SWOT Science Team Meeting

Current Status on Water Detection and the Reference Water Mask

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OUTLINE

- Water detection status update
  - Baseline and additional risk mitigation algorithms
  - Prototyping, integration in science simulator, operational software
- Reference water mask status update
  - Foreseen use
  - Pekel water occurrence map and additional data sources
  - Definition of Pixel Cloud inclusion (and exclusion?) zones

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- Use of reference water mask to flag dark water
- Water Detection Performance Assessment
  - Performance w.r.t. science requirements
  - Assessment on huge simulated data sets

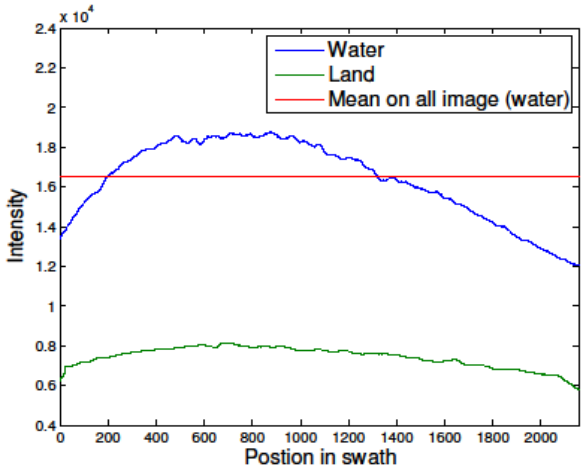
WATER DETECTION IN SWOT HR IMAGES

Goal: Distinguish water and land pixels

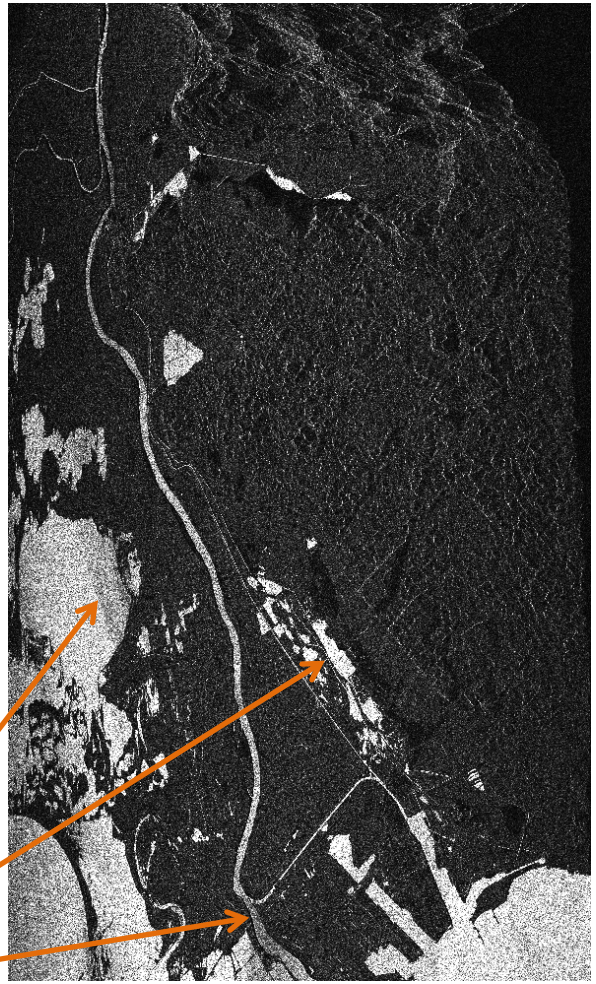
Main challenges

- Speckle noise
- Variable water/land contrast
  - Nominal case: water σ_0 ~10dB, land σ_0 ~0dB
  - Systematic variations: antenna pattern, SNR…

Average range profile of water and land intensity



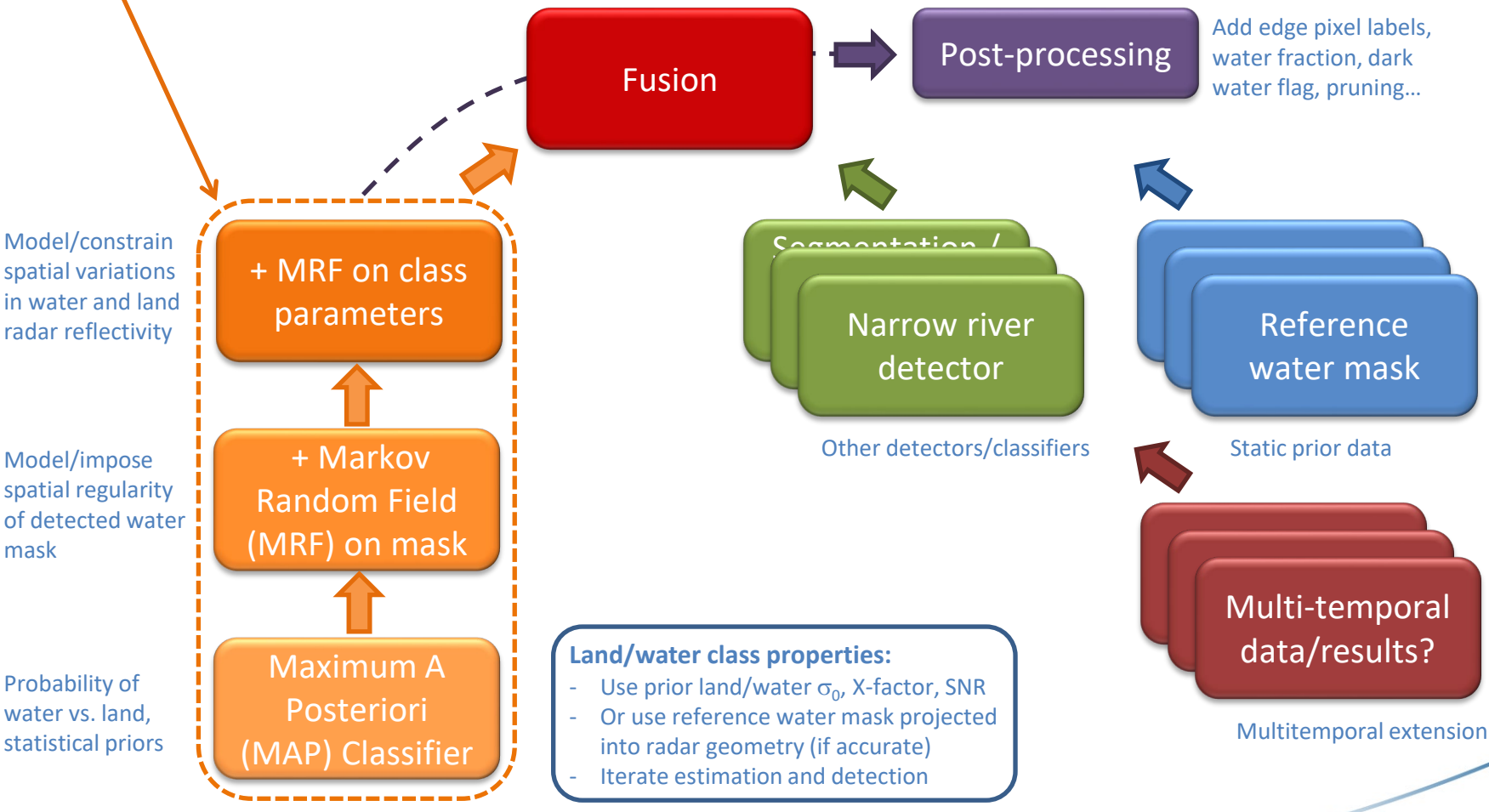
  - Local surface variations: water roughness…
  - Extreme case: dark water (no roughness, no signal)



Extract of simulated amplitude image of Camargue area

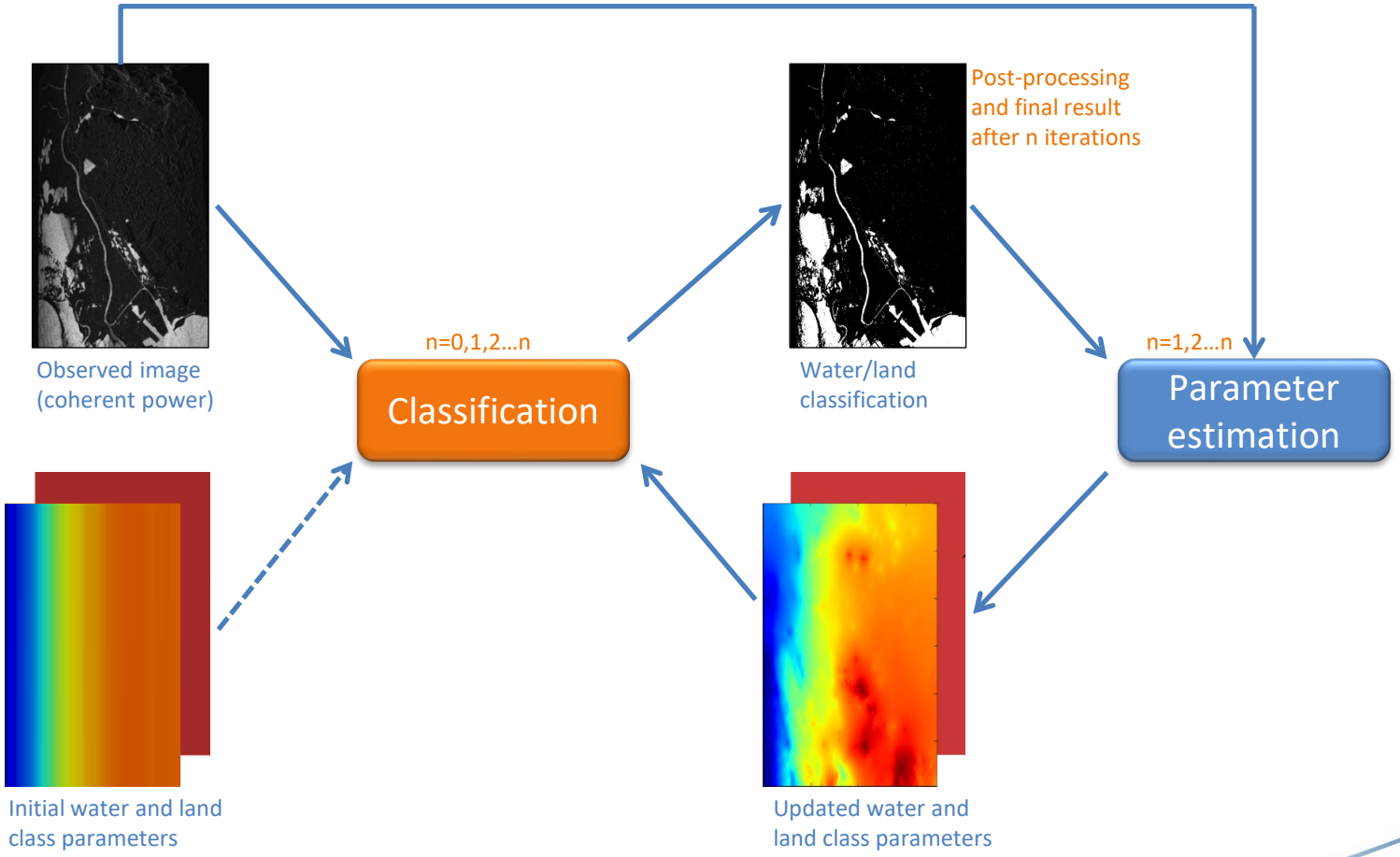
WATER DETECTION STATUS UPDATE

Baseline algorithm and additional risk mitigation algorithms



WATER DETECTION BASELINE METHOD

Iterative parameter estimation and classification



WATER DETECTION STATUS UPDATE

Development status and way forward

- All the aforementioned classification algorithms have been prototyped
  - Still being improved (handling of NoData, use of X-factor…)
  - Harmonized in terms of input/output
  - Comparison on limited simulated data sets
  - Further work needed on fusion module (some algorithms already prototyped)
- Integration in HR science simulator
  - Pixelwise MAP with iterative estimation and clean-up filter already included (JPL)
  - MAP with double MRF (current baseline) integrated and soon ready for large-scale tests in preparation of Measurement Review 2 (scheduled for December 2017)
    - » Parameter tuning and implementation of some post-processing and performance assessment functionalities remain
    - » Will be made available as a stand-alone simulator module afterwards
  - Other classifiers and fusion scheme will be added progressively
- ATBDs and first version of operational software (baseline method) in 2018.

REFERENCE WATER MASK

A prior water probability map that can be used in several processing steps

- Water detection
  - Could be used as training set to estimate class characteristics (incl. local variations)
    - Binary mask corresponding to high inundation probability (i.e. a thresholded probability map)
    - Only meaningful if the projection of the mask in SAR geometry is sufficiently accurate (TBC)
    - Current baseline is therefore to use prior knowledge of water and land σ_0, X-factor, and SNR instead
  - Use as additional data layer in data fusion scheme (risk mitigation option)
    - Prior water probability map, subject to sufficient projection accuracy
- Dark water flagging (next presentation)
  - Extend detected water mask (compensate dark water, misclassification)
    - Prior water probability map, subject to sufficient projection accuracy
- Pruning (deciding what is included in or excluded from the Pixel Cloud product)
  - Define zones to always include in the Pixel Cloud (floodplain, wetlands…)
    - Prior water probability > 0 plus additional inclusion criteria
  - Define zones to always exclude from the Pixel Cloud (where water is very unlikely)?
    - Prior water probability = 0 with additional restrictions?
- Land/water layover prediction
- Phase unwrapping

CURRENT BASELINE FOR REFERENCE WATER MASK

Augmented Pekel mask

- Main information source: The water probability maps of Pekel et al.
  - Jean-Francois Pekel, Andrew Cottam, Noel Gorelick, Alan S. Belward, High-resolution mapping of global surface water and its long-term changes. Nature 540, 418-422 (2016). (doi:10.1038/nature20584)
  - Available for download: https://global-surface-water.appspot.com
- Augmented with additional data to define areas to always include in Pixel Cloud
- Augmented with additional data to define areas to always exclude from Pixel Cloud?

WATER PROBABILITY MAPS OF PEKEL ET AL.

Data set

- Based on 32 years (1984-2015) of LandSat images at ~30 m resolution
- GeoTiff files, WGS84, 10° x 10° tiles (40000 x 40000 pixels)

- Several data layers (backup slide)
- Our baseline is to use occurrence
  - ✦ occurrence = surface water occurrence between 1984 and 2015
    - » Pixel values between 0 (never water) and 100 (always water)
- Other layers could also be useful
  - ✦ change, seasonality, recurrence, transitions, extent

Example: Occurrence map over the Mississippi River (courtesy of J.-F. Pekel)

AREAS TO ALWAYS INCLUDE IN THE PIXEL CLOUD

Why define inclusion zones?

- What will be included in the Pixel Cloud?
  - Detected water bodies
  - Buffer zone around detected water bodies (based on distance, floodplain DEM?)
  - Areas to always include according to reference water mask (inclusion zones)
    - Proportion of HR pixels included in Pixel Cloud assumed to be < 10% in average

- Motivation for defining inclusion zones
  - Water detection will not be perfect – risk of missed detection (false negatives)
    - Speckle, varying water/land contrast…
  - To include in the pixel cloud the floodplain, wetlands, dark water and other areas of hydrological interest that don't necessarily look like water in SWOT images
    - Reprocessing from the pixel cloud: we need to include everything that could be water, in case we missed it in the first processing.
    - Not preclude future science team investigations based on the Pixel Cloud by cutting out data that may be useful (multi-temporal studies, undetected wetlands, floodplains,… cryosphere?)
    - Floodplain DEM generation with stacking approach (goal only, requirement is for bathtub ring approach)

AREAS TO ALWAYS INCLUDE IN THE PIXEL CLOUD

Other masks or data bases needed to define inclusion areas?

- Pekel occurrence > 0
  - Main source of information, but not perfect
  - Can replace 0 occurrence by specific values based on other information sources
- Lakes in the lake database (polygons)
- Rivers in the river database (centerlines + width?)
- Additional inundation maps, wetland databases?
  - To compensate possible omissions in the Pekel occurrence map (and databases)
  - Science Team input is needed
  - See presentation of Filipe Aires et al. in the next session
- Optionally
  - Floodplains extended from these water bodies using the reference DEM?
  - Relatively flat and uniform areas for cryosphere studies?

AREAS TO ALWAYS EXCLUDE FROM THE PIXEL CLOUD?

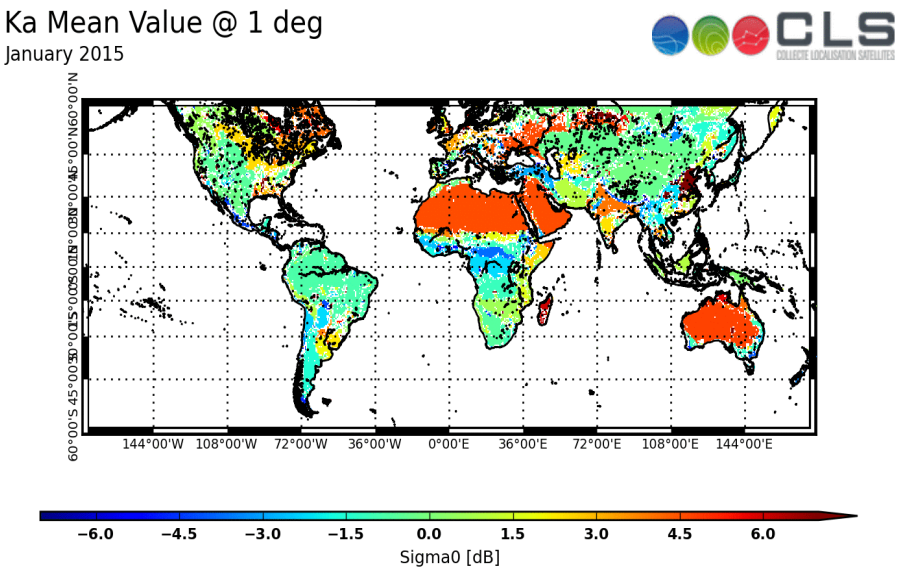
Define exclusion zones where water is so unlikely that detected water bodies can be systematically ignored?

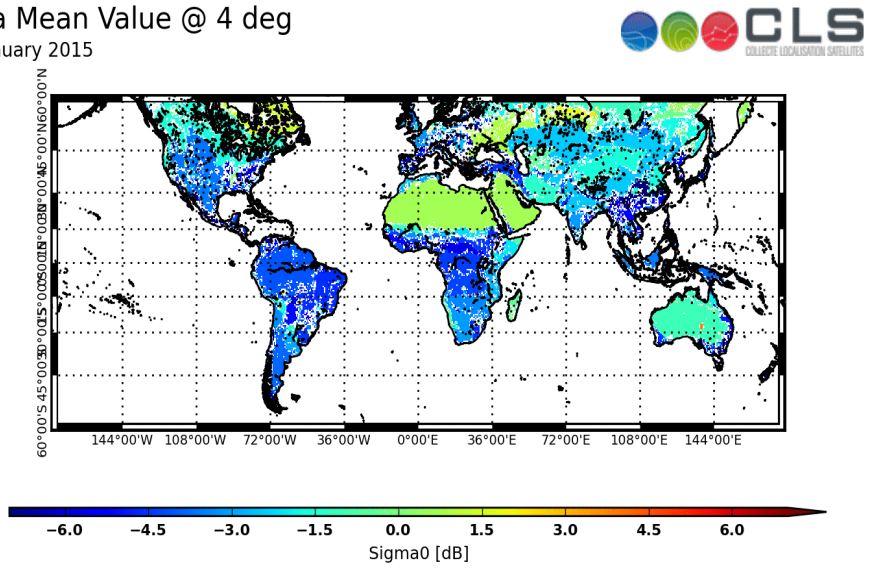
- Motivation
  - Reduce the number of false detections (false positives)
    - » Due to speckle, and the fact that other natural surfaces or man-made objects may look like water in SWOT HR images (bare soil, land/land layover, roads…)
    - » Consequences: pixels erroneously labelled as water in the Pixel Cloud, with impact on river and lake processing and products
- Could be based on
  - Landcover maps
  - Open Street Map (OSM) or similar (roads etc.)
  - Global Human Settlement Layer (GHSL) or similar (urban areas, buildings…)
  - Topography from DEM (e.g. land/land layover, convex hills, steep terrain)?
  - Ka-band near-nadir σ_0 measured by GPM?
  - …
  - Science Team input wanted

AREAS TO ALWAYS EXCLUDE FROM THE PIXEL CLOUD?

Example: Low incidence Ka-band σ_0 of land surfaces from GPM

- Map based on GPM data falling into clustered LULC MODIS data





Courtesy: Nicolas Longépé, CLS, 2017

- High σ_0 @1° observed by GPM for deserts, barren and sparsely vegetated land
- Many of these areas are outside the HR mask (no HR data coverage)
- Need for exclusion zones to reduce false water detection within HR mask?

WAY FORWARD FOR REFERENCE WATER MASK

Reference water mask: augmented Pekel occurrence map

- Get input from science team on
  1. Relevant additional data sources to define inclusion zones (beyond Pekel occurrence > 0, and areas covered by the SWOT river and lake databases)
  2. Whether and how we can safely define exclusion zones where water is so unlikely that detected water bodies can be ignored (assumed to be false detection)
- Study coherency and interest of a shortlist of data sources
- Prototype tools and create reference water mask for limited areas using the selected data sources
- Produce and validate the global reference water mask

BACKUP

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- Several data layers:
  - <occurrence> = Surface water occurrence between 1984 and 2015
    - Pixel values: (100 = always water) … (0 = never water)
  - <change> = Surface water occurrence change intensity between 1984 and 2015
    - Pixel values: (1 = decrease) …(255 = increase) [0 = land]
  - <seasonality> = Surface water seasonality between 2014 and 2015
    - Pixel values:(1 = seasonal) … (12 = permanent) [0 = land]
  - <recurrence> = Surface water recurrence between 1984 and 2015
    - Pixel values: (1 = 0%) … (255 = 100%) [0 = land]
  - <transitions> = Transitions in surface water class between 1984 and 2015
    - Pixel values: (1 = permanent) … (10 = ephemeral seasonal) [0 = land]
  - <extent> = Maximal water extent between Oct 2014 and Oct 2015
    - Pixel values: (0 = never water) or (1 = at least once water)