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Positioning and integrity monitoring using the new DFMC SBAS service in the road transport

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Second-Generation SBAS

Augmentation system to support positioning not only in aviation, but also in transport, precision agriculture, maritime, surveying, etc.

- Test-bed developed by:



- Managed by:



Second-Generation SBAS

Service and Solution types (non-aviation mode)

Solution types	GNSS signals	SBAS augmentation
L1 SBAS	GPS (L1) + (Galileo E1)	GPS
DFMC SBAS	GPS (L1+L5) + Galileo (E1+E5a)	GPS + Galileo
PPP over L5	GPS (L1+L5) + Galileo (E1+E5a)	GPS + Galileo
PPP over L1	GPS (L1+L5)	GPS

Features:

- Precise satellite orbits and clocks in real-time
- Free-of-charge
- Support single-receiver dual-frequency GPS+Galileo positioning

New weighting model

- $l(t_i)$: Carrier-smoothed code observations
- $\hat{x}(t_i)$: Receiver coordinates, receiver clocks (GPS+Galileo)

Applications in road transport → Complicated multipath environment

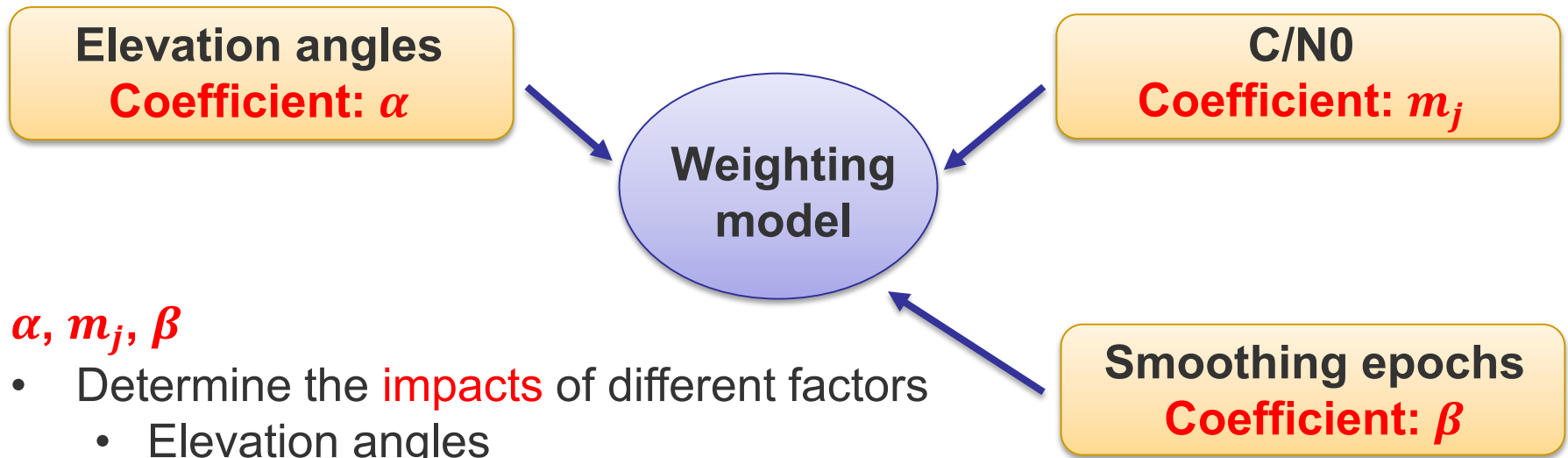
Challenge 1: Multipath at high elevation angles

- C/N0 considered for weighting

Challenge 2: Frequent cycle slips and filter initializations

- Using well smoothed observations → Significant data loss
- Smoothing epochs considered for weighting

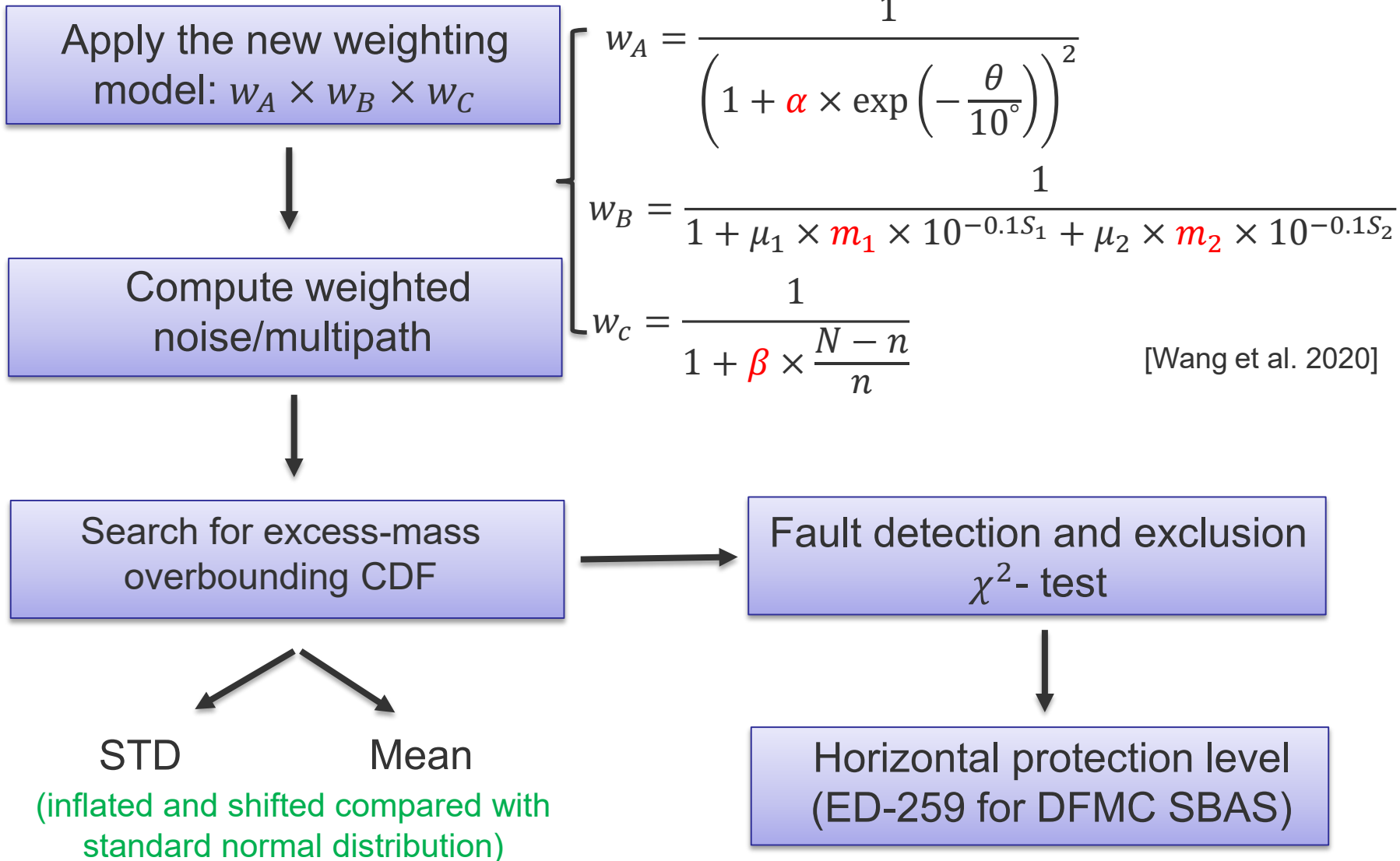
New weighting model



α, m_j, β

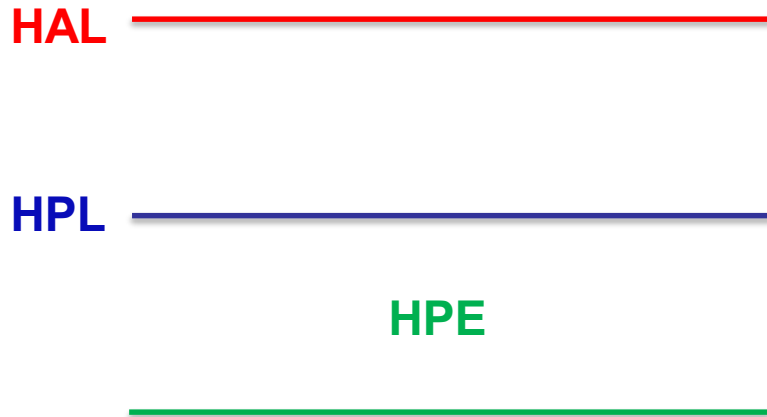
- Determine the **impacts** of different factors
 - Elevation angles
 - C/N0
 - Smoothing epochs
- Coefficients are empirically searched to **best match** the empirical and formal CDFs of the normalised and weighted noise/multipath
- Investigated for
 - Open-sky, suburban and urban **scenarios**
 - **Smoothing windows** of 300, 600 and 900 s

Integrity monitoring: Overbounding CDF + FDE + HPL



Horizontal protection level

- Computed in the direction along the **semi-major axis** of the horizontal error ellipse
- **Bound** the horizontal positioning error (**HPE**) with a pre-defined PHMI
- When **exceeding** the horizontal alert limit (**HAL**), **warning** message is sent to user



$$\text{HPL} = K \times \sigma + |T| \times M$$

Determined by the PHMI

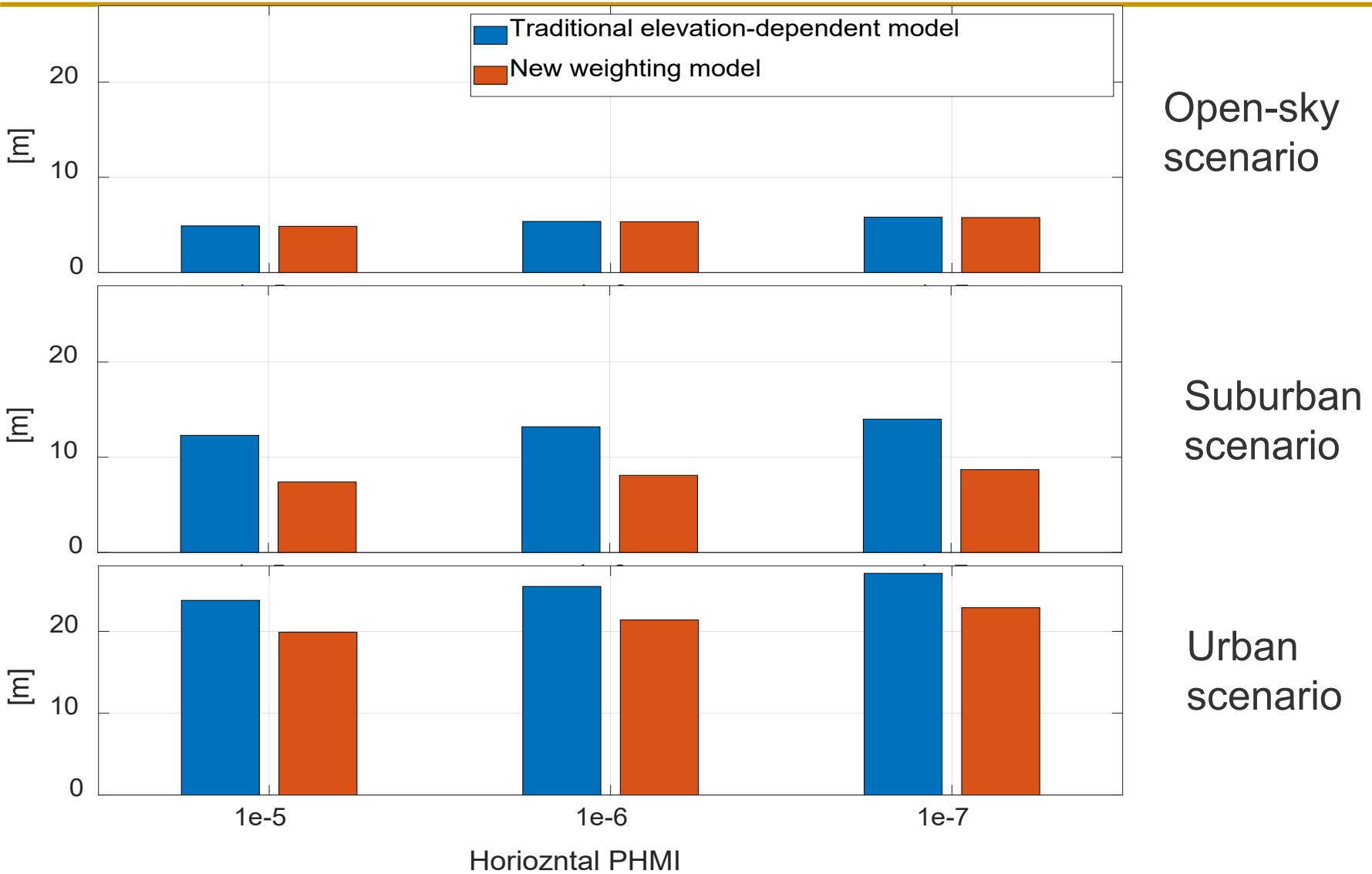
Overbounding mean of noise/multipath mapped into slant direction

Observation → Position domain transformation

Determined by:

- Precision of the satellite clocks/orbits
- STD of unmodelled tropospheric residuals
- STD of remaining ion. effects after forming the IF combination
- Overbounding STD of noise/multipath mapped into slant direction

Mean HPL



Questions

Reference:

Wang K., El-Mowafy A., Rizos C., Wang J. (2020) SBAS DFMC service for Road Transport: Positioning and integrity monitoring with a new weighting model. Journal of Geodesy, under review.



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