Error Contributions and Mitigation Strategies in Ocean Doppler Observations with Harmony

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Quick introduction to Harmony

Harmony will resolve motion vectors and topography changes associated with dynamic Earth processes at kilometre scale:

- 3D land deformation
- Volume changes of glaciers
- Sea-ice motion vectors
- Submesoscale upper ocean processes

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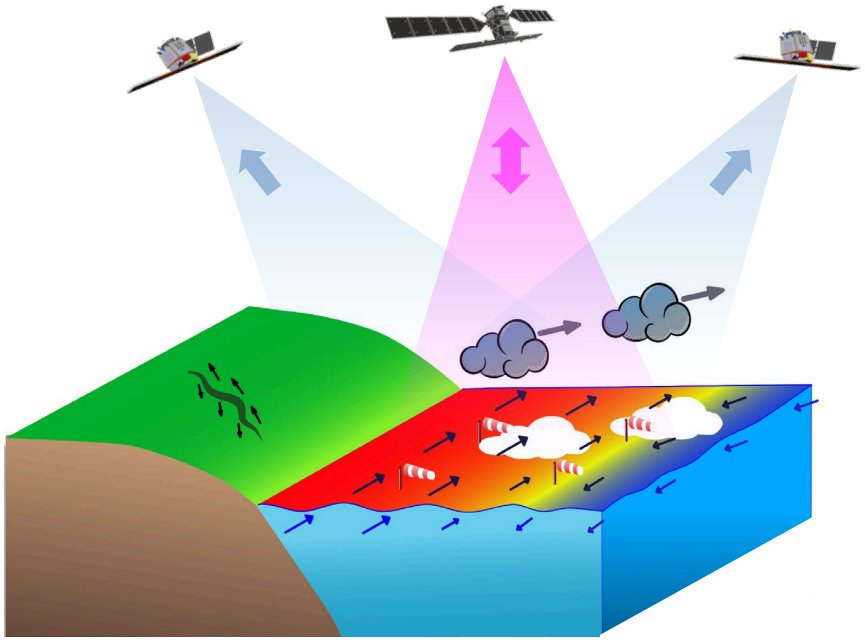
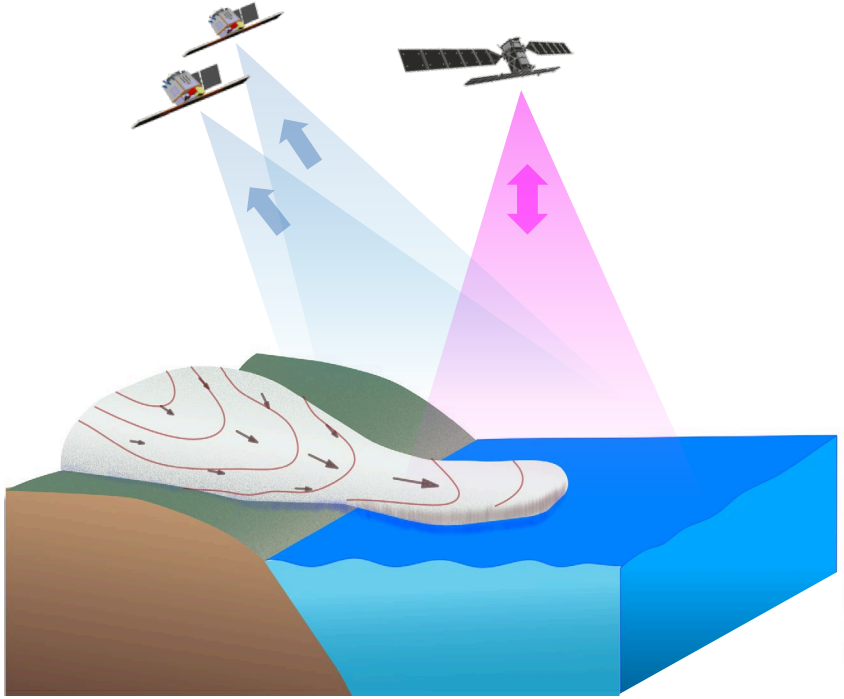
The two Harmony formations



Stereo formation

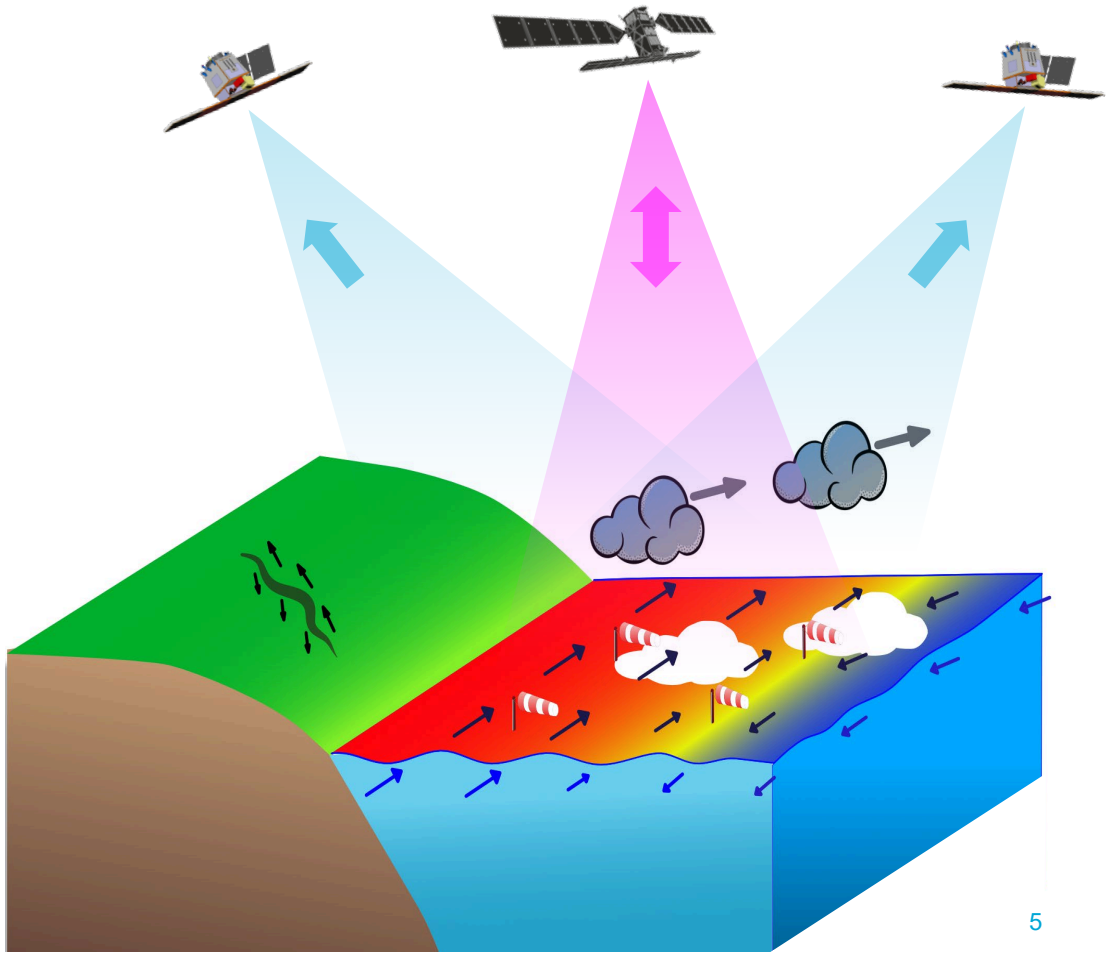


Cross-track formation

Stereo formation

- Line-of-sight diversity for high resolution:

- 3-D surface deformation
- Ocean surface motion
- Surface winds (scatterometry)
- Improved directional surface wave spectra
- Sea Surface (skin) temperature
- Cloud-top motion



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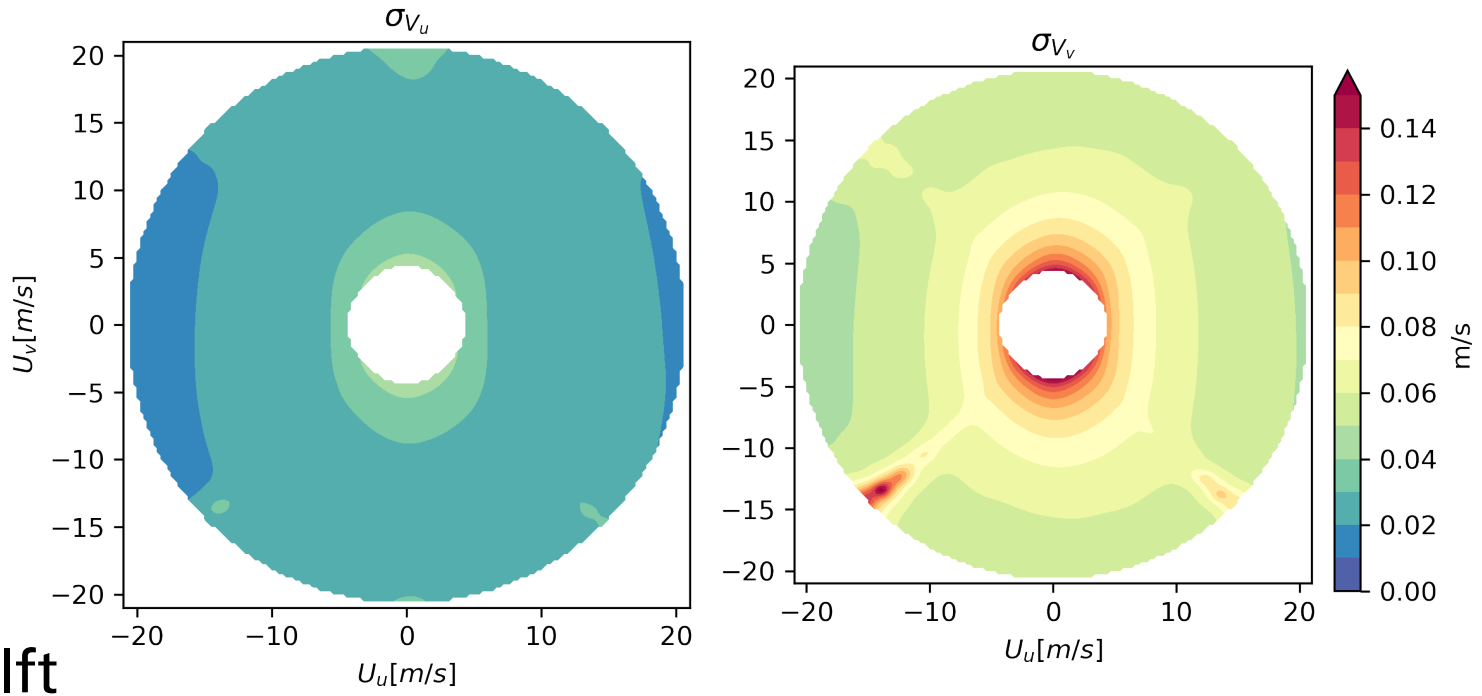
Error sources

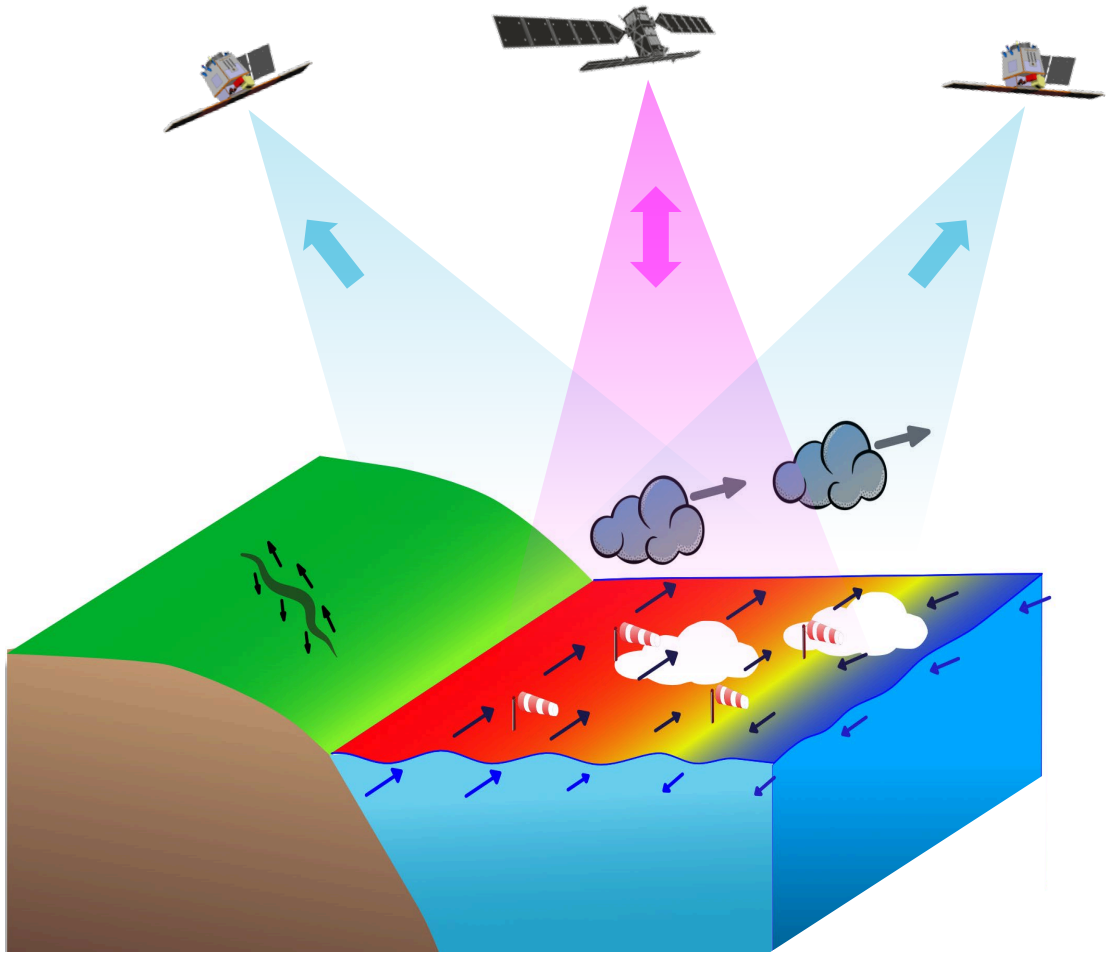
- Doppler measurement
  - Random errors due to the instrument (driven by NRCS and NESZ)
  - Systematic instrument errors
  - Ambiguities (not discussed in this presentation)
  - Baseline errors
  - Clock synchronization errors
  - Pointing errors
- Wave Doppler estimation errors
  - Wind estimation errors mapped to Doppler through the forward model
  - Errors introduced by the forward model

Instrument Performance



Clock synchronisation

- Two companion receivers
- Each with their own local oscillator
- Instanteneous frequency offset between S-1 and each of the receivers
- Leads to an error in the velocity estimate
- Minimal in range, predominantly in azimuth
- Synchronisation scheme using GNSS. Error in the correction translates to an error in the velocity estimate



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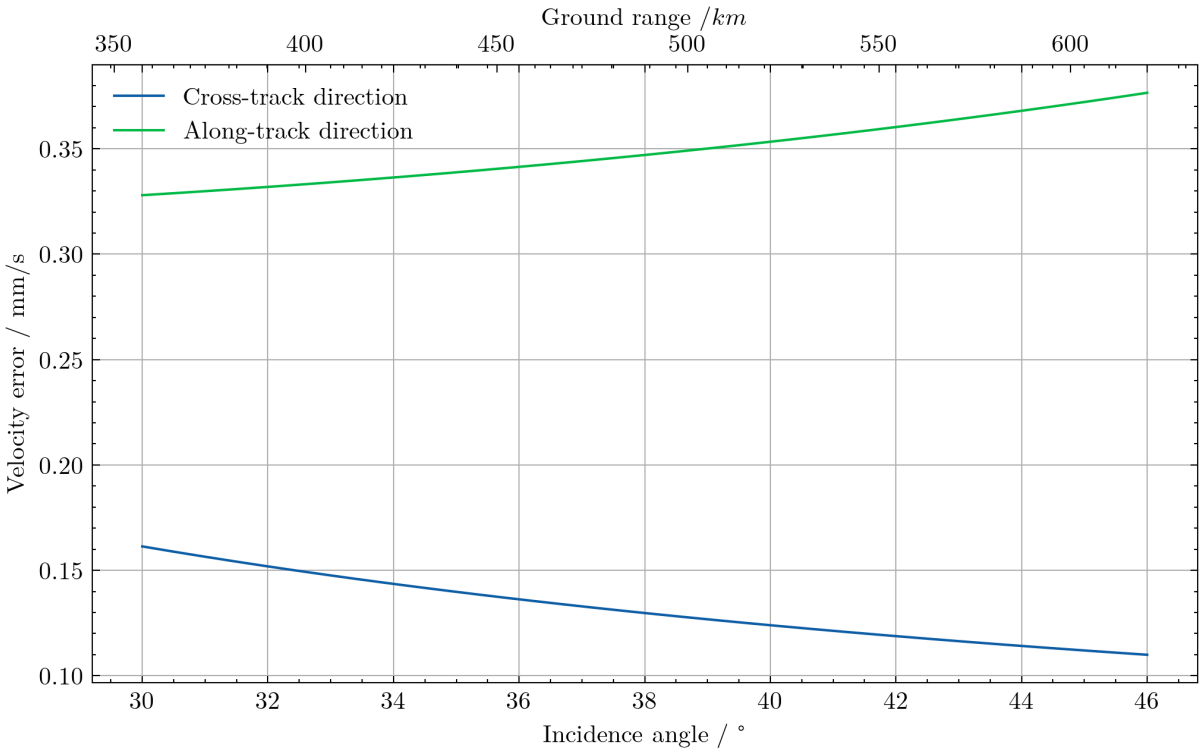
Clock synchronisation



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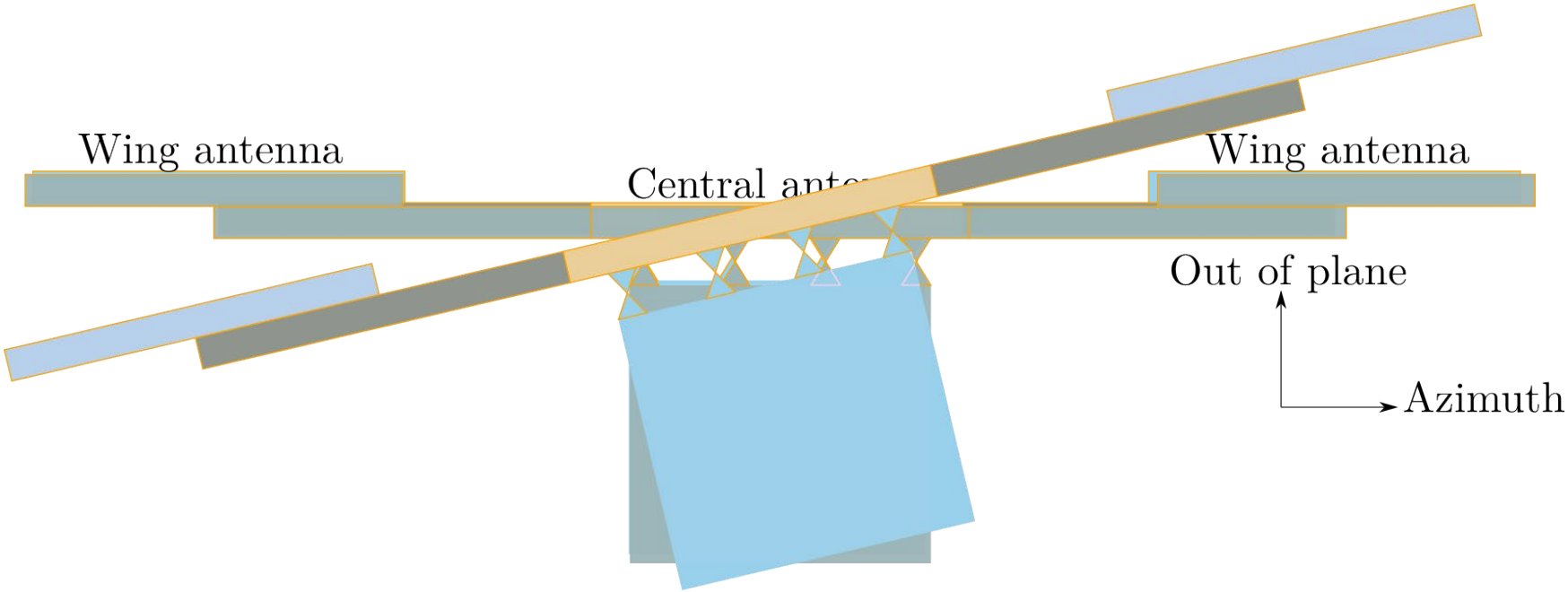
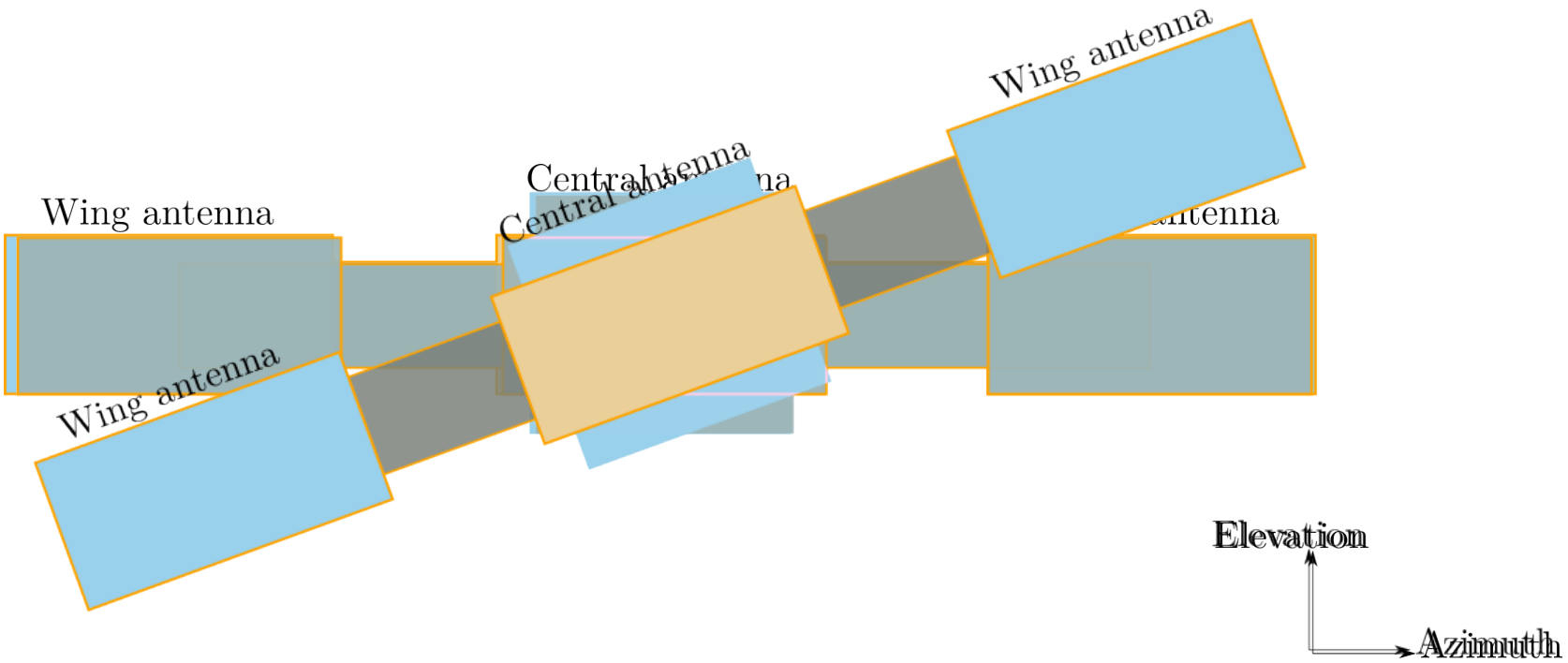
Pointing error – Rotation about elevation

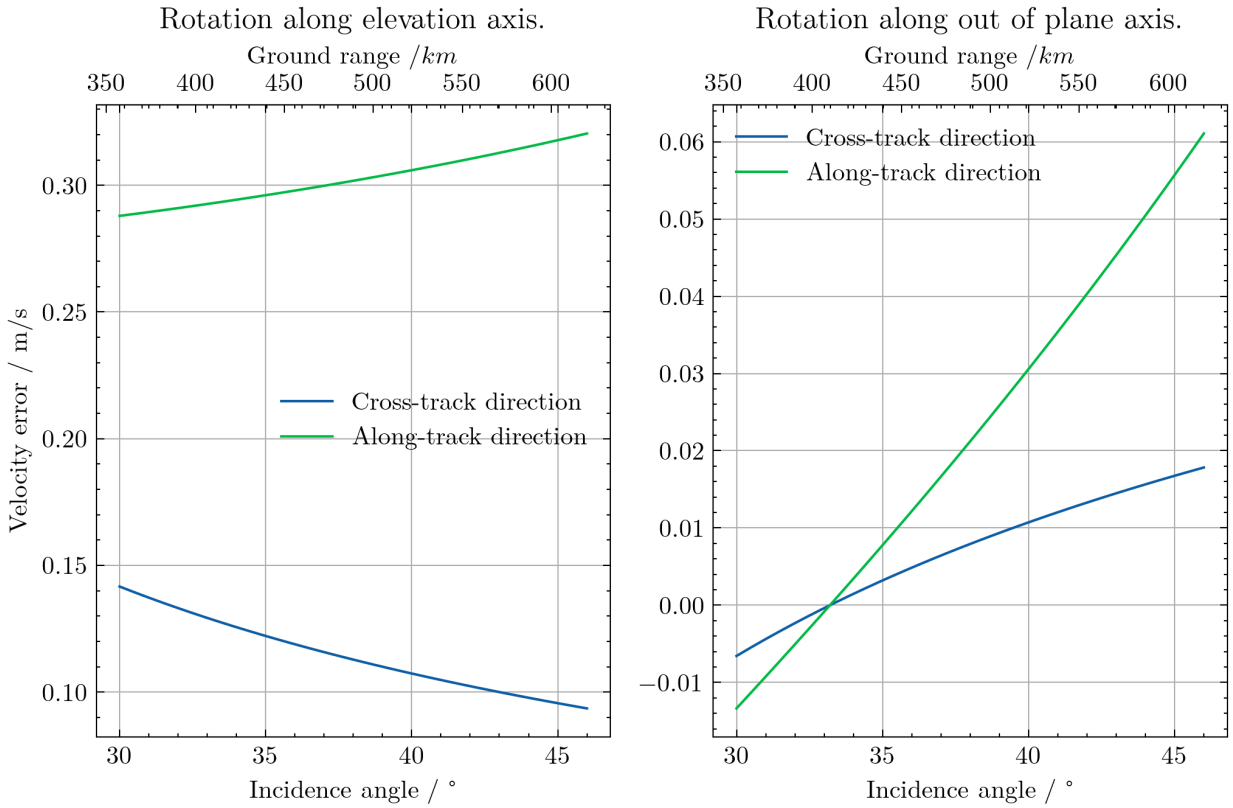


Pointing error – Rotation about out of plane axis



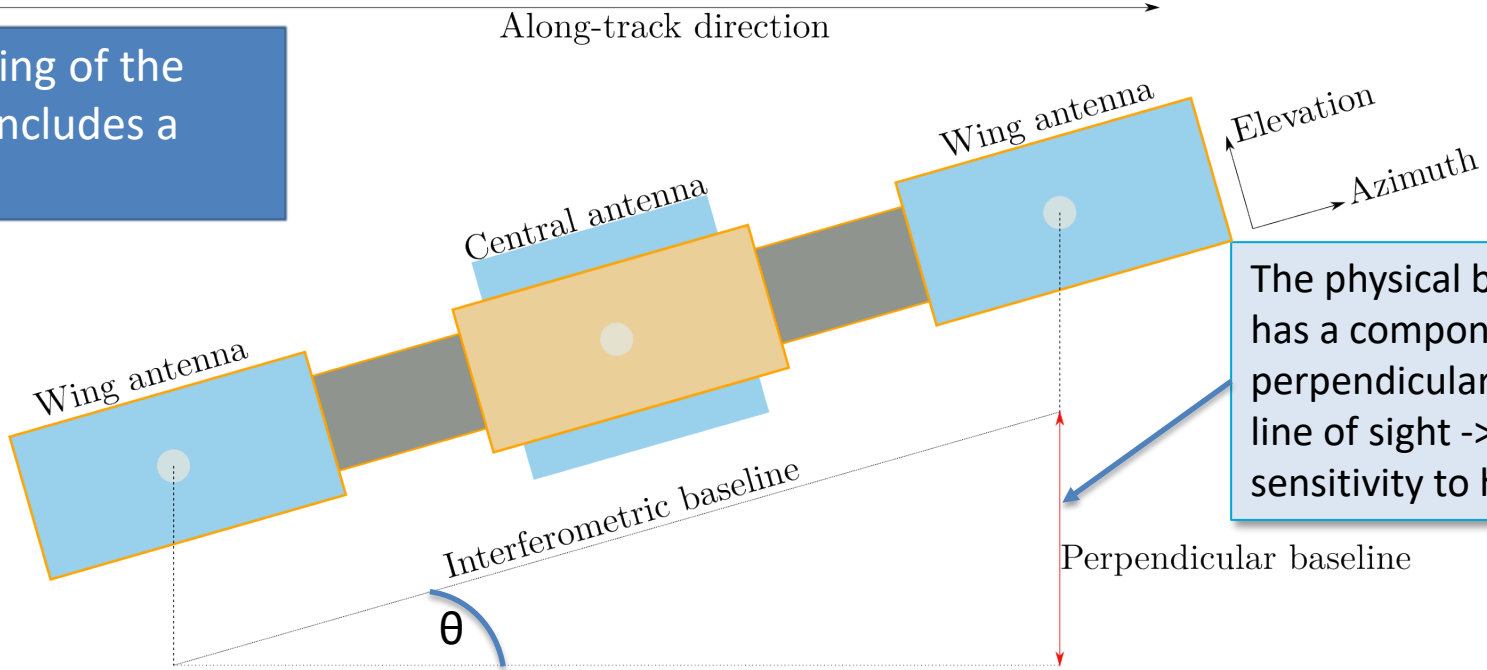
Pointing error

Rotation: 15 µrad



Error due to the perpendicular baseline

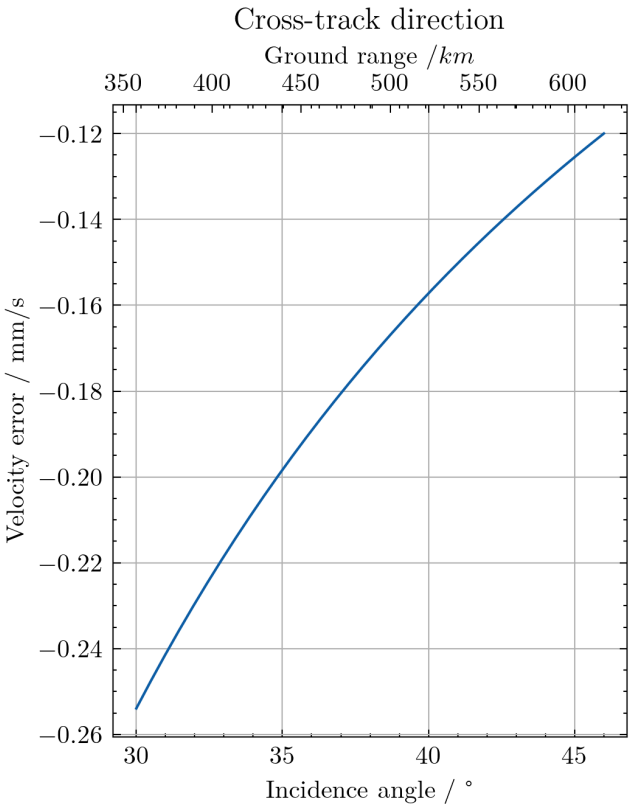
The pointing of the antenna includes a pitch.

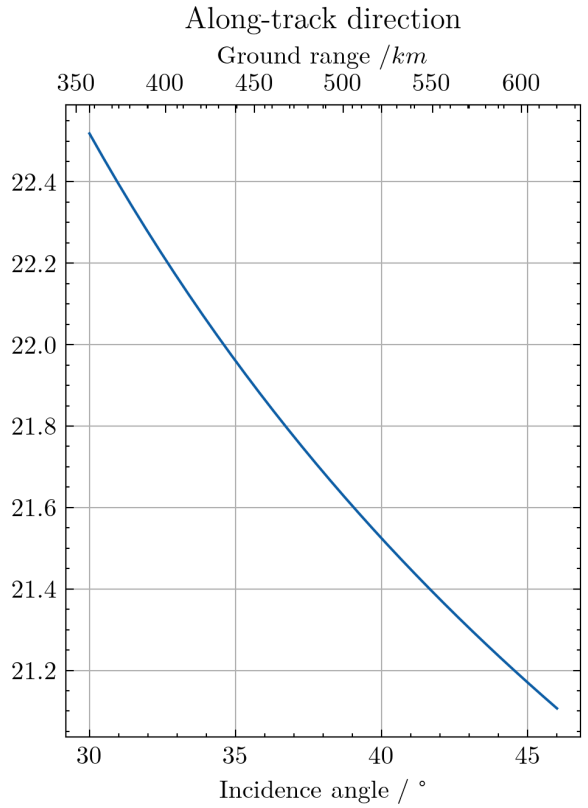


The physical baseline has a component perpendicular to the line of sight -> sensitivity to height

Error due to topography correction

Per 1 m of surface height





Along-track component significantly larger.

Correction using DEM is necessary.

Mitigation strategies

- Not necessary to achieve the aims of Harmony (10 cm/s at submesoscales)
- Correct L-2 data by constraining to minimal gradients
- Data-driven approach: Self-cohering antenna using the partial correlation properties of radar clutter

Conclusions

- Clock synchronisation error is within the requirements of the mission
- Pointing error is substantial for absolute velocity. In terms of gradients, over submesoscales it is smaller
- Pointing law of the mission produces a sensitivity to height. Correction using DEM must be applied.