United Nations Committee on Peaceful Uses of Outer Space (COPOUS):

UNISPACE+50 Thematic Priority 4: Developing an International Framework for Space Weather Services (2018-30).

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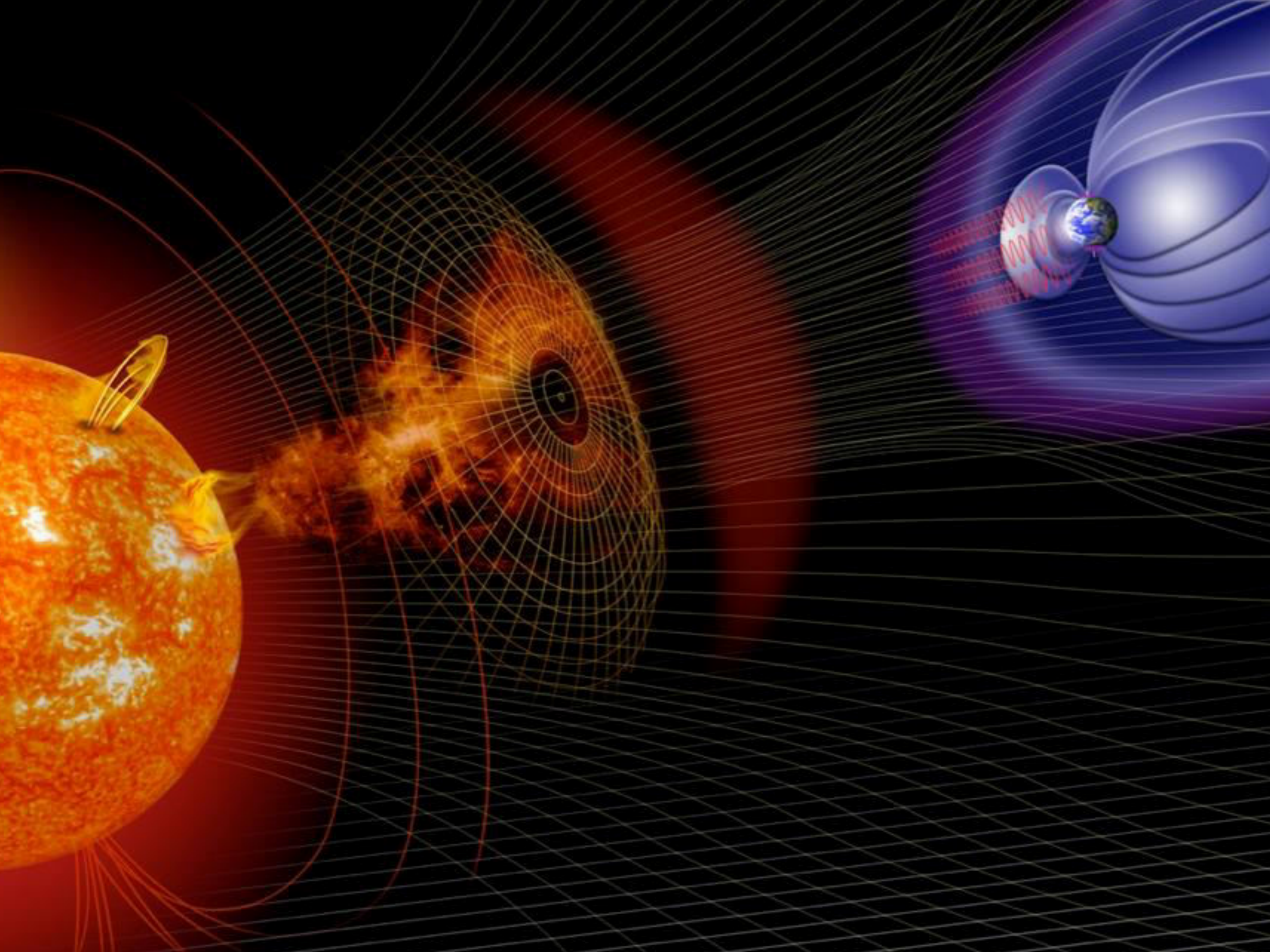
Thanks to Expert Group & Karel Schrijver, Chair of COSPAR-ILWS Space Weather Roadmap Team.



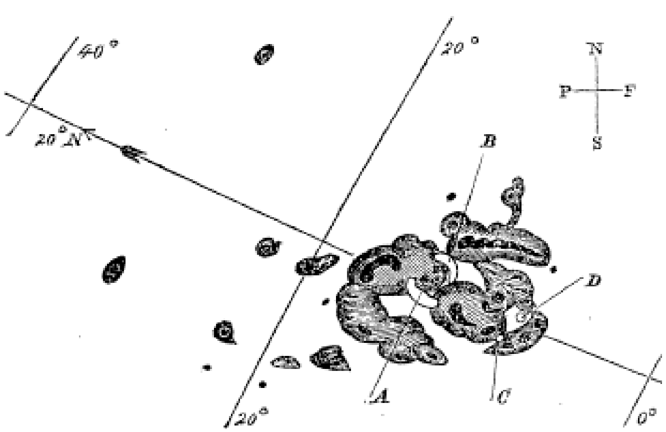
Solar flaring and the connection to geospace: discovered in 1859

On a curious Appearance seen in the Sun.
By R. Hodgson, Esq.

"While observing a group of solar spots on the 1st September, I was suddenly surprised at the appearance of a very brilliant star of light, much brighter than the sun's surface, most dazzling to the protected eye, illuminating the upper edges of the adjacent spots and streaks, not unlike in effect the edging of the clouds at sunset; the rays extended in all directions; and ... ng brilliancy of the ... ge telescope with ... s, and disappeared ... pe used, an equa- ...

Description of a Singular Appearance seen in the Sun on September 1, 1859. By R. C. Carrington, Esq.

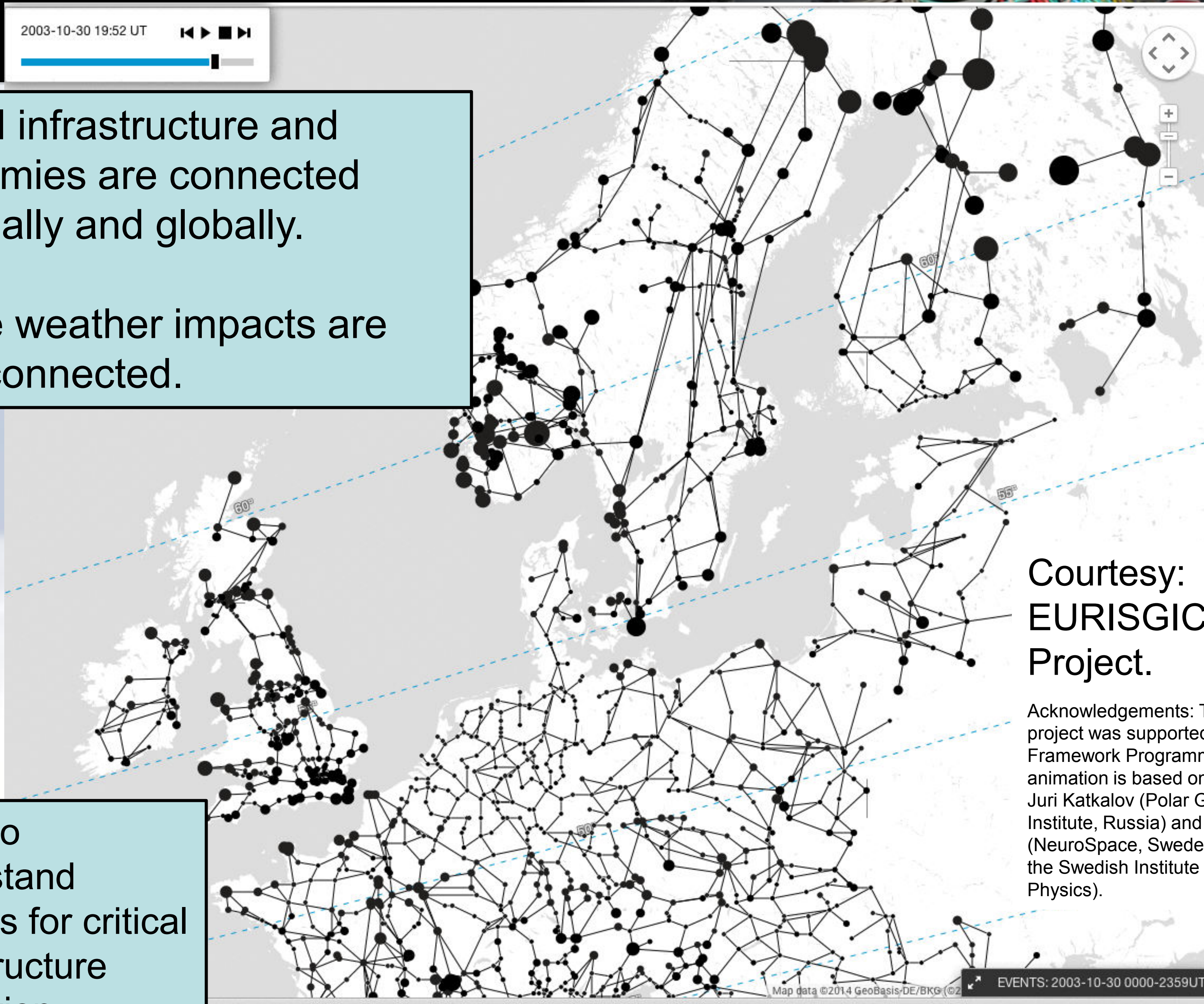
While engaged in the forenoon of Thursday, Sept. 1, in taking my customary observation of the forms and positions of the solar spots, an appearance was witnessed which I believe to be exceedingly rare. The image of the sun's disk was, as usual with me, projected on to a plate of glass coated with distemper of a pale straw colour, and at a distance and under a power which presented a picture of about 11 inches diameter. I had secured diagrams of all the groups and detached spots, and was engaged at the time in counting from a chronometer and recording the contacts of the spots with the cross-wires used in the observation, when within the area of the great north group (the size of which had previously excited general remark), two patches of intensely bright and white light broke out, in the positions indicated in the appended diagram by the letters A and B, and of the forms of the spaces left white. My



first impression was that by some chance a ray of light had penetrated a hole in the screen attached to the object-glass, by

Global infrastructure and economies are connected regionally and globally.

Space weather impacts are inter-connected.



Need to understand impacts for critical infrastructure protection.

Courtesy: EURISGIC Project.

Acknowledgements: The EURISGIC project was supported by EU's 7th Framework Programme. The animation is based on the work by Juri Katkalov (Polar Geophysical Institute, Russia) and Magnus Wik (NeuroSpace, Sweden) (both now at the Swedish Institute of Space Physics).

Recognised Space Weather Risks

- <u>High Impact:</u> Can have very high socio-economic impact on wide range of ground and space-based technological infrastructure (~$10s B to perhaps upto ~$1-2 Trillion; Baker et al., 2008).

- <u>High Likelihood of Extreme Event:</u> Comparatively high likelihood of extreme event (e.g., 23 July 2012 event – Baker et al., 2013). According to Riley (2012) probability of extreme event happening in the next decade might be as high as ~12%.

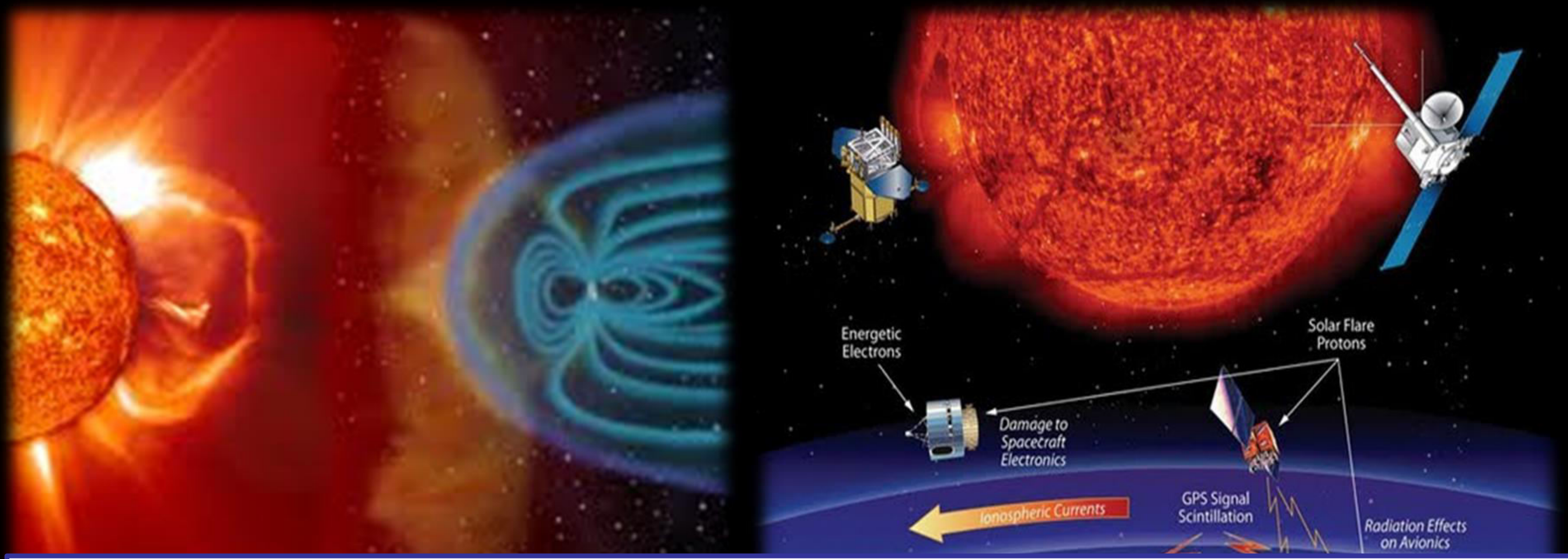
- <u>Impacts span all Space Weather Activity Levels:</u> Even modest space weather can have significant impacts (e.g., Schrijver et al., 2014; Schrijver and Mitchell, 2013).

- <u>Impacts are Regional:</u> Different geographical regions are vulnerable to different space weather; these need to be understood.

- <u>New Science and Applications Research</u>: Advances require both increased scientific understanding of the space weather processes as well as better applied research of impacts and mitigation.

Space Weather has a wide range of impacts on terrestrial and space-based infrastructure.

International co-ordination and collaboration is critical to understand and quantify impacts and for ***future critical infrastructure protection.***



UN – Long-Term Sustainability of Outer Space Activities program resulted in approval of new space weather guidelines by COPUOS in 2016.

Courtesy NASA.

Advancing space weather science to protect society's technological infrastructure: a COSPAR/ILWS roadmap

chaired by

Karel Schrijver and **Kirsti Kauristie**

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Finnish Meteorological Institute, Helsinki Finland

COSPAR site: http://tinyurl.com/swxrm

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- Michael Terkildsen; IPS Radio and Space Services, Australia
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- Nicole Vilmer; LESIA Observatoire de Paris, France

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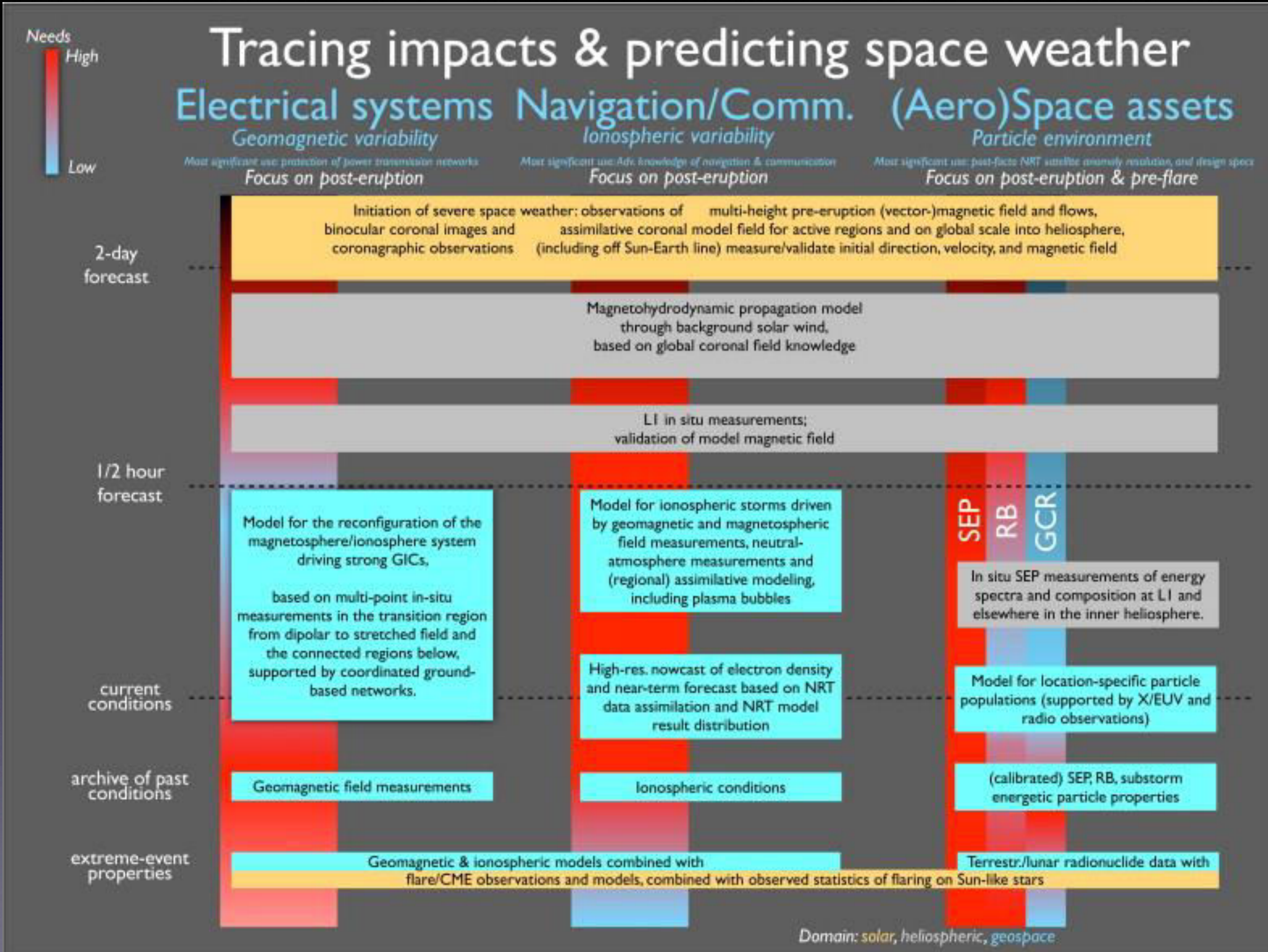
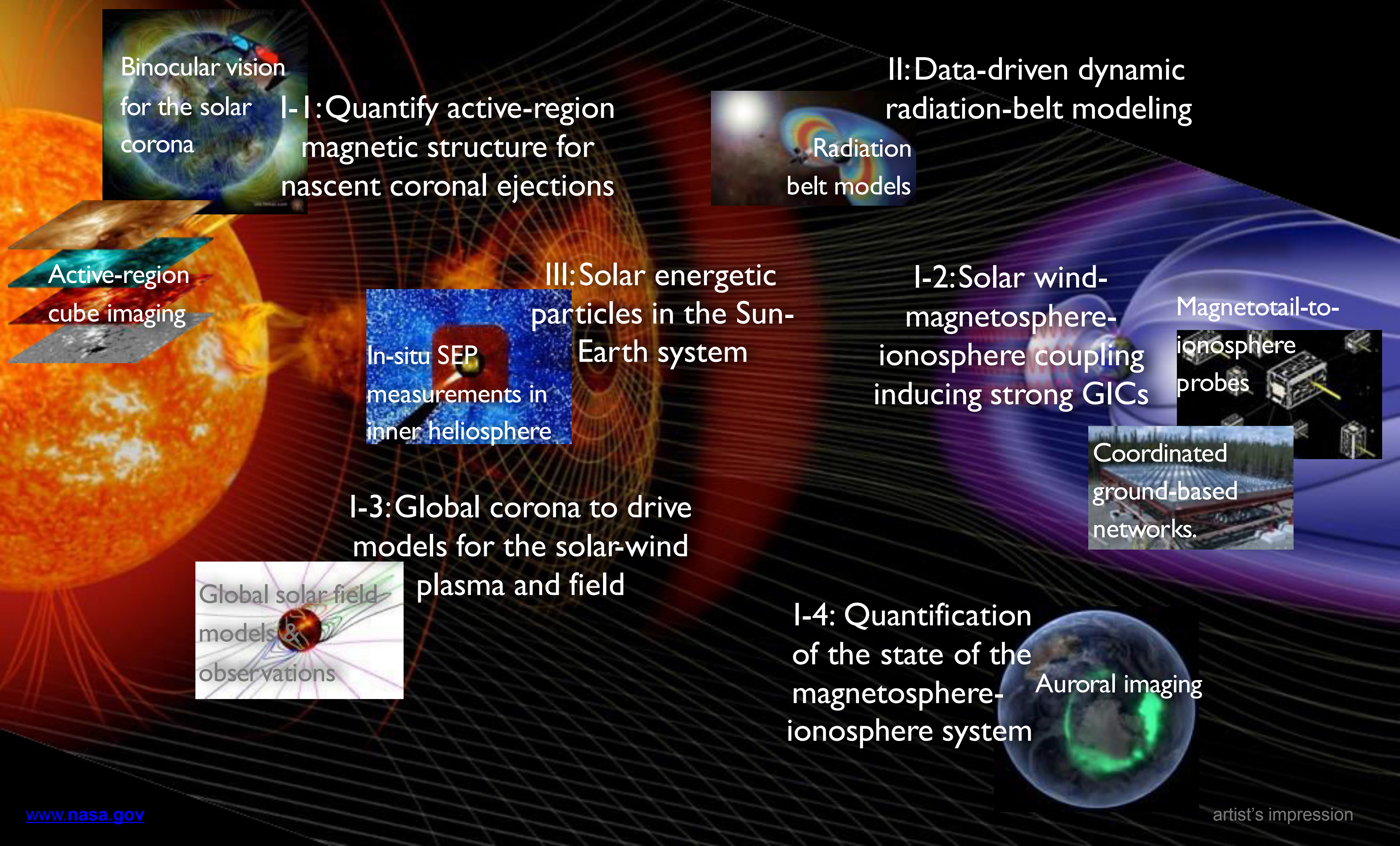

Tracing impacts & predicting space weather
Needs
High
Low
Electrical systems
Geomagnetic variability
Most significant use: protection of power transmission networks
Focus on post-eruption
Navigation/Comm.
Ionospheric variability
Most significant use: Adv. knowledge of navigation & communication
Focus on post-eruption
(Aero)Space assets
Particle environment
Most significant use: post-facto NRT satellite anomaly resolution, and design specs
Focus on post-eruption & pre-flare
2-day forecast
Initiation of severe space weather: observations of binocular coronal images and coronagraphic observations
multi-height pre-eruption (vector-)magnetic field and flows, assimilative coronal model field for active regions and on global scale into heliosphere, (including off Sun-Earth line) measure/validate initial direction, velocity, and magnetic field
Magnetohydrodynamic propagation model through background solar wind, based on global coronal field knowledge
L1 in situ measurements; validation of model magnetic field
1/2 hour forecast
Model for the reconfiguration of the magnetosphere/ionosphere system driving strong GICs, based on multi-point in-situ measurements in the transition region from dipolar to stretched field and the connected regions below, supported by coordinated ground-based networks.
Model for ionospheric storms driven by geomagnetic and magnetospheric field measurements, neutral-atmosphere measurements and (regional) assimilative modeling, including plasma bubbles
SEP
RB
GCR
In situ SEP measurements of energy spectra and composition at L1 and elsewhere in the inner heliosphere.
current conditions
High-res. nowcast of electron density and near-term forecast based on NRT data assimilation and NRT model result distribution
Model for location-specific particle populations (supported by X/EUV and radio observations)
archive of past conditions
Geomagnetic field measurements
Ionospheric conditions
(calibrated) SEP, RB, substorm energetic particle properties
extreme-event properties
Geomagnetic & ionospheric models combined with
Terrestr./lunar radionuclide data with
flare/CME observations and models, combined with observed statistics of flaring on Sun-like stars
Domain: solar, heliospheric, geospace

Deployment of new/additional instrumentation, to add to existing observational resources and to modeling capabilities to be developed soon:



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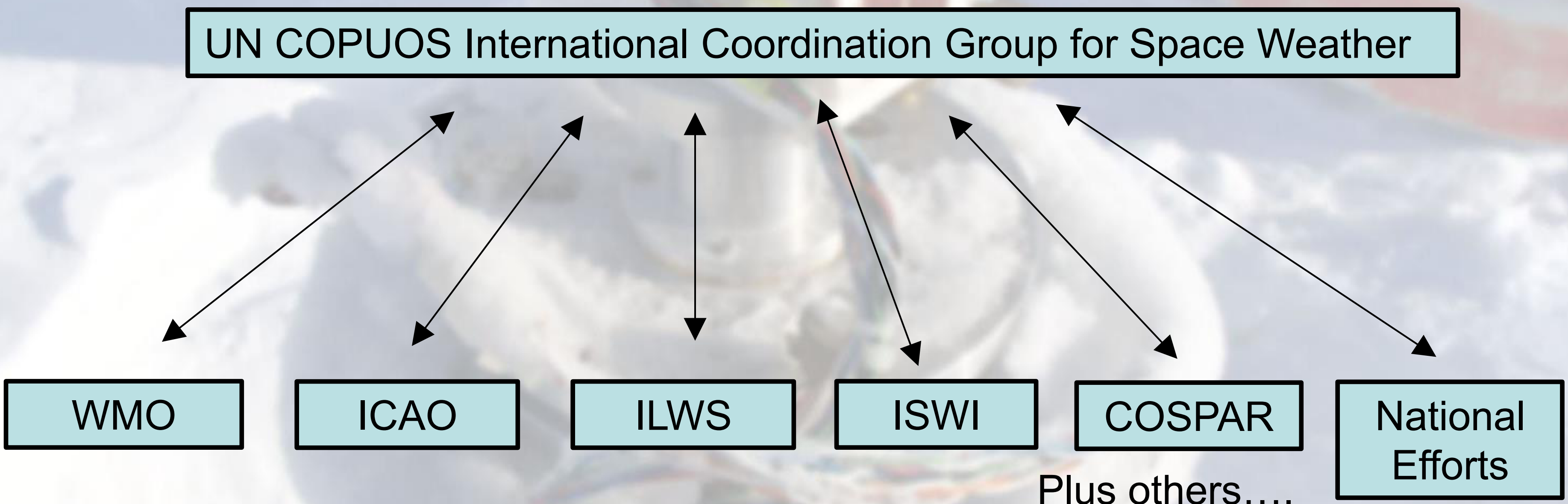
artist's impression

Active International Space Weather Efforts

UN has political role to promote and coordinate

Future COPUOS approach around new science, approved LTS guidelines, science roadmap, and impact studies



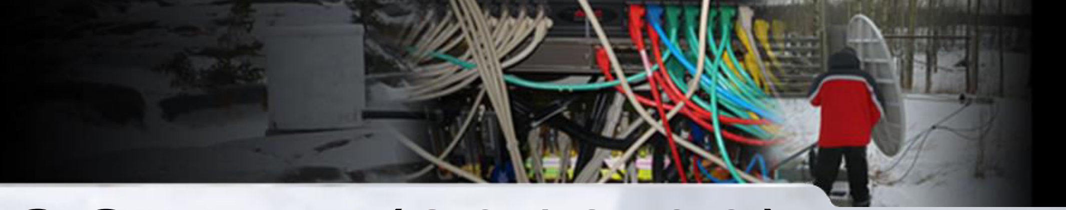
With new understanding of both increased likelihood and impact of space weather, international coordination at strategic level is essential.


Target for Improved
Space Weather Resilience
COPUOS
INTERNATIONAL COORDINATION
COPUOS
UNDERSTANDING
ASSESSMENT
SERVICES
DISSEMINATION
MODELING
OBSERVATIONS
Mitigating the effects of extreme space weather

Future COPUOS Foci (2018-30)

- WHEN: *Important to know when to act.*
  - ***International Space Weather Warning Network*** Cf. UN International Asteroid Warning Network (IAWN)?
- WHAT: *Important to know what to do.*
  - Promote study of ***socio-economic and risk impact studies*** in member states.
  - Promote engagement of ***Critical Infrastructure Protection*** administrations in Member States.
  - Promote definition of ***actionable operational responses***.
  - Improve modeling and ***Research-to-Operations*** – using UN/COSPAR to introduce new International Space Weather Action Teams (I-SWAT)

UN COPUOS has political influence for communication and coordination with and between Member States; implementation expected to be delivered by other entities (WMO, ISES, national space weather plans etc).



Future COPUOS Foci (2018-30)

- HOW: *Define appropriate mechanism/administration to meet space weather needs in UN context.*
  - Suggesting a potential ***International Coordination Meeting on Space Weather*** to kick-off of the post-2018 Space Weather actions in summer 2019
  - Proposed new ***International Coordination Group for Space Weather (ICSW)***

- SCIENCE: New science research needs to be prioritized at UN Member State and international agency level. How best to promote and achieve this?

UN COPUOS has political influence for communication and coordination with and between Member States; implementation expected to be delivered by other entities (WMO, ISES, national space weather plans etc).