PhD Topic 6: Exploring and Analyzing Environmental Data with Visual Analytics Methods

First Supervisor	Prof. Dr. Silvia Miksch
Second Supervisor	Prof. Nebojsa Nakicenovic
Primary Field	Visual Analytics
Secondary Field	Resource Management
Interdisciplinary References	B1, B2, B3

Visual Analytics denotes "the science of analytical reasoning facilitated by visual interactive interfaces" [2] and mains to make complex information structures more comprehensible, facilitate new insights, and enable knowledge discovery. Visual Analytics focus on the information discovering process exploiting both the computational power of computers and the human eye's broad bandwidth. Therefore, it aims to enable the exploration and the understanding of large and complex data sets intertwining interactive visualization, data analysis, and human-computer interaction. The overall goal of Visual Analytics is to design and create methods to enable users to [3]:

- synthesize information and derive insight from massive, dynamic, ambiguous, and often conflicting data,
- detect the expected and discover the unexpected,
- provide timely, defensible, and understandable assessments, and
- Communicate these assessments effectively for actions.

Visualization is a big field and has a long tradition [4], however, the visualization of time-oriented data and its temporal properties is still a challenging topic [1]. Time is an important data dimension with distinct characteristics that is common across many application domains. In contrast to other quantitative data dimensions that are usually "flat", time has inherent semantic structures, which increase its complexity dramatically. Especially the hierarchical structure of granularities in time, as for example minutes, hours, days, weeks, months, is unlike most other quantitative dimensions. Specifically, time comprises different forms of divisions (e.g., 60 minutes resemble one hour while 24 hours resemble one day) and granularities are combined to form calendar systems (e.g., Gregorian, Business, or Academic calendars). Moreover, time contains natural cycles and re-occurrences, as for example seasons, but also social (often irregular) cycles, like holidays or school breaks. Therefore,

time-oriented data need to be treated differently from other kinds of data and demand appropriate interaction, visual and analytical methods to analyze them.

Sustainable exploration, understanding, and management of natural and person-made resources and biodiversity are challenging application domains, which provide various multivariate and time-oriented data and information. In particular, in the environmental domain, exploring and managing resources (monitored as multivariate and time-oriented data and information) in a changing environment asks for innovative Visual Analytics methods. The research challenges will be to utilize Visual Analytics methods to explore and understand such environmental resources, to detect the expected and discover the unexpected, and to provide a visual discovery environment for decision support for the analysts. The research challenging will be to tackle the following aspects

- Users – Data – Task: designing Visual Analytics methods for particular users (e.g., the environmental analysts) using particular multivariate and time-oriented data (or datasets) and performing particular tasks or achieving particular goals.
- Uncertainty: Visual Analytics is a valuable approach to explore large data sets. In the environmental domain these data sets may contain an unavoidable amount of uncertainty that needs to be visualized, analyzed, and communicated.
- Scalable Visual Analytics Methods: Visualizing such a huge amount of multivariate and time-oriented data sets need scalable problem solving methods.

References:

[1] Wolfgang Aigner, Silvia Miksch, Heidrun Schumann, and Christian Tominski. Visualization of Time-Oriented Data. Human-Computer Interaction. Springer, 1st edition, 2011.

[2] Jim J. Thomas and Kristin A. Cook. Illuminating the Path: The Research and Development Agenda for Visual Analytics. IEEE Computer Society, 2005.

[3] Daniel Keim, Jörn Kohlhammer, Geoffrey Ellis, and Florian Mansmann, editors. Mastering the Information Age-Solving Problems with Visual Analytics. Eurographics, 2010.

[4] Matthew Ward, Georges G. Grinstein, and Daniel Keim. Interactive Data Visualization: Foundations, Techniques, and Application, A K Peters, 2010.