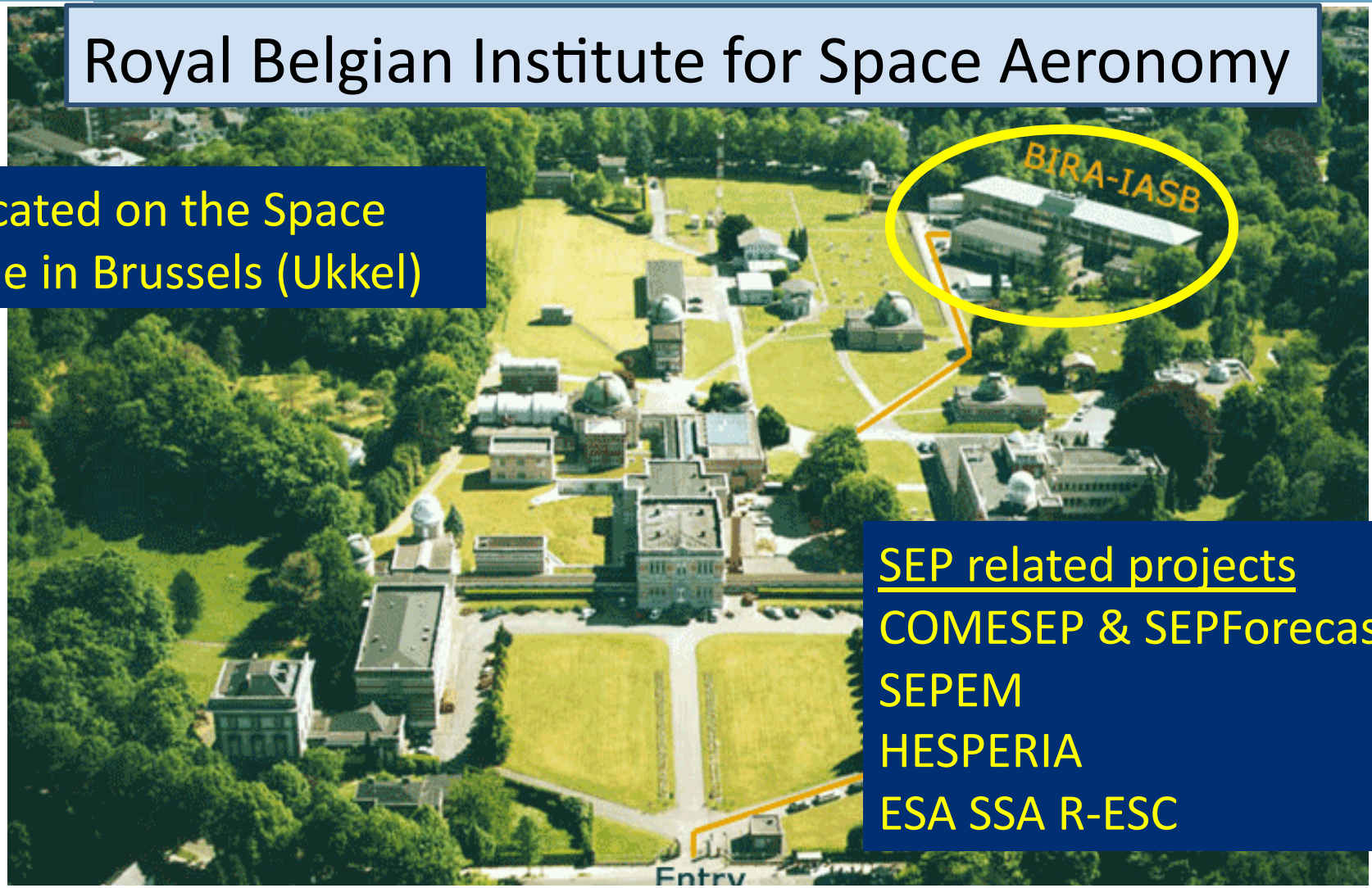

BIRA·IASB
aeronomie·be
Royal Belgian Institute for Space Aeronomy
Institut royal d'Aéronomie Spatiale de Belgique
Koninklijk Belgisch Instituut voor Ruimte-Aeronomie
COMESEP, SEPForecast and other SEP related activities at BIRA-IASB
Mark Dierckxsens
8th CCMC Workshop
April 10-15, 2016

BIRA-IASB

Royal Belgian Institute for Space Aeronomy



Located on the Space Pole in Brussels (Ukkel)

SEP related projects
COMESEP & SEPForecast
SEPEM
HESPERIA
ESA SSA R-ESC

COMESEP & SEPFORECAST

The COMESEP Project

COronal Mass Ejections and Solar Energetic Particles: forecasting the space weather impact

http://www.comesep.eu/

- European Commission 7th Framework Programme (FP7)
- Starting date: 01 Feb. 2011
- Duration: 36 months
- Coordinator: Norma B. Crosby (BIRA-IASB)
- 7 Teams and 3 External Collaborators

This project has receiving funding from the European Commission FP7 Project COMESEP (263252).

COMESEP Objectives

Overall Goal

- Build an operational space weather alert system to forecast SEP radiation storms and geomagnetic storms based on risk analysis

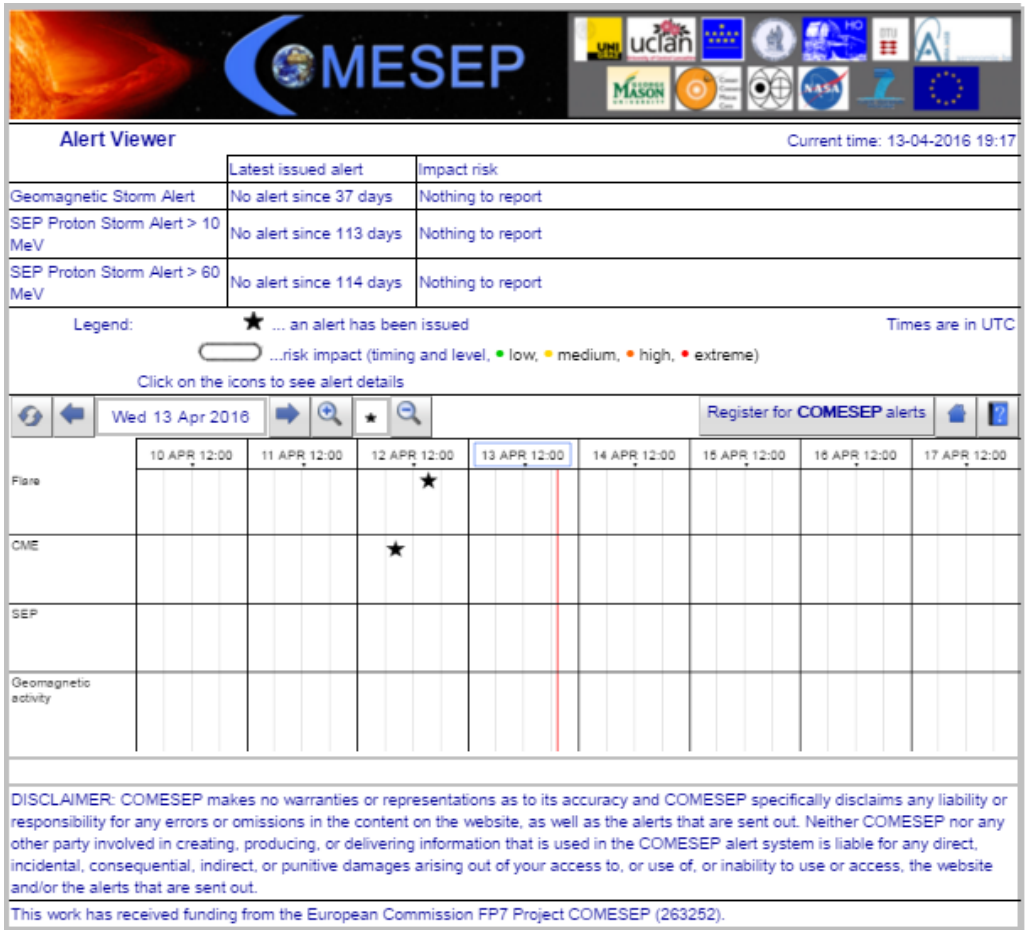
Main Objectives

- Optimize models and forecasting methods based on scientific results
- Link SEP and inter-planetary CME forecast tools with real-time automated CME detection
- Integrate scientific results, individual detection tools and models into an automated “start-to-end-service” alert system
- Disseminate alerts to the space weather community.

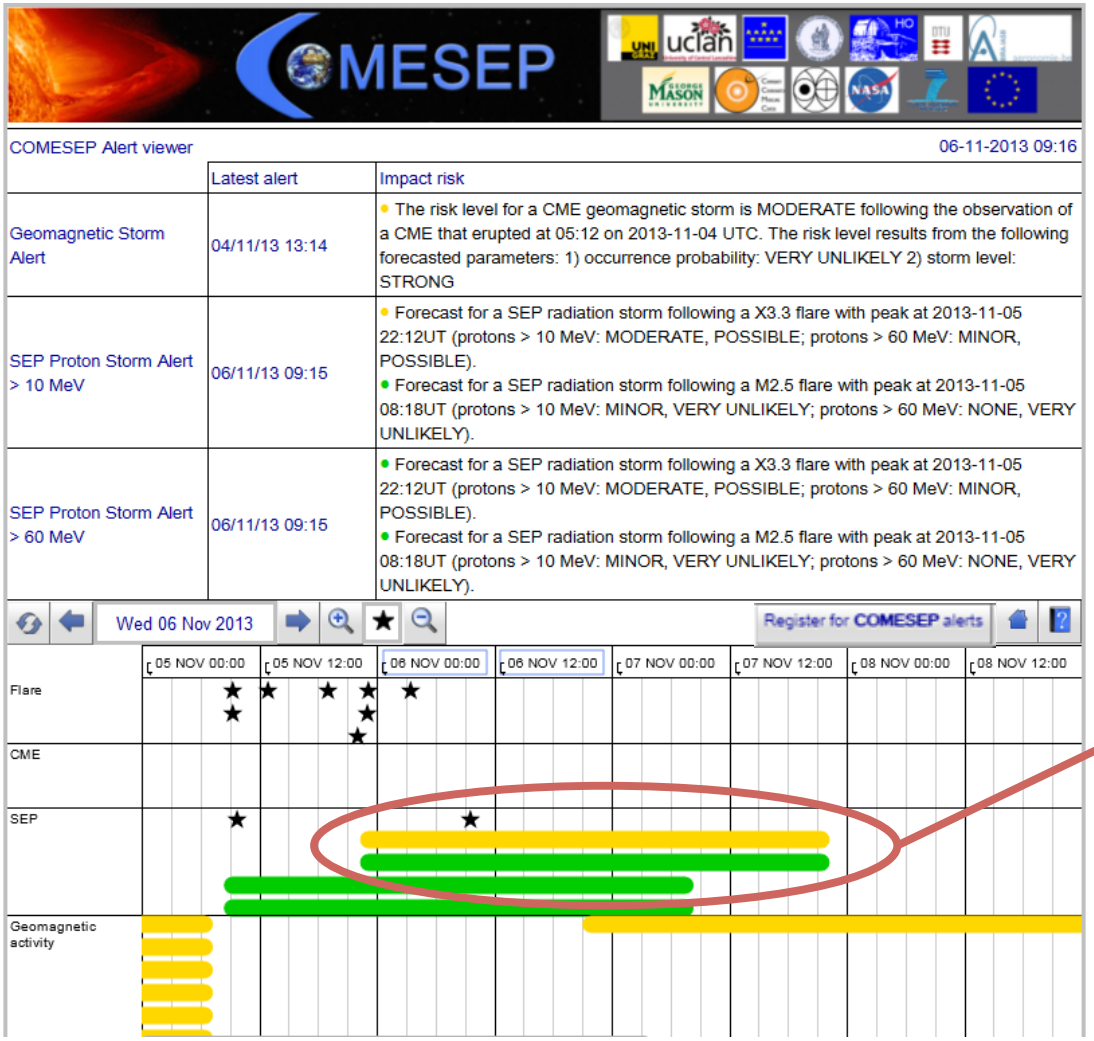
COMESEP Alert System

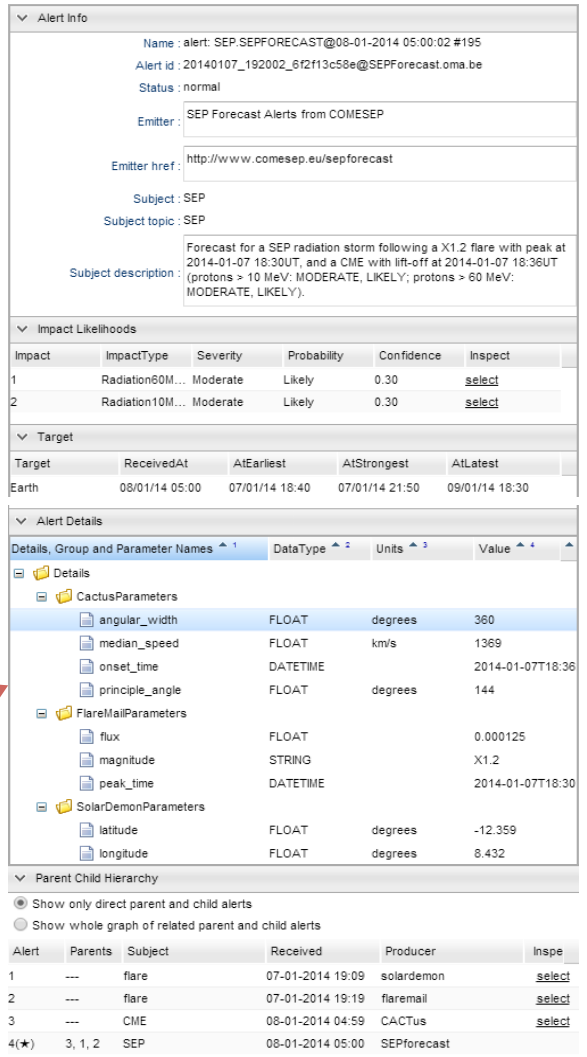
- Launched in November 2013
- Provides alerts for
  - Geomagnetic storms:
    - "Event based"
    - "Next 24 hours"
  - SEP (proton) storms:
    - E > 10 MeV
    - E > 60 MeV
- Alerts displayed on web interface
- Alerts can be received through email subscription

http://www.comesep.eu/alert



COMESEP Alert System





COMESEP Risk Matrix

- Geomagnetic and SEP radiation storm alerts are based on the COMESEP definition of risk.

Risk Levels:

L = LOW

M = MEDIUM

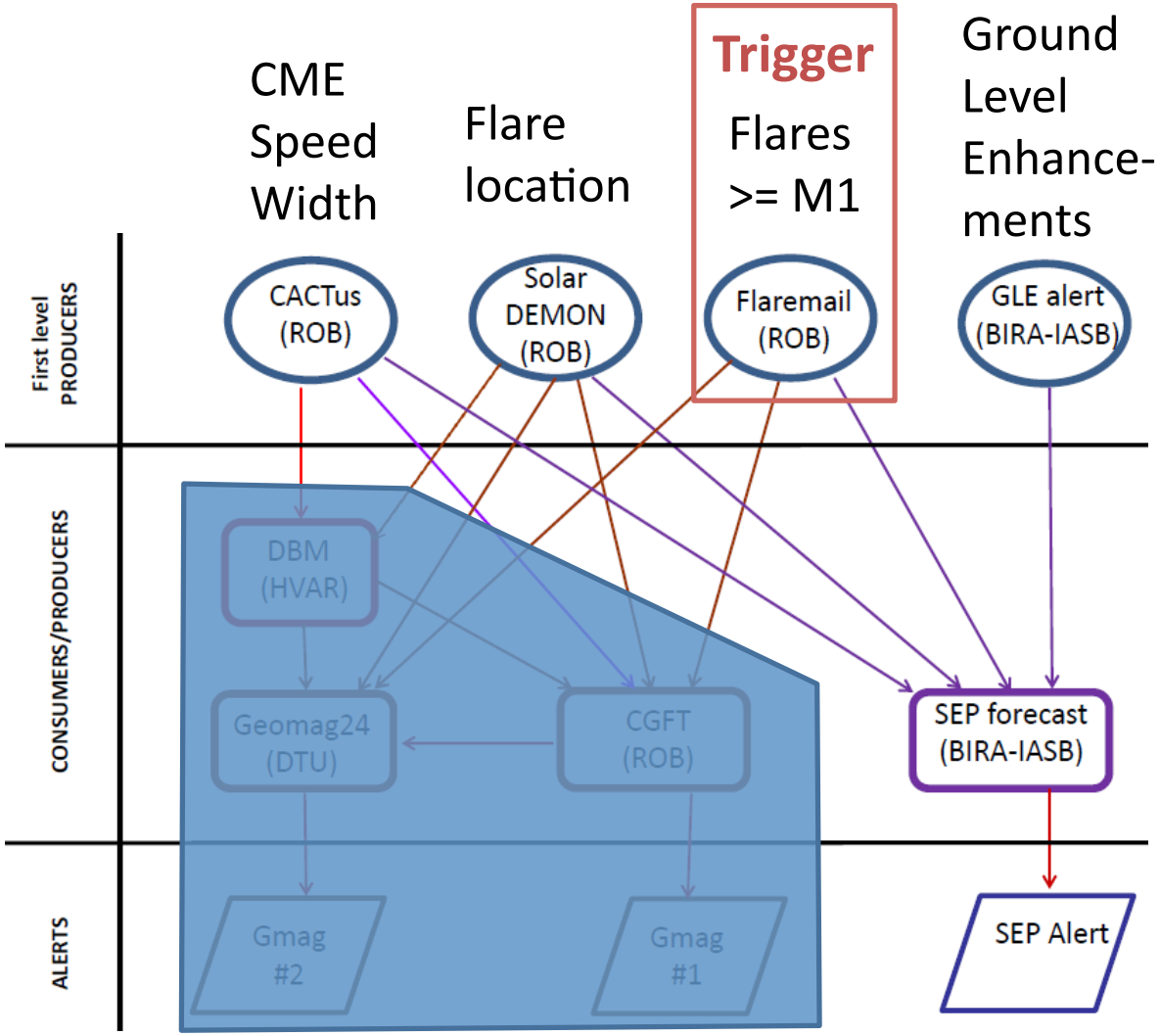
H = HIGH

E = EXTREME

Arrival of CME / Likelihood of occurrence						
Ongoing (100%)	L	M	H	H	E	E
Very likely (90-100%)	L	M	H	H	E	E
Likely (70-90%)	L	M	M	H	H	E
Possible (40-70%)	L	L	M	M	H	E
Unlikely (10-40%)	L	L	M	M	H	H
Very Unlikely (0-10%)	L	L	L	M	M	H
Storm Level	None	Minor	Moderate	Strong	Severe	Extreme
Geomagnetic |Dst| in nT	<50	50-100	100-200	200-300	300-400	>400
SEP peak flux > 10 MeV in $s^{-1}sr^{-1}cm^{-2}$	$<10^1$	10^1-10^2	10^2-10^3	10^3-10^4	10^4-10^5	$>10^5$
SEP peak flux > 60 MeV in $s^{-1}sr^{-1}cm^{-2}$	$<7.9\times10^{-2}$	7.9×10^{-2} - 1.4	1.4 - 2.5×10^1	2.5×10^1 - 4.5×10^2	4.5×10^2 - 7.9×10^3	$>7.9\times10^3$
Kp	<5	5	6	7	8	9

COMESEP SEPForecast

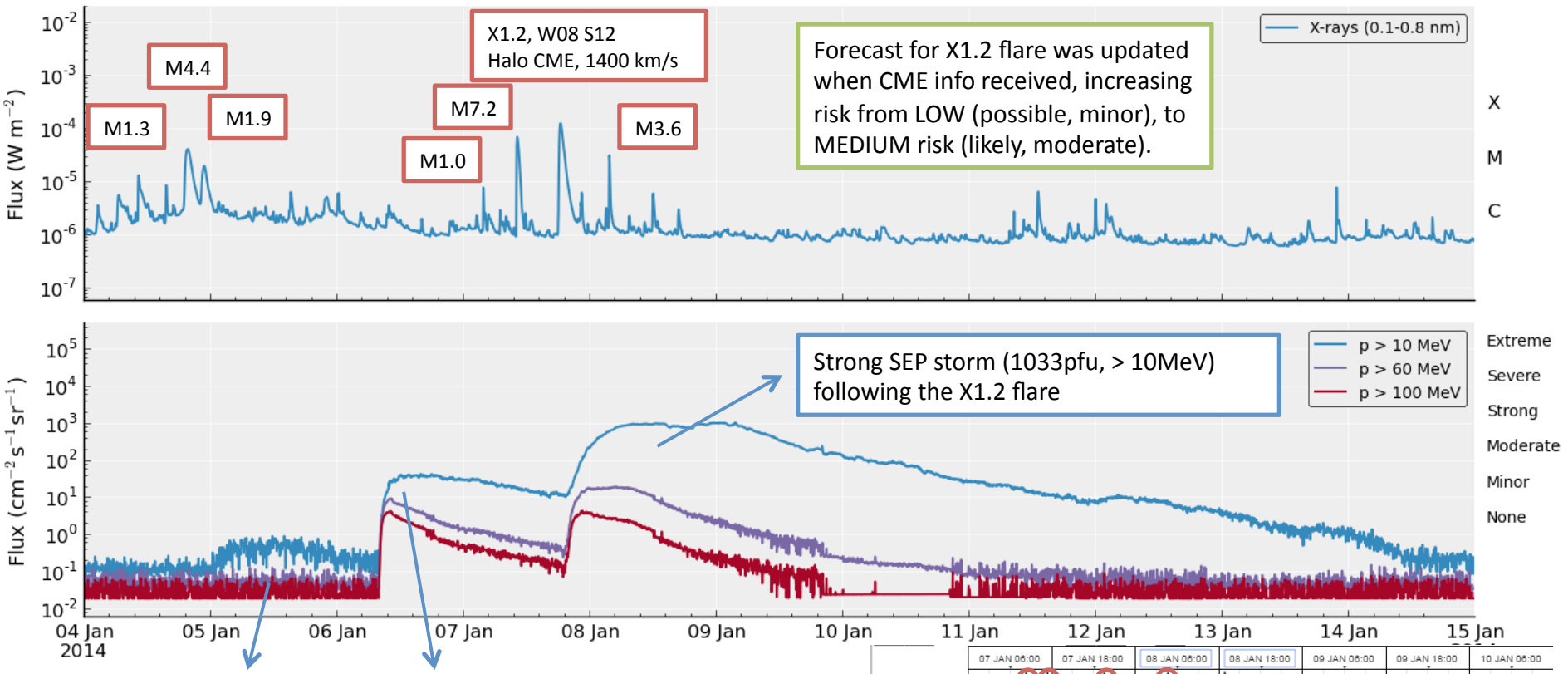
- SEPForecast depends on various other alert tools developed within COMESEP
- Alerts pass through COMESEP server
- SEP alerts are updated if new information becomes available.
- Runs fully automatic without human intervention



SEPForecast

- Predictions for occurrence probability and storm level based on an analysis of SEP events during solar cycle 23 [Dierckxsens et al., Sol. Phys. 290, 841 (2015)]
- The SEP intensity time profiles near Earth are based on Solar Particle Radiation SWx (SPARX), which combines outputs from previously run test particle model simulations [Marsh *et al*. SW 13, 386 (2015)]
- Initial evaluated on SC22 and SC24 events (up to 2013) performed during the project
- More detailed performance studies under way, including operational performance and will be part of a forthcoming publication

SEPForecast 4-15 January 2014



Forecast for X1.2 flare was updated when CME info received, increasing risk from LOW (possible, minor), to MEDIUM risk (likely, moderate).

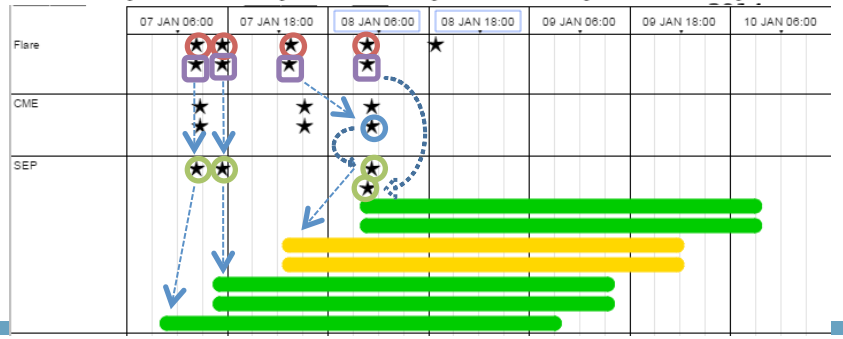
Very small increase in proton flux. Most likely following the M4.4 flare

Minor SEP storm (42pfu, > 10MeV) Most likely associated with C2 flare beyond the limb + halo CME with speed 500 km/s.

All 3 forecasts:
- Probability (very) unlikely
- Level: minor

→ risk: LOW

No forecast as flare was < M1, the flare was "hidden" by the Sun and appeared much weaker than it probably was.



SEPEM

The SEPEM Project

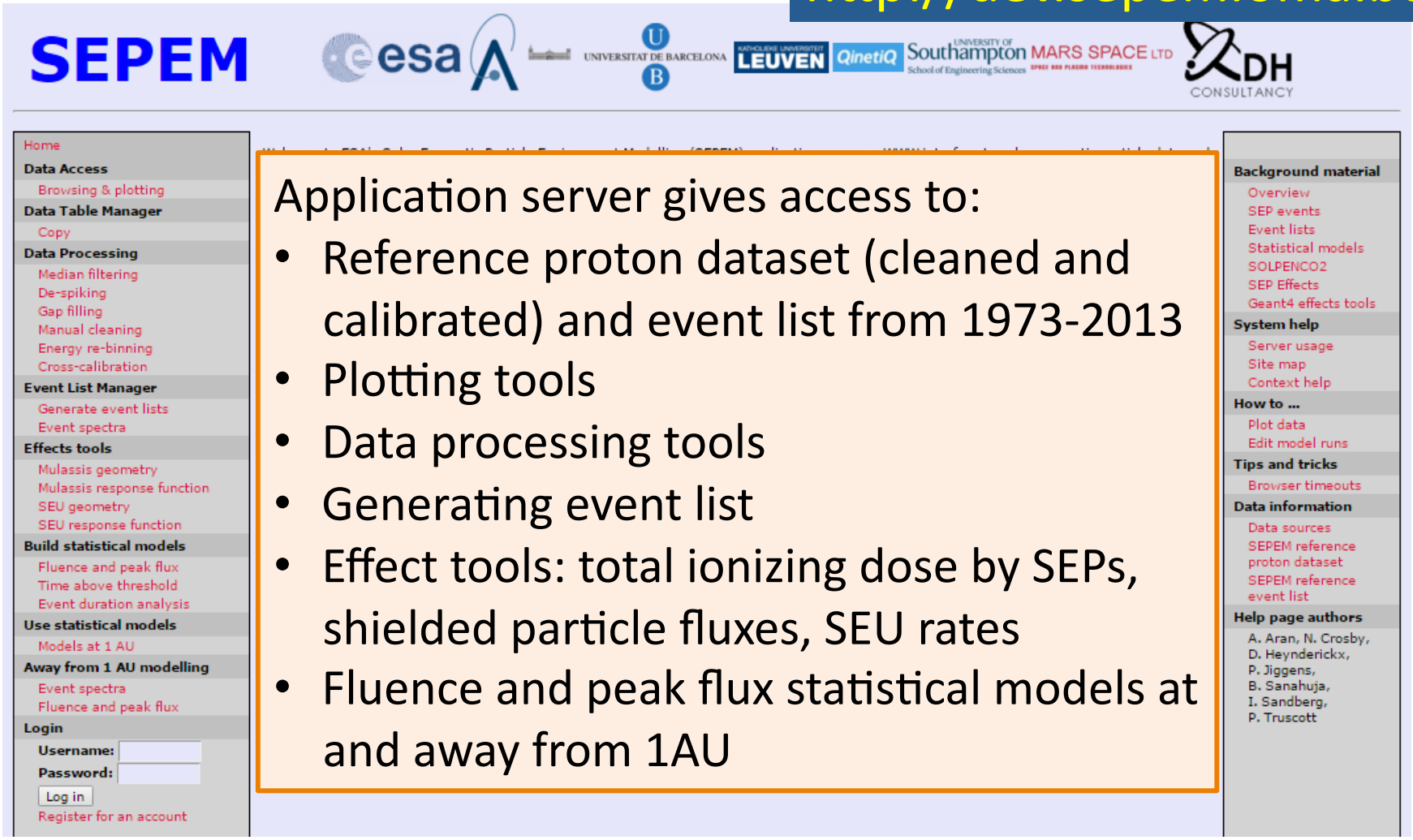
Solar Energetic Particle Environment Modelling

http://sepem.aeronomie.be/

- ESA funded project
- Coordinator: Norma B. Crosby (BIRA-IASB)
- 7 consortium members
- ESA/ESTEC Contract No. 20162/06/NL/JD

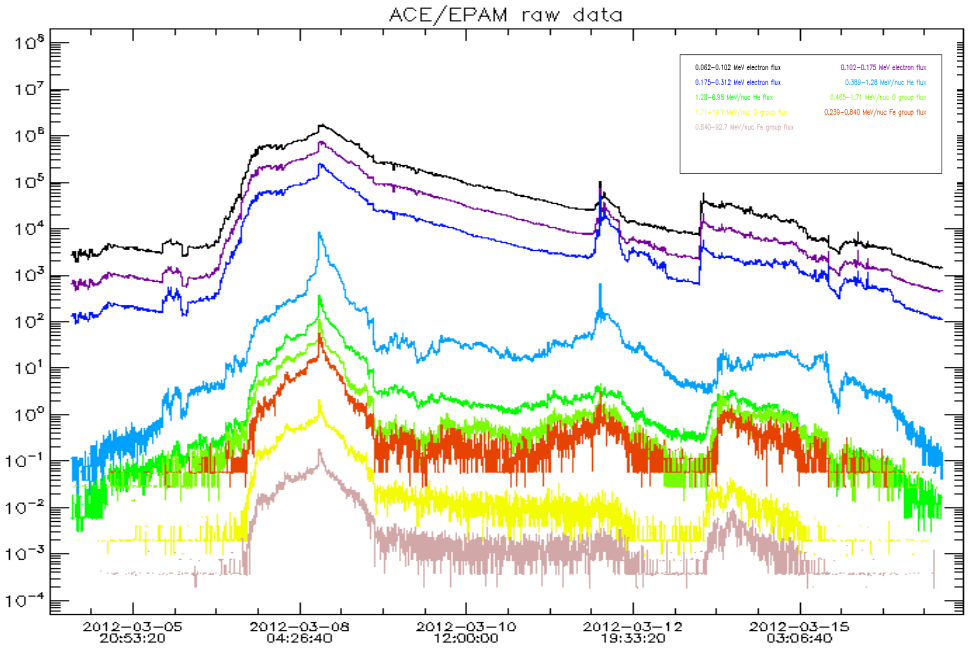
SEPEM Application server

http://dev.sepem.oma.be/

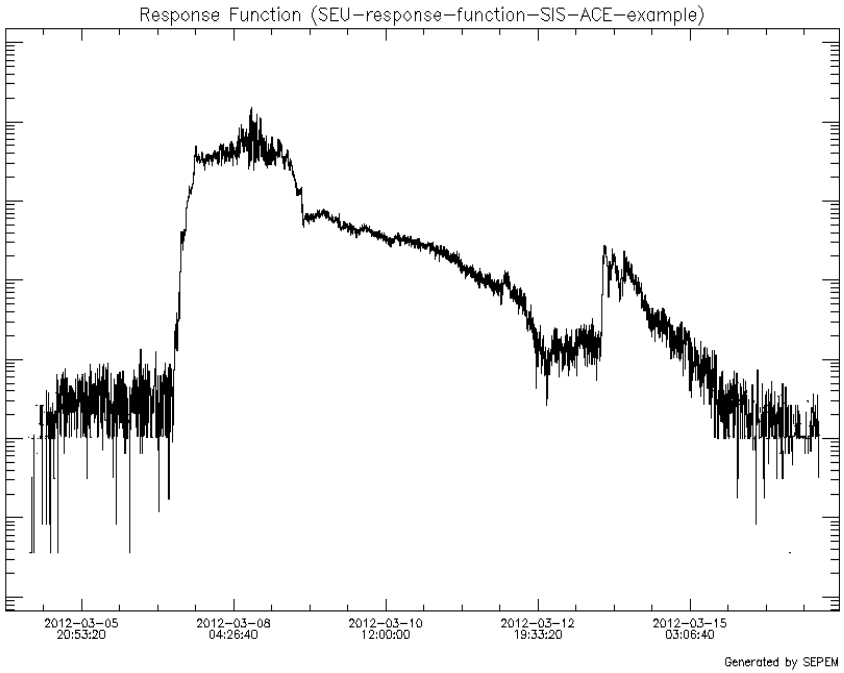


SEPEM Example

Electron, He, O, Fe flux profiles at L1



SEU rate (oxygen data)



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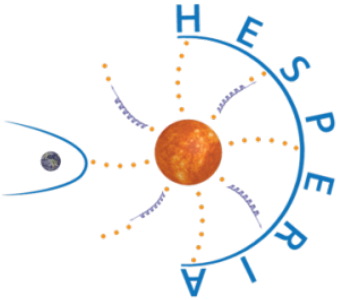
HESPERIA

The HESPERIA Project

High Energy Solar Particle Events Forecasting and Analysis

http://www. hesperia-space.eu/

- Horizon 2020 - PROTEC-1-2014 'Space Weather'
- Starting date: May 1, 2015
- Duration: 24 months
- Coordinator: Olga Malandraki (National Observatory of Athens)
- 9 European Teams and 5 External Collaborators



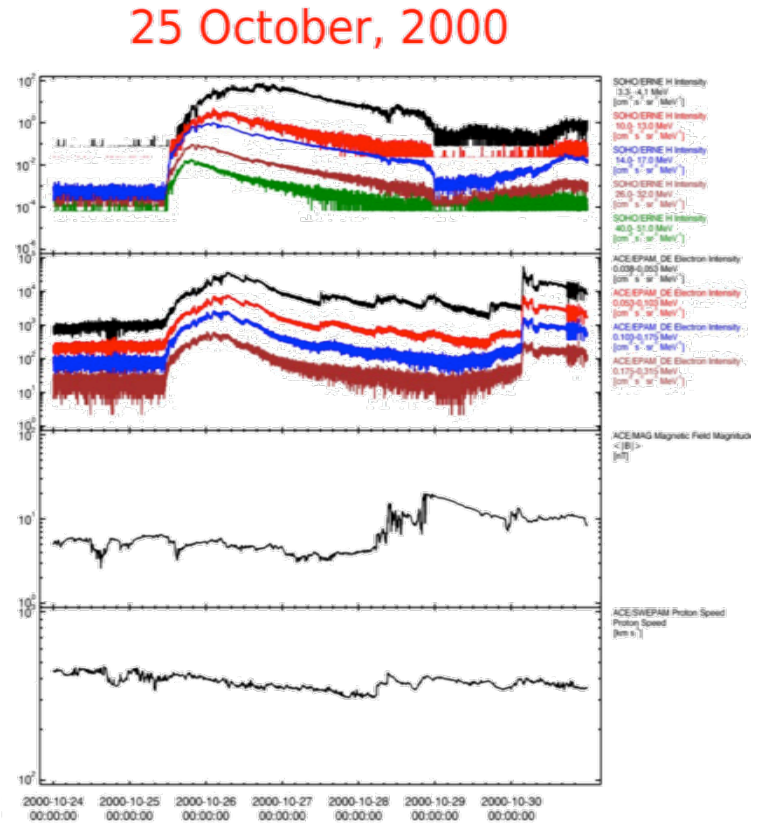
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 637324.

HESPERIA Objectives

- Develop two SEP forecasting systems based upon proven concepts (UMASEP, REleASE)
- Develop SEP forecasting tools using electromagnetic proxies of the gamma-ray emission
- Exploitation of FERMI high-energy gamma-ray observations and SEP measurements near 1 AU
- Develop inversion of neutron monitor data to physical parameters to compare with space-borne measurements
- Study statistical relations among the parent solar events and SEPs for solar cycles 23 & 24
- Provide recommendations for future SEP forecasting systems

HESPERIA SEP Statistical Analysis

- Event catalogue based on SOHO/ERNE 14-17 MeV proton channel for period 1996-2015:
  - onset & peak time, peak intensity
  - associated flare & CME
  - overview plots
- Comparison between SC23 and SC24 of occurrence rate and correlations
- Comparison of composition measurements
- The first results published via the Consortium Server in May 2016



R-ESC

R-ESC

The Expert Service Centre for Space Radiation

http://swe.ssa.esa.int/web/guest/space-radiation

- Funded through P2-SWE-I as part of ESA's Space Situational Awareness (SSA) Space Weather (SWE) Network program
- Lead by BIRA-IASB
- Coordinator: Norma B. Crosby
- Deputy coordinator: Mark Dierckxsens
- Network consists of 11 members
- ESA Contract No. 4000113187/15/D/MRP

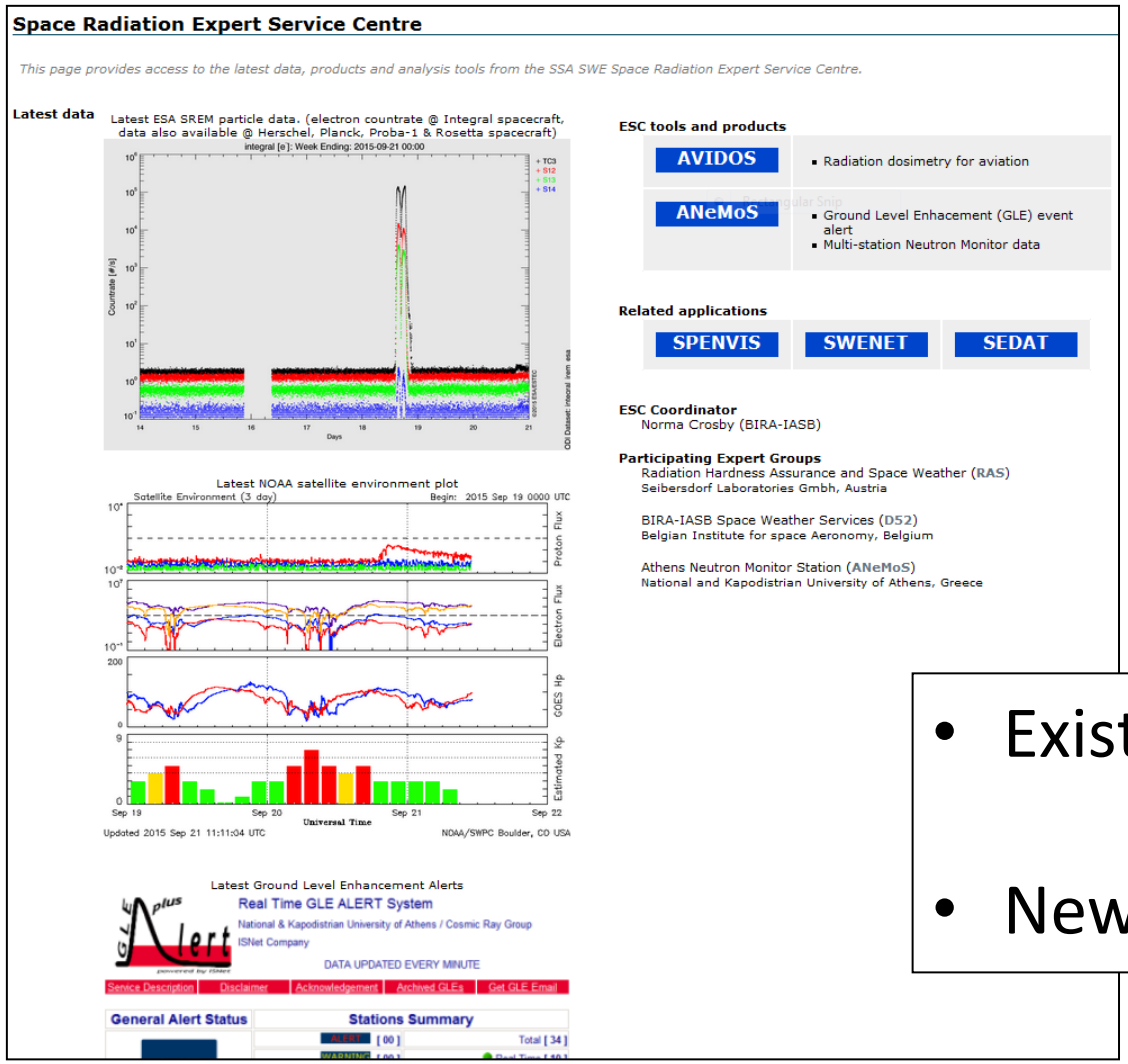
esa space situational awareness

R-ESC Objectives

- R-ESC domain:
  - Space particle radiation (ambient plasma, solar energetic particles, radiation belts, galactic cosmic rays) and micron-size particulates (from meteoroids and space debris) in the near-Earth space environment
  - All types of phenomena induced effects on technologies and biological systems

- Activities:
  - Further develop the existing ESC beyond the results of the SSA Preparatory Program
  - New Service Product Implementation and Provision
  - ESC Network Expansion

R-ESC Products



- Existing Products (7)
- New Products (28)

R-ESC Existing Products

Radiation exposure estimation at aircraft altitude (AVIDOS)	Seibersdorf Laboratories
GLE alert service and Multi-station Neutron Monitor data	University of Athens
Space Environment Information System (SPENVIS)	BIRA-IASB
Space Environment Data System (SEDAT)	developed by Rutherford Appleton Laboratory
Environment Information System for Operations (SEISOP)	initially developed by a consortium led by DEIMOS Space S.L.U
European Debris Impact Database (EDID)	developed by Etamax Space GmbH based on software by Space Systems Finland

R-ESC New Products

PROBA-V Energetic Particle Telescope (EPT) derived products	Center for Space Radiations, Université Catholique de Louvain
Standard Radiation Environment Monitor (SREM) data	Paul Buehler
Radiation environment & accumulated dose at ISS and SEP aviation radiation exposure	Institute of Aerospace Medicine, German Aerospace Center
Very high-energy SEP environment and event catalogue	Space Research Laboratory, University of Turku
Electron Radiation Belt Model at GEO, MEO, LEO	Mullard Space Science Laboratory, University College London
COMESEP Alert System	BIRA-IASB
SEPEM Application Server	
SWIFF plasmasphere electron density distribution model	

SEP SCOREBOARD

SEP Scoreboard

- SEP scoreboard under development by BIRA-IASB, Met Office and CCMC
- Identified three different cases of SEP forecasts:
  - Model simulations (with long running time)
  - Event based forecasts (e.g. triggered by flare, CME, …)
  - Continuous forecasts (e.g. 1-day, 3-day,…)
- XML Schema developed for submitting forecasts
- Need to setup the evaluation scheme and define test cases
- Forecasters and model providers will be contacted
- We invite everyone who is interested to join

Summary

- BIRA-IASB is (has been) involved with several SEP related projects
- COMESEP: alert system and SEP forecast
- SEPEM: data calibration/cleaning, statistical models and engineering tools
- HESPERIA: statistical analysis of SEP events
- R-ESC: coordination of network and product provision
- SEP scoreboard: setting up the scoreboard

BACKUP SLIDES

COMESEP Team Members

Solar Energetic Particles [SEP] Teams:

- Institut d'Aeronomie Spatiale de Belgique, Belgium [PI: Norma Crosby, Project Coordinator]
- National Observatory of Athens, Greece [PI: Olga Malandraki]
- University of Central Lancashire, United Kingdom [PI: Silvia Dalla]

Coronal Mass Ejections [CME] Teams:

- Universitaet Graz, Austria [PI: Astrid Veronig]
- Koninklijke Sterrenwacht van België, Belgium [PI: Eva Robbrecht]
- Hvar Observatory, Faculty of Geodesy, University of Zagreb, Croatia [PI: Bojan Vrsnak]
- Technical University of Denmark, Denmark [PI: Susanne Vennerstrøm]

External Collaborators:

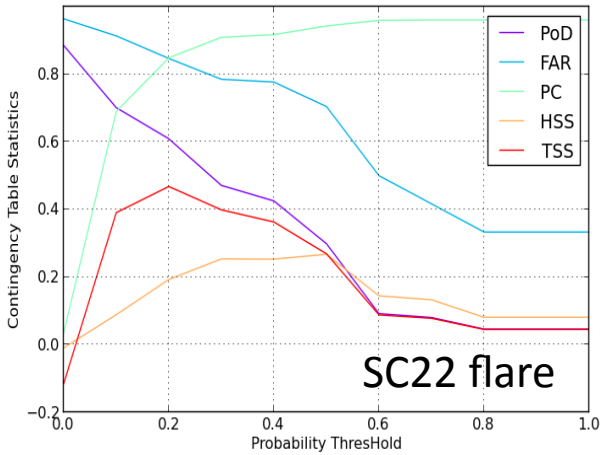
- Associate Professor Dr. Nandita Srivastava, Udaipur Solar Observatory, India
- Dr. Michael Hesse, NASA Goddard Space Flight Center, U.S.A.
- Dr. Dusan Odstrcil, George Mason University, Fairfax – NASA Goddard Space Flight Center, U.S.A.

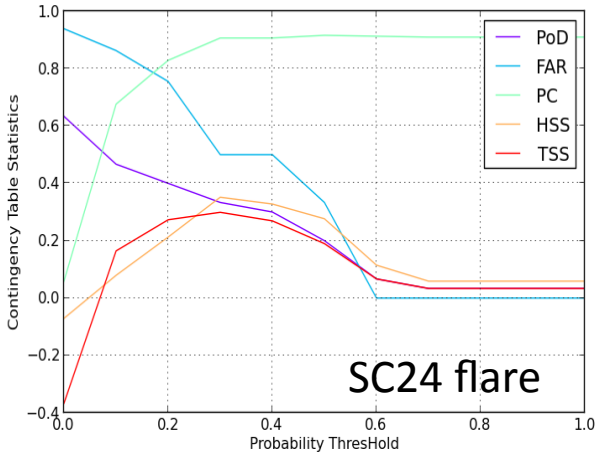
SEPForecast Inputs

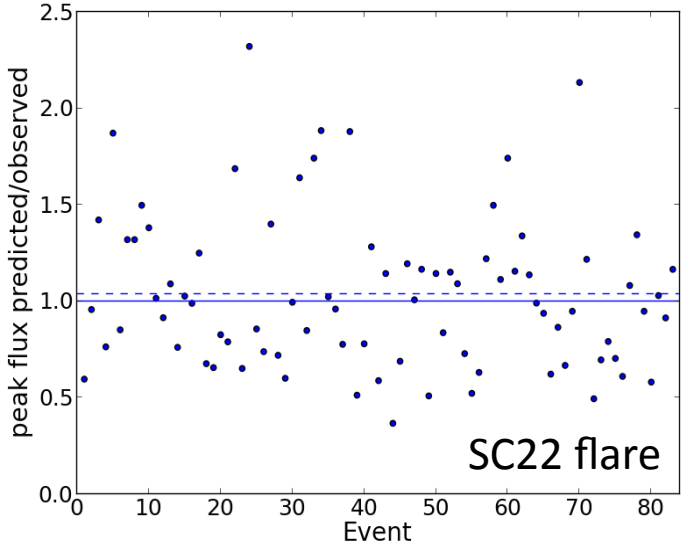
Input tools

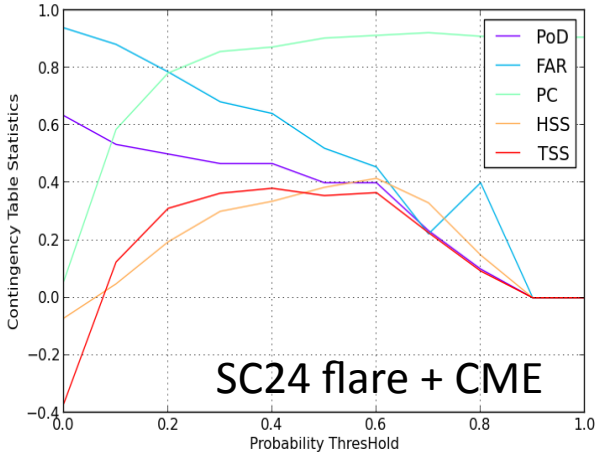
- Flaremail: flare peak intensity and time from GOES soft X-ray data (0.1nm-0.8nm)
  http://sidc.oma.be/products/flaremail/
- Solar DEMON: flare location and peak time in SDO/AIA 94 data
  http://solardemon.oma.be/
- CACTus: CME speed, width and liftoff time from SOHO/LASCO data
  http://sidc.oma.be/cactus/
- GLE Alert: monitors the GLE Alert Plus service, wich detects detects ground level enhancements events in neutron monitor data
  http://cosray.phys.uoa.gr/index.php/glealertplus

SEPForecast Performance









SEPEM Consortium

Project Coordinator

- Royal Belgian Institute for Space Aeronomy [PI: Norma Crosby]

Other members

- K.U.Leuven, Belgium
- QinetiQ, UK
- University of Barcelona, Spain
- University of Southampton, UK
- Mars Space Ltd, UK
- DH Consultancy, Belgium

HESPERIA Team Members

Project Coordinator:

- Olga Malandraki [National Observatory of Athens, Greece]

Other Teams:

- Ludwig Klein [Observatoire de Paris, OBSPARIS, France]
- Rami Vainio [Turun Yliopisto, UTU, Finland]
- Neus Agueda [Universitat de Barcelona, UB, Spain]
- Marlon Nunez [Universidad de Malaga, UMA, Spain]
- Bernd Heber [Cristian-Albrechts-Universitaet zu Kiel, CAU, Germany]
- Rolf Buetikofer [Universitaet Bern, UBERN, Switzerland]
- Christos Sarlanis [ISNet, Greece]
- Institut d'Aeronomie Spatiale de Belgique, Belgium [PI: Norma Crosby, Project Coordinator]

External Collaborators:

- Galina Bazilevskaya [Lebedev Physical Institute of Russian Academy of Sciences, Moscow, Russia]
- Veronica Bindi [University of Hawai at Manoa, Honolulu, USA]
- Ron Murphy [Naval Research Laboratory, Washington DC, USA]
- Allan Tylka [Washington DC, USA]
- Juan Rodriguez [NOAA, USA]

R-ESC Network

Coordinator:

- Institut d'Aeronomie Spatiale de Belgique, Belgium [PI: Norma Crosby, Project Coordinator]

Network Members:

- Seibersdorf Labor GmbH, Austria [Peter Beck]
- Université Catholique de Louvain (UCL), Center for Space Radiations, Belgium [Mathias Cyamukungu]
- DLR Institute of Aerospace Medicine, Department Radiation Biology, Germany [Gunther Reitz]
- University of Turku, Space Research Laboratory, Finland [Rami Vainio]
- University College London (UCL), Mullard Space Science Laboratory, U.K. [Andrew Coates]
- Paul Buehler, Austria [Paul Buehler]
- Institute of Atmospheric Physics, Czech Republic [Ondrej Santolik]
- University of Oulu, Sodankylä Geophysical Observatory, Finland [Ilya Usoskin]
- CSDRadConsultancy Ltd, U.K. [Clive Dyer]
- University of Athens, Physics Department, Greece [Helen Mavromichalaki]