GLSL Shaders

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Vertex shader

```
1  void main()
2  {
3      gl_Position = ftransform();
4  }
```

Fragment shader

```
1  void main()
2  {
3      gl_FragColor = gl_FrontMaterial.diffuse;
4  }
```

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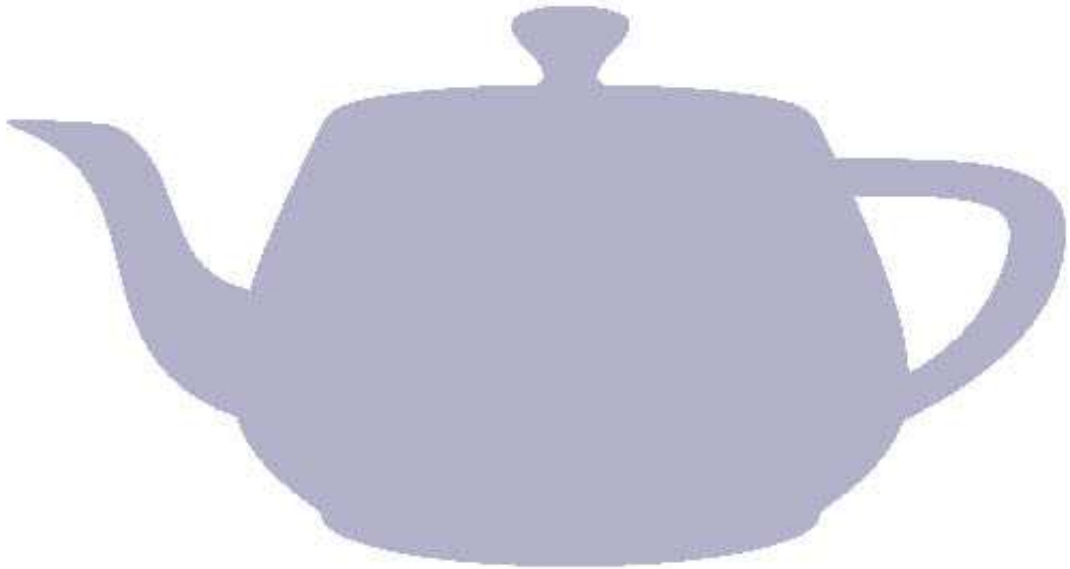

Vertex shader

```
1  varying float albedo;
2
3  void main()
4  {
5      vec3 pos_EC = vec3(gl_ModelViewMatrix * gl_Vertex);
6      vec3 normal_EC = normalize(gl_NormalMatrix * gl_Normal);
7      vec3 light_EC = normalize(gl_LightSource[0].position.xyz -
           pos_EC);
8
9      albedo = dot(normal_EC, light_EC);
10
11     gl_Position = ftransform();
12 }
```

Fragment shader

```
1  varying float albedo;
2
3  void main()
4  {
5      gl_FragColor = vec4(albedo * gl_FrontMaterial.diffuse.rgb,
           1.0);
6  }
```

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Vertex shader

```
1  varying float albedo, specular;
2
3  void main()
4  {
5      vec3 pos_EC = vec3(gl_ModelViewMatrix * gl_Vertex);
6      vec3 normal_EC = normalize(gl_NormalMatrix * gl_Normal);
7      vec3 light_EC = normalize(gl_LightSource[0].position.xyz -
           pos_EC);
8      vec3 half_EC = normalize(light_EC - normalize(pos_EC));
9
10     albedo = max(dot(normal_EC, light_EC), 0.0);
11     specular = pow(max(dot(normal_EC, half_EC),0.0),
           gl_FrontMaterial.shininess);
12
13     gl_Position = ftransform();
14 }
```

Fragment shader

```
1  varying float albedo, specular;
2
3  void main()
4  {
5      vec4 ambientp =   gl_LightSource[0].ambient  *
           gl_FrontMaterial.ambient;
6      vec4 diffusep =   gl_LightSource[0].diffuse  *
           gl_FrontMaterial.diffuse;
7      vec4 specularp =  gl_LightSource[0].specular *
           gl_FrontMaterial.specular;
8
9      gl_FragColor = ambientp + albedo * diffusep + specular *
           specularp;
10 }
```

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Vertex shader

```
1  varying vec3 normal_EC, light_EC, pos_EC;
2
3  void main()
4  {
5      pos_EC = vec3(gl_ModelViewMatrix * gl_Vertex);
6      normal_EC = normalize(gl_NormalMatrix * gl_Normal);
7      light_EC = gl_LightSource[0].position.xyz - pos_EC;
8
9      gl_Position = ftransform();
10 }
```

Fragment shader

```
1  varying vec3 normal_EC, light_EC, pos_EC;
2
3  void main()
4  {
5      vec4 ambientp =   gl_LightSource[0].ambient  *
           gl_FrontMaterial.ambient;
6      vec4 diffusep =   gl_LightSource[0].diffuse  *
           gl_FrontMaterial.diffuse;
7      vec4 specularp =  gl_LightSource[0].specular *
           gl_FrontMaterial.specular;
8
9      vec3 n_EC = normalize(normal_EC);
10     vec3 l_EC = normalize(light_EC);
11     vec3 h_EC = normalize(l_EC - normalize(pos_EC));
12
13     float albedo = max(dot(n_EC, l_EC), 0.0);
14     float specular = pow(max(dot(n_EC, h_EC),0.0),
           gl_FrontMaterial.shininess);
15
16     gl_FragColor = ambientp + albedo * diffusep + specular *
           specularp;
17 }
```

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Regarding Vector Normalization

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- normalize vectors after interpolation
- swizzle away extraneous components when normalizing
- `gl_Normal` is a vec3

Two-Sided Lighting: Method 1

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- disable backface culling
- in FS:

```
1  if (!gl_FrontFacing) n = -n;
```

Two-Sided Lighting: Method 2

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- disable backface culling, enable `GL_VERTEX_PROGRAM_TWO_SIDE`
- in VS, write to `gl_FrontColor` and `gl_BackColor`
- in FS, read from `gl_Color`

Note: `gl_Color` is an attribute in VS and a varying in FS. This method is for per-vertex lighting only.

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In VS add:

```
1  gl_TexCoord[0] = gl_MultiTexCoord0;
```

In FS add:

```
1  uniform sampler2D tunit;
```

```
1  vec4 t = texture2D(tunit, gl_TexCoord[0].st);
```

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OpenGL Red Book describes two methods of rendering a wireframe view with *the hidden surfaces removed*.

A much better method is described in:

- A. Bærentzen, S. L. Nielsen, M. Gjøl, B. D. Larsen, and N. J. Christensen. Single-Pass Wireframe Rendering. In *SIGGRAPH*, page 149, 2006

Main Idea

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- provide triangle vertices to the VS
  - In OpenGL 2.0 this can be done by using `gl_MultiTexCoordN.xyz`.
- project the vertices into screen space
- calculate distances to the triangle edges
- interpolate them to determine location of the border in FS

Project

```
1  uniform vec4 viewport;
```

...

```
1  vec4 vp0 = gl_ModelViewProjectionMatrix*vec4(
       gl_MultiTexCoord0.xyz, 1.0);
2  vp0.x /= vp0.w;
3  vp0.y /= vp0.w;
4  vp0.z /= vp0.w;
5  vp0.x = viewport.x + 0.5*viewport.z*(vp0.x + 1.0);
6  vp0.y = viewport.y + 0.5*viewport.w*(vp0.y + 1.0);
7  //vp0.z = gl_DepthRange.near + 0.5*gl_DepthRange.far*(vp0
       .z + gl_DepthRange.diff);
```

code credit T. Hinks

Compute Distance

```
1  float dx, dy;
2  dx = vp1.x - vp0.x;
3  dy = vp1.y - vp0.y;
4  gl_TexCoord[0].x = abs(dx*(vp0.y - vp.y) - (vp0.x - vp.x)
       *dy)/sqrt(dx*dx + dy*dy);
5  gl_TexCoord[0].x *= vp.w; // Perspective pre-
       multiplication.
6  // Varying post-multiplication for fragment shader.
7  gl_TexCoord[0].w = 1.0/vp.w;
```

code credit T. Hinks

Fragment Shader

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- find the minimum distance
- compare to line width
- fill in color appropriately

To antialias the lines fade out line color using e^{-kx^2}.
Can use functions exp or exp2.

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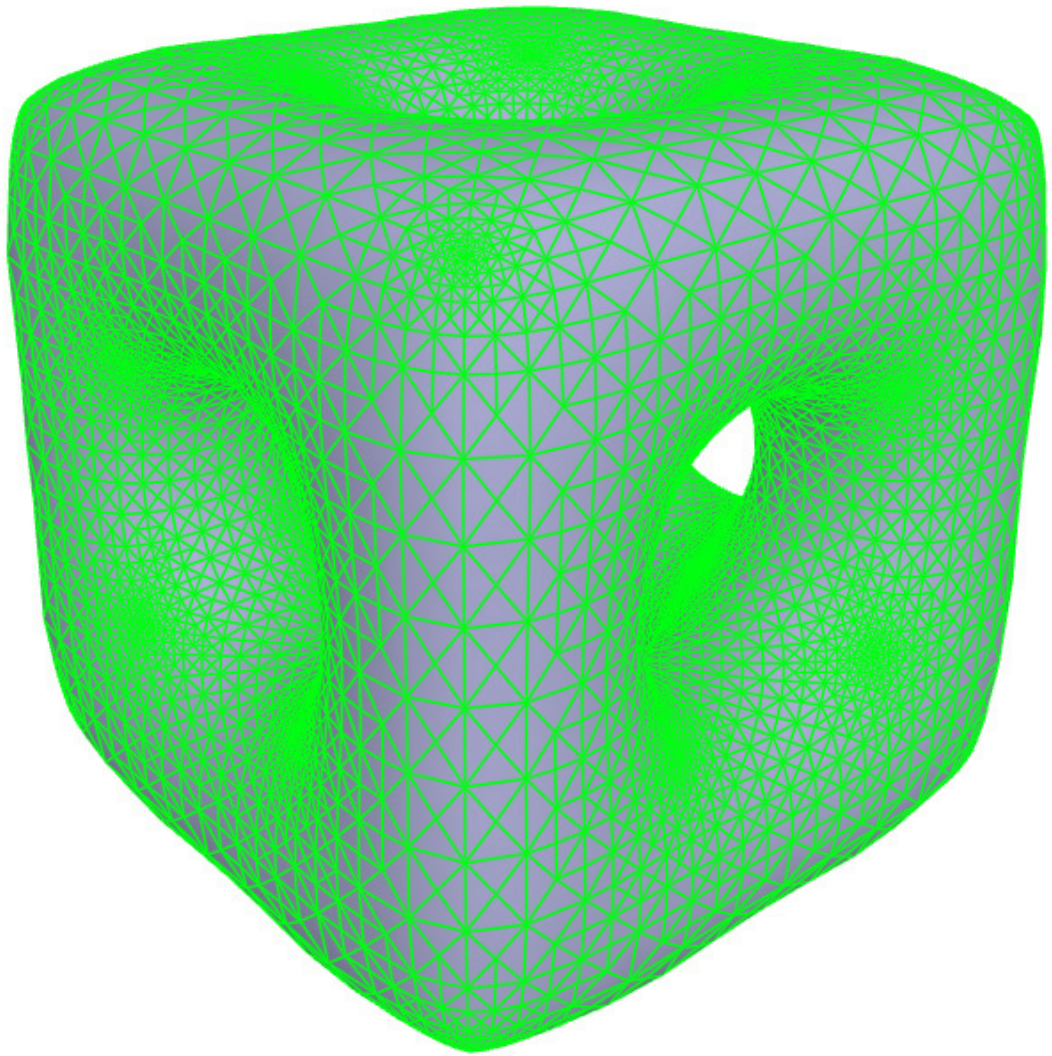

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A simple method of volume visualization involves tracing voxels in a shader.

Described in:

- W. F. Engel, editor. *ShaderX2*, chapter Voxel Rendering with PS 3.0. pages 161–171.
- maybe also in *Graphics Shaders* by M. Bailey and S. Cunningham

Vertex Shader

Get starting location from (3D) texture coordinates.

Get ray direction from:

```
1  vec4 dir_WCS = gl_ModelViewMatrix*gl_Vertex;
2  dir_WCS.w = 0.0;
3  vec3 DIR = normalize(vec3(gl_ModelViewMatrixInverse *
       dir_WCS));
```

or:

```
1  vec3 DIR = normalize(vec3(gl_Vertex -
       gl_ModelViewMatrixInverse * vec4(0.0, 0.0, 0.0, 1.0)))
       ;
```

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Composite voxel samples along the ray using α and $1 - \alpha$.
Back to front equation:

$$result_i = \alpha_i \cdot c_i + (1 - \alpha_i) \cdot result_{i-1}$$

Front to back equation (indexed in opp. order):

$$result_N = \sum_{i=0}^{N} \left(\Pi_{k=0}^{i-1}(1 - \alpha_k)\right) \cdot \alpha_i \cdot c_i$$

Note: similar for α of the result.

```
1  float alpha_acc = 1.0;                    // Π_i(1 − α_i)
2  vec3 result = vec3(0.0, 0.0, 0.0); // resulting color
3  float result_alpha = 0.0;
4
5  for(int i=0; i < steps; ++i)
6  {
7      // bounds check: must be inside the texture cube
8      if (all(greaterThan(cur_pos, zero_m_eps)) &&
9          all(lessThan(cur_pos, one_p_eps)))
10       {
11         float alpha_i = ??;
12         vec3 color_i = ??;
13
14         // calculate the contribution:
15         result += alpha_acc * alpha_i * color_i;
16         result_alpha += alpha_acc * alpha_i;
17
18         alpha_acc *= (1.0 - alpha_i);
19       }
20     cur_pos += dir_step;
21 }
22 gl_FragColor = vec4(result + alpha_acc * bg_color,
       result_alpha);
```

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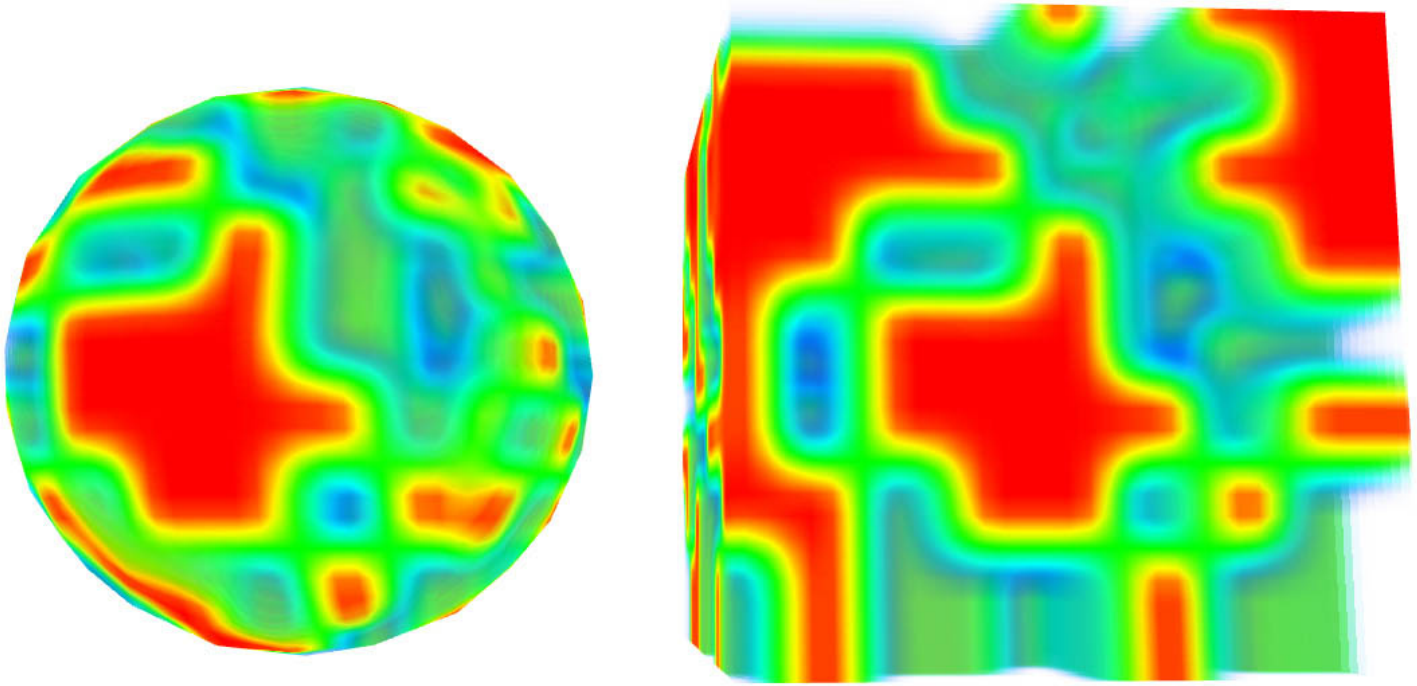

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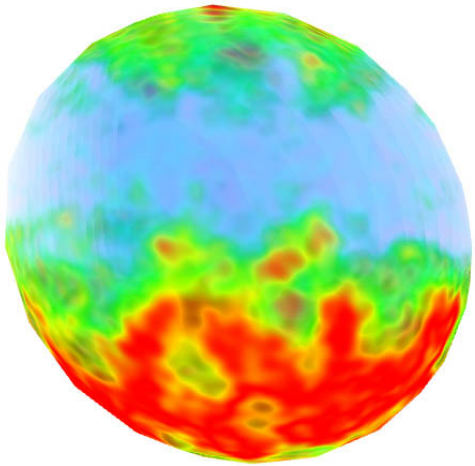

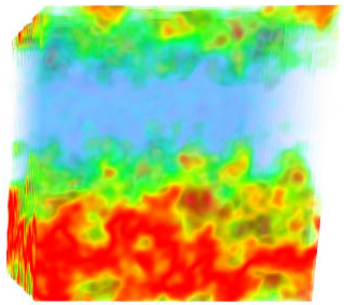

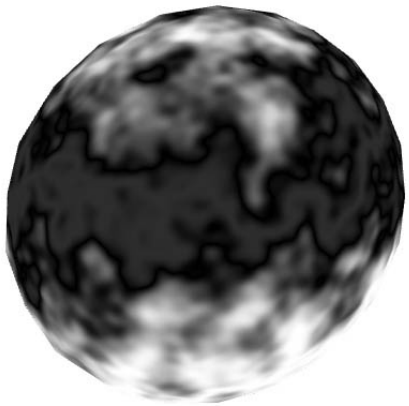

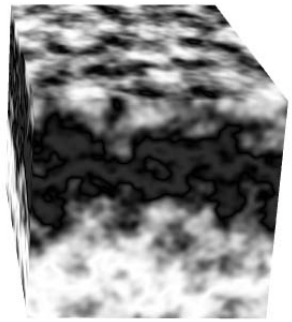

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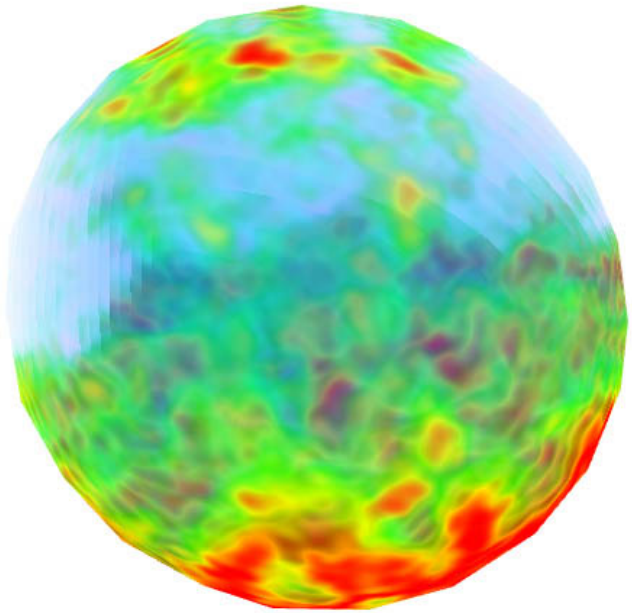

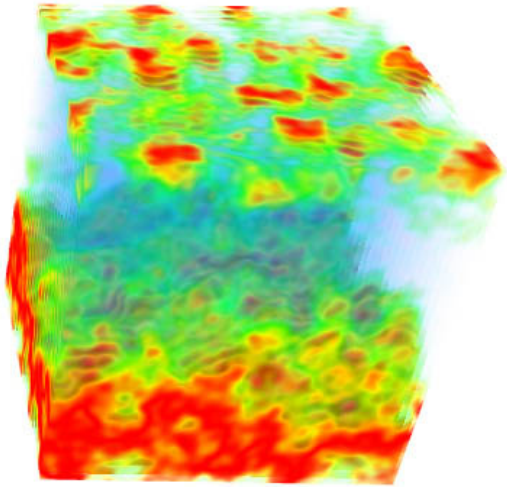

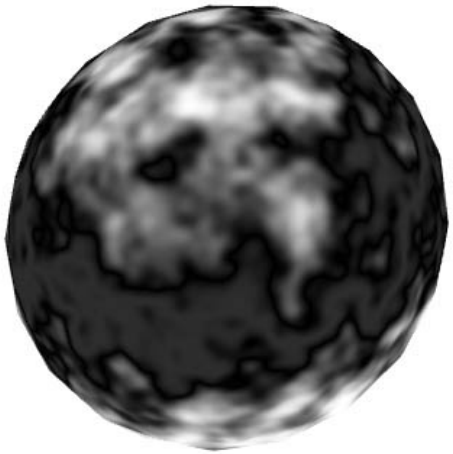

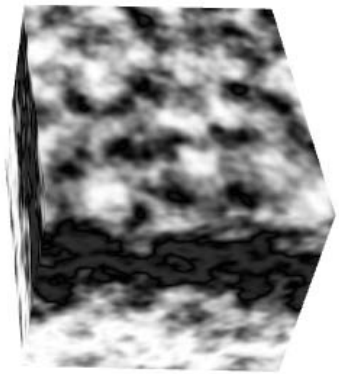

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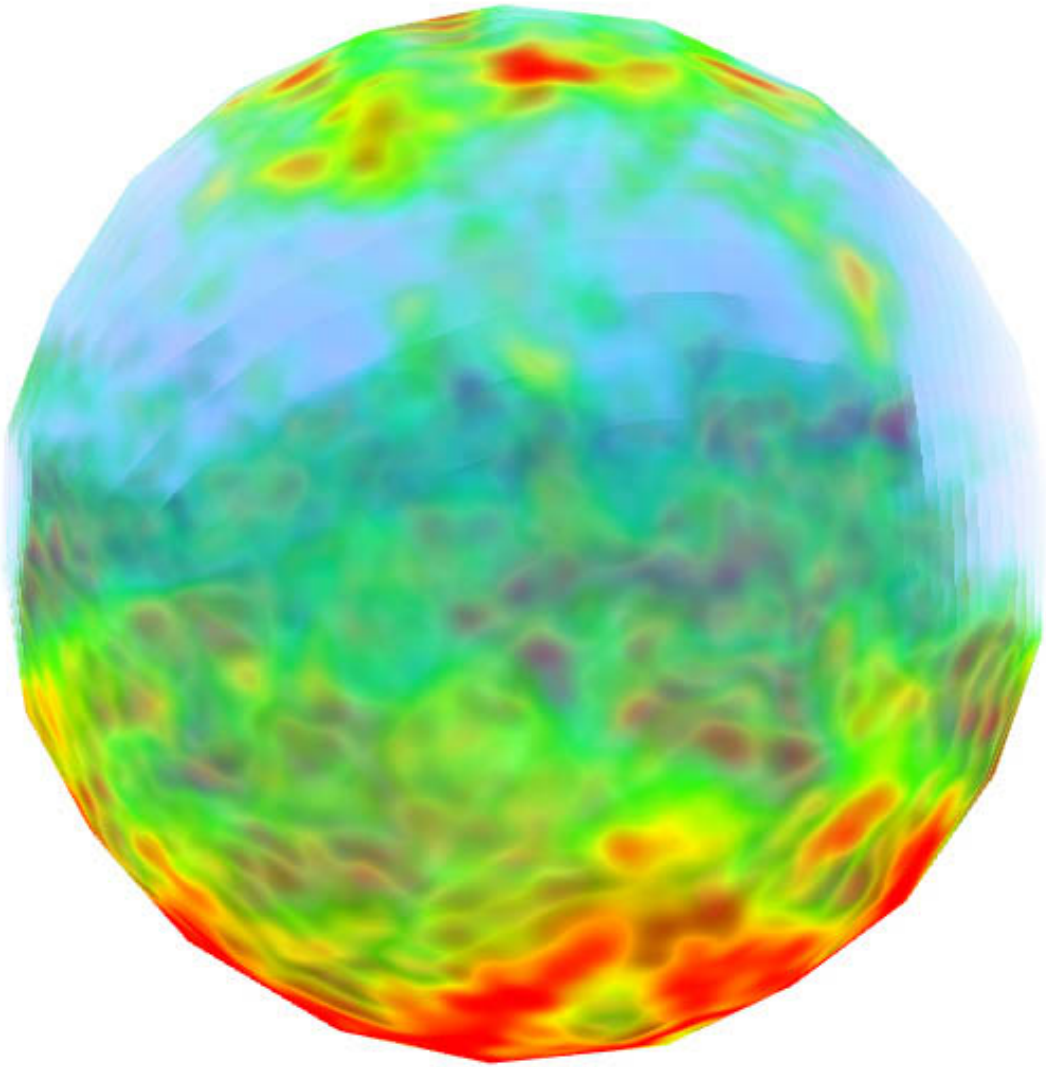

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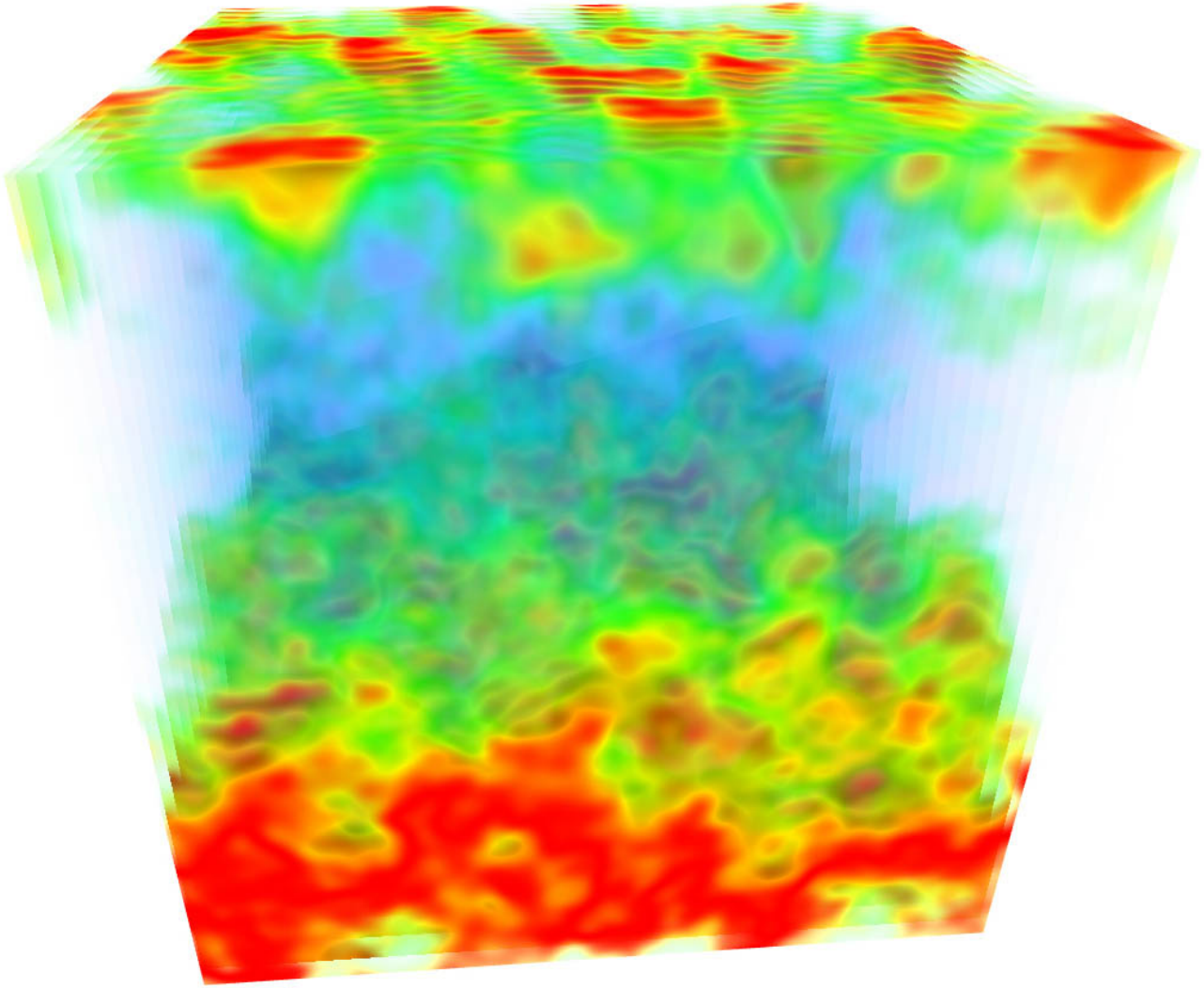

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OpenGL Version: 2.0.1
Shading language version: 1.10 NVIDIA via Cg 1.3 compiler