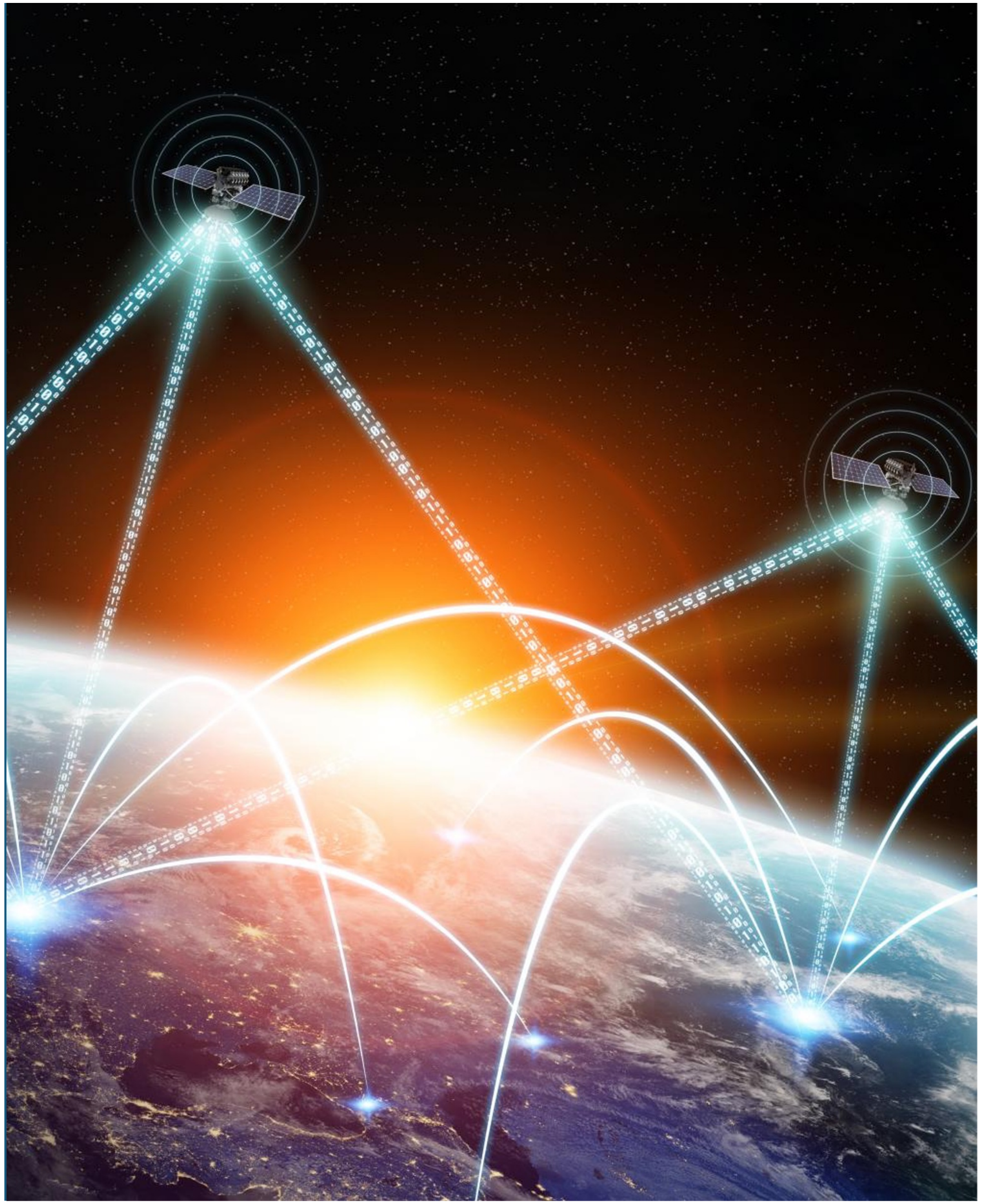
Short talk



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Effect of PCOs on phase biases

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Satellite PCO model

- Classical model is to estimate frequency-independent satellite PCO by IGS ACs
  - Earlier GPS, GLONASS satellites
- Spacecraft manufacturers tend to provide trustworthy frequency-specific PCO calibrations
  - GPS Block III, Galileo, BDS satellites

G24 (GPS Block IIF)

	X	Y	Z
L1	394.00	0.00	1247.10
L2	394.00	0.00	1247.10

G04 (GPS Block IIIA)

	X	Y	Z
L1	3.80	-18.10	1082.20
L2	3.10	-16.20	590.30

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Effect of satellite PCOs on phase bias

- Frequency-specific PCO effect cannot cancel in the Melbourne-Wübbena combination

$$L_{\mathrm{MW}} = \frac{f_1 L_1 - f_2 L_2}{f_1 - f_2} - \frac{f_1 P_1 + f_2 P_2}{f_1 + f_2}$$

←Melbourne-Wübbena combination

$$s_{\mathrm{MW}} = \frac{f_1 s_1 - f_2 s_2}{f_1 - f_2} - \frac{f_1 s_1 + f_2 s_2}{f_1 + f_2} = \frac{2 f_1 f_2}{f_1^2 - f_2^2}\left(s_1 - s_2\right)$$

←Effect of satellite PCO

- s_{MW} become zero only when PCO (*i.e.*, s_1 and s_2) are equal on the two frequencies

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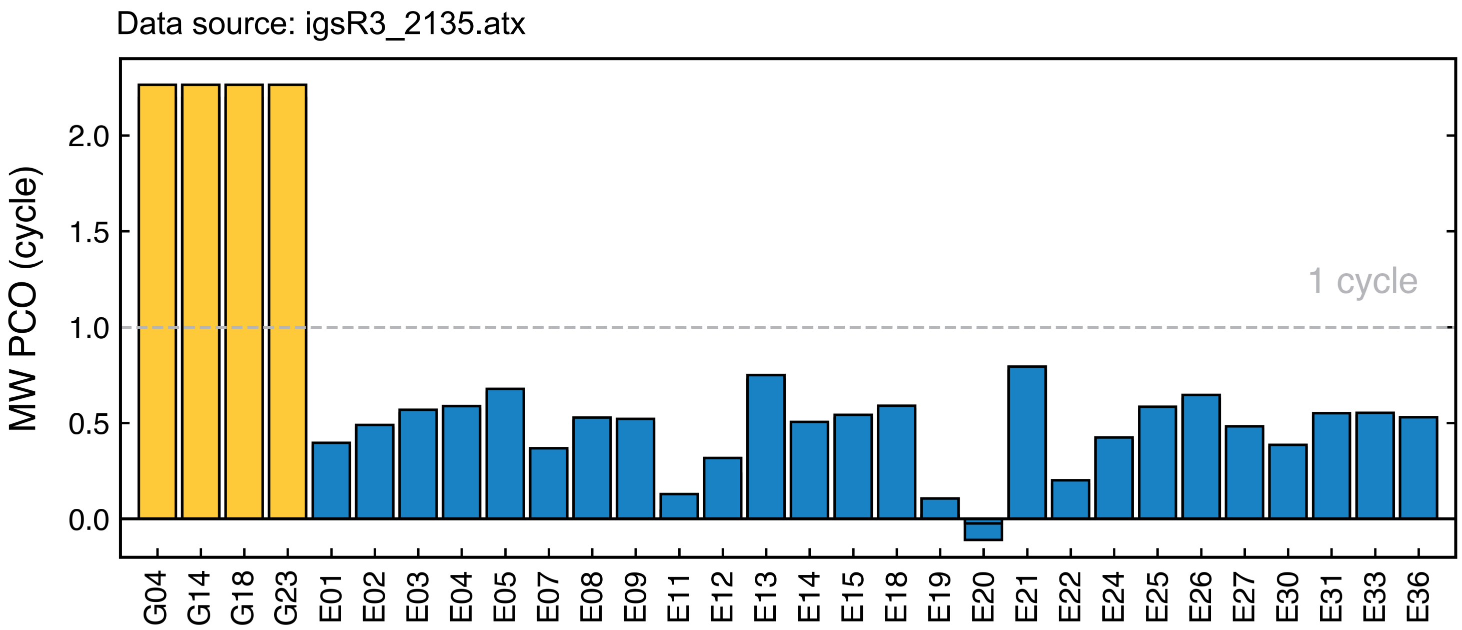
Effect of satellite PCOs on phase bias

- The PCO effect on the Melbourne-Wübbena ranges from 0.1 to 2.3 cycles



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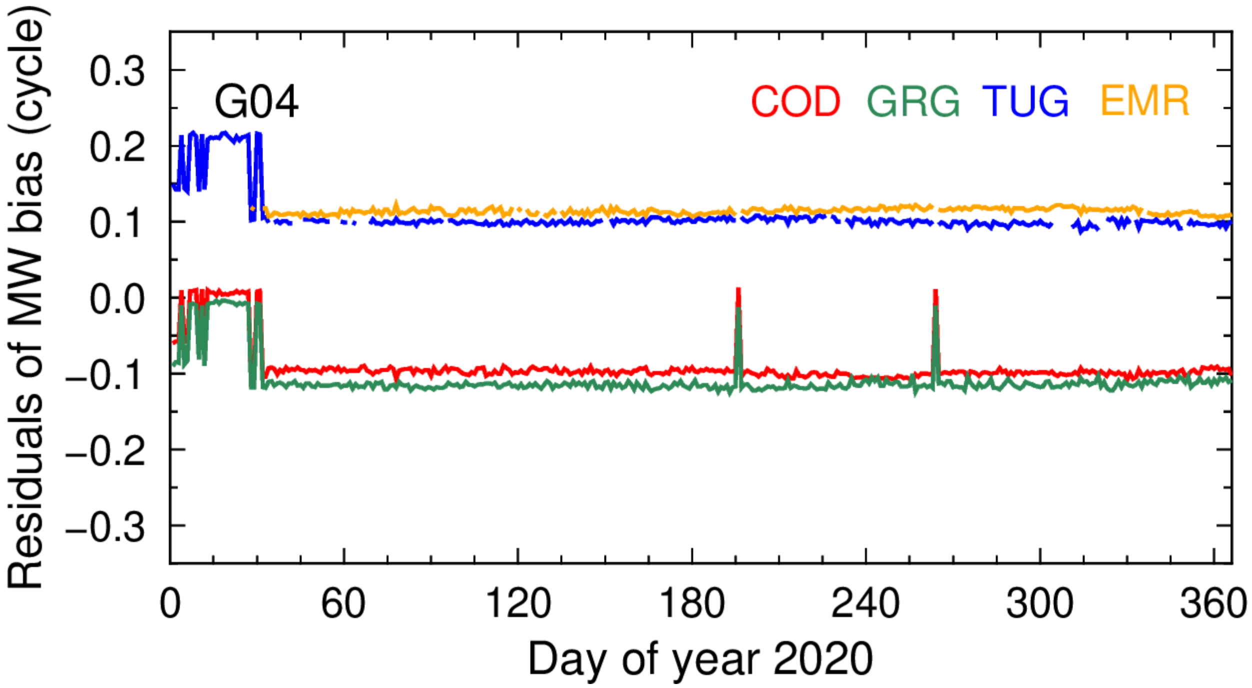
Effect of satellite PCOs on phase bias

- The satellite PCO effects are mostly absorbed into wide-lane phase biases



- PCO corrected
  TUG and EMR
- PCO uncorrected
  COD and GRG

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Effect of satellite PCOs on phase bias

- Such phase bias products cannot be applied to uncombined PPP-AR
  - Wide-lane ambiguities in uncombined PPP are computed by raw ambiguity estimates
- Case study: uncombined PPP-AR at 15 stations for day 4, 2020 using Wuhan phase bias products with/out PCO corrections

	Biases without PCO corrections	Biases with PCO corrections
GPS fixing rate (%)	98.48/93.62	98.46/93.56
Galileo fixing rate (%)	71.53/97.15	98.96/97.84

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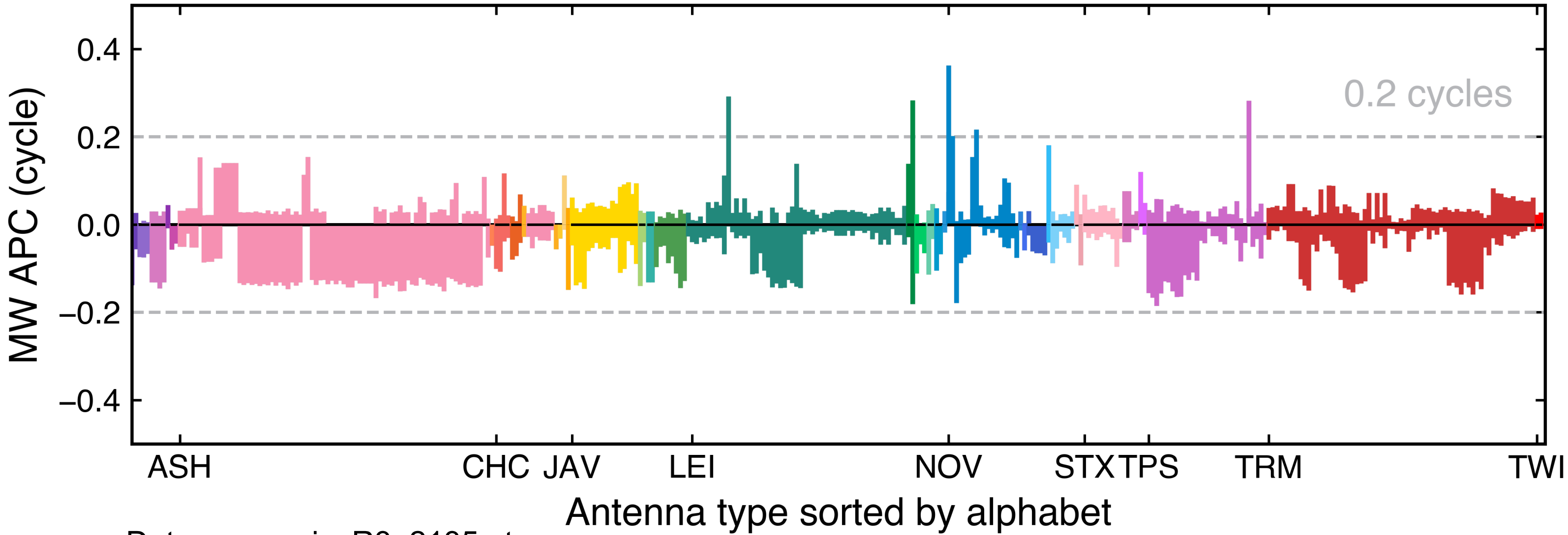
Effect of receiver PCOs on phase bias

- The receiver PCO effects are generally much less significant than the satellite PCO
  - Some exceed 0.2 cycles
- The receiver PCO effect is highly elevation and azimuth dependent



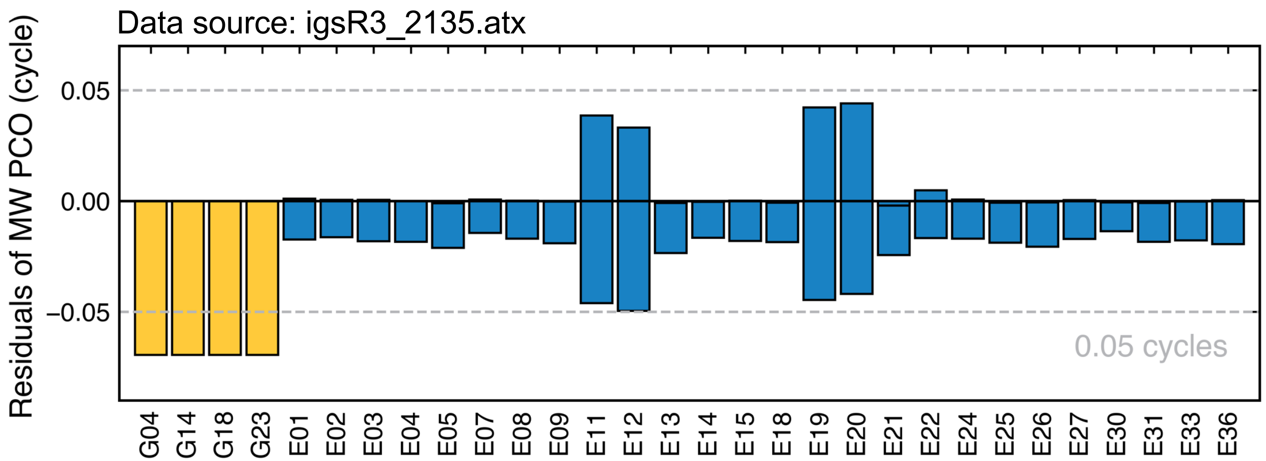
Data source: igsR3_2135.atx

Approximate mitigation of PCO effects

- Approximate the true satellite PCO effect by the difference of frequency-specific *z*-PCO

Time-variable constant

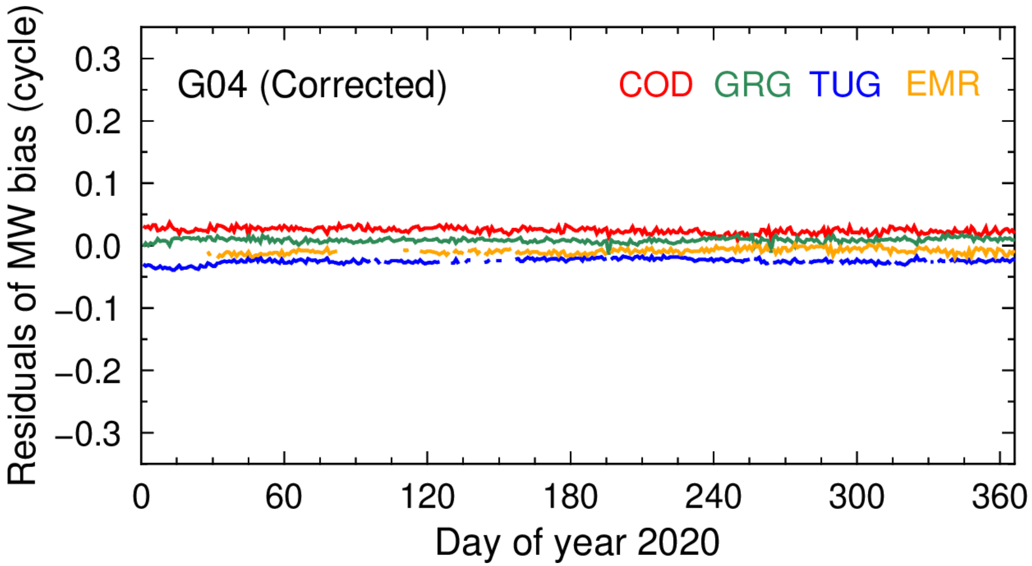
$$s_{\mathrm{MW}} = \frac{2 f_1 f_2}{f_1^2 - f_2^2}\left(s_1 - s_2\right) \approx \frac{2 f_1 f_2}{f_1^2 - f_2^2}\left(z_1 - z_2\right)$$



- The residuals of PCO effects after approximate corrections

Approximate mitigation of PCO effects

- The interoperability between wide-lane biases from different ACs can be recovered
- The consistency among the corrected wide-lane biases are less than 0.03 cycles



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Summary

- The frequency-specific PCO effect cannot cancel in the Melbourne-Wübbena combination
  - Phase biases without correcting for PCO cannot be applied to uncombined PPP-AR
  - The interoperability between phase biases from different ACs might be corrupted
- The PCO effect on wide-lane biases can be mitigated by a *z*-PCO approximation strategy
- ACs are recommended to correct for PCO effects fully in their every observation modeling with no exception
  - For a rigorous processing, receiver PCO effects should also be corrected though