Estimable phase and code biases in the frame of global multi-GNSS processing

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EGU General Assembly 2022

2022-05-24

DOI: 10.5194/egusphere-egu22-12557

Global GNSS processing with the raw observation approach

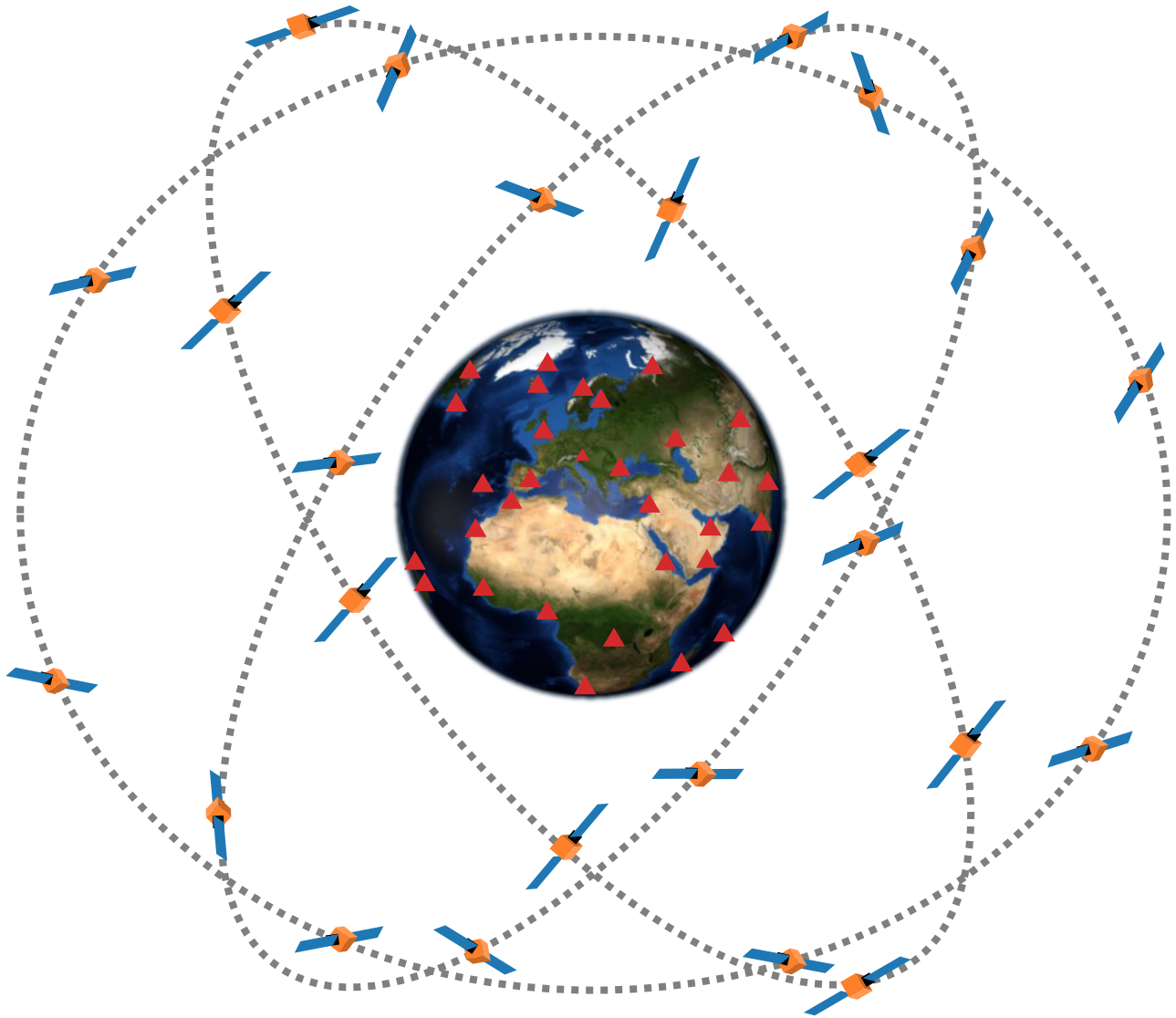
We want to process all available signals on all available frequencies.

We need to consider

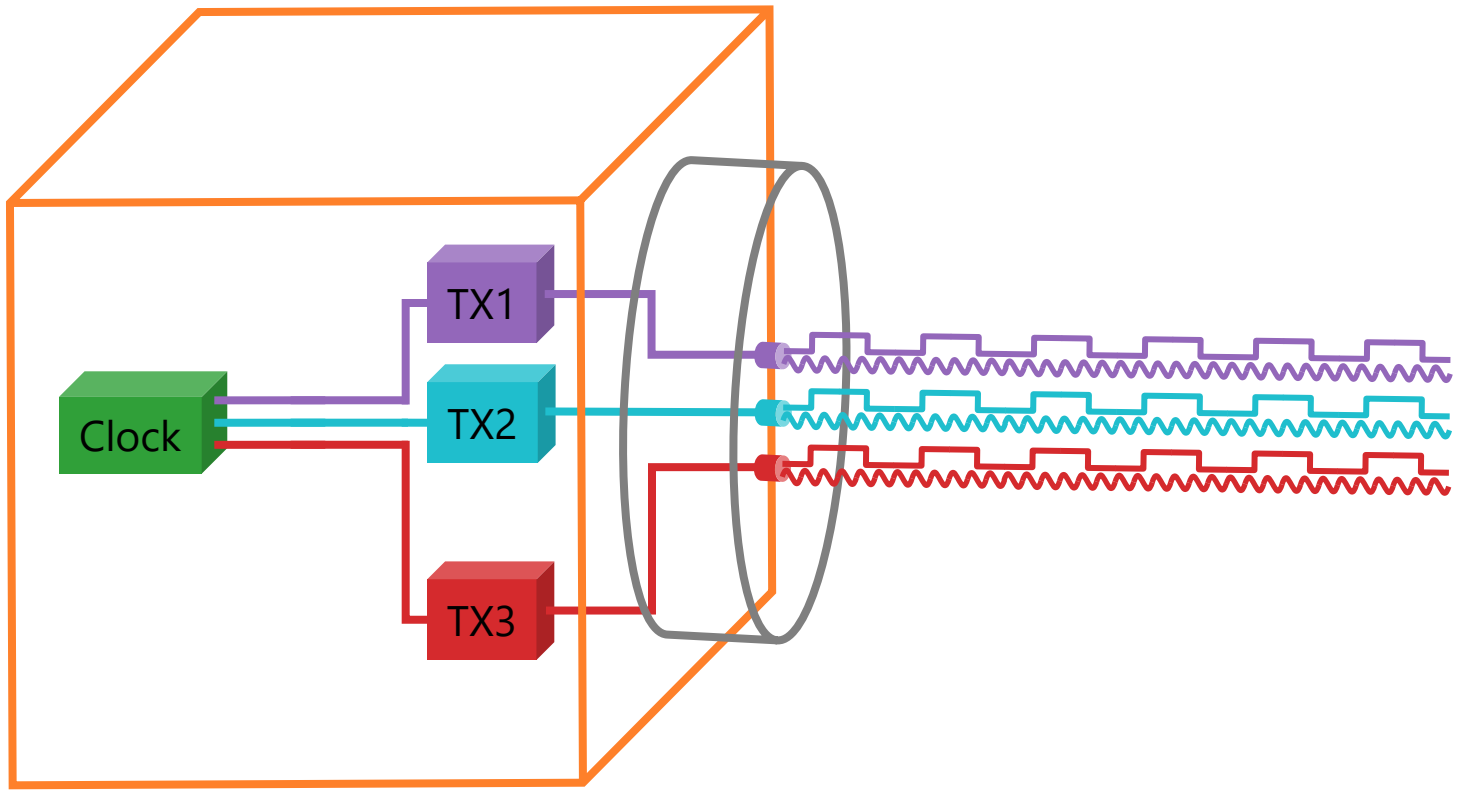
- clock error
- signal biases

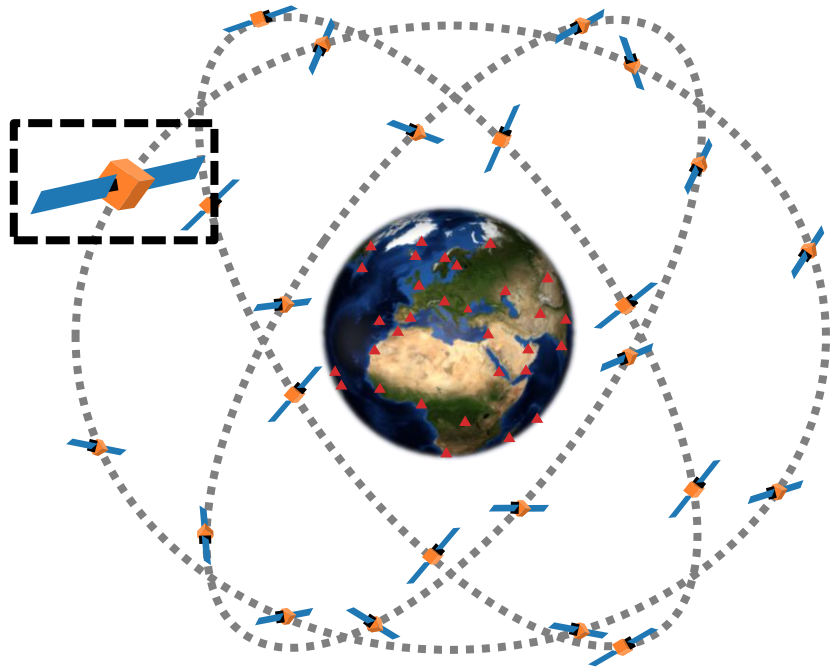
at each satellite and receiver.

Each code and phase observation type has its own signal bias.



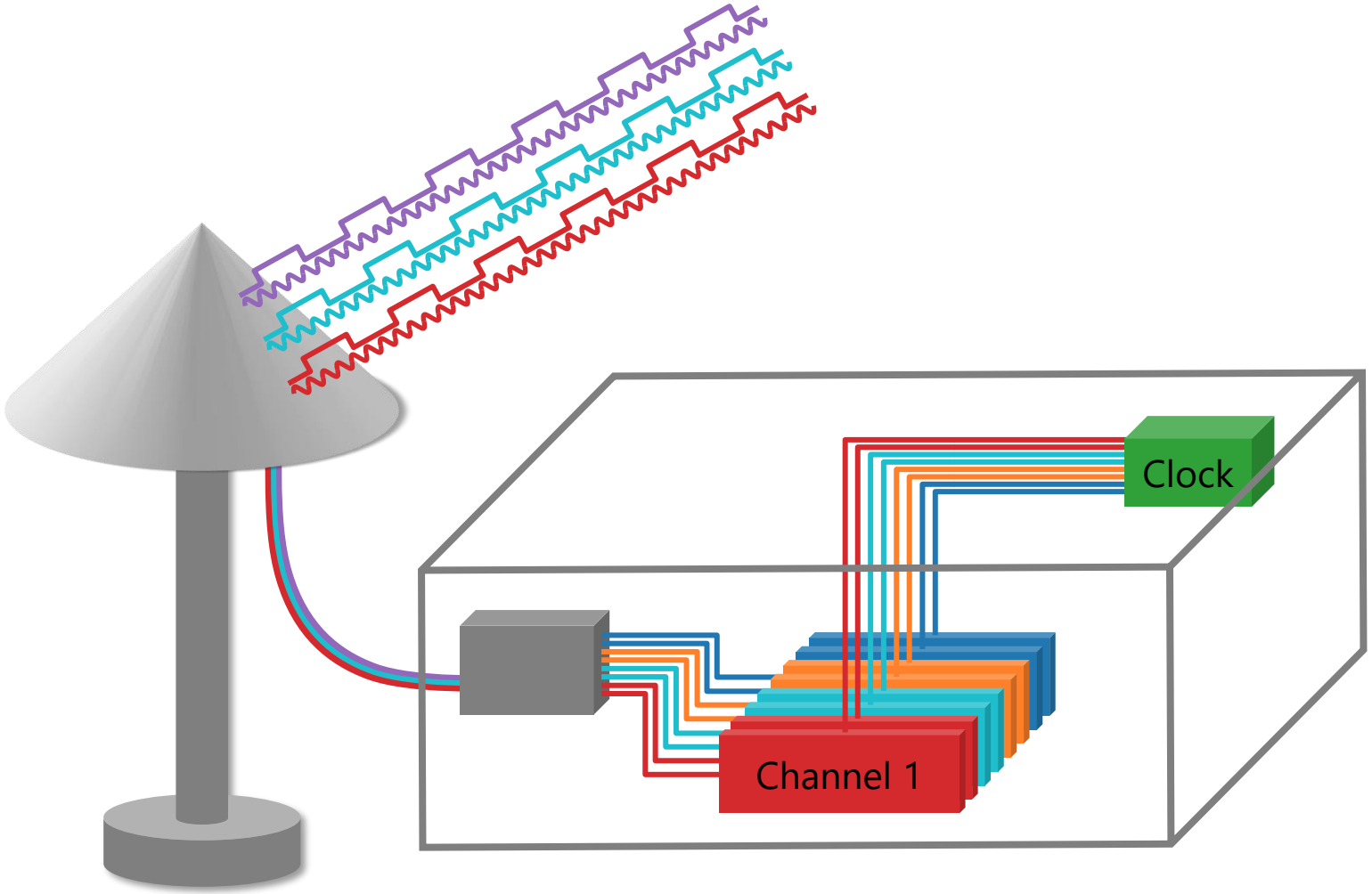
Transmitter signal biases

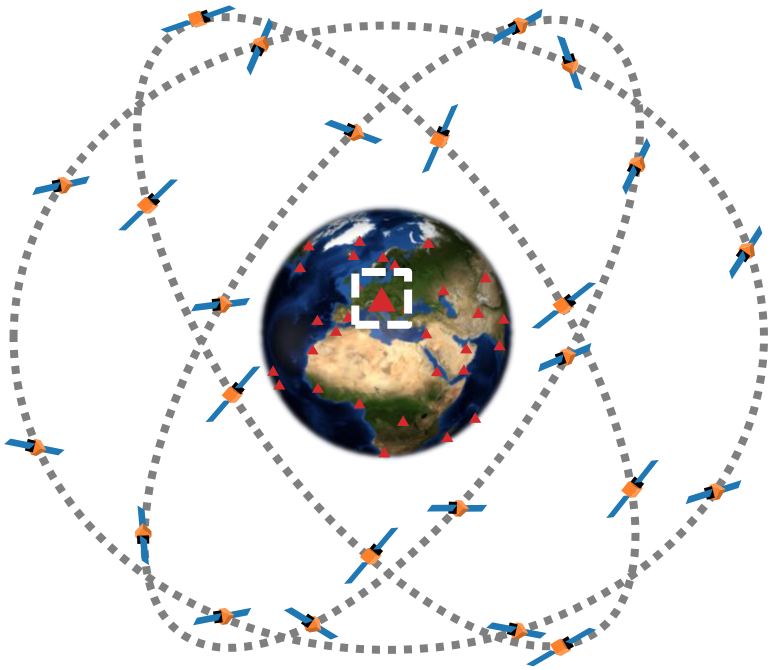




Transmitter clock and signal biases are unknown parameters.

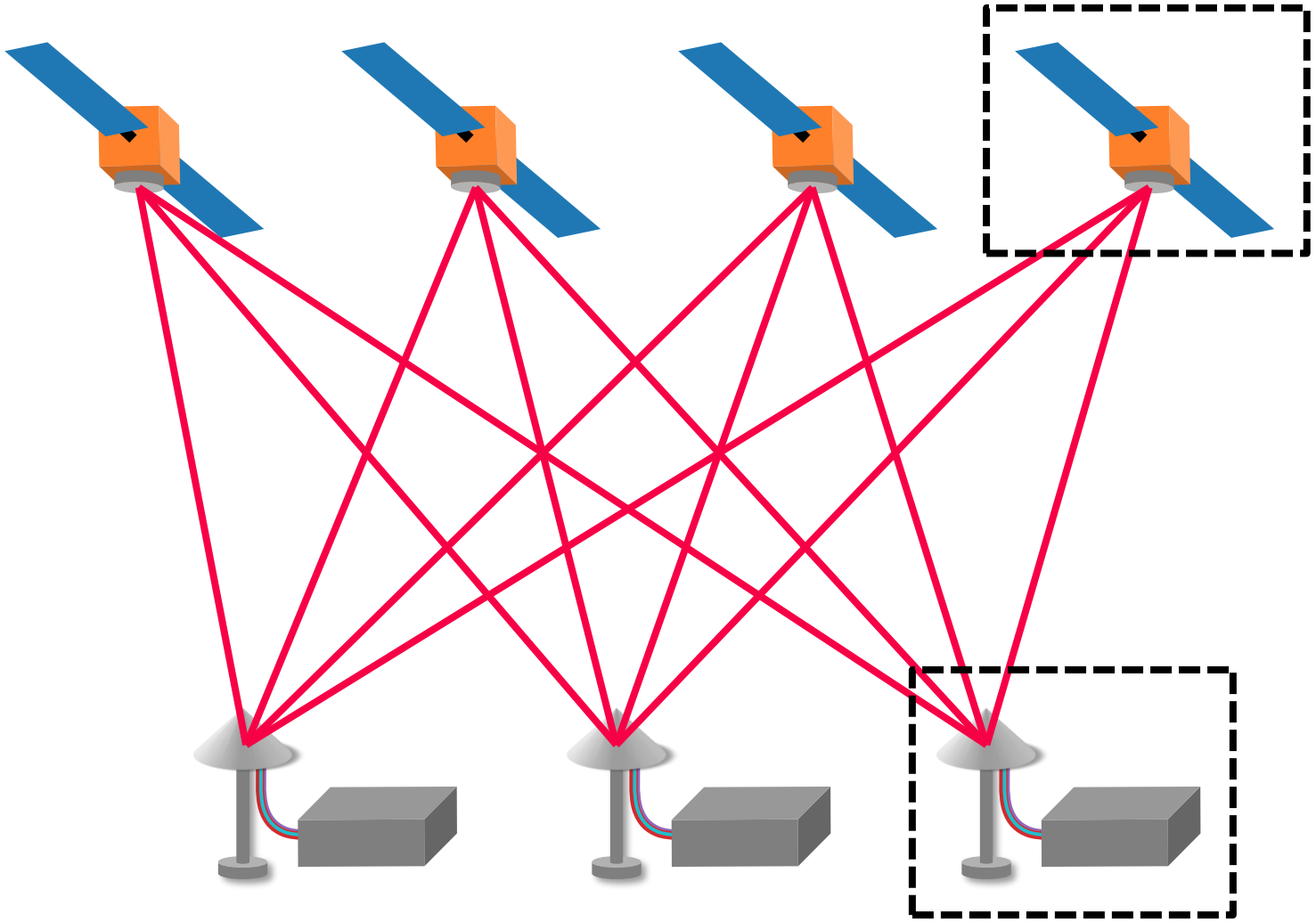
Receiver signal biases

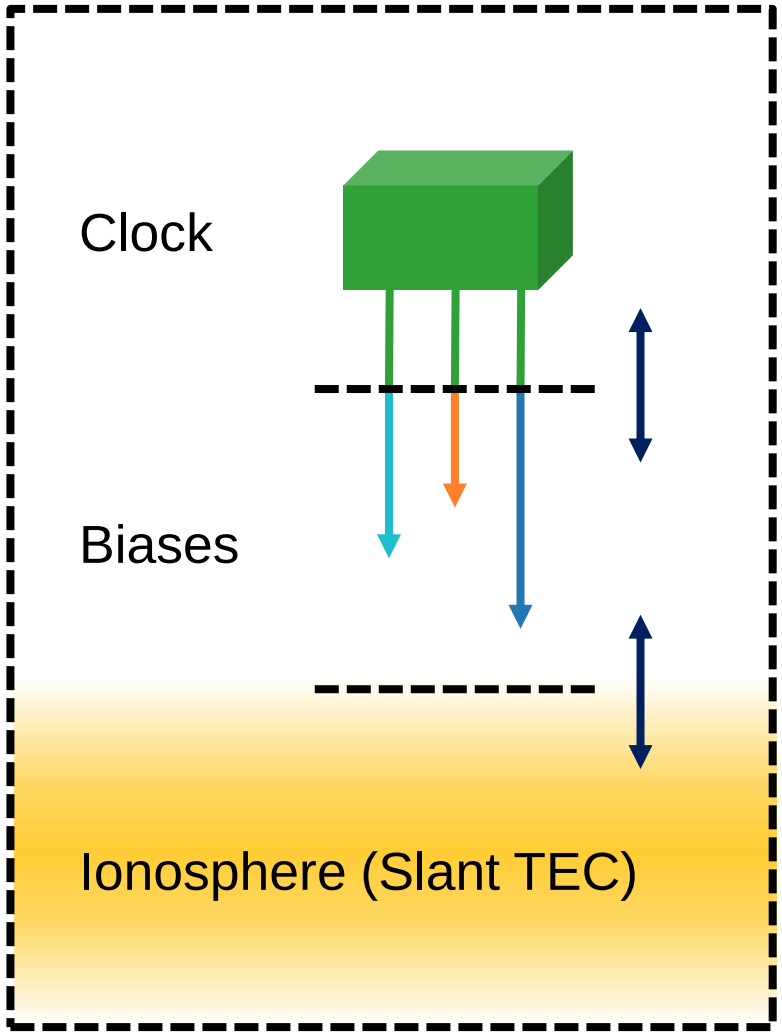




Receiver clock and signal biases are also unknown parameters.

Code biases – Local rank deficiencies





Clocks and signal biases cannot be determined absolutely.

Estimable code bias linear combinations at a receiver

- Simplified observation equations (one receiver to all satellites)

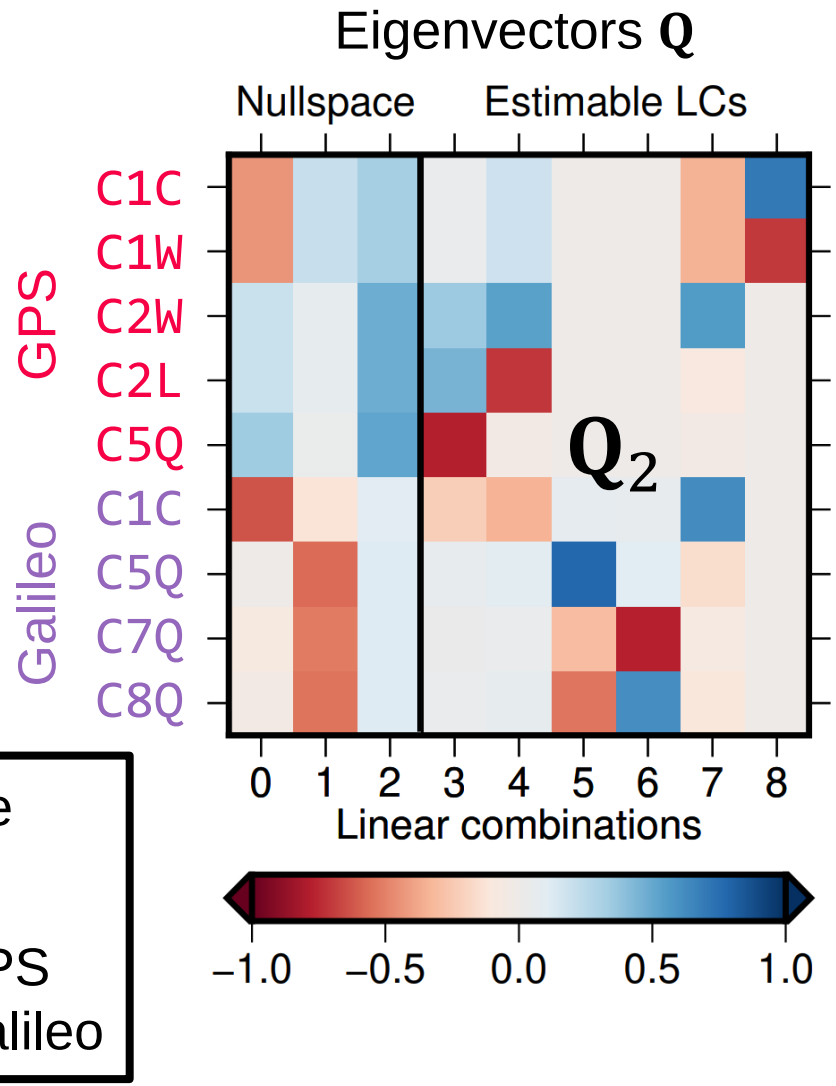
$$\mathrm{obs}[\mathrm{C}fa]_r^s = \mathrm{bias}[\mathrm{C}fa]_r + \mathrm{clock}_r + \mathrm{iono}[f](STEC_r^s)$$

- Set up normal equations
- Eliminate clock and ionosphere parameters
- Eigenvalue decomposition

$$\mathbf{N} = \mathbf{Q}\boldsymbol{\Lambda}\mathbf{Q}^T$$

- New parameters (estimable linear combinations)

$$\mathbf{x} = \mathbf{Q}_2\bar{\mathbf{x}}$$



Nullspace

- Clock
- TEC GPS
- TEC Galileo

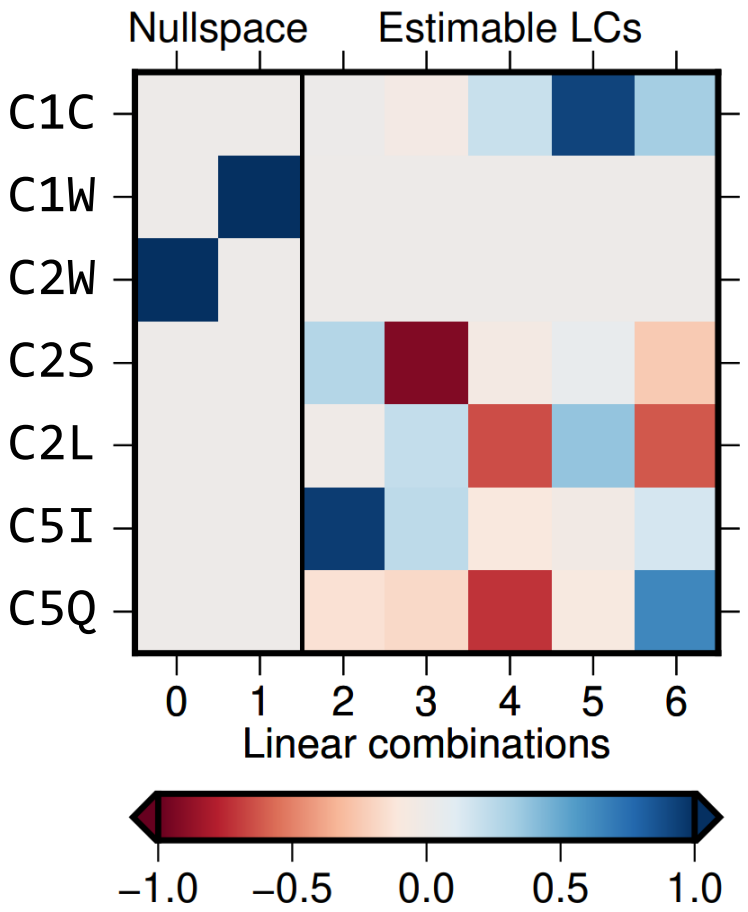
Estimable code bias linear combinations at a satellite

- Same approach as at receiver

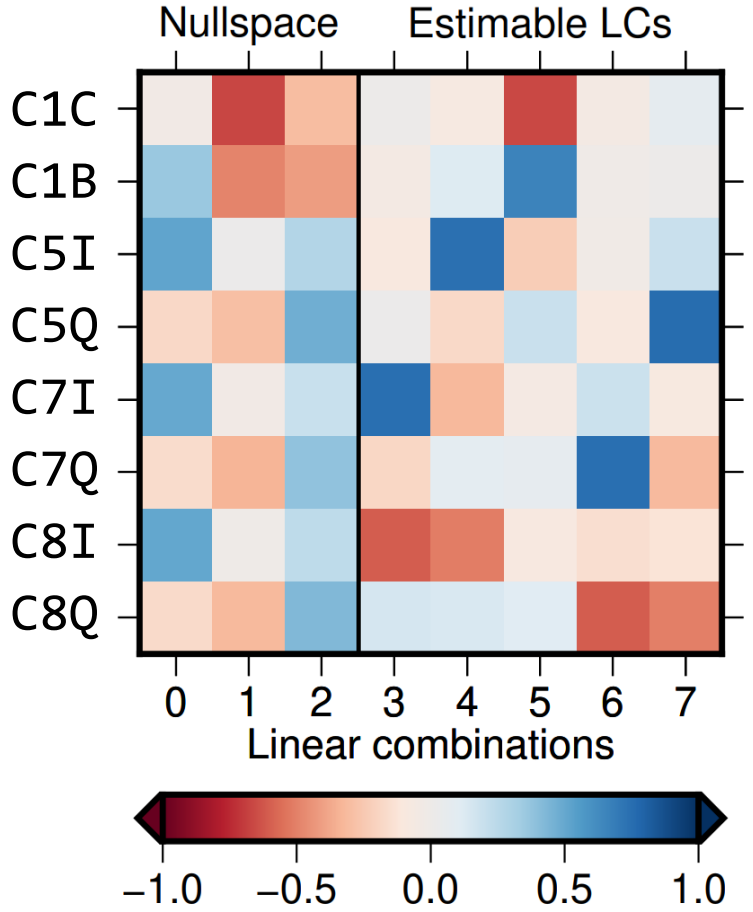
GPS special case:

C1W and C2W set to zero

Satellite G01 (G063, GPS-IIF)



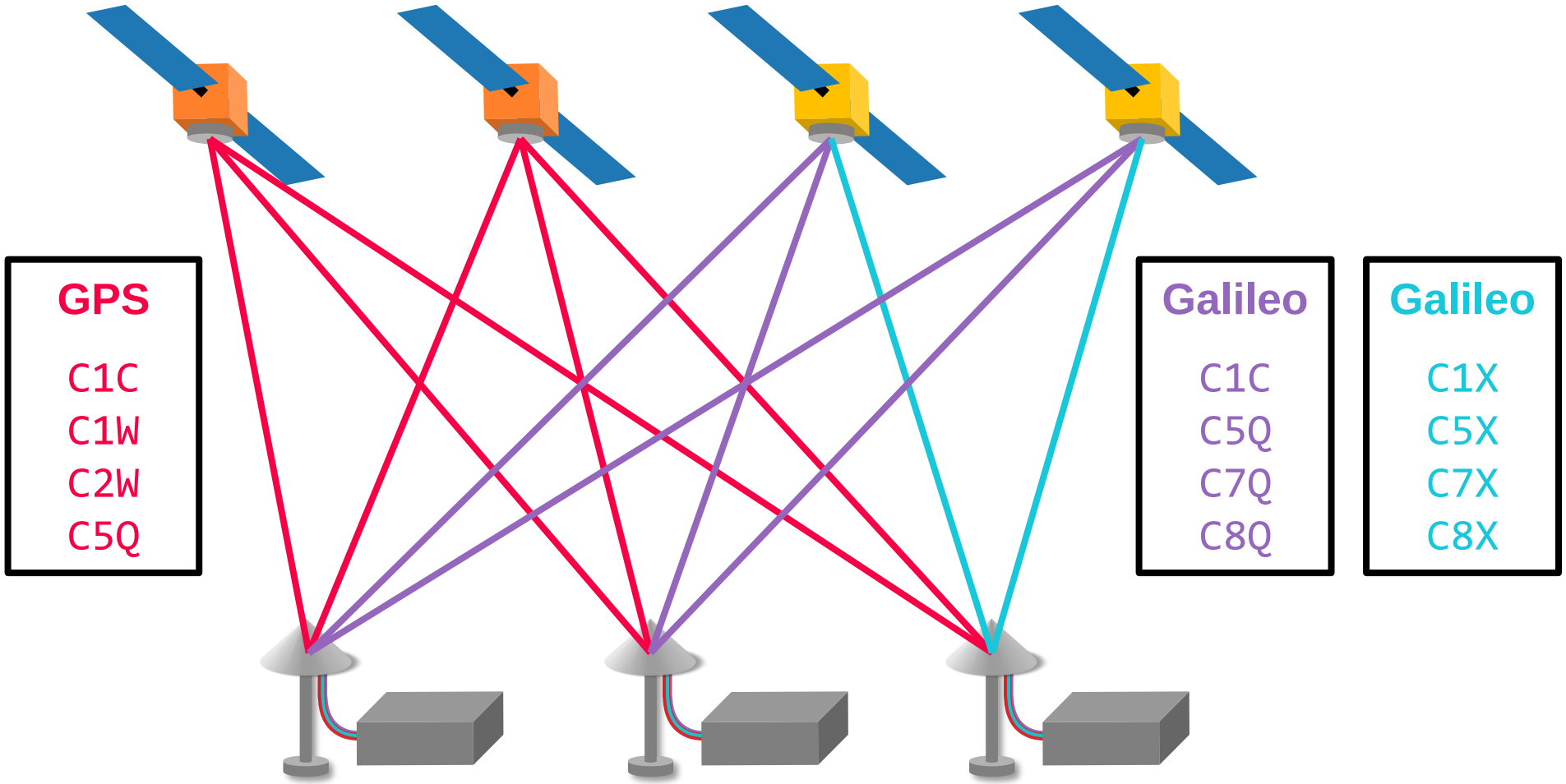
Satellite E01 (G210, GAL-2)



Galileo special case:

Two receiver groups with distinct observation types (C/Q vs. X)

Code biases – Global rank deficiencies



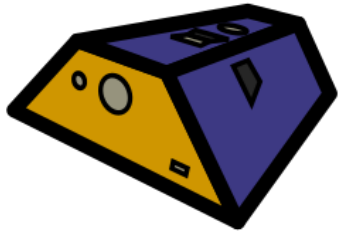
Global rank deficiencies can again be solved with a similar approach.

Want to know more?

Detailed description can be found in doctoral thesis

Strasser (2022) DOI 10.3217/978-3-85125-885-1

Approach is implemented into our open-source software



Available at GitHub

https://github.com/groops-devs/groops

Now with example scenarios for GNSS processing, LEO orbit determination, gravity field determination, and more.