Monitoring the COROT satellite at Natal – Potential Ionospheric Effects

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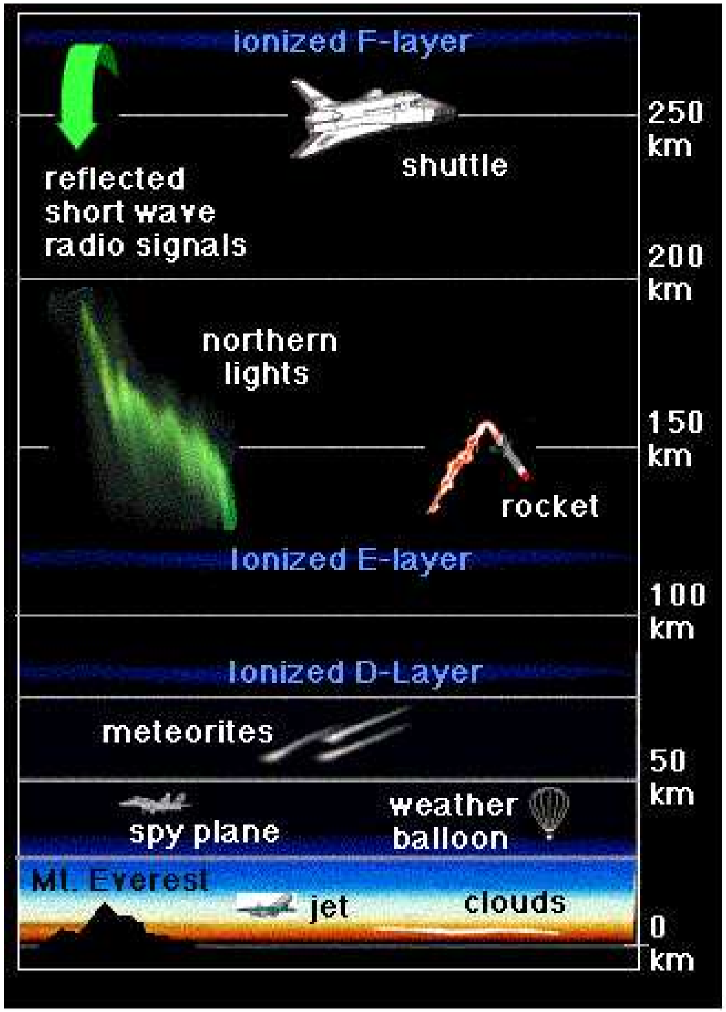
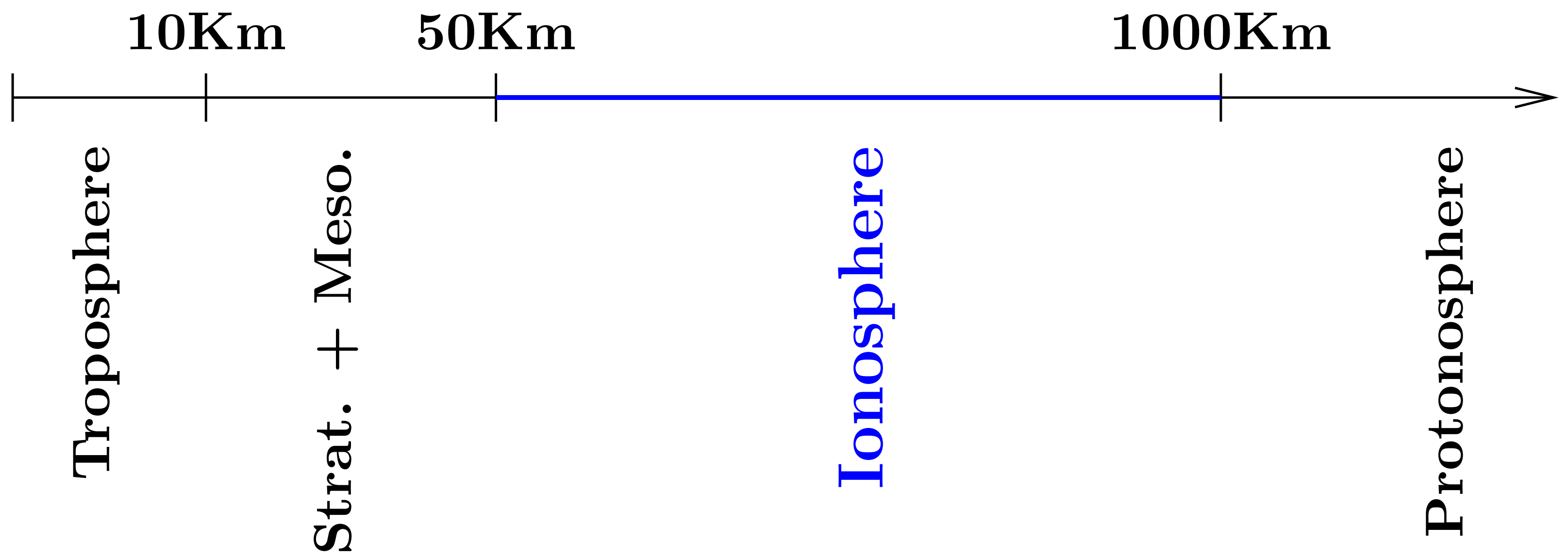
The Earth-Space Interface



COROT: ≈ 900Km, GPS: $\approx 20,000$Km

The Ionosphere

Part of the upper atmosphere where free electrons occur in sufficient density to have an appreciable influence on the propagation of radio frequency electromagnetic waves

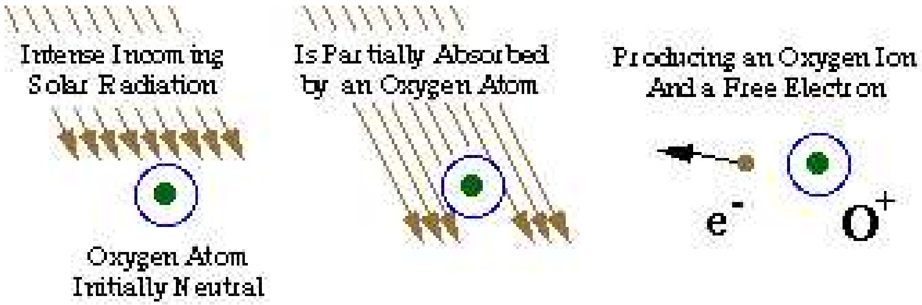


10Km
50Km
1000Km

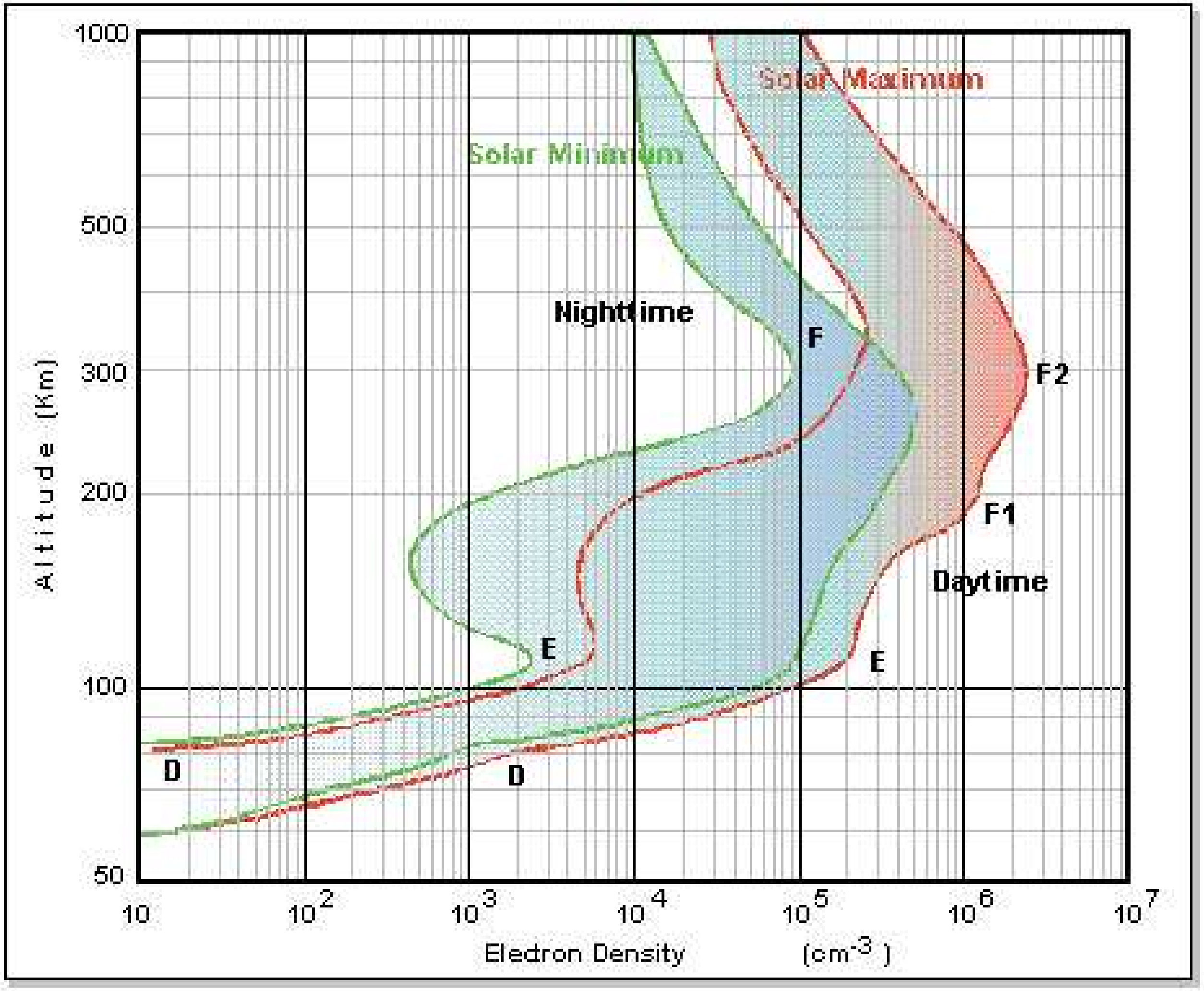
Troposphere
Strat. + Meso.
Ionosphere
Protonosphere

How is the Ionosphere Formed?

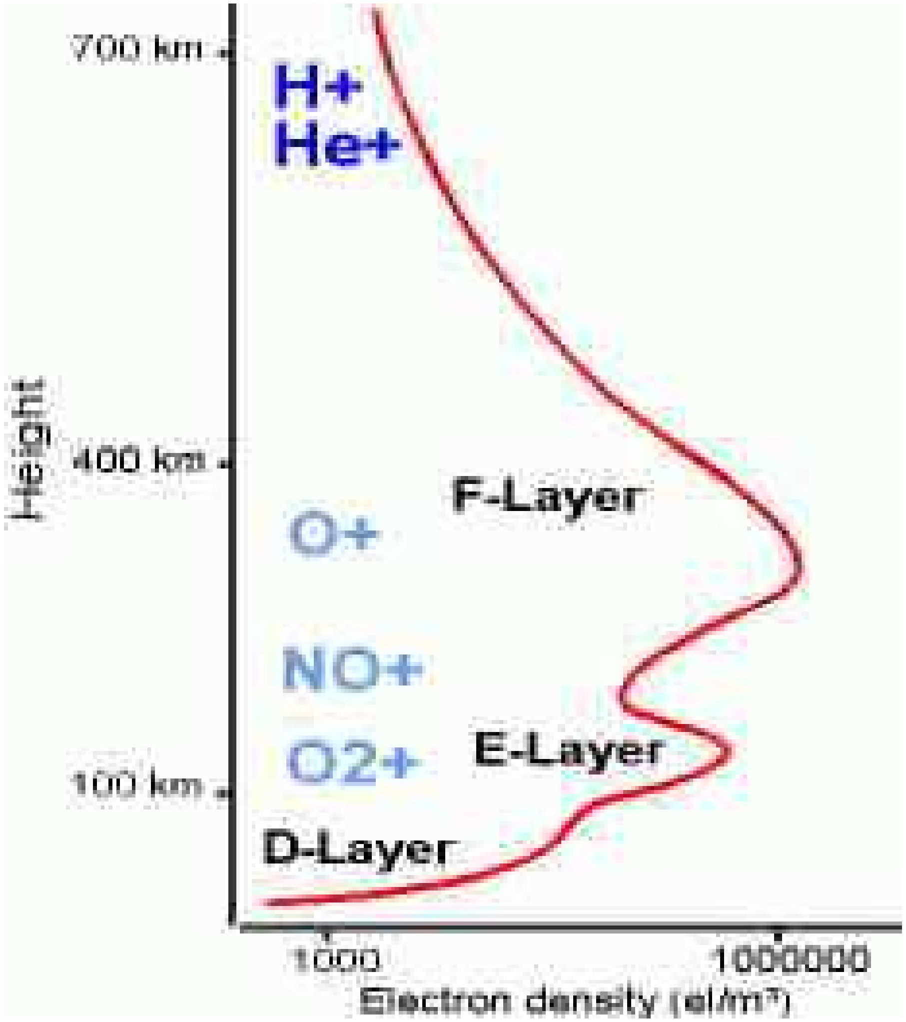
- **Solar radiation strikes the atmosphere with a power density of 1.37 kW/m^2 (“Solar Constant”);**
- **Spectrum ranging from radio frequencies through infrared radiation and visible light to X-rays;**
- **Ultraviolet (and shorter wavelengths) is considered to be “ionizing” – cosmic rays and solar wind particles also play a role.**



Ionospheric Layers



Ionospheric Layers (Continued)



Equatorial Ionosphere

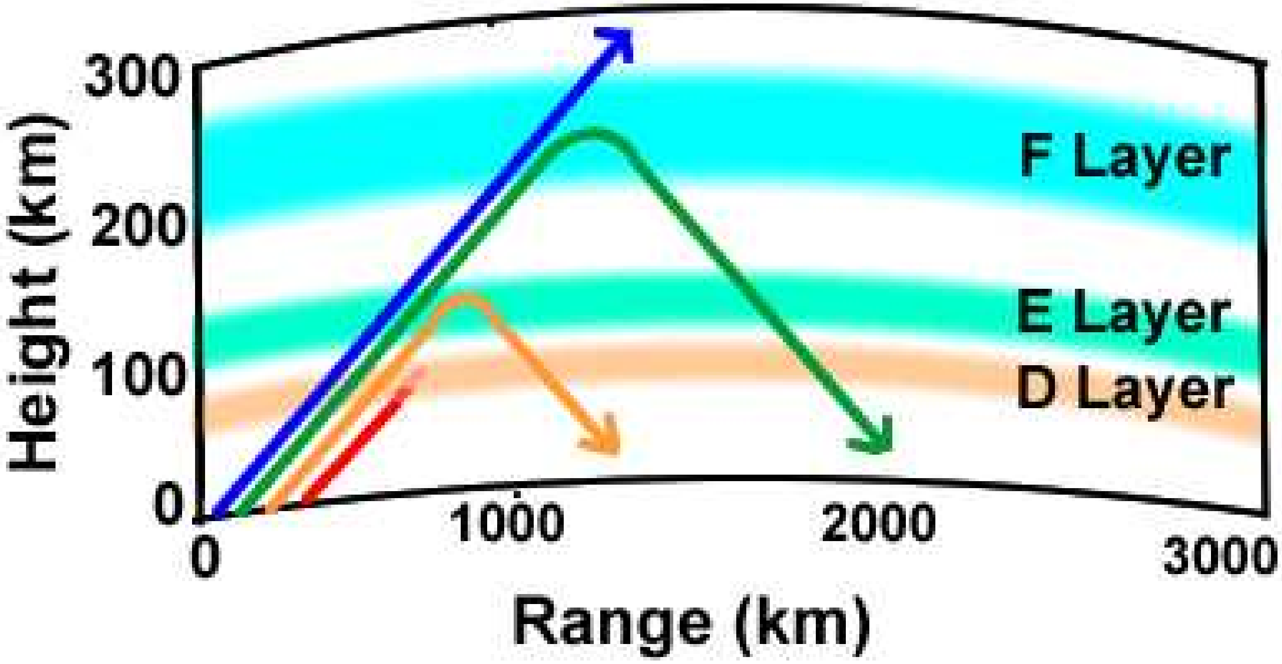
Natal: 5°46′S, 35°12′W

Equatorial Ionospheric Bubbles

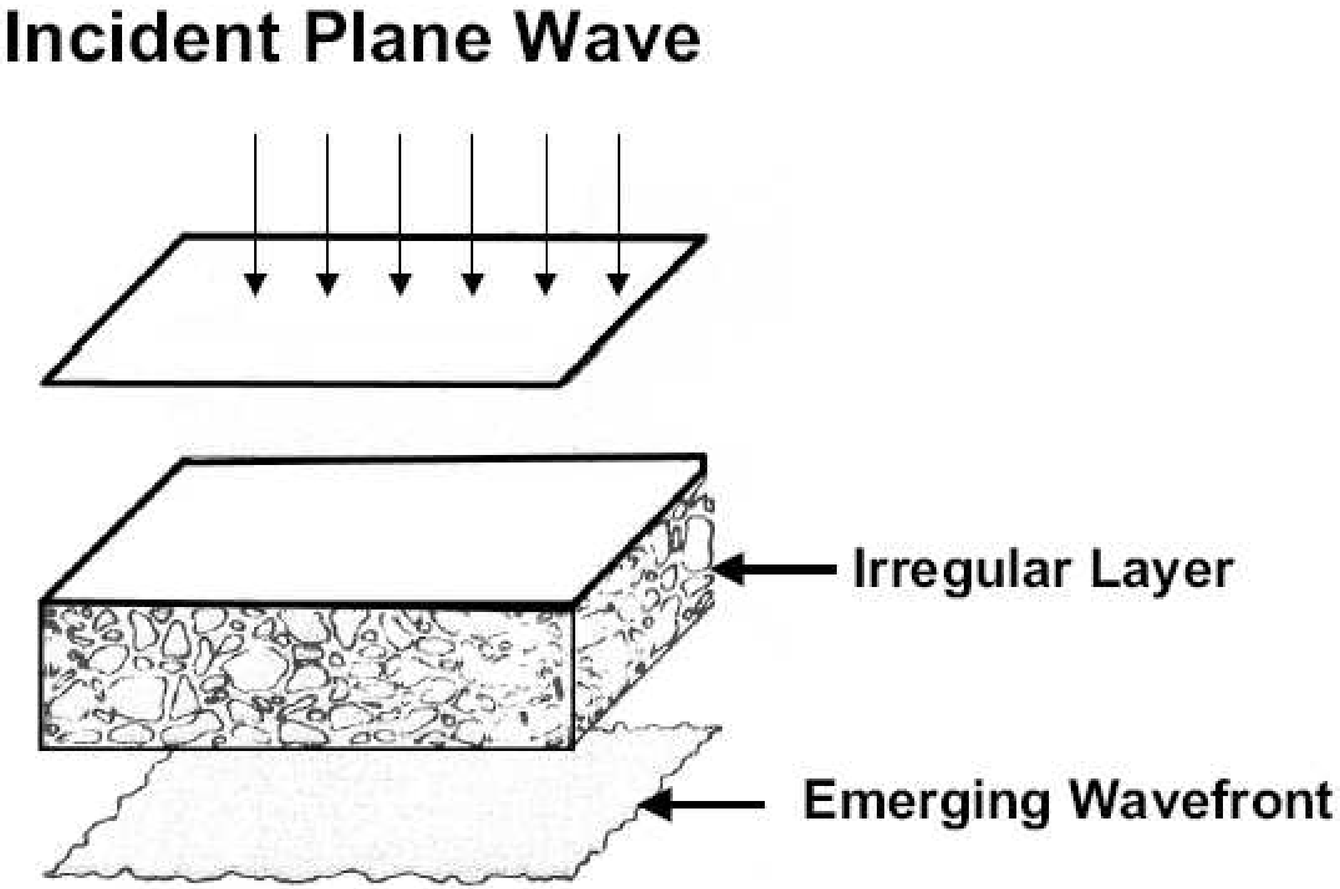
- **At equatorial regions diferent rates of chemical recombination at the sunset may cause the ionosphere F-Layer to be filled with irregular density structures called ionospheric irregulaties or bubbles;**
- **Individual bubbles have lifetimes of 2-3 hours. However, irregularities have been seen for periods of up to 8 hours; also they have scale sizes ranging from 1m to greater than 200Km;**
- **These types of irregularities are not related to space weather disturbances but do increase with the solar activity cycle and often show extreme variability from day to day.**

Ionospheric Efects on Radio Signals

- **The refractive index depends on electron concentration and the frequency of the transmitted wave;**
- **The path of a radio wave is affected by any free charges in the medium through which it is travelling;**



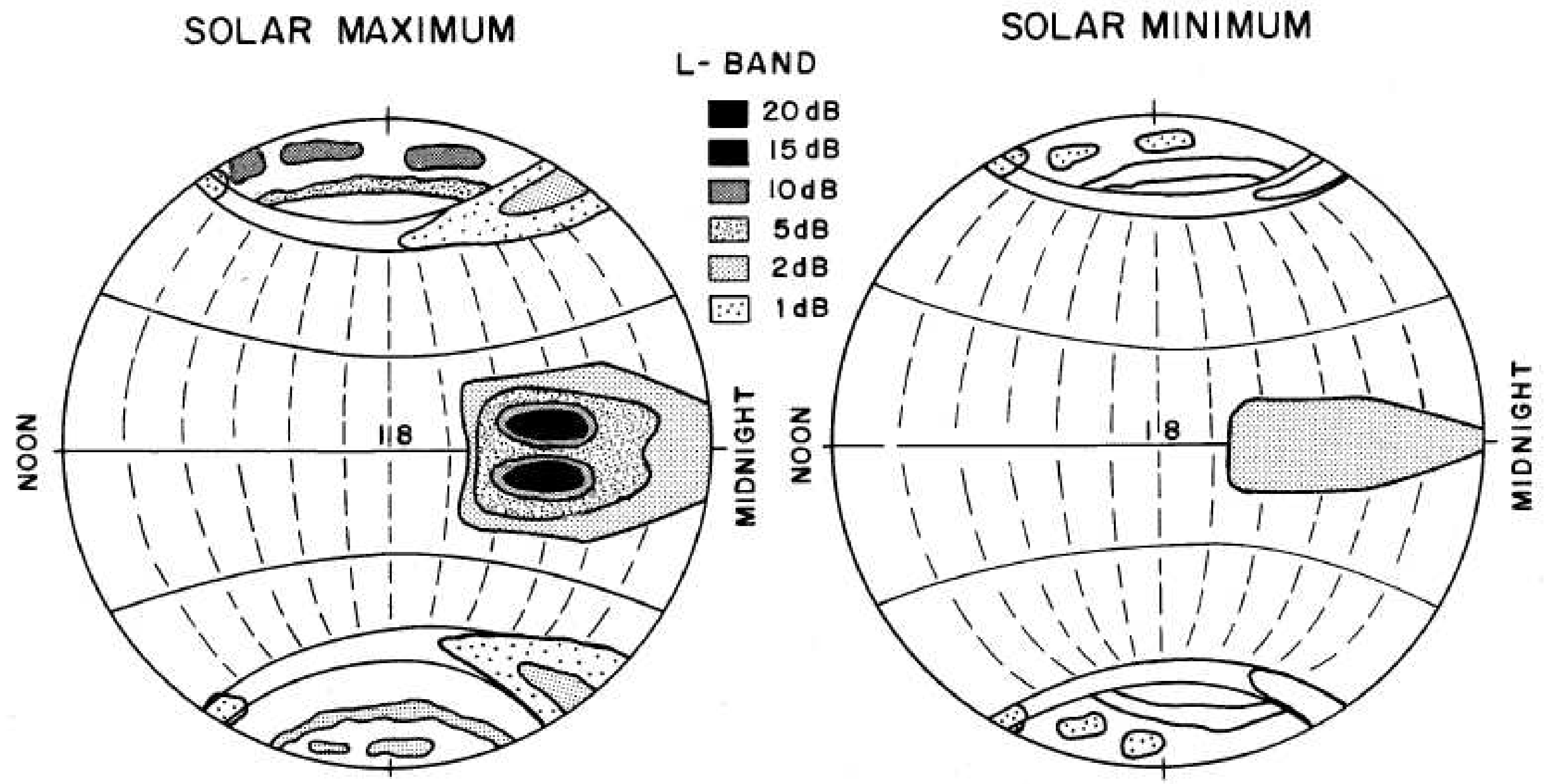
Pictorial View of Scintillation



Signal Scintillations

- Transionospheric propagation through equatorial (and polar) regions has experienced deep fadings at frequencies ranging from 54MHz to 4GHz;
- These fadings, also called scintillations, are known to be caused by the ionospheric irregularities;
- The net result is that information can be lost or become extremely difficult to decipher;
- The strongest L-band scintillations, with signal fade of 20dB or more during solar maximum, occur around ±15° dip latitude.

"WORST CASE" FADING DEPTHS AT L-BAND



SOLAR MAXIMUM

SOLAR MINIMUM

Scintillation Measurements

- **We measure fluctuations in signal intensity due to propagation through ionospheric irregularities.**
- **A ground station with a low noise temperature receiver is needed;**
- **Scintillation Index ($\mathbb{S}_4$): it is the normalized RMS deviation of the signal strength S**

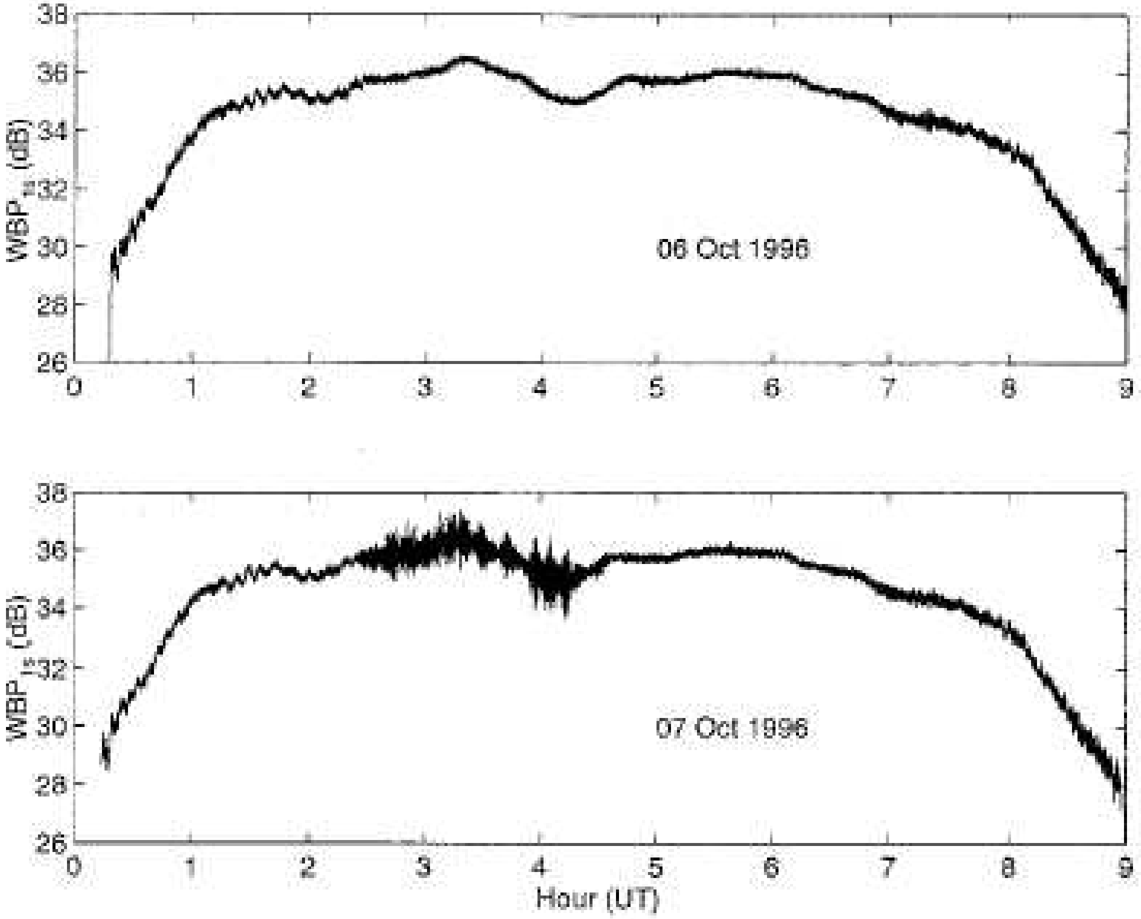
$$\boxed{\mathbb{S}_4^2 = \frac{\langle S^2 \rangle - \langle S \rangle^2}{\langle S \rangle^2}}$$

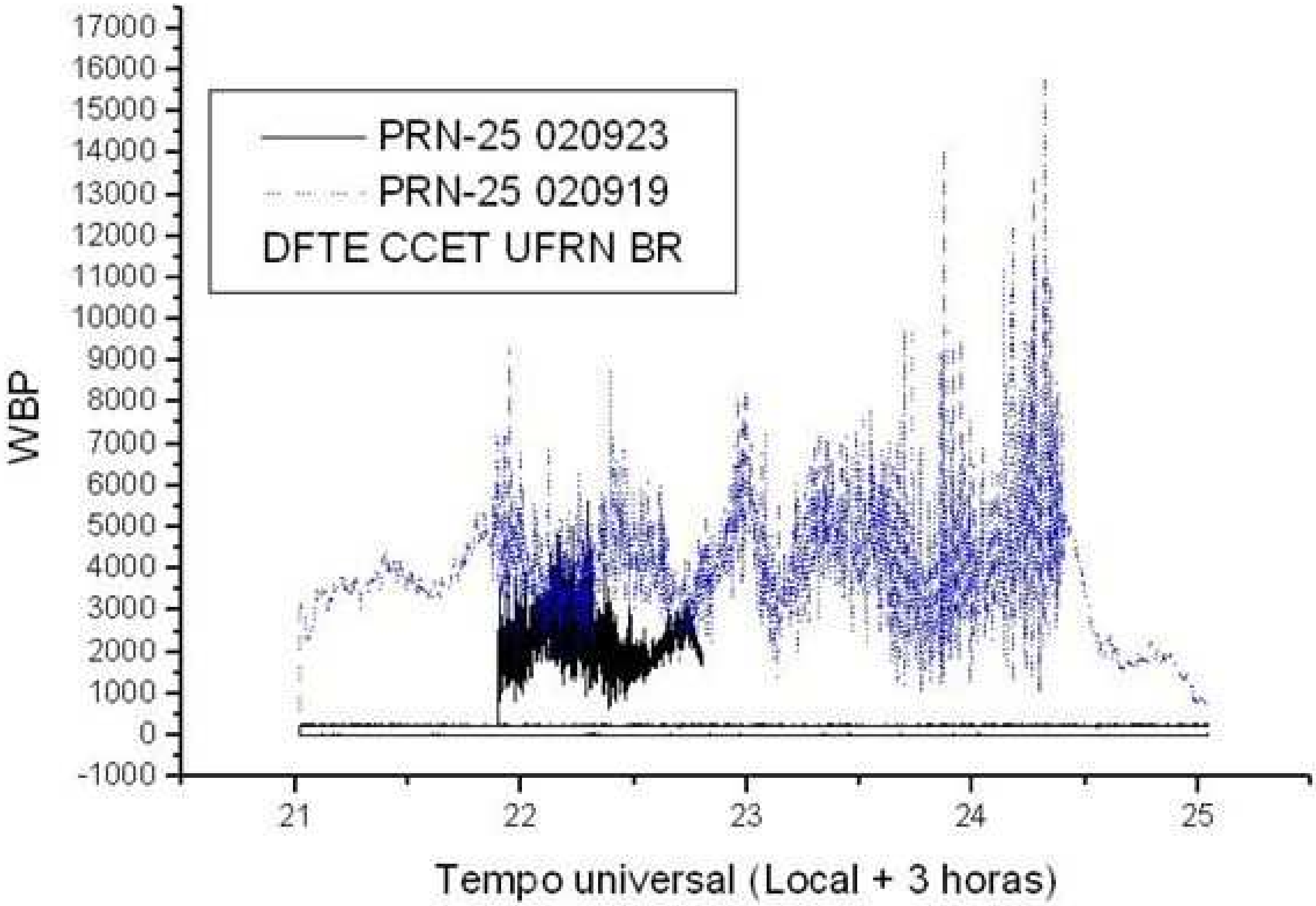
Measuring Scitillations on GPS Signals

- Besides their intended use in radionavigation, GPS signals provide a convenient radio beacon for ionospheric studies;
- The constellation of 24 satellites broadcast signals at frequencies of 1.228 GHz and 1.575 GHz (L-Band);
- The low cost receivers can (in some cases) be adapted to monitor the $\mathbb{S}_4$ index;
- Signal strength S is evaluated as

$$\boxed{S = \sum_{n=1}^{M} (I_n^2 + Q_n^2)}$$

I, Q: In-phase, Quadrature components of the signal


38
36
34
32
30
28
26
WBP_{ls} (dB)
0
1
2
3
4
5
6
7
8
9
06 Oct 1996
07 Oct 1996
Hour (UT)


17000
16000
15000
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
WBP
PRN-25 020923
PRN-25 020919
DFTE CCET UFRN BR
21
22
23
24
25
Tempo universal (Local + 3 horas)

Considerations about the COROT

- COROT satellite will broadcast a 2GHz signal for a ground station at Natal;
- We expect to see the same effects as in GPS signals; so it would be a new useful source for ionospheric scintillation studies;
- How can we measure signal strength at Natal ground station?
- Will scintillations have any efect on COROT measurements?