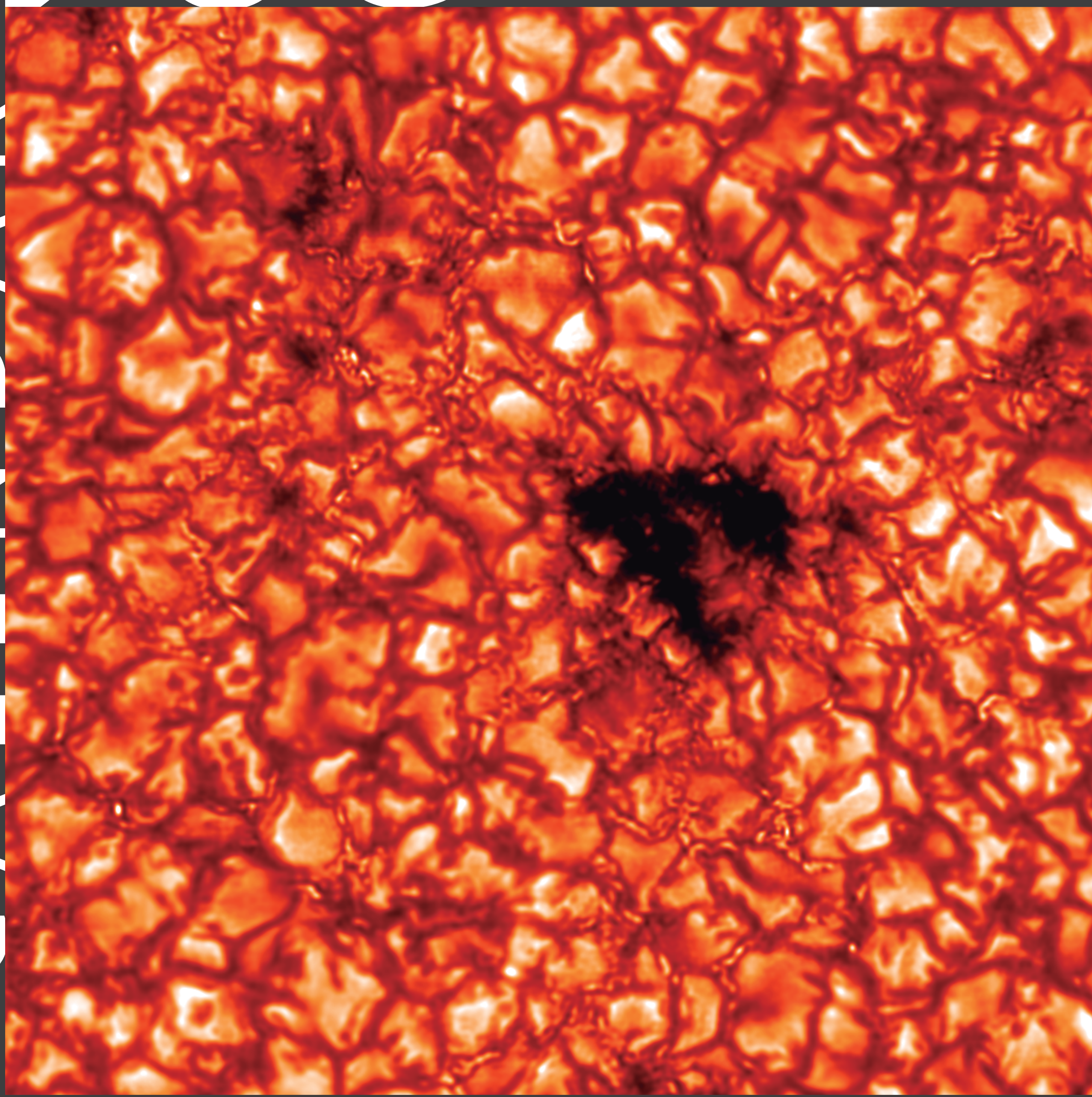
2019

CALENDAR

EST science Targets



EST european solar telescope

www.est-east.eu

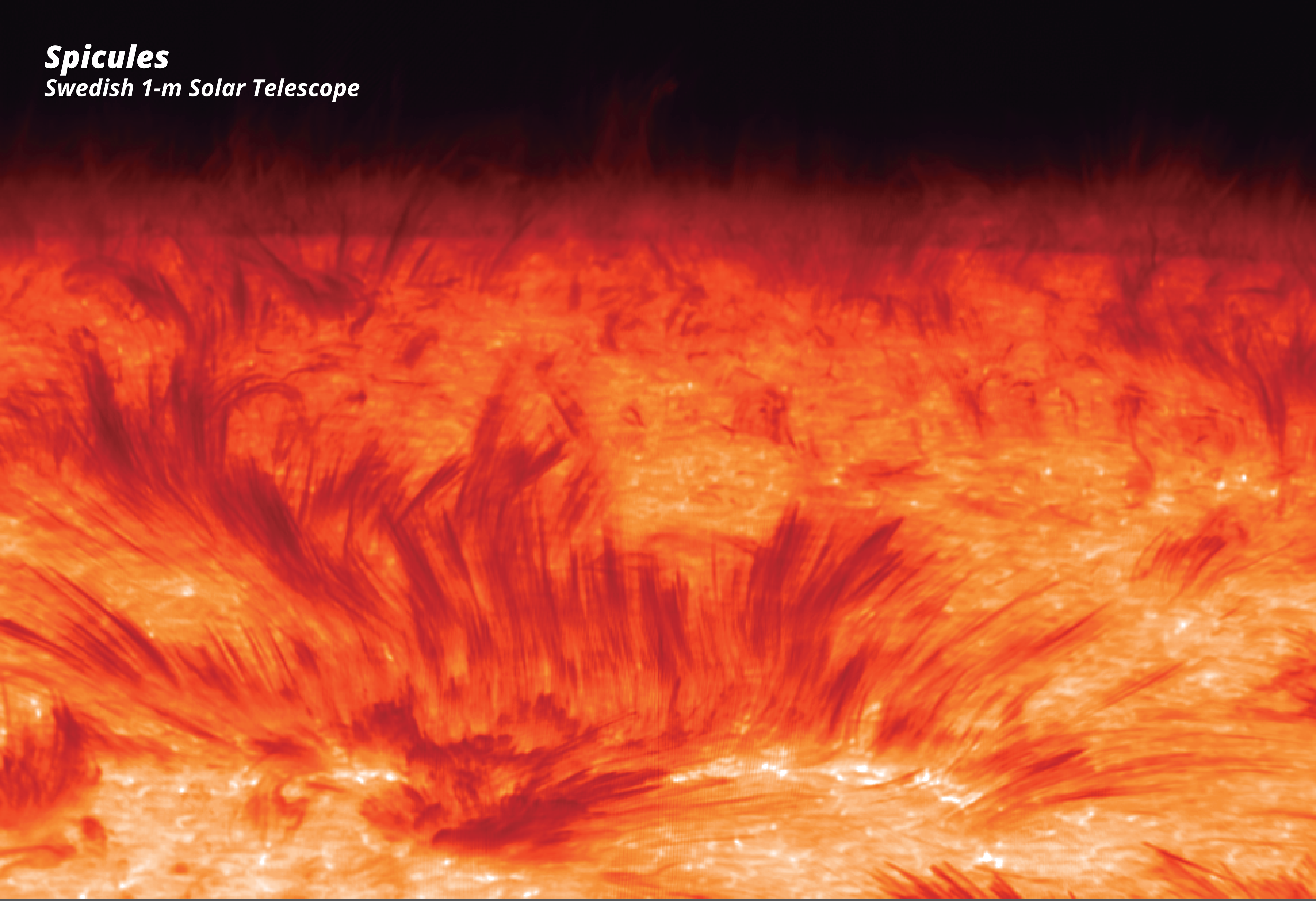
Cover: False-colored broad-band image at 450 nm observed on 2018 May 09 with the High-Resolution Fast Imager (HiFI) attached to the 1.5-meter GREGOR telescope (Tenerife, Spain). It shows a small pore belonging to NOAA active region 12708, surrounded by granulation, tiny pores and bright points. The post-processing speckle-interferometry technique was used for the image restoration.
Credit: Kuckein, Balthasar & González Manrique 2018

European Commission

Horizon 2020
European Union funding
for Research & Innovation

This activity has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no 739500

Spicules
Swedish 1-m Solar Telescope



Credit: L. Rouppe van der Voort

Spicules are thin, elongated jets that are a few hundred km wide and reach up to over 6000 km height. They live for only a few minutes and are very dynamic, sometimes moving at speeds of 100 km/s. Spicules are found all over the solar surface but can be observed most easily near the limb of the Sun. They were already studied by Father Angelo Secchi in the 19th century but with their complex and dynamic behaviour it is still a challenge to observe and understand how spicules are generated.

This image was obtained with the Swedish 1-meter Solar Telescope on La Palma and shows spicules close to the solar limb in the red wing of the H-alpha spectral line.

In the image we can clearly see the bright points at the root of the spicules in the bushes in the foreground. We know that these bright points are regions with strong magnetic fields and it is clear that magnetic fields play an important role in the generation of spicules. With the extreme capabilities of EST we will be able to measure magnetic fields in great detail and this will allow us to understand the origin of spicules and further determine the role of spicules in the mass transport and heating of the outer solar atmosphere.

JANUARY

MON	TUE	WED	THU	FRI	SAT	SUN
31	01	02	03	04	**05**	**06**
07	08	09	10	11	**12**	**13**
14	15	16	17	18	**19**	**20**
21	22	23	24	25	**26**	**27**
28	29	30	31	01	**02**	**03**
04	05	06	07	08	**09**	**10**

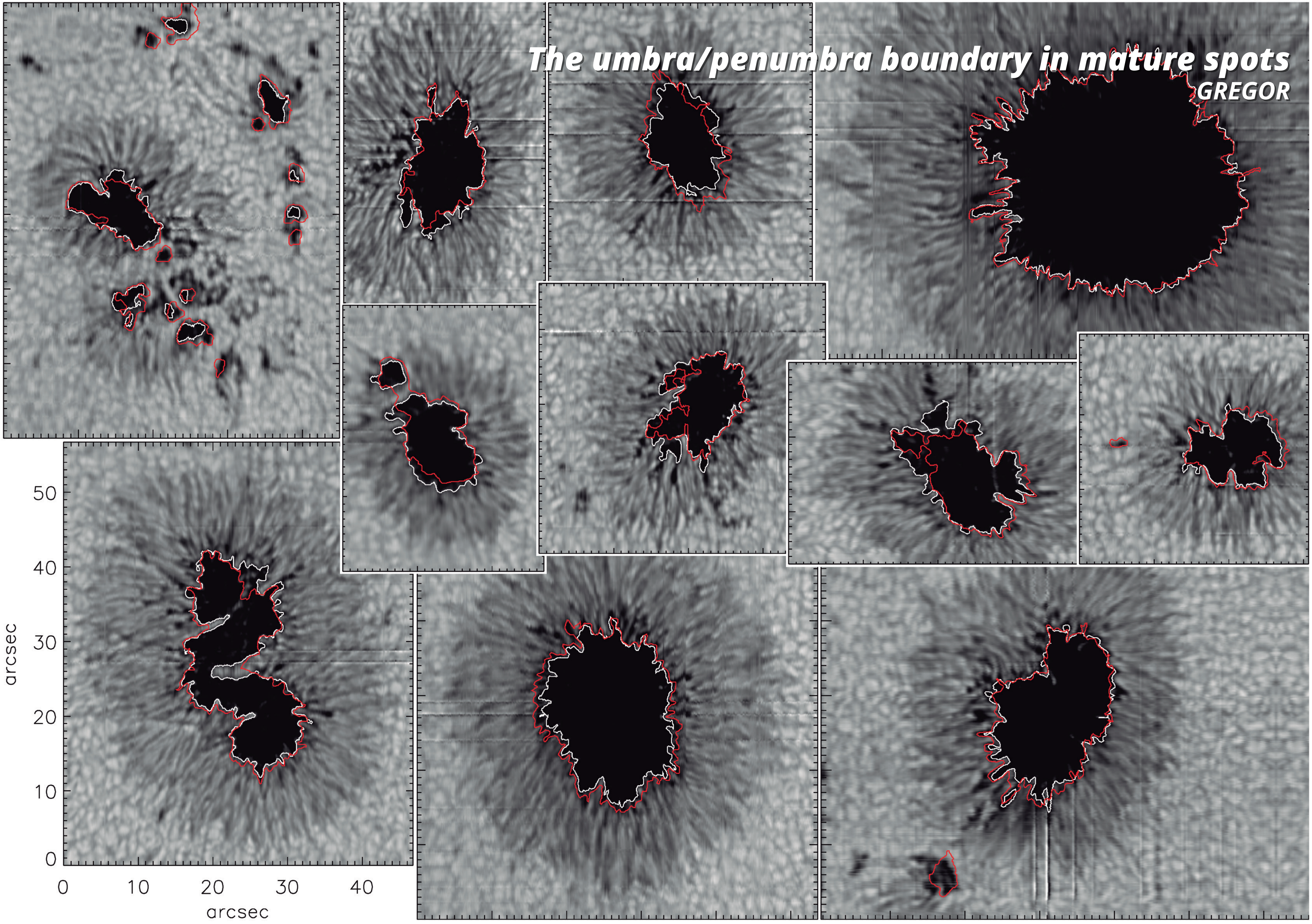
January 4: *02:20 GMT-Peak of Quadrantids meteor shower*

January 5-6: *Partial solar eclipse*

January 10: *The UK Missions Forum, Royal Astronomical Society, London, UK*

January 21: *Total lunar eclipse*

The European Solar Telescope (EST) is the next step in the European quest for a better understanding of the Sun



Credit: P. Lindner, J. Jurcak, N. Bello González, R. Schlichenmaier

The umbra and penumbra of sunspots, the most prominent and renowned manifestations of solar activity, are separated by a boundary that has always been defined by an intensity threshold. Using data from the Hinode satellite, Jurcak and collaborators found that the umbra-penumbra boundary in stable sunspots is characterised by an invariant vertical component of the magnetic field. This law is known as the Jurcak criterion. For more details, see Jurcak et al., 2018, A&A 611, 4.

The figure shows a sample of sunspots scanned with the Gregor Infrared Spectrograph attached to the GREGOR telescope at the Observatorio del Teide (Tenerife, Spain). The white contours outline the umbral boundary as seen in intensity and the independently defined red contours outline the vertical component of the magnetic field at 1843 Gauss. This value is consistent with the results achieved with the Hinode data and validates the Jurcak criterion in the infra-red part of the spectrum.

FEBRUARY

MON	TUE	WED	THU	FRI	SAT	SUN
28	29	30	31	01	**02**	**03**
04	05	06	07	08	**09**	**10**
11	12	13	14	15	**16**	**17**
18	19	20	21	22	**23**	**24**
25	26	27	28	01	**02**	**03**
04	05	06	07	08	**09**	**10**

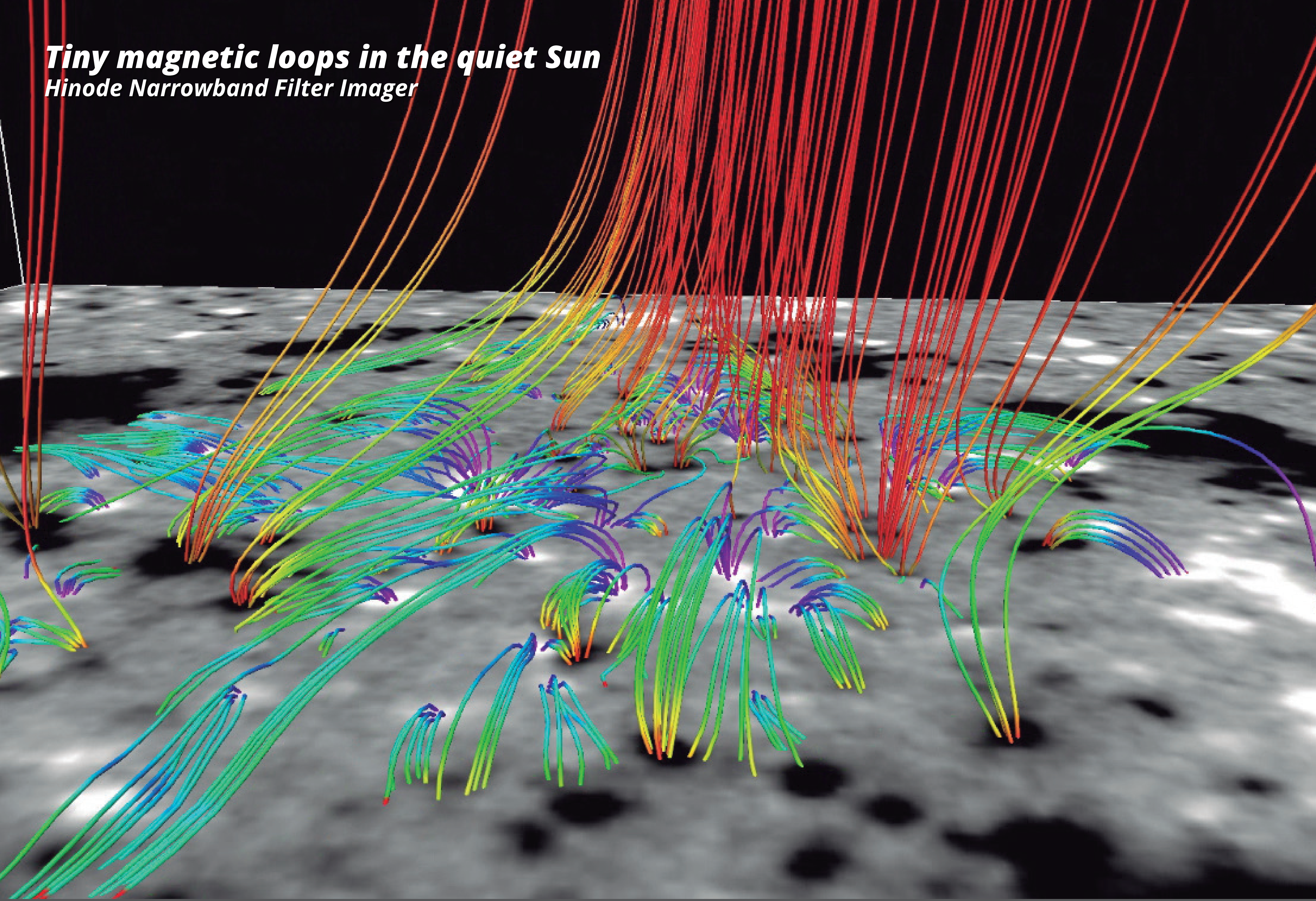
February 7-8: *PROBA-2 Symposium, Redu, Belgium*

February 11: *International Day of Women and Girls in Science*

February 11-15: *Chapman Conference on Scientific Challenges Pertaining to Forecasting, Pasadena, USA*

The European Solar Telescope (EST) is the next step in the European quest for a better understanding of the Sun

Tiny magnetic loops in the quiet Sun
Hinode Narrowband Filter Imager



Credit: M. Gosic, M. Cheung, L. Bellot Rubio

The quiet Sun is the area of the solar surface outside of active regions. Dominated by granular convection, it appears to be dull and uninteresting. However, observations with high sensitivity have demonstrated that the quiet Sun harbors ubiquitous magnetic fields. These fields are extremely weak, but may contain most of the magnetic energy of the solar surface, outweighing sunspots and active regions by far. Unfortunately, we do not know much about their properties and evolution due to the lack of sensitive measurements at high spatial resolution.

Recent observations with the Narrowband Filter Imager on the Japanese satellite Hinode have been used to investigate this important aspect of the solar magnetism. Quiet Sun fields emerge on the surface in the form of tiny, low-lying magnetic loops that connect patches of opposite polarity, as shown by the closed colored field lines resulting from a magneto-frictional simulation of the data. Some loops are able to reach the chromosphere. On their way up, they interact with pre-existing fields and other quiet Sun loops. These interactions may release energy on very small spatial scales, perhaps contributing to chromospheric heating. EST will allow us to detect even weaker loops, trace their ascent in the atmosphere, and quantify how much energy they deposit in the chromosphere through interactions with ambient fields.

MARCH

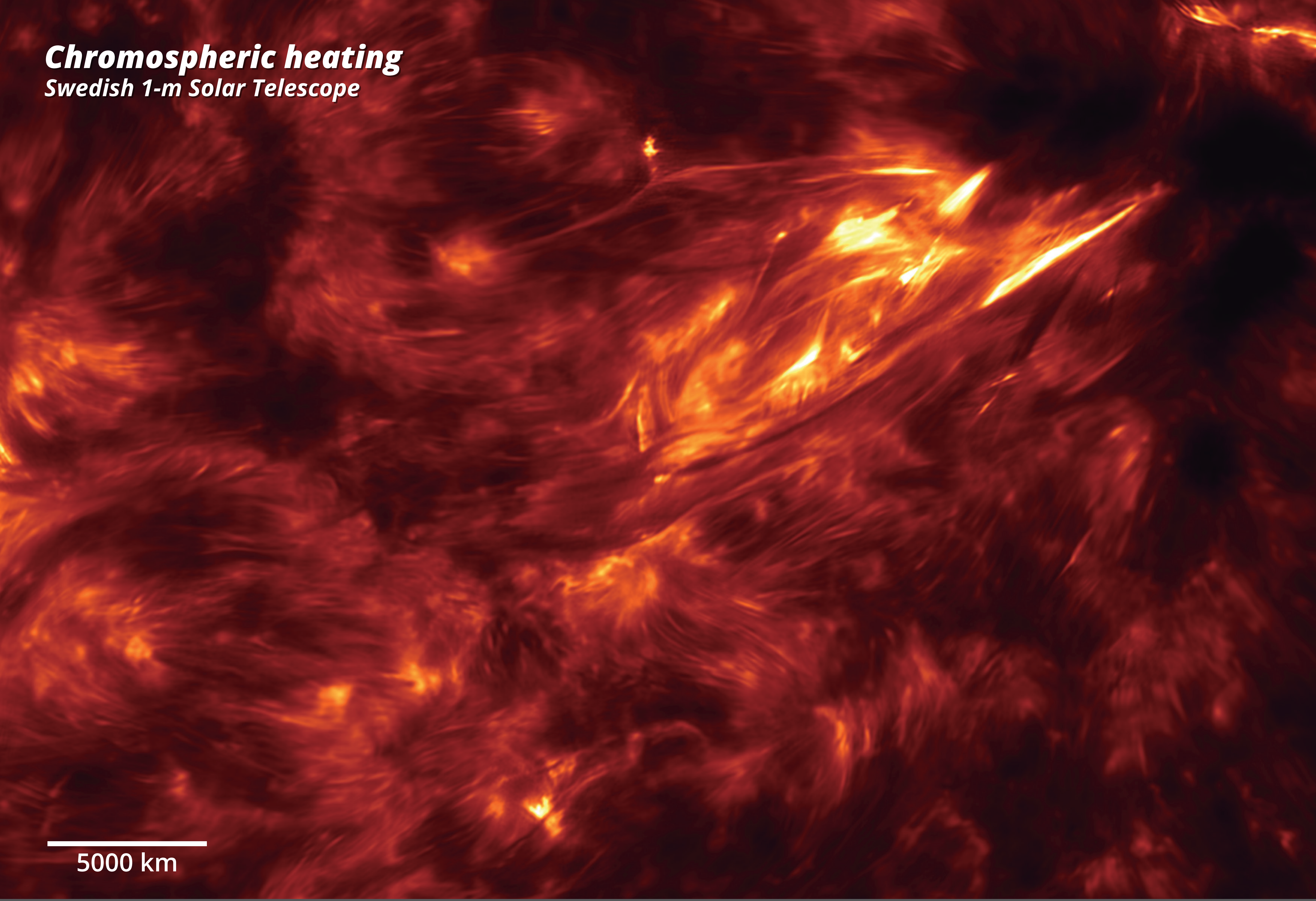
MON	TUE	WED	THU	FRI	SAT	SUN
25	26	27	28	01	02	03
04	05	06	07	08	09	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31
01	02	03	04	05	06	07

March 4-8: *Solar Helicities in Theory and Observations, Stockholm, Sweden*

March 18-22: *Flux Emergence Workshop 2019, Tokyo, Japan*

March 20: *21:58 GMT - Vernal equinox*

Chromospheric heating
Swedish 1-m Solar Telescope



Credit: Leenaarts et al. 2017, A&A, 612, 28L

Observations reveal that the solar chromosphere radiates more energy than it absorbs in areas where the magnetic field is strong. The origin of this surplus energy must be in the photosphere or below. Physical processes involved in transporting this energy to the chromosphere, and the dissipation there, are made more efficient by the presence of magnetic fields. However, the precise role of the various processes is not known.

The image shows the lower part of the chromosphere observed in the wing of the Ca II K line at the highest spatial resolution available today. The target is an active region where new magnetic flux is emerging into the surface of the Sun. One can see many small scale (bright) reconnection events at the foot-points of magnetic loops and long threaded features where the magnetic field is more horizontal.

The observations were acquired by the Institute for Solar Physics (Stockholm University) at the Swedish 1-m Solar Telescope on La Palma (Spain) with the CHROMIS and CRISP imaging spectropolarimeters. They allowed us to conclude that the heating of this active region primarily is from locations with large scale horizontal magnetic field in the chromosphere, and not at locations of the brightest magnetic reconnection events where the magnetic field is more vertical.

APRIL

MON	TUE	WED	THU	FRI	SAT	SUN
01	02	03	04	05	**06**	**07**
08	09	10	11	12	**13**	**14**
15	16	17	18	19	**20**	**21**
22	23	24	25	26	**27**	**28**
29	30	01	02	03	**04**	**05**
06	07	08	09	10	**11**	**12**

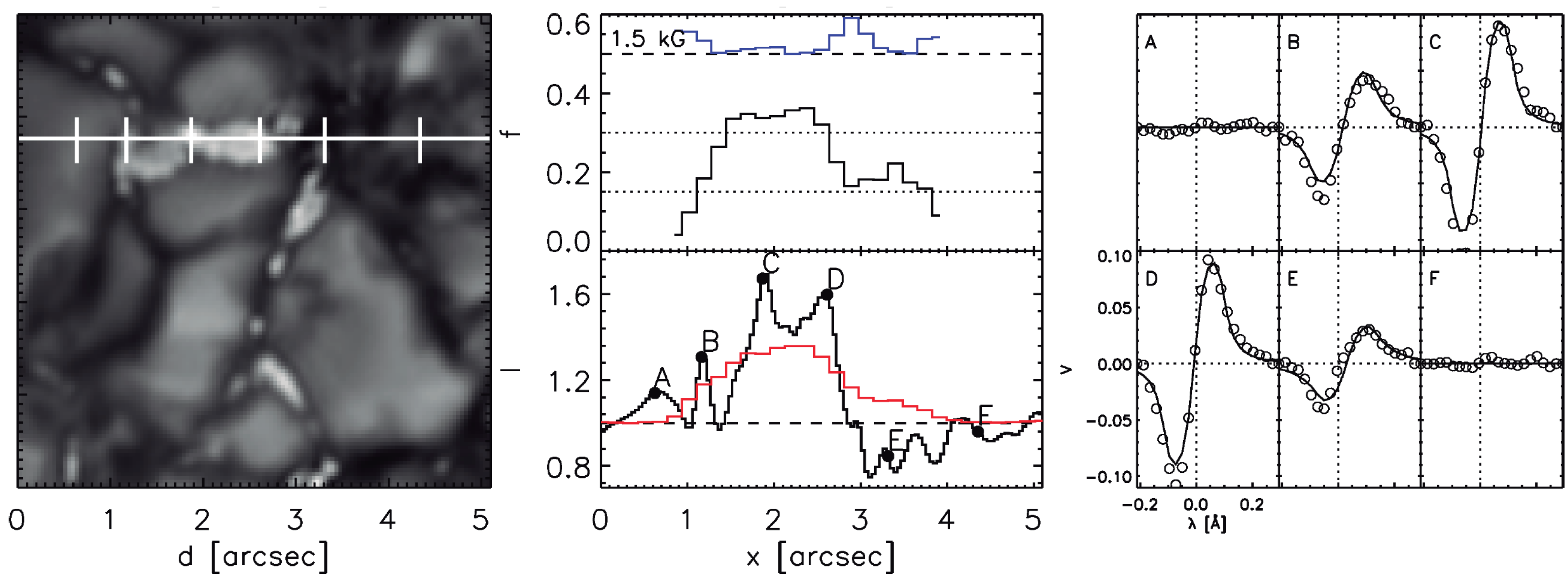
April 1-5: *Turbulence and Magnetic Fields, Tuusula, Finland*

April 1-5: *2019 Space Weather Workshop, Boulder, USA*

April 23: *Peak of Lyrids meteor shower*

Strong magnetic fields are ubiquitous on the Sun

IBIS at Dunn Solar Telescope



Credit: Viticchié et al., 2010, ApJ, 723, 787

Solar magnetic fields manifest in the photosphere in a large variety of structures. At sub-arcsecond spatial scales they can appear concentrated in bright features, located in convective downflow regions, preferentially at the vertexes of granules. These bright features are ubiquitous on the solar photosphere and, when observed in the G-band spectral region (around 430.8 nm), they show enhanced contrast with respect to the quiet Sun average intensity (typically 30%). They are therefore referred to as G-band bright points.

Due to their small size, the investigation of these features has long been hampered by spatial resolution limits imposed by instrumentation and atmospheric seeing. The development of adaptive optics systems and post-facto restoration techniques enabled the study of their finest structure and temporal evolution.

The observations performed with the Interferometric Bidimensional Spectrometer (IBIS) at the Dunn Solar Telescope (National Solar Observatory, USA) had the advantage of combining high spatial resolution spectropolarimetry with high cadence G-band imaging, allowing us to associate the appearance of bright points with a local increase in the filling factor of strong magnetic fields induced by the photospheric advection field.

MAY

MON	TUE	WED	THU	FRI	SAT	SUN
29	30	01	02	03	**04**	**05**
06	07	08	09	10	**11**	**12**
13	14	15	16	17	**18**	**19**
20	21	22	23	24	**25**	**26**
27	28	29	30	31	**01**	**02**
03	04	05	06	07	**08**	**09**

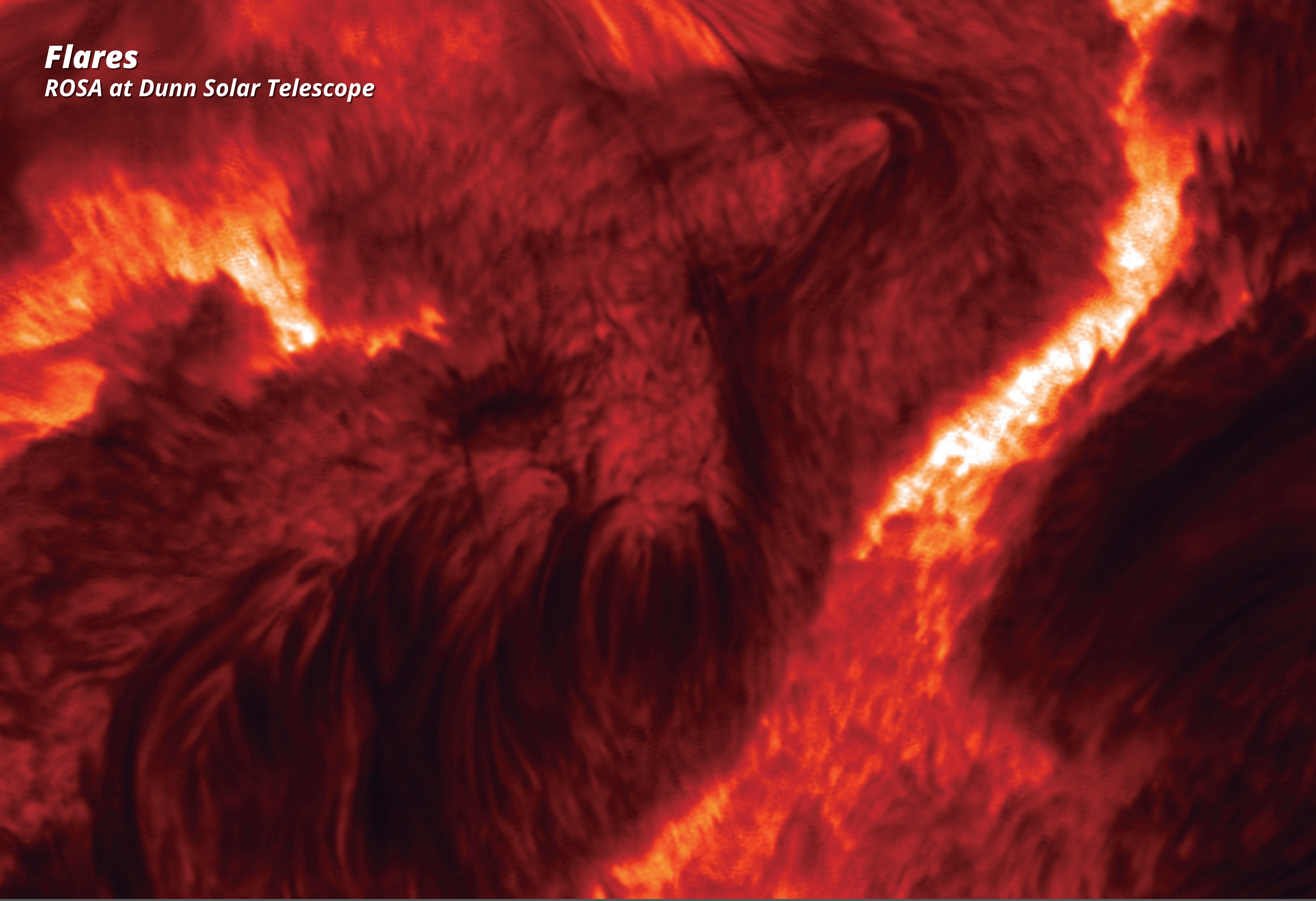
May 6: *14:00 GMT - Peak of Eta Aquariids meteor shower*

May 6-10: *2nd China-Europe Solar Physics Meeting, Hvar, Croatia*

May 28-June 1: *18th RHESSI Workshop, Minneapolis, USA*

Flares

ROSA at Dunn Solar Telescope



Credit: P. Keys

The Rapid Oscillations in the Solar Atmosphere (ROSA) instrument is a high cadence broad-band imager installed as a common-user instrument on the Dunn Solar Telescope at the National Solar Observatory in New Mexico since August 2008. It was designed, built and maintained by Queen's University Belfast. It is capable of imaging the lower solar atmosphere simultaneously in six bandpasses at typical frame rates of 30 frames-per-second and a diffraction-limited spatial sampling of 0.069 arcsecs/pixel.

This image was taken on the 6th of November 2010 of active region NOAA 11121. It shows an M5 class flare occurring within the active region as observed in the H-alpha line with ROSA. Flares are highly energetic events caused by magnetic reconnection in active regions. They are interesting to researchers due to the high energies involved and due to the undesired effects they can cause on Earth (e.g., satellite communication disruptions and power grid failures). They are often difficult to image from ground-based facilities due to the lack of predictability in both their timings and locations.

JUNE

MON	TUE	WED	THU	FRI	SAT	SUN
27	28	29	30	31	01	02
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June 3-7: *Partially Ionized Plasmas in Astrophysics, Palma de Mallorca, Spain*

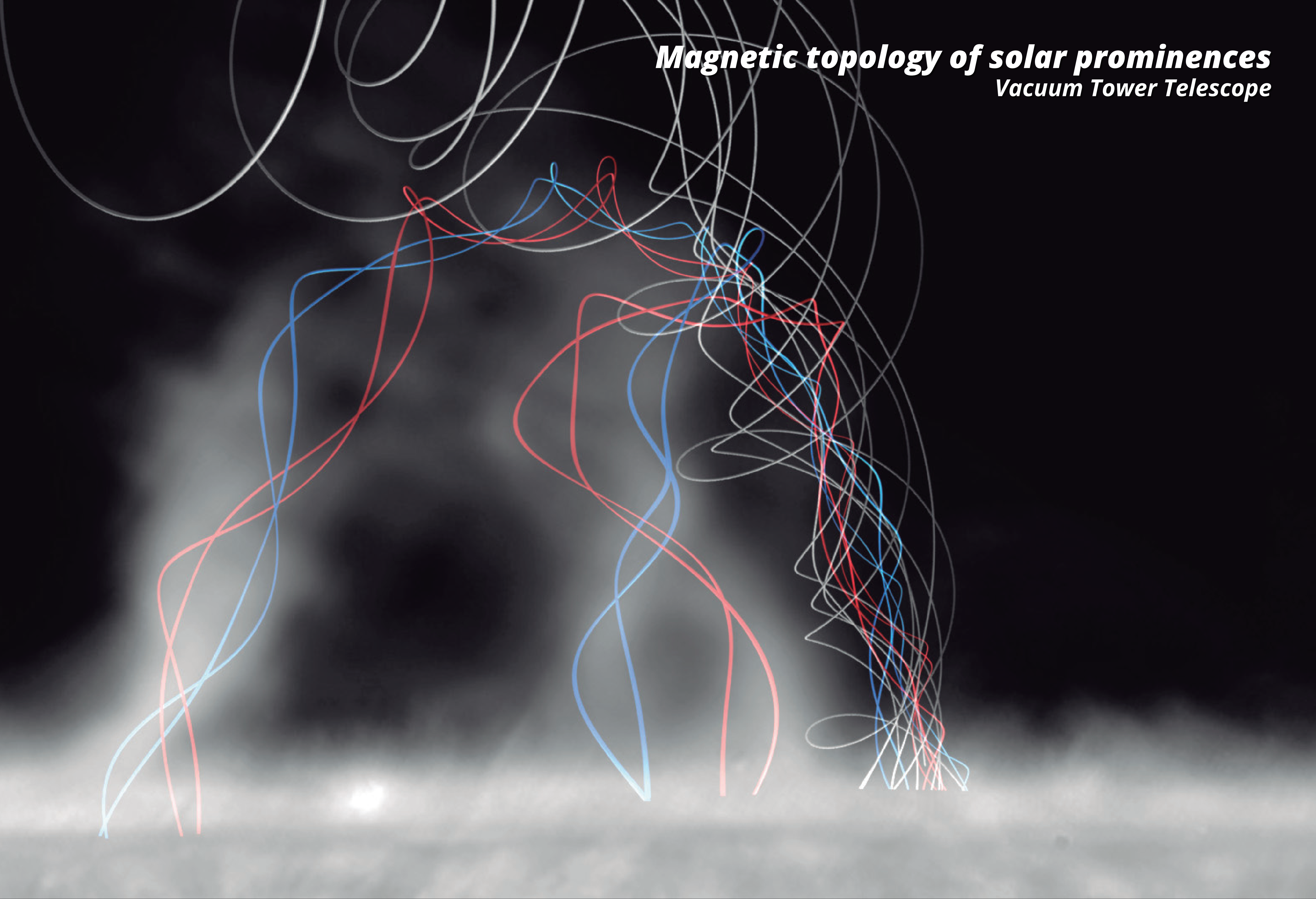
June 11-14: *Coronal Loops IX, St. Andrews, UK*

June 21: *15:54 GMT - Summer solstice*

June 24-28: *European Week of Astronomy and Space Science 2019, Lyon, France*

Magnetic topology of solar prominences

Vacuum Tower Telescope



Credit: Martínez González et al., 2015, ApJ 802:3

Solar prominences are seen as bright translucent clouds at the solar limb because they mainly scatter light from the underlying disc. These clouds form in regions of complex magnetic topology, which can evolve abruptly, disintegrating the prominence and ejecting magnetised material into the heliosphere. Interestingly for space weather predictions, 50% of solar tornadoes — a particular kind of prominence associated with apparently rotating, vertical, funnel-shaped dark structures — are eruptive and can have strong implications for the coronal magnetic field and the heliosphere.

The actual topology of the magnetic field is what maintains the tornado stable. When it erupts, the polarity of this field determines whether or not the ejected cloud of magnetised material will reconnect with the Earth's magnetic fields inducing geomagnetic storms.

Spectro-polarimetric observations in the He I 1083 nm spectral line obtained with the Tenerife Infrared Polarimeter at the Vacuum Tower Telescope (Observatorio del Teide, Spain) revealed the three-dimensional topology of the magnetic field in a tornado prominence. Drawing the field lines obtained using the most sophisticated analysis tools to date, we can see that tornadoes harbour vertical, helical fields that connect the main body of the prominence with the underlying surface, in contrast to most of the theoretical predictions so far.

JULY

MON	TUE	WED	THU	FRI	SAT	SUN
01	02	03	04	05	**06**	**07**
08	09	10	11	12	**13**	**14**
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22	23	24	25	26	**27**	**28**
29	30	31	01	02	**03**	**04**
05	06	07	08	09	**10**	**11**

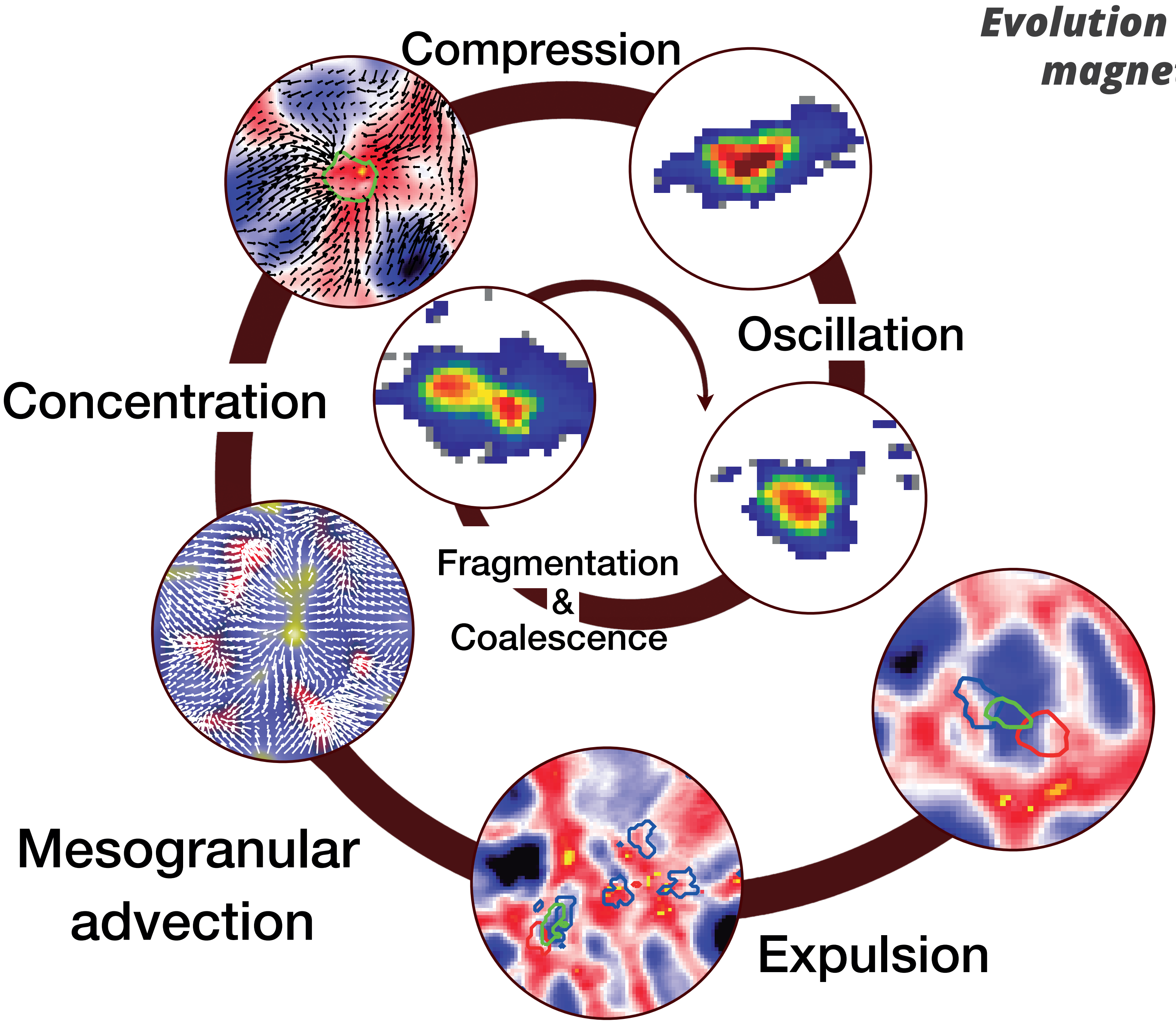
June 30-July 6: *IAUS 354 – Solar and Stellar Magnetic Fields, Copiapo, Chile*

June 30-July 4: *RAS Meeting, Lancaster, UK*

July 2: *Total solar eclipse*

July 2-7: *Towards Future Research on Space Weather Drivers, San Juan, Argentina*

The European Solar Telescope (EST) is the next step in the European quest for a better understanding of the Sun



Evolution of quiet-Sun magnetic elements

SUNRISE/IMaX

Credit: Requerey et al., 2014, ApJ, 789, 6

Since their discovery in the early 1970s, small-scale magnetic elements have been elusive to direct observations. Their size was too small to available ground-based telescopes because of the atmospheric seeing. Only indirect evidence had been gathered from the polarization of spectral lines. After the first two flights of the Sunrise balloon observatory (2009 and 2013), stable observations have clearly shown a panoply of such features and, most importantly, their evolution for periods of up to half an hour.

The results from the IMaX magnetograph reveal both isolated magnetic flux tubes and bunches of them (multi-core flux tubes) coherently interacting with the surrounding convection. Much in agreement with current theories, we can see how magnetic loops emerge on granules and are expelled by them (flux expulsion). They later merge and concentrate by granular and mesogranular advection (dragging) until their magnetic field strength exceeds 1 kG (maturity) through convective collapse. The mature elements display fragmentations and coalescence that explain oscillations in their magnetic field strength, velocity, and area, always in tight interaction with the surrounding convective motions.

AUGUST

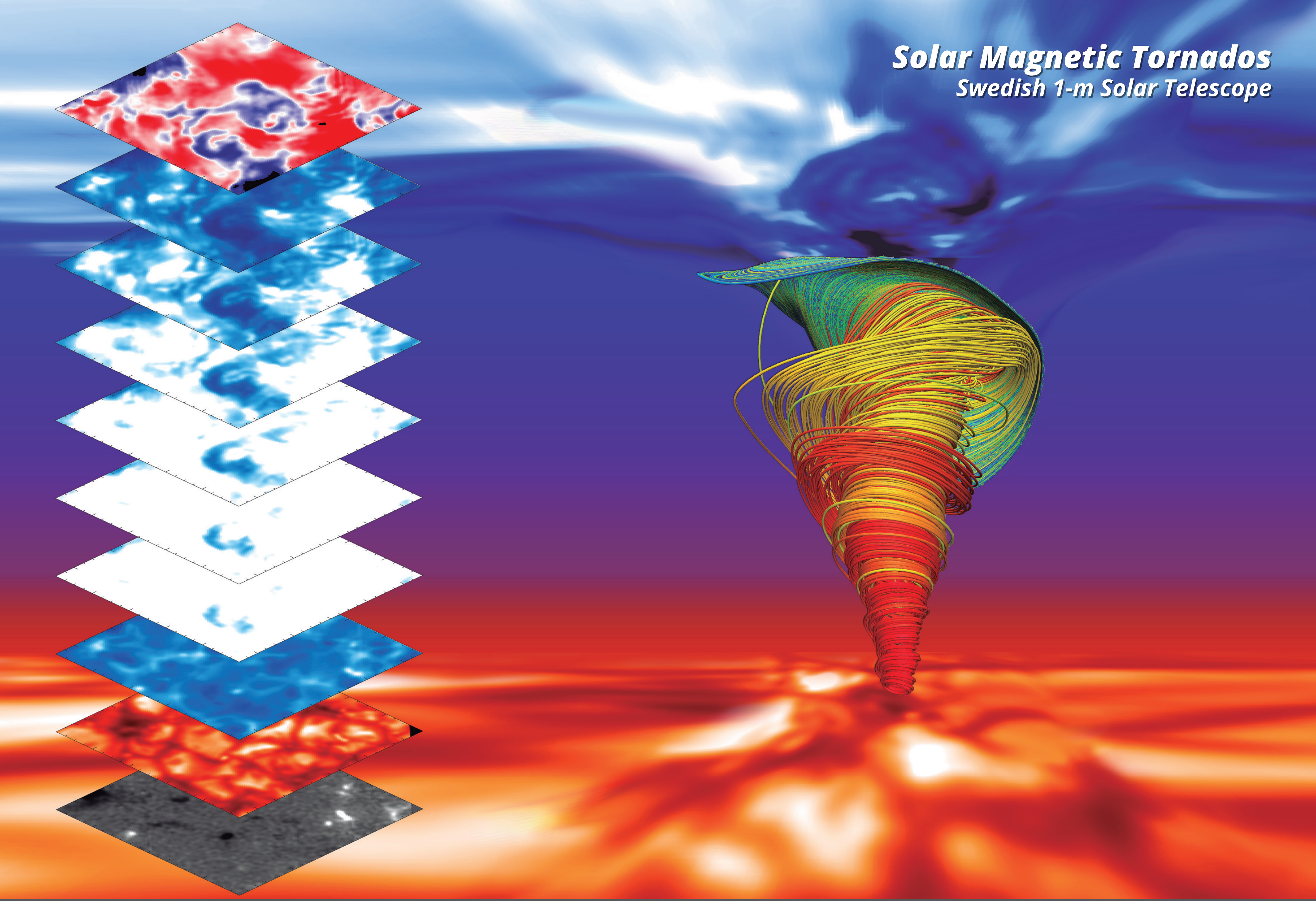
MON	TUE	WED	THU	FRI	SAT	SUN
29	30	31	01	02	**03**	**04**
05	06	07	08	09	**10**	**11**
12	13	14	15	16	**17**	**18**
19	20	21	22	23	**24**	**25**
26	27	28	29	30	**31**	**01**
02	03	04	05	06	**07**	**08**

August 9: *Mercury at greatest western elongation*

August 13: *Peak of Perseids meteor shower*

Solar Magnetic Tornados

Swedish 1-m Solar Telescope



Credit: S. Wedemeyer, based on material by Wedemeyer et al., 2012, Nature 486, 505

Rotating plasma flows in the dynamic atmosphere of the Sun are referred to as solar magnetic tornadoes. The smallest tornados were first observed in 2008 with the SST as rotating dark rings called chromospheric swirls. The swirls have diameters of a few 1,000 km and rotate with speeds of many 10,000 km/hour. The images to the left show SST observations of a swirl at different wavelengths, mapping the underlying magnetic tornado at different heights in the atmosphere.

The twisted lines represent instantaneous streamlines produced with numerical simulations of the solar atmosphere that help to understand the physical processes behind magnetic tornadoes. These features are driven by the bathtub effect in the lower photosphere that leads to the rotation of magnetic field structures, which extend into the upper atmosphere and thus mediate the rotation into the upper layers.

Magnetic tornadoes transport energy from the Sun's surface into the corona, where they contribute to the heating of the solar outer atmosphere. EST will provide an unprecedented insight into the formation, fine structure and energy transport of magnetic tornadoes. The higher spatial resolution may also lead to the discovery of smaller tornadoes that are predicted by numerical models.

SEPTEMBER

MON	TUE	WED	THU	FRI	SAT	SUN
26	27	28	29	30	31	01
02	03	04	05	06	07	08
09	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	01	02	03	04	05	06

September 2-6: *Hinode 13 Science Meeting/IPELS 2019, Tokyo, Japan*

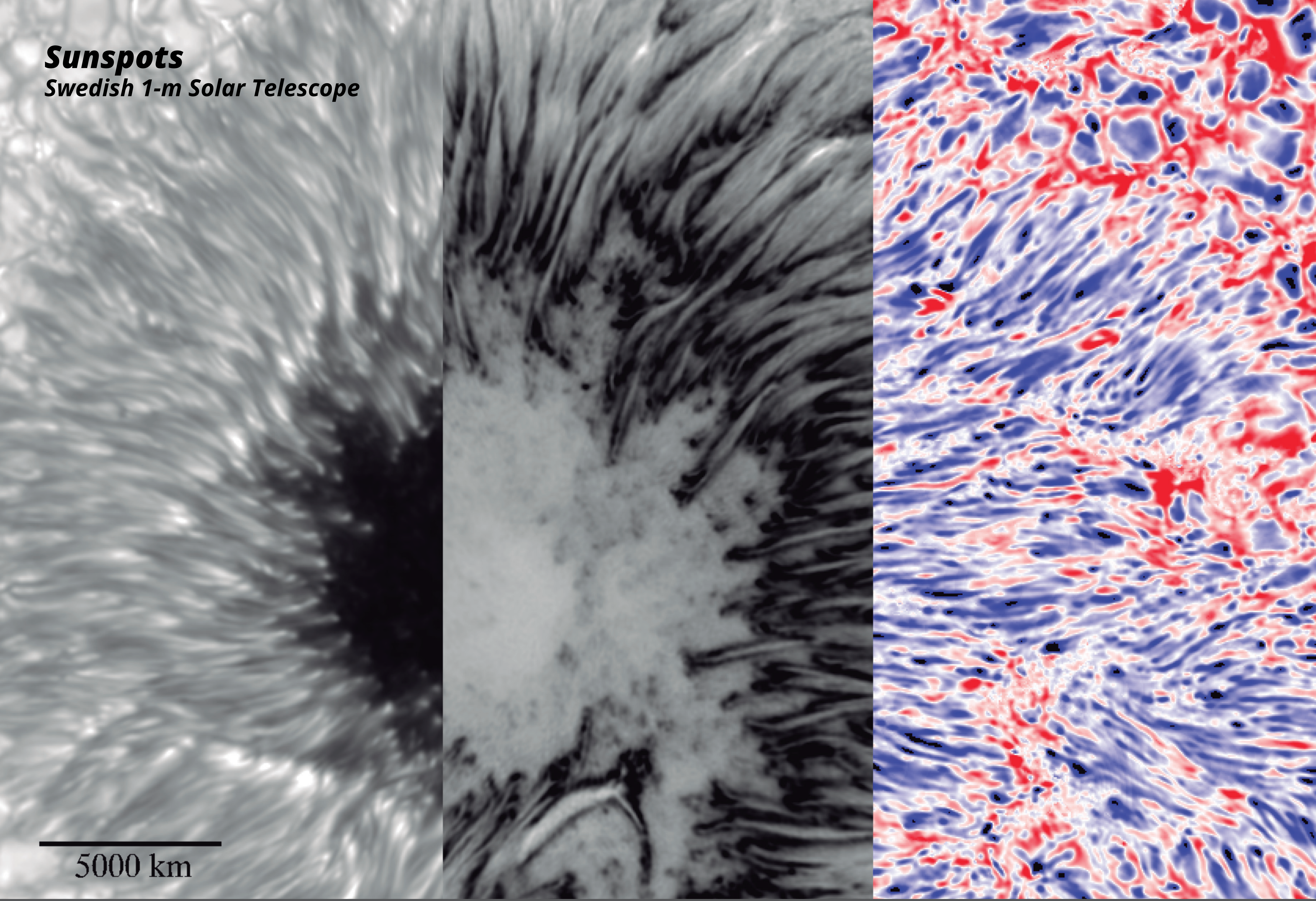
September 3-5: *VII Spanish Solar and Heliospheric Physics Meeting, Valencia, Spain*

September 16-20: *Machine Learning in Heliophysics, Amsterdam, The Netherlands*

September 23: *07:50 GMT – Autumnal equinox*

The European Solar Telescope (EST) is the next step in the European quest for a better understanding of the Sun

Sunspots
Swedish 1-m Solar Telescope



Credit: Esteban Pozuelo et al., 2015, ApJ, 803, 93

The penumbra of sunspots is a magnetized region where convective motions are not entirely inhibited. Understanding its structure, brightness, and dynamics represents a challenge, as our ability to make progress depends on improvements in the spatial resolution of the observations.

Penumbral filaments are formed by a dark core and two lateral brightenings. They carry the Evershed flow, an outward flow of several km/s extending from the umbra to the outer penumbral boundary, whose origin and nature have been discussed for decades. The magnetic field of the penumbra decreases from the inner to the outer penumbral edges and shows at least two components. According to current views, penumbral filaments are related to extended lanes of horizontal field lines embedded in a more vertical and stronger magnetic background.

Recent high-resolution observations obtained with the CRisp Imaging SpectroPolarimeter at the Swedish 1-m Solar Telescope have revealed penumbral filaments with unprecedented detail. Filaments show clear magnetic field variations in magnetograms. Furthermore, velocity maps display penumbral filaments as elongated convective cells with upflows along their length, weak downflows related to opposite polarity field lines at the lateral edges, and a strong downflow at the end, whose appearance is similar to that of granules in the quiet Sun.

OCTOBER

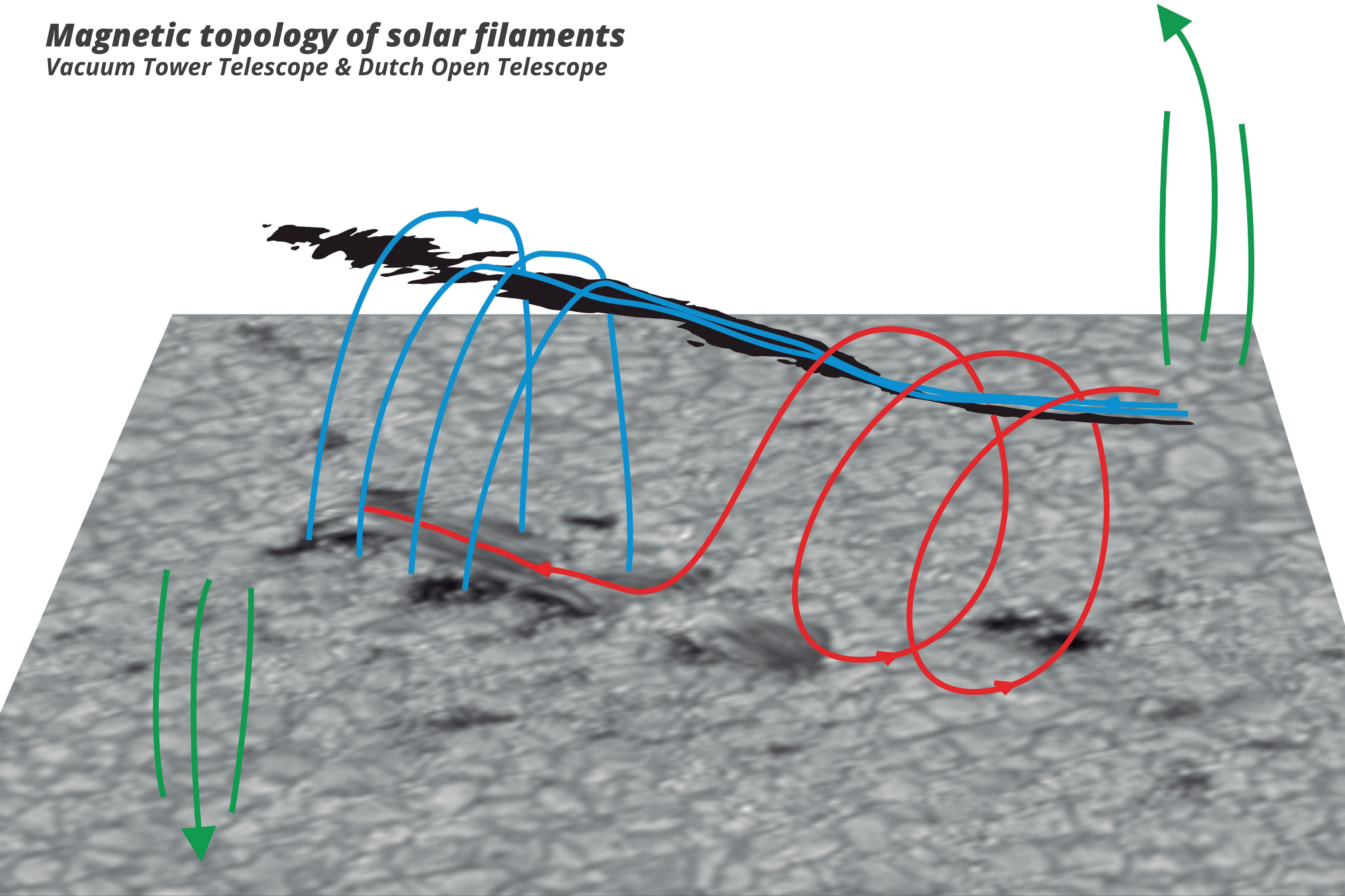
MON	TUE	WED	THU	FRI	SAT	SUN
30	01	02	03	04	**05**	**06**
07	08	09	10	11	**12**	**13**
14	15	16	17	18	**19**	**20**
21	22	23	24	25	**26**	**27**
28	29	30	31	01	**02**	**03**
04	05	06	07	08	**09**	**10**

October 8: *Peak of Draconids meteor shower*

October 21 *Peak of Orionids meteor shower*

October 27: *Uranus at opposition*

Magnetic topology of solar filaments
Vacuum Tower Telescope & Dutch Open Telescope



Credit: Kuckein, 2012, PhD Thesis, Universidad de La Laguna, Tenerife, Spain

Solar filaments are best seen using an H-alpha filter, visible even with amateur telescopes, and resemble dark clouds which lie in the upper atmosphere of the Sun, the chromosphere and corona. Since many decades, solar physicists have tried to explain how filaments are formed, how they remain stable in the solar atmosphere and why they are sometimes violently expelled into space.

The image shows a possible scenario of a stable filament. The surface is represented by a continuum image and the filament (upper black structure) by an H-alpha image, both observed with the Dutch Open Telescope (La Palma, Spain). The magnetic field lines were inferred and interpreted using observations from the German Vacuum Tower Telescope (Tenerife, Spain). They are shown in different colors depending on their location on the Sun. In the image it is seen that the magnetic field lines support the filament's plasma against gravity. Furthermore, the field lines are responsible for the stability of the filament.

NOVEMBER

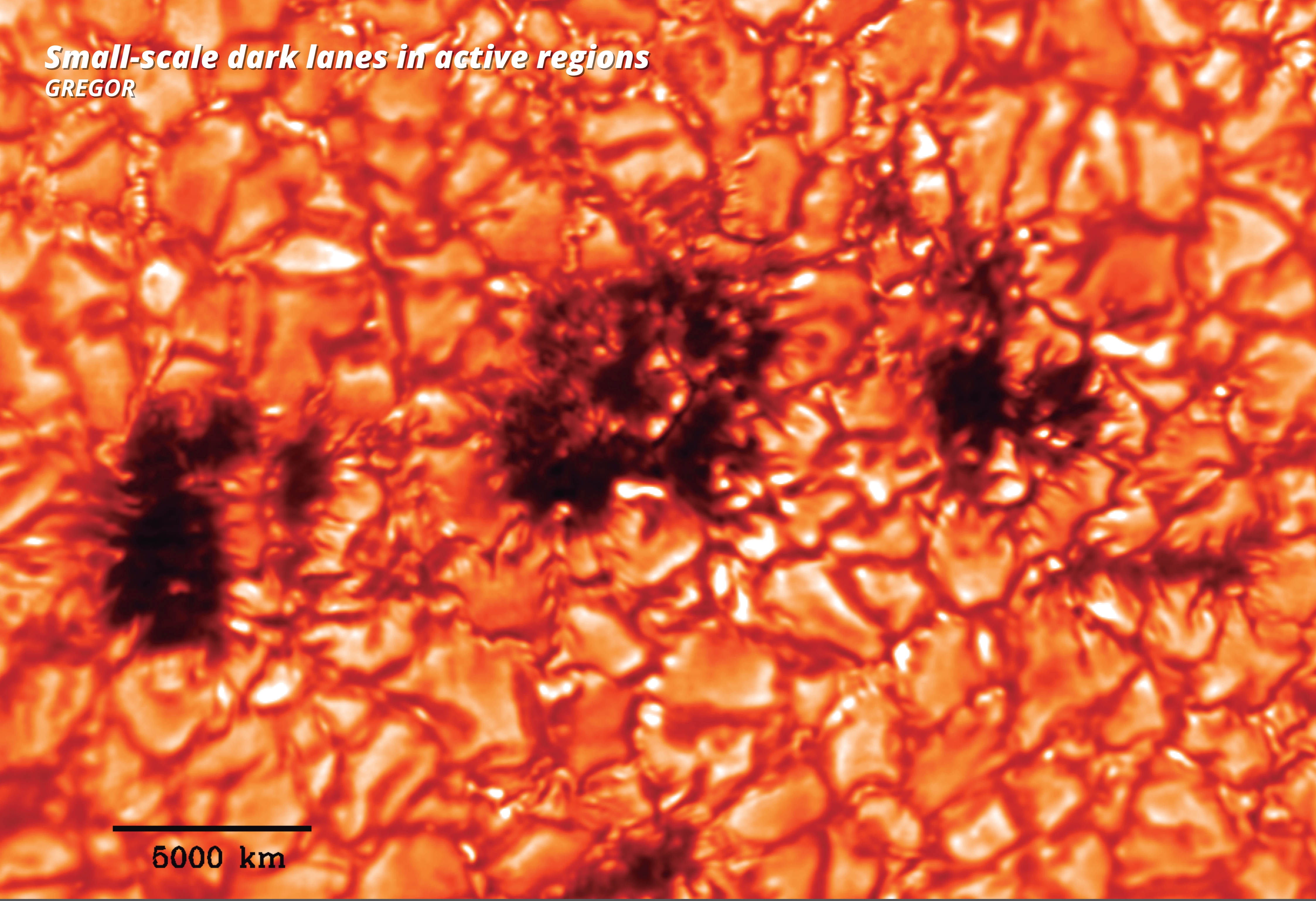
MON	TUE	WED	THU	FRI	SAT	SUN
28	29	30	31	01	**02**	**03**
04	05	06	07	08	**09**	**10**
11	12	13	14	15	**16**	**17**
18	19	20	21	22	**23**	**24**
25	26	27	28	29	**30**	**01**
02	03	04	05	06	**07**	**08**

November 5-8: *IRIS-10 Science Workshop, Shenzhen, China*

November 18: *Peak of Leonids meteor shower*

The European Solar Telescope (EST) is the next step in the European quest for a better understanding of the Sun

Small-scale dark lanes in active regions
GREGOR



Credit: Schlichenmaier et al., 2016, A&A, 596, A7

Active region 11768 was observed on 13 June 2013 with the Broad Band Imager at the German 1.5 m GREGOR telescope (Observatorio del Teide, Tenerife). The image was speckle reconstructed from a burst of 100 frames taken within 20 seconds. In order to freeze the seeing, each image was exposed for 1 millisecond. During the measurements, the GREGOR adaptive optics system was locked on the pores to partially correct for seeing effects and for the static aberrations of the optical train. The reconstructed image has a resolution of 60 kilometers on the surface of the Sun.

Dark lanes very prominently outline the bright features observed in the dark area of the central pore. This and other images from GREGOR indicate that bright dots and bright features are always associated with dark lanes and that adjacent bright features are connected by such dark lanes. The width of the dark lanes can be 60 kilometers or smaller. Dark lanes do not only occur as central lanes in light bridges of pores, they are also seen as narrow dark intergranular lanes, as striations at the boundary of pores and granules, and as dark cores of filaments intruding into the pore.

DECEMBER

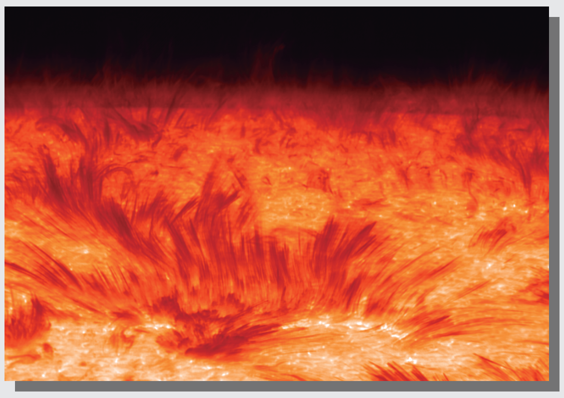
MON	TUE	WED	THU	FRI	SAT	SUN
25	26	27	28	29	30	**01**
02	03	04	05	06	**07**	**08**
09	10	11	12	13	**14**	**15**
16	17	18	19	20	**21**	**22**
23	24	25	26	27	**28**	**29**
30	31	01	02	03	04	05

December 21: *Peak of Ursids meteor shower*

December 22: *04:19 GMT - Winter solstice*

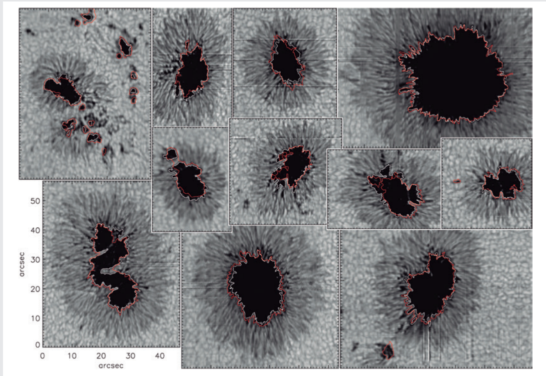
December 26: *Annular solar eclipse*

JANUARY



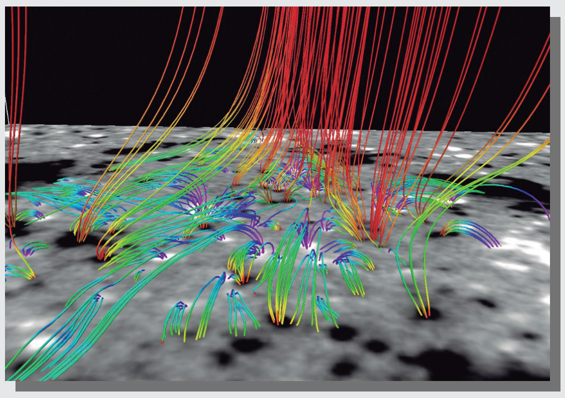
Spicules
Swedish 1-m Solar Telescope

FEBRUARY



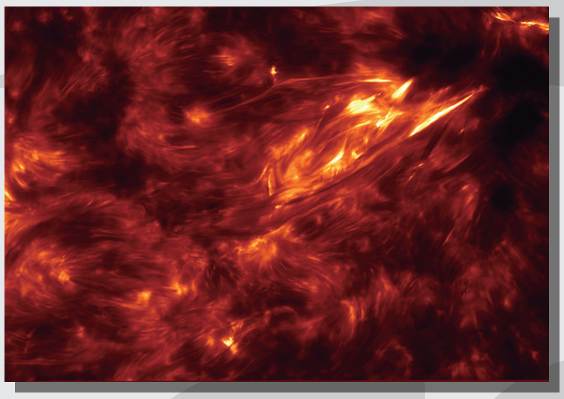
The umbra/penumbra boundary in mature spots
GREGOR

MARCH



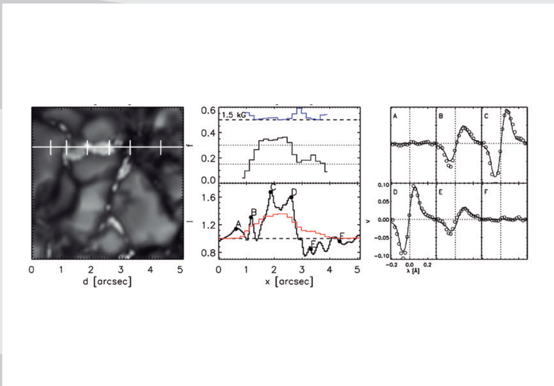
Tiny magnetic loops in the quiet Sun
Hinode Narrowband Filter Imager

APRIL



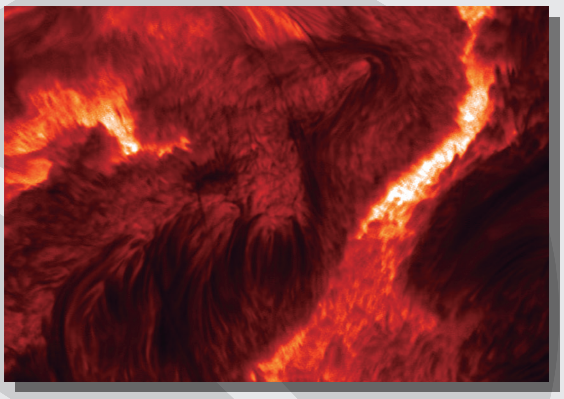
Chromospheric heating
Swedish 1-m Solar Telescope

MAY



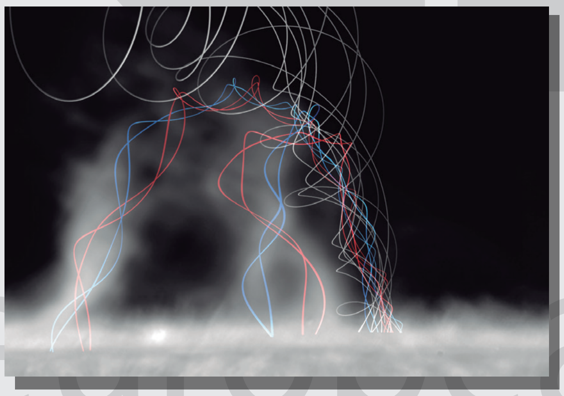
Strong magnetic fields are ubiquitous on the Sun
IBIS at Dunn Solar Telescope

JUNE



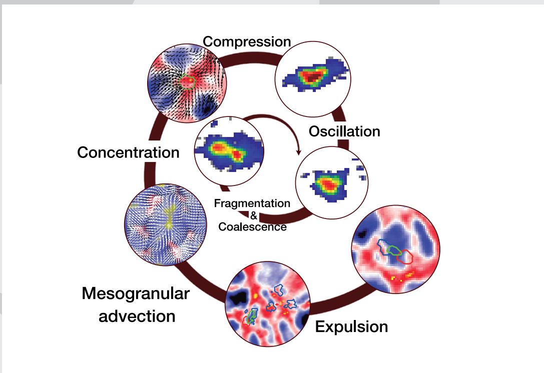
Flares
ROSA at Dunn Solar Telescope

JULY



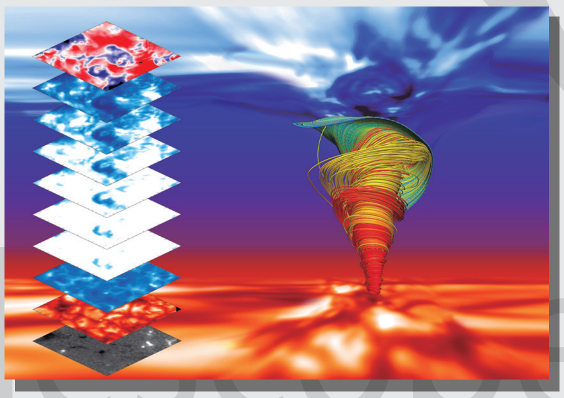
Magnetic topology of solar prominences
Vacuum Tower Telescope

AUGUST



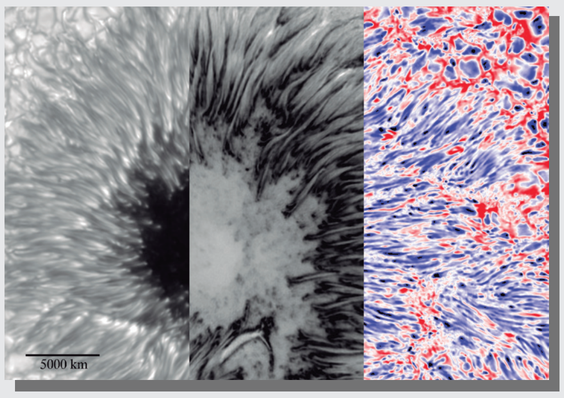
Evolution of quiet-Sun magnetic elemets
SUNRISE/IMaX

SEPTEMBER



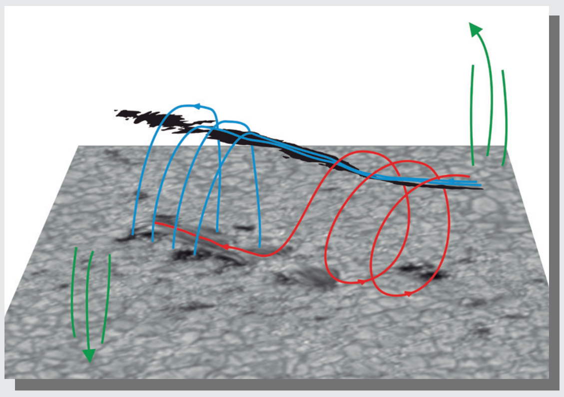
Solar Magnetic Tornados
Swedish 1-m Solar Telescope

OCTOBER



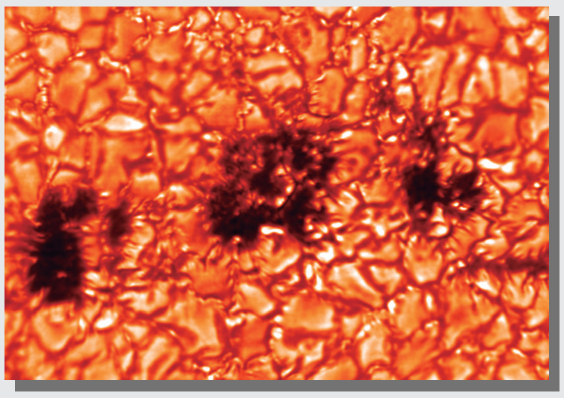
Sunspots
Swedish 1-m Solar Telescope

NOVEMBER



Magnetic topology of solar filaments
Vacuum Tower Telescope & Dutch Open Telescope

DECEMBER



Small-scale dark lanes in active regions
GREGOR

The European Solar Telescope (EST) is the next step in the European quest for a better understanding of the Sun