



Kartverket

# Modelling and Correction of Carrier Phase Multipath Effects

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# Outline

**Introduction**

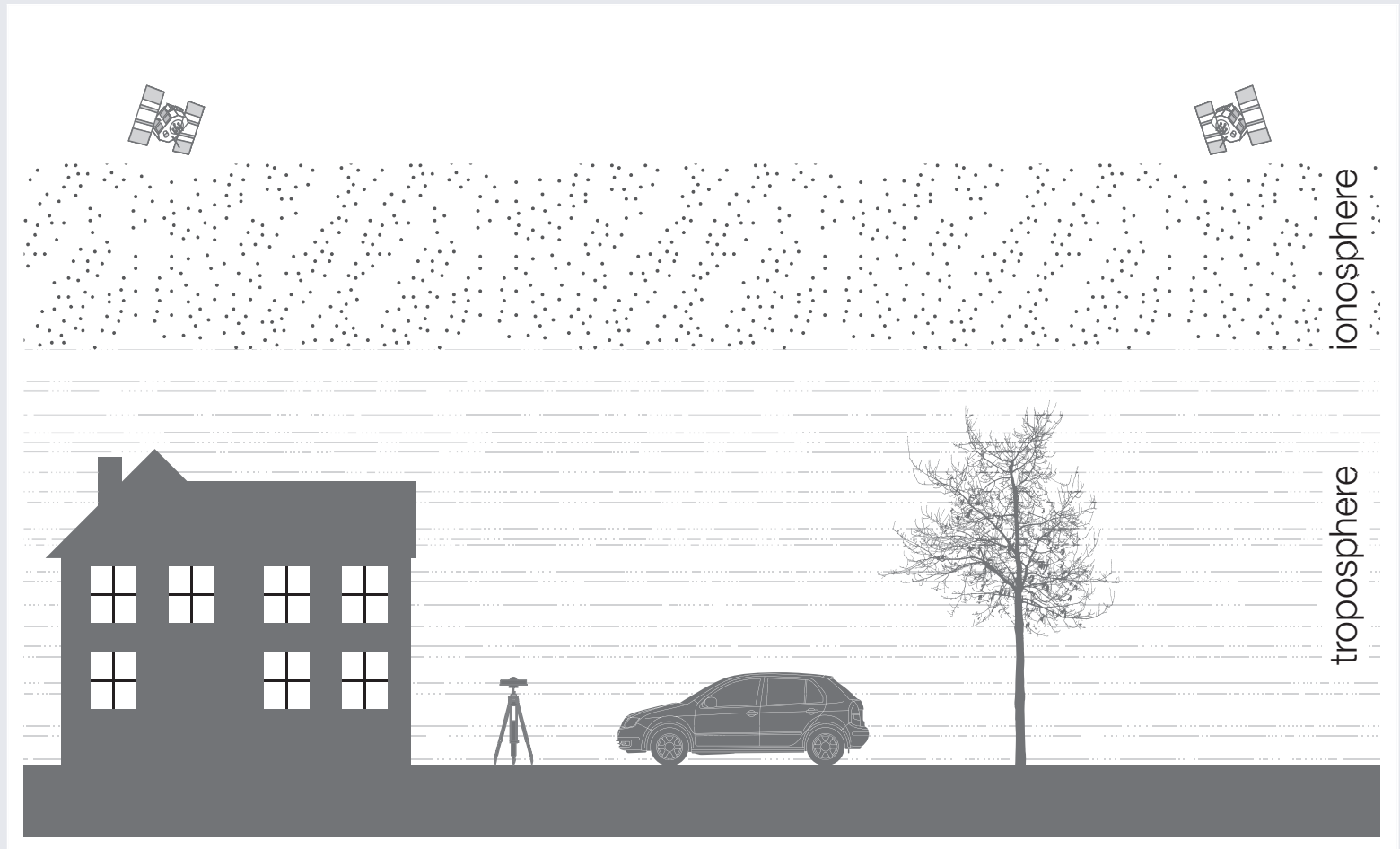
**Multipath influence**

**Modelling and Correction**

**Conclusions**

# Motivation

## STATION DEPENDENT MULTIPATH EFFECT



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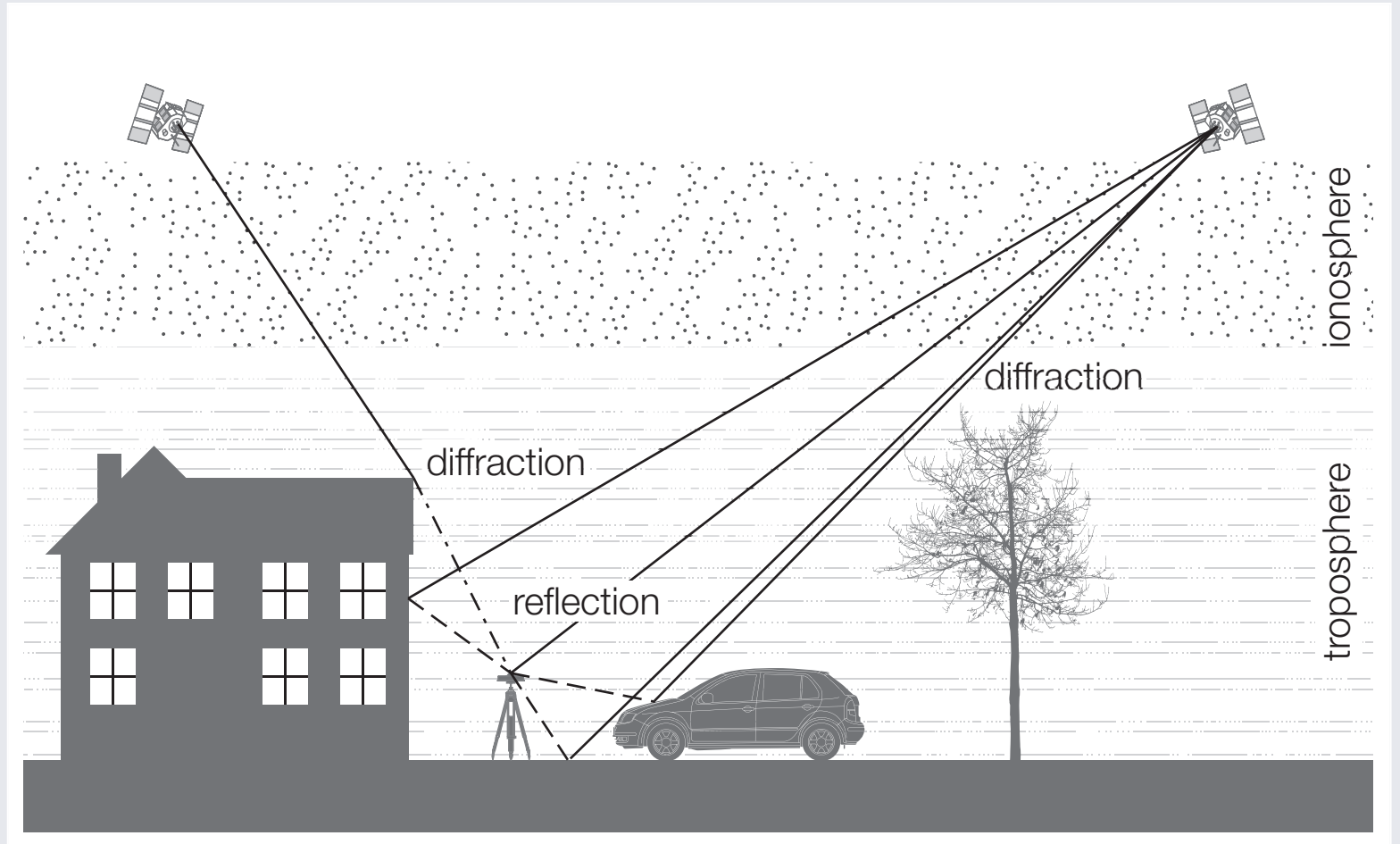
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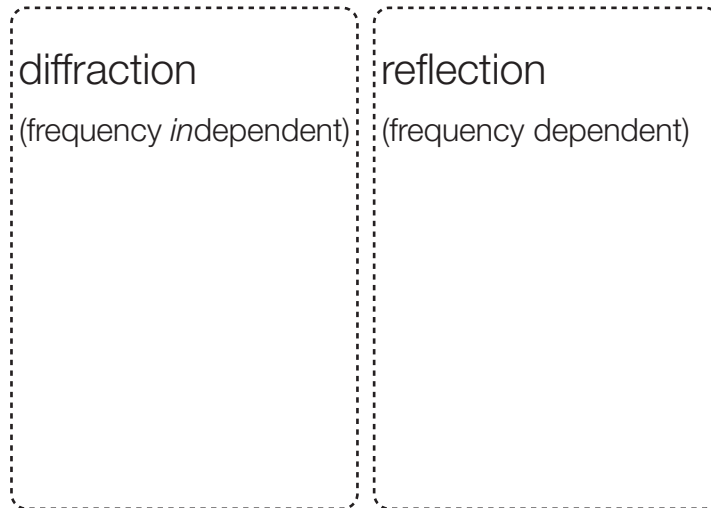
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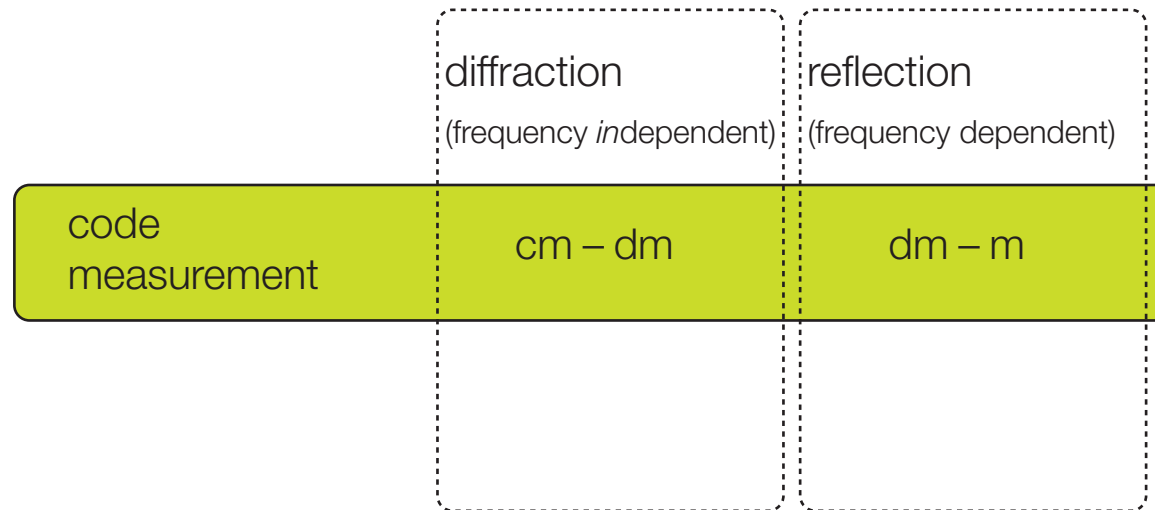
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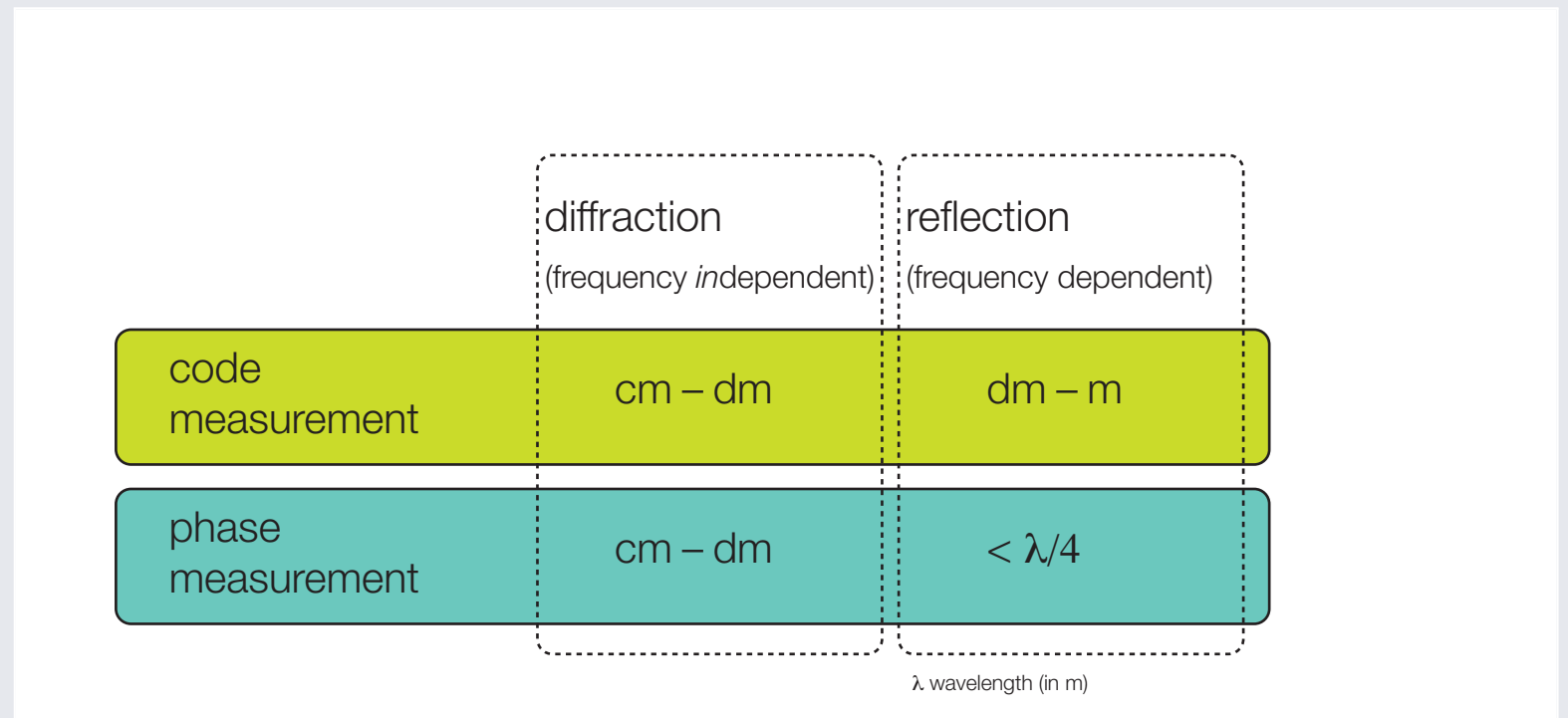
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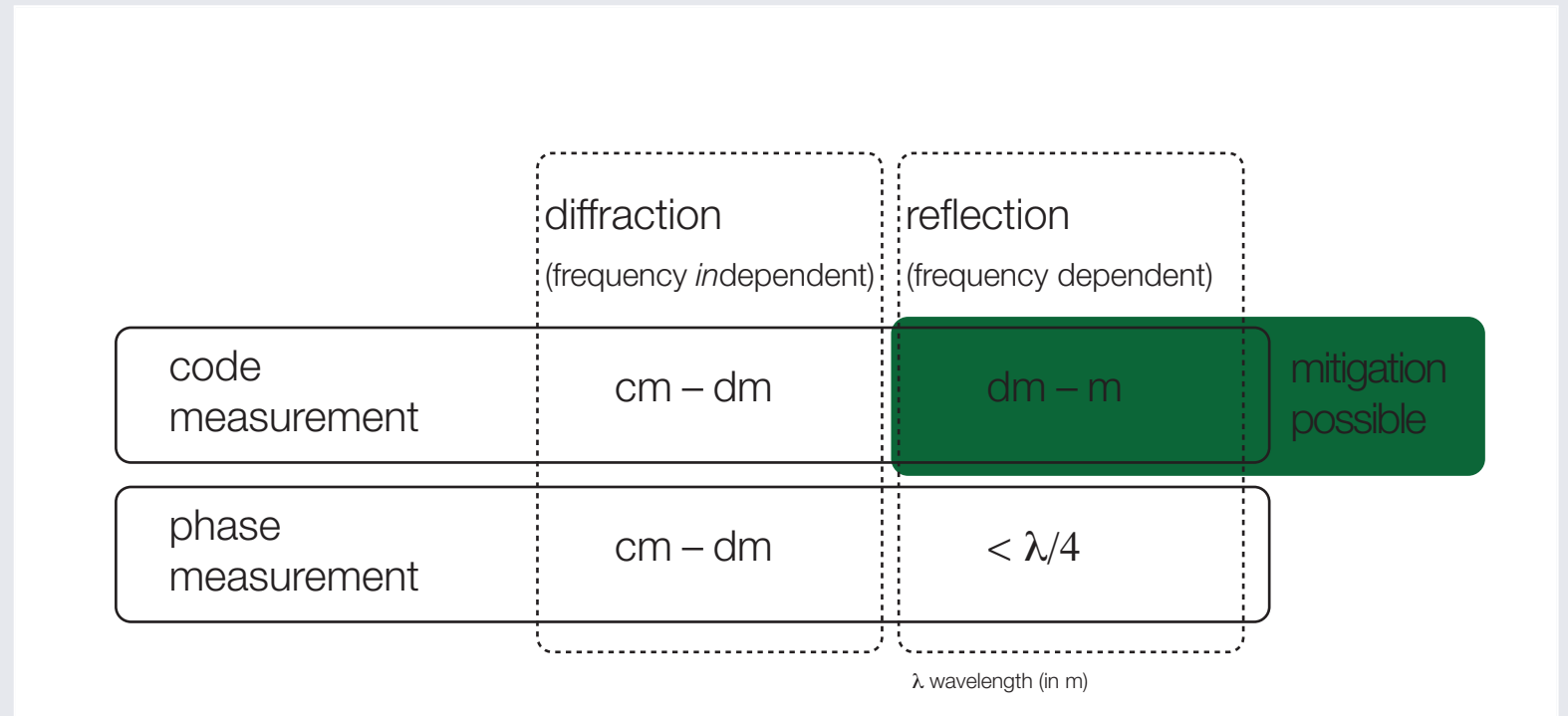
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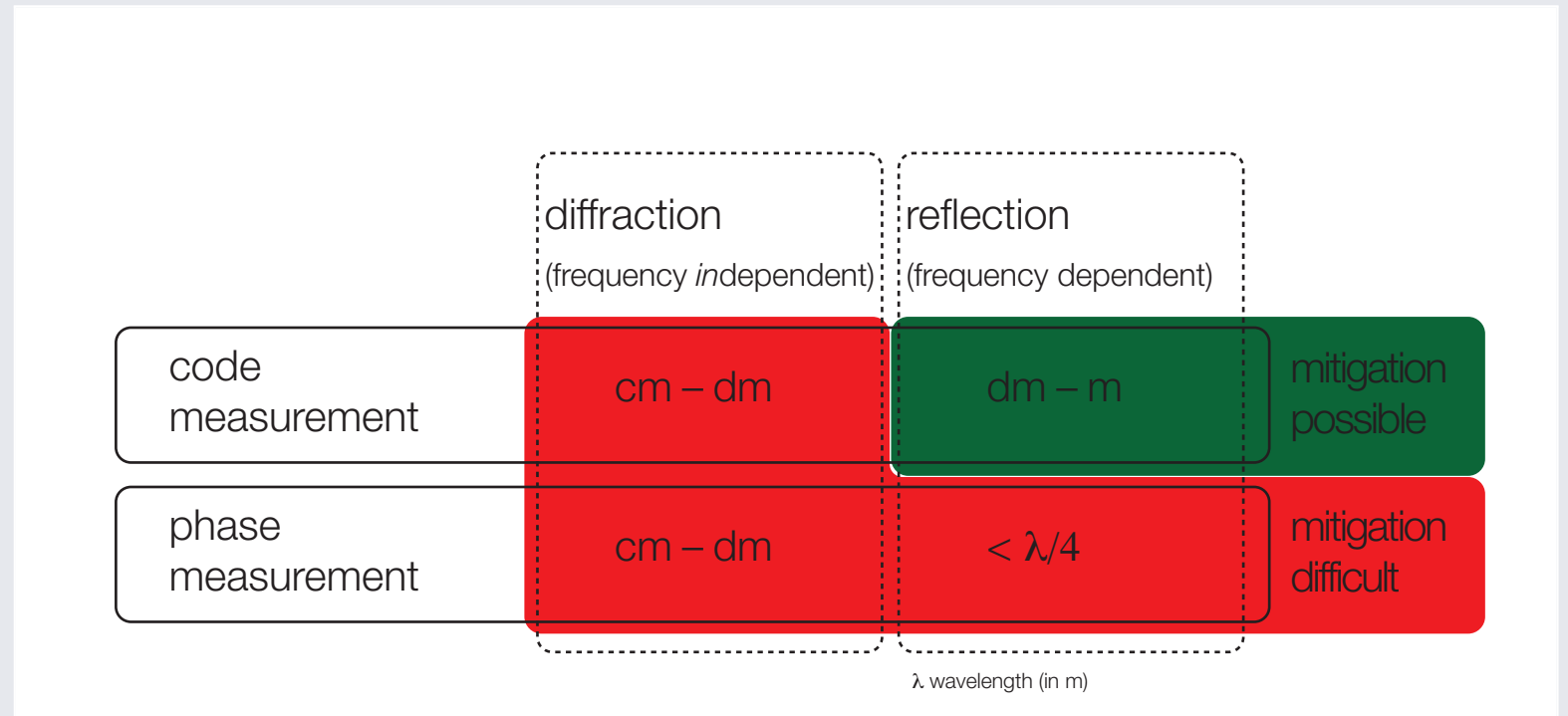
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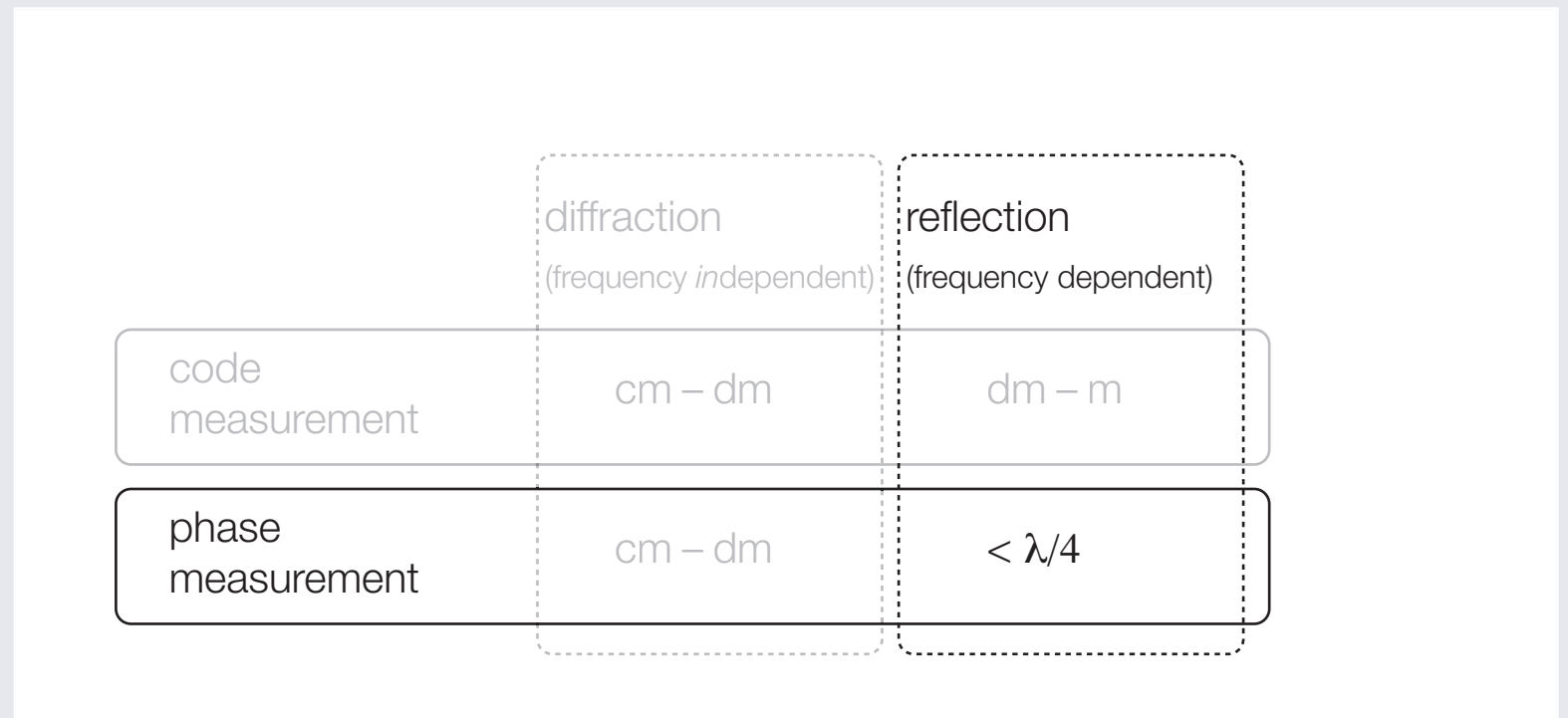
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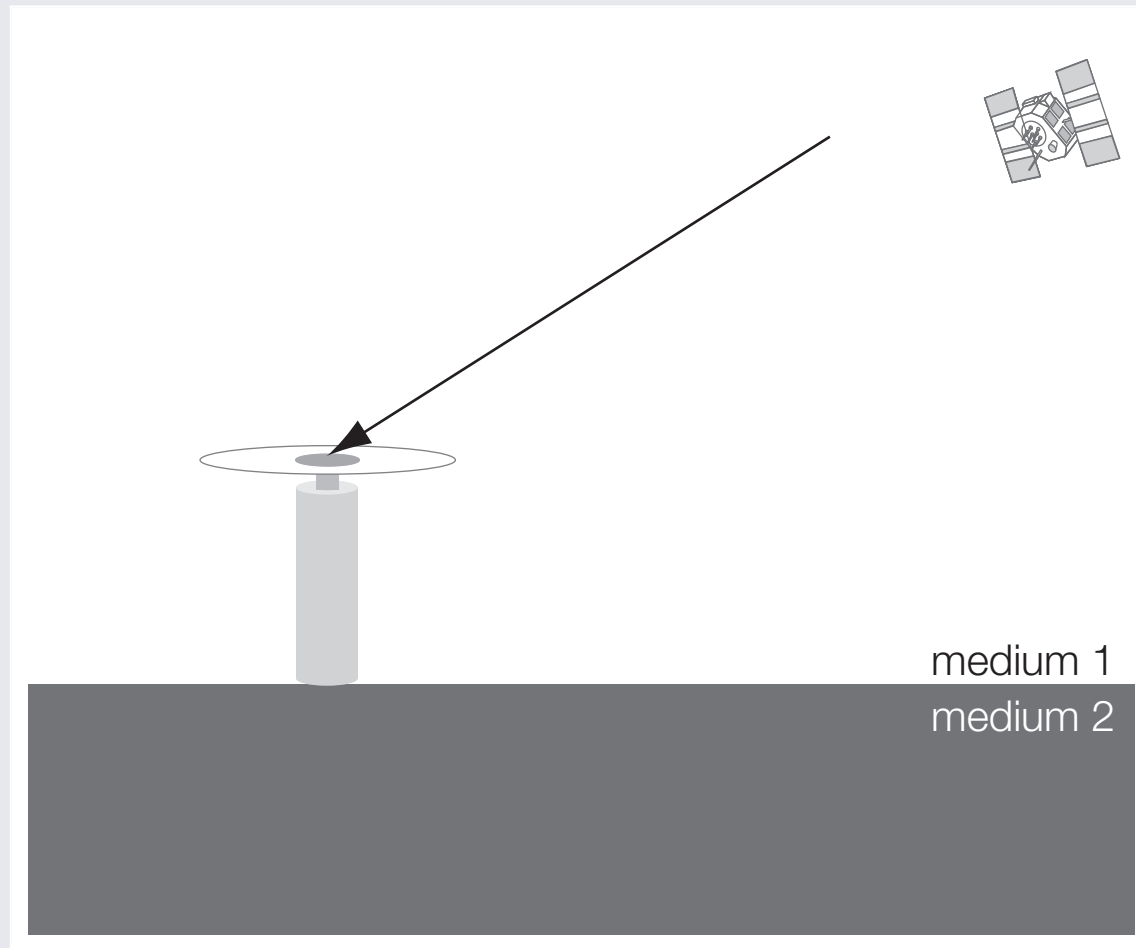
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# Multipath geometry – additional path length

## ”IDEAL SCENARIO” – SIMPLE RAY GEOMETRY



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Additional path length

Simulation

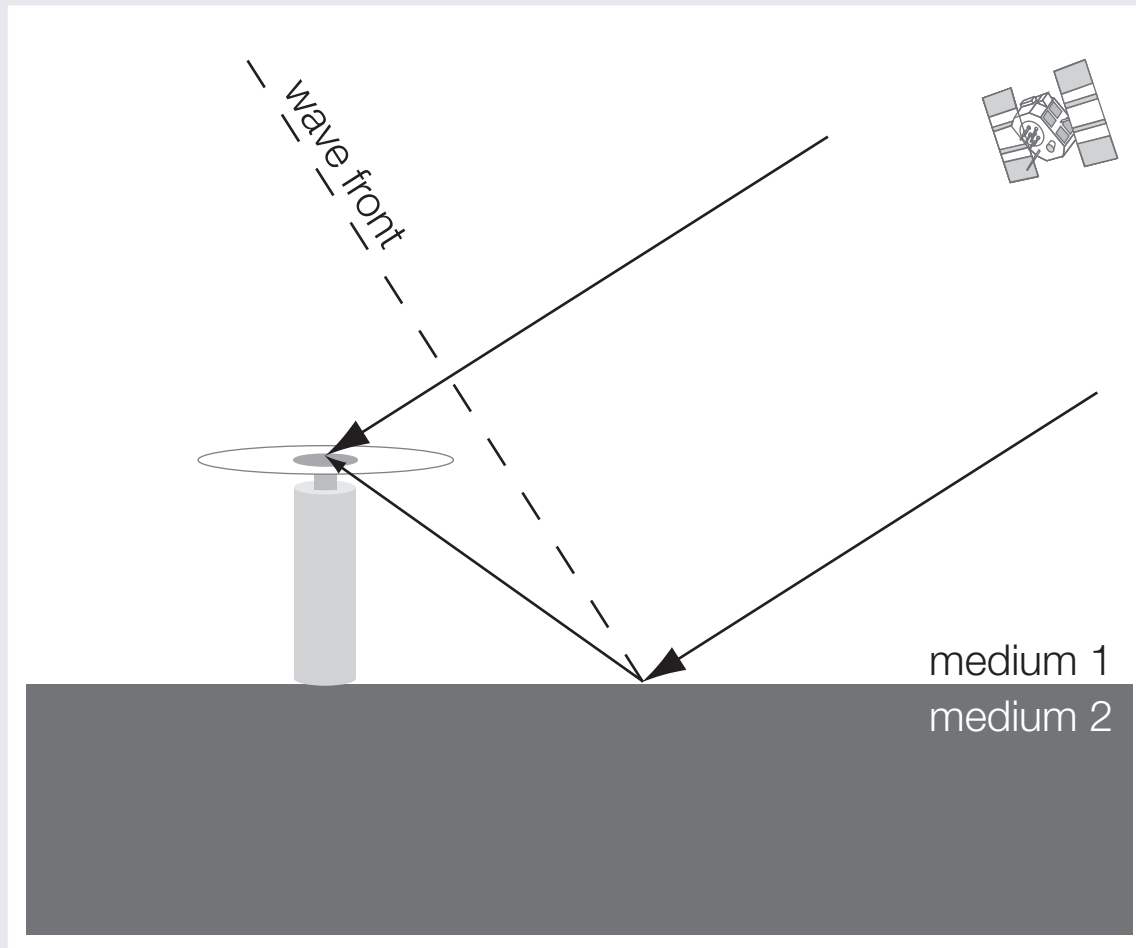
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# Multipath geometry – additional path length

## ”SIMPLIFIED REALITY” – SIMPLE RAY GEOMETRY



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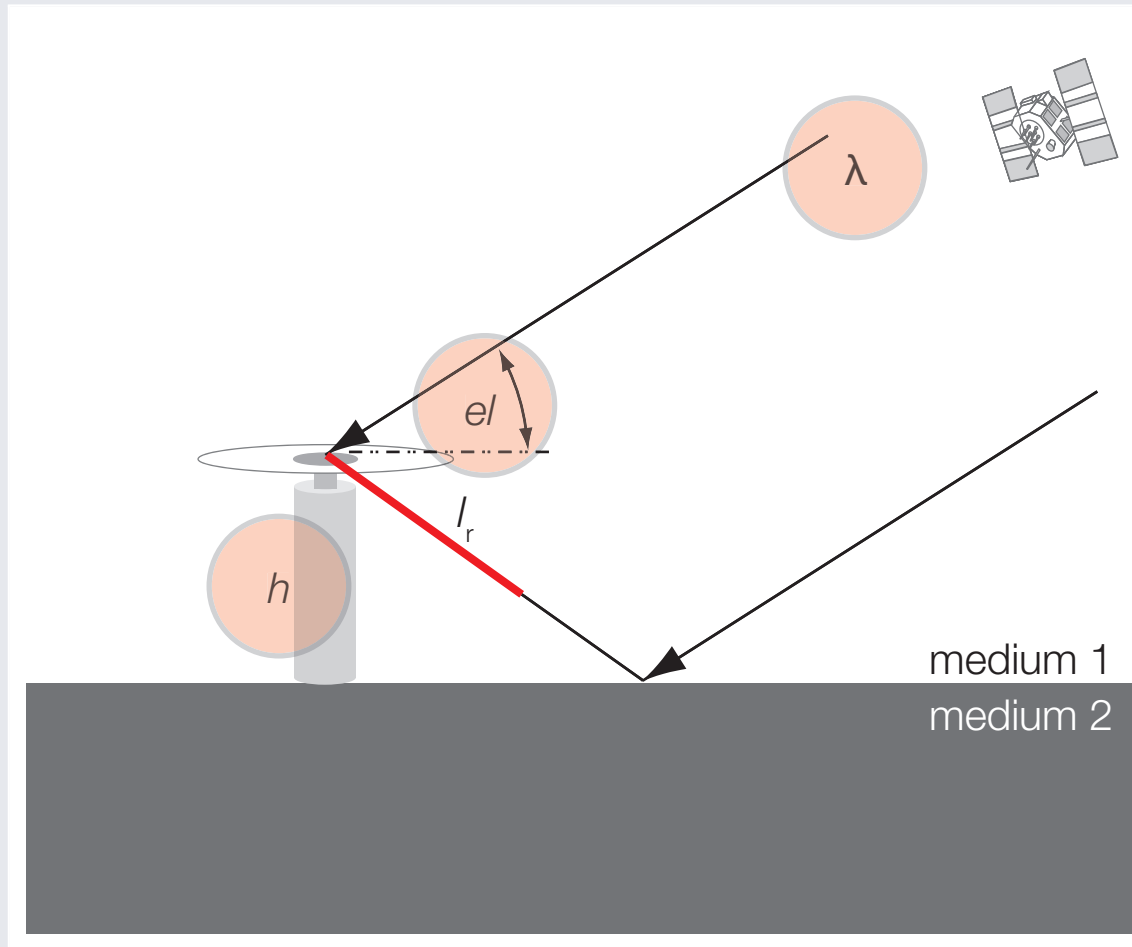
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”SIMPLIFIED REALITY” – SIMPLE RAY GEOMETRY



$$\Delta\varphi_r = \frac{2\pi}{\lambda} l_r = \frac{2\pi}{\lambda} 2 h \sin el$$

# Influence antenna height and elevation – simulation

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Multipath influence

Additional path length

**Simulation**

Theory vs. practice

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Play/Pause

# Influence antenna height and elevation – practice

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Multipath influence

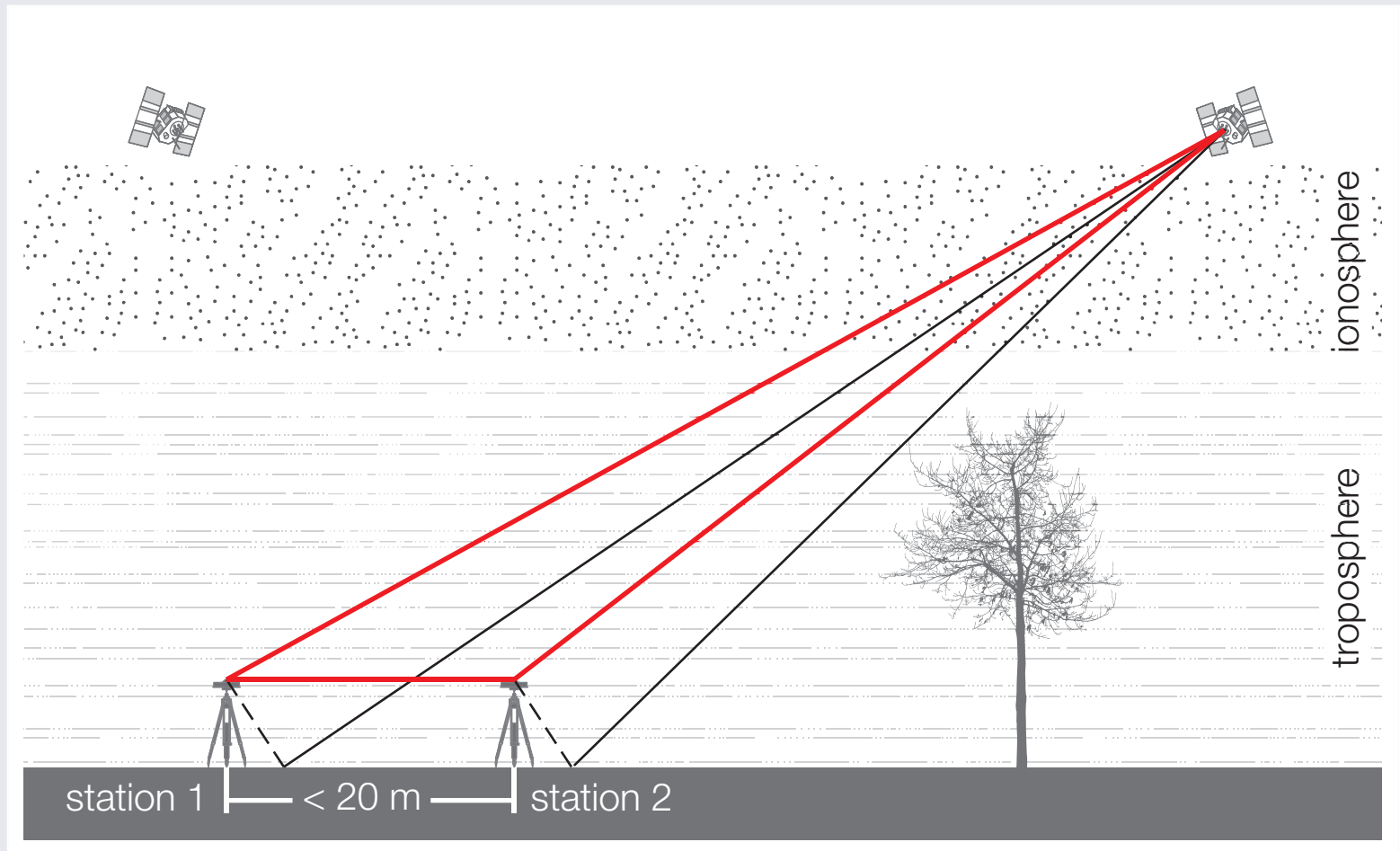
Additional path length

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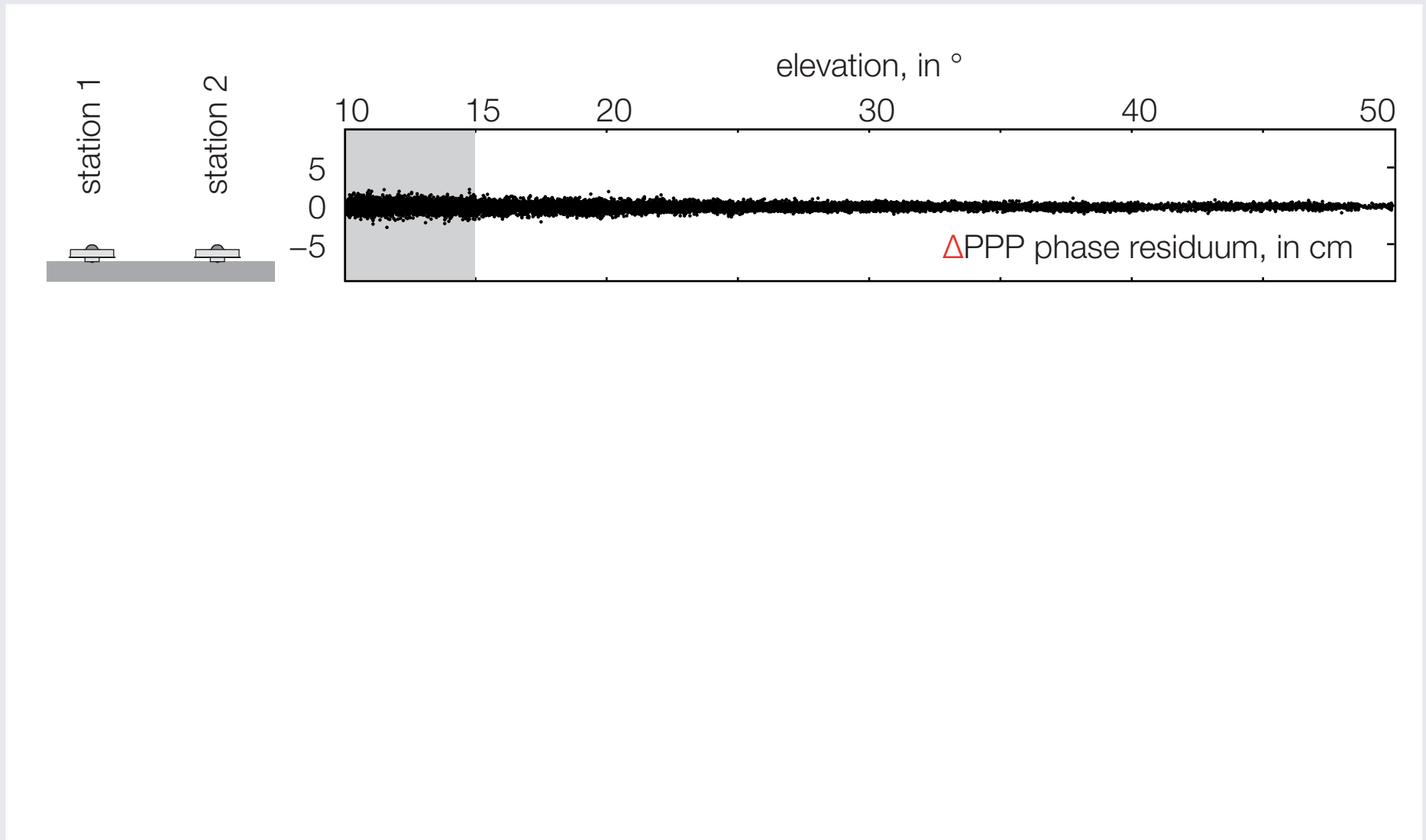
**Theory vs. practice**

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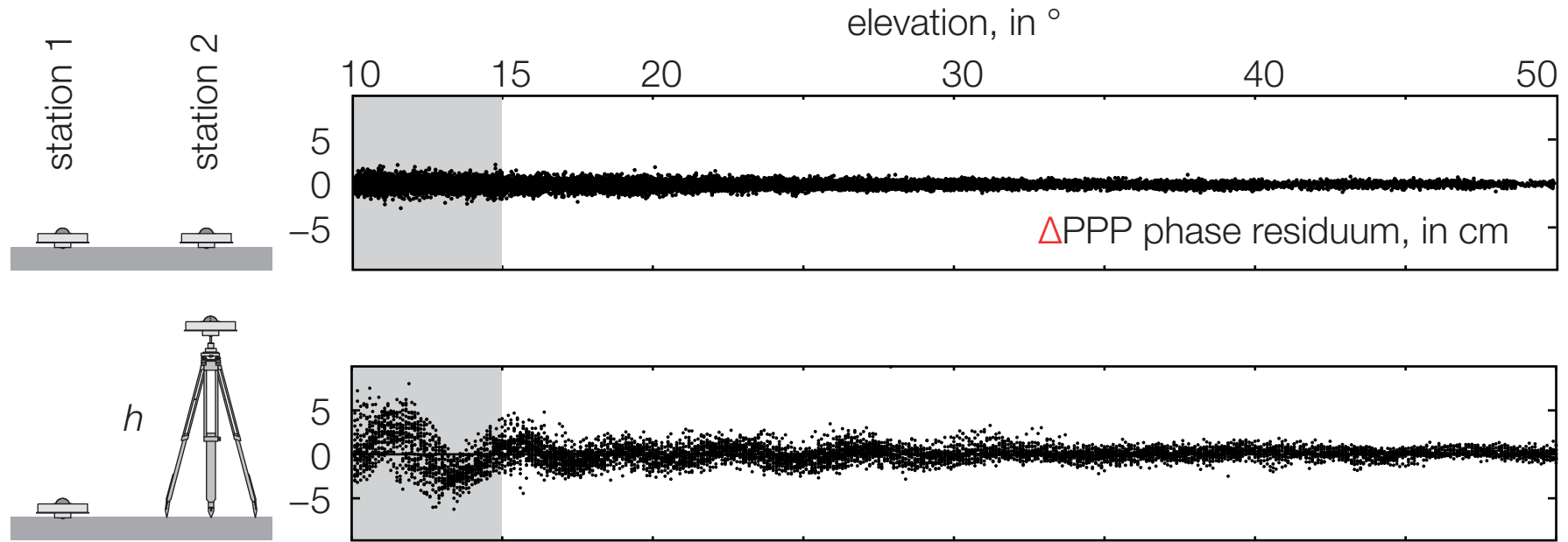


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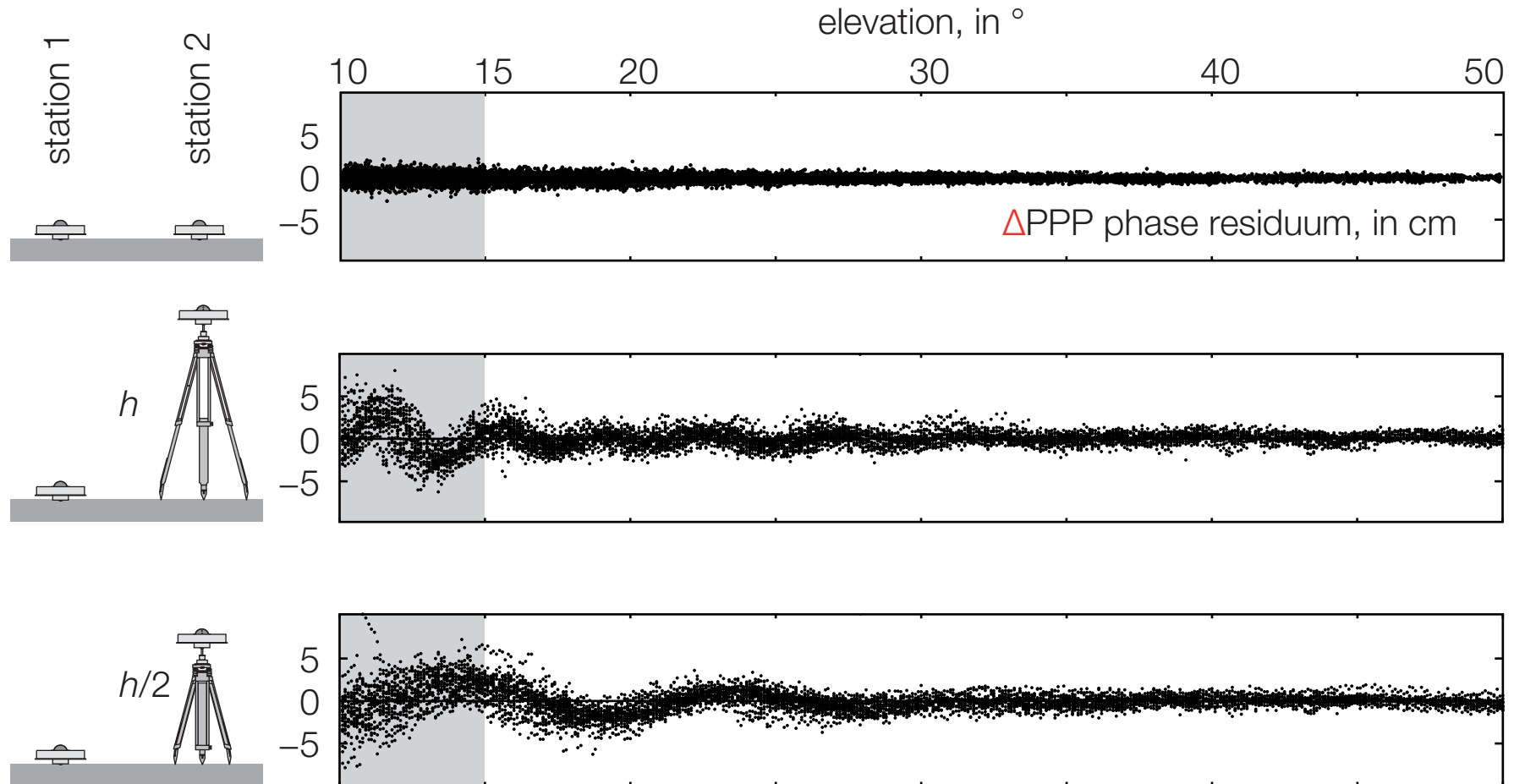




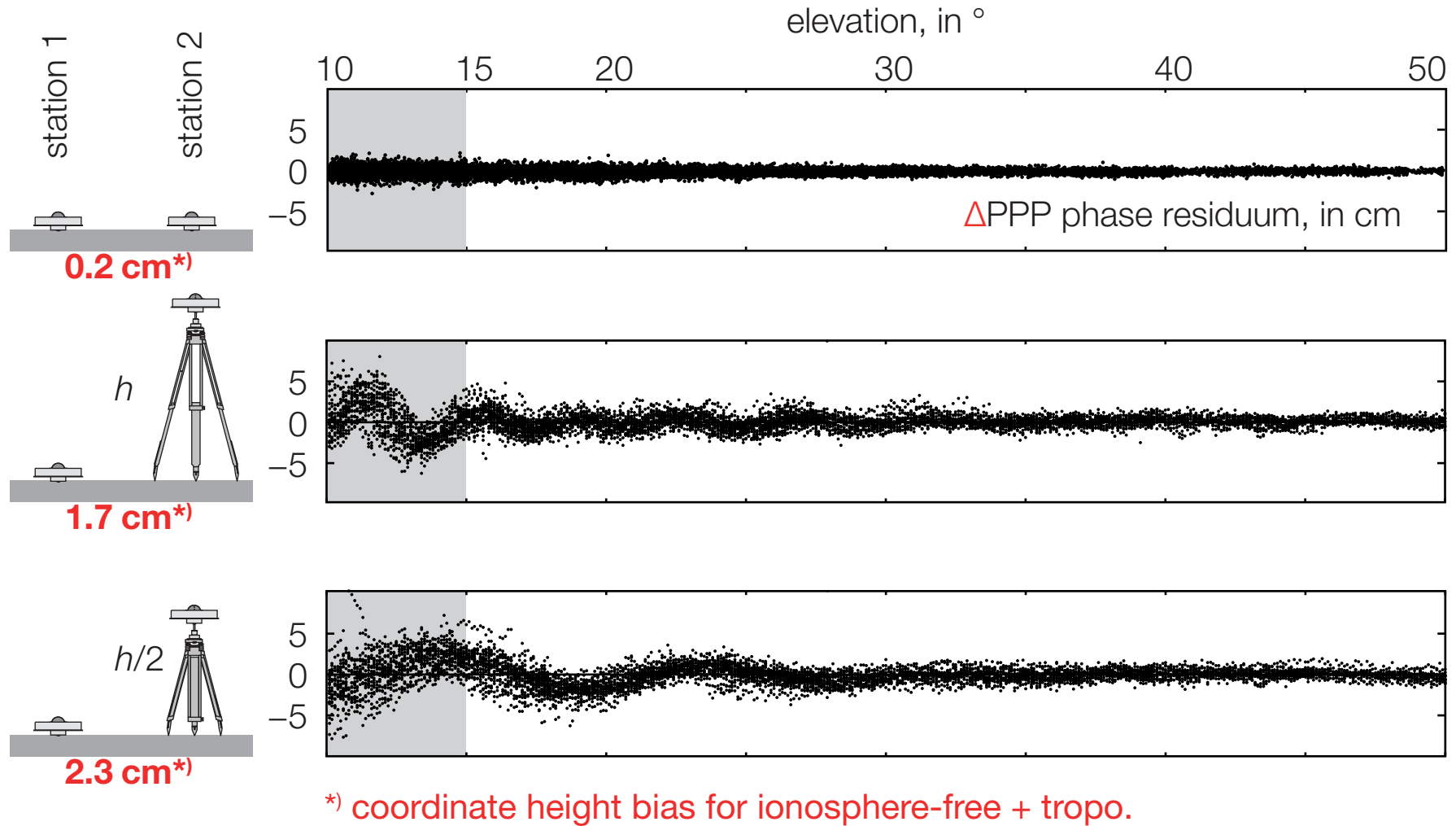
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# Overview mitigation techniques – general

multipath mitigation

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multipath mitigation

site-  
dependent



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multipath mitigation

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# Overview mitigation techniques – general

multipath mitigation

site selection/  
monumentation



(www.epncb.oma.be)



(http://igscb.jpl.nasa.gov)



(Ray 2007)

equipment-  
dependent



(Leica, Trimble, Septentrio 2012)



(Brown & Mathews 2005)



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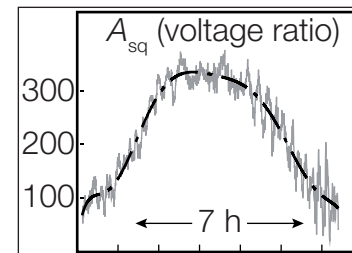
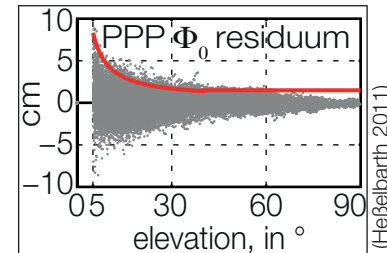
site selection/  
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equipment-  
dependent



observation  
weighting





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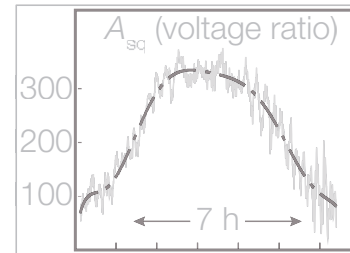
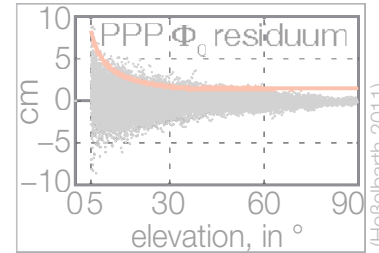
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observation  
weighting



station  
calibration

Modelling of  
station  
environment

Analysis of  
signal quality  
(e.g. C/N<sub>0</sub>)

Analysis of  
carrier phase  
residuals

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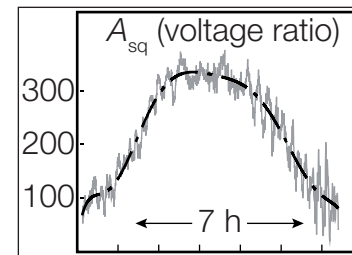
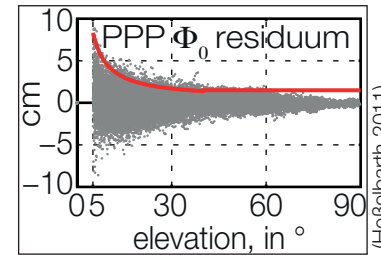
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station  
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+ model of physical cause

- model deficiencies

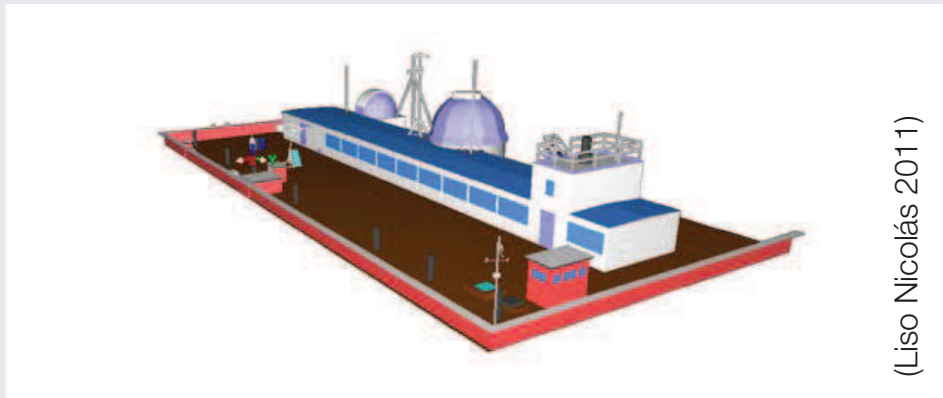


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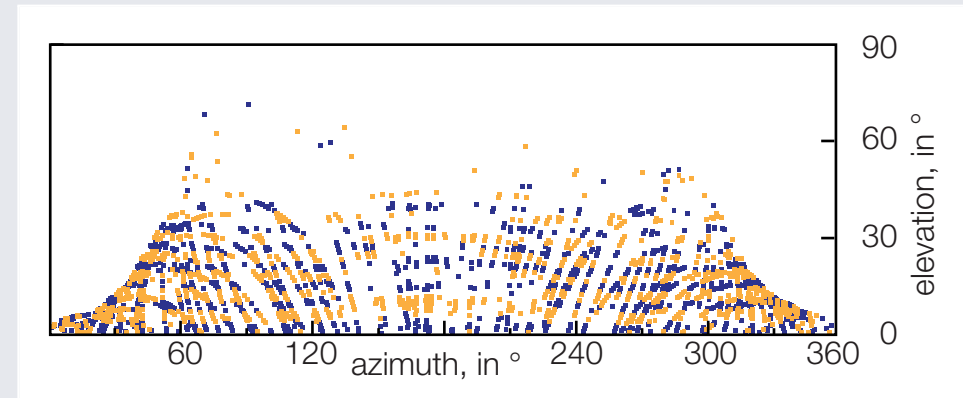
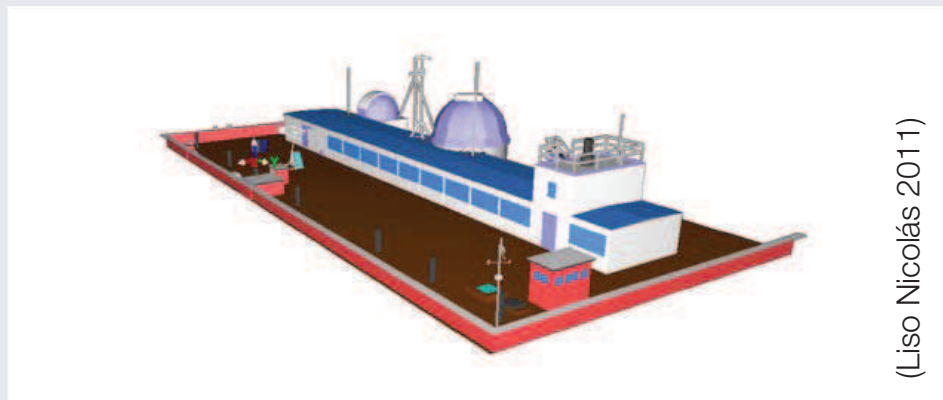
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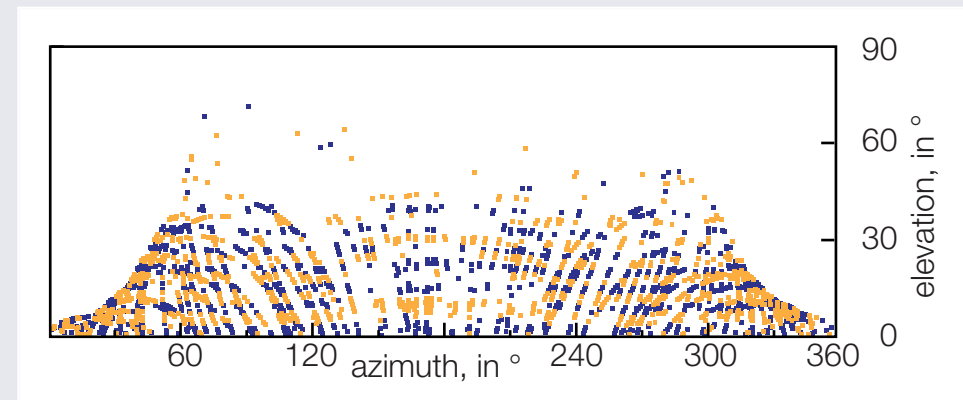
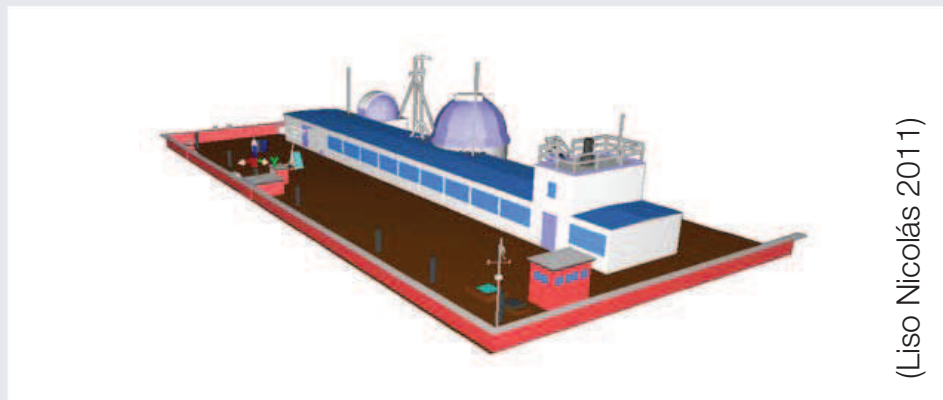


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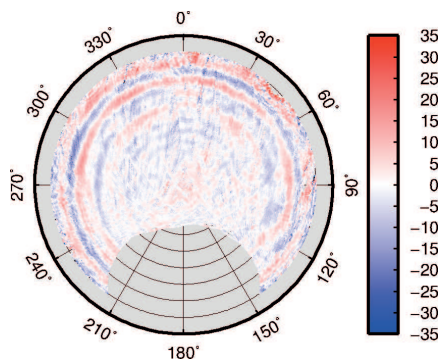
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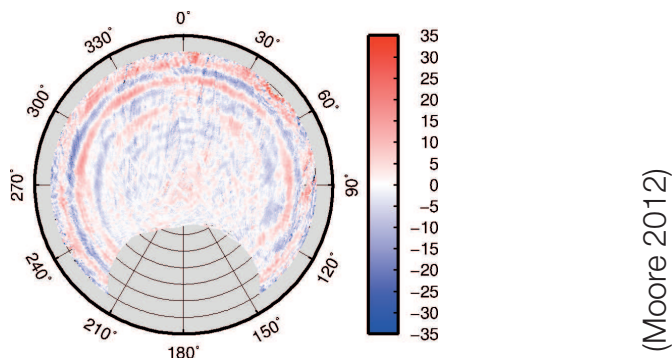
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(Lidberg et al. 2007; Moore et al. 2012)
  - + applicable to all stations without additional effort
  - ionosphere-free only, far-field multipath only



(Moore 2012)

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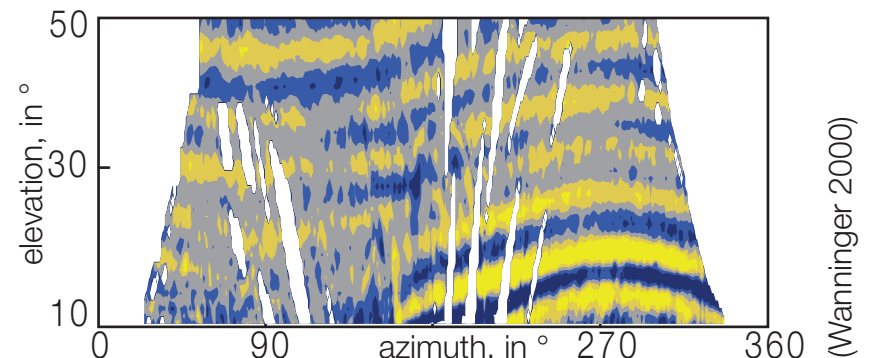
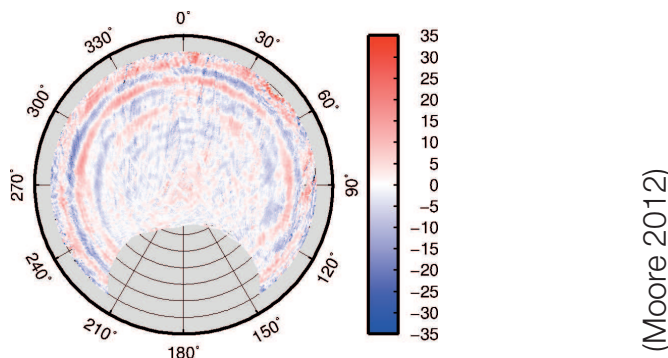


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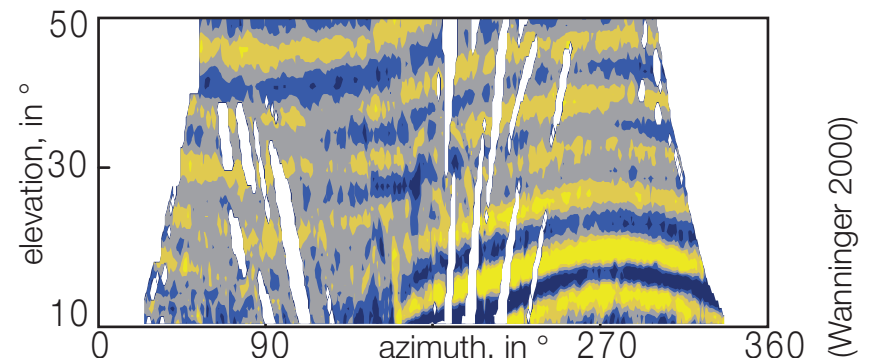
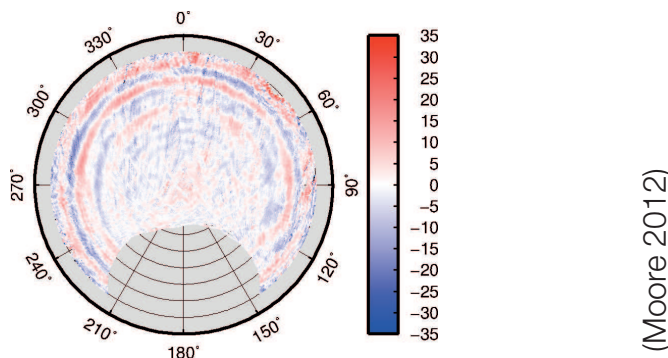


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- additional temporary local site with low multipath
  
- + L1/L2/L5                      - large efforts and costs
  - directional antenna (Park et al. 2004)
  - robot (kinematic site, multipath → noise)  
(Böder et al. 2001)
  - high poles (Wübbena et al. 2010)



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# Summary

## CARRIER PHASE MULTIPATH:

- ❑ far-field effects → residuals → corrections,
- ❑ near-field effects → parameters → ground-truth?

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## DETECTION:

- ❑ far-field effects in ionosphere-free carrier phase observation residuals

## CORRECTION of L1/L2/L5 carrier phase observations:

- ❑ most promising → additional local observations
- ❑ **but** → large effort and costs
- ❑ **but** → environmental changes (vegetation, rain, snow etc.)

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