MLT wind estimations obtained from specular and non-specular meteor trails at Jicamarca: Preliminary results

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Abstract

Many non-specular meteors studies have been conducted with the high-power large-apertura (HPLA) radar at the Jicamarca Radio Observatory (JRO). Here, the authors present the preliminary results of a comparative study of Mesosphere and Lower Termosphere (MLT) winds (85-105 km) obtained from non-specular meteor trails detected with this radar and specular trails obtained with the Jicamarca All-Sky METeor system that operates at 30 MHz (JASMET 30).

A coordinated campaign was conducted on the night of June 2nd-3rd. As in previous studies, the non-specular meteor trails were contaminated by the Equatorial ElectroJet (EEJ). Therefore, an algorithm was developed to calculate winds under this condition.

Introduction

MLT winds are essential for the understanding of tides, gravity waves, and planetary waves. These winds can be measured through various techniques such as rockets that release chemical tracers (Larsen, 2002), or optical MLT imagers (Shiokawa et al., 2009). However, rockets are too expensive, and optical imagers cannot resolve winds as a function of height.

Another tool is the specular meteor radar, which can detect plasma trails and estimate neutral winds with them, but only when the trail paths lie perpendicular to the radar beam. An example is shown in Holdsworth et al. (2004), where researchers continously monitored wind velocities from 75 km to 100 km for a week. However, measurements required high spatial and time averaging, which can remove some extreme velocities observed with other techniques.

Recent attention has been driven to non-specular meteor trails. This technique can provide detailed estimations with a height resolution of a few hundred meters. Promising results have been obtained with JRO HPLA radar (Oppenheim et al. 2014). However, additional experiments are needed. In addition, at JRO, EEJ is a major interference source that complicates estimations.

Objectives

- •Estimate and compare MLT zonal and meridional winds profiles from two different instruments.
- •Develop a computational method to automatically identify non-specular meteor trails in the presence EEJ, using Digital Image Processing (DIP) algorithms.

Data Collection and Analysis

1. Specular Meteor Trails (SMT)

- •JASMET 30 system was used to detect specular meteor trails.
- •The radar antennas are distributed according to Jones et al. [1998]
- •A computational method was implemented following Holdsworth et al. [2004] to process the data

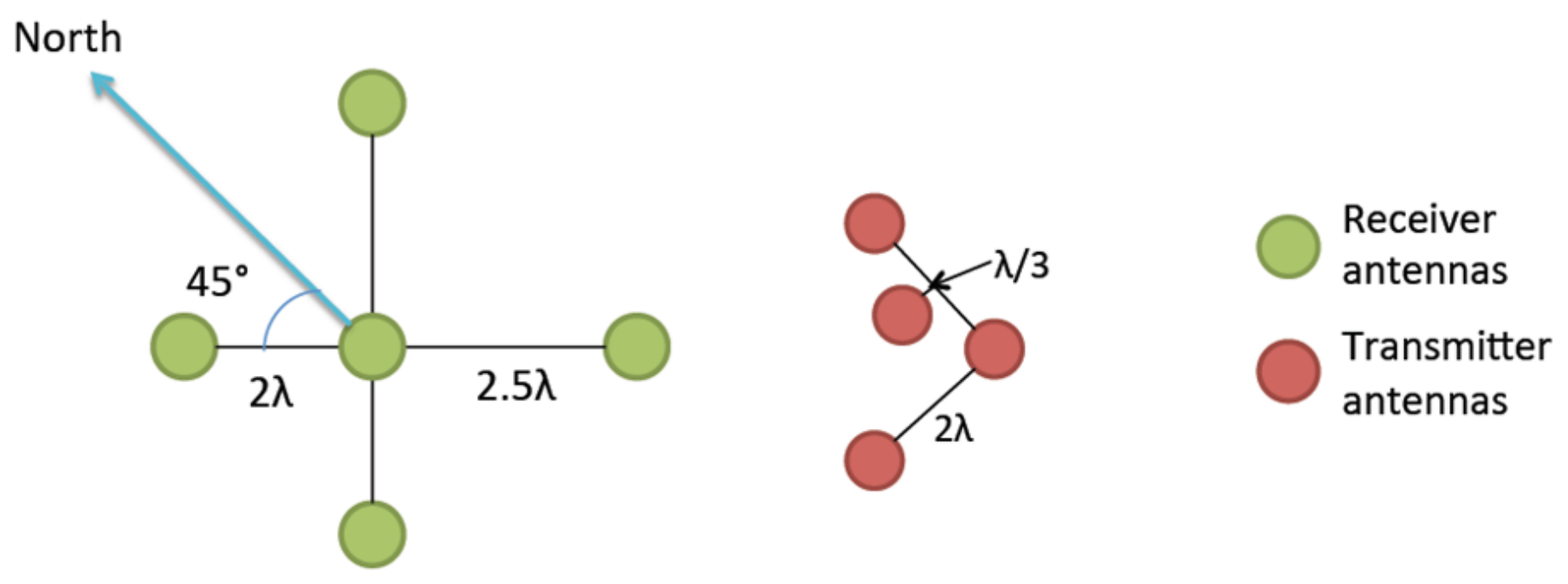


Figure 1 : JASMET 30 antenna distribution Jones et al. [1998] configuration is optimized to detect specular meteor trails.

2. Non-Specular Meteor Trails (NSMT)

- •Jicamarca HPLA radar was used in the ¨Meteors¨ interferometric mode (Chau & Woodman, 2004).
- •Three quarters of the antenna were used as receptors.
- •The array pointed 1.9° off-perpendicular to $\vec{B}$ to decrease the contamination from EEJ at the cost of weaker meteor trail signals.
- •Winds are estimated with the phase differences between channels following Oppenheim et al. (2009).

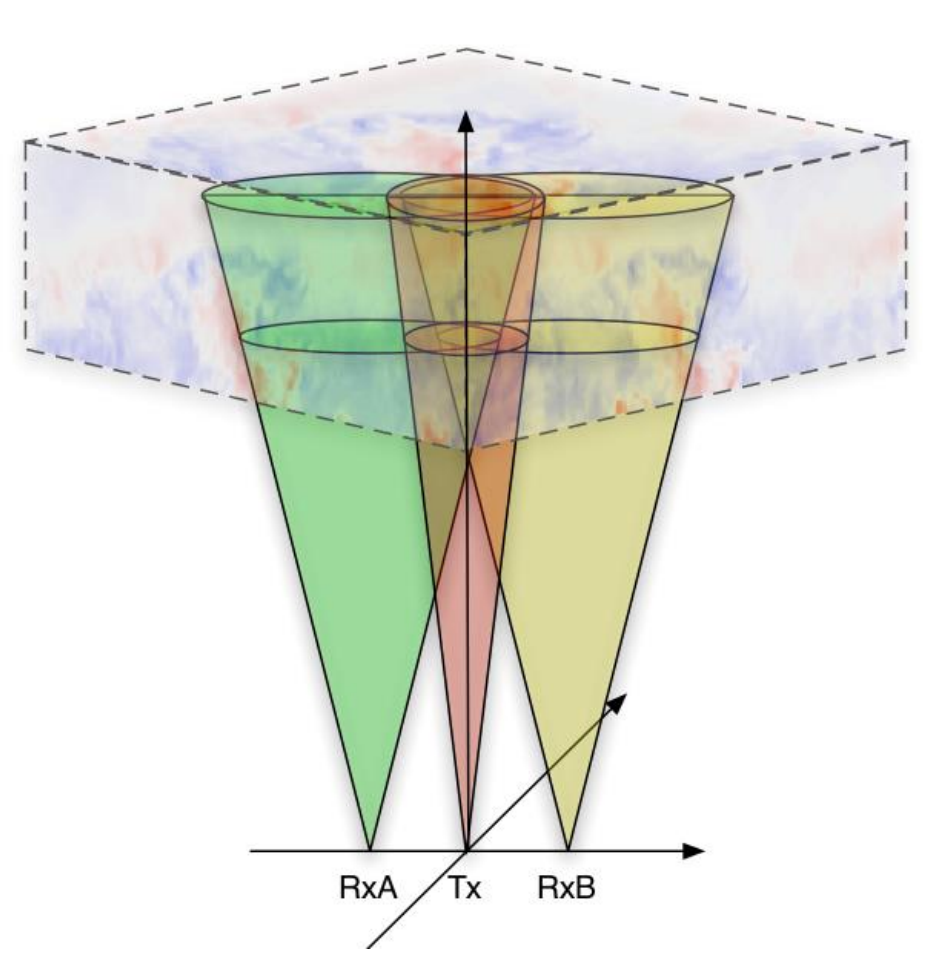


Figure 2: Simplified Interferometry diagram. Two receptors detect the meteor echoes. Winds are estimated along the baselines with the phase difference between channels.

3. NSMT Automatic Detection in the presence of EEJ

3.1 Parameters Calculation, the following parameters are calculated:

- Coherence between channels
- Phase difference between channels
- Average SNR

3.2 SNR Analysis, SNR is thresholded (default 10 dB), which yields binary image $I_{SNR}(x,y)$. Small objects are identified using the Labeling algorithm (Gonzalez & Woods, 2002) and excluded.

Heights contaminated by EEJ are identified with the percentage of selected profiles from the total. Those heights are deleted.

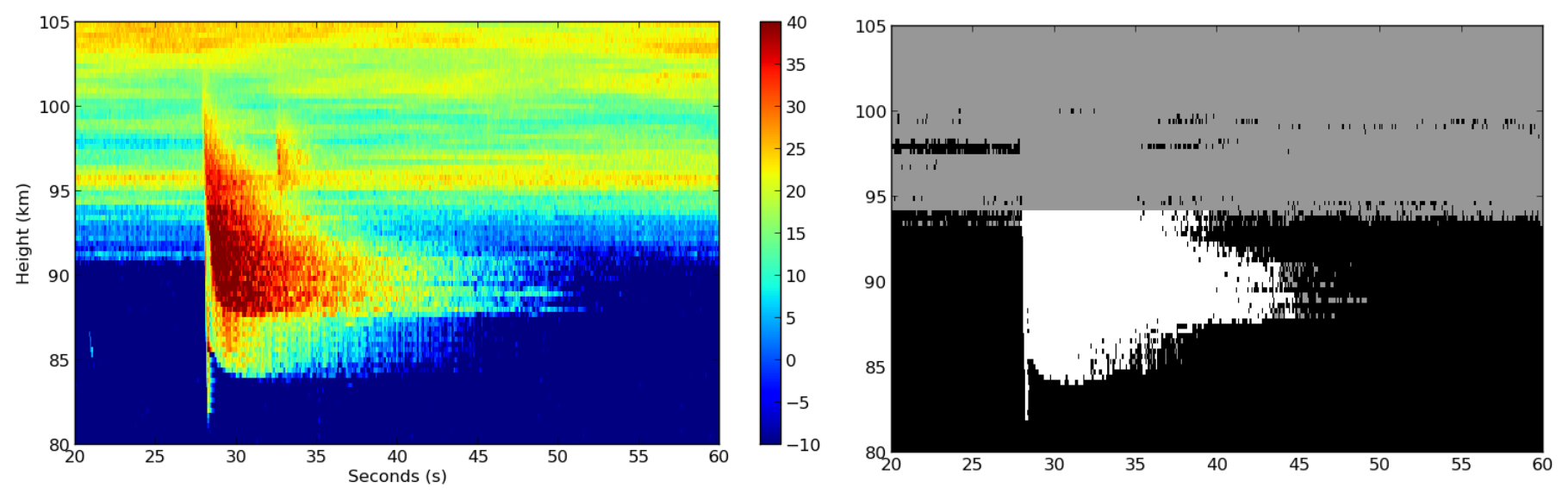


Figure 3: SNR analysis. (Left) Meteor trail SNR, (Right) Thresholded image $I_{SNR}(x,y)$. Points excluded after the threshold are colored gray.

3.3 Coherence analysis, Coherence is also thresholded (default 0.8), which yields image $I_{COH}(x,y)$. Small objects are excluded as in step 3.2 and, in this case, heights free of EEJ interference are erased.

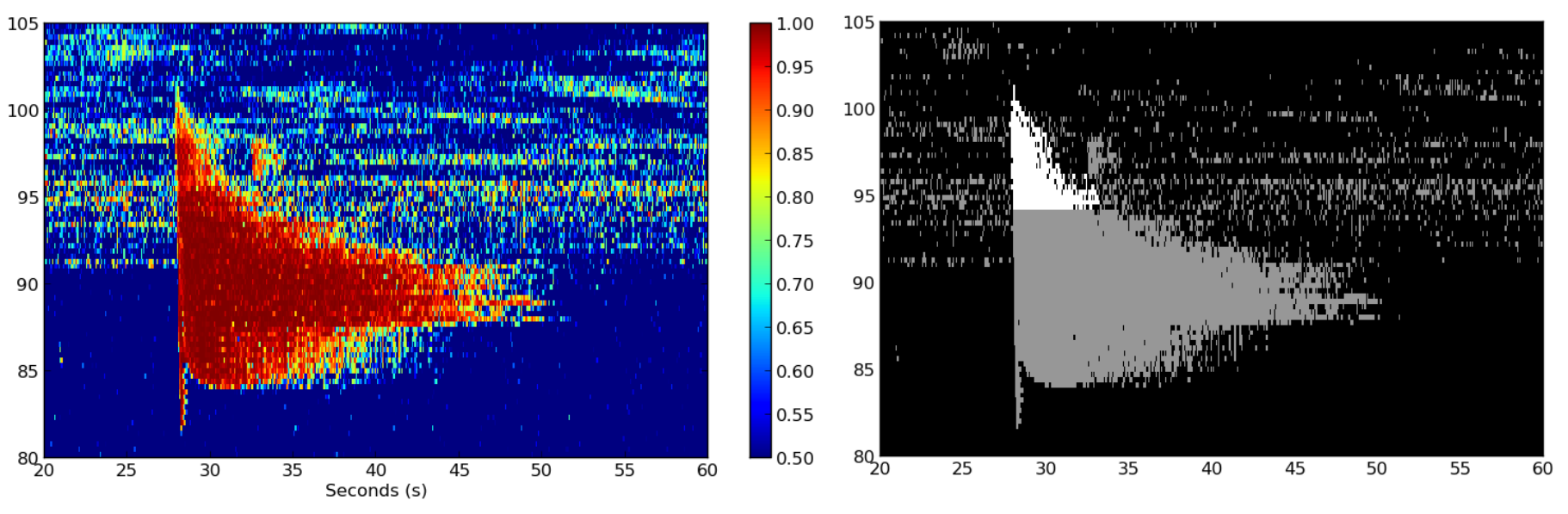


Figure 4: Coherence analysis. (Left) Coherence between two channels. (Right) Thresholded image $I_{COH}(x,y)$. Points excluded after the threshold are colored gray.

3.4 Mask combination

I_{SNR} and I_{COH} are combined to obtain the final mask which will segment the meteor trail and provide only the useful phase difference information.

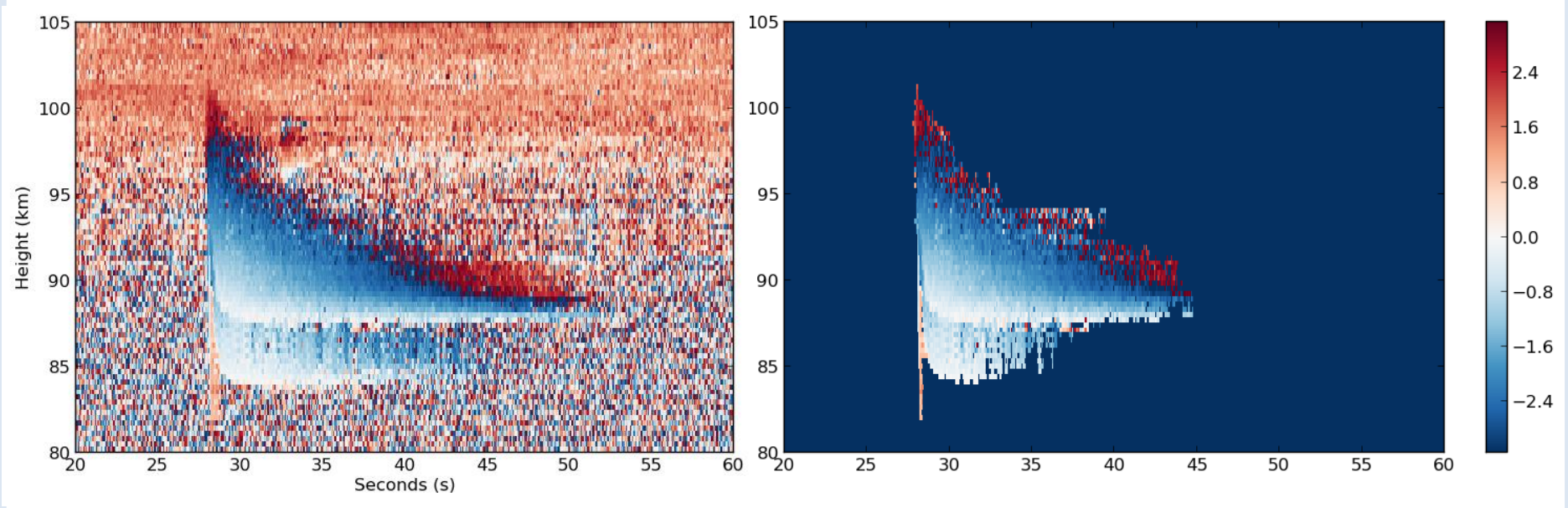
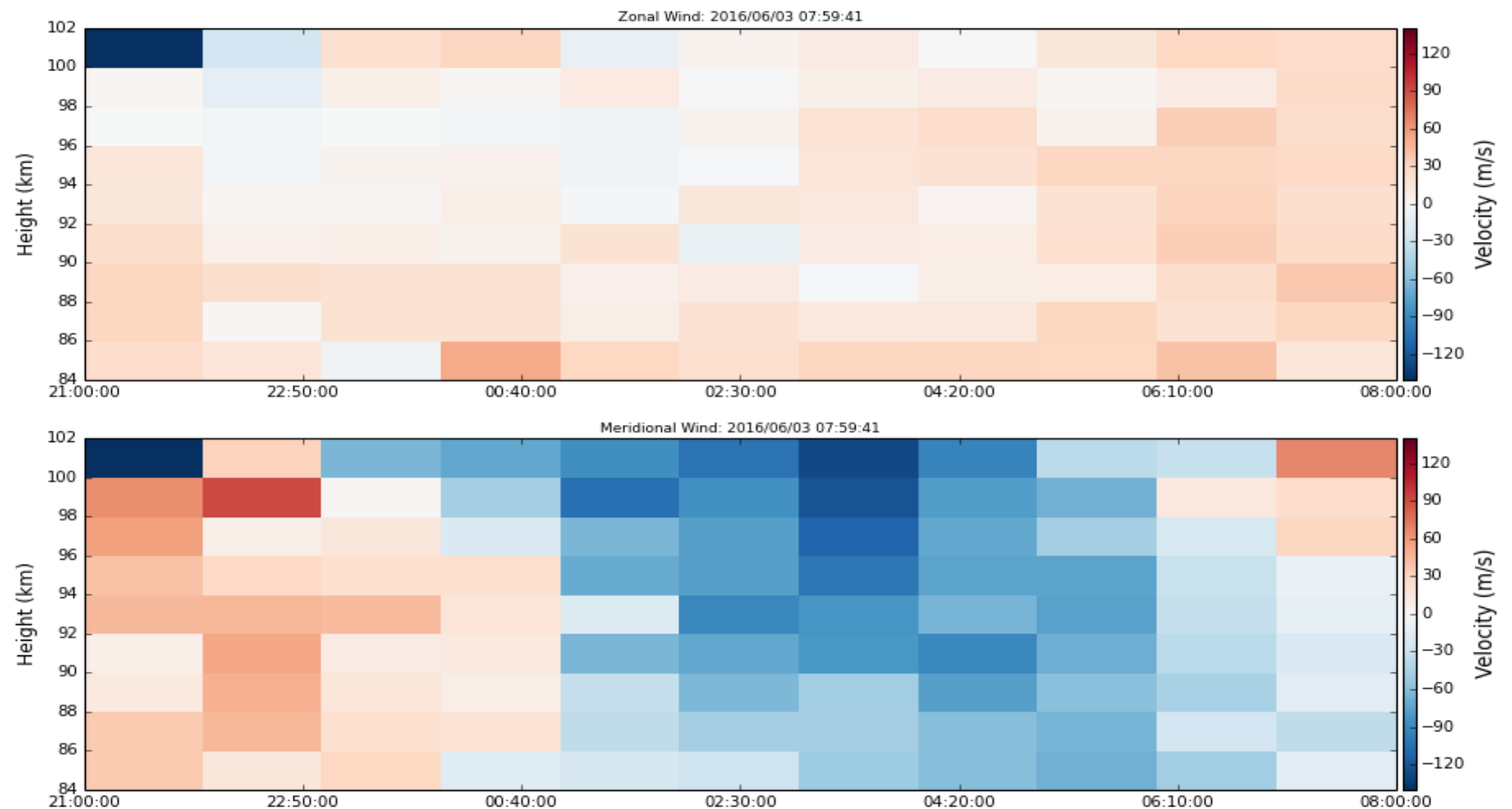


Figure 5: Trail Segmentation. (Left) Phase difference between channels. (Right) Segmented phase information for wind estimations.

Results

a. Estimations with Specular Trails



b. Estimations with Non-Specular Trails

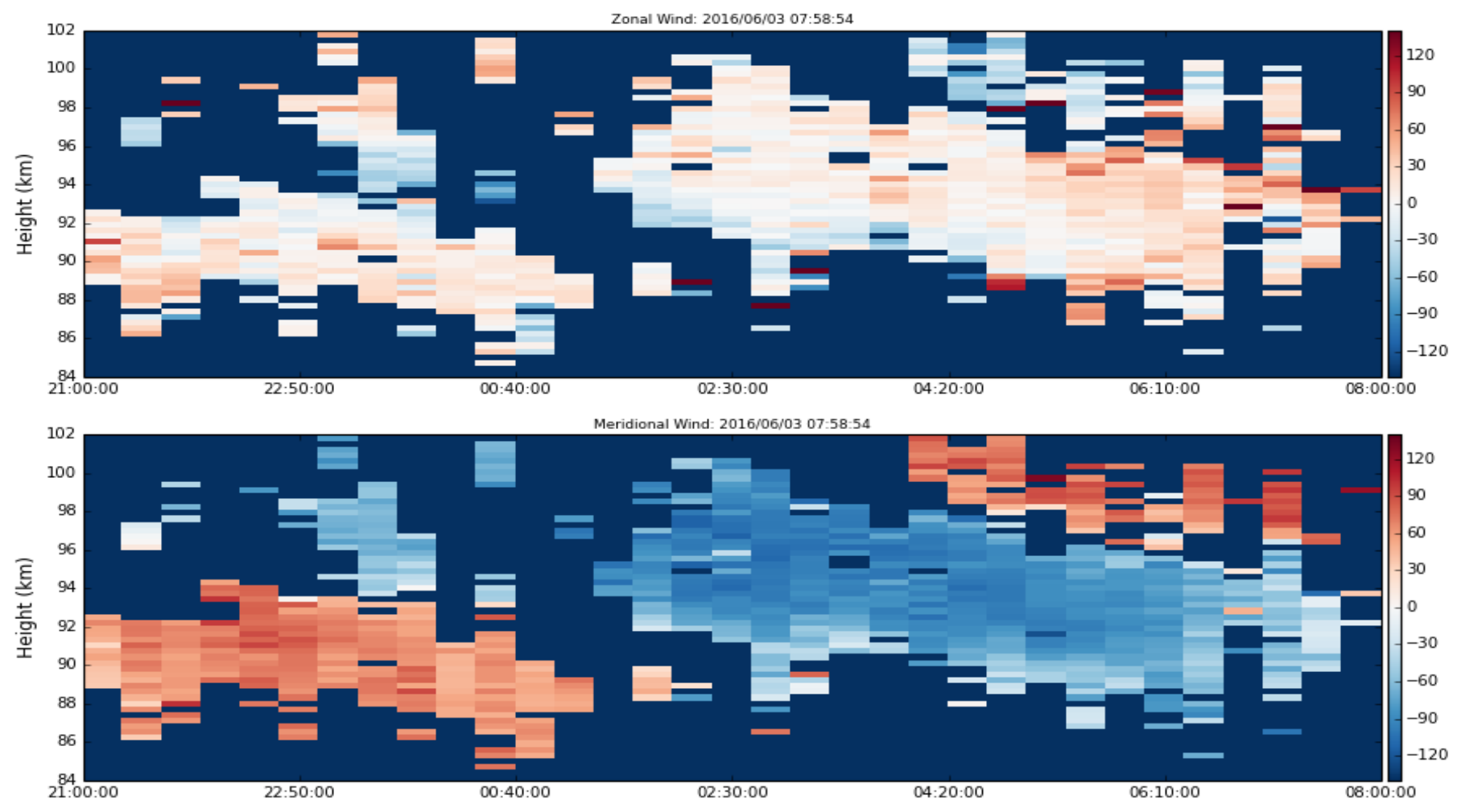


Figure 6: **a.** Wind estimates with SMT. **b.** Wind estimates with NSMT. Zonal winds (up) and Meridional (down) for both.

Conclusions and Future work

- •Zonal and Meridional wind estimations are in reasonable agreement.
- •Labeling algorithm was useful to reject unwanted echoes.
- •As a first attempt, the NSMT detection inside EEJ was succesful. However, these meteor trails have less phase information as they are partially masked by EEJ.
- •The estimations can be improved by enhancing the meteor trails segmentation with more DIP algorithms.
- •A larger campaign is planned to make a more thorough validation of the methods.
- •A third wind estimation method is planned to be added, which is based on the Doppler Beam Swinging technique.

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