

Abstracts of Publications
submitted by Assoc. Prof. Pencho Marinov
to the competition for the academic position “professor”
in professional field 4.5 “Mathematics”, Scientific Specialty 01.01.13:
”Mathematical Modeling and Applications of Mathematics”
for needs of the section “Parallel Algorithms”,
announced in Newspaper of State, No. 59/26.07.2019

- | № | Публикация |
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| 01 | <p>Kutiev, I., Oyama, K.-I., Abe, T., Marinov, P. Plasmasphere electron temperature model based on Akebono data. (2004) <i>Advances in Space Research</i>, 33 (6), pp. 975-979. DOI: 10.1016/j.asr.2003.06.011, ISSN: 02731177, (IF 0.548 -Q1 -2004)</p> <p><u>Abstract:</u> Average electron temperature (T_e) distribution in altitude range 1000–10,000 km and in geomagnetic latitude range $\# 70^\circ$ are used to construct a simple analytical model of T_e. T_e distribution is considered constant during daytime (9–16 h) and nighttime (22–04 h) local time sectors. Transition between the constant thermal states is described by cubic splines. The vertical T_e profiles at fixed geomagnetic latitudes are approximated by second order polynomials and then the three constants of these polynomials are approximated by another set of analytical expressions, being explicit functions of altitude, geomagnetic latitude and local time. No seasonal variation or hemispheric asymmetry is considered in the model. The average T_e distributions at L shells greater than three were reconstructed, in order to avoid the unrealistically high temperatures measured in the regions with low plasma density. For this purpose, T_e distributions above 3000 km along the L shells were calculated, taking the gradients obtained at L 1/4 2 (0.3 K/km during the day and 0.1 K/km during the night), reduced with latitudes as $1/(L-1)$. The accuracy and limitations of the model are discussed.</p> |
| 02 | <p>Oyama, K.-I., Marinov, P., Kutiev, I., Watanabe, S. Low latitude model of T_e at 600 km based on Hinotori satellite data. (2004) <i>Advances in Space Research</i>, 34 (9), pp. 2004-2009. DOI: 10.1016/j.asr.2004.07.013, ISSN: 02731177. IF 0.548, Q1</p> <p><u>Abstract:</u> A new model of electron temperature (T_e) variations in the low latitude ionosphere (600 km) has been developed by using T_e measurements onboard Hinotori satellite (February 1981–June 1982). The model is based on spline-approximation of the measured T_e in 5-dimensional space comprised of solar activity (F10.7), month of the year, local time, geographic longitude and geomagnetic latitude. Each axis is divided into subintervals delimited by a number of nodes. To find T_e at a point of interest, spline interpolation from the nearest nodes to the point of interest is used. During the lifetime of Hinotori mission, F10.7 varied between 140 and 230, so the model is constrained to this solar activity range. The geomagnetic latitude range is limited to $\pm 42^\circ$ due to the low inclination orbit of the satellite. The model error has been evaluated using the whole database, containing 17 months of data ($4.2 \cdot 10^5$ measured values). The standard (mean square root) deviation of the model from the data is found to be around 14%. A detailed comparison between the model and IRI-95 predictions shows a discrepancy of 100–200 K in most cases, although some larger deviations are also found to occur. Contrary to IRI, the present model captures satisfactorily the morning overshoot and the afternoon enhancement of T_e.</p> |
| 03 | <p>Marinov, P., Kutiev, I., Watanabe, S. Empirical model of $O + -H +$ transition height based on topside sounder data. (2004) <i>Advances in Space Research</i>, 34 (9), pp. 2021-2025. DOI: 10.1016/j.asr.2004.07.012, ISSN: 02731177, IF 0548, (Q1)</p> <p><u>Abstract:</u> A new model of the $O + -H +$ transition height (denoted as THM) is developed, based on vertical electron density profiles from topside ionosondes. The model provides the transition height as a function of month of the year, local time, geomagnetic latitude, longitude and solar flux F 10.7. To define TH, the $O +$ scale height is approximated by the lowest gradient in the measured profile and the $O +$ profile is reconstructed. TH is taken at the height where $O +$ density becomes half of total electron density. The model data base contains 170,033 TH values, sufficiently sampling all parameter's ranges. THM describes the transition height by a multivariable polynomial consisted with Chebishev's and trigonometric base functions, which is fitted to the data in the five-dimensional space. The model results are compared with other available models. The comparison shows that THM predictions agree in general with those of the other models, but THM variations along latitude, longitude and local time have larger amplitudes.</p> |
| 04 | <p>Kutiev, I.S., Marinov, P.G., Watanabe, S. Model of topside ionosphere scale height based on topside sounder data. (2006) <i>Advances in Space Research</i>, 37 (5), pp. 943-950. DOI: 10.1016/j.asr.2005.11.021, ISSN: 02731177, IF 0.706 (Q2 - 2005)</p> <p><u>Abstract:</u>
A new model of topside ionosphere scale height is developed, based on the vertical electron density (N_e) profiles obtained from topside ionosondes. The model provides the vertical scale height (VSH) as a function of month of the year, local time, geomagnetic latitude, solar flux F 10.7 and K p index. To define VSH, the $O +$ scale height above the peak of the F2 layer is assumed to be represented by the lowest gradient in the measured profile. The model data base contains 170,033 VSH values, extracted from individual $N(h)$ profiles gathered between 1962 and 1978 by Alouette and ISIS satellites. The data sample sufficiently all parameter's ranges. The model describes the vertical plasma scale height by a multivariable polynomial consisted from Tchebishev's and trigonometric base-functions, which are fitted to</p> |

the data in the 5-dimensional space. The overall model error is 34.6 km, or 23%. The model VSH variations along the different parameters are presented. The model results are compared with those extracted from IRI.

- 05 Belehaki, A., Marinov, P., Kutiev, I., Jakowski, N., Stankov, S. Comparison of the topside ionosphere scale height determined by topside sounders model and bottomside digisonde profiles. (2006) *Advances in Space Research*, 37 (5), pp. 963-966. DOI: 10.1016/j.asr.2005.09.014, ISSN: 02731177, IF 0.706 (Q2 - 2005)

Abstract:

Topside ionospheric electron density extrapolation techniques rely on the applied profiler model with different techniques resulting in different profile shape. In all these techniques, the parameter that largely determines the shape of the profile is the scale height. Recently, an empirical model of the topside ionosphere scale height was developed, based on the vertical electron density profiles from the topside sounders onboard Alouette and ISIS satellites. The aim of this paper is to compare the scale height determined by the topside sounders model and bottomside digisonde profiles extrapolated above the maximum of the F layer. Theoretical scale height values, calculated by using the IRI plasma temperature model are also included in the comparison.

- 06 Kutiev, I., Marinov, P. Topside sounder model of scale height and transition height characteristics of the ionosphere. (2007) *Advances in Space Research*, 39 (5), pp. 759-766. DOI: 10.1016/j.asr.2006.06.013; ISSN: 02731177; IF 0.774 (Q3)

Abstract:

The topside scale height (T_s) and transition height (T_h) models, previously developed by the authors, provided T_s and T_h for any set of input parameters: month, local time, geomagnetic latitude, solar flux $F_{10.7}$, and K_p . It was found that the scale height and transition $O^+ - H^+$ height, extracted from each individual measured Ne profile, highly correlate, with a correlation coefficient exceeding 0.8 at mid-latitudes. The ratio $R_t = T_s/T_h$ obtained from the individual profiles is modelled as a function of the same input parameters. Three subsets of data, for T_s , T_h , and R_t , were organized to obtain the respective model coefficients. The three models: T_s , T_h , and R_t are now incorporated in a single model TSM (topside sounder model). It is found that T_s and T_h have a dispersion of about 40% around the respective average, while the model reduces the dispersion (model error) to 27%. The most remarkable fact is that the dispersion of R_t is only 25% and model error is reduced to 18%. This fact promotes R_t as a reliable parameter in the topside modeling. The main variations of the model quantities versus geomagnetic latitude and local time are shown for different conditions. It is shown that the model values capture well the data variations. TSM output parameters are used to formulate a concept of a new profiler, named topside ionosphere and plasmasphere profiler (TIPP), as a tool for obtaining the vertical Ne distribution in the upper ionosphere and plasmasphere when NmF_2 and hmF_2 are specified. The concept consider either the sech-squared, a-Chapman, or exponential shape of the topside F layer, which have to be tested against the measured profiles for selecting most reliable.

- 07 Stankov, S.M., Marinov, P., Kutiev, I. Comparison of NeQuick, PIM, and TSM model results for the topside ionospheric plasma scale and transition heights. (2007) *Advances in Space Research*, 39 (5), pp. 767-773. IF 0.774-Q3. DOI: 10.1016/j.asr.2006.10.023; ISSN: 02731177;

Abstract:

The topside ionospheric scale height (T_s) and the $O^+ - H^+$ transition height (T_h) are key ionospheric characteristics that are of special interest when studying and modelling the plasma composition and dynamics. Recently, a new Topside Sounder Model (TSM) has been developed which provides the T_s and T_h quantities together with the ratio between them, T_s/T_h . The database for this model has been built upon thousands of T_s and T_h values deduced from electron density profiles retrieved from topside sounding measurements. For validation purposes, it would be interesting to compare calculations of the ionospheric scale/transition heights from TSM with corresponding calculations from two other well-known models – the NeQuick Model (NeQ) and the Parameterized Ionospheric Model (PIM). For the purpose, electron density profiles have been computed with both the NeQuick and PIM models over suitable grids of input parameters such as month, local time, geomagnetic latitude, solar activity, and in the altitude range between 200 and 2000 km. The topside ionospheric scale height and the $O^+ - H^+$ transition height values have been extracted from each profile in the same manner as previously done for the TSM development database. Finally, the T_s and T_h values deduced from the NeQuick and PIM profiles have been compared with the respective values provided by the TSM. Results of this comparison are analysed and suggestions are put forward for further improving the models in question. TSM applications are discussed as well.

- 08 Warnant, R., Kutiev, I., Marinov, P., Bavier, M., Lejeune, S. Ionospheric and geomagnetic conditions during periods of degraded GPS position accuracy: 1. Monitoring variability in TEC which degrades the accuracy of Real-Time Kinematic GPS applications. (2007) *Advances in Space Research*, 39 (5), pp. 875-880. DOI: 10.1016/j.asr.2006.03.044; IF 0.774 (Q3)

Abstract: The Real-Time Kinematic (RTK) positioning technique, providing centimetre-level accuracy, is most vulnerable to the ionospheric irregularities having a size comparable with the distance between the reference station and the users. In practice this distance is of order of 10–20 km. These irregularities can severely degrade the position accuracy. To monitor and study these smaller-scale ionospheric disturbances, a new method is developed, using the GPS derived TEC. The method calculates time derivatives (rate of change) from successive TEC values taken from individual satellites, de-trend their variations in 15 min intervals with low order polynomial and calculates the standard deviation from residuals. This standard deviation is a measure of amplitudes of ionospheric irregularities with characteristic period of 5–10 min and wavelength of 30–60 km. By changing the time of accumulation, the method becomes sensitive to smaller or higher scale irregularities. The standard deviation is quantified in nine grades and characterizes the level of disturbance, named RTK ionospheric intensity. The RTK ionospheric intensity above a define level is called RTK ionospheric event. It is found that the RTK ionospheric intensity has well expressed diurnal, seasonal and solar cycle occurrence. The probability of degraded positioning accuracy increases in morning hours in winter at high solar activity. It is shown that the RTK ionospheric intensity can be used as an effective tool in studying the smaller-scale ionospheric disturbances.

- 09 Warnant, R., Kutiev, I., Marinov, P., Bavier, M., Lejeune, S. Ionospheric and geomagnetic conditions during periods of degraded GPS position accuracy: 2. RTK events during disturbed and quiet geomagnetic conditions. (2007) *Advances in Space Research*, 39 (5), pp. 881-888. DOI: 10.1016/j.asr.2006.06.018; ISSN: 02731177; IF 0.774 (Q3 – 2007).

Abstract:

The paper analyzes the ionospheric conditions associated with strong RTK events observed during the strong geomagnetic storm on 31 March 2001 and on 16 January 2000, a day with very low geomagnetic activity. The analysis is based on ionograms obtained from ground-based ionosondes stations at Chilton (UK), Juliusruh (Germany), and Dourbes (Belgium). The storm onset on 31 March 2001 occurs at 0058UT followed by decreasing the F layer ionization and sharp increase of its height. At sunrise, a layer, classified as F0.5, tears off the normal F layer and start descending as the time develops. It merges the normal E layer about 2 h later. The second RTK event on that day, with larger intensities, occurs in association of a series of substorms in the afternoon hours. Then ionograms clearly show the presence of side reflections, interpreted as large-scale traveling ionospheric disturbances (LSTIDs). In the quiet period 16–19 January 2000, strong RTK events are observed to appear in the morning hours and disappear in afternoon. The behavior of the bottomside ionosphere on 16 January 2000 is analyzed in details. The E layer traces first appear on ionograms at height of 150 km instead of 100 km, as it usually happens. This layer, classified as E2 layer, is accompanied in most of the cases examined with a “c” type Es layer, as they both descent to the height of the normal E layer within 2–3 h. The appearing of morning RTK events during winter months is suggested to reflect phenomena known in the literature as tidal ion layers and solar terminator associated processes.

- 10 Kamberov, G., Popova, L., Nickolov, T., Marinov, P., Hristov, V. Effect of nitrogen impurities in the scrape-off layer of magnetically confined plasma. (2007) *Comptes Rendus de L'Academie Bulgare des Sciences*, 60 (8), pp. 821-826. IF 0.106 (Q4); ISSN: 13101331

Abstract: The effect of nitrogen impurities on ELM characteristics has been investigated performing computer simulations of plasma drift from the edge to the divertor target. Considerable cooling of plasma near the divertor is found.

- 11 Kamberov, G., Popova, L., Nickolov, T., Marinov, P., Hristov, V. Impact of the experimental conditions on edge plasma turbulences in Tokamak. (2007) *Comptes Rendus de L'Academie Bulgare des Sciences*, 60 (10), pp. 1059-1064. IF 0.106 (Q4); ISSN: 13101331

Abstract: Our simulations reveal resonance conditions for Edge Localized Mode (ELM) in accordance with experimental observations. Magnetic resonance perturbations have a mitigation effect on ELM turbulences within limits determined by the nonlinear effects of particle collisions and thermal motion. Additional conditions are found for the edge plasma density to be high enough and for the temperature in the edge not to be too high. The threshold values depend on plasma configuration. Increasing density or decreasing temperature of edge plasma mitigates ELM turbulences. Impurities injected in small concentrations in the Scrape-Off-Layer (SOL) reduce ELM size and frequency, decreasing essentially divertor heating.

- 12 Bankov, L., Heelis, R., Parrot, M., Berthelier, J.-J., Marinov, P., Vassileva, A. WN4 effect on longitudinal distribution of different ion species in the topside ionosphere at low latitudes by means of DEMETER, DMSP-F13 and DMSP-F15 data. (2009) *Annales Geophysicae*, 27 (7), pp. 2893-2902. DOI: 10.5194/angeo-27-2893-2009; ISSN: 09927689; IF 1.648 (Q2)

Abstract: Plasma probe data from DMSP-F13, DMSP-F15 and DEMETER satellites were used to examine longitudinal structures in the topside equatorial ionosphere during fall equinox conditions of 2004 year. Since the launch of DEMETER satellite on 29 June 2004, all these satellites operate close together in the topside ionosphere. Here, data taken from Special Sensor-Ion, Electron and Scintillations (SSIIES) instruments on board DMSP-F13, F15 and Instrument Analyser de Plasma (IAP) on DEMETER, are used. Longitudinal variations in the major ions at two altitudes (~730 km for DEMETER and ~840 km for DMSP) are studied to further describe the recently observed “wavenumber-four” (WN4) structures in the equatorial topside ionosphere. Different ion species H⁺, He⁺ and O⁺ have a rather complex longitudinal behavior. It is shown that WN4 is almost a regular feature in O⁺ the density distribution over all local times covered by these satellites. In the evening local time sector, H⁺ ions follow the O⁺ behavior within WN4 structures up to the premidnight hours. Near sunrise H⁺ and later in the daytime, He⁺ longitudinal variations are out of phase

with respect to O⁺ ions and effectively reduce the effect of WN4 on total ion density distribution at altitudes 730–840 km. It is shown that both a WN4 $E \times B$ drift driver and local F-region winds must be considered to explain the observed ion composition variations.

- 13 Kutiev, I., Marinov, P., Belehaki, A., Reinisch, B., Jakowski, N. Reconstruction of topside density profile by using the topside sounder model profiler and digisonde data. (2009) *Advances in Space Research*, 43 (11), pp. 1683-1687. IF 1.079 (Q3 – 2009). DOI: 10.1016/j.asr.2008.08.017; ISSN: 02731177

Abstract:

To improve the accuracy of the real time topside electron density profiles given by the Digisonde software a new model-assisted technique is used. This technique uses the Topside Sounder Model (TSM), which provides the plasma scale height (H_s), O⁺–H⁺ transition height (H_T), and their ratio $R_t = H_s/H_T$, derived from topside sounder data of Alouette and ISIS satellites. The Topside Sounder Model Profiler (TSMP) incorporates TSM and uses the model quantities as anchor points in construction of topside density (Ne) profiles. For any particular location, TSMP calculates topside Ne profiles by specifying the values of foF2 and hmF2. In the present version, TSMP takes the F2 peak characteristics – foF2, hmF2, and the scale height at hmF2 – from the Digisonde measurements. The paper shows results for the Digisonde stations Athens and Juliusruh. It is found that the topside scale height used in Digisonde reconstruction is less than that extracted from topside sounder profiles. Rough comparison of their bulk distributions showed that they differ by an average factor of 1.25 for locations of Athens and Juliusruh. When the Digisonde scale heights are adjusted by this factor, the reconstructed topside profiles are close to those provided by TSM. Compared with CHAMP reconstruction profiles in two cases, TSMP/Digisonde profiles show lower density between 400 and 2000 km

- 14 Kutiev, I., Marinov, P., Fidanova, S., Warnant, R. Modeling medium-scale TEC structures, observed by Belgian GPS receivers network. (2009) *Advances in Space Research*, 43 (11), pp. 1732-1739. DOI: 10.1016/j.asr.2008.07.021; ISSN: 02731177; IF 1.079 (Q3 - 2009)

Abstract: GALOCAD project “Development of a Galileo Local Component for the nowcasting and forecasting of atmospheric disturbances affecting the integrity of high precision Galileo applications” aims to perform a detailed study on ionospheric small- and medium-scale structures and to assess the influence of these structures on the reliability of Galileo precise positioning applications. GPS-derived TEC (total electron content) is obtained from the Belgium Dense Network (BDN), consisting of 67 permanent GPS stations. An empirical 3-D model is developed for studying these ionospheric structures. The model, named LLT model, described temporal variations of TEC in latitude/longitude frame (46°, 52°N and (#1°, 11°)E). The spatial variations of TEC are modeled by Tchebishev base functions, while the temporal variations are described by a trigonometric basis. To fit the model to the data, the observed area is divided into bins with (1° # 1°) geographic scale and 6 min on time axis. LLT model is made flexible, with varying number of coefficients along each axis. This allows different degree of smoothing, which is the key element of the present approach. Model runs with higher number of coefficients, capturing in details medium-scale TEC structures are subtracted from results obtained with smaller number of coefficients; the latter represent the background ionosphere. The residual structures are localized and followed as they travel across the observed area. In this way, the size, velocity, and direction of the irregular structures are obtained.

- 15 Kutiev, I., Marinov, P., Belehaki, A., Jakowski, N., Reinisch, B., Mayer, C., Tsagouri, I. Plasmaspheric electron density reconstruction based on the topside sounder model profiler. (2010) *Acta Geophysica*, 58 (3), pp. 420-431. IF 1.000 (0.893 -5 year IF) Q3 DOI: 10.2478/s11600-009-0051-4; ISSN: 18956572

Abstract: We apply a model-assisted technique to construct the topside electron density profile based on Digisonde measurements. This technique uses the Topside Sounder Model (TSM), which provides the plasma scale height, O⁺–H⁺ transition height, and their ratio $R_t = H_T/h_T$, derived from topside sounder data of Alouette and ISIS satellites. The Topside Sounder Model Profiler (TSMP) incorporates TSM and uses the model quantities as anchor points for the construction of topside density profiles. TSMP provides its model ratios with transition height and plasmaspheric scale height. The analysis carried out indicates that Digisonde derived F-region topside scale height H_m is systematically lower than one derived from topside sounder profiles. To construct topside profiles by using H_m , a correction factor of around 3 is needed to multiply the neutral scale height in the α -Chapman formula. It was found that the plasmaspheric scale height strongly depends on latitude and its ratio with the F-region scale height expresses large day-to-day variability.

- 16 Belehaki, A., Kutiev, I., Reinisch, B., Jakowski, N., Marinov, P., Galkin, I., Mayer, C., Tsagouri, I., Herekakis, T. Verification of the TSMP-assisted digisonde topside profiling technique. (2010) *Acta Geophysica*, 58 (3), pp. 432-452. IF 1.000 (0.893 -5 year IF) Q3 DOI: 10.2478/s11600-009-0052-3; ISSN: 18956572

Abstract: The purpose of this paper is to evaluate the performance of the TSMP-assisted Digisonde (TaD) topside profiling technique. We present systematic comparisons between electron density profiles and TEC parameters extracted from TaD model with (a) CHAMP-derived TEC parameters, (b) CHAMP reconstructed profiles, (c) ground based GPS-derived TEC parameters, and (d) profiles reconstructed from RPI/ IMAGE plasmagrams. In all cases, TaD follows the general trend of plasmaspheric observations derived from the above datasets. Especially during storm cases, TaD shows remarkable agreement with the variations of the ground based GPS-derived TEC parameters. Overall, the comparison results shows that TaD method can be adopted by

EURIPOS to provide the electron density distribution up to plasmaspheric heights in real-time.

- 17 Bankov, L.G., Parrot, M., Heelis, R.A., Berthelier, J.-J., Marinov, P.G., Vassileva, A.K. DEMETER and DMSP satellite observations of the disturbed H⁺/O⁺ ratio caused by Earth's seismic activity in the Sumatra area during December 2004. (2010) *Advances in Space Research*, 46 (4), pp. 419-430. IF 1.076-Q3; DOI: 10.1016/j.asr.2009.07.032; ISSN: 02731177.

Abstract: In the present paper, plasma probe data taken from DEMETER and DMSP-F15 satellites were used to study the ion density and temperature disturbances in the morning topside ionosphere, caused by seismic activity at low latitudes. French DEMETER (Detection of Electro-Magnetic Emissions Transmitted from Earthquake Regions) micro-satellite mission had been especially designed to provide global scale observations in the topside ionosphere over seismically active regions. Onboard the DEMETER satellite, the thermal plasma instrument called "Instrument Analyser de Plasma" (IAP) provides ion mass and densities, ion temperature, three component ion drift and ion density irregularities measurements. As a part of "Defense Meteorological Satellite Program", DMSP-F15 satellite is on orbit operation since 1999. It provides ionospheric plasma diagnostics by means of the "Special Sensor-Ion, Electron and Scintillations" (SSIES-2) instrument. We examined few examples of possible seismic effects in the equatorial ionosphere, probably associated with seismic activity during December month in the area of Sumatra Island, including main shock of giant Sumatra event. It is found that the localized topside ionospheric disturbances appear close to the epicenters of certain earthquakes in the Sumatra region. In two cases, ion H⁺/O⁺ ratio rises more than one hour before the main shock, due to the O⁺ density decrease at the winter side of the geomagnetic equator, with longitudinally closest location to the epicenter of the earthquakes. These anomalous depletions in O⁺ density do exist in all cases of SSIES-2 data. Particularly for Sumatra main event, more than one hour after the main shock, we observe large-scale depletion in O⁺ density northward of the geomagnetic equator at winter side hemisphere. Associated with O⁺ depletion, ion temperature latitudinal profile around the geomagnetic equator shows enhanced asymmetry with minimum at the summer side and maximum in positive Ti deviation from mean value at the winter side. This disturbance lasted for more than three hours, later in time observed at the same place by IAP/DEMETER.

- 18 Belehaki, A., Tsagouri, I., Kutiev, I., Marinov, P., Fidanova, S. Upgrades to the topside sounders model assisted by Digisonde (TaD) and its validation at the topside ionosphere. (2012) *Journal of Space Weather and Space Climate*, 2, art. no. A20, DOI: 10.1051/swsc/2012020; ISSN: 21157251 (IF 2.519, Q2 - 2012)

Abstract:

This paper presents a series of improvements made in the Topside Sounders Model assisted by Digisonde (TaD), verification results on these improvements, and its validation at the topside part of the profile. The TaD is based on the simple empirical functions for the O⁺/H⁺ transition height (h_T), the topside electron density scale height (H_T), and their ratio, based on the Alouette/ISIS database. From its first release, published some years ago, TaD offers analytical formulas for obtaining the shape of the vertical plasma distribution in the topside ionosphere and plasmasphere. This first version of the TaD model (TaDv1) is using Digisonde measured parameters of the F layer maximum density, its height, and its scale height to specify the profiler's characteristics at its lower boundary. TaDv1 models separately the O⁺ and H⁺ density profiles, providing the H⁺ scale height in the plasmasphere, extracted from ISIS-1 topside sounder data, as a function of geomagnetic latitude. The upgraded version of TaD (TaDv2) provides calculation of O⁺, H⁺, and He⁺ density distributions in transition region between topside F region and plasmasphere, extracted from the analysis of the electron density profiles from ISIS-1, and in addition approximates the plasmaspheric scale height as a function of altitude, latitude, local time, and season using an optimization procedure to achieve best fit with the measured profiles. These improvements, which concern the part of the profile above the transition height, are presented in detail in the first part of the paper. In the second part we present statistical results for the verification of the model's improvements that show that the optimization procedure contributes to a reduction of the model error of more than two times. The model validation for the topside part of the profile is presented in the last part of this paper, comparing Incoherent Scatter Radar (ISR) electron density profiles (EDP) with the model reconstructed profiles. Comparison with measured EDP from ISR at middle latitudes gives a model error of 3TECU which is close to the GNSS measurement error. Further improvements of TaD reconstruction model are attempted in a follow-on paper, mainly targeted to the reliable operational implementation of the algorithm.

- 19 Kutiev, I., Marinov, P., Fidanova, S., Belehaki, A., Tsagouri, I. Adjustments of the TaD electron density reconstruction model with GNSS-TEC parameters for operational application purposes. (2012) *Journal of Space Weather and Space Climate*, 2, art. no. A21. DOI: 10.1051/swsc/2012021; ISSN: 21157251; (IF 2.519, Q2).

Abstract:

Validation results on the latest version of TaD model (TaDv2) show realistic reconstruction of the electron density profiles (EDPs) with an average error of 3 TECU, similar to the error obtained from GNSS-TEC calculated parameters. The work presented here has the aim to further improve the accuracy of the TaD topside reconstruction, adjusting the TEC parameter calculated from TaD model with the TEC parameter calculated by GNSS transmitting RINEX files provided by receivers co-located with the Digisondes. The performance of the new version is tested during a storm period demonstrating further improvements in respect to the previous version. Statistical comparison of modeled and observed TEC confirms the validity of the proposed adjustment. A significant benefit of the proposed upgrade is that it facilitates the real-time implementation of TaD. The model needs a reliable measure of the scale height at the peak height, which is supposed to be provided by Digisondes. Often, the automatic scaling software fails to correctly calculate the scale height at the peak, H_m, due to interferences in the receiving signal. Consequently the model estimated topside scale height is wrongly calculated leading to unrealistic results for the modeled EDP. The proposed TEC adjustment forces the model to correctly reproduce the topside scale height, despite the inaccurate values of H_m. This adjustment is very important for the application of TaD in an operational environment

- 20 Marinov, P., Zhang, S., Kutiev, I. Comparison of topside ionosphere scale height modeled by the Topside Sounder Model and incoherent scatter radar ionospheric model. (2013) *Advances in Space Research*, 52 (10), pp. 1717-1725. IF 1.238 (Q3) DOI: 10.1016/j.asr.2013.03.008; ISSN: 02731177

Abstract: The topside ionosphere scale height extracted from two empirical models are compared in the paper. The Topside Sounder Model

(TSM) provides directly the scale height (H_T), while the incoherent scatter radar ionospheric model (ISRIM) provides electron density profiles and its scale height (H_R) is determined by the lowest gradient in the topside part of the profile. H_T and H_R are presented for 7 ISR locations along with their dependences on season, local time, solar flux $F_{10.7}$, and geomagnetic index ap . Comparison reveals that H_T values are systematically lower than respective H_R values as the average offset for all 7 stations is 55 km. For the midlatitude stations Arecibo, Shigaraki, and Millstone Hill this difference is reduced to 43 km. The range of variations of H_R is much larger than that of H_T , as the H_T range overlaps the lower part of the H_R range. Dependences on ap , DoY and LT are much stronger in the ISRIM than in TSM. This results in much larger values of H_R at higher ap . Diurnal amplitude of H_R is much larger than that of H_T , with large maximum of H_R at night. The present comparison yields the conclusion that the ISR measurements provide steeper topside N_e profiles than that provided by the topside sounders.

- 21 Fidanova, S., Shindarov, M., Marinov, P. Multi-objective ant algorithm for wireless sensor network positioning. (2013) *Comptes Rendus de L'Academie Bulgare des Sciences*, 66 (3), pp. 353-360. IF 0.198 (Q4 – 2013); DOI: 10.7546/CR-2013-66-3-13101331-6; PUBLISHER: Academic Publishing House; ISSN: 13101331

Abstract: It is impossible to imagine our modern life without telecommunications. Wireless networks are a part of telecommunications. Wireless sensor networks (WSN) consist of spatially distributed sensors, which communicate in wireless way. This network monitors physical or environmental conditions. The objective is the full coverage of the monitoring region and less energy consumption of the network. The most appropriate approach to solve the problem is meta-heuristics. In this paper the full coverage of the area is treated as a constrain. The objectives which are optimized are a minimal number of sensors and energy (lifetime) of the network. We apply multi-objective Ant Colony Optimization to solve this important telecommunication problem. We chose MAX–MIN Ant System approach, because it is proven to converge to the global optima.

- 22 Ferencz, C., Lizunov, G., Crespon, F., Price, I., Bankov, L., Przepiórka, D., Brieß, K., Dudkin, D., Girenko, A., Korepanov, V., Kuzmych, A., Skorokhod, T., Marinov, P., Piankova, O., Rothkaehl, H., Shtus, T., Steinbach, P., Lichtenberger, J., Sterenharz, A., Vassileva, A. Ionosphere waves service (IWS) - A problem-oriented tool in ionosphere and space weather research produced by POPDAT project. (2014) *Journal of Space Weather and Space Climate*, 4, art.no. A17, IF 2.558 (Q2), DOI: 10.1051/swsc/2014013, PUBLISHER: EDP Sciences; ISSN: 21157251

Abstract: In the frame of the FP7 POPDAT project the Ionosphere Waves Service (IWS) has been developed and opened for public access by ionosphere experts. IWS is forming a database, derived from archived ionospheric wave records to assist the ionosphere and Space Weather research, and to answer the following questions: How can the data of earlier ionospheric missions be reprocessed with current algorithms to gain more profitable results? How could the scientific community be provided with a new insight on wave processes that take place in the ionosphere? The answer is a specific and unique data mining service accessing a collection of topical catalogs that characterize a huge number of recorded occurrences of Whistler-like Electromagnetic Wave Phenomena, Atmosphere Gravity Waves, and Traveling Ionosphere Disturbances. IWS online service (<http://popdat.cbk.waw.pl>) offers end users to query optional set of predefined wave phenomena, their detailed characteristics. These were collected by target specific event detection algorithms in selected satellite records during database buildup phase. Result of performed wave processing thus represents useful information on statistical or comparative investigations of wave types, listed in a detailed catalog of ionospheric wave phenomena. The IWS provides wave event characteristics, extracted by specific software systems from data records of the selected satellite missions. The end-user can access targets by making specific searches and use statistical modules within the service in their field of interest. Therefore the IWS opens a new way in ionosphere and Space Weather research. The scientific applications covered by IWS concern beyond Space Weather also other fields like earthquake precursors, ionosphere climatology, geomagnetic storms, troposphere-ionosphere energy transfer, and trans-ionosphere link perturbations.

- 23 Belehaki, A., Tsagouri, I., Kutiev, I., Marinov, P., Zolesi, B., Pietrella, M., Themelis, K., Elias, P., Tziotziou, K. The European Ionosonde Service: Nowcasting and forecasting ionospheric conditions over Europe for the ESA Space Situational Awareness services. (2015) *Journal of Space Weather and Space Climate*, 5, art. no. A25, 22 pages. IF 2.846, (Q2); DOI: 10.1051/swsc/2015026, PUBLISHER: EDP Sciences, ISSN: 21157251

Abstract: The Earth's ionosphere is a magnetoionic medium imbedded in a background neutral atmosphere, exhibiting very interesting refractive properties, including anisotropy, dispersion, and dissipation. As such, it poses a challenge for several radio systems that make use of signal transmission through all or some portion of the medium. It is important therefore to develop prediction systems able to inform the operators of such systems about the current state of the ionosphere, about the expected effects of forthcoming space weather disturbances and about support long-term planning of operations and data post-processing projects for improving modelling and mitigation techniques. The European Space Agency (ESA) in the framework of the Space Situational Awareness (SSA) Programme has supported the development of the European Ionosonde Service (EIS) that releases a set of products to characterise the bottomside and topside ionosphere over Europe. The Service is based on a set of prediction models driven by data from ground-based ionosondes and supportive data from satellites and spacecraft. The service monitors the f_oF_2 and the electron density profile up to the height of the Global Navigation Satellite System (GNSS) at European middle and high latitudes and provides estimates for forthcoming disturbances mainly triggered by geo-effective Coronal Mass Ejections (CMEs). The model's performance has been validated and based on these results, it was possible to issue together with the products, quality metrics characterizing the product's reliability. The EIS products meet the requirements of various SSA

service domains, especially the transionospheric radio link and the spacecraft operations. Currently, the service is freely available to all interested users, and access is possible upon registration

- 24 Marinov, P., Kutiev, I., Belehaki, A., Tsagouri, I. Modeling the plasmasphere to topside ionosphere scale height ratio. (2015) *Journal of Space Weather and Space Climate*, 5, art. no. A27, 12 pages. IF 2.846, (Q2 – 2015); DOI: 10.1051/swsc/2015028, PUBLISHER: EDP Sciences; ISSN: 21157251.

Abstract: A new model of plasmasphere to topside ionosphere scale heights ratio is developed, based on topside electron density (N_e) profiles deduced from the International Satellites for Ionospheric Studies (ISIS)-1 satellite measurements. The model is able to improve operational algorithms for space weather predictions. The topside ionospheric and plasmaspheric scale heights are determined by the lowest and largest gradients of measured profiles, respectively, converted in $dh/d\ln N_e$ units. The new model depends on four parameters: the month of the year (M), the local time (LT), the geomagnetic latitude (glat), and the $\ln(O^+)$ density (zO) at the $O^+ - H^+$ ion transition height. It is designed to replace the old one-dimensional model of the ratio in the TaD (TSM-assisted Digisonde) profiler. The parameters M, LT, and glat are approximated by trigonometric basis functions, while zO is described by a polynomial. A series of models were produced with different number of coefficients (number of terms) of the basis functions. Comparison between models revealed that those with larger number of coefficients can produce unrealistic extremes of the model curves due to the non-uniform sampling of data along the axes. Further considered is the simplest model approximating M, LT, and glat by simple 24 sinusoidal functions and linearly depending on zO . The model description and its 54 coefficients are given in Appendix 1 and can be used by other users for reconstruction of plasmasphere density profiles. The main variation of the ratio along geomagnetic latitude at fixed values of the other model parameters is illustrated in a series of plots

- 25 Tchekalarova, J., Kortenska, L., Marinov, P., Boyanov, K. Comparative power spectrum analysis of EEG activity in spontaneously hypertensive and Wistar rats in kainate model of temporal model of epilepsy. (2016) *Brain Research Bulletin*, 124, pp. 62-75. IF 3.033 (Q2); DOI: 10.1016/j.brainresbull.2016.03.021; PUBLISHER: Elsevier Inc. ISSN: 03619230.

Abstract: Recently, we have reported that spontaneously hypertensive rats (SHRs) exhibit higher susceptibility than Wistar rats in kainate (KA) model of epilepsy. The aim of the present study is to compare the baseline of EEG signals in SHRs and Wistar rats using Discrete Fourier transform (DFT) during the three phases of KA model (acute, latent and chronic). The SHRs showed higher baseline relative power of delta waves in the left frontal cortex and lower gamma-HF waves in the left frontal and left/right parietal cortex, respectively, compared to Wistar rats. During the acute phase, both absolute and relative power of fast EEG bands (gamma-HF) was lower in the left/right frontal and the left/right parietal cortex in SHRs compared to Wistar rats. During the latent phase, no difference in the power of the investigated bands was detected between the two strains. During the chronic epileptic phase, the SHRs were characterized with higher power of HF oscillations than Wistar rats both in the frontal and parietal cortex without brain lateralization while theta, alpha and beta bands were with diminished power in the left parietal cortex of SHRs compared to normotensive Wistar rats. Taken together, the presented results suggest that the increased delta waves and lower gamma-HF waves in the frontal/parietal cortex are associated with a higher seizure susceptibility of SHRs compared to Wistar rats while fastest oscillations has a critical role in seizure generation and propagation of hypertensive rats.

- 26 Traneva, V., Marinov, P., Atanassov, K. Index matrix interpretations of a new transportation-type problem. (2016) *Comptes Rendus de L'Academie Bulgare des Sciences*, 69 (10), pp. 1275-1282. IF 0.251, PUBLISHER: Academic Publishing House; ISSN: 13101331

Abstract: New type of a transportation problem is formulated. Its index matrix interpretation is discussed. The algorithm for solving of the new problem is described. The objective of the transportation problem is to determine the amount of a shipment from sources to destinations to maintain the supply and demand requirements at the lowest transportation cost. The basic transportation problem was originally developed by Hitchcock in 1941 [4] and after that – by Kantorovich in 1949 [6] and Dantzig, in 1951 [3]. A new approach to transportation problem is used. It is based on the Index Matrix (IM) concept, which apparatus was introduced in 1987 in [1], defined in a series of papers and summarized in the book.

- 27 Kutiev, I., Marinov, P., Belehaki, A.; Real time 3-D electron density reconstruction over Europe by using TaD profiler. (2016) *Radio Science*, 51 (7), pp. 1176-1187. IF 4.664; DOI: 10.1002/2015RS005932, PUBLISHER: Blackwell Publishing Ltd; ISSN: 00486604

Abstract: The TaD (Topside Sounder Model (TSM)-assisted Digisonde) profiler, developed on the basis of the Topside Sounder Model (TSM), provides vertical electron density profiles (EDP) over Digisondes from the bottomside ionosphere up to Global Navigation Satellite Systems (GNSS) orbit heights. TaD EDP uses the Digisonde bottomside profile and extends it above the F 2 layer peak, representing O^+ distribution by α -Chapman formula and H^+ distribution by a single exponent. Topside scale height H_T and transition height h_T are taken from TSM, while the plasmasphere scale height H_p is defined as a function of H_T . All profile parameters are adjusted to the current conditions comparing the profile integral with the GNSS vertical total electron content (TEC) retrieved from the European Reference Frame (EUREF) maps. To expand to three

dimensions (3-D), European maps of foF2 and hmF2 are produced, based on Digisonde data, with spatial resolution $1^\circ \times 1^\circ$ in latitude and longitude, and TaD profiles are calculated at each grid node. Electron density (ED) at any point of the 3-D space is obtained by linear interpolation of TaD parameters between neighbor nodes. Samples of two dimensional (2-D) electron density distribution (EDD) at different cross sections of the 3-D space between 200 km and 1150 km over the mapping area are presented, along with distributions of the electron density along various raypaths of GNSS signals. The modeled 3-D EDD is compared with vertical (vTEC) and slant (sTEC) TEC parameters calculated from individual GNSS receivers. The model error (relative deviation of model from the data), based on 6780 data values, is 10% for sTEC and 6% for vTEC.

- 28 Belehaki, A., Kutiev, I., Marinov, P., Tsagouri, I., Koutroumbas, K., Elias, P. Ionospheric electron density perturbations during the 7–10 March 2012 geomagnetic storm period. (2017) *Advances in Space Research*, 59 (4), pp. 1041-1056. IF 1.529, (Q3 2017); DOI: 10.1016/j.asr.2016.11.031, PUBLISHER: Elsevier Ltd, ISSN: 02731177

Abstract:

From 7 to 10 March 2012 a series of magnetospheric disturbances caused perturbations in the ionospheric electron density. Analyzing the interplanetary causes in each phase of this disturbed period, in comparison with the total electron content (TEC) disturbances, we have concluded that the interplanetary solar wind controls largely the ionospheric response. An interplanetary shock detected at 0328UT on 7 March caused the formation of prompt penetrating electric fields in the dayside that transported plasma from the near-equatorial region to higher in altitudes and latitudes forming a giant plasma fountain which is part of the so-called dayside ionospheric super-fountain. The super-fountain produces an increase in TEC which is the dominant effect at middle latitude, masking the effect of the negative storm. Simultaneously, inspecting the TEC maps, we found evidence for a turbulence in TEC propagating southward probably caused by large scale travelling ionospheric disturbances (LSTIDs) linked to auroral electrojet intensification. On 8 March, a magnetospheric sudden impulse at 1130UT accompanied with strong pulsations in all interplanetary magnetic field (IMF) components and with northward Bz component during the growth phase of the storm. These conditions triggered a pronounced directly driven substorm phase during which we observe LSTID. However, the analysis of DMSP satellite observations, provided with strong evidence for Sub-Auroral Polarization Streams (SAPS) formation that erode travelling ionospheric disturbances (TID) signatures. The overall result of these mechanisms can be detected in maps of de-trended TEC, but it is difficult to identify separately each of the sources of the observed perturbations, i.e. auroral electrojet activity and LSTIDs, super-fountain and SAPS.

In order to assess the capability of the ionospheric profiler called Topside Sounder Model - assisted Digisonde (TaD model) to detect such perturbations in the electron density, electron density disturbances at heights from 200 to 1000 km have been calculated with the TaD model and compared with slant TEC parameters obtained from GPS receivers co-located with the Digisondes whose data were used to generate the TaD model predictions. The model matches in qualitative terms the GPS TEC observed perturbations independently from the source. The physical mechanisms that govern the ionosphere, such as ion drag by neutral winds along magnetic field lines, $E \times B$ drifts, and increased recombination due to the neutral composition changes, offer various combinations of foF2, hmF2 and TEC variations, which TaD resolves. Counterwise, TaD can help the interpretation of various physical scenarios which cannot be achieved if solely TEC or F layer variations are considered

- 29 Krumova, S., Todinova, S., Mavrov, D., Marinov, P., Atanassova, V., Atanassov, K., Taneva, S.G. Intercriteria analysis of calorimetric data of blood serum proteome. (2017) *Biochimica et Biophysica Acta - General Subjects*, 1861 (2), pp. 409-417. IF 3.679 (Q1,2017) DOI: 10.1016/j.bbagen.2016.10.012, PUBLISHER: Elsevier B.V. [ISSN: 03044165](https://doi.org/10.1016/j.bbagen.2016.10.012)

Abstract:

Background: Biological microcalorimetry has entered into a phase where its potential for disease diagnostics is readily recognized. A wide variety of oncological and immunological disorders have been characterized by differential scanning calorimetry (DSC) and characteristic thermodynamic profiles were reported. Now the challenge before DSC is not the experimental data collection but the development of analysis protocols for reliable data stratification/classification and discrimination of disease specific features (calorimetric markers).

Methods: In this work we apply InterCriteria Analysis (ICA) approach combined with Pearson's and Spearman's correlation analysis to a large dataset of calorimetric and biochemical parameters derived for the serum proteome of patients diagnosed with multiple myeloma (MM).

Results: We have identified intercriteria dependences that are general for the various types of MM and thus can be regarded as a characteristic of this largely heterogeneous disease: strong contribution of the monoclonal (M) protein concentration to the excess heat capacity of the immunoglobulins-assigned thermal transition; shift of the albumin assigned calorimetric transition to allocation where it overlaps with the globulins assigned transition and strong shift of the globulins assigned transition temperature attributable to M proteins conformational changes.

Conclusions: Our data justify the applicability of ICA for deciphering of the complex thermodynamic behavior

of the MM blood serum proteome.

General significance: The applied approach is suitable for more general application in the analysis of biocalorimetric data since it can help identify the biological relevance of the distinguished thermodynamic features observed for variety of diseases.

- 30 Harizanov, S., Margenov, S., Marinov, P., Vutov, Y. Volume constrained 2-phase segmentation method utilizing a linear system solver based on the best uniform polynomial approximation of $x^{-1/2}$. (2017) *Journal of Computational and Applied Mathematics*, 310, pp. 115-128. IF 1.632 (Q1) DOI: 10.1016/j.cam.2016.06.020, PUBLISHER: Elsevier B.V. ISSN: 03770427

Abstract: Volume constrained image segmentation aims at improving the quality of image reconstruction via incorporating physical information for the underline object of interest into the mathematical modeling of the segmentation problem. In this paper, we develop a general framework for 3D 2-phase image segmentation, based on constrained L_2 minimization of a non-local regularizer, the Euler–Lagrange derivative of which is the discrete graph-Laplacian of a weighted graph, associated with the image voxels. It involves a convenient change of basis in the image domain, for which the optimization function is decomposed element-wise. Using univariate polynomial approximation techniques, we show that the transformation matrix does not need to be explicitly computed and its action is well approximated by a suitable matrix polynomial. The error is independent of the domain size, thus our approach is applicable to high resolution data. The model allows for adding arbitrary linear terms into the optimization function in order to increase the control on the output, in particular to add its scalar product with another, already known, segmentation vector. Such a “hybrid” process may significantly improve on the individual quality of each of the involved segmentations.

- 31 Marinov, P., Kutiev, I., Belehaki, A., Tsagouri, I. 3D electron density specification to support LEO and MEO satellite applications. (2018) *Journal of Atmospheric and Solar-Terrestrial Physics*, 177, pp. 228-236. IF 1.790 (Q3, 2018) DOI: 10.1016/j.jastp.2017.10.003, PUBLISHER: Elsevier Ltd, [ISSN: 13646826](https://doi.org/10.1016/j.jastp.2017.10.003).

Abstract:

The TaD three-dimensional (3D) electron density (Ne) specification model is compared with in situ measured Ne by the Instrument Sonde Langmuir (ISL) onboard DEMETER satellite. For this purpose, over 2000 parts of satellite orbits over the European region in the years 2009–2011 were selected. For each measured Ne value, a corresponding value was calculated with the TaD 3D model, using maps of foF2 and hmF2 from ionosondes and maps of TEC values from CODE software. To compare modelled and measured Ne, the relative to the model deviation between the two quantities was calculated. The comparisons exceeded the total number of 180,000. The main result shows that the modelled Ne extracted by the TaD profiles that have been calculated through adjustment with the TEC CODE parameters, exhibit significant deviations from the measured Ne at the satellite orbit height.

Histograms of the relative deviations relNe show an average offset of 50–60%, while the standard deviation is around 30%. Separate analysis was performed to compare the modelled Ne over 11 ionosonde stations with the measured Ne by the satellite over the ionosonde locations and thus to eliminate the error inferred from the mapping procedure. Here the TaD profiles were adjusted with both the TEC CODE parameters and with TEC values extracted with the single GNSS station solution software with data from GNSS receivers co-located with the ionosondes. In the latter case, the lower TEC values compared to those of TEC CODE yield lower modelled Ne which resulted to smaller deviations with the satellite data. The present study reveals the low consistency between different measurements involved in modeled reconstruction. The comparison presented here shows the importance of assessing the inconsistency between different measurements being assimilated or ingested in the 3D Ne models. Probable inconsistency of different data can create a wrong base for further geophysical studies.

- 32 Tchekalarova, J., Atanasova, D., Kortenska, L., Lazarov, N., Shishmanova-Doseva, M., Galchev, T., Marinov, P. Agomelatine alleviates neuronal loss through BDNF signaling in the post-status epilepticus model induced by kainic acid in rat. (2019) *Brain Research Bulletin*, 147, pp. 22-35. IF 3.103, Q2 – 2018; DOI: 10.1016/j.brainresbull.2019.01.017, PUBLISHER: Elsevier Inc. ISSN: 03619230.

Abstract:

Recently, we have reported that while agomelatine (Ago) is unable to prevent development of epilepsy it exerts a strong neuroprotective and anti-inflammatory response in the KA post-status epilepticus (SE) rat model. In the

present study, we aimed to explore whether the brain-derived neurotrophic factor (BDNF) in the hippocampus is involved in the neuroprotective effect of Ago against the KA-induced SE and epileptiform activity four months later in rats. Lacosamide (LCM) was used as a positive control. The EEG-recorded seizure activity was also evaluated in two treatment protocols. In Experiment#1, Ago given repeatedly at a dose of 40 mg/kg during the course of SE was unable neither to modify EEG-recorded epileptiform activity nor the video- and EEG-recorded spontaneous seizures four months later compared to LCM (50 mg/kg). However, both Ago and LCM inhibited the expression of BDNF in the mossy fibers and also prevented neuronal loss in the dorsal hippocampal and the piriform cortex after SE. In Experiment#2, acute injection of Ago and LCM on epileptic rats, characterized by high seizure rates, did not prevent EEG-recorded paroxysmal events while only LCM decreased either absolute or relative powers of gamma (28–60 Hz) and high (HI) (60–120 Hz) frequency bands to baseline in the frontal and parietal cortex, respectively. Our results suggest that the protection against neuronal loss in specific limbic regions and overexpressed BDNF in the mossy fibers resulting from the repeated treatment with Ago and LCM, respectively, during SE is not a prerequisite for alleviation of epileptogenesis and development of epilepsy. In addition, a reduction of gamma and HI bands in the frontal and parietal cortex is not associated with EEG-recorded paroxysmal events after acute injection of LCM.

- 33 Harizanov, S., Lazarov, R., Margenov, S., Marinov, P. Numerical solution of fractional diffusion–reaction problems based on BURA. (2019) Computers and Mathematics with Applications, IF 2.811 (Q1 2018); DOI: 10.1016/j.camwa.2019.07.002, ISSN: 08981221.

Abstract: The paper is devoted to the numerical solution of algebraic systems of the type $(A^\alpha + qI)u = f$, $0 < \alpha < 1$, $q > 0$, $u, f \in \mathbb{R}^N$, where A is a symmetric and positive definite matrix. We assume that A is obtained by finite difference approximation of a second order diffusion problem in $\Omega \subset \mathbb{R}^d$, $d = 1, 2$ so that $A^\alpha + qI$ approximates the related fractional diffusion–reaction operator or could be a result of a time-stepping procedure in solving time-dependent sub-diffusion problems. We also assume that a method of optimal complexity for solving linear systems with matrices $A + cI$, $c \geq 0$ is available. We analyze and study numerically a class of solution methods based on the best uniform rational approximation (BURA) of a certain scalar function in the unit interval. The first such method, originally proposed in Harizanov et al. (2018) for numerical solution of fractional-in-space diffusion problems, was based on the BURA $r_{-\alpha}(\xi)$ of $\xi^{1-\alpha}$ in $[0, 1]$ through scaling of the matrix A by its largest eigenvalue. Then the BURA of $t^{-\alpha}$ in $[1, \infty)$ is given by $t^{-1} r_{-\alpha}(t)$ and correspondingly, $A^{-1} r_{-\alpha}(A)$ is used as an approximation of $A^{-\alpha}$. Further, this method was improved in Harizanov et al. (2019) using the same concept but by scaling the matrix A by its smallest eigenvalue. In this paper we consider the BURA $r_{-\alpha}(\xi)$ of $1 / (\xi^{-\alpha} + q)$ for $\xi \in (0, 1]$. Then we define the approximation of $(A^\alpha + qI)^{-1}$ as $r_{-\alpha}(A^{-\alpha})$. We also propose an alternative method that uses BURA of ξ^α to produce certain uniform rational approximation (URA) of $1 / (\xi^{-\alpha} + q)$. Comprehensive numerical experiments are used to demonstrate the computational efficiency and robustness of the new BURA and URA methods.