Dirección del Instituto Geográfico Nacional

Transformación de Coordenadas de CR05 A CR-SIRGAS mediante herramientas SIG

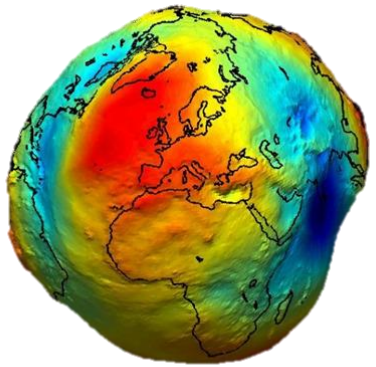
Agenda

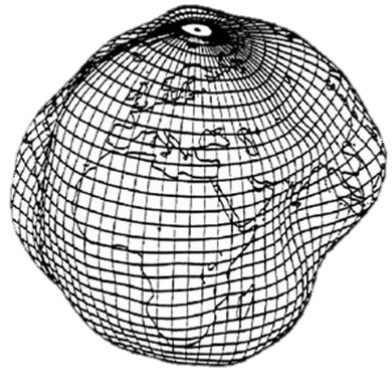
- Resumen Conceptual
- ArcMap y ArcGIS Pro
- QGIS
- Recomendaciones

Resumen

Esfera

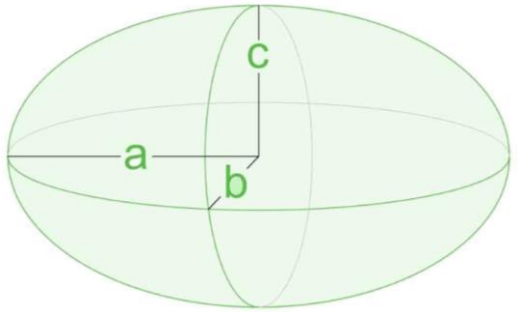
Geoide



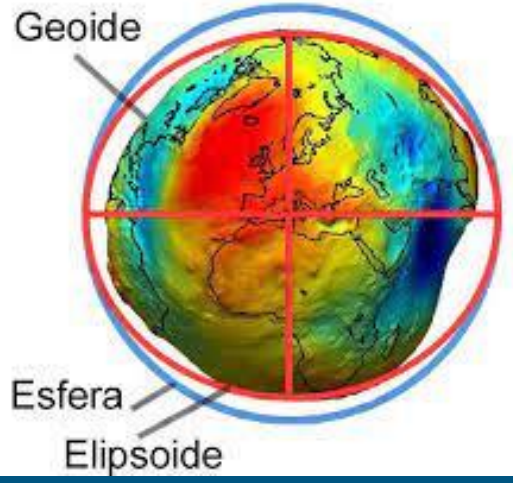


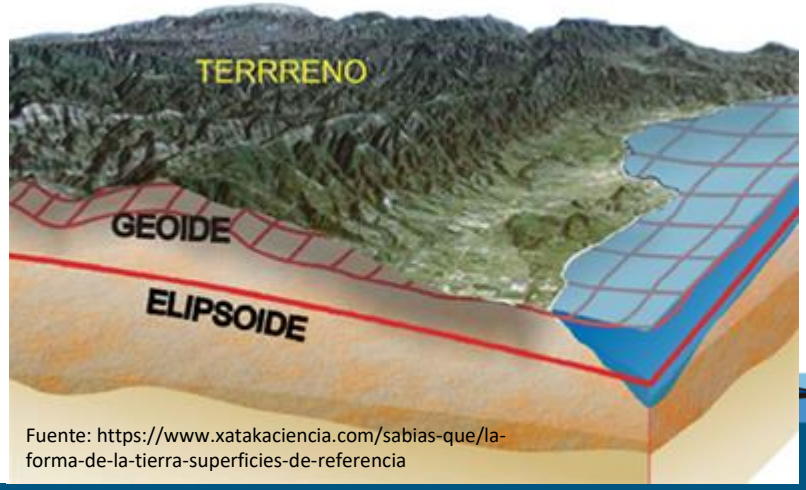
Fuente https://www.freepng.es/png-s17wqk/

Elipsoide



Fuente https://es.foxcalculators.com/geometry/5937.html



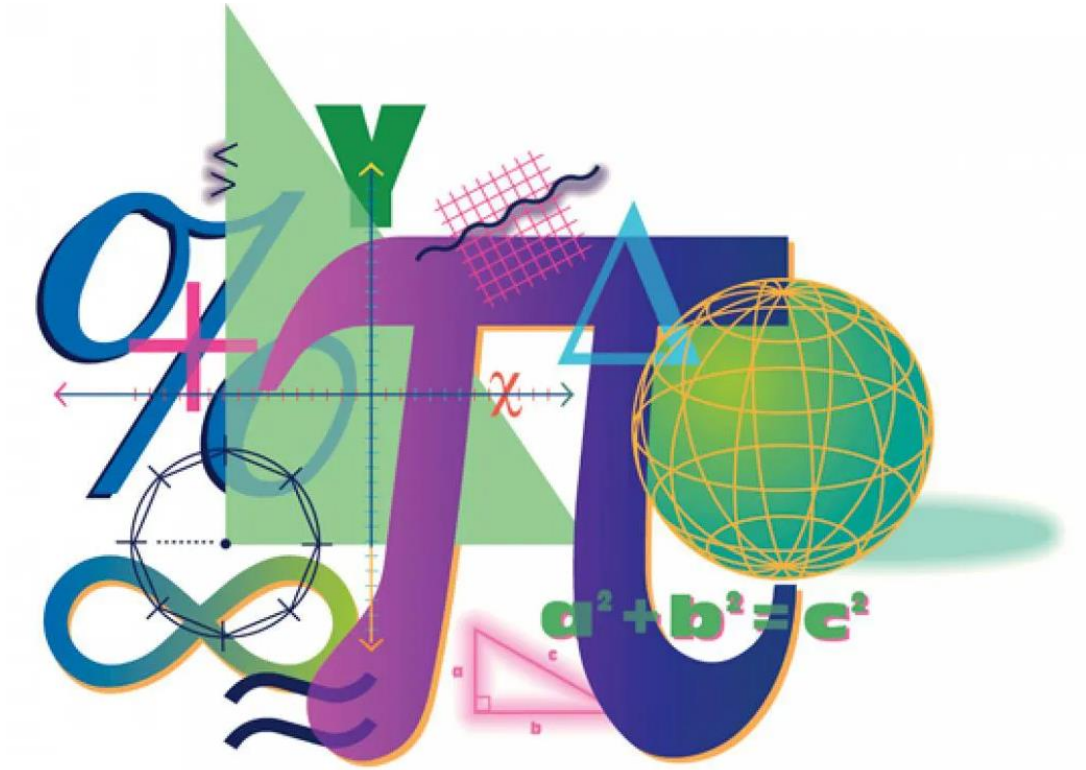


Fuente: https://www.xatakaciencia.com/sabias-que/la-forma-de-la-tierra-superficies-de-referencia

Fuente: https://es-es.facebook.com/TERRASAT.SIG/photos/qu%C3%A9-es-un-geoidese-denomina-geoide-al-cuerpo-definido-por-la-superficie-equipote/2893023120774989/

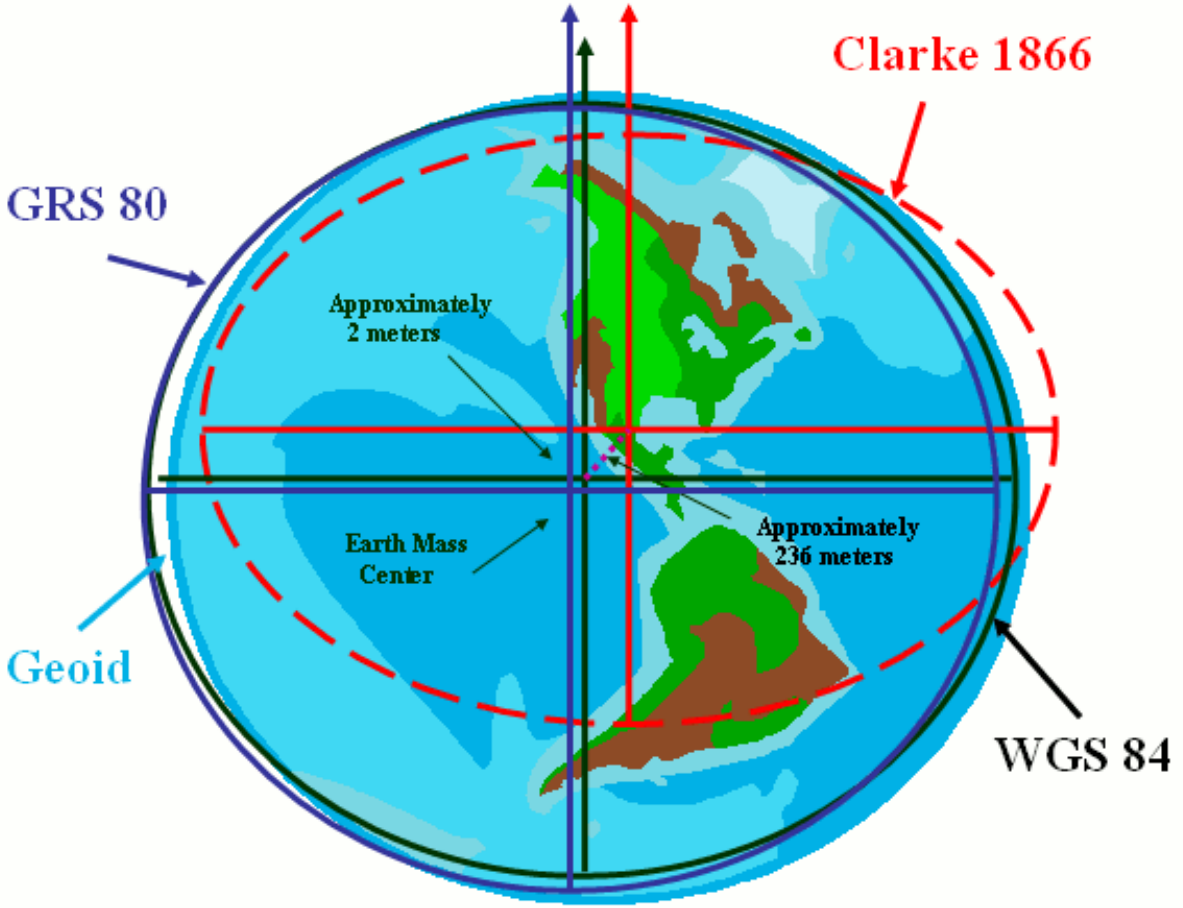
Resumen

Sistema de Referencia



Marco de Referencia

Resumen



Fuente: https://vdatum.noaa.gov/docs/datums.html#geodetic

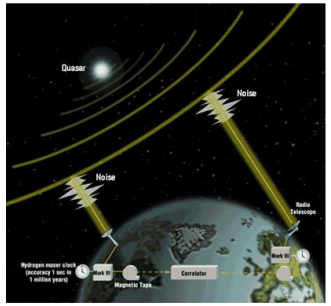
Nombre	Semi-mayor a (m)	Semi-menor b (m)	Aplanamiento inverso 1/f
Clarke 1866	6 378 206.4	6 356 583.8	294.978 698 2
Sistema de Referencia Global 1980 - GRS 80	6 378 137	6 356 752.3141	298.257 222 101
Sistema Geodésico Mundial 1984 - WGS 84	6 378 137	6 356 752.3142	298.257 223 563

ITRF

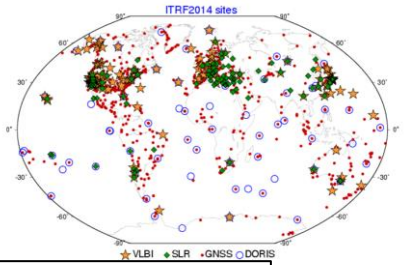
Resumen

International Terrestrial Reference Frame

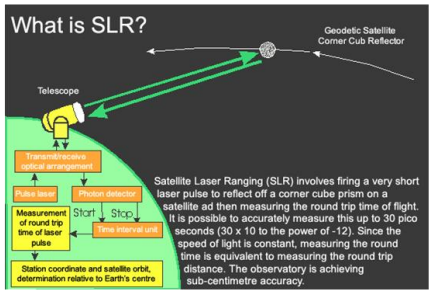
★ **VLBI:** very long baseline interferometry



https://www.rediris.es/difusion/publicaciones/casos_uso/mm/cuso_VLBI_eng.pdf

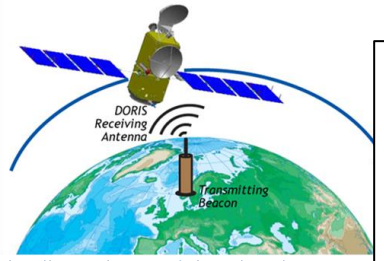


◆ **SLR:** Satellite Laser Ranging



https://www.ga.gov.au/__data/assets/image/0014/11372/GA13408.gif

○ **DORIS:** Doppler Orbitography and Radiopositioning Integrated by Satellite



https://space-geodesy.nasa.gov/techniques/images/DORIS.jpg

● **GNSS:** Global Navigation Satellite System

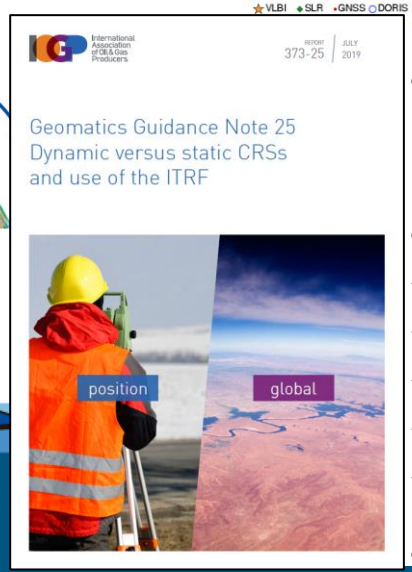
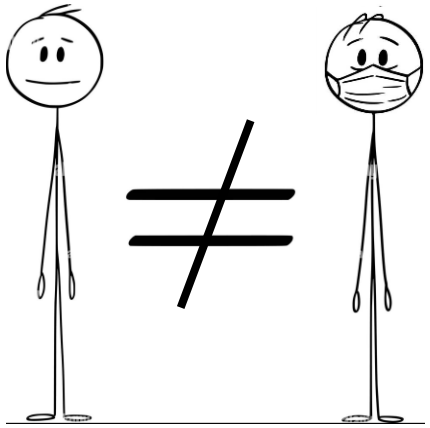


Table 3: Successive realizations of WGS 84

WGS84 realization	Used for GPS Broadcast ephemeris		Used for GPS Precise ephemeris		Approximately coincident with
	from	to	from	to	
WGS 84 (Transit)	1987-01-01	1994-06-28	1987-01-01	1994-01-01	(not related to ITRF)
WGS 84 (G730)	1994-06-29	1997-01-28	1994-01-02	1996-09-28	ITRF92@1994.00
WGS 84 (G873)	1997-01-29	2002-01-19	1996-09-29	2002-01-19	ITRF94@1997.00
WGS 84 (G1150)	2002-01-20	2012-02-07	2002-01-20	2012-05-06	ITRF2000@2001.00
WGS 84 (G1674)	2012-02-08	2013-10-15	2012-05-07	2013-10-15	ITRF2008@2005.00
WGS 84 (G1762)	2013-10-16	present[4]	2013-10-16	present[4]	ITRF2008@2005.00 = ITRF2008@2005.00

Resumen

Decreto 33797
2005.83
ITRF2000



Ejemplo del movimiento por tectónica de placas

Tomado de: https://youtu.be/IKM-bR6SwVs

Resumen

Proyección Lambert

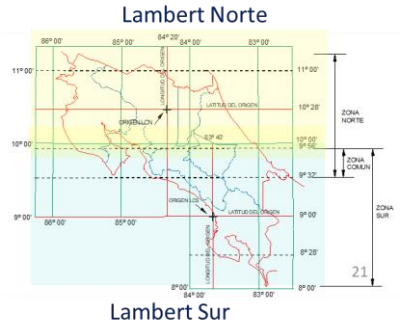
Elipsoide: Clark 1986
Proyección es cónica conforme secante con 2 paralelos.

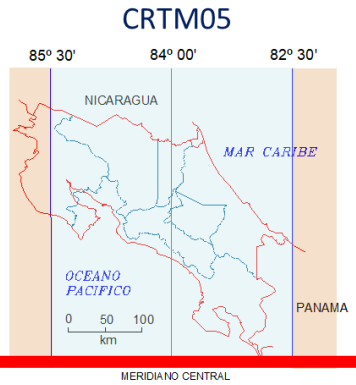
- Lambert Costa Rica Norte.
- Lambert Costa Rica Sur.

Sistema de Referencia

Datum: Ocotepeque.

Decreto 33797-MJ-MOPT





Decreto 40962-MJP

Proyección CRTM05

Elipsoide: WGS 1984
Proyección Transversal de Mercator, parámetros:

- Paralelo de origen: 0°.
- Meridiano de origen: 84°W.
- Falso Este: 500000 m
- Factor de escala: 0.9999

Sistema de Referencia CR05

Sistema Internacional de Referencia Terrestre: **ITRF 2000**.

- Época de Referencia: **2005.83**

Proyección CRTM05

Elipsoide: GRS 1980
Proyección Transversal de Mercator, parámetros:

- Paralelo de origen: 0°.
- Meridiano de origen: 84°W.
- Falso Este: 500000 m
- Factor de escala: 0.9999

Sistema de Referencia CR-SIRGAS

Sistema Internacional de Referencia Terrestre: **ITRF 2008**.

- Época de Referencia: **2014.59**.

Nota: Cambia según época de referencia y se actualiza el ITRF.

Directriz N. DIG-001-2020

Sistema de Referencia CR-SIRGAS

Sistema Internacional de Referencia Terrestre: ITRF 2014.

- Época de Referencia: 2019.24**.**

Resumen

EPSG

European Petroleum Survey Group

SRID

Spatial Reference System Identifier

Proyección Lambert

- Lambert Costa Rica Norte **EPSG 5456**
- Lambert Costa Rica Sur **EPSG 5457**

Decreto 33797-MJ-MOPT

Proyección CRTM05

Sistema de Referencia CR05

EPSG 5367

Decreto 40962-MJP

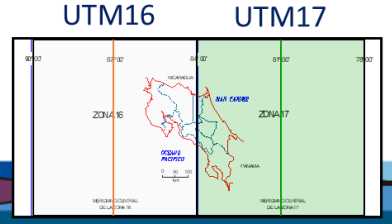
Proyección CRTM05

Sistema de Referencia CR-SIRGAS

EPSG 8908

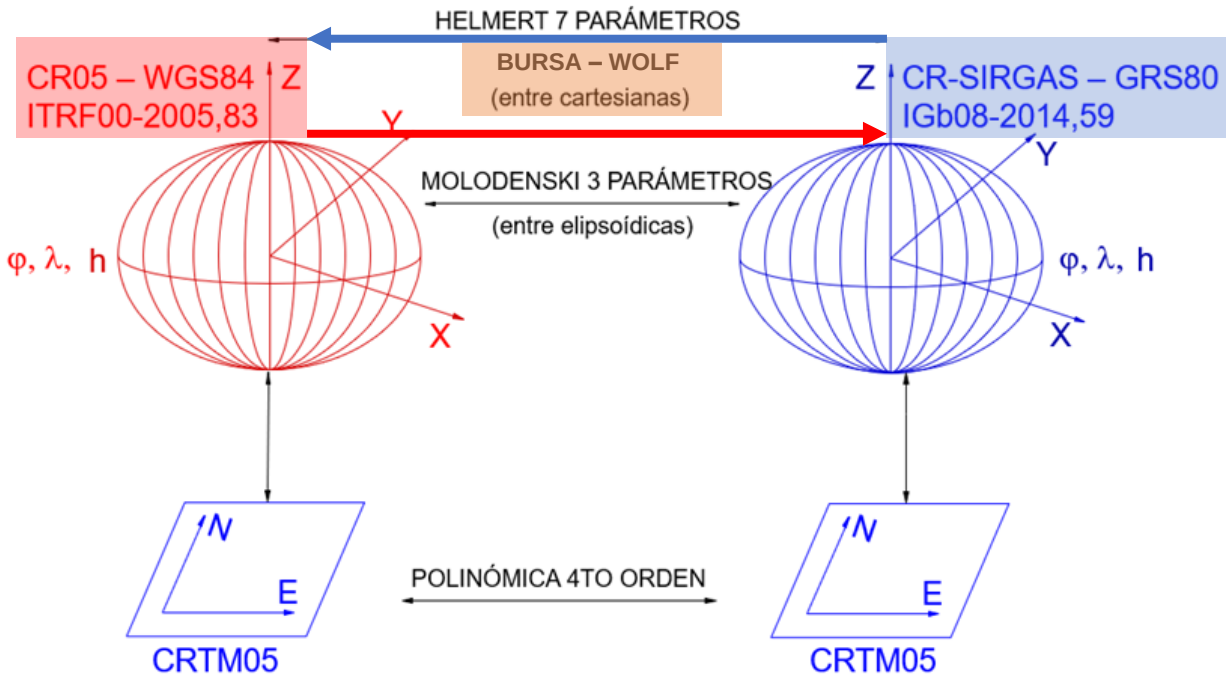
Época de Referencia: **2014.59**.

CR-SIRGAS / UTM zona 16	**8909**
CR-SIRGAS / UTM zona 17	**8910**



Resumen

Coordinate Frame



Parámetros para la transformación Bursa-Wolf

$$\begin{bmatrix} X_2 \\ Y_2 \\ Z_2 \end{bmatrix} = \begin{bmatrix} Tx \\ Ty \\ Tz \end{bmatrix} + (1+k) \begin{bmatrix} 1 & -Rz & Ry \\ Rz & 1 & -Rx \\ -Ry & Rx & 1 \end{bmatrix} \begin{bmatrix} X_1 \\ Y_1 \\ Z_1 \end{bmatrix}$$

Parámetro	De CR05 a CR-Sirgas(2014.59)	De CR-Sirgas(2014.59) a CR05	Exactitud
$T_x[m]$	-0.16959	0.16959	± 2.33
$T_y[m]$	0.35312	-0.35312	± 1.65
$T_z[m]$	0.51846	-0.51846	± 3.56
$R_x["]$	-0.03385	0.03385	± 0.12
$R_y["]$	0.16325	-0.16325	± 0.05
$R_z["]$	-0.03446	0.03446	± 0.08
$k[ppm]$	0.03693	-0.03693	± 0.23

Exactitud de la transformación ± 0.09 m

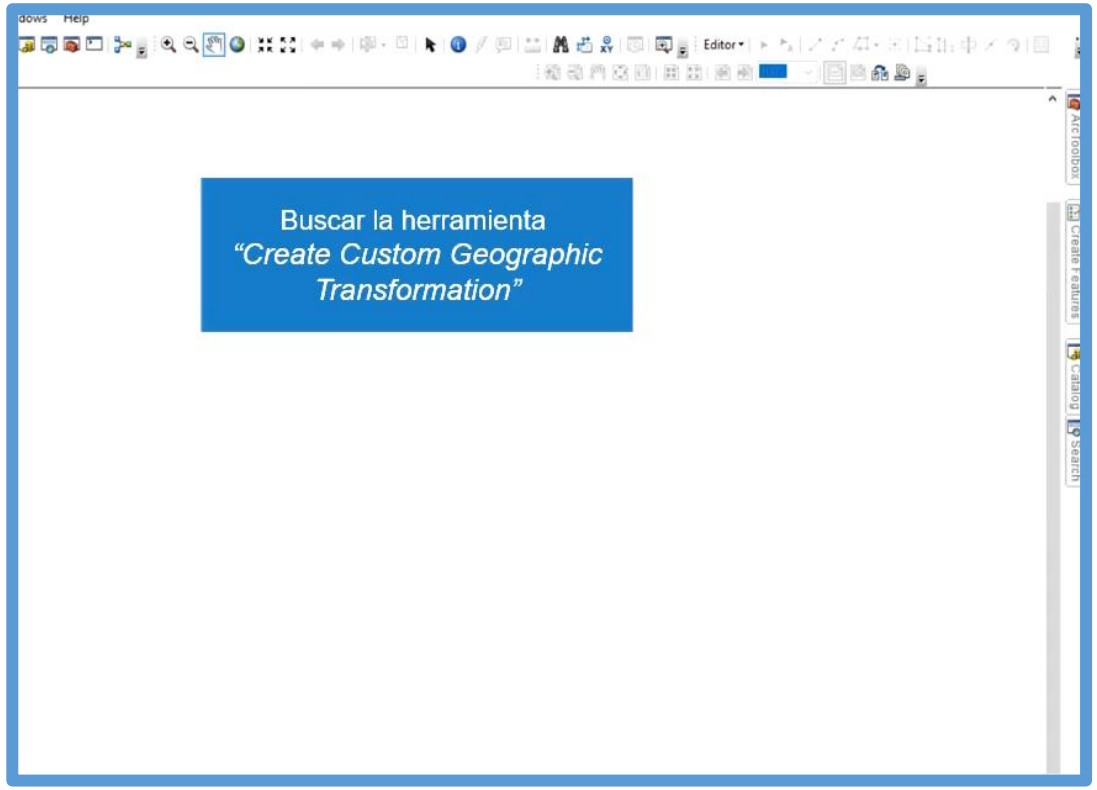
Coordinate Frame **Position Vector**

Transformación de coordenadas CR05/CRTM05 a CR-SIRGAS/CRTM05 utilizando ArcMap 10.7 y ArcGIS Pro

Se cargan los parámetros de transformación **Bursa-Wolf** en la **época de referencia 2014.59** para la transformación entre ambos sistemas y es aplicable a la reproyección de datos vectoriales o ráster.

Transformación de coordenadas CR05/CRTM05 a CR-SIRGAS/CRTM05 utilizando ArcMap 10.7 y ArcGIS Pro

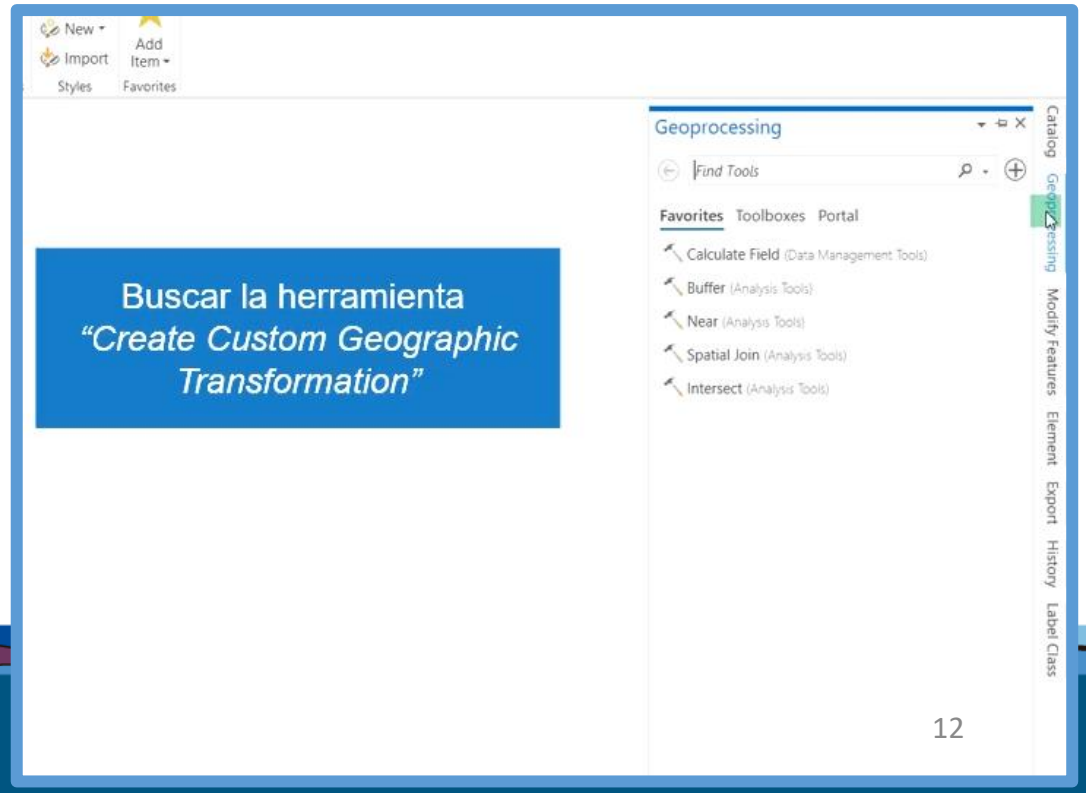
ArcMap 10.7



Herramienta
- *"Create Custom Geographic Transformation"*

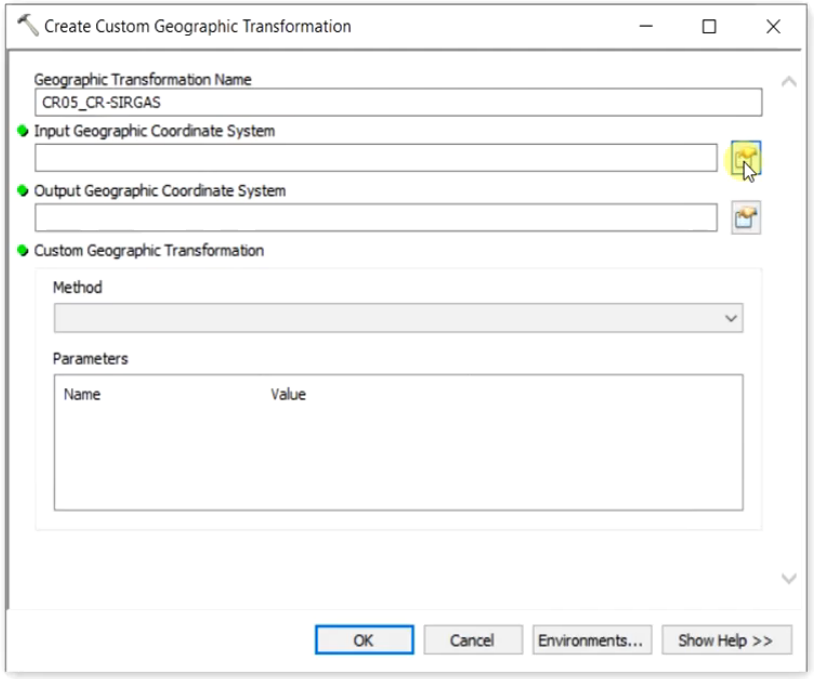
Título de la transformación
- **CR05_CR-SIRGAS**

ArcGIS Pro



Transformación de coordenadas CR05/CRTM05 a CR-SIRGAS/CRTM05 utilizando ArcMap 10.7 y ArcGIS Pro

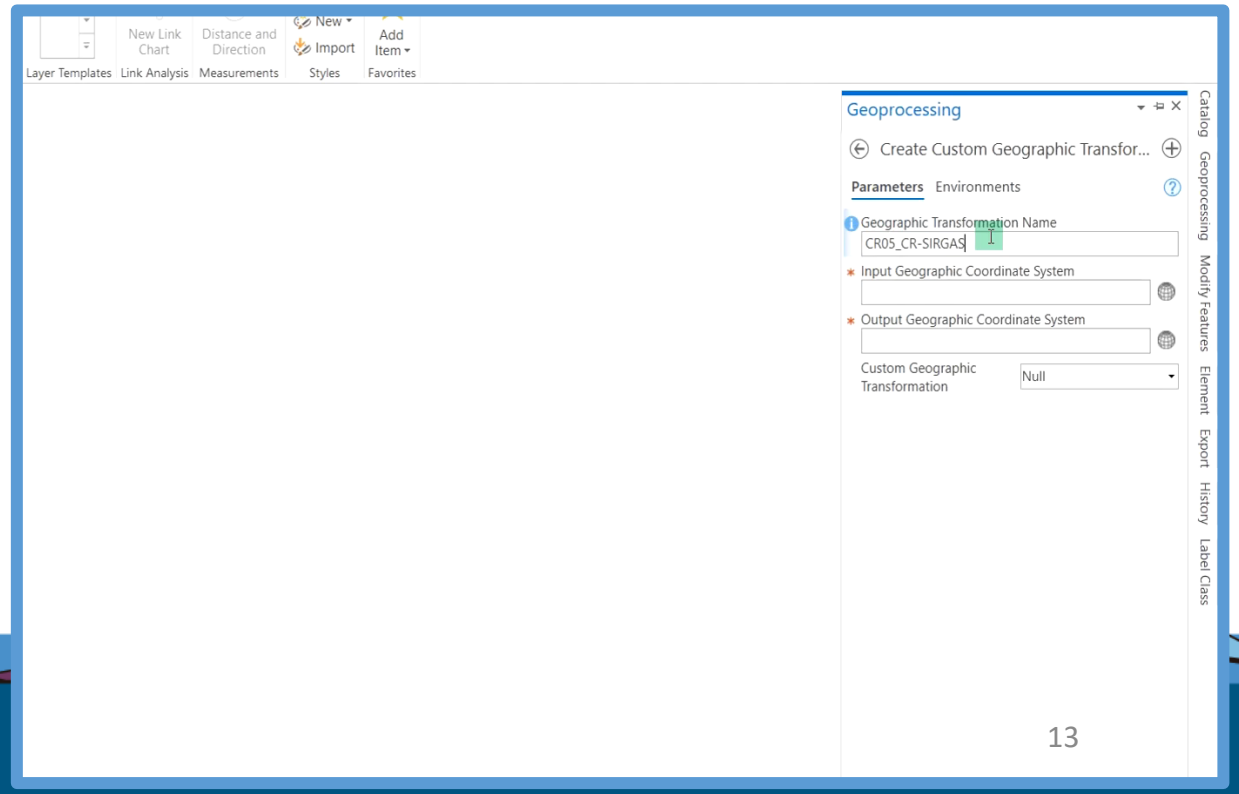
ArcMap 10.7



Sistema de coordenadas de ingreso
Código EPSG
- **5365**

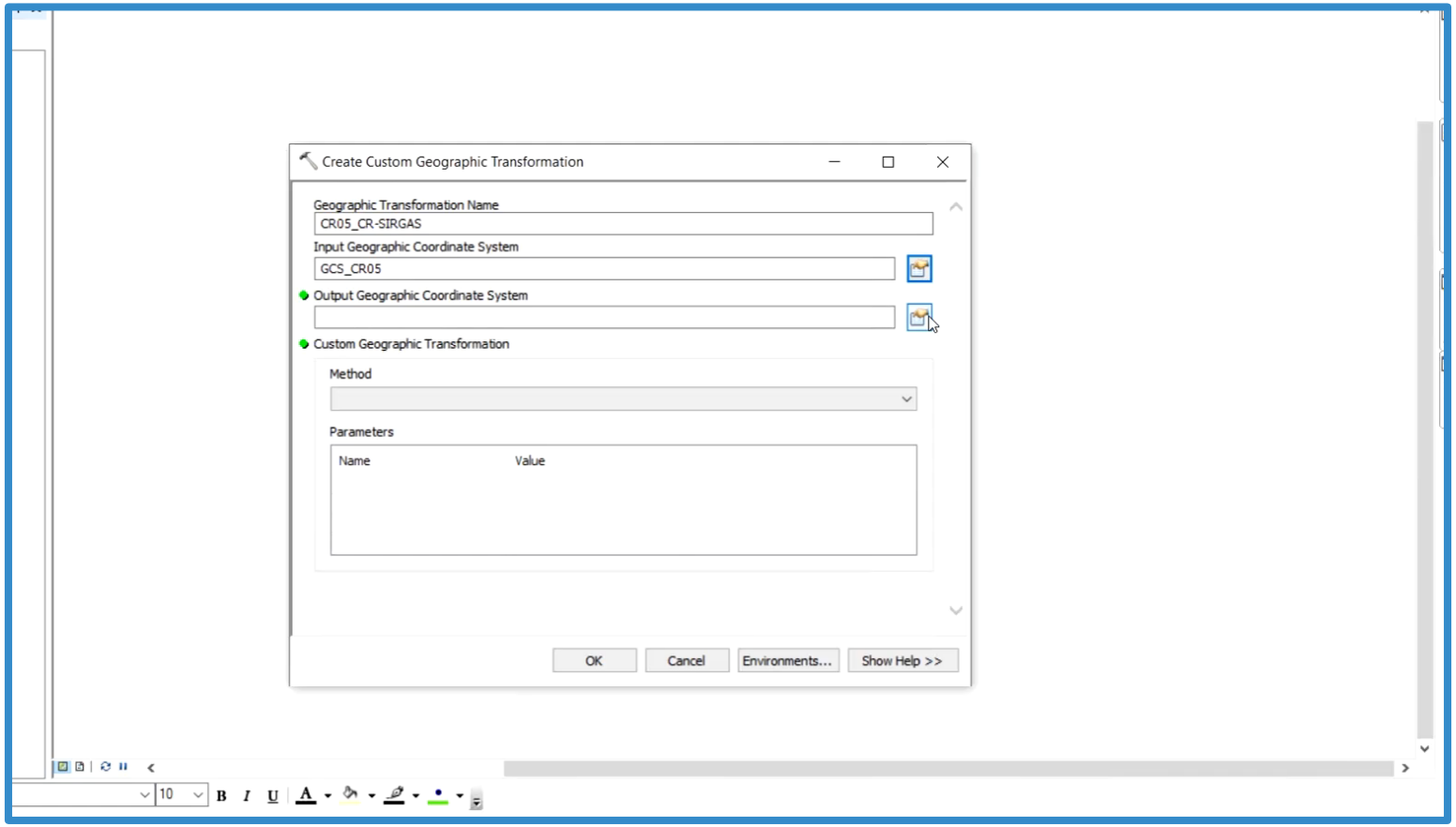
Sistema de Referencia
- **CR05**

ArcGIS Pro



Transformación de coordenadas CR05/CRTM05 a CR-SIRGAS/CRTM05 utilizando ArcMap 10.7 y ArcGIS Pro

ArcMap 10.7



Sistema de coordenadas de salida

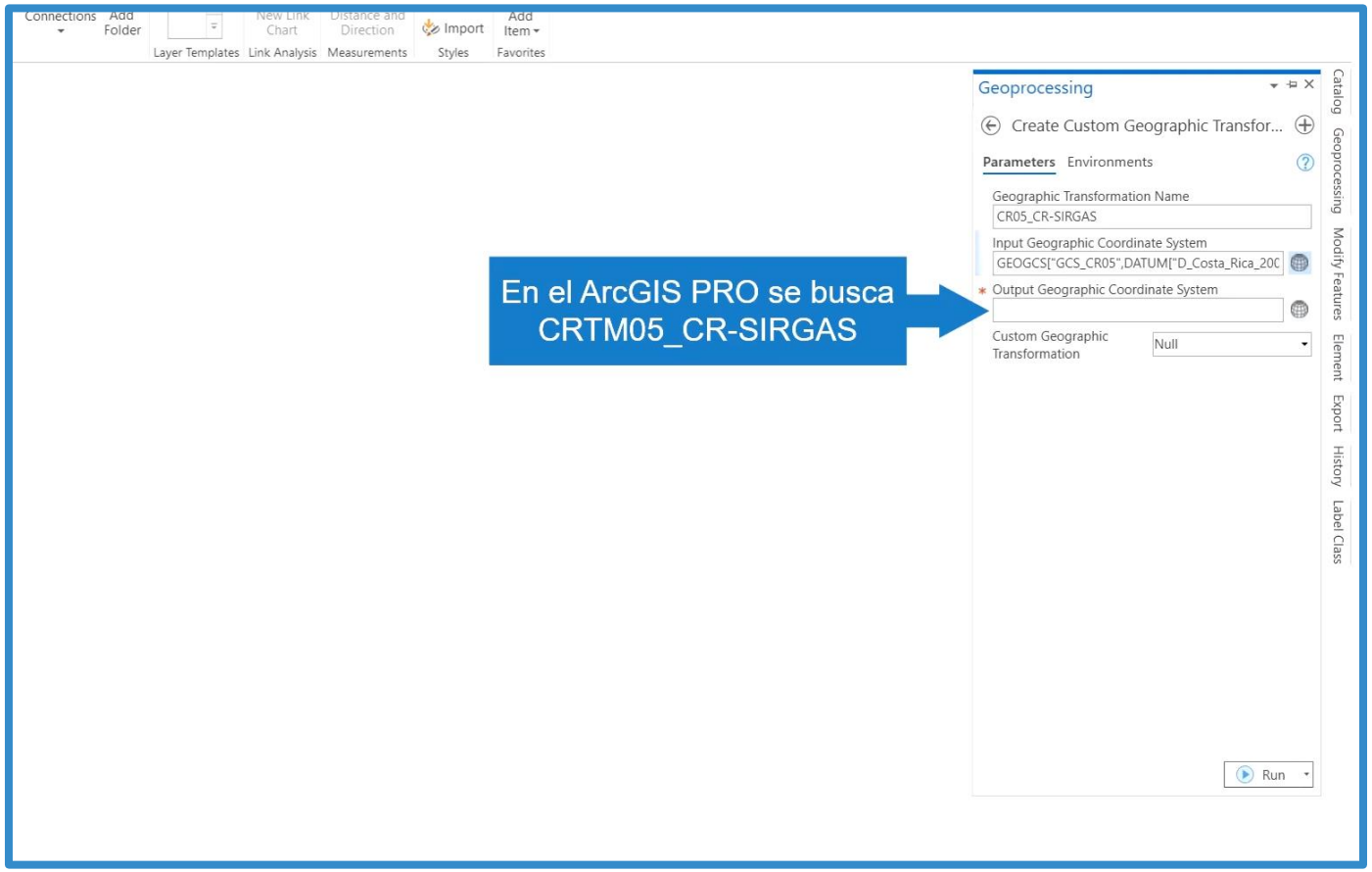
Crear **CRTM05-CRSIRGAS**

- Modificando el *EPSG 5367,* utilizando lo establecido en el *Decreto 40962-MJP*
  - Parámetros de proyección CRTM05
  - Elipsoide GRS80
  - ITRF 2008

Guardar en favorito

Transformación de coordenadas CR05/CRTM05 a CR-SIRGAS/CRTM05 utilizando ArcMap 10.7 y ArcGIS Pro

ArcGIS Pro

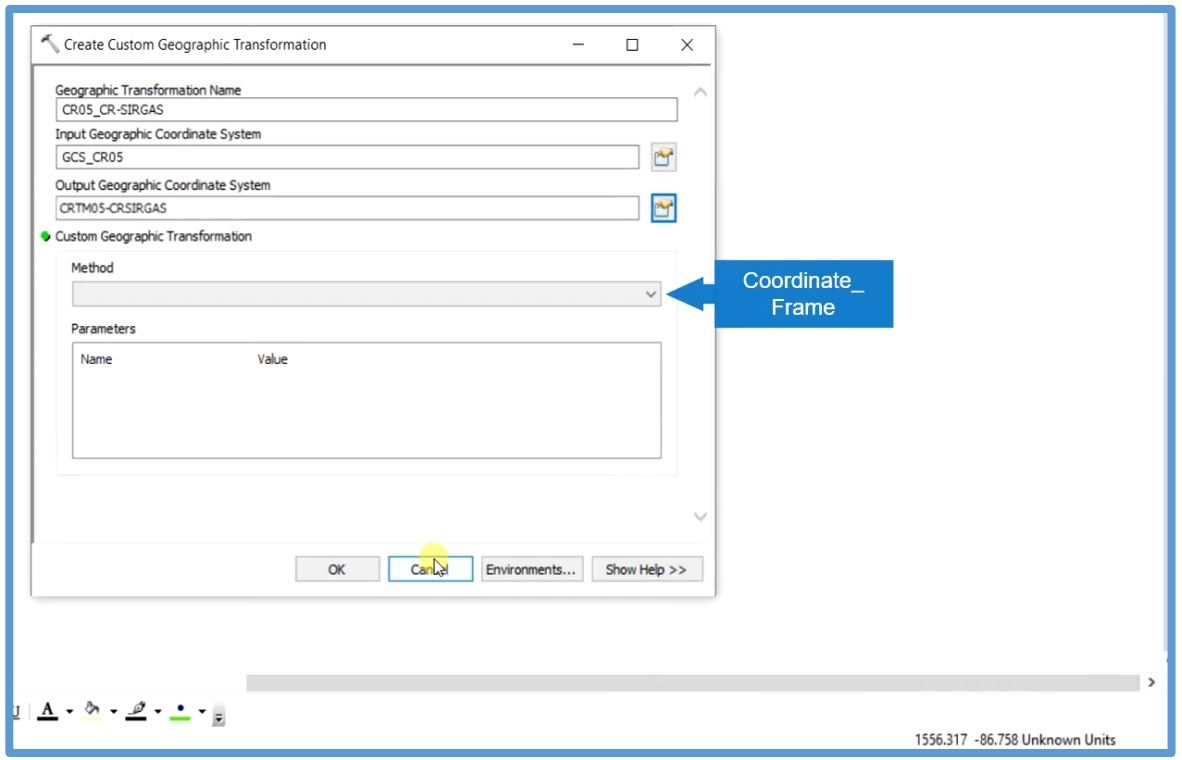


Sistema de coordenadas de salida

- Buscar CRTM05-CRSIRGAS

Transformación de coordenadas CR05/CRTM05 a CR-SIRGAS/CRTM05 utilizando ArcMap 10.7 y ArcGIS Pro

ArcMap 10.7



Parámetros para la transformación Bursa-Wolf

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Parámetro	De CR05 a CR-Sirgas(2014.59)	De CR-Sirgas(2014.59) a CR05	Exactitud
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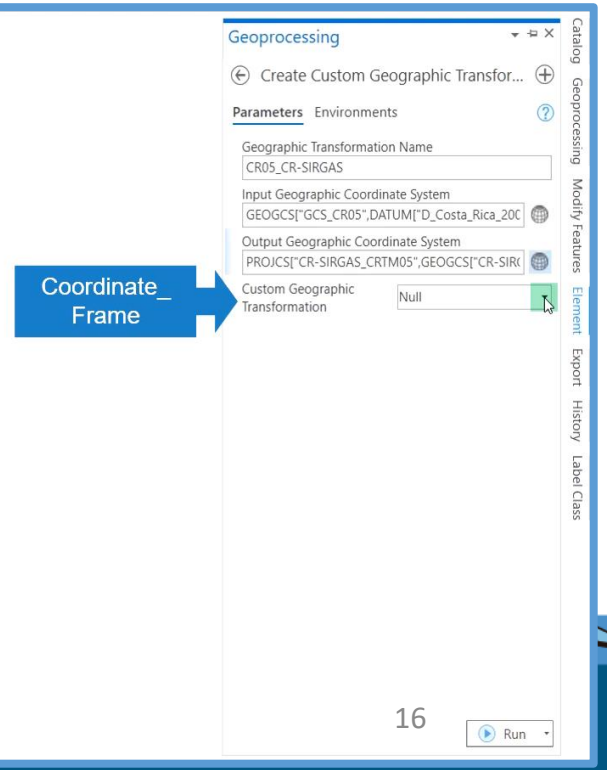
$R_y["]$	0.16325	-0.16325	± 0.05
$R_z["]$	-0.03446	0.03446	± 0.08
$k[ppm]$	0.03693	-0.03693	± 0.23

Exactitud de la transformación ± 0.09 m

ArcGIS Pro

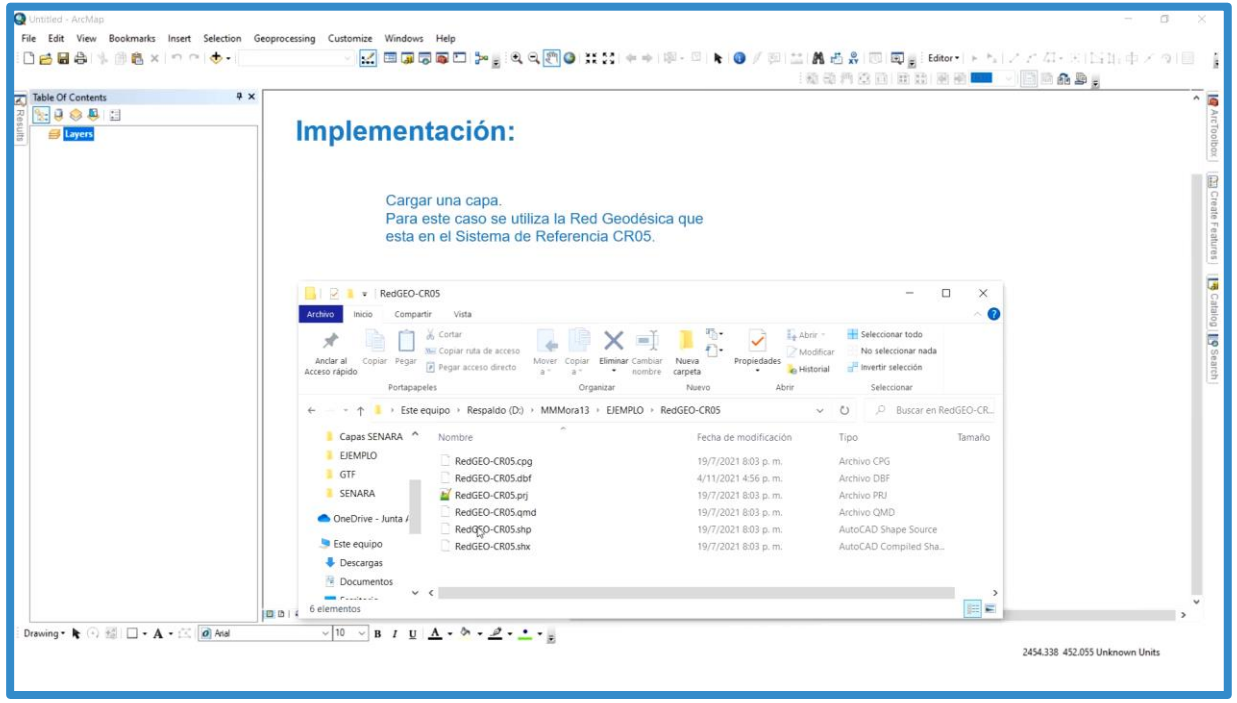


Transformación Geográfica Personalizada

- Coordinate Frame
  - Parámetros de transformación **Bursa –Wolf**

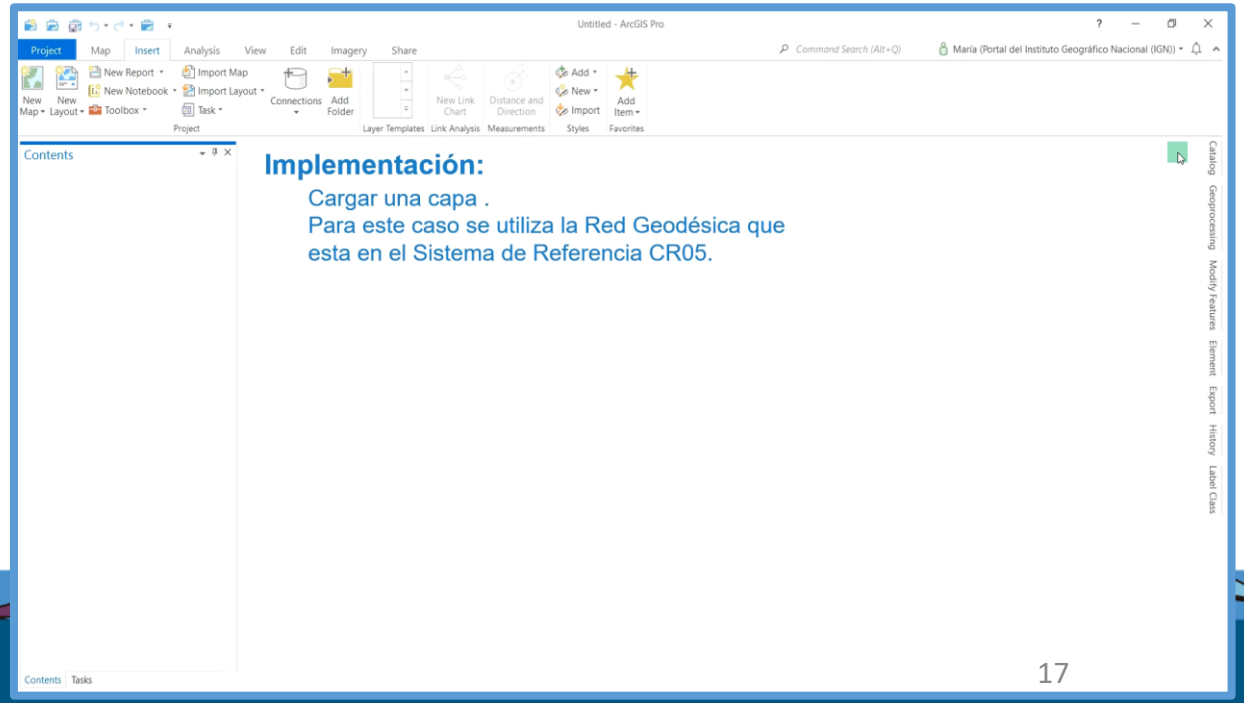
Transformación de coordenadas CR05/CRTM05 a CR-SIRGAS/CRTM05 utilizando ArcMap 10.7 y ArcGIS Pro

ArcMap 10.7



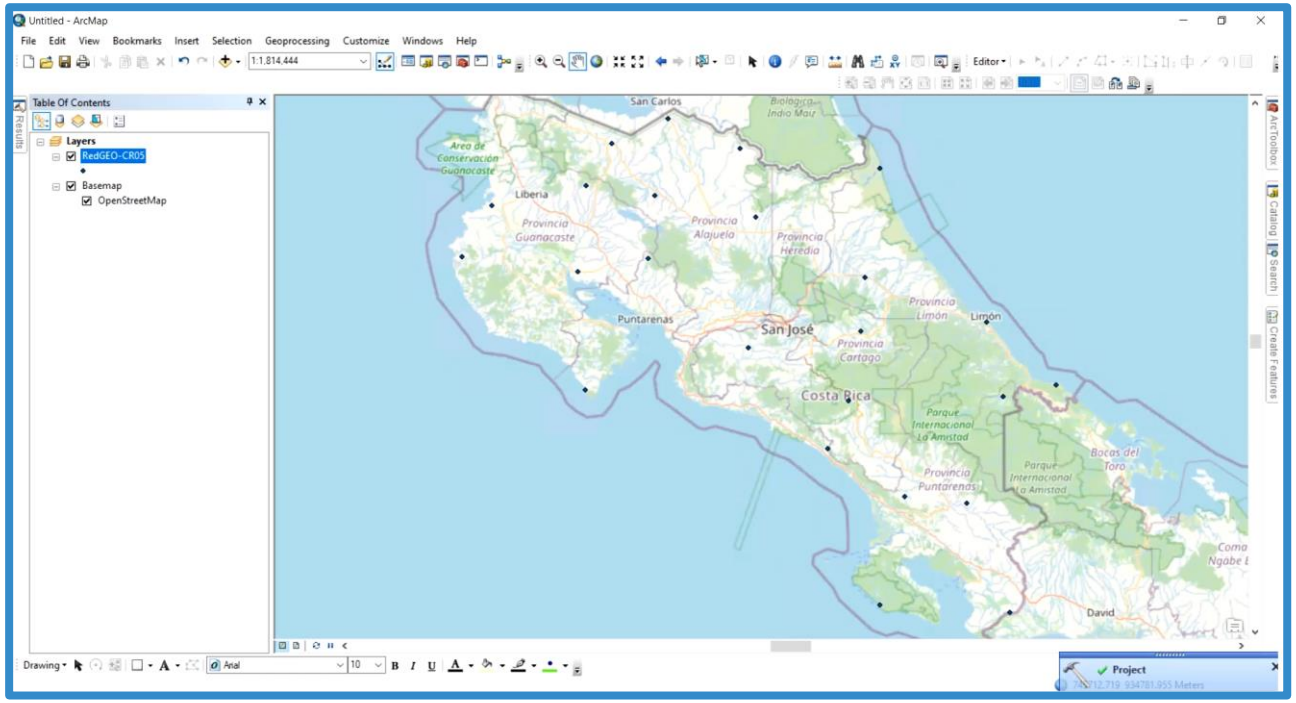
Implementación
- Carga una capa en CRTM05-CR05
- Herramienta Project

ArcGIS Pro



Transformación de coordenadas CR05/CRTM05 a CR-SIRGAS/CRTM05 utilizando ArcMap 10.7 y ArcGIS Pro

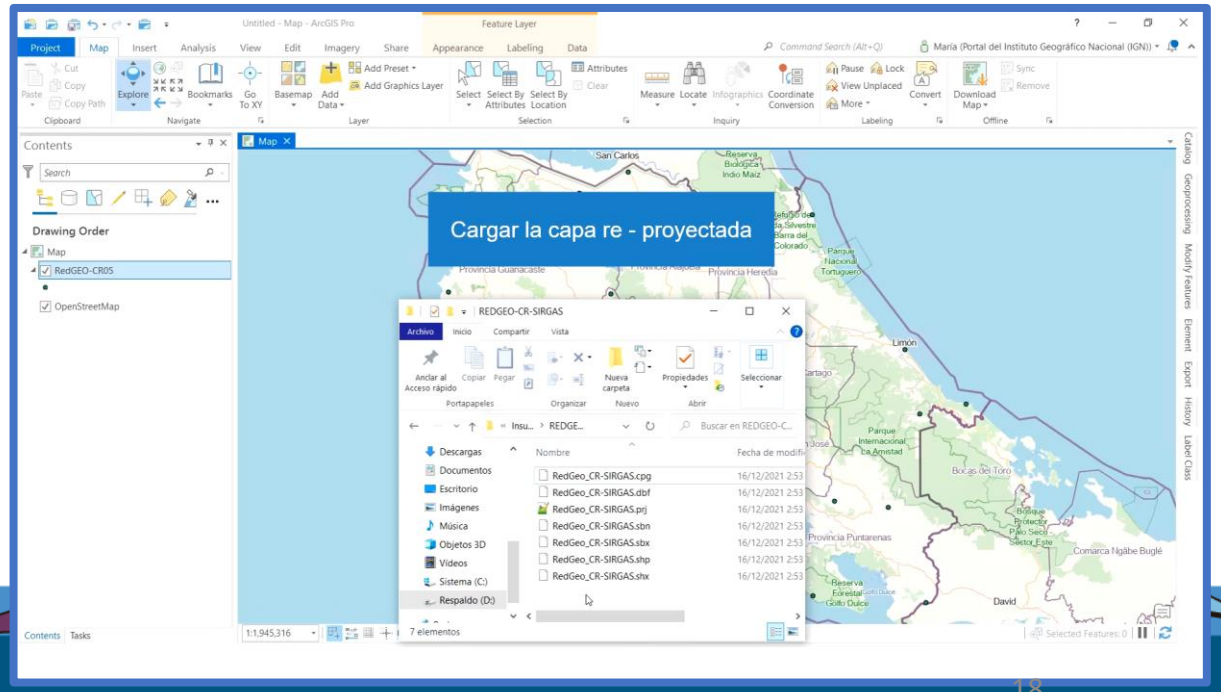
ArcMap 10.7



Implementación

- Carga la capa re-proyectada CRSIRGAS-CR05
- Calcular las coordenadas

ArcGIS Pro



Transformación de coordenadas CR-SIRGAS/CRTM05 a CR05/CRTM05 en QGIS

Se cargan los parámetros de transformación **Bursa-Wolf** en la **época de referencia 2014.59** en archivo **WKT** para la transformación entre ambos sistemas y es aplicable a la reproyección de datos vectoriales o ráster.

Transformación de coordenadas CR-SIRGAS/CRTM05 a CR05/CRTM05 en QGIS

```
BOUNDCRS[
  SOURCECRS[
    PROJCRS["CR-SIRGAS / CRTM05",
      BASEGEOGCRS["CR-SIRGAS",
        DATUM["CR-SIRGAS_2014.59",
          ELLIPSOID["GRS80",6378137,298.257222101206,
            LENGTHUNIT["metre",1]]],
        PRIMEM["Greenwich",0,
          ANGLEUNIT["degree",0.0174532925199433]]],
      CONVERSION["Costa Rica TM 2005",
        METHOD["Transverse Mercator",
          ID["EPSG",9807]],
        PARAMETER["Longitude of natural origin",-84,
          ANGLEUNIT["degree",0.0174532925199433],
          ID["EPSG",8802]],
        PARAMETER["Latitude of natural origin",0,
          ANGLEUNIT["degree",0.0174532925199433],
          ID["EPSG",8801]],
        PARAMETER["Scale factor at natural origin",0.9999,
          SCALEUNIT["unity",1],
          ID["EPSG",8805]],
        PARAMETER["False easting",500000,
          LENGTHUNIT["metre",1],
          ID["EPSG",8806]],
        PARAMETER["False northing",0,
          LENGTHUNIT["metre",1],
          ID["EPSG",8807]]],
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        AXIS["easting",east,
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          LENGTHUNIT["metre",1]],
        AXIS["northing",north,
          ORDER[2],
          LENGTHUNIT["metre",1]],
      ID["EPSG",8908]]],
  TARGETCRS[
      GEOGCS["CR05",
        DATUM["Costa_Rica_2005",
          SPHEROID["WGS 84",6378137,298.257223563,
            AUTHORITY["EPSG","7030"]],
          TOWGS84[0,0,0,0,0,0,0],
            AUTHORITY["EPSG","1065"]],
        PRIMEM["Greenwich",0,
          AUTHORITY["EPSG","8901"]],
        UNIT["degree",0.0174532925199433,
          AUTHORITY["EPSG","9122"]],
        AUTHORITY["EPSG","5365"]]],
    ABRIDGEDTRANSFORMATION["Transformation from CR-SIRGAS to CR05",
      METHOD["Position Vector transformation (geog2D domain)",
        ID["EPSG",9606]],
      PARAMETER["X-axis translation",0.16959,
        ID["EPSG",8605]],
      PARAMETER["Y-axis translation",-0.35312,
        ID["EPSG",8606]],
      PARAMETER["Z-axis translation",-0.51846,
        ID["EPSG",8607]],
      PARAMETER["X-axis rotation",-0.03385,
        ID["EPSG",8608]],
      PARAMETER["Y-axis rotation",0.16325,
        ID["EPSG",8609]],
      PARAMETER["Z-axis rotation",-0.03446,
        ID["EPSG",8610]],
      PARAMETER["Scale difference",1.00000003693,
        ID["EPSG",8611]]]]
```

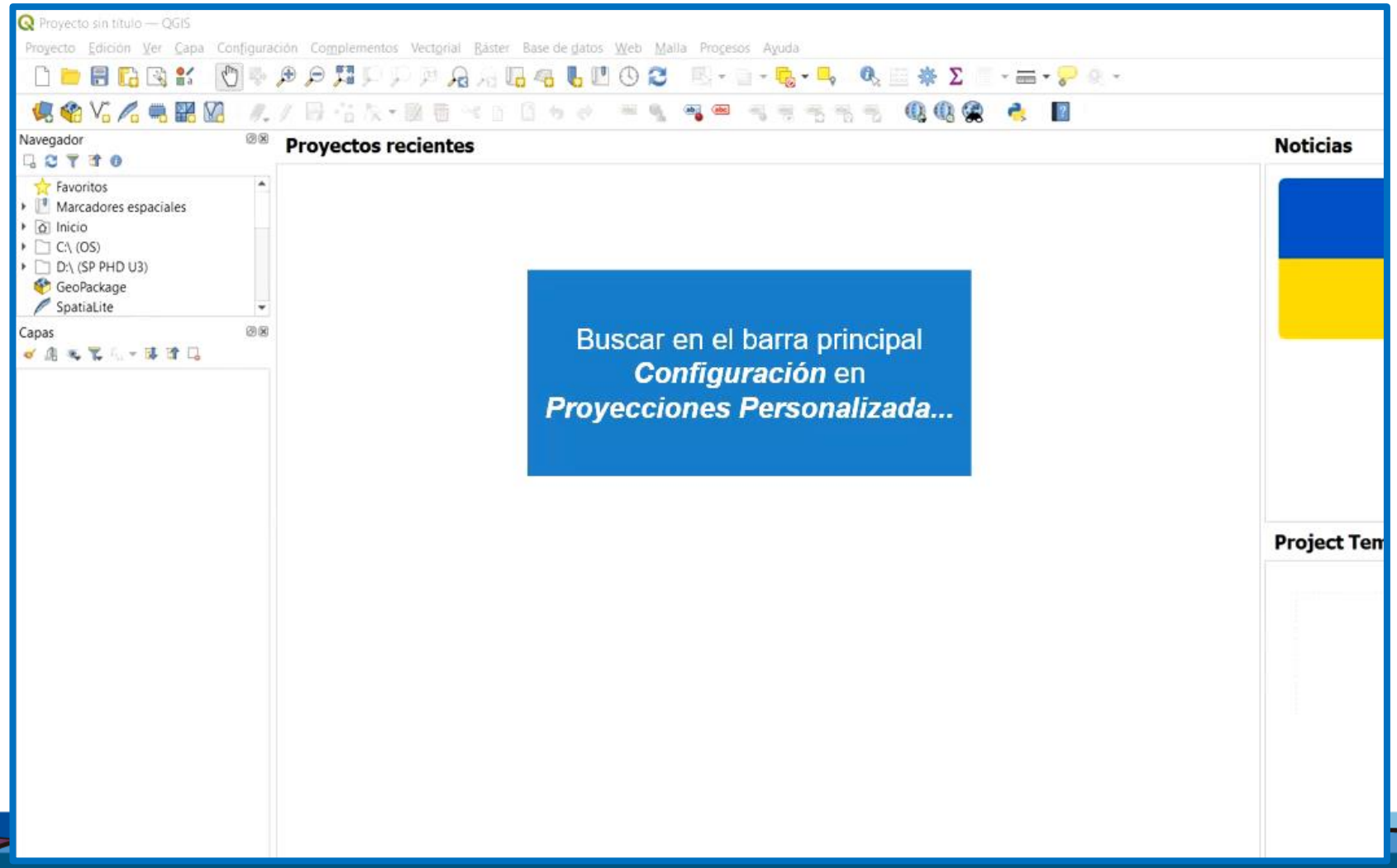
Parámetros para la transformación Bursa-Wolf

$$\begin{bmatrix} X_2 \\ Y_2 \\ Z_2 \end{bmatrix} = \begin{bmatrix} Tx \\ Ty \\ Tz \end{bmatrix} + (1+k) \begin{bmatrix} 1 & -Rz & Ry \\ Rz & 1 & -Rx \\ -Ry & Rx & 1 \end{bmatrix} \begin{bmatrix} X_1 \\ Y_1 \\ Z_1 \end{bmatrix}$$

Parámetro	De CR05 a CR-Sirgas(2014.59)	De CR-Sirgas(2014.59) a CR05	Exactitud
$T_x[m]$	-0.16959	0.16959	± 2.33
$T_y[m]$	0.35312	-0.35312	± 1.65
$T_z[m]$	0.51846	-0.51846	± 3.56
R_x["]	-0.03385	0.03385	± 0.12
R_y["]	0.16325	-0.16325	± 0.05
["]	-0.03446	0.03446	± 0.08
ppm]	0.03693	-0.03693	± 0.23
ud de la transformación			± 0.09 m

Tenga en cuenta que la misma Rotación que se define como positiva en el método del *Position Vector*, intercambia los signos para los parámetros de transformación

Transformación de coordenadas CR-SIRGAS/CRTM05 a CR05/CRTM05 en QGIS



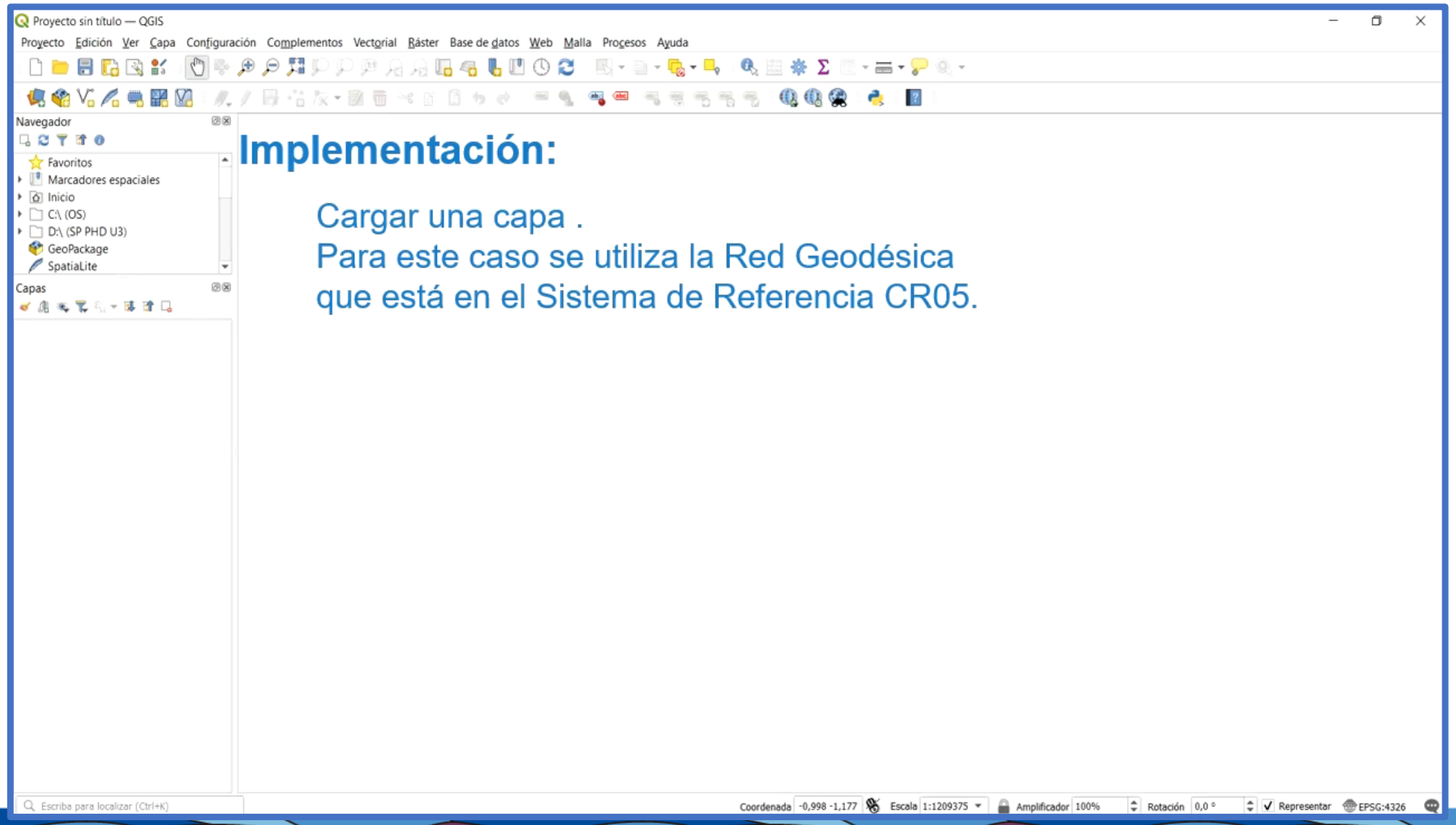
Configuración
- Proyecciones personalizadas

Nombre de la transformación
- CR-SIRGAS/CRTM05 a CR05/CRTM05

Buscar, copiar y pegar archivo WKT

Validar el WKT

Transformación de coordenadas CR-SIRGAS/CRTM05 a CR05/CRTM05 en QGIS



Implementación

- Carga una capa en CRTM05-CR05
- Se calculan las coordenadas en CRSIRGAS-CR05

Comparación de Resultados

PUNTO	Coordenadas de entrada en CR05/CRTM05			Transformación de CR05/CRTM05 a CR-SIRGAS/CRTM05			QGIS		Comparación de transformaciones		ArcGIS		Comparación de transformaciones	
	Norte[m]	Este[m]	Altura[m]	Norte[m]	Este[m]	Altura [m]	Norte[m]	Este[m]	Diferencia Norte[m]	Diferencia Este[m]	Norte[m]	Este[m]	Diferencia Norte[m]	Diferencia Este[m]
ALEGRE	996738.3055	595407.0568	334.342	996738.441	595407.165	334.290	996738.440	595407.183	0.000	-0.018	996738.440	595407.183	0.000	-0.018
BELLA	1087136.327	468522.6522	802.293	1087136.362	468522.681	802.252	1087136.362	468522.699	0.000	-0.018	1087136.362	468522.699	0.000	0.018
BLANCA	1062619.37	374258.7467	13.678	1062619.327	374258.791	13.637	1062619.326	374258.810	0.000	-0.018	1062619.326	374258.810	0.000	0.018
BUVIS	1056434.752	526721.1717	3509.109	1056434.833	526721.228	3509.064	1056434.833	526721.246	0.000	-0.018	1056434.833	526721.246	0.000	0.018
CHILES	1220010.487	422270.227	49.813	1220010.489	422270.144	49.785	1220010.490	422270.163	0.000	-0.018	1220010.490	422270.163	0.000	0.018
CRUCITAS	1202724.593	464025.553	83.464	1202724.629	464025.486	83.433	1202724.629	464025.505	0.000	-0.018	1202724.629	464025.505	0.000	0.018
CUCARACHA	1175181.131	414316.5761	198.842	1175181.125	414316.530	198.810	1175181.125	414316.548	0.000	-0.018	1175181.125	414316.548	0.000	0.018
DOMINICAL2	1028273.012	514585.6044	352.031	1028273.082	514585.683	351.984	1028273.082	514585.701	0.000	-0.018	1028273.082	514585.701	0.000	0.018
GIGANTA	1180982.019	374765.7707	669.98	1180981.980	374765.718	669.950	1180981.980	374765.737	0.000	-0.018	1180981.980	374765.737	0.000	0.018
GRANDE	1169407.112	319957.6136	168.933	1169407.028	319957.568	168.903	1169407.028	319957.587	0.000	-0.018	1169407.028	319957.587	0.000	0.018
GUÁCIMO	1127784.794	536509.8355	118.805	1127784.887	536509.833	118.766	1127784.886	536509.852	0.000	-0.018	1127784.886	536509.852	0.000	0.018
LAUREL	933276.2732	620593.3554	30.893	933276.426	620593.517	30.835	933276.426	620593.535	0.000	-0.018	933276.426	620593.535	0.000	0.018
LIMÓN1	1101718.553	606766.8297	12.964	1101718.702	606766.852	12.921	1101718.701	606766.870	0.000	-0.018	1101718.701	606766.870	0.000	0.018
LUCIA	1131337.003	369629.3741	122.501	1131336.959	369629.362	122.466	1131336.958	369629.380	0.000	-0.018	1131336.958	369629.380	0.000	0.018
MAÍZ	1000705.235	559621.1933	327.577	1000705.341	559621.297	327.526	1000705.341	559621.315	0.000	-0.018	1000705.341	559621.315	0.000	0.018
MANZANILLO2	1065561.971	647512.4162	12.023	1065562.152	647512.470	11.976	1065562.151	647512.488	0.000	-0.018	1065562.151	647512.488	0.000	0.018
MONTEVERDE	1138825.466	410548.0977	1358.428	1138825.456	410548.081	1358.393	1138825.455	410548.100	0.000	-0.018	1138825.455	410548.100	0.000	0.018
SIRENA	937708.5789	545190.1319	24.986	937708.670	545190.286	24.930	937708.670	545190.305	0.000	-0.018	937708.670	545190.305	0.000	0.018
SURETKA	1058638.246	616477.0714	69.023	1058638.401	616477.130	68.976	1058638.401	616477.148	0.000	-0.018	1058638.401	616477.148	0.000	0.018
TAMARINDO2	1140007.167	302391.2364	36.571	1140007.067	302391.214	36.538	1140007.067	302391.233	0.000	-0.018	1140007.067	302391.233	0.000	0.018
TERECITA	1191301.346	545164.5204	10.587	1191301.448	545164.467	10.554	1191301.448	545164.485	0.000	-0.018	1191301.448	545164.485	0.000	0.018
TURRI1	1096415.797	533835.0998	721.983	1096415.886	533835.123	721.941	1096415.885	533835.142	0.000	-0.018	1096415.885	533835.142	0.000	0.018
UPALA5	1205708.42	389655.14	53.813	1205708.395	389655.068	53.784	1205708.395	389655.086	0.000	-0.018	1205708.395	389655.086	0.000	0.018
VERACRUZ	1162669.867	473157.6754	102.824	1162669.909	473157.642	102.790	1162669.908	473157.660	0.000	-0.018	1162669.908	473157.660	0.000	-0.018

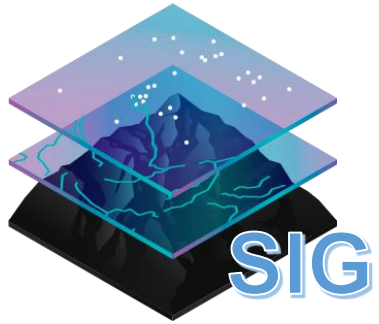
Recomendación

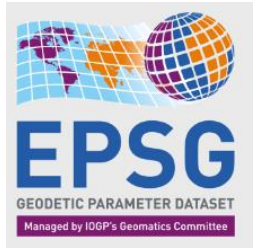
TRANSFORMACIÓN DE COORDENADAS

Método de BURSA-WOLF para el paso directo de CR05 a CR-SIRGAS y visceversa ambos en la proyección CRTM05.
Elija a la derecha el datum de sus *Datos de entrada*

Datos entrada:	CR05
Datos Salida:	CR-SIRGAS

PUNTO	Norte[m]	Este[m]	Altura[m]	Norte[m]	Este[m]	Altura[m]
ALEGRE	996 738.3055	595 407.0568	334.3420	996 738.4405	595 407.1650	334.2899
BELLA	1 087 136.3274	468 522.6522	802.293	1 087 136.3623	468 522.6805	802.2519
BLANCA	1 062 619.3702	374 258.7467	13.6780	1 062 619.3268	374 258.7910	13.6368
BUVIS	1 056 434.7520	526 721.1717	3 509.1090	1 056 434.8333	526 721.2278	3 509.0639





Parámetros para la transformación Bursa-Wolf

$$\begin{bmatrix} X_2 \\ Y_2 \\ Z_2 \end{bmatrix} = \begin{bmatrix} Tx \\ Ty \\ Tz \end{bmatrix} + (1+k) \begin{bmatrix} 1 & -Rz & Ry \\ Rz & 1 & -Rx \\ -Ry & Rx & 1 \end{bmatrix} \begin{bmatrix} X_1 \\ Y_1 \\ Z_1 \end{bmatrix}$$

Parámetro	De CR05 a CR-Sirgas(2014.59)	De CR-Sirgas(2014.59) a CR05	Exactitud
$T_x[m]$	-0.16959	0.16959	± 2.33
$T_y[m]$	0.35312	-0.35312	± 1.65
$T_z[m]$	0.51846	-0.51846	± 3.56
$R_x["]$	-0.03385	0.03385	± 0.12
$R_y["]$	0.16325	-0.16325	± 0.05
$R_z["]$	-0.03446	0.03446	± 0.08
$k[ppm]$	0.03693	-0.03693	± 0.23
Exactitud de la transformación		± 0.09 m	

https://www.snitcr.go.cr/

REGISTRO NACIONAL
REPÚBLICA DE COSTA RICA

Consultas

SecretariaIGN@rnp.go.cr

aalvarezc@rnp.go.cr

mmorar@rnp.go.cr

Presento: María Marta Mora Rivas

¡Muchas Gracias!