“SWOT HR Product” large scale simulator

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Purpose

- Recognition of various needs to **simulate easily and quickly point cloud over huge spatial** (large basins, continental scale…) and **temporal domains**
- Envisioned usages:
  - Generate and test potential hydro products + associated tools
    - Example : understanding how to merge partial observations of lakes in the per cycle product
  - Synthetic point clouds cases on huge domain for testing ground system processing chains (functional tests, tiles based river and lake processing).
  - Compute easily SWOT pseudo-obs for large scale hydraulic/hydrologic modeling
- Compute only water elevation error
  - will be added to “true” elevation

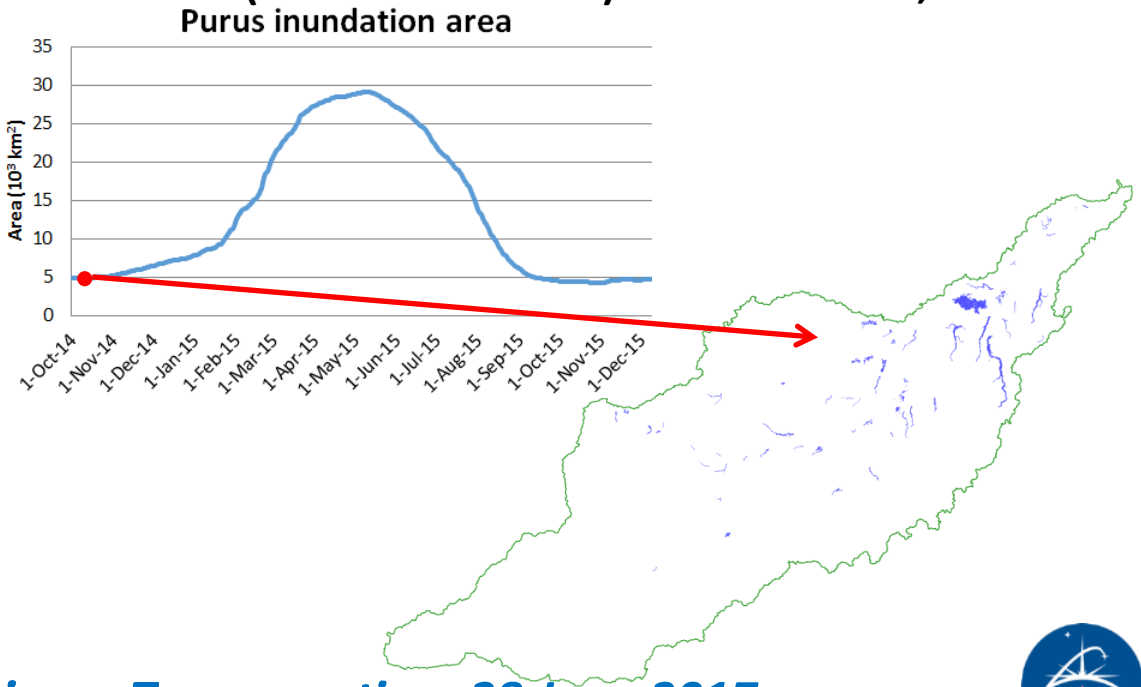
Method

- Only keep functions deemed essential for usages
  - Waterbodies geometry (area and height variation with time)
  - Measurement points density (not exact position of the grid)
  - Realistic instrument noise
    - coupling between height error and geolocation error
    - takes into account impact of water backscatter hypothesis
- Justification
  - Height error due to layover can be (statistically) parameterized for use over huge datasets
  - Point cloud « grid » deformation caused by water elevation changes is unimportant for intended purposes

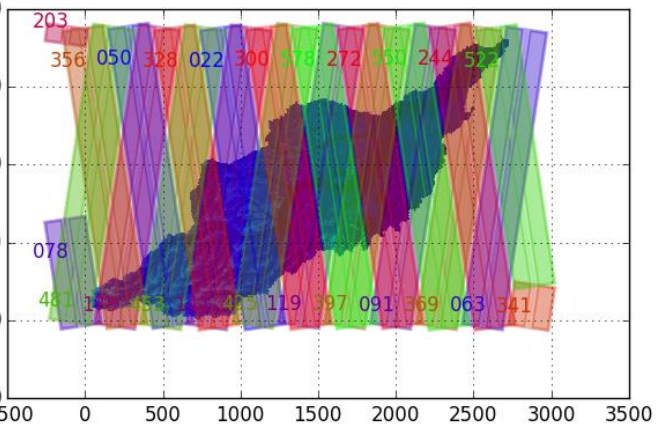
Usage: Purus basin example

- Multi temporal runs with changing water mask possible -> example from MGB hydro. model outputs (vectorized)
- **Inputs**: only **water mask** (**shapefile format**) + orbits on the study domain (JPL binaries)

Water masks (from MGB model) for October 13, 2014:

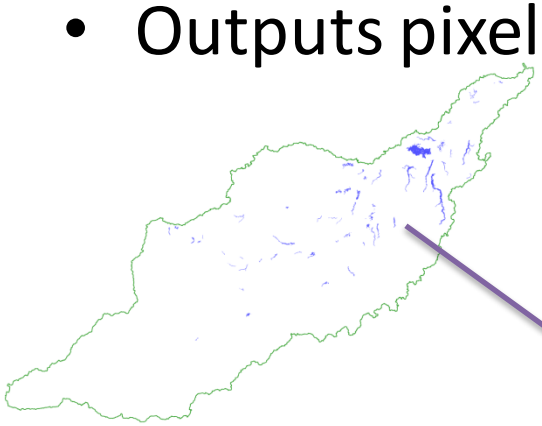


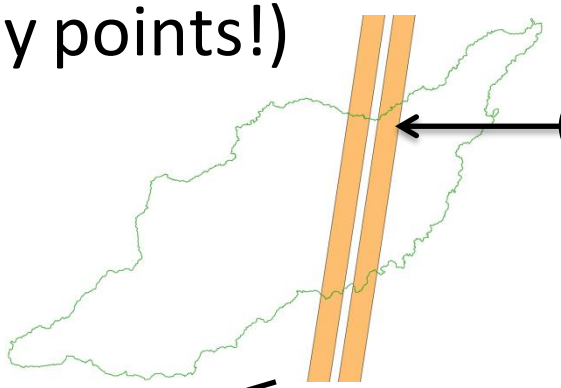
Orbit selection:



Usage: Purus basin example

- Swath radar grid intersected with water body polygons
- Add very simple (x,y,z) errors using parameters
- Outputs pixel clouds (-> many points!)



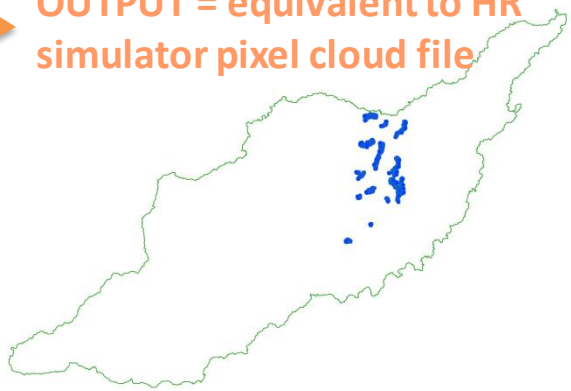


Orbit selection

INPUT = water mask
(shapefile polygon)

Large scale simulator

OUTPUT = equivalent to HR simulator pixel cloud file



SWOT error parameters:

- Localization perturbation : yes/no
- Orbit shift: distance [1 km]
- Height perturbation : file + bias
- Multiplicative factor on perturbation [1]
- Simplified temporal model of perturbation: A/t0/T

How it works

- Assumed: spherical earth, water elevation ~ 0 m and geolocalization approx. accurate for 60°S<lat<60°N
- No interferogram computation, no height inv., **no layover**…
- Algorithm:
  - perturb orbit location (constant shift, white noise ±1km std),
  - compute geolocated radar swath pixels for curr. track & cycle,
  - select pixels intersecting polygons in the water mask,
  - add noise to (row radar grid, col. radar grid, z) -> (lon, lat, z).
- Due to geolocation approx. used, i.e. coupling height error (instrument noise+bias)/geolocation:
  - error on z < 0 -> pixel closer to the near range (nadir),
  - Error on z > 0 -> pixel closer to the far range.

How it works

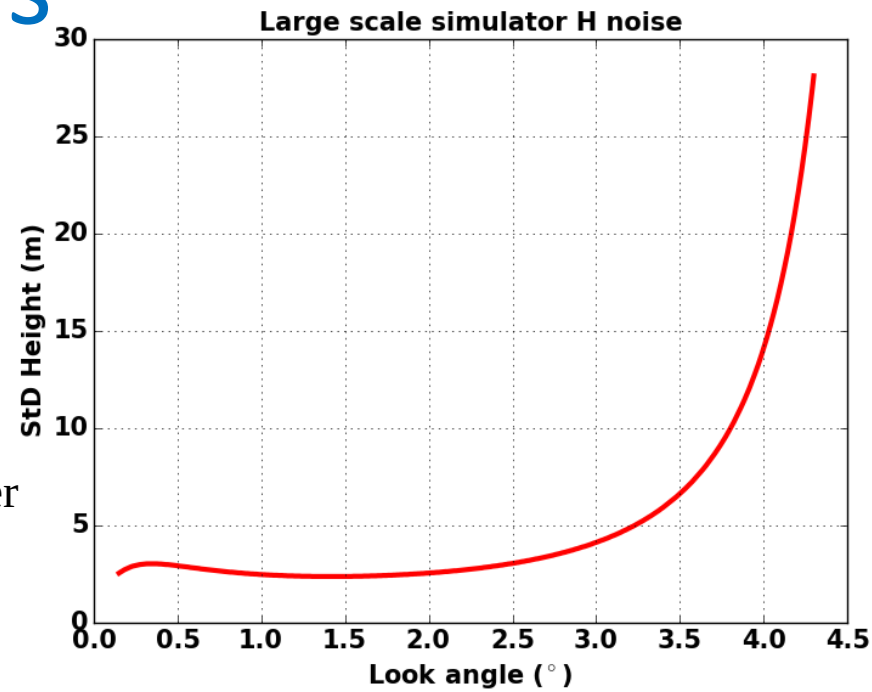
- Water elev. h for pixel (i,j): $z(i,j,t) = \zeta(t) + \delta z(i,j,t)$
- $\zeta(t)$ **same** for all **pixels** and does **not impact geolocation**:

$$\zeta(t) = A*\sin(2*\pi*(t-t_0)/\lambda)$$

with A=10m (default), t0=47076s (default), λ=365.25 days (default). All these values could be changed

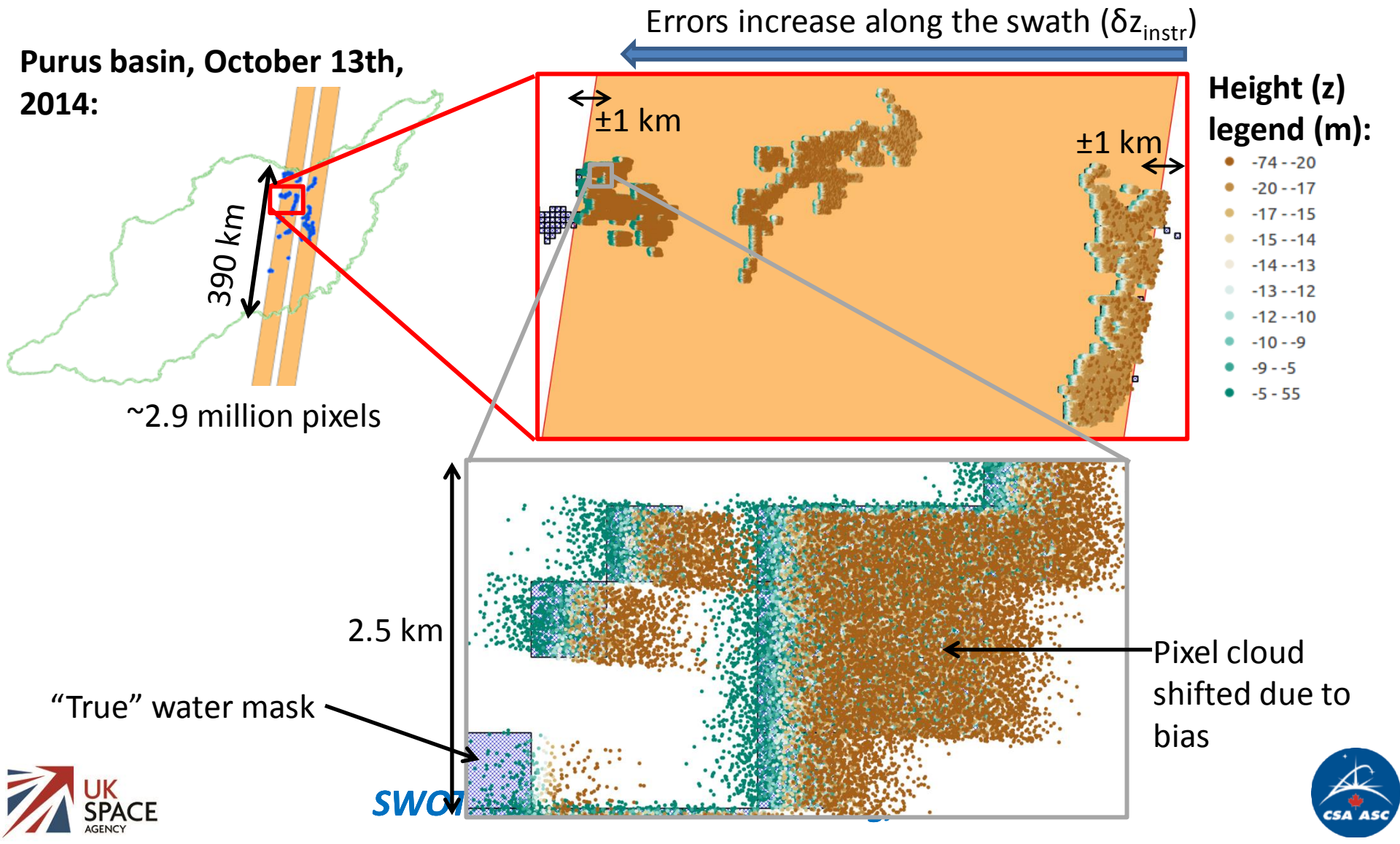
- **$\zeta(t)$ = idealized hydrogram** (for example). Removed with A=0
- $\delta z(i,j,t) = f*\{\delta z_{instr}(i,j,t) + bias(t)\}$, with
  - f: constant factor (default=1),
  - δz_{instr}: instrument noise (white noise different for each pixel),
  - bias: constant in the swath (white noise, default = std 5 m)

Errors



- $\delta z_{instr}(i,j,t)$ = white noise with std varying along swath (input file):
- f could represent impact of σ_{0water}
- δz impacts on (lon, lat) could be deactivated. Equivalent to well-done geoloc PIX_VEC product with no height error).
- ±1km orbit shift: no impact on (lon, lat, z), but impact observed water bodies
- Some outup (nc, shp) variables: height (z in m), no_noise_height (ζ), latitude, longitude… (similar to SWOT HR)

Purus example

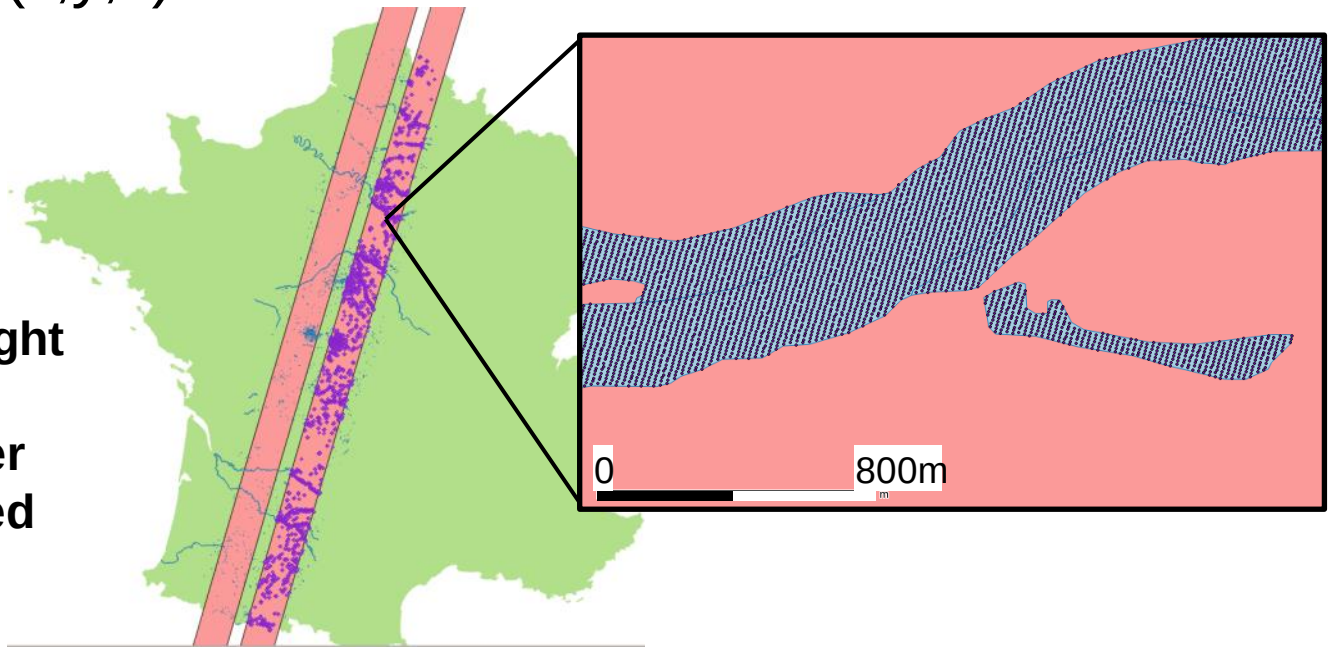


Summary

- Output pixel cloud same format than HR simulator
- Need other post-processing tools to manipulate pixel cloud -> /!\ Huge amount of points
- Simple error parametrization: no layover, no dark water, no impact of SAR processing…
- Need to improve error parametrization and add new type of errors
- Contact to get access to large scale simulator: Damien Desroches (damien.desroches@cnes.fr)

Large-scale SWOT Pixel-cloud Simulator

- A simplified tool currently underdevelopment at CNES/LEGOS:
  - Aim: simulate easily and quickly point cloud over huge spatial and temporal domains
  - Swath radar grid intersected with water body polygons + very crude (x,y,z) errors



- **1,025,321 points on left swath**
- **888,444 points on right swath**

-> 2 Million points over 920 km track computed less than 1 minute!

Large-scale SWOT Pixel-cloud Simulator

- Envisioned usages:
  - Generate and test potential hydro products + associated tools
  - Synthetic point clouds cases on huge domain for testing ground system processing chains.
  - Compute easily SWOT pseudo-obs for hydraulic/hydrologic modeling at large scale (?)
- Errors:
  - Impact of radiometric noise on height and geolocation (x,y,z)
  - No accurate layover computed: could be added (statistically or other method…)