Unveiling offshore wind resources during the WFIP-3 field campaign

Preliminary results from one ground-based scanning LiDAR

105th AMS Annual Meeting - New Orleans LA, USA

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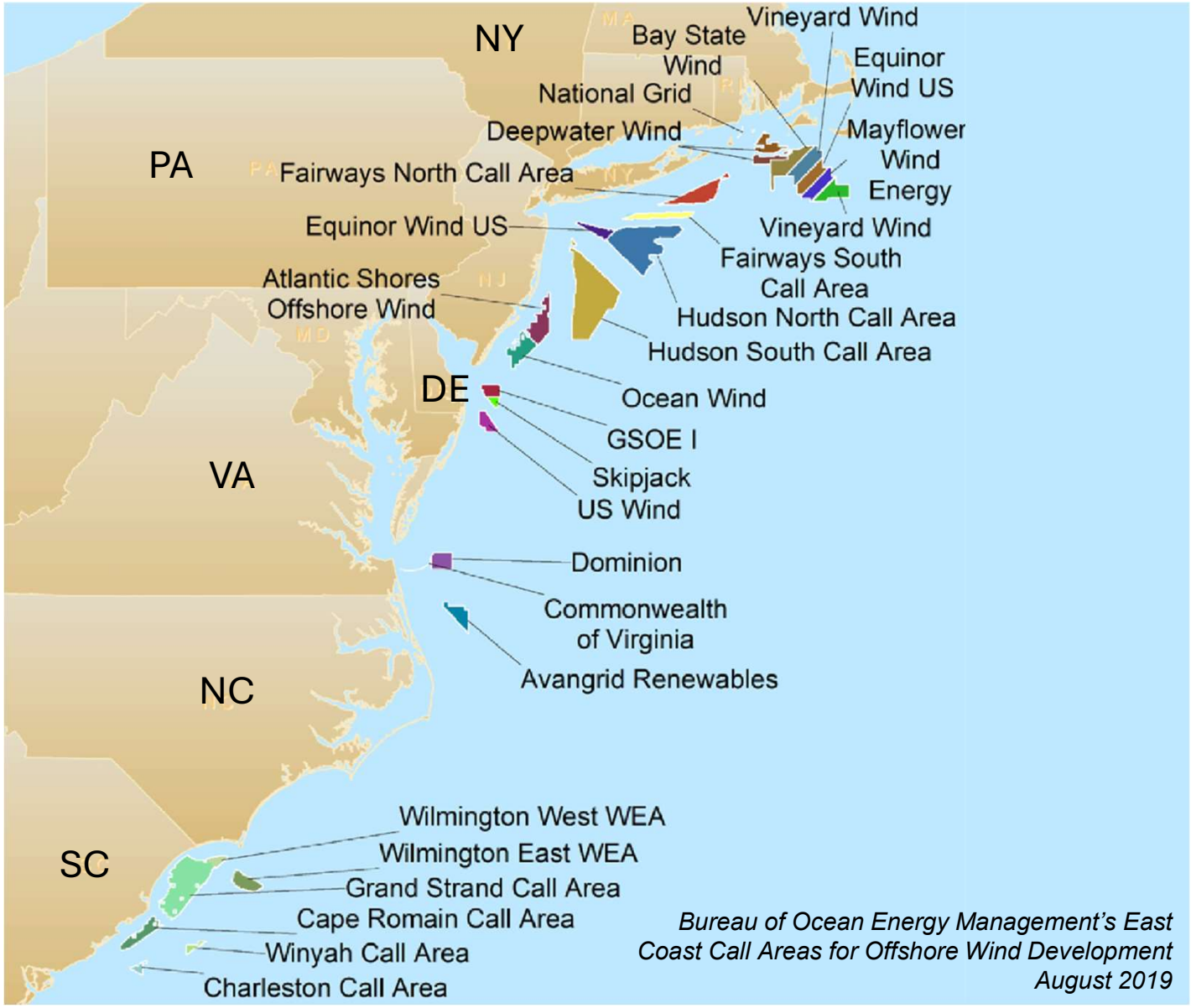


LLNL-PRES-2001864

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Offshore wind energy is rising along the North-East

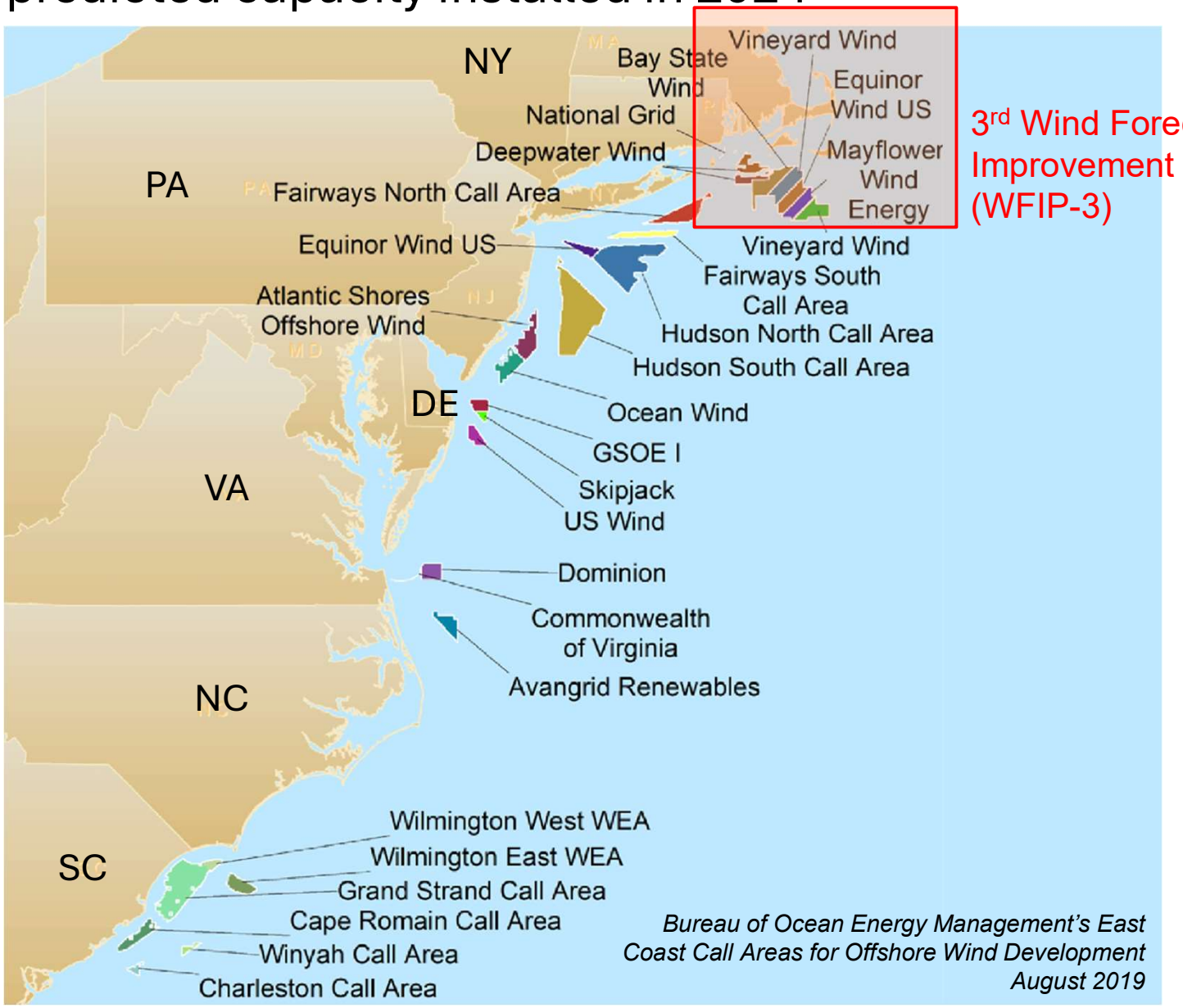
56.3 GW predicted capacity installed in 2024



Bureau of Ocean Energy Management's East Coast Call Areas for Offshore Wind Development August 2019

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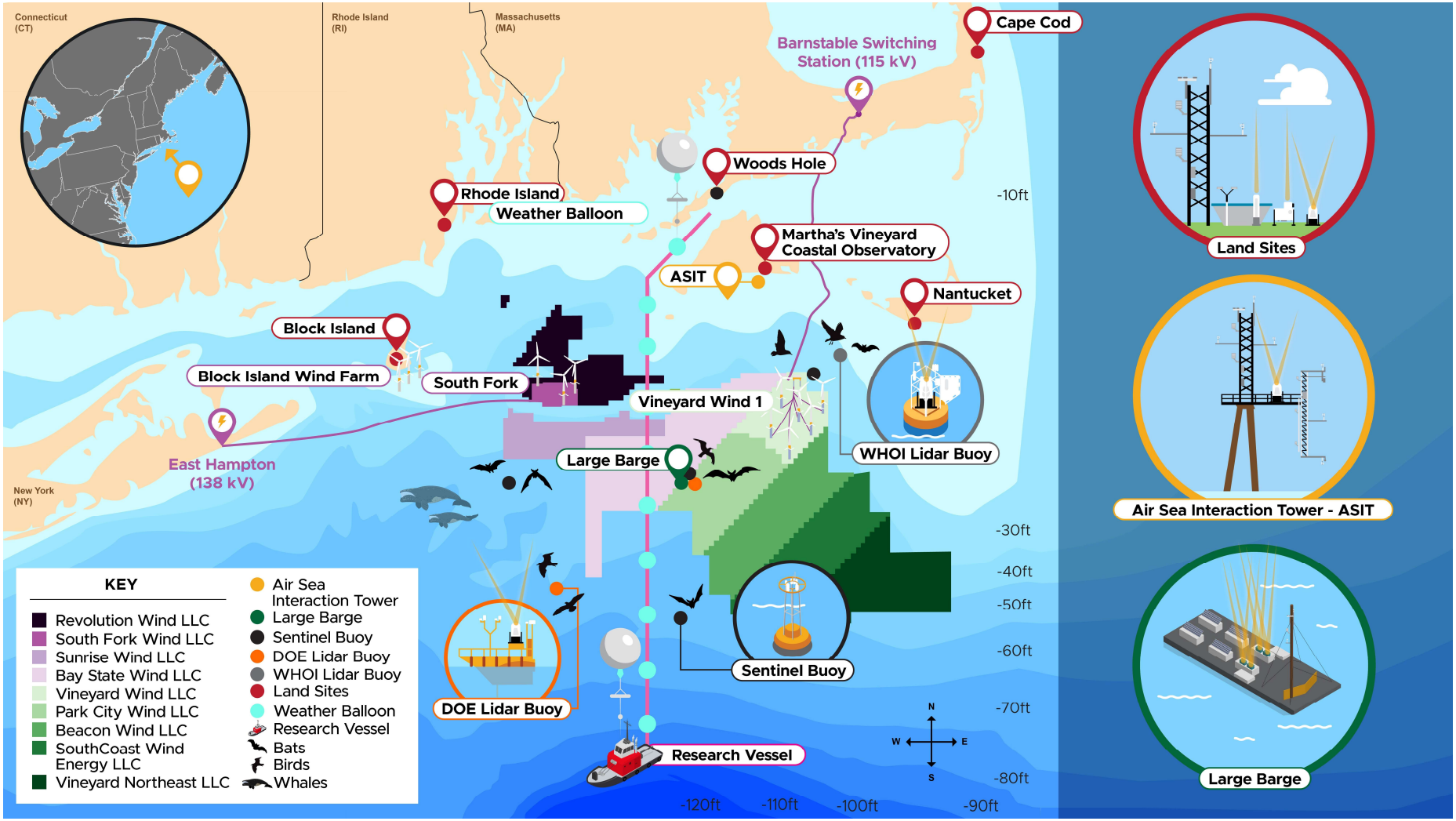


Bureau of Ocean Energy Management's East Coast Call Areas for Offshore Wind Development August 2019

3rd Wind Forecast Improvement Project (WFIP-3)

WFIP-3 explores focuses on various scientific areas

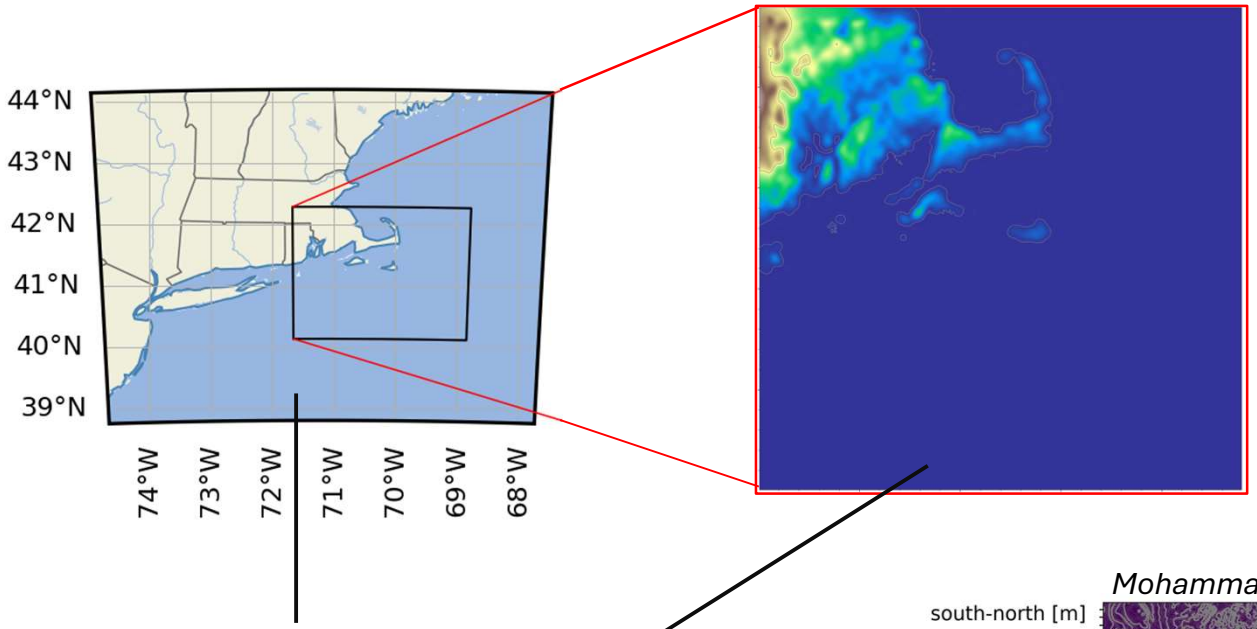
Land sites, buoys, barges, ships, etc. are utilized



Anthony Kirincich, WHOI

A key goal of WFIP-3 is to validate numerical tools

A broad range of resolutions is used for nested numerical domains

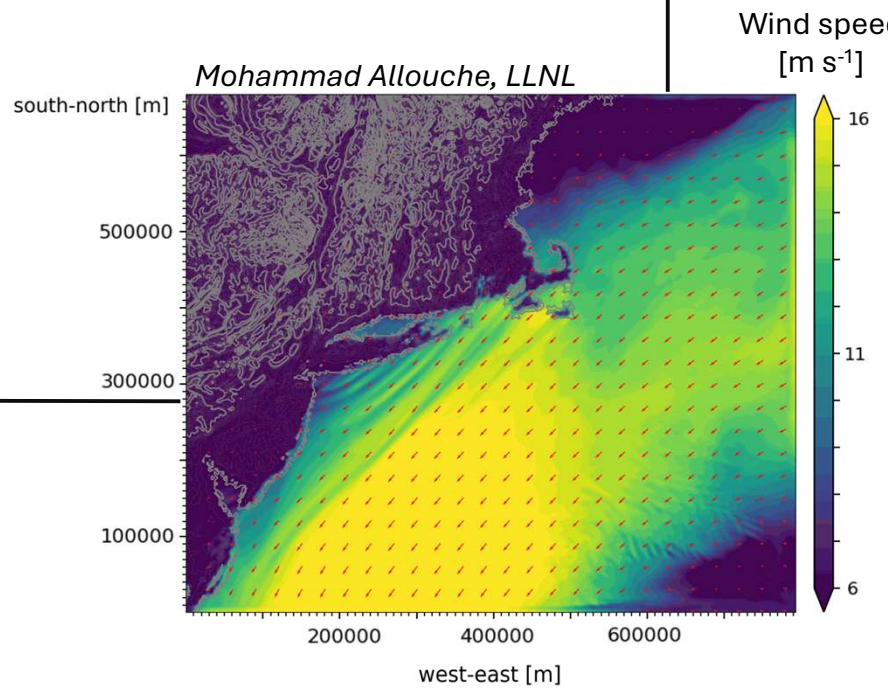


Offshore wind speed predicted by WRF + 1.5TKE LES

Resolution: **2400** m

Resolution: **800** m

Resolution: **40** m

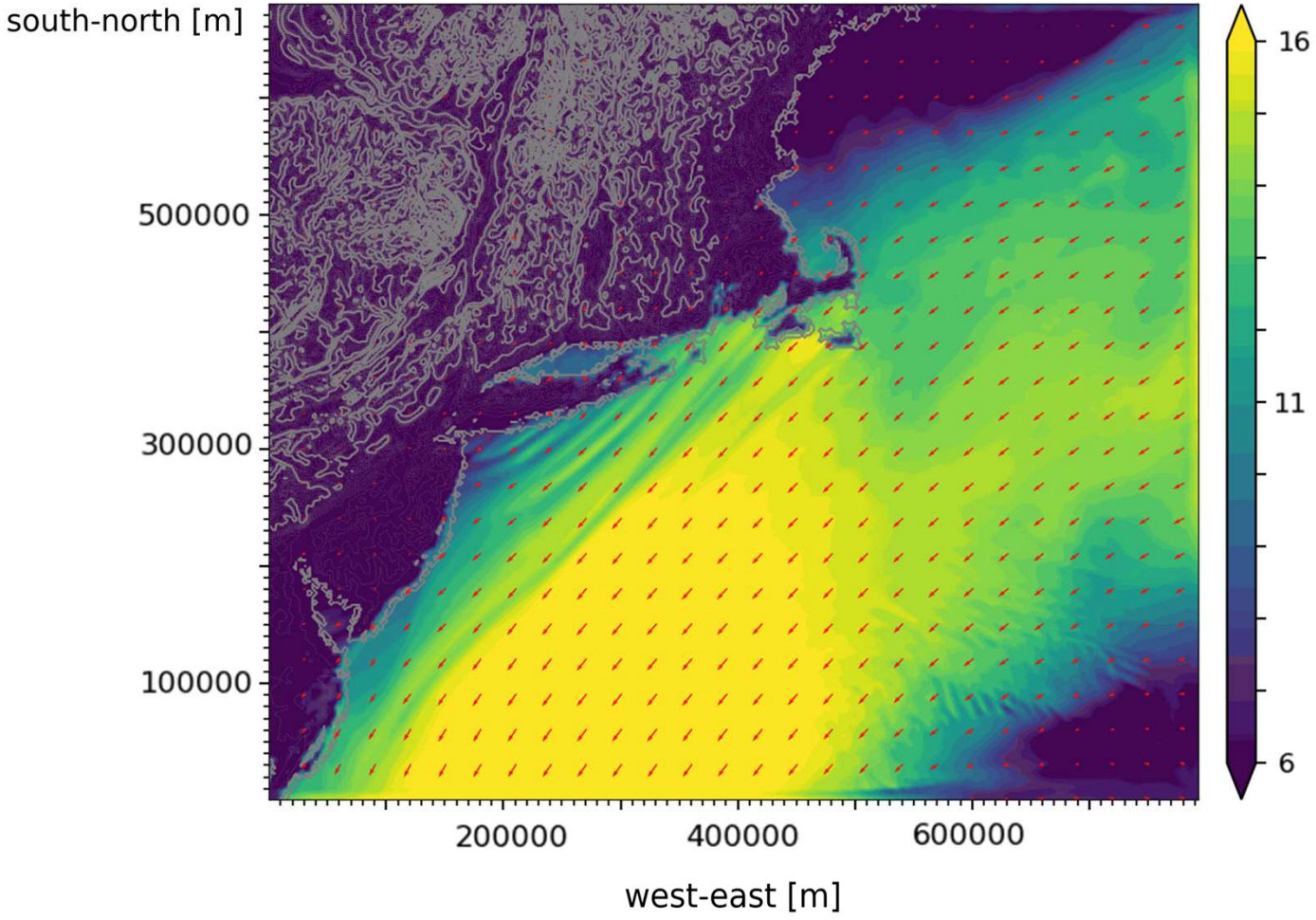


Does WRF/LES correctly predict the wind resources?

A key goal of WFIP-3 is to validate numerical tools

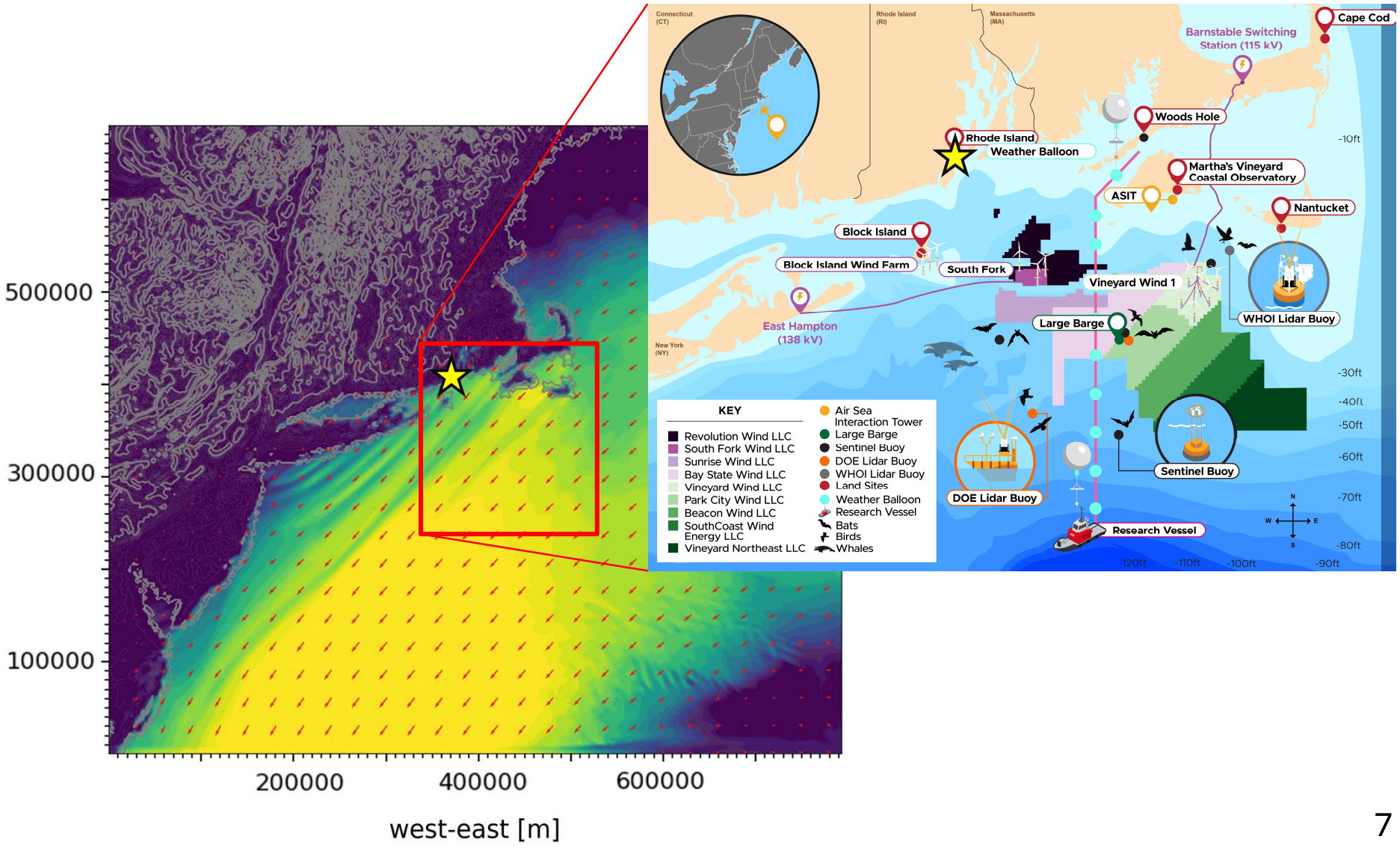
Coastal and island impacts are of particular interest

Goal: Build up observational datasets to validate WRF-LES results



An onshore site (RHOD) is chosen to collect ABL data

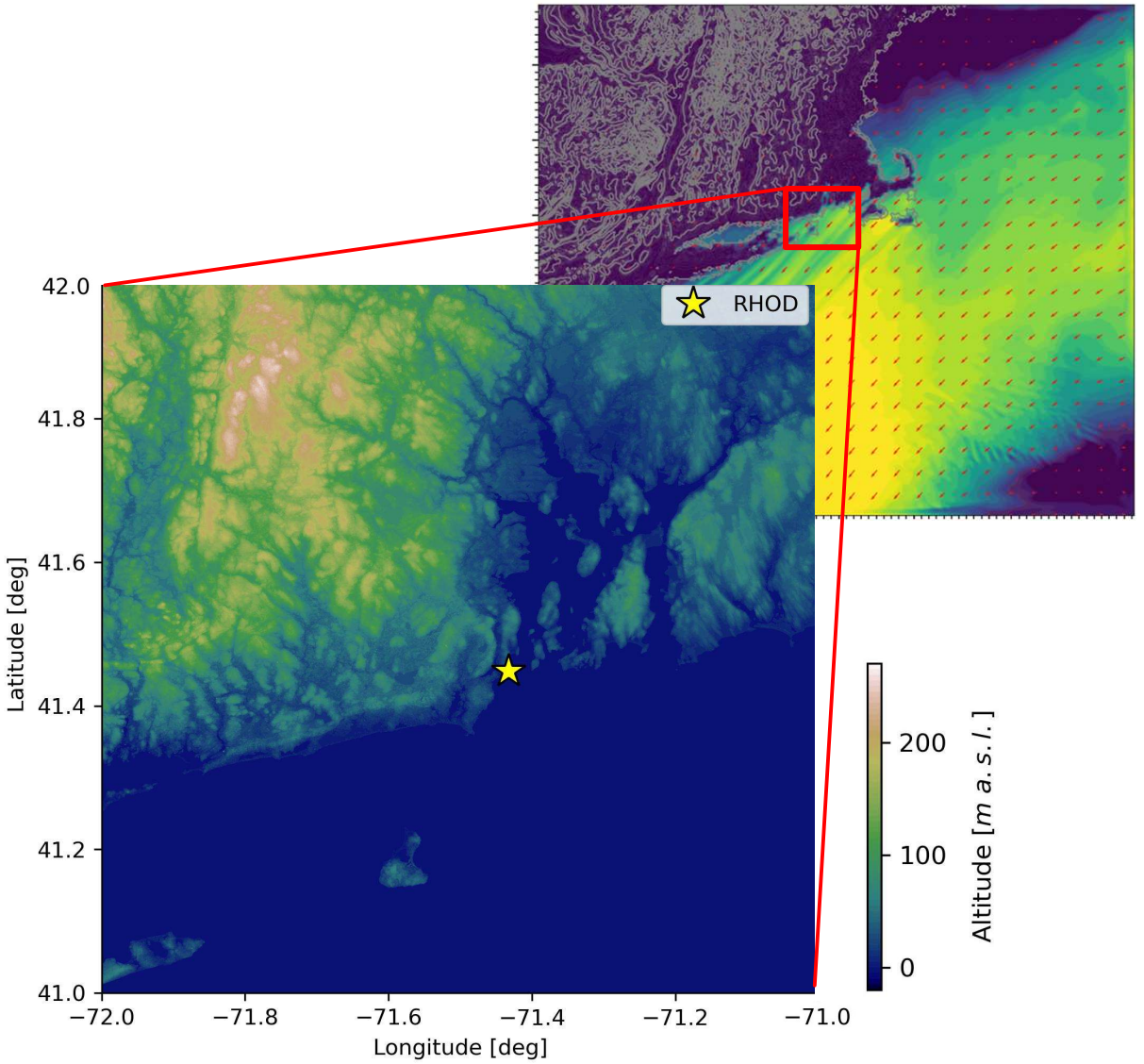
The RHOD site is within the numerical domain



An onshore site (RHOD) is chosen to collect ABL data

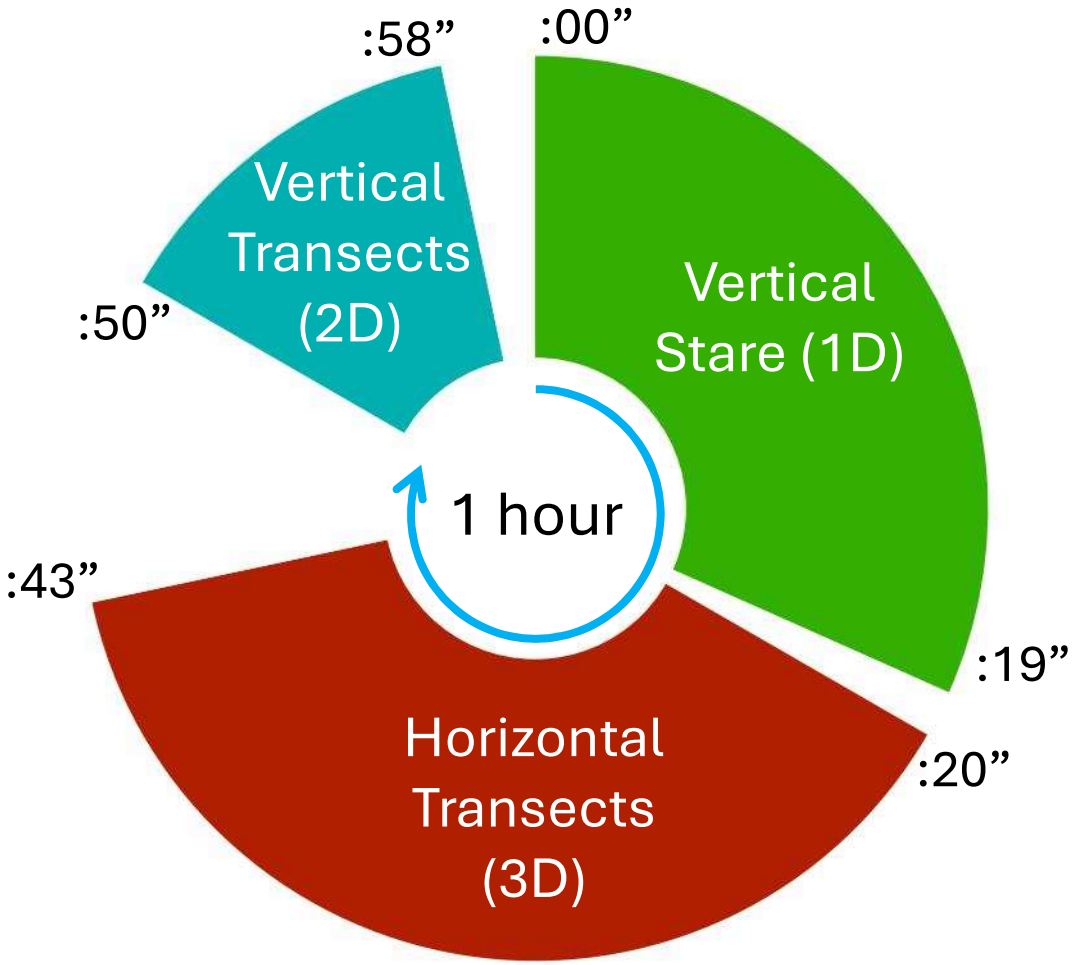
One scanning LiDAR is deployed at RHOD for 7.5 months





The LiDAR resolves the flow at 1D, 2D and 3D

The scan schedule is repeated every hour





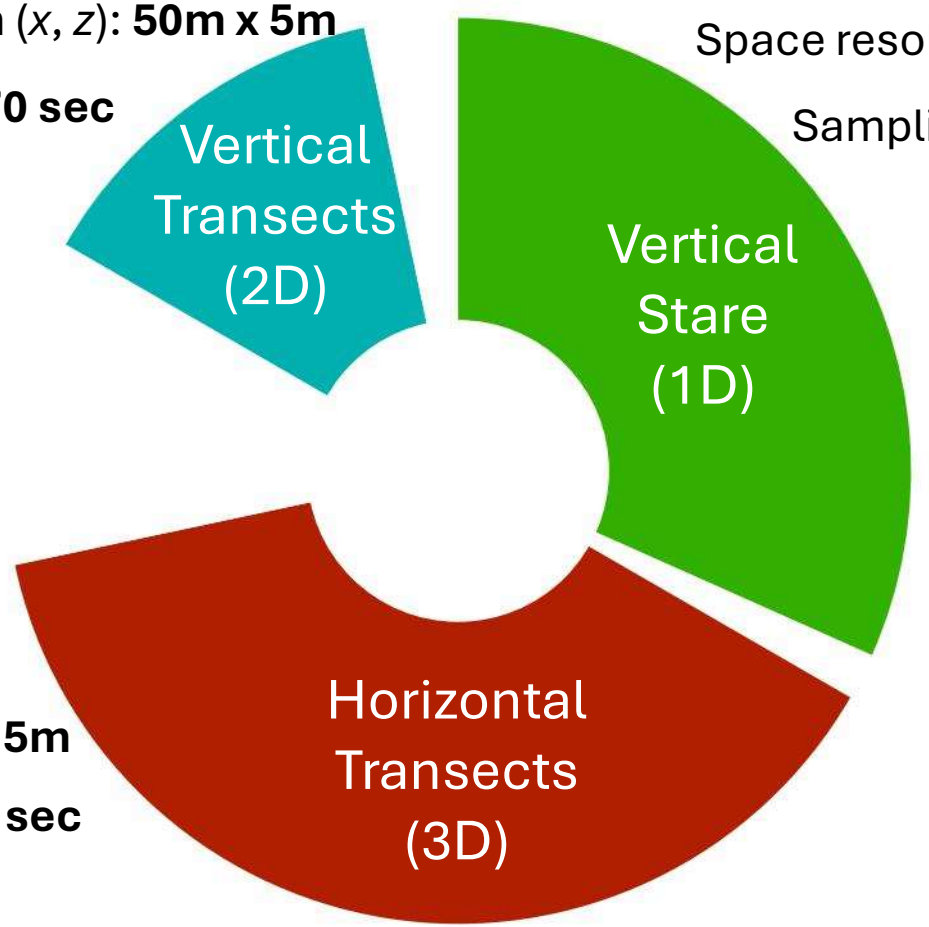
The LiDAR resolves the flow at 1D, 2D and 3D

The LiDAR resolution is the same order of magnitude as WRF/LES

Target resolution (WRF-LES): 40m, 1 sec

Space resolution (*x*, *z*): **50m x 5m**

Sampling time: **70 sec**



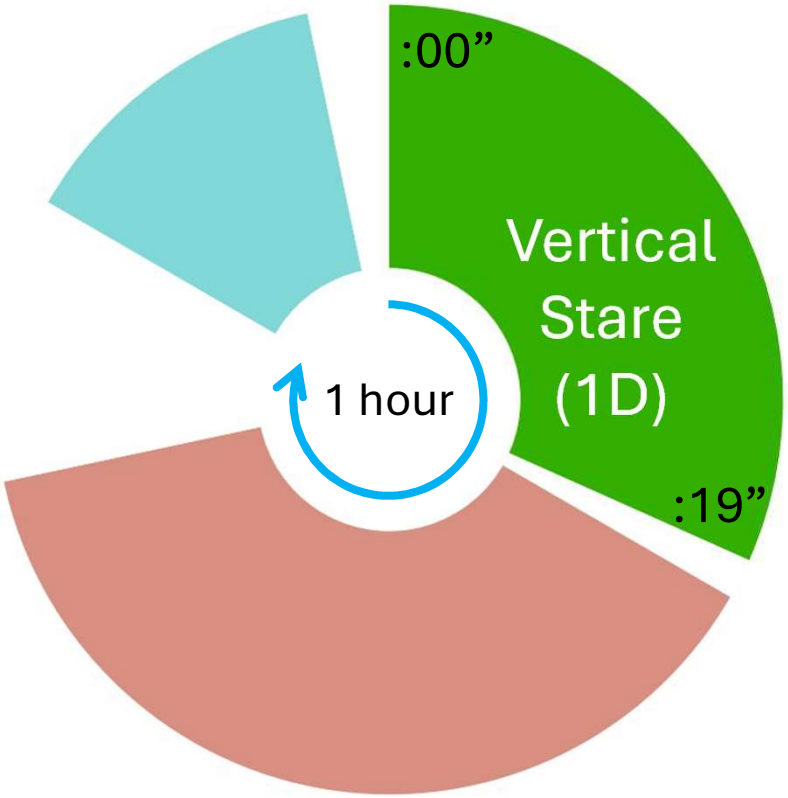
Space resolution (*z*): **30 m**

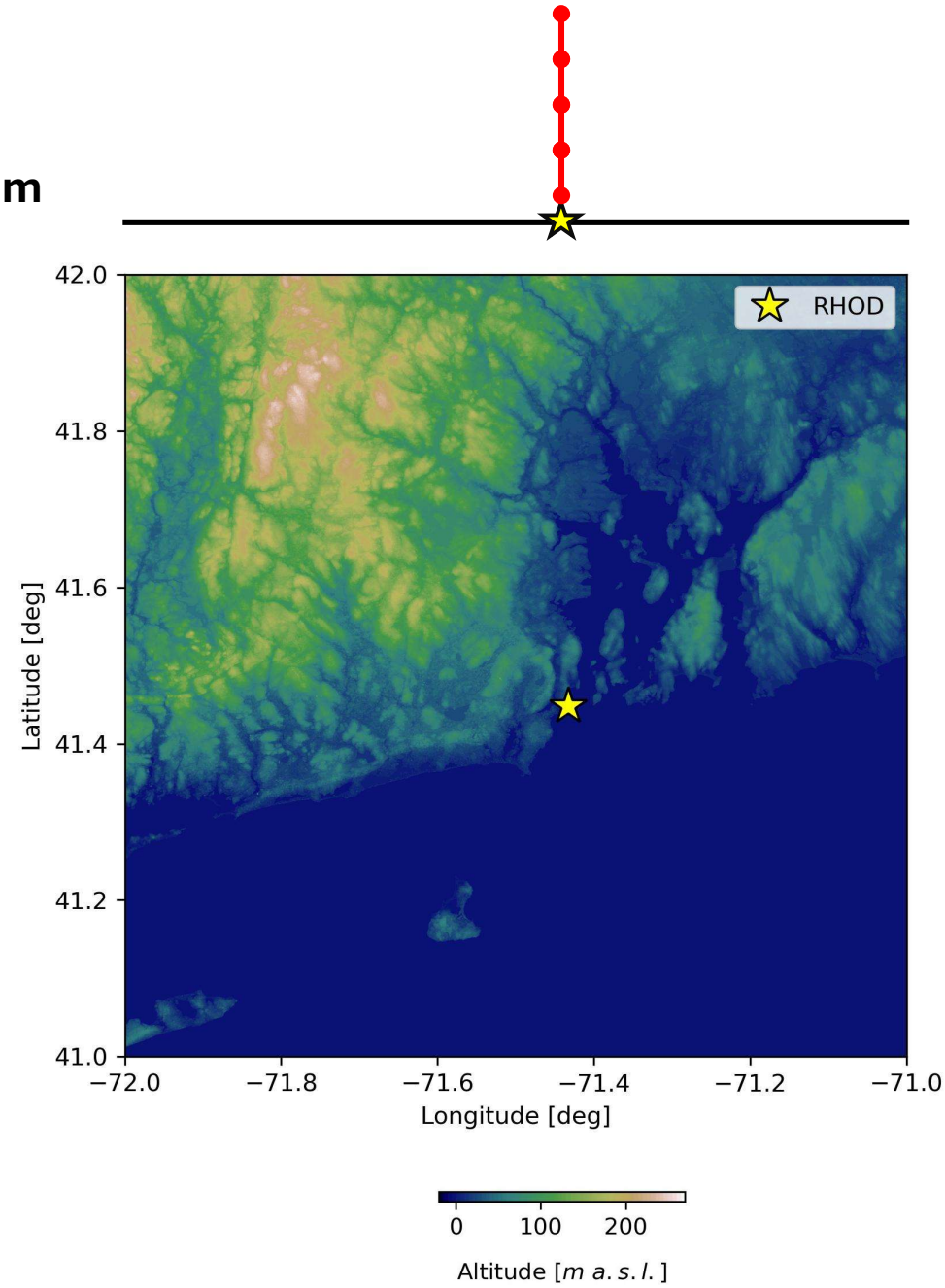
Sampling time: **1 sec**

Space resolution (*x, y, z*): **50m x 50m x 5m**

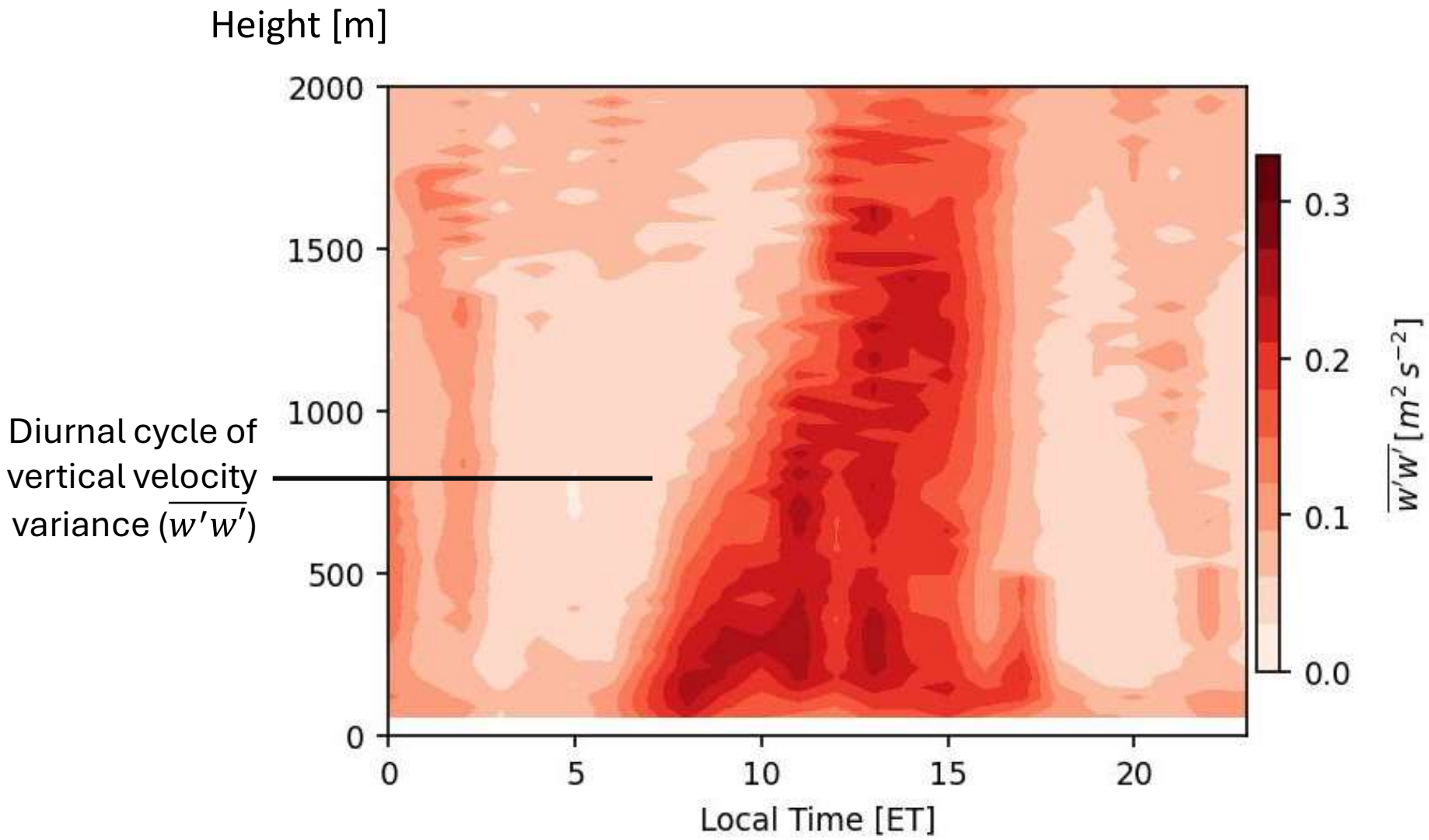
Sampling time: **1140 sec**

Space resolution (z): **30 m**
Sampling time: **1 sec**





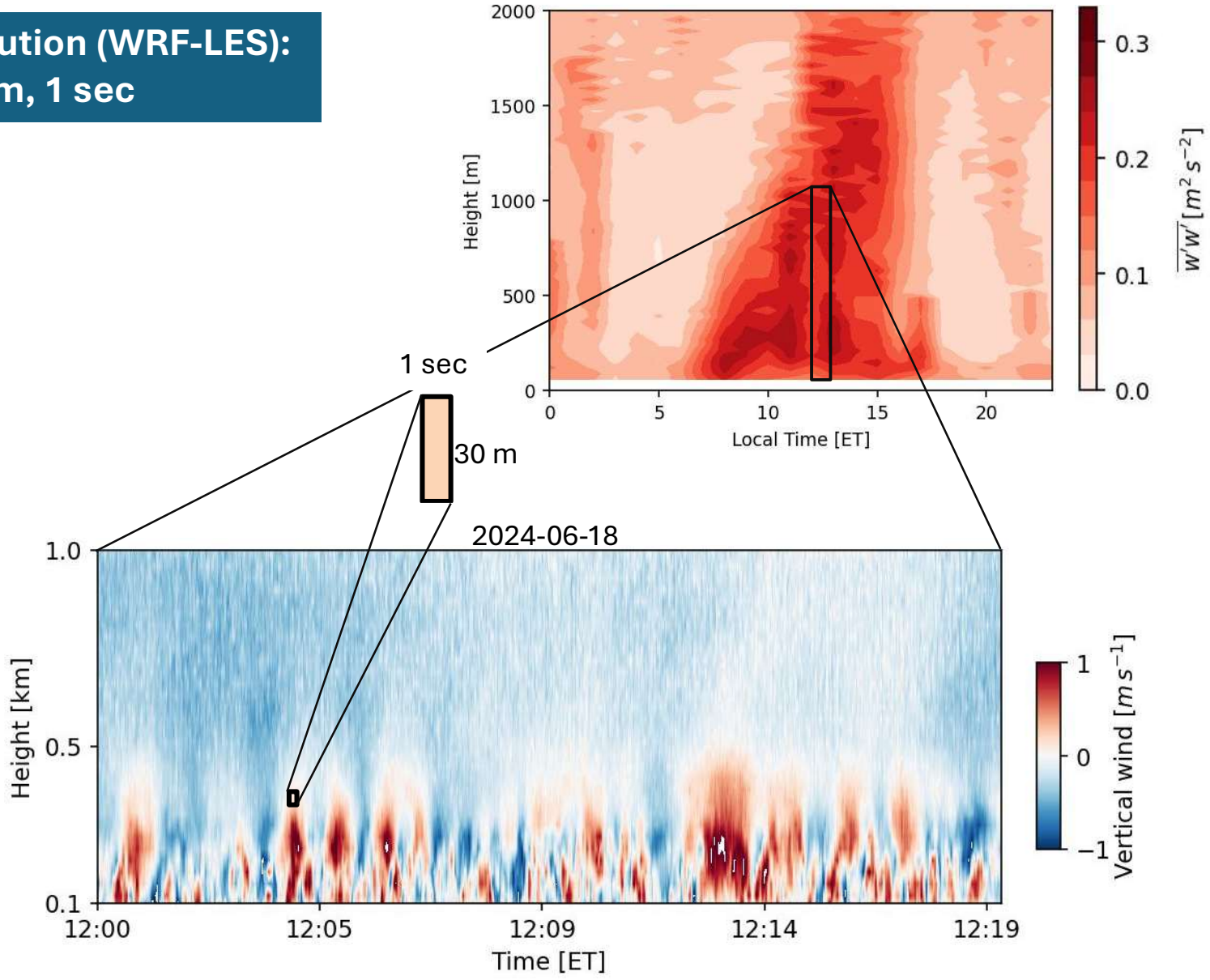
Stare scans resolve vertical turbulent motions



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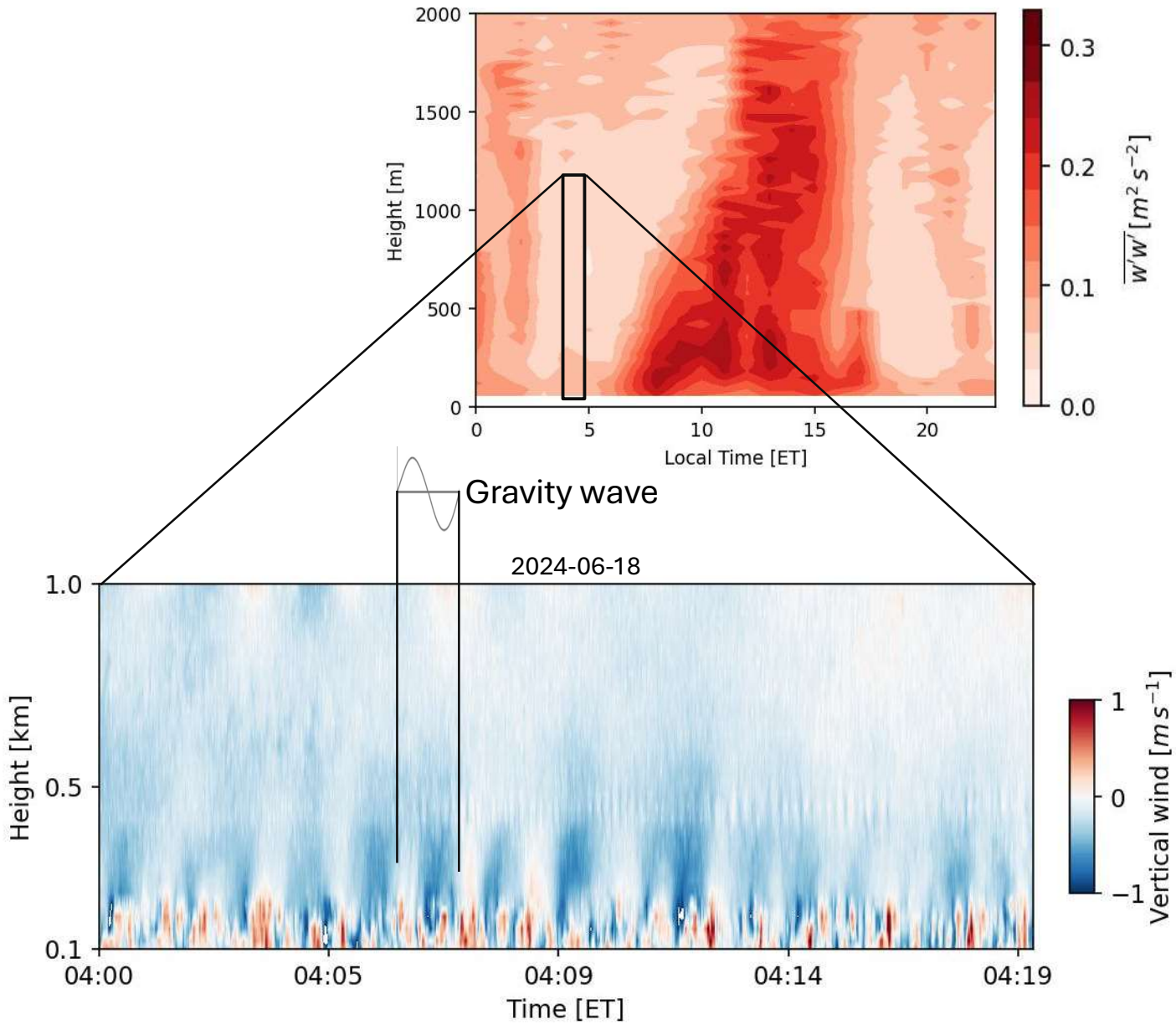
Convective rolls are observed during daytime

Target resolution (WRF-LES): 40m, 1 sec

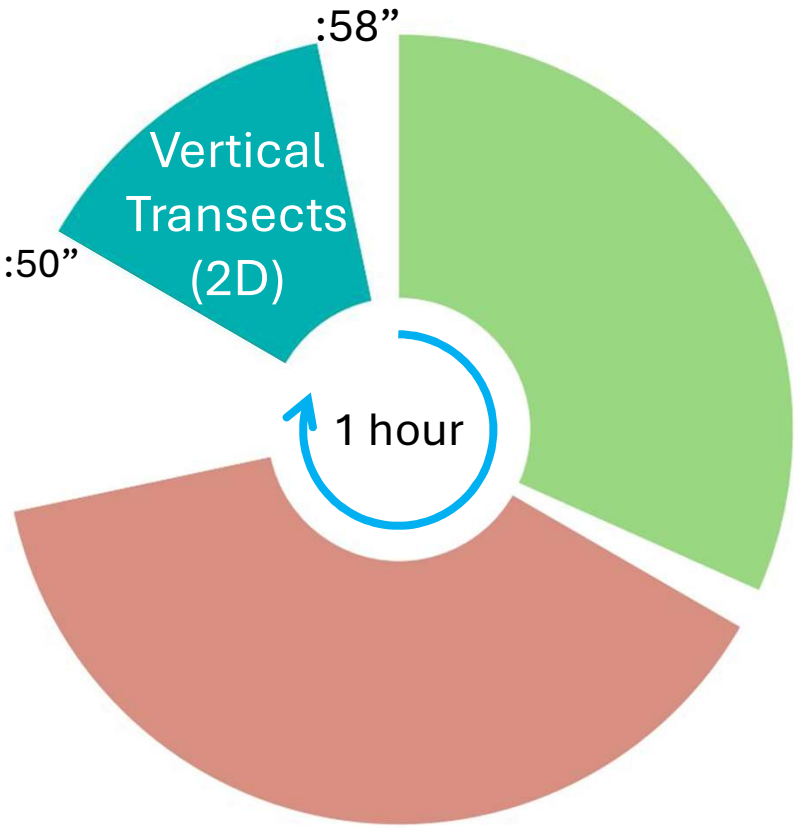


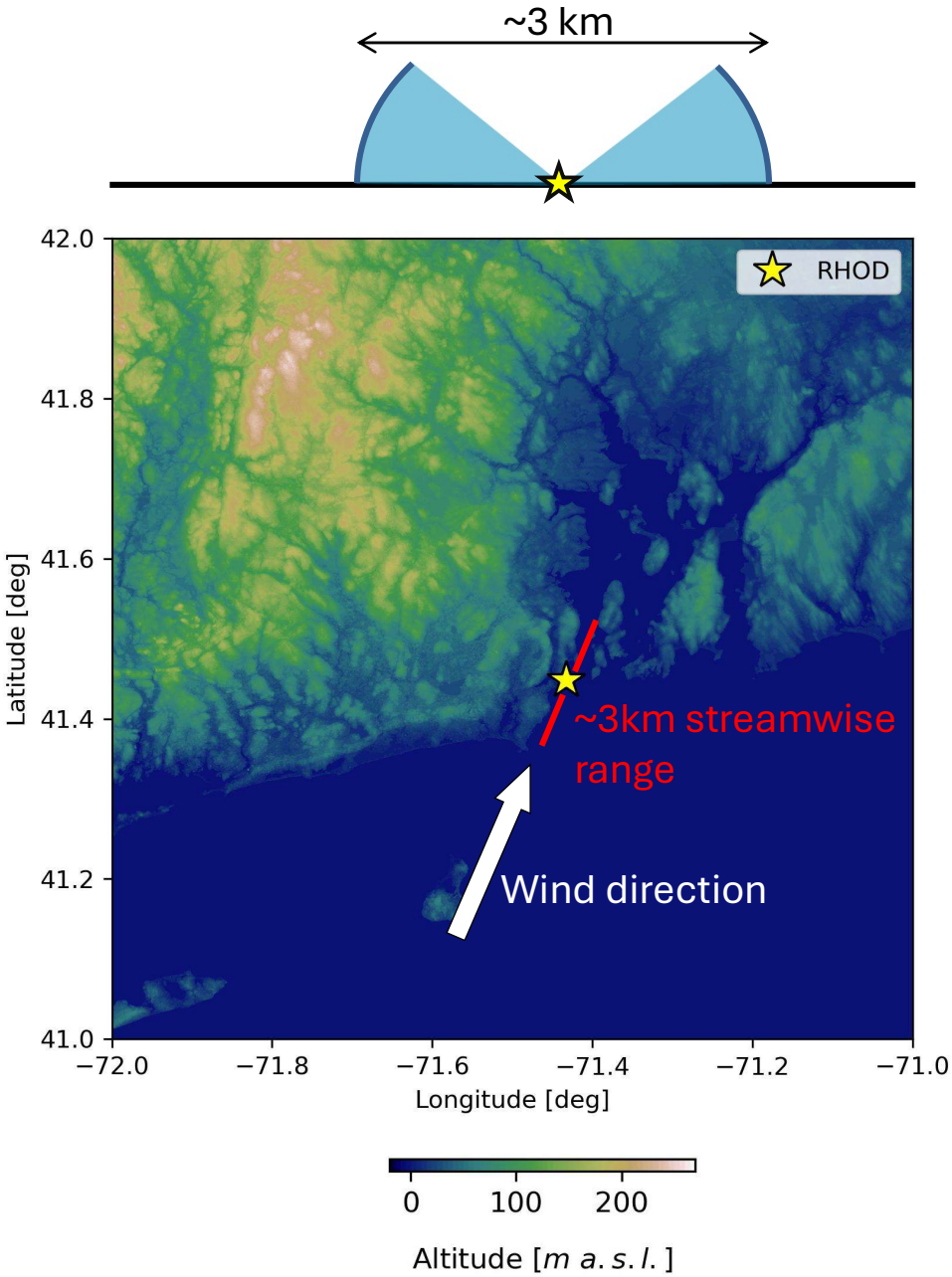
Stare scans resolve vertical turbulent motions

Atmospheric gravity waves observed during nighttime



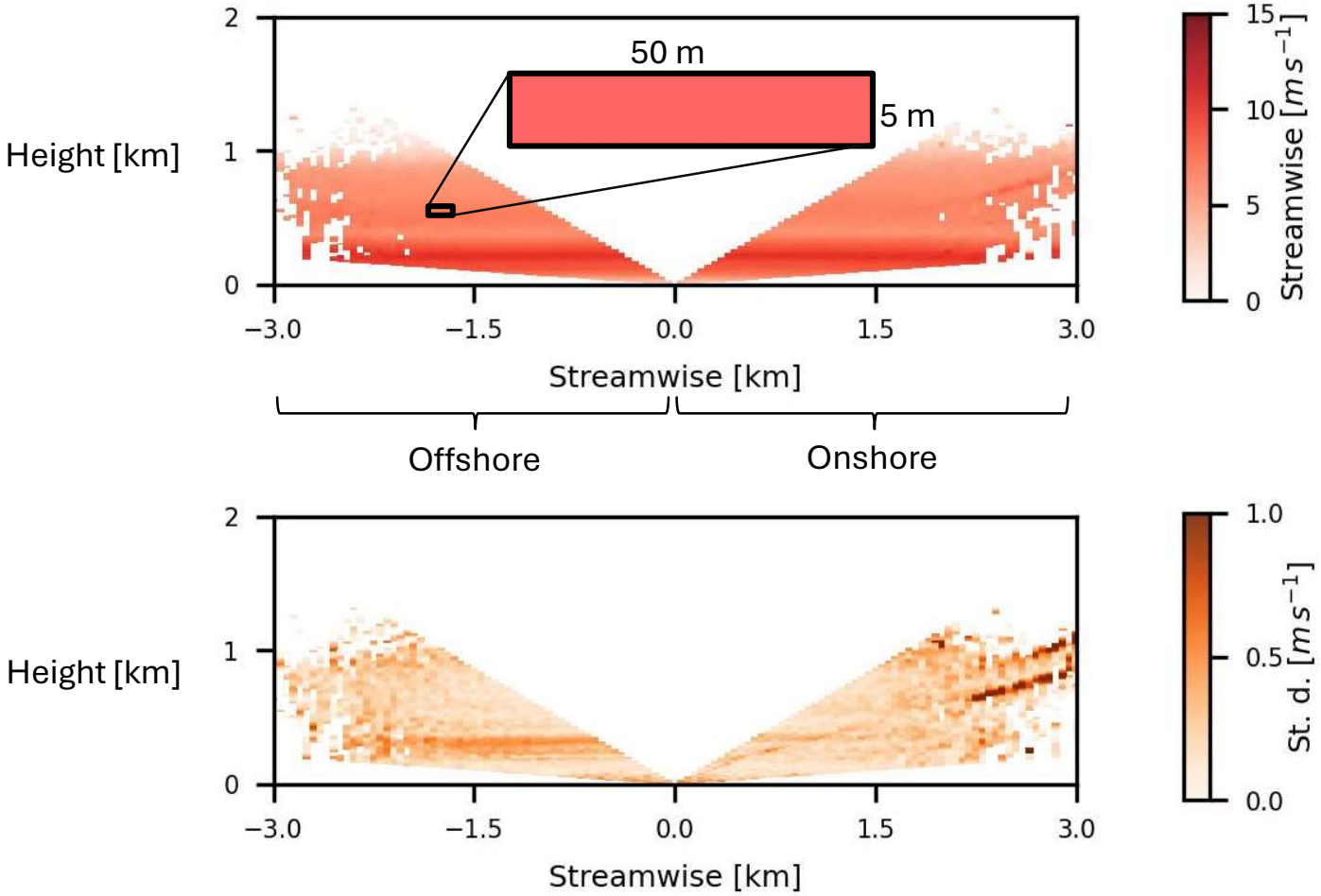
Space resolution (x, z): **50m x 5m**
Sampling time: **70 sec**





Range Height Indicator (RHI) reveal 2D flow structures

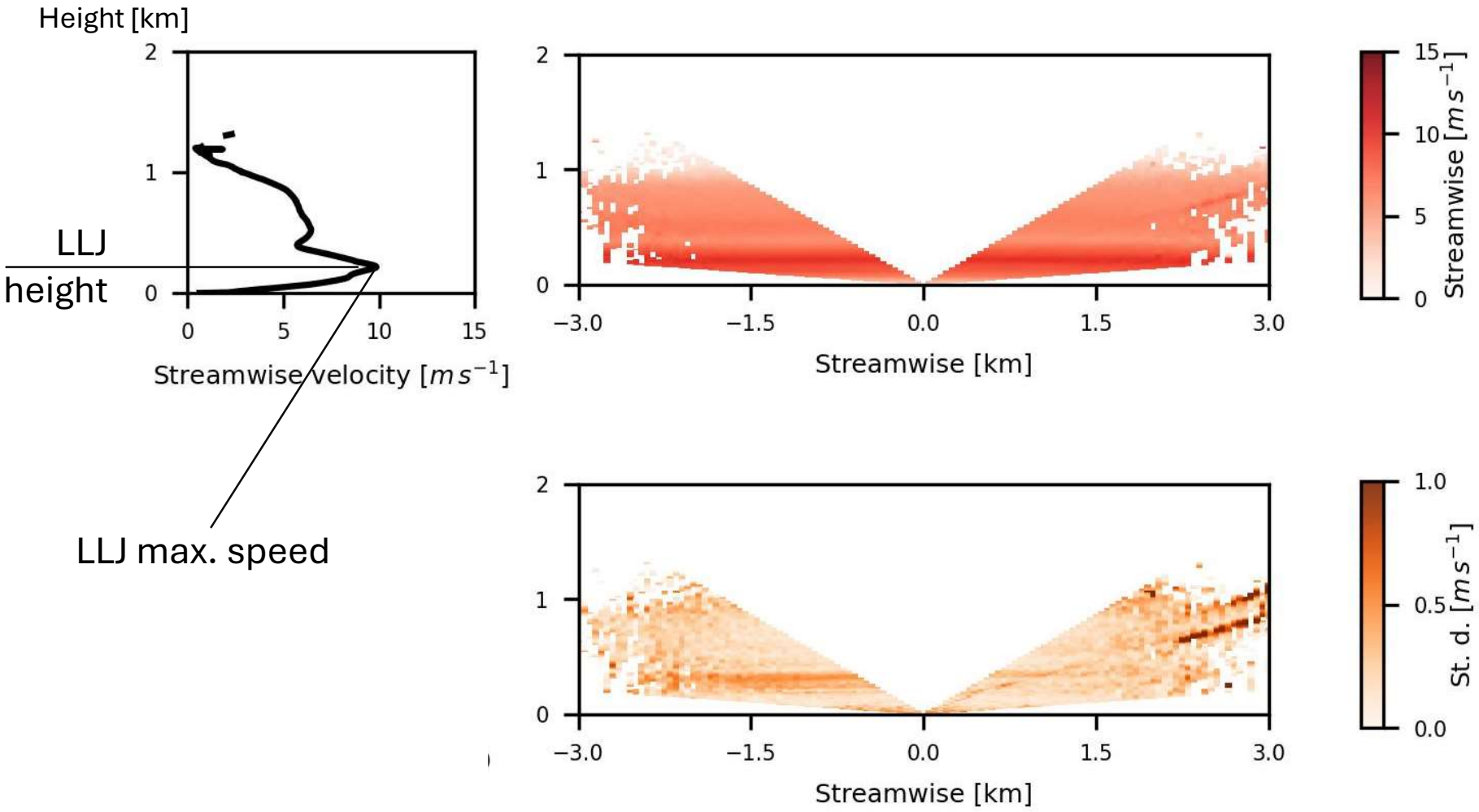
Low-level jets (LLJ) are resolved in 2D



Target resolution (WRF-LES): 40m, 1 sec

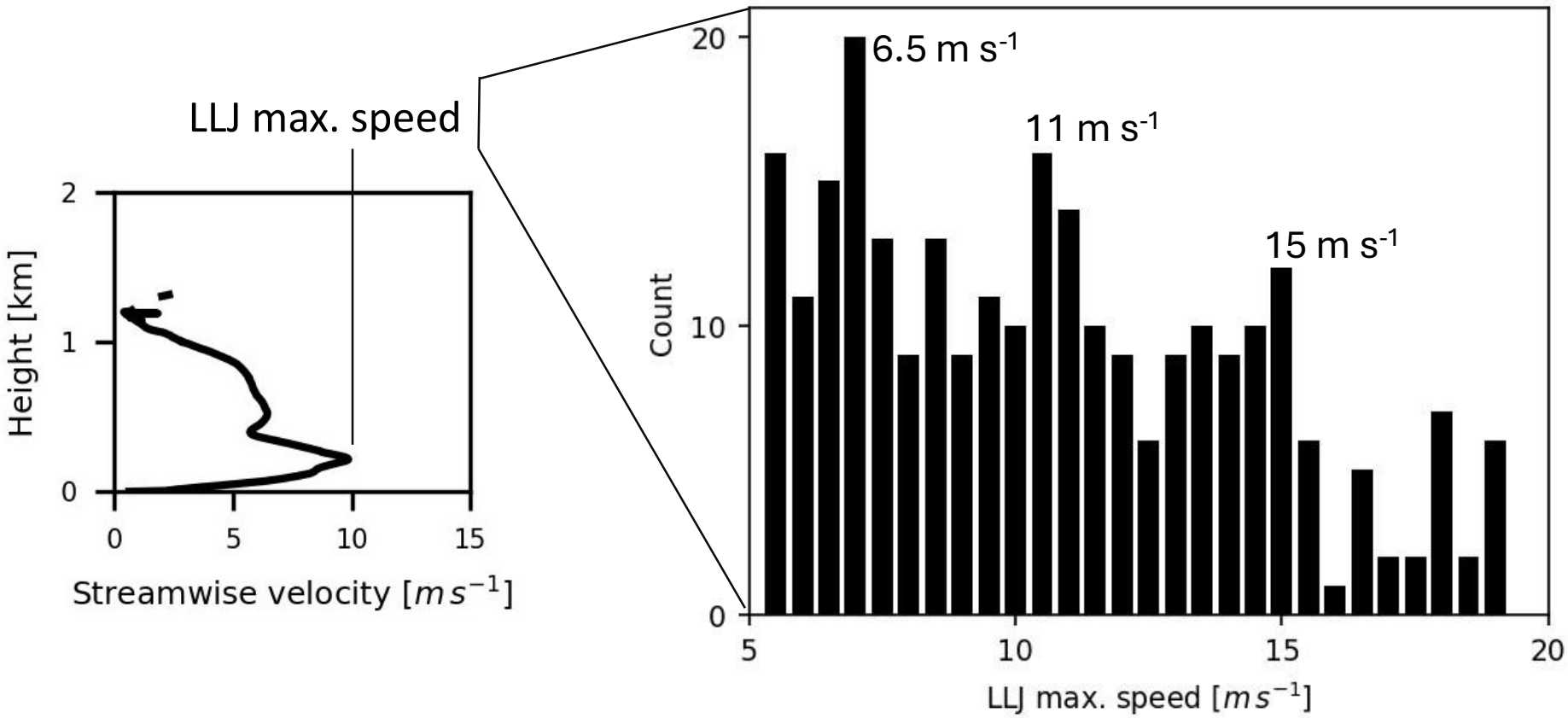
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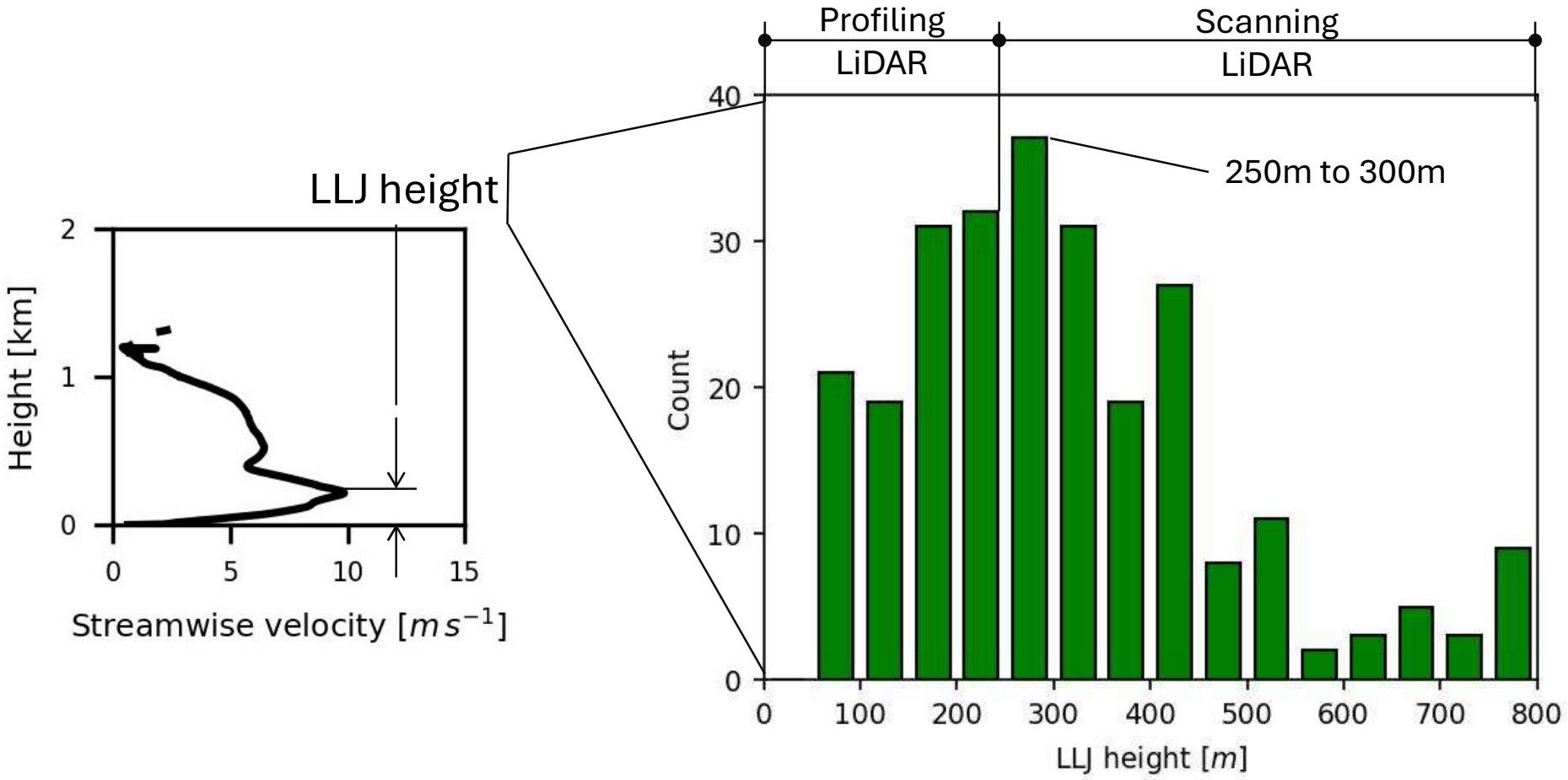
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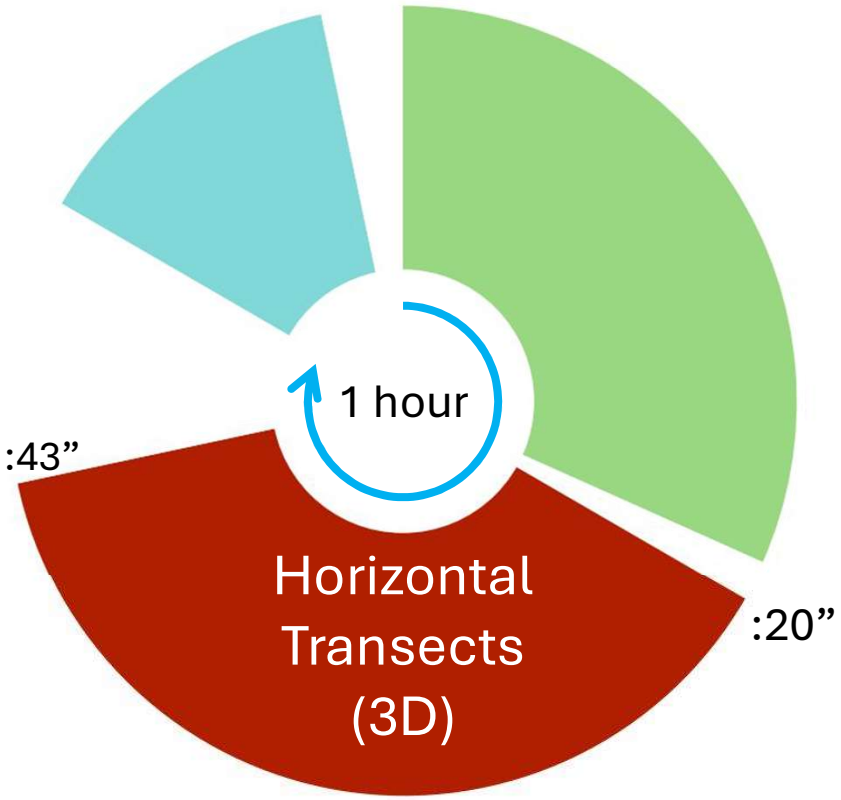
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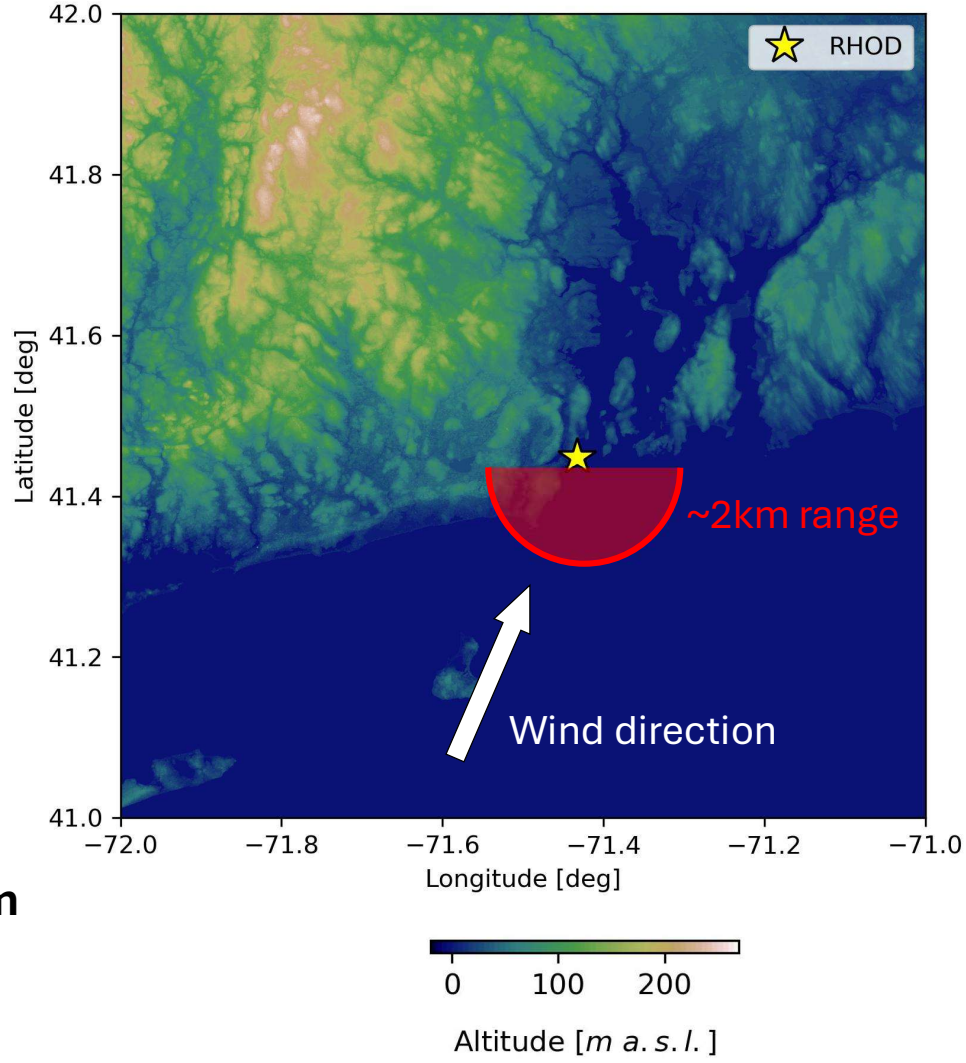


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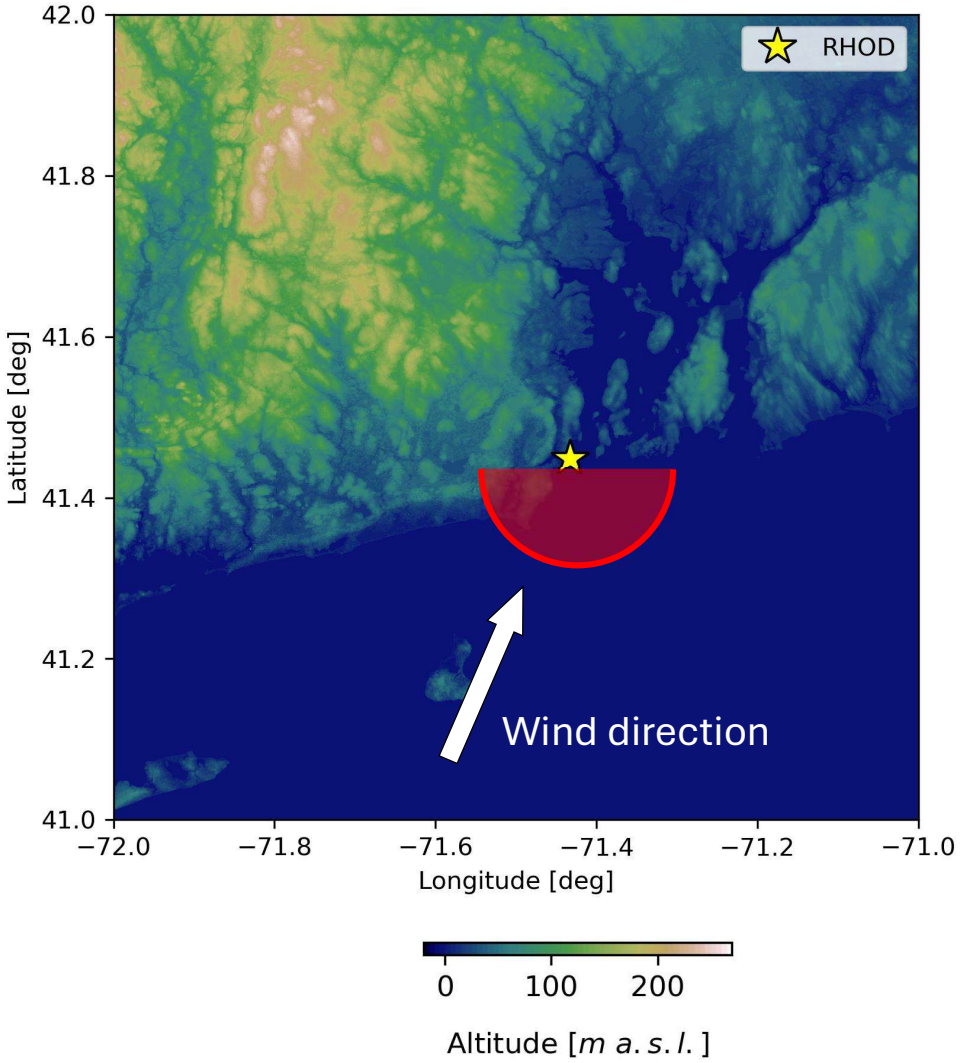


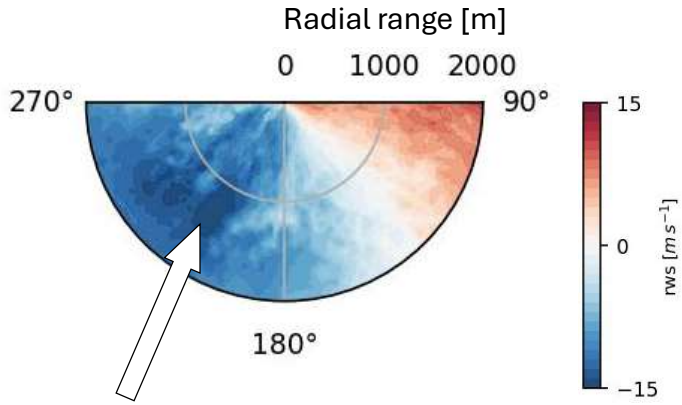


Space resolution (*x, y, z*): **50m x 50m x 5m**
Sampling time: **1140 sec**

Plan Position Indicator (PPI) reveal 3D flow structures

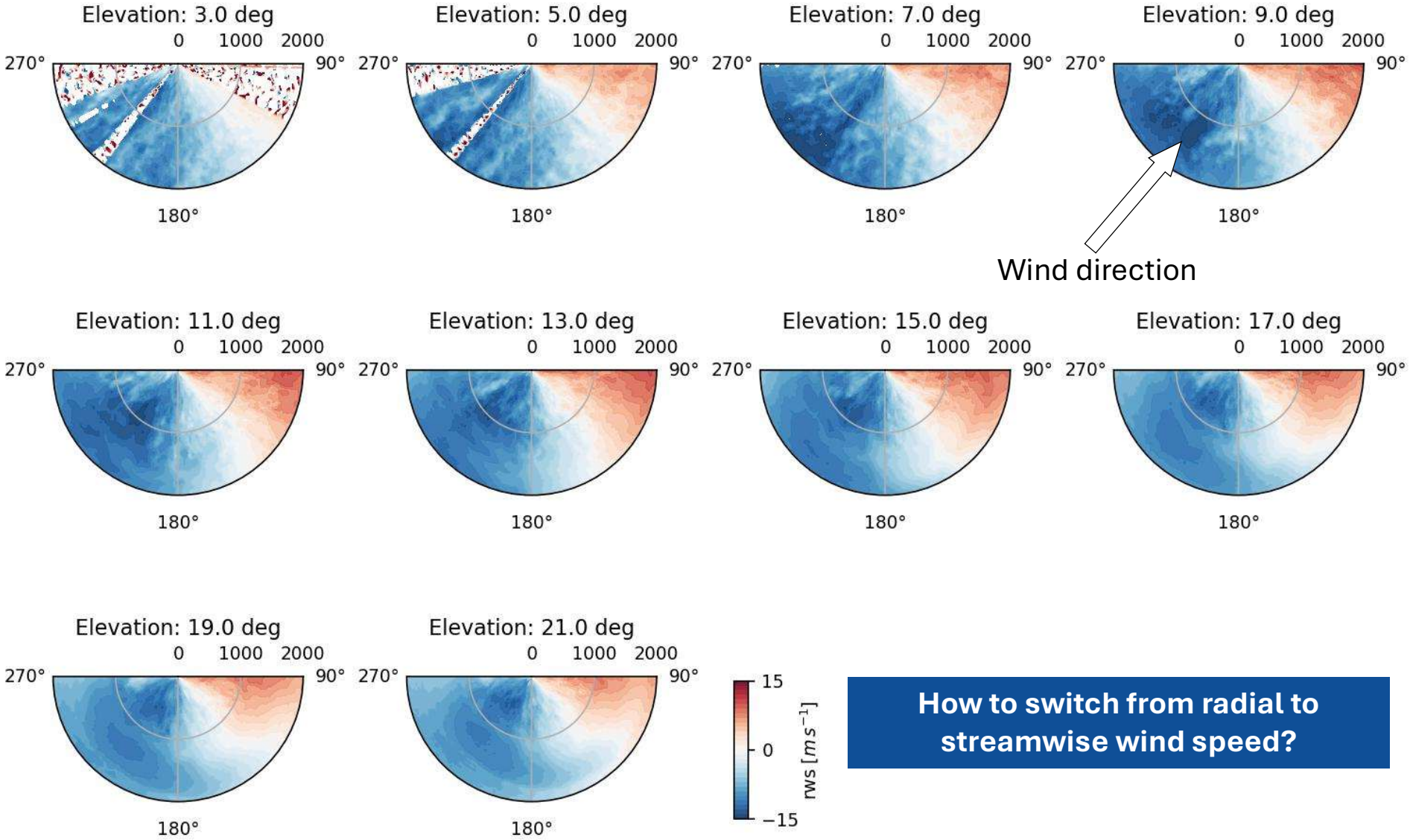
Streamwise velocity is calculated from radial wind speed





Plan Position Indicator (PPI) reveal 3D flow structures

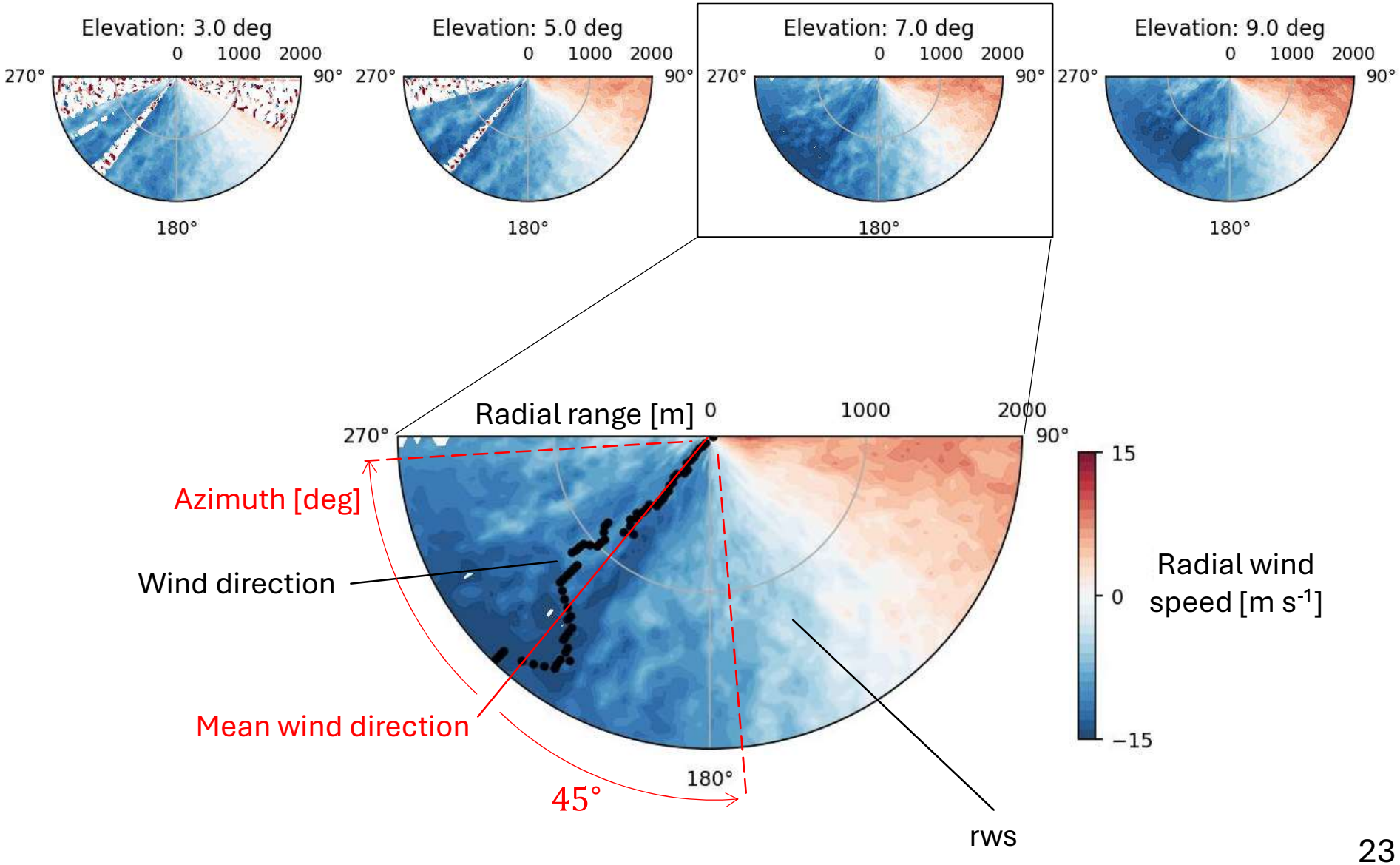
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How to switch from radial to streamwise wind speed?

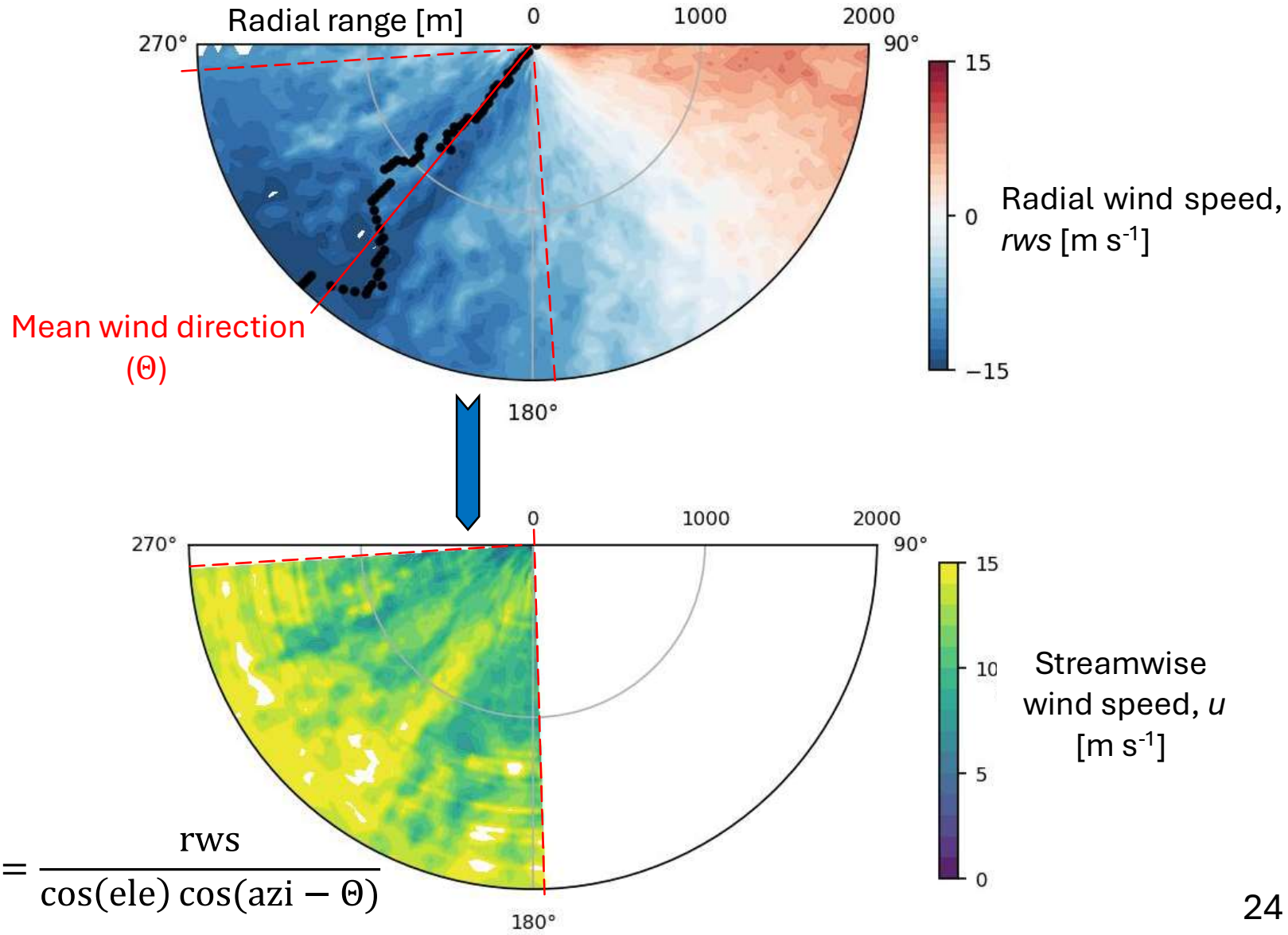
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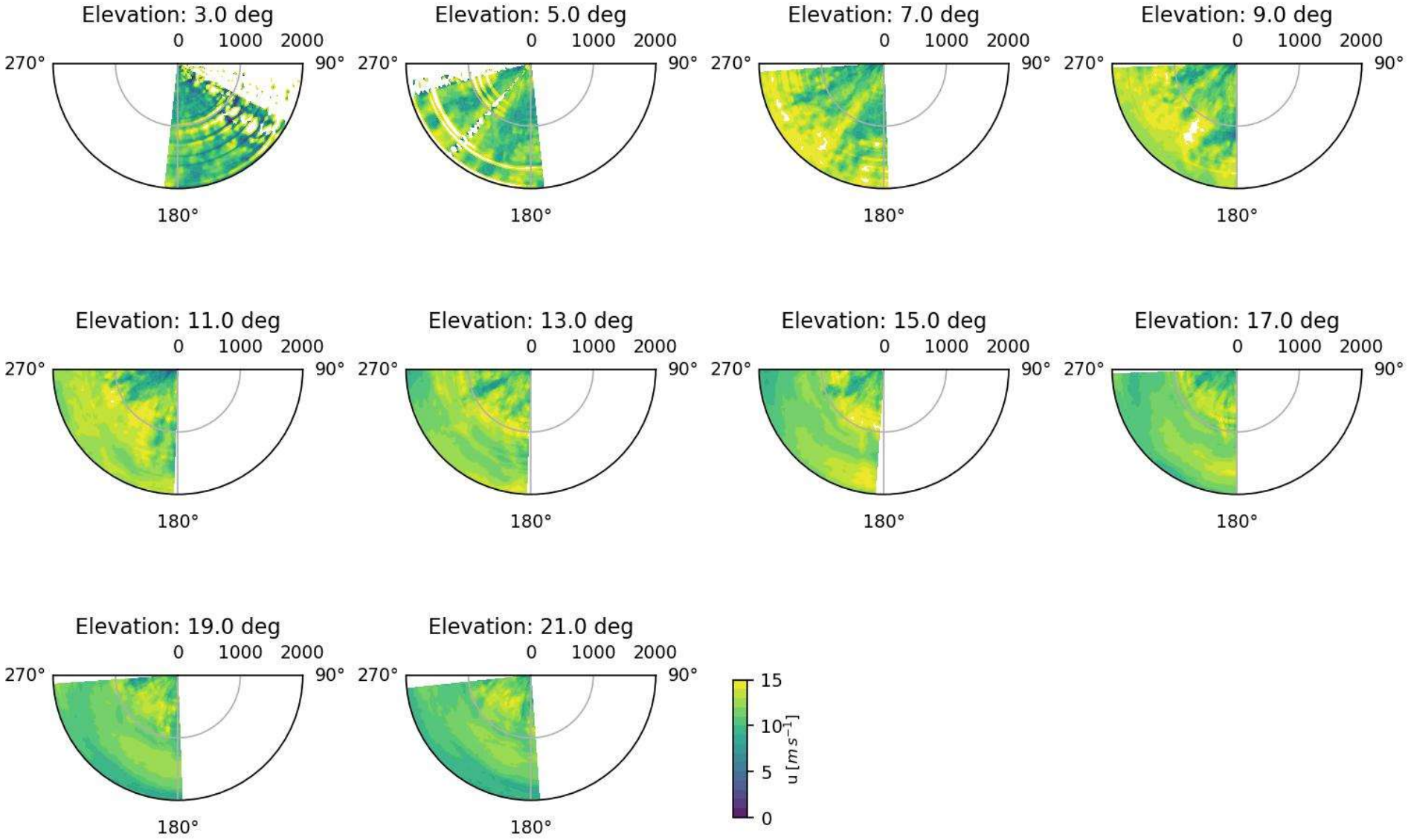
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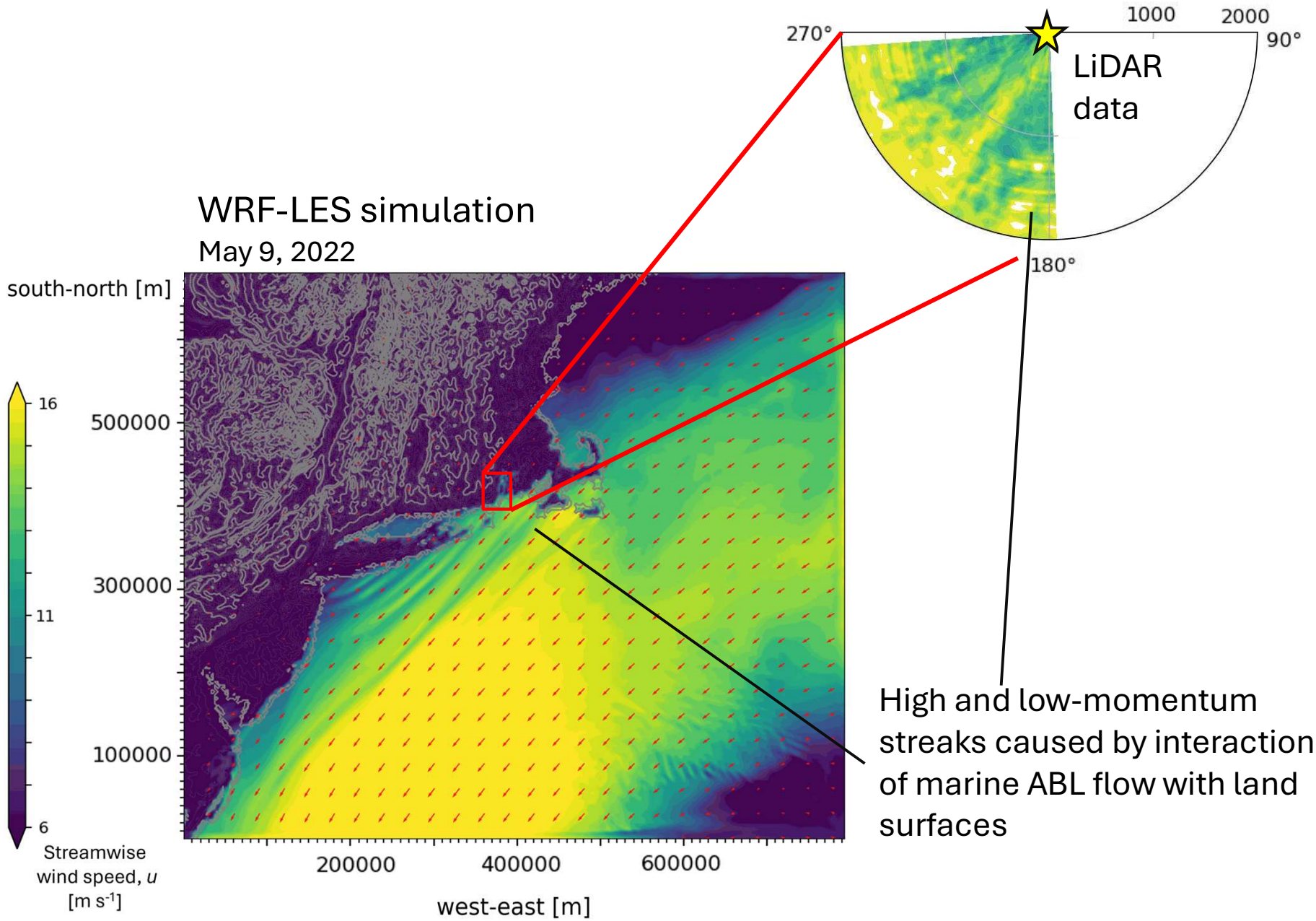
$$u(r, \text{azi}, \text{ele}) = \frac{\text{rws}}{\cos(\text{ele})\cos(\text{azi} - \Theta)}$$

Plan Position Indicator (PPI) reveal 3D flow structures

Streamwise velocity is finally resolved within a 3D volume

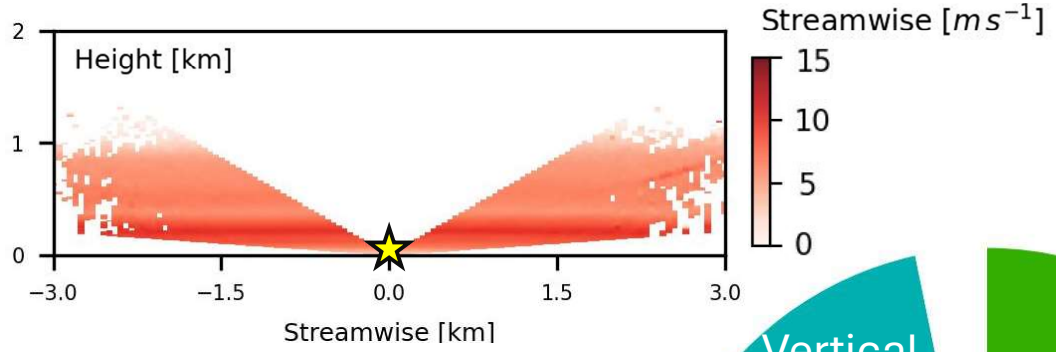


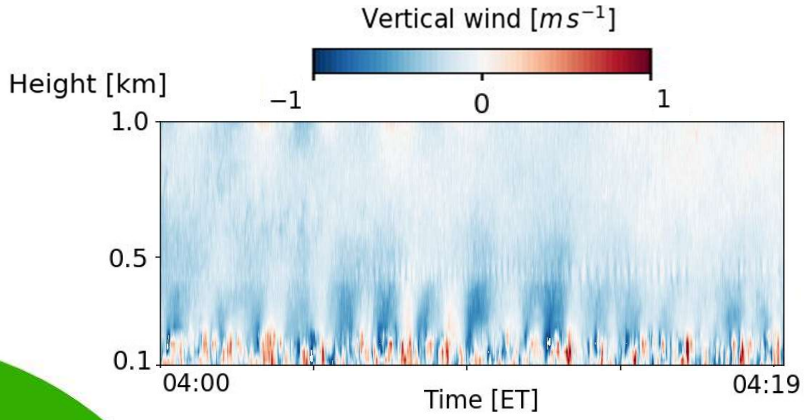
The numerical results are now ready to be validated

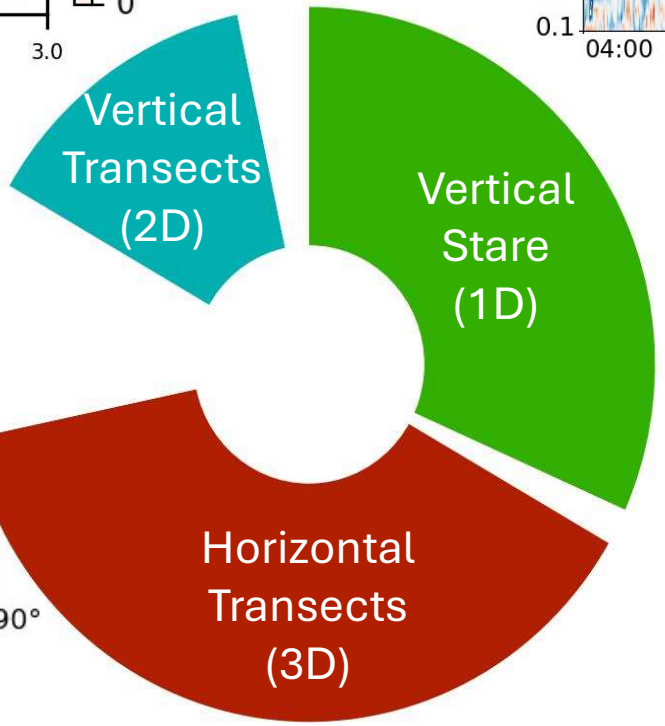


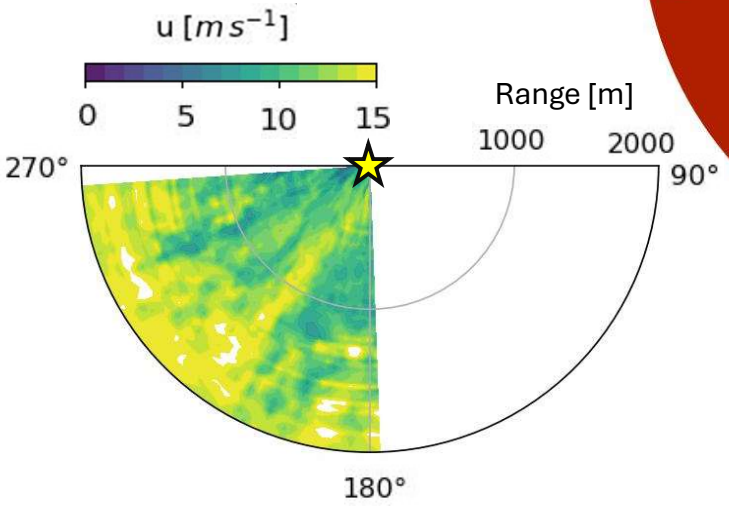
High and low-momentum streaks caused by interactions of marine ABL flow with land surfaces

Conclusion











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