The Versatile Electron Radiation Belt (VERB) code: Overview

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Acknowledgments

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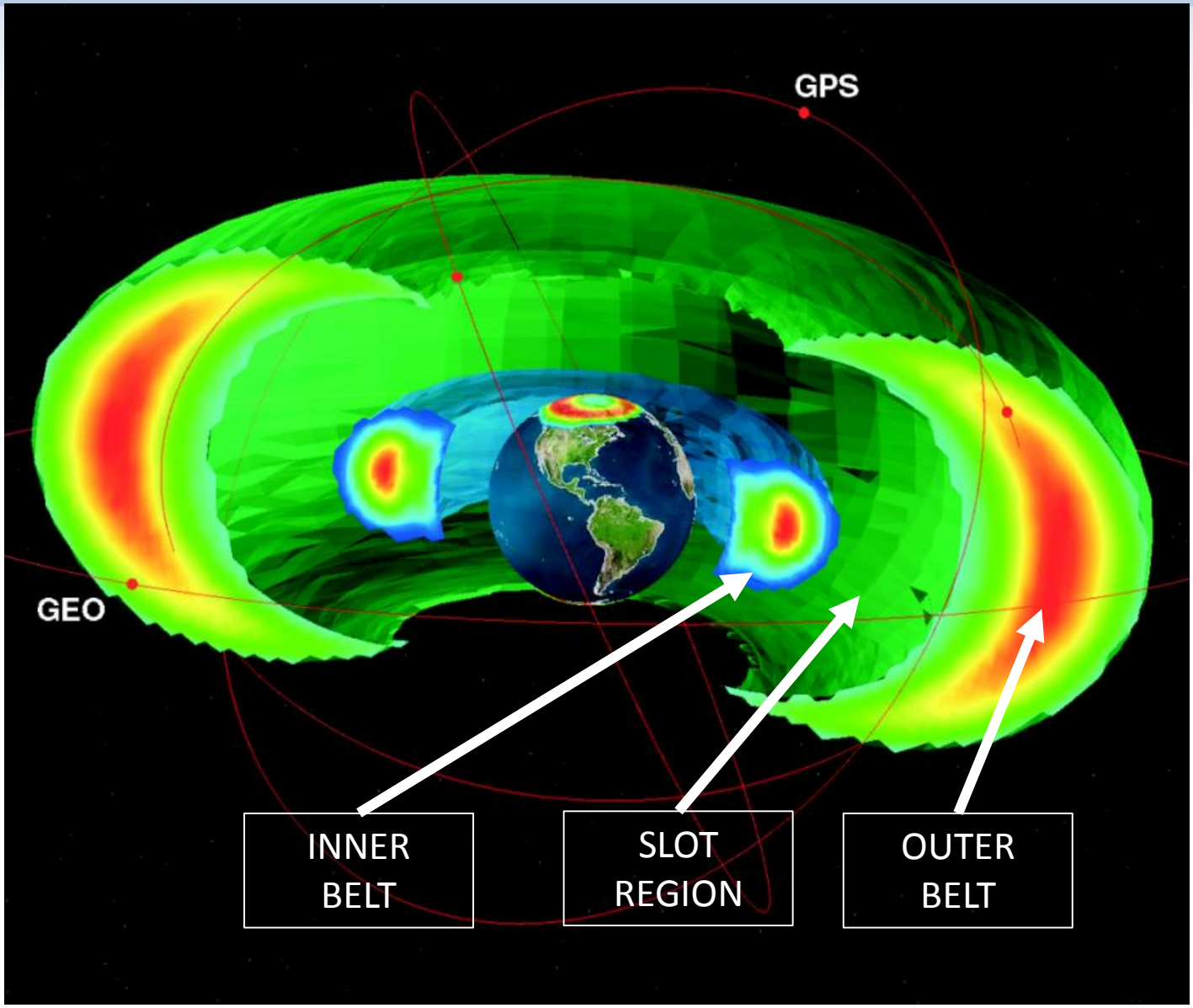
Radiation Belts



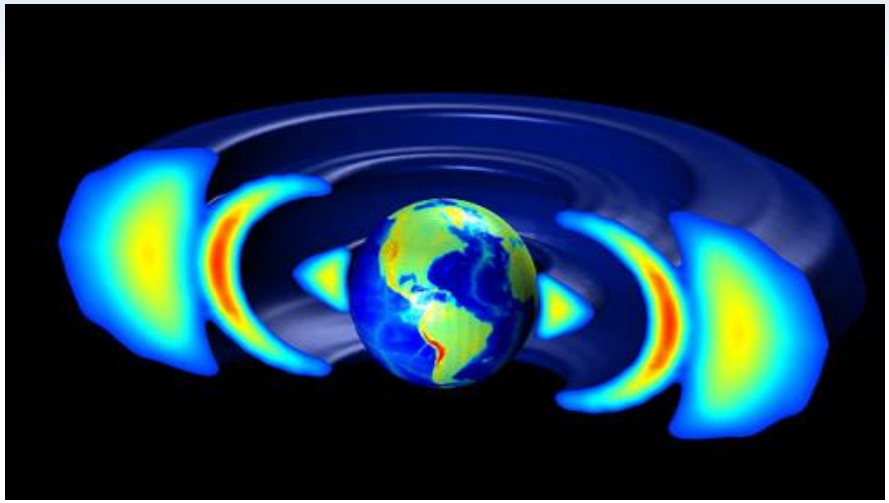
VERB code

- **The Versatile Electron Radiation Belt (VERB) code is designed to model the dynamics of the radiation belts.**

- **It includes various physical processes and can reproduce the dynamics of relativistic and ultrarelativisic electrons.**

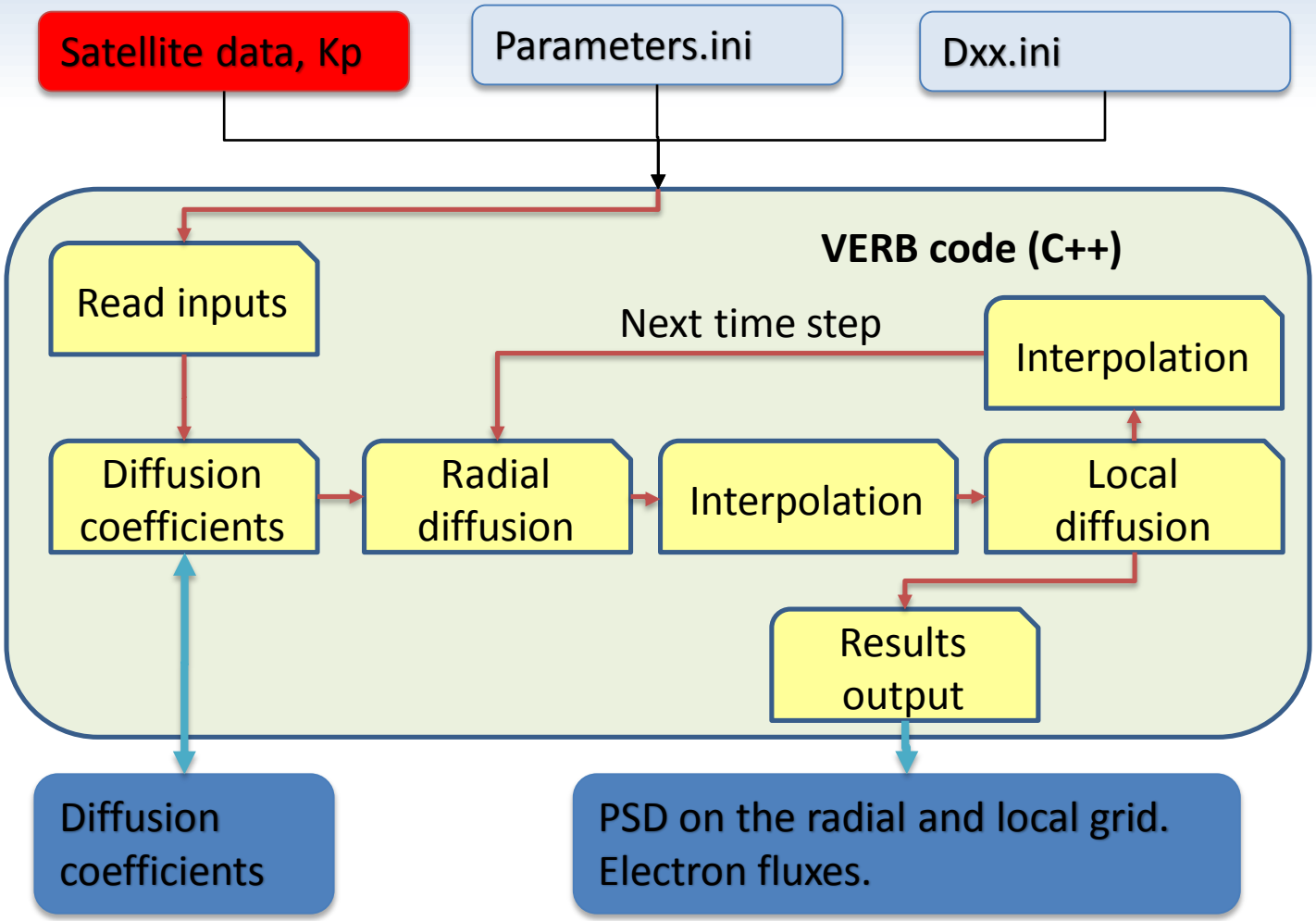
- **3D VERB code allows to obtain the dose at various orbits and can be used for deep dielectric charging calculation.**

- **The VERB code has been validated in the number of sensitivity tests, examples and long-term simulations during CREES and Van Allen Probes operation periods.**



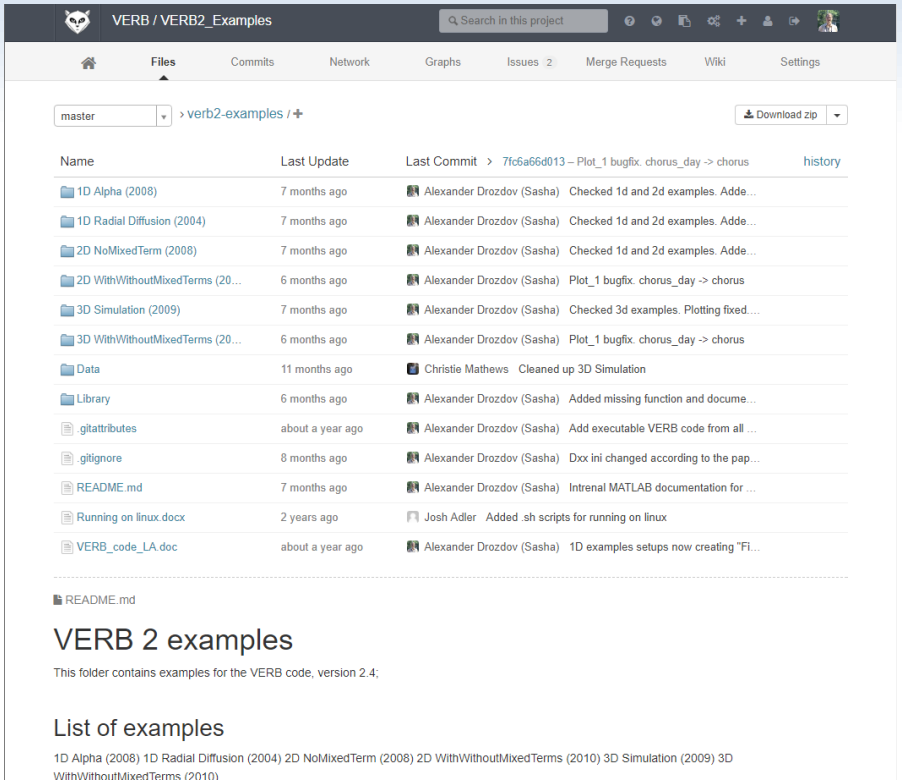
Shprits et al., 2013

VERB code scheme



The VERB code uses an unconditionally stable, implicit scheme and the operator-splitting method to numerically solve the Fokker-Planck equation.

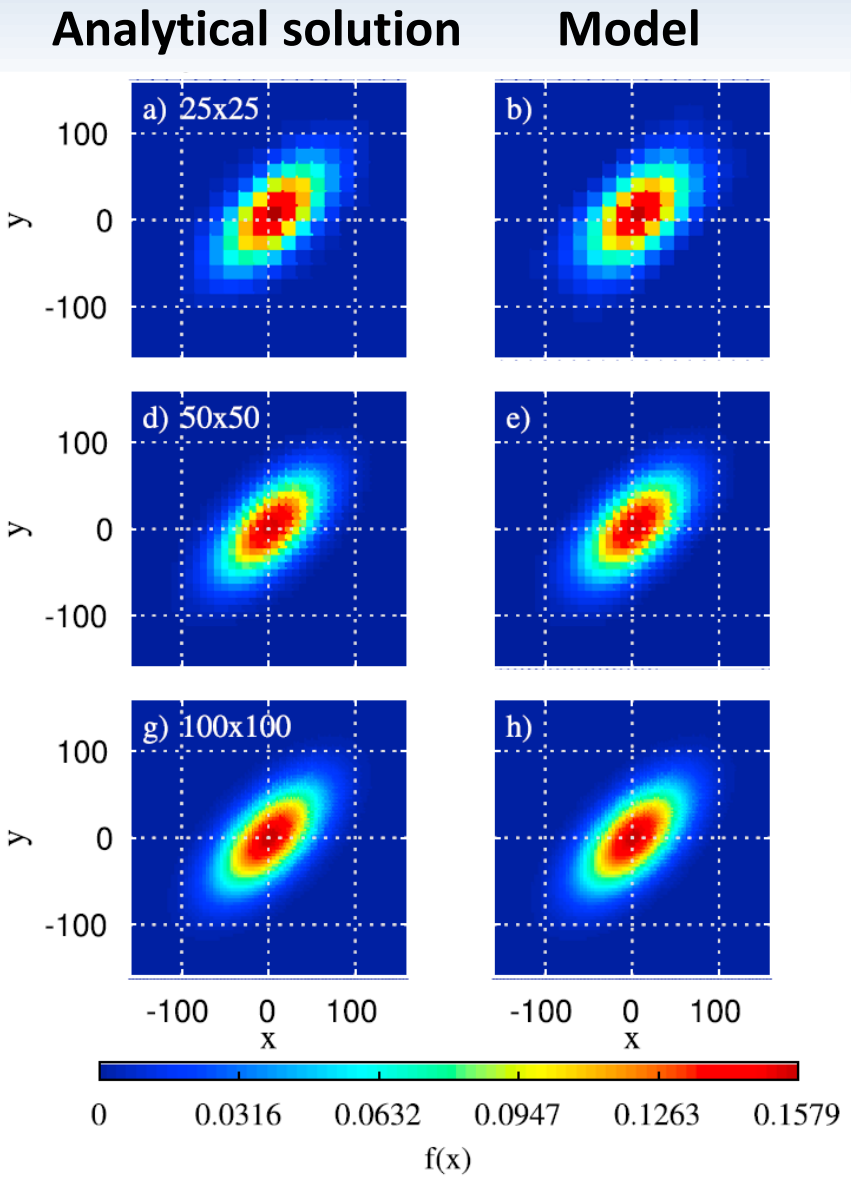
The code development



- **The VERB code has been developed using git and svn version control systems. The tests, examples and supporting libraries are also under version control.**
- **The VERB code is cross-platformed and can be compiled for Windows, MAC and Linux systems using cmake built system.**
- **The code can be executed on the multiprocessor clusters.**

Verification

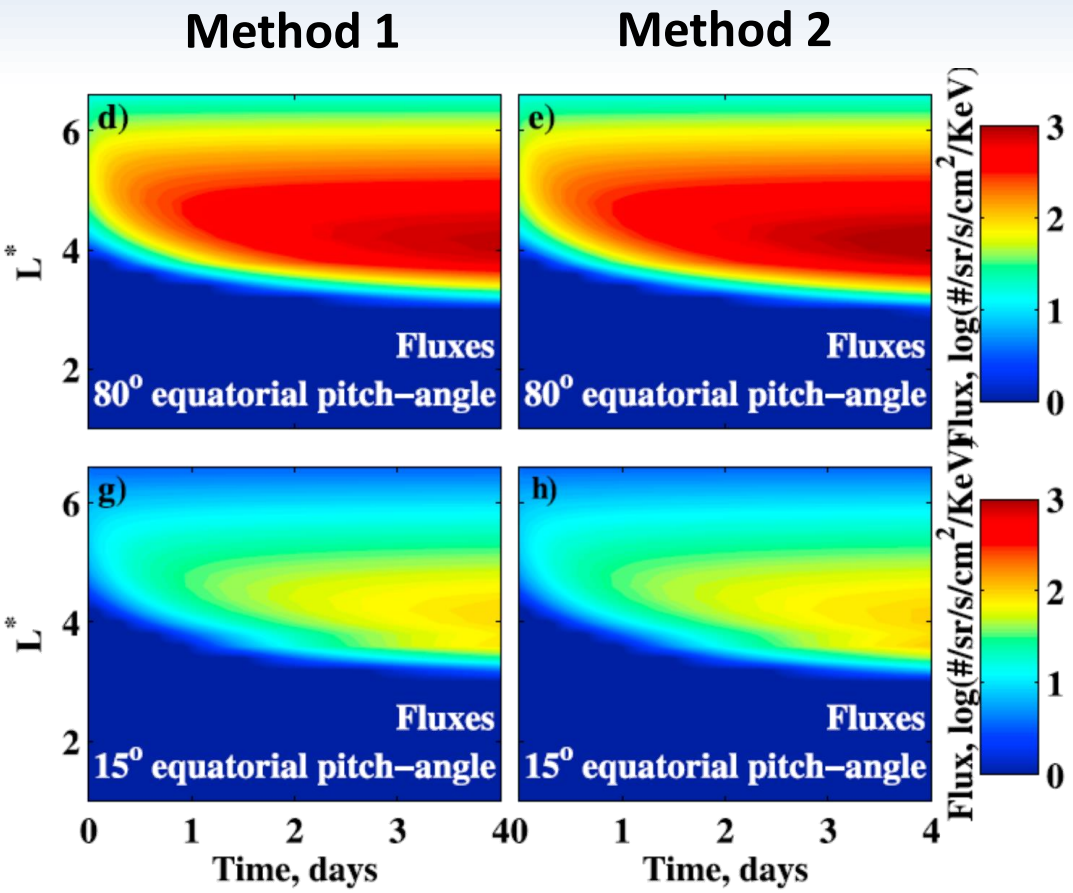
The comparison shows that the VERB code numerical solution of the two-dimensional diffusion equation with mixed terms converges to the analytical solution.



Aseev at al, 2016

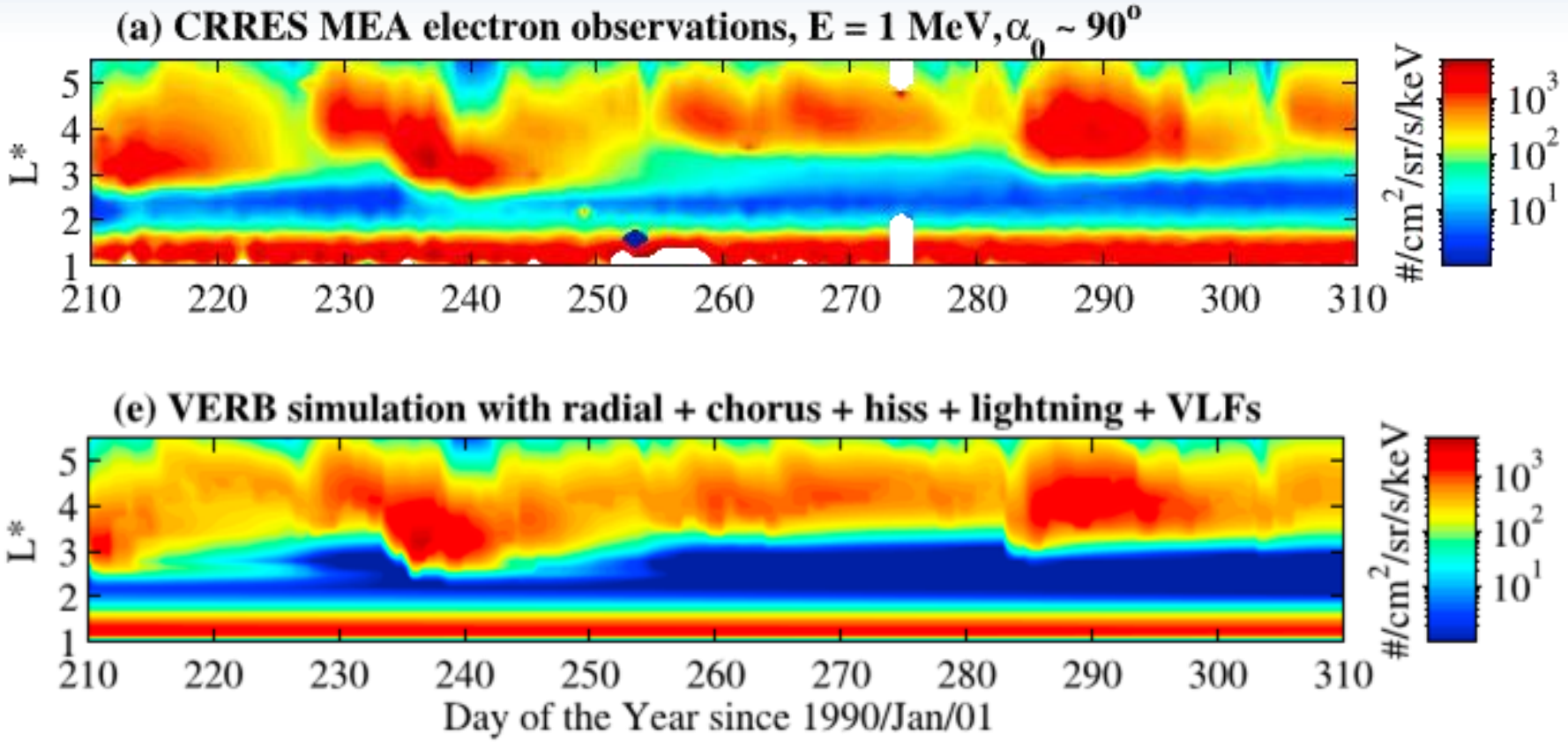
Verification

The comparison of the simulations with two-grid method (Method 1) and new single-grid methods (Method 2) produce similar result.



Subbotin at al, 2012

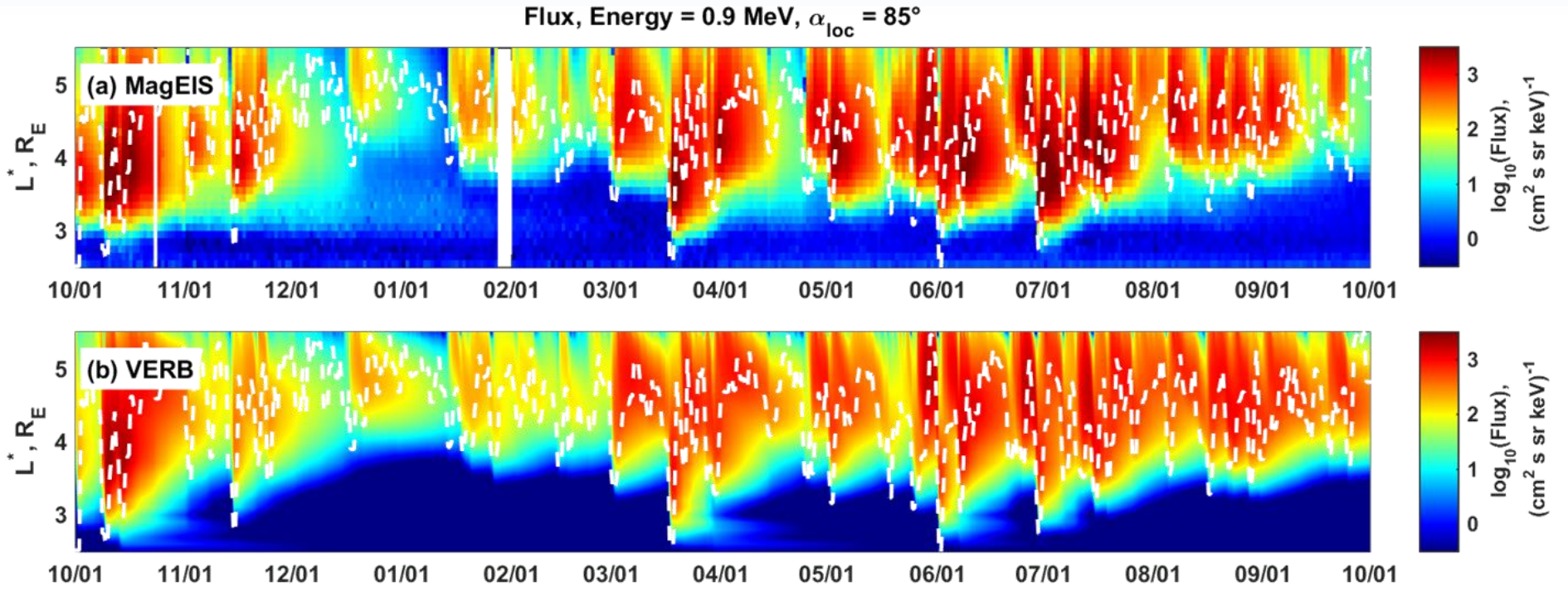
Validation



The comprehensive 100-day VERB code simulations provide a qualitative agreement with the observations during the CREES period.

Kim et al., 2011

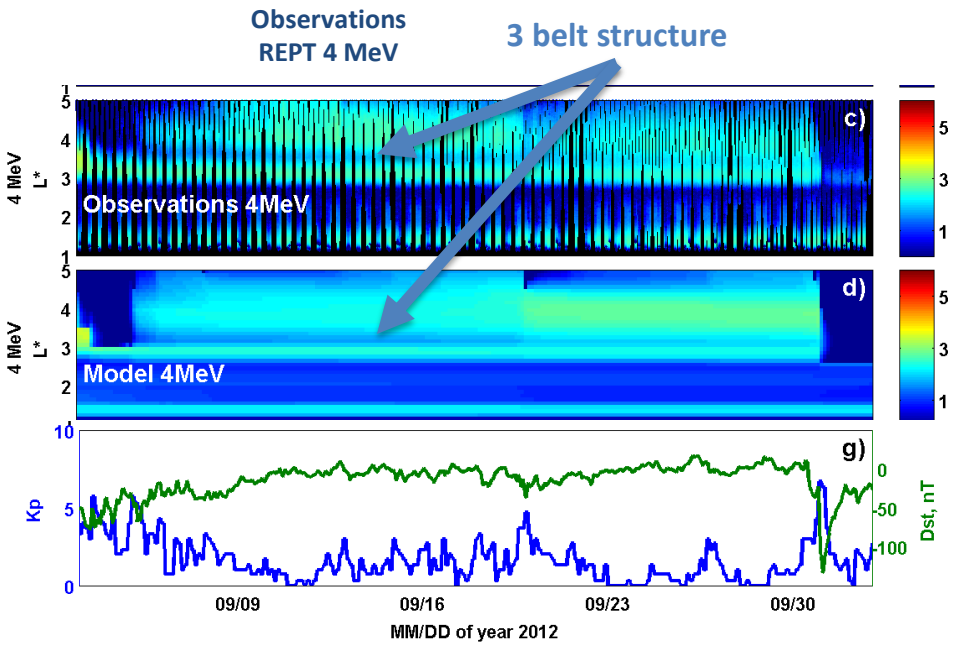
Validation



Drozdov et al., 2015

The one-year VERB code simulations provide a qualitative agreement with the observations during the Van Allen Probes period.

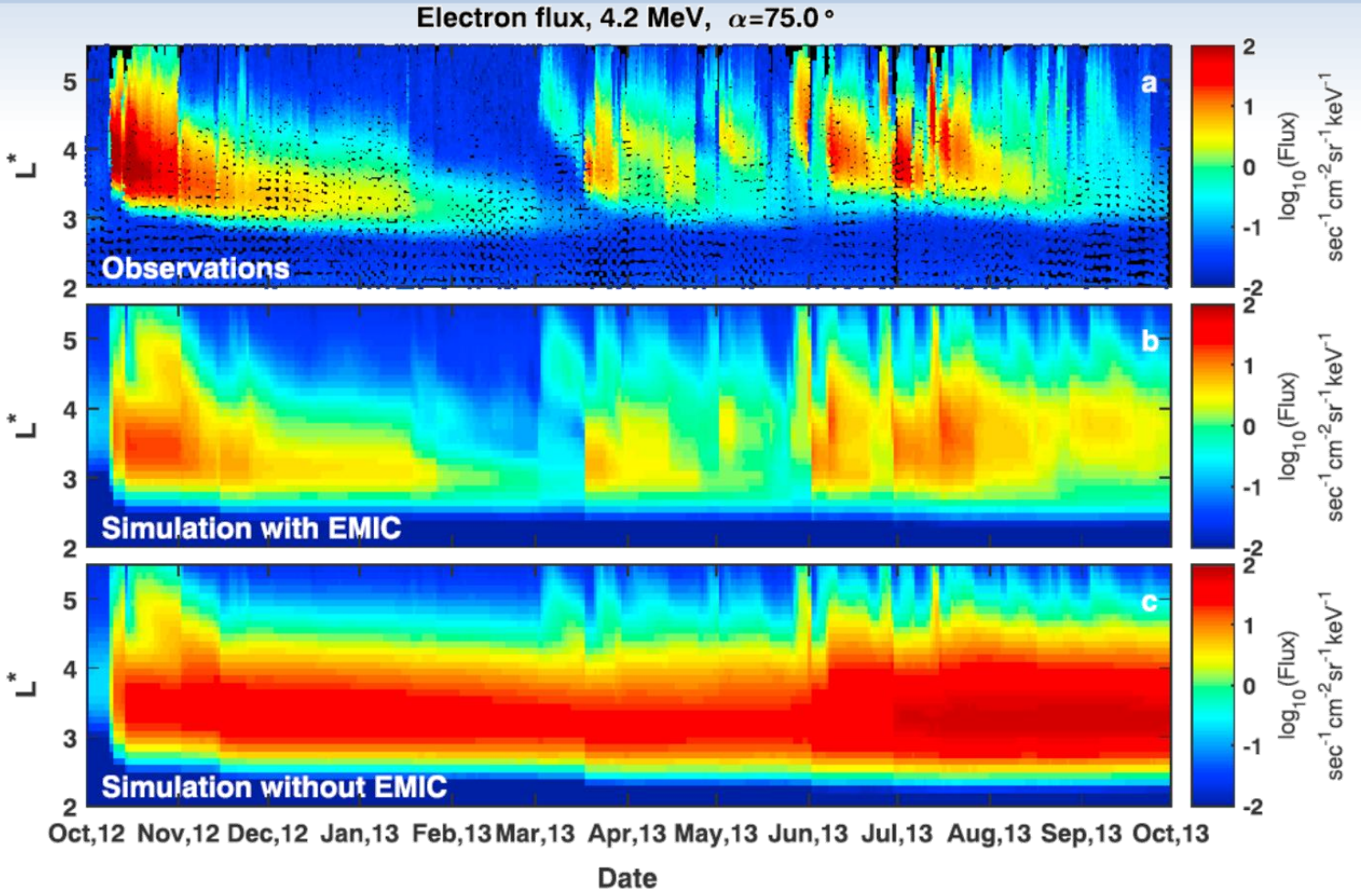
Storm simulation



Shprits et al., 2014, Nature Physics

The VERB code simulation with EMIC waves reproduces the third belt structure during September 2012.

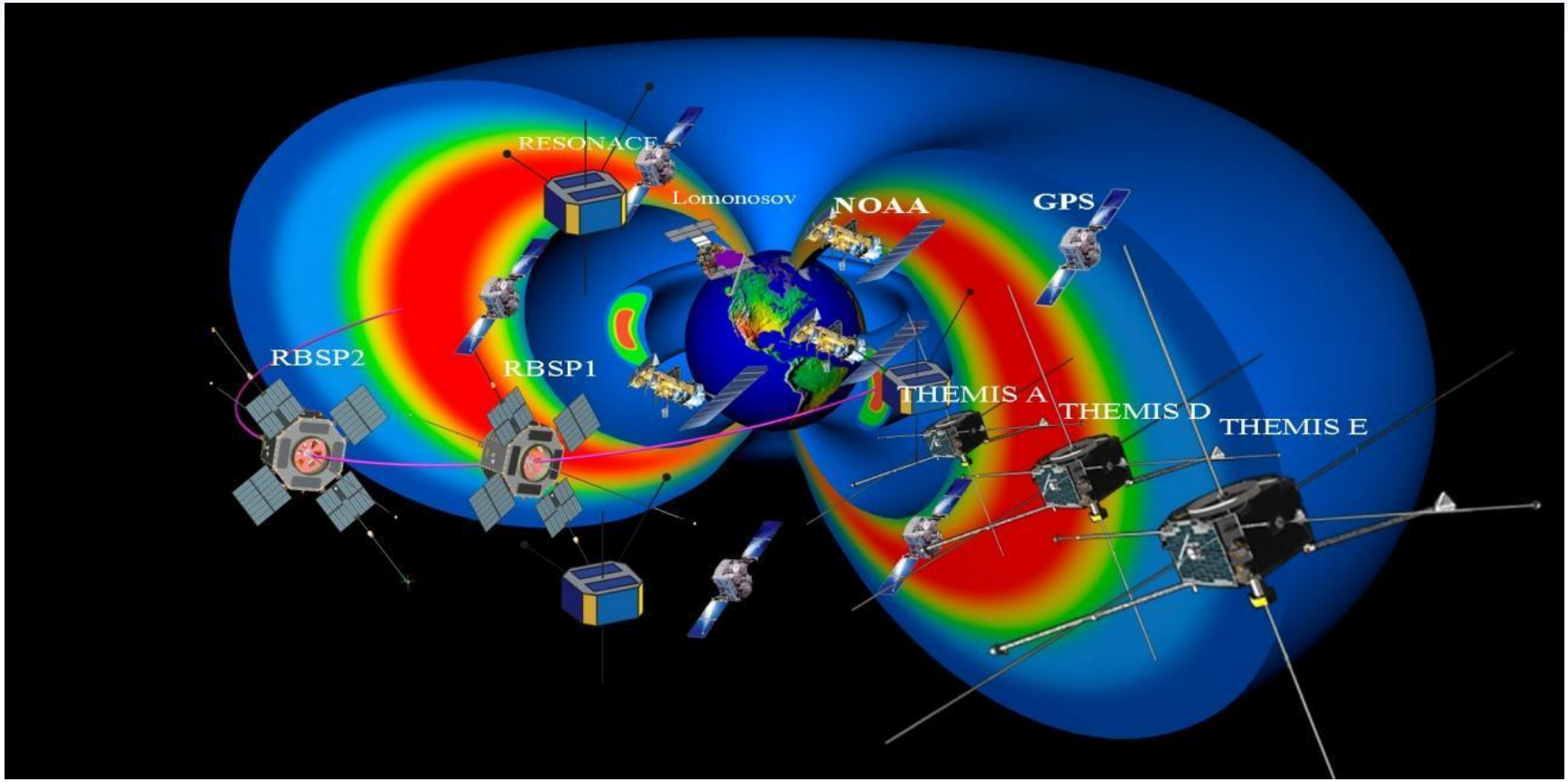
Long-term simulation



Recent long-term simulations includes EMIC waves. *Drozdov et al. 2017*

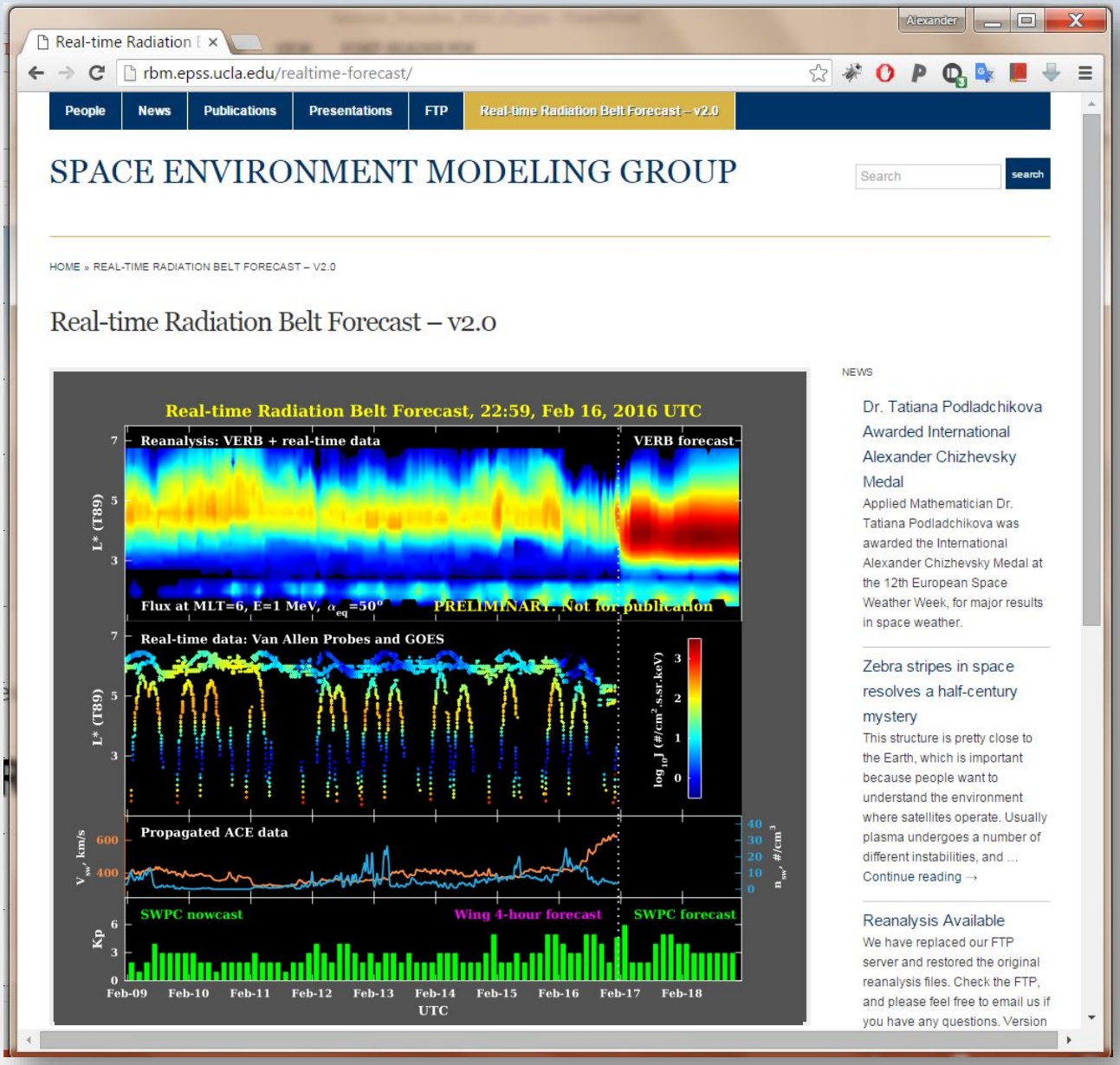
The VERB code reproduces the dynamics of the ultrarelativisic electrons during one year of the Van Allen Probe observations.

Data Assimilation



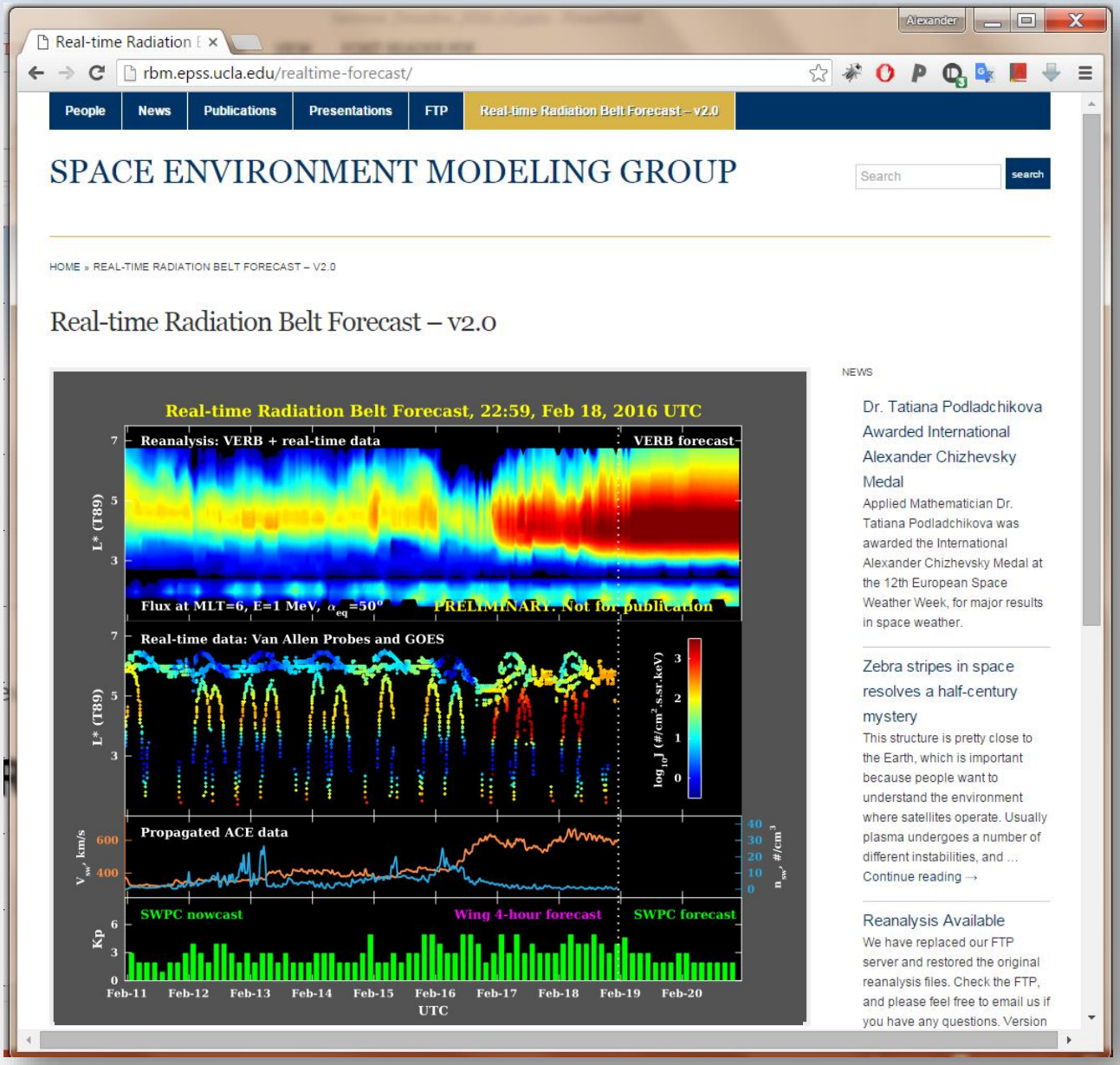
The multipoint observations from various satellites can be included in the VERB code driven data assimilation to fill the spatial and temporal gaps. Data assimilation can be used in nowcast and forecast. *See more on Friday.*

Forecast



Real-time forecast of the electron radiation belt dynamics is available on http://rbm.epss.ucla.edu

Forecast



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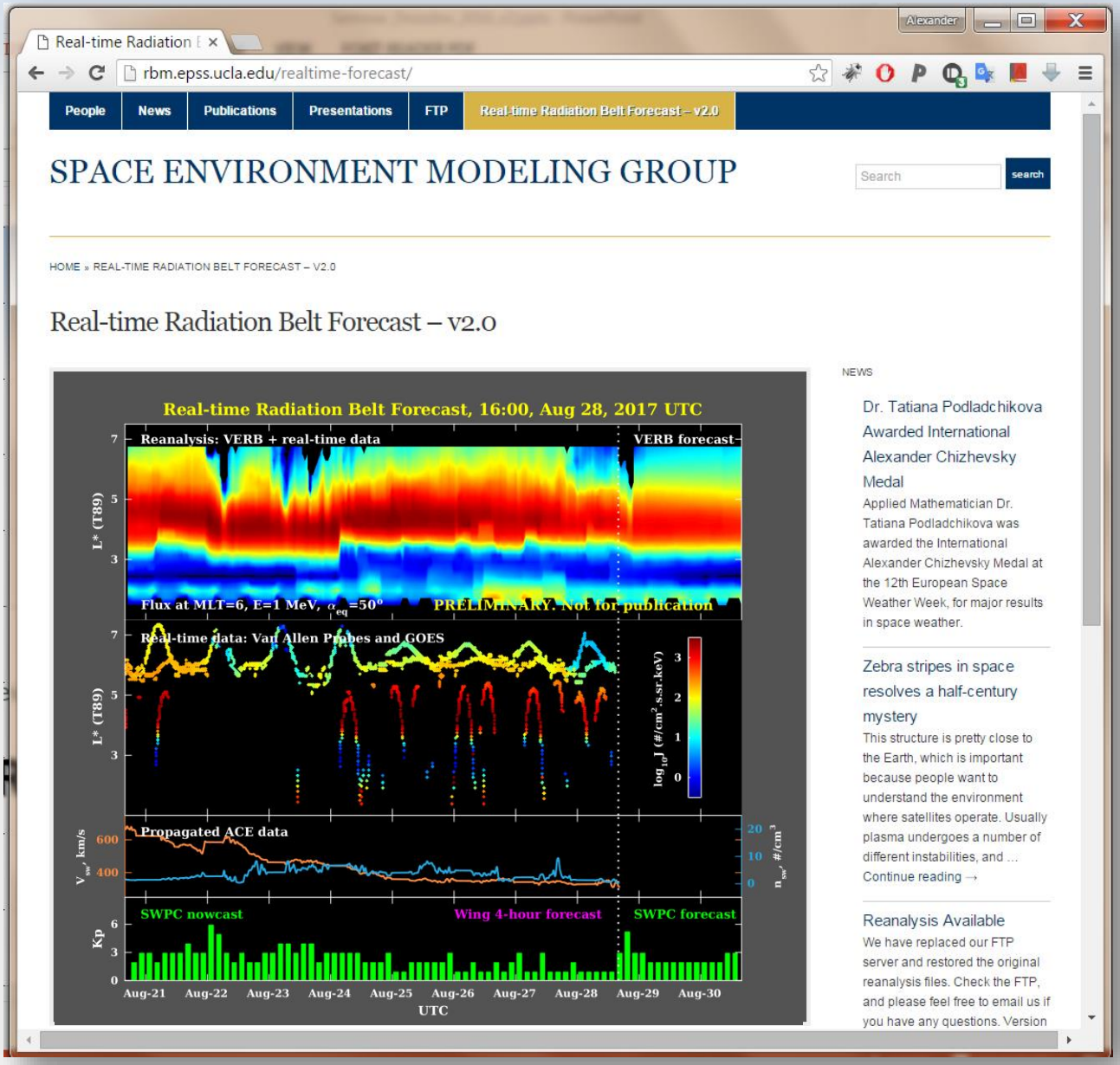
Forecast



Real-time forecast of the electron radiation belt dynamics is available on http://rbm.epss.ucla.edu

Conclusions

- **The Versatile Electron Radiation Belt (VERB) code can quantitatively reproduce the outer belt relativistic and ultrarelativisic energies.**

- **The VERB code supports multiprocessing calculations and can be compiled for different platforms.**

- **The VERB code has been validated during CREES and Van Allen Probes periods. The results of the validations are published in peer-reviewed journals.**

- **The VERB code can be used for reanalysis with data assimilation and in the real-time nowcasting and forecasting.** *See more on Friday.*

- **The new improved version of the VERB code models the dynamics of low-energy electrons and can be used to estimate surface charging.**
  See more at the poster session.