



# Procedural cloud shader

## Project documentation

### Project 2

The goal of this project is to research and implement a procedural, volumetric cloud shader. The following document reveals the process of creating such a shader from both a technical and mathematical perspective, considering different algorithms for techniques like noise generation and raymarching.

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Specialization:	Computer perception and virtual reality
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# 1 General

## 1.1 Purpose

During this project, all gathered information and knowledge about the researched algorithms and techniques are written down in this document.

## 1.2 Revision History

Version	Date	Name	Comment
0.1	March 29, 2020	Matthias Thomann	Initial draft

## 2 Natural clouds

### 2.1 Formation

Clouds, as seen in nature, consist of a visible body of tiny water droplets and frozen crystals. In their natural occurrence, clouds are mostly generated from a nearby source of moisture, usually in the form of water vapor. This composition of particles creates the pleasant look of a white-grayish "fluffy" mass, floating in the sky.

Due to certain factors like altitude or water source, different types of cloudscapes can be formed. They vary in shape, convection, density and more. That makes different cloudscapes highly unique in terms of appearance.

For now, those factors are regarded as nature's randomness. However, an approximation of randomness will be covered in section ??.

### 2.2 Types of clouds

Cloudscapes are classified in multiple groups, mainly differing depending in their altitude, meaning the distance from the earth's surface to the cloud formation. The following four cloud genera stand out due to their distinctiveness. A realistic simulation of a cloud system would consist of a combination of these types, which is why they are displayed here.



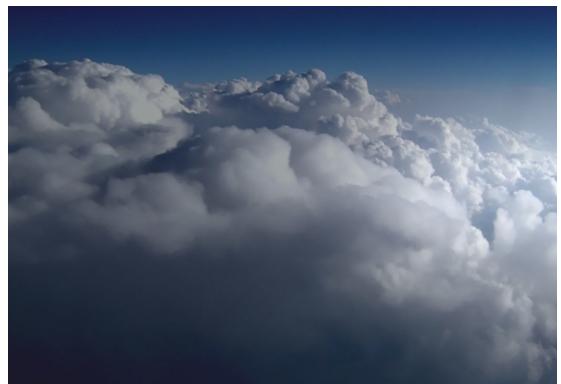
**Figure 1:** Photographic reference of stratus clouds[1].



**Figure 2:** Photographic reference of cirrus clouds[2].



**Figure 3:** Photographic reference of an altocumulus cloud formation[3].



**Figure 4:** Photographic reference of stratus cumulus cloudscape[4].

## 2.3 Clouds in games

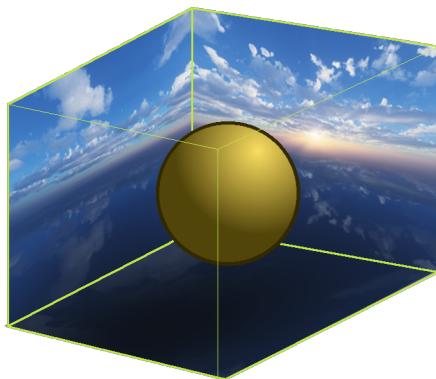
Depicted in Figure 3 and Figure 4 of subsection 2.2 are clouds of the genus *cumulus*, which translated to English means *heap* or *pile*. Their distinctive cotton-like look makes them easy to recognize, which is also why they are often used in games as a reference for "normal" clouds.

In games, the formation as well as the composition of clouds are irrelevant, as they are essentially only used for cinematic ambience or as a medium to enhance the atmosphere. This leaves just the rendering technique to worry about.

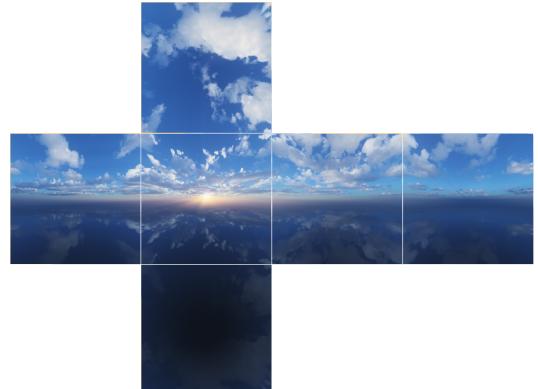
### 2.3.1 Rendering techniques

#### 2.3.1.1 Skybox

A widespread solution for representing clouds in games is not rendering them separately at all, but instead using a set of polar sky dome images, also known as the skybox. This is a six-sided cube which is rendered around the whole game world. On each inward looking face of the cube, one of the sky dome images is rendered, creating a seamless sky around the inner side of the box.



**Figure 5:** The skybox cube as it used in games.



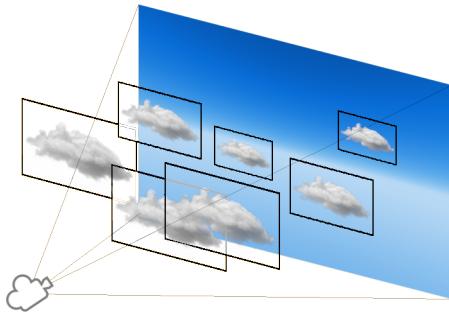
**Figure 6:** The polar sky dome images, layed out.

Besides showing the sky, this of course allows clouds to be drawn right into the background. Also, in terms of performance, this is extremely cheap and efficient. On the other hand, it removes the ability for the clouds to move. They also have no volumetric body and no way of interaction with the game world whatsoever.

This method does indeed give the scenery a more cloudy look, but what is missing is the "feel", or in other words the motion, interaction and lifelikeness.

### 2.3.1.2 Billboards

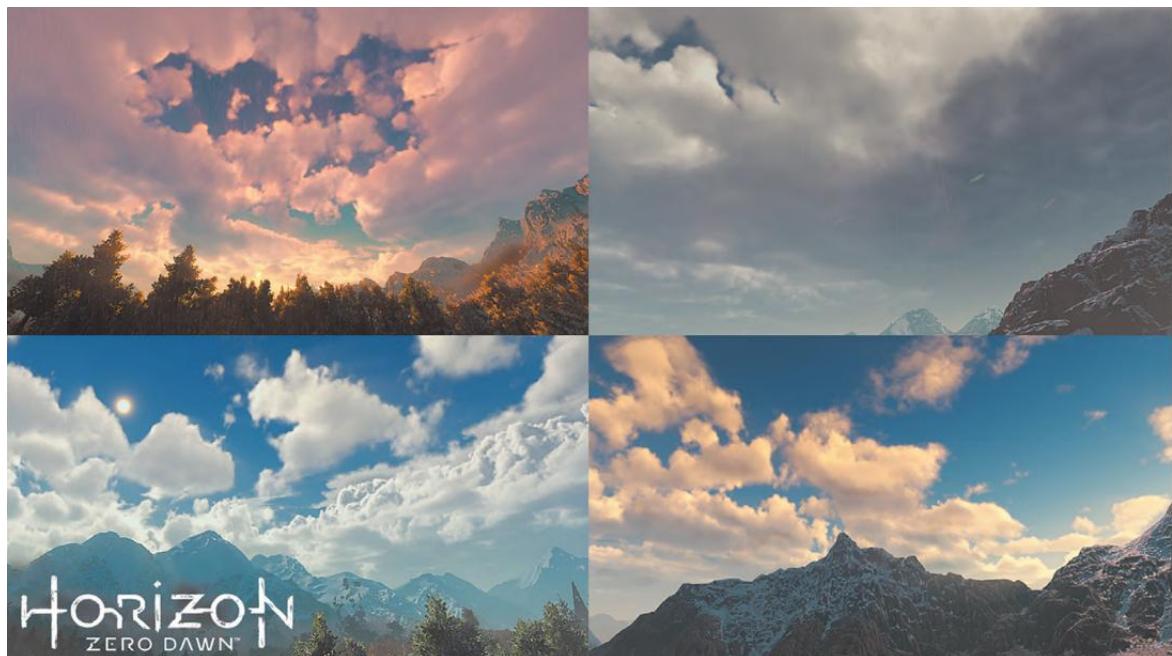
Another rather simple way of rendering clouds is by only showing 2D images. When always facing the main camera, those are called billboards.



**Figure 7:** A collection of 2D cloud billboards facing the camera



**Figure 8:** The rendered result of the image to the left



**Figure 9:** Several volumetric cloudscapes from the game *Horizon: Zero Dawn*, drawn in real time[5].

## Glossary

**Billboard** A 2D image always facing towards the main camera. 4

**Convection** Convection describes the transfer of heat from movement of liquid or gas. 2

## References

- [1] *Photographic reference of stratus clouds*. [Online]. Available: [https://en.wikipedia.org/wiki/Stratus\\_cloud](https://en.wikipedia.org/wiki/Stratus_cloud).
- [2] *Photographic reference of cirrus clouds*. [Online]. Available: [https://en.wikipedia.org/wiki/Cirrus\\_cloud](https://en.wikipedia.org/wiki/Cirrus_cloud).
- [3] *Photographic reference of an altocumulus cloud formation*. [Online]. Available: [https://en.wikipedia.org/wiki/Altocumulus\\_cloud](https://en.wikipedia.org/wiki/Altocumulus_cloud).
- [4] *Photographic reference of stratocumulus cloudscape*. [Online]. Available: [https://en.wikipedia.org/wiki/Stratocumulus\\_cloud](https://en.wikipedia.org/wiki/Stratocumulus_cloud).
- [5] *Several volumetric cloudscapes from the game horizon: Zero dawn, drawn in real time*. [Online]. Available: <https://tech4gamers.com/horizon-zero-dawn-gets-new-screenshots/>.