WEATHER IN GAMES

Researching the possibilities of weather in games

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Abstract

The weather is an incredibly powerful, and often very beautiful, natural force. One that influences our everyday lives more than we probably even realise. It is a real shame therefore that the weather is all too often completely absent in videogames, apart from the occasional visual fluff.

Of course, there are games that use the weather, but most of the time they only use a few simple characteristics of the weather. The most familiar characteristic, and consequently the one used most, is the way it looks. Dark clouds, piercing lightning and white snowflakes are a familiar sight in videogames. They are often used to enhance the player by creating an atmosphere for the scene in much the same way as a film or a novel.

However, there are many other unique characteristics of the weather that have hardly been used in videogames. One of those characteristics is the fact that the weather is always changing, i.e. the weather can be different from time to time and from place to place. This could make for some very interesting gameplay, where the weather actually has an effect on the virtual world and its' characters, but it has hardly ever been done.

For this supportive narrative, I have searched for games that do use the weather in one way or another. There were two things in particular I have tried to find out about those games.

The first question was how other games use the weather. Based on these results, I have come up with three different categories of uses of the weather. These categories being use of the weather as atmosphere, use of the weather as a puzzle and finally, the one I'm looking for, use of the weather as gameplay element.

The second question I have tried to answer was what kind of system those games use to accommodate the weather. These systems have also been divided into three distinct categories, namely a simulated system, a scripted system and a random system.

In addition to just finding out how other games have used the weather, I have also come up with a concept for a game that uses the weather extensively as a gameplay element, which I will discuss in this supportive narrative.

The goal of the concept is to provide an example to others as to how the weather can be used in games, instead of simply to create an atmosphere. Of course, there are dozens of other ways the weather could potentially be used by games that are not covered here. However, it is not my goal to provide a complete, exhaustive list, merely to give an example.

Because of time restrictions, I have only been able to create and test a vertical slice of the full concept, which serves as a solid base on which can be expanded in different directions. I will discuss the vertical slice and the issues I ran into with this, as well as the ideas for the full concept.

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Introduction

Ever since the first videogames, games have become more and more realistic. This includes beautiful engaging environments, ever more detailed human faces, amazing looking weather effects, intelligent computer opponents and lots more. Games really try to make you believe the digital world is alive and breathing.

There is, however, in my opinion, one area that hasn't been thoroughly explored yet. The weather. By weather I mean rain, lightning, moonlight and sunshine, snow and ice, hurricanes, tsunami's and even sandstorms. Sure, games like The Elder Scrolls: Skyrim (2012) and Alan Wake (2010) have beautiful looking clouds, rain and sunshine, but that's all it is, nice to look at. It sets the tone, the mood of the area, but it's not interactive. It doesn't have any direct effect on the way you play at all.

Then there are games like Disaster: Day of Crisis (2008), that use the weather as an excuse for their puzzles. It's nothing more than a visual representation of the 'puzzle' the player has to solve, e.g., you're running away for a hurricane, but it might as well have been a wild grizzly bear, or a policeman. Whatever fits in with the games' narrative.

I'm not saying these uses of the weather are bad, but I think there is a lot of unused potential if you want to create an engaging, living, breathing world.

For example, the original Pokémon Silver and Gold (1999) already incorporated the weather into their battle system. When it rained, fire attacks were weaker and sun-based attacks took longer to charge, but lightning attacks would never miss their targets. However, when it got sunny, the opposite became true. Players even had an influence on the weather, because there were a limited number of Pokémon that could actually change the weather into their advantage. This way, it really made the game-world feel more dynamic and alive, even though it's only an old, 2-dimensional, 8-bit game.

It's things like these that I really miss in most weather systems in games. So I thought I'd try to do it myself.

The main question I will try to answer throughout this supportive narrative is: 'In what ways can the weather be used in games as an actual gameplay element?'

I started by doing research into existing games, to see in what way they use the weather. There were two particular questions I wanted to answer. 'In what ways do other games use the weather?' and 'What kind of weather systems do other games use?'

This paper will by no means provide a complete, exhaustive list. It will, however, try to provide an insight into the ways existing games have used the weather and the different types of systems those games have used to accommodate that weather, based on my own research into those games.

In addition to that, I have come up with multiple other ideas on how to expand on existing uses of weather in games and completely new ways of how the weather can impact the gameplay.

As a case study, I have been working on a simple game in which I've implemented some of these ideas on a basic level. Throughout this supportive narrative, I will discuss the ideas that I have implemented, why I did it in such a way and how those ideas could be further expanded to create an ever more realistic, beautiful, engaging, breathing and dynamic world.

Uses of weather in games

Throughout my research to existing games that use the weather in one way or another, I have distinguished three major types of 'roles' the weather can have in games. Weather used to create a certain atmosphere, weather as the puzzle itself and weather as an additional gameplay element.

Of course, the weather can have multiple roles in the game, but what I found is that more often than not, one of these roles could be considered the 'major' role.

Atmosphere

This type of weather is used to give players a certain feeling while playing the game, which only indirectly affects the gameplay.

For example, grey clouds and a slight drizzle could be used to create a sort of nostalgic feeling, whereas an overwhelming downpour could be used to add to the excitement of an event, and a cloudless sky with a bright sun could set the tone for an idyllic, carefree day of working at the farm.

The weather is used to put the player into a certain state of mind, i.e., it would give the player a certain feeling, thus indirectly influencing the way a player interacts with the game world. If the player were to feel nostalgic, he or she would be more likely to walk around and take in the scenery, instead of rushing straight to the end, whereas when the player is in a carefree state of mind, he or she probably wouldn't be paying much attention to possible threats, which may be looming just around the corner.

> "The end result is that even the most realistic games offer a hodgepodge of realistic and very unrealistic effects; a patch of grass might flow in the wind, but a character standing in the midst of a terrible rainstorm won't even get wet." (Barton, 2008)

Because of the nature of the role of the weather in this case, it is almost always scripted, so that the level designer or scriptwriter has complete control over what the player should be experiencing at any given moment.

A good example of such a game is Alan Wake, where the player is being haunted by darkness. So, you've guessed it, during most of the game it's night, with perhaps a bit of fog, designed with the sole purpose to creep you out.

"I've never been this glad to see the sun rise." – Alan Wake

However, on some occasions, if you've managed to survive through the night, the sun rises. Because it has been dark and creepy for quite some time, you actually feel the relief when you look at that virtual sun. I remember the main character saying: 'I've never been this glad to see the sun rise.' At that moment, I couldn't have agreed more.

In this example, the weather is clearly completely scripted. The designers decide when it's dark and for how long and when the sun rises. This is good, because if it were any different, it wouldn't be as exciting to play.

Also, the weather doesn't have any direct effect on the in-game character. It does, however, have an effect on the player. The player gets scared, more careful, or perhaps even panics, which does indirectly lead to a different play-style. Thus, the weather does have an effect on the gameplay, but it's indirect.

Two other examples of this type are The Elder Scrolls: Skyrim and Eternal Sonata (2007). Snow is used in idyllic towns to make the atmosphere feel really calm and relaxed, and rain is used to describe a sad situation.

One last example that surprised me quite a bit, was Farming Simulator 2013 (2012). It is a farm simulation, the perfect game where you'd expect the weather to have some effect, on growing crop for instance, but it hardly has any, apart from stopping your machinery from working. A missed opportunity.

Puzzle

In this type the weather has become the actual puzzle, thus the weather has become the core mechanic itself. Therefore, it is no longer a feature on its own. Without the weather, there would be no gameplay, so there wouldn't be a game at all.

On the other hand, the weather as the puzzle could be replaced by just about anything else. In this case, the weather is simply the visualisation of the puzzle the player has to solve. For example, the fact that you can't open a door might be explained by an extreme blizzard outside, or by a bear looking for food or even a giant boulder blocking the door. Whether it has anything to do with the weather, doesn't really matter, the question is how to get outside.

Weather used in this case is also almost always scripted by the level designer, who wants to have full control over the puzzle the player has to solve.

Note here that even though the main use of the weather here is to provide the player with a puzzle, the reason the weather is used in this case might very well be that it adds to the complete atmosphere and the overall experience of the level.

The player being chased by lava in Disaster: Day of Crisis.

For example in Disaster: Day of Crisis, one after the other natural disaster, such as an earthquake, volcanic eruption and a tsunami, occurs and it's the players' job to survive and rescue others. Now one can imagine, if it weren't for these weather conditions, there wouldn't be a game to play. For that very reason, all these weather effects are, again, completely scripted. The game designers have created a tsunami that will behave almost exactly the same every time you face it, because if it were different, it wouldn't be the same challenge.

In this example, you can also clearly see that the weather could be replaced by just about anything else, yet the challenge would remain exactly the same. You could change the tsunami you're running away for into a hungry lion, an angry neighbour or a scary mother-in-law. The fact that you're running away, however, remains intact.

Another example of this would be Rayman 3: Hoodlum Havoc (2003), where Rayman's path is being blocked by extreme gusts of wind, so the player has to find a way around it, or to stop the wind. Or Super Mario Galaxy (2007), where levels can be extra slippery, because the planet is frozen solid.

Gameplay element

In this last type, the weather has become a part of the game, without taking over the gameplay. It's an extra part of the puzzle, another factor to take into account while playing. The difference with the previous category, however, is that the game itself doesn't revolve around the weather. If you remove the weather from the game, the gameplay would still stand, it would just become less interesting.

This is by far the smallest and least explored group of games. There's only a handful of games that belong in this group and even the one that do use the weather as an active gameplay element, only do it on a very basic level.

One example of a game in this group is Harvest Moon (1996). Harvest Moon is a simple, relaxing farming-game. As the player, you are the owner of your very own farm. It is your task to sow the seeds, water the crops, milk the cows and feed the chickens.

You don't have to water all these crops in Harvest Moon when it's raining.

To make things more interesting, they've added weather and seasons. Every season has crops that only grow during their particular time of the year. Simple as this may be, it does make the player think twice before buying new potato seeds when the season ends the next day, thus giving the player a feeling of understanding the system.

They've also added a few simple weather effects. When it's raining, you don't have to water the crops that day, but you do need to make sure that all your livestock is inside, or they might get sick.

These games generally use some kind of simple simulation for the weather, or sometimes they change the weather randomly, as is the case in Harvest Moon. The reason for this is that it doesn't matter to the player. There is no benefit for the player in using a simulation, because there is no need for the player to be able to predict what the weather will do.

The randomness of the weather in Harvest Moon becomes very clear, however, when you save your game just before going to bed, check what the weather will be the next day and then restart the game. If you go to sleep and check the weather again in the morning, it can be completely different.

Another example of a game that uses the weather as a gameplay element, is Pokémon. The weather has an effect on the attacks of the Pokémon in battles. For example, when it's raining, lightning attacks never miss, but sun-based moves take longer to charge and fire attacks get weaker. Then there can also be a sandstorm brewing, which damages everyone except group type Pokémon. The weather in Pokémon can even be changed by certain Pokémon, they have moves to make it rain, or to whip up said sandstorm.

However, this is where I see a big, unexplored possibility. What if the player were able to predict the weather and change his actions accordingly? Perhaps the player would look at the sky and say, 'a storm is brewing, better not go into the mountains now'. This could, for example, be used in a race-game, so that the player might opt to change his tires before the big race. Or perhaps in a shooter game, where the rain will greatly reduce your visibility. Or even in a platform- or adventure-game, where the rain will make the surface really slippery.

Simulations

This group is a bit of an odd one, which I don't really count as a separate group, but more of a sub-group of the third group. The weather is again used as a gameplay element, as was the case in the third group. However, instead of adding the weather to provide the player with an extra gameplay element for the sake of fun, it is added for the sake of realism. While this added sense of realism is generally considered to be fun by the small group of simulation enthusiasts, it is designed to be realistic, not fun per se.

Just because these games try to be realistic, it doesn't necessarily mean the underlying systems are realistic, just the effects.

A very good example of this particular group of games, and probably the most well-known, is Flight Simulator (2006), in which you control an airplane during take-off, flight and landing. There's nothing more to it, no goals, no achievements, no collectibles and no storyline, yet airplane-fanatics still play it, because it makes them feel like they're actually controlling the aircraft. For that reason, actual simulated weather isn't that important, the player just wants to feel like the effect of the weather is realistic.

Rain makes take-off a lot harder in Flight Simulator X.

Conclusion

There are a lot of different ways in which the weather can be used in games. I have grouped them together into three main categories.

The first group uses the weather to create a certain atmosphere, to make the player feel a certain way. Because the way the player will feel has been predefined, so has the weather. The designers have full control over the weather, thus the weather will always be the same at any given play-through.

The second group uses the weather as a puzzle. By doing this, the weather becomes the challenge itself and is therefore no longer an individual gameplay element. It has become the visual representation of the challenge the player has to face.

The third group is in my opinion the most interesting group, and also the group that has been used the least. In this group, the weather is used as an extra gameplay element for the player to play with, an extra parameter to take into account. The game would still be playable without this type of weather, but the weather adds an extra dimension to the gameplay that wouldn't otherwise be there.

A sub-group of the third group is the group of simulations. While it incorporates the weather as an actual gameplay element, it serves a purpose of simulating realism, instead of just adding fun.

In the next chapter I will discuss various types of weather systems that can be used in games to simulate the weather and why certain games choose to use a certain system.

Types of weather systems

There are various methods of accommodating weather in a game, all of which have their own pros and cons. Games can use a simulation of real-life weather, some kind of scripted weather events, or the weather can be completely random. The type of system that should be used in a game completely depends on what you want the player to experience and what the role of the weather is.

Simulation

A simulation can be defined as: 'The imitation of the operation of a real-world process or system over time.' (Wikipedia, 2013) This can either be the complete process or system, or just a simplified version. Games that use a simulation often only use a very simplified simulation, which may or may not be based on realism, for two main reasons.

The first reason is a technical one. Real-world weather is just too complex to completely simulate on a computer. If it weren't so complex, perhaps we would have actually had 100% accurate weather predictions. But even these predictions, which are the most complete simulations in the world, are right just as often as they are wrong. And they use supercomputers for their calculations.

The other reason is a matter of necessity. Is it really necessary to completely simulate the weather in order to deliver the best player experience? Most of the time, the player won't even notice how the weather changes over time, only that it changes, unless the changing of the weather is in itself part of the gameplay experience. But even then, a simplified simulation will probably suffice, because the player couldn't be bothered with the complexity of the system, the player only wants it to be fun.

The reason why you would want to use a simulation, would be that the changing weather has an effect on the player, whether it's just the 'feeling' created by the atmosphere or an actual change in gameplay, or the player can have an influence on the weather. In the latter case, it is important that the weather is generated by some kind of simulation, because the weather system has to react to the players' actions.

A game that uses a simulation for their weather system, is for example F1 2010 (2010). In this F1 race-game, the weather can actually change over the course of the race, as is explained by the developers in an online video (gamezplay, 2010). Players won't know what the weather will do before the race starts, but they can roughly see what the weather is doing on the radar, e.g. they can see the rain coming and how long it will last, and so they can change their strategy accordingly.

In F1 2010, the weather can change during the course of the race.

Scripted

A scripted weather system is the complete opposite of a simulation. In such a system, everything that will happen is predefined. That means that every time the player makes a certain move, the system will respond exactly the same way as before. For example, every time the player leaves the house for the very first time, it will start to rain. No exceptions.

This system is often used when the game designers need full control over what the player will experience at any given moment. This is most notable in games that use the weather as a puzzle, because if the weather were to change dynamically, the whole puzzle would disappear, and thus the fun of solving the puzzle.

Scripted weather systems are also often used in story-driven games, where the designers really want to make the player feel connected to the virtual world and the characters, as if the player were reading a book or watching a film. In these circumstances, scripted weather can be a powerful tool to create the appropriate atmosphere for the story.

Eternal Sonata is one of the many games that used a scripted weather system. This game is entirely story-driven, so it makes sense for them to use the weather to strengthen the connection the player feels towards the world and the characters.

The player will never be able to explore this place in Eternal Sonata during day-time.

Random

If you want the weather to be unpredictable, you're best off using a random system. A random system is completely different from the other two in that it is completely unpredictable for the player, so the player wouldn't have any time to prepare in advance. Even the system itself won't know what it will be doing in a few seconds. The designer does have some control over it, however. I will get more into that in the next chapter, 'Designing the System'.

There are a number of ways in which you can use a random system. You can make the weather change randomly over a certain amount of time, allowing for a nice transition, or you can let the system randomly pick a type of weather to use for the next race or arena, it all depends on what you're trying to do.

A random system is most often used to make the game-world more dynamic, to make it feel more alive and changing, without having to resort to some kind of complicated simulation.

Harvest Moon is one of those games where the weather is completely random. The game simply picks a random weather type for the next day and then the weather will remain exactly the same for the whole day. This does mean that the weather prediction for the day is always spot-on, so you can plan your day accordingly. Exactly what the designers intended to accomplish.

When you restart Harvest Moon and try again, the forecast will probably be different.

Designing the system

Unfortunately, not every type of weather system is suitable for every situation, every game requires a different approach, depending on what you want the player to experience. So when you start designing the weather system for a game, you'll have to start by asking yourself, 'what do I want to accomplish with the weather?'

Most of the time, a combination of multiple systems is used. For example, games can use random input in a weather simulation to make things a bit more unpredictable and less repetitive.

Even a mostly scripted weather system can use a bit of randomness, just to give the player the feeling that not every play-through is the same.

In the end, no matter what kind of system you use, the system itself has to be designed to your specific needs.

Even a random system needs to be designed. There have to be certain boundaries for the randomness, otherwise it might just start snowing in the desert. So you might come up with limitations to the kinds of weather types that can occur in certain areas, like temperature, rain and wind. Or you cloud make some 'extreme' weather conditions less probable to happen.

The same holds true of course for a simulation. You need to decide on the kinds of weather you want to simulate and how you want it to be simulated. How fast does the weather change? How does the system decide what the weather will do next? Will the system choose a random new type of weather, or will it be scripted, where it will always stop raining after a certain time, no matter what.

Designing a scripted system is a bit different from the other two, because the weather will be tailor-made for every situation, event or cut-scene. Here, every such situation requires the designers to ask themselves, 'what do I want the player to experience?' Once you've answered that question, you can decide on the type and severity of the weather and try it out.

Conclusion

There are different systems you can use in a game to accommodate weather. I have grouped them together into three categories.

In a simulation the weather changes over time in a more or less realistic way, adding to a dynamic, breathing virtual world. This system could also be used when player can have influence on the weather, because the system would need to react to the players' actions.

A scripted system never changes, unless the designers want the weather to change at a certain moment in the story or at a predefined place. This system is mostly used in story-driven games, where the atmosphere of a scene is extremely important.

A random system is mostly used instead of a more complicated simulation when it doesn't matter whether the weather changes in a predictable way, and when the player doesn't have any influence on the weather.

Most of the time, elements from more than one of these categories are combined to create the weather system for a game, because all of these systems have their pros and cons and perhaps not every aspect from one category fits the purpose. Therefore, the first question you have to ask yourself when implementing weather in a game is, 'what do I want to accomplish with the weather?'

In the next chapter I will discuss the game I've designed for my graduation project, in which ways it uses the weather and the way I've designed my own weather system.

Designing a game with weather

During the course of this project, I've also been working on a game to accompany this paper, dubbed: Project Lightning. Project Lightning serves as a case study in which I've tried to implement a number of effects the weather can have on the gameplay.

Unfortunately, because this is a time-restricted, one-man project, the games' concept was simply too big to build in its entirety, the final result is a prototype in which I have implemented a vertical slice of the concept. I've chosen this particular vertical slice, because it forms a basis on which can be expanded in different directions.

I will start this chapter by explaining the core mechanics of the game and the effects the weather has on these mechanics. Later on, I will discuss the rest of my concept, to give an idea of the different direction you can move in with the weather. Finally, I'll discuss the underlying weather system.

The gameplay

If I would have to define a genre for the game, it would be a first-person real-time strategy game.

The goal of the game is to defeat your opponent in combat. You accomplish this by creating units, producing food to keep your units from starving and ultimately leading your units into battle to try and kill your opponent.

Combat units can simply be built at your home base and will spawn after a few seconds. Farms can be built all over the world, where there is sufficient flat space. A number of farmers can be added to produce food, as long as there is enough free space. Every farmer then starts producing food on their own. It takes a full to produce an amount of food. The payoff is based on fertility and the weather, which I will discuss later.

Instead of viewing the battlefield from a top-down perspective, as is usually the case in a strategy game, the player is always in direct control of one of his units. As such, the player also looks at the world through the eyes of the unit he controls.

The player looks at the world through the eyes of one of his units.

This perspective serves two main purposes. The first one is to create a feeling of engagement with the virtual world. To make the player feel like he is actually a part of the world, instead of just a passer-by.

The other purpose is to provide better feedback about the weather. The best way to actually experience the weather is not simply looking through a window hoping the sky will clear up soon, it's walking right in the middle of the rain, getting soaked. So by giving the player direct control over one of his units, I've put the player right in the middle of the weather, where he will experience the weather first-hand. This way, as opposed to just guessing what the weather is doing from a distance, the player can 'feel' exactly how bad it is, like the difference between a drizzle and a downpour. If Napoleon had actually experienced the cold in Russia for himself, he'd never have sent his army there.

> "The final factor was the weather. First it was too hot — making it a dry, dusty march to Moscow. Then when the Retreat began, it was too cold at first. This was a bone-chilling well below zero cold that few had experienced before. First to die were the weak who, too exhausted to walk, laid down and died. As the little food supplies they had ran out, the strong got weaker and they too began to die. But then the weather changed. There was a warm spell which thawed the frozen roads — slowing down the march even more. Roads that were heavily rutted, but solid soon were quagmires of mud. Streams that were once frozen were quick moving and obstacles that had to be overcome. Rivers that could have been crossed without bridges now needed bridges. All of which took precious time and energy, something the army did not have. Then once again the weather took a turn for the worse — this time far colder than before. Thousands died in their sleep overcome by exhaustion and exposure. By the time the army crossed into Poland in early December, less than 100,000 exhausted, tattered soldiers remained of the 600,000 proud soldiers who crossed the Nieman five months before." (Burnham, 2007)

The historic events described above also gave a few examples of ways the weather could be used in a strategy-game, which I will discuss more in-depth later.

For simplicity's sake, there is only one resource for the player to manage: food. Your units need food every once in a while. If they don't eat, they'll literally starve to death. I've chosen food in particular because the production of food is extremely dependent on the weather conditions. I'll discuss the effects of the weather on the production of food in the next section.

When you're satisfied with the size of your army and you've got the food production to uphold said army, it's time to march. Giving orders works as one would expect from a strategy-game. You select your units, you point where you want them to go with the mouse and then give them the order to move there, to defend another unit, or to attack your opponent.

Because you're looking through the eyes of one of your units, it can be a little tough to keep an eye on where all of your units are. That's why at all times you have the ability to change the unit you're controlling, directly by pointing at him or by selecting him on the map. This way, you can manage your troops around the world, while still being able to experience what's going on around you.

In the next section, I will discuss the effects the weather has on the gameplay.

Influence of the weather

> "A strategy game or strategic game is a game (e.g. video or board game) in which the players' uncoerced, and often autonomous decision-making skills have a high significance in determining the outcome." (Wikipedia, 2013)

In layman's terms, the goal of a strategy-game is to make better decisions and come up with a better strategy than your opponent. This can be as simple as 'my units are stronger than yours', or 'you never expected me to attack from behind', or more sophisticated like 'I made better use of my environment'.

Strategies can get even more complicated when the player also needs to take the effects of the weather into account. The fact that the weather is always changing and different in different areas, is what makes the weather especially interesting as a gameplay element in this case. The player actually needs to keep checking back with what the weather is doing, because the advantage the player had when it was raining, might just disappear when it stops raining and he wasn't prepared for it.
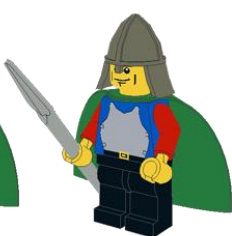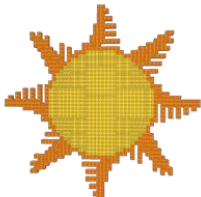
I've used two types of weather in the game. It can either be dry, or it can rain. Whether it's dry or wet at any place and at any time, depends on different factors, which I will discuss later on.

The world is divided into three 'areas'. A high pressure area on one side of the world, where it's warm and dry most of the time, a low pressure area on the other side of the world, where it's cold and it rains most of the time, and a temperate area right in the middle, where it rains about fifty percent of the time. Note that while it's dry most of the time in the high pressure area, it can rain, but it happens less often.

Influence on Units

Units form the keystone of any strategy-game, so it makes sense that the weather has a big influence on the units. To keeps things simple, I've created three different types of units and three different things the weather has an effect on. This way, every unit has a different advantage when it's dry and another advantage when it's wet.

The weather has an influence on the units' walking speed, strength and visibility, i.e. how far the units can see. All three units have an advantage in one of these areas. Because of this, players can pick their favourite units based on their own way of playing, focussing more on strength or stealth, for example. However, if the players are not careful with the weather, their advantage might disappear and your opponent might in fact gain an advantage.

Every unit has its own advantage when it's wet and another when it's dry.

What I found during an early playtest, is that it's extremely important for the player to know how the weather is currently influencing his units, so there has to be some kind of feedback. This feedback of the weather needs to be instantaneous and obvious. If the player doesn't know how the weather is influencing his units, or his opponents' units for that matter, there is no way he can effectively change his strategy.

Because the players didn't know the effects of the weather at first, they just randomly spawned a high number of units and sent them to fight, hoping for the best. They didn't even pay attention to the weather, because they didn't know how it affected them.

To make it clear what the effects of the weather were, I've made the strong unit bulky, the fast one tall and thin and I gave the one with improved visibility a pair of binoculars. After this, I noticed that players chose their units more carefully and paid more attention to the weather, not just directly above their heads, but also the weather close to their opponents.

Influence on food production

As I've stated earlier, I've chosen food as the only resource because the production of food is incredibly dependent on the weather. Every specific type of food needs enough sunlight, but also enough rain, which differs per type of food.

To produce food, you have to build a farm and assign it a number of farmers. Again, to keep things simple, there are two types of food that can be produced. One type that needs a lot of sunlight and another that needs a lot of water. If the one that needs a lot of sunlight only gets rain during the time of production, you'll only get a bare minimum amount of food.

Players can choose at any time which type of food to produce. However, it takes time to grow the crops, so you'll have to wait until the current crops have been harvested, before a farmer starts producing the other type of food you've selected. Because of this, players need to try to predict what the weather will do during production time before choosing what to produce, and even keep checking back once in a while to see to it that enough is being produced, otherwise the units will starve.
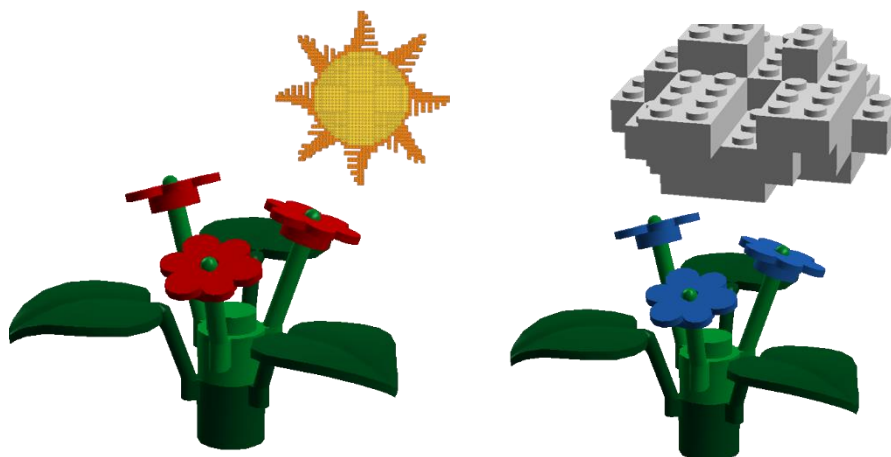
The player can choose between two different crops to produce.

This way, the weather is used as an extra gameplay element to make resource management more interesting and dynamic.

Problem of mass production

At first, this mechanic led to a problem of mass production. Because the weather was fairly certain in two areas of the world, there was nothing to prevent the player from simply building a lot of farms at those

edges and just leave them be. However, I wanted the players to actually take the changing weather into account when deciding what to produce where.

To try and solve this, I've added a system of fertility to the world. The more temperate the climate, the more fertile the ground, the higher the potential harvest, but also the higher the risk of a minimal harvest when the weather takes a turn for the worst.

Unfortunately, this alone did not solve my problem, due to the fact that there was still nothing that prevented the player from placing a lot of farms. Even though the potential gain was much lower at the edge, if you just placed more than enough farms, it wouldn't matter.

Something I didn't want to do was put a restriction on the number of farms you could place, because I didn't want to restrict the player in their strategies. It might actually be a good strategy to place a lot of small farms all over the world to spread production risks, instead of one or two big farms, which are easier to manage. I wanted to player to choose the strategy that suits him best.

What I did was put a restriction on the maximum number of farmers you can have in total, instead of the number of farms. This had multiple benefits.

First, it forced the player to strategically think about where to place a farm, because he could only place so much. So it now makes more sense for the player to take the risk of the temperate climate, where the production could be much higher.

A higher food production automatically means a higher 'population limit', i.e. the number of combat units you can have. This is because the more units you have, the higher the food consumption is. If your opponent has a higher food production, you could be at a disadvantage in number of units, so it would strategically be wise to have a high food production rate.

Another, unintended, benefit of the restriction on number of farmers was that it actually introduced the dynamic population limit, which became a mechanic of the game. I did not have to force a population limit upon the player. In fact, theoretically, there is no limit. It all depends on how well the player is able to manage his food resources.

In the next section, I will discuss the weather system I've designed for this game.

The system

For the weather to be interesting as a gameplay mechanic in this game, it had to be dynamic. If the weather didn't change over time, the player wouldn't have to pay attention to it, as if it wasn't there at all.

In addition, it had to be predictable enough for the player to try and predict it, in order for the player to be able to plan ahead and actually use the weather as part of their strategy.

However, the weather also had to unpredictable enough not to take over the whole gameplay. If it weren't unpredictable to at least some extent, it would simply become a matter of 'Who knows the system best?' instead of 'How adaptable are you in your strategies and can you cope with the ever-changing weather?'

This balance between predictability and unpredictability is what makes the weather interesting as a gameplay element.

Simplified simulation

When I started working on this project, I thought I would have to create a real-life weather simulation for this game, or at least a slightly simplified simulation, in order to really create the impression of dynamic weather and to account for all the different types of weather.
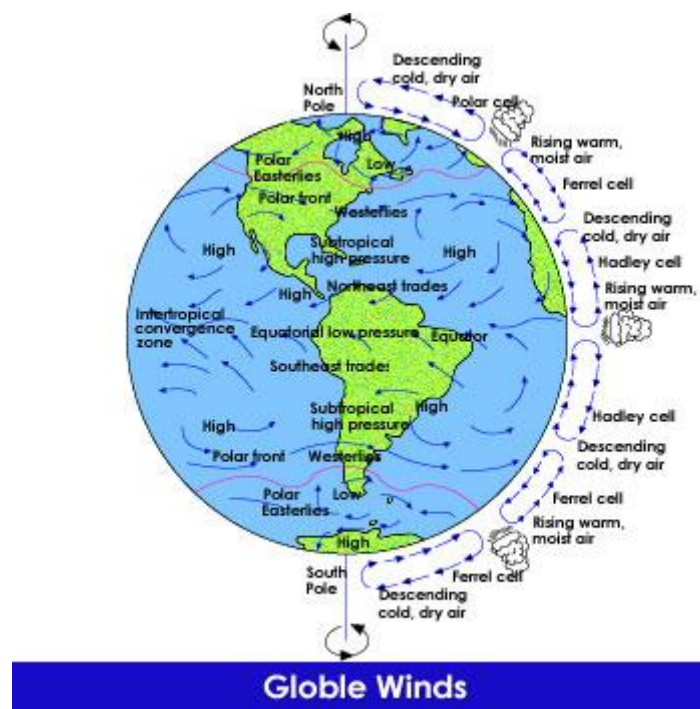
*Even the air flow in this image is extremely simplified.*

However, as I dug deeper into the physics behind the weather, as explained in 'Inleiding tot de meteorologie' (Schmidt, 1970), I began to realize that it's far too complicated to put into a simple game. If even the most powerful supercomputers in the world aren't able to properly predict tomorrow's weather, how on earth am I going to put an accurate weather simulation in a game? It's just not possible.

In addition, it's not even necessary to create a real-life simulation in a game. The player won't even notice it's there. The only thing that matters for the player is that the weather system is believable within the confines of the virtual world, not whether it resembles the real world accurately.

> "Makes the world feel more ... i won't say believable (because if you have rainbow unicorns why limit yourself to realistic weather), but complete." (Dumac, 2011)

After that, I set out to design a simplified simulation, using only a few rules of physics, but it was enough for what I wanted this system to be able to do.

The main rule was that air always flows from an area of high air pressure to an area of low air pressure. This rule forms the basis of my system, because it gives me a lot of parameters to play with.
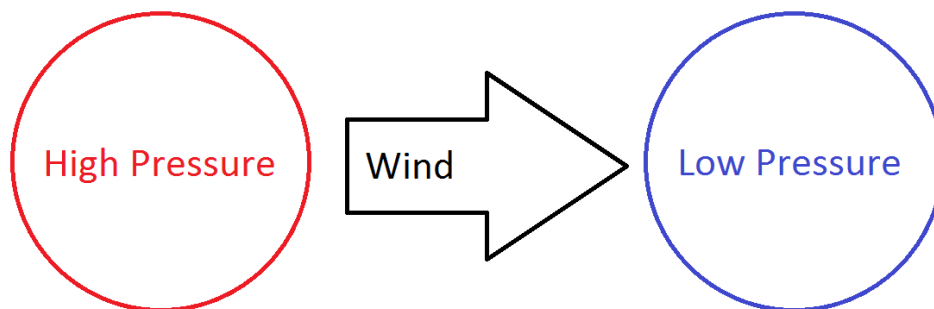

Air flows from a high pressure centre to a low pressure centre.

The positions of the pressure centres give me control over the direction of the air flow, i.e. the wind. If I change the position of one of the pressure centres, the direction of the wind will automatically change.

The air pressure itself gives me control over the wind speed. The higher the pressure difference between the two pressure centres, the faster the air will flow, i.e. the higher the wind speed.

The final thing I needed for this game was rain, which is a result of humidity. As the air temperature drops when moving from the high pressure area to the low pressure area, the relative vapour pressure of the air rises and when a certain humidity threshold has been reached, water starts to condense and clouds begin to form, which will result in rain if the clouds get too heavy.

I've used the forming of clouds as an indication for the player of what the weather is doing, by first making the clouds small and white and then make them grow and turn grey before it actually starts to rain. Based on those clouds, players can see where the wind is blowing from, how fast the direction of the wind is changing, how fast the wind is blowing, if it's slowing down and whether it will start to rain. So based on the clouds, players can try to predict what the weather will be like during the next few seconds, half a minute or more.
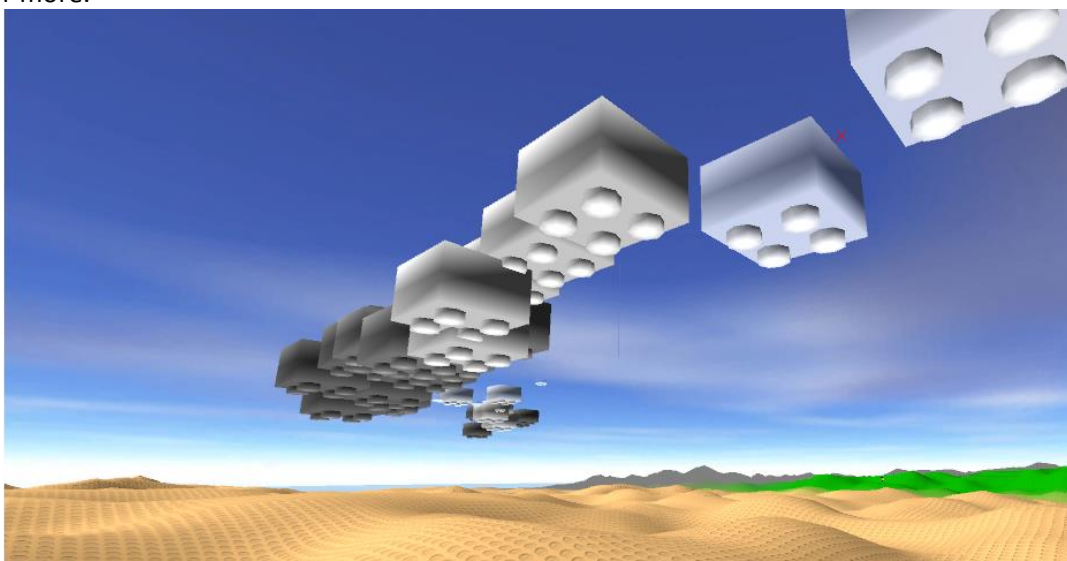
Clouds indicate how the wind is blowing and where you can expect it to rain.

Unpredictability

So far, the system I've described is very predictable, because it doesn't change over time. The fact that it has to change over time, is an important part of this system. If it changed instantly, the player wouldn't be able to predict anything.

Why the weather changes, is not important for the player in this game, just like it isn't important for us why it's raining outside. We only want to know whether or not it's raining and if it is, when it will stop, something we can never know for sure.

Because it doesn't matter why the weather is changing, I've made the weather change randomly over time.

More specifically, every once in a while a new random target value is chosen for the position of the pressure centre, a new random target pressure and a new random target humidity are chosen. Then the actual values change gradually over time to meet the random target values. The player will only see the clouds slowing down or speeding up, changing direction and starting to form earlier or later, but he won't know why it's happening.

Knowing why it's changing is not important for the player, because he doesn't need the information in order to make choices about his strategy.

I had to set up certain restrictions to the random values, in order to prevent the system from becoming too random. If it were random without restrictions, anything would be possible and the player would fail to see any logic, thus rendering him unable to make any decisions based on the weather. So by putting restrictions on the random values, I've made sure the player would still be able to try to predict the weather.

In the next section, I will discuss the process of implementing and testing the mechanics as well as the weather system and the difficulties I ran into.

Trying out the system

During the first phase of development of Project Lightning I have split the game into two different prototypes.

The first prototype focussed completely on the mechanics. How does the player navigate the world, how does he interact with the world? This is the place where I got to test the controls.

The second prototype was used to develop the weather system itself, mainly focussing on the technical side of the weather system, on how to simulate the weather.

At first, this approach appeared to work just fine. I was able to get the controls working the way I want and I even got a slightly realistic air flow simulation. This simulation consisted of a bubble of air that moved in a more or less realistic fashion from a high pressure centre to a low pressure centre. Eventually, as the bubble of air became too heavy, it even started to rain.

Merging the prototypes

It went wrong the moment I started to merge the prototypes. As it turned out, while the weather simulation looked rather promising on paper and in a standalone prototype, it was completely unfit for the game I had in mind.

The main issue was that the weather system was simply too complex for the player to understand. Where in real life air is constantly changing direction, horizontally as well as vertically, while flowing from high pressure to low pressure, this behaviour completely confused the player. The player had no idea where this behaviour was coming from and therefore he was unable to make any predictions about the weather.

The primary reason for this problem was the scale of the weather system. In real life, the weather changes at a much slower rate and at a much larger scale (i.e. it moves over a much larger area) than is the case in my weather system. This way, in real life, we don't notice the strange twists and turns the clouds are making, it simply looks as if they are moving in the same direction everywhere.

Only by slowing down the time and enlarging the whole weather system at least tenfold, could this system be of use in my game. However, slowing down the time of the weather system would also insurmountably slow down the pace of the whole game, which is undesirable.

This problem required me to come up with a different, simpler, system. A system that doesn't rely as much on actual physics as I had first intended, the system I have described in the previous section.

While I think using two different prototypes to test mechanics and the underlying system can be of great use, you have to be careful with this. I would suggest using a separate prototype to implement new features and then merging them into the actual game as soon as possible. In the end, it doesn't matter whether the system works on a technical level. The only thing that really matters is that it works from the players' point of view, when it's actually a part of the full gameplay experience.

In the next section, I will discuss some of the different directions in which the weather in this game could be expanded, given enough time.

Expanding Project Lightning

In an ideal world, where there was no time limit to this project, there would be much more that could be done with the weather in this game. However, this is not an ideal world, because unfortunately I'm not able to cope with the summer heat outside, so I have only been able to implement a vertical slide of the full concept.

I will use this chapter to discuss some of the ideas I have about using the weather in my game. These ideas have not been tested, they're just examples of how I think the weather could be used.

One of the first things that comes to mind is adding more weather types, to make the game more dynamic. Those weather types could be basic ones like snow, lightning and fog, but also more complicated ones like blizzards and sandstorms. Of course, all of these weather types could have very different effects on the player, resource production or even the environment.

The effects of the weather could also be greatly expanded. Right now, the effects are only short-term effects. There are no lasting effects of the rain, once it stops raining. However, I think the weather could also be used to create some longer lasting effects, like effects on the environment, seasonal changes and even culture.

Resource management

Right now, there is only one resource and the effect of the weather is fairly basic. However, there are various ways in which this could be expanded.

Instead of just having two types of food that either need water or drought, I'd like to create multiple types of food. Food that grows well in a cold climate, or in the desert. Different types of food for different seasons. Food that needs a combination of water and sun, instead of just one or the other.

It doesn't matter where your units are, as long as you have sufficient food supplies, your units can eat. However, the game could gain a whole new dimension of strategy when you actually had to supply your units with food every now and then. By sending a caravan from your warehouse to your units, for example. Of course, you'd have to make sure your food caravan doesn't get stuck in bad weather, or your units might not get their food in time and starve, or they'd have to resort to robbing nearby villages.

In the long run, types of food could even be based on different cultures, so to get different kinds of food, you'd have to trade with other cultures or create your own settlement somewhere. I will discuss cultures later on.

You could also add different kinds of resources. One resource I'd like to add to this game is water, because water is, like food, essential for your units' survival. Every unit would then need water and food every once in a while. As the area gets warmer, units would need more water. The colder it gets, the more food they'd need. However, because people living in the desert are used to the heat, they'd need less water than the people used to living in a cold area, whereas those people would need less food.

Perhaps, once the game gets this deep into things like resource management, it might actually be a better idea to switch back to a top-down perspective, because this would give the player a better overview of the world and different weather patterns and climates.

Environment

At the moment, the weather only has a direct effect on the plants and the units, but not on the terrain itself. This is something I would like to add, effects on terrain.

For example, after a heavy downpour, the ground gets completely wet and only dries up over time. On a dirt road, this might result in the ground turning into mud, making it more difficult to walk, thus slowing down your units.

In addition, a lot of rain in a very short time might even lead to rivers overflowing, making it impossible to cross them.

On the other hand, when it gets cold enough, that same river could get frozen solid, allowing your units to cross the river and travel into areas that were previously unreachable. The hillside on the other side of the river, however, might become too slippery to climb, especially with those caravans carrying your food supply.

By making the weather have an effect on the environment, the effects of the weather can still be seen and felt even after it has passed. This would make for some interesting gameplay strategies that would otherwise be unnecessary.

Culture

The effects of the weather on culture could defined as the long-term effects of the weather, like climate. The way I envision this is that every player starts out somewhere in the world with exactly the same type of units and buildings. The world is divided into various climates, where every climate has its own average temperature, rainfall and vegetation.

While the player is expanding his settlement, he has to adapt to the climate in various ways. The types of food available will be different depending on where you live, just like the amount of water. Depending on where you live, other types of resources might be available to you. For example, in a forest, the amount of wood would be plentiful, but iron might be hard to come by. For that, you'd need to get to a mountain area.

These resources would also define what your settlement might look like and how strong it is. You can't build a stone fort when there's no stone available.

The environment and climate would also play a huge role in how your units would develop. In a forest, units might learn to climb trees to ambush their opponents, but they probably wouldn't use throwing spears as weapons, those would be more common in the tundra. This way, your units would definitely have a home advantage, but you'd have to use some real good strategy to invade your opponents' lands.

Different cultures could develop based on the environment and climate.

Summary/Conclusion

I've been fascinated by the weather for a long time. And during the same time, I've mostly been disappointed by the lack of proper weather in one of my favourite pastime activities, videogames.

In my research I've come across various games that actually do use the weather in one way or another. I have categorised these games into three groups, depending on how they use the weather.

The first group uses the weather primarily to create a certain atmosphere. The weather is used by the designers to help tell a story, to make the player feel a certain way when watching a cut-scene or walking in a village.

The second group uses the weather as a means to present a puzzle, a challenge for the player. In this case, it's not the weather that matters, it's about the puzzle itself. The weather is merely a visual presentation of the puzzle. In fact, the weather could be replaced by just about anything else, and the puzzle or the gameplay wouldn't change.

The final group is in my opinion the most interesting and the most underused group. This group uses the weather as an extra gameplay element, but it doesn't take over the game or the challenge. It is merely used to add an extra layer to the gameplay. You could remove the weather from the game, but the gameplay would remain intact, it would just become less interesting to play. A requirement for a use of weather to fall under this category is that it has to use some of the unique properties of the weather, that can't be replaced by anything else, like the unpredictability of changing weather.

There are different ways in which the weather can be accommodated in a game. Again, based on my research, I've divided these weather systems into three categories.

A simulation is a system that tries to model the changing of the weather in a more or less realistic way. A simulation doesn't mean the way the weather changes is realistic, it's only meant to be realistic within the confines of the virtual world. There are two main reasons for that. For starters, real-world weather is just too complex to simulate in game. Second, it's not necessary. Players won't even notice the difference between a real-life- and a simplified simulation. All they care about is whether or not it works in the game.

A scripted system is most often used in story-driven games, where every detail of the cut-scene matters to provide the best player experience possible. It has to be as if the player is reading a book or watching a movie. Therefore, the designers need full control over what the weather is doing every second. This system is never dynamic, it's always predefined.

A random system is often used to make a game world feel more dynamic and alive, but when it doesn't matter how or why the weather is changing, or whether there is any logic to the system at all. As long as it happens within certain restrictions set up by the designer.

When choosing what kind of system to use when incorporating the weather in a game, you first have to ask yourself, 'what do I want to accomplish with the weather?' Most of the time, you will end up with a combinations between multiple of these types of systems, because every system has its uses.

As a case study, I've been working on a simple game that uses the weather as a gameplay element, with a weather system that has become a simple simulation with some random elements added.

The game has become a simple first-person real-time strategy game, in which the player can build units to defeat his opponent, all the while producing food to keep his own units from starving.

The weather has various effects on the gameplay. The production of food is extremely dependent on the weather. I've introduced two types of food, one that needs sunlight and one that needs rain to grow. Because the weather is continuously changing, players have to choose carefully what type of food to grow, based on what they think the weather is about to do.

The weather also has an effect on the units themselves. Every unit has a particular advantage when it's dry and another one when it's raining. This way, players also have to carefully plan what type of units to bring with them to defeat their opponent, based on what they expect the weather to be like on the battlefield.

There were to main requirements the weather system had to meet. The weather had to be predictable enough for the player to be able to try and predict the weather, but it also had to be unpredictable enough so the player would always have to pay attention to the weather and adapt his strategy accordingly.

I ended up creating a system that uses two main rules of physics. Air always flows from a high pressure area to a low pressure area and in air that becomes too humid, clouds will start to form and it will eventually start to rain. The actual positions of the pressure areas, the pressure itself and the humidity level all change randomly, but gradually, over time.

Unfortunately, this has been a severely time-restricted project, so I still have tons of ideas to implement even more weather effects into this game. These are very direct effects, such as the influence of fog on your visibility, and also indirect effects, such as a river freezing over in winter and even the effect of climate on different cultures in different places in the world.

There are tons of different ways in which the weather could be used in a game, and I believe I've only scratched the surface of what's possible.

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