ABSTRACTS
2024 ICA Mountain Cartography Workshop

Alphabetical by last name of primary presenter

AITKEN, GEOFF NewTopo NZ Ltd

Progress in design

Mountain mapping has always taken advantage of contemporary advances in the creation and dissemination of maps, and in the data gathering that precedes these processes. Initially to facilitate travel and the exploitation of resources, more recent mapping has focussed on preservation and recreation. The design of mountain maps has developed along a continuum that can be described as Tradition>Convention>Evolution>Revolution - always with the end-user in mind. This paper will attempt to explore this continuum from a 2024 perspective.

BASHORE, COLMAN Middlebury College

Mapping Wildfires in Complex Terrain: A 21st-Century Cartographic Learning Journey through Open Tutorials and Techniques

The focus of this presentation is the process of creating a map titled "Fire in the Foothills" during an advanced cartography seminar at Middlebury College. This self-guided map project is an example of mapping mountainous terrain using tools learned primarily through tutorials freely available online, a learning process that has only become possible recently through social media and the internet. "Fire in the Foothills" is a map of the wildfires that occurred in 2023 in Central Oregon between Eugene and Bend. It is an exercise in highly detailed terrain representation as a means of telling a story about a natural landscape. I would like to present through a 5 or 10 minute poster presentation and spend the first half walking through the map itself and describing the processes that went into creating the terrain and layering. The basemap of "Fire in the Foothills" is an amalgamation of many layers of terrain and land cover combined in Photoshop, and I used the free 3D modeling software Blender to create the shaded relief terrain representation. The rugged terrain of Central Oregon warranted the high level of detail and reality that could only be achieved by using the Blender software. "Fire in the Foothills" is an example of sifting through the internet's resources to create a map that, while not focused entirely on mountains, weaves their impact and magnitude throughout its visualization and storytelling.

The second portion of the presentation would focus on the journey of undergraduate self-guided learning in the realm of cartography, particularly terrain representation. The modern field of cartography is remarkably democratic in the way that many great cartographers have used social media and the internet to share their methods and workflows with the public behind no paywall. The poster presentation would describe the approaches that other students and I took when attempting to conquer the ever-growing collection of software and techniques that exist for modern cartography. While the amount of free information available provided us with the ability to quickly learn software such as Blender, because there are very few established schools of cartography in the United States, many undergraduates are forced to rely on this self-guided exploration of the internet's resources. This experience is a rewarding one, yet it is a journey that will continue to be a challenge for students so long as there does not exist a more standardized, consolidated guide to teaching and learning cartography. Self-guided learning in modern times is in many ways far easier than ever before, however, the quality of our final work will always be a representation of the quality of the tools and tutorials that we work with. The presentation will explore the current state of global cartographic curriculum and emphasize how the unique time in which we are living and learning presents an opportunity for growth in this field.

BROWN, LELAND Instituto Superior Técnico, Lisbon, Portugal

Texture Shading Online

Texture shading is a mathematical algorithm that takes a digital elevation model (DEM) and renders an image layer highlighting the canyon and ridge structure of the terrain. It can be used on its own for visualization of the topography, or combined with hill-shading and other standard techniques to enhance details in the terrain.
While open-source code is available for this algorithm, until now this required downloading or purchasing software in order to use it. Now a website is available that allows anyone to upload a DEM, generate a texture-shaded image, and save the result, free of charge. A preview window allows the user to adjust parameters of the algorithm and see their effects in real time, before selecting the final image settings. This online version will also enable immediate access to any future improvements in the algorithm without needing to install a software update.
This presentation will demonstrate the use of the new website.

CORDOLA, BENJAMIN Middlebury College

Presentation of Map of Almaty, Kazakhstan

My oblique map of Almaty, Kazakhstan, focuses on the city's location at the base of the Trans-Ile Alatau mountain range, part of the broader Tian Shan Mountain Range. Created during an undergraduate cartography class, the process of working from concept to completion has taught me skills and tools, and the ability to identify and learn them on my own. I used blender to create the oblique view of the mountain range, layering land cover, shadows, and satellite images both in Blender and in Photoshop. While the map showcases physical features of Almaty and the mountains, it also tells the story of the apple, and its long history that began in those mountains millions of years aso. The fruit is still relevant and remembered in the region and city of Almaty, highlighted by the fact that Almaty means "father of all apples," in Kazakh. A poster presentation of this map will shed light on this story, as well as the process undergone in creation of the map, and the tools used in doing so.

FARMAN, ALI

Earthquake-induced landslide risk assessment and disaster impact zone on JSR (Juglot Skardu Road) fault zone by using GIS and RS and COSSI-Corr Techniques

Earthquake is a common natural hazard in the mountainous region, especially along the fault zone seismic activities on its apex due the movement of tectonic plates. Seismic events is common but its consequences depend upon two main factors as natural (movement of tectonic plates, Geology of that area) and the most important is anthropogenic factors (construction, blasting, etc.) responsible for extensive damage and losses in the mountainous region. This research determines earthquake risk assessment and disaster impact zone along Gilgit to Skardu road named as JSR (Juglot Skardu road) 167 km long (104 mi) the only route which connects the Baltistan region to the rest of the country and the adjacent valleys. Data used is the Digital Elevation Model (DEM), Shuttle Radar Topography Mission (SRTM) of 30m resolution, Panchromatic band of 15m resolution of Landsat-8, previous data of the earthquake record was used from the USGS data portal, Geological data, soil data and the fault line data of HKH (Hindu Kush Himalaya) available on different data portals and the most important the primary data 'field data' gathered from the people of the affected valleys used. The source of the secondary data is USGS data portal which provides the free data. The analysis shows the surface movement during the last six to seven months along the fault line is maximal and the valleys nearer to fault zone and the epicenter are the most effected as

compare to far flag areas. This analysis shows that the active fault lines Main Karakorum thrust fault and one other which crossed the JSR at many places are the main reasons of the seismic events observed by using the feature tracking technique implementing the software "COSSI-Corr", the movement of the ground surface from last 6 to 7 months was maximum along the fault line and the valleys nearer to fault zone and the valleys within the range of the 25 km to the epicenter(25km from the south of Astore) was the most demolished areas. As the magnitude of the 4.7 to 5.4 is thought to be the moderate earthquake but it causes havoc destruction along the road and its adjacent valleys due the hazards (land sliding, rock falling) triggered by the continuous seismic events within these 6 to 7 months was the anthropogenic factors (road construction, blasting) , and the geology of that area. The risk ranking of the valleys along the JSR, particularly along the fault zone, had been completed based on all the observations mentioned above and the primary data estimation. This information provides detailed information about the risk and vulnerability ranking of these valleys from the most recent event, which was first recorded on December 27, 2021, and its aftershocks.

FARMAN, ALI

Decadal Spatio-Temporal Changes in Glacier Volume Estimated Using Remotely Sensed Images, Digital Elevation Data, and GIS Modeling in District Nagar Northern Pakistan

Glacier velocity is one of the significant parameters for the assessment of glacier dynamics, which directly signifies the response of the glacier's health with the respect to climate change. The present work focuses on analyzing the Spatio-temporal characteristics of the surface velocity in the Nagar basin for seven glaciers. The rapid changes in glaciers must be precisely mapped and continuously monitored to avoid any severe effects like floods, avalanches, etc. In such situations, manually digitizing the movements of glaciers by experts can be time-consuming, costly, and may not be suitable for real application. In this study, we proposed an Analytic Hierarchy Process (AHP) model to detect spatial and temporal changes in the District Nagar glacier using Landsat satellite imagery. Snow cover area (SCA) is an important component of the solid water reservoir in the catchment. The study of snow trends is essential for managing water resources and for understanding regional climate change. Changes in the snow budget have socioeconomic and environmental implications for agriculture, water-based industries, the environment, land management, water supplies; and many other areas related to snow melt water resources. To date, however, only a few scientific studies are available to analyze the Nagar District, The basic objective of this study was to map the change assessment of SCA of Nagar District from 2000 to 2021. Landsat satellite data were retrieved for 2000, 2010, and 2021. Three different digital image processing techniques,

including normalized difference snow index (NDSI), satellite image classification, and band threshold values were applied to assess the SCA. The results show that snow accumulation typically starts from the beginning of October and continues up to mid of March. From the end of March, the snow starts melting until it is reduced to a minimum in September.

FORD, JAMES

Semi-Automated Reclassification of New Zealand LiDAR: An Open-Source Workflow for Improved Elevation Grids

Aotearoa New Zealand is a country known for its dramatic landscapes. From the Southern Alps forming the spine of Te Waipounamu (the South Island), to monolithic stratovolcanoes dominating Te Ika-a-Māui (the North Island), Aotearoa is a playground for outdoor enthusiasts and cartographers alike. To the delight of cartographers, *80% of the country will have high resolution elevation available as open data by 2024.
As surveying an entire country with LiDAR is a challenging task and in this case is occurring in a piecemeal fashion, the outputs are of varying quality. Pre-processed elevation grids can be full of TIN artefacts and the point clouds can have limited or unreliable classification.
There are a few obvious approaches to this issue: use the data products as-is and apply touch ups to the final design; generalize the elevation grids to remove unwanted artefacts; or clean up the point clouds and create custom elevation grids from scratch. This presentation will explore the latter.
This technical demonstration will cover a prototype open-source workflow for reclassifying point clouds. A tool-agnostic overview of the workflow will be covered, followed by a demonstration of a semi-automated implementation which uses Python, PDAL, GeoPandas, and QGIS.
* See the LINZ "Elevation Aotearoa" storymap

FRIES, ALEX US National Park Service

The Man-made "Mountains" of Eastern North America: The Platform Mounds of the Mississippian Culture

Prior to the arrival of Europeans in North America, the prehistoric Mississippian culture had developed a complex and expansive society that spread from the upper reaches of the Mississippi River to the Gulf of Mexico and the Appalachian Mountains. Today, the Mississippians are perhaps best remembered for their practice of constructing earthen, pyramid-like platform mounds at major settlements and ceremonial centers. While the

Mississippians are most associated with the floodplains of the Mississippi River and the American Southeast, where their largest cities were located, they also constructed an impressive number of mounds and ceremonial sites within the more rugged landscapes of eastern North America, including within the Appalachian, Ozark, and Ouachita mountain ranges. On the other hand, many Mississippian mounds have been historically depicted, likely by mistake, as natural rises on the landscape, and conversely, many natural features have likewise been mistaken as being prehistoric, man-made constructions. This talk thus aims to provide a brief looks at both the spatial relationship that these ancient Mississippian mounds exhibit with the landscapes they inhabit, as well as the impact they have had on our modern cartographic representations of these landscapes, mountainous or otherwise.

GARTNER, GEORG TU Wien

Learning from the cartographic methods of Alpine Club Maps for mapping mountains in a new era

The Austrian and German Alpine clubs have been offering regional maps for more than 150 years. These special maps cover selected areas of the Eastern Alps. AddiDonally, so called "Expedition maps" of selected non-european high mountain areas have been produced. The methods of cartographic depiction in general and especially the methods of rock depiction and drawing have always been a key concern in producing those maps. This has gone as far as allowing for non-standardized individual methods and styles being developed and applied. While the usage of those maps is clearly dedicated to mountaineers using maps as artefacts, the transition of Alpine Club Maps into a service-oriented use scenario includes a number of challenges. Alpine Clubs Maps are like all other maps a result of many decisions. Many of those decisions allow for several options and It is rather a characteristic of the alpine club cartography that individual decisions have been made, especially on data preparation, selection and design aspects.
Because every map is a result of many decisions the trust in maps depends on that those decisions are reasonable, not questioned, transparently accessible or are underpinned by reliable decision makers (reliable in terms of a record as an institution, because of reputation, because of competence). The advent of easy-to-use map making software and data handling instruments put some of those decisions in the hand of "everyone", but also eventually in the hand of mapAI and machine learning algorithms. This is similar to other means of communication and has led to a rising discussion on "fake news", "fake media" and "fake maps", thus ultimately in which way we can trust the communicated information and in which way we can distinguish "fake" from "trustworthy" maps.
Therefore, in this paper the proposal is made, that the existing knowledge on the methodology of the cartographic depiction, especially on the rock depictions, need to be described in a kind of cartographic ontology, so that a transparency check of future maps can be perfomed.

GILGEN, JÜRG swisstopo

Updating Alpine Terrain at the Swiss Federal Office of Topography Workflow Described at the Example of 1:25,000 in the year 2024

This article describes the revision of the rock, scree, glacier and shaded relief representation in the topographic map model 1:25,000 (DKM25) of swisstopo in the year 2024.

Topics: topographic map, cartographic terrain representation, rock, scree, glacier, shaded relief.

Keywords: Swiss Federal Office of Topography, swisstopo, digital map model 1:25,000, DKM25, topographic map, Swiss style, cartographic terrain representation, rock, scree, glacier, shaded relief, ®ArcMap, ®Photoshop, ©Scree Painter, raster data, year 2024

GOŁĘBIOWSKA, IZABELA University of Warsaw

Traditional vs. multidirectional sky illumination: A relief inversion study

On shaded relief maps (SRMs), typically a single light source Lambertian illumination is applied (Kennelly & Stewart 2014) from north-west (NW), or north-north-west (NNW) to prevent a visual illusion called *relief inversion effect* (RIE) (Imhof 1969, Biland & Çöltekin 2017, Çöltekin & Biland 2019), otherwise users often perceive concave forms as convex, and vice versa. This also occurs in satellite images when the Sun shines from south at the time of image acquisition (e.g. Bernabé & Çöltekin 2014). The *multidirectional sky model illumination* (MSM) creates shading based on multiple light sources coming from a surrounding theoretical sky (Tranthan & Kennelly 2022, Kennelly & Stewart 2014, Kennelly & Stewart 2006). It is currently unknown if MSM reduces RIE compared to a NW/NNW illumination.

In a between-subjects experiment, we examine if MSM reduces or overcomes the RIE. Our independent variables are (1) Lambert vs. MSM; and (2) Azimuth: 225° (strong RIE) vs. 337.5° (minimum RIE). Participants identify valleys and ridges, higher and lower elevations, steepness of slopes, and elevation profiles. Stimuli are SRMs counterbalanced for levels of ruggedness and orientation of linear landforms. The study is conducted in a lab under controlled lighting conditions. Our dependent variables are: response accuracy, time and confidence, and perceived level of difficulty per task.

In this work-in-progress effort, we are collecting data from Bachelor's students at the University of Warsaw. At the workshop, we will present the initial results of the study and discuss the differences between participant responses based on the tested relief shading types.

GRÖBE, MATHIAS Technische Universität Dresden

New approaches in data collection for an Alpine Club map

After completing the data collection for a new Alpine Club map covering Mt. Ushba and its surroundings in the Greater Caucasus, we may now draw conclusions on the range of data sources and the associated challenges in transforming them into a map product. Geo-data access is unprecedented today. It is, however, demanding to locate, evaluate, and integrate diverse source data properly.

A starting point was a request for archived maps of the area. Studying them strengthened the knowledge of the team about the area, as well as the planning of customised data collection in the field and from other sources as e.g. remote sensing. The "FID Karten" (English: special information service for maps) of the Berlin State Library provided various scanned maps. After geo-referencing, they could be compared to other data, such as OpenStreetMap vector data, satellite images, and digital terrain models. An intermediate product, a dynamic working map, was established, which became central in guiding our data selection, new data acquisition, data corrections, and improvements through iterative teamwork over 3 years. Both, digital and printed map copies were used and tuned to specific tasks in terms of content and design: Digital maps were used to compare and evaluate sources, but printed maps were essential in the fieldwork, where small teams could be spatially directed, and notes and sketches be added to thelarge-scaleprints.

OpenStreetMap has, right from the beginning, been chosen as the principal data platform. Our team intensively used, but also corrected and augmented existing information. We both profit from previous work but now also support smartphone applications for routing and navigation through better data. Digital map and image overlays allowed the detection of gaps and inconsistencies. Such places were visited,and the situation was mostly clarified during fieldwork. Ultimately, the upgraded data on road and river networks, building stock, and toponyms from OpenStreetMap will now show up in the final map.

Remote sensing data have been processed to complete the map content with relief and land cover information. A new DEM has been calculated by a large set of PlanetScope satellite data, which had been granted to us by the provider. Results are fine, but local problems occur on dynamic features (glaciers), where temporal decorrelation of multi-stereo scenes partly leads to elevation artefacts. Land cover is a further layer, which cannot be controlled and updated in a limited time of field work. We have composed and harmonised a time-series of no or low-cloud Sentinel-2 scenes. They were used to derive six land-cover classes adapted to the geography of the mapped area.

In our data-rich world, it was still essential to spend much time on the site. Many map features, such as toponyms, specific land cover, and small ways, still need fieldwork. Older maps and partly outdated data were found to be highly beneficial in settingthe focus on the critical spots and areas of major change.

GRUBB, MADELINE National Park Service

Making an Atlas of Teton Glaciers

This presentation will be a walkthrough of the historic glacier research and mapping in the Teton
Range, as well as an introduction to "The Atlas of Teton Glaciers" an upcoming publication showcasing the glacial history of the Tetons through a series of maps and imagery. The maps shown will cover historic glacial periods, capture the current state of the ranges' 11 named ice bodies, and feature relatively new research and mapping on the rock glaciers within Grand Teton National Park. A variety of cartographic techniques will be used throughout this series of maps, including 3D views of each Glacier created in Blender, and LIDAR differencing elevation surface change maps.
I would love for this presentation to be a broad overview of some of these maps, showcasing different techniques and specific glaciers, as well the work that Grand Teton National Park has done over the last 10 years to map glaciers in the face of a changing climate.

ILIES, GABRIELA Babes-Bolyai University

Introducing the mountains to young students - challenges and opportunities

This talk will be mostly a reflection regarding the trends in tourism and the role of mountain maps. In a post-pandemic era we (as society) have (re-)discovered at least two new types of tourism: outdoor offline tourism and couch surfing tourism, both leaning heavily on maps and other visualization tools. Teaching and guiding young students showed that there is a significant shift in what we consider as norm in the way they interact with the terrain, their knowledge about nature or the strategies used to select their upcoming destination. Also, our view of "going beyond the fascination of mountains – training the mind and the body" is translated into "experience" by the digitally native generations. That is why we wanted to know more about the profiling process while designing mountain maps, for on-line and off-line environments. First, we focused on the data gathered along a trendy mountain track in Maramures (Creasta Cocosului) before and after 2020, combined with a focus group conducted on students related to other regional mountain paths. Next, we analyzed a range of websites that offer information about the mountains, based on the reported data. The results show that the quality of the online content in terms of maps, photo-video and ratings determine the tourist flows towards the mountains with a higher number of inexperienced (see less trained) tourists. That may be a good opportunity to expand the base of services in

the area but it is also a challenge to tackle the map-reading literacy and the terrain/landscape understanding.

KENNELY, PATRICK Penn State University, Long Island University

Designing a Web Mapping Application for Avalanche Forecasters

Avalanche forecasters need local meteorological data to predict events, and overviews of the terrain to better define where in a known avalanche path an event may occur. In this study, a web mapping application was designed for forecasters at the Colorado Avalanche Information Center (CAIC) in Boulder, Colorado to address both needs.

Using historic and well delineated avalanche paths along US Routes 550 and 145 in southwestern Colorado USA, this study includes data on daily snow, wind, and wind direction from the High-Resolution Rapid Refresh (HRRR) model from the National Oceanic and Atmospheric Administration (NOAA) over the 2018 – 2022 coldest weather (January and February) period. The three selected variables were determined significant up to three days before an event from a binary logical regression (BLR) model. These variables were then input into a weighted forecast value index (FVI) to determine that avalanches could be predicted with 64% to 72% accuracy for 2023 data excluded from the input model. CAIC forecasters in 2024 will use this web app to map probability of avalanches symbolized by color in known paths for recent weather conditions.

Given a high probability of an avalanche within a path, the web app displays terrain and land cover data to help forecaster better understand where within a path an event may occur. Digital elevation models and land cover data are used to delineate areas of steep slope, high curvature, and bare earth (i.e. no vegetation). Maps symbolize these morphometric considerations separately and highlight areas of overlap where more than one factor may come into play.

An important consideration of this study was the varying spatial and temporal resolution of datasets. NOAA's HRRR model is real-time data that has been collected for years with a spatial resolution of 3 km. In some cases, one or more avalanche paths fit into a single HRRR grid cell. Regardless, the distribution of paths along highway corridors in southwestern Colorado allow this application to calculate probability with reasonable certainty. Conversely, DEM and land cover data are of much higher spatial resolution (10 and 30 m. respectively) but only collected on occasion. The bare earth map displays show the underlying morphometry in detail, allowing forecasters to interpret how the snow cover they observe in the field differs, and how these variations may put certain areas at higher risk.

KOZMUS TRAJKOVSKI, KLEMEN University of Ljubljana

Mapping a climber's path

In accordance with to the workshop's theme Mapping Mountains in a New Era, the Himalaya's path of a mountaineer is presented using various visualizations. Nejc Zaplotnik was one of the most talented and respected mountain climbers of his time. He climbed Makalu (8485 m.a.s.l.) in 1975, Gasherbrum I (8080 m.a.s.l.) in 1977 and Mount Everest (8848 m.a.s.l.) in 1979, all as a member of the national expeditions. All were the first ascents of the respective climbing routes. An avalanche buried him on Manaslu (8163 m.a.s.l.) in 1983.

A publicly available data is used to create different maps and visualizations of the Himalaya and Nejc's climbing routes. A global DEM with an adequate resolution serves as the elevation model. Satellite images and online topographic maps are used for the raster overlay. Contour lines and shading assist with the relief presentation.

The expeditions' climbing routes along with the standard routes are presented on separate 2D maps for each successful ascent. The routes are also presented in the perspective views of 3D maps. A virtual fly-through over the climbing route is formed for each ascent.

The emphasis of the presentation is on the first ascent of Mount Everest over the west ridge, which was a huge Yugoslavian project and a grand worldwide success at the time.

Nejc Zaplotnik was also an author. His book named "Pot" ("The Path" or "The Way" in English) is still one of the most popular Slovenian written works.

KRIZ, KAREL University of Vienna

Combining rock, scree and glacier depiction methods in topographic maps – the next step of an attempt to adopt an all in one approach

The significance of processing spatial information and creating high-quality visualizations is on the rise, underscoring the growing demand for corresponding cartographic solutions. This need is particularly pronounced in the scientific realm of high mountain cartography, dedicated to addressing the unique challenges posed by mapping mountainous regions. The field of high mountain cartography focuses specifically on the topographic representation of the terrain that distinguish cartographic depiction in such elevated landscapes.
Beyond conventional digital and analog displaying methods of contour lines and hill shading, the depiction of rocks, scree and in glaciers stands out as a key element in representing the relief in analog as well as digital maps.

The main objective of this paper is to show and discuss the development of methods towards an automated generation of rock, scree and glacier depiction methods for large scale maps based on open data and other freely available geodata.

KUMAR, SHEKHAR Government College, Hoshiarpur

Exposure to Climatic Variability and Associated Hydro-Meteorological Hazards in Beas River Basin of Western Himalaya, India

There is ongoing concern about current and potential climate change impacts on the Indian Himalayan Region from both a physical and societal perspective. The region is facing important challenges in view of coping with adverse effects of climate change. Thus understanding and anticipating the impacts of climate change on Himalayan mountain and the services it provides to people are critical. In this investigation, Beas river basin has been taken to measure the spatial pattern of exposure to climate change and associated hydro-meteorological hazards. Exposure was conceptualized as the sum of current state of various elements of climate, their changes in last 120 years, future climatic scenarios and extent of hydro-meteorological hazards. This approach allowed us to frame a climate change exposure index at basin scale integrating past and present. Exposure index has the potential to integrate different parameters representing climatic variability and associated hydro-meteorological hazards to guide preventive decision making. We integrated various such indicators in a single index to calculate the degree of exposure to climatic variability and associated hazards in the study area. It is noted that upper Beas basin is relatively more exposed to climatic change as compare to lower Beas river basin.

MARSTON, BROOKE U.S. Department of State

Kashmir Valley Panorama

The Kashmir Valley, also known as the Vale of Kashmir, is a historic lake basin situated between the Great Himalayas and the Pir Panjal Range in India's northwestern-most union territory. Sitting just above 6,000 feet in elevation along the Line of Control separating Pakistan and India, the Kashmir Valley is a northwest-southeast oriented elongated valley about 20 miles wide and 85 miles long. The Jhelum River drains through the valley, creating a wide, fertile floodplain where the population of the larger Kashmir region is densely concentrated. Surrounded completely by steep, remote mountains, the Kashmir Valley is an island of flatness in the white-capped peaks of rugged terrain. The unique mountain geography presents both

challenges and benefits for panoramic mapping of this politically and culturally significant landscape.

MEACHAM, JAMES University of Oregon

Transitions in Cartographic Methods used in Mapping Archaeology and Landscape in the Mongolian Altai Mountains: 1994 to 2010.

During the 16-year period, from 1994 to 2010, our mapping team experienced rapid advances in available geospatial data and mapping technologies for our work in the remote Mongolian Altai Mountains. Our project, the Mongolia Altai Inventory, was a culmination of yearly seasonal field work, mapping and documenting surface archaeology including petroglyphs and rock monuments. The study region covered an area of far western Mongolia, bordering Russia and China. The Inventory was organized by the drainages extending eastward from the Tavan Bogd ridge on the west and north from the high peaks that border with China.

Our team's GPS spatially located points of documentation included several thousand surface structures and standing stones, as well as several thousand concentrations of petroglyphs. At the beginning of the effort detailed base map data and imagery was hard to get, or unavailable. Within a decade or so, detailed satellite imagery was accessible that made viewing the distributions of major rock monuments in this remote landscape remarkably easy compared to earlier years.

The increasing ease of access of detailed base information allowed us to improve our base GIS layers from hand digitized Soviet-era topo maps, and 1950s aerial photos, to a robust database of detailed satellite imagery and SRTM elevation data. This improvement greatly enhanced our mapping, analysis, interpretation, and cartographic visualization of the archaeology in the landscape.

In addition to several published papers and reports with detailed maps and photographs, an atlas of the project was released in 2010, *Archaeology and Landscape in the Mongolian Altai: An Atlas* (Esri Press). The work of the Mongolia Altai Inventory project provided key documentation contributing to area comnplexes being designated as a UNESCO World Heritage Site in 2011.

MESTRES, NOLAN Univ. Grenoble Alpes

Faking reality for generating panorama maps

Panorama maps are widely used by mountain operators to promote their resorts. They are both used to beautify the landscape and depict the relief and tracks so that users easily find their way.
Depending on the chosen viewpoint, they can be subject to many different constraints: the full resort should be visible; the ski tracks should always go down in the rendered image; the terrain should be legible everywhere, without strong shadow areas; etc. To fulfill all these goals, a panorama map is designed as a mix between realistic and abstract elements. If well known artists (e.g. Heinrich C. Berann, Heinz Vielkind, James Niehues or Pierre Novat) mastered at creating panoramas by hand, generating such maps digitally is still challenging. In this work, we present the digital tools and manual processes we used to create "Les 7 Laux" panorama map. One major difficulty here is to make sure that all ski tracks clearly appear in the image, as they are located on two different sides of the mountain. To do so, we introduce a dedicated terrain deformation tool allowing to locally warp parts of the relief such that all tracks are visible while still generating a plausible rendering. The shading model automatically selects color patterns (snow/rocks) according to shape properties and locally modifies light directions to maximize contrasts and prevent too dark or too bright areas. Trees are then generated automatically using procedural sprites that can adapt to lighting conditions. Tracks themselves are finally drawn by hand to satisfy the aforementioned constraints.

MILBRATH, JOE US National Park Service

3D Oblique Mapping of Mountains Above the Arctic Circle: Two Maps of Alaska's Remote National Parks

This presentation will explore techniques and a short tutorial describing the creation of two National Park Service maps for Bering Land Bridge National Preserve and Gates of the Arctic National Park and Preserve. The talk will share approaches to mapping expansive mountainous terrain with the help of Terrain Texture Shading and Eduard, a Swiss-style terrain rendering software. I'll explore the use of high-resolution land cover data, satellite imagery, and approaches to digitizing complex hydro datasets for oblique views.

NEVISTIĆ, ZVONIMIR Zagreb University

Geodesy and mountaineering: The importance of trigonometers, GIS and other methods for hikers

Since ancient times, geodetic methods have been used in mountaineering for numerous purposes. In the past, mountaineers used thematic mountain and topographic maps and compasses to find peaks, while in recent times GNSS (GPS) devices are used, which can have an integrated digital map. By using such simple devices, today everyone can collect geodetic coordinates, which is of great importance for mountaineering to better navigate in space, especially in the conditions of an unknown and uniform landscape where orientation is limited. One of the basic geodetic methods is triangulation, which, in addition to determining the shape of the Earth and the state survey, is also used when determining the heights of mountain peaks. The highest peak in the world (Mt. Everest) was determined by this method, the geodetic measurement of a series of triangulation points (trigonometers) and the determination of a trigonometric grid. Today, GNSS and satellite methods are increasingly used to determine the heights of mountain peaks, but trigonometric points have remained preserved. Trigonometers represent the points of the trigonometric grid whose coordinates are determined, and which is permanently marked on the ground, and is used as a reference point for other measurements. Using the classic method of triangulation, these points are placed at certain distances to form a continuous network of triangles, and they are placed on dominant points of the terrain, such as mountain peaks, in order to see each other. As most trigonometers of the 1st order network are located on mountain peaks, they are of particular interest to mountaineers. Trigonometers placed on mountain peaks are generally stabilized as pillars or pyramids, and most of them are located on grassy or rocky peaks with a wide view. To popularize the peaks on which there are trigonometric points, a new hiking trail for Republic of Croatia was designed at the Faculty of Geodesy in Zagreb - the Geodetic Hiking Trail (GPO) whose control points are these trigonometric points. The development and implementation of the trail began in 2017, and the Geodetic Mountaineering Portal was developed in parallel as a functional and content-reliable and rich IT support for the trail. It was implemented as a web GIS application that serves as a database of checkpoints of the trail and provides future hikers with a lot of information and various IT tools for preparation and a successful visit of the checkpoints of the GPO. This paper will present an overview of the basic geodetic methods used in mountaineering with a detailed description of the Geodetic Mountaineering Portal in the Republic of Croatia as an example of a Web GIS application that is indispensable today in modern society for displaying spatial data and attribute information about mountain peaks and objects.

PATTERSON, TOM US National Park Service (retired)

Mapping Prince William Sound, Alaska

Prince William Sound is a 160-kilometer-wide bay on the south-central coast of Alaska indented by fjords and sheltered from the Gulf of Alaska by barrier islands. The rugged Kenai and Chugach mountains, the source of numerous tidewater glaciers, arc around Prince William Sound on the west, north, and east. Most of Prince William Sound lies within the Chugach National Forest. The major ports are Whittier, Cordova, and Valdez; the latter being the terminus of the Trans-Alaska Pipeline. Prince William Sound is where the 1989 *Exxon Valdez* oil spill occurred. The sound has superficially recovered from this catastrophe, although the long-term environmental impact is still unknown.

Despite having a natural beauty rivaling that of nearby Kenai Fjords National Park, relatively fewer tourists visit Prince William Sound. This is mostly due to limited road access. Valdez is 480 kilometers from Anchorage. And driving to Whittier, which is much closer to Anchorage, involves long waits at a one-way tunnel through the mountains. Cruise ship visits are increasing, however, and the Alaska State Ferry goes to several Prince William Sound communities.

Available maps of Prince William Sound are the standard products published by government agencies, which inadequately depict the world-class natural setting. To remedy this situation, I set out in early 2019 to make a 1:250,00-scale wall map of Prince William Sound and surroundings that emphasizes the physical environment. An abundance of public-domain cartographic data of the area to be mapped encouraged me to take on the project. However, because of climate change and glacier retreat, every available dataset no matter how recently published, required massive updating and reconciling in order to make a cohesive map. For example, I mapped glaciers, drainages, and coastlines from Landsat and Sentinel satellite images. Mapping these base data took several hundred hours. Despite this effort, I expect that the map will require frequent updates given how fast the landscape is changing.

Having completed the base data, I next turned my attention to the map design. Generalization was a key concern because of the complex and interrelated physical features. For example, natural colors on the map are derived from National Land Cover Database that Iß collapsed from 20 classes to five. Shaded relief was generated from a 5-meter DEM downsampled to 50 meters. Vector coastlines were simplified using the Visvalingam-Whyatt algorithm. Texture shadings represents cliffs on the highest mountain peaks and the underwater realm is revealed with bathymetric shading.

The final map was released in early 2020, followed by a major update in late 2023. It is available for free online at shadedrelief.com/pws/ and the Avenza Map Store.

PETROVIČ, DUŠAN University of Ljubljana

Harmonization of the database of peaks in Slovenia

The peak is the highest point of the elevated surface form and as a geographical term relatively easily and uniquely determined. With the goal of establishing a unified topographical database of Slovenia, we also provided a layer of peaks as one of the layers, which should uniquely define the peaks, their horizontal positions, heights and names. As sources, we used topographic maps of various scales and from them derived Register of Geographical Names by Surveying and Mapping Authority of the Republic of Slovenia, as well as Mountain maps and other evidences of the Alpine Association of Slovenia. However, the analysis of the situation showed that for different groups of users the peak can be defined and named very differently, and therefore different records and names of peaks were created over time, as well as differences in the display of peaks appeared on different maps, both national topographic and thematic, as are, for example, mountainous. On national topographic maps, geodetic points were often marked as summit points, but they are not always at the highest point of the summit. Mountain maps supported by mountain guides generally showed the point of the summit that provides access, often also offers an adequate view, and is also not necessarily at the highest point. There are even more problems with the naming, in which the surrounding inhabitants often named the part of the elevated surface that they saw as exposed from the valley. When establishing a single database, we thus identified 883 peaks where the data from different sources differed markedly, and thus trying to create some rules for similar cases or individually assessed those, which were unique. In the presentation, the process of harmonising available source data into unified peaks database of Slovenia with focus on some typical differences will be presented.

PROCHAZKA, ONDREJ Seznam.cz, a.s.

Map Scale and Vertical Exaggeration in 3D Terrain Maps: A Mathematical Perspective

Cartographic literature seldom discusses the mathematical relationship between map scale and vertical exaggeration applied to DEM, yet the concept appears well-established in multi-scale analytical shaded relief and even integrated into commercial software. This talk will first

provide an overview of the formula(e) linking map scale to vertical exaggeration. I will then propose and demonstrate its application to automatically generated web-based 3D terrain maps.

STREUFERT, PETER Middlebury College

Watching The Sky: Building Trails on Colorado's Tallest Mountains

Lighting and inclement weather exist as a constant reality on the mountains of Colorado, making it difficult for trail crews to protect and restore the fragile alpine ecosystems. However, the storm's predictability has allowed crews to work around the weather by shifting their work to the early morning hours. Sometimes storm clouds roll in earlier than expected and hasty evacuations are needed. This map depicts one such day from my summer leading a high alpine trail crew on Colorado's tallest mountain, Mount Elbert. The map aims to educate how the unique geography of the region leads to recurring weather patterns and emphasize the arduous and at times dangerous work of high alpine trail crews.
This 36 x 24 in print map is an exercise of 3d terrain representation using the open source software blender to create an oblique representation of the landscape. The map was created through a cartographic design seminar at Middlebury College, however much of the process was through self guided learning. Along with four other students also submitting abstracts for this conference, I found necessary resources and tutorials to build terrain representation skills and produce my map. This poster presentation will include the map as well as illuminate a student's perspective of learning tools for mountain cartography and terrain representation.

SULZER, WOLFGANG University of Graz

Darstellung eines Gebirgsraumes in historischen Karten (Niedere Tauern, Ostalpen)

In antiquity and the Middle Ages, mountains, especially the Alps, were generally considered "hideous, useless and dangerous". This negative image was mostly created by people who did not live in the Alps themselves and saw the Alps, if at all, as an annoying and dangerous obstacle that had to be overcome. However, since the mountains primarily represented an obstacle and the Roman interest was primarily in maintaining trade routes over the passes and in the large Alpine valleys, the cartographic description was limited exclusively to these areas. Until the 17th century, the information content of maps in mountains went little

beyond the location of the valley landscapes; the topographical conditions were rarely depicted realistically. The mountains were often represented by chains of connected mountains, which sometimes had pointed or rounded, sometimes plateau-like shapes and were clearly highlighted by shading. Historical mountain maps are among the indispensable historical sources due to their distinctive and unique geographical statements. Maps report on conditions and events of the past; However, maps are irreplaceable in terms of their representation of the spatial situation. Compared to landscape descriptions, cartographic information is superior; only the latter can adequately capture and depict landscape-related conditions. Old maps are important image and written sources. Maps visually report on spaces and document mountain areas in a temporal dimension. But they also reflect the world view at the time the maps were created. Maps not only provide important "topographical information from the past", but also say a lot about the perspective of cartography and human society on mountain areas, which usually represents a limited external view. The article is intended to document and describe, by way of example, the development of the topographical representation of a mountain area in the Lower Tauern (Styria/Austria). The period under consideration is from the end of the Middle Ages to the 20th century.

SUTTER, TATE Middlebury College

Peaks and playas: presenting Nevada's landscape on the precipice of transition

The map *Peaks and Playas* conveys the extreme diversity of Nevada's terrain and the cartographer's experience learning terrain representation at an undergraduate university. Incongruently the most mountainous and one of the flattest of the contiguous states, Nevada possesses playas and glacier saddled peaks. Rivers flow from mountain ranges and drain into the state's many endorheic basins. Nevada rests at a point of transition. Over the last thirty years, the Las Vegas and Reno metropolitan areas have pressed against the confines of their basins. Climate in Nevada, like the rest of the world, is becoming more extreme with droughts, heat waves, and fire. Ecosystems may shift by elevation or latitude. Possessing minerals necessary for renewable energy technology, mining is predicted to expand in Nevada. Though potentially powering a transition to renewable energy, Nevada's landscape will be altered. *Peaks and Playas* documents the landscape of Nevada at this precipitous point of change. The map emphasizes Nevada's changing characteristics while minimizing political and transportation elements which traditionally feature significantly on maps of Nevada. The wall map is twenty inches by thirty inches at a 1:1,150,000 inch scale.

Developed in undergraduate cartography seminar, the processes of creating *Peaks and Playas* taught principles and technical requirements of representing mountainous terrain while fostering independent learning in a collaborative environment. The map was created with a combination of QGIS, Blender, Adobe Photoshop, and Adobe Illustrator. Technical skills including shaded relief created in Blender and terrain representation in Adobe Photoshop were self-taught with existing public internet tutorials. The collaborative classroom environment let us, cartography students, receive feedback and crowdsource approaches to new challenges. Educating undergraduate students in cartography developed our cartographic and collaborative abilities while fostering a desire to further our learning. Though less frequently found at the undergraduate level, cartography, including mountain cartography, still provides benefits to aspiring geographers.

TZELEPIS, NIKOS National Technical University of Athens

Multi-directional Analytical Hill-Shading for Enhanced Cartographic Relief Presentation

Multi-Directional Hill-Shading (MDHS) methods are able to restore lost or incomplete relief information from artifacts and weaknesses of usual, one source, ideally diffused Hill-Shading (HS), in order to illustrate most information possible of the shape of earth's surface. On the other hand, a dominant illumination with strong tonal contrast is responsible for the familiar, realistic character of hill-shading method, which should be properly chosen to depict most of the terrain formations. To compose these two needs and achieve maximum performance without critical discounts in the visual effect of hill-shading, the proposed framework of actions is based on three axes:

- Implementation of a dominant HS image with optimal illumination
- Implementation of a MDHS model
- Selective enhancement of dominant, optimal HS with MDHS

There have been many proposals which gradually enrich illumination from a single source, from light source's local adaptation, then to combinations of different light directions and even up to simulative sky illumination models. Among them, this research focuses on the analytical solution proposed by Robert Mark (1992) -which initially referred to the term "Multi-Directional" in its Multi-Directional Oblique-Weighted (MDOW) method- as it encourages the unified use of the full range of perceptually correct illumination, originating from southwest to north directions. The research firstly deals with skepticism on the tonal equalization and consequent lagging of tonal contrast, caused by multiple illumination, by establishing visual

relevance of MDHS images with the familiar character of hill-shading, after experimental evaluation of visual complexity by using eye-tracking technique.

Existing and additional, alternative models for MDHS are listed and organized in terms of the analytical weighted synthesis used, into: global-weighted, oblique-weighted and incident-weighted (that is, based on the incidence angle of illuminating source). Discussion is carried out about west to north illumination range, considered as a perceptually effective choice, as well as for terrain analysis procedures that can contribute to the determination of optimal HS direction for revealing most of ground's relief changes (e.g., diagrammatic analysis of orientation data, structural line identification, land surface generalization, morphometric classification). The final mixing between a dominant, optimal HS and MDHS images is analytically controlled by the local incidence angle of optimal illumination, so that the dark areas of the former are enhanced with multiple illumination.

Several MDHS models and combinations are implemented as software tools (in *ESRI's ArcGIS Desktop*) and then they are applied on mountainous study areas. The images produced are evaluated in terms of completeness in rendering the topographic relief, through online questionnaire filled by university staff members with experience in cartographic and spatial visualizations. In addition, conclusive questions for further research are set out.

ZALECKI, ALEXANDRA Middlebury College

The Coal Mine Next Door

For the 2024 ICA Mountain Cartography Workshop I wish to present a map poster titled: "The Coal Mine Next Door." As part of a cartographic design seminar during my fall semester at Middlebury College I developed an original print map of the prevalence and proximity of surface mining in and around Kanawha County, West Virginia. Surface mining, which includes mountain top removal mining, is an extremely destructive mining process that includes the removal of surface terrain to extract the minerals found below. Mountain top removal mining is predominantly practiced in the mountainous landscape of the Appalachian coal field within the eastern United States. This is a map that incorporates shaded relief with thematic representations of physical features in order to highlight the unique physical landscape of the region and the destructive mining practices that threaten it. For this map, I wanted to consider how we can use methods of terrain representation to consider spatial relationships between people and their environment. Therefore, this map is not just about the scale of mountain top removal mining in West Virginia but it is an attempt put it into perspective with the people that live there. This is a story with multiple characters: the unique mountainous

terrain, the blotches of surface mines, inhabited valley lands and the streams that link them all. This print map measures approximately 76.2 x 53.34 cm (30 x 21 in) and was developed using GIS and design programs including: QGIS, Google Earth Engine, Adobe Illustrator and Adobe Photoshop.