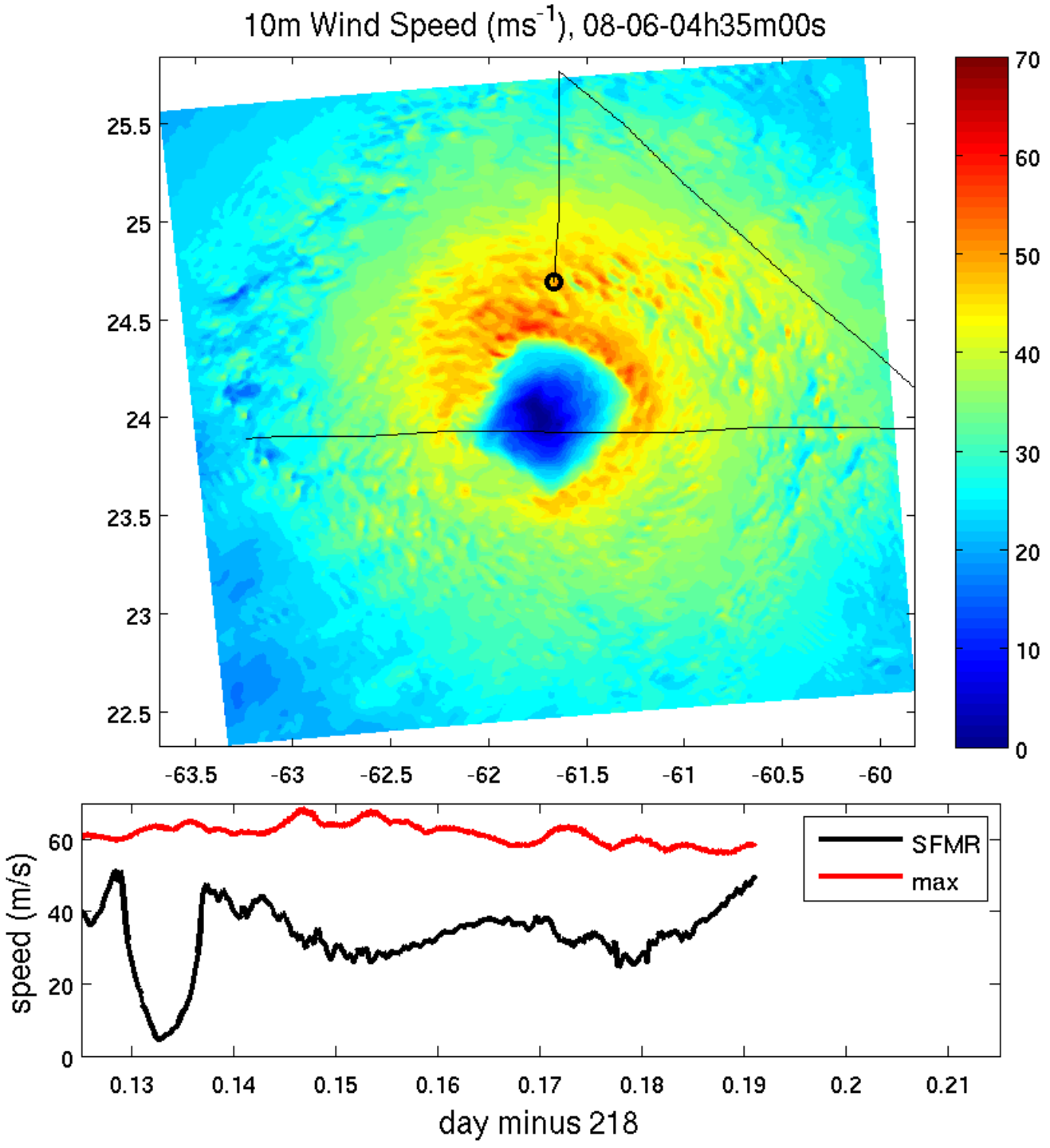
Guidance on Observational Undersampling over the Tropical Cyclone Lifecycle

Dave Nolan, RSMAS

Brad Klotz, CIMAS/HRD

Eric Uhlhorn, in spirit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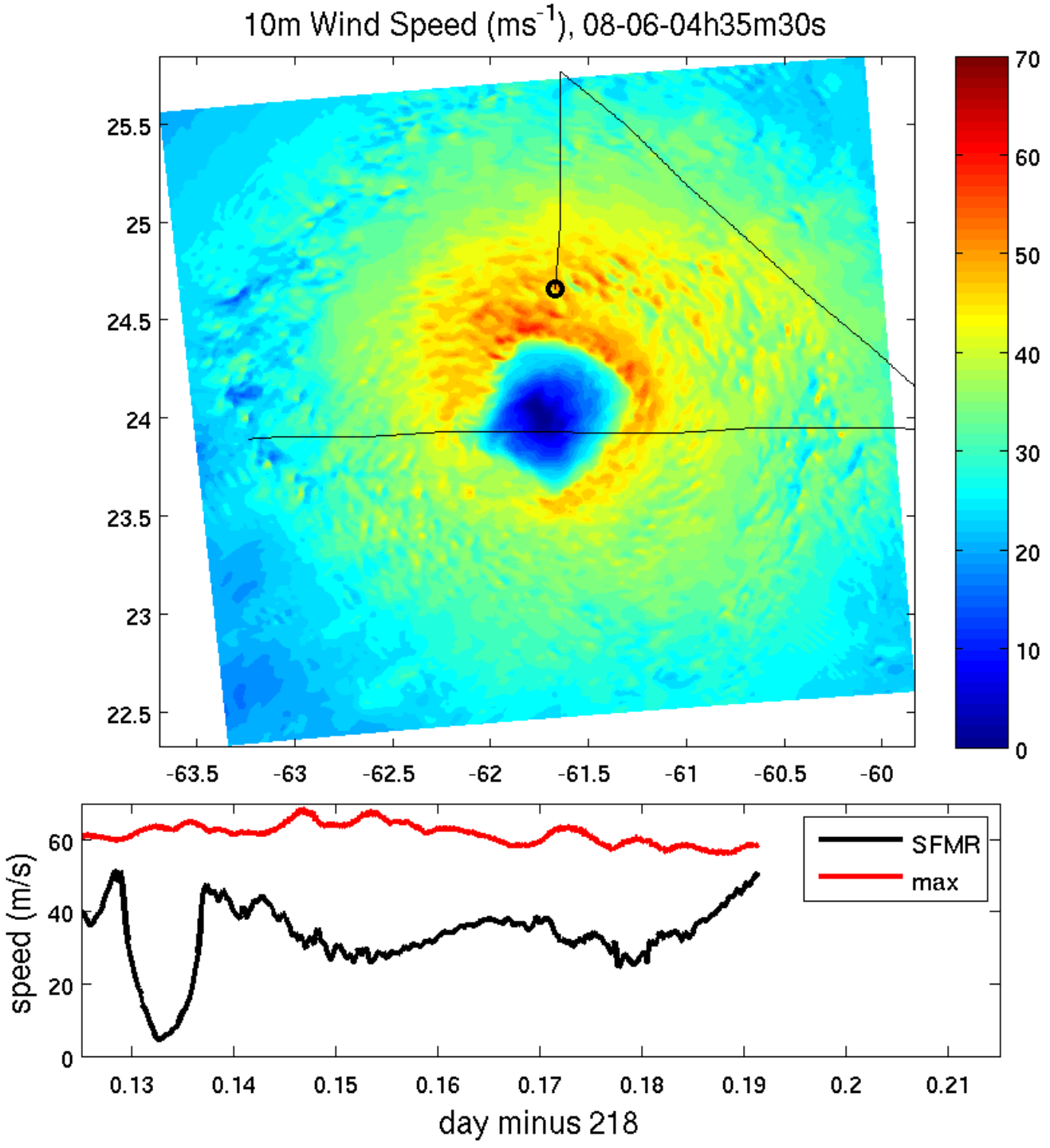
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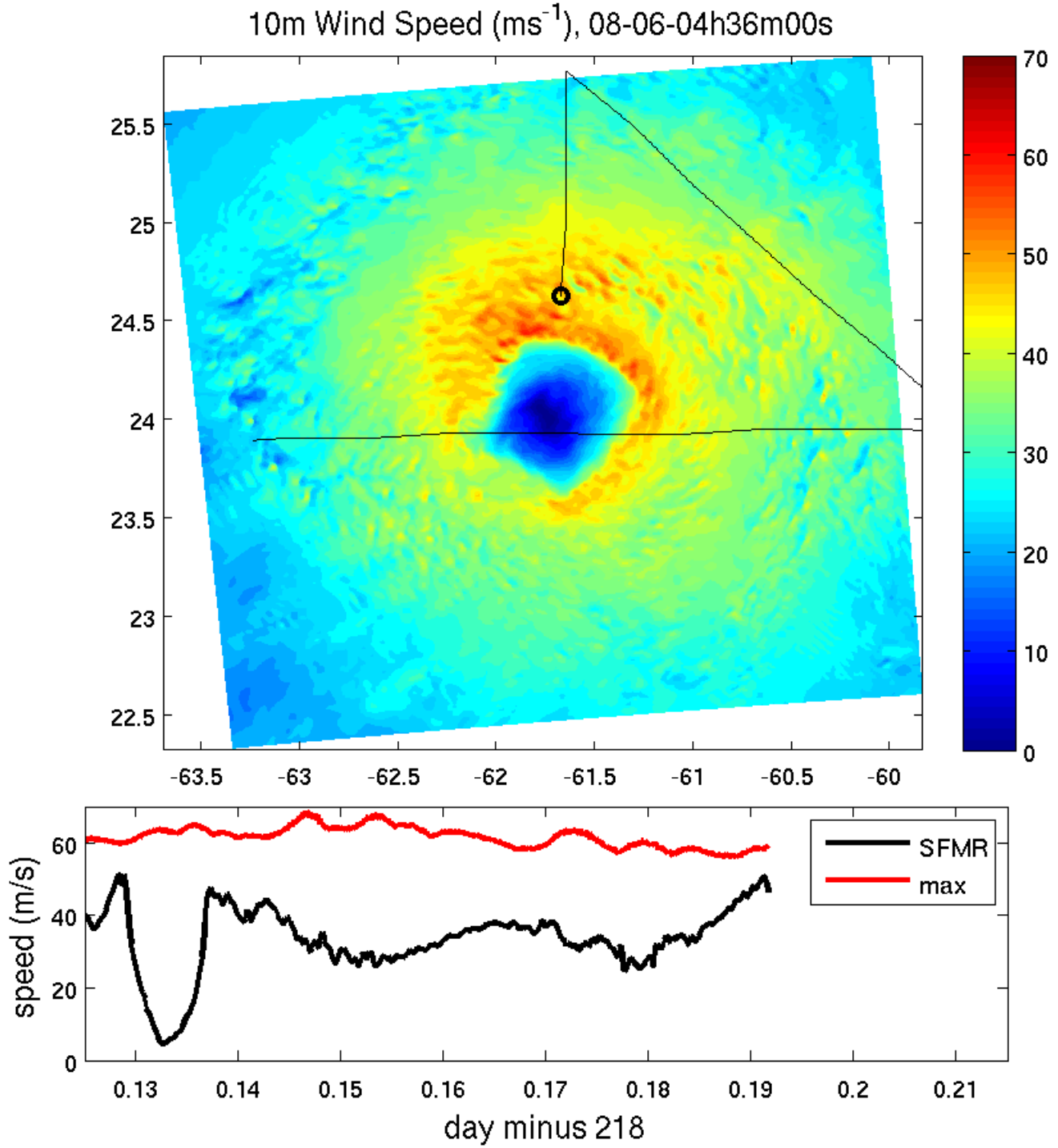
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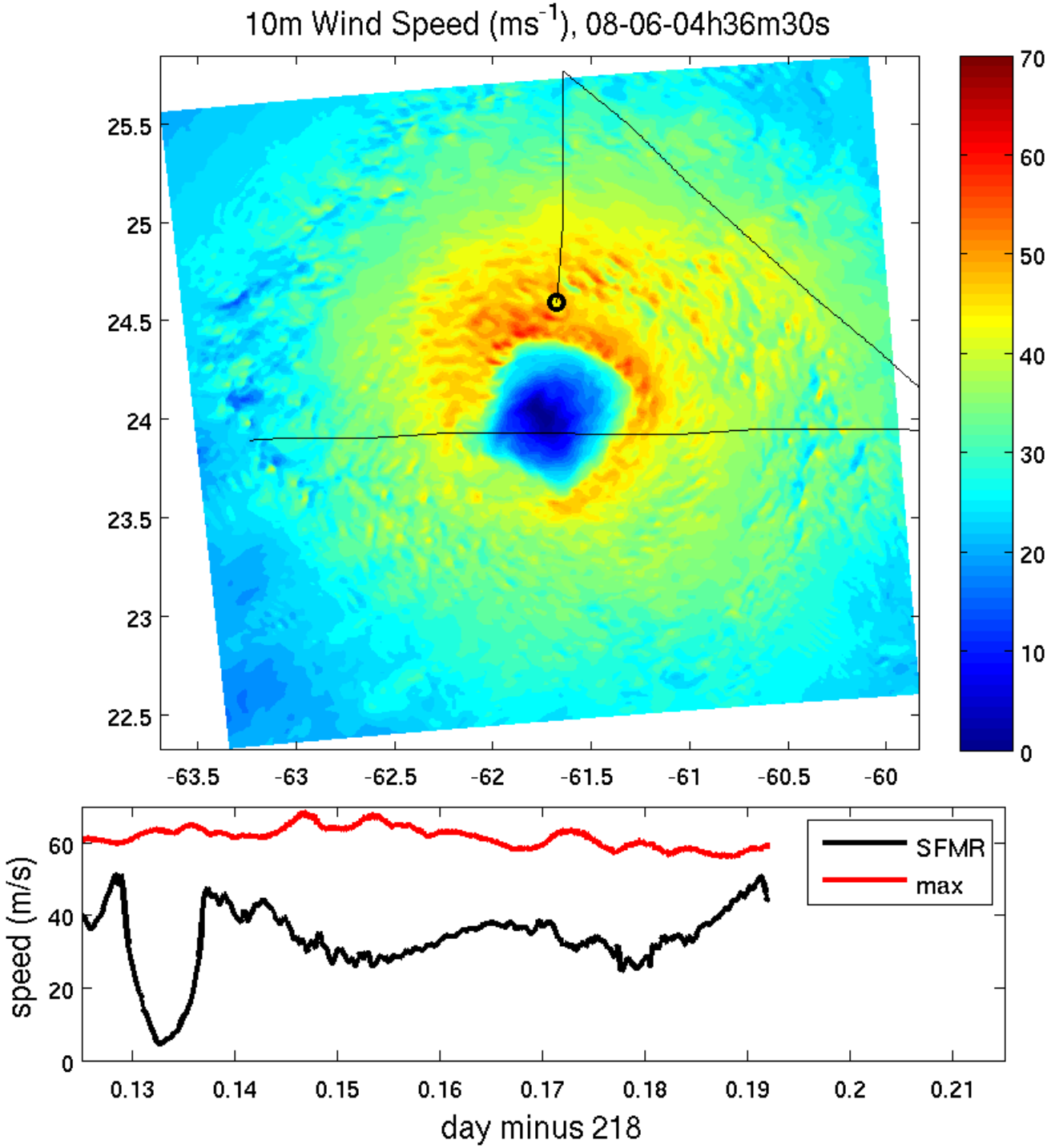
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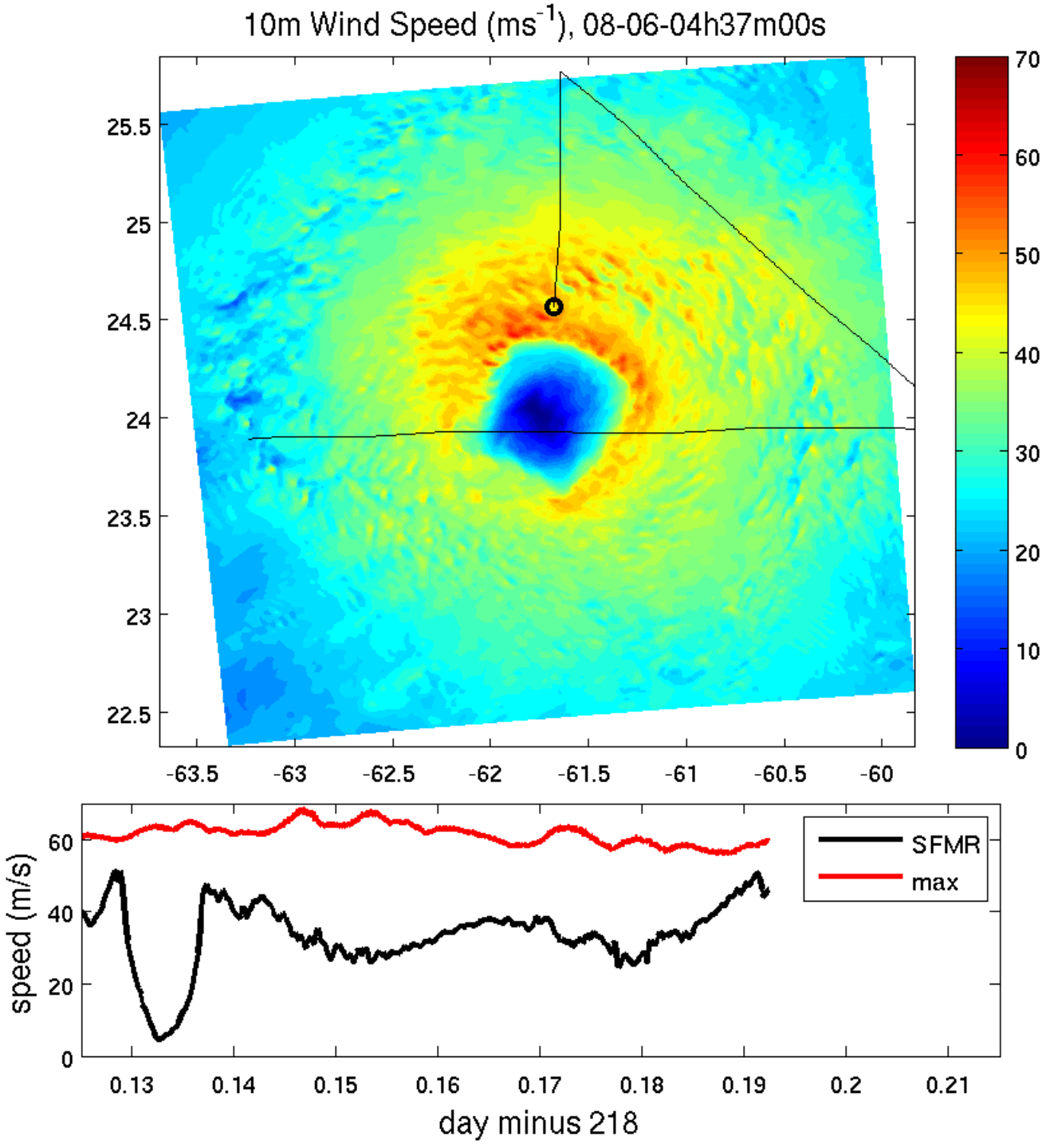
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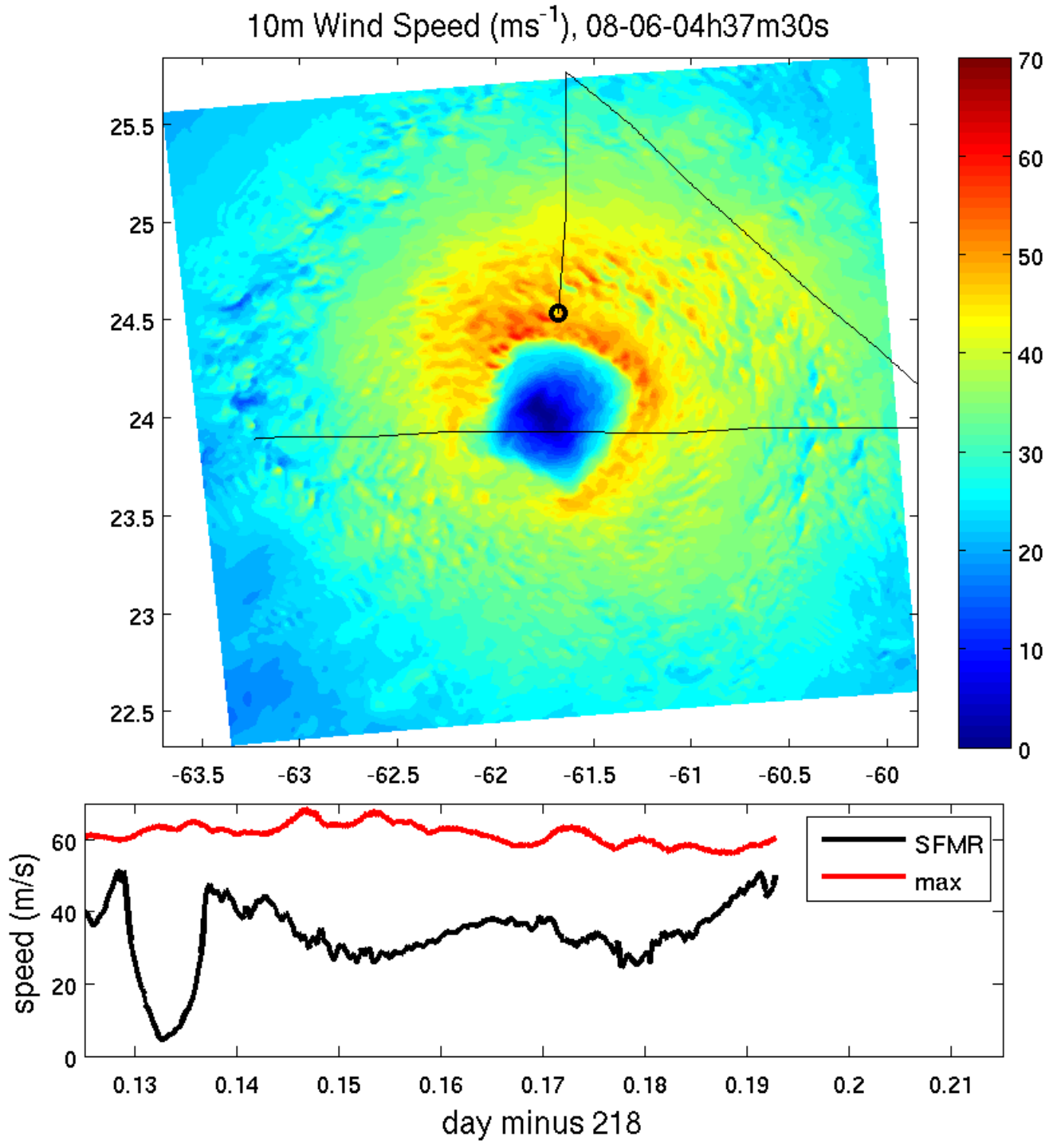
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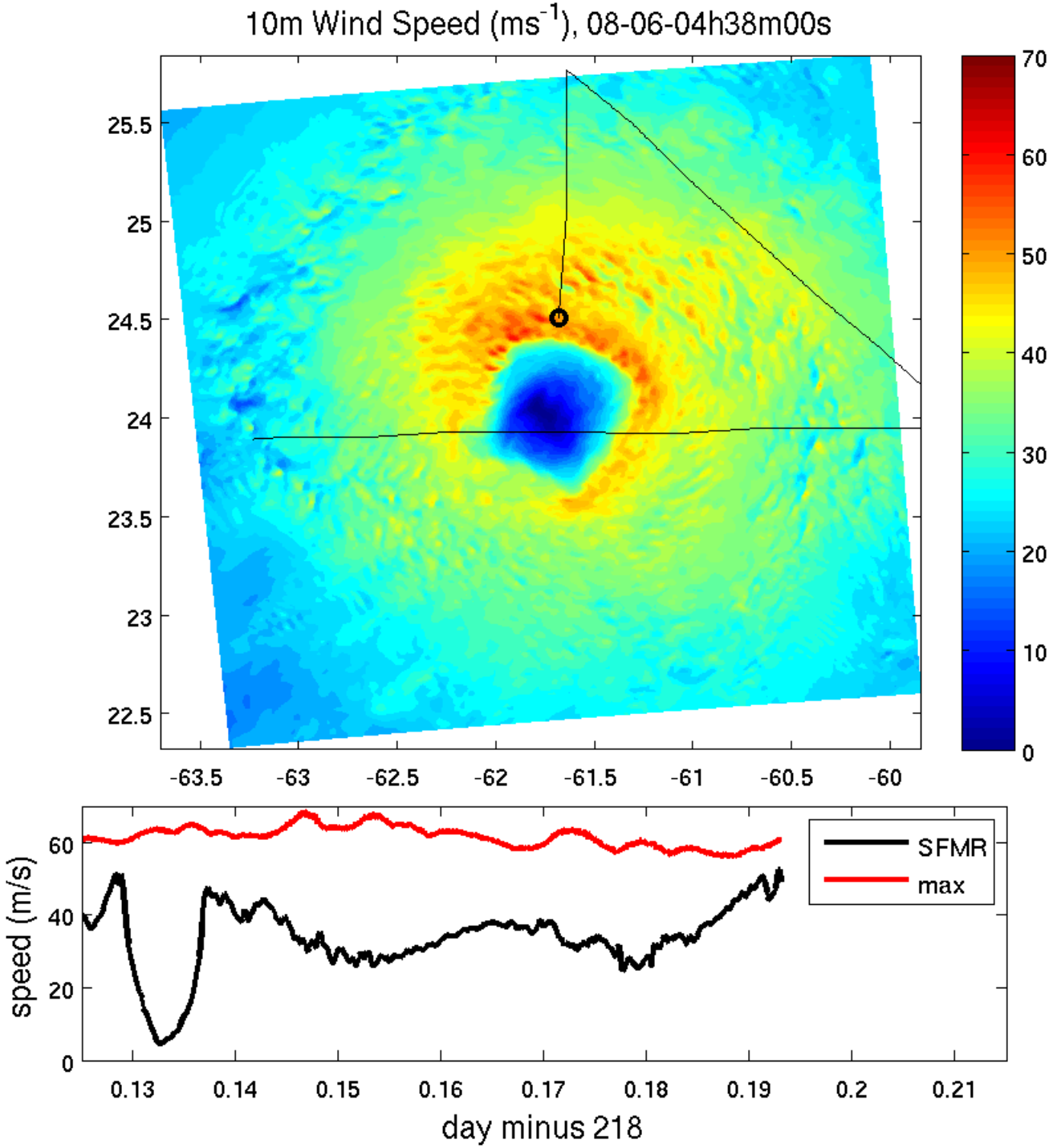
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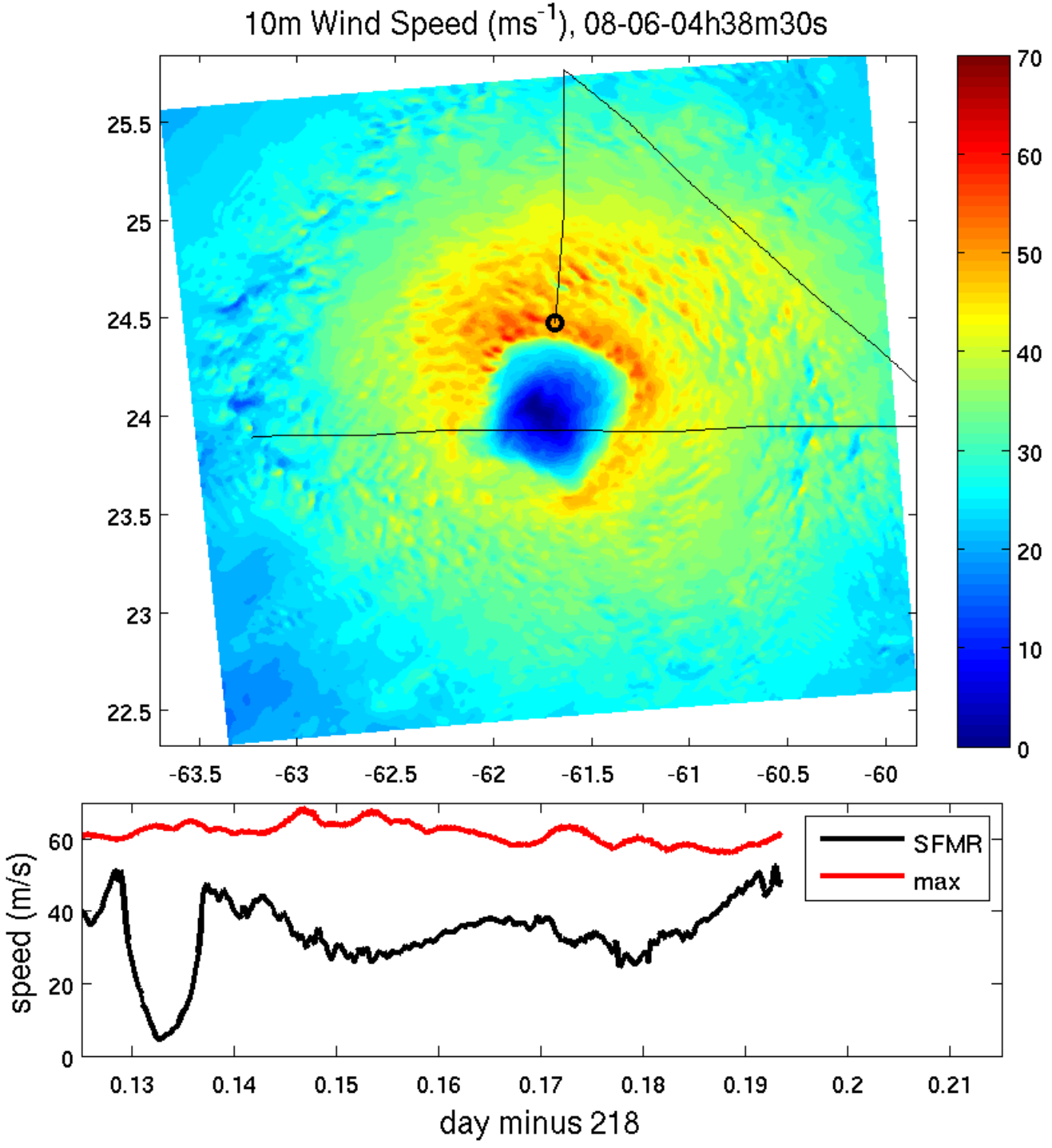
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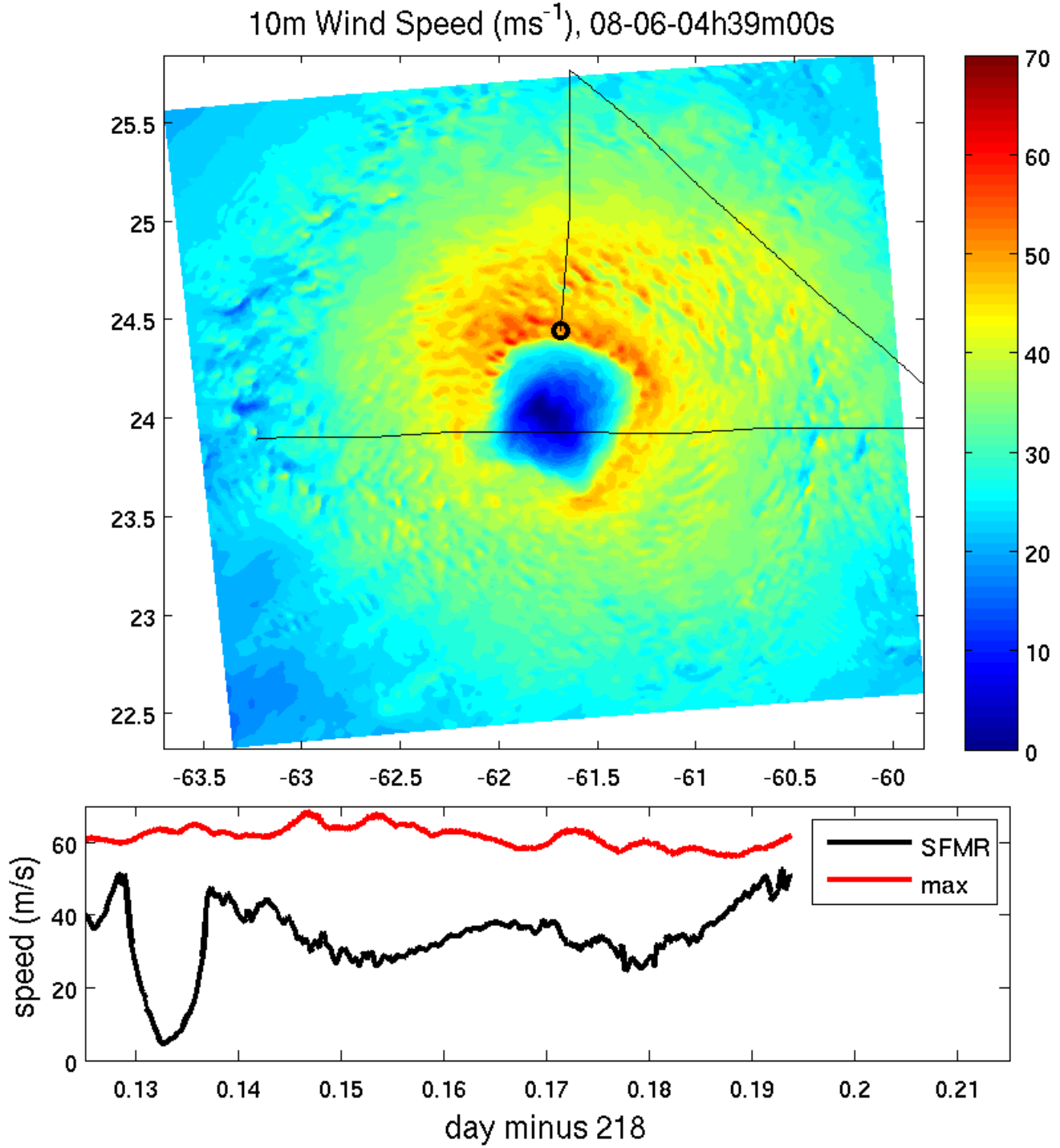
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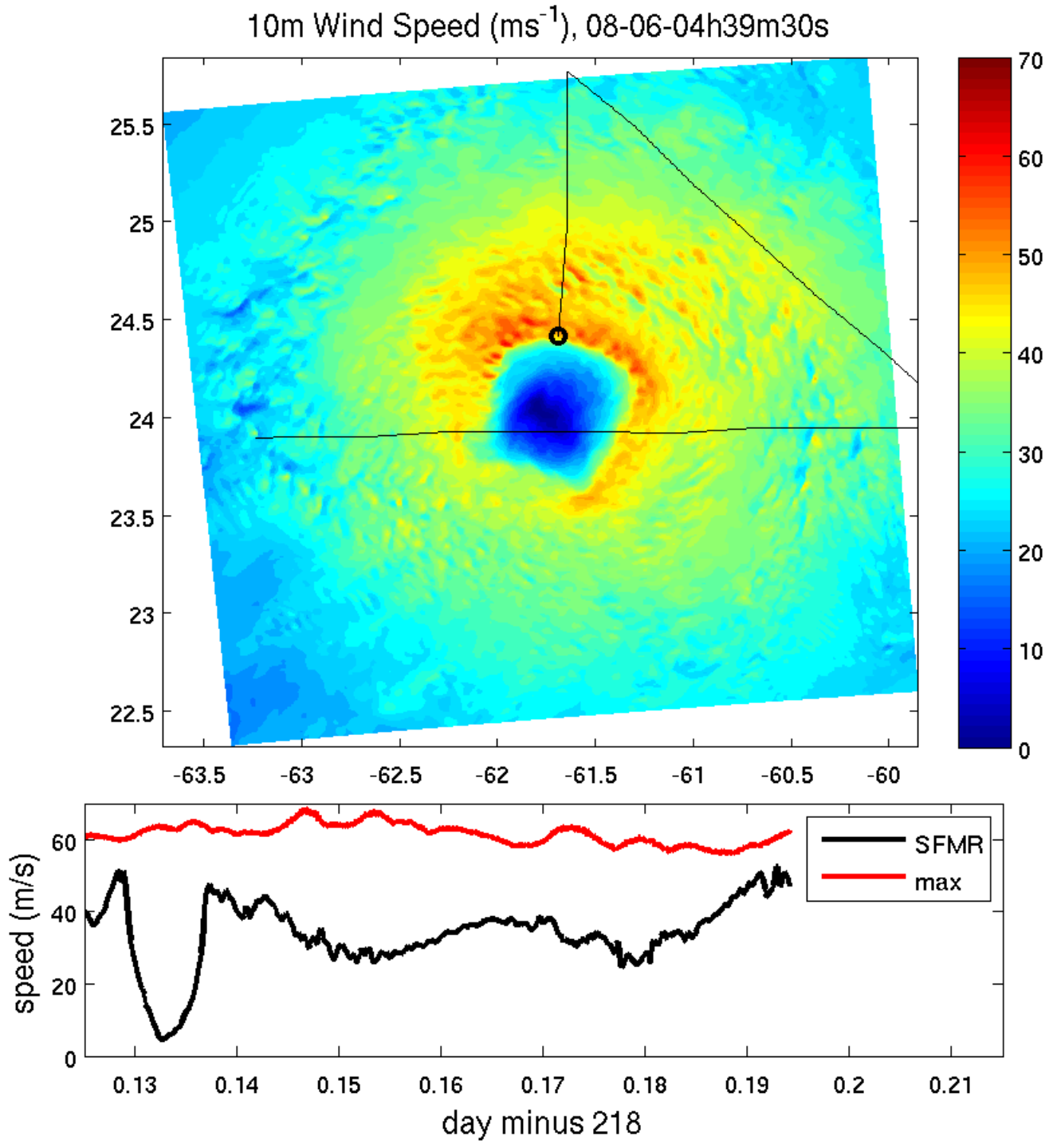
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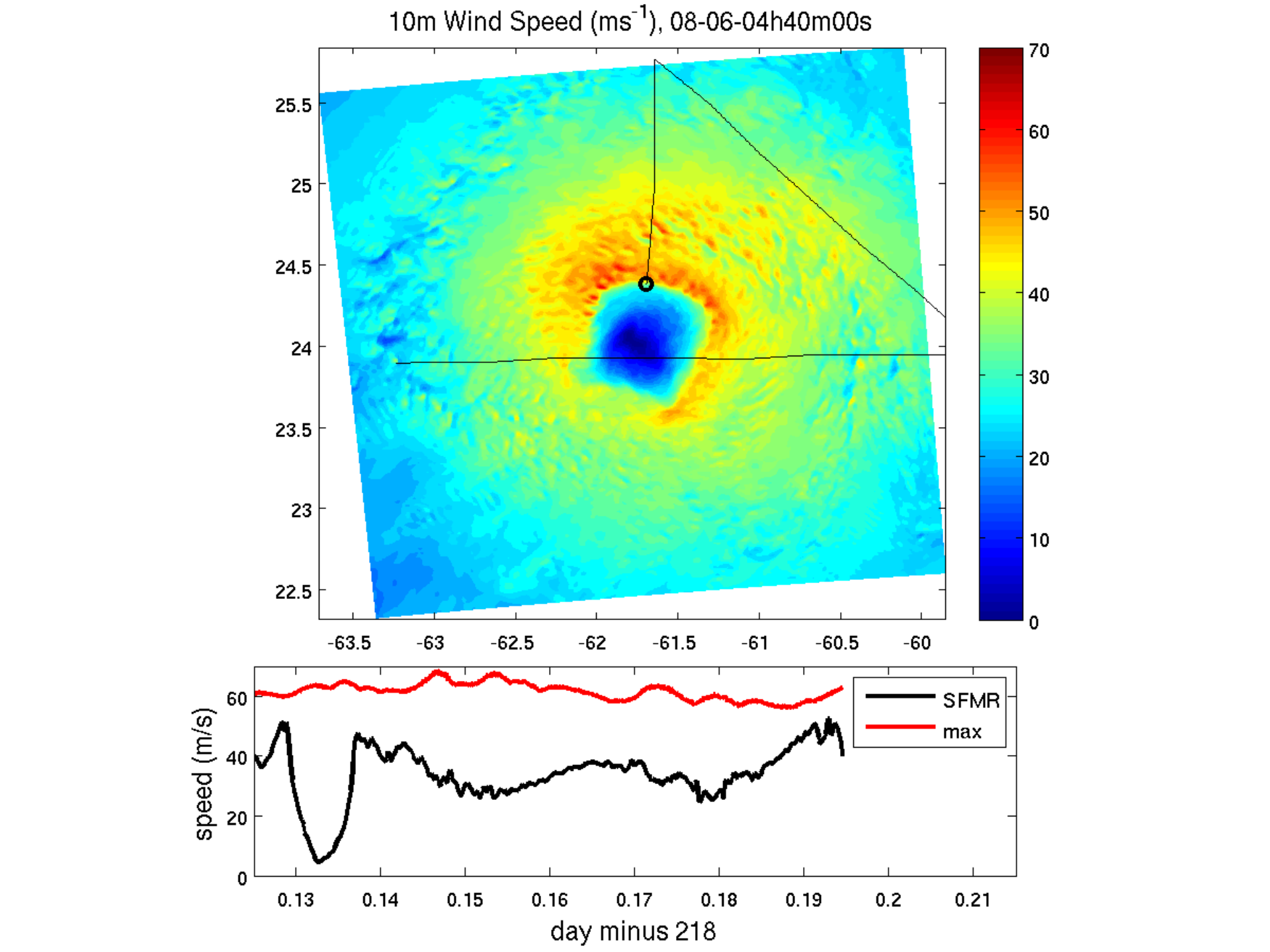
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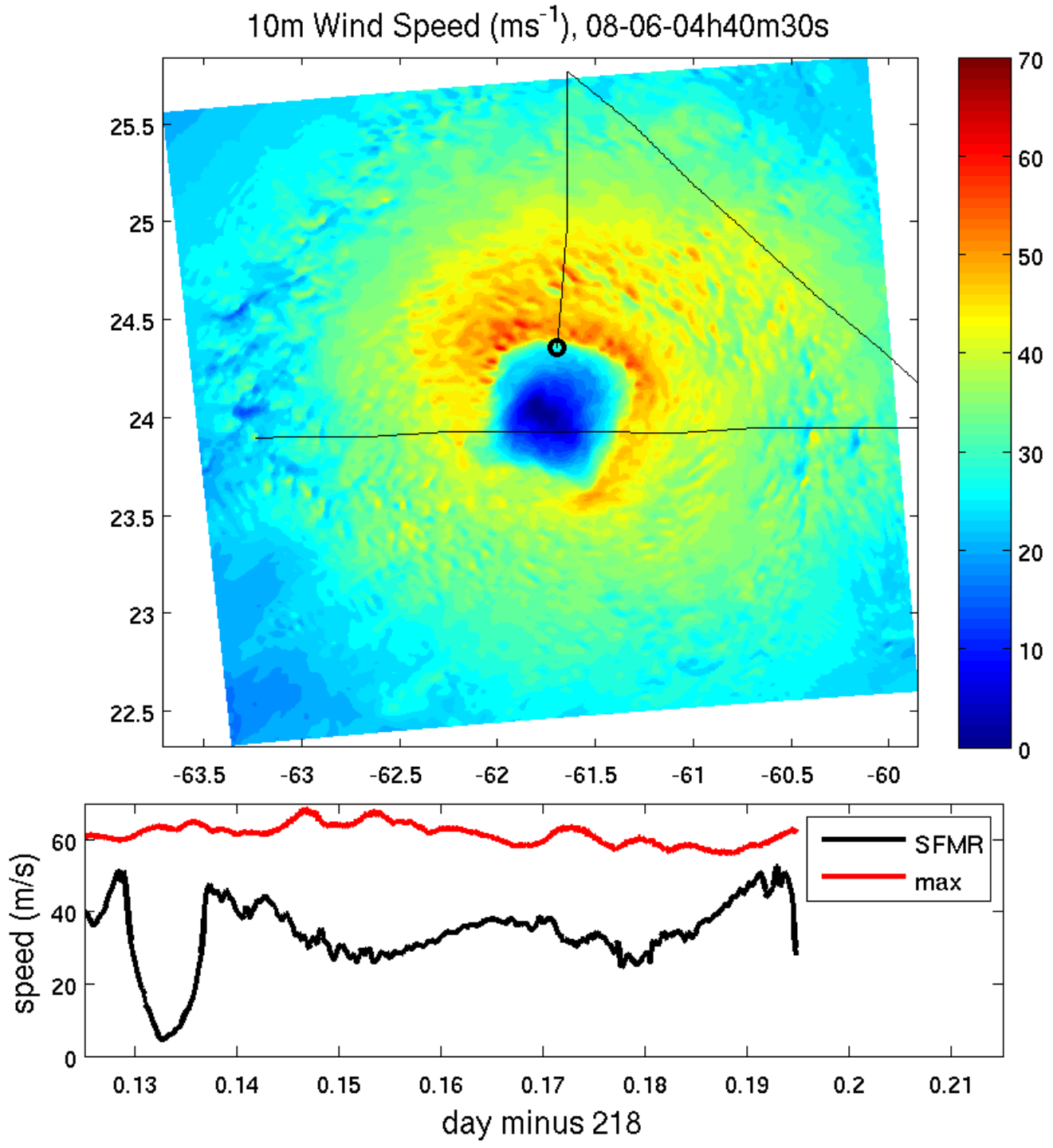
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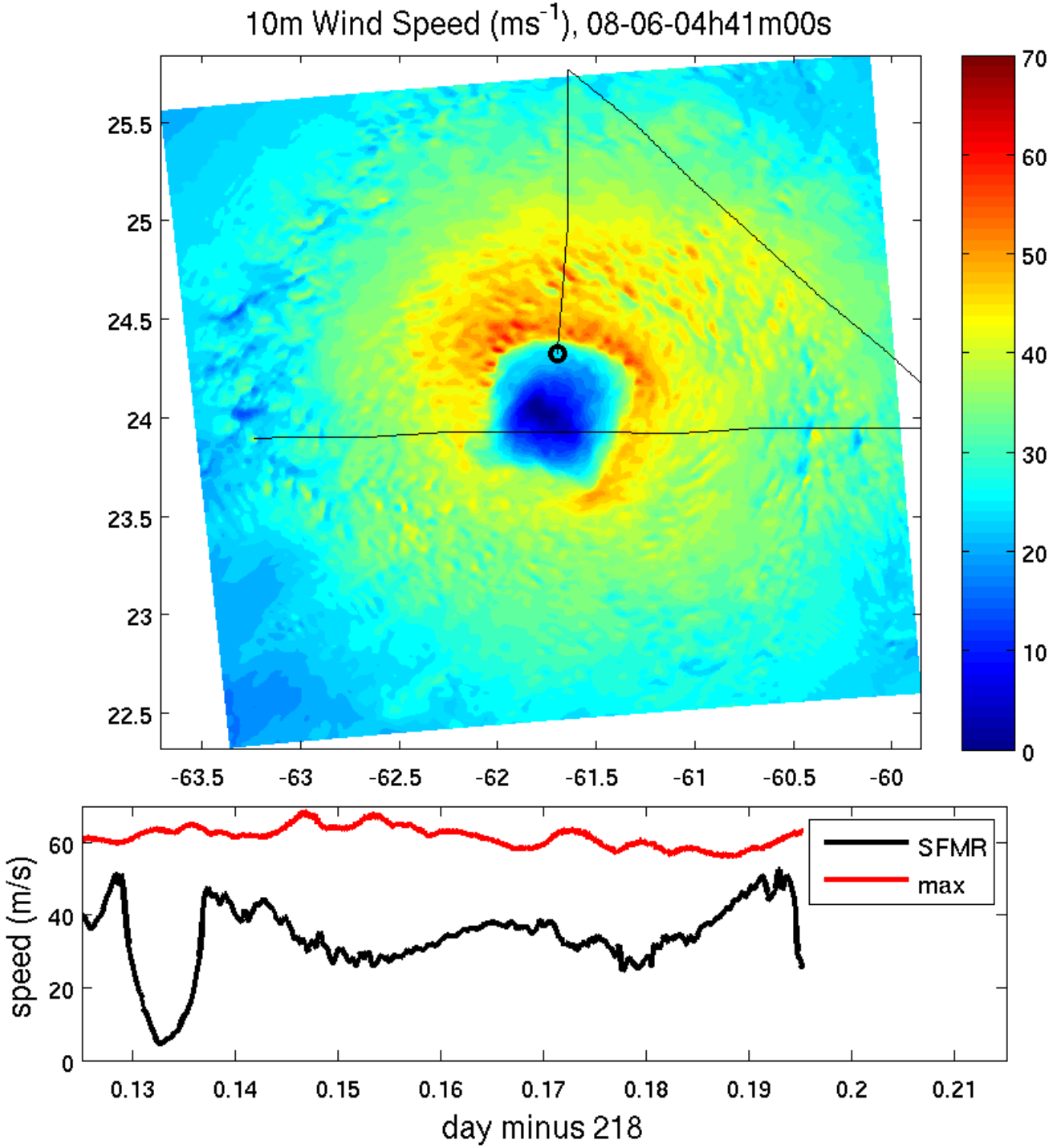
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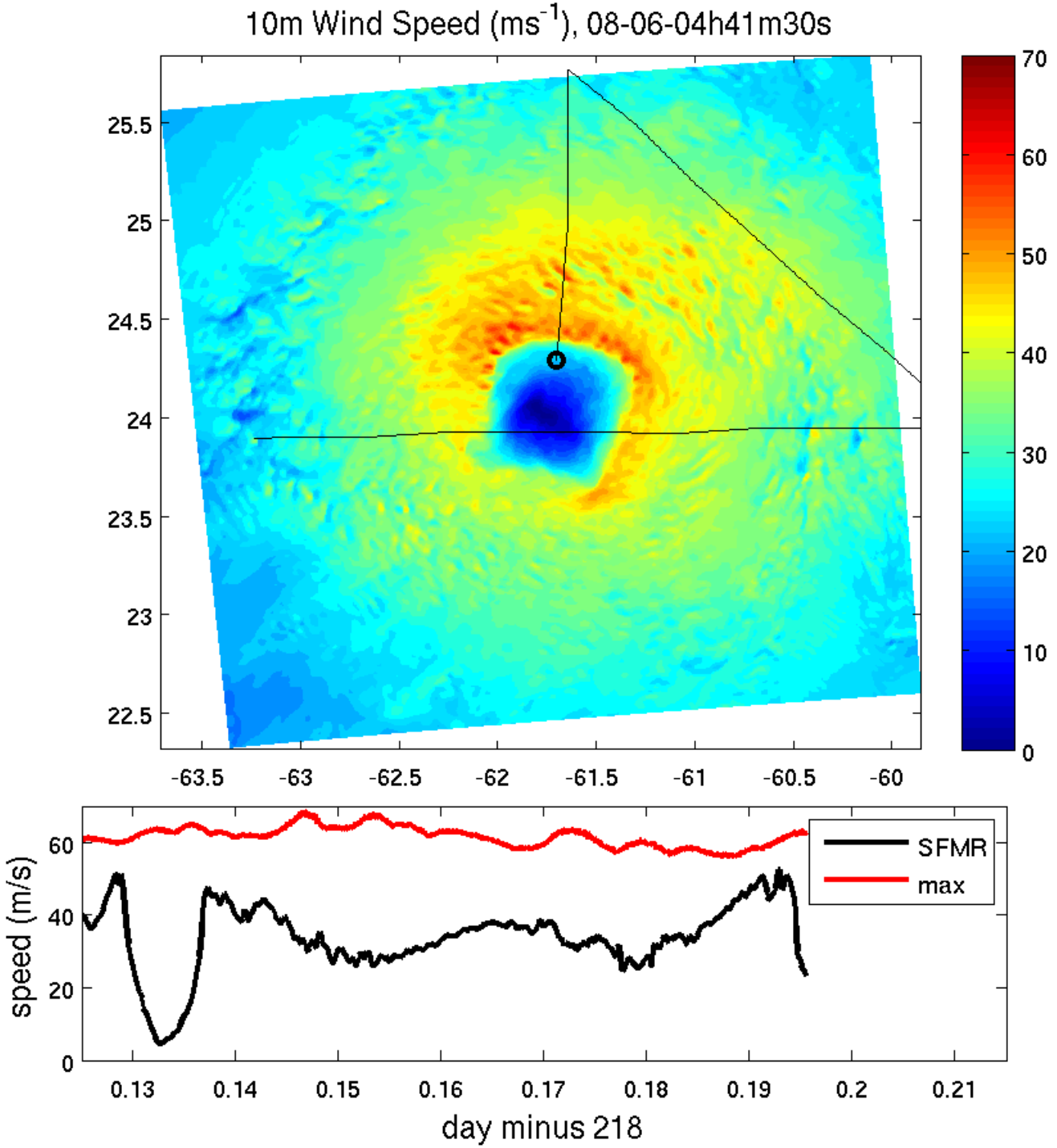
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I. Undersampling: Previous Work

- Uhlhorn and Nolan (2012) attempted to determine the typical "underestimate" of peak surface winds from aircraft penetrations with SFMR

  They generated hundreds of simulated SFMR profiles by "flying" aircraft through a simulation of Hurricane Isabel (2003).

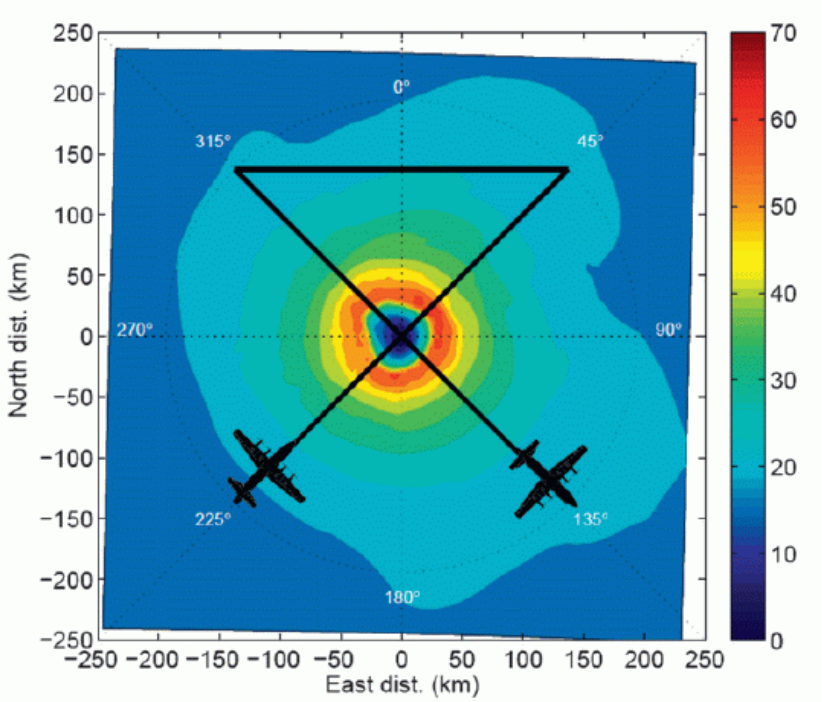


FIG. 6. Single figure-four (or alpha) flight pattern superimposed on a surface wind field snapshot (m s^{-1}). Aircraft symbols identify initial and final points of the pattern.

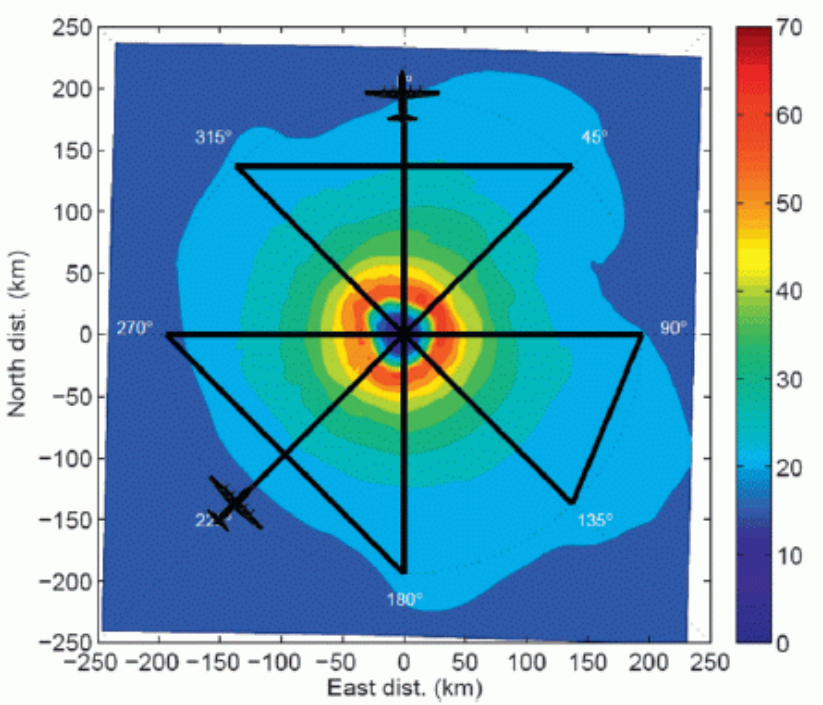
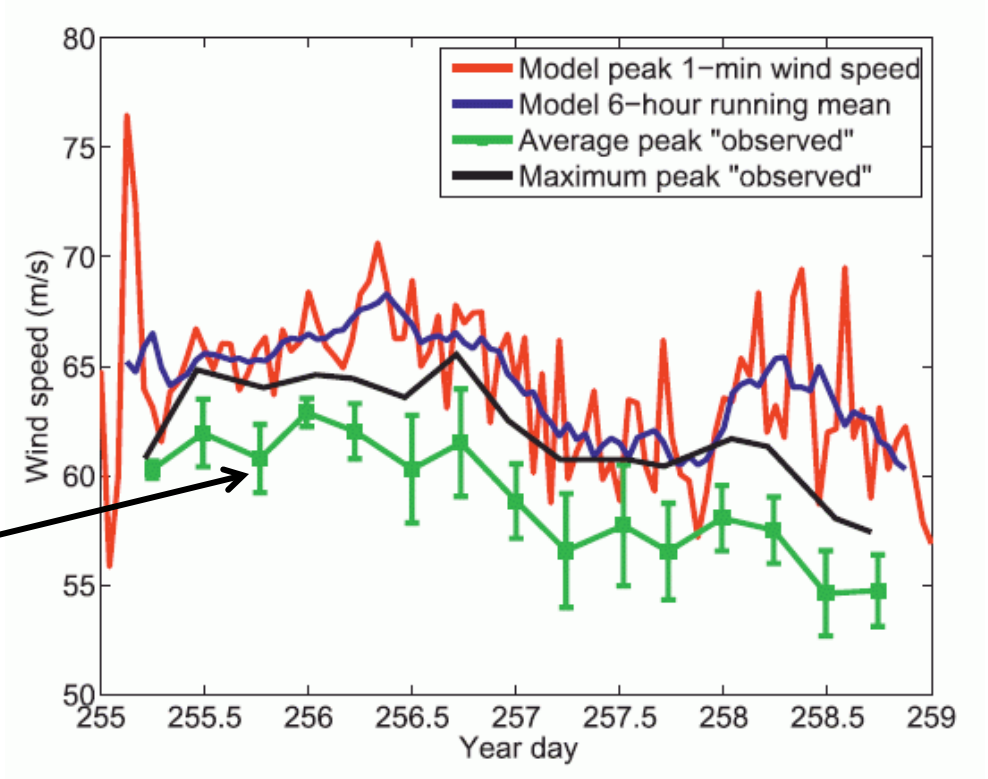


FIG. 14. Example rotated figure-four experimental flight pattern superimposed on surface wind field (m s^{-1}). Aircraft symbols identify initial and final points of the pattern.

Each point is the average over 8 flights from different starting points



Main Conclusion: A single figure-4 pattern will underestimate, on average, the “best track” intensity by 8.5%.

But…

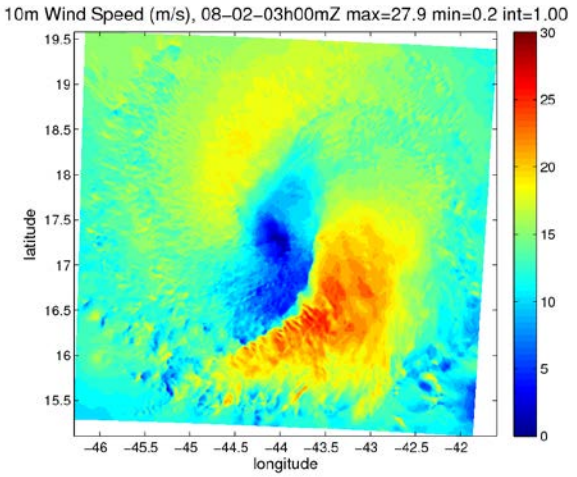
That study used one simulation of a very symmetric, major hurricane, with model output every 1 hour.

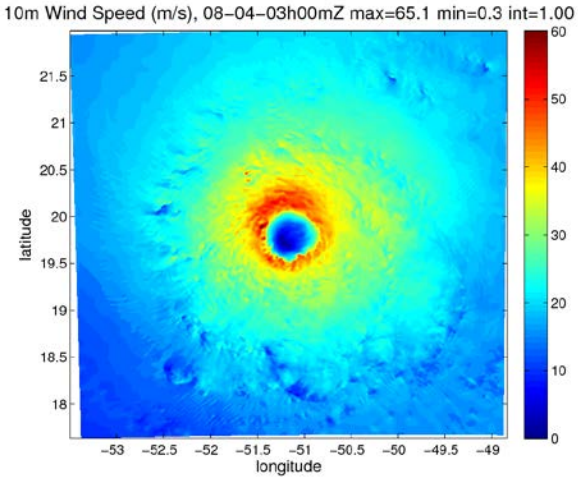
What about weaker storms? Asymmetric storms? Better simulations?

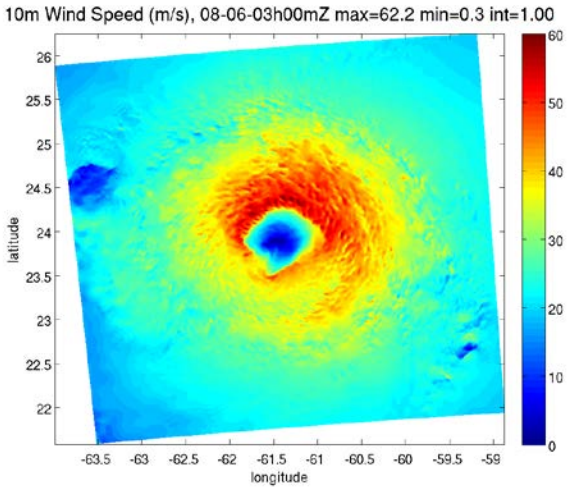
II. Goals of this Project

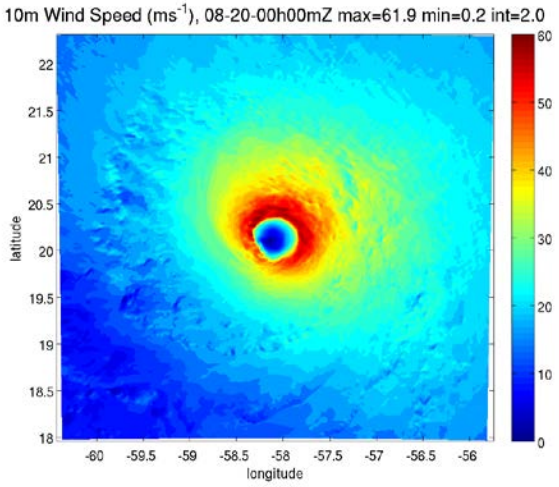
- To apply the same (or improved) methods of Uhlhorn and Nolan (2012) to assess undersampling on a wider variety of storms.

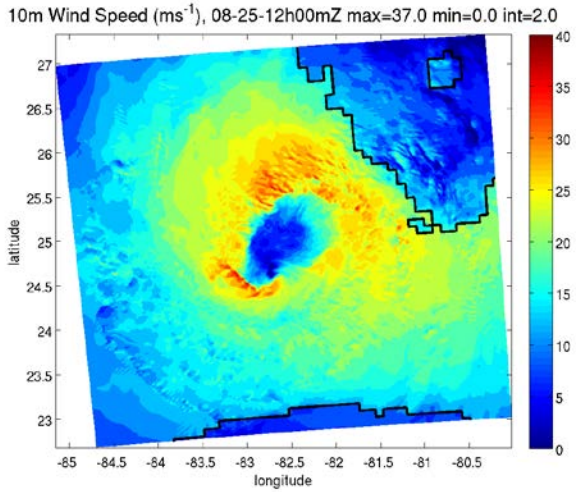
- We have a collection of simulations with 1 km resolution and frequent output:

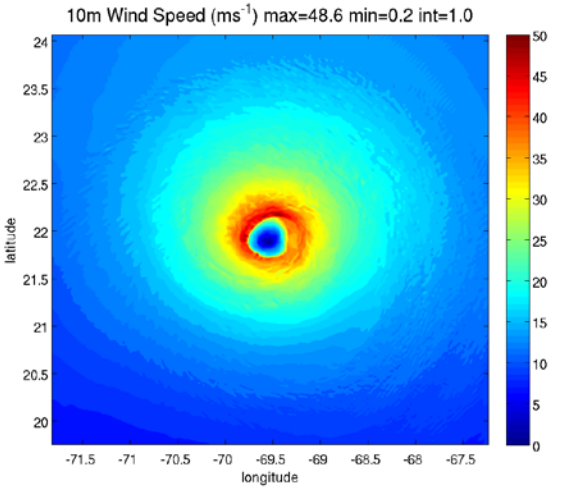




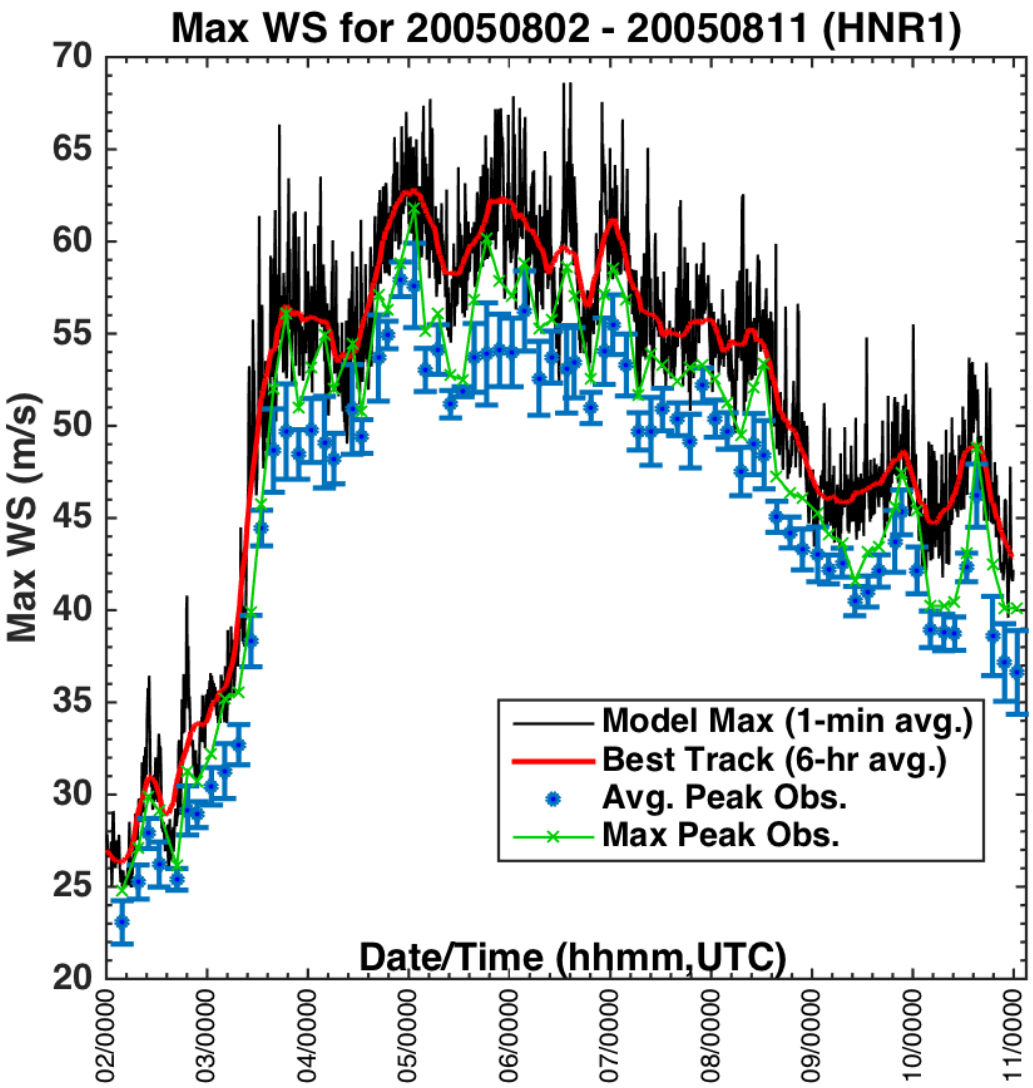




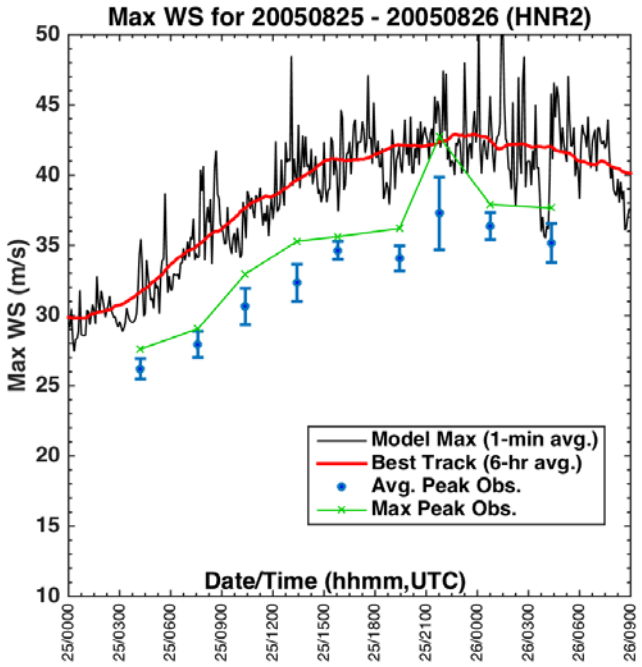




III. Early Results

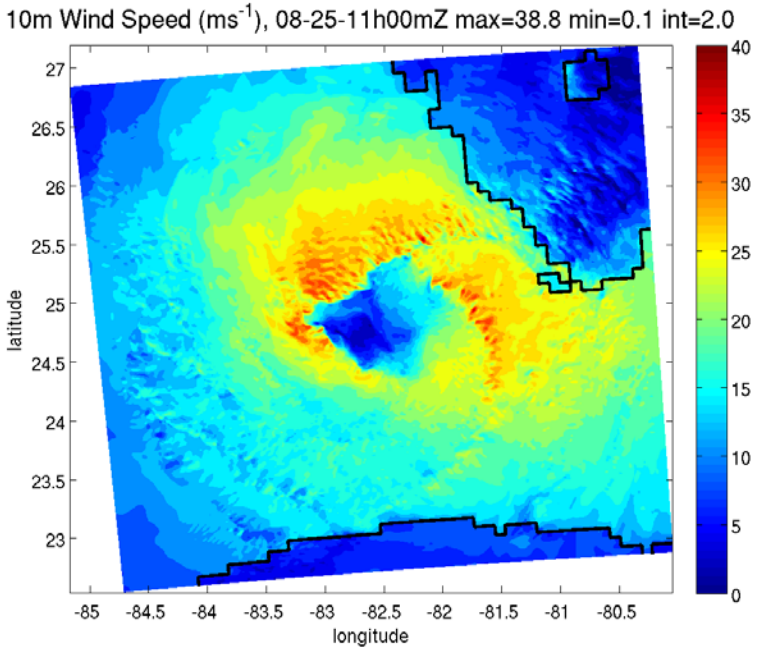


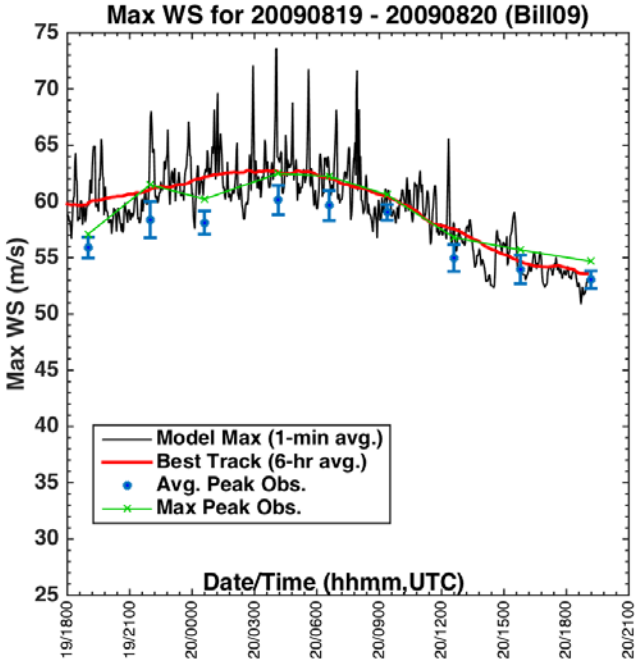
- Storm evolves from TS to RI to ERC to recurvature
- 8 simulated penetrations every 3 hours (more data)
- Mean undersampling of “best track” intensity is 11%
- 14% during RI



Nature Run 2

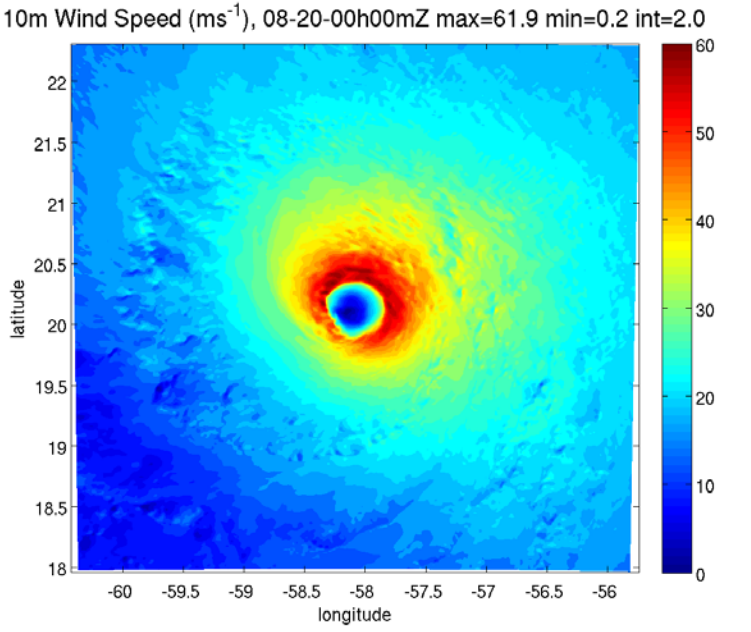
Average Underestimate: 16%

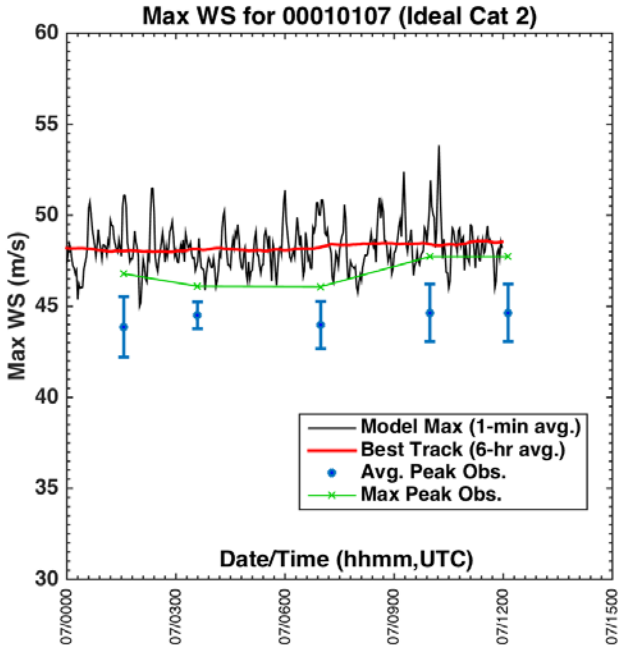




Hurricane Bill

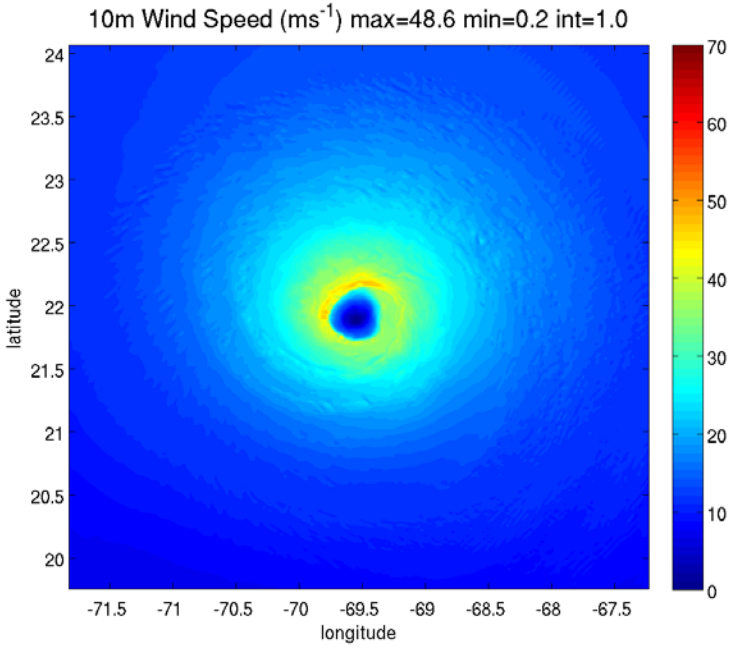
Average Underestimate: 4%



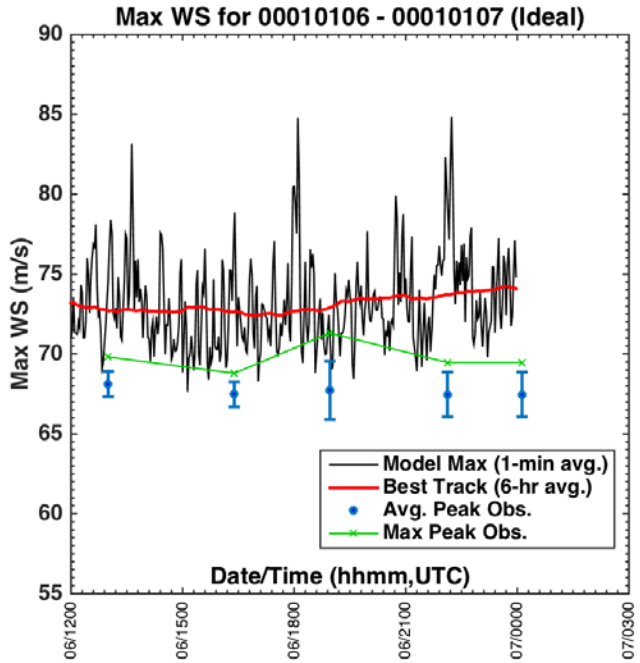


Idealized Cat 2

Average Underestimate: 8.1%



Note: Idealized, *but moving west with light westerly shear*



Idealized Cat 5

Average Underestimate: 7.5%

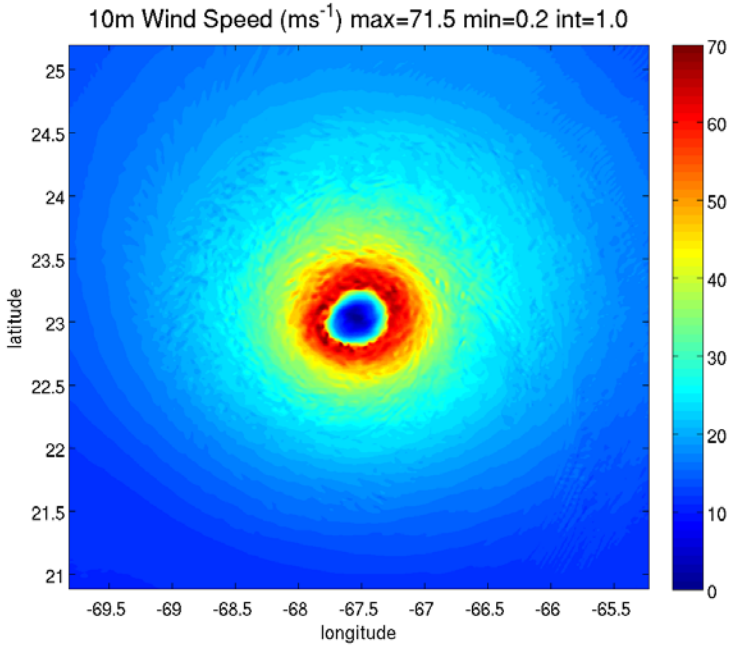
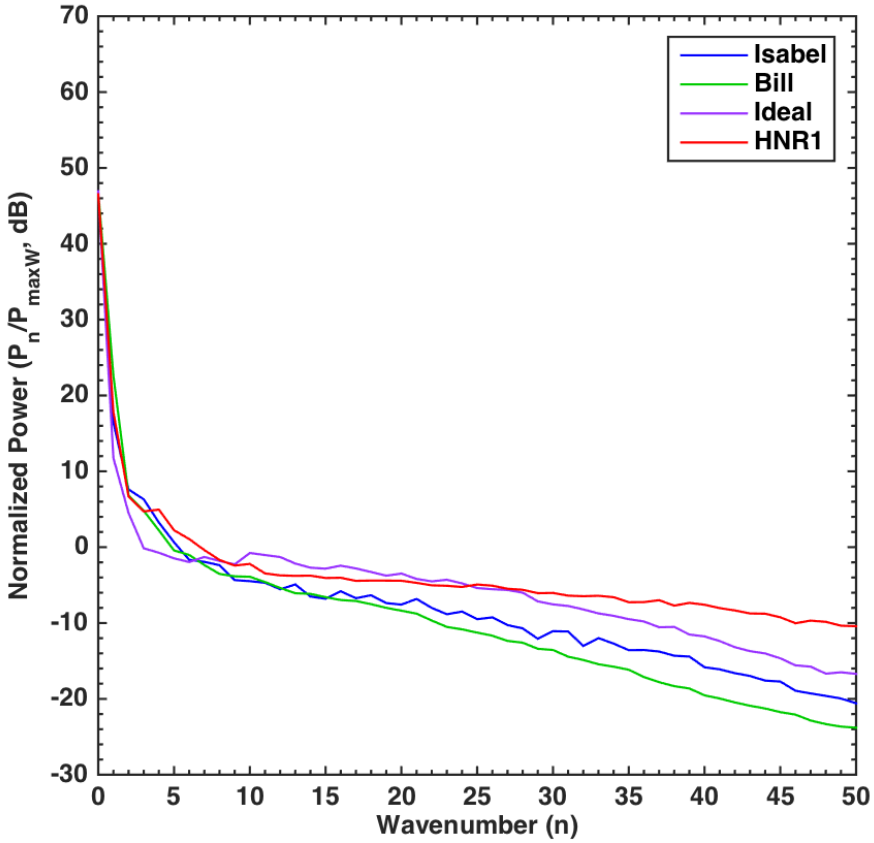


Figure shows power for azimuthal wavenumbers of wind speed around the vortex, near the RMW.



Early results suggest that the undersampling effect is larger for:

- Asymmetric/disorganized storms
- Larger storms
- More realistic physics – microphysics, radiation, air-sea coupling

Bill results are probably anomalous.

IV. Plans for This Year

- Further work on SFMR undersampling:

  1. Continue analyses of simulated P3 penetrations

  2. Update Bill and Idealized simulations to “Nature Run” quality physics:
     * Double moment microphysics
     * Most advanced radiation schemes
     * Simple ocean cooling

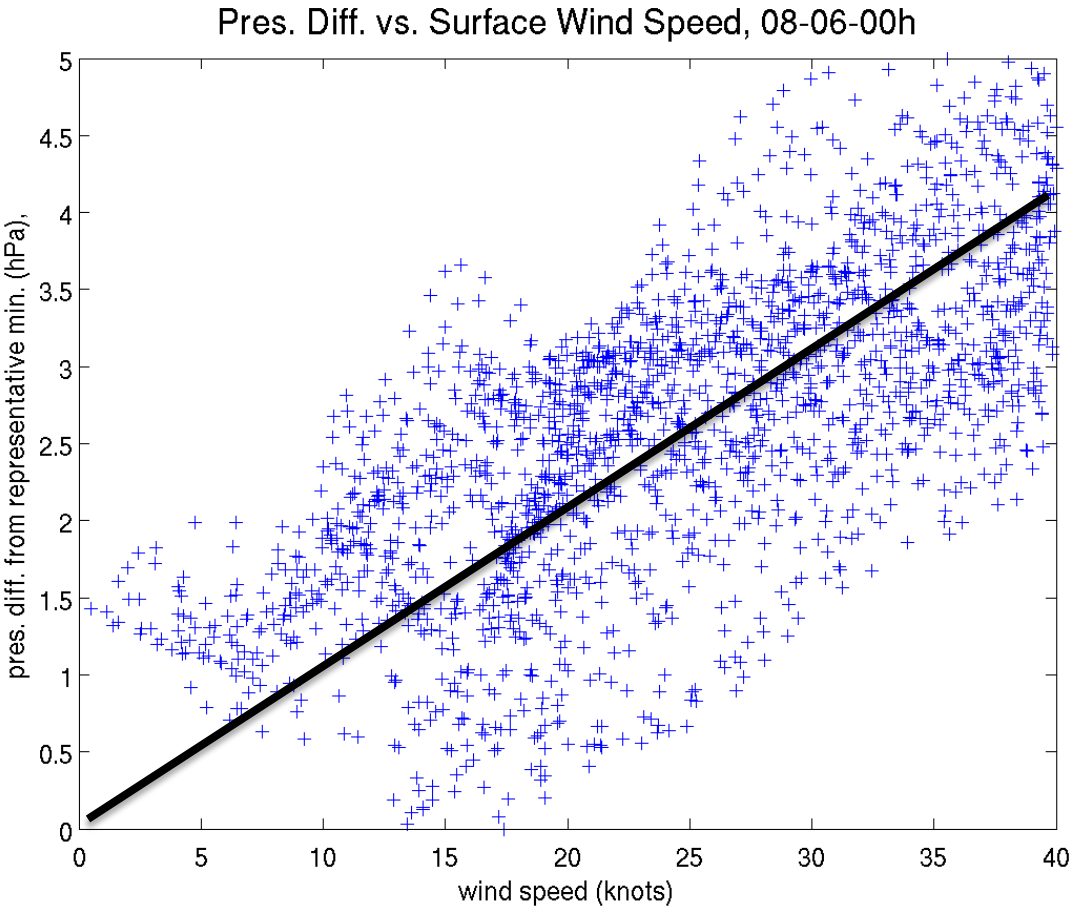
- Other proposed activities:

  1. Simulated undersampling by scatterometer overpasses

  2. Correcting dropsonde splash pressures according to reported wind speeds

What is right correction to minimum pressure given dropsonde wind speed at splash?

An example for one model time:



Preliminary result: 1 hPa per 10 knots of wind is a pretty good rule!

But – zero winds actually means you are not at the pressure minimum.