameters to estimate forest structure indices.

Chaskovskyy Oleh
Ukrainian National Forestry University
Ukraine
Near real time monitoring of forest clear cuts in Ukrainian Carpathian
Normalized Difference Vegetation Index (NDVI) is a robust tool for identifying changes in forestchar acteristics. Within the DIABOLO project, a NDVI based approach was implemented to give information on disturbance indications in near real-time and to give 29 reliable information on significant forest disturbances in the form of annual maps. The approach was tested in UkrainianCarpathians where clear-cuts are a standard forest management activity and the entire automatic approach was implemented on Copernicus Research and User Support (RUS) platform. The results of near real-time

implementation achieve higher producer accuracies (hotspots where disturbances may have occurred) and the results of annual mapping approach achieved higher user accuracies (areas of reliable significant disturbances which could be directly targeted using management intervention). The methodology can produce even higher quality results with improved forest masks and improved cloud and cloud shadow masks than were available during this study.

Gašparović Mateo
University of Zagreb - Faculty of Geodesy
Croatia
FOREST MONITORING BY REMOTE SENSING METHODS AND COPERNICUS DATA
The forests are the most widely spread land cover and therefore play a significant role in ecology and create processes' dynamics. To implement timely and effective adaptation actions against climate change, one of the main prerequisites is identifying changes, especially in the case of deforestation and forest degradation. Monitoring the health status, especially the intensity and dynamics of tree damage in stands of disturbed health status, is necessary for forest management. As a source of information, satellite imagery and remote sensing effectively analyse forests. Activities on our two recent scientific projects, „Automatic monitoring of narrow-leaved ash (Fraxinus angustifolia Vahl) forests by remote sensing methods and Copernicus data (RS4EST)" (https://rs4est.geof.hr/en/) and „Earth Observations and Artificial Intelligence for the Natura2000 floodplain forests mapping" founded by the European space agency will be presented.

Havryliuk Serhii
Ukrainian National Forestry University
Ukraine
Near real time monitoring of forest clear cuts in Ukrainian Carpathian
Normalized Difference Vegetation Index (NDVI) is a robust tool for identifying changes in forest characteristics. Within the DIABOLO project, a NDVI based approach was implemented to give information on disturbance indications in near real-time and to give 29 reliable information on significant forest disturbances in the form of annual maps. The approach was tested in Ukrainian Carpathians where clear-cuts are a standard forest management activity and the entire automatic approach was implemented on Copernicus Research and User Support (RUS) platform. The results of near real-time implementation achieve higher producer accuracies (hotspots where disturbances may have occurred) and the results of annual mapping approach achieved higher user accuracies (areas of reliable significant disturbances which could be directly targeted using management intervention). The methodology can produce even higher quality results with improved forest masks and improved cloud and cloud shadow masks than were available during this study.

Hoscilo Agata
Institute of Geodesy and Cartography
Poland
Mapping and monitoring of forest status in Poland using the satellite remote sensing.

The aim of the presentation is to inform about ongoing activities related to satellite-based mapping and monitoring of forest status and forest health condition in Poland. The study is focused on the use of the archive and current satellite datasets for the forest related applications.

Nita Mihai Daniel
Transilvania University of Brasov
Romania
Can spaceborne and terrestrial LiDAR technology be used to map the forest structure?
Can spaceborne and terrestrial LiDAR technology be used to map the forest structure? And if so, how can we use the acquired information to help our understanding of biodiversity and ecosystem services or the role of forests as carbon sinks? The need for better and more detailed information on the three-dimensional structure of forest vegetation has been pointed out since 2011 and underlined in programs such as Reducing Emissions from Deforestation and Forest Degradation. Forest structure is a good proxy for characterizing the habitat since any change in the horizontal or vertical configuration, visible or not, can impact the aboveme ntioned aspects.
Vertical structure reflects the hierarchy of trees and their compatibility with the site conditions and growing space, which affects their growth and development. It can further be defined as vegetation complexity, as opposed to horizontal configuration, that shows vegetation heterogeneity.
The main aim of this research is to assess the performance of spaceborne LiDAR missions in forest applications. To achieve this goal, we evaluated the use of GEDI and ICESat-2 datasets to determine biodiversity indices with the aid of forest vertical and horizontal structure. The resulting products were validated based on MLS (Mobile Laser Scanner) observations.

Švik Marian
Global Change Research Institute CAS
Czech Republic
Retrieving floodplain forest parameters through time series analysis of satellite observations using machine learning methods
The aim of this study is the spatial mapping of selected quantitative parameters of highly heterogeneous floodplain forest stands (4 tree species) using advanced machine learning methods implemented in ARTMO toolbox. A large database of ground-based surveys (7 campaigns covering different phenological phases of vegetation on 18 plots) was used to develop different machine learning models over a time series of satellite observations from 1) Landsat 8, 2) Sentinel-2 and 3) an HLS product combining both systems.

This allowed us to determine the accuracy of the quantitative vegetation parameter retrieval and the robustness of the trained models (i.e. their application to different tree species and their phenological phases). Assessing the potential of Landsat 8, Sentinel-2, and HLS time series to retrieve these products with respect to their spatial and temporal resolution is also considered an integral part of the study. By doing so, we will be able to recommend an appropriate dataset of time series observations for each of the selected quantitative vegetation parameters and study the benefits of improved spatial (Sentinel-2)

vs. temporal (HLS) and spectral (Sentinel-2) resolution for monitoring of highly heterogeneous forest ecosystems.

FG 2: Land Cover Changes

Kussainova Maira
Kazakh National Agrarian Research University
Kazakhstan
Study of greenhouse gas emissions using various treatments and automated measuring chambers on Kazakhstan croplands
Wheat, barley and corn is an important and main cover crops cultivated in Kazakhstan; hence, carbon dioxide (CO2), methane (CH4), and particularly fertilizer-derived nitrous oxide (N2O) emissions during cultivation must be quantified to assess putative greenhouse gas (GHG) savings, thus creating an urgent and increasing need for such data. At the COP-26 meeting, Kazakhstan confirmed the achievement of carbon neutrality by 2060. In this connection, our research has several aims to: (i) produce an accurate GHG budget of fertilizer application; (ii) characterize short- to medium-term variation in GHG fluxes; (iii) establish the processes driving N2O emission in croplands. Three treatments were applied: ammonium nitrate fertilizer (NH4NO3, 69 kg-N ha−1), organic manure and control. We deployed Licor-8100 for the very first time in cropland for Kazakhstan, a novel automated chamber system to measure CO2, CH4 and N2O fluxes at unprecedented high temporal and spatial resolution from Campbell Scientific weather stations. This suggests that the supply of carbon (C) from soil may have been the key driver of the observed diurnal pattern in N2O emission and thus should be considered in future process-based models of GHG emissions. This study began in 2021 in April and will be conducted until the end of December 2023. The research work is carried out with the support of the grant of the State Financial Service of the Ministry of Education and Science of the Republic of Kazakhstan IRN AP09057853-KC-21 titled: “Evaluating the effectiveness of various land cover/use systems to mitigate climate change by reducing greenhouse gas emissions and increasing albedo”.

Pashova Lyubka
National Institute of Geophysics, Geodesy and Geography - Bulgarian Academy of Sciences
Bulgaria
The SatWebMare project and its outputs related to change detection in the western Black Sea coastal zone
Ognyan Kounchev, Lyubka Pashova and SatWebMare project team

A short introduction about the SatWebMare project implemented by the IMI-BAS and Intellics Engineering Ltd, which was funded under the ESA PECS agreement with Bulgaria will be presented. The project's main idea is to build a prototype of an information system that provides integrated thematic and multidisciplinary services for different end-users of geospatial information about the coastal zone. Some peculiarities related to integrating the Copernicus S1/S2 and other Earth Observation (EO) data during the project time implementation (2018- 2022) will be discussed. Research highlights of the WP4

related to the monitoring of endangered areas from natural disasters, establishment of slow movements of the earth's surface, and determination of boundaries of destructive natural hazards for the coastal zone will be highlighted. General inferences concerning change detection in the western part of the Black Sea basin will be summarized. Special attention to the dynamics of LCLUC, built-up areas and artificial impervious surfaces will be paid.

Vatseva Rumiana
Geological Institute, Bulgarian Academy of Sciences
Bulgaria
Analysis of land use land cover changes and urban expansion in the Black Sea coastal zone in Bulgaria
Remote sensing and GIS prove to be the basic components of recent urban monitoring and mapping. This study aims to examine the dynamics of urban areas of the Bulgarian Black Sea coastal zone for the period 1977-2011 based on an integration of GIS and remote sensing. Geodatabase for urban areas was created using satellite and orthophoto imagery for five time series (for the years 1977, 1990, 2000, 2006, 2011) at both regional (1:50,000) and local (1:10,000) scales. It was used to evaluate and map the land use/land cover spatial structure and to reveal urban change patterns for the 35-year period. Results obtained from the analysis and mapping of built-up area dynamics indicates three main hot-spots: 1) Nesebar – Ravda – Sunny Beach – St. Vlas; 2) Sozopol; 3) Kavarna and Balchik. These endangered regions are emerged based on the extensive use of tourism resources and manifestation of certain negative impacts of tourism expansion.

FG 3: Validation/verification network

Campbell Petya
UMBC and GSFC
USA and Bulgaria
Assessment of vegetation traits using multispectral and hyperspectral images
Field and satellite optical remote sensing offer effective tools for assessing vegetation changes because of the ability of the reflectance spectra to capture the dynamics in canopy biophysical parameters. This study used surface reflectance images from multiple sensors, collected at a subset of pseudo-invariant and vegetated sites. Canopy traits derived using VNIR and VSWIR reflectance are compared to field data and to simulations using empirical and biophysical models. The results demonstrate the importance of the SWIR data for estimating vegetation traits.

FG 4: Water management and LC impacts

Brovkina Olga
Global Change Research Institute of the Czech Academy of Sciences
Czech Republic
Spatial and temporal distribution of Kaniv Reservoir hydromorphic landscapes formation

The overview of Global Surface Water product (Pekel et al. 2016) is provided to describe and analyze the spatial and temporal distribution of Kaniv Reservoir hydromorphic landscapes formation over the last 37 years – from 1984 to 2020. Several layers of the Global Surface Water data were used: occurrence, seasonality, recurrence, transitions and maximum extent.

The Water Occurrence shows where surface water occurred between 1984 and 2020 and provides information about overall water dynamics. This product captures both the intra and inter-annual variability and changes. The Seasonality map provides information concerning the intra-annual behavior of water surfaces for a single year (2020) and shows permanent and seasonal water and the number of months water was present. The Recurrence layer refers specifically to the temporal behavior of water surfaces; unlike occurrence, recurrence is not systematically computed over the full span of the archive, because water may not have been present from the beginning to the end of the archive. The Transitions map provides information on the change in seasonality between the first and last years and captures changes between the three classes of not water, seasonal water and permanent water. The Maximum Water Extent provides information on all the locations ever detected as water over the 37-year period. It is the union of all of the other datasets.

The data are used to support land use land cover change analysis of Kaniv Reservoir coastal area on the second stage of the research.

The material has been prepared within the framework of joint UA-CZ research project “Spatial-temporal dynamics of hydromorphic landscapes in changing climate and impact on local ecosystems in the Kaniv reservoir area” (2021-2022).

References:

Pekel, J-F., Cottam, A., Gorelick, N., Belward, A.S. 2016. High-resolution mapping of global surface water and its long-term changes. Nature 540, 418-422, doi:10.1038/nature20584.

Starodubtsev, V.M., Ladyka, M.M., Dyachuk, P.P., Naumovska, O.I. 2021. Main features of reforming the coasts of Kaniv Reservoir. Scientific reports of NULES of Ukraine, 6 (94), ISSN 2223-1609.

Kussainova Maira
Kazakh National Agrarian Research University
Kazakhstan

The effects of excessive water use and agricultural intensification on Aral Sea shrinkage: socioeconomic-environmental systems (SES) dynamics within the Syr Darya River Basin

One of the most dramatic changes in the Earth’s surface over the past six decades has been the shrinking of the Aral Sea in Central Asia. This project focuses on the causes of reduced stream flows through analysis of land cover trends, agricultural development, water withdrawals, irrigation intensity trends, population density, economic development, and policy shifts. Concepts, principles and methods from socioeconomic-environmental systems (SES) will be applied for three districts along the Syr River, the largest tributary for water supply to the shrinking Aral Sea. The long-term goal is to build a comprehensive database and knowledge to understand physical and socioeconomic changes, as well as their forcing and consequences on the ecosystems and societies within the Syr Darya River basin (SDRB). Specific project objectives are as follows: (1) to construct a comprehensive database of climate, stream flows, agricultural lands, time series of land cover at 5-year intervals since 1973, economic measures,

social indicators, and major policies for three districts along the Syr Darya River; (2) to explore the interdependent changes of food, energy, and water fluxes for the three districts with high-resolution data for mechanistic understanding of coupled changes between climate and land use; (3) to identify critical drivers (including policy shifts) on stream flows and evapotranspiration loss for the sustainable future of food, water, and energy; and (4) to construct an open-access webpage to share all the data and research findings with the public. The research team will integrate socioeconomic and biophysical changes by infusing databases from multiple sources, including satellite images, government statistics, past ground measurements of vegetation, soil, stream and climate, the literature, and their own field measurements. They will focus on three districts (Aralskiy, Syrdariya, and Zhanakorganskiy) that are located in the upper, middle, and lower sections of the river. Installations of three automatic weather stations and extensive surveys of the landscapes in Kyzylorda will fill some major data gaps.

Ladyka Maryna
National University of Life and Environmental Sciences of Ukraine
Ukraine
Spatial and temporal distribution of Kaniv Reservoir hydromorphic landscapes formation (presenter Olga Brovkina)

Ronczyk Levente
University of Pécs
Magyarország
Anthropogenic changes of the Lower Danube section in Hungary
River bed transformation and its consequences on the water regime in the lower section of Danube in Hungary.

Starodubtsev Volodymyr
National University of Life and Environmental Sciences of Ukraine
Ukraine
Spatial and temporal distribution of Kaniv Reservoir hydromorphic landscapes formation (presenter Olga Brovkina) 1

Woznicki Sean
Annis Water Resources Institute, Grand Valley State University
United States
Water scarcity in the Serbian Danube: Agricultural land use change and irrigation.
Water availability in the Serbian Danube is declining. As growing season precipitation decreases and becomes more unpredictable, farmers have difficult decisions to make. They can invest in irrigation to sustain yields or transition to less water-intensive crops. Water exploitation will exacerbate climate-driven water scarcity and could result in a race to the bottom for irrigation access. In Serbia, this process could play out across 630,000 farms that employ 21% of the working population. Meanwhile, Serbia is negotiating accession into the EU single market, increasing agricultural exports and altering

domestic agricultural policy. The interactions of market integration, climate change, and increasing water scarcity are uncertain, but they are drivers of agricultural land use decisions and understanding the feedback between them is critical. The goal of this research is to quantify how climate change, water scarcity, and markets drive farmer decision-making and resulting land use change. We are integrating remotely sensed crop land use and evapotranspiration with a hydrological model to quantify water use and availability. Crop maps, water availability, and commodity prices will inform conditional crop choice and irrigation adoption socioeconomic models to identify the drivers of agricultural land use change. This presentation will provide an overview of the project.

Regional hot-topics and remote sensing highlights

Brovkina Olga
Global Change Research Institute of the Czech Academy of Sciences
Czech Republic
Czech Republic remote sensing highlights contribution
Several topics from our outgoing research projects will be mentioned, such as: forest aboveground biomass estimation, species composition classification, urban vegetation, monitoring of municipal solid waste landfills.

Chaskovskyy Oleh
Ukrainian National Forestry University
Ukraine
Forest damages in Ukraine according to the war
One of the consequences of the war are the ecological disasters. It is including the forest damages, which are caused mostly forest fires and pollutions as a result of weapon using. The investigation of such disasters is necessary to taking into consideration for the common ecological losses. Because the ground investigations of such disasters are impossible in these conditions, one of the main ways to find a solution is the using of remote sensing data. For these investigations it is good to use the approaches and develops of change detection analyze, which based on the using different types of remote sensing data with different spatial resolution.

Filchev Lachezar
Space Research and Technology Institute, SRTI-BAS
Bulgaria
Application of UAVs and GIS in organic einkorn cultivation
Chanev, M., Valcheva, D., Bonchev, B., Filchev, L.

Havryliuk Serhii
Ukrainian National Forestry University
Ukraine

Forest damages in Ukraine according to the war
One of the consequences of the war are the ecological disasters. It is including the forest damages, which are caused mostly forest fires and pollutions as a result of weapon using. The investigation of such disasters is necessary to taking into consideration for the common ecological losses. Because the ground investigations of such disasters are impossible in these conditions, one of the main ways to find solution is the using of remote sensing data. For these investigations it is good to use the approaches and develops of change detection analyze, which based on the using different types of remote sensing data with different spatial resolution.

Kovacs Daniel Marton
University of Pécs
Hungary
Sentinel data fusion for official agriculture statistics in Hungary
Field level crop mapping is a rather conventional technology today, utilizing a wide range of satellite imagery fused and validated with ground-level datasets. However, there are certain land-cover categories and crop types that are difficult to distinguish from one another, even with the ever-developing tools of satellite remote sensing. The primary purpose of this study was to demonstrate the capability of fused Sentinel-1 and Sentinel-2 data and explore the possibility of aggregating the results into official statistics. During our project, we intended to detect and quantify grasslands, and two of the most frequently sown winter cereals: wheat, and barley. These are difficult domains of crop mapping, and coincidently, the area where regular and reliable data is rather difficult to acquire for various reasons in Hungary.

Merganicova Katarina
Slovak Academy of Sciences
Slovakia
Remote sensing groups in Slovakia focus on a broad range of topics including ecosystem monitoring, mapping and quantification of non-photosynthetic vegetation, mapping phenological phases of different plant ecosystems, mapping historical land use changes and ecosystem disturbances, and linking RS data with process-based models that simulate temporal vegetation dynamics. In our presentation we briefly present the ongoing works and results of the individual studies.

Ozdogan Mutlu
University of Wisconsin-Madison
USA
Crop yield assessments

Sackov Ivan
National Forest Centre
Slovakia
Remote sensing highlights from Slovakia

tbd

joint activities, projects, manuscripts and future venues

Brovkina Olga
Global Change Research Institute of the Czech Academy of Sciences
Czech Republic
I am contributing the joint manuscript preparation which is lead by Lucie K.
Preparation of review of current studies in Europe about bark beetle RS monitoring

Campbell Petya
UMBC and GSFC
USA and Bulgaria
Joint activities: Joint project: MuSLI Canopy Chlorophyll
This talk will report on the advancement for canopy chlorophyll estimation: 1) using field chlorophyll meters, and 2) using multispectral and hyperspectral canopy reflectance

Chaskovskyy Oleh
Ukrainian National Forestry University
Ukraine
Forest damages in Ukraine according to the war
Discussion with partners about possibility to prepare new proposals/join to the current project in the frame of SCERIN or EU Programs.

Filchev Lachezar
Space Research and Technology Institute, SRTI-BAS
Bulgaria
Future venue of SCERIN, Bulgaria, 2023
An update for the future SCERIN, 2023 organisation in Bulgaria.

Gašparović Mateo
University of Zagreb - Faculty of Geodesy
Croatia
Joint research and project activities in remote sensing for forests mapping.
We will present activities on our two recent scientific projects, „Automatic monitoring of narrow-leaved ash (Fraxinus angustifolia Vahl) forests by remote sensing methods and Copernicus data (RS4EST)" (https://rs4est.geof.hr/en/) and „Earth Observations and Artificial Intelligence for the Natura2000 floodplain forests mapping" founded by the European space agency. The forests are the most widely spread land cover and therefore play a significant role in ecology and create processes' dynamics. To implement timely and effective adaptation actions against climate change, one of the main prerequisites

is identifying changes, especially in the case of deforestation and forest degradation. Monitoring the health status, especially the intensity and dynamics of tree damage in stands of disturbed health status, is necessary for forest management. As a source of information, satellite imagery and remote sensing effectively analyse forests.

Harutyunyan Aghavni
American University of Armenia
Armenia
Copernicus assisted environmental monitoring across the Black Sea Basin - PONTOS" project and results
Copernicus assisted environmental monitoring across the Black Sea Basin - PONTOS is a 30-month project funded by the European Union's ENI CBC Black Sea Basin Programme 2014-2020. The PONTOS makes information about the Black Sea environment from the EU Copernicus Earth Observation platform accessible to scientists, policymakers, citizens, and other relevant stakeholders. It utilizes information technologies to automatically retrieve Copernicus products, couples them with national or regional infrastructures for data acquisition and processing, and provides monitoring services for the Black Sea and the surrounding environment in a transboundary, standardized, and homogenized manner. The environmental monitoring system developed is tested in pilot sites across Armenia, Greece, Georgia, and Ukraine.

Havryliuk Serhii
Ukrainian National Forestry University
Ukraine
Forest damages in Ukraine according to the war
Discussion with partners about possibility to prepare new proposals/join to the current project in the frame of SCERIN or EU Programs.

Homolová Lucie
Global Change Research Institute CAS
Czech Republic
potential contribution to potential future venue

Hoscilo Agata
Institute of Geodesy and Cartography
Poland
Joined activities related to collaboration with Ukrainian partners on space-borne forest mapping and monitoring
Joined activities related to collaboration with Ukrainian partners on space-borne forest mapping and monitoring (exchange of knowledge, views and good practices)

Kupková Lucie
Charles University Prague, Faculty of Science, Dpt. of Applied geoinformatics and cartography

Česko
Bark Beetle (TACR, CZ) project and Joined paper on Beetle damage

Kussainova Maira
Kazakh National Agrarian Research University
Kazakhstan
I would like to do joint activities related to our research title
We have research about greenhouse gas emissions in the croplands of Kazakhstan and water management in Aral Sea region.

Ladyka Maryna
National University of Life and Environmental Sciences of Ukraine
Ukraine
Join project with CzechGlobe
Future recomended venue - Turkey

Lukeš Petr
Global Change Research Institute AS CR
Czech Republic
Candidate presentation : Czechglobe, Brno, Czech Republic
In this short presentation we will introduce the Global Change Research Institute (Czechglobe) and the city of Brno, which will apply for candidacy for the next scheduled (in-person) meeting of the SCERIN project

Starodubtsev Volodymyr
National University of Life and Environmental Sciences of Ukraine
Ukraine
Joint activity - CzechGlobe

Štych Přemysl
Charles University, Prague
Česko
The main objective of the Trans-Atlantic Training (TAT) initiative is training activities for students and the early-career scientists in the area of Earth Observation, with an emphasis on remote sensing of land-cover changes and ecosystem dynamics. The presentation deals with a history and this year event of TAT. Discussion will be focused on a cooperation between SCERIN and TAT in the future.

additional inputs or suggestions for SCERIN-9

Campbell Petya
UMBC and GSFC

USA and Bulgaria
I suggest that we collectively sign a letter voicing support for our Ukrainian colleagues

Pashova Lyubka
National Institute of Geophysics, Geodesy and Geography - Bulgarian Academy of Sciences
Bulgaria
i think that it would be of mutual interests to prepare and suggest a joint project for the Black Sea region

Skakun Sergii
University of Maryland
US
Prof. Nataliia Kussul, nataliia.kussul@gmail.com

Tomaszewska Monika
Michigan State University
United States
Experts from Polish Institute of Geodesy and Cartography. I have already provided Petya with names.

List of participants

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Woznicki	Sean	Annis Water Resources Institute, Grand Valley State University	United States	woznicse@gvsu.edu