NWP Resolution Considerations
Implications for Marine Wind Forecasts

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NWP Capability

- Rules of thumb based on mixing depth and flow at prescribed levels (e.g., 925 mb, 850 mb) are outdated
- Modern NWP simulate complicated boundary layer flow - especially forced via convective motions
- Be cognizant of what Boundary Layer Winds in NWP represent
  - BL wind is average over lowest 30 mb
  - separate BL levels extend to 150 mb AGL
NWP Capability

• High resolution NWP is very capable simulating lake/land breezes
  ○ outcomes are very sensitive to prescribed lake surface temperatures and modeling of thermal properties over high emissivity land use (e.g., urban, freshly tilled ground, …)
  ○ accuracy of over water portion of lake/land breeze circulation is unknown due to lack of observations
NWP Capability

- High res models produce short time scale high amplitude episodes
  - useful subjectively characterizing impactful meteorology
  - over-specifying details can prove a challenge to operational applications
- Individual solutions or small ensembles can become unusable quickly
- Coarse models are useful to frame the forecast with high res providing greater definition where downscaling appears skillful
Resolution Comparison

- WRF Research Grade Simulations from CSP sponsored research
- Grid spacing tested - Resolution $\geq 5x$
  - 12 km - comparable to NAM / RAP
  - 4 km - comparable to NAM Nest, HiRes Windows, HRRR
  - 1 km - next generation Convection Allowing Model
- Same implicit physics / parameterizations
  - except KF convection operating within 12 km domain
- Initial and Boundary conditions supplied by NARR or RAP analyses
NWP Resolution Comparisons - 12km
Effects of over water differential stability become much more apparent. Greatest speeds coincident with greatest instability along windward shore.
Similar results except for stronger land breeze contribution along Ohio shoreline.
NWP Resolution Comparisons - 12km
Similar results with a slightly more mottled appearance.
Effects of over water convection become much more apparent. Greatest speeds coincident with shower activity.
Depth of over water instability appears to allow rapid boundary layer overturning - even within the coarse representation.
Boundary layer growth not as abrupt as the 12km representation - signifying smaller scale processes are really at play in the growth of the mixing layer.
Refined detail indicating formation of convective roll structures are responsible for the momentum transport to the surface rather than slab overturning as shown in the coarse domain.
NWP Resolution Comparisons - 12km
Boundary layer growth not as abrupt as the 12km representation - signifying smaller scale processes are really at play in the growth of the mixing layer.
Refined detail indicating formation of convective roll structures are responsible for the momentum transport to the surface rather than slab overturning as shown in the coarse domain.
NWP Resolution Comparisons - 12km
Momentum structure much more structured than 12km representation - signifying smaller scale processes once again are the dominant mode.
NWP Resolution Comparisons - 1km

Refined detail indicating formation of cellular convection is responsible for the momentum transport to the surface rather than slab overturning as shown in the coarse domain.
Momentum more structured than 12km representation - signifying smaller scale processes once again are the dominant mode.
Refined detail showing complex momentum structures including edge eddies, transverse waves, and horizontal convective rolls.
Centered 1 hour average may be necessary to increase coherency for visualizing and integration as forcing for hydrodynamics.
NWP Resolution - 1km of “Sandy”
Temporal Resolution Considerations

- Scales of motion are coupled in space and time and need to be considered
- NWP spatial resolution is at a minimum 5 delta grid spacing with an intrinsic time scale
  - 12 km grid -> 60+ km feature
    - 3+ hour time evolution
  - 4 km grid -> 20+ km feature
    - 1+ hour evolution
  - 1 km grid -> 5+ km feature
    - 10+ minute evolution
NWP Resolution - temporal variance
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1km x 5(10) minute Output
NWP Resolution - temporal variance

● Many wind episodes are an hour or less in length or greatest amplitude is very brief
  ○ example of squall line winds very representative in scale and scope - however 3-4 hour timing error
  ○ useful output to convey character of potential episode

● Poses a challenge to characterize the resultant hydrodynamics using hourly drivers
  ○ wind bubble crosses Lake Erie in an hour
  ○ peak wind events are shorter than observational time windows - effect not really known
  ○ requires sub-hourly drivers - better yet, a fully coupled system
Summary

- Understand the capabilities of the applied NWP
  - can the model produce a reasonable wind field given the construction?
  - inappropriate resolution can result in dramatically large errors (e.g., artificial slab overturning of the boundary layer in convective roll situations)
  - given the extreme detail, time averaged (O 1hr) high resolution winds may be more applicable to a gridded forecast environment
  - application to hydrodynamic models will require a substantial amount of retuning
Questions

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Additional Information: Impacts on Wavewatch3

- Current generation wave models are a very good wind aggregators
- Very fine scale wind features do not strongly influence the wave field
Wave sensitivity - 12km
Wave sensitivity - 4km

Spatial Plot of Hsig(m) and Wave Direction of Ardhuin 2010 physics
Erie_WW3 4km WRF 20131026 09:00:00
Wave sensitivity - 1km
Wave sensitivity - 12km
Wave sensitivity - 4km
Wave sensitivity - 1km