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to the challenges of modern world”

Geodetics measurements within the scope of current and future perspectives of GNSS-Reflectometry and GNSS-Radio Occultation

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Organised by: FIG, CHAMBER OF GRADUATED SURVEYORS

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Introduction

- The aim of this presentation is to provide an overview of the GNSS-R and GNSS-RO concept both in theory and application.
- Investigation of direct, reflected and bent MW GPS signals and its capability for sensing the Earth’s environmental transition impacted by the global warming.

GNSS signal ability:

GNSS-Reflectometry:

- Sensing land and soil moisture, the ocean and sea roughness including monitoring wind speed and wind-driven waves.
- Monitoring of the polar ice sheets, snow thicknesses, glaciers, their surrounding sea's level and estimating new ice on the Arctic region.

GNSS-Radio Occultation:

- Weather and climate forecasting; atmospheric sounding which include water vapor, temperature and pressure

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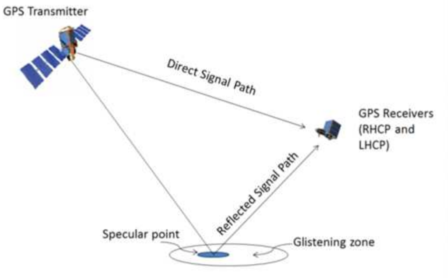
GNSS-Reflectometry



- GNSS-Reflectometry measures reflected navigation satellite signal from water, ice or wet land surfaces
- GPS satellites are constantly broadcasting radio signals to the Earth and some of these signals are reflected back from the rough Earth's surface

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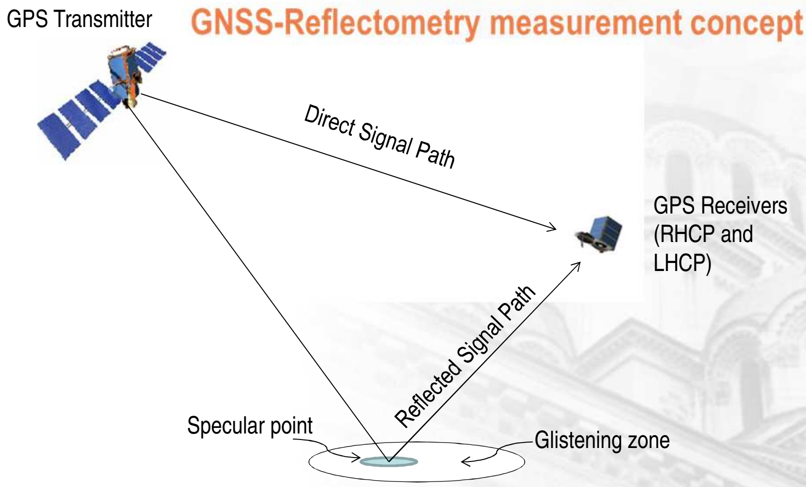
GNSS-Reflectometry measurement concept



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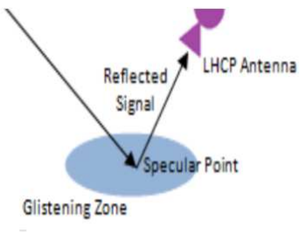
GNSS-R, elements of reflections



- Reflected signal is scattered in different directions
- A majority of the signals reaching the receiver reflects of an area called the *glistening zone*
- Size of glistening zone depends on the surface roughness, incidence angle and receiver height
- *Specular point* is physical contact of signal with surface in glistening zone

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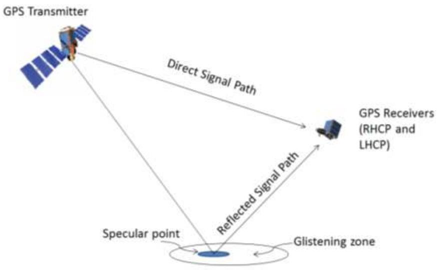
GNSS-Reflectometry



- The receivers were carried either by space platforms (LEO orbit) or by aircraft and stratospheric balloons or based on the ground

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Space-based Instruments 1/2

- LEO Orbit (piggy pack)
- Day and night operation without the influence of the different weather conditions
- GPS L-band signals are sensitive to the atmospheric gas and plasma distribution over the ocean

- Possible to quickly detect a tsunami in the deep ocean.

The early warning system of tsunami detecting, presents the large synoptic view of ocean in only 150 seconds for an area of 1000km x 1000km

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Air-based Instruments 1/2

- Working on the same principle as space-based, air-based instruments in general record the raw data on board the one aircraft (or balloon) and later post-processed them in a laboratory.

- Main parameters to observe over the sea surfaces are:
  - Wind speed at 10 m
  - Duration of the wind
  - The fetch (the distance over which sea surfaces wind was blowing at the constant speed

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Air-based Instruments 2/2

Challenges:

- The airplane position is not stable, causing a change in the distance between the transmitter and the receiver (characterized by a Doppler effect)

The characteristics of the sea surfaces is divided into three stages :

1. Creation of a theoretical model (Input Elfouhaily Model into Kirchhoff Model helps to estimate and understand the expected behavior of scattering signal from glistening zone)
2. Creating the Delay-Doppler map (DDM)
3. Analysis of DDM (characterization of the sea surfaces)

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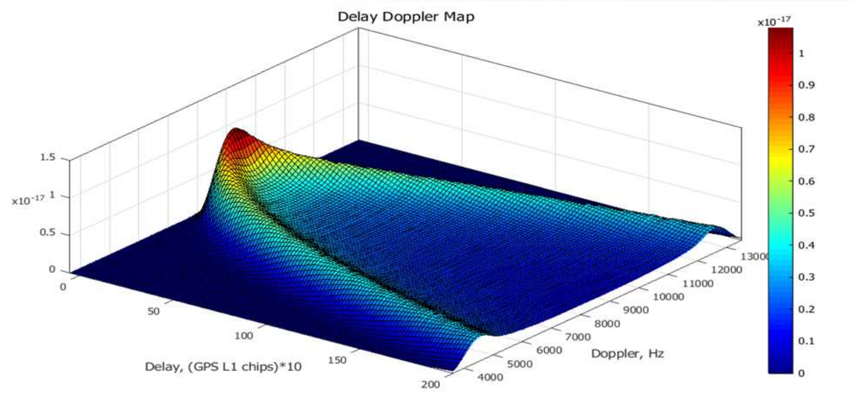
Air-based Instruments 2/2



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Ground based Instruments

- For local observation, many coastal and "bridge" experimental campaigns were done
- The accuracy of given results are more than satisfactory
- The main principle to accumulate and process measurement data for a long period continuously and compare with measurement in situ

(e.g. Disko Bay - objective was to explore the sustainability of using reflected GPS signals to scrutinize properties of dry snow, sea-ice and the prediction of the ice age from space.

Performance of GNSS is limited in the Arctic area compared to latitude (maximum elevation through a GPS reflection of 65 °

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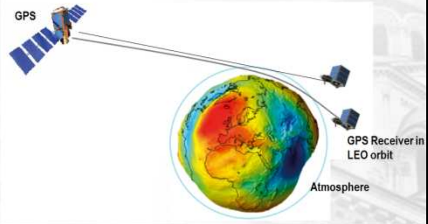
GNSS-RadioOccultation

Advantage :

- to augment current weather data sets to produce accurate weather results which consist of density profiles and temperature in different atmospheric layers like troposphere and stratosphere.
- Also measure is the ionospheric total electron content (TEC) which is involve in calculation of carrier phase delays of transmitted radio signals from satellites.



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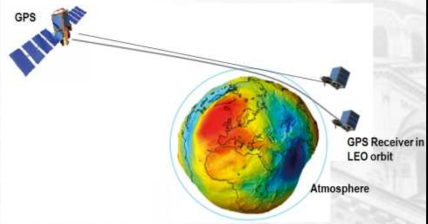
GNSS-RadioOccultation

- The continuous radio signals are broadcasted until the GNSS signals set below the Earth's atmosphere (go down below the surface).
- GNSS signal bends due to the atmosphere of the Earth before it arrives to the receiver
- The signals that have passed through the Earth's atmosphere scan layers of the atmosphere and simultaneously determine the vertical profiles of the refractive atmospheric index



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Conclusion

- Implementation of GNSS-Reflected measurements in monitoring of the current situation and future disasters prediction such as prediction of tsunami, monitoring ocean eddies, flooding and other observations of the Earth.
- *Radio Occultation* measurements have been proven also as good and accurate results compare to the results given by number of meteorological centers around the world.
- Relatively low cost of mission

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Future work

- In the near future, GNSS-R and GNSS-RO are expected to flourish as an emerging application in the field of remote sensing obtaining fast and accurate results.
- Future research will be focused on the capabilities of those techniques in terrestrial measurements and its benefits on possible replacement of present geodetic techniques of remote sensing.
- GNSS-RO has to be investigated in research for monitoring the Ozone Hole

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Thank you !

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