National Aeronautics and Space Administration

Jet Propulsion Laboratory
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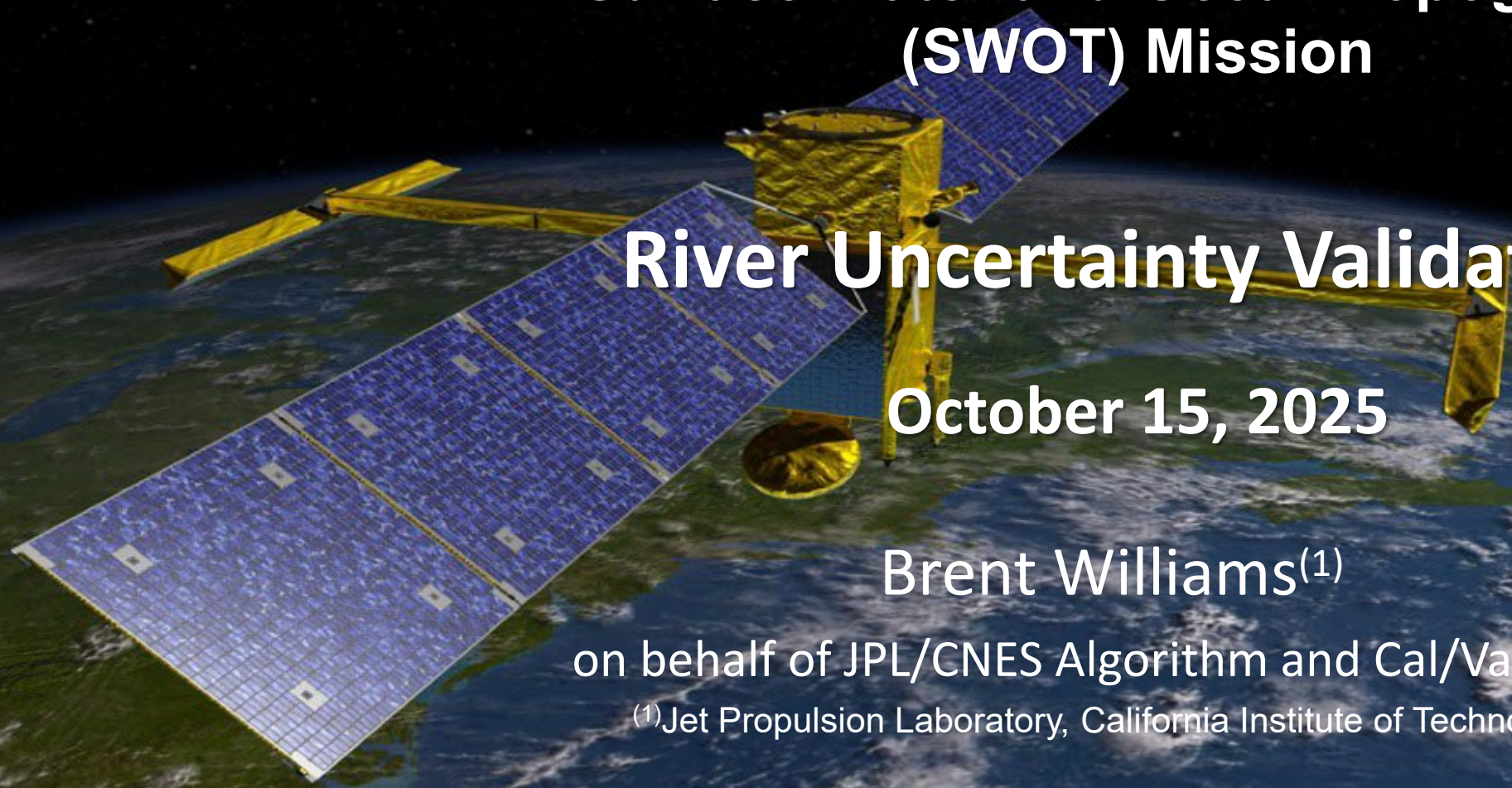
Pasadena, California

Surface Water and Ocean Topography (SWOT) Mission



River Uncertainty Validation

October 15, 2025

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

[1]Jet Propulsion Laboratory, California Institute of Technology

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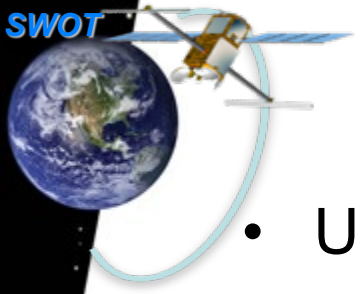

Overview

- Uncertainty validation
  - Characterizing how well the *_u quantities represent the actual 1-σ errors

- River WSE, slope, area/width
  - Node and reach for WSE/area
  - Reach-only for slope

- Compare estimated uncertainty with measured errors relative to field-data
  - Cal orbit-only for WSE
  - Science orbit only for area/width
  - Current development (offline, Version D-like) and Version C
    - Same “Outer” and “Inner” filters as in width assessment slides

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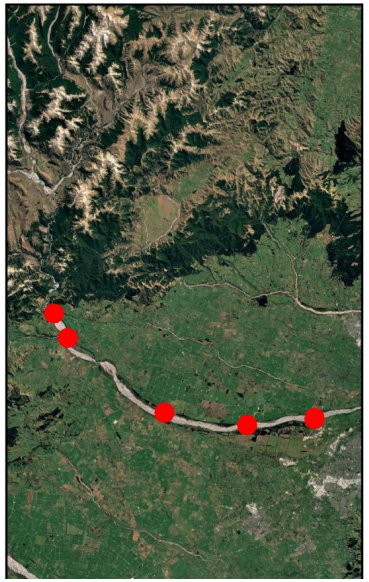
WSE and Slope Dataset

- Cal/val dataset over Tier1 sites
- Focusing on pressure transducer (pt) data
  - Most reliable for relative wse and slope assessments
- Cal orbit only

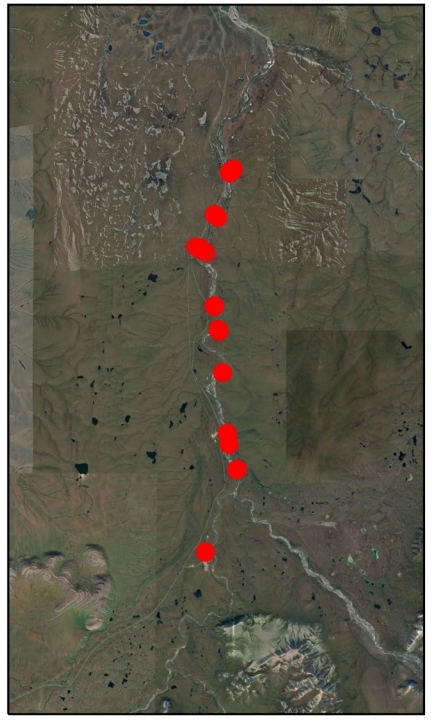
River validation paper (in prep) describes more details of validation set

PT Nodes Waimakariri River OIIT

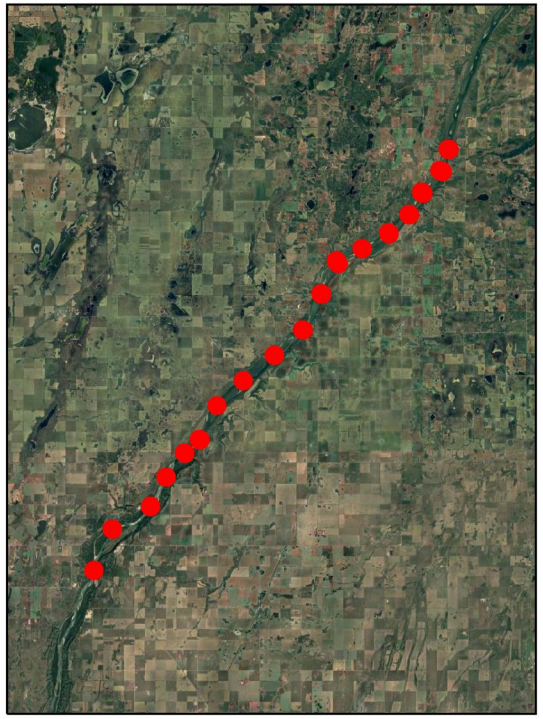


PT Nodes Willamette River OIIT

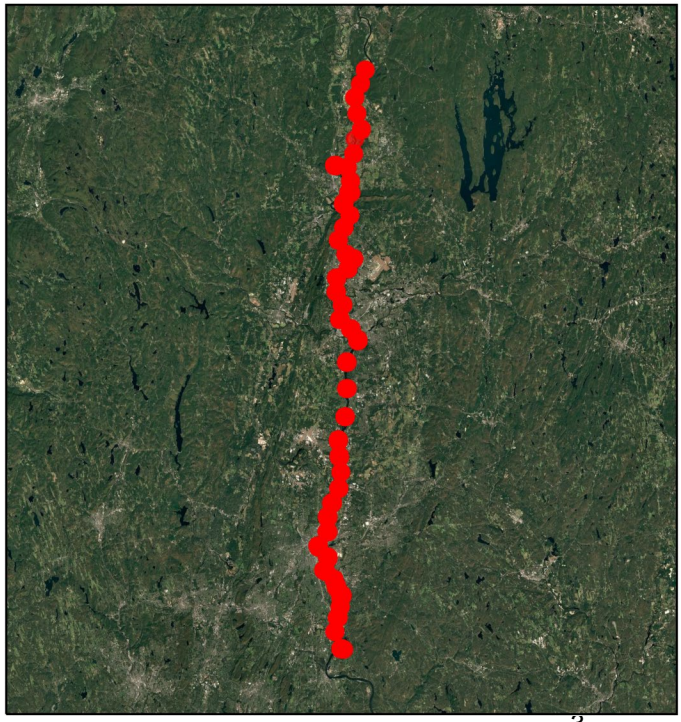
PT Nodes Sagavanirktok River OIIT



PT Nodes North Saskatchewan River OIIT



PT Nodes Connecticut River OIIT



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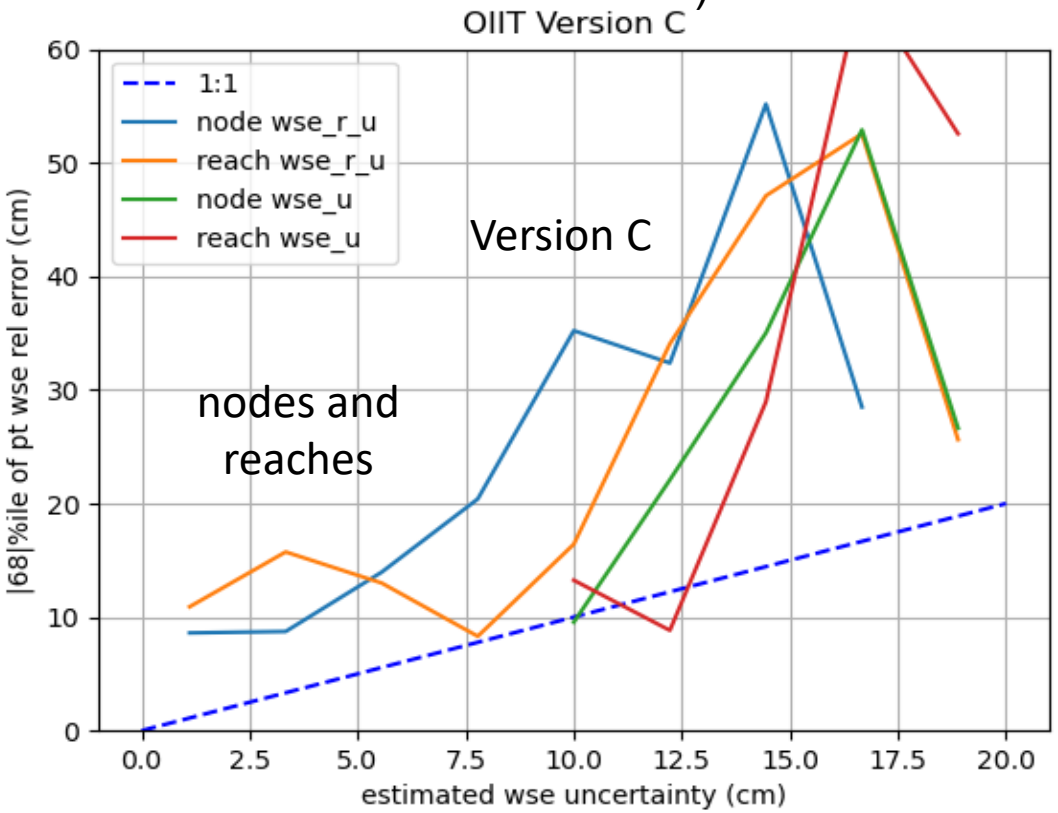
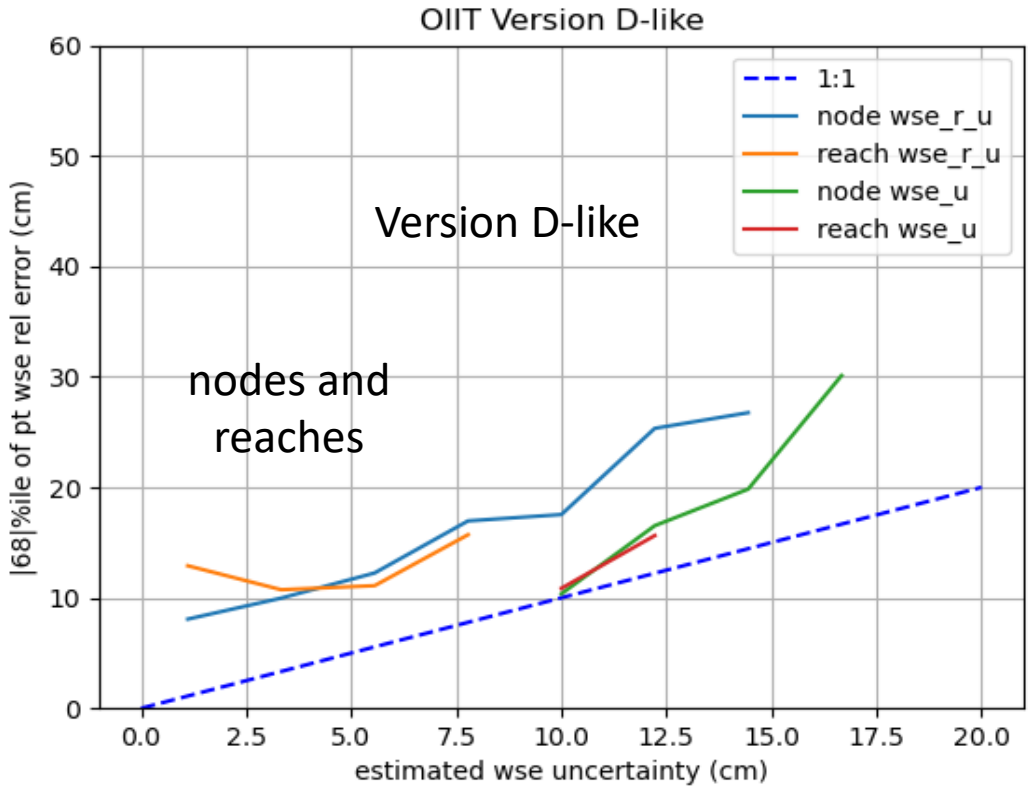
WSE Uncertainty

- WSE |68|%ile (1-σ) errors are generally close to what they are designed to model
  - Ideally on the 1:1 line
  - Trend correctly with the estimated quantities in the river products
  - There is a minor under-estimate (expected since we do not model every error and field data errors also contribute)



- Wse uncertainty estimates are generally reliable
  - For both wse_r_u and wse_u
    - Offset between wse_r_u and wse_u expected from difference in the systematic terms (e.g., residual xover error)
  - For both node and reach
  - Better for Version D-like, but still not terrible for Version C



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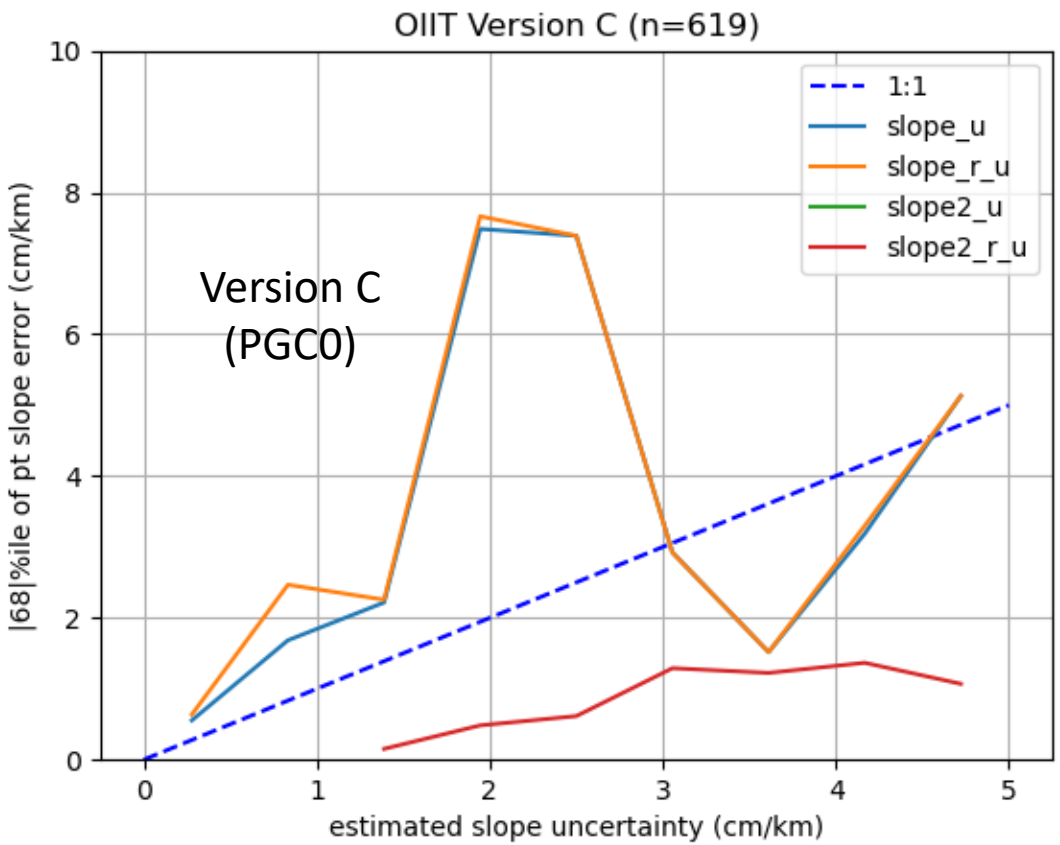
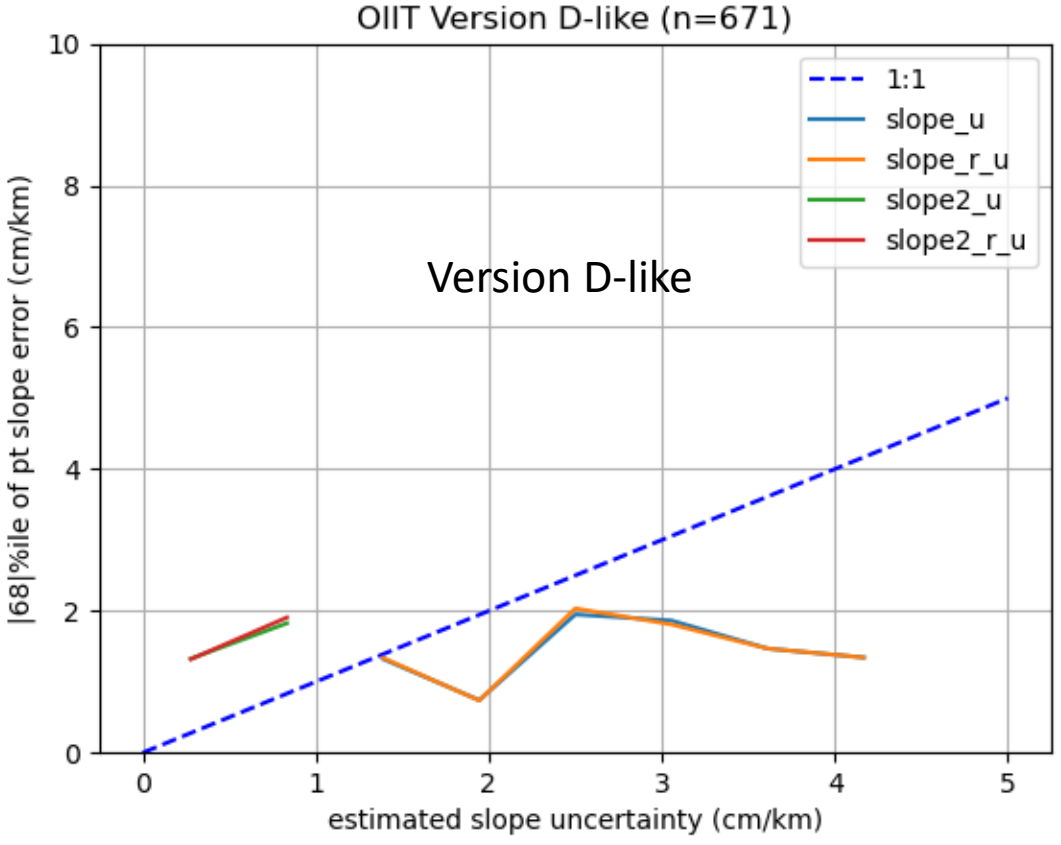
Slope Uncertainty

- Slope uncertainties are in the right ballpark
  - Version D more reliable than version C (was a bug in C0, fixed in C2 and D)
  - Similar between slope_u and slope_r_u, expected since systematic terms less important for slope





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Width Dataset

- Width errors relative to DSWx 30m data
  - Same dataset as width assessments in previous talk
  - ~300 tile-observation collocations over science orbit
  - Representative in terms of global sampling

- area_u and area_r_u converted to width_u = area_u / p_length
  - Same conversion for node and reach (p_length is node or reach length)

- Note that there are known error classes that are not well modeled in the area/width uncertainties reported in the product
  - Dark water
  - Various known pixel assignment errors

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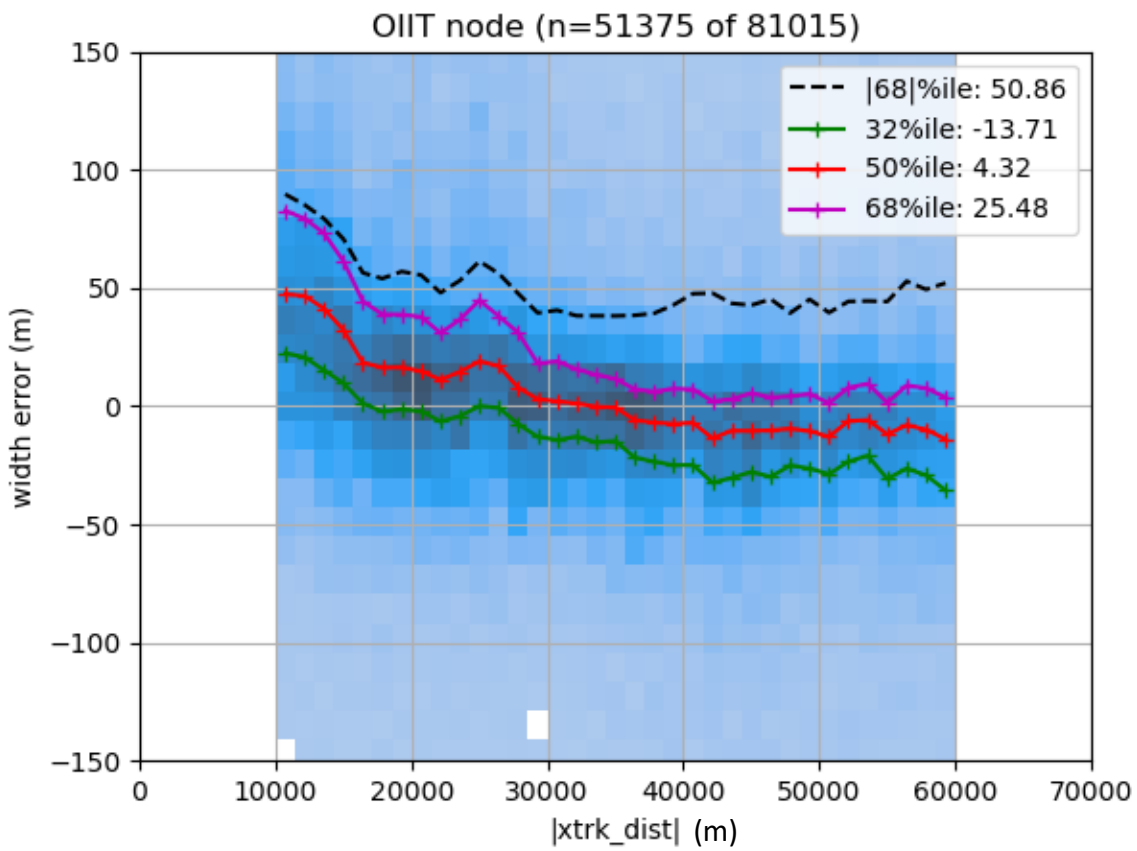
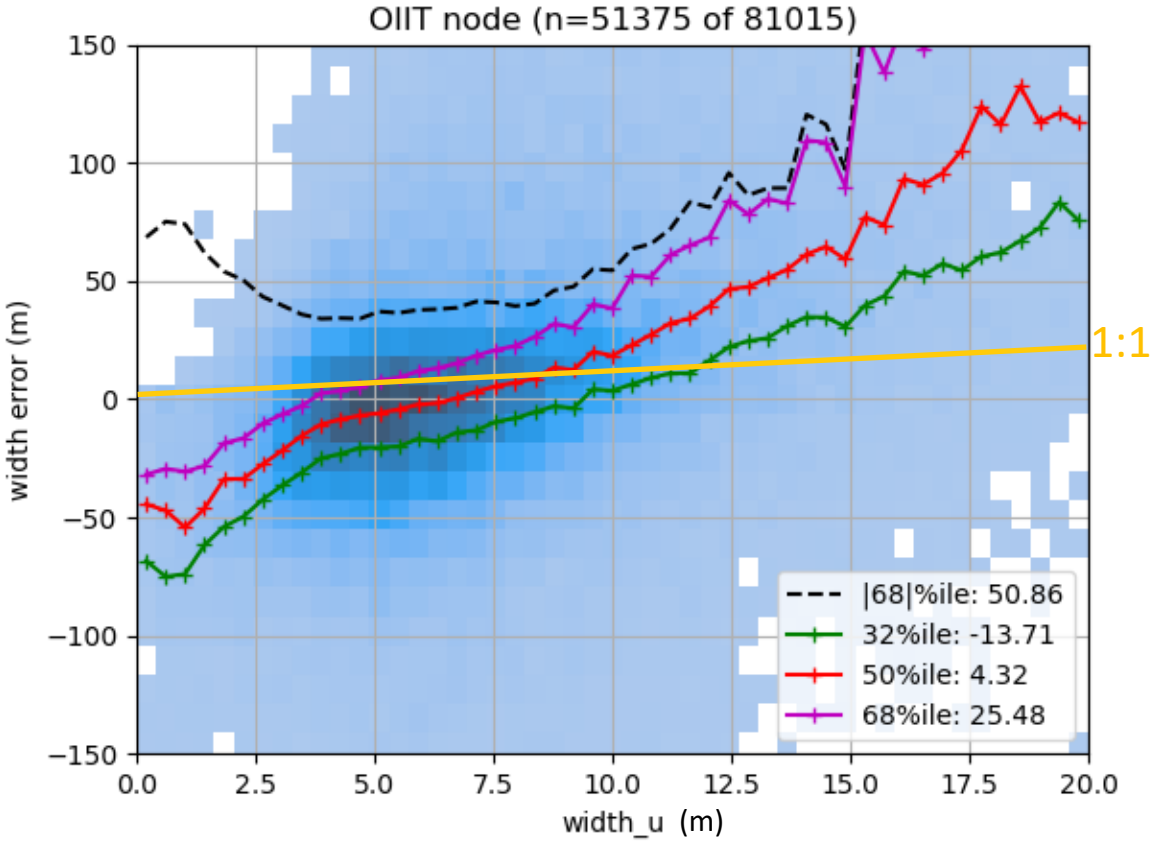
Width Errors vs Uncertainty (Node)

- Width uncertainties not reliable predictor of |68|%ile width error
  - Bias trend as a function of cross-track
  - Bias with width_u is not expected, and couples with cross-track bias
    - width_u bias also trends with cross-track (not shown here)
  - Hard to see the variability of the errors vs width_u because of the strong bias
- Can empirically take out the bias





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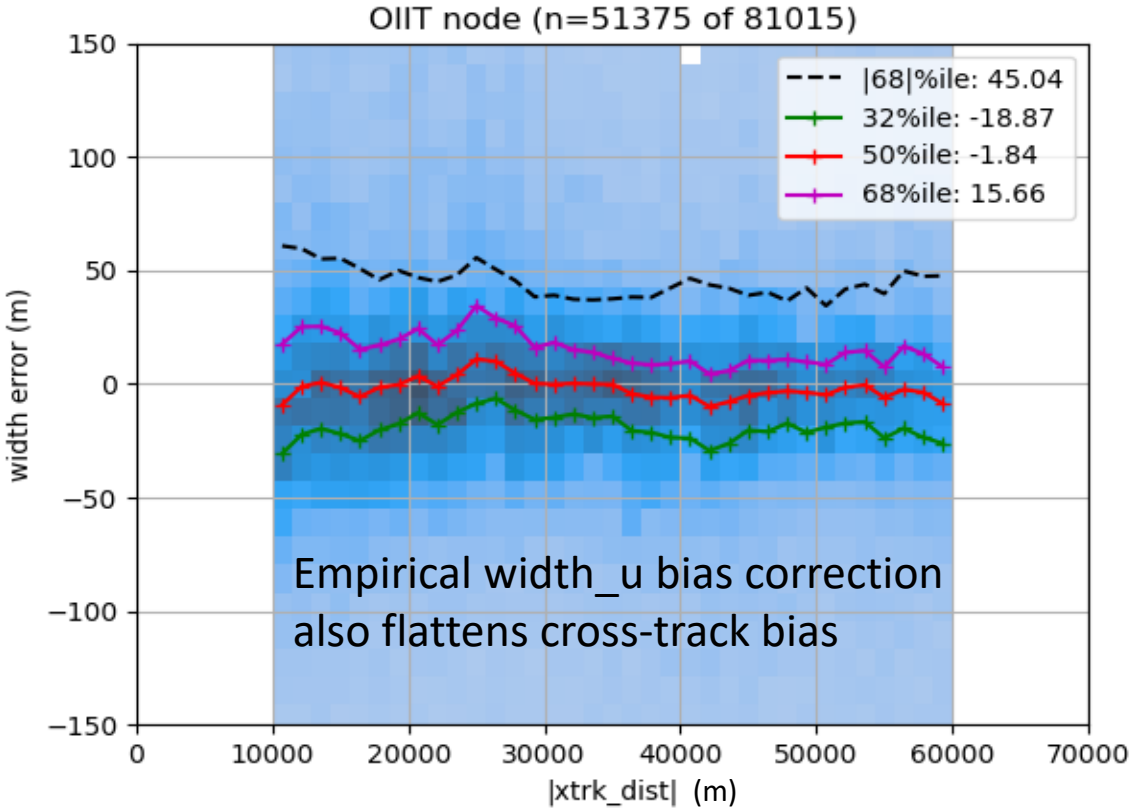
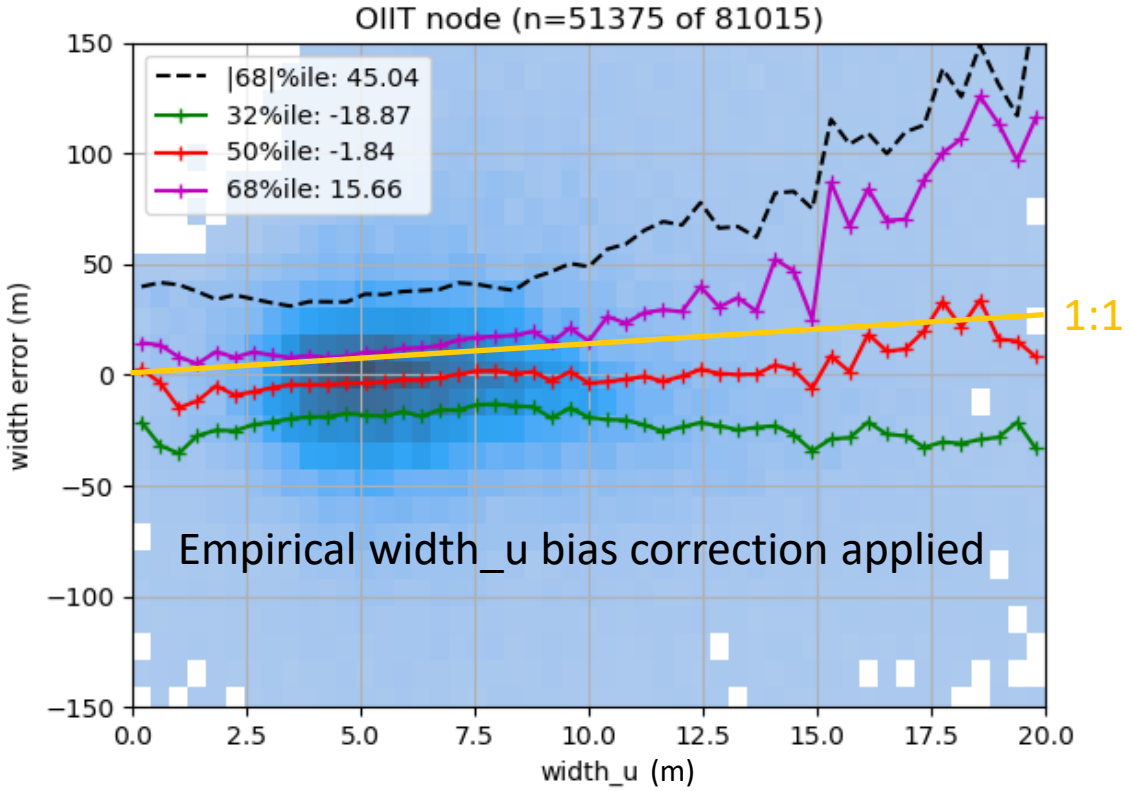
Width Errors vs Uncertainty (Node)

- Simple piecewise-linear empirical bias correction vs width_u
  - Flattens the cross-track bias (as well as the width_u bias)
- Errors vs width_u
  - Bulk of the data distribution (width_u between 2.5m and 10m) may trend with correct slope but large offset
  - Errors larger than ~40m trend with width_u, but not at correct rate (~order of magnitude off)
  - |68|%ile curve in right plot flattens out around 40m (possible limit for errors smaller than ~30-40 m due to resolution limit of both DSWx and SWOT)





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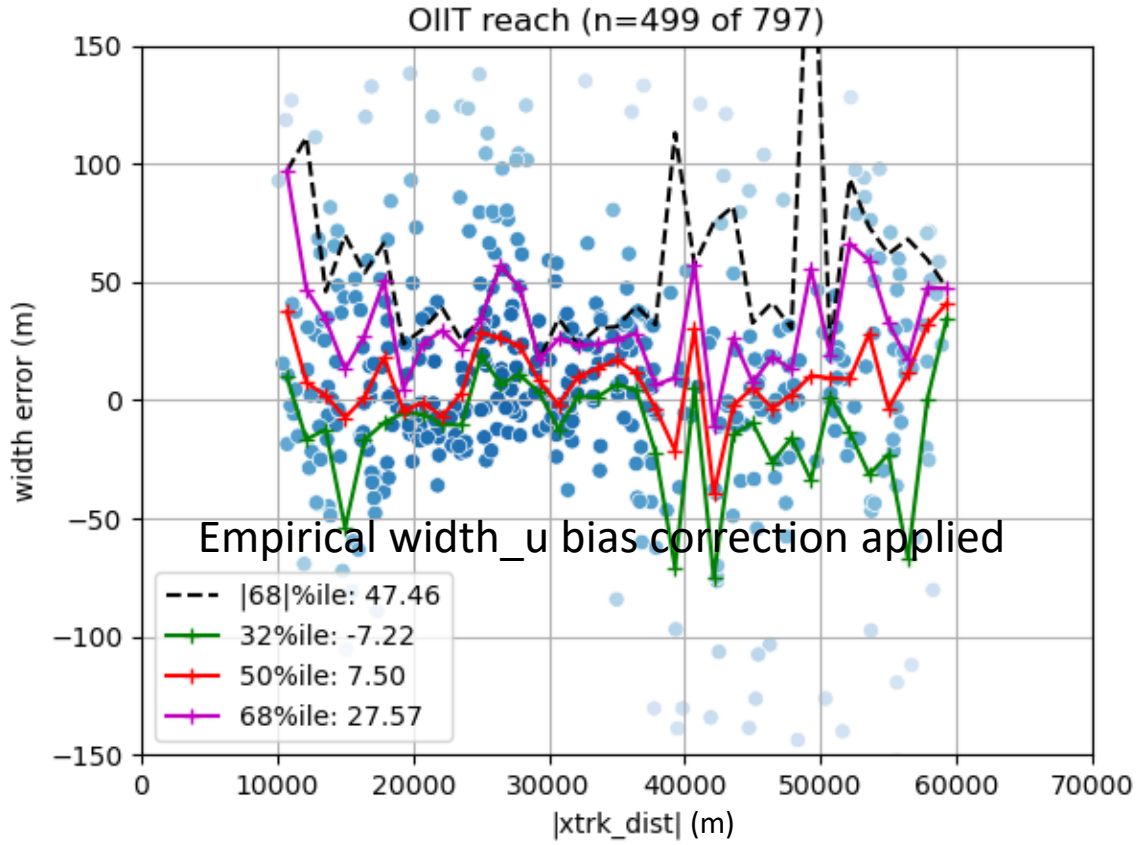
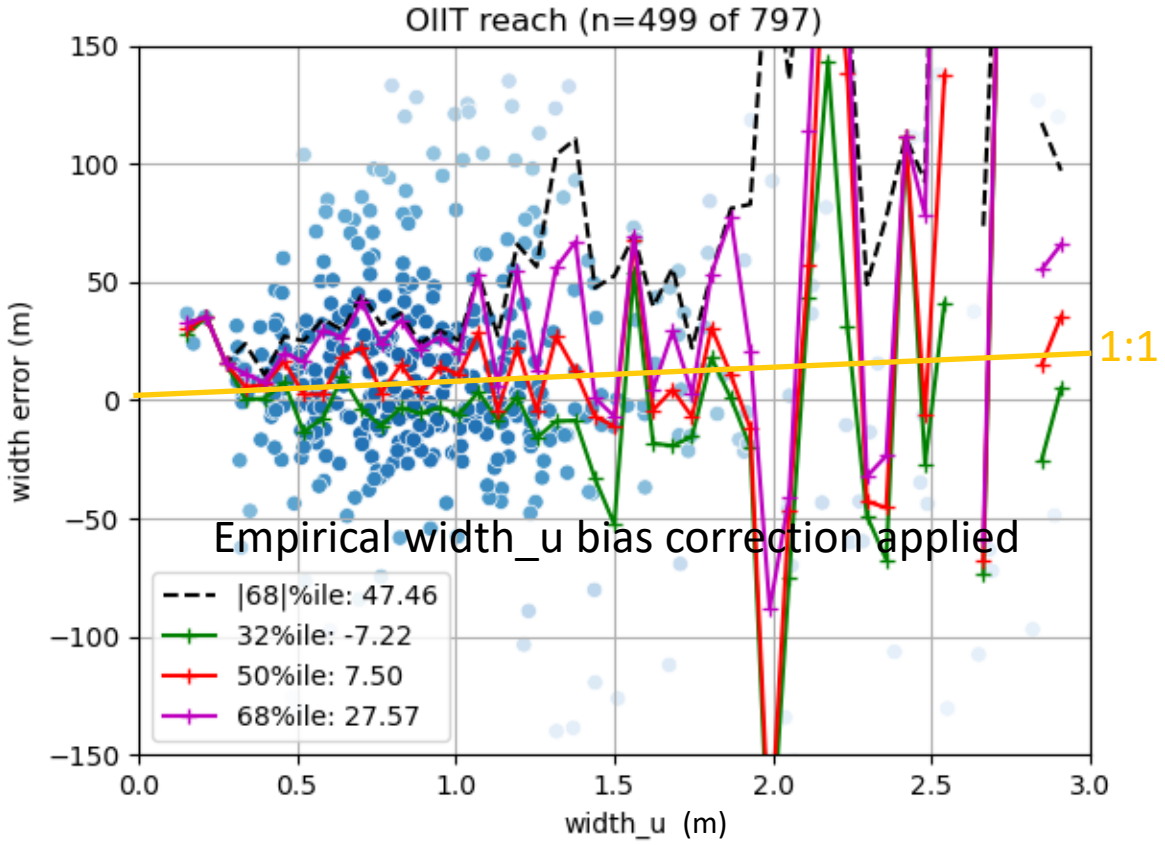
Width Errors vs Uncertainty (Reach)

- Reach behavior (with bias correction) generally similar to nodes
- Range/magnitude of width_u is ~order of magnitude smaller at reach than node
  - The actual 1-sigma width error does not seem to reduce when going from node to reach
  - Maybe most width errors occur on water body edges (and fraction of edges to interior does not typically reduce as you aggregate along a river)?





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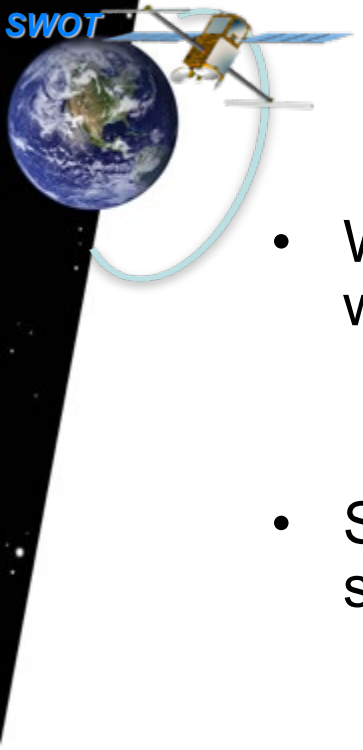

Takeaways

- WSE uncertainty estimate wse_u in the RiverSP product are consistent with relative wse error variability(, i.e., 1-sigma, or |68|%ile)
  - wse*_u fields are generally usable for coarse error predictions for version C, C2, and D
- Slope uncertainty estimate in the RiverSP product are generally consistent with slope error variability(, i.e., 1-sigma, or |68|%ile)
  - Possibly a slight overestimation for slope_u
  - Version C0 had a bug, but version C2, and D have generally reliable slope*_u fields
- Width uncertainty derived from the area_u in the RiverSP product are currently poor predictors of width uncertainty (even in offline Version D-like)
  - Users should ignore area*_u fields for all Versions currently available
  - Strong bias
  - After bias correction width errors do trend with width_u but not close to 1:1 line
  - Assessment may be limited for small uncertainties (clipping ~40m width error)
  - Node- and reach-level uncertainty reduction not consistent with current width errors

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Back up

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Dataset Details

- Offline run
  - (WSE) PIXC run id:asdelivered_v1.4.2; River run id: asdelivered_cal_v16_v1.4.1_250429
  - (Width) Offline run “flagtests2”, version D-like with Version C cross-over corrections and SWORD v16 and some extra RiverTile output variables
  - Version D software, but with Version C cross-over corrections and SWORD v16
- Quality Filters
  - OIIT: outer-iceflag-inner-team
  - Also filtered for valid *_u fields (e.g., wse_r_u etc)
- Current development (offline, Version D-like) and Version C
  - Selecting only data for offline where we have both in ”Outer” filter

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