Mapping coastal & estuarine vegetation using VHR satellite imagery in St Lucia

M. Lück-Vogel, C. Mbolambi, J. Adams, K. Rautenbach

mluckvogel@csir.co.za

Coastal Systems Research Group
Natural Resources and the Environment
CSIR Stellenbosch

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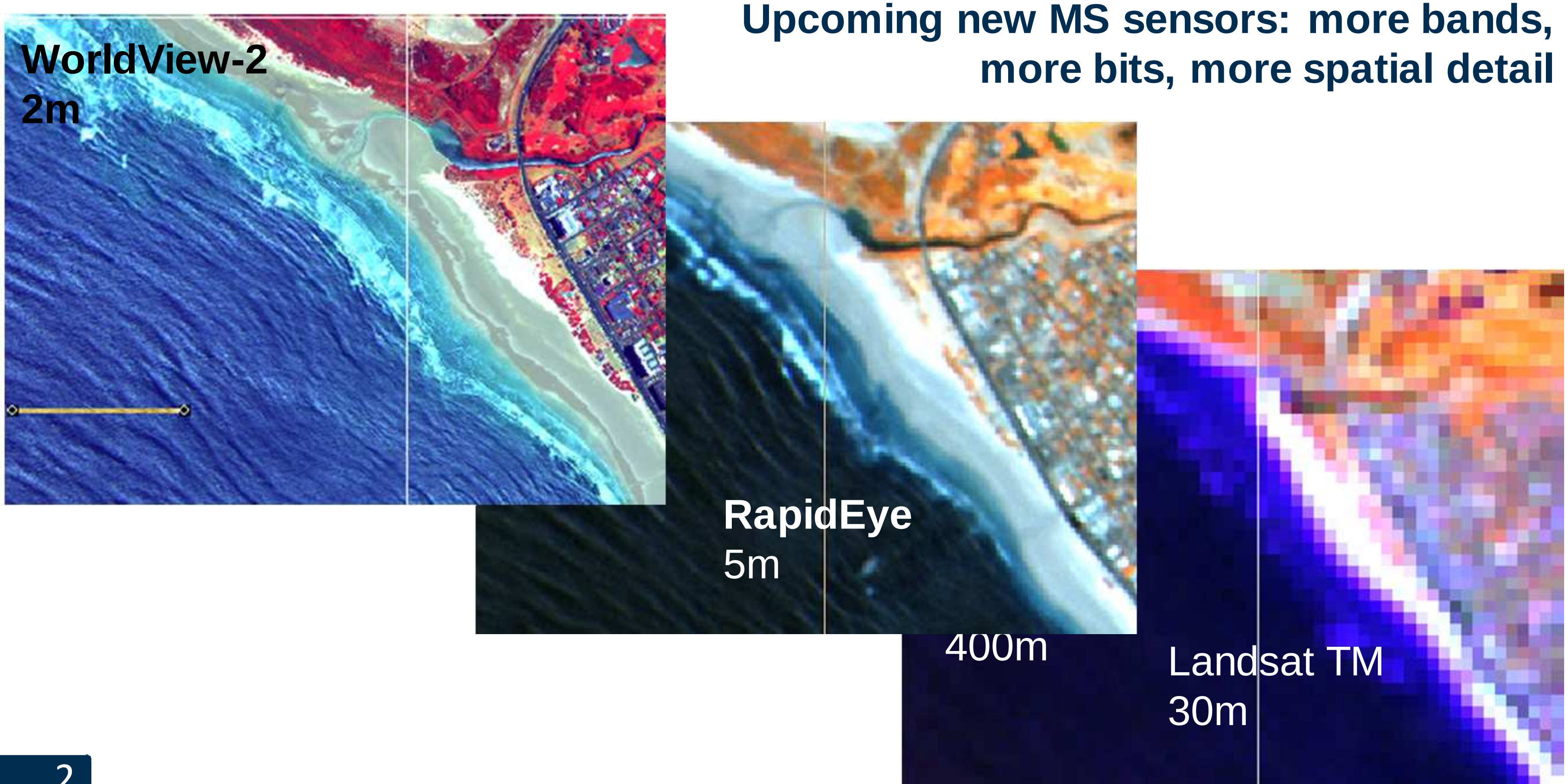
Coastal remote sensing

Coast has long been neglected in South Africa because of small scale pattern of landscape features
→ „traditional“ RS sensors of little use

Upcoming new MS sensors: more bands, more bits, more spatial detail



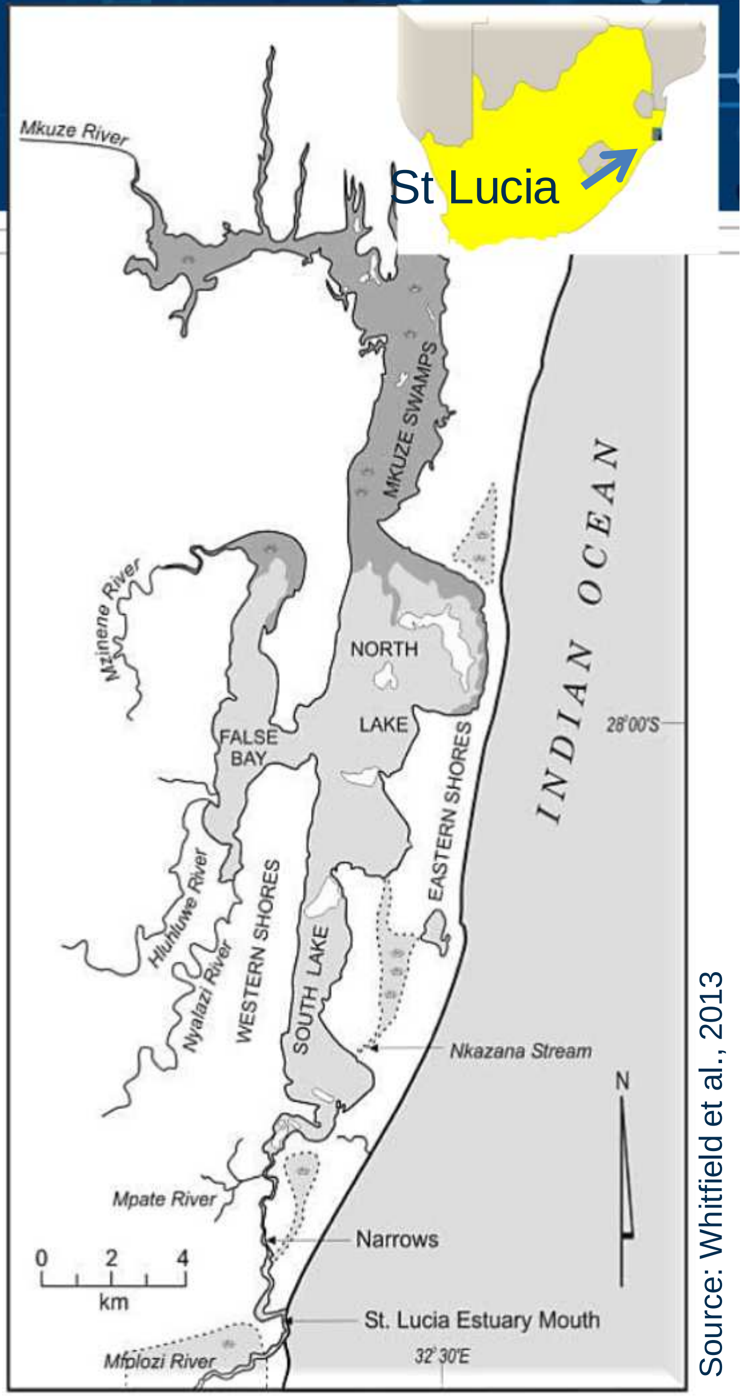
The opportunity: WRC project in St Lucia

The uMfolozi/uMsunduzi/St Lucia estuaries (iSimangaliso Wetland Park) form the largest estuarine system in Africa.

To date, only few spatial-temporal information on estuarine vegetation composition, distribution and health exists.

In the context of an ongoing WRC project, remote sensing mapping has been used in the St Lucia estuaries region.

Given the small scale of the habitats, imagery with very high spatial resolution (VHR) had to be used.



Source: Whitfield et al., 2013

Aim of this mapping project

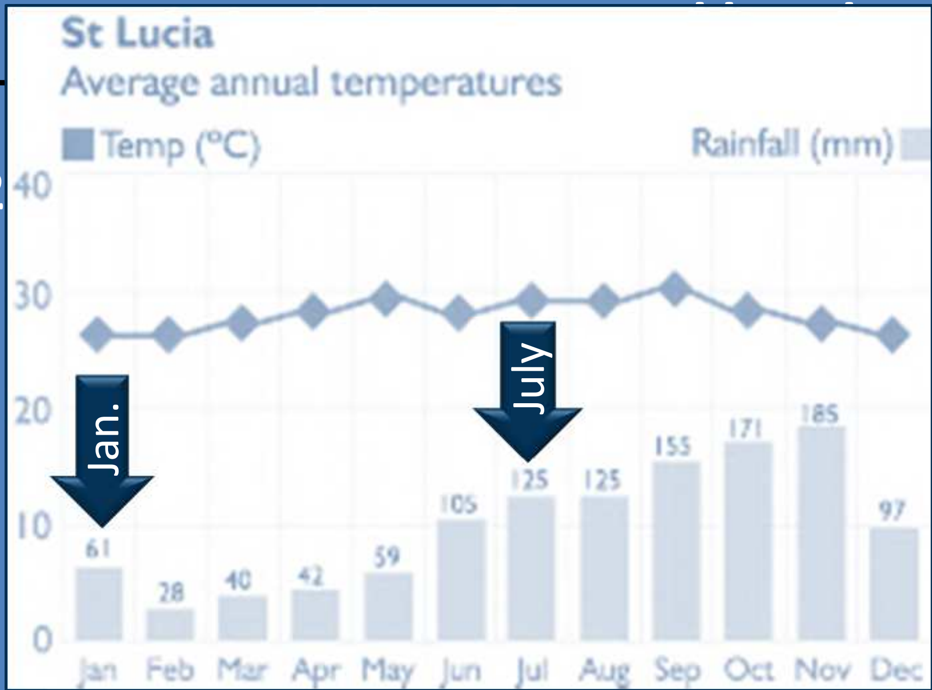
- To assess suitability of upcoming VHR sensors for estuarine habitat mapping and integrated management
- To assess the value of LiDAR derived elevation data for mapping purposes
- To assess impact of weather and seasonality on classification results

Details of used sensors

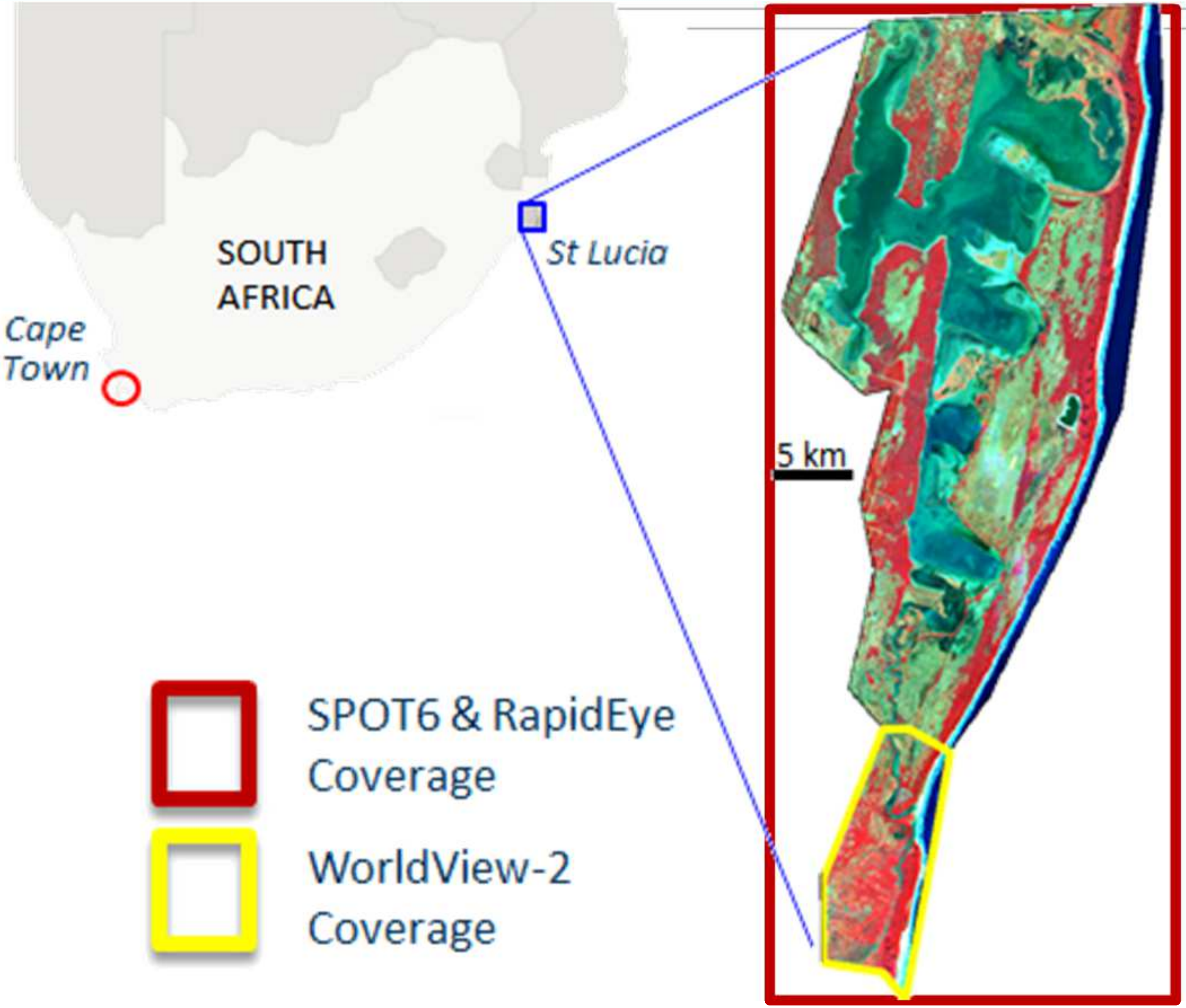
Sensor	Resolution (m)	Spectral bands	Acquisition Date
WorldView-2	2.0	8: Coastal, B, G, Y, R, RedEdge, NIR1, NIR2	9 Apr. 2010
RapidEye	5.0	5: B, G, R, RedEdge, NIR	18/20 July 2011
			13 Jan. 2012
SPOT6	5.0*	4: B, G, R, NIR	8 Feb. 2014
LiDAR	Rasterised to match above	1	ca. July/Aug 2013

Dry and wet season images

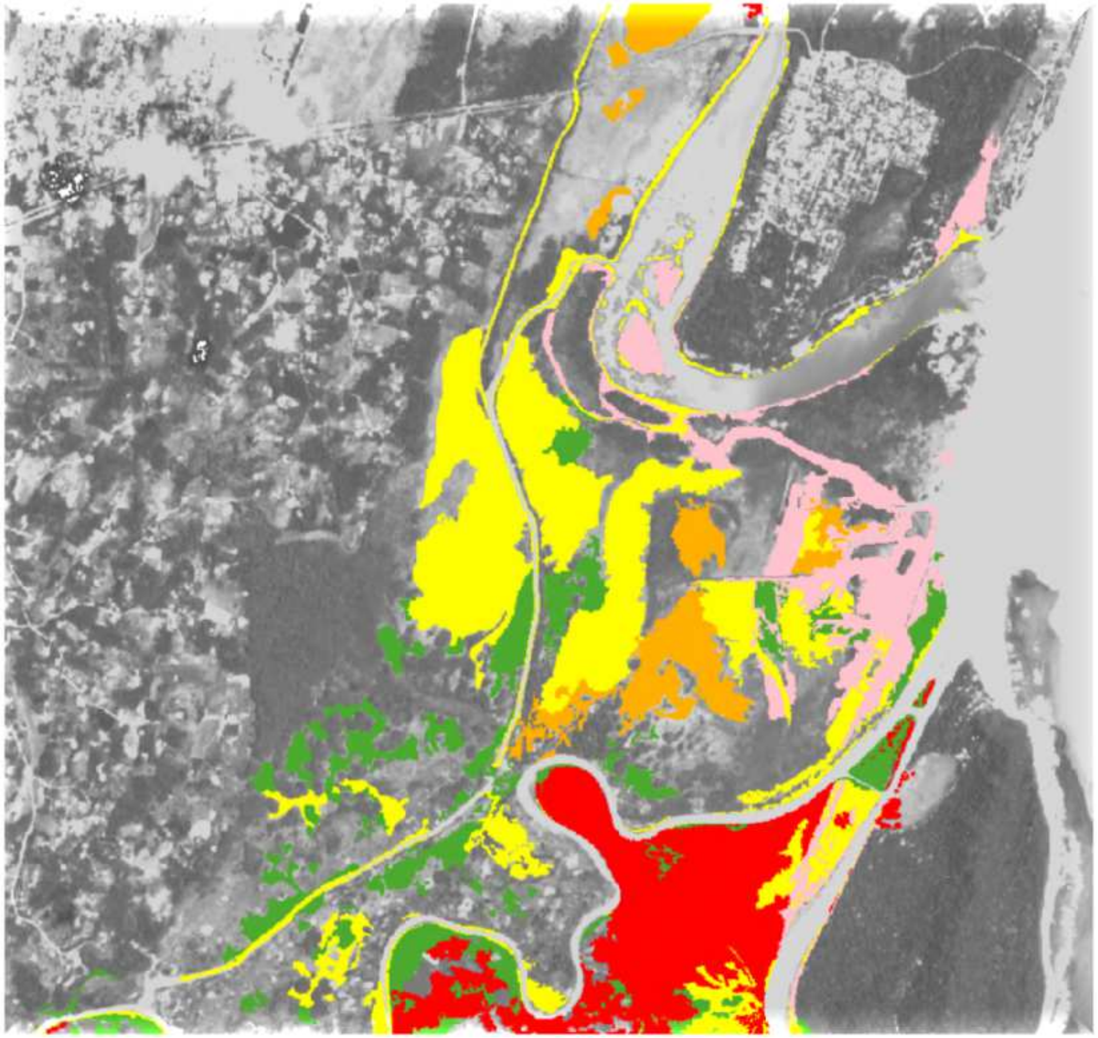
Sensor			Acquisition Date
WorldView2			9 Apr. 2010
RapidEye			18/20 July 2011 13 Jan. 2012
SPOT6			8 Feb. 2014
LiDAR	Rasterised to match above	1	ca. July/Aug 2013



Coverage of data



Reference data

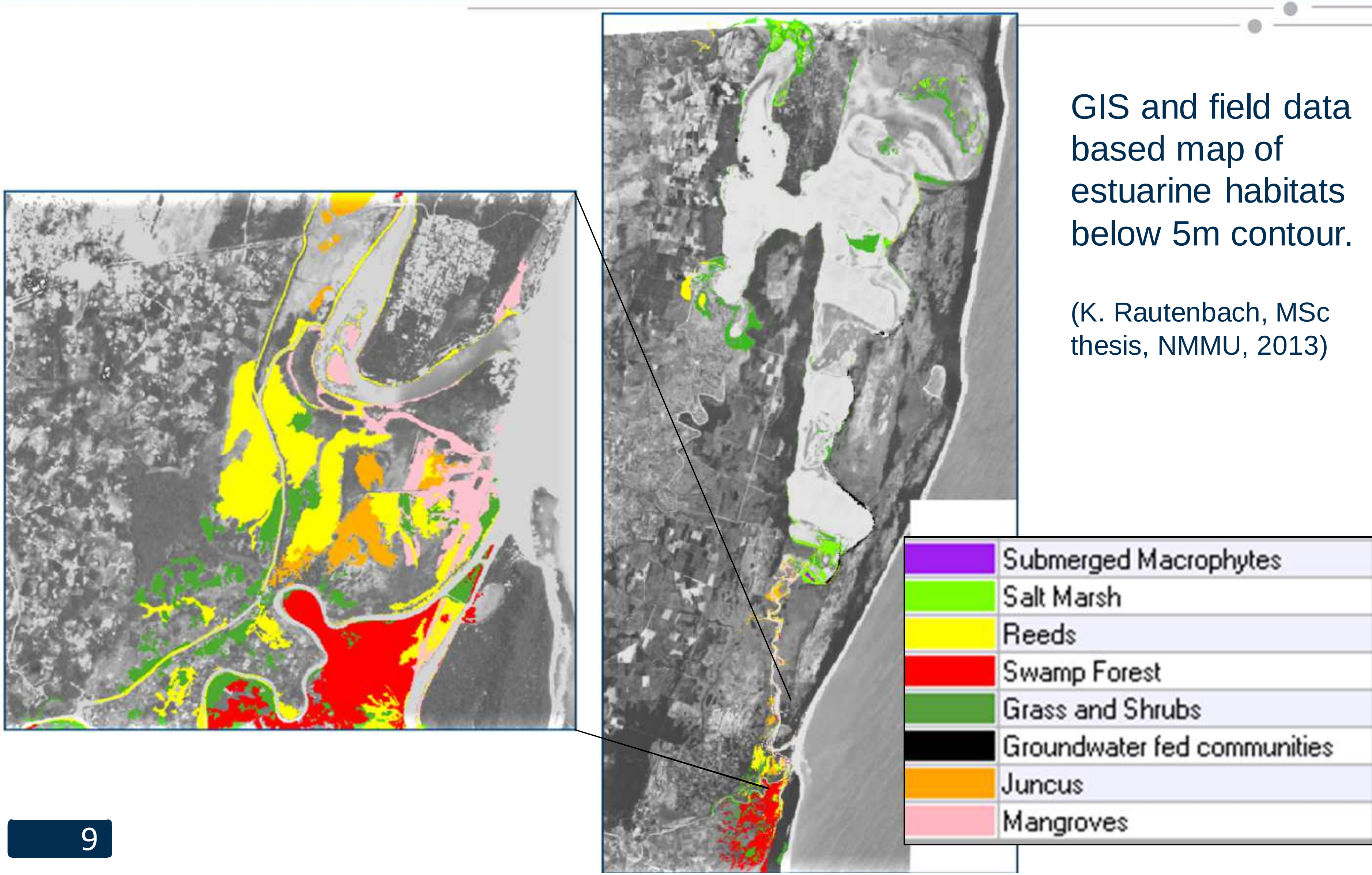


GIS and field data based map of estuarine habitats below 5m contour.

K. Rautenbach, MSc thesis, NMMU, 2013

	Submerged Macrophytes
	Salt Marsh
	Reeds
	Swamp Forest
	Grass and Shrubs
	Groundwater fed communities
	Juncus
	Mangroves

Reference data



GIS and field data based map of estuarine habitats below 5m contour.

(K. Rautenbach, MSc thesis, NMMU, 2013)

Methods

- Preprocessing
  - Atmospheric correction
  - Mosaicking of image tiles
  - Reprojection to match reference data
- Generation of training and validation points
  - Stratified random from Kelly's GIS-based habitat map
  - Cleaned for obvious temporal changes:
    - some swamp forest points in 2013 reference were open grass and shrub land in 2010 (abandoned forest plantation)
    - Some mangroves disappeared.

Classification

- Maximum Likelihood (ML)
  - of respective multispectral images
  - of multispectral stacked with DSM derived from 25 cm LiDAR contours
  - of multispectral stacked with DSM derived from original LiDAR xyz point clouds

- Filtering of results to remove single pixels

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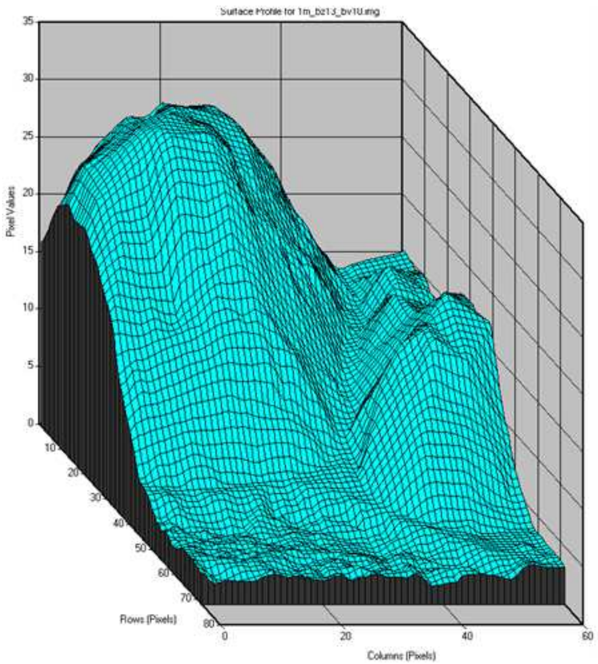
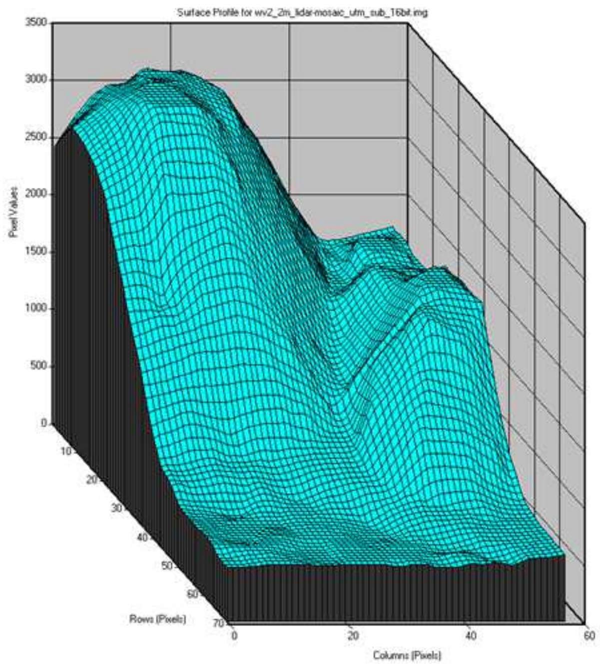
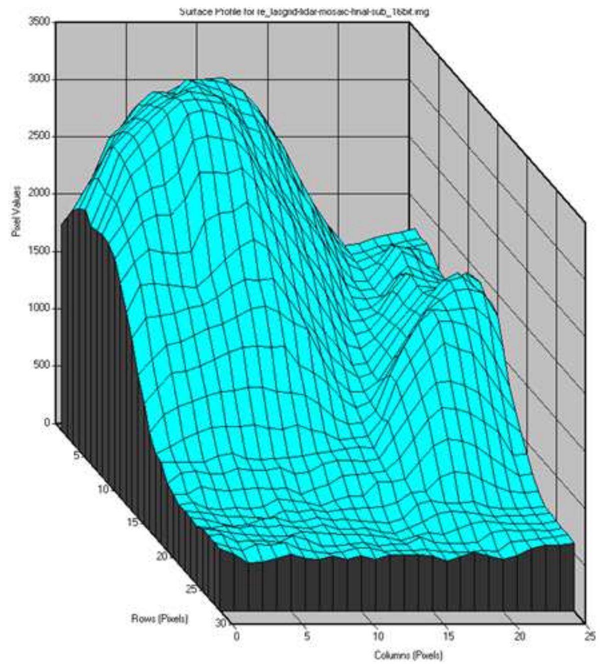
LiDAR-derived DSM raster products



1m grid from
unthinned point cloud



2m grid from
25cm contours

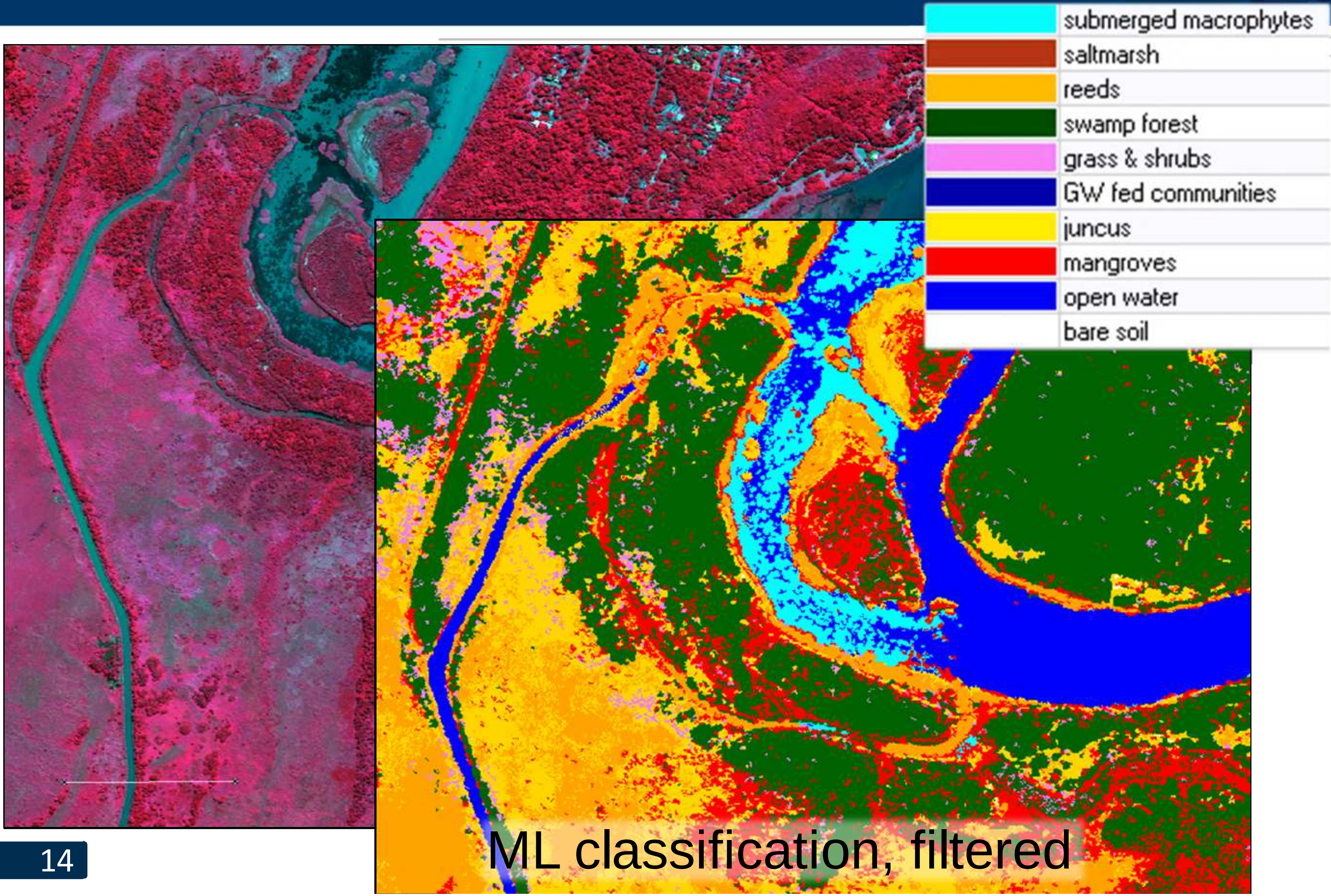


5m grid from
unthinned point cloud

Increasing loss of detail

Example: WV2-based classification results

Example: WV2-based classification results



Accuracies

		WV-2 2010		RE 2011		RE 2012		SPOT6 2014	
		overall accuracy	kappa	overall accuracy	kappa	overall accuracy	kappa	overall accuracy	kappa
1st run	multispectral (MS)	65.8	0.58	51.1	0.45	52.2	0.46	65.1	0.61
	MS + LiDAR from 25 cm contours	68.4	0.61	56.1	0.51	56.7	0.51	63.6	0.59
2nd run	MS	72.4	0.66	50.0	0.44	52.2	0.47	64.9	0.61
	MS+ LiDAR from raw xyz	72.4	0.66	61.4	0.57	50.9	0.45	70.7	0.67

Validation basis: Stratified random points from GIS reference.

WorldView-2 Error matrix

LASGRID LIDAR			Overall Classification Accuracy = 72.37%								
test-all-sigs-2_recode.img			Overall Kappa Statistics = 0.6571								
									Producers	Users	
Classified Data	Reeds	Sw. for.	Gr. & Shr.	Juncus	Mangr.	Water	Bare	Row Total	Accuracy	Accuracy	Kappa
Reeds	6	0	1	4	0	0	0	11	28.6%	54.6%	0.47
Swamp forest	0	45	2	0	1	0	0	48	81.8%	93.8%	0.90
Grass and Shrubs	9	9	13	1	1	0	0	33	68.4%	39.4%	0.31
Juncus	6	0	1	3	0	0	0	10	37.5%	30.0%	0.26
Mangroves	0	1	1	0	7	0	0	9	70.0%	77.8%	0.76
Open water	0	0	0	0	0	22	0	22	88.0%	100.0%	1.00
Bare soil	0	0	1	0	1	3	14	19	100.0%	73.7%	0.71
Column Total	21	55	19	8	10	25	14	152			

Main confusion in all classifications:

- Juncus / Reeds
- Reeds / Grass-Shrubs
- Grass-Shrubs / Swamp forest

Solution:

Merge Juncus & Reeds

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Accuracies with Reeds & Juncus merged

		WV-2 2010		RE 2011		RE 2012		SPOT6 2014	
		overall accuracy	kappa	overall accuracy	kappa	overall accuracy	kappa	overall accuracy	kappa
1st run	multispectral (MS)	65.8	0.58	51.1	0.45	52.2	0.46	65.1	0.61
	MS + LiDAR from 25 cm contours	68.4	0.61	56.1	0.51	56.7	0.51	63.6	0.59
2nd run	MS	72.4	0.66	50.0	0.44	52.2	0.47	64.9	0.61
	MS+ LiDAR from raw xyz	72.4	0.66	61.4	0.57	50.9	0.45	70.7	0.67
3rd run	MS+ LiDAR from raw xyz fused*	79.0	0.73	64.6	0.60	51.9	0.45	73.7	0.70

Input for

*: fused = classes Juncus and reeds merged

Accuracies: Bad RapidEye performance?

		WV-2 2010		RE 2011		RE 2012		SPOT6 2014	
		overall accuracy	kappa	overall accuracy	kappa	overall accuracy	kappa	overall accuracy	kappa
1st run	multispectral (MS)	65.8	0.58	51.1	0.45	52.2	0.46	65.1	0.61
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3rd run	MS+ LiDAR from raw xyz fused*	79.0	0.73	64.6	0.60	51.9	0.45	73.7	0.70

*: fused = classes Juncus and reeds merged

RapidEye 2011 accuracies

LASGRID LIDAR__FUSED					Overall Classification Accuracy =			64.55%					
2011-07-18_re_plus-lasgrid-lidar_ml-no-dunes-no-flooded_recode-fus					Overall Kappa Statistics = 0.5964								
											Producers	Users	
Classified Data	Submerged	Salt Marsh	Sw. forest	Gr. & Shr.	GW. Fed	Mangr.	Water	Bare Soil	Juncus & R.	Row Total	Accuracy	Accuracy	Kappa
Submerged Macroph.	20	0	0	0	0	0	0	0	0	20	87.0%	100.0%	1.00
Salt Marsh	0	20	0	4	5	0	1	0	2	32	83.3%	62.5%	0.58
Swamp forest	0	0	22	5	0	2	0	0	3	32	75.9%	68.8%	0.64
Grass & Shrubs	0	2	0	7	0	3	0	7	6	25	33.3%	28.0%	0.20
Groundw. Fed comms.	0	0	0	1	7	1	0	0	3	12	58.3%	58.3%	0.56
Mangroves	0	0	3	0	0	17	0	0	1	21	68.0%	81.0%	0.79
Open Water	0	0	0	0	0	0	9	0	0	9	39.1%	100.0%	1.00
Bare Soil	3	1	0	0	0	0	13	11	1	29	61.1%	37.9%	0.32
Juncus & Reeds	0	1	4	4	0	2	0	0	29	40	64.4%	72.5%	0.65
Column Total	23	24	29	21	12	25	23	18	45	220			

Potential reasons for misclassifications??

- **Seasonality**
- **Water levels**
- **Weather (wind!)**

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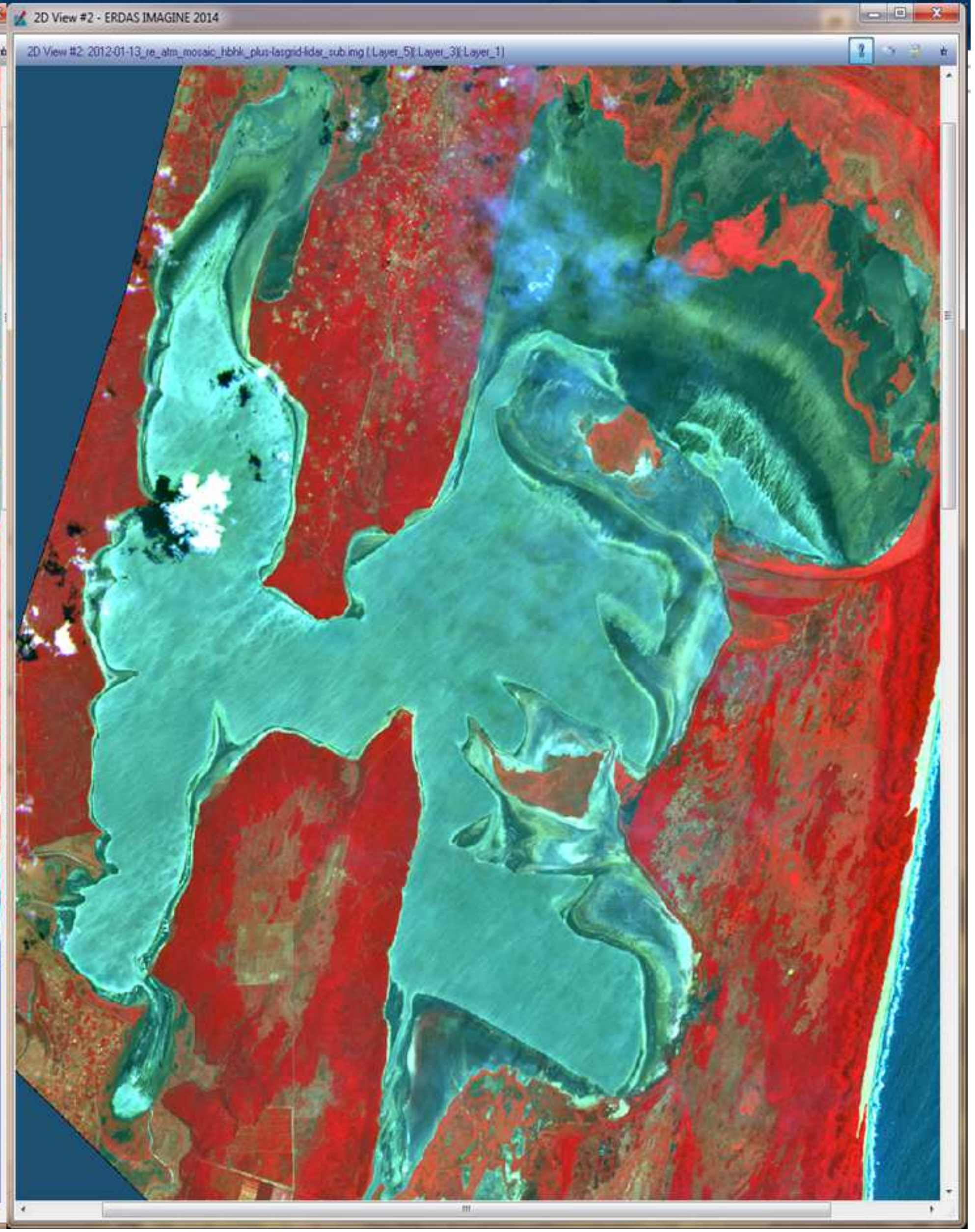
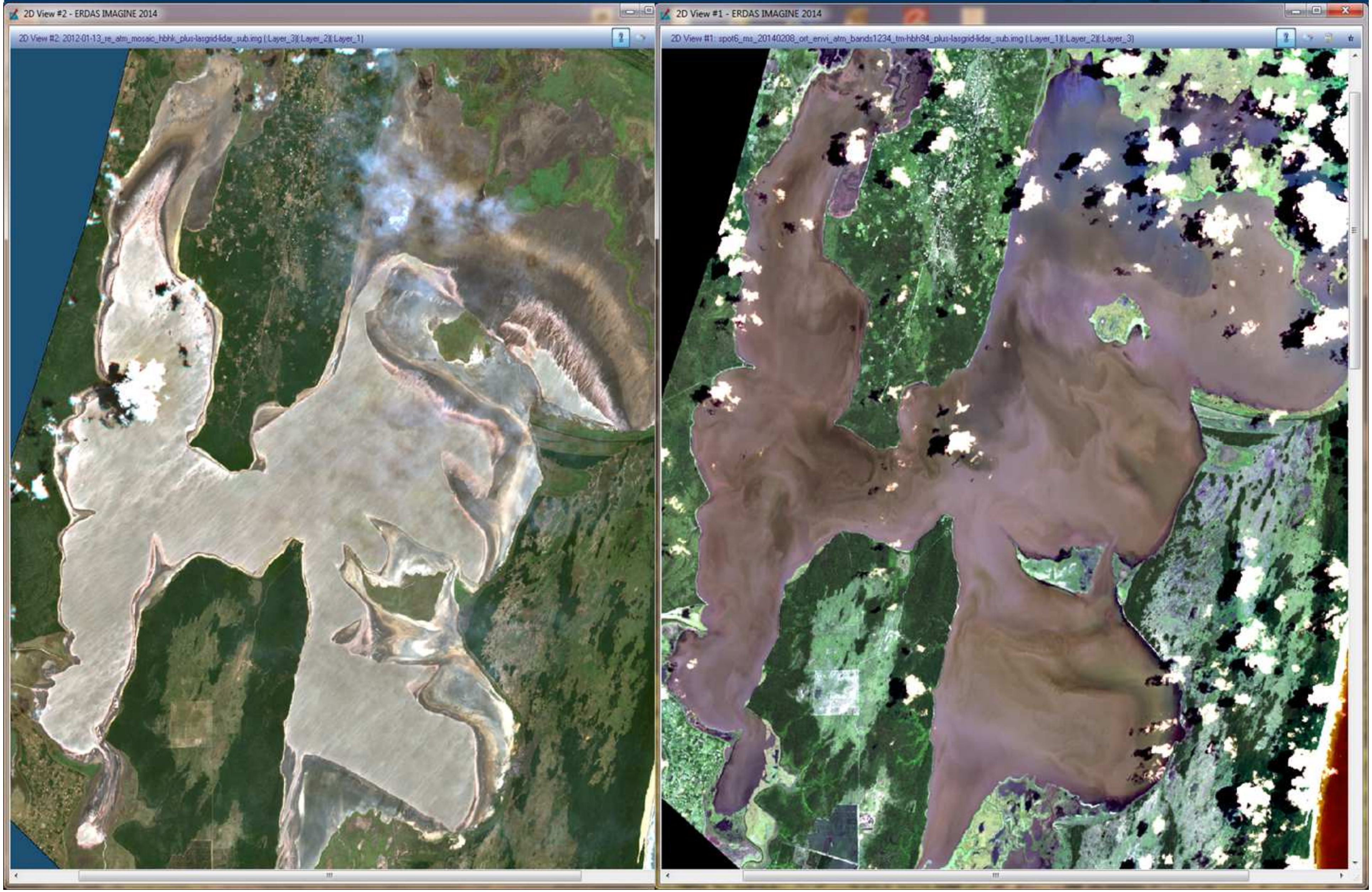
RE July 2011 vs RE Jan 2012

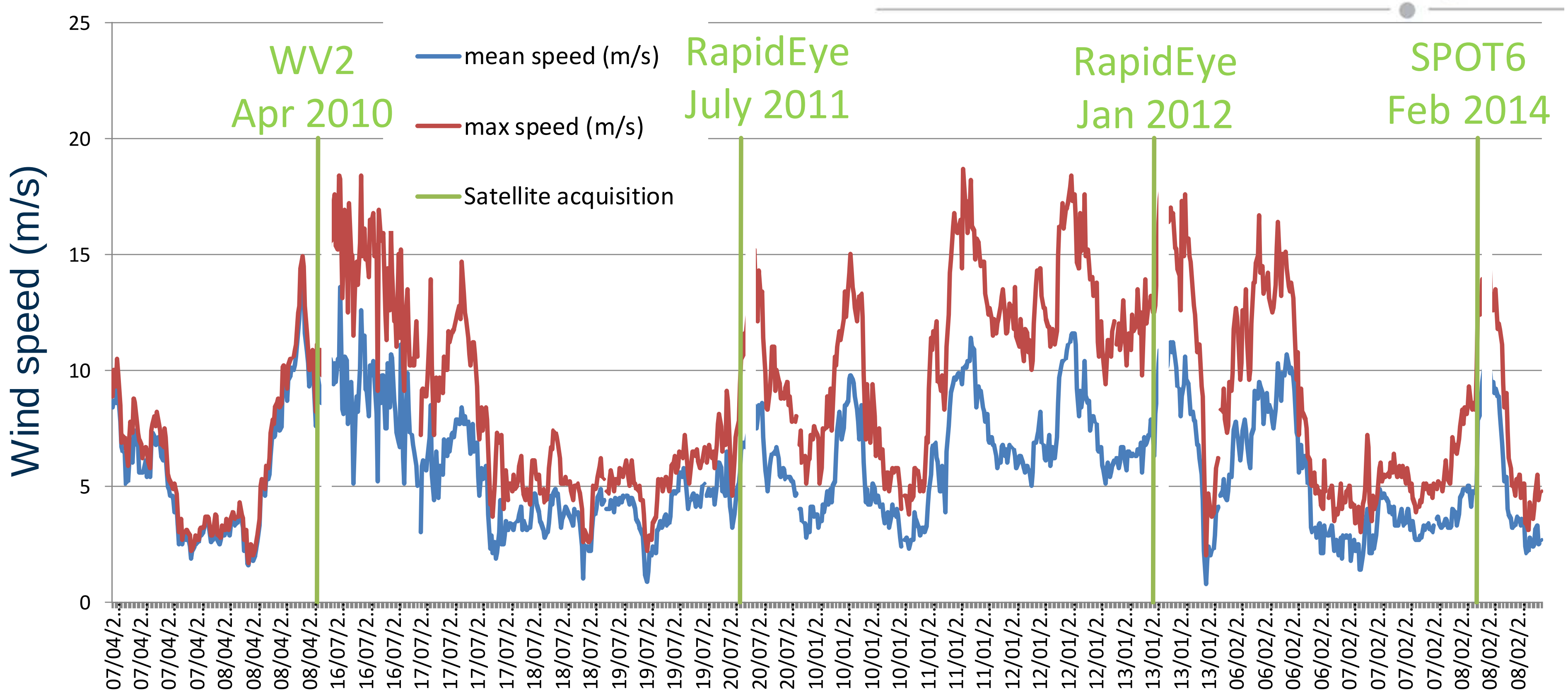
RE July 2011 vs RE Jan 2012



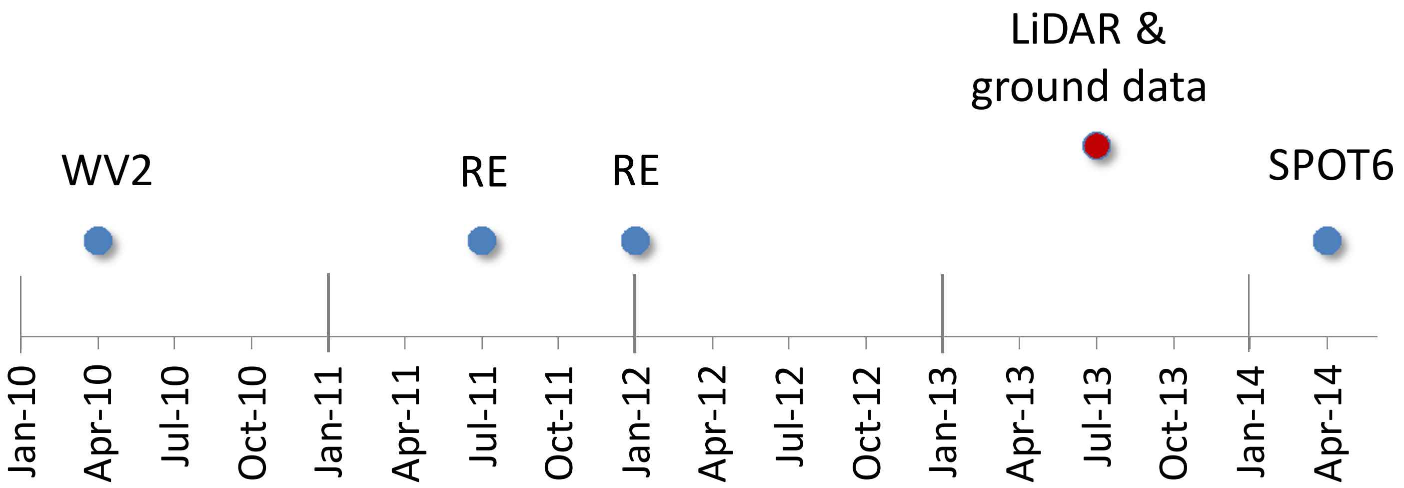
RE 2012 vs SPOT-6 2014



3-day wind history for images



Impact of time lag between images and reference data



Reference data are entirely from highly dynamic zone < 5m elevation and time lag between data leading to:

- Various degrees of flooding between images in saltmarsh, groundwater fed, reeds, juncus, mangroves
- Rapid vegetation succession from grass/shrubs to swamp forest
- Single flood events eradicated entire submerged vegetation patches
- Salinity changes (?) prompted shift from submerged to reeds

Lessons learnt

- Coastal specific challenges:
  - High landscape dynamics
    - Ground data optimally to match image dates
  - Spectrally similar classes
    - Surface/elevation data useful for distinguishing
  - Wind & weather conditions
    - May cause turbid water conditions
  - Submerged & temporarily flooded vegetation types

Thank you!

Melanie Luck-Vogel
mluckvogel@csir.co.za