PREDICTABLE REGULAR DAILY IONOSPHERIC SCINTILLATION

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The objective of this study is to discover the regular scintillation events as a result of space weather impact on the GPS observation reduction results in Latvian Continuously Operating Reference Stations (CORS) network in selected months in years 2007-2017. In the case of interplanetary Cosmic Ray excess movement in space, the term of the movement of molecular clouds is used [1]. In this study, the term "GPS positioning discrepancy clouds" (clouds) is used when analyzing the nature of the ionospheric scintillation's disturbed positioning results that occurred simultaneously in various number of CORS stations. Union of the subsets of adjacent 90-sec duration clouds is named "wave" where is fixed scintillation simultaneously in 2-3 stations and more. The term "evil waveform" is used to denote the disturbed information for navigation in some area caused by the GPS erroneous information [2]. In this study the regularly daily occurred erroneous waves are searched.

GPS observation data with an elevation cut-off angle of 15˚ were used 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 v5.2 post-processed data of kinematic solution were used.

For further analysis of processing results the authors made software programs were used. Table 1 shows the count of both waves and clouds that should be checked in order to find a regular daily ionospheric impact waves disturbing positioning results.

Table 1. Monthly ionospheric impact waves and 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
		SUM	**38907**	**3279**				**45920**	**3439**

The total number of waves is 6718 with a total of 84827 clouds. It is necessary to choose some algorithm to detect the presence of regular waves in these monthly subsets of data. In Figure 1 one of the regular waves in October 13/14, 2013 is described, where in each row description of cloud: No., date, time and list of CORS station DOMEs where positioning discrepancies appeared simultaneously at the same time, is given. Union of the adjacent 90-sec clouds presented as ionospheric scintillation wave's impacted station subset, for simplification also is used to name a wave.

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2 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 PLSM SALP
495 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
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Fig. 1. Type of regular skewed wave formed by cloud union, with time and peak coverage of clouds (green), beginning of time sequence, median of time sequence and end of time sequence (yellow) and cloud's DOME subsets correspondingly

The search algorithm was developed based on the example of the month of March 2015 [3] where daily regular waves are repeated with a 4.5-minute lag on the time scale, graduated in increments of 90 seconds (1.5 minutes). With the same 4.5-minute step, each of the 1.5-minute clouds shifts from day to day – wave's peak, beginning, median and end (Figure 1). However, the time lag for each of these clouds varies due to the changes of daily wave configuration. The initially assumed 4.5-minute lag also varies and the time scale, graduated in increments of 90 seconds has not been a good fit for regular wave search.

However, the regular wave search was successful. The search difficulties and final results will be presented and discussed in the conference.

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