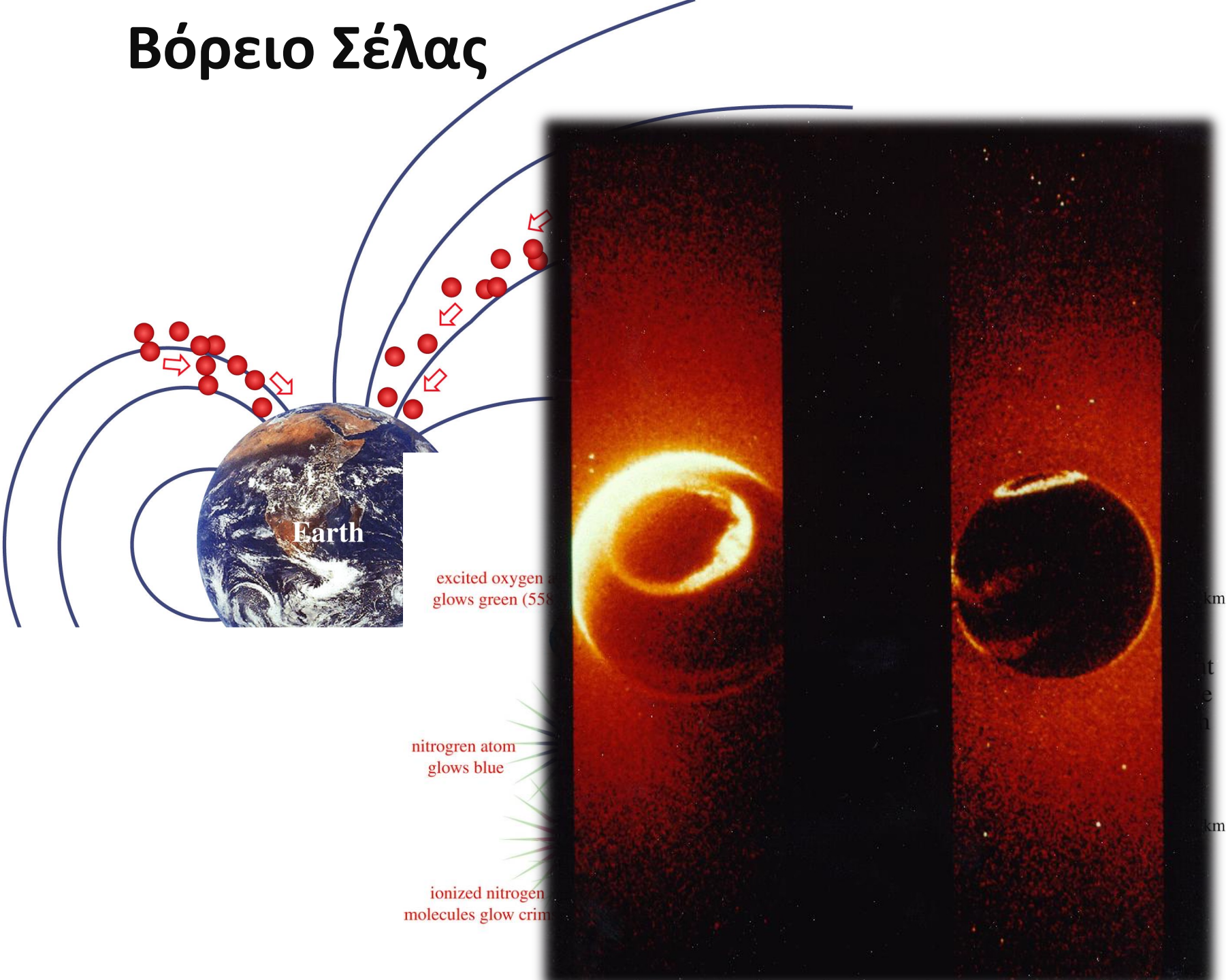
Διαστημικό Περιβάλλον

Space Environment

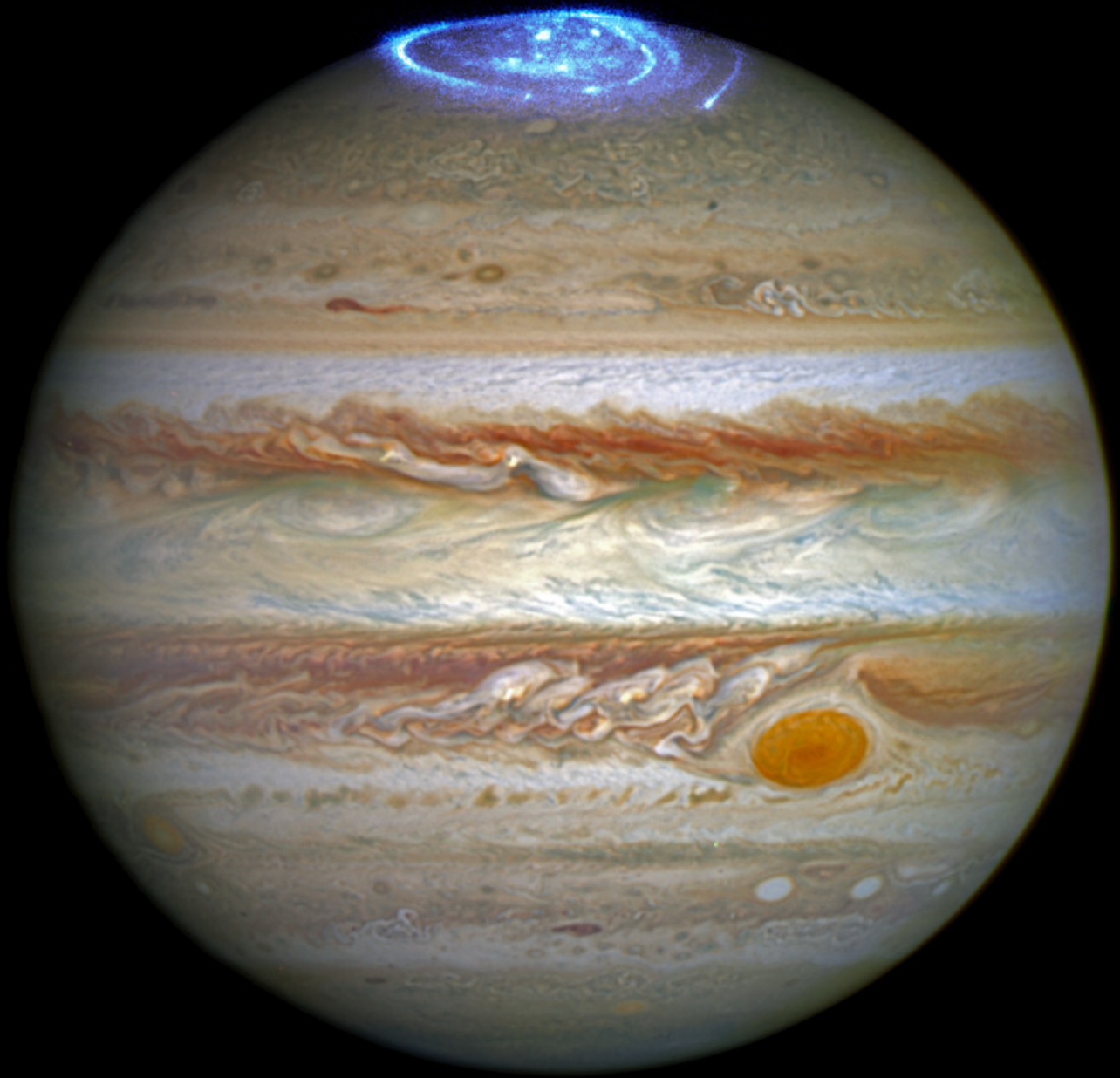
Space Environment
Lecture 8

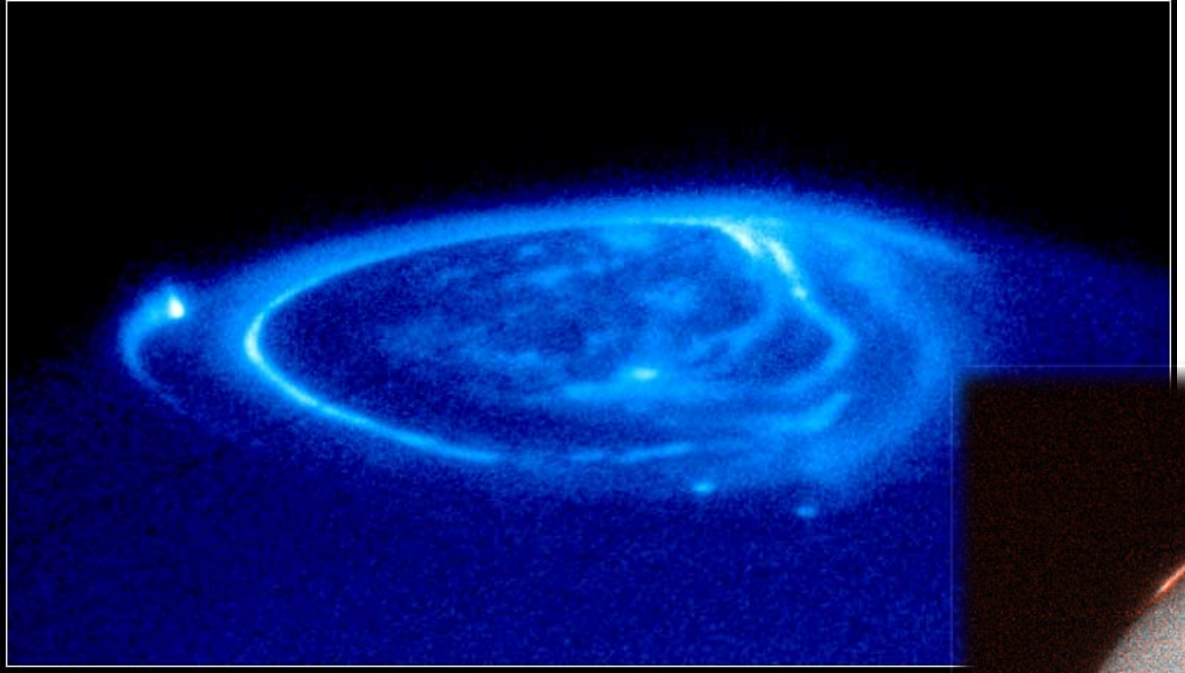
Aurora

Βόρειο Σέλας



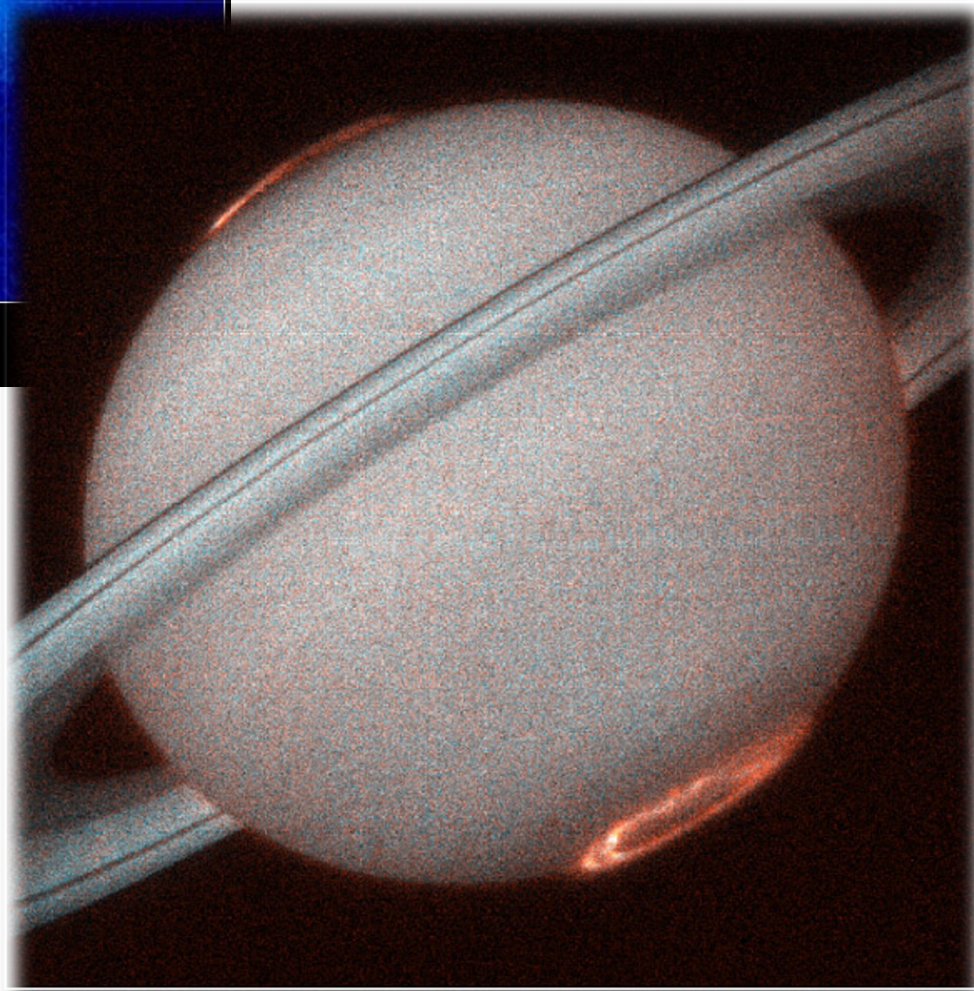
όταν χορεύουν οι ουρανοί





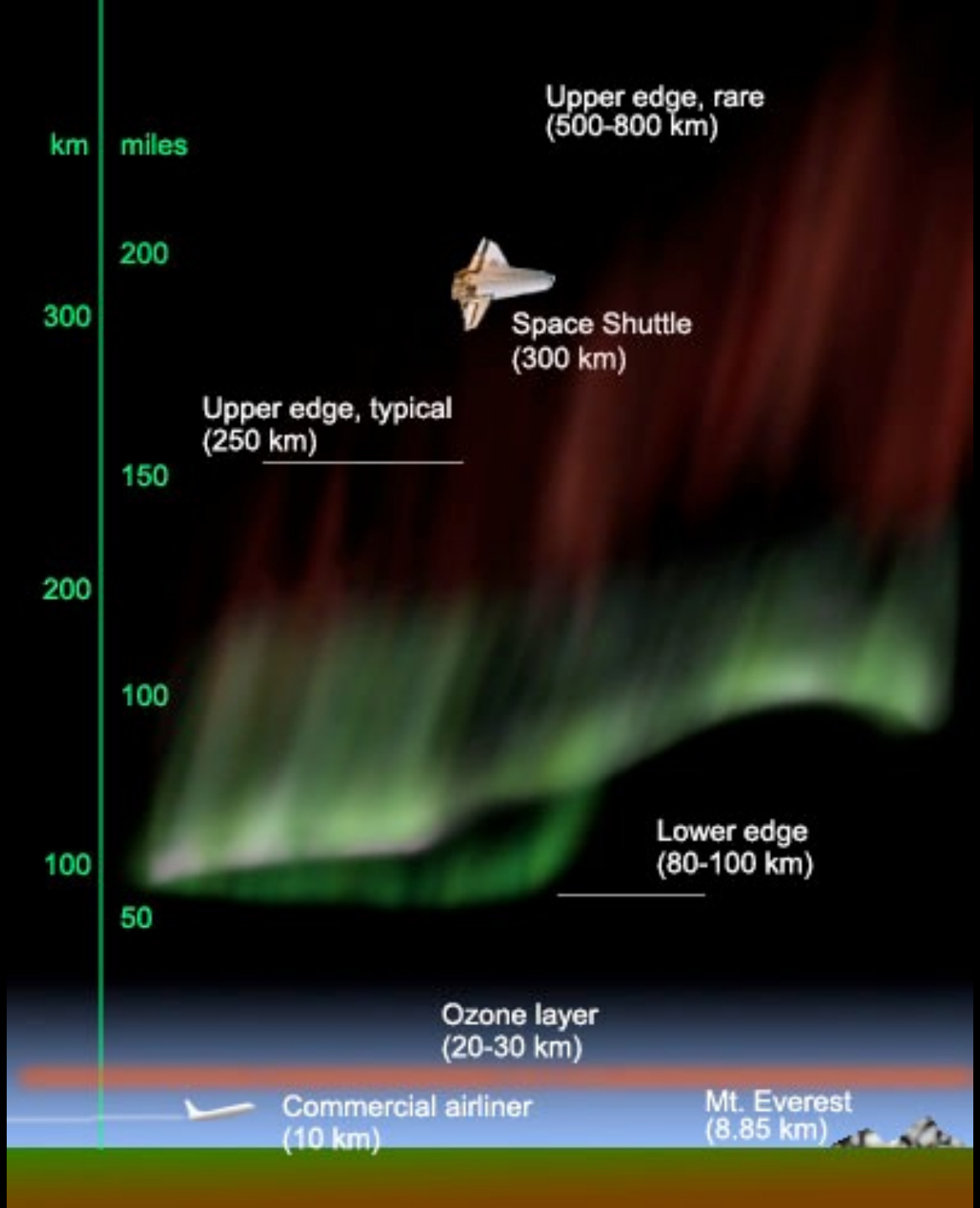
Jupiter Aurora

NASA and J. Clarke (University of Michigan) • STScI-PRC00-38



Saturn Aurora HST • STI

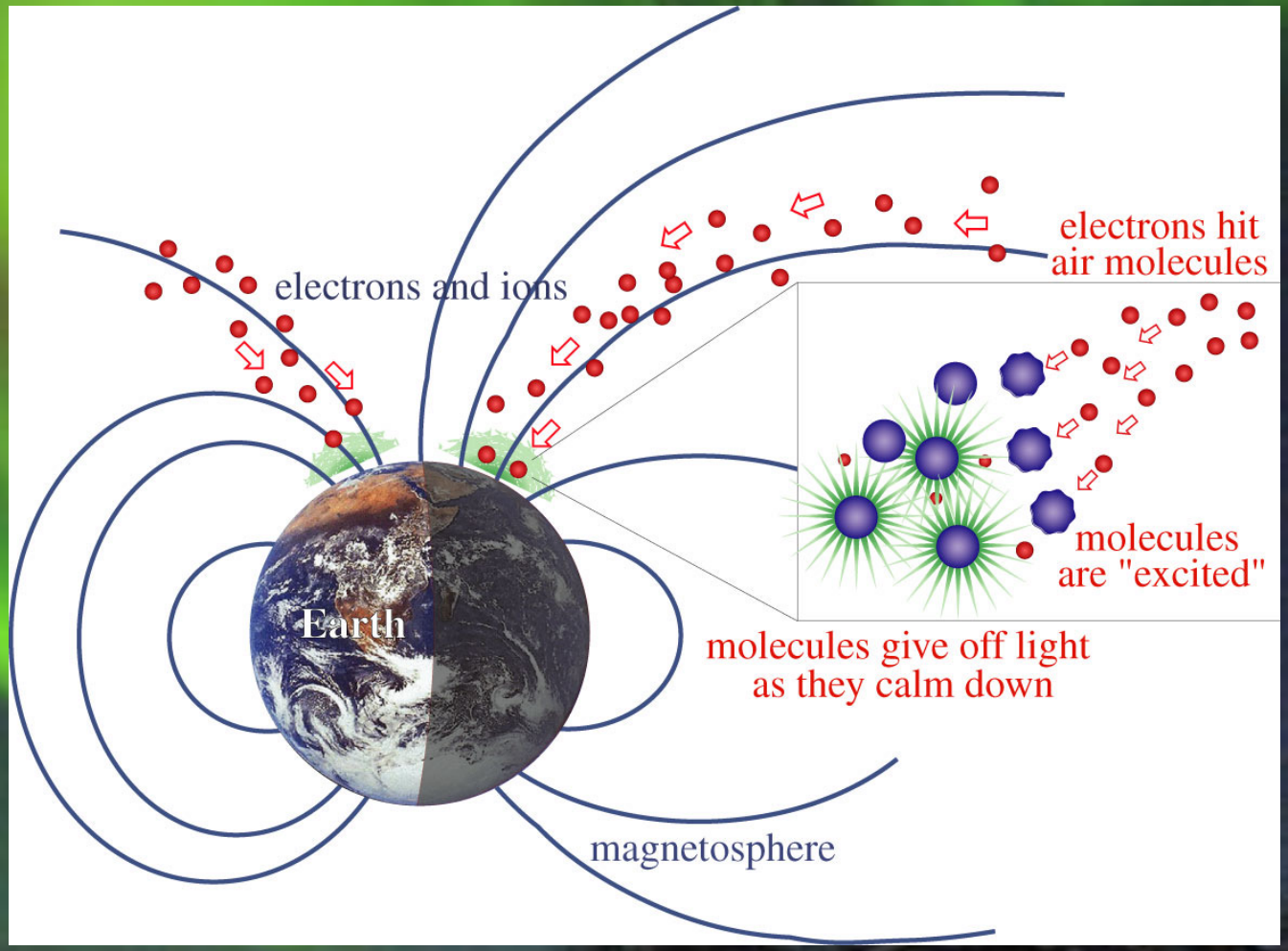
PRC98-05 • ST ScI OPO • January 7, 1998 • J. Trauger (JPL) and NASA


km
miles
200
300
150
200
100
100
50
Upper edge, rare
(500-800 km)
Space Shuttle
(300 km)
Upper edge, typical
(250 km)
Lower edge
(80-100 km)
Ozone layer
(20-30 km)
Commercial airliner
(10 km)
Mt. Everest
(8.85 km)


Aurora

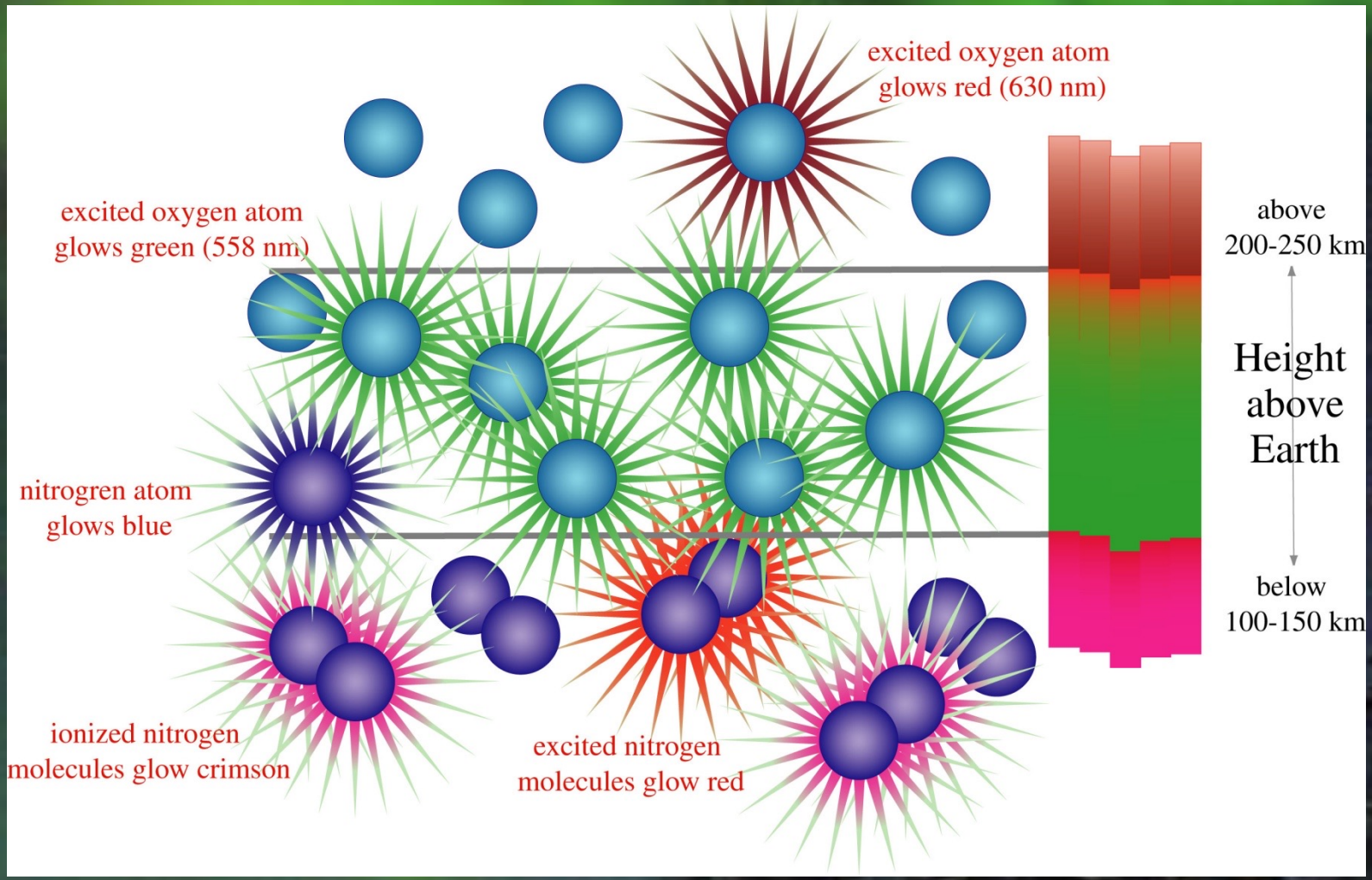
Πώς δημιουργείται το σέλας;

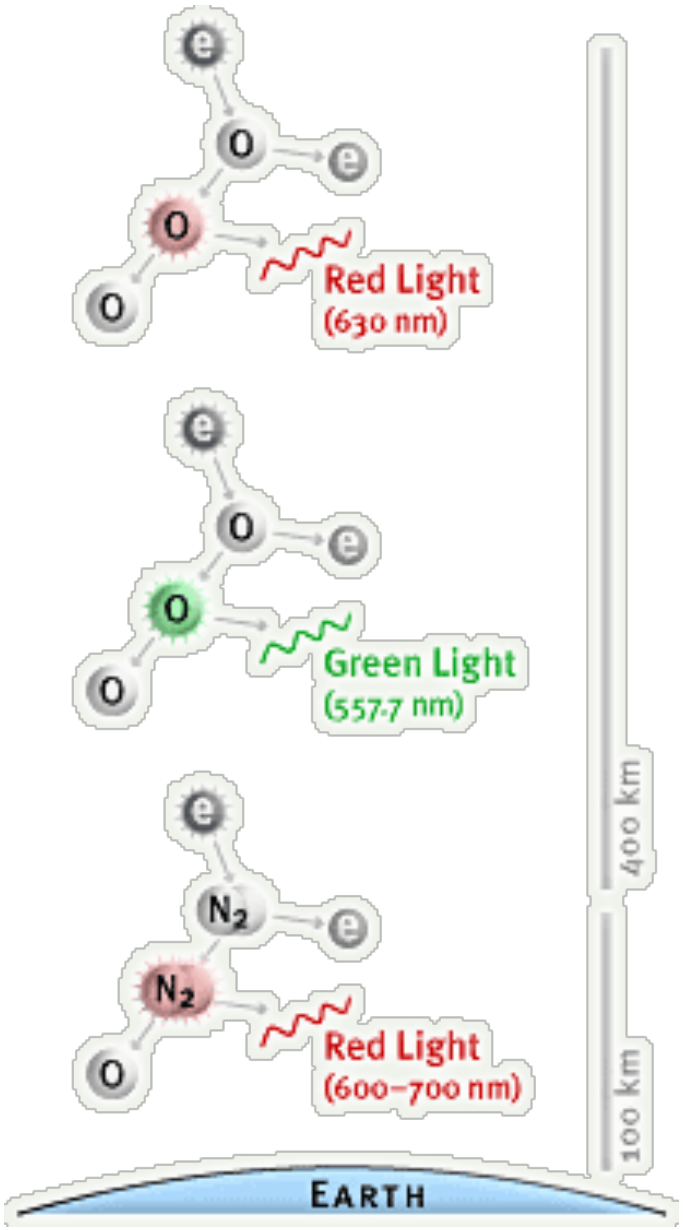
Hot magnetospheric electrons ionize and excite atoms and molecules of the atmosphere, which give off light when they calm down

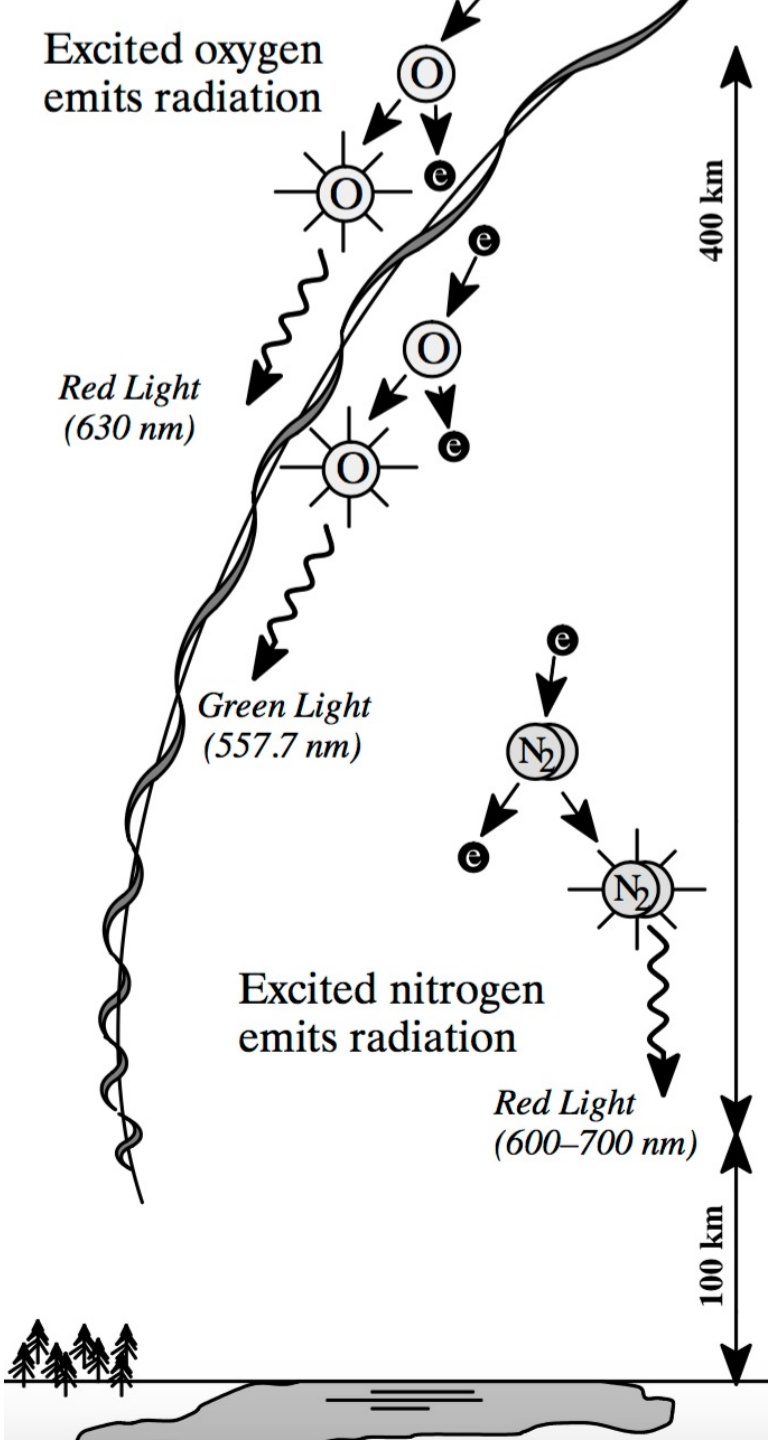


What Causes the Aurora?

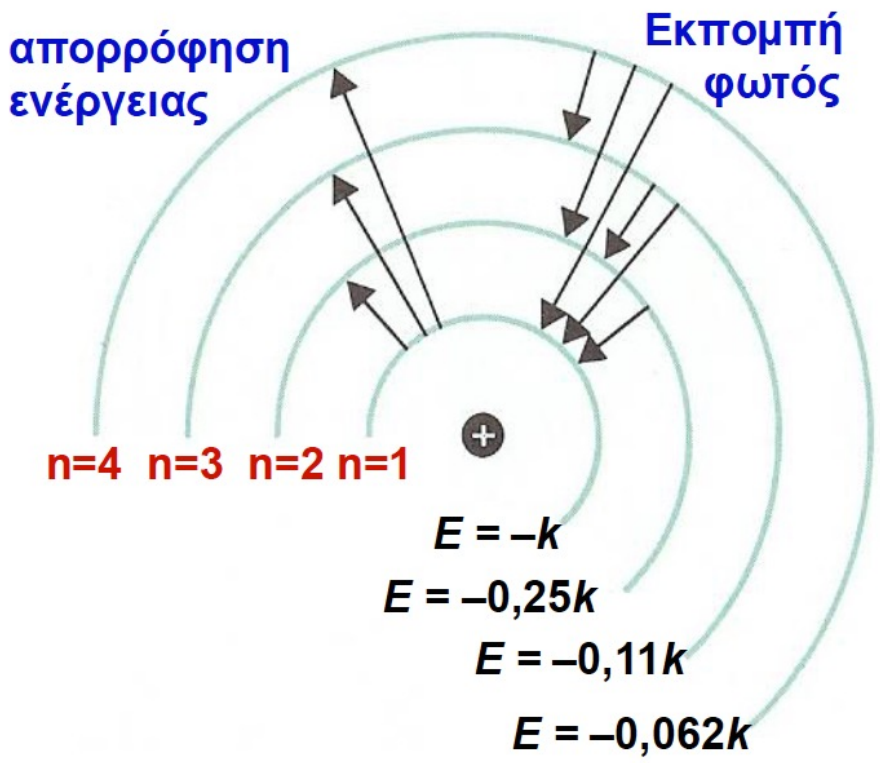
The color of the light depends on what type of particle is hit and to what energy level it is excited




e
O
e
O
O
Red Light
(630 nm)
e
O
e
O
O
Green Light
(557.7 nm)
e
N2
e
N2
O
Red Light
(600–700 nm)
400 km
100 km
EARTH


Excited oxygen
emits radiation
O
e
Red Light
(630 nm)
Green Light
(557.7 nm)
N_2
Excited nitrogen
emits radiation
Red Light
(600–700 nm)
400 km
100 km

Το ατομικό πρότυπο του Bohr



Απορρόφηση ενέργειας και εκπομπή φωτός από το άτομο Η.

Στην τροχιά με $n = 1 \Rightarrow$ θεμελιώδης κατάσταση, ελάχιστη ενέργεια.

a_o = 53 pm (ακτίνα του Bohr)

Επιτρεπόμενες τροχιές (ή ενεργειακά επίπεδα): ακτίνα τροχιάς: $r_n = n^2 a_o$

Μύθος και ιστορία

Κίνα
Ασσυρία
Παλαιστίνη
Ελλάδα
(Ινουίτ Αμερικής, Σάμι Σκανδιναβίας)

Ησίοδος (Θεογονία, 8ος αι. πΧ): φλεγόμενοι ουρανοί

Ησίοδος (Θεογονία, 8ος αι. πΧ): φλεγόμενοι ουρανοί
Ιεζεκιήλ (6ος αι. πΧ): φλεγόμενος τροχός
(σέλας, κομήτης, ή UFO;)


Erſchreckliche Wunderwerck/ ſo abermal den 5. October/ im 1591. Jar/ in der Nacht zu Nürnberg iſt geſehen worden.

Γιατί αναφερόμαστε
(σχεδόν) πάντα
στο ΒΟΡΕΙΟ σέλας;


Aurora Australis

L-shell contours

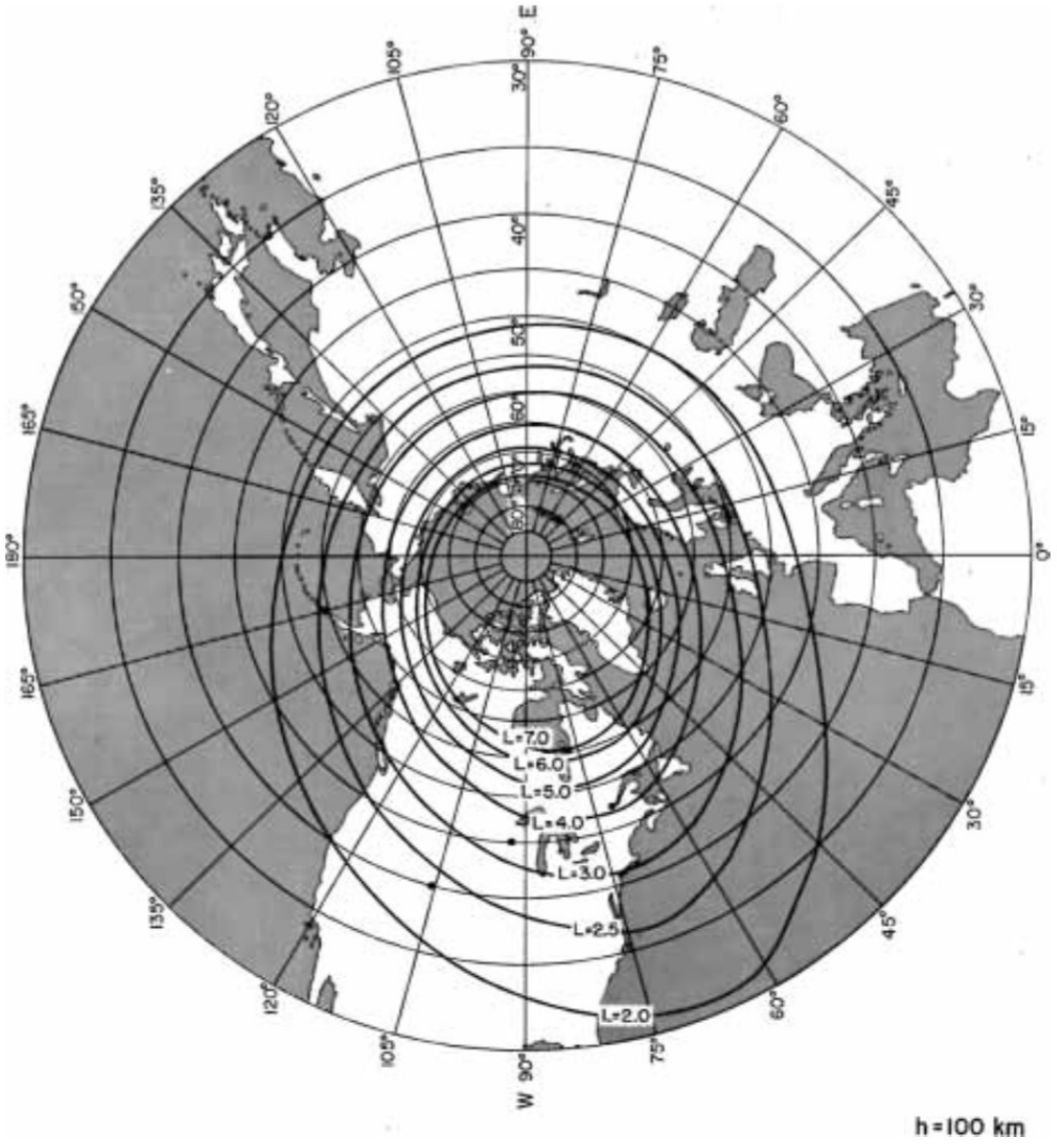
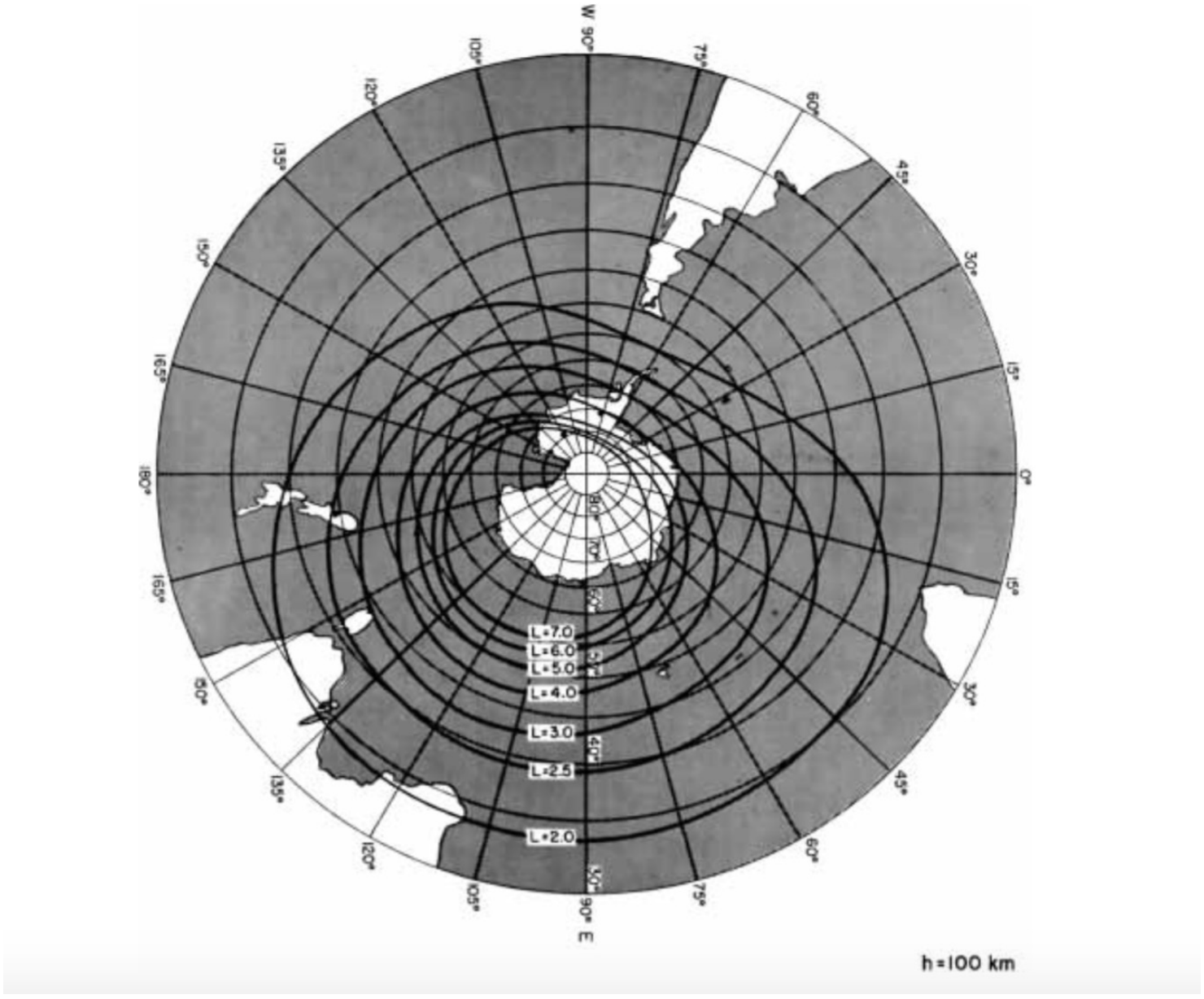
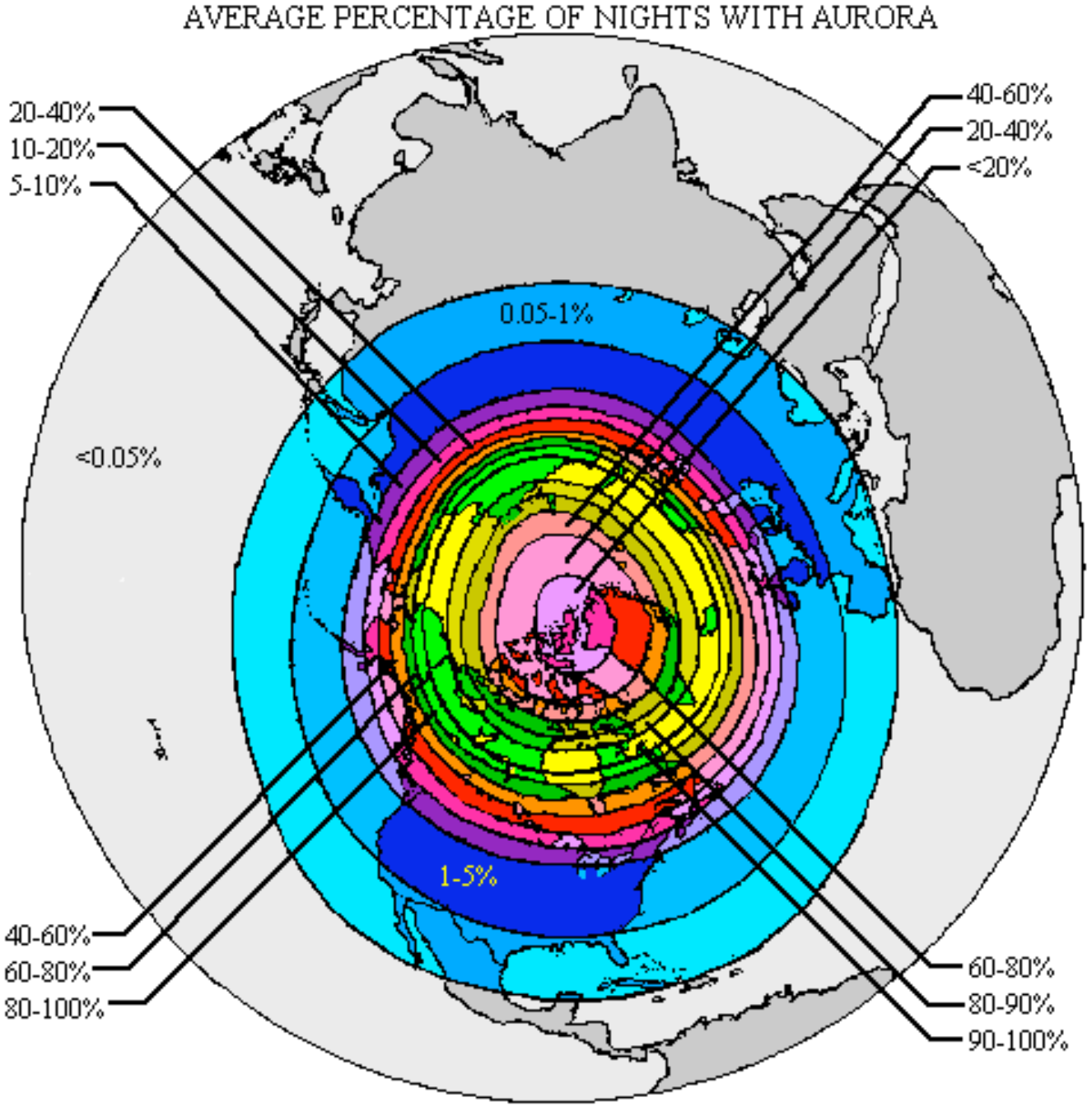


Figure 1.10. *L*-shell contours, computed for 100-km altitude, in the Northern (top) and Southern (bottom) Hemisphere regions. Geographic east and west radial longitude lines and circles of latitude (from 30° to the pole) are shown. These *L*-values were computed for the extremely quiet year, 1965, when there was a minimum distortion of the polar contours by solar wind.

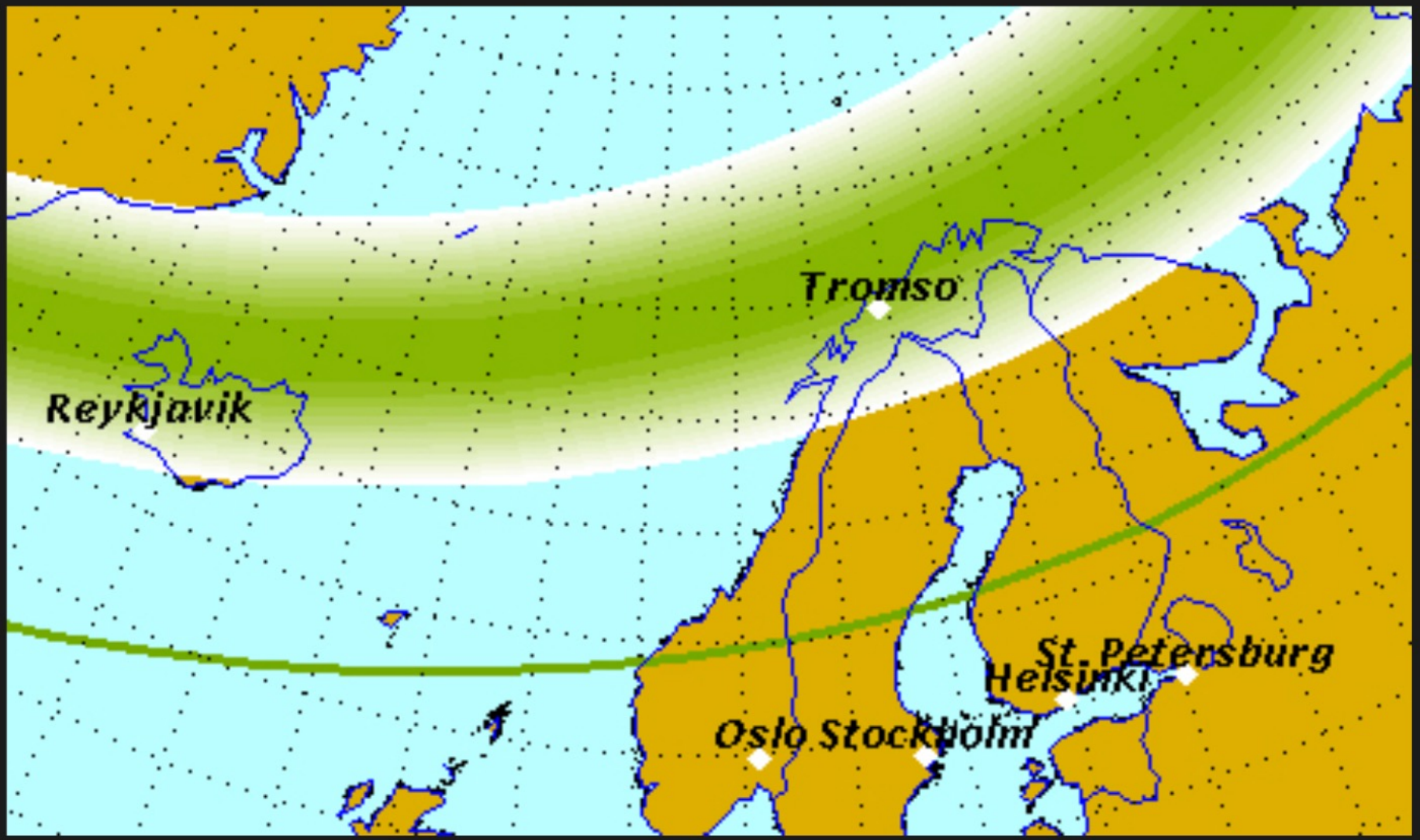
L-shell contours southern hemisphere

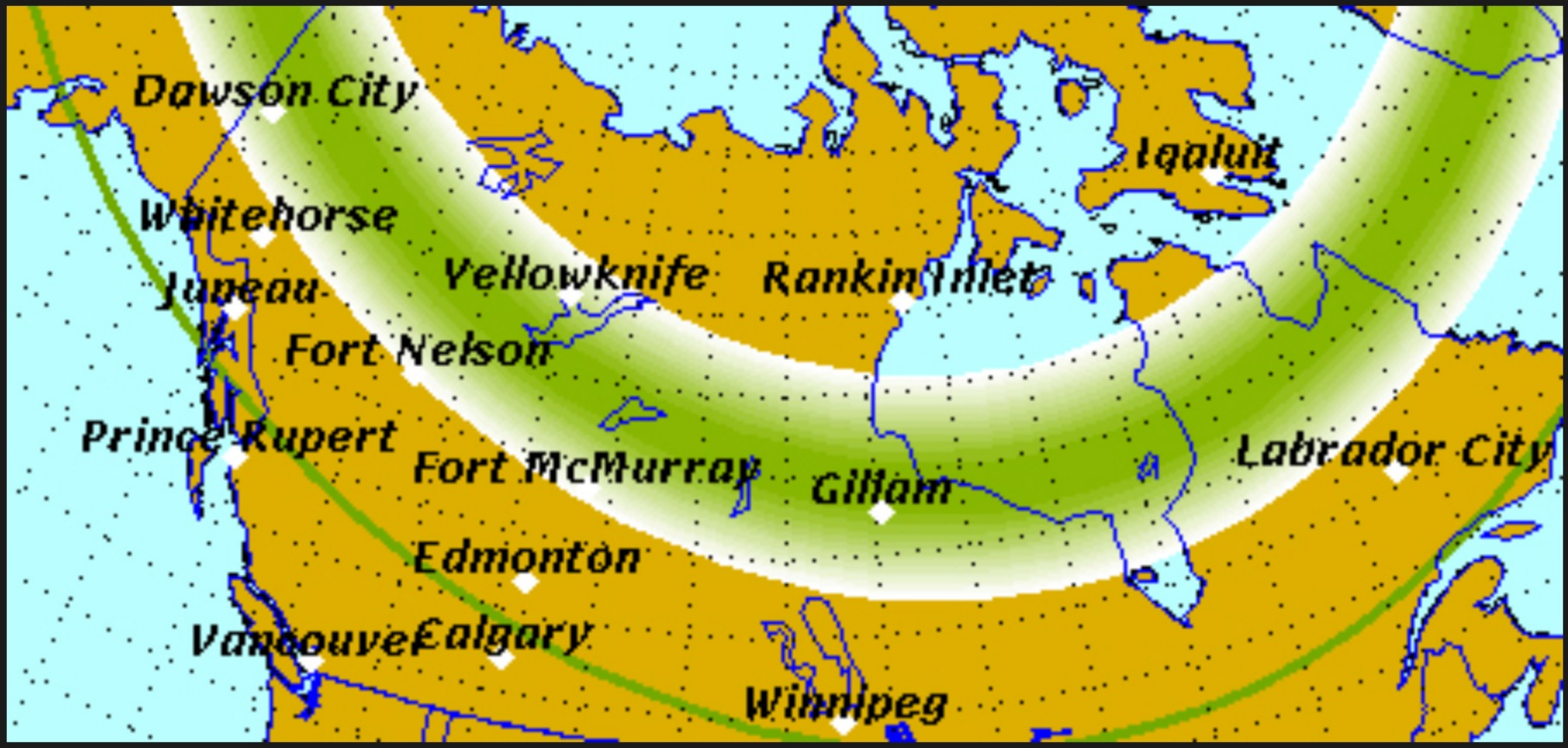


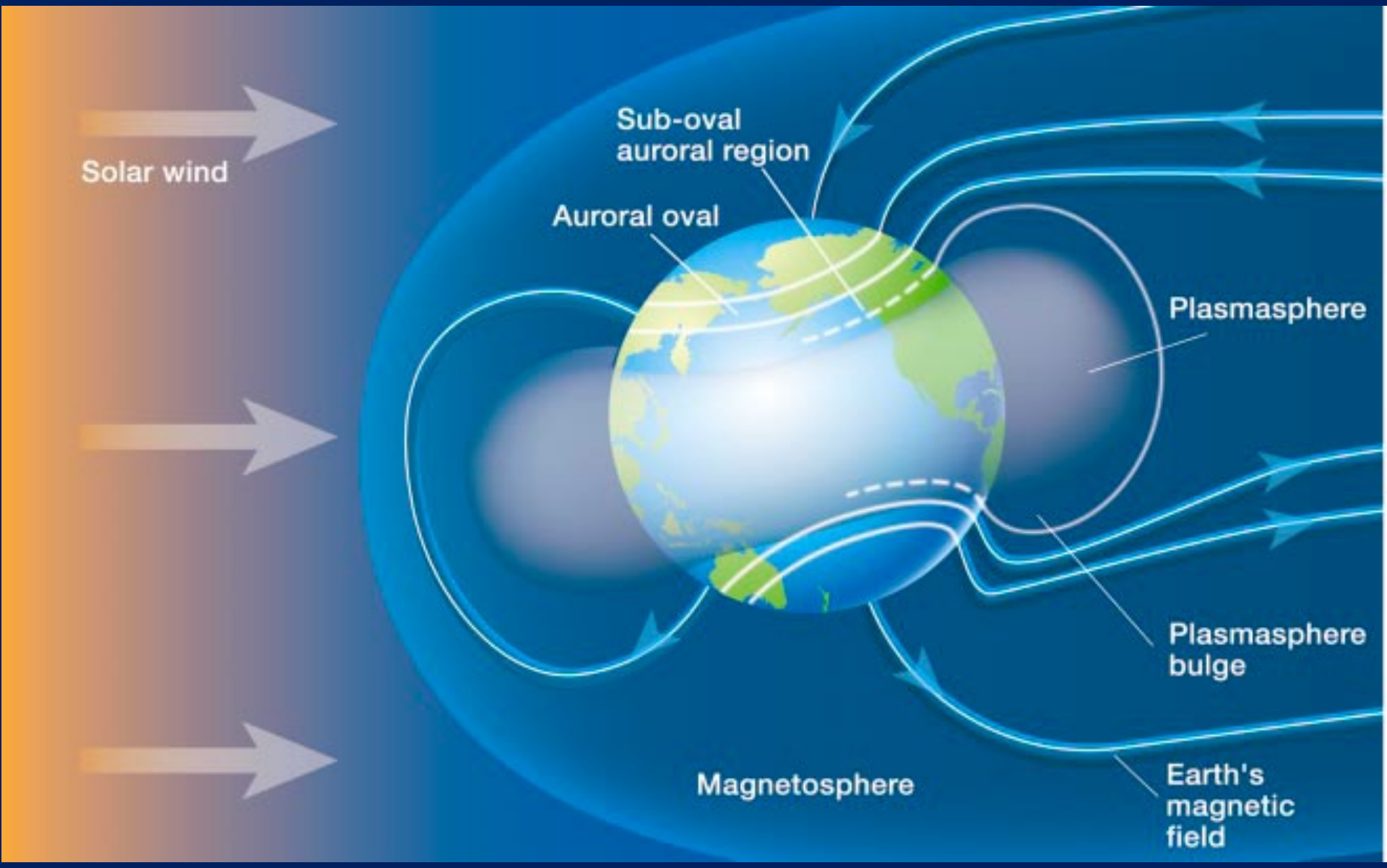


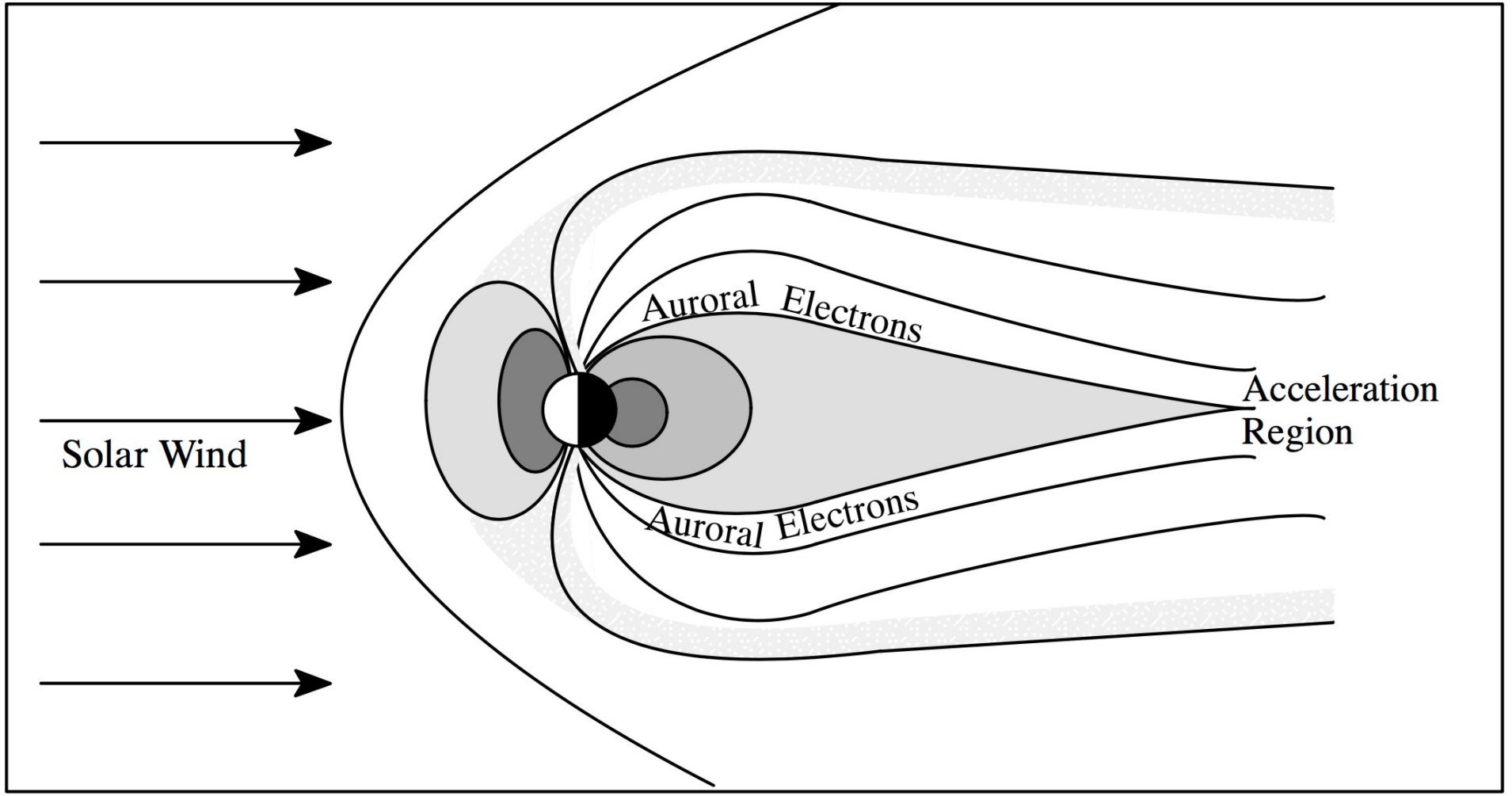
(After Vestine [1944])

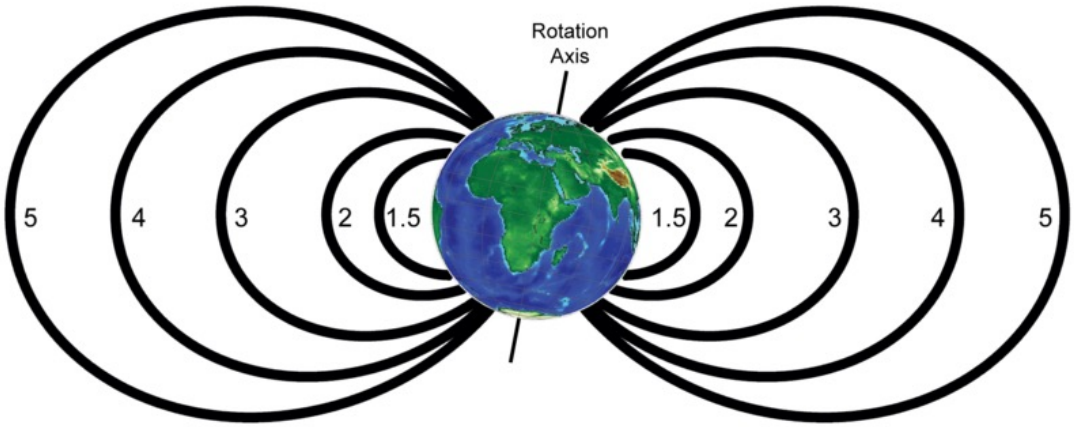
SWPC


Tromso
Reykjavik
St. Petersburg
Helsinki
Oslo
Stockholm


Dawson City
Iqaluit
Whitehorse
Yellowknife
Rankin Inlet
Juneau
Fort Nelson
Prince Rupert
Fort McMurray
Gillam
Labrador City
Edmonton
Vancouver
Calgary
Winnipeg


Solar wind
Sub-oval
auroral region
Auroral oval
Plasmasphere
Plasmasphere
bulge
Magnetosphere
Earth's
magnetic
field

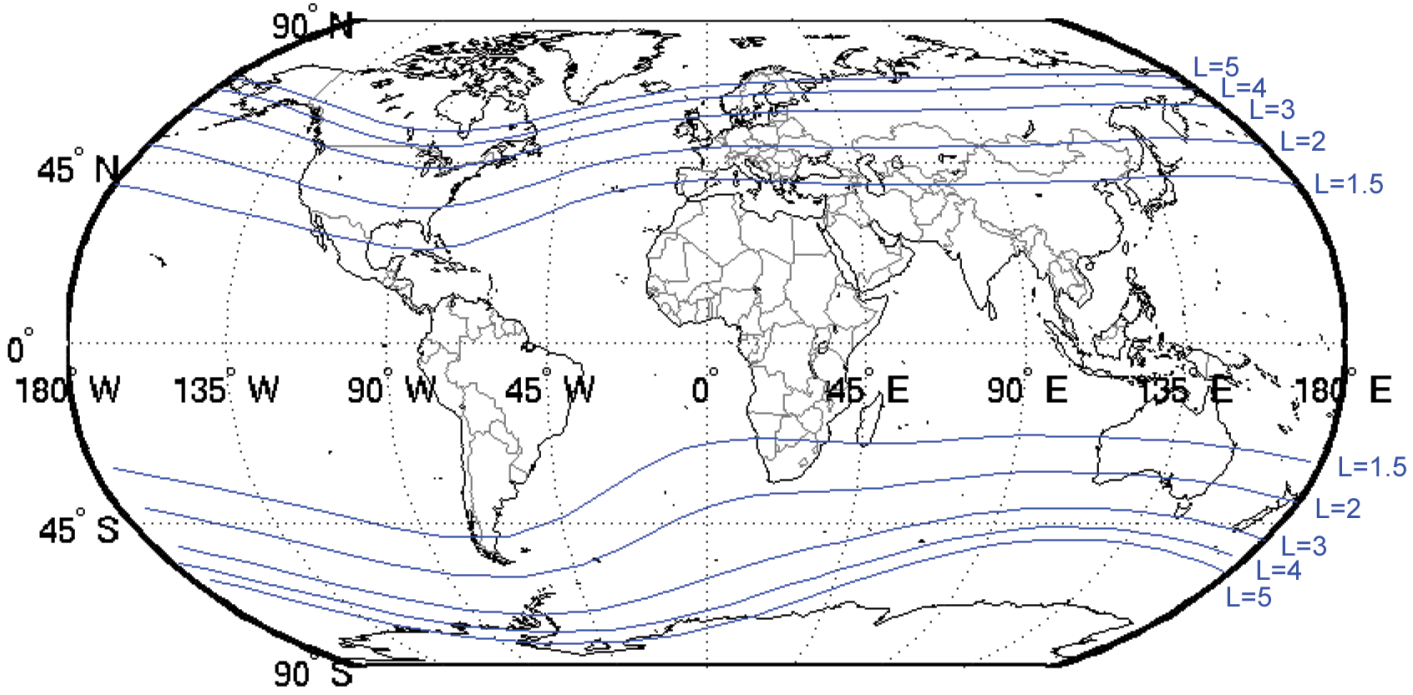

Solar Wind
Auroral Electrons
Acceleration Region
Auroral Electrons



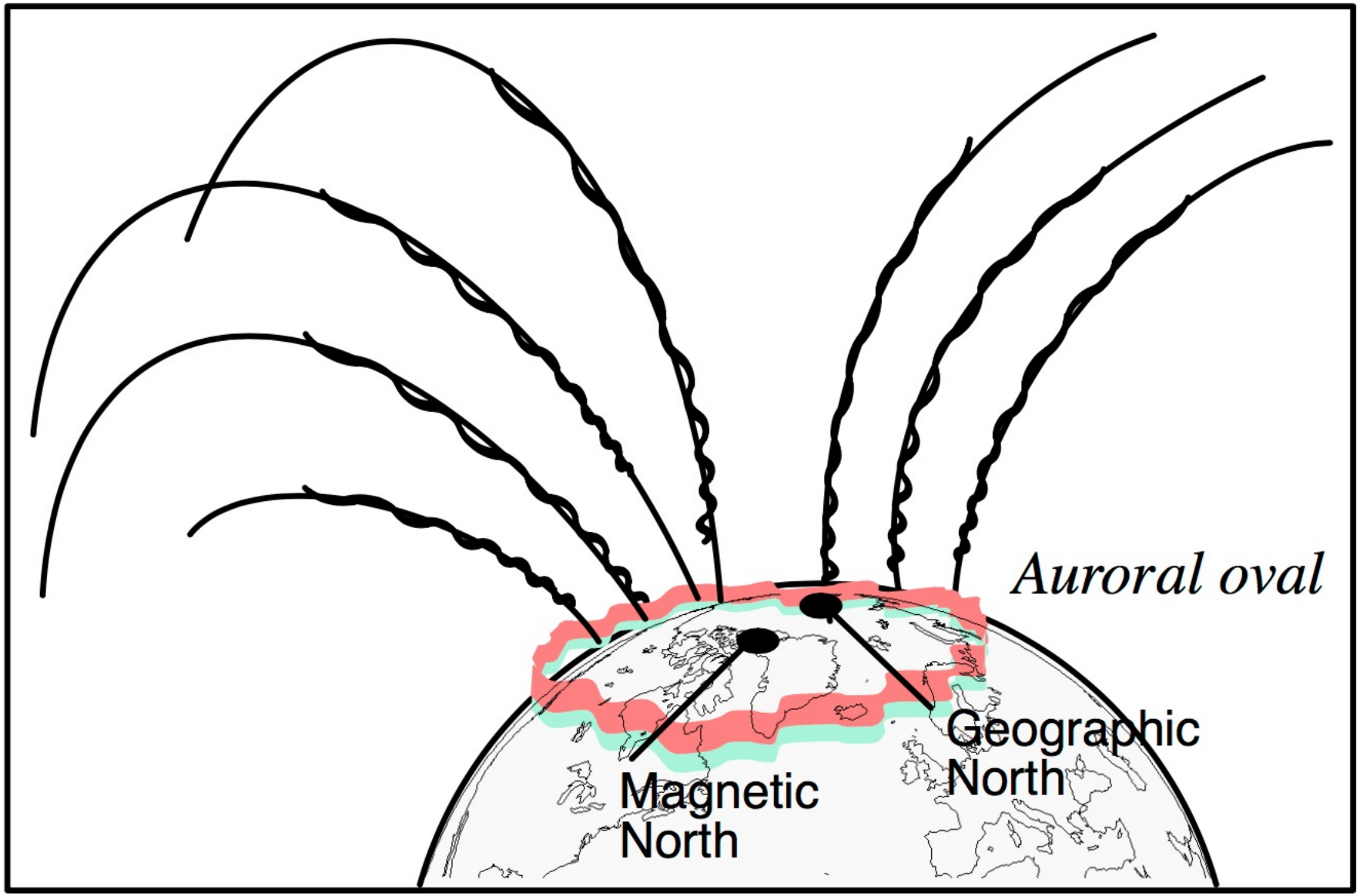
$$r = L\cos^2\lambda$$

Από πού έρχονται τα ηλεκτρόνια του σέλαος;

Προβολή φλοιών L



Σέλας: Σκανδιναβία, Αλάσκα


Auroral oval
Geographic
North
Magnetic
North

Comparison of Auroral Boundaries from Kp and Auroral Activity Level at Local Midnight

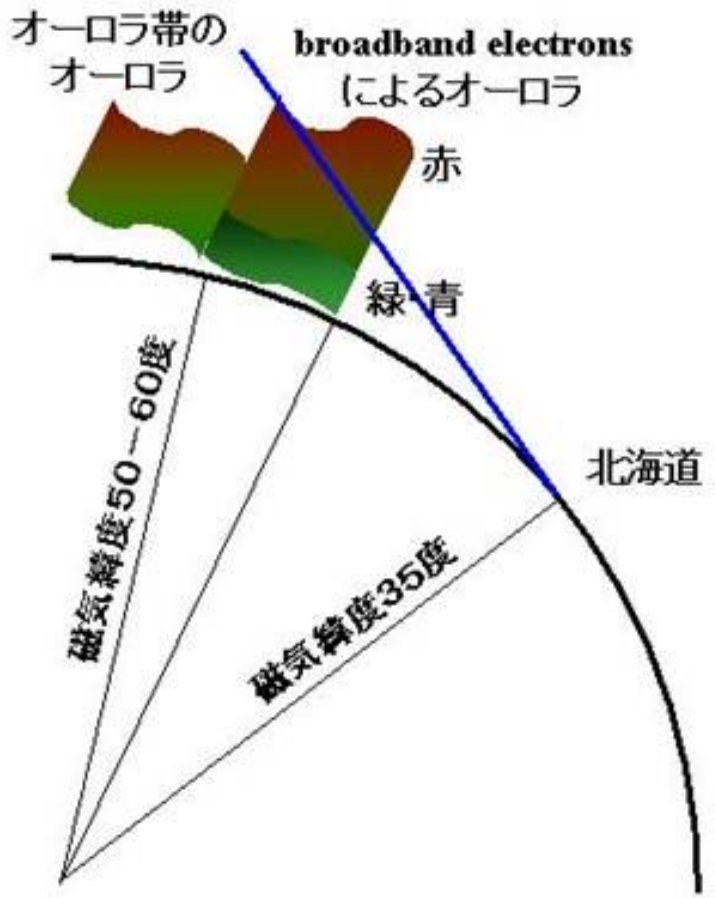
Magnetic Latitude	Kp		Magnetic Latitude	NOAA POES Auroral Activity Level
66.5	0		67.5	1
64.5	1		66.5	2
62.4	2		65.6	3
60.4	3		63.9	4
58.3	4		62.5	5
56.3	5		60.7	6
54.2	6		58.6	7
52.2	7		56.7	8
50.1	8		54.6	9
48.1	9		51.0	10
			48.5	10+
			45.0	10++

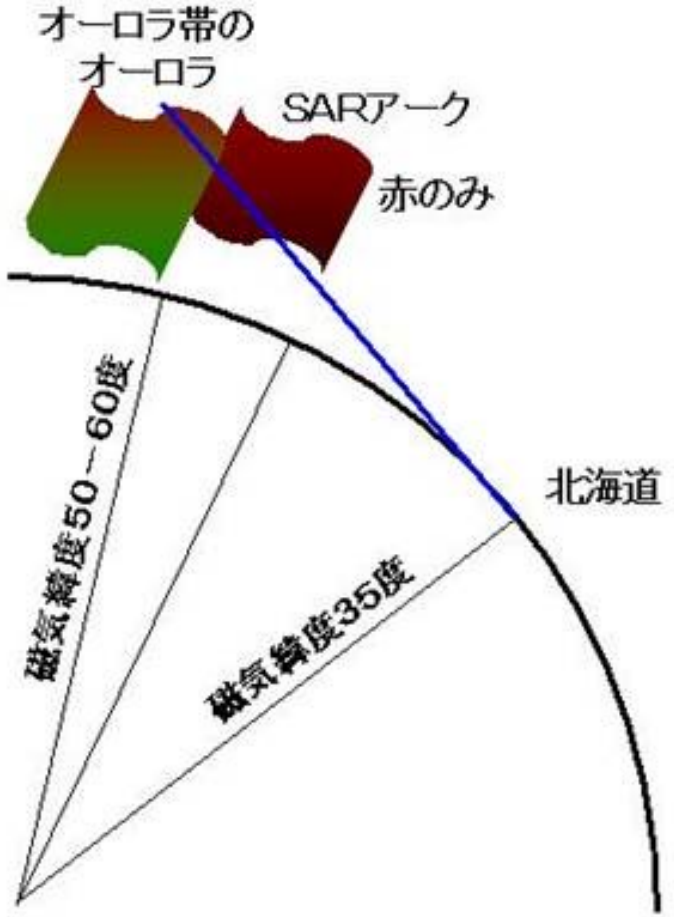
Aurora in Greece

Rare, but impressive (blood-red)


りくべつ
おすい


05-11-2023 Sun 19:05:54
METEOKAV.GR
Ο ΚΑΙΡΟΣ ΣΤΗΝ ΚΑΒΑΛΑ
PALAIOCHORI, KAVALA, GR


オーロラ帯の
オーロラ
broadband electrons
によるオーロラ
赤
緑-青
磁気緯度50－60度
磁気緯度35度
北海道


オーロラ帯の
オーロラ
SARアーク
赤のみ
磁気緯度50－60度
磁気緯度35度
北海道

If an oxygen atom is excited to the energy level corresponding to green...

... and it has no collisions...

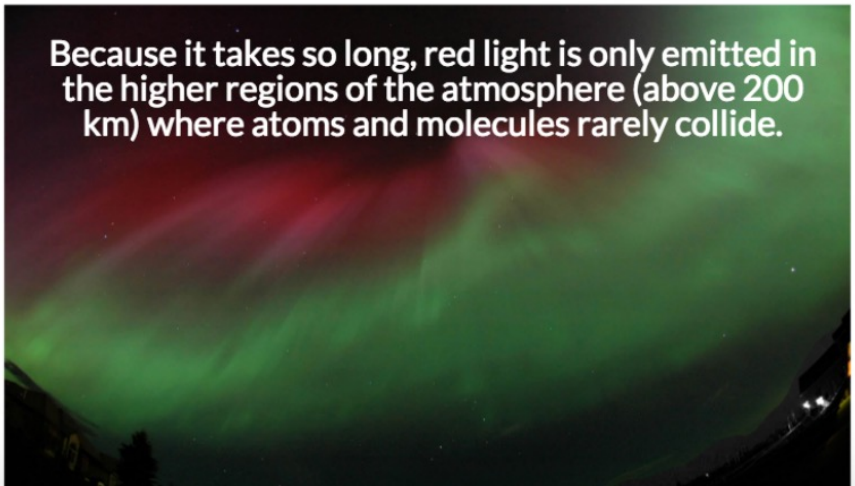
... then it will emit light after 1 second.

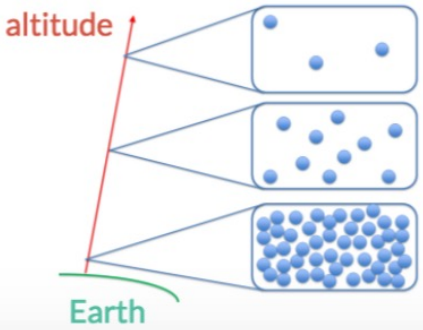
If an oxygen atom is excited to the energy level corresponding to red...

... and it has no collisions...

... then it will emit light after 110 seconds.

It may seem short to you, but 110 seconds is a long time for an excited oxygen atom to avoid collisions!





The 630 nm emission, the "red line", is sometimes seen in the upper border of auroral arcs. It is emitted by atomic oxygen in its transition from the lowest excited electronic state $O(^1D)$ to the atomic ground state $O(^3P_2)$. The **metastable $O(^1D)$ state** has a radiative lifetime of 107 s. The main sources of $O(^1D)$ are direct electron impact excitation of atomic oxygen:

$$O(^3P_2) + e \rightarrow e + O(^1D)$$

Metastable state: a particular excited state of an atom or nucleus that **has a longer lifetime** than the ordinary excited states and that generally has a **shorter lifetime than the lowest, often stable, energy state**, called the ground state. A metastable state may thus be considered a kind of temporary energy trap or a somewhat **stable intermediate stage of a system** the energy of which may be lost in discrete amounts. In quantum mechanical terms, transitions from metastable states are "forbidden" and are much less probable than the "allowed" transitions from other excited states. **Metastable atoms often lose their stored energy by collision with other atoms before they can radiate it**, but in the rarefied upper atmosphere of Earth, in which atoms travel a longer time before collision, radiation from metastable oxygen atoms accounts for the aurora.

Due to the 107s radiative lifetime of $O(^1D)$, the emission of the 630nm line competes with collisional de-excitation, quenching, as a cause of energy loss of $O(^1D)$, where the excitation energy is lost as kinetic, vibrational or rotational energy of the colliding particles without emission of photons.

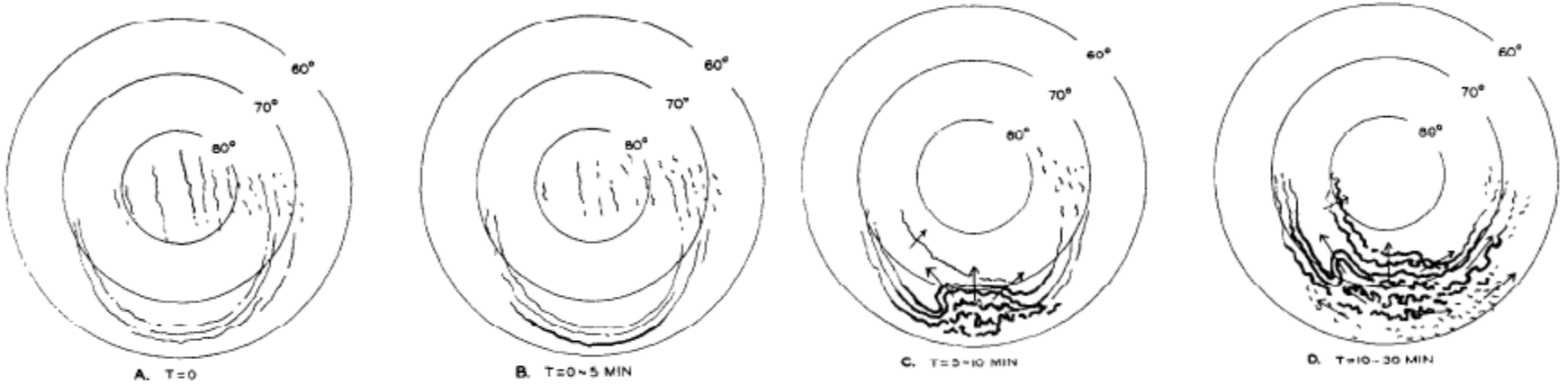
http://www2.irf.se/~bjorn/thesis/node5.html

THE DEVELOPMENT OF THE AURORAL SUBSTORM

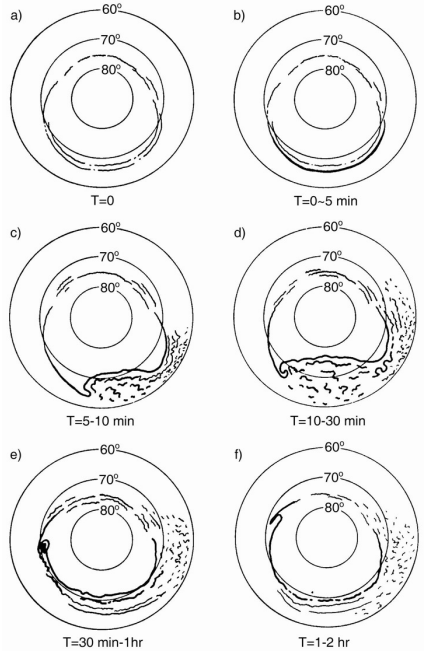
S.-I. AKASOFU
Geophysical Institute, University of Alaska, College, Alaska

(*Received* 13 *January* 1964)

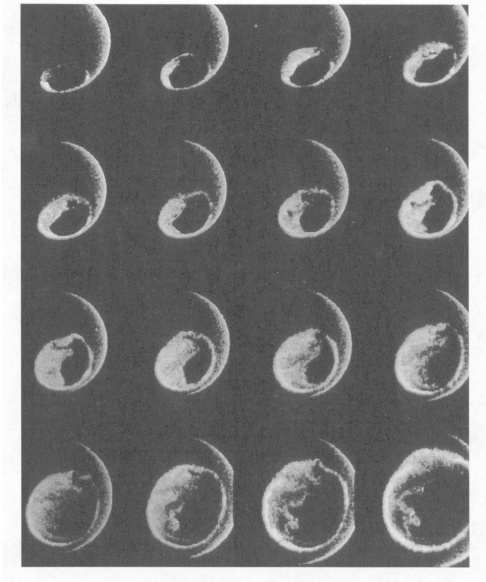
Abstract—A working model of simultaneous auroral activity over the entire polar region is presented in terms of the auroral substorm. The substorm has two characteristic phases, an expansive phase and a recovery phase. Each phase is divided into three stages, and characteristic auroral displays over the entire polar region during each stage are described in detail. Further, all the major features seen at a single station are combined into a consistent picture of large-scale auroral activity.



Φάσεις της μαγνητοσφαιρικής υποκαταιγίδας



Model based on ground observations



Pictures from space

- Growth phase – energy stored
- Onset – energy begins to be released
- Expansion – activity spreads

Εξέλιξη μαγνητοσφαιρικής υποκαταιγίδας