Deutsches Geodätisches Forschungsinstitut
Technische Universität München

Automated Extraction of Time-Variable Water Surfaces based on Google Earth Engine

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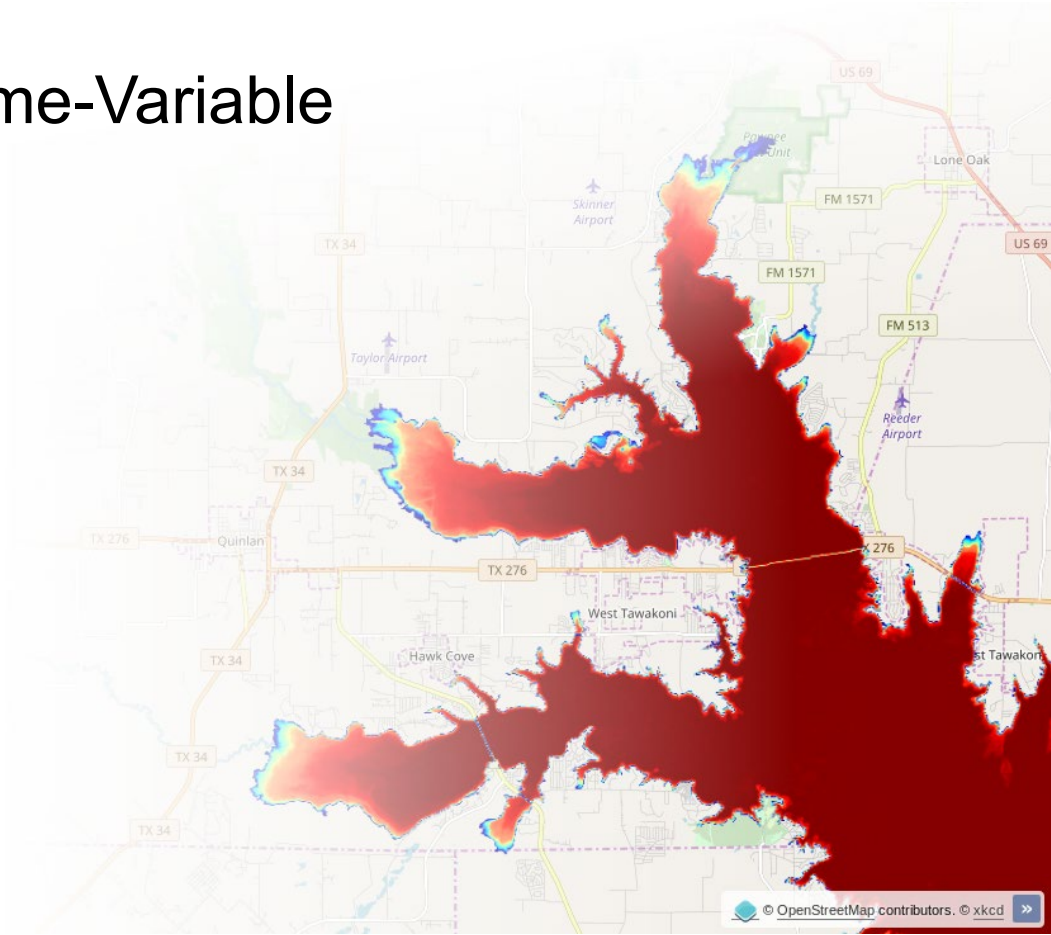
Technische Universität München (DGFI-TUM)



Geodätische Woche | Frankfurt | 17 Oktober 2018
Session 5: Umweltmonitoring und Fernerkundung

Motivation

- Inland Gewässer Daten sind essentiell für hydrologische Anwendungen
- Zahl der in-situ Stationen sinkt seit 1980 (GRDC)
- Fernerkundung ermöglicht Messungen in abgeschiedenen Gegenden
- Satellitenaltimetrie misst Gewässerhöhe
- Mehr als 750 Altimetrie Zeitreihen verfügbar

  über DAHITI (Database for Hydrological Time Series of Inland Waters)

- AWAX (Automated Water Area Extraction Tool)
  wurde mit der Google Earth Engine entwickelt um monatliche Flächendaten aus Satellitenbildern zu extrahieren und Altimetrie Datenverarbeitung zu optimieren

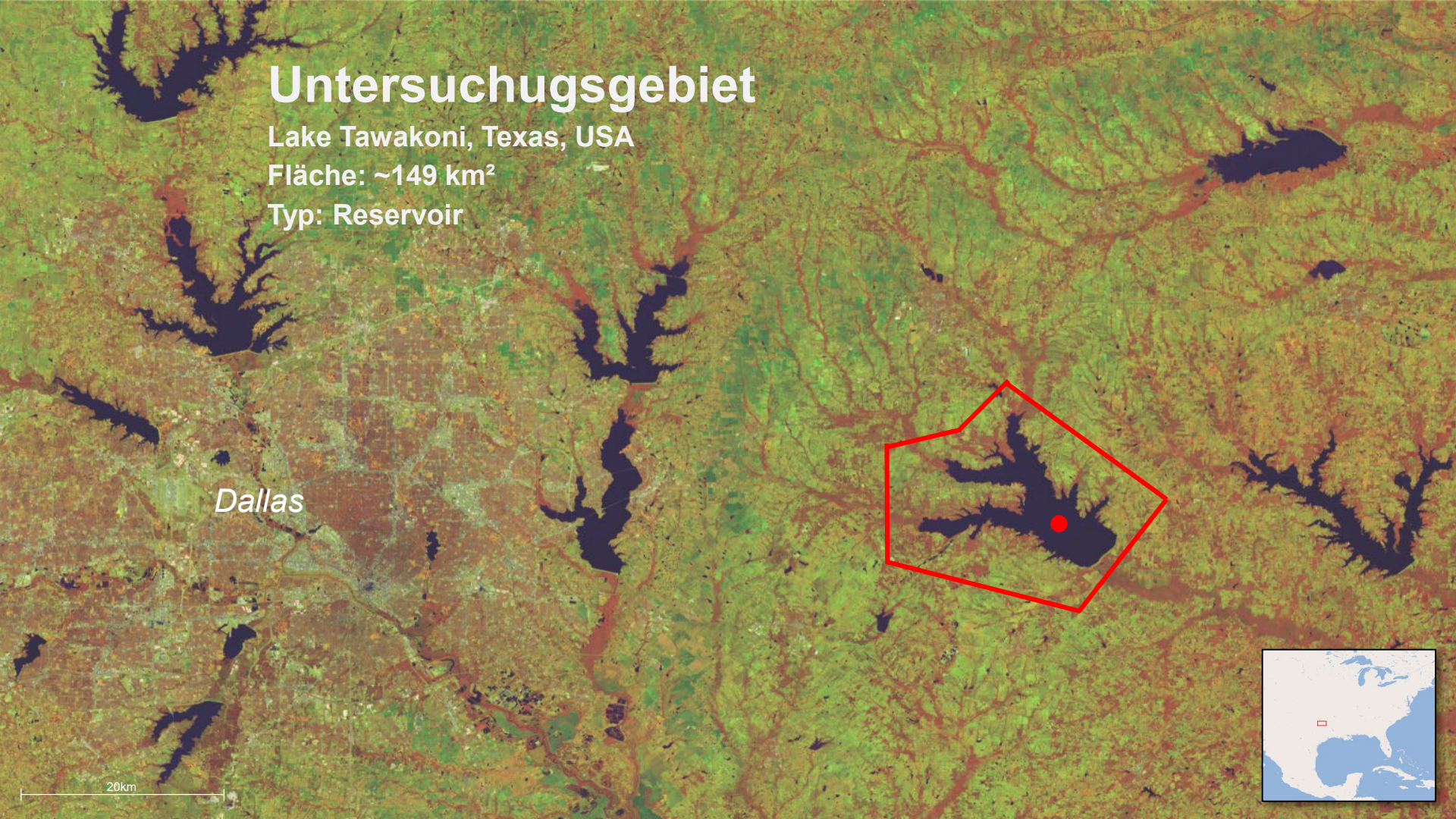
DAHITI - Website

Untersuchugsgebiet

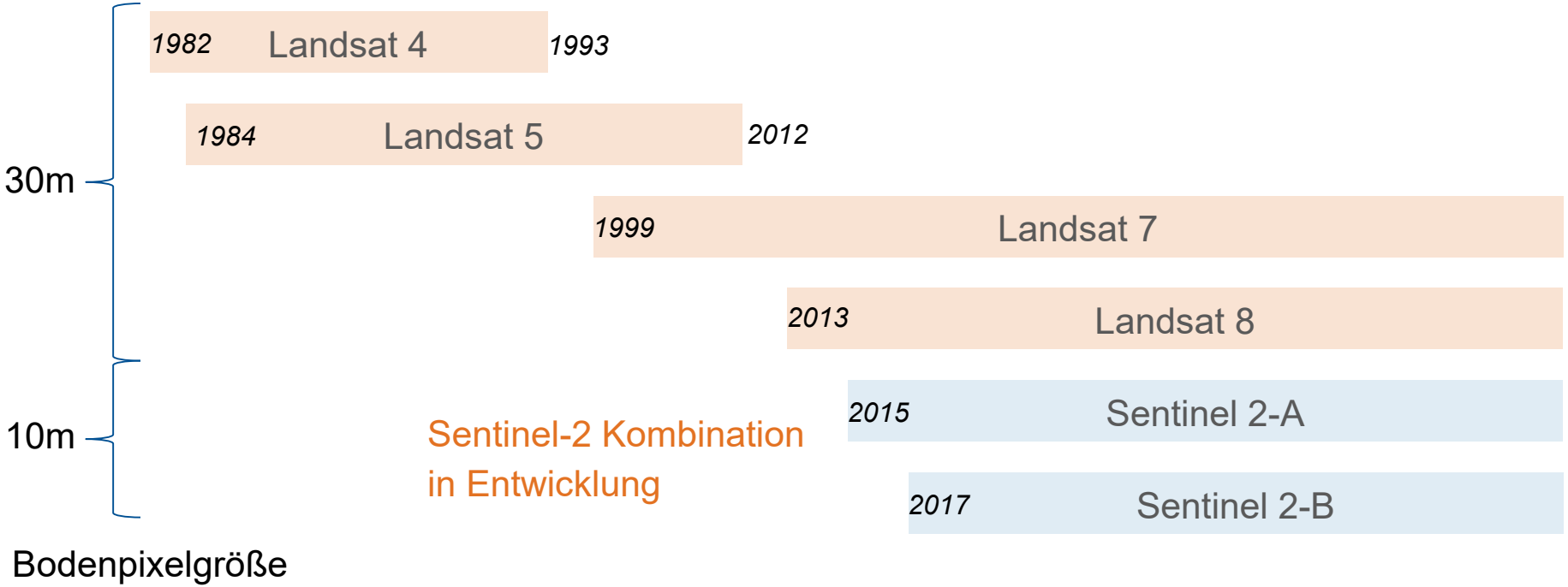
Lake Tawakoni, Texas, USA

Fläche: ~149 km²

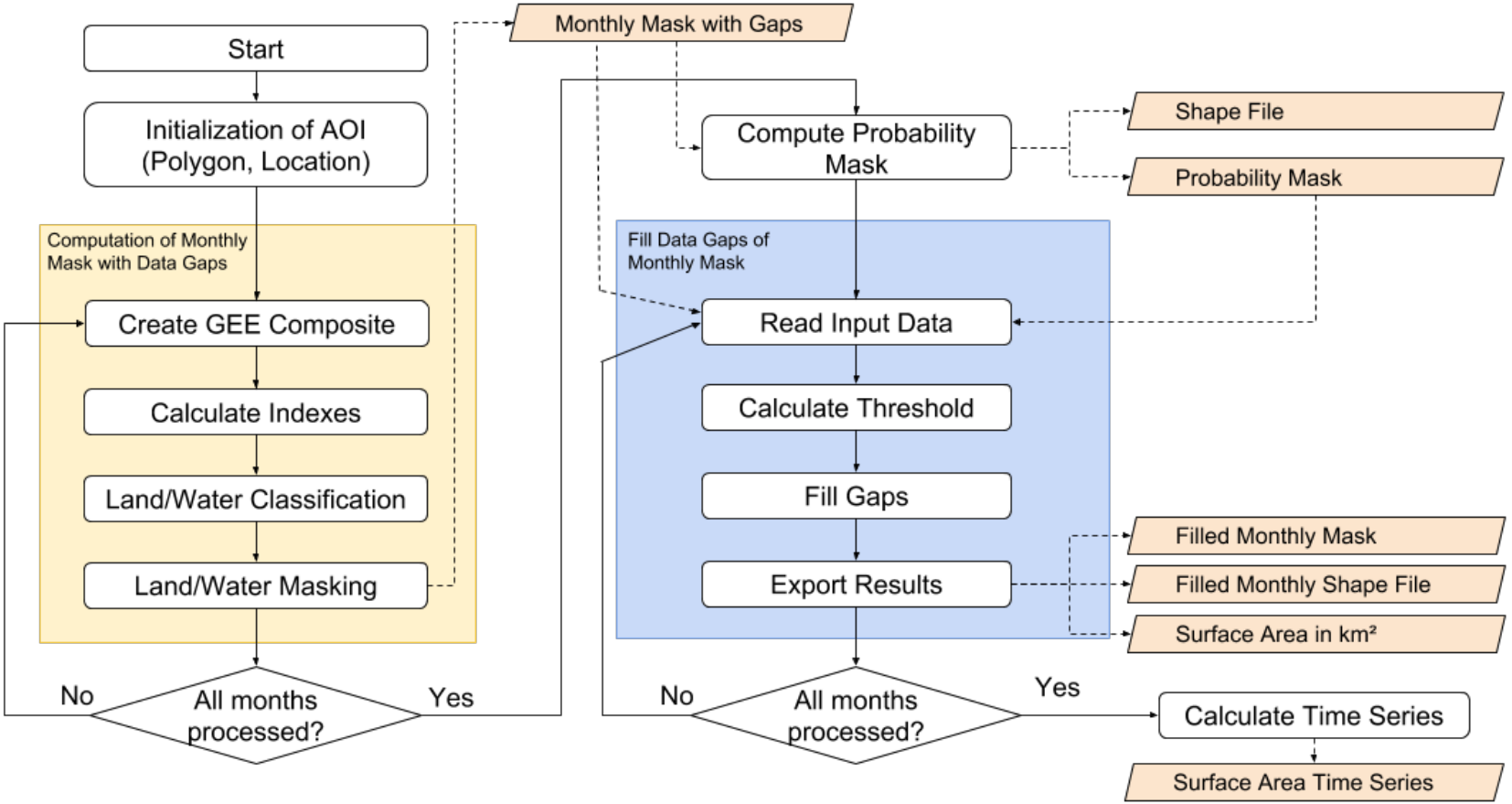
Typ: Reservoir



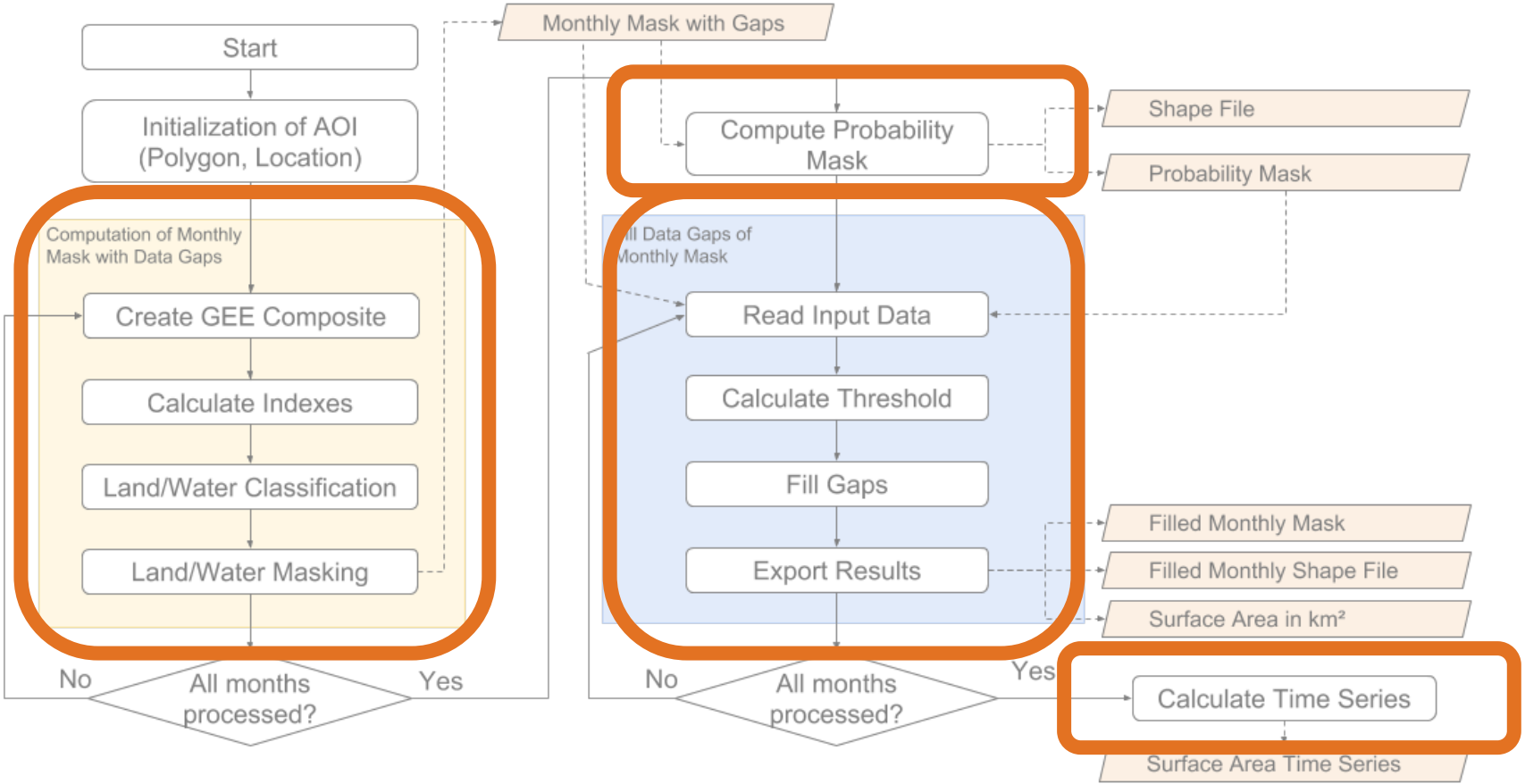
Frei verfügbare optische Daten in der Google Earth Engine



Methodik


Start
Initialization of AOI (Polygon, Location)
Computation of Monthly Mask with Data Gaps
Create GEE Composite
Calculate Indexes
Land/Water Classification
Land/Water Masking
No
All months processed?
Yes
Monthly Mask with Gaps
Compute Probability Mask
Shape File
Probability Mask
Fill Data Gaps of Monthly Mask
Read Input Data
Calculate Threshold
Fill Gaps
Export Results
Filled Monthly Mask
Filled Monthly Shape File
Surface Area in km²
No
All months processed?
Yes
Calculate Time Series
Surface Area Time Series

Methodik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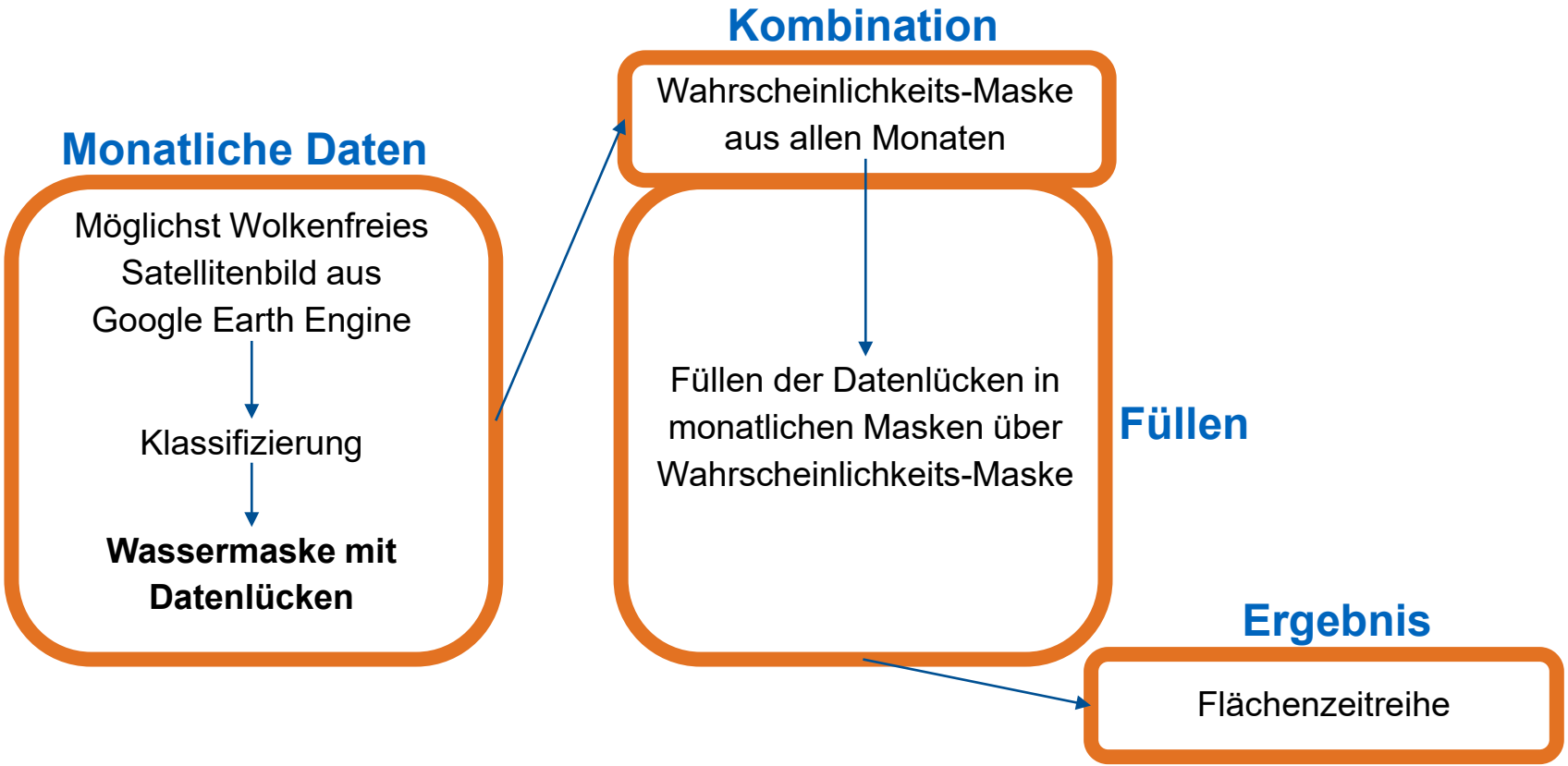
Methodik


Monatliche Daten
Möglichst Wolkenfreies Satellitenbild aus Google Earth Engine
Klassifizierung
Wassermaske mit Datenlücken
Kombination
Wahrscheinlichkeits-Maske aus allen Monaten
Füllen der Datenlücken in monatlichen Masken über Wahrscheinlichkeits-Maske
Füllen
Ergebnis
Flächenzeitreihe

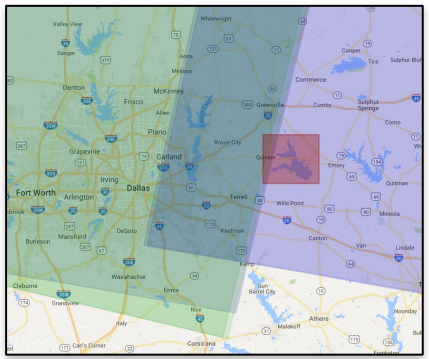
Monatliches Composite

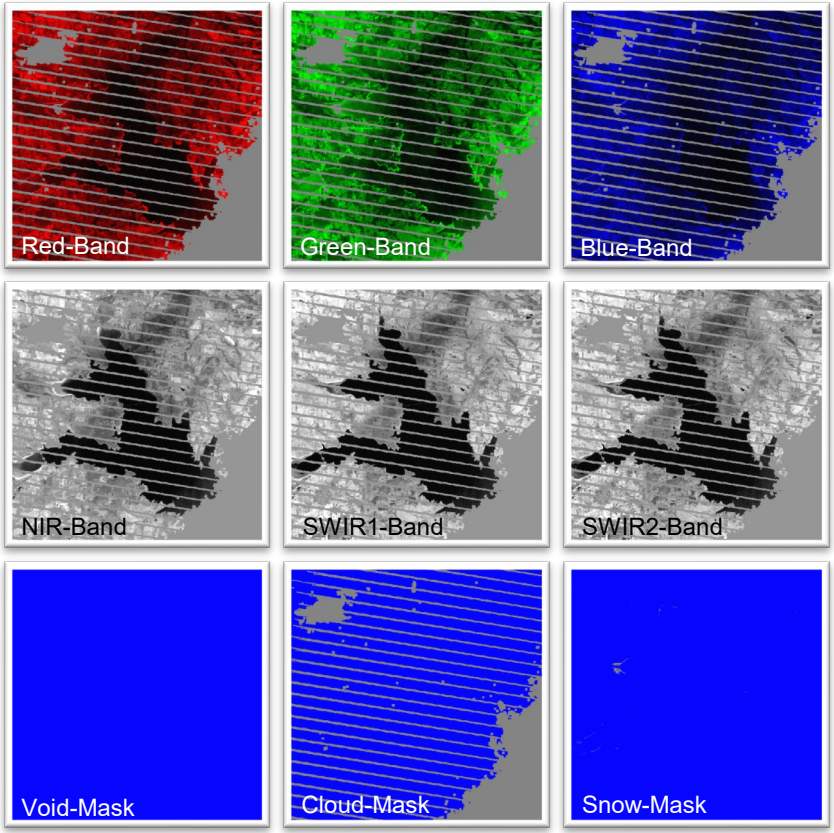
- Wolkenmaskierung aller verfügbaren Satellitenbilder mit FMask Algorithmus (*Zhu und Woodcock, 2012*) (in Earth Engine bereits prozessiert)

- Kombination zu möglichst wolkenfreien Bild

- Extraktion von 6 Bändern:
  Red, Green, Blue, NIR, SWIR1, SWIR2
- Und drei Masken: *Voids, Clouds, Snow*

- Lake Tawakoni
  Dezember 2014:
  3 x Landsat 7
  2 x Landsat 8





Wasser Indizes

- **Modified Normalized Difference Water Index** (Xu, 2006)

$$MNDWI = \frac{Green\ - SWIR_1}{Green + \ SWIR_1}$$

- **New Water Index** (Li, 2016)

$$NWI = \frac{Blue\ - (NIR + \ SWIR_1 + \ SWIR_2)}{Blue + (NIR + \ SWIR_1 + SWIR_2)} * C$$

- **Automated Water Extraction Index for Non-Shadow Areas and Shadow Areas** (Feyisa et al, 2014)

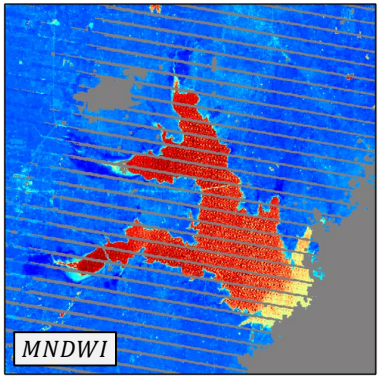
$$AWEI_{nsh} = 4 * (Green\ - \ SWIR_1) - (0.25\ * NIR + 2.75\ * \ SWIR_2)$$

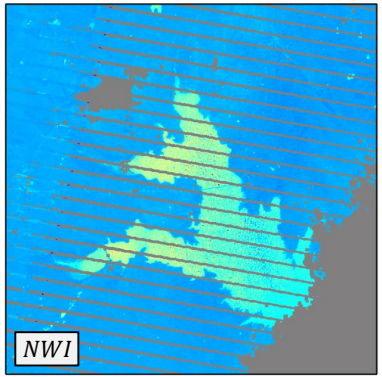
$$AWEI_{sh} = Blue + 2.5 * Green - 1.5 * (NIR + SWIR_1) - 0.25\ * \ SWIR_2$$

- **Tasseled Cap – Wetness** (Crest, 1985)

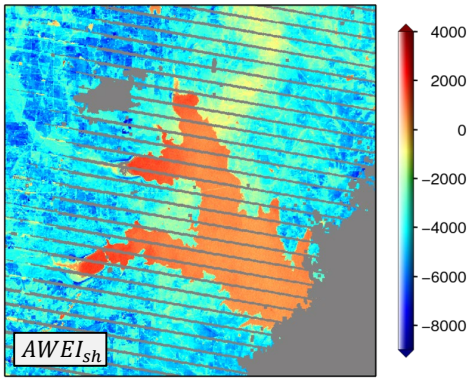
$$TC_{wet} = 0.0315\ * \ Blue + 0.2021 * Green + 0.3102\ * Red + 0.1594\ * NIR - 0.6806\ * SWIR_1 - 0.6109\ * \ SWIR_2$$

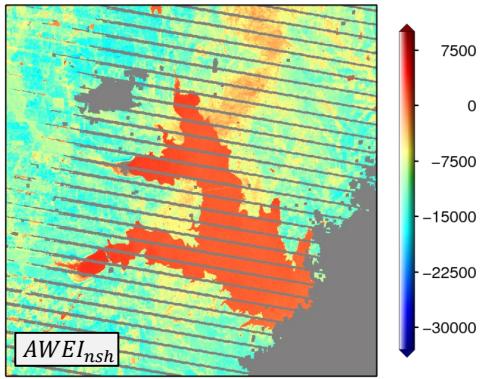
Indizes berechnen

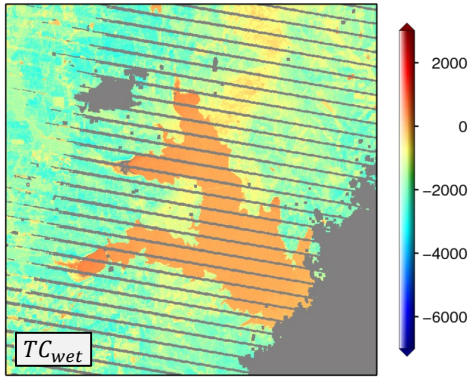




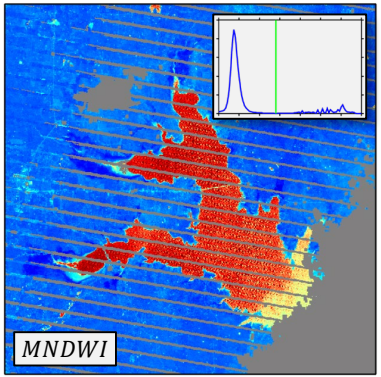
1. Indizes berechnen

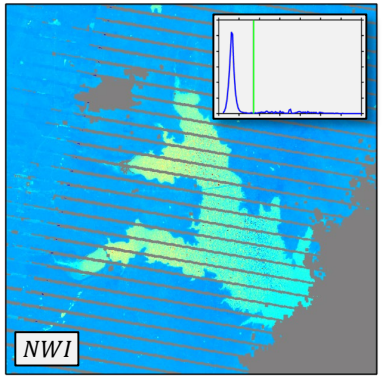




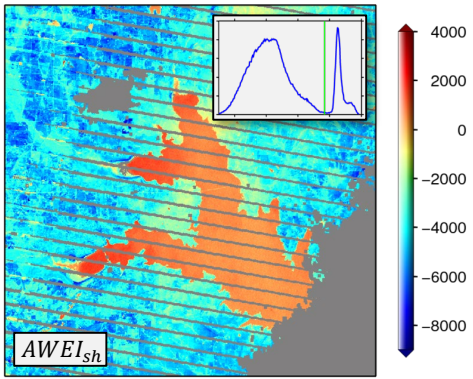


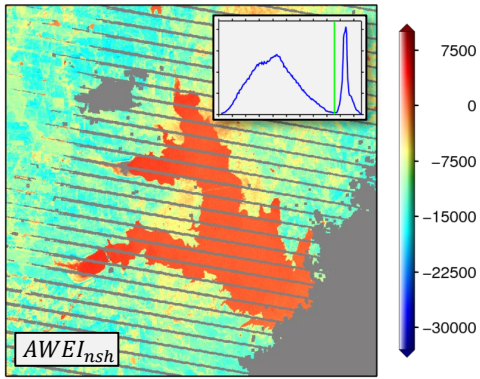
Histogramme erzeugen

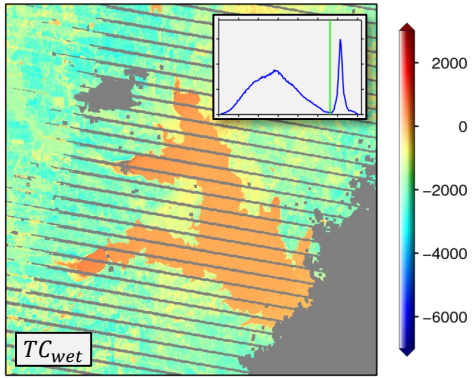




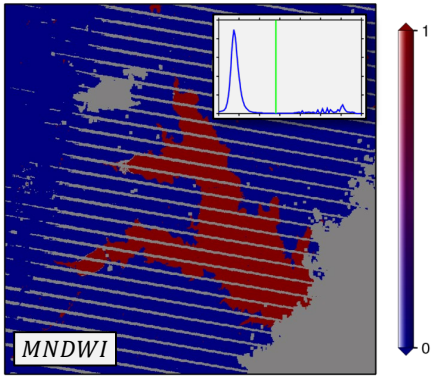
1. Indizes berechnen
2. Histogramme erzeugen

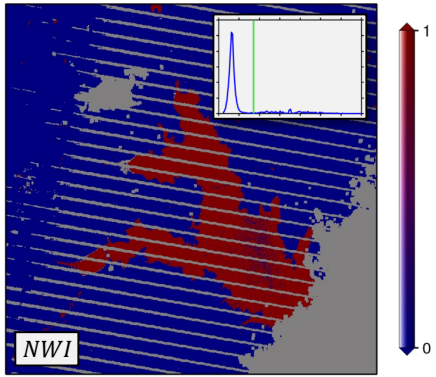


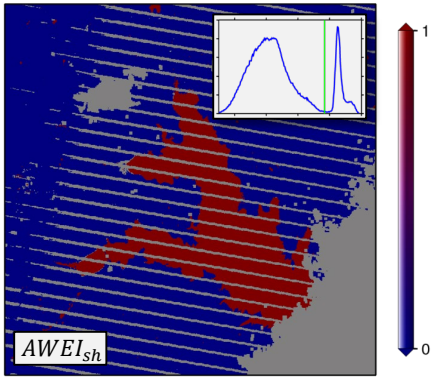


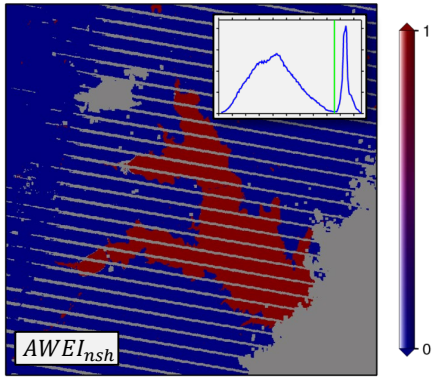


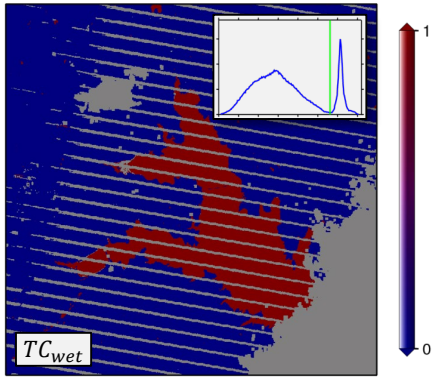
Schwellwerte berechnen und anwenden





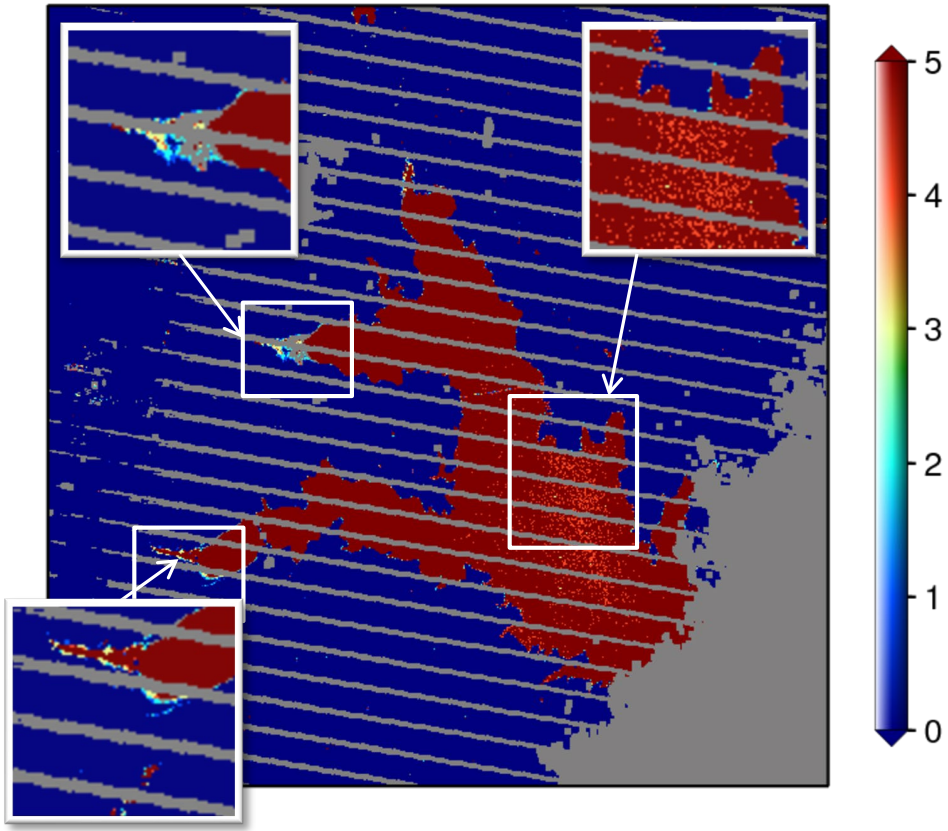






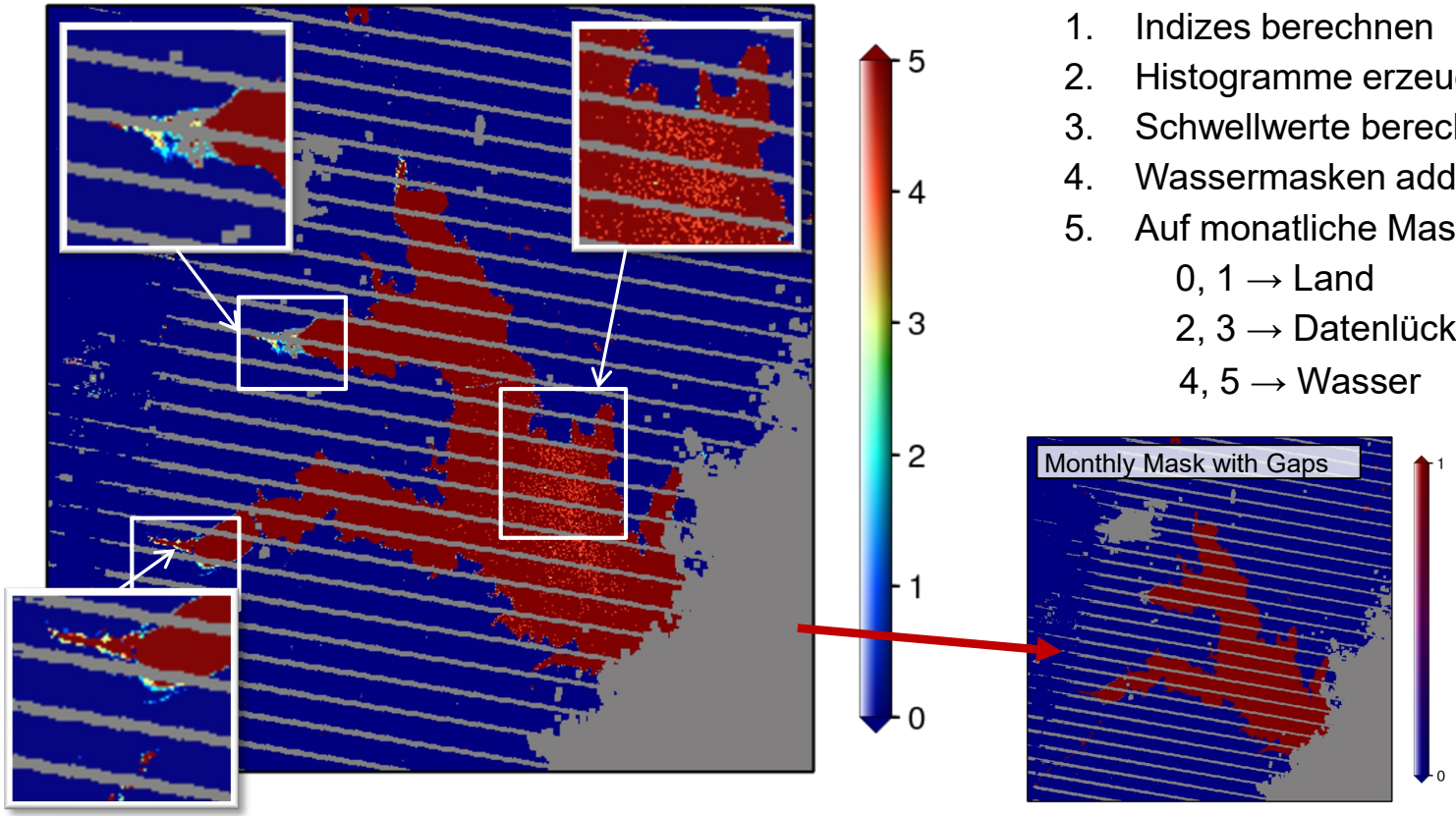
1. Indizes berechnen
2. Histogramme erzeugen
3. Schwellwerte berechnen und anwenden

Wassermasken addieren



1. Indizes berechnen
2. Histogramme erzeugen
3. Schwellwerte berechnen und anwenden
4. Wassermasken addieren

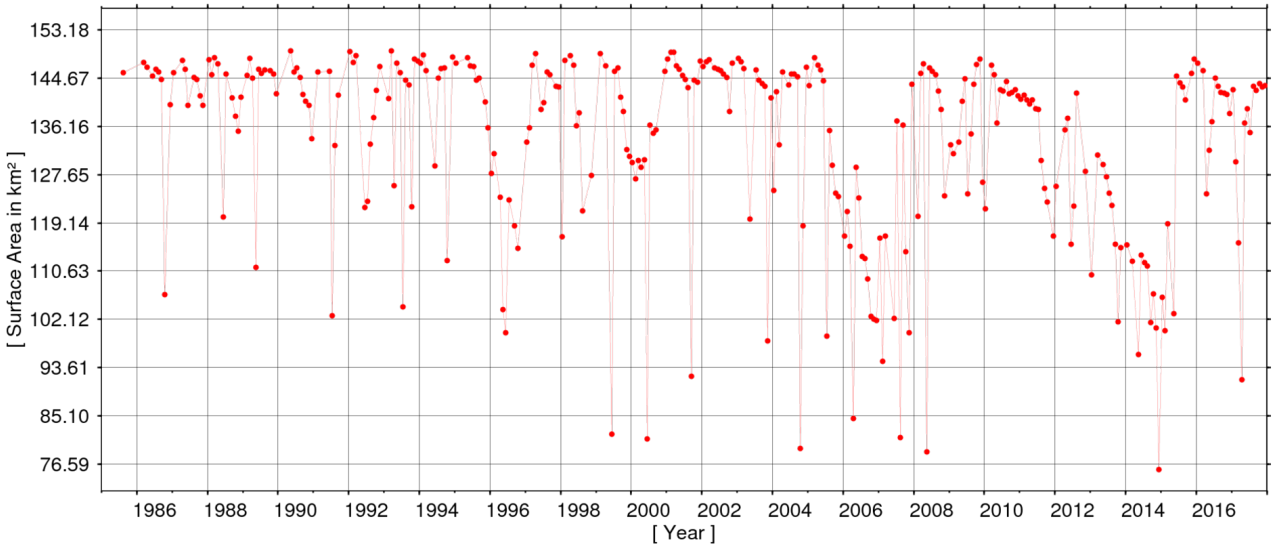
Auf monatliche Maske reduzieren

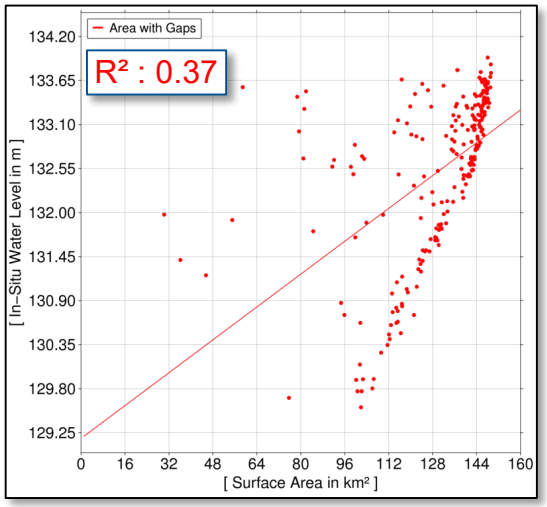


1. Indizes berechnen
2. Histogramme erzeugen
3. Schwellwerte berechnen und anwenden
4. Wassermasken addieren
5. Auf monatliche Maske reduzieren
   - 0, 1 → Land
   - 2, 3 → Datenlücke
   - 4, 5 → Wasser

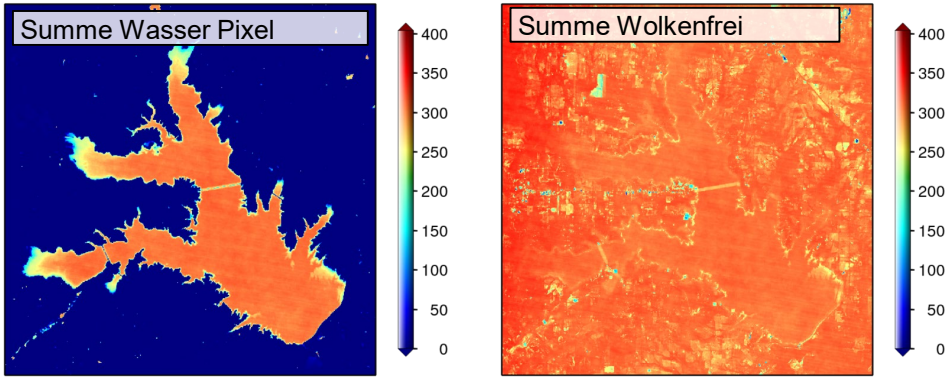
Zeitreihe mit Datenlücken

Zeitreihe der Gewässerfläche des Lake Tawakoni mit Datenlücken

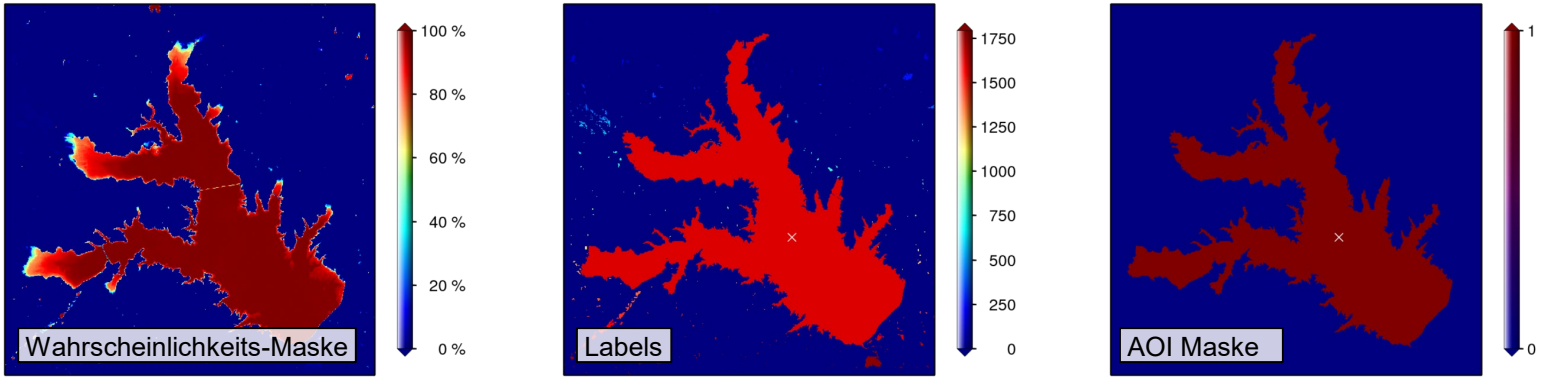




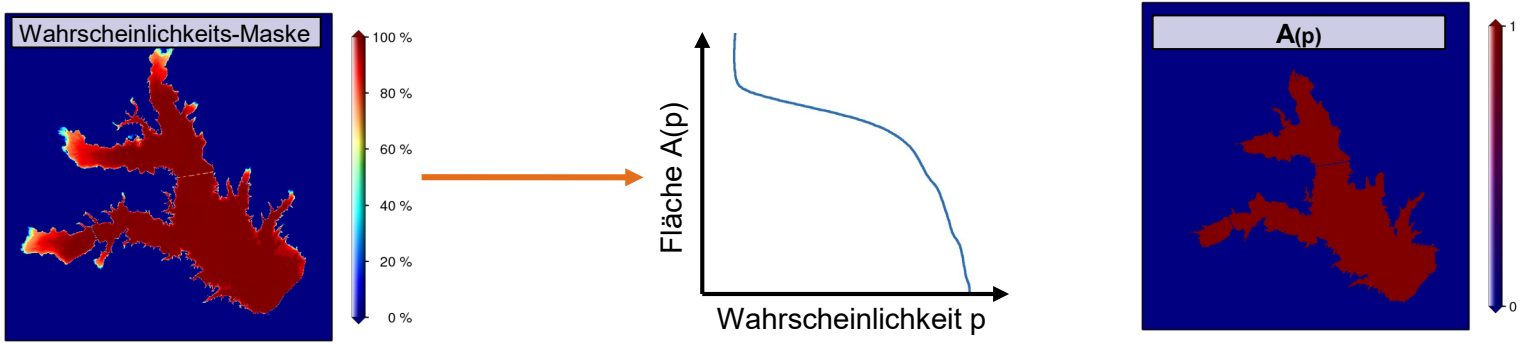
Wahrscheinlichkeits-Maske



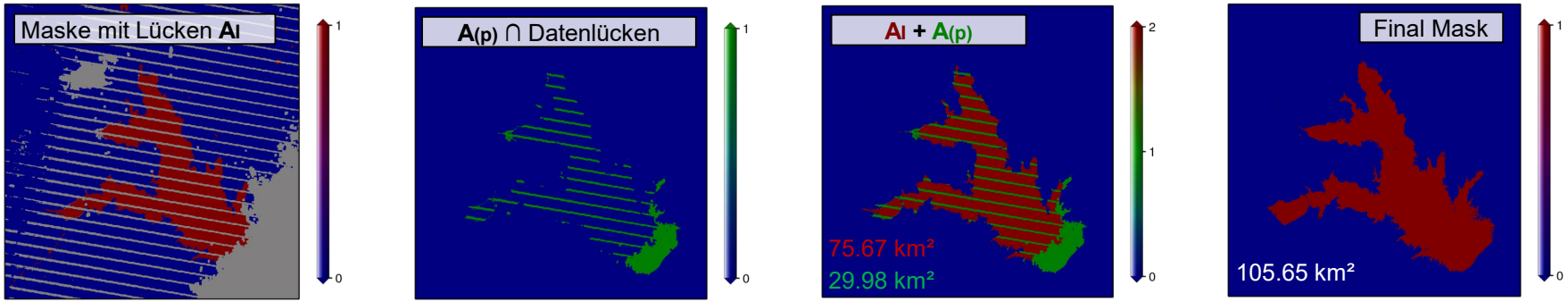
1. Summieren der Wasser und wolkenfreien Pixel aller verfügbarer Monate
2. Berechnung der Wahrscheinlichkeits-Maske
3. Labeln aller verbundenen Flächen
4. Auswahl über Referenz Punkt
5. Erzeugung der AOI Mask



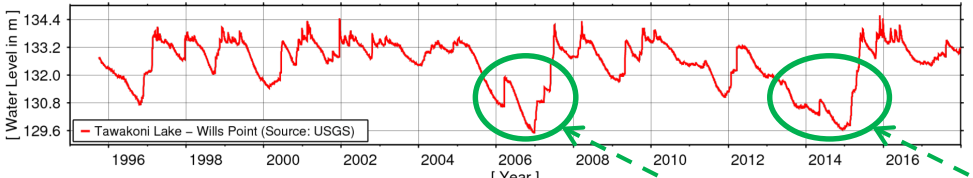
Füllen von monatlichen Datenlücken

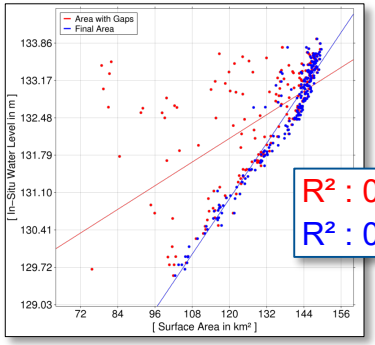


Iteration von p bis: (A_I + ($A_{(p)}$ ∩ Datenlücken)) - $A_{(p)}$ = **Min**



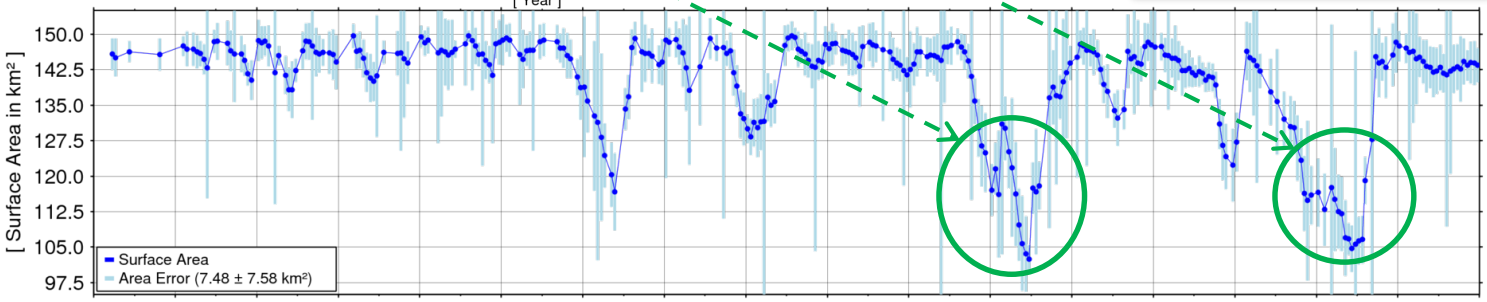
Ergebnisse – Tawakoni, Lake

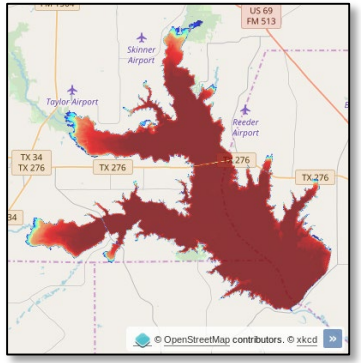


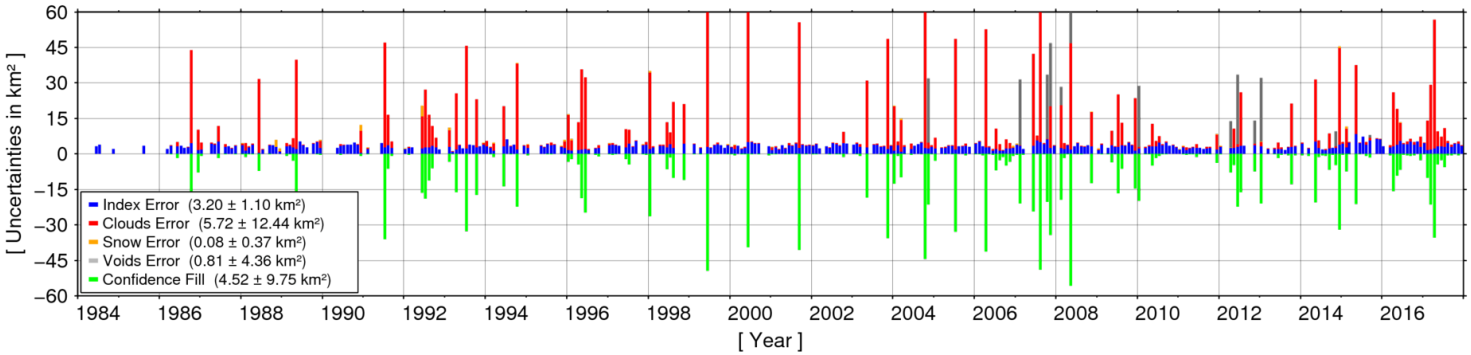


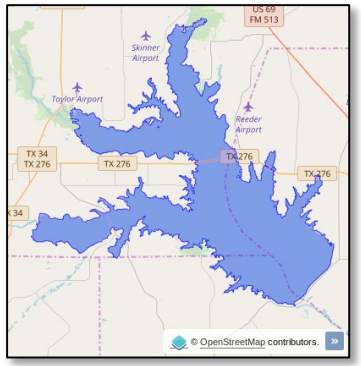
R^2 : 0.37

R^2 : 0.93

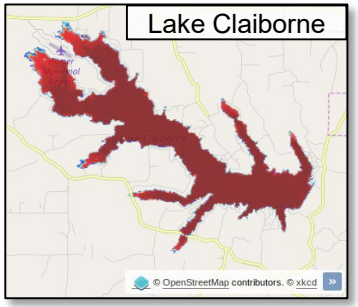


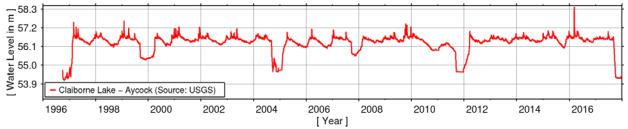


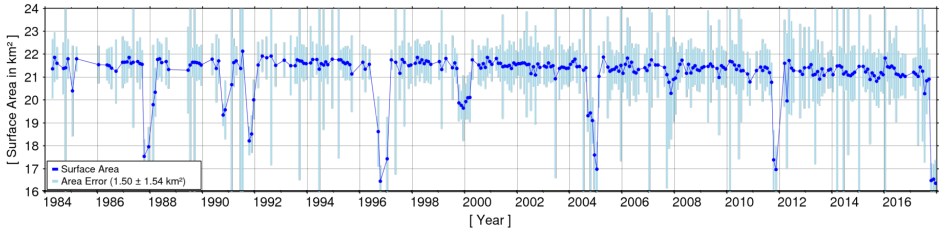


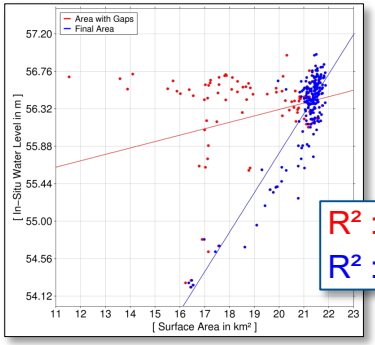


Weitere Ergebnisse

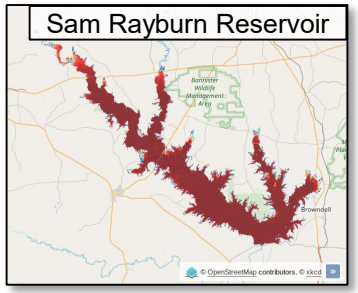


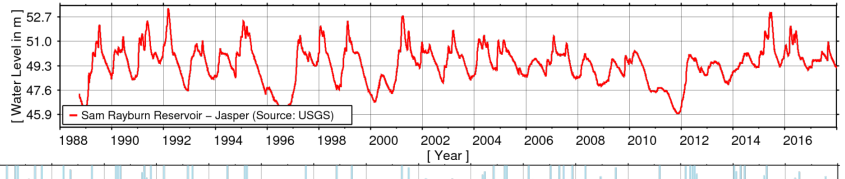


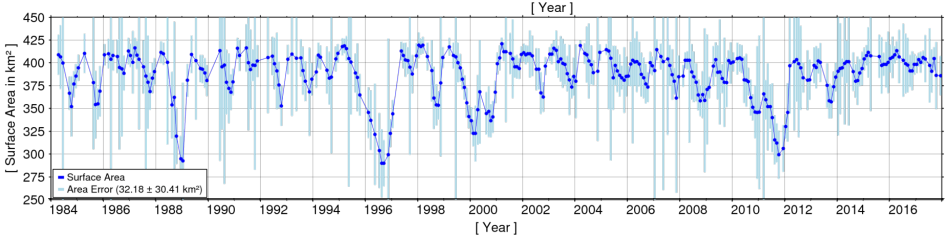


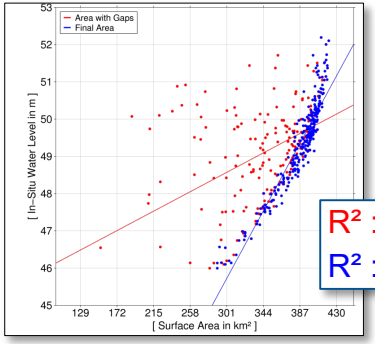


R² : 0.11
R² : 0.77









R² : 0.24
R² : 0.87

Daten Verfügbarkeit

- Flächenzeitreihen werden sukzessive zu DAHITI hinzugefügt
- Alle Daten sind frei verfügbar
- See you on DAHITI!