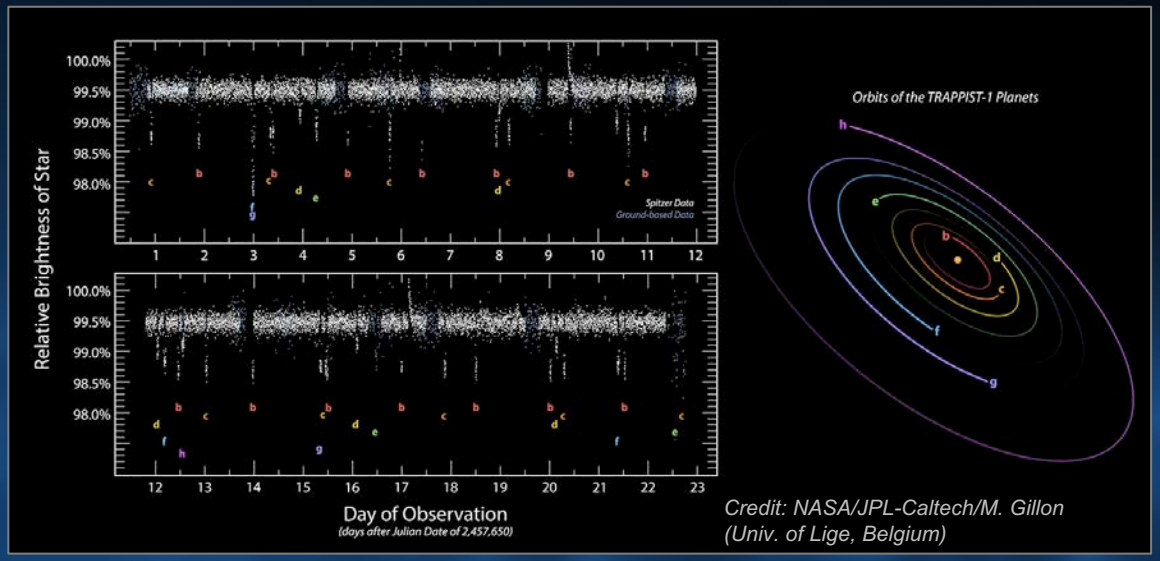
National Aeronautics and Space Administration

SCIENCE MISSION DIRECTORATE

Weekly Highlights

February 24, 2017

Largest Batch of Earth-Size Habitable-Zone Planets Around a Single Star



Credit: NASA/JPL-Caltech/M. Gillon (Univ. of Lige, Belgium)

The data plot on the left shows Spitzer infrared observations of a system of seven planets orbiting TRAPPIST-1, an ultracool dwarf star. Over 21 days, Spitzer measured the drop in light as each planet passed in front of the star. Spitzer was able to identify a total of seven rocky worlds, including three in the habitable zone where liquid water might be found. The planets may be tidally locked to their star. A diagram of the layouts of the orbits is shown on the right.

NASA's Spitzer Space Telescope has revealed the first known system of seven Earth-size planets around a single star, a new record for greatest number of habitable-zone planets found around a single star outside our solar system. All of these seven planets could have liquid water under the right atmospheric conditions, but the chances are highest with the three in the habitable zone.

This exoplanet system, called TRAPPIST-1, is in the constellation Aquarius, about 40 light-years (235 trillion miles) from Earth. It was named for The Transiting Planets and Planetesimals Small Telescope (TRAPPIST) in Chile. In May 2016, researchers using TRAPPIST announced they had discovered three planets in the system. Spitzer, assisted by several ground-based telescopes, confirmed the existence of two of these planets and discovered five additional ones.

Using Spitzer data, the team precisely measured the sizes of the seven planets and developed first estimates of the masses of six of them, allowing their density to be estimated. Based on their densities, the TRAPPIST-1 planets are likely to be rocky. The mass of the seventh and farthest exoplanet has not yet been estimated – scientists believe it could be an icy, "snowball-like" world.

In contrast to our sun, the TRAPPIST-1 star – classified as an ultra-cool dwarf – is so cool that liquid water could survive on planets orbiting very close to it. All seven of the TRAPPIST-1 planetary orbits are closer to their host star than Mercury is to our sun. The planets also are very close to each other. The planets may be tidally locked to their star, which means the same side of the planet is always facing the star. This could mean they have weather patterns totally unlike those on Earth.

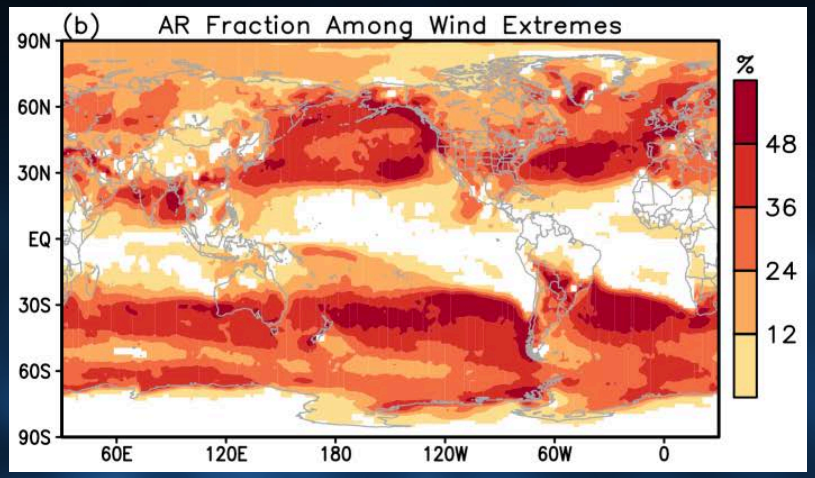
Following up on the Spitzer discovery, NASA's Hubble Space Telescope has initiated the screening of four of the planets. These observations aim at assessing the presence of puffy, hydrogen-dominated atmospheres around these planets. In May 2016, the Hubble team observed the two innermost planets, and found no evidence for such puffy atmospheres. This strengthened the case that the planets closest to the star are rocky in nature.

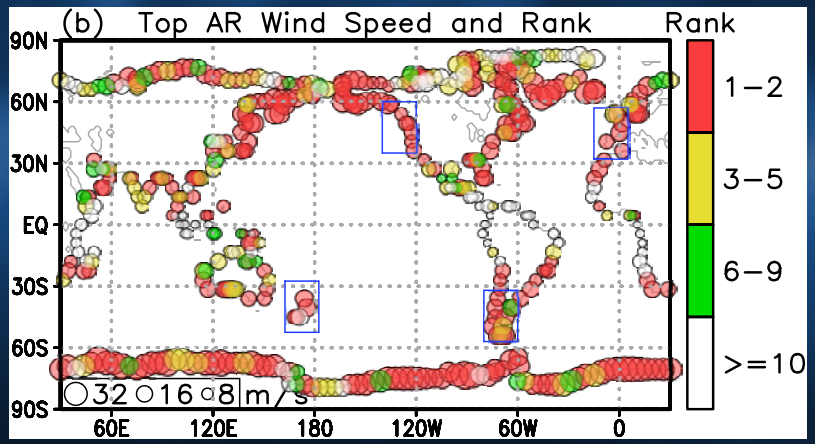
Extreme Winds And Precipitation During Landfall Of Atmospheric Rivers

Waliser & Guan | Nature Geoscience | February 2017 | doi:10.1038/ngeo2894

NASA-funded scientists applied a global detection algorithm for atmospheric rivers to the European Centre for Medium-Range Weather Forecasts (ECMWF) Interim reanalysis (ERA-Interim) data during 1997–2014, to investigate the impact of atmospheric rivers on wind and precipitation extremes. They found that atmospheric rivers are associated with up to half of the extreme events in the top 2% of the precipitation and wind distribution, across most mid-latitude regions globally. Landfalling atmospheric rivers are also linked to about 40–75% of extreme wind and precipitation events over 40% of the world's coastlines. Atmospheric rivers are associated with a doubling or more of the typical wind speed compared to all storm conditions, and a 50–100% increase in the wind and precipitation values for extreme events. The study also showed that the majority of extreme wind events catalogued between 1997 and 2013 over Europe with billion US dollar losses were associated with atmospheric rivers, and concluded that landfalling atmospheric rivers can represent a significant hazard around the globe, because of their association with not only extreme precipitation, but also extreme winds.

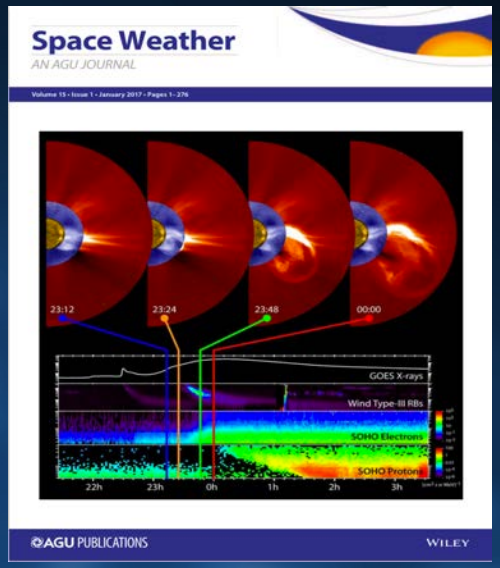
Atmospheric rivers (ARs)—long, narrow filaments of large integrated water vapor transport—are associated with weather and water extremes, such as precipitation extremes and flooding in western North America and northern Europe. In recent years, there has been a growing interest in ARs, their regional impacts on water availability and flooding , their modulation by climate variability and change , and their representation in weather forecast models.





Above: **(top)** Global map showing the frequency (% of times) that ARs are associated with surface (at 10 m) wind extremes; **(bottom)** Circle color (size) indicates the rank (speed) of wind extremes that are connected to an AR considering all 6-hourly ECWMF surface wind values from 1997-2014.

Scientists Demonstrate a New Solar Energetic Particle Warning Technique Using K-Cor Ground-based Coronagraph Data



A Heliophysics science publication using ESA/NASA SOHO observations and data from the National Center for Atmospheric Research's K-Cor ground-based coronagraph is highlighted on the cover of the January 2017 issue of *Space Weather*, an American Geophysical Union Publication.

The paper's authors analyzed data on a fast coronal mass ejection (CME) event in early 2016 from the K-Cor ground-based coronagraph and SOHO particle and coronagraph observations. Fast CMEs have a high association rate with solar energetic particle events (SEPs), which can produce hazardous conditions for human and robotic space exploration, as well as airline passengers on polar routes. According to recent recommendations from the National Research Council, the forecasting and warning of SEP events "should be an essential part of a comprehensive radiation mitigation strategy".

The scientists found that using the ground-based coronagraph observations to warn of the 2 January 2016 SEP event could have provided a significant temporal advantage when compared with other existing techniques used to forecast SEP events. K-Cor was able to detect the eruption of the CME low in the solar corona. Therefore, this work was the first demonstration that an SEP onset could be predicted based on observations of a solar eruption before the energetic particles leave the solar environment.

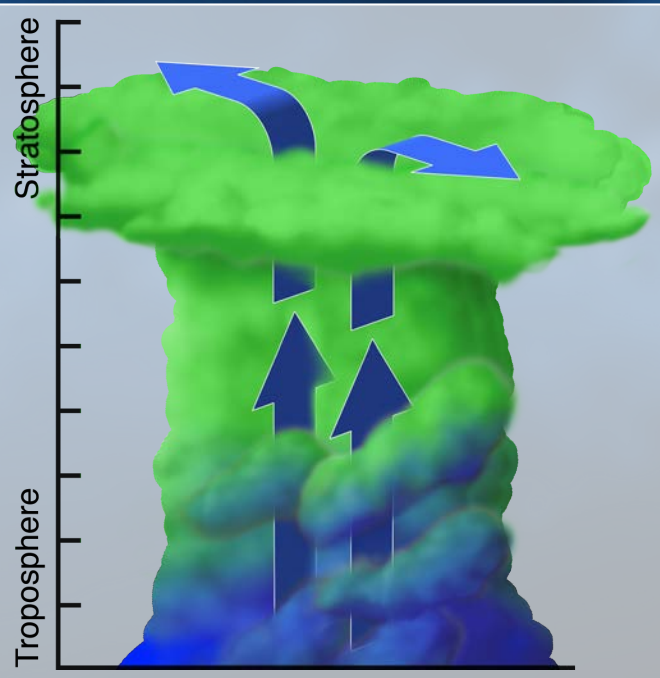
NOAA's Space Weather Prediction Center (SWPC) *proton* model also predicts SEP events; it's driven by solar flare parameters and flare location on the sun. The RELeASE model is driven by measurements of first-arriving solar relativistic electrons observed by the SOHO CoSTEP instrument, which is led by the University of Kiel (Germany). The technique demonstrated in this paper could augment existing capabilities for predicting SEP events with earlier initial detection of solar eruptions.

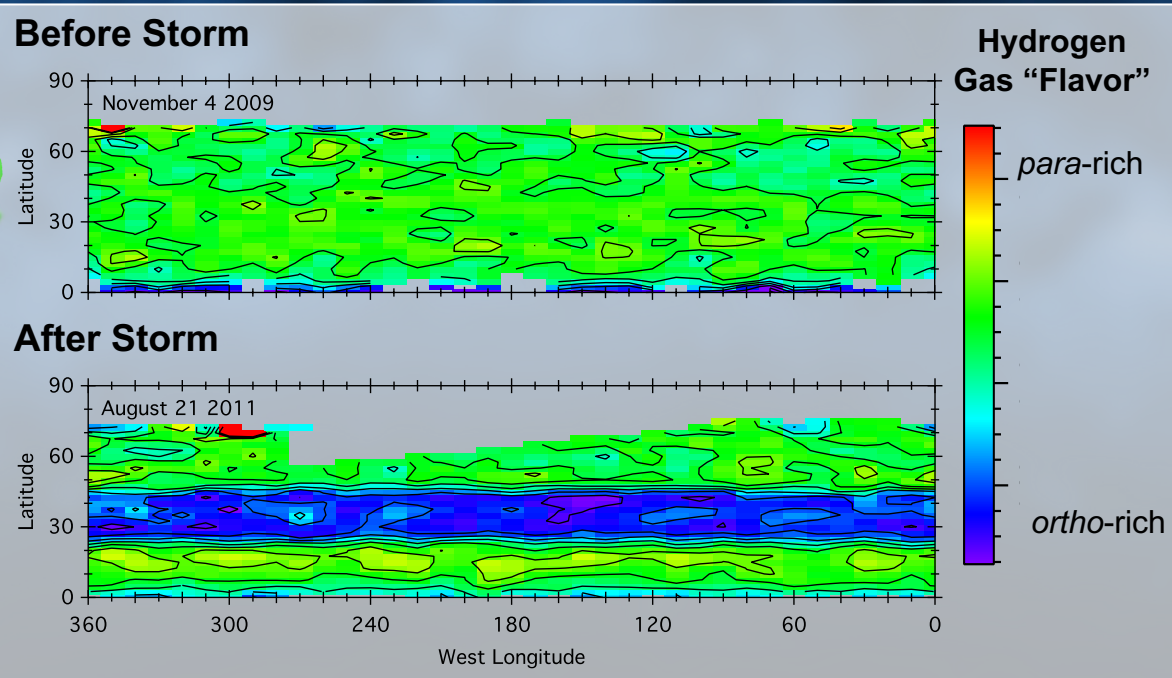
The paper notes that a prototype SEP-onset warning capability can be realized with only modest modifications to the K-Cor observations to include software-based CME detection, measurement and warning schemes.

These findings were the result of collaboration by scientists from NASA GSFC, NASA HQ and the High Altitude Observatory in Boulder Colorado. DOI: 10.1002/2016SW001545

Saturn Storm Serves Up Two “Flavors” of Hydrogen

- A new study of temperature and composition changes shows that air was lofted more than 200 km (120 miles) higher by powerful convective forces during Saturn’s massive storm in 2010-2011 (background image).
- This confirms earlier evidence of powerful convection in Saturn’s atmosphere, revealed by the presence of water ice within storm clouds. Water ice normally resides at the level where water condenses, 200 km deep.
- Cassini used infrared measurements to find a significant change in the “flavor” of hydrogen gas, with deeper *ortho*-rich hydrogen, usually found deeper in the atmosphere (shown in blue, below) replacing the higher altitude *para*-rich “flavor” (green).
- These results informs us about complexity in large-scale storms in giant planet atmospheres.





Changes to Saturn’s Zonal-Mean Tropospheric Thermal Structure After the 2010-2011 Northern Hemisphere Storm, Achterberg, et al., *Astrophysical J.* 786, 92-99, 2014

STEM Role Model Training

- On February 10, 2017, Goddard Space Flight Center held a three-hour training program developed by NASA LaRC (Jessica Taylor and Sarah McCrea)
- Participants included the NASA Earth Science Education Collaborative, and Goddard Center employees
- The training is designed to help participants reflect on their identity as a role model and provide research-based strategies to effectively engage youth, particularly girls, in STEM