Comparison Study on Network RTK and Precise Point GNSS Positioning

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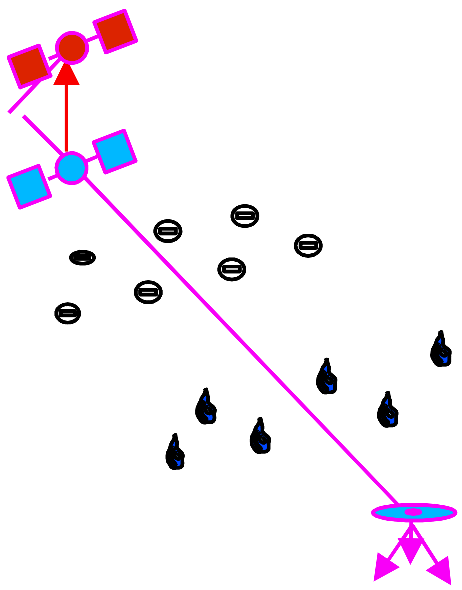
Conventional RTK GNSS Positioning

Spatial correlated errors can be effectively cancelled out only when the baseline length is not greater than about 20 km – **error de-correlation effect**



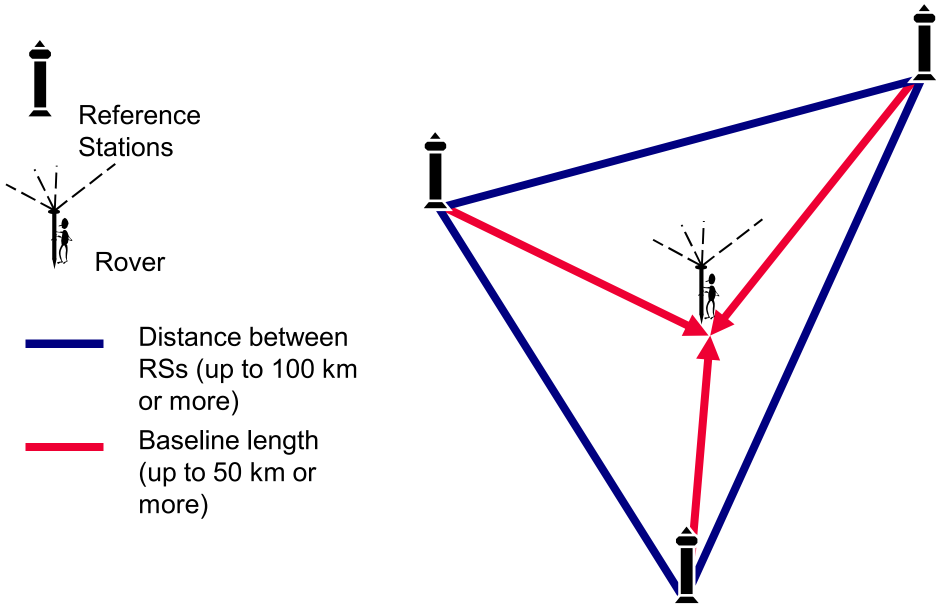
Error sources:

- Satellite clock error δsat_clock
- Satellite orbit error δorbit
- **Ionosphere δiono**
- **Troposphere δtropo**
- Multipath δmpath
- Antenna PCV δPCV
- Receiver clock error δrec_clock
- Receiver Bias δbiases

As baseline length increases δiono and δtropo decorrelate causing a decrease in accuracy, reliability and availability.

Network RTK GNSS Positioning

- Precisely model distance dependent errors of a region
- Reduce the number of RSs needed (inter-RS distances > 100 km) & huge saving in infrastructure construction
- Expand rover-to-nearest-RS baseline > 50 km
- GSM/GPRS link



Advantages of Network RTK

- Modelling GPS errors over the entire network area
- Increased positioning robustness against failures
- Increased mobility and efficiency– no need for temporary stations
  - one person surveys!
- Quicker initialisation times for rovers
- Extended surveying range
- No restriction in network size (regional, national, international)
- Capable of supporting multiple users and applications
- Continuous operation 365/24/7
- Provide data & corrections in a consistent datum
- Apart from RTK GPS corrections, other services provided include:
  - RINEX datasets for post-processing
  - GPS corrections for DGPS
  - Wide exploitation for geospatial, transport and engineering applications
- Allow central control and monitoring of all stations/high integrity monitoring scheme

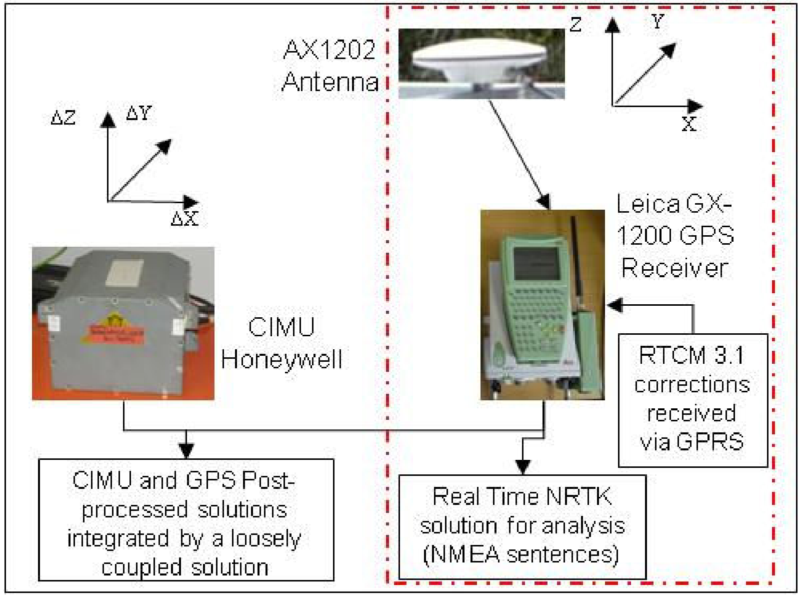
SmartNet NRTK: Reference Stations

For covering whole country in the United Kingdom more than 150 geodetic grade RSs are installed to deliver quality correction services

These RSs are equipped with dual frequency network enabled geodetic receivers and Choke-ring antennas

Some of them are GPS/GLONASS receivers

NRTK Quality Assessment

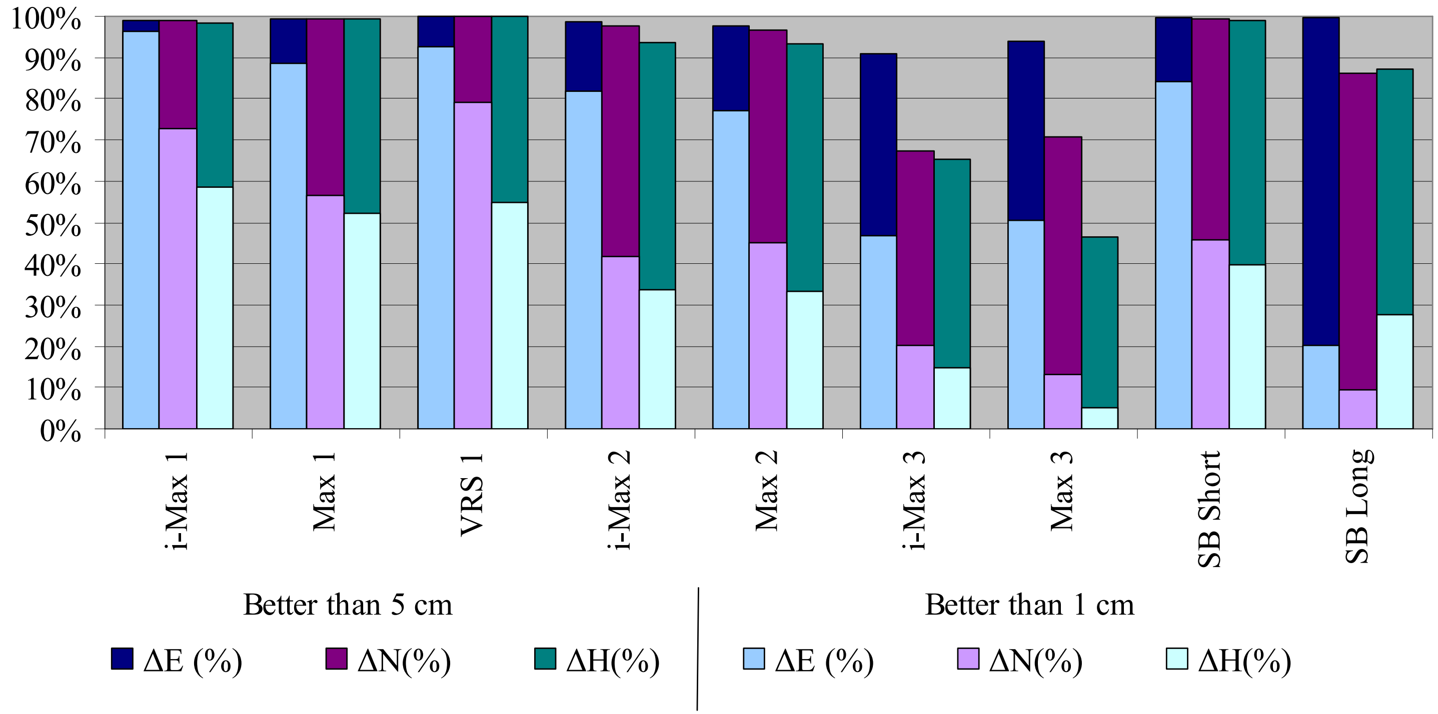


Approach: real-time NRTK positioning vs pp GPS/INS "ground truth" solutions

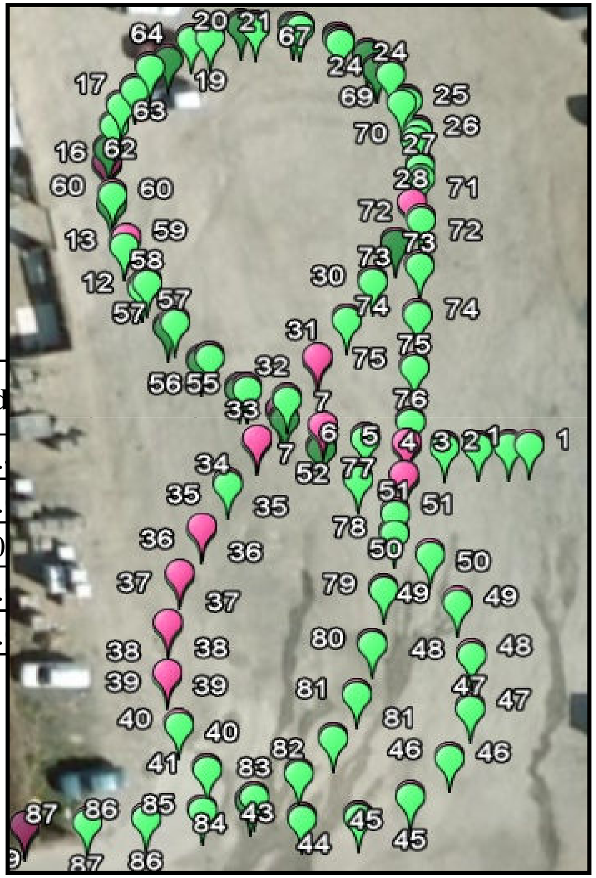
Static Performance of NRTK

- **Availability: percentage of coordinates in which a NRTK solution (integer ambiguities resolved) was achieved.**

Test	Availability (%)
i-Max 1	99.00
Max 1	99.23
VRS 1	99.95
i-Max 2	98.54
Max 2	97.74
i-Max 3	91.53
Max 3	95.47
SB Short	99.80



Kinematic Performance of NRTK

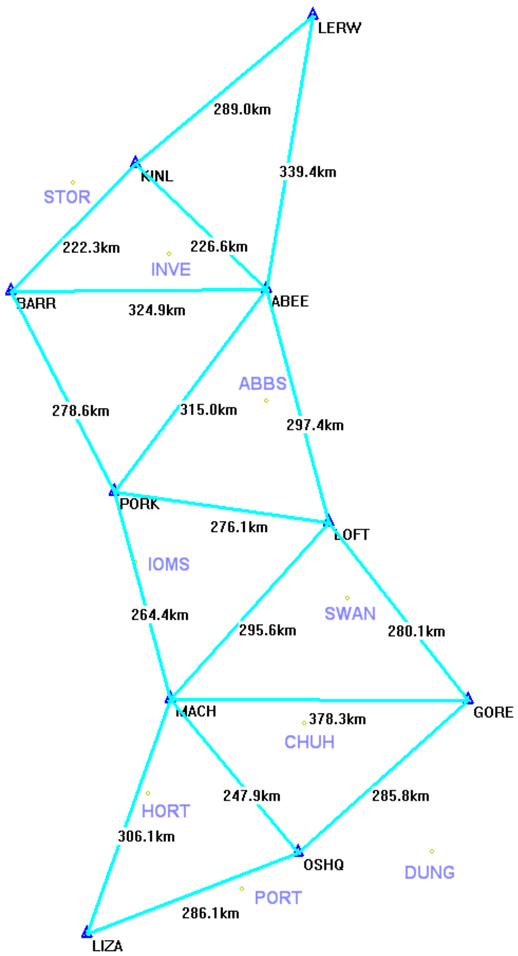


NRTK epochs DGPS epochs IMU/GPS epochs

Availability (%)

Test	Track	Lost Lock	Stand-Alone	DGPS	NRTK
T1	1	16.41	0.48	37.83	45.29
	2	9.58	0.00	39.60	50.82
	3	29.86	20.86	15.57	33.71
	4	12.34	0.00	36.76	50.90
T2	-	7.44	0.00	52.80	39.77

Sparse Network RTK Positioning



153 RSs

10 RSs

Sparse Network RTK Positioning

Simulated results from other 9 RSs

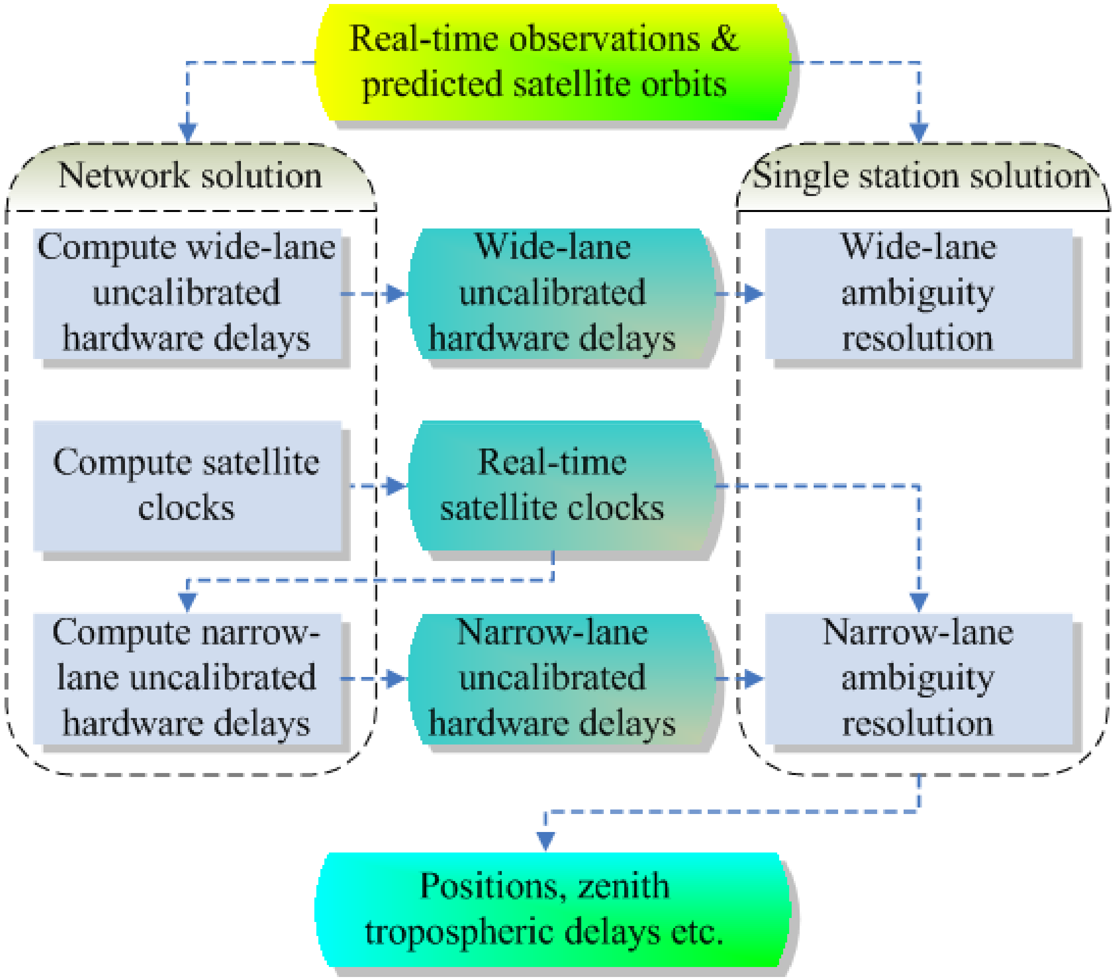
	Name	Receiver	Session	Init. Time (S)	N (m)	E (m)	U (m)
1	CHUH	SR530	1	8	0.0152	0.0117	0.0441
			2	13	0.0077	0.0080	0.0235
2	INVE	SR530	1	4	0.0122	0.0172	**0.0652**
			2	4	0.0095	0.0061	0.0294
3	STOR	SR530	1	9	0.0127	0.0150	**0.0554**
			2	12	0.0061	0.0069	0.0277
4	ABBS	SR530	1	6	0.0129	0.0080	0.0576
			2	11	0.0105	0.0150	0.0234
5	SWAN	SR530	1	5	0.0106	0.0132	0.0268
			2	8	0.0084	0.0098	0.0458
6	DUNG	SR530	1	18	0.0174	0.0124	0.0425
			2	15	0.0219	0.0359	0.0403
7	PORT	SR530	1	35	0.0250	0.0146	0.0399
			2	6	0.0111	0.0067	0.0177
8	HORT	SR530	1	23	0.0249	0.0153	0.0232
			2	19	0.0181	0.0126	0.0236
9	IOMS	SR530	1	14	0.0111	0.0063	0.0330
			2	13	0.0117	0.0129	0.0110
	Average			**12.39**	**0.0137**	**0.0126**	**0.0350**

Precise Point Positioning (PPP)

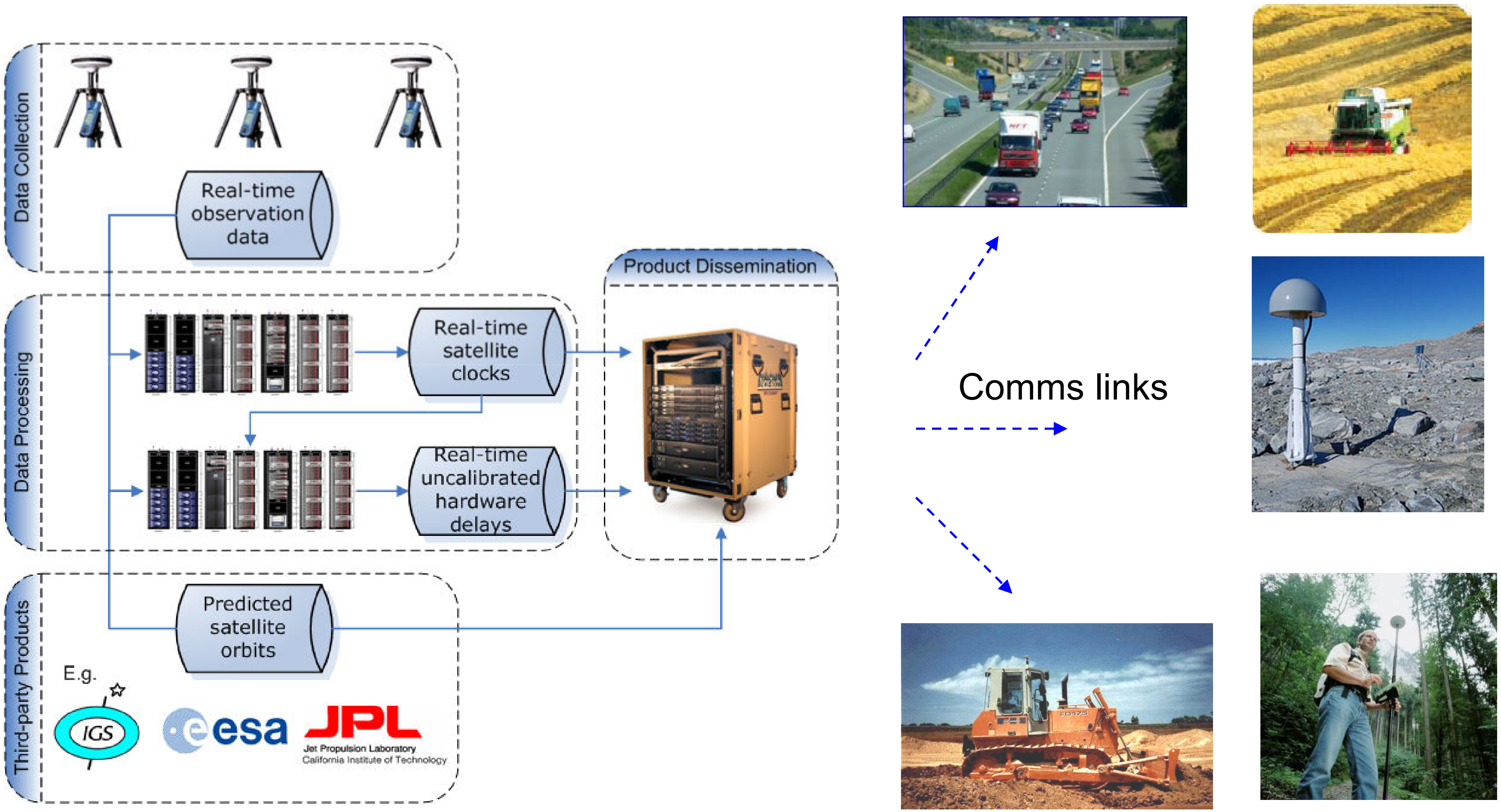
- Precise positioning at only a single station when precise satellite orbits and clocks are provided
  - Absolute positioning based on a sparse network
  - Homogeneous positioning accuracy on a global scale

- Current applications
  - Crustal deformation monitoring
  - Meteorology
  - Orbit determination of low Earth orbiters
  - Engineering surveying
  - Environmental applications

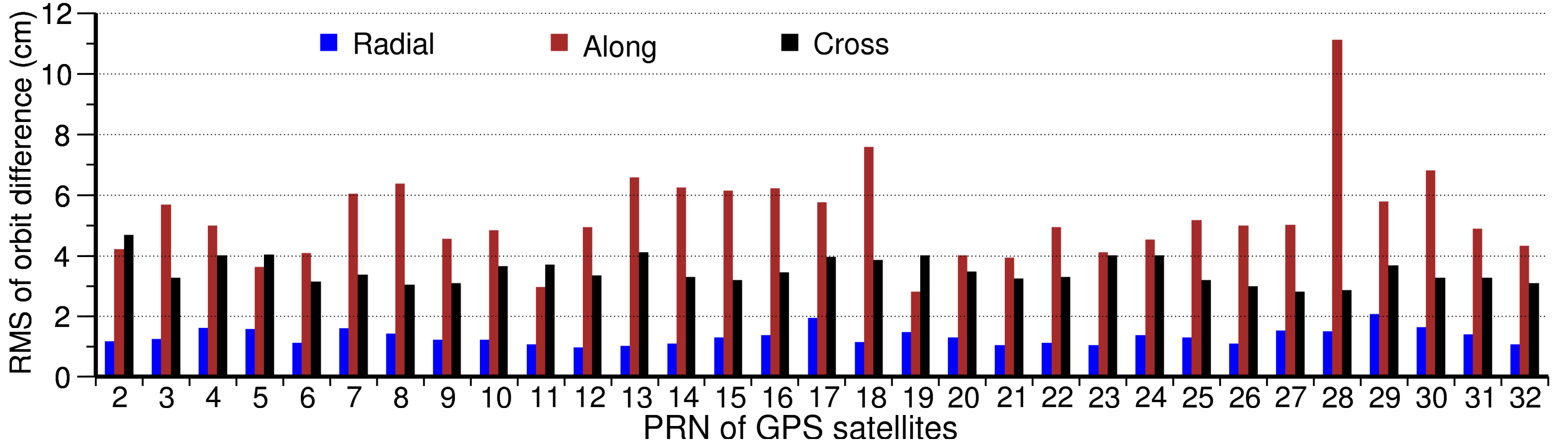
Real-Time PPP
Through Ambiguity Resolution

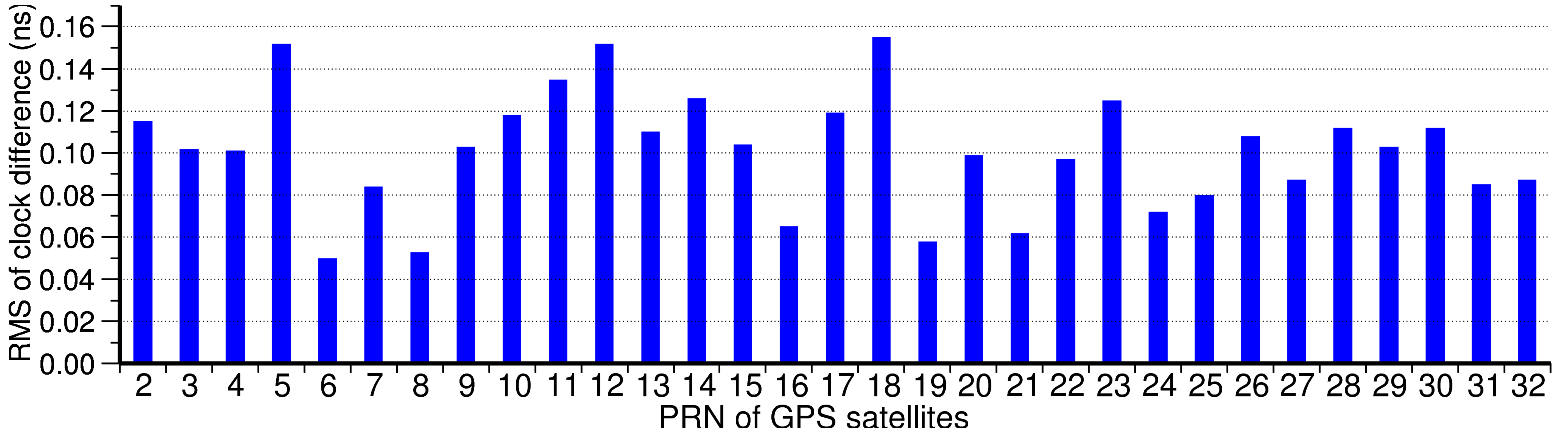


A Prototype Real-Time PPP System



Real-Time Orbit and Clock Products





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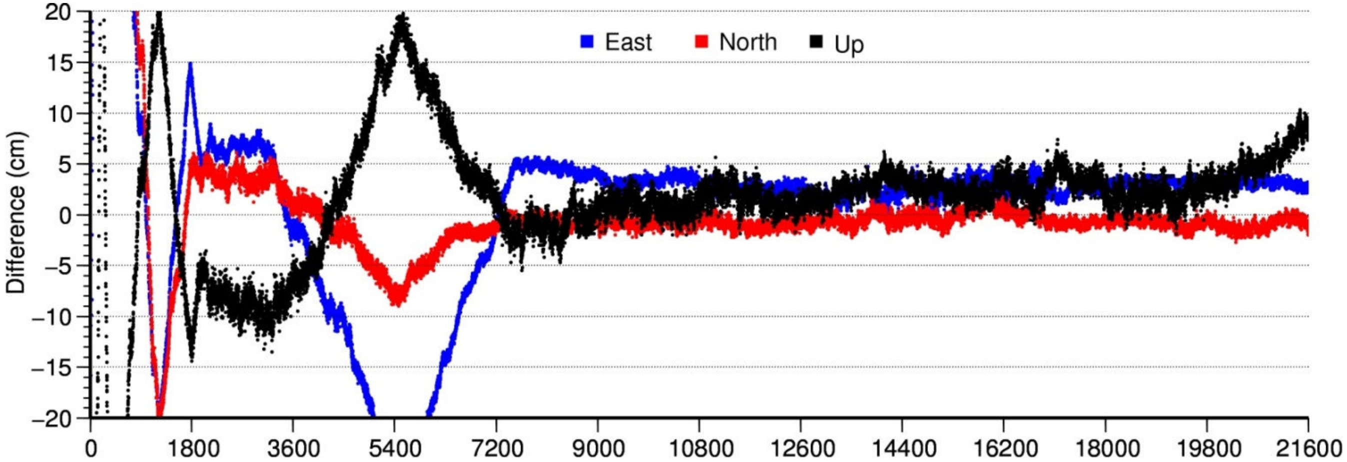
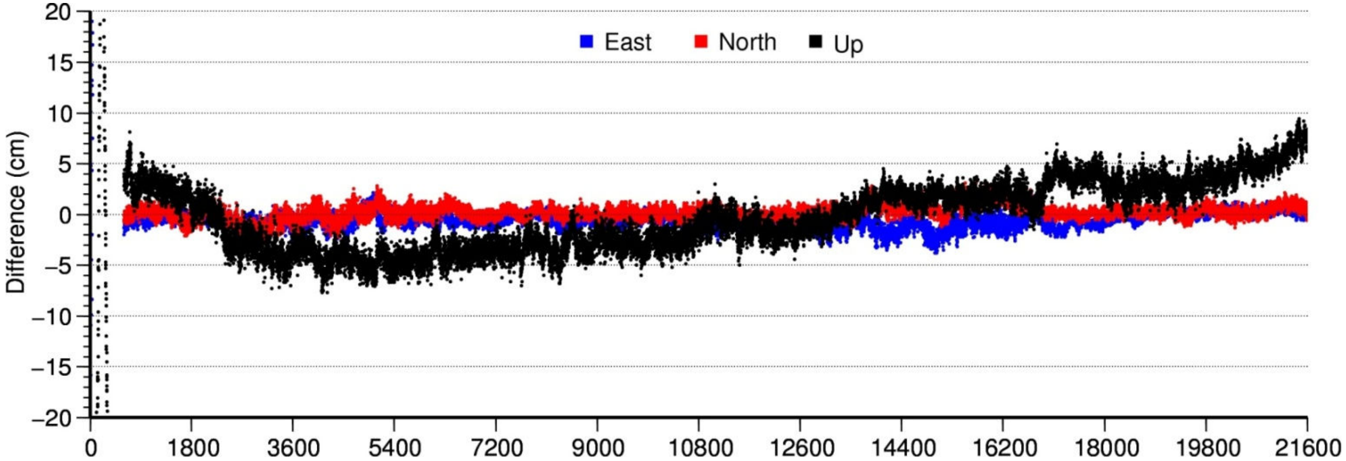
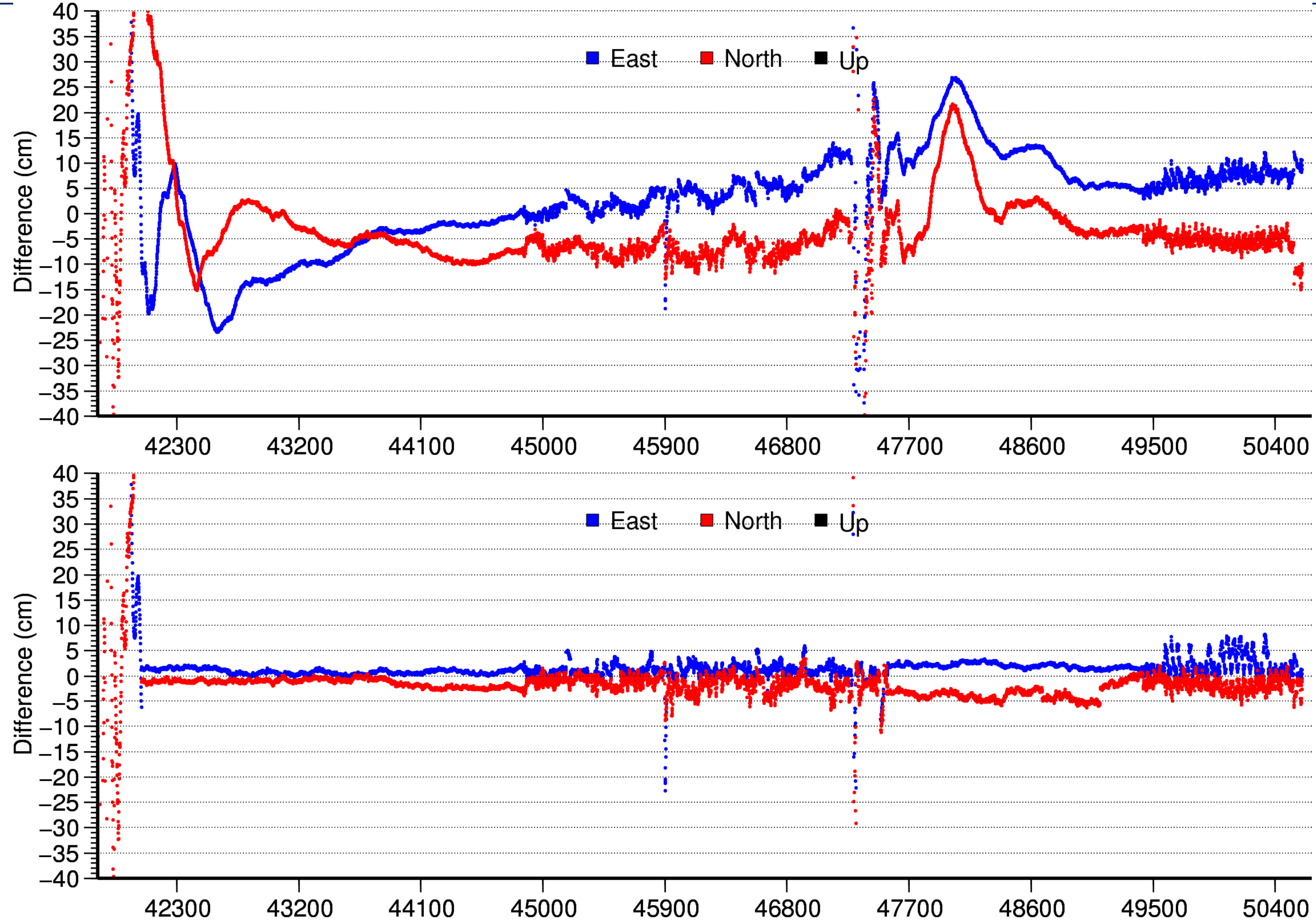
Floating vs AMB Fixed Solution (staitc)





Floating vs AMB Fixed Solution (kinematic)



Conclusions and Discussion

- Over traditional RTK GNSS positioning NRTK has many advantages in terms of improvements in positioning accuracy, system reliability and production efficiency. However, there exist many issues in
  - Sustaining reliable communications links
  - Proper correction models
  - High infrastructure construction cost and services subscription fees
- Sparse NRTK can significantly reduce the number of reference stations but need to further investigate effective correction models
- PPP has many potential for geoscience and engineering applications but long convergence time and low positioning accuracy are impeding factors