Testing Ionospheric Faraday Rotation correction for LOFAR

Cameron Van Eck, for the MKSP

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Faraday rotation

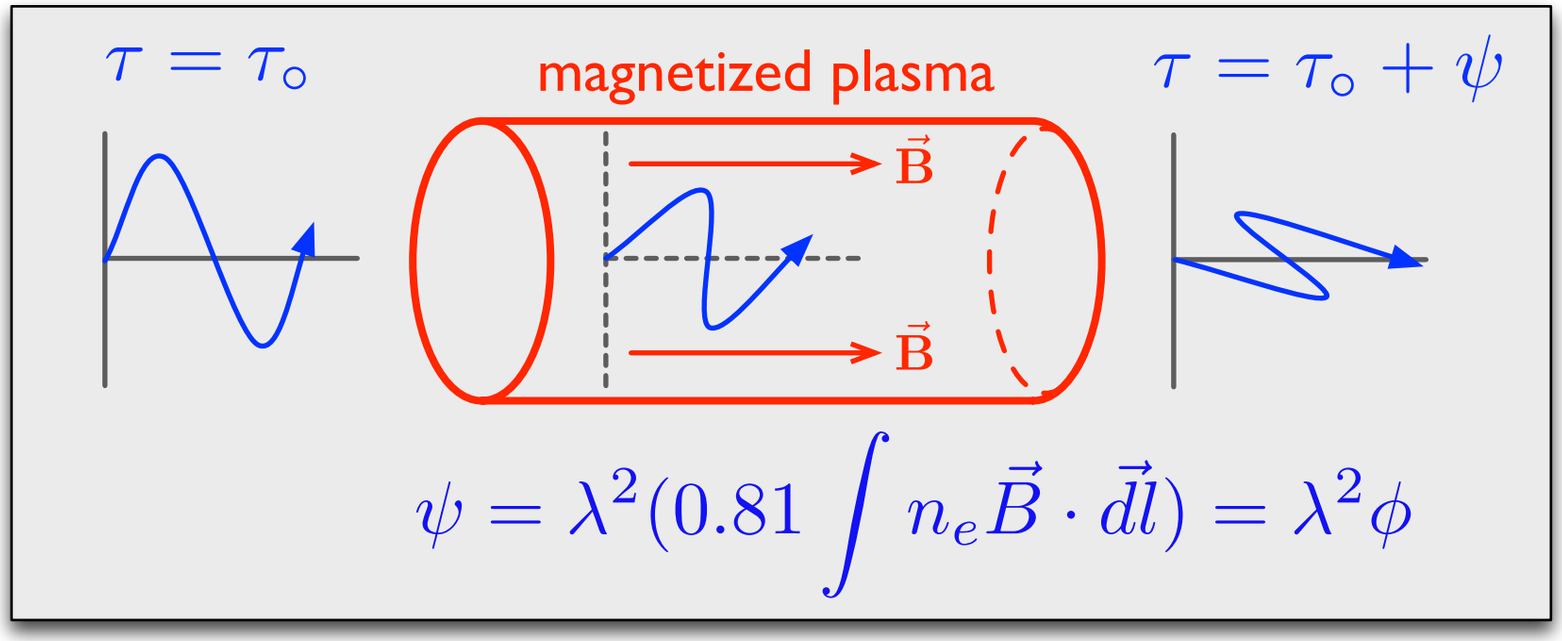


Image credit: Jo-Anne Brown

Faraday rotation

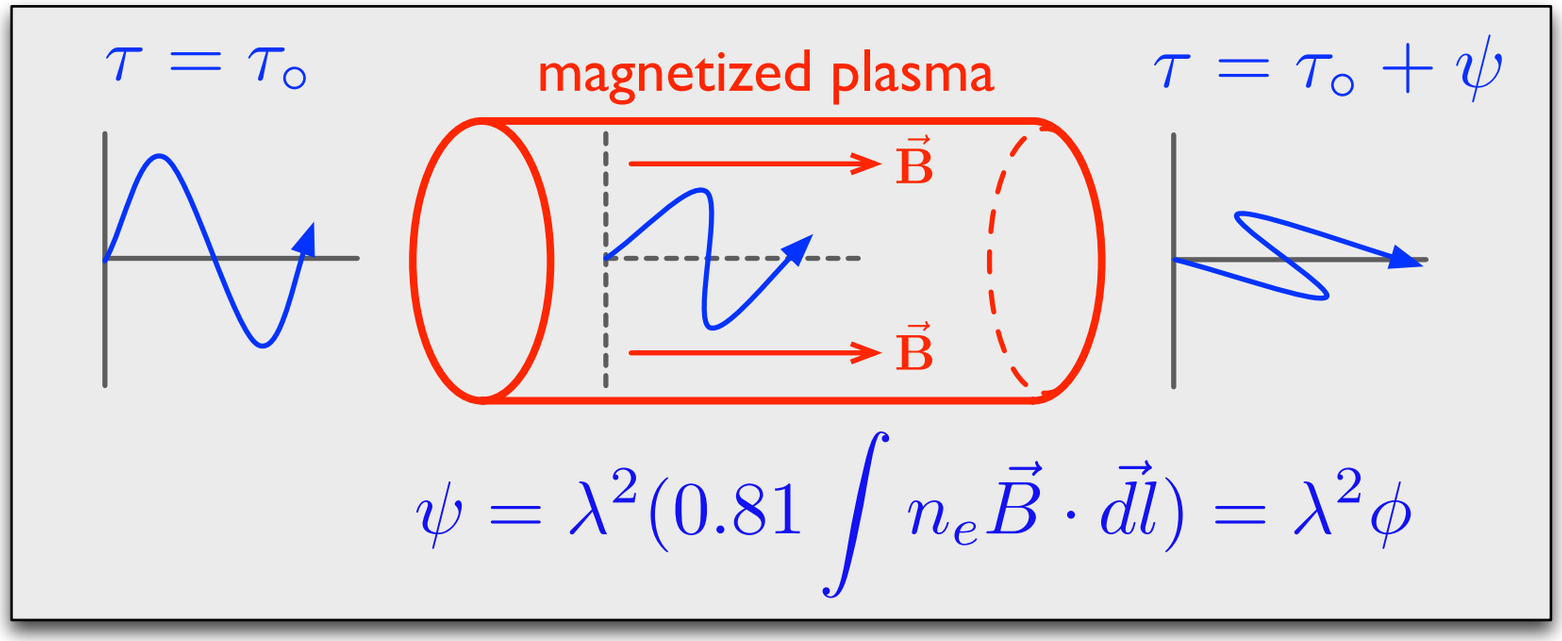
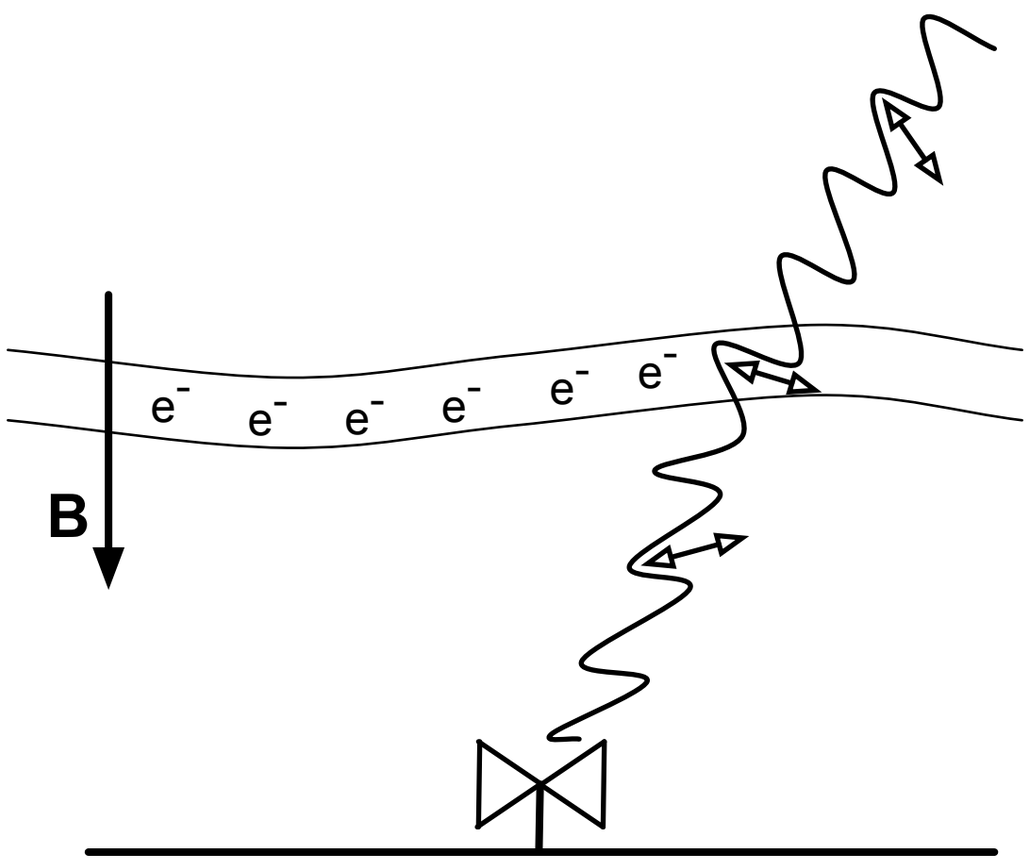


Image credit: Jo-Anne Brown

$$\phi_{\rm measured} = \phi_{\rm source} + \phi_{\rm Galactic} + \phi_{\rm ionosphere}$$

Ionospheric Faraday Rotation

$$\phi_{\text{ionosphere}} = 0.81 \int_{\text{ion}} n_e \vec{B} \cdot \vec{dl} \approx 0.81\ (\text{TEC})\ B_{\|}$$



- $B_{\|}$ from Earth's magnetic field model
- Total electron content (TEC) from published TEC maps
- Typically $\phi_{\text{ionosphere}} \approx$ 1-2 rad/m^2

maaijke / RMextract

extract TEC, vTEC, Earthmagnetic field and Rotation Measures from GPS and WMM data for radio interferometry observations

26 commits **1** branch **0** releases **1** contributor

Branch: **master** RMextract / +

removed small bug in getRM.py

maaijke authored 25 days ago latest commit 4788d3e254

EMM	NEW coefficients forWMM model, NOTE :EMM model still needs update	3 months ago
RMextract	removed small bug in getRM.py	25 days ago
examples	removed small bug in getRM.py	25 days ago
INSTALL	added INSTALL	5 months ago
README.md	moved readme	5 months ago
setup.py	first working version	5 months ago

README.md

RMextract

RMextract

- Calculates Ionospheric RM based on World Magnetic field Model (WMM) and supplied TEC map, and can output a ParmDB with predicted RM.

- Can read in TEC maps from either Center for Orbital Determination in Europe (CODE) or Royal Observatory of Belgium (ROB)

RMextract

- How well can we remove the ionospheric RM? Which TEC source better predicts ionospheric RM in LOFAR observations?

- CODE:
  Time resolution: 2 hours
  Spatial resolution: 5x2.5°? (~300 km)

- ROB:
  Time resolution: 15 minutes
  Spatial resolution: 0.5x0.5° (~55 km)

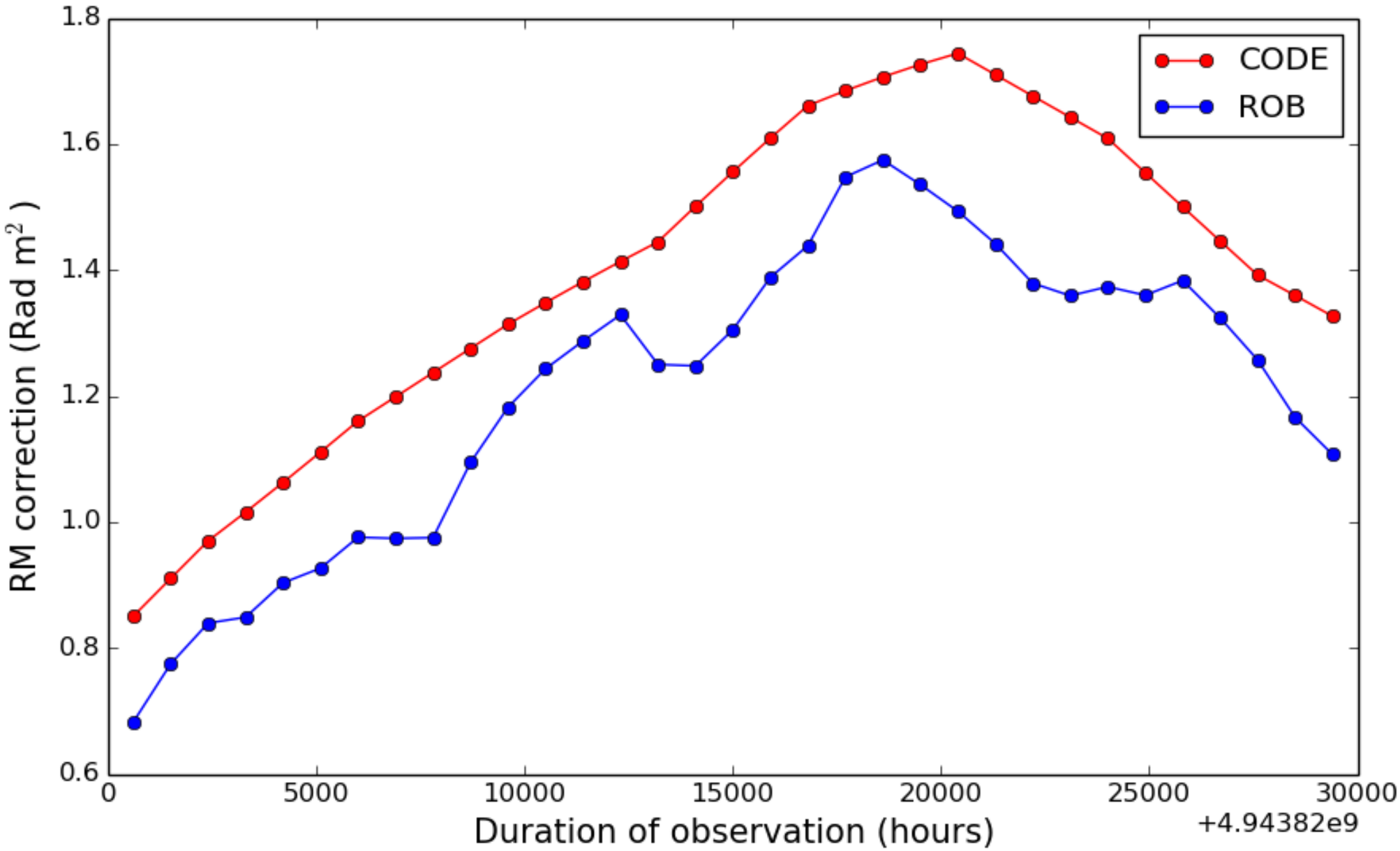
Test observations

- 8hr observation of pulsar B0329+54, calibrated by David Mulcahy

- Time variations in the ionospheric RM are expected to cause major depolarization: at 150 MHz, 0.4 rad/m^2 will rotate the polarization by 90°.

- The predicted variations for this observation are ~1 rad/m^2, so this is a great test of the ability to remove the ionospheric RM in a LOFAR dataset.

Predicted Ionospheric RM



Test 1: Integrated polarization

- I produced RM cubes, using the full time range, for 3 copies of the data:
  -with no correction
  -with CODE correction
  -with ROB correction

- I measured the resulting polarized flux of the pulsar in each cube.

Correction:	Polarized flux:
None	67 mJy
CODE	480 mJy
ROB	420 mJy

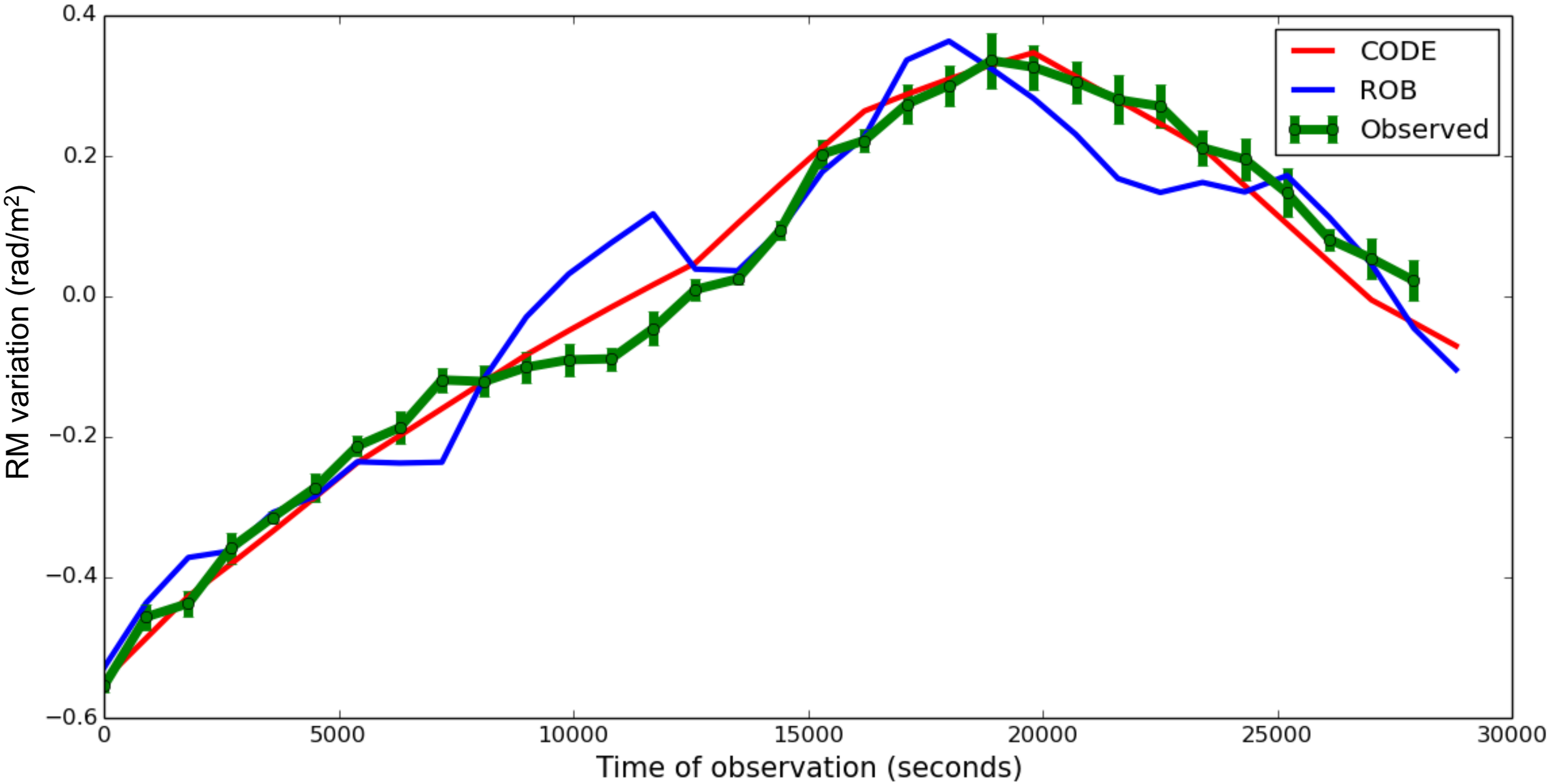
Test 2: Variation over time

- Are the short-term variations predicted by ROB reflected in the observations?

- I took 1 minute slices of data at 15 minute intervals, and measured the observed RM of the pulsar.

- The measured RMs, and the RM predictions, were mean-subtracted so they could be directly compared.

Test 2: Variation over time



Conclusions

- We can successfully correct for ionospheric Faraday rotation, with remaining time variations of ~0.1 rad/m^2 and systematic uncertainty of ~0.2 rad/m^2.

- Despite having lower spatial/temporal resolution, CODE performs better than ROB in predicting the ionospheric RM.

- Still room for future improvement, such as Michiel's RM selfcal.

- Thanks to Maaijke, for RMextract and David Mulcahy, for organizing the Busy Days