

Automating Error Detection in Photogrammetric Forest Structure Measurements

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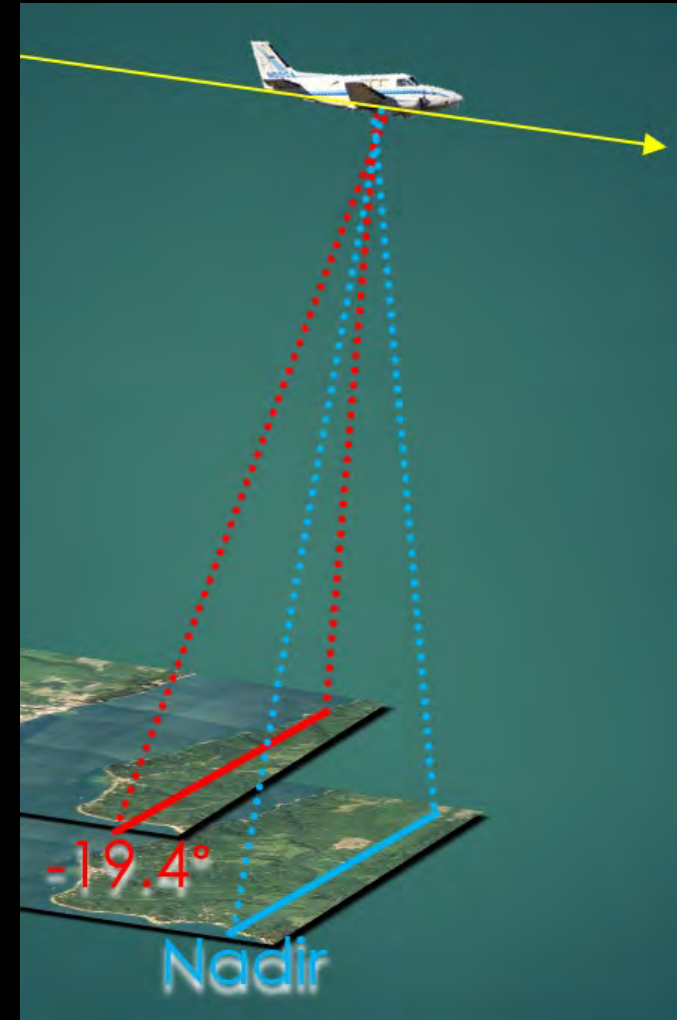
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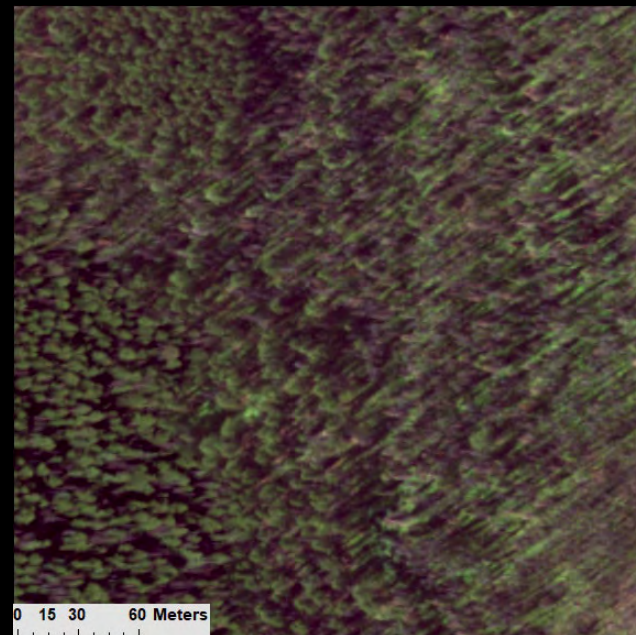
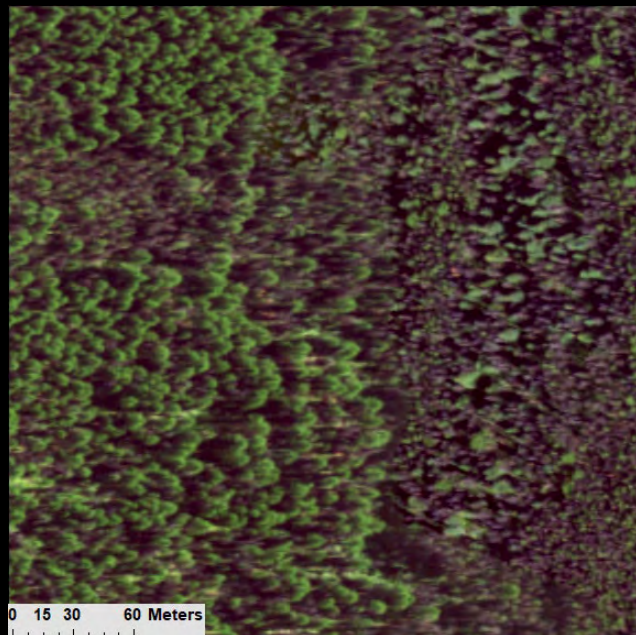
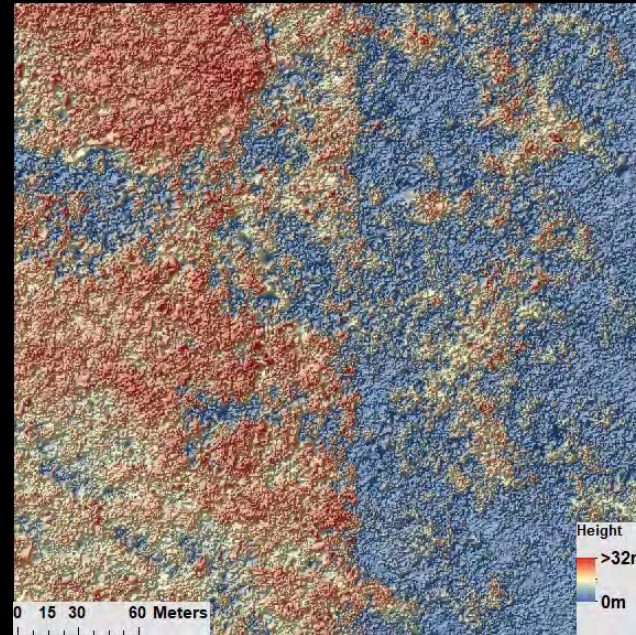
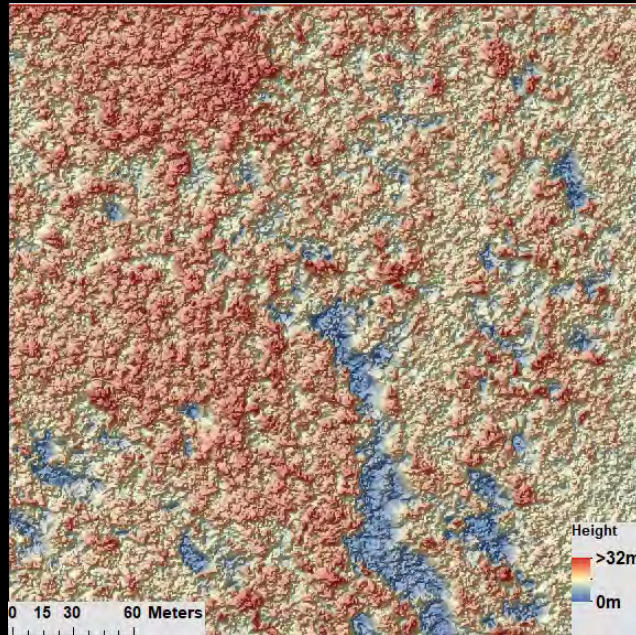
What is DAP?

- Digital Aerial Photogrammetry
- Photogrammetry is a century-old technique for combining multiple images into a single 3D object
- This current product uses the imagery underlying NAIP to produce a state-wide canopy surface model every two years



Pre-fire

Post-fire



Why DAP?

- The imagery is nation-wide every two years
 - Washington was the first to begin photogrammetrically processing it, but other states have begun to follow
- It's cheap
- It produces a lidar-like product that can be slotted into existing workflows
- The accuracy is usable
 - Worse than a high quality lidar flight, better than a low-quality lidar flight

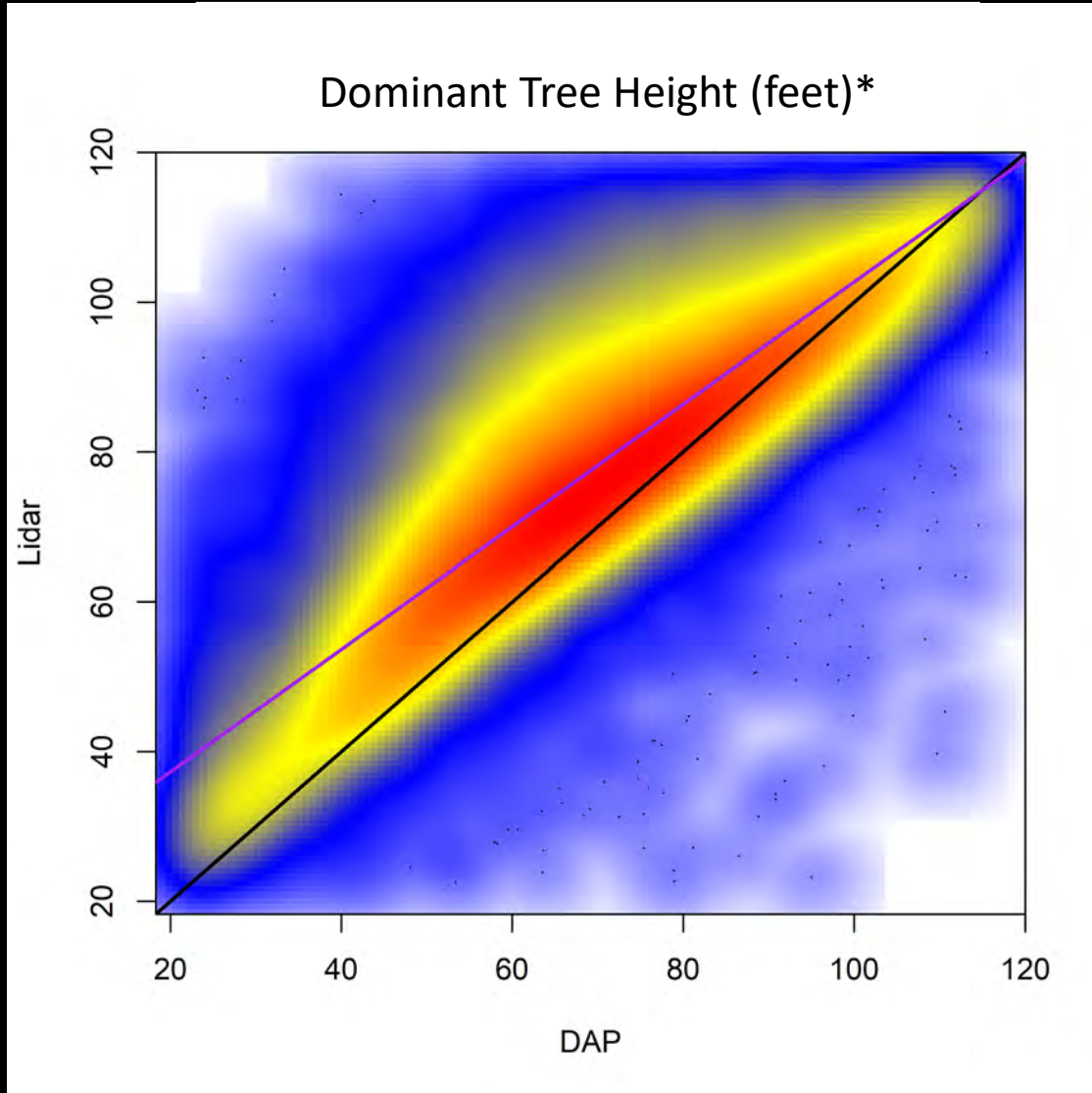
This presentation

- DAP has been presented as a new remote sensing tool at OLI before so I'll be focusing on new developments
- Right now, we're primarily working on error detecting and correction
- If you're interested in DAP and want a more thorough introduction to the basics, I'm happy to talk after the presentation or answer questions via email
 - jontkane@uw.edu

What might go wrong with DAP?

- The imagery was designed for orthophotos, not for photogrammetry
 - If you're used to the high-quality data from drone photogrammetry, you might be surprised
- The software capable of handling the suboptimal imagery is primarily designed to produce ground models in unforested areas
- Errors might be caused by the input data, or by the software. Our goal is to minimize the latter kind
- Fixing the problems requires specialized expertise

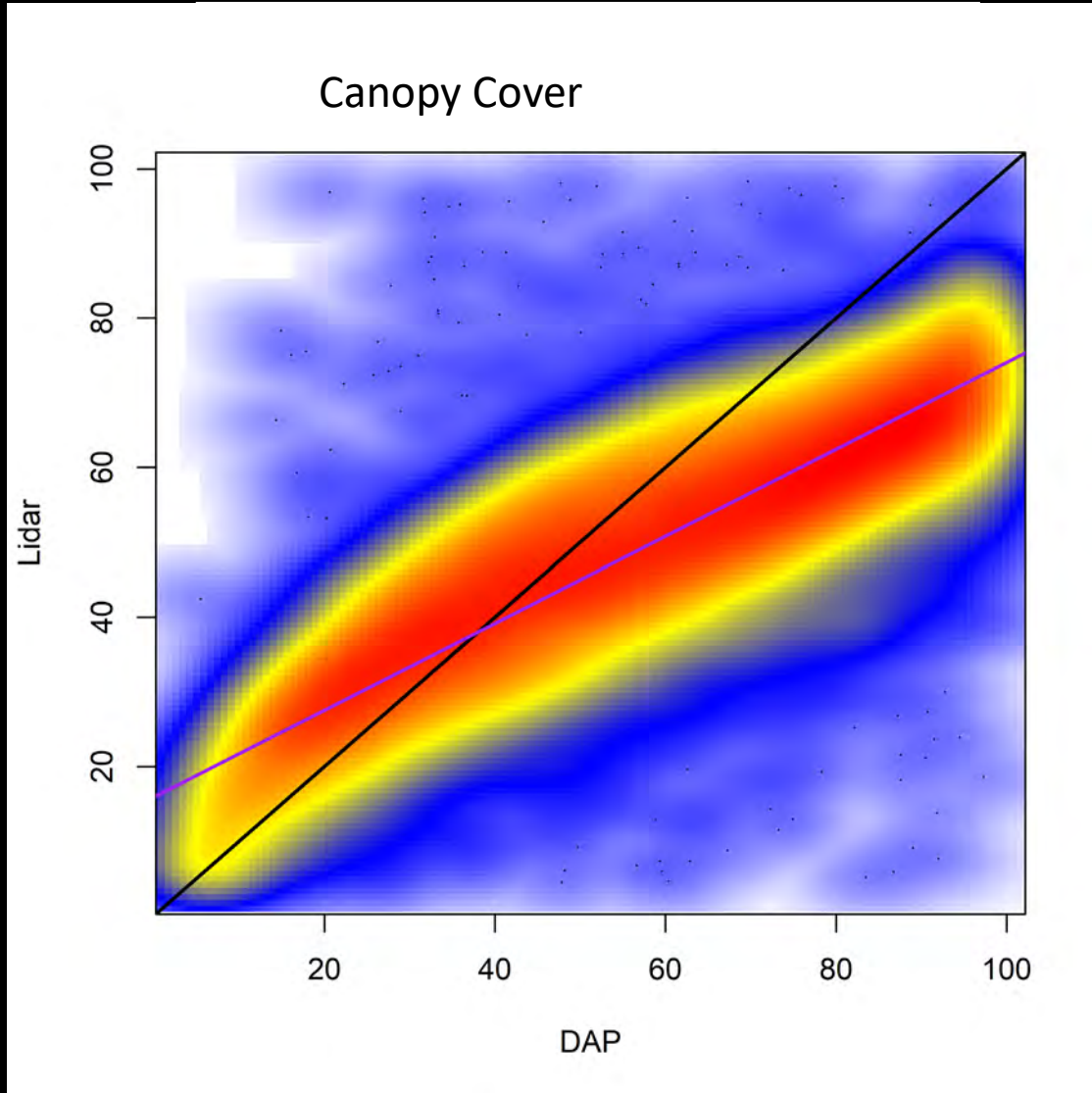
Detecting errors automatically



- You need reliable measurements of forest structure over a large area (usually QL1 or equivalent lidar)
- In areas without this, you can only speculate about the quality of the product

*Measured as 95th percentile height >6ft

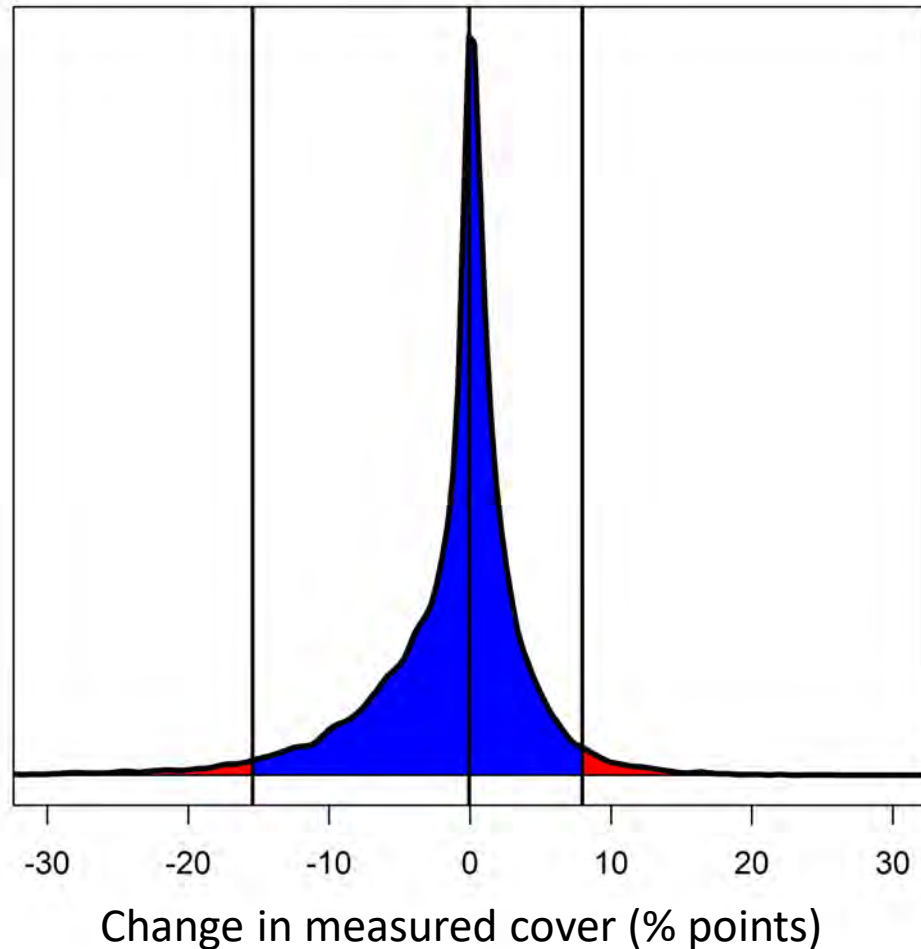
Detecting errors automatically



- There's two kinds of error here
- Consistent bias—shown here by DAP consistently underestimating low cover and overestimating high cover
 - This can be corrected for in analyses
- Random error—shown here by the large width of the red area
 - This can't be corrected post-hoc. Shrinking this error is our primary goal

Precision in repeat measurements

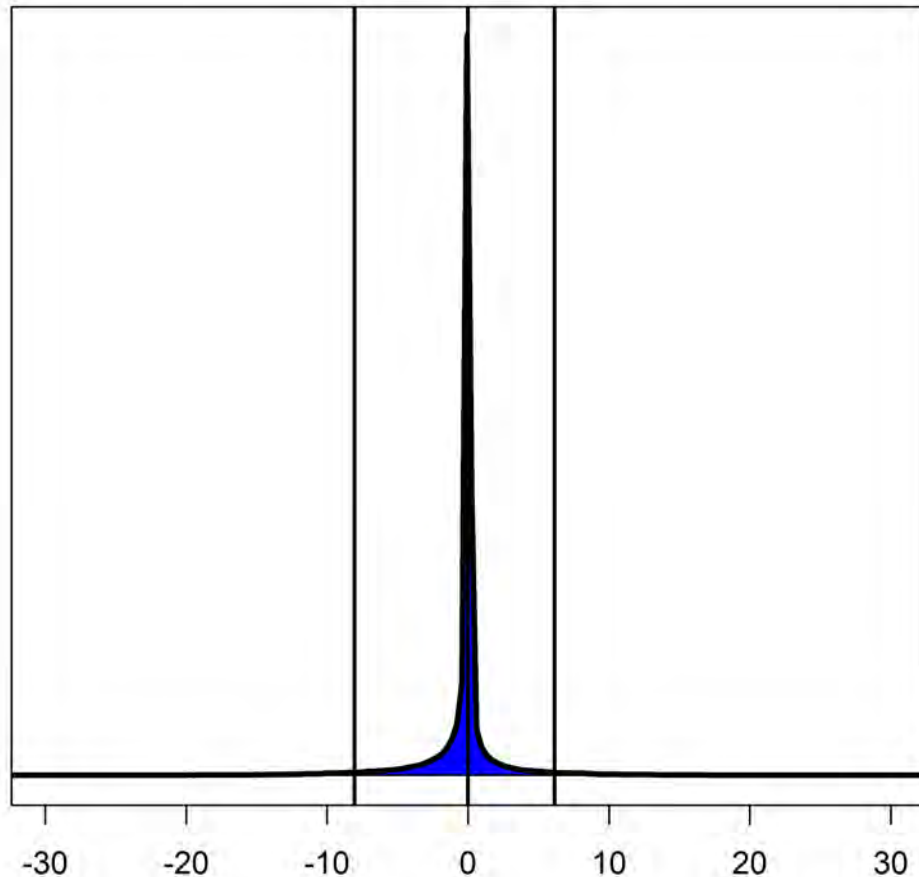
Change in DAP cover in unchanged pixels
Eastern WA



- DAP tends to have a fairly reliable 90% interval for repeat measurements, but a long tail of outliers
- This means 5-10% of pixels will have large changes from year to year just due to measurement error
- The core accuracy of “decent” pixels is likely inherent to the methodology, but we’d like to shrink the tails

Importance of considering multiple ecoregions

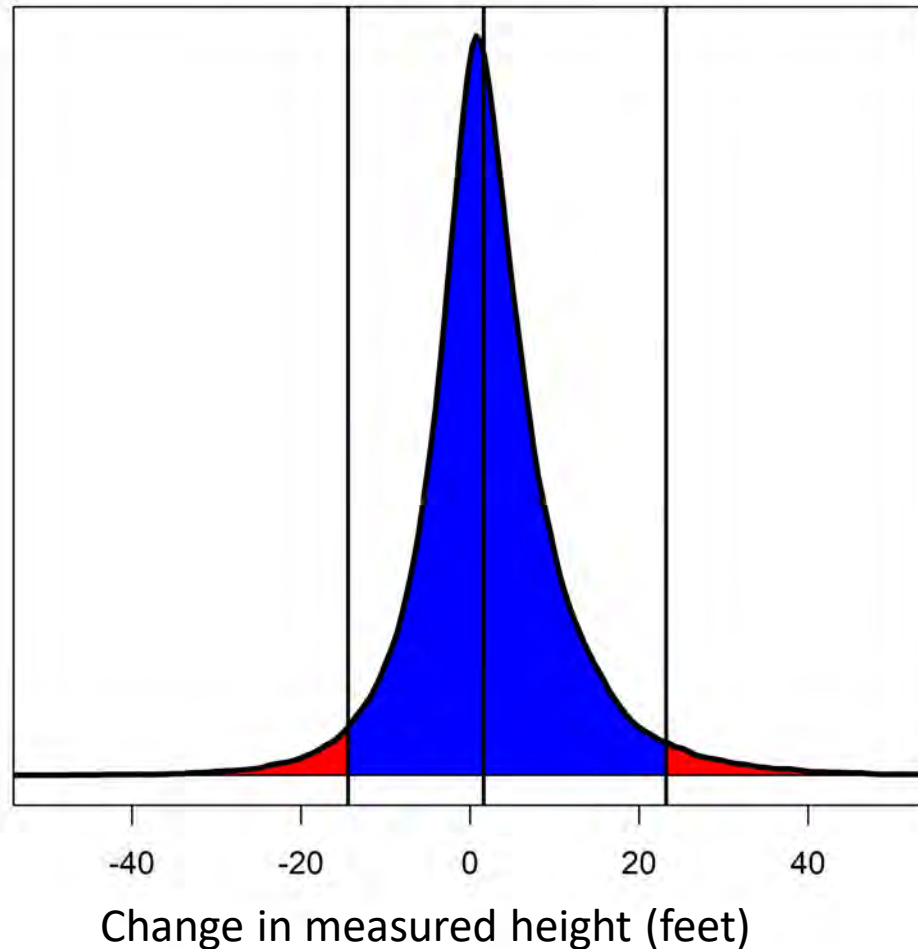
Change in DAP cover in unchanged pixels
Western WA



- Doing the same test in western WA you see a different pattern
- The long tails are still there, but the “good” part is much more clustered around no change
- This is just because of all the areas with 100% measured canopy cover!
- WA has to be broken into at least three sections to be handled properly: Eastern, Western, and Olympics

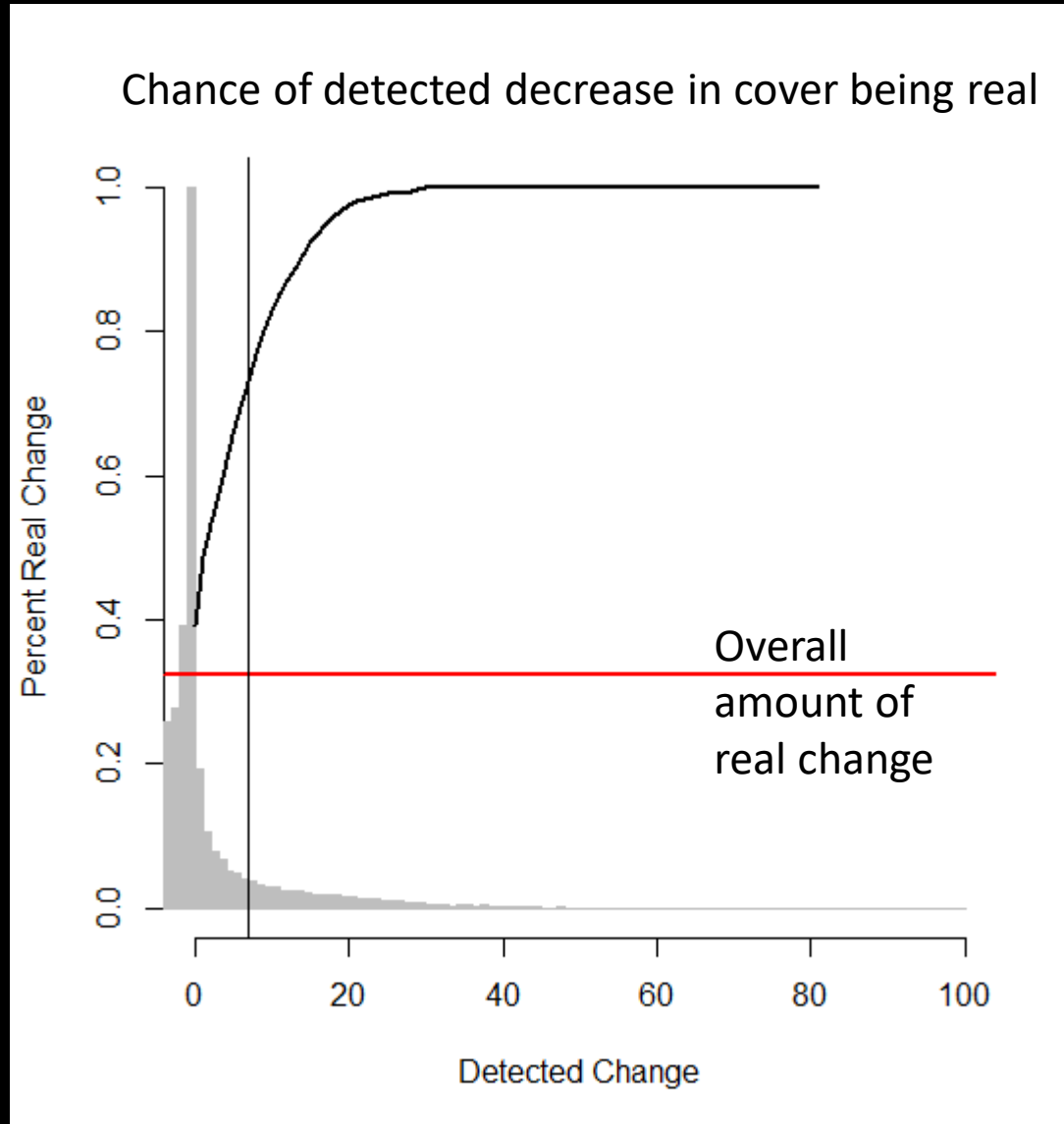
Importance of considering multiple metrics

Change in DAP P95 in unchanged pixels
Western WA



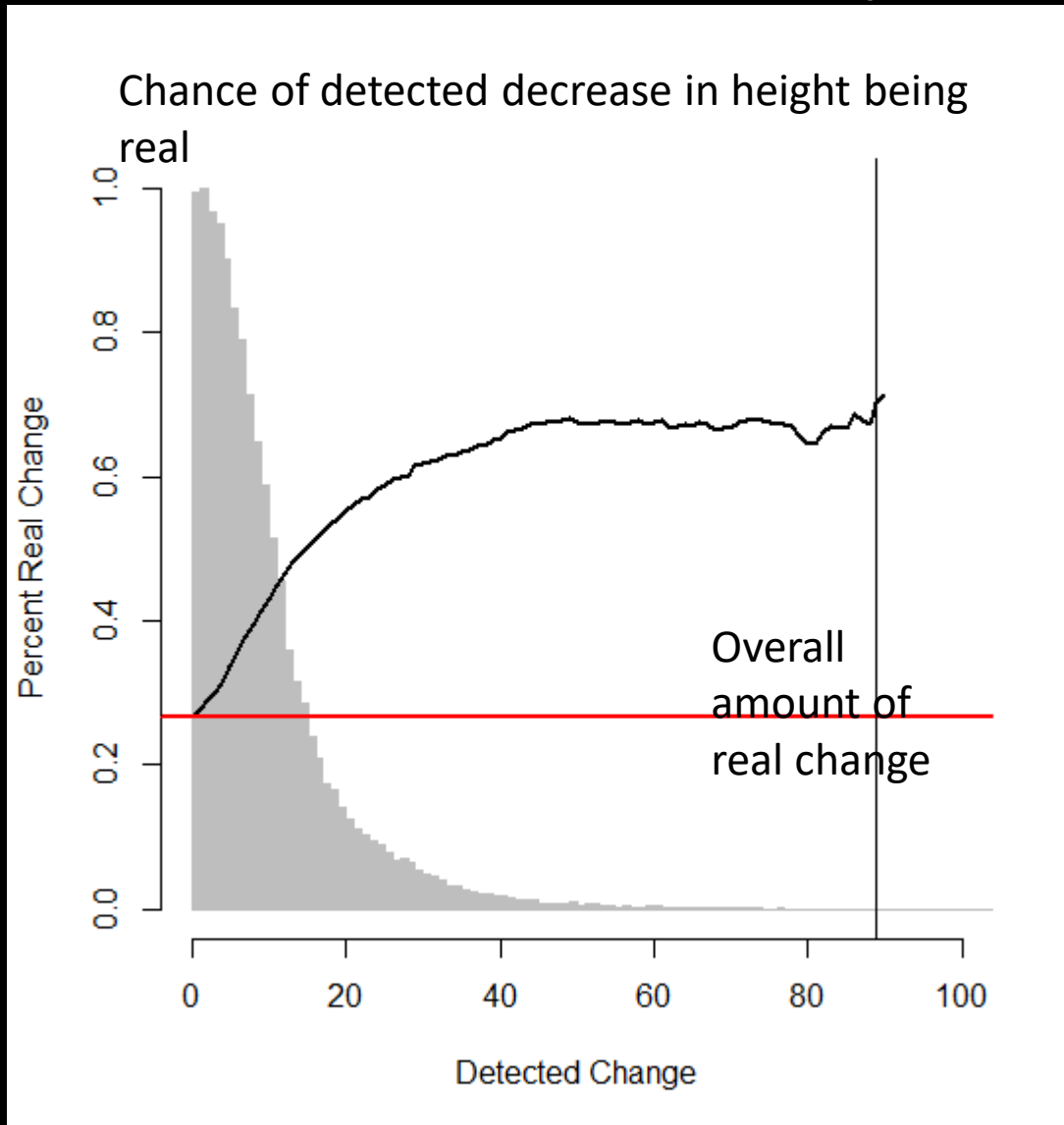
- It's routine for DAP measurements to change by up to 20 feet (7m) just due to measurement error

Importance of having truly unchanged areas



- Sometimes changes in DAP reflect real underlying change!
- You need *repeated* QL1 lidar to disentangle that—and not paying for repeated lidar is the whole point of DAP!
- DAP is suggestive (70%) of real cover loss with detected change as low as 7 percentage points and significant (95%) with 15 percentage points

You can't reliably detect change in height

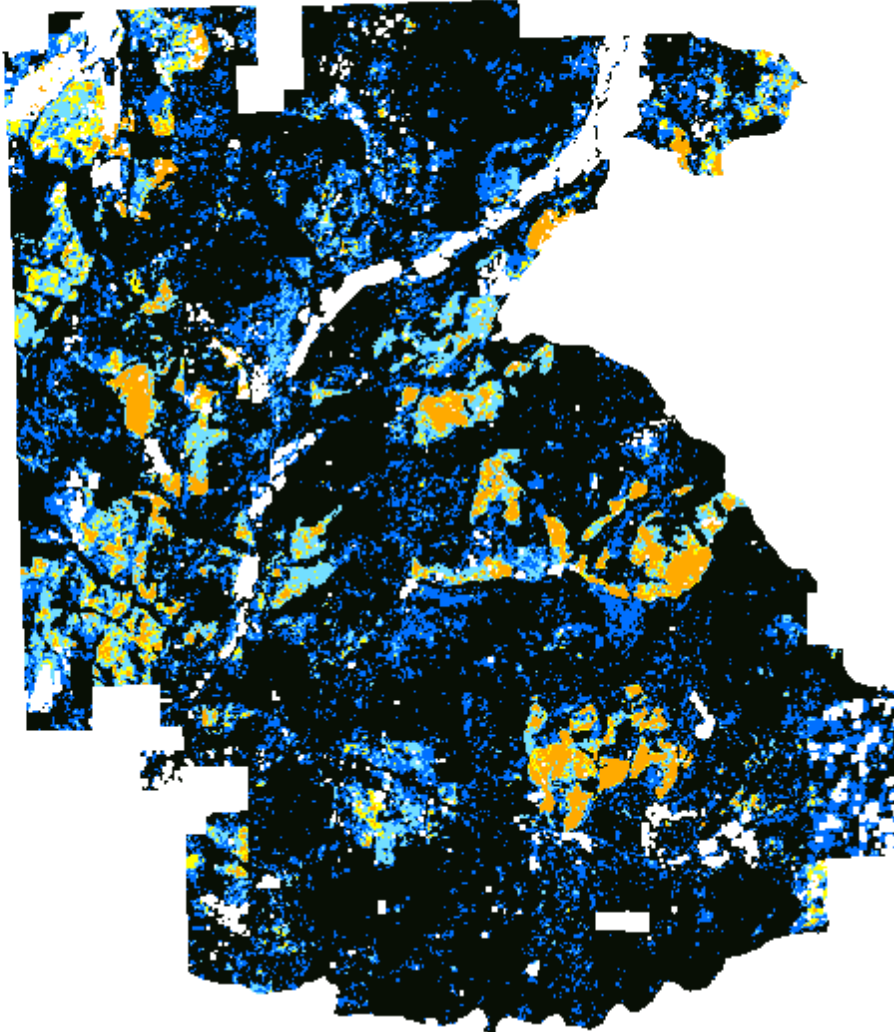


- There is no amount of change in height that can convince you that it's due to a real disturbance, rather than due to measurement error

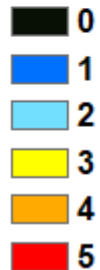
Likely Error Maps

- Reprocessing the photogrammetry to alleviate these issues but is laborious and requires a lot of expertise
- The goal of the current work is to automate the process of flagging areas as suspect—either for reprocessing, or just as a warning to future users of the data

Colville (Zoom-in), 2019 DAP Before Masking by Change

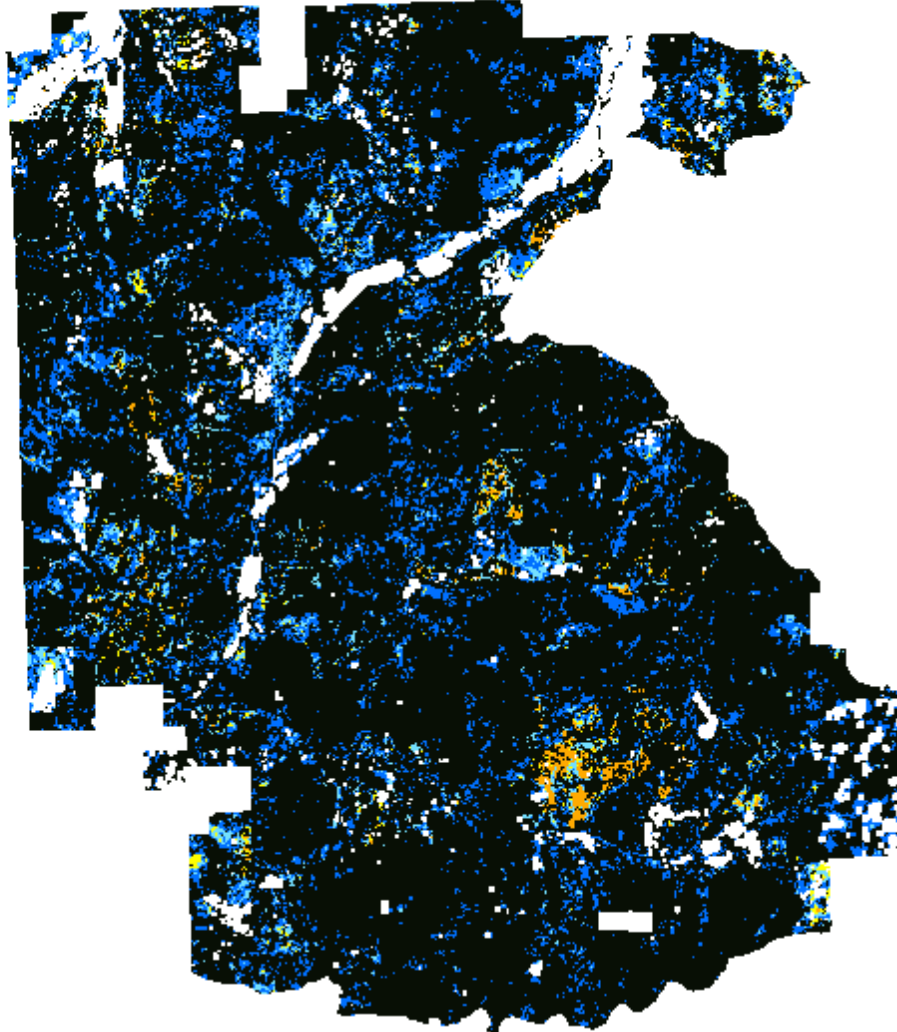


of Warnings



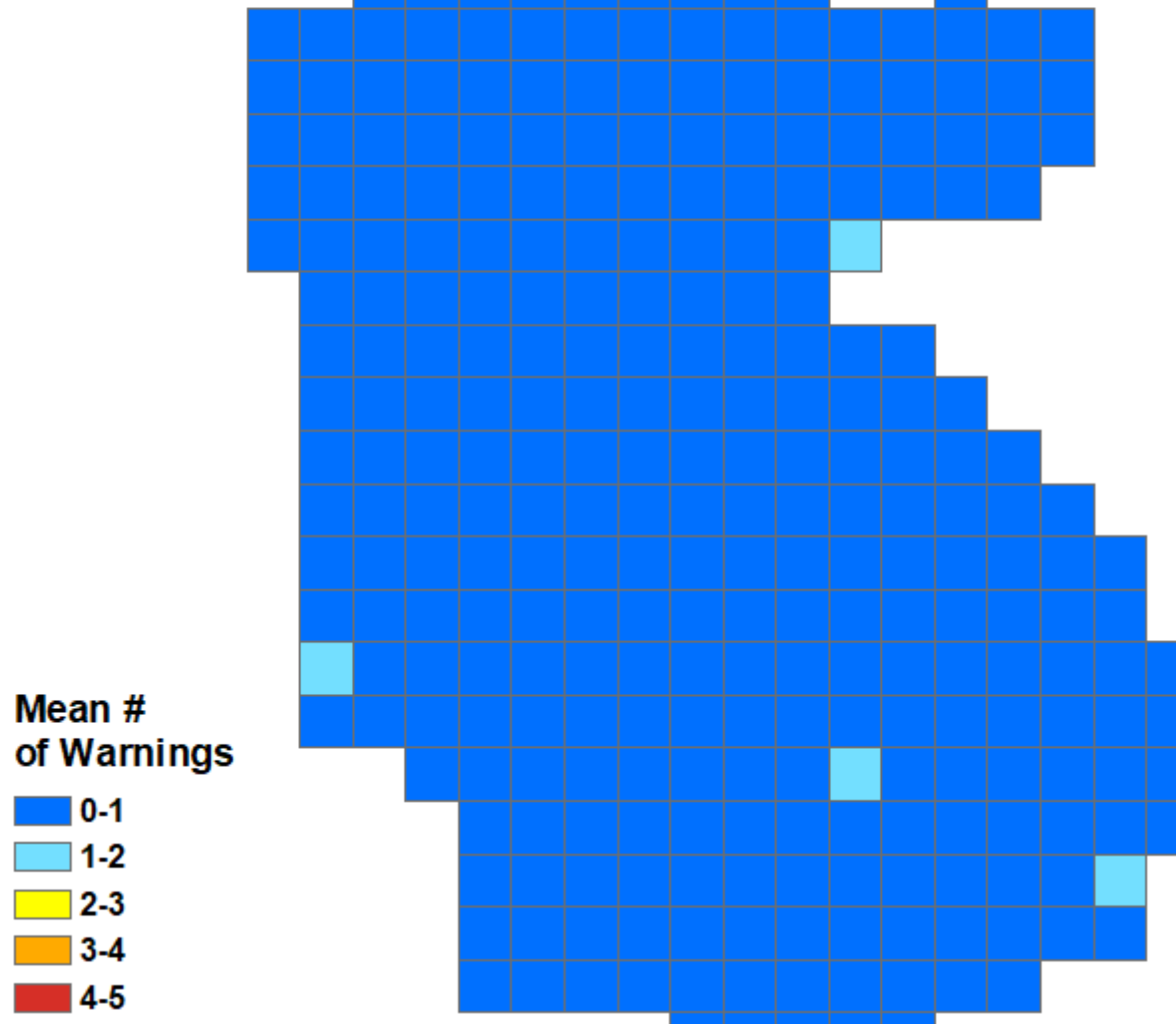
- Five warning codes:
 - Trees impossibly tall—this is rare but usually indicative of deep problems
 - Large difference in height since previous lidar
 - Large difference in cover (after crosswalking) since previous lidar
 - Large difference in height compared to other DAP years
 - Large difference in cover compared to other DAP years

Colville (Zoom-in), 2019 DAP After Masking by Change



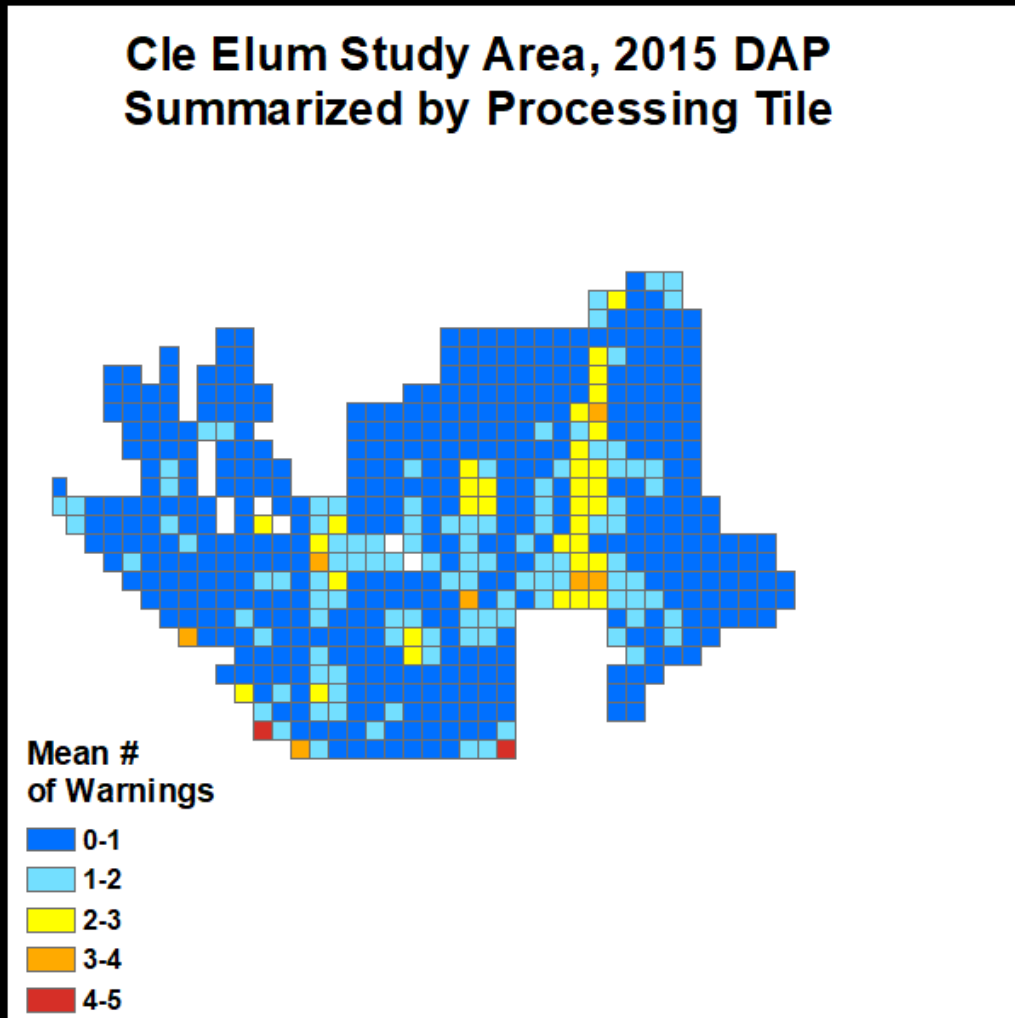
- This method depends on previous lidar, but you need that for a ground model already
- It can be fooled by legitimate change, so we mask it by areas where satellites also detected change
- Satellite measures of forest structure have their own accuracy issues but if DAP and satellites agree, the change is likely real

Colville (Zoom-in), 2019 DAP Summarized by Processing Tile



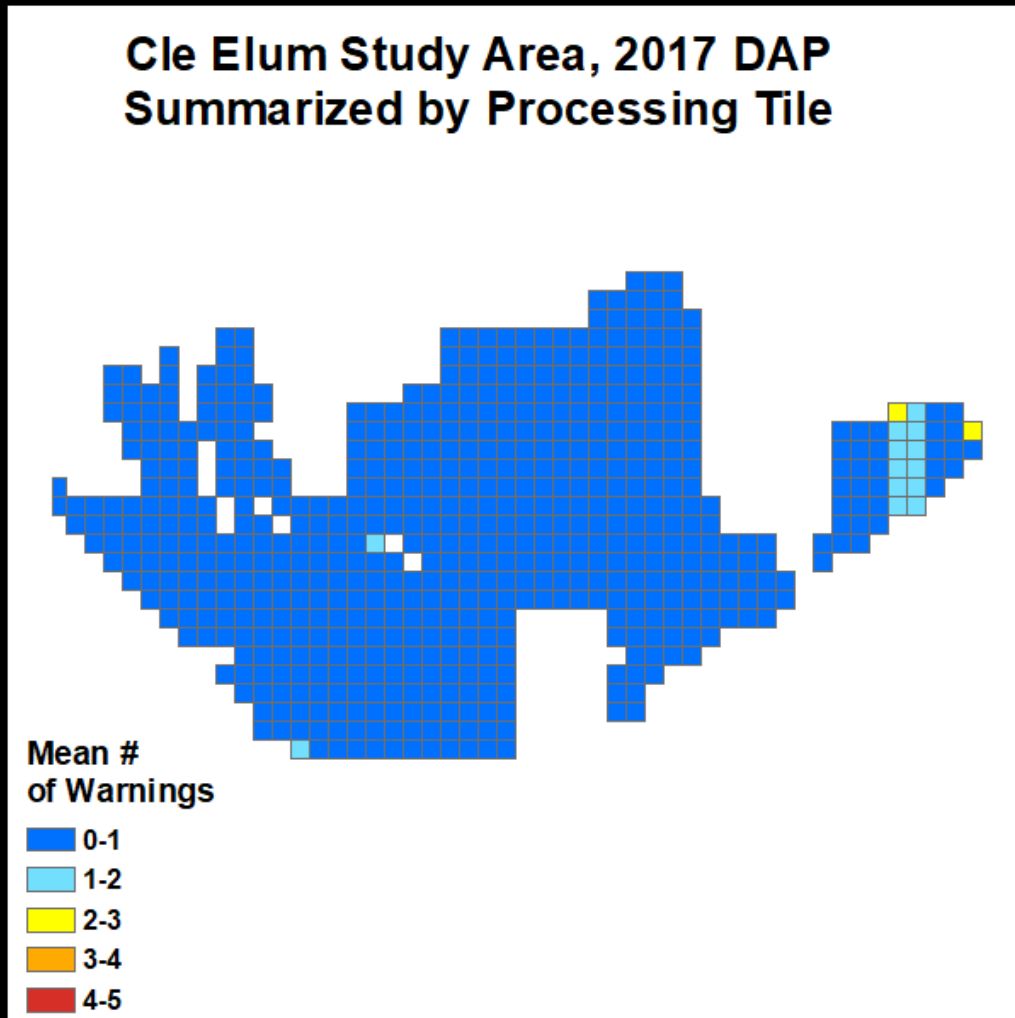
- We can aggregate by processing tile to determine which areas potentially need to be rerun—or just use this layer to warn users that the data in that area might be untrustworthy

Current state of the data



- 2017 DAP has been laboriously QA-ed and is very reliable
- 2019 is nearly as reliable, but doesn't cover the entire state
 - 2020 data covers the rest
- 2015 hasn't been as extensively QA-ed and has a number of issues

Current state of the data



- The issues tend to be concentrated in north-south rectangles which align with the edges of processing tiles
- This is indicative of a software issue, as opposed to an issue with the underlying data, and is likely fixable