ESTIMATION OF THE ATMOSPHERIC REFRACTIVITY FROM WEATHER RADAR DATA

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AtlantTIC

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MOTIVATION OF THE WORK

Knowledge with enough temporal and spatial resolution of the atmospheric refractivity variations in the lowest part of the atmosphere.

It is of importance in numerous fields, such as:

- Meteorology where it is used to derive temperature and humidity which is important because the convergence of moisture at low-levels is related to the initiation of severe storms and large horizontal variations in moisture are related to initiation of deep convection [1].

Figure 1: Initiation of deep convection.

- Electromagnetic wave propagation coverage prediction, where in this case, it is important to reduce interference between nearby stations and to ensure the required signal level within the whole coverage area. Besides, knowledge of the refractivity gradient with enough temporal resolution will be of interest in the dynamic management of the spectrum [2].

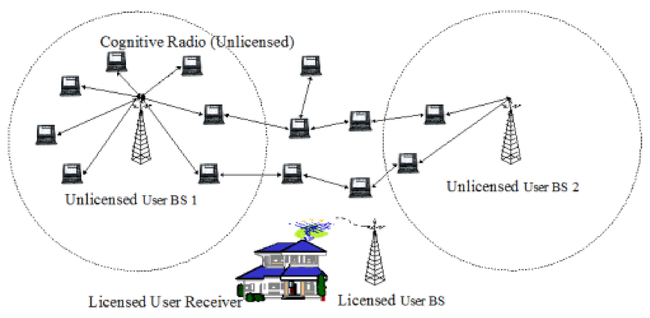

Figure 2: Coverage predictions.

The most commonly used techniques, such as radiosonde launches or radio occultation techniques using a GPS signal, are not able to provide sufficient spatial or temporal resolution and they are not suitable for measuring near surface refractivity.

Recently it has been shown that refractivity can be obtained from radar measurements with a high spatial and temporal resolution about flat terrain [3, 4]. In particular, it can be obtained from measurements of phase variation between responses from stationary targets at different time instants.

Remaining challenges are to estimate the refractivity about complex terrain taking into account height variations between radar and targets, vertical gradient variations and the Earth's curvature [5].

THESIS OBJECTIVE

The objective of this thesis is to improve the actual algorithms for estimating refractivity by means of weather radar data. With this purpose the work lines considered will be:

- A search method of stationary targets independent of the atmospheric conditions. For this purpose, a variability index based on dual polarization measurements, which depends only on the movement of the targets, was defined as:

$$SI = \frac{1}{(S-1)M}\left|\sum_{l=1}^{S-1}\sum_{k=1}^{M} e^{j[\{\phi^{HV}_{l,k}\}-\{\phi^{HV}_{l-L,k}\}]}\right| \quad (1)$$

- A more accurate description of the phenomena involved to reduce uncertainties improving the existing algorithms to estimate the refractivity taking into account the height variation between the selected targets and the radar whose paths might be misaligned, the vertical variation of the atmospheric refractivity and the height ray above the surface of the ground.

$$n(h,t) = n(h_R,t) + (h(r,t) - h_R)\frac{\partial n(h_R,t)}{\partial h} \quad (2)$$

RESEARCH PLAN

In order to achieve the objectives proposed the following research plan is considered. This plan is reviewed after each task in view of the results obtained.

	2013	2014				2015				2016		
	T4	T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3
Bibliographical review												
Analysis and improvement of wave propagation models												
Evaluation of available technological resources												
Planning of measurements campaign												
Implementation of the proposed algorithm												
Analysis of the proposed algorithm and comparison with others in related literature												
Dissermination of the results (Thesis)												

NEX YEAR PLANNING

- Current works are focused on including height variations, whenever the radar and the ground clutter are not at the same height, and refractivity vertical gradient in the algorithms for the estimation of refractivity on the surface.
- Next year work will focus on the publication of results and the production and defense of the dissertation.

RESULTS: VARIABILITY INDEX

Variability measurements of the received voltage taking into account the variations between the co-polarized components from the ground clutter to remove the refractivity contribution.

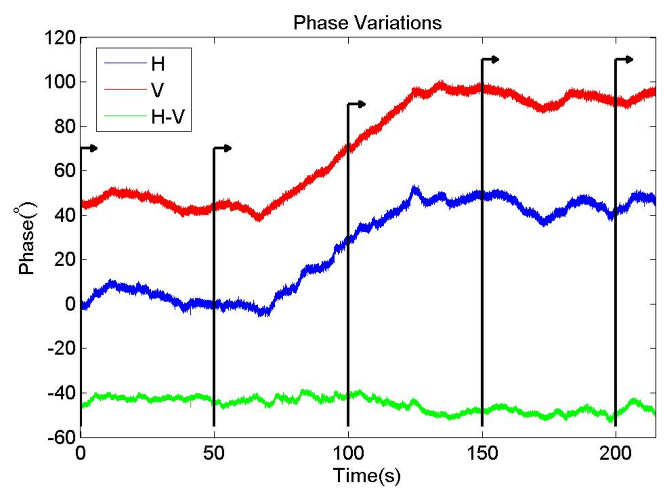

Figure 3: Stationary target and slight ΔN.

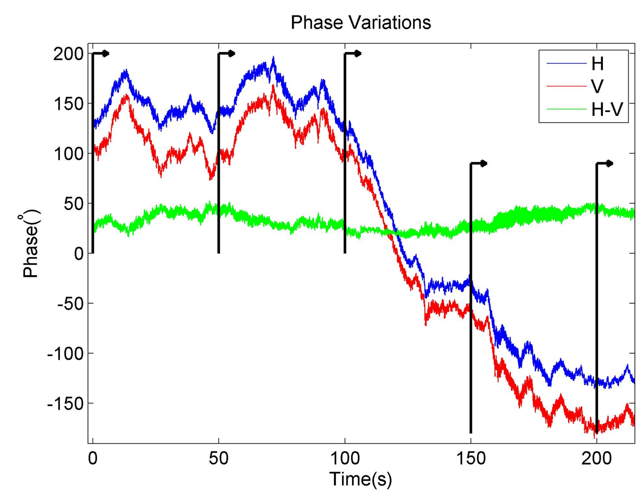

Figure 4: Stationary target and strong ΔN.

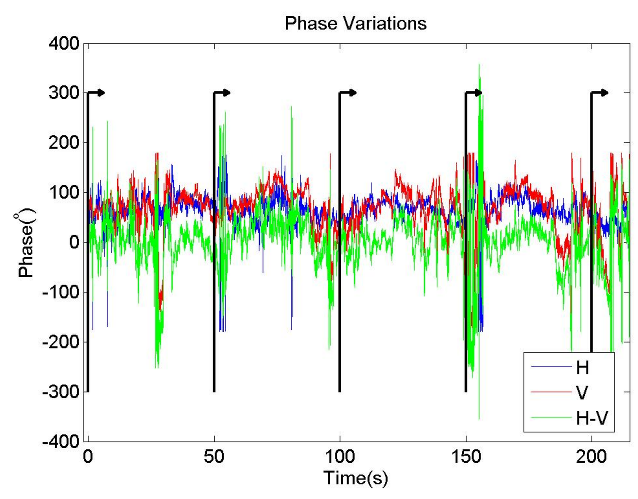

Figure 5: Non-stationary target.

- R. Nocelo and V. Santalla. "Statistical Characterization of the Ground Clutter Variability from Dual-Polarization Radar Measurements". In the 2015 IEEE International Radar Conference (RadarCon), Arlington, Virginia, USA, May 2015.

RESULTS: VERTICAL GRADIENT

Phase increments about several tens of degrees between nearby targets is necessarily due to height variations between targets and vertical gradient variations unless a very strong refractivity variation happens inside radar resolution cell. However, a high degree of similarity is observed among vertical gradient increments when height variations are corrected for.

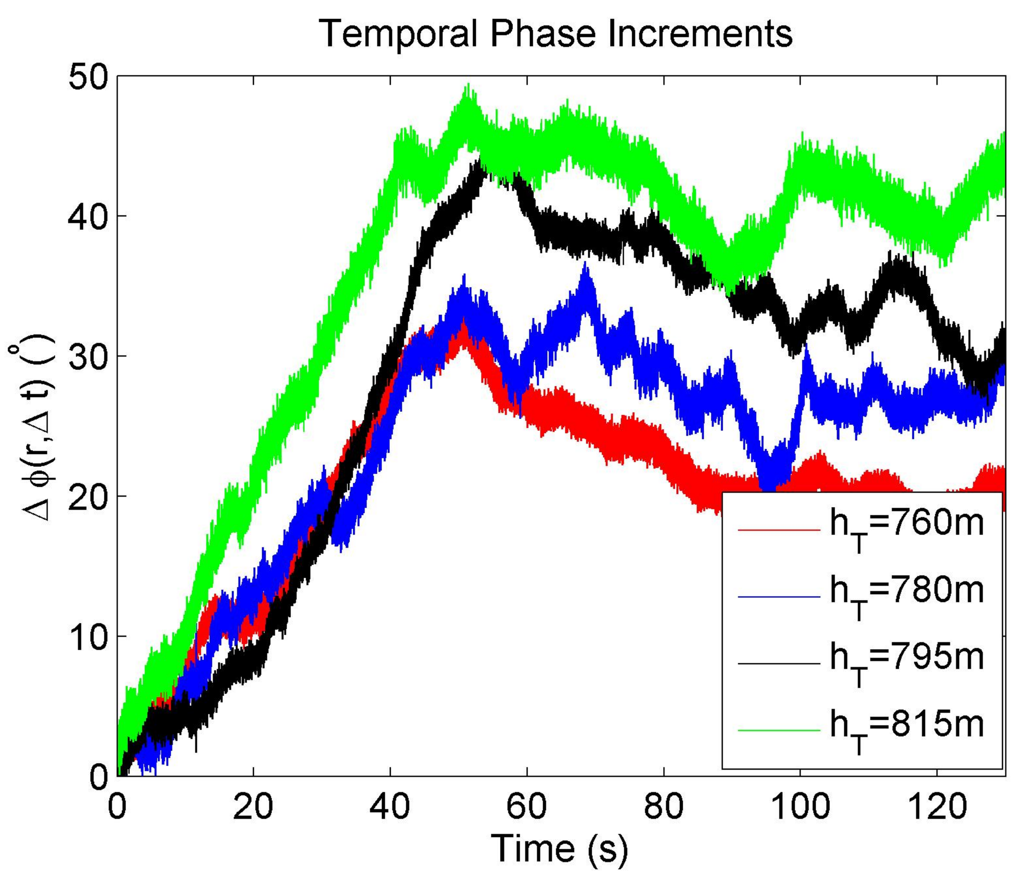

Figure 6: Phase increments obtained from trihedral reflectors.

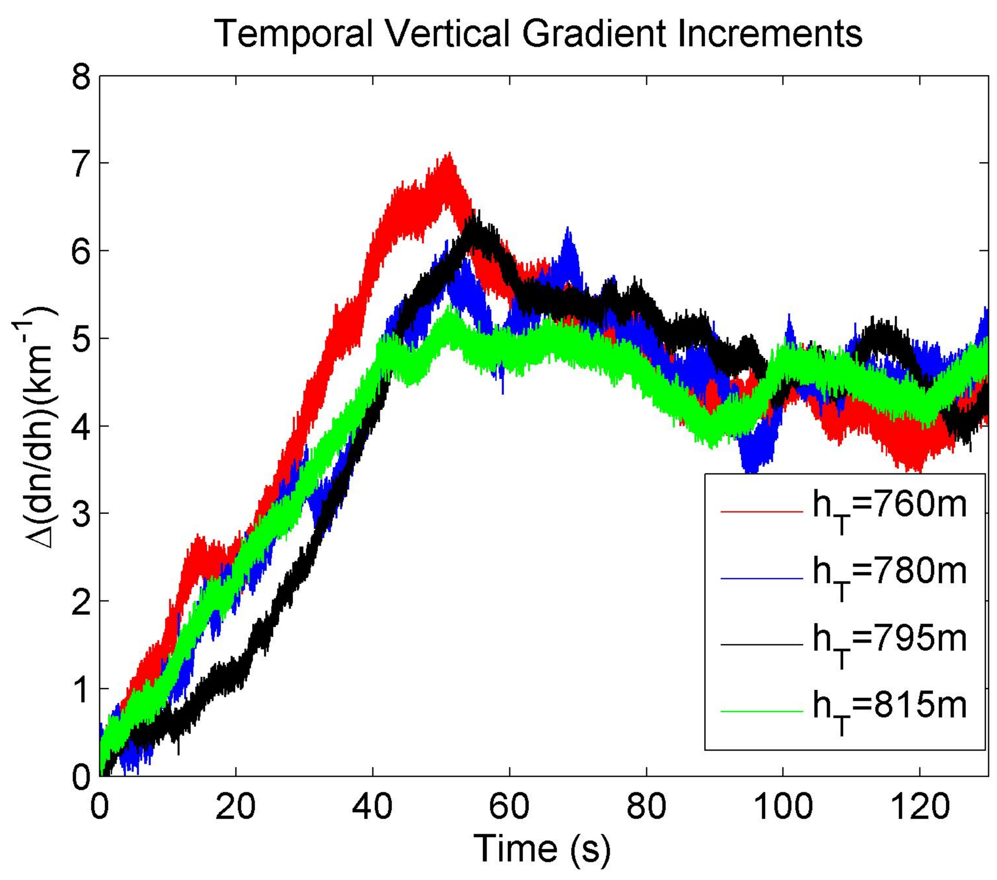

Figure 7: Vertical gradient increments from trihedral reflectors.

- R. Nocelo and V. Santalla. "Estimation of the Vertical Gradient of the Atmospheric Refractivity from Weather Radar Data using Square Trihedral Corner Reflector Returns". In the 2015 International Geoscience and Remote Sensing Symposium (IGARSS), Milan, Italy, July 2015.

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