Exometeorology

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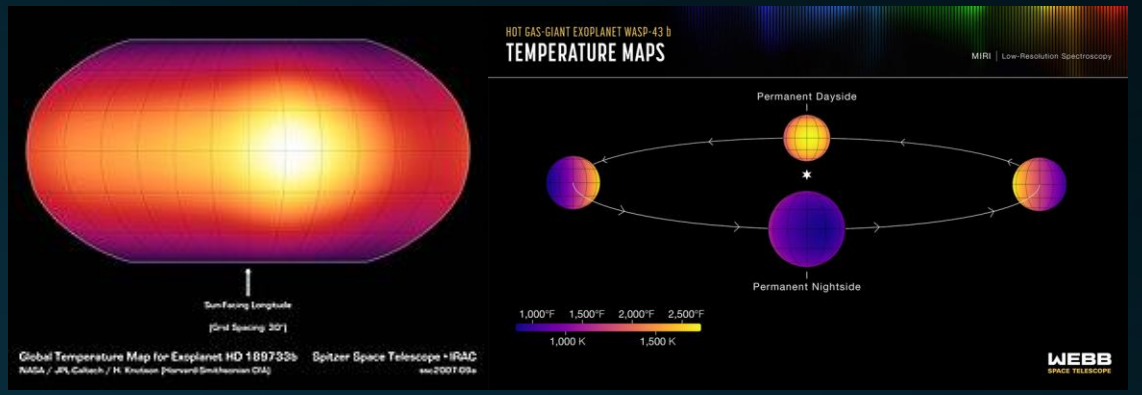
Exometeorology is the study of atmospheric conditions of exoplanets and other non-stellar celestial bodies outside the Solar System, such as brown dwarfs.



Background

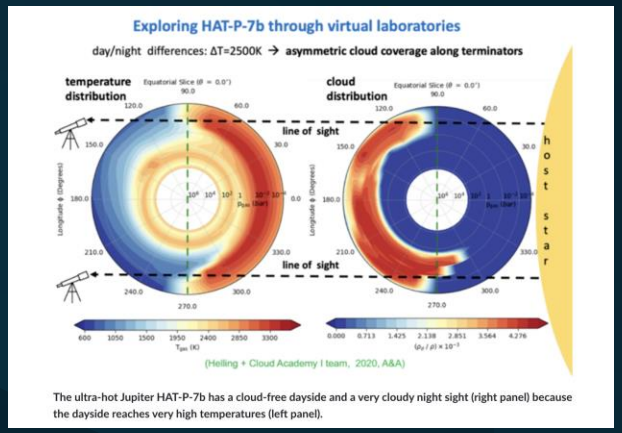
Climate models have been used to study Earth's climate since the 1960s and other planets in our solar system since the 1990s. However, exoplanet detection technology has only recently developed enough to allow direct observation of exoplanet atmospheres, so there is currently very little observational data about meteorological variations in those atmospheres.

Clouds and rain

When we talk about weather, we can't avoid talking about clouds. On Earth, clouds are made of water. But on exoplanets, due to different pressures and temperatures, clouds may be made of other substances.

For example, 55 Cancri e is a lava planet. Due to tidal locking, the side of the planet facing the star is extremely hot, even capable of melting rock. As a result, the clouds on this planet are made of **liquid lava droplets**. But this assumption was overturned by JWST observations. The results of JWST indicated a "bona fide volatile atmosphere likely rich in **CO2 or CO**". The authors stated that 55 Cancri e's magma ocean could be outgassing and sustaining this atmosphere.

HD 189733b

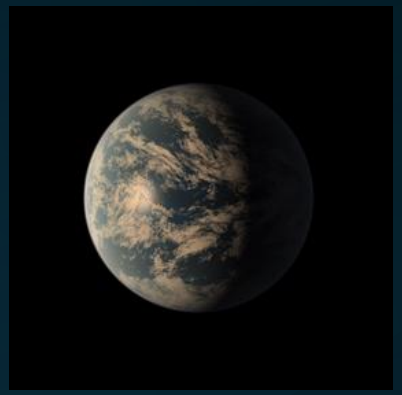


The ultra-hot Jupiter HAT-P-7b has a cloud-free dayside and a very cloudy night sight (right panel) because the dayside reaches very high temperatures (left panel).

Another example is the WASP-12b. The temperature of this planet could reach about 2300K. The most likely cloud-forming material is an aluminum oxide called corundum, which forms the basis of rubies.

Rain and clouds are closely related. As mentioned before, the clouds on WASP-12b are made of corundum. Therefore, scientists believe that it is rubies that are raining on this planet.

WASP-43b



Wind

Wind is another important factor in weather. On HD189733bs, due to tidal locking, the temperature on the side facing the star is much higher than the other side. However, according to observations, the temperature difference between the two sides is not as high as expected. Therefore, there must be a strong wind on this planet to balance the temperature difference. In fact, the planet's winds reach speeds of up to 8,700 kilometers per hour, making them some of the fastest in the universe.

JWST observations of WASP-43b show that there are also strong winds on this planet, exceeding 5,000 kilometers per hour. Such extreme wind speeds make the distribution of substances (such as methane) throughout the planet's atmosphere very uniform.

The second home?

Weather is an important factor affecting the habitability of a planet. In the solar system, Mars, Earth and Venus are all in the habitable zone, but the weather on Mars and Venus makes them uninhabitable.

In the Trappist-1 system (in the previous course, we calculated the surface temperature of several planets), since most planets in this system are tidally locked, the temperature on one side of the planet will be very high, and the temperature on the other side will be very low. But scientists believe that there will be a world full of life at the boundary between the two sides!

Of course, if the planet has a thicker atmosphere, then under long-term heat exchange, it is also possible that the entire planet is habitable!

However, the Earth is still unique so far. Because of various coincidental conditions, It gave birth to abundant life. So, while Earth's weather isn't as extreme as on other planets, it's the most special weather in the universe.