

Common Student Ideas about Weather and Seasons

	Common Student Idea(s)	Scientific Explanation
Weather Conditions	1. Clouds go to the sea and get filled with water.	Clouds are created when water vapor condenses onto dust or other particles in the air. The water vapor is in the atmosphere as a result of evaporation of water from the surface of Earth, and from respiration of plants and animals.
	2. Clouds are sponges that hold water. Clouds come from somewhere above the sky. Empty clouds are refilled by the sea (water stays as a liquid through the entire process). Clouds are formed by boiling— vapors from kettles or the Sun boiling the sea. Clouds are mostly smoke, made of cotton or wool, or they are bags of water.	A visible cloud is primarily tiny water droplets and/or tiny ice crystals; it is not water vapor [or a container holding water].
	3. Clouds move when we move. We walk, and the clouds move with us.	Clouds move when wind blows them. [Winds typically move from high-pressure regions to lower-pressure regions.]
	4. Clouds and rain are independent. OR Clouds foretell rain.	Clouds are necessary but not sufficient predictors of rain. The presence of clouds does not mean it will rain.
	5. Rain falls out of the sky when the clouds evaporate. Rain comes from holes in clouds (like salt from a salt shaker). Rain comes from clouds sweating. Rain comes from clouds melting. Rain falls from funnels in the clouds.	Rain begins to fall when water drops in the cloud are too heavy to remain airborne.

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Weather Conditions	6. Rain occurs because we need it. Rain occurs when clouds get scrambled and melt. Rain occurs when clouds are shaken (by the wind). Rain occurs when clouds collide. Rain occurs when clouds become too heavy.	Rain occurs whether or not we want/need it to, [and we have no control where rain will fall]. When the water droplets [that have condensed onto dust particles and other particles in the air] become sufficiently heavy, they fall from the clouds.
	7. Thunder occurs when two clouds collide.	Thunder and lightning are the visible and auditory effects of a massive charge transfer between clouds.
	8. Frost falls from the sky. Frost is frozen dew.	Frost forms when water vapor comes in contact with very cold surfaces. The water freezes directly instead of condensing to a liquid in a process called <i>deposition</i> (gas becomes a solid without becoming a liquid first).
	9. Flooding only occurs along rivers when the snow melts in the spring. OR Flooding only occurs after a heavy rainfall.	Flooding is a phenomenon that occurs when there is more water than the ground or rivers can accommodate.
	10. Cold days are caused by the clouds covering the Sun.	The temperature of a given day is dependent upon many different things, including time of year, location, altitude [elevation], [and prevailing] winds.
	11. Snow and ice make it cold.	The snow and ice are functions of cold temperatures, not the cause of them.
	12. Clouds block wind and slow it down. Cold temperatures produce fast winds.	Winds are produced by the uneven heating of Earth's surface and the resulting rise and fall of differentially heated air masses.

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Atmosphere and Gases	13. The atmosphere is made up solely of air.	Small size prevents us from seeing them, but there are significant numbers of particles present in the atmosphere.
	14. Air is not the same everywhere. Air in a container is different than air in the room or outside.	Air is composed of several gases. The predominant gases include oxygen, nitrogen, water, [and] carbon dioxide.
	15. Air and oxygen are the same thing.	Air is a mixture of gases, [such as nitrogen, oxygen, carbon dioxide, and water vapor, along with small amounts of other gases].
	16. Humid air is oppressive and heavy; humid air is more dense than dry air.	Humid air is less dense than dry air. It has more water vapor in it, but that makes the air less dense—water’s molecular weight is 18; dry air’s is 29.
	17. Heated air weighs more than cold air. Hot air weighs less than cold air.	Heated air has the same mass as cold air. Other properties of the gas will change as heat is added (either increased pressure or volume), but the mass remains constant.
	18. Air in motion always ... flows in a direction from high to low pressure.	Surface winds do flow from high to low pressure, but only at the surface. At high altitude, winds and vertical air flows (air currents) violate this idea.
	19. The H on weather maps stands for hot temperatures, whereas L means cold weather. Isobars on weather maps represent wind speed or temperature.	Symbols on weather maps are misleading to many people. The H and L represent areas of high and low pressure. The isobars represent areas of equal pressure.
	20. Ozone, no matter its location, is bad. Ozone, no matter its location, is good.	Ozone can be beneficial or harmful, depending upon where it is located in the atmosphere. Ozone in the upper atmosphere blocks out damaging UV radiation. Ozone in the lower atmosphere (near Earth’s surface) is a major constituent of smog.
	21. The ozone hole is a hole in the sky.	The “ozone hole” is an area of the atmosphere where the ozone levels are lower than expected.

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Heating of Earth and Seasons	22. Earth gets heat from the Sun.	The Sun is actually too far from Earth to heat it directly. Instead, objects on Earth, including the gases in the atmosphere, clouds, land, and oceans, absorb or reflect sunlight (solar radiation or energy). Absorbed light usually increases energy in an object, causing the object to heat up.
	23. Light can only be reflected from shiny surfaces (such as a mirror). Objects can't absorb and reflect light. They must do one or the other.	All objects absorb and reflect light to different degrees. Our ability to see objects depends on their reflection of light, and seeing different colors in an object indicates that that object has absorbed certain wavelengths of light and reflected the colors we see.
	24. Some students confuse Earth's daily spin (rotation) with its yearly orbit (revolution) around the Sun. For example, they believe that the side of Earth not facing the Sun experiences winter.	Earth's daily spin (rotation) causes day and night. When we're on the side of Earth that's facing away from the Sun, it's dark outside, and when we're on the side that is facing the Sun, it's daytime.
	25. Seasons are caused when Earth is closer to the Sun in summer and farther away from the Sun in winter. <i>[Researchers attribute this misconception to the representations students often see in their textbooks that show an elongated elliptical orbit, which makes it appear as if the Sun is closer to Earth during certain times of the year.]</i>	Just the opposite! In the Northern Hemisphere, Earth is closest to the Sun during the winter and farthest from the Sun during the summer. Seasons are caused by the tilt of Earth's axis and different amounts of the Sun's energy that regions north or south of the equator receive during the year. Earth's tilt (which oscillates a little) is currently about 23.5 degrees. This means that during summer, the Northern Hemisphere is tilted toward the Sun and receives light at a more direct angle. In contrast, the Northern Hemisphere is tilted away from the Sun in the winter, and the Sun's rays hit at a more indirect angle, which causes the light to spread out over a larger space.

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	26. The temperature near the equator is warmer because it's closer to the Sun, and the poles are colder because they're farther from the Sun.	The difference in the distance from the equator to the Sun or the poles to the Sun is so small that it's inconsequential in creating temperature variations at different latitudes. Rather, the angle at which sunlight hits Earth's surface causes these temperature variations. Sunlight hits Earth more directly (straight on) at the equator and at more of an angle (more spread out) at the poles. Because of Earth's tilt, the equator receives the most direct sunlight on the planet only twice a year—during the spring equinox (March 20 or 21) and the autumn equinox (September 22 or 23). This direct, incoming sunlight moves north of the equator between the spring and autumn equinox (causing summer in the Northern Hemisphere and winter in the Southern Hemisphere) and south of the equator between the autumn and spring equinox (causing winter in the Northern Hemisphere and summer in the Southern Hemisphere).
	27. Temperatures are warmer on the top of mountains because the mountains are closer to the Sun.	The distance between sea level and a mountain peak is insignificant compared to the distance between Earth and the Sun. Temperatures at higher elevations are actually much cooler because air density is lower. As air molecules rise into the atmosphere, they expand and cool. Locations at higher elevations generally experience cooler temperatures than locations at lower elevations.

References

Content for weather conditions and atmosphere and gases adapted from Henriques, L. (2002, May).

Children's ideas about weather: A review of the literature. Retrieved from <https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1949-8594.2002.tb18143.x>.