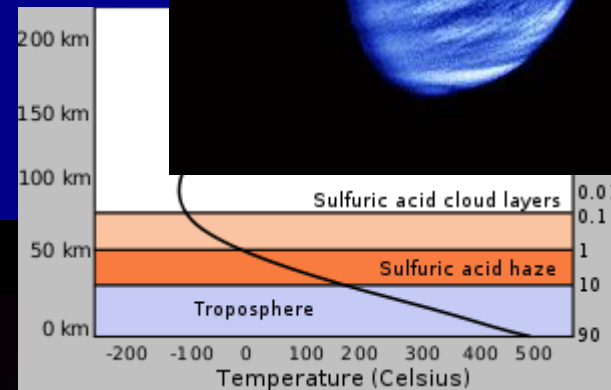
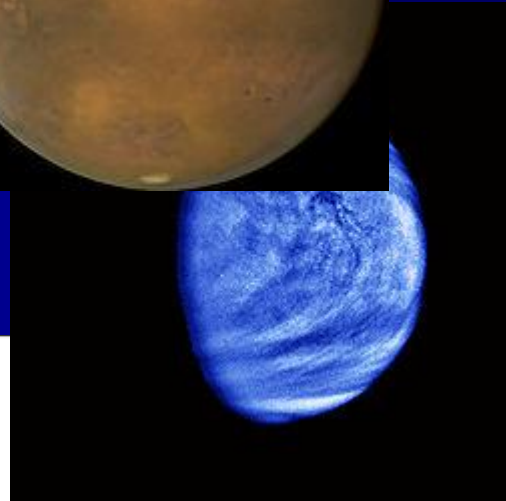
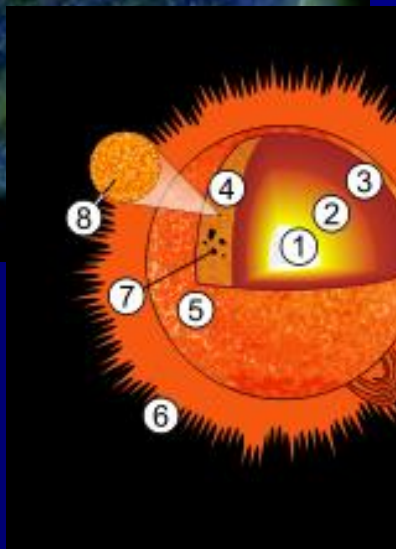
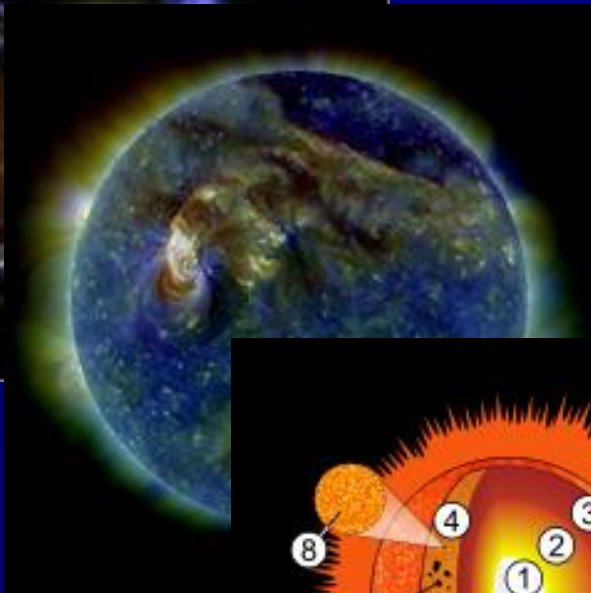
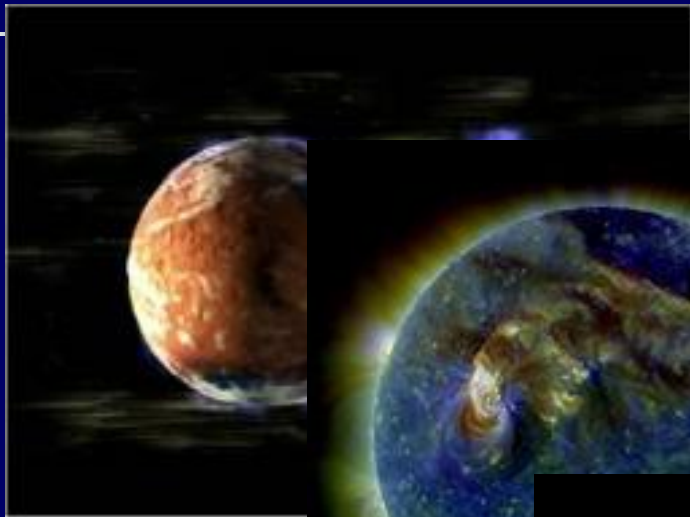


# Space Physics

# Space Physics



Lecture – 07

# Global Warming

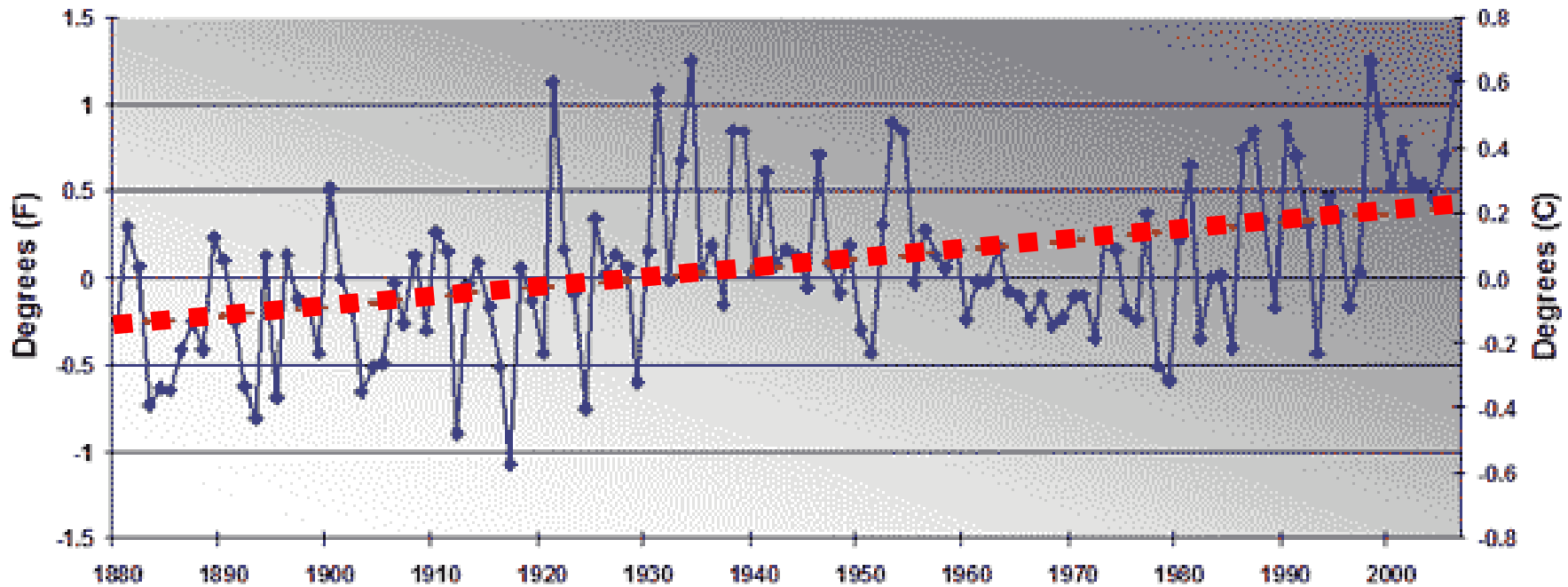
**Global warming** is the rise in the average temperature of Earth's atmosphere and oceans since the late 19th century and its projected continuation.

Since the early 20th century, Earth's mean surface temperature has increased by about 0.8 °C, with about two-thirds of the increase occurring since 1980.



# Global Warming

**U.S. National Surface Temperature (48 states)-- 1880 to 2006**  
Annual Temperature Deviation from Period 1951-1980 (NASA)



# Top 10 Things You Can Do to Reduce Global Warming

1. **Reduce, Reuse, Recycle**
2. **Use Less Heat and Air Conditioning**
3. **Change a Light Bulb** (CFL, most suitable LED Bulbs)
4. **Drive Less and Drive Smart**
5. **Buy Energy-Efficient Products** (Plasma Display, CRT Display, **LCD, LED, OLED**)
6. **Use Less Hot Water**
7. **Use the "Off" Switch**
8. **Plant a Tree**
9. **Get a Report Card from your Utility Company**
10. **Encourage Others to Conserve**

Share information about recycling and energy conservation with your friends, neighbors and co-workers, and take opportunities to encourage public officials to establish programs and policies that are good for the environment.

These 10 steps will take you a long way toward reducing your energy use and your monthly budget. And less energy use means less dependence on the fossil fuels that create greenhouse gases and contribute to global warming.

# The Ionosphere

# The Ionosphere

Introduction

The Chapman Layer Theory

Plasma Frequency

Collision Frequency and Absorption

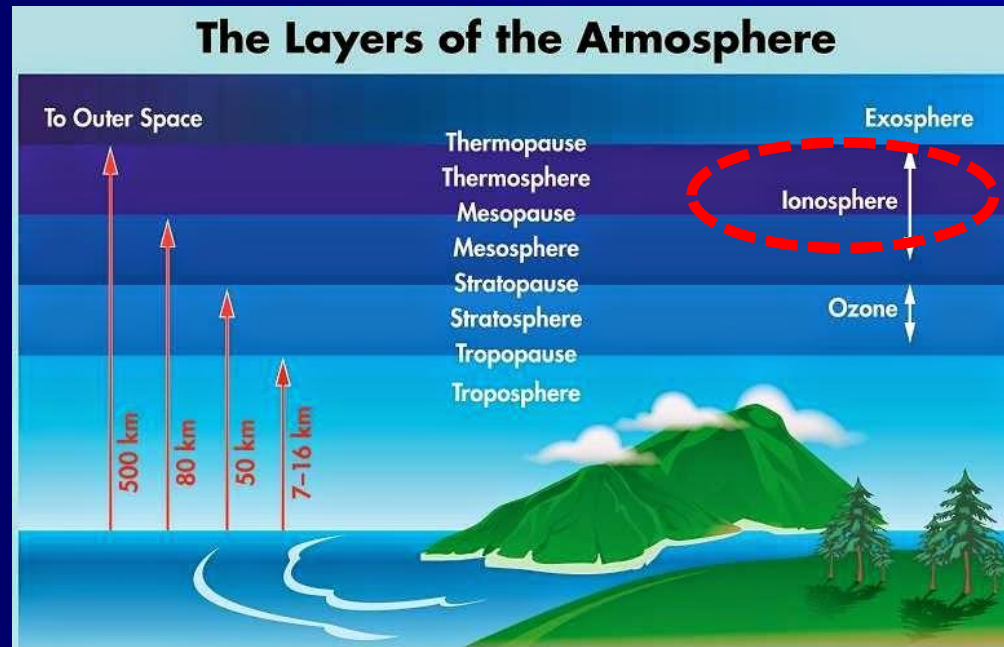
The Structure of the Ionosphere and the Plasmasphere

Regular and Irregular Variations of the Ionosphere

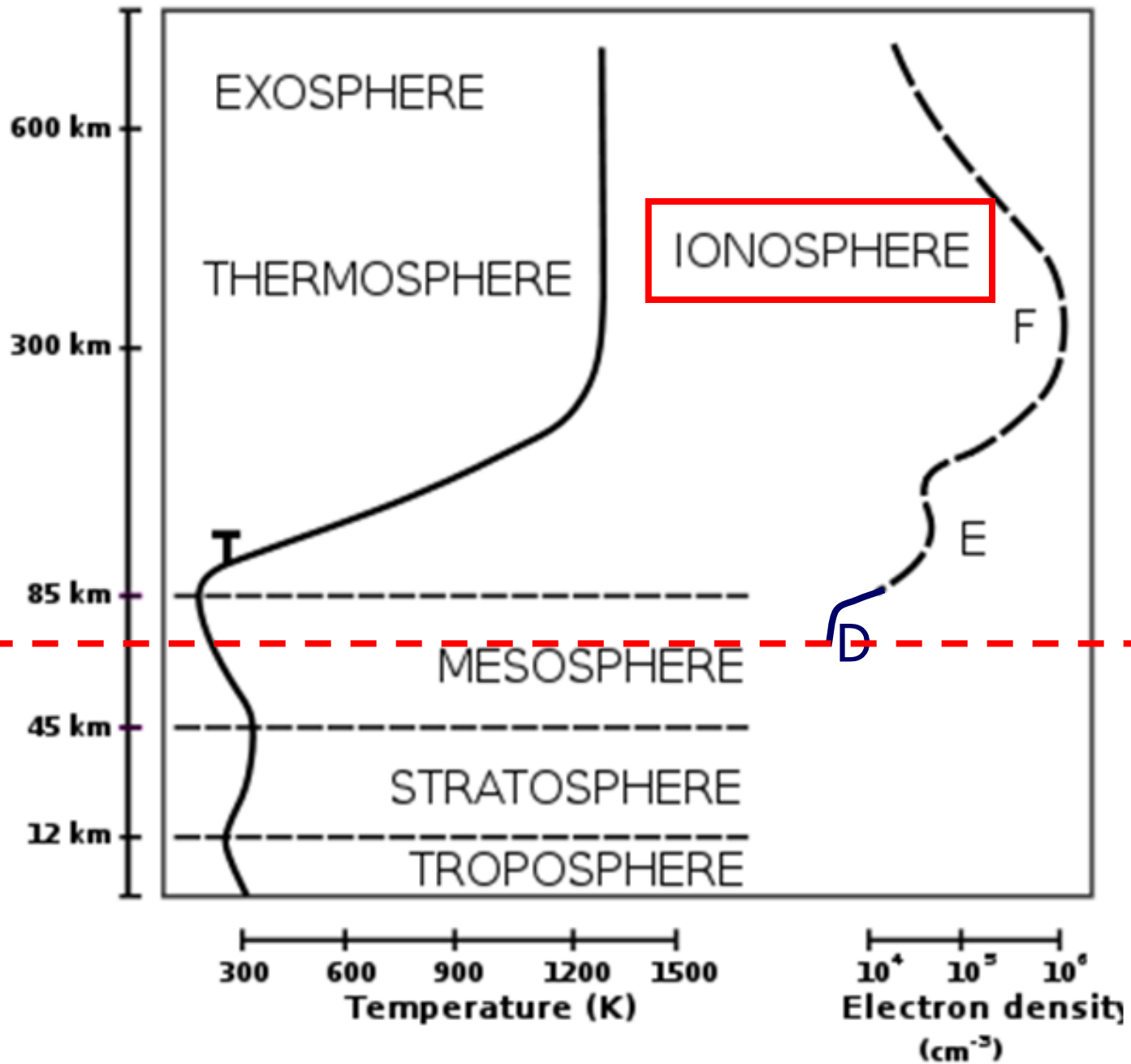
# Introduction

The ionosphere is a portion of the upper atmosphere, between the thermosphere and the exosphere, distinguished because it is ionized by solar radiation.

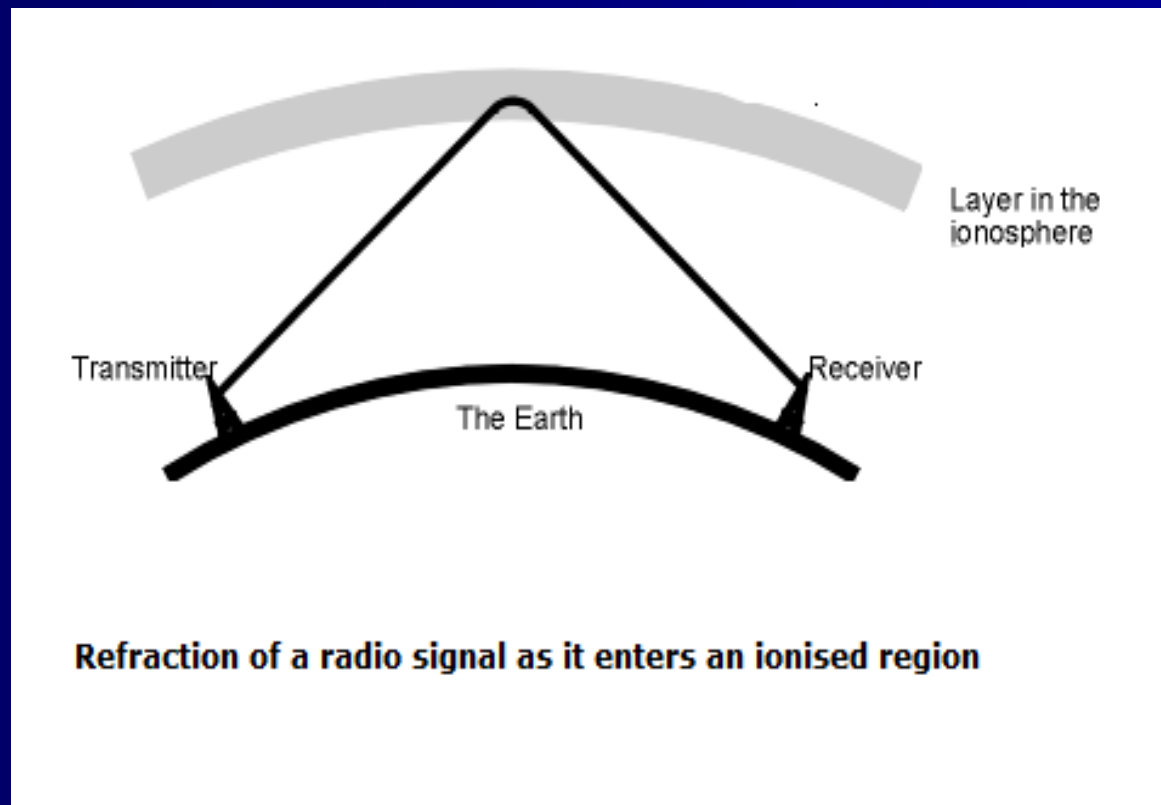
The ionosphere is a shell of **electrons** and **electrically charged atoms** and **molecules** that surrounds the Earth, stretching from a height of about **70 km** on up.







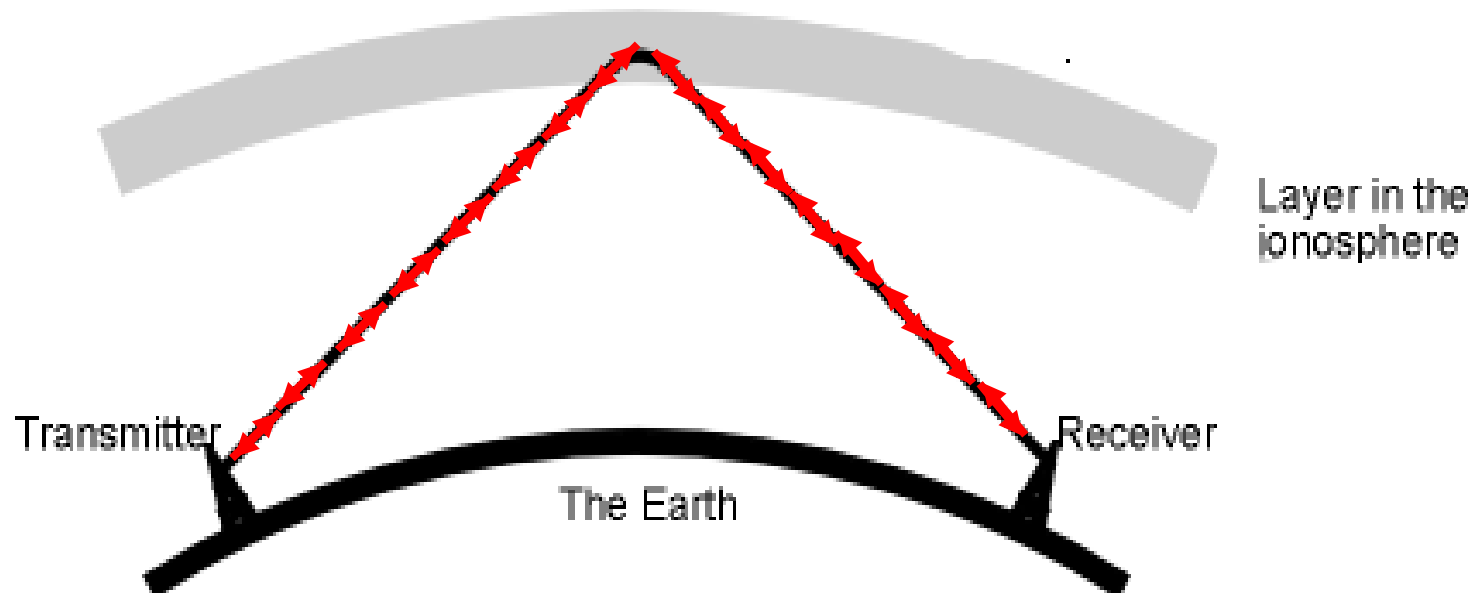
The existence of the ionosphere, as an electrically conducting region of the atmosphere, was first suggested by the Scottish meteorologist **Belfour Stewart** in **1883**. It has practical importance because among other functions, it influences Radio Propagation to distant places on Earth.



Marconi's successful experiments in 1901 of wireless communication across the Atlantic prompted **Heaviside** and **Kennelly** to postulate independently the existence of an **ionized layer** in the atmosphere. This electrically conducting layer was originally called the **Heaviside Layer** and later the **E-Layer** because of its many free electrons.

The E-layer as seen in the following figure, acts as a **reflector** and makes it possible for Radio Signals to bridge large distance over the spherical Earth. **The E-layer is an altitude of approximately 110 km.**

The Ionosphere acting as a reflector of radio waves making possible radio telecommunication over the horizon.



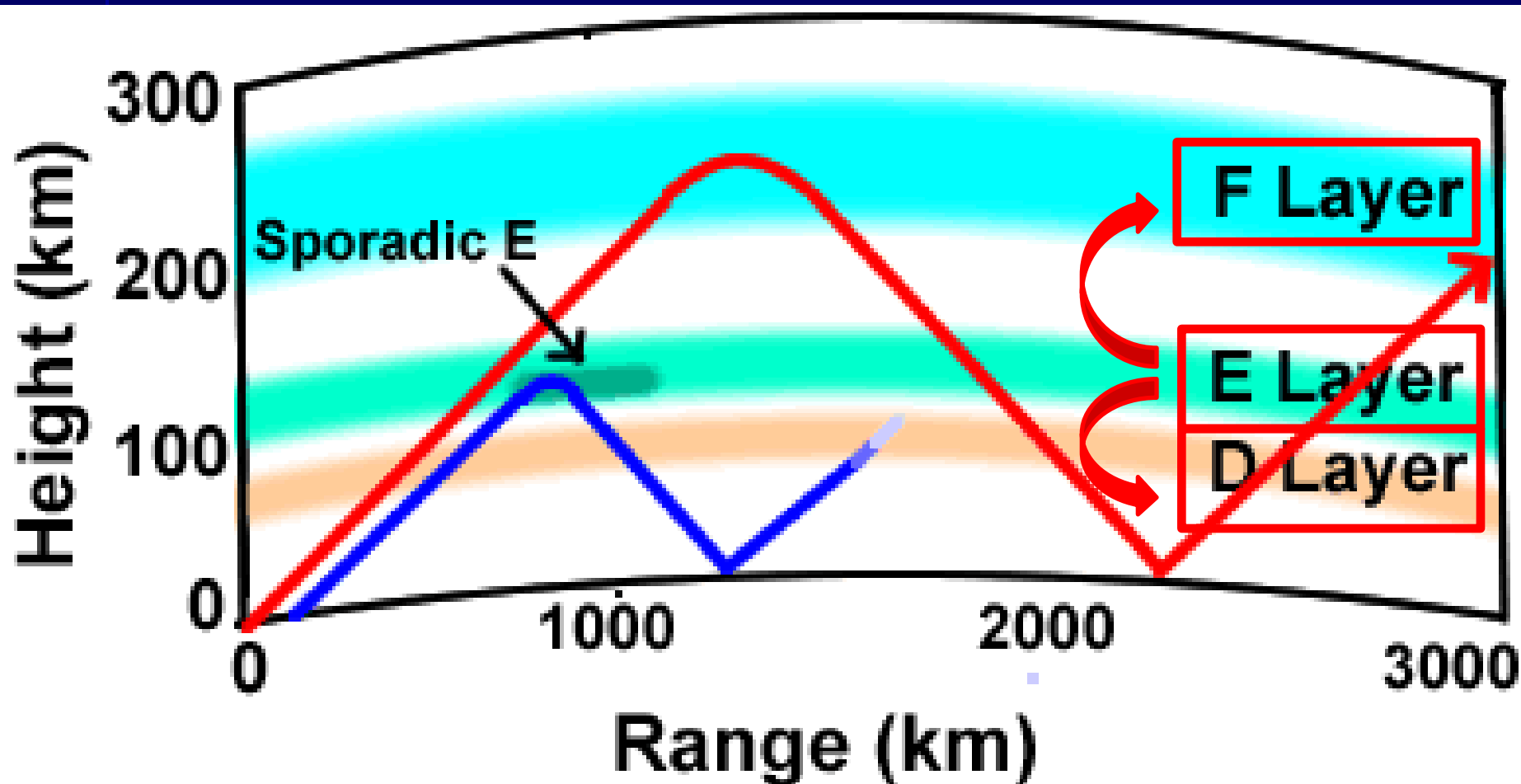
**Refraction of a radio signal as it enters an ionised region**

The First attempts to **study the structure of the ionosphere with Radio signals bounced back from the ionosphere** were made in **1925** by **Appleton** and **Barnett** in England.

Similar ionospheric sounding experiments were performed also in America in **1928** by **Brest** and **Tuve**.

An ionospheric sounder consists basically of a **Radio Transmitter** and a **Radio Receiver** connected in a way which allows them to **measure the time interval** between the transmission and the return of the Radio Pulse.

By multiplying one half of this time interval, which is of the order of a millisecond, with the speed of light, we obtain the **heights of the Reflection Layer**.

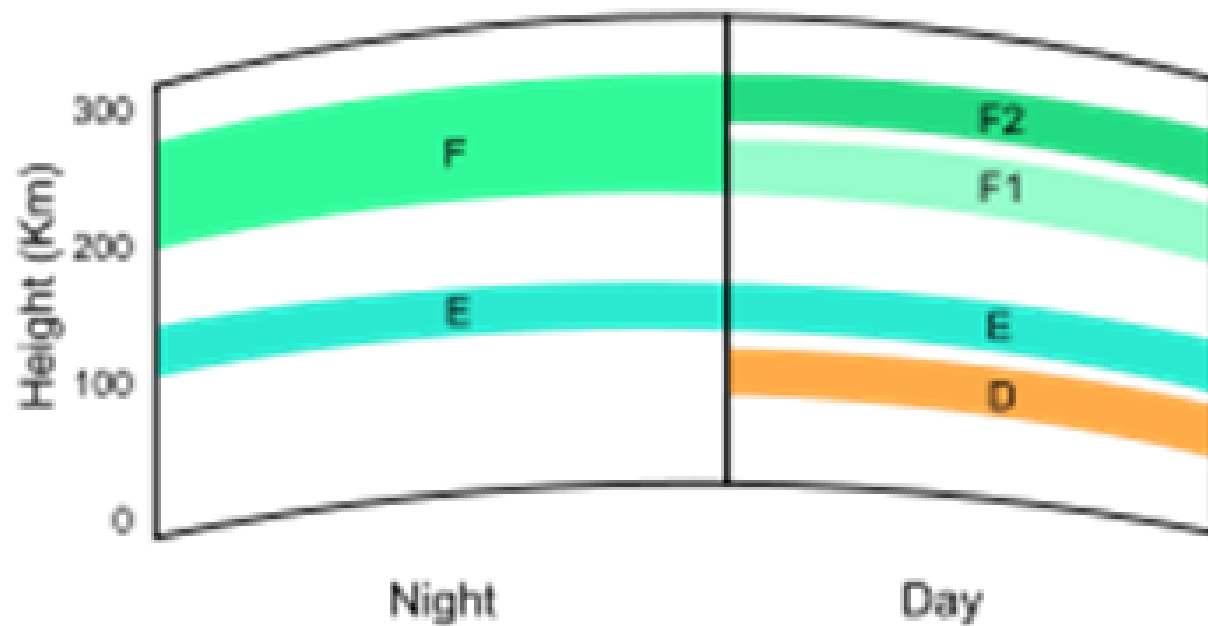


# The ionospheric layers

At night the **F layer** is the only layer of significant ionization present, while the ionization in the **E** and **D** layers is extremely low.

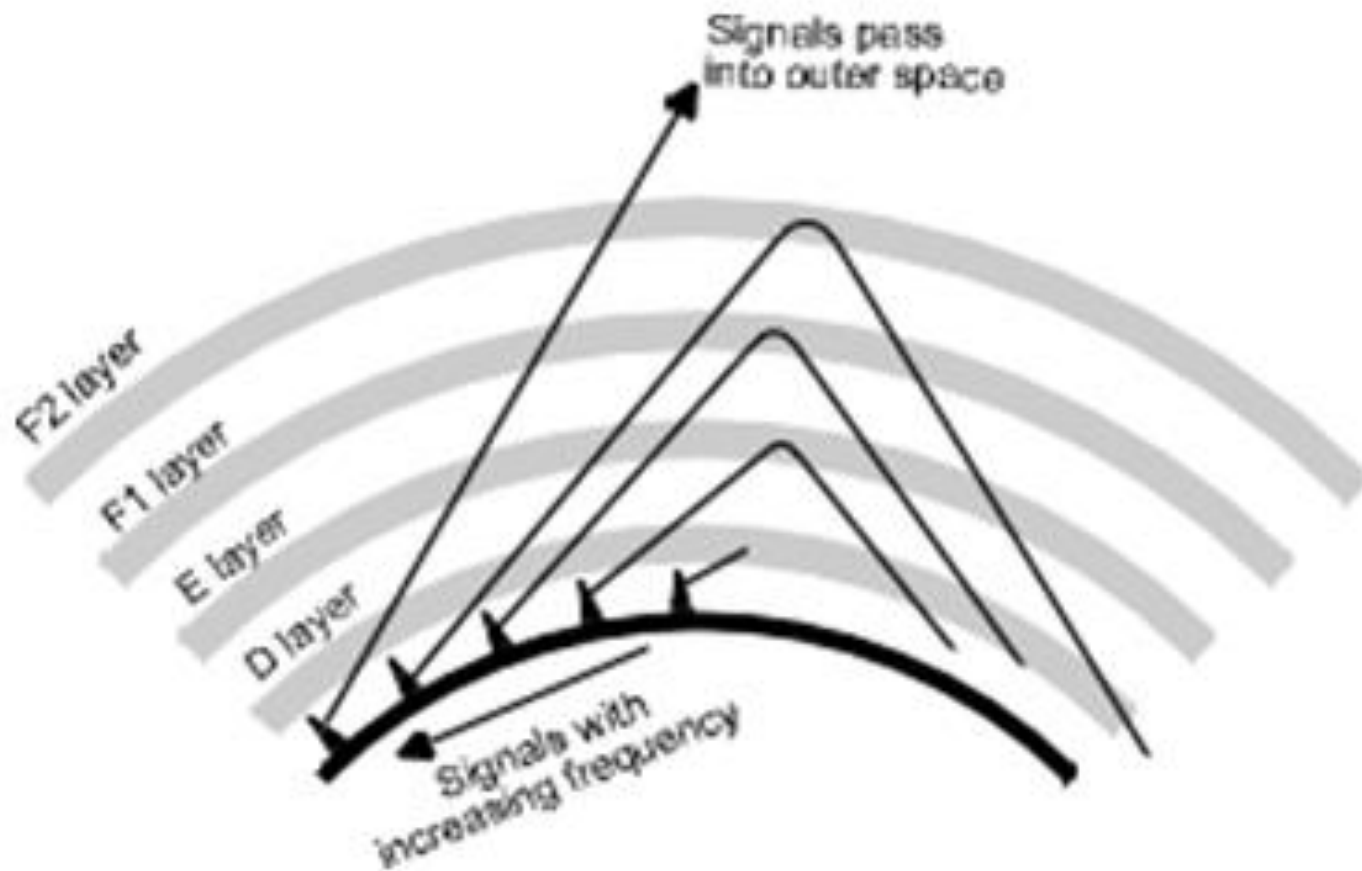
During the day, the **D** and **E** layers become much more heavily ionized, as does the **F layer**, which develops an additional, weaker region of ionisation known as the **F1 layer**. The **F2 layer** persists by day and night and is the region mainly responsible for the refraction of radio waves.

# The ionospheric layers



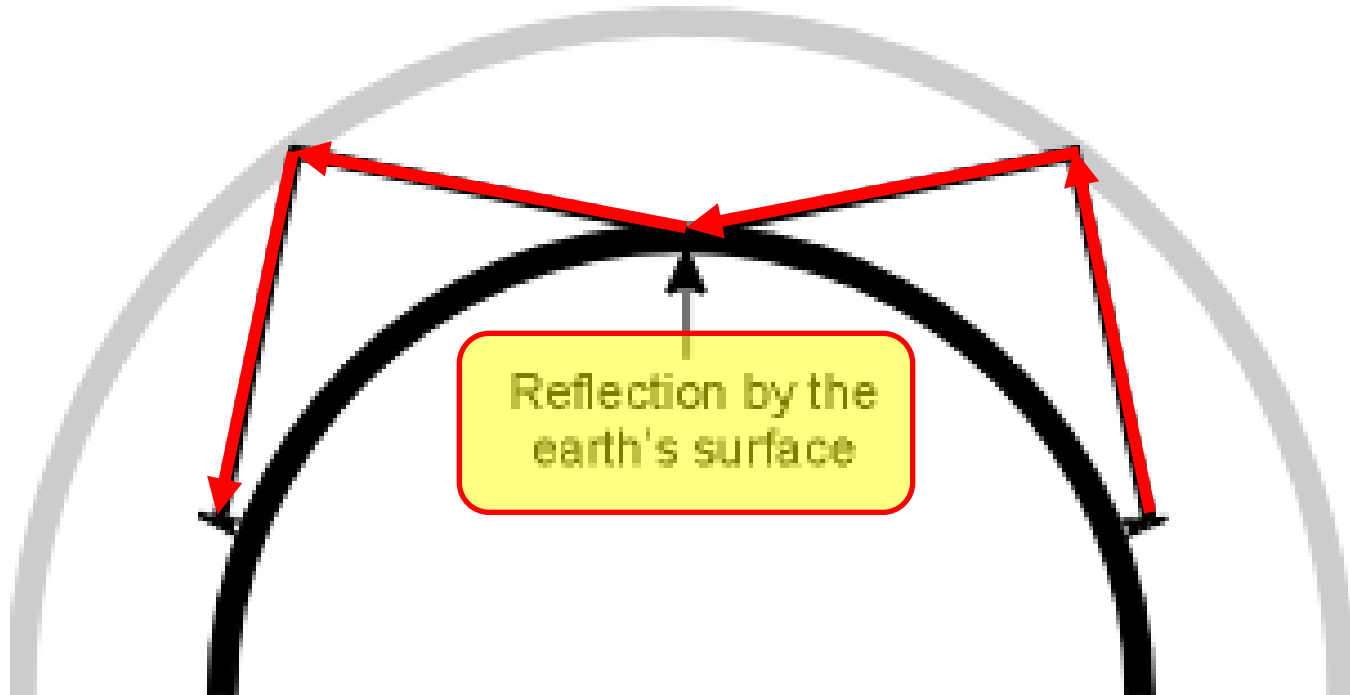
Ionospheric layers.





**Signals reflected by the E and F regions**

Layer in the ionosphere



**Multiple reflections**

# The ionospheric layers

## D-layer or D-region

The D layer is the innermost layer, 60 km to 90 km above the surface of the Earth.

Ionization here is due to **Lyman series-alpha hydrogen radiation** at a **wavelength of 121.5 nm** ionizing **nitric oxide (NO)**.

In addition, with high solar activity **hard X-rays ( $\lambda < 1 \text{ nm}$ )** may ionize ( $\text{N}_2, \text{O}_2$ ).

During the night cosmic rays produce a residual amount of ionization.

# The ionospheric layers

## **D-layer or D-region**

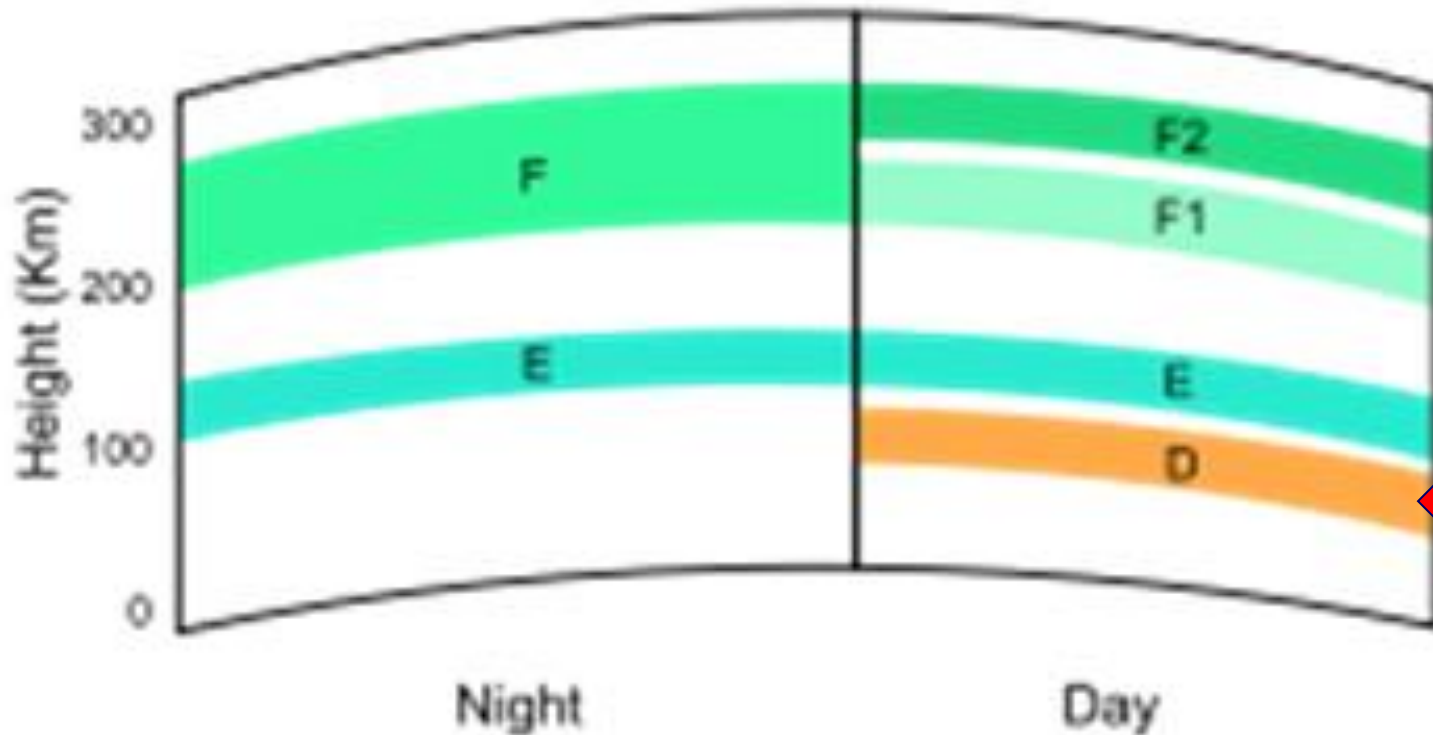
Recombination is high in the D layer, the net ionization effect is low, but loss of wave energy is great due to frequent collisions of the electrons (about 10 collisions every milli-seconds).

**As a result high-frequency (HF) radio waves are not reflected by the D layer but suffer loss of energy there in.**

This is the main reason for absorption of HF radio waves, particularly at **10 MHz and below**, with progressively smaller absorption as the frequency gets higher.

# The ionospheric layers

## D-layer or D-region



Ionization is due to – Lyman series - Alpha

Ionizing of – Nitric Oxide (NO)

Also ionization due to –

Hard X – rays ( $\lambda < 1 \text{ nm}$ )

Ionizing of – N<sub>2</sub>, O<sub>2</sub>

# The ionospheric layers

## E-layer or E-region

The E - layer is the middle layer, **90 km** to **120 km** above the surface of the Earth.

Ionization is due to **soft X-ray (1–10 nm)** and **far ultraviolet (UV)** solar radiation **ionization of molecular oxygen (O<sub>2</sub>)**.

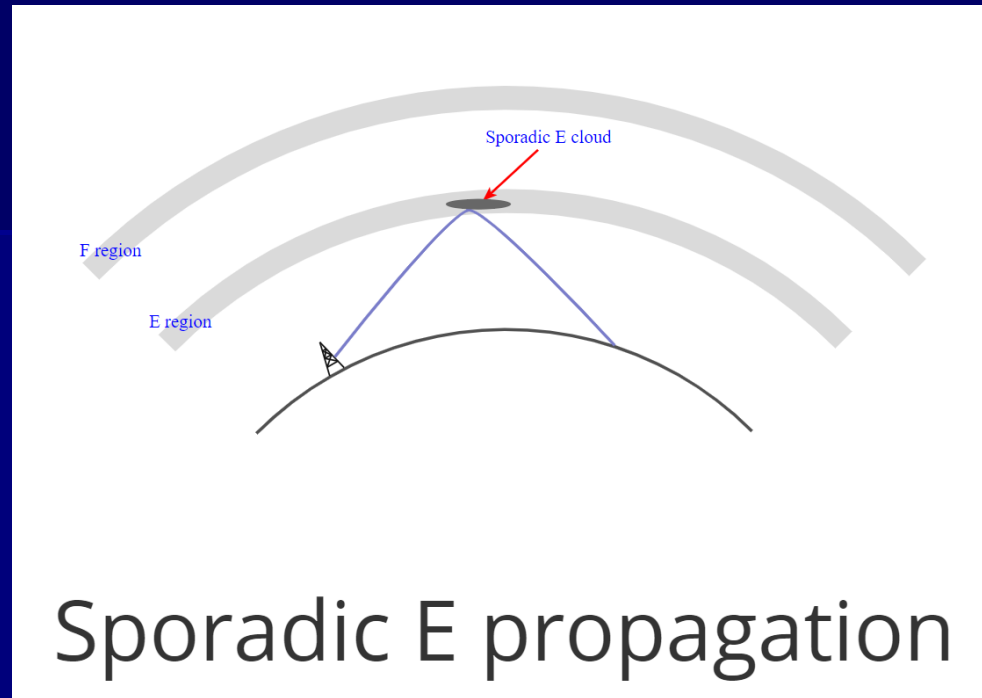
Normally this layer can only reflect radio waves having frequencies **lower than about 10 MHz** and may contribute a bit to absorption on frequencies above.

However, **during intense** (quick) **Sporadic E events, the E<sub>s</sub> layer (Sporadic E layer ) can reflect frequencies up to 50 MHz and higher.**

# The ionospheric layers

## **E<sub>s</sub> – Sporadic** (කඩින් කඩ) **layer**

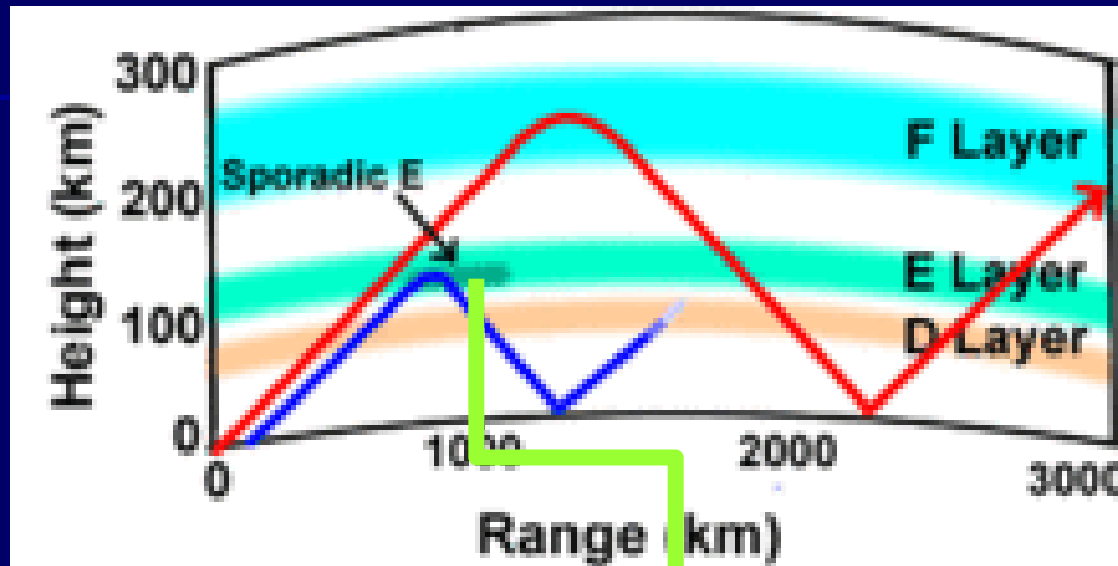
**E sporadic** is a form of **E layer** ionisation that occurs randomly in the ionosphere. It can affect frequencies normally affected by **ionospheric** propagation, but as the levels of ionisation can rise very high, it can affect frequencies much higher than would be expected by normal **E** region ionisation.



**Sporadic E propagation** bounces signals off smaller "clouds" of unusually ionized atmospheric gas in the lower **E-region** (located at altitudes of approx. 90 to 160 km).

# The ionospheric layers

## $E_s$ – Sporadic (කඩින් කඩ) E - layer



The  $E_s$  layer is **characterized by small, thin clouds of intense ionization, which can support reflection of radio waves, rarely up to 225 MHz**. Sporadic-E events may last for **just a few minutes to several hours**. Sporadic E propagation makes radio amateurs (learner) very excited, as propagation paths that are generally unreachable can open up.



# The ionospheric layers

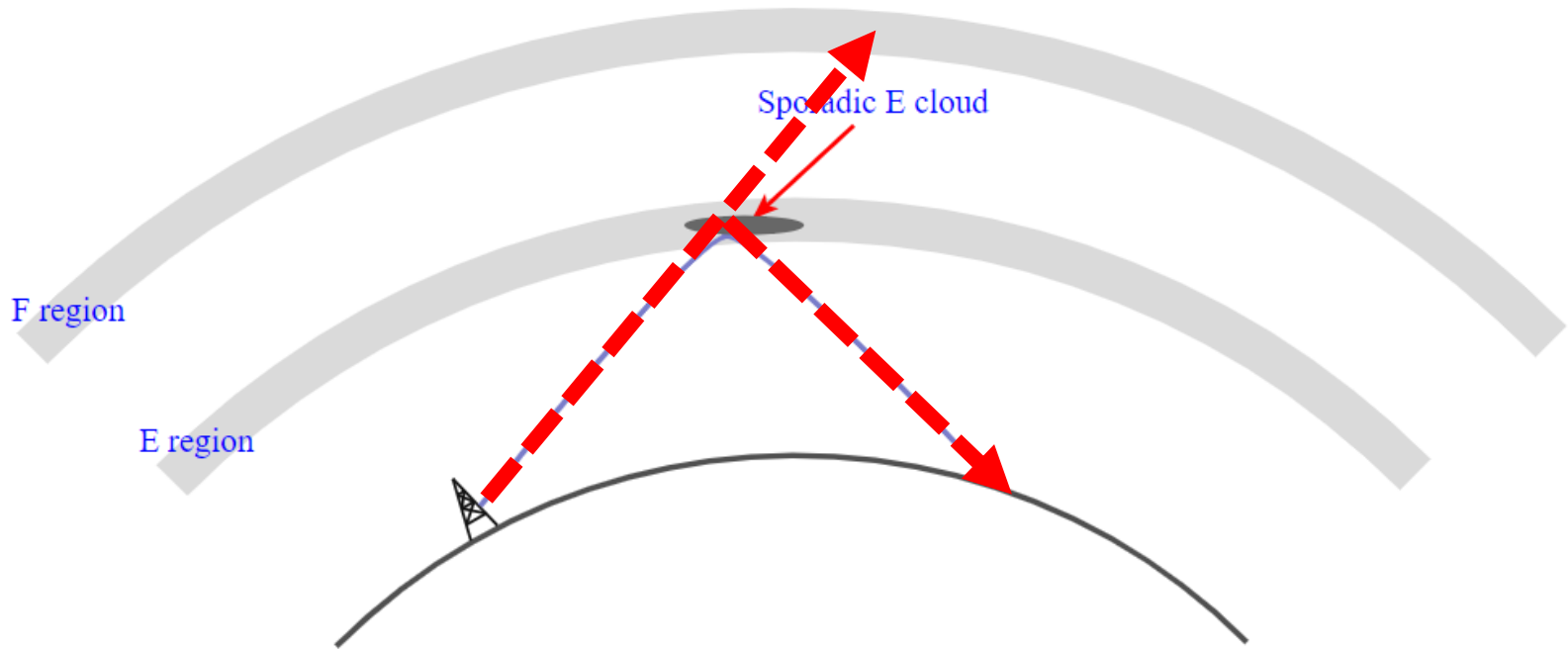
## E-layer or E-region

### $E_s$ - Sporadic E - layer

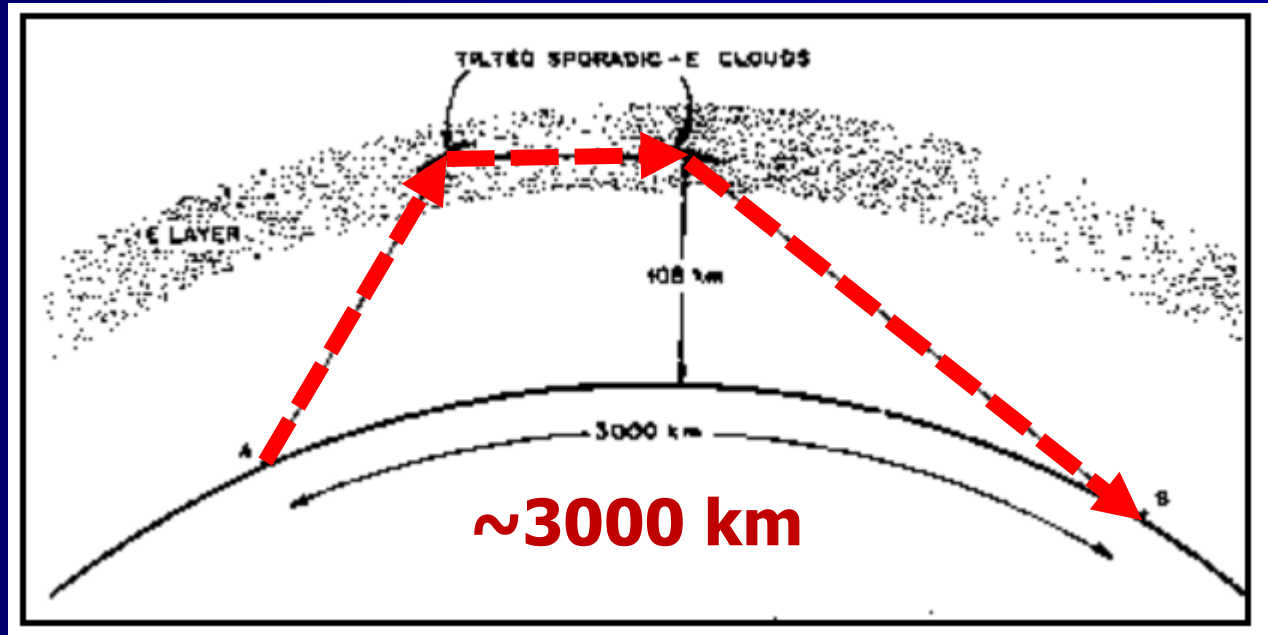
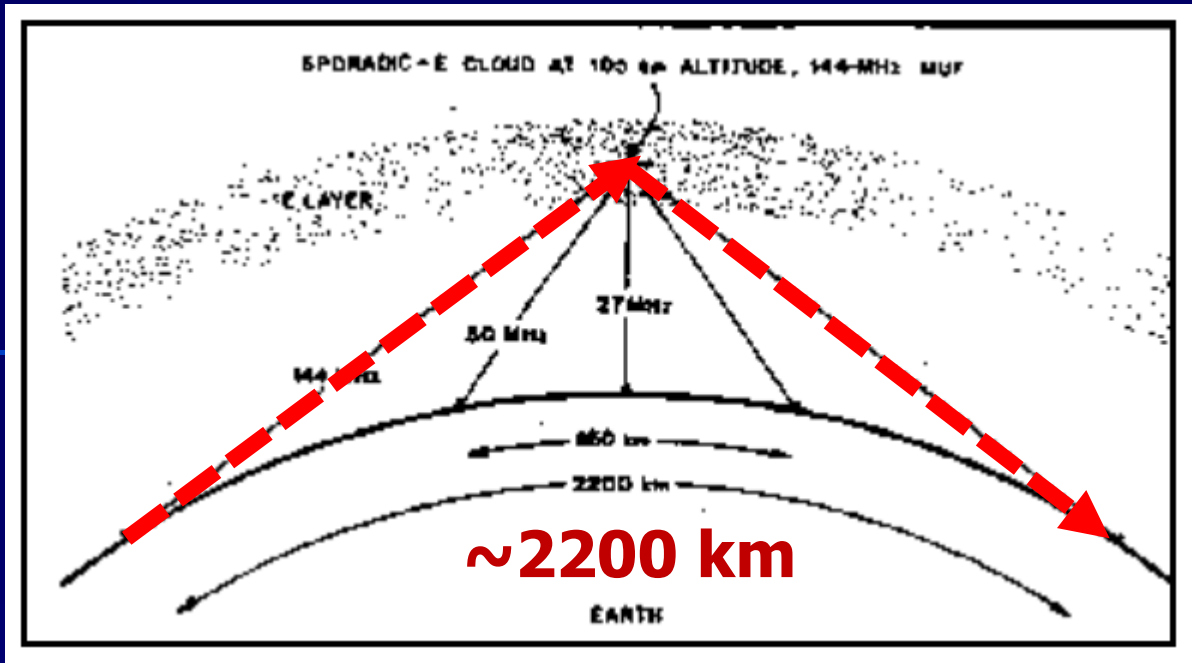
There are multiple causes of sporadic-E that are still being pursued by researchers. This propagation occurs most frequently during the summer months when high signal levels may be reached.

The **skip distances are generally around 1000 km**. VHF TV and FM broadcast also get excited as their **signals can be bounced back** to Earth by  $E_s$ .

**Distances for one hop propagation** can be as close as **900 km** or up to **2,500 km**. **Double-hop** reception **over 3,500 km** is possible too.

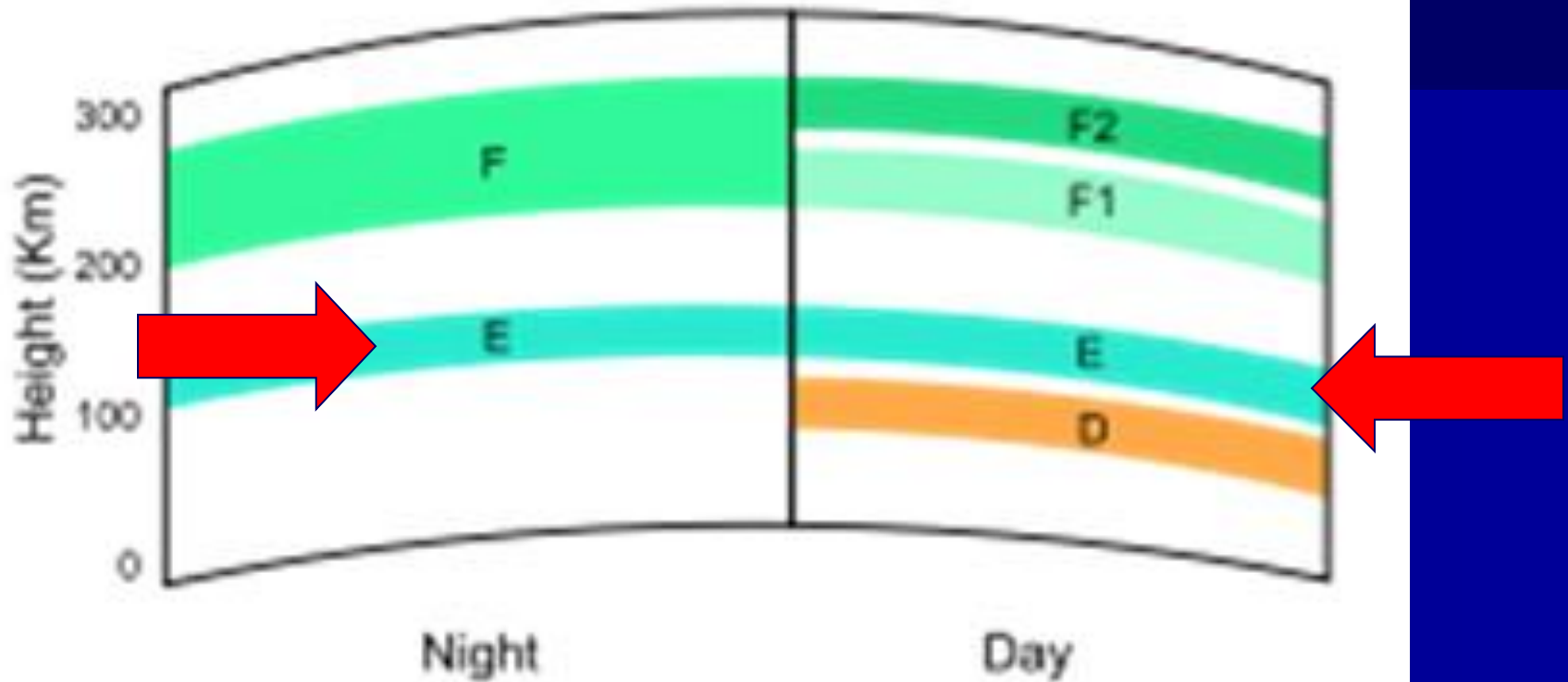


# Sporadic E propagation



# The ionospheric layers

## E-layer or E-region



Ionization is due to –

Soft X – rays ( $\lambda$ , 1-10 nm) &  
Far Ultra Violet

Ionizing of – Molecular Oxygen (O)

**E<sub>s</sub> – Sporadic E-layer**

# The ionospheric layers

## **F-layer or F-region**

The F layer or F region, also known as the **Appleton layer**, extends from about **200 km to more than 500 km** above the surface of Earth.

It is the **densest point of the ionosphere**, which **implies signals penetrating this layer will escape into space**.

**Beyond this layer is the topside ionosphere. Here extreme ultraviolet (UV, 10–100 nm) solar radiation ionizes atomic oxygen.**

# The ionospheric layers

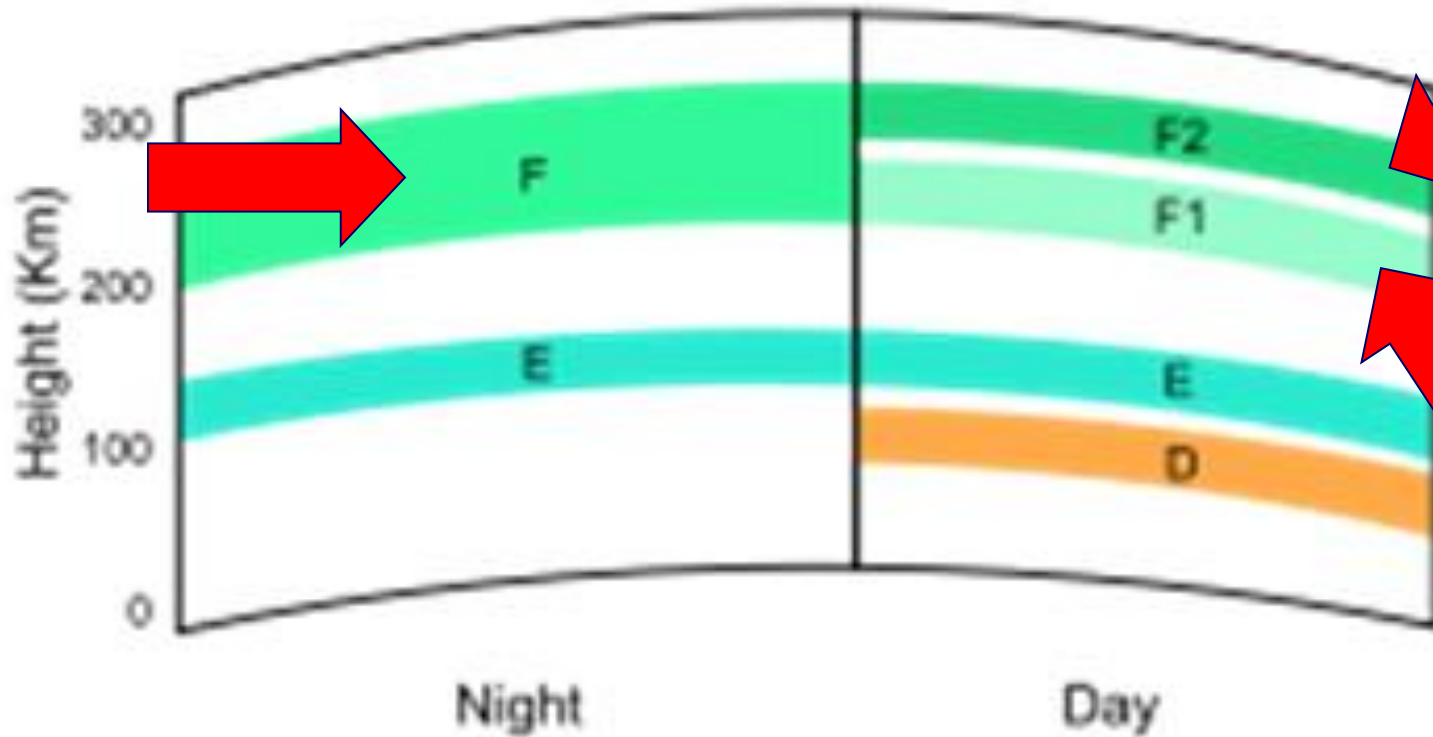
## **F-layer or F-region**

**The F layer consists of one layer at night**, but during the day, a deformation often forms in the profile that is labeled  $F_1$ .

The  $F_2$  layer remains by day and night responsible for most sky wave propagation of radio waves, **facilitating high frequency (HF or shortwave, SW) radio communications over long distances.**

# The ionospheric layers

## F-layer or F-region



Ionization is due to –

Extreme Ultra Violet

( $\lambda$ , 10-100 nm)

Ionizing of – Atomic Oxygen

**F<sub>1</sub> and F<sub>2</sub> - layer**

# Ionospheric regions

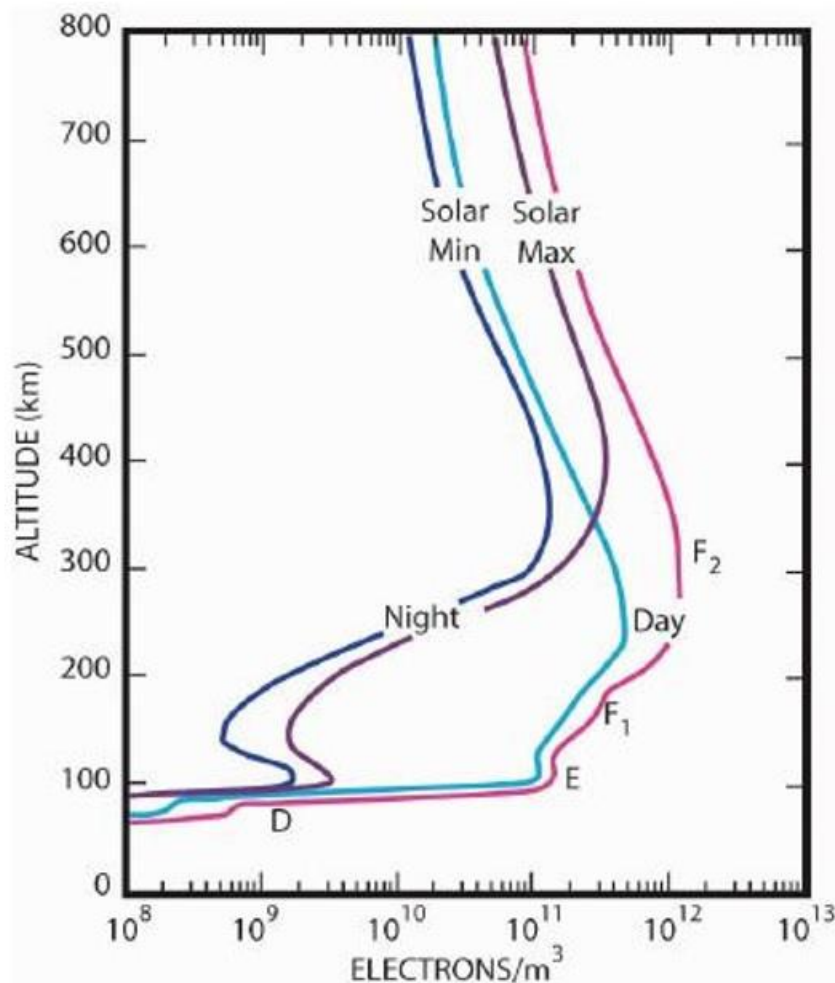


Figure: Typical ionospheric electron density profiles.

Ionospheric regions and typical daytime electron densities:

- **D region:** 60–90 km,  $n_e = 10^8 - 10^{10} \text{ m}^{-3}$
- **E region:** 90–150 km,  $n_e = 10^{10} - 10^{11} \text{ m}^{-3}$
- **F region:** 150–1000 km,  $n_e = 10^{11} - 10^{12} \text{ m}^{-3}$ .

Ionosphere has great variability:

- **Solar cycle variations** (in specific upper F region)
- **Day-night variation** in lower F, E and D regions
- **Space weather effects** based on short-term solar variability (lower F, E and D regions)



# The Ionosphere

Introduction

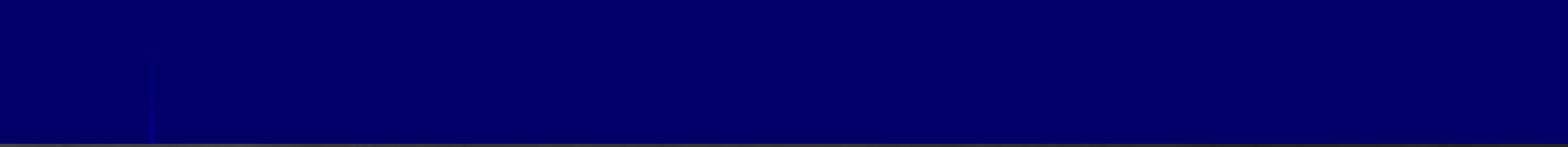
**The Chapman Layer Theory**

Plasma Frequency

Collision Frequency and Absorption

The Structure of the Ionosphere and the Plasmasphere

Regular and Irregular Variations of the Ionosphere



Thank You !