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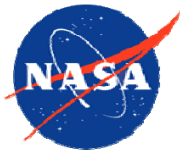

Use of Multi-Year MODIS Phenological Data Products to Detect and Monitor Forest Disturbances at Regional and National Scales

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Project Background

- This presentation discusses an effort to use select MODIS phenological products for forest disturbance monitoring at the regional and CONUS scales
- Forests occur on ~1/3 of the U.S. land base and include regionally prevalent forest disturbances that can threaten forest sustainability
- Regional and CONUS forest disturbance monitoring is needed for a national forest threat early warning system being developed by the USDA Forest Service with help from NASA, ORNL, and USGS
- MODIS NDVI phenology products are being used to develop forest disturbance monitoring capabilities of this EWS

Which Phenology Products?

- The project employs several MODIS phenology products
  - Phenological state products that record NDVI magnitude and Day of Year (DOY) for multiple phenological states
  - Cumulative integral NDVI products (22 per year)
  - Other NDVI integral products for the growing season
- With phenological state products, baselines can be normalized for a given phenological parameter, instead of fixed sampling time frame (e.g., June 10 – July 27)
- MODIS phenology products can be used to compute multiple disturbance monitoring products
  - Current NDVI or DOY versus baseline RGB visualization products
  - % Change in NDVI or DOY for given phenological state
  - Classification products based on unsupervised clustering

Goal and Objectives

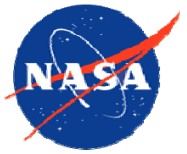
- Goal - Assess use of multi-year MODIS MOD13 NDVI-based phenology products for detecting forest disturbances evident at regional and CONUS scales
- Objective 1 – Assess phenological state products (e.g., NDVI magnitude and Day of Year) for developing useful forest disturbance detection products
- Objective 2 – Assess cumulative NDVI integral products for developing useful forest disturbance detection products

Focus of this presentation

Phenological Product Development Background

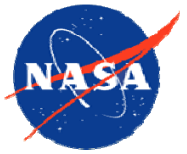
- Project employs MODIS phenological parameter products from C5 MOD13 NDVI 16-day 250 m time series data
  - 2003–2008 NDVI time series products were computed using Time Series Product Tool software in conjunction with MODIS Aqua and Terra products
  - Phenological state and cumulative integral NDVI products were computed using the Phenological Parameter Estimation Tool software

Method for Computing Baseline Products



- NDVI magnitude products
  - A maximum NDVI baseline was computed for each phenological state for the 2003–2008 period
- DOY products
  - A median DOY baseline was computed for each phenological state for the 2003–2008 period
- Cumulative integral NDVI products
  - A maximum cumulative integral NDVI baseline was computed for each cumulative integral across the calendar year

Evaluation Methods



- Assess phenological state products with respect to reference data on known disturbances
- Assess quality of products in terms of completeness and noise artifacts
- Assess products compared to higher resolution satellite and aerial data
- Assess products for potential in near real time applications

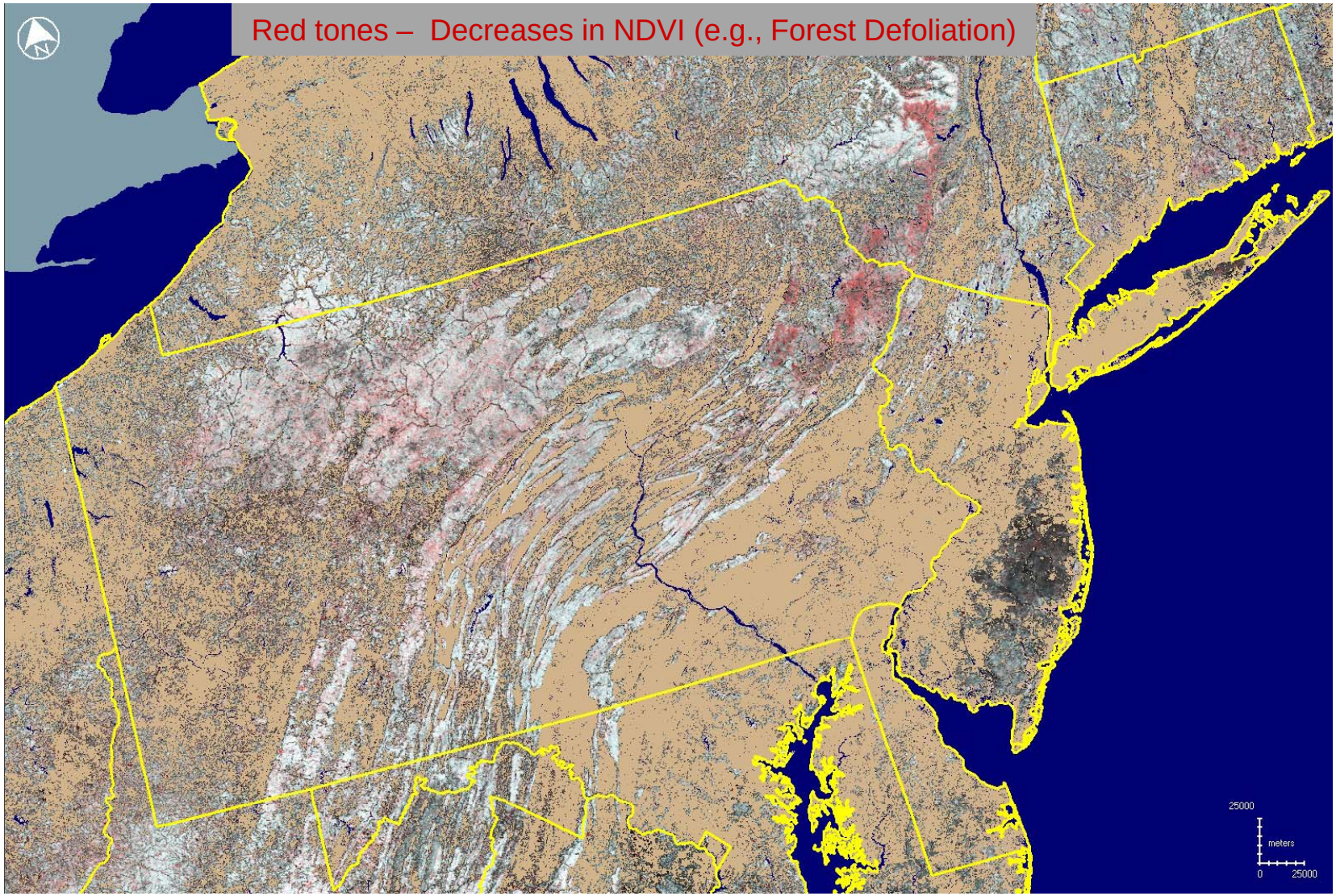
Example Multi-Year NDVI Magnitude Products for Select Phenological States

Application: Ephemeral Forest Defoliation 2005–2008

2005 Forest Defoliation from MODIS Peak Growing Season NDVI

Stennis Space Center

RGB = Baseline Peak NDVI in Red; 2005 Peak NDVI in Blue and Green



2006 Forest Defoliation from MODIS Peak Growing Season NDVI

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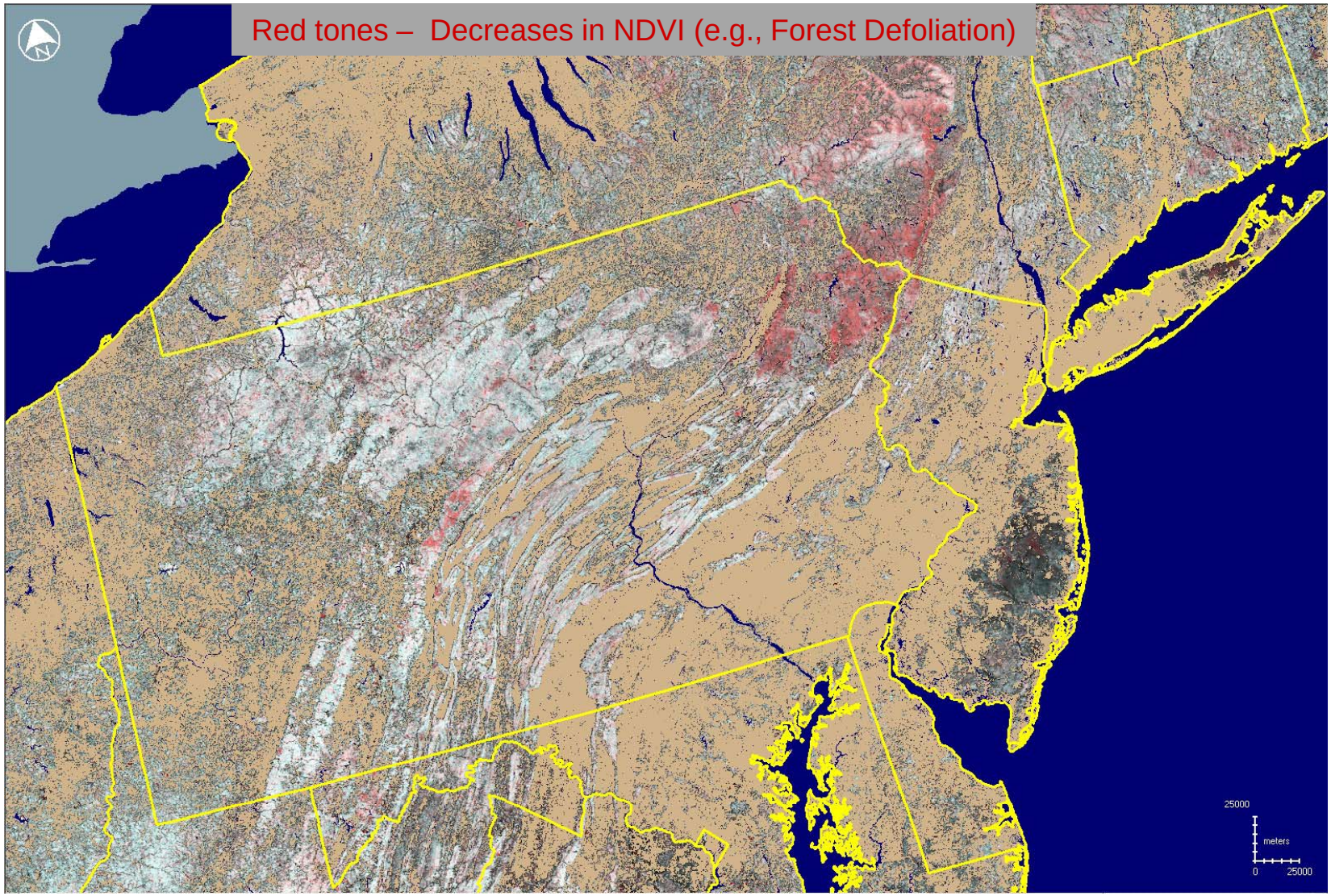
RGB = Baseline Peak NDVI in Red; 2006 Peak NDVI in Blue and Green



2007 Forest Defoliation from MODIS Peak Growing Season NDVI

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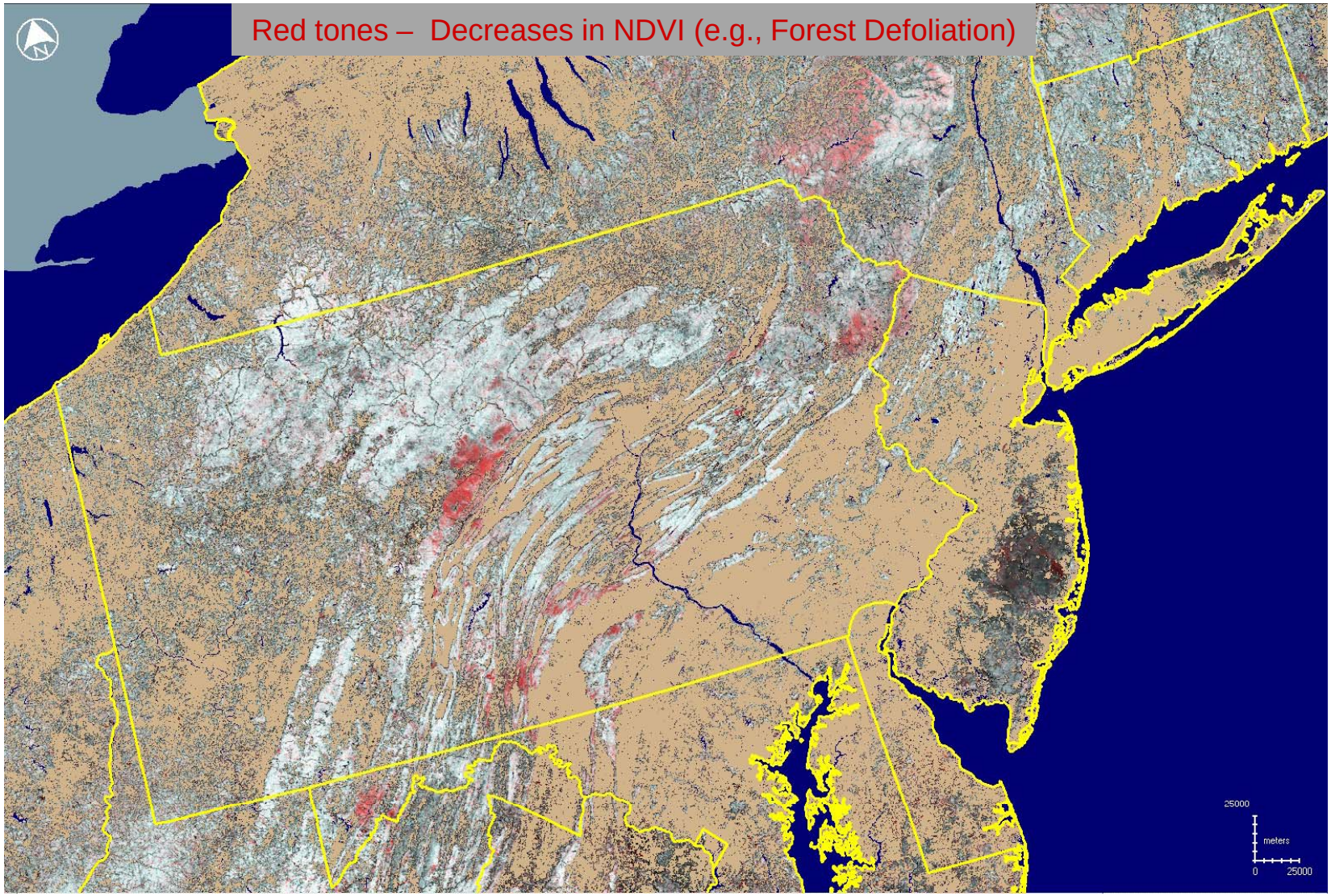
RGB = Baseline Peak NDVI in Red; 2007 Peak NDVI in Blue and Green



2008 Forest Defoliation from MODIS Peak Growing Season NDVI

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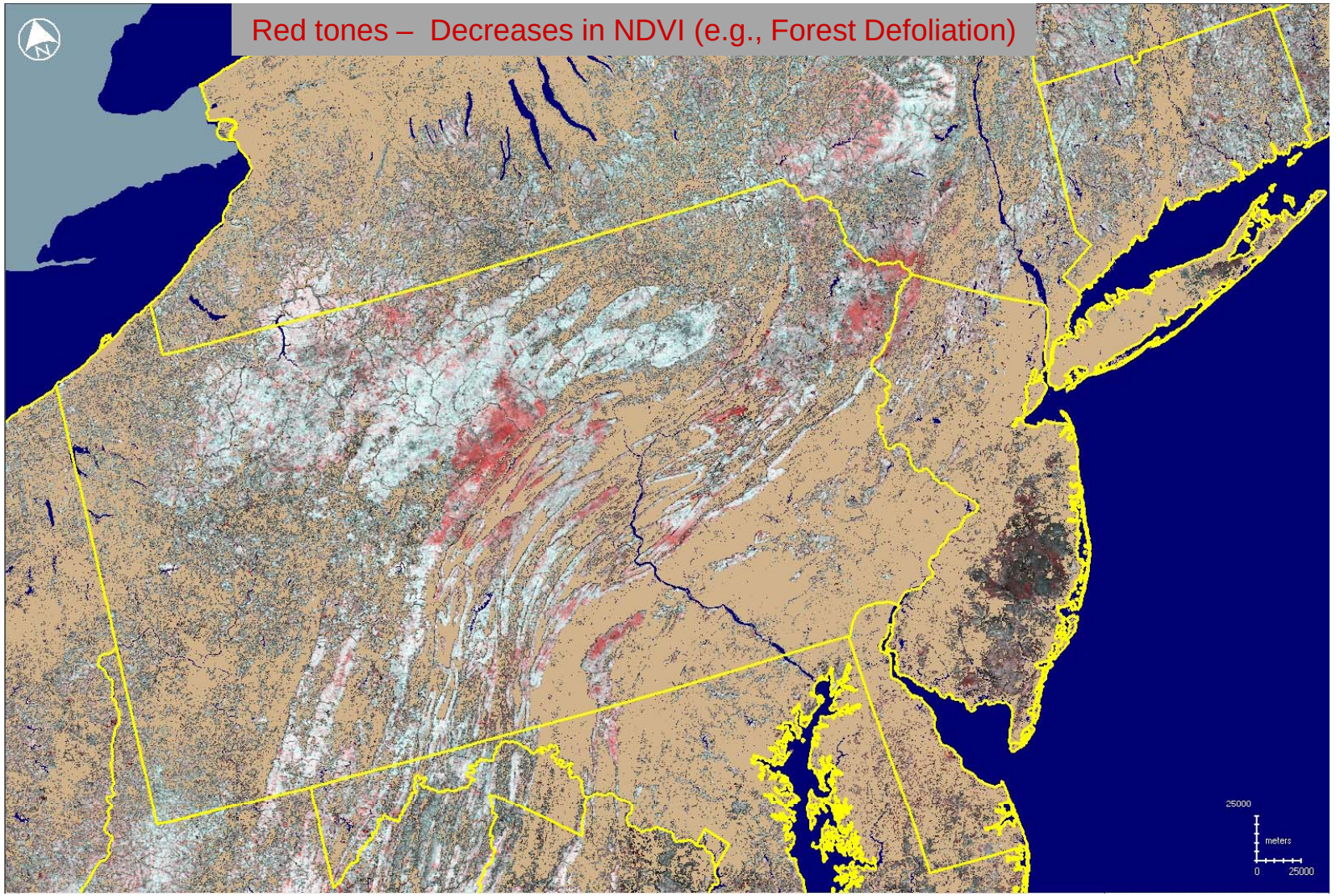
RGB = Baseline Peak NDVI in Red; 2008 Peak NDVI in Blue and Green



2008 USDA Forest Service Defoliation Sketch Maps versus MODIS Product

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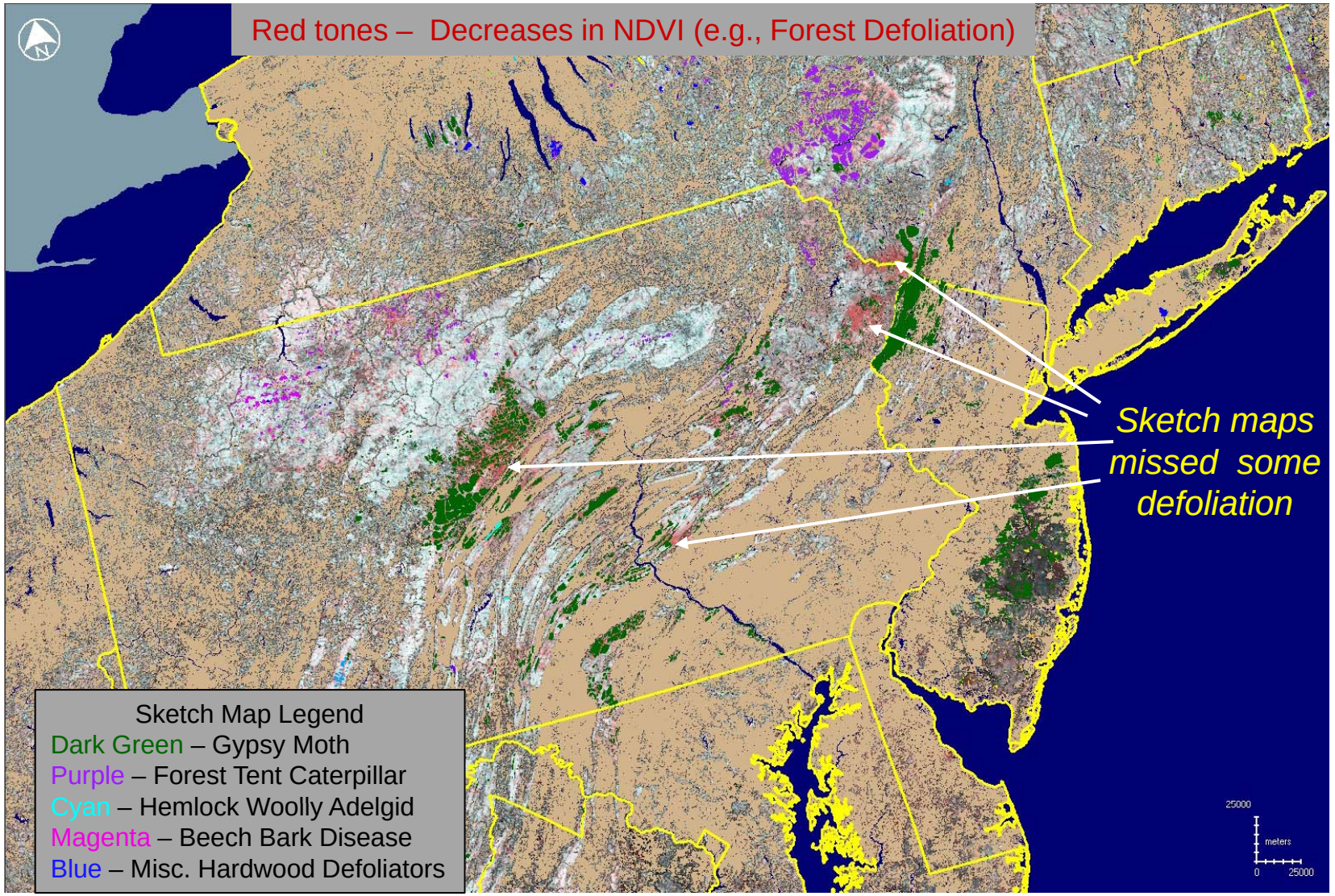
RGB = Baseline Peak NDVI in Red; 2008 Peak NDVI in Blue and Green



Example Intra-Seasonal NDVI Magnitude Products for Select Phenological States

Application: 2008 Ephemeral Forest Defoliation

2008 Forest Defoliation from MODIS 80% Left NDVI

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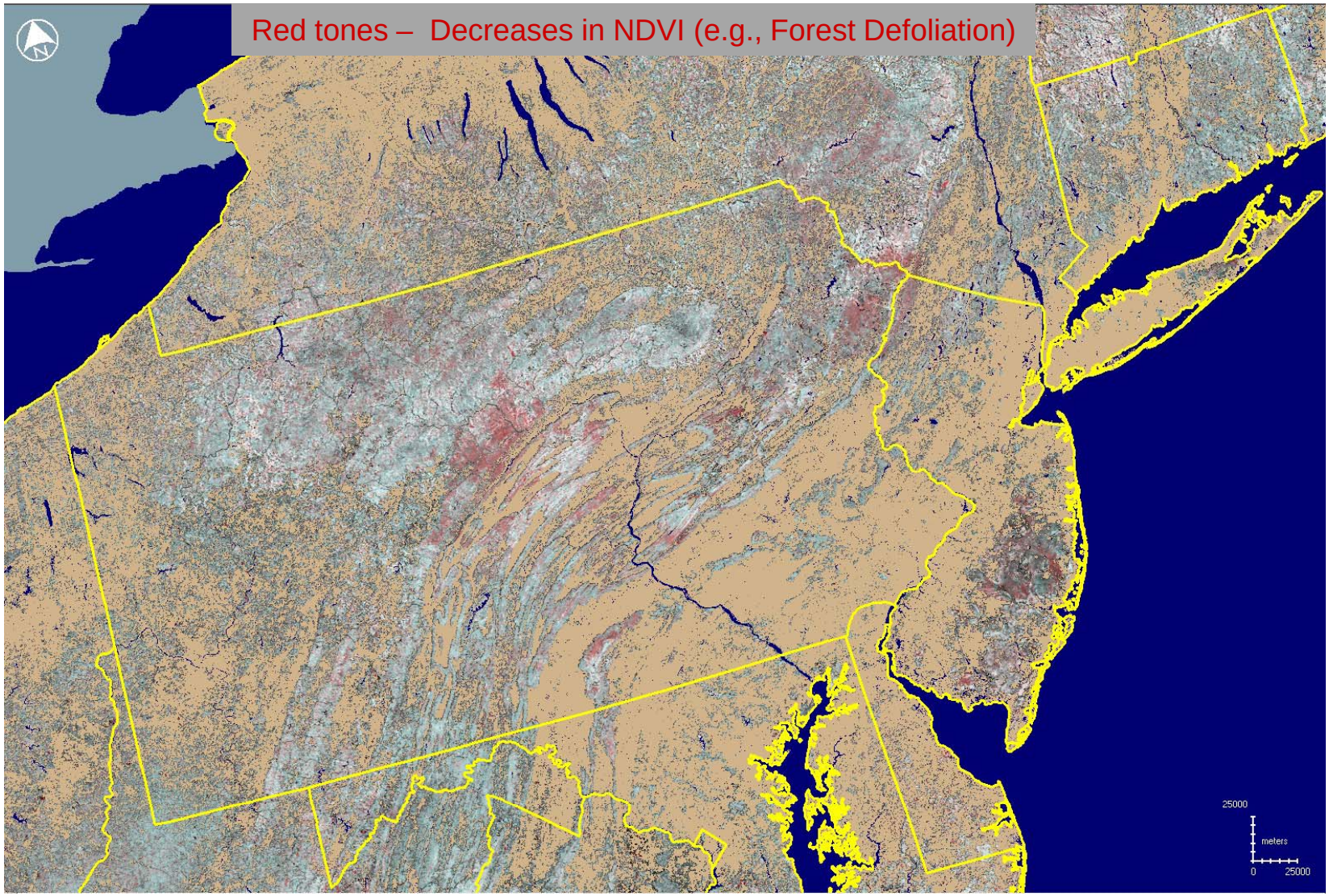
RGB = Baseline 80% Left NDVI in Red; 2008 80% Left NDVI in Blue and Green



2008 Forest Defoliation from MODIS Peak Growing Season NDVI

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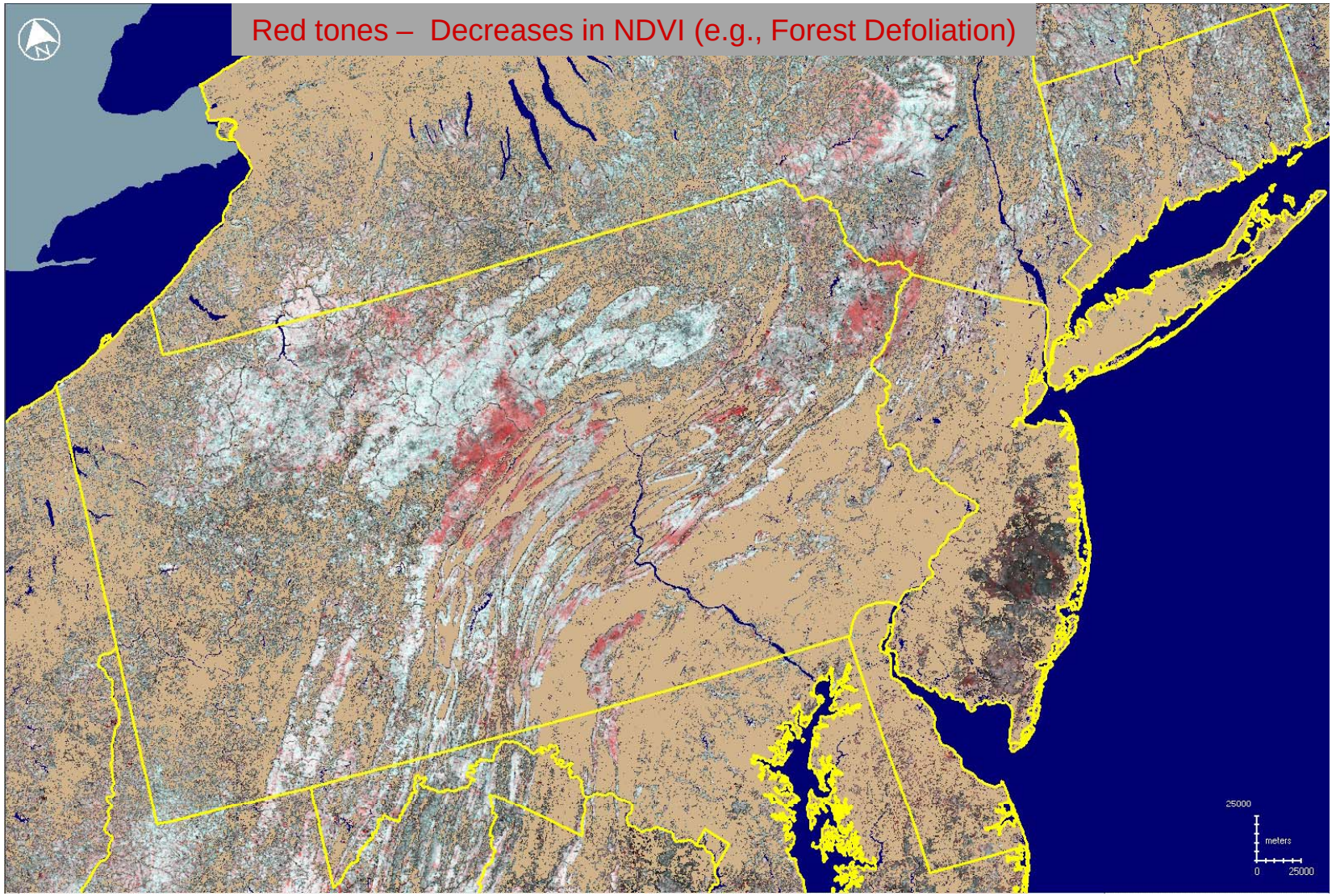
RGB = Baseline Peak NDVI in Red; 2008 Peak NDVI in Blue and Green



2008 Forest Defoliation from MODIS 80% Right NDVI

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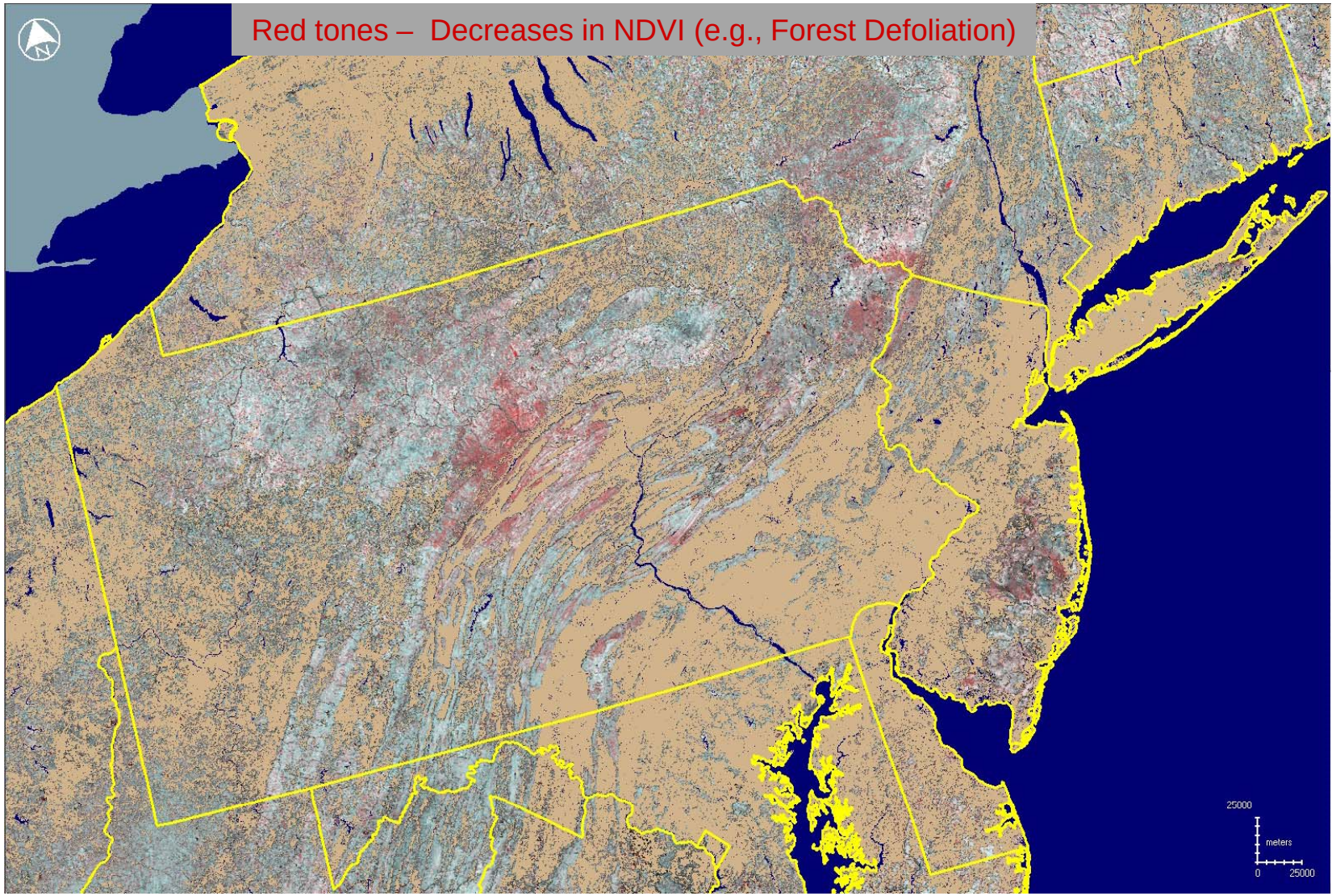
RGB = Baseline 80% Right NDVI in Red; 2008 80% Right NDVI in Blue and Green



Example Day of Year Products for Select Phenological States

Application: Views of Forest Phenology Change Associated with 2008 Hurricane Landfalls

2008 Forest Phenology Change Based on 80% Right DOY Data

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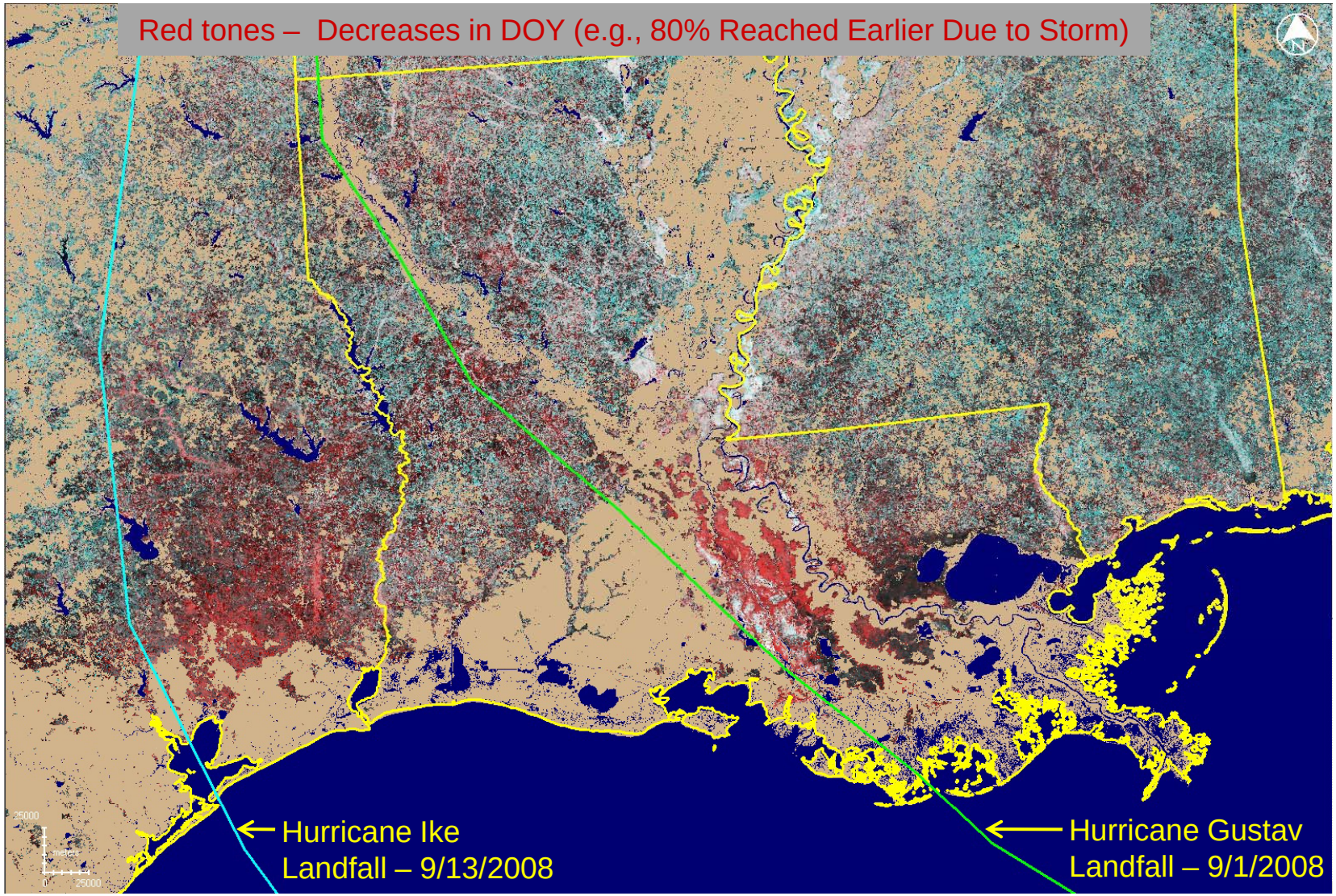
RGB = Baseline 80% Right DOY in Red; 2008 80% Right DOY in Blue and Green



2007 Forest Phenology Change Based on 80% Right DOY Data

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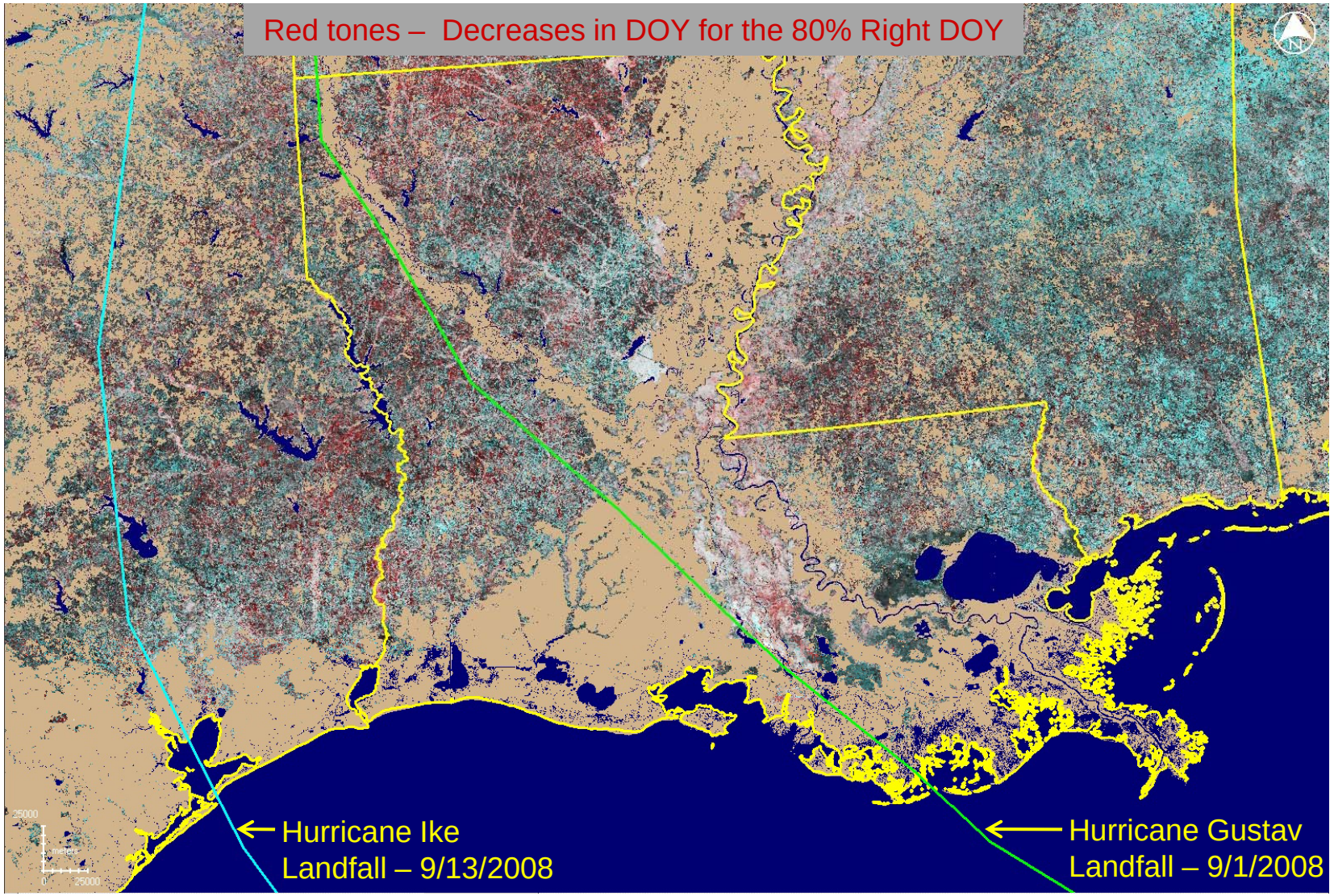
RGB = Baseline 80% Right DOY in Red; 2007 80% Right DOY in Blue and Green



Initial Findings

- Phenology NDVI magnitude products
  - 80% Left, Peak, and 80% Right NDVI products all depict regional patterns of insect defoliation
  - All products capture large fire and clearcut disturbances
- Phenology DOY products
  - DOY products noisier than NDVI magnitude products
  - DOY products appear to show drought-impacted forest
- General
  - Forest mask useful for focusing assessments of forest
  - Products could be improved to eliminate data voids
  - Product line could benefit from expanded baseline from 2000 to present
  - Products can show intra-annual defoliation persistence trends

Final Remarks

- The assessed phenological state products showed promise for detecting and tracking regional forest disturbances
- It's possible that NDVI magnitude and DOY products could be used together for NRT disturbance detection
- For a given phenological state, an NRT system could be established as follows:
  - A median DOY baseline product could be applied to determine when to collect relevant NDVI imagery for the current season
  - The current NDVI magnitude product could then be compared to the historical max NDVI baseline product to compute percent change in NDVI for that phenological state
- Cumulative integral NDVI also has good potential for aiding NRT disturbance detection (discussed in next presentation)

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