Title: Combined Mesonet and Trackers (UNL Mobile Mesonets)

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CoMeT Overview

The University of Nebraska-Lincoln operates three Combined Mesonet and Tracker (CoMeTs). CoMeTs are Ford Explorers (model years 2015, 2017, and 2019) with forward-mounted suites of meteorological sensors and dual moonroofs, combining the capability of a mobile mesonet to collect near-surface observations with the capability of an uncrewed aircraft systems (UAS) tracker vehicle, which enables an observer in the second row of seats to see the aircraft and maintain compliance with Federal Aviation Administration policies on UAS operation.

Instrument Description

The specific sensors included on each CoMeT are summarized in the table at the end of this section. In general each CoMeT collects observations of slow temperature and humidity at ~2 m above ground level (AGL) using a Vaisala HMP155, fast temperature at ~2 m AGL using a Campbell Scientific 109SS-L thermistor, pressure at ~2.5 m AGL using a Vaisala PTB210 barometer with a Gill pressure port, wind speed and direction at ~3.25 m AGL using an R.M. Young 05103 propeller anemometer, position using a Garmin 19x HVS receiver, and vehicle heading using a KVH Industries C-100 fluxgate compass. The HMP155 and 109SS are shielded and aspirated within a U-tube (Waugh and Frederickson 2010; Houston et al. 2016). Fast temperature and corrected RH measurements (using sensors housed within the U-tube) have a time constant of 10-12 s based on data collected across a temperature and RH shock during the CLOUD-MAP 2017 calibration/validation tests on June 26, 2017. Vehicle speed was < 10 kts for this test. Manufacturer specifications for these instruments are given in Table 1 of Hanft and Houston (2018). This list of sensors is also included in the CoMeT data file metadata.

	CoMeT-1	CoMeT-2	CoMeT-3
Slow Temperature Slow RH	Vaisala HMP155A-L20-PT Part #: 22280-7	Vaisala HMP155E Part #: E1AA11A0B1A1A0A	Vaisala HMP155E Part #: E1AA11A0B1A1A0A
Fast temperature	Campbell Scientific 109SS-L20-PT Part #: 21448-3	Campbell Scientific 109SS-L12-PW Part #: 21448-109	Campbell Scientific 109SS-L12-PW Part #: 21448-150
Pressure	Vaisala PTB-210 Part #: A1A1B Gill Pressure Port Part #: 61002	Vaisala PTB-210 Part #: A1A1B Gill Pressure Port Part #: 61002	Vaisala PTB-210 Part #: A1A1B Gill Pressure Port Part #: 61002
Wind	RM Young 05103-L20-PT Part #: 18435-310	RM Young 05103-L20-PW Part #: 18435-244	RM Young 05103-L20-PW Part #: 18435-244
GPS	Garmin GPS 19x HVS (NMEA 0183) Part #: 010-01010-00	Garmin GPS 19x HVS (NMEA 0183) Part #: 010-01010-00	Garmin GPS 19x HVS (NMEA 0183) Part #: 010-01010-00
Compass	KVH C-100 Part #: 01-0177-15	KVH C-100 Part #: 01-0177-15	KVH C-100 Part #: 01-0177-15
Logger	Campbell Scientific CR6-NA-XT-SW Part #: 28385-9	Campbell Scientific CR6-WIFI-XT-SW Part #: 28385-6	Campbell Scientific CR6-WIFI-XT-SW Part #: 28385-6

Data Collection and Real-Time Processing

The reported measured quantities are summarized in the table below.

Quantity	Units	Source
Epoch time	Seconds	GPS
Latitude and longitude	Degrees	GPS
Altitude	m	GPS
Pressure	hPa	PTB210
Temperature (fast)	deg C	109SS-L
Temperature (slow)	deg C	HMP155
RH (slow)	%	HMP155
Vehicle speed	m/s	GPS
Vehicle heading	deg	C-100 and GPS

In addition to the measured variables, several derived variables are calculated.

Corrected/fast relative humidity (%)
Relative humidity is adjusted to the fast temperature following Richardson et al. (1998) and Houston et al. (2016). This adjustment differs between CoMeT-1 and the other two CoMeTs.

CoMeT-1
Corrected/fast relative humidity is calculated using,

$$RH = 100\frac{e}{e_s} \tag{1}$$

where vapor pressure and saturation vapor pressure are calculated using the Wexler (1976) formulation fitted by Bolton (1980):

$$e_* = 6.112\, exp\left[\frac{17.67 \cdot T_*}{243.5 + T_*}\right]. \tag{2}$$

For e, the slow dew point temperature (T_{d-slow}) is used for T_* in (2) and is calculated using

$$T_d = \frac{257.14\gamma}{18.678 - \gamma} \tag{3}$$

where

$$\gamma = ln(0.01 \cdot RH_*) + T_* \frac{18.678 - \frac{T_*}{234.5}}{257.14 + T_*} \tag{4}$$

where slow temperature (T_s) and slow RH_{slow} are used for T_* and RH_*, respectively. For e_s, fast temperature (T_{fast}) is used in (2).

CoMeT-2 and CoMeT-3
As with CoMeT-1, corrected/fast relative humidity RH_{fast} uses (1) but dew point temperature is calculated within the logger using

$$T_d = \frac{A_3\, ln\left(\frac{e}{A_2}\right)}{A_2 - ln\left(\frac{e}{A_1}\right)} \text{ (Campbell Scientific manual)} \tag{5}$$

where $A_1 = 0.61078$, $A_2 = 17.558$, and $A_3 = 241.88$ and both e and e_s are calculated within the logger using the expression from Lowe (1977):

$$e_* = B_0 + B_1T + B_2T^2 + B_3T^3 + B_4T^4 + B_5T^5 + B_6T^6 \tag{6}$$

where $B_0 = 6.107799961$, $B_1 = 4.436518521 \times 10^{-1}$, $B_2 = 1.428945805 \times 10^{-2}$, $B_3 = 2.650648471 \times 10^{-4}$, $B_4 = 3.031240396 \times 10^{-6}$, $B_5 = 2.034080948 \times 10^{-8}$, and $B_6 = 6.136820929 \times 10^{-11}$.

Water vapor mixing ratio (g/kg)
For all CoMeTs, water vapor mixing ratio q_v is calculated using (2), with T_{fast}, and RH_{fast}, described above, to get e and

$$q_v = 62.2\frac{e}{p}. \tag{7}$$

to get q_v.

Dew point temperature (°C)
CoMeT-1
The reported dew point temperature is calculated using (3) and (4) with T_{fast} and RH_{fast} for T_* and RH_*, respectively.

CoMeT-2 and CoMeT-3
The reported dew point temperature is calculated using (6) with T_{slow} to calculate e_s, (7) with RH_{slow} to calculate e, and (5) to calculate T_{d-slow}.

Potential temperature (Kelvin)

$$\theta = T_{fast}\left(\frac{10^5}{p}\right)^{\frac{R_d}{C_{pd}}}$$

Virtual potential temperature (Kelvin)

$$\theta_v = \theta(1 + 0.61q_v)$$

Equivalent potential temperature (Kelvin)
The expressions use for the calculation of equivalent potential temperature are from Bolton (1980):

$$\theta_e = T_m \, exp\left[\left(\frac{3376}{T_{LCL}} - 2.54\right) q_v(1 + 0.81q_v)\right]$$

$$T_m = \theta\left(\frac{T_{fast} + 273.15}{\theta}\right)^{0.286q_v}$$

$$T_{LCL} = 55 + \frac{2840}{3.5\, ln\left(T_{fast} + 273.15\right) - ln(e) - 4.805}$$

Regular intercomparisons between all three CoMeTs were performed during TORUS 2019. Comparisons were also conducted between CoMeT-1 and CoMeT-2 during LAPSE-RATE (2018) on 14 July. In these intercomparisons, the vehicles were parked adjacent to each other aligned perpendicular to (and facing into) the wind. To minimize engine heating effects, intercomparisons were only conducted when the wind speed was >10 kts.

Data Format

Original data files for each deployment are saved as text files and then converted to NetCDF. NetCDF versions have units that are CF compliant and may not match the original units in the txt files. The naming convention for the NetCDF files is as follows:

UNL.CoMeT3.{YYYYMMDD}.{HHMM}.L2_2024.{post-processing codes}.cdf

Example: UNL.CoMeT3.20190627.1931.L2_2024.g1.f1.cdf

The date and time correspond to the start of observation collection (in UTC). Post-processing codes are included to track modifications to the raw data. These codes are closely connected to error flags associated with each record. Each letter corresponds to a particular instrument:

- g: GPS
- p: Barometer
- tf: Fast temperature
- ts: Slow temperature
- rh: Relative humidity
- f: Compass
- w: Wind monitor
- a: All instruments

Each number corresponds to a particular post-processing action described below.

Measured and derived variables are included in the following table.

Variable Heading	Standard Name	Units
time	Time	seconds since 00:00:00, 01-01-1970
Alt	Altitude	meters
lat	Latitude	degrees north
lon	Longitude	degrees east
fast_temp	Air Temperature	kelvin
slow_temp	Air Temperature	kelvin
pressure	Air Pressure	pascals
logger_RH	Relative Humidity	percent
calc_corr_RH	Relative Humidity	percent
wind_speed	Wind Speed	meters per second
wind_dir	Wind From Direction	degrees
vehicle_dir	Vehicle Direction	degrees
dewpoint	Dew Point Temperature	kelvin
mixing_ratio	Humidity Mixing Ratio	g/g
theta	Air Potential Temperature	kelvin
theta_v	Virtual Potential Temperature	kelvin

theta_e	Equivalent Potential Temperature	Kelvin
error_flag		

The error_flag variable is a string that ties into the post-processing codes listed above. Not all post processing codes relevant for a particular file are applied to all records. Thus, error flags could differ across records for a given file.

All instruments will have an associated code but will have a "0" if the datum is unaffected by post processing. The format for a record's error flag is as follows:

a#-g#-p#-tf#-ts#-rh#-w#-f#

where the letter corresponds to a particular instrument (see above) and "#" is a number reflecting the bitwise accumulation of post processing corrections.

Level	Bits
1	1
2	2
3	4
4	8

For example, if the pressure sensor has undergone level 1 and level 3 processing for a given record, the "p" error flag for that record would be "p05". If the sensor has undergone level 2 and level 4 post processing, the error flag for that record would be "p10".

Post-Processing Codes

Code		
Instrument	**Level**	**Description**
a	1	Exact correction. Intermittent missing data reprocessed from raw data
g	1	Exact correction. GPS position reprocessed from raw data
	2	As far as we can tell this is an exact correction to an error in the GPS time. During the corrected time periods the time suddenly went backwards ~250s and stayed at this offset for 750s when it corrected itself. The offset was applied to the "time warp" period.
	3	Exact correction. Vehicle speed was improperly logged so it's reprocessed from raw data.
p	1	Approximate correction. Hole in the pressure tube connecting the pressure port to the barometer. Resulted in erroneously low air pressure measurements when the vehicle was in motion. Derived variables recalculated (water vapor mixing ratio, potential

		temperature, virtual potential temperature, equivalent potential temperature)
	2	No correction, data removed. Malfunctioning pressure sensor or raw data not archived to perform pressure correction. Replaced pressure, water vapor mixing ratio, potential temperature, virtual potential temperature, and equivalent potential temperature with missing value.
	3	Approximate correction. A bias in pressure as a function of flow speed across the Gill pressure port was discovered. The correction was developed by S. Waugh: $p = p_0 + 5 \times 10^{-7}\ V^3 - 1 \times 10^{-3}\ V^2 - 6 \times 10^{-5}\ V$ where p_0 is the uncorrected pressure in hPa and V is the vehicle-relative flow (raw anemometer speed) in m/s.
	4	Approximate correction. A bias in pressure as a function of flow speed across the NSSL (aluminum) pressure port was discovered. The correction was developed by S. Waugh: $p = p_0 + 3.5 \times 10^{-5}\ V^3 - 5 \times 10^{-4}\ V^2 + 4.5 \times 10^{-3}\ V$ where p_0 is the uncorrected pressure in hPa and V is the vehicle-relative flow (raw anemometer speed) in m/s.
f	1	No correction, missing data. Fluxgate compass inoperable. Heading replaced by GPS heading. When the vehicle is stationary, wind speed and direction are ordinarily calculated using the fluxgate compass heading but, for this error, winds when stationary are calculate using GPS-derived vehicle heading
ts	1	Approximate correction. Constant correction of **-0.6K** implemented. Derived variables recalculated (corrected/fast relative humidity, dew point temperature, water vapor mixing ratio, virtual potential temperature, equivalent potential temperature)
	2	Approximate correction. Constant correction of **-1.1K** implemented. Derived variables recalculated (corrected/fast relative humidity, dew point temperature, water vapor mixing ratio, virtual potential temperature, equivalent potential temperature)
	3	Approximate correction. A hard-wired correction of -1.4K was applied in 2023 to CoMeT-1 slow temperature. Subsequent analysis showed that this correction should have been -1.1K so a **+0.3K** correction is applied here to compensate. Derived variables recalculated (corrected/fast relative humidity, dew point temperature, water vapor mixing ratio, virtual potential temperature, equivalent potential temperature)

	4	No correction, data removed. Replaced slow temperature, corrected/fast relative humidity, dew point temperature, water vapor mixing ratio, virtual potential temperature, and equivalent potential temperature with missing value.
tf	1	No correction, data removed. Replaced fast temperature, corrected/fast relative humidity, dew point temperature, water vapor mixing ratio, potential temperature, virtual potential temperature, and equivalent potential temperature with missing value.
rh	1	Approximate correction. Constant correction of **-1.4%** implemented. Derived variables recalculated (corrected/fast relative humidity, dew point temperature, water vapor mixing ratio, virtual potential temperature, equivalent potential temperature)
	2	No correction, data removed. Replaced slow RH, corrected/fast relative humidity, dew point temperature, water vapor mixing ratio, virtual potential temperature, and equivalent potential temperature with missing value.
w	1	Approximate correction. Recalculation of winds because WNDDIROFF (used in the logger script) was wrong.
	2	Approximate correction. Large spikes in wind speed are removed. Done through correction to u and v and, thus, wind direction is also corrected.
	3	No correction, missing data.

P1 Correction

For the CoMeT-2 data collected during LAPSE-RATE (2018), a hole in the pressure tube required a correction to the pressure and fields derived using pressure. To correct this error, observations from times when CoMeT-1 and CoMeT-2 were in motion and in close proximity were used to evaluate the level of inaccuracy of the CoMeT-2 measurement. Here "close proximity" was defined as any observations within 25 meters of the same point, measured within 90 seconds of one another. The observations with the smallest distance between them were used, and duplicates were removed such that an observation from either vehicle was not used twice. The pressure difference and CoMeT-2 anemometer speed were then aligned with those from CoMeT-1 using a 2nd order polynomial (Fig. 1). The polynomial fit was used to calculate a pressure correction for all CoMeT-2 data obtained when the vehicle was in motion and the anemometer speed was greater than 10 m/s.

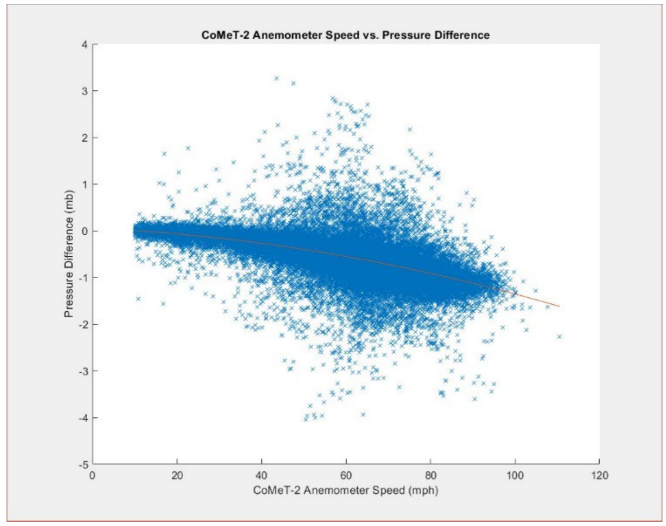

Figure 1. Scatterplot of CoMeT-2 pressure error as a function of anemometer speed. The 2nd-order polynomial fit (red curve) was used for the error correction.

TS1 Correction

For the CoMeT-1 data collected during LAPSE-RATE (2018), an approximately constant slow temperature bias of +0.6 K was diagnosed using an intercomparison 16:00-16:30 Z on 19 July. As reflected in the table below, when comparing slow temperature for CoMeT1 to other temperature sensors, RMSE minimization occurred for a bias of ~0.6 K.

	T fast CoMeT1-	T slow CoMeT-1	T fast CoMeT-2	T slow CoMeT-2
T fast CoMeT-1	0	0.4	-0.35	-0.05
T slow CoMeT-1	-0.4	0	-0.8	-0.5
T fast CoMeT-2	0.35	0.8	0	0.3
T slow CoMeT-2	0.05	0.5	-0.3	0
Average*	**0.2**	**0.57**	**-0.325**	**0.125**

* Average does not include "diagonal" values

TS2 Correction

For the CoMeT-1 data collected during TORUS (2019 and 2022) and TORUS-LItE (2023) an approximately constant slow temperature bias of +1.1 K was diagnosed using designated intercomparisons and "in-motion" comparisons. Average biases computed across multiple temperature sensors and across all three CoMeTs appear below. While biases were a little larger in 2022, a value of 1.1 is used for consistency.

		CoMeT-1		CoMeT-2		CoMeT-3	
Date	**Time**	**T fast**	**T slow**	**T fast**	**T slow**	**T fast**	**T slow**
5/17/2019	20:25-20:30	0.025	1.067	-0.125	0.100	NaN	NaN
5/28/2019	20:22-20:27	0.062	1.120	0.000	0.062	-0.075	-0.050
6/2/2019	23:03-23:08	-0.088	1.050	-0.100	0.225	-0.125	0.088
6/13/2019	19:06-19:11	-0.075	1.070	-0.075	0.113	-0.075	0.113
	Average	**-0.019**	**1.077**	**-0.075**	**0.125**	**-0.092**	**0.050**
5/23/2022	19:45-19:58	0.088	1.400	-0.113	-0.125	-0.050	0.200
5/30/2022	16:50-17:30	0.037	1.180	0.037	0.037	-0.088	-0.025
6/7/2022	20:38-20:48	0.450	1.420	-0.088	-0.163	-0.075	-0.125
6/9/2022	23:22-23:40	0.100	1.020	0.037	-0.150	-0.025	0.037
6/11/2022	22:40-22:55	0.163	1.530	0.225	0.300	-0.325	-0.363
	Average	**0.167**	**1.310**	**0.020**	**-0.020**	**-0.113**	**-0.055**
5/23/2023	18:45-19:05	0.200	1.030	-0.163	0.238	-0.038	-0.238
5/26/2023	20:05-20:15	-0.088	0.970	-0.088	0.100	0.037	0.037
6/11/2023	19:20-19:45	0.000	1.170	-0.125	0.062	0.125	-0.063
6/13/2023	20:35-20:45	-0.050	1.060	-0.113	0.012	0.075	0.075
6/15/2023	21:30-21:40	-0.013	1.370	-0.200	0.050	0.050	0.113
	Average	**0.010**	**1.120**	**-0.138**	**0.092**	**0.050**	**-0.015**

RH1 Correction
For the CoMeT-1 data collected during LAPSE-RATE (2018) and TORUS-LItE (2023) an approximately constant bias in slow RH of +1.4% was identified.

		CoMeT-1		CoMeT-2		CoMeT-3	
Date	**Time**	**RH fast***	**RH slow**	**RH fast**	**RH slow**	**RH fast**	**RH slow**
7/19/2018	16:00-16:30		**1.075****	**0.025**	**-1.1**	**NaN**	**NaN**
5/17/2019	20:25-20:30		0.675	0.075	-0.750	NaN	NaN
5/28/2019	20:22-20:27		0.725	-0.025	-0.363	-0.075	-0.263
6/2/2019	23:03-23:08		0.825	0.200	-0.988	0.388	-0.425
6/13/2019	19:06-19:11		0.663	0.213	-0.225	-0.100	-0.550
	Average		**0.722**	**0.116**	**-0.581**	**0.071**	**-0.413**
5/23/2022	19:45-19:58		-0.175	0.263	0.200	0.325	-0.613
5/30/2022	16:50-17:30		-0.088	-0.525	-0.525	0.725	0.413
6/7/2022	20:38-20:48		-0.113	-0.188	0.000	0.100	0.200
6/9/2022	23:22-23:40		0.925	-0.263	0.363	-0.400	-0.625
6/11/2022	22:40-22:55		-0.013	-0.900	-1.263	1.050	1.125

	Average		**0.107**	**-0.323**	**-0.245**	**0.360**	**0.100**
5/23/2023	18:45-19:05		0.975	0.350	-0.825	-0.525	0.025
5/26/2023	20:05-20:15		1.300	0.175	-0.513	-0.450	-0.513
6/11/2023	19:20-19:45		1.200	0.250	-0.438	-0.750	-0.263
6/13/2023	20:35-20:45		1.450	0.025	-0.575	-0.488	-0.413
	Average		**1.317**	**0.200**	**-0.588**	**-0.553**	**-0.291**

* Fast RH from CoMeT-1 is not included because it's negatively impacted by the bias in slow temperature

** Even though this value is less than 1.4%, the bias when compared to slow RH from CoMeT-2 is 1.45%.

Other potential sources of error

Although not flagged in the QC'd data, temperature and relative humidity data when the CoMeTs are stationary should be treated with caution. Generally, CoMeT operators try to direct the vehicle into the wind to minimize the impact of the vehicle (heated exterior, engine heat, exhaust from the air conditioner, engine exhaust, etc.) on temperature and humidity. However, this is not always done and, even when it is, light winds may be insufficient to mitigate these external influences.

Wind speed and direction are suspected to be less accurate when the vehicle speed or direction changes rapidly. This is likely a consequence of a lagged GPS response. These instances are not flagged in QC'ing so it is the user's responsibility to assess the consistency in wind speed and direction across these times.

Differences compared to previous QC'ing

LAPSE-RATE and TORUS-2019 data were previously QC'd and made available between 2020 and 2021. Differences between the current QC'd data and the previous QC'd data are quantified in the succeeding table.

PROJECT	date_time	CoMeT	Dewpoint Diff	Θe Diff	Θv Diff	U Diff	V Diff
LAPSE-RATE	7/14/2018 14:18	1	-0.067	-0.20401	0.026978	-0.02972	0.042597
LAPSE-RATE	7/14/2018 15:44	1	-0.2447	-0.60898	-0.01398	0.05124	0.131225
LAPSE-RATE	7/14/2018 17:29	1	-0.1399	-0.46298	-0.022	0.026145	-0.15745
LAPSE-RATE	7/14/2018 15:14	2	0	0	0	0	0
LAPSE-RATE	7/15/2018 13:19	1	-0.1926	-0.375	0.024017	-0.01508	-0.00308
LAPSE-RATE	7/15/2018 13:55	2	0	-0.01663	-0.00754	0	0
LAPSE-RATE	7/16/2018 13:38	1	0.1872	0.516998	0.130005	-0.23786	-0.40298
LAPSE-RATE	7/16/2018 13:20	2	0	-0.00613	-0.00824	0	0
LAPSE-RATE	7/17/2018 13:03	1	-0.0226	-0.043	0.057983	1.15312	-0.15323
LAPSE-RATE	7/17/2018 12:09	2	0	0	0	0	0

LAPSE-RATE	7/18/2018 12:06	1	-0.01778	0.024994	0.034027	-0.33188	-0.39453
LAPSE-RATE	7/18/2018 12:48	2	0	-0.00742	-0.0069	0	0
LAPSE-RATE	7/19/2018 11:05	1	-0.03652	-0.09299	-0.02798	-0.0254	0.150163
LAPSE-RATE	7/19/2018 11:19	2	0	-0.00806	-0.00671	0	0
TORUS	5/17/2019 15:58	1	0.0027	-0.065	0.061005	0.019958	0.312443
TORUS	5/17/2019 16:04	2	0	-0.00095	0.008423	0	0
TORUS	5/18/2019 20:28	1	0.7082	1.49402	0.14801	1.86523	-0.86962
TORUS	5/18/2019 20:29	2	0	0.034363	0.023468	0	0
TORUS	5/20/2019 14:38	1	0.1362	0.143005	0.026001	-0.90726	-0.52415
TORUS	5/20/2019 16:20	1	0.583099	1.33899	0.068024	-2.11135	0.362388
TORUS	5/20/2019 18:58	1	0.6047	1.504	0.078003	0.174139	-1.10821
TORUS	5/20/2019 16:18	2	0	0.031342	0.017578	0	0
TORUS	5/22/2019 18:57	1	0.6665	1.54602	0.075989	-0.1752	0.133514
TORUS	5/22/2019 22:39	1	0.5357	1.23401	0.020996	-1.62183	0.550154
TORUS	5/22/2019 17:15	2	0	3.05E-05	0.007324	0	0
TORUS	5/23/2019 16:23	1	0.500999	1.255	0.102997	-0.48476	-0.11945
TORUS	5/23/2019 16:22	2	0	0.16629	0.09848	0	0
TORUS	5/24/2019 16:54	1	0.1072	0.019989	-0.095	0.846416	0.529714
TORUS	5/24/2019 16:44	2	0	0.010223	-0.0007	0	0
TORUS	5/25/2019 15:26	1	0.539101	1.31	0.122009	-0.53879	0.105918
TORUS	5/25/2019 18:19	2	0	0.222748	0.141693	0	0
TORUS	5/25/2019 18:54	3	0	NaN	NaN	11.8096	74.702
TORUS	5/26/2019 14:57	1	0.0259	-0.09698	0.026001	-2.3728	-1.28946
TORUS	5/26/2019 15:29	2	0	0.132294	0.068756	0	0
TORUS	5/26/2019 19:36	3	0	NaN	NaN	-33.381	49.2032
TORUS	5/26/2019 21:27	3	0	NaN	NaN	0.004802	1.53818
TORUS	5/27/2019 16:55	1	0.501	0.878998	0.004974	0.619075	0.385037
TORUS	5/27/2019 16:38	2	0	0.004852	-0.00946	0	0
TORUS	5/27/2019 20:39	2	0	0.033295	0.013641	0	0
TORUS	5/27/2019 19:31	3	0	0.108337	0.080322	44.5941	-30.8772
TORUS	5/28/2019 20:21	1	0.7313	1.798	0.153015	0.056923	-0.01319
TORUS	5/28/2019 16:08	2	0	0.172577	0.113617	0	0
TORUS	5/28/2019 17:55	3	0	0.207855	0.126038	-52.0385	39.5859
TORUS	6/2/2019 15:30	1	-0.0295	-0.125	0.026001	0.208821	1.33413
TORUS	6/2/2019 15:33	2	0	-0.01498	-0.00662	0	0
TORUS	6/2/2019 15:45	3	0	0.002594	-0.00125	0	0
TORUS	6/8/2019 16:06	1	0.0536	-0.039	-0.00098	-1.64887	-1.09617
TORUS	6/8/2019 16:18	2	0	0.051148	0.032623	0	0
TORUS	6/8/2019 16:23	3	0	0.289612	0.196686	0	0
TORUS	6/11/2019 17:09	1	0.22494	0.467987	0.129974	3.04941	-2.39412
TORUS	6/11/2019 16:56	2	0	-0.00922	-0.00449	0	0

TORUS	6/11/2019 17:19	3	0	0.232971	0.17453	0	0
TORUS	6/13/2019 19:06	1	0.213201	0.365021	0.042999	-0.97021	0.313331
TORUS	6/14/2019 2:07	1	0.7243	1.336	0.133972	-1.86884	-1.19982
TORUS	6/13/2019 17:13	2	0	0.053467	0.05838	0	0
TORUS	6/13/2019 16:34	3	0	0.165833	0.123383	0	0
TORUS	6/14/2019 16:48	1	0.863601	1.68198	0.052979	-2.53794	-0.7931
TORUS	6/14/2019 17:21	2	0	-0.03253	-0.00562	0	0
TORUS	6/14/2019 18:16	3	0	0.132477	0.101013	0	0
TORUS	6/15/2019 18:20	1	0.6826	1.67902	0.085999	0.409099	-0.42689
TORUS	6/15/2019 18:04	2	0	-0.03149	-0.0029	0	0
TORUS	6/15/2019 18:12	3	0	0.0448	0.041107	0	0

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