A Traveler's Guide to the Aurora

A description of the aurora, how to predict its occurrence and how best to view it

by
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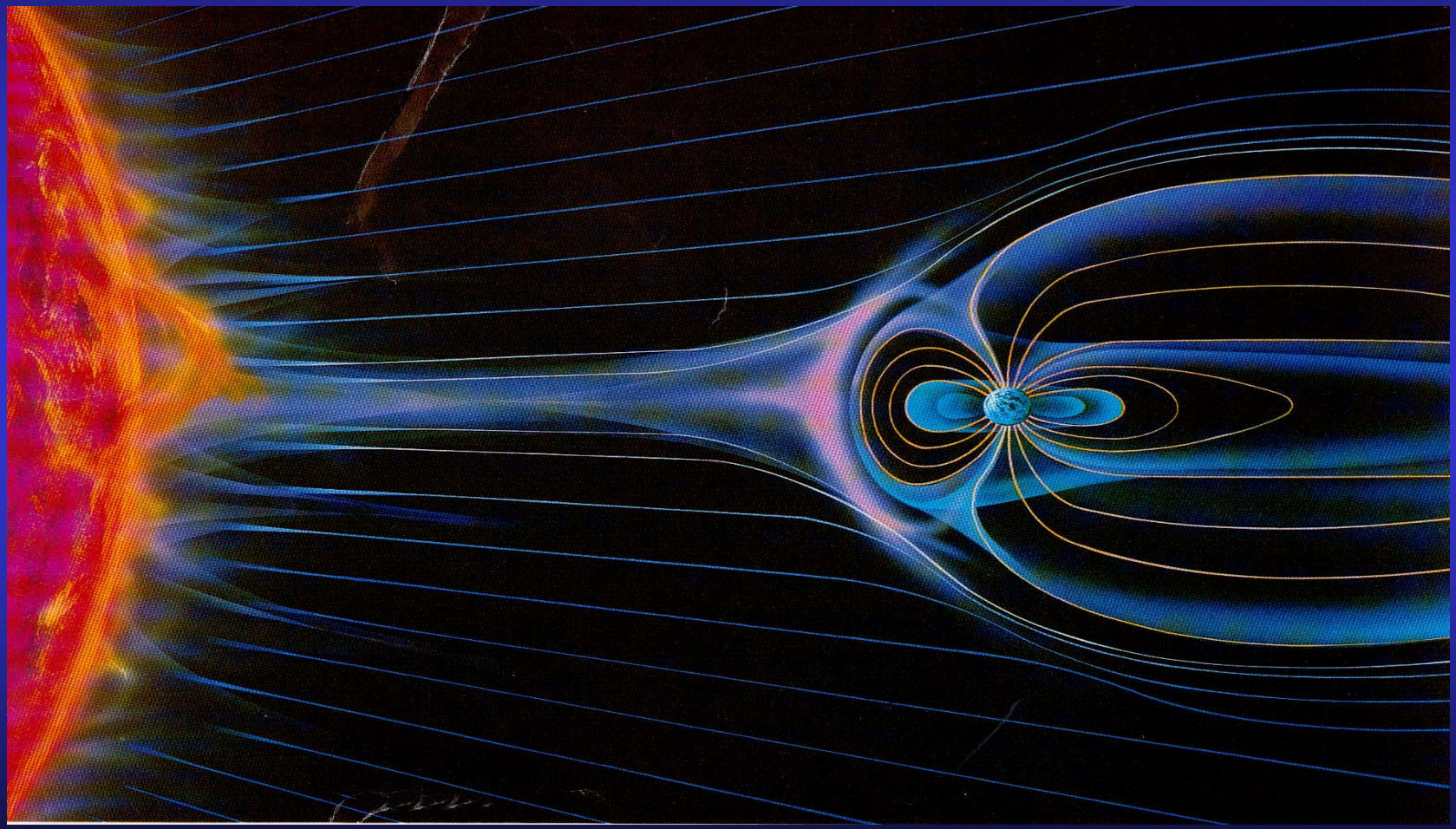
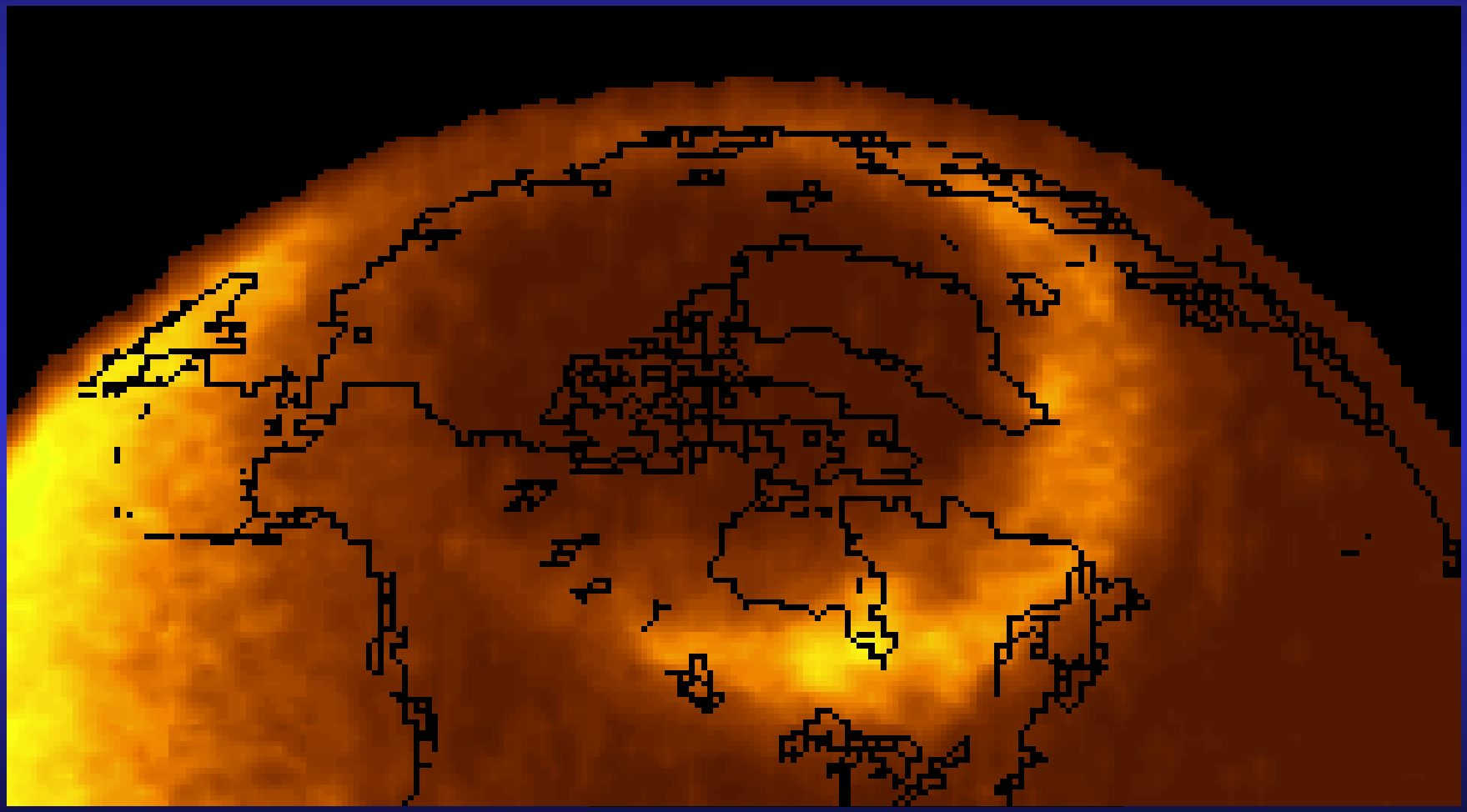
E-mail from the Solar System

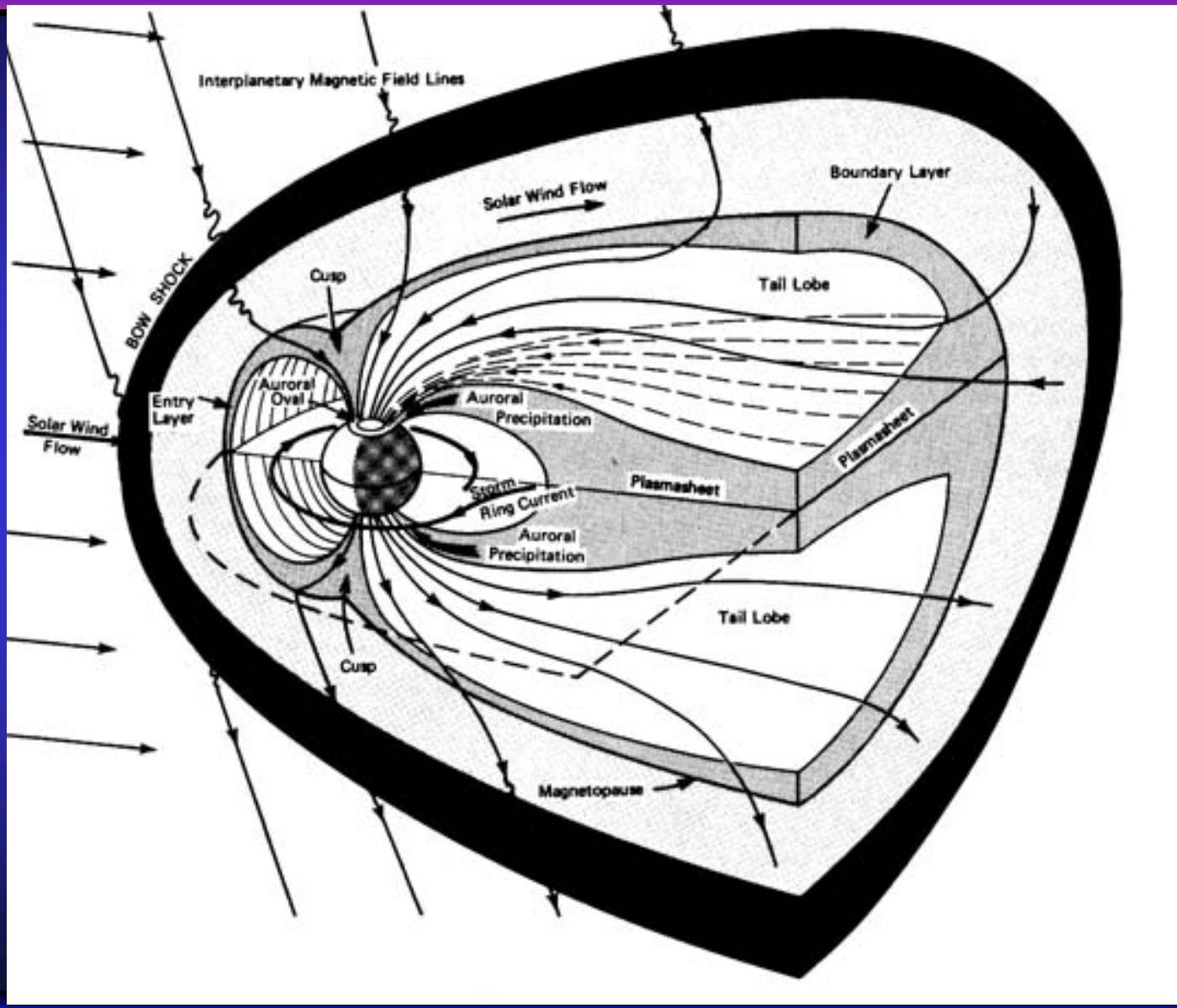


The Biggest Show on Earth



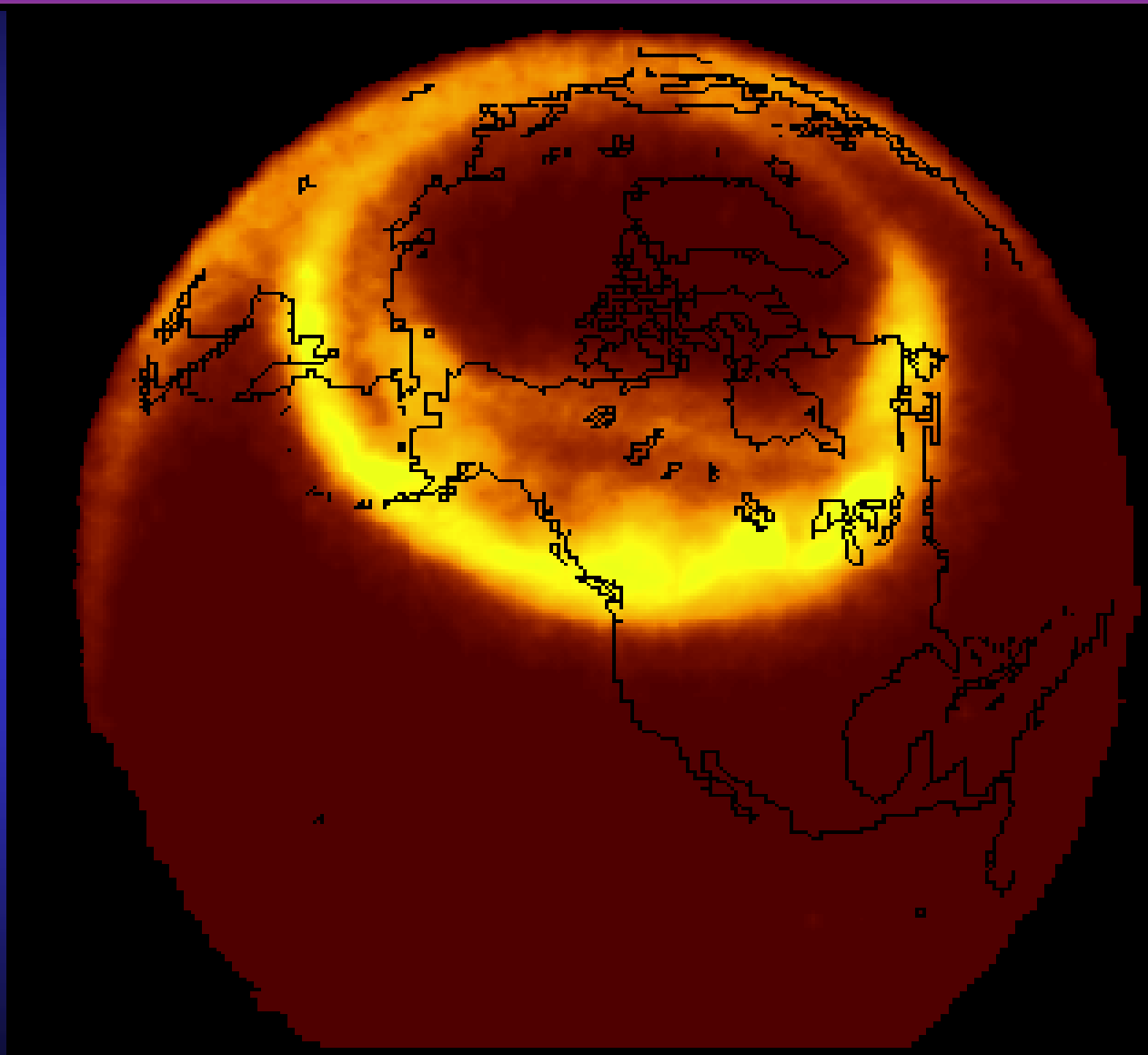
Magnetic Fields of Sun & Earth

- Any planet with an atmosphere has aurorae. The planet's magnetic field makes it special.
- The Earth's magnetic field acts as a generator, sending current along the field lines towards the atmosphere around the poles.



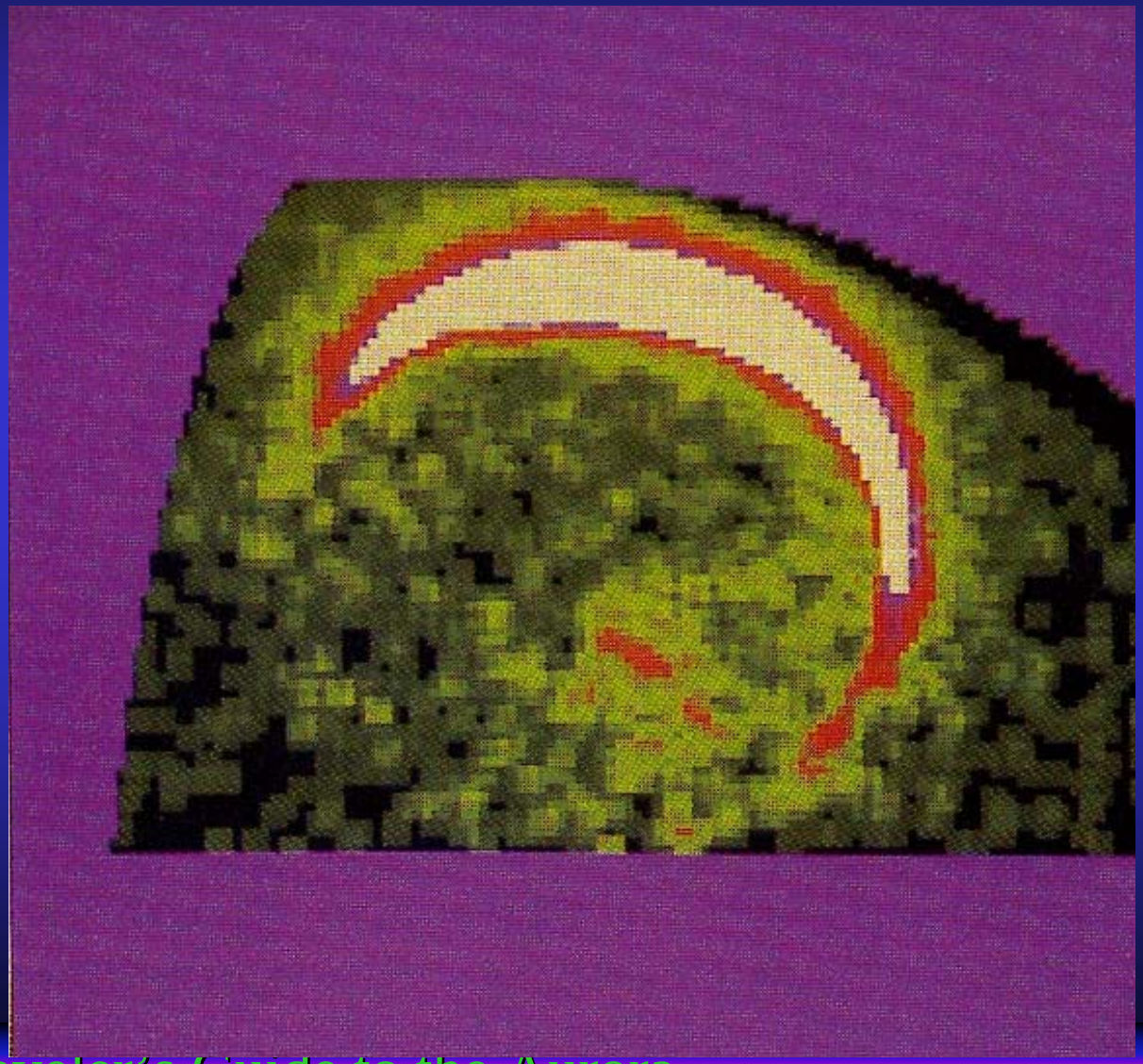
The Biggest Show on Earth

- The aurora is an unrivaled natural wonder.
- On Earth, it forms a circle around the poles.



Venus – no magnetic field

- The airglow is created by electromagnetic radiation from the sun.
- The aurora is concentrated particle bombardment of the atmosphere guided by remnant magnetic fields.

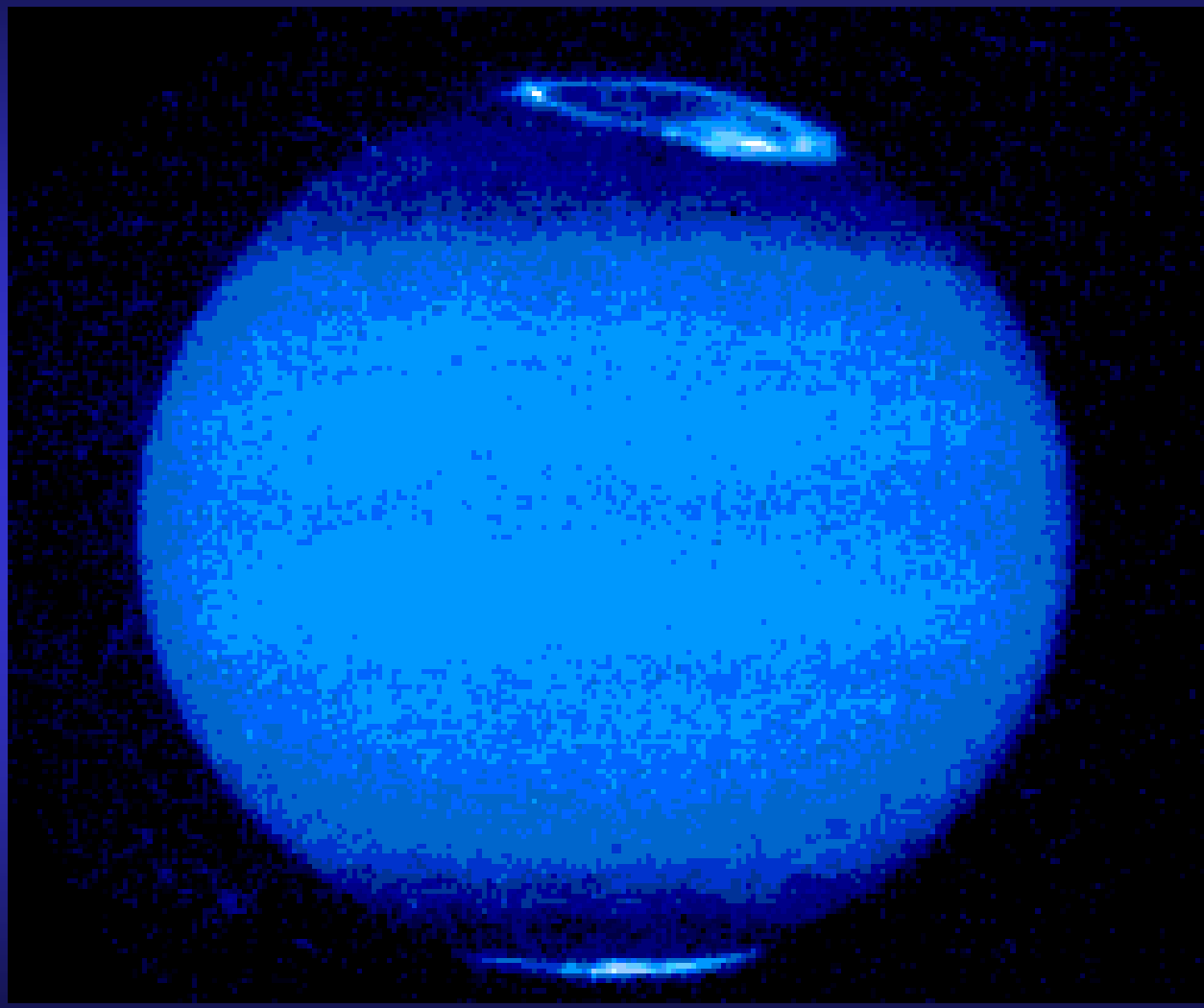


Mars – no magnetic field

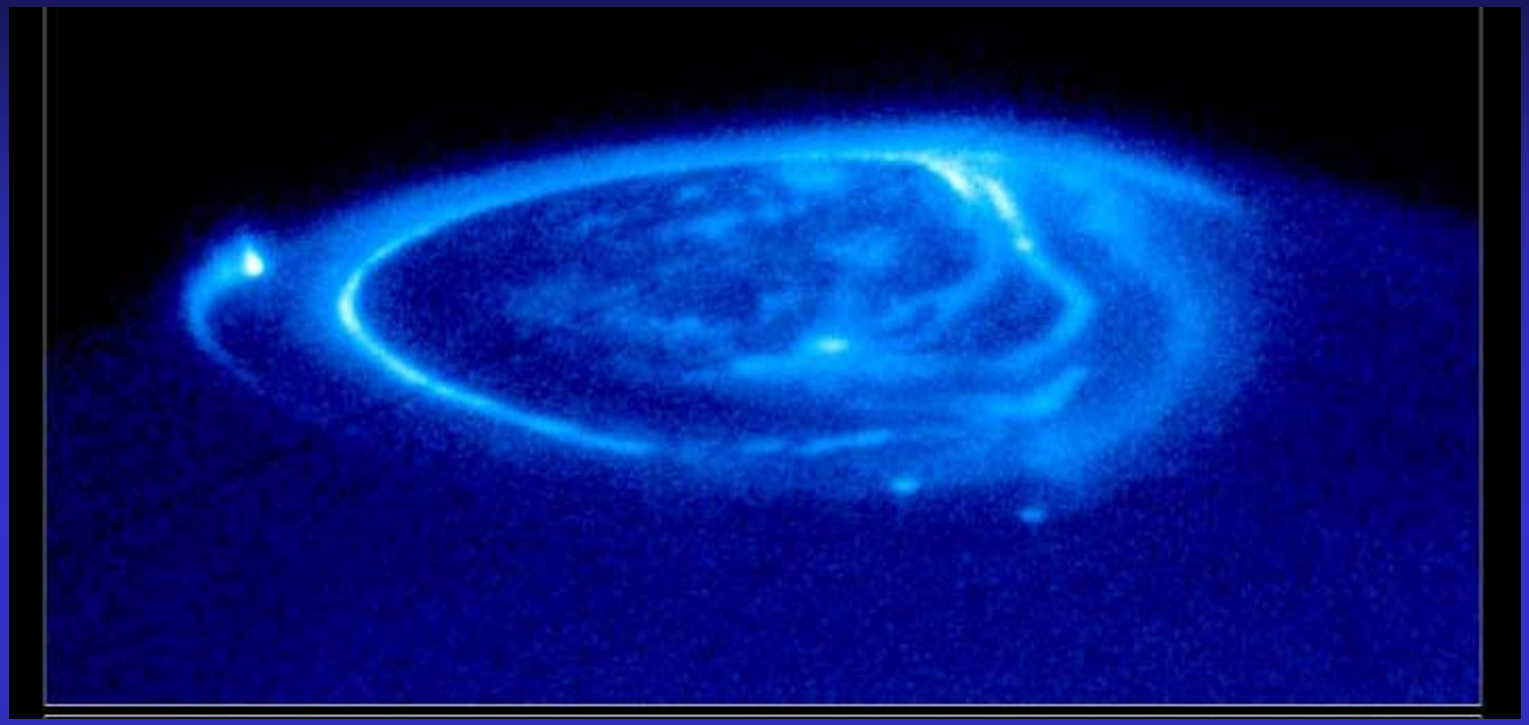
- The aurora is concentrated particle bombardment of the atmosphere guided by remnant magnetic fields

Jupiter – largest magnetic field

- The giant planets have huge magnetic fields.
- This concentrates the particle bombardment to the poles and restricts direct access from solar wind.
- Most of the aurora is internally generated



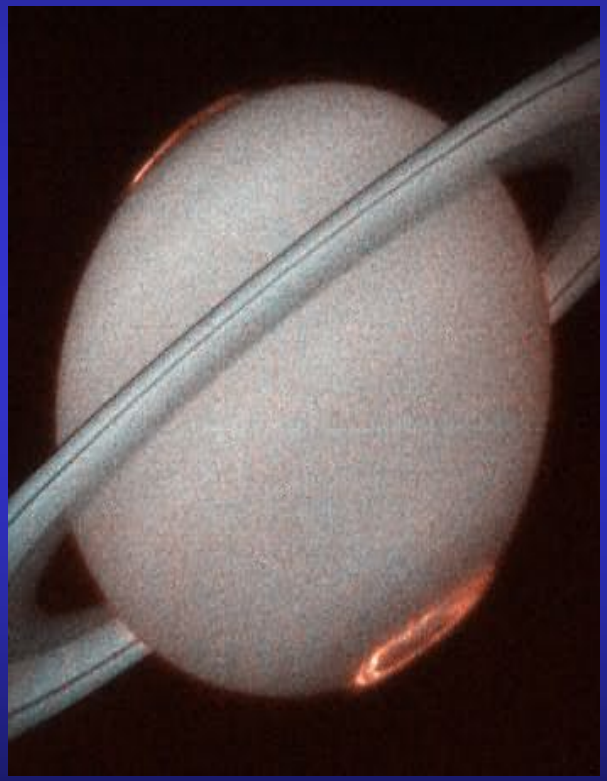
Jupiter



- Jupiter aurorae is produced by energetic particles from its planets and from its magnetic field radiation belts.
- There may be some produced by the solar wind.

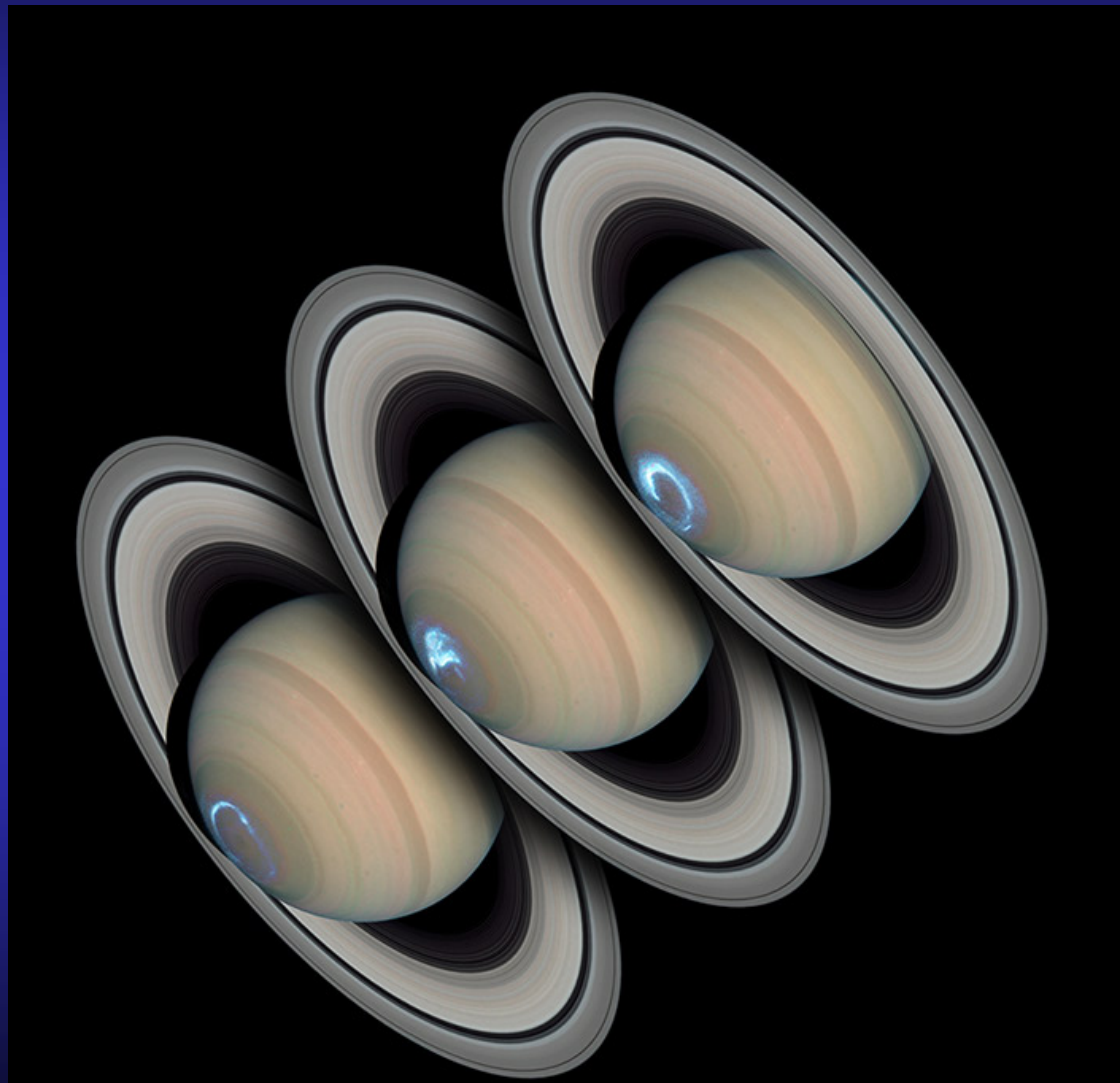
Saturn – medium magnetic field

- Saturn's aurorae are similar to Jupiter's.



Saturn

- Saturn's aurora are more active than Jupiter's.
- This is evidence that the solar wind more directly influences the aurora.



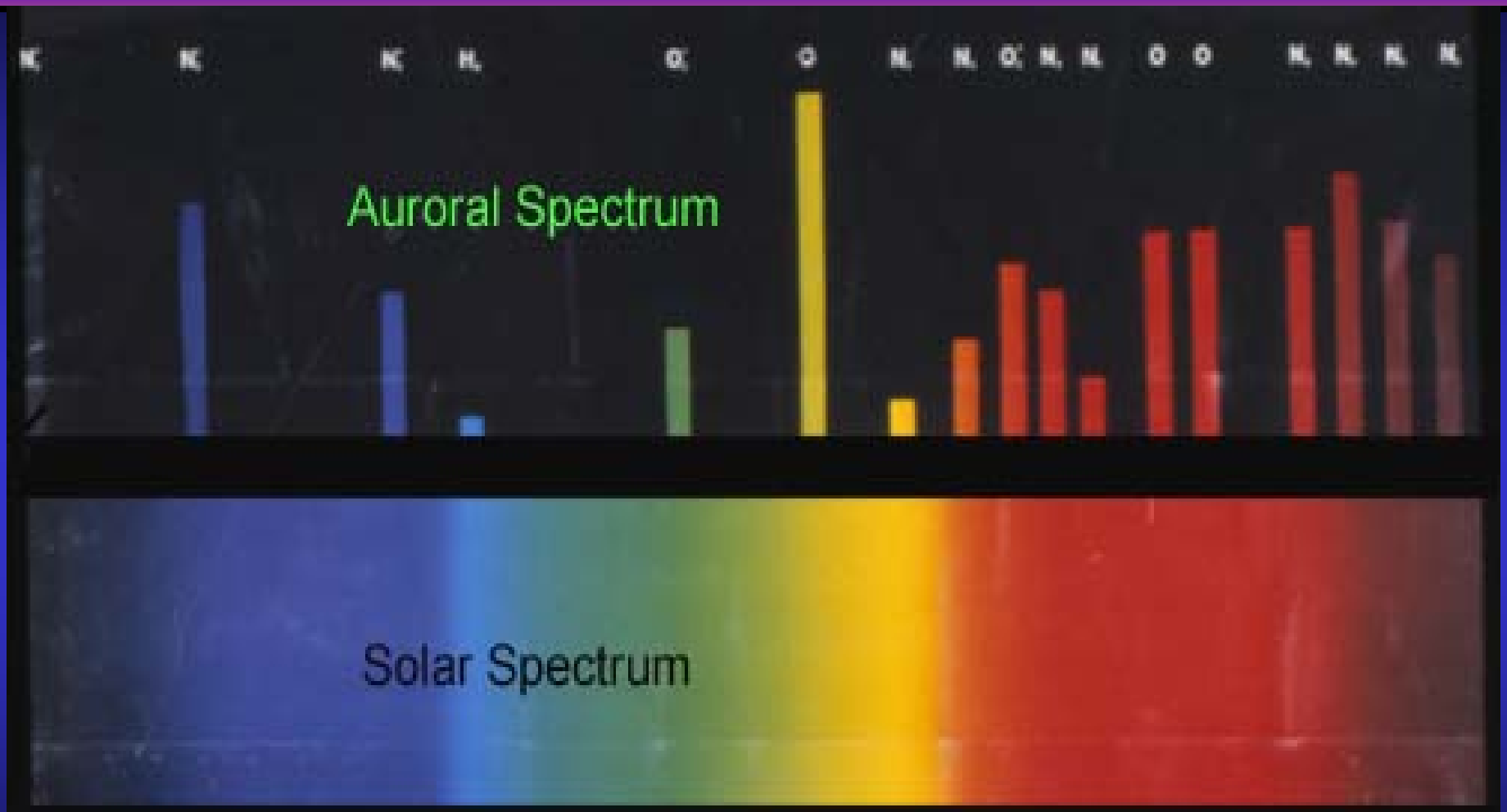
Closer to home, a view from the Shuttle

- From 400 km above the Earth, we can see that it is suspended in the atmosphere about 100 km above the surface.

Incomparable Light in the Sky

An Array of Colors

Color from the Earth's Atmosphere



- The colors of the aurora come from the nitrogen and oxygen molecules and atoms in the atmosphere.

Classify According to Color

- Type a - crimson upper border
- Type b – magenta lower border
- Type c – green arc
- Type d – red overall
- Type e – magenta and green lower border
- Type f – blue or purple

Classify According to Color

Type b

Magenta

Lower

Border

Classify According to Color

Type c

Normal

Green,

Gray

Classify According to Color

Type d

Great

Red

Aurora

Classify According to Color

Type e

Magenta

Moving

Ahead

Of

Green

Classify According to Color

Type f

Blue or

Purple

Sunlit

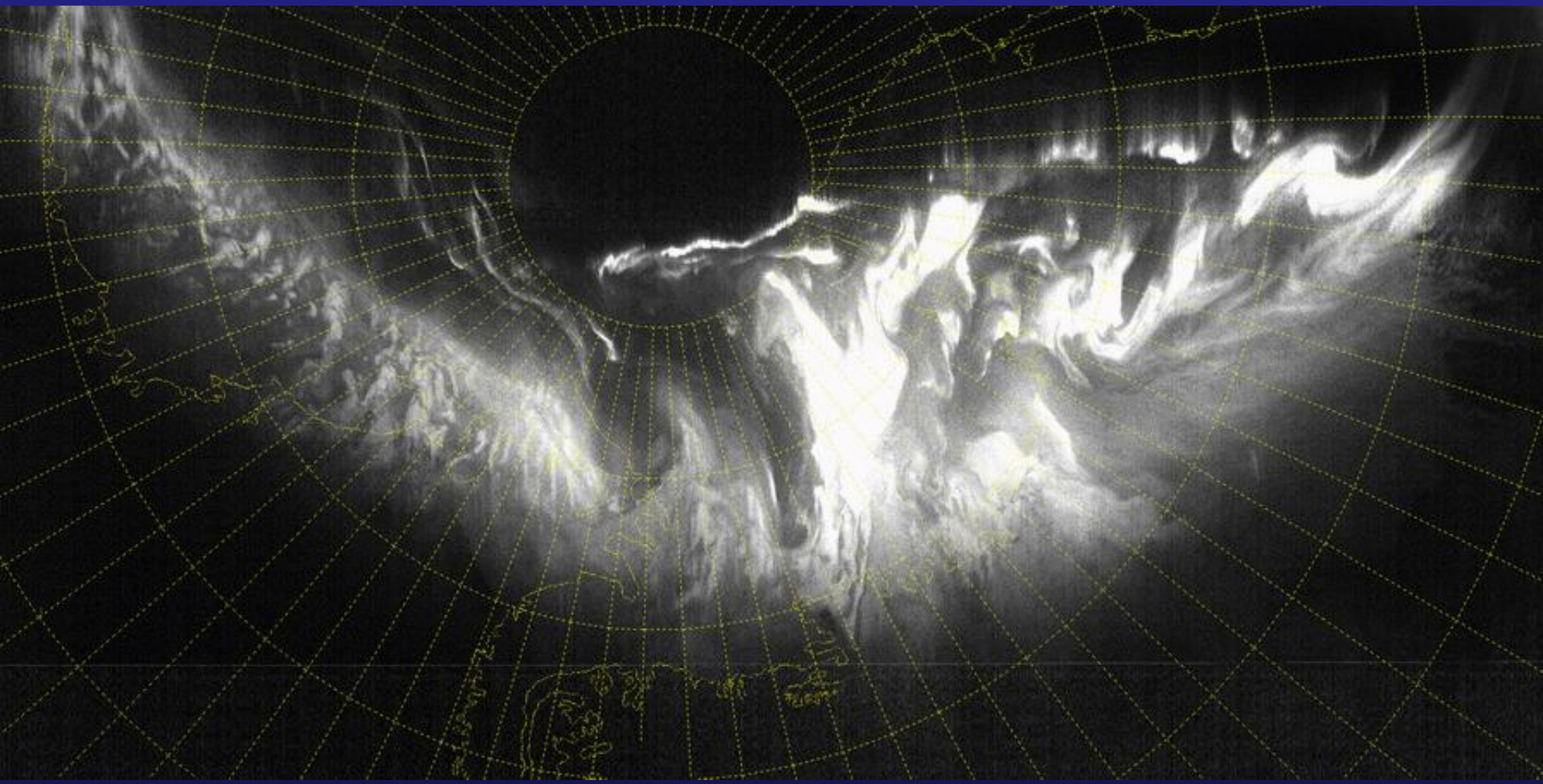
Aurora

Classify According to Color

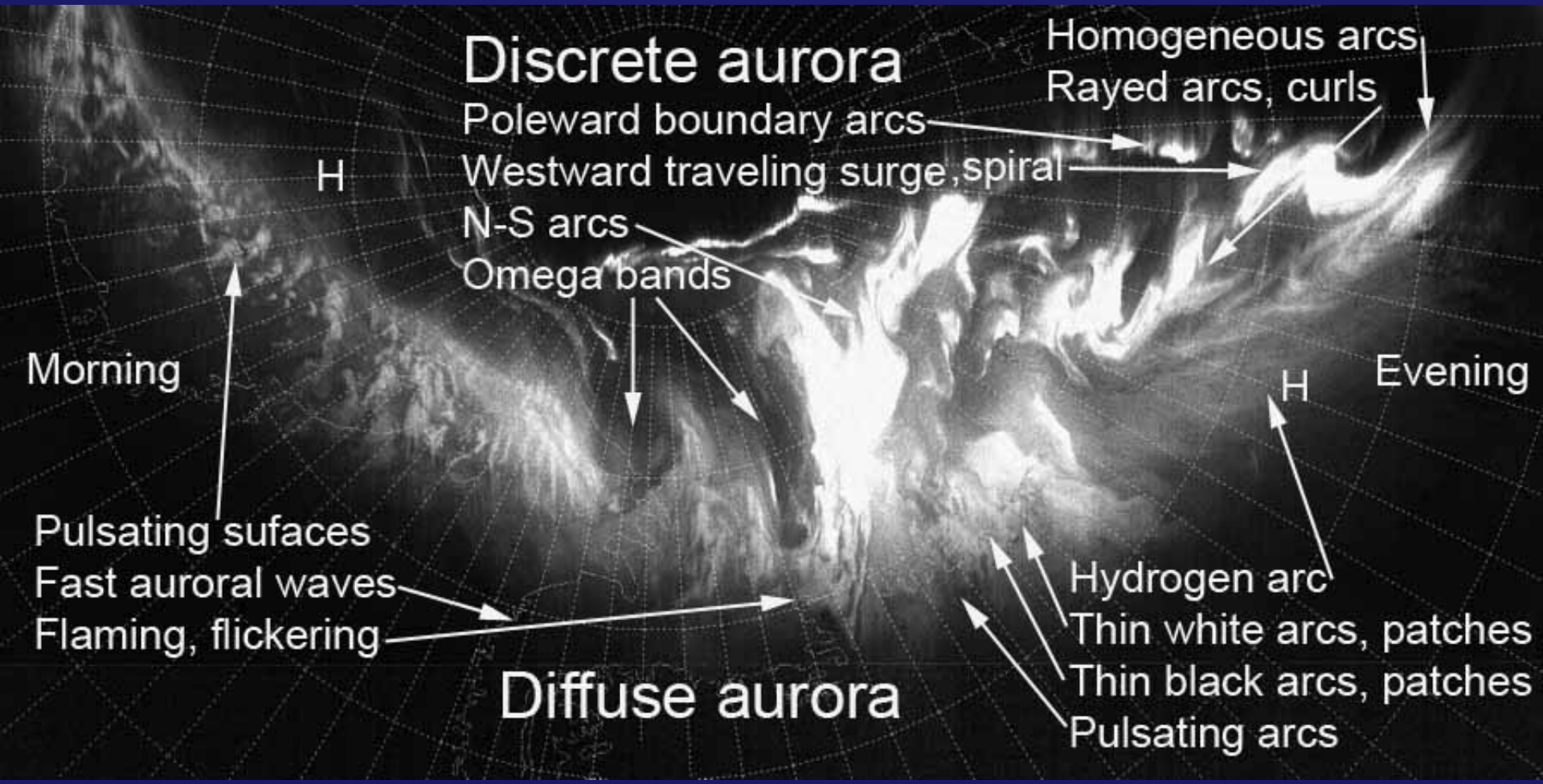
Type f - Blue or Purple Sunlit Aurora

Color Due to Local Ionosphere

Forms Differ With Local Time



Forms Differ With Local Time

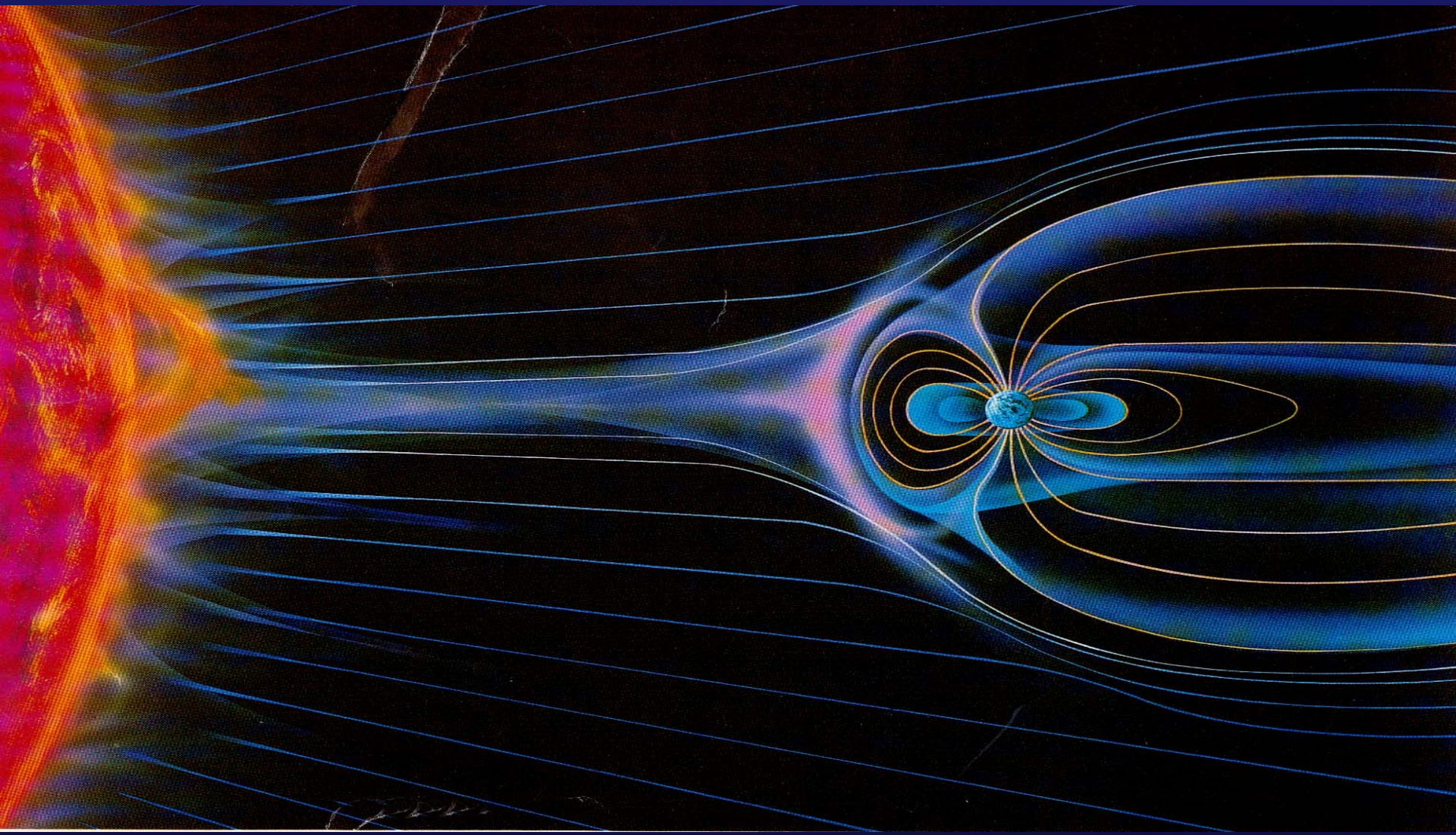


Forms Differ With Local Time

Forms Differ With Local Time

070409_aurora(8)_hres

Auroral Forecast Begins at the Sun



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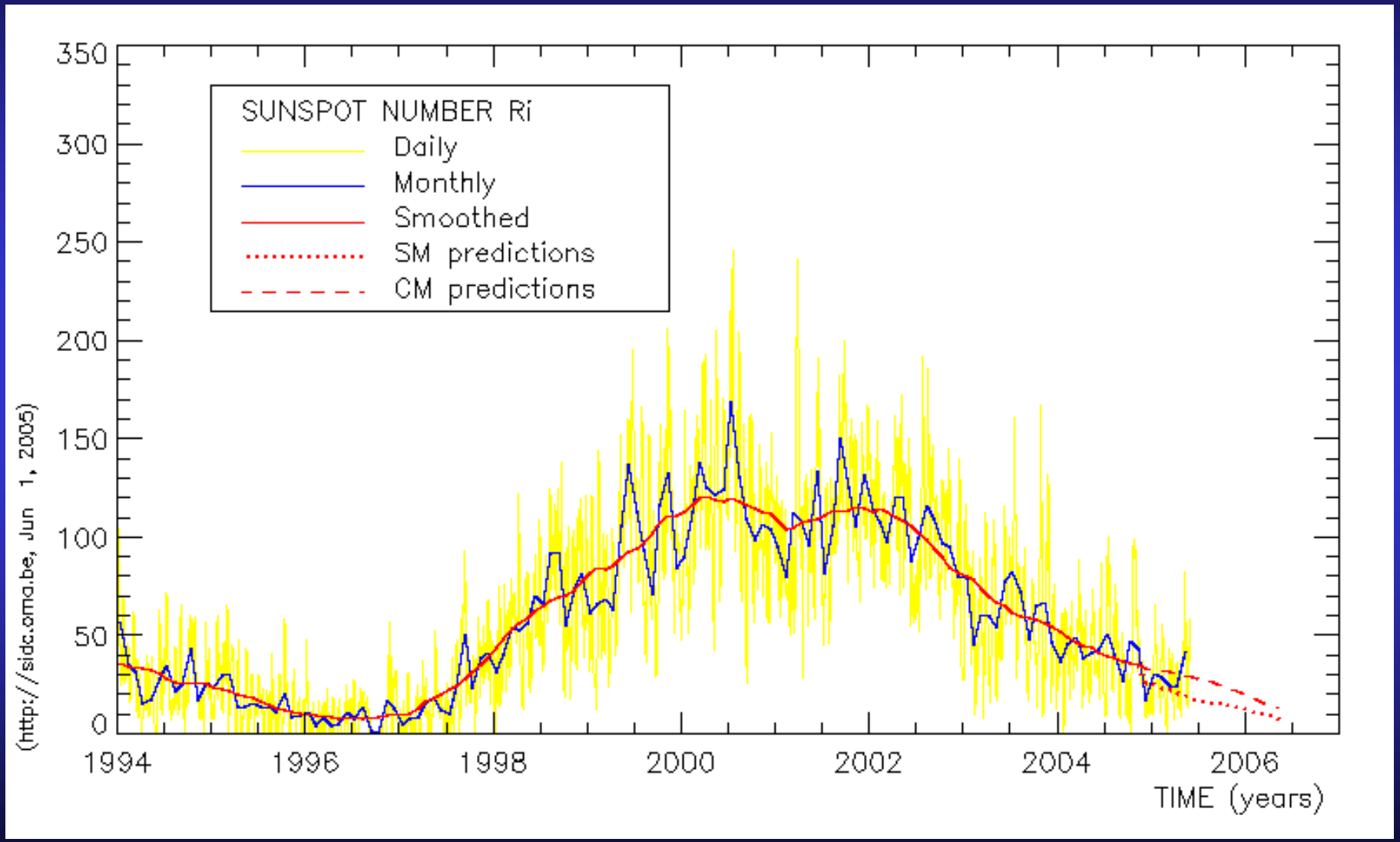

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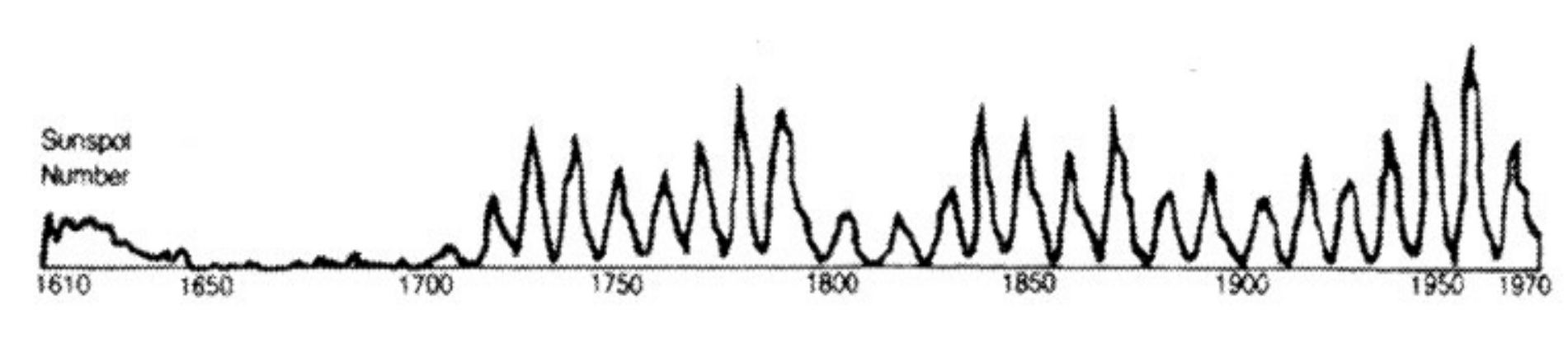


- Invention of the telescope led to sunspot counting and close solar observation.
- Cycles of 11 years , 100 years and ?.
- Aurora correlates with sunspots.
- Historical aurora sketchy measure of solar activity.

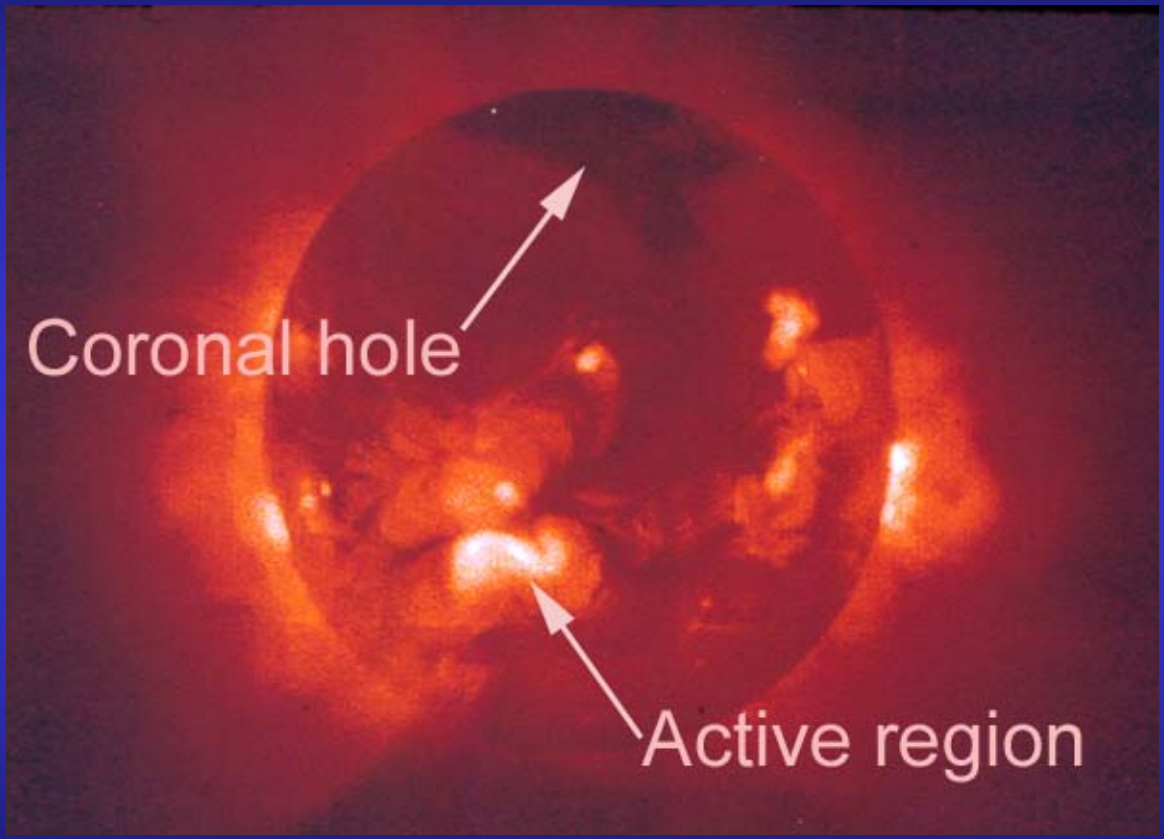
The Aurora in History

- Before 1700, aurorae were viewed as a sign of something in the sky.
- Ezekiel in Bible
- Babylonian tablets
- Chinese astrologers
- Greeks & Romans
- Beowulf
- Charles Morton

11 year solar cycle

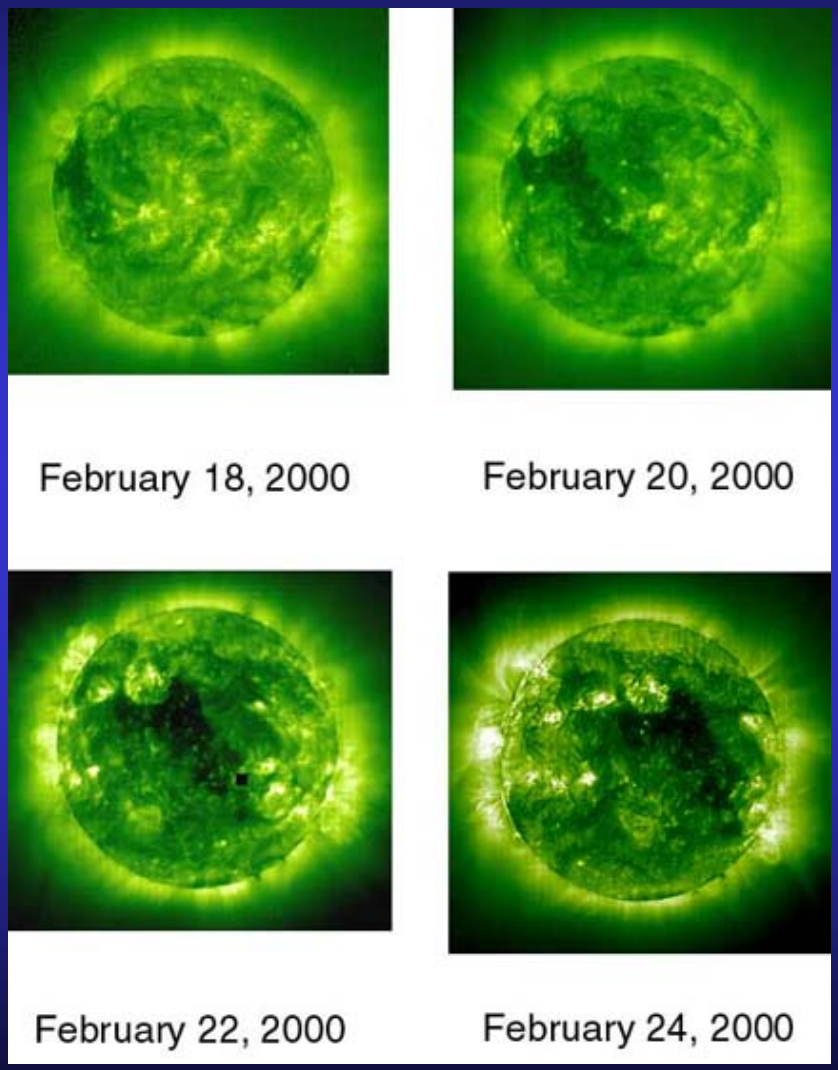
Two Types of Solar Activity

- Type 1: Fast streams from coronal holes exist for several solar rotations
- Type 2: Eruptions from solar events produce shock and exist for few hours



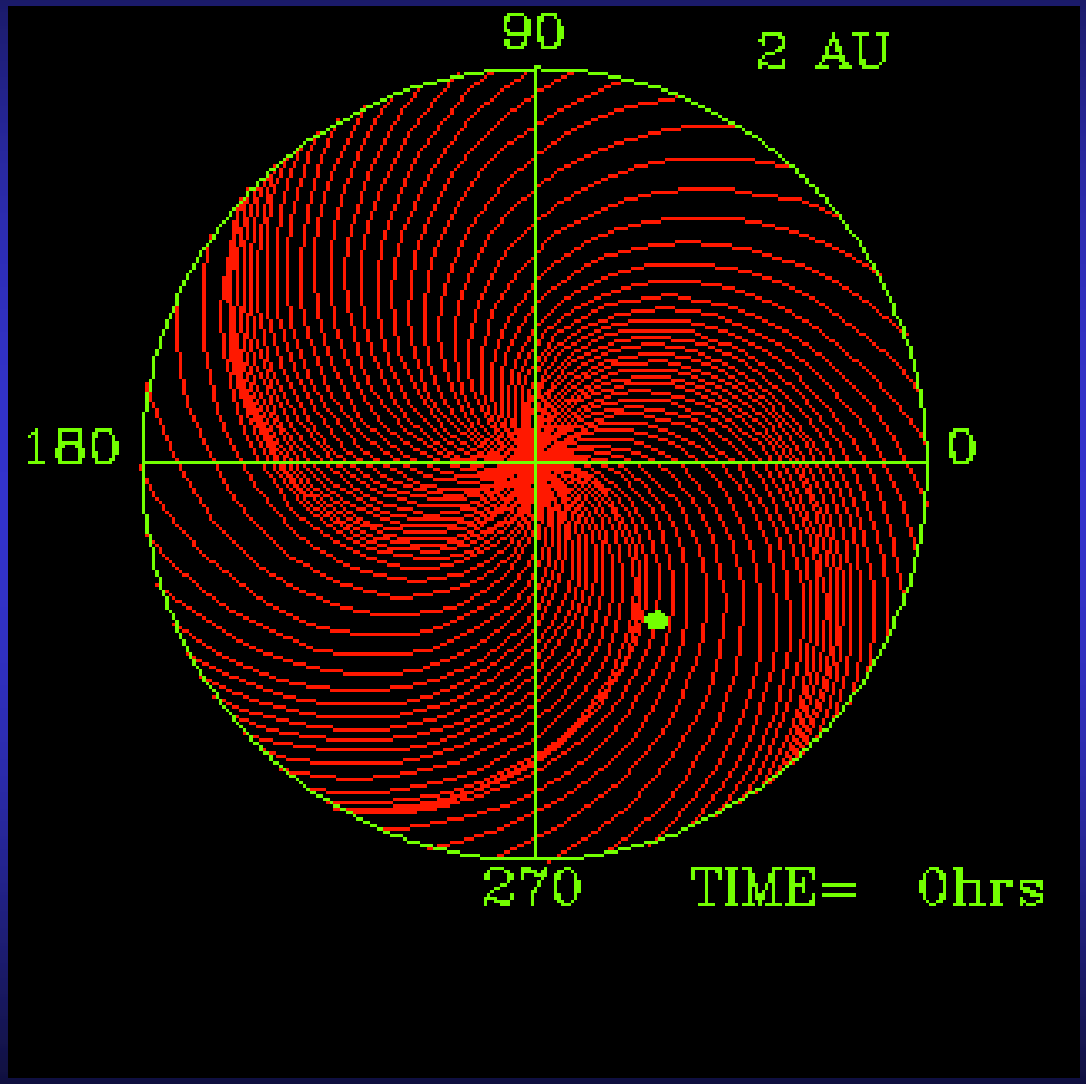
Coronal Holes

- Type 1: Fast streams from coronal holes exist for several solar rotations.
- They enhance auroral activity each time they sweep by (28 days).



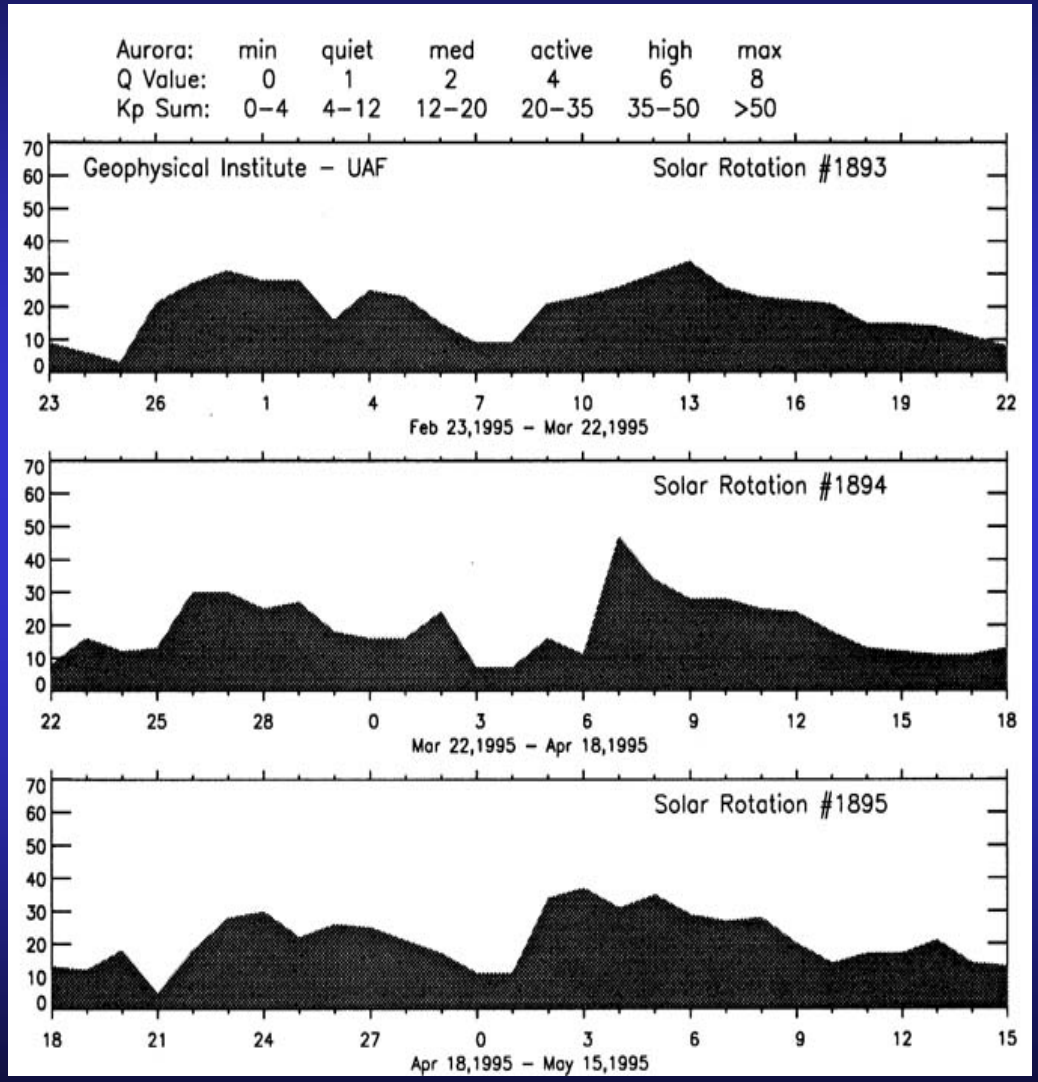
Fast Streams in the Solar Wind

- A model of the solar wind developed at the Geophysical Institute shows the part of the solar wind that is otherwise invisible.
- The solar wind is like a garden sprinkler.
- The fast streams from the coronal holes crowd the field lines.



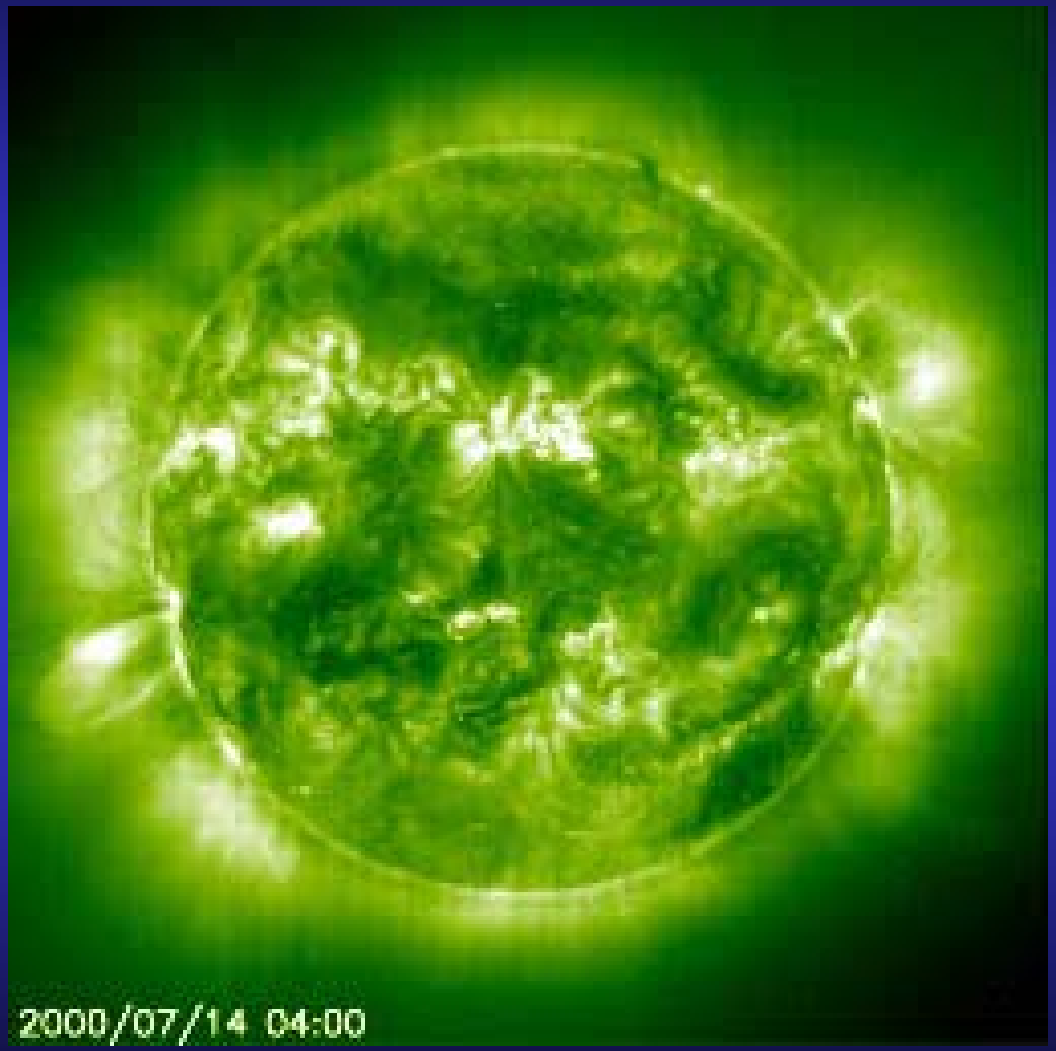
Effect of Coronal Holes on Aurora

- Auroral activity repeats with 27 day solar rotation
- Auroral Forecast up to 3-4 months in advance



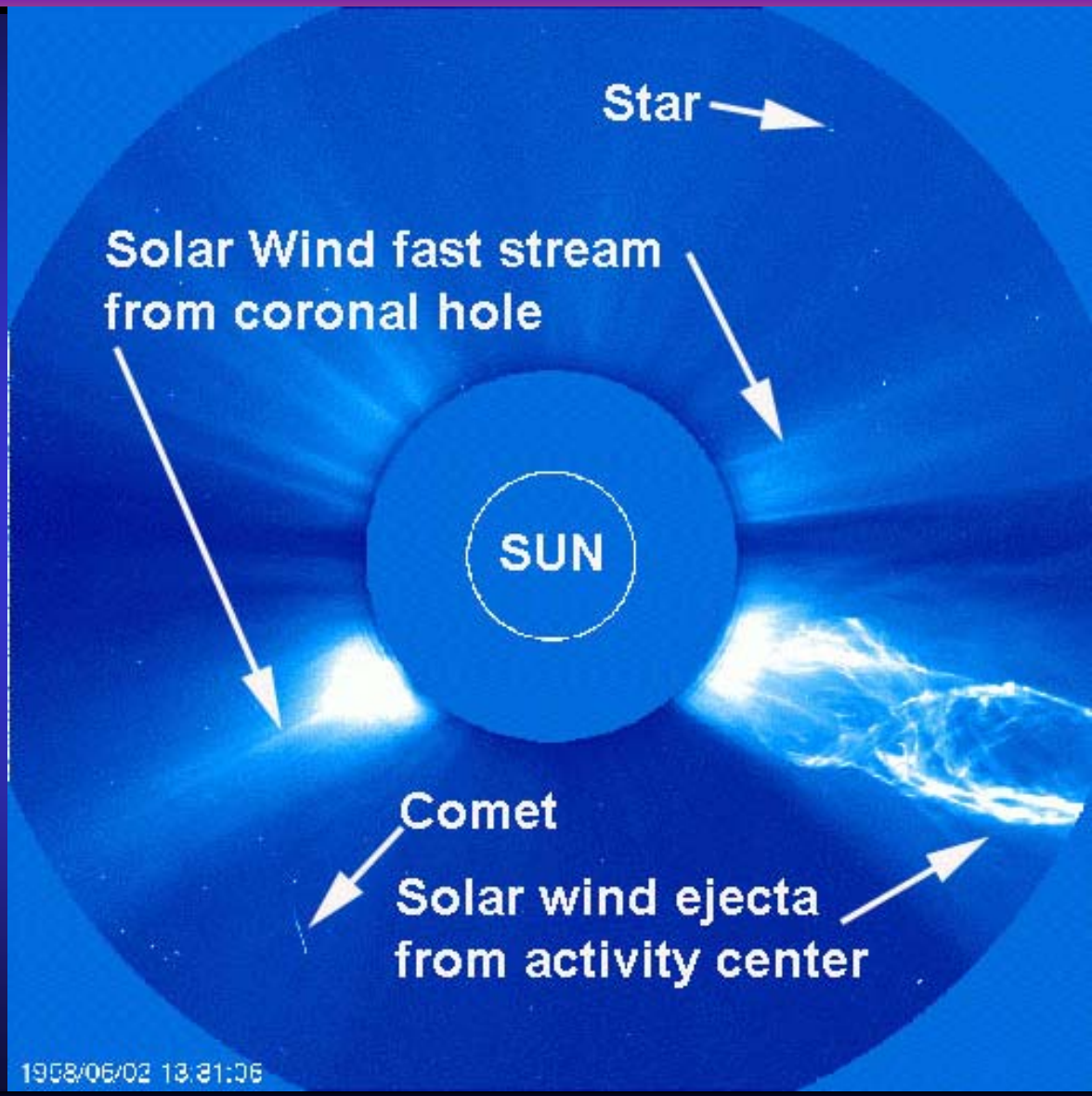
Type 2: Solar Events

- Type 1: Fast streams from coronal holes exist for several solar rotations
- Type 2: Eruptions from solar events produce shock and exist for few hours



Coronal Mass Ejection (CME)

- Type 2: Eruptions from solar events produce shock and exist for few hours.
- A coronograph on a satellite shows the solar wind near the sun.
- An explosion sends material, electrons and protons out into space.

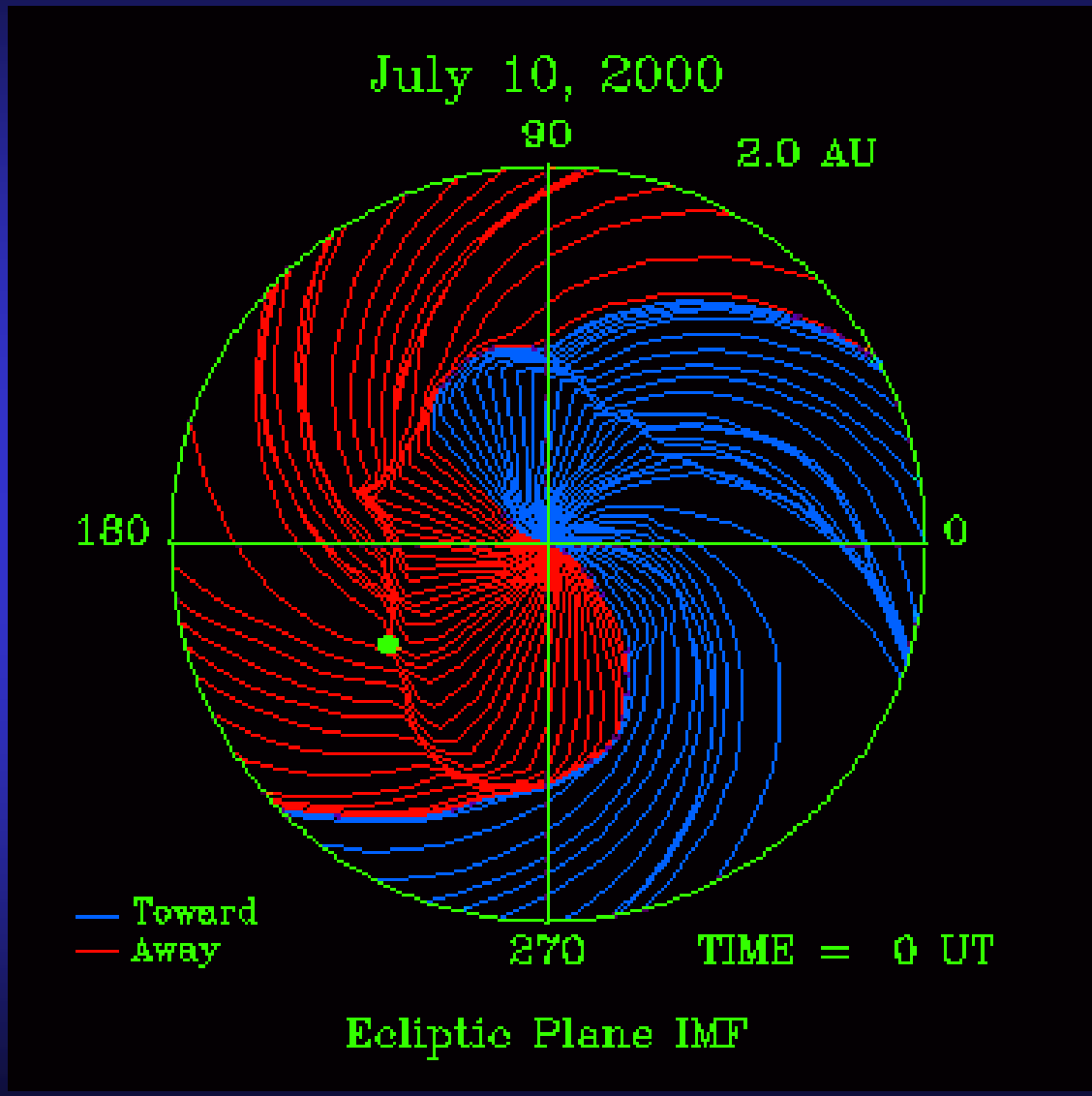


Coronal Mass Ejection (CME)

- Type 2: Eruptions from solar events produce shock and exist for few hours.
- When the material is a halo around the Sun, it is heading toward Earth.
- Its arrival affects the satellite camera.

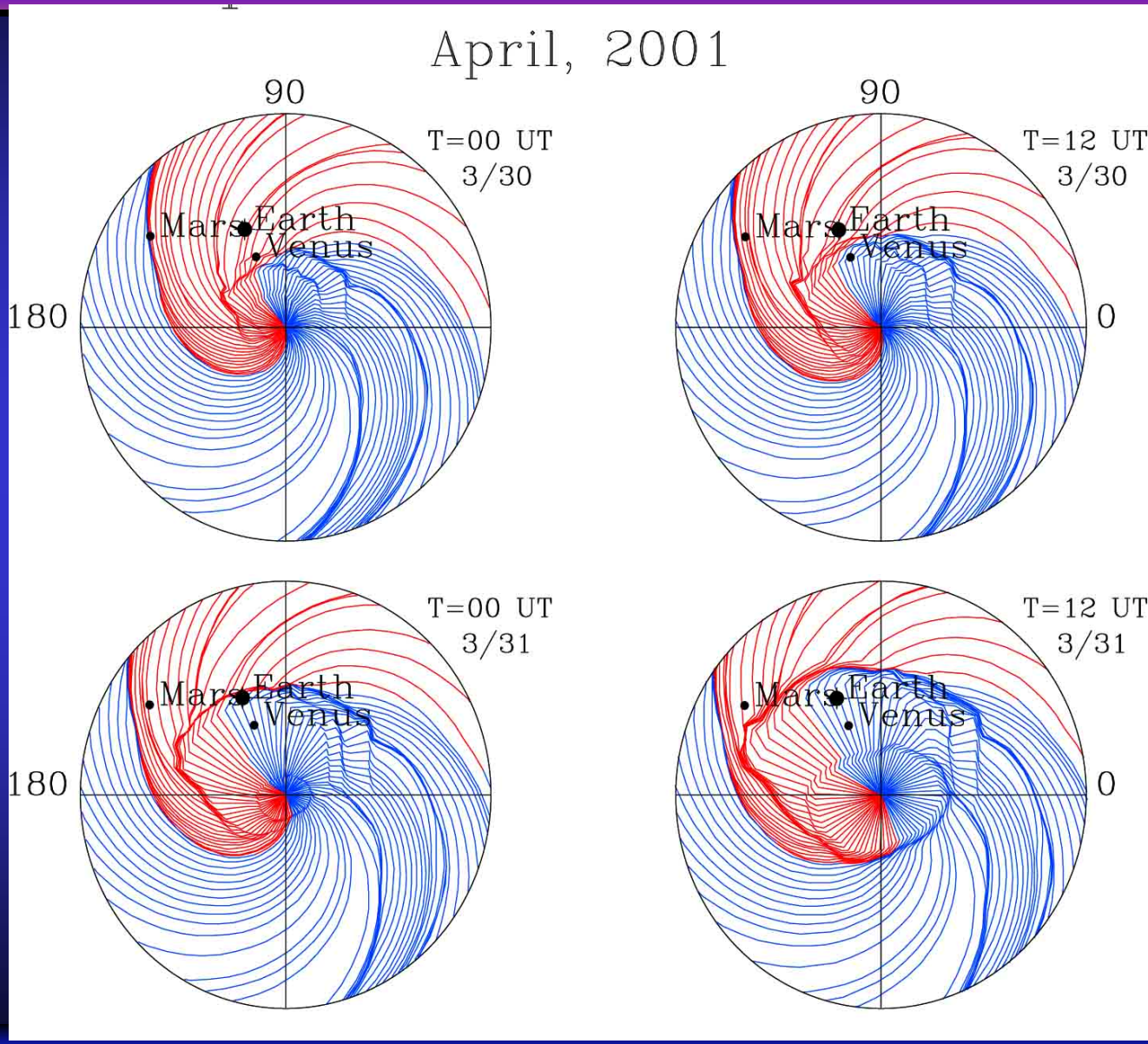
Disturbance in the Solar Wind

- Type 2: Eruptions from solar events produce shock and exist for few hours.
- The shock and some of the material takes 1- 5 days to reach Earth.



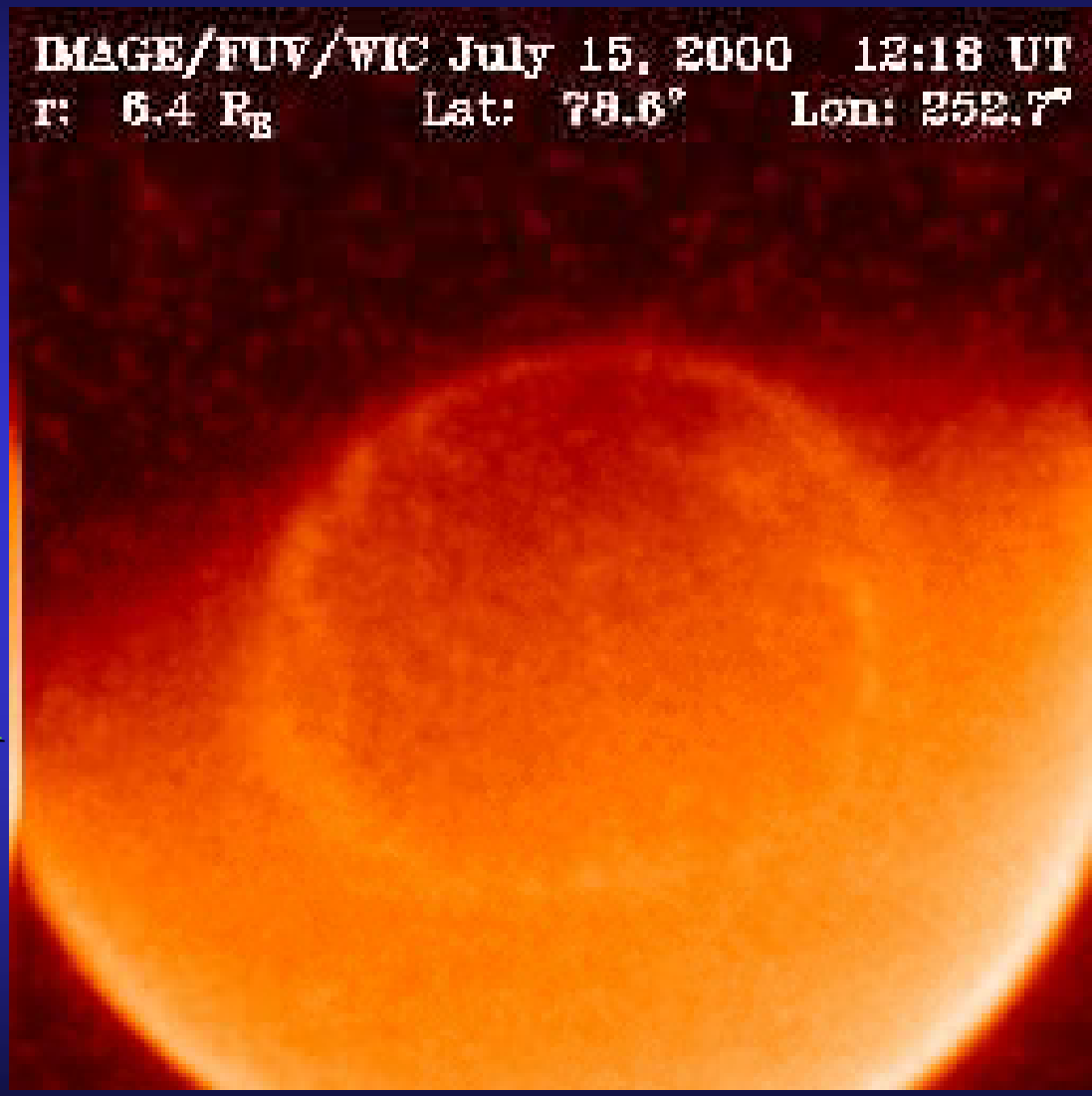
The Venusian Connection

- Oxygen and carbon ions observed in the wind from Venus
- Evidence for transport of microbes from Venus



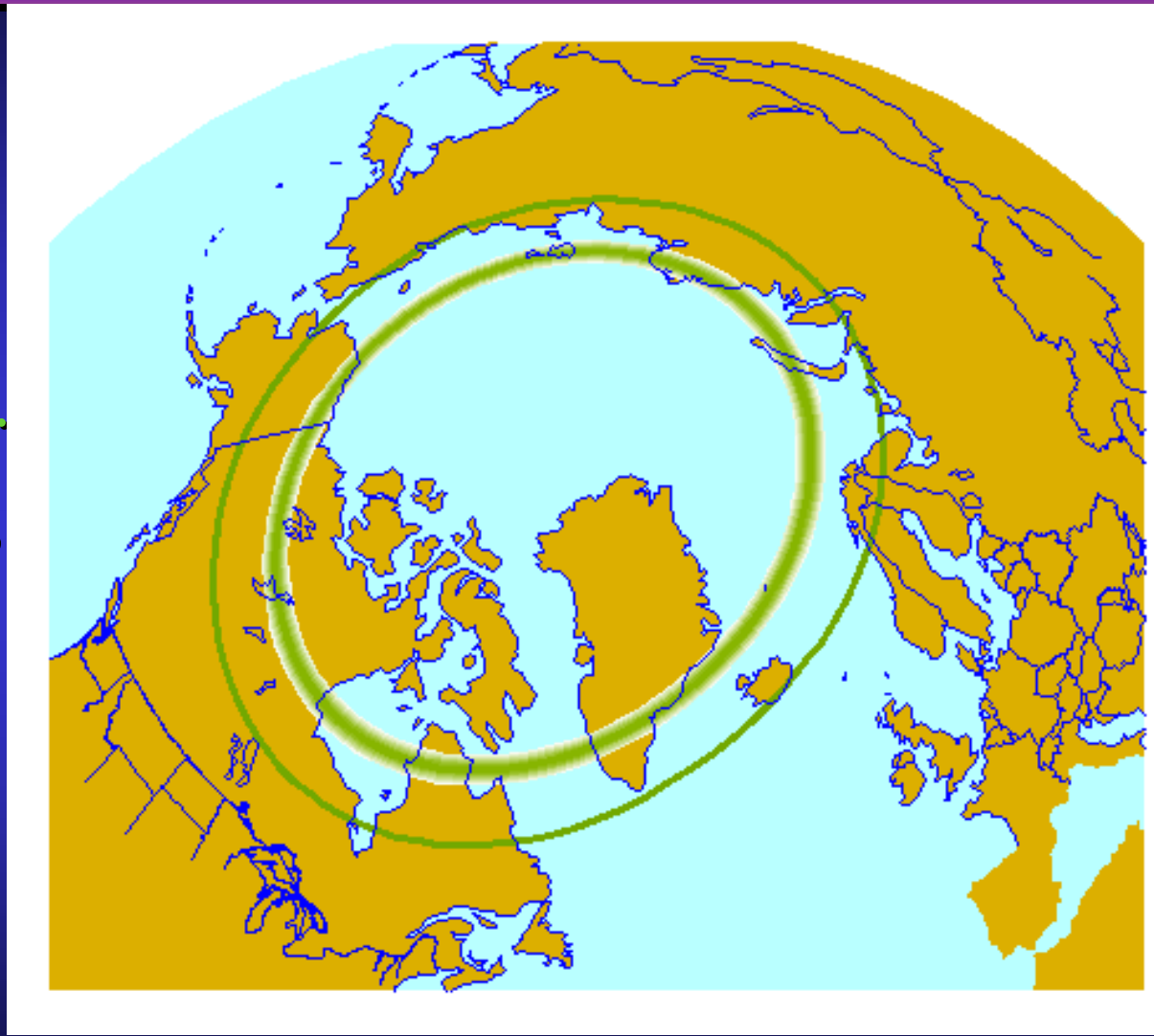
Resulting Aurora

- The magnetic field of the solar wind links up with the magnetic field of the Earth and the solar wind power is transferred to the Earth's magnetic field where it drives electrical currents into the atmosphere creating the aurora.



Levels of Auroral Activity

- The more power injected into the Earth's magnetic field the greater the extent of the aurora.
- The measure of this activity is the planetary magnetic disturbance index, Kp.
- Kp varies from 0-9.



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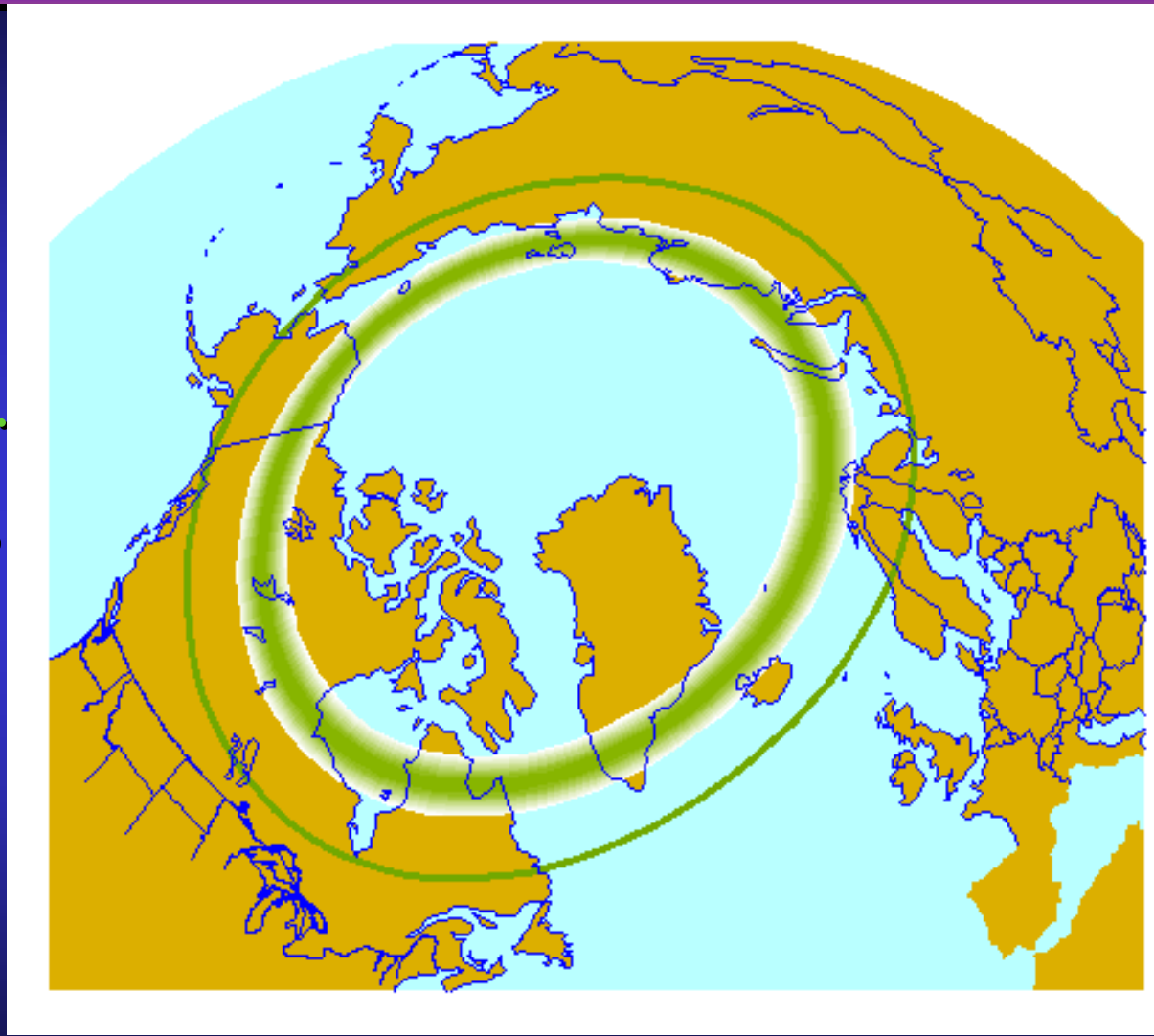

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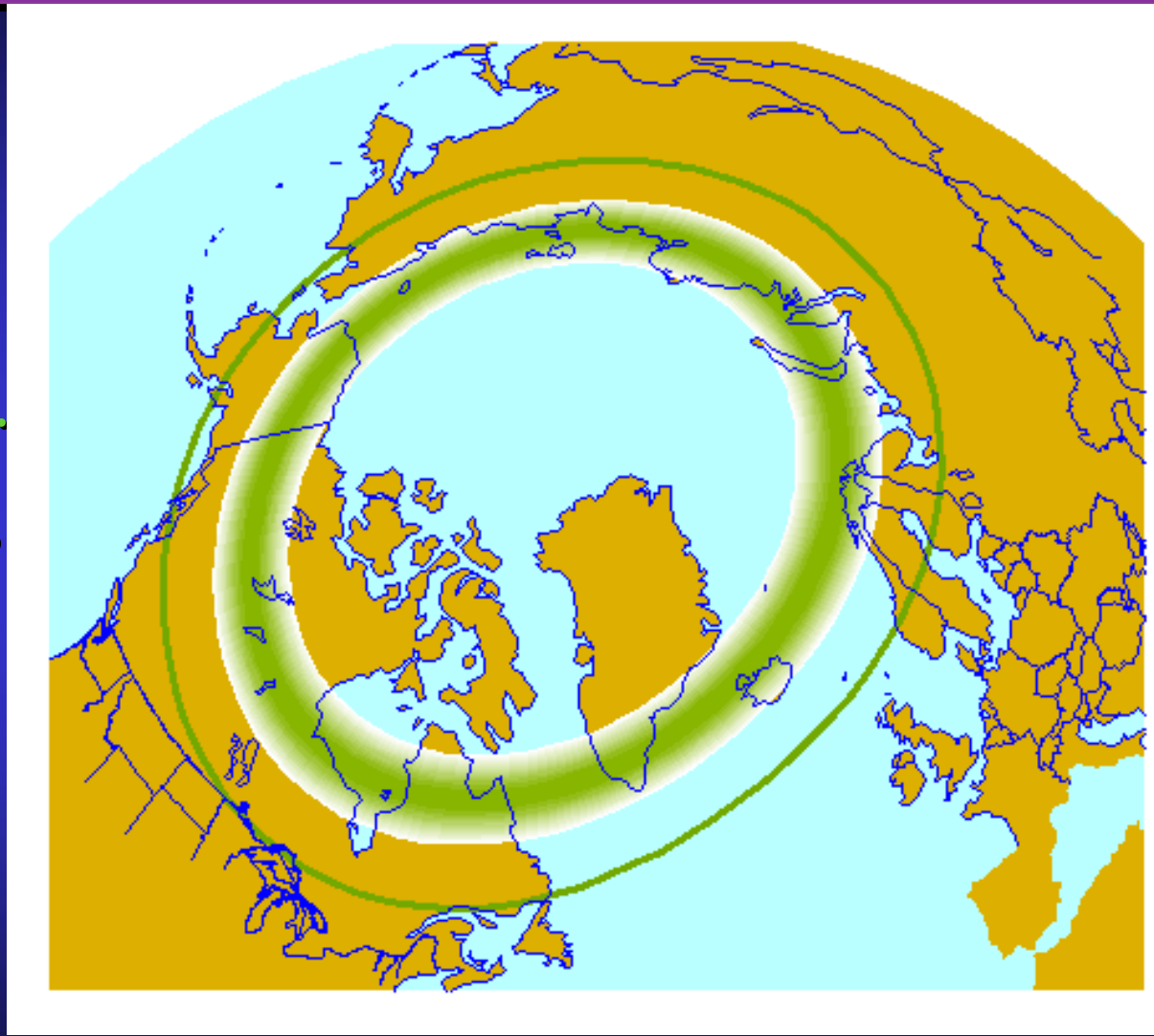

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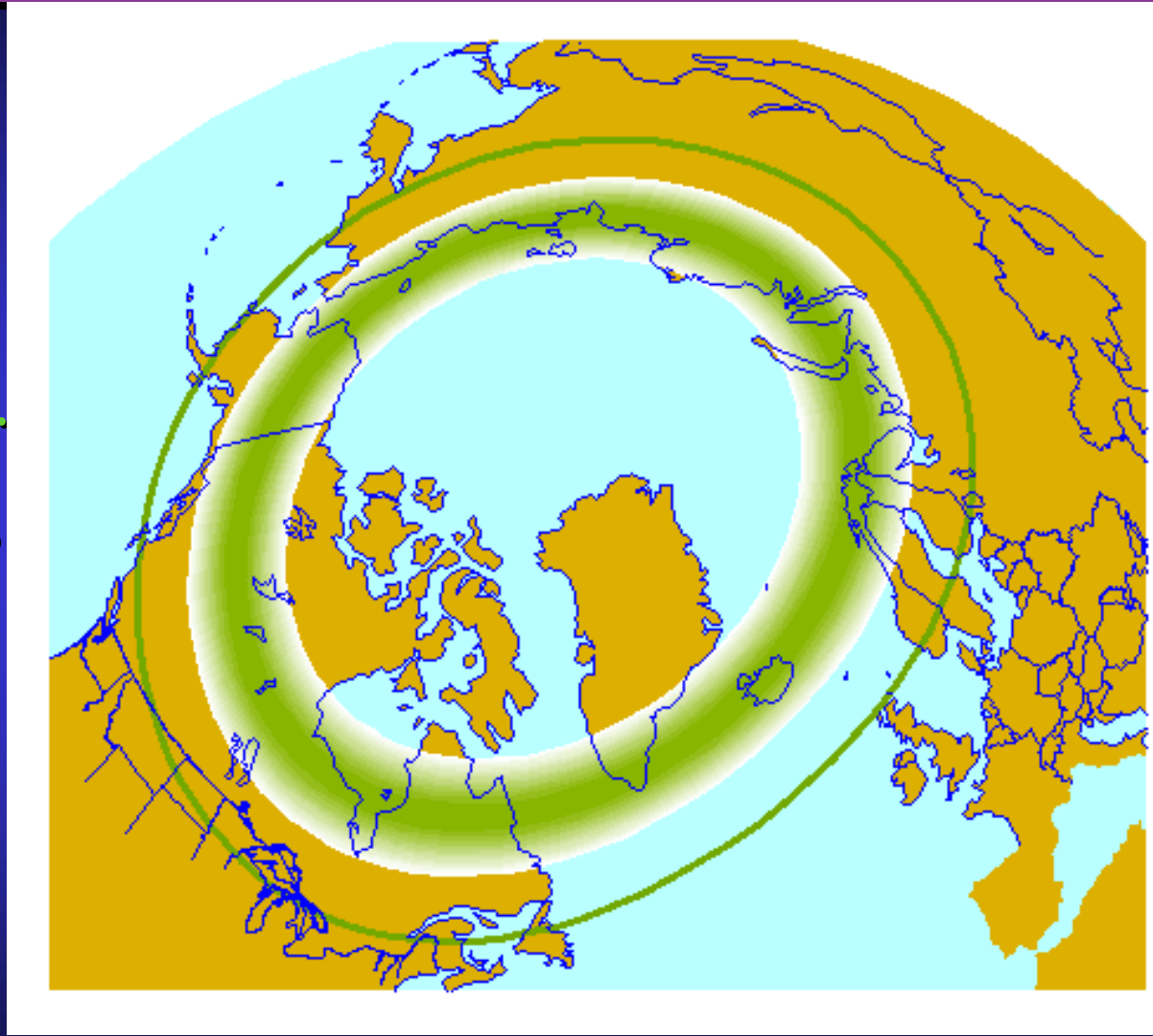

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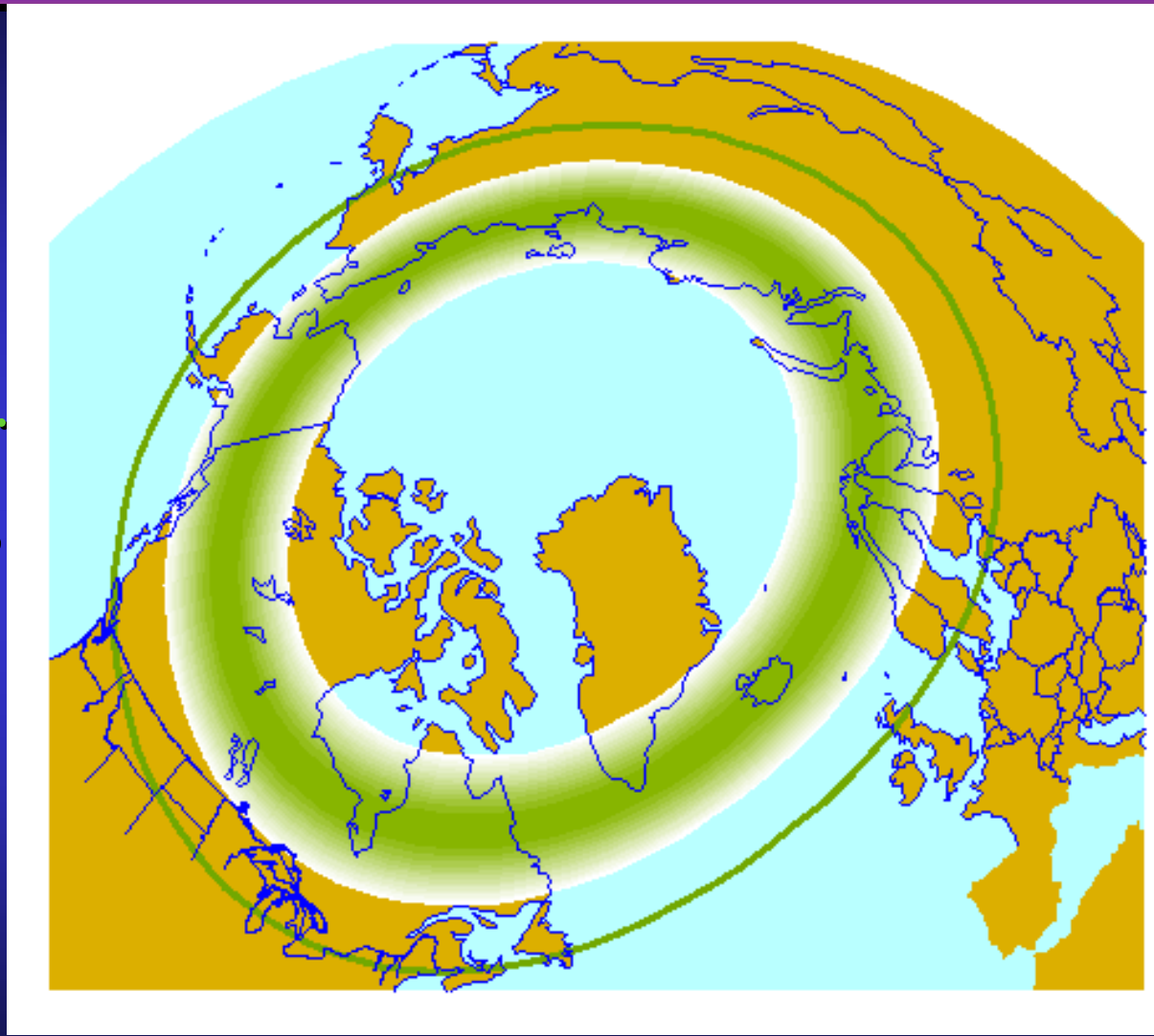

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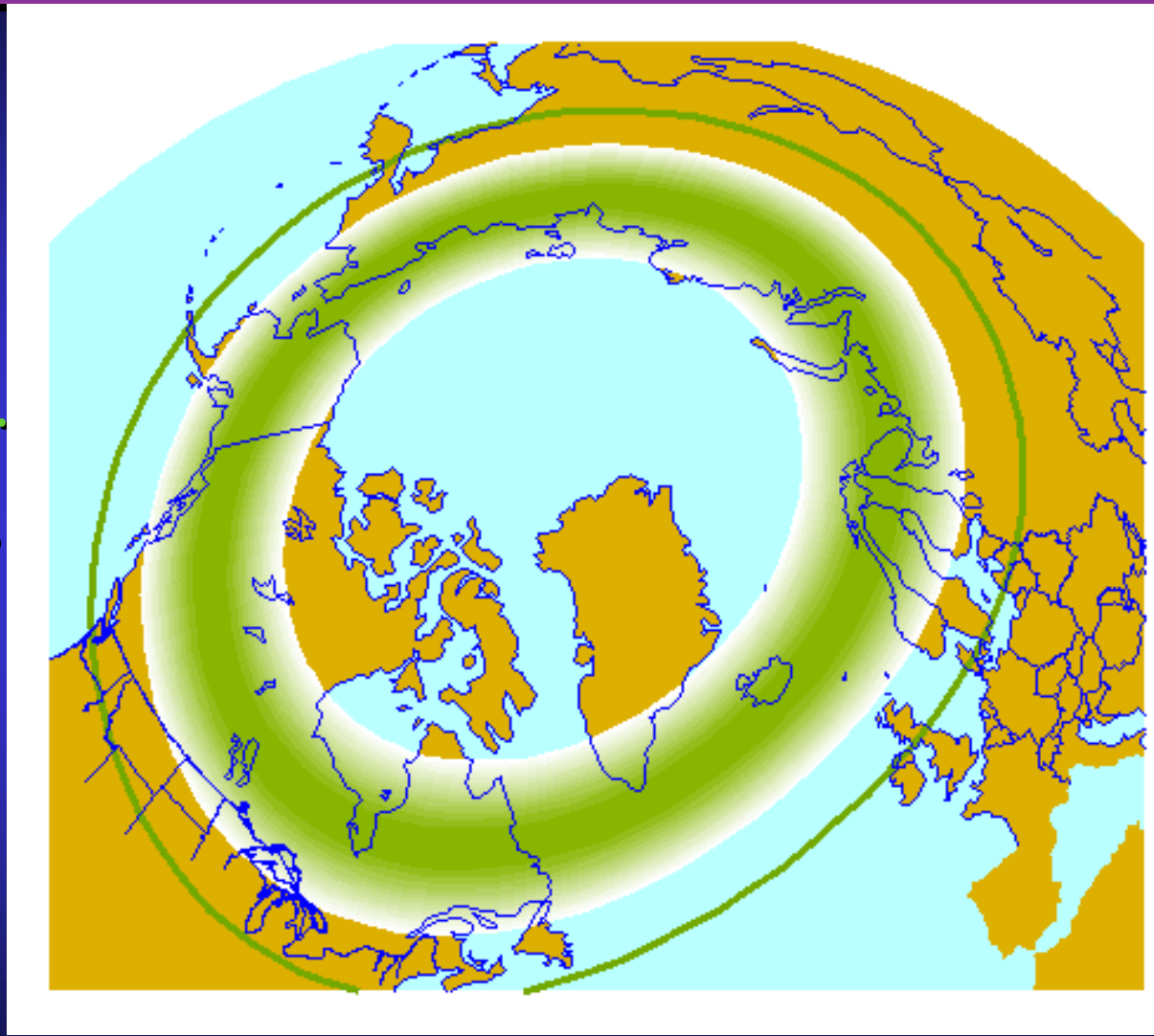

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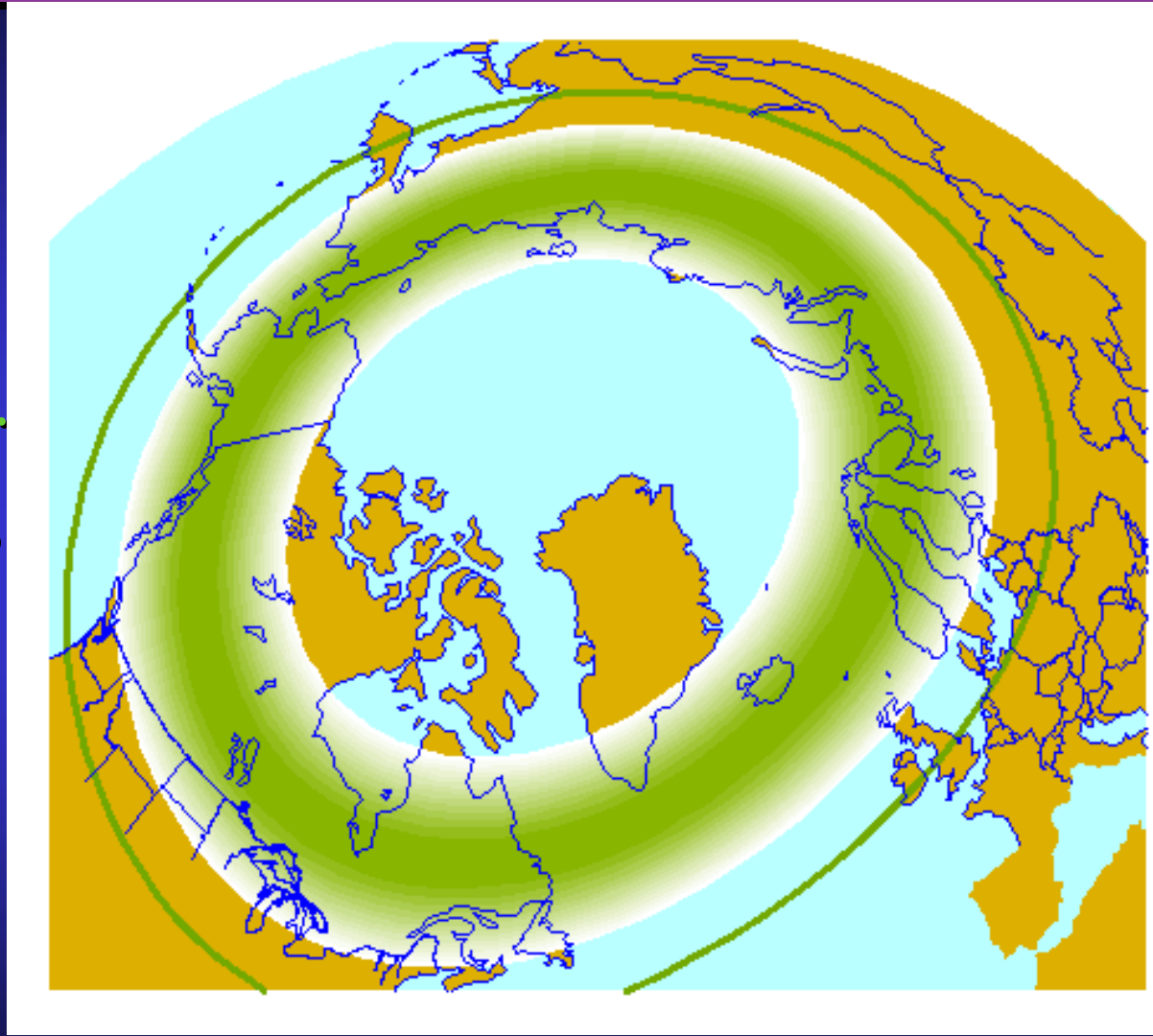

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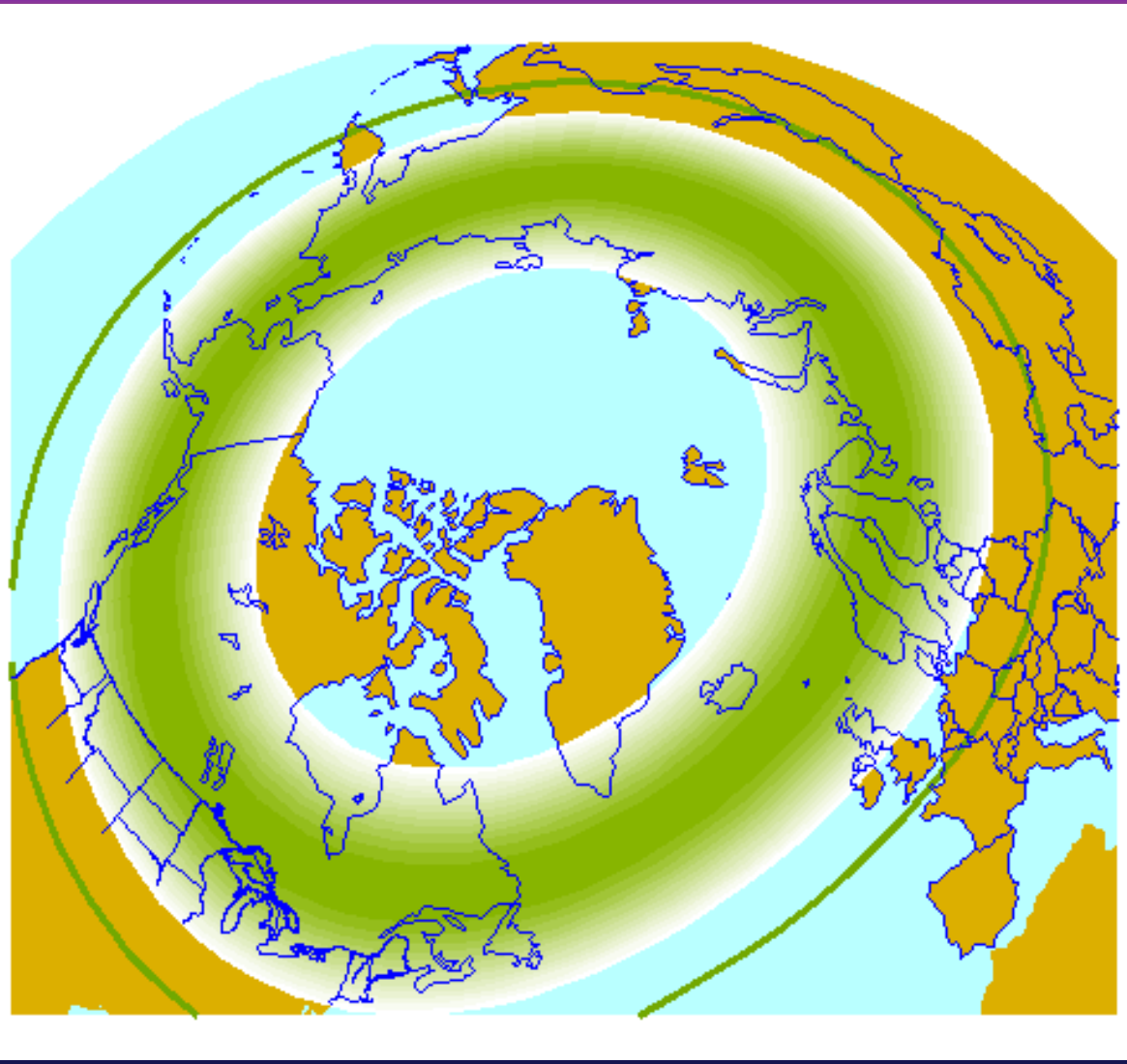

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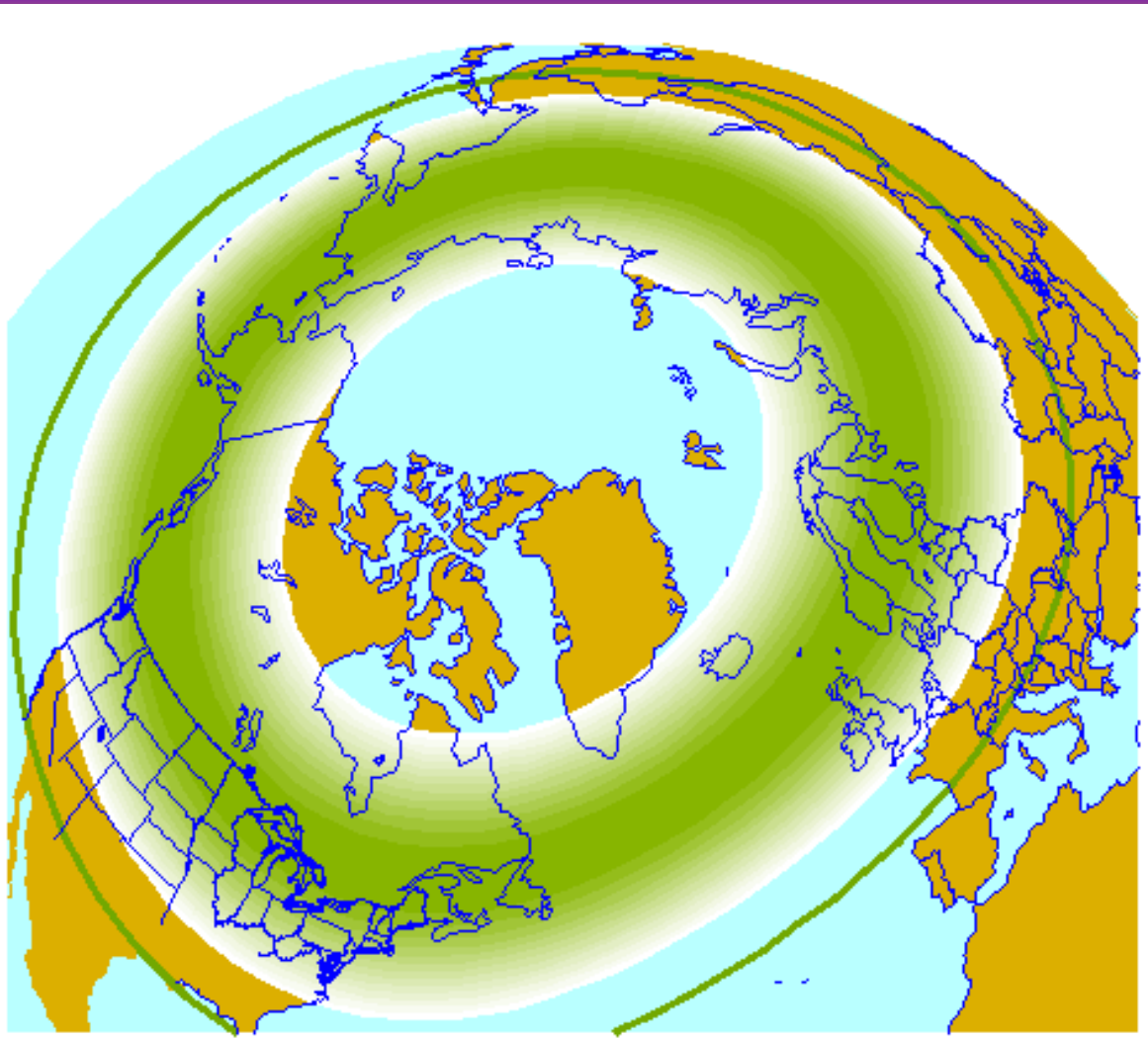

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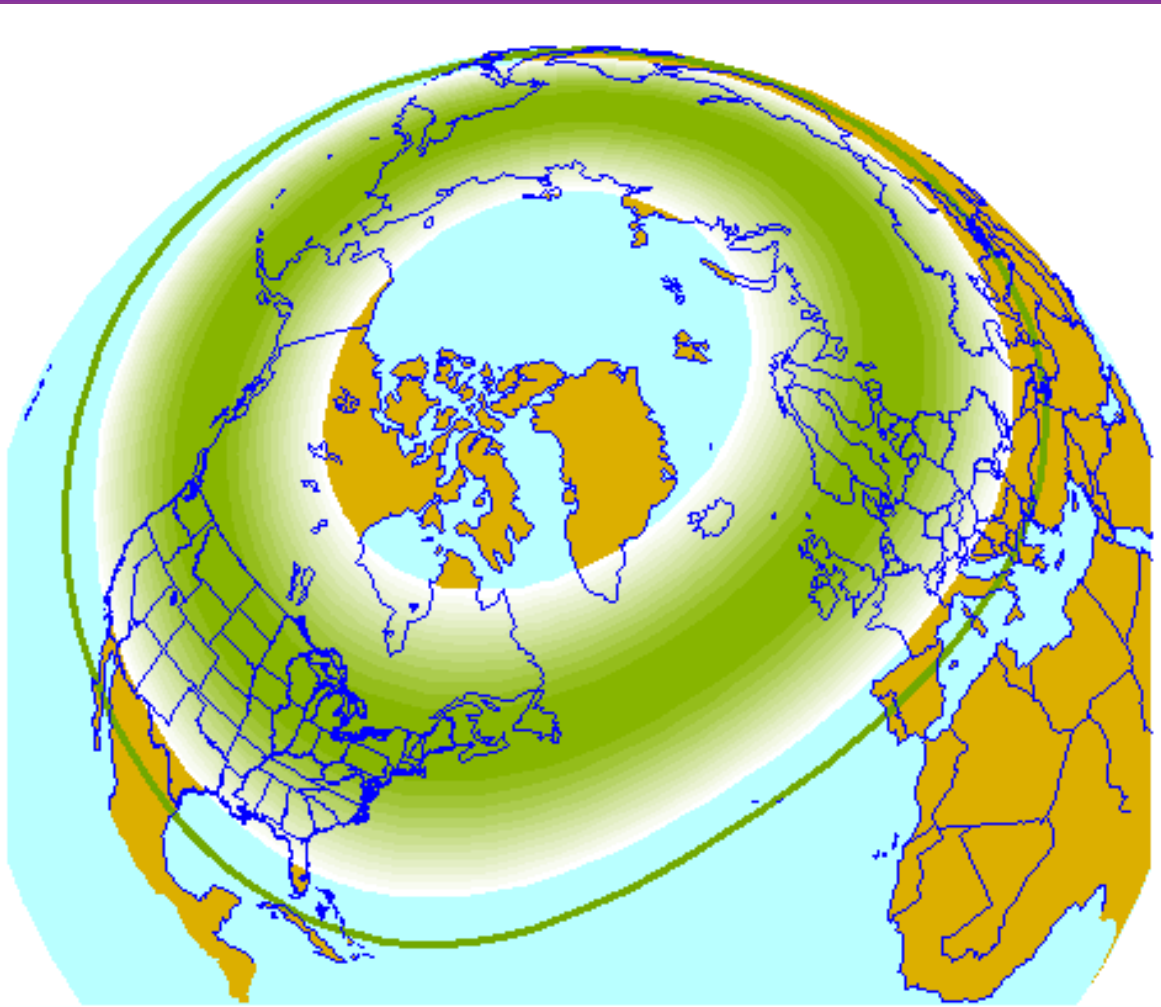

Levels of Auroral Activity

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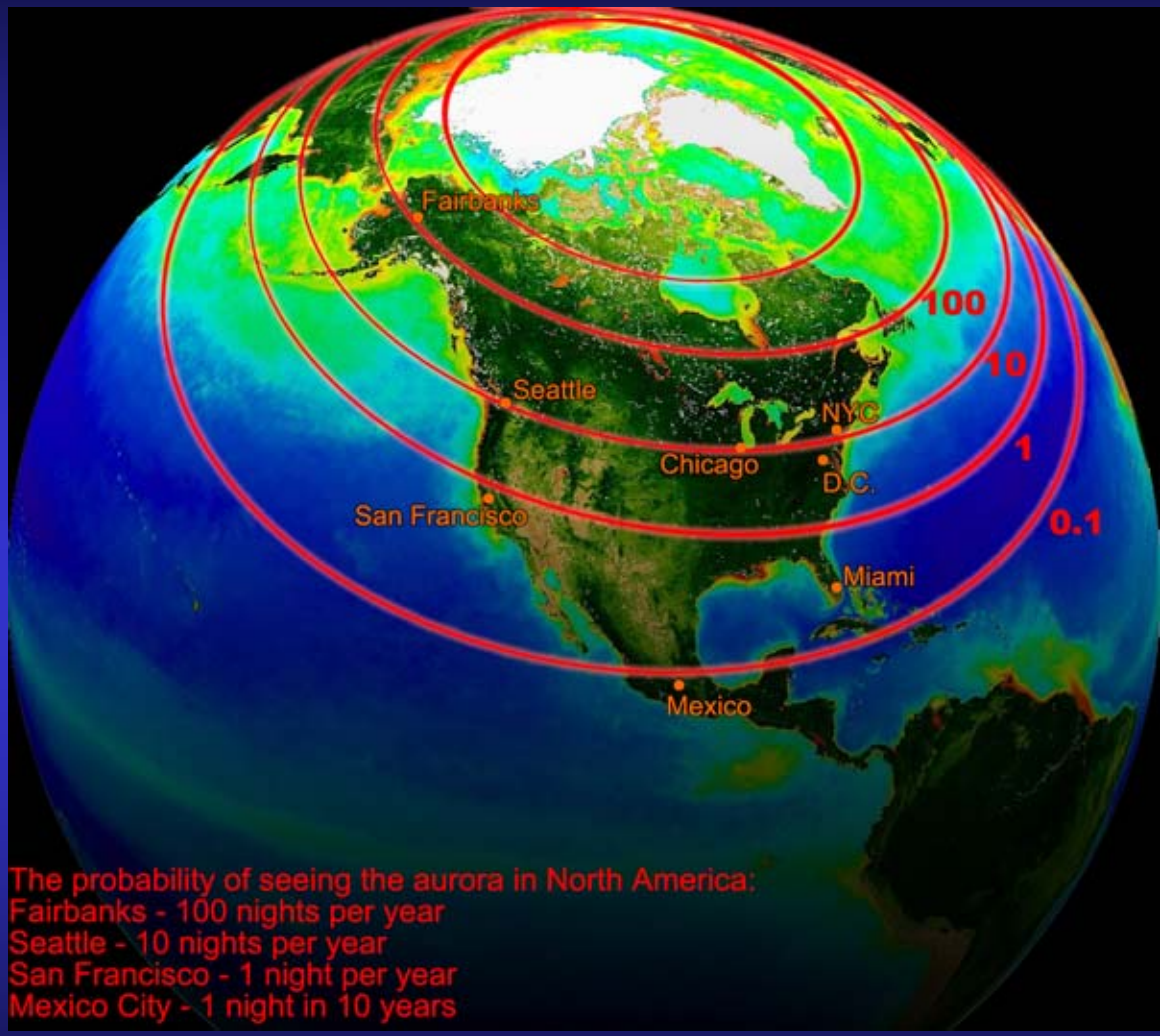
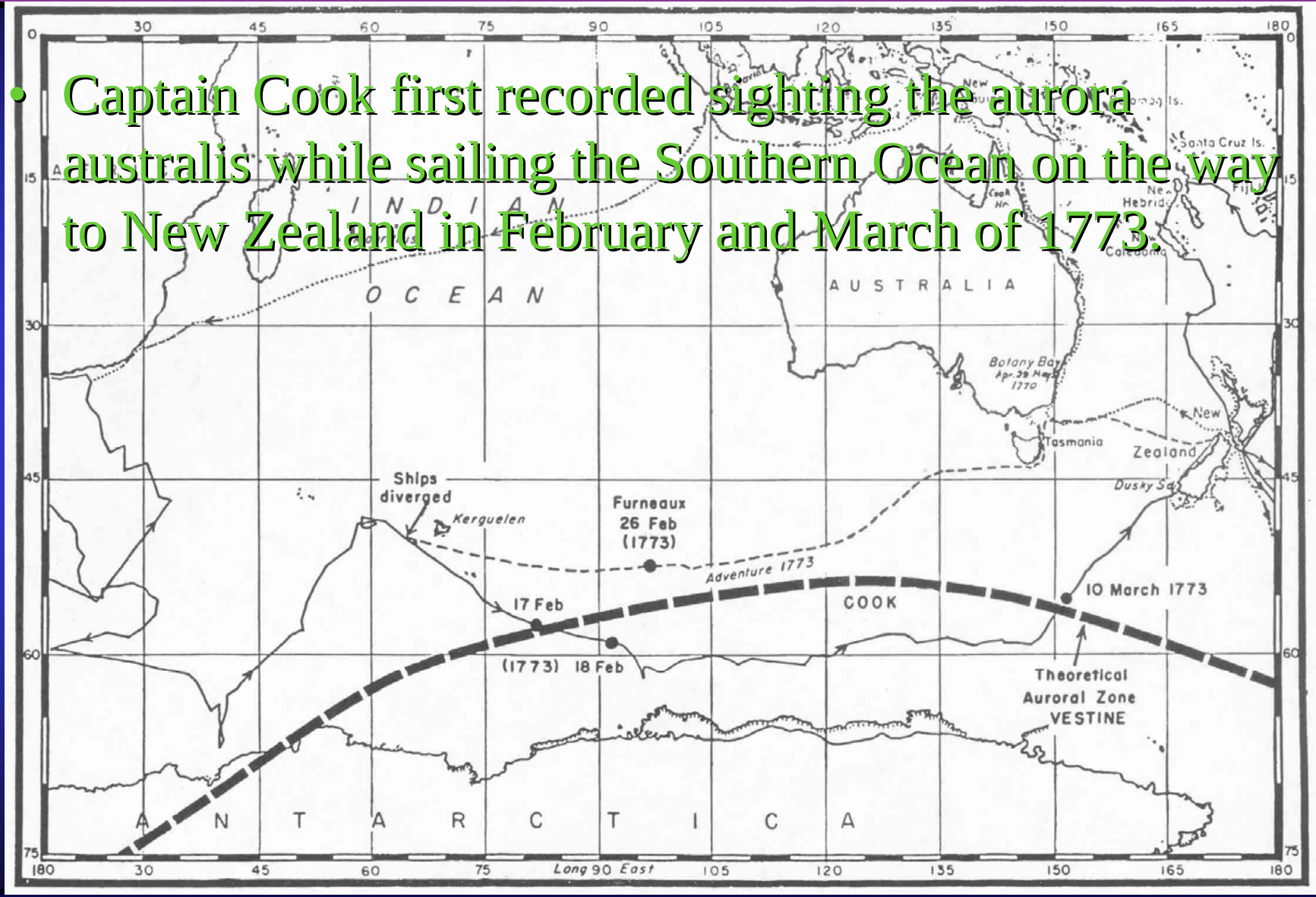
- The measure of this activity is the planetary magnetic disturbance index, Kp.
- Kp = 3 is most common



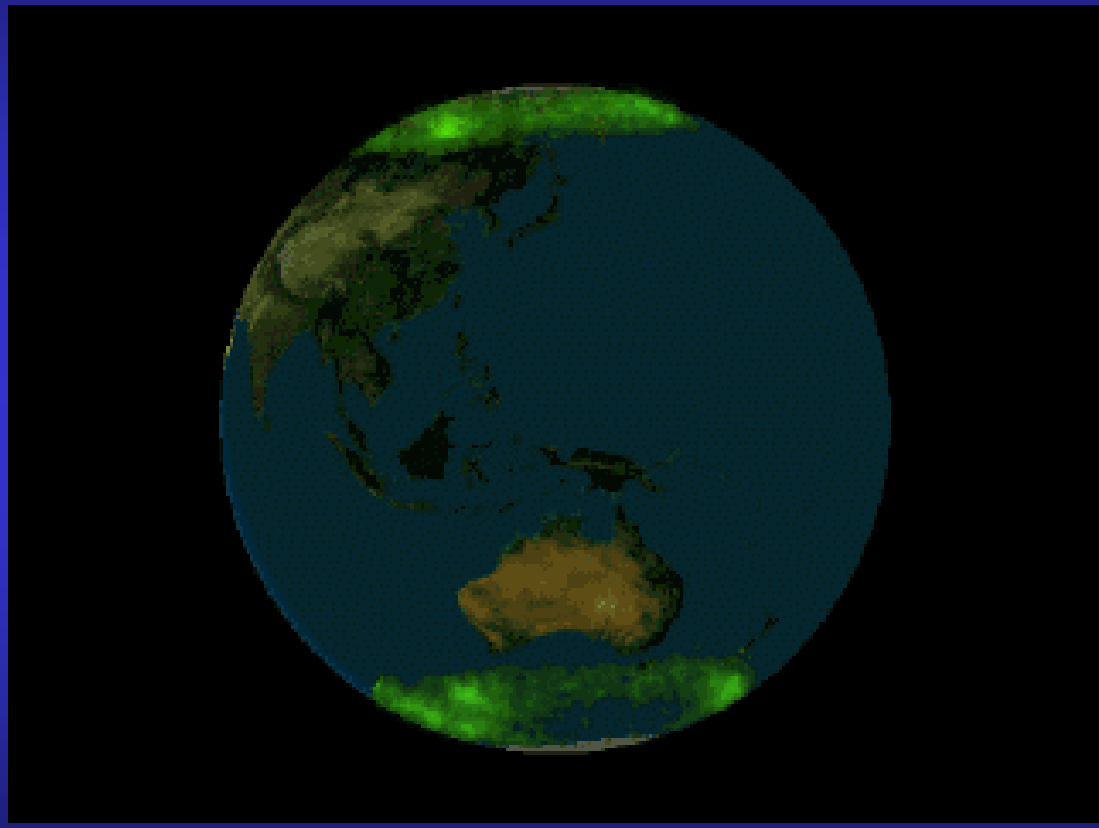
Aurora Australis

- Captain Cook first recorded sighting the aurora australis while sailing the Southern Ocean on the way to New Zealand in February and March of 1773.



The Southern Hemisphere

- The sun rises in the east and sets in the west in both hemispheres, but travels from left to right in the north and right to left in the south.
- Auroral features follow the same directions in both hemispheres, but look different to the observer.



Conjugate Mirror Images

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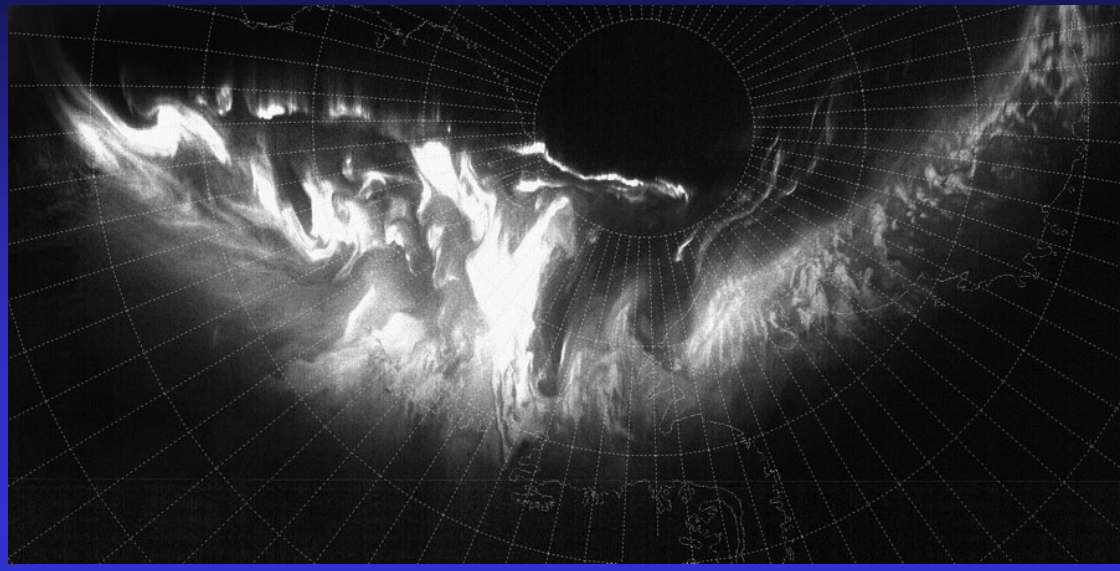
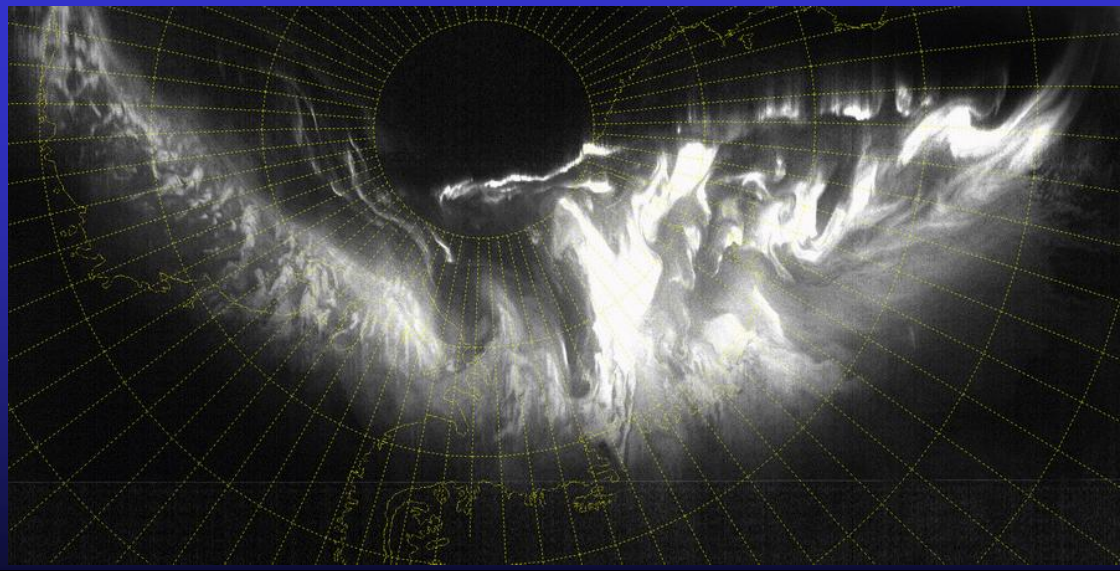
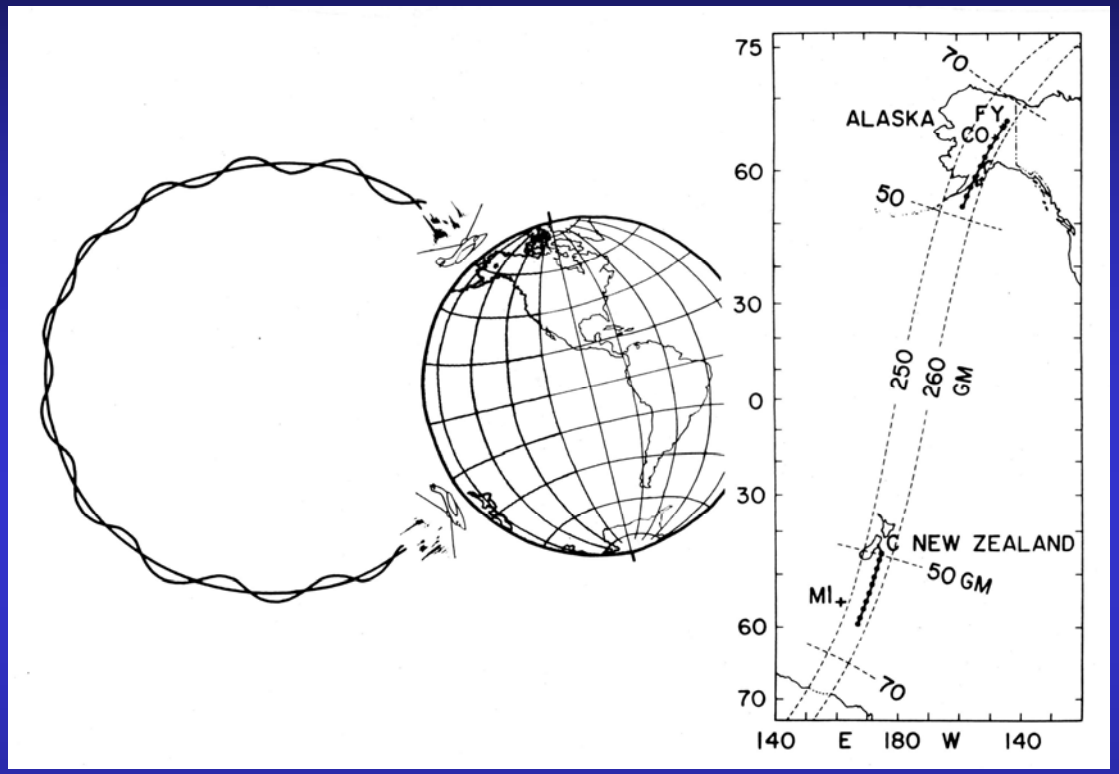




The Conjugate Flights

- Because the magnetic field lines have aurora at both ends, we designed an experiment to see if the aurorae at both ends were similar in type, brightness and occurrence.

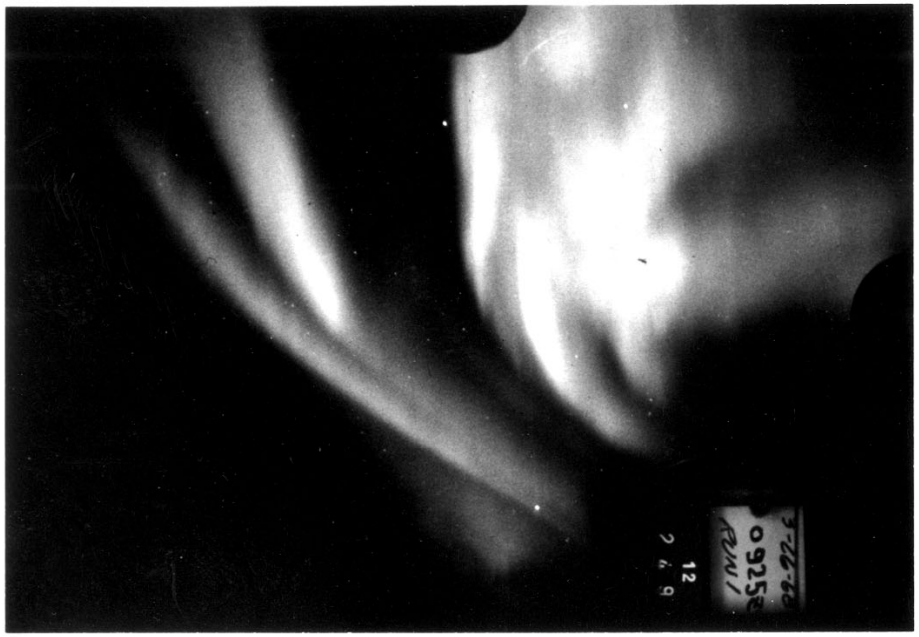
The Conjugate Flights



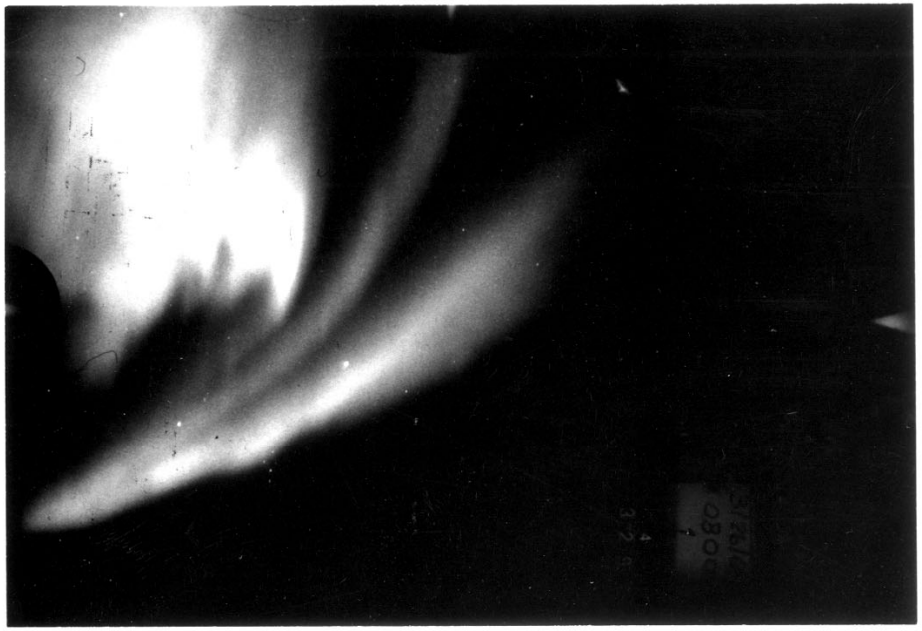
- In the 1960s there were two airplanes maintained by LANL in readiness for nuclear test monitoring.
- These planes were used in a number of auroral studies, one of which was the conjugate flights.

The Conjugate Flights

26 March 1968, 10:48:05 UT



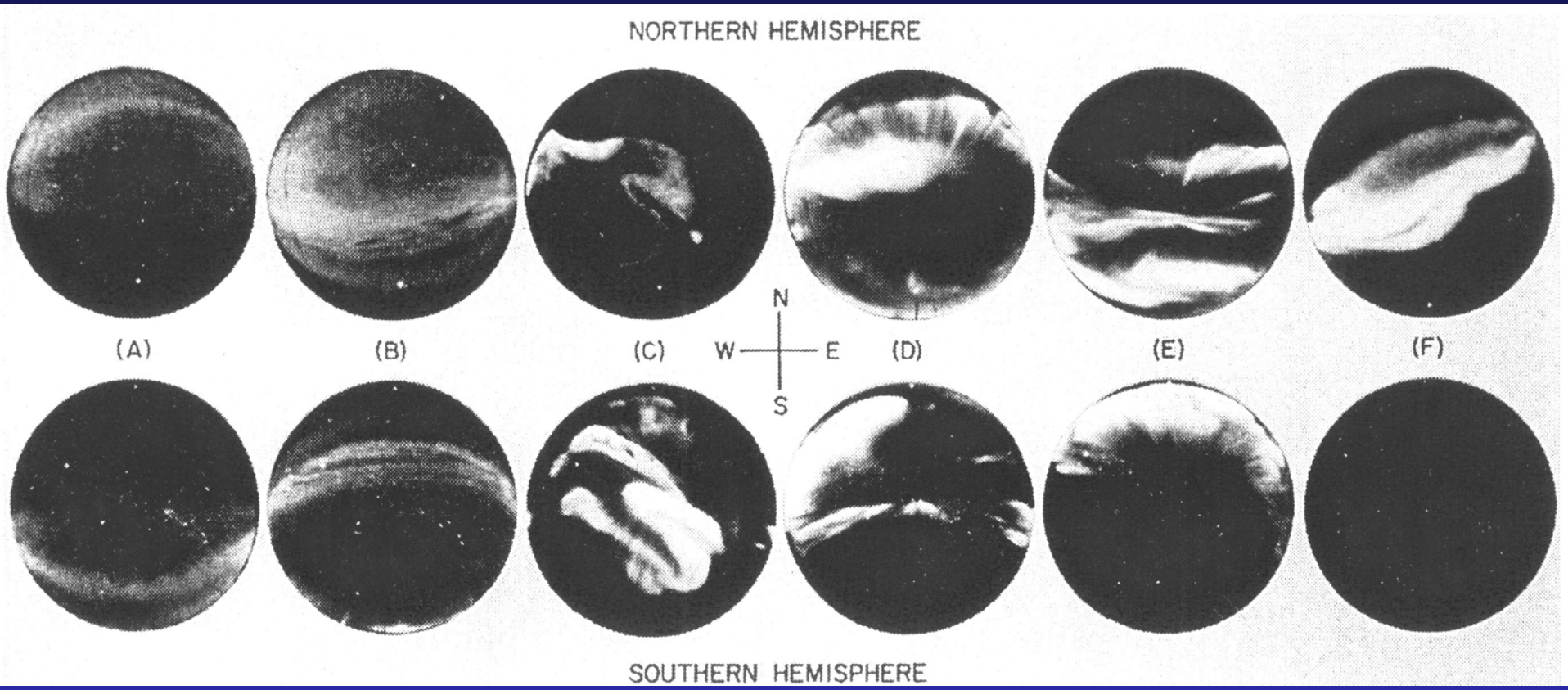
Northern Hemisphere



Southern Hemisphere

- Narrow field cameras were located in the rabbit windows and recorded amazing conjugate details.

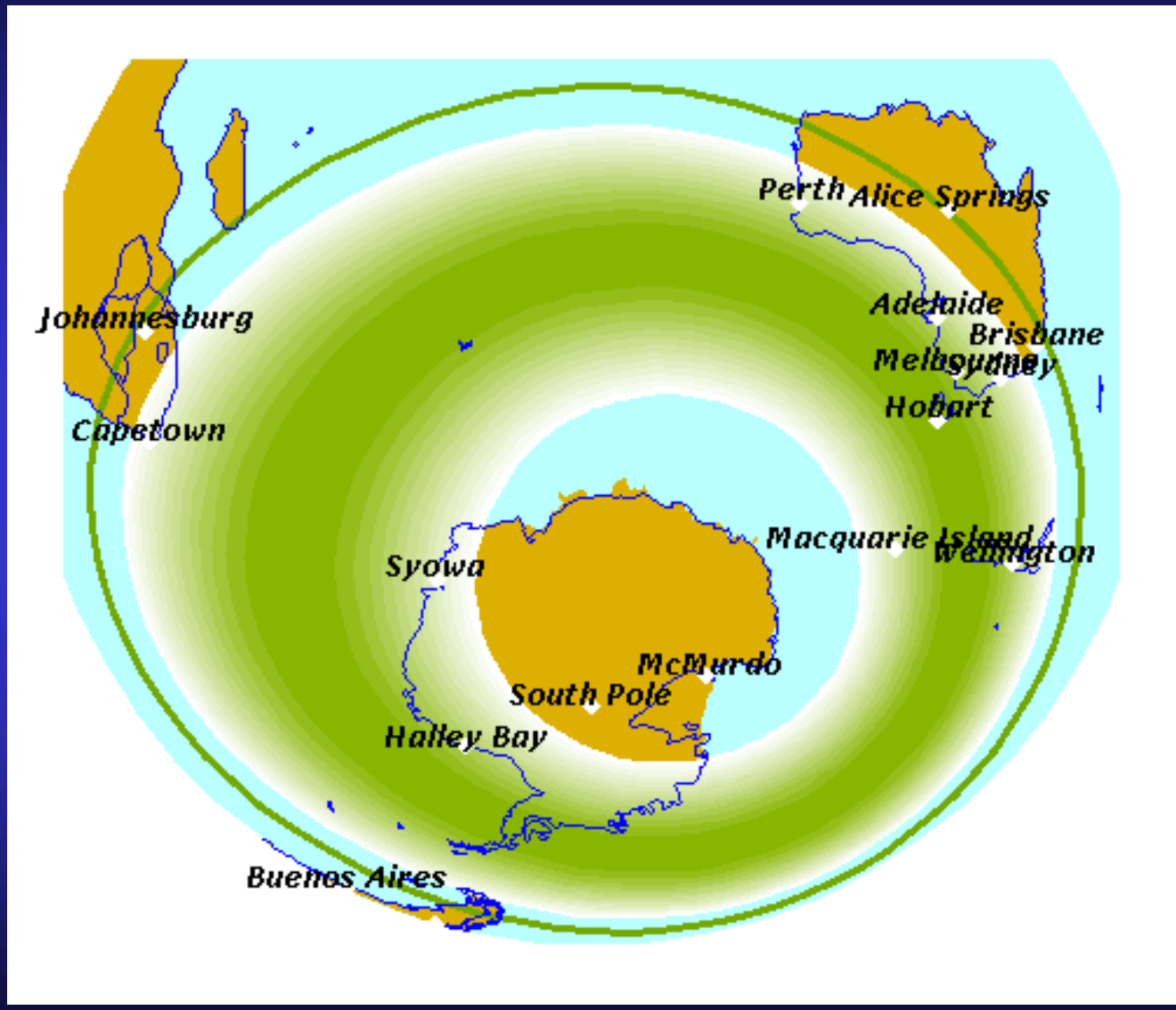
The Alaskan Aurora is Brighter



- The magnetic field is weaker at the same altitude above Alaska than above New Zealand.

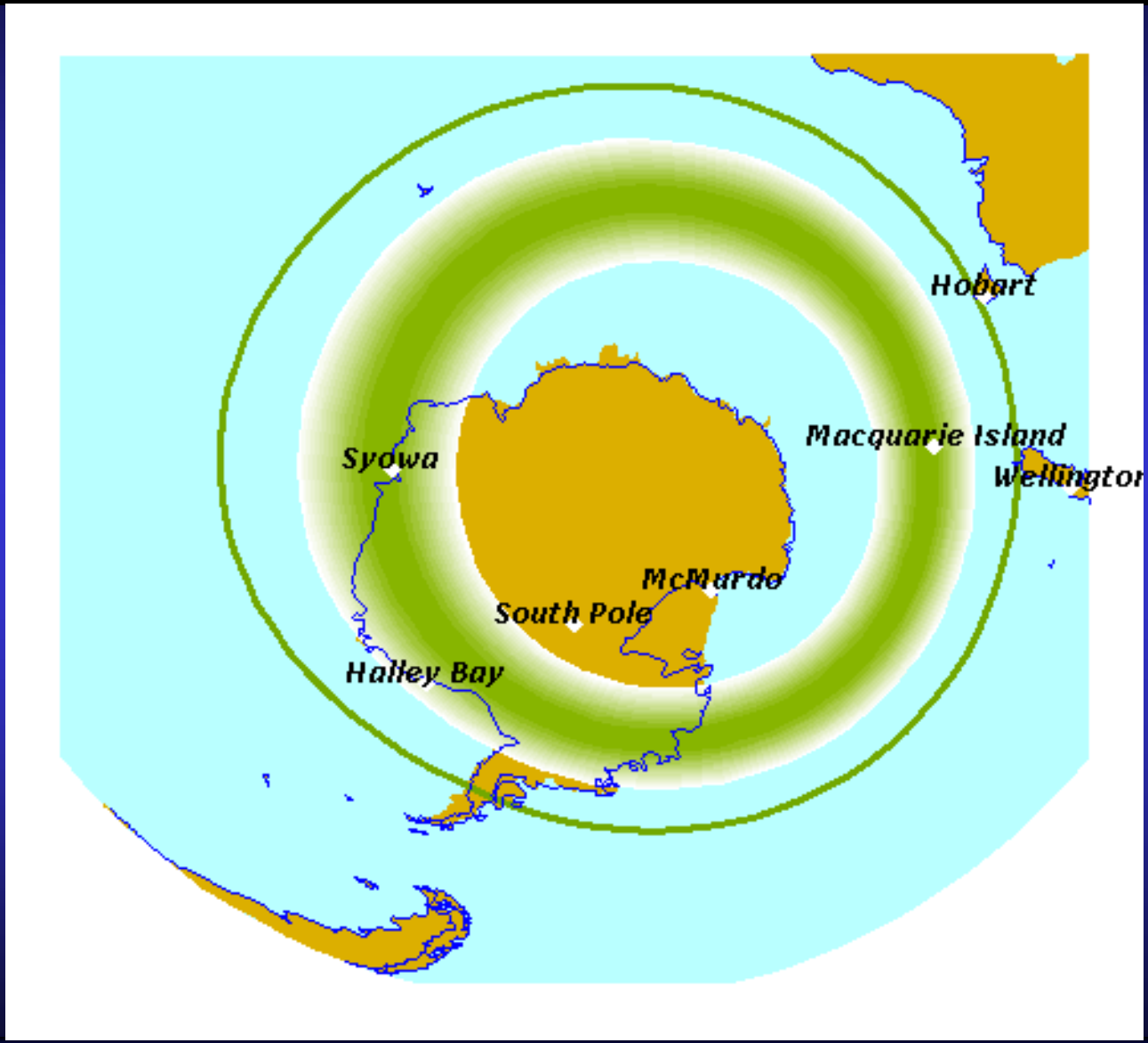
The Aurora Australis

- Where would you go to see the aurora in the Southern hemisphere?
- This is the maximum extent of the aurora.
- This occurs about once every 10 years.



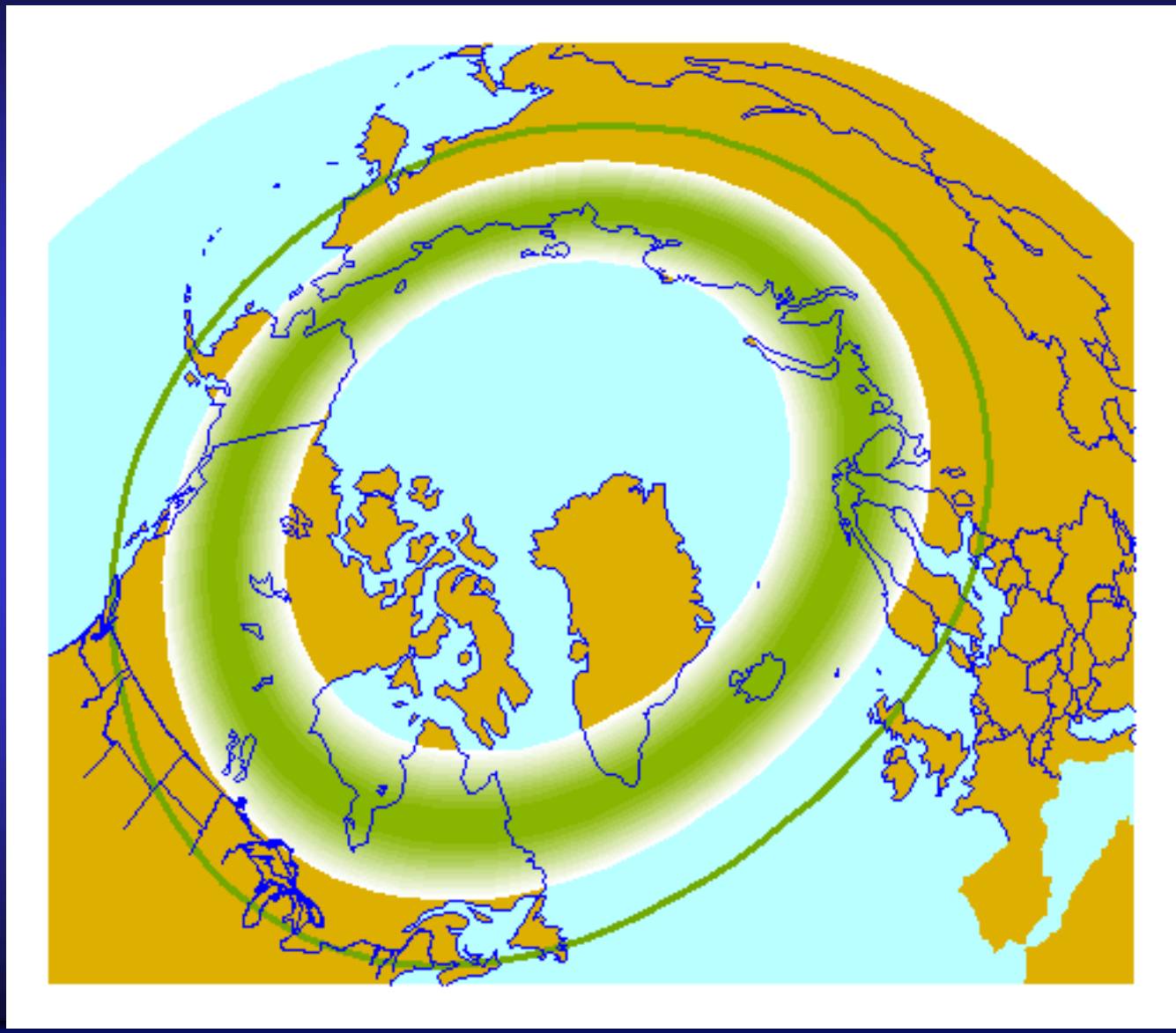
The Aurora Australis

- A more realistic appraisal is shown here.
- This is average activity.
- The number of people under the aurora australis is less than the population of Fairbanks.



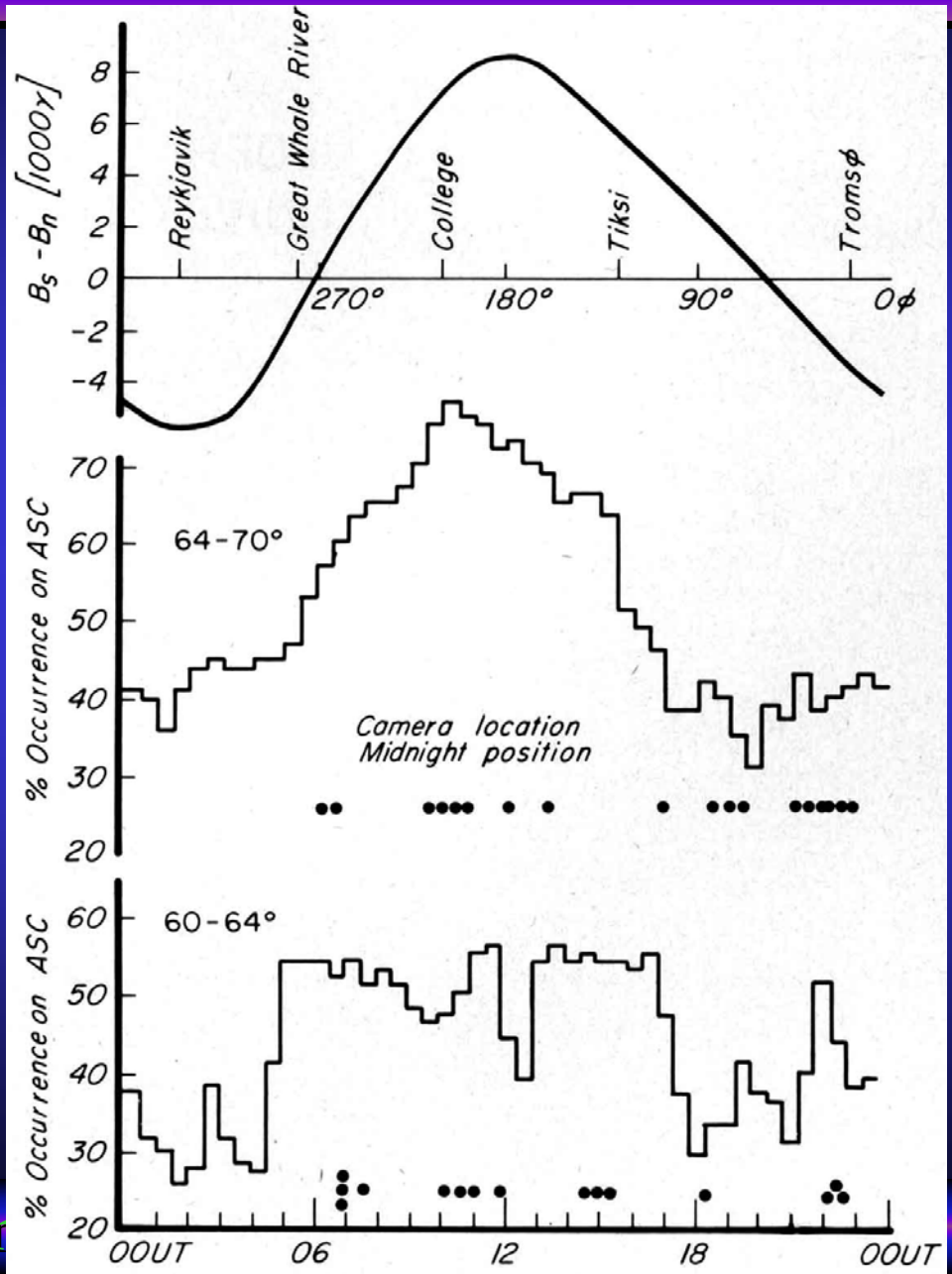
The Aurora Borealis

- The equivalent activity in the northern hemisphere is on the edge of very populated areas.



Two Reasons to go West

- The brightness and occurrence frequency is greatest over Alaska and Eastern Russia.
- The skies are clear more often over Alaska and Eastern Russia.



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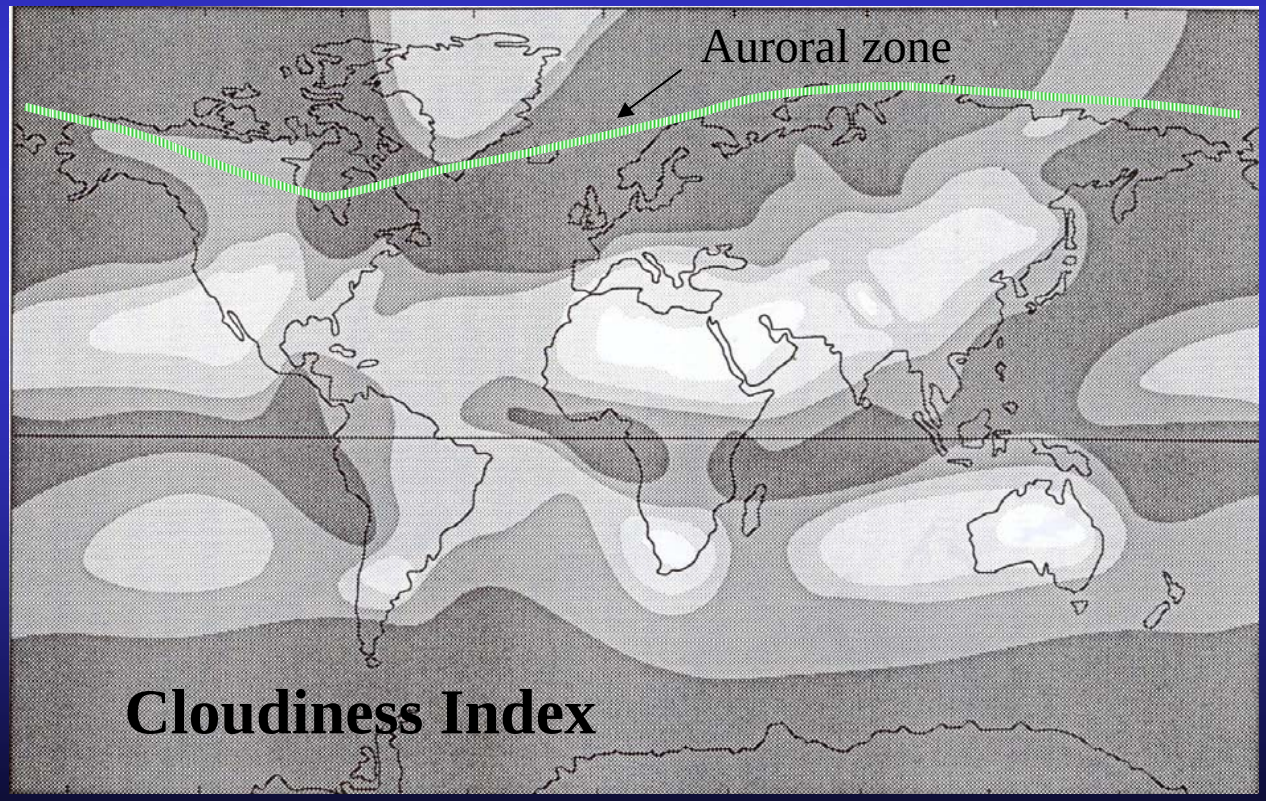
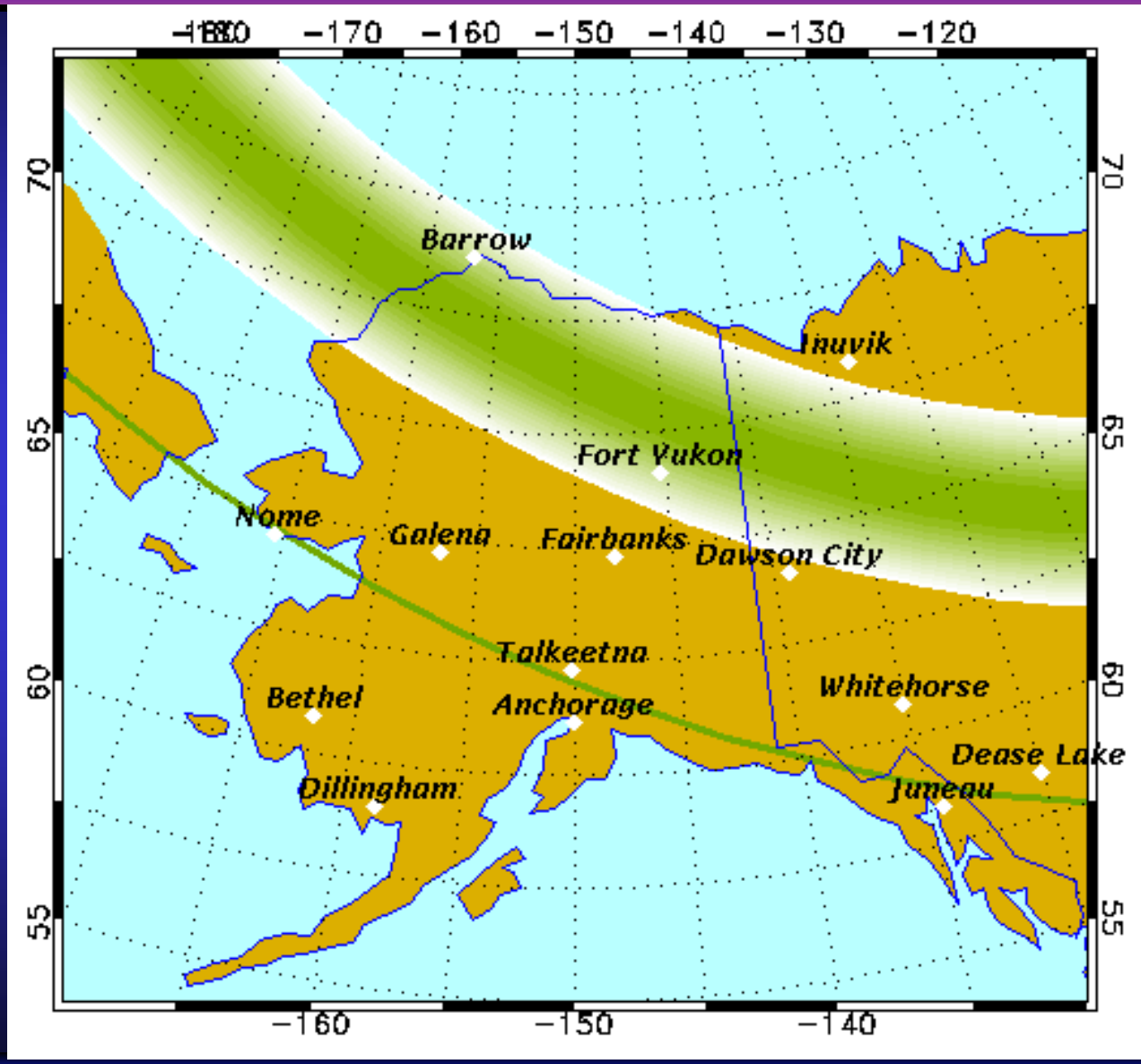


Alaska and the Yukon are Therefore Best

- Conclusion: relative to the rest of the world, the aurora is brighter, more frequent and accessible and in clearer skies in Alaska and the Yukon.



There are few roads to the aurora.

- Secondary roads and some air access is availble in Canada, but east of Manitoba, the weather deteriorates.

The Best View

- Away from city lights
- On a summit or open country
- With a clear view of the horizon, especially to North and West
- Prepare to stay up late – sometimes 3 – 4 am.
- Watch the 1 hour auroral forecast.
- Watch the weather forecast.