NWP Resolution Considerations

Implications for Great Lakes Wind Forecasts

23rd U.S./Canada Great Lakes Operational Meteorology Workshop
August 2015

Greg E. Mann, Ph.D.
NWS WFO Detroit

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- Rules of thumb based on mixing depth and flow at prescribed levels (e.g., 925 mb, 850 mb) are outdated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

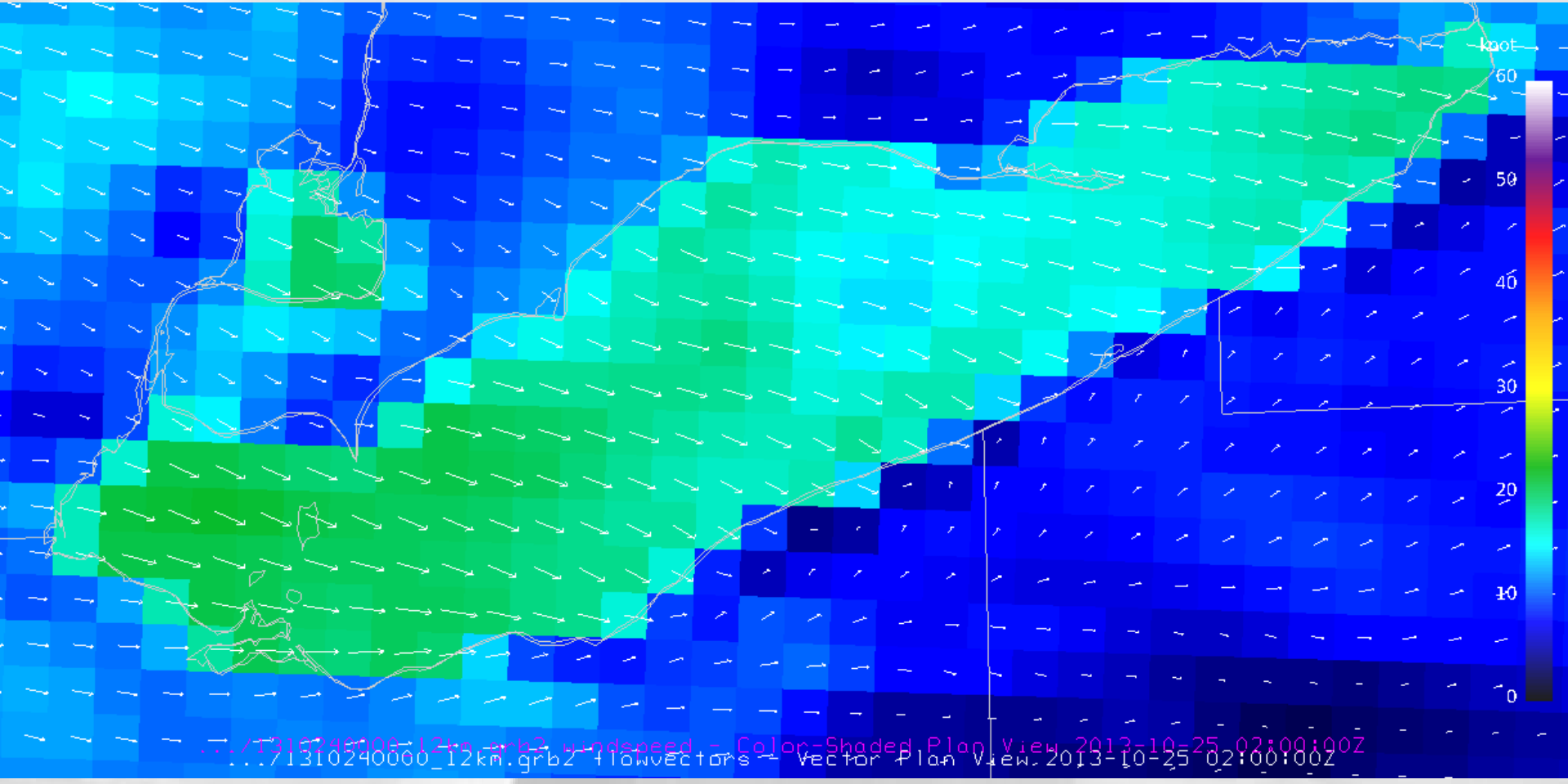
NWP Capability

- 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 become unusable when divergent from reality
- Coarse models are useful to frame the forecast with high res providing greater definition where applicable

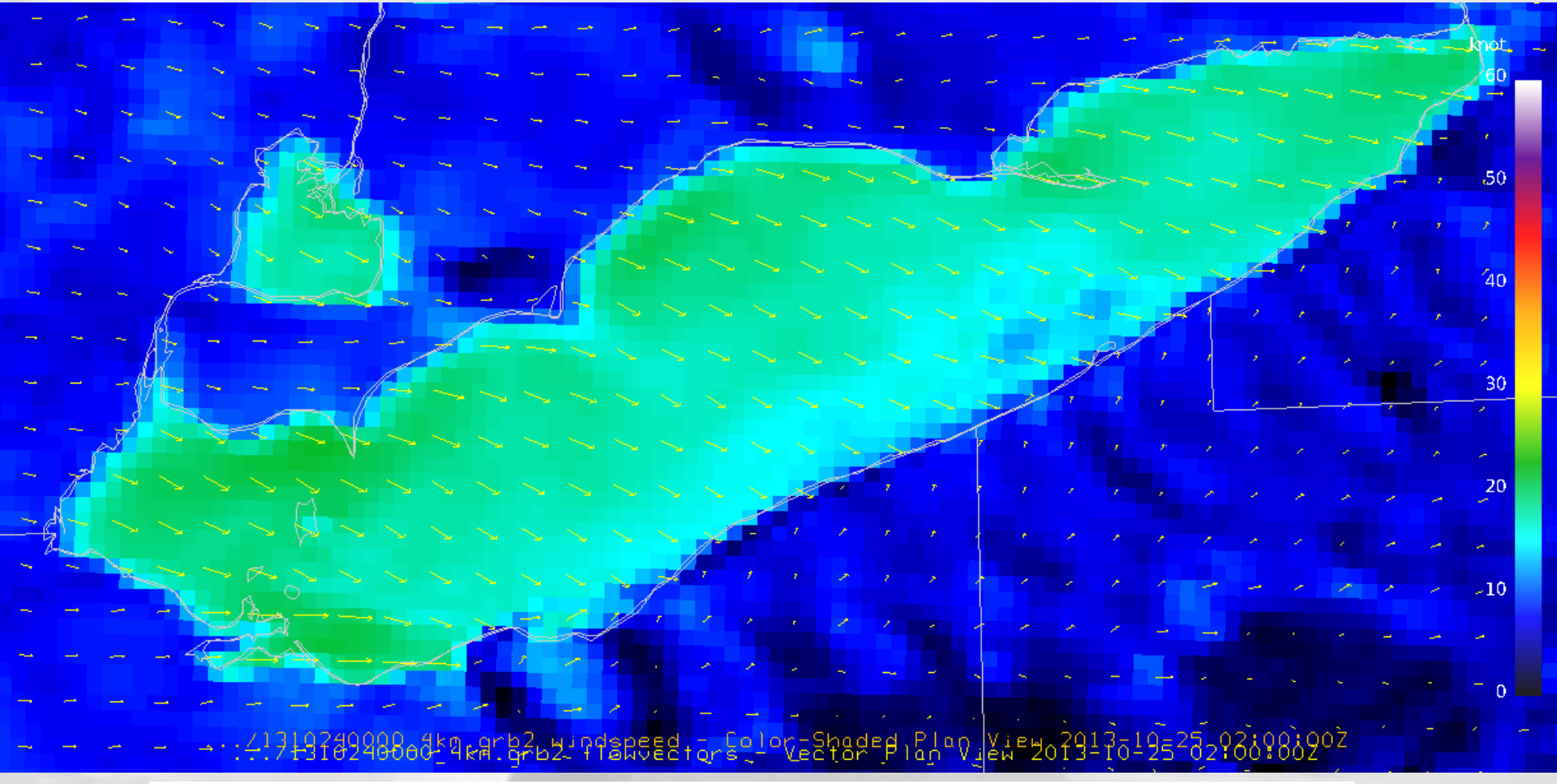
Resolution Comparison

- WRF Simulations from CSP sponsored research
- Grid spacing tested - Resolution >= 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
- Demonstration primarily from an October 2013 Storm event on Lake Erie

NWP Resolution Comparisons - 12km

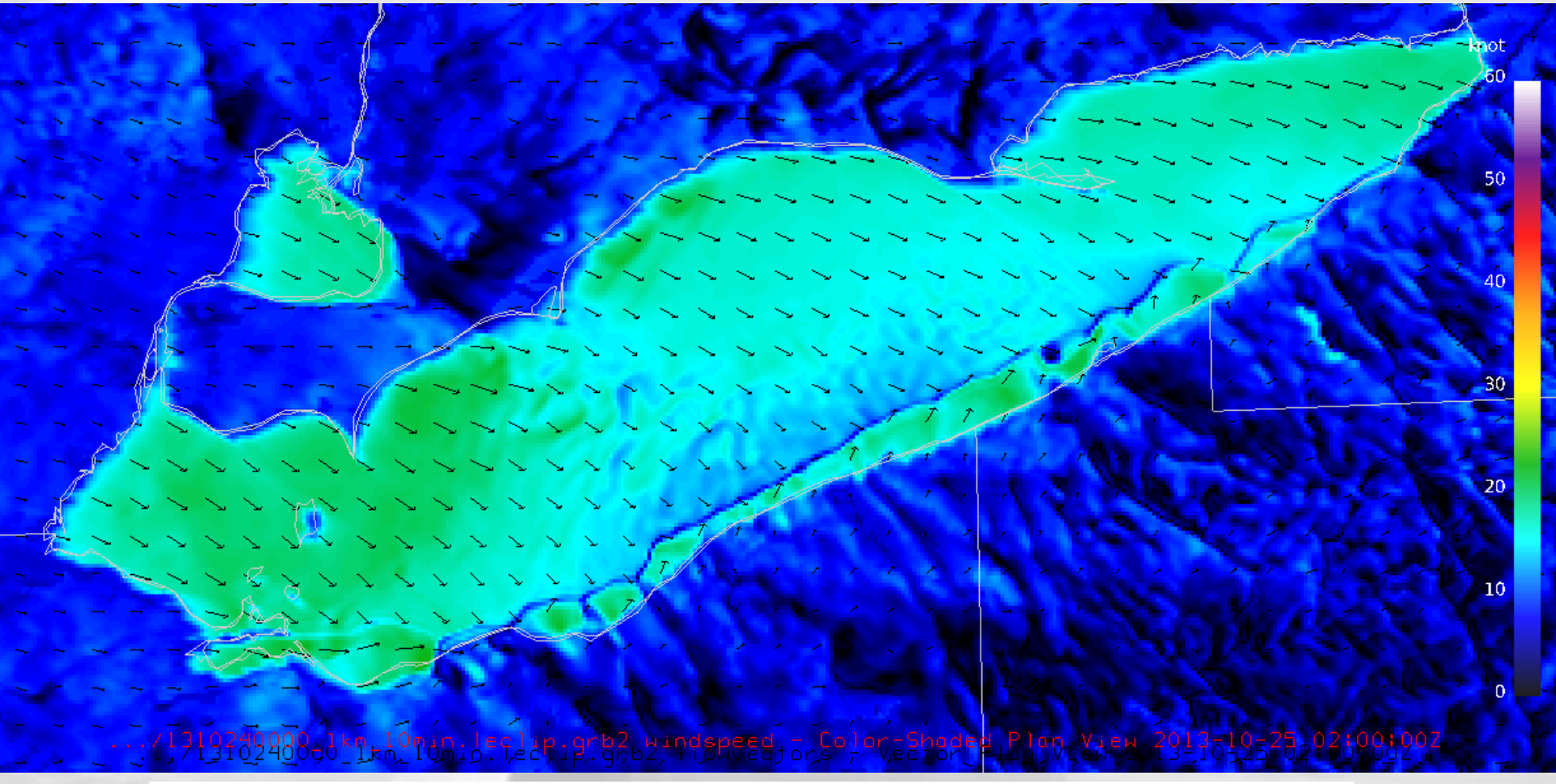


NWP Resolution Comparisons - 4km



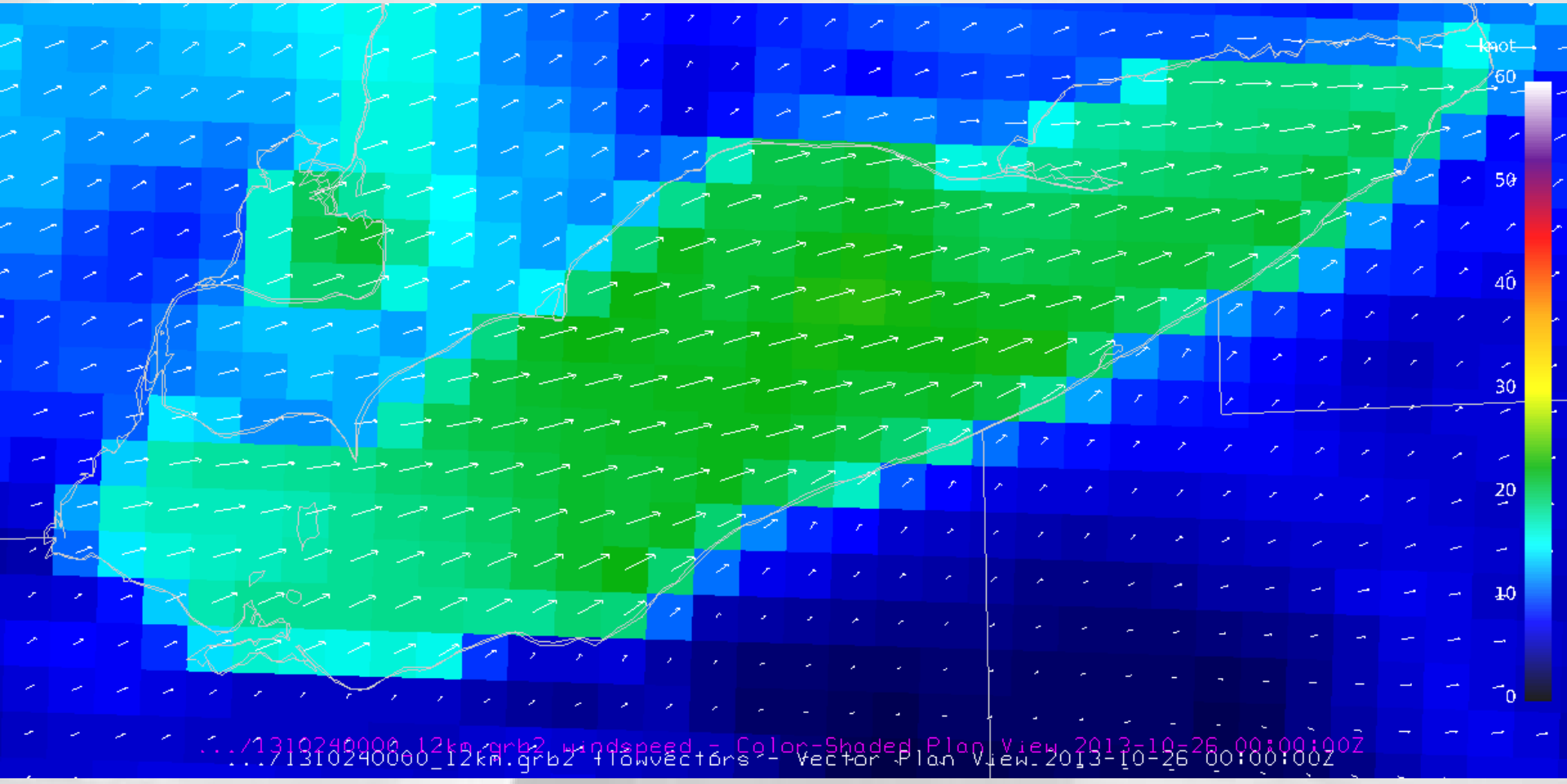
Effects of over water differential stability become much more apparent.
Greatest speeds coincident with greatest instability along windward shore.

NWP Resolution Comparisons - 1km



Similar results except for stronger land breeze contribution along Ohio shoreline.

NWP Resolution Comparisons - 12km



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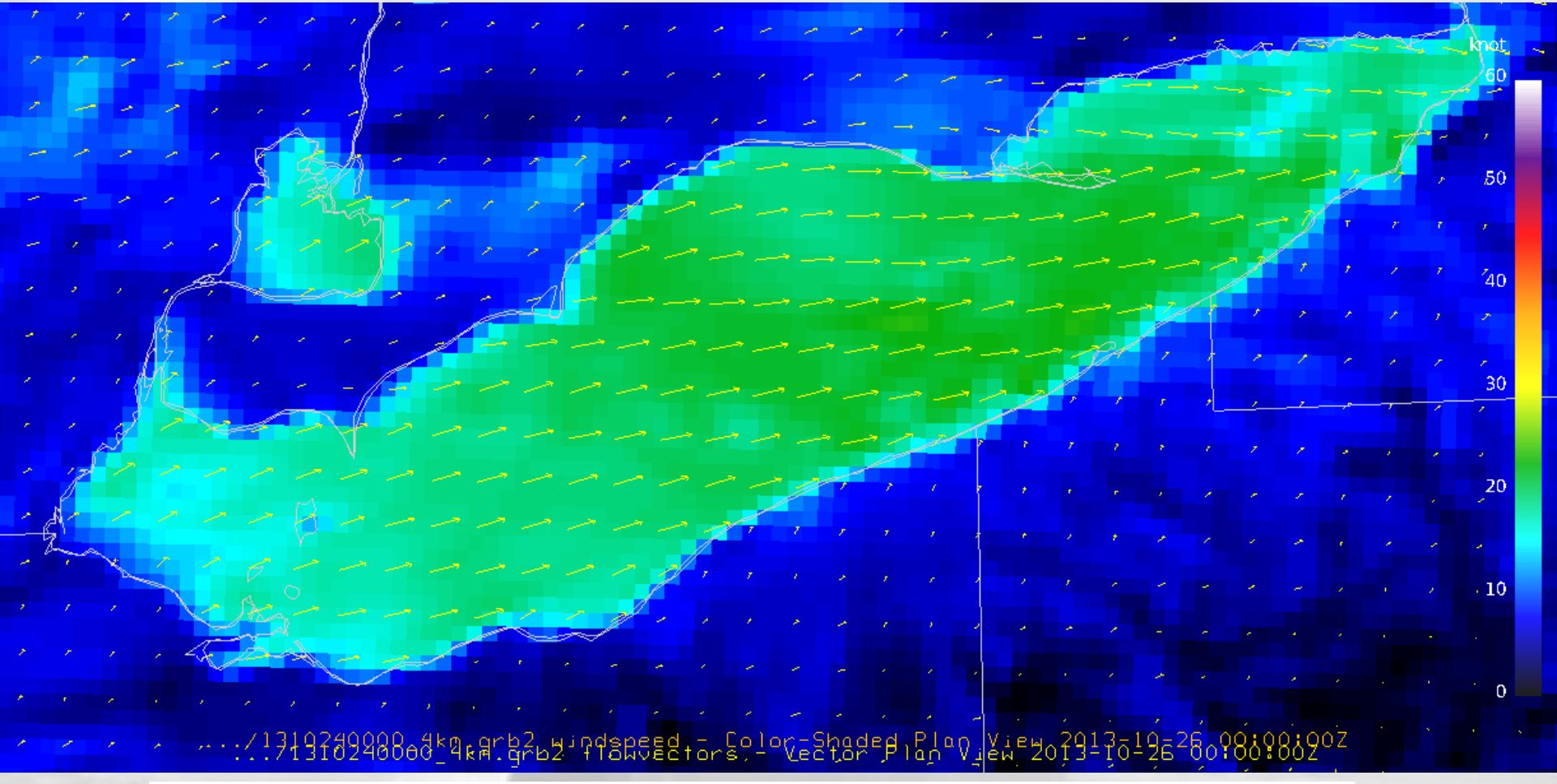
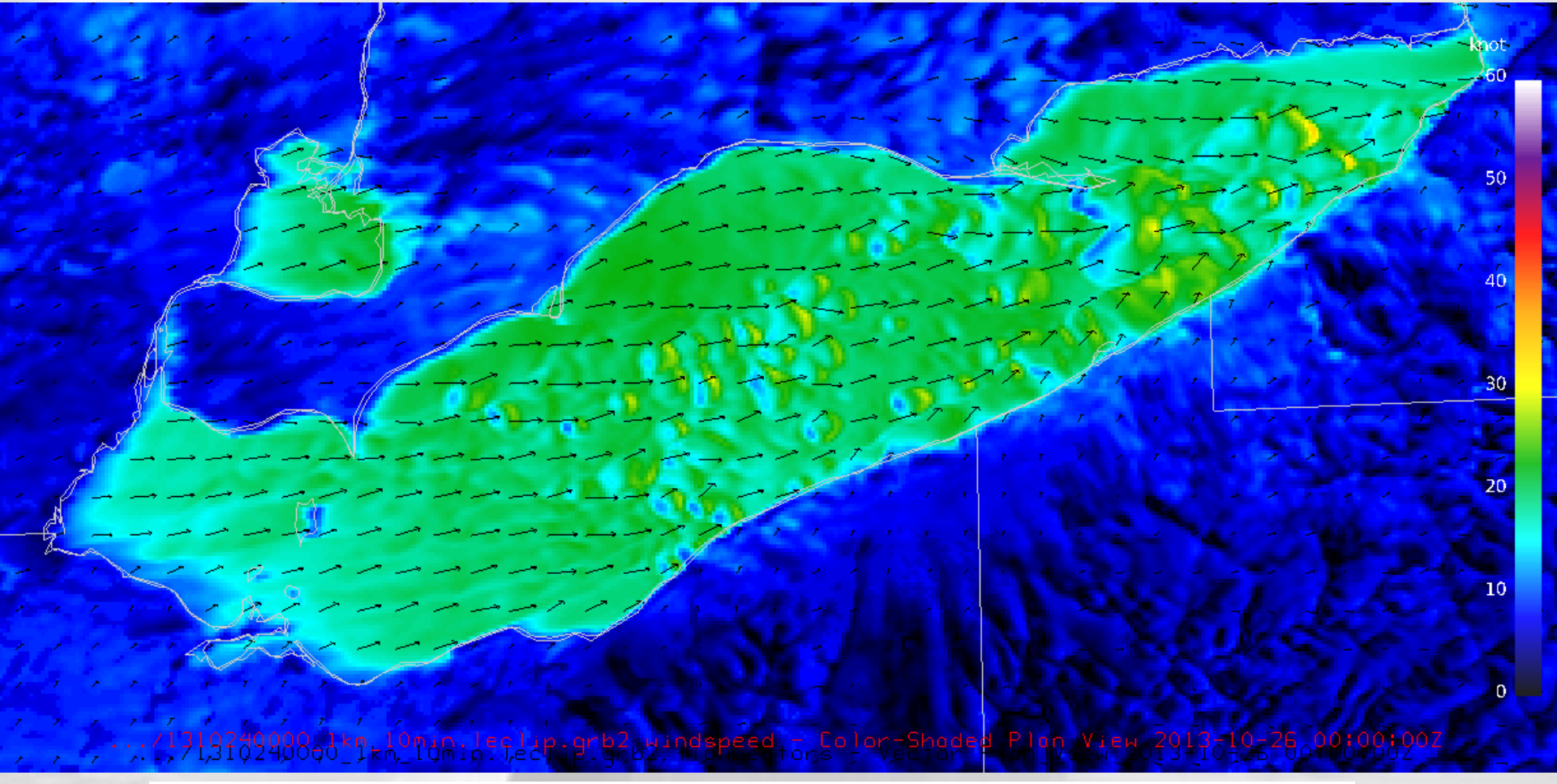


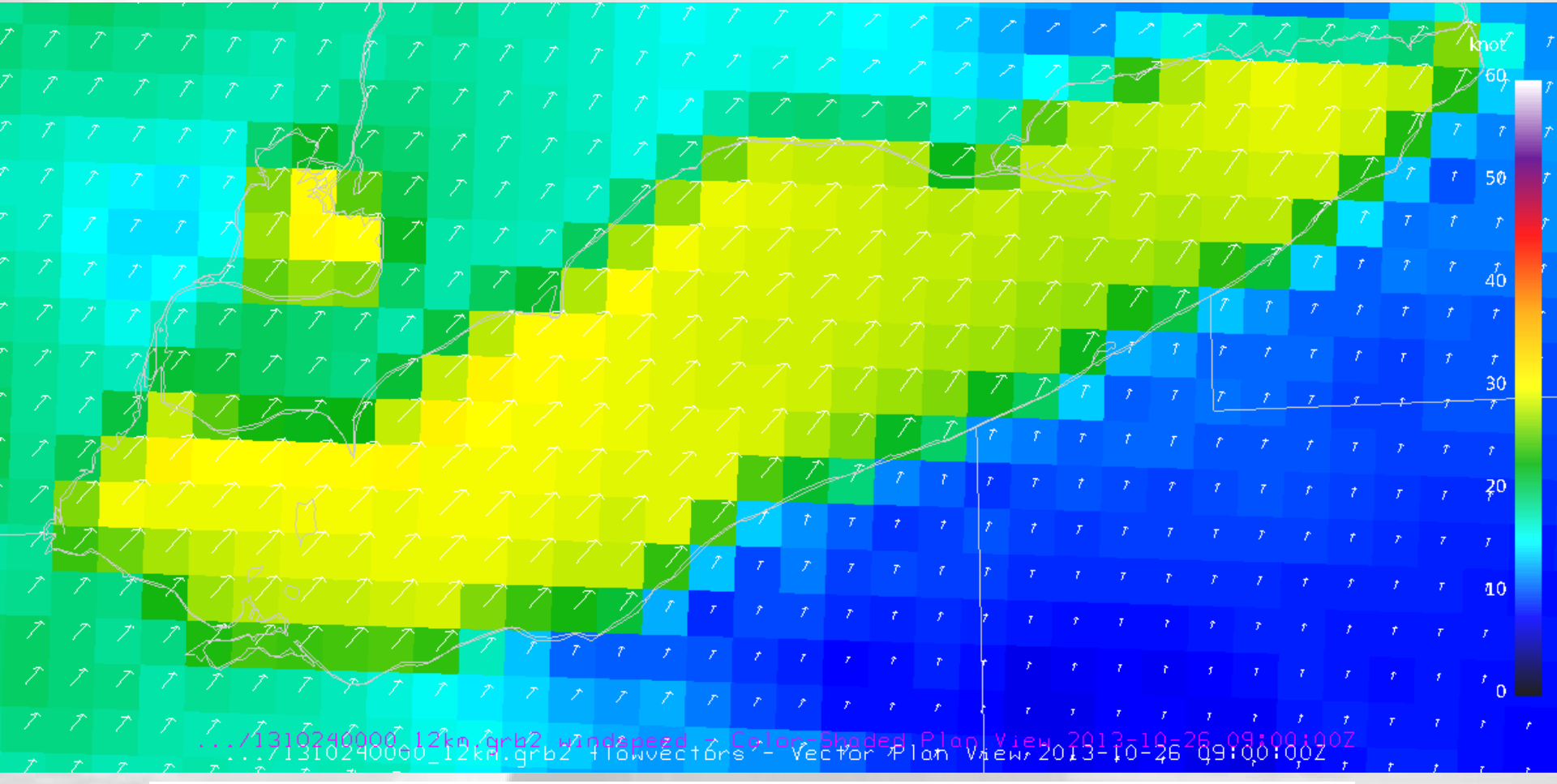
Similar results with a slightly more mottled appearance.

NWP Resolution Comparisons - 1km



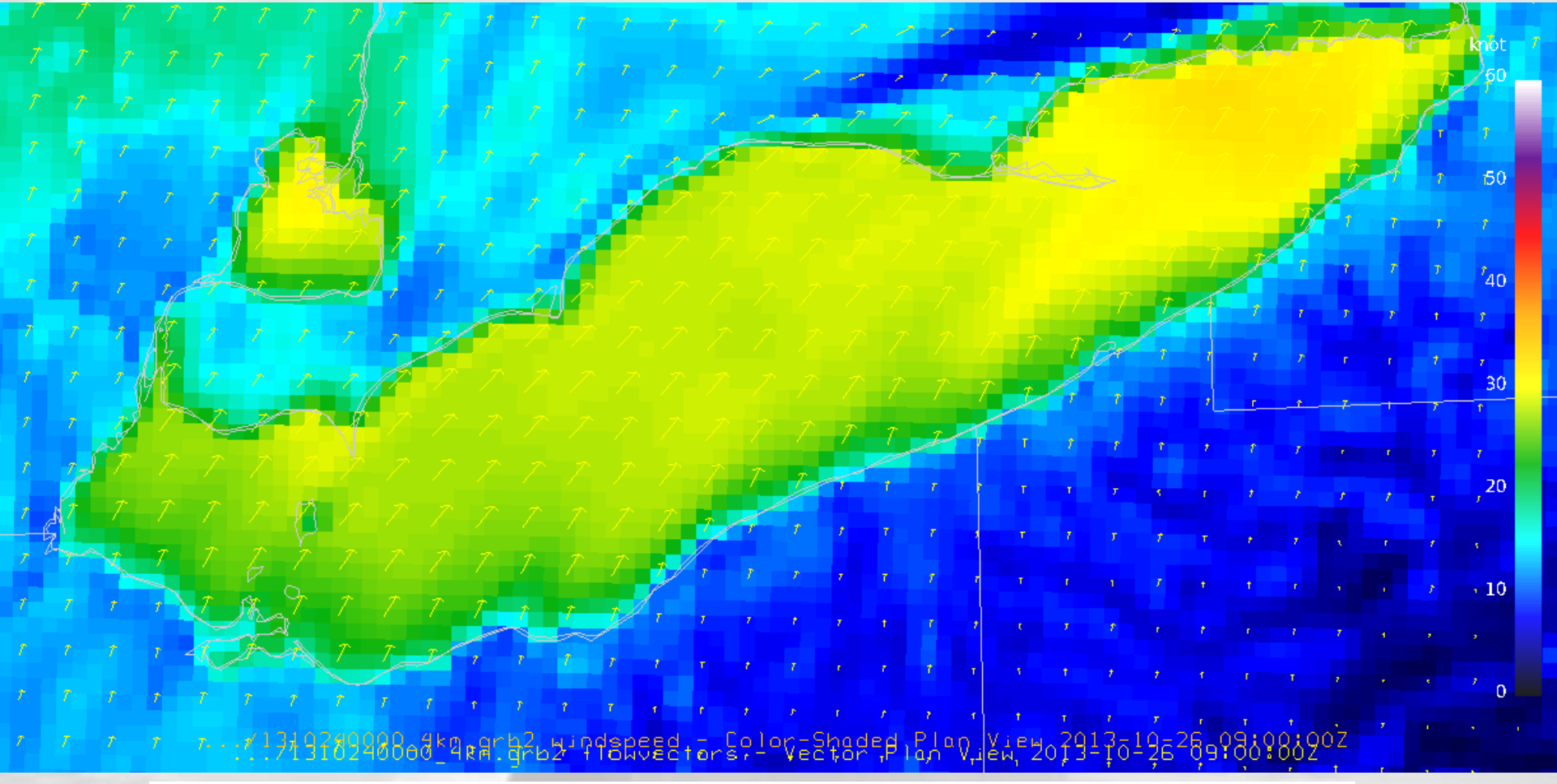
Effects of over water convection become much more apparent.
Greatest speeds coincident with shower activity.

NWP Resolution Comparisons - 12km



Depth of over water instability appears to allow rapid boundary layer overturning - even within the coarse representation.

NWP Resolution Comparisons - 4km



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.

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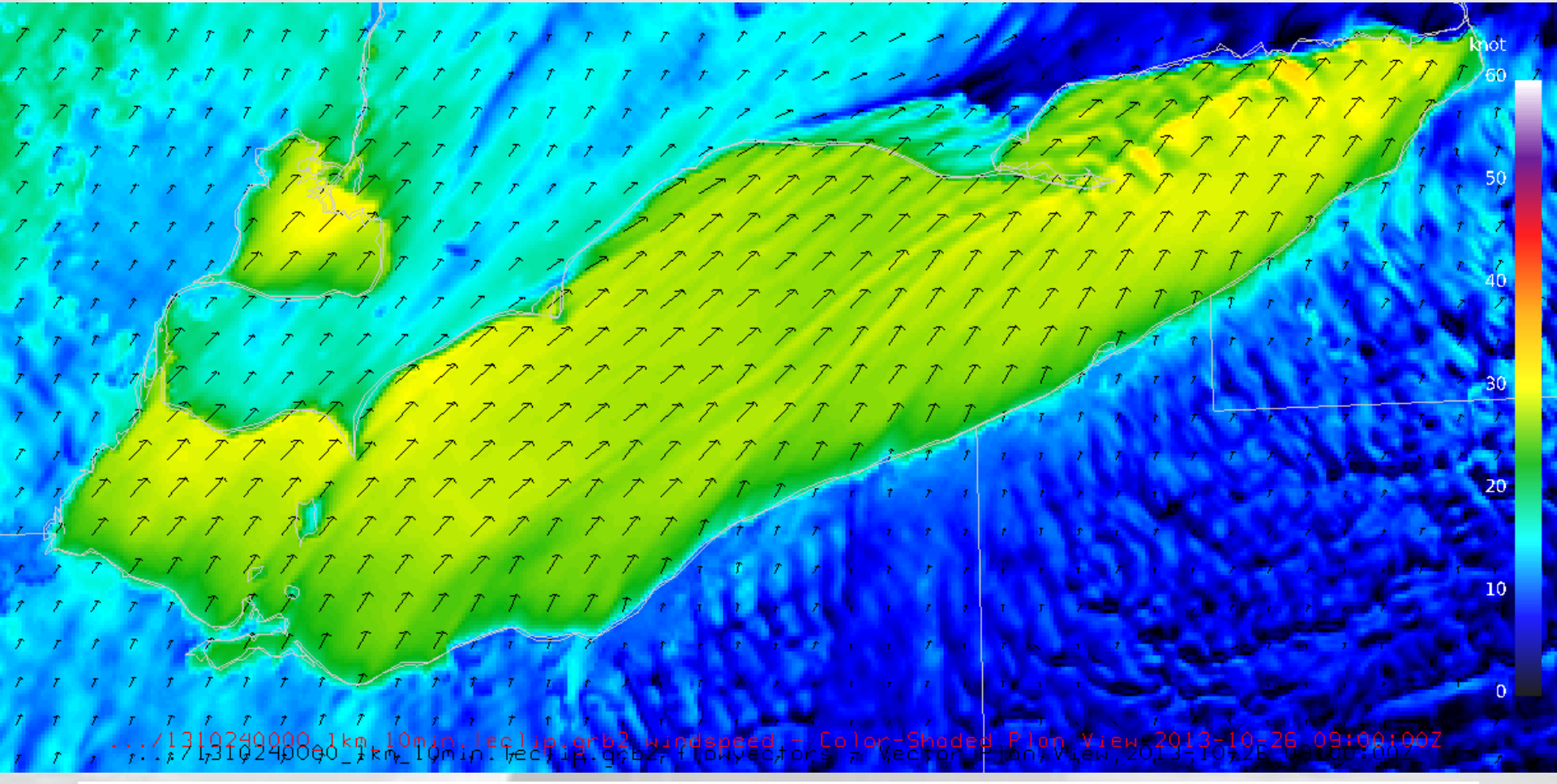
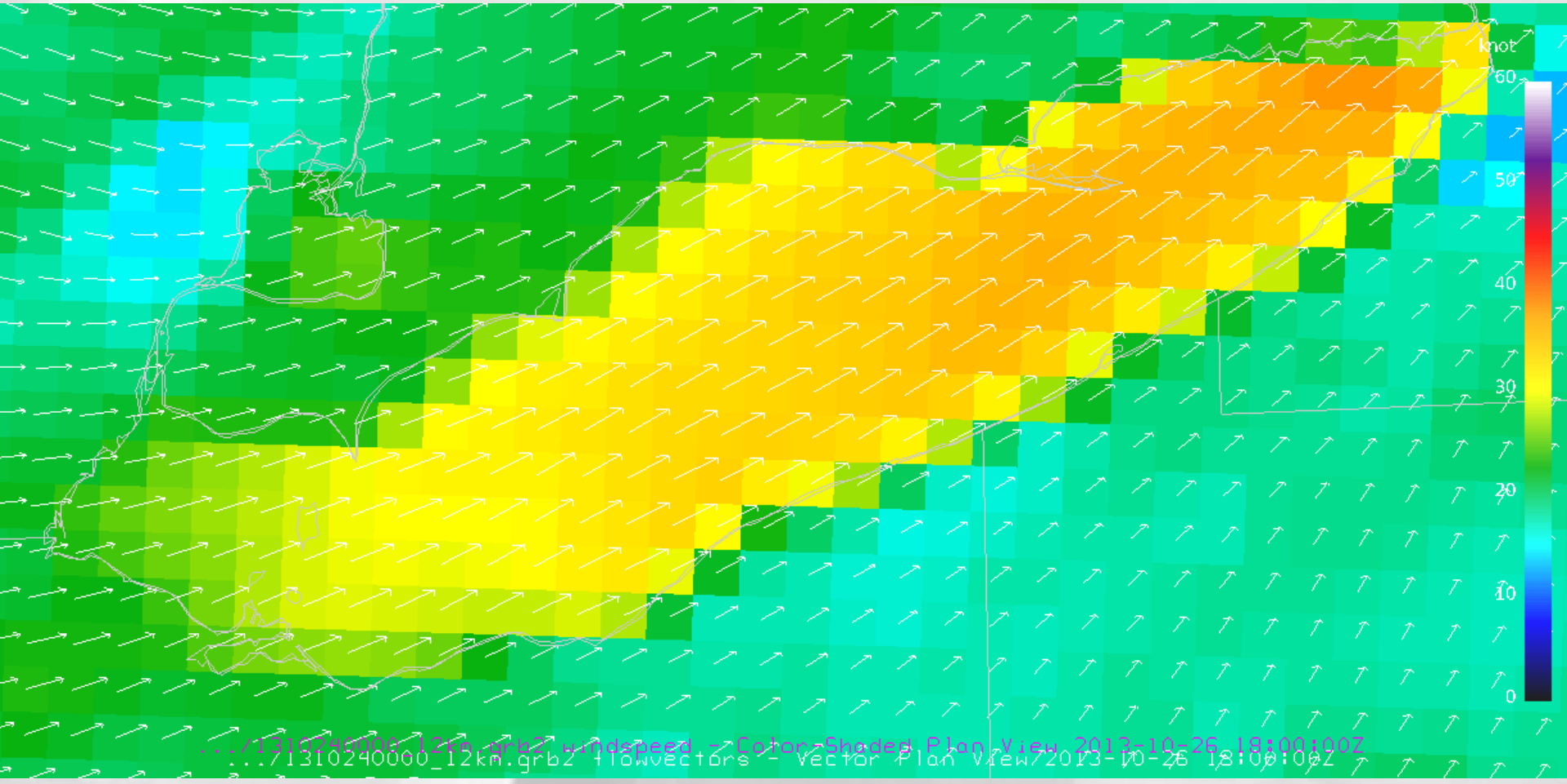


Refined detail indicating formation of convective roll structures are responsible for the momentum transport to the surface rather than slab overturning as shown in the coarse domain.

NWP Resolution Comparisons - 12km



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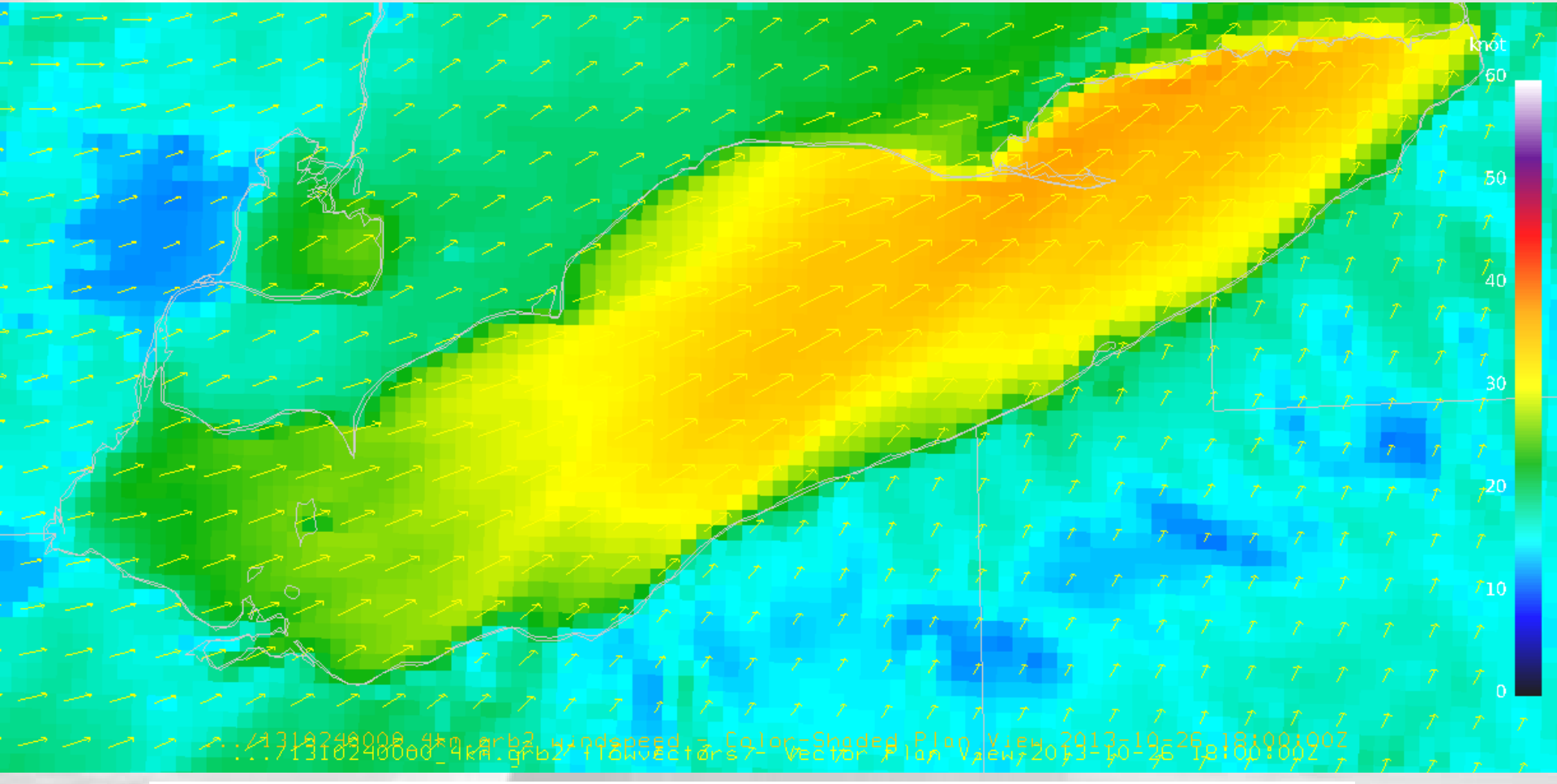

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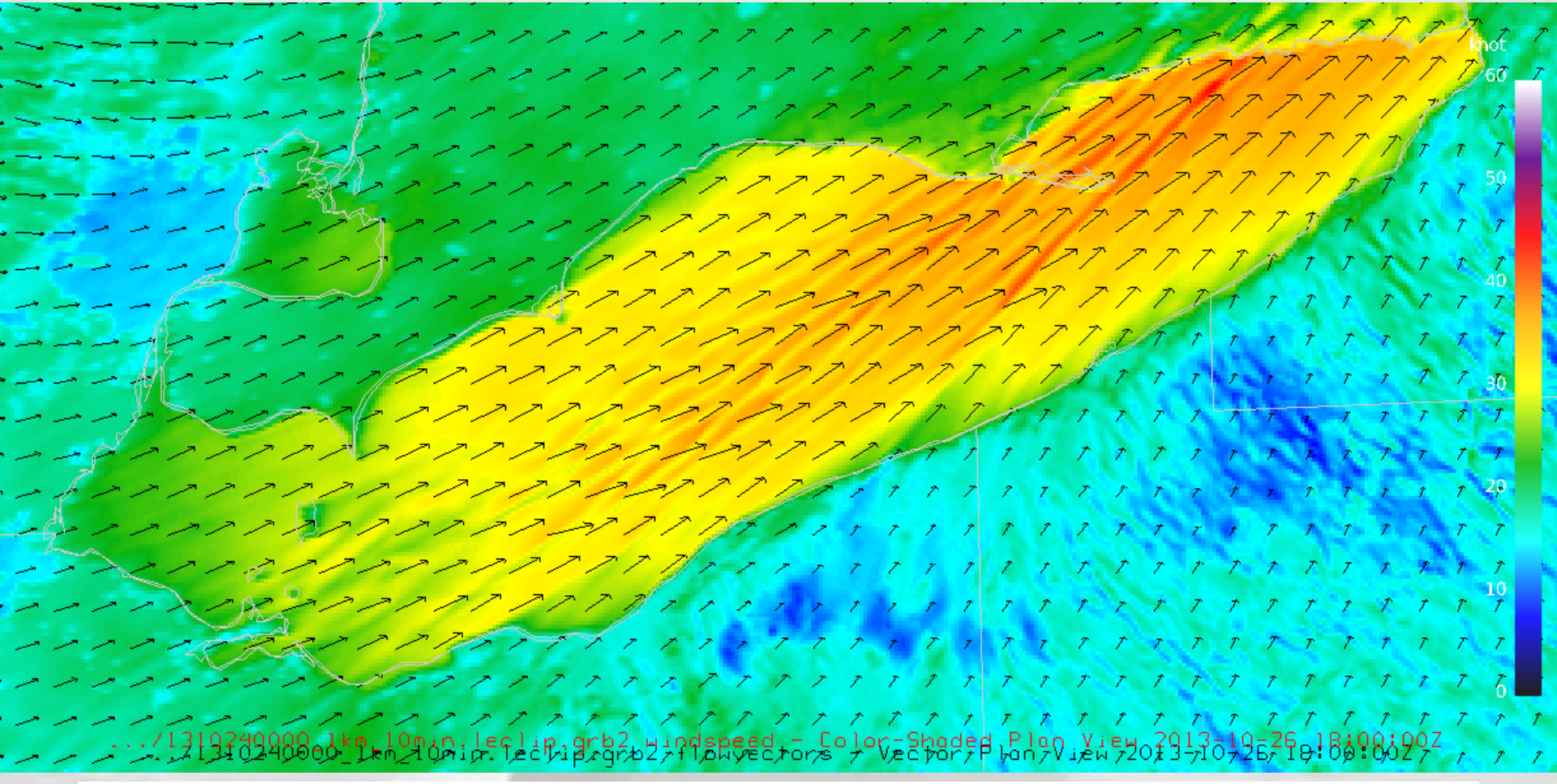

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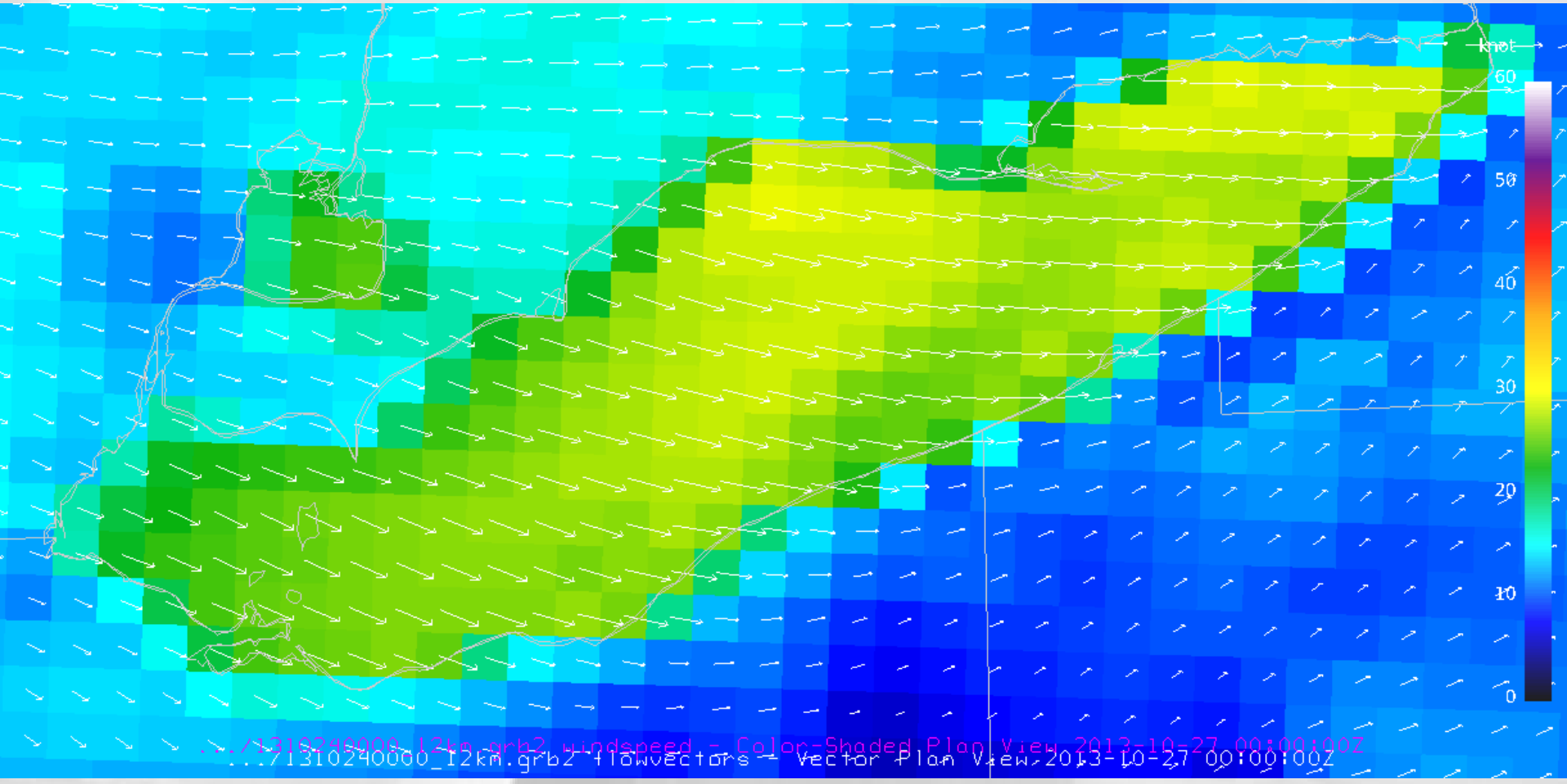

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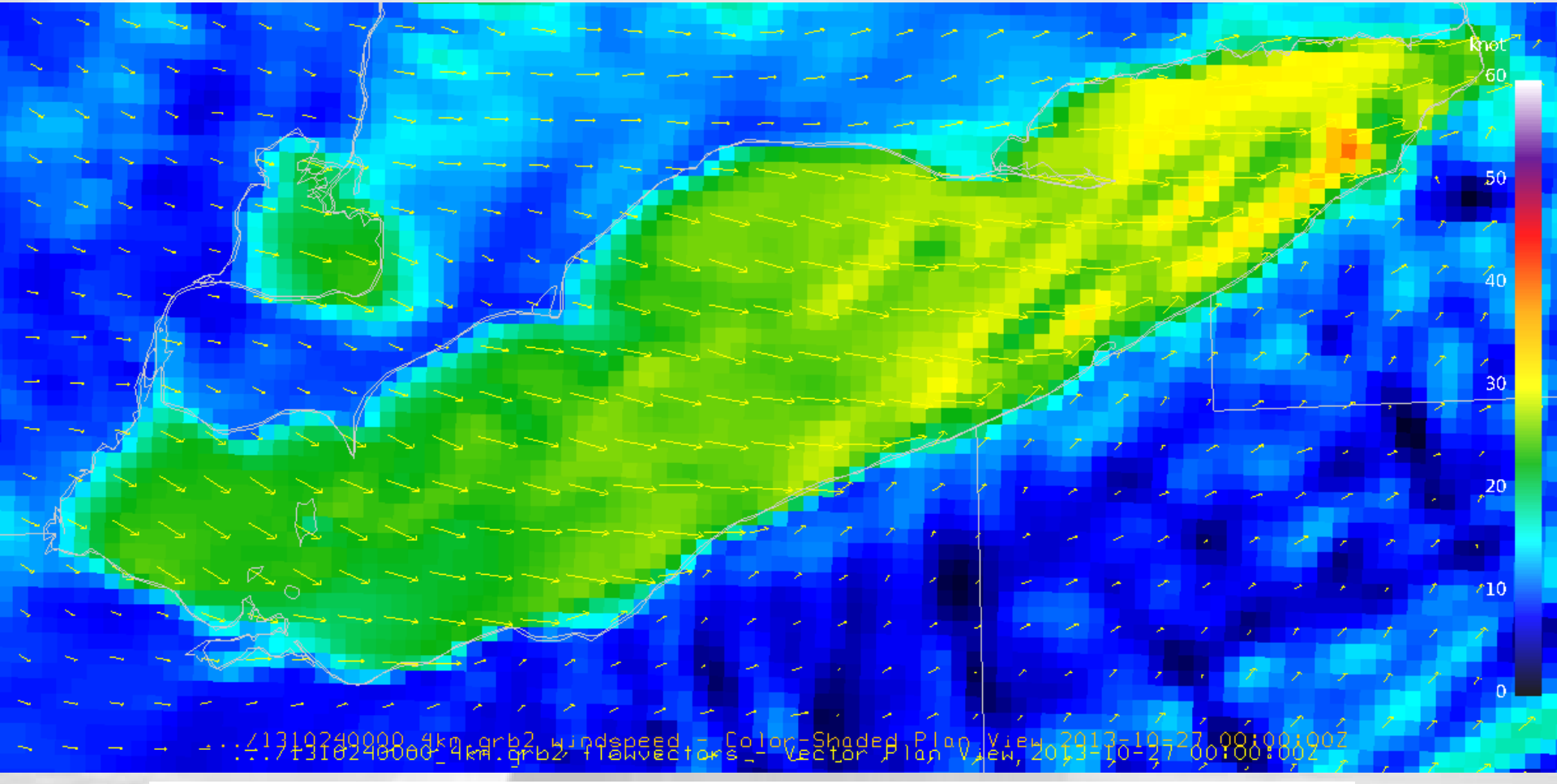
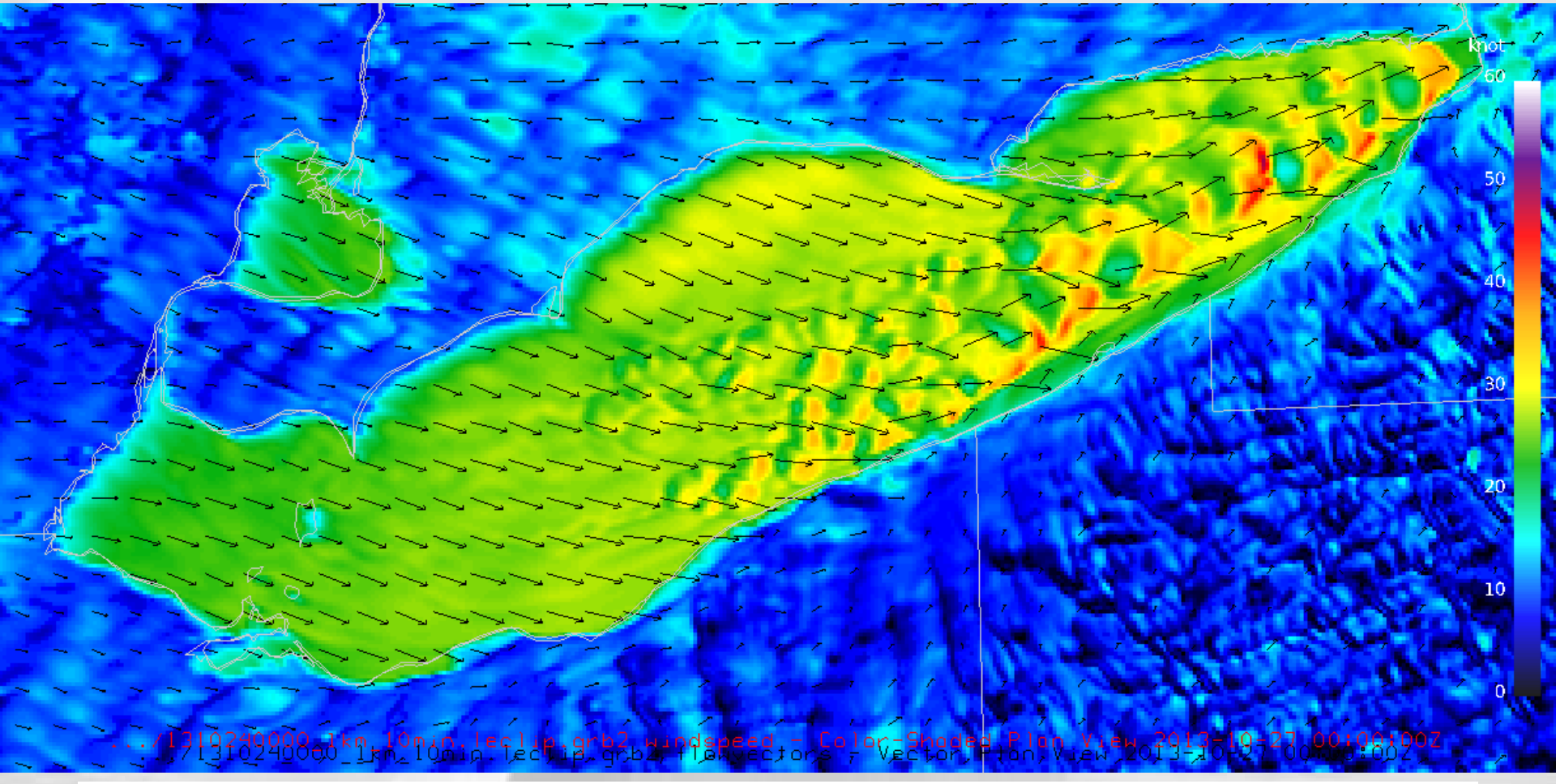


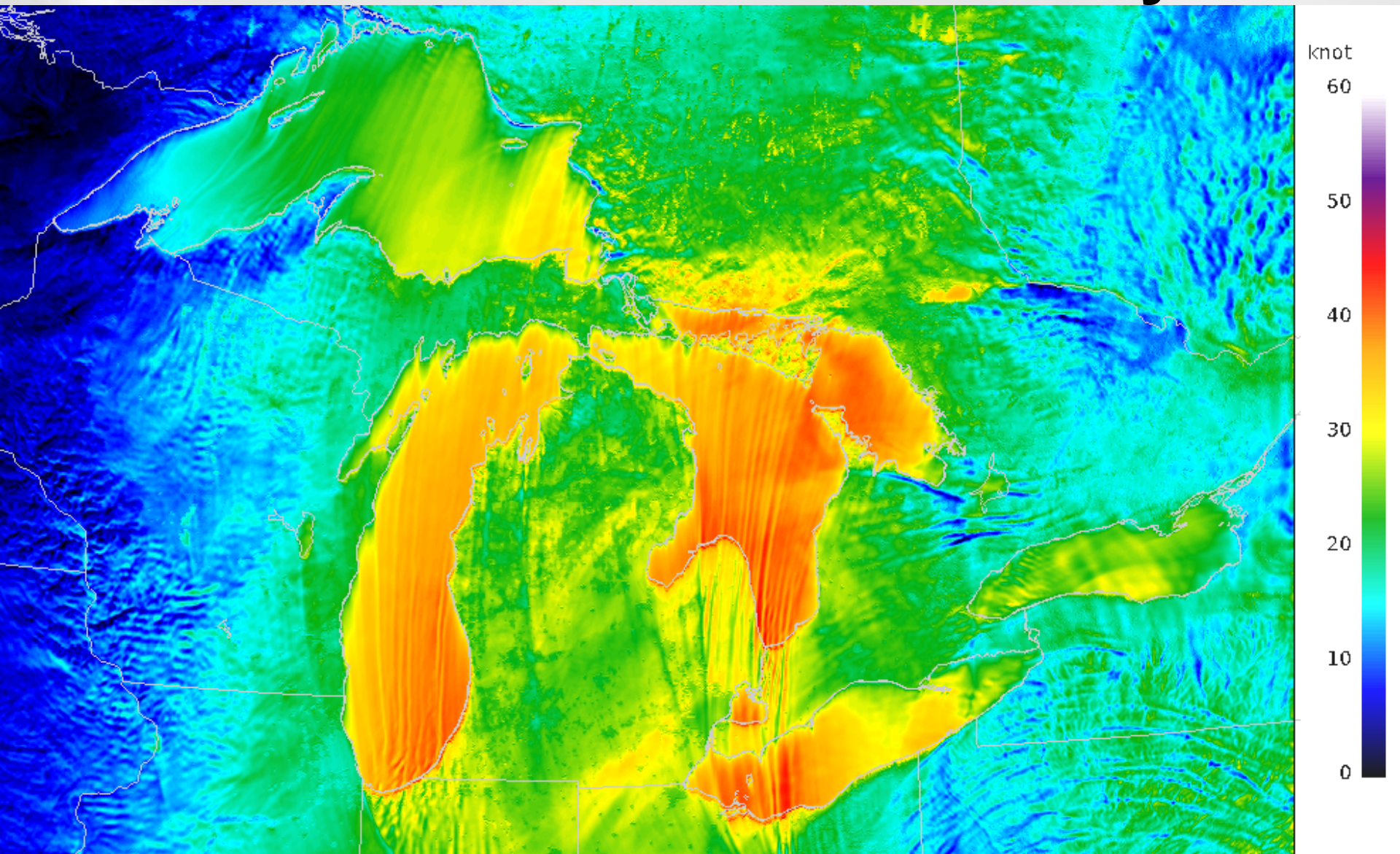
Momentum structure much more structured than 12km representation - signifying smaller scale processes once again are the dominant mode.

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.

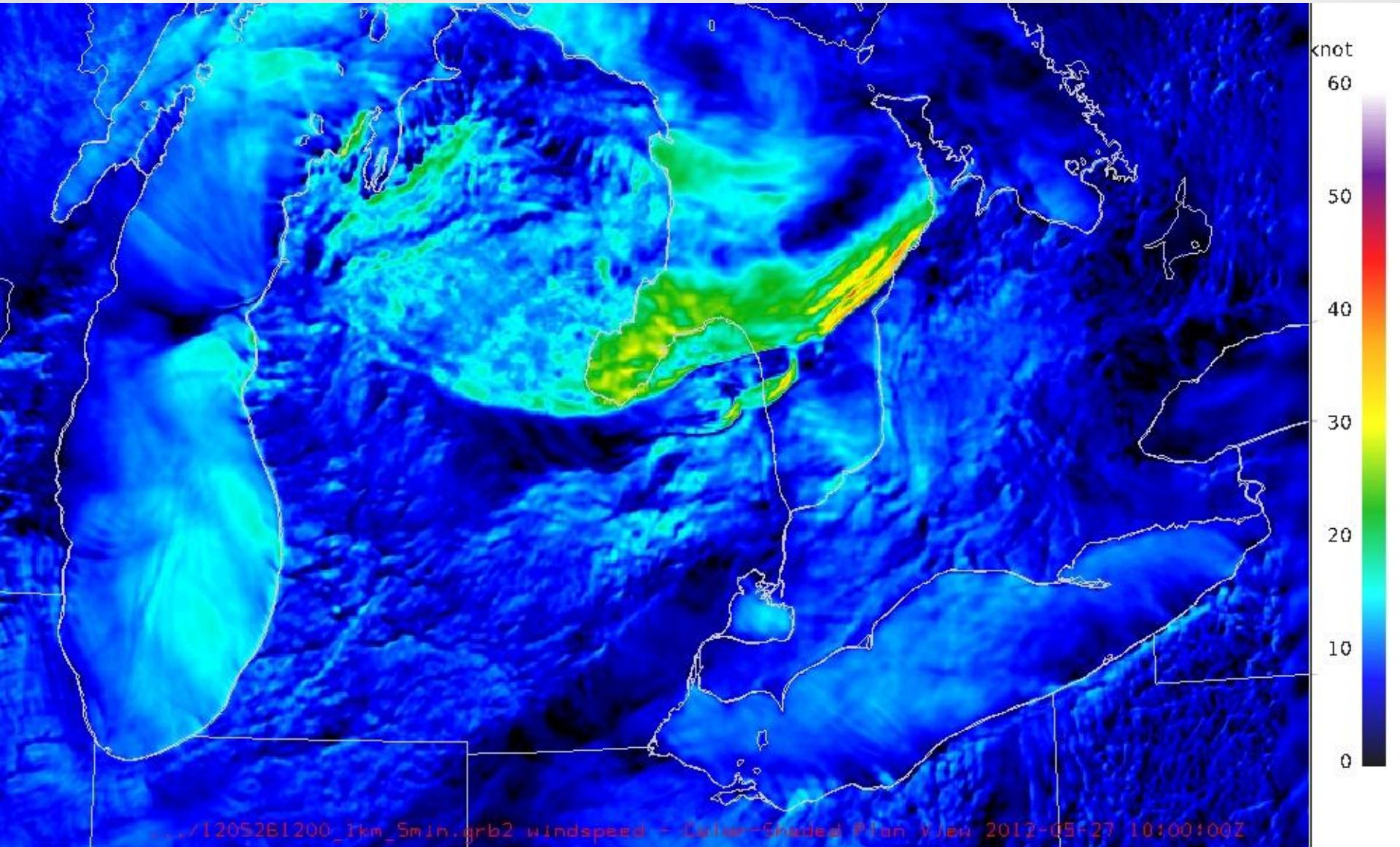
NWP Resolution - 1km of “Sandy”



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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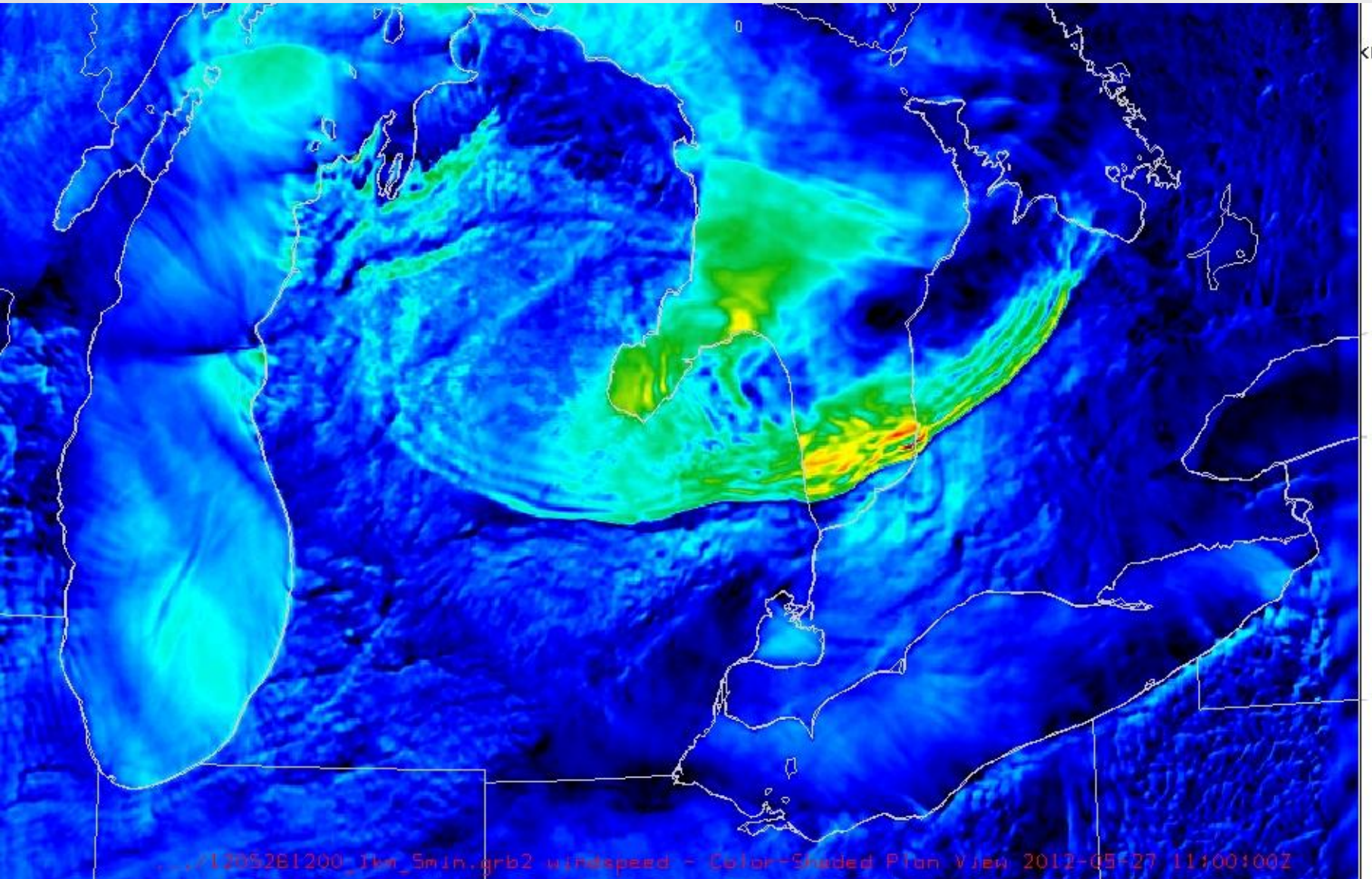

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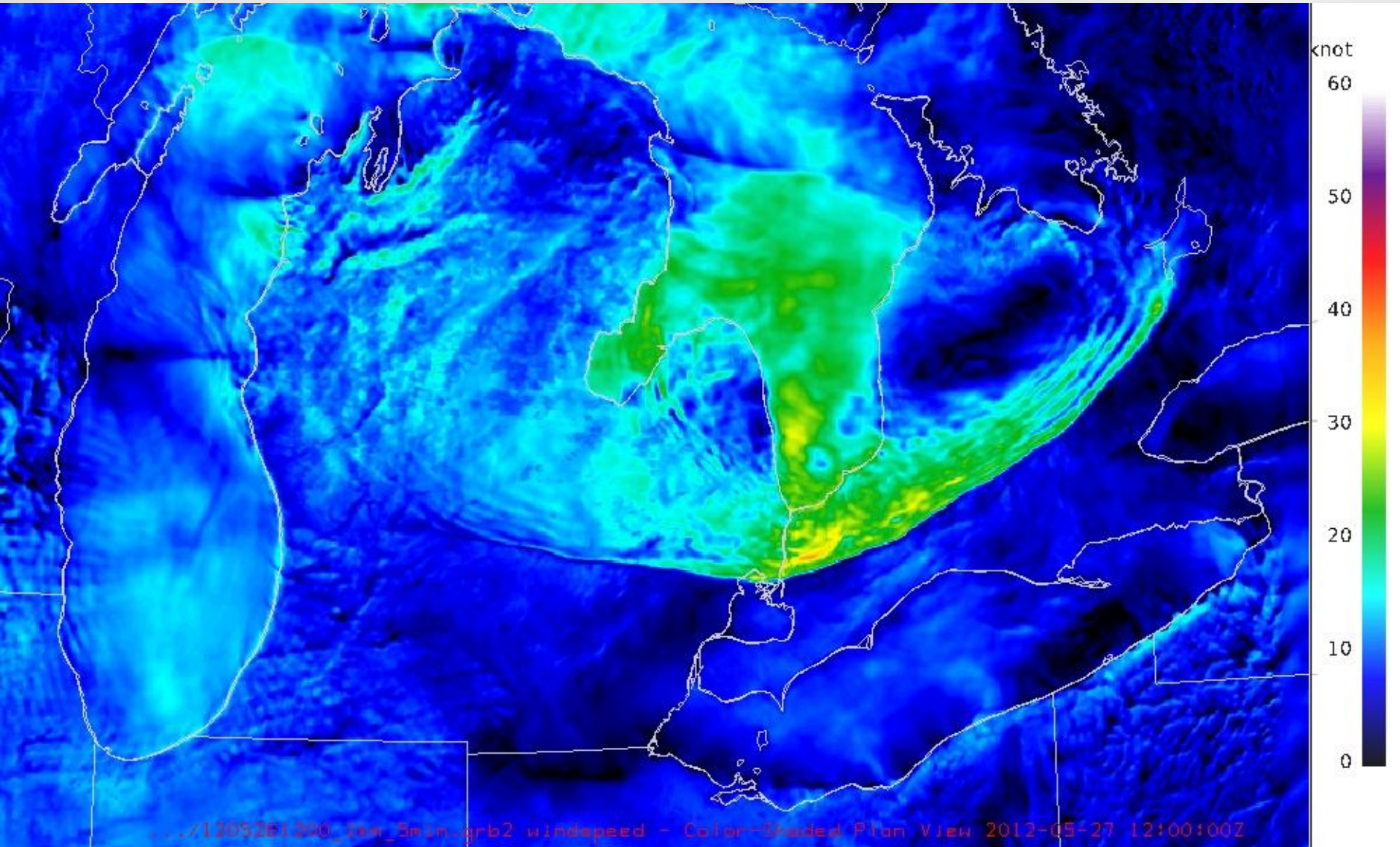

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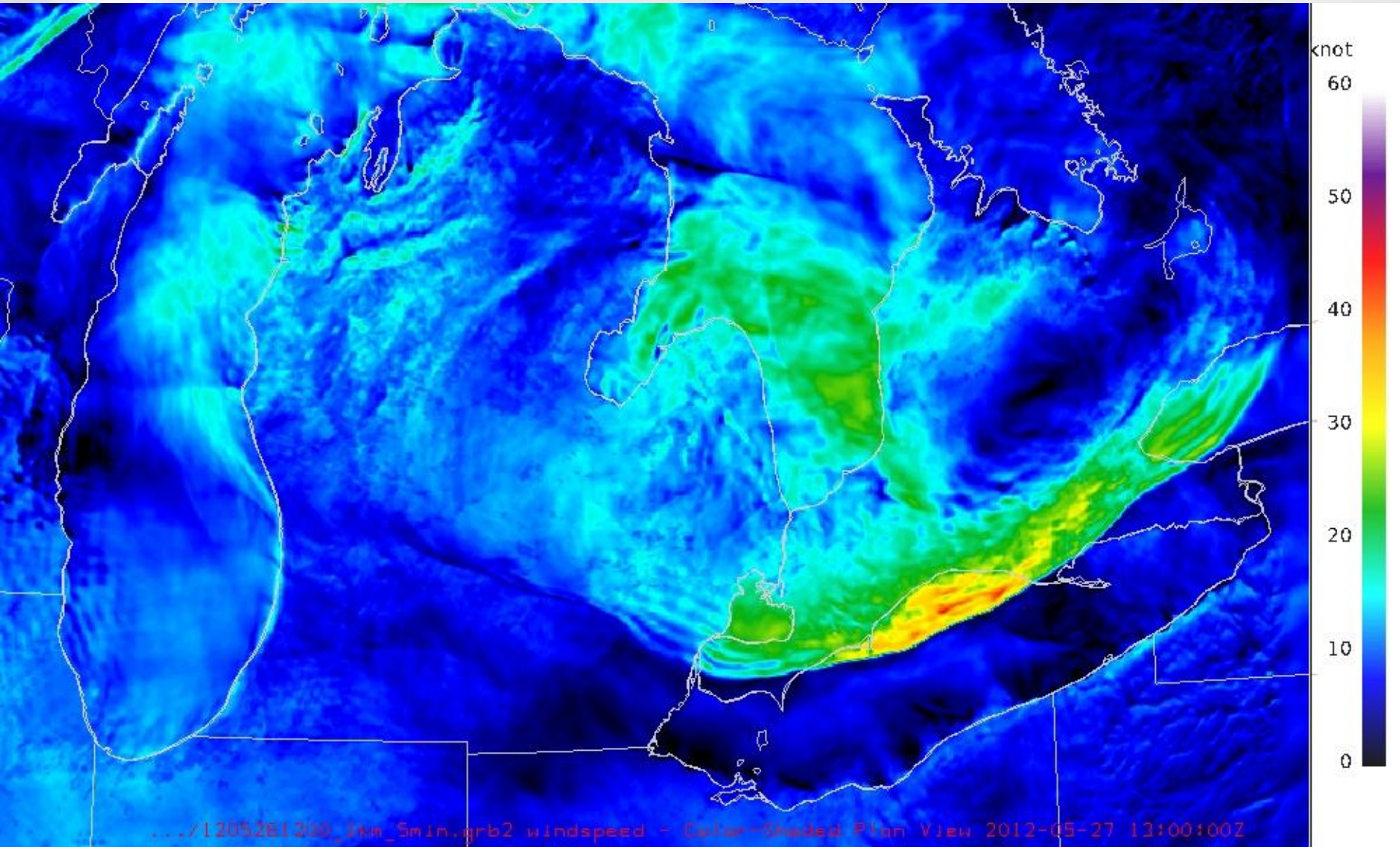

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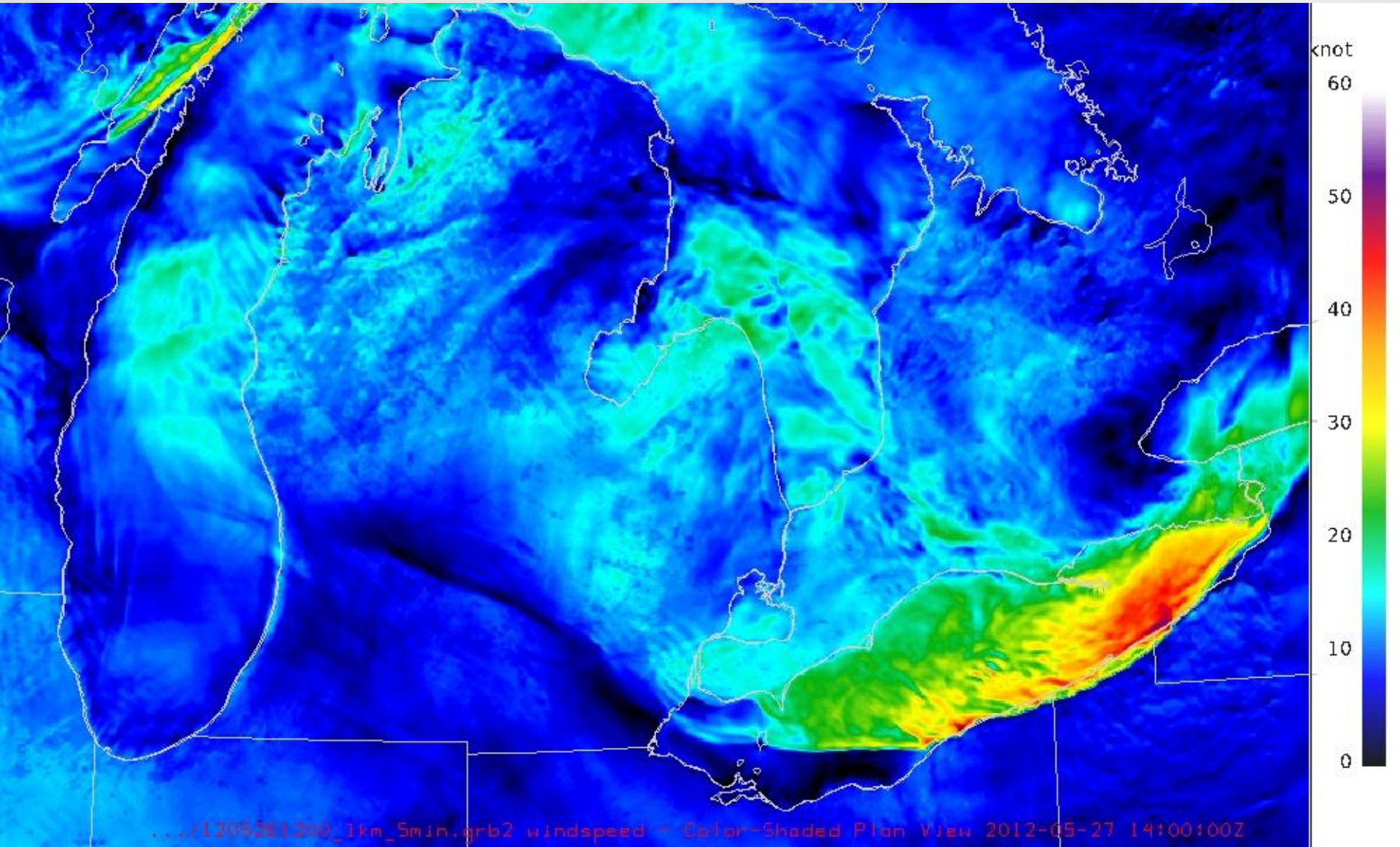

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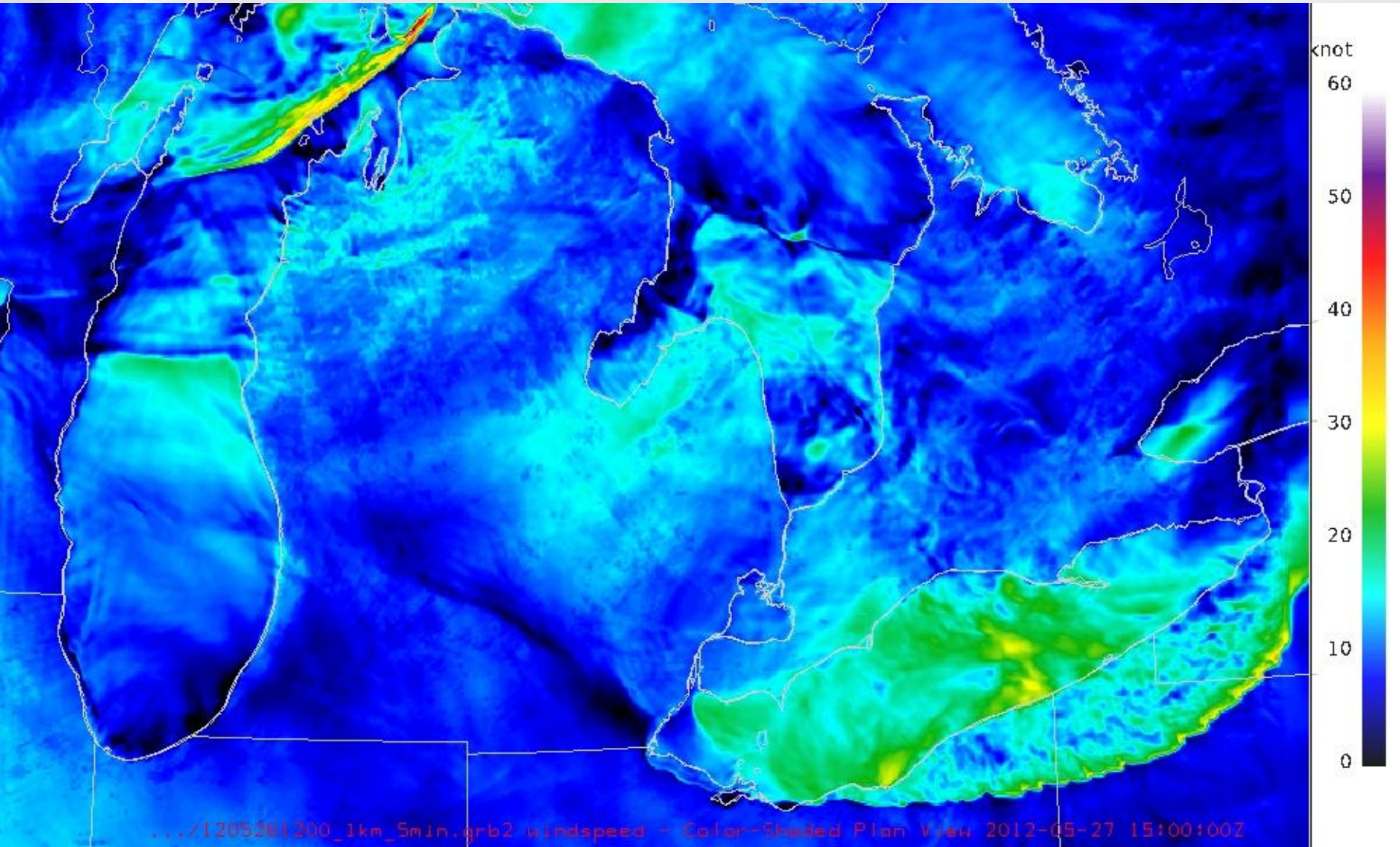

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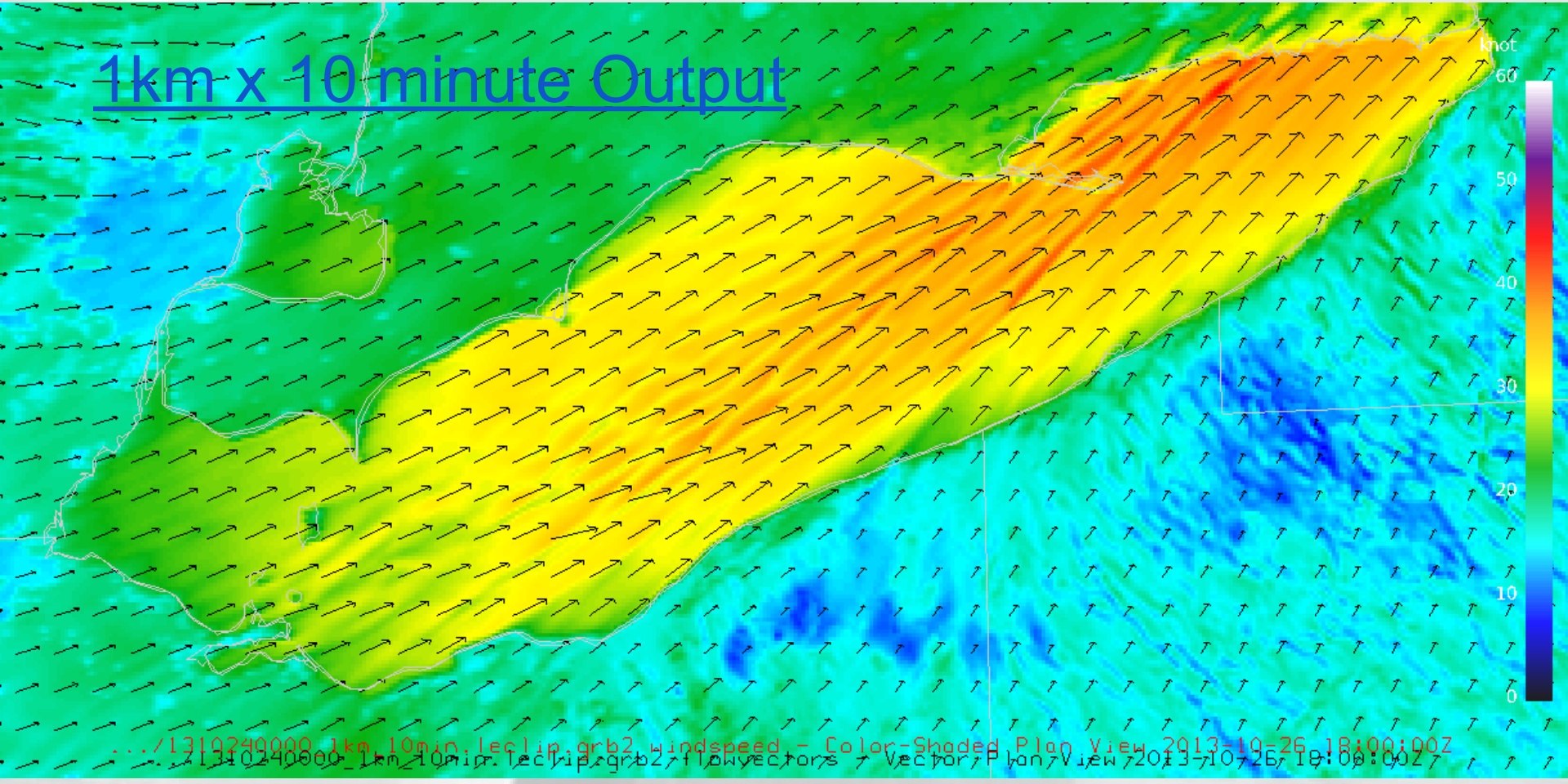


NWP Resolution - temporal variance

- 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 is 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

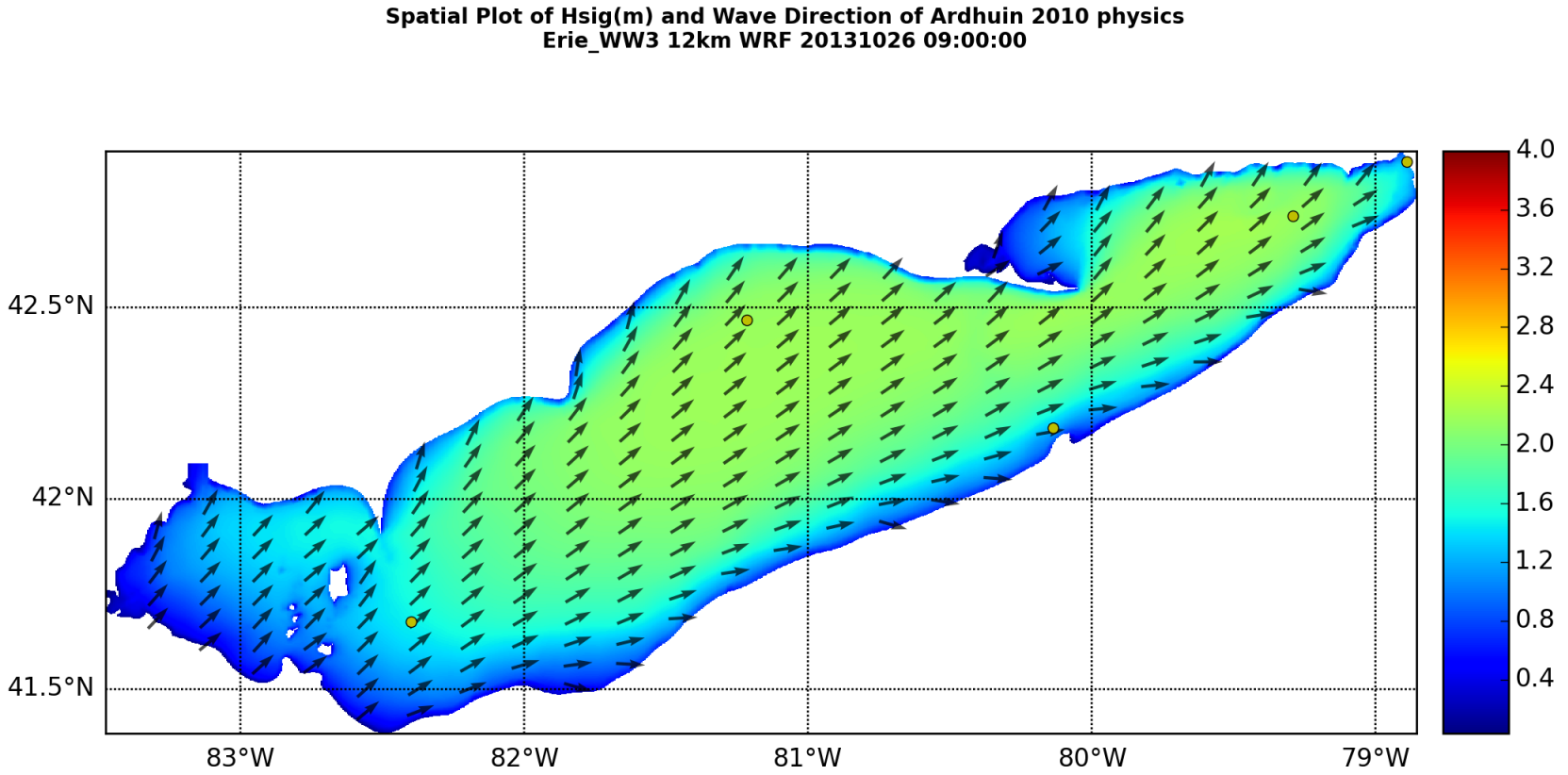
??? Questions ???

greg.mann@noaa.gov

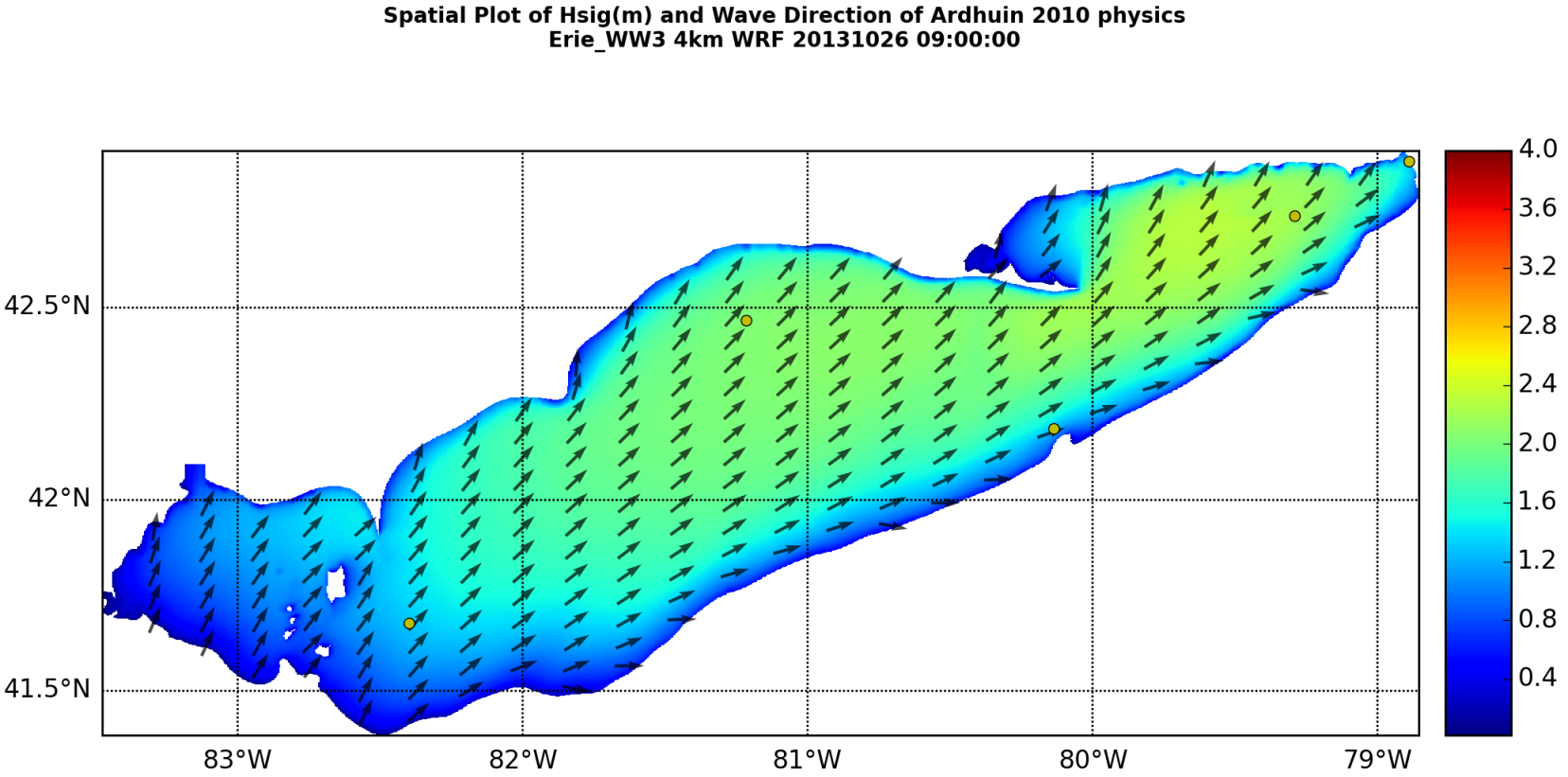
Additional Information: Impacts on Wavewatch3

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

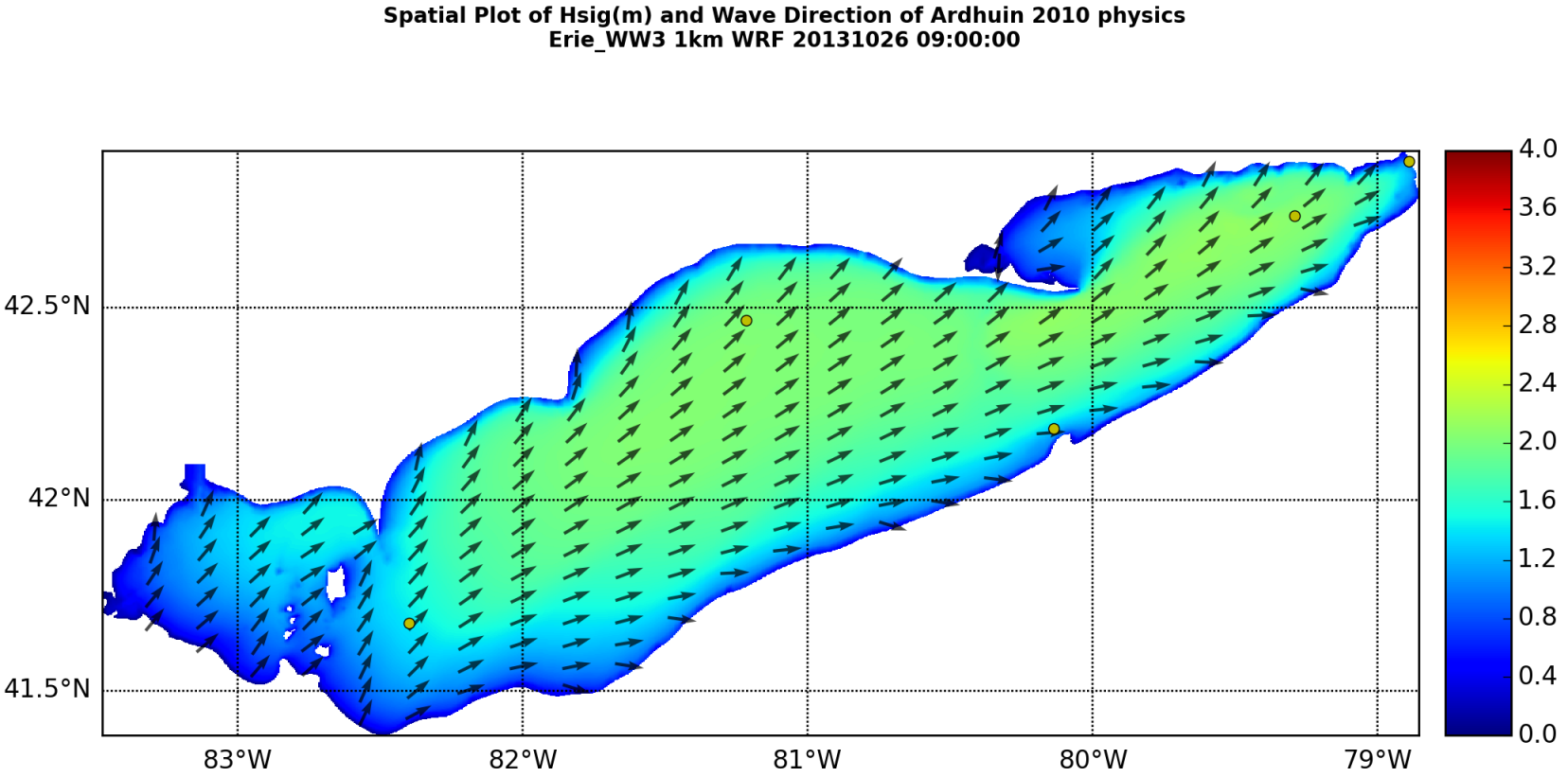
Wave sensitivity - 12km



Wave sensitivity - 4km



Wave sensitivity - 1km



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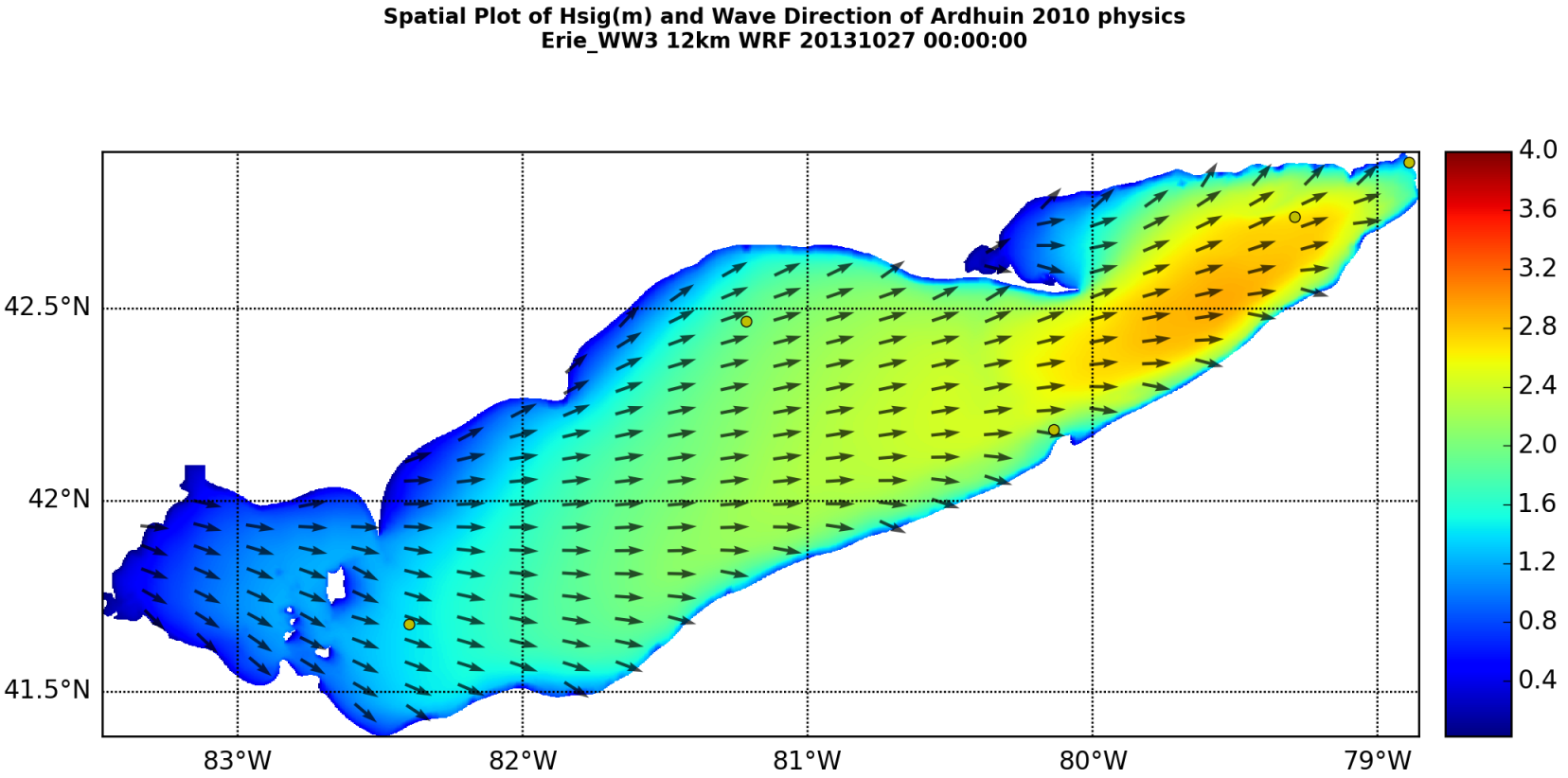
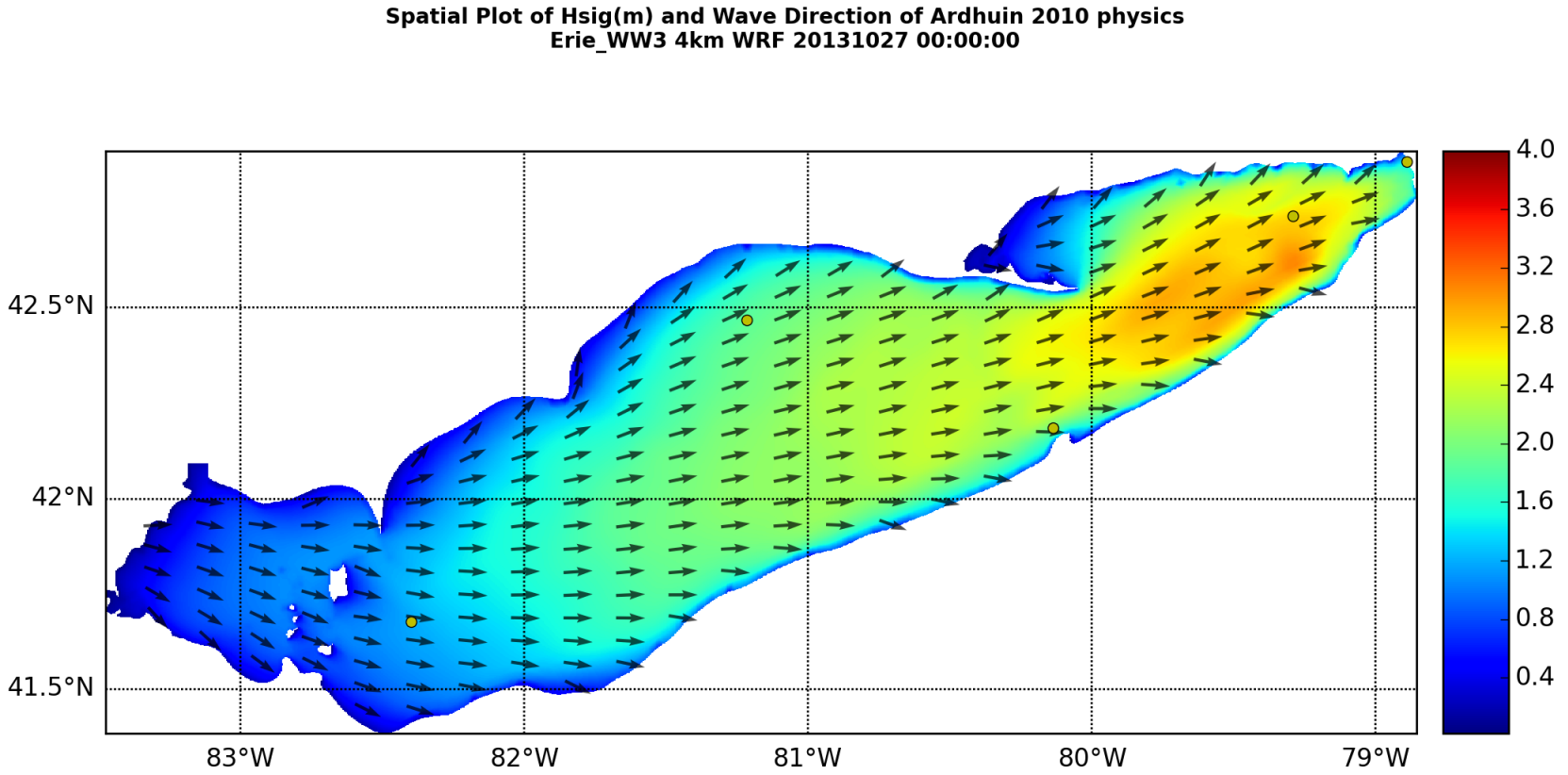


Wave sensitivity - 4km



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