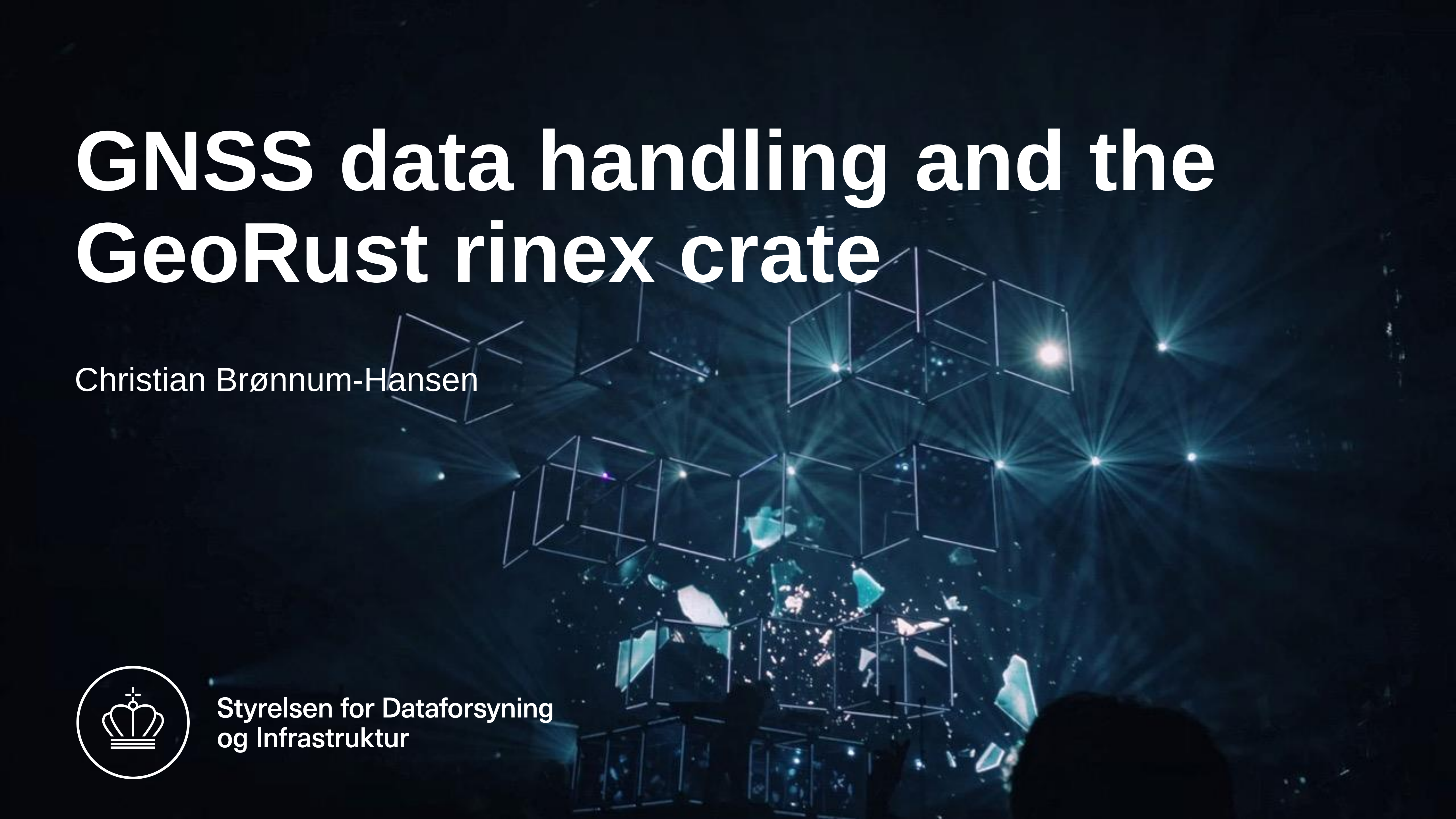
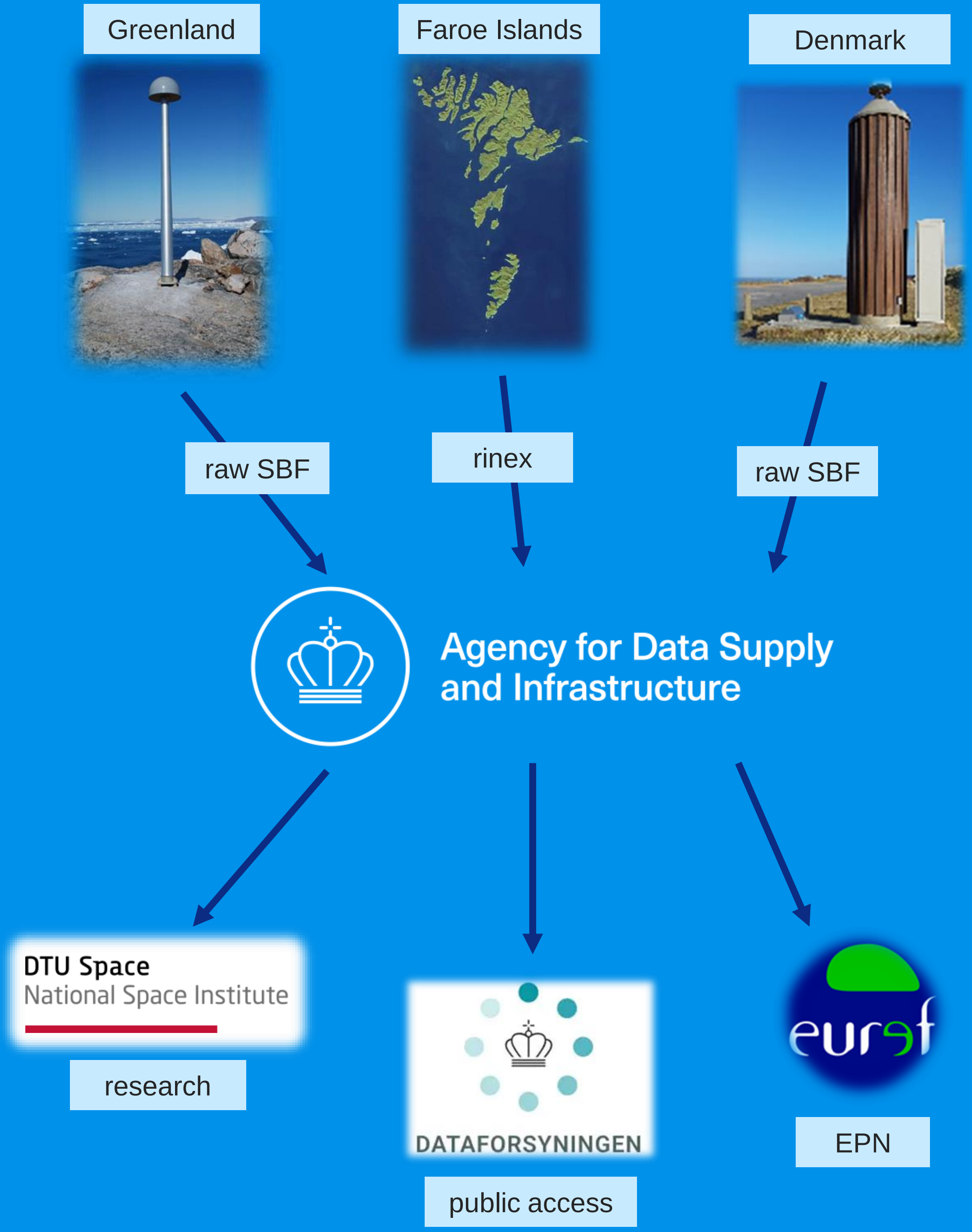


GNSS data handling and the GeoRust rinex crate

Christian Brønnum-Hansen

Styrelsen for Dataforsyning
og Infrastruktur

Flow of GNSS data



Greenland

Faroe Islands

Denmark

raw SBF

rinex

raw SBF

Agency for Data Supply and Infrastructure

DTU Space National Space Institute

research

DATAFORSYNINGEN

public access

euref

EPN

- different data formats arrive at SDFI from Greenland, Faroe Islands, and Denmark as well as commercial providers

- for Greenland the observation interval relies on the available data connection

- processed at our servers and distributed to
  - DTU
  - dataforsyningen.dk
  - EPN (EUREF Permanent GNSS Network)

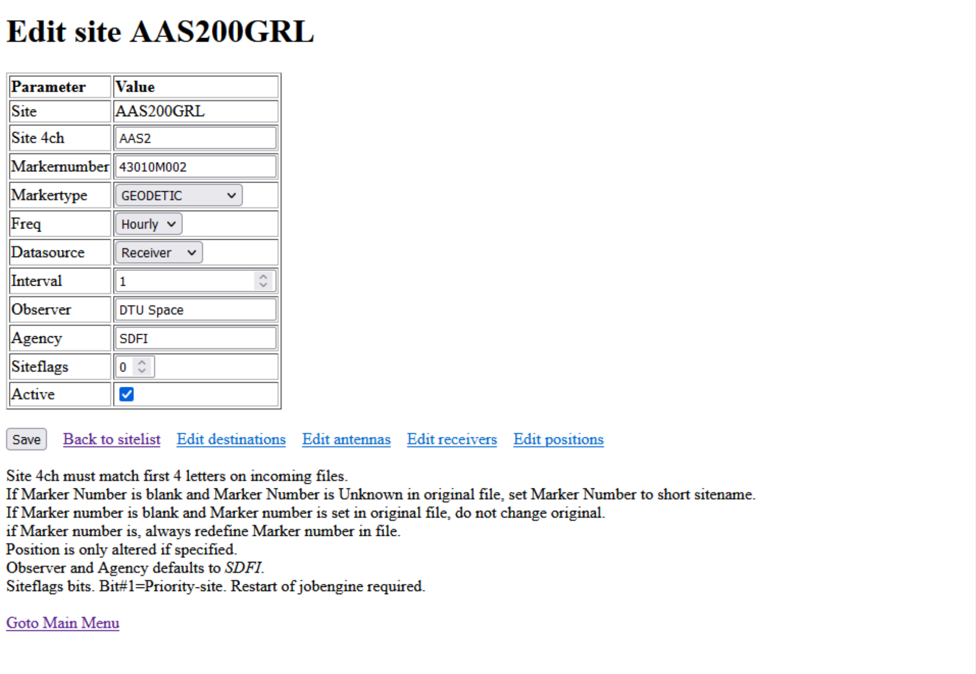
- EPN guidelines for reference stations largely sets the standard for outgoing data

Agency for Data Supply
and Infrastructure

GORM

GNSS Operations, Register and Monitoring system

- old (read: thoroughly tested)
- developed in PERL
- relies on closed-source software

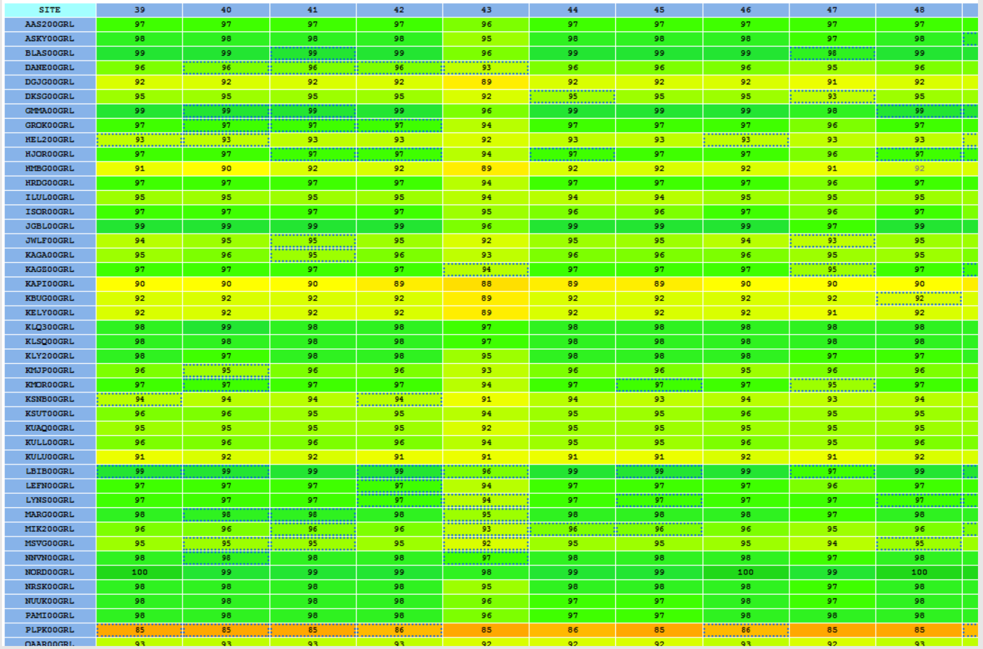


Edit site AAS200GRL

Parameter	Value
Site	AAS200GRL
Site 4ch	AAS2
Markernumber	43010M002
Markertype	GEODETIC
Freq	Hourly
Datasource	Receiver
Interval	1
Observer	DTU Space
Agency	SDFI
Siteflags	0
Active	☑

Site 4ch must match first 4 letters on incoming files.
If Marker Number is blank and Marker Number is Unknown in original file, set Marker Number to short sitename.
If Marker number is blank and Marker number is set in original file, do not change original.
if Marker number is, always redefine Marker number in file.
Position is only altered if specified.
Observer and Agency defaults to *SDFI*.
Siteflags bits. Bit#1=Priority-site. Restart of jobengine required.

Goto Main Menu



SITE	39	40	41	42	43	44	45	46	47	48
AAS200GRL	97	97	97	97	96	97	97	97	97	97
ASKY00GRL	98	98	98	98	95	98	98	98	97	98
BLAS00GRL	99	99	99	99	96	99	99	99	98	99
DANE00GRL	96	96	96	96	93	96	96	96	95	96
DGJG00GRL	92	92	92	92	89	92	92	92	91	92
DKSG00GRL	95	95	95	95	92	95	95	95	93	95
GMMA00GRL	99	99	99	99	96	99	99	99	98	99
GROK00GRL	97	97	97	97	94	97	97	97	96	97
HEL200GRL	93	93	93	93	92	93	93	93	93	93
HJOR00GRL	97	97	97	97	94	97	97	97	96	97
HMBG00GRL	91	90	92	92	89	92	92	92	91	92
HRDG00GRL	97	97	97	97	94	97	97	97	96	97
ILUL00GRL	95	95	95	95	94	94	94	95	95	95
ISOR00GRL	97	97	97	97	95	96	96	97	96	97
JGBL00GRL	99	99	99	99	96	99	99	99	97	99
JWLF00GRL	94	95	95	95	92	95	95	94	93	95
KAGA00GRL	95	96	95	96	93	96	96	96	95	95
KAGZ00GRL	97	97	97	97	94	97	97	97	95	97
KAPI00GRL	90	90	90	89	88	89	89	90	90	90
KBUG00GRL	92	92	92	92	89	92	92	92	92	92
KELY00GRL	92	92	92	92	89	92	92	92	91	92
KLQ300GRL	98	99	98	98	97	98	98	98	98	98
KLSQ00GRL	98	98	98	98	97	98	98	98	98	98
KLY200GRL	98	97	98	98	95	98	98	98	97	97
KMJP00GRL	96	95	96	96	93	96	96	95	96	96
KMOR00GRL	97	97	97	97	94	97	97	97	95	97
KSNB00GRL	94	94	94	94	91	94	93	94	93	94
KSUT00GRL	96	96	95	95	94	95	95	96	95	95
KUAQ00GRL	95	95	95	95	92	95	95	95	95	95
KULL00GRL	96	96	96	96	94	95	95	96	95	96
KULU00GRL	91	92	92	91	91	91	91	92	91	92
LBIB00GRL	99	99	99	99	96	99	99	99	97	99
LEFN00GRL	97	97	97	97	94	97	97	97	96	97
LYNS00GRL	97	97	97	97	94	97	97	97	97	97
MARG00GRL	98	98	98	98	95	98	98	98	97	98
MIK200GRL	96	96	96	96	93	96	96	96	95	96
MSVG00GRL	95	95	95	95	92	95	95	95	94	95
NNVN00GRL	98	98	98	98	97	98	98	98	97	98
NORD00GRL	100	99	99	99	98	99	99	100	99	100
NRSK00GRL	98	98	98	98	95	98	98	98	97	98
NUUK00GRL	98	98	98	98	96	97	97	98	97	98
PAMI00GRL	98	98	98	98	96	97	97	98	98	98
PLPK00GRL	85	85	85	86	85	86	85	86	85	85
QAAR00GRL	93	93	93	93	92	92	92	93	92	93

Goals for data handling: scalability and maintainability

- Python for maintainability

  - concurrency (asyncio)

- containerized for easy deployment (Docker)

- central database (postgreSQL)

- open-source
  - version control with git
  - external dependencies

Software dependencies for data processing

Processing step	**Current software**	**Open?**	**OSS alternatives** **(non-exhaustive list)**
SBF to rinex (ver. 3)	sbf2rin [1]	✖	? (some projects)
decimate	gfzrnx [2]	✖	BNC [4], **GeoRust rinex** [5]
gap analysis	GORM		**GeoRust rinex**
file splicing	gfzrnx	✖	BNC, **GeoRust rinex**
quality check	g-nut/anubis [3]	✖	BNC, **GeoRust rinex**

[1] https://www.septentrio.com/en/products/gps-gnss-receiver-software/rxtools
[2] https://gnss.gfz-potsdam.de/services/gfzrnx
[3] https://gnutsoftware.com/software/anubis/
[4] https://igs.bkg.bund.de/ntrip/bnc
[5] https://github.com/georust/rinex

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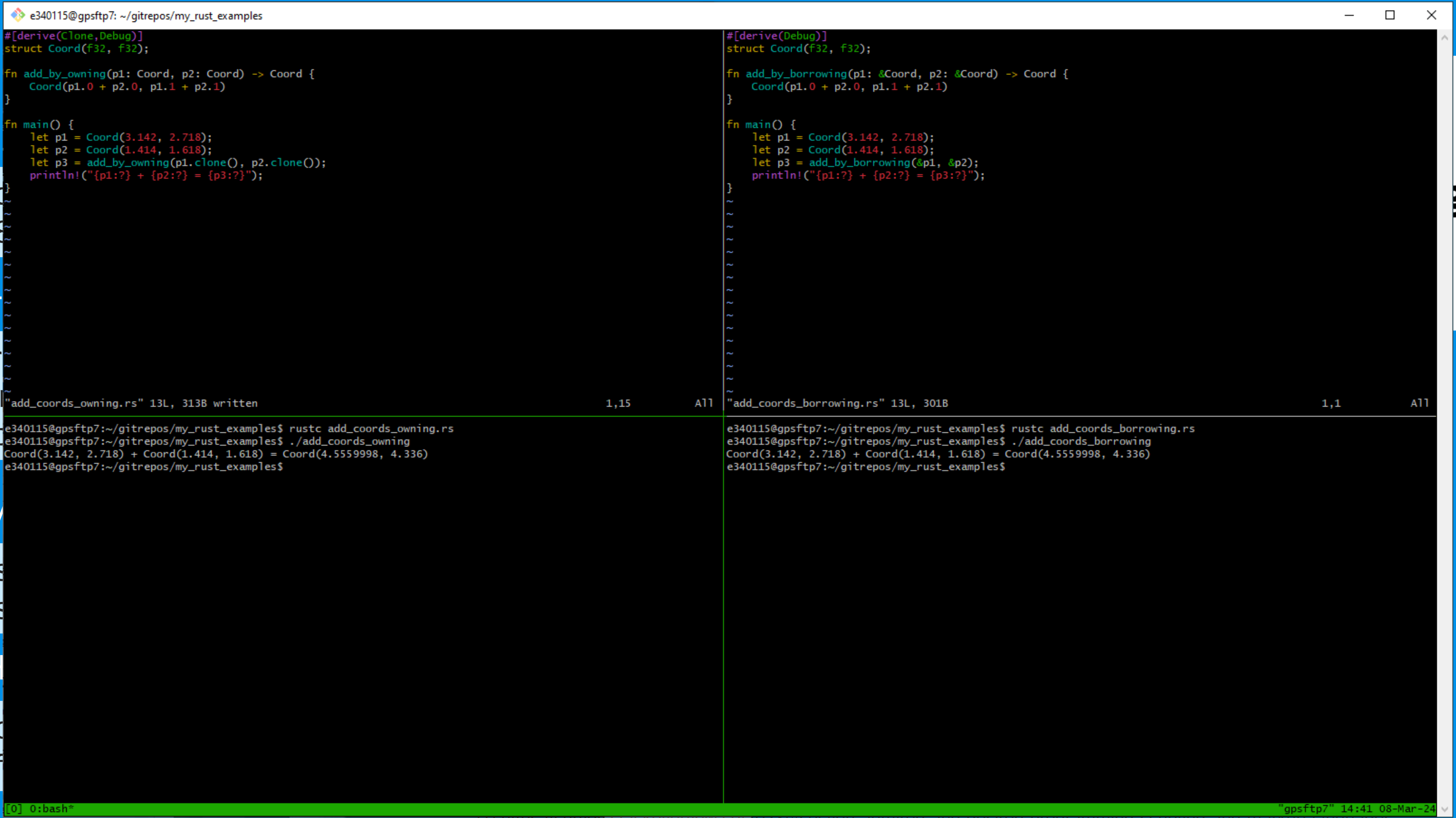


```
#[derive(Clone,Debug)]
struct Coord(f32, f32);

fn add_by_owning(p1: Coord, p2: Coord) -> Coord {
    Coord(p1.0 + p2.0, p1.1 + p2.1)
}

fn main() {
    let p1 = Coord(3.142, 2.718);
    let p2 = Coord(1.414, 1.618);
    let p3 = add_by_owning(p1.clone(), p2.clone());
    println!("{p1:?} + {p2:?} = {p3:?}");
}
~
~
~
~
~
~
~
~
~
~
~
~
~
~
~
~
"add_coords_owning.rs" 13L, 313B written                          1,15          All
```

```
e340115@gpsftp7:~/gitrepos/my_rust_examples$ rustc add_coords_owning.rs
e340115@gpsftp7:~/gitrepos/my_rust_examples$ ./add_coords_owning
Coord(3.142, 2.718) + Coord(1.414, 1.618) = Coord(4.5559998, 4.336)
e340115@gpsftp7:~/gitrepos/my_rust_examples$
```

```
#[derive(Debug)]
struct Coord(f32, f32);

fn add_by_borrowing(p1: &Coord, p2: &Coord) -> Coord {
    Coord(p1.0 + p2.0, p1.1 + p2.1)
}

fn main() {
    let p1 = Coord(3.142, 2.718);
    let p2 = Coord(1.414, 1.618);
    let p3 = add_by_borrowing(&p1, &p2);
    println!("{p1:?} + {p2:?} = {p3:?}");
}
~
~
~
~
~
~
~
~
~
~
~
~
~
~
~
~
"add_coords_borrowing.rs" 13L, 301B                               1,1           All
```

```
e340115@gpsftp7:~/gitrepos/my_rust_examples$ rustc add_coords_borrowing.rs
e340115@gpsftp7:~/gitrepos/my_rust_examples$ ./add_coords_borrowing
Coord(3.142, 2.718) + Coord(1.414, 1.618) = Coord(4.5559998, 4.336)
e340115@gpsftp7:~/gitrepos/my_rust_examples$
```

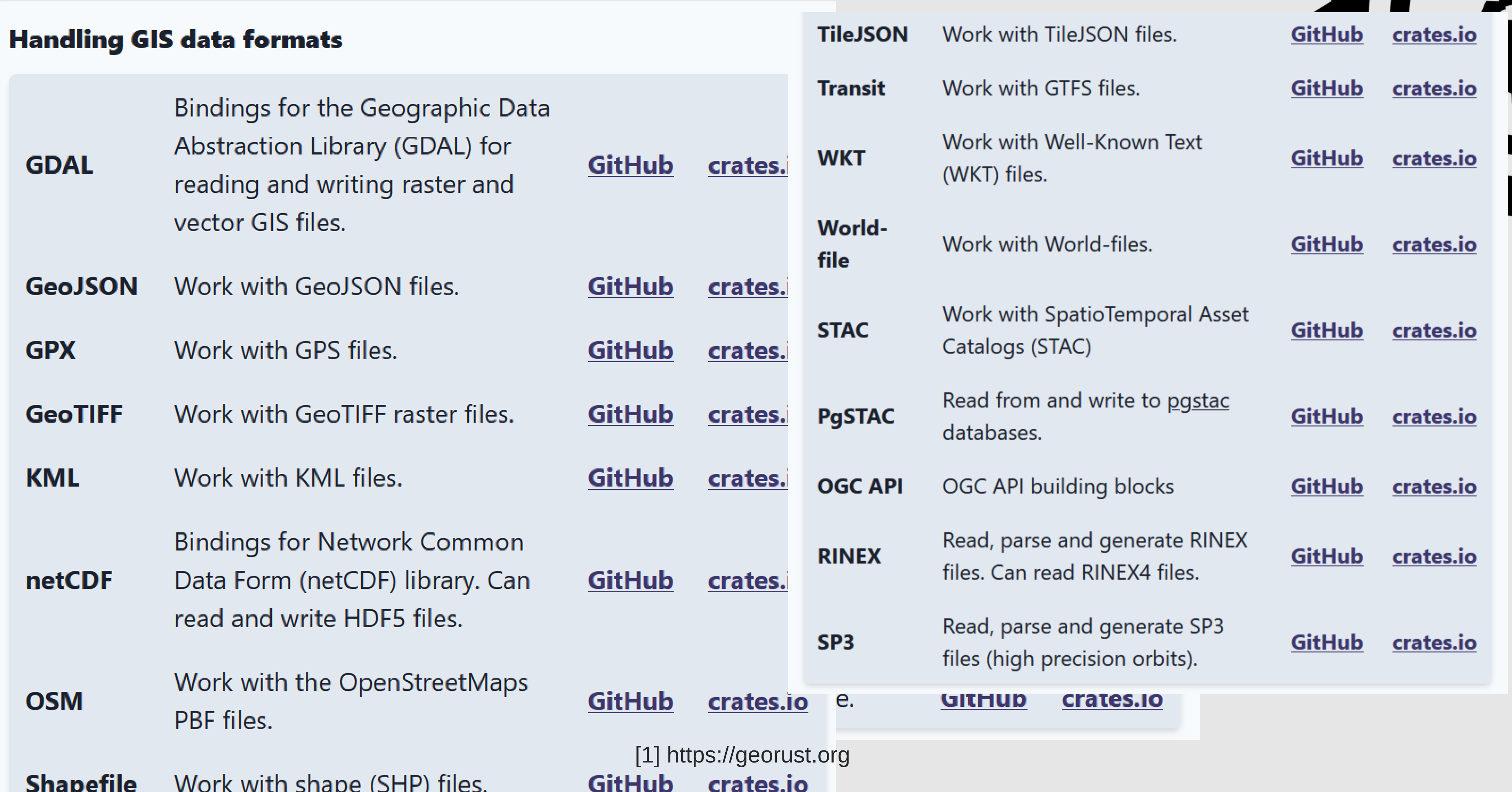
```
[0] 0:bash*                                                "gpsftp7" 14:41 08-Mar-24
```

[1] https://survey.stackoverflow.co/2023/#section-admired-and-desired-programming-scripting-and-markup-languages

[2] https://google.github.io/comprehensive-rust/cargo/rust-ecosystem.html

[3] https://benchmarksgame-team.pages.debian.net/benchmarksgame/fastest/rust-gpp.html

The GeoRust ecosystem



Handling GIS data formats

GDAL	Bindings for the Geographic Data Abstraction Library (GDAL) for reading and writing raster and vector GIS files.	GitHub	crates.i
GeoJSON	Work with GeoJSON files.	GitHub	crates.i
GPX	Work with GPS files.	GitHub	crates.i
GeoTIFF	Work with GeoTIFF raster files.	GitHub	crates.i
KML	Work with KML files.	GitHub	crates.i
netCDF	Bindings for Network Common Data Form (netCDF) library. Can read and write HDF5 files.	GitHub	crates.i
OSM	Work with the OpenStreetMaps PBF files.	GitHub	crates.io
Shapefile	Work with shape (SHP) files.	GitHub	crates.io

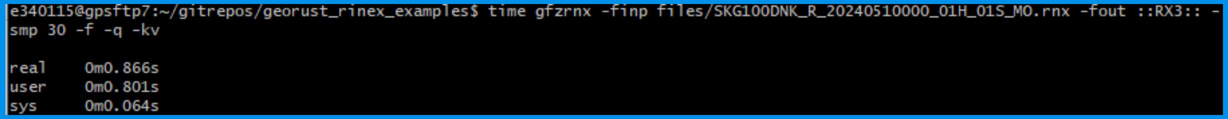
e.	GitHub	crates.io

TileJSON	Work with TileJSON files.	GitHub	crates.io
Transit	Work with GTFS files.	GitHub	crates.io
WKT	Work with Well-Known Text (WKT) files.	GitHub	crates.io
World-file	Work with World-files.	GitHub	crates.io
STAC	Work with SpatioTemporal Asset Catalogs (STAC)	GitHub	crates.io
PgSTAC	Read from and write to pgstac databases.	GitHub	crates.io
OGC API	OGC API building blocks	GitHub	crates.io
RINEX	Read, parse and generate RINEX files. Can read RINEX4 files.	GitHub	crates.io
SP3	Read, parse and generate SP3 files (high precision orbits).	GitHub	crates.io

[1] https://georust.org

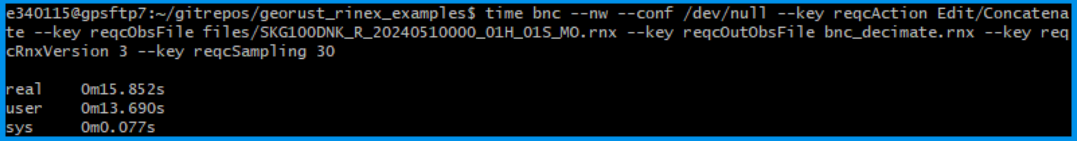
GeoRust rinex[1] operations: decimation and splicing

- decimation with gfzrnx ~1s



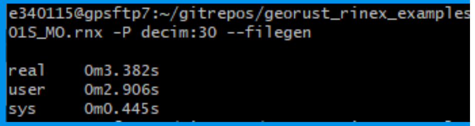
```
e340115@gpsftp7:~/gitrepos/georust_rinex_examples$ time gfzrnx -finp files/SKG100DNK_R_20240510000_01H_01S_MO.rnx -fout ::RX3:: -
smp 30 -f -q -kv

real    0m0.866s
user    0m0.801s
sys     0m0.064s
```

- with BNC ~15s



```
e340115@gpsftp7:~/gitrepos/georust_rinex_examples$ time bnc --nw --conf /dev/null --key reqcAction Edit/Concatena
te --key reqcObsFile files/SKG100DNK_R_20240510000_01H_01S_MO.rnx --key reqcOutObsFile bnc_decimate.rnx --key req
cRnxVersion 3 --key reqcSampling 30

real    0m15.852s
user    0m13.690s
sys     0m0.077s
```

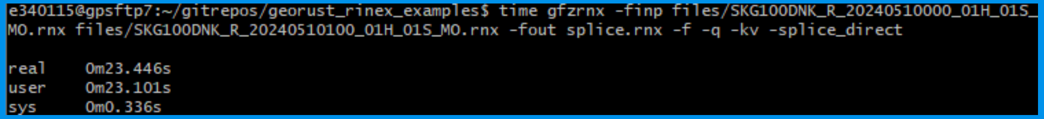
- with GeoRu



```
e340115@gpsftp7:~/gitrepos/georust_rinex_examples
01S_MO.rnx -P decim:30 --filegen

real    0m3.382s
user    0m2.906s
sys     0m0.445s
```

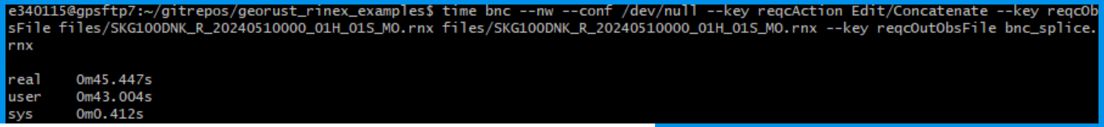
- GeoRust us
memory tha

- splicing with gfzrnx ~23s

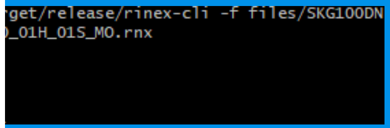


```
e340115@gpsftp7:~/gitrepos/georust_rinex_examples$ time gfzrnx -finp files/SKG100DNK_R_20240510000_01H_01S_
MO.rnx files/SKG100DNK_R_20240510100_01H_01S_MO.rnx -fout splice.rnx -f -q -kv -splice_direct

real    0m23.446s
user    0m23.101s
sys     0m0.336s
```

- with BNC ~45s



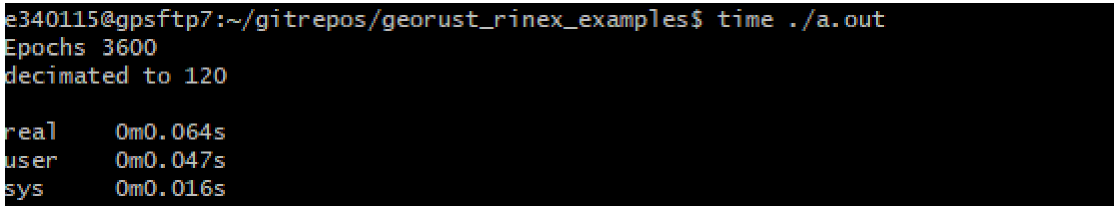
```
e340115@gpsftp7:~/gitrepos/georust_rinex_examples$ time bnc --nw --conf /dev/null --key reqcAction Edit/Concatenate --key reqcOb
sFile files/SKG100DNK_R_20240510000_01H_01S_MO.rnx files/SKG100DNK_R_20240510000_01H_01S_MO.rnx --key reqcOutObsFile bnc_splice.
rnx

real    0m45.447s
user    0m43.004s
sys     0m0.412s
```



```
rget/release/rinex-cli -f files/SKG100DN
0_01H_01S_MO.rnx
```

- s more
memory than gfzrnx when merging 24
one-hour files

switch to a stream-based approach desired

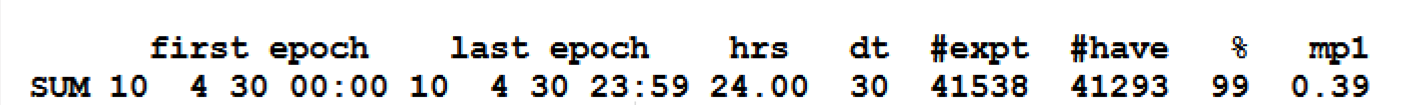


```
e340115@gpsftp7:~/gitrepos/georust_rinex_examples$ time ./a.out
Epochs 3600
decimated to 120

real    0m0.064s
user    0m0.047s
sys     0m0.016s
```

[1] GeoRust RINEX Team (2023), RINEX: analysis and processing (Apache-2/MIT), https://georust.org

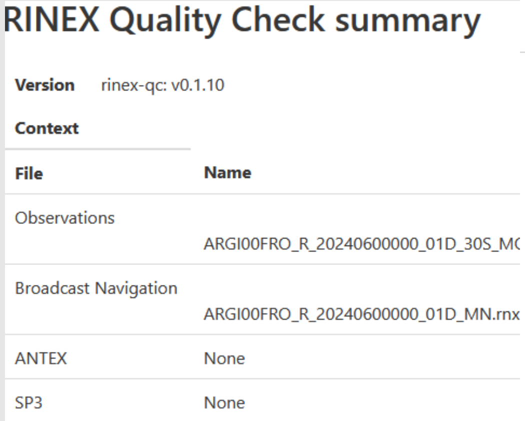
GeoRust rinex operations: quality analysis

- aims for teqc-like quality check with support for new rinex fo



```
      first epoch     last epoch     hrs   dt  #expt  #have   %   mp1
SUM 10  4 30 00:00 10  4 30 23:59 24.00   30  41538  41293  99  0.39
```

- excerpts from GeoRus

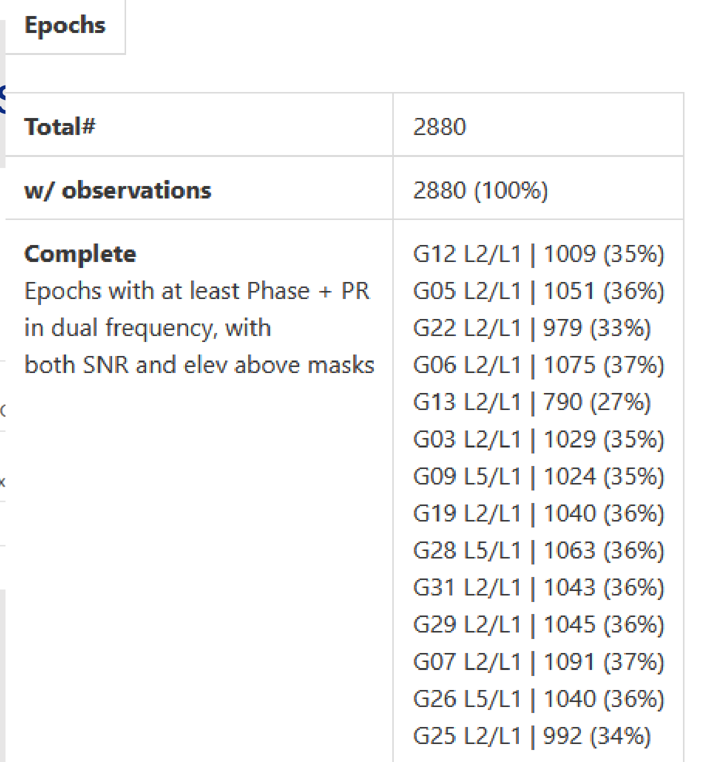


RINEX Quality Check summary

Version rinex-qc: v0.1.10

Context

File	**Name**
Observations	ARGI00FRO_R_20240600000_01D_30S_MC
Broadcast Navigation	ARGI00FRO_R_20240600000_01D_MN.rnx
ANTEX	None
SP3	None



Epochs

Total#	2880
w/ observations	2880 (100%)
Complete Epochs with at least Phase + PR in dual frequency, with both SNR and elev above masks	G12 L2/L1 | 1009 (35%) G05 L2/L1 | 1051 (36%) G22 L2/L1 | 979 (33%) G06 L2/L1 | 1075 (37%) G13 L2/L1 | 790 (27%) G03 L2/L1 | 1029 (35%) G09 L5/L1 | 1024 (35%) G19 L2/L1 | 1040 (36%) G28 L5/L1 | 1063 (36%) G31 L2/L1 | 1043 (36%) G29 L2/L1 | 1045 (36%) G07 L2/L1 | 1091 (37%) G26 L5/L1 | 1040 (36%) G25 L2/L1 | 992 (34%)

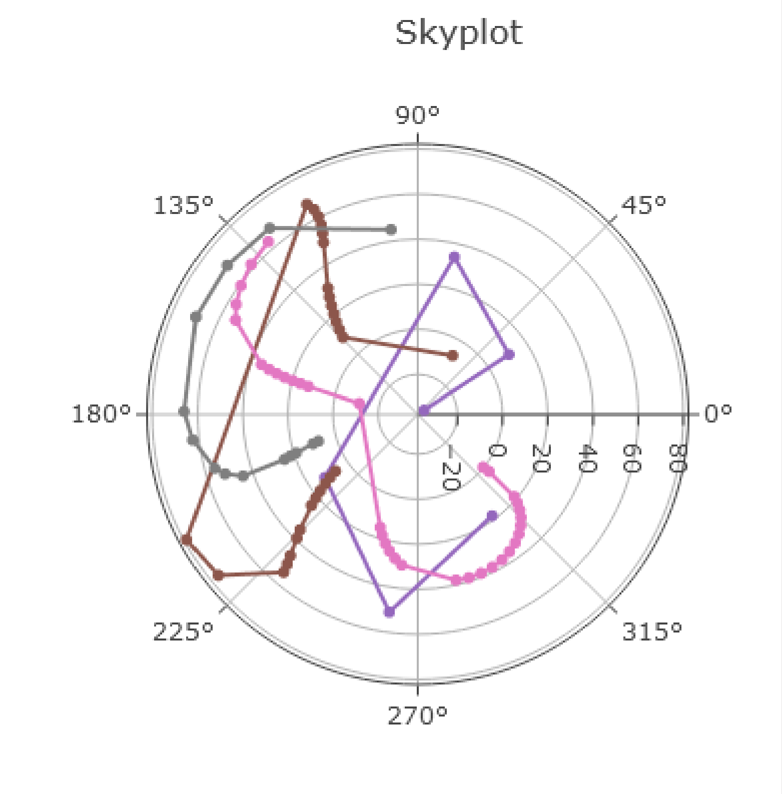
alysis

ng

-28T23:59:23 U

rate (Header)

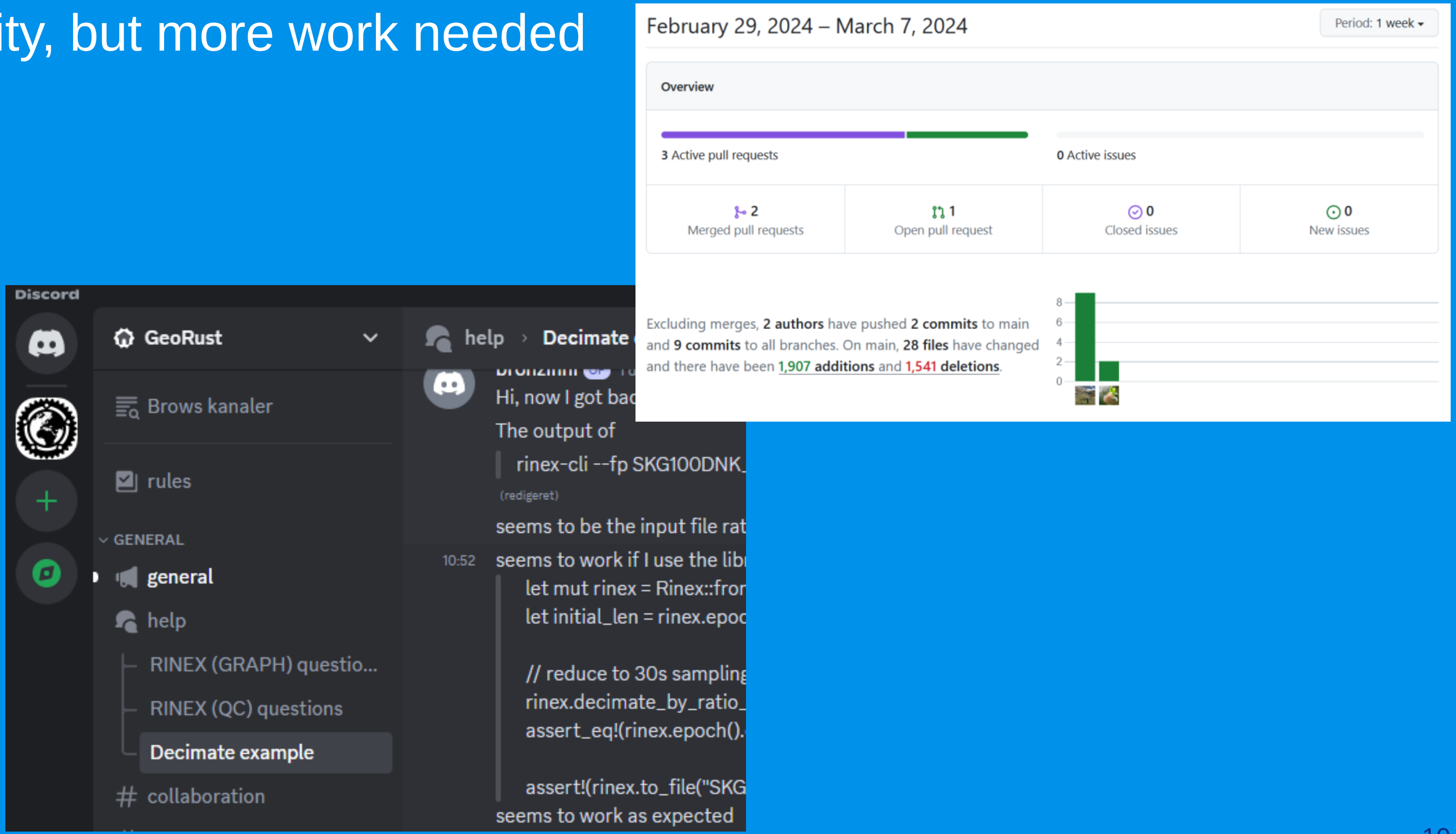
ant Sample rate	30 s (0.033 Hz)
alysis	**No gaps detected**



[1] https://www.unavco.org/software/data-processing/teqc/teqc.html

GeoRust rinex is (promising) work in progress

- promising with plenty functionality, but more work needed
- on-going development
- get involved?
  - coding
  - testing
  - feature requests



February 29, 2024 – March 7, 2024

Period: 1 week

Overview

3 Active pull requests

0 Active issues

2 Merged pull requests

1 Open pull request

0 Closed issues

0 New issues

Excluding merges, 2 authors have pushed 2 commits to main and 9 commits to all branches. On main, 28 files have changed and there have been 1,907 additions and 1,541 deletions.

Hi, now I got bac

The output of

```
rinex-cli --fp SKG100DNK_
```

(redigeret)

seems to be the input file rat

10:52 seems to work if I use the libr

```
let mut rinex = Rinex::fror
let initial_len = rinex.epoc

// reduce to 30s sampling
rinex.decimate_by_ratio_
assert_eq!(rinex.epoch().

assert!(rinex.to_file("SKG
```

seems to work as expected