Introduction to Change Detection

Lecture 4: Image standardization and thresholding

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November 17-18, 2021

Housekeeping

- Keep video off and stay on mute
- If you have questions:
  - Raise hand in Teams
  - Respond in chat box
  - Q + A at the end
- Closed captions are available
- Take care of your body!

Software and Data for Exercises 4 & 5

- Required Software:
  - ArcGIS 10.x
- Required Data for Exercises 4:
  - Outputs from exercise 3
- Required Data for Exercise 5:
  - Outputs from exercise 4

Course Agenda

- Day 2 – Morning
  - 10:00-10:45 – Presentation: Image standardizations and image differencing
  - 10:30-11:00 – Demonstration: Calculating z-scores
  - 11:00-11:10 – Break
  - 11:10-11:30 – Presentation: Change thresholding and discussion of accuracy assessment
  - 11:30-12:00 – Demonstration: Exploring histograms and creating change maps

Tasks to complete before the next session: Exercise 4 + 5

Day 2 – Afternoon

- 2:00-2:30 – Q + A and Exercise Help
- 2:30-3:00 – Presentation: Change detection applications within USFS
- 3:00-4:00 – Final Q + A; help with course-related projects/ideas

Lecture outline:

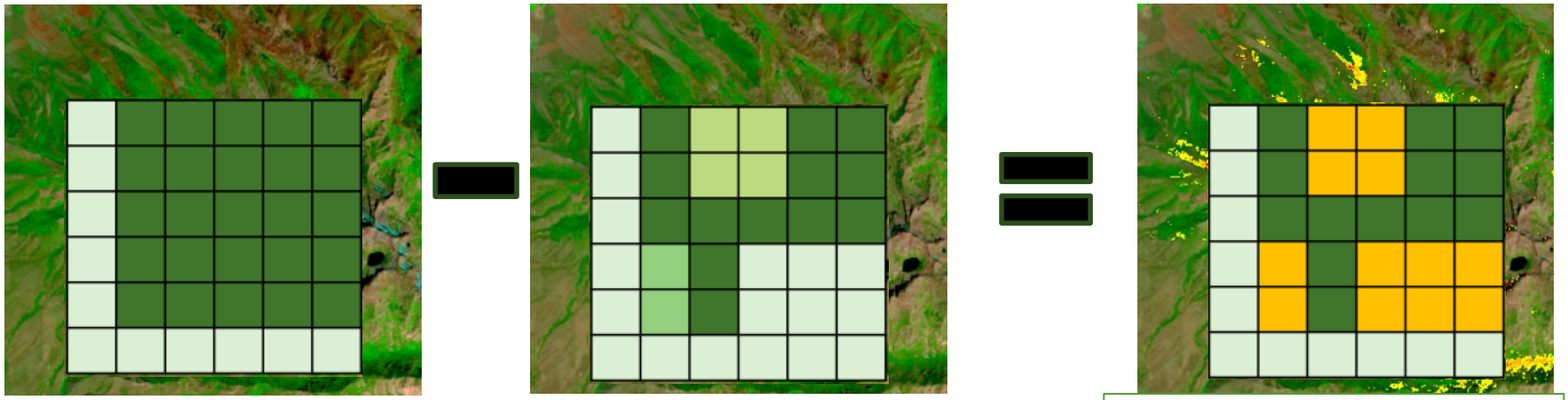
- Image differencing review
- Methods of change detection
- Image standardization
- Calculating z-scores
- Demo of calculating z-scores in ArcMap

Creating a change map

- Review:
  - You have learned how to select and prepare your data and analyze spectral changes…
- Next steps:
  - Create difference image
  - Standardize difference image
  - Threshold standardized difference image
  - Evaluate change output

Analysis- Image Differencing

- Use raster math to calculate a difference image
  - Pixel values in change image represent spectral change (positive/negative)



Pre-change image composite

Post-change image composite

Difference image, thresholded to represent change

Means of conducting change detection

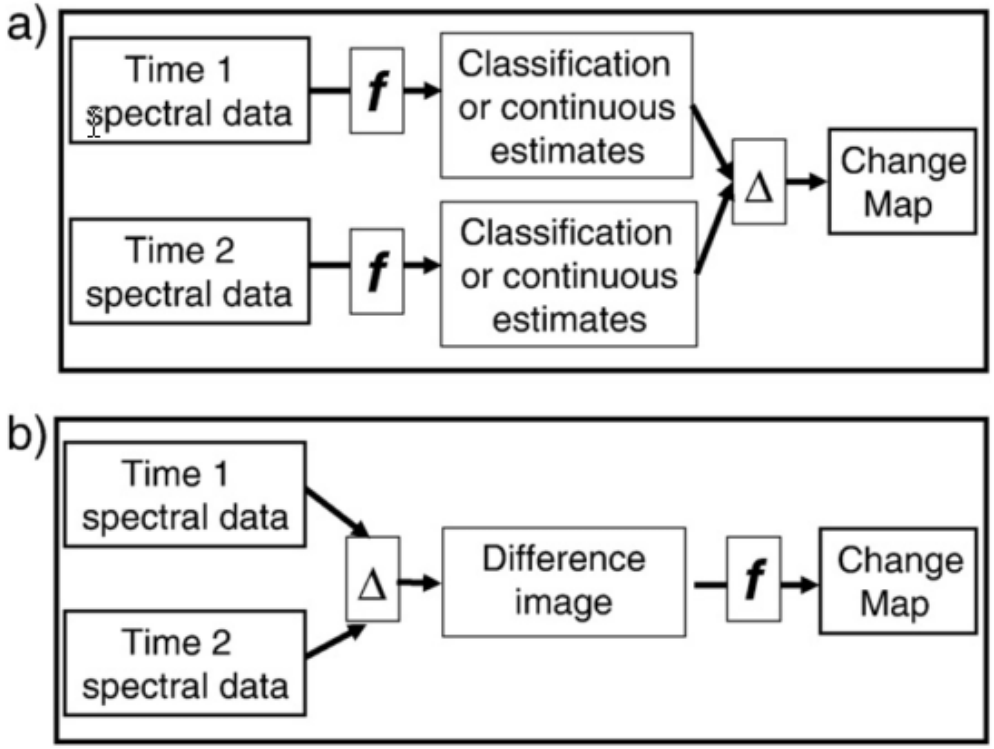


Fig. 2. Two means of conducting remote sensing based change detection. a) From two separate spectral images, a mapping or classification function is applied, resulting in two separate maps. These maps are then compared through differencing or analogous process to derive change. b) The spectral values of the two images are differenced directly, and a mapping or classification algorithm is applied to that different space.

Image Standardization

- How do we standardize our data?
  - Radiometric and atmospheric corrections
  - Image enhancements, such as NBR and NDVI
  - Calculating Z-scores

- Why is this important?
  - Accounts for differences between images
    - Illumination, time, space
  - Allows for the direct comparison of images
  - Creates direct measurements that are transferable across studies

The Standard Score (z-score)

- can be calculated from the raw difference values for each pixel in an image using the equation below, where:
  - *x* represents the difference value for a pixel
  - mu *μ* represents the estimated (observed) mean of the difference values of all pixels in the image
  - sigma *σ* represents the estimated (observed) standard deviation of the difference values of all pixels in the image

$$z = \frac{x - \mu}{\sigma}$$

Demonstration

Exercise 4: Image Differencing and Calculating z-scores

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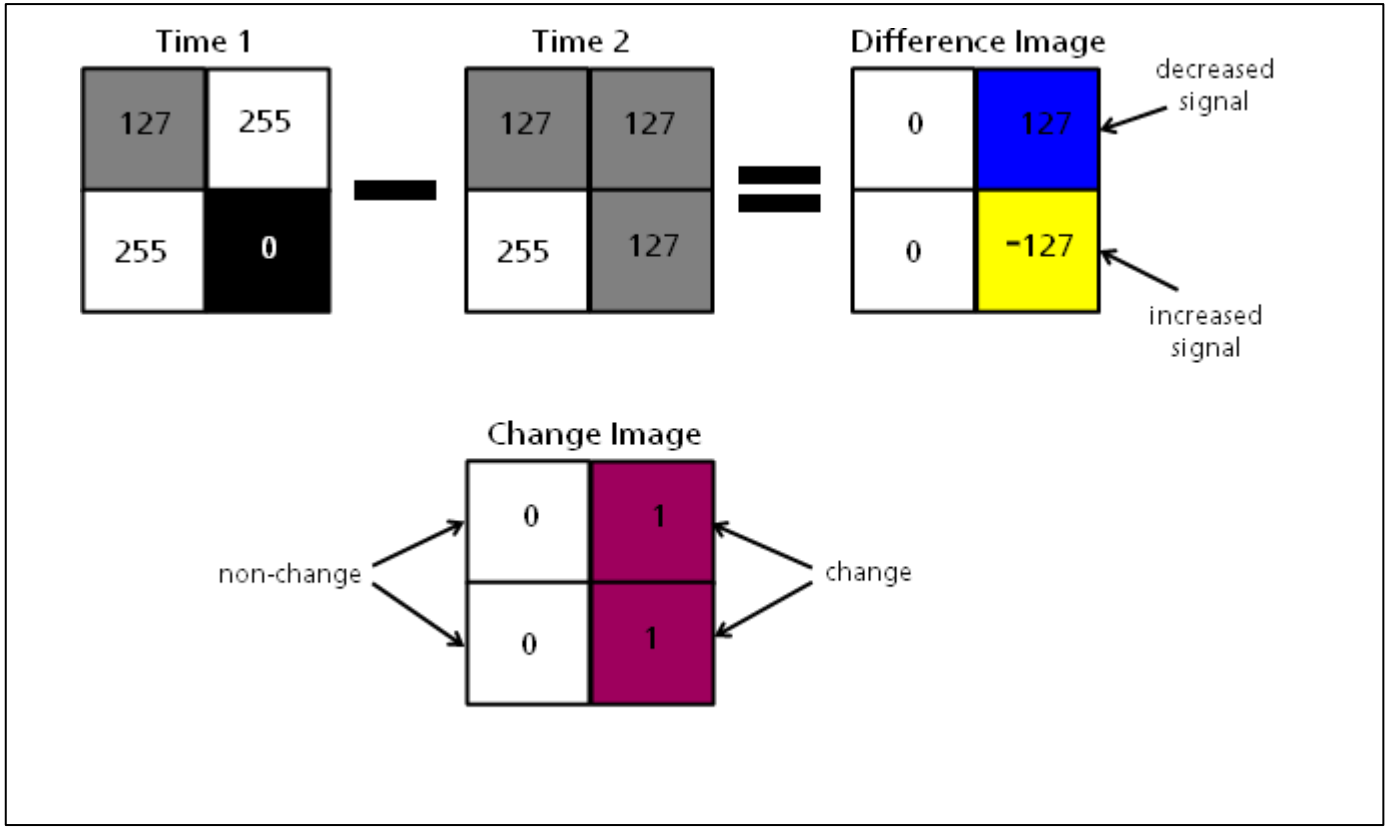
Lecture outline:

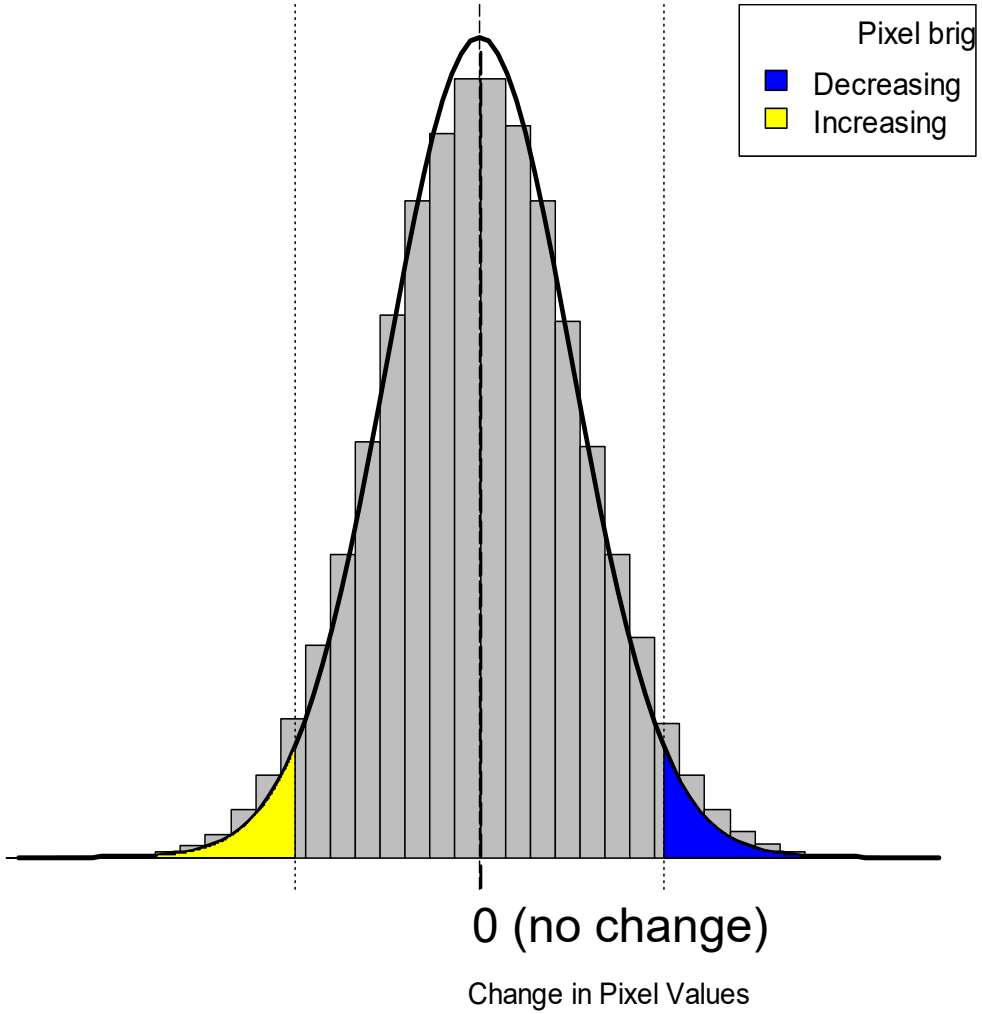
- Image differencing example and discussion
- Thresholding
  - Change histograms
  - Methods of change thresholding
- Evaluation and accuracy assessment
  - Importance of accuracy assessment
  - Site vs. non-site-specific accuracy assessment
  - Error matrices
  - Limitations
- Demo: Exploring histograms and creating change maps

Image Differencing



Change Histograms

- Distribution of pixel values in change image (*Time1-Time2)*
  - *Rarely will a pixel have exactly the same value in both images*
  - *Changed pixels deviate most from the central tendency*
- Classify change in pixels to separate “real change” from noise.
  - E.g., apply thresholds



Change Thresholding

- Manual
  - Hand digitizing
  - Manual threshold placement
- Automated
  - Algorithm placement
  - Defined thresholds based on empirical research
- Semi-automated
  - Classifying change

Evaluation of Change Maps

- *Despite our efforts, change maps likely contain errors…*
- **Accuracy assessment** – Evaluate the correctness of the change map produced
  - Compare the change map to reference data
    - Independent training and reference data
  - Many assessment options depending on goals and resources

Importance of Accuracy Assessments

Accuracy assessments are essential parts of all modeling exercises, remote sensing or otherwise.

- They allow users to compare different change detection approaches.
- They provide information on the reliability and usefulness of change detection techniques
- They support the use of change map for decision-making.

Site-specific vs. non-site-specific accuracy

Non-Site

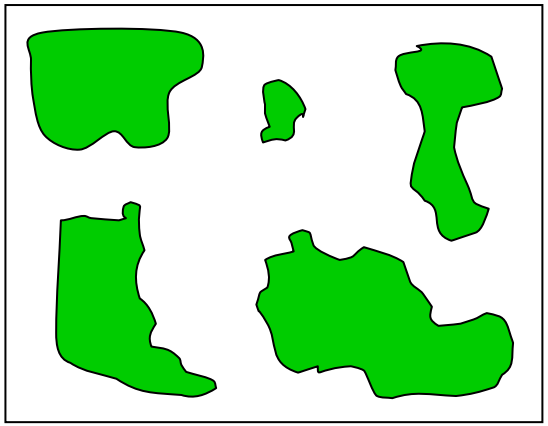
- No locational component
- Total acreage by category comparison between a change map and some reference data (e.g. FIA data)

Site

- Locational/Spatial component
- Use of error matrix to represent errors of omission and commission of change (spatial error)

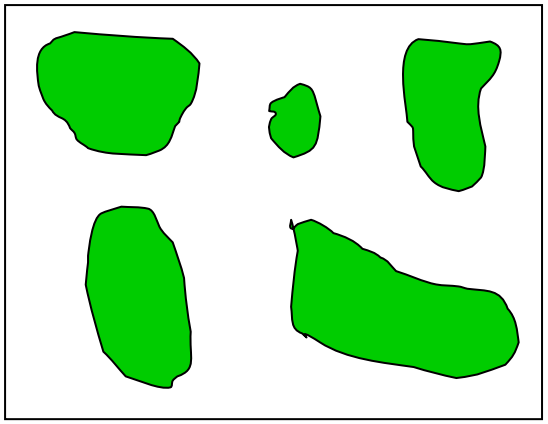
Non-Site-Specific Accuracy

Reference Data



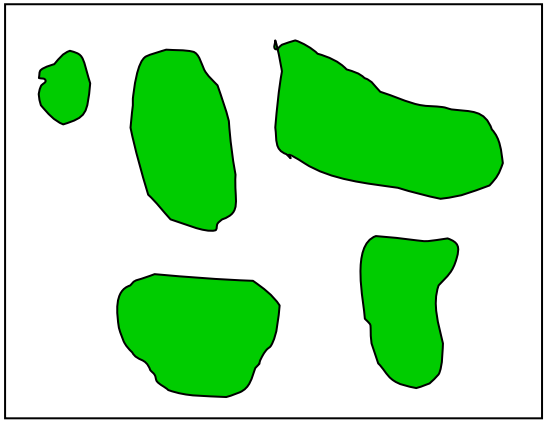
Change = 1,000 acres

Classified Image #1



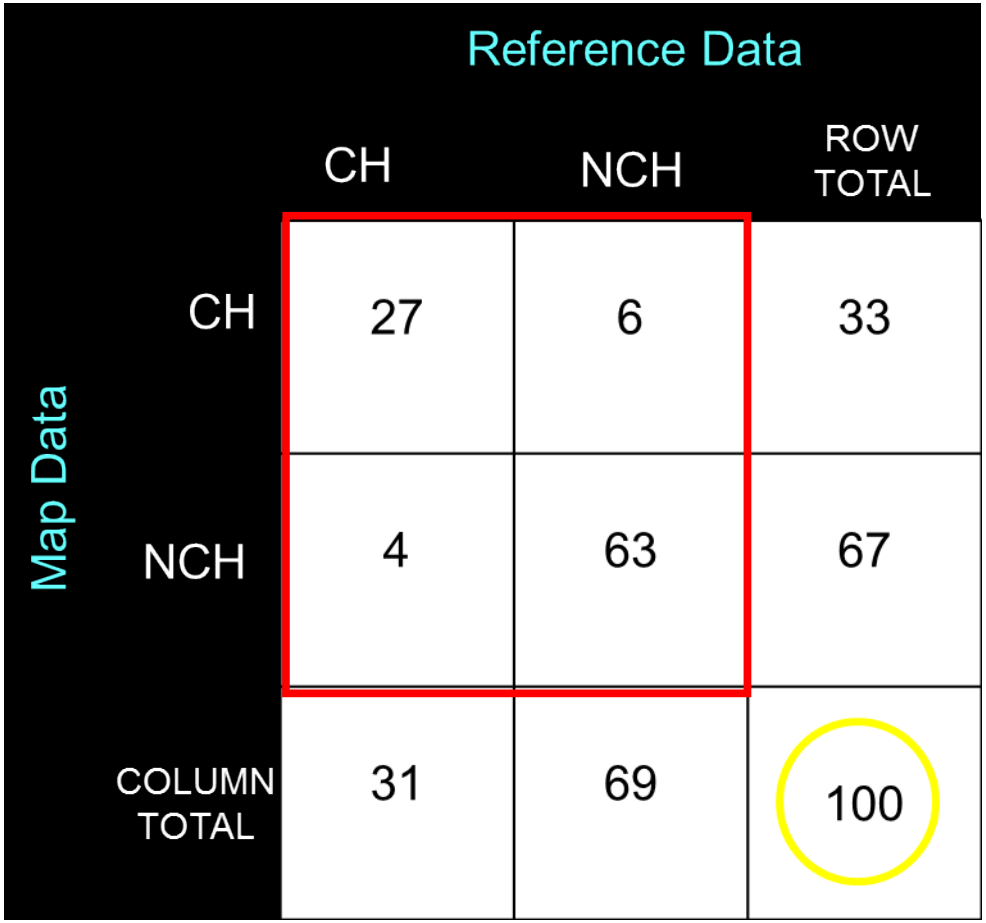
Change = 1,200 acres

Classified Image #2



Change = 1,200 acres

Change Map- Error Matrix

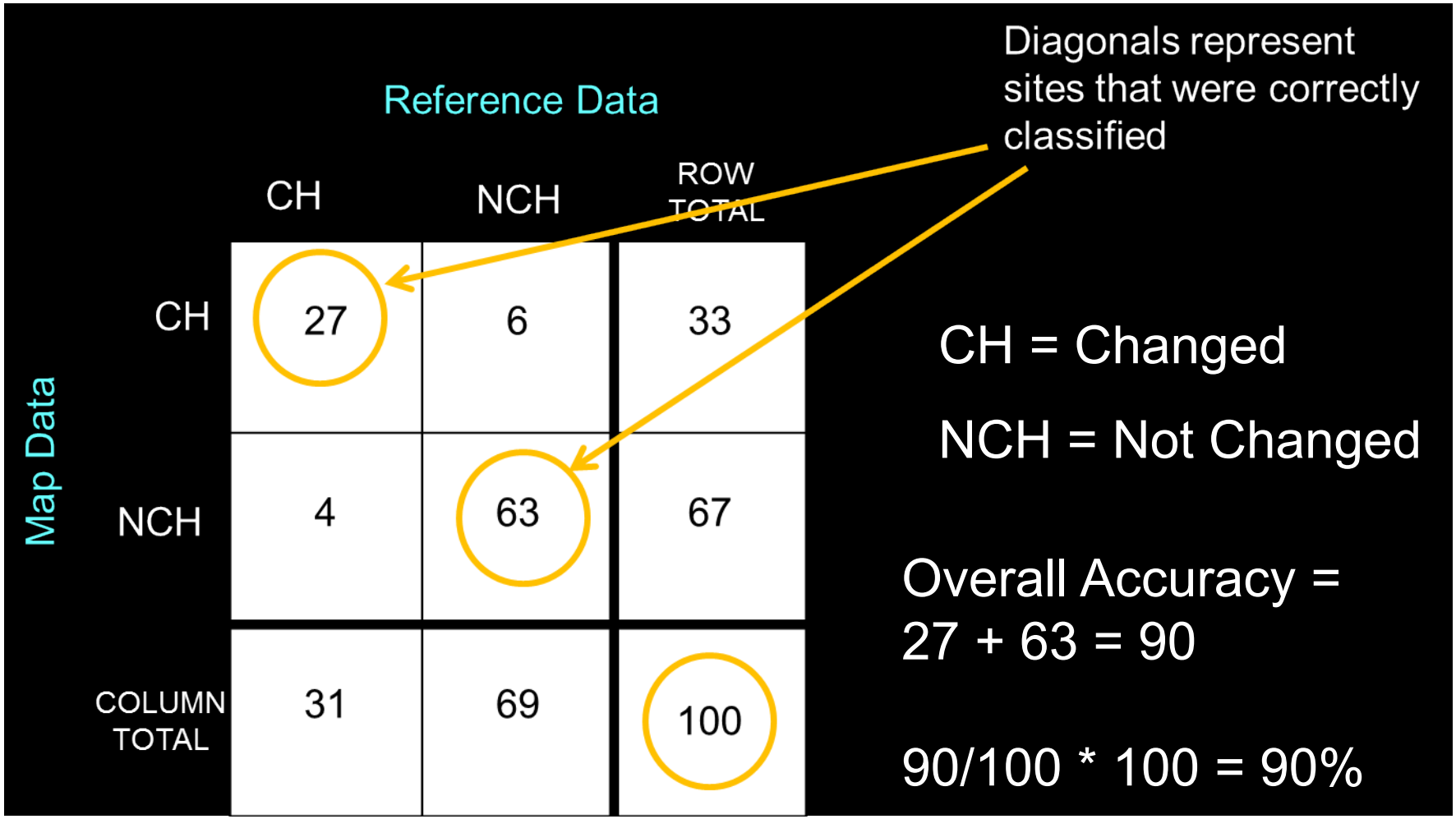


Map Data	Reference Data: CH	Reference Data: NCH	ROW TOTAL
CH	27	6	33
NCH	4	63	67
COLUMN TOTAL	31	69	100

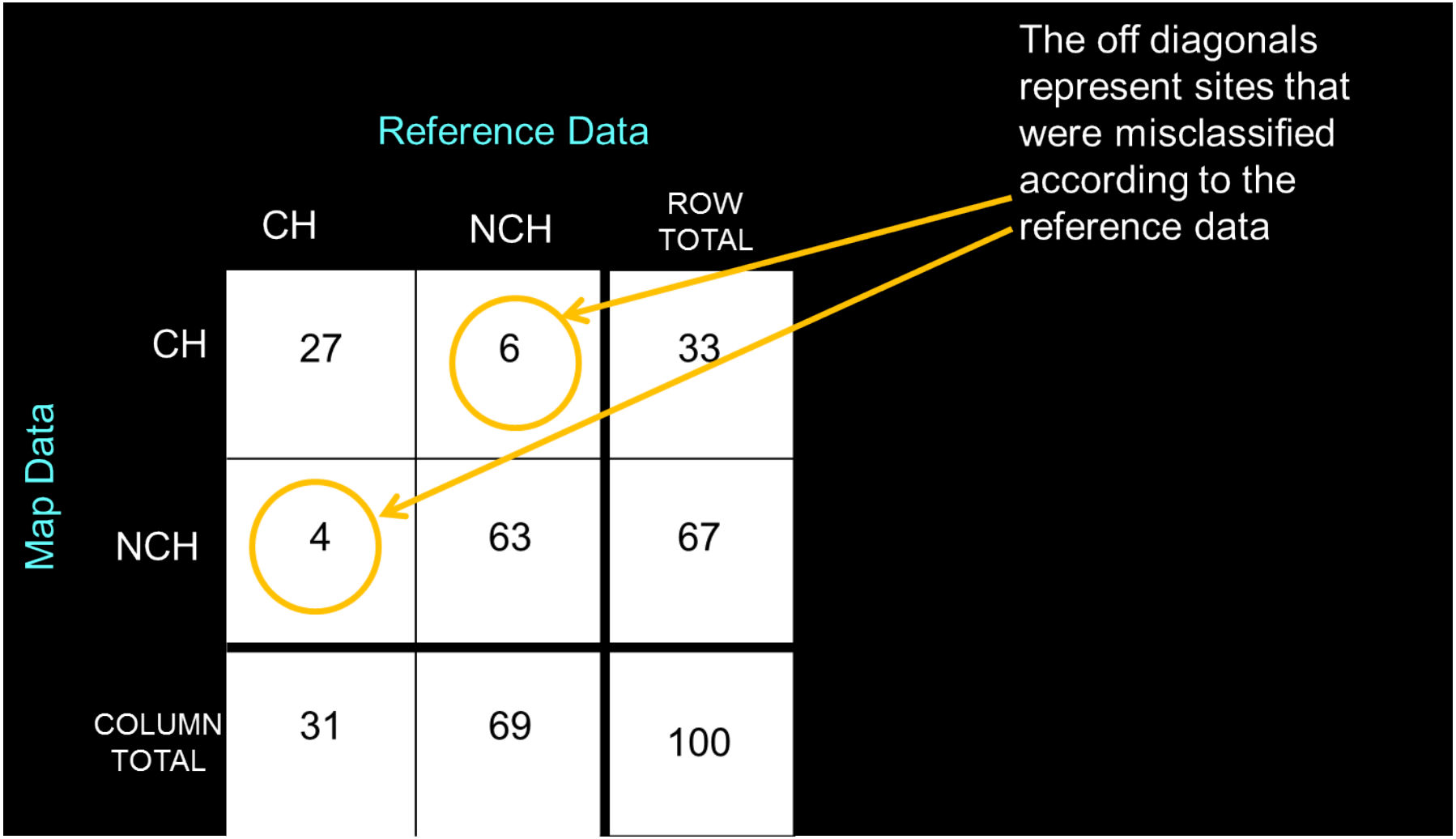
CH = Changed

NCH = Not Changed

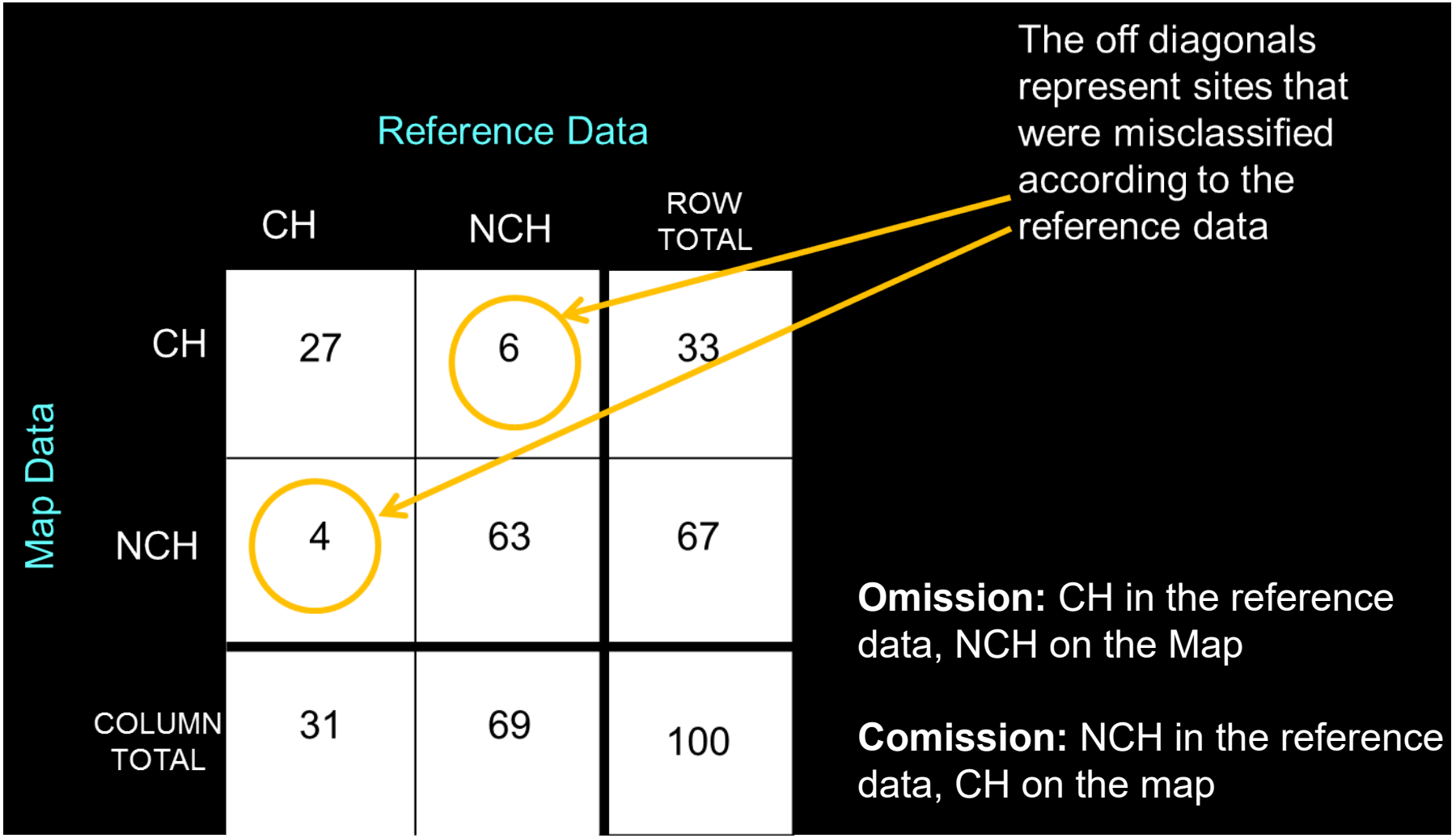
Change Map- Error Matrix



Change Map- Error Matrix



Change Map- Error Matrix



Site Specific Accuracy - Summary

- It's more complicated than simply reporting overall accuracy…
  - Consider the relative costs of omission vs commission errors
  - These considerations should influence your choice of analysis methods, thresholds, post processing steps, etc.

Limitations

- Doesn't consider the accuracy of the change blob boundaries
- With multiple change classes:
  - Makes no distinction for the magnitude of error
  - Assumes each site can only be assigned to one map category

Assessment Options

- Best Option –
  - Quantitative evaluation with field-collected reference data – many points from a designed sample (i.e., stratified vs. random).
    - *Requires time, money and resources.*
- Mid-level Option –
  - Computer validation of the map, using ancillary GIS layers and photo interpretation.
  - Qualitative assessment of map product in the field.
- Low-level option
  - No quantitative/qualitative accuracy assessment is done of the map product… Rather, quality of the product is inferred by the quality of the process.
    - *Assumption: If the logic and data are sound, the output are reasonable*

Demonstration

Exercise 5: Exploring Histograms and Creating Change Maps