Digital elevation models for the Everglades Depth Estimation Network (EDEN) with elevation uncertainty treatment

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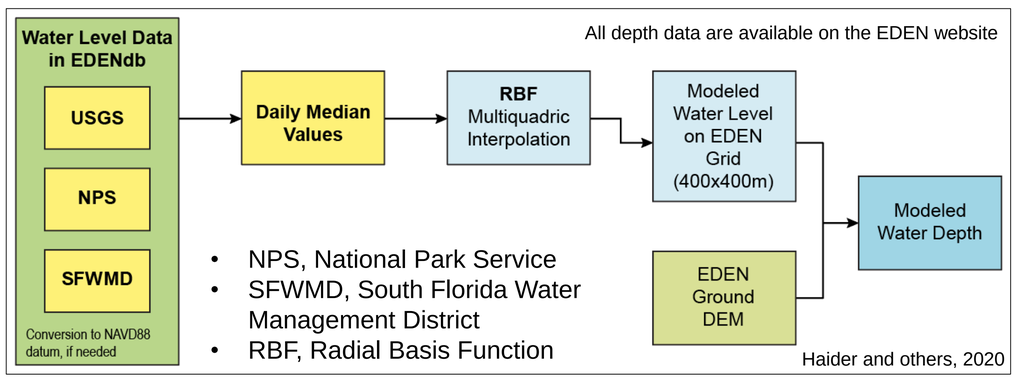
Key points

- EDEN has used a 400-m digital elevation model (DEM) produced from observations made via helicopter/airboat in the mid 2000s.
- Over the past few years, high-resolution DEMs produced from light detection and ranging (lidar) data have become available for the EDEN study area.
- Lidar-based DEMs can have a substantial amount of error due to the inability to penetrate densely vegetated areas and inundated areas.
- Using Monte Carlo simulations, we developed new 10-m and 50-m lidar-based DEMs with reduced error for the EDEN study area.
- These DEMs are now available for hydrologic and ecologic analyses and can be enhanced via regression-based correction approaches.

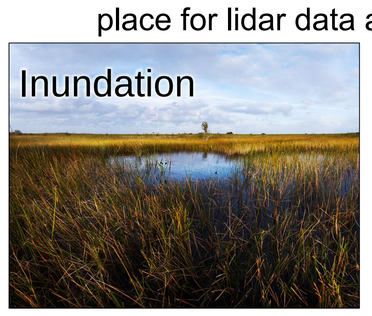
Background

EDEN models daily water depth in the Everglades using water level data and a DEM



Original EDEN DEM was 400-m DEM from helicopter and airboat elevation observations (HAED; Jones and others, 2011)

There has been a recent increase in lidar data availability, but the Everglades can be a challenging place for lidar data acquisition due to…



Credit: NPS, Brian Call

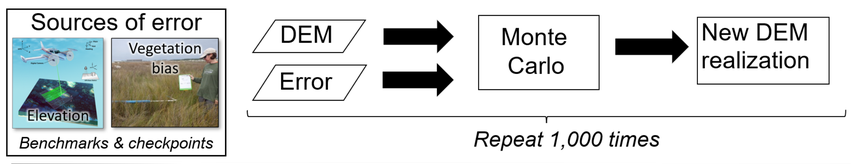
Credit: NPS

Objective: Utilize Monte Carlo simulations to reduce the error for lidar-based DEMs

Methodology

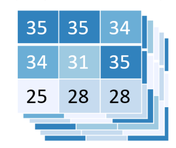
- Monte Carlo simulations utilize elevation error information to produce new DEM realizations (Wechsler and Kroll, 2007)
- Data sources
  - *DEMs*, mostly 1-m lidar-based DEMs resampled to 10-m and 50-m via median bin
  - *Benchmarks and elevation checkpoints* for quantifying elevation error
  - *Land cover* for vegetation information
    - 2016 30-m National Oceanic and Atmospheric Administration's Coastal Change Analysis Program data
    - Florida Land Use Cover and Forms Land Classification System
  - *HAED observations* for validation and fixing issues associated with inundation

Monte Carlo simulation approach



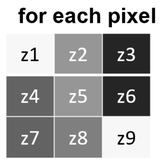
Objective

Many realizations! (maps of elevation)



Darker colors = higher values

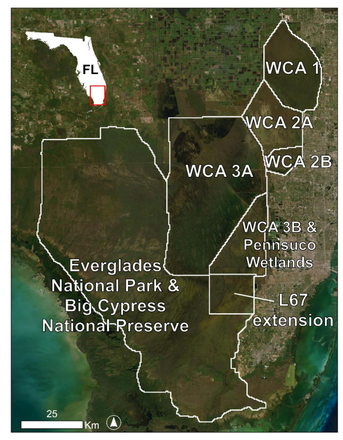
Calculate statistics for each pixel



Statistics
Minimum
5th percentile elevation
10th percentile elevation
...
Median elevation
...
90th percentile elevation
95th percentile elevation
Maximum

- Develop surfaces by subunit using elevation error for full EDEN area
- Error metrics were mean error and root mean square error (RMSE)
  - "Best": Percentile with lowest mean error
  - Lower/upper: Percentile with mean error that was farthest away from but within (+/-) 5 cm
- Fixing inundation errors in WCAs using lidar acquisition information

Study area and subunits



Results

- The median bin DEMs had a 95th percentile error of 0.453 m for the 10-m DEM (n = 833) and 0.543 m for the 50-m DEM (n = 324)

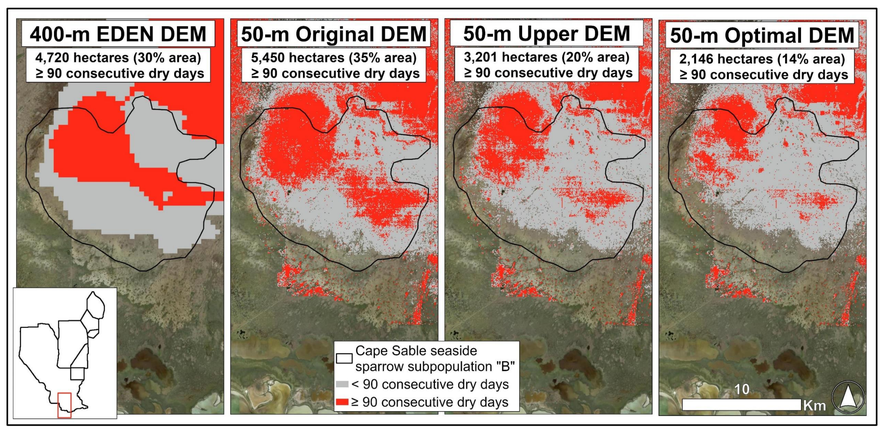
Elevation error for the "best" 10-m and 50-m DEMs (10-m value; 50-m value)

	Error before Monte Carlo simulations (cm)		Error after Monte Carlo simulations (cm)	
EDEN subunit	Mean error	RMSE	Mean error	RMSE
Everglades National Park & Big Cypress National Preserve	13; 14	22; 22	-1; 0	18; 21
L67 extension	15; 15	21; 24	0; 0	15; 17
WCA 1	49; 49	55; 55	-1; 0	26; 28
WCA 2A	51; 51	56; 56	0; 0	22; 26
WCA 2B	86; 87	90; 90	10; -2	30; 30
WCA 3A	39; 38	47; 45	0; -1	29; 32
WCA 3B & Pennsuco Wetlands	55; 54	57; 56	-4; 4	18; 28

- Reduced error DEMs published as a USGS data release (Simons and others, 2025)

Applications and next steps

- Hydrologic modeling
- Cape Sable seaside sparrow nesting habitat availability
- U.S. Fish and Wildlife targets ≥90 days for nesting habitat suitability



- Update/revise DEM with Monte Carlo simulations per subunit rather than full EDEN footprint
- Remote sensing-based error reduction (Daniel Gann is actively working on this topic with state and federal partners)
- Remote sensing-based error reduction and Monte Carlo integration

References

Haider & others, 2020
EDEN website
Jones & others, 2011
Wechsler & Kroll, 2007
Simons & others, 2025; the DEMs produced in this study

Acknowledgements

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