Merging GNSS Kinematic Tracks - using the TanDEM-X mission in Africa

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Outline

- Objective
- Tandem-X in Africa
  - Planning
  - Execution
- Processing
  - Issues
  - Examples
- Concluding Remarks

Objective

Use of the Tandem-X missions in Africa to develop automatic procedures to merge single GNSS kinematic tracks

Why Tandem-X? Why Africa?

SEGAL (Portugal) has doing intense collaborative projects in Africa and has privileged relations with many Institutions in Africa.

In this project, we worked together with:

RCMRD – Kenya

BRRI - Ghana

Due to logistical and security constraints, double tracks were measured in the African tracks.

Major Advantage: Redundancy!!!!

But: The double tracks needed to be merged into a single track as final product.

Automatic Procedures necessary due to the huge amount of collected data

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Planned - Southern Africa

Dar es Salaam	Km
Iringa	490
Mbeya	350
Mpika	480
Saulo	460
Solwezi	400
Mbuya (Border)	380
Luacano	320
Luena	220
Saurimo	270
Malanje	570
Luanda	390
Final	***4330***

Southern Africa:

Dar-Es-Salaam (Tanzania) to Luanda (Angola)

2 Tracks:

1. Tanzania & Zambia
2. Angola

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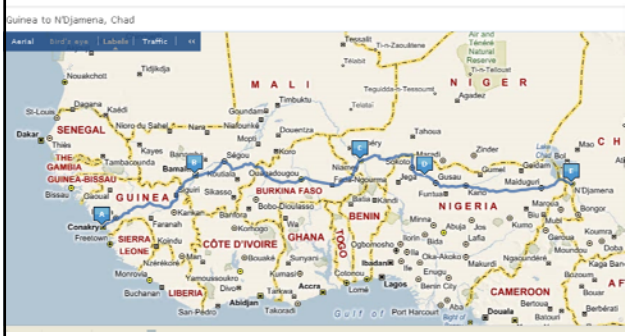
Planned - West Africa



End Town	Date
Accra, Ghana	15-Jul
Abidjan, Côté d'Ivoire	16-Jul
Daguna, Côté d'Ivoire	17-Jul
Monrovia, Liberia	18-Jul
Monrovia, Liberia	19-Jul
Conakry, Guinea	20-Jul
Conakry, Guinea	21-Jul
Kouroussa, Guinea	22-Jul
Bamako, Mali	23-Jul
Segou, Mali	24-Jul
Ouagadougou, Burkina Faso	25-Jul
Fada-Ngourma, Burkina Faso	26-Jul
Niamey, Niger	27-Jul
Dogondoutchi, Niger	28-Jul
Sokoto, Nigeria	29-Jul
Kano, Nigeria	30-Jul
Maiduguri, Nigeria	31-Jul
N'Djamena, Chad	01-Aug
Jos, Nigeria	02-Aug
Lagos, Nigeria	03-Aug
Kumasi, Ghana	04-Aug
Distance	3379
Measurement	4148

West Africa:
Conakry (Guinea) to N'Djamena (Chad)

Starting & End Point:
Kumasi (Ghana)

Executed - Southern Africa

Southern Africa:
Dar-Es-Salaam (Tanzania) to
Skeleton Coast (Namibia)

Starting: Nairobi

4700Km

Executed - West Africa

West Africa:
Conakry (Guinea) to N'Djamena (Chad)

Starting & End Point:
Kumasi (Ghana)

Measured Tracks: 4437 Km

Setup

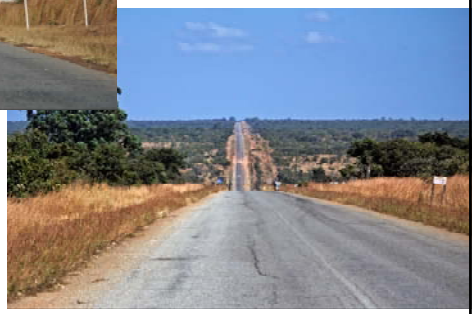
2 Teams separated by 45m (not always pos
1h30m survey + 30m synchronizing
12h-14h daily surveys

Measuring...

Guinea

Measuring...

Zambia



Measuring...

Niger

Processing

GIPSY-OASIS software

Precise Point Positioning (PPP) on kinematic mode

For this study, 1sec data was used - Enough for the development and analysis of the automatic procedures

2 Examples:

Guinea
(dense forest and heavy traffic)

Zambia
(average conditions w.r.t. obstructions)

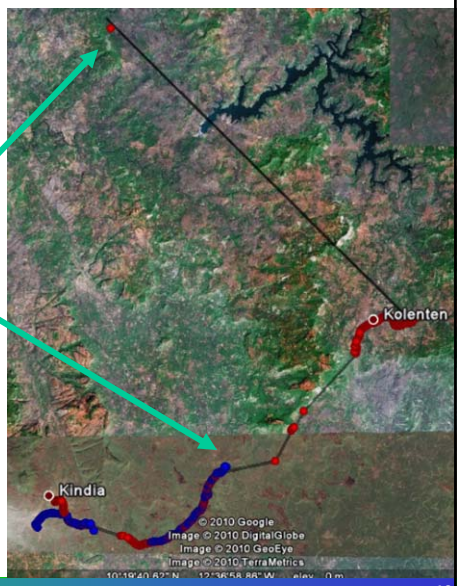
Processed Tracks
Guinea – worst case

Parts of the tracks

not processed

or

with major errors on the estimated positions.



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Processed Tracks
Zambia – average situation

No major issues observed at large scale

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Processed Tracks
Zambia – average situation

Zoom in on Initial part and Final parts of the Track

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Google Earth as validation tool?

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Filtering
Horizontal

Criteria to detect jumps in the tracks:

$T = \min(2^{*}\text{mean}(\Delta d), 28)$ m

$\Delta d = \text{dist}(P_K, P_{K+1})$, $P_K = \{X_K, Y_K, Z_K\}$

IF $\Delta d > T$, it was applied the following correction to all following points in the track:

their position was offset by the same value in order that the new position for P_{K+1} is now on the adjusted line (using linear regression) based on the last 6 points at a distance from P_K that is the average of the distances between the last 6 points.

Comparison between original and filtered tracks

Original

Filtered

Comparison between filtered tracks

Car 1

Car 2

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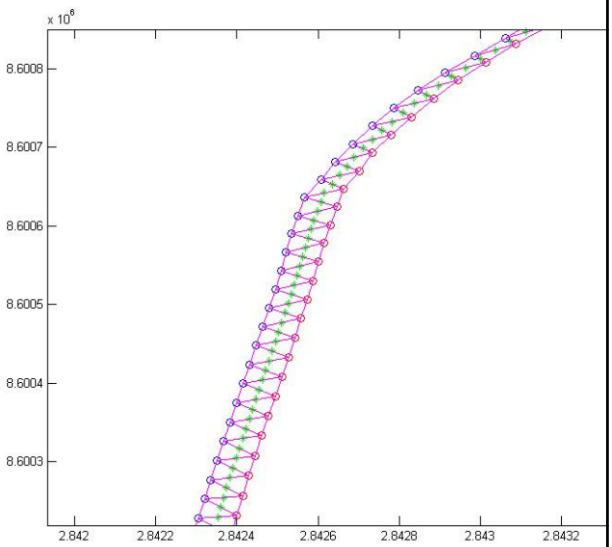
Computation of the merged track

Delauney triangulation using the vertices of both tracks (2+1; 1+2)

Based on Matlab functions



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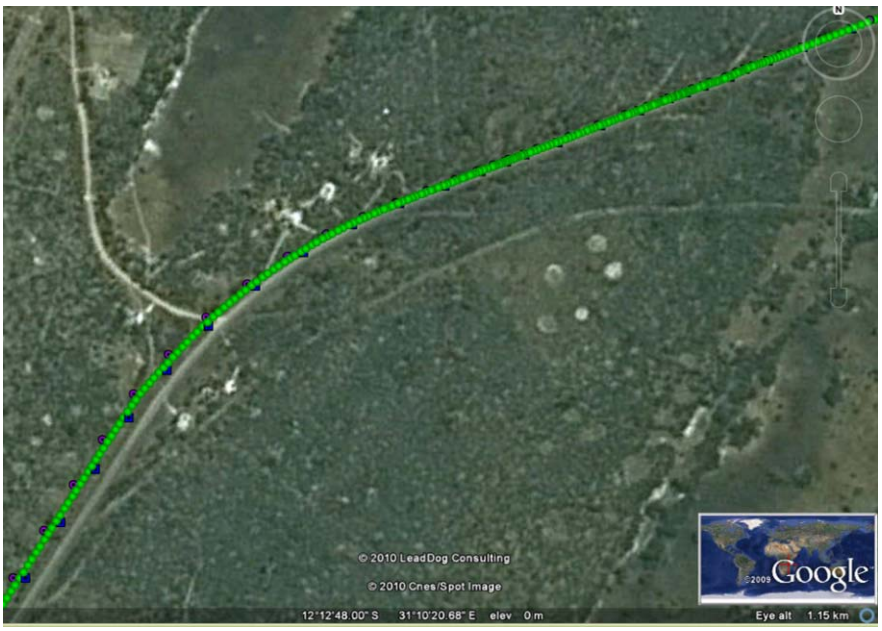
Merged Track (1)



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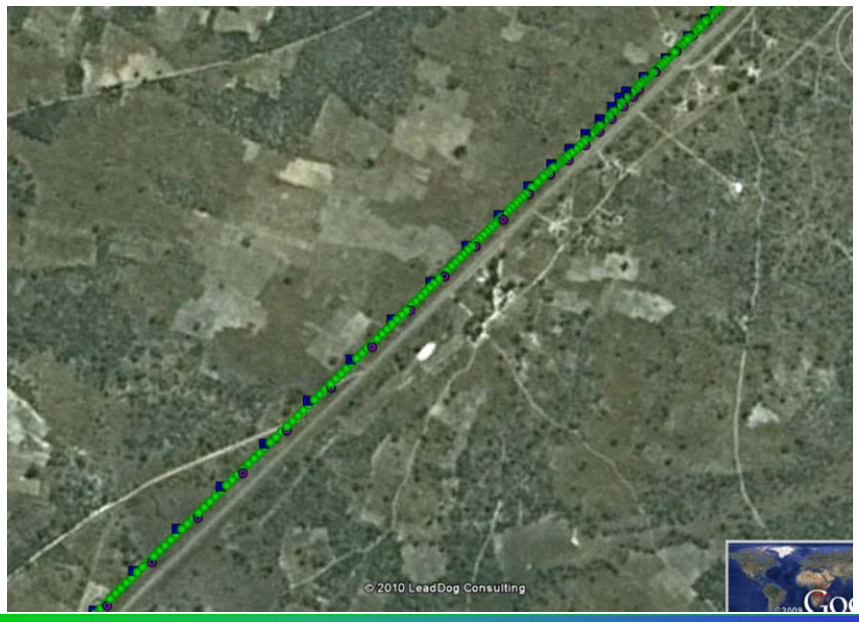
Merged Track (2)



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Filtering Vertical

Criteria to detect jumps in the tracks:

the slope was computed using:

$\Delta s = (\Delta h / \Delta d) * 100 \ (\%)$

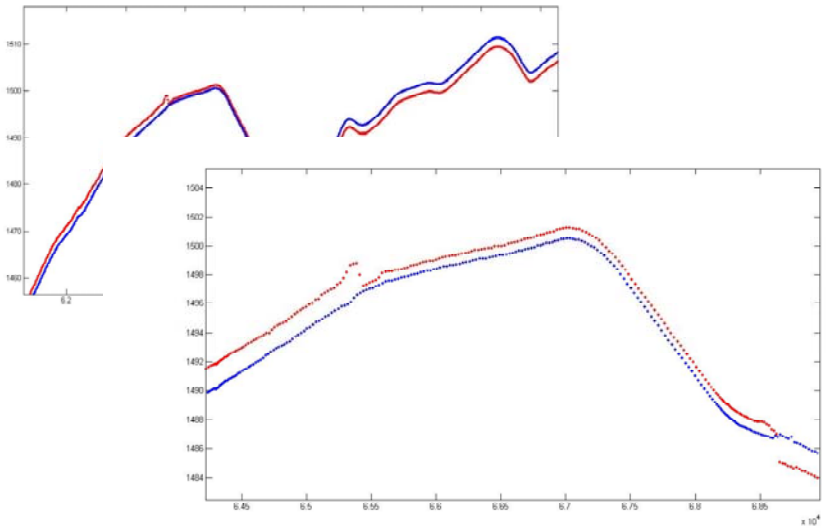
$\Delta h = abs(H_K - H_{K+1})$

$\Delta d = dist(P_K, P_{K+1}),\ P_K = \{X_K, Y_K, Z_K\}$

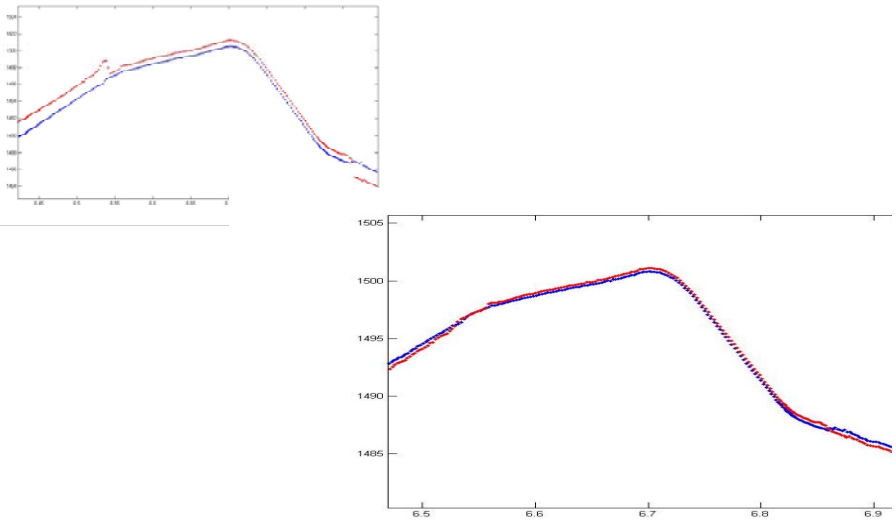
IF $\Delta s > 1.5\%$ or $\Delta h > 1m$, it was applied the following correction to all following points in the track:

their height was offset in order that the new height for P_{K+1} is the value that makes the slope between P_K and P_{K+1} equal to the average slope between the last 6 points.

Filtering Vertical Before



Filtering Vertical After



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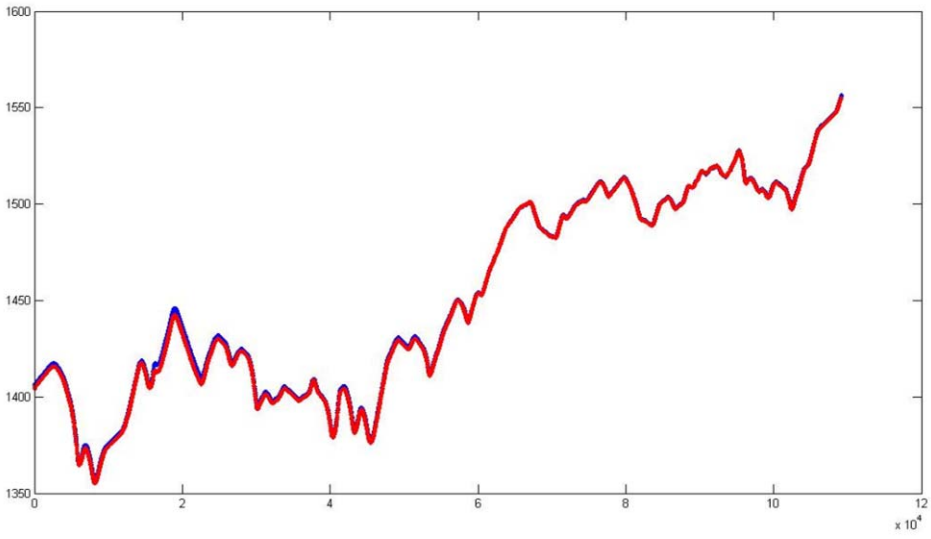
Vertical Complete Profiles



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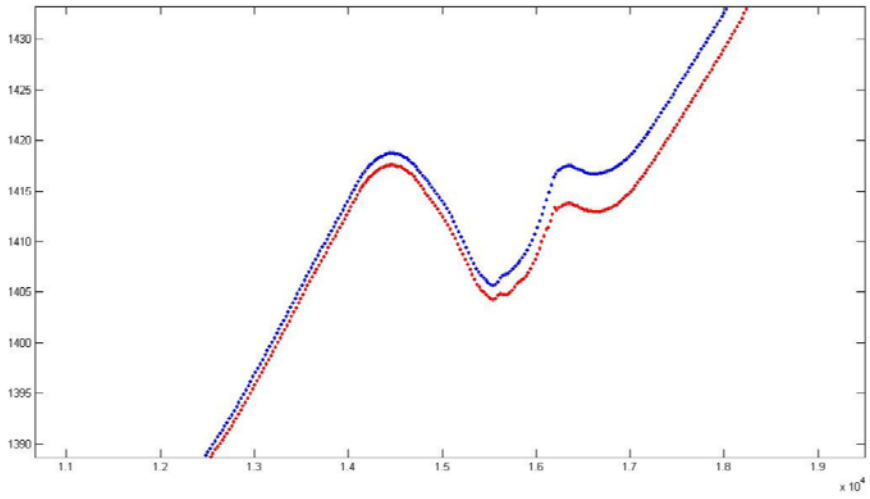
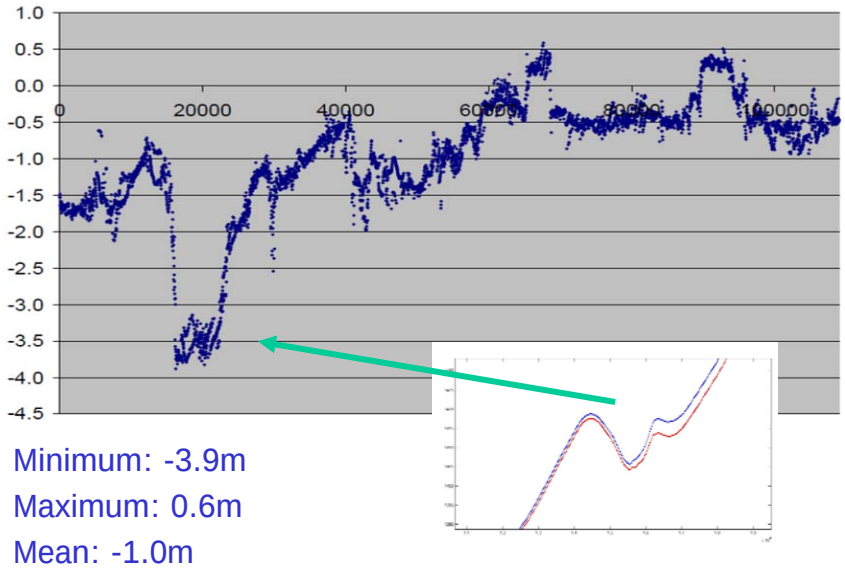
Filtering Vertical Real Offsets?



Vertical Statistics on the Track Height Differences



Minimum: -3.9m

Maximum: 0.6m

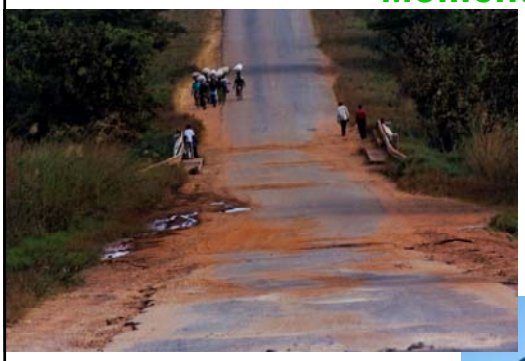
Mean: -1.0m

Concluding Remarks (1/14)

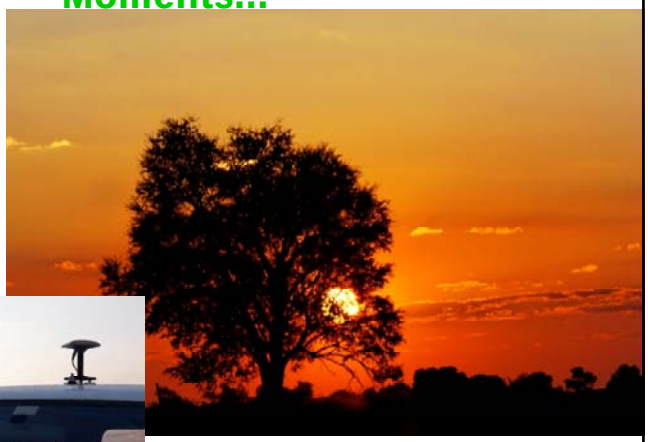
- The use of double tracks allowed us to have independent check of the quality of the observed (processed tracks).
- The application of filters are clearly necessary in order to correct the estimated tracks coming from GIPSY.
- The quality of the final product is dependent of the processing accuracy. Nevertheless, the filtering methodologies here developed independently of the quality of the original tracks.
- Future plans involve the development of adaptative filters.

Moments...

Moments…



Moments…



Thank You