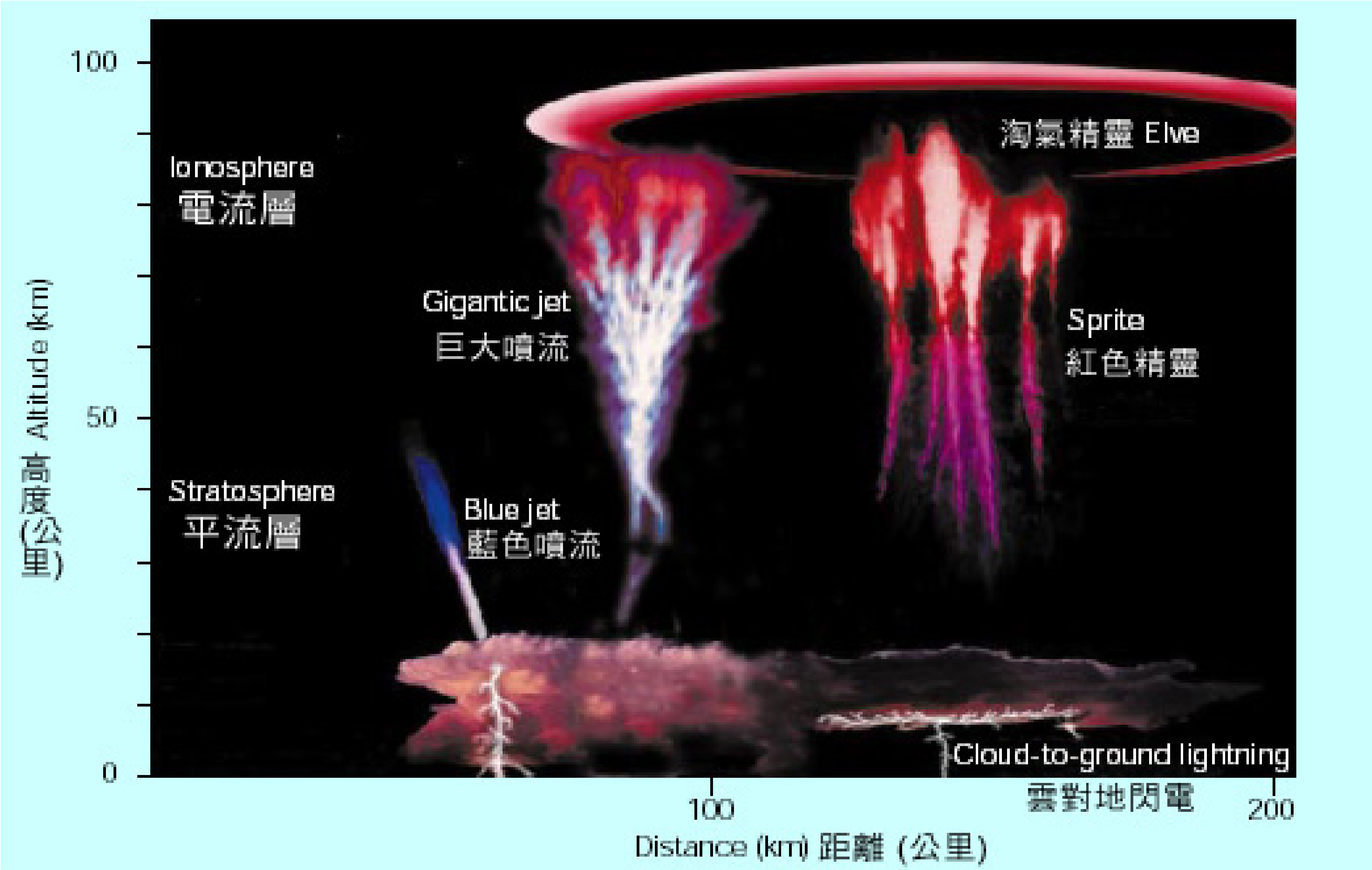
高空閃電



http://sprite.phys.ncku.edu.tw/NewSprite/article.php?topic=1123567881&article=sprite

當雷雨胞內的靜電荷，發生正、負電荷中和的放電現象，此為"雲內閃電"。當雷雨胞內的靜電荷與地表產生的感應電荷交換電荷、彼此中和，所發生的放電現象，即為一般常見的"雲對地閃電"。

由於電離層與地表一樣，都具有很高導電度(為良導體)，因此雷雨胞內的電子也可能向上與電離層內的感應電荷中和，發生放電現象，此即所謂的"高空閃電"。

另外也有人稱高空閃電為高空放電(upper-atmospheric discharge)或暫態發光事件(transient luminous events，TLEs)。

http://www.ss.ncu.edu.tw/~SpaceEdu/database/IntroSpace_notes_exam/Sprite.html http://highscope.ch.ntu.edu.tw/wordpress/?p=2785

截至目前為止，科學家發現的高空閃電現象有：紅色精靈(Red Sprites)、藍色噴流(Blue Jet)、淘氣精靈(Emission of Light and Very Low Frequency Perturbations From Electro-magnetic Pulse Sources，ELVES)、巨大噴流(Gigantic jets)，它們都是伴隨著雷雨雲的高空短暫發光現象。

因為發生位置較高、時間比閃電更加短暫、亮度低且常被閃電光輝所遮掩，因此以往很少有針對高空閃電的研究。

http://highscope.ch.ntu.edu.tw/wordpress/?p=2785

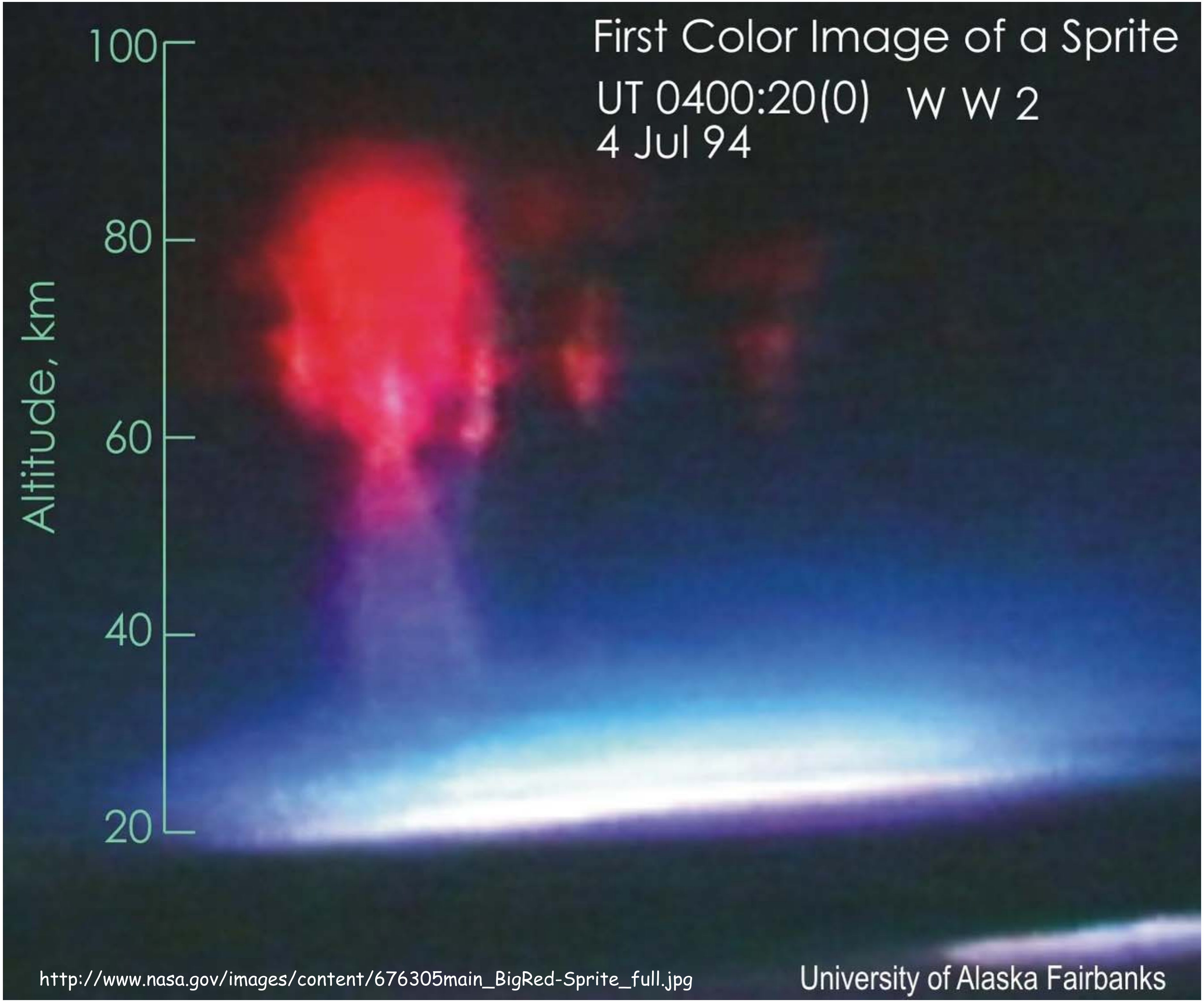
紅色精靈

研究結果顯示，紅色精靈是在雷雨雲向地面閃電後千分之幾秒內，在雲層頂端與電離層之間，離地面約30~90公里的高空中所引起的一種放電發光現象。這些發光體主要顏色為紅色，且在空中出現的時間非常短暫，通常不到三十分之一秒，故稱之為紅色精靈。

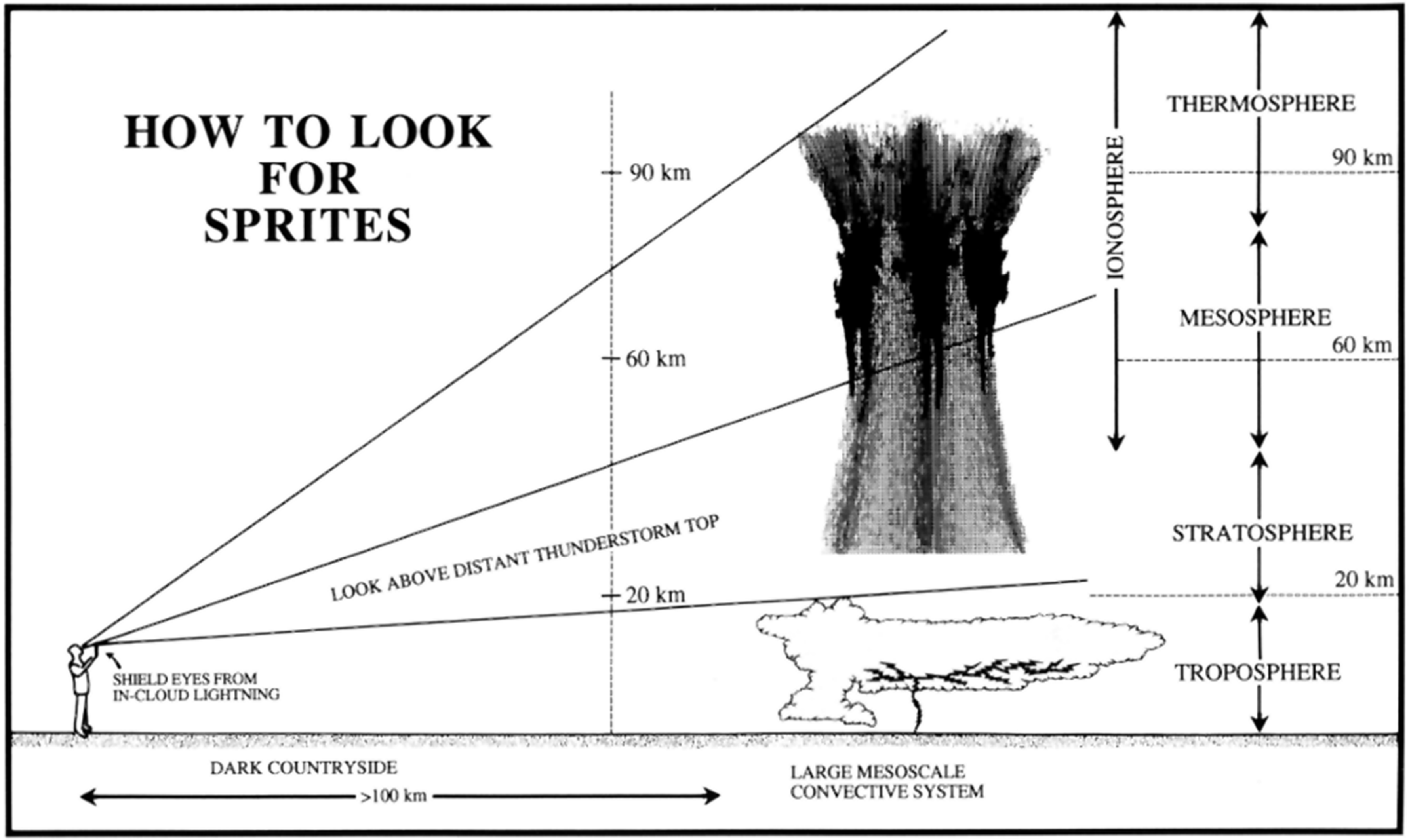
有蘿蔔狀與柱狀兩種主要型態，典型的蘿蔔狀紅色精靈，長度約50公里，寬度約5~10公里，上半部主要是紅色，底部的鬚狀部分則漸漸轉變為藍色。柱狀的紅色精靈長度約10~15公里，寬度小於1公里。

經由光譜分析可知，紅色精靈的紅色主要是來自於受激發的氮分子所發出的紅光，而藍色的鬚狀部分主要是受激發的氮離子所發出的藍光。

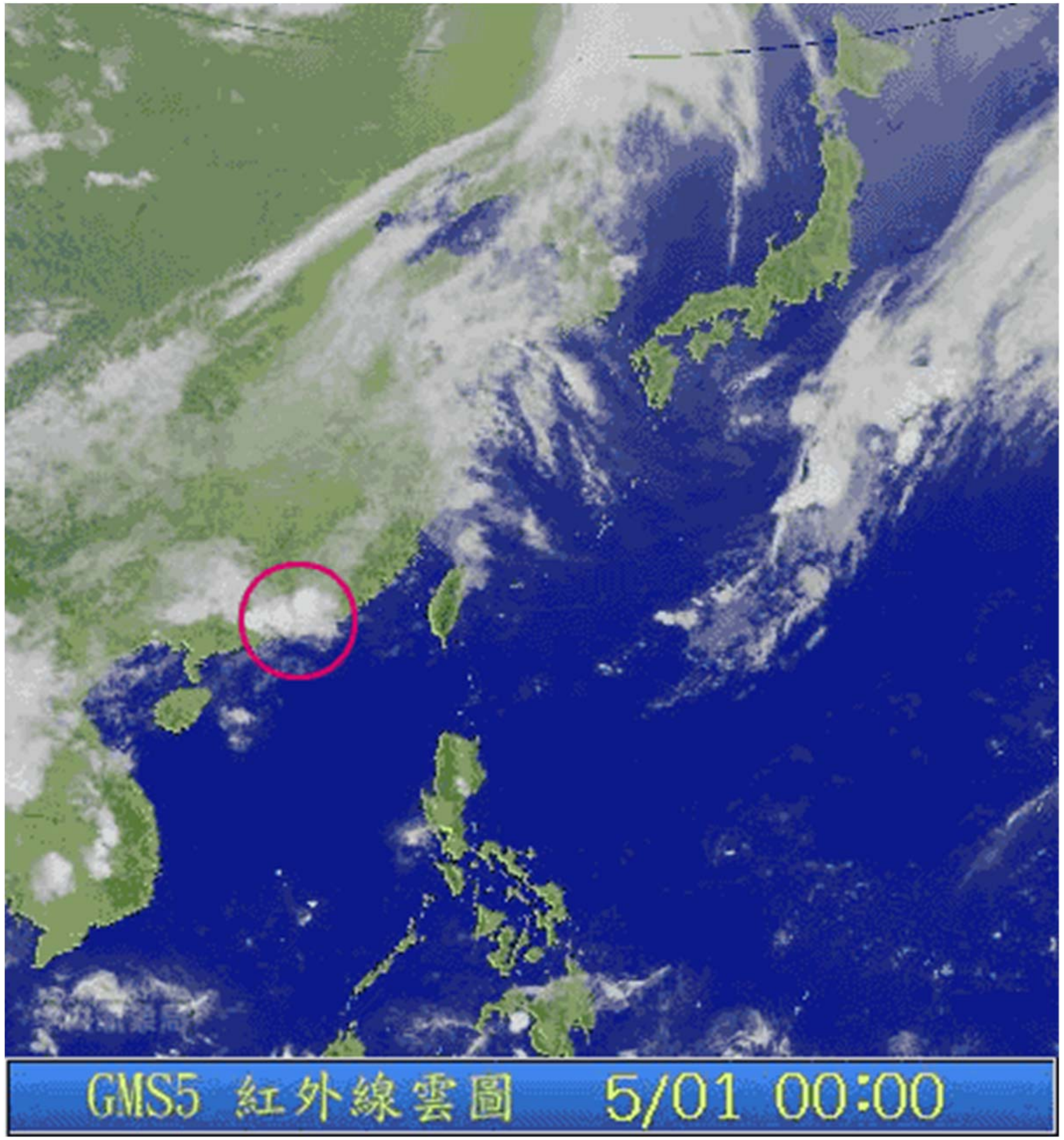
http://web1.nsc.gov.tw/ct.aspx?xItem=7787&ctNode=40&mp=1

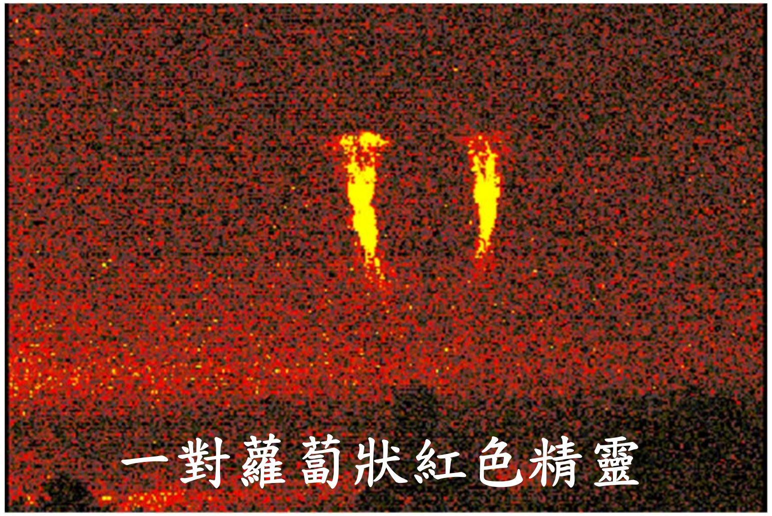

First Color Image of a Sprite
UT 0400:20(0) W W 2
4 Jul 94
100
80
60
40
20
Altitude, km
http://www.nasa.gov/images/content/676305main_BigRed-Sprite_full.jpg
University of Alaska Fairbanks

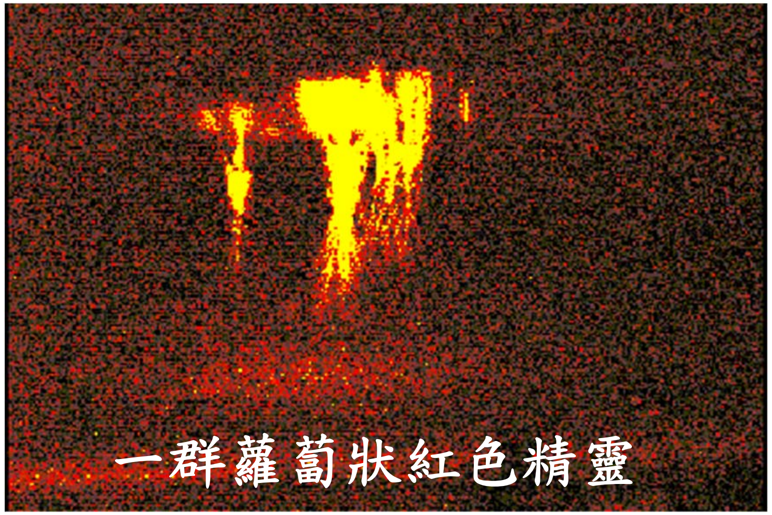
由於事件是發生在雷雨雲的上空，觀測時都會選擇在二百至八百公里遠處的雷雨雲作為觀測對象，且為避免大氣造成的干擾，觀測地點也都會選擇在高山上，如此就可遠觀雲層頂上的大氣放電現象。每次觀測都必須在觀測地點是天氣非常晴朗，但遠方卻有雷雨的系統，才能觀測到好的紅色精靈的現象，可見觀測的困難度是相當高的。

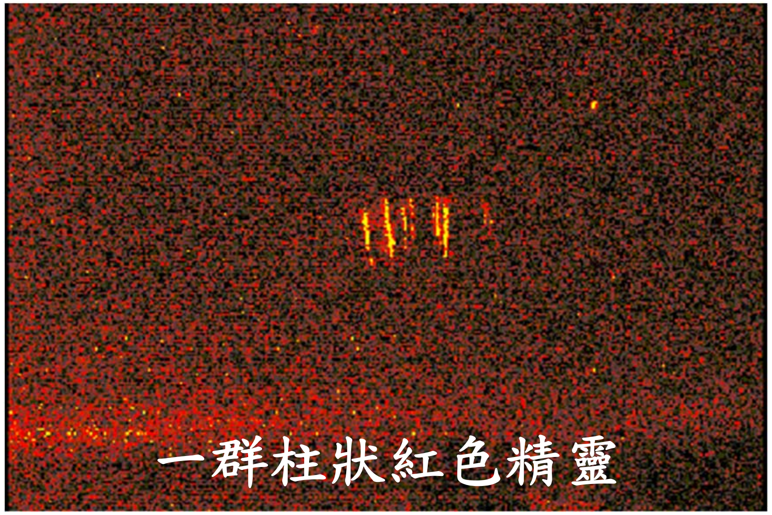


http://spaceweather.com/images2017/22may17/spr-look.gif









成大物理紅色精靈團隊於2001年5月1日凌晨從阿里山氣象站往大陸廣東方向攝得的紅色精靈影像。此為亞洲地區所捕捉到的第一批紅色精靈影像。

http://sprite.phys.ncku.edu.tw/new/news/010502.htm

What's up in space

Tuesday, Apr. 30, 2019

Solar minimum is here - but even now strangely be
auroras are dancing around the poles. Deep inside
Circle, the expert guides of Aurora Holidays in Utsj
Finland, can help you chase them. Book now!

GEOMAGNETIC UNREST EXPECTED: A large ho
facing Earth and spewing a stream of solar wind in
of arrival: **May 2nd**. Minor geomagnetic storms are
material arrives. **Aurora Alerts:** SMS Text

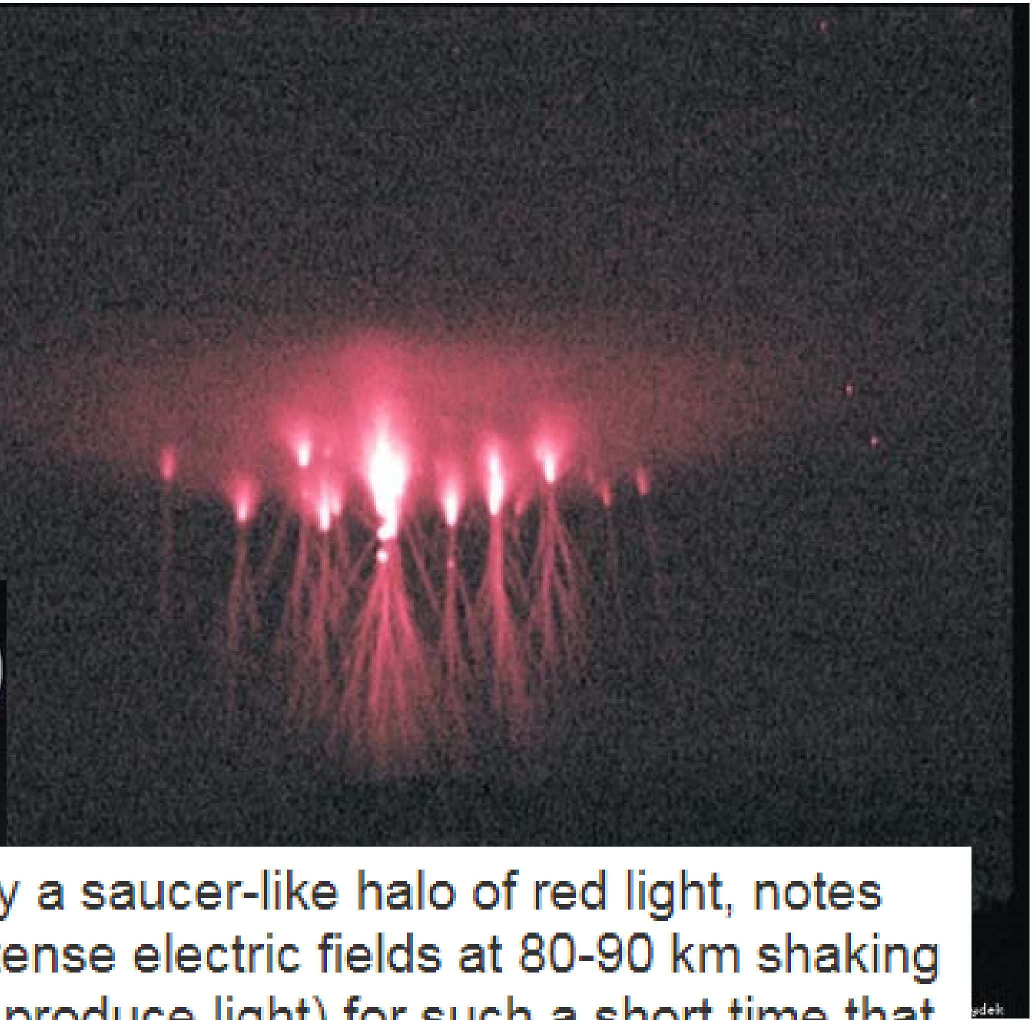
NAKED EYE SPRITE STORMS: Have you ever se
impossible. The strange and fleeting forms of red li
thunderheads, then disappear again in less time th
week veteran sprite chaser Paul Smith says he *did*
number with my bare eyes over the last two big sto

Sprites are an exotic form of electricity that leap up from storm clouds instead of down like ordinary lightning. Although sprites have been reported for at least a century, many scientists did not believe they existed until after 1989 when sprites were accidentally photographed by researchers from the University of Minnesota and confirmed by video cameras onboard the space shuttle.

The underlying physics of sprites is still not fully understood. Some models hold that cosmic rays help them get started by creating conductive paths in the atmosphere. If cosmic rays do indeed spark sprites, now is a good time to look for them because cosmic rays are nearing a Space Age high.

http://spaceweather.com/archive.php?view=1&day=20&month=04&year=2019

What's up in space



Lights Over lapland is excited to announce that Autumn
Aurora Adventures are available for immediate booking
Reserve your adventure of a lifetime in Abisko Nationa
Sweden today!

CO-ROTATING INTERACTION REGION: NOAA forec
rotating interaction region (CIR) might brush against Ea
June 22nd or **23rd**. CIRs are transition zones between
streams of solar wind. They contain enhanced magneti
gradients that sometimes spark geomagnetic storms w
Earth. Chance of storms this week: 20%. **Free:** Space

JELLYFISH SPRITES OVER EUROPE: On June 20th

The tops of the sprites were surrounded by a saucer-like halo of red light, notes van der Velde. "The halo is evidence of intense electric fields at 80-90 km shaking up the electrons (colliding with nitrogen to produce light) for such a short time that sprite streamers cannot form. At lower altitudes the field exists longer, allowing the jellyfish sprite streamers to grow from electron avalanches."

http://spaceweather.com/archive.php?view=1&day=22&month=06&year=2017

What's up in space

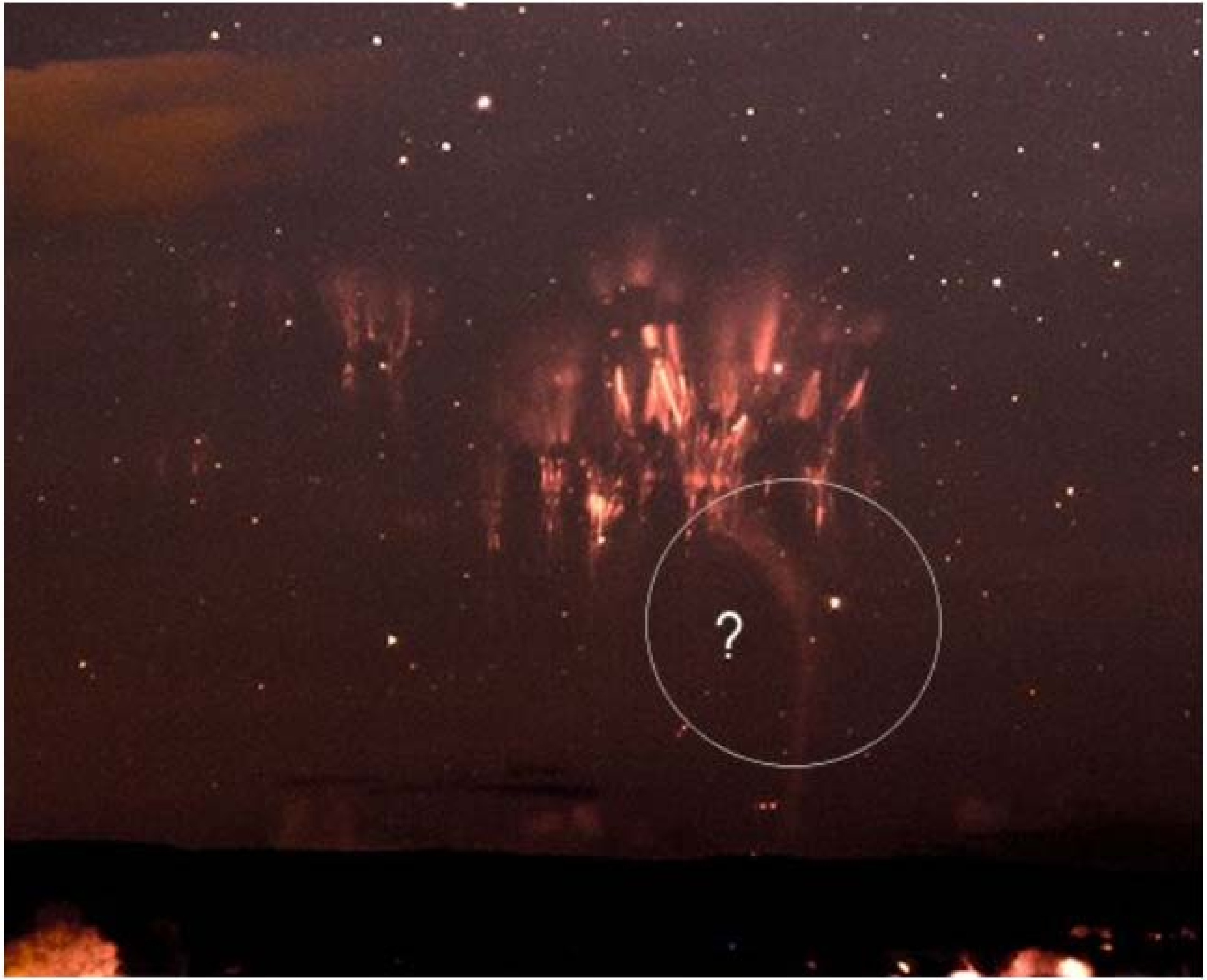
Thursday, Aug. 31, 2017

Lights Over Lapland is excited to announc
Customisable Aurora Adventures are avai
booking! Reserve your adventure of a lifet
National Park, Sweden today!

GEOMAGNETIC STORM UNDERWAY: A
underway on Aug. 31st as Earth enters a
contact with the stream sparked bright au
the solar wind around Earth to blow faster
hours, so more high-latitude auroras are p

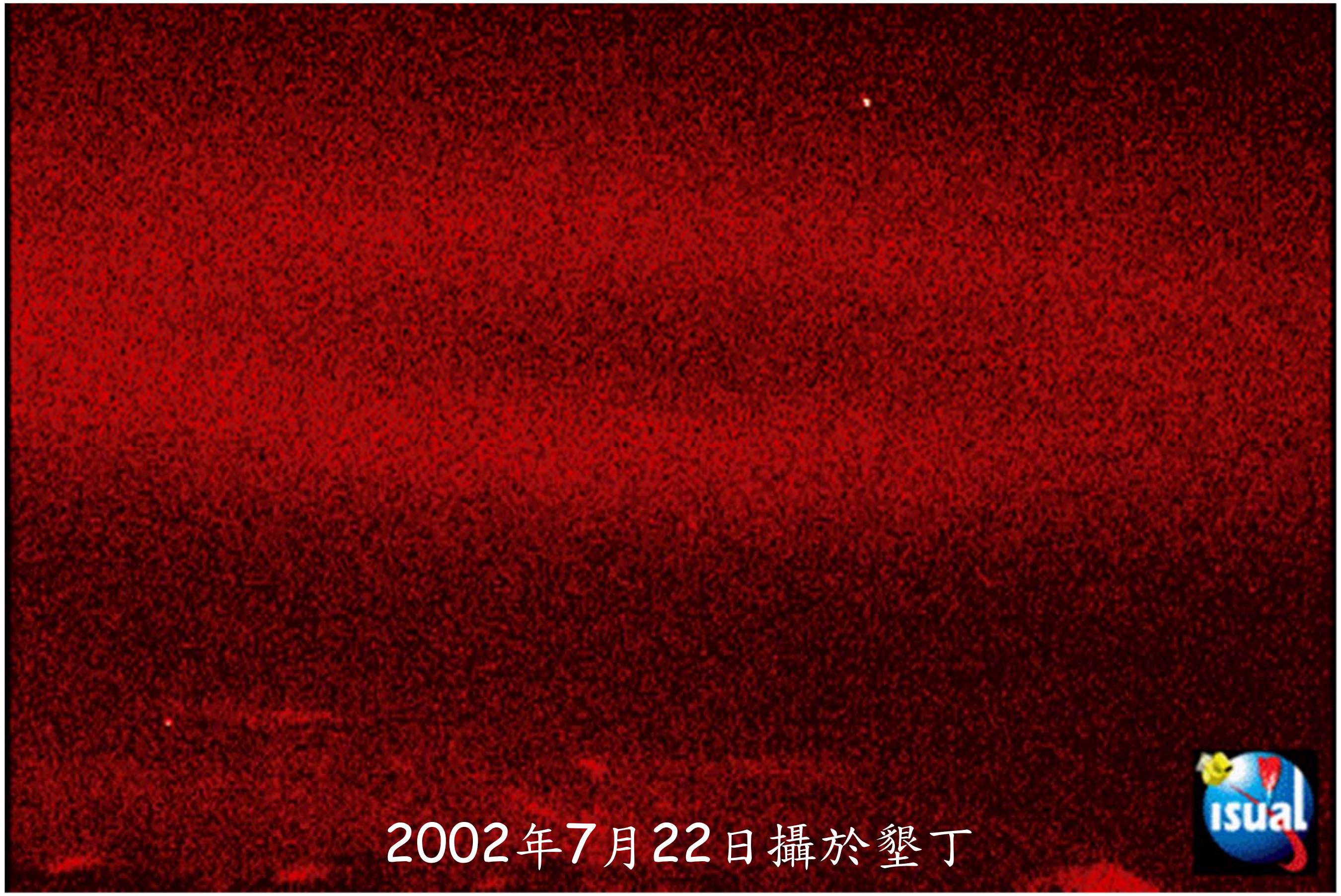
A NEW KIND OF SPRITE? Barely 30 yea
believe that upper atmospheric lightning e
from the University of Minnesota captured
menagerie of accepted forms: sprites, elv
"transient luminous events" (TLEs) appea
space rather than lancing down to the gro

On Aug.14th, Thomas Ashcraft may have
photographing a cluster of sprites over a t
something curved snaked up behind the n
of the event shows the strange form:

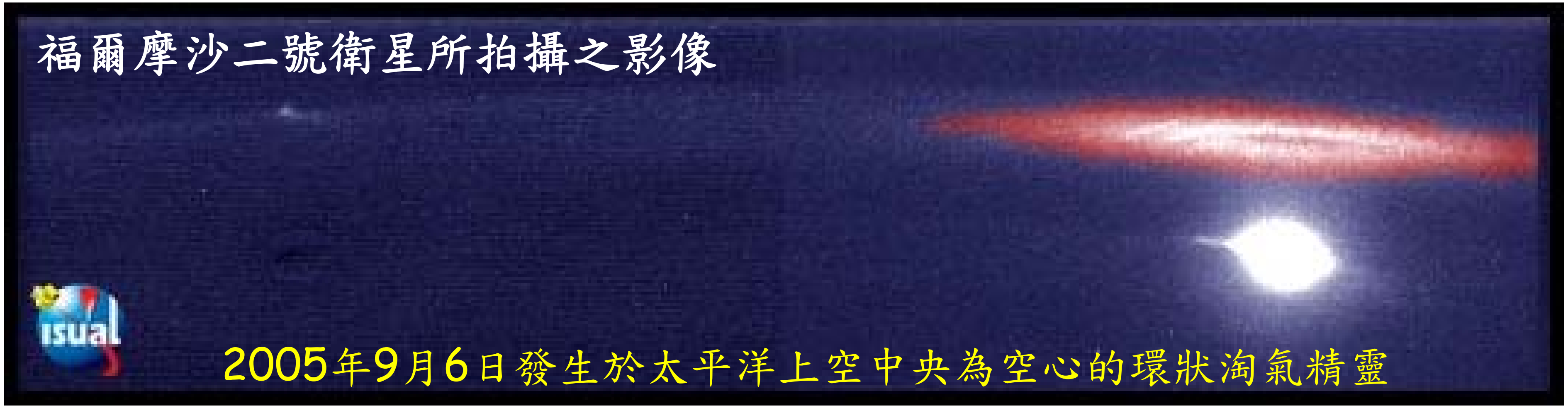


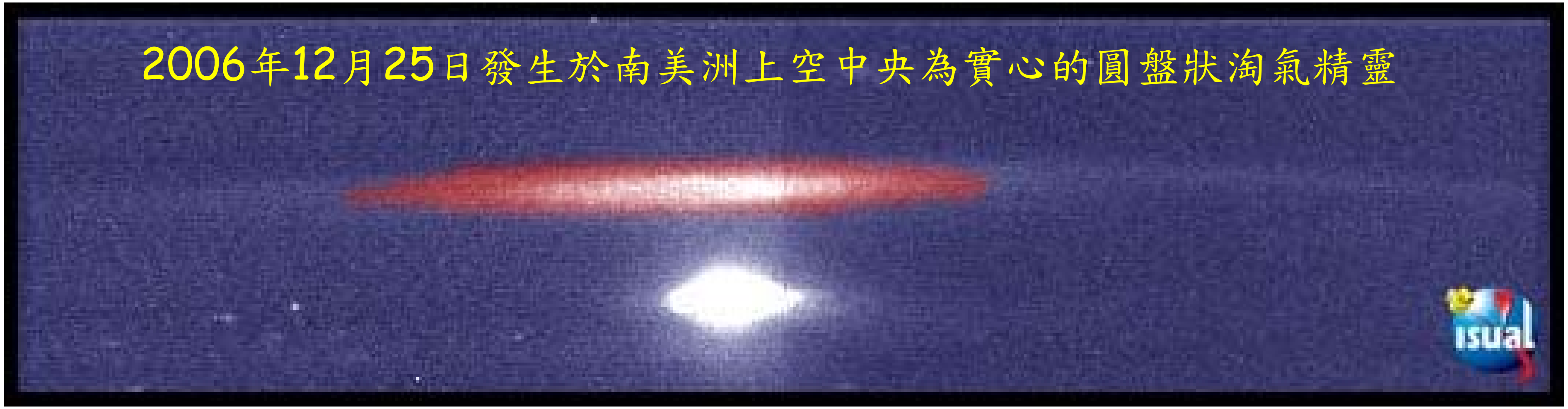
淘氣精靈

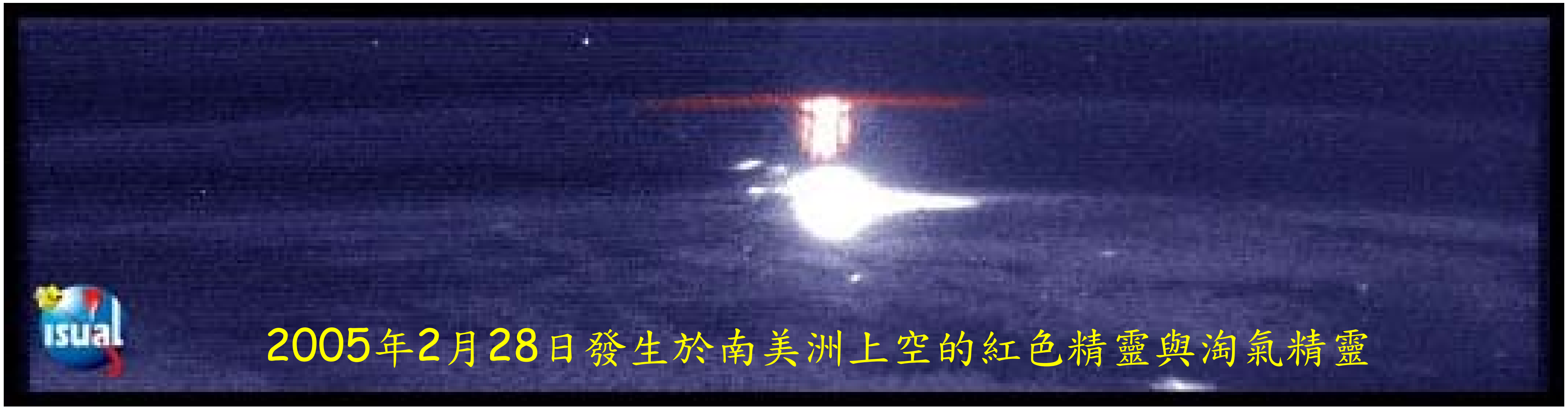
當雲對地閃電之後，所產生的電磁脈衝波會向上傳播，加熱電離層中的帶電粒子，產生的短暫發光現象。淘氣精靈具有火紅色、向外擴張的圈圈餅形狀，高度約在離地75~105公里，寬幅可達約300公里，持續時間很短，大約1毫秒。



http://web1.nsc.gov.tw/ct.aspx?xItem=7787&ctNode=40&mp=1
http://sprite.phys.ncku.edu.tw/index.php?option=com_content&view=article&id=51:elves&catid=13:2010-09-24-08-24-58&Itemid=165







http://sprite.phys.ncku.edu.tw/NewSprite/upload/070112170101.htm

http://sprite.phys.ncku.edu.tw/index.php?option=com_content&view=article&id=51:elves&catid=13:2010-09-24-08-24-58&Itemid=165

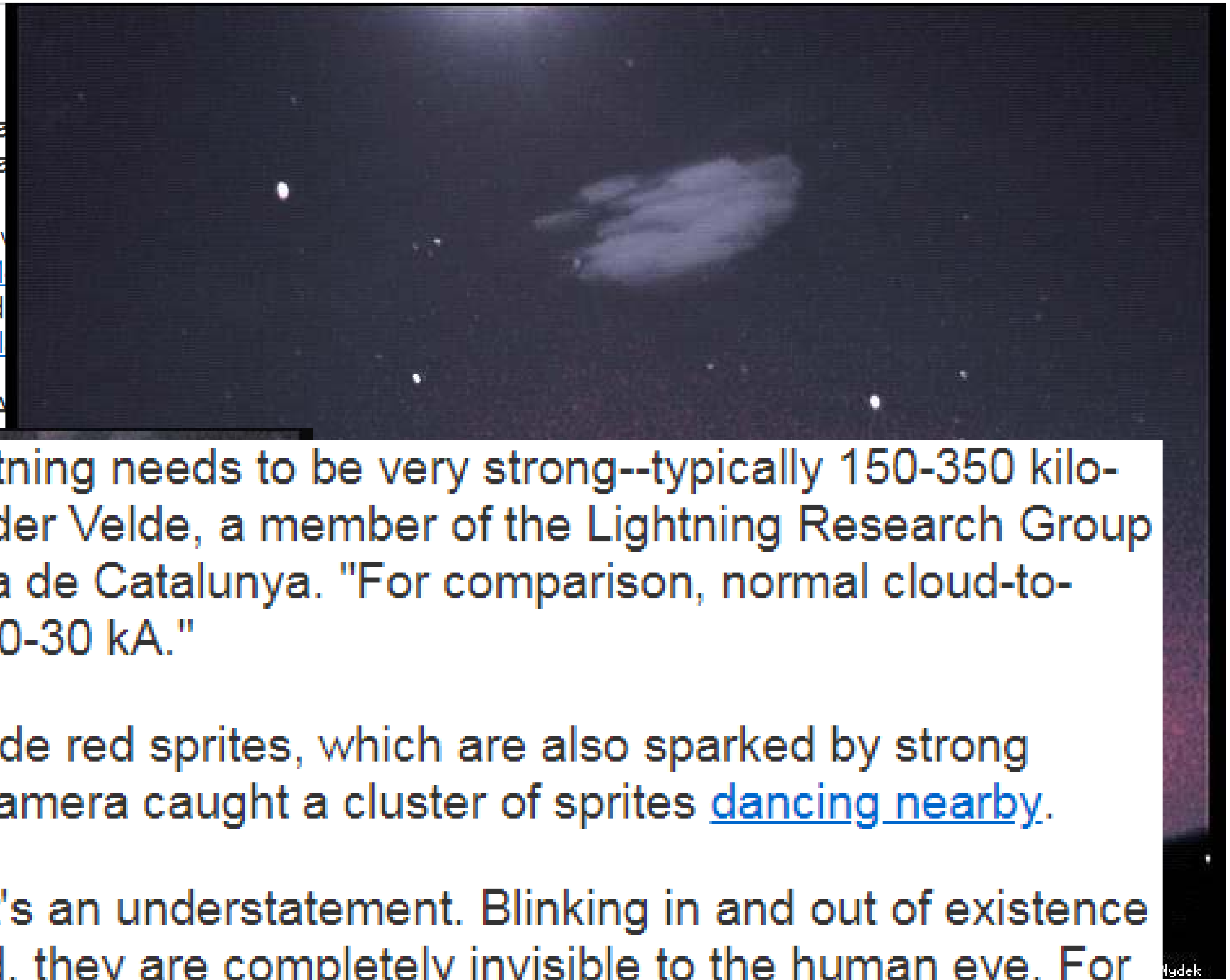
What's up in space

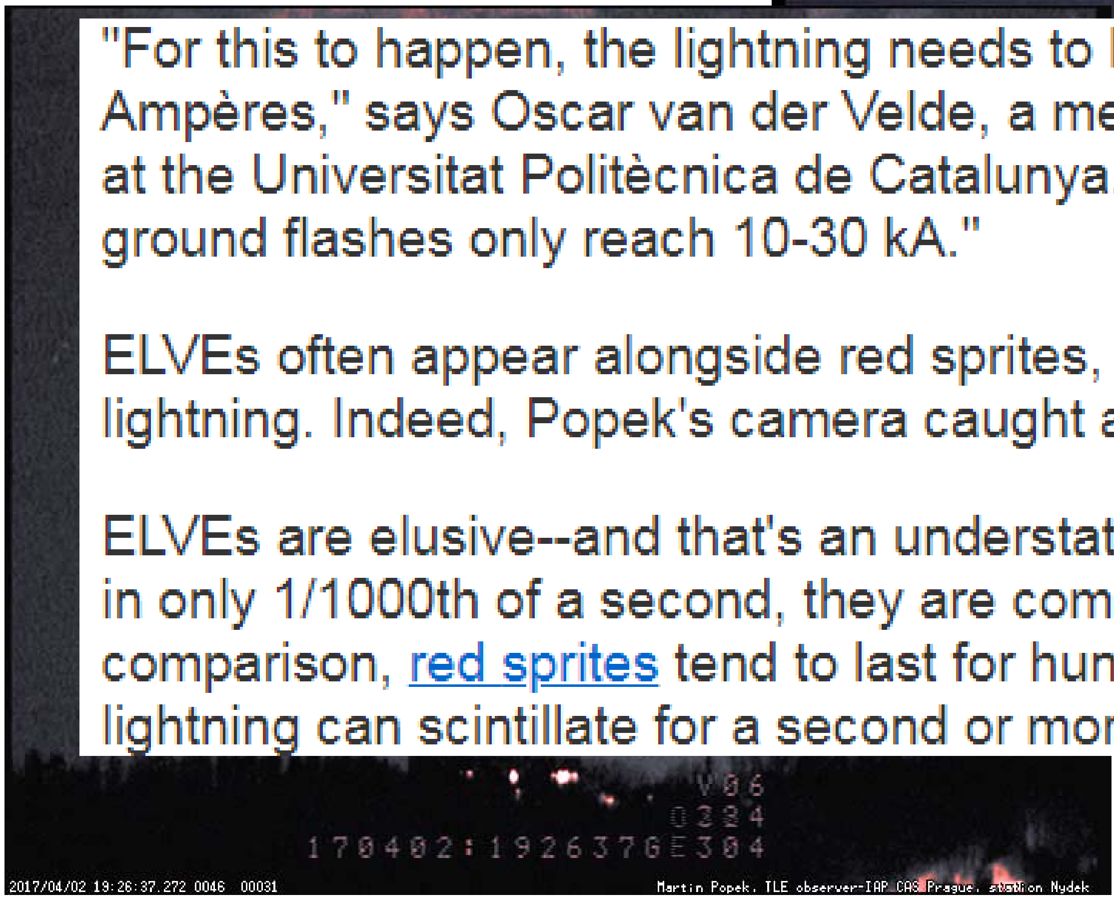
Thursday, Apr. 6, 2017

Directly under the Arctic Circle! Marianne's Arctic
Tromsø offers fjord, whale and wildlife tours by da
tours by night. Email Marianne for bookings and a

SUBSIDING CHANCE OF FLARES: Earlier this
high as sunspot AR2644 unleashed a series of M
however, the sun is quieting. AR2644 has rotated
poses a threat for Earth-directed flares. **Free:** Sol

GIANT 'ELVE' APPEARS OVER EUROPE: On A





"For this to happen, the lightning needs to be very strong--typically 150-350 kilo-Ampères," says Oscar van der Velde, a member of the Lightning Research Group at the Universitat Politècnica de Catalunya. "For comparison, normal cloud-to-ground flashes only reach 10-30 kA."

ELVEs often appear alongside red sprites, which are also sparked by strong lightning. Indeed, Popek's camera caught a cluster of sprites dancing nearby.

ELVEs are elusive--and that's an understatement. Blinking in and out of existence in only 1/1000th of a second, they are completely invisible to the human eye. For comparison, red sprites tend to last for hundredths of a second and regular lightning can scintillate for a second or more. Their brevity explains why ELVEs

http://spaceweather.com/archive.php?view=1&day=06&month=04&year=2017

藍色噴流

當閃電發生時，雲層頂端也會以每秒100公里的高速，向上噴出帶電粒子流。由於這些高速帶電粒子流會激發氮分子發出藍光，因此稱為藍色噴流，其持續時間約為200~300毫秒，最高可達高空40~50公里處。

http://web1.nsc.gov.tw/ct.aspx?xItem=7787&ctNode=40&mp=1
http://sprite.phys.ncku.edu.tw/index.php?option=com_content&view=article&id=8&Itemid=124

巨大噴流

“巨大噴流”和“紅色精靈”有相當大的差別。除了顏色是藍色之外，巨大噴流持續發光的平均時間約0.3秒，比紅色精靈要長約20倍。

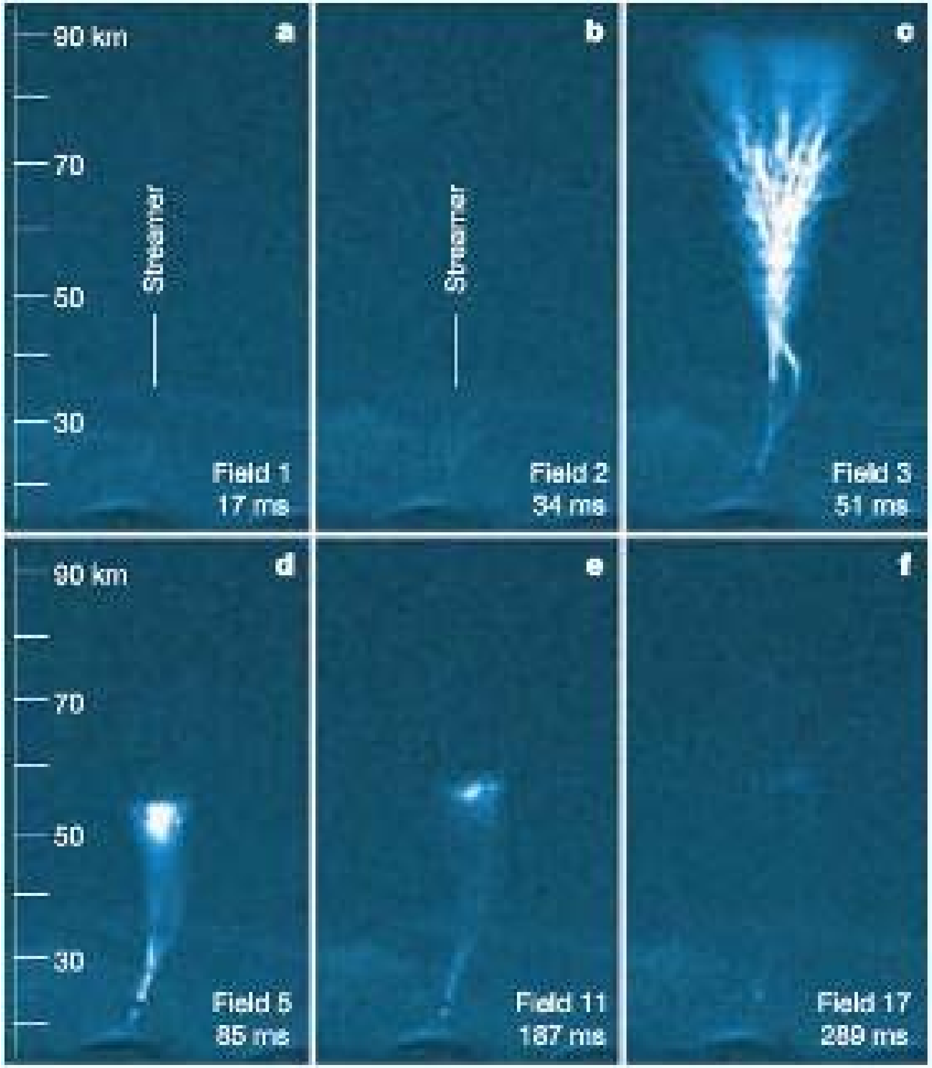
巨大噴流可以很明顯看出發光的噴流從雲層中向高空噴出，與紅色精靈在高空發光但沒有噴射的現象是完全不同。

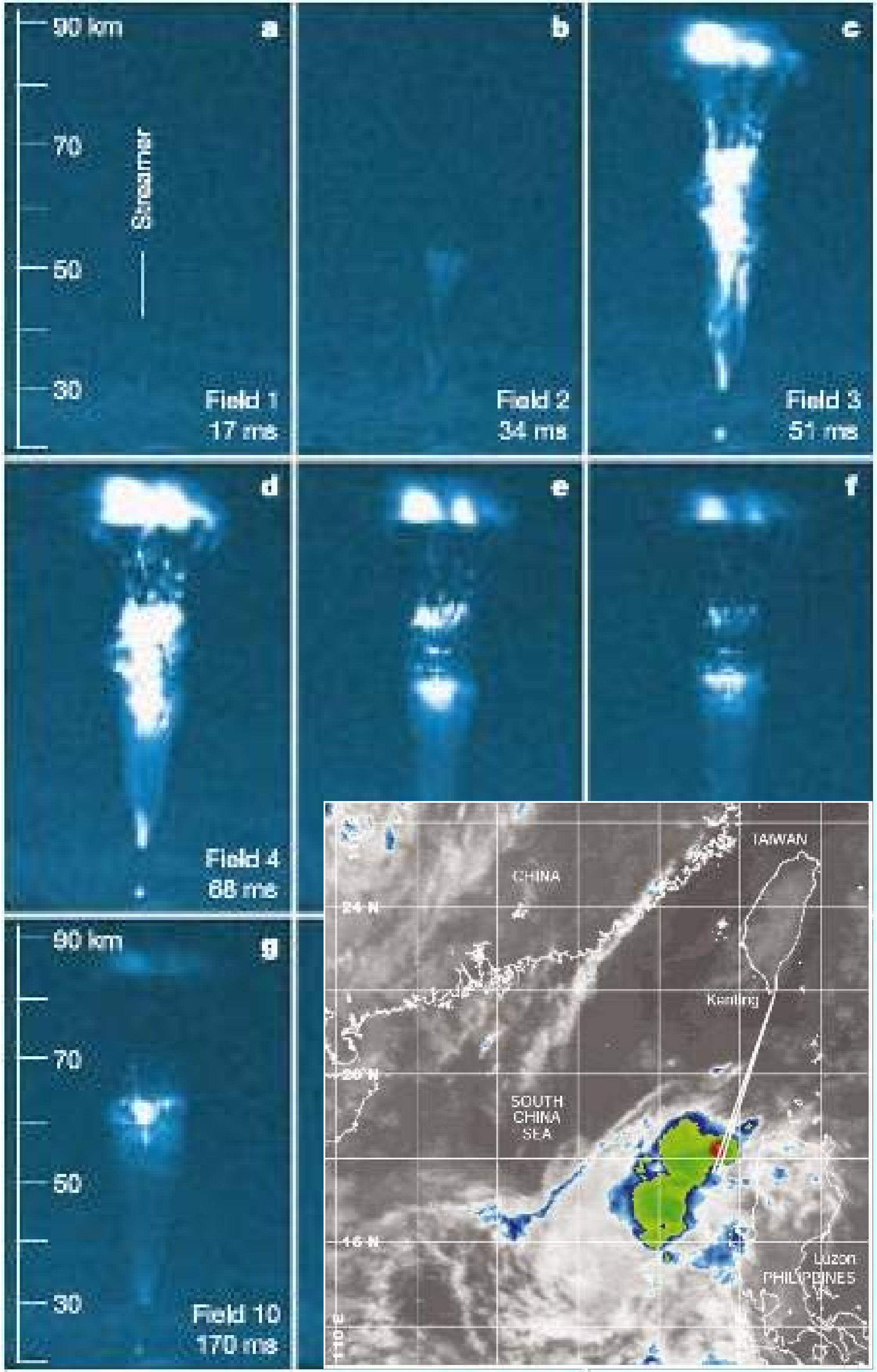
噴流首先由15公里高的雷雨雲頂噴出，並在短時間內形成類似紅色精靈，但比紅色精靈還要巨大的光柱，最高的發光部分是約為90公里高的電離層。

在上半部的發光體漸漸轉為黯淡之際，可以看到下半部的噴流持續地上升到約70公里處，最後才逐漸消失。

http://sprite.phys.ncku.edu.tw/NewSprite/upload/070112170202.htm

巨大噴流





成大團隊在2002年7月22日所記錄的樹狀(上)與蘿蔔狀(右)巨大噴流，噴流頂端寬度約有40公里。

http://sprite.phys.ncku.edu.tw/NewSprite/upload/070112170404.htm

What's up in space

Wednesday, Jul. 26, 2017

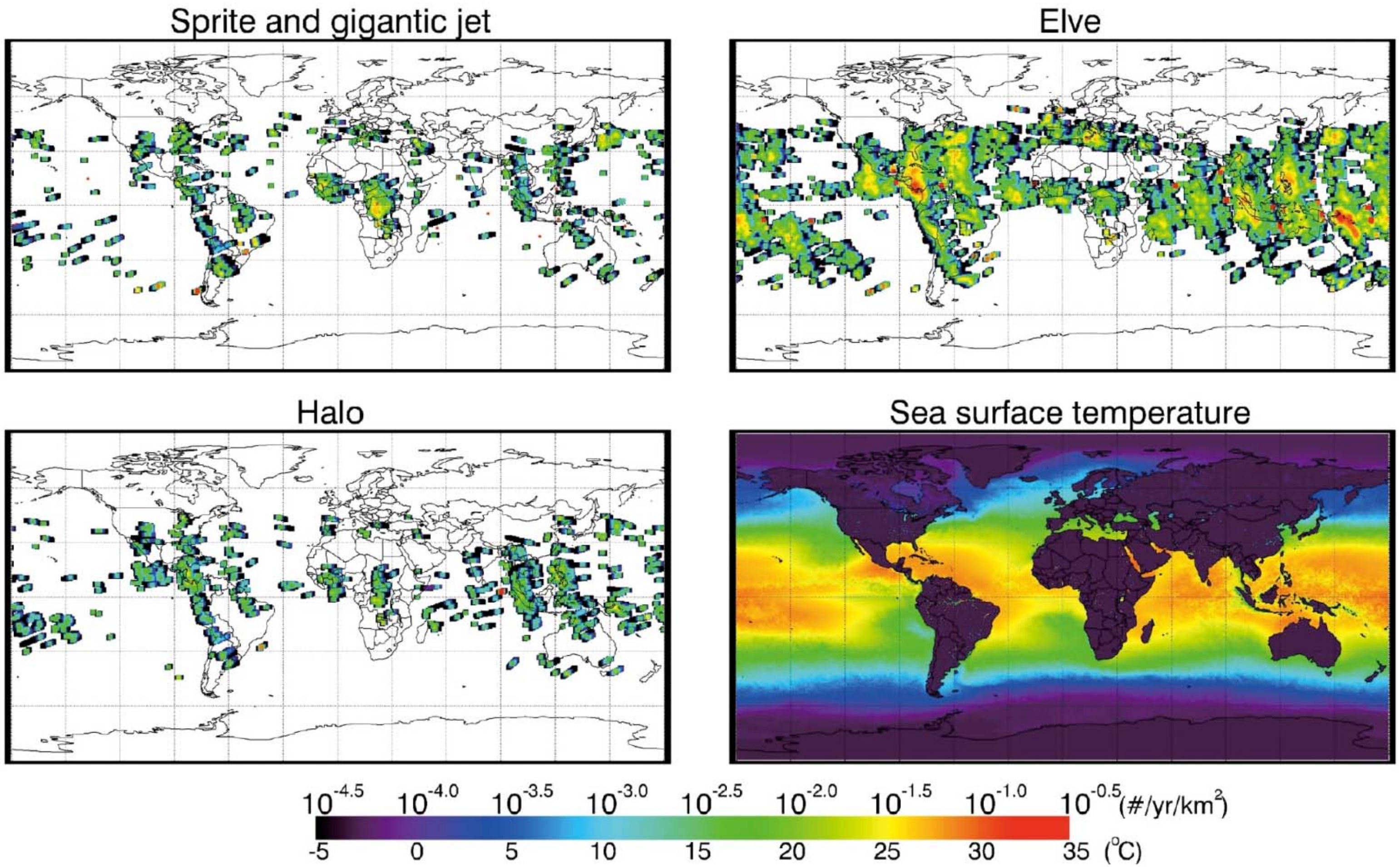
"This amazing lightning-like phenomenon is known as a Gigantic Jet," says Frankie Lucena of Puerto Rico, who processed the video. "They are related to sprites, but more powerful and easier to see with the naked eye."

Cloudcam video caught at least three of these jets springing from the tops of a powerful growing thunderstorm. The tallest of them reached all the way to the ionosphere some 80 km overhead.

"Gigantic Jets are much more rare than sprites," says Oscar van der Velde, a member of the Lightning Research Group at the Universitat Politècnica de Catalunya. "While sprites were discovered in 1989 and have since been photographed by the thousands, it was not until 2001-2002 that Gigantic Jets were first recorded from Puerto Rico and Taiwan." Only a few dozen Gigantic Jets have ever been seen, mostly over open ocean.

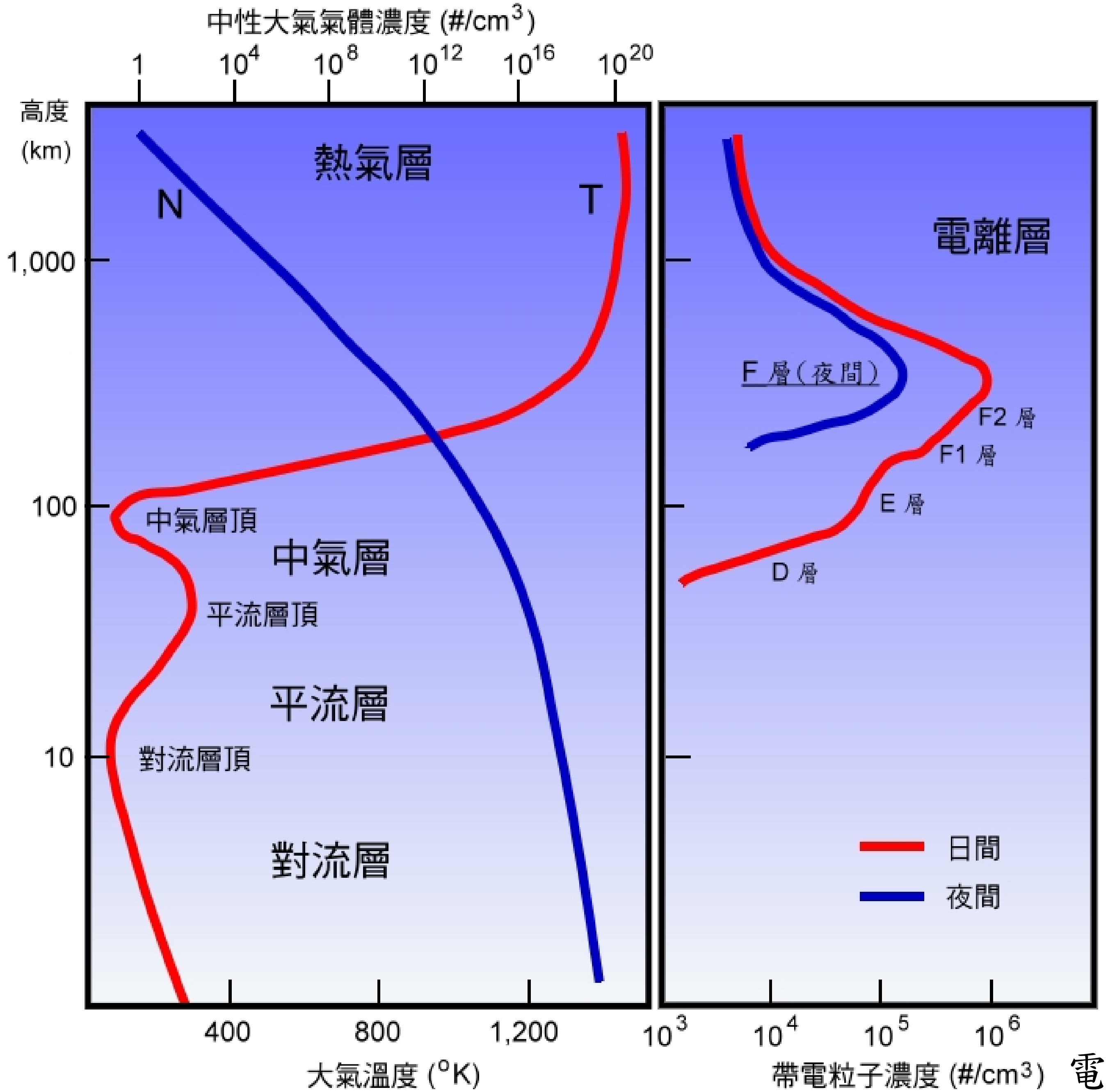
"高空大氣閃電影像儀"(Imager of Sprites and Upper Atmospheric Lightnings，ISUAL)是福爾摩沙二號衛星上唯一的科學酬載，也是世界上第一個長期從太空觀測高空短暫發光現象(Transient Luminous Events，TLEs)的衛星。

ISUAL的觀測結果顯示，各種TLEs以淘氣精靈數量最多，約佔80%；推翻了以前從地面觀測所累積的成見--- "認為紅色精靈是最常發生的TLEs"。獲得世界上第一張TLEs的全球分布圖。



http://www.narl.org.tw/tw/topic/topic.php?topic_id=78

地球大氣層與電離層



電漿密度

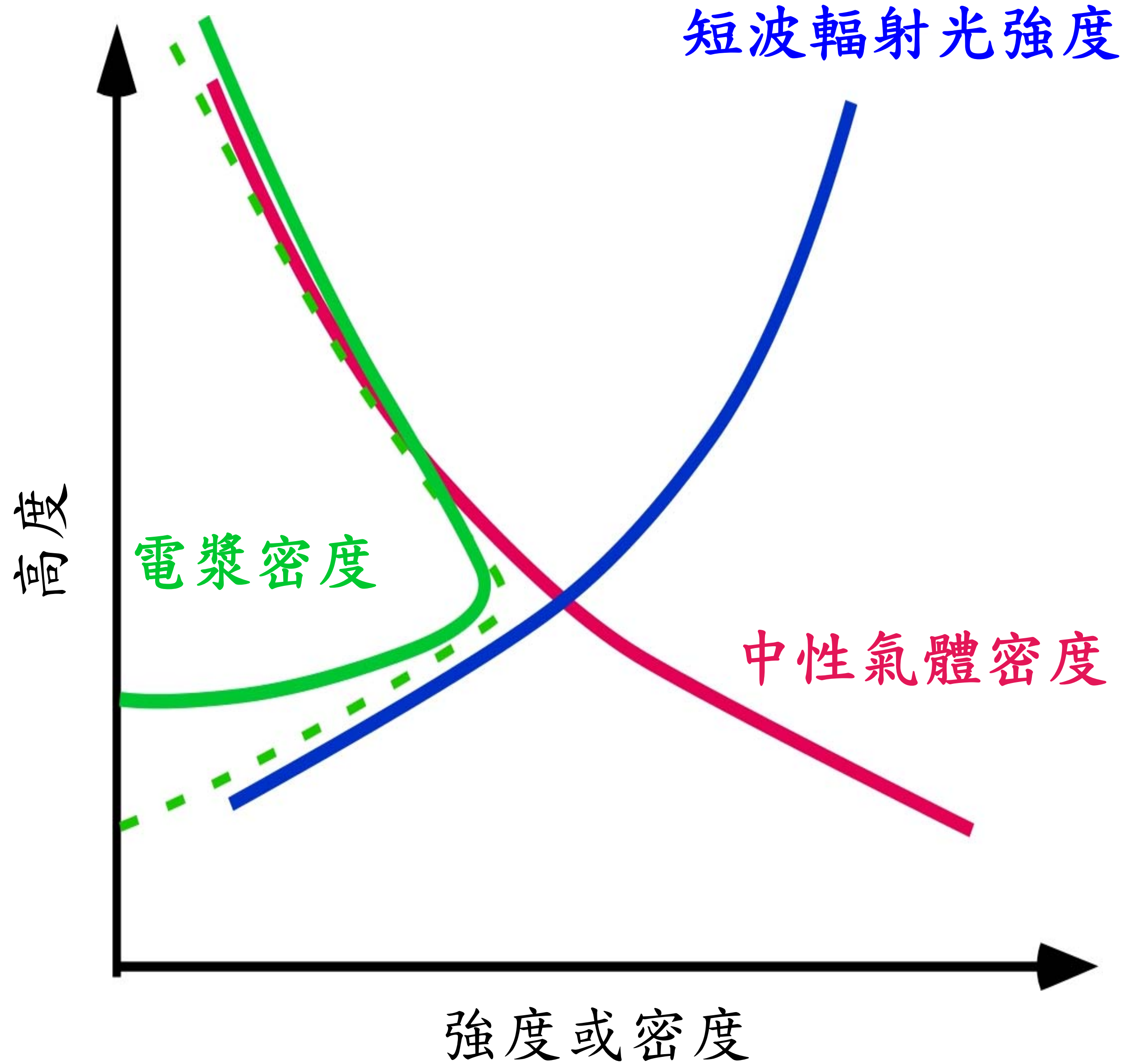
http://irsl.ss.ncu.edu.tw/course/

地球電離層

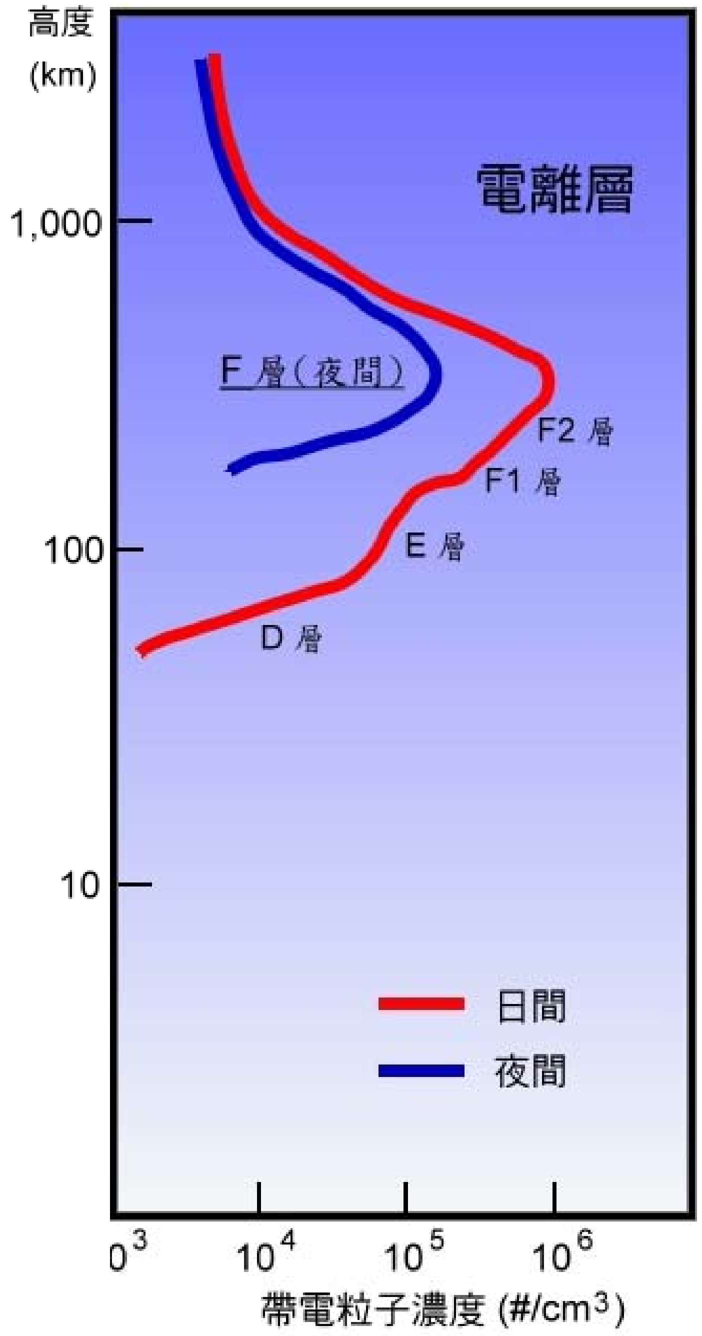
地球表面的中性大氣因為受到太陽短波輻射而游離成質子與自由電子成為電漿態，若電子濃度高到足以影響無線電波傳播，使之產生折射、反射或散射現象時，此區域即為電離層。簡而言之，電離層為地表上空可以反射、折射無線電波且導電率很高(電阻很小)的大氣層。

電離層為部分或完全游離的電漿態，這是因為大氣中的原子與分子吸收了來自太陽的短波輻射而游離，又由於此處的大氣太稀薄了，這些正離子與電子，很難重新結合還原成中性原子或分子，因此會經常保持著中性粒子、正離子與電子共存的部分游離態。電離層與上方的磁層並無明顯的邊界，而磁層幾乎可視為完全游離的電漿態。

電離層中游離氣體的產生(例如:光游離;photo ionization)與消失(例如:正負電荷粒子碰撞後重新再結合成中性粒子;recombination)速率達到平衡就可以維持一定的游離程度。



http://www.ss.ncu.edu.tw/~lyu/lyu_lecture_ch.html



120公里以上稱為F層，為電離層中電子濃度最高的區域(F2)。由於此處電漿粒子與中性大氣的碰撞頻率相當小，因此幾乎沒有碰撞消失作用，所以F層日夜皆可存在。

D層位於地表上空約50-80公里的區域，在白天時為部分游離的電漿態，日落後由於光化游離作用消失，且電漿與中性大氣碰撞頻率相當高，會使得電漿粒子還原為中性氣體，故D層會於夜晚消失殆盡。

http://irsl.ss.ncu.edu.tw/course/

→太陽光中的紫外光、X射線、伽馬射線等短波的電磁波能量，可以提供中性粒子的游離能，造成光游離現象。但不論可見光的強度多強，都無法游離氣體。

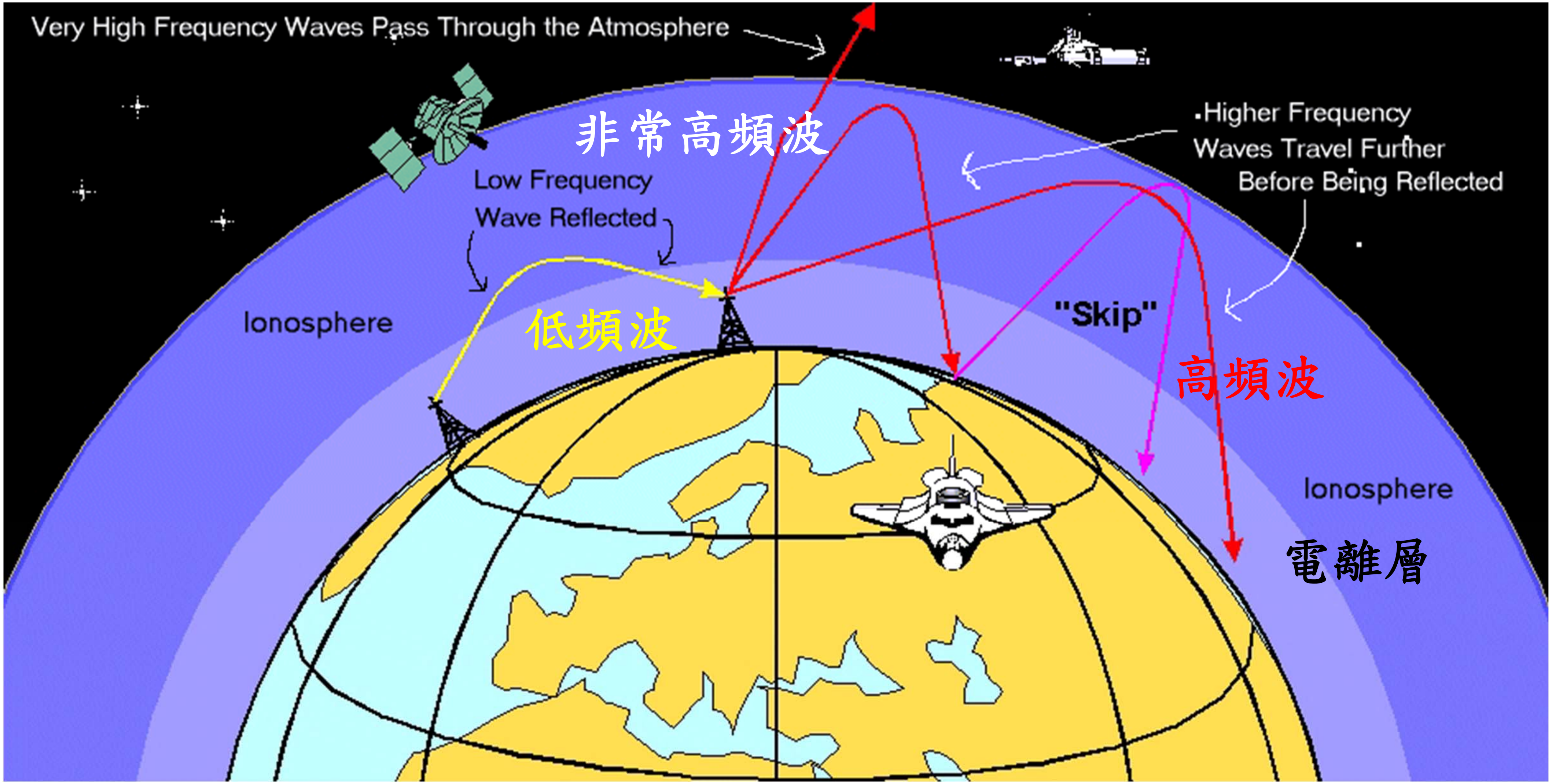
→太陽光直射時光游離效果較佳，斜射時的光游離效果較差。

→高空處的透光度越佳，短波輻射量足，光游離效果較佳，且可供重新再結合成中性粒子的氣體數量較少，所以即便是在晚上，也能維持一定的游離度。

→低空處的透光度較差，短波輻射量少，光游離效果較差，且可供重新再結合成中性粒子的氣體數量較多，所以到了晚上就不能維持一定的游離度。

→電離層會隨著日夜、季節、緯度和太陽活動而改變其高度與電漿濃度，或有一些暫態性的變化。

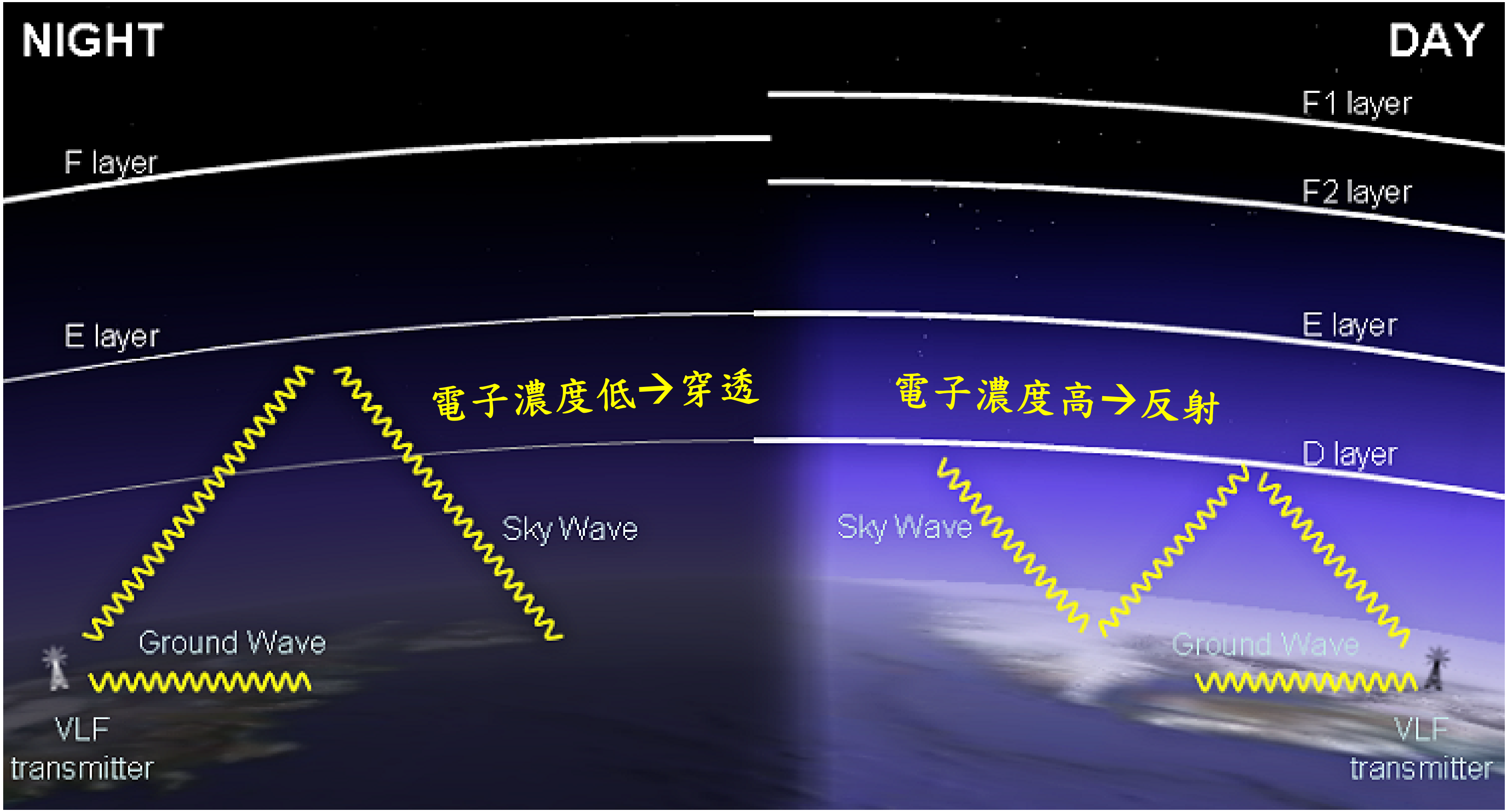
電離層的電波傳播



何種頻率的電磁波會被電離層反射與"電漿頻率"有關，電漿頻率與當地的電子密度有關，電子密度越大，被反射的電磁波頻率越高。

http://radiojove.gsfc.nasa.gov/education/educ/radio/tran-rec/exerc/images/propo1.gif

D層的電子密度較低，因此對於高頻的無線電波影響較小。
夜晚F層的電子密度會持續下降，使得可被反射的電磁波也越來越低頻。



太陽閃焰發生後，電離層的電子密度會突然增加，使得原先直接穿透電離層的電磁波便有機會被反射。

http://sidstation.loudet.org/ionosphere-en.xhtml http://www.ss.ncu.edu.tw/~lyu/lecture_files/