”Stations DAU1 (DAUG) and LIMB in LatPos network (2007-2017)”

“Stacijas DAU1 (DAUG) un LIMB LatPos tīklā (2007-2017)”

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Stations DAU1 (DAUG) and LIMB in LatPos network (2007-2017)

Content of the presentation

- Introduction
- Data and post-processing strategy
- Results
- Conclusions

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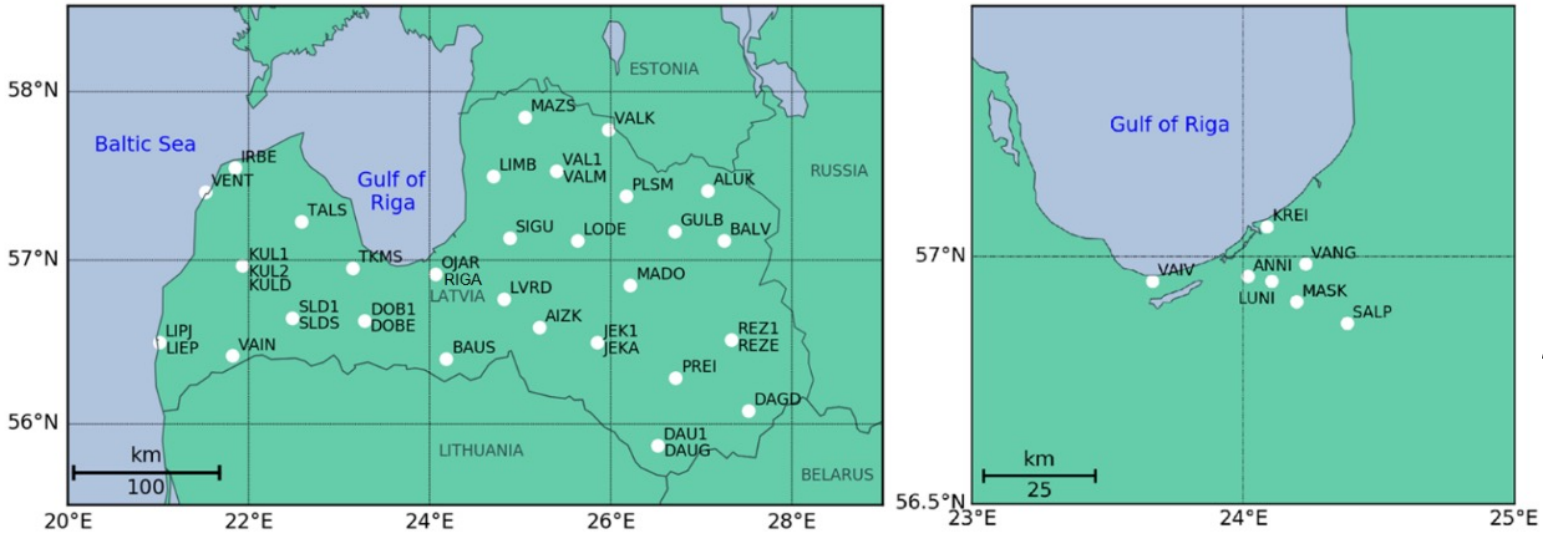
Stations DAU1 (DAUG) and LIMB in LatPos network (2007-2017)

Introduction

- Continuously Operating Reference Station (CORS) networks in Latvia: LatPos, and *EUPOS*®-Riga



LatPos - maintained by the Latvian Geospatial Information Agency (LGIA)

***EUPOS*®-Riga** - maintained by the Riga Municipality

Figure 1. LatPos and *EUPOS*®-Riga networks and IGS/ EPN station RIGA.

- There is one IGS/ EPN station RIGA, which is operated by the Institute of Astronomy, University of Latvia.

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Stations DAU1 (DAUG) and LIMB in LatPos network (2007-2017)

Introduction

- Within a development of the CORS networks in Latvia, a continuous use of these networks has become possible, either in research, either in everyday use in mapping, land surveying, cadaster and many other branches of engineering.
- /Latvian CORS data was regularly post-processed by the Institute of Geodesy and Geoinformation, University of Latvia (GGI) for the Permanent GNSS Network densification of the Regional Reference Frame Sub-Commission for Europe (EUREF), as well as for the EPOS (European Plate Observing System) program.

- During several research projects that were carried out at the GGI, based on LatPos and *EUPOS®*-Riga network GPS observation data, collected since the implementation of these networks, the LatPos network stations **LIMB** and **DAU1 (DAUG)** have attracted the attention and (therefore) require more in-depth research./

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Stations DAU1 (DAUG) and LIMB in LatPos network (2007-2017)

Introduction

DOMES names (station names):

/The different **DOMES names** shown in **Figure 2**., indicate the number of times the station has been relocated and their respective new assigned DOMES names./

DAUG from **2007** until **2010**
DAU1 from **2010** until **present**

/In the city of Daugavpils, the station with a **DOMES name DAUG** was moved to another location in **2010**, correspondingly changing the **DOMES name to DAU1** (**Figure 2**).

LIMB from **2007** until **present**

/has not changed its location since its installation, year **2007**./

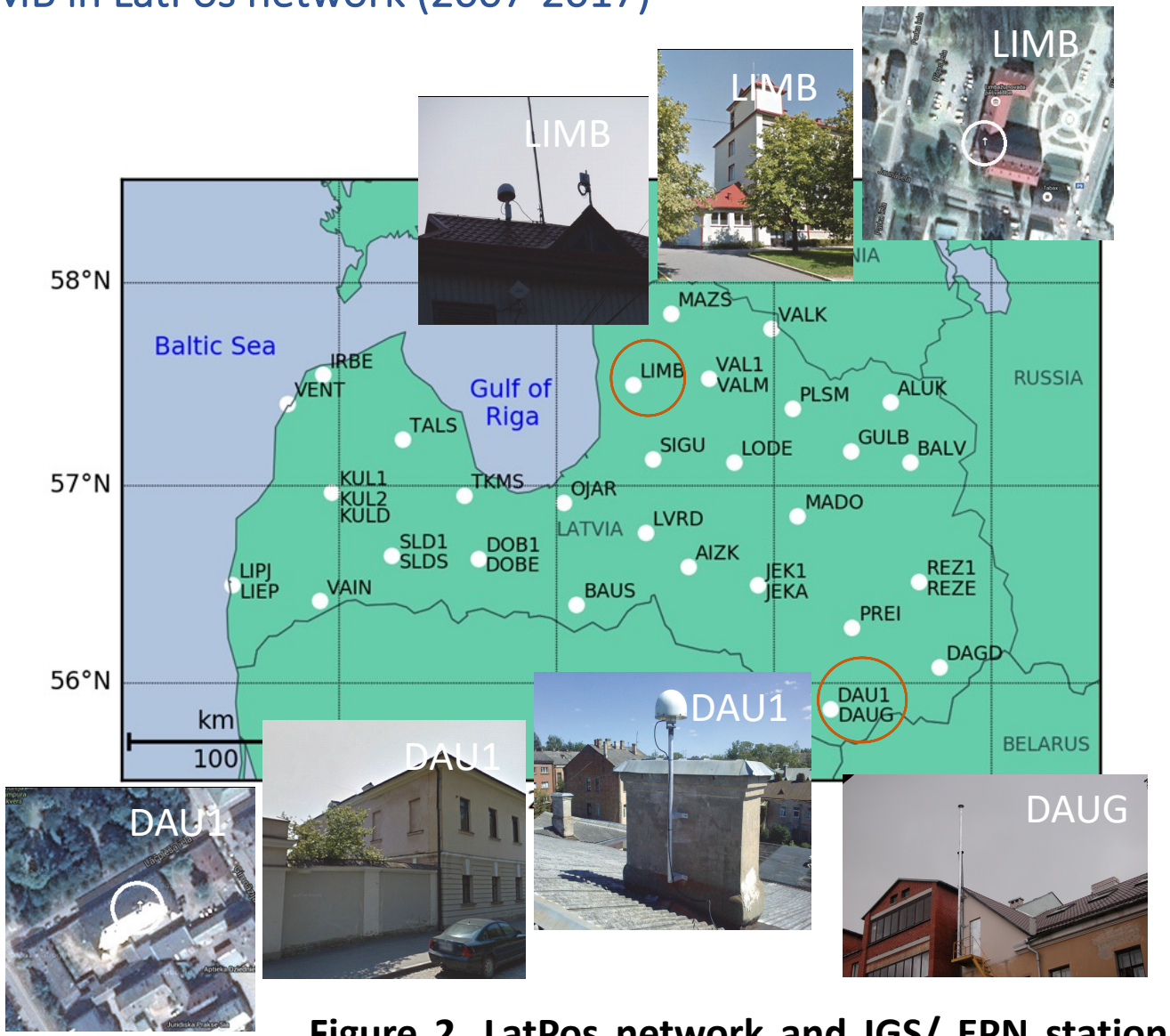

Figure 2. LatPos network and IGS/ EPN station RIGA. /Station photos – J. Zvirgzds/

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Data and post-processing strategy

- **The present study** of the LatPos network CORS stations **DAU1** (**DAUG**) **and LIMB** is based on **a statistical analysis of the GPS observation data, for the selected 4-5 months** (Table 1.)**, over a period of 11 years, namely 2007-2017.**

- The chosen time frame covers the 24th solar cycle.

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Stations DAU1 (DAUG) and LIMB in LatPos network (2007-2017)

Data and post-processing strategy

Table 1. Selected months for data post-processing

Year	Month				
2007	FEB	JUN	SEP	OCT	
2008	MAR	JUN	SEP	OCT	
2009	JUL	AUG	OCT	DEC	
2010	JAN	FEB	APR	MAY	
2011	MAR	AUG	SEP	NOV	
2012	JAN	MAR	JUL	OCT	
2013	MAY	OCT	NOV	DEC	
2014	FEB	JUN	OCT	DEC	
2015	MAR	MAY	JUN	OCT	DEC
2016	FEB	APR	MAY	JUL	
2017	APR	MAY	JUL	SEP	OCT

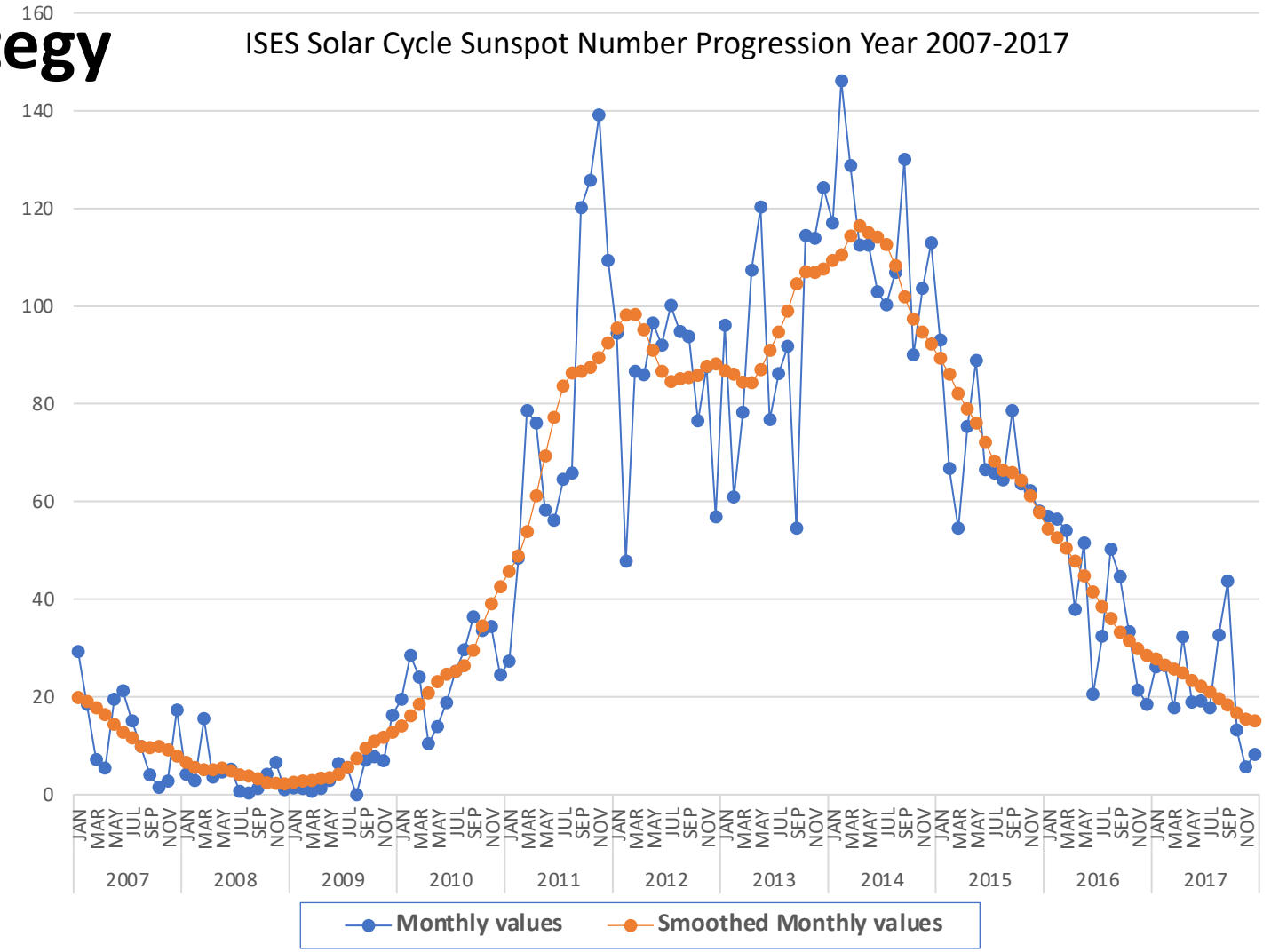

Figure 3. ISES Solar Cycle Sunspot Number Progression, Year 2007-2017
data gathered from: https://www.swpc.noaa.gov/products/solar-cycle-progression

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Stations DAU1 (DAUG) and LIMB in LatPos network (2007-2017)

Data and post-processing strategy

- The number of LatPos network stations varies during the selected time frame.
- 2007 was the first year of operation of Latvian CORS stations and 23 were operational.

/New stations have been gradually added to the network in order to achieve a homogenous coverage over the territory of Latvia.

Many of them were removed to other sites.

Amongst all the stations from both included in the analysis, only 8 stations BAUS, KREI, LIMB, LUNI, PREI, RIGA, TALS, VANG) were not moved during the selected months of the whole period of 11 years.

- **Statistical approach** - widely used when large amount of data is considered.
- In order to perform the statistical analysis, the GPS observation data was post-processed using **Bernese GNSS Software v5.2**, available at GGI.

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Stations DAU1 (DAUG) and LIMB in LatPos network (2007-2017)

Data and post-processing strategy

Parameter	Value
Processing strategy	Double-difference mode, ionosphere-free linear combination; MAURPP for cycle slip detection
Ground and satellite antenna phase center calibrations	Absolute, IGS
CODE products used	Precise (Final) orbits, Earth orientation, clock, ionospehre, stochastic ionosphere parameters and CODE's global ionosphere maps
4 IGS/ EPN Reference stations for each solution computation	LAMA (Olsztyn, Poland), METS (Metsahovi, Finland), VISO (Visby, Sweden), VLNS (Vilnius, Lithuania)
Satellite System	GPS
Elevation cut-off angle	15°
Sampling interval	90 second sampling interval of kinematic post-processing was chosen
Ocean tidal loading corrections	FES2004
Corrections of solid Earth tide effect	Yes
Tropospheric delay modelling	Dry Global Mapping Function (GMF)

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Stations DAU1 (DAUG) and LIMB in LatPos network (2007-2017)

Results

1. Loss-of-Lock situations in LatPos network CORS stations

- **/Loss-of-lock means the GNSS receiver no longer tracks the signal accurately; under such status navigation messages cannot be further decoded, leading to less visible satellites for positioning, thus degrading positioning accuracy.** [Yang Liu, Lianjie Fu, Jinling Wang and Chunxi Zhang, Study of GNSS Loss of Lock Characteristics under Ionosphere Scintillation with GNSS Data at Weipa (Australia) During Solar Maximum Phase; Sensors 2017, 17, 2205; doi:10.3390/s17102205]/

2. Simultaneously occurred discrepancies in LatPos network CORS stations

- **/The monthly discrepancy diagrams revealed simultaneous discrepancies at numerous individual stations. The output was analyzed, and it was identified that for several stations the disturbed solutions usually appear more than 150-200 times. This is assumed to be the Loss-of-Lock of GNSS receivers./**

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Stations DAU1 (DAUG) and LIMB in LatPos network (2007-2017)

Results

1. The analysis discovers that LatPos network is most stable with less Loss-of-Lock situations, except DAU1 and LIMB stations.

/The stations' **DAU1** Loss-of-Lock occasions are very uniform. They are irregular by date, the sequences are not long and the discrepancies are about 15-20 cm. However, **since 2011** there are **70** sequences in **58 days**. The shape of the discrepancy distribution plots is uniform and differs from other stations' discrepancy plots./

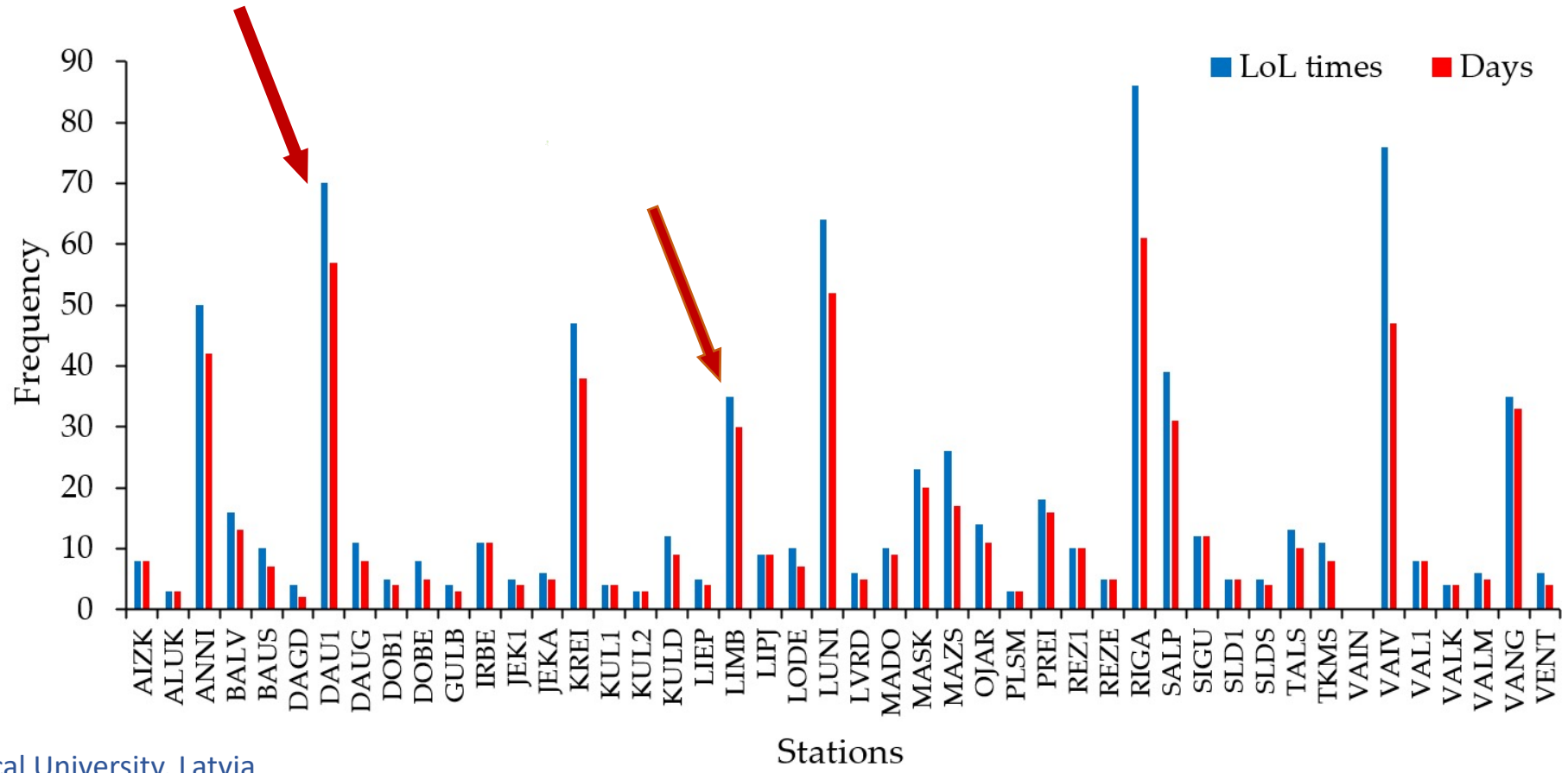

Figure 4. Frequency of Loss-of-Lock in CORS stations.

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Stations DAU1 (DAUG) and LIMB in LatPos network (2007-2017)

Results

March 17, 2015 - St. Patrick's day geomagnetic storm

/Experiments demonstrate that the percentage of occurrence of Loss-of-Lock events under ionosphere scintillation is closely related with solar activity and seasonal shifts./[Sensors 2017, 17, 2205; doi:10.3390/s17102205]/

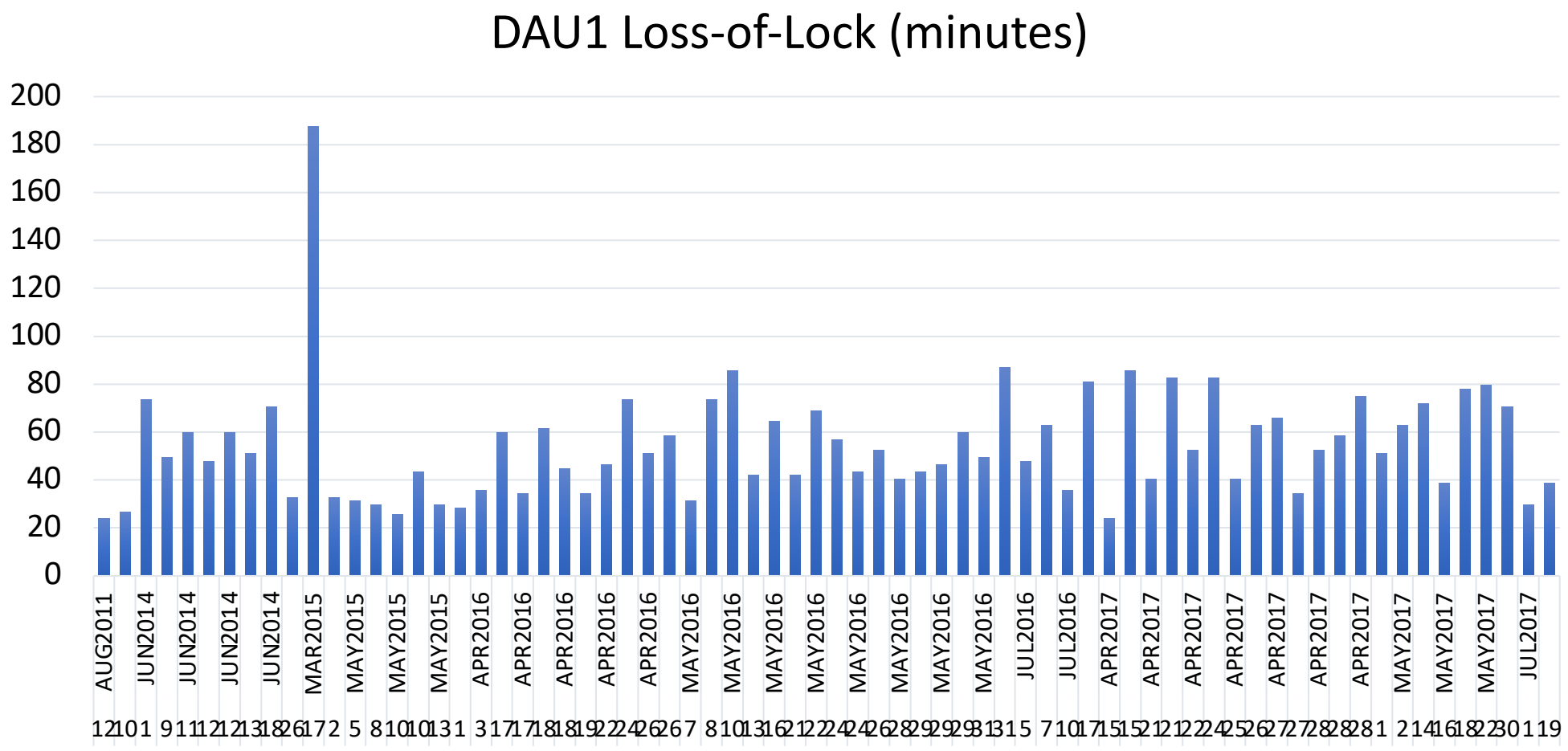

Figure 5. DAU1 Loss-of-Lock (minutes)

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Stations DAU1 (DAUG) and LIMB in LatPos network (2007-2017)

Results

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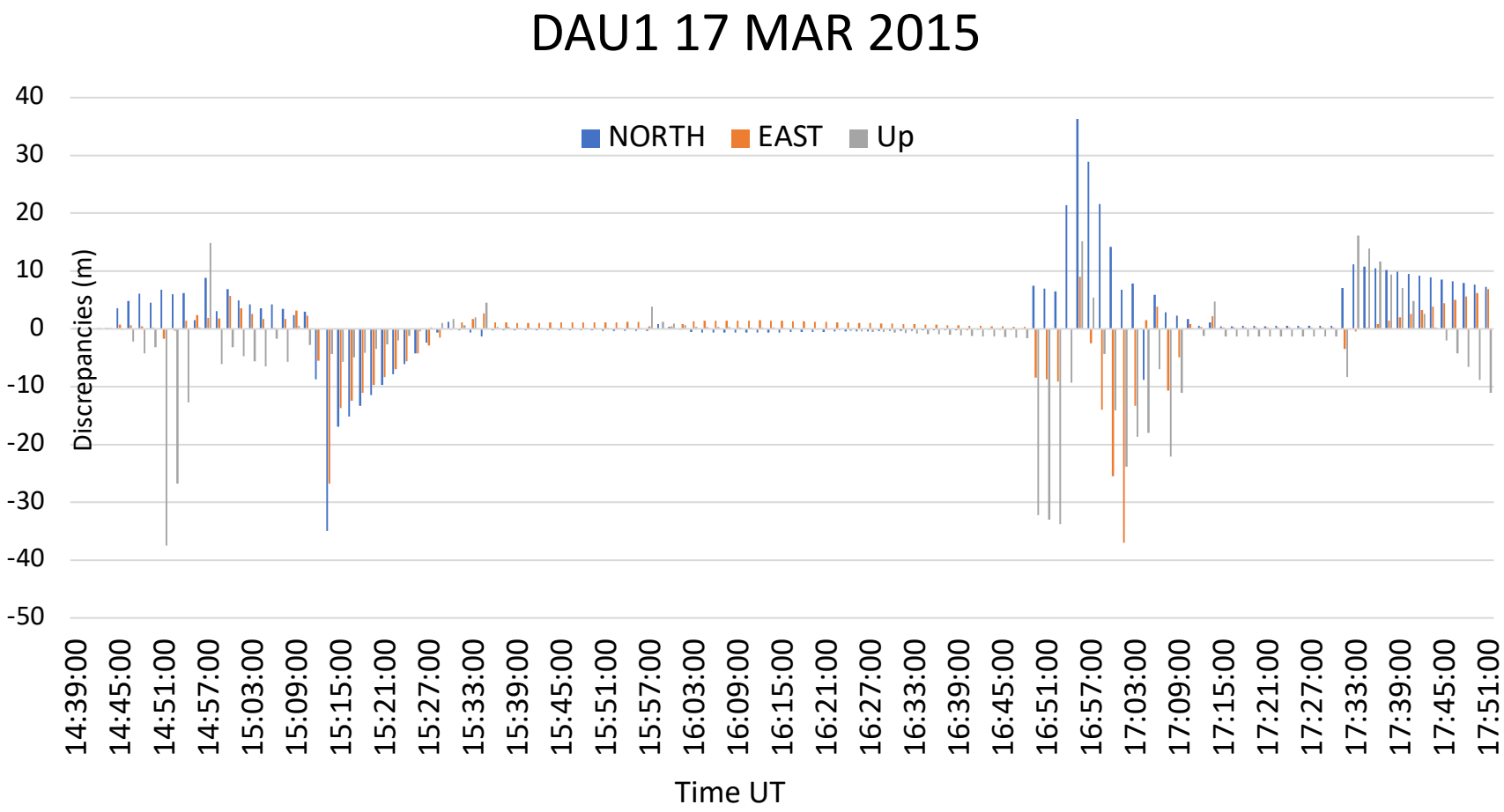

Figure 6. Plot of discrepancies of station DAU1 on 17 March, 2015.

Stations DAU1 (DAUG) and LIMB in LatPos network (2007-2017)

Results

December 2009

The month of December 2009 is at the beginning part of the Solar cycle 24 when the sun activity awakes after a long, calm period.

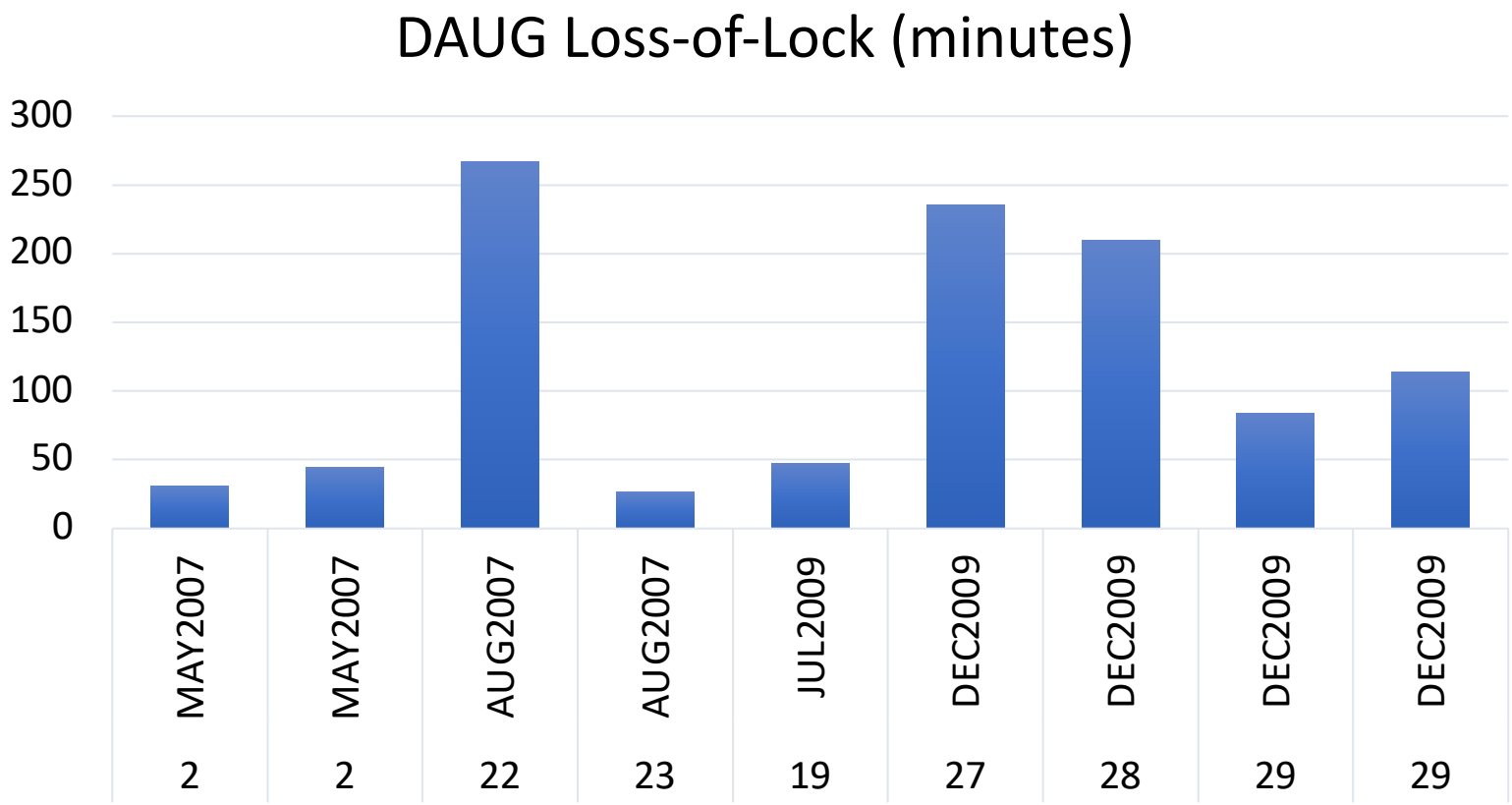

Figure 7. DAUG Loss-of-Lock (minutes).

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Stations DAU1 (DAUG) and LIMB in LatPos network (2007-2017)

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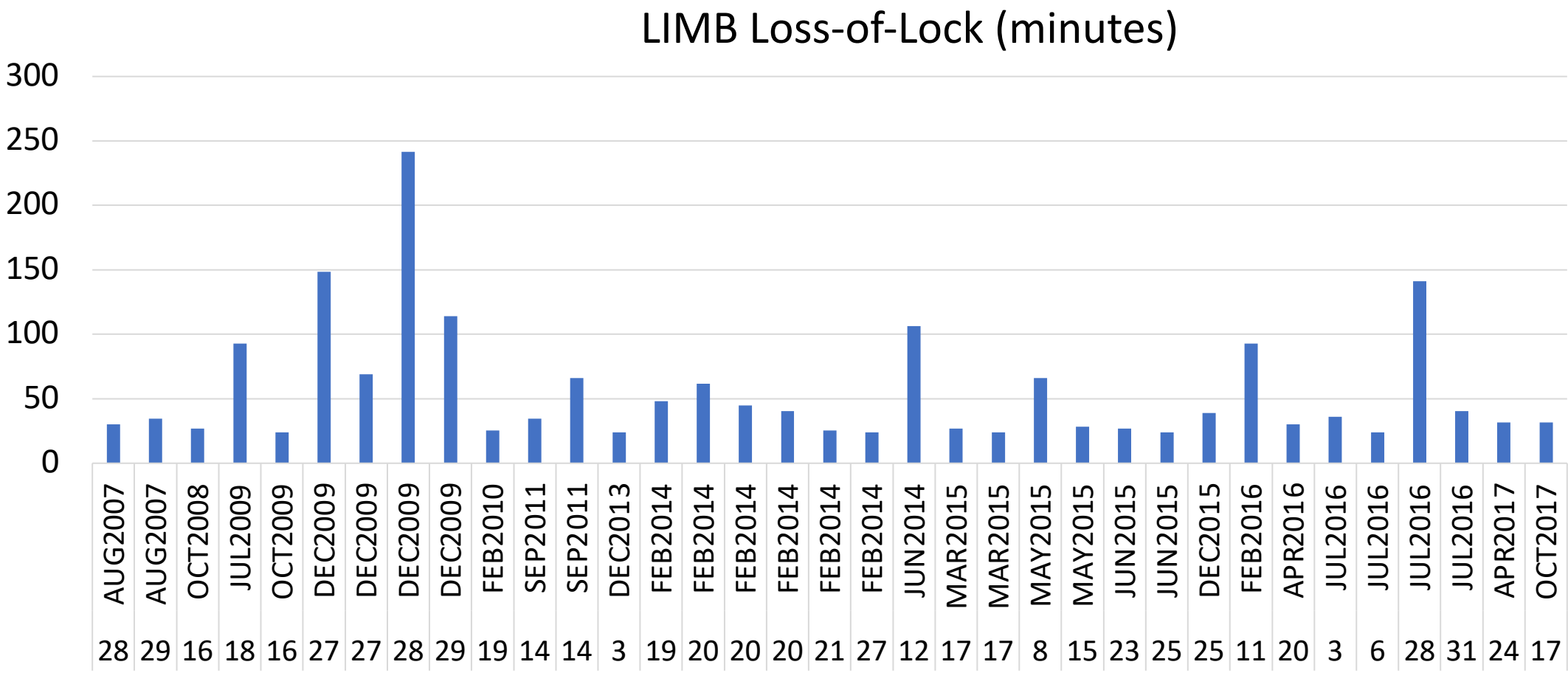

Figure 8. LIMB Loss-of-Lock (minutes)

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Stations DAU1 (DAUG) and LIMB in LatPos network (2007-2017)

Results

December 2009

The month of December 2009 is at the beginning part of the Solar cycle 24 when the sun activity awakes after a long, calm period.

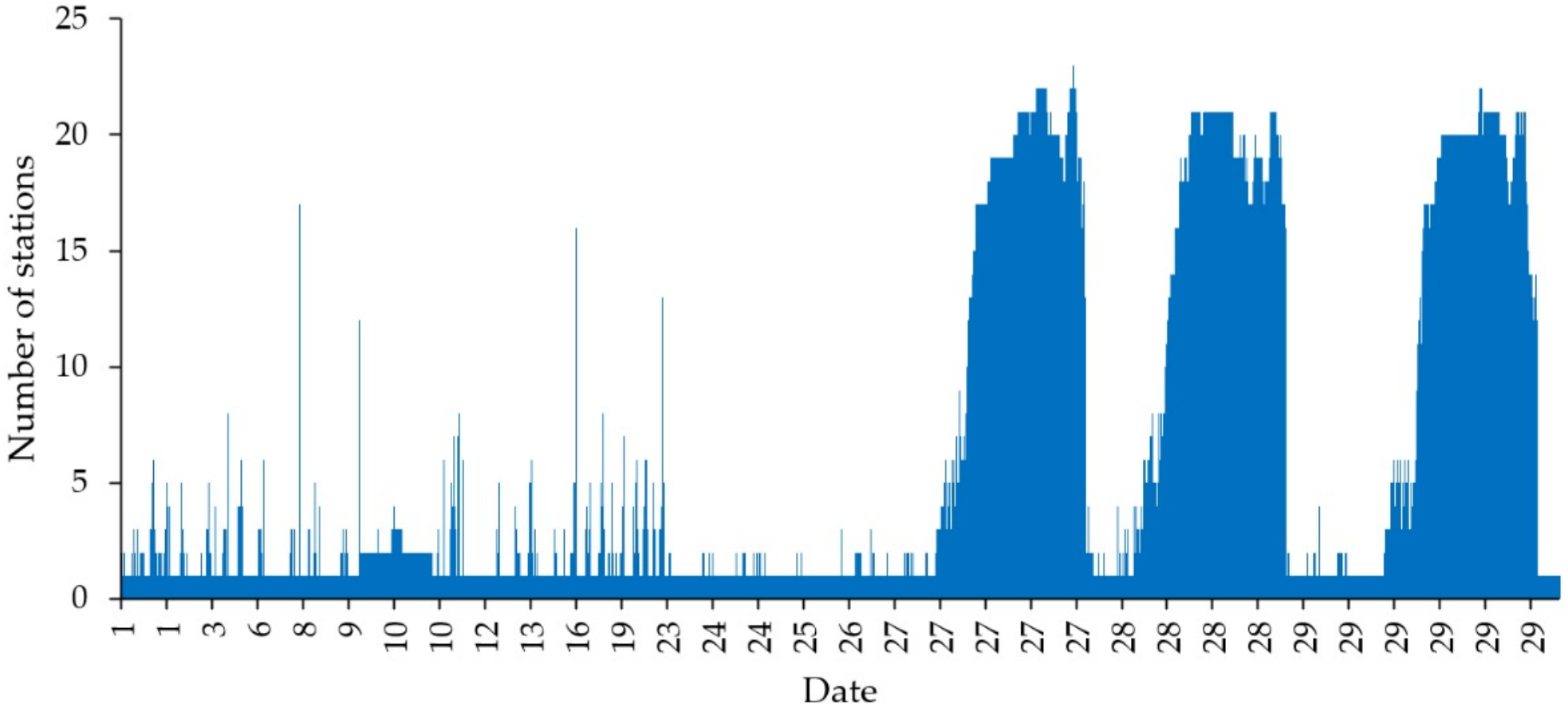

Figure 9. Plot of the distribution of simultaneously occurred discrepancies in December 2009.

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Stations DAU1 (DAUG) and LIMB in LatPos network (2007-2017)

Results

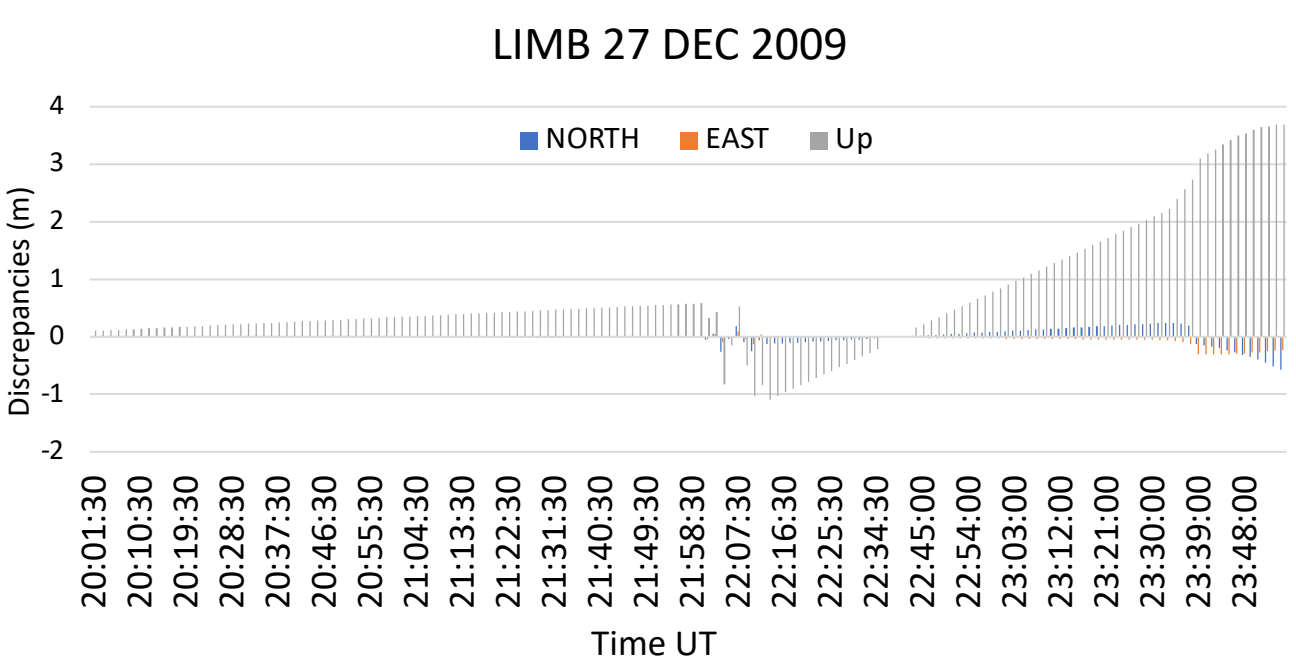

Figure 10. Plot of discrepancies of station LIMB on 27 December, 2009.

/Skulte is the nearest meteo station of CORS LatPos network station LIMB/

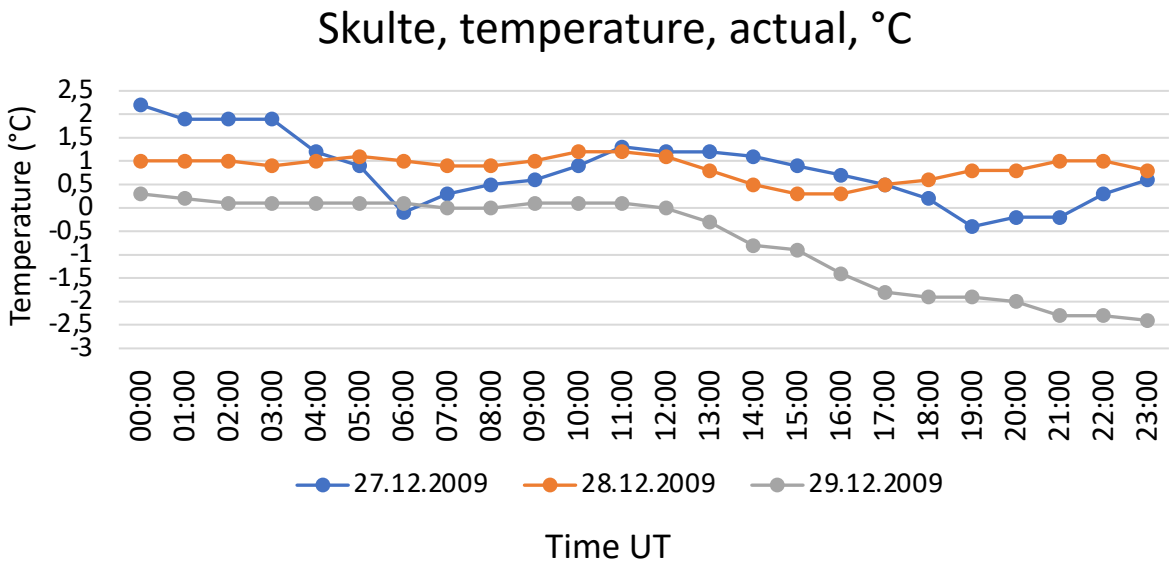

Figure 11. Plot of the Skulte meteo station temperature data on December 27th, 28th and 29th, 2009

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Stations DAU1 (DAUG) and LIMB in LatPos network (2007-2017)

Results

/Skulte is the nearest meteo station of CORS LatPos network station LIMB/

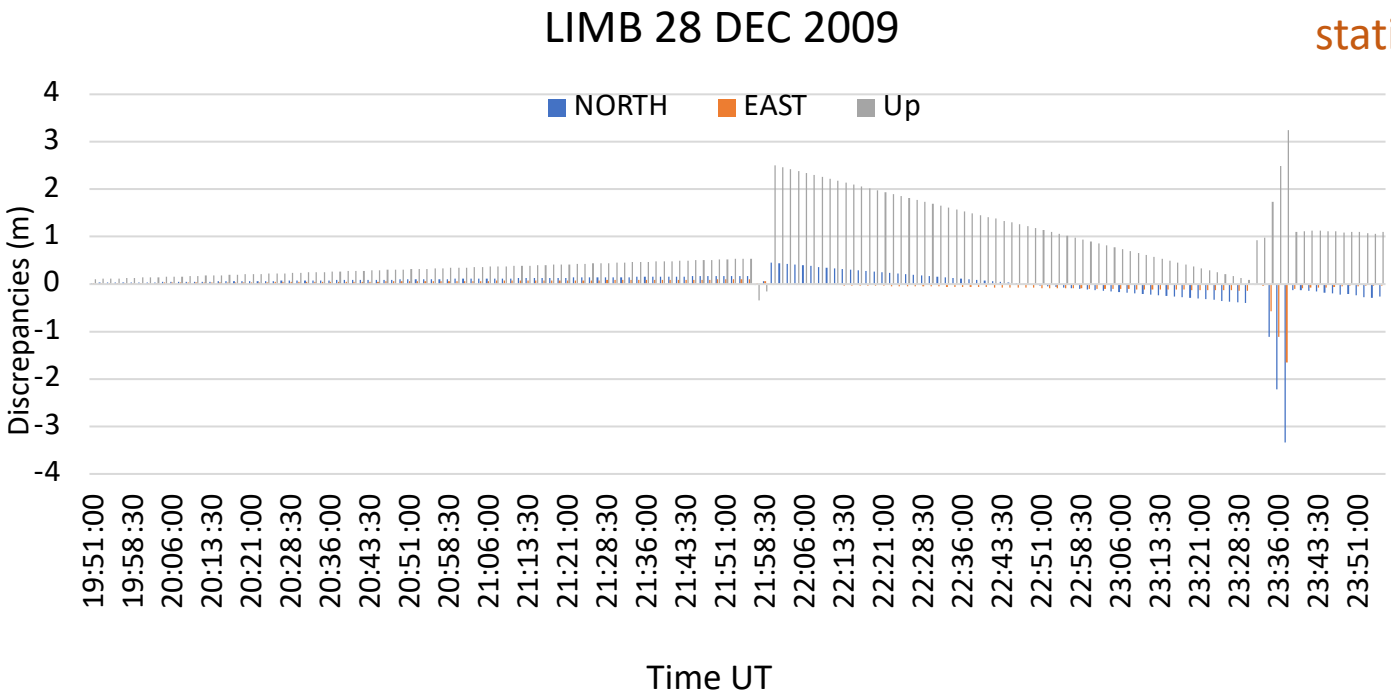

Figure 12. Plot of discrepancies of station LIMB on 28 December, 2009.

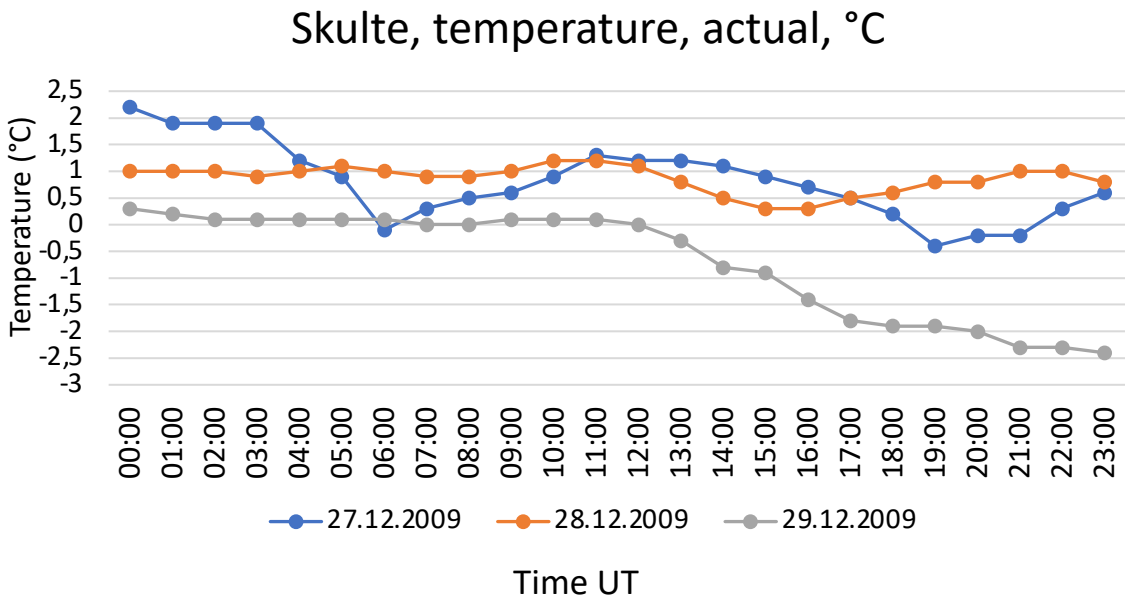

Figure 13. Plot of the Skulte meteo station temperature data on December 27th, 28th and 29th, 2009

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Stations DAU1 (DAUG) and LIMB in LatPos network (2007-2017)

Results

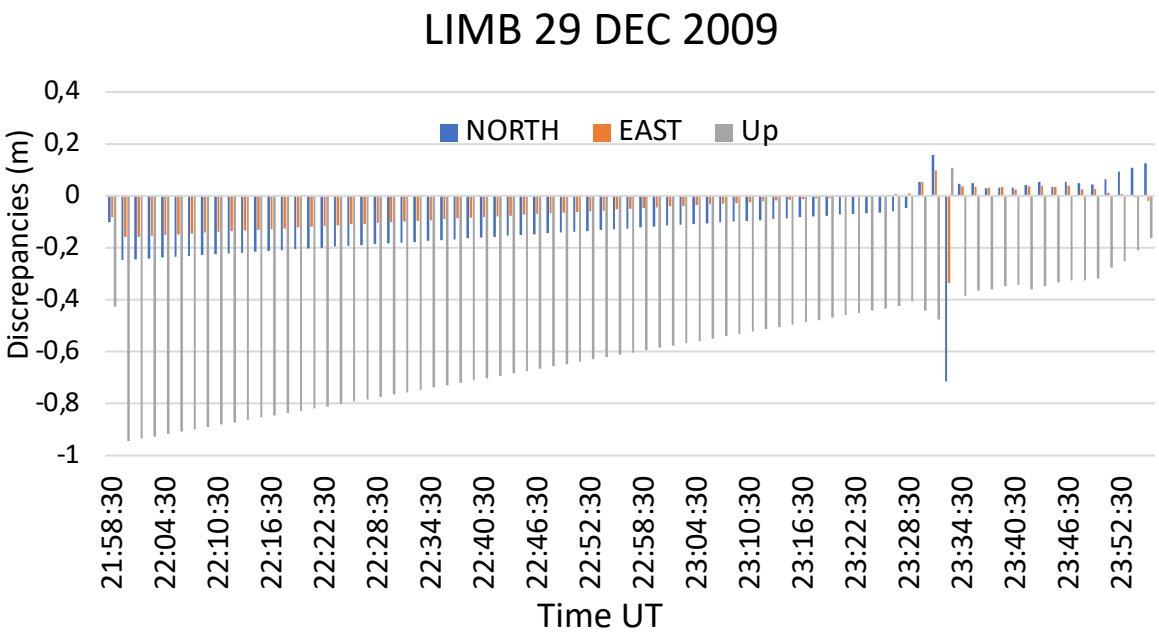

Figure 14. Plot of discrepancies of station LIMB on 29 December, 2009

/Skulte is the nearest meteo station of CORS LatPos network station LIMB/

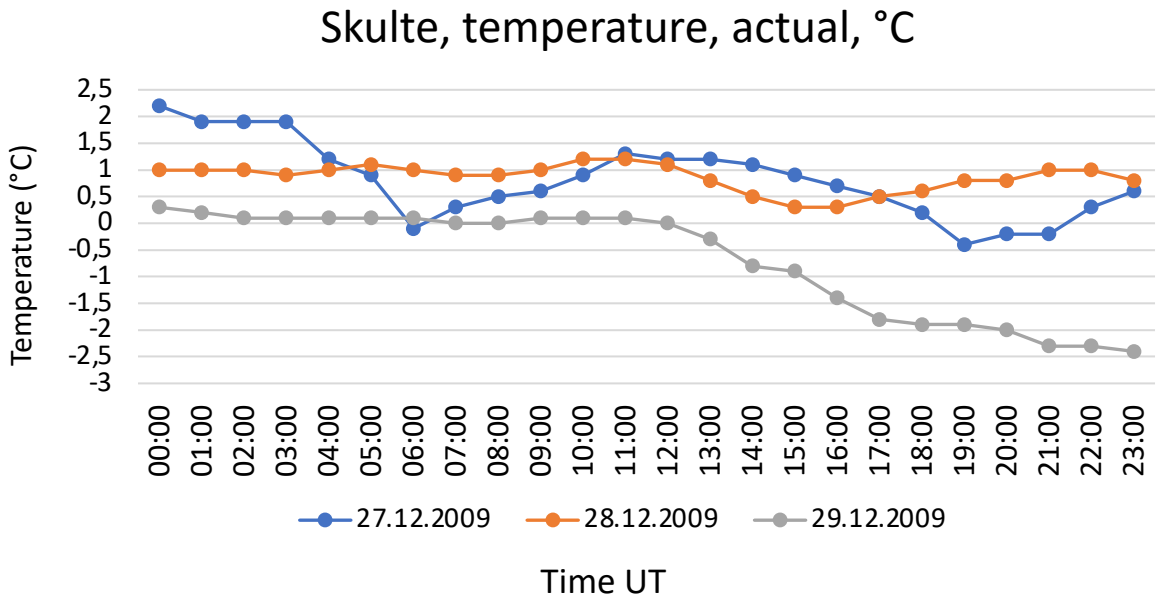

Figure 15. Plot of the Skulte meteo station temperature data on December 27th, 28th and 29th, 2009

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Stations DAU1 (DAUG) and LIMB in LatPos network (2007-2017)

Results

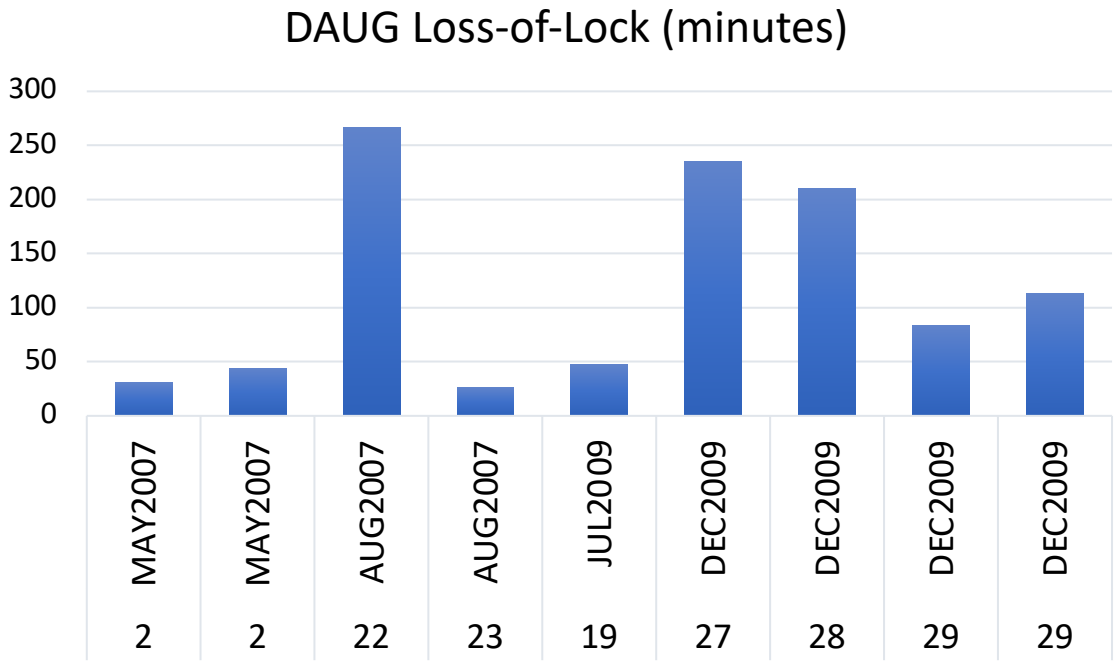

Figure 16. DAUG Loss-of-Lock (minutes).

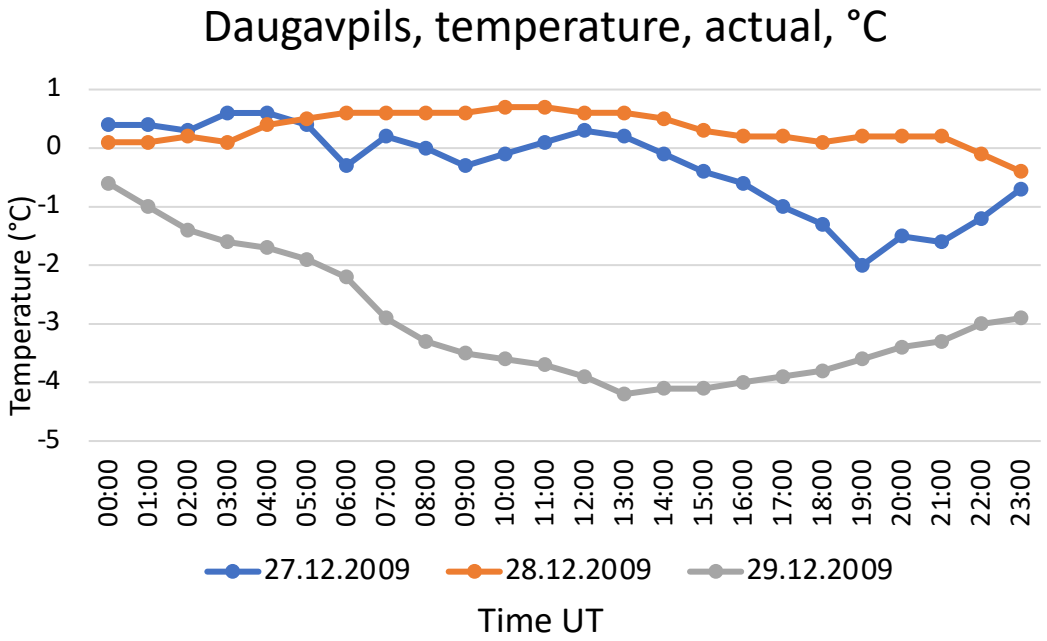

Figure 17. Plot of the Daugavpils meteo station temperature data on December 27th 28th and 29th, 2009

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Conclusions

- There are much more occasions of Loss-of-Lock for IGS/EPN station RIGA and for a set of EUPOS-RIGA stations. However, this was not considered in current report;
- DAU1 (DAUG) and LIMB station 90-second kinematic coordinate time series has significantly highest number of discrepancies and Loss-of Lock situations amongst LatPos stations. There could be several reasons for the behavior of DAU1 (DAUG) and LIMB stations, considering that they must be mostly of local nature except of **December 2009** and **17 March, 2015**;
- 27, 28, 29 December 2009 – probably HALO phenomena (LIMB, DAUG);
- 17 March 2015 St. Patrick's geomagnetic storm (DAU1);
- Deformations/vibrations of buildings, deformations of mounting (DAUG);
- Malfunctioning of receiver/antenna due to the interference of outer source (jamming, electronic disturbances);
- DAU1 remote site at the edge of LatPos network – weaker mutual control capabilities in system.

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Stations DAU1 (DAUG) and LIMB in LatPos network (2007-2017)

THANK YOU!

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