Estimation of the stochastic measurement error model when applying GNSS techniques based on the positioning in real time services provided by RGAN

Ana Fernández Militino

Departamento de Estadítica e Investigación Operativa
Universidad Pública de Navarra

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Outline

Objective

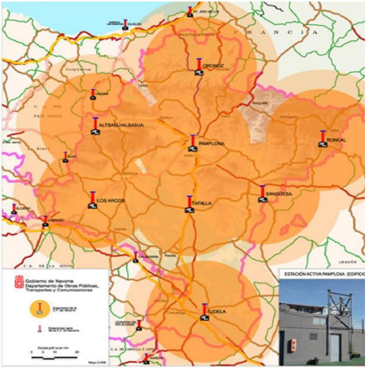
Main objective

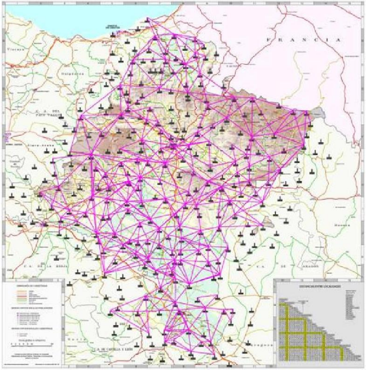
Obtaining a *measurement error model* when applying GNSS techniques based on the positioning in real time services provided by RGAN in Navarra

- Applications: topographic and cartographic works (land surveying, boundaries conducting, detail mapping, positioning for precise agriculture)
- Steps:
  - The definition of an error model based on the available punctual measurements

Geodetic network

- The old **RGAN** was a geodetic infrastructure consisting of eight reference GNSS stations distributed along Navarra
- Stability of the communications is proven → qualification of the corrections positioning in real time
- For this aim, 20 vertex points of the ROI are used





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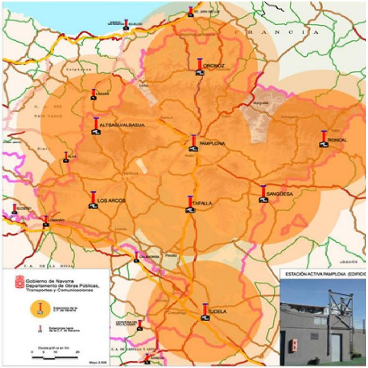

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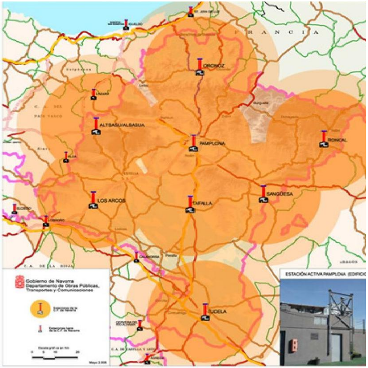
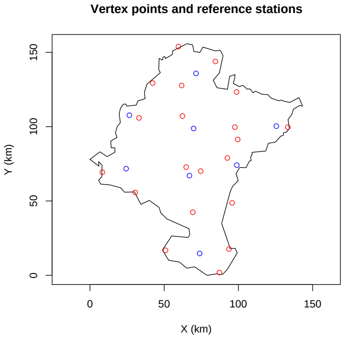




Data

- The Department of Civil Engineering, Transport and Communication of the Navarra Government: 20 vertex points and their network solution and closest reference receiver measurements
- Two different studies:
  - The precision of the GPS measurements based only on the closest reference receiver to the vertex point
  - The precision of the GPS measurements based on the network solution. The network solution is a weighted solution of the measurements at every available station

Outline

Geostatistics

- **Geostatistics** is defined as the statistical techniques over the regionalized variable in order to estimate a phenomena in space or time.
- The most important feature of Geostatistics is the correlation nature of the variables of study
- Geostatistics use the **Kriging** method in order to estimate the variable of interest in other points. It allows obtaining:
  - The estimation
  - A measurement of uncertainty
- The optimization criterium is minimizing the Kriging variance

Outline

Resolution to the problem

Remember that, within each of the models, two data set are taken:

- Measurements based on the *closest reference receiver*
- Measurements based on the *network solution*

For each model:

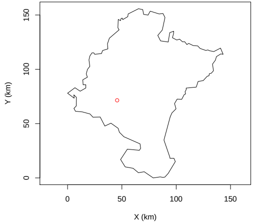
- Differences in X axis
- Differences in Y axis
- Differences in Z axis
- Horizontal differences: X and Y combined

Steps:

- Look for systematic part
- Estimate it by OLS
- Fit the empirical variogram to the residuals
- Reestimate the linear model
- Use cross validation graphics in order to validate the model
- Check the normality (**Shapiro** test) of the residuals
- Find the model with lowest **AIC** and **BIC**

Field measurement: "San Bartolomé"

Axis	Measured value	True field data	Measured error (mm)
$X\ UTM$	587302.536	587302.532	−3.667
$Y\ UTM$	4712873.110	4712873.104	−6.333
Ellipsoid height	569.575	569.544	−31.333

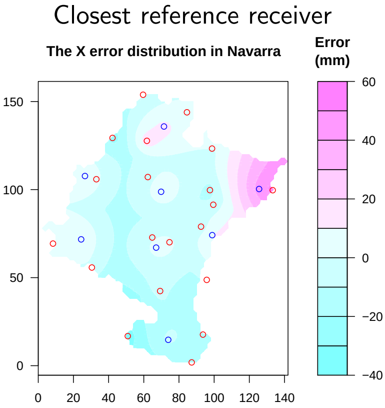


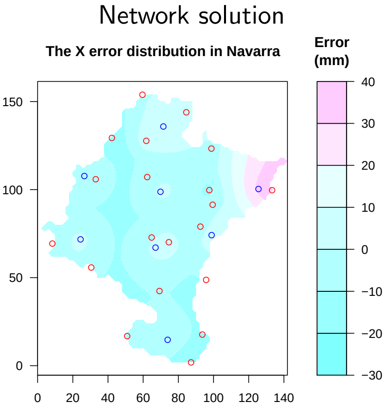
Axis	Predicted error (mm)	Predicted standard deviation (mm)	95% Confidence interval (mm)
X	−11.215	7.574	(−26.060, 3.630)
Y	−6.832	6.361	(−19.300, 5.636)
Z	−14.450	17.787	(−49.313, 20.413)

Outline

Results and Conclusions (Prediction Error)

Statistical models: Differences in X axis



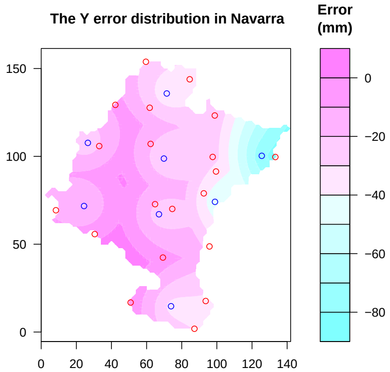


- Precision tends to decrease with the distance to a reference receiver, as it was expected
- A tendency is observed in the northeastern part of Navarra: measurement errors tend to increase with respect to the true field

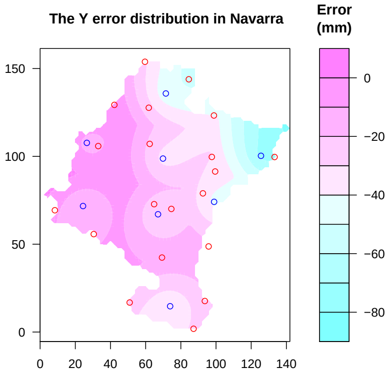
Results and Conclusions (Prediction Error)

Statistical models: Differences in Y axis

Closest reference receiver



Network solution

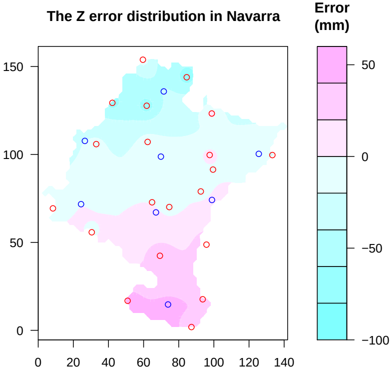


- Precision tends to decrease with the distance to a reference receiver, as it was expected
- Moreover, measurement errors tend to be negative. This feature of the system must be studied deeply. In case it was confirmed, the system should be calibrated
- Finally, another general characteristic is observed: precision tends to decrease as one moves from west to east

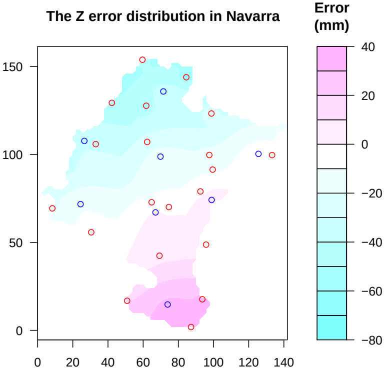
Results and Conclusions (Prediction Error)

Statistical models: Differences in Z axis

Closest reference receiver



Network solution

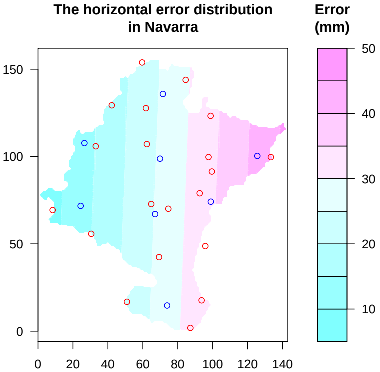


- Distance to the closest reference receiver does not influence in the error measurement
- Uncertainty tends to be higher than in the previous models
- Errors show a high dependency with the Y axis, being measurements by defect in the south, and by excess in the north.

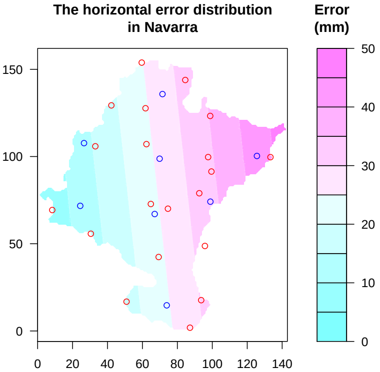
Results and Conclusions (Prediction Error)

Statistical models: Differences in horizontal plane

Closest reference receiver



Network solution

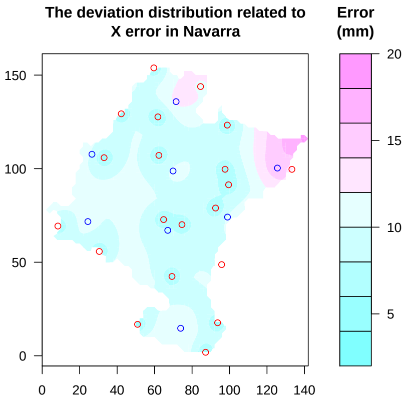


- The inclusion of the distance to the closest reference receiver could not be carried out
- A general tendency is observed in the whole region: errors increase as one moves from west to east.

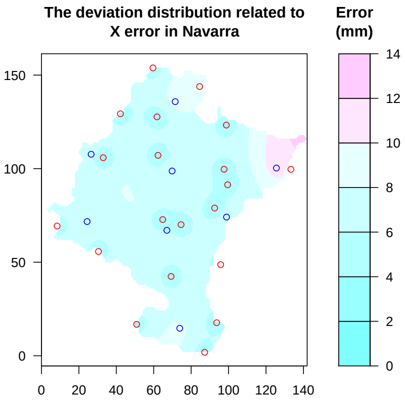
Results and Conclusions (Standard Errors)

"Closest reference receiver" against "network solution": X

Closest reference receiver



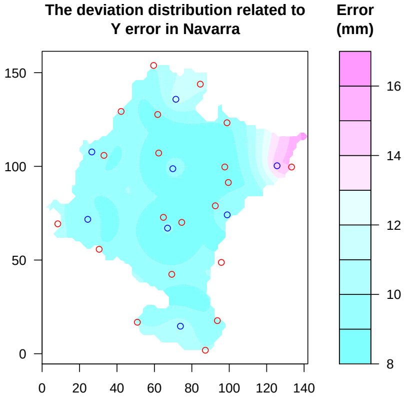
Network solution



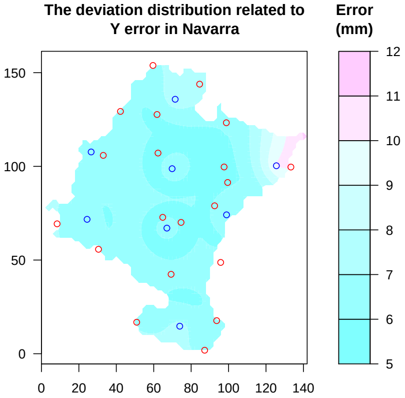
Results and Conclusions (Standard Errors)

"Closest reference receiver" against "network solution": Y

Closest reference receiver



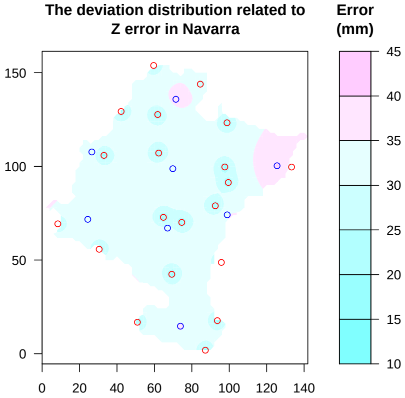
Network solution



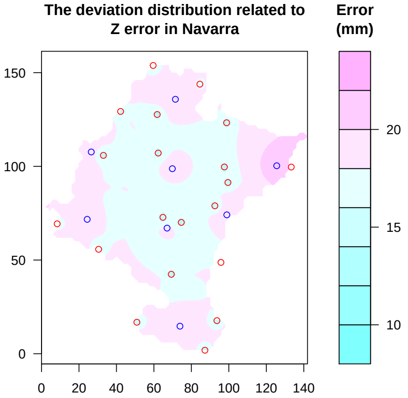
Results and Conclusions (Standard Errors)

"Closest reference receiver" against "network solution": Z

Closest reference receiver



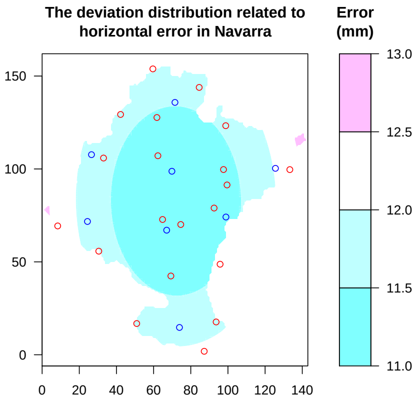
Network solution



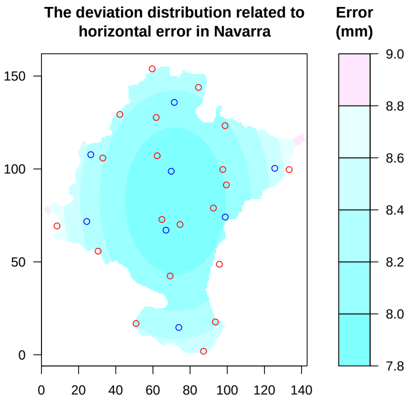
Results and Conclusions (Standard Errors)

“Closest reference receiver” against “network solution”: horizontal

Closest reference receiver



Network solution



Results and Conclusions (cont)

- Statistical models
  - Differences in X axis
  - Differences in Y axis
  - Differences in Z axis
  - Differences in horizontal plane
- "Closest reference receiver" against "network solution"
- The PDOP was not significant in any statistical model
- Further work is recommended to obtain more field measurements on vertex points not included previously in order to validate the statistical models
- Further work is recommended to have more data in order to obtain a better adjustment of the statistical model
- Further work is recommended to follow a specific and studied procedure when collecting data

Outline

Acknowledgements

- The Department of Civil Engineering, Transport and Communication of the Navarra Government, and in particular to Miguel Ángel Jiménez de Cisneros Fonfría and Jorge Luis Iribas Cardona

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