Using virtual reality to visualize extreme rainfall events derived from climate simulations

Daniel Kolb, Wolfgang Kurtz, Jens Weismüller, Alexander von Ramm, Dieter Kranzlmüller, Leibniz Supercomputing Centre, Garching near Munich, Germany
Ralf Ludwig, Ludwig-Maximilians-Universität, Munich, Germany

Introduction
Virtual Reality is a powerful tool for scientific visualization and science communication. Utilizing all three spatial dimensions as well as intuitive interaction methods allows us to present large sets of data in immersive ways. We present a VR visualization of precipitation data pertaining to the hydrological area of Bavaria.

Data originating from the ClimEx Project:
- Climate change simulation for 1950-2100
- RCP 8.5 scenario using the Canadian Regional Climate Model (CRCM5)
- SO-member ensemble run on the SuperMUC
- Numerous climatological and hydrological variables, e.g. temperature, pressure, soil humidity and rainfall

Our goal is a scientific visualization that is:
- Able to display various events of 60 hours of accumulated rainfall each
- Immersive and engaging
- Easy to control and understand, especially for non-experts
- Open to exploration
- Able to render 90+ frames per second per eye on commercial hardware

Method
We use the feature-rich Unreal Engine 4 to design the 3D scene as well as the VR interaction. For this we create a 3D surface from the grid of data values. The z-value of the surface corresponds to the aggregated amount of rainfall since the beginning of each respective event.

Results
We were able to present our VR visualization to a wide field of interested people in varied settings. The users included prospective secondary school graduates evaluating branches of study, climate scientists, non-climate scientists, politicians, elder citizens and other decision makers. While different groups focused on different aspects of the visualization, all were able to independently control and explore the VR application with minimal introduction and guidance.

Conclusion
We have developed a way to present data results from climate computations in an immersive and accessible manner.

Challenges:
1. Boundaries imposed by hardware:
   - Rendering time
   - Memory usage
2. Technological barrier to exploring the virtual world:
   - Powerful, yet concise controls
   - Meaningful, yet unhindering displays

Solutions:
1. Optimization of the 3D meshes:
   - Polygon count reduction
   - Laplace Smoothing
   - Level of detail system
2. Application of familiar design patterns and principles:
   - Contour lines
   - Established UI designs
   - Flat interaction hierarchy
   - Feedback on current status
   - Visible input options

Acknowledgement
We would like to thank our colleagues, Elisabeth Mayer, Lea Weil and Kristian Weinand, for their support with the processing of 3D objects as well as their helpful feedback on design choices. We also gratefully acknowledge funding of the project ClimEx by the Bavarian State Ministry of the Environment and Consumer Protection.

References
Leduc, Martin, et al. „ClimEx project: a 50-member ensemble of climate change projections at 12-km resolution over Europe and northeastern North America with the Canadian Regional Climate Model (CRCM5).” Journal of Applied Meteorology and Climatology 2019.

Contact
Daniel Kolb
Boltzmannstraße 1
85748 Garching bei München
Phone: +49 89 35831 - 7891
E-Mail: daniel.kolb@lrz.de

Leibniz Supercomputing Centre
85748 Garching near Munich
Phone: +49 89 35831 - 8000
Fax: +49 89 35831 - 9700
E-mail: lrzpost@lrz.de
Internet: www.lrz.de