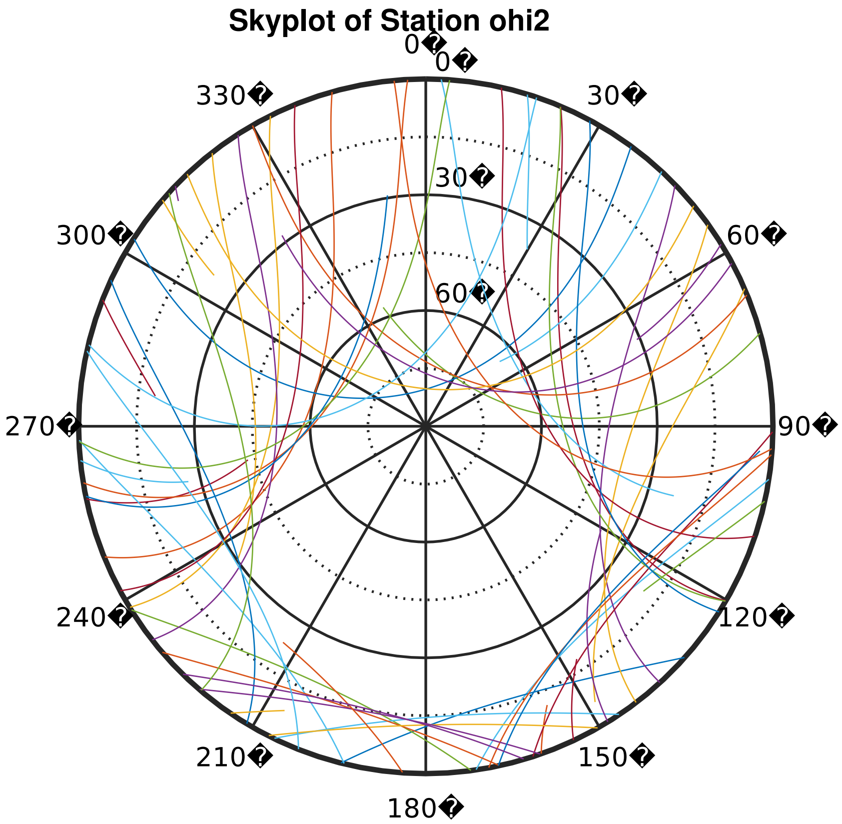
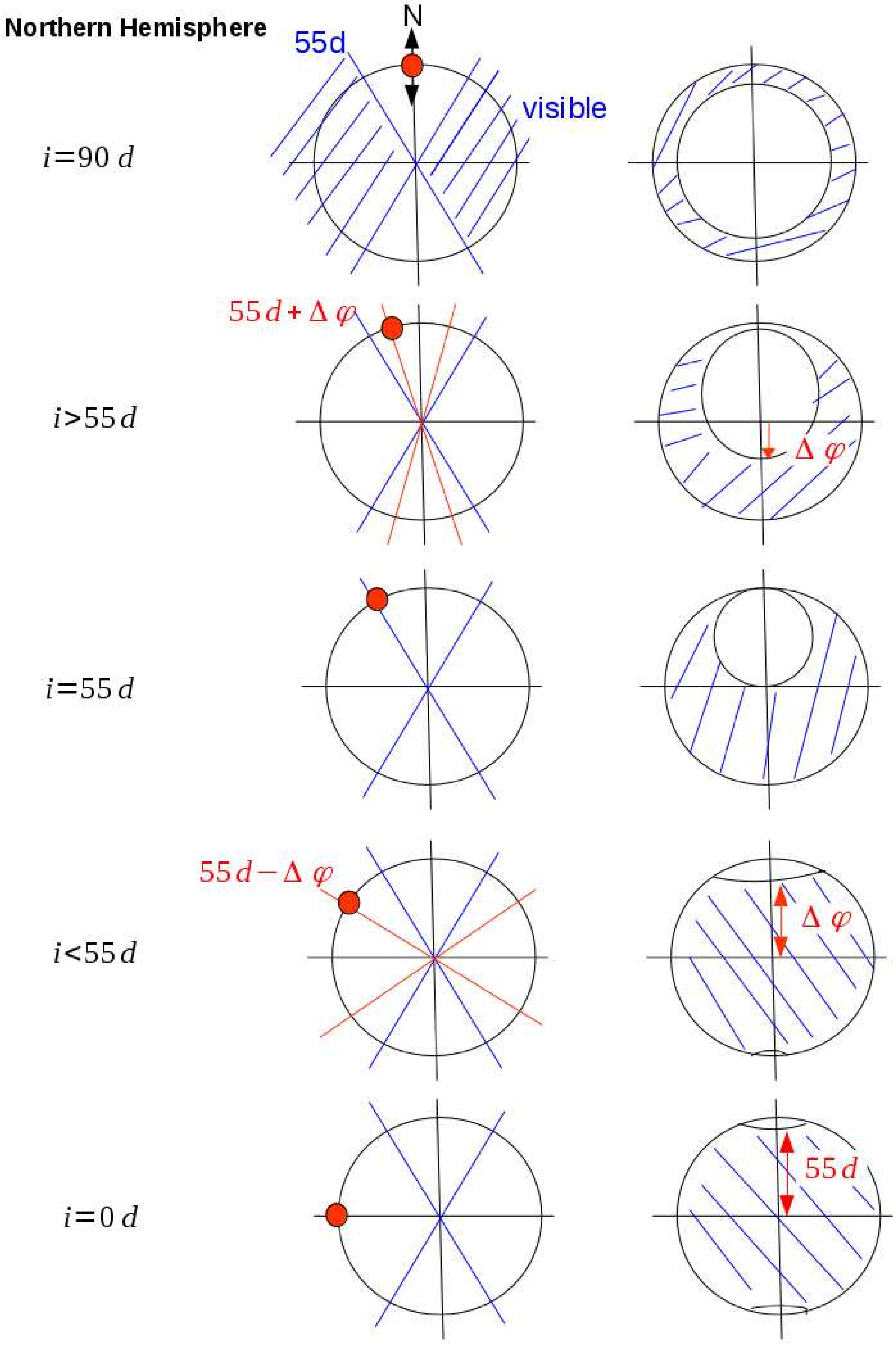
3 Lab Tasks Explanation

1) `ohi2` = General Bernardo O'Higgins Base ($\phi \sim 63.3218°$)



- Satellites fly to the higher inclination, then goes down
- A hole where no satellite is visible

How can we approximately determine the receiver's latitude ϕ with a skyplot?

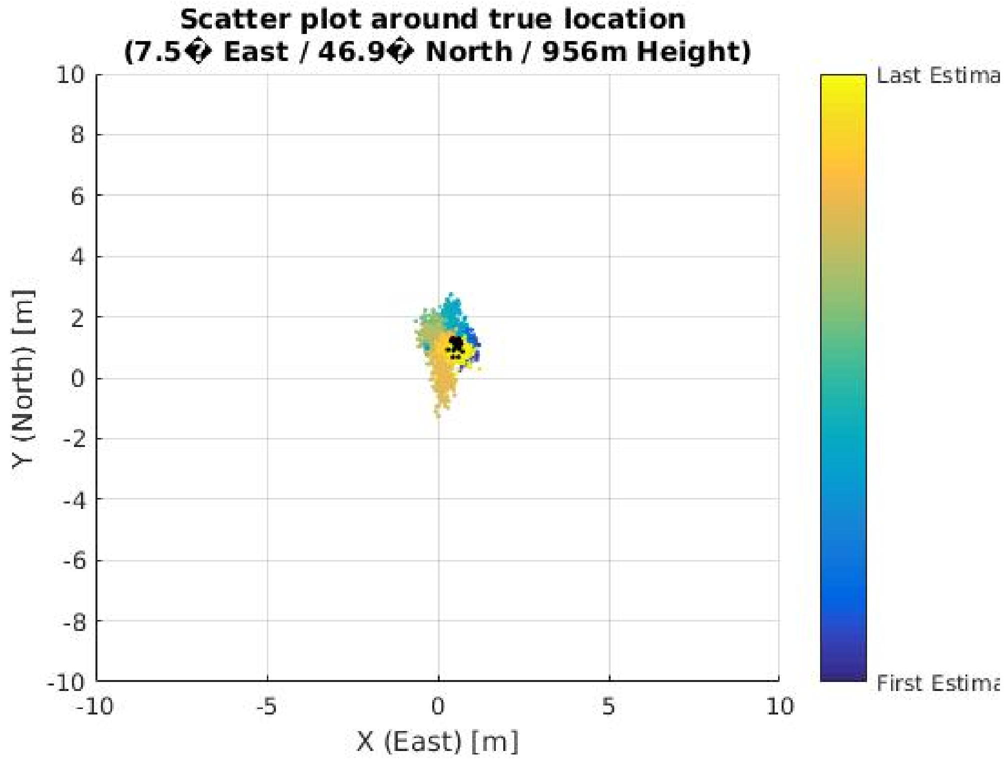


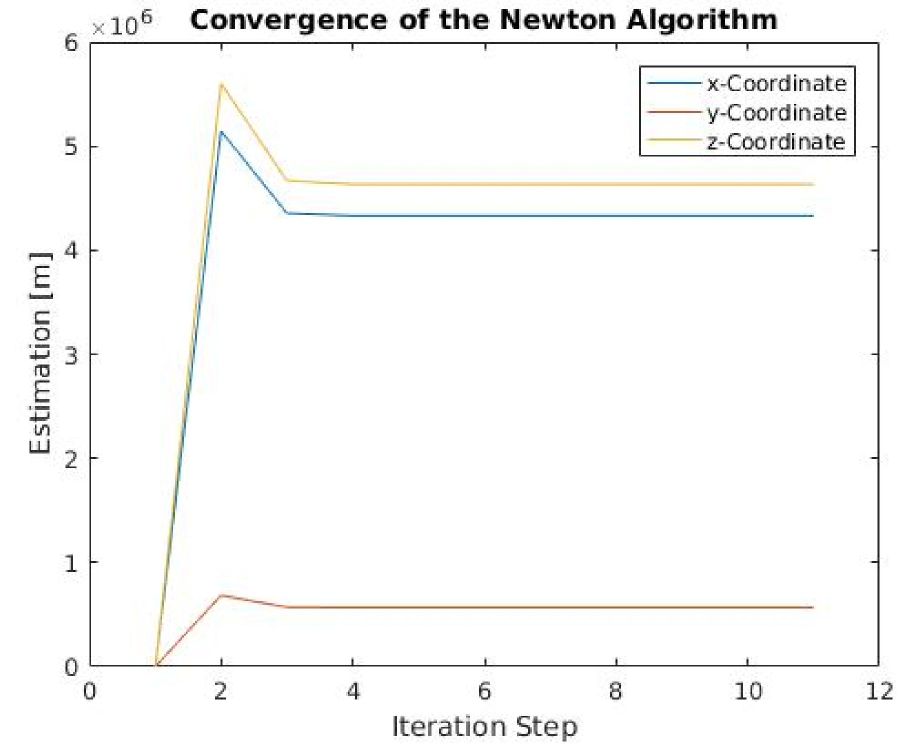
If we apply the same approach to the southern hemisphere, we can determine that the latitude is around $55 + 7 = 63°$ S.

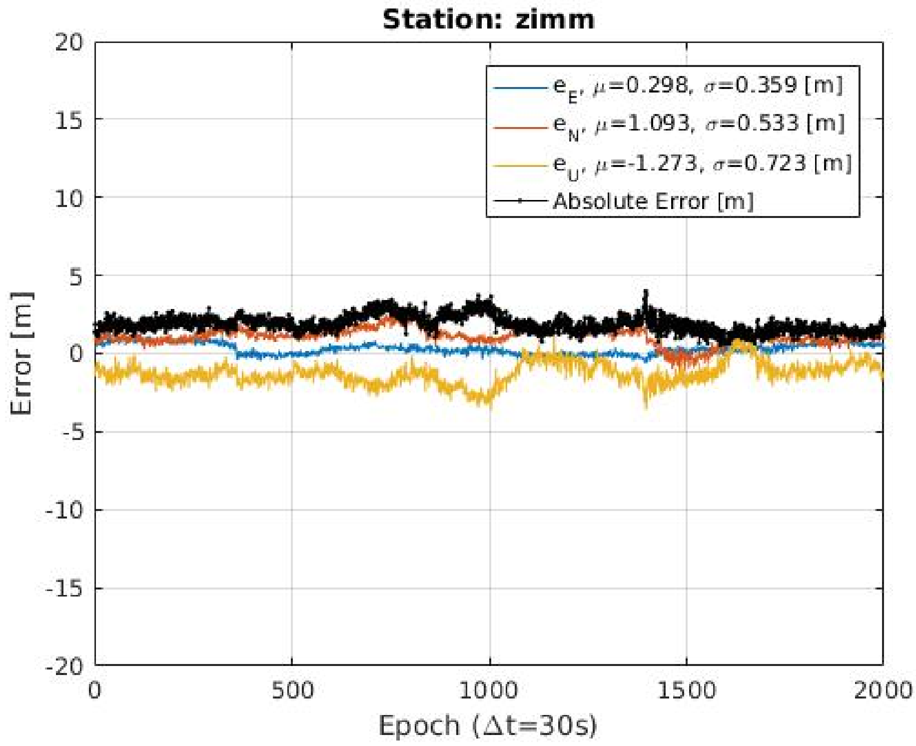
2) Implement LS and WLS

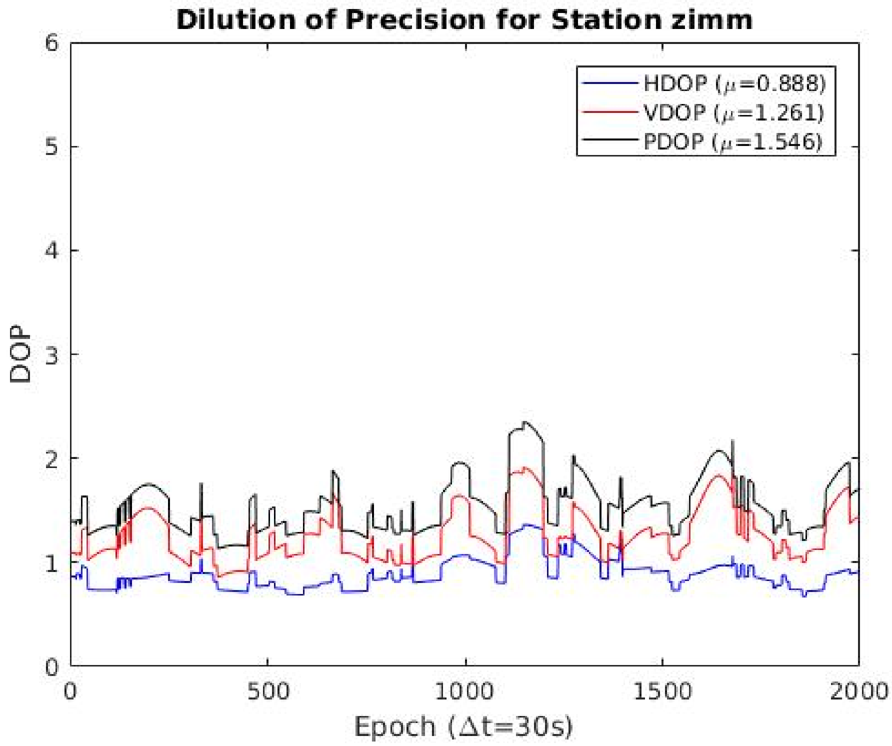
- `nya1` = NY-ALESUND base, Norway ($\phi \sim 78.93°$ N, $\lambda \sim 11.87°$ E)
- `isco` = Cocos (Keeling) island base, Australia ($\phi \sim 12.19°$ S, $\lambda \sim 96.83°$ E)
- `zimm` = Zimmerwald base, Switzerland ($\phi \sim 46.88°$ N, $\lambda \sim 7.47°$ E)

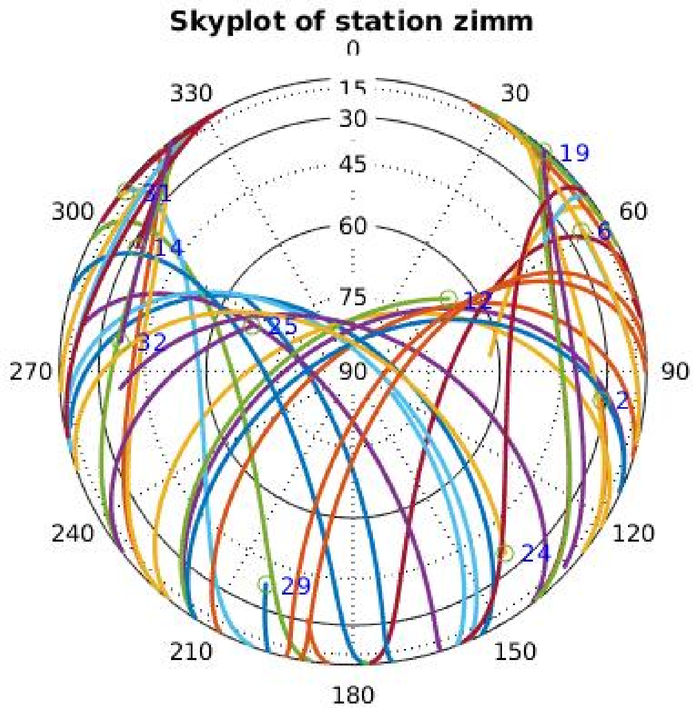
Expected results of the WLS estimation (station: `zimm`, epoch=2000):




Convergence of the Newton Algorithm
×10^6
x-Coordinate
y-Coordinate
z-Coordinate
Estimation [m]
Iteration Step
0
1
2
3
4
5
6
0
2
4
6
8
10
12


Station: zimm
e_E, μ=0.298, σ=0.359 [m]
e_N, μ=1.093, σ=0.533 [m]
e_U, μ=-1.273, σ=0.723 [m]
Absolute Error [m]
Error [m]
Epoch (Δt=30s)
20
15
10
5
0
-5
-10
-15
-20
0
500
1000
1500
2000


Dilution of Precision for Station zimm
HDOP (μ=0.888)
VDOP (μ=1.261)
PDOP (μ=1.546)
DOP
Epoch (Δt=30s)
0
1
2
3
4
5
6
500
1000
1500
2000


Skyplot of station zimm
0
30
60
90
120
150
180
210
240
270
300
330
15
45
75
19
6
31
14
12
25
32
2
24
29

Algorithm	Station	Mean HDOP/VDOP/PDOP	σ_E	σ_N	σ_U
LS	`nya1`	0.732/1.527/1.695	0.592	0.483	2.241
	`isco`	1.134/2.330/2.596	1.144	0.827	3.033
	`zimm`	0.888/1.261/1.546	0.405	0.575	0.907
WLS	`nya1`	0.732/1.527/1.695	0.451	0.463	1.699
	`isco`	1.134/2.330/2.596	1.146	0.801	2.905
	`zimm`	0.888/1.261/1.546	0.359	0.533	0.723

- WLS is more precise compared to LS
- Same DOP for LS and WLS since DOP shows only geometrical factors $(H^T H)^{-1}$
- $\Sigma = \sigma^2 (H^T H)^{-1} \Rightarrow$ Similar DOP (geometry), but different standard derivation of the estimates due to σ (e.g. better receiver, smaller σ). For example, σ_U of `nya1` and `zimm`

3) WLS with a different initialization: $\mathtt{x_{uv}} = \mathtt{10} * \mathtt{ones}(\mathtt{4}, \mathtt{iter_{max}} + \mathtt{1})$;

Init	Station	Mean HDOP/VDOP/PDOP	σ_E	σ_N	σ_U
zeros (previous)	`zimm`	0.888/1.261/1.546	0.359	0.533	0.723
ones (new)	`zimm`	0.888/1.261/1.546	0.359	0.533	0.723

$\Rightarrow$ User position initialization does not affect on the performance that much since the user and GPS satellites are very far away.

4) Gaussian errors on pseudorange measurements
`zimm` = Zimmerwald base, Switzerland ($\phi \sim 46.88°$ N, $\lambda \sim 7.47°$ E)

Mean[m]	σ_E[m]	σ_N[m]	σ_U[m]
5	0.929	1.286	1.763
10	1.727	2.480	3.147
50	8.362	12.452	14.692

We can detect and exclude the faulty satellite with e.g. the following approach:

- Exclude a GPS satellite one by one, and estimate the user position
- If we exclude the faulty satellite, we will have a position estimate which is very different from the other solutions. This is the position estimated without a faulty satellite

5) Gaussian noise with $\mu = 0.1\text{m}, 1\text{m}, 5\text{m}$ and $\sigma = 0.1\text{m}$ on each coordinates of the first satellite's LoS vector:
`zimm` = Zimmerwald base, Switzerland ($\phi \sim 46.88°$ N, $\lambda \sim 7.47°$ E)

Mean[m]	σ_E[m]	σ_N[m]	σ_U[m]
0.1	0.365	0.537	0.733
1	12.128	30.526	24.110
5	26.960	30.131	53.292

The error on LoS vectors affect on the positioning performance much more than the ranging error since since the user and GPS satellites are far away (approximately 20,200km).

6) The best constellation for positioning:
The lowest DOP ⇐ More satellites, evenly distributed satellites. e.g. station: `zimm`, epoch≈ 50