Enhancing high-resolution storm cell tracking

A multi-threshold TITAN algorithm in synergy with optical flow technique

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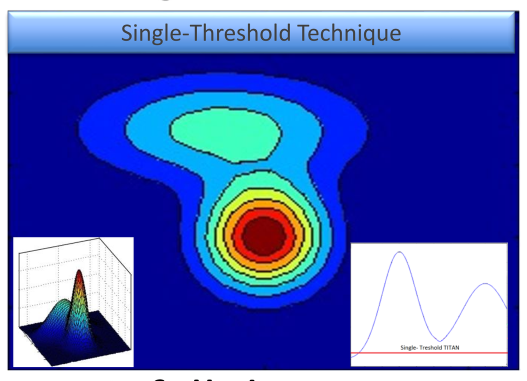
1. Introduction

TITAN (Thunderstorm Identification, Tracking, Analysis, and Nowcasting) is an object-based storm tracking algorithm, which was developed for convective rain cell tracking (Dixon and Wiener, 1993). However, due to the single-threshold setting, TITAN was not able to well identify adjacent storm cell clusters. In addition, its tracking algorithm was developed based upon an overlapping technique, which has proven to be less effective for capturing fast moving storms and for high spatial-resolution rainfall data.

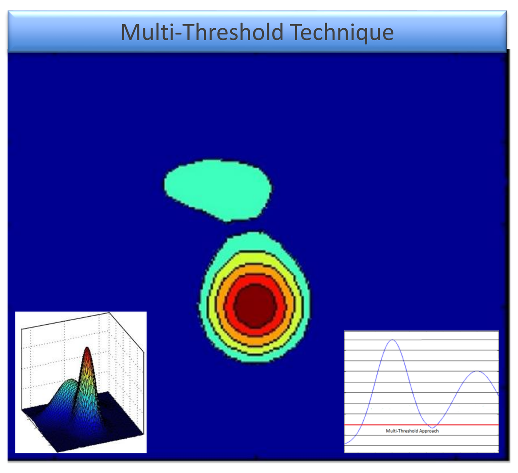


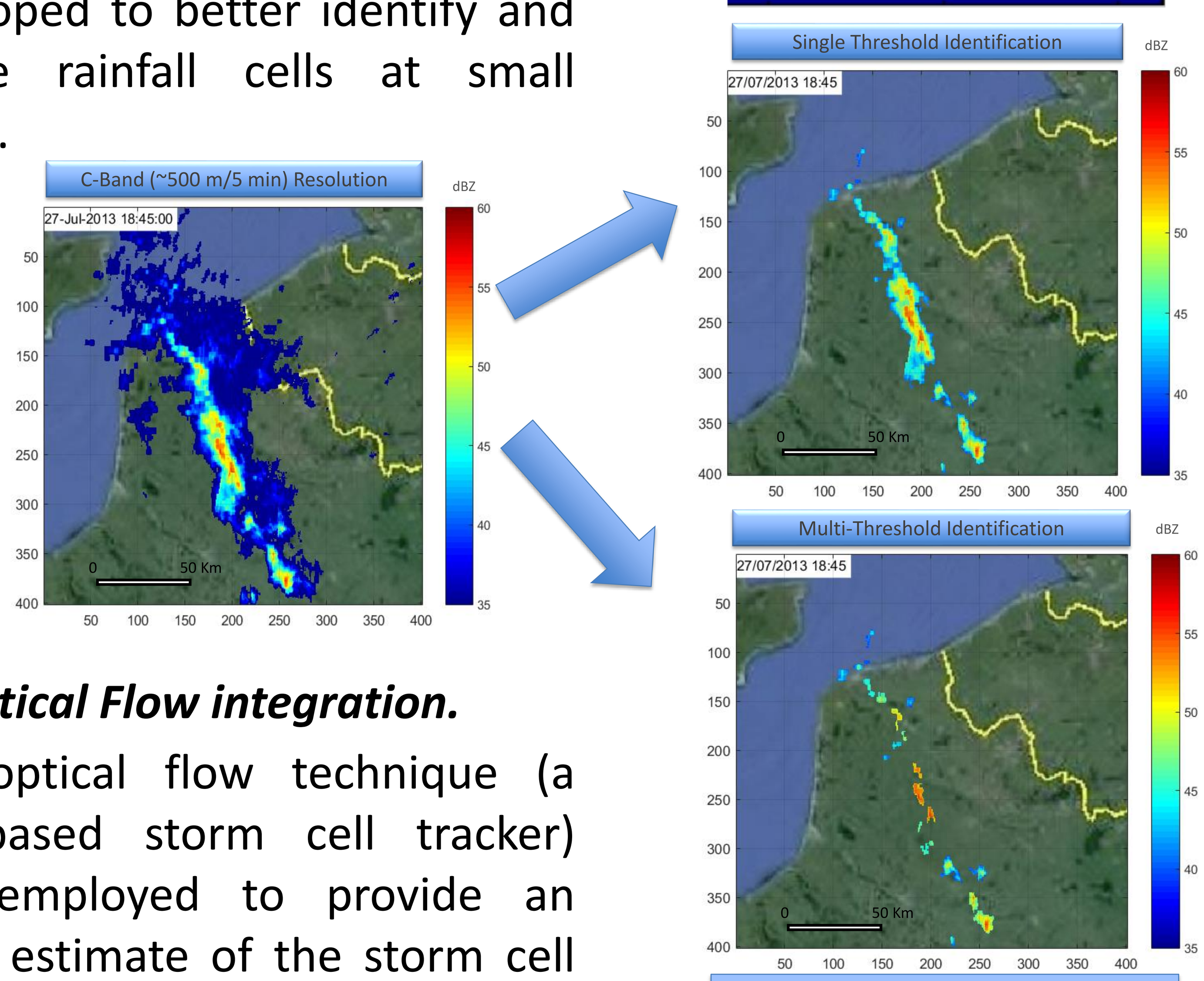
2. Methodology

To improve the applicability of the original TITAN to high-resolution rainfall data processing, two treatments have been incorporated in this work.

1. ***Multi-threshold identification.***

Based upon the hierarchical threshold segmentation (HTS) method (Peak and Tag, 1993), a multi-threshold technique was developed to better identify and isolate rainfall cells at small scales.





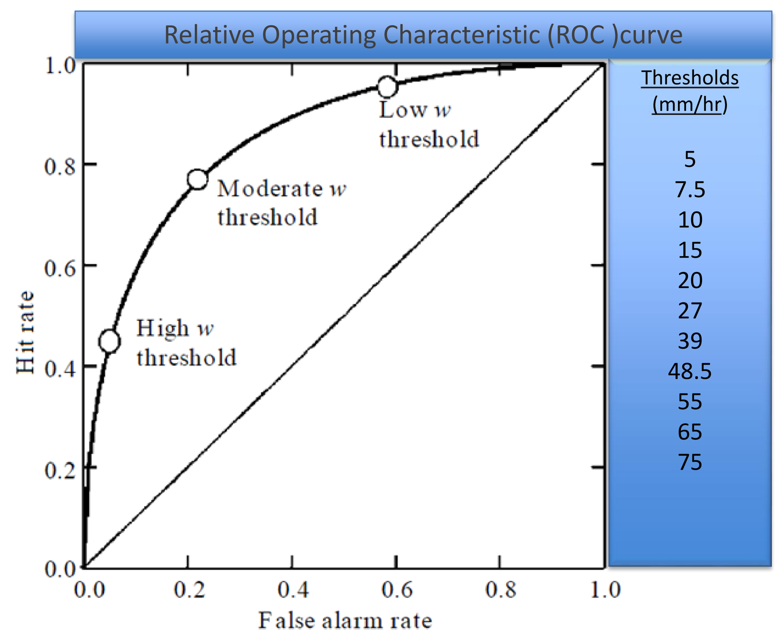
2. ***Optical Flow integration.***

The optical flow technique (a field-based storm cell tracker) was employed to provide an initial estimate of the storm cell movement. On the basis of this, a combinatorial optimisation method based upon overlapping and dynamic constraints techniques , was developed in order to match storm cells at two successive time steps.

Final Image

3. Results & Discussion

The performance of the enhanced TITAN tracking algorithm was assessed by measuring how well an one time-step deterministic precipitation forecast (making use of the velocity field obtained from the tracking process) captures the real radar observations. The ROC (Receiver Operating Curve) curve analysis was used to evaluate the forecasting result, which allows the investigation of the performance at a range of different rainfall intensities.



Forecast	Observed		
	Yes	No	Total
Yes	a (True Positive)	b (False Positive)	$a+b$
No	c (False Negative)	d (True False)	$c+d$
Total	$a+c$	$b+d$	$a+b+c+d=n$

Hit Rate:

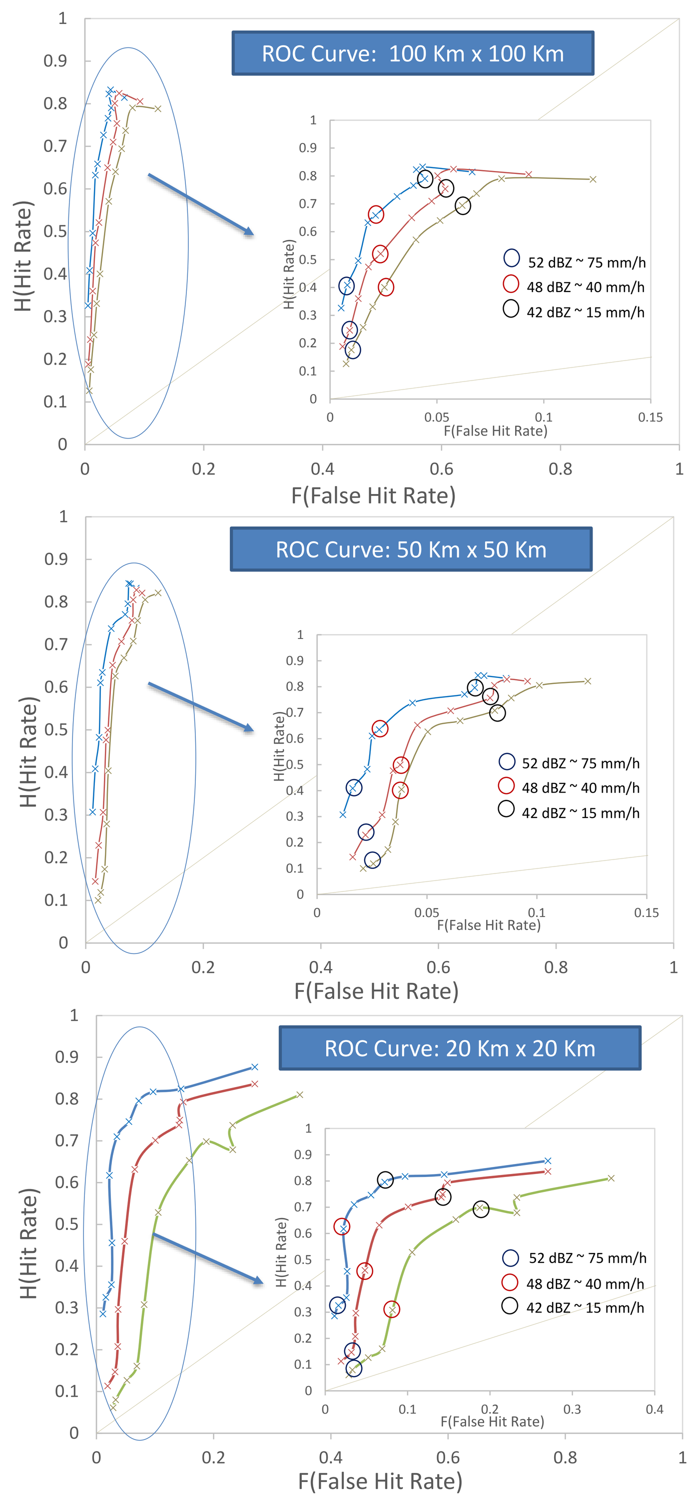
$$H = \frac{a}{a+c}$$

False Alarm Rate:

$$F = \frac{b}{b+d}$$

For unskilled forecasts a ROC plot will follow the diagonal line whereas an ideal forecast would occupy the upper left triangle entirely.

The performance of the proposed treatments are evaluated at the areas centred at Ghent urban catchment but with different extents (i.e. 20, 50 and 100 km). The results suggest that both treatments can lead to improved performance, and the combined use of these two can result in the best performance, which is in particular evident for moderate and high rainfall intensities.



4. Conclusions and future work

Results shows that the enhanced TITAN algorithm can better:

- ✓ Handle high-resolution and high intensity storm details.
- ✓ Avoid faulty tracking between decaying and new born storm cells.
- ✓ Deal with mergers and splits.

It also provides a great basis for future applications, where high-resolution rainfall estimates are critical; e.g., stochastic spatial-temporal rainfall modelling and nowcasting for urban hydrology.

Dixon, M. and Wiener, G. (1993), TITAN: Thunderstorm identification, tracking, analysis, and nowcasting—A radar-based methodology, J. Atmos. Oceanic Technol., 10, 785–797.
Peak, J. E. and Tag, P. M. (1994), Segmentation of satellite imagery using hierarchical thresholding and neural networks, J. Appl. Meteor., **33**, 605–616.
Wang, L.-P., et al., 2015. Enhancement of radar rainfall estimates for urban hydrology through optical flow temporal interpolation and Bayesian gauge-based adjustment, Journal of Hydrology. In press.