

# TEXAS TECH UNIVERSITY TTUKA DOCUMENTATION FOR THE TORUS FIELD PROJECT

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*last updated: 28 December 2022*  
**1.0 DATA SET OVERVIEW**

This document provides information concerning the Texas Tech University mobile Ka radar deployment and data structure details from the TORUS 2022 field campaign.

### DEPLOYMENT INFORMATION

<b>2022-05-19 Nicolville, Minnesota</b>					
Radar	Deployment #	Time [UTC]	Latitude	Longitude	RHI Azimuths [north relative]
Ka1	1	21:51 - 21:56	44.022045	-92.85646	139-189 : 10
Ka1	1	21:56 - 22:05	44.022045	-92.85646	119-159 : 10
Ka1	2	23:28 - 00:05	43.667176	-92.871057	341-41 : 10

<b>2022-05-23 Morton, Texas</b>					
Radar	Deployment #	Time [UTC]	Latitude	Longitude	RHI Azimuths [north relative]
Ka2	1	20:50 – 20:54	-	-	311
Ka1	1	22:44 - 22:51	33.93029	-102.905161	233-303 : 10
Ka1	2	23:05 - 23:09	34.026877	-102.838899	232-302 : 10
Ka2	2	23:22 – 23:25	33.873075,	-102.72165	70-100 : 10
Ka2	2	23:25 – 23:30	33.873075,	-102.72165	80-110 : 10
Ka2	2	23:30 – 23:32	33.873075,	-102.72165	90-120 : 10
Ka2	2	23:32 – 23:41	33.873075,	-102.72165	110-210 : 10
Ka1	3	23:37 – 23:41	33.911651	-102.648889	231-301 : 10
Ka1	4	00:06 – 00:22	33.793971	-102.645381	250-320 : 10
Ka1	4	00:22 – 00:29	33.793971	-102.645381	280-340 : 10
Ka2	3	00:22 – 00:39	33.794945	-102.52164	206-316 : 10

Ka2	3	00:39 – 00:49	33.794945	-102.52164	236-336 : 10
Ka1	5	00:40 – 00:45	33.787352	-102.579183	272-342 : 10
Ka1	5	00:45 – 00:49	33.787352	-102.579183	252-342 : 10
Ka2	3	00:49	33.787352	-102.579183	236
Ka2	4	00:58 – 01:07	33.786768	-102.514652	247-337 : 10
Ka1	6	01:06 – 01:08	33.786463	-102.475652	273-323 : 10
Ka1	7	01:23 – 01:32	33.704868	-102.527235	-
Ka2	5	01:24 – 01:31	33.706523	-102.530607	201-31 : 10
Ka2	5	01:31	33.706523	-102.530607	241-311 : 10
Ka1	7.5	01:38-01:40	33.656278 33.661117	-102.524157 -102.505567	-
Ka1	8	02:03 – 02:05	33.59326	-102.304445	272-352 : 10
Ka2	6	02:09 – 02:18	33.593198	-102.299499	-
Ka1	9	02:26 – 02:38	33.58716	-102.206899	281-1 : 10
Ka2	7	02:27 – 02:39	33.587712	-102.210921	-
Ka2	8	02:56 – 03:14	33.59253	-102.035702	-
Ka1	10	02:58 – 03:14	33.59253	-102.035702	263-343 : 10

**2022-05-24 Andrews, Texas**

Radar	Deployment #	Time [UTC]	Latitude	Longitude	RHI Azimuths [north relative]
Ka2	1	19:59 – 20:05	32.38266	-102.78061	-
Ka1	1	20:19 – 20:31	32.409208	-102.96533	306-356 : 10
Ka1	1	20:31 – 20:41	32.409208	-102.96533	336-36 : 10
Ka2	2	21:03 – 21:04	32.367383	-102.563298	247-317 : 10
Ka1	2	21:22 – 21:32	32.195277	-102.497014	286-356 : 10
Ka1	2	21:32 – 21:38	32.195277	-102.497014	266-336 : 10
Ka2	3	21:35 – 21:42	32.140213	-102.329918	284-14 : 10
Ka2	3	21:43 – 21:54	32.140213	-102.329918	254-344 : 10
Ka1	3	21:47 – 21:50	32.14016	-102.468587	290-360 : 10

**2022-05-30 Balaton, Minnesota**

Radar	Deployment #	Time [UTC]	Latitude	Longitude	RHI Azimuths [north relative]
Ka2	1	19:15 – 20:00	44.444477	-96.125269	-
Ka1	1	20:05 – 20:07	44.22626	-96.061473	165-225 : 10

Ka1	2	20:18 – 20:36	44.239823	-95.988295	202-272 : 10
Ka1	3	20:50 – 20:55	44.239787	-95.796929	199-269 : 10
Ka2	2	21:06 – 21:10	44.457655	-95.69747	172-272 : 10
Ka2	2	21:10 – 21:35	44.457655	-95.69747	172-22 : 10
Ka1	4	21:19 – 21:36	44.23903	-95.544764	201-271 : 10

2022-05-31 Arkansas City, Kansas					
Radar	Deployment #	Time [UTC]	Latitude	Longitude	RHI Azimuths [north relative]
Ka1	1	21:25 – 21:32	36.964287	-97.381992	247-317 : 10
Ka1	1	21:32 – 21:39	36.964287	-97.381992	297-7 : 10
Ka1	1	21:39 – 21:50	36.964287	-97.381992	307-27 : 10
Ka1	1	21:50 – 22:05	36.964287	-97.381992	317-37 : 10
Ka2	1	21:55 – 22:17	36.998983	-97.183806	255-345 : 10
Ka2	1	22:17 – 22:21	36.998983	-97.183806	275-5 : 10
Ka2	1	22:21 – 22:27	36.998983	-97.183806	305-15 : 10
Ka2	2	22:35 – 22:36	36.999298	-97.165777	313-63 : 10
Ka2	3	22:53 – 22:59	37.013202	-97.075512	1-61 : 10
Ka1	2	22:55 – 23:12	37.081821	-96.895872	270-360 : 10
Ka1	2	23:12 – 23:23	37.081821	-96.895872	300-10 : 10
Ka1	2	23:23 – 23:35	37.081821	-96.895872	320-30 : 10
Ka2	4	23:29 – 23:40	37.111392	-96.724087	269-9 : 10
Ka2	4	23:40 – 23:51	37.111392	-96.724087	289-9 : 10
Ka1	3	00:00 – 00:02	37.158108	-96.626178	329-29 : 10
Ka1	3	00:02 – 00:16	37.158108	-96.626178	319-19 : 10
Ka1	3	00:16 – 00:24	37.158108	-96.626178	339-29 : 10
Ka2	5	00:33 – 00:35	36.998994	-97.046052	238-358 : 10
Ka2	5	00:35 – 00:56	36.998994	-97.046052	268-18 : 10
Ka2	5	00:56 – 00:57	36.998994	-97.046052	338-18 : 10
Ka1	4	00:59 – 01:21	37.03064	-96.822635	280-350 : 10
Ka1	4	01:21 – 01:24	37.03064	-96.822635	310-20 : 10
Ka1	4	01:24 – 01:40	37.03064	-96.822635	340-40 : 10

2022-06-06 Rushville, Nebraska					
Radar	Deployment #	Time [UTC]	Latitude	Longitude	RHI Azimuths [north relative]
Ka1	1	21:13 – 21:21	42.904656	-102.221612	337-27 : 10
Ka1	1	21:21 – 21:29	42.904656	-102.221612	357-57 : 10
Ka1	1	21:29 – 21:37	42.904656	-102.221612	17-67 : 10
Ka1	1	21:37 – 21:38	42.904656	-102.221612	37-77 : 10
Ka1	1	21:38 – 21:50	42.904656	-102.221612	47-97 : 10
Ka2	1	21:40 – 21:42	42.800172	-102.012749	341-41 : 10
Ka2	1	21:42 – 21:45	42.800172	-102.012749	351-41 : 10
Ka2	1	21:45 – 21:50	42.800172	-102.012749	1-61 : 10
Ka2	1	21:50 – 22:02	42.800172	-102.012749	11-91 : 10
Ka2	1	22:02 – 22:12	42.800172	-102.012749	41-101 : 10
Ka1	2	22:48 – 22:52	42.817058	-102.49465	293-3 : 10
Ka1	3	22:56 – 22:59	42.81675	-102.49418	292-2 : 10
Ka1	3	22:59 – 23:05	42.81675	-102.49418	292-22 : 10
Ka2	2	23:07 – 23:10	42.667514	-102.204933	311-11 : 10
Ka2	2	23:10 – 23:22	42.667514	-102.204933	281-11 : 10
Ka2	2	23:22 – 23:28	42.667514	-102.204933	261-31 : 10
Ka1	4	23:26 – 23:34	42.63224	-102.458682	359-59 : 10
Ka1	4	23:34 – 23:41	42.63224	-102.458682	49-109 : 10
Ka2	3	02:01 – 02:05	41.532131	-100.50193	261-1 : 10

2022-06-07 Sedgwick, Colorado					
Radar	Deployment #	Time [UTC]	Latitude	Longitude	RHI Azimuths [north relative]
Ka1	1	22:06 – 22:15	41.08618	-102.973782	311-21 : 10
Ka1	2	22:25 – 22:31	41.00704	-102.982968	10-90 : 10
Ka2	1	22:41 – 22:58	40.837513	-102.552912	295-5 : 10
Ka2	1	22:58 – 23:00	40.837513	-102.552912	315-25 : 10
Ka2	1	23:00 – 23:03	40.837513	-102.552912	345-45 : 10
Ka2	1	23:03 – 23:10	40.837513	-102.552912	5-55 : 10
Ka2	2	23:13 – 23:18	40.837553	-102.552897	-
Ka1	3	23:48 – 23:57	40.585733	-102.093743	295-35 : 10
Ka1	3	23:57 – 00:02	40.585733	-102.093743	245-335 : 10

<b>2022-06-09 Arnold, Nebraska</b>					
Radar	Deployment #	Time [UTC]	Latitude	Longitude	RHI Azimuths [north relative]
Ka2	1	00:44 – 00:50	41.408015	-100.499228	155-215 : 10
Ka2	1	00:50 – 00:54	41.408015	-100.499228	125-185 : 10
Ka1	1	01:00 – 01:01	41.60963	-100.49057	39-119 : 10
Ka2	2	01:37 – 01:41	41.263671	-100.063773	311-21 : 10
Ka1	2	01:38 – 01:52	41.281117	-100.196829	1-61 : 10
Ka2	2	01:41 – 01:53	41.263671	-100.063773	311-41 : 10
Ka1	2	01:52 – 01:56	41.281117	-100.196829	31-91 : 10
Ka2	2	01:53 – 01:56	41.263671	-100.063773	311-91 : 10
Ka2	2	01:56 – 02:00	41.263671	-100.063773	341-91 : 10
Ka2	2	02:00 – 02:02	41.263671	-100.063773	41-101 : 10
Ka2	2	02:02 – 02:02	41.263671	-100.063773	41-81 : 10

<b>2022-06-11 Alzada, Montana</b>					
Radar	Deployment #	Time [UTC]	Latitude	Longitude	RHI Azimuths [north relative]
Ka1	1	01:16 – 01:28	44.8661	-104.527461	284-334 : 10
Ka1	1	01:28 – 01:33	44.8661	-104.527461	304-14 : 10
Ka1	1	01:33 – 01:39	44.8661	-104.527461	314-44 : 10
Ka1	1	01:39 – 01:44	44.8661	-104.527461	324-74 : 10
Ka1	1	01:44 – 01:58	44.8661	-104.527461	4-94 : 10
Ka2	1	01:58 – 02:05	44.765585	-103.866752	279-339 : 10
Ka2	1	02:05 – 02:12	44.765585	-103.866752	269-9 : 10

<b>2022-06-12 Belle Fourche, South Dakota</b>					
Radar	Deployment #	Time [UTC]	Latitude	Longitude	RHI Azimuths [north relative]
Ka1	1	21:42 – 22:01	44.88916	-104.188159	-
Ka1	2	22:31 – 22:40	44.691142	-103.723578	-
Ka2	1	22:50 – 22:51	44.590155	-103.770482	278
Ka2	1	22:51 – 22:54	44.590155	-103.770482	278-338 : 10
Ka2	1	22:54 – 23:01	44.590155	-103.770482	278-348 : 10
Ka2	1	23:01 – 23:02	44.590155	-103.770482	278-9 : 10
Ka1	3	23:07 – 23:13	44.590172	-103.433193	270-330 : 10
Ka1	3	23:13 – 23:18	44.590172	-103.433193	260-320 : 10

## 2.0 INSTRUMENT DESCRIPTION

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Texas Tech maintains two mobile Ka-band radars that have been operated in several field projects for more than 10 years (Weiss et al. 2009). These radars operate in the millimeter wavelength range, and with a small beamwidth and high range resolution, can resolve fine scale details of atmospheric phenomena like supercells. More information may be found here: <https://www.depts.ttu.edu/ttuhr/Instrumentation/TTUKa.php>

### TTUKA DETAILS

Frequency	~35 GHz
Peak/Average Power	200/100 W
Beamwidth	0.33 deg
Gate Spacing	15 m

Note: Ka2 had a temporary waveguide installed through the entire 2022 field campaign resulting in less sensitivity than Ka1, but still usable.

## 3.0 DATA COLLECTION AND PROCESSING

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TTUKa data include two corrections:

- Truck heading – all data are rotated to be north-relative. The correction is a combination of a first guess, obtained via GPS heading, followed by an adjustment to align with

ground clutter targets identified in a 0° surveillance scan conducted at the beginning of every deployment.

- Removal of RHI jitter – Due to the nonlinear accelerations of the TTUKa antenna at the endpoints of individual RHIs, a small elevation angle error is often introduced. A manual correction was applied to every RHI, such that the 0 deg elevation angle is in line with the surface.

Note: On May 23, Ka1 carried out a driving deployment where multiple tornadoes within 6 km were identified as well as a vertical vorticity sheet. This deployment is highlighted in the table in section 1. An attempt was made to correct the ray orientations and velocities based on the onboard 1 HZ GPS data. These data shared because other assets may have been in position to observe in the novel features present. If you are interested more in these data, please contact Alex Schueth.

## 4.0 DATA FORMAT

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These radar data were processed with Py-ART and stored in a Cfradial file format as described here: <http://ncar.github.io/CfRadial/>

The metadata are stored within the netcdf data standard. The correct longitude, latitude, heading correction, and jitter correction have all been applied.

## 5.0 DATA REMARKS

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Access and view data with:

Radx: [https://www.ral.ucar.edu/projects/titan/docs/radial\\_formats/radx.html](https://www.ral.ucar.edu/projects/titan/docs/radial_formats/radx.html)

Solo3: <https://www.eol.ucar.edu/software/solo3>

Py-ART: <https://arm-doe.github.io/pyart/>

Outstanding data issues:

While the radar deployment heading and jitter were corrected, outstanding issues remain in these data. These radial velocity data remain aliased with a Nyquist velocity of approximately 15 m s<sup>-1</sup> for most deployments. Additionally, multiple trip echoes exist in many of the RHIs and PPIs. Users can employ the software listed above to manually edit these artifacts.

## 6.0 REFERENCES

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Weiss, C. C., Schroeder, J. L., Guynes, J., Skinner, P. and Beck, J., 2009: The TTUKa Mobile Doppler Radar: Coordinated Radar and In Situ Measurements of Supercell Thunderstorms during Project VORTEX2. *34th Conf. on Radar Meteorology, Amer. Meteor. Soc.*