

## 1. Datum CR05

In 2005 a 34 points network was measured using GPS technology which results were the base of the Costa Rica's datum named CR05. Adjusted coordinates were reduced to 2005,83 epoch and linked to ITRF2000. This network and its densification were adopted as national geodetic reference by Executive Decree in 2007 (figure 1). Due its definition and compute process, this network has been considered as a passive frame. CR05 was officially in force for a decade.

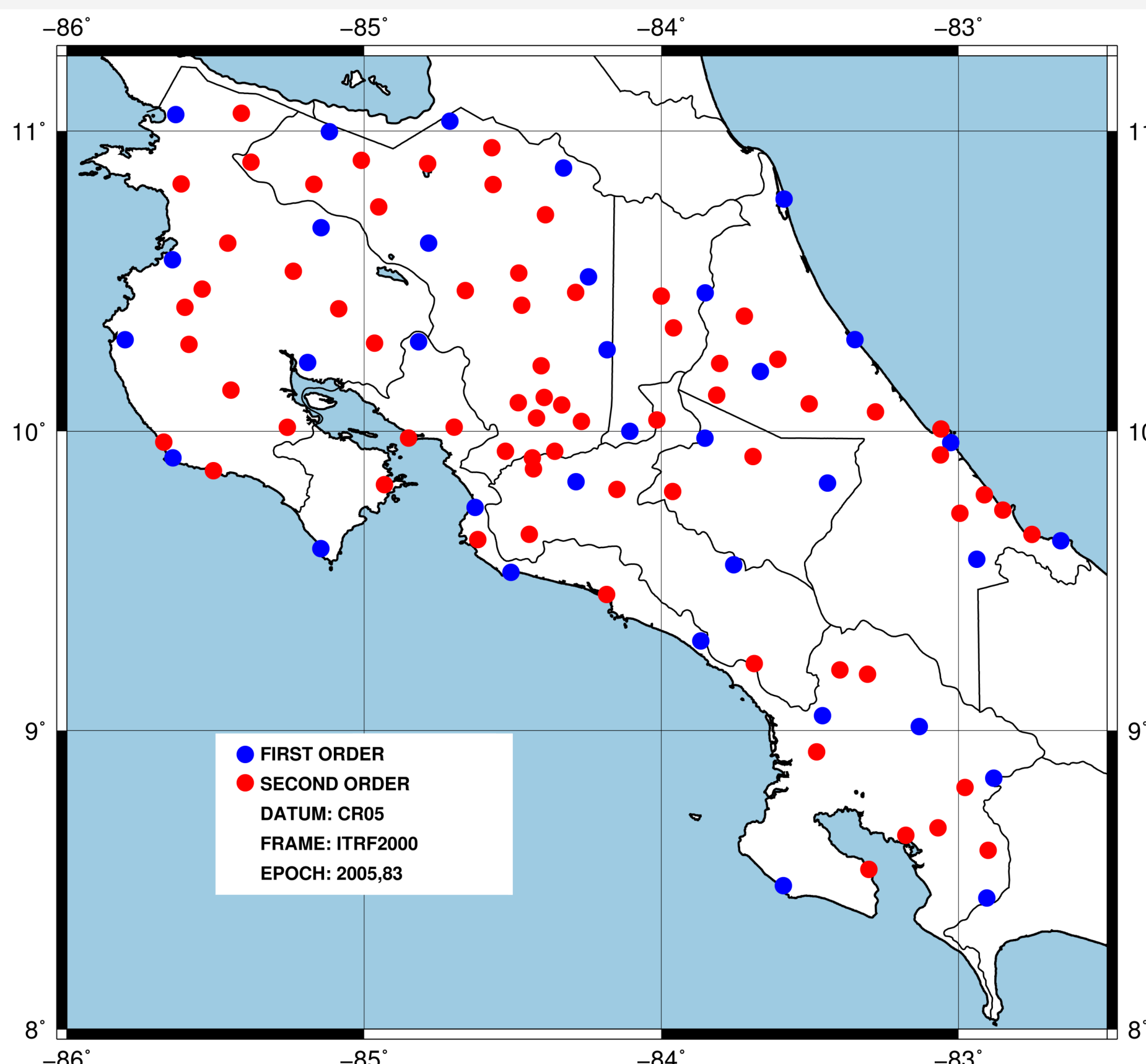


Figure 1. Location of first and second order points of the CR05 datum

## 2. Datum CR-SIRGAS

On April 2018, the Instituto Geográfico Nacional of Costa Rica (IGNCR), through an Executive Decree updated the new geodetic reference of the country (Costa Rica, 2018). This new frame named CR-SIRGAS is composed of 8 GNSS continuous operation stations and passive points (figure 2). The coordinates of CR-SIRGAS stations were linked to ITRF2008, reference epoch 2014,59. CR-SIRGAS is a dynamic frame due to the weekly processing of the SIRGAS stations. However, we are currently working on ITRF2014.

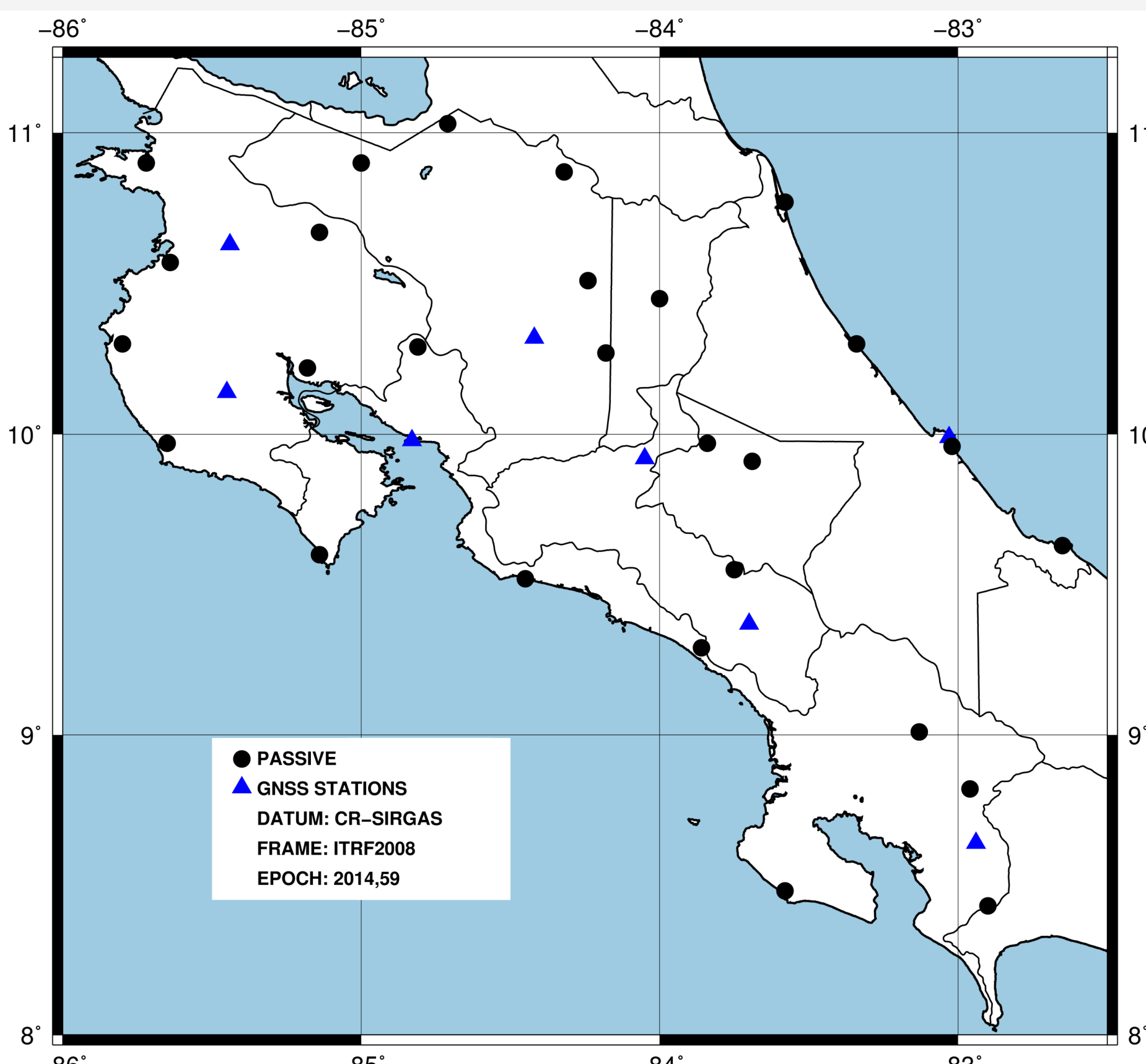


Figure 2. Location of active and passive points of datum CR-SIRGAS

## 3. Geodetic Frames Relations

The general relationship between two reference systems A and B is given by 7 parameters: three translations, three rotations and a scale factor ( $\Delta X, \Delta Y, \Delta Z, RX, RY, RZ, m$ ) and their corresponding temporal variations (Altamimi et al, 2002, 2007, 2012, 2017). Basically there are two versions of the transformation: considering the geocenter (Bursa, 1962) and calculating the barycenter (Badekas, 1969)

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix}_B = \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}_A + \begin{bmatrix} \Delta X \\ \Delta Y \\ \Delta Z \end{bmatrix} + (1+m) \begin{bmatrix} 0 & -RZ & RY \\ RZ & 0 & -RX \\ -RY & RX & 0 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}_A$$

$$X_B = X_A + \Delta X + RX_A$$

In week 1934 the ITRF2014 solution was published. The final weekly coordinates of the SIRGAS-CON network stations are linked to this frame. However, since Costa Rica established the CR05 datum in 2007 there have been different ITRF solutions which must be incorporated into the transformation process. In addition, physical events that had a strong impact on the frame, should also be taken into account.

## 4. From CR05 to CR-SIRGAS

Figure 3 shows that since the implementation of CR05 in 2005 until the new national reference CR-SIRGAS in 2018, at least two ITRF solutions have been available.

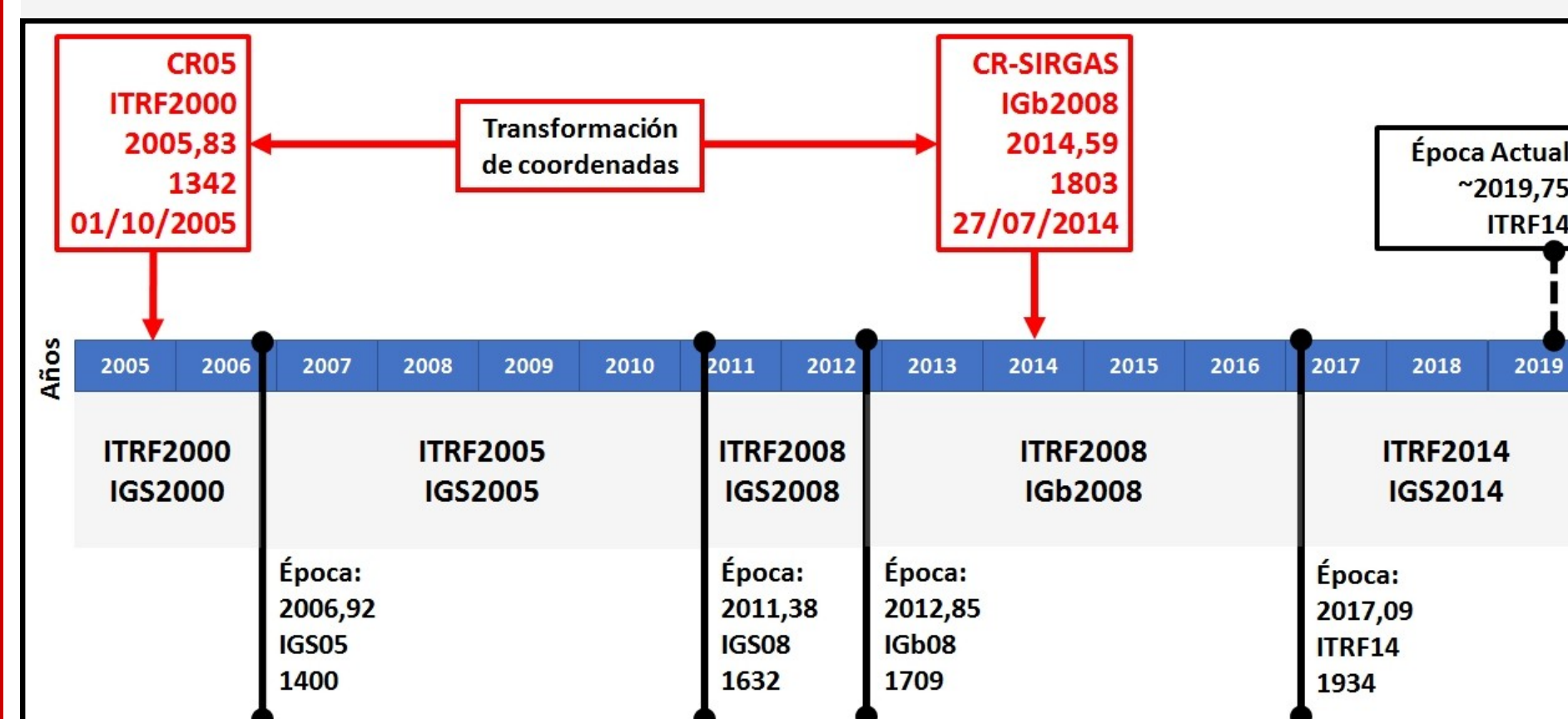


Figure 3. Different ITRF solutions between CR05 and CR-SIRGAS

## 5. Selected points

A total of 34 (figure 4) identical points were found for the transformation process. Working with a tolerance of 10 cm, at the end of the process, a total of 22 points were taken for the estimation of the transformation parameters (figure 5).

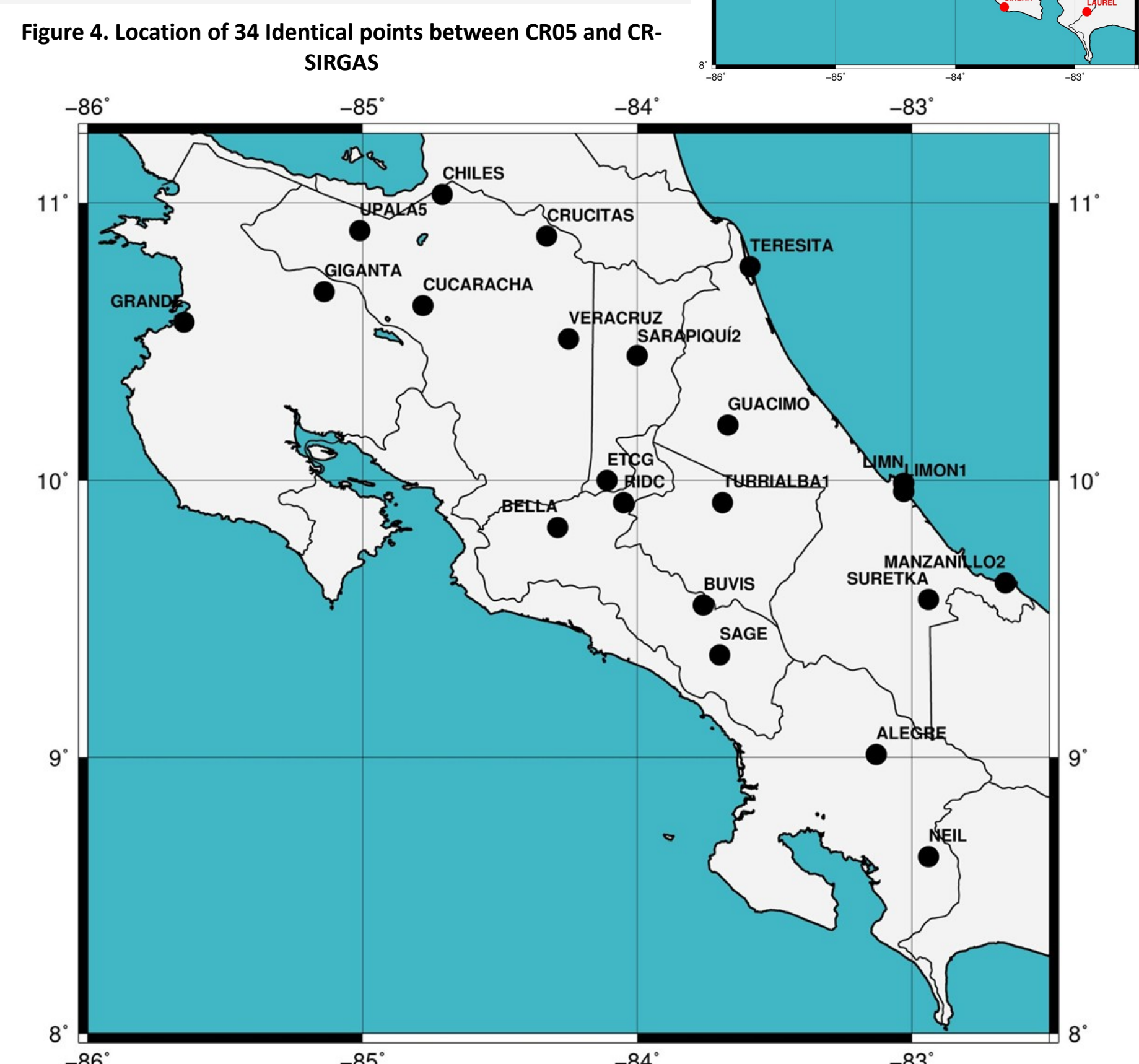


Figure 4. Location of 34 identical points between CR05 and CR-SIRGAS  
Figure 5. Location of the 22 identical points used to calculate the transformation parameters

## 6. Transformation Parameters

According to Drewes (2012), 6 transformation parameters were calculated between the CR05 datum (ITRF2000, reference epoch 2005,83) and the new CR-SIRGAS datum (ITRF2008, reference epoch 2014,59). The results are presented below. In addition, figure 6 shows the behavior of the final residuals in the components north, east, up and horizontal.

**RESUMEN**

Época inicial	: 2005,83
Época final	: 2014,59
Tiempo	: 8,76 años
Puntos Idénticos	: 22
Total de observaciones	: 66
Error de la transformación	: 0,0459 m
Tolerancia N, E	: ± 100 mm
Tolerancia U	: ± 200 mm
Menor residuo N	: -76,6 mm
Mayor residuo N	: +84,4 mm
Menor residuo E	: -96,4 mm
Mayor residuo E	: +50,7 mm
Menor residuo U	: -63,9 mm
Mayor residuo U	: +60,8 mm

**BARICENTRO**

X0	: 664237,**** m
Y0	: -6244356,**** m
Z0	: 1110353,**** m

**TRASLACIONES**

Traslación en eje X	: +0,1*** m ± 0,009* m
Traslación en eje Y	: +0,1*** m ± 0,009* m
Traslación en eje Z	: +0,1*** m ± 0,009* m

**ROTACIONES**

Rotación en eje X	: -0,0***** " ± 0,04***** "
Rotación en eje Y	: -0,1***** " ± 0,01***** "
Rotación en eje Z	: +0,0***** " ± 0,03***** "

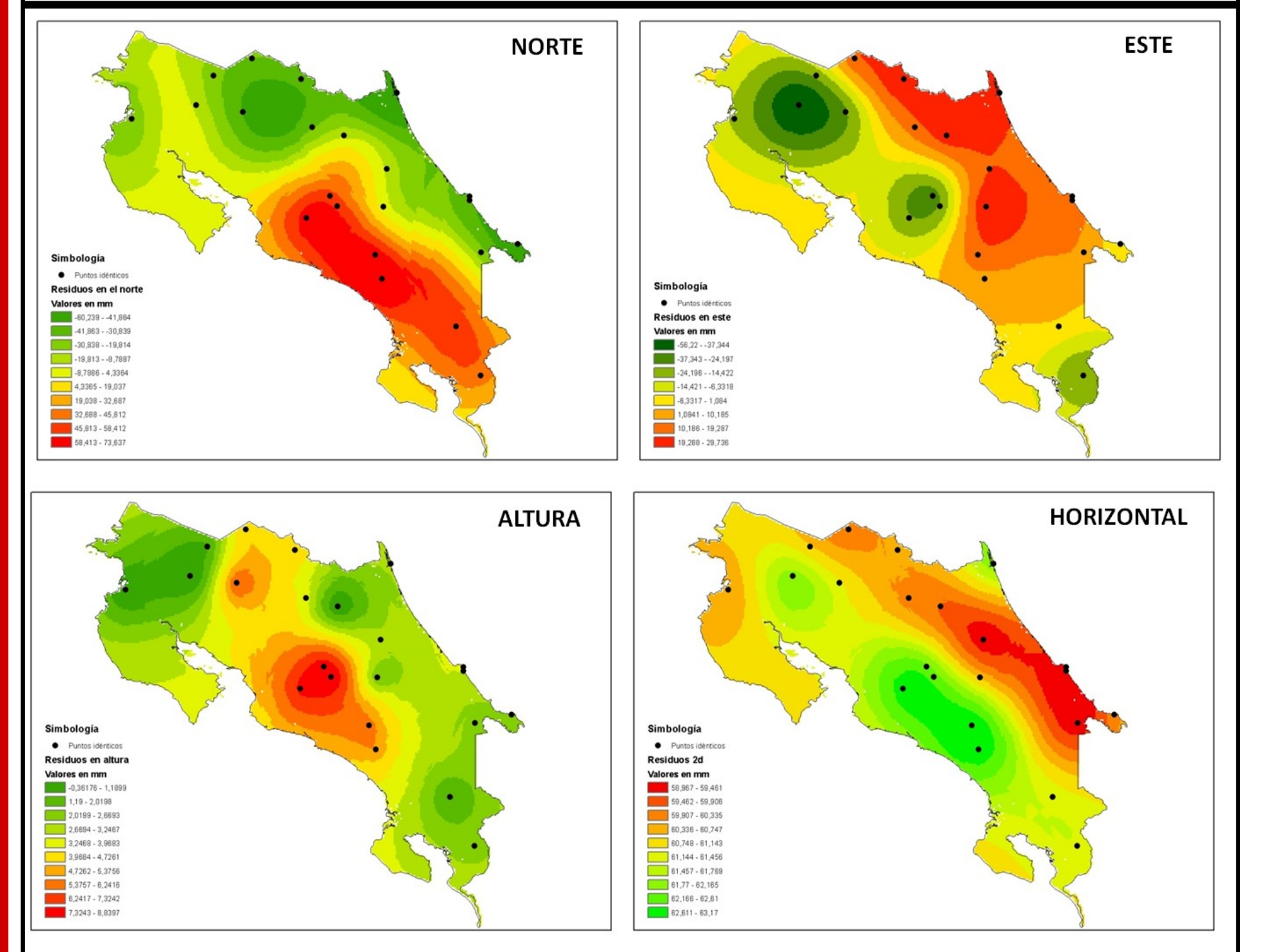


Figure 6. Residual in north, east, up and horizontal components

## 7. Ladder Transformation

Considering now the different ITRF solutions as well as an earthquake in 2012 that greatly affected the national geodetic structure, a transformation process called a ladder was carried out (Céspedes, 2017).

As a result 7 sets of transformation parameters from CR05 to CR-SIRGAS were mainly calculated.

In the upper part of figure 7 the fundamental diagram of the periods considered for the transformation is presented and in the lower part the results of the parameters are shown.

The investigation at the moment has not determined the set of transformation parameters between the start of the CR-SIRGAS datum in week 1803 and week 1934 beginning of ITRF14 (red circle).

At the moment the IGNCR has not issued the respective technical resolution authorizing the new reference epoch of CR-SIRGAS into the ITRF14.

Assuming that the new CR-SIRGAS reference time is in the week 1934, work is currently being done to estimate the temporary variations of the transformation parameters (VTX, VTY, VTX, VRY, VRZ) from 1803 to 1934.

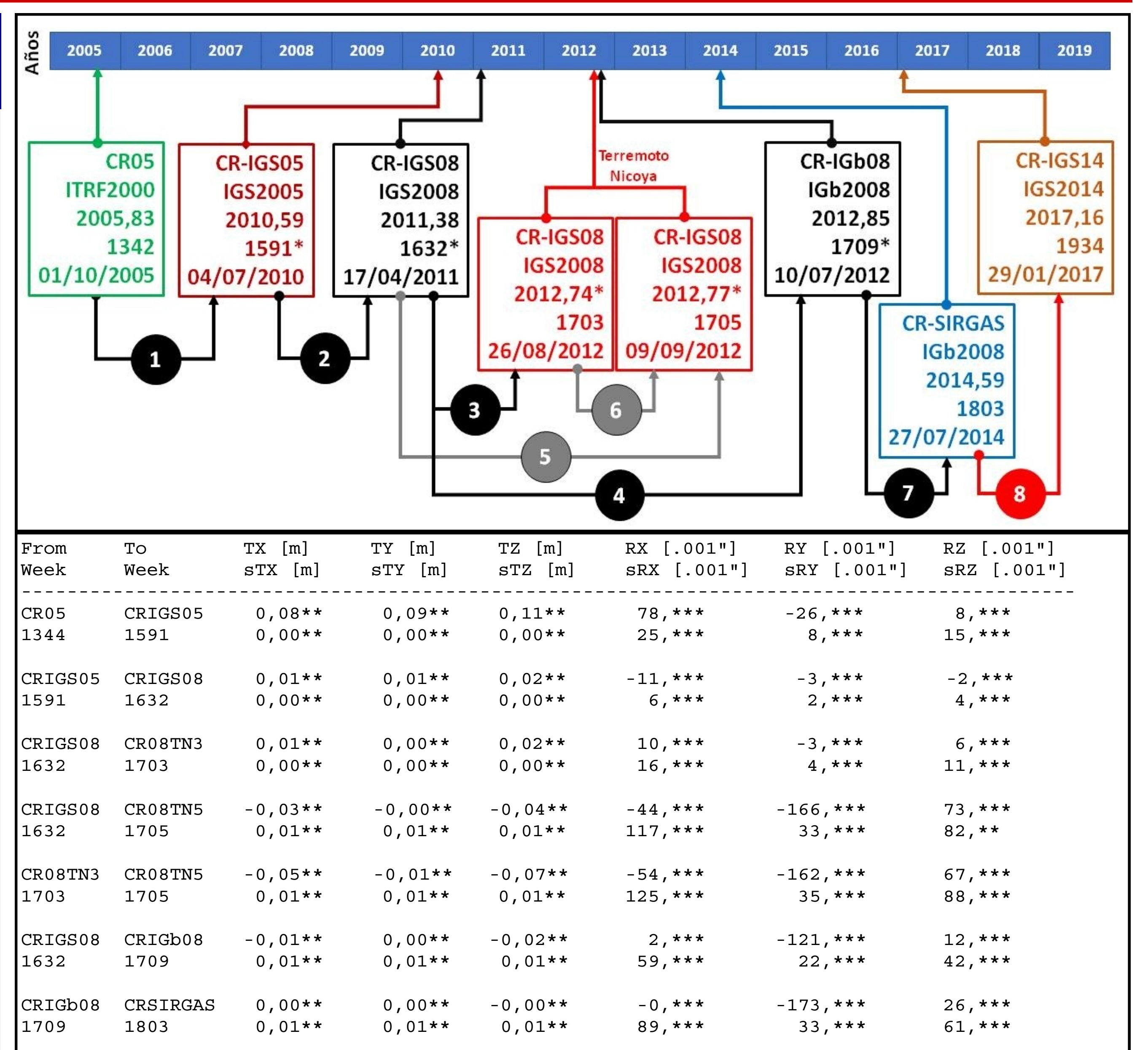


Figure 7. Ladder transformation diagram between CR05 and CR-SIRGAS and their values

Referencias:  
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