PRediction Of Geospace Radiation Environment and Solar wind parameterS 637302

4th Project Review Meeting
August 2-3, 2018

University of Sheffield, Amy Johnson Bld., Sheffield, UK

Minutes

Attendees

Andrej Rozkov (project officer, REA, Belgium), Zerefsan Kaymaz (external reviewer, Istanbul Technical University, Turkey), Robertus von Fay-Siebenburgen (coordinator, University of Sheffield), Simon Walker (project manager, University of Sheffield), Michael Balikhin, (Chair Scientific Steering Committee, University of Sheffield), Carol Heathcote (PA to M. Balikhin), Richard Boynton and Hua-Liang Wei (University of Sheffield), Natalia Ganushkina (Finnish Meteorological Institute), Tony Arber (University of Warwick), Mike Liemohn (University of Michigan), Vitaliy Yatsenko (Space Research Inst. Ukraine), Peter Wintoft (Swedish Institute of Space Physics), Angelica Castillo Tibocha (GFZ German Research Centre, Potsdam).

Yuri Shprits (GFZ German Research Centre) via SKYPE.

Dave Pitchford and David Jackson (Stakeholder Advisory Board) via Webex.

1 Apologies

Didier Mourenas (Stakeholder Advisory Board, France); Volodya Krasnoselskikh, (LPC2E, France).

2 Agenda

The agenda, as previously circulated, was adopted.

3 Introductions

Robertus von Fay-Siebenburgen welcomed everyone to Sheffield for the Final PROGRESS project meetings.

4   Aims of Meeting

Simon Walker (SW) asked Andrej Rozkov (AR) and Zeresfan Kaymaz (ZK), what they wanted from the meetings.

AR replied that he would like to see results from work completed, improvements which can be done and what lessons have been learned.

ZK gave a presentation to explain what she understood about PROGRESS:

- PROGRESS was a grand project to increase the forecasting capabilities of the environment parameters from the Sun to ground.

- Ultimate goal: To give space weather users better predictions to decrease the causalities from the space environment in space and on the ground and increase the public awareness

- Also with the objective of creating European Forecasting Tool

- Aims- overall aim of PROGRESS is to exploit the synergy of the complementary expertise available within partner groups, available spacecraft, ground-based data, combined with state of art data assimilation methodologies.

ZK showed what other projects had done in comparison to PROGRESS. She said that she wanted to see what was accomplished, outputs, failure points, things to improve etc. She showed WP2 as an example. She also wanted to hear about the latest deliverables and to see products from the PROGRESS project.

5   Work Package Reports

WP1: Management - *Simon Walker*, Robertus von Fay-Siebenburgen

(presentation)

The current status of the project and compliance to the schedule were presented.

Deviations from the Workplan A new amendment, AMD-23, was prepared to enable WP 3 to be revisited to allow SRI more time to complete and deliver their models.

Ethical issues No ethical issues were identified

IPR issues No IPR issue were raised.

Use of resources There were changes in the planned use of project resources which were outlined in the new amendment.

Risks No new risks were encountered during the current reporting period. The Participant at SRI failed to deliver the promised models and results for WP3 so the Commission allowed extra time for SRI to complete their tasks. Redistribution of resources outlined in Amendment 23 allowed SRI to deliver forecast models/results. The tasks redistributed were:

- SRI – Guaranteed NARMAX model

- USFD – Bilinear models

- IRF – Testing and comparison of results

- Changes to work schedule: SRI 4 PM; USFD 4PM; IRF 1PM

Deliverables SW presented a table of new deliverables list see below: New deliverables submitted according to schedule in GA; all deliverables available from EC participant portal:

	Title	Due date	Submission date
D5.3	The VERB-IMPTAM low energy seed population	2018-01-31	2018-02-02
D7.3	On orbit forecasts of the energetic electron populations	2018-01-31	2018-07-18
D6.3	Results of the VNC model and two methods of model couplings	2018-02-28	2018-07-30
D7.2	Forecasts of the energetic electron populations within the inner magnetosphere	2018-04-30	2018-07-30
D3.7	Dst and Kp Models	2018-07-31	2018-07-18
D7.4	Summary of the space weather environment	2018-07-31	2018-07-18

Feedback

Following the third Review Meeting a number of deliverables required updates. These changes were made and reports resubmitted according to the schedule set by the Project Officer and External Reviewer.

Milestones

The current schedule for Project Milestones has been met.

MS1	NARMAX models for electrons at GEO	100%	Results available on web
MS2	Availability of models for Kp, Dst, and AE	100%	Model results available on web
MS3	Statistical wave models	100%	Models are available from the web site
MS4	Fusion of VERB and IMPTAM	100%	Report in deliverable D5.3
MS5	Availability of AWSoM/SWIFT for testing within the consortium	100%	Models are available on request
MS6	Fusion of NARMAX and VERB	100%	model results available on website

WP8: Dissemination - *Simon Walker*, Robertus von Fay-Siebenburgen

A total of 51 papers relating to the activities within PROGRESS have been published during the project as a whole. Papers are listed on the project dissemination web page with a link to publishers website where available. PDF files of papers have been removed.

There were 111 presentations at conferences, workshops including the Summer School in Majorca. Conferences were held in Hawaii, Sweden, Austria (EGU, Vienna), Israel and USA (COSPAR, Pasadena). All project related presentations are listed in the presentations web page. SW asked participants to check the list and provide details of missing publications.

SW stated that the website had been updated and gave brief demonstration showing where publications were listed with publication date in order and said more details would be given on Friday 3 August with demonstrations.

WP 2: Propagation of the solar wind from the Sun to L1 - *Tony Arber*, Bart van der Holst, Mike Liemohn

(presentation)

TA reported on the the work for WP2 was done jointly between the University of Warwick and University of Michigan.

The objective of WP 2 is to forecast the MHD variables at L1 and 1A.U. using first principles physics models and beginning with GONG magnetogram observations of the Solar surface.

Aim: To predict variables at 1 A.U. from GONG data. Replace empirical models of WSA with first principles model. Allow full vector field B-field. Use 2 temperature MHD. Shock heating of ions, thermal conduction in electrons.

The latest improvements to the modelare:

- AWSoM-SWIFT optimised for full Carrington rotation synoptic GONG magnetograms

- AWSoM speed improved by a factor 100

- Optimised codes now run on 32 cores in 12 hours

- Parallel conduction no traceable within fluid model, ad hoc limiter chosen over SNB

- Carrington fit ?good? but predictions from daily synoptic maps ?poor?

- Need long time base to test accuracy of predictions cf. WSA-ENLIL but initial visual inspection show neither approach ?good? cf. Carrington rotation fits

WP 3: Forecast of the evolution of geomagnetic indices - Peter Wintoft, Magnus Wik, Simon Walker, Vitaliy Yatsenko

WP 3 activities focused on Task T3.7, a task newly created by AMD-23.

IRF activities - *Peter Wintoft*

(presentation)

SRI had originally agreed to develop models for geomagnetic indices based on the following methodologies:- A recursive robust bilinear dynamical model, A Guaranteed NARMAX model

After Amendment 23, the Commission proposed reallocation of some of the tasks to other participants in order to complete them. It was agreed that SRI continued to develop their models for Kp, Dst, and AE based on their guaranteed NARMAX model

PW summarised the work performed in T3.7 and the contents of the deliverable D3.7

- Guaranteed NARMAX models for Dst, Kp and AE indices were constructed using 2 different algorithms by SRI.

- All the developed forecasts with the exception of the GP based Kp forecast, which has too wide a prediction interval, provide useful information and are ready for transition to near-real time operations.

- Bi-linear models for the Kp and Dst indices were constructed by USFD.

- The performance of each of the models generated within PROGRESS were assessed for common periods of data.

- For Kp predictions the IRF-Kp-T0 and T1 models performs best, using past Kp seems to have minor effect.

- For Dst predictions the SRI-Dst-RM-T1 model performs best, past Dst values have significant effect.

- Lead-times beyond 1 hour is generally not possible.

- For real-time implementation, if past indices are used as inputs it will reduce the real time. PW showed a link to IRF Rest server to show what data can or can not do.

SRI activities - *Vitaliy Yatsenko*

(presentation)

VY provided an overview of the background to the development of their recursive, robust bilinear models and Guaranteed NARMAX Model, both of which are variants of the global NARMAX modelling methodology.

The objectives of this activity are:

- Structure and parameter identification of NARMAX and bilinear models

- Combination of NARMAX model and Lyapunov exponents

- Combination of NARMAX model and Lyapunov dimension

- Guaranteed prediction

- Robust prediction

- Software implementation

VY explained that his research concerned improvement and new development of models based on data driven modelling such as bi-linear and NARMAX. He aimed to find weaknesses in existing models for Dst and Kp and solar wind and geomagnetic indices would be analysed to develop models for identification of features such as shocks, sudden commencements, and substorms. Such categorisation would aid the model development and verification, and canal so serve as alternative approach to models providing numerical input-output mapping. In addition to the development to fD stand Kp models, new models would be developed to forecast AE.

VY presented the results of the development activities and the resulting forecasts of the models.

WP 4: Statistical wave models and quasi-linear diffusion coefficients - Volodya Krasnoselskikh (SW presented a summary on his behalf)

WP4 was completed a year ago. VK had developed 3 sets of wave models: Lower Band Chorus, HISS and Equatorial Magnetosonic Waves. He used NARMAX to determine the most influential solar wind parameters of the observed wave activity. These parameters were then used as inputs to the wave models.

SW showed the website pages from which the resulting wave models may be viewed or downloaded. This web page also contains links to the project deliverables describing parameter selection and derivation of the models.

WP 5: Low energy electron models - Natalia Ganushkina, Angelica Tibocha

FMI activities - *Natalia Ganushkina*

(presentation)

The work at FMI was led by NG said that WP5 was led by FMI mainly herself and Stepan Dubyagin.

The objectives of WP were:

- Develop an empirical solar wind and IMF driven model for low energy electrons in the plasma sheet

- Adapt the IMPTAM to include proper diffusion coefficients provided by VERB radiation belts model

- Provide the low energy seed population to VERB radiation belts model

- Develop a trial version of forecast model for low energy electrons

The previous deliverables were briefly reviewed and the key results highlighted.

- A new model for the the boundary conditions in the plasma sheet was developed.

- New methods for the description of wave-particle interactions, in terms of electron life times was developed.

NG discussed the implementation of IMPTAM as a forecasting tool. A trial version of a forecast model for low energy electrons was developed. This version of IMPTAM is driven using the solar wind and IMF parameters such as the density, pressure, velocity, and magnetic field components in conjunction with geomagnetic indices. IMPTAM can run using either real-time measurements or using the forecasts of these parameters delivered by the AWSoM/SWIFT model developed in WP 2 and geomagnetic index forecasts resulting from WP 3.

MB asked about data for others. NG replied that these data are available from a data server at U. Michigan.

Y. Shprits (via SKYPE) said that using results from PROGRESS hopefully a further improved model could be constructed.

GFZ activities - *Angelic Tibocha*

(presentation)

AT described the coupling strategy used to couple the IMPTAM and VERB models and how to model the electrons in the radiation belt region of the Earth based on the dynamics of the electron seed population. The method involves:

- Combine available physics-based models of each dynamic region to compute the dynamics of each electron population.

- IMPTAM (Inner Magnetospheric Particle Transport and Acceleration Model) traces low energy electrons from the plasma sheet (9 Re) to geosynchonous orbit (6.6 Re).

- The electron evolution modelled by IMPTAM is used to drive VERB-3D simulations, which describe the evolution of energetic electrons in the inner magnetosphere.

The relative strengths of the two models, IMPTAM and VERB, were discussed.

The results of this model, such as the reproduction of the general intensification of electron fluxes in the ring current and in the radiation belts, were presented. Addition updates for further improvements were suggested.

WP 6: Forecast of the radiation belt environment - Richard Boynton, Simon Walker and Yuri Shprits

USFD activities - *Richard Boynton*

(presentation)

RB described the NARMAX methodology used for creating models for forecasting the fluxes of electrons at various energies measured at GSO by the GOES MAGED. The current model forecasts were presented.

USFD activities - *Simon Walker*

(presentation)

VERB requires a value for the electron flux at its outer boundary. Value may be fixed or variable (from file). Task 6.1 has produced models that generate accurate estimates of the electron fluxes at GEO. These estimates can be used to produce the outer boundary flux required by VERB. However, these values need translating from GEO (L=6.6) to L*=7. Initial model coupling assumed fixed value of L* for GEO (L*=6.2). The value of L* for GEO is not constant, and can vary with geomagnetic activity. Task 6.3 investigated effects of introducing a variable L*.

Examples of the results obtained were shown.

WP 7: Fusion of forecast tools - *Simon Walker*

(presentation)

SW presented the outline of tasks, deliverables and tasks in WP7.

T7.1 Outline:

The models for Dst and Kp, developed in WP 3 will be implemented at USD. Initially the models will be driven using real time solar wind data from ACE/DSCOVR. Once their operation has been verified, the data interfaces will be modified to accept input from the SWIFT MHD solar wind simulation being developed in WP 2. A similar set of steps will be carried out to the models of AE when they become available. The activities of WP 6 will result in a number of NARMAX models for GEO and for the flux of high energy electrons in the radiation belts. The forecasts of these models will be displayed on the project web site, together with facilities to download the numerical values.

T7.1. Activity:

All models are implemented at the institute of the developer. This means that the results from the latest models are always available and that all web sites will display the same set of results. Plots of results are presented on the PROGRESS web site. Access to numerical data added (where possible).

7.1. Overview:

The VERB-NARMAX and VERB-IMPTAM models will be installed at USD and tested. Initially they will be driven using solar wind parameters from ACE/DSCOVR and forecasts of geomagnetic indices from the models developed in WP 3 and implemented at USD. This output of these models will provide forecasts of the particle environment throughout the radiation belt

region.

7.2. Activity:

The VERB-NARMAX and VERB-IMPTAM models remain with the developers. This reduces any maintenance tasks. The results, in the form of plots and numerical data, are downloaded from the developers web site and displayed on the PROGRESS web site. Provision for the user to access numerical data is ongoing

7.3. Overview:

The VERB-NARMAX and VERB-IMPTAM models, provide forecasts of the flux of electrons at various energies within the inner magnetosphere. This task will use these forecasts to determine the path integrated electron fluxes in various energy ranges encountered along the orbital path of a satellite.

7.3 Activity:

A tool has been created to calculate the fluxes of electrons along a user selected satellite's trajectory. This tool currently uses the high energy electron fluxes from VNC (Task 6.3). Access to IMPTAM (low energy) fluxes will be added soon.

7.4. Overview:

In order to disseminate the results of the forecasts in a timely an email circular will be generated and circulated. It is envisaged that this circular will be distributed when forecasts show evidence of potentially hazardous conditions. The exact triggering factors will be defined as a result of meetings of the stakeholder advisory board. Subscription to the email list will be performed from the project web site.

Results:

SW showed the website pages and drop down menus where results can be viewed.

Demonstrations

The second day of the meeting was used for demonstrations of the various models etc. that have been developed by the PROGRESS project.

WP2: Tony Arber, Mike Liemohn

TA gave a overview/demonstration of the processes run in order to calculate the forecasts of the solar wind parameters at L1 and put them on-line.

The Warwick University webpage provides access to the AWSoM and SWIFT predictions. Data are available in either GSM or HGC coordinates.

ZK inquire as to the format of the output results. SW and TA said that it was a plain text file that follows the JSON format. When opened in the browser, the data are automatically reformatted in a reader friendly view.

VY asked how Sheffield read the data. SW replied that they download and process the data using MATLAB functions.

WP3: Peter Wintoft

PW showed the forecast plots for the geomagnetic indices Kp, Dst, and AE that are available from the Regional Warning Center, Sweden. These plots are also shown on the PROGRESS web site.

The models developed may use input from either real-time measurements or AWSoM/SWIFT

forecasts. The model results are available from the RESTful data server.

WP3: Hua-Liang Wei

HW gave a demonstration and presentation on latest developments for the NARMAX methodology at USFD. These include the use of an ensemble NARMAX model for Kp to further improve the accuracy of results and the use of cloud modelling methods to better represent the spread of data.

ZK reminded MB that he did not think it was possible to predict and MB replied that although some models work they are still unreliable for L1. PW asked how many models were used and H-LW replied that 3 were used for Kp.

WP3: Richard Boynton

RB briefly presented USFD NARMAX based forecasts for the Kp index, using inputs from real-time measurements and AWSoM/SWIFT forecasts.

WP5: Natalia Ganushkina

NG demonstrated wealth of IMPTAM results made available via the PROGRESS web site. This includes results based on real-time measurements as well as those generated using parameter forecasts in the form of radial or equatorial flux maps and estimates of the fluxes at Geostationary Orbit such as GOES 15, MEO orbits as utilised by GPS satellites, and the orbit used for the Van Allen probes mission.

WP6: Richard Boynton

RB showed electron fluxes and MLT forecast figures and where to get information on the web site.

WP6: Angelica Tibocha

AT showed the results of real-time forecasts from the coupled VERB-IMPTAM model. This model is based on the output from the IMPTAM model which used to initialise the electron flux boundary conditions and the Kp forecasts from the Lund Kp models. The results are available from GFZ.

WP7: Simon Walker

SW demonstrated the functionality available from the panel of the PROGRESS web site home page that displays the current solar wind parameter, geomagnetic indices, and radiation belt electron fluxes. These values are colour coded to highlight potential risk levels (green = low risk; orange = medium; red = high potential risk). This panel is updated on an hourly basis.

Access to the output of PROGRESS related models for electron fluxes and geomagnetic indices was demonstrated via the PROGRESS web site.

The operation of the Orbit Tool was shown along with the current set of data products to visualise the particle fluxes along the requested orbit.

Summary of Project Officer/External Reviewer

Zerefsan Kaymaz, External Reviewer

ZK said that all groups had worked well together. Most of the work was done on time.

Work group 3 modules were improved and most of the work was completed. Group 4 modules were completed 2 years ago. Group 5 was successful. Group 6 was completed and VERB was successful.

There were no major problems identified with the project. ZK suggested that it would be good

to continue with the work now this project was completed. and added that she was pleased with the responses to the questions she had asked each group. She would encourage us to proceed further with the results.

Andrej Rozkov, Project Officer

AR said he would like us to take the initiative and contact potential users and to continue with the results. He would encourage us to exploit it. He reported that all the objectives set out in the project had been reached and it was successful. He also said that he would pass on our project and results to prospective journals who may then contact us to produce papers. He added that we need to publish the results and we should budget for open access.

Closing comments

MB thanked ZK and AR for their assistance and support of the project and for coming to Sheffield to the meetings. He agreed that we do need to publicise the results and need to plan to do joint papers. He also said we should expand our website.

RVS thanked ZK, AR and all the project members and SW for his role as project manager and CH for administration duties.