Draconids

Video observation of Draconids 2011 from Italy

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The joint observation of Draconids 2011 by one all-sky video camera of the Slovak Video Meteor Network (SVMN), cameras of the Central European Meteor Network (CEMeNt), the Polish Fireball Network and local Italian Meteor and TLE Network in the night of October 8–9 brought hundreds of detected meteors over Italy. Due to the problematic weather situation in Central Europe, several groups had to move up and locate their video equipment in the Northern Italy to become a part of a ground-based observational Draconids 2011 campaign. This enthusiasm and effort resulted in valuable observations, of which results are presented in this brief paper.

Received 2012 January 20

1 Introduction

The Draconid meteor shower belongs to established low level annual meteor showers, which are capable of producing outbursts or even meteor storms. The parent comet 21P/Giacobini-Zinner was discovered in 1900 and following dust ejecta modeling showed a possible outburst in activity on 2011 October 8 (Watanabe & Sato, 2008; Vaubaillon et al., 2011). The Draconids are one of the slowest meteor streams and the most fragile material (Borovička et al., 2007). An observational campaign from air and ground was needed. Due to uncertain weather conditions in Central Europe, several groups of observers have moved to Northern Italy, among them also the members of the Slovak Video Meteor Network (SVMN – Comenius University Bratislava) and of the Central European Meteor Network (CEMeNt – an amateur network consisting of several observers from the Czech Republic and Slovak Republic) and also members of the Polish Fireball Network (PFN). Later, common video meteors were identified also from the local Italian Meteor and TLE Network (IMTN).

2 Observations

We set up double-station observation performed by one all-sky video camera developed and constructed at the Astronomical and Geophysical Observatory in Modra (SVMN) and three video cameras of the CEMeNt network. The equipment of SVMN and CEMeNt was described in Tóth et al. (2008, 2011a, 2011b). The first station was located near the town Bettola (44°.7948 N, 9°.6244 E), the second one close to the village of Cavandola (44°.5658 N, 10°.4652 E) at a distance of 71 km east from the first station. Independently, double-station video observations were set up from PFN in location Nogara (45°.1569 N, 11°.0925 E) and the second station close to the town of Bettolino di Novellara (44°.8864 N, 10°.7750 E) 39 km to the south-west from Nogara. Local Italian video stations of the IMTN, where we were able to find common meteors were located at Cuneo Associazione Astrofili Bisalta (44°.3957 N, 7°.5174 E), Fanano (Modena) (44°.2120 N, 10°.7559 N), Contigliano (Rieti) (42°.41141 N, 12°.7682 E), Tortoreto (Teramo) (13°.9350 E, 42°.8075 N) and Ferrara (44°.8181 N, 11°.6167 E). Visual observations were performed from the station of Cavandola. In total, there were 9 stations with 14 cameras participating on this joint campaign. The location of stations is shown in Figure 1.

Figure 1 – Location of ground-based video meteor stations of the SVMN, CEMeNt, PFN and IMTN in Northern Italy during the Draconids 2011.

3 Detection and data reduction

Video signals from the majority of cameras were detected by the UFOCapture software (SonotaCo, 2009), which is able to recognize meteors and bolides from camera analogue or digital signal. The meteor data were astrometrically analyzed by each experienced observer by using the UFOAnalyzer (SonotaCo, 2009) and the data from two Polish stations were recorded and analyzed by the Metrec software (Molau, 1999). These data were later transformed to the UFOOrbit format. The following results were obtained by the UFOOrbit software (SonotaCo, 2009). The meteor

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IMO bibcode WGN-404-toth-draconids
NASA-ADS bibcode 2012JIMO...40..117T

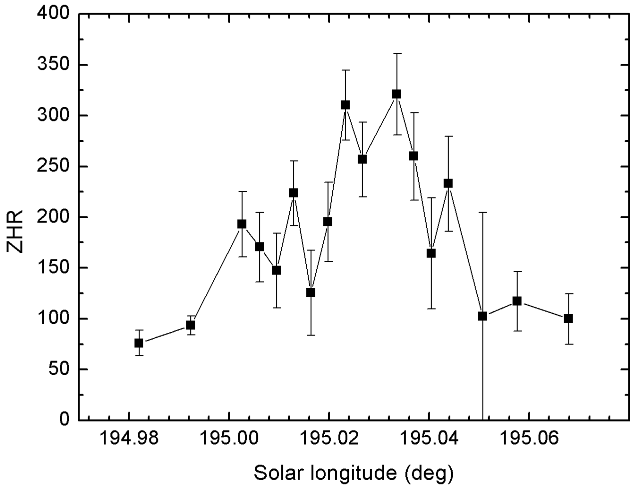

Figure 2 – Visual activity profile of the Draconids (2011 October 8–9) from the station Cavandola derived by J. Koukal.

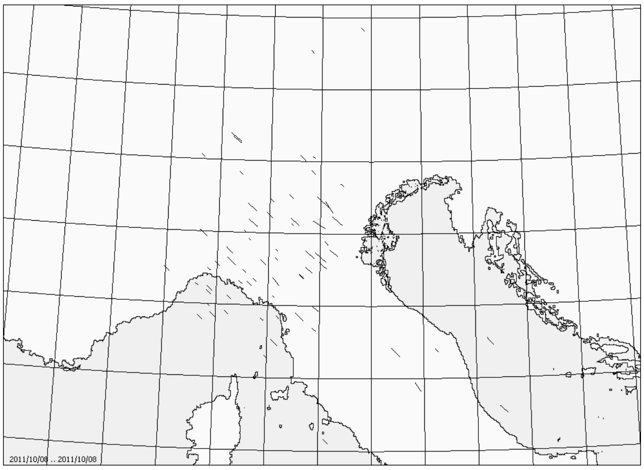

Figure 3 – Ground projection of the detected Draconid trails.

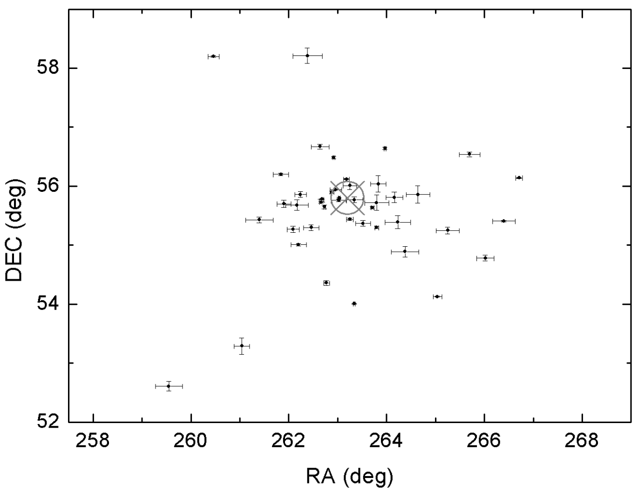

Figure 4 – Individual geocentric radiant positions (J2000.0) distribution of the Draconids in right ascension (RA) and declination (DEC). The expected radiant position $\alpha = 263\overset{\circ}{.}2$ and $\delta = 55\overset{\circ}{.}8$ according to Vaubaillon (2011a) is depicted as $\otimes$.

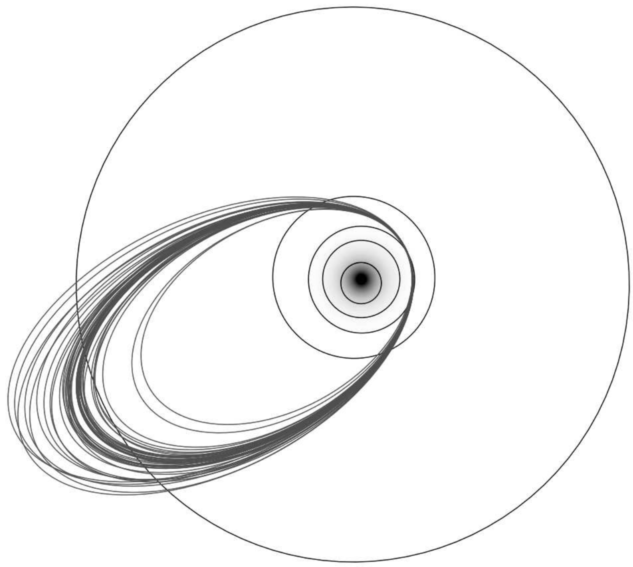

Figure 5 – Orbits of multi-station Draconids detected by video stations, derived by the UFOOrbit software. The orbits are projected onto the ecliptic plane. The orbits of Jupiter and the inner planets are also plotted. The direction to the vernal equinox is from the center to the right.

observations were performed during the maximum activity of the Draconids (2011 October 8–9), when 62 meteors were observed simultaneously at least from two stations.

During the observational interval the elevation of the Draconid radiant has changed from 68 to 29 degrees.

4 Results

The visual activity profile of the observed Draconids was derived according to IMO standards from the station Cavandola by J. Koukal (Figure 2). Observations were performed in 5 to 15 minutes intervals from $18^{h}45^{m}$ to $21^{h}05^{m}$ UT. There appeared two peaks at $19^{h}50^{m}$–$19^{h}55^{m}$ UT and at $20^{h}05^{m}$–$20^{h}10^{m}$ UT with ZHR of about 310 and 320, respectively. The mean population index of the Draconids was calculated as 2.62 ± 0.27 from the visual magnitude distribution in the interval -2 to $+5.5$ magnitude.

As was mentioned above, 62 meteors were identified as Draconids, simultaneously observed by video techniques in the time interval from $17^{h}56^{m}$ to $23^{h}22^{m}$ UT on October 8. The ground projection of the individual meteor trails as seen by the multi-station observation is depicted in Figure 3. After the precise reduction and inspection, 43 Draconids with sufficient precision were selected. An additional 19 possible Draconids were excluded due to small convergence angle of planes, small number of measured meteor positions or other geometrical and astrometrical issues which led to large trajectory uncertainty.

The orbit precision depends mostly on the accuracy of the velocity determination. Due to fragmentation of the Draconid meteoroids in the atmosphere and following deceleration, the measurement of meteor velocities was problematic and could be determined with large uncertainties. Therefore, according to Borovička et al. (2007) and Koten et al. (2007) we assumed the initial velocity of the Draconids as 23.57 $\mathrm{km\,s^{-1}}$. This value was obtained from very precise photographic measurement of the Draconid fireball EN081005B in 2005 (Koten et al., 2007). The relevance of the assumption is supported by velocity fitting in several cases, where we were able to

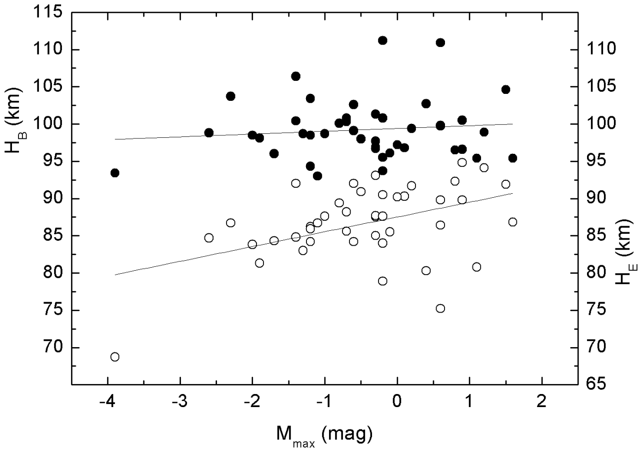

Figure 6 – The beginning (black circles) and terminal heights (open circles) of Draconids as a function of the absolute maximum brightness.

determine the deceleration in our video data. The geophysical data (geocentric radiant and velocity, absolute maximum brightness, beginning and terminal height) of 43 Draconids are listed in Table 1 and the orbital parameters are shown in Table 2 also with their standard deviations. The absolute brightness was determined with a lower precision of about ±1 magnitude and an error in the height of ±0.2 km. In Table 2, there is also presented the orbit of the parent comet 21P/Giacobini-Zinner obtained by a numerical integration from the epoch of comet's perihelion passage in 1900 to Oct., 2011. Individual geocentric radiant equatorial coordinates are shown in Figure 4. The mean radiant is $\alpha = 263\overset{\circ}{.}25 \pm 1\overset{\circ}{.}47$, $\delta = 55\overset{\circ}{.}61 \pm 1\overset{\circ}{.}00$. This is in good agreement with the expected radiant $\alpha = 263\overset{\circ}{.}2 \pm 0\overset{\circ}{.}2$ and $\delta = 55\overset{\circ}{.}8 \pm 0\overset{\circ}{.}2$ according to the model of Vaubaillon (2011a).

The heliocentric orbits projected on to the ecliptic plane are shown in Figure 5.

The beginning and endpoint heights as a function of the absolute maximum brightness of the Draconids are presented in Figure 6 and in the equation (1)

$$\begin{aligned} H_\mathrm{B} &= 99.4(\pm 0.7) + 0.4(\pm 0.5)\ M_\mathrm{max} \\ H_\mathrm{E} &= 87.5(\pm 0.8) + 2.0(\pm 0.6)\ M_\mathrm{max}, \end{aligned} \qquad (1)$$

where H_B stands for the beginning height (km), H_E for the endpoint height (km) and M_max for the absolute maximum brightness (mag). However, the beginning heights do not change too much, which is a surprising result and will need detailed inspection. Naturally, the endpoint heights decrease with increasing brightness, which is standard for meteor showers.

5 Conclusion

We present geophysical data and heliocentric orbits of 43 Draconids obtained from multi-station video observations by the cameras of the Slovak Video Meteor Network (SVMN), the Central European Meteor Network (CEMeNt), the Polish Fireball Network and local Italian Meteor and TLE Network employed in Italy during the expected enhanced display of the Draconids on 2011 October 8. Comparison of the meteor shower orbits with the proposed parent body comet 21P/Giacobini-Zinner (JPL NASA) indicates a very close similarity. This work is a nice example of new video observations and cooperation of the networks in Poland, Czech Republic, Slovak Republic and Italy, which monitor regular and exceptional meteor activity as in the case of the Draconids 2011.

Acknowledgment This work was supported by the VEGA grant No. 1/0636/09, APVV-0516-10 grant and grant of Jozef Klačka. We greatly appreciate the help of Peter Vereš and video observations and data analysis done by professional and amateur astronomers of the video meteor networks and broad international cooperation and smooth data sharing.

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Handling Editor: Javor Kac

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Table 1 – Double and multi-station Draconids detected on 2011 October 8 by joint ground based video expedition in Italy. Individual geocentric radiants α_G, δ_G (J2000.0), V_g – geocentric velocity (computed with the assumed $v_\infty = 23.57$ km s^{-1}), M_{max} – absolute maximum brightness, H_B – beginning and H_E – endpoint height of meteors as well as acronyms of observing cameras are presented. Cameras: Bettola – all sky (BA), Bettola – north (BN), Bettola – south (BS), Cavandola – south (CS), Cavandola – north (CN), Nogara (Pa), Cuneo Ass. Astrofili Bisalta (CU), Ferrara south (FEs), Ferrara north-west (FEn), Fanano (FA), Fanano zenith (FAz), Contigliano – Rieti (TUs3), Teramo north (TUn), Teramo west (TUw). The mean geocentric radiant, the mean geocentric velocity, the mean beginning and terminal height in the observing time interval ($17^h55^m50^s$–$23^h21^m53^s$ UT) are also presented.

No	Time [UT]	α_G [°]	δ_G [°]	V_g [km s^{-1}]	M_{max} [mag]	H_B [km]	H_E [km]	Camera
1	17:55:50	263.80 ± 0.04	55.30 ± 0.02	20.85 ± 0.32	−1.2	103.4	86.2	BA-FEs
2	17:56:04	260.46 ± 0.11	58.20 ± 0.01	20.86 ± 0.76	−0.1	96.1	85.5	BA-CS
3	18:14:50	262.64 ± 0.18	56.67 ± 0.04	20.88 ± 1.09	−1.7	96.0	84.3	TUs3-FEs
4	18:28:11	263.18 ± 0.06	56.12 ± 0.01	20.88 ± 0.36	+1.1	95.4	80.8	CS-FAz
5	18:39:34	266.40 ± 0.23	55.41 ± 0.01	20.88 ± 1.41	+0.8	96.5	92.3	BA-CS
6	18:42:54	265.04 ± 0.09	54.13 ± 0.01	20.89 ± 0.53	−0.3	97.7	87.5	BA-CS
7	19:04:44	261.40 ± 0.28	55.43 ± 0.05	20.91 ± 1.39	+0.6	110.9	75.2	Pa-CN
8	19:07:16	263.34 ± 0.02	54.01 ± 0.01	20.91 ± 0.15	−1.1	93.0	86.7	BA-CN
9	19:07:32	262.96 ± 0.12	55.94 ± 0.01	20.90 ± 0.63	−0.3	96.7	85.0	BA-CN
10	19:11:26	259.55 ± 0.28	52.61 ± 0.08	20.93 ± 1.29	−0.2	111.2	78.9	Pa-CN
11	19:22:14	265.70 ± 0.21	56.54 ± 0.04	20.90 ± 1.13	+0.4	102.7	80.3	FA-Pa-BS
12	19:22:30	262.20 ± 0.16	55.01 ± 0.02	20.92 ± 0.68	−0.3	96.9	87.7	BA-CU
13	19:23:20	261.84 ± 0.16	56.20 ± 0.02	20.91 ± 0.73	+0.6	99.8	89.8	BA-CS
14	19:39:35	263.34 ± 0.17	55.77 ± 0.05	20.92 ± 0.86	−0.3	101.3	93.1	BS-CS
15	19:49:06	263.02 ± 0.16	55.76 ± 0.02	20.92 ± 0.63	−1.0	98.7	87.6	BA-CS-CU
16	19:58:45	263.52 ± 0.15	55.37 ± 0.05	20.93 ± 0.66	−3.9	93.4	68.7	BA-FEn-CN-BN
17	20:00:24	265.25 ± 0.24	55.25 ± 0.06	20.93 ± 1.04	+0.2	99.4	91.7	BA-CS
18	20:03:22	263.97 ± 0.02	56.64 ± 0.02	20.93 ± 0.10	−0.6	102.6	84.2	BA-FA
19	20:11:32	262.17 ± 0.23	55.68 ± 0.09	20.93 ± 1.05	+1.5	104.6	91.9	BA-CS
20	20:15:01	262.46 ± 0.16	55.30 ± 0.05	20.94 ± 0.68	+0.9	100.5	94.8	BA-CS
21	20:17:30	262.09 ± 0.12	55.27 ± 0.05	20.94 ± 0.47	−2.0	98.5	83.8	BA-TUs3-FEs-BN
22	20:18:27	266.71 ± 0.07	56.14 ± 0.01	20.93 ± 0.26	+1.2	98.9	94.1	BA-CS
23	20:20:07	262.66 ± 0.03	55.73 ± 0.02	20.93 ± 0.14	−1.2	98.5	85.9	BA-CN-BN
24	20:21:09	264.38 ± 0.28	54.89 ± 0.09	20.94 ± 1.17	+0.9	96.6	89.8	BA-CS
25	20:27:46	262.24 ± 0.12	55.86 ± 0.05	20.94 ± 0.58	+0.1	96.8	90.3	BA-CU
26	20:31:13	262.38 ± 0.30	58.21 ± 0.13	20.93 ± 1.29	−1.9	98.1	81.3	BA-CN-BN
27	20:31:40	263.03 ± 0.02	55.80 ± 0.01	20.94 ± 0.07	−0.7	100.3	88.2	BA-CS-CU
28	20:34:38	266.02 ± 0.18	54.78 ± 0.05	20.94 ± 0.66	−2.6	98.8	84.7	BA-CS-CU
29	20:37:03	262.88 ± 0.04	55.90 ± 0.02	20.95 ± 0.13	−2.3	103.7	86.7	TUs3-FEs
30	20:46:56	264.23 ± 0.26	55.39 ± 0.11	20.94 ± 1.06	+1.6	95.4	86.8	BA-CS
31	20:49:14	262.68 ± 0.03	55.78 ± 0.01	20.94 ± 0.01	−1.2	94.3	84.2	BA-CU
32	20:51:52	263.25 ± 0.07	55.44 ± 0.02	20.95 ± 0.16	−1.3	98.7	83.0	BA-CU
33	20:55:30	264.16 ± 0.17	55.81 ± 0.09	20.94 ± 0.74	−0.7	100.8	85.6	BA-CS
34	20:57:36	262.77 ± 0.06	54.36 ± 0.04	20.95 ± 0.25	−1.4	106.4	84.8	BA-CN
35	21:02:48	261.90 ± 0.14	55.70 ± 0.06	20.95 ± 0.47	−0.2	93.7	84.0	BA-CS-CU
36	21:04:05	263.25 ± 0.14	56.01 ± 0.07	20.95 ± 0.57	−0.6	99.1	92.0	BA-CN-BN
37	21:05:29	263.80 ± 0.25	55.72 ± 0.13	20.95 ± 1.06	+0.6	99.7	86.4	BA-CS
38	21:15:24	263.71 ± 0.03	55.64 ± 0.02	20.95 ± 0.16	−0.5	98.0	90.9	BA-CU
39	21:32:38	264.64 ± 0.24	55.86 ± 0.15	20.95 ± 1.04	0.0	97.2	90.2	BA-CS-CU
40	22:01:39	261.04 ± 0.16	53.29 ± 0.14	20.97 ± 0.66	−1.4	100.4	92.0	TUn-TUs3
41	22:22:08	263.83 ± 0.16	56.04 ± 0.14	20.95 ± 0.65	−0.2	100.8	90.5	BA-FAz
42	23:00:36	262.92 ± 0.02	56.49 ± 0.02	20.94 ± 0.03	−0.2	95.5	87.6	TUw-TUs3
43	23:21:53	262.73 ± 0.02	55.65 ± 0.03	20.93 ± 0.15	−0.8	100.1	89.4	BN-FEn
mean		263.25	55.61	20.93		99.2	86.6	
st. dev		1.47	1.00	0.03		4.0	5.1	

Table 2 – Double and multi-station Draconids detected on 2011 October 8 by joint ground based video expedition in Italy. The orbital elements (J2000.0) and observing cameras are presented. Cameras: Bettola – all sky (BA), Bettola – north (BN), Bettola – south (BS), Cavandola – south (CS), Cavandola – north (CN), Nogara (Pa), Cuneo Ass. Astrofili Bisalta (CU), Ferrara south (FEs), Ferrara north-west (FEn), Fanano (FA), Fanano zenith (FAz), Contigliano – Rieti (TUs3), Teramo north (TUn), Teramo west (TUw). The mean orbital elements (J2000.0) from the observing time interval ($17^h55^m50^s$–$23^h21^m53^s$ UT) are also presented. The Draconid fireball EN081005B from 2005 (Koten et al., 2007) is mentioned for comparison as well as the forward integrated orbit (JPL NASA) of the comet 21P/Giacobini-Zinner (1900) to the epoch Oct., 2011.

No	a [AU]	q [AU]	e	i [°]	ω [°]	Ω [°]	Camera
1	3.63 ± 0.25	0.9967 ± 0.0001	0.726 ± 0.019	31.49 ± 0.35	173.84 ± 0.05	194.9437	BA-FEs
2	2.80 ± 0.34	0.9956 ± 0.0001	0.645 ± 0.042	32.64 ± 0.86	172.33 ± 0.20	194.9439	BA-CS
3	3.22 ± 0.69	0.9964 ± 0.0001	0.691 ± 0.064	32.05 ± 1.20	173.41 ± 0.25	194.9568	TUs3-FEs
4	3.39 ± 0.25	0.9966 ± 0.0001	0.706 ± 0.021	31.83 ± 0.40	173.63 ± 0.08	194.9659	CS-FAz
5	3.80 ± 1.33	0.9979 ± 0.0001	0.737 ± 0.085	31.44 ± 1.52	175.69 ± 0.26	194.9737	BA-CS
6	4.16 ± 0.56	0.9971 ± 0.0001	0.760 ± 0.032	31.07 ± 0.56	174.39 ± 0.11	194.9760	BA-CS
7	3.47 ± 0.95	0.9952 ± 0.0001	0.713 ± 0.080	31.71 ± 1.55	172.15 ± 0.43	194.9910	Pa-CN
8	4.07 ± 0.14	0.9961 ± 0.0001	0.756 ± 0.009	31.12 ± 0.16	173.15 ± 0.03	194.9927	BA-CN
9	3.44 ± 0.44	0.9964 ± 0.0001	0.710 ± 0.037	31.81 ± 0.69	173.41 ± 0.17	194.9929	BA-CN
10	4.23 ± 1.55	0.9926 ± 0.0002	0.766 ± 0.078	30.83 ± 1.38	170.04 ± 0.43	194.9955	Pa-CN
11	3.44 ± 0.86	0.9979 ± 0.0001	0.710 ± 0.066	31.90 ± 1.25	175.52 ± 0.27	195.0029	FA-Pa-BS
12	3.65 ± 0.55	0.9956 ± 0.0001	0.728 ± 0.041	31.53 ± 0.74	172.61 ± 0.23	195.0031	BA-CU
13	3.31 ± 0.48	0.9958 ± 0.0001	0.699 ± 0.043	31.96 ± 0.81	172.69 ± 0.23	195.0037	BA-CS
14	3.51 ± 0.64	0.9965 ± 0.0001	0.716 ± 0.050	31.75 ± 0.95	173.63 ± 0.25	195.0148	BS-CS
15	3.50 ± 0.48	0.9964 ± 0.0001	0.716 ± 0.037	31.76 ± 0.69	173.40 ± 0.22	195.0213	BA-CS-CU
16	3.65 ± 0.51	0.9965 ± 0.0001	0.727 ± 0.038	31.62 ± 0.73	173.64 ± 0.21	195.0280	BA-FEn-CN-BN
17	3.81 ± 0.94	0.9974 ± 0.0001	0.738 ± 0.062	31.49 ± 1.13	174.83 ± 0.31	195.0291	BA-CS
18	3.33 ± 0.06	0.9971 ± 0.0001	0.701 ± 0.006	32.03 ± 0.12	174.33 ± 0.03	195.0311	BA-FA
19	3.47 ± 0.76	0.9958 ± 0.0002	0.713 ± 0.060	31.79 ± 1.17	172.77 ± 0.36	195.0367	BA-CS
20	3.60 ± 0.53	0.9959 ± 0.0001	0.724 ± 0.040	31.64 ± 0.75	172.87 ± 0.24	195.0391	BA-CS
21	3.59 ± 0.34	0.9956 ± 0.0001	0.722 ± 0.027	31.65 ± 0.52	172.59 ± 0.17	195.0408	BA-TUs3-FEs-BN
22	3.62 ± 0.20	0.9981 ± 0.0001	0.724 ± 0.015	31.74 ± 0.29	176.09 ± 0.08	195.0415	BA-CS
23	3.49 ± 0.10	0.9961 ± 0.0001	0.715 ± 0.008	31.79 ± 0.16	173.13 ± 0.04	195.0426	BA-CN-BN
24	3.87 ± 1.11	0.9969 ± 0.0002	0.743 ± 0.069	31.42 ± 1.28	174.11 ± 0.37	195.0433	BA-CS
25	3.43 ± 0.39	0.9959 ± 0.0001	0.710 ± 0.033	31.85 ± 0.65	172.87 ± 0.18	195.0479	BA-CU
26	2.91 ± 0.55	0.9967 ± 0.0002	0.657 ± 0.069	32.64 ± 1.52	173.69 ± 0.50	195.0502	BA-CN-BN
27	3.50 ± 0.05	0.9964 ± 0.0001	0.715 ± 0.004	31.80 ± 0.08	173.42 ± 0.03	195.0505	BA-CS-CU
28	4.04 ± 0.62	0.9976 ± 0.0001	0.753 ± 0.039	31.31 ± 0.72	175.23 ± 0.23	195.0526	BA-CS-CU
29	3.47 ± 0.10	0.9963 ± 0.0001	0.713 ± 0.008	31.85 ± 0.14	173.33 ± 0.05	195.0542	TUs3-FEs
30	3.70 ± 0.89	0.9969 ± 0.0002	0.731 ± 0.062	31.61 ± 1.17	174.15 ± 0.36	195.0610	BA-CS
31	3.49 ± 0.10	0.9961 ± 0.0001	0.714 ± 0.010	31.81 ± 0.10	173.16 ± 0.10	195.0626	BA-CU
32	3.62 ± 0.13	0.9964 ± 0.0001	0.725 ± 0.010	31.67 ± 0.18	173.47 ± 0.10	195.0644	BA-CU
33	3.57 ± 0.56	0.9970 ± 0.0001	0.721 ± 0.043	31.75 ± 0.83	174.21 ± 0.25	195.0669	BA-CS
34	3.94 ± 0.23	0.9957 ± 0.0001	0.747 ± 0.015	31.32 ± 0.28	172.82 ± 0.08	195.0683	BA-CN
35	3.46 ± 0.30	0.9956 ± 0.0001	0.712 ± 0.026	31.83 ± 0.51	172.58 ± 0.21	195.0719	BA-CS-CU
36	3.46 ± 0.42	0.9965 ± 0.0001	0.712 ± 0.033	31.87 ± 0.65	173.63 ± 0.20	195.0727	BA-CN-BN
37	3.58 ± 0.81	0.9968 ± 0.0002	0.721 ± 0.060	31.74 ± 1.19	173.93 ± 0.37	195.0737	BA-CS
38	3.60 ± 0.12	0.9967 ± 0.0001	0.723 ± 0.009	31.72 ± 0.18	173.84 ± 0.04	195.0805	BA-CU
39	3.59 ± 0.80	0.9972 ± 0.0002	0.723 ± 0.059	31.76 ± 1.18	174.55 ± 0.35	195.0923	BA-CS-CU
40	4.17 ± 0.68	0.9941 ± 0.0002	0.762 ± 0.038	31.04 ± 0.74	171.28 ± 0.26	195.1122	TUn-TUs3
41	3.49 ± 0.45	0.9968 ± 0.0001	0.714 ± 0.036	31.85 ± 0.76	174.03 ± 0.25	195.1262	BA-FAz
42	3.31 ± 0.10	0.9964 ± 0.0001	0.699 ± 0.010	32.04 ± 0.30	173.51 ± 0.30	195.1526	TUw-TUs3
43	3.51 ± 0.10	0.9961 ± 0.0001	0.717 ± 0.008	31.75 ± 0.18	173.12 ± 0.04	195.1672	BN-FEn
mean	3.58	0.9964	0.720	31.70	173.51		
st. dev	0.29	0.0010	0.023	0.34	1.10		
EN081005B	3.53	0.99606	0.717	31.74	173.25	195.51097	
st. dev	0.07	0.00010	0.005	0.10	0.12	0.00001	
21P	3.519	1.032	0.707	31.905	172.574	195.403	