ETH zürich

Animations for 3D Solid Charts in a Virtual Globe

Techniques, Use cases, and Implementation

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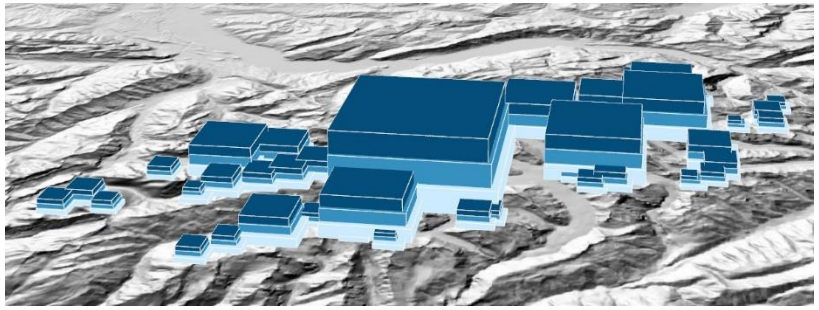
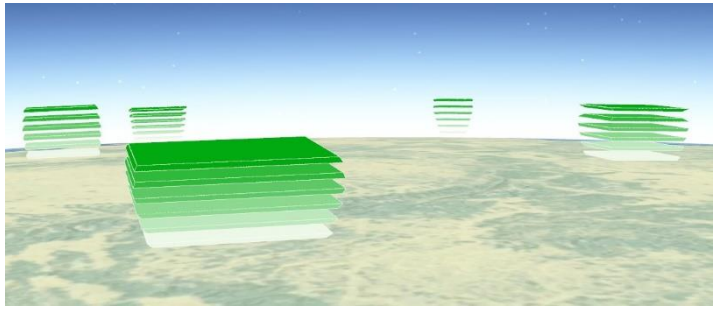
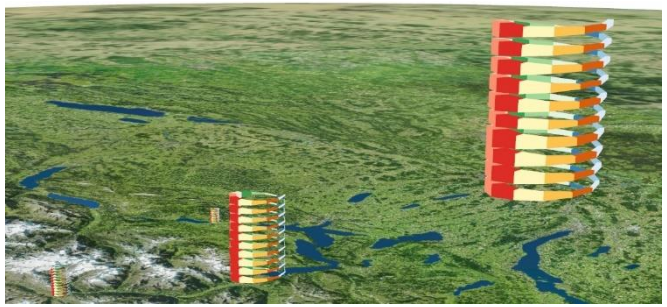
3D Solid Charts in a Virtual Globe (presented at ICC 2015)



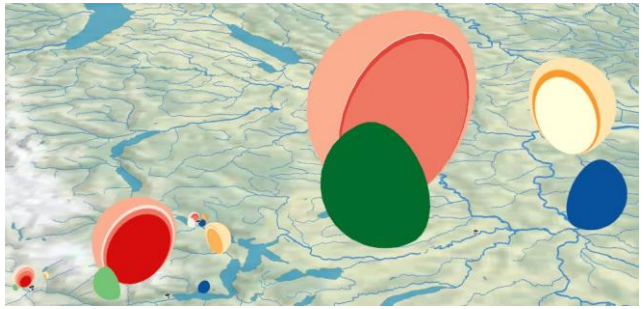
Stacked cuboids



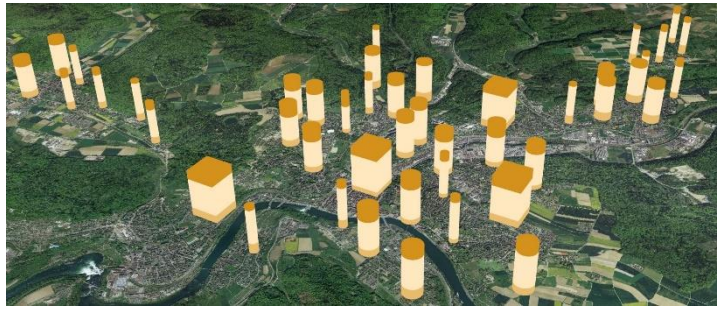
Stacked pyramid frustums



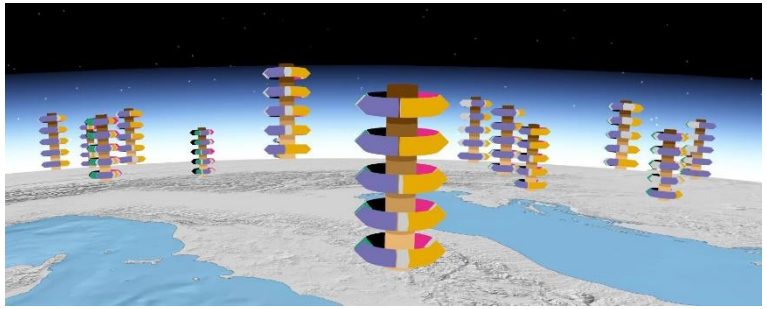
Helix charts



Nested hemispheres



3D coin chart



Abacus charts

Animation techniques

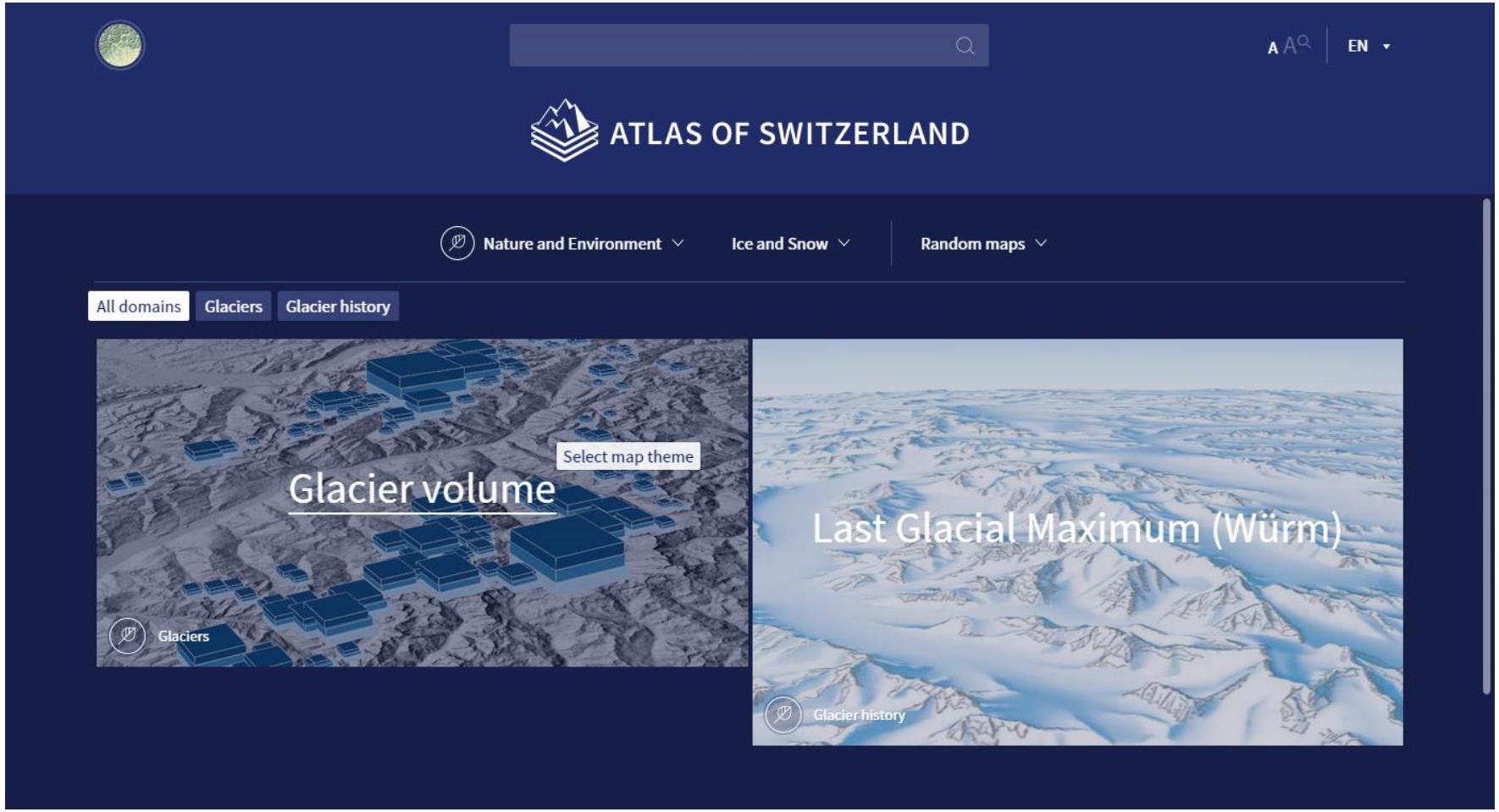
Shape-preserving animations:

- Translation, Rotation, Uniform scaling
- Change of surface properties (e.g. color, transparency, texture, reflection, glow)
- Change of environment lighting

Shape-altering animations (= deformations):

- Splitting & Merging
- Extrusion & Compression
- Twisting, Bending, Shearing
- Morphing

Use cases: An atlas map



User loads map

Initialization: Extrusion

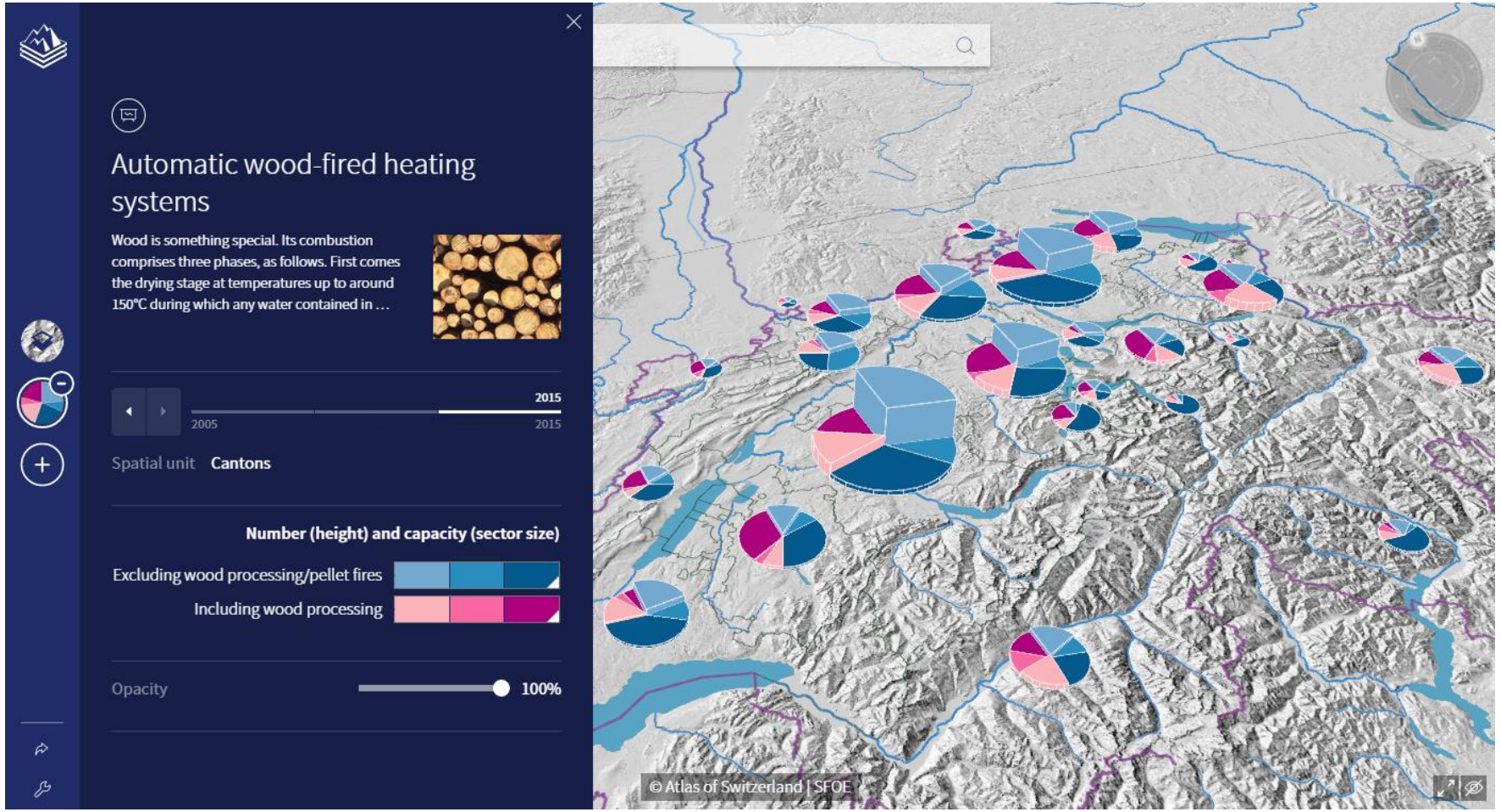
User selects chart segment

Highlighting: Colorization

User zooms out

Aggregation: Morphing

Use cases: Another atlas map



User changes temporal unit

Temporal animation: Extrusion & Scaling

User selects category

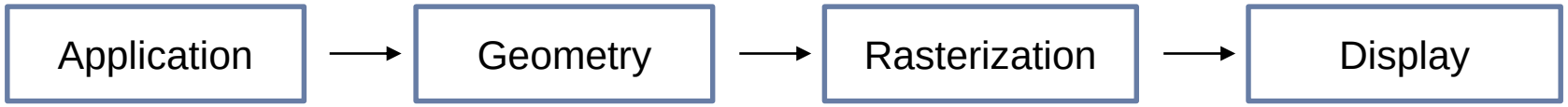
Refinement: Splitting

User selects chart segment

Displacement: Translation

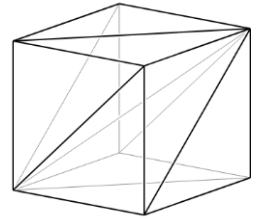
Implementation: First attempt

- Rendering by traditional 3D graphics pipeline



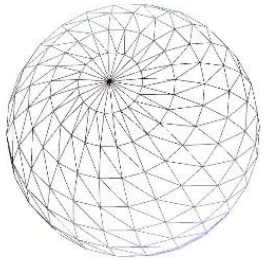
[Möller et al. 2008]

- Well-suited for shape-preserving animations
- Transformation of vertices of 3D shapes



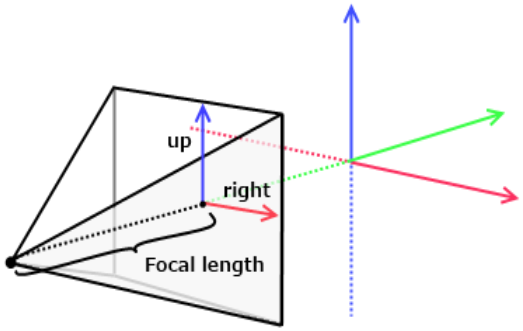
Challenges:

- Large amount of vertices for some shapes (e.g. spheres)
- CSG operations (union, difference, intersection)
- Deformations

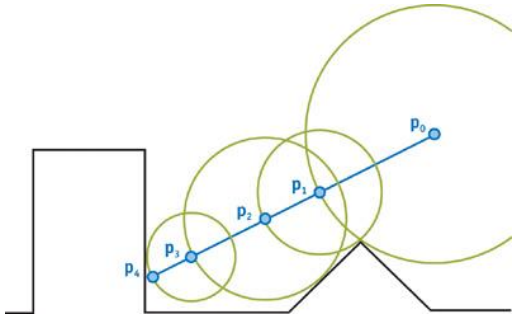


Implementation: Next attempt

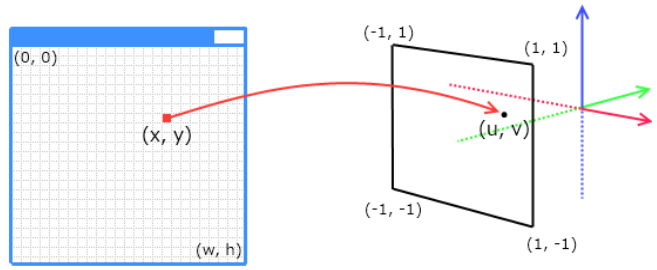
- Describe 3D shapes implicitly by mathematical functions → Functional representations (F-Reps), minimum distance functions
- Rendering by ray tracing algorithms, here sphere tracing (ray marching)



[Hugo 2013]



[Donnelly 2005]

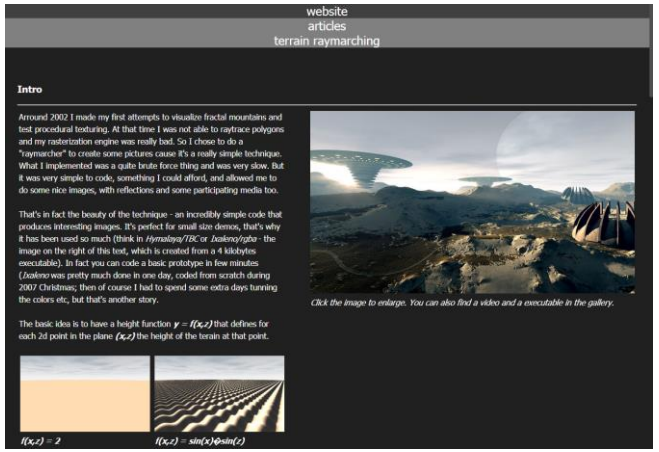


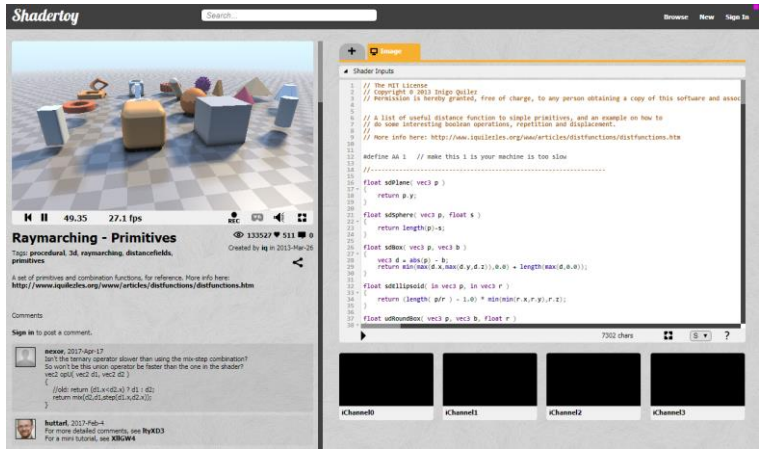
[Hugo 2013]

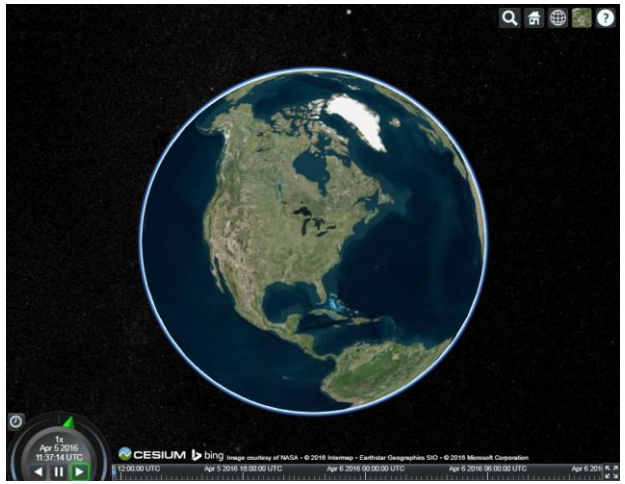
Challenges:

- Calculations per pixels → slower for large screen-sizes, but real-time rendering possible with modern graphic cards

Implementation: Resources







Inigo Quilez' website
Computer graphics experiments
http://www.iquilezles.org

Shadertoy
Fragment shader examples
http://www.shadertoy.com

Cesium
Virtual Globe SDK
http://cesiumjs.org/

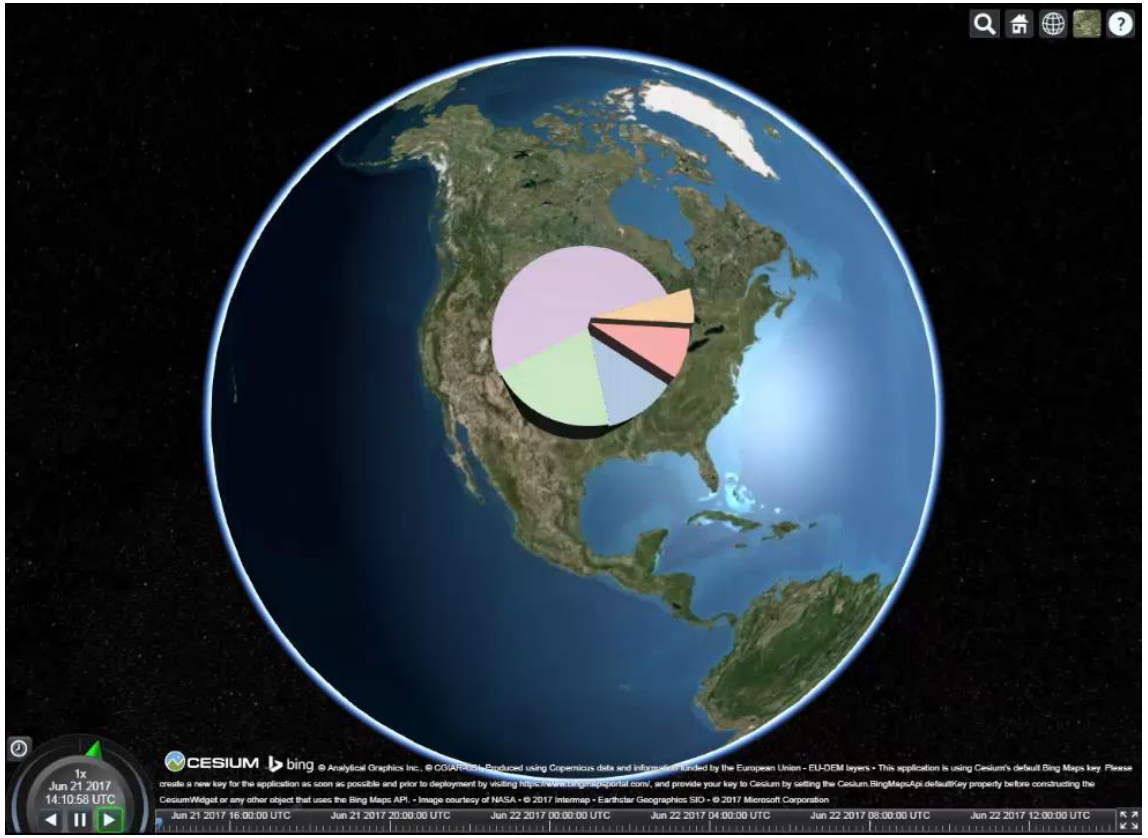
Implementation: Steps

- Creating a vertex and fragment shader
- Synchronizing perspective projections
- Calculating the depth buffer
- Adding the Lambertian reflectance model
- Finding minimum distance functions
- Extending rays for transparency
- Handling the selection of chart segments
- Optimizing performance

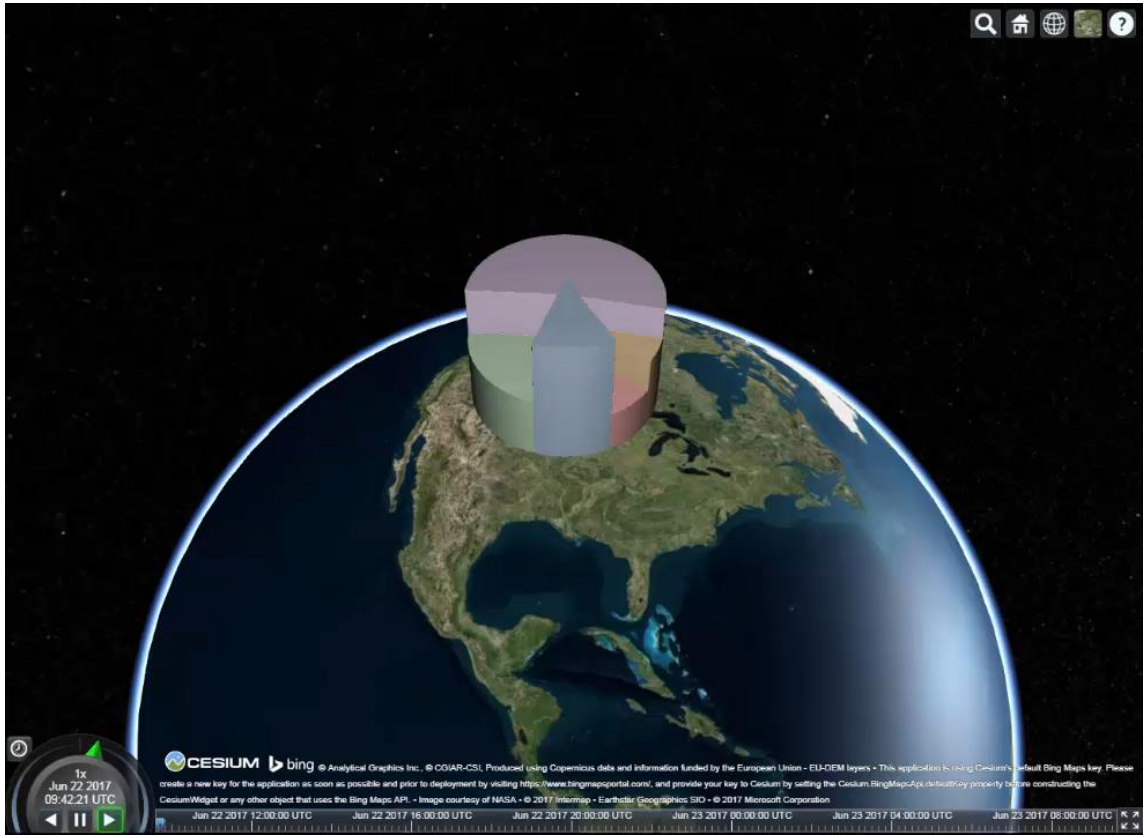
```
float raySphere(vec3 p, float r) {
    return length(p) - r;
}
```

```
float rayBox(vec3 p, vec3 b) {
    vec3 d = abs(p) - b;
    return max(d.x, max(d.y, d.z));
}
```

Results: 3D pie charts



Translation



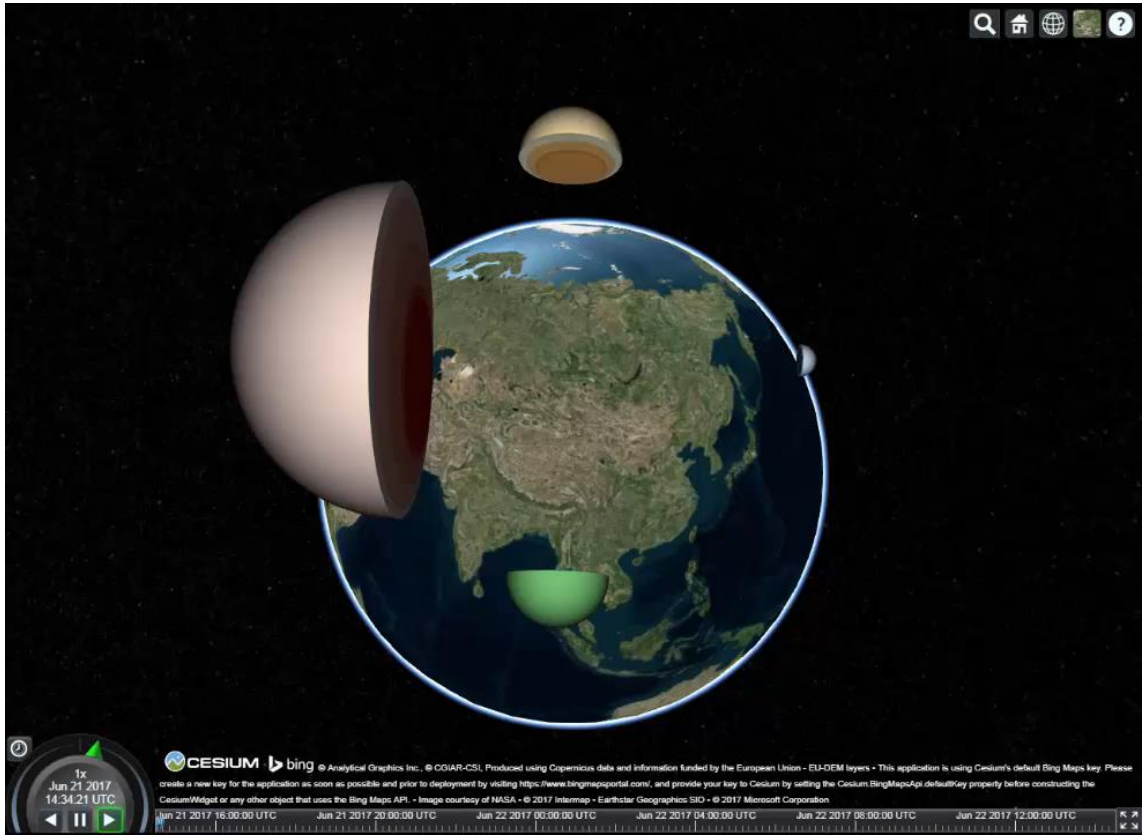
Extrusion & Compression

Results: Stacked pyramid frustums

Fading

Scaling

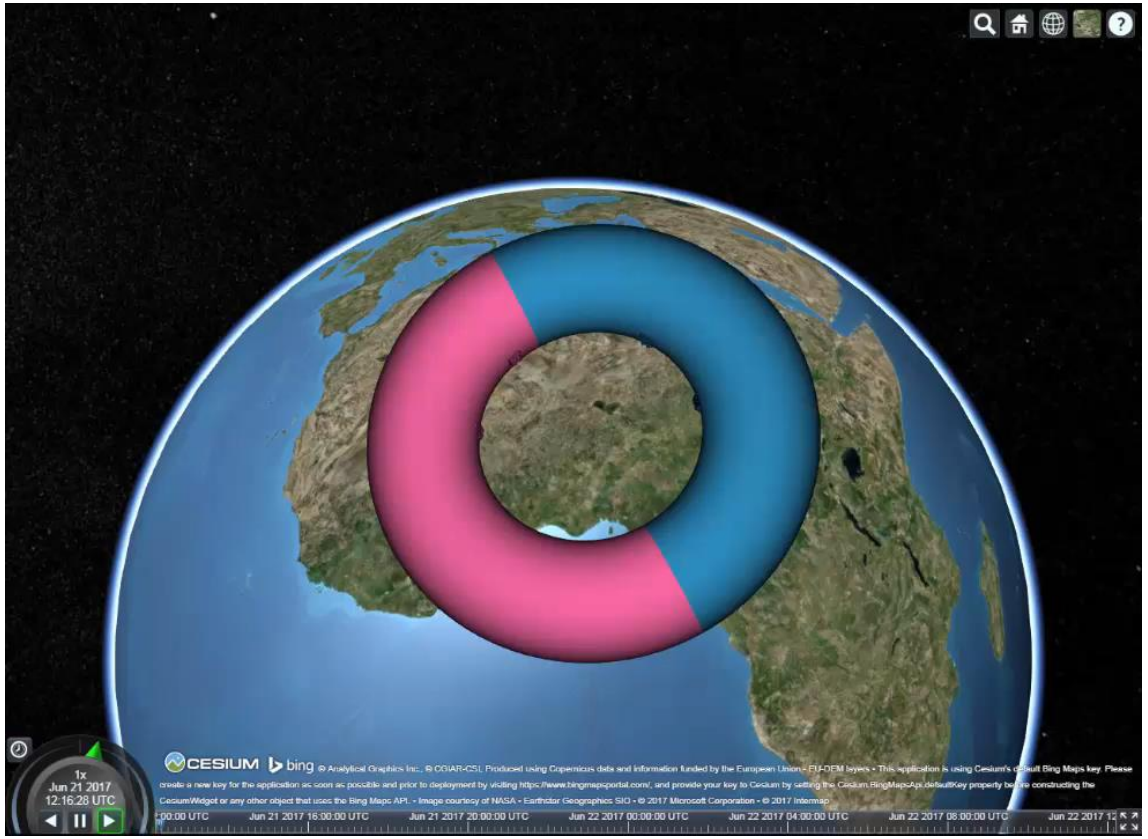
Results: Nested hemispheres



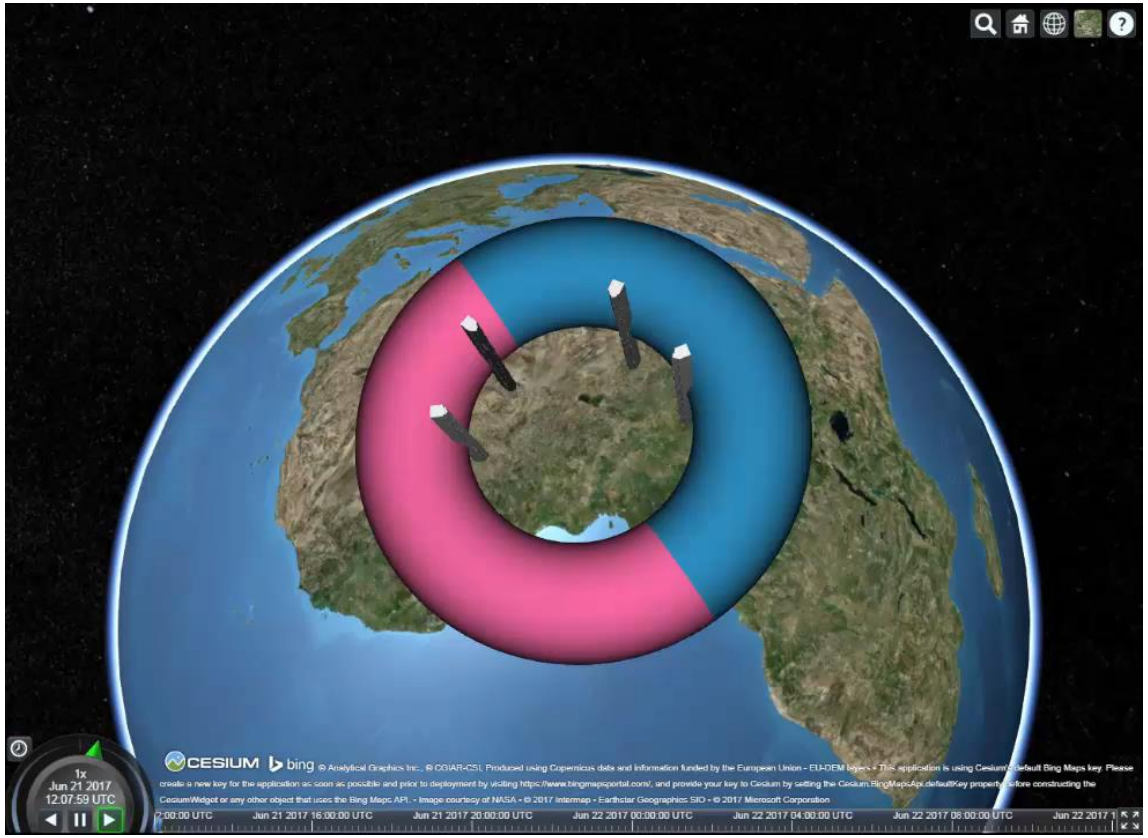
Rotation

Translation & Morphing

Results: 3D donut chart

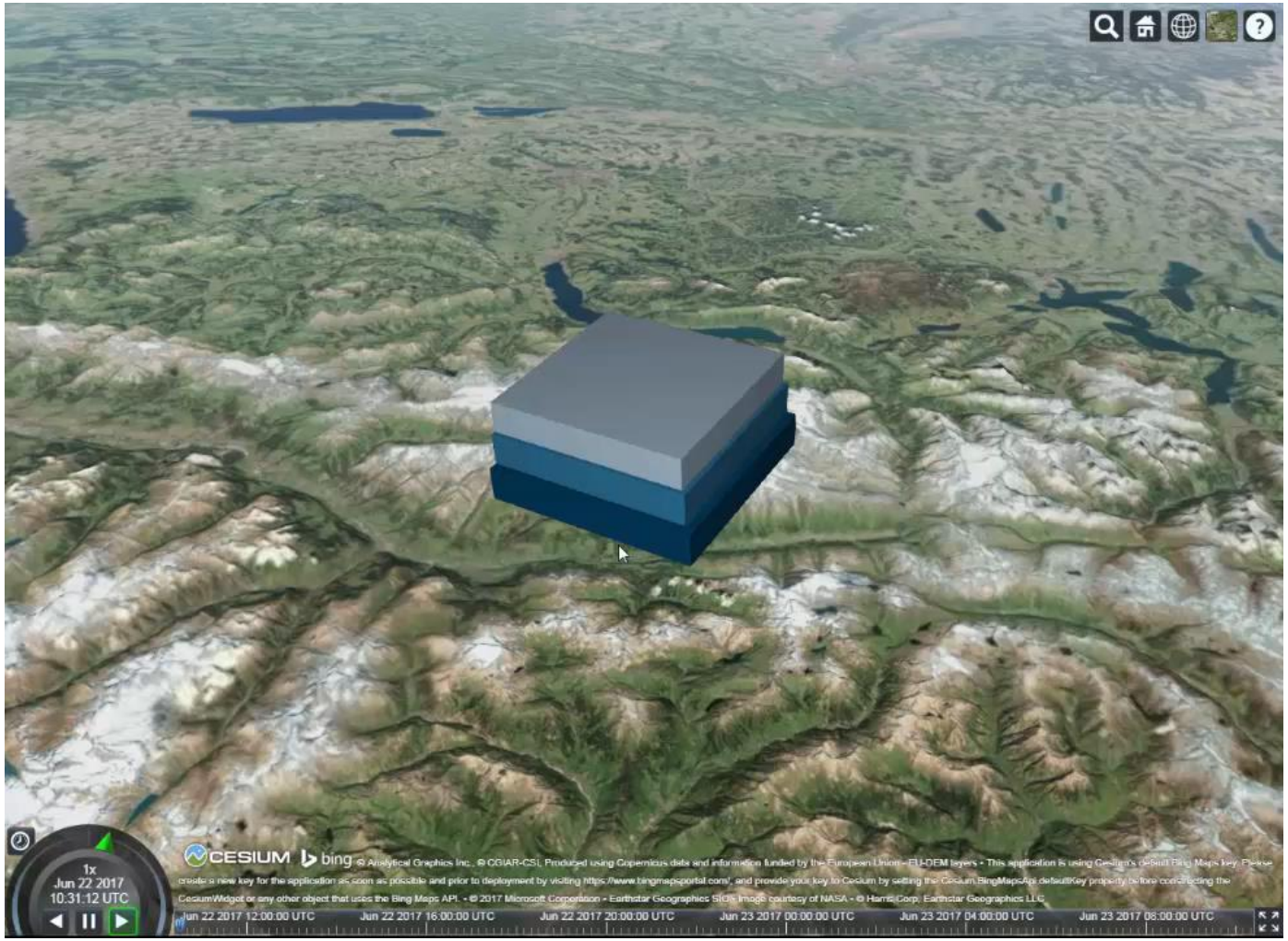


Splitting & Merging



Splitting & Merging
(with poles)

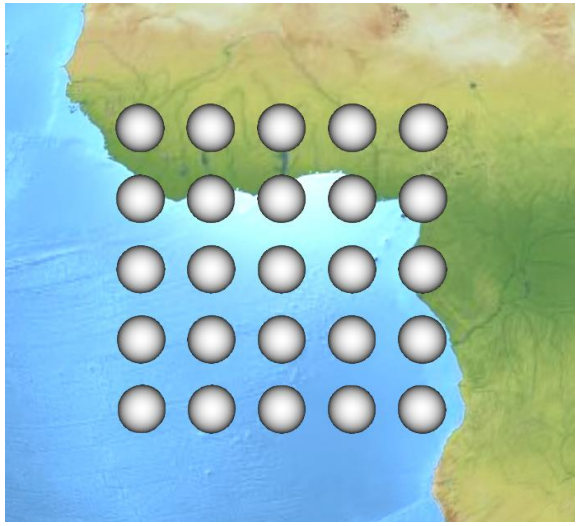
Results: Stacked cuboids



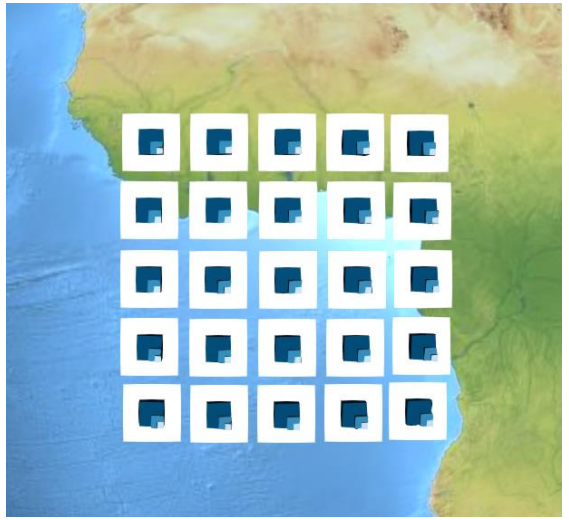
Colorization &
Rotation

Results: Performance

25 charts in one scene:
8 FPS



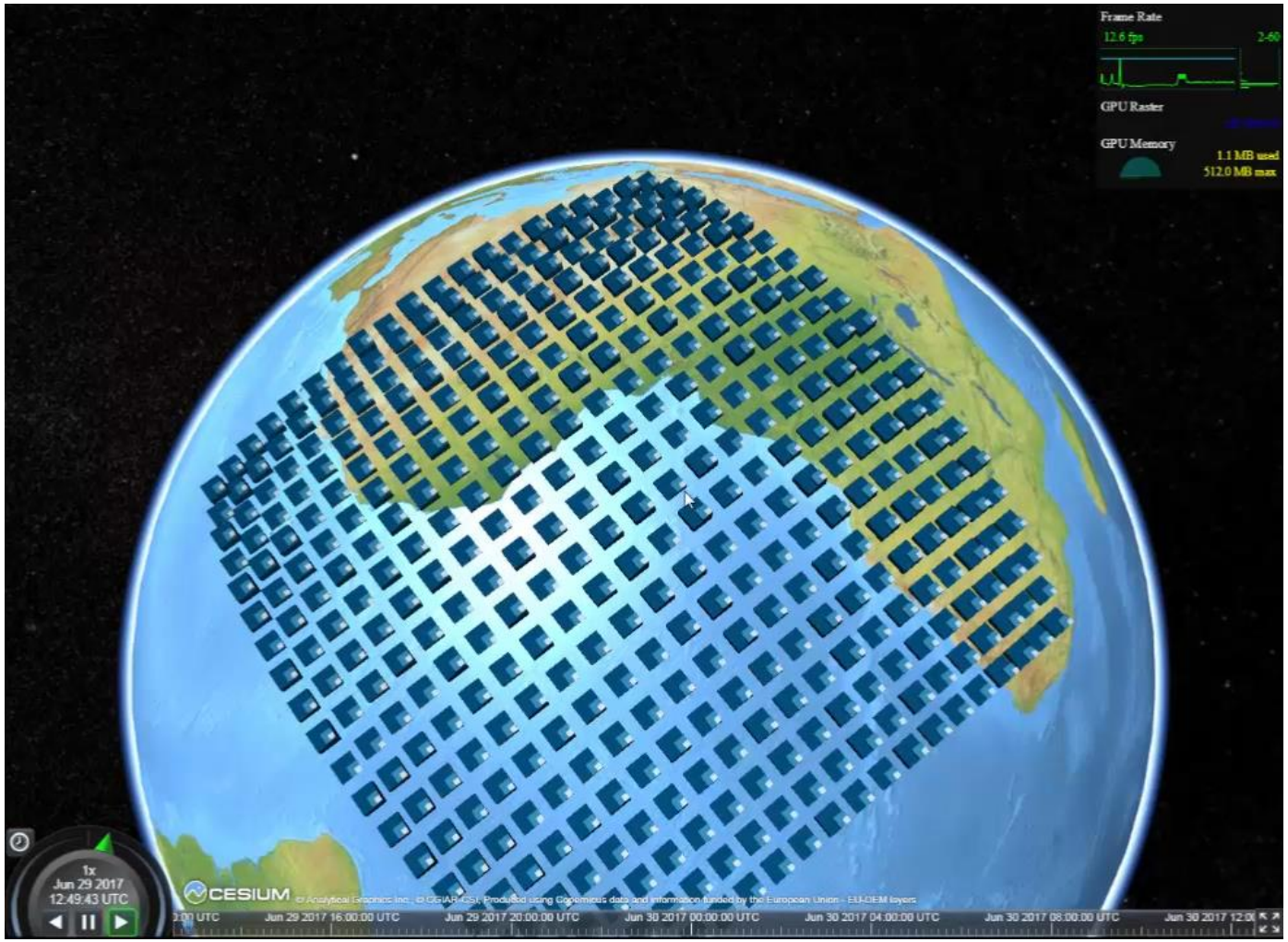
Bounding sphere pre-test:
16 FPS



Charts on individual billboards:
32 FPS

Test environment: Intel Xeon quad-core 3.30 GHz processor, Nvidia Quadro 600 graphics card, Chromium browser, 1280x936 window

Results: Performance



200 animated charts
on individual billboards:
11-14 FPS

Conclusion

- Creation and animation of 3D solid charts in real-time
- Shape-preserving and shape-altering animations
- Interactions with charts in a virtual globe environment

Outlook:

- Definition of a 3D chart animation language
- Post-processing: Anti-aliasing, outline rendering
- Usability study

Thank you for your attention!

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