

Galileo-only Cadastral Survey

Galileo-only RTK Experiment

FIG 2020 Working Week, Amsterdam

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European
Global Navigation
Satellite Systems
Agency



GALILEO **EGNOS**

NAVIGATION MADE IN EUROPE

Release information



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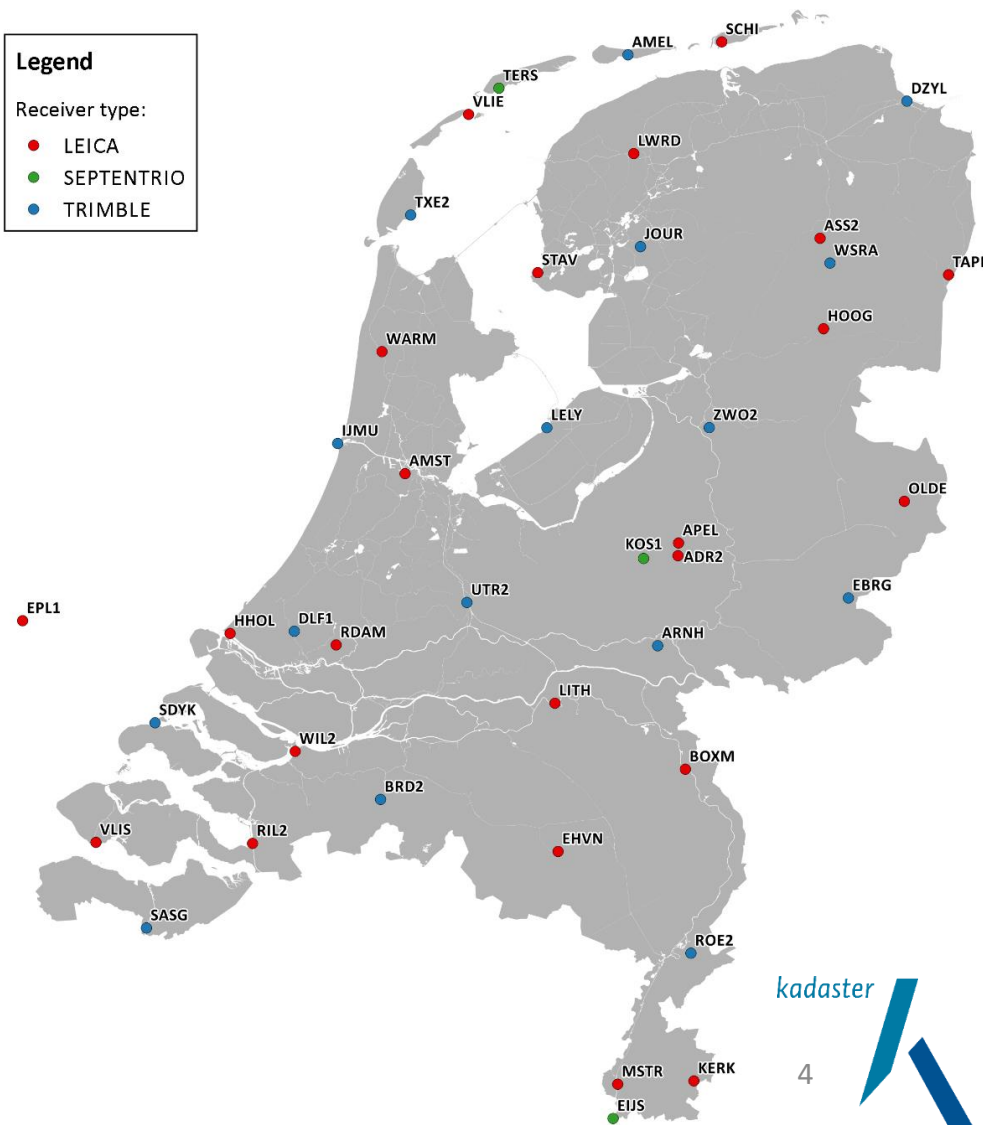


- Motivation
- Experiment setup
- Results

Motivation



- Galileo has declared the initial services starting December 15th, 2016
- The content of the Open Services (OS) and the expected availability and accuracy are described in a service definition document
- Anticipating Galileo OS, Kadaster national GNSS network upgrade to Galileo 'ready' hardware finished
- Galileo observations not yet used in Kadaster RTK-service
- Explore the possibility of using Galileo as a stand-alone system, for RTK surveying. Question raised:
 - Can we plan a time slot where it is possible to do Galileo only RTK?
 - Can we do a cadastral boundary reconstruction of the Galileo Reference Centre (GRC) in Noordwijk (NL)?



Galileo Reference Centre



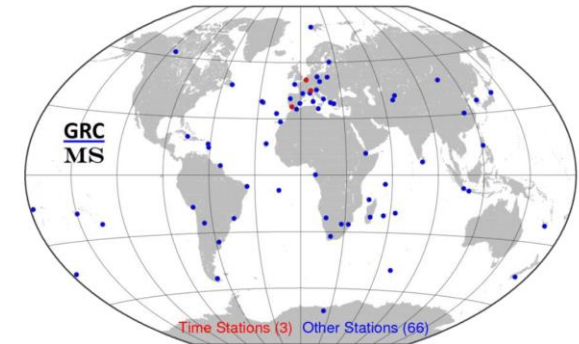
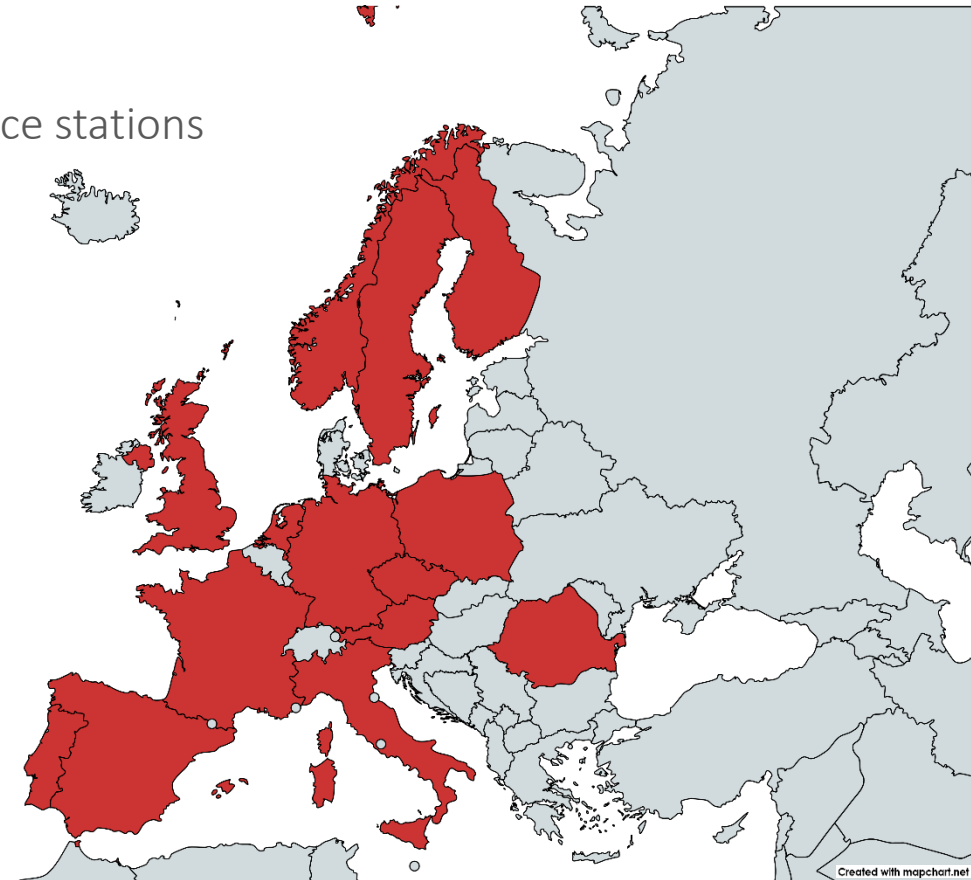
- Perform **independent monitoring** and assessment of service provision
- When feasible, assess the compatibility and **interoperability** between Galileo and other GNSS
- Provide service **performance expertise** to Programme
- Support **investigations** of service **performance** and service degradations
- Archive service performance data over nominal operational lifetime of system
- Integrate **data and products** from EU Member States, Norway and Switzerland (MS)



Member States' Contributions



- 23 organisations from 14 countries
- Including
 - Worldwide network of reference stations
 - Reference products
 - Timing labs
 - Radio telescopes
 - Laser ranging
 - Vehicles, vessels and airplanes



Experiment setup

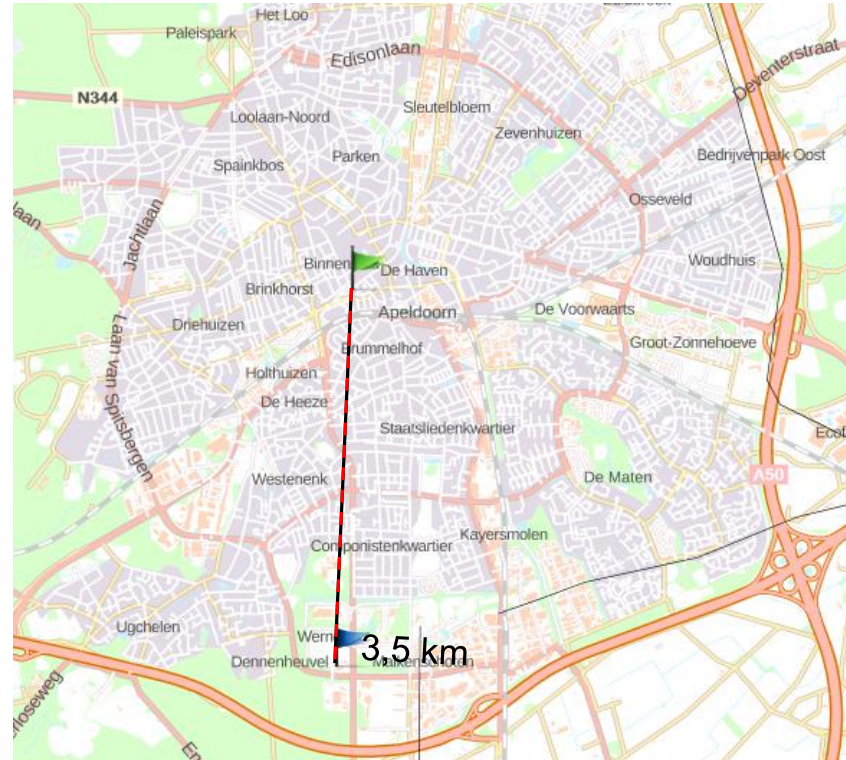


- Planning the time slot
 - Single baseline (3.5 km, identical receivers)
 - RTKLIB library with minor modification to handle Galileo navigation messages and E5b signals.
 - Post-processed as if RTK with ambiguity resolution
 - 1 Hz data
 - Triple frequency solutions (E1/E5a/E5b)
 - Processing restarted every 15 minutes

Experiment setup

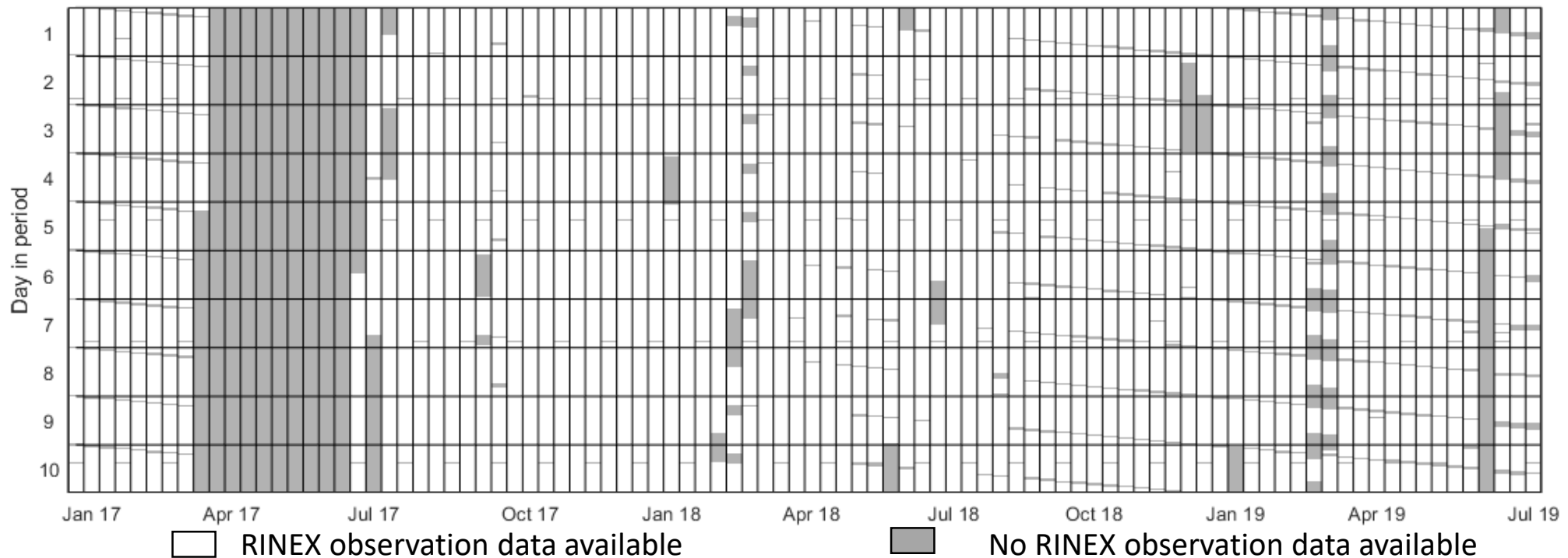
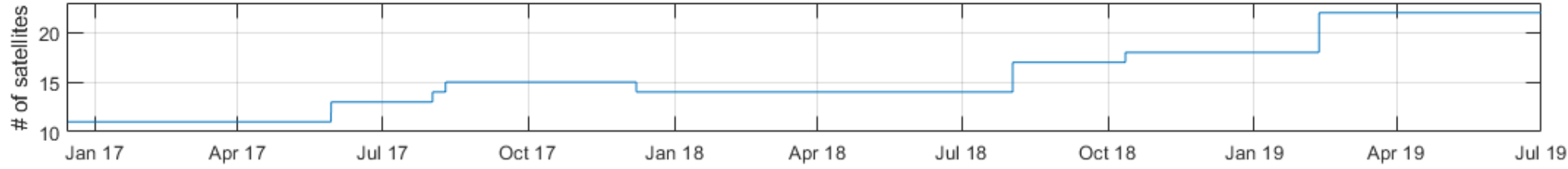


Site: ADR200NLD
Receiver: Leica GR 50
Antenna: Leica AR20 LEIM



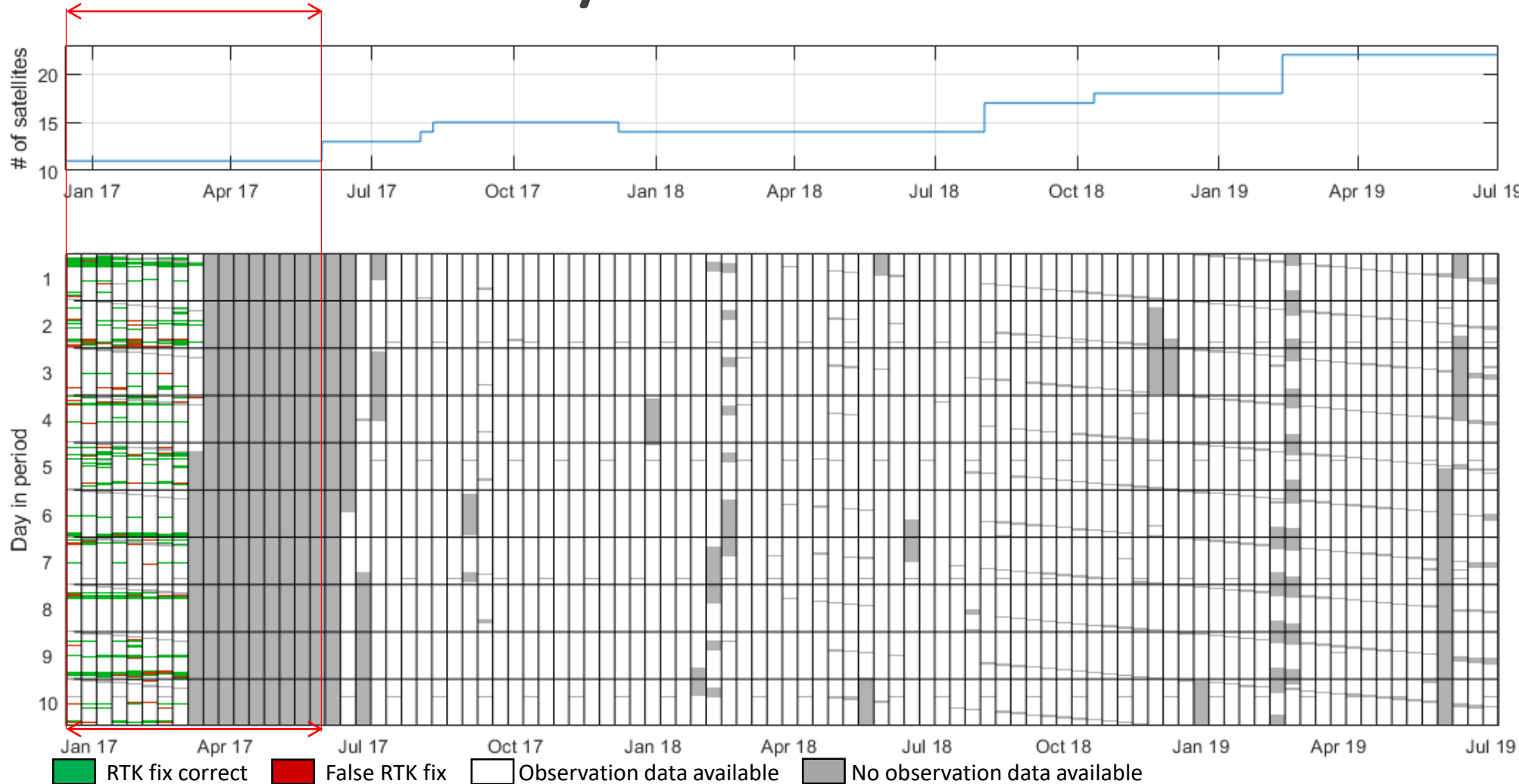
Site: APEL00NLD
Receiver: Leica GR 50
Antenna: Leica AR25.R4 LEIT

Observation and satellite data availability



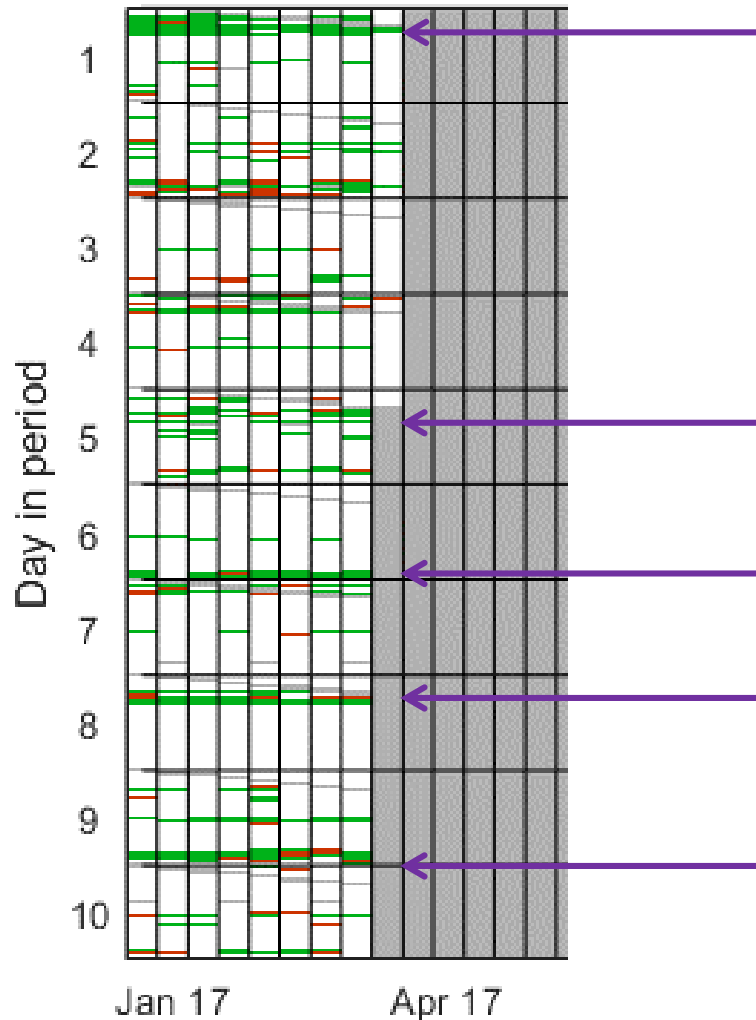
- The top graph show the number of operational Galileo satellites
- The bottom graph shows the availability of RINEX observation data
 - The vertical axis shows the number of days in a 10 sidereal days Galileo geometry repetition period (start date 2016-12-15).
 - The horizontal axis show the start of an Galileo repetition period from 2016-12-15 until 2017-07-31
 - Each cell in the plot is a 'Galileo day'.

RTK availability 2016-12-15 to 2017-05-29



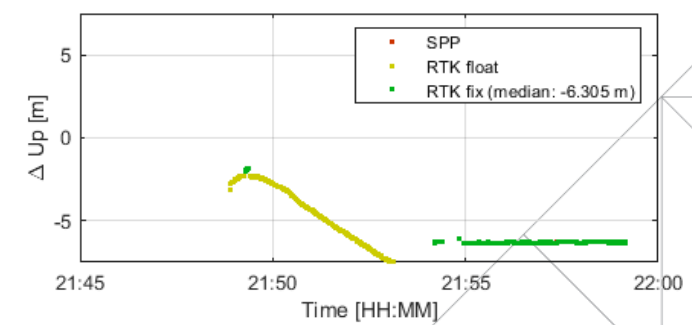
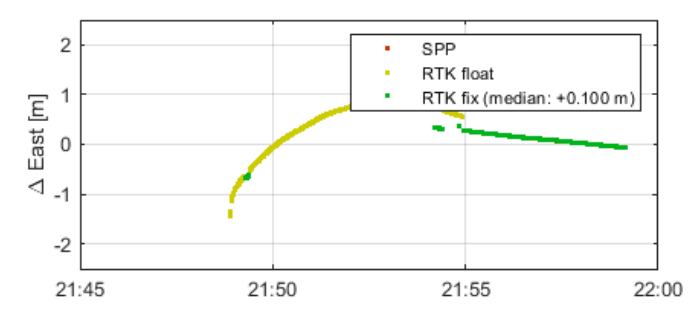
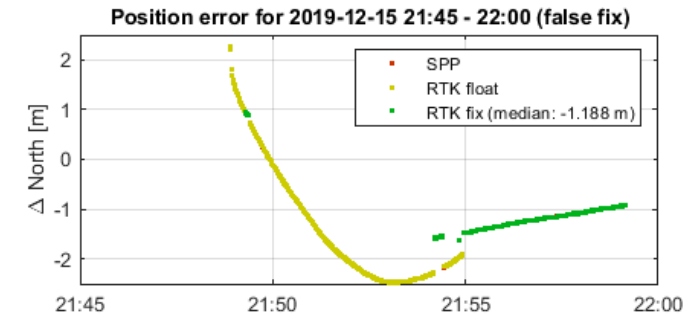
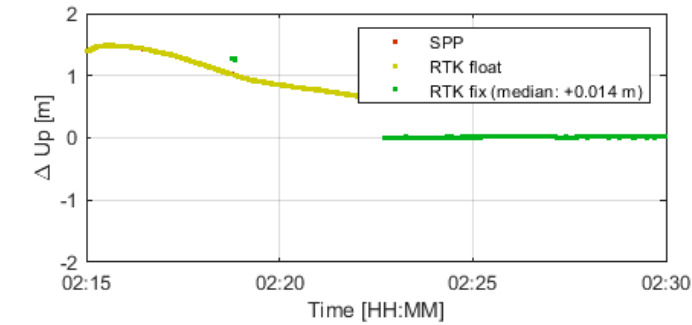
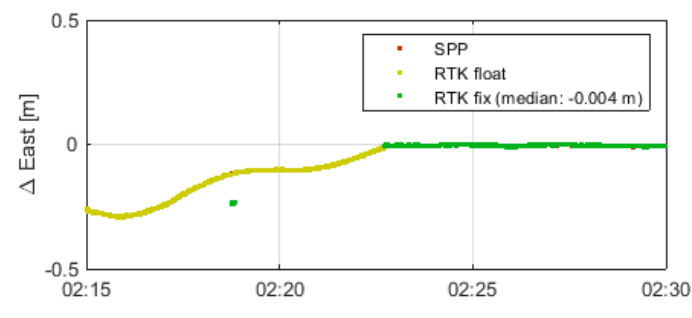
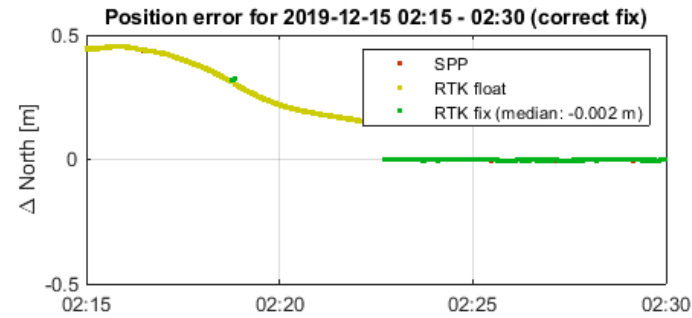
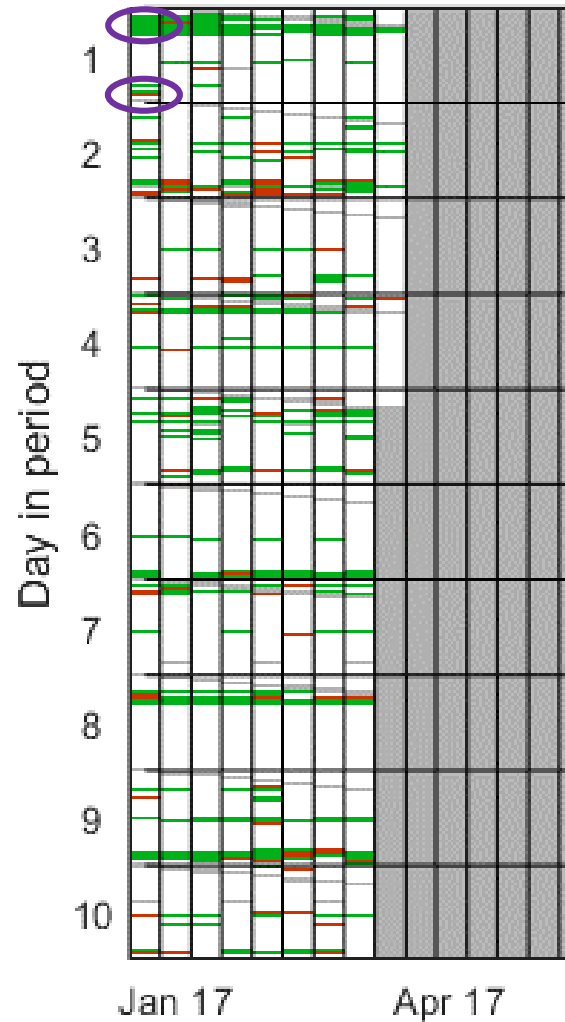
- This graph shows the availability of RTK fixes.
- A green line indicates that a correct Galileo only RTK fix was possible for a 15 minute interval.
- A red line indicates that an incorrect Galileo only RTK fix was achieved in the 15 minute interval.

RTK availability 2016-12-15 to 2017-05-29

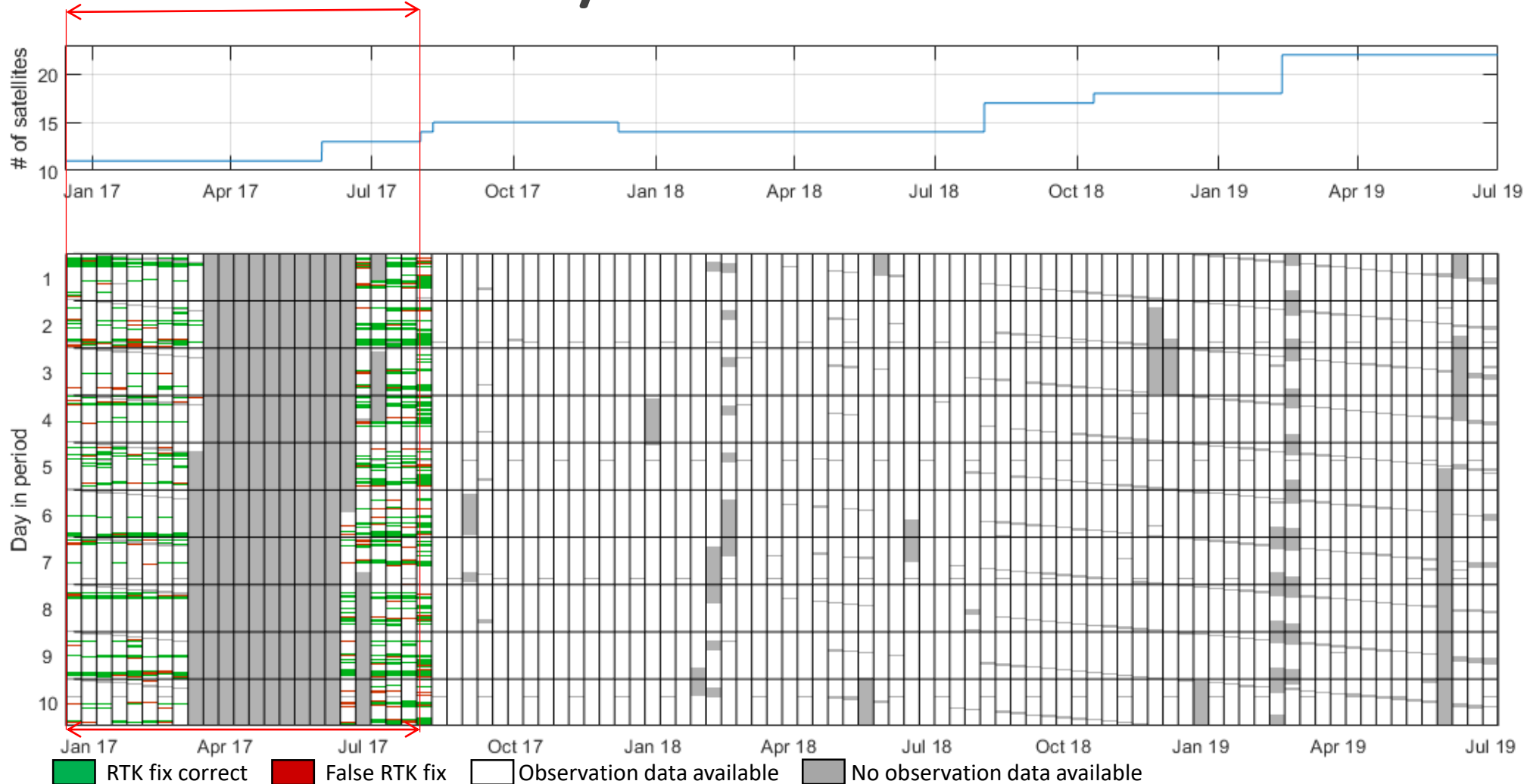


- A **green** line indicates that a correct Galileo only RTK fix was possible.
- A **red** line indicates that a incorrect Galileo only RTK fix was achieved.
- The criterion for a 'RTK fix' session is that a fix was possible at least 60 seconds of the 15 minute interval.
- The criterion for a 'RTK fix correct' session is that the median of the 3D position error of fixed epochs is less than 0.05 meter.
- The availability is limited but **repeatable**.

RTK fix and false fix example

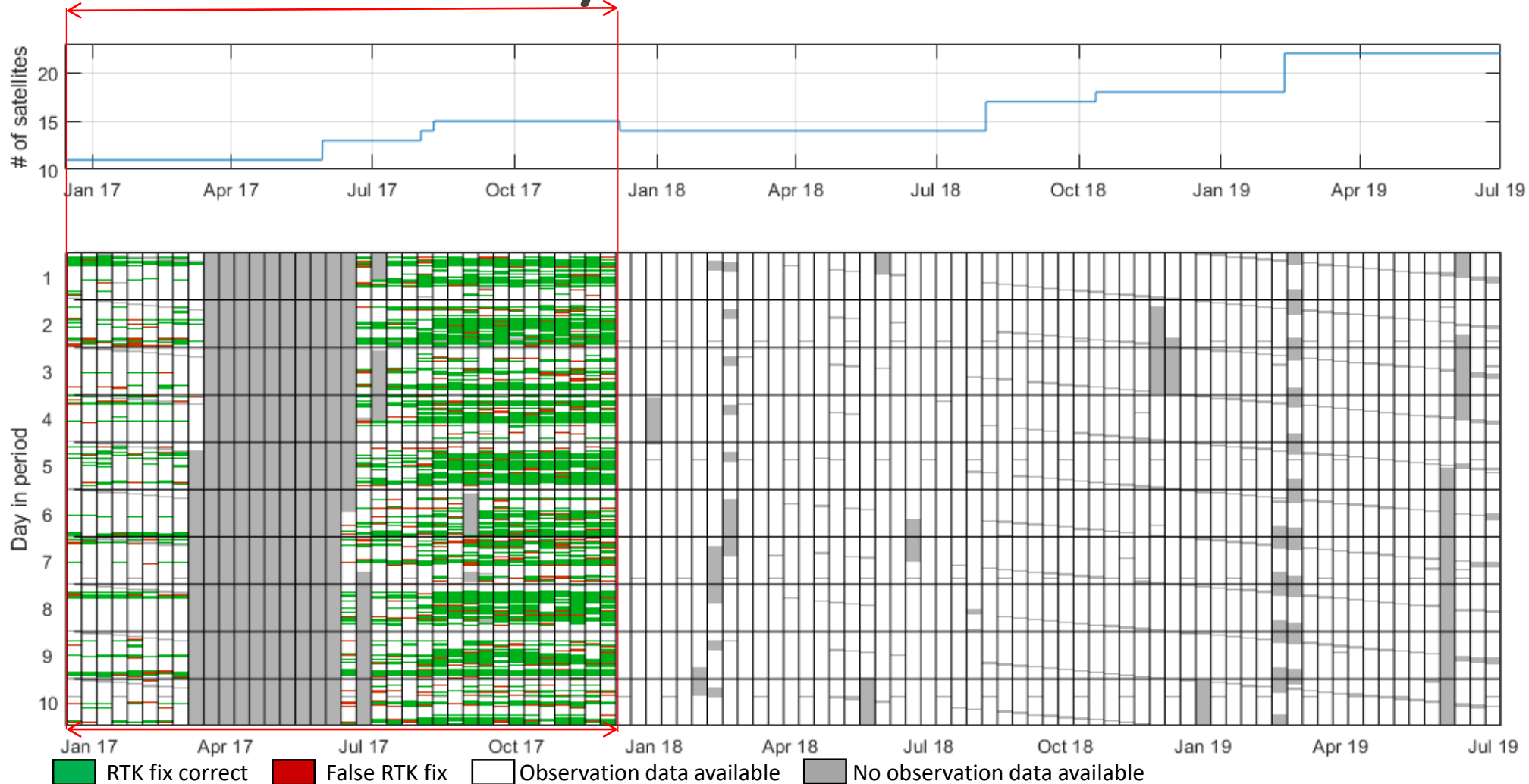


RTK availability 2016-12-15 to 2017-08-01



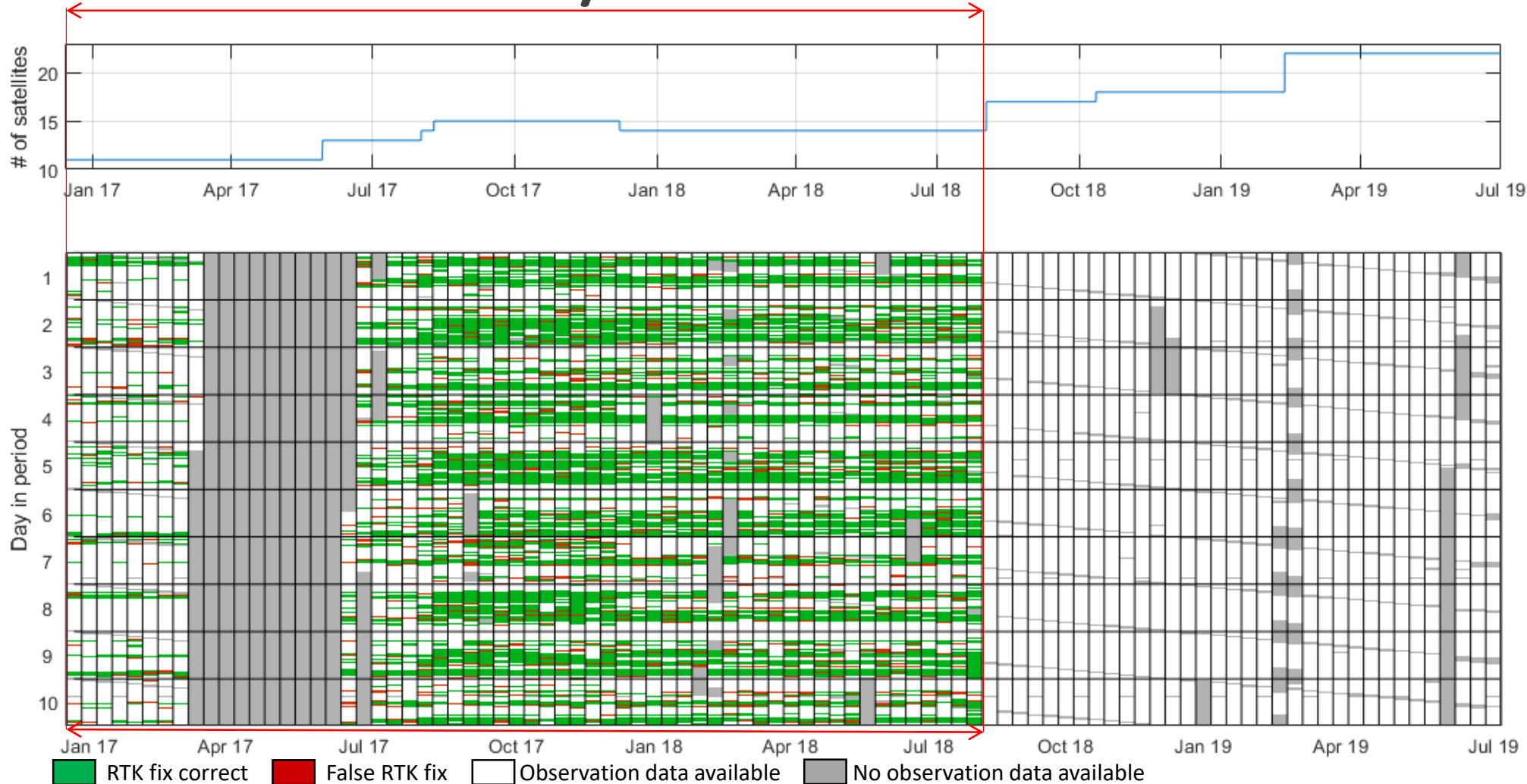
- This graph shows the availability of RTK fixes.
- A green line indicates that a correct Galileo only RTK fix was possible for a 15 minute interval.
- A red line indicates that a incorrect Galileo only RTK fix was achieved in the 15 minute interval.
- The availability increases with more satellites.
- The system remains stable.

RTK availability 2016-12-15 to 2017-12-08



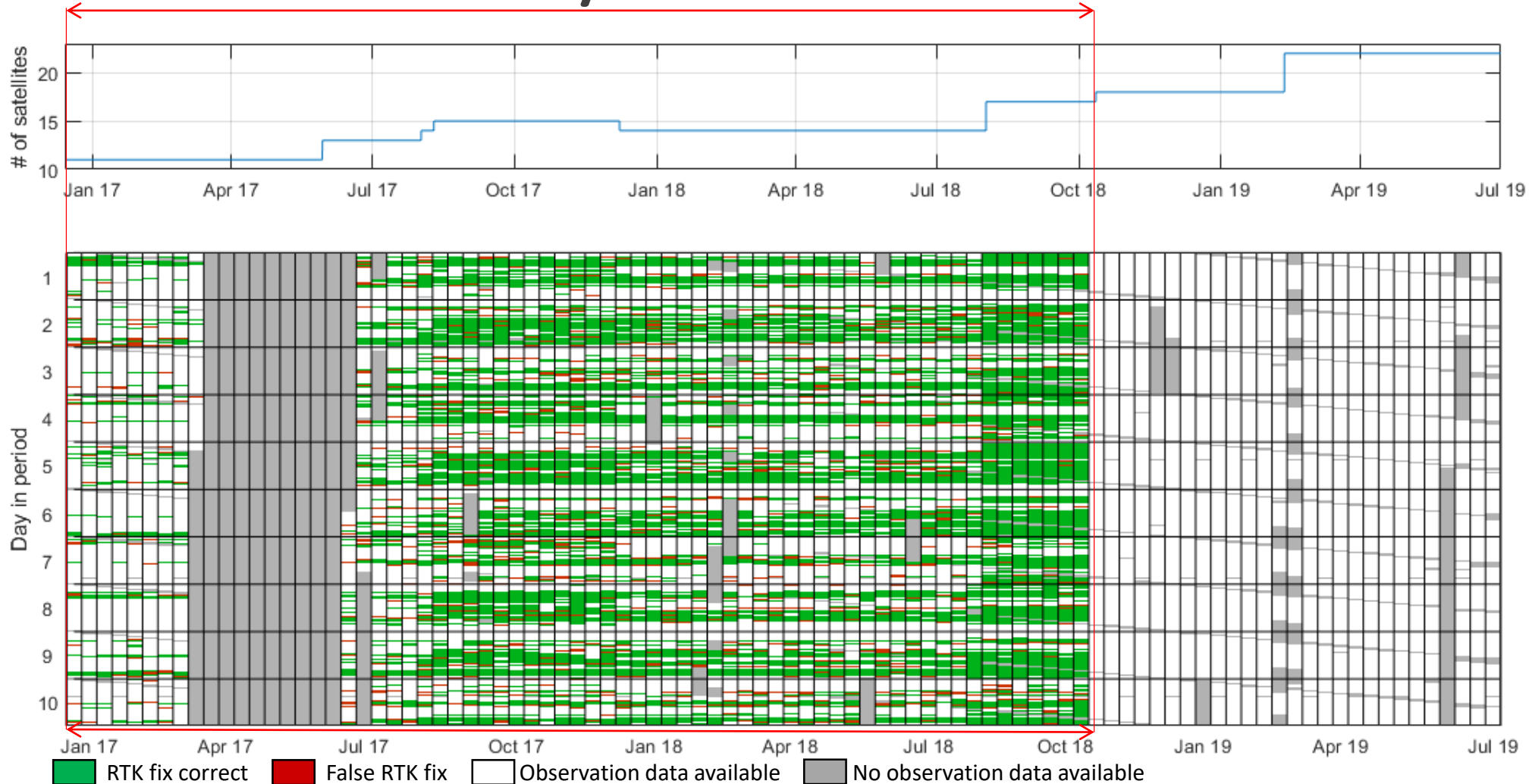
- The availability increases further with more satellites.
- The system remains stable.

RTK availability 2016-12-15 to 2018-08-02



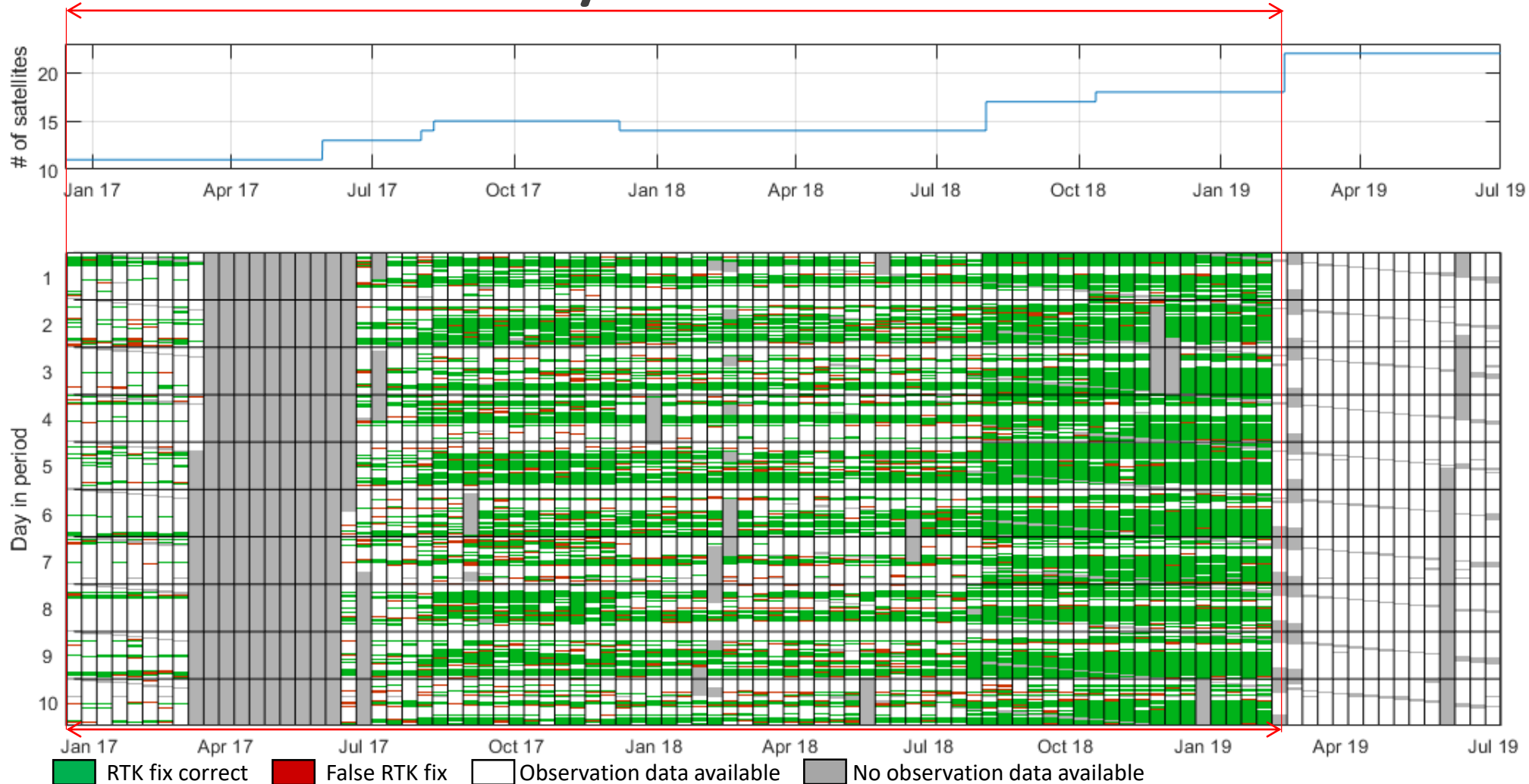
- The availability is slightly decreased with one satellite less.
- The system remains stable.

RTK availability 2016-12-15 to 2018-10-12



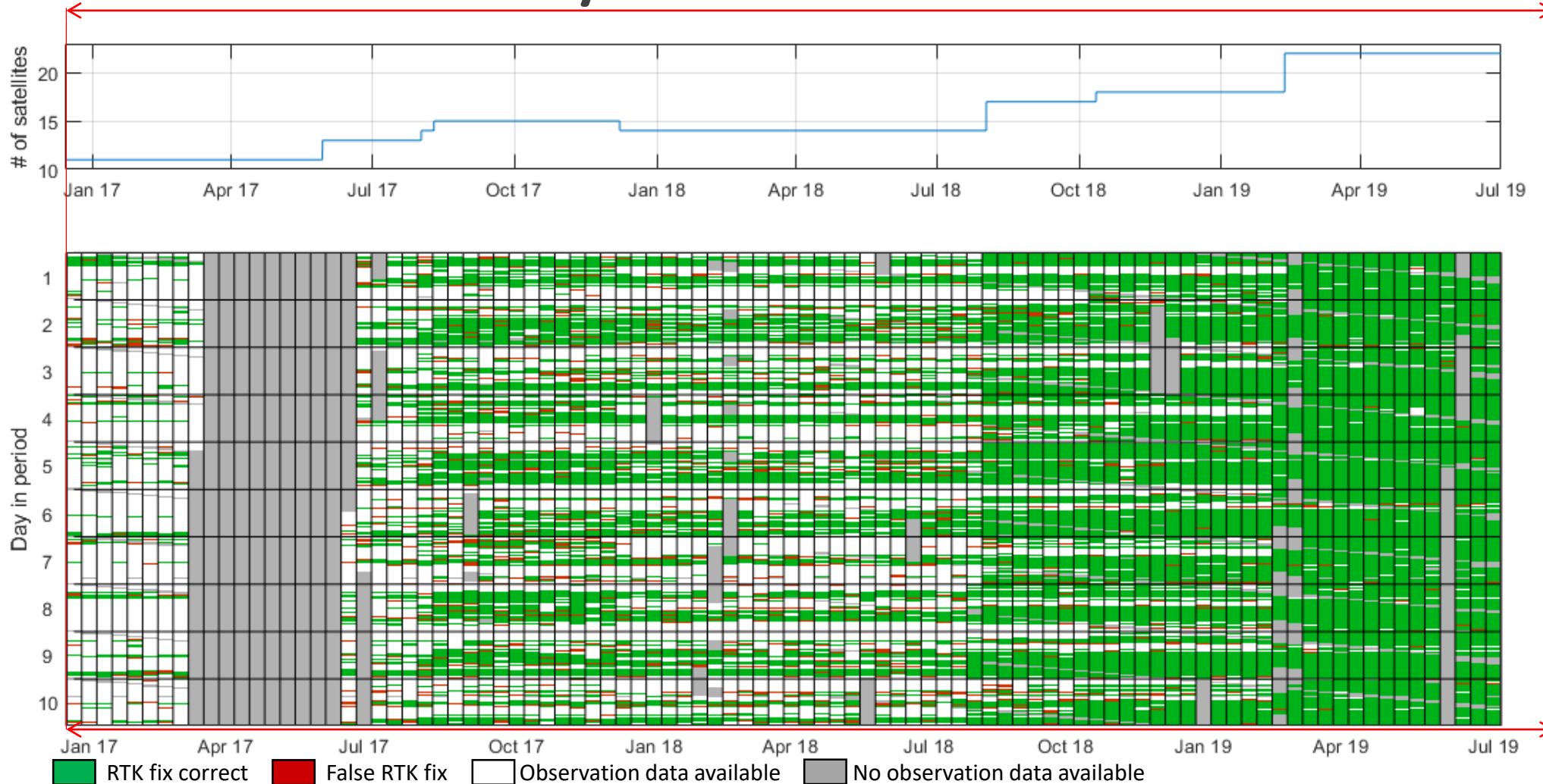
- A fix is available more often than not.

RTK availability 2016-12-15 to 2019-02-11



- A fix is available more often than not.

RTK availability 2016-12-15 to 2019-06-30



- A fix is available almost every 15 minutes.
- False fixes are rare.

Summary

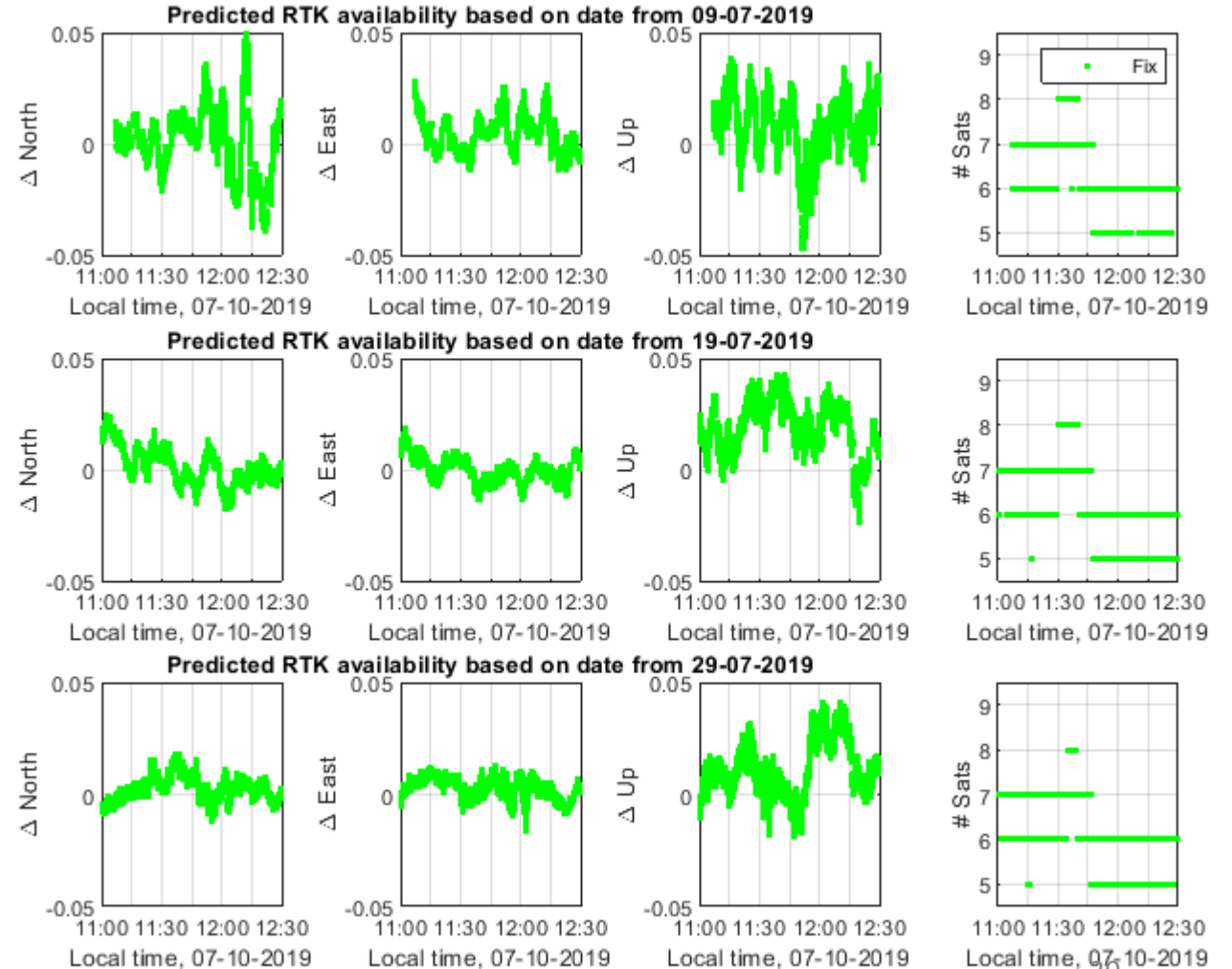


- Can we plan a time slot where it is possible to do Galileo only RTK?
 - Galileo only RTK is possible with initial services.
 - Availability of RTK fixes depends on the number of satellites.
 - Availability is repeatable with same satellite geometry.
 - Surveying hardware is Galileo capable.
- Yes, Galileo only RTK cm-level accuracy is possible now and availability is increasing with number of available satellites

Planning a Galileo only survey for October 7th 2019



- Same satellite geometry available on 09-07-2019, 19-07-2019 and 29-07-2019.
- Between 5 and 8 satellites available between 10:00 and 11:30 local time.
- Fixing is possible at this time.



October 7th 2019

Cadastral boundary reconstruction of the Galileo Reference Centre (GRC) in Noordwijk (NL) using Galileo only RTK

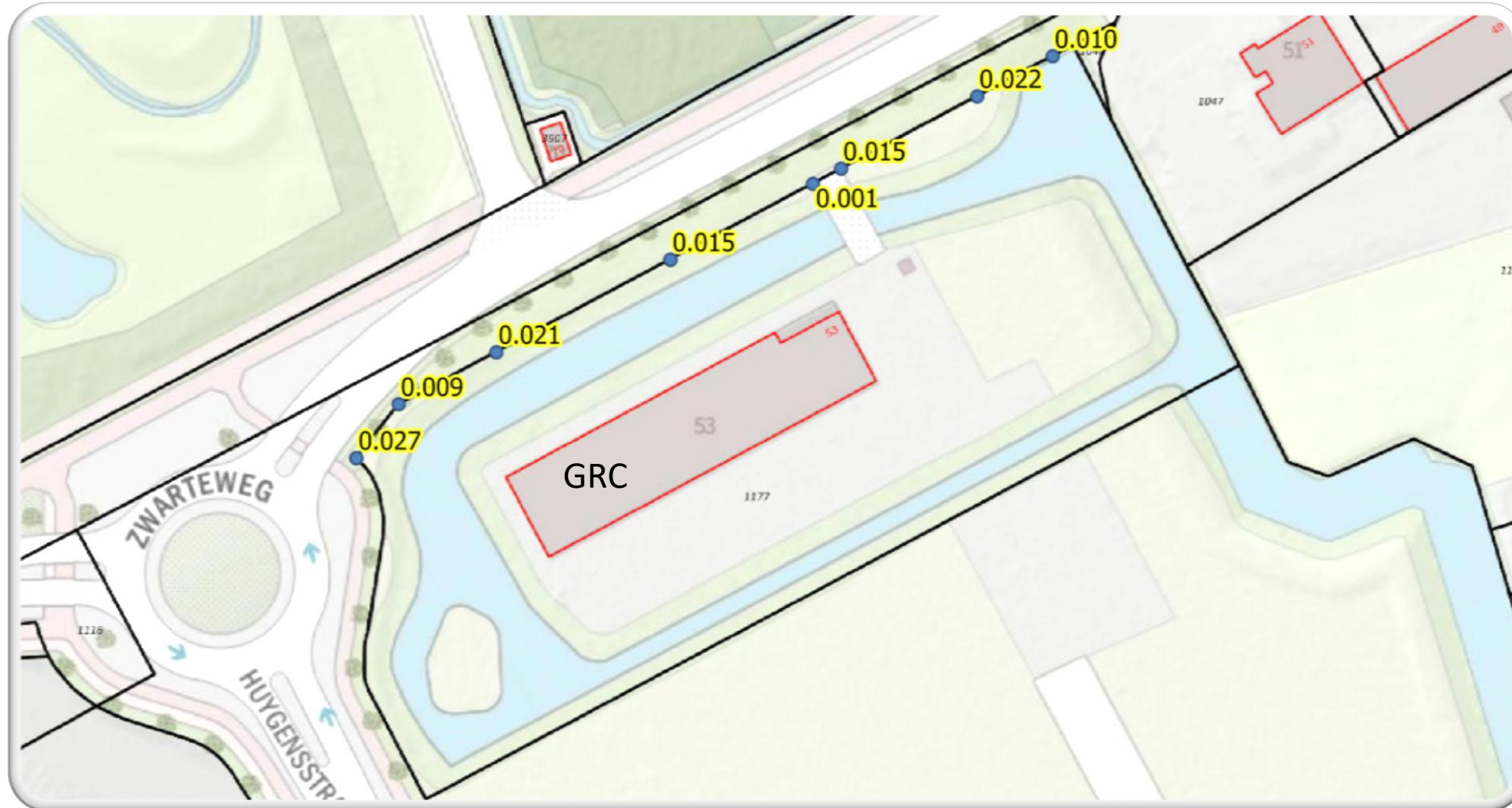


Boundary reconstruction result



- Black line shows cadastral boundary.
- Blue points were staked out October 7th with Galileo only

Boundary reconstruction result



- Black line shows cadastral boundary.
- Blue points were staked out October 7th with Galileo only
- **Values** show difference between coordinates obtained with Galileo only RTK and NETPOS RTK service (GPS+GLONASS)

Map source:
www.opentopo.nl

Summary



- Can we plan a time slot where it is possible to do Galileo only RTK?
 - Galileo only RTK is possible with initial services.
 - Availability of RTK fixes depends on the number of satellites.
 - Availability is repeatable with same satellite geometry.
 - Surveying hardware is Galileo capable.
- Yes, Galileo only RTK with cm-level accuracy is possible now and availability will increase when more satellites become available.
- Galileo only Cadastral boundary reconstruction of the Galileo Reference Centre premises by Kadaster on 2019-10-07.

Linking space to user needs



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