Error sources in RTK-surveying and possibilities to increase the accuracy in the SWEPOS Network-RTK-service

Ragne Emardson, Per Jarlemark, Jan Johansson, and Tobias Nilsson

SP Sveriges Tekniska Forskningsinstitut

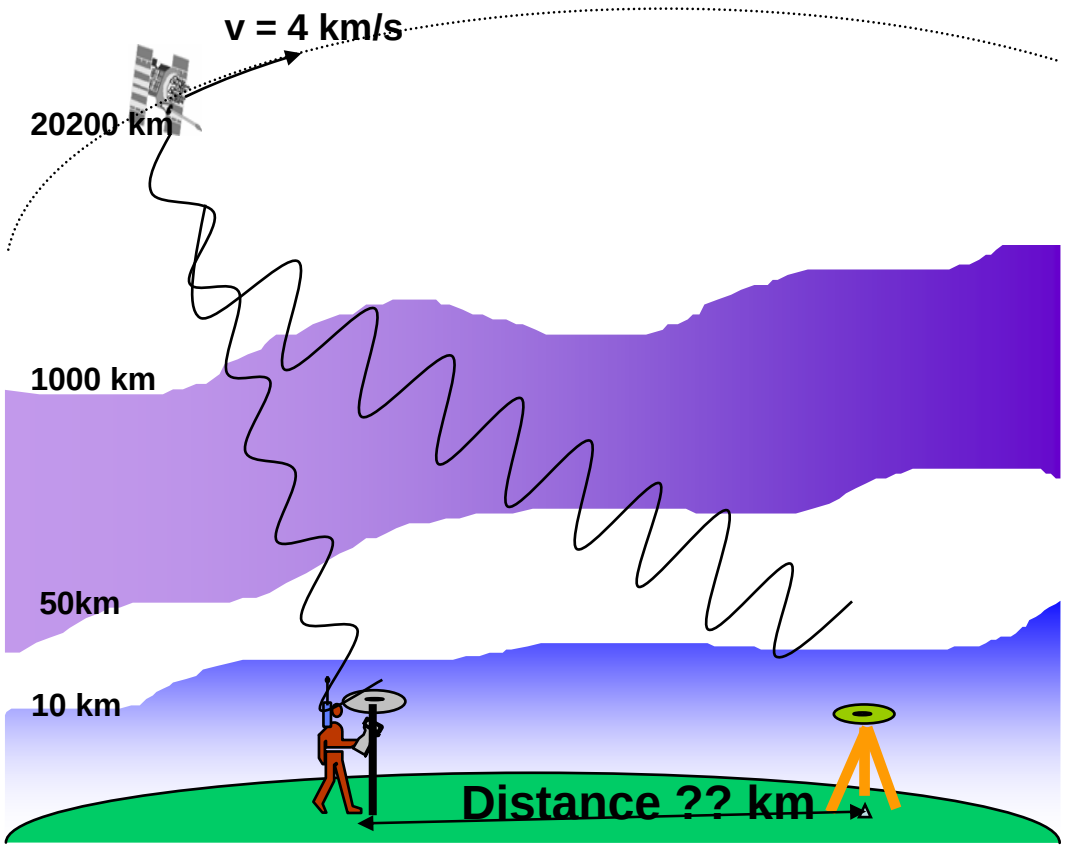
Main questions

- What is the quality of real-time measurements with GNSS based on a detailed studies of the error sources?

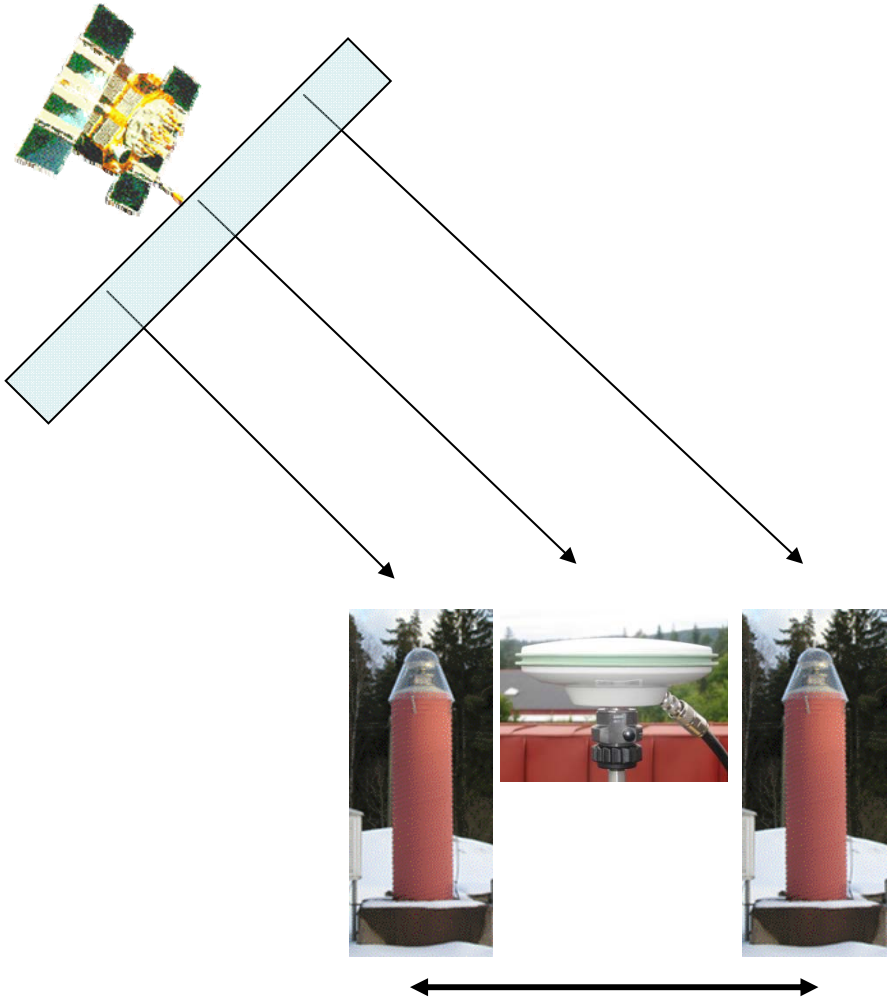
- What measures are needed in order to improve the accuracy?

Error Sources

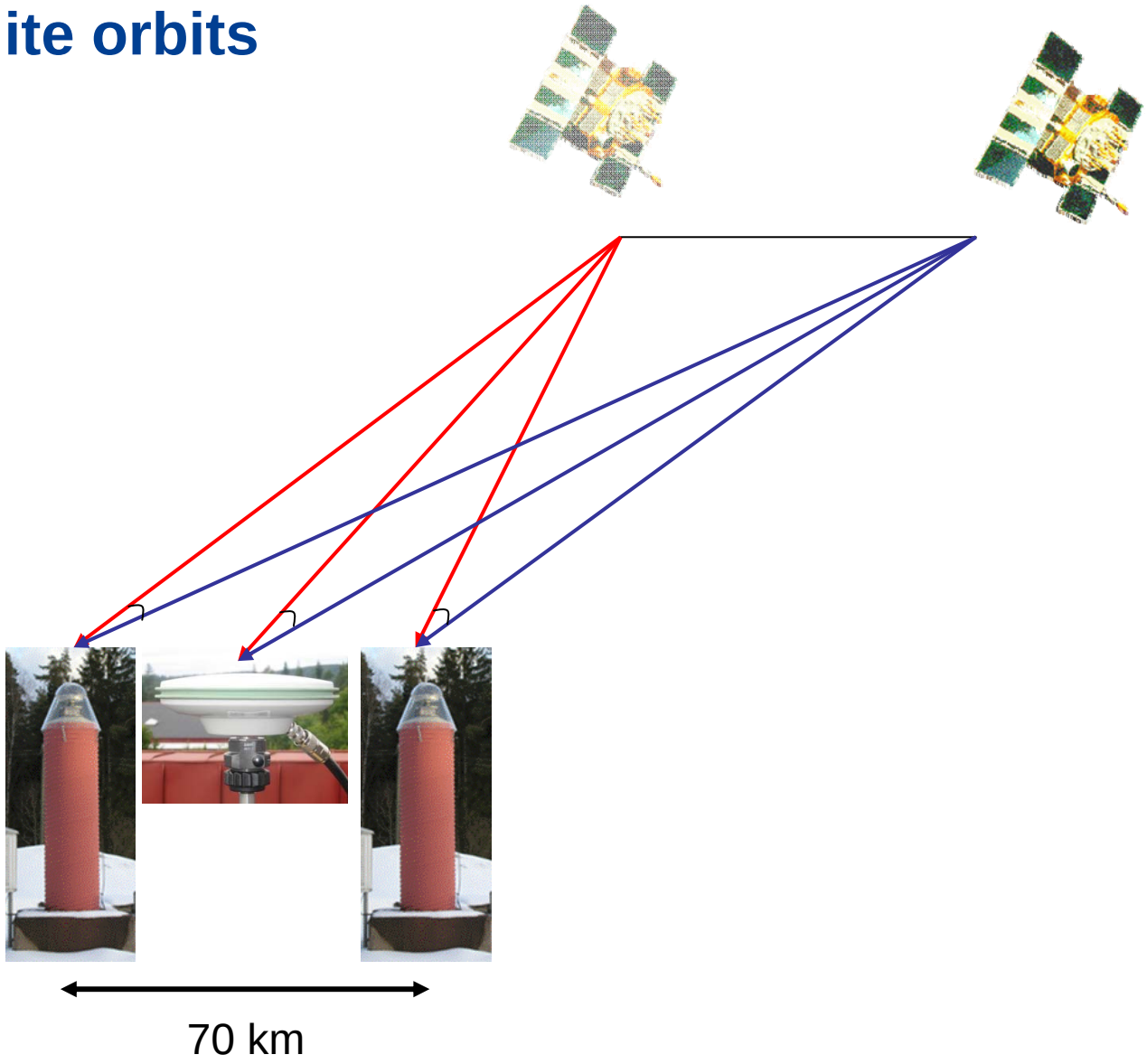
- Satellite clocks
- Satellite orbits
- Ionosphere
- Troposphere
- Local effects



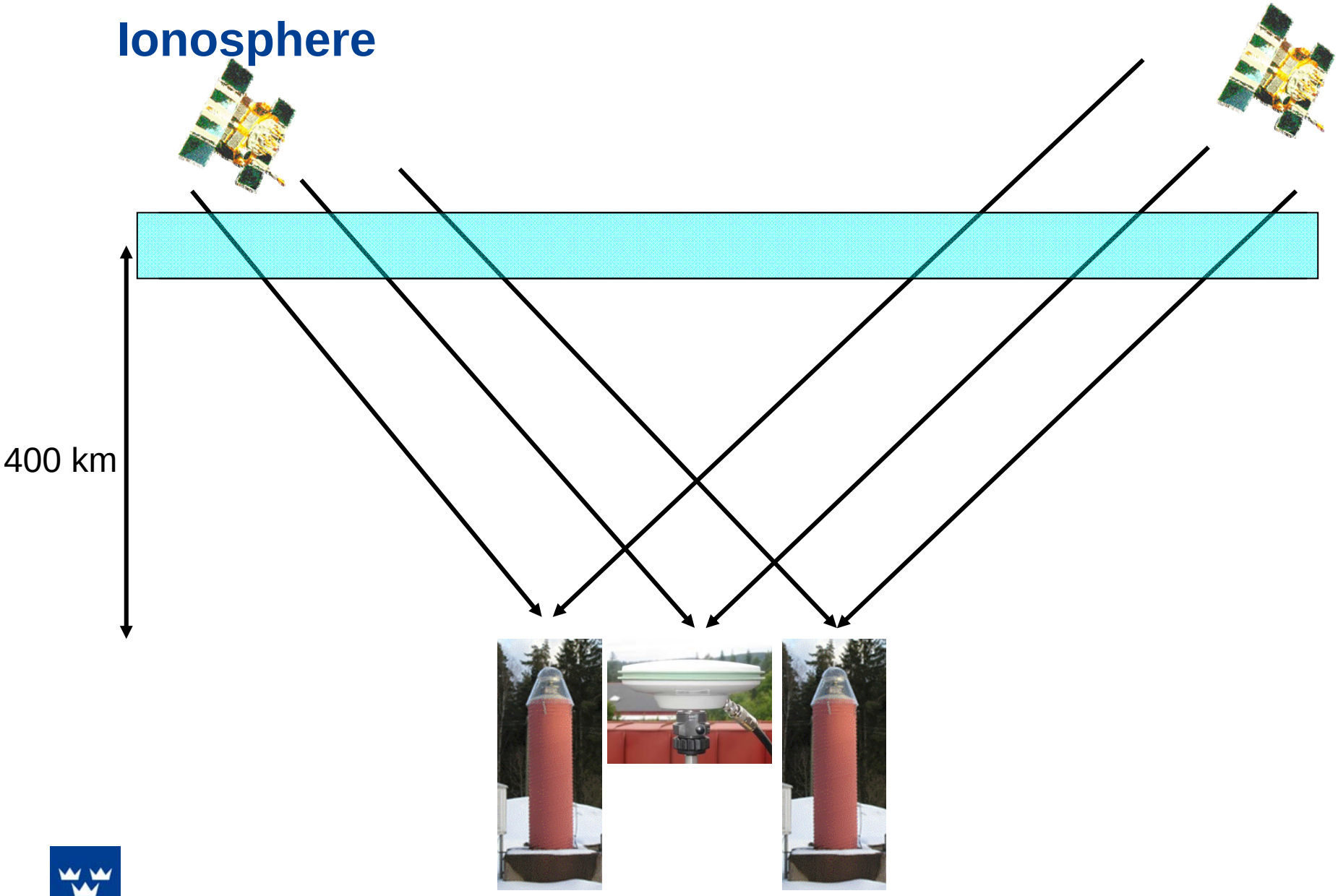
Satellite clocks



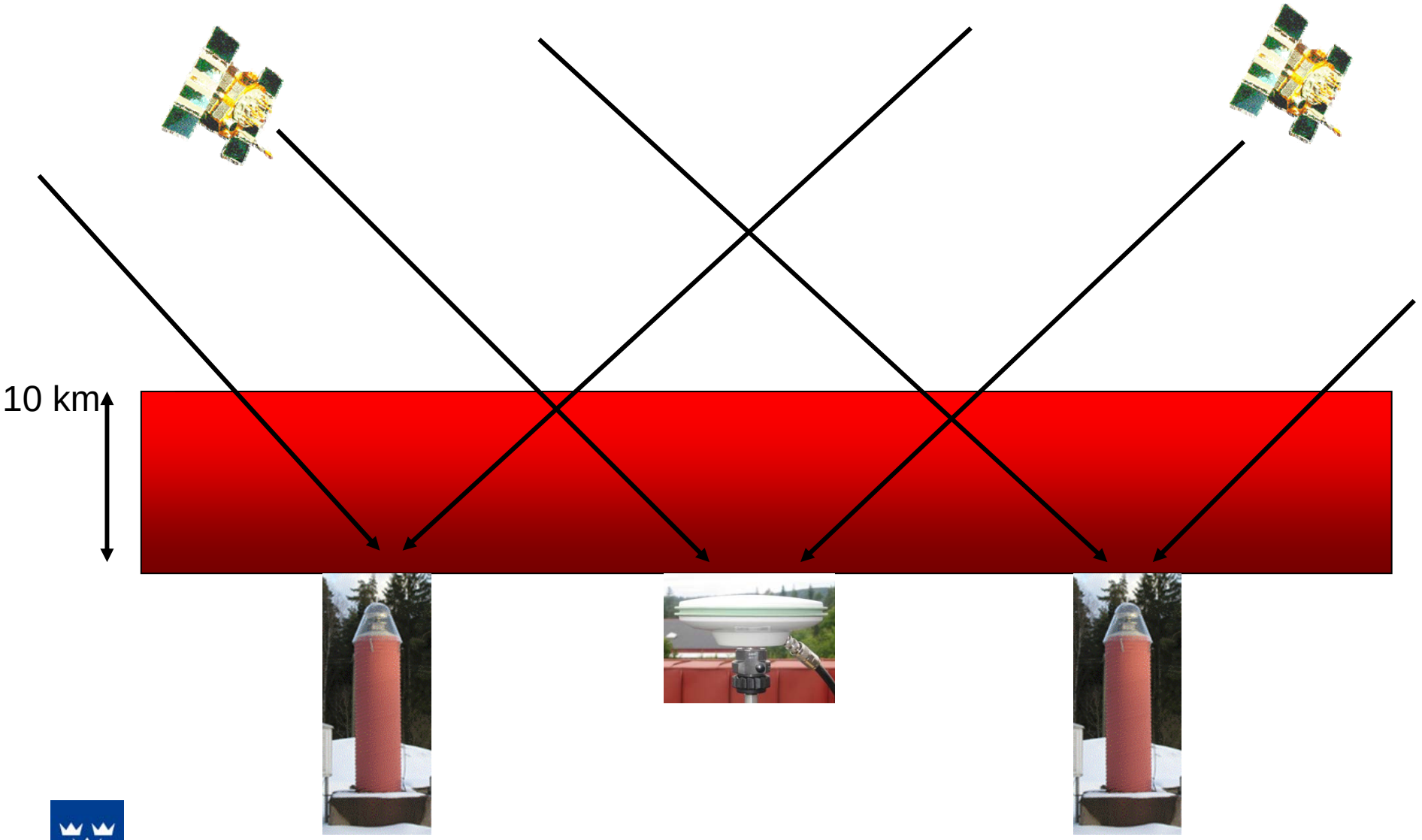
Satellite orbits



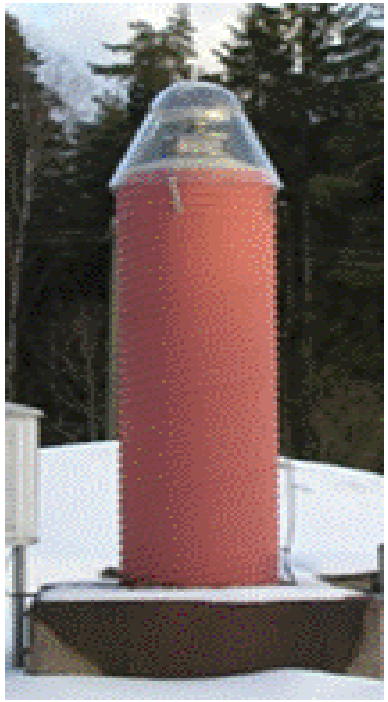
Ionosphere



Troposphere



Local effects



Reference

Rover

Error budget - Vertical

Error source		Error Nominal situation(mm)	Error 5% (mm)	Error 95% (mm)
Satellite clocks		0	0	0
Satellite orbits		0	0	0
Ionosphere		16.6	4.3	36.2
Troposphere		20.9	6.4	32.2
Local Effects	Rover	5.5	3.3	11.1
	Reference sites	1.4	1.4	1.4
Total (rms)		27.3	-	-

Error budget - Horisontal

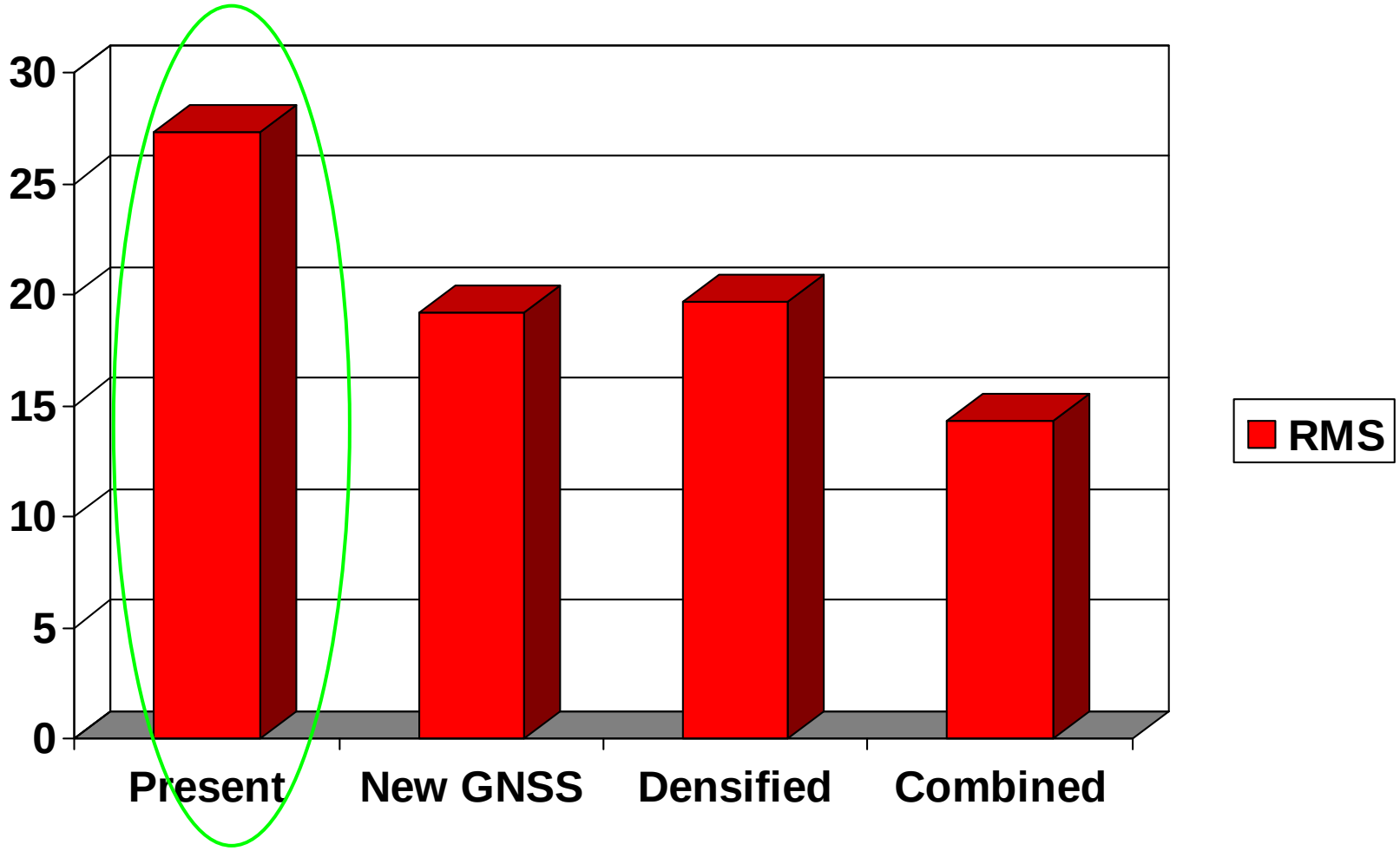
Error source		Error Nominal situation(mm)	Error 5% (mm)	Error 95% (mm)
Satellite clocks		0	0	0
Satellite orbits		0	0	0
Ionosphere		10.7	2.8	23.4
Troposphere		3.9	1.4	7.0
Local Effects	Rover	3.5	2.1	7.0
	Reference sites	0.9	0.9	0.9
Total (rms)		12.0	-	-

What can we do?

- Combination of observables
- Elevation cutoff
- Network density
- Reference network interpolation

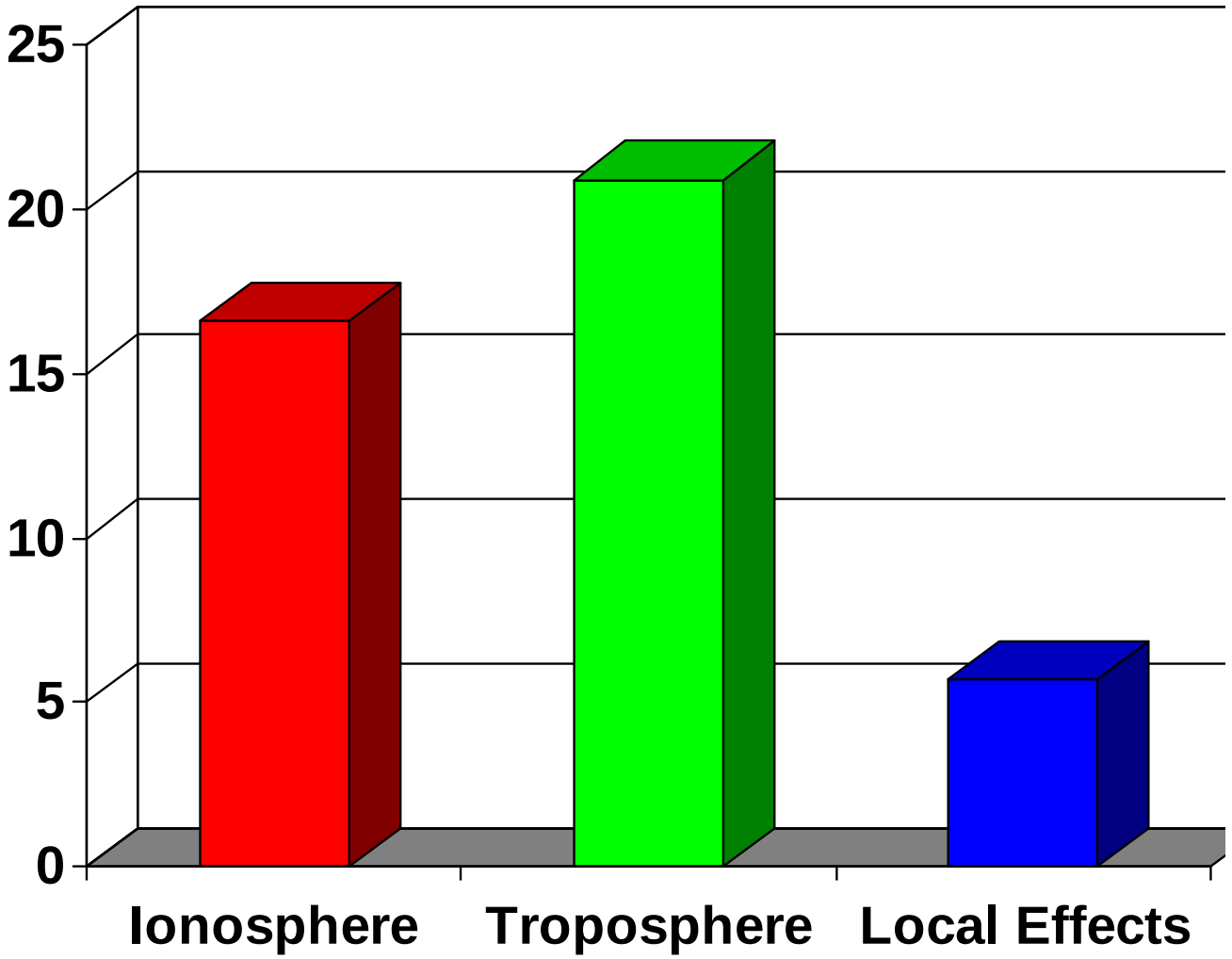
- Satellite constellation

Vertical Error



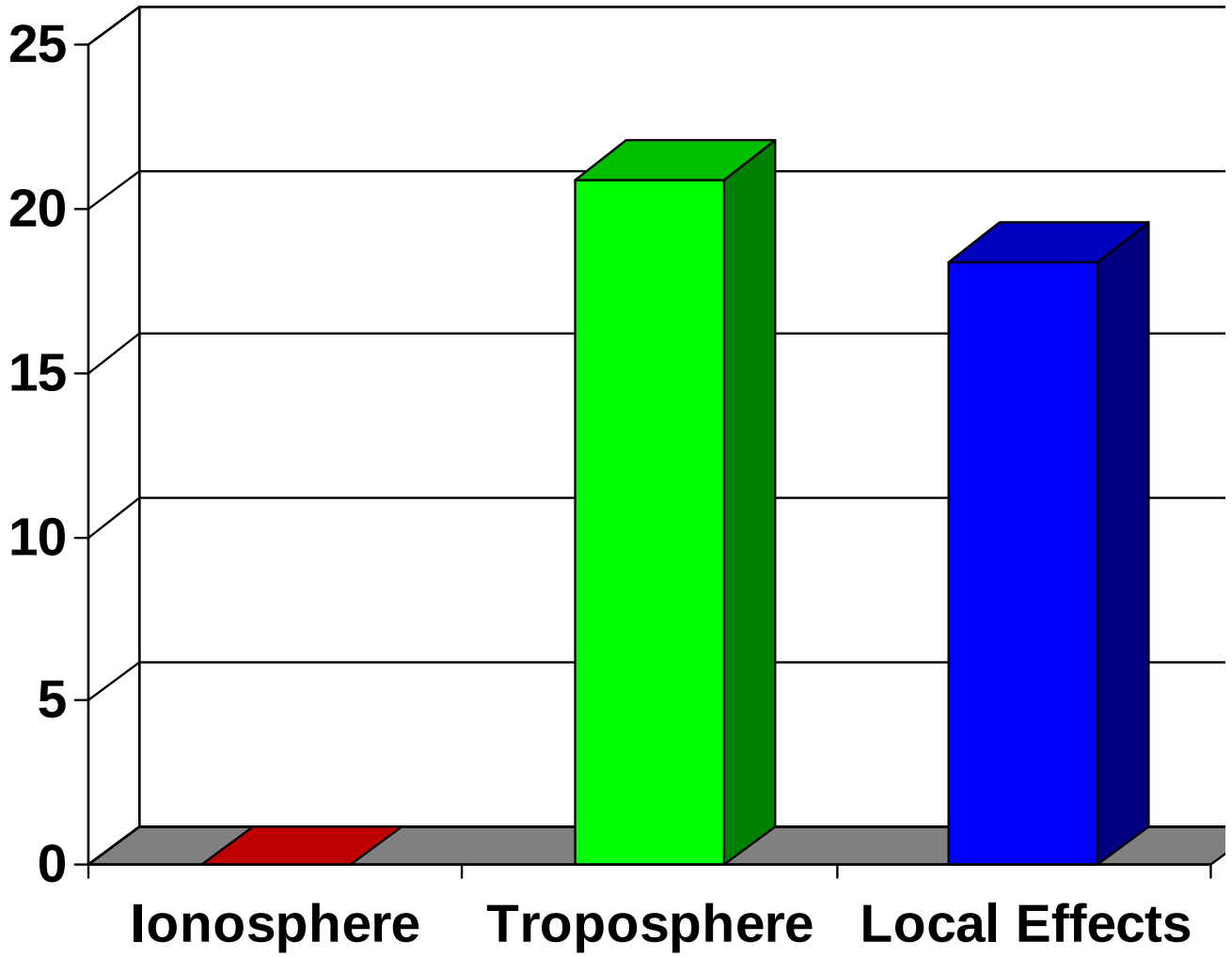
L1 - Processing

Total
27 mm

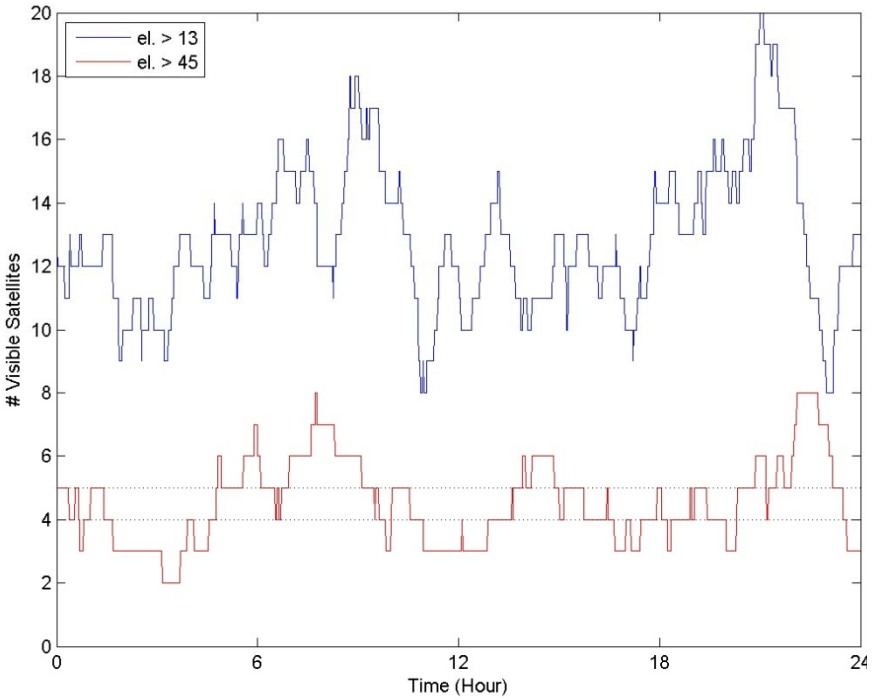


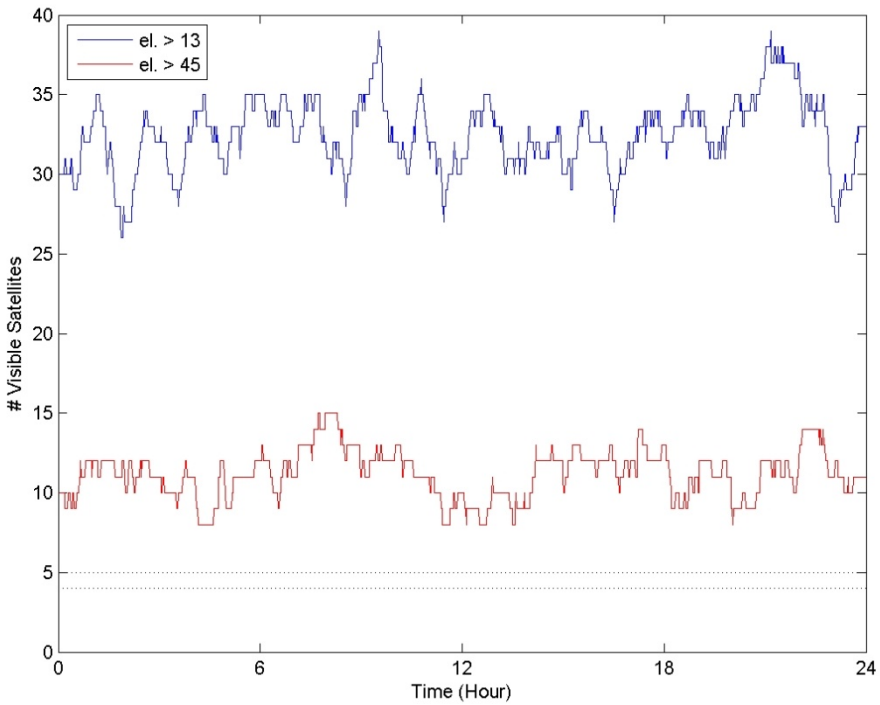
L3 - Processing

Total
28 mm



Satellite constellation

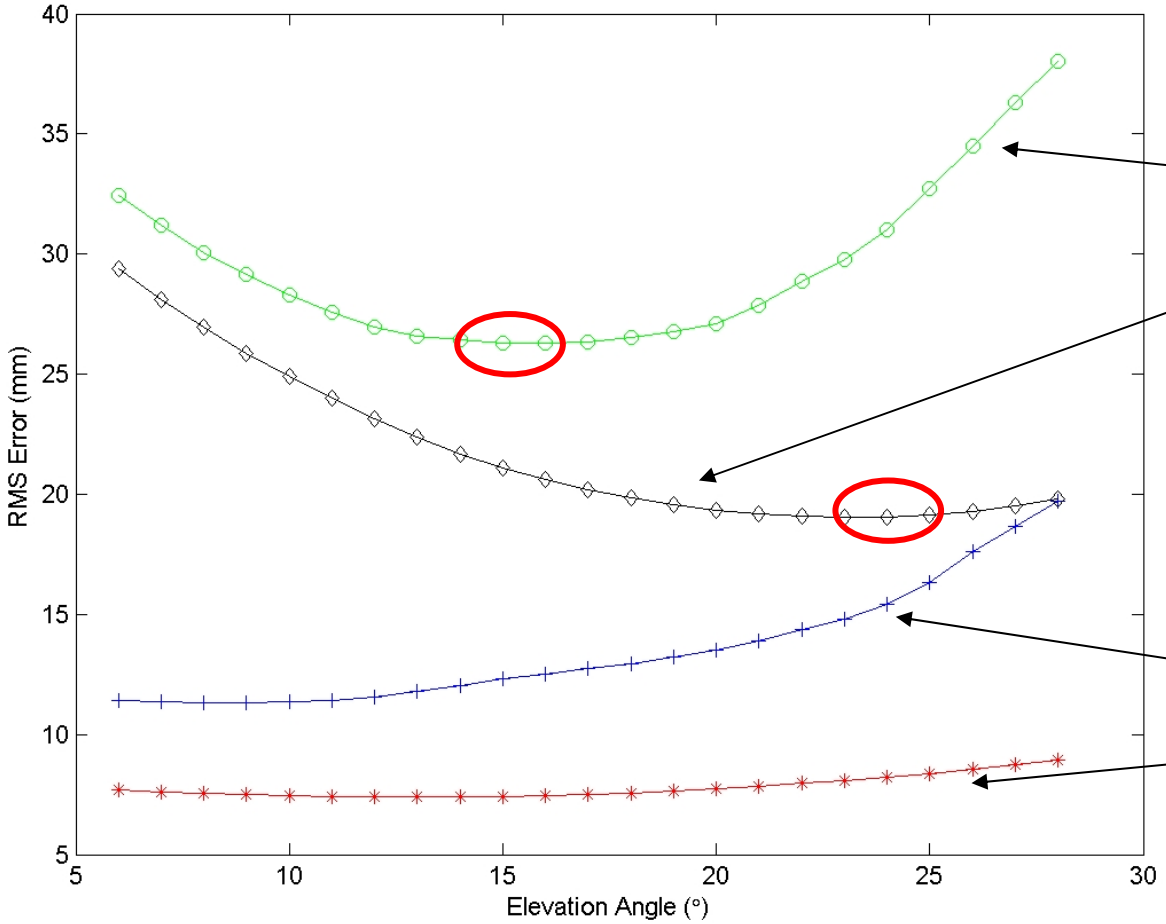




Present

Future

Elevation cutoff



Vertical

Present

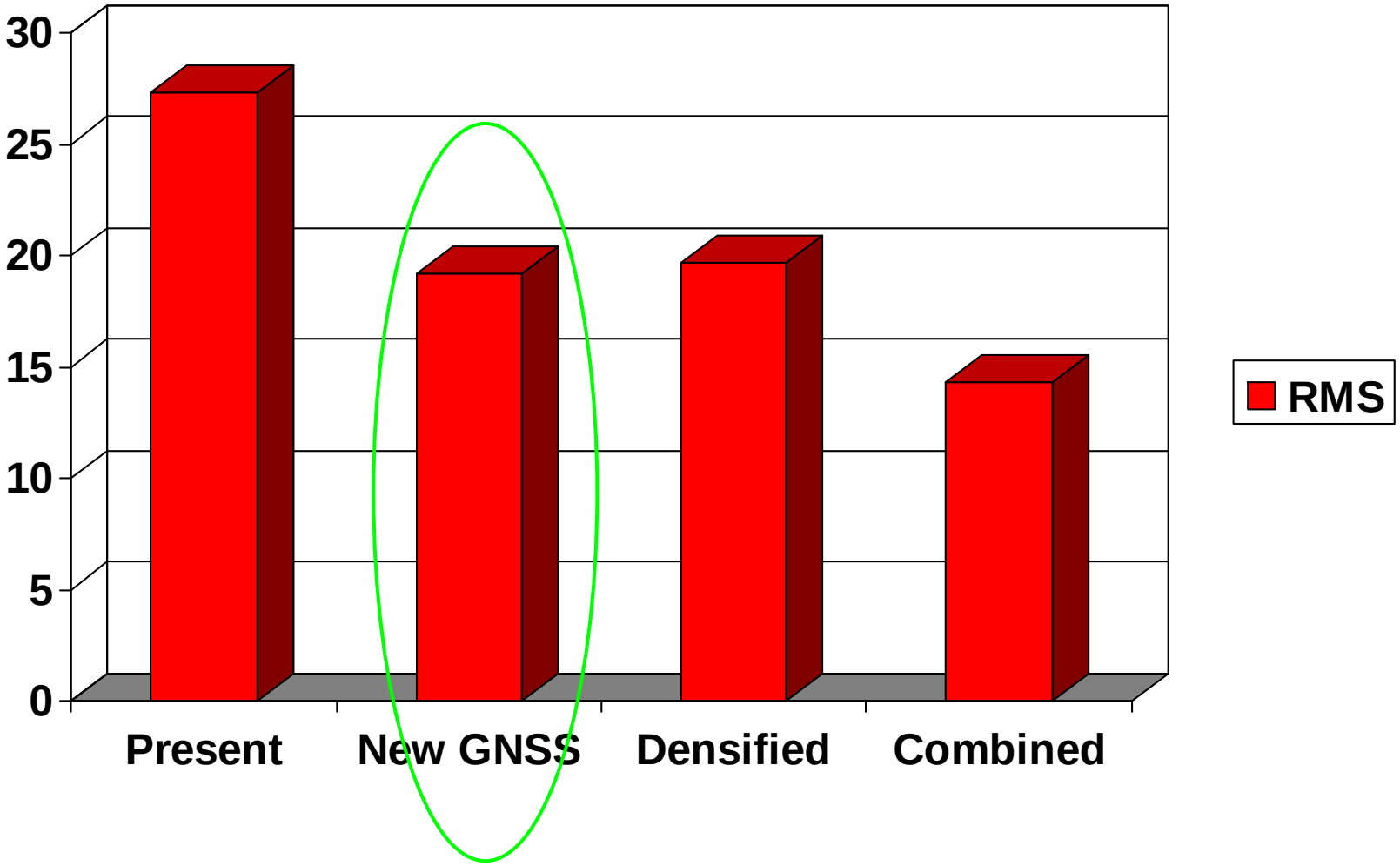
Future

Horisontal

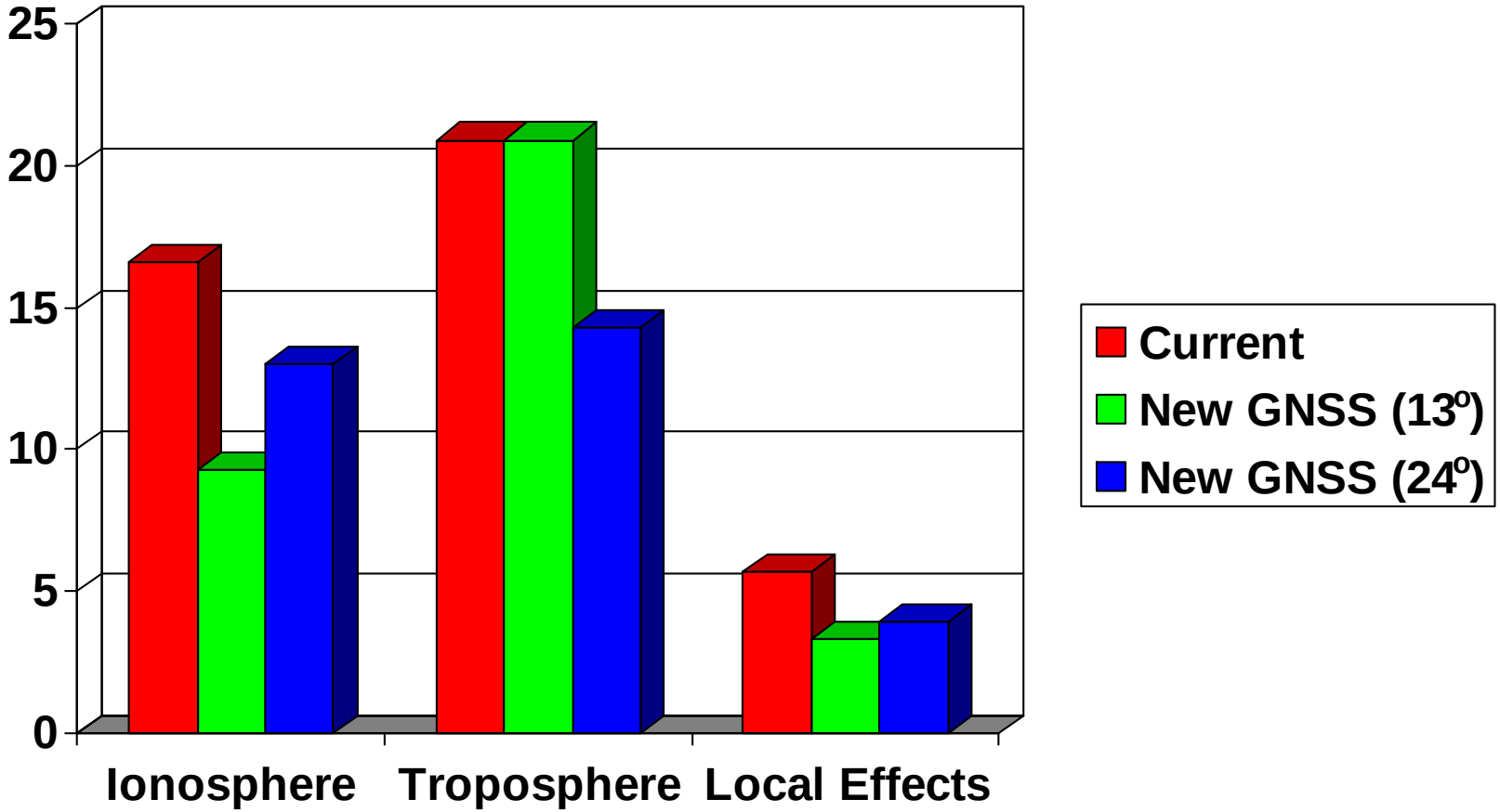
Present

Future

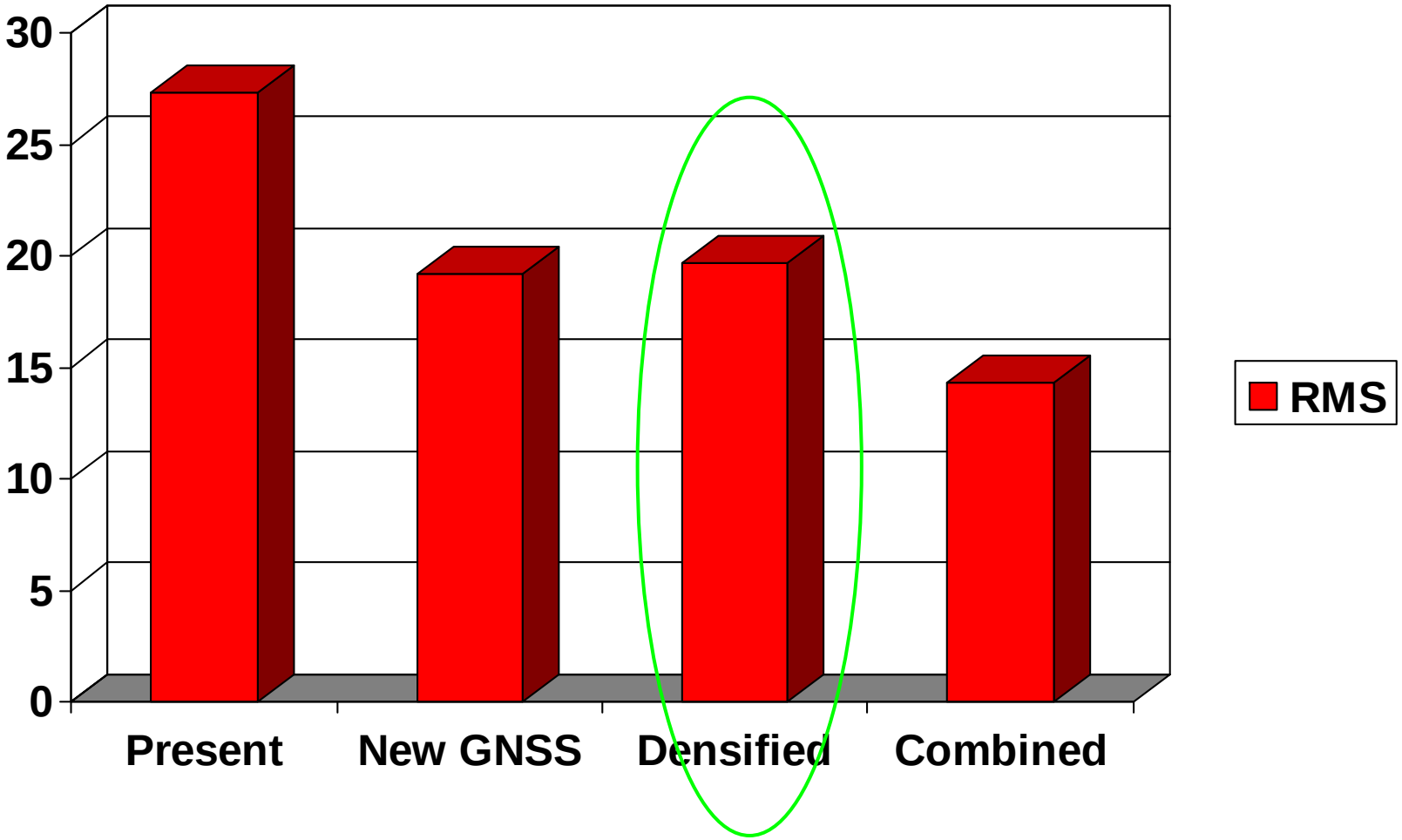
Vertical error



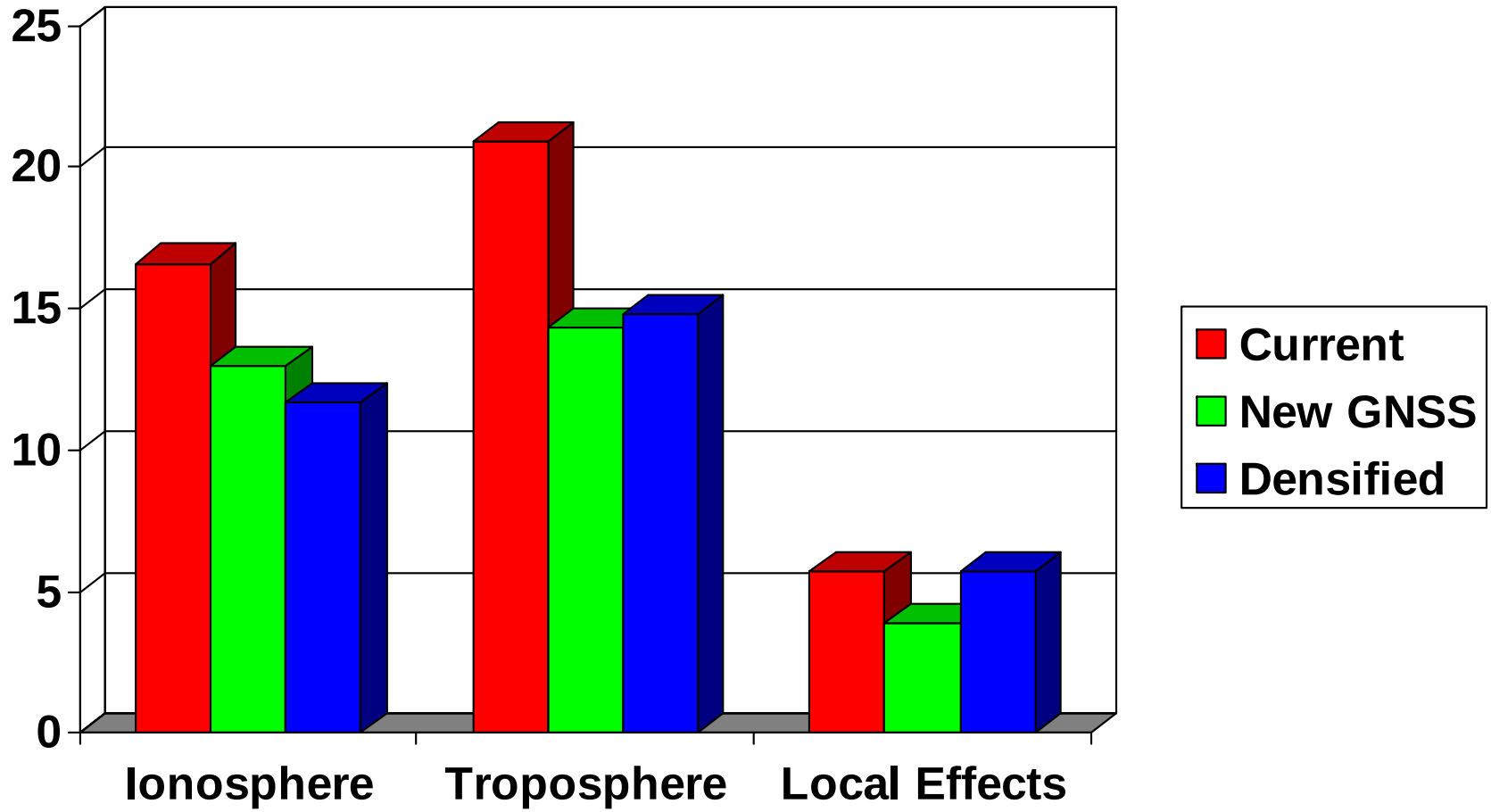
L1 - Processing



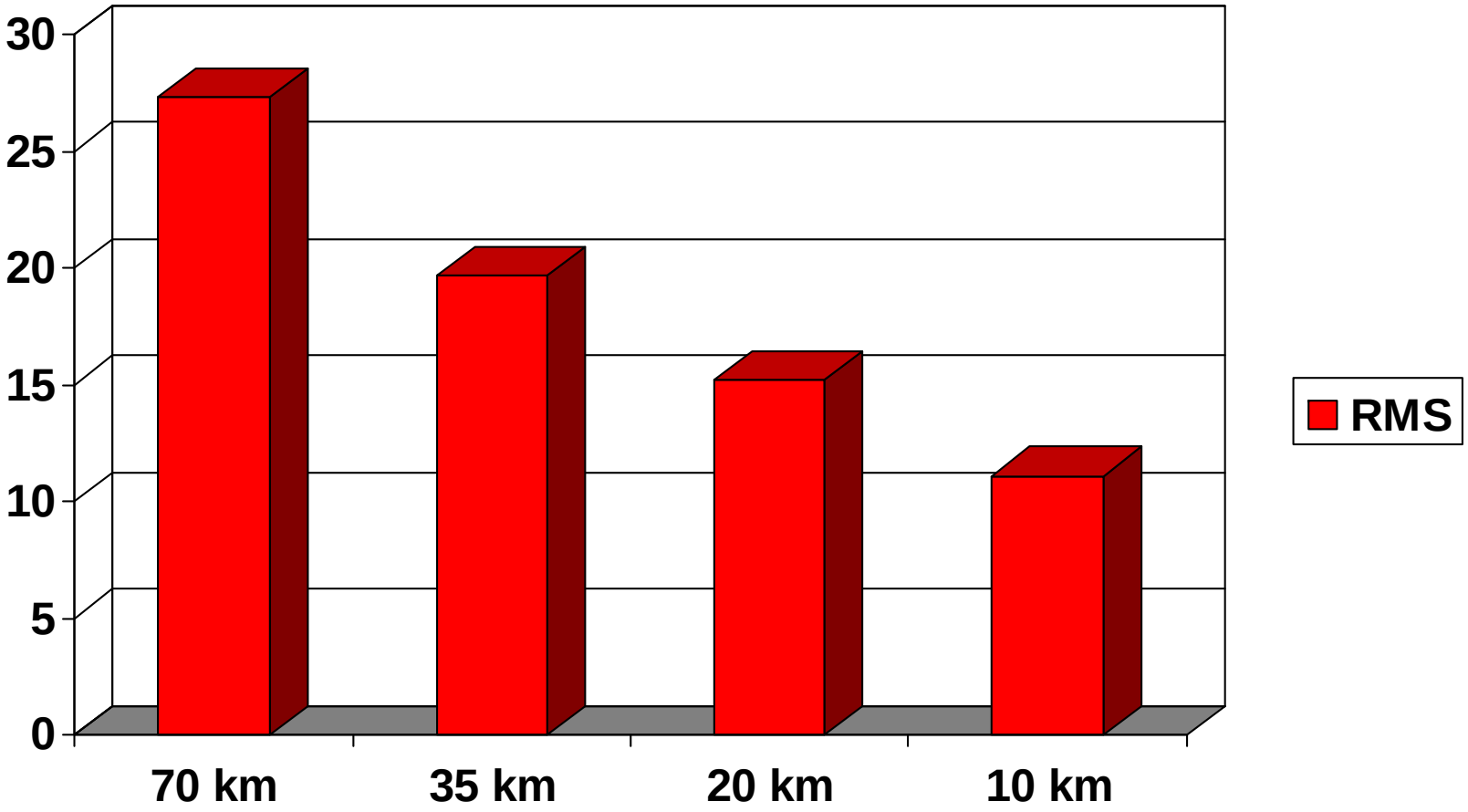
Vertical error



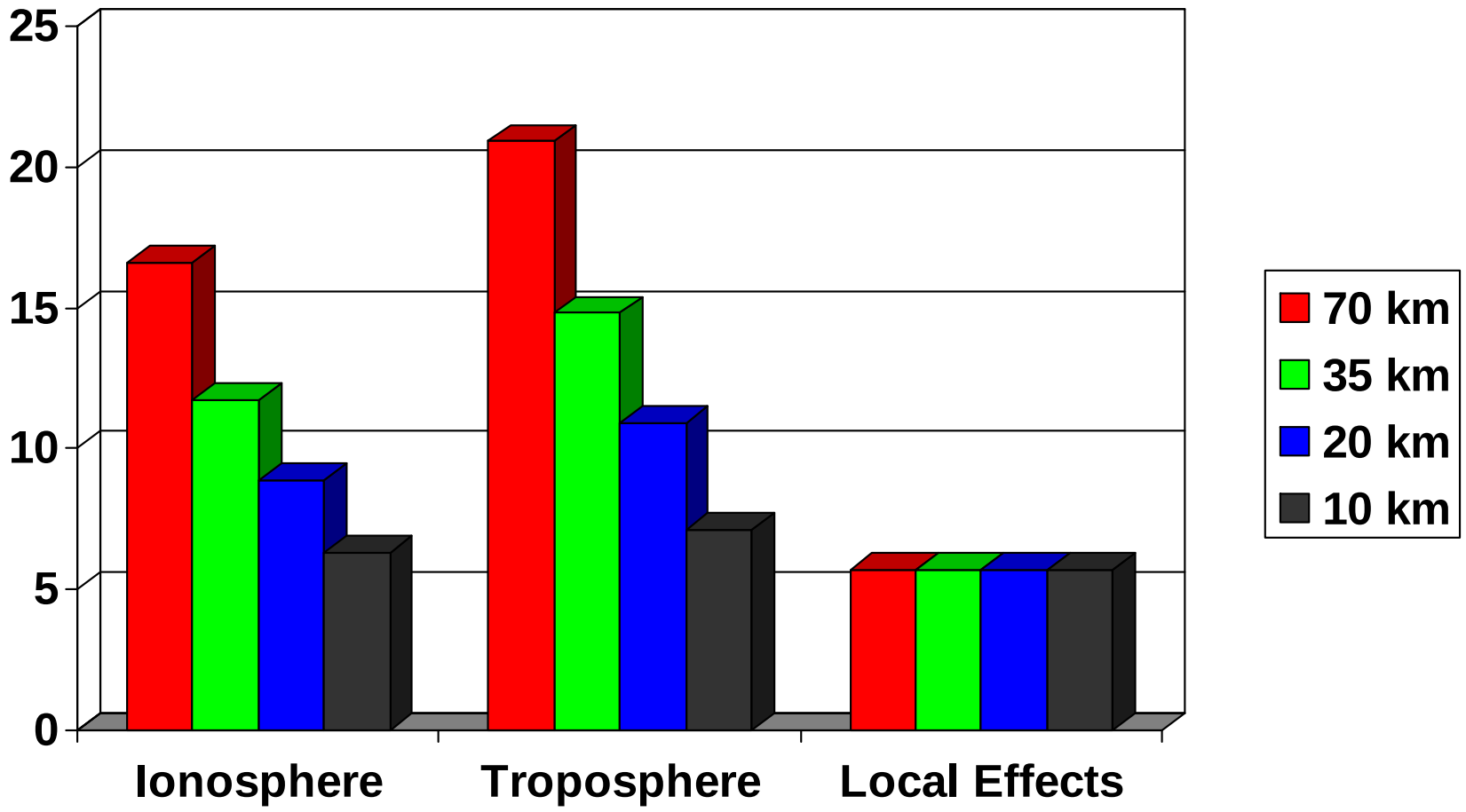
Error Components



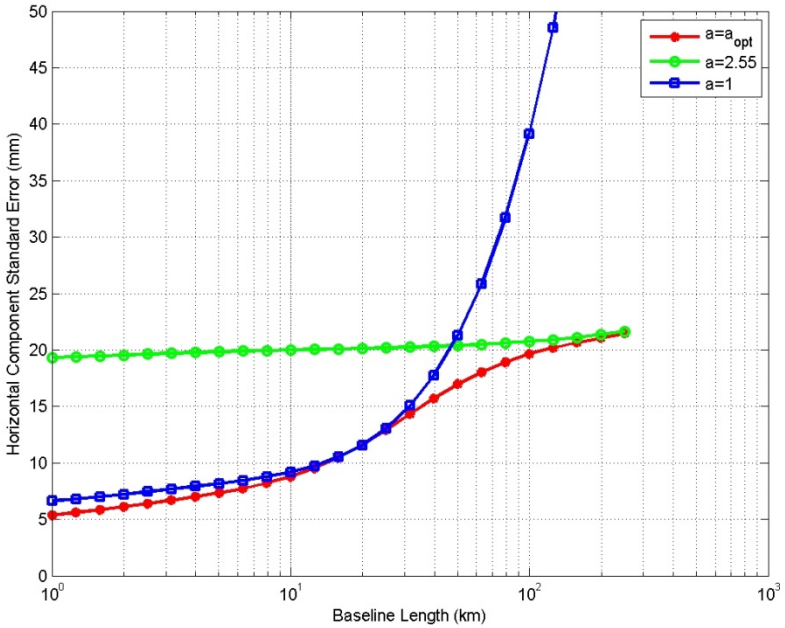
Vertical error - Densification

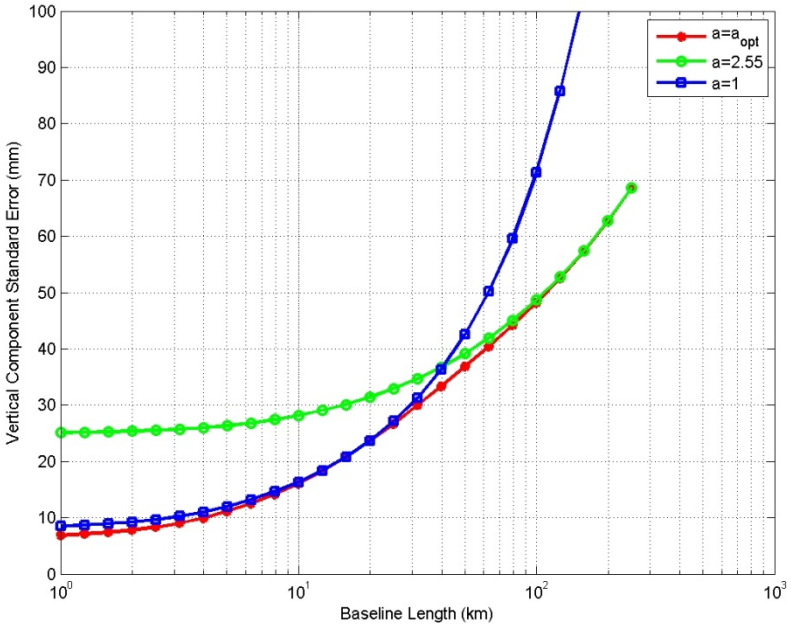


Standard - Processing

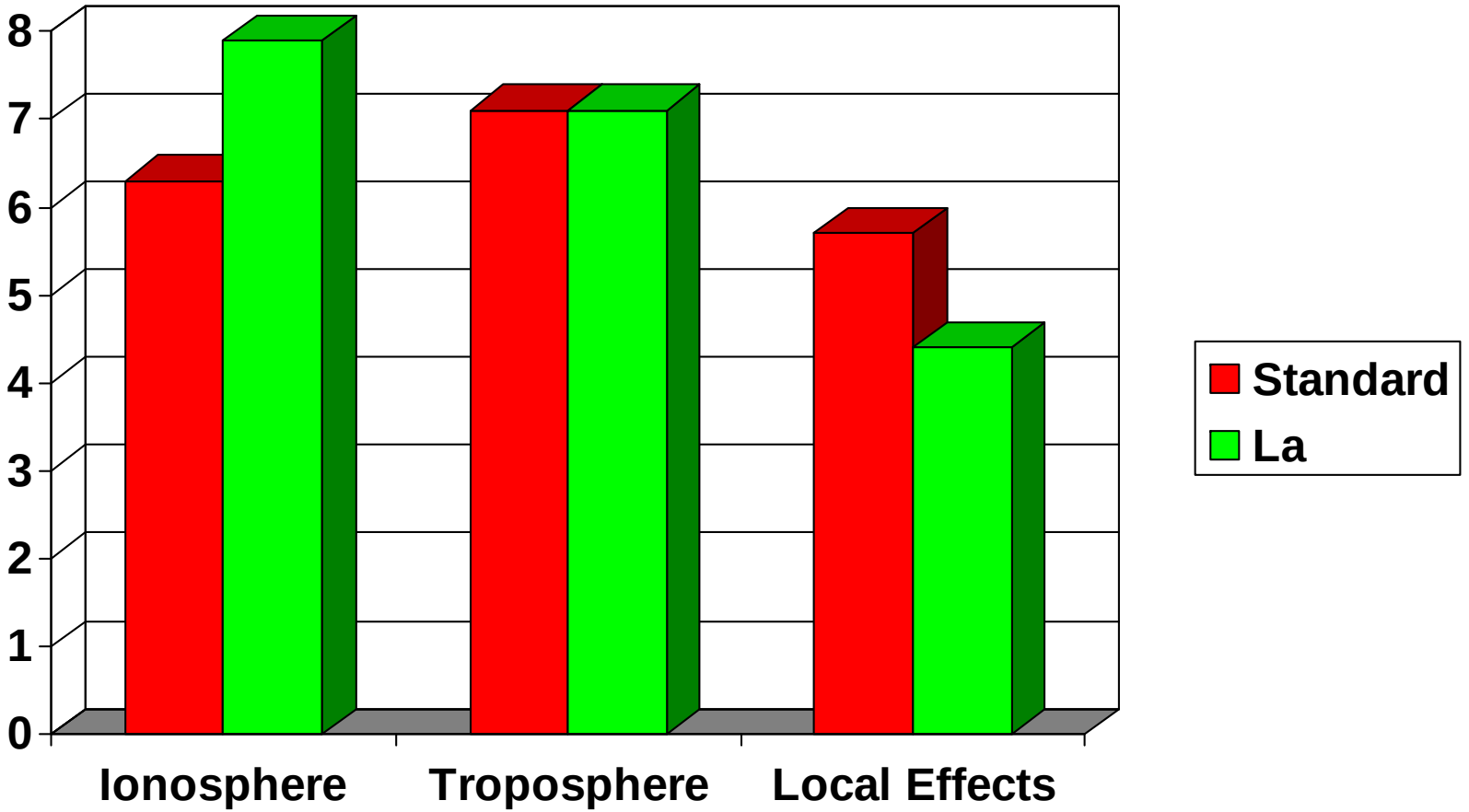


Linear combinations

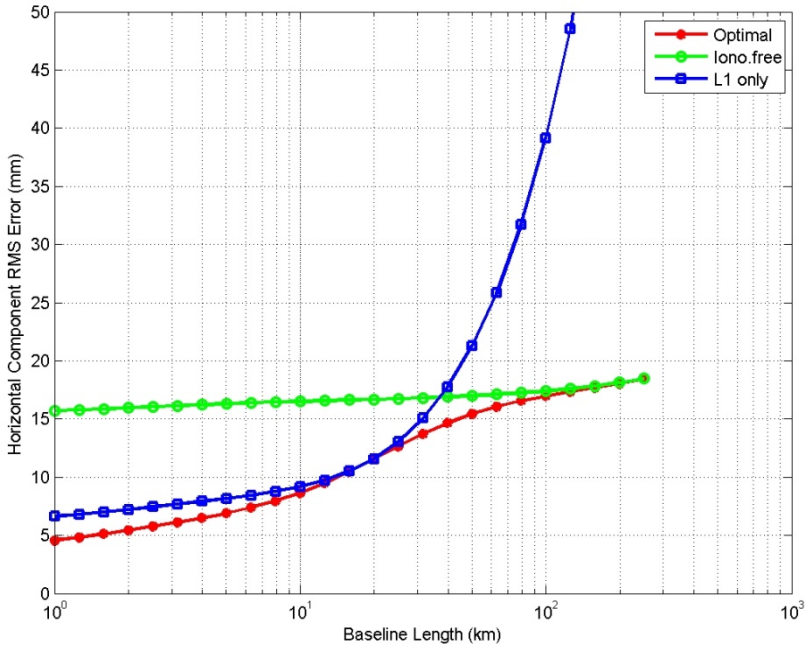


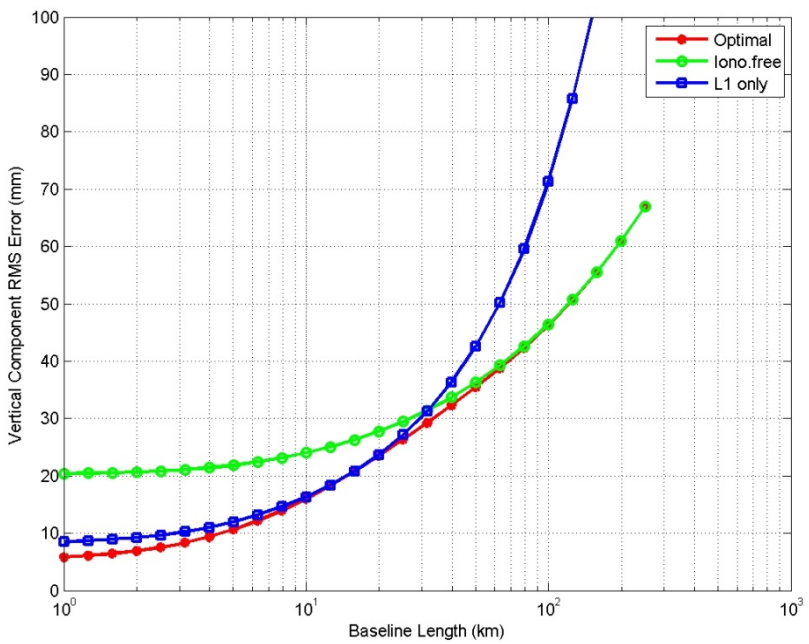


10 km network

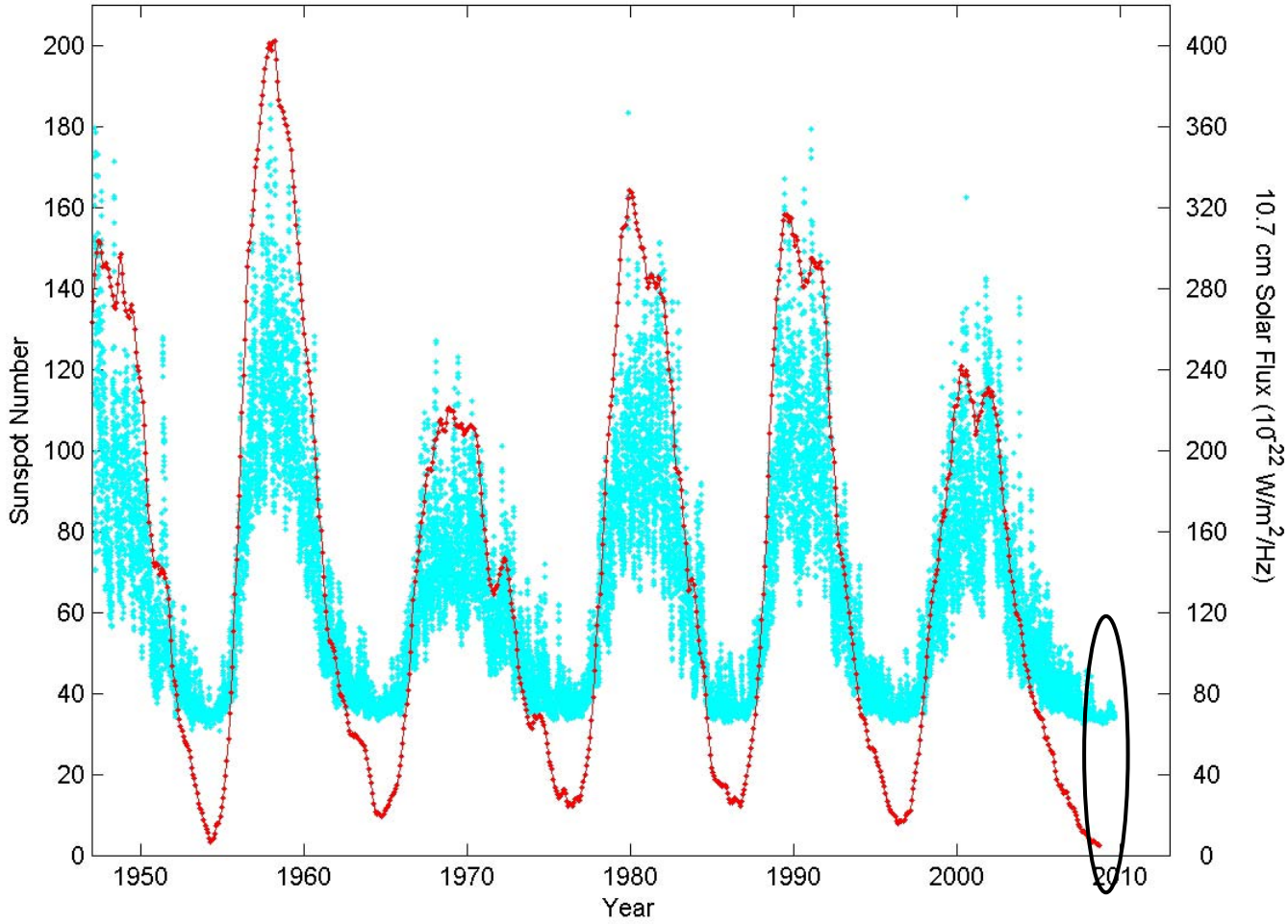


Linear combinations – Three frequencies

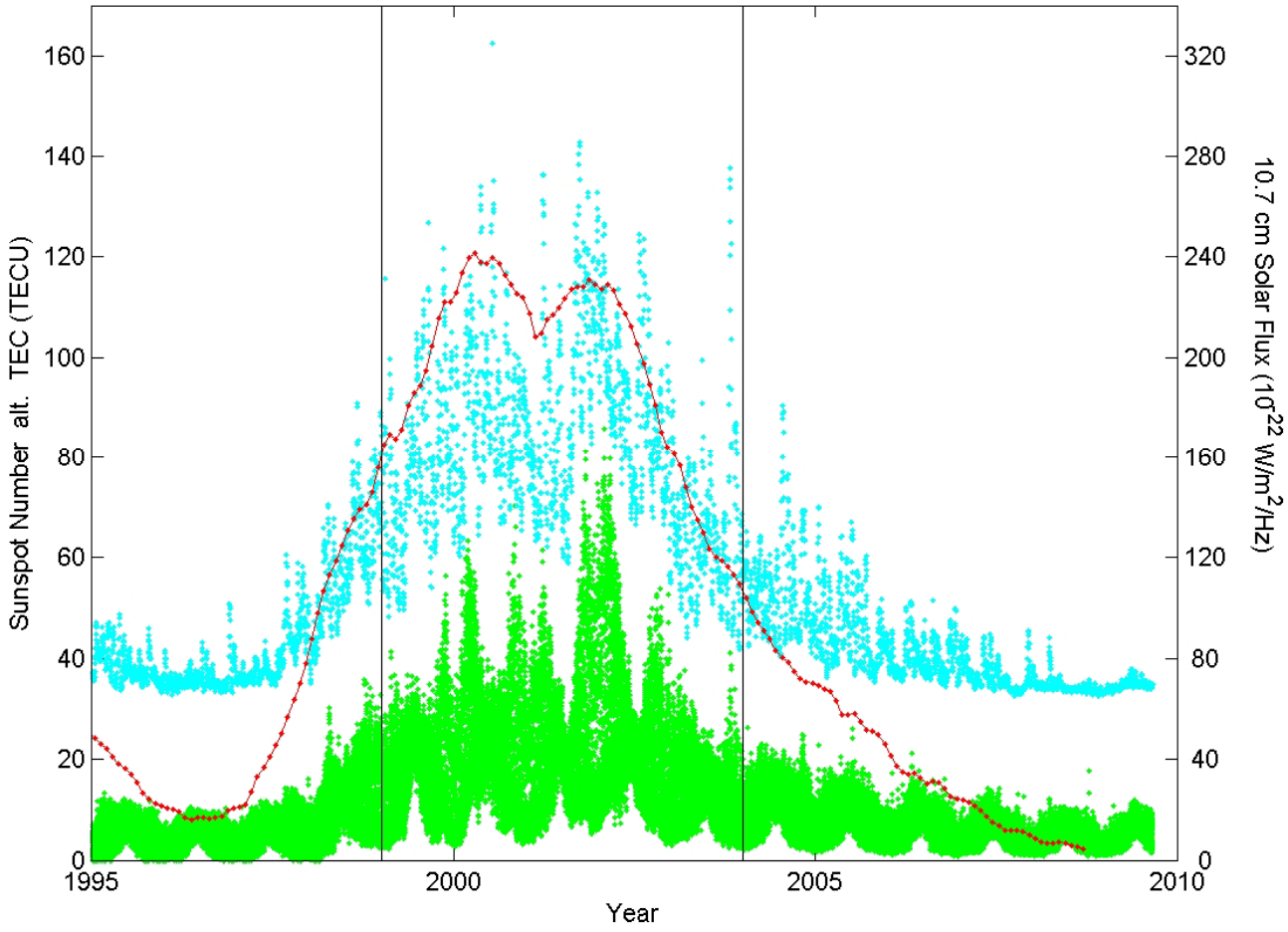




Solar cycles



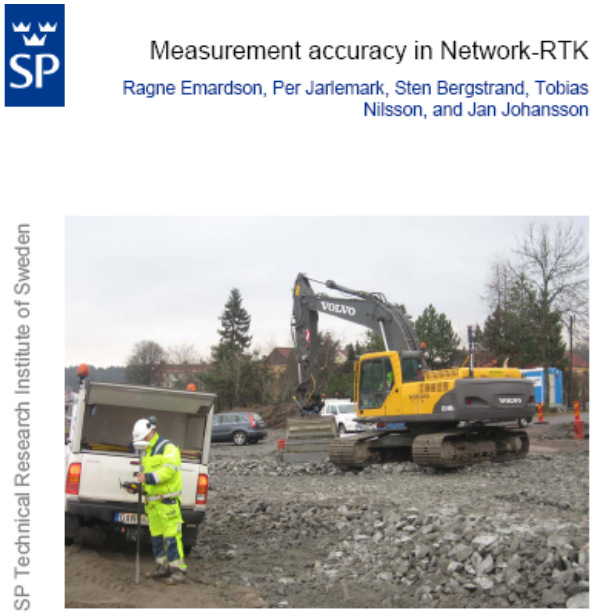
One solar cykle



Summary

- A condensed network (35 km) reduces the vertical error from 27 mm to 20 mm
- The availability of future systems will reduce the vertical error from 27 mm to 20 mm
- Future system allows for higher cutoff angle
- The Ionosphere is periodically a dominant error source
- The use of the L3 combination removes these errors at the expense of local effects
- New systems open up for other linear combinations of observables
- The combination of a condensed network (35 km) and new satellite systems will result in a vertical error of 14 mm
- The combination of a condensed network (10 km) and new satellite systems will result in a vertical error of 8 mm

Rapport



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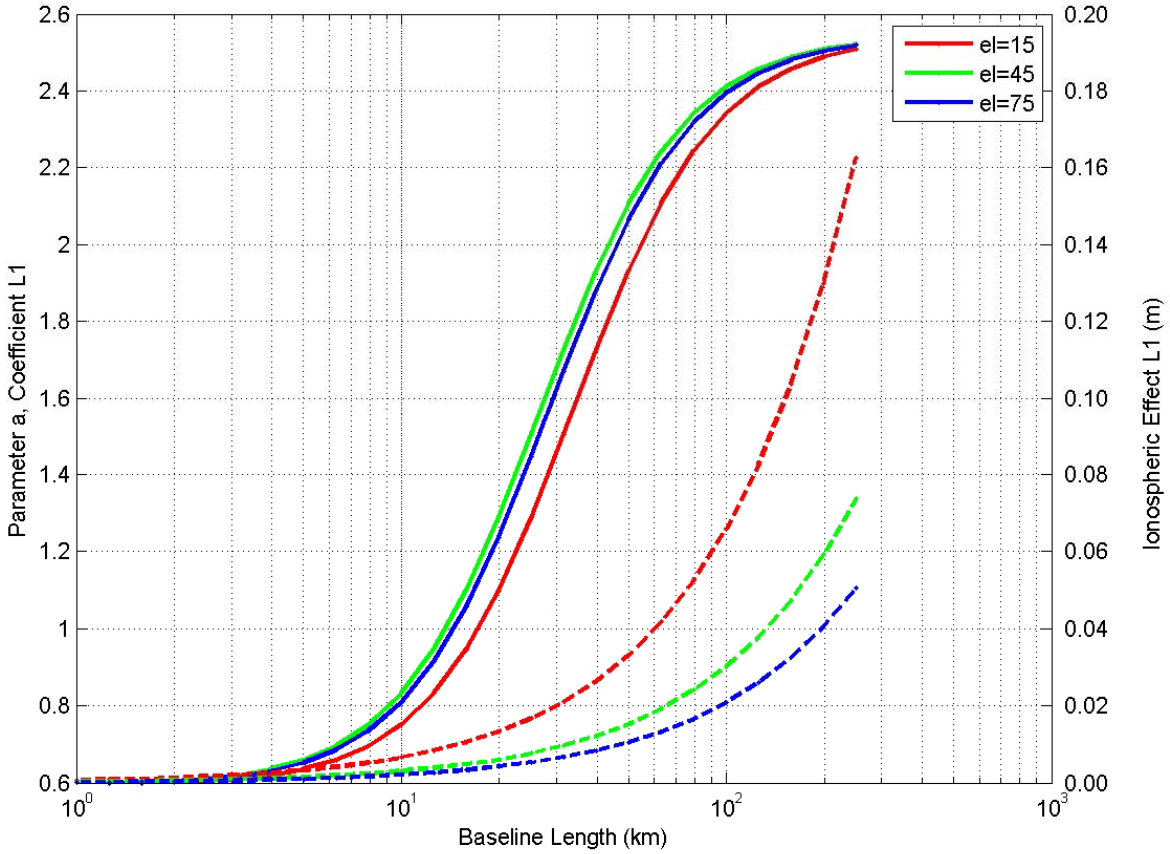
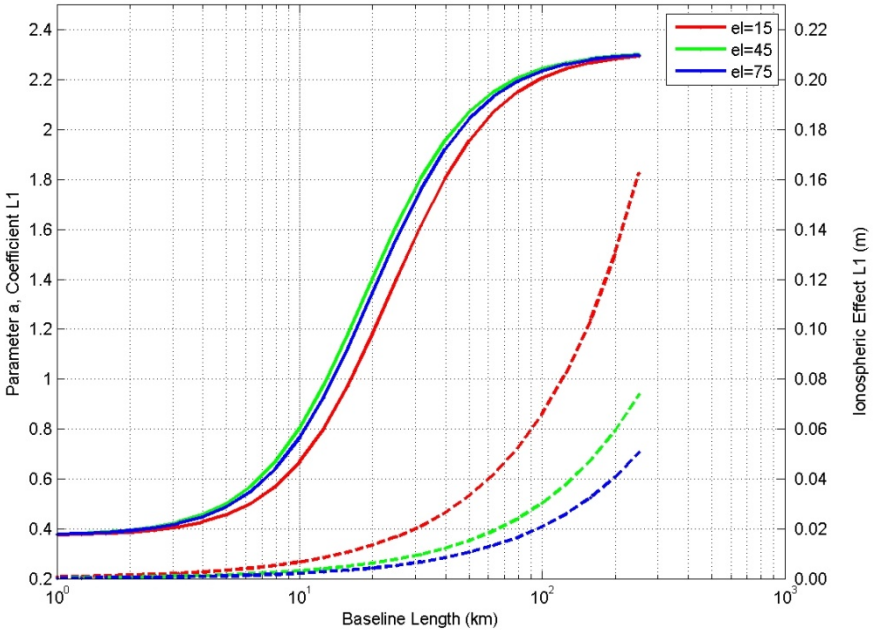
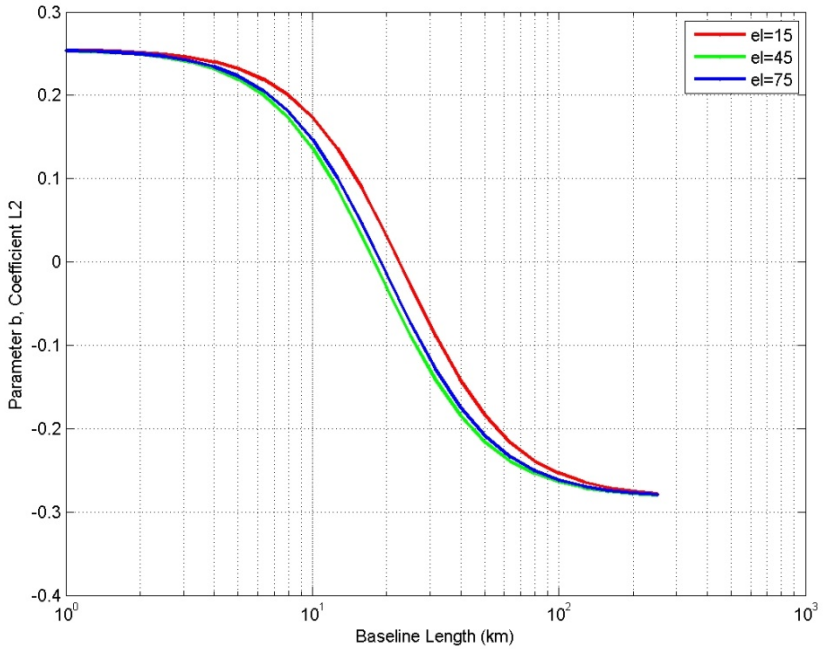
Linear combinations



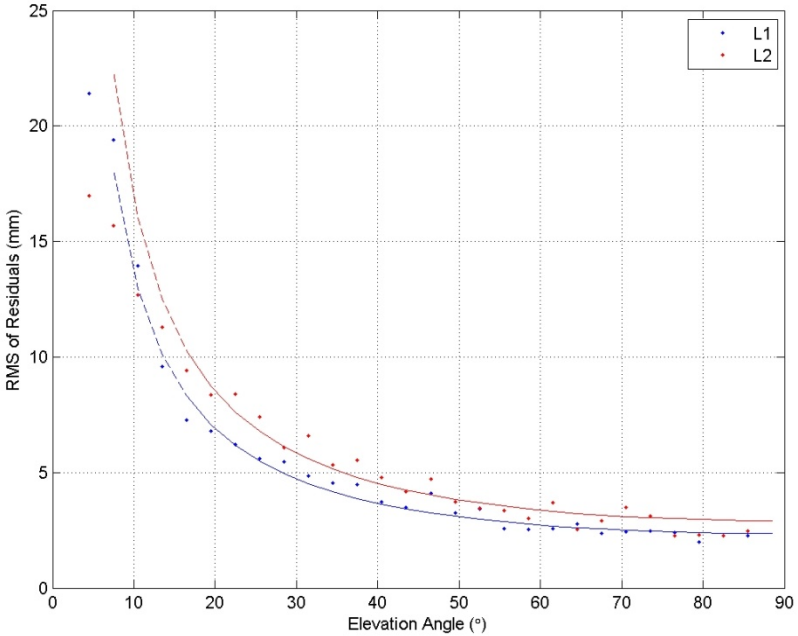
Linear combinations – Three frequencies





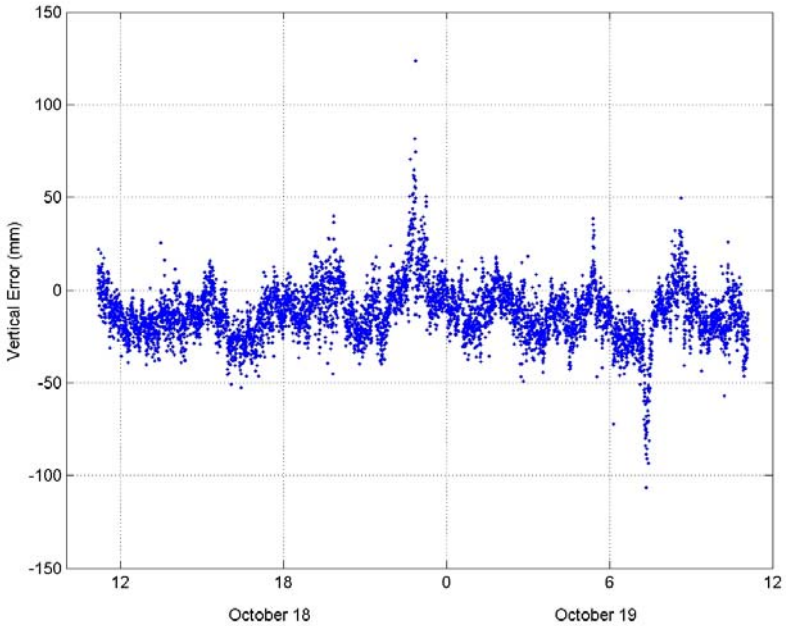
Local effects

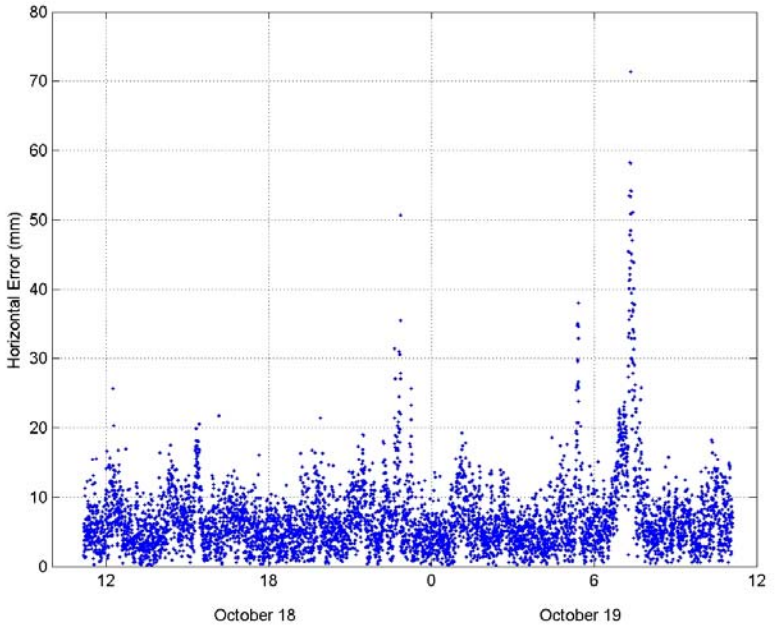
Experiment



Model

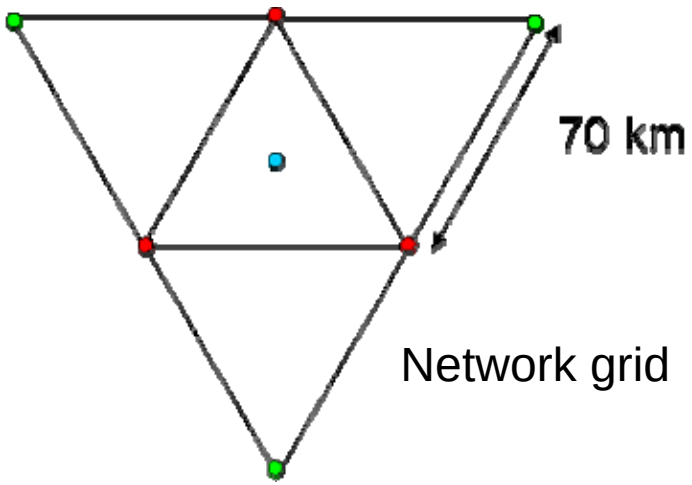
Vertical and Horisontal Errorrs (24 h)





Assessment

Error source		Measured(mm)	Simulated(mm)	Measured(mm)	Simulated(mm)
		Vertical		Horizontal	
Satellite clocks		-	0	-	
Satellite orbits		-	0	-	
Ionosphere		-	5.1	-	3.3
Troposphere	Zenith interpolation	-	17.4	-	1.5
Local Effects	Rover	-	5.5	-	3.5
	Reference sites	-	1.9	-	1.2
			-		
Total (rms)		19.3	20.5	8.6	6.9

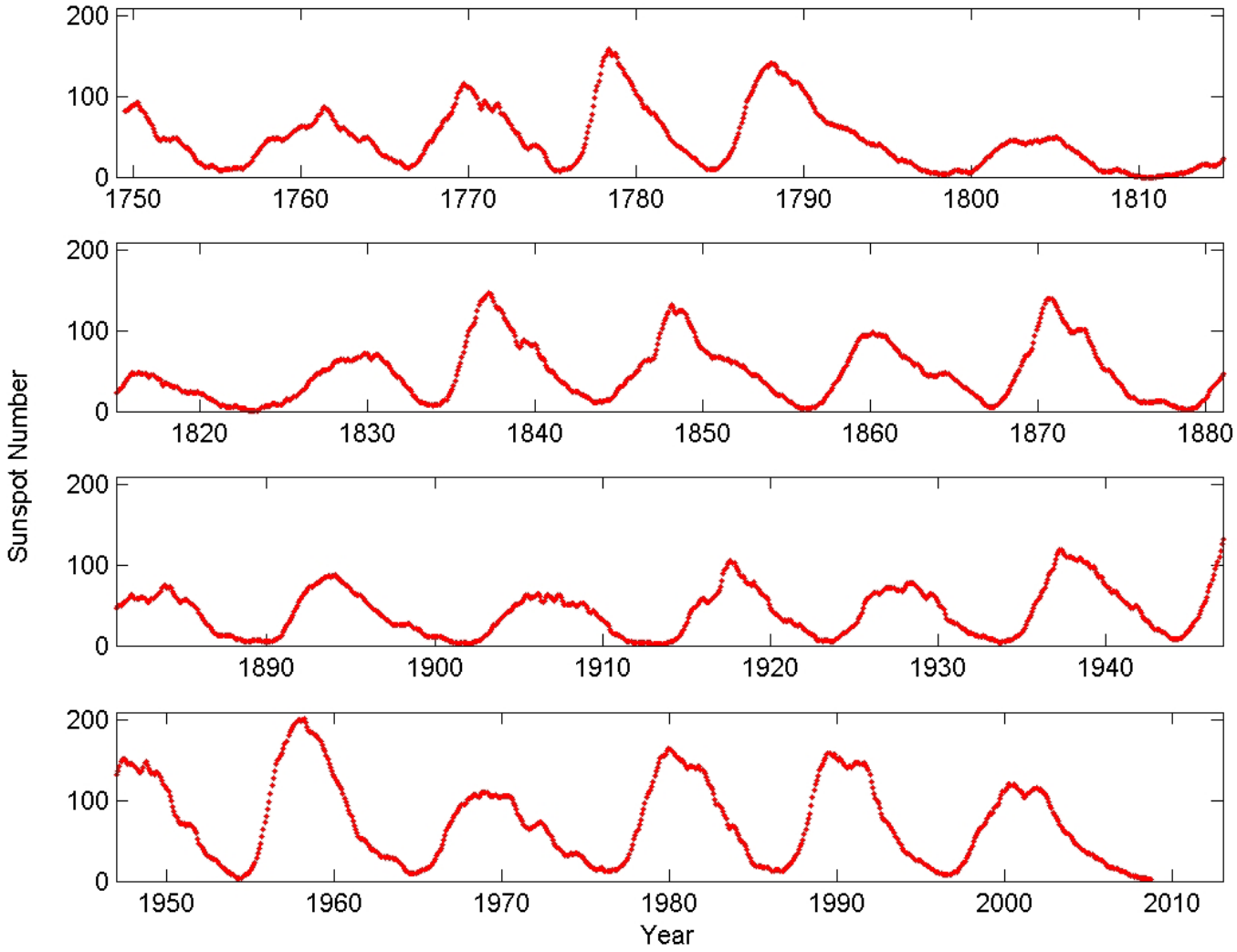


Terminology

- All listed errors in this presentation corresponds to the square root of the variance of the difference between the measured and the true value.

- This means that the reported errors can be used to estimate the measurement uncertainty of the corresponding measurements.

Solcykler


Sunspot Number
200
100
0
1750
1760
1770
1780
1790
1800
1810
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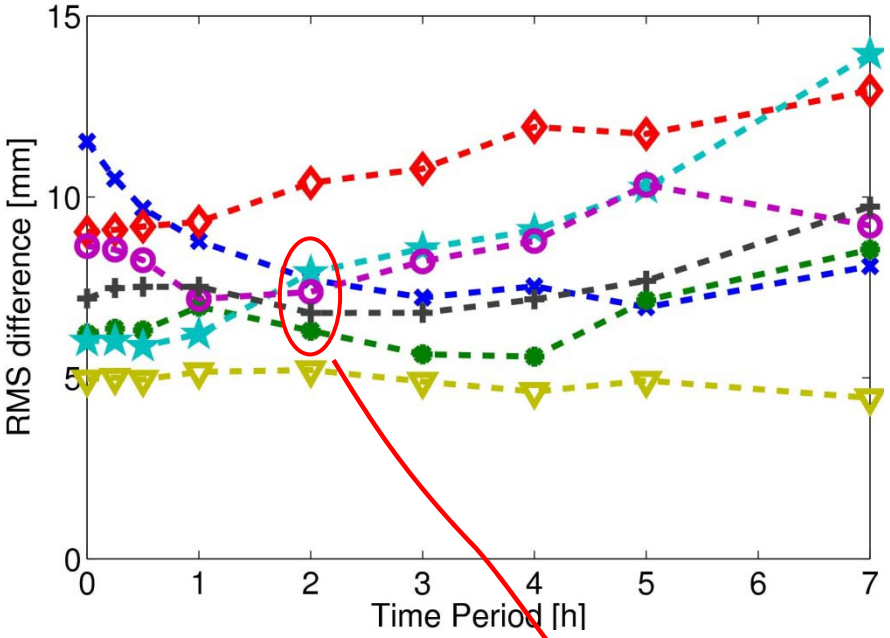
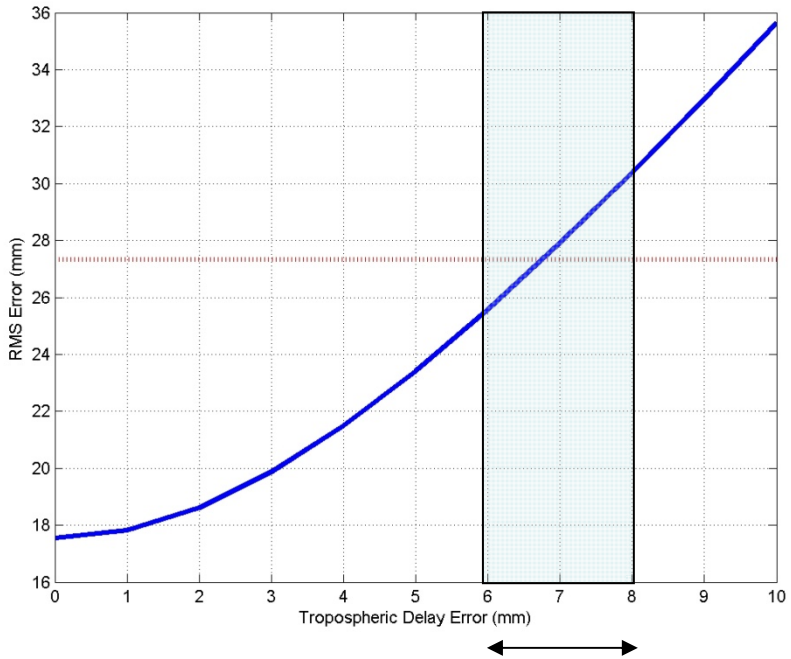
1830
1840
1850
1860
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Year

Troposphere interpolation





Troposphere interpolation