WP4000: Potential Secondary Products

- WP4100: Investigation of PSP for Rivers and Lakes (Starlab)
- WP4200: Investigation of PSP for Swell and Ocean/Atmosphere (Ifremer)
- WP4300: Investigation of PSP for Cryosphere (Polar Imaging / SatOC)
- WP4400: Compilation and review of D4 (all)

WP4100

Potential Secondary Products: Lakes & Rivers

Introduction

Objective:

- To evaluate the capability of Wavemill to retrieve secondary terrestrial hydrology products

Demanding requirements:

- Environment heterogeneity
- Complexity of inflow and outflow processes

WP Focus

- Focus → main processes governing terrestrial hydrology:
  - **Discharge:** volume flow rate, associated with rivers
  - **Storage:** water mass stored (lakes, reservoirs)

- Not measured directly, but through models implying measurable *hydraulic variables*:
  - Channel width, stage, depth, water-surface slope, water-surface velocity...

WP Status

- **Performed activities:**
  - Definition and characterisation of the hydrological processes: river discharge & water storage.
  - Definition of preliminary scientific requirements for channel width, stage, depth, water-surface velocity & slope, and surface extent.
  - Preliminary evaluation of Wavemill Performance for each hydrological variable.
  - Estimation of potential benefit of water-surface currents derived from Wavemill in the SWOT mission.

River discharge

- Defined as the volume rate of water flow:
  - Volume of water that traverses a given cross-sectional area of the river per unit of time.

$$Q = A\bar{v}\ [\mathrm{m}^3/\mathrm{s}]\,,$$

where

A	Area of the cross-section [m²]
$\bar{v}$	Average velocity [m/s]

  - Assuming a rectangular channel: $Q = W\,Y\,\bar{v}$

River discharge

- Not likely that all the variables can be measured simultaneously with enough confidence.
- Statistically derived relationships:
    - Channel width, *W* [m]
    - Stage (*H*, [m]) and depth (*Y,* [m]).
    - Water-surface slope ($S = \mathrm{d}\,h / \mathrm{d}\,x$, [m/m])
    - Water-surface velocity (*V*, [m/s]).
    - Channel morphology parameters: sinuosity, channel slope, meander length, radius of curvature...

River discharge

- Estimation of hydraulic variables from space:
  - TOPEX/Poseidon nadir-looking radar altimeter: stage measurements with accuracies of decimetres
  - TerraSAR-X experimental ATI: river current velocities.
  - Future SWOT: river stage, slope and width
- Wavemill: Chance of estimating all required hydraulic variables in a single satellite pass:
  - ATI: currents velocity
  - XTI? Altimetry payload? Stage, slope

Storage in lakes and reservoirs

- Defined as the volume [m^3] of accumulated water:
  - Main inputs: Direct rainfall, discharge of tributaries, underground inputs
  - Main outputs: Evaporation, ground seepage, surface outflow

$$\mathrm{d}V/\mathrm{d}t = Q - A(E - P),$$

where

V	Lake or reservoir volume [m^3]
Q	Discharge (runoff) from the catchment basin [m^3/s]
E	Evaporation rate over the lake per unit of area [$m^3/m^2 \cdot s$]
P	Precipitation rate over the lake per unit of area [$m^3/m^2 \cdot s$]

Storage in lakes and reservoirs

- Estimated indirectly from water level (stage) and inundated area variations.
- SAR systems are useful for shoreline detection
- XTI can provide measurements of water level and water level fluctuations
- Wavemill: XTI? Altimetry payload? TBD

Preliminary Scientific Requirements

Table 4.1: Requirements for streamflow/river discharge estimation.

Variable	Product	Accuracy	Horizontal resolution	Observation cycle
Width	Georeferenced SLC	5,00%	100 m	3 d
Water-surface velocity	ATI	10 cm/s	100 m	3 d
Stage	XTI	10 cm	100 m	3 d
Depth	XTI + additional data	5,00%	100 m	3 d
Slope	XTI	1 cm / km	100 m	3 d
Discharge	ATI + XTI	30,00%	100 m	3 d

Table 4.2: Requirements for storage estimation.

Variable	Product	Accuracy	Horizontal resolution	Observation cycle
Surface extent	Georeferenced SLC	25,00%	1 km	30 d
Stage	XTI	10 cm	1 km	30 d

[IGOS – Coastal Theme Report]

Preliminary Wavemill performance

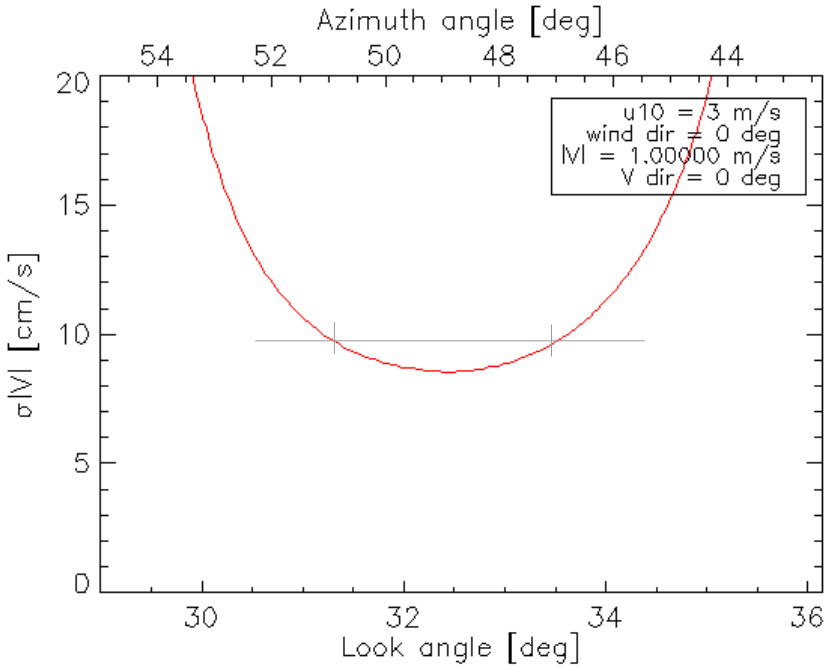
- Discharge:
  - 3 days obs. cycle → WM 3-5 days revisit time
  - Channel width 5% accuracy → WM 50 m resolution
    - High resolution stripmap mode to be considered over land
    - Channel width limited by azimuth displacement, geometric and vegetation effects
  - Stage and depth 10 cm accuracy → requires XTI.
  - Water-surface slope → requires XTI.
    - Synergy with SWOT altimetry products (11 days revisit time, 1-3 days revisit at fast sampling phase (at most 3 months)

Preliminary Wavemill performance

- Discharge:

  Water surface velocity acc. 10 cm/s → Requires a high number of looks: wide rivers, long reach

  – For WM baseline operation mode, minimum river area 0.02 km^2 (100m width x 200m reach), ENL approx. 450 → <10 cm/s accuracy for a ~30 km swath



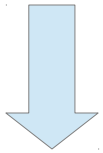
High resolution stripmap mode may help complying with the 100m resolution requirement

Preliminary Wavemill performance

- Storage:
  - 30 days obs. cycle → WM 3-5 days revisit time, req. met
    - Potential to monitor flood events
  - Surface extent: 25% accuracy for 1 km^2 surface → Wavemill SLC resolution 50 m, requirement met.
  - Stage measurement 10 cm accuracy → requires XTI and high ENL:
    - A WM hybrid ATI-XTI configuration might provide stage estimates for calm water bodies.
    - A positive yaw attitude (platform steering) over land areas might be considered to provide XT baseline

Synergy with SWOT

- SWOT → river discharge from stage/slope observations + surface velocity model (Manning equation) (11 days revisit time)
- Wavemill → river discharge from direct surface velocity observations + external knowledge of stage/depth (3-5 days revisit time)



- Wavemill + SWOT → velocity + stage + channel width direct observations → **Improved discharge estimates**

Conclusions

- Discharge might be measured from surface velocity coupled with external information on the channel, for rivers > 100 m wide → Synergy with SWOT stage/slope capabilities
- Storage estimate will only be feasible with external knowledge of depth/stage in a pure AT configuration
- In order to measure discharge or storage in a single satellite pass, XTI or altimetry payload is required

  → yaw steering over land to monitor calm waters
- River current velocity estimates can complement stream gauges or provide coverage for non-gauged streams
- To simultaneously comply with discharge accuracy and resolution requirements, a stripmap operation mode over land should be considered.