



المملكة العربية السعودية  
الهيئة العامة للمساحة  
والمعلومات الجيومكانية

# Online VRF-TT

## Vertical Reference Frame Transformation Tool

### User Manual

Version 2.0



07 November 2022

## TABLE OF CONTENT

Table of Content .....	2
List of Figures .....	2
List of Tables .....	2
List of Abbreviations .....	3
INTRODUCTION .....	4
HOW TO USE ONLINE VRF-TT.....	6
STEP 1. TRANSFORMATION TYPE SELECTION .....	7
STEP 2. DATA INPUT, TRANSFORMATION AND RESULT OUTPUT.....	8
2.1 SINGLE POINT MODE: DATA INPUT.....	8
2.2 SINGLE POINT MODE: DATA TRANSFORMATION AND RESULT OUTPUT.....	11
2.3 MULTIPOINT MODE: DATA INPUT .....	11
2.4 MULTIPOINT MODE: DATA TRANSFORMATION AND RESULT OUTPUT.....	12

## LIST OF FIGURES

Figure 1. Geodetic Services landing web page.....	6
Figure 2. Service selection from the drop-down menu .....	6
Figure 3. Selection of orthometric height transformation .....	7
Figure 4. Help page with “How to use our tools” links .....	8
Figure 5. Decimal Degree input.....	9
Figure 6. Degrees, Minutes and Seconds input .....	9
Figure 7. Degrees, Minutes and Seconds client-side detection of input errors .....	10
Figure 8. Degrees, Minutes and Seconds input errors report .....	10
Figure 9. Transformation result in the Single Point mode.....	11
Figure 10. Multi Point mode transformation window .....	12
Figure 11. Multi Point mode result download link .....	13

## LIST OF TABLES

Table 1. Approximate change of ellipsoidal height due to GRF transformation to KSA-GRF17 .....	4
Table 2. Coordinate range values for KSA area.....	8
Table 3. Example of the input data file .....	12
Table 4. Example of the output data file .....	13

## LIST OF ABBREVIATIONS

AAA	Ain-Al-Abd datum
ARAMCO	Saudi Arabian Oil Company
GASGI	General Authority for Survey and Geospatial Information (former GCS), KSA
GCS	General Commission for Survey (name before Sep 2020), KSA
GDMS	General Directorate of Military Survey, KSA
GRF	Geodetic Reference Frame
GUI	Graphical User Interface
ITRF94	ITRF1994 at epoch 1993.0 - one of realisations of ITRS
ITRF2014	ITRF2014 at epoch 2010.0 - one of realisations of ITRS
ITRS	International Terrestrial Reference System
JED69	Jeddah 1969 Vertical Datum in KSA
KSA	Kingdom of Saudi Arabia
KSA-GEOID09	Geoid model created by GDMS/GCS, KSA in the year 2009
KSA-GEOID17	KSA Hybrid Geoid Model produced by GASGI, KSA in the year 2017
KSA-GEOID21GASGI	Latest KSA Hybrid Geoid Model produced by GASGI, KSA in the year 2021
KSA-GRF	Geodetic Reference Frame for KSA
KSA-GRF17	First and latest realization of KSA-GRF. The number “17” reflects the last year of the GNSS observation data included in the computation.
KSA-VRF	Vertical Reference Frame for KSA
KSA-VRF14	Latest realisation of KSA-VRF
MOMRA	Ministry of Municipalities and Rural Affairs, KSA
MTRF2000	MOMRA’s geodetic reference system
NVRS	National Vertical Reference System, NVN
Online VRF-TT	Online VRF Transformation Tool
SANSRS	Saudi Arabia National Spatial Reference System
SRS	Spatial Reference System
SVD78	SVD-1978: Saudi ARAMCO Vertical Datum 78, KSA
UTF-8	Unicode Transformation Format–8 bit - a variable-width character encoding
VRF	Vertical Reference Frame

## INTRODUCTION

**Online VRF-TT (Vertical Reference Frame Transformation Tool)** is web-based software developed by GASGI to transform *orthometric* heights from two *Vertical Reference Frames* (JED69 & SVD78) & reference surfaces of two *Geoid* models KSA-GEOID09 and KSA-GEOID17 to the latest *Kingdom of Saudi Arabia Vertical Reference Frame* KSA-VRF14 & reference surface of geoid model KSA-GEOID21GASGI correspondingly. The *Online VRF-TT* can be accessed and used from any *Internet Browser*.

Compared to the previous realizations of the Kingdom's *NVRS*, the *KSA-VRF14* is a modern and precise *VRF* that utilizes ground, satellite, levelling and gravity data, and its distribution is homogeneous all over the Kingdom.

For *orthometric* height transformations, the *Online VRF-TT* uses input values of *Longitude & Latitude* to calculate a height correction by using bilinear interpolation of transformation *1D* grid, and applies this correction to the input *orthometric Height*.

When using **Online VRF-TT**, the input coordinates (*Latitudes, Longitudes*) of points must be in *KSA-GRF17*. But a user could have the coordinates in any of existing *Geodetic Reference Frame (GRF)* ([Technical Summary for Saudi Arabia National reference System \(SANSRS\)](#)) listed in the (*Table 1*).

Usually, *ellipsoidal* heights are used to calculate *orthometric* heights if geoid model is available. The *Table 1* shows the approximate *ellipsoidal* height changes due to transformation of various *GRFs* to *KSA-GRF17*. It shows that to avoid lower than *1 cm* accuracy of *ellipsoidal* height in *KSA-GRF17*, it's compulsory to transform *3D* coordinates from the first four *GRFs* (*Table 1*) to *KSA-GRF17*, then use transformed *ellipsoidal* heights to calculate *orthometric* heights in one of *VRFs*, and only then horizontal coordinates in *KSA-GRF17* and calculated *orthometric* heights can be used in *Online VRF-TT* as input values.

If the input coordinates are referenced to the last four *GRFs* in the (*Table 1*), there is no need to transform them to *KSA-GRF17*. The horizontal coordinates might be at *a few meters* level to provide *1 mm* grid interpolation accuracy.

*Table 1. Approximate change of ellipsoidal height due to GRF transformation to KSA-GRF17*

#	Geodetic Reference Frame	Ellipsoidal height change [cm]
1	ARAMCO Ain-Al-Abd	25 000
2	ARAMCO (ITRF94) (named as well as ARAMCO_WGS84 (ITRF94 at the epoch 1998.0))	-10
3	GCS/GDMS (ITRF2000 at the epoch 2003.1998)	1
4	MTRF2000 (ITRF2000 at the epoch 2004.0)	-16
6	WGS84 (G1762) (ITRF2008 at the epoch 2005.0)	-0.3
7	WGS84 (G2139) (ITRF2014 at the epoch 2016.0)	0
5	WGS84 (defined in EPSG-9383 as ITRF2014 at the epoch 2010.0)	0
8	KSA-GRF17 (ITRF2014 at the epoch 2017.0)	0

**KSA-VRF14** ([Technical Summary for Saudi Arabia National reference System \(SANSRS\)](#)) is the latest realization of *National Vertical Reference System (NVRS)* that is defined on the base of satellite altimetry and satellite gravity data utilizing as well as in-situ terrestrial observations from *Tide Gauges*, levelled height differences and gravity.

**KSA-GEOID21GASGI** ([Technical Summary for Saudi Arabia National reference System \(SANSRS\)](#)) is the latest hybrid gravimetric geoid combining all available relevant data in the Kingdom, including ground, satellite and ship-borne gravity data, and *GASGI GPS* levelling. The grid has been derived by the fitting of the *Gravimetric Geoid KSA-GEOID21Grav* to geoid heights (in *KSA-VRF14*) of 3522 *GASGI GPS/Levelling* benchmarks. Further in the text and in the tool's *GUI*, we'll use the shorter name *KSA-GEOID21* instead of *KSA-GEOID21GASGI*.

**KSA-GRF17** ([Technical Summary for Saudi Arabia National reference System \(SANSRS\)](#)) is unified geodetic reference frame for the *Kingdom of Saudi Arabia (KSA-GRF)*, and it is defined in such a way that it

(1) coincides with *ITRF2014* at the epoch 2017.0 and

(2) is co-moving with the stable part of the *Arabian* tectonic plate.

## HOW TO USE ONLINE VRF-TT

To launch the *Online VRF-TT*:

- Launch any internet browser.
- Type the URL <http://gds.gasgi.gov.sa> in browser's address bar to access the *Geodetic Services* landing web page (Figure 1).
- In the web page, select *SANSRS Transformation Tools* → *Online VRF-TT* → *Start* button to access *Online VRF-TT* transformation tool on the page <https://gds.gasgi.gov.sa/VRF> (Figure 3).
- Perform the actions according to the steps described below.
- Otherwise, the tools can be accessed by clicking *Services* → *Tools* → *Vertical Reference Frames* in the top right corner of the web page and selecting the tool from the drop-down menu (Figure 2).

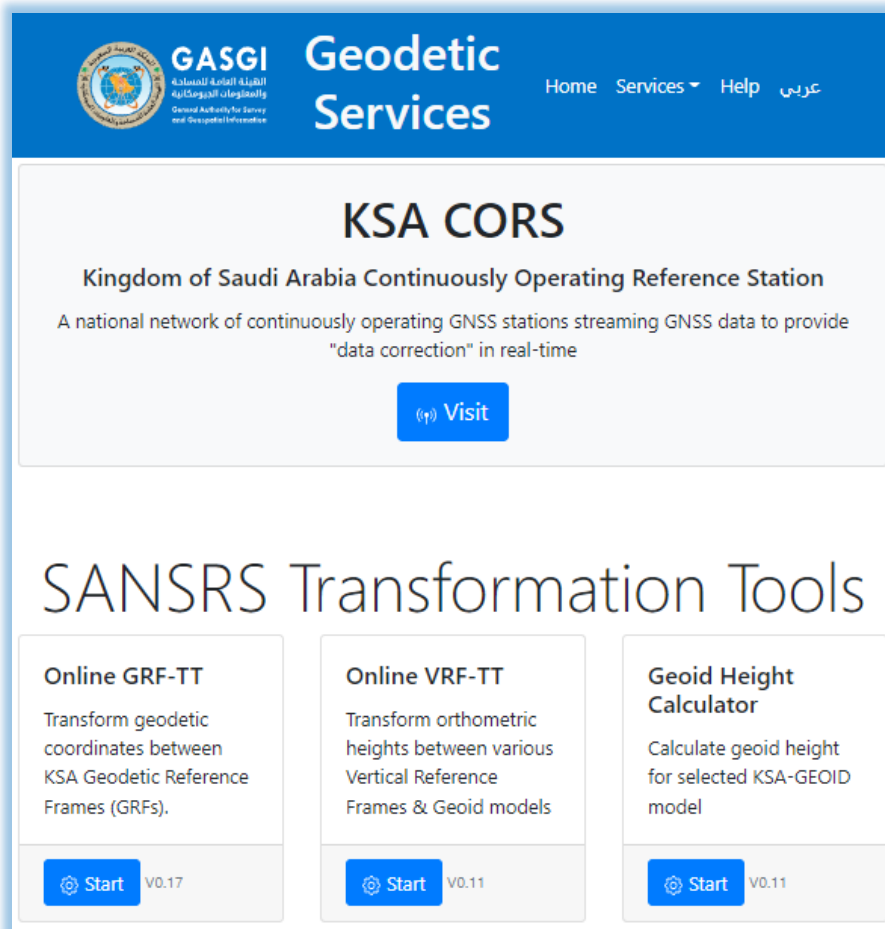


Figure 1. Geodetic Services landing web page

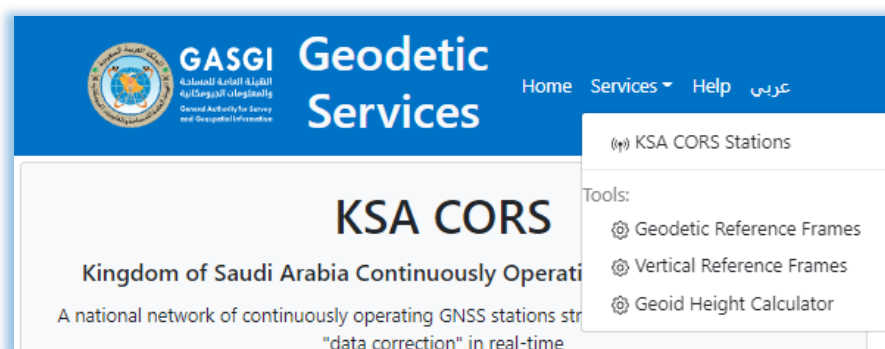
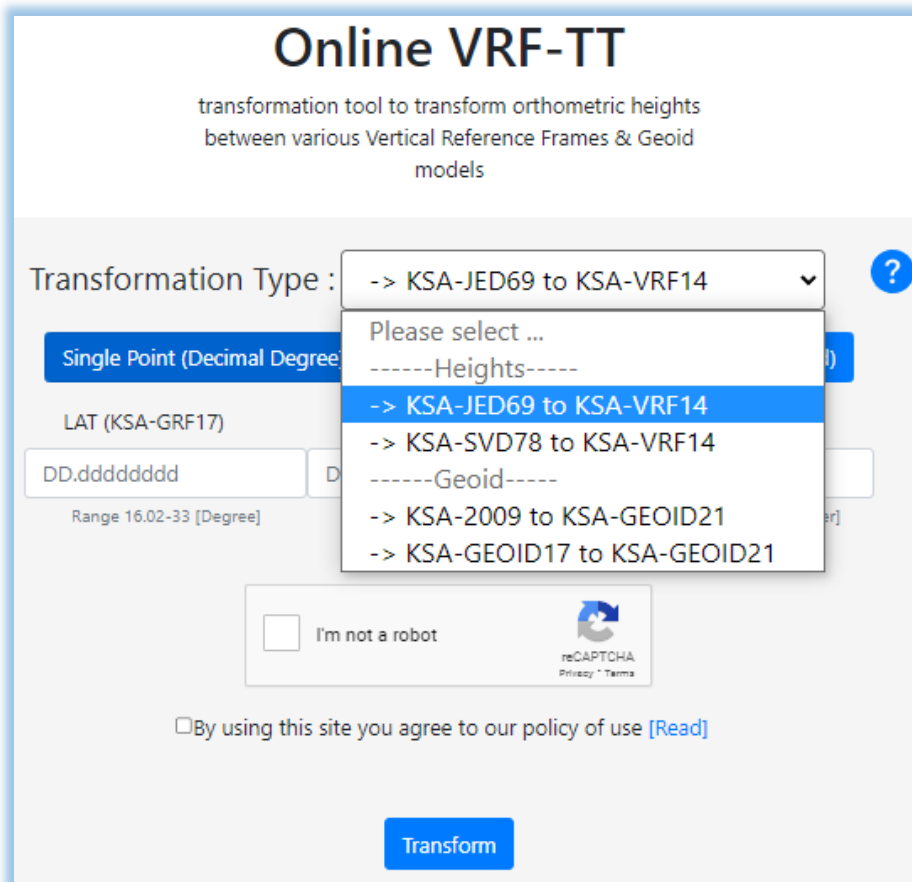


Figure 2. Service selection from the drop-down menu

## STEP 1. TRANSFORMATION TYPE SELECTION

Type of the transformation can be selected from the drop-down menu in *Online VRF-TT GUI (Figure 3)*.



The screenshot shows the 'Online VRF-TT' web interface. At the top, it says 'transformation tool to transform orthometric heights between various Vertical Reference Frames & Geoid models'. Below this, there is a 'Transformation Type' dropdown menu. The current selection is '-> KSA-JED69 to KSA-VRF14'. A dropdown menu is open, showing options: 'Please select ...', '-----Heights-----', '-> KSA-JED69 to KSA-VRF14' (highlighted), '-> KSA-SVD78 to KSA-VRF14', '-----Geoid-----', '-> KSA-2009 to KSA-GEOID21', and '-> KSA-GEOID17 to KSA-GEOID21'. To the left of the dropdown, there is a 'Single Point (Decimal Degree)' button and a 'LAT (KSA-GRF17)' input field with a placeholder 'DD.ddddddd' and a range 'Range 16.02-33 [Degree]'. Below the input field is a reCAPTCHA 'I'm not a robot' checkbox and a 'By using this site you agree to our policy of use [Read]' checkbox. At the bottom, there is a blue 'Transform' button.

Figure 3. Selection of orthometric height transformation

In *Online VRF-TT*, there are the following transformation types available:

### Orthometric to orthometric height transformation because of change of VRF :

- from *KSA-JED69* to *KSA-VRF14*
- from *KSA-SVD78* to *KSA-VRF14*


Corresponding two grids for transformation above have been recalculated and implemented in the current version of the tool simultaneously with two grids below for orthometric height transformation to *KSA-GEOID21* geoid surface.

### Orthometric to orthometric height transformation because of change of geoid model:

- from *KSA-GEOID09* to *KSA-GEOID21*
- from *KSA-GEOID17* to *KSA-GEOID21*.

For the details on the reference systems, please refer to

[Technical Summary for Saudi Arabia Spatial Reference System \(SANSRS\)](#).

By clicking the question mark  or *Help* link (top right corner) in the *GUI (Figure 3)*, you'll arrive to the *Help page* with links to the detailed information "How to use the our tools" (*Figure 4*).

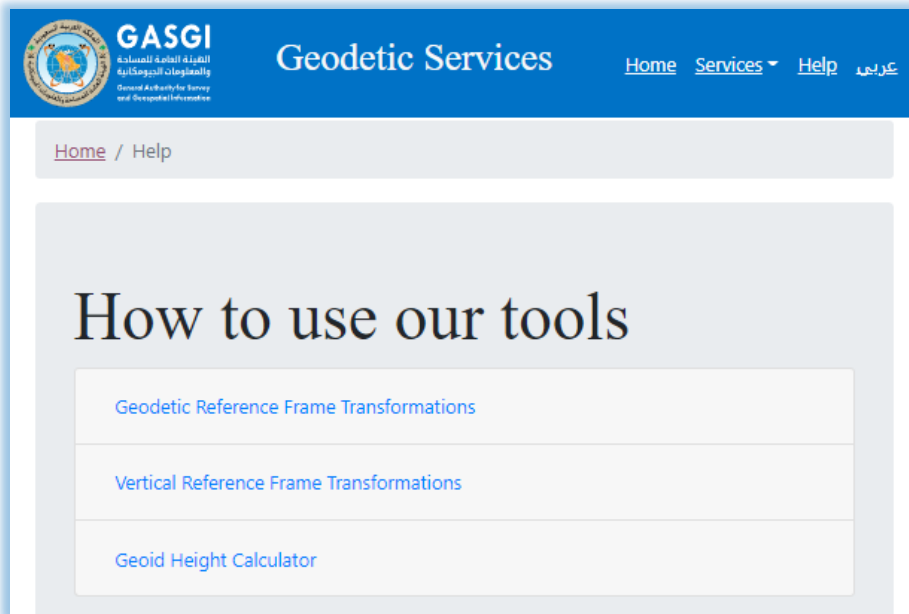


Figure 4. Help page with “How to use our tools” links

## STEP 2. DATA INPUT, TRANSFORMATION AND RESULT OUTPUT

The input information includes values of coordinates (*Latitude & Longitude*) and *Height* (which needs transforming). There are two modes (*Figure 5*) of the data input:

- *Single Point* mode
- *MultiPoint* (file upload) mode - multiple points (each point’s coordinates are saved into *Input File* (*Upload File*) where the same data formats are used as in the *Single Point* mode except of the absence of *DMS* measurement units format in the *MultiPoint* mode.

### 2.1 SINGLE POINT MODE: DATA INPUT

*Single Point* input is used when the user needs to transform height or geoid height for one point only. In this mode, the user should input *Longitude*, *Latitude* and *Height* values in the appropriate text-boxes.

There are two types of value formats for the input *Longitude* and *Latitude*:

- *Decimal Degree* format (*Figure 5*) with float values with up to *eight digits* after the decimal dot
- *Degrees, Minutes, Seconds (DMS)* format (*Figure 6*) with *degrees & minutes* – as integer values, and *seconds* – float value with up to *five digits* after the decimal dot.
- *Height* should be entered in [*meters*] with up to *three digits* after the decimal dot.

Input values of *Latitude*, *Longitude* and *Orthometric Height* have to be within the certain ranges (specified under the input value fields in *GUI* and shown in the *Table 2* as well) covering the *KSA* area.

Table 2. Coordinate range values for KSA area

Coordinate	Range values
Latitude [°]	16.02 – 33.00
Longitude [°]	34.00 – 56.00
Ellipsoidal height [m]	Less than 3200 meters

## Online VRF-TT

transformation tool to transform orthometric heights between various Vertical Reference Frames & Geoid models

Transformation Type : -> KSA-JED69 to KSA-VRF14 ?

LAT (KSA-GRF17)	LON (KSA-GRF17)	Orth.Height (JED69)
20.12345678	40.12345678	100.123
Range 16.02-33 [Degree]	Range 34-56 [Degree]	Range: -40 to +3200 [Meter]

I'm not a robot

By using this site you agree to our policy of use [\[Read\]](#)

*Figure 5. Decimal Degree input*

## Online VRF-TT

transformation tool to transform orthometric heights between various Vertical Reference Frames & Geoid models

Transformation Type : -> KSA-JED69 to KSA-VRF14 ?

LAT (KSA-GRF17)	LON (KSA-GRF17)	Orth. Height (JED69)
20   12   12.12345	40   12   12.12345	100.123
Range 16.02-33 [Degree]	Range 34-56 [Degree]	Range: -40 to +3200 [Meter]

I'm not a robot

By using this site you agree to our policy of use [\[Read\]](#)

*Figure 6. Degrees, Minutes and Seconds input*

If the values are out of range, the tool detects the errors on the client side by showing in the GUI corresponding error indicators (\* - red stars) above the wrong values (*Figure 7*):

## Online VRF-TT

transformation tool to transform orthometric heights between various Vertical Reference Frames & Geoid models

Transformation Type : -> KSA-JED69 to KSA-VRF14 ?

LAT (KSA-GRF17)			LON (KSA-GRF17)			Orth. Height (JED69)
*	*	*	*	*	*	*
34	60	99.12345	-4	rr	-34.1234	4567.123
Range 16.02-33 [Degree]			Range 34-56 [Degree]			Range: -40 to +3200 [Meter]

I'm not a robot

By using this site you agree to our policy of use [\[Read\]](#)

*Figure 7. Degrees, Minutes and Seconds client-side detection of input errors*

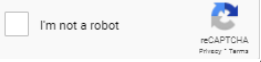
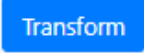
and, on the server-side, by reporting the error (*Figure 8*):


• Lat : out of range values (16.02 - 33)

*Figure 8. Degrees, Minutes and Seconds input errors report*

## 2.2 SINGLE POINT MODE: DATA TRANSFORMATION AND RESULT OUTPUT

Next, to transform the entered *Height*, the user should check the box in the *Captcha* test in *GUI*

 , tick the box to agree with our *Policy of Use* (the link [Read](#)) and click  button. The tool will display the resulting *Height* in the *Result* field as shown in the *Figure 9*.

To copy the resulting value of the *Height* into the computer buffer, click the  button.

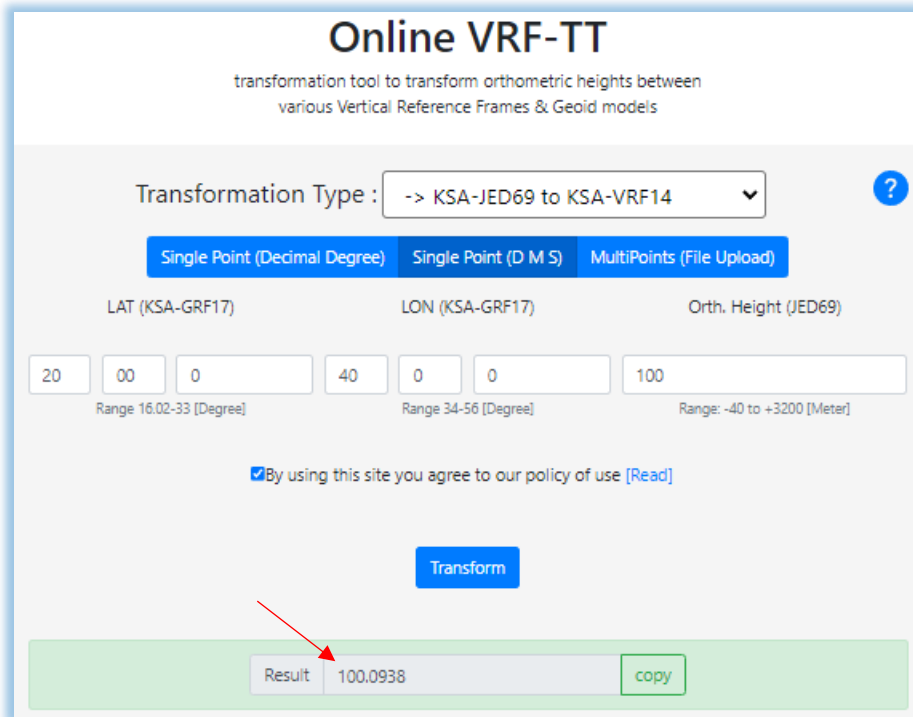


Figure 9. Transformation result in the Single Point mode

## 2.3 MULTIPOINT MODE: DATA INPUT

*Multipoint* mode of coordinates input is designed to transform heights of a large number of points simultaneously. For that, the user should compile the input data in *UTF-8* encoded text file with extension *.txt*.

It doesn't matter has the file been created in *MS Windows* (with *CR/LF* system characters at the end of each line), *Macintosh* (with *CR* character) or *LINUX/UNIX* (with *LF* character). But the output file will be created with *CR/LF* system characters at the end of each line. Don't forget to perform *EOL (End Of Line)* file conversion to the operational system of your computer with, e.g., *Notepad++* text editor.

The input data should be provided in the following order (without measurement units):

***Latitude*** [°] "space" ***Longitude*** [°] "space" ***Height*** [meter]


Values should be separated with a single or a few spaces, and one record line should contain coordinates for one point only. The example of the input text file is given in the *Table 3*. The  highlight shows the values which are out of ranges provided in the *Table 2*.

Table 3. Example of the input data file

24.12345678	36.12345678	-1.123
24.12345678	36.12345678	100.123
25.12345678	37.12345678	101.123
26.12345678	38.12345678	102.123
27.12345678	39.12345678	103.123
28.12345678	40.12345678	104.123
29.12345678	47.12345678	3105.123
29.12345678	20.12345678	105.123
10.12345678	42.12345678	106.123
35.12345678	42.12345678	106.123

While adding input values to the text file, the user should pay attention to keeping the *Latitude* and *Longitude* values within the same ranges that have been provided for the *Single Point* mode's input values in the *Table 2*.

## 2.4 MULTIPPOINT MODE: DATA TRANSFORMATION AND RESULT OUTPUT

The user should upload the input data file on the server by clicking **Select File** button and selecting the input file from your computer (the file name , e.g., “*Example of input file.txt*” will appear instead of “*No file selected*” text), and clicking “*Open*” option. Then, check the checkbox in the *Captcha* test “*I am not a robot*”, check the box “*By using this site you agree to our policy*” of the tool use, and click the **Transform** button (*Figure 10*).

The screenshot shows the 'Online VRF-TT' web interface. At the top, it states 'transformation tool to transform orthometric heights between various Vertical Reference Frames & Geoid models'. The 'Transformation Type' dropdown is set to '-> KSA-JED69 to KSA-VRF14'. Below this are three buttons: 'Single Point (Decimal Degree)', 'Single Point (D M S)', and 'MultiPoints (File Upload)'. The 'MultiPoints (File Upload)' button is active. Underneath is an 'Upload File' section with a 'Select File' button and the text 'No file selected.'. Below that, instructions for the input file format are provided: 'Input File to upload has 3 values in each record line: "Lat [degree] Lon [degree] Height [meter]" with at least one space between the values, and file extension must be ".txt". Example : 23.43546534 46.42938473 351.655'. Further down, instructions for the output file are given: 'Output File to download has 4 values in each record line: "Lat [degree] Lon [degree] Height [meter] Transformed-Height [meter]" with at least one space between the values. Example : 23.43546534 46.42938473 351.655 352.126'. At the bottom, there is a checkbox for 'By using this site you agree to our policy of use [Read]' and a 'Transform' button.

Figure 10. Multi Point mode transformation window

*Online VRF-TT* will transform the data and generate output *UTF-8* encoded text file with extension *\*.txt*. The user can download the file to his computer by clicking the button “*Download*” (*Figure 11*), and inspect it.

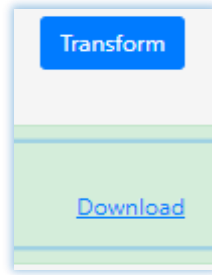


Figure 11. Multi Point mode result download link

In addition to the input data (Table 3), the output file includes one new column (last one) with the transformed Heights (Table 4).

Table 4. Example of the output data file

24.12345678	36.12345678	-1.1230	-0.3330
24.12345678	36.12345678	100.1230	100.9130
25.12345678	37.12345678	101.1230	101.0946
26.12345678	38.12345678	102.1230	102.1639
27.12345678	39.12345678	103.1230	103.2385
28.12345678	40.12345678	104.1230	104.3775
29.12345678	47.12345678	3105.1230	3105.5193
29.12345678	20.12345678	105.1230	Out of range
10.12345678	42.12345678	106.1230	106.9130
35.12345678	42.12345678	106.1230	Out of range

If a value of the input *Latitude* or *Longitude* is out of grid zone range for some point, the *Online VRF-TT* will not transform this point's *Height*, but will add a string "Out of range" in the result output file as it is shown in the Table 4. Note, the yellow highlighted value has been computed despite the input latitude's value is out the range given in the Table 2. This is because the input values are checked with the server-side command-line executable rather than with the client-side web *GUI*, and that executable is using grid validity range values which could be different from the ranges in the Table 2.