Article

Not peer-reviewed version

Discovery About GPS Positioning Regular Daily Ionospheric Scintillation Disturbances

Janis Balodis * , Madara Normanda , Ingus Mitrofanovs

Posted Date: 8 September 2025

doi: 10.20944/preprints202509.0575.v1

Keywords: regular daily ionospheric scintillation; Pc1 waves; GPS positioning regular disturbance; enhancement by solar activity

Article

Discovery About GPS Positioning Regular Daily Ionospheric Scintillation Disturbances

Janis Balodis *, Madara Normanda and Ingus Mitrofanovs

University of Latvia, Faculty of Science and Technology, Institute of Geodesy and Geoinformatics, Jelgavas street 3, Riga LV-1004, Latvia

* Correspondence: janis.balodis@lu.lv

Abstract

The aim of this study was to find out whether, just like in March 2015, daily regular GPS positioning disturbances caused by ionospheric scin tillations occurred in other months of the solar activity cycle 24. The GPS positioning 90-sec kinematic solutions of selected 46 month covering 11 years were used for search of regular daily scintillation events. The hypothesis on predictable regular daily ionospheric scintillation was tested. Discovered scintillation waves as a result of space weather impact with the siderial day regularity. It leads to conclusion of the radiation origin from the interplanetary media. The enhancement of radiation waves by solar activity is similar as it is for Pc1 waves. The regular daily ionospheric scintillation waves are recorded at any time of the day. In years of low solar activity in 2010 and 2012, regular scintillation waves were not found. It cannot be claimed that the comparison of daily regular ionospheric scintillation cases over time with the mentioned Pc1 wave cases indicates any interrelation.

Keywords: regular daily ionospheric scintillation; Pc1 waves; GPS positioning regular disturbance; enhancement by solar activity

---

1. Introduction

Global Navigation Satellite Systems (GNSS) have become so widely used that it's hard to imagine an industry in the national economy where they are not used. However, those people who use GNSS for obtaining high-precision results in positioning, navigation and timing (PNT) understand that high precision requires taking into account various nuances, including the impact of space weather. In this article, we will touch upon several topics related to GNSS positioning and navigation in the introduction, and in more detail about the daily regular ionospheric scintillation waves of interplanetary origin, which cause positioning accuracy errors.

Recently, some Low Earth Orbiter (LEO) systems have been rapidly developing. He, B. et al [1] explain that GNSS precise point positioning (PPP) technique has been widely used due to its high accuracy, low cost, and flexible operation. Nevertheless, its convergence time usually takes tens of minutes, which limits its applications, especially in the navigation field. There are two main reasons for this slow convergence. On the one hand, GNSS satellites' spatial geometry change is too slow due to higher GNSS orbit altitude. On the other hand, atmospheric delay parameters need to be estimated due to a lack of accurate atmospheric delay corrections, leading to over-parameterization and simultaneously increasing the parameters' correlation. Although a dual-frequency ionosphere-free combination can be applied to remove most effects of the ionospheric delay instead of direct estimation as unknowns, it sacrifices the number of usable observations. Fortunately, the emergence of Low Earth Orbit (LEO) satellites provides an opportunity to speed up the PPP convergence. The orbit altitudes of the LEO satellites are typically between 300 and 2000 km, which facilitates the quick variation of the satellites' geometric distribution. Also, LEO satellites can increase the redundancy of observation data and improve the integrity of the navigation system. In addition, regional GNSS tracking networks have become commonly available, which can be utilized to generate precise atmospheric delay information at the user station. Both the LEO- and atmosphere-augmented information contribute to speeding up the PPP convergence. Recently, some LEO systems have been rapidly developing, like the Iridium system, SpaceX, OneWeb, Hongyun, and Hongyan systems. In addition, some research institutions have attempted to launch LEO satellites, such as Luojia-1 from Wuhan University, China [1]. LEO-augmented multi-GNSS PPP has been widely investigated in recent years, performing the GPS/LEO combined PPP and concluded that LEO satellites can accelerate the PPP convergence and improve its accuracy. They also compared the GPS/LEO combination with the GPS/GLONASS combination, and the results demonstrate that the LEO satellites contribute more to improving the GPS PPP performance than the GLONASS satellites [1].

He, B. et al. [1] processed the GNSS observations and simulated LEO observations under a Walker/polar mixed constellation that used to test the double augmentation PPP sample solutions. Improved convergence time is achieved by over 73% compared to GNSS constellation scenarios and over 83% compared to the LEO only. The double augmentation PPP observation equations are presented as the integrated atmosphere-augmented LEO and the atmosphere-augmented GNSS observations. The LEO constellation design is discussed. The double-augmentation PPP data simulation and solution validation is summarized in conclusion [1].

Sun X. et al [2] evaluated the International GNSS Service (IGS) 10 day continuous observations in 8 combinations of BeiDou (BDS-3) and Galileo frequencies. The dual frequency ionospheric free (DFIF) Precise Point Positioning (PPP) in static and kinematic mode were used by applying the open source Nett_Diff software produced by GNSS Analysis Center of Shanghai Astronomical Observatory [2]. The observations were selected from 60 stations of IGS Multi-GNSS Pilot Project MGEX that were equipped with receivers produced by different GNSS production companies. The satellite orbit and clock bias products obtained from Deutsche Geo-Forschungs Zentrum (GFZ) data base, the daily multi-GNSS differential code biases (DCB) from Chinese Academy of Science. For troposphere delay the Saastamoinen model used and GPT2_6w and VMF1 models applied. The PPP solution mathematics is explained. The computed results are compared to IGS Solution Independent Exchange (SINEX) daily solutions [2]. The comparison of Root Mean Square Error (RMSE) of computed positioning components Northing, Easting,UP (NEU) are used as the main tool for evealuation of various frequency combination results. Sun et al [2] concluded that BDS-3 is competitive with Galileo. The best results gained with equal accuracy of BDS-3 only, B1C/B3I and Galileo only, E1/E5 [2].

GNSS provides users with all-weather continous high precision PNT services. However, the influence of the space weather is a factor that must be considered [3]. During geomagnetic storms a series of changes in the Earth's magnetosphere, ionosphere and upper atmosphere affect GNSS's positioning performance. Xing S. [3] selected three geometric storm events that occurred from September to December 2023. Utilizing the global positioning system GPS/Beidou navigation satellite system (BDS) dual system kinematic PPP experiments were conducted and the raw observational data from 100 stations worldwide was analyzed. The experimental results show that the positioning accuracy of some stations in high-latitude areas decreases significantly when using the conventional Geometry Free (GF) cycle-slip detectionthreshold during geomagnetic storms which means that GF is no longer applicable to high precision services [3].

To start talking about the potential use of GNSS on the Moon, it is necessary to mention the successful 2024 expedition of Chinese science mission Chong'e -6 to the far side of the Moon, bringing back about 2 kg of soil samples to Earth [4].

The lunar PNT is very important issue for lunar exploration currently carried out by many countries and private companies.The article [5] mainly is devoted to LuGRE mission that aims to receive GPS and Galileo signals at the Moon.

Authors characterize the lunar GNSS signal environment for PNT estimation and analize collected data for support of development of GNSS receivers specific to lunar use. This contribution investigated a case of code-based differential GNSS for two lunar orbiters as it has never been done before. In particular, it has been assessed the potential of Inter-Spacecraft Range (ISR) estimation both through theoretical simulations and Hardware-in-the-Loop (HWiL) tests using the "soon-to-be-flying NaviMoon Galileo-GPS receiver" [5]. It has been shown that commonly used terrestrial algorithms for kinematic code-based differential GNSS ranging techniques are not applicable for a scenario of GNSS receiver in lunar orbit. Using the standard code-based DGNSS algorithm, a significant bias is introduced. It's magnitude increases with the angular separation between the two users with respect to the GNSS constellation. The results are obtained and experimentally,making use of GNSS observables generated by a GNSS receiver specifically designed for a Moon mission, through a Hardware-in-the-Loop (HWiL) set-up. The Moon receiver is called the NaviMoon and will be hosted by the Lunar Pathfinder space mission [5]. The space scenario considered for the present analysis, the architecture of the theoretical Monte Carlo simulations as well as the functional blocks of the test bench designed to test the presented techniques on the NaviMoon receiver [5]. This work shows that modelling assumptions used for linearization of the relationship between the inter-user vector and the pseudorange single and double differences taken for granted in terrestrial and LEO applications are violated in the case of lunar GNSS differential scenarios [5]. Updating the modelling assumption significantly improved the performances with respect to the terrestrial standard algorithm by reducing the bias introduced by the increasing baseline. The potential performances of inter-spacecraft GNSS ranging in space, showing that the various techniques presented seem to be lower bounded by taking the difference of the individual Single Point Position (SPP) [5]. This is physically grounded in the fact that sensor-specific errors are typically independent, enabling the more effective decoupling of instrumental biases from true atmospheric signals [6]. Space weather events such as the May 2024 Mother's Day Superstorm, induce hazardous perturbations in the coupled thermosphere–ionosphere–magnetosphere system [7]. Filjar et al. [8] demonstrate that in the case of the short-term fast-developing geomagnetic storm, a machine learning-based environment-aware GNSS ionospheric correction model for sub-equatorial regions may provide a substantial improvement over the global mode Ning Huang et al [9] presented the analysis of the GNSS precipitable water vapor (PWV) for evaluation of the accuracy of MERRA-2 and ERA5 water vapor products under extreme rainfall conditions. The relationship between the evolution of heavy rainfall and changes in water vapor are examined. The method of GNSS PWV retrieval described and the accuracy analysis of MERRA-2 and ERA5 water vapor products under different rainfall levels is presented and compared them with ground-based precipitation time series.

If up to now this introduction has discussed the problems of GNSS data processing, then further on we will talk a little about the effects of ionospheric scintillation and their studies. Ionospheric scintillation, caused by irregularities in the ionosphere, can lead to rapid changes in signal amplitude and phase, particularly affecting GPS signals at high latitudes and during space weather events [10–14]. The presence of moderate to strong scintillation can double positioning errors and induce clustering effects on positioning solutions, complicating navigation tasks [11]. The positioning performance of GNSS is notably affected during severe geomagnetic storms, with studies indicating that the accuracy of precise point positioning (PPP) can be significantly reduced due to frequent cycle slips [12]. The correlation between geomagnetic storm indices and GNSS signal loss highlights the need for effective monitoring and forecasting to mitigate the impacts of space weather on navigation systems [13]. Ionospheric scintillation, can lead to rapid changes in signal amplitude and phase, particularly affecting GPS signals during space weather events [14–17]. The positioning accuracy of some stations in high-latitude areas decreases significantly when using the conventional Geometry Free (GF) cycle-slip detection threshold during geomagnetic storms, which means that the GF is no longer applicable to high-precision positioning services [18]. The need for effective monitoring and forecasting to mitigate the impacts of space weather on navigation and positioning systems is of continuous concern of many users [19–22].

Space weather events such as the May 2024 Mother's Day Superstorm, caused by a series of interplanetary coronal mass ejections (ICMEs) and high-speed streams, induce hazardous perturbations in the coupled thermosphere–ionosphere–magnetosphere system [23,24]. Analyzing such unique events offers valuable insight into the evolution of extreme geospace dynamics [23–25].

The Mother's Day storm event originated from the solar active region classified as AR13664 [26], which produced at least four M-class flares and one X1.0 flare on 8 May 2024, followed by further strong solar flares (including six X-class flares) between 9 and 11 May, launching a series of fast ICMEs. For a detailed analysis of this storm, including a list of the ICMEs and their associated flares, see Spogli et al. [12,24]. Several authors have studied the ionospheric response and the impact on GPS positioning accuracy during the tropical cyclons [27,28] and volcano eruption [29].

By comparing solar X-ray observations (RHESSI) with in situ electron data from STEREO/SEPT [30], the researchers identified patterns in electron acceleration and transport. X-ray observations provide crucial insights into solar system dynamics, including planetary auroras, solar wind interactions, and interplanetary electrons [31,32]. High-energy electrons from solar flares follow complex propagation paths, affecting their detection in space. X-ray and radio studies help track energetic electrons from the Sun into interplanetary space [33]. Interplanetary X-rays are high-energy electromagnetic emissions that originate from interactions within the interplanetary medium, including the solar wind, planetary atmospheres, and cosmic radiation. These X-rays can be produced by several mechanisms, such as solar Wind Charge Exchange (SWCX), scattering and fluorescence, high-energy particle interactions of electrons and ions from the Sun or cosmic rays producing X-ray emissions [34]. Recent studies have identified various celestial bodies, including planets and moons, as X-ray emitters, with emissions primarily resulting from solar X-ray scattering and charge exchange processes [30,31,34].

An extended dataset of Loss of Lock (LoL) events recorded by the Swarm constellation from December 2013 to December 2020, the longest ever used, and discusses the corresponding occurrence as a function of latitude, local time, season, and solar activity [35]. In addition, the analyses aim was at finding a relation between the LoL occurrence and defined values of the following two ionospheric indices: the rate of change of electron density index (RODI) and the rate of change of total electron content (TEC) index (ROTI). This kind of research was done both to characterize the background conditions of the ionosphere for such events, and to start understanding whether these events can be som The large-scale ducting of Pc1 pulsations observed by Swarm satellites and multiple ground magnetometer networks on 25 June and September 2015 [36].

Pc1 waves (Pc1 pulsations) are ultra-low-frequency (ULF) electromagnetic waves in the range of 0.2–5 Hz.They are part of the geomagnetic pulsation spectrum and are closely associated with Electromagnetic Ion Cyclotron (EMIC) waves, which play a key role in magnetosphere-ionosphere interactions [37]. Pilipenko et al [38] compare the magnetosphere-ionosphere current system with a circuit analogy, where the nonsteady field-aligned currents interact with the ionosphere in a different way depending on the ratio between the driver time scale ꚍ and the Alfven field line eigenperiod TA [39]. The theoretical predictions with observational results from conjugate high latitude stations in Antarctica and Greenland during summer (7 June 2014) and winter (7 January 2014) periods performed. A disturbance is a sudden commencement (SC) pulse caused by the impact of an interplanetary shock (IS) on the magnetosphere. At high latitude when the duration of the local field line eigenperiod TA is ~5-10 min which can be longer than an SC impulse with ꚍ ~ 1-2 min [38]. ehow forecast, which would be very important for Space Weather effects mitigation purposes [35].

It is still a challenge to determine the apparent relationship between ionospheric conditions and Pc1 wave occurrence [37]. Pc1 waves originate in the Earth's magnetosphere, often near the plasmapause or in regions of high plasma density [40]. They are usually triggered by solar wind pressure variations or wave-particle interactions with energetic protons. Fransia et al [40] examined a Pc1 event observed at a high-latitude station during geomagnetic quiet conditions, with the aim at looking for possible correspondences with the ionospheric response. The results can be summarized as follows: 1) correspondence is found between the Pc1 pulsation activity and the occurrence of ionospheric irregularities, as clearly showed by the analysis of ROT fluctuations; 2) the study clearly shows that signatures of EMIC waves, driven by increased solar wind pressure, can be observed also at polar latitudes, simultaneously in both hemispheres, due to their propagation in the ionospheric waveguide. Such waves, generated just inside the magnetopause, propagate through the

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 8 September 2025 doi:10.20944/preprints202509.0575.v1

magnetosphere and transmit as Alfven waves along geomagnetic field lines up to the auroral ionosphere. They can produce the precipitation of magnetospheric energetic electrons into the atmosphere, causing electron/ion density variations as measured by TEC fluctuations. Fransia et al believe [40] that the observations of this work, although present a very interesting result, should be substantiated by further investigations, based on a number of events and additional data (satellite and/or riometer data) to be fully explained. 3) These waves propagate along geomagnetic field lines and can reach the Earth's ionosphere, where they influence ionospheric conductivity and electron density. Pc1 waves can modulate ionospheric Total Electron Content (TEC), leading to irregularities and affecting radio signals [40]. Geomagnetic measurements from ground and space represent the main ingredient in modelling and understanding the Earth's magnetic field [41].

The issues of space weather related to PNT are relevant worldwide. [42,43]. The significant research centers for geomagnetism, space physics, and space weather in Europe are ESA space weather network and GFZ Helmholtz Centre for Geosciences in Potsdam, Germany. There are also studies in Latvia on the impact of space weather on GNSS measurements 44].

The second section of this study provides a brief overview of the study's raw data, describing those data from March 2015 that clearly illustrate the presence of regular daily ionospheric scintillation waves. Further analysis datasets and their reduction formulas are presented. The third section presents the results of the data analysis and reflects the characteristics of the obtained results. Additional information about the resu and compares them with geomagnetic measurements of the Pc1 waves mentioned lts is provided in Appendix A and Appendix B. The fourth section discusses the results obtained and comoare them with a Pc1 observations repoorted in the literature.

2. Materials and Methods

In this study, the hypothesis regarding the possible regular daily ionospheric scintillation disturbances affecting GPS positioning observations was tested in 46 selected month of 24th solar activity cycle (Years 2007-2017).

GPS observation data of Latvian Continuously Operating GPS Station (CORS) network were used with an elevation cut-off angle of 15° for 90 second (sampling data 30 sec) intervals of kinematic post-processing. The FES2004 ocean tidal model was used, along with correction of the solid Earth tide effect. The Dry Global Mapping Function (DRY-GMF) was used for the tropospheric delay modelling. The maximum size of accepted cycle slip corrections was 10. The results of Bernese 5.2 post-processed kinematic solution data were used for furter analysis by using the authors made software programs [45].

2.1. Ionospheric Scintillation Waves

The regular daily disturbances were observed in Latvian CORS stations in March 2015 [42]. The graphical image of the information subset of the ionospheric scintillation wave is depicted in Figure 1.

```
804 2015 MAR 16 22: 1:29 UT  KREI MAZS
805 2015 MAR 16 22: 3: 0 UT  MAZS
806 2015 MAR 16 22: 4:30 UT  MAZS OJAR
807 2015 MAR 16 22: 6: 0 UT  MAZS
808 2015 MAR 16 22: 7:30 UT  MAZS OJAR
809 2015 MAR 16 22: 9: 0 UT  MAZS                      TILL 22:12: 0  UT REPEATEDLY  3 TIMES
812 2015 MAR 16 22:13:30 UT  BALV ALUK MAZS
813 2015 MAR 16 22:15: 0 UT  PLSM PREI BALV DAGD MADO ALUK MAZS LODE JEK1
814 2015 MAR 16 22:16:29 UT  RIGA OJAR JEK1 BALV PLSM PREI MADO REZ1 DAU1 VAL1 MAZS ALUK DOB1 BAUS SIGU LODE LIMB
815 2015 MAR 16 22:18: 0 UT  JEK1 DAU1 PLSM DAGD LUNI LVRD ALUK BAUS VANG MADO VAIV REZ1 KREI SIGU TKMS LIMB RIGA LODE MAZS DOB1 OJAR
816 2015 MAR 16 22:19:29 UT  RIGA SLD1 LIPJ TKMS SIGU LVRD BALV VAIV DAGD VAL1 DAU1 REZ1 KREI OJAR KUL1 ALUK TALS SALP BAUS VANG LIMB LODE MAZS DOB1 PREI IRBE
817 2015 MAR 16 22:21: 0 UT  PREI OJAR JEK1 LUNI KUL1 DOB1 DAU1 LODE VANG LVRD SLD1 ALUK REZ1 BAUS PLSM DAGD RIGA LIPJ KREI LIMB TALS VAL1 BALV IRBE SALP
818 2015 MAR 16 22:22:30 UT  MAZS TALS SLD1 PREI ALUK OJAR BAUS KREI PLSM BALV MADO LIPJ VANG LODE TKMS IRBE LVRD SALP RIGA
819 2015 MAR 16 22:24: 0 UT  SALP LIMB MAZS KREI VAL1 SLD1 LODE LIPJ JEK1
820 2015 MAR 16 22:25:30 UT  VAL1 SIGU VANG SALP REZ1 LIPJ SLD1 DAU1 LODE TKMS OJAR DOB1 BALV ALUK LVRD PREI KREI
821 2015 MAR 16 22:27: 0 UT  REZ1 MADO KREI DAU1 KUL1 JEK1 LIMB TKMS
822 2015 MAR 16 22:28:29 UT  BALV DAU1 REZ1 KREI RIGA LODE ALUK
823 2015 MAR 16 22:30: 0 UT  RIGA LIMB DAU1
824 2015 MAR 16 22:31:30 UT  JEK1 REZ1 SLD1 DAU1
825 2015 MAR 16 22:33: 0 UT  PREI JEK1 TKMS IRBE
826 2015 MAR 16 22:34:29 UT  LIMB ALUK JEK1 TKMS
827 2015 MAR 16 22:36: 0 UT  LIMB ALUK JEK1
828 2015 MAR 16 22:37:29 UT  VAL1
829 2015 MAR 16 23:10:30 UT  TKMS                      TILL 23:13:29  UT REPEATEDLY  3 TIMES
```

Figure 1. Information subset of the ionospheric scintillation wave registered in the analysis of positioning discrepancies in network of Latvian CORS.

Starting from first row is a No. of recorded information of scintillation event, date and time and list of Latvian CORS station DOMEs where simultaneously occurred ionospheric scintillation causing positioning 3D discrepancy ≥10 cm. In next row is information on the next event occurred in the next 90 seconds. The various subsets of stations imagine the covered area of station network that is impacted by various size of electron clouds. Therefore, the information subset of each row we call a cloud and whole sequence of uninterrupted 90-sec events by ionospheric scintillation wave (evil wave [43]). During one day there may occurre various count of waves depending of the solar activity.

Subset of the any wave $\boldsymbol{w_k}$ is described in Formula (1) as a union of subsets of scintillation clouds with their date and time and GPS position discrepancy data 3. Results

This section may be divided by subheadings. It should provide a concise and precise description of the experimental results, their interpretation, as well as the experimental conclusions that can be drawn.

$$w_k := \cup \left\{\langle k_i, D_k, t_{k_i}, s_{k_{ij}}, d_{k_ij}, r_{k_ij}, w'_k \rangle : j \in \langle D_k, t_{k_i}\rangle, n_{k_i} \in \langle D_k, t_{k_i}\rangle, 1 \le \mathrm{i} \le n_k, 1 \le \mathrm{j} \le |S_{k_i}|\right\} \quad (1)$$

where k_i is No. of recorded scintillation's wave in date D_k and k_i-cloud's time t_{k_i}; s_{k_ij} - subset of station DOME names in each row's subsets S_{k_i} with cardinality $|S_{k_i}|$ where simultaneously fixed scintillations. S_{k_i} subsets will be named a clouds, similarly to electron clouds in space impacted area of station subset of cardinality j. Positioning 3D discrepamcies subset d_{k_ij} and subset of Rate of Total Electron Content Index ROTI denoted by r_{k_ij}, correspondingly,. Further in this article will be described the tuple w'_k of Modified Julian Days (MJD) denoted by formula (2) where day and time converted to MJD. Cardinality of subset w_k is n_k and the count of CORS statins in each k_i −cloud is $|S_{k_i}|$, correspondingly. The number of waves per day varies, and the number of clouds in the wave also varies. Therefore, based on a data-driven approach, the actual spatiotemporally matched structure of the electron cloud can be inferred from these patterns on ground [6].

2.2. Graphical Representation of the Registered Ionospheric Wave Sets Over the Month

In Figure 2 depicted the occurrence of monthly ionospheric scintillation waves in March 2015. There are visible waves of type of Figure 1, that clearly repeating daily. The biggest peak is geomagnetic storm of St Patric's day in March 17.

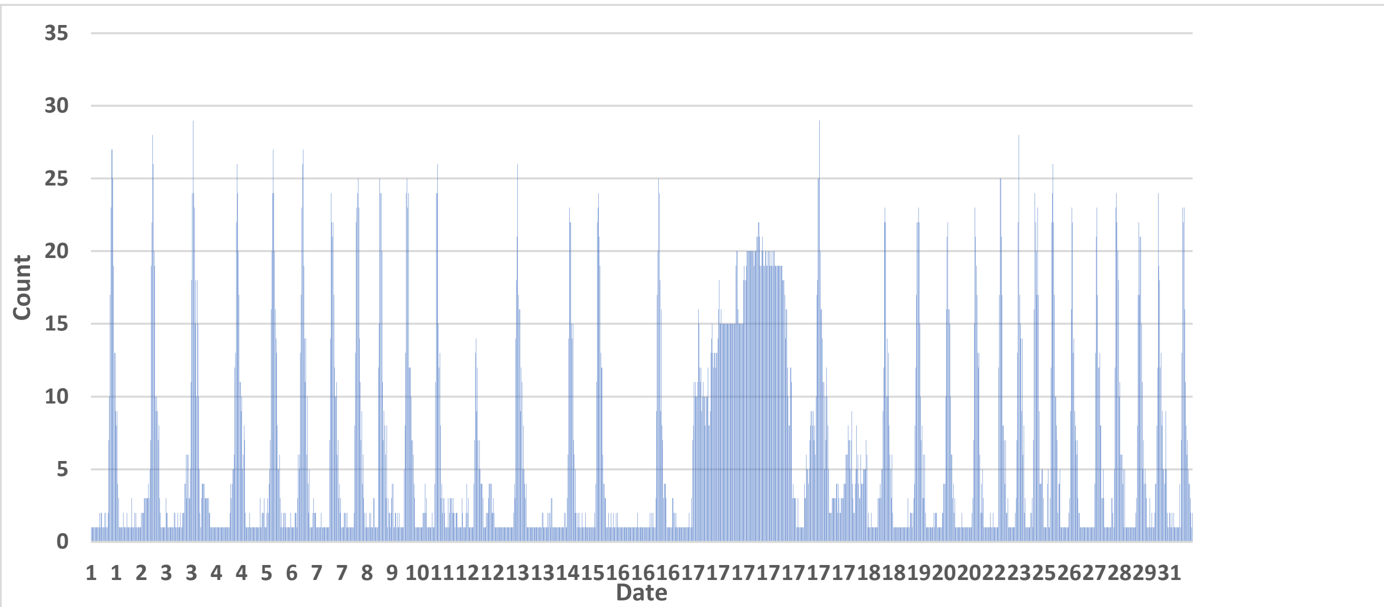


Figure 2. Count of CORS stations in regular daily waves in March 2015.

More complicated is Figure 3 where scintillation events on August 2007 are depicted.

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 8 September 2025 doi:10.20944/preprints202509.0575.v1

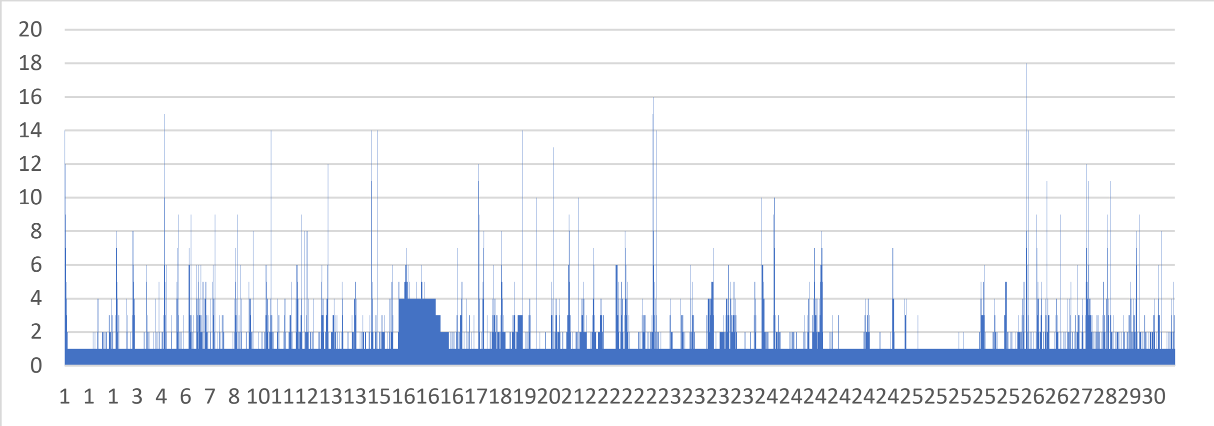


Figure 3. Count of CORS stations in waves of August 2007.

In Figure 4 depicted scintillation events in July 2016. On the surface, it is hard to say whether scintillation waves have been regularly recurring on a daily basis this month.

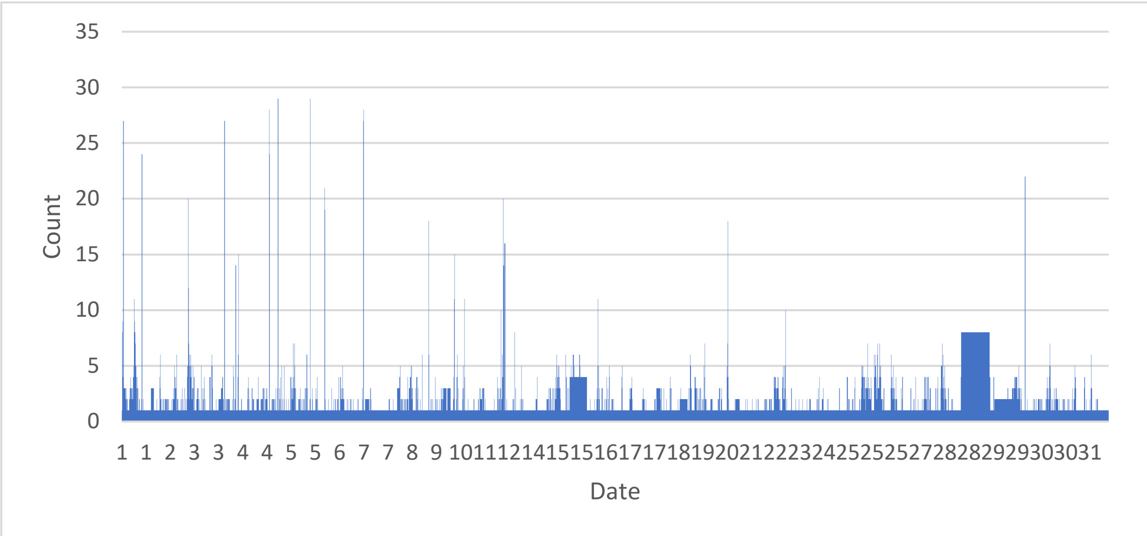


Figure 4. Count of CORS stations in waves of July 2016.

Table 1. Monthly ionospheric impact waves with minimum 2 cloudsand clouds.

#	Year	Month	Clouds	Waves	#	Year	Month	Clouds	Waves
1	2007	FEB	1569	120	24	2012	OCT	837	88
2	2007	MAY	4359	308	25	2013	MAY	1587	201
3	2007	JUN	3501	272	26	2013	OCT	3772	152
4	2007	AUG	5830	491	27	2013	NOV	935	114
5	2008	MAR	726	69	28	2013	DEC	1155	136
6	2008	JUN	1600	140	29	2014	FEB	1268	99
7	2008	SEP	1986	193	30	2014	JUN	3393	295
8	2008	OCT	1328	107	31	2014	OCT	1241	117
9	2009	JUL	2473	216	32	2014	DEC	1837	126
10	2009	AUG	1413	126	33	2015	MAR	1584	119
11	2009	OCT	1304	107	34	2015	MAY	1749	170
12	2009	DEC	2056	115	35	2015	JUN	2499	154
13	2010	JAN	255	20	36	2015	OCT	880	118
14	2010	FEB	1123	66	37	2015	DEC	988	119
15	2010	APR	449	59	38	2016	FEB	1166	104

16	2010	NOV	1263	45	39	2016	APR	1401	105
17	2011	MAR	747	48	40	2016	MAY	2541	175
18	2011	AUG	1943	248	41	2016	JUL	3445	339
19	2011	SEP	1477	134	42	2017	APR	1980	120
20	2011	NOV	523	77	43	2017	MAY	2894	136
21	2012	JAN	366	35	44	2017	JUL	6442	214
22	2012	MAR	461	56	45	2017	SEP	1181	126
23	2012	JUL	2155	227	46	2017	OCT	1145	112

The total number of waves is 6718 and 84827 clouds. It is necessary to choose some algorithm to detect the presence of regular waves in these monthly subsets of data. Based on the example of the month of March 2015 daily regular waves are repeated with a 4.5-minute lag on the time scale graduated in increments of 1.5 minutes. For better transparency the count of clouds and waves depicted in Figure 5.

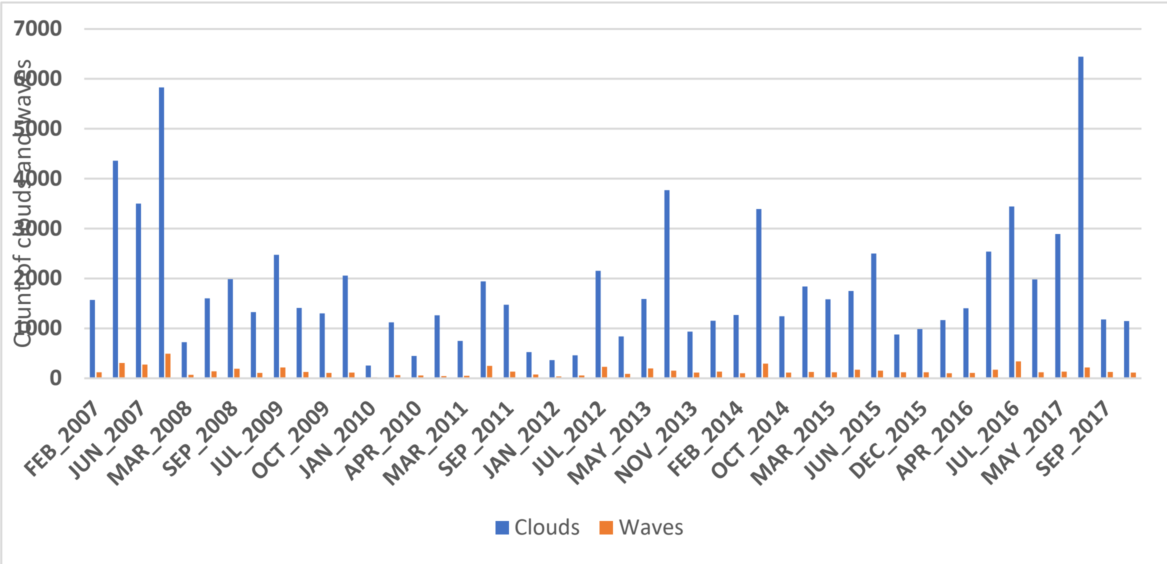


Figure 5. Count of clouds and waves.

2.3. The Classification of the Characteristic Elements of the Waves Of Ionospheric Scintillation - Clouds

Figure 6 once again shows some scintillation k-wave and sketches the details of that wave used in the subsequent analysis process.

92 2014 OCT 13 23:57: 0 UT LIMB
493 2014 OCT 13 23:58:29 UT OJAR TKMS
494 2014 OCT 14 0: 0: 0 UT TALS MADO SIGU IRBE LUNI LODE MAZS DAGD VANG OJAR ALUK PREI RIGA VAL1 JEK1 LIMB TKMS REZ1
2014 OCT 14 0: 1:30 UT MADO ALUK DAGD DAU1 BALV BAUS SIGU PREI MAZS PLSM OJAR REZ1 LIMB SALP
496 2014 OCT 14 0: 3: 0 UT DAU1 DAGD PLSM LIMB SALP REZ1 TKMS
497 2014 OCT 14 0: 4:30 UT DAU1 VANG ALUK PLSM LIMB SALP REZ1
498 2014 OCT 14 0: 6: 0 UT REZ1 DAU1 LIMB ALUK
499 2014 OCT 14 0: 7:29 UT DAU1 LIMB
500 2014 OCT 14 0: 9: 0 UT REZ1 LIMB DAU1
501 2014 OCT 14 0:10:30 UT DAU1 RE
502 2014 OCT 14 0:12: 0 UT REZ1 DAU1 TKMS
503 2014 OCT 14 0:13:29 UT DAU1
504 2014 OCT 14 0:15: 0 UT DAU1

 doi:10.20944/preprints202509.0575.v1

Figure 6. View of the typical scintillation wave and it's skewed distribution of clouds. The date, time and peak cloud (green), the beginning of time sequence and initial cloud, and both the median of time sequence and end of time sequence clouds (yellow).

Additionally, to the elements of each wave with index k the information subset of the tuples of Modified Julian Days (MJD) is introduced, where MJD for peak cloud is denoted by p_k , beginning cloud b_k , end cloud e_k , middle cloud g_k , wave length l_k , station count in peak cloud $|S_{k_i}|$, k is No. of wave in month, c_1 is record No.of first wave's cloud and n_k *is* count of clouds in a wave. Initially was planned to use the differences between element values of adjacent waves (denited by o) but in practice, its use turned out to be insignificant.

$$W' := \bigcup_{k=1}^{|W'|} \{(k, c_1, b_k, e_k, p_k, g_k, l_k, o_k^b, o_k^e\ o_k^p, o_k^g, n_k, max|S_{k_i}|) \in w_k, n_{k_i} \in w_k, 1 \leq \mathrm{i} \leq n_k\} \quad (2)$$

An example from such a subset of tuples is shown in Table 2 for March 11-13 2015.

Table 2. Example of the subset of tuples of wave information (P is $max|S_{k_i}|$).

k	c_1	b	e	p	g	l	o^b	o^e	o^p	o^g	n	P
50	WAVE 516	57092.991667	57092.998958	PK 57092.992708	MED 57093.995313	DIFF 0.007291	0.002084	0.009375	0.003125	0.005730	PK 8	3
51	WAVE 525	57093.534375	57093.581250	PK 57093.534375	MED 57093.557813	DIFF 0.046875	0.542708	0.582292	0.541667	0.562500	PK 3	2
52	WAVE 534	57093.817708	57093.894792	PK 57093.817708	MED 57093.856250	DIFF 0.077084	0.283333	0.313542	0.283333	0.298437	PK 2	3
53	WAVE 540	57093.902083	57093.906250	PK 57093.903125	MED 57093.904166	DIFF 0.004167	0.084375	0.011458	0.085417	0.047916	PK 4	4
54	WAVE 551	57093.938542	57093.952083	PK 57093.941667	MED 57093.945312	DIFF 0.013541	0.036459	0.045833	0.038542	0.041146	PK 14	15
55	WAVE 569	57093.986458	57093.997917	PK 57093.990625	MED 57093.992188	DIFF 0.011459	0.047916	0.045834	0.048958	0.046875	PK 12	4
56	WAVE 608	57094.932292	57094.951042	PK 57094.938542	MED 57094.941667	DIFF 0.018750	0.945834	0.953125	0.947917	0.949479	PK 19	27
57	WAVE 649	57094.975000	57094.976042	PK 57094.975000	MED 57094.975521	DIFF 0.001042	0.042708	0.025000	0.036458	0.033854	PK 2	2

2.4. Characteristic of regular daily wave elements in March 2015

The duration of the wave will be named in this article a length of wave. The length of the waves will be of various size in dependance of annual season and solar activity level. In March 2015 the regularity of waves is clearly visible (Figure 2). But it is quite a difficult to imagine regular daily waves in Figure 3 or in Figure 4.

With a 4.5-minute lag in adjacent days of March 2015 each of the 1.5-minute (90 sec) clouds shifts. However. the time lag for each of these proper clouds (peak, med and others) varies due to the changes of daily wave configuration. It turned out that the times of regular daily repetition are variable. Table 2 shows how the parameters of daily waves are changing. The Shift time is given in minutes for peak cloud. Uncertainties dpeak in time minutes (min) are obtained in result of linear approximation of daily peak times. Similarly. linear approximation performed for median (dmed) and beginning (dbeg). Length of wave in minutes mean the duration of the GPS positioning discrepansies. Time differences for the peak minus beginning (peak-beg). median minus peak (med-peak) and end-peak (end-peak) characterizes the changing shape of the waves.

Table 2. Regular daily wave characterization parameters (min) in March 2015.

(Denoted: p-b=peak-beg; m-p=med-peak; p-e=peak-end)

Date	MJD	Shift	peak	med	beg	Length	p-b	m-p	p-e
2	57083.969792		-0.1	-4	-10.242	24	-3	18	
3	57084.966667	-4.5	-0.5	-5.5	-9.5	37.5	22.5	-3.7	15
4	57085.963542	-4.5	-0.9	-1	-2.7	33	15	1.5	18
5	57086.961458	-3.0	0.2	-1	-0.4	28.5	13.5	0.8	15
6	57087.959375	-3.0	1.3	0.5	1.9	27	12	1.5	15
7	57088.954167	-7.5	-2.1	4.3	7.1	24	3	9	21
8	57089.954167	0.0	2.1	1.3	4.9	22.5	9	2.2	13.5
9	57090.948958	-7.5	-1.3	1.3	7.2	18	3	6	15
10	57091.946875	-3.0	-0.2	1.3	5	22.5	6	5.3	16.5
11	57092.944792	-3.0	0.9	1.4	5.8	21	6	4.5	15
12	57093.941667	-4.5	0.5	1.4	6.5	19.5	4.5	5.2	15
13	57094.938542	-4.5	0.1	-0.1	1.3	27	9	4.5	18
14	57095.934375	-6.0	-1.8	-1.6	3.6	19.5	4.5	5.3	15
15	57096.933333	-1.5	0.8	-0.1	4.4	21	6	4.5	15
16	57097.930208	-4.5	0.4	-0.1	3.7	22.5	6	5.3	16.5
17	57098.928125	-3.0	1.6	29.9	-22.6135		33	34.5	102
18	57099.923958	-6.0	-0.3	-6.1	-6.8	31.5	15	0.8	16.5
19	57100.922917	-1.5	2.3	-3	-1.5	27	12	1.5	15
20	57101.917708	-7.5	-1.1	-5.3	-3.7	27	10.5	3	16.5
21	57102.914583	-4.5	-1.5	-3	0.1	24	6	6	18
22	57103.912500	-3.0	-0.4	-1.5	3.8	19.5	3	6.8	16.5
23	57104.910417	-3.0	0.7	-4.5	0.1	21	7.5	3	13.5
24	57105.906250	-6.0	-1.2	-2.2	2.4	21	3	7.5	18
25	57106.905208	-1.5	1.5	-2.2	1.7	22.5	6	5.3	16.5
26	57107.901042	-6.0	-0.4	-4.4	-0.5	22.5	6	5.2	16.5
27	57108.898958	-3.0	0.7	-3.7	1.7	19.5	4.5	5.3	15
28	57109.895833	-4.5	0.3	-4.4	1	19.5	4.5	5.3	15
29	57110.892708	-4.5	-0.1	-5.2	-1.2	22.5	6	5.3	16.5
30	57111.889583	-4.5	-0.5	21.9	-3.4	817.5	33	73.5	
31	57112.886458	-4.5	-0.9	-4.4	0.3	21	3	7.5	18

The root mean square error (RMS) of linear approximation is 1.12 min for time of occurrence of the peak cloud (peak), 7.75 min for cloud at the middle of time sequence (further median - med) and 6.15 min for time sequence beginning of wave (further beginning – beg). The linear approximation errors of the daily time are depicted in Figure 7. The peak's daily repetition is most regular. The monthly mean value of the length of wave (Length) is 30.0 min. mean value without outlier is 24.4 min (Figure 7). Mean time difference from beginning to peak is 9.05 min. peak to middle of wave 5.95 min and from peak to the end of wave 20.95 min. This means that in average the peak of the ionospheric wave is closer to the beginning of the wave, but the wave part from the peak to the end is 2 times more stretched. Daily regular waves repeated with a -4.11 minute lag on the time for peak, -3.76 min for wave median and -3.78 min for the beginning of wave.

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 8 September 2025 doi:10.20944/preprints202509.0575.v1

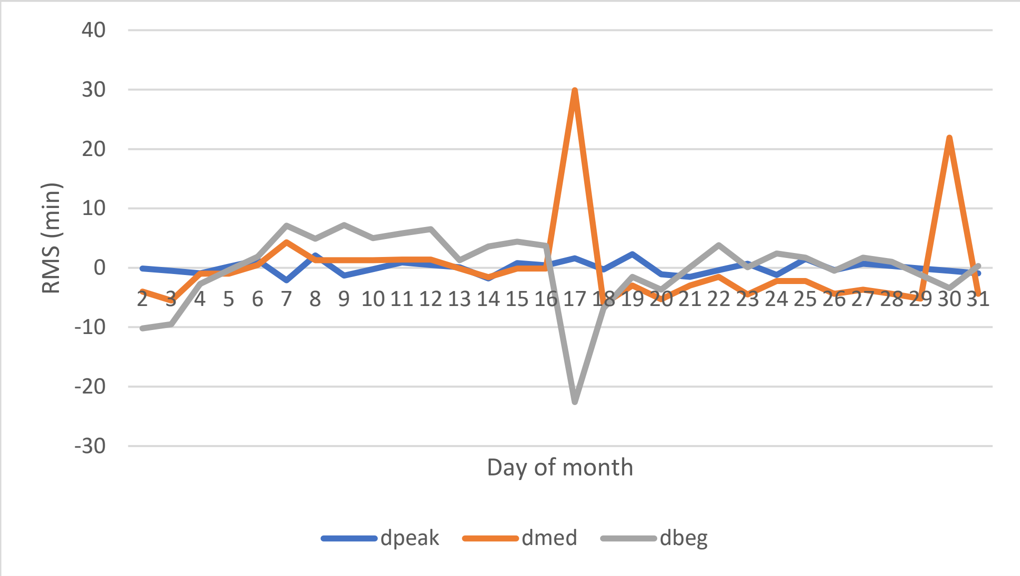


Figure 7. Linear approximation errors for daily time (min) of peak. median and beginning.

Variation of the length of regular waves depicted in Figure 8. It will be proven later in the article that the wavelength changes depending on solar activity. This is also shown in this image, where the longest wavelength occurs on the day of the geomagnetic storm, March 17. The geomagnetic storm appears in the Latvian CORS observations from 14:27 UT to 18:18 UT, while the regular daily scintillation wave is from 21:43:30 UT to 23:58:30 UT.

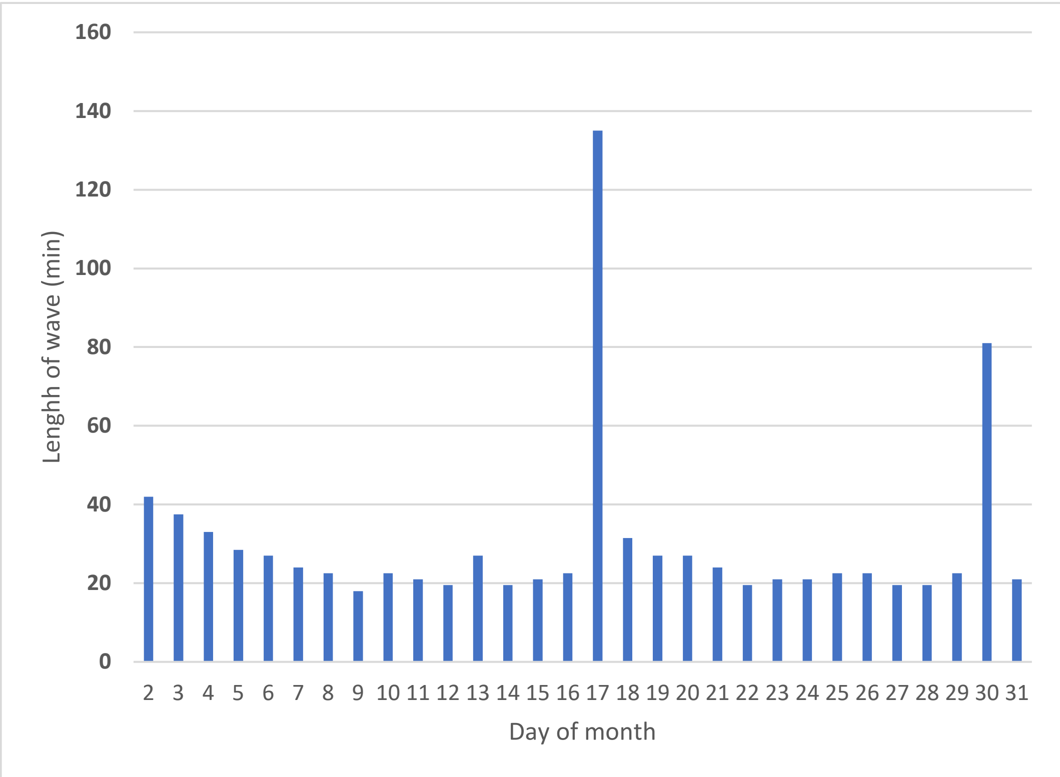


Figure 8. Length of regular daily waves (min) in March 2015.

Since the most stable regularity is indicated by the time lag of the peak, it is useful to carry out the search for the next regular daily wave in relation to the forecast of the next day of the peak time. . In order to search for the peak of the next day it was necessary to take into account both the fluctuation of the lag time and the discrepancy between the gradation of the measurement time 1.5 min (see Figure 1) and the regular predicted daily time lag -4.11 min.

When the study began, there were only thoughts that there might be regular waves of GPS interference in a few other months as well. However, the example from March 2015 sparked interest in exploring the regularity of positioning disorders in other months.

2.5. Search of Regular Daily Waves

The monthly set of regular daily scintillation waves is

$W := \cup \{w_k : \exists p_k \ \exists p'_k \ \mathrm{abs}(p_k - p'_k) \le c', p_k, p'_k \in w_k, \ 1 \le \mathrm{k} \le 31\}$ (3)

$p'_k = p_{k-1} + \mathrm{const}$ (4)

The c' is a threshold for uncertainty of the constant for peak clooud $p_k$occurrence time daily regularity. For the initial search test, sets of CORS GPS measurement erroneous results of the October and December 2014 were selected. A cloud of the largest cardinality of the first wave of the first day of the month was chosen as the starting point. The search process confirmed the daily varying difference in time between the wave beginnings, peaks, and midpoints.The results of experimentation will be reflected in the next section of article.

The final test was based on the assumption that the predicted regular wave of the next day partially overlaps the regular wave of the current day in terms of time in minutes and seconds, unless one of the regular wavelengths of the comparable adjacent days is less than a certain time limit.

$W_{tested} := \cup \left\{(w_i, w_j) : \left(\left(t'_{j_1} < t_{i_l}\right) \wedge \left(t'_{j_l} > t_{i_1}\right)\right), t_{i1}, t_{il} \in D_i, w_j, t'_{j_1}, t'_{j_l} \in D_{i+1}, 1 \le \mathrm{i} \le |w_i|, 1 \le \mathrm{j} \le |w_j| \right\}$ (5)

$t'_j = t_i + \mathrm{const}$ (6)

where t_{i_1} means time of the first cloud of the wave, t_{i_l} - the last cloud of the wave, $|w_i|$ is cardinality - count of the clouds in current day. The t'_{j_1} and t'_{j_l} belong to the wave found for the next day., correspondingly.. Const means a daily lag in time changes of the regular waves occurred in adjacent days. The value of const will be discussed in section of Discussion.

2.6. ROTI@ground and Positioning Errors

In conclusion, in a few months, the average values of ROTI@ground and the affected CORS station average positioning errors will be calculated to gain insight into what impact these regular daily scintillation waves have on positioning accuracy.

In Table 4 is shown the sample o+f discrepancies in GPS positioning for all the stations of one cloud: Northing dN, Easting dE, height dh, 3D error, azimuth Az abd Rate of Total electron content Index ROTI with time resolution 8 min for ROTI for each station. Both the results of ROTI@ ground and average positioning error is computed for each daily regular wave. Results will be discussed in next sections, but the sample of input data for each station on fixed time is shown in Table 3.

Table 3. Example of discrepancies and ROTI for each cloud's station.

D	#	Date	Time UT	DOME	#	dN	dE	dh	3D	Az	ROTI
258	2015	MAR 5	22:58:30 UT	IRBE	1211	0.017	0.004	0.105	0.106	13.2	0.0394
				OJAR	1214	-0.005	-0.007	-0.110	0.110	-125.5	0.0403
				DAU1	1210	0.024	0.003	0.115	0.118	7.1	0.0384
				KREI	1212	-0.029	-0.002	-0.150	0.153	-176.1	0.0403
				VANG	1215	0.043	0.006	0.154	0.160	7.9	0.0403
				MAZS	1213	0.059	-0.001	0.219	0.227	-1.0	0.0407
				ALUK	1209	-0.076	0.009	-0.236	0.248	173.2	0.0403

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 8 September 2025 doi:10.20944/preprints202509.0575.v1

3. Results

By analogy with the month of March 2015, initially the search for regular waves in other month began from the first wave of the first day of the month. The results were disappointing. Then the search began with the largest wave of the first day, then with the highest peak of the first day. It happened that the amount of waves on the first day of a few months was unexpectedly large, and it was necessary to change the initial search parameters in software program. Several search parameters were improved step by step and as a result, the search was carried out 6 times with both different and matching results.

Doubts and disbelief about the regularity of scintillation led to its existence being tested again and again. The search conditions were not fundamentally different, The differences were only the change in the choice of the starting point cloud or in the choice of regular daily repetition time shift constant (Const). By changing the Const value, the number of identified waves per month changed. In the search process with a different Const value there was a peak cloud as the starting point always. But in seach of subsequent day's wave, a different cloud of the same wave entered instead of the peak cloud because of it's fluctuating time. In months with shorter wave lengths, the search process collapsed, as the accepted time Const shifted beyond the limits of the next wave. In Figure 9 depicted the fluctuation of the time of peak cloud and subsequent variation of Const value. Dashed line shows the mean Const that is close to the length of siderial day.

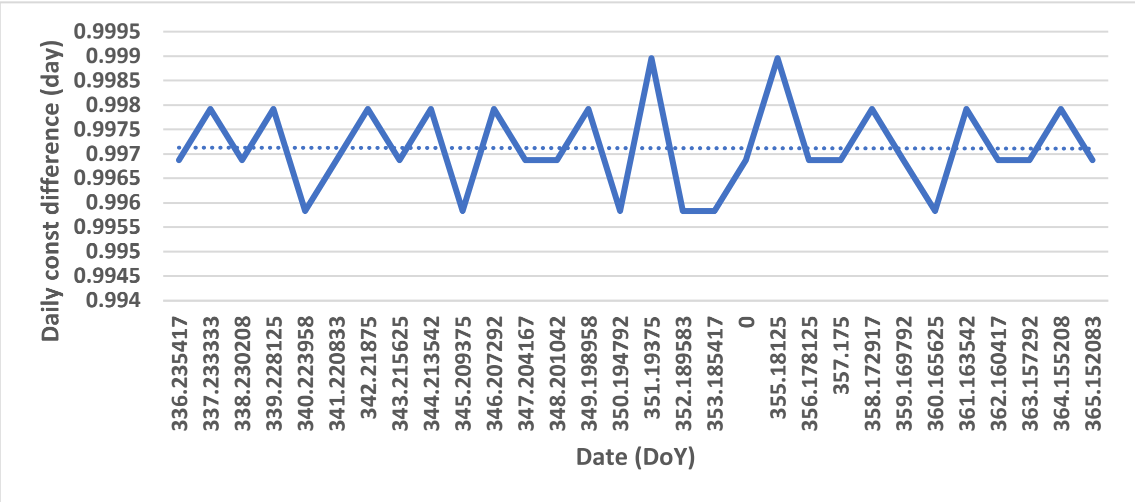


Figure 9. Variations in Const in December 2014.(DoY – Day of Year).

The results of the experiments were summarized. Result is shown in Figure 10 and example of summary in Table 4. The column St mens number of stations in cloud, Stations/cloud in 6 columns expose the search results in 6 experiments. For control purposes numbers in Štations/cloud" mean count of stations in cloud that coinside with data in column St. "Adj.days time lag" show the difference in minutes (min) between identified cloud of regular waves in adjacent days (current minus previous). Information in lines 31-33 are about clouds in one wave, lines 50-54 other regular wave, lines 114-115 other very small wave, lines 127-130 one more wave. The complete information of this data subset for June 2014 is in Table A1 where the summarized search results of selected month are shpwn.

doi:10.20944/preprints202509.0575.v1

Table 4. Sample of summarized search results in NOV 2011.

	MJD	Date	Day	Time	St.	Stations/cloud (min)	Adj.day's	time	lag			
31	55867.073958	2011 NOV	2	1:46:29 UT	4	4 0 4 0 4 0	-4.5	0.0	-4.5	0.0	-4.5	0.0
32	55867.075000	2011 NOV	2	1:48: 0 UT	2	0 2 0 0 0 0	0.0	-3.0	0.0	0.0	0.0	0.0
33	55867.076042	2011 NOV	2	1:49:30 UT	1	0 0 0 0 0 0	0.0	0.0	0.0	0.0	0.0	0.0
50	55868.070833	2011 NOV	3	1:42: 0 UT	3	0 0 3 0 3 0	0.0	0.0	-4.5	0.0	-4.5	0.0
51	55868.071875	2011 NOV	3	1:43:29 UT	4	0 0 0 0 0 0	0.0	0.0	0.0	0.0	0.0	0.0
52	55868.072917	2011 NOV	3	1:45: 0 UT	3	0 0 0 0 0 0	0.0	0.0	0.0	0.0	0.0	0.0
53	55868.073958	2011 NOV	3	1:46:29 UT	2	0 2 0 0 0 0	0.0	-1.5	0.0	0.0	0.0	0.0
54	55868.077083	2011 NOV	3	1:51: 0 UT	1	0 0 0 0 0 0	0.0	0.0	0.0	0.0	0.0	0.0
114	55871.063542	2011 NOV	6	1:31:30 UT	2	0 0 2 0 2 0	0.0	0.0	-3.0	0.0	-3.0	0.0
115	55871.064583	2011 NOV	6	1:33: 0 UT	2	0 2 0 0 0 0	0.0	-4.5	0.0	0.0	0.0	0.0
127	55872.059375	2011 NOV	7	1:25:29 UT	2	0 0 0 0 0 0	0.0	0.0	0.0	0.0	0.0	0.0
128	55872.060417	2011 NOV	7	1:27: 0 UT	5	0 0 5 0 5 0	0.0	0.0	-4.5	0.0	-4.5	0.0
129	55872.061458	2011 NOV	7	1:28:29 UT	2	0 2 0 0 0 0	0.0	-4.5	0.0	0.0	0.0	0.0
130 November 2011	55872.062500	2011 NOV	7	1:30: 0 UT	1	0 0 0 0 0 0	0.0	0.0	0.0	0.0	0.0	0.0

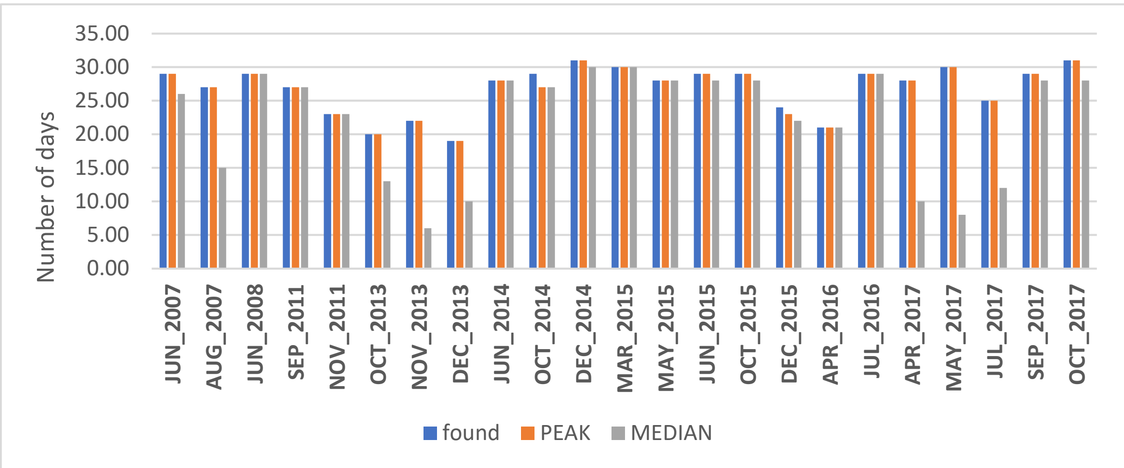


Figure 10. Search results as an Input data for linear approximation with number of days in month with found regular waves.

November of year 2011 in a 24th solar activity cycle is a month of low solar activity. The article will demonstrate that the wavelength of ionospheric scintillation regular waves is dependent on solar activity. In the example of Table 4, the regular waves are very short. According to Formula (5) the predicted regular wave of the next day partially overlaps the regular wave of the current day in terms of time in minutes and seconds, unless one of the regular wavelengths of the comparable adjacent days is less than a certain time limit. For examle, in Table 4 in NOV 2 and 3 the time 1:42:00 < 1:49:30 and 1:51:00 >1:46:29. But wave of NOV 6 is not covering the adjacent day NOOV 7 in sense of minutes and seconds.

3.1. Linear Approximation

Due to the fact that in some months it was not possible to find regular ionospheric scintillation waves on all days, a linear approximation of the time series of the detected waves was performed for both peak clouds, median clouds, and initial (beginning) clouds. The approximation for initial clouds showed the greatest errors, making its use for forecasts invalid. The number of input data for peak and median clouds is shown in Figure 10.

In the linear approximation algorithm, approximation precision criteria were incorporated. For example, the criterion for the precision of peak time series approximation was 3 minutes. To achieve this precision, it was allowed to discard times with the largest discrepancy during iteration, but keeping the number of remaining times no less than 4 in the solution. In the case of the median, there were 2 solutions. One with the same conditions as for peak cloud times, but the other with different precision conditions: a precision of 17 minutes and a minimum of 6 time counts.

Based on the results of the linear approximation, it was checked whether such scintillation waves were present in the CORS dataset. The search results are shown in Figure 11.

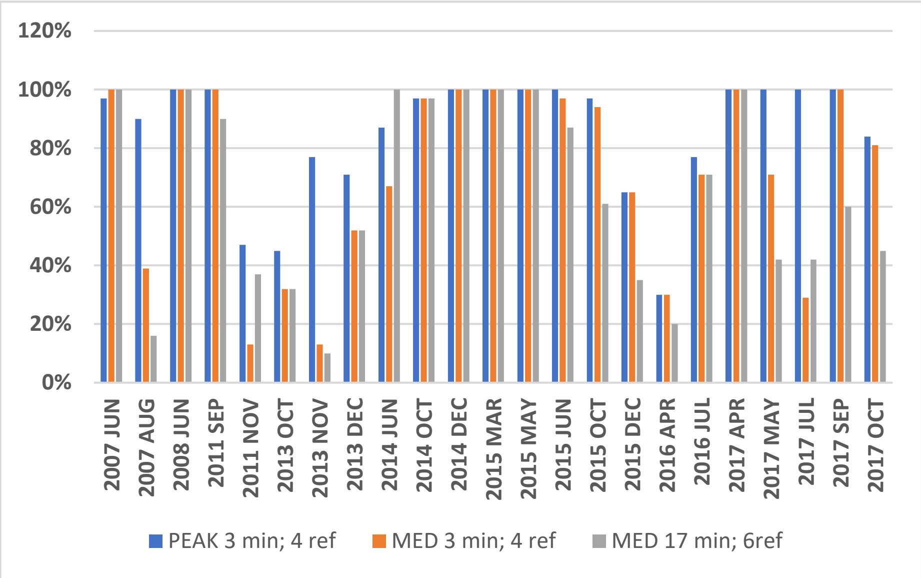


Figure 11. The presence of predicted scintillation waves in the CORS data set in linear approximation.

As a result of linear approximation, the peak cloud times of the unidentified waves were also predicted. The search results are shown in Table 5. The information in columns as follows: "Pred" – number of predicted wave's peak time; "Not"- number of waves that are not found in search procedures; "found"- found in final search procedures based on linear approximation results; "Wlen"- mean wave lrngth (min); "For-mean"- numbrr of waves without outliers of length;"Mean"- mean wave lrngth (min) without outliers; "Outliers"- number of outliers; "Thr"- threshold for outliers 60 (min).

Table 5. Results of wave search after peak's time approximation.

#	Year	Mpnth	Pred	Not	Found	Wlen	Forme an	Mean	Outlier s	Thr
1	2007	JUN	30	1	30	39.2	27	11.7	3	60.0
2	2007	AUG	31	4	31	11.6	31	11.6	0	60.0
3	2008	JUN	30	1	30	14.2	29	13.3	1	60.0
4	2011	SEP	30	3	28	36.1	27	10.4	3	60.0
5	2011	NOV	30	8	5	28.5	4	2.3	26	60.0
6	2013	OCT	24	5	8	11.4	8	11.4	16	60.0

7	2013	NOV	30	8	26	31.6	24	3.4	6	60.0
8	2013	DEC	31	2	23	41.2	20	2.4	11	60.0
9	2014	JUN	30	2	30	26.8	29	25.4	1	60.0
10	2014	OCT	31	2	31	82.2	28	14.6	3	60.0
11	2014	DEC	31	0	31	57.6	24	25.3	7	60.0
12	2015	MAR	31	1	31	29.1	29	23.6	2	60.0
13	2015	MAY	31	3	31	22.6	29	10.2	2	60.0
14	2015	JUN	30	1	30	45.0	28	13.9	2	60.0
15	2015	OCT	31	2	30	57.6	26	6.1	5	60.0
16	2015	DEC	31	7	9	34.7	8	3.0	23	60.0
17	2016	APR	30	9	6	6.9	6	9.2	24	60.0
18	2016	JUL	31	2	28	28.3	25	8.9	6	60.0
19	2017	APR	30	2	28	57.6	25	11.0	5	60.0
20	2017	MAY	31	1	31	129.0	24	14.9	7	60.0
21	2017	JUL	31	6	31	143.2	26	16.8	5	60.0
22	2017	SEP	30	1	30	23.3	27	9.0	3	60.0
23	2017	OCT	31	0	28	33.8	24	5.6	7	60.0

The results demonstrated in Table 5 and Figure 11 confirm that the method of finding waves predicted by linear transformation is not applicable in months of low solar activity, when the scintillation wave length is less than 10 minutes. It is quite successfully used in months of elevated solar activity.

3.2. Solar Activity and Length of Regular Ionospheric Scintillation Waves

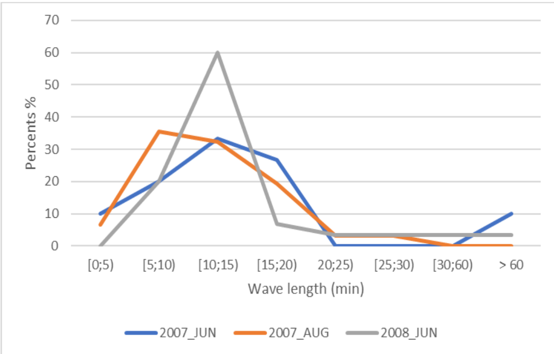
The overview of the percentage of distribution of wave's length of the identified regular waves is shown in Table 6 for various month and years of 24th solar cycle in mid-latitude country Jatvia.

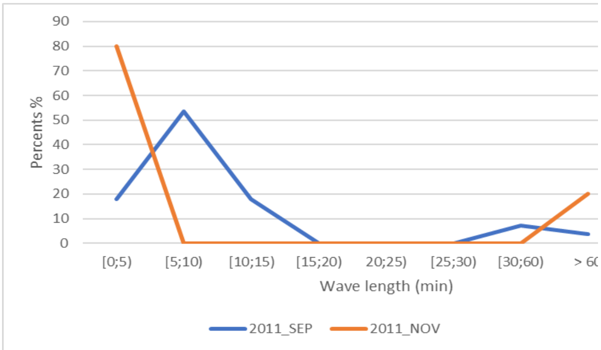
Table 6. Percentage of wavelength in min.

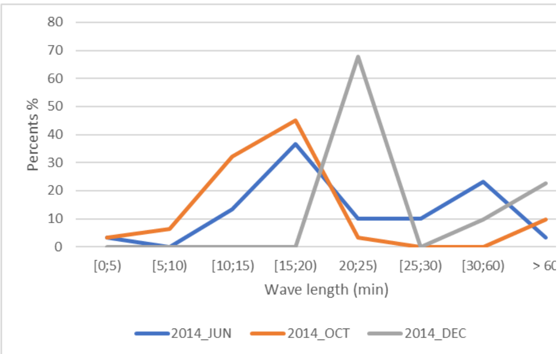
Year	Month	[0;5)	[5;10)	[10;15)	[15;20)	[20;25)	[25;30)	[30;60)	> 60
2007	JUN	10.0	20.0	33.3	26.7	0.0	0.0	0.0	10.0
2007	AUG	6.5	35.4	32.3	19.4	3.2	3.2	0.0	0.0
2008	JUN	0.0	20.0	60.1	6.7	3.3	3.3	3.3	3.3
2011	SEP	17.9	53.5	17.9	0.0	0.0	0.0	7.1	3.6
2011	NOV	80.0	0.0	0.0	0.0	0.0	0.0	0.0	20.0
2013	OCT	62.5	12.5	0.0	0.0	12.5	0.0	12.5	0.0
2013	NOV	69.3	19.2	3.8	0.0	0.0	0.0	0.0	7.7
2013	DEC	82.7	0.0	4.3	0.0	0.0	0.0	0.0	13.0
2014	JUN	3.3	0.0	13.3	36.8	10.0	10.0	23.3	3.3
2014	OCT	3.2	6.5	32.3	45.1	3.2	0.0	0.0	9.7
2014	DEC	0.0	0.0	0.0	0.0	67.7	0.0	9.7	22.6
2015	MAR	3.3	0.0	0.0	19.4	41.9	16.1	12.9	6.5
2015	MAY	12.9	35.5	29.0	16.1	0.0	0.0	0.0	6.5
2015	JUN	10.0	13.3	46.7	13.3	0.0	0.0	10.0	6.7
2015	OCT	50.0	30.0	3.3	0.0	0.0	0.0	3.3	13.4
2015	DEC	66.7	22.2	0.0	0.0	0.0	0.0	0.0	11.1
2016	APR	83.3	0.0	0.0	0.0	0.0	0.0	16.7	0.0
2016	JUL	39.4	21.4	10.7	10.7	0.0	7.1	0.0	10.7

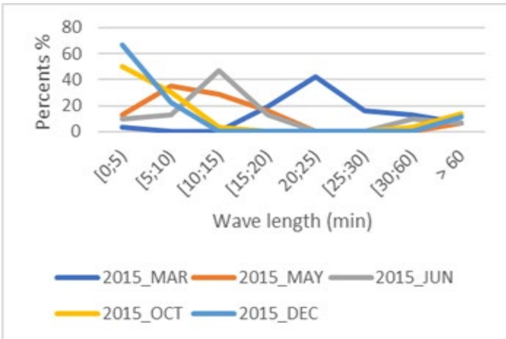
2017	APR	0.0	25.0	57.2	7.1	0.0	0.0	0.0	10.7
2017	MAY	0.0	0.0	61.3	9.7	3.2	0.0	3.2	22.6
2017	JUL	3.2	0.0	42.0	25.8	3.2	3.2	6.5	16.1
2017	SEP	10.0	50.0	23.4	3.3	3.3	0.0	0.0	10.0
2017	OCT	42.8	35.7	3.6	3.6	0.0	0.0	0.0	14.3
		28.6	17.4	20.6	10.6	6.6	1.9	4.7	9.6

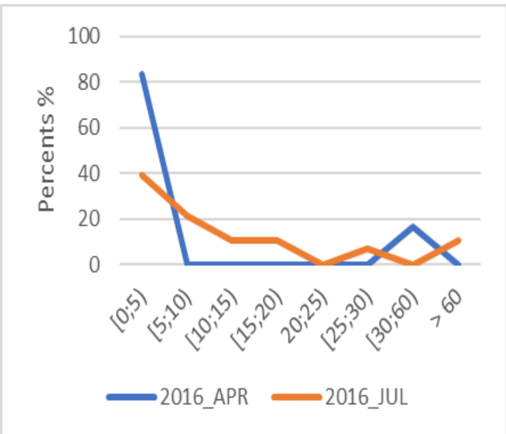
The period was selected from the first to the last MJD day in which the regular disturbance was identified over the course of a month. For better visibility, Figures 12-17 show the distributions of wavelengths mentioned in Table 6 by individual years. These graphs llustrate the dependence of wavelength distribution on solar geomagnetic activity. In the years 2007 and 2008, solar activity decreased, but it is still relatively high.In period of low solar activity in November 2011 up to 80% of wavelength is very short [0;5) minutes (Table 6, Figure 13). However, 20 % of waves are lasting more than 1 hour.

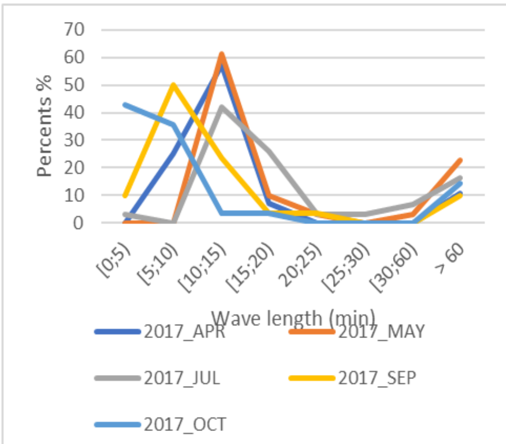












Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 8 September 2025 doi:10.20944/preprints202509.0575.v1

Figures 12-17. The percentage distribution of wave lengths in the months analyzed of 2007 and 2008 (Fig 12), 2011 (Fig 13),2014 (Fig 14), 2015 (Fig 15), 2016 (Fig 16) and 2017 (Fig 17).

In period of high solar activity June 2014 in 36.8% of occurrances the wavelength was [[15,20] minutes of time, in October 2014 45.1%, in December 2014 67.7% of occurrances of wave length [20;25) and 22.6% of more than 1 hour waves (Figure 14). Figure 15 shows how wave lengths change depending on changes in solar activity. In March, May, and June 2015, solar activity is very high, while in October and December it is significantly lower. In March, there is a very uniform distribution starting from 15 minutes and more (42% [20;25)). In October, 50%, and in December, in 67% of cases, the wavelength does not exceed 5 minutes. The Figure 16 shows the wave length distribution in low solar activity year 2016. Solar geomagnetic activity has begun to increase since April 2017, and shaply decreased in October. In September 2017 very strong geomagnetic storm was observed in USA and Canada, but it doesn't appears in Latvia. This is also reflected in the distribution of wavelengths in Figure 17.

3.3. The Impact of Daily Regular Ionospheric Waves on Positioning Accuracy

To assess the impact of regular scintillation wave on positioning accuracy, error data and ROTI data were randomly selected from the Latvia CORS dataset defined in formula (1). In Table 7 shown example of ROTI@ground and mean positioning 3D discrepancies for all clouds of regular wave in March 23, 2015. In column St is a number of staations in cloud.

Table 7. ROTI@ground and mean positioning 3D discrepancies (m) for each cloud of wave.

#	Date	Time UT		St		ROTI		Discr (m)
1328	2015 MAR 23	21:43:29	STATIONS	2	ŖOTI@ground	0.0190	Mean discr	0.061
1329	2015 MAR 23	21:45: 0	STATIONS	3	ŖOTI@ground	0.0325	Mean discr	0.246
1330	2015 MAR 23	21:46:30	STATIONS	7	ŖOTI@ground	0.0379	Mean discr	0.341
1331	2015 MAR 23	21:48: 0	STATIONS	13	ŖOTI@ground	0.0386	Mean discr	1.783
1332	2015 MAR 23	21:49:29	STATIONS	23	ŖOTI@ground	0.0386	Mean discr	0.963
1333	2015 MAR 23	21:51: 0	STATIONS	29	ŖOTI@ground	0.0389	Mean discr	0.408
1334	2015 MAR 23	21:52:29	STATIONS	18	ŖOTI@ground	0.0390	Mean discr	0.326
1335	2015 MAR 23	21:54: 0	STATIONS	16	ŖOTI@ground	0.0394	Mean discr	0.213
1336	2015 MAR 23	21:55:30	STATIONS	14	ŖOTI@ground	0.0392	Mean discr	0.197
1337	2015 MAR 23	21:57: 0	STATIONS	9	ŖOTI@ground	0.0391	Mean discr	0.169
1338	2015 MAR 23	21:58:30	STATIONS	14	ŖOTI@ground	0.0394	Mean discr	0.165
1339	2015 MAR 23	22: 0: 0	STATIONS	6	ŖOTI@ground	0.0391	Mean discr	0.182
1340	2015 MAR 23	22: 1:29	STATIONS	7	ŖOTI@ground	0.0398	Mean discr	0.140
1341	2015 MAR 23	22: 3: 0	STATIONS	2	ŖOTI@ground	0.0395	Mean discr	0.167
1342	2015 MAR 23	22: 4:30	STATIONS	3	ŖOTI@ground	0.0390	Mean discr	0.150
22	WAVE No1328	AVERAGE				0.0373		0.368

In Table 8 depicyed the ROTI@ground and mean discrepancies for individual clouds in situation example when solar activity was low.

Table 8. ROTI@ground and mean positioning 3D discrepancies for each cloud of wave.

#	Date	Time UT		St		ROTI		Discr (m)
63	2011 NOV 4	1:39: 0	STATIONS	6	ŖOTI@ground	0.0334	Mean discr	0.179
64	2011 NOV 4	1:40:30	STATIONS	3	ŖOTI@ground	0.0391	Mean discr	0.160
3	WAVE No 63	AVERAGE				0.0363		0.169

114 2011 NOV 6	1:31:30 STATIONS	2 ŖOTI@ground 0.0173 Mean discr	0.097
115 2011 NOV 6	1:33: 0 STATIONS	2 ŖOTI@ground 0.0255 Mean discr	0.141
4 WAVE No 114	AVERAGE	0.0214 0.119	
127 2011 NOV 7	1:25:29 STATIONS	2 ŖOTI@ground 0.0187 Mean discr	0.066
128 2011 NOV 7	1:27: 0 STATIONS	5 ŖOTI@ground 0.0343 Mean discr	0.159
129 2011 NOV 7	1:28:29 STATIONS	2 ŖOTI@ground 0.0353 Mean discr	0.147
5 WAVE No 127	AVERAGE	0.0294 0.124	

In March 2015, there was increased solar activity. Table 9 shows the impact of regular wave ROTI@ground and the average positioning error of each day. It is not for individual clouds like in Tables 7 and 8. There is computed the meam values of impact of daily regular scincillation waves. Table 9 data shows that daily regular scintillation waves cause serious positioning errors.

Table 9. ROTI@ground and Mean discrepancies of regular waves in March 2015.

Date	ROTI@ground	Discr	Date	ROTI@ground	Discr
2	0,0386	0,271	17	0,0532	3,993
3	0,0383	0,378	18	0,0387	1,423
4	0,0385	1,202	19	0,0379	0,329
5	0,0396	0,422	20	0,0366	0,301
6	0,0409	0,334	21	0,0386	0,371
7	0,0382	0,354	22	0,0373	0,64
8	0,0413	0,363	23	0,0419	0,368
9	0,0398	0,424	24	0,0404	0,343
10	0,0391	0,672	25	0,0396	1,495
11	0,0428	0,822	26	0,0413	0,407
12	0,0413	0,686	27	0,0388	0,38
13	0,0414	0,306	28	0,0368	0,466
14	0,039	0,597	29	0,0372	0,641
15	0,5576	0,414	30	0,0374	0,4
16	0,1046	0,318	31	0,0372	0,932

Table 9 data shows that daily regular scintillation waves cause serious positioning errors.

3.4. Time Lag of Daily Regular Ionospheric Scintillation Waves

The period was selected from the first to the last MJD day in which the regular disturbance was identified over the course of a year. The average daily time lag for regular ionospheric scintillations was calculated (Table 10). The value of daily time lag is close to the length of siderial day. This confirms the hypothesis that the initial source of the radiation causing the scintillation is not the Sun. It is enhanced by solar activity, but origin is from interplanetary media, similarly like Pc1 pulsation waves. 4. Time lag of daily regular ionospheric scintillation waves.

Table 10. Regularity results for peak daily shift.

#	Time span	Daily shift (day)	Daily shift (min)
1	JUN 2007 -> 30 AUG 2007	0.997210	-4.0
2	SEP 2011 -> 28 NOV 2011	0.997195	-4.0
3	OCT 2013 -> 23 DEC 2013	0.997055	-4.2
4	JUN 2014 -> 30 Dec 2014	0.997155	-4.1
5	mar 2015 -> 31 12 2015	0.997177	-4.1
6	APR 2016 -> 30 JUL 2016	0.997153	-4.1
7	APR 2017 -> 30 OCY 2017	0.997145	-4.1
	Average	0.997156	
	STDV	0.000046	0.1 min

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 8 September 2025 doi:10.20944/preprints202509.0575.v1

Researchers conclude [37] that Pc1 waves appear at midnight just before dawn. Our studies demonstrate the likelihood of the regular cyclical occurrence of daily regular scintillation waves at any time of day (Table B1). Of course, if they are indeed the scintillation waves referred to similarity as Pc1 waves.

Pc1 waves enhanced by solar activity [37–39], It is seen in Figures 12-17 that wavelength of regular wavws is dependent from the solar activity.enhancement.

Regular waves repetition shift is 0.997156 days (or -4. 1 minutes), that is approximate siderial day different from solar UT day. Consequently, the origin of waves is supposed to be interplanetary media.

4. Discussion

It is revealed that the regularity of daily disturbances is time-shifted, close to the length of a sidereal day. The duration (length) of daily scintillation waves) is influenced by the olar activity. This daily regular ionospheric scintillation wave phenomenon is similar to the Pc1 interplanetary wave phenomenon, but unlike Pc1 observations, they are recorded at any time of the day (Table B1). Only during periods of low solar activity the regular scintillation waves not appear. Table 11 provides the dates of the observed Pc1 waves [37] and a comparison of the lengths of these waves with the number and length of waves observed by GPS in Latvia on those dates. The Pc1 dates were published in a preprint of publication [37], unfortunately, without the indication of the observation time.

Table 11. Comparison of Pc1 waves with GPS observations of ionospheric waves on the same date.

#	Date of Pc1 waves	Pc1 waves	Dur. (min)	CPS d. waves	Dur. (min)
1	4th, November 2011	1	10	1	1.5
2	29th, November 2011	1	30	1	7.5
3	18th, March 2015	2	12	1	31.5
4	19 th, March 2015	4	10	3	3; 27; 4.1
5	23 th, March 2015	4	46	1	21
6	29 th, March 2015	3	19	1	22.5
7	25th, June 2015	1	2	3	12; 4.5; 6
8	28th, June 2015	1	4	4	1.5; 3; 4.5; 607.5
9	3rd, April 2017	1	8	2	1.5; 7.5
10	9th , April 2017	1	88	2	16.6; 16.5
11	26 th, April 2017	1	10	3	255; 1.5; 10.5
12	27th , April 2017	1	10	1	12
13	19th , May, 2017	1	36	6	82.5; 3; 1.5; 16.5; 126; 15

In two other studies, the dates and times of the Pc1 wave magnetometric measurements have been mentioned.

The theoretical predictions with observational results from conjugate high latitude stations in Antarctica and Greenland performed by Pilipenko et al [38] during summer (7 June 2014) and wintwr (7 January 2014) periods. A disturbance is a sudden commencement (SC) pulse caused by the impact of an interplanetary shock (IS) on the magnetosphere. At high latitude when the duration of the local field line eigenperiod T_A is ~5-10 min which can be longer than an SC impulse with 1-2 min [38]. In 7

June 2014 accordingtothe SuperDARNTEC maps, for the 7 June 2014 event (1650–1655). In Figure 18 shown daily regular scintillaion event registered by Latvian CORS on 7 June 2014

915 2014 JUN 7 17:36: 0 UT JEK1
916 2014 JUN 7 17:37:30 UT LUNI DAGD TKMS VAIV OJAR MADO KREI
917 2014 JUN 7 17:39: 0 UT VAIV BALV SALP OJAR IRBE
918 2014 JUN 7 17:40:29 UT KUL1 OJAR PREI IRBE RIGA KREI SALP
919 2014 JUN 7 17:42: 0 UT TKMS DOB1 OJAR VAL1 SLD1 VAIV SIGU SALP LIPJ
920 2014 JUN 7 17:43:30 UT BALV TKMS IRBE OJAR MAZS VAL1 VAIV TALS KREI REZ1 LIPJ PREI ALUK MADO RIGA SLD1
921 2014 JUN 7 17:45: 0 UT LIMB LIPJ LODE MADO SLD1 REZ1 SIGU MAZS TALS TKMS VAL1
922 2014 JUN 7 17:46:29 UT PLSM VANG RIGA VAL1 KREI SALP LUNI VAIV SLD1 TALS REZ1 SIGU TKMS IRBE BALV DAGD MAZS LODE
923 2014 JUN 7 17:48: 0 UT DAGD MAZS BALV LODE LIPJ KUL1 PLSM JEK1 IRBE VANG RIGA VAL1 LIMB SLD1 SIGU TALS REZ1 PREI OJAR MADO KREI SALP VAIV LUNI
924 2014 JUN 7 17:49:29 UT LIMB
925 2014 JUN 7 17:51: 0 UT MAZS
926 2014 JUN 7 17:52:30 UT LIMB VAIV SALP LUNI LODE MAZS
927 2014 JUN 7 17:54: 0 UT KREI VAIV LUNI SALP
928 2014 JUN 7 17:57: 0 UT LIMB
929 2014 JUN 7 17:58:29 UT LODE LIMB BALV

Figure 18. Daily regular scintillaion event registered by Latvian CORS on 7 June 2014.

Francia et al [40] studied the correspondence between Pc1 activity and ionospheric irregularities at polar latitudes. They performed magnetometric observations in 22 february 2007 in MST station in Antarctica. between 0200 and 1400 UT.

Latvian CORS GPS observations confirmed that the month of February 2007 had low solar activity. However, on February 22, two cases of ionospheric scintillation were 872

3007 FEB 22 0:16:29 UT OJAR
873 3007 FEB 22 1:37:29 UT SIGU TALS LIMB OJAR MADO PREI RIGA VALM
874 3007 FEB 22 1:39: 0 UT RIGA VALM
875 3007 FEB 22 1:40:30 UT REZE TALS SIGU SLDS VALM RIGA
876 3007 FEB 22 1:42: 0 UT VALM RIGA REZE TALS SIGU SLDS
877 3007 FEB 22 1:43:29 UT TALS SIGU PREI SLDS MADO
878 3007 FEB 22 1:45: 0 UT PREI SLDS
879 3007 FEB 22 1:46:29 UT DAUG
883 3007 FEB 22 8:15: 0 UT REZE SIGU TALS SLDS OJAR PREI MADO LIMB JEKA KULD LIEP VALM RIGA
884 3007 FEB 22 10:30: 0 UT LIMBrecorded (Figure 19).

Figure 19. Ionospheric scintillaion 2 event registered by Latvian CORS on 22 Feb 2007.

It is still a challenge to determine the apparent relationship between ionospheric conditions and Pc1 wave occurrence [37].

It cannot be claimed that the comparison of daily regular ionospheric scintillation cases over time with the mentioned Pc1 wave cases indicates any interrelation. But it can be asserted that, judging by the periodic shift of the day, the scintillation recurrence impulse comes from the interplanetary environment.with some mutual relationship.

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 8 September 2025 doi:10.20944/preprints202509.0575.v1

Author Contributions: Conceptualization. J.B, M.N, I.M.; methodology. J.B..; software. J.B..; validation. J.B., M.N. and I.M..; formal analysis. J.B.; investigation. J.B.; resources. J.B., M.N.; data curation. J.B..; writing—original draft preparation. J.B..; writing—review and editing. J.B.,M.N; visualization. J.B..; supervision. J.B., I.M..; project administration. J.B., I.M..; funding acquisition. J.B.. I.M. All authors have read and agreed to the published version of the manuscript.

Funding:: This research was funded by the Programme for European Cooperating States (PECS), European Space Agency Contract No: 4000128661/19/NL/SC, project "Ionospheric characterization by statistical analysis of Latvian GBAS 11-year selective daily observations". The views expressed in this publication can in no way be taken to reflect the official opinion of the European Space Agency. The APC was funded by the University of Latvia.

Informed Consent Statement: Not applicable.

Data Availability Statement: Some of the data presented in this study are available in a Microsoft Office 365 OneDrive account provided by the LU GGI.

Acknowledgments: The authors would like to express gratitude to Inese Vārna and to Diana Haritonova for their support and assistance in the GNSS data processing with the Bernese GNSS Software v5.2.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Summary of 6 searches of daily regular scintillation waves for June 2014.

YEAR 2014 MONTH JUN

2014 JUN 1 0 1 0 1 0

#	MJD	Date Day	Time	St.	Stations/cloud	Adj.day's time lag

L,L1= 135 143 This wave content Clouds 135-143

135 56809.751042 2014 JUN 1 18: 1:30 UT 6 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
136 56809.752083 2014 JUN 1 18: 3: 0 UT 9 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
137 56809.753125 2014 JUN 1 18: 4:30 UT 11 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
138 56809.754167 2014 JUN 1 18: 6: 0 UT 12 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
139 56809.755208 2014 JUN 1 18: 7:29 UT 18 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
140 56809.756250 2014 JUN 1 18: 9: 0 UT 10 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
141 56809.757292 2014 JUN 1 18:10:30 UT 22 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
142 56809.758333 2014 JUN 1 18:12: 0 UT 23 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
143 56809.844792 2014 JUN 1 20:16:30 UT 1 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0

2014 JUN 2 0 2 2 2 0 2 means day of month. The regular cloud identified I columns 1,3,4,5.

L,L1= 241 254 This wave content Clouds 241-254

135 56809.751042 2014 JUN 1 18: 1:30 UT
241 56810.743750 2014 JUN 2 17:51: 0 UT 2 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
242 56810.744792 2014 JUN 2 17:52:30 UT 2 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
243 56810.745833 2014 JUN 2 17:54: 0 UT 3 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
244 56810.746875 2014 JUN 2 17:55:29 UT 2 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
245 56810.747917 2014 JUN 2 17:57: 0 UT 6 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
246 56810.748958 2014 JUN 2 17:58:29 UT 12 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
247 56810.750000 2014 JUN 2 18: 0: 0 UT 16 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
248 56810.751042 2014 JUN 2 18: 1:30 UT 15 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
249 56810.752083 2014 JUN 2 18: 3: 0 UT 19 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
250 56810.753125 2014 JUN 2 18: 4:30 UT 23 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 8 September 2025 doi:10.20944/preprints202509.0575.v1

251 56810.754167 2014 JUN 2 18: 6: 0 UT 20 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
252 56810.755208 2014 JUN 2 18: 7:29 UT 26 26 0 26 26 26 0 -4.5 0.0 -4.5 -0.2 -4.5
0.0 The regular cloud identified I columns 1,3,4,5. 26 st.in cloud
253 56810.756250 2014 JUN 2 18: 9: 0 UT 26 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
254 56810.757292 2014 JUN 2 18:10:30 UT 1 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0

2014 JUN 3 0 3 3 3 0
L,L1= 565 577
565 56811.740625 2014 JUN 3 17:46:29 UT 2 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
566 56811.741667 2014 JUN 3 17:48: 0 UT 2 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
567 56811.743750 2014 JUN 3 17:51: 0 UT 3 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
568 56811.744792 2014 JUN 3 17:52:30 UT 4 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
569 56811.745833 2014 JUN 3 17:54: 0 UT 5 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
570 56811.746875 2014 JUN 3 17:55:29 UT 13 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
571 56811.747917 2014 JUN 3 17:57: 0 UT 15 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
572 56811.748958 2014 JUN 3 17:58:29 UT 13 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
573 56811.750000 2014 JUN 3 18: 0: 0 UT 14 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
574 56811.751042 2014 JUN 3 18: 1:30 UT 15 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
575 56811.752083 2014 JUN 3 18: 3: 0 UT 11 11 0 11 0 11 0 -4.5 0.0 -4.5 0.0 -4.5
0.0 The regular cloud identified I columns 1,3,,5. 11 st. in cloud
576 56811.753125 2014 JUN 3 18: 4:30 UT 22 0 0 0 22 0 0 0.0 0.0 0.0 1.3 0.0 0.0
The regular cloud identified I columns ,4. 22 st.in cloud
577 56811.754167 2014 JUN 3 18: 6: 0 UT 1 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0

2014 JUN 4 0 4 4 4 0
L,L1= 725 741
725 56812.740625 2014 JUN 4 17:46:29 UT 4 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
726 56812.741667 2014 JUN 4 17:48: 0 UT 3 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
727 56812.742708 2014 JUN 4 17:49:29 UT 8 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
728 56812.743750 2014 JUN 4 17:51: 0 UT 11 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
729 56812.744792 2014 JUN 4 17:52:30 UT 13 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
730 56812.745833 2014 JUN 4 17:54: 0 UT 16 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
731 56812.746875 2014 JUN 4 17:55:29 UT 16 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
732 56812.747917 2014 JUN 4 17:57: 0 UT 17 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
733 56812.748958 2014 JUN 4 17:58:29 UT 18 18 0 18 18 18 0 -4.5 0.0 -4.5 -1.7 -4.5
0.0 The regular cloud identified I columns 1,3,4,5. 18 st.in cloud

734 56812.750000 2014 JUN 4 18: 0: 0 UT 11 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
735 56812.751042 2014 JUN 4 18: 1:30 UT 3 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
736 56812.752083 2014 JUN 4 18: 3: 0 UT 2 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
737 56812.753125 2014 JUN 4 18: 4:30 UT 2 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
738 56812.756250 2014 JUN 4 18: 9: 0 UT 3 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
739 56812.757292 2014 JUN 4 18:10:30 UT 2 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
740 56812.758333 2014 JUN 4 18:12: 0 UT 3 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
741 56812.773958 2014 JUN 4 18:34:29 UT 1 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0

2014 JUN 5 0 5 5 5 0
L,L1= 917 938
917 56813.734375 2014 JUN 5 17:37:30 UT 4 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
918 56813.735417 2014 JUN 5 17:39: 0 UT 4 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
919 56813.736458 2014 JUN 5 17:40:29 UT 4 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 8 September 2025 doi:10.20944/preprints202509.0575.v1

920 56813.737500 2014 JUN 5 17:42: 0 UT 3 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
921 56813.738542 2014 JUN 5 17:43:30 UT 4 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
922 56813.739583 2014 JUN 5 17:45: 0 UT 3 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
923 56813.740625 2014 JUN 5 17:46:29 UT 12 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
924 56813.741667 2014 JUN 5 17:48: 0 UT 14 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
925 56813.742708 2014 JUN 5 17:49:29 UT 18 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
926 56813.743750 2014 JUN 5 17:51: 0 UT 19 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
927 56813.744792 2014 JUN 5 17:52:30 UT 21 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
928 56813.745833 2014 JUN 5 17:54: 0 UT 16 16 0 16 0 16 0 -4.5 0.0 -4.5 0.0 -4.5
0.0
929 56813.746875 2014 JUN 5 17:55:29 UT 22 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
930 56813.747917 2014 JUN 5 17:57: 0 UT 27 0 0 0 27 0 0 0.0 0.0 0.0 2.8 0.0 0.0
931 56813.748958 2014 JUN 5 17:58:29 UT 7 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
932 56813.750000 2014 JUN 5 18: 0: 0 UT 7 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
933 56813.751042 2014 JUN 5 18: 1:30 UT 7 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
934 56813.752083 2014 JUN 5 18: 3: 0 UT 6 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
935 56813.753125 2014 JUN 5 18: 4:30 UT 2 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
936 56813.754167 2014 JUN 5 18: 6: 0 UT 2 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
937 56813.755208 2014 JUN 5 18: 7:29 UT 2 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
938 56813.756250 2014 JUN 5 18: 9: 0 UT 1 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0

2014 JUN 6 0 6 6 6 0
L,L1= 1151 1164
1151 56814.733333 2014 JUN 6 17:36: 0 UT 2 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1152 56814.734375 2014 JUN 6 17:37:30 UT 2 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1153 56814.735417 2014 JUN 6 17:39: 0 UT 3 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1154 56814.736458 2014 JUN 6 17:40:29 UT 7 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1155 56814.737500 2014 JUN 6 17:42: 0 UT 7 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1156 56814.738542 2014 JUN 6 17:43:30 UT 12 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1157 56814.739583 2014 JUN 6 17:45: 0 UT 13 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1158 56814.740625 2014 JUN 6 17:46:29 UT 16 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1159 56814.741667 2014 JUN 6 17:48: 0 UT 17 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1160 56814.742708 2014 JUN 6 17:49:29 UT 16 16 0 16 0 16 0 -4.5 0.0 -4.5 0.0 -4.5
0.0
1161 56814.743750 2014 JUN 6 17:51: 0 UT 15 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1162 56814.744792 2014 JUN 6 17:52:30 UT 24 0 0 0 24 0 0 0.0 0.0 0.0 -0.2 0.0
0.0
1163 56814.748958 2014 JUN 6 17:58:29 UT 2 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1164 56814.750000 2014 JUN 6 18: 0: 0 UT 1 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0

2014 JUN 7 0 7 7 7 0
L,L1= 1203 1211
1203 56815.734375 2014 JUN 7 17:37:30 UT 7 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1204 56815.735417 2014 JUN 7 17:39: 0 UT 6 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1205 56815.736458 2014 JUN 7 17:40:29 UT 8 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1206 56815.737500 2014 JUN 7 17:42: 0 UT 10 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1207 56815.738542 2014 JUN 7 17:43:30 UT 17 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1208 56815.739583 2014 JUN 7 17:45: 0 UT 12 12 0 12 0 12 0 -4.5 0.0 -4.5 0.0 -4.5
0.0
1209 56815.740625 2014 JUN 7 17:46:29 UT 19 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0

1210 56815.741667 2014 JUN 7 17:48: 0 UT 26 0 0 0 26 0 0 0.0 0.0 0.0 -0.2 0.0
0.0
1211 56815.742708 2014 JUN 7 17:49:29 UT 1 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0

2014 JUN 8 0 8 8 8 0
L,L1= 1297 1308
1297 56816.729167 2014 JUN 8 17:30: 0 UT 3 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1298 56816.730208 2014 JUN 8 17:31:29 UT 4 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1299 56816.731250 2014 JUN 8 17:33: 0 UT 4 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1300 56816.732292 2014 JUN 8 17:34:30 UT 8 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1301 56816.733333 2014 JUN 8 17:36: 0 UT 7 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1302 56816.734375 2014 JUN 8 17:37:30 UT 13 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1303 56816.735417 2014 JUN 8 17:39: 0 UT 18 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1304 56816.736458 2014 JUN 8 17:40:29 UT 18 18 0 18 0 18 0 -4.5 0.0 -4.5 0.0 -4.5
0.0
1305 56816.737500 2014 JUN 8 17:42: 0 UT 19 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1306 56816.738542 2014 JUN 8 17:43:30 UT 20 0 0 0 20 0 0 0.0 0.0 0.0 -0.2 0.0
0.0
1307 56816.768750 2014 JUN 8 18:27: 0 UT 2 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1308 56816.769792 2014 JUN 8 18:28:30 UT 1 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0

2014 JUN 9 0 9 9 9 0
L,L1= 1382 1418
1382 56817.700000 2014 JUN 9 16:48: 0 UT 2 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1383 56817.701042 2014 JUN 9 16:49:30 UT 3 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1384 56817.702083 2014 JUN 9 16:51: 0 UT 3 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1385 56817.703125 2014 JUN 9 16:52:30 UT 4 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1386 56817.704167 2014 JUN 9 16:54: 0 UT 3 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1387 56817.705208 2014 JUN 9 16:55:29 UT 5 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1388 56817.706250 2014 JUN 9 16:57: 0 UT 5 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1389 56817.707292 2014 JUN 9 16:58:30 UT 9 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1390 56817.708333 2014 JUN 9 17:60: 0 UT 10 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1391 56817.709375 2014 JUN 9 17: 1:29 UT 10 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1392 56817.710417 2014 JUN 9 17: 3: 0 UT 9 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1393 56817.711458 2014 JUN 9 17: 4:29 UT 16 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1394 56817.712500 2014 JUN 9 17: 6: 0 UT 12 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1395 56817.713542 2014 JUN 9 17: 7:30 UT 11 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1396 56817.714583 2014 JUN 9 17: 9: 0 UT 14 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1397 56817.715625 2014 JUN 9 17:10:29 UT 13 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1398 56817.716667 2014 JUN 9 17:12: 0 UT 12 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1399 56817.717708 2014 JUN 9 17:13:29 UT 10 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1400 56817.718750 2014 JUN 9 17:15: 0 UT 15 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1401 56817.719792 2014 JUN 9 17:16:30 UT 9 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1402 56817.720833 2014 JUN 9 17:18: 0 UT 10 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1403 56817.721875 2014 JUN 9 17:19:30 UT 10 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1404 56817.722917 2014 JUN 9 17:21: 0 UT 13 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1405 56817.723958 2014 JUN 9 17:22:29 UT 5 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1406 56817.725000 2014 JUN 9 17:24: 0 UT 3 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1407 56817.726042 2014 JUN 9 17:25:30 UT 6 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1408 56817.727083 2014 JUN 9 17:27: 0 UT 10 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1409 56817.728125 2014 JUN 9 17:28:30 UT 13 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0

1410 56817.729167 2014 JUN 9 17:30: 0 UT 14 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1411 56817.730208 2014 JUN 9 17:31:29 UT 15 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1412 56817.731250 2014 JUN 9 17:33: 0 UT 21 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1413 56817.732292 2014 JUN 9 17:34:30 UT 21 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1414 56817.733333 2014 JUN 9 17:36: 0 UT 23 23 0 23 0 23 0 -4.5 0.0 -4.5 0.0 -4.5
0.0
1415 56817.734375 2014 JUN 9 17:37:30 UT 24 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1416 56817.735417 2014 JUN 9 17:39: 0 UT 27 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1417 56817.736458 2014 JUN 9 17:40:29 UT 29 0 0 0 29 0 0 0.0 0.0 0.0 1.3 0.0
0.0
1418 56817.743750 2014 JUN 9 17:51: 0 UT 1 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0

2014 JUN 10 0 10 10 10 0
L,L1= 1520 1531
1520 56818.723958 2014 JUN 10 17:22:29 UT 3 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1521 56818.725000 2014 JUN 10 17:24: 0 UT 4 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1522 56818.726042 2014 JUN 10 17:25:30 UT 9 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1523 56818.727083 2014 JUN 10 17:27: 0 UT 16 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1524 56818.728125 2014 JUN 10 17:28:30 UT 16 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0
0.0
1525 56818.729167 2014 JUN 10 17:30: 0 UT 15 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1526 56818.730208 2014 JUN 10 17:31:29 UT 18 18 0 18 0 18 0 -4.5 0.0 -4.5 0.0 -4.5
0.0
1527 56818.731250 2014 JUN 10 17:33: 0 UT 18 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1528 56818.732292 2014 JUN 10 17:34:30 UT 20 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0
0.0
1529 56818.733333 2014 JUN 10 17:36: 0 UT 24 0 0 0 24 0 0 0.0 0.0 0.0 -0.2 0.0
0.0
1530 56818.734375 2014 JUN 10 17:37:30 UT 3 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1531 56818.735417 2014 JUN 10 17:39: 0 UT 1 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0

2014 JUN 11 0 11 11 11 0
L,L1= 1578 1588
1578 56819.720833 2014 JUN 11 17:18: 0 UT 3 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1579 56819.721875 2014 JUN 11 17:19:30 UT 4 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1580 56819.722917 2014 JUN 11 17:21: 0 UT 6 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1581 56819.723958 2014 JUN 11 17:22:29 UT 8 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1582 56819.725000 2014 JUN 11 17:24: 0 UT 15 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1583 56819.726042 2014 JUN 11 17:25:30 UT 20 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0
0.0
1584 56819.727083 2014 JUN 11 17:27: 0 UT 19 19 0 19 0 19 0 -4.5 0.0 -4.5 0.0 -4.5
0.0
1585 56819.728125 2014 JUN 11 17:28:30 UT 12 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0
0.0
1586 56819.729167 2014 JUN 11 17:30: 0 UT 16 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
1587 56819.730208 2014 JUN 11 17:31:29 UT 22 0 0 0 22 0 0 0.0 0.0 0.0 -0.2 0.0
0.0
1588 56819.737500 2014 JUN 11 17:42: 0 UT 1 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0

2014 JUN 12 0 12 12 12 0
L,L1= 2049 2062

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 8 September 2025 doi:10.20944/preprints202509.0575.v1

2049 56820.718750 2014 JUN 12 17:15: 0 UT 5 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2050 56820.719792 2014 JUN 12 17:16:30 UT 10 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0
0.0
2051 56820.720833 2014 JUN 12 17:18: 0 UT 9 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2052 56820.721875 2014 JUN 12 17:19:30 UT 12 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0
0.0
2053 56820.722917 2014 JUN 12 17:21: 0 UT 17 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2054 56820.723958 2014 JUN 12 17:22:29 UT 14 14 0 14 0 14 0 -4.5 0.0 -4.5 0.0 -4.5
0.0
2055 56820.725000 2014 JUN 12 17:24: 0 UT 19 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2056 56820.726042 2014 JUN 12 17:25:30 UT 25 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0
0.0
2057 56820.727083 2014 JUN 12 17:27: 0 UT 24 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2058 56820.728125 2014 JUN 12 17:28:30 UT 26 0 0 0 26 0 0 0.0 0.0 0.0 1.3 0.0
0.0
2059 56820.729167 2014 JUN 12 17:30: 0 UT 4 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2060 56820.730208 2014 JUN 12 17:31:29 UT 4 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2061 56820.732292 2014 JUN 12 17:34:30 UT 4 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2062 56820.734375 2014 JUN 12 17:37:30 UT 1 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0

2014 JUN 13 0 13 13 13 0
L,L1= 2196 2216
2196 56821.707292 2014 JUN 13 16:58:30 UT 4 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2197 56821.708333 2014 JUN 13 17:60: 0 UT 4 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2198 56821.709375 2014 JUN 13 17: 1:29 UT 5 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2199 56821.710417 2014 JUN 13 17: 3: 0 UT 2 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2200 56821.711458 2014 JUN 13 17: 4:29 UT 4 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2201 56821.712500 2014 JUN 13 17: 6: 0 UT 4 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2202 56821.713542 2014 JUN 13 17: 7:30 UT 4 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2203 56821.714583 2014 JUN 13 17: 9: 0 UT 5 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2204 56821.715625 2014 JUN 13 17:10:29 UT 10 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0
0.0
2205 56821.716667 2014 JUN 13 17:12: 0 UT 12 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2206 56821.717708 2014 JUN 13 17:13:29 UT 10 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0
0.0
2207 56821.718750 2014 JUN 13 17:15: 0 UT 13 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2208 56821.719792 2014 JUN 13 17:16:30 UT 16 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0
0.0
2209 56821.720833 2014 JUN 13 17:18: 0 UT 20 20 0 20 0 20 0 -4.5 0.0 -4.5 0.0 -4.5
0.0
2210 56821.721875 2014 JUN 13 17:19:30 UT 16 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0
0.0
2211 56821.722917 2014 JUN 13 17:21: 0 UT 17 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2212 56821.723958 2014 JUN 13 17:22:29 UT 25 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0
0.0
2213 56821.725000 2014 JUN 13 17:24: 0 UT 26 0 0 0 26 0 0 0.0 0.0 0.0 -0.2 0.0
0.0
2214 56821.727083 2014 JUN 13 17:27: 0 UT 2 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2215 56821.753125 2014 JUN 13 18: 4:30 UT 2 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2216 56821.754167 2014 JUN 13 18: 6: 0 UT 1 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0

 doi:10.20944/preprints202509.0575.v1

2014 JUN 14 0 14 14 14 0
L,L1= 2390 2423
2390 56822.694792 2014 JUN 14 16:40:30 UT 2 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2391 56822.695833 2014 JUN 14 16:42: 0 UT 3 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2392 56822.696875 2014 JUN 14 16:43:30 UT 3 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2393 56822.697917 2014 JUN 14 16:45: 0 UT 3 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2394 56822.698958 2014 JUN 14 16:46:29 UT 4 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2395 56822.700000 2014 JUN 14 16:48: 0 UT 4 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2396 56822.701042 2014 JUN 14 16:49:30 UT 4 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2397 56822.702083 2014 JUN 14 16:51: 0 UT 4 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2398 56822.703125 2014 JUN 14 16:52:30 UT 4 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2399 56822.704167 2014 JUN 14 16:54: 0 UT 5 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2400 56822.705208 2014 JUN 14 16:55:29 UT 5 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2401 56822.706250 2014 JUN 14 16:57: 0 UT 6 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2402 56822.707292 2014 JUN 14 16:58:30 UT 6 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2403 56822.708333 2014 JUN 14 17:60: 0 UT 7 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2404 56822.709375 2014 JUN 14 17: 1:29 UT 6 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2405 56822.710417 2014 JUN 14 17: 3: 0 UT 8 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2406 56822.711458 2014 JUN 14 17: 4:29 UT 8 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2407 56822.712500 2014 JUN 14 17: 6: 0 UT 8 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2408 56822.713542 2014 JUN 14 17: 7:30 UT 10 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2409 56822.714583 2014 JUN 14 17: 9: 0 UT 11 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2410 56822.715625 2014 JUN 14 17:10:29 UT 11 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0
0.0
2411 56822.716667 2014 JUN 14 17:12: 0 UT 13 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2412 56822.717708 2014 JUN 14 17:13:29 UT 15 15 0 15 0 15 0 -4.5 0.0 -4.5 0.0 -4.5
0.0
2413 56822.718750 2014 JUN 14 17:15: 0 UT 18 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2414 56822.719792 2014 JUN 14 17:16:30 UT 17 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0
0.0
2415 56822.720833 2014 JUN 14 17:18: 0 UT 22 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2416 56822.721875 2014 JUN 14 17:19:30 UT 23 0 0 0 23 0 0 0.0 0.0 0.0 -0.2 0.0
0.0
2417 56822.722917 2014 JUN 14 17:21: 0 UT 5 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2418 56822.723958 2014 JUN 14 17:22:29 UT 4 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2419 56822.725000 2014 JUN 14 17:24: 0 UT 5 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2420 56822.726042 2014 JUN 14 17:25:30 UT 2 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2421 56822.727083 2014 JUN 14 17:27: 0 UT 2 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2422 56822.728125 2014 JUN 14 17:28:30 UT 2 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2423 56822.747917 2014 JUN 14 17:57: 0 UT 1 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0

2014 JUN 15 0 15 15 15 0
L,L1= 2438 2448
2438 56823.709375 2014 JUN 15 17: 1:29 UT 2 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2439 56823.710417 2014 JUN 15 17: 3: 0 UT 12 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2440 56823.711458 2014 JUN 15 17: 4:29 UT 6 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2441 56823.712500 2014 JUN 15 17: 6: 0 UT 4 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2442 56823.713542 2014 JUN 15 17: 7:30 UT 8 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2443 56823.714583 2014 JUN 15 17: 9: 0 UT 12 12 0 12 0 12 0 -4.5 0.0 -4.5 0.0 -4.5
0.0

2444 56823.715625 2014 JUN 15 17:10:29 UT 14 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0
0.0
2445 56823.716667 2014 JUN 15 17:12: 0 UT 8 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2446 56823.717708 2014 JUN 15 17:13:29 UT 11 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0
0.0
2447 56823.718750 2014 JUN 15 17:15: 0 UT 15 0 0 0 15 0 0 0.0 0.0 0.0 -0.2 0.0
0.0
2448 56823.746875 2014 JUN 15 17:55:29 UT 1 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0

2014 JUN 16 0 16 16 16 0
L,L1= 2494 2508
2494 56824.706250 2014 JUN 16 16:57: 0 UT 3 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2495 56824.707292 2014 JUN 16 16:58:30 UT 6 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2496 56824.708333 2014 JUN 16 17:60: 0 UT 9 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2497 56824.709375 2014 JUN 16 17: 1:29 UT 8 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2498 56824.710417 2014 JUN 16 17: 3: 0 UT 9 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2499 56824.711458 2014 JUN 16 17: 4:29 UT 17 17 0 17 0 17 0 -4.5 0.0 -4.5 0.0 -4.5
0.0
2500 56824.712500 2014 JUN 16 17: 6: 0 UT 20 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2501 56824.713542 2014 JUN 16 17: 7:30 UT 21 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2502 56824.714583 2014 JUN 16 17: 9: 0 UT 20 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2503 56824.715625 2014 JUN 16 17:10:29 UT 19 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0
0.0
2504 56824.716667 2014 JUN 16 17:12: 0 UT 22 0 0 0 22 0 0 0.0 0.0 0.0 1.3 0.0
0.0
2505 56824.717708 2014 JUN 16 17:13:29 UT 7 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2506 56824.718750 2014 JUN 16 17:15: 0 UT 5 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2507 56824.719792 2014 JUN 16 17:16:30 UT 5 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2508 56824.721875 2014 JUN 16 17:19:30 UT 1 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0

2014 JUN 17 0 17 0 17 0
L,L1= 2556 2570
2556 56825.703125 2014 JUN 17 16:52:30 UT 3 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2557 56825.704167 2014 JUN 17 16:54: 0 UT 2 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2558 56825.705208 2014 JUN 17 16:55:29 UT 3 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2559 56825.706250 2014 JUN 17 16:57: 0 UT 5 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2560 56825.707292 2014 JUN 17 16:58:30 UT 9 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2561 56825.708333 2014 JUN 17 17:60: 0 UT 11 11 0 11 0 11 0 -4.5 0.0 -4.5 0.0 -4.5
0.0
2562 56825.709375 2014 JUN 17 17: 1:29 UT 15 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2563 56825.710417 2014 JUN 17 17: 3: 0 UT 12 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2564 56825.711458 2014 JUN 17 17: 4:29 UT 15 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2565 56825.712500 2014 JUN 17 17: 6: 0 UT 15 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2566 56825.713542 2014 JUN 17 17: 7:30 UT 18 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2567 56825.714583 2014 JUN 17 17: 9: 0 UT 3 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2568 56825.715625 2014 JUN 17 17:10:29 UT 3 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2569 56825.716667 2014 JUN 17 17:12: 0 UT 2 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2570 56825.717708 2014 JUN 17 17:13:29 UT 1 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0

2014 JUN 18 0 18 0 18 0
L,L1= 2607 2616

2607 56826.704167 2014 JUN 18 16:54: 0 UT 5 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2608 56826.705208 2014 JUN 18 16:55:29 UT 6 6 0 6 0 6 0 -4.5 0.0 -4.5 0.0 -4.5
0.0
2609 56826.706250 2014 JUN 18 16:57: 0 UT 11 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2610 56826.707292 2014 JUN 18 16:58:30 UT 13 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0
0.0
2611 56826.708333 2014 JUN 18 17:60: 0 UT 12 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2612 56826.709375 2014 JUN 18 17: 1:29 UT 18 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2613 56826.710417 2014 JUN 18 17: 3: 0 UT 21 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2614 56826.712500 2014 JUN 18 17: 6: 0 UT 6 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2615 56826.739583 2014 JUN 18 17:45: 0 UT 4 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2616 56826.740625 2014 JUN 18 17:46:29 UT 1 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0

2014 JUN 19 0 19 0 19 0
L,L1= 2741 2752
2741 56827.696875 2014 JUN 19 16:43:30 UT 3 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2742 56827.697917 2014 JUN 19 16:45: 0 UT 2 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2743 56827.698958 2014 JUN 19 16:46:29 UT 3 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2744 56827.700000 2014 JUN 19 16:48: 0 UT 7 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2745 56827.701042 2014 JUN 19 16:49:30 UT 6 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2746 56827.702083 2014 JUN 19 16:51: 0 UT 9 9 0 9 0 9 0 -4.5 0.0 -4.5 0.0 -4.5 0.0
2747 56827.703125 2014 JUN 19 16:52:30 UT 18 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0
0.0
2748 56827.704167 2014 JUN 19 16:54: 0 UT 19 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2749 56827.705208 2014 JUN 19 16:55:29 UT 20 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0
0.0
2750 56827.706250 2014 JUN 19 16:57: 0 UT 21 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2751 56827.707292 2014 JUN 19 16:58:30 UT 16 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0
0.0
2752 56827.708333 2014 JUN 19 17:60: 0 UT 1 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0

2014 JUN 20 0 20 0 20 0
L,L1= 2834 2846
2834 56828.693750 2014 JUN 20 16:39: 0 UT 2 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2835 56828.694792 2014 JUN 20 16:40:30 UT 2 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2836 56828.695833 2014 JUN 20 16:42: 0 UT 2 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2837 56828.696875 2014 JUN 20 16:43:30 UT 7 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2838 56828.697917 2014 JUN 20 16:45: 0 UT 11 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2839 56828.698958 2014 JUN 20 16:46:29 UT 10 10 0 10 0 10 0 -4.5 0.0 -4.5 0.0 -4.5
0.0
2840 56828.700000 2014 JUN 20 16:48: 0 UT 14 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2841 56828.701042 2014 JUN 20 16:49:30 UT 11 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0
0.0
2842 56828.702083 2014 JUN 20 16:51: 0 UT 22 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2843 56828.703125 2014 JUN 20 16:52:30 UT 21 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0
0.0
2844 56828.704167 2014 JUN 20 16:54: 0 UT 23 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2845 56828.705208 2014 JUN 20 16:55:29 UT 22 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0
0.0
2846 56828.710417 2014 JUN 20 17: 3: 0 UT 1 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0

2014 JUN 21 0 21 0 21 0
L,L1= 2895 2905
2895 56829.693750 2014 JUN 21 16:39: 0 UT 7 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2896 56829.694792 2014 JUN 21 16:40:30 UT 4 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2897 56829.695833 2014 JUN 21 16:42: 0 UT 5 5 0 5 0 5 0 -4.5 0.0 -4.5 0.0 -4.5 0.0
2898 56829.696875 2014 JUN 21 16:43:30 UT 11 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2899 56829.697917 2014 JUN 21 16:45: 0 UT 15 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2900 56829.698958 2014 JUN 21 16:46:29 UT 8 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2901 56829.700000 2014 JUN 21 16:48: 0 UT 9 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2902 56829.701042 2014 JUN 21 16:49:30 UT 20 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2903 56829.702083 2014 JUN 21 16:51: 0 UT 29 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2904 56829.703125 2014 JUN 21 16:52:30 UT 4 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2905 56829.704167 2014 JUN 21 16:54: 0 UT 1 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0

2014 JUN 22 0 22 0 22 0
L,L1= 2933 2944
2933 56830.689583 2014 JUN 22 16:33: 0 UT 5 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2934 56830.690625 2014 JUN 22 16:34:30 UT 5 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2935 56830.691667 2014 JUN 22 16:36: 0 UT 4 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2936 56830.692708 2014 JUN 22 16:37:29 UT 3 3 0 3 0 3 0 -4.5 0.0 -4.5 0.0 -4.5 0.0
2937 56830.693750 2014 JUN 22 16:39: 0 UT 10 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2938 56830.694792 2014 JUN 22 16:40:30 UT 13 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2939 56830.695833 2014 JUN 22 16:42: 0 UT 14 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2940 56830.696875 2014 JUN 22 16:43:30 UT 12 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2941 56830.697917 2014 JUN 22 16:45: 0 UT 23 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2942 56830.698958 2014 JUN 22 16:46:29 UT 16 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2943 56830.721875 2014 JUN 22 17:19:30 UT 2 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2944 56830.722917 2014 JUN 22 17:21: 0 UT 1 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0

2014 JUN 23 0 23 0 23 0
L,L1= 2997 3010
2997 56831.685417 2014 JUN 23 16:27: 0 UT 6 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2998 56831.686458 2014 JUN 23 16:28:29 UT 7 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
2999 56831.687500 2014 JUN 23 16:30: 0 UT 8 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3000 56831.688542 2014 JUN 23 16:31:30 UT 11 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3001 56831.689583 2014 JUN 23 16:33: 0 UT 10 10 0 10 0 10 0 -4.5 0.0 -4.5 0.0 -4.5 0.0
3002 56831.690625 2014 JUN 23 16:34:30 UT 12 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3003 56831.691667 2014 JUN 23 16:36: 0 UT 12 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3004 56831.692708 2014 JUN 23 16:37:29 UT 18 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3005 56831.693750 2014 JUN 23 16:39: 0 UT 18 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 8 September 2025 doi:10.20944/preprints202509.0575.v1

3006 56831.694792 2014 JUN 23 16:40:30 UT 23 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0
0.0
3007 56831.695833 2014 JUN 23 16:42: 0 UT 26 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3008 56831.696875 2014 JUN 23 16:43:30 UT 19 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0
0.0
3009 56831.700000 2014 JUN 23 16:48: 0 UT 2 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3010 56831.712500 2014 JUN 23 17: 6: 0 UT 1 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0

2014 JUN 24 0 24 0 24 0
L,L1= 3061 3084
3061 56832.678125 2014 JUN 24 16:16:29 UT 2 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3062 56832.679167 2014 JUN 24 16:18: 0 UT 3 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3063 56832.680208 2014 JUN 24 16:19:29 UT 2 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3064 56832.681250 2014 JUN 24 16:21: 0 UT 2 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3065 56832.682292 2014 JUN 24 16:22:30 UT 2 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3066 56832.683333 2014 JUN 24 16:24: 0 UT 5 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3067 56832.684375 2014 JUN 24 16:25:29 UT 6 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3068 56832.685417 2014 JUN 24 16:27: 0 UT 5 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3069 56832.686458 2014 JUN 24 16:28:29 UT 9 9 0 9 0 9 0 -4.5 0.0 -4.5 0.0 -4.5
0.0
3070 56832.687500 2014 JUN 24 16:30: 0 UT 7 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3071 56832.688542 2014 JUN 24 16:31:30 UT 12 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0
0.0
3072 56832.689583 2014 JUN 24 16:33: 0 UT 17 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3073 56832.690625 2014 JUN 24 16:34:30 UT 19 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0
0.0
3074 56832.691667 2014 JUN 24 16:36: 0 UT 14 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3075 56832.692708 2014 JUN 24 16:37:29 UT 16 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0
0.0
3076 56832.693750 2014 JUN 24 16:39: 0 UT 28 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3077 56832.694792 2014 JUN 24 16:40:30 UT 2 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3078 56832.695833 2014 JUN 24 16:42: 0 UT 2 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3079 56832.696875 2014 JUN 24 16:43:30 UT 5 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3080 56832.697917 2014 JUN 24 16:45: 0 UT 2 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3081 56832.698958 2014 JUN 24 16:46:29 UT 4 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3082 56832.700000 2014 JUN 24 16:48: 0 UT 3 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3083 56832.712500 2014 JUN 24 17: 6: 0 UT 2 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3084 56832.740625 2014 JUN 24 17:46:29 UT 1 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0

2014 JUN 25 0 25 0 25 0
L,L1= 3123 3134
3123 56833.681250 2014 JUN 25 16:21: 0 UT 5 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3124 56833.682292 2014 JUN 25 16:22:30 UT 7 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3125 56833.683333 2014 JUN 25 16:24: 0 UT 4 4 0 4 0 4 0 -4.5 0.0 -4.5 0.0 -4.5 0.0
3126 56833.684375 2014 JUN 25 16:25:29 UT 7 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3127 56833.685417 2014 JUN 25 16:27: 0 UT 11 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3128 56833.686458 2014 JUN 25 16:28:29 UT 13 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0
0.0
3129 56833.687500 2014 JUN 25 16:30: 0 UT 14 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3130 56833.688542 2014 JUN 25 16:31:30 UT 13 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0
0.0

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 8 September 2025 doi:10.20944/preprints202509.0575.v1

3131 56833.689583 2014 JUN 25 16:33: 0 UT 10 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3132 56833.690625 2014 JUN 25 16:34:30 UT 28 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0
0.0
3133 56833.691667 2014 JUN 25 16:36: 0 UT 5 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3134 56833.692708 2014 JUN 25 16:37:29 UT 1 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0

2014 JUN 26 0 26 0 26 0
L,L1= 3194 3210
3194 56834.671875 2014 JUN 26 16: 7:30 UT 3 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3195 56834.672917 2014 JUN 26 16: 9: 0 UT 3 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3196 56834.673958 2014 JUN 26 16:10:29 UT 2 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3197 56834.675000 2014 JUN 26 16:12: 0 UT 3 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3198 56834.676042 2014 JUN 26 16:13:30 UT 2 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3199 56834.677083 2014 JUN 26 16:15: 0 UT 2 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3200 56834.678125 2014 JUN 26 16:16:29 UT 4 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3201 56834.679167 2014 JUN 26 16:18: 0 UT 5 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3202 56834.680208 2014 JUN 26 16:19:29 UT 12 12 0 12 0 12 0 -4.5 0.0 -4.5 0.0 -4.5
0.0
3203 56834.681250 2014 JUN 26 16:21: 0 UT 10 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3204 56834.682292 2014 JUN 26 16:22:30 UT 19 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0
0.0
3205 56834.683333 2014 JUN 26 16:24: 0 UT 14 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3206 56834.684375 2014 JUN 26 16:25:29 UT 18 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0
0.0
3207 56834.685417 2014 JUN 26 16:27: 0 UT 23 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3208 56834.686458 2014 JUN 26 16:28:29 UT 20 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0
0.0
3209 56834.687500 2014 JUN 26 16:30: 0 UT 16 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3210 56834.688542 2014 JUN 26 16:31:30 UT 1 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0

2014 JUN 27 0 27 0 27 0
L,L1= 3236 3255
3236 56835.668750 2014 JUN 27 16: 3: 0 UT 2 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3237 56835.669792 2014 JUN 27 16: 4:30 UT 6 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3238 56835.670833 2014 JUN 27 16: 6: 0 UT 3 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3239 56835.671875 2014 JUN 27 16: 7:30 UT 3 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3240 56835.672917 2014 JUN 27 16: 9: 0 UT 2 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3241 56835.673958 2014 JUN 27 16:10:29 UT 4 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3242 56835.675000 2014 JUN 27 16:12: 0 UT 4 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3243 56835.676042 2014 JUN 27 16:13:30 UT 6 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3244 56835.677083 2014 JUN 27 16:15: 0 UT 6 6 0 6 0 6 0 -4.5 0.0 -4.5 0.0 -4.5 0.0
3245 56835.678125 2014 JUN 27 16:16:29 UT 12 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0
0.0
3246 56835.679167 2014 JUN 27 16:18: 0 UT 10 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3247 56835.680208 2014 JUN 27 16:19:29 UT 16 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0
0.0
3248 56835.681250 2014 JUN 27 16:21: 0 UT 14 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3249 56835.682292 2014 JUN 27 16:22:30 UT 18 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0
0.0
3250 56835.683333 2014 JUN 27 16:24: 0 UT 14 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 8 September 2025 doi:10.20944/preprints202509.0575.v1

3251 56835.684375 2014 JUN 27 16:25:29 UT 18 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0
0.0
3252 56835.685417 2014 JUN 27 16:27: 0 UT 21 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3253 56835.686458 2014 JUN 27 16:28:29 UT 3 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3254 56835.687500 2014 JUN 27 16:30: 0 UT 3 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3255 56835.877083 2014 JUN 27 21: 3: 0 UT 1 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0

2014 JUN 28 0 28 0 28 0
L,L1= 3278 3289
3278 56836.671875 2014 JUN 28 16: 7:30 UT 4 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3279 56836.672917 2014 JUN 28 16: 9: 0 UT 5 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3280 56836.673958 2014 JUN 28 16:10:29 UT 4 4 0 4 0 4 0 -4.5 0.0 -4.5 0.0 -4.5
0.0
3281 56836.675000 2014 JUN 28 16:12: 0 UT 5 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3282 56836.676042 2014 JUN 28 16:13:30 UT 7 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3283 56836.677083 2014 JUN 28 16:15: 0 UT 6 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3284 56836.678125 2014 JUN 28 16:16:29 UT 13 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0
0.0
3285 56836.679167 2014 JUN 28 16:18: 0 UT 11 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3286 56836.680208 2014 JUN 28 16:19:29 UT 7 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3287 56836.681250 2014 JUN 28 16:21: 0 UT 10 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3288 56836.682292 2014 JUN 28 16:22:30 UT 12 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0
0.0
3289 56836.687500 2014 JUN 28 16:30: 0 UT 1 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0

2014 JUN 29 0 29 0 29 0
L,L1= 3313 3325
3313 56837.668750 2014 JUN 29 16: 3: 0 UT 5 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3314 56837.669792 2014 JUN 29 16: 4:30 UT 5 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3315 56837.670833 2014 JUN 29 16: 6: 0 UT 10 10 0 10 0 10 0 -4.5 0.0 -4.5 0.0 -4.5
0.0
3316 56837.671875 2014 JUN 29 16: 7:30 UT 8 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3317 56837.672917 2014 JUN 29 16: 9: 0 UT 12 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3318 56837.673958 2014 JUN 29 16:10:29 UT 12 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0
0.0
3319 56837.675000 2014 JUN 29 16:12: 0 UT 16 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3320 56837.676042 2014 JUN 29 16:13:30 UT 17 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0
0.0
3321 56837.677083 2014 JUN 29 16:15: 0 UT 12 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3322 56837.678125 2014 JUN 29 16:16:29 UT 18 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0
0.0
3323 56837.679167 2014 JUN 29 16:18: 0 UT 18 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3324 56837.680208 2014 JUN 29 16:19:29 UT 4 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0
3325 56837.681250 2014 JUN 29 16:21: 0 UT 1 0 0 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0

Appendix B

Table A2. Daily regular ionospheric scincilation events (peak cloud denoted by @).(Cl – number of clouds in wave; P – number of stations in peak cloud).

#	MJD	Date	Time	Cl	P	0h 6h 12h 18h 24h
604	54252.787500	2007 JUN 1	18:54: 0 UT	9	8	. . . . @ .
605	54253.786458	2007 JUN 2	18:52:29 UT	12	10	. . . . @ .
606	54254.782292	2007 JUN 3	18:46:30 UT	9	7	. . . . @ .
607	54255.780208	2007 JUN 4	18:43:29 UT	11	9	. . . . @ .
608	54256.773958	2007 JUN 5	18:34:29 UT	11	9	. . . .@ .
609	54257.773958	2007 JUN 6	18:34:29 UT	10	7	. . . .@ .
610	54258.771875	2007 JUN 7	18:31:29 UT	6	8	. . . .@ .
611	54259.767708	2007 JUN 8	18:25:29 UT	12	9	. . . .@ .
612	54260.765625	2007 JUN 9	18:22:30 UT	11	8	. . . .@ .
613	54261.763542	2007 JUN 10	18:19:30 UT	10	8	. . . @ .
614	54262.760417	2007 JUN 11	18:15: 0 UT	8	8	. . . @ .
615	54263.756250	2007 JUN 12	18: 9: 0 UT	12	6	. . . @ .
616	54264.753125	2007 JUN 13	18: 4:30 UT	9	9	. . . @ .
617	54265.751042	2007 JUN 14	18: 1:30 UT	10	10	. . . @ .
618	54266.747917	2007 JUN 15	17:57: 0 UT	11	10	. . . @. .
619	54267.744792	2007 JUN 16	17:52:30 UT	11	8	. . . @. .
620	54268.741667	2007 JUN 17	17:48: 0 UT	10	8	. . . @. .
621	54269.739583	2007 JUN 18	17:45: 0 UT	7	6	. . . @. .
622	54270.736458	2007 JUN 19	17:40:29 UT	6	6	. . . @. .
623	54271.736458	2007 JUN 20	17:40:29 UT	12	8	. . . @. .
624	54272.731250	2007 JUN 21	17:33: 0 UT	5	7	. . . @ . .
625	54273.730208	2007 JUN 22	17:31:29 UT	7	6	. . . @ . .
626	54274.725000	2007 JUN 23	17:24: 0 UT	5	4	. . . @ . .
627	54275.721875	2007 JUN 24	17:19:30 UT	5	7	. . . @ . .
628	54276.719792	2007 JUN 25	17:16:30 UT	9	8	. . . @ . .
629	54277.717708	2007 JUN 26	17:13:29 UT	11	8	. . . @ . .
630	54278.713542	2007 JUN 27	17: 7:30 UT	6	7	. . . @ . .
631	54279.712500	2007 JUN 28	17: 6: 0 UT	11	10	. . . @ . .
632	54280.709375	2007 JUN 29	17: 1:29 UT	6	7	. . . @ . .
633	54314.000000	2007 AUG 2	0: 0: 0 UT	12	8	@ . . . .
634	54314.994792	2007 AUG 2	23:52:30 UT	12	8	. . . . @.
635	54315.991667	2007 AUG 3	23:48: 0 UT	7	6	. . . . @.
636	54316.987500	2007 AUG 4	23:42: 0 UT	7	15	. . . . @.
637	54317.990625	2007 AUG 5	23:46:29 UT	11	7	. . . . @.
638	54318.984375	2007 AUG 6	23:37:30 UT	8	7	. . . . @ .
639	54319.982292	2007 AUG 7	23:34:30 UT	6	6	. . . . @ .
640	54320.978125	2007 AUG 8	23:28:30 UT	10	7	. . . . @ .
641	54321.973958	2007 AUG 9	23:22:29 UT	11	5	. . . . @ .
642	54322.971875	2007 AUG 10	23:19:30 UT	13	6	. . . . @ .
643	54323.972917	2007 AUG 11	23:21: 0 UT	15	6	. . . . @ .
644	54324.965625	2007 AUG 12	23:10:29 UT	10	6	. . . . @ .
645	54325.966667	2007 AUG 13	23:12: 0 UT	12	5	. . . . @ .
646	54326.960417	2007 AUG 14	23: 3: 0 UT	6	14	. . . . @ .

647 54327.962500 2007 AUG 15 23: 6: 0 UT 6 6 . . . . @ .
648 54328.957292 2007 AUG 16 22:58:30 UT 9 7 . . . . @ .
649 54329.951042 2007 AUG 17 22:49:30 UT 8 12 . . . . @ .
650 54330.954167 2007 AUG 18 22:54: 0 UT 10 5 . . . . @ .
651 54332.944792 2007 AUG 20 22:40:30 UT 7 5 . . . . @ .
652 54333.943750 2007 AUG 21 22:39: 0 UT 20 9 . . . . @ .
653 54334.937500 2007 AUG 22 22:30: 0 UT 15 16 . . . . @ .
654 54336.931250 2007 AUG 24 22:21: 0 UT 11 7 . . . . @ .
655 54337.928125 2007 AUG 25 22:16:29 UT 8 18 . . . . @ .
656 54338.929167 2007 AUG 26 22:18: 0 UT 9 4 . . . . @ .
657 54339.922917 2007 AUG 27 22: 9: 0 UT 11 12 . . . . @ .
658 54340.919792 2007 AUG 28 22: 4:30 UT 5 9 . . . . @ .
659 54341.920833 2007 AUG 29 22: 6: 0 UT 8 8 . . . . @ .
660 54342.917708 2007 AUG 30 22: 1:29 UT 11 6 . . . . @ .

661 54619.630208 2008 JUN 2 15: 7:29 UT 9 22 . . . @ . .
662 54620.627083 2008 JUN 3 15: 3: 0 UT 9 20 . . . @ . .
663 54621.625000 2008 JUN 4 15: 0: 0 UT 9 25 . . . @ . .
664 54622.621875 2008 JUN 5 14:55:29 UT 8 24 . . . @ . .
665 54623.618750 2008 JUN 6 14:51: 0 UT 8 23 . . . @ . .
666 54624.616667 2008 JUN 7 14:48: 0 UT 9 20 . . . @ . .
667 54625.613542 2008 JUN 8 14:43:30 UT 8 22 . . . @ . .
668 54626.610417 2008 JUN 9 14:39: 0 UT 9 25 . . . @ . .
669 54627.607292 2008 JUN 10 14:34:30 UT 11 23 . . . @ . .
670 54628.605208 2008 JUN 11 14:31:29 UT 10 23 . . . @ . .
671 54629.602083 2008 JUN 12 14:27: 0 UT 14 25 . . . @ . .
672 54630.598958 2008 JUN 13 14:22:29 UT 8 20 . . . @ . .
673 54631.595833 2008 JUN 14 14:18: 0 UT 10 22 . . . @ . .
674 54632.593750 2008 JUN 15 14:15: 0 UT 10 22 . . . @ . .
675 54633.590625 2008 JUN 16 14:10:29 UT 9 21 . . . @ . .
676 54634.587500 2008 JUN 17 14: 6: 0 UT 9 23 . . . @ . .
677 54635.585417 2008 JUN 18 14: 3: 0 UT 11 23 . . . @ . .
678 54636.581250 2008 JUN 19 13:57: 0 UT 8 21 . . . @ . .
679 54637.579167 2008 JUN 20 13:54: 0 UT 10 23 . . . @ . .
680 54638.577083 2008 JUN 21 13:51: 0 UT 13 23 . . . @ . .
681 54639.572917 2008 JUN 22 13:45: 0 UT 15 20 . . . @ . .
682 54640.570833 2008 JUN 23 13:42: 0 UT 29 24 . . . @ . .
683 54641.566667 2008 JUN 24 13:36: 0 UT 7 21 . . . @ . .
684 54642.565625 2008 JUN 25 13:34:30 UT 8 21 . . . @ . .
685 54643.562500 2008 JUN 26 13:30: 0 UT 20 24 . . . @ . .
686 54644.559375 2008 JUN 27 13:25:29 UT 10 23 . . . @ . .
687 54645.556250 2008 JUN 28 13:21: 0 UT 11 23 . . . @ . .
688 54646.554167 2008 JUN 29 13:18: 0 UT 10 25 . . .@ . .
689 54647.550000 2008 JUN 30 13:12: 0 UT 13 22 . . .@ . .

690 55806.244792 2011 SEP 2 5:52:30 UT 7 9 . @. . . .
691 55807.242708 2011 SEP 3 5:49:29 UT 8 6 . @. . . .

 doi:10.20944/preprints202509.0575.v1

692 55808.239583 2011 SEP 4 5:45: 0 UT 8 7 . @. . . .
693 55809.236458 2011 SEP 5 5:40:29 UT 7 6 . @. . . .
694 55810.236458 2011 SEP 6 5:40:29 UT 8 6 . @. . . .
695 55811.231250 2011 SEP 7 5:33: 0 UT 7 5 . @ . . . .
696 55812.227083 2011 SEP 8 5:27: 0 UT 7 8 . @ . . . .
697 55813.225000 2011 SEP 9 5:24: 0 UT 4 7 . @ . . . .
698 55814.222917 2011 SEP 10 5:21: 0 UT 5 6 . @ . . . .
699 55815.218750 2011 SEP 11 5:15: 0 UT 6 5 . @ . . . .
700 55816.216667 2011 SEP 12 5:12: 0 UT 6 8 . @ . . . .
701 55817.215625 2011 SEP 13 5:10:29 UT 9 9 . @ . . . .
702 55818.210417 2011 SEP 14 5: 3: 0 UT 8 7 . @ . . . .
703 55819.208333 2011 SEP 15 5:60: 0 UT 4 6 . @ . . . .
704 55820.206250 2011 SEP 16 4:57: 0 UT 6 4 . @ . . . .
705 55821.203125 2011 SEP 17 4:52:30 UT 7 6 . @ . . . .
706 55822.200000 2011 SEP 18 4:48: 0 UT 6 7 . @ . . . .
707 55823.196875 2011 SEP 19 4:43:29 UT 8 8 . @ . . . .
708 55824.194792 2011 SEP 20 4:40:30 UT 7 6 . @ . . . .
709 55825.192708 2011 SEP 21 4:37:29 UT 4 5 . @ . . . .
710 55826.189583 2011 SEP 22 4:33: 0 UT 6 5 . @ . . . .
711 55827.186458 2011 SEP 23 4:28:29 UT 6 7 . @ . . . .
712 55828.182292 2011 SEP 24 4:22:30 UT 15 5 . @ . . . .
713 55829.181250 2011 SEP 25 4:21: 0 UT 8 6 . @ . . . .
714 55830.177083 2011 SEP 26 4:15: 0 UT 5 5 . @ . . . .
715 55831.175000 2011 SEP 27 4:12: 0 UT 6 6 . @ . . . .
716 55832.172917 2011 SEP 28 4: 9: 0 UT 8 5 . @ . . . .
717 55833.170833 2011 SEP 29 4: 6: 0 UT 9 6 . @ . . . .
718 55834.167708 2011 SEP 30 4: 1:29 UT 8 8 . @ . . . .

719 55866.077083 2011 NOV 1 1:51: 0 UT 6 5 . @ . . . .
720 55867.073958 2011 NOV 2 1:46:29 UT 3 4 . @ . . . .
721 55868.071875 2011 NOV 3 1:43:29 UT 5 4 . @ . . . .
722 55869.068750 2011 NOV 4 1:39: 0 UT 3 6 . @ . . . .
723 55871.063542 2011 NOV 6 1:31:30 UT 3 2 . @ . . . .
724 55872.060417 2011 NOV 7 1:27: 0 UT 4 5 . @ . . . .
725 55873.057292 2011 NOV 8 1:22:30 UT 4 3 . @ . . . .
726 55875.052083 2011 NOV 10 1:15: 0 UT 3 2 . @ . . . .
727 55876.047917 2011 NOV 11 1: 9: 0 UT 4 2 . @ . . . .
728 55877.045833 2011 NOV 12 1: 6: 0 UT 4 3 . @ . . . .
729 55877.477083 2011 NOV 12 11:27: 0 UT 10 3 . . @ . . .
730 55879.040625 2011 NOV 14 0:58:29 UT 4 4 .@ . . . .
731 55880.037500 2011 NOV 15 0:54: 0 UT 4 3 .@ . . . .
732 55882.032292 2011 NOV 17 0:46:30 UT 3 2 .@ . . . .
733 55883.029167 2011 NOV 18 0:42: 0 UT 4 3 .@ . . . .
734 55884.022917 2011 NOV 19 0:33: 0 UT 6 4 @ . . . .
735 55885.023958 2011 NOV 20 0:34:29 UT 3 3 @ . . . .
736 55887.019792 2011 NOV 22 0:28:30 UT 3 3 @ . . . .
737 55888.015625 2011 NOV 23 0:22:30 UT 3 3 @ . . . .
738 55889.012500 2011 NOV 24 0:18: 0 UT 5 3 @ . . . .
739 55890.011458 2011 NOV 25 0:16:29 UT 5 5 @ . . . .

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 8 September 2025 doi:10.20944/preprints202509.0575.v1

740 55891.007292 2011 NOV 26 0:10:30 UT 10 6 @ . . . .
741 55892.000000 2011 NOV 27 0: 0: 0 UT 8 11 @ . . . .
742 55893.997917 2011 NOV 28 23:57: 0 UT 3 2 . . . . @.
743 55894.995833 2011 NOV 29 23:54: 0 UT 7 4 . . . . @.

---

744 56568.443750 2013 OCT 3 10:39: 0 UT 3 4 . . @ . . .
745 56572.422917 2013 OCT 7 10: 9: 0 UT 18 9 . . @ . . .
746 56573.419792 2013 OCT 8 10: 4:30 UT 4 3 . . @ . . .
747 56574.417708 2013 OCT 9 10: 1:29 UT 3 4 . . @ . . .
748 56575.416667 2013 OCT 10 10: 0: 0 UT 5 6 . . @ . . .
749 56576.410417 2013 OCT 11 9:51: 0 UT 7 3 . . @ . . .
750 56577.375000 2013 OCT 12 9: 0: 0 UT 3 3 . . @ . . .
751 56579.405208 2013 OCT 14 9:43:29 UT 4 4 . . @ . . .
752 56583.391667 2013 OCT 18 9:24: 0 UT 4 5 . . @ . . .
753 56584.390625 2013 OCT 19 9:22:30 UT 3 3 . . @ . . .
754 56585.386458 2013 OCT 20 9:16:29 UT 5 5 . . @ . . .
755 56586.380208 2013 OCT 21 9: 7:29 UT 5 3 . . @ . . .
756 56587.380208 2013 OCT 22 9: 7:29 UT 3 3 . . @ . . .
757 56588.376042 2013 OCT 23 9: 1:30 UT 6 2 . . @ . . .
758 56589.377083 2013 OCT 24 9: 3: 0 UT 6 5 . . @ . . .
759 56590.371875 2013 OCT 25 8:55:29 UT 4 5 . . @ . . .
760 56591.368750 2013 OCT 26 8:51: 0 UT 4 6 . . @ . . .
761 56592.365625 2013 OCT 27 8:46:30 UT 3 3 . . @ . . .
762 56593.363542 2013 OCT 28 8:43:30 UT 3 3 . . @ . . .
763 56594.366667 2013 OCT 29 8:48: 0 UT 6 3 . . @ . . .
764 56595.357292 2013 OCT 30 8:34:30 UT 3 3 . . @ . . .

---

765 56597.392708 2013 NOV 1 9:25:29 UT 10 24 . . @ . . .
766 56598.389583 2013 NOV 2 9:21: 0 UT 9 22 . . @ . . .
767 56600.343750 2013 NOV 4 8:15: 0 UT 4 4 . . @ . . .
768 56601.340625 2013 NOV 5 8:10:29 UT 10 6 . . @ . . .
769 56602.338542 2013 NOV 6 8: 7:30 UT 4 5 . . @ . . .
770 56603.335417 2013 NOV 7 8: 3: 0 UT 3 5 . . @ . . .
771 56604.332292 2013 NOV 8 7:58:30 UT 6 9 . . @ . . .
772 56605.330208 2013 NOV 9 7:55:29 UT 7 5 . . @ . . .
773 56606.327083 2013 NOV 10 7:51: 0 UT 3 3 . . @ . . .
774 56608.320833 2013 NOV 12 7:42: 0 UT 5 3 . . @ . . .
775 56610.314583 2013 NOV 14 7:33: 0 UT 3 3 . . @ . . .
776 56612.309375 2013 NOV 16 7:25:29 UT 3 3 . . @ . . .
777 56613.307292 2013 NOV 17 7:22:30 UT 3 5 . . @ . . .
778 56614.304167 2013 NOV 18 7:18: 0 UT 3 5 . .@ . . .
779 56615.301042 2013 NOV 19 7:13:30 UT 5 4 . .@ . . .
780 56616.297917 2013 NOV 20 7: 9: 0 UT 5 5 . .@ . . .
781 56617.294792 2013 NOV 21 7: 4:30 UT 4 4 . .@ . . .
782 56618.292708 2013 NOV 22 7: 1:29 UT 3 5 . .@ . . .
783 56619.290625 2013 NOV 23 6:58:29 UT 7 5 . .@ . . .
784 56620.286458 2013 NOV 24 6:52:29 UT 3 5 . .@ . . .

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 8 September 2025 doi:10.20944/preprints202509.0575.v1

785 56621.283333 2013 NOV 25 6:48: 0 UT 4 3 . . @ . . .
786 56622.281250 2013 NOV 26 6:45: 0 UT 3 4 . . @ . . .
787 56623.278125 2013 NOV 27 6:40:29 UT 6 5 . . @ . . .
788 56624.276042 2013 NOV 28 6:37:30 UT 4 6 . .@ . . .
789 56625.273958 2013 NOV 29 6:34:29 UT 5 3 . .@ . . .

---

790 56629.261458 2013 DEC 3 6:16:29 UT 4 4 . @ . . .
791 56630.259375 2013 DEC 4 6:13:29 UT 3 5 . @ . . .
792 56631.255208 2013 DEC 5 6: 7:29 UT 4 8 . @ . . .
793 56632.253125 2013 DEC 6 6: 4:30 UT 9 7 . @ . . .
794 56633.250000 2013 DEC 7 6: 0: 0 UT 5 9 . @ . . .
795 56634.246875 2013 DEC 8 5:55:29 UT 4 6 . @. . . .
796 56635.244792 2013 DEC 9 5:52:30 UT 3 4 . @. . . .
797 56636.241667 2013 DEC 10 5:48: 0 UT 3 2 . @. . . .
798 56637.238542 2013 DEC 11 5:43:30 UT 3 5 . @. . . .
799 56638.236458 2013 DEC 12 5:40:29 UT 4 4 . @. . . .
800 56639.233333 2013 DEC 13 5:36: 0 UT 3 3 . @ . . . .
801 56641.227083 2013 DEC 15 5:27: 0 UT 5 7 . @ . . . .
802 56642.223958 2013 DEC 16 5:22:29 UT 3 2 . @ . . . .
803 56644.218750 2013 DEC 18 5:15: 0 UT 3 2 . @ . . . .
804 56645.216667 2013 DEC 19 5:12: 0 UT 4 5 . @ . . . .
805 56646.213542 2013 DEC 20 5: 7:30 UT 3 6 . @ . . . .
806 56647.210417 2013 DEC 21 5: 3: 0 UT 3 6 . @ . . . .
807 56648.208333 2013 DEC 22 5:60: 0 UT 3 4 . @ . . . .
808 56649.205208 2013 DEC 23 4:55:29 UT 3 5 . @ . . . .

---

809 56809.758333 2014 JUN 1 18:12: 0 UT 9 23 . . . @ .
810 56810.755208 2014 JUN 2 18: 7:29 UT 14 26 . . . @ .
811 56811.753125 2014 JUN 3 18: 4:30 UT 13 22 . . . @ .
812 56812.748958 2014 JUN 4 17:58:29 UT 17 18 . . . @. .
813 56813.747917 2014 JUN 5 17:57: 0 UT 22 27 . . . @. .
814 56814.744792 2014 JUN 6 17:52:30 UT 14 24 . . . @. .
815 56815.741667 2014 JUN 7 17:48: 0 UT 9 26 . . . @. .
816 56816.738542 2014 JUN 8 17:43:30 UT 12 20 . . . @. .
817 56817.736458 2014 JUN 9 17:40:29 UT 37 29 . . . @. .
818 56818.733333 2014 JUN 10 17:36: 0 UT 12 24 . . . @ . .
819 56819.730208 2014 JUN 11 17:31:29 UT 11 22 . . . @ . .
820 56820.728125 2014 JUN 12 17:28:30 UT 14 26 . . . @ . .
821 56821.725000 2014 JUN 13 17:24: 0 UT 21 26 . . . @ . .
822 56822.721875 2014 JUN 14 17:19:30 UT 34 23 . . . @ . .
823 56823.718750 2014 JUN 15 17:15: 0 UT 11 15 . . . @ . .
824 56824.716667 2014 JUN 16 17:12: 0 UT 15 22 . . . @ . .
825 56825.713542 2014 JUN 17 17: 7:30 UT 15 18 . . . @ . .
826 56826.710417 2014 JUN 18 17: 3: 0 UT 10 21 . . . @ . .
827 56827.706250 2014 JUN 19 16:57: 0 UT 12 21 . . . @ . .
828 56828.704167 2014 JUN 20 16:54: 0 UT 13 23 . . . @ . .
829 56829.702083 2014 JUN 21 16:51: 0 UT 11 29 . . . @ . .

830 56830.697917 2014 JUN 22 16:45: 0 UT 12 23 . . . @ . .
831 56831.695833 2014 JUN 23 16:42: 0 UT 14 26 . . . @ . .
832 56832.693750 2014 JUN 24 16:39: 0 UT 24 28 . . . @ . .
833 56833.690625 2014 JUN 25 16:34:30 UT 12 28 . . . @ . .
834 56834.685417 2014 JUN 26 16:27: 0 UT 17 23 . . . @ . .
835 56835.685417 2014 JUN 27 16:27: 0 UT 20 21 . . . @ . .
836 56836.678125 2014 JUN 28 16:16:29 UT 12 13 . . . @ . .
837 56837.678125 2014 JUN 29 16:16:29 UT 13 18 . . . @ . .

---

838 56931.409375 2014 OCT 1 9:49:30 UT 12 17 . . @ . . .
839 56932.405208 2014 OCT 2 9:43:29 UT 12 19 . . @ . . .
840 56933.403125 2014 OCT 3 9:40:29 UT 13 14 . . @ . . .
841 56934.400000 2014 OCT 4 9:36: 0 UT 7 13 . . @ . . .
842 56935.398958 2014 OCT 5 9:34:29 UT 13 15 . . @ . . .
843 56936.396875 2014 OCT 6 9:31:30 UT 12 15 . . @ . . .
844 56937.392708 2014 OCT 7 9:25:29 UT 13 16 . . @ . . .
845 56938.388542 2014 OCT 8 9:19:30 UT 13 16 . . @ . . .
846 56939.386458 2014 OCT 9 9:16:29 UT 13 17 . . @ . . .
847 56940.384375 2014 OCT 10 9:13:29 UT 8 16 . . @ . . .
848 56941.380208 2014 OCT 11 9: 7:29 UT 12 18 . . @ . . .
849 56942.376042 2014 OCT 12 9: 1:30 UT 12 11 . . @ . . .
850 56943.376042 2014 OCT 13 9: 1:30 UT 11 16 . . @ . . .
851 56944.373958 2014 OCT 14 8:58:29 UT 13 15 . . @ . . .
852 56945.369792 2014 OCT 15 8:52:30 UT 43 9 . . @ . . .
853 56946.367708 2014 OCT 16 8:49:29 UT 11 9 . . @ . . .
854 56947.361458 2014 OCT 17 8:40:29 UT 11 9 . . @ . . .
855 56948.358333 2014 OCT 18 8:36: 0 UT 10 6 . . @ . . .
856 56949.354167 2014 OCT 19 8:30: 0 UT 11 7 . . @ . . .
857 56950.348958 2014 OCT 20 8:22:29 UT 14 8 . . @ . . .
858 56951.346875 2014 OCT 21 8:19:30 UT 12 6 . . @ . . .
859 56952.348958 2014 OCT 22 8:22:29 UT 17 11 . . @ . . .
860 56953.345833 2014 OCT 23 8:18: 0 UT 15 10 . . @ . . .
861 56954.342708 2014 OCT 24 8:13:29 UT 10 6 . . @ . . .
862 56955.341667 2014 OCT 25 8:12: 0 UT 12 7 . . @ . . .
863 56956.332292 2014 OCT 26 7:58:30 UT 4 6 . . @ . . .
864 56957.336458 2014 OCT 27 8: 4:29 UT 13 12 . . @ . . .
865 56958.334375 2014 OCT 28 8: 1:30 UT 10 10 . . @ . . .
866 56960.327083 2014 OCT 30 7:51: 0 UT 17 10 . . @ . . .
867 56961.320833 2014 OCT 31 7:42: 0 UT 14 14 . . @ . . .

---

868 56993.235417 2014 DEC 2 5:39: 0 UT 17 27 . @ . . . .
869 56994.233333 2014 DEC 3 5:36: 0 UT 17 25 . @ . . . .
870 56995.230208 2014 DEC 4 5:31:29 UT 19 27 . @ . . . .
871 56996.228125 2014 DEC 5 5:28:29 UT 18 26 . @ . . . .
872 56997.223958 2014 DEC 6 5:22:29 UT 16 26 . @ . . . .
873 56998.220833 2014 DEC 7 5:18: 0 UT 18 25 . @ . . . .
874 56999.218750 2014 DEC 8 5:15: 0 UT 18 27 . @ . . . .

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 8 September 2025 doi:10.20944/preprints202509.0575.v1


```
875 57000.215625 2014 DEC 9 5:10:29 UT 16 26 .       @ .       .       .       .
876 57001.213542 2014 DEC 10 5: 7:30 UT 17 27 .      @ .       .       .       .
877 57002.209375 2014 DEC 11 5: 1:30 UT 18 27 .      @ .       .       .       .
878 57003.207292 2014 DEC 12 4:58:30 UT 18 27 .     @  .       .       .       .
879 57004.204167 2014 DEC 13 4:54: 0 UT 18 25 .     @  .       .       .       .
880 57005.201042 2014 DEC 14 4:49:30 UT 19 25 .     @  .       .       .       .
881 57006.198958 2014 DEC 15 4:46:29 UT 17 26 .     @  .       .       .       .
882 57007.194792 2014 DEC 16 4:40:30 UT 17 26 .     @  .       .       .       .
883 57008.193750 2014 DEC 17 4:39: 0 UT 16 26 .     @  .       .       .       .
884 57009.189583 2014 DEC 18 4:33: 0 UT 16 28 .     @  .       .       .       .
885 57010.185417 2014 DEC 19 4:27: 0 UT 17 26 .     @  .       .       .       .
886 57011.182292 2014 DEC 20 4:22:30 UT 26 27 .     @  .       .       .       .
887 57012.181250 2014 DEC 21 4:21: 0 UT 16 25 .     @  .       .       .       .
888 57013.178125 2014 DEC 22 4:16:30 UT 17 28 .    @   .       .       .       .
889 57014.175000 2014 DEC 23 4:12: 0 UT 20 28 .    @   .       .       .       .
890 57015.172917 2014 DEC 24 4: 9: 0 UT 20 26 .    @   .       .       .       .
891 57016.169792 2014 DEC 25 4: 4:30 UT 18 27 .    @   .       .       .       .
892 57017.165625 2014 DEC 26 3:58:29 UT 19 26 .    @   .       .       .       .
893 57018.163542 2014 DEC 27 3:55:30 UT 20 27 .    @   .       .       .       .
894 57019.160417 2014 DEC 28 3:51: 0 UT 18 26 .    @   .       .       .       .
895 57020.157292 2014 DEC 29 3:46:30 UT 18 28 .    @   .       .       .       .
896 57021.155208 2014 DEC 30 3:43:29 UT 17 26 .    @   .       .       .       .
897 57022.152083 2014 DEC 31 3:39: 0 UT 18 28 .   @    .       .       .       .
```

```
898 57083.969792 2015 MAR 2 23:16:30 UT 29 29 .      .       .       .       @ .
899 57084.966667 2015 MAR 3 23:12: 0 UT 27 30 .      .       .       .       @ .
900 57085.963542 2015 MAR 4 23: 7:30 UT 24 27 .      .       .       .       @ .
901 57086.961458 2015 MAR 5 23: 4:29 UT 21 28 .      .       .       .       @ .
902 57087.959375 2015 MAR 6 23: 1:29 UT 20 28 .      .       .       .       @ .
903 57088.954167 2015 MAR 7 22:54: 0 UT 18 25 .      .       .       .       @  .
904 57089.954167 2015 MAR 8 22:54: 0 UT 17 26 .      .       .       .       @  .
905 57090.948958 2015 MAR 9 22:46:29 UT 14 26 .      .       .       .       @  .
906 57091.946875 2015 MAR 10 22:43:30 UT 17 26 .     .       .       .       @  .
907 57092.944792 2015 MAR 11 22:40:30 UT 16 27 .     .       .       .       @  .
908 57093.941667 2015 MAR 12 22:36: 0 UT 15 15 .     .       .       .      @   .
909 57094.938542 2015 MAR 13 22:31:30 UT 20 27 .     .       .       .      @   .
910 57095.934375 2015 MAR 14 22:25:30 UT 15 24 .     .       .       .      @   .
911 57096.933333 2015 MAR 15 22:24: 0 UT 16 25 .     .       .       .      @   .
912 57097.930208 2015 MAR 16 22:19:29 UT 17 26 .     .       .       .      @    .
913 57098.928125 2015 MAR 17 22:16:29 UT 92 30 .     .       .       .      @    .
914 57099.923958 2015 MAR 18 22:10:29 UT 23 24 .     .       .       .      @    .
915 57100.922917 2015 MAR 19 22: 9: 0 UT 20 24 .     .       .       .     @     .
916 57101.917708 2015 MAR 20 22: 1:29 UT 20 22 .     .       .       .     @     .
917 57102.914583 2015 MAR 21 21:57: 0 UT 18 24 .     .       .       .    @      .
918 57103.912500 2015 MAR 22 21:54: 0 UT 15 26 .     .       .       .    @      .
919 57104.910417 2015 MAR 23 21:51: 0 UT 16 29 .     .       .       .    @      .
920 57105.906250 2015 MAR 24 21:45: 0 UT 16 25 .     .       .       .    @      .
921 57106.905208 2015 MAR 25 21:43:29 UT 16 27 .     .       .       .     @     .
922 57107.901042 2015 MAR 26 21:37:30 UT 17 24 .     .       .       .     @     .
```

923 57108.898958 2015 MAR 27 21:34:29 UT 15 24 .   .   .   .   @   .
924 57109.895833 2015 MAR 28 21:30: 0 UT 15 25 .   .   .   .   @   .
925 57110.892708 2015 MAR 29 21:25:29 UT 17 23 .   .   .   .   @   .
926 57111.889583 2015 MAR 30 21:21: 0 UT 20 25 .   .   .   .   @   .
927 57112.886458 2015 MAR 31 21:16:29 UT 4 24 .   .   .   .   @   .

928 57143.805208 2015 MAY 1 19:19:29 UT 6 6 .   .   .   . @   .
929 57144.803125 2015 MAY 2 19:16:29 UT 12 10 .   .   .   . @   .
930 57145.798958 2015 MAY 3 19:10:29 UT 7 6 .   .   .   . @   .
931 57146.792708 2015 MAY 4 19: 1:29 UT 9 8 .   .   .   . @   .
932 57147.793750 2015 MAY 5 19: 3: 0 UT 14 9 .   .   .   . @   .
933 57148.790625 2015 MAY 6 18:58:30 UT 7 7 .   .   .   . @   .
934 57149.785417 2015 MAY 7 18:51: 0 UT 13 7 .   .   .   . @   .
935 57150.783333 2015 MAY 8 18:48: 0 UT 10 9 .   .   .   . @   .
936 57151.779167 2015 MAY 9 18:42: 0 UT 8 7 .   .   .   . @   .
937 57152.775000 2015 MAY 10 18:36: 0 UT 62 8 .   .   .   .@   .
938 57153.777083 2015 MAY 11 18:39: 0 UT 12 6 .   .   .   .@   .
939 57154.773958 2015 MAY 12 18:34:29 UT 12 7 .   .   .   .@   .
940 57155.768750 2015 MAY 13 18:27: 0 UT 8 6 .   .   .   .@   .
941 57156.768750 2015 MAY 14 18:27: 0 UT 11 7 .   .   .   .@   .
942 57157.763542 2015 MAY 15 18:19:30 UT 7 7 .   .   .   @   .
943 57158.763542 2015 MAY 16 18:19:30 UT 9 5 .   .   .   @   .
944 57159.757292 2015 MAY 17 18:10:30 UT 11 9 .   .   .   @   .
945 57160.752083 2015 MAY 18 18: 3: 0 UT 13 5 .   .   .   @   .
946 57161.752083 2015 MAY 19 18: 3: 0 UT 11 9 .   .   .   @   .
947 57162.747917 2015 MAY 20 17:57: 0 UT 11 9 .   .   .   @.   .
948 57163.746875 2015 MAY 21 17:55:29 UT 10 8 .   .   .   @.   .
949 57164.743750 2015 MAY 22 17:51: 0 UT 5 7 .   .   .   @.   .
950 57165.740625 2015 MAY 23 17:46:29 UT 8 8 .   .   .   @.   .
951 57166.735417 2015 MAY 24 17:39: 0 UT 8 7 .   .   .   @ .   .
952 57167.735417 2015 MAY 25 17:39: 0 UT 10 8 .   .   .   @ .   .
953 57168.731250 2015 MAY 26 17:33: 0 UT 7 10 .   .   .   @ .   .
954 57169.727083 2015 MAY 27 17:27: 0 UT 3 5 .   .   .   @ .   .
955 57170.727083 2015 MAY 28 17:27: 0 UT 8 8 .   .   .   @ .   .
956 57171.723958 2015 MAY 29 17:22:29 UT 8 9 .   .   .   @ .   .
957 57172.719792 2015 MAY 30 17:16:30 UT 12 9 .   .   .   @ .   .

958 57175.713542 2015 JUN 2 17: 7:30 UT 26 11 .   .   .   @ .   .
959 57176.710417 2015 JUN 3 17: 3: 0 UT 9 12 .   .   .   @ .   .
960 57177.707292 2015 JUN 4 16:58:30 UT 12 11 .   .   .   @ .   .
961 57178.705208 2015 JUN 5 16:55:29 UT 12 12 .   .   .   @ .   .
962 57179.702083 2015 JUN 6 16:51: 0 UT 12 13 .   .   .   @ .   .
963 57180.697917 2015 JUN 7 16:45: 0 UT 11 11 .   .   .   @ .   .
964 57181.700000 2015 JUN 8 16:48: 0 UT 10 10 .   .   .   @ .   .
965 57182.693750 2015 JUN 9 16:39: 0 UT 10 11 .   .   .   @ .   .
966 57183.690625 2015 JUN 10 16:34:30 UT 11 11 .   .   .   @ .   .
967 57184.688542 2015 JUN 11 16:31:30 UT 9 10 .   .   .   @ .   .

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 8 September 2025 doi:10.20944/preprints202509.0575.v1

968 57185.685417 2015 JUN 12 16:27: 0 UT 11 13 . . . @ . .
969 57186.683333 2015 JUN 13 16:24: 0 UT 10 12 . . . @ . .
970 57187.680208 2015 JUN 14 16:19:29 UT 14 10 . . . @ . .
971 57188.677083 2015 JUN 15 16:15: 0 UT 9 12 . . . @ . .
972 57189.673958 2015 JUN 16 16:10:29 UT 12 11 . . . @ . .
973 57190.671875 2015 JUN 17 16: 7:30 UT 9 11 . . . @ . .
974 57191.667708 2015 JUN 18 16: 1:29 UT 12 7 . . . @ . .
975 57192.668750 2015 JUN 19 16: 3: 0 UT 10 13 . . . @ . .
976 57193.667708 2015 JUN 20 16: 1:29 UT 8 13 . . . @ . .
977 57194.664583 2015 JUN 21 15:57: 0 UT 9 15 . . . @ . .
978 57195.658333 2015 JUN 22 15:48: 0 UT 13 11 . . . @ . .
979 57196.655208 2015 JUN 23 15:43:29 UT 3 3 . . . @ . .
980 57197.657292 2015 JUN 24 15:46:30 UT 10 9 . . . @ . .
981 57198.652083 2015 JUN 25 15:39: 0 UT 6 6 . . . @ . .
982 57199.651042 2015 JUN 26 15:37:30 UT 14 13 . . . @ . .
983 57200.646875 2015 JUN 27 15:31:29 UT 6 7 . . . @ . .
984 57201.644792 2015 JUN 28 15:28:30 UT 5 7 . . . @ . .
985 57202.642708 2015 JUN 29 15:25:29 UT 7 12 . . . @ . .
986 57203.634375 2015 JUN 30 15:13:30 UT 9 7 . . . @ . .

987 57297.369792 2015 OCT 2 8:52:30 UT 5 11 . . @ . . .
988 57298.367708 2015 OCT 3 8:49:29 UT 6 14 . . @ . . .
989 57299.364583 2015 OCT 4 8:45: 0 UT 4 6 . . @ . . .
990 57300.361458 2015 OCT 5 8:40:29 UT 5 10 . . @ . . .
991 57301.359375 2015 OCT 6 8:37:30 UT 4 5 . . @ . . .
992 57302.354167 2015 OCT 7 8:30: 0 UT 4 8 . . @ . . .
993 57303.353125 2015 OCT 8 8:28:29 UT 9 8 . . @ . . .
994 57304.350000 2015 OCT 9 8:24: 0 UT 7 6 . . @ . . .
995 57305.346875 2015 OCT 10 8:19:30 UT 5 8 . . @ . . .
996 57306.344792 2015 OCT 11 8:16:30 UT 4 7 . . @ . . .
997 57307.341667 2015 OCT 12 8:12: 0 UT 6 9 . . @ . . .
998 57308.339583 2015 OCT 13 8: 9: 0 UT 4 5 . . @ . . .
999 57309.336458 2015 OCT 14 8: 4:29 UT 8 7 . . @ . . .
1000 57310.333333 2015 OCT 15 8:60: 0 UT 6 8 . . @ . . .
1001 57311.330208 2015 OCT 16 7:55:29 UT 5 6 . . @ . . .
1002 57312.328125 2015 OCT 17 7:52:30 UT 3 6 . . @ . . .
1003 57313.323958 2015 OCT 18 7:46:29 UT 4 6 . . @ . . .
1004 57314.321875 2015 OCT 19 7:43:29 UT 5 5 . . @ . . .
1005 57315.318750 2015 OCT 20 7:39: 0 UT 6 6 . . @ . . .
1006 57316.314583 2015 OCT 21 7:33: 0 UT 5 5 . . @ . . .
1007 57317.311458 2015 OCT 22 7:28:29 UT 5 8 . . @ . . .
1008 57318.309375 2015 OCT 23 7:25:29 UT 9 6 . . @ . . .
1009 57319.307292 2015 OCT 24 7:22:30 UT 5 6 . . @ . . .
1010 57320.304167 2015 OCT 25 7:18: 0 UT 36 8 . . @ . . .
1011 57321.301042 2015 OCT 26 7:13:30 UT 4 5 . . @ . . .
1012 57322.298958 2015 OCT 27 7:10:29 UT 7 8 . . @ . . .
1013 57323.295833 2015 OCT 28 7: 6: 0 UT 4 10 . . @ . . .
1014 57324.292708 2015 OCT 29 7: 1:29 UT 4 6 . . @ . . .
1015 57325.290625 2015 OCT 30 6:58:29 UT 7 9 . . @ . . .

1016 57326.287500 2015 OCT 31 6:54: 0 UT 5 4 . . @ . . .

1017 57357.719792 2015 DEC 1 17:16:30 UT 3 22 . . . @ . .
1018 57358.436458 2015 DEC 2 10:28:29 UT 3 2 . . @ . . .
1019 57359.191667 2015 DEC 3 4:36: 0 UT 3 2 . @ . . . .
1020 57360.190625 2015 DEC 4 4:34:30 UT 3 4 . @ . . . .
1021 57361.187500 2015 DEC 5 4:30: 0 UT 5 3 . @ . . . .
1022 57362.183333 2015 DEC 6 4:24: 0 UT 3 4 . @ . . . .
1023 57363.180208 2015 DEC 7 4:19:29 UT 5 4 . @ . . . .
1024 57364.178125 2015 DEC 8 4:16:30 UT 6 3 . @ . . . .
1025 57365.175000 2015 DEC 9 4:12: 0 UT 3 5 . @ . . . .
1026 57367.169792 2015 DEC 11 4: 4:30 UT 3 4 . @ . . . .
1027 57368.166667 2015 DEC 12 4: 0: 0 UT 5 6 . @ . . . .
1028 57369.164583 2015 DEC 13 3:57: 0 UT 9 5 . @ . . . .
1029 57370.159375 2015 DEC 14 3:49:30 UT 4 5 . @ . . . .
1030 57372.155208 2015 DEC 16 3:43:29 UT 4 7 . @ . . . .
1031 57373.151042 2015 DEC 17 3:37:30 UT 4 4 . @ . . . .
1032 57374.147917 2015 DEC 18 3:33: 0 UT 6 3 . @ . . . .
1033 57375.862500 2015 DEC 19 20:42: 0 UT 6 28 . . . . @ .
1034 57376.143750 2015 DEC 20 3:27: 0 UT 3 7 . @ . . . .
1035 57377.140625 2015 DEC 21 3:22:30 UT 6 3 . @ . . . .
1036 57378.137500 2015 DEC 22 3:18: 0 UT 4 2 . @ . . . .
1037 57379.135417 2015 DEC 23 3:15: 0 UT 5 4 . @ . . . .
1038 57380.132292 2015 DEC 24 3:10:30 UT 6 3 . @ . . . .
1039 57381.128125 2015 DEC 25 3: 4:30 UT 3 3 . @ . . . .
1040 57382.127083 2015 DEC 26 3: 3: 0 UT 5 5 . @ . . . .
1041 57384.120833 2015 DEC 28 2:54: 0 UT 4 2 . @ . . . .
1042 57386.637500 2015 DEC 30 15:18: 0 UT 7 13 . . . @ . .
1043 57387.111458 2015 DEC 31 2:40:29 UT 5 4 . @ . . . .

1054 57570.158333 2016 JUL 1 3:48: 0 UT 16 28 . @ . . . .
1055 57571.134375 2016 JUL 2 3:13:30 UT 10 3 . @ . . . .
1056 57599.506250 2016 JUL 30 12: 9: 0 UT 6 7 . . @ . .
1057 57572.997917 2016 JUL 3 23:57: 0 UT 19 4 . . . . @.
1058 57574.865625 2016 JUL 5 20:46:29 UT 4 21 . . . . @ .
1059 57576.781250 2016 JUL 7 18:45: 0 UT 4 3 . . . . @ .
1060 57578.575000 2016 JUL 9 13:48: 0 UT 3 3 . . . @ . .
1061 57579.562500 2016 JUL 10 13:30: 0 UT 5 5 . . . @ . .
1062 57580.563542 2016 JUL 11 13:31:30 UT 9 20 . . . @ . .
1063 57581.556250 2016 JUL 12 13:21: 0 UT 3 2 . . . @ . .
1064 57582.552083 2016 JUL 13 13:15: 0 UT 4 5 . . . @ . .
1065 57583.551042 2016 JUL 14 13:13:30 UT 3 4 . . . @ . .
1066 57584.547917 2016 JUL 15 13: 9: 0 UT 6 5 . . . @ . .
1067 57585.544792 2016 JUL 16 13: 4:30 UT 4 5 . . . @ . .
1068 57586.543750 2016 JUL 17 13: 3: 0 UT 5 6 . . . @ . .
1069 57587.538542 2016 JUL 18 12:55:30 UT 5 6 . . . @ . .
1070 57588.537500 2016 JUL 19 12:54: 0 UT 10 8 . . . @ . .

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 8 September 2025 doi:10.20944/preprints202509.0575.v1

1071 57589.534375 2016 JUL 20 12:49:30 UT 8 19 . . . @ . .
1072 57591.527083 2016 JUL 22 12:39: 0 UT 14 10 . . .@ . .
1073 57593.522917 2016 JUL 24 12:33: 0 UT 3 5 . . .@ . .
1074 57594.520833 2016 JUL 25 12:30: 0 UT 21 7 . . .@ . .
1075 57595.873958 2016 JUL 26 20:58:29 UT 4 4 . . . . @ .
1076 57596.507292 2016 JUL 27 12:10:30 UT 10 4 . . @ . .
1077 57597.505208 2016 JUL 28 12: 7:29 UT 13 7 . . @ . .
1078 57598.505208 2016 JUL 29 12: 7:29 UT 90 6 . . @ . .
1079 57599.506250 2016 JUL 30 12: 9: 0 UT 6 7 . . @ . .

1080 57844.812500 2017 APR 1 19:30: 0 UT 9 26 . . . . @ .
1081 57845.809375 2017 APR 2 19:25:30 UT 9 27 . . . . @ .
1082 57846.806250 2017 APR 3 19:21: 0 UT 7 24 . . . . @ .
1083 57847.803125 2017 APR 4 19:16:29 UT 8 25 . . . . @ .
1084 57848.801042 2017 APR 5 19:13:30 UT 7 28 . . . . @ .
1085 57849.797917 2017 APR 6 19: 9: 0 UT 9 28 . . . . @ .
1086 57850.795833 2017 APR 7 19: 6: 0 UT 8 24 . . . . @ .
1087 57851.792708 2017 APR 8 19: 1:29 UT 8 24 . . . . @ .
1088 57852.789583 2017 APR 9 18:57: 0 UT 13 25 . . . . @ .
1089 57853.786458 2017 APR 10 18:52:29 UT 11 29 . . . . @ .
1090 57854.783333 2017 APR 11 18:48: 0 UT 9 23 . . . . @ .
1091 57855.781250 2017 APR 12 18:45: 0 UT 10 26 . . . . @ .
1092 57856.778125 2017 APR 13 18:40:30 UT 17 28 . . . . @ .
1093 57857.775000 2017 APR 14 18:36: 0 UT 10 26 . . . .@ .
1094 57858.771875 2017 APR 15 18:31:29 UT 12 27 . . . .@ .
1095 57859.769792 2017 APR 16 18:28:30 UT 9 27 . . . .@ .
1096 57860.766667 2017 APR 17 18:24: 0 UT 9 30 . . . .@ .
1097 57861.763542 2017 APR 18 18:19:30 UT 8 23 . . . @ .
1098 57862.760417 2017 APR 19 18:15: 0 UT 14 28 . . . @ .
1099 57863.758333 2017 APR 20 18:12: 0 UT 9 28 . . . @ .
1100 57864.755208 2017 APR 21 18: 7:29 UT 12 27 . . . @ .
1101 57865.752083 2017 APR 22 18: 3: 0 UT 9 28 . . . @ .
1102 57866.748958 2017 APR 23 17:58:29 UT 9 27 . . . @. .
1103 57867.746875 2017 APR 24 17:55:30 UT 8 28 . . . @. .
1104 57868.743750 2017 APR 25 17:51: 0 UT 10 28 . . . @. .
1105 57869.740625 2017 APR 26 17:46:29 UT 9 26 . . . @. .
1106 57870.738542 2017 APR 27 17:43:30 UT 10 27 . . . @. .
1107 57871.735417 2017 APR 28 17:39: 0 UT 10 27 . . . @ . .
1108 57872.733333 2017 APR 29 17:36: 0 UT 10 25 . . . @ . .

1109 57875.723958 2017 MAY 2 17:22:29 UT 16 32 . . . @ . .
1110 57876.720833 2017 MAY 3 17:18: 0 UT 9 28 . . . @ . .
1111 57877.718750 2017 MAY 4 17:15: 0 UT 10 30 . . . @ . .
1112 57878.715625 2017 MAY 5 17:10:30 UT 9 26 . . . @ . .
1113 57879.712500 2017 MAY 6 17: 6: 0 UT 10 31 . . . @ . .
1114 57880.709375 2017 MAY 7 17: 1:29 UT 9 24 . . . @ . .
1115 57881.707292 2017 MAY 8 16:58:30 UT 10 25 . . . @ . .

1116 57882.704167 2017 MAY 9 16:54: 0 UT 19 31 . . . @ . .
1117 57883.701042 2017 MAY 10 16:49:30 UT 19 31 . . . @ . .
1118 57884.698958 2017 MAY 11 16:46:29 UT 11 30 . . . @ . .
1119 57885.977083 2017 MAY 12 23:27: 0 UT 47 3 . . . . @ .
1120 57886.692708 2017 MAY 13 16:37:29 UT 11 30 . . . @ . .
1121 57887.689583 2017 MAY 14 16:33: 0 UT 12 30 . . . @ . .
1122 57888.687500 2017 MAY 15 16:30: 0 UT 10 27 . . . @ . .
1123 57889.684375 2017 MAY 16 16:25:29 UT 10 29 . . . @ . .
1124 57890.681250 2017 MAY 17 16:21: 0 UT 10 27 . . . @ . .
1125 57891.678125 2017 MAY 18 16:16:29 UT 11 26 . . . @ . .
1126 57892.572917 2017 MAY 19 13:45: 0 UT 13 31 . . . @ . .

1127 57936.548958 2017 JUL 2 13:10:29 UT939 21 . . . @ . .
1128 57937.546875 2017 JUL 3 13: 7:30 UT 10 19 . . . @ . .
1129 57938.543750 2017 JUL 4 13: 3: 0 UT 10 25 . . . @ . .
1130 57939.541667 2017 JUL 5 13: 0: 0 UT 12 23 . . . @ . .
1131 57940.538542 2017 JUL 6 12:55:30 UT 11 26 . . . @ . .
1132 57941.535417 2017 JUL 7 12:51: 0 UT 11 26 . . . @ . .
1133 57942.533333 2017 JUL 8 12:48: 0 UT 11 21 . . . @ . .
1134 57943.530208 2017 JUL 9 12:43:29 UT 11 23 . . . @ . .
1135 57944.528125 2017 JUL 10 12:40:29 UT 10 19 . . . @ . .
1136 57945.519792 2017 JUL 11 12:28:30 UT 28 21 . . .@ . .
1137 57946.521875 2017 JUL 12 12:31:29 UT 11 21 . . .@ . .
1138 57947.518750 2017 JUL 13 12:27: 0 UT 10 24 . . .@ . .
1139 57948.515625 2017 JUL 14 12:22:30 UT964 26 . . .@ . .
1140 57949.512500 2017 JUL 15 12:18: 0 UT 10 23 . . @ . .
1141 57950.509375 2017 JUL 16 12:13:30 UT 10 20 . . @ . .
1142 57951.507292 2017 JUL 17 12:10:30 UT 21 19 . . @ . .
1143 57952.504167 2017 JUL 18 12: 6: 0 UT 13 23 . . @ . .
1144 57953.500000 2017 JUL 19 12: 0: 0 UT 16 21 . . @ . .
1145 57954.498958 2017 JUL 20 11:58:29 UT 10 21 . . @. . .
1146 57955.494792 2017 JUL 21 11:52:30 UT220 17 . . @. . .
1147 57956.492708 2017 JUL 22 11:49:29 UT 14 17 . . @. . .
1148 57957.489583 2017 JUL 23 11:45: 0 UT457 26 . . @. . .
1149 57958.486458 2017 JUL 24 11:40:29 UT 12 24 . . @. . .
1150 57959.483333 2017 JUL 25 11:36: 0 UT 12 15 . . @ . . .
1151 57960.481250 2017 JUL 26 11:33: 0 UT 11 21 . . @ . . .

1152 57997.375000 2017 SEP 1 9: 0: 0 UT 9 20 . . @ . . . .
1153 57998.372917 2017 SEP 2 8:57: 0 UT 9 15 . . @ . . . .
1154 57999.369792 2017 SEP 3 8:52:30 UT 10 10 . . @ . . . .
1155 58000.365625 2017 SEP 4 8:46:29 UT 7 11 . . @ . . . .
1156 58001.362500 2017 SEP 5 8:42: 0 UT 6 16 . . @ . . . .
1157 58002.361458 2017 SEP 6 8:40:29 UT 8 8 . . @ . . . .
1158 58003.357292 2017 SEP 7 8:34:30 UT 8 10 . . @ . . . .
1159 58004.355208 2017 SEP 8 8:31:29 UT 12 10 . . @ . . . .
1160 58005.352083 2017 SEP 9 8:27: 0 UT 6 7 . . @ . . . .

```
1161 58006.350000 2017 SEP 10 8:24: 0 UT 9 9 .     .  @     .     .     .
1162 58007.347917 2017 SEP 11 8:21: 0 UT 6 10 .    .  @     .     .     .
1163 58008.342708 2017 SEP 12 8:13:29 UT 9 7 .     .  @     .     .     .
1164 58009.341667 2017 SEP 13 8:12: 0 UT 8 13 .    .  @     .     .     .
1165 58010.338542 2017 SEP 14 8: 7:30 UT 11 12 .   .  @     .     .     .
1166 58011.332292 2017 SEP 15 7:58:30 UT 17 22 .   .  @     .     .     .
1167 58012.333333 2017 SEP 16 8:60: 0 UT 8 10 .    .  @     .     .     .
1168 58013.328125 2017 SEP 17 7:52:30 UT 10 10 .   .  @     .     .     .
1169 58014.327083 2017 SEP 18 7:51: 0 UT 9 9 .     .  @     .     .     .
1170 58015.323958 2017 SEP 19 7:46:29 UT 7 9 .     .  @     .     .     .
1171 58016.320833 2017 SEP 20 7:42: 0 UT 7 6 .     .  @     .     .     .
1172 58017.319792 2017 SEP 21 7:40:30 UT 5 6 .     .  @     .     .     .
1173 58018.315625 2017 SEP 22 7:34:30 UT 6 8 .     .  @     .     .     .
1174 58019.313542 2017 SEP 23 7:31:30 UT 5 7 .     .  @     .     .     .
1175 58020.309375 2017 SEP 24 7:25:29 UT 6 5 .     .  @     .     .     .
1176 58021.305208 2017 SEP 25 7:19:29 UT 7 5 .     . @      .     .     .
1177 58022.302083 2017 SEP 26 7:15: 0 UT 7 6 .     . @      .     .     .
1178 58023.300000 2017 SEP 27 7:12: 0 UT 5 5 .     . @      .     .     .
1179 58024.297917 2017 SEP 28 7: 9: 0 UT 9 4 .     . @      .     .     .
1180 58025.293750 2017 SEP 29 7: 3: 0 UT 7 5 .     . @      .     .     .
```

```
1181 58027.289583 2017 OCT 1 6:57: 0 UT 4 6 .      . @      .     .     .
1182 58028.285417 2017 OCT 2 6:51: 0 UT 6 5 .      . @      .     .     .
1183 58029.285417 2017 OCT 3 6:51: 0 UT 10 7 .     . @      .     .     .
1184 58030.282292 2017 OCT 4 6:46:30 UT 12 8 .     . @      .     .     .
1185 58031.278125 2017 OCT 5 6:40:29 UT 6 5 .      . @      .     .     .
1186 58032.276042 2017 OCT 6 6:37:30 UT 8 7 .      .@       .     .     .
1187 58033.272917 2017 OCT 7 6:33: 0 UT 7 9 .      .@       .     .     .
1188 58034.269792 2017 OCT 8 6:28:30 UT 5 9 .      .@       .     .     .
1189 58035.265625 2017 OCT 9 6:22:30 UT 7 5 .      .@       .     .     .
1190 58036.263542 2017 OCT 10 6:19:30 UT 4 6 .      @       .     .     .
1191 58037.262500 2017 OCT 11 6:18: 0 UT 5 5 .      @       .     .     .
1192 58038.259375 2017 OCT 12 6:13:29 UT 5 4 .      @       .     .     .
1193 58039.255208 2017 OCT 13 6: 7:29 UT 5 5 .      @       .     .     .
1194 58040.251042 2017 OCT 14 6: 1:30 UT 12 6 .     @       .     .     .
1195 58041.250000 2017 OCT 15 6: 0: 0 UT 8 5 .      @       .     .     .
1196 58042.247917 2017 OCT 16 5:57: 0 UT 6 6 .      @.      .     .     .
1197 58043.245833 2017 OCT 17 5:54: 0 UT 3 5 .      @.      .     .     .
1198 58044.241667 2017 OCT 18 5:48: 0 UT 6 6 .      @.      .     .     .
1199 58045.238542 2017 OCT 19 5:43:30 UT 3 4 .      @.      .     .     .
1200 58046.235417 2017 OCT 20 5:39: 0 UT 5 8 .      @ .     .     .     .
1201 58047.232292 2017 OCT 21 5:34:30 UT 3 6 .      @ .     .     .     .
1202 58050.225000 2017 OCT 24 5:24: 0 UT 5 4 .      @ .     .     .     .
1203 58052.216667 2017 OCT 26 5:12: 0 UT 5 4 .      @ .     .     .     .
1204 58053.213542 2017 OCT 27 5: 7:30 UT 7 4 .      @ .     .     .     .
1205 58055.210417 2017 OCT 29 5: 3: 0 UT 5 4 .      @ .     .     .     .
1206 58056.207292 2017 OCT 30 4:58:30 UT 3 2 .      @  .    .     .     .
```

References

1. He, B.; Cai, C.; Pan, L. A Rapid-Convergence Precise PointPositioning Approach Using Double Augmentations of Low Earth Orbit Satellite and Atmospheric Information. Remote Sens. 2023, 15,5265. https://doi.org/10.3390/rs15225265
2. Sun X., Shu Z., Yao J. Analyzing the Precise Precise Point Positioning Performance of Different Dual-Frequency Ionospheric-Free Combunations with BDS-3 and Galoleo. Atmosphere 2025. 16(3), 316; https://doi.prg/10.3390/atmos16030316
3. Xing S., Jiajun., Quan Z., Zhimin L., Qiang L., et al. Initial Study of Adaptive Threshold Cycle Slip Detection on BDS/GPS Kinematic Precise Point Positioning during Geomagnetic Storms. *Remote Sens.* 2024, *16*(10), 1726; https://doi.org/10.3390/rs16101726
4. Xin L. First Ever Rocks From the Moon's Far Side Have Landed on Earth. Nature Vol 631, 4 July 2024, 13
5. Anaïs Delépaut, Alex Minetto and Fabio Dovis. Code-based differential GNSS ranging for lunar orbiters: theoretical review and application to the NaviMoon observables. *Remote Sens.* 2024, *16*(15), 2755; https://doi.org/10.3390/rs16152755
6. Zheng, Z.; Yang, J.; Lv, T.; Yi, Y.; Lin, Z.; Dong, J.; Li, S. A Cloud Vertical Structure Optimization Algorithm Combining FY-4A and DSCOVR Satellite Data. Remote Sens.2025, 17, 2484. https://doi.org/10.3390/rs17142484
7. Berenyi, K.A.; Barta, V.; Szarnya, C.; Buzas, A.; Heilig, B. Subauroral and Auroral Conditions in the Mid- and Low-Midlatitude Ionosphere over Europe During the May 2024 Mother's Day Superstorm. Remote Sens. 2025, 17, 2492.
8. https://doi.org/10.3390/rs17142492
9. Filjar, R.; He ¯di, I.; Prpi´c-Orši´c, J.; Iliev, T. An Ambient Adaptive Global Navigation Satellite System Total Electron Content Predictive Model for Short-Term Rapid Geomagnetic Storm Events. Remote Sens. 2024, 16, 3051. https://doi.org/10.3390/rs16163
10. Huang N., Fu S., Chen B., Huang L., Jin W. Assessing the Performance of Water Vapor Products from ERA5 and MERRA-2 During Heavy Rainfals in the Guanghi Region of China. *Atmosphere* 2024, *15*(3), 306; https://doi.org/10.3390/atmos15030306
11. Linty, N., Minetto, A., Dovis, F., & Spogli, L. (2018). Effects of Phase Scintillation on the GNSS Positioning Error During the September 2017 Storm at Svalbard. *Space Weather*, *16*(9). https://doi.org/10.1029/2018SW001940
12. Marques, H. A., Marques, H. A. S., Aquino, M., Veettil, S. V., & Monico, J. F. G. (2018). Accuracy assessment of Precise Point Positioning with multi-constellation GNSS data under ionospheric scintillation effects. *Journal of Space Weather and Space Climate*, *8*. https://doi.org/10.1051/swsc/2017043
13. Lu, Y., Wang, Z., Ji, S., & Chen, W. (2020). Assessing the Positioning Performance Under the Effects of Strong Ionospheric Anomalies With Multi-GNSS in Hong Kong. *Radio Science*, *55*(8). https://doi.org/10.1029/2019RS007004
14. He, L., Guo, C., Yue, Q., Zhang, S., Qin, Z., & Zhang, J. (2023). A Novel Ionospheric Disturbance Index to Evaluate the Global Effect on BeiDou Navigation Satellite System Signal Caused by the Moderate Geomagnetic Storm on May 12, 2021. *Sensors*, *23*(3). https://doi.org/10.3390/s23031183
15. Paziewski, J., Høeg, P., Sieradzki, R., Jin, Y., Jarmolowski, W., Hoque, M. M., Berdermann, J., Hernandez-Pajares, M., Wielgosz, P., Lyu, H., Miloch, W. J., & Orús-Pérez, R. (2022). The implications of ionospheric disturbances for precise GNSS positioning in Greenland. *Journal of Space Weather and Space Climate*, *12*. https://doi.org/10.1051/swsc/2022029
16. Hayes, L. A., O'Hara, O. S. D., Murray, S. A., & Gallagher, P. T. (2021). Solar Flare Effects on the Earth's Lower Ionosphere. *Solar Physics*, *296*(11). https://doi.org/10.1007/s11207-021-01898-y
17. Hamza, A. M., Song, K., Meziane, K., & Jayachandran, P. T. (2024). Two-Component Phase Scintillation Spectra in the Auroral Region: Observations and Model. *Journal of Geophysical Research: Space Physics*, *129*(1). https://doi.org/10.1029/2023JA031998
18. Grunwald, G., Ciećko, A., Kozakiewicz, T., & Krasuski, K. (2023). Analysis of GPS/EGNOS Positioning Quality Using Different Ionospheric Models in UAV Navigation. *Sensors*, *23*(3). https://doi.org/10.3390/s23031112

19. Xing, s.; Jiajun, Z.; Quan, Z.; Zhimin, L.; Qiang, L.; et al. Initial Study of Adaptive Threshold Cycle Slip Detection on BDS/GPS Kinematic Precise Point Positioning during Geomagnetic Storms. *Remote Sens.* 2024, *16*(10),; https://doi.org/10.3390/rs16101726
20. Yang, Z.; Liu, C.; Mei, P.; Wang L. A Spatiotemporical Sequence Prediction Framework Based on Mask Reconstruction: Application to Short-Duration Precipitation Radar Eshoes. J. Remote Sensing 2025. Volume 17.Issue 13/10.3390/rs17132326
21. Jayachandran, P.T.; Langley, R.; Macdougall, J.; Mushini, Sajan & Hamza, A.; Mann, Ian; Milling, D.; Kale, Z.; Chadwick, R.; Kelly, T.; Danskin, D.; Carrano, C.; Pokhotelov, D. (2009). Canadian High Arctic Ionospheric Network (CHAIN). Radio Science. 44. n/a-n/a. 10.1029/2008RS004046.
22. Yang, Z.; Liu, C.; Mei, P.; Wang L. A Spatiotemporical Sequence Prediction Framework Based on Mask Reconstruction: Application to Short-Duration Precipitation Radar Eshoes. J. Remote Sensing 2025. Volume 17.Issue 13/10.3390/rs17132326
23. Pan, Y.; Luo, X.. (2025) Feasibility ana;ysisof the Doppler Index DI in ionospheric scintillation detection at High Arctic region of Canada. J. Survey Review. 1-15 https://doi.org/10.1080/00396265.2025.2470514
24. Berenyi, K.A.; Barta, V.; Szarnya, C.; Buzas, A.; Heilig, B. Subauroral and Auroral Conditions in the Mid- and Low-Midlatitude Ionosphere over Europe During the May 2024 Mother's Day Superstorm. Remote Sens. 2025, 17, 2492.
25. https://doi.org/10.3390/rs17142492
26. Spogli, L.; Alberti, T.; Bagiacchi, P.; Cafarella, L.; Cesaroni, C.; Cianchini, G.; Coco, I.; Di Mauro, D.; Chidoni, R.; Giannattasio, F; etal. The Effects of the May 2024 Mother's Day Superstorm Over Mediterranean Sector: FromData to Public Communication.ESS Open Arch.2024. [CrossRef]
27. Yang, Z., Morton, Y. T. J., Zakharenkova, I., Cherniak, I., Song, S., & Li, W. (2020). Global View of Ionospheric Disturbance Impacts on Kinematic GPS Positioning Solutions During the 2015 St. Patrick's Day Storm. *Journal of Geophysical Research: Space Physics*, *125*(7). https://doi.org/10.1029/2019JA027681
28. Dongsheng Zhaoa,, Shuanglei Cuia, Xueli Zhanga, Longjiang Lia, Peng Suna, Chaofa Biana, Wei Banc, Craig M. Hancockd, Qianxin Wanga, Kefei Zhanga, Analyzing Global Ionospheric Scintillation and GPS Positioning Disruptions Caused by M-Class Solar Flare; A Case Study. J. Advances in Space Research 74(2024)2492–2509 https://doi.org/10.1016/j.asr.2024.06.001
29. Ma, Mengwei & Jin, Shuanggen & Jin, Xu Zhan. (2024). Characteristics of Ionospheric Disturbances during the 2021 Typhoon Chanthu Based on GPS and GLONASS. Advances in Space Research. 74. 10.1016/j.asr.2024.03.060.
30. Ayyagari, D.; Datta, S.; Das, S.; Datta, A. (2023). Ionospheric response during Tropical Cyclones - A Brief Review on Amphan and Nisarga. *Advances in Space Research*, *71*(6). https://doi.org/10.1016/j.asr.2022.11.026
31. Ke, F., Cui, W., Ming, L., & Hu, X. (2024). Ionospheric response and the impact on GPS positioning accuracy during the Tonga volcano eruption on 15 January 2022. *Advances in Space Research*, *73*(3). https://doi.org/10.1016/j.asr.2023.10.042
32. Dresing, N., Warmuth, A., Effenberger, F., Klein, K. L., Musset, S., Glesener, L., & Brüdern, M. (2021). Connecting solar flare hard X-ray spectra to in situ electron spectra: A comparison of RHESSI and STEREO/SEPT observations. *Astronomy and Astrophysics*, *654*. https://doi.org/10.1051/0004-6361/202141365
33. [31]] .Paipa-Leon, D.; Vilmer, N.;, Milan Maksimovic, M.; Krupar, V.; Vecchio, V. Connecting energetic electrons at the Sun and in the heliosphere through X-ray and radio diagnostics. *A&A, 694 (2025)* A111. https://doi.org/10.1051/0004-6361/202452278
34. Zhang, Z.; He, F.; Zhang, X.-X.; Liang, G.; Wang, X.; Wei, Y. Solar Wind Charge-Exchange X-ray Emissions from the O^{5+} Ions in the Earth's Magnetosheath. *Remote Sens.* 2024, *16*, https://doi.org/10.3390/rs16091480
35. Hayes, L. A., Gallagher, P. T., McCauley, J., Dennis, B. R., Ireland, J., & Inglis, A. (2017). Pulsations in the Earth's Lower Ionosphere Synchronized With Solar Flare Emission. *Journal of Geophysical Research: Space Physics*, *122*(10). https://doi.org/10.1002/2017JA024647

 doi:10.20944/preprints202509.0575.v1

36. Bozóki, T., & Heilig, B. (2025). Spatial distribution of Pc1/EMIC waves relative to the nightside ionospheric footprint of the plasmapause. *Journal of Geophysical Research: Space Physics*, 130, e2024JA033385. https://doi.org/10.1029/2024JA033385
37. Pezzopane, M.; Pignalberi, A.; Coco, I.; Consolini, G.; De Michelis, P.; Giannattasio, F.; Marcucci, M.F.; Tozzi, R. Occurrence of GPS Loss of Lock Based on a Swarm Half-Solar Cycle Dataset and Its Relation to the Background Ionosphere. Remote Sens. 2021, 13, 2209. https://doi.org/10.3390/rs13112209
38. Kim, H., Hwang, J., Park, J., Miyashita, Y., Shiokawa, K., Mann, I. R., Raita, T., Lee, J. (2018). Large-Scale Ducting of Pc1 Pulsations Observed by Swarm Satellites and Multiple Ground Networks. *Geophysical Research Letters Volume 45, Issue 23 pp. 12,703-12,712* https://doi.org/10.1029/2018GL080693
39. Kwak J, Hwang J, Park J, Kim J & Kim H, et al. 2024. Comparison of geomagnetic storm and non-storm periods midlatitude Pc1 pulsations characteristics. *J. Space Weather Space Clim.* 14, 26. https://doi.org/10.1051/swsc/2024026.
40. Pilipenko, V. A., Fedorov, E. N., Xu, Z., Hartinger, M. D., Engebretson, M. J., & Edwards, T. R. (2020). Incidence of Alfvenic SC pulse onto the conjugate ionospheres. Journal of Geophysical Research: Space Physics, 125(2), Article e2019JA027397. https://doi.org/10.1029/2019ja027397
41. Lysak R.L. Kinetic Alfvén waves and auroral particle acceleration: a review. Vol.:(0123456789) Reviews of Modern Plasma Physics (2023) 7:6
42. Francia, P., Regi, M., De Lauretis, M. et al. A case study of correspondence between Pc1 activity and ionospheric
43. irregularities at polar latitudes. Earth Planets Space 72, 59 (2020). https://doi.org/10.1186/s40623-020-01184-4
44. Mandea, M., Isac, A. (2021). Geomagnetic Field, Measurement Techniques. In: Gupta, H.K. (eds) Encyclopedia of Solid Earth Geophysics. Encyclopedia of Earth Sciences Series. Springer, Cham. https://doi.org/10.1007/978-3-030-58631-7_117
45. David ,P., Kriegel, M., Berdermann, J., Kauristie, K., Jacobsen, K.S., Fabbro, V. , Laurens, H., Keil, R. Performance indicator development addressing mitigation of the space weather impacts on GNSS. Journal of Space Safety Engineering Volume 10, Issue 3, September 2023, Pages 324-330
46. Yang, Z., Morton, Y. T. J.,Zakharenkova, I., Cherniak, I., Song, S.,& Li, W. (2020). Global view of Ionospheric disturbance impacts on kinematic GPS positioning solutions during the 2015 St. Patrick's Day storm. Journal of Geophysical Research: Space Physics, 123, e2019JA027681. https://doi.org/10.1029/2019JA02768
47. Dobelis, D.; Zvirgzds, J.; Kaļinka, M. High Ionospheric Activity Effects on LatPos RTK Network Performance in Latvia. In Proceedings of the IOP Conference Series: Materials Science and Engineering; Institute of Physics Publishing, October 25 2017; Vol. 251.
48. Balodis J., Normand M. Zarins A. The Movement of GPS Positioning Discrepancy Clouds at a Mid-Latitude Region in March 2015. Journal: Remote Sens., 2023. Volume 15, Issue 8. 20 pages and Supplementary files. DOI:10.3390/rs15082032