Volume Rendering of Meteorological Simulation Data

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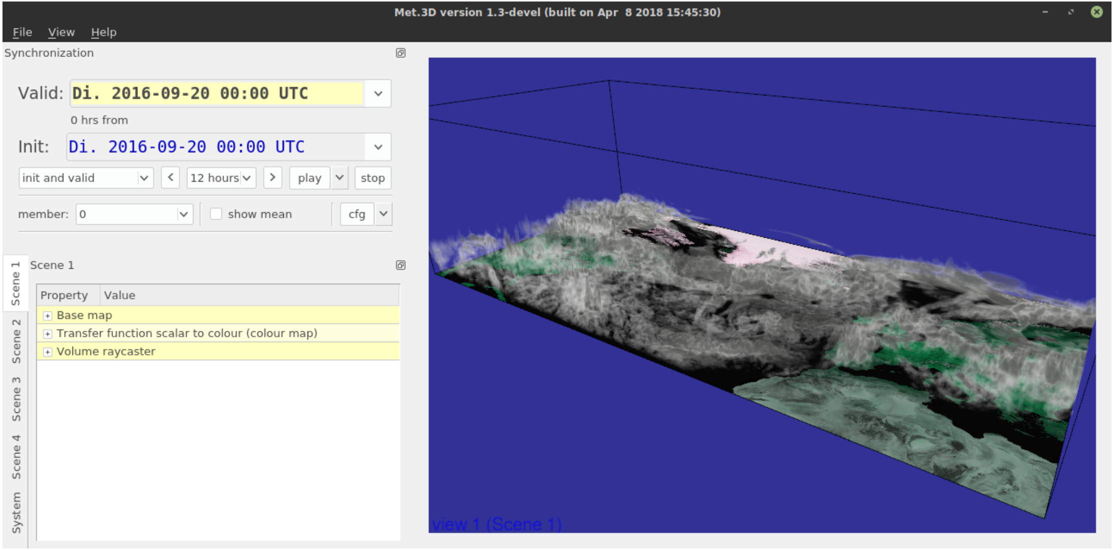
Technical University of Munich

May 14, 2018


Met.3D version 1.3-devel (built on Apr 8 2018 15:45:30)
File View Help
Synchronization
Valid: Di. 2016-09-20 00:00 UTC
0 hrs from
Init: Di. 2016-09-20 00:00 UTC
init and valid
12 hours
play
stop
member: 0
show mean
cfg
Scene 1
Scene 2
Scene 3
Scene 4
System
Property
Value
Base map
Transfer function scalar to colour (colour map)
Volume raycaster
view 1 (Scene 1)

Effects of lighting
often serve as visual cues.

$$T_r(x_0 \leftrightarrow x) = e^{-\tau(x_0 \leftrightarrow x)}$$

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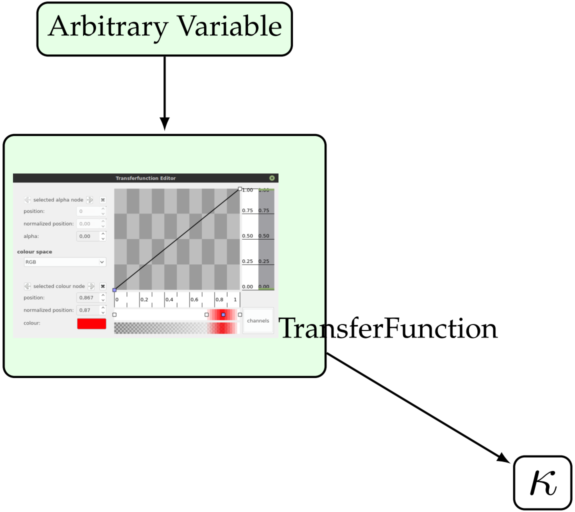
$$\tau(x_0 \leftrightarrow x) = \int_{x_0}^{x} \kappa_t(y) dy$$

$$T_r(x_0 \leftrightarrow x) = e^{-\tau(x_0 \leftrightarrow x)}$$

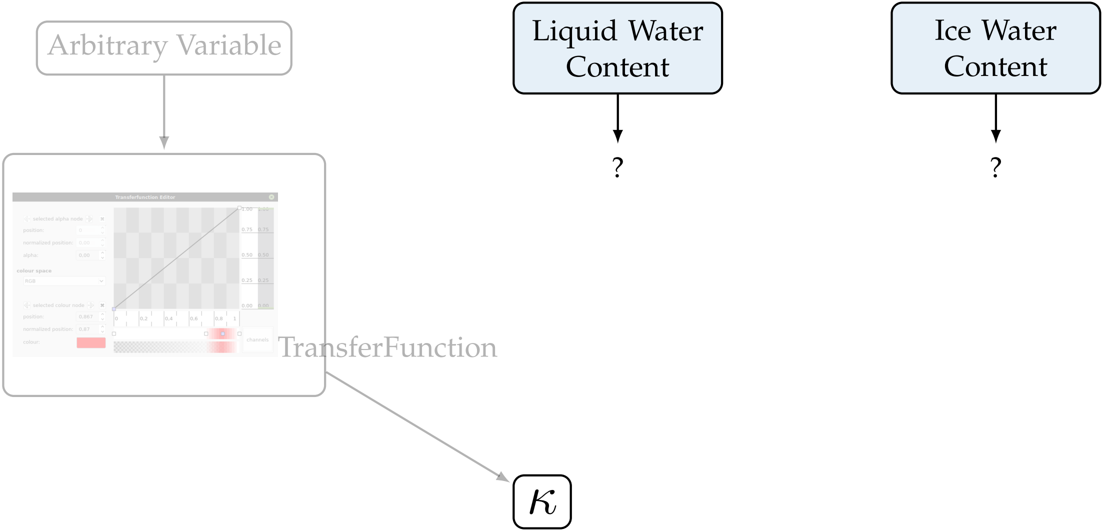
$$\tau(x_0 \leftrightarrow x) = \int_{x_0}^{x} \underbrace{\kappa_t(y)}_{\text{input from cloud data}} dy$$

Extinction Coefficient

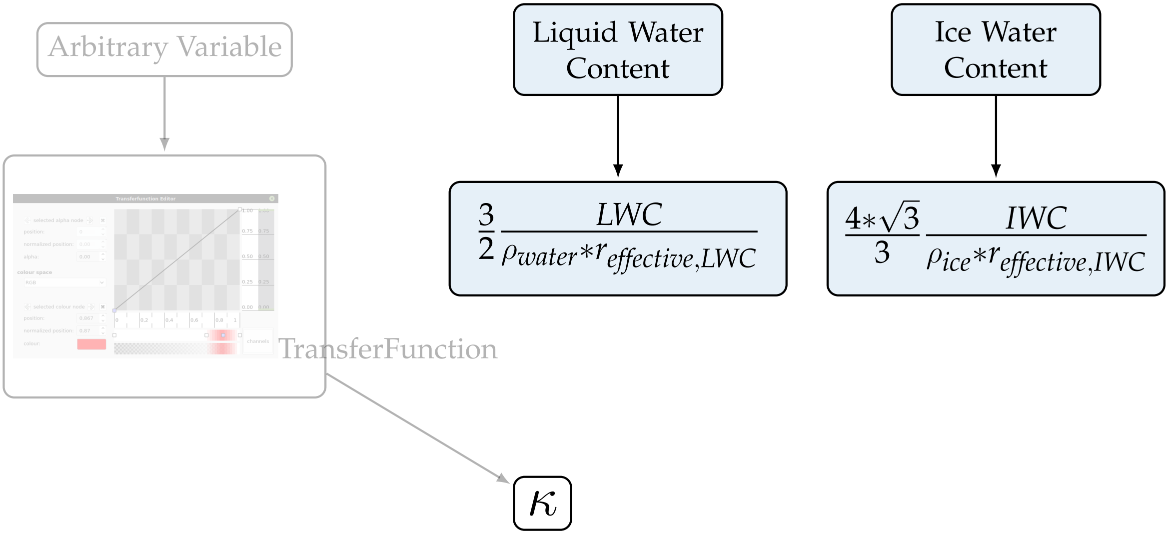
from Input Data



Extinction Coefficient
from Input Data

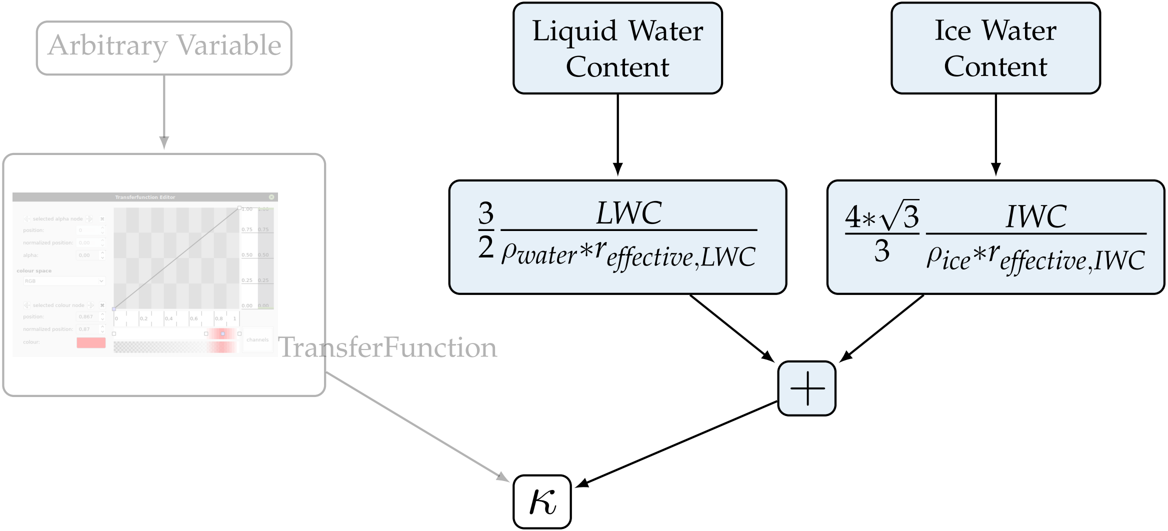


Extinction Coefficient
from Input Data



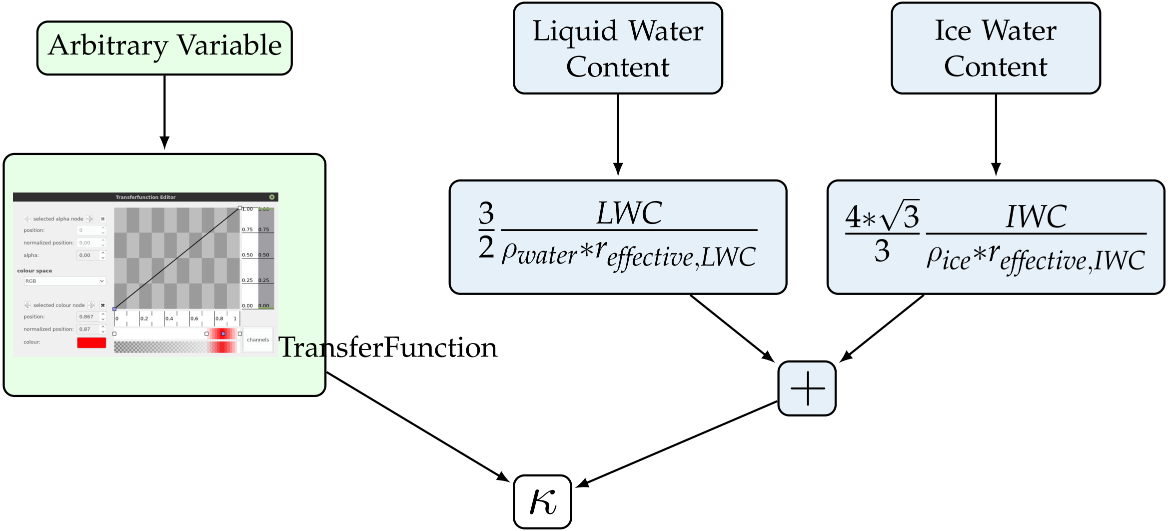
Extinction Coefficient

from Input Data



Extinction Coefficient

from Input Data



$$T_r(x_0 \leftrightarrow x) = e^{-\tau(x_0 \leftrightarrow x)}$$

$$\tau(x_0 \leftrightarrow x) = \int_{x_0}^{x} \kappa_t(y) \underbrace{dy}$$

awareness of length units necessary!

Scaling Options

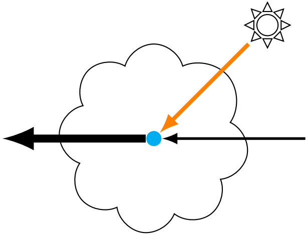
ice water content variable	Specific_cloud_ice_water_content_hybrid
liquid water effective radius (micron)	10.00
ice water effective radius (micron)	25.00
account for earth's curvature	True
use real vertical scale	True
space scale	1,000
force uniform scale for view	True
additional space scale for view	1,000
isosurface raycaster	
bounding box	North Atlantic and Europe
draw bounding box	True
isosurface lighting	

Simple

Photon Mapping

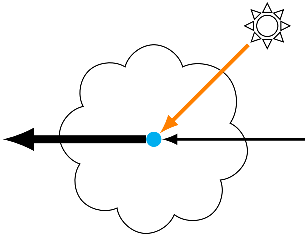

HORIZON
ZERO DAWN

- Direct Illumination through Single Scattering



- Direct Illumination through Single Scattering

$$T_r(x_0 \leftrightarrow x) = e^{-\tau(x_0 \leftrightarrow x)}$$



- Direct Illumination through Single Scattering

$$T_r(x_0 \leftrightarrow x) = e^{-\tau(x_0 \leftrightarrow x)}$$

- Silver Lining

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- Direct Illumination through Single Scattering
- Silver Lining

$$T_r(x_0 \leftrightarrow x) = e^{-\tau(x_0 \leftrightarrow x)}$$

$$p_{HG}(\theta, g) = \frac{1-g^2}{4\pi(1+g^2-2g\cos\theta)^{1.5}}$$

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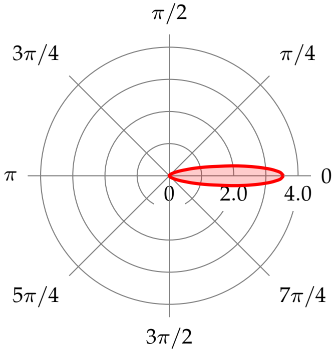


$g = 0.8$

- Direct Illumination through Single Scattering
- Silver Lining
- Powder Effect

$$T_r(x_0 \leftrightarrow x) = e^{-\tau(x_0 \leftrightarrow x)}$$

$$p_{HG}(\theta, g) = \frac{1-g^2}{4\pi(1+g^2-2g\cos\theta)^{1.5}}$$

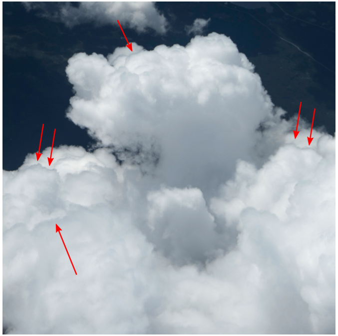
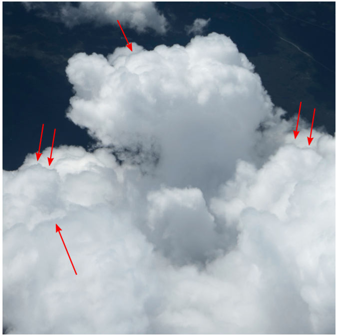


Photo by Staff Sgt. Stephany Richards U.S. Department of Defense Current Photos (140807-F-IG195-010) [Public domain], via Wikimedia Commons

- Direct Illumination through Single Scattering
- Silver Lining
- Powder Effect

$$T_r(x_0 \leftrightarrow x) = e^{-\tau(x_0 \leftrightarrow x)}$$

$$p_{HG}(\theta, g) = \frac{1-g^2}{4\pi(1+g^2-2g\cos\theta)^{1.5}}$$



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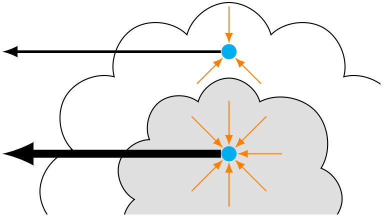
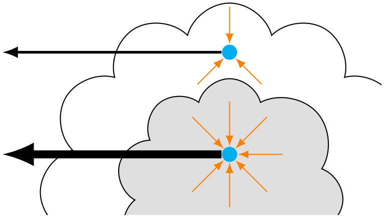
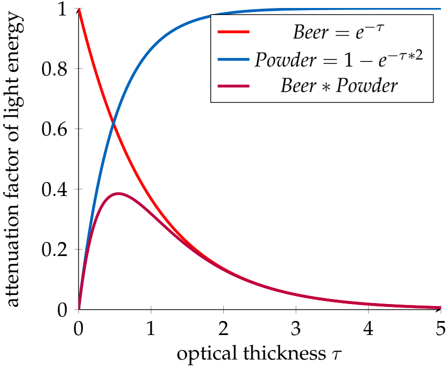


- Direct Illumination through Single Scattering $T_r(x_0 \leftrightarrow x) = e^{-\tau(x_0 \leftrightarrow x)}$
- Silver Lining $p_{HG}(\theta, g) = \frac{1-g^2}{4\pi(1+g^2-2g\cos\theta)^{1.5}}$
- Powder Effect $Powder(x_0 \leftrightarrow x) = 1 - e^{-powderDepth*\tau(x_0 \leftrightarrow x)} * powderStrength$





- Direct Illumination through Single Scattering $T_r(x_0 \leftrightarrow x) = e^{-\tau(x_0 \leftrightarrow x)}$
- Silver Lining $p_{HG}(\theta, g) = \frac{1-g^2}{4\pi(1+g^2-2g\cos\theta)^{1.5}}$
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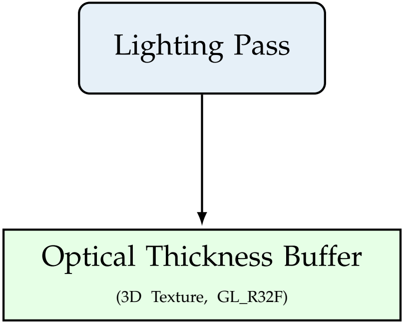
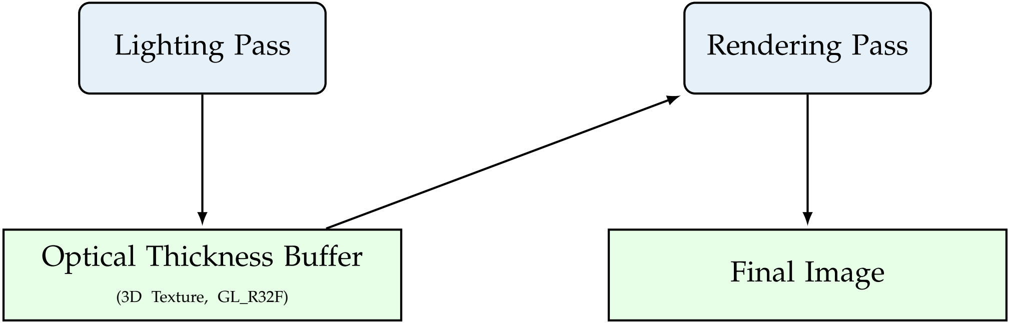
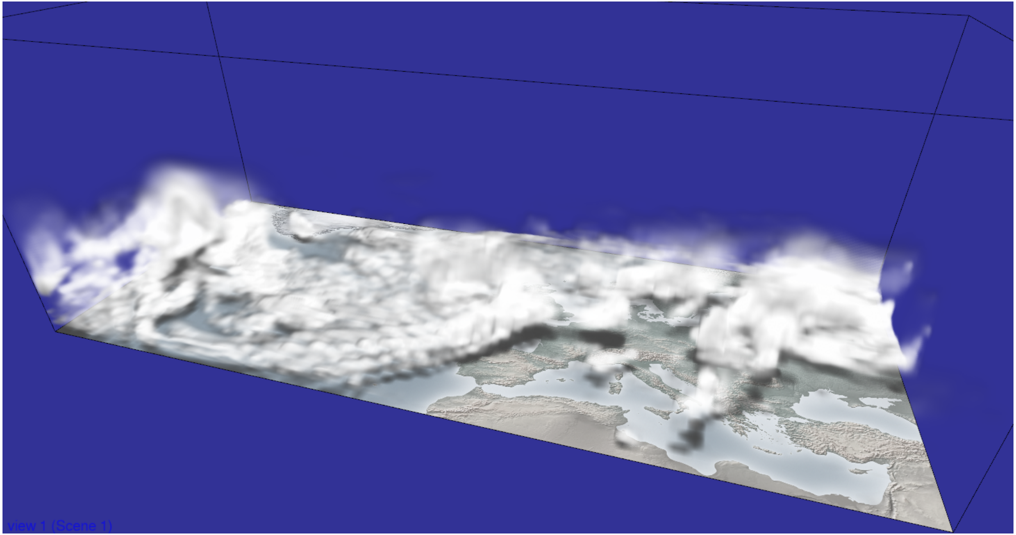
$$L_i(x \rightarrow \vec{\omega}) = \frac{1}{\kappa_s} Tr(x_0 \leftrightarrow x) Powder(x_0 \leftrightarrow x) p_{HG}(\vec{\omega_l} \rightarrow \vec{\omega}, g)$$

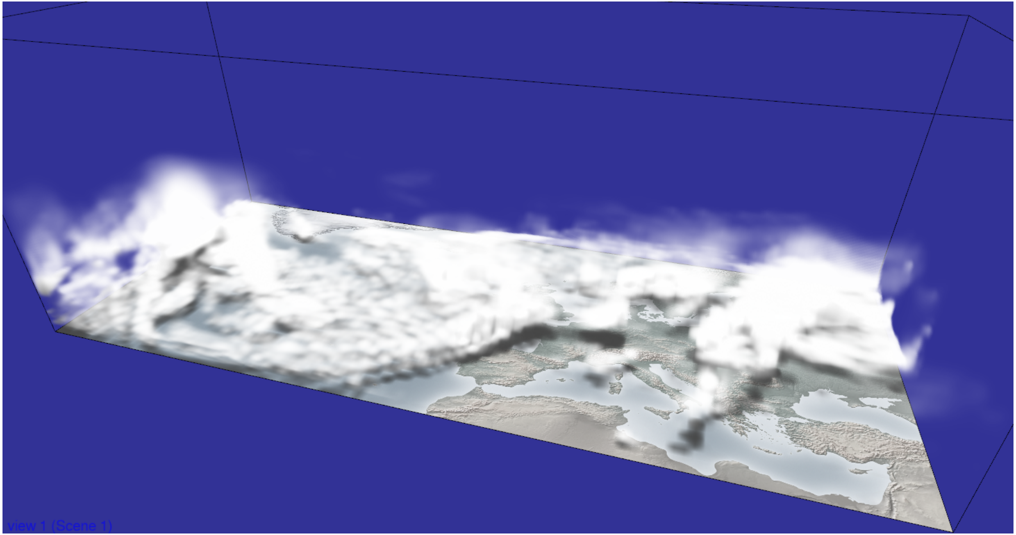

Lighting Pass
Optical Thickness Buffer
(3D Texture, GL_R32F)

Simple
Implementation

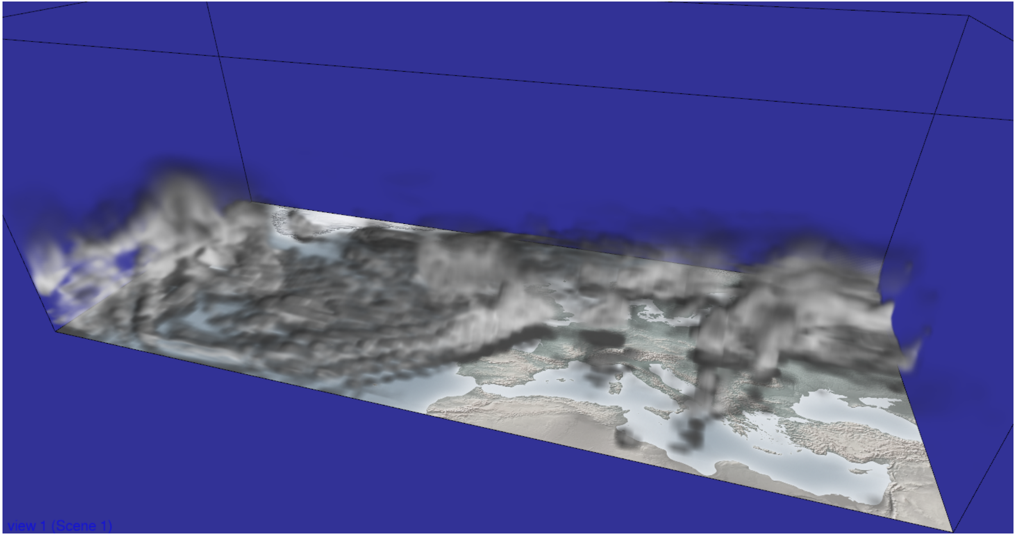




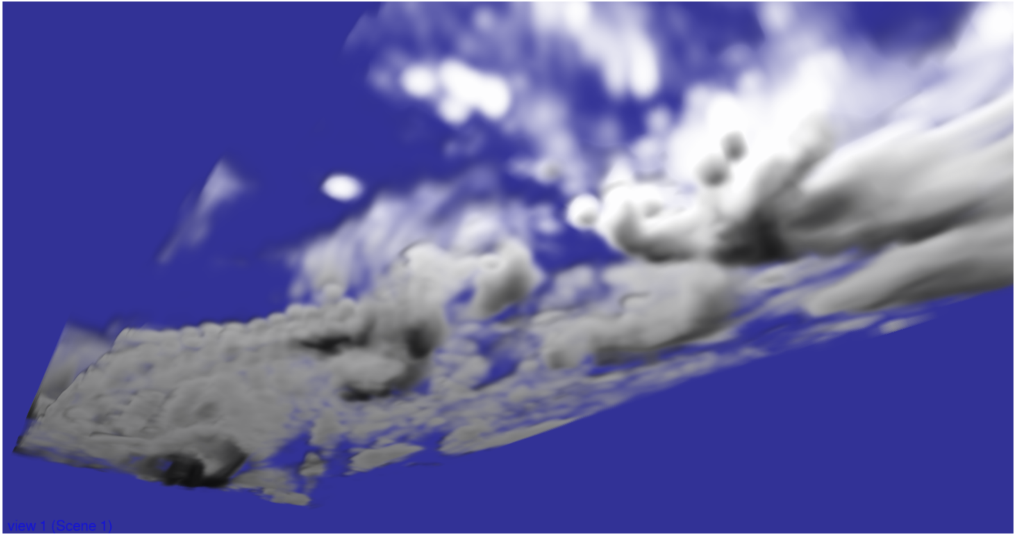
powder strength = 1.0, powder depth = 100.0



powder strength = 0.0, powder depth = 100.0



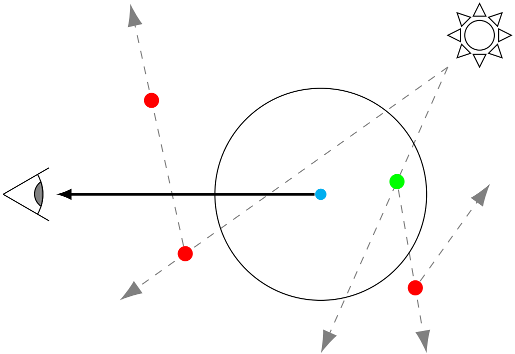
powder strength = 1.0, powder depth = 10.0

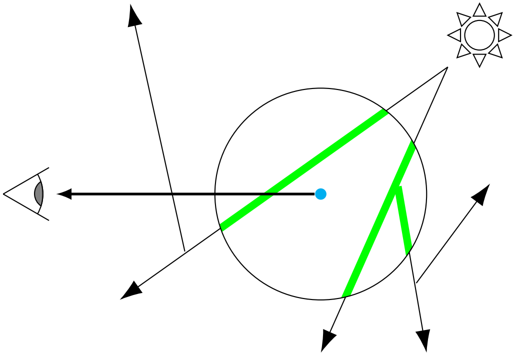


powder strength = 1.0, powder depth = 100.0, g = 0.7

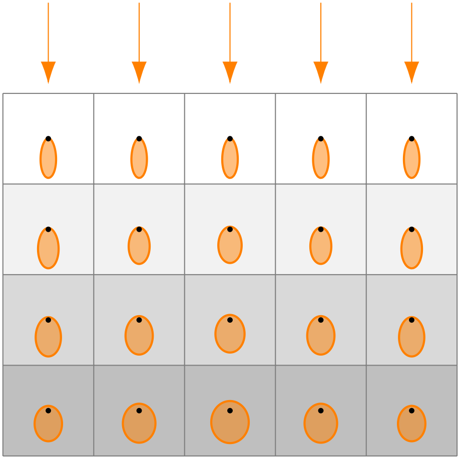
Simple

Photon Mapping



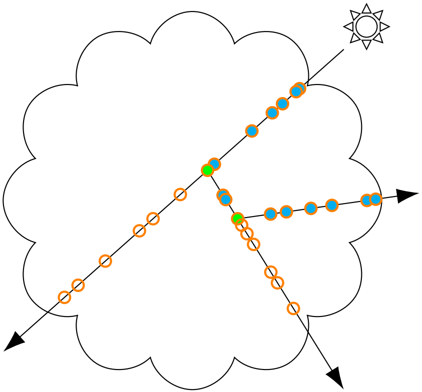


Photon Mapping
Regular Grid Photon Map

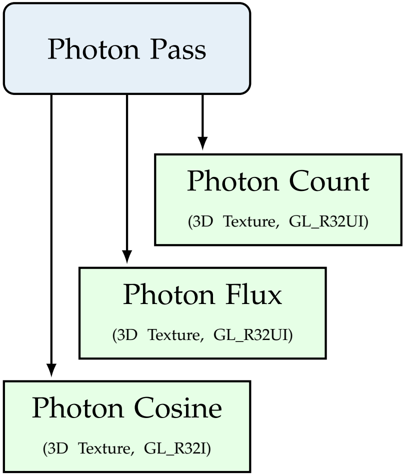


Photon Mapping

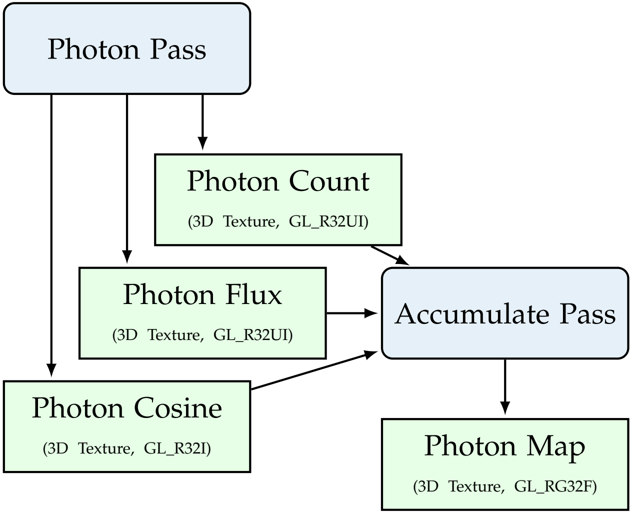
Woodcock Tracking

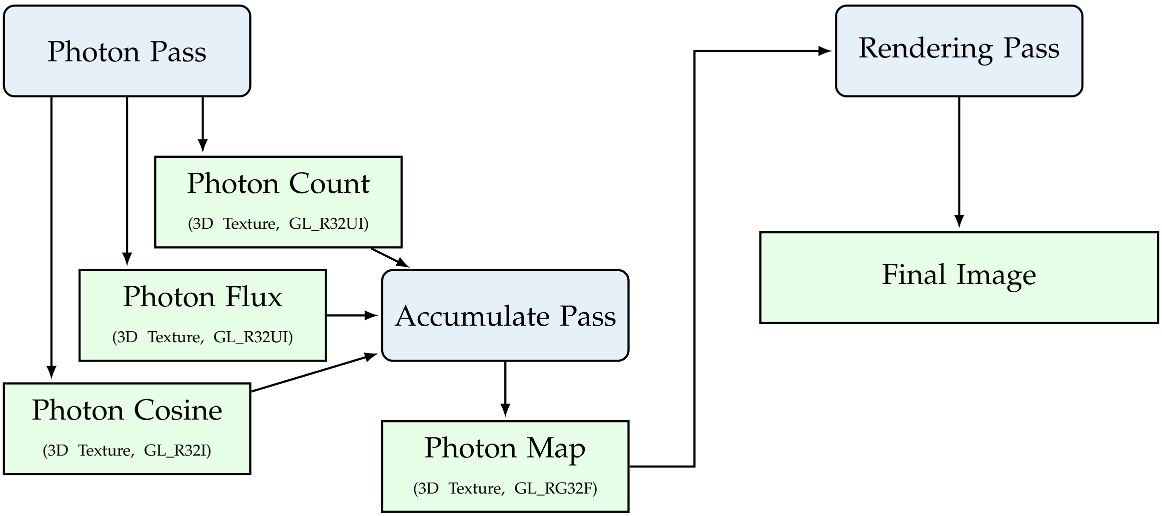


- virtual scattering event
- real scattering event
- photon storing



Photon Pass
Photon Count
(3D Texture, GL_R32UI)
Photon Flux
(3D Texture, GL_R32UI)
Photon Cosine
(3D Texture, GL_R32I)


Photon Pass
Photon Count
(3D Texture, GL_R32UI)
Photon Flux
(3D Texture, GL_R32UI)
Accumulate Pass
Photon Cosine
(3D Texture, GL_R32I)
Photon Map
(3D Texture, GL_RG32F)

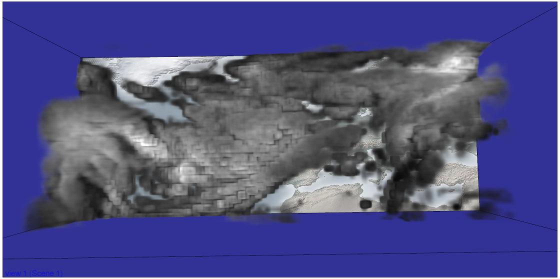


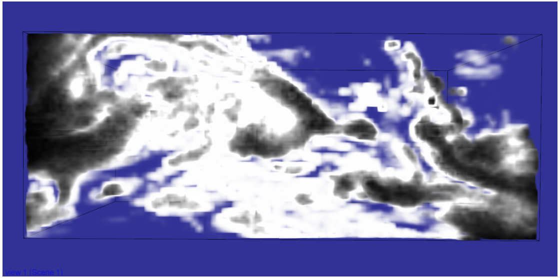
Photon Pass
Photon Count
(3D Texture, GL_R32UI)
Photon Flux
(3D Texture, GL_R32UI)
Photon Cosine
(3D Texture, GL_R32I)
Accumulate Pass
Photon Map
(3D Texture, GL_RG32F)
Rendering Pass
Final Image

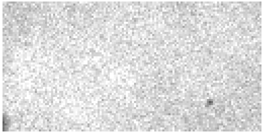
Video

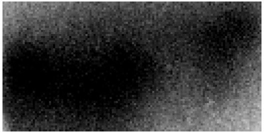
Photon Mapping

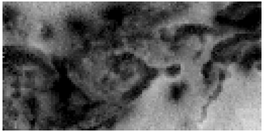
Results



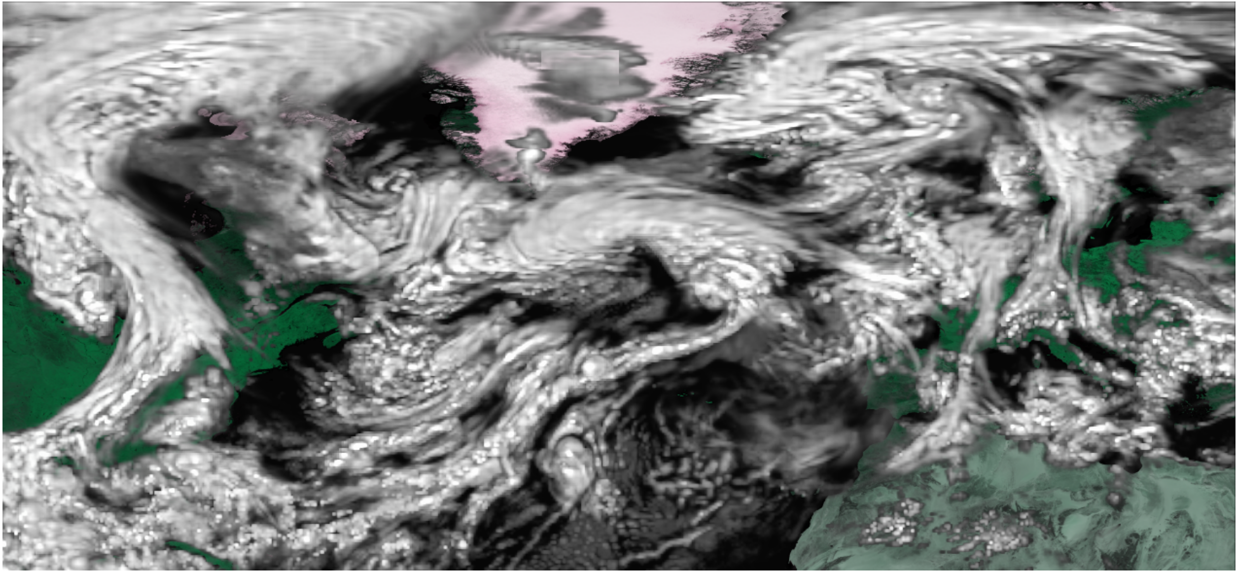




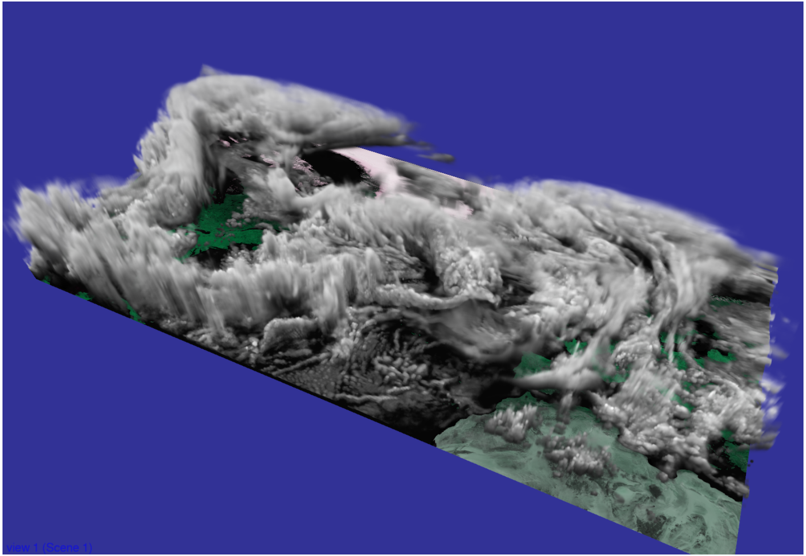


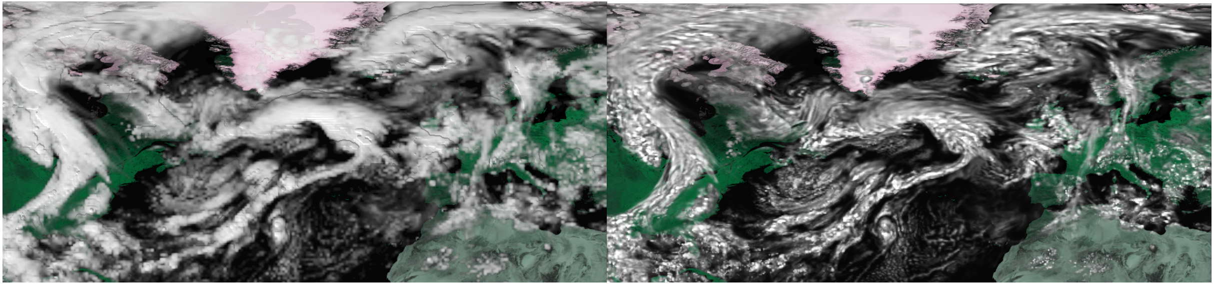


Video



Photon Mapping
Results





Future Work

- Upsampling of Photon Map

Future Work

- Upsampling of Photon Map
- Empty Space Skipping

Future Work

- Upsampling of Photon Map
- Empty Space Skipping
- Continuous Photon Map Generation

Summary

- Input Data
  - Arbitrary Variable + Transfer Function
  - Liquid/Ice Water Content Parameterization
- Lighting Methods
  - Simple
    - Visuals Based
    - Only Single Scattering
  - Photon Mapping
    - More Physically Accurate
    - Multiple Scattering
- Results
  - Visualization of Volumes with user-defined Scaling and Lighting for Visual Cues
  - Rendering of Cloud Data with an Approximation of real Lighting