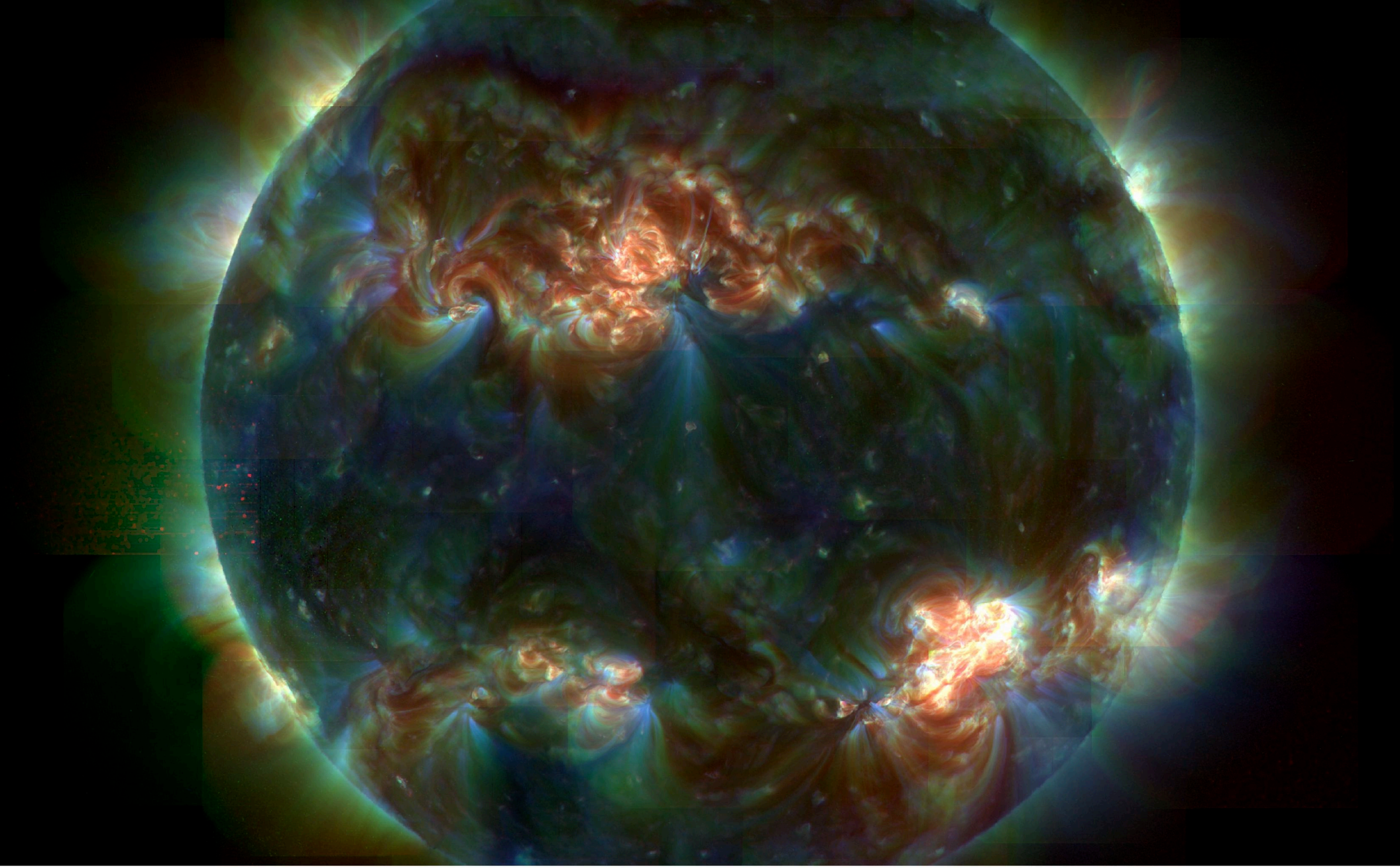


TRACE

Views of the Sun with a NASA Small Explorer Mission

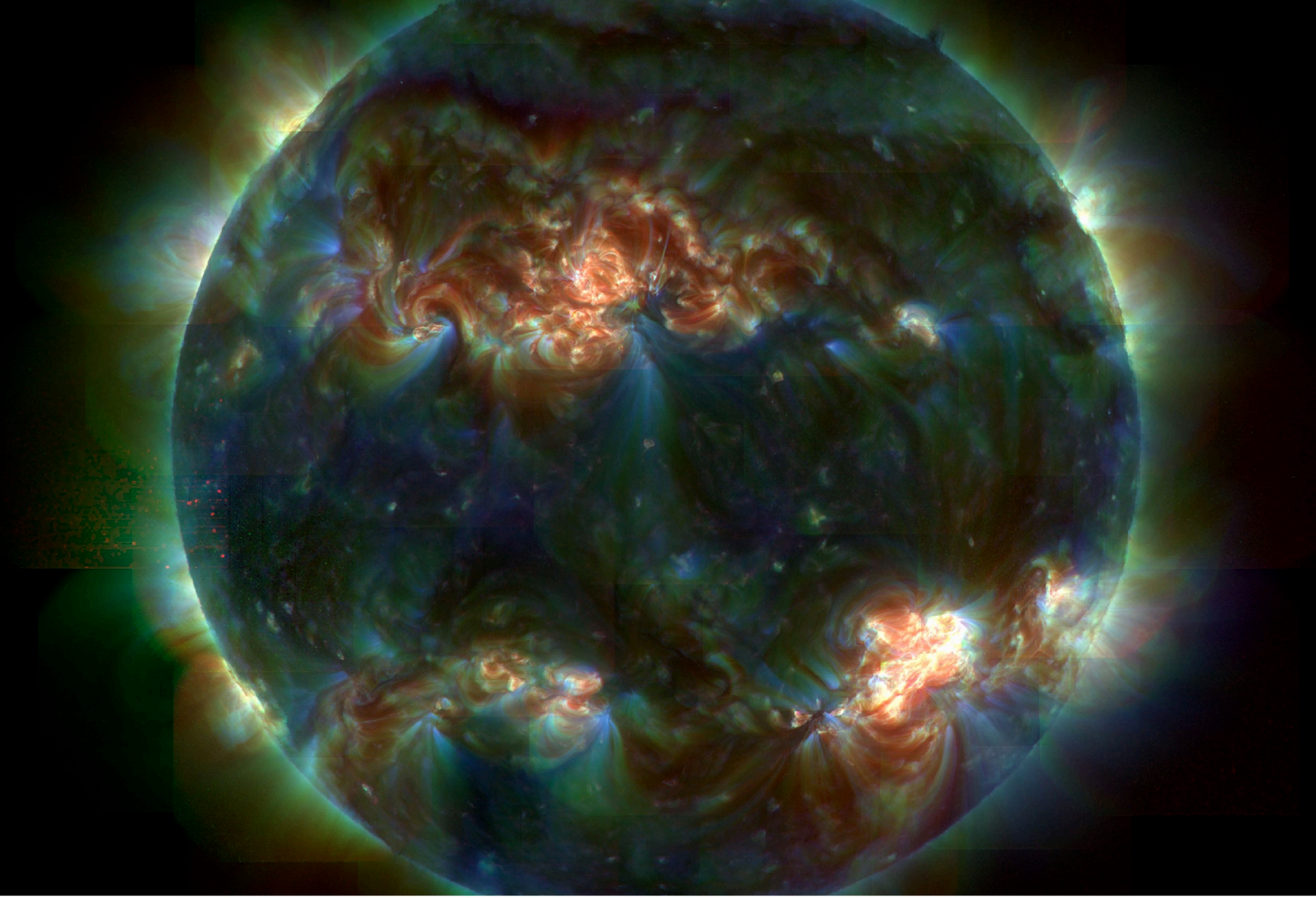
TRACE

The Transition Region and Coronal Explorer, TRACE, is a mission of the Stanford Lockheed Institute for Space Research (a joint program of the Lockheed Martin Advanced Technology Center's Solar and Astrophysics Laboratory and Stanford's Solar Observatories Group), and part of the NASA Small Explorer program. TRACE was launched into a Sun-synchronous orbit on April 1, 1998.

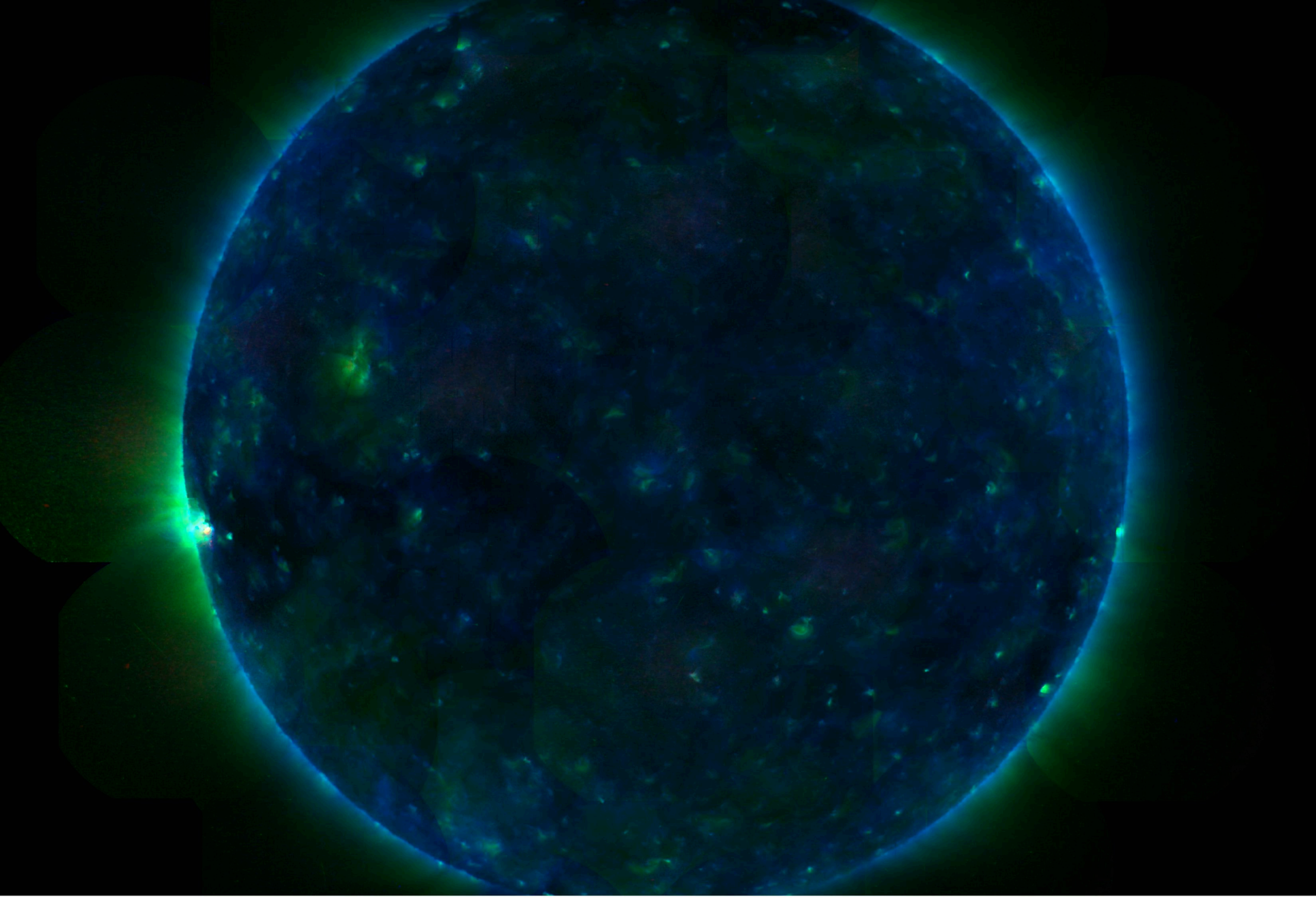
TRACE
A NASA Small Explorer Mission

Alan Title and Karel Schrijver

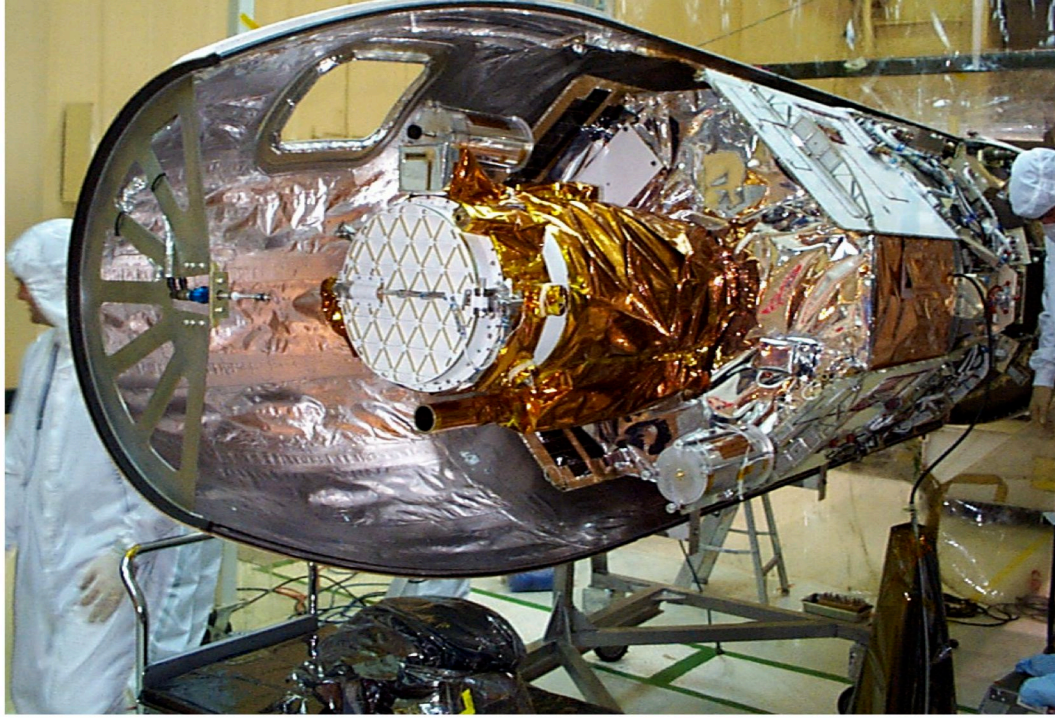
Lockheed Martin Advanced Technology Center
Palo Alto, California

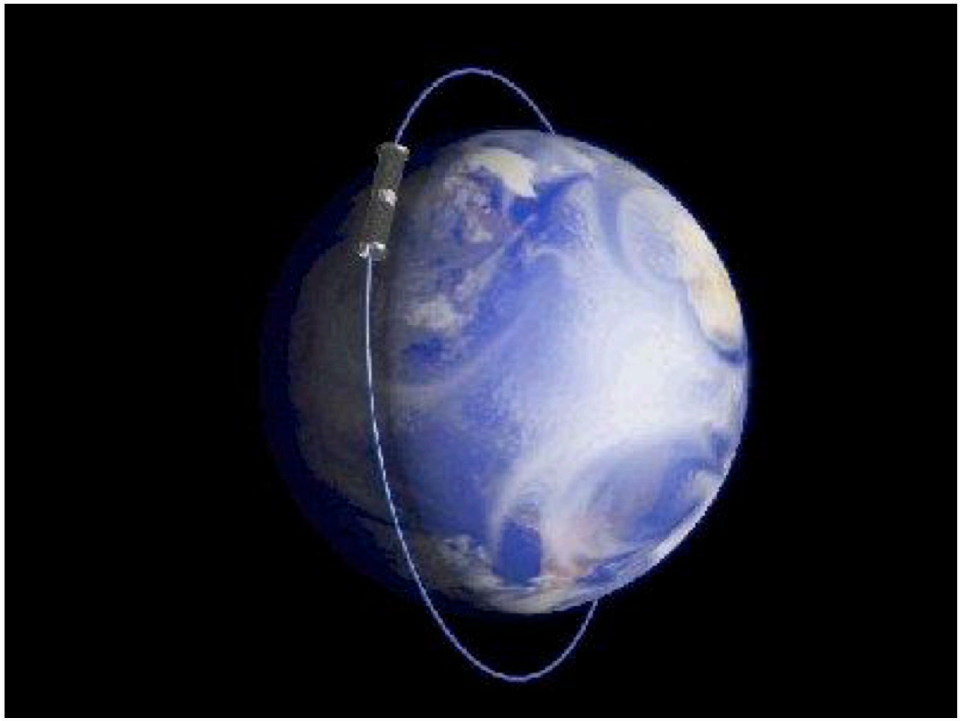


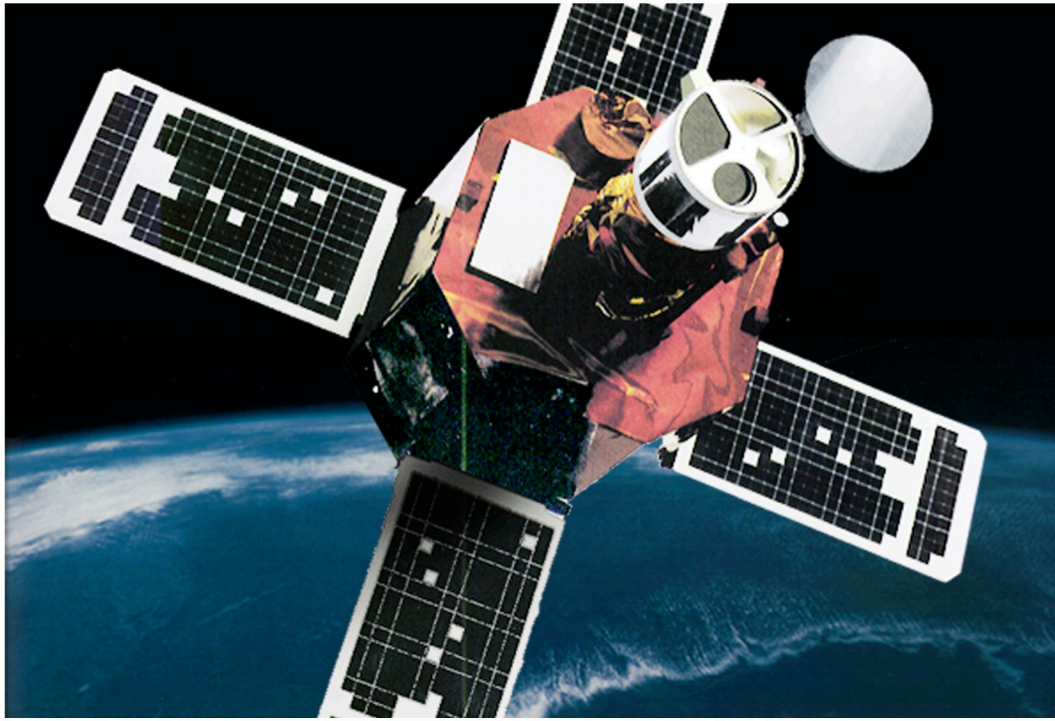
The image shows the corona enveloping a moderately active Sun, with some (red) hot active regions in both hemispheres, surrounded by the (blue/green) cooler gases of the quiet-Sun corona. It shows the corona on August 2, 1999, in a false-color, 3-layer composite for the 171Å, 195Å, and 284Å filters. TRACE's field of view covers only a fraction of the entire Sun, but by repeatedly repointing, it can view the entire solar corona.



A three-channel image of a very inactive corona with the sunspot cycle near its minimum on 2007/09/15: the 171Å channel (most sensitive to emission from 1 million degree gases) in blue, the 195Å channel (1.5 MK) in green, and (hardly visible for this inactive Sun) the 284Å (2 MK) in red. Most of the solar surface is covered with compact ephemeral regions, and a few coronal holes. Little material at 2 million degrees or above is present; hence the 'cool' blue-green look.







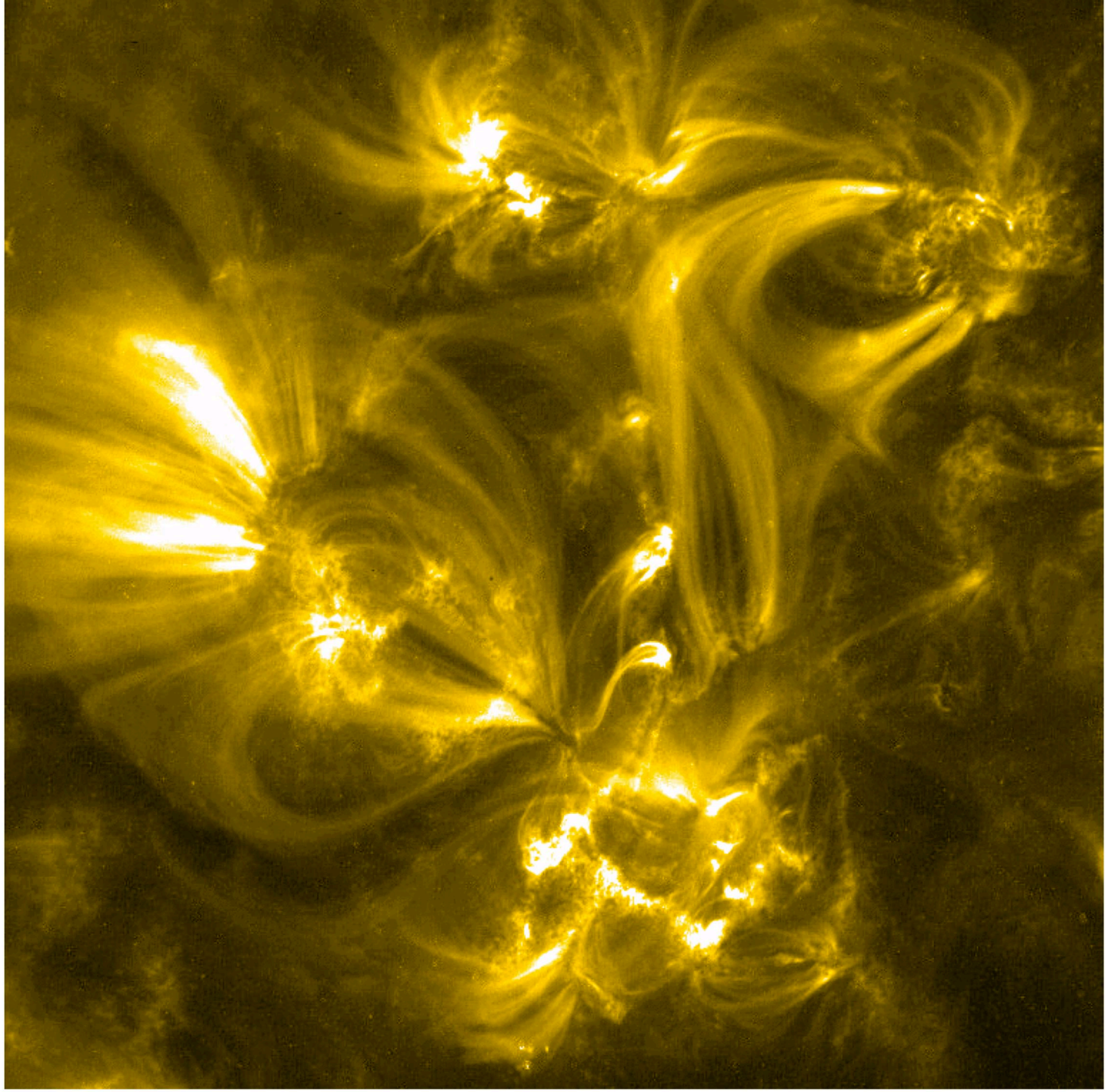
TRACE was launched with a Pegasus rocket into a low Earth orbit that carries it from pole to pole, allowing it uninterrupted viewing of the Sun for months on end.

TRACE

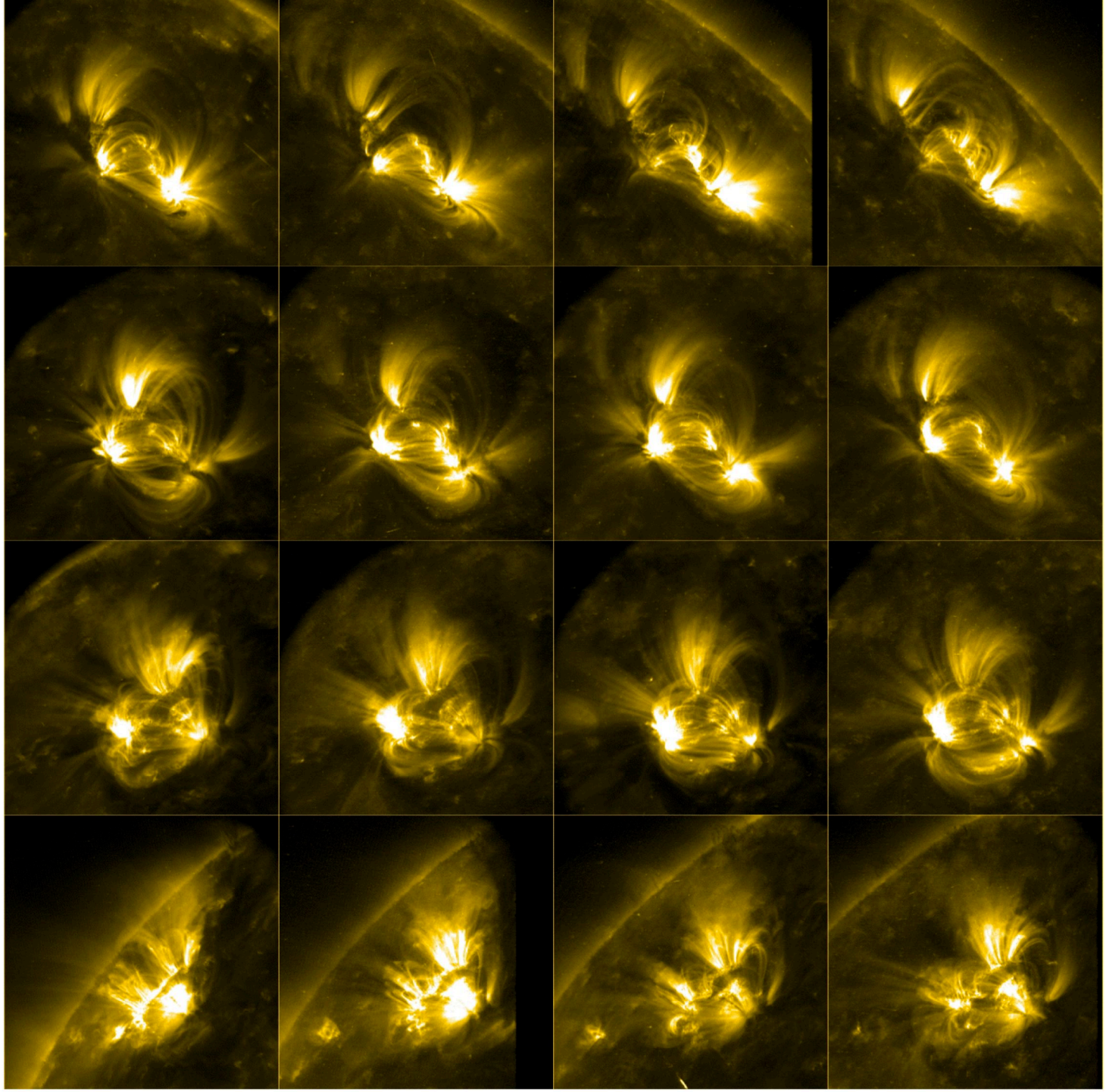
The Transition Region and Coronal Explorer is a NASA Small Explorer (SMEX) mission that images the solar corona and transition region at high angular and temporal resolution. The goal of the TRACE science investigation is to deepen our understanding of the effects of the Sun's magnetic field on its own atmosphere, and to help us understand the changes that this causes in the heliosphere between Sun and Earth, and in the space around Earth, including Earth's atmosphere.

TRACE offers unparalleled views of the fine structure of the solar corona. In the millions of images taken with TRACE we see a solar atmosphere that is extremely dynamic even during times of quiescence, and that is pervaded by flows and wave phenomena, in which thin strands - called coronal loops - evolve rapidly in temperature, density, and even shape.

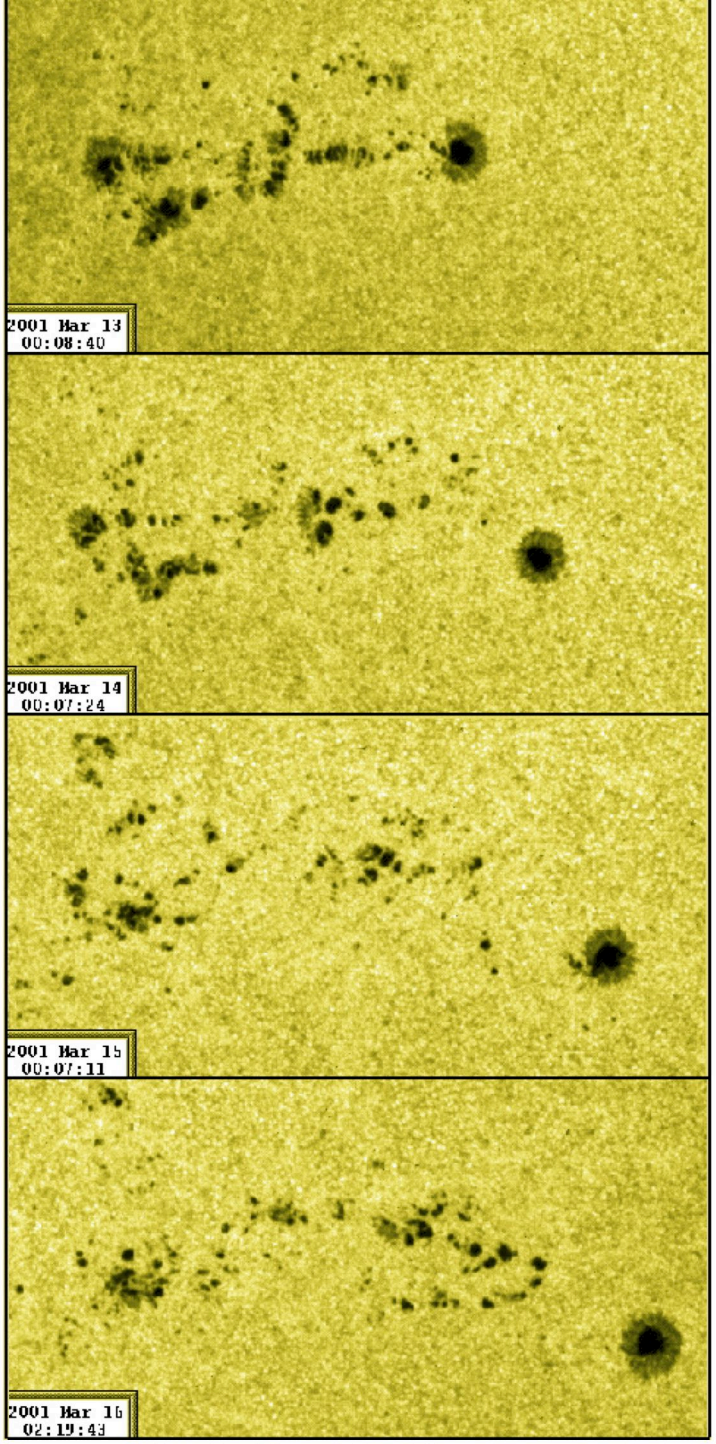
The TRACE home page at http://trace.lmsal.com/ provides access to all images through the data archive. It has many more examples of images like those in this book with descriptions of what makes them interesting, movies to show the dynamic corona, and - among many other things - listings of special events that were observed, a summary of the hundreds of scientific publications based on TRACE observations, and mission and instrument details.

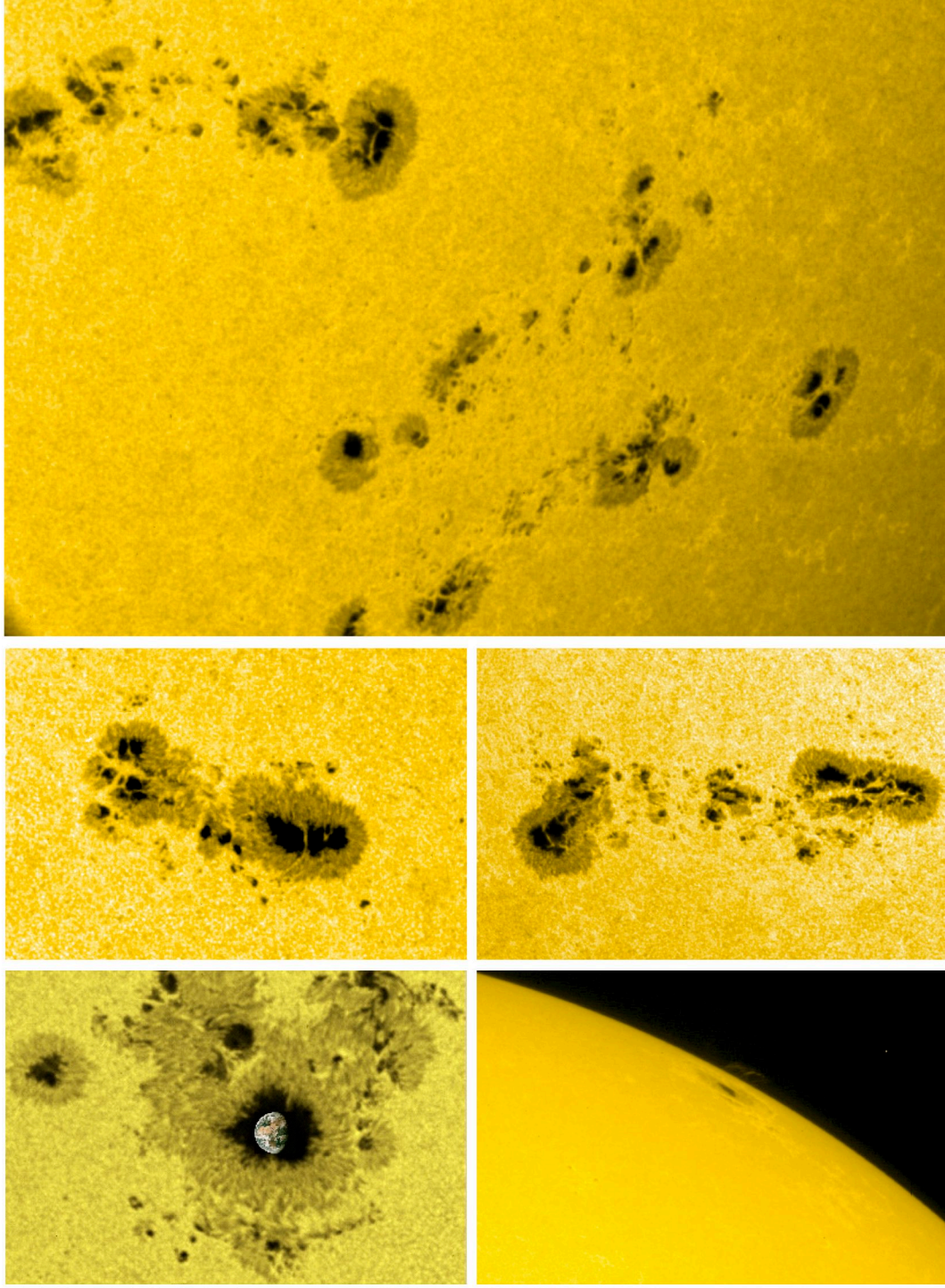


An example of the solar corona seen in the extreme ultraviolet, with hot glowing gases shaped by magnetic field. The smallest details in the TRACE images are about 500 miles in size.

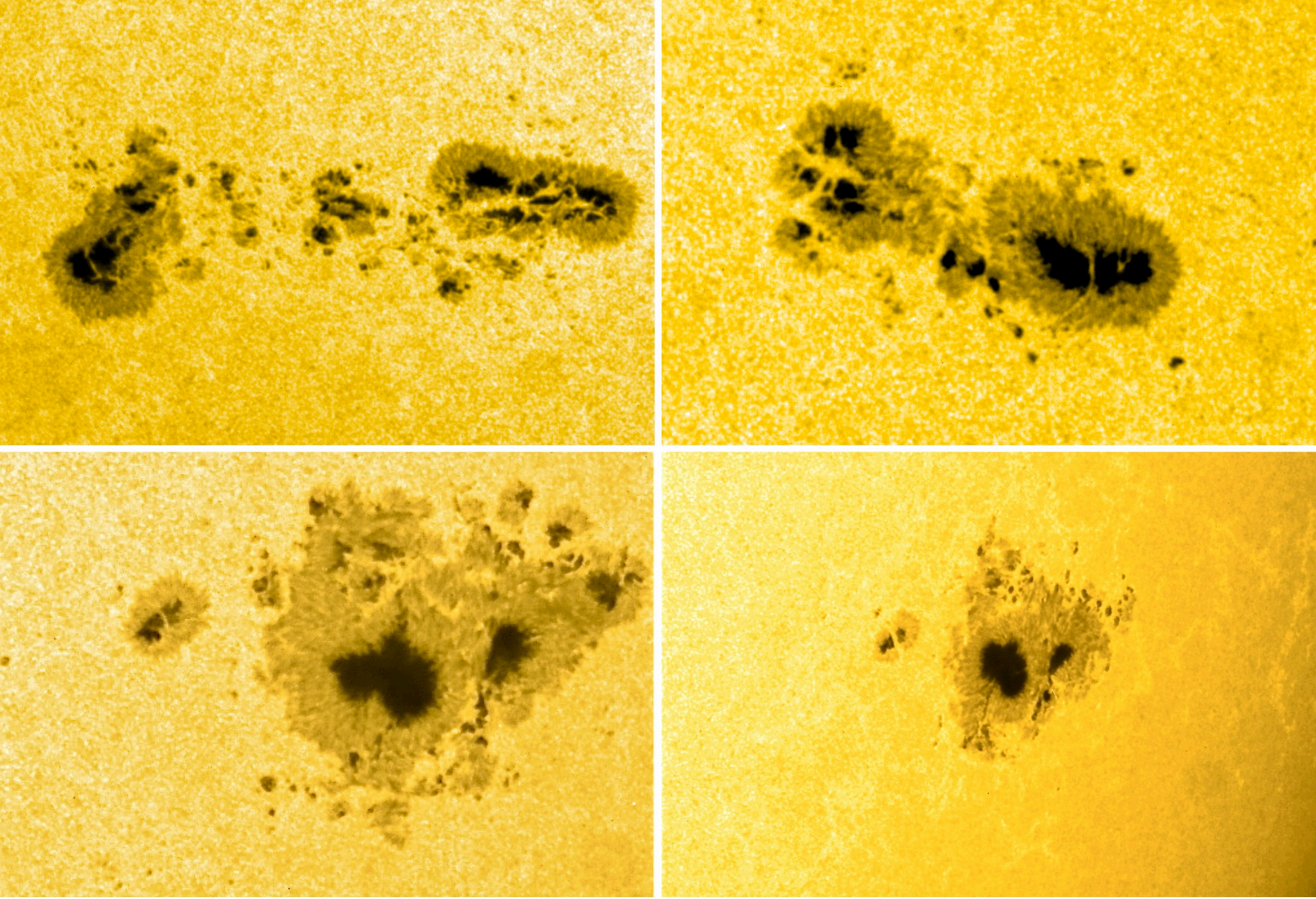


TRACE's uninterrupted solar viewing enables continuous observations in order to follow the two-week disk passage of solar active regions as the Sun rotates approximately once every 25 days.

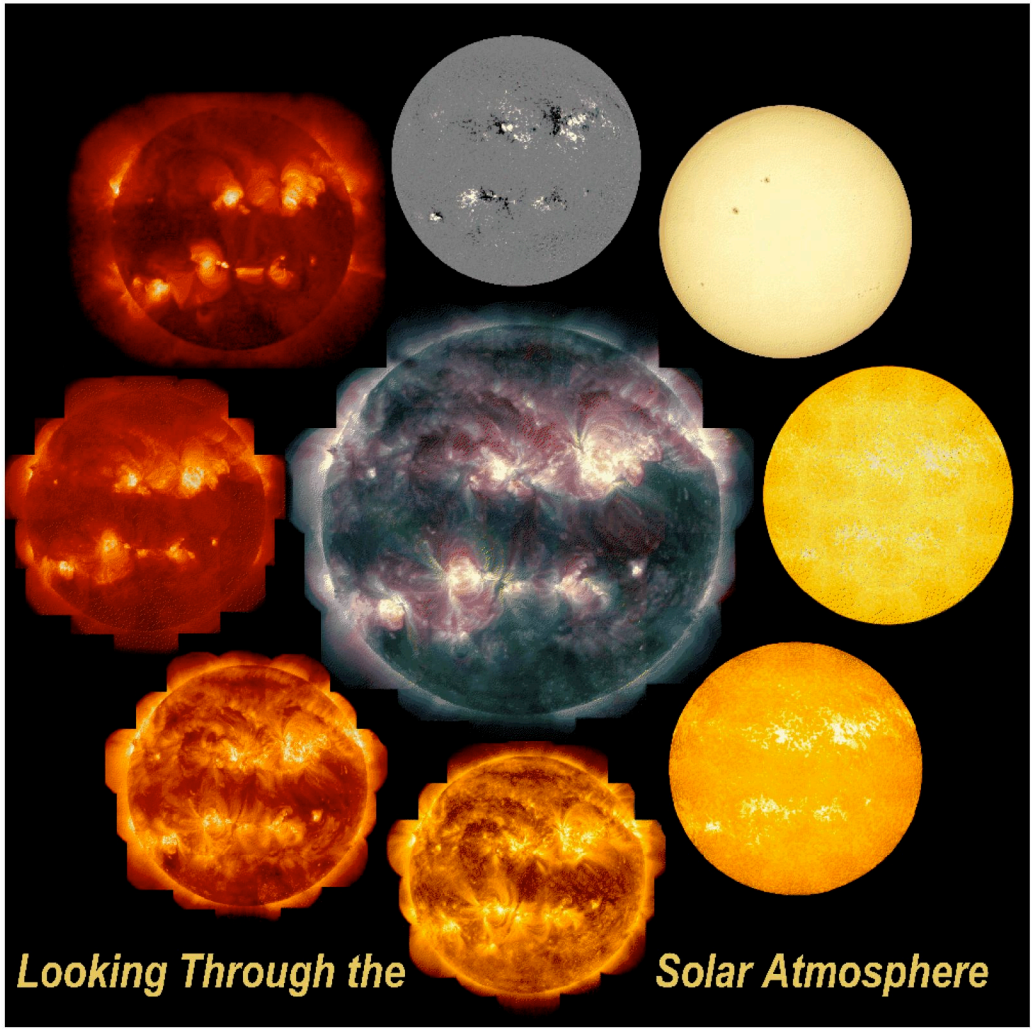


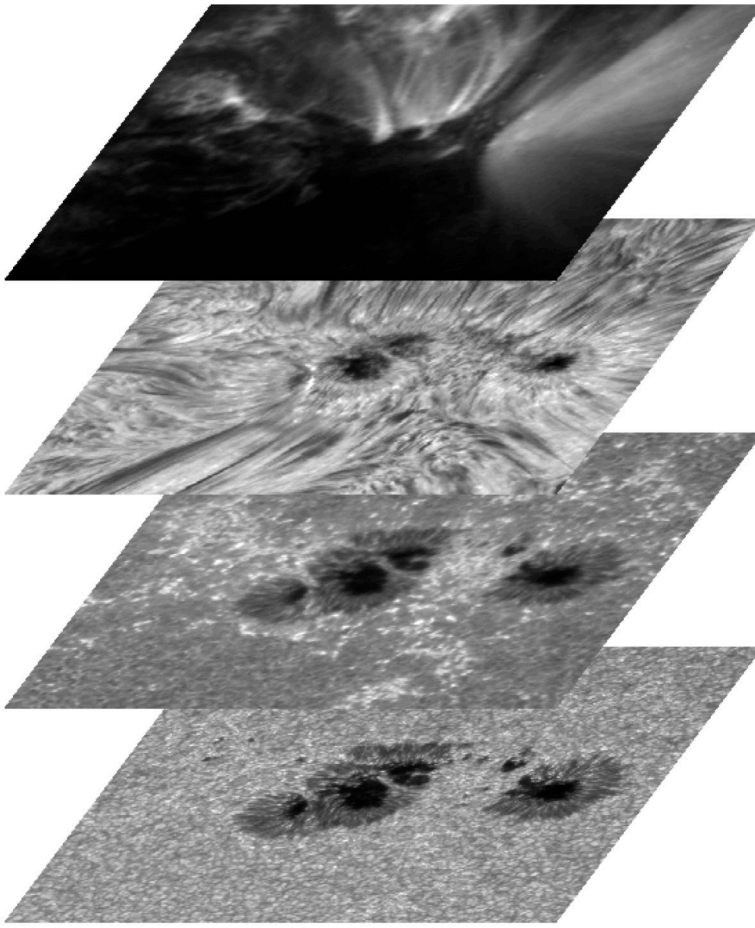


Sunspots come in many sizes and often cluster with others and with their smaller counterparts, the pores. Some are large enough to easily contain the Earth.

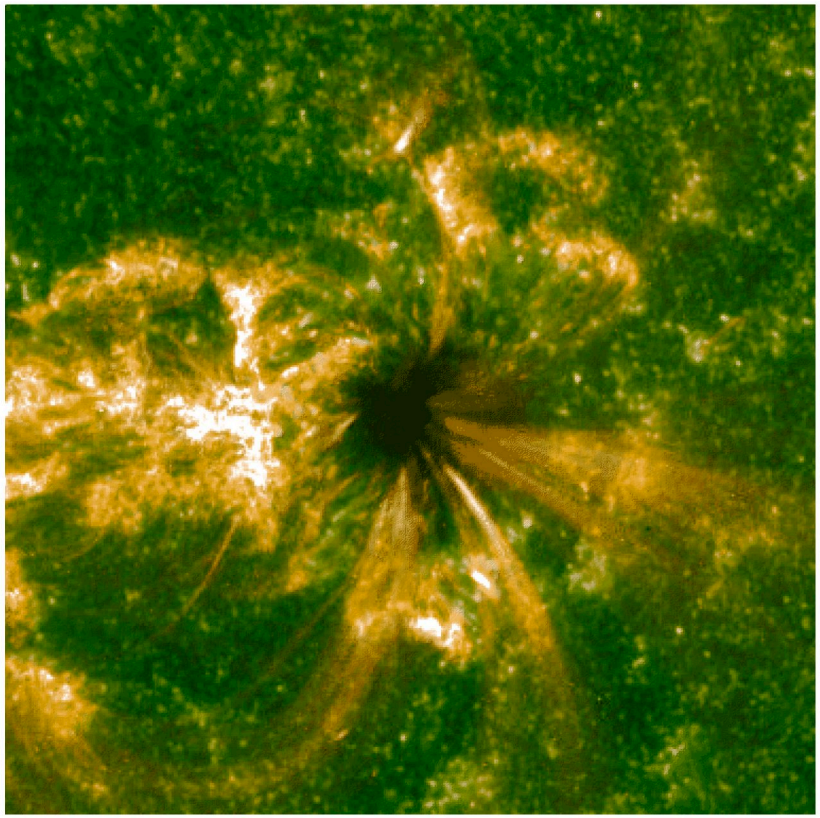


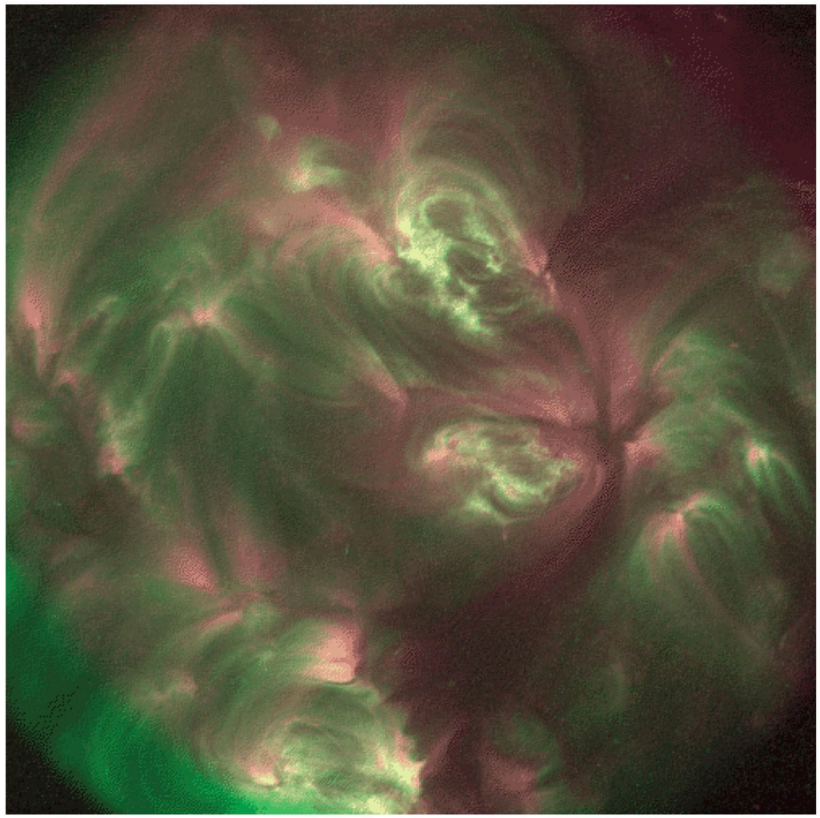
Much of the magnetic field of solar active regions threads the surface contained in sunspots and pores, but much of it is hard to see as it clusters in much smaller bundles. All together, they form the foundation of the magnetically shaped corona above it.



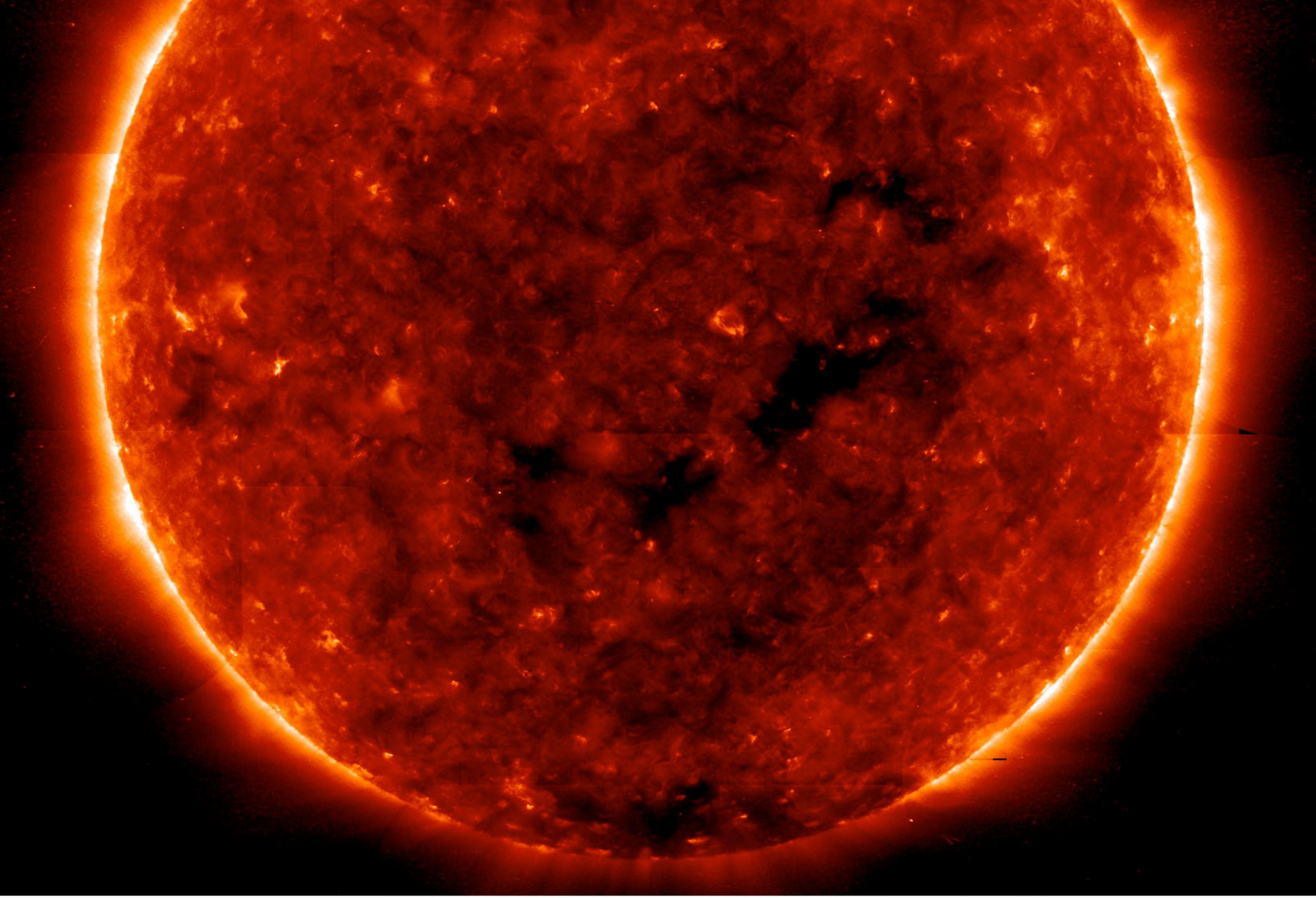


TRACE's visible, UV, and extreme-UV filters complement observations by other instruments, both in space and on Earth, to provide a complete picture of the solar atmosphere, from its magnetic field at the surface (shown at the top in the left image) and sunspots (in the bottom panel of the right) to the hottest parts of the corona.

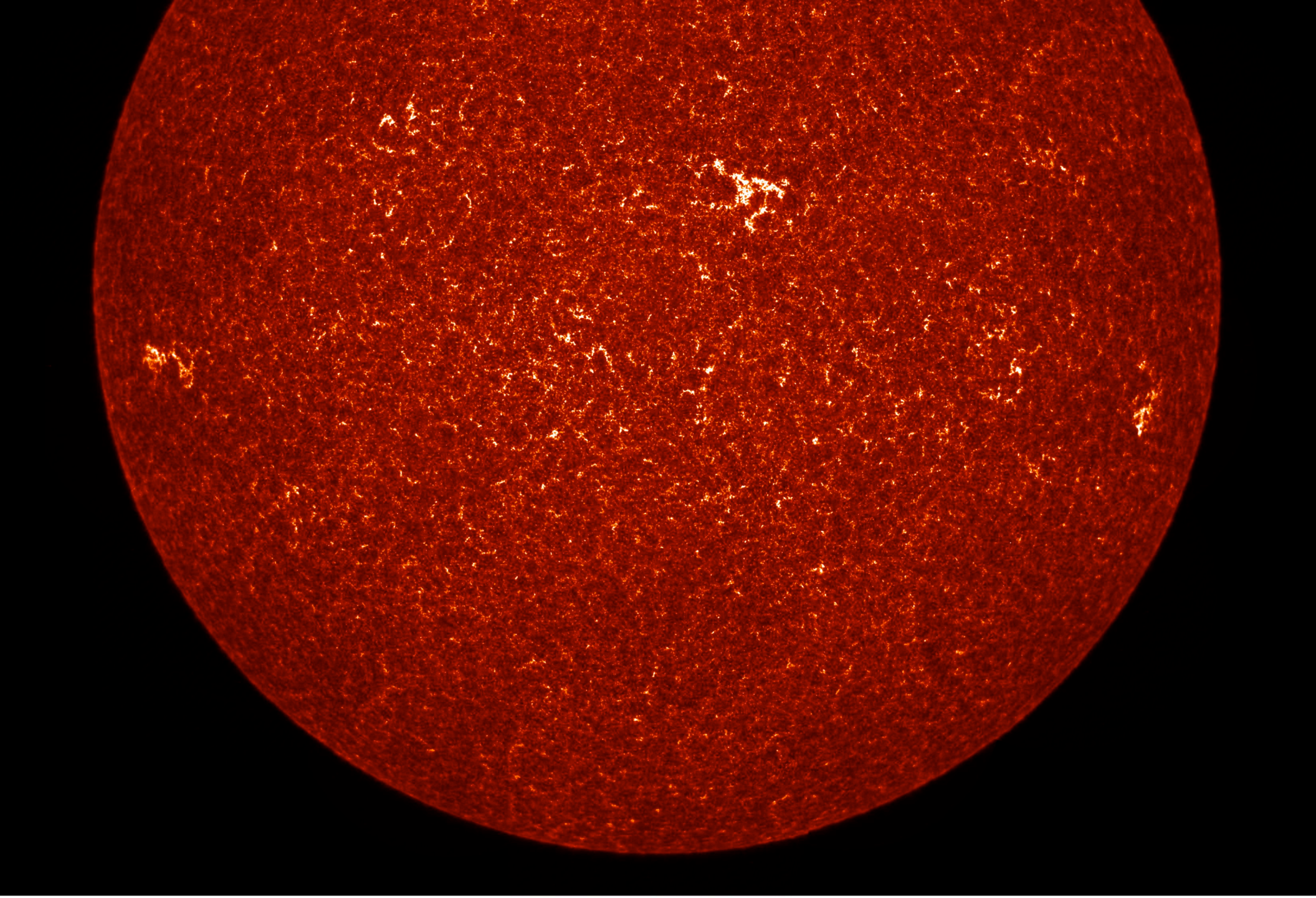




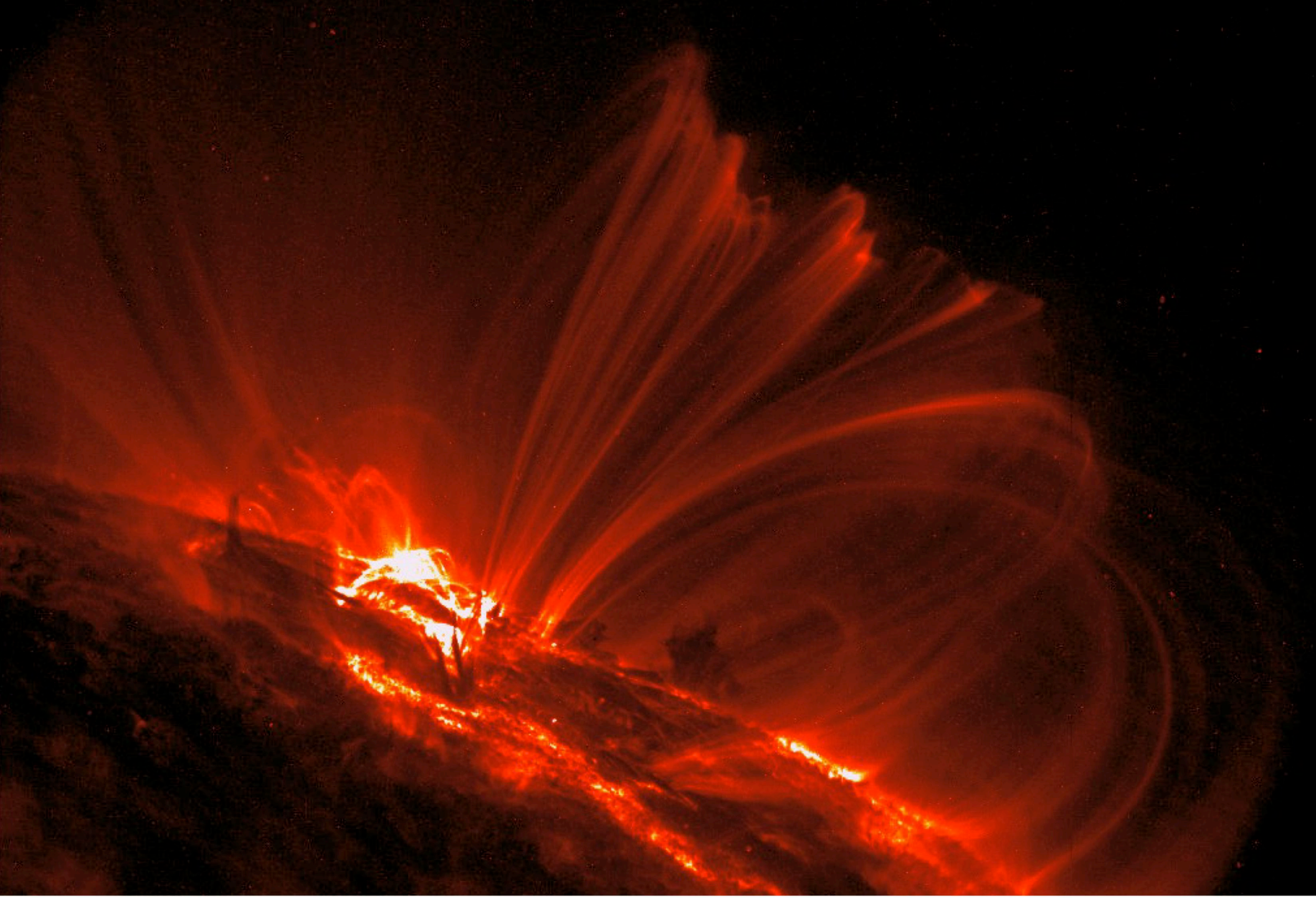
TRACE's different filter combinations reveal different parts of the solar atmosphere from the near-surface layers to loop fans at millions of degrees (left), and reveal that the hot corona has very different temperatures in different regions so that composite images are needed for a comprehensive picture (right).



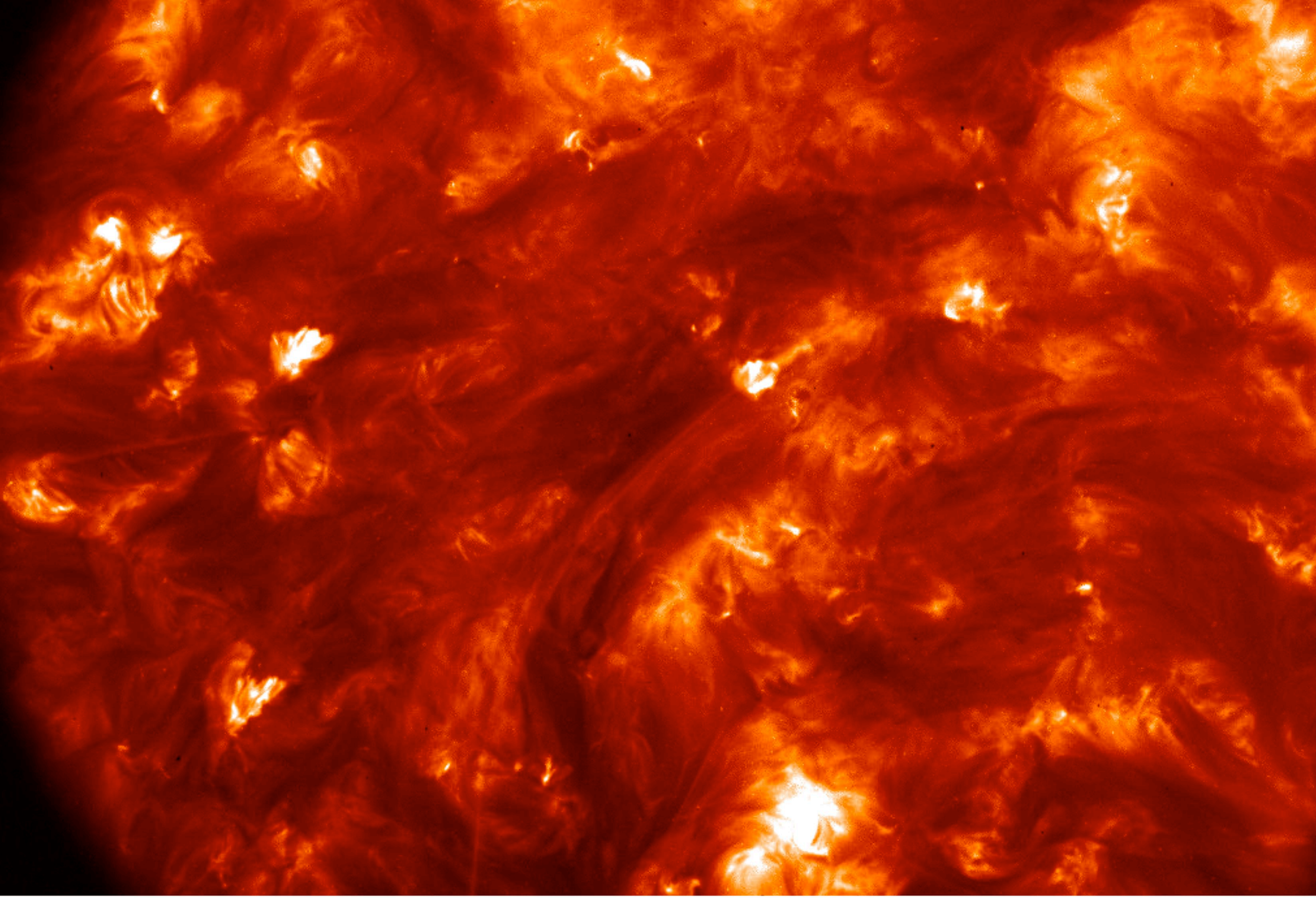
A relatively quiet solar corona observed by TRACE on May 5, 2009, by combining dozens of individual fields of view into a full-Sun composite.



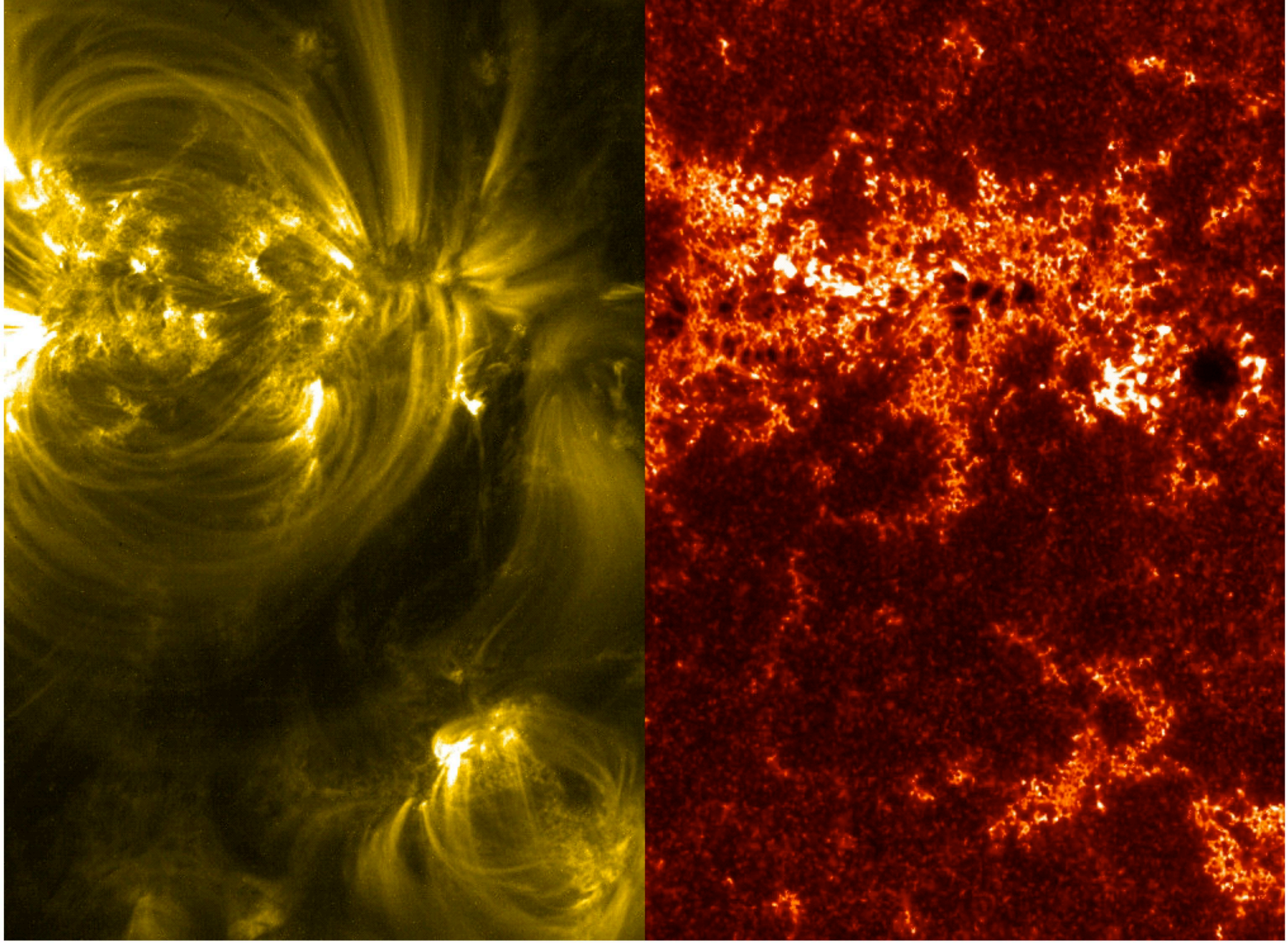
A relatively quiet solar 'transition region' that lies between the surface and the extended, hot corona, observed in the ultraviolet by TRACE on May 22, 2008, by combining images of dozens of regions into a full-Sun composite.



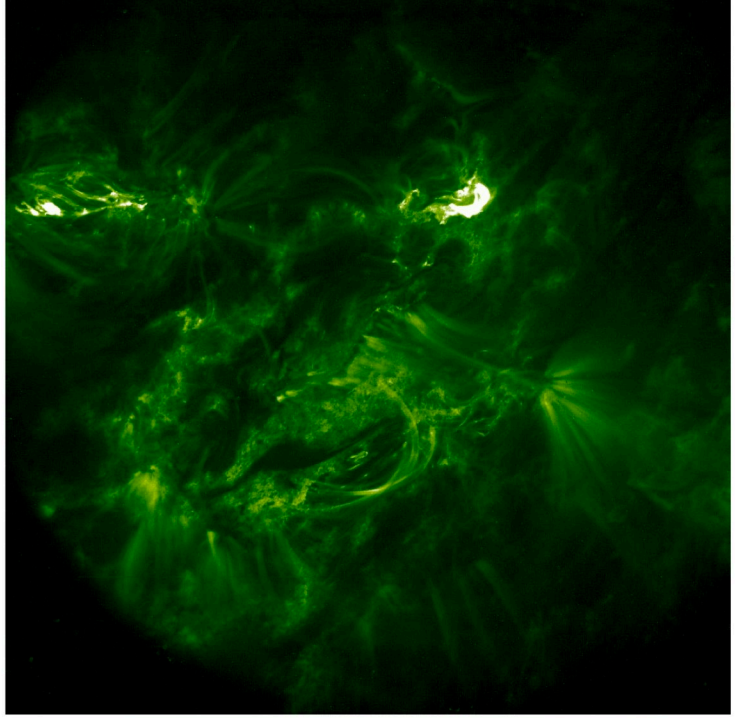
The Sun's magnetic field shapes the hot gases in the solar corona into loops and arches, clearly seen against the dark sky in this image of the edge of the Sun.

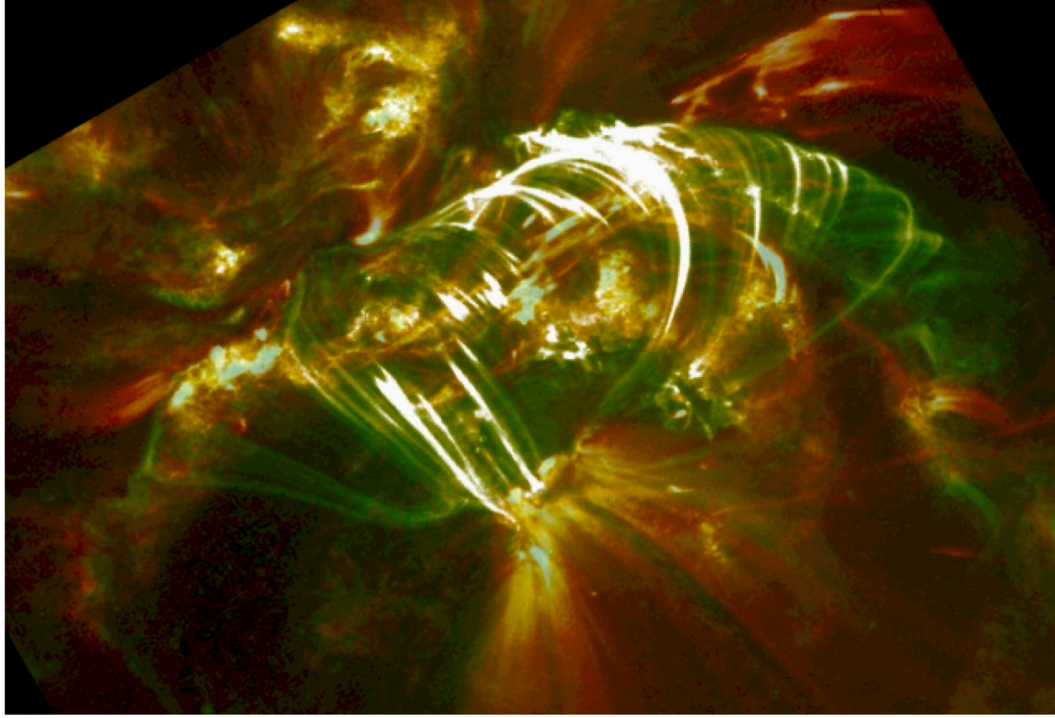


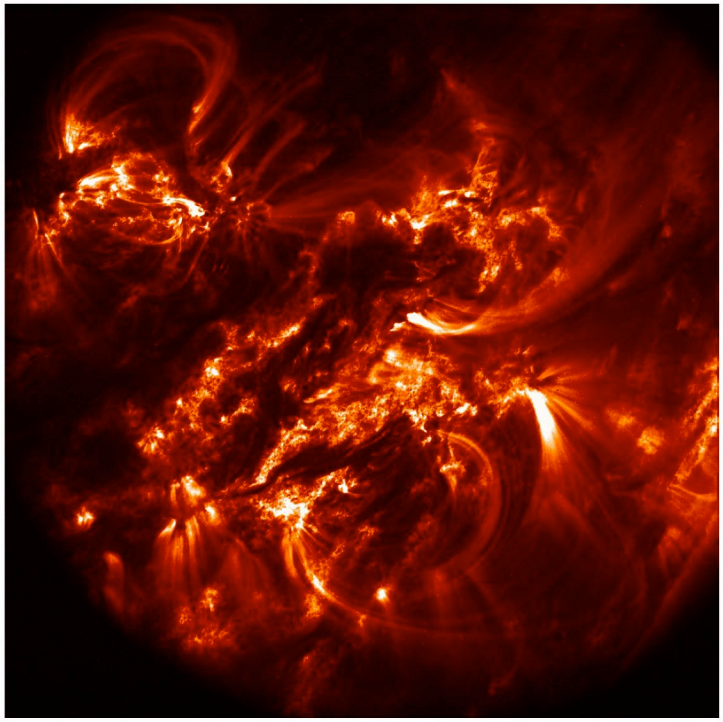
The regions in the corona outside the large active regions are not nearly as bright, but finely structured here too, with a multitude of connections between the many small ephemeral magnetic regions that dot the solar surface.

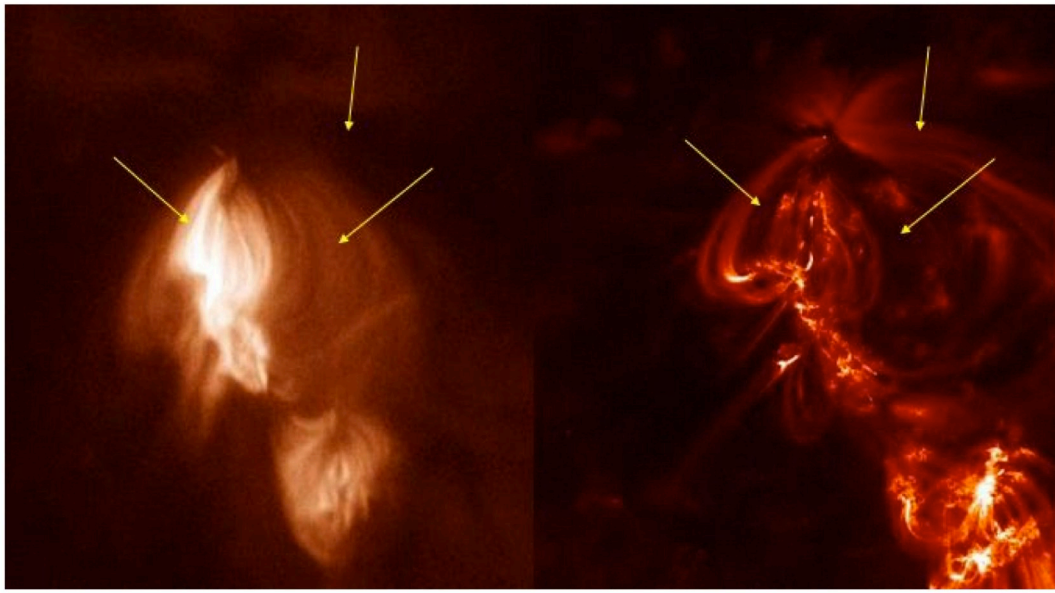


The hot million-degree coronal loops (left) reflect the shape of the magnetic field that threads the surface, chromosphere, and transition region below. The transition region (right) glows brightly in the UV, surrounding dark sunspots and pores.

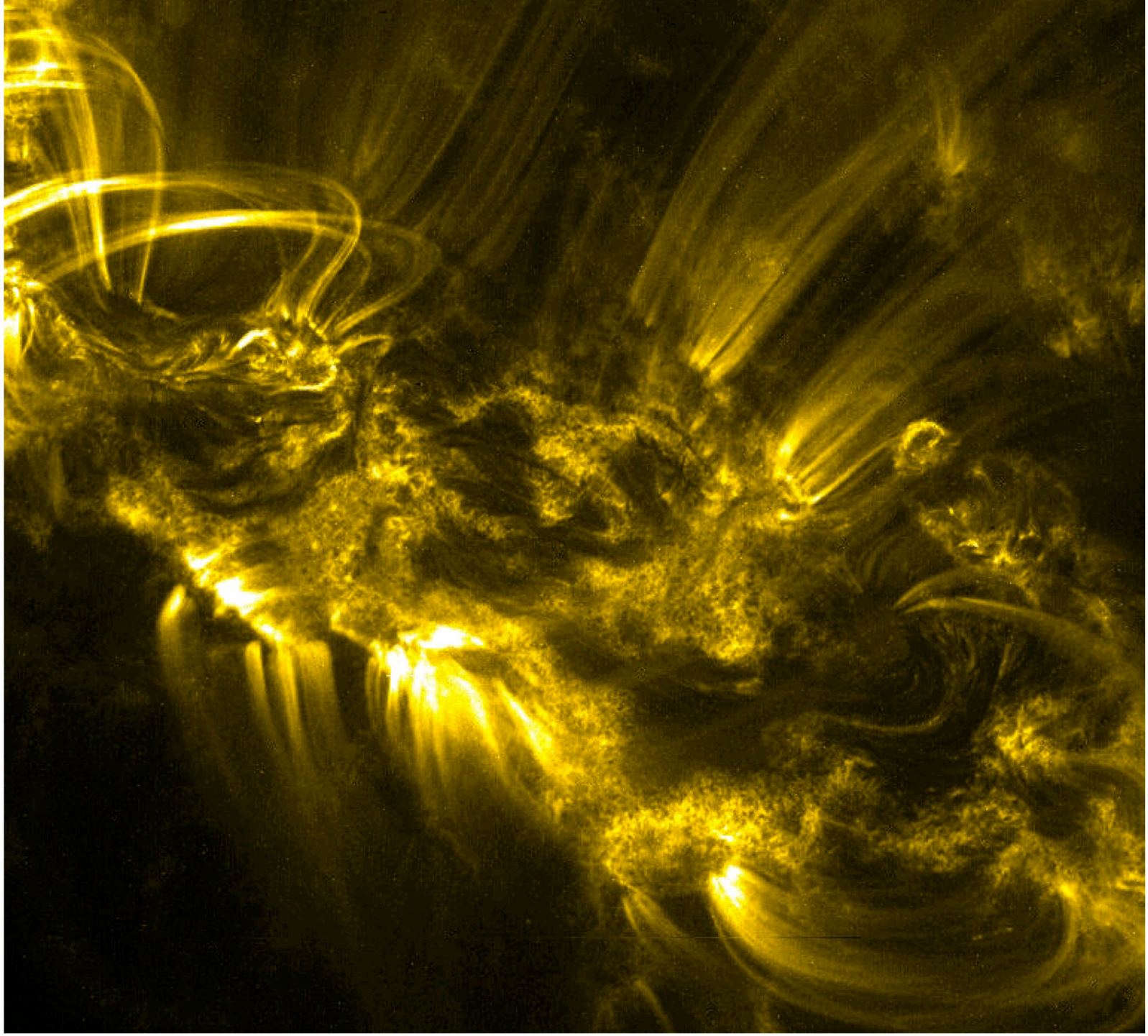




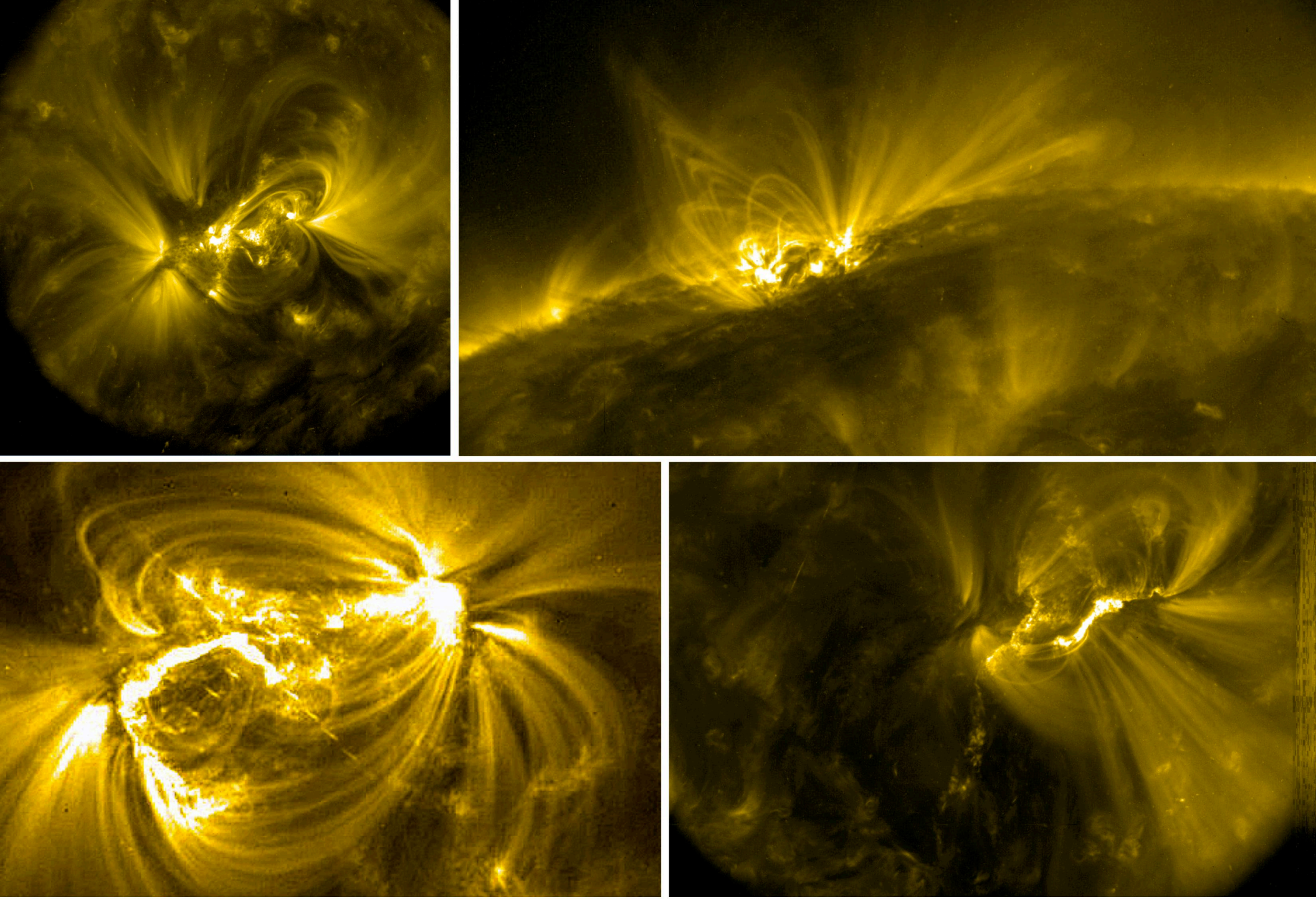




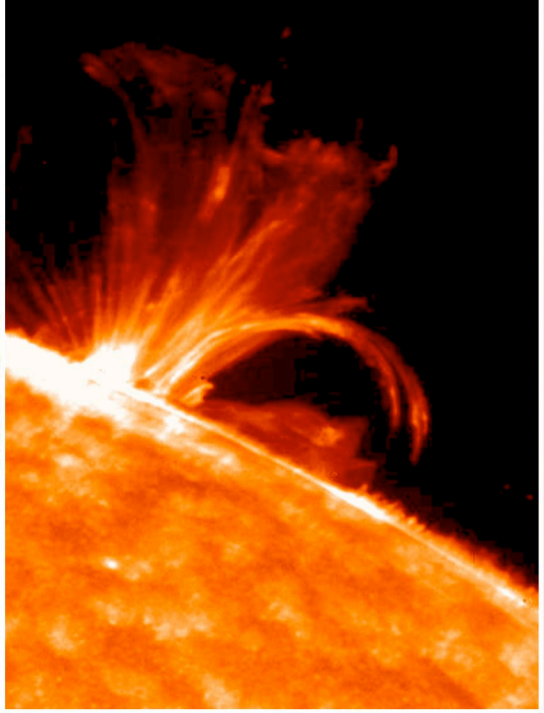
The different passbands of TRACE reveal many different structures within the same field of view (in the 171Å - bottom left - and 195Å - top left - filters, or combined in a three-color composite - top right). Comparing TRACE EUV images with X-ray images (by Hinode's XRT - bottom right) reveals even more thermal differences.

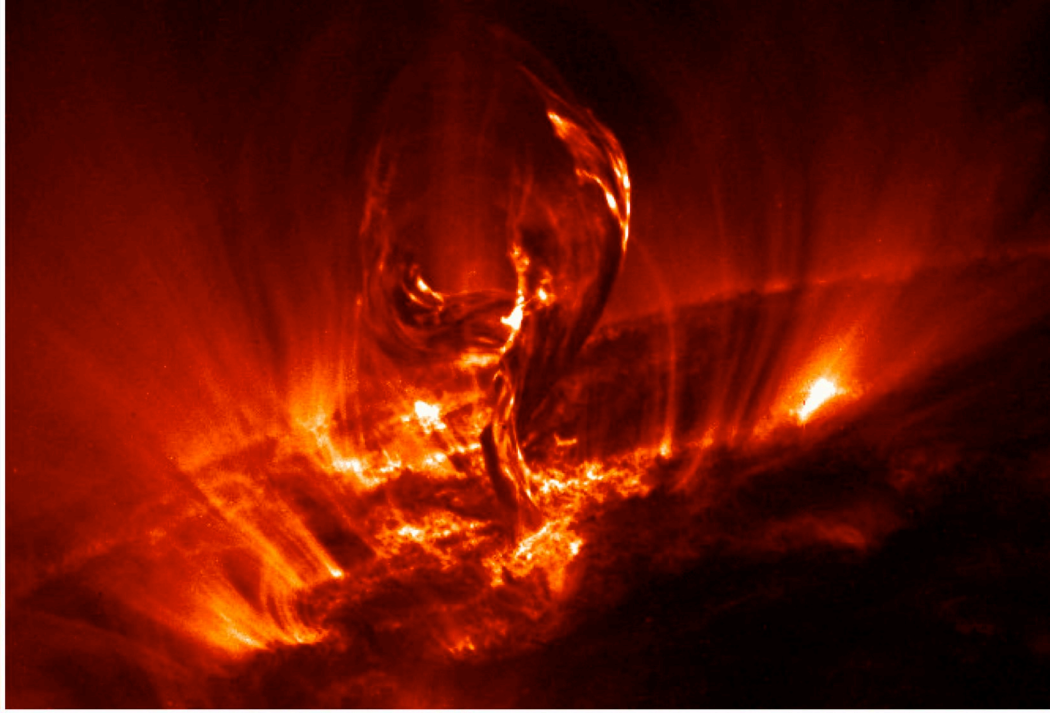


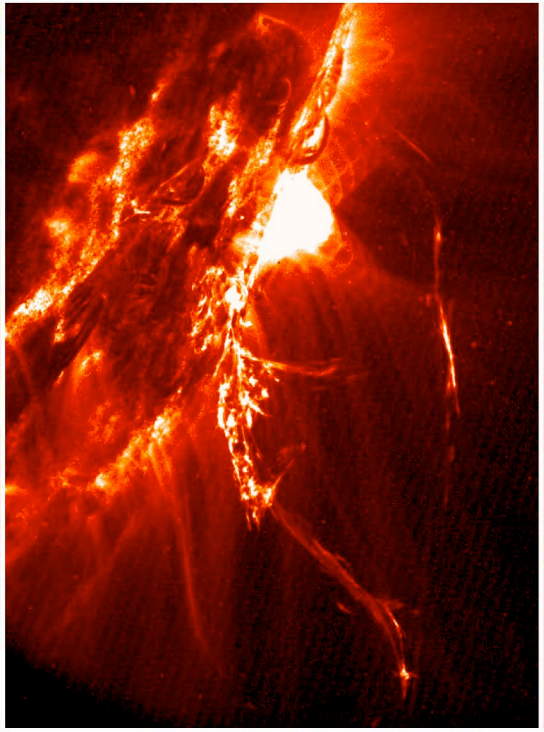
TRACE's 171Å images reveal both active region loops at a relatively low temperature of one million degrees as well as the thin 'mossy' transition region that lies at the base of even hotter loops that are invisible to TRACE.

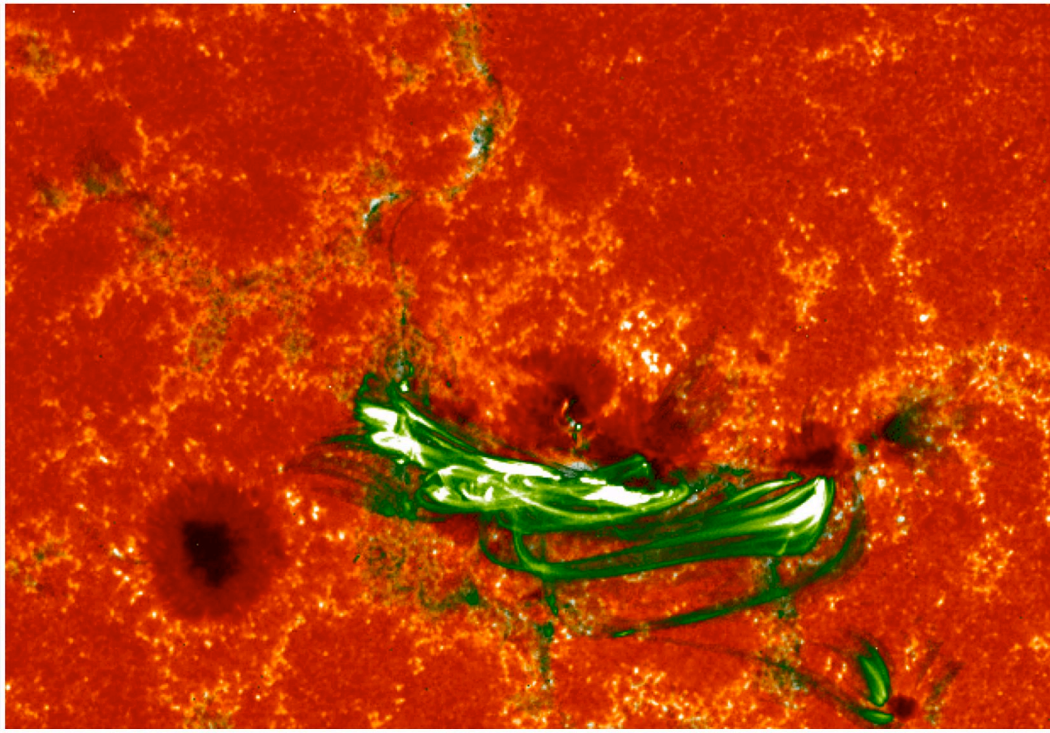


A variety of magnetic configurations over magnetically active regions.

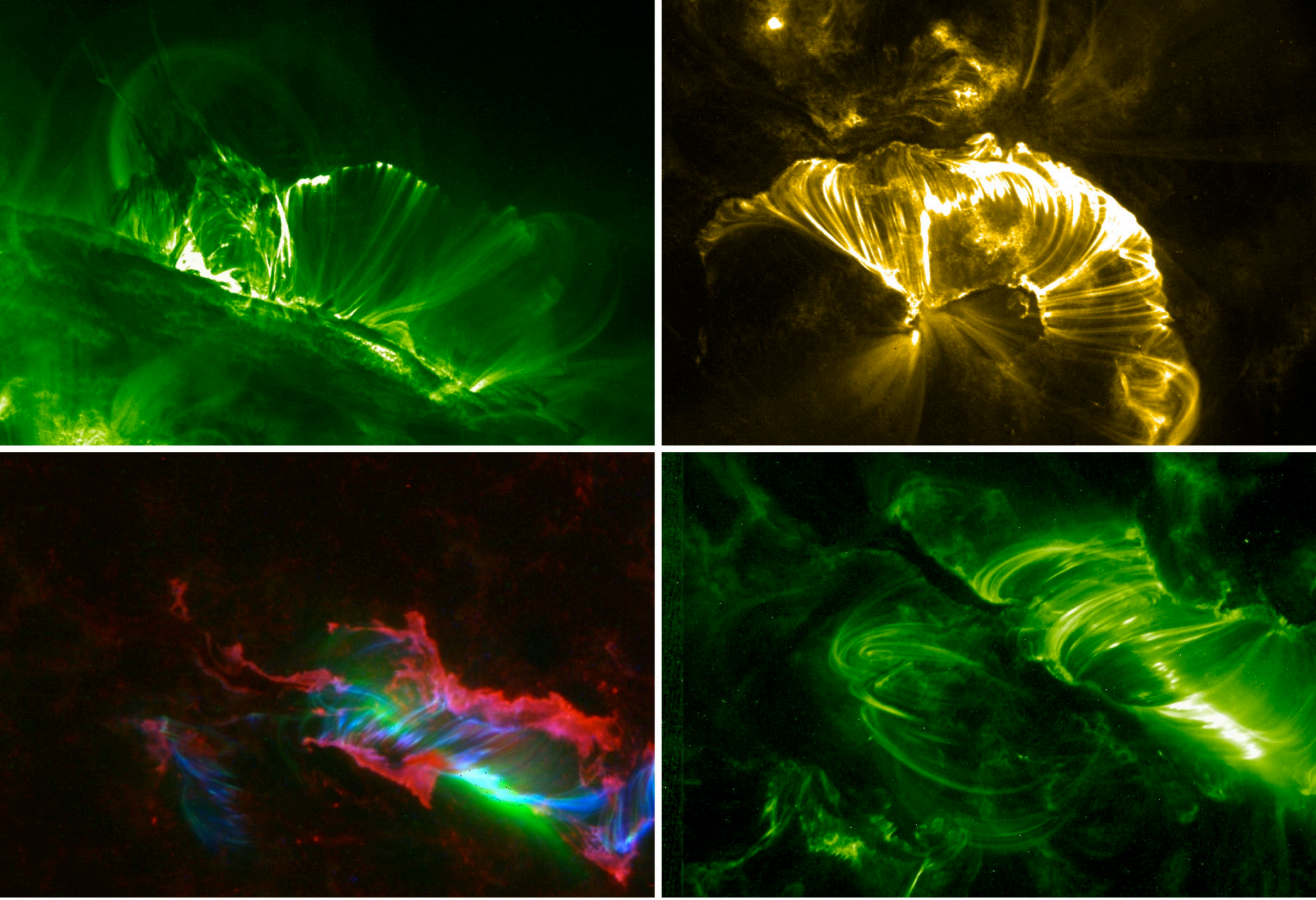




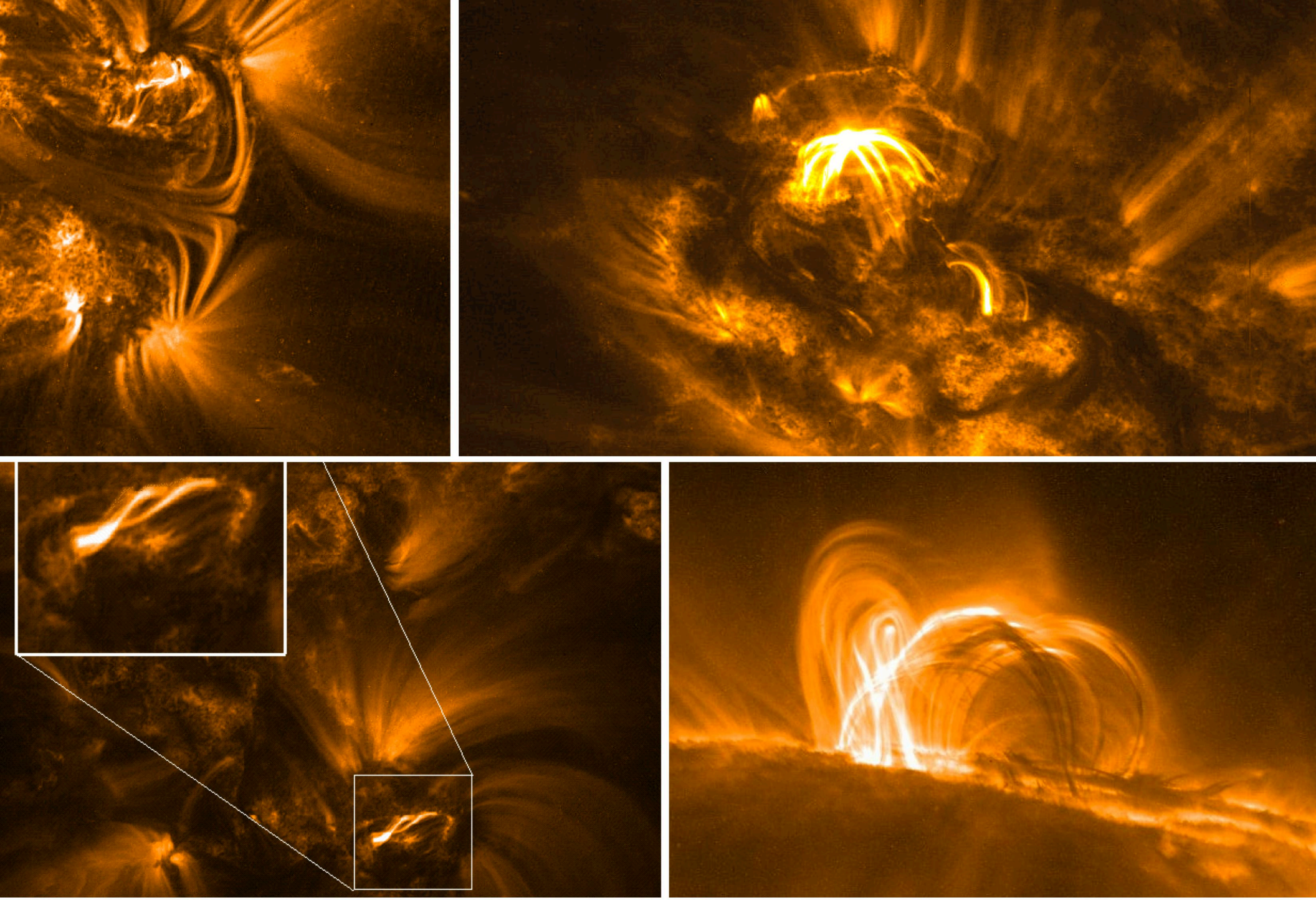




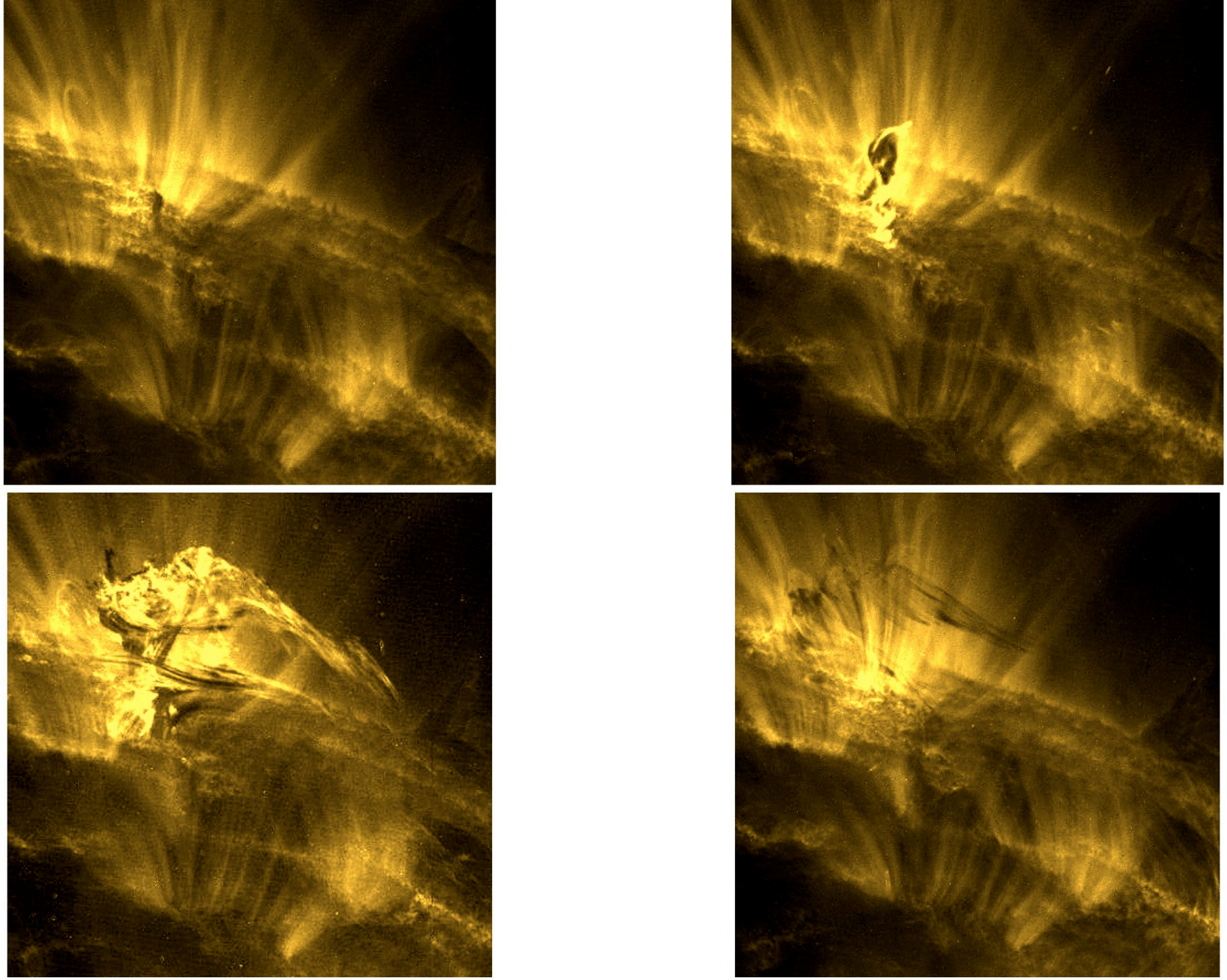
TRACE has revealed a surprising variety in solar flares and eruptions, showing the hot coronal material over the much cooler solar surface with its sunspots and surrounding bright magnetic clumps called faculae. The top-left and bottom right images show the solar surface or transition region (orange) under bright coronal flares (green).



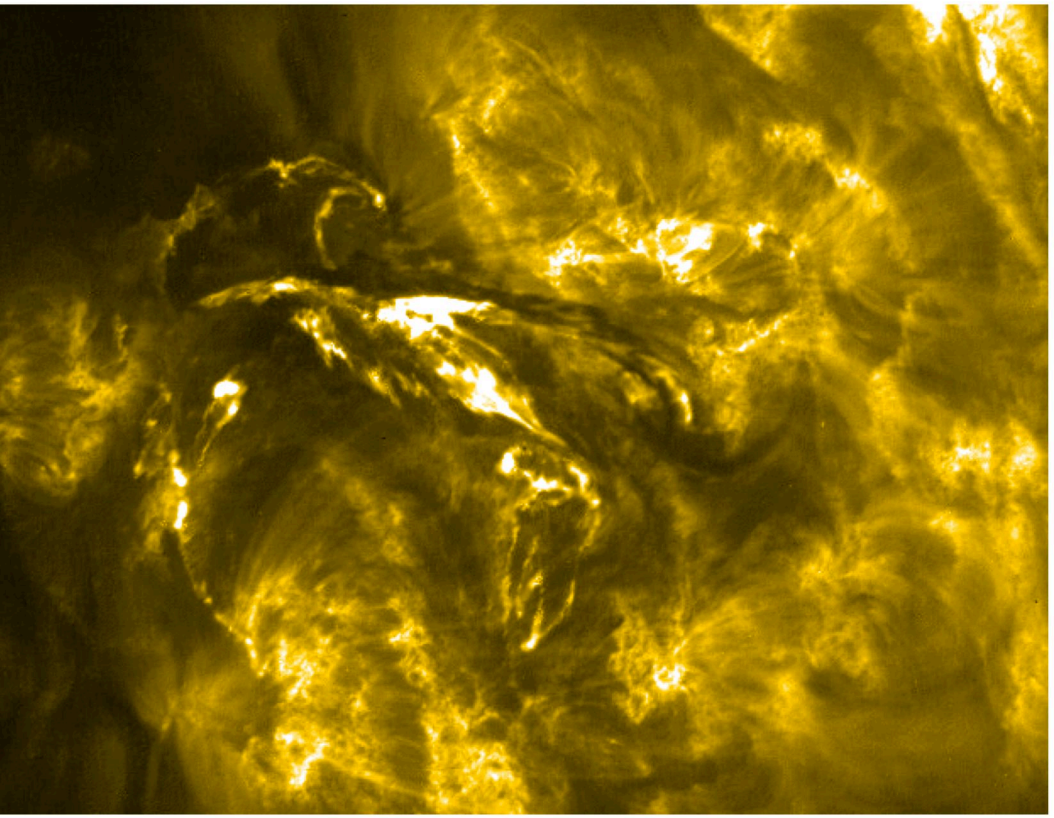
Eruptions of filaments, often parts of coronal mass ejections into interplanetary space, disrupt the magnetic field. When this field reforms, glowing arcades often persist for many hours after the early impulsive phase of flares.

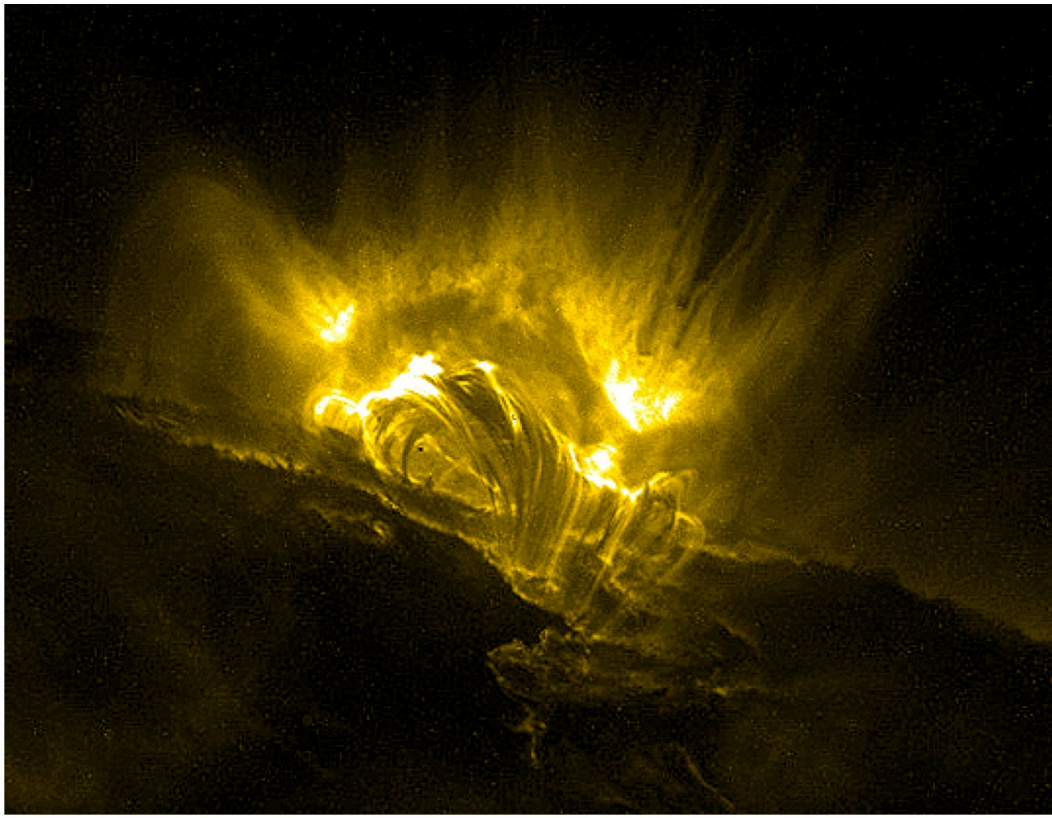


A variety of magnetic geometries: an X point (top left) and a coronal null point above a separator dome (top right), a slightly wound magnetic geometry (bottom left) and a diversely angled configuration (bottom right).

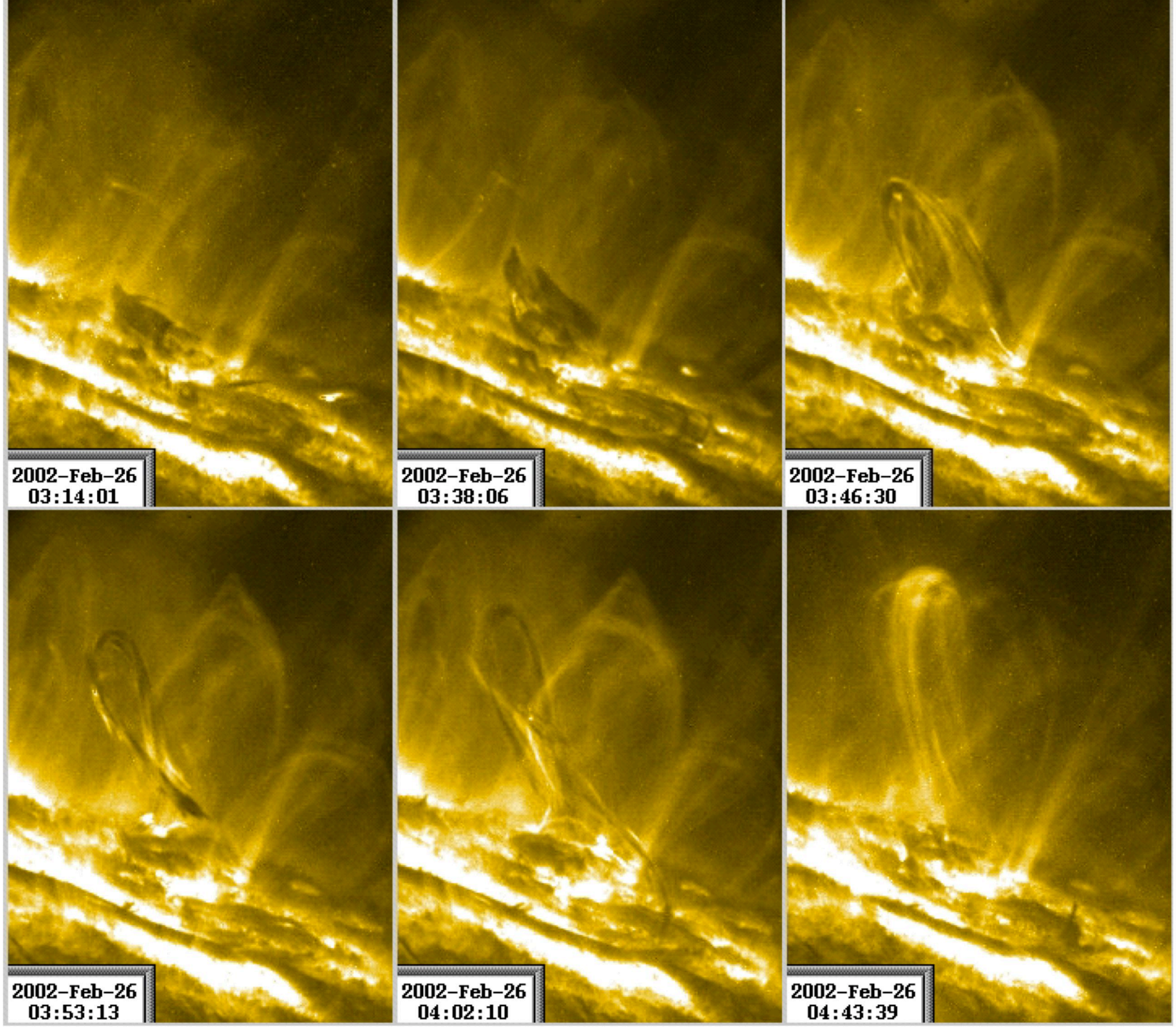


Four snapshots in the extreme ultraviolet (171Å) of an erupting filament with both hot (glowing) and cooler (dark absorbing) material thrown up into the high corona.

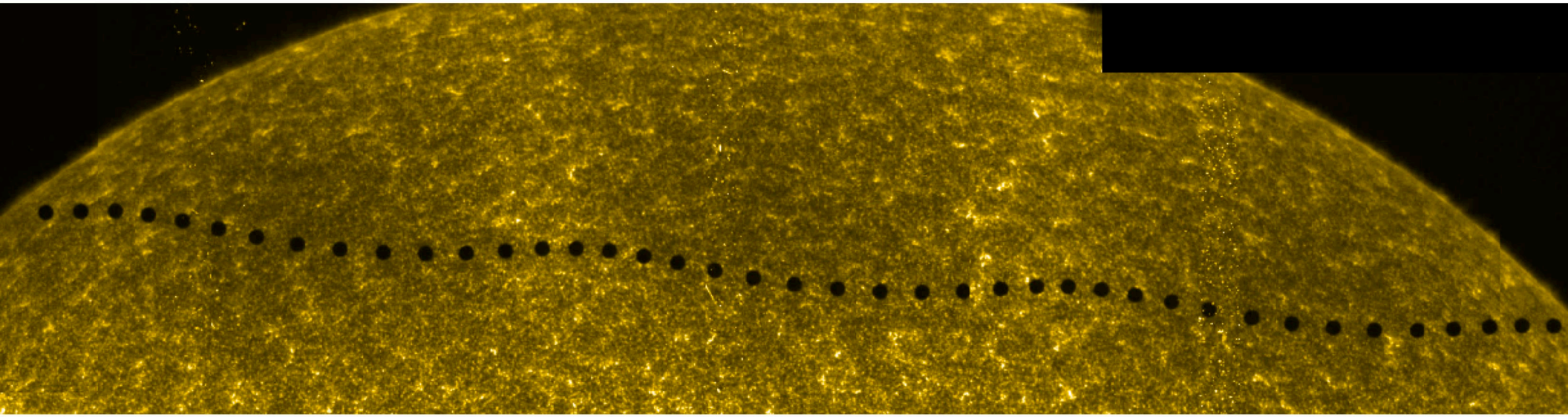


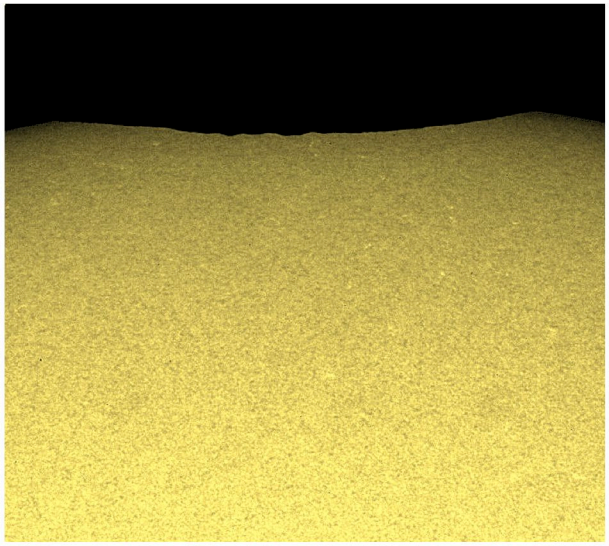


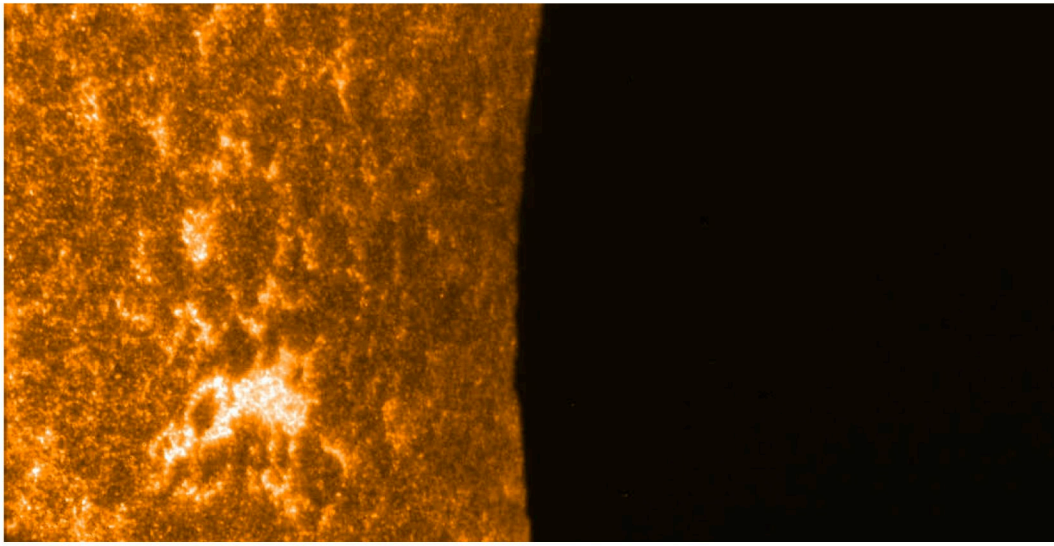
Examples of a filament eruption (left) and a disruptive flare (right; with enclosed wiggling dark structures high on the right thought to reflect the reconnection of the field after it was explosively disrupted earlier in the flare).



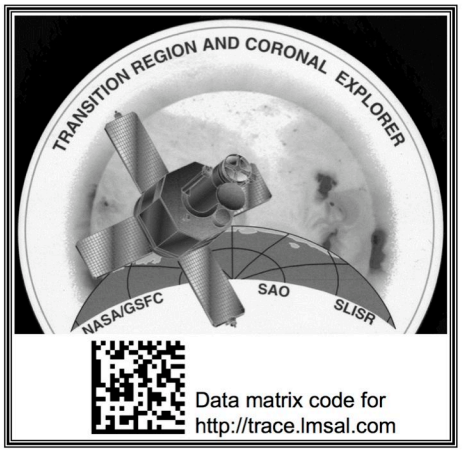
A series of TRACE extreme-UV pictures of an erupting, twisting filament. This relatively small filament reaches a height equivalent to six times the diameter of the Earth.







TRACE observed two transits of Mercury (one composite of image slices is shown at the top, with Mercury's track made to appear wobbly because TRACE orbits the Earth going from north pole to south pole and back), a Venus transit, and transits of the Moon (lower panels - see the mountains on the dark lunar edge covering the bright visible (left) and ultraviolet (right) Sun?).


TRANSITION REGION AND CORONAL EXPLORER
NASA/GSFC
SAO
SLISR
Data matrix code for
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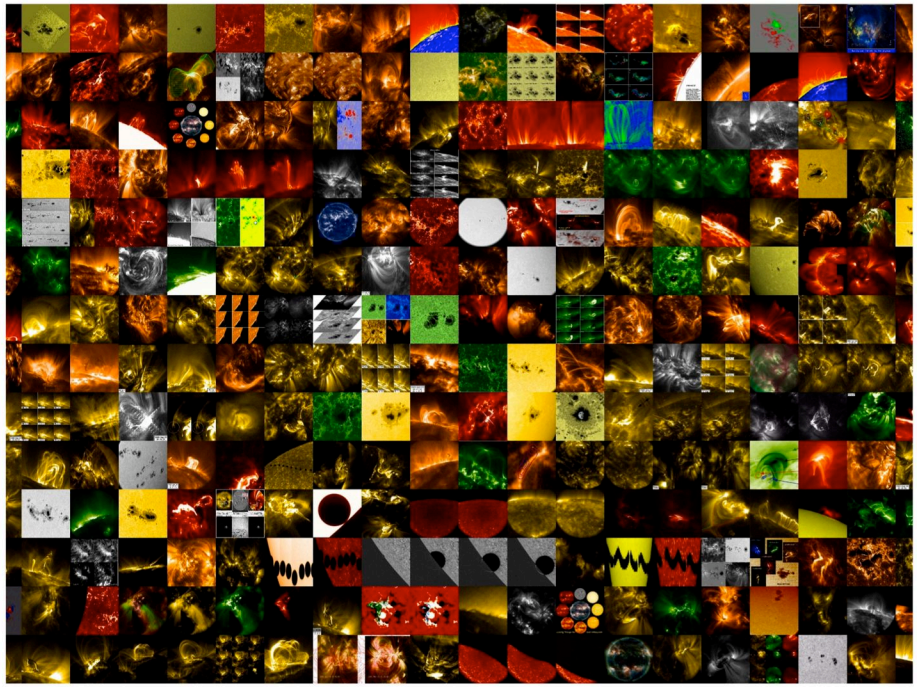

Transition Region And Coronal Explorer

http://trace.lmsal.com