Overview of COMESEP Project

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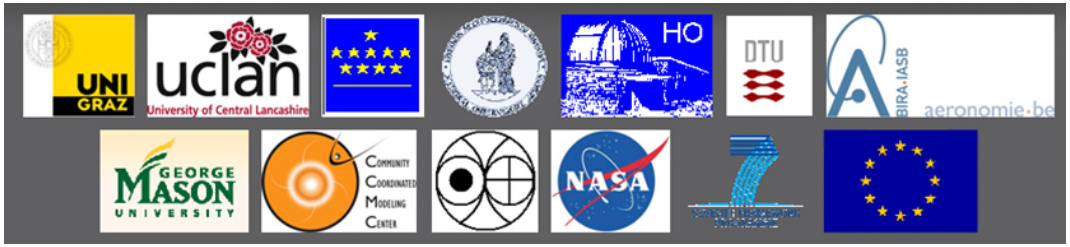
on behalf of the COMESEP Consortium



This work has received funding from the European Commission FP7 Project COMESEP (263252).

The 7th CCMC Community Workshop, 4 April 2014, Annapolis, Maryland

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

Funding: European Commission Seventh Framework Programme
Starting date: 01 Feb. 2011
Duration: 36 months
Coordinator: Norma B. Crosby (BIRA-IASB)

7 Teams and 3 External Collaborators

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 => Luciano Rodriguez]
- Hvar Observatory, Faculty of Geodesy, University of Zagreb, Croatia [PI: Bojan Vrsnak]
- Technical University of Denmark, Denmark [PI: Susanne Vennerstrøm]

External Collaborators

- Dr. Nandita Srivastava, Associate Professor, Udaipur Solar Observatory, India
- Dr. Michael Hesse, Director Emeritus and Senior Advisor of the "Community Coordinated Modeling Center (CCMC)" at NASA GSFC, U.S.A.
- Dr. Dusan Odstrcil, George Mason University, Fairfax – NASA GSFC, U.S.A.

COMESEP Overall Objectives

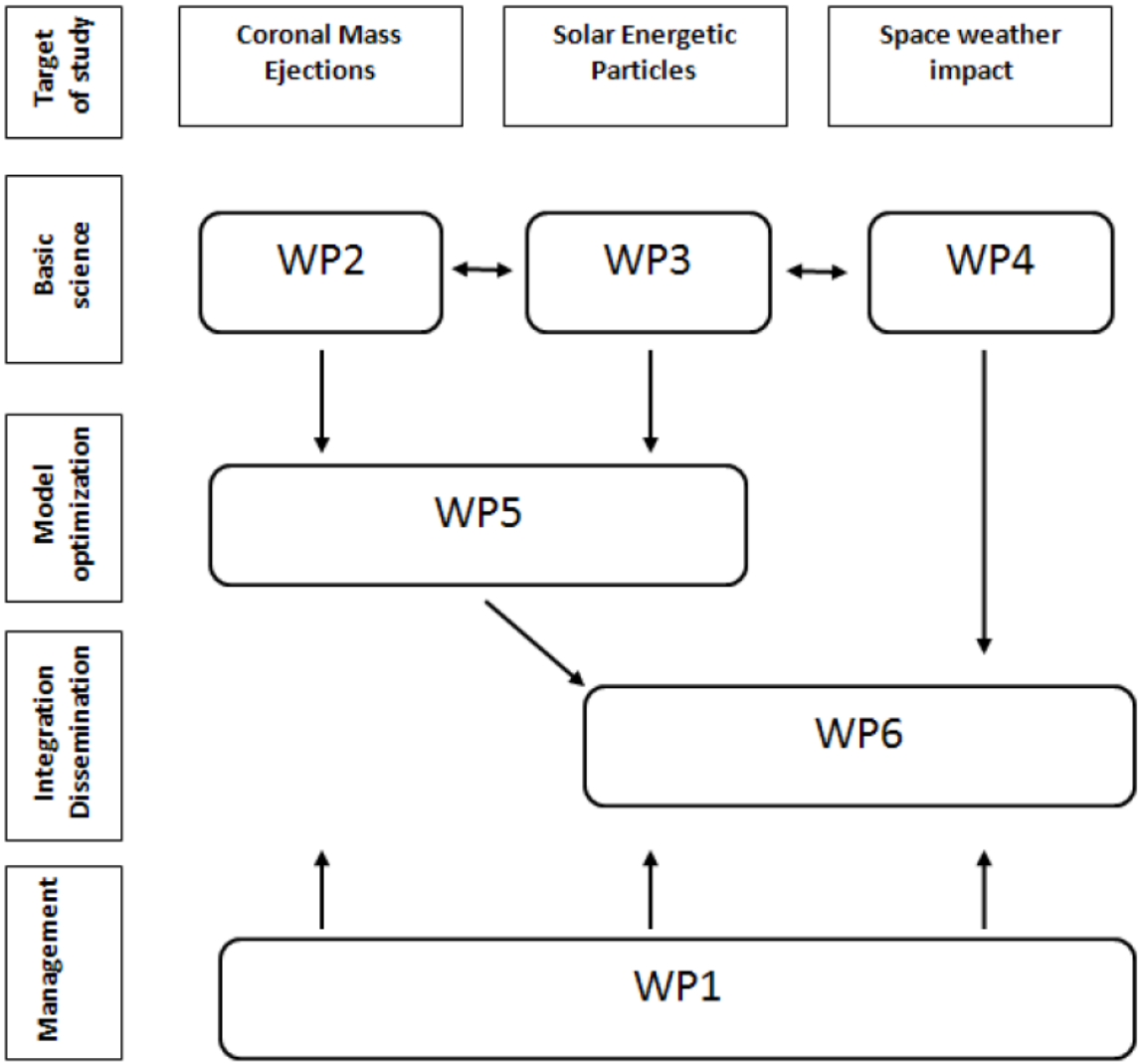
- Combine basic research on space weather events with the development of an European space weather alert system.
- Optimise models and forecasting methods based on obtained scientific results.
- Link the derived SEP and interplanetary CME (ICME) forecast tools with real-time automated detection of CMEs.
- Integrate individual detection tools and models into an automated “start-to-end-service” system.
- Disseminate SEP radiation storm and geomagnetic storm alerts to the European space weather community.

COMESEP Overall Goal & WP Overview

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

Realisation of the project has been based on:

- extensive data analysis,
- model development,
- risk assessment.



WP2: CORONAL MASS EJECTIONS

- Much better understanding of and insight into the:
  - Evolution of ICME 3-D geometry.
  - Physical background of ICME-ICME interactions and the role of variable solar wind in ICME kinematics.
  - Evolution of the ICME size, magnetic field strength, and electric current during the heliospheric propagation.
  - Solar cycle dependence of the ICME dynamics.
- Found a way to include the shock-arrival prediction into the drag-based-model (DBM) and the effect of source region position in the forecasting.

WP3: SOLAR ENERGETIC PARTICLES

DATA ANALYSIS:

- Identified particle reservoirs in the 3-D heliosphere, established compositional and spectral invariance during reservoir periods.
- Showed importance of reflecting boundaries for formation of particle reservoirs.
- Explained initial, transient Fe/O enhancements in large, gradual events and entire temporal profile of Fe/O by rigidity-dependent transport rather than direct flare contribution
- Investigated the possibility to forecast the proton event duration in the later phase of a GLE event based on the faster electron measurements at the GLE onset.

SEP TEST PARTICLE MODEL DEVELOPMENT:

- Identified particle drifts for the first time as significant for SEP propagation in the IMF (especially: partially ionized heavy ions).
- Results led to basic understanding of the acceleration and transport of SEPs and to the construction of the SEP propagation model used for the COMESEP Alert System.
- Propagation processes were included and taken into account in the model.

WP4: SPACE WEATHER IMPACT

- Statistical relations between key parameters of solar eruptions, their geo-efficiency and their SEP characteristics were resolved.

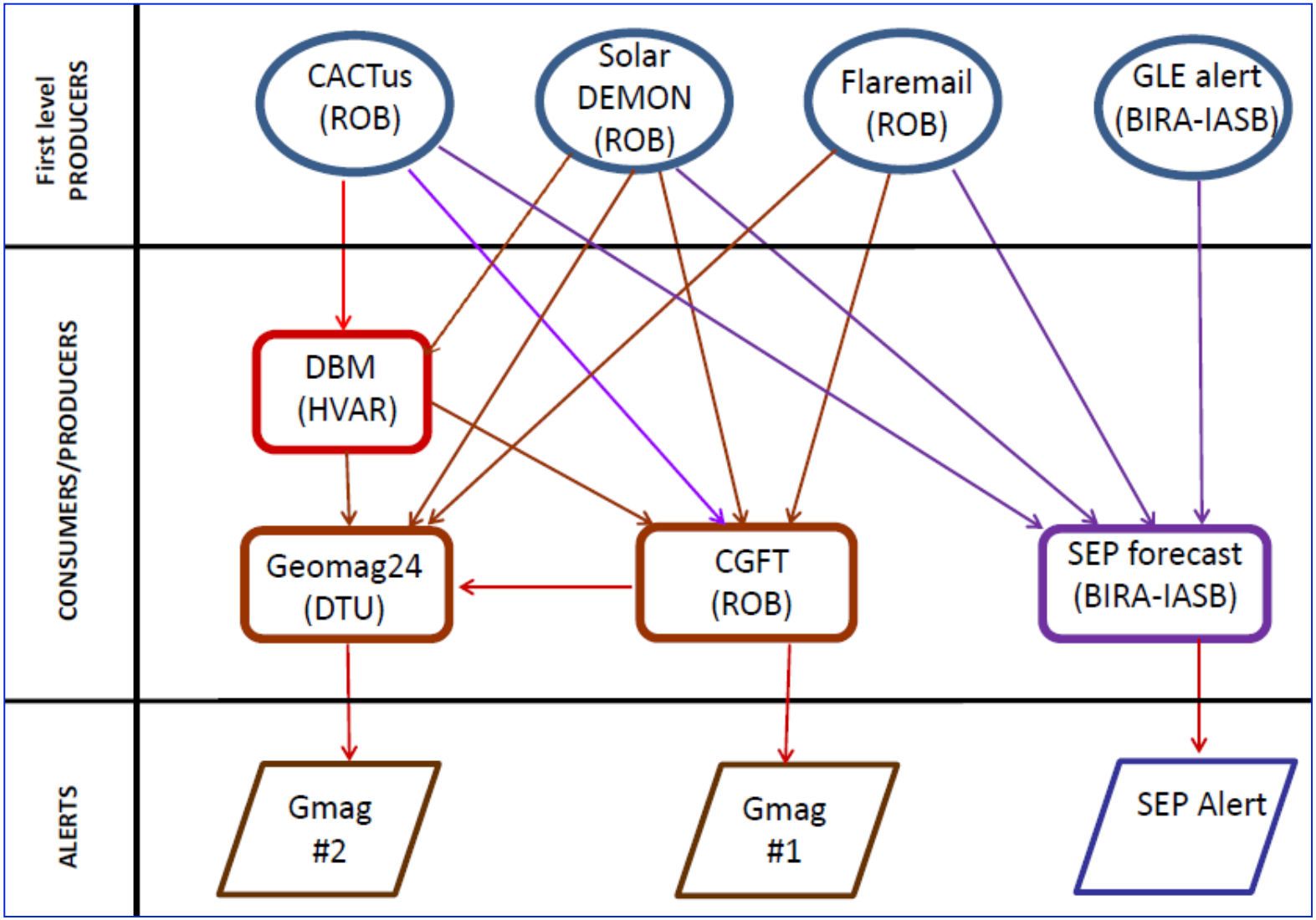
- New empirical methods to assess geo-efficiency of CMEs with large lead times as well as SEP event characteristics were developed and incorporated into the COMESEP Alert System.

- Identified important ingredients in the chain of processes from Sun to Earth leading to extreme geomagnetic storms.

- Identified key parameters leading to geomagnetic storm false alarms, and a scheme to include them in the Alert System was developed.

WP5: DEVELOPMENT OF FORECASTING METHODS

- Built tools for the automated real time detection of solar flares and CMEs, and derived their characteristics.
- Developed tools for forecasting the arrival of an ICME (DBM) and the arrival of SEPs (SEPForecast).
- Both forecasting tools (DBM and SEPForecast) were prepared for integration in the COMESEP Alert System, able to adapt to the number and type of inputs detected in real time.



Geomagnetic storm risk for the next 24 hours

Geomagnetic storm risk based on a CME that may arrive several days later

SEP radiation storm risk for protons with E > 10 MeV & E > 60 MeV

Risk Analysis

Forecasting tools estimate the storm probability and impact,

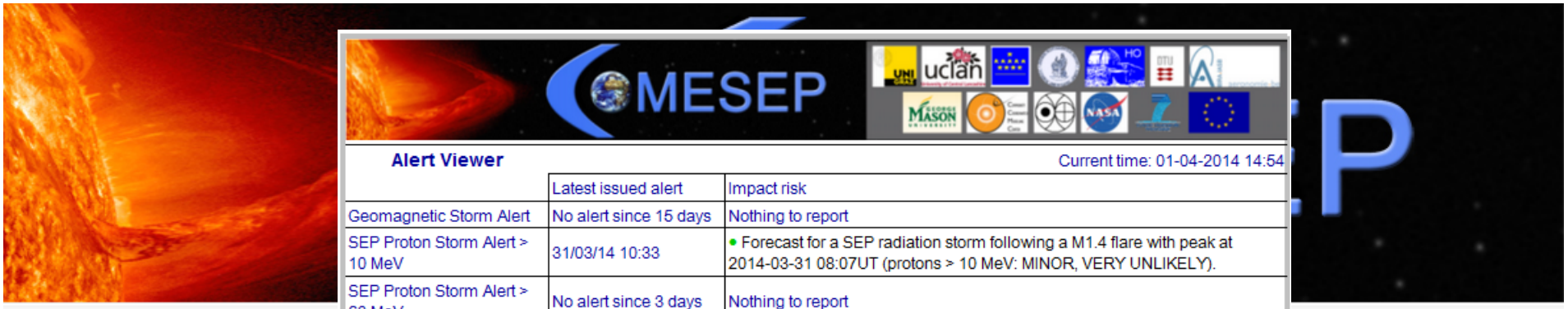
both of which are combined to obtain an estimated risk.

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	$>7.9\times10^3$

COMESEP Risk Matrix

WP6: SPACE WEATHER ALERT SYSTEM

- The COMESEP Alert System is running in real time, automatically and without human intervention.
- The forecast tools were validated using historical data.
- The Alert System was evaluated by external users.
- Users can access the results on the webpage and subscribe to email alerts.
- Help pages and Alert System documentation are available.



COMESEP

Alert Viewer Current time: 01-04-2014 14:54

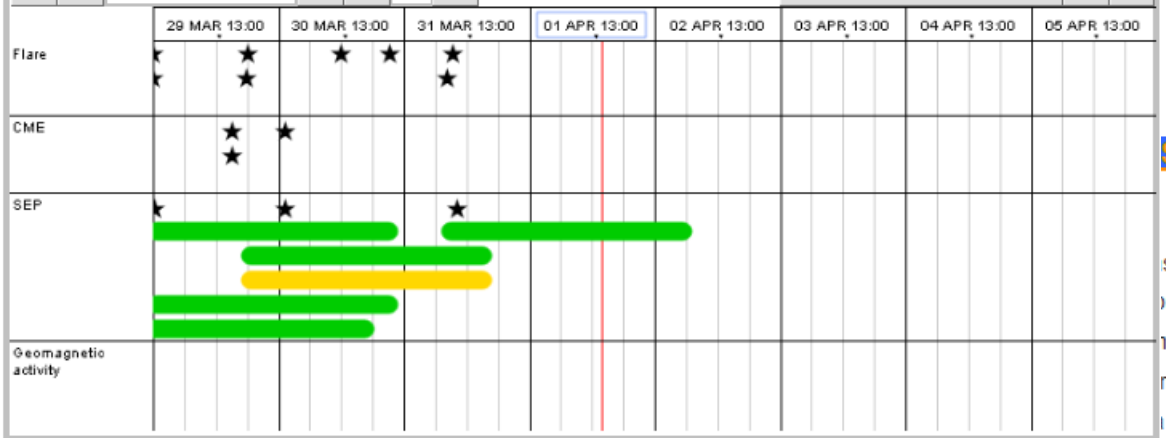
	Latest issued alert	Impact risk
Geomagnetic Storm Alert	No alert since 15 days	Nothing to report
SEP Proton Storm Alert > 10 MeV	31/03/14 10:33	• Forecast for a SEP radiation storm following a M1.4 flare with peak at 2014-03-31 08:07UT (protons > 10 MeV: MINOR, VERY UNLIKELY).
SEP Proton Storm Alert > 60 MeV	No alert since 3 days	Nothing to report

Legend: ★ ... an alert has been issued Times are in UTC

...risk impact (timing and level, • low, • medium, • high, • extreme)

Click on the icons to see alert details

Tue 01 Apr 2014 Register for **COMESEP** alerts



DISCLAIMER: COMESEP makes no warranties or representations as to its accuracy and COMESEP specifically disclaims any liability or responsibility for any errors or omissions in the content on the website, as well as the alerts that are sent out. Neither COMESEP nor any other party involved in creating, producing, or delivering information that is used in the COMESEP alert system is liable for any direct, incidental, consequential, indirect, or punitive damages arising out of your access to, or use of, or inability to use or access, the website and/or the alerts that are sent out.

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You are here: Home

Main Menu

- **Home**
- Project Description
- Consortium
- Alert System
- Alert System Help
- News
- Publications
- Meetings
- Jobs
- Links
- Frequently Asked Questions
- Consortium Members Only

SEP Alerts

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Welcome to the COMESEP Alert System

http://www.comesep.eu/

Mini-User COMESEP Alert System Meeting

BIRA-IASB, Brussels, Belgium, 24 Jan. 2014

Objective:

- Obtain feedback by discussing the current version of the COMESEP Alert System in detail.
- Look forward (suggestions/ improvements for post-COMESEP).

COMESEP Alert System questionnaire:

- COMESEP Advisory Board
- Colleague-Researchers from BIRA-IASB and ROB
- 'Real' End-Users.

Attendees

1. COMESEP Advisory Board
   - Karl-Ludwig Klein, Observatoire de Meudon, France
   - Angelos Vourlidas, Naval Research Laboratory, U.S.A.
   - Aleksandar Jovanovic, Steinbeis Advanced Risk Technologies, Germany

2. COMESEP External Collaborators
   - Nandita Srivastava, Udaipur Solar Observatory, India
   - M. Leila Mays, CCMC at NASA Goddard Space Flight Center, U.S.A.

3. End Users
   - Dave Pitchford, SES Engineering, Luxembourg
   - Johan De Keyser, BIRA-IASB, Belgium

CCMC space weather scoreboard

CME: 2014-01-07T18:24:00-CME-001

Actual Shock Arrival Time: 2014-01-09T19:32Z

Observed Geomagnetic Storm Parameters:
Max Kp: 3.0

Predicted Shock Arrival Time	Difference (hrs)	Submitted On	Lead Time (hrs)	Predicted Geomagnetic Storm Parameter(s)	Method	Submitted By
2014-01-09T19:26Z (-10.0h, +10.0h)	-0.10	2014-01-07T21:00Z	46.53	----	STOA	Leila Mays (GSFC)
2014-01-09T00:38Z (-7.0h, +7.0h)	-18.90	2014-01-08T00:41Z	42.85	Max Kp Range: 6.0 - 8.0	WSA-ENLIL + Cone (GSFC SWRC)	Leila Mays (GSFC)
2014-01-09T08:00Z	-11.53	2014-01-08T01:31Z	42.02	Max Kp Range: 6.0 - 7.0	WSA-ENLIL + Cone (NOAA/SWPC)	Leila Mays (GSFC)
2014-01-08T22:00Z	-21.53	2014-01-08T03:17Z	40.25	Dst min. in nT: -146 Dst min. time: 2014-01-09T11:00Z	Anemomilos	WKent Tobiska (SET SWD)
2014-01-09T00:17Z (-6.9h, +9.2h)	-19.25	2014-01-08T04:11Z	39.35	Max Kp Range: 6.0 - 8.0	Ensemble WSA-ENLIL + Cone (GSFC SWRC)	Leila Mays (GSFC)
2014-01-09T04:30Z (-2.5h, +2.5h)	-15.03	2014-01-08T05:02Z	38.50	Max Kp Range: 5.0 - 8.0	Other (SIDC)	Leila Mays (GSFC)
2014-01-08T12:30Z	-31.03	2014-01-08T05:58Z	37.57	----	ESA	Leila Mays (GSFC)
2014-01-09T12:00Z (-7.0h, +7.0h)	-7.53	2014-01-08T06:32Z	37.00	----	WSA-ENLIL + Cone	RWC Jeju (KSWC)
2014-01-09T04:00Z (-6.0h, +6.0h)	-15.53	2014-01-08T09:42Z	33.83	----	DBM	Manuela Temmer (UNIGRAZ)
2014-01-10T04:04Z (-16.0h, +36.0h)	8.53	2014-01-08T14:56Z	28.60	Max Kp Range: 8.0 - 8.0 Dst min. in nT: -300	COMESEP	Andy Devos (SIDC)
2014-01-09T08:02Z	-11.50	2014-01-08T16:37Z	26.92	----	Expansion Speed Prediction Model	Alisson Dallago (INPE)
2014-01-09T02:00Z	-17.53	2014-01-08T17:53Z	25.65	Max Kp Range: 8.0 - 9.0	BHV	Volker Bothmer (UGOE)
2014-01-09T01:00Z	-18.53	2014-01-08T23:00Z	20.53	Dst min. in nT: -142 Dst min. time: 2014-01-09T12:00Z	Anemomilos	WKent Tobiska (SET SWD)
2014-01-09T13:00Z (-7.0h, +7.0h)	-6.53	2014-01-08T23:17Z	20.25	Max Kp Range: 6.0 - 8.0	WSA-ENLIL + Cone	Duty Forecaster (ASFC)
2014-01-09T11:22Z (-11.7h, +9.1h)	-8.17	2014-01-09T18:57Z	0.58	Max Kp Range: 3.0 - 5.0	Ensemble WSA-ENLIL + Cone (GSFC SWRC)	Leila Mays (GSFC)

Main Achievements

Built an operational Alert System by integrating individual tools into an automated start-to-end Alert System.

"Research to Operations"

COMESEP has provided:

- More awareness on the links that exist between the SEP, CME, and terrestrial effects communities.
- A platform for increasing international collaboration on space weather forecasting.