Leonids

Leonid predictions for the period 2001–2100

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This article provides a set of summaries of what to expect from the Leonid meteor shower for each year of the period 2001–2100. Each summary contains the moments of maximum/maxima, their expected intensity and some comments about average meteor brightness during them. Special attention was paid to background (traditional) maxima, which are characterized with their expected times and intensities.[1]

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1 Introduction

Today meteor shower activity remains one of the most unpredictable astronomical phenomena. Scientists have learned how to make very detailed predictions of such events as solar and lunar eclipses and planetary transits across the Sun. Evolution of the main bodies in the Solar system can be computed for many thousands of years into the past and future; for asteroids such computations are made for at least hundreds of years (the most important purpose being to search for those of them which can collide with the Earth). At the same time, meteor showers, whose activity in astronomical terms occurs literally next to the Earth, continue to surprise us.

During many decades meteor astronomers tried to predict meteor activity using various criteria. But it was a form of guessing. In some cases their expectations were realized, although often meteor activity anyway caused surprise in some aspects (for example, occurring at unexpected times or giving strong fireball activity). Sometimes such forecasts proved to be completely wrong.

The method of meteor activity prediction by computing meteor particle orbital evolution after ejection by a comet become more widespread in the 1990s. Earlier its use was restricted by the low computing abilities of computers. But such Russian forecasters as V.V. Reznikov and E.A. Emel'yanenko had already issued their computations for the Leonids, Draconids, Bielids and some other showers. By the end of the 1990s, when computers became powerful enough, several researchers — Robert MacNaught, David Asher and Esko Lyytinen — published their predictions of Leonid activity for several years nearest to the date of publication.

Of course, mainly due to the lack or inaccuracy of initial orbital elements of parent comets, as well as probable imperfections in the method itself, its reliability is still lower than desired. Serious faults in the accuracy of the time of maximum and especially the intensity of outbursts are still typical for meteor predictions, as well as cases of their failure (the last such situation was with predicting the activity of the Draconids for 2005). Nevertheless, it is obvious that this method is a large step forward compared to predictions based on the distances between the Earth's orbit and the orbital nodes of parent comets and times of their passage by the Earth.

Observational data allowed a model to be built for the calculation of the expected ZHR of meteor outbursts. Such a model, created by E. Lyytinen and T. van Flandern, was taken by us as the base for the computation of the expected intensity of Leonid outbursts.

The results of other researchers in the field of Leonid activity prediction (as well as many other showers) should not be ignored. The author is familiar with predictions by E. Lyytinen and T. van Flandern for a number of years after the comet 55P perihelion in 1998, excellent graphic predictions by J. Vaubaillon (for many Leonid returns in the 19th to 21st centuries, but mainly for around the 1998 and 2031 returns), predictions by D. Asher and R. McNaught (in particular, they were the first who pointed out the probable Leonid enhancements in 2006 and 2007), computations by M. Sato (who helped the author in coordination and refinement of some predictions), and results by I. Sato for a large number of years in the 19th to 21st centuries. This list is far from full, and we apologize to those, who were omitted due to our ignorance. We hope that these prepared predictions will be a good addition to the results of these authors, and the reader will expand his/her knowledge about such a great shower as the Leonids.

2 The Leonid shower

The Leonids are a meteor shower known for its variable activity. The years around parent comet 55P Tempel-Tuttle's returns gave considerable activity enhancements, sometimes up to storm levels. The latest perihelion of 55P was in 1998 and now it is moving to the outer areas of Solar system — its aphelion lies beyond the orbit of Saturn. Significant enhancements in Leonid activity were recorded during the period 1994–2003. In 1999, 2001 and 2002 the shower gave several storms, when the ZHR reached 3000–4000 (ZHR — zenithal hourly rate — the average number of shower meteors an observer can see during one hour when its radiant is directly overhead and stars to 6.5 mag. are visible). In 2003 and 2004 activity was slightly above

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[1] This is a shortened version of Leonid predictions. Full information is available on the author's Web page: http://feraj.narod.ru/Radiants/Predictions/predicteng.html .

the background level with ZHRs of 60 and 28, respectively (background activity is shown by the Leonids in their 'quiet' years, it usually reaches ZHR=10–20).

All main peaks of Leonid activity are traced very well with the use of meteor particle evolution modeling. Particles ejected by the comet form lengthy trails. One of the reasons is the radiation pressure force, which acts along with gravitational forces. Gravitational force depends on a particle's mass, i.e. it is proportional to the third power of the particle's radius. The radiation pressure varies as the second power of particle radius. So the influence of radiation pressure is relatively large for smaller particles. Its action is equivalent to a reduction of the gravitational constant G. So it increases the orbital period of particles, and the tinier a particle is, the more it is continuously retarded from larger particles after their ejection by the parent comet. This process therefore leads to the formation of lengthy comet trails.

Meteor modeling is done through computation of the orbital evolution of particles ejected by a comet with different velocities in directions tangential to the comet trajectory at the moment of perihelion. In reality, of course, particles are ejected not only at the point of perihelion, but also during several months around it. However, comets are in the perihelion part of their orbits for quite a short time compared to their overall orbital period and the main perturbations happen around their aphelia; so when comets are close to the Sun, newly ejected particles move very close to them in a compact dust cloud. This is the reason the cloud can be considered as being completely ejected at the point of perihelion, with virtually no influence on the results of computations.

Speaking of the directions in which particles are ejected, it should be underlined that, again, in reality they are ejected not only in tangential directions but in all possible ones. However, ejection velocities (from 0 to 100 m/s, and the overwhelming majority of real ejections are from 0 to 20 m/s (Lyytinen & van Flandern, 1998)) are negligibly small compared to the comet's own velocity (from 30 to 40 km/s near the Earth's orbit), ejected particles have only slightly changed orbits and do not 'fly away in all directions'. The radial part of ejection velocity defines only the thickness of a trail, which usually reaches several hundred thousand kilometers. The shape of the trail is defined by the tangential part of ejection velocity.

Finally, non-gravitational forces are often not taken into consideration in meteor calculations, as in our case. However some of them, say, radiation pressure, can be considered indirectly. As far as this kind of force works as a diminishing of the gravitational constant G, this is equivalent to an increase of ejection velocity which could be easily incorporated in the model. So this non-gravitational force like many others does not change the configuration of the trails, but leads to a shifting of particles with different masses along these trails.

As already stated, Leonid trail modeling has allowed the preparation of very good predictions of shower activity around the latest comet perihelion. Real maxima differed from the predicted ones mostly by no more than 10–15 minutes — not very much considering that computations are made for several hundreds years of particle movement. Also successful post-predictions were done for Leonid outbursts in the past, for example, for the famous storm in 1966. A more serious problem is the prediction of outburst intensity — how strong the maximum could be. For such predictions special empirical models were elaborated (the only way in this case) but as before for their improvement new observations are necessary.

The results the author obtained for predicted past and future Leonid showers during the period 2001–2100 are presented in this paper. Predictions were done for each year in the period mentioned, and, as this work is finished in 2006, it contains 'real' predictions for the years 2006–2100, while for the years 2001–2005 'post-predictions' were compiled. Also, although the models used in computations are based after all on meteor observations of real activity in the past, no comparisons for each year between the elaborated predictions and respective real Leonid activity are made.

3 Computation characteristics

This paper presents the results of the Leonid meteor stream simulation aimed at predicting its meteor activity in 2001–2100. The simulation was made for the trails of 30 past revolutions and 2 future ones, i.e. beginning from the 1001 trail, and partially for three earlier ones, i.e. the 901, 935 and 967 trails. The two future trails are the 2031 and 2065 ones. The author used the program Comet's Dust 2.0 created by S. Shanov and S. Dubrovsky to calculate orbital elements of ejected meteor particles. To estimate expected ZHRs for different encounters the model built by E. Lyytinen and T. van Flandern was used with some author's alterations made in order to adopt the model for ejection velocity (Vej) instead of da0 (difference in a, the major semiaxis) as well as to correct the fn function to consider factual Leonids activity during recent storms and outbursts. The computation considered only gravitational forces, but the results are on the whole in good accordance with those of other researchers. The prediction includes all encounters found within the range ±0.007 AU. The following parts of trails were computed: the first 5 rev. trails for ejection velocities [−50;100] m/s, 6–10 rev. trails for [−30;50] m/s, 10–20 rev. trails for [−20;30], older than 20 rev. trails for [−10;20] m/s.

4 Leonids 2001–2101

In 2001 a strong background maximum is expected. At 08^h UT 17 November activity will rise to 40–50 meteors on the ZHR scale. Also, a number of outbursts from trails are expected. The first will be a small increase from the 1965 trail. It will happen at 12^h49^m UT 17 November, the ZHR will rise to 30–40 meteors with a lowering of their average brightness. The next strong outburst will occur at 10^h25^m UT 18 November. It will be caused by the 1767 trail, its intensity will be 550–600 meteors on the ZHR scale, and brightness will be on the average level or slightly above it. After that a

Table 1 – Orbit of the comet 55P in 1901–2100.

Time of perihelion	q AU	e	AOP	Node	i	Min. dist. AU	$\lambda_\odot$
1932.07.12.7024	0.9785688	0.9051097	172°68761	235°06108	162°70792	−0.0061323	234°86925
1965.04.30.0078	0.9816245	0.9044541	172°56352	235°11505	162°70653	−0.0030093	235°02198
1998.02.28.0970	0.9765868	0.9055202	172°49739	235°25826	162°48612	−0.0079092	235°00813
2031.05.24.1519	0.9644153	0.9077893	172°86186	235°60482	162°57237	−0.0202647	234°95046
2065.03.19.6790	0.9677816	0.9072625	173°83873	236°74127	162°52970	−0.0176772	236°27196
2098.06.03.6488	0.9790155	0.9052530	174°02966	236°95791	162°50368	−0.0066467	236°80005

Initial orbital elements of 55P, starting from perihelion of 901 and up to 1998 are taken from Nakano's site (Nakano, 1999). Orbital elements for perihelia in 2031, 2065 and 2098 are generated by the program Comet's Dust 2.0 (by S. Shanov and S. Dubrovsky). Orbital elements of 55P in the period 1901–2100, as well as values of minimal distances to the Earth orbit for these elements and relative solar longitudes are given.
Orbital elements are given for the Epoch J2000. The symbols are: q: perihelion distance; e eccentricity; AOP: argument of the perihelion; Node: longitude of the ascending node; i: inclination. A positive value of minimal distance means that point of such minimum lies outside the Earth's orbit, and a negative value means that this point is inside the Earth's orbit. $\lambda_\odot$: solar longitude.

strong storm will take place. It will be produced by the 1699 and 1866 trails which will be partly superimposed. From 17^h33^m to 18^h18^m UT 18 November quite a long peak is expected, during this period activity will vary between 4400–5200 meteors on the ZHR scale. The first part of the storm will be characterized by bright meteors, then their brightness will decline to a little lower that average level.

In 2002 two storms will happen, but the first peak will be the traditional maximum. Considering the proximity of comet 55P, activity at 14^h UT 17 November will rise to 20–30 meteors on the ZHR scale. Then a small enhancement from the 1965 trail will follow. At 19^h UT 17 November activity will rise to 30–40 meteors on the ZHR scale, meteor brightness will be very low. For radio meteors a much stronger outburst is likely. After that at 04^h09^m UT 18 November the first storm caused by the 1767 trail will occur. Activity will rise to 1300 meteors on the ZHR scale and brightness close to the average level. The second storm will be much stronger. At 10^h44^m UT 18 November the 1866 trail will give activity up to 4300 meteors on the ZHR scale and brightness will be noticeably lower than average.

In 2003 several comparatively small enhancements are expected. The first one will be an outburst from the 1499 trail at 14^h–15^h UT 13 November. Activity will rise to 30 meteors on the ZHR scale and brightness will be considerably lower than average. The next peak, again from the 1499 trail will happen at 21^h UT 13 November. Activity will reach 20–25 meteors on the ZHR scale, and brightness will be considerably below average. Then at 14^h UT 14 November, the 1433 trail will give the next enhancement. Activity will rise to 50 meteors on the ZHR scale and brightness considerably below average. Then a traditional maximum will follow. Considering the proximity of comet 55P, activity at 20^h UT 17 November will reach 20–30 meteors on ZHR scale. After that a small increase from the 1733 trail will occur. At 18^h44^m UT 19 November, activity will rise to 15–20 meteors on the ZHR scale and brightness will be considerably lower than average. The final enhancement will happen at 18^h54^m UT 20 November. It will be produced by the 1866 trail, activity will reach 15–20 meteors on the ZHR scale. Brightness will be considerably lower than average level.

In 2004 a weak background maximum is expected, but considering the proximity of comet 55P activity at 02^h UT 17 November will rise to 15–20 meteors. Also, an enhancement from the 1733 trail is expected. At 20^h37^m UT 19 November activity will rise to 25–30 meteors on the ZHR scale with brightness notably lower than average level.

In 2005 a traditional maximum weaker than average level is expected. At 08^h UT 17 November activity will rise to 10 meteors on the ZHR scale. Also, at 00^h–02^h UT 21 November an enhancement from the 1167 trail is possible. Its intensity will reach 15–20 meteors on the ZHR scale, and brightness will be somewhat lower than the average level.

In 2006 a weak traditional maximum is expected. At 15^h UT 17 November activity will rise to 10–15 meteors on the ZHR scale. Besides that at 04^h55^m UT 19 November an outburst from the 1932 trail will follow. Its intensity will reach 35–40 meteors on the ZHR scale, meteor brightness will be very low, but for radio meteors a much higher activity is likely.

In 2007 a traditional maximum weaker than average is expected. At 21^h UT 17 November activity will rise to 15 meteors on the ZHR scale. Besides that at 23^h05^m UT 18 November an outburst from the 1932 trail will follow. Its intensity will reach about 30 meteors on the ZHR scale, meteor brightness will be very low, but for radio meteors a much higher activity is likely.

In 2008 a traditional maximum somewhat higher than average level is expected, and it will almost coincide with considerable outburst from the 1466 trail. At 00^h22^m UT 17 November activity should rise to 130 meteors on the ZHR scale. Meteor brightness will be somewhat higher than average.

In 2009 a very strong traditional maximum is expected. At 09^h UT 17 November activity should rise to 25–30 meteors on the ZHR scale. Also, at 21^h–22^h UT 17

November a considerable outburst from the 1466 and 1533 trails is likely. Activity will reach 130–140 meteors on the ZHR scale and a number of submaxima are likely. Meteor brightness will be about average level. Another small enhancement can be produced by the 1201 trail. At 19^h UT 18 November activity will rise to 10–15 meteors on the ZHR scale and meteor brightness will be a little lower than average level.

In 2010 a quite strong traditional maximum is expected. At 15^h UT 17 November activity will rise to about 20 meteors on the ZHR scale. No other outbursts are found.

In 2011 a weak background maximum is expected. At 21^h UT 17 November activity will rise to 5–10 meteors on the ZHR scale. Also, at 23^h UT 18 November, the 1567 trail should give a small enhancement. Activity will reach about 10 meteors on the ZHR scale and brightness will be a little below average level.

In 2012 a weak background maximum is expected. At 03^h UT 17 November activity will rise to 5–10 meteors on the ZHR scale. Also, at 06^h UT 20 November, the 1400 trail can give a small increase. Activity will rise to 10–15 meteors on the ZHR scale and brightness will be somewhat lower than the average level.

In 2013 quite a strong traditional maximum is expected. At 10^h UT 17 November activity will rise to 15–20 meteors on the ZHR scale. No other outbursts are found.

In 2014 a moderate traditional maximum is expected. At 16^h UT 17 November activity will rise to 10–15 meteors on the ZHR scale. No other outbursts are found.

In 2015 a strong traditional maximum is expected. At 21^h UT 17 November activity will rise to 20 meteors on the ZHR scale. No other outbursts are found.

In 2016 quite a weak traditional maximum is expected. At 04^h UT 17 November activity will rise to 10 meteors on the ZHR scale. No other outbursts are found.

In 2017 quite a weak traditional maximum is expected. At 10^h UT 17 November activity will rise to 10 meteors on the ZHR scale. No other significant outbursts are found.

In 2018 a very strong traditional maximum is expected. At 16^h UT 17 November activity will rise to 25 meteors on the ZHR scale. Also, at 09^h UT 20 November average meteor brightness can increase due to the 1466 trail.

In 2019 an average traditional maximum is expected. At 23^h UT 17 November activity will rise to 15–20 meteors on the ZHR scale. Also, at 02^h UT 16 November a small increase from the 1400 trail is possible. Activity will reach 15–20 meteors on the ZHR scale and brightness will be considerably above average. Activity from another, the 1800 trail, can appear at 05^h UT 19 November as an increase in the number of bright meteors.

In 2020 a traditional maximum somewhat lower than average level is expected. At 03^h UT 17 November activity will rise to 10–15 meteors on the ZHR scale. No other significant outbursts are found.

In 2021 a weak traditional maximum is expected. At 09^h UT 17 November activity will rise to 10 meteors on the ZHR scale. No other outbursts are found.

In 2022 a moderate traditional maximum is expected. At 16^h UT 17 November activity will rise to 10–15 meteors on the ZHR scale. Also, a strong outburst from the 1733 trail is possible. At 06^h UT 19 November activity can reach 250–300 meteors on the ZHR scale and brightness will be much higher than the average level. Another small enhancement to 5–10 meteors on the ZHR can occur at 15^h UT 21 November due to the 1800 trail. Meteor brightness will be again much higher than average level.

In 2023 a moderate background maximum is expected. At 22^h UT 17 November activity will rise to 15 meteors on the ZHR scale. Also, at 12^h UT 21 November a little increase from the 1767 trail is possible. Activity will rise to 10–15 meteors on the ZHR scale. Brightness will be much higher than the average level.

In 2024 a quite strong traditional maximum is expected. At 04^h UT 17 November activity will rise to 15–20 meteors on the ZHR scale. No other significant outbursts are found.

In 2025 a quite weak traditional maximum is expected. At 10^h UT 17 November activity will rise to 10–15 meteors on the ZHR scale. Also, from 19^h to 23^h UT 17 November an outburst from the 1699 trail is possible. Activity will reach 60–90 meteors on the ZHR scale and brightness will be much higher than the average level.

In 2026 a moderate traditional maximum is expected. At 16^h UT 17 November activity will rise to 15 meteors on the ZHR scale. No other significant outbursts are found.

In 2027 a strong background maximum is expected and due to the proximity of comet 55P and activity will rise to 40–50 meteors on the ZHR scale at 22^h UT 17 November. Also, at 04^h UT 20 November an outburst from the 1167 trail is possible. Activity will rise to 40–50 meteors on the ZHR scale and brightness will be notably above average.

In 2028 a moderate background maximum is expected, but considering the proximity of comet 55P, activity at 05^h UT 17 November can rise to 30–40 meteors on the ZHR scale. No other outbursts are found.

In 2029 a background maximum somewhat lower than usual is expected, but considering the proximity of comet 55P, activity at 11^h UT 17 November can rise to 30–40 meteors on the ZHR scale. No other outbursts are found.

In 2030 a very weak traditional maximum is expected. Only due to the proximity of comet 55P an optimistic estimation of maximum activity would be 15–20 meteors on the ZHR scale, the peak is to occur at 17^h UT 17 November. But it is not impossible that the traditional maximum will be very weak even by the standards of usual years, lower than 10 meteors on the ZHR scale. Outbursts from trails are not found.

In 2031, as in the previous year, a very weak traditional maximum is expected, despite the perihelion passage of comet 55P. An optimistic estimation of maximum activity would be 15–20 meteors on the ZHR scale, the peak is to occur at 23^h UT 17 November. But it is not impossible that the traditional maximum will be very weak even by the standards of usual years, lower than 10 meteors on the ZHR scale. Outbursts from trails are not found.

In 2032, as in the previous year, a very weak traditional maximum is expected, despite the proximity of comet 55P. An optimistic estimation of maximum activity would be 15 meteors on the ZHR scale, the peak is to occur at 05^h UT 17 November. But it is not impossible that the traditional maximum will be very weak even by the standards of usual years, lower than 10 meteors on the ZHR scale. Outbursts from trails are not found.

In 2033 a quite weak background maximum is expected, but considering the proximity of comet 55P, activity at 11^h UT 17 November will rise to 25–35 meteors on the ZHR scale. After that a small enhancement from the 1932 trail will occur. At 17^h UT 17 November activity will reach about 30 meteors on the ZHR scale and their brightness will be below average. Finally, the last will be a strong outburst from the 1899 trail. At 20^h53^m UT 17 November activity will rise to 300–400 meteors on the ZHR scale and brightness will be somewhat lower than average.

In 2034 a number of outbursts are expected. The first will be the traditional maximum. It will be quite strong, and considering the proximity of comet 55P, activity at 18^h UT 17 November will reach 40–50 meteors on the ZHR scale. After that a strong outburst from the 1932 trail will happen. At 03^h04^m UT 18 November activity will rise to 400–500 meteors on the ZHR scale, brightness will be significantly lower than average, for radio meteors activity should be stronger. Then a small enhancement from the 1899 trail will occur. At 09^h02^m UT 18 November activity will rise to 30–40 meteors on the ZHR scale and brightness will be somewhat lower than average. Then the next significant outburst from the 1767 trail will follow. At 22^h04^m UT 18 November activity will reach 150–250 meteors on the ZHR scale and brightness will be close to the average level. Another strong outburst will be produced by the 1699 and 1866 trails, which will be partially superimposed. At 05^h–06^h UT 19 November activity will reach 300–400 meteors on the ZHR scale, a number of submaxima are possible. At 05^h UT 19 November the rate will be somewhat lower than average, but closer to 06^h UT it should increase considerably.

In 2035 again a number of outbursts is expected. The first will be a quite strong traditional maximum. At 00^h UT 18 November activity will rise to 30–40 meteors on the ZHR scale. The next increase will be a rather weak enhancement from the 1800 and 1833 trails. At 15^h24^m UT 19 November activity will reach 50–60 meteors on the ZHR scale and brightness will be close to average level. After that a weak enhancement from the 1866 trail will follow. At 20^h10^m UT 19 November activity will rise to 30 meteors on the ZHR scale and brightness will be a little lower than average. Finally, at 06^h06^m UT 20 November, the 1633 trail will give a strong outburst to 300–350 meteors on the ZHR scale and brightness will be significantly above average level.

In 2036 a quite weak traditional maximum is expected, but considering the proximity of comet 55P activity will reach 20–30 meteors on the ZHR scale at 06^h UT 17 November. A number of weak enhancements is also expected. At 16^h01^m UT 17 November, the 1965 trail will give an increase to 30–40 meteors on the ZHR scale and brightness will be significantly lower than average, for radio meteors a much stronger peak is likely. The next one will be outburst from the 1466 trail at 21^h49^m UT 18 November. Activity will reach 15–25 meteors on the ZHR scale and brightness will be considerably lower than average. Another enhancement from the 1800 and 1833 trails will occur at 08^h–11^h UT 19 November. Activity will rise to 20–30 meteors on the ZHR scale, a number of submaxima is possible and brightness will be a little lower than average level.

In 2037 a quite weak traditional maximum is expected, but considering the proximity of comet 55P and maximum from the 1499 trail, activity will reach 40–50 meteors on the ZHR scale at 02^h UT 17 November. Some other outbursts will also occur. At 22^h58^m UT

17 November, the 1965 trail will give a peak of 30–40 meteors on the ZHR scale. For radio meteors activity should be much stronger. Finally, at 20^h15^m UT 19 November and at 01^h21^m UT 20 November a double maximum from the 1800 and 1833 trails is expected. The first peak will reach 250–350 meteors on the ZHR scale, and the second one 200–300 meteors on the ZHR scale. Brightness will be a little lower than the average level.

In 2038 a moderate traditional maximum is expected. At 18^h UT 17 November activity will reach 15 meteors on the ZHR scale. Also a number of outbursts from trails will occur. All before, at 05^h21^m UT 18 November a radio outburst from the 1965 trail is expected. Then at 08^h48^m UT 20 November 1767 trail will give an outburst to 60–70 meteors on the ZHR scale and brightness will be somewhat lower than average. The next outburst from the 1800 trail will happen at 14^h23^m UT 20 November. Its intensity will reach about 20 meteors on the ZHR scale. Then at 21^h18^m UT 20 November, the 1833 trail will also give an enhancement to 20 meteors on ZHE scale, brightness a little lower than average. Finally at 10^h32^m UT 21 November, the 1866 trail will produce a peak of 70–90 meteors on the ZHR scale and brightness will be significantly lower than average.

In 2039 a quite strong background maximum is expected. At 00^h UT 18 November activity will reach 10–15 meteors on the ZHR scale. Also, at 09^h UT 20 November, the 1333 trail can give a small enhancement to about 10 meteors on the ZHR scale and brightness will be close to the average level. Another small increase will be produced by the 1767 trail at 02^h08^m UT 21 November. Activity will reach 10–20 meteors on the ZHR scale, brightness will be notably lower than average.

In 2040 a moderate background maximum is expected. At 06^h UT 17 November activity will reach 15–20 meteors on the ZHR scale. Also, at 00^h UT 19 November an enhancement from the 1366 trail is possible. Activity will reach 25–35 meteors on the ZHR scale, brightness close to average level.

In 2041 a moderate traditional maximum is expected. At 13^h UT 17 November activity will reach about 15 meteors on the ZHR scale. No other outbursts are found.

In 2042 a quite weak traditional maximum is expected. At 19^h UT 17 November activity will reach about 10–15 meteors on the ZHR scale. No other significant outbursts are found.

In 2043 a strong background maximum is expected. At 01^h UT 18 November activity will rise to 25 meteors on the ZHR scale. Also, at 18^h UT 19 November an enhancement from the 1400 trail is likely. Activity will reach 50–60 meteors on the ZHR scale, a number of submaxima are possible. Meteor brightness will be a little lower than average level. Then at 13^h45^m UT 20 November, the 1932 trail can give a significant radio outburst.

In 2044 a moderate background maximum is expected. At 07^h UT 17 November activity will reach about 15 meteors on the ZHR scale. Also, at 16^h43^m UT 19 November 1932 trail can give a significant radio outburst.

In 2045 a quite strong traditional maximum is expected. At 13^h UT 17 November activity will reach about 20 meteors on the ZHR scale. No other significant outbursts are found.

In 2046 a quite strong traditional maximum is expected. At 19^h UT 17 November activity will reach about 15–20 meteors on the ZHR scale. No other significant outbursts are found.

In 2047 a weak traditional maximum is expected. At 02^h UT 18 November activity will reach about 10 meteors on the ZHR scale. No other significant outbursts are found.

In 2048 a moderate traditional maximum is expected. At 08^h UT 17 November activity will reach about 10–15 meteors on the ZHR scale. No other significant outbursts are found.

In 2049 a very weak traditional maximum is expected. At 14^h UT 17 November activity will reach about 5–10 meteors on the ZHR scale. No other significant outbursts are found.

In 2050 a quite weak traditional maximum is expected. At 20^h UT 17 November activity will reach about 10–15 meteors on the ZHR scale. Also, at 08^h UT 18 November an outburst from the 1234 trail is possible. Activity will rise to 15–20 meteors on the ZHR scale and brightness will be much higher than average level.

In 2051 a quite strong traditional maximum is expected. At 02^h UT 18 November activity will rise to about 20 meteors on the ZHR scale. Also, at 09^h UT 20 November average meteor brightness can increase due to the 1466 trail. It is not impossible that activity would rise to 10 meteors on the ZHR scale.

In 2052 a quite weak background maximum is expected. At 08^h UT 17 November activity will rise to 10–15 meteors on the ZHR scale. Also at 14^h32^m UT 17 November 1866 trail can give a radio outburst.

In 2053 a quite weak traditional maximum is expected. At 14^h UT 17 November activity will rise to 10–15 meteors. Also, at 01^h UT 17 November, the 1433 trail can give an enhancement to 20 meteors on the ZHR scale and brightness will be much higher than average level. After that at 09^h49^m UT 22 November meteor brightness can increase due to the 1800 trail.

In 2054 a very weak traditional maximum is expected. At 04^h UT 19 November activity will reach about 5–10 meteors on the ZHR scale. No other outbursts are found.

In 2055 a weak traditional maximum is expected. At 10^h UT 19 November activity will reach about 10 meteors on the ZHR scale. No other significant outbursts are found.

In 2056 a quite weak traditional maximum is expected. At 17^h UT 19 November activity will reach about 10–15 meteors on the ZHR scale. No other significant outbursts are found.

In 2057 a quite weak traditional maximum is expected. It will partially coincide with the 1866 trail. Maximum will occur at 01^h38^m UT 19 November, its intensity will reach 25–30 meteors on the ZHR scale and brightness will be much higher than average.

In 2058 a weak traditional maximum is expected. At 05^h UT 19 November activity will reach about 10 meteors on the ZHR scale. No other significant outbursts are found.

In 2059 a moderate traditional maximum is expected. At 11^h UT 19 November activity will reach about 15 meteors on the ZHR scale. Also, at 21^h54^m UT 18 November average meteor brightness can increase due to the 1998 trail.

In 2060 a moderate traditional maximum is expected. At 17^h UT 18 November activity will reach about 15 meteors on the ZHR scale. Also, at 05^h45^m UT 18 November an outburst from the 1965 trail is likely. Activity will rise to about 25 meteors on the ZHR scale and brightness will be much higher than average. After that at 12^h UT 19 November average meteor brightness can increase due to the 1600 trail.

In 2061 a strong traditional maximum is expected, and considering the proximity of comet 55P, at 23^h UT 18 November activity will rise to 40–50 meteors on the ZHR scale. A number of outbursts from trails will also occur. At 01^h56^m UT 19 November, the 1965 trail can increase activity to 60 meteors on the ZHR scale and brightness will be much higher than average level. Another strong outburst, from the 1998 trail, should happen at 15^h51^m UT 19 November. Activity will rise to about 300 meteors on the ZHR scale and brightness will be much higher than average.

In 2062 a quite strong traditional maximum is expected, and considering the proximity of comet 55P, at 06^h UT 19 November activity will rise to about 30–40 meteors on the ZHR scale. No other significant outbursts are expected.

In 2063 a moderate traditional maximum is expected, and considering the proximity of comet 55P, at 11^h UT 19 November activity will rise to about 30–40 meteors on the ZHR scale. No other significant outbursts are expected.

In 2064 a weak traditional maximum is expected, and considering the proximity of comet 55P, at 18^h UT 18 November activity (in optimistic expectations) will rise to about 20–30 meteors on the ZHR scale. It is possible that activity will not surpass 10–15 meteors on the ZHR scale. No other outbursts are found.

In 2065 a very weak traditional maximum is expected. Despite the perihelion passage of comet 55P, at 00^h UT 19 November, an optimistic estimate suggests that activity will rise to about 15–20 meteors on the ZHR scale. It is possible that activity will not surpass 5–10 meteors on the ZHR scale. No other outbursts are found.

In 2066 again a very weak traditional maximum is expected. Despite the perihelion passage of comet 55P, at 06^h UT 19 November an optimistic estimate suggests that activity will rise to about 15–20 meteors on the ZHR scale. It is possible that activity will not surpass 5–10 meteors on the ZHR scale. No other outbursts are found.

In 2067 a quite weak traditional maximum is expected. Considering the proximity of comet 55P, at 12^h UT 18 November activity will rise to about 25–35 meteors on the ZHR scale. No other outbursts are found.

In 2068 a quite strong traditional maximum is expected, considering the proximity of comet 55P activity will rise to 40–50 meteors on the ZHR scale at 18^h UT 18 November. Also, at 00^h48^m UT 19 November, the 1866 trail will give an outburst to 50 meteors on the ZHR scale. Brightness will be a little lower than the average level.

In 2069 a moderate background maximum is expected, but considering the proximity of comet 55P, activity at 00^h UT 19 November will rise to about 30–40 meteors on the ZHR scale. Also, a number of outbursts from trails are expected. The first (earlier than the traditional maximum) will be an outburst from the 1932 trail. At 05^h35^m UT 18 November activity will rise to 100 meteors on the ZHR scale, meteor brightness will be significantly lower than average, and for radio meteors a much stronger activity is expected. Then, after the traditional maximum an outburst from the 1433 trail will follow. At 09^h UT 19 November activity will rise to 70–80 meteors on the ZHR scale, brightness will be considerably lower than average. After that a small enhancement from the 1800 and 1833 trails will occur. Activity will rise to 30–40 meteors on the ZHR scale and brightness will be close to the average level. Finally, the last outburst will be produced by the 1699 trail. At 10^h21^m UT 20 November activity will reach 300–350 meteors on the ZHR scale and brightness will be above average.

In 2070 a moderate traditional maximum is expected. Considering the proximity of comet 55P, at 06^h UT 19 November activity will rise to about 20–30 meteors on the ZHR scale. No other significant outbursts are found.

In 2071 a traditional maximum a little weaker than usual is expected, but considering the proximity of comet 55P, at 13^h UT 19 November activity will rise to about 20–25 meteors on the ZHR scale. No other significant outbursts are found.

In 2072 a moderate traditional maximum is expected. At 19^h UT 18 November activity will rise to 15 meteors on the ZHR scale. Also, at 16^h UT 19 November, the 1499 trail will give a small outburst to 10–15 meteors on the ZHR scale and brightness will be somewhat lower than average.

In 2073 a quite weak traditional maximum is expected. At 19^h UT 18 November activity will rise to 10–15 meteors on the ZHR scale. Also, at 12^h29^m UT 18 November 1998 trail will give an outburst to 35–40 meteors on the ZHR scale. Brightness will be much lower than average level, for radio meteors activity should be much higher.

In 2074 a quite strong traditional maximum is expected. At 07^h UT 19 November activity will rise to 15–20 meteors on the ZHR scale. Also, at 05^h26^m UT 23 November, the 1800 trail will give an outburst to 25–30 meteors on the ZHR scale. Brightness will be a little lower than average.

In 2075 a strong traditional maximum is expected. At 13^h UT 19 November activity will rise to 20 meteors on the ZHR scale. Also, at 13^h–14^h UT 21 November, the 1533 trail will give a small enhancement to 5–10 meteors on the ZHR scale and brightness will be close to the average level.

In 2076 a weak traditional maximum is expected. At 19^h UT 18 November activity will rise to about 10 meteors on the ZHR scale. No other outbursts are found.

In 2077 a moderate traditional maximum is expected. At 02^h UT 19 November activity will rise to 15 meteors on the ZHR scale. Also, at 02^h UT 20 November, the 1400 trail will give an outburst to 15–20 meteors on the ZHR scale and brightness will be a little lower than average.

In 2078 a quite weak traditional maximum is expected. At 08^h UT 19 November activity will rise to 10–15 meteors on the ZHR scale. No other outbursts are found.

In 2079 a quite weak traditional maximum is expected. At 14^h UT 19 November activity will rise to 10–15 meteors on the ZHR scale. No other significant outbursts are found.

In 2080 a moderate traditional maximum is expected. At 20^h UT 18 November activity will rise to 15 meteors on the ZHR scale. No other outbursts are found.

In 2081 a quite faint traditional maximum is expected. At 02^h UT 19 November activity will rise to 10–15 meteors on the ZHR scale. No other outbursts are found.

In 2082 a quite faint traditional maximum is expected. At 08^h UT 19 November activity will rise to 10–15 meteors on the ZHR scale. No other significant outbursts are found.

In 2083 a quite faint traditional maximum is expected. At 14^h UT 19 November activity will rise to 10–15 meteors on the ZHR scale. No other outbursts are found.

In 2084 a moderate traditional maximum is expected. At 21^h UT 18 November activity will rise to 15 meteors on the ZHR scale. No other outbursts are found.

In 2085 a moderate traditional maximum is expected. At 03^h UT 19 November activity will rise to 15 meteors on the ZHR scale. No other significant outbursts are found.

In 2086 a quite strong traditional maximum is expected. At 03^h UT 19 November activity will rise to 15–20 meteors on the ZHR scale. No other significant outbursts are found.

In 2087 a strong traditional maximum is expected. At 04^h UT 20 November activity will rise to about 20–25 meteors on the ZHR scale. Also, at 09^h–11^h UT 19 November it is not impossible that the 1567 trail will give some bright meteors.

In 2088 a weak traditional maximum is expected. At 10^h UT 19 November activity will rise to 10 meteors on the ZHR scale. No other significant outbursts are found.

In 2089 a very weak traditional maximum is expected. At 16^h UT 20 November activity will rise to about 5–10 meteors on the ZHR scale. Also, at 08^h UT 21 November it is not excluded, that the 1567 trail will give some bright meteors.

In 2090 a very weak traditional maximum is expected. At 22^h UT 19 November activity will rise to 5–10 meteors on the ZHR scale. Also, at 20^h24^m UT 20 November the 1800 trail can give a small enhancement to 10 meteors on the ZHR scale and brightness will be much higher than average.

In 2091 a weak traditional maximum is expected. At 04^h UT 20 November activity will rise to 5–10 meteors on the ZHR scale. No other outbursts are found.

In 2092 a moderate traditional maximum is expected. It will coincide with possible activity from the 1998 trail. At 09^h11^m UT 19 November activity will rise to 50–60 meteors on the ZHR scale and brightness will be much higher than average. Also, at 13^h UT 18 November, the 1965 trail can give a number of bright meteors.

In 2093 a number of outbursts is expected. The first one will be a peak from the 1965 trail which will partially coincide with a strong background maximum. Activity will rise to 25–35 meteors on the ZHR scale and brightness will be much higher than average. After that at 03^h27^m UT 20 November, the 1998 trail will give an enhancement to 15–20 meteors and brightness will be much higher than average. Finally, another small increase is possible at 15^h UT 20 November due to the 1600 trail. Activity will rise to 20–25 meteors on the ZHR scale and brightness will be much higher than average.

In 2094, as in the previous year, a number of outbursts are expected, but they will be considerably stronger. First of all, a number of bright meteors can come from the 1466 trail at 11^h UT 19 November. After that a strong outburst from the 1899 trail will follow, partially coinciding with a strong traditional maximum. At 00^h47^m UT 20 November activity will rise to about 800–900 meteors on the ZHR scale and brightness will be much higher than average. The next, less intensive outburst will be produced by the 1932 trail at 07^h07^m UT 20 November. Activity will reach 100–150 meteors on the ZHR scale and brightness will be much higher than average. Then a potentially stormy outburst from the 1965 trail will follow. At 11^h43^m UT 20 November activity will rise to 1300–1400 meteors on the ZHR scale, brightness will be much higher than average. It is very likely that 2094 will give the first Leonid storm return since 2002.

In 2095 a quite strong traditional maximum is expected, and considering the proximity of comet 55P, at 05^h UT 20 November activity will rise to 40–50 meteors on the ZHR scale. No other significant outbursts are found.

In 2096 a quite strong traditional maximum is expected, and considering the proximity of comet 55P, at 11^h UT 20 November activity will rise to 40–50 meteors on the ZHR scale. No other significant outbursts are found.

In 2097 a quite strong traditional maximum is expected, and considering the proximity of comet 55P, at 17^h UT 20 November activity will rise to 30–40 meteors on the ZHR scale. No other significant outbursts are found.

In 2098 a very powerful traditional maximum is expected, and considering the perihelion passage of comet 55P, at 23^h UT 19 November activity will rise to 100–150 meteors on the ZHR scale. Also, at 06^h UT 20 November, the 1499 trail will give an outburst to 80–100 meteors on the ZHR scale and brightness will be much higher than average.

In 2099 a quite strong background maximum is expected, and considering the proximity of comet 55P, at 06^h UT 20 November activity will rise to about 40–50 meteors on the ZHR scale. Also, the 1633 and 1699 trails should give two small enhancements at 01^h UT 16 November and at 18^h UT 17 November, respectively. Activity will reach 15–20 meteors on the ZHR scale in the first case, and about 25–30 meteors on the ZHR scale in the second one. Brightness will be both times considerably lower than average level.

In 2100 a very weak traditional maximum is expected. Considering the proximity of comet 55P, at 12^h UT 20 November activity can reach to 15–20 meteors on the ZHR scale, but it is possible that activity will not exceed 10 meteors on the ZHR scale. No other outbursts are found.

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