The Application of Synthetic Aperture Radar (SAR) to Natural Resource Damage Assessment

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NOAA's Ocean Service, Office of Response & Restoration

April 2nd, 2015

Coastal GeoTools

Charleston, SC

Coastal GeoTools

Overview: NRDA and SAR

NOAA
Damage Assessment Remediation & Restoration Program

- OR&R and NRDA
- SAR and TCNNA Processing
- SAR Products
  - Cumulative Composite
  - Cumulative Days of Oiling
  - Shoreline Days of Oiling
  - Time of Oiling
- Summary/Conclusions

Continuum of "Response" Framework for The Office of Response & Restoration

Response (24 hours) → **Recovery or Restoration (Years/Decades)**

Response

Assessment

Restoration

What is NRDA?

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Damage Assessment Remediation & Restoration Program

- Legal Process
  - OPA 90, CERCLA, CWA
  - Specific steps to follow and things to prove
- Based in Science
- Goal: Public Compensation
  - Determine public loss
  - Recover loss through restoration
- Success = appropriate restoration achieved

NRDA Requires Demonstration of Causality: Oil causing injury

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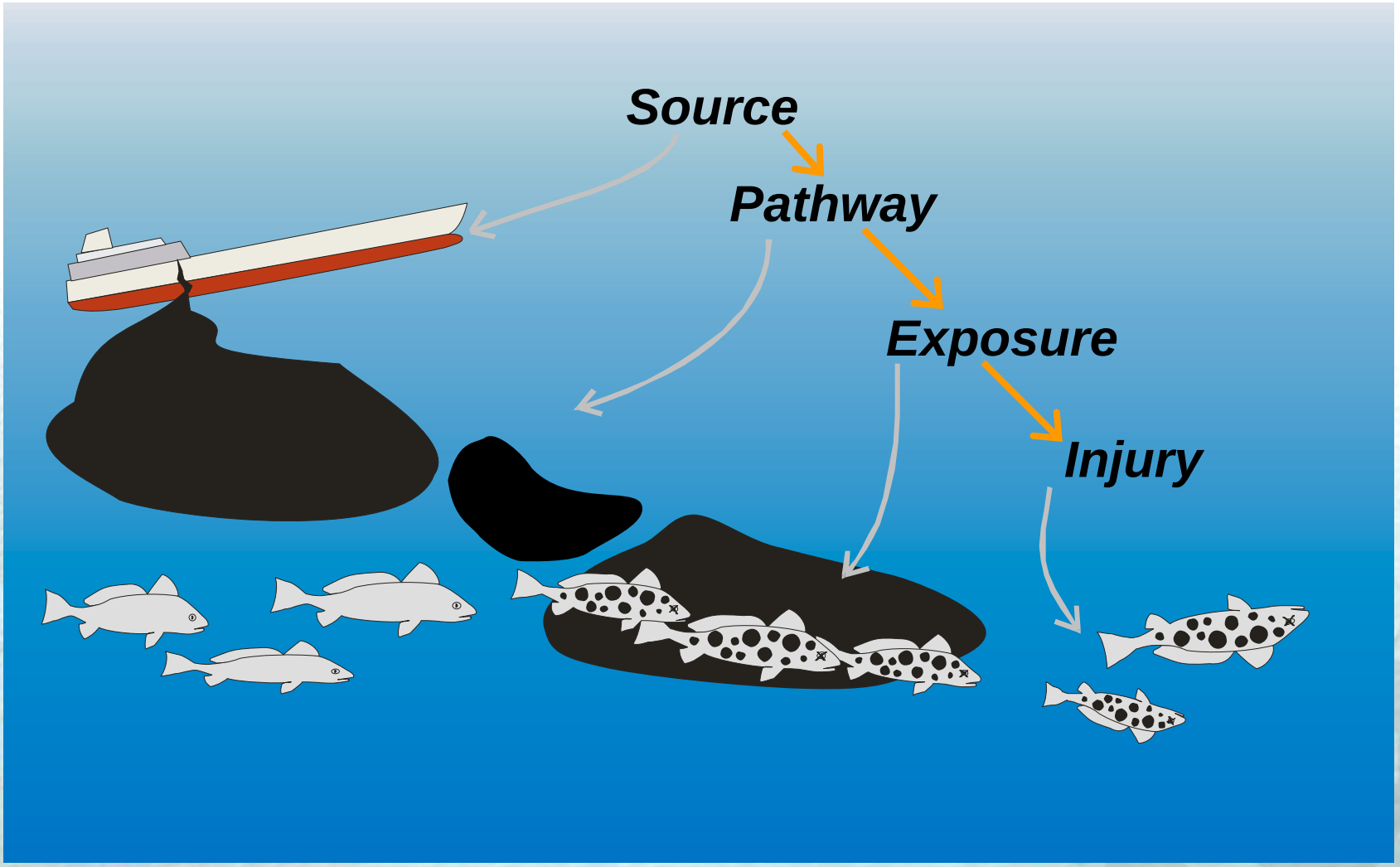
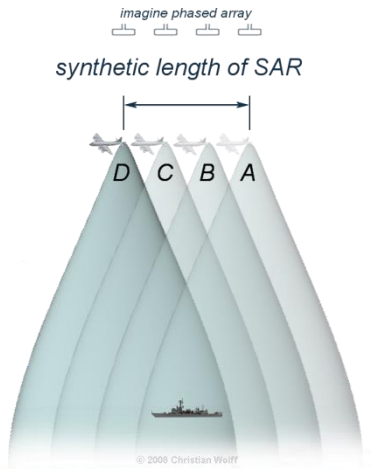


What is SAR?



- Synthetic Aperture Radar
- Flight path simulates large antenna
- Magnitude and phase of signal pulse
- Broad area coverage at high resolution
- Penetrates clouds, limited visibility conditions
- NOAA NESDIS uses SAR and a variety of other sensors for response
- NESDIS used many different SAR sensors during Deepwater Horizon

What do we use SAR for?

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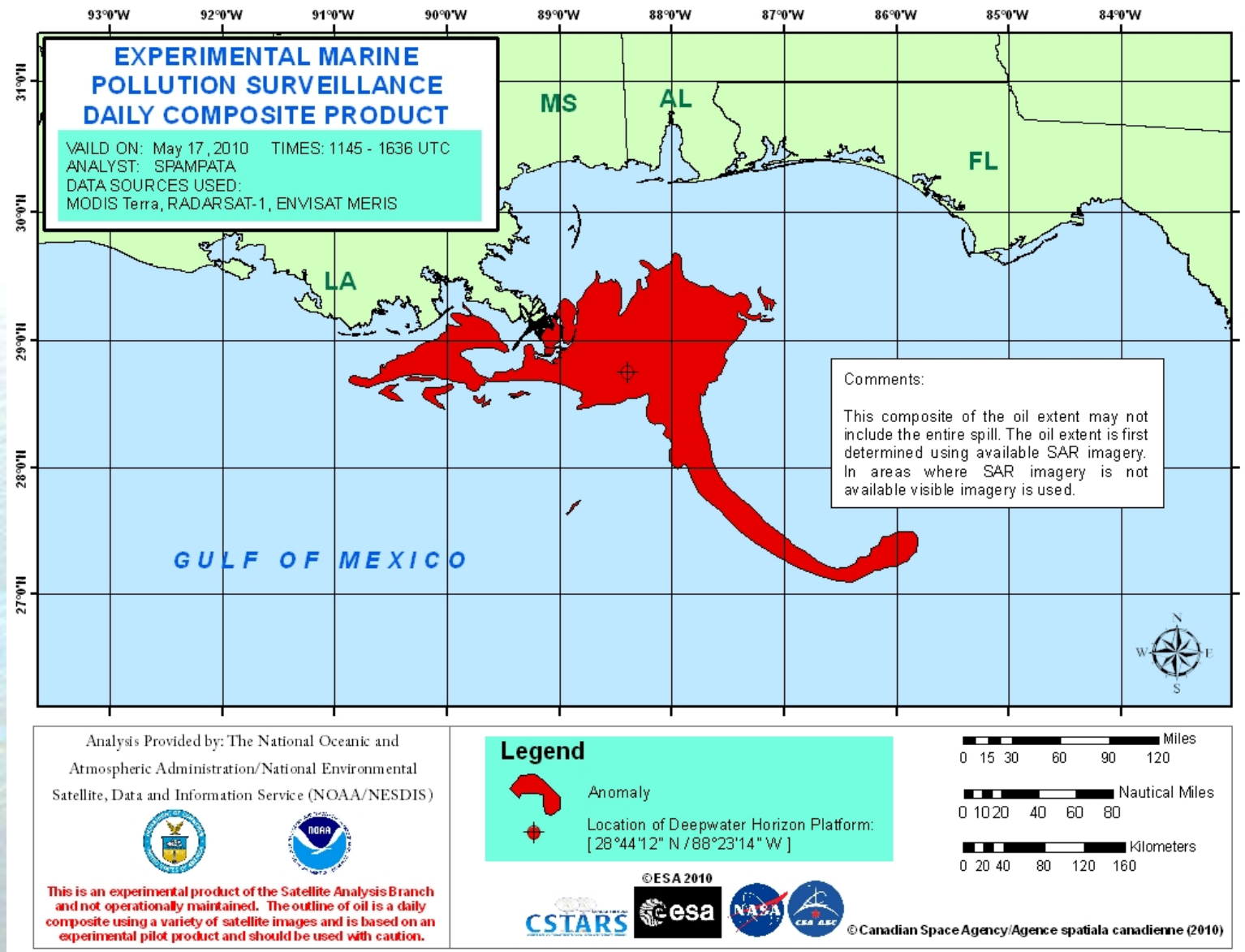
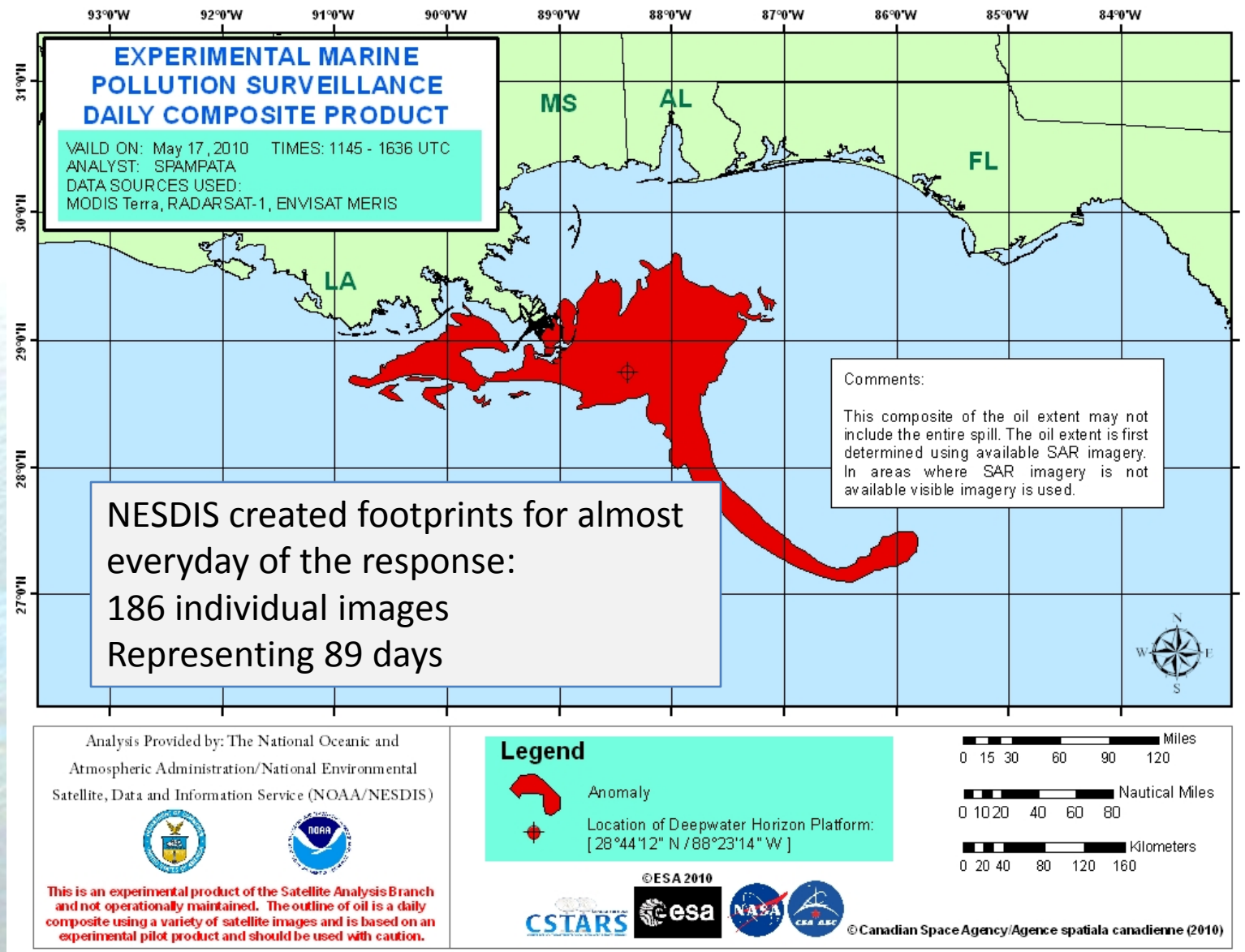
Damage Assessment Remediation & Restoration Program

- Analysis of SAR imagery are often used to identify ***surface anomalies***
- These anomalies are used to represent the predicted ***oiling extent***
- In Deepwater Horizon and many medium to large spills SAR imagery have been used to identify ***"actionable" oil***
- The NOAA NESDIS SAR data products were used as the ***search area*** for oil overflight observation for DWH
- These SAR footprints were also used as the ***initialization area*** for OR&R trajectory models
- We use SAR to identify and quantify areas of potential ***resource exposure***

NOAA NESDIS Experimental MPSR – Anomaly Footprint



NOAA NESDIS Experimental MPSR – Anomaly Footprint



SAR Oiling Extent Analysis

- SAR Anomaly Classification Methods
  - ***NESDIS SAR analysis*** (analyst specific, manual)
  - ***TCNNA algorithm*** (semi-automated)
- TCNNA (texture classifying neural network algorithm) developed jointly between NESDIS and FSU
- Methodology published in 2009

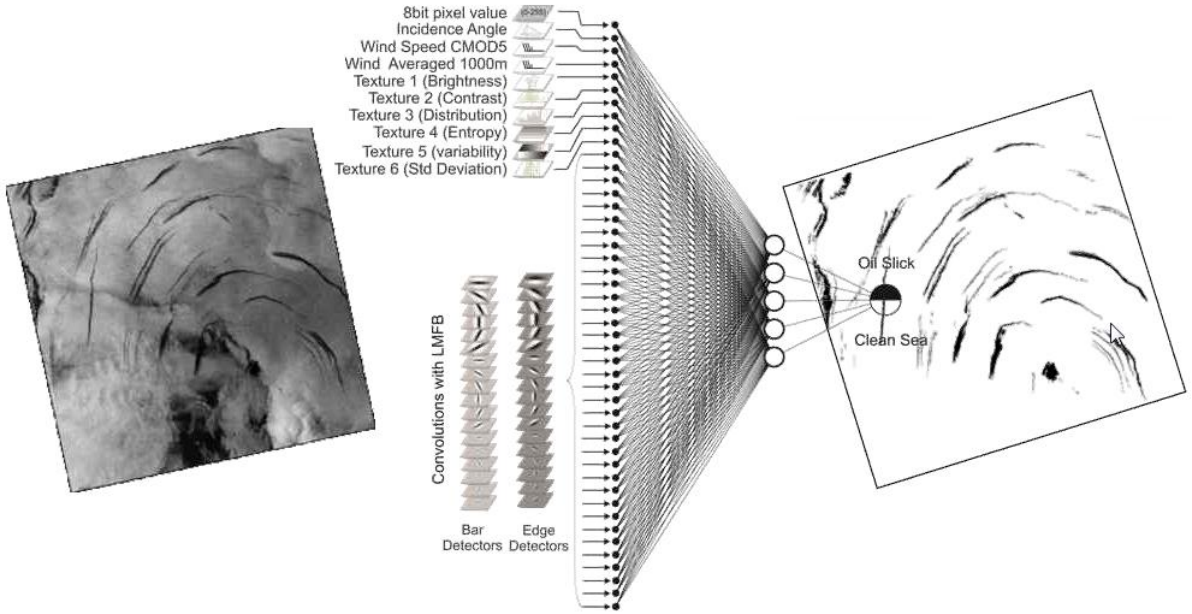
Can. J. Remote Sensing, Vol. 35, No. 5, pp. 411–421, 2009

Using SAR images to delineate ocean oil slicks with a texture-classifying neural network algorithm (TCNNA)[1]

Oscar Garcia-Pineda, Beate Zimmer, Matt Howard, William Pichel, Xiaofeng Li, and Ian R. MacDonald

Texture Classifying Neural Network – (TCNNA) SAR Oil Footprint

Texture Classifying Neural Network Algorithm
Garcia et al DSR-II 2010



File size ~100 Mbyte

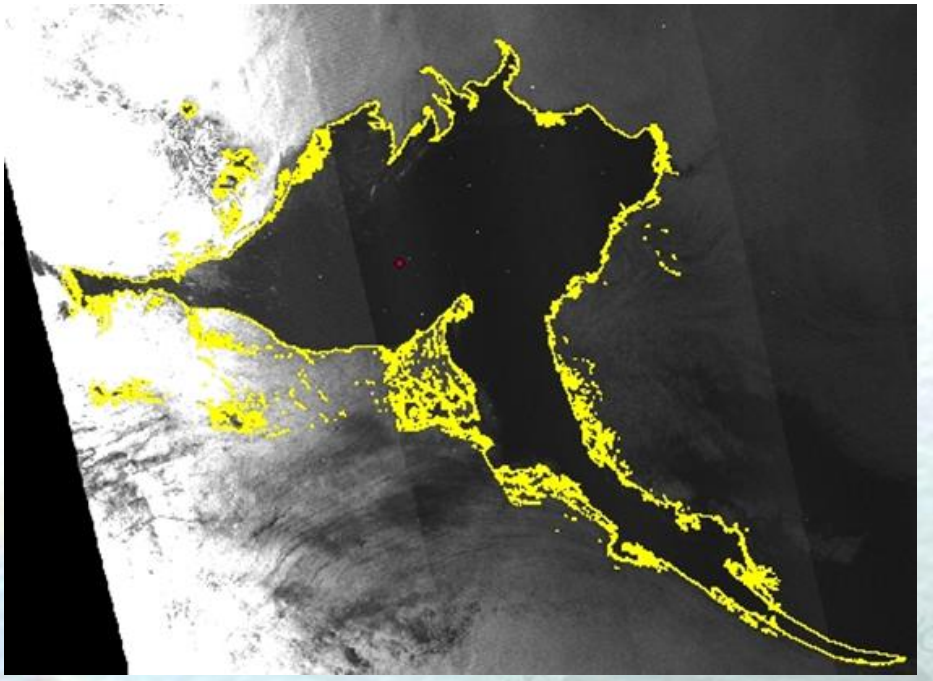
File size ~1 Mbyte

HYFLUX

Remote Sensing Inventory

SAR TCNNA Oiling Footprint

- Semi-automated process
- Detailed examination of environmental conditions
- Use data to map low wind features, false positives
- Help eliminate subjectivity of individual analyst
- Expedite delivery
- Oil not anomaly



SAR TCNNA Products

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- SAR Products and Model Builder
  - Daily Composites
  - Cumulative Composite
  - Cumulative Days of Oiling
  - Shoreline Days of Oiling
  - Time of Oiling

SAR TCNNA Tools

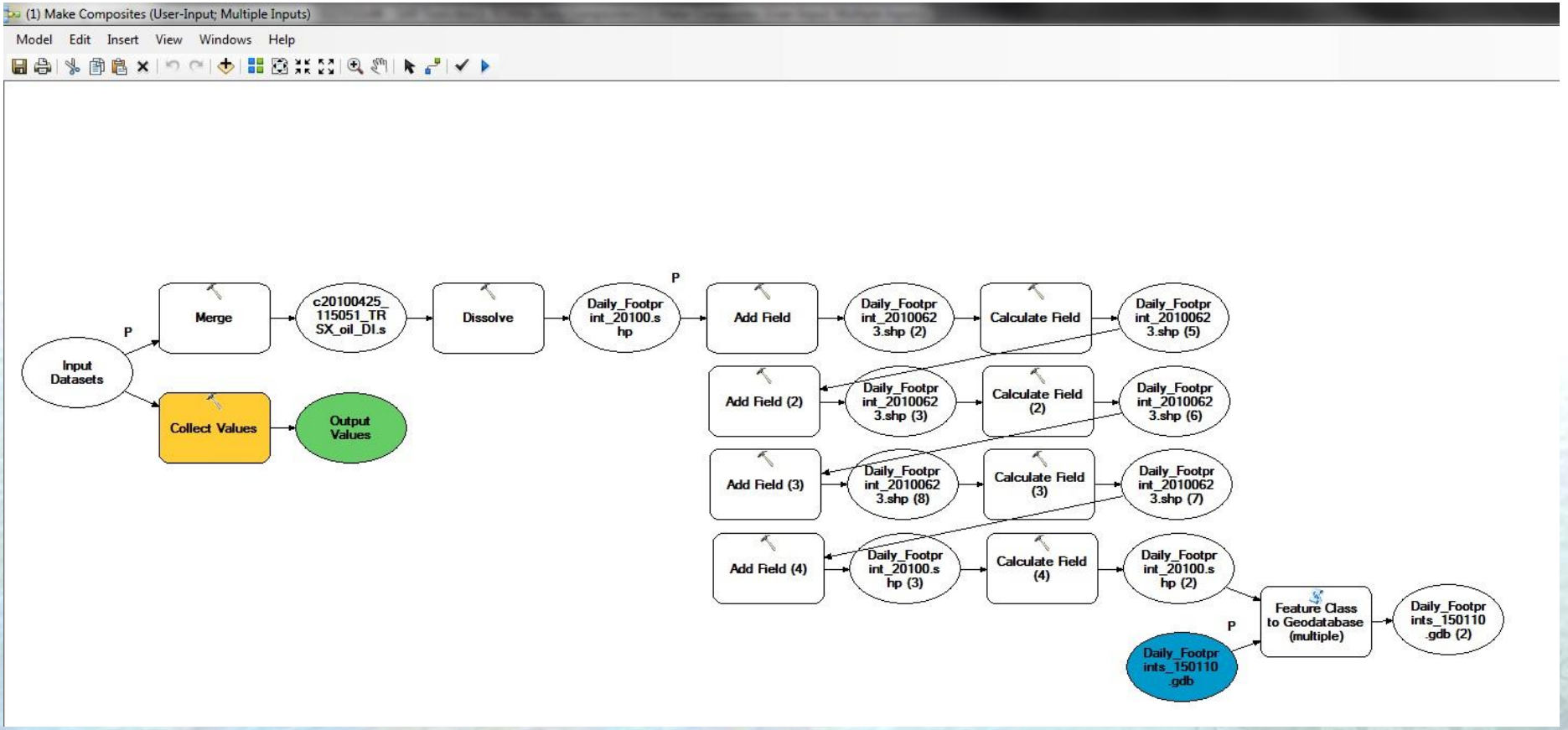
Damage Assessment Remediation & Restoration Program

Process required preparation for multiple interations of data and reprocessing these large complex datasets multiple times….

ArcGIS Model Builder **OoW – SAR Tools.tbx**

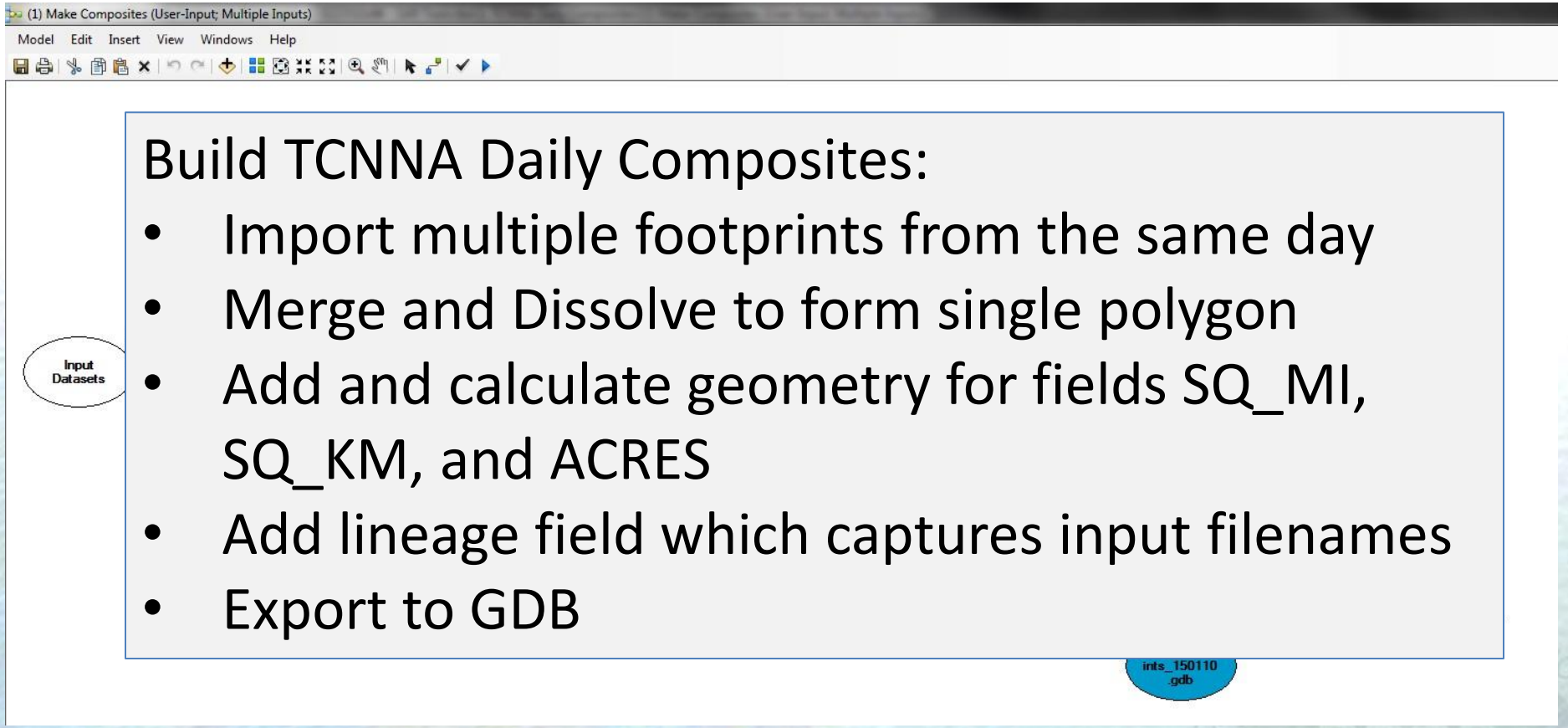
In-line Ref.	Model Name	Toolset Application
1A	(1) Make Composites (Single/Multiple)	1. TCNNA Daily Comp.
1B	(2) Add Date Fields	1. TCNNA Daily Comp.
1C	(3) Add ‘Day’ Count Field	1. TCNNA Daily Comp.
2A	(1) Add Julian Date to Daily Composites	2. TCNNA Shoreline Int.
2B	(2) Add Julian Date to Shoreline	2. TCNNA Shoreline Int.
2C	(3) Calculate Intersections	2. TCNNA Shoreline Int.
3A	(1) Convert Daily Footprints to Rasters	3. TCNNA Days of Oiling

SAR – Daily Composites



SAR – Daily Composites

Damage Assessment Remediation & Restoration Program



Build TCNNA Daily Composites:

- Import multiple footprints from the same day
- Merge and Dissolve to form single polygon
- Add and calculate geometry for fields SQ_MI, SQ_KM, and ACRES
- Add lineage field which captures input filenames
- Export to GDB

SAR TCNNA Shoreline Analysis Products
Daily Composite/Cumulative Composite

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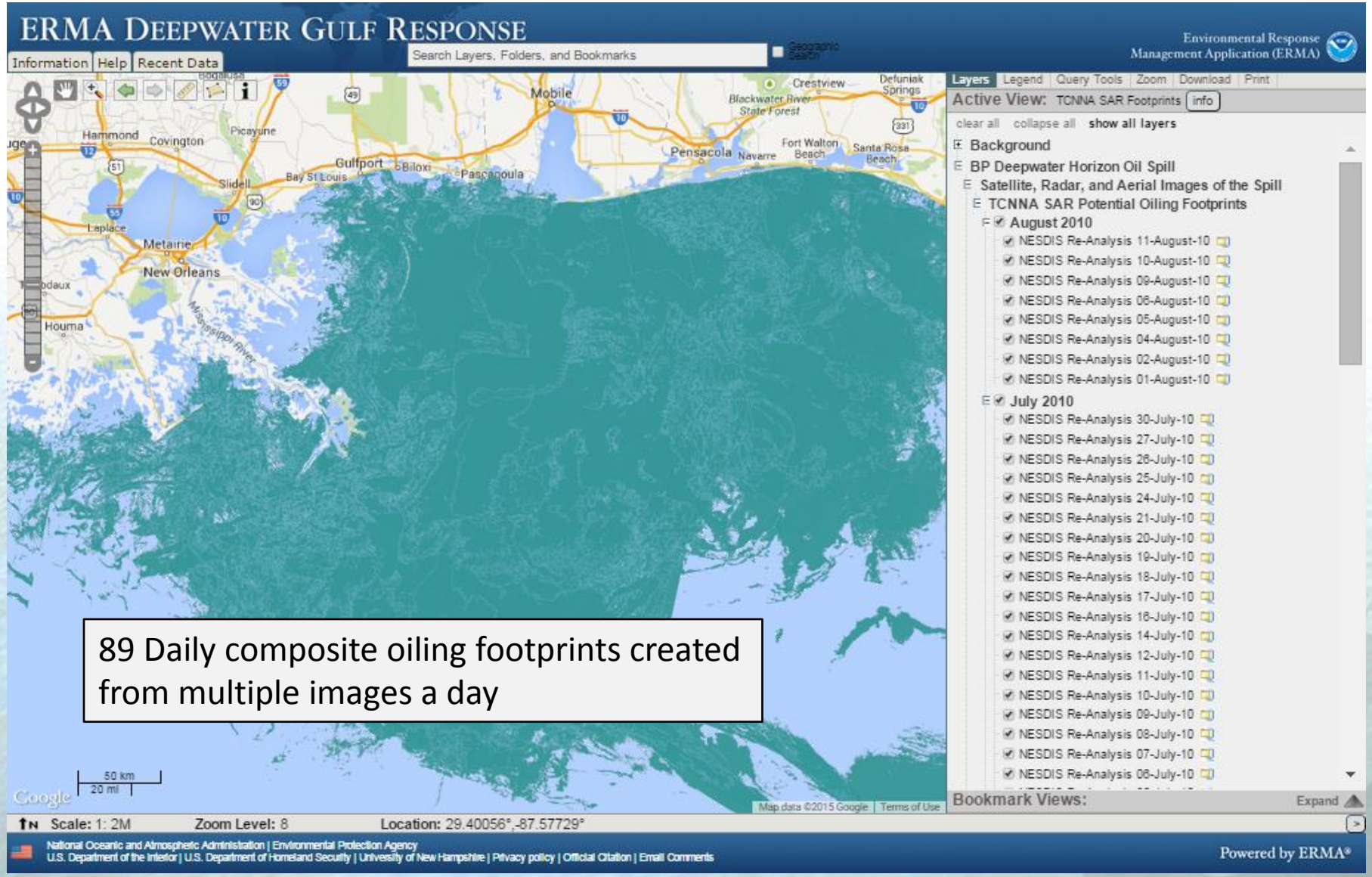

89 Daily composite oiling footprints created from multiple images a day

Cumulative SAR TCNNA Footprint

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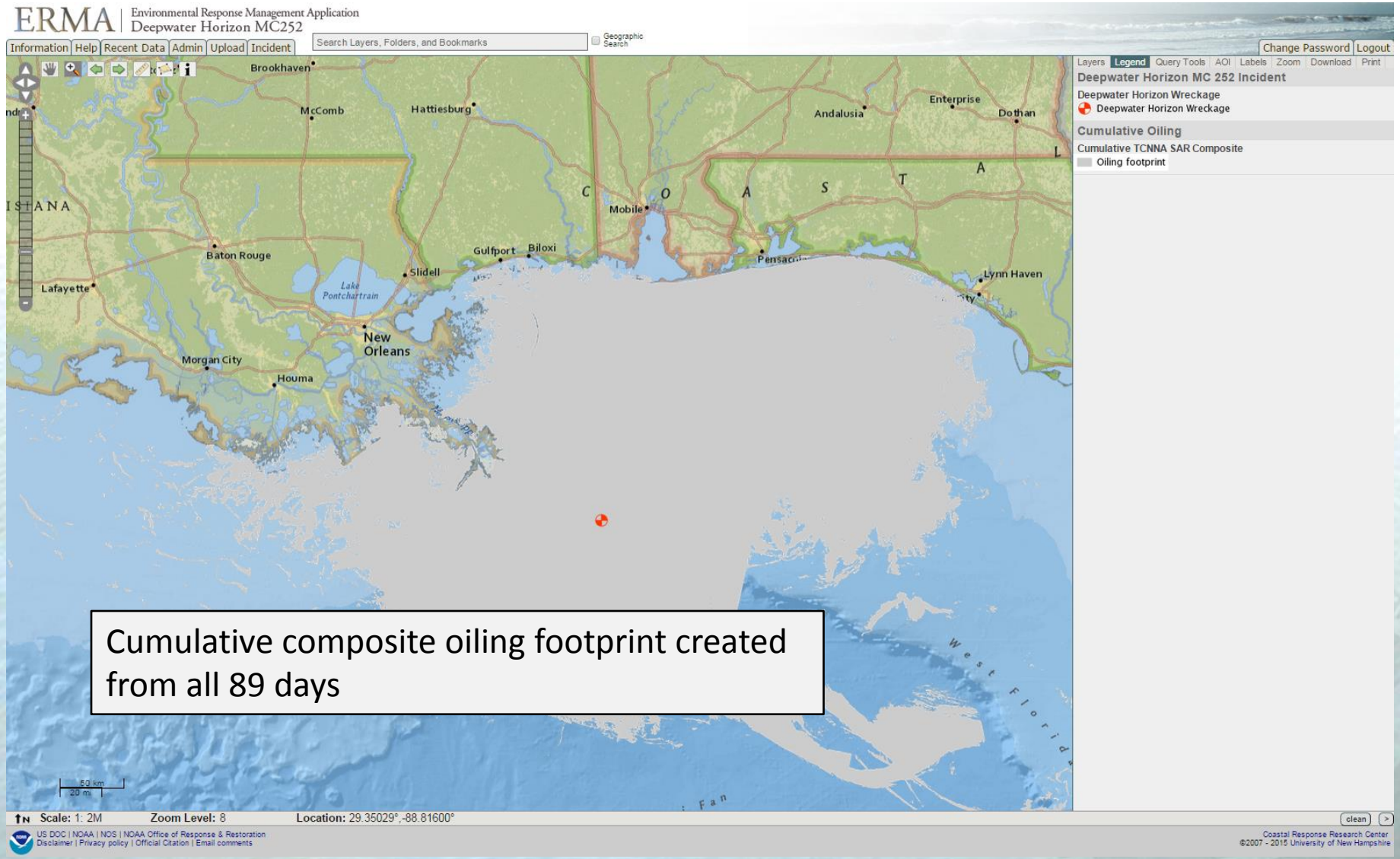
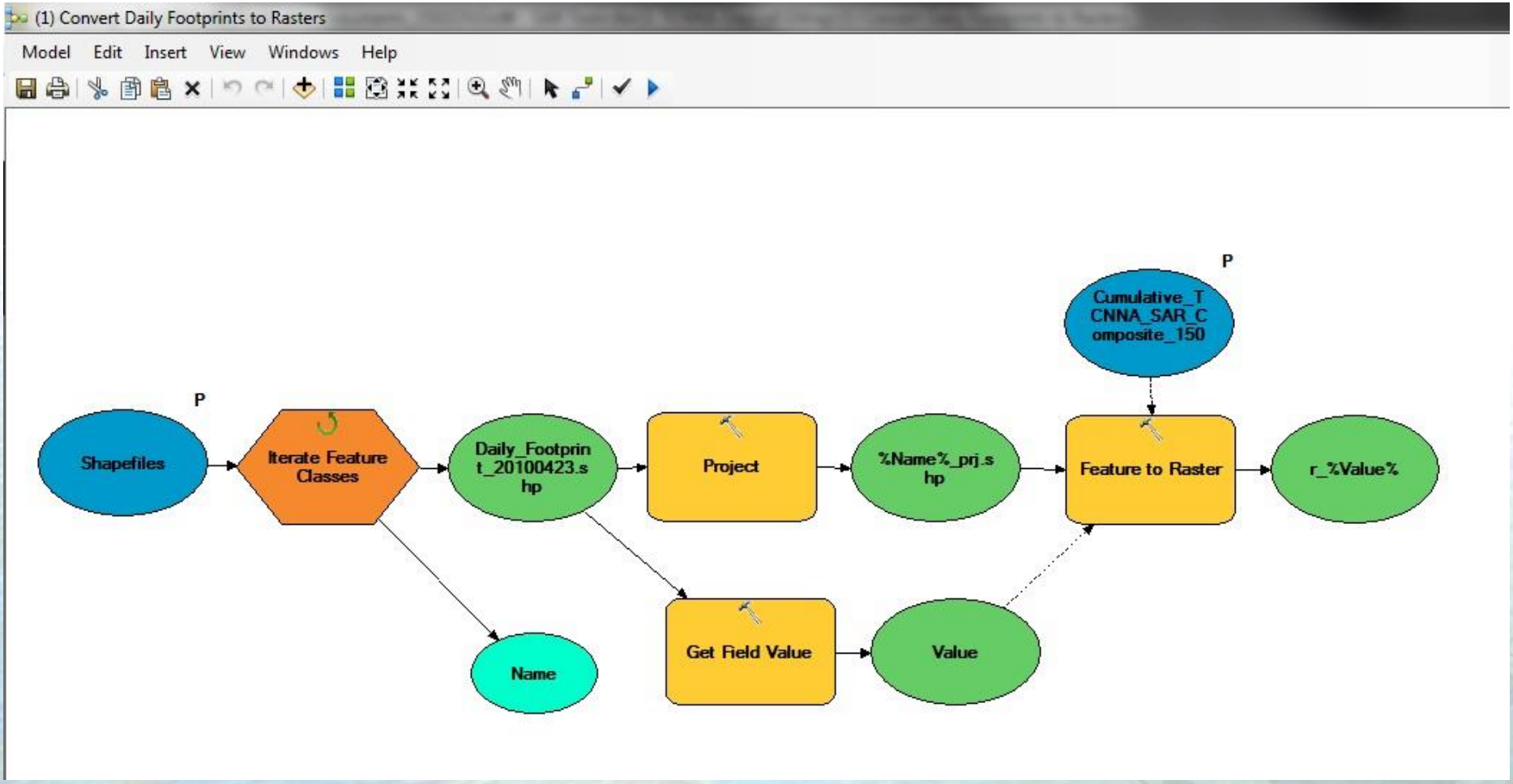
Damage Assessment Remediation & Restoration Program



Cumulative composite oiling footprint created from all 89 days

SAR – Days of Oiling



SAR – Days of Oiling

Days of Oiling - Convert to Raster

- Iterate across TCNNA Daily Composites
- Re-project data
- Convert Daily Composite to Raster using Cumulative Composite as extent
- Tally days of oil
- Create binned geotif

SAR TCNNA Shoreline Analysis Products
Days of Oiling

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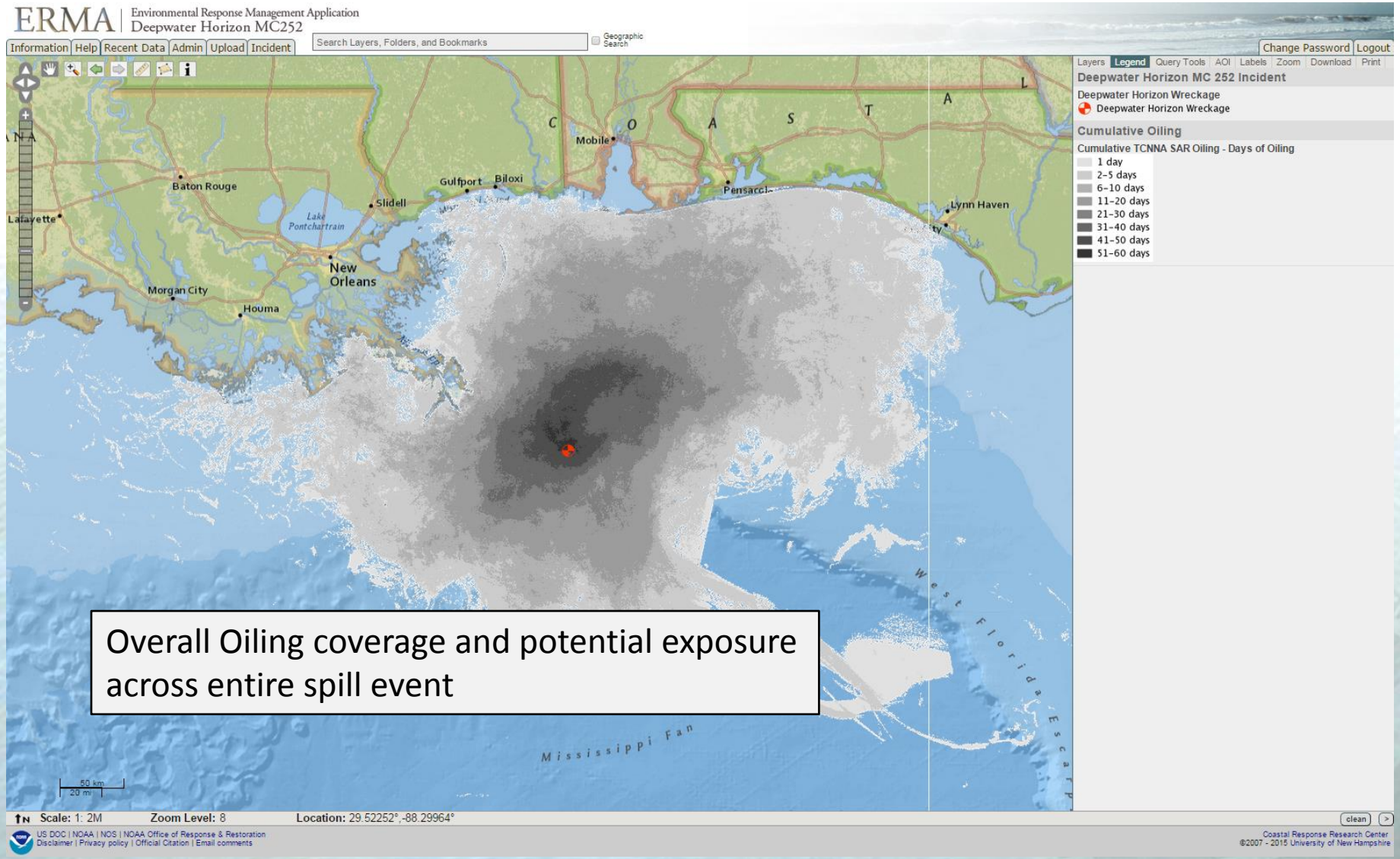
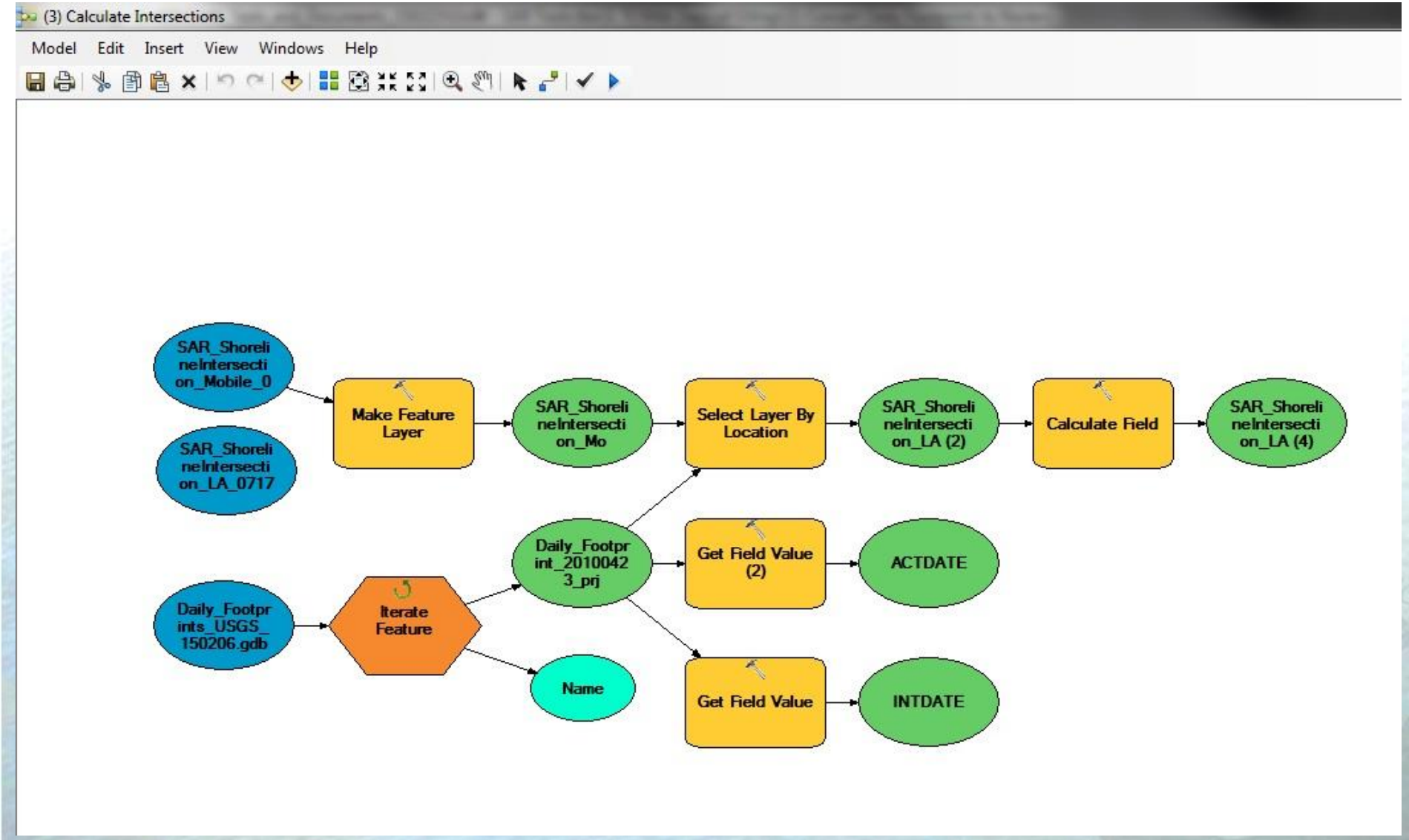


Overall Oiling coverage and potential exposure across entire spill event

SAR – Shoreline Intersections



SAR – Shoreline Intersections

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Calculate TCNNA Daily Shoreline Intersections:

- Iterate across TCNNA Daily Composites
- Select shoreline segments <=3km from a given Daily Composite
- Calculate the appropriate date field with the day being assessed
- Create Days of shoreline oiling

SAR TCNNA Shoreline Analysis Products
Days of Shoreline Oiling

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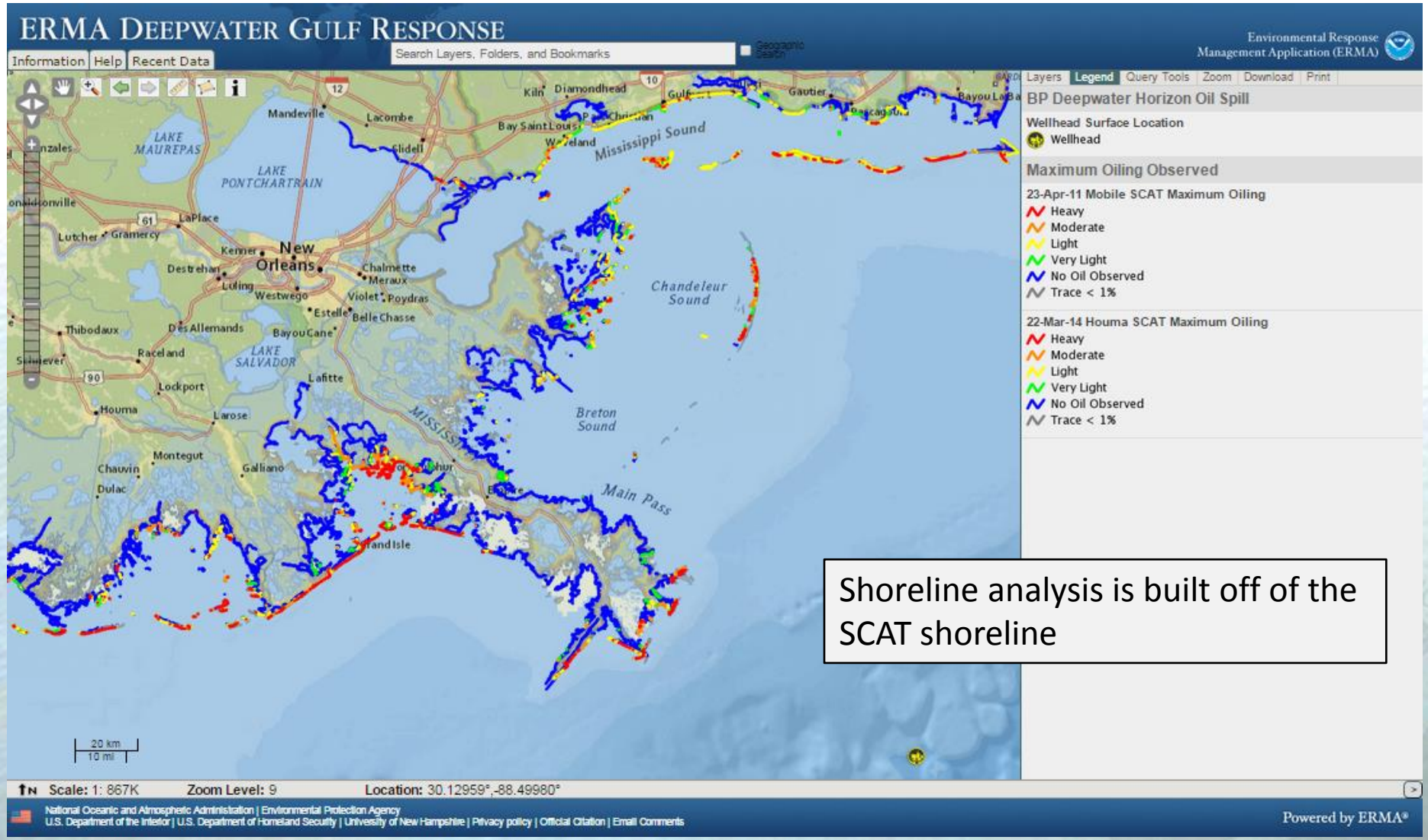

Shoreline analysis is built off of the SCAT shoreline

SAR TCNNA Shoreline Analysis Products
Days of Shoreline Oiling

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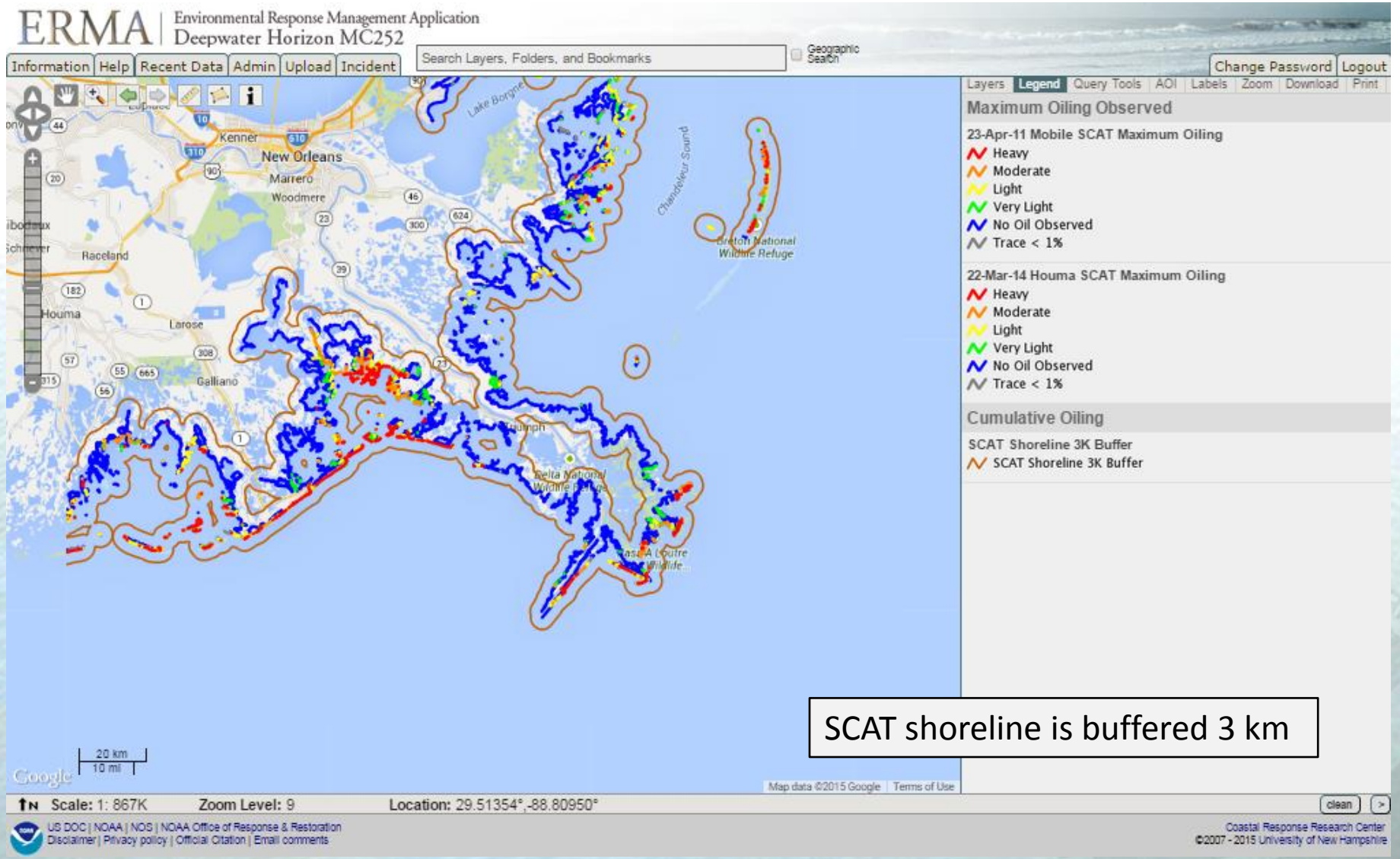

SCAT shoreline is buffered 3 km

SAR TCNNA Shoreline Analysis Products
Days of Shoreline Oiling

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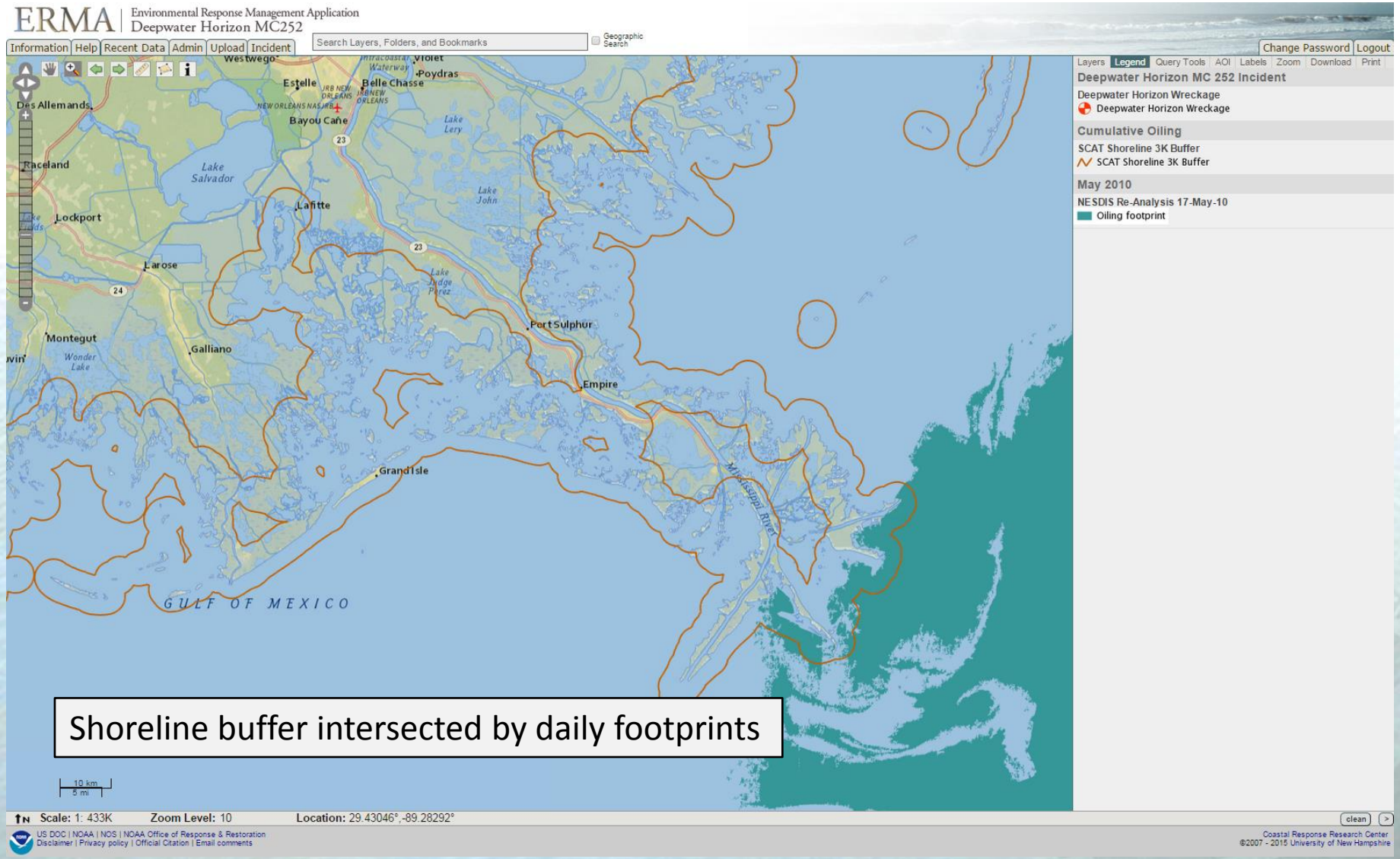

Shoreline buffer intersected by daily footprints

SAR TCNNA Shoreline Analysis Products
Days of Shoreline Oiling

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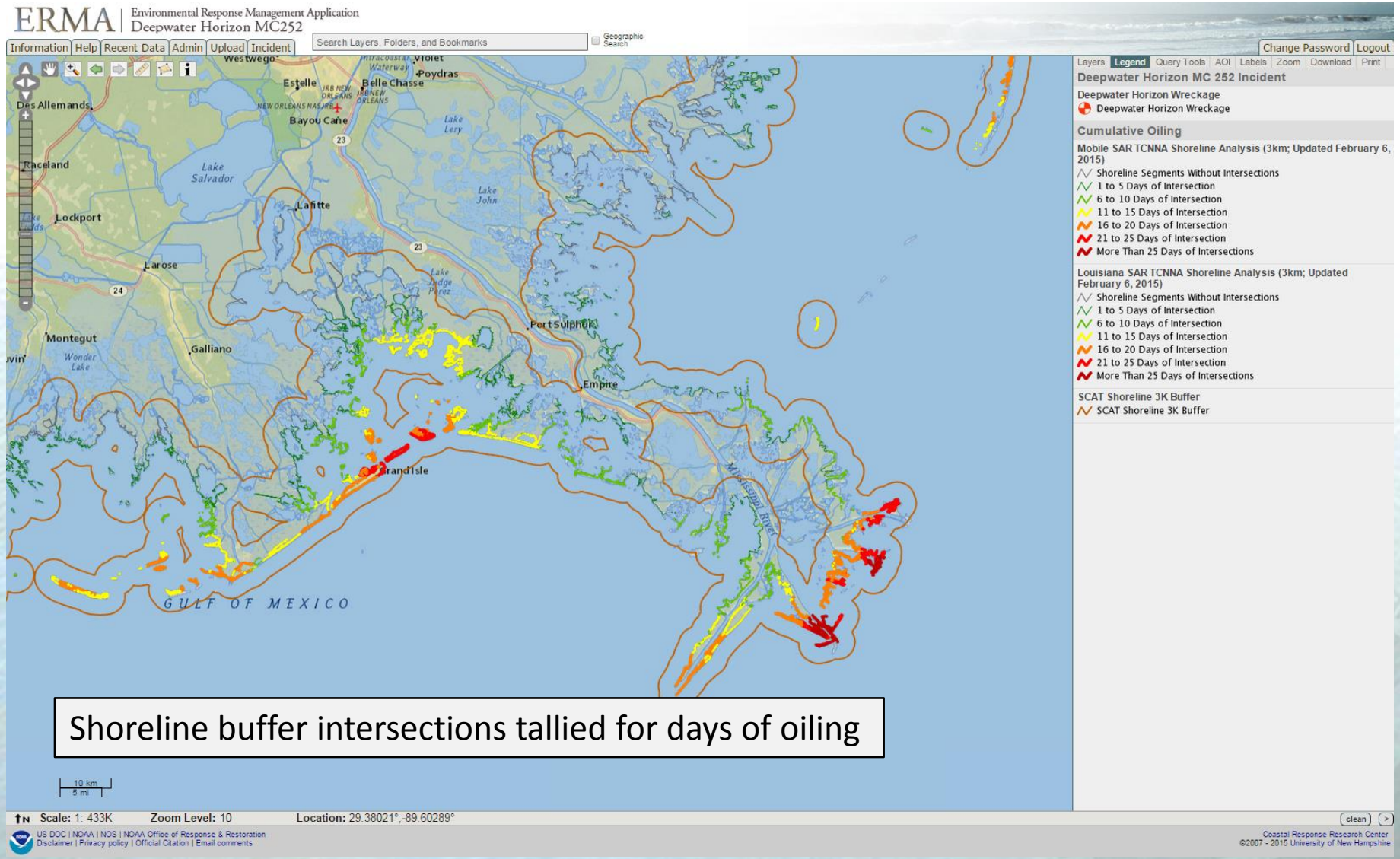

Shoreline buffer intersections tallied for days of oiling

SAR TCNNA Shoreline Analysis Products
Days of Shoreline Oiling

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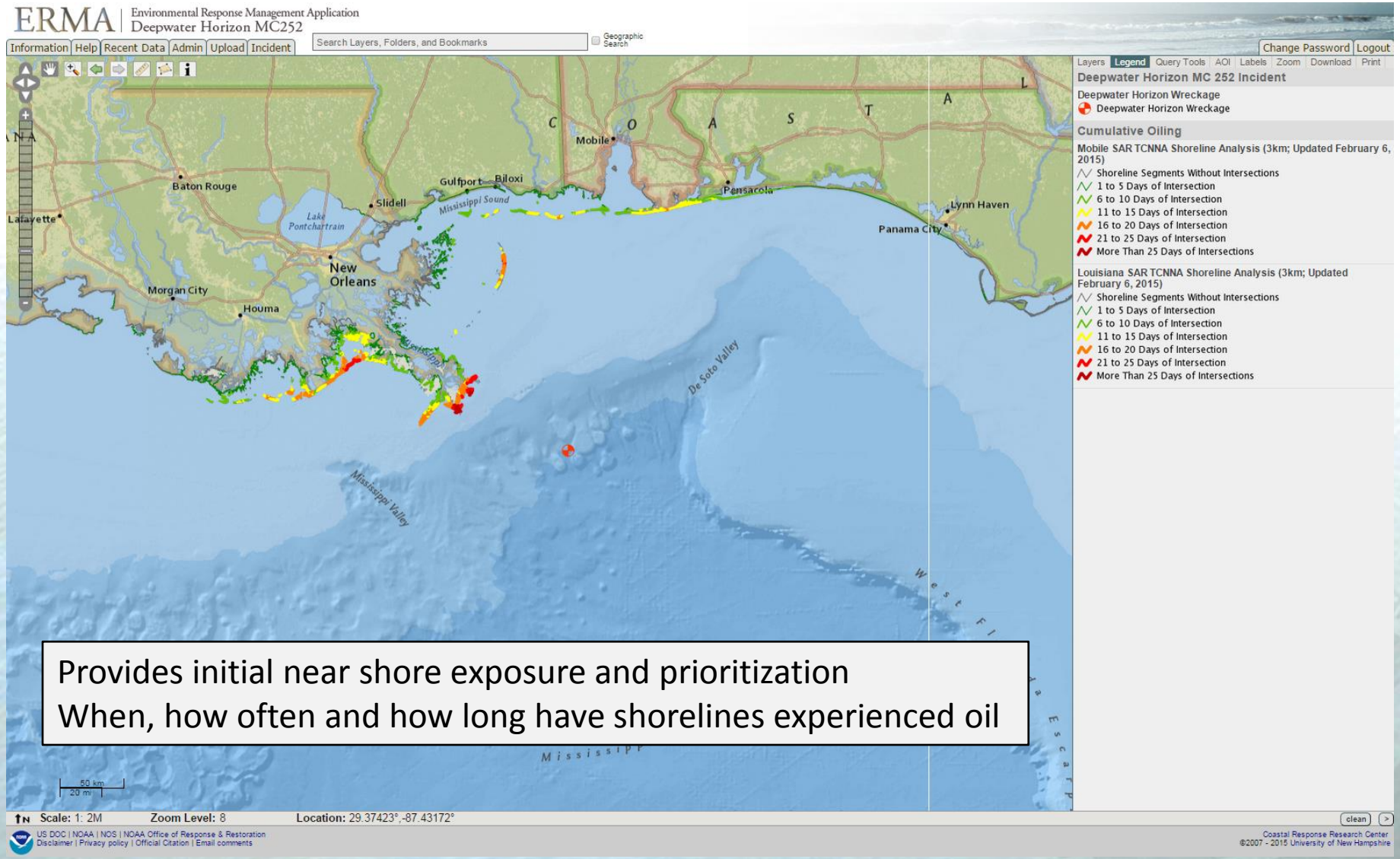

Provides initial near shore exposure and prioritization
When, how often and how long have shorelines experienced oil

SAR TCNNA SAR Analysis Products
Time of Oiling

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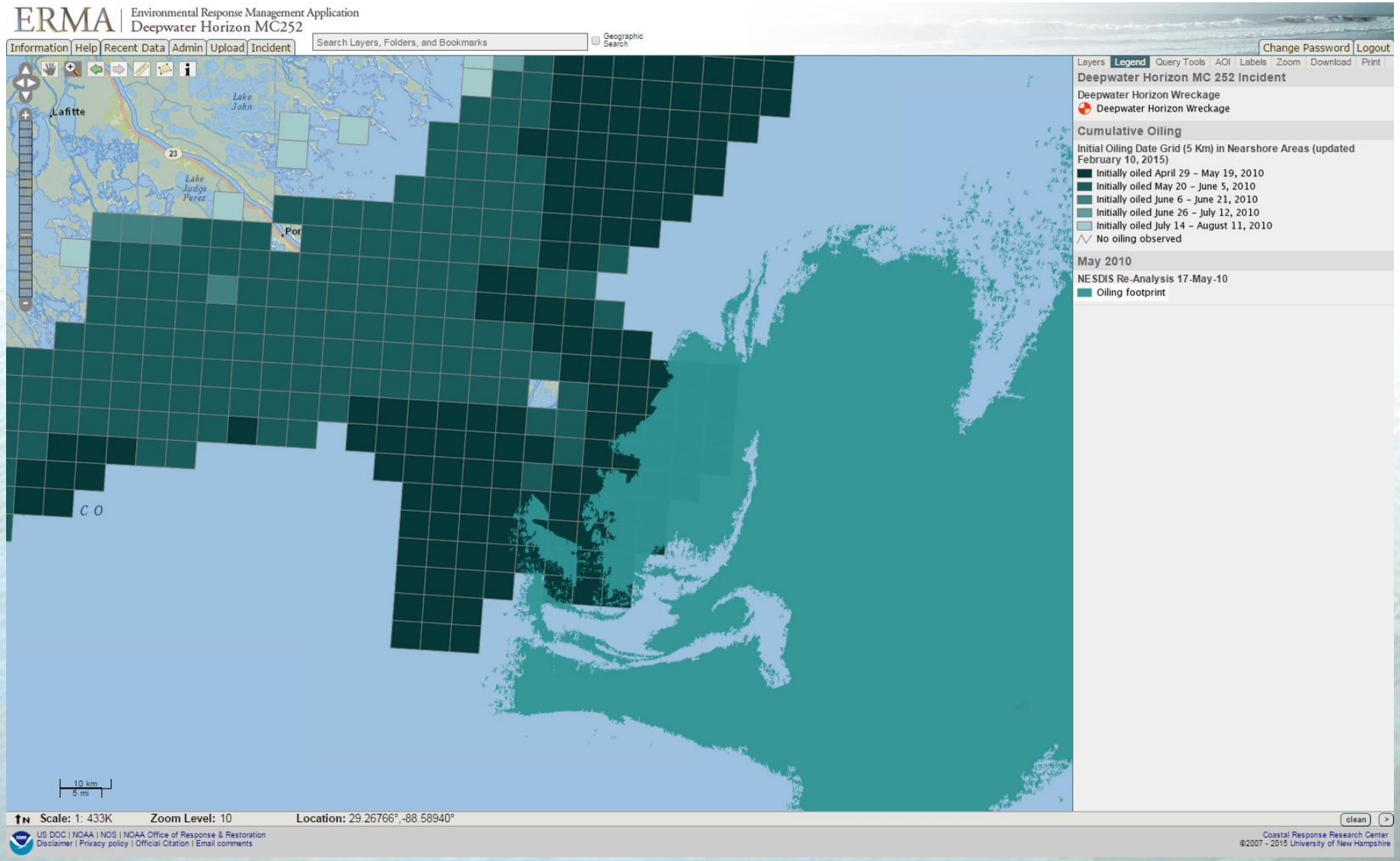

SAR TCNNA SAR Analysis Products
Time of Oiling

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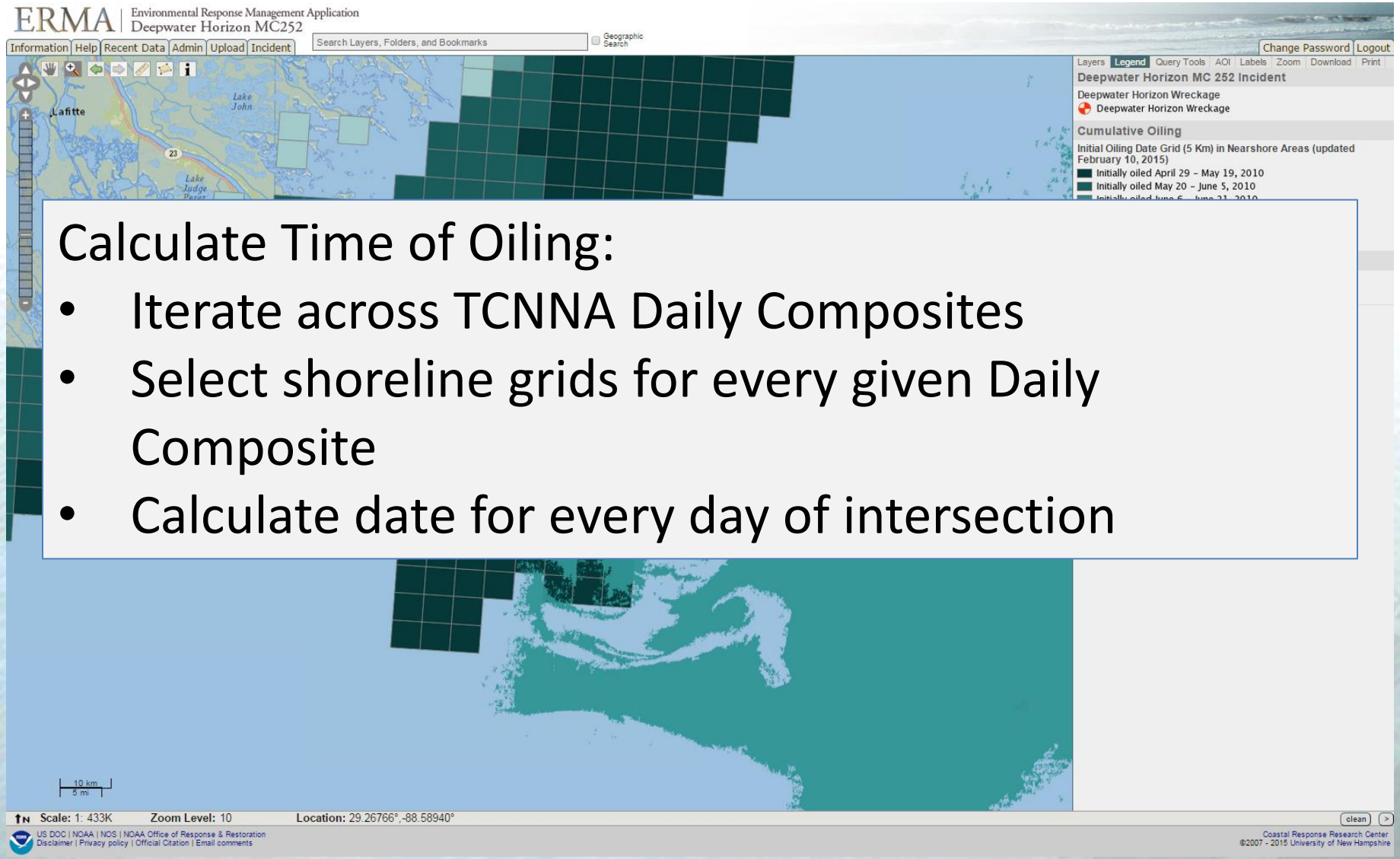

Calculate Time of Oiling:

- Iterate across TCNNA Daily Composites
- Select shoreline grids for every given Daily Composite
- Calculate date for every day of intersection

SAR TCNNA SAR Analysis Products
Time of Oiling

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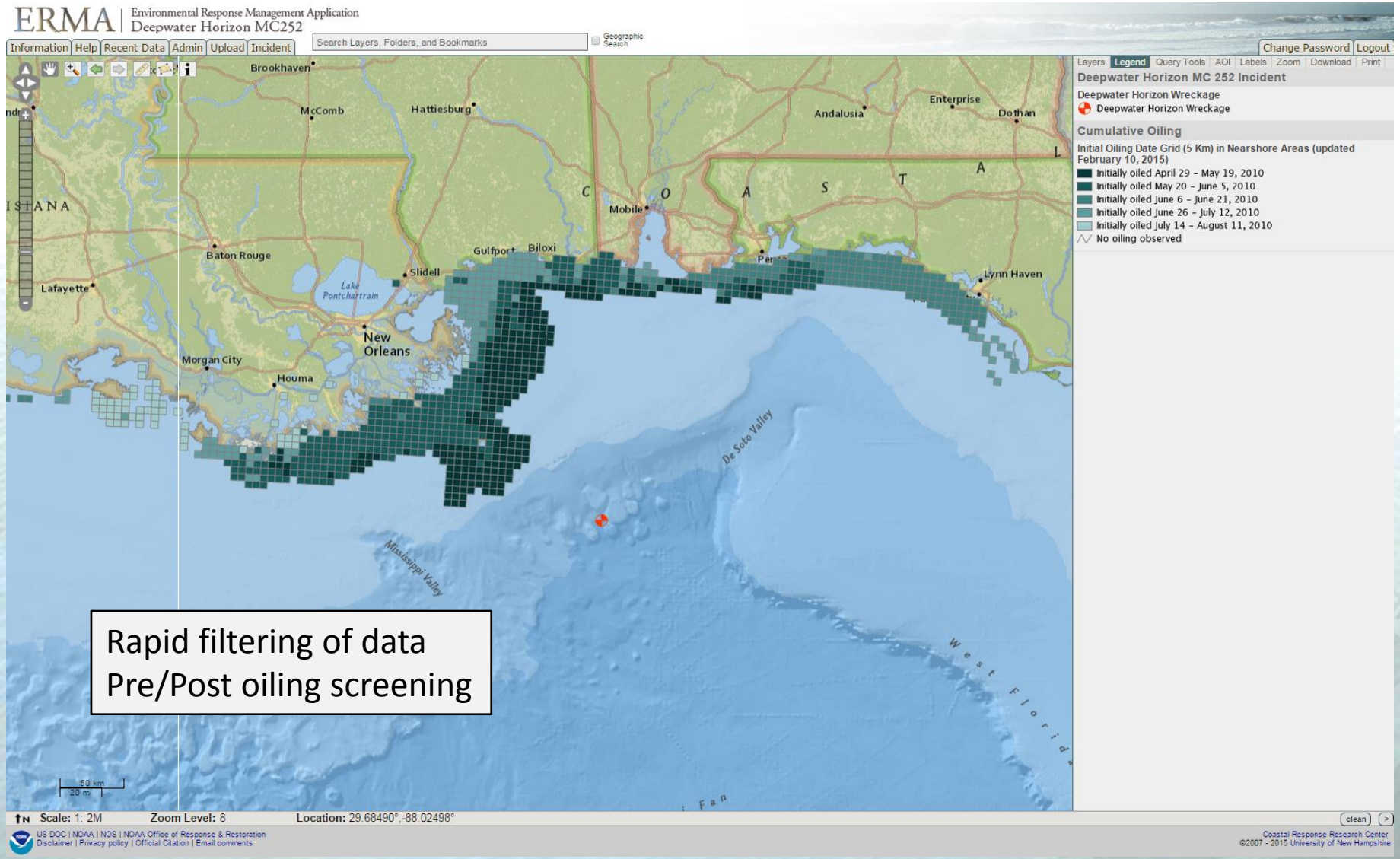

Rapid filtering of data
Pre/Post oiling screening

SAR use in NRDA

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- Data provide tools for filtering and focusing allowing prioritization
- SAR data provide an effective screening tool
- Allows us to focus assessment efforts to habitats and species assemblages at the greatest risk of exposure

SAR and NRDA

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- SAR data allow us to look at overall extent and duration of potential exposure
- Open water and shoreline conditions are informed by SAR analysis
- Satellite analysis supplements in situ observations and sampling
- SAR data are a useful as an indication of exposure, but not injury

SAR and Future Assessments

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- Unmanned Aerial Systems (UAS) are beginning to support the use of traditional satellite sensors such as IR, Thermal and Radar
- New technology in SAR technology provides real promise for enhanced response and damage assessment
- SAR and other remote sensing resources will be part of future assessments

Thank-you!

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Questions?