In-situ Investigations of SATCOM/GNSS outage regions

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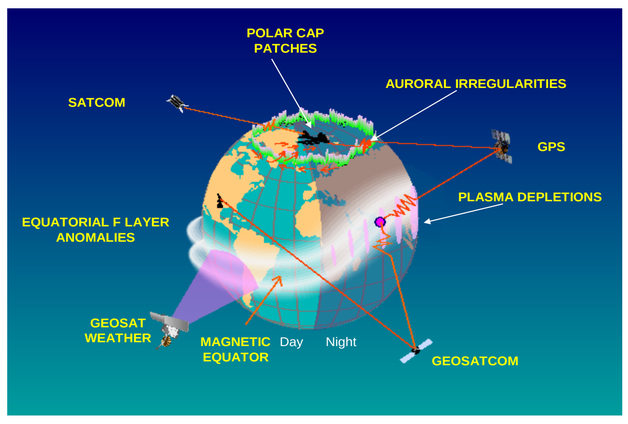
It is well known that diffraction of radio phase fronts produces amplitude and phase fluctuations even at GHz frequencies used for satellite communication and navigation systems. These scintillations are caused by naturally occurring ionospheric plasma density irregularities at scales from hundred of meters to a few kilometres that are generally most severe at high and low latitudes, the so-called SATCOM outage regions. In order to forecast scintillation events it is necessary to obtain a description of the underlying physical processes, and we have developed the ICI space weather rocket program, and we are going to launch a new concept space weather satellite, CubeSTAR, in 2014.

Global Satcom Outage Regions

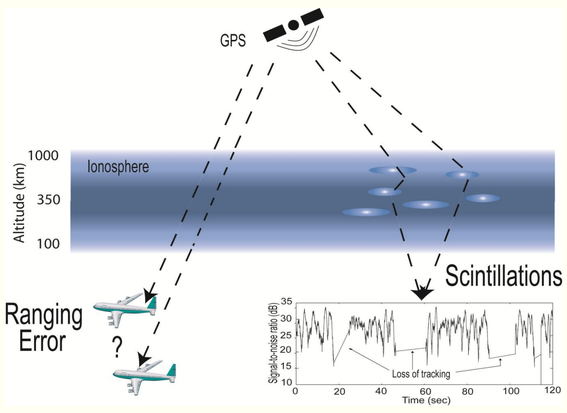


User needs in GNSS for Aviation and Offshore:

- Scintillation forecasts
- Signal integrity
- Service continuity
- Position accuracy

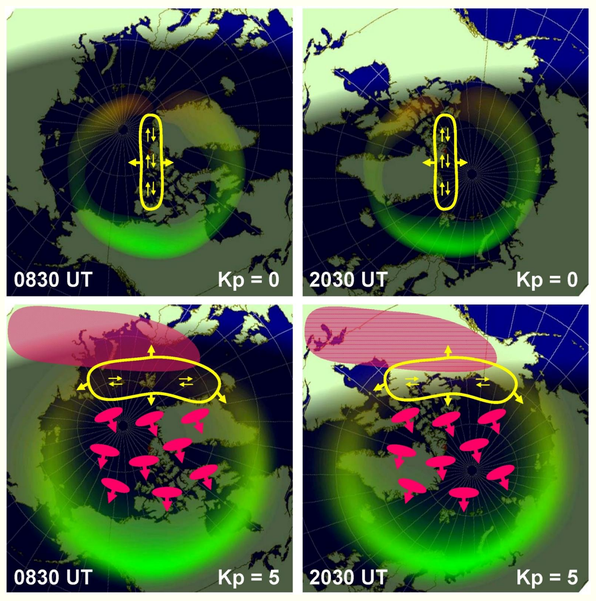
Forecast and mitigation techniques pending on a proper description of the **physical processes**

Ionospheric Effects on GNSS Signals:



- If the receiver, satellite, or ionospheric irregularities are in motion, a time series of signal fading and phase fluctuations will occur at the receiver.
- Cycle slips – loss of tracking frequently occur even during solar minimum conditions
- **?**We are lacking a detailed physical description why**?**

There are two generic mechanisms of ionospheric irregularities:



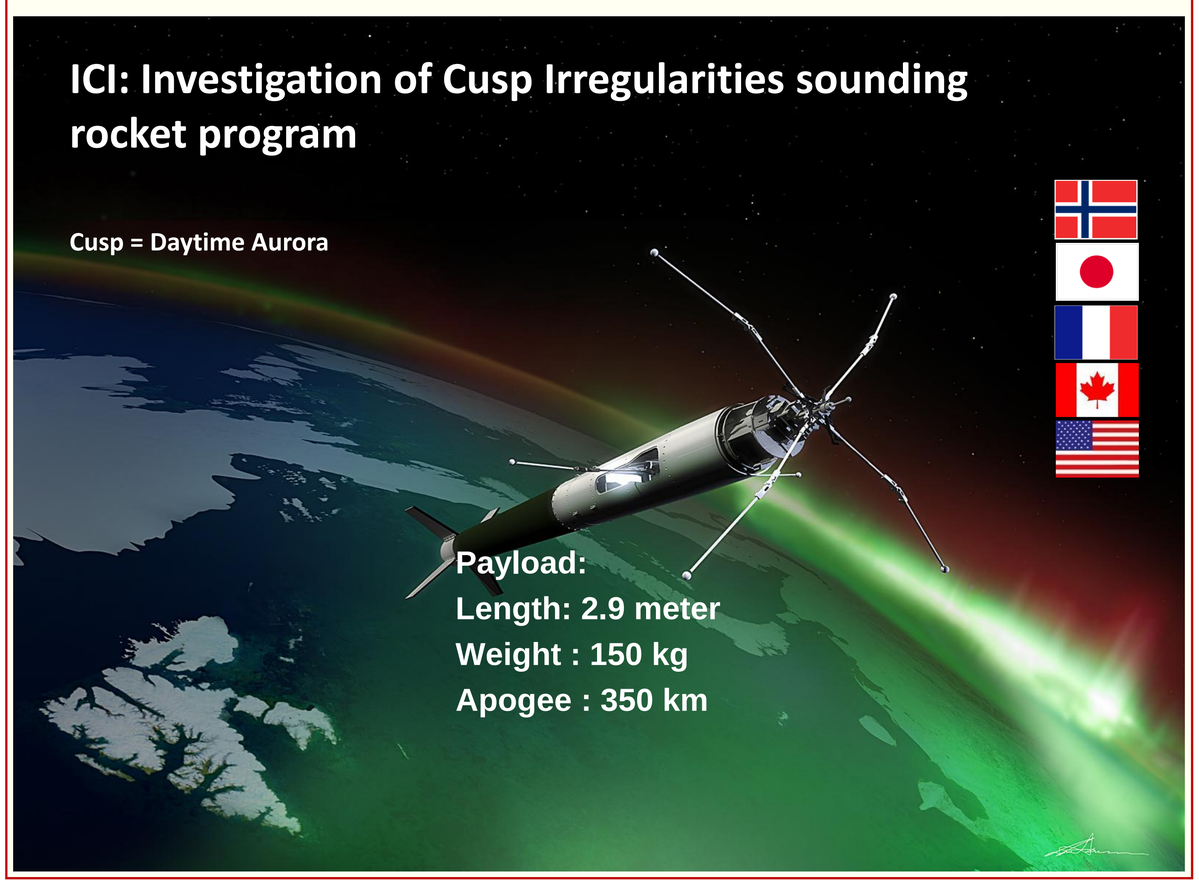
- **Gradient drift instability** on polar cap patches propagating across the polar cap (pink)
- **Flow shear instability** in flow channels associated with auroral activity (yellow)

Science Objectives:

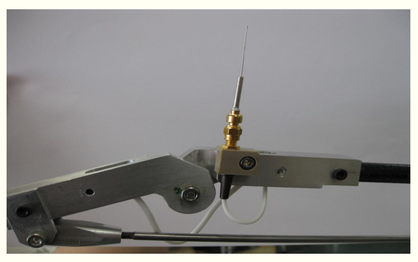
- Study the ionosphere instability processes and their drivers
- Quantify the instability growth rates
- Quantify the plasma structures associated with the instabilities

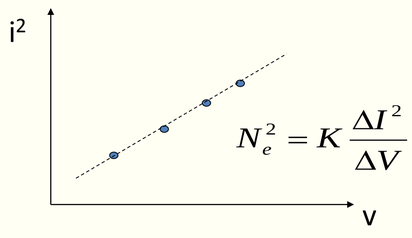
In-situ measurements are required!!

Taking advantage that Svalbard is the only place in the worlds here auroral phenomena can be studied by auroral optics, radars and in-situ by sounding rockets. Gruond based instruments essential to determine launch conditions



UiO has developed a novel miniaturized Langmuir Probe system to measure plasma turbulence





- 4-Needle Langmuir probe system consisting of 4 cylidrical probes (r = 0.25 mm, l = 25 mm)
- 10 kHz sampling rates (meter resolution)
- absolute electron densities within the range 10^8-10^{12}m^{-3}
- Insensitive to platform potential and electron temperature
- Light-weight system (300 g) including electronics, booms and sensors for CubeSATS
- Data can be processed onboard – growth rate of a straight line

ICI – instrumentation package:

- FBP : Fixed Bias Langmuir Probe – ISAS/JAXA
- m-NSLP : multi –Needle Langmuir Probe system – UiO
- LEP-ESA : Low Energy Electron spectrometer (10eV-10keV), ISAS/JAXA
- EFW : Electric Field and Wave Experiment, UiO
- ADM : AC/DC Magnetometer - LPP. (**ICI-3 onwards**)
- Ion spectrometer, LPP (**ICI-4 onwards**)
- FGM : Flux Gate Magnetometer U. Alberta (**ICI-4 onwards**)
- SRADS: Sounding Rocket Attitude Detection System, UiO
- GPS receiver, APL/JHU (**ICI-4 onwards**)

ICI – 2 Results:

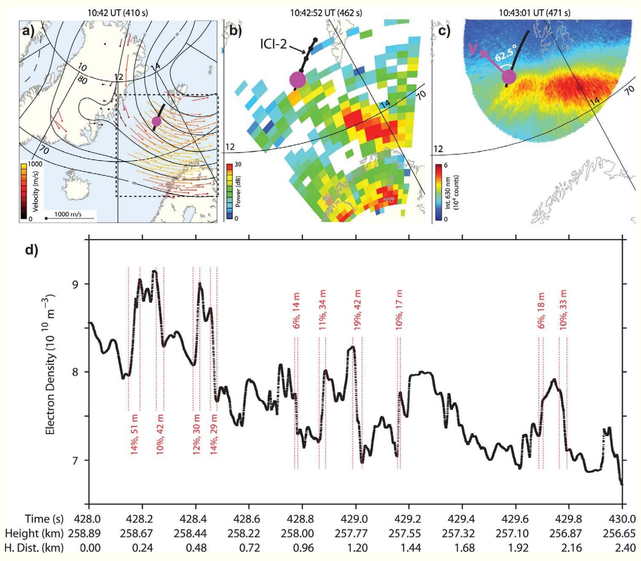


Figure to the left:
(a) SuperDARN convection map
(b) HF backscatter power recorded by the SuperDARN
(c) A 630.0 nm all-sky auroral image
(d) 2 s high-resolution electron density data, measured by ICI as it flew through the auroral arc. They showed that the steep gradients in electron densities were consistent with a gradient drift instability process at work

From *Moen et al., Geophys. Res. Lett. 39, L07104, 2012*.

CubeSTAR: Planned Launch in 2014

2U CubeSat : A new concept Space Weather satellite to map turbulent ionospheric regions around the Earth