Mapping Daily and Maximum Flood Extents at 90-m Resolution During Hurricanes Harvey and Irma Using Passive Microwave Remote Sensing

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Summary

- During Hurricanes Harvey and Irma we used AMSR2 (passive microwave) remote sensing data to map flood extents in near real time
- Results begin with the first post-storm rain-free satellite passes and track flood evolution over time
- Our standard flood extent algorithm derives flooded fraction from normalized 22-km AMSR2 or GMI data and downscales it to a ~90-m flood map using a relative floodability database built from topography, hydrology, and Global Surface Water Occurrence (Pekel et al., 2016) data
- Here we tested experimental algorithm versions designed to rapidly map the maximum flood extent and provide updates at least daily
- Versions of the maps shown here were shared in real time during the floods through, e.g., the Global Flood Partnership

Standard flood extent depiction SFED

- Enforces consistency between historical and near-real-time products
- Minimizes false positive rates
- Uses 3-day averaging to improve precision for large, longer-duration floods
- Used in, e.g., insurance applications with index-based payout triggers

Rapid-response flood extent depiction RFED

- Ignores false-positive flags; to be used only as a flood event unfolds
- Uses 3-day maximum flooded fraction to capture full extent of floods
- Intended to help decision-makers monitor and respond to on-going floods

Why use microwave sensors to map floods?

✓ They can provide twice-daily measurements globally
- They "see through" non-precipitating clouds
- They make measurements day and night

✓ They provide a historical record from 1992 to the present from multiple satellite sensors
- SSM/I, TMI, AMSR-E, AMSR2, GMI

✓ Multiple satellite sensors currently provide redundant data for more reliable near-real-time operations
- AMSR2, GMI, [WSF-M launch ~2022]

✓ Our algorithms address key microwave sensor limitations
- **Coarse resolution**: Downscaling algorithm depicts floods at finer scale using relative floodability database
- **Ambiguity:** Temporal-spatial processing filters out non-flood signals

Clouds block optical sensors …

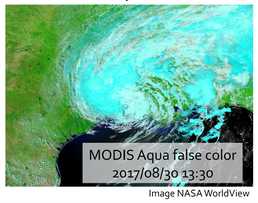
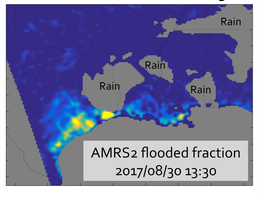


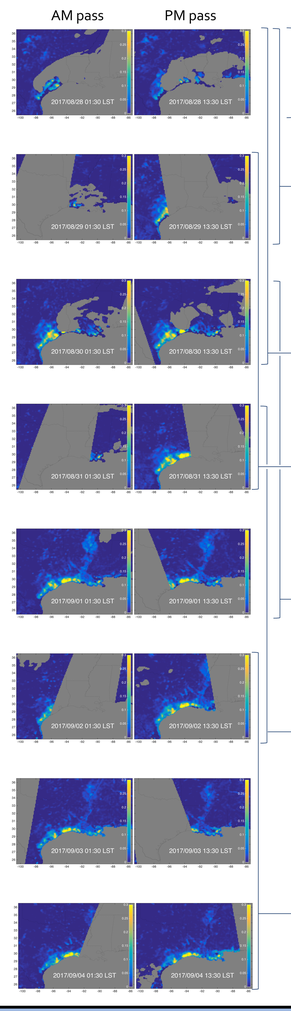
Image NASA WorldView

… microwave sensors see through

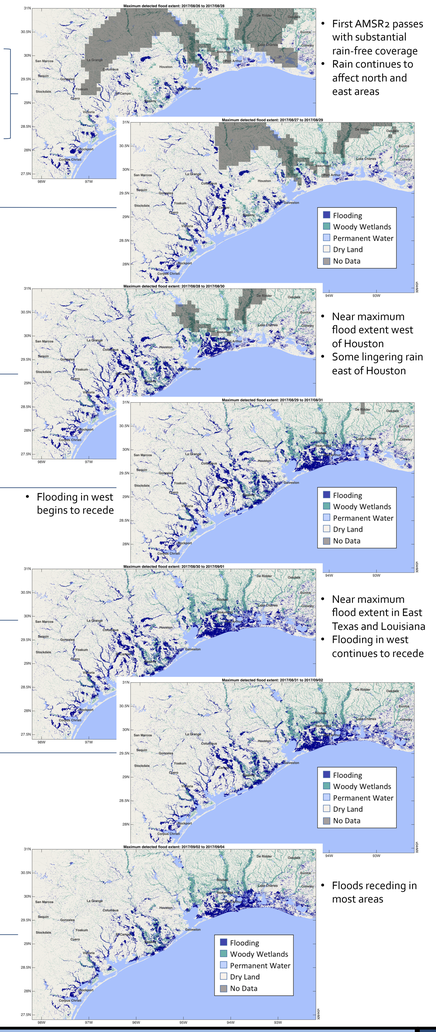


Harvey Daily Flood Evolution and Maximum Extent

AMSR2 flooded fraction
2017/08/28 – 2017/09/04

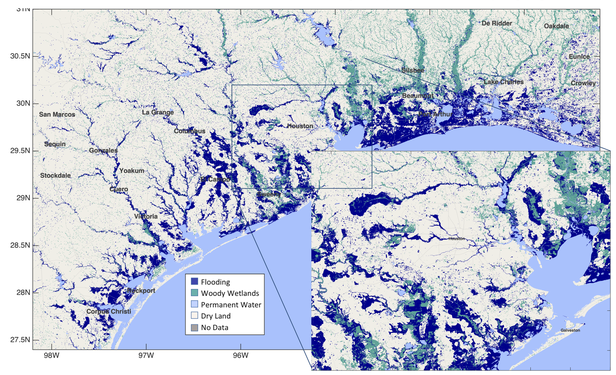


Rapid-response flood extent depiction updates
Downscaled from 3-day maximum flooded fraction

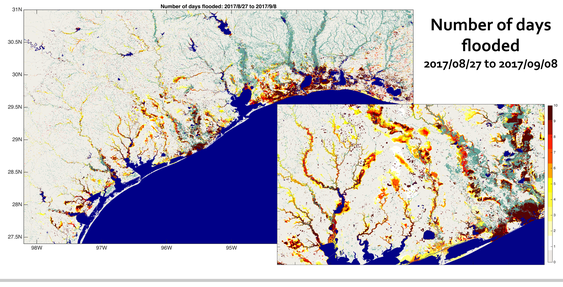


- First AMSR2 passes with substantial rain-free coverage
- Rain continues to affect north and east areas
- Near maximum flood extent west of Houston
- Some lingering rain east of Houston
- Flooding in west begins to recede
- Near maximum flood extent in East Texas and Louisiana
- Flooding in west continues to recede
- Floods receding in most areas

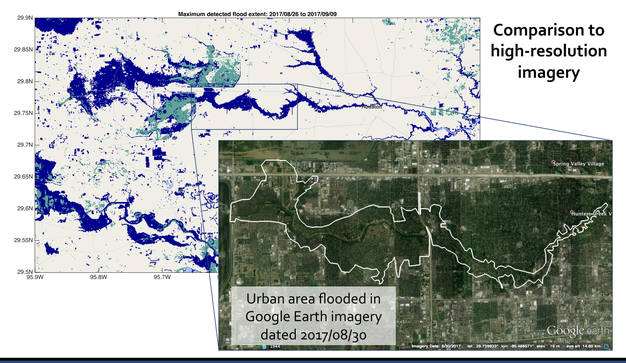
Maximum detected flood extent, 2017/08/26 to 2017/09/09



Number of days flooded
2017/08/27 to 2017/09/08

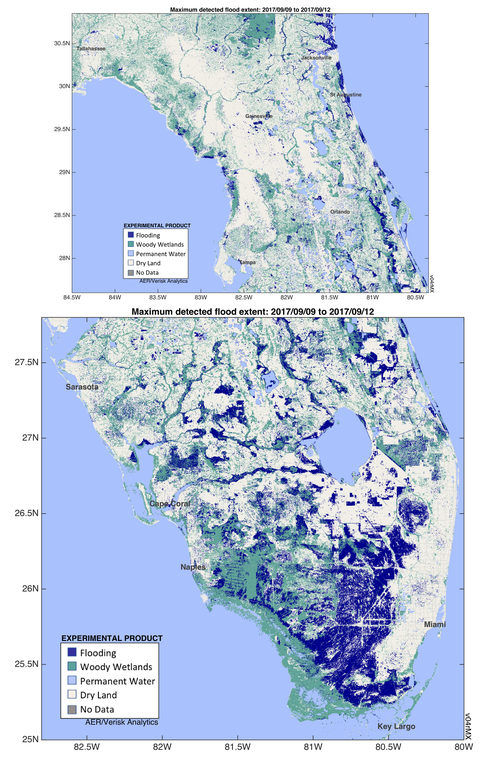


Comparison to high-resolution imagery

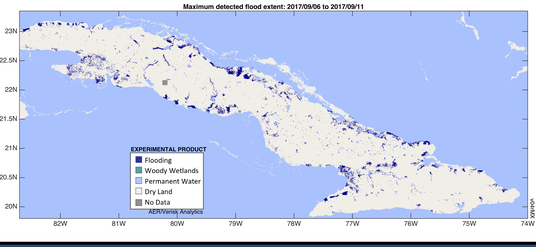


Irma Maximum Flood Extent

Florida maximum detected flood extent, 2017/09/09 to 2017/09/12



Cuba maximum detected flood extent, 2017/09/06 to 2017/09/11



Flood Mapping Methodology

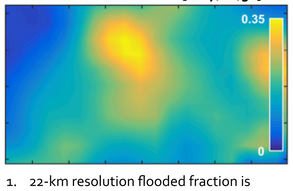
Flooded fraction from microwave data

1. **Footprint matching and regridding**: isolates temporal variation at grid locations on a 22-km circularized footprint scale
2. **Rain flagging**: liberal flagging reduces flood detection false negatives
3. **Linearization**: "Q" transform linearizes polarization ratio index vs. water fraction
4. **Atmospheric correction**: enhances land/water contrast
5. **Flooded fraction (initial)**: end-member mixing model makes a best estimate of the dry-land end-member, Q_d, per each gridded footprint location
6. **False positive "flash" detection**: temporal/spatial filter flags large areas of sudden flooding as likely false positives
7. **Compute daily flooded fraction (FF)**
   - Combines initial flooded fraction data over 3-day period, day and night observations, excluding flagged data
   - Standard: 3-day weighted mean
   - Rapid response: 3-day maximum
6. **Apply minimum detectable flooded fraction limit (FF>MDFF)**: reduces false positives at the expense of smaller flood features

Rapid response flooded fraction

Downscaling flooded fraction

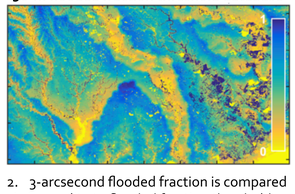
22-km flooded fraction [2017/08/30]



1. 22-km resolution flooded fraction is interpolated from 5-arcminute grid 3-arcsecond flood map grid.

≥

90-m flooded fraction threshold database



2. 3-arcsecond flooded fraction is compared via inequality to flooded fraction threshold (FFo) computed from relative floodability.

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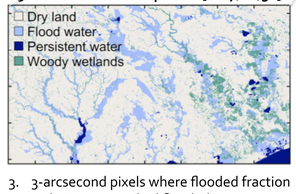
90-m flood extent depiction [2017/08/30]



3. 3-arcsecond pixels where flooded fraction exceeds FFo are marked flooded.

4. The flood map is iteratively upscaled and recomputed until reconciled with flooded fraction.

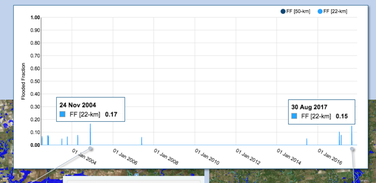
FloodScan Web Interface with Flooded Fraction Time Series Analysis

FloodScan provides web access to historical and near-real-time flood maps from AER's standard flood mapping system.
- Daily historical 90-m flood maps
- Automatic daily updates
- Continent-wide coverage
  - North America: 2002-present
  - South America: 2002-present
  - Africa: 1992-present
- Plots historical flooded fraction time series at any location to instantly put flooding into historical context

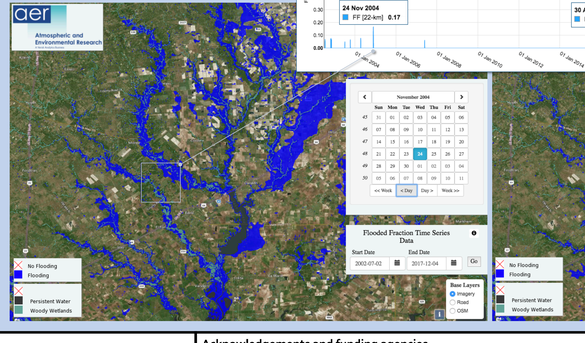
floodscan.aer.com

AGU Access
Username: agu2017
Password: agu2017

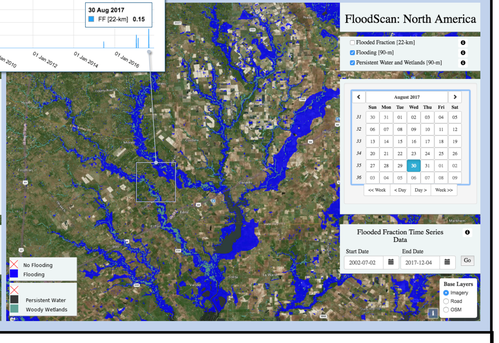
Flooded fraction time series



Historic flood
2004/11/24



Hurricane Harvey
2017/08/30



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AER (2017b), *ARC Flood Extend Depiction Algorithm Performance Document*, AFED Version V03R01, Doc. Rev. R05, AER document P3908-AFM-APD-V03R01-R05, 205 pp. http://product.aer.com/images/FloodScan/afm_algo_perf_doc_v03r01_r05.pdf

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