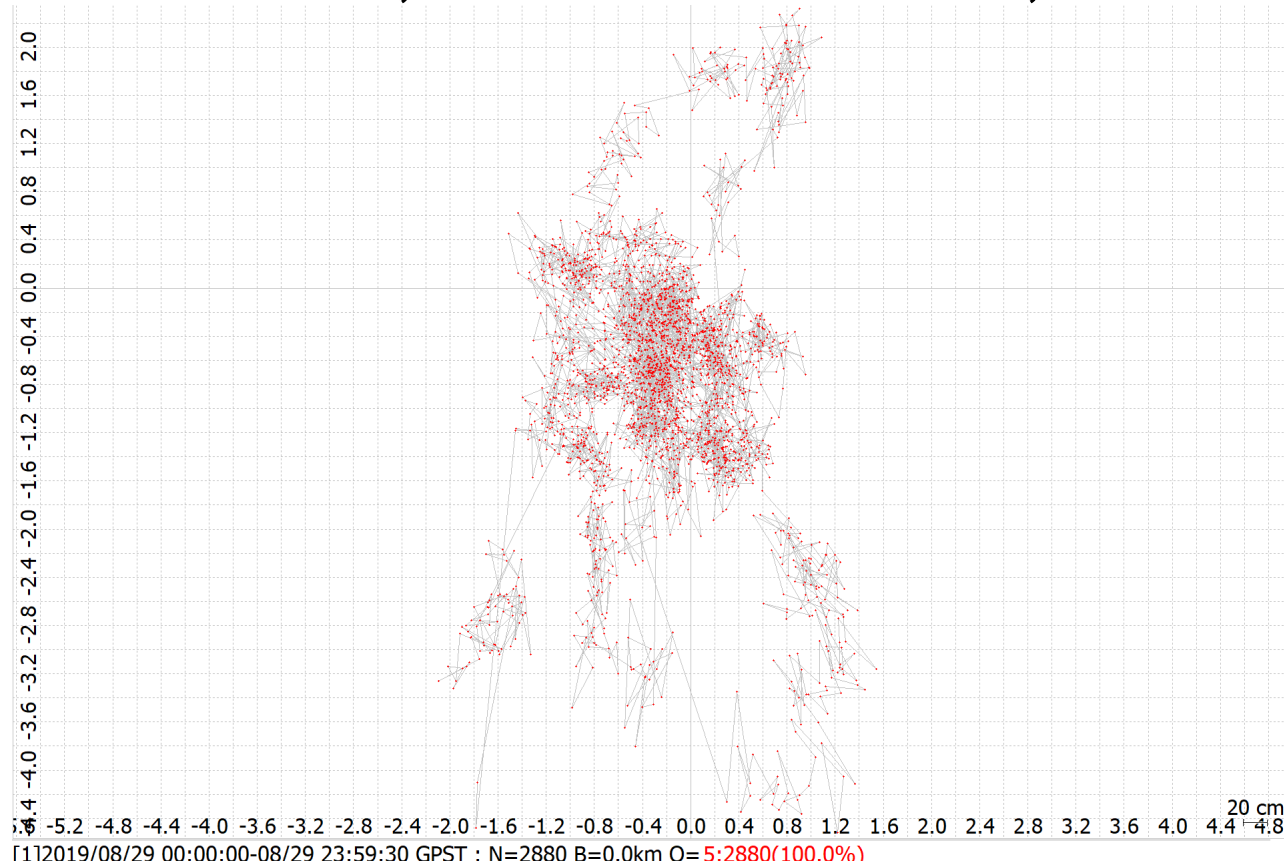


United Nations/Mongolia Workshop on the Applications of Global Navigation Satellite Systems Ulaanbaatar, Mongolia

25th October, 2021 - 29th October, 2021



A Risk Assessment of Geomagnetic Conditions Impact on GPS Positioning Accuracy Degradation in Tropical Regions Using Dst Index

Nenad Sikirica

(Krapina University of Applied Sciences, Krapina, Croatia)

UN/Mongolia Workshop on GNSS Applications, 2021

A Risk Assessment of Geomagnetic Conditions Impact on GPS Positioning Accuracy Degradation in Tropical Regions Using Dst Index Nenad Sikirica, Krapina University of Applied Sciences, Krapina, Croatia

- Content
- Introduction and motivation
- Method
- Data
- Research results
- Discussion
- Conclusion



Source: <http://www.safety4sea.com/north-p-i-club-publishes-new-bridge-guide-on-how-to-avoid-collisions/>

- Based on the conference manuscript made by international team:
- **Sikirica, N**, Dimc, F, Jukić, O, Iliev, T B, Špoljar, D, Filjar, R. (2021). A Risk Assessment of Geomagnetic Conditions Impact on GPS Positioning Accuracy Degradation in Tropical Regions Using Dst Index. Proc ION ITM 2021, 606 -615. San Diego, CA. doi: 10.33012/2021.17852

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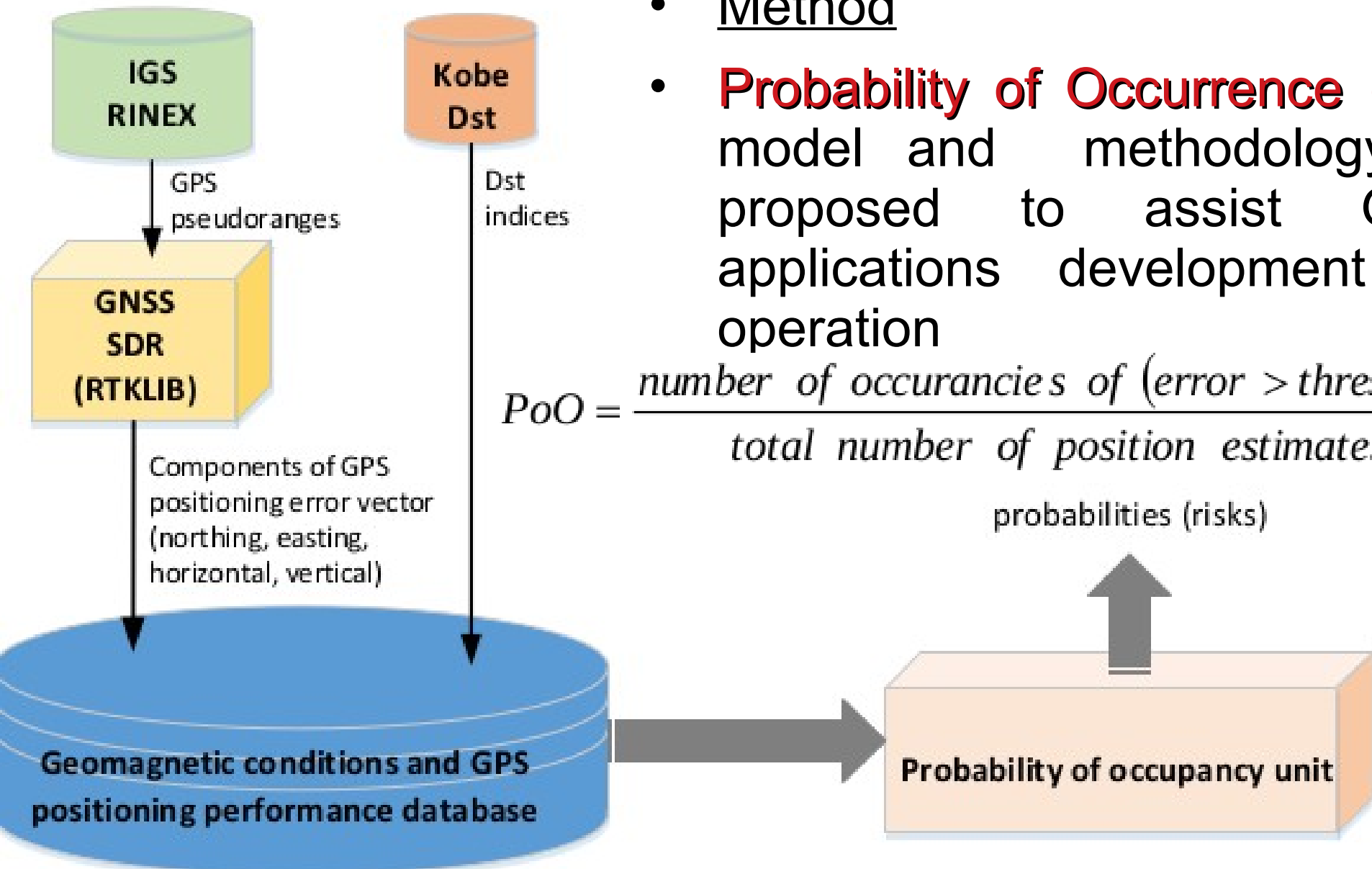
- Introduction and motivation
- **Problem: GNSS utilisation risk assessment from perspective of a GNSS application – how to map PNT performance onto GNSS application Quality of Service?**
- Problem sources: **Geometric Dilution of Precision (GDOP)**, **GNSS positioning environment** (space weather, geomagnetic, ionospheric conditions, tropospheric conditions, local topography, multipath), **artificial sources of disturbances** (jamming, spoofing, meaconing)
- Requirements for GNSS resilience for provision of robust and sustainable GNSS applications with service guarantees

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Accuracy Degradation in Tropical Regions Using Dst Index

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- Method
- **Probability of Occurrence (PoO)** model and methodology are proposed to assist GNSS applications development and operation

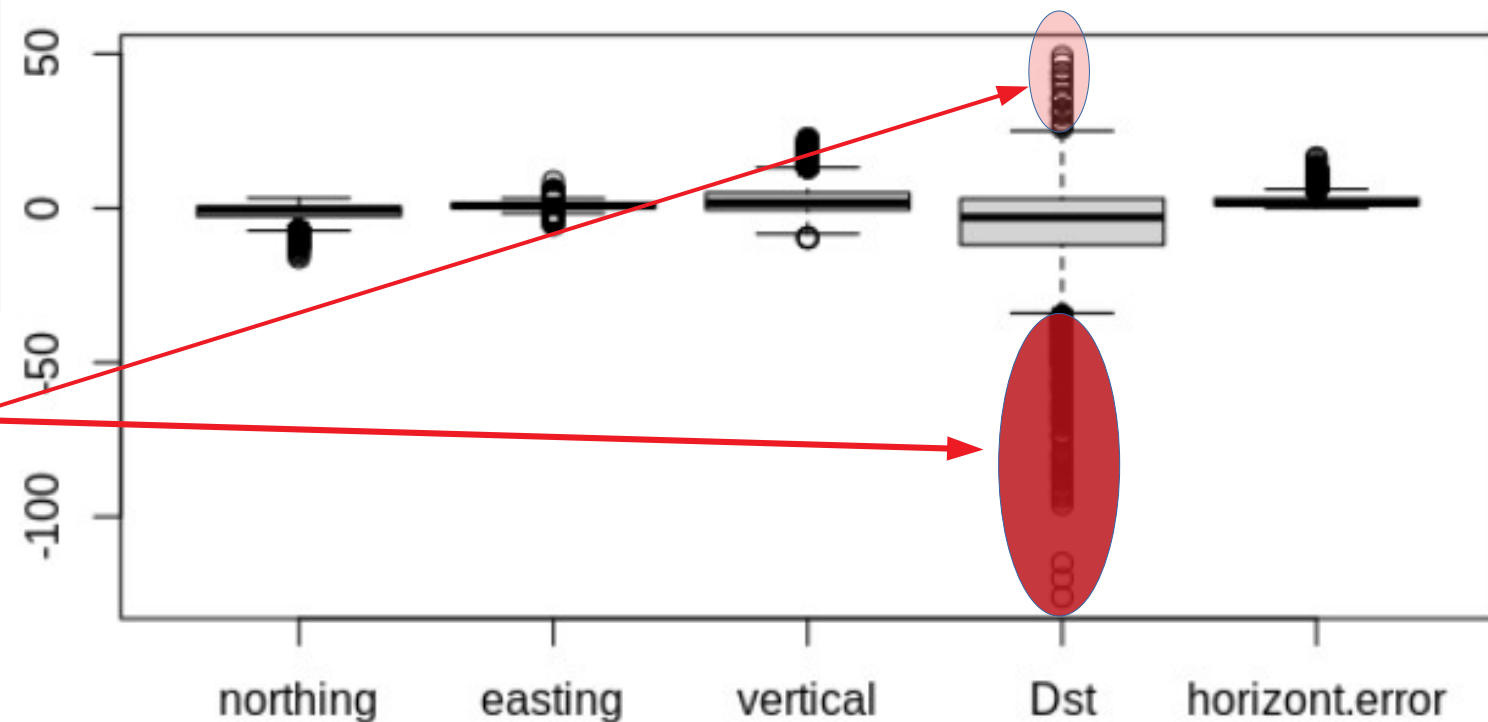
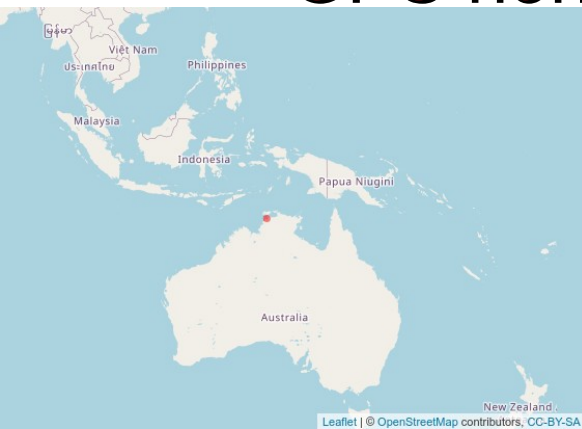
$$PoO = \frac{\text{number of occurrences of (error > threshold)}}{\text{total number of position estimates}}$$

probabilities (risks)

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- Material
- A massive set of 4917 hourly observations of GNSS pseudoranges and **Dst** index at Darwin, NT in 2014
- **GPS horizontal errors** derived from single-GPS pseudoranges



Analysis of annual Dst outliers points to disturbing geomagnetic events

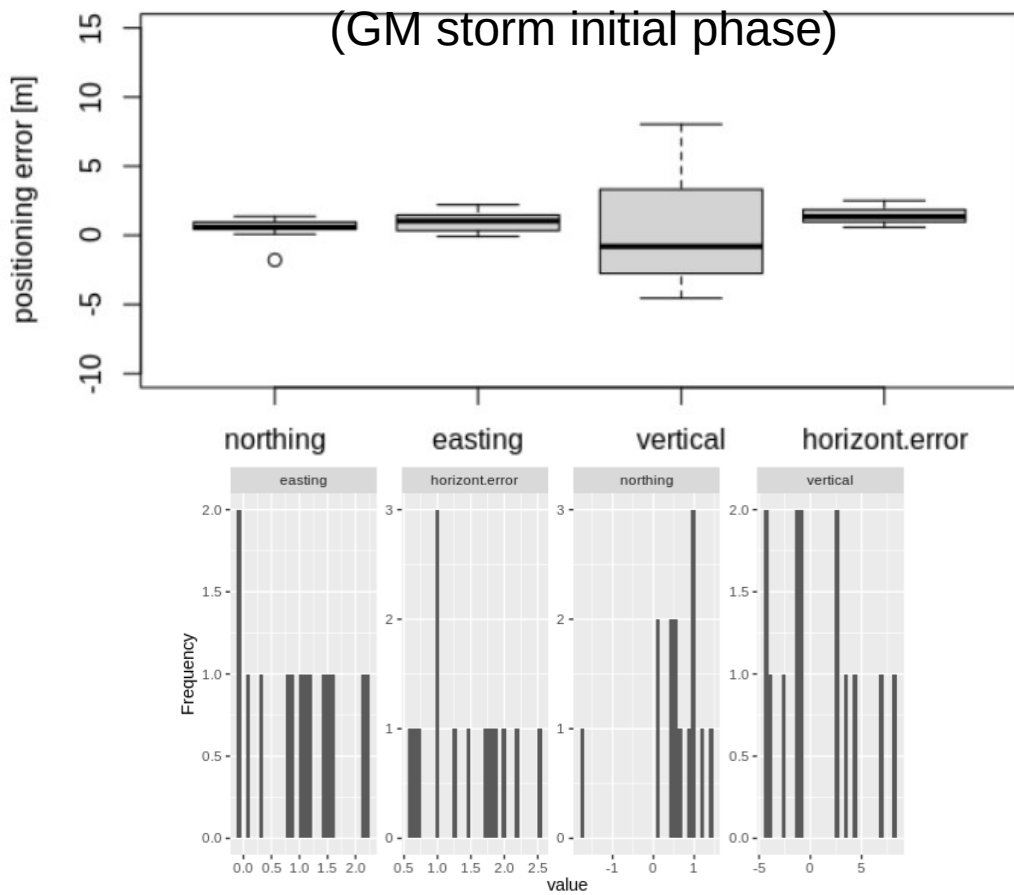
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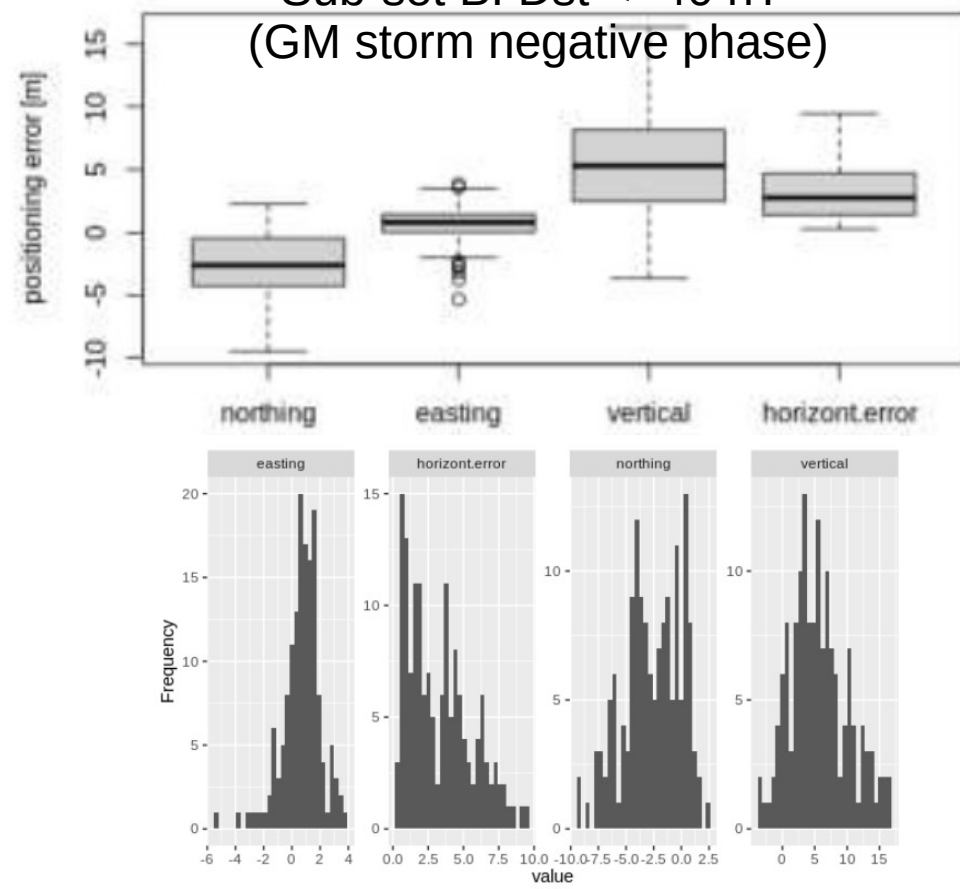
Nenad Sikirica, Krapina University of Applied Sciences, Krapina, Croatia

- Research results
- Original database of annual observations is sub-setted according to Dst outlier analysis

Sub-set A. Dst > 30 nT
(GM storm initial phase)



Sub-set B. Dst < -40 nT
(GM storm negative phase)



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- Research results
- The sub-sets are used for PoO estimation through GPS horizontal error occurrence counts

Table 1: Counts-based Subset A Probability of Occurrence estimates for selected GPS positioning error levels

Horizontal error exceeding:	1 m	2 m	5 m	10 m
Number of occurrences	9	2	0	0
PoO (of the subset)	64.29%	14.29%	0.00%	0.00%

Table 2: Counts-based Subset B Probability of Occurrence estimates for selected GPS positioning error levels

Horizontal error exceeding:	1 m	2 m	5 m	10 m
Number of occurrences	125	93	33	0
PoO (of the subset)	82.78%	61.59%	21.85%	0.00%

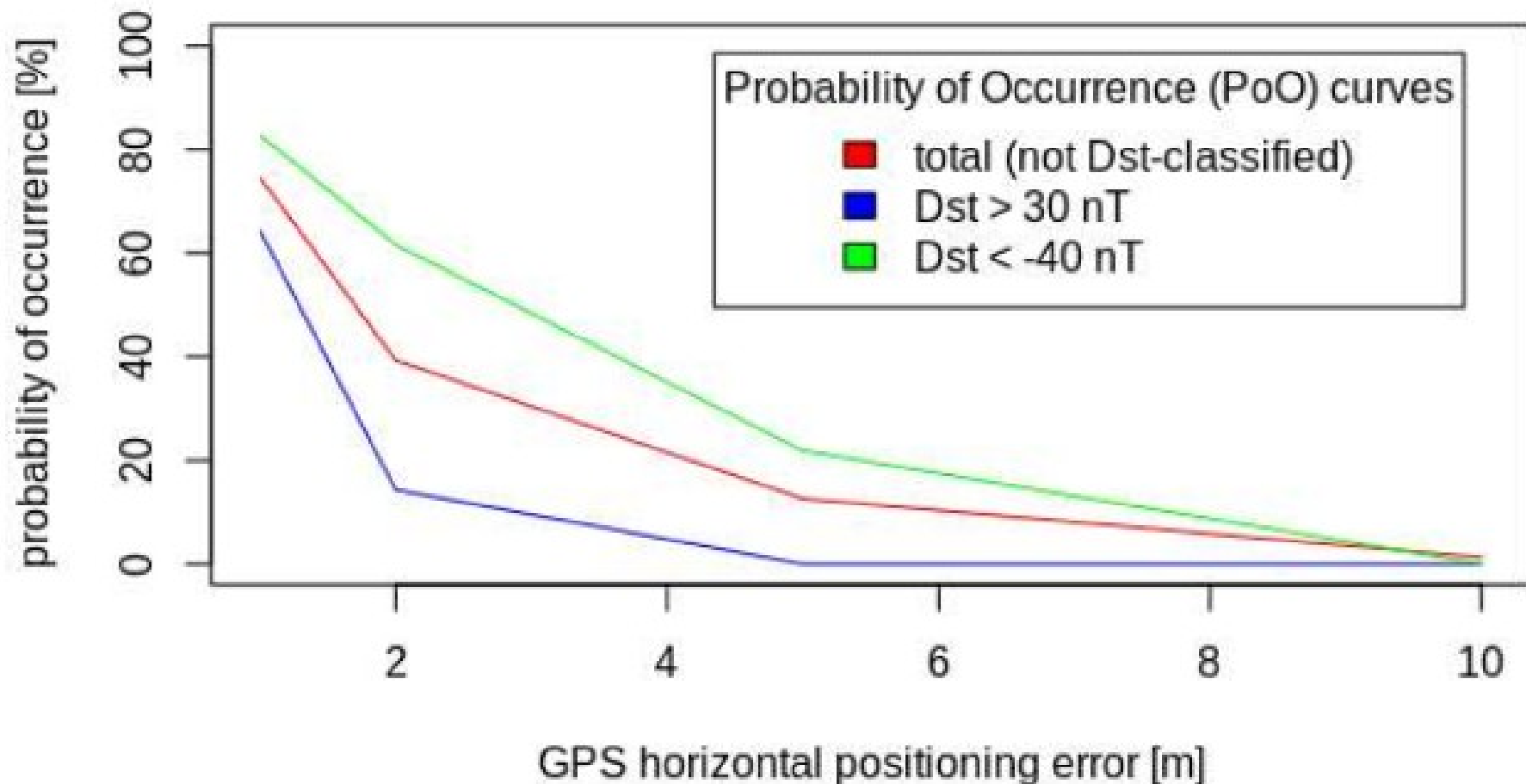
Table 3: Counts-based population Probability of Occurrence estimates for selected GPS positioning error levels

Horizontal error exceeding:	1 m	2 m	5 m	10 m
Number of occurrences	3706	1953	627	64
PoO (in total set of 4971 observations)	74.55%	39.29%	12.61%	1.29%

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- Research results
- PoO diagrams in various classes of geomagnetic field disturbance



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- Discussion and recommendations
- Probability of Occurrence (PoO) is introduced as a measure of risk of GNSS horizontal positioning error degradation
- PoO model development methodology is proposed, and demonstrated in the case of risk assessment in tropical regions using Dst index (Darwin, NT data)
- Proposed PoO aims at assisting GNSS applications developers in quantification of Quality of Service degradation risk due to vulnerabilities of GNSS as an underlying technology

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APPRECIATE YOUR ATTENTION.

DO STAY WELL AND SAFE!

Nenad Sikirica, MRIN

Dean

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