The Great Lakes Wind Resource

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Objective of Wind Resource Characterization

Define the 3-dimensional wind characteristics in the lowest 200 m layer of the lake environment

Relevant to

- Site Evaluation
- Structural Loads Determination
- Turbine Performance Prediction & Plant Operations
- Production Scheduling

Lake Characteristics and Impact on Weather & Wind

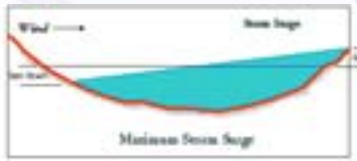
- Low surface roughness
- Major source of moisture & heat (latent & sensible)
  - Especially in late-fall & winter
  - Moderating effect on air temperature year-round
  - Surface temperature changes slowly
- Atmospheric stability
  - Determined by difference between lake surface temperature and overlying air temperature
  - Land-lake temp differences ⇨ coastal breezes
- Seasonal ice cover
  - Spatially variable, function of water depth & wind

Examples of Lake-Weather Dynamics

- Lake-Effect Snow

- Waterspouts

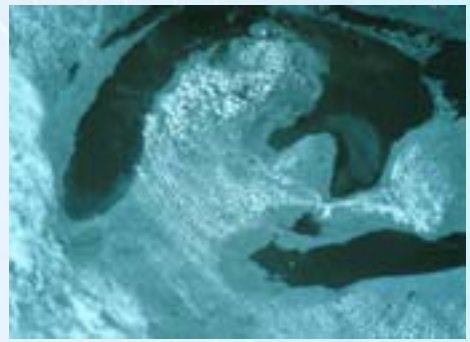
- Surges & Seiches



- Land/Lake Breezes

Role of Atmospheric Stability

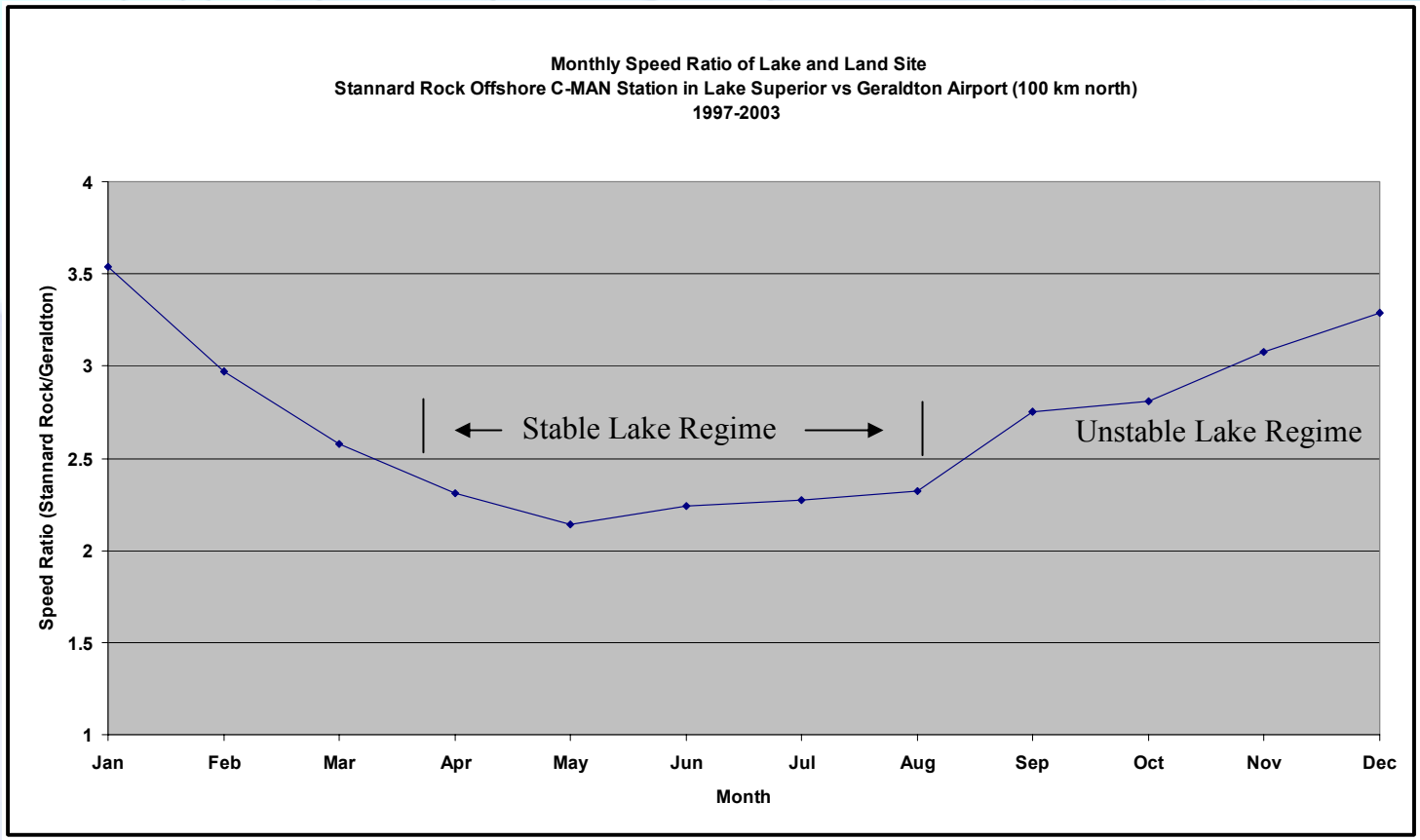
- Fall-Winter
  - Water warmer than air ⇨ unstable atmosphere
  - Promotes vertical mixing and stronger surface winds

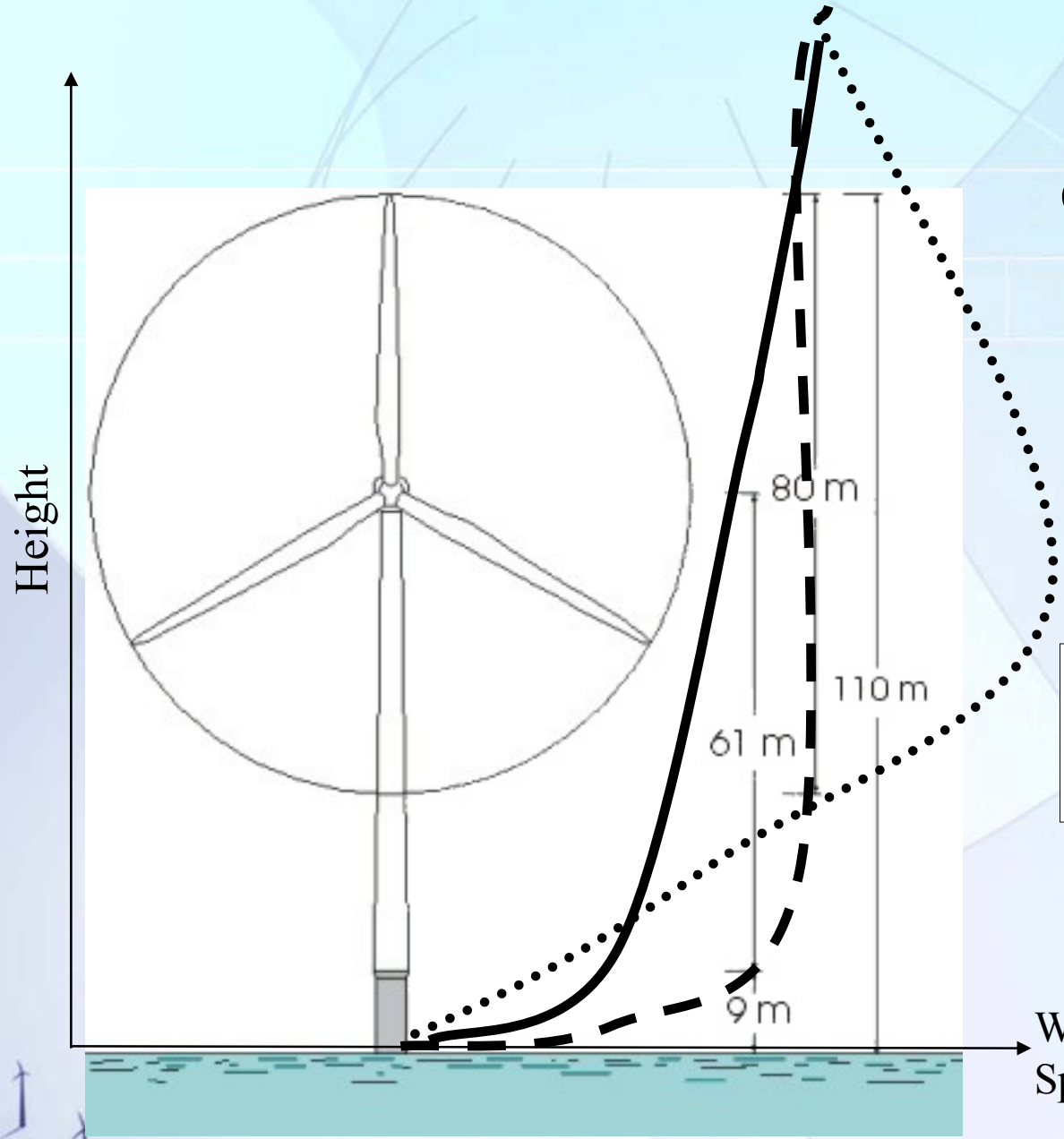


- Spring-Summer
  - Water cooler than air ⇨ stable atmosphere
  - Suppresses mixing and winds

Seasonal Lake-Land Speed Ratios

Ratios are function of stability & fetch





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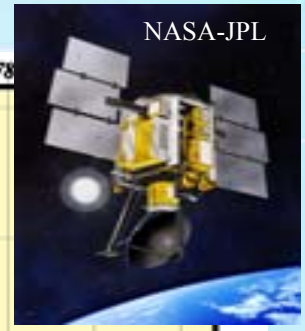
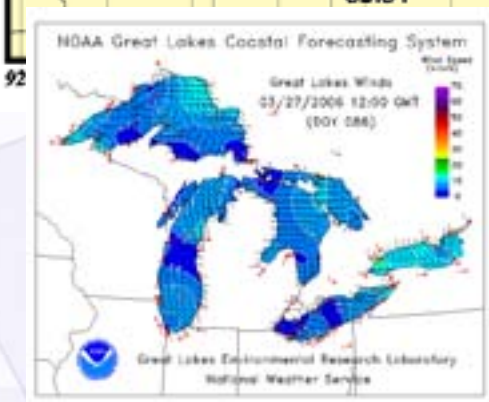
Stability Effects on Wind Shear

Sources of Resource Info

- **Surface**
  - Buoys *(seasonal)*
  - Coastal Marine Automated Network Stations *(C-MAN)*
  - Ships *(seasonal, moving, accurate?)*
  - Coastal met. Stations *(NWS, Envir. Canada)*
- **Remote Sensing**
  - Satellite (QSCAT)
  - Weather balloons from land
- **Modeling/Mapping**
  - Numerical weather models
  - High resolution wind maps





National Data Buoy Center

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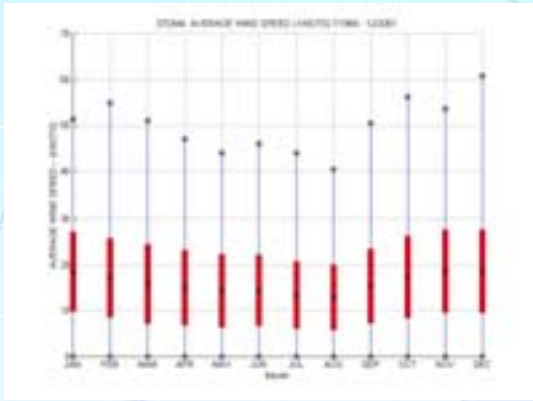
Monthly Speed Trends Within Three Lakes

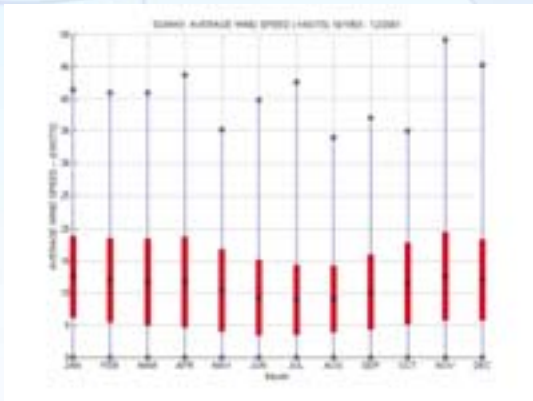
C-MAN Stations Are Year-Round; Buoys Are Not

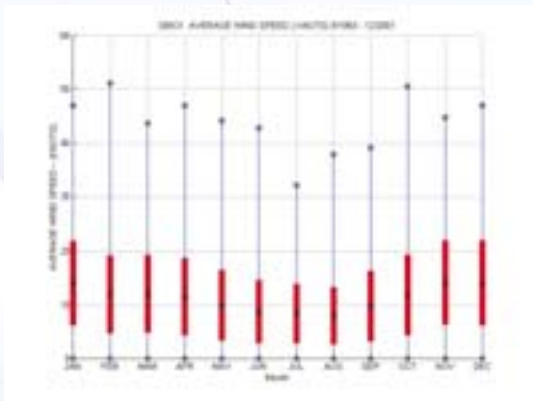
Stannard Rock, MI
(central Lake Superior)

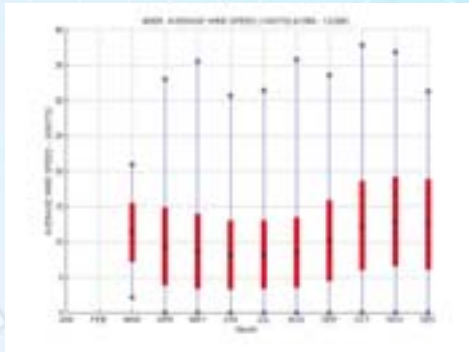
Sheboygan, WI
(Western Lake Michigan)

South Bass Island, OH
(SW Lake Erie)





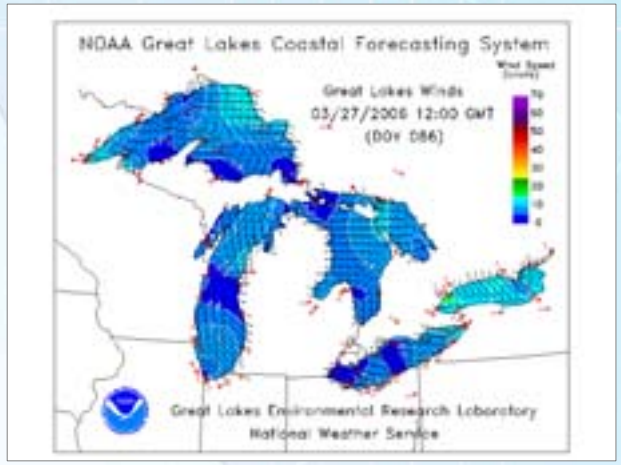


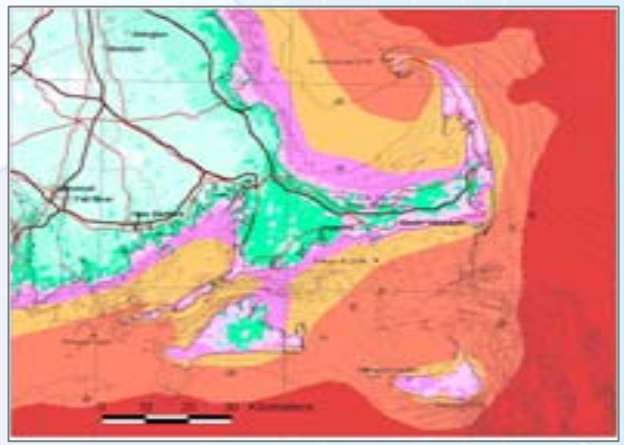


Moored Buoy 28 nm NW
of Cleveland (Lake Erie)

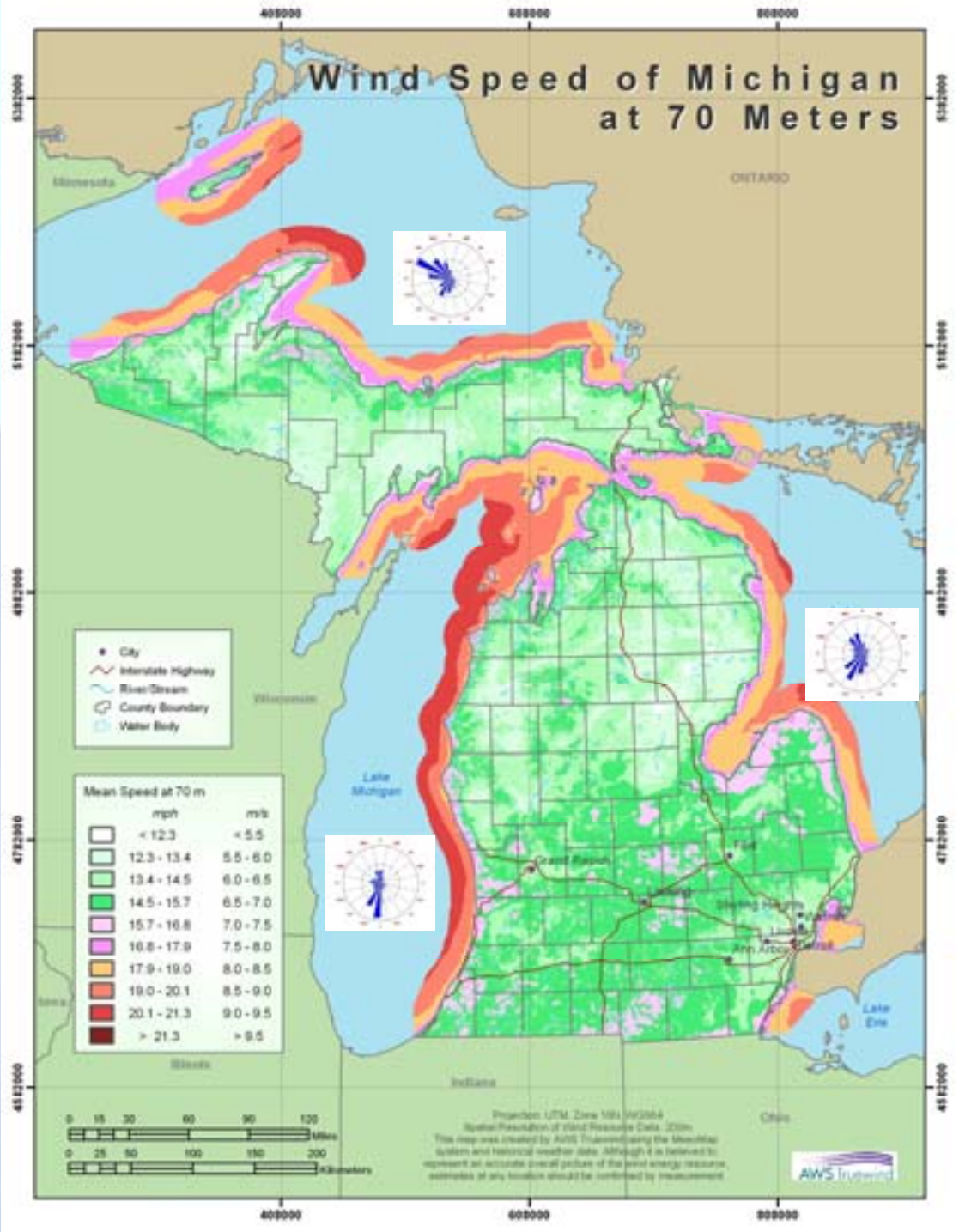
Using Models To Define The Resource

- Nowcasts
  - Interpolated/adjusted winds @ 5 km grid
- Wind maps
  - Developed from 3-D mesoscale numerical weather models
  - Combine boundary layer properties and atmospheric databases to simulate all physics of the atmosphere





Cape Cod MesoMap - AWS Truewind



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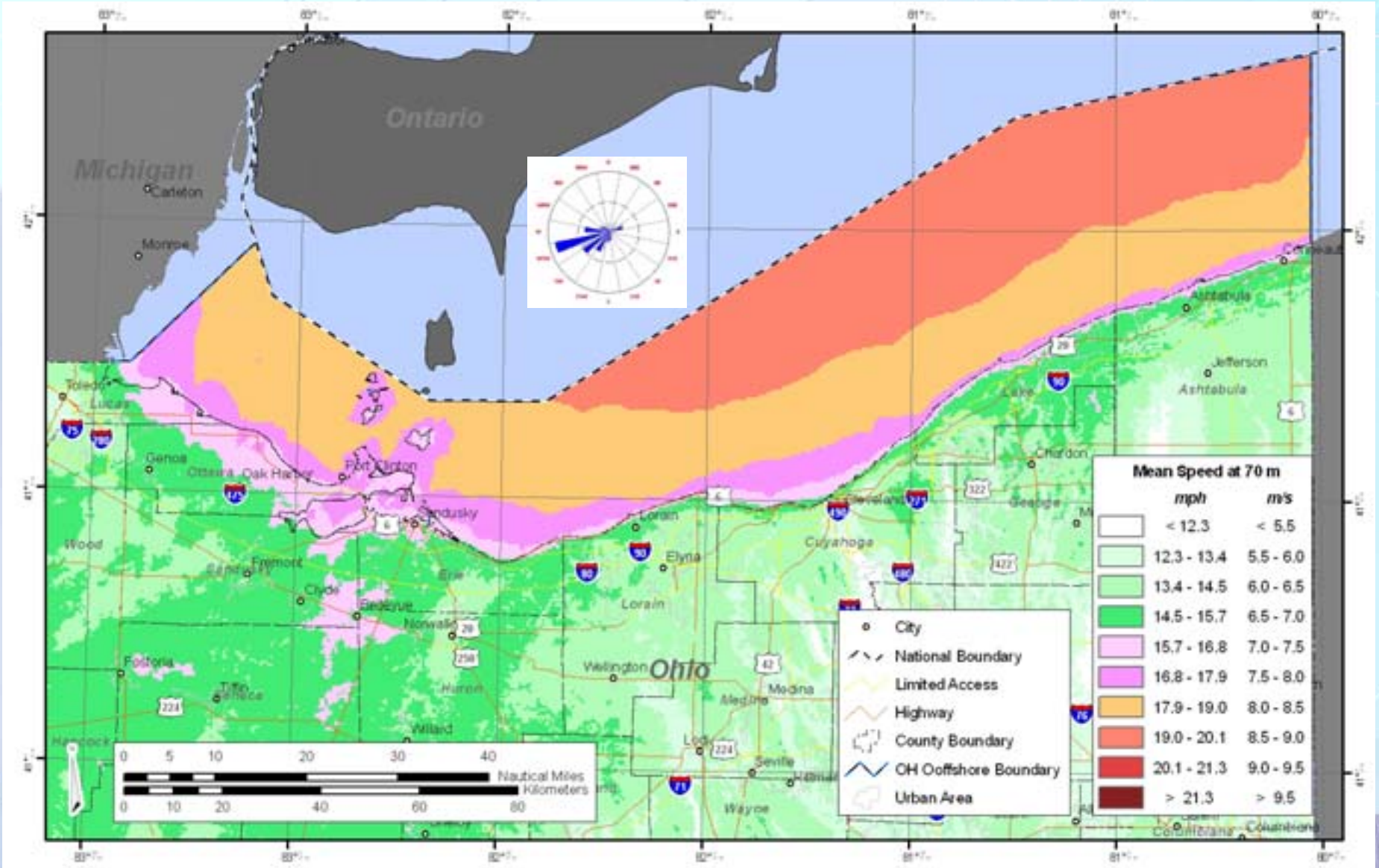
Michigan Wind Resource @ 70 m

Sponsored by the
Michigan State Energy Office

Ohio Wind Resource @ 70 m

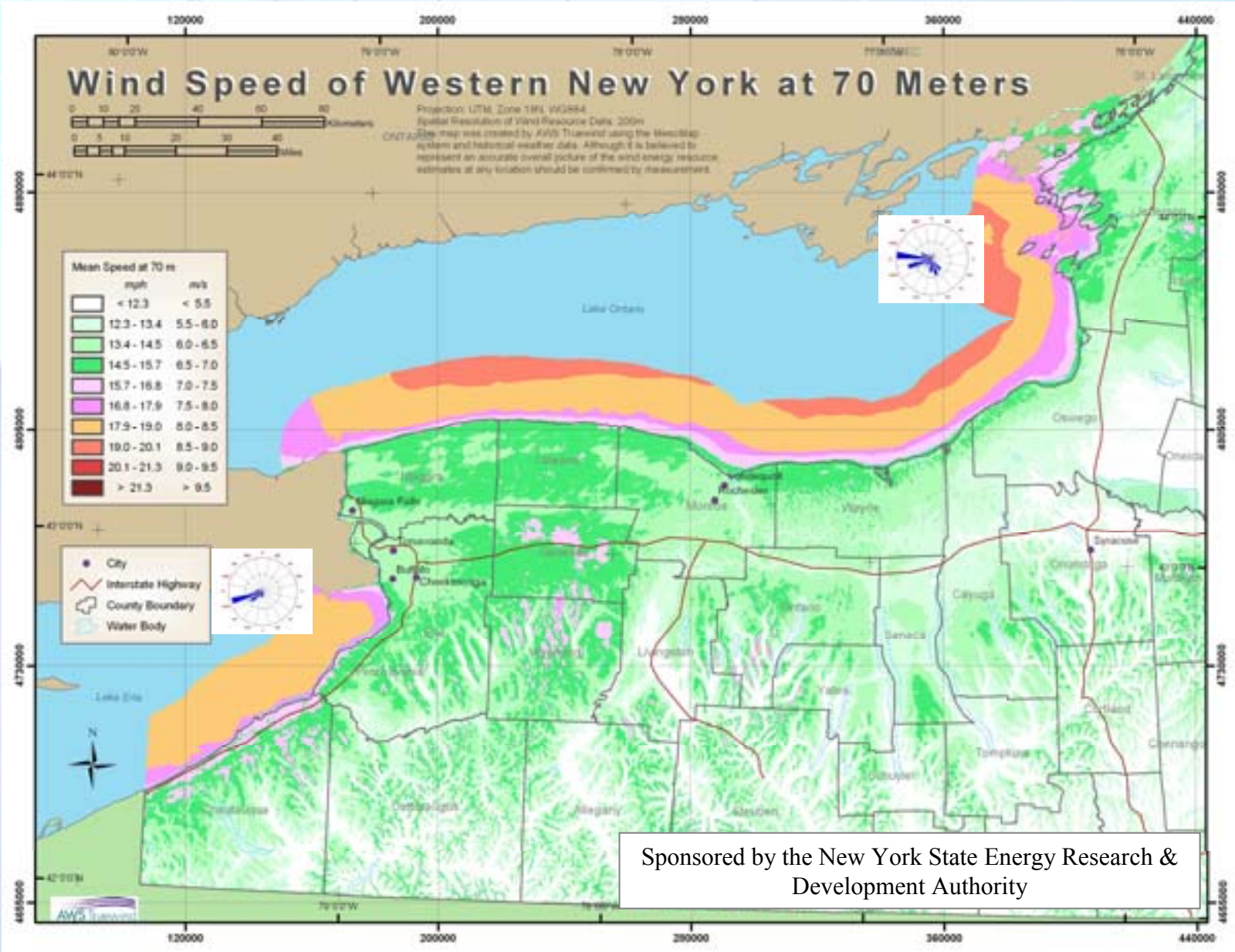
AWS Truewind

Sponsored by the Ohio Department of Development



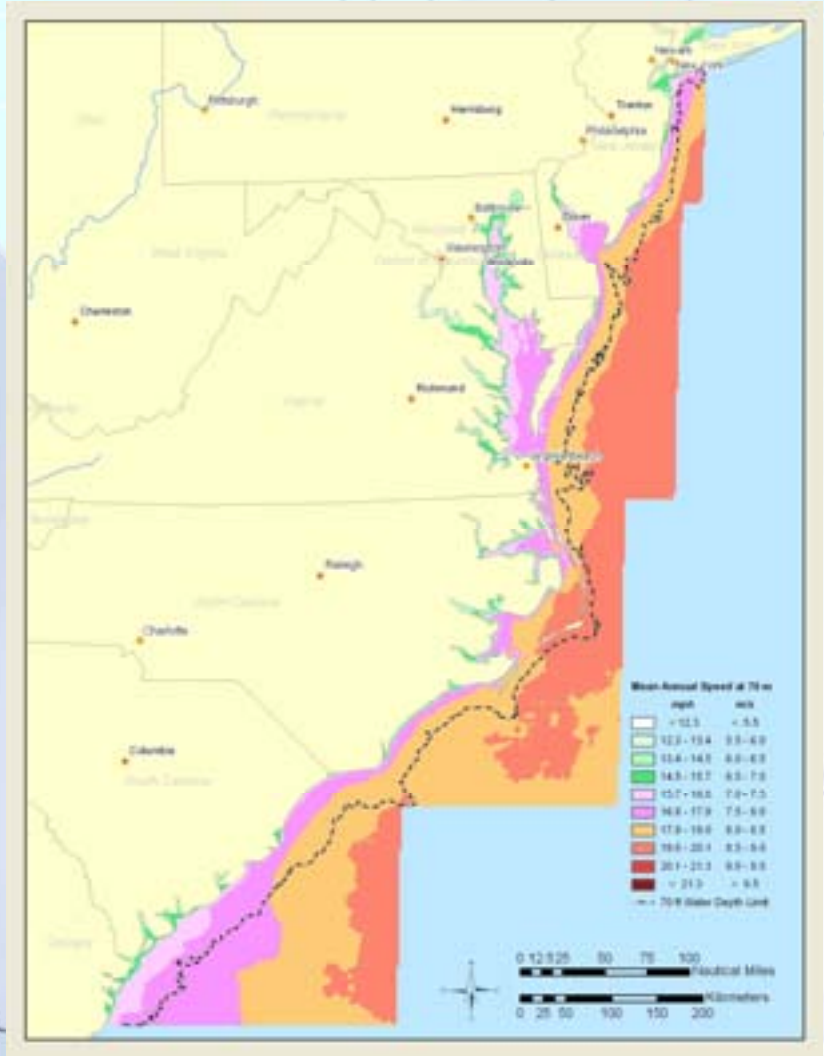
NY Wind Resource @ 70 m

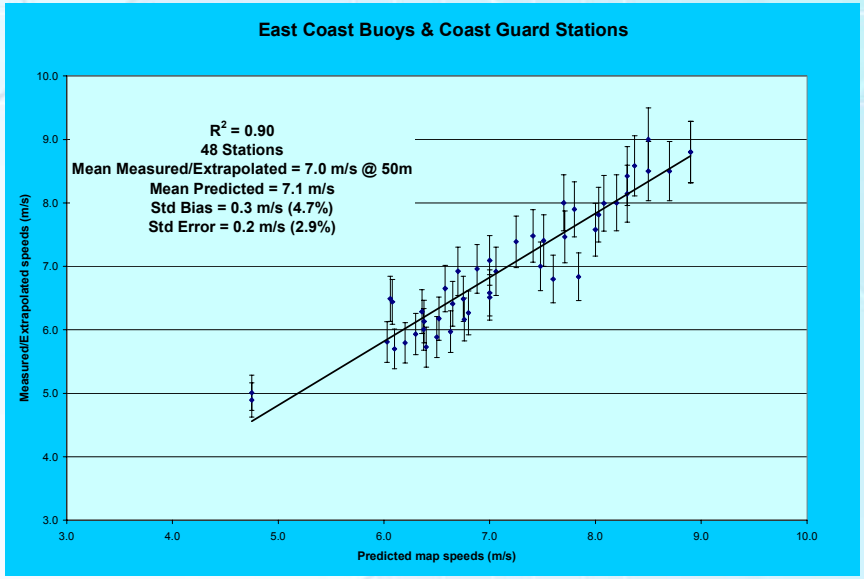
AWS Truewind



Accuracy of MesoMap Wind Maps In Coastal Environments

AWS Truewind



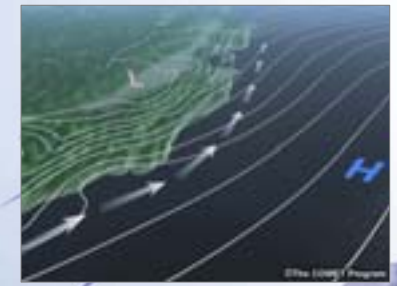


Key Data Inputs:

- Global Reanalysis Data – 1989-2004
- National Elevation Database
- USGS Landsat Land Cover
- Differential Vegetation Index
- NCEP Sea Surface Temperature (1° res.) or MODIS/Pathfinder 4 km resolution
- Sea Ice (20-25 km resolution)

Future Needs in Offshore Wind Characterization

- More wind stations/buoys, sampling year-round
- Info on vertical wind structure & stability
  - Profilers (sodar, lidar) on fixed or moored platforms
- Remote sensing data (lake surface properties)
- Mesoscale modeling using higher resolution lake property inputs; more prediction validations
- Collaboration with govt. agencies & related research programs



Data Sources For Great Lakes

- NOAA's Great Lakes Environmental Research Lab. (www.glerl.noaa.gov)
- NOAA Great Lakes Coastal Forecasting System (www.glerl.noaa.gov/res/glcfs)
- NOAA's Great Lakes Observing System (www.glos.us)
- NOAA's National Data Buoy Center (www.ndbc.noaa.gov)
- Wind maps (www.awstruewind.com)