



National Aeronautics and  
Space Administration

Jet Propulsion Laboratory  
California Institute of Technology  
Pasadena, California



# Surface Water and Ocean Topography (SWOT) Mission

## Validation Meeting

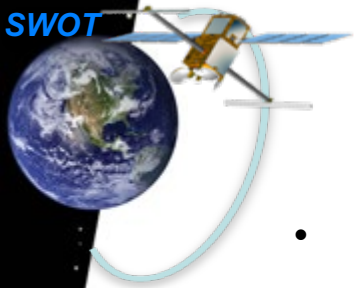
June 18-19, 2024

### Raster Validation

Alexander Corben<sup>(1)</sup>

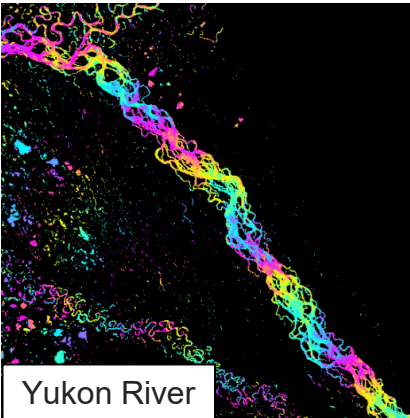
on behalf of JPL/CNES Algorithm and Cal/Val Team

<sup>(1)</sup>Jet Propulsion Laboratory, California Institute of Technology

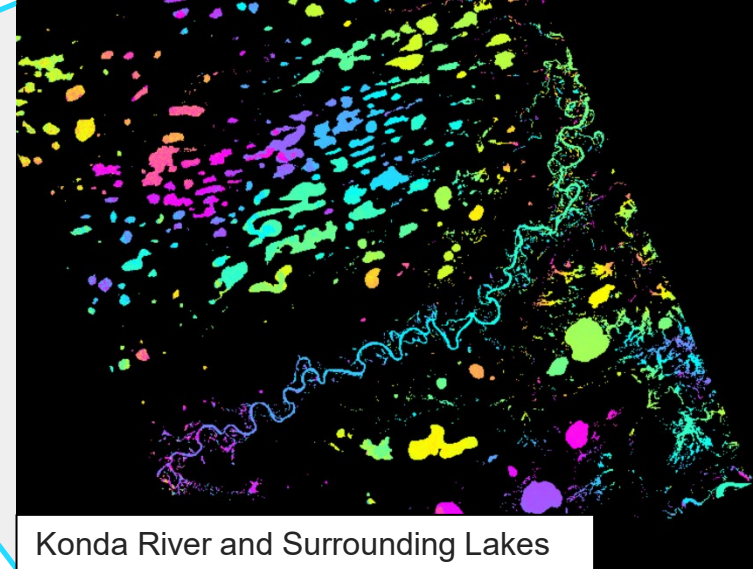
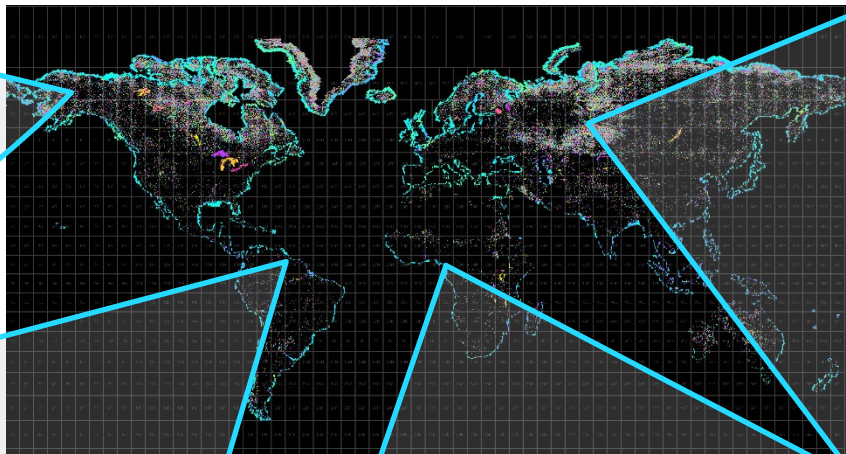


# General Performance

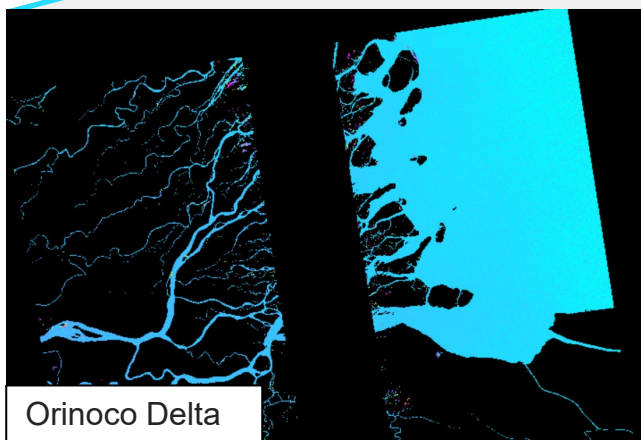
- Raster performance seems to be very good, comparable to the input pixel cloud performance in terms of WSE and water area
- RiverSP and LakeSP products are generally better suited to making measurements over well-defined rivers and lakes. However, high quality river and lake in-situ data gathered during the SWOT Cal orbit for validation of those products were readily available and were used for the purposes of this raster-level validation



Yukon River



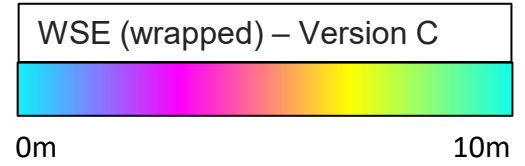
Konda River and Surrounding Lakes

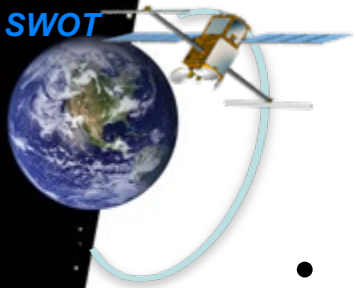


Orinoco Delta



Coastal Cameroon

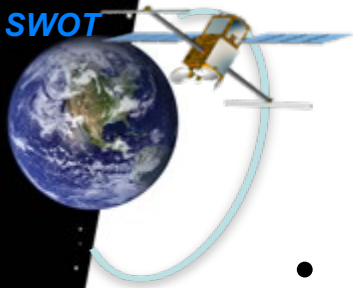




# Overview

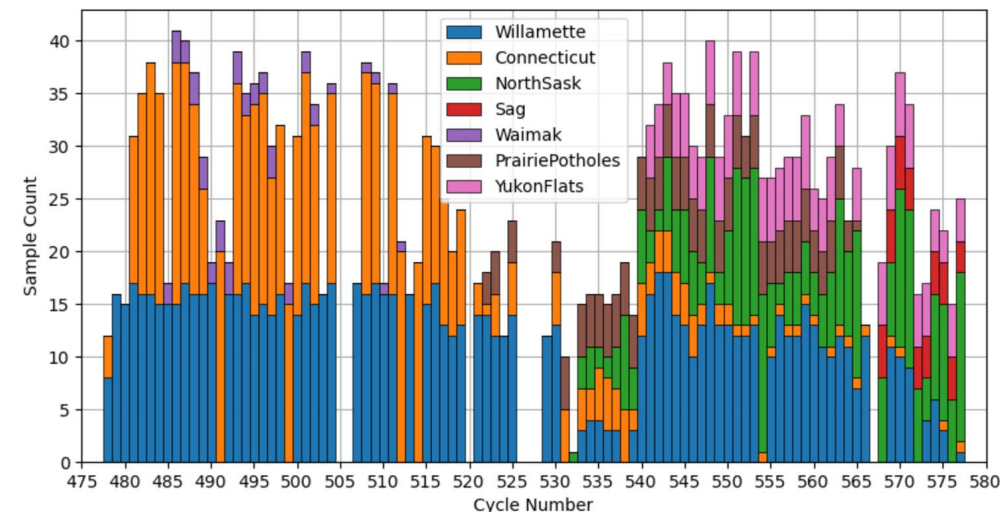
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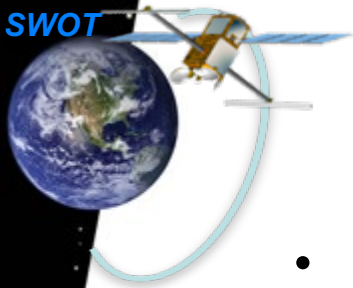
- WSE Data and Methodology
- 100m Raster WSE Validation over Rivers
- 100m Raster WSE Validation over Lakes
- Water Area Data and Methodology
- 100m Raster Water Area Validation
  - Dark Water Projection Errors
- 250m Raster Validation



# WSE Data and Methodology

- Rasterized pressure transducer (PT) data +/- 15 minutes from each SWOT observation over US CalVal site rivers and lakes
  - Calculated absolute WSE statistics for each site over the SWOT Cal orbit
- WSE Validation Thresholds/Filters
  - Good estimated PT quality
  - Good/Suspect raster pixel-level quality
  - Between 10 and 60 km cross-track
  - Exclude bright land and low-coherence water
  - Some plots exclude dark water
  - Some plots exclude raster bins flagged as “few\_pixels”, which indicates raster bins with fewer than 5 pixel cloud samples aggregated to them. This excludes pixels without sufficient height averaging as well as edge pixels from statistics.
- Thresholds and filters are loose and not strictly based on the waterbody-level science requirements placed on the river and lake products

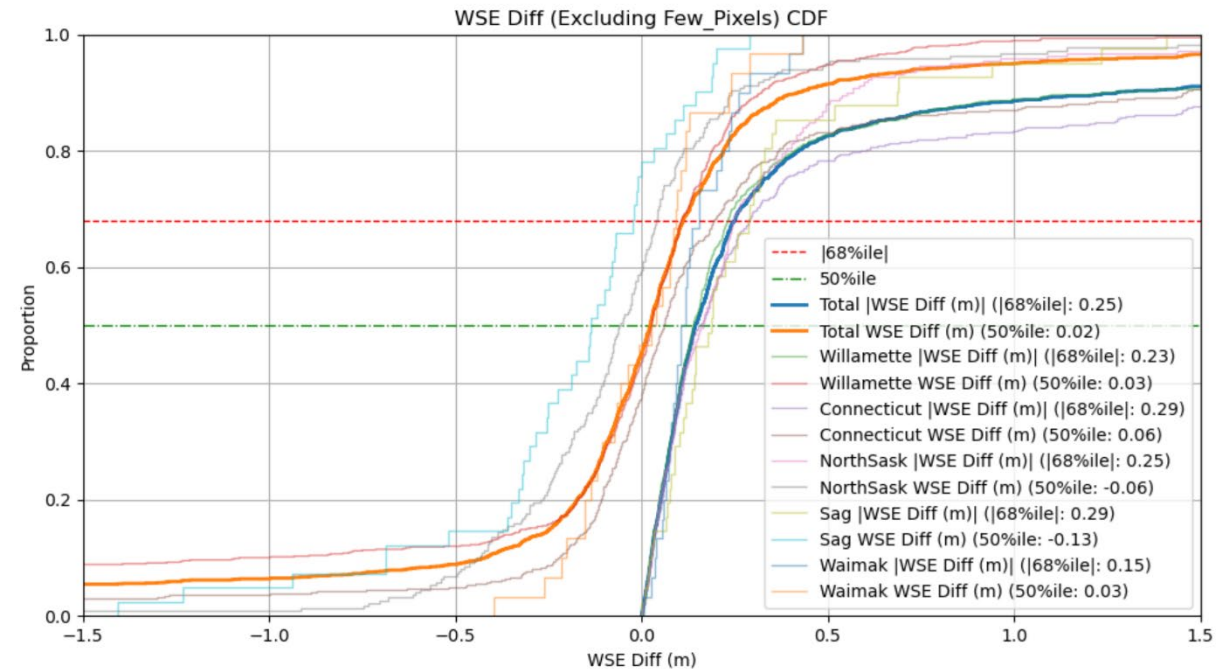
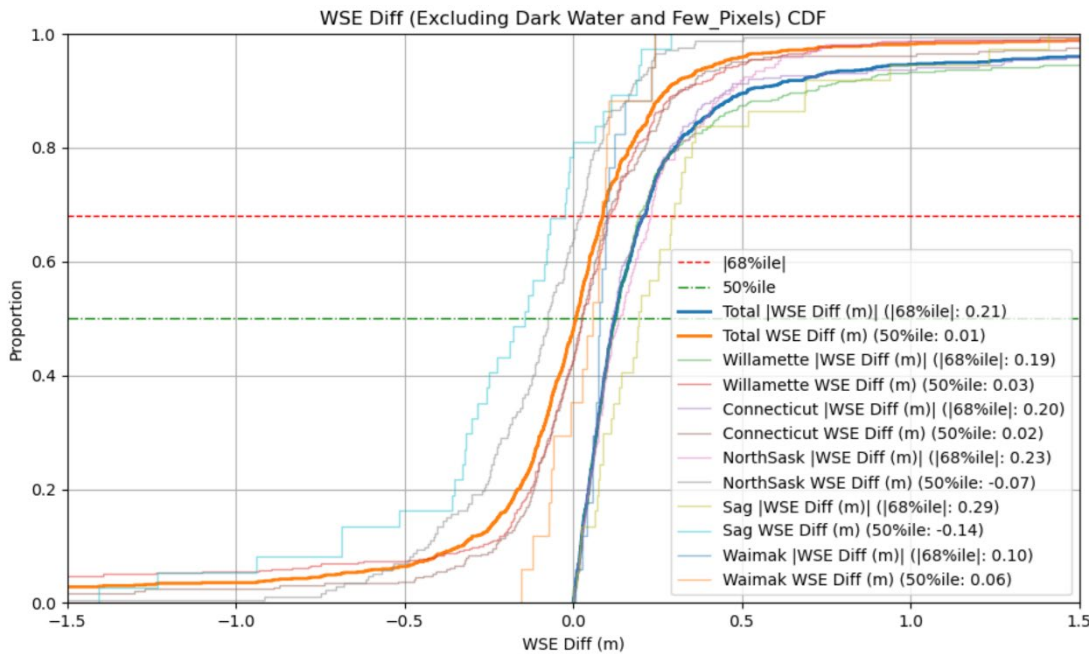
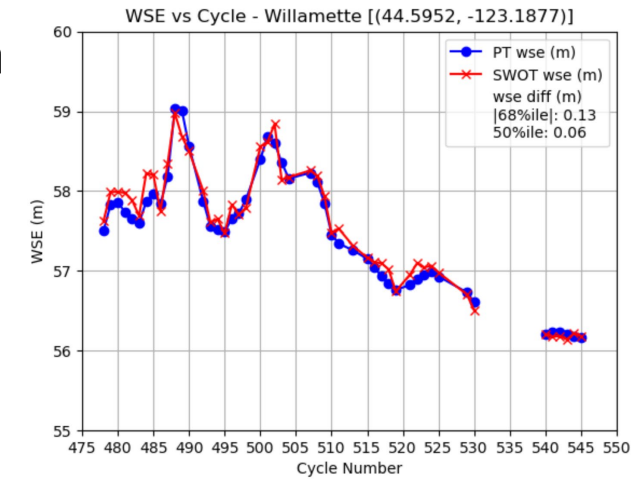


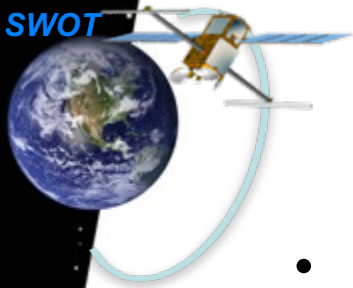


# Raster WSE Validation over Rivers

## 100m Raster - Interior Water

- US CalVal river statistics show centimeter-level biases from scene-to-scene, but very little bias when accumulating results from all scenes
- Very good observed WSE performance for interior water
  - |68%ile| without dark water: **0.21m**
  - |68%ile| with dark water: **0.25m**

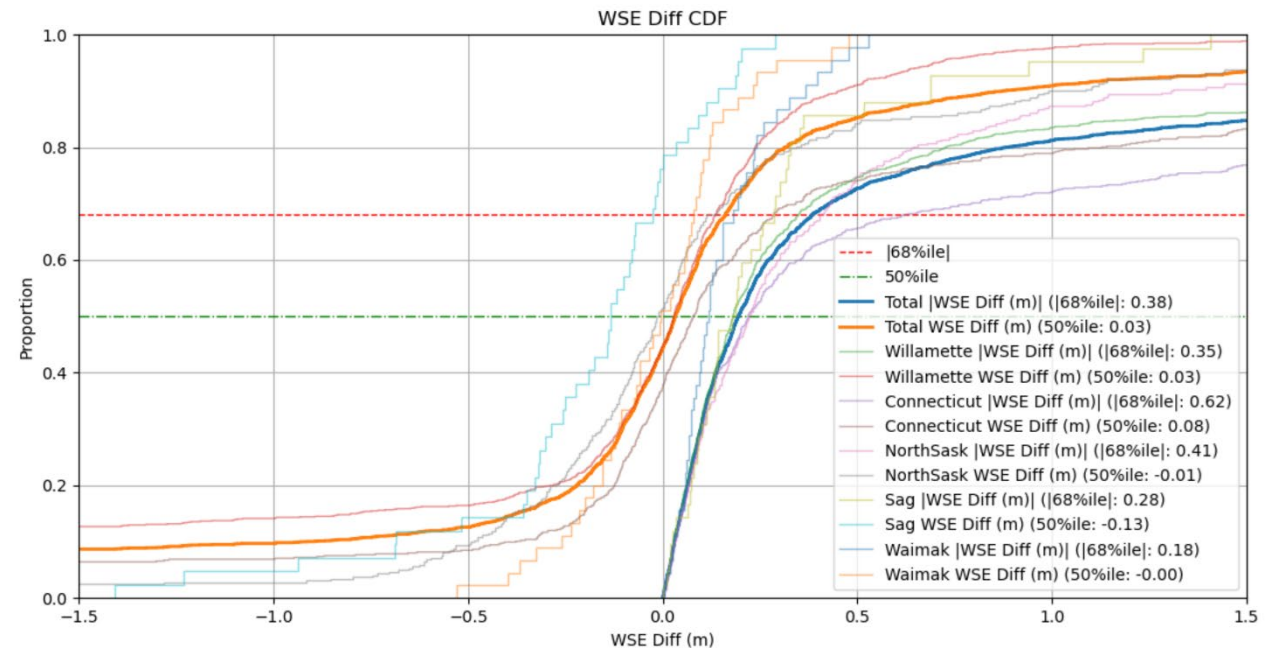
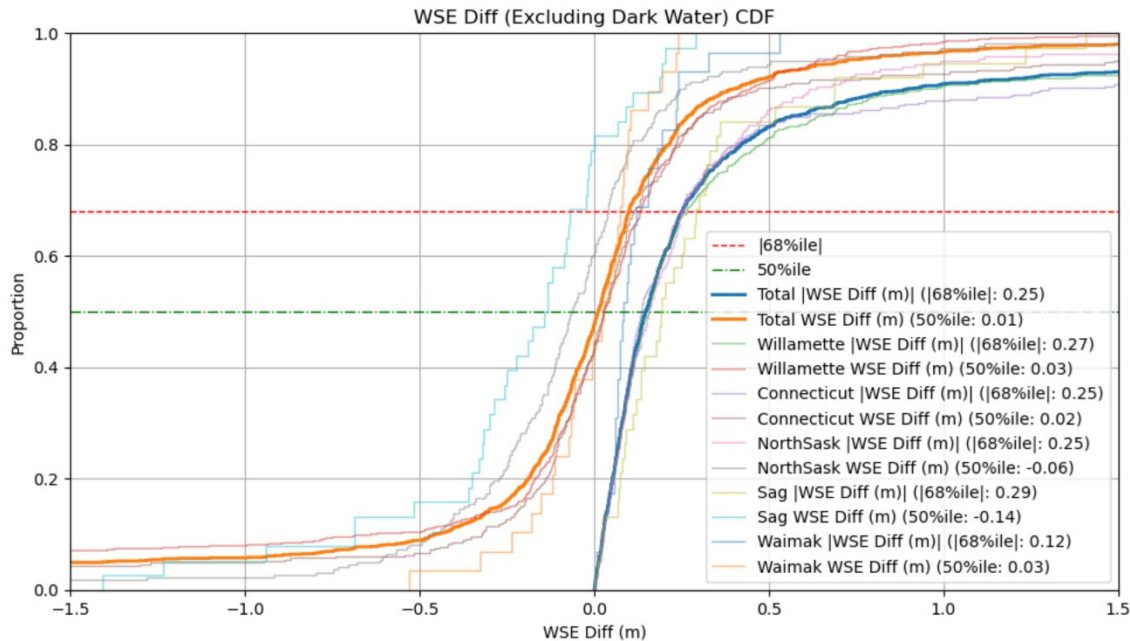


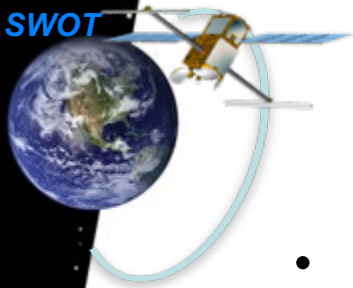


# Raster WSE Validation over Rivers

## 100m Raster - All Water

- Including pixels flagged as “few\_pixels” shows an increase in difference as expected
  - |68%ile| without dark water: **0.25m**
  - |68%ile| with dark water: **0.38m**
- Impacts from including both “few\_pixels” and dark water are more significant for some scenes than others (e.g. Connecticut and North Saskatchewan Rivers)

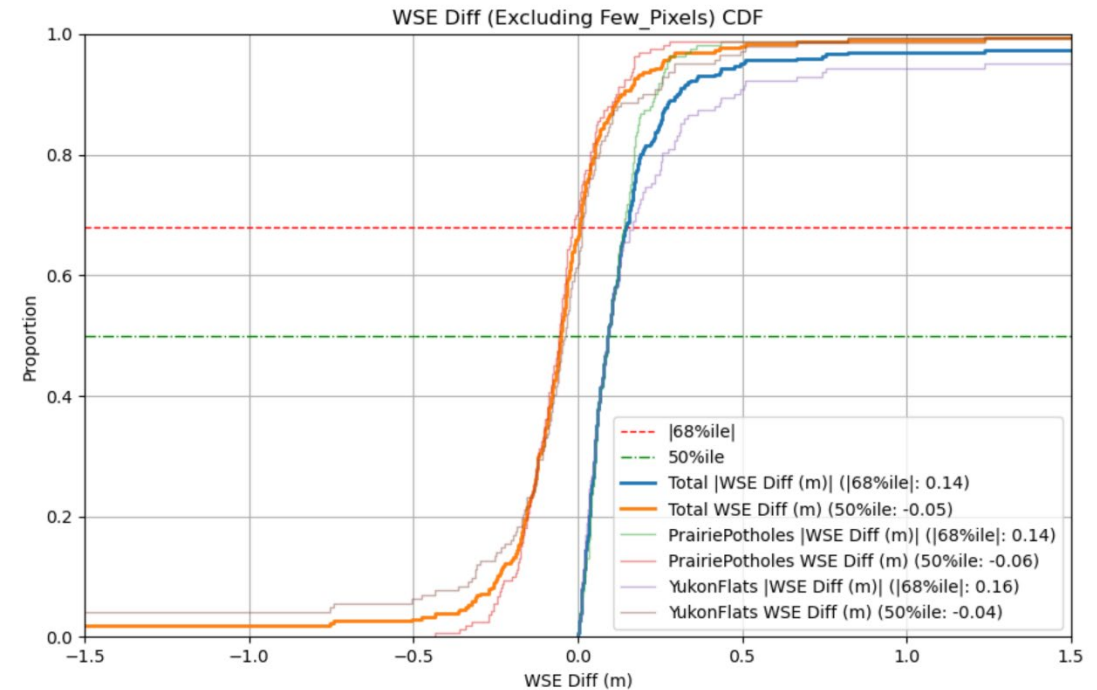
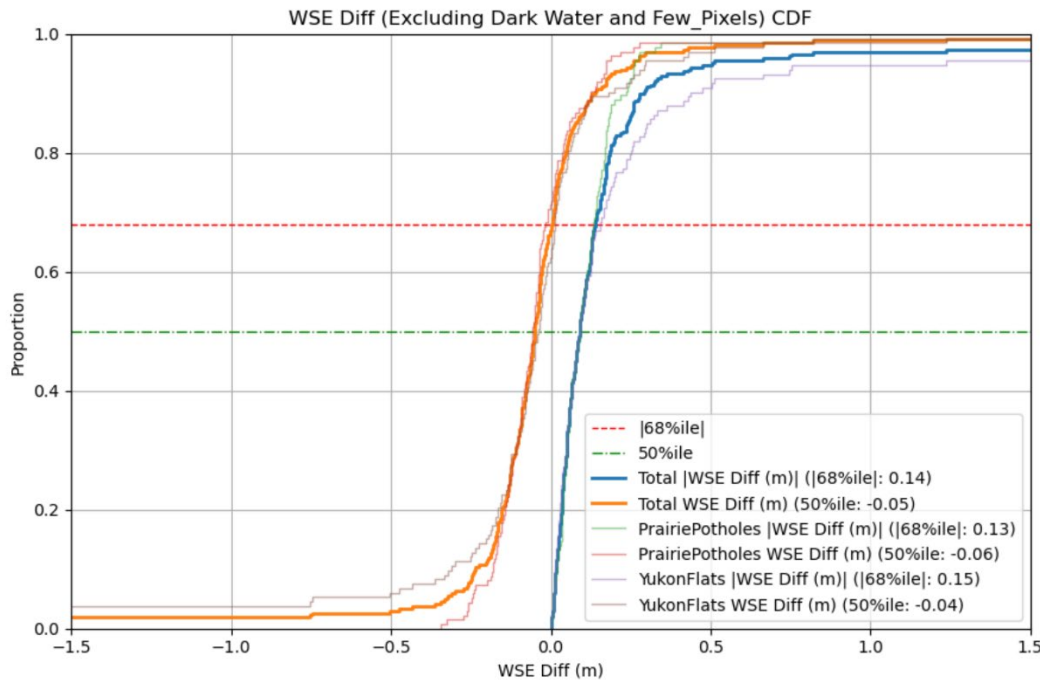
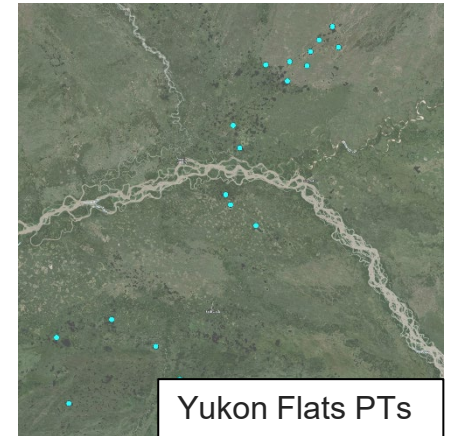


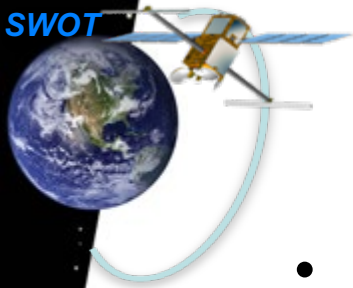


# Raster WSE Validation over Lakes

## 100m Raster - Interior Water

- US CalVal lake sites have less data coverage than rivers
  - 2 sites with valid data for statistics – Prairie Potholes and Yukon Flats
  - Combined coverage of 28 lakes ranging from approx. 0.05 km<sup>2</sup> to 15 km<sup>2</sup>
- Very good observed WSE performance for interior water
  - |68%ile| with or without dark water: **0.14m**

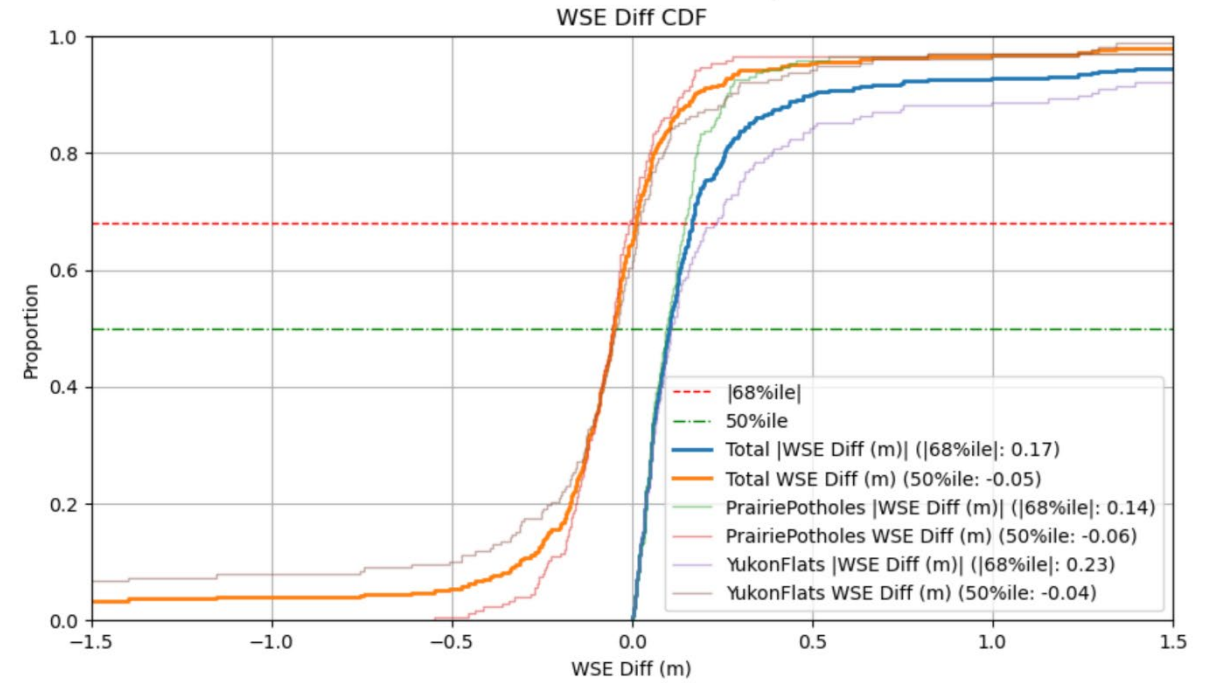
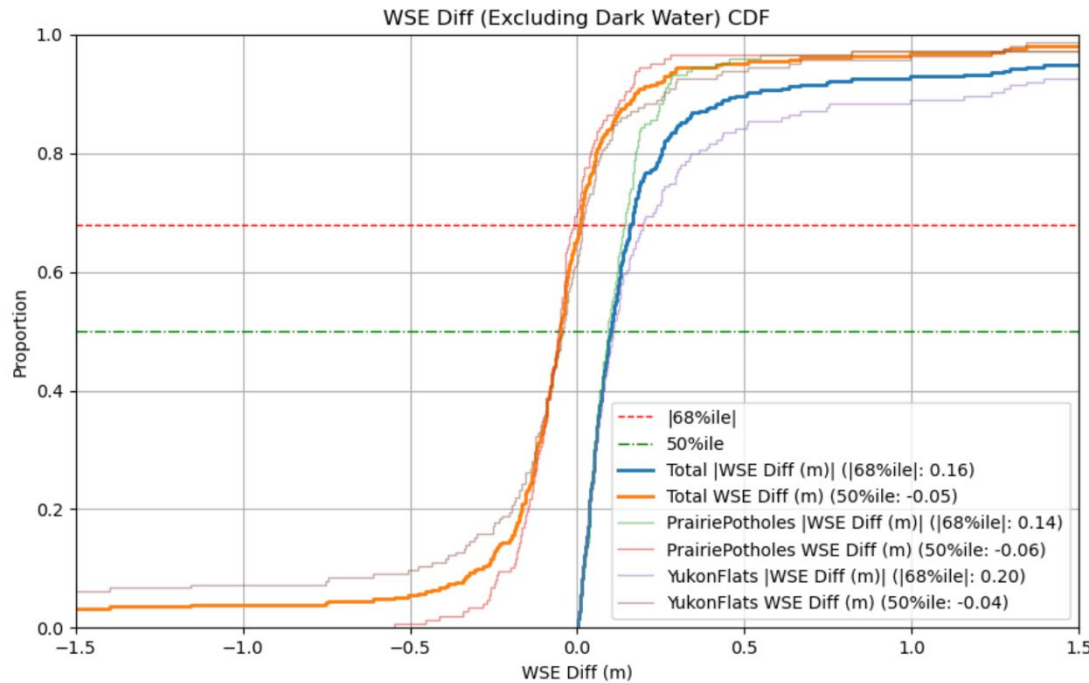
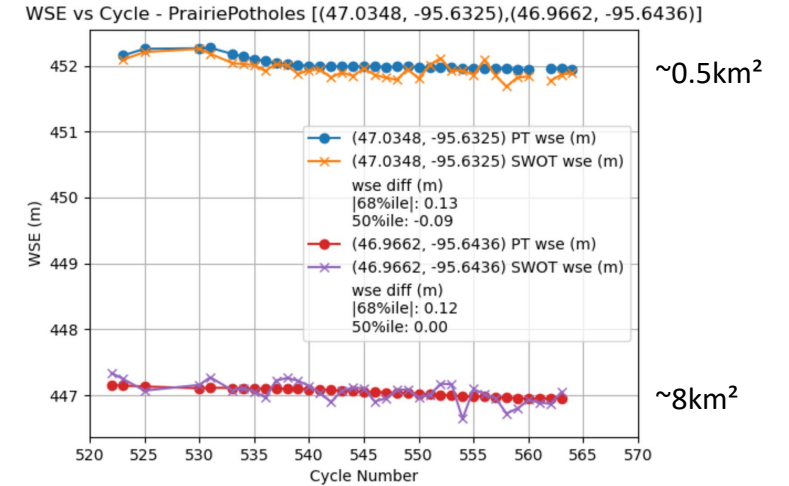




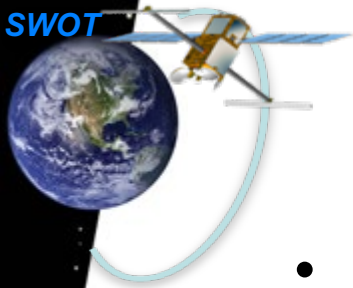
# Raster WSE Validation over Lakes

## 100m Raster - All Water

- Including pixels flagged as “few\_pixels” shows a slight increase in difference as expected
  - |68%ile| without dark water: **0.16m**
  - |68%ile| with dark water: **0.17m**

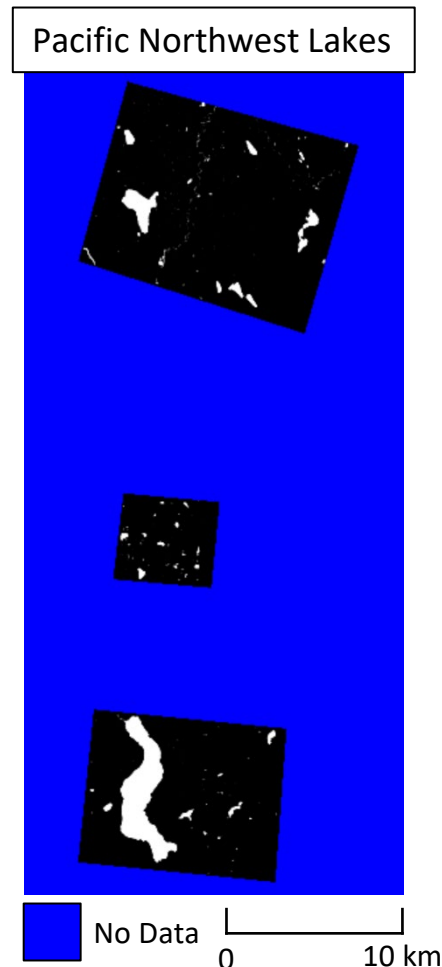


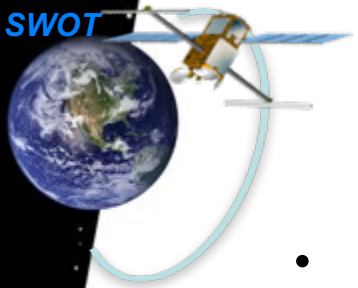




# Water Area Data and Methodology

- Rasterized Area data from watermasks generated from NV5 4-band aerial imagery over Willamette River, Connecticut River and Pacific Northwest Lakes
  - 3 days over Willamette River in June 2023
  - 1 day over Connecticut River in July 2023
  - 2 days over Pacific Northwest Lakes in June 2023 (Multiple small watermasks over select waterbodies, across two SWOT tiles)
  - Scene-level differences estimated over watermask bounds (i.e. all covered waterbodies, not just the primary river or lake of interest in the scene)
- Compared each watermask to +/- 1 day of SWOT data
- Assessments include all data within the extent of the watermask that is not flagged as bright land
  - The Willamette and Connecticut River watermasks only extend a short distance from the main river channel, but do include some lakes near each river

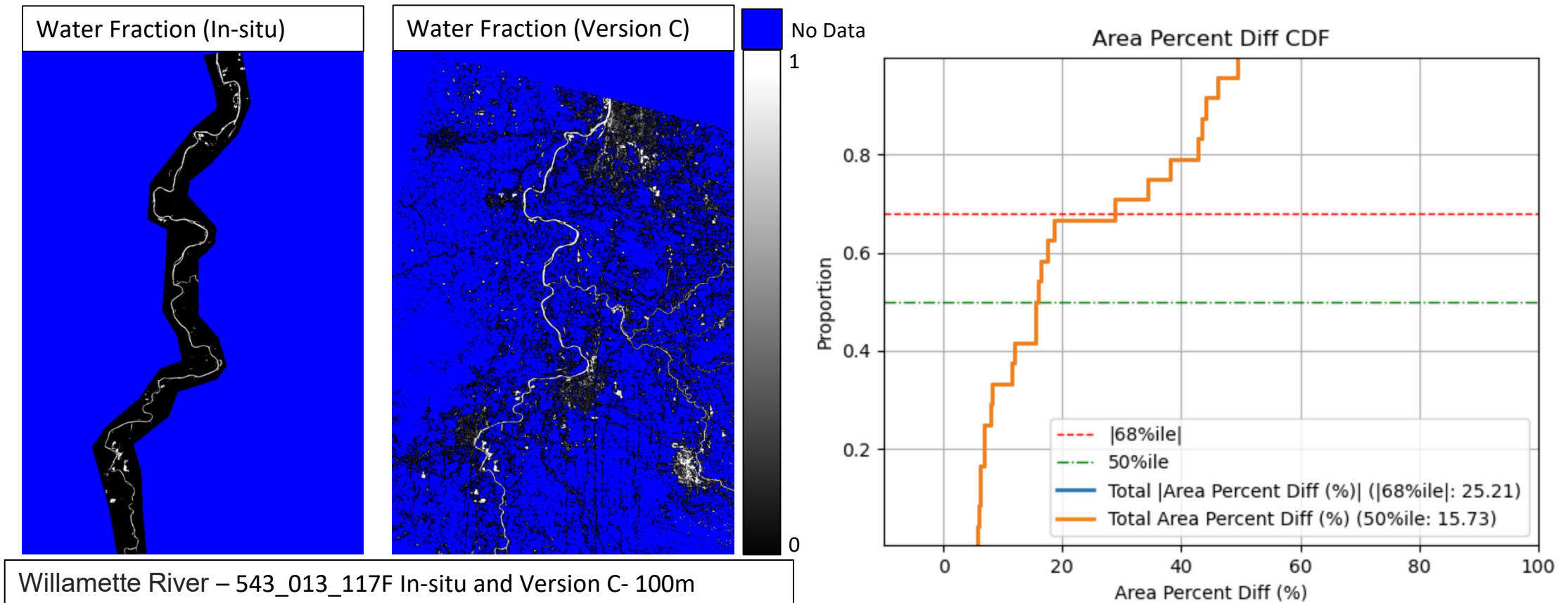




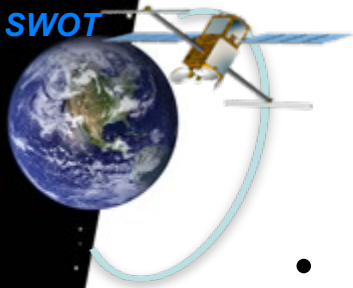
# Raster Water Area Validation

## 100m Raster – Version C

- Total Area Percent Difference per-scene shows that Version C products over-estimate water surface area by approximately **21%** on average
- River over-estimates are more severe as large segments of both the Willamette and Connecticut flow parallel to the orbit track and are sensitive to dark water projection errors



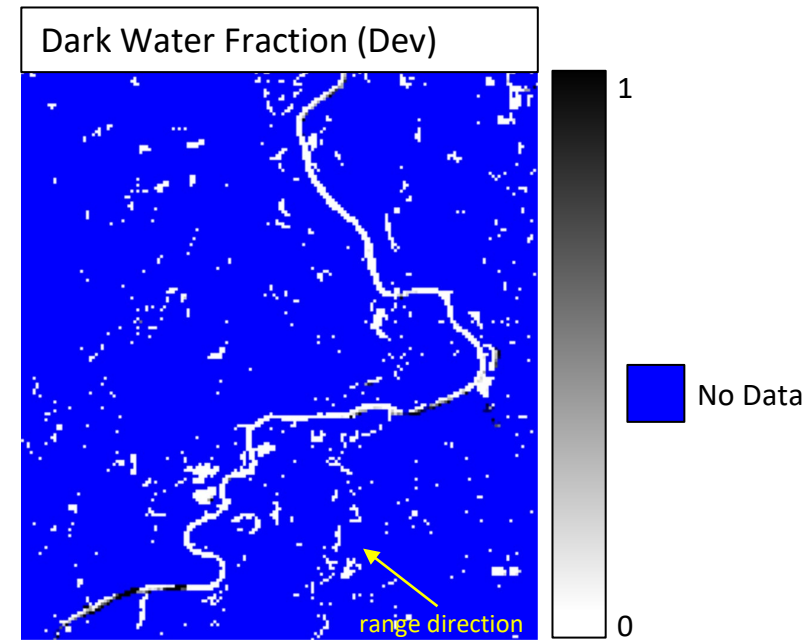
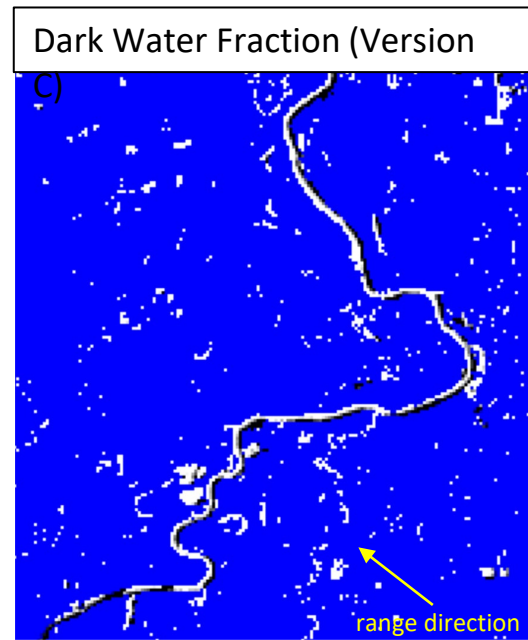
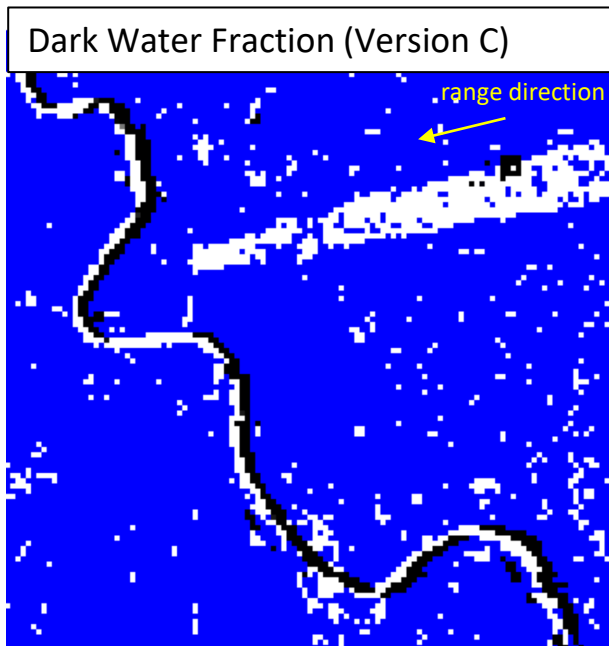
Willamette River – 543\_013\_117F In-situ and Version C- 100m Rasters



# Raster Water Area Validation

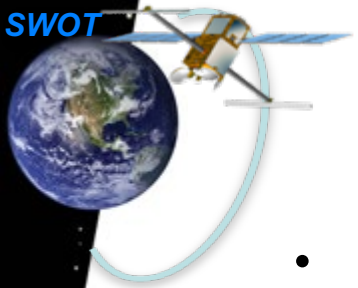
## Dark Water Projection Errors

- Dark Water projection errors in Version C Pixel Cloud processing can cause water area over-estimates
- For rivers flowing parallel to the SWOT orbit track, this can lead to consistent over-estimates of water along one side of the river
- Developmental Pixel Cloud processing greatly reduces this type of error



Garonne River – 545\_016\_038F Version C - 100m Raster

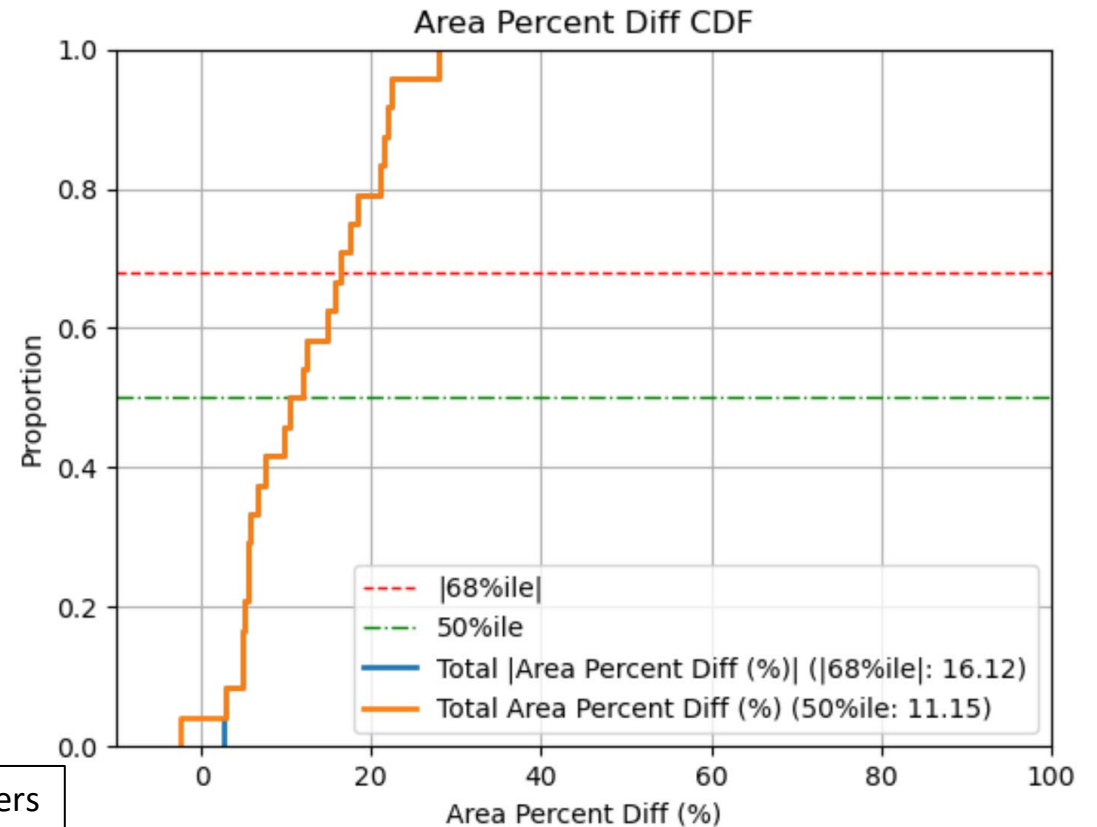
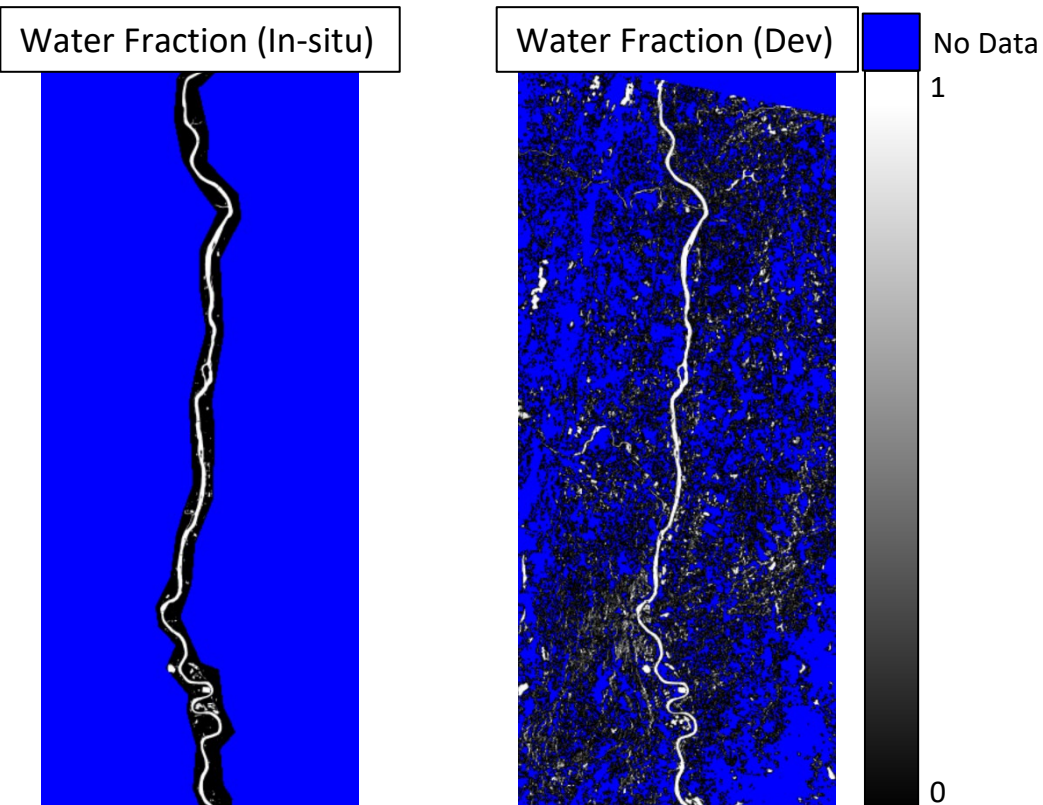
Willamette River – 542\_013\_117F Version C and Developmental - 100m Rasters



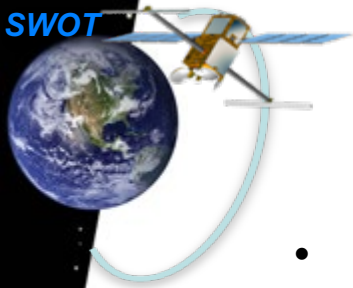
# Raster Water Area Validation

## 100m Raster – Developmental

- Total Area Percent Difference per-scene shows that developmental products still overestimate water surface area by approximately **12%** on average
- Dark water projection errors primarily impact rivers, therefore the effect of this fix on the Pacific Northwest lakes is less significant than for Willamette and Connecticut Rivers

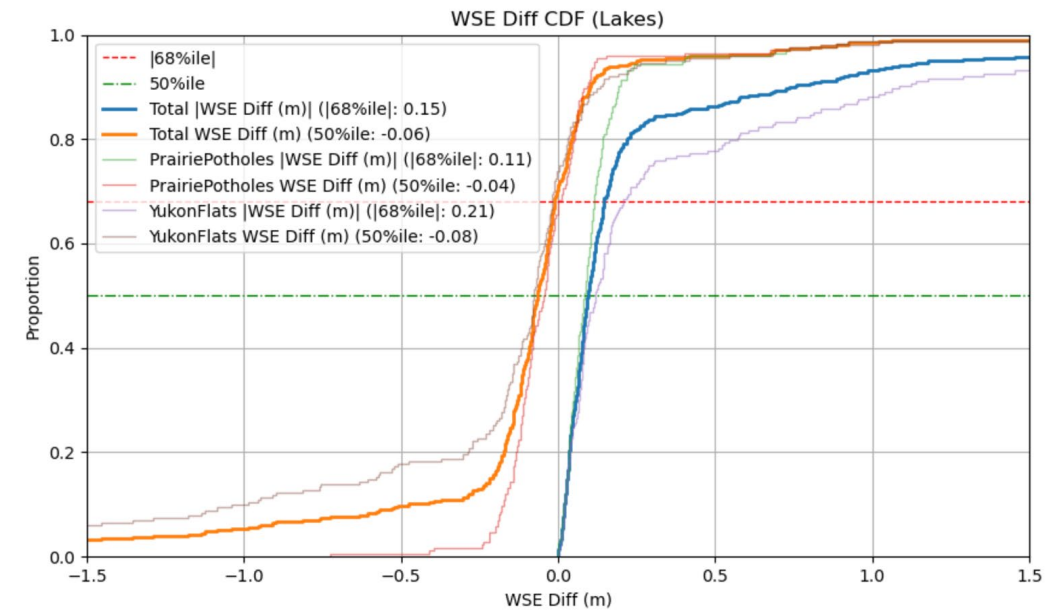
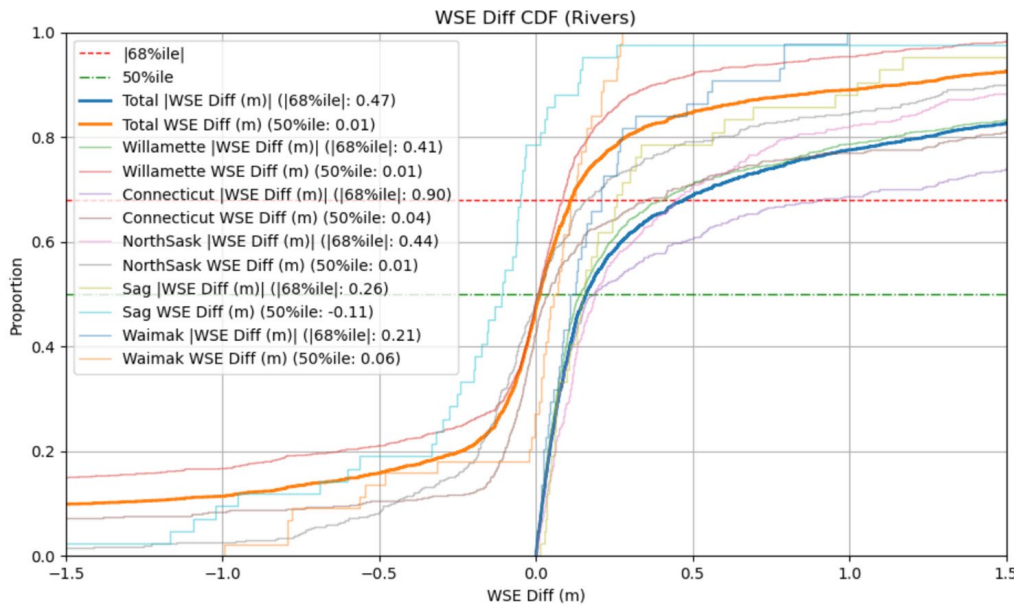


Connecticut River – 575\_009\_114F In-situ and Developmental - 100m Rasters

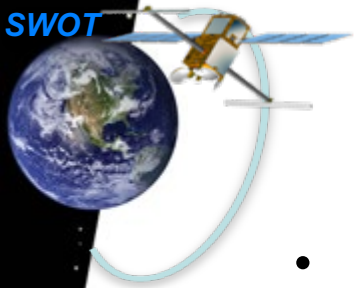


# 250m Raster Validation

- WSE performance statistics degrade slightly for rivers when compared to 100m raster
  - Rivers |68%ile|: **0.47m** when including dark water pixels
  - Lakes |68%ile|: **0.15m** when including dark water pixels
  - PT samples provide the WSE at a single location on a single water body, while raster bins average all samples within the extent of the pixel, which is impacted by river slope and may include nearby water
  - This is not to say that the 250m raster is worse than the 100m raster, but that it is not necessarily the best option to obtain precise WSE measurements for the kinds of relatively narrow rivers in this dataset



- Total water area is generally the same regardless of resolution
  - Minor differences due to pixels at the edges of any given raster scene and less common degraded flags



# Conclusion

- WSE performance at the raster level is very good for both rivers and lakes, based on the US CalVal site data
  - River |68%ile| WSE difference: **0.25m** for bright water pixels
  - River |68%ile| WSE difference: **0.38m** when including dark water pixels
  - Lake |68%ile| WSE difference: **0.16m** for bright water pixels
  - Lake |68%ile| WSE difference: **0.17m** when including dark water pixels
- Water area tends to be over-estimated in both the Version C and developmental products
  - **21%** over-estimated water for Version C products
  - **12%** over-estimated water for developmental products
- RiverSP and LakeSP products are generally better suited to making measurements over well-defined rivers and lakes
  - High quality data for comparison over other classes of features (e.g. floods, coasts/estuaries, etc) is limited, but we expect comparable results over those features as well