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

Space Weather Expert Group

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

Hermann Opgenoorth

University of Umeå, Sweden

University of Leicester, UK

and ESF / ESSC

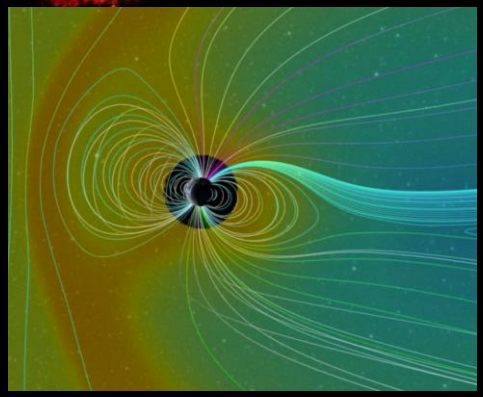
Thanks to Ian R. Mann

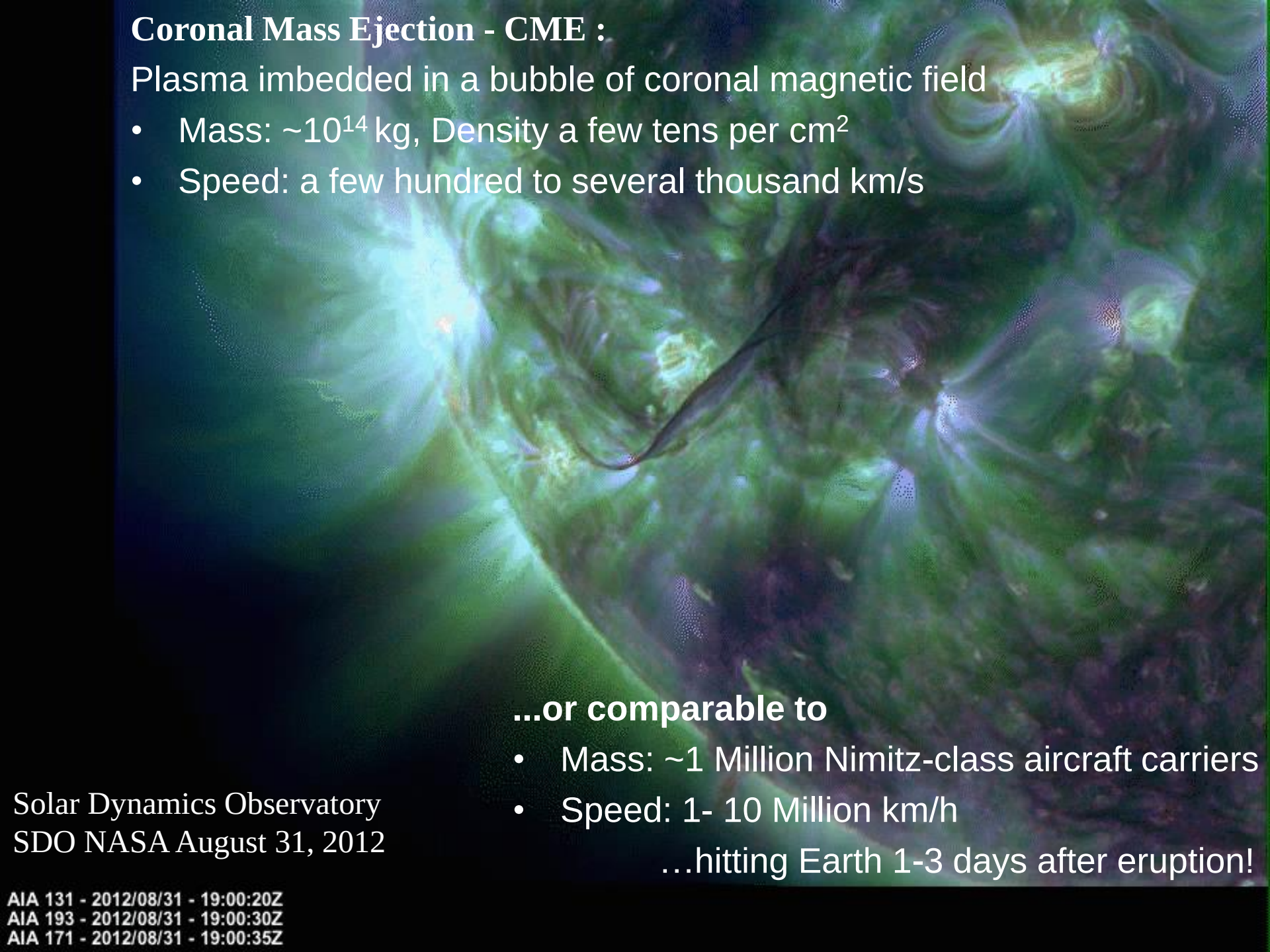
Chairman and Rapporteur UN COPOUS

Space Weather Expert Group

and Karel Schrijver, Chair of the

COSPAR-ILWS Space Weather Roadmap Team





Coronal Mass Ejection - CME :

Plasma imbedded in a bubble of coronal magnetic field

- Mass: ~10^{14} kg, Density a few tens per cm^2
- Speed: a few hundred to several thousand km/s

...or comparable to

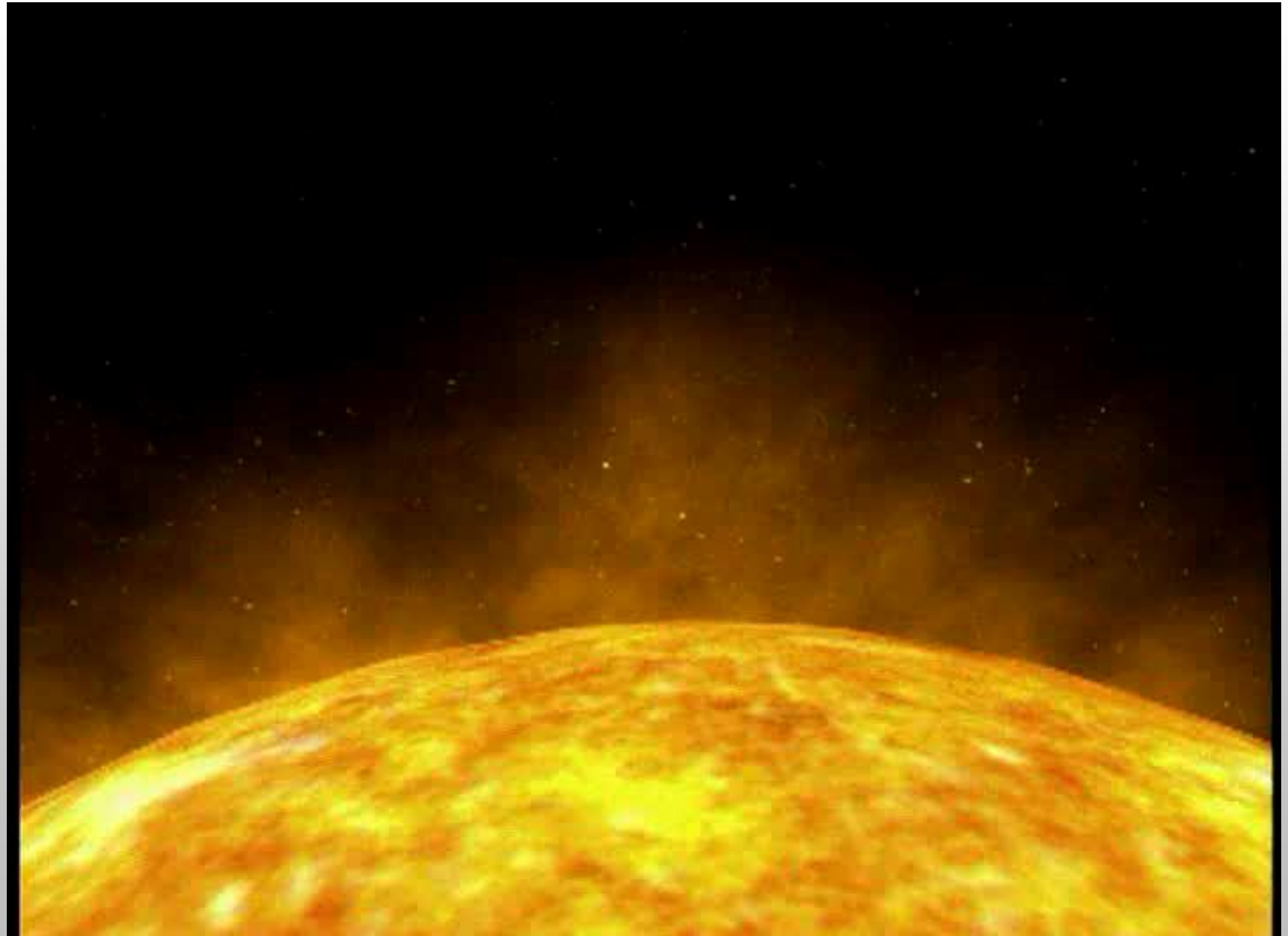
- Mass: ~1 Million Nimitz-class aircraft carriers
- Speed: 1- 10 Million km/h

…hitting Earth 1-3 days after eruption!

Solar Dynamics Observatory
SDO NASA August 31, 2012

AIA 131 - 2012/08/31 - 19:00:20Z
AIA 193 - 2012/08/31 - 19:00:30Z
AIA 171 - 2012/08/31 - 19:00:35Z

CME-Earth Interaction

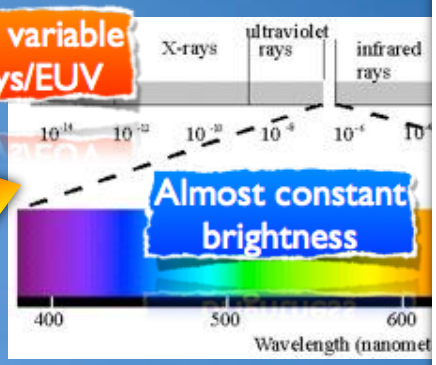


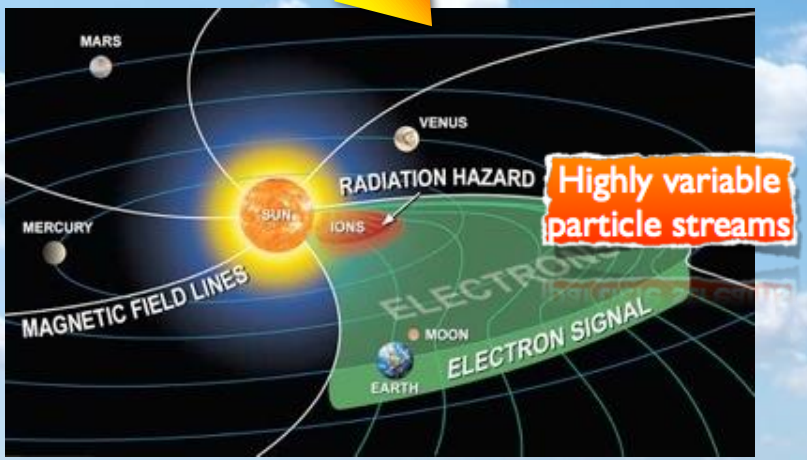
What the Sun sends our way

Light (X-ray to radio)

Magnetized wind

Particle radiation





Geomagnetic storms: couple into power grids, cause ionospheric disturbances affecting satellite-based navigation.

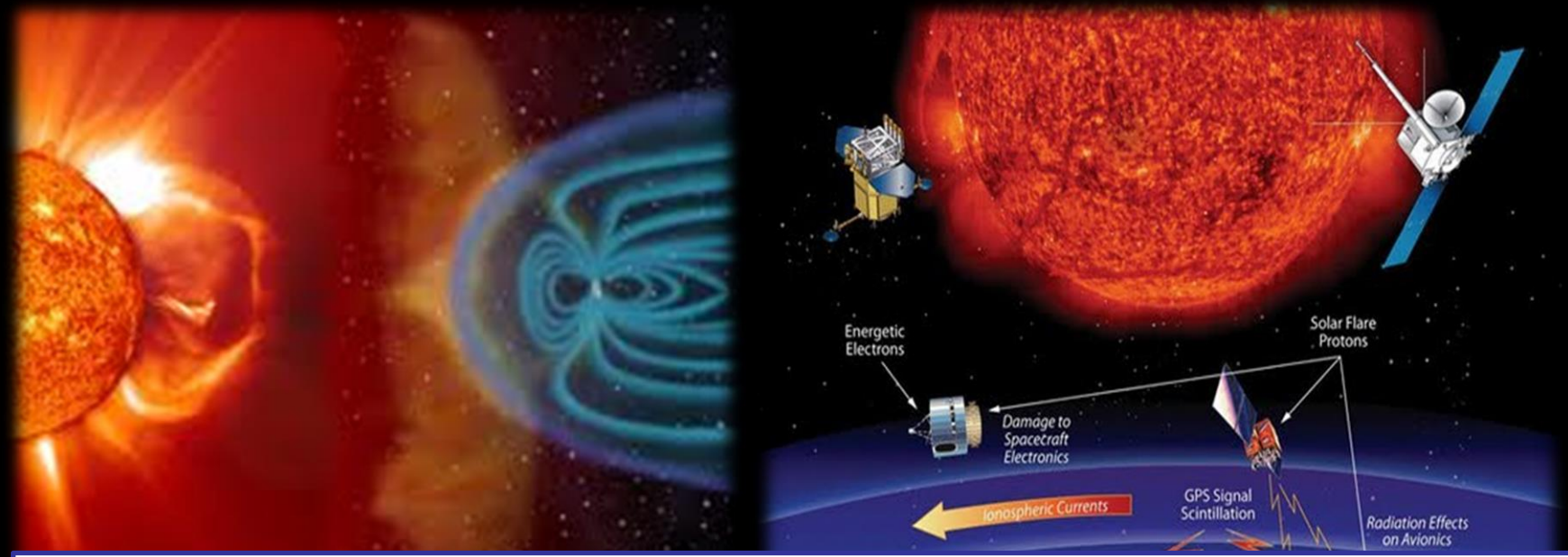
Aurorae

Radiation storms: hazard to astronaut health and satellite function; affects high-latitude radio comm.; position errors on navigation.

Ionospheric storms: Scintillations and GPS signal loss, time stamp problems, Radio blackouts. Satellite drag affecting orbits and re-entry.

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.

Space Weather Risks

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

- **High Impact:** Can have very high socio-economic impact on wide range of ground and space-based technological infrastructure (~ 10s B$ to perhaps up to ~1-2 Trillion $ - e.g., Baker et al., 2008).

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

- **Impacts are Regional:** Different geographical regions are vulnerable to different space weather; these differences need to be understood.

- **New Science and Applications Research:** Advances in SWx efforts require both increased basic scientific understanding of the space weather processes as well as a better applied research of impacts and mitigation.

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

chaired by

Karel Schrijver and **Kirsti Kauristie**

Lockheed Martin Adv. Techn. Lab, Palo Alto, CA — Finnish Meteorological Institute, Helsinki Finland

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

Advances in Space Research 55, 2745 (2015)

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- Michael Terkildsen; IPS Radio and Space Services, Australia
- Cesar Valladares; Boston College, USA
- Nicole Vilmer; LESIA Observatoire de Paris, France

science.**nasa.gov**

Deployment of new/additional instrumentation, to add to existing observational resources and to modeling capabilities to be developed in international collaboration

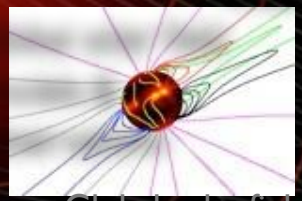
Binocular vision for the solar corona

I-1: Quantify active-region magnetic structure for nascent coronal ejections

Active-region cube imaging

III: Solar energetic Particles in the Sun-Earth System

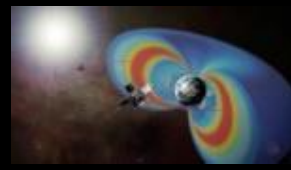
In-situ SEP measurements in inner heliosphere



Global solar field models & observations

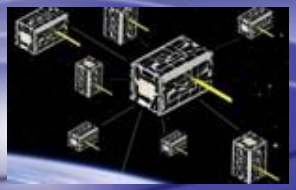
I-3: Global corona to drive models for the solar-wind plasma and field

II: Data-driven dynamic radiation-belt models



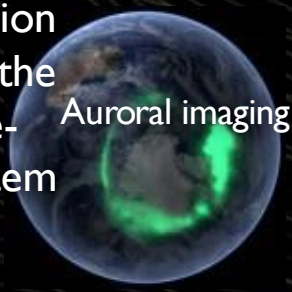
Magnetotail-to-ionosphere probes

I-2: Solar wind-magnetosphere-ionosphere coupling inducing strong GICs



Coordinated ground-based networks.

I-4: Quantification of the state of the magnetosphere-ionosphere system



Auroral imaging

artist's impression

Heritage of Space Weather in COPUOS

- Builds on work of Expert Group C (Space Weather) in the Long-Term Sustainability of Outer Space Activities (LTS) of the UN Committee on Peaceful Uses of Outer Space (COPUOS). 2011- 2015.
- COPUOS has two Subcommittees: Scientific and Technical Subcommittee (STSC) and the Legal Subcommittee.
- STSC approved a regular Space Weather agenda item in 2013, following the ILWS 10th Anniversary workshop in Vienna
- New Space Weather Expert Group with Rapporteur Ian Mann, reporting to UN COPUOS under permanent agenda item since Feb. 2015 in Vienna.

Opportunity to define the activities of the Space Weather Expert Group to meet needs of international community for 2018-2030.

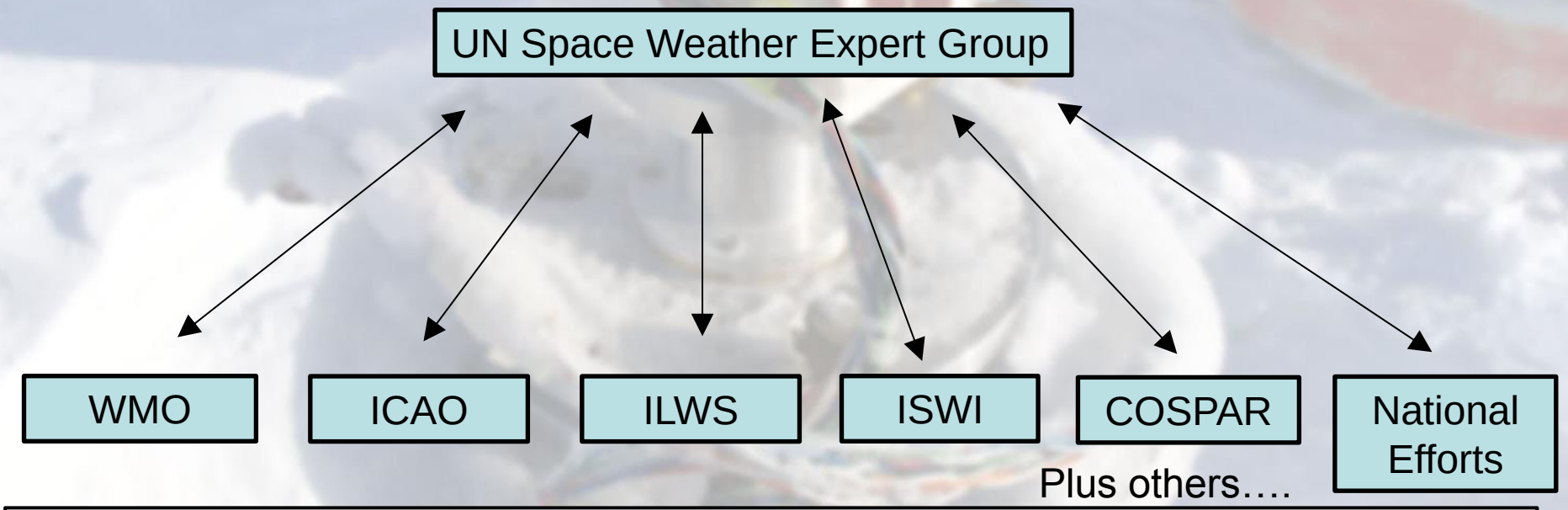
UN Space Weather Expert Group
(UN COPUOS STSC)

- Mandate: promote awareness, provide guidance, and enable communication and cooperation in space weather related activities among Member States and related national and international organisations.

- Specific actions and definite outcomes: Ensure that any future work is complementary to other space weather coordination activities such as those within the WMO, ISES, COSPAR, ILWS, ICAO etc.

Active International Space Weather Efforts

UN has political role to both **promote** and **coordinate!**



With new understanding of both increased likelihood and potential severity of impacts of space weather, international coordination will become essential.

Potential Prioritisation of Space Weather in UN COPUOS for 2018-30

- UN COPUOS defined 7 Thematic Priorities for 2018-2030.
- Space Weather is considered as Thematic Priority 4: Developing an International Framework for Space Weather Services.

  (TP-4 report available for download from UN).
- All 7 Thematic Priorities were discussed at the June 2018 COPUOS meeting during UNISPACE+50.

EG will develop a strategy over next three years

Potential COPUOS SWx Foci (2018-30)

- **<u>WHEN</u>:** *Important to know when to act.*
  - ***International Space Weather Warning Network?***
- **<u>WHAT:</u>** *Important to know what to do.*
  - Promote ***socio-economic and risk impact studies*** in member states.
  - Promote the engagement of ***Critical Infrastructure Protection*** **Administrations** in Member States.
  - Promote the definition of ***actionable operational responses***.
  - Improve modeling and R2O – SWx action teams ISWAT under UN/COSPAR MOU
- **<u>HOW:</u>** *Define appropriate mechanism/administration to meet space weather needs in UN context.*
  - EG is suggesting a potential ***International Meeting/Workshop on Space Weather*** *in 2019* to kick-off of the post-2018 Space Weather actions.
  - Need to define future administration in UN context – proposal to form an ***International Coordination Group on Space Weather (ICGSW)*** in 2020.
- **<u>SCIENCE:</u>** New science research needs to be prioritized at UN Member State and international agency level. Plan to achieve this through UN promotion and the COSPAR Panel on SWx and community-based I-SWAT activities

UN COPUOS has political influence for **communication** and **coordination** with and between Member States - **implementation** expected to be delivered by other entities (WMO, COSPAR,…, and regional and national space weather actions etc).

Future UN Foci for 2018-30

- Space Weather Expert Group via TP-4 proposes the formation of potential new ***"International Coordination Group for Space Weather" (ICGSW).***

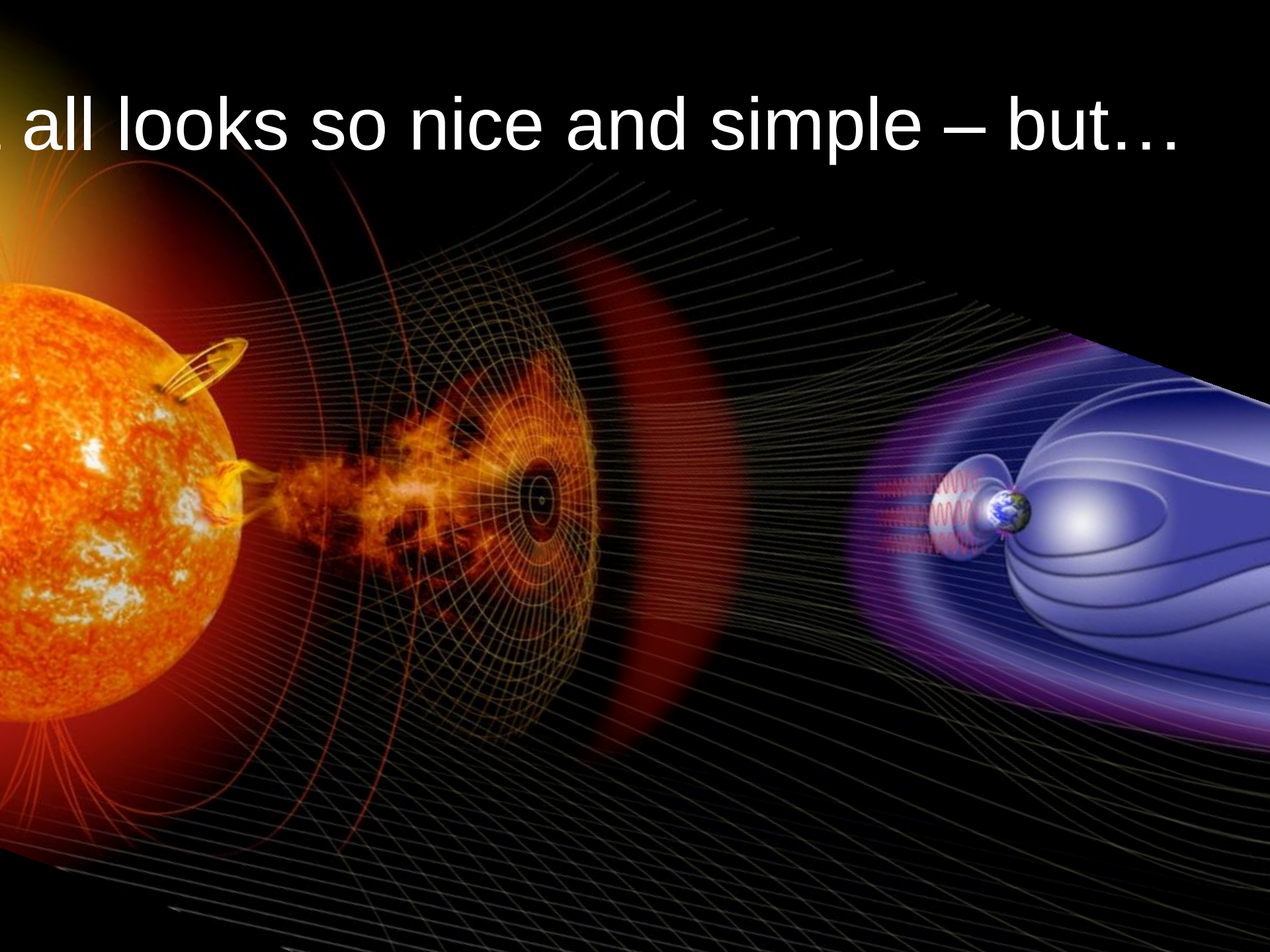
- By incorporating formal membership of appropriate space weather stakeholder organisations the ICGSW can provide a forum to effectively promote improved international communication and collaboration,.

- If approved, the ICGSW could replace the UN Space Weather Expert Group with appropriately modified Terms of Reference and Mandate.

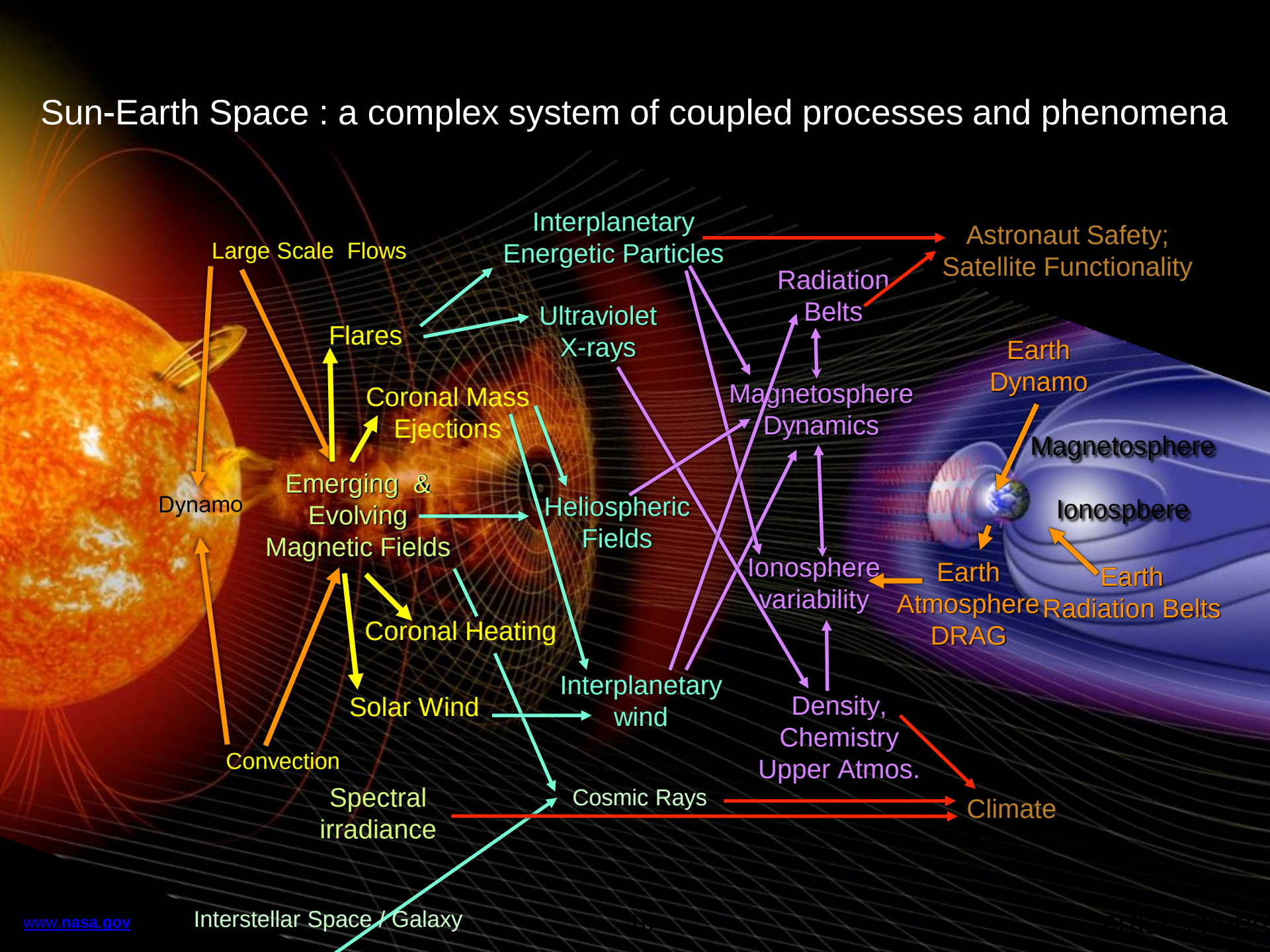
….see also publication: "Mann et al., "*International Collaboration Within the United Nations Committee on the Peaceful Uses of Outer Space: Framework for International Space Weather Services (2018–2030)*" **J**. ***Space Weather***, 2018".

UN COPUOS has political influence for **communication** and **coordination** with and between Member States - **implementation** expected to be delivered by other entities (WMO, COSPAR,…, and regional and national space weather actions etc).

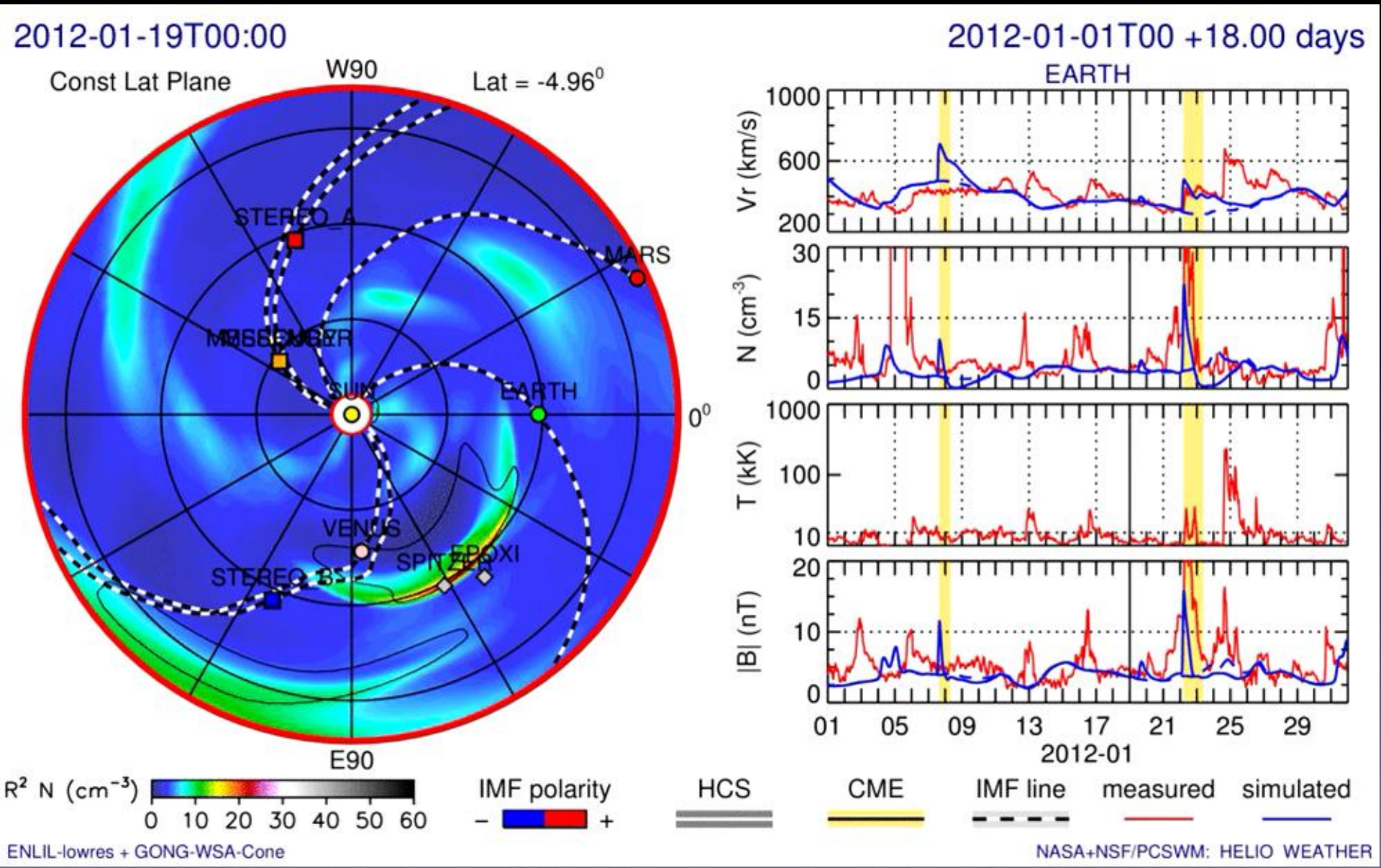
all looks so nice and simple – but…



Sun-Earth Space : a complex system of coupled processes and phenomena



MHD Model of CME Propagation in Solar Wind



DOUBLE CME DOES NOT REALLY MERGE EN ROUTE TO EARTH => NON-MHD

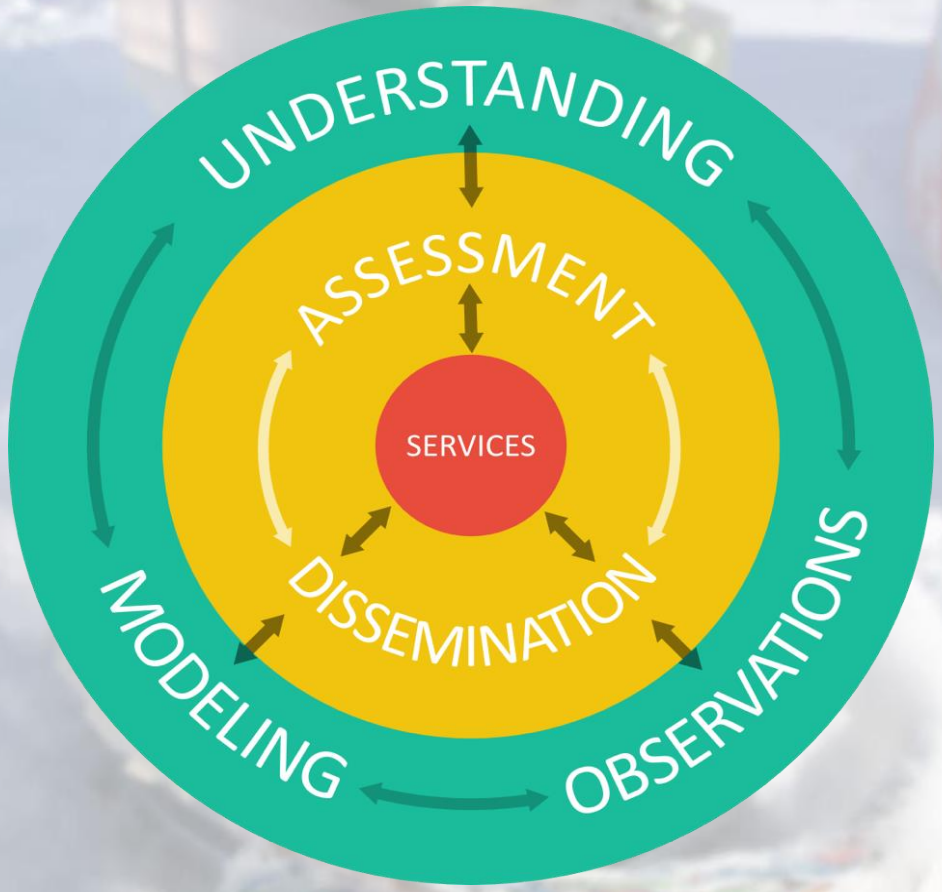
COSPAR PSW: See Space Weather as a "Shooting Target"

Research, Observations, Modeling, and consequent Assessment & Dissemination are Critical for Improving Operational Services

RESEARCH

Major Efforts are still required for **Enabling Research** to improve space weather

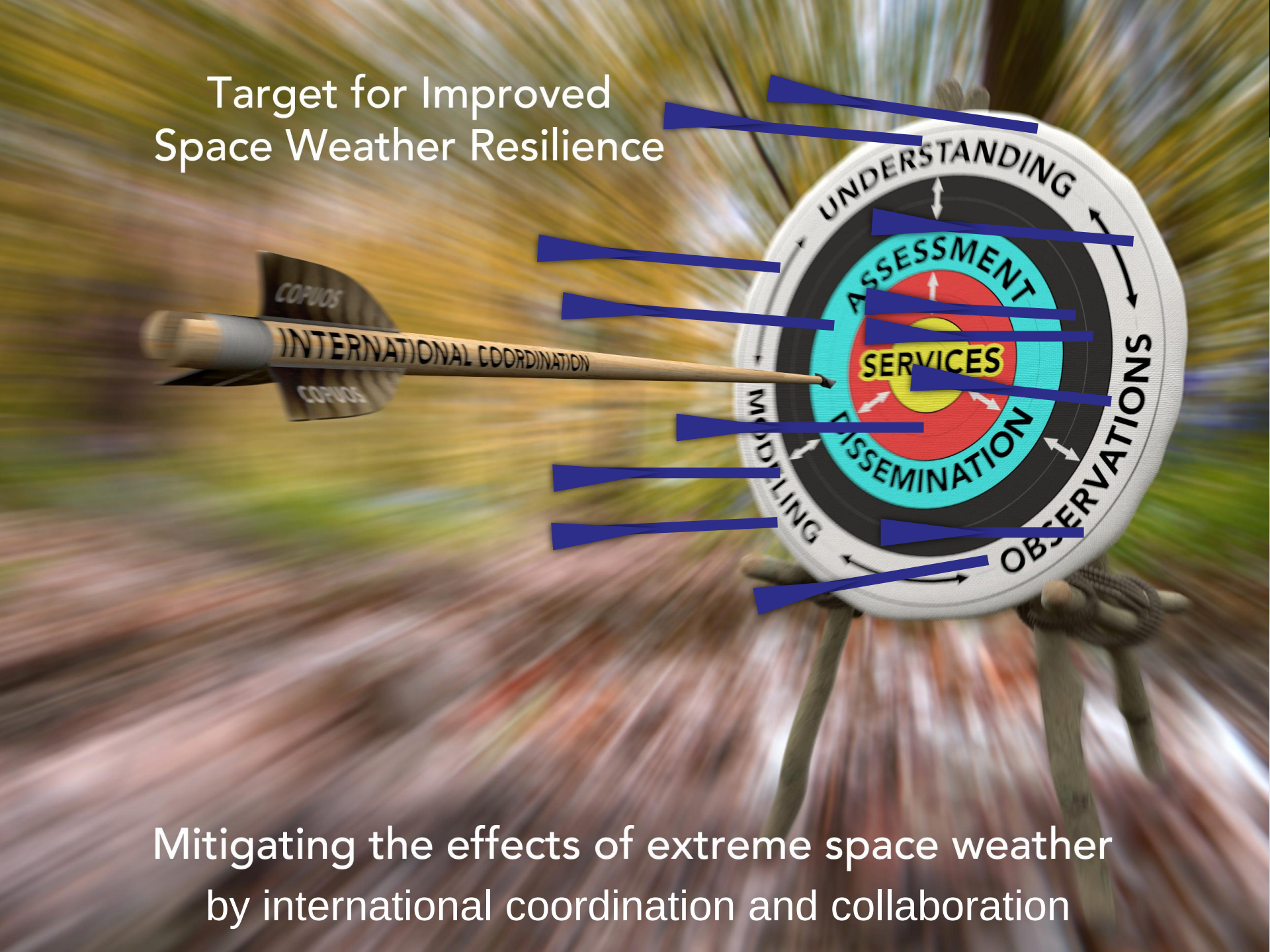
SERVICES



R2O-O2R

Connecting **Research** with **Operational Services** interactively

An iterative coordination between Research and Operational Organizations is required


Target for Improved
Space Weather Resilience
COPUOS
INTERNATIONAL COORDINATION
COPUOS
UNDERSTANDING
ASSESSMENT
SERVICES
DISSEMINATION
OBSERVATIONS
Mitigating the effects of extreme space weather
by international coordination and collaboration

Contacts:

Please provide any discussion and feedback items directly to the Members of the Expert Group - or by email to

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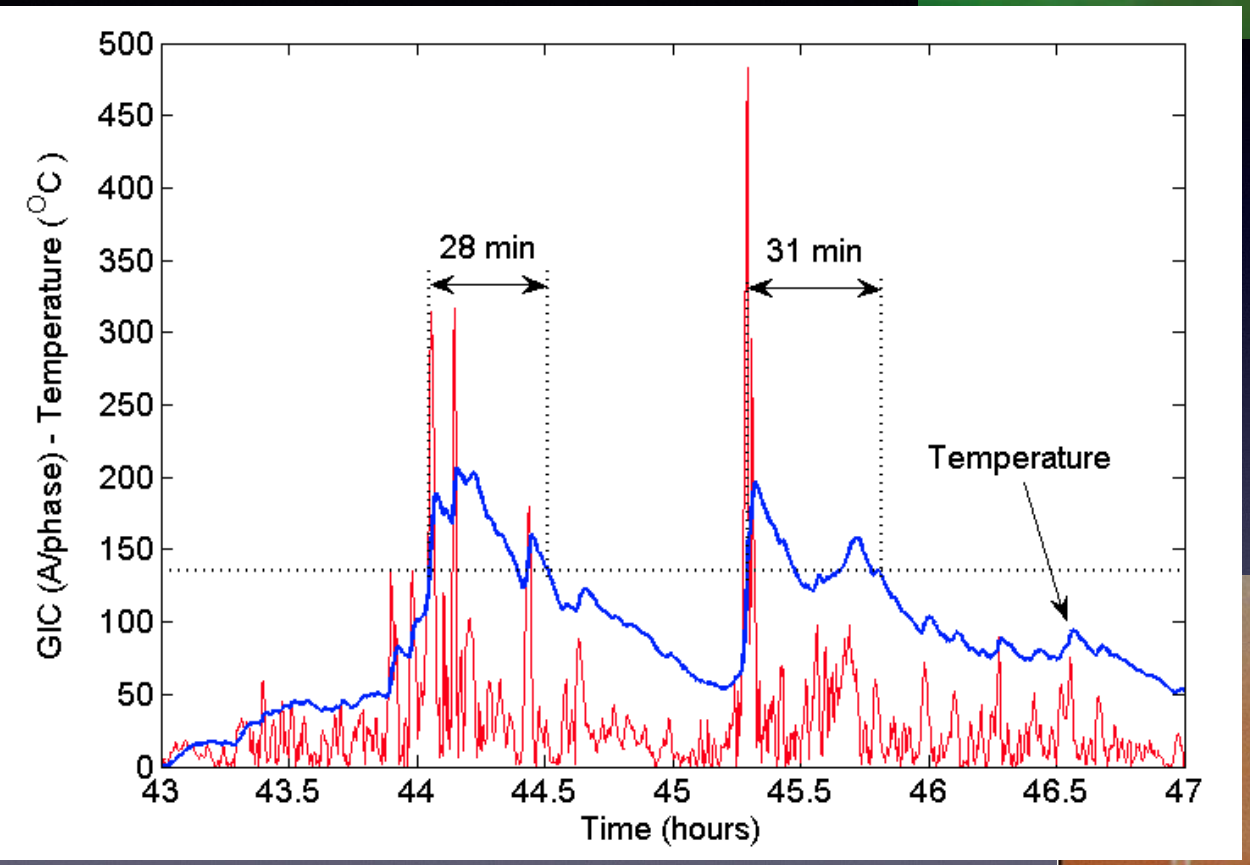
- Dr. Mamoru Ishii, NICT(Japan) (mishii@nict.go.jp)

etc.


michael ericsson : visuals

Space Weather Damage

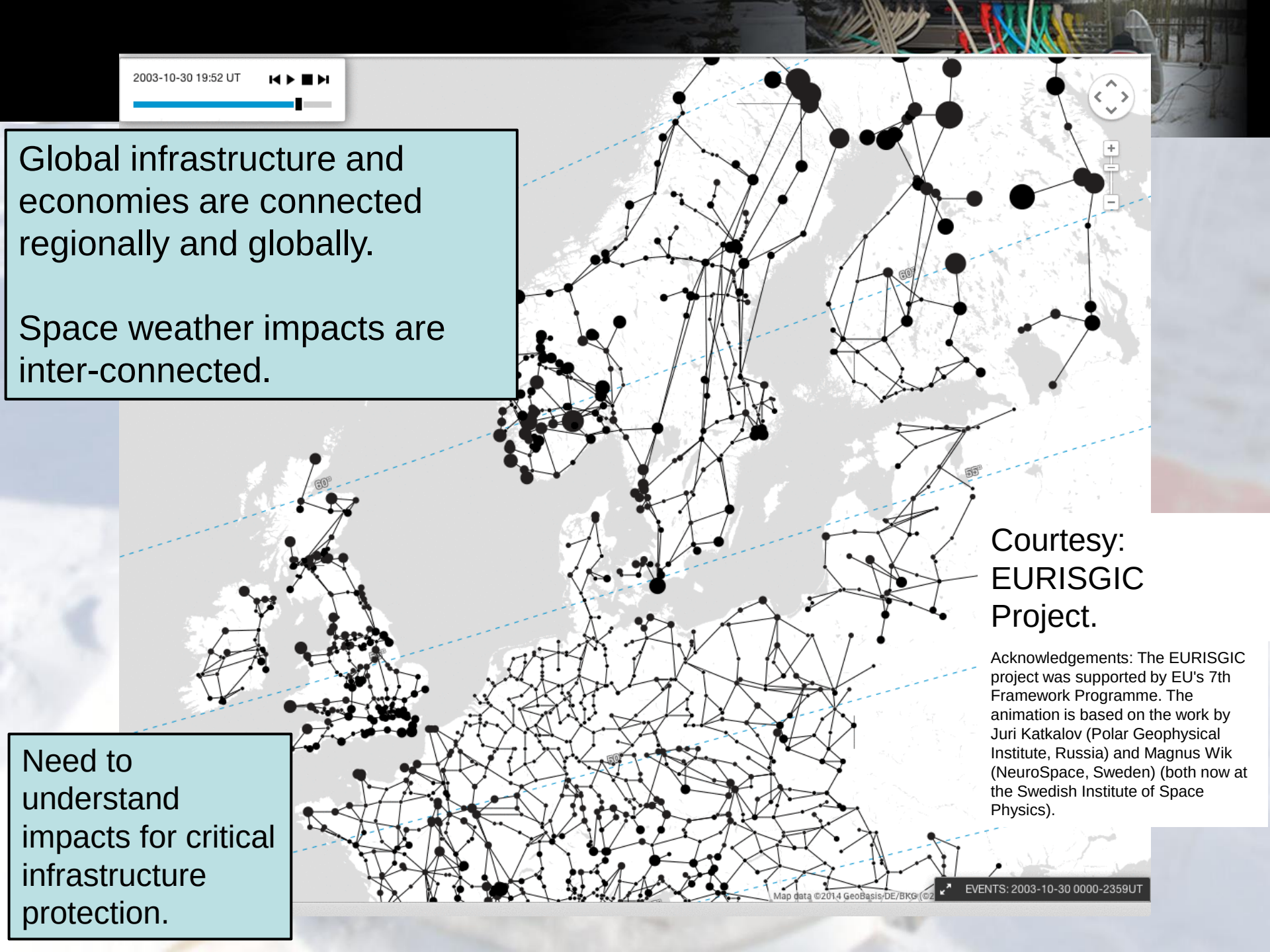


Sample tie plate temperature calculation for a transformator exposed to multiple events of Geomagnetically Induced Currents (GICs) during a magnetic storm.

Blue trace is incremental temperature and
Red trace is the magnitude of the GIC/phase.

From NERC report

"The Beauty and the Beast"


2003-10-30 19:52 UT
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).
EVENTS: 2003-10-30 0000-2359UT

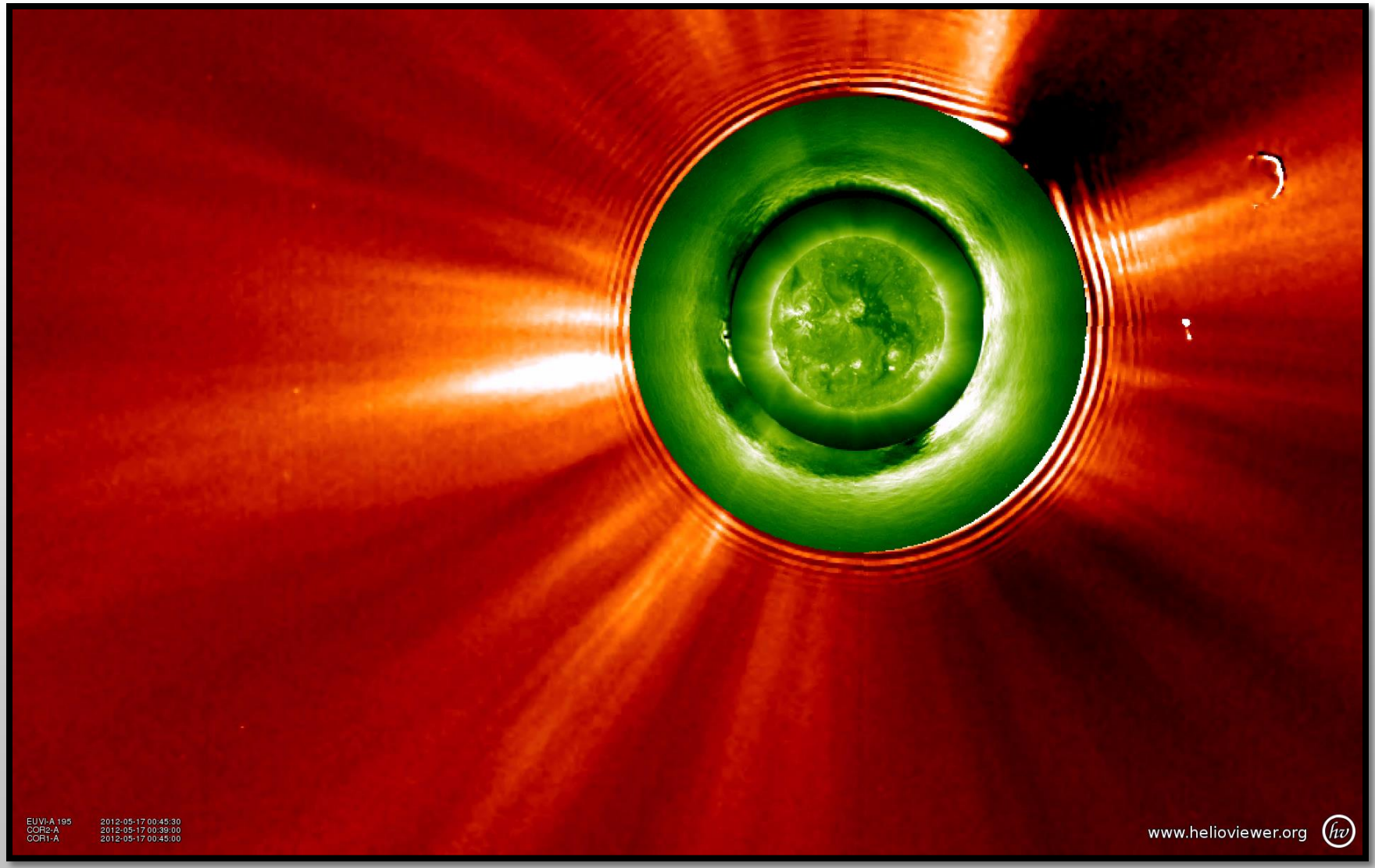
S: Space weather origins at the Sun	H: Propagation of transient through evolving ambient	G: Coupled magnetosphere Ionosphere-atmosphere	Impacts and primary user groups
Input to heliosphere and geospace	*input to geospace*	*response to solar drivers*	
S1: Long-term solar variability. S2: Solar magnetic field & heating. Evolving magnetized solar wind and spectral irradiance. S3: Solar eruptions: (a) flares and enhanced electromagnetic emissions; (b) high energy particle fluxes; (c) CMEs	H1: Evolving ambient heliosphere. H2. CME structure, evolution and propagation through heliosphere. H3. SEP and GCR in heliosphere.	G1: Geomagnetic environment. G3a: Atmosphere variability. G2b: Ionosphere variability. G3: Near-Earth radiation and plasma environment	*Climate* *Electric power systems, GICs* *Satellite/debris drag* *Navigation Communication* *(Aero)space assets functions* *Human exploration*

SS: Space weather in solar system and beyond.

Overarching Activities:

TE: Testing and Evaluation IA: Information Architecture EO: Education & Outreach

Solar Eruptive Events



STEREO A observations of CME/eruptive flare of 17 May 2012