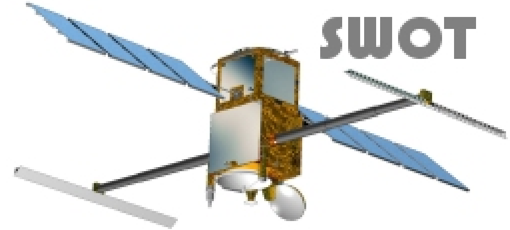

SWOT Science Team Meeting

Water Detection Performance Assessment

Roger FJØRTOFT, Manuel GRIZONNET, Lucie LABAT-ALLEE,
Sylvain LOBRY, Santiago PENA LUQUE, Victor POUGHON,
Nadine POURTHIE, Brent WILLIAMS

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Toulouse, France

National Aeronautics and
Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

CONTEXT AND INTRODUCTION

Water detection performance assessment

- Critical HR processing steps identified at Measurement Review 1 (2016)
  - Water detection
  - Layover prediction
  - Phase unwrapping

- Further prototyping of algorithms and consolidated performance assessment needed for Measurement Review 2 (December 2017)

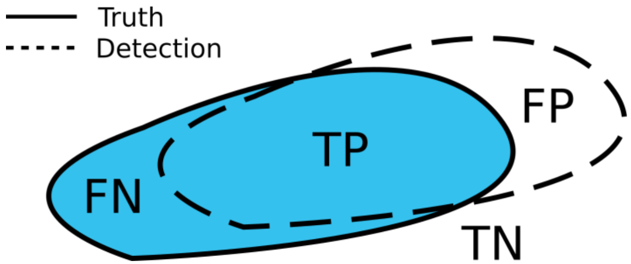
- Water detection performance assessment w.r.t. science requirement
  - Not the same as pixel-by-pixel error rate computed from confusion matrix
  - Science requirement interpretation

- Performance assessment based mainly on simulated data sets
  - Simulation and processing of huge US and European data sets

WATER DETECTION ALGORITHM BENCHMARKING

Goal

- Compare the capacity of different algorithms to detect water pixels in the right location in radar geometry.
- Separate detection errors from interferometric geolocation errors.
- This can easily be done pixel-by-pixel for simulated data as we have a perfect ground truth (simulation water mask projected in radar geometry)



Detected versus true water extent in radar geometry

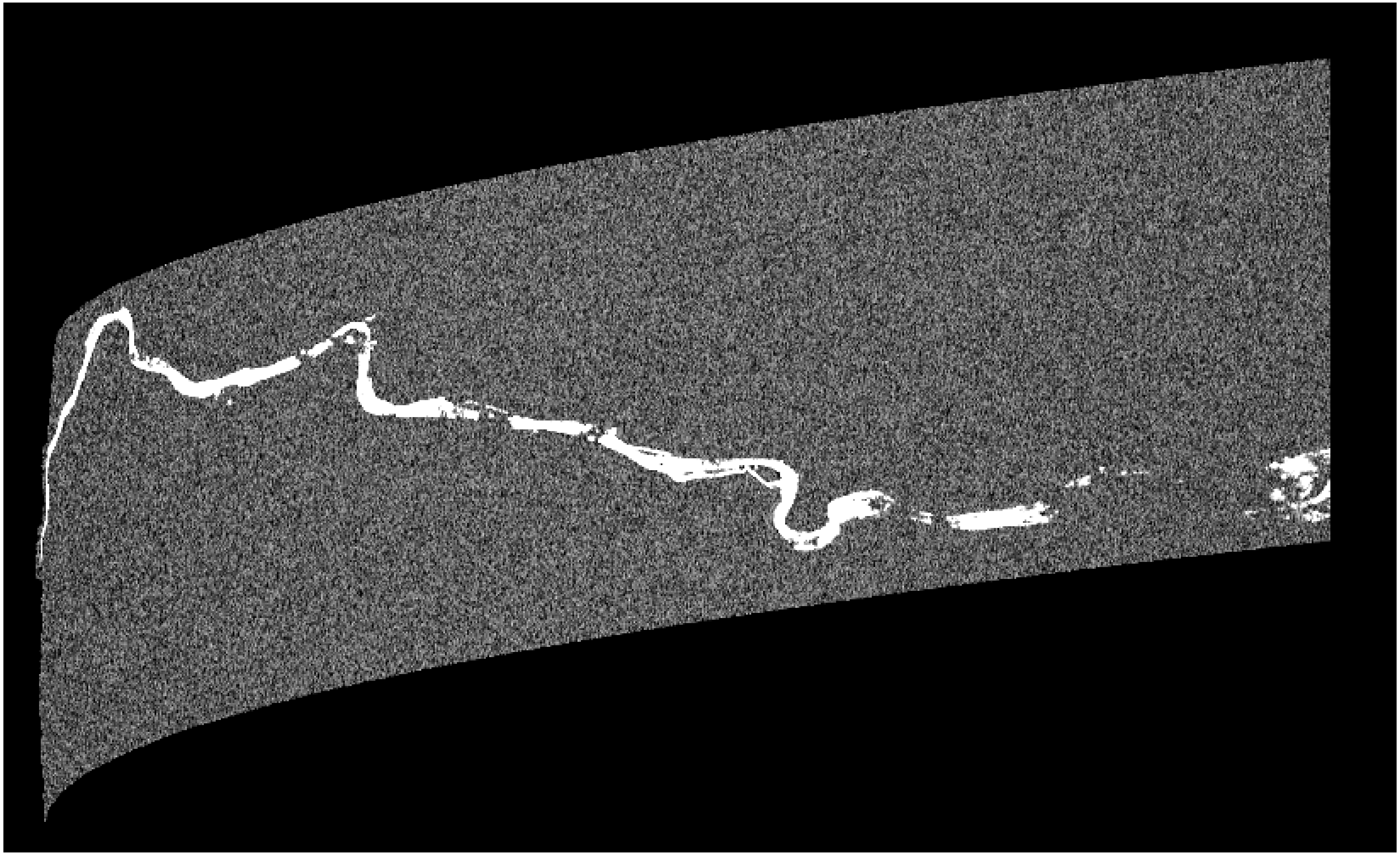
	Detected Land (0)	Detected Water (1)
Land (0)	**True Negative (TN)**	**False Positive (FP)**
Water (1)	**False Negative (FN)**	**True Positive (TP)**

Confusion matrix

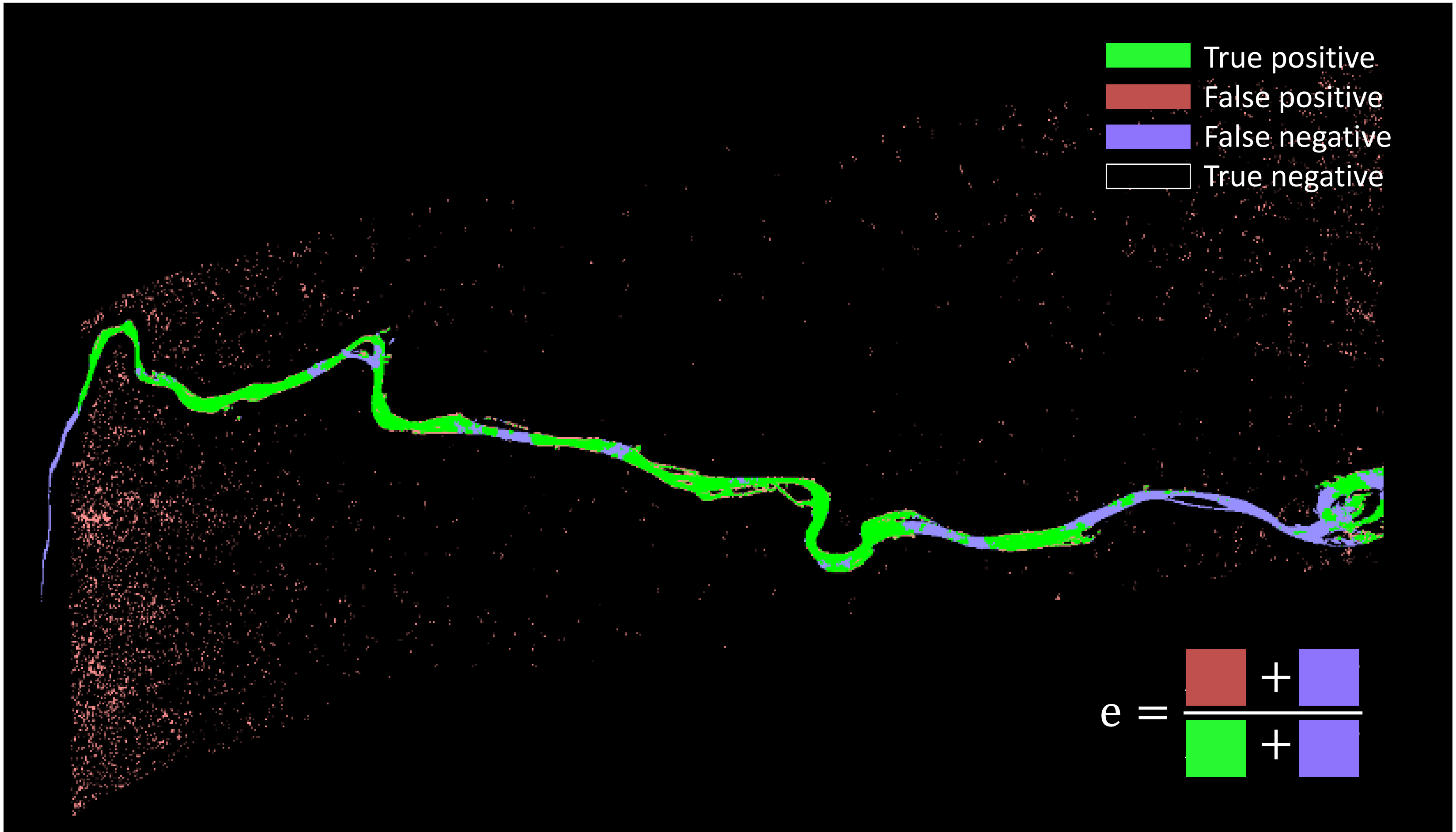
Method

- Compute confusion matrix using projected simulation water mask as ground truth (occurrence weighted by ground-projected pixel area)
- Main criteria: water error rate $e = \frac{FP+FN}{FN+TP}$
- Several other binary classification metrics

PO RIVER – SIMULATED AMPLITUDE IMAGE



PO RIVER – CLASSIFICATION RESULT*



*) The algorithm was here mistuned to trigger more errors, for illustration purposes.

- Performance assessment w.r.t. science requirement is quite different…

SCIENCE REQUIREMENTS

2.6.3.a [Requirement] The following Level-2 standard data products shall be produced for the surface water data:

- For each pass, **a geolocated water mask** of all water bodies identified in the data downlinked by SWOT, regardless of surface area. The mask resolution will be reported at the finest resolution consistent with meeting **appropriate geolocation accuracy**. […]

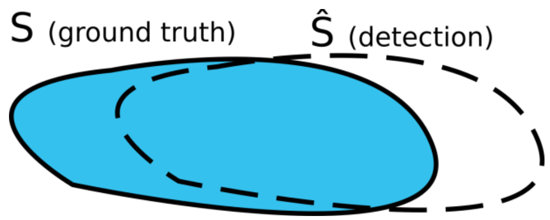
2.8.2.a [Requirement] The **surface water areas** estimated using the Level-2 water mask (requirement 2.6.3a) shall have a **relative error smaller than 15% (1σ)** of the total water body area for water bodies whose non-vegetated surface area exceeds $(250m)^2$ or river reaches whose width exceeds 100 m on average and length exceeds 10 km.

2.8.2.b [TSM Requirement] The surface water areas estimated using the Level-2 water mask (requirement 2.6.3a) shall have a relative error smaller than 15% (1σ) of the total water body area for water bodies whose non-vegetated surface area exceeds $1km^2$ or river reaches whose width exceeds 170 m on average and length exceeds 10 km.

2.8.2.c [Goal] The surface water areas estimated using the Level-2 water mask (requirement 2.6.3a) will have a relative error smaller than 25% (1σ) of the total water body area for water bodies whose non-vegetated surface area is between $(100m)^2$ and $(250m)^2$ or river reaches whose width is between 50 m and 100m on average and length exceeds 10 km.

ASSESSMENT W.R.T. SCIENCE REQUIREMENTS

	Relative Error	Water Body size	River size
Req.	15% (1σ)	>(250m²)	>100m x 10 km
TSM Req.	15% (1σ)	>1km²	>170m x 10km
Goal	25% (1σ)	(100m)² - (250m)²	[50 – 100]m x 100km

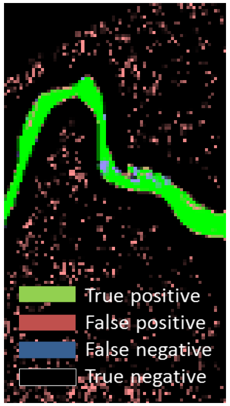


Method

- For each water body, compute relative error of surface area: $E = \frac{|S - \hat{S}|}{S}$
- Science requirement: smaller than 15% (1σ)
  - Compute error rate for a large number of water bodies (lakes and river reaches, uniformly distributed in the swath)
  - The (1σ) figure means that ~2/3 of the water bodies have a lower error rate
- Note that the science requirement is on surface area
  - No explicit requirement that the detected water body perfectly overlaps the true water body (in radar geometry)
  - Thanks to water/land contrast we will generally detect water in ~ the right place

ASSESSMENT W.R.T. SCIENCE REQUIREMENTS

Extract of classification result with many false detections



False detection, dark water, rain etc.

- How to handle false detections w.r.t. error computation?
  - What ultimately matters for discharge and storage change computation, are only the detected water bodies attributed to a known river or lake (DB)
  - Above a certain distance from known rivers and lakes, false detections will just end up as unknown water bodies in the Lake product (polygon and height only)
    - Should be limited although not disturbing discharge and storage change computation
  - Hypothesis used in Measurement Review 1: Only known water bodies are considered; false detections ignored unless they are so close that they are attributed to a known water body (in the river or lake database)
  - Same approach reconducted for Measurement review 2

- Missed detections due to dark water can be compensated by flagging.

- Areas with rain, severe layover, or water surfaces covered by ice/snow, will not be used for performance assessment.

TEST DATA FOR PERFORMANCE ASSESSMENT

Simulation of huge data sets with the HR science simulator

- About 100 hydrology scenes based on continental US Lidar data (also used for layover, phase unwrapping…)
  - Large-scale statistical analysis
  - Four different parameter settings for each scene

1 Conservative (priority 1)	2 Conservative with randomly different water heights (priority 2)	3 CBE with typical phenomenology (priority 3)	4 Margin with typical phenomenology (priority 4)
• Dark Water ON (68-percentile GMF) (~2/3 worst) • SNR: with margin (2.2 dB) • 68-percentile coherence time • Land: 68-percentile sigma-0 vs incidence angle	• Dark Water ON (68-percentile GMF) (~2/3 worst) • SNR: with margin (2.2 dB) • 68-percentile coherence time • Land: 68-percentile sigma-0 vs incidence angle	• Dark Water ON (50-percentile GMF) • SNR: CBE (no margin) • Typical Coherence time • Land: Typical sigma-0 vs incidence angle (around -5dB)	• Dark Water ON (50-percentile GMF) • SNR: with margin (2.2 dB) • Typical Coherence time • Land: Typical sigma-0 vs incidence angle (around -5dB)

- Additional simulated data sets over France and Europe
  - Po (multitemporal ~one year), Seine, Garonne, Camargue…
  - Same four parameters settings, plus additional stress cases
  - Statistical and qualitative analysis (impact of varying water level, DEM resolution and accuracy, dark water, layover…)