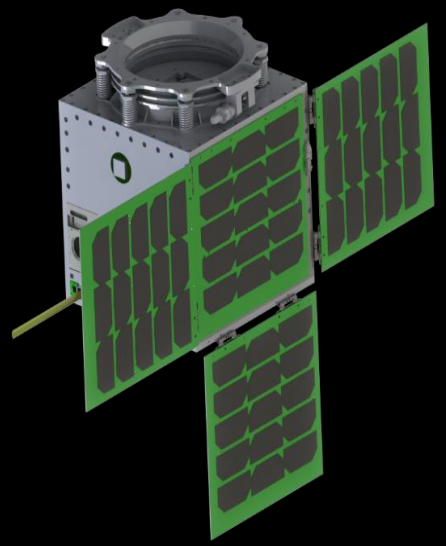
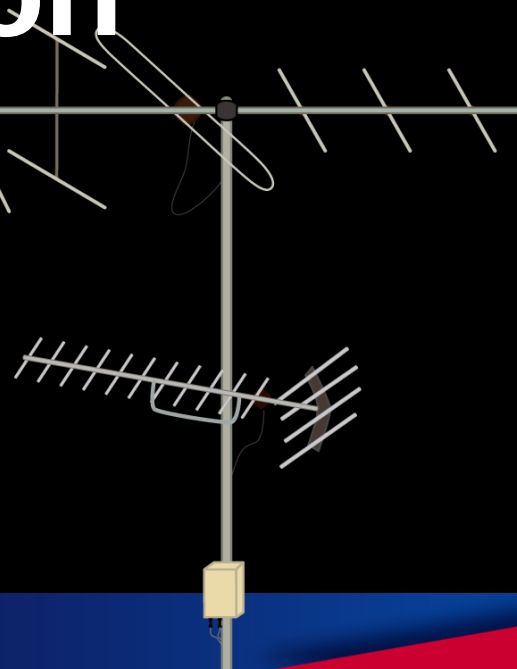


NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

Satellite Research Centre
School of Electrical and Electronic Engineering

Open Space SG

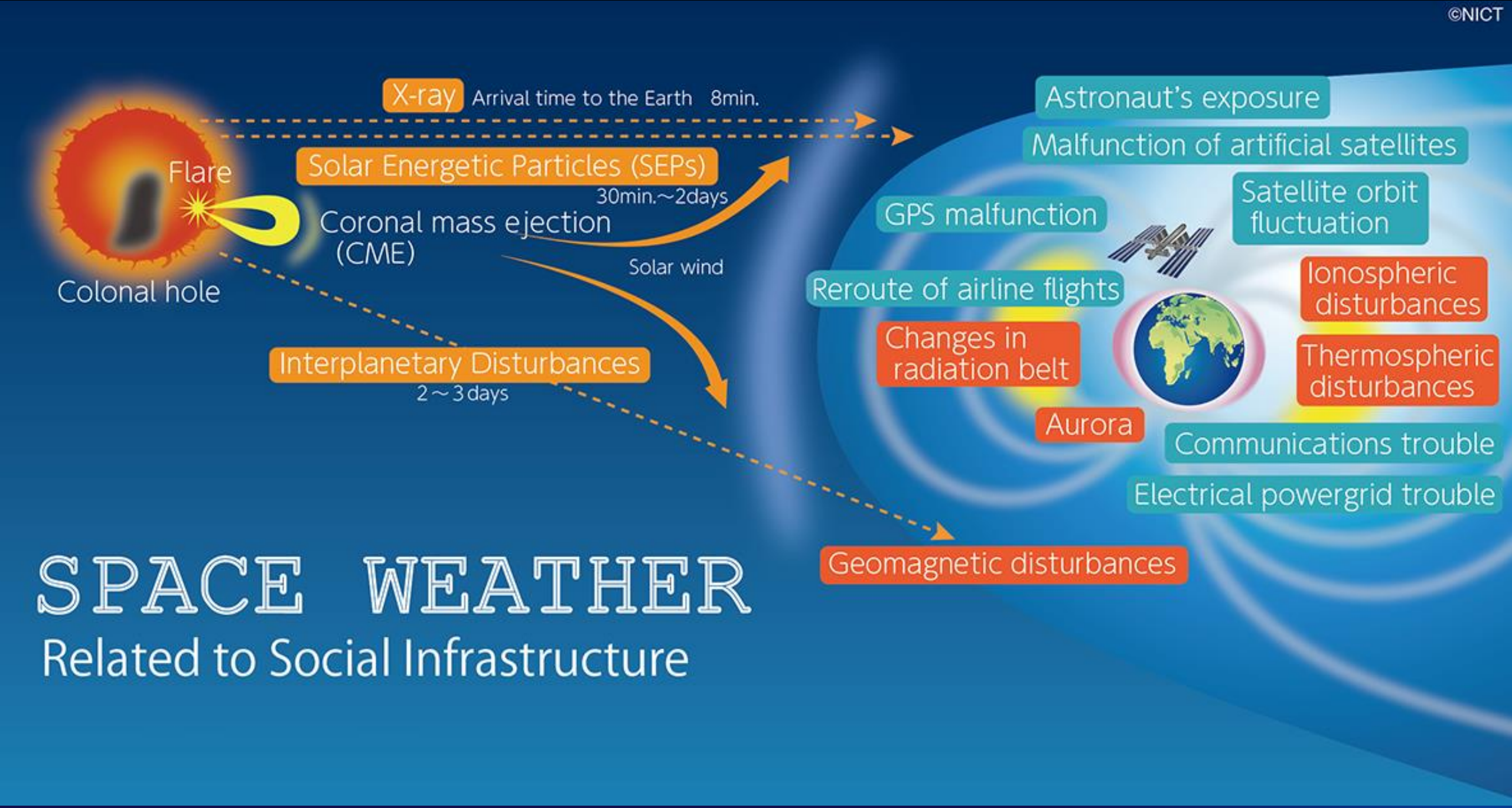
Twinkling Signals: The Ionosphere and its Impact on Radio-based Systems



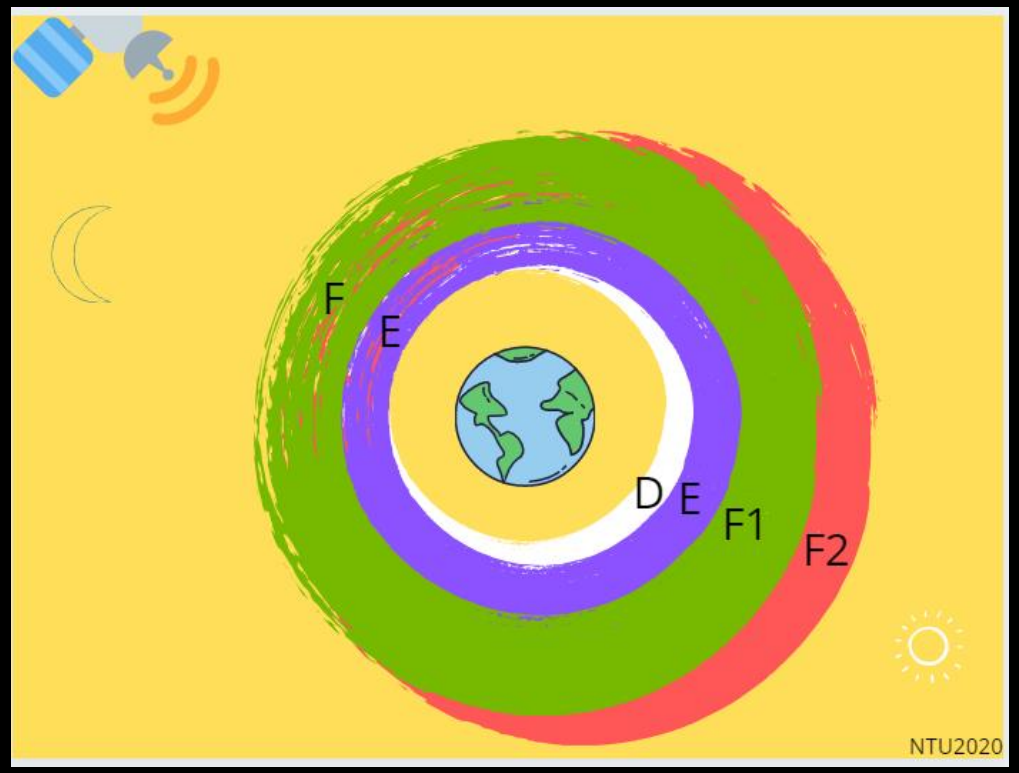
LUWANGA CHRISTOPHER

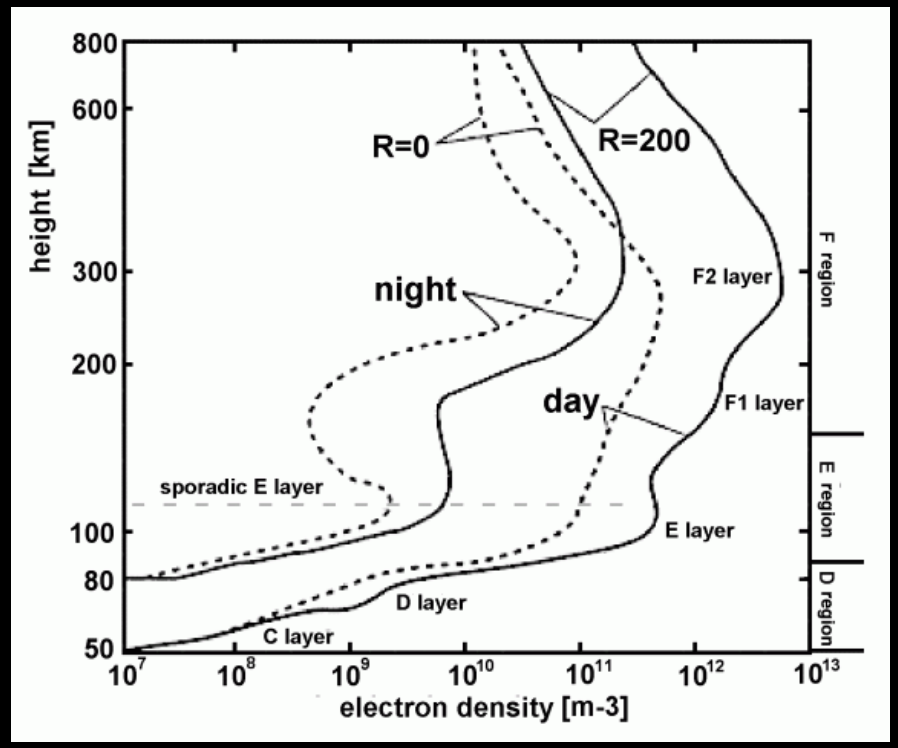
Supervisor: A/P Amal Chandran
External Advisor: Dr. Tzu-Wei Fang

June 25 2021


©NICT
X-ray
Arrival time to the Earth 8min.
Flare
Solar Energetic Particles (SEPs)
30min.~2days
Coronal mass ejection
(CME)
Solar wind
Colonal hole
Interplanetary Disturbances
2~3 days
Astronaut's exposure
Malfunction of artificial satellites
Satellite orbit fluctuation
GPS malfunction
Reroute of airline flights
Ionospheric disturbances
Changes in radiation belt
Thermospheric disturbances
Aurora
Communications trouble
Electrical powergrid trouble
Geomagnetic disturbances
SPACE WEATHER
Related to Social Infrastructure

The Ionosphere





Photoionization mostly due to
1. X rays (10 to 0.01 nm)
2. Extreme Ultraviolet (124 to 10 nm)

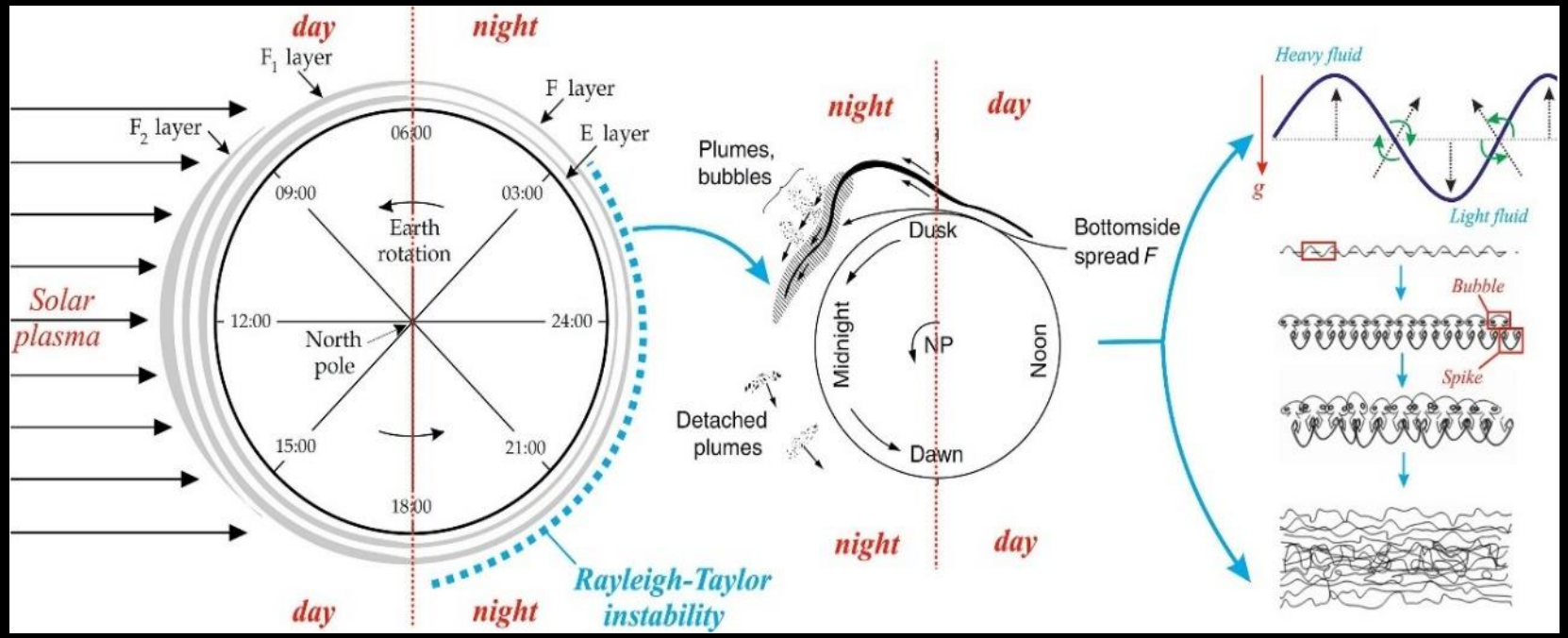
Formation of ions/electrons
1. Photoionization
2. Collisional ionization

Loss
1. Photodetachment
2. Recombination
3. Associative detachment
4. Mutual neutralization

Sum of ions = electron density

Plot from:
http://roma2.rm.ingv.it/en/research_areas/4/ionosphere

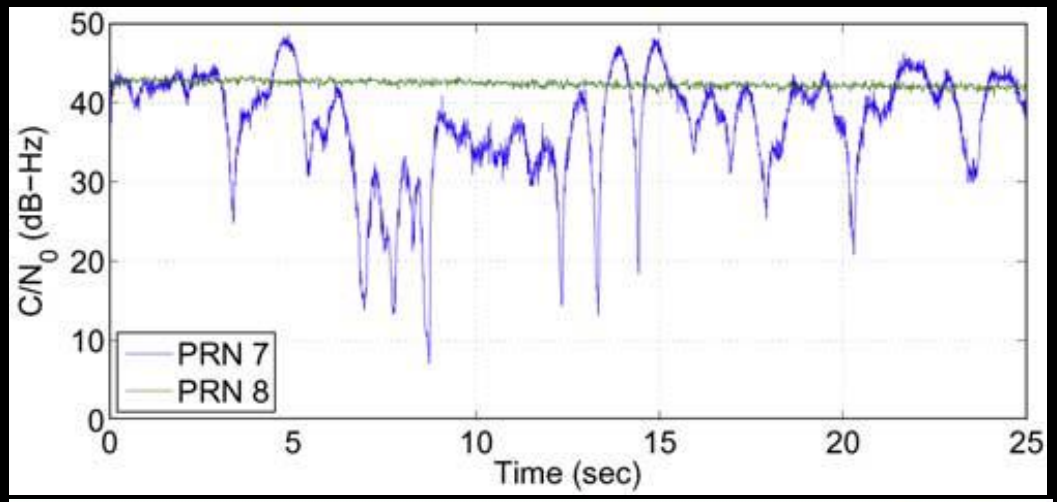
Plasma Bubble Formation

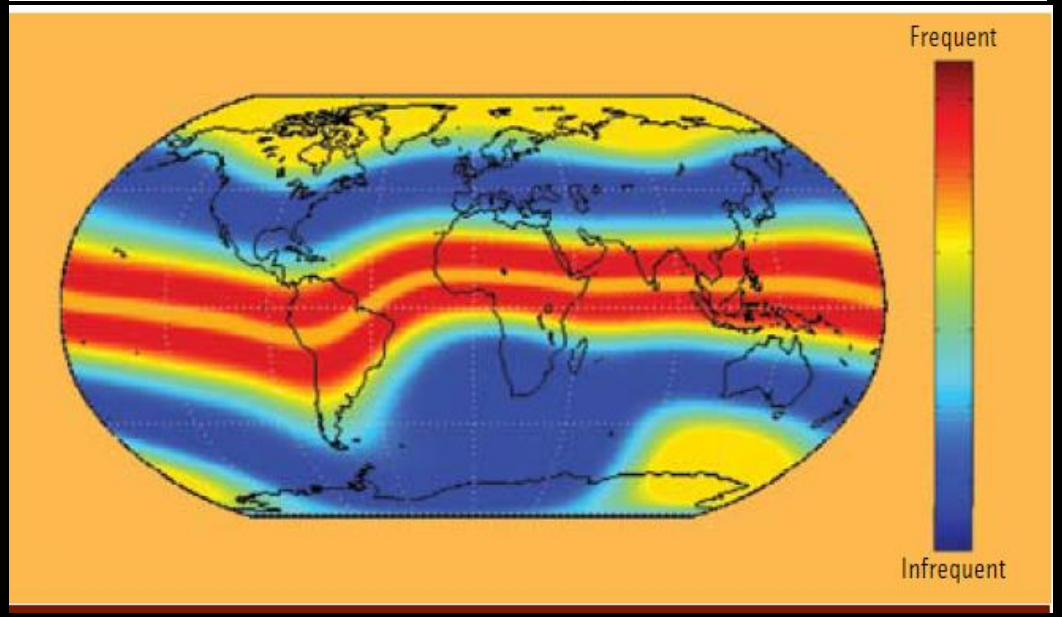


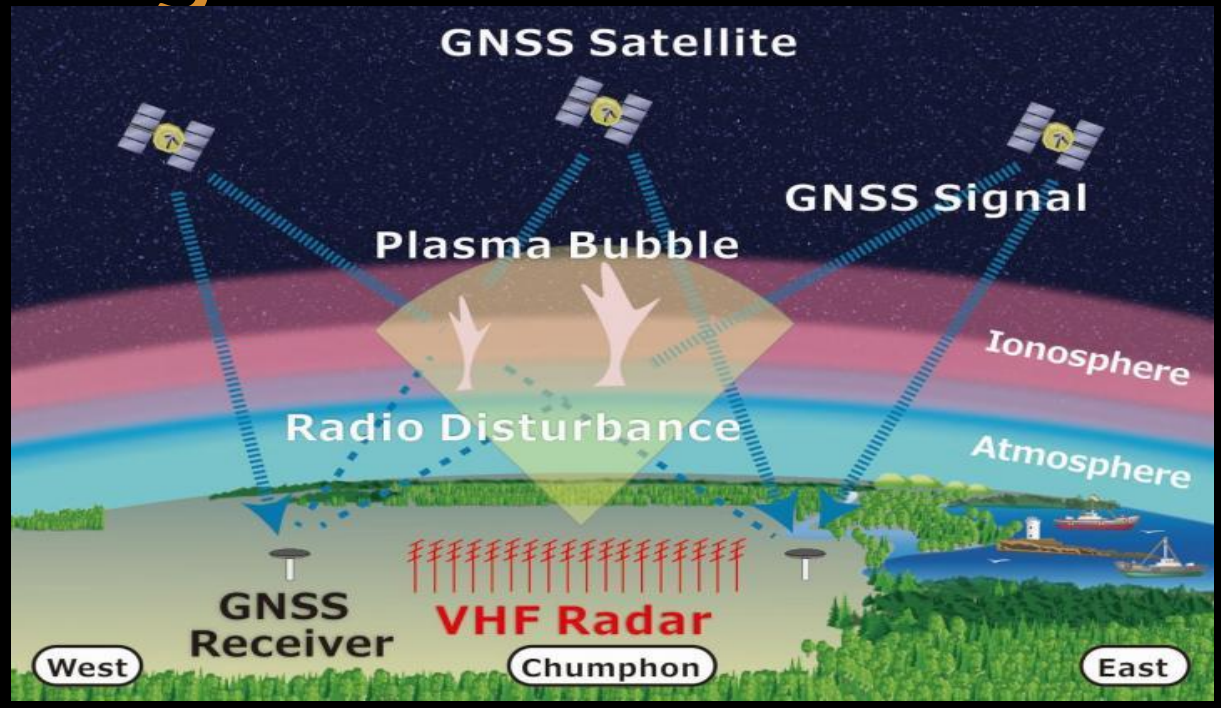
After Sunset:

- Reduced ion creation esp. in D and E regions
- F layer still dense due to transport
- This is Rayleigh Taylor Instability, which can lead to
- Plasma density depletions called Plasma Bubbles

Scintillation: Twinkling





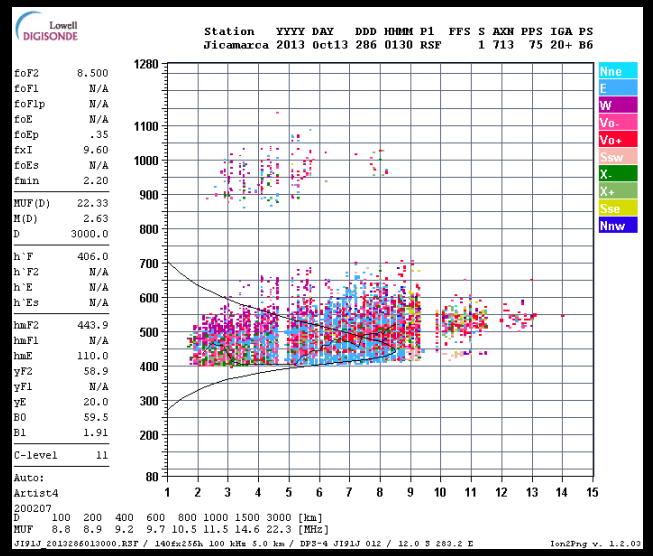


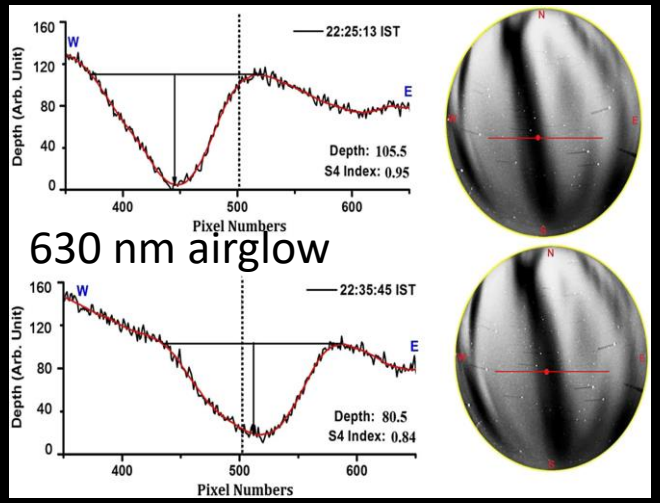
Scintillation Class	Index Value	
	S4	ϕ_σ
Weak	0.1 to 0.25	0.1 to 0.25
Moderate	0.25 to 0.7	0.25 to 0.7
Strong	>0.7	0.7

Kintner et. al, 2006, Correia et al 2018

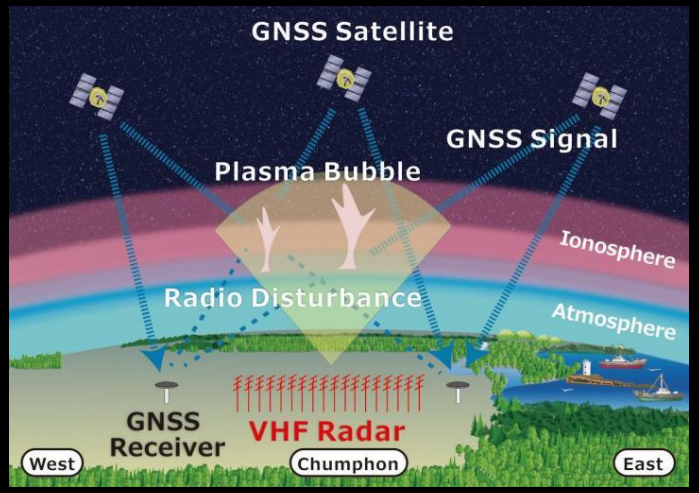
Plasma Bubble, Spread F, Scintillation

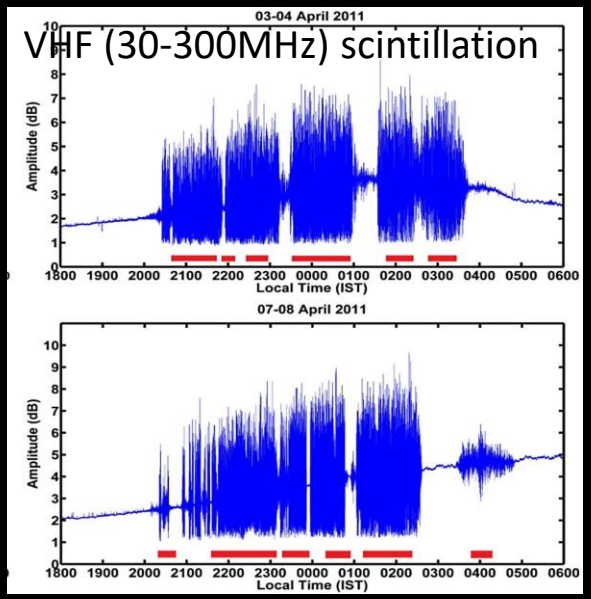
Spread F on ionogram

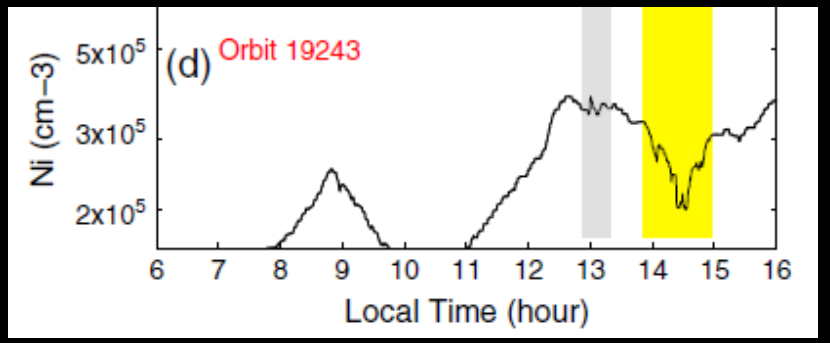




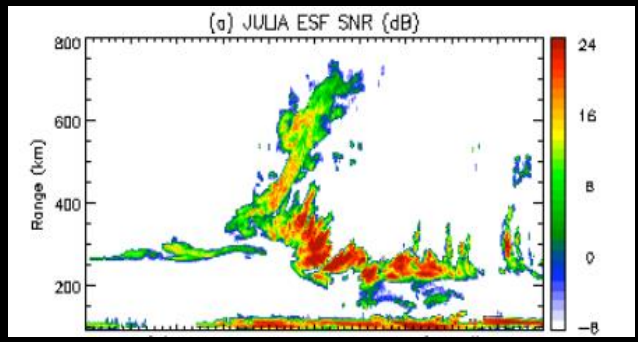
The Physical Phenomenon





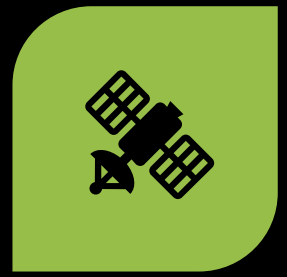


In-situ aboard satellite



Incoherent scatter radar (50 MHz)

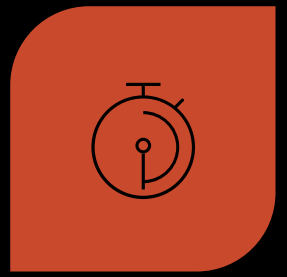
Motivation



CONDITIONS IN THE IONOSPHERE AFFECT SYSTEMS SUCH AS FOR POSITIONING, NAVIGATION AND COMMUNICATION

SPREAD F IS A SIGNATURE OF PERTURBATION IN THE IONOSPHERE

IDENTIFYING SPREAD F MANUALLY IS VERY TIME CONSUMING



NEED FOR FASTER IDENTIFICATION OF SPREAD F IN ORDER TO FORECAST CONDITIONS IN THE IONOSPHERE

Acknowledging…

- 谢谢你 to my advisor and ጣጣ to my supervisor for the guidance
- Yebo to my parents for the cells
- THANK YOU to you all for the attention