

2009 Leonids Peak Visibility

NASA Meteoroid Environment Office (MEO)

January 2009

2009 Leonid Overview from the IMO

Leonids (LEO)

| | |
|----------------|--|
| Active: | November 10-21 |
| Maximum: | November 17 15h10m UT (nodal crossing at $\lambda_o = 235^\circ 27'$) but see below |
| ZHR = | 100+? |
| Radiant: | $\alpha = 152^\circ \delta = +22^\circ$ |
| Radiant drift: | see Table 6 |
| $V_\infty =$ | 71 km/s; $r = 2.9$ |
| TFC: | $\alpha = 140^\circ \delta = +35^\circ$ and $\alpha = 129^\circ \delta = +06^\circ$ ($\beta > 35^\circ$ N) or $\alpha = 156^\circ \delta = -03^\circ$ and $\alpha = 129^\circ \delta = +06^\circ$ ($\beta < 35^\circ$ N) |
| IFC: | $\alpha = 120^\circ \delta = +40^\circ$ before 0h local time ($\beta > 40^\circ$ N); \p $\alpha = 120^\circ \delta = +20^\circ$ before 4h local time and $\alpha = 160^\circ \delta = 00^\circ$ after 4h ($\beta > 0^\circ$ N) $\alpha = 120^\circ \delta = +10^\circ$ before 0h local time and $\alpha = 160^\circ \delta = -10^\circ$ ($\beta < 0^\circ$ N) |

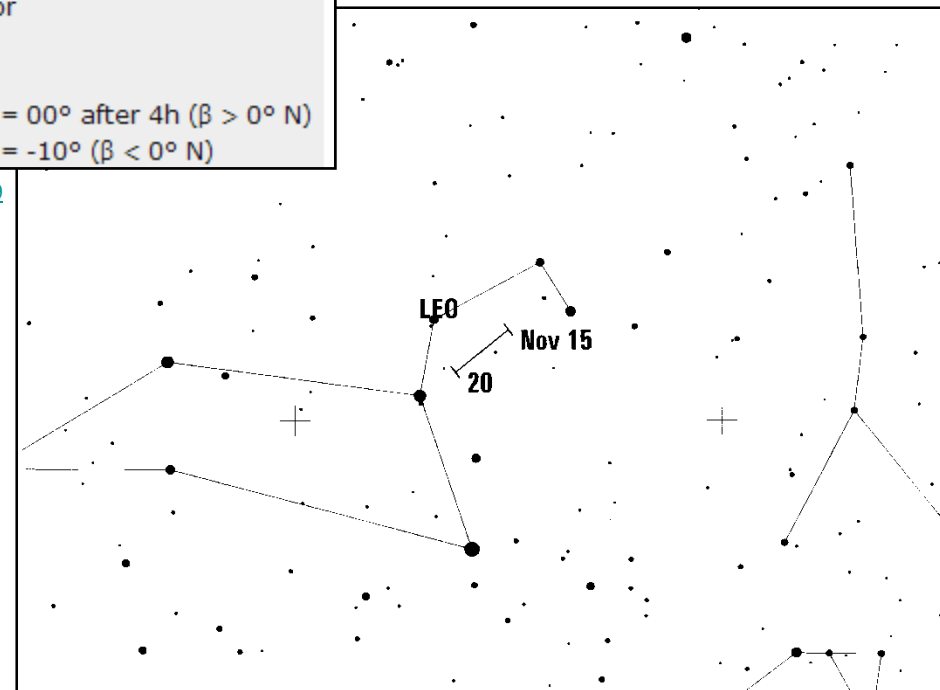
<http://www.imo.net/calendar/2009>

Table 6 - Radiant positions during the year in α and δ

| | |
|--------|-----------------------|
| Nov 10 | $147^\circ +24^\circ$ |
| Nov 15 | $150^\circ +23^\circ$ |
| Nov 20 | $153^\circ +21^\circ$ |

Main Contributing Trails

- 1466
- 1533



Modeling the 2009 Leonids

- Peak Prediction Summary
 - Modeling Results

-Summary-

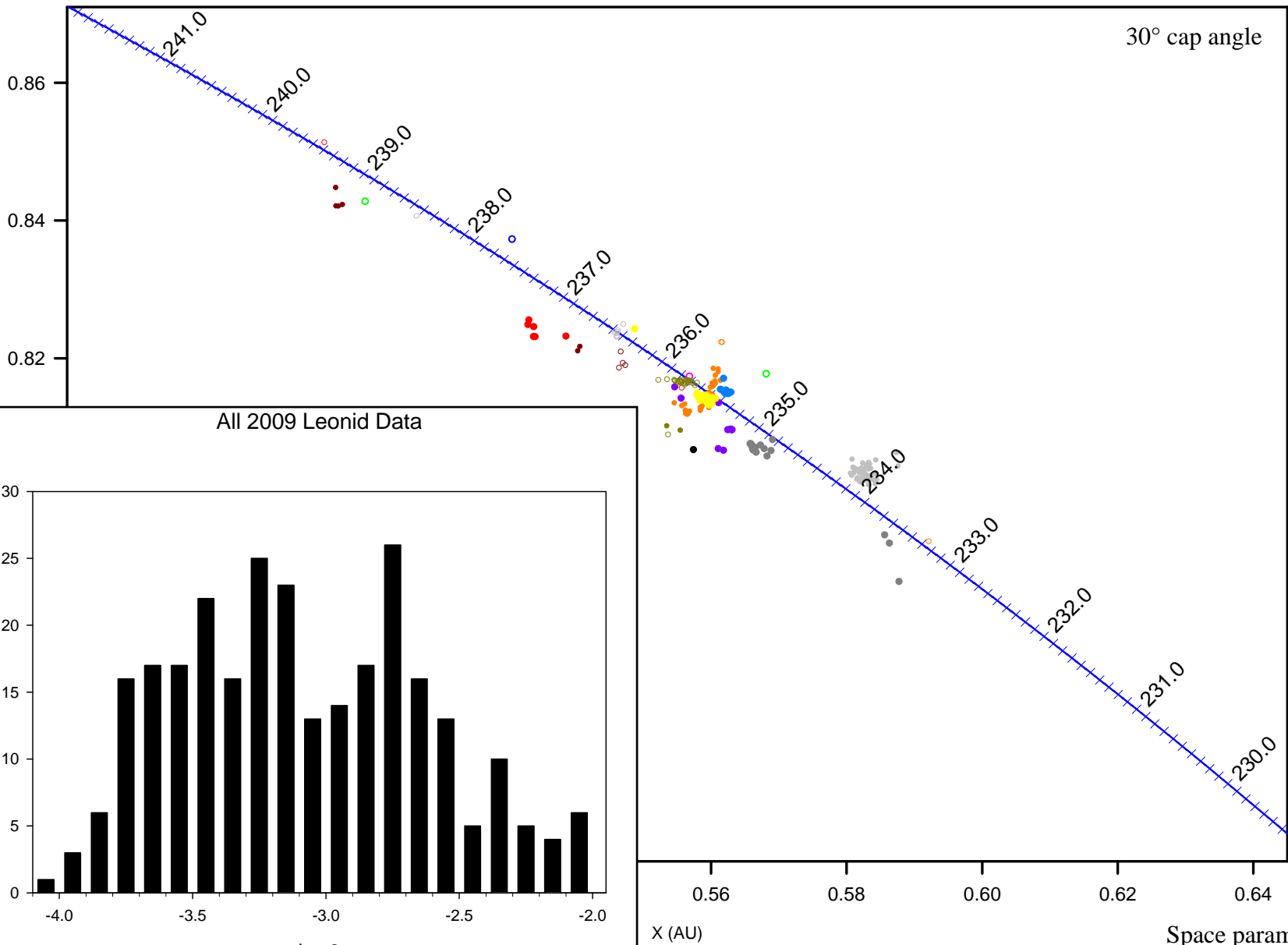
PEAK Predictions as of Dec 2008

| Modeler | Revs considered | Peak Time | ZHR |
|-----------------------|-----------------|---|---------|
| Moser & Cooke, MEO | 1001-1965 (30) | Nov 17, 2009 21:33 UT 21:44 UT | 300±100 |
| J Vaubaillon | 604-1965 (42) | Nov 17, 2009 21:43 UT (may be 0.5 – 1hr later) | 500 |
| M Maslov | 901-1965 (33) | Nov 17, 2009 21-22 UT | 130-140 |

2009 Leonids

MEO

Particles ejected hourly
proportional to r^{-5} while
Tempel-Tuttle is inside 2.5 AU.



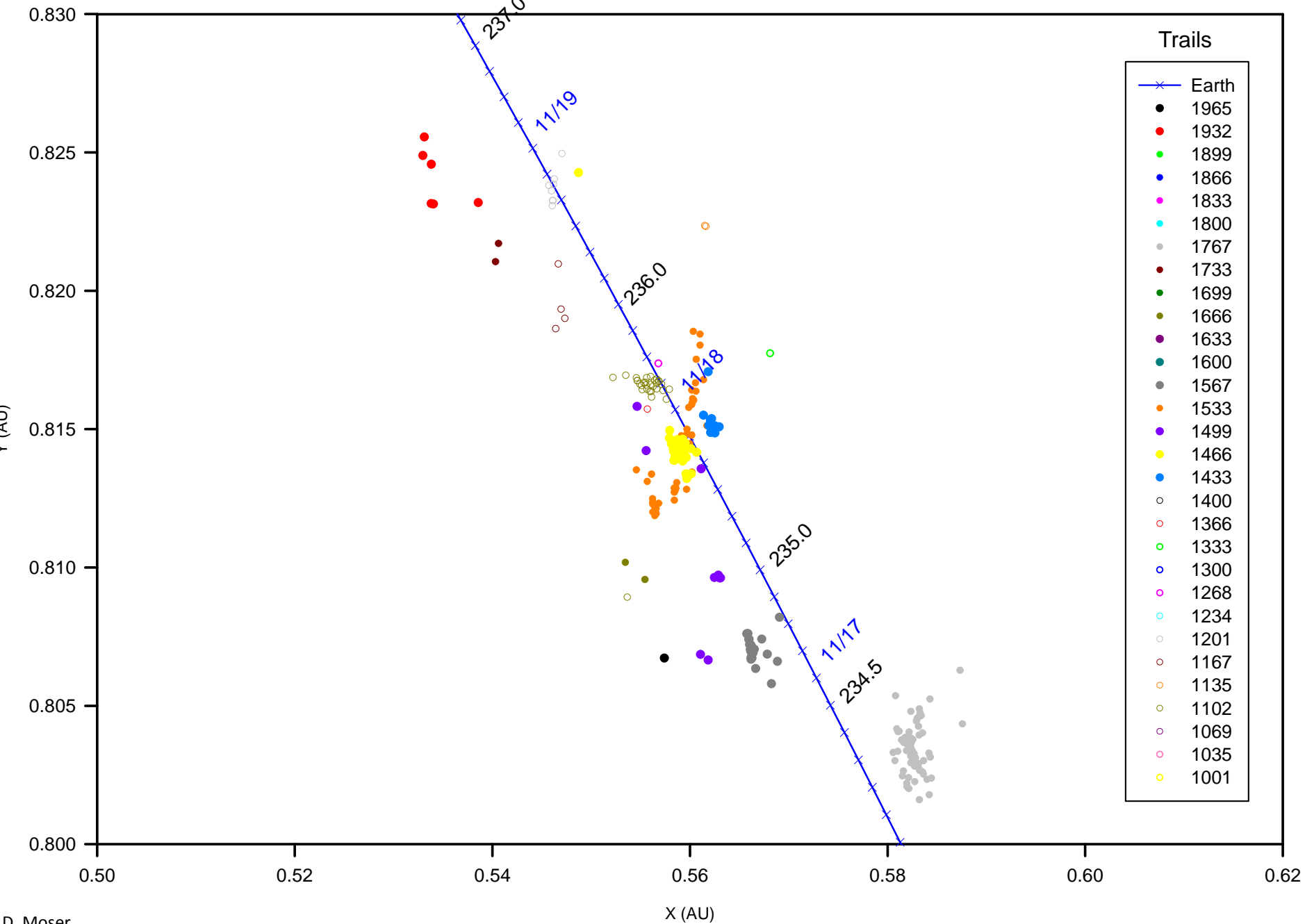
Trails

- ✕ Earth
- 1965
- 1932
- 1899
- 1866
- 1833
- 1800
- 1767
- 1733
- 1699
- 1666
- 1633
- 1600
- 1567
- 1533
- 1499
- 1466
- 1433
- 1400
- 1366
- 1333
- 1300
- 1268
- 1234
- 1201
- 1167
- 1135
- 1102
- 1069
- 1035
- 1001

300,000 p/rev

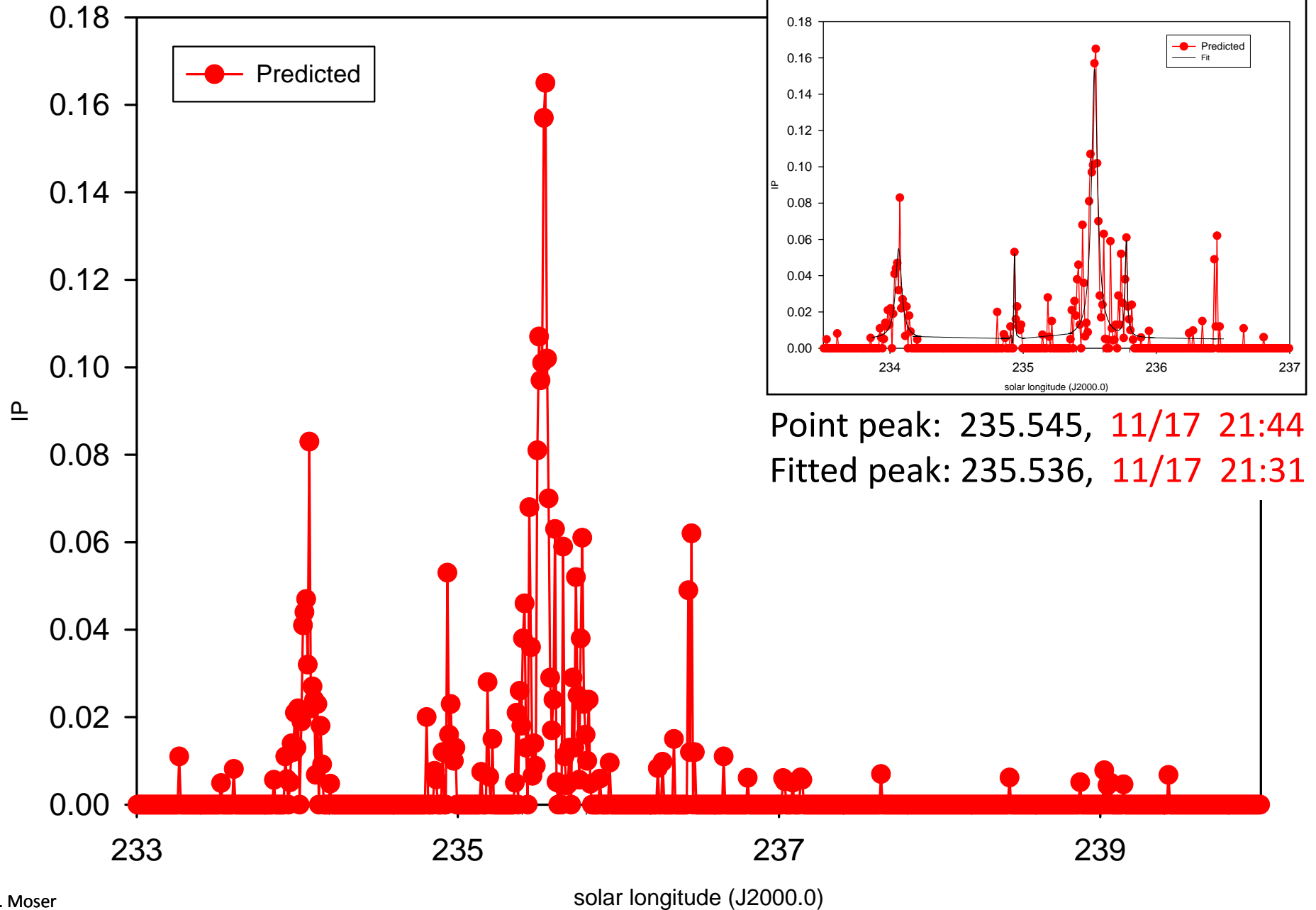
2009 Leonids - Zoom

MEO

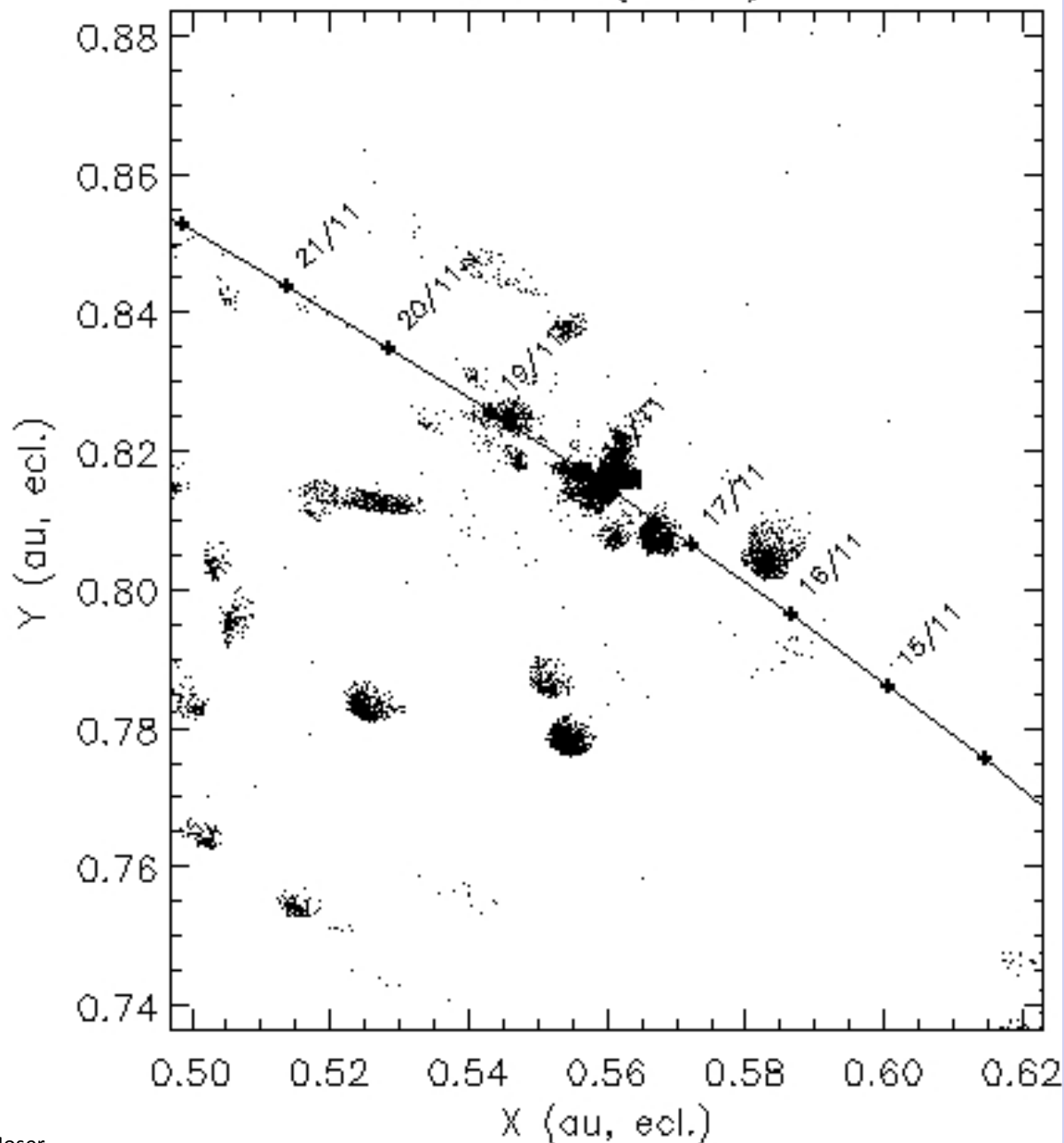


2009 Leonids

MEO



Nodes (2009)



Year 2009
TrailL 1466
Nrev 16
Time of max: 17/11/2009 at
21:43 (may be 0.5-1hr later)
Sol.Long. 235.54461 deg
 (idem)
dist (au) -0.000447
DeltaA (au) 0.09939
f_M 0.195
ZHR 500 /hr

f_M is less than in 2008 but the trail will be much closer to the Earth, explaining why we expect a ZHR reaching the 'half-storm' level (a storm is typically defined as ZHR=1000). The time of maximum may be later than expected, as in 2008: the whole calculation of the orbit of the comet has to be done before we are able to provide a time of maximum with greater confidence.

So 2009 will not see a Leonid storm, but an outburst that will reach 5 times the level of the Perseids.

| encounters with trails | | | | | | | | |
|------------------------|------|----------|-------|---------|-----------|------------------|---------|-------------|
| trail | year | rD-rE | Vej | fM(fMD) | sol.long. | Max. time | ZHRex | Reliability |
| rev. | - | m/s | - | ° | AU | UT | meteors | - |
| 7 | 1767 | 0.00247 | 43.04 | -0.731 | 234.160 | 16.11.2009 12:50 | 2 | 4 |
| 7 | 1767 | 0.00307 | 43.38 | 1.356 | 234.183 | 16.11.2009 13:23 | 3 | 4 |
| 13 | 1567 | -0.00244 | 13.04 | -0.012 | 234.776 | 17.11.2009 3:30 | 1 | 2 |
| 13 | 1567 | -0.00289 | 10.00 | 0.074 | 234.895 | 17.11.2009 6:20 | 3 | 2 |
| 16 | 1466 | -0.00082 | 9.82 | 0.001 | 235.440 | 17.11.2009 19:18 | 1 | 2 |
| 17 | 1433 | 0.00194 | 11.36 | 0.010 | 235.441 | 17.11.2009 19:20 | 1 | 2 |
| 16 | 1466 | -0.00005 | 9.66 | -0.002 | 235.448 | 17.11.2009 19:31 | 2 | 2 |
| 16 | 1466 | -0.00066 | 9.84 | -0.007 | 235.448 | 17.11.2009 19:31 | 4 | 2 |
| 17 | 1433 | 0.00203 | 11.12 | -0.035 | 235.457 | 17.11.2009 19:42 | 4 | 2 |
| 16 | 1466 | 0.00039 | 9.99 | -0.004 | 235.486 | 17.11.2009 20:25 | 3 | 2 |
| 16 | 1466 | 0.00054 | 9.98 | 0.001 | 235.488 | 17.11.2009 20:26 | 1 | 2 |
| 16 | 1466 | -0.00076 | 10.11 | 0.081 | 235.506 | 17.11.2009 20:53 | 39 | 2 |
| 14 | 1533 | -0.00039 | 13.01 | -0.010 | 235.522 | 17.11.2009 21:16 | 10 | 2 |
| 14 | 1533 | 0.00001 | 12.83 | 0.002 | 235.537 | 17.11.2009 21:38 | 2 | 2 |
| 16 | 1466 | -0.00058 | 10.27 | -0.030 | 235.538 | 17.11.2009 21:39 | 18 | 2 |
| 14 | 1533 | 0.00044 | 10.68 | -0.072 | 235.550 | 17.11.2009 21:55 | 65 | 2 |
| 14 | 1533 | -0.00006 | 10.43 | -0.001 | 235.586 | 17.11.2009 22:46 | 1 | 2 |
| 15 | 1499 | -0.00025 | 11.32 | 0.001 | 235.626 | 17.11.2009 23:44 | 1 | 2 |
| 27 | 1102 | 0.00008 | 8.25 | -0.002 | 235.699 | 18.11.2009 1:28 | 1 | 0 |
| 27 | 1102 | 0.00012 | 8.24 | 0.013 | 235.700 | 18.11.2009 1:30 | 3 | 0 |
| 24 | 1201 | -0.00019 | 14.82 | -0.042 | 236.445 | 18.11.2009 19:14 | 8 | 1 |
| 25 | 1167 | -0.00032 | 10.14 | -0.002 | 236.475 | 18.11.2009 19:56 | 1 | 1 |
| 20 | 1333 | -0.00163 | 17.66 | -0.004 | 236.635 | 18.11.2009 23:44 | 1 | 1 |

In 2009 a very strong traditional maximum is expected. At 9 UT 17 November activity should rise to 25-30 meteors on ZHR scale. Also, at **21-22 UT 17 November** a considerable outburst from 1466 and 1533 trails is likely. **Activity will reach 130-140 meteors on ZHR scale**, a number of submaximas is likely. Meteor brightness will be about average level. Another small enhancement can be produced by 1201 trail. At 19 UT 18 November activity will rise to 10-15 meteors on ZHR scale, meteor brightness will be a little lower than average level.

| traditional maximum | | | |
|---------------------|--------------------|---------|-----------|
| Sol.long. | Max. time | ZHRex | Intensity |
| ° | UT | Meteors | - |
| 235.008 | 17.11.2009 9:02 | 25-30 | 4 |

More from the IMO

'This year may produce another enhanced return, with ZHRs predicted to peak at 100+ according to independent theoretical work by David Asher, Esko Lyytinen & Marku Nissinen, Mikhail Maslov, and Jérémie Vaubaillon. Trails laid down by the comet in 1466 and 1533 are expected to be the chief contributors to whatever happens, with peaks on November 17, due at sometime from about 20h40m to 22h UT then.

Esko & Marku's work suggests the 1466 trail may produce heightened rates generally, with ZHRs above 20, from about 6h30m UT on November 17 till 0h30m UT on November 18, and likely above ~ 40 from ~ 16h-23h UT on November 17. This increased ZHR level will probably combine with that from the 1533 trail to push ZHRs up perhaps towards 120 at some stage between 21h-22h UT on the 17th.

Mikhail suggested ZHRs should peak in that hour too, with ZHRs of ~ 130-140.

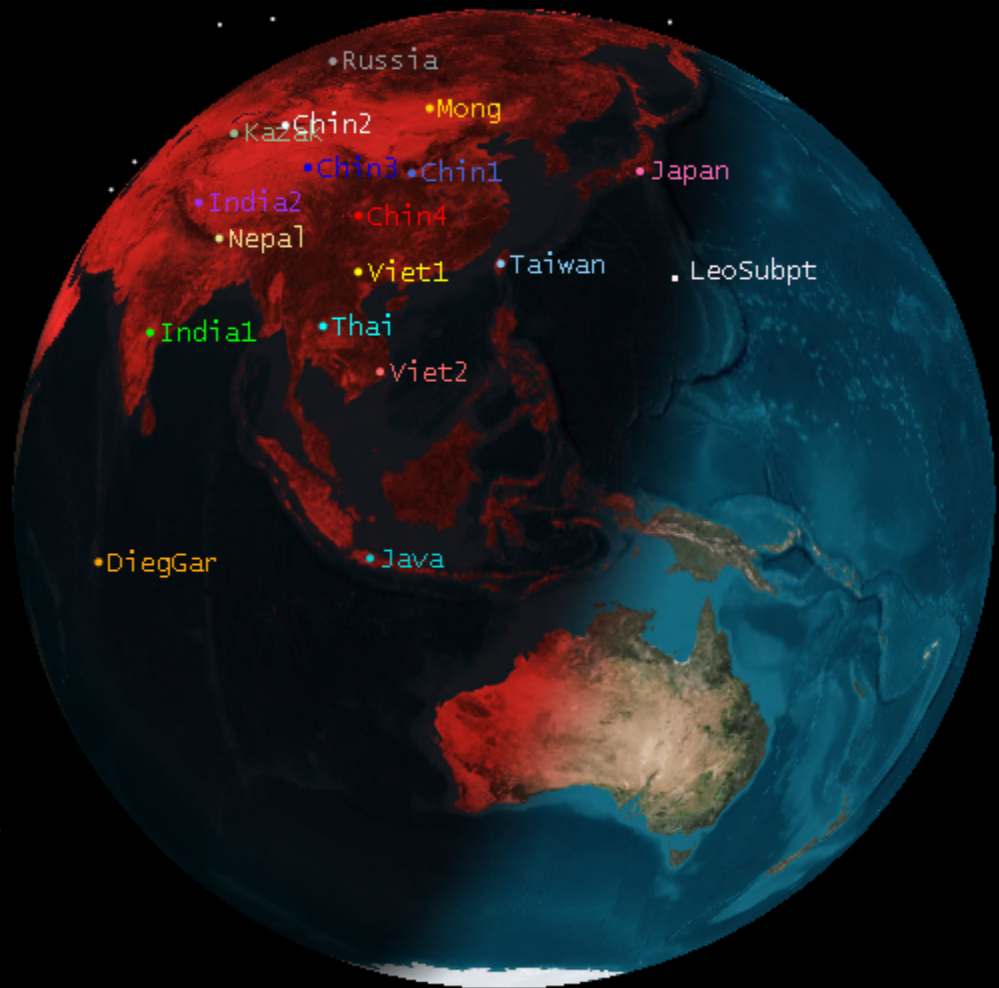
Jérémie's modeling implied the chance of a possible meteor storm, with ZHR peaks around 21h44m (ZHRs ~ 950+) and 21h51m UT (~ 600) combining to give a rate perhaps in the 1000-1500 range briefly.

Other submaxima with lower rates are possible too, around November 17, 7h26m (ZHRs ~ 200+), 9h (~ 25-30), November 18, 0h04m (~ 15) and 19h UT (~ 10-15, faint meteors), according to some of these same researchers. The nodal crossing time listed above is another possible peak, based on previous non-enhanced returns, though its ZHR is likely to be a more modest 10-20.'

<http://www.imo.net/calendar/2009#leo>

Viewing the 2009 Leonids

- Candidate Deployment Sites
 - Weather
 - Moon Phase



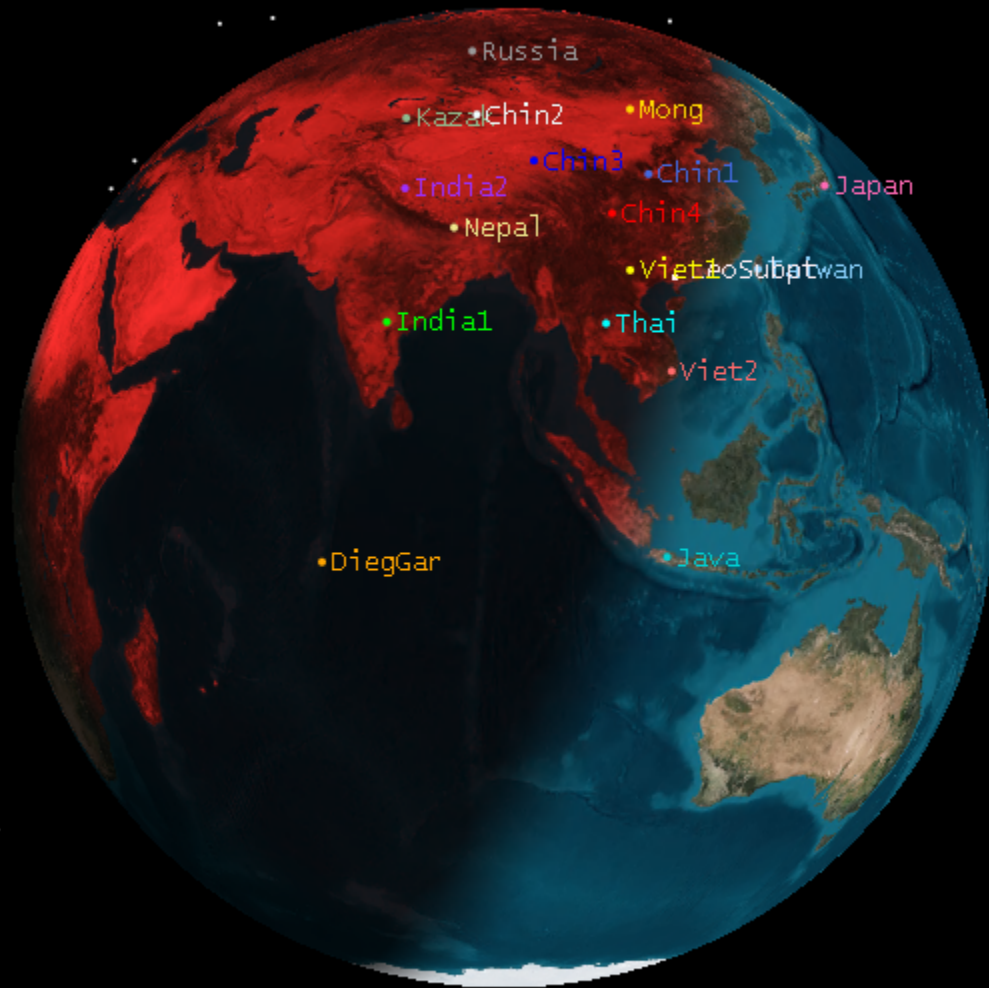
Earth Inertial Axes

17 Nov 2009 21:00:00.000 Time Step: 30.00 sec.



Earth Inertial Axes

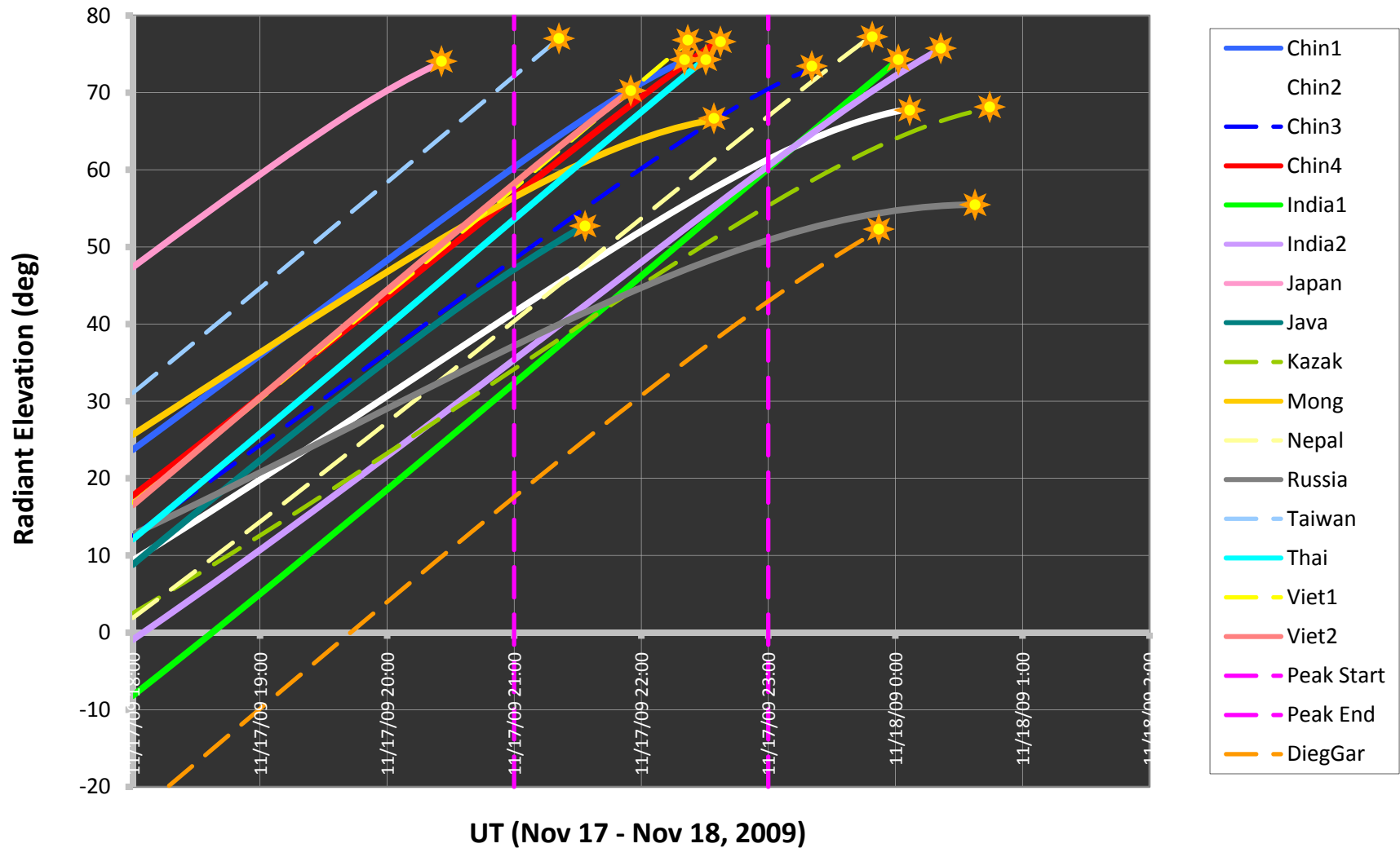
17 Nov 2009 22:00:00.000 Time Step: 30.00 sec.



Earth Inertial Axes

17 Nov 2009 23:00:00.000 Time Step: 30.00 sec.

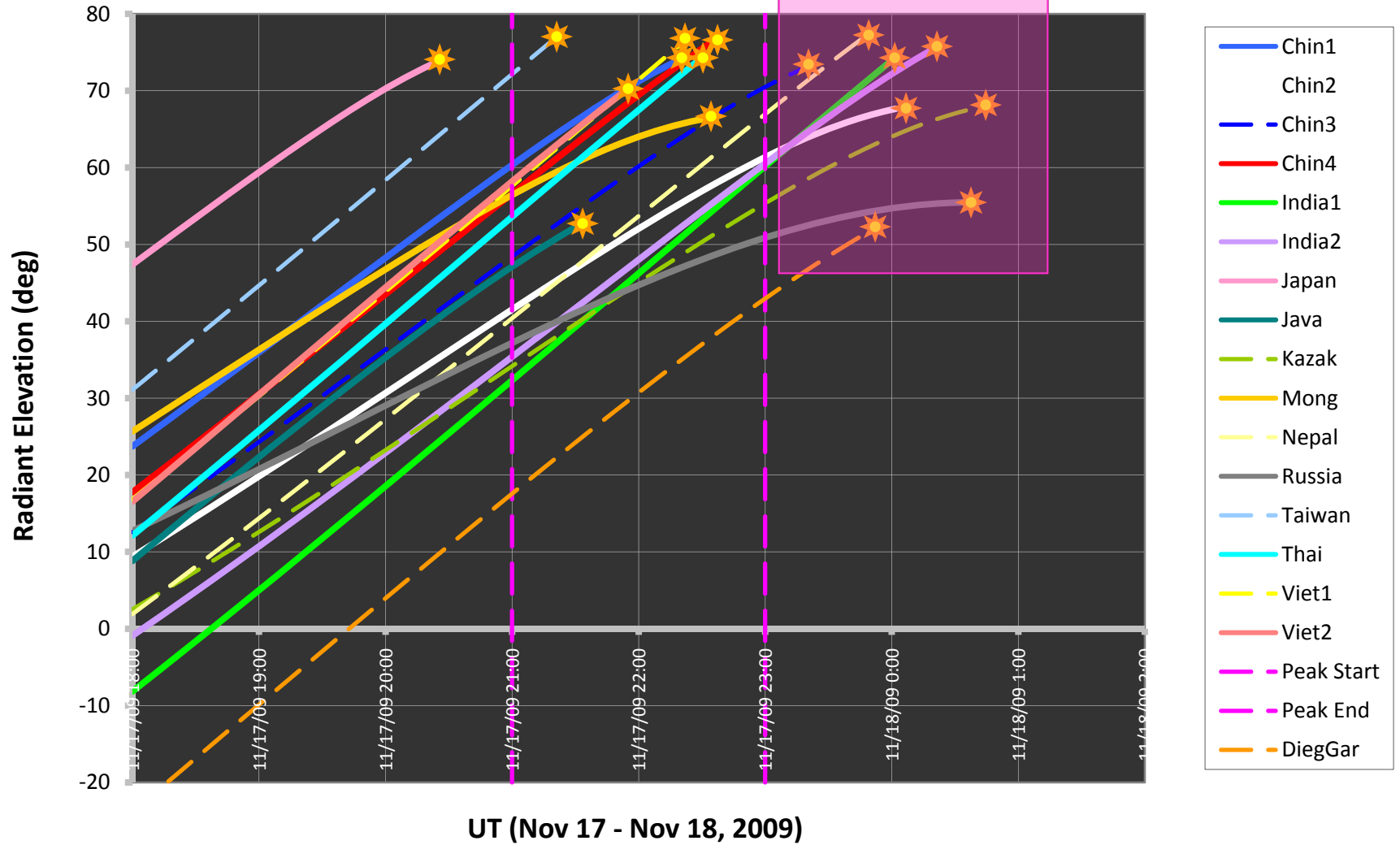
Candidate 2009 Leonid Deployment Sites



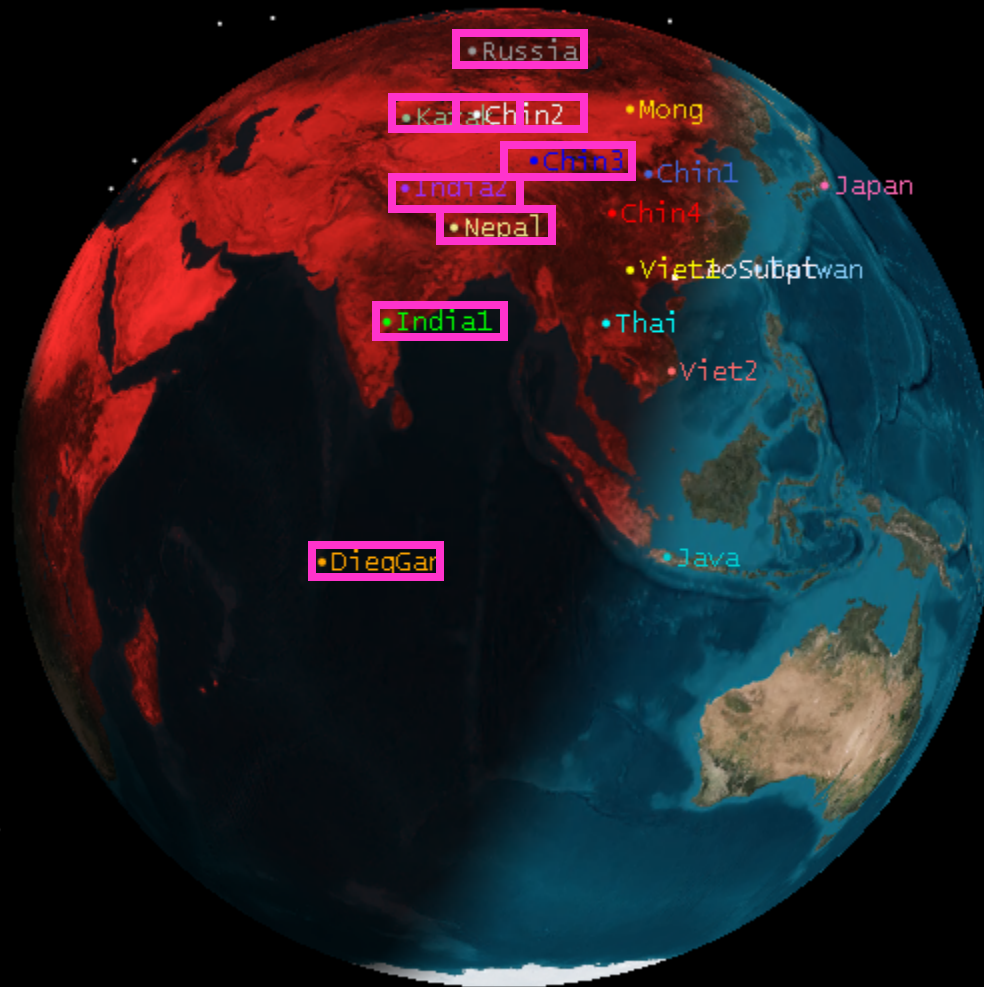
★ Indicates nautical twilight

Candidate 2009 Leonid Deployment Sites

Chin3, Nepal, India1,
India2, Chin2, Kazak,
Russia, DiegGar



★ Indicates nautical twilight



Earth Inertial Axes

17 Nov 2009 23:00:00.000 Time Step: 30.00 sec.

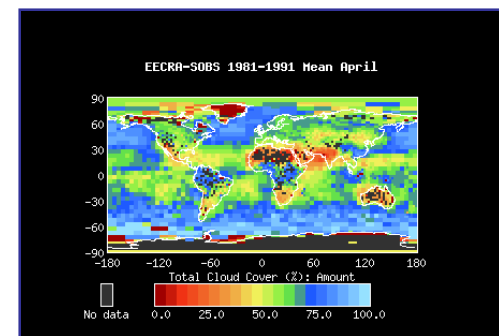
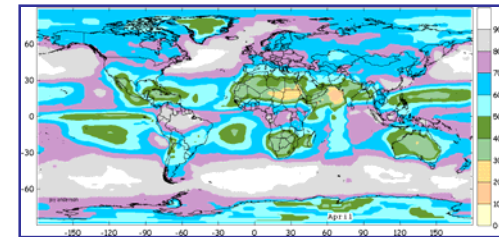
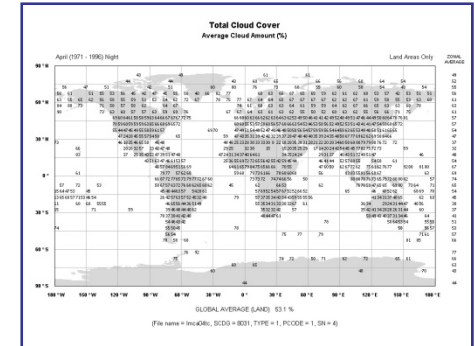
More Comments from the IMO

'As the Leonid radiant rises usefully only around local midnight (or indeed afterwards south of the equator), the 21h-22h UT apparently critical interval will fall best chiefly for sites across Asia, from the extreme east of Europe eastwards to Japan and places at similar longitudes, but with the possibility of some unusual activity at almost any stage from ~ 6h-24h UT on November 17, only European and African longitudes look set to miss out. Even here, radio coverage of the shower will be possible for part of that time. Of course, other possible maxima are not excluded (look out for updates nearer the time), and observers should be alert as often as conditions allow throughout the shower, in case something unexpected happens. All observing techniques can be usefully employed.'

<http://www.imo.net/calendar/2009#leo>

Cloud Data Sources

- **EECRA, 1971-1996**
 - Extended Edited Cloud Reports Archive
 - Night observations only
 - 5°-5° resolution
- **ISCCP, 1982-2001**
 - International Satellite Cloud Climatology Project
 - Day and night observations
 - Smoothed 2.5°-2.5° resolution
- **EECRA-SOBS, 1981-1991**
 - Extended Edited Cloud Reports Archive-Surface OBServations
 - Day and night observations
 - Originally 2.5°-2.5° resolution over land, 5°-10° resolution over water; remapped to 2.5°-2.5°



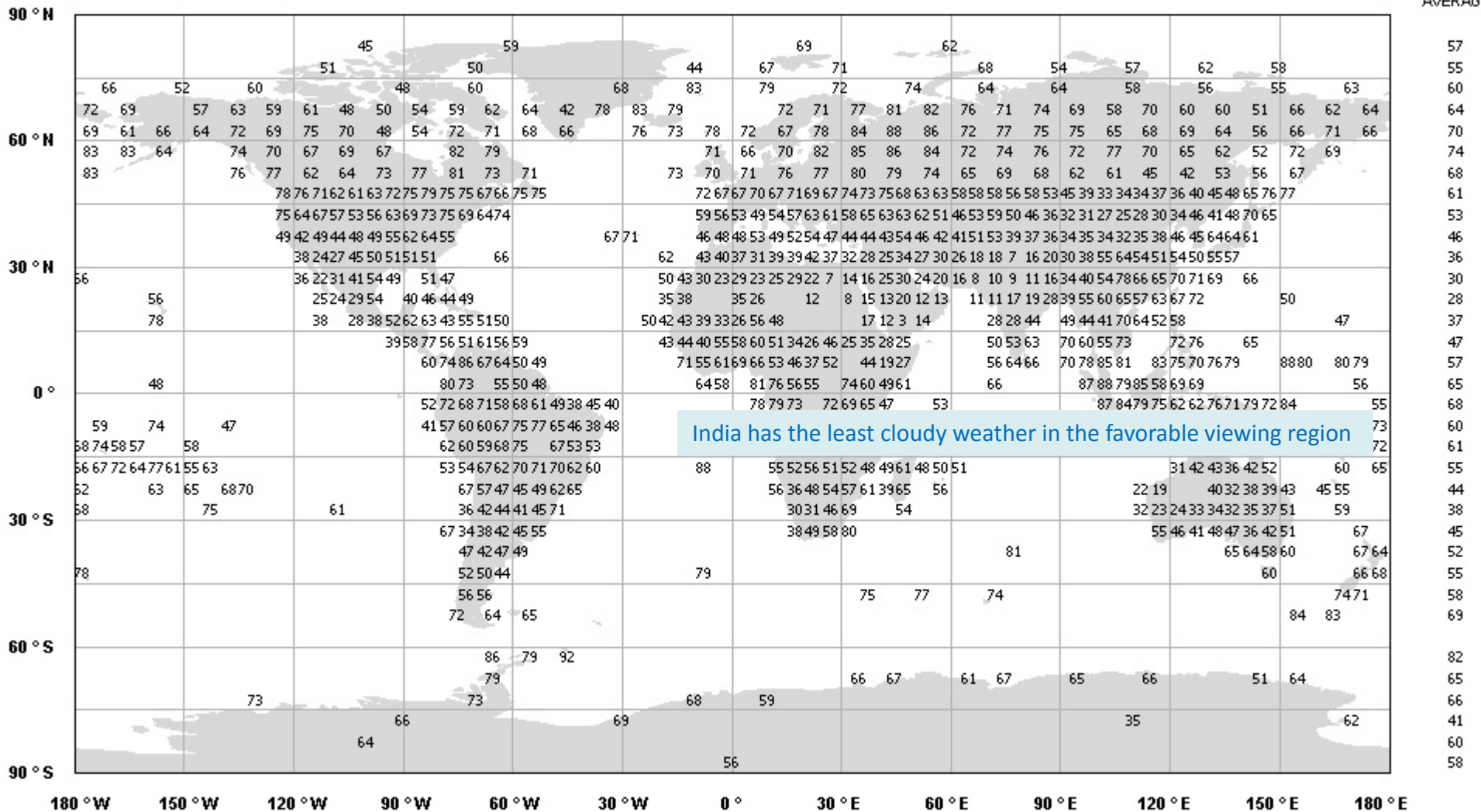
Mean Monthly Cloud Cover (%)

Night only

November (1971 - 1996) Night

Land Areas Only

ZONAL AVERAGE



India has the least cloudy weather in the favorable viewing region

GLOBAL AVERAGE (LAND) 53.2 %

(File name = lmca11tc, SCDG = 8101, TYPE = 1, PCODE = 1, SN = 11)

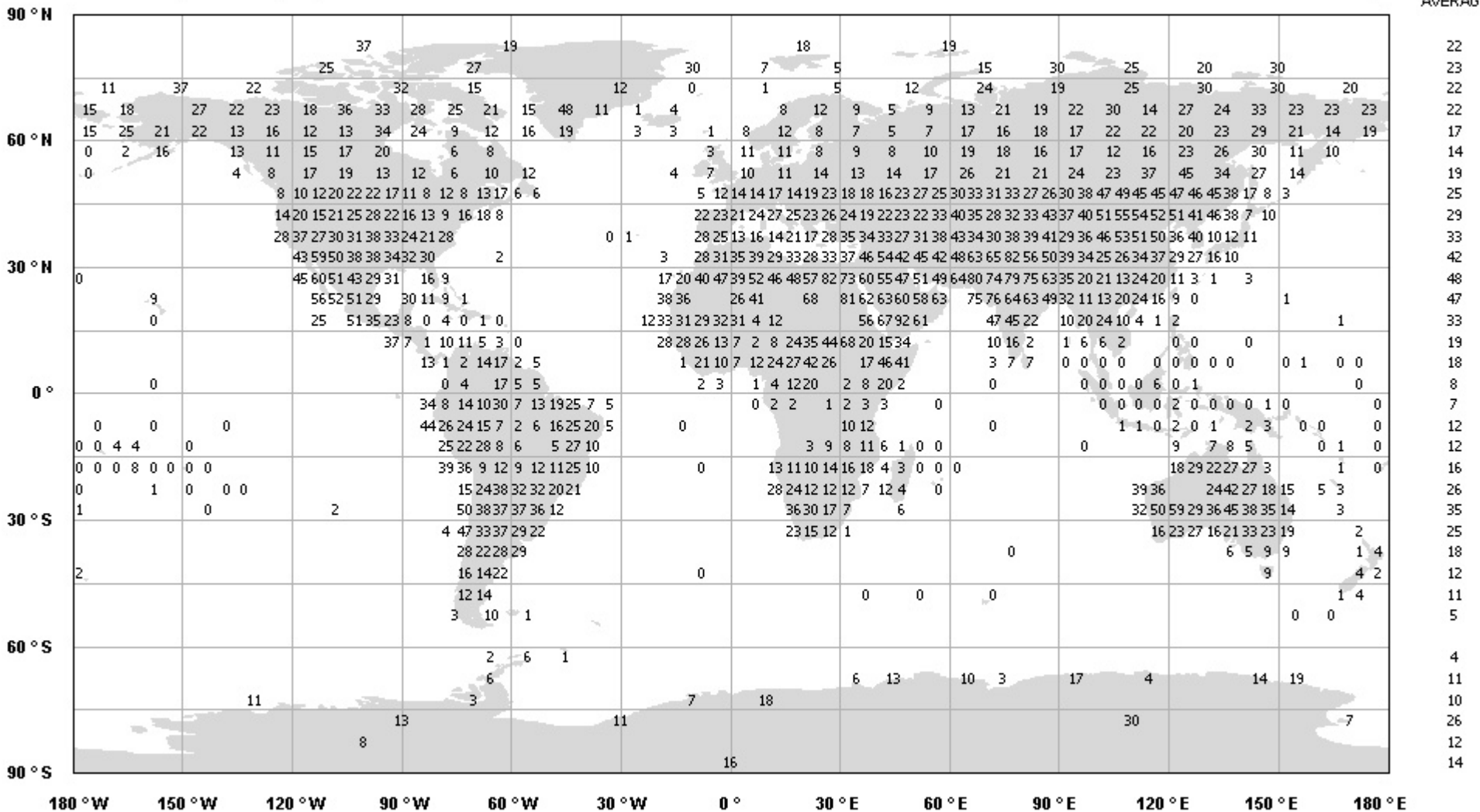
Mean Monthly Completely Clear Sky (%)

Night only

November (1971 - 1996) Night

Land Areas Only

ZONAL AVERAGE

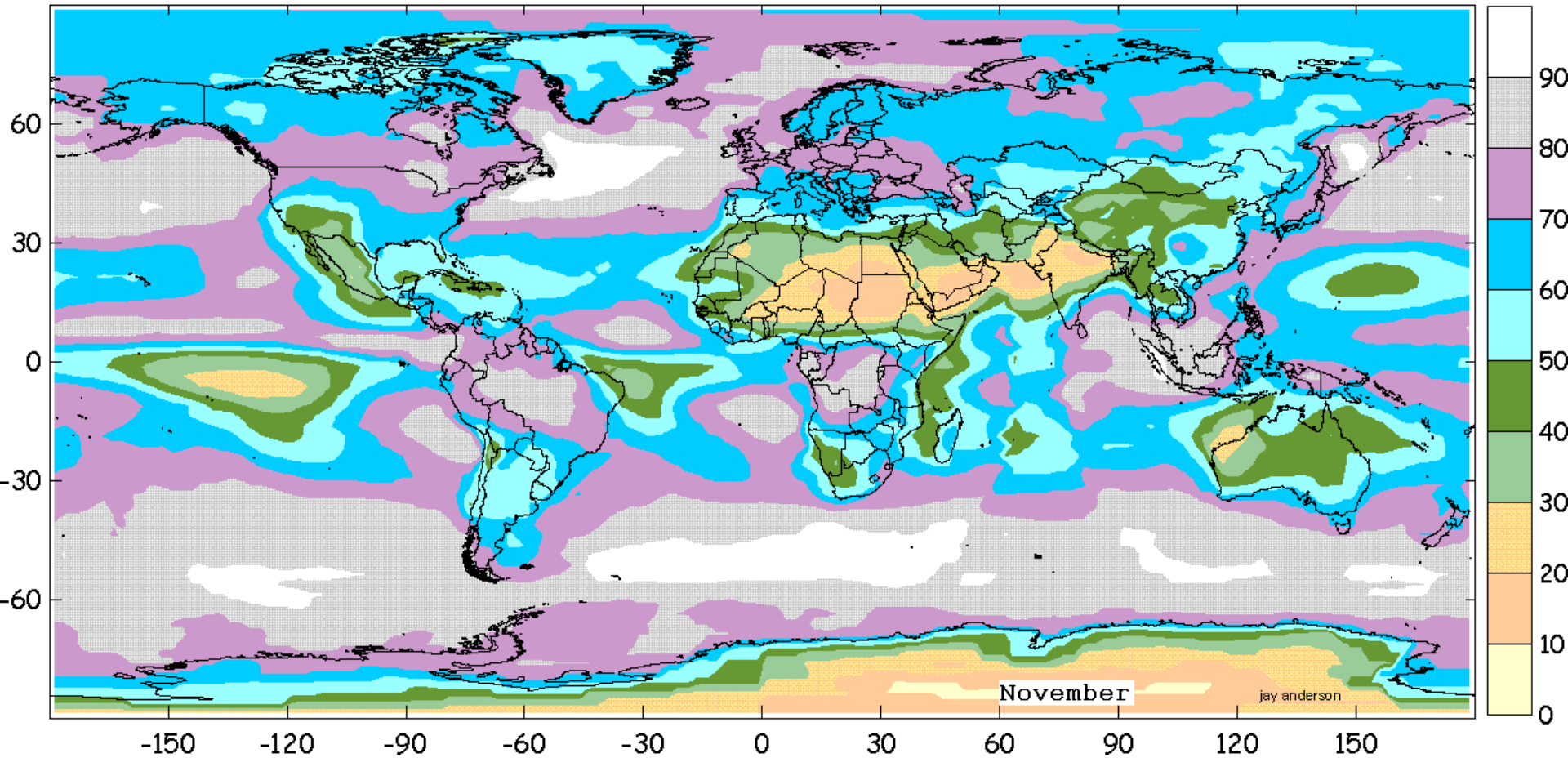


GLOBAL AVERAGE (LAND) 24.1 %

(File name = lmcf11cr, SCDG = 9111, TYPE = 2, PCODE = 2, SN = 11)

Mean Monthly Cloud Cover (%)

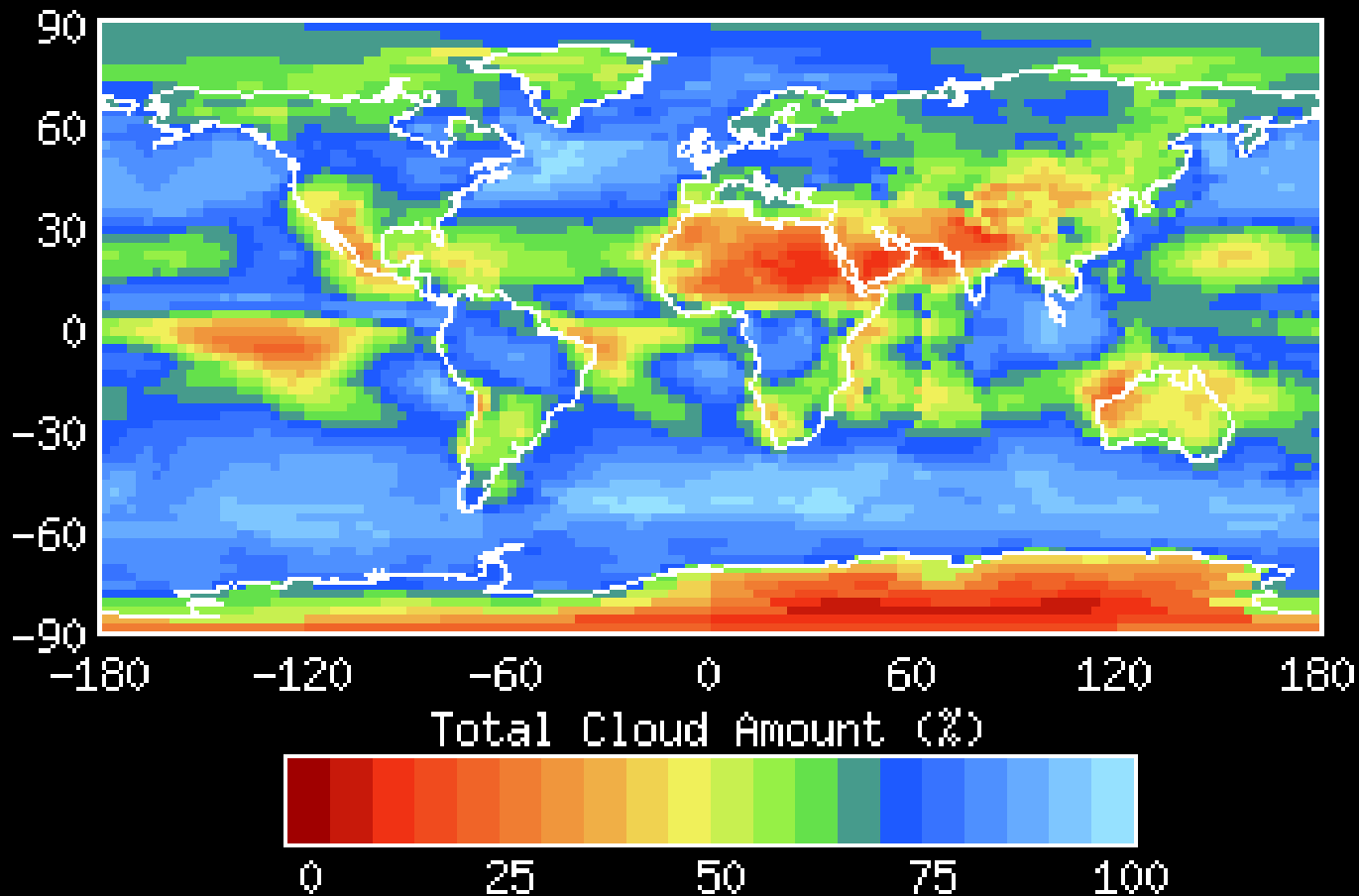
Day and Night



Mean Monthly Cloud Cover (%)

Day and Night

ISCCP-D2 198307-200606 Mean November









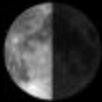
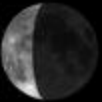






















Lunar Phase

[PREV](#)

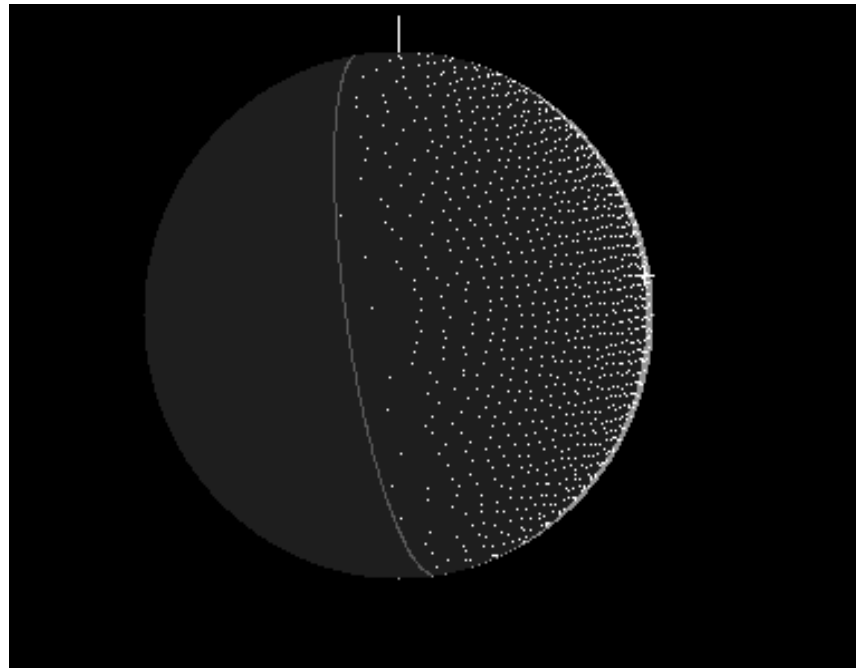
November 2009

[NEXT](#)

| SUN | MON | TUE | WED | THU | FRI | SAT |
|---|---|---|--|--|--|--|
| 1  99% 14 days | 2  Full Moon 2:15 P.M. | 3  99% 16 days | 4  96% 17 days | 5  90% 18 days | 6  82% 19 days | 7  72% 20 days |
| 8  61% 21 days | 9  Last Quarter 10:57 A.M. | 10  38% 23 days | 11  28% 24 days | 12  18% 25 days | 13  11% 26 days | 14  5% 27 days |
| 15  1% 28 days | 16  New Moon 2:14 P.M. | 17  1% 1 day | 18  4% 2 days | 19  8% 3 days | 20  14% 4 days | 21  22% 5 days |
| 22  30% 6 days | 23  39% 7 days | 24  First Quarter 4:38 P.M. | 25  58% 9 days | 26  67% 10 days | 27  76% 11 days | 28  84% 12 days |
| 29  91% 13 days | 30  97% 14 days | | | | | |

Moon almost new
– good viewing
conditions!

Lunar Impact Monitoring



Though the near side of the Moon will see the Leonid radiant at the peak predicted time, this shower is not a candidate for Earth-based lunar meteoroid impact monitoring due to the lunar phase and viewing geometry.

Related Links

<http://meo.nasa.gov>

<http://www.imo.net>

<http://www.imcce.fr/page.php?nav=/en/ephemerides/phenomenes/meteor/DATABASE/Leonids/2009/index.php>

<http://feraj.narod.ru/Radiants/Predictions/1901-2100eng/Leo2001-2010eng.html>