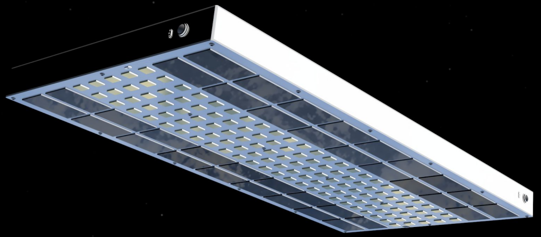
CAREWEATHER

Performance Simulations for Veery, a Small Scatterometer for an Hourly OSVW Constellation

IOVWST 2024



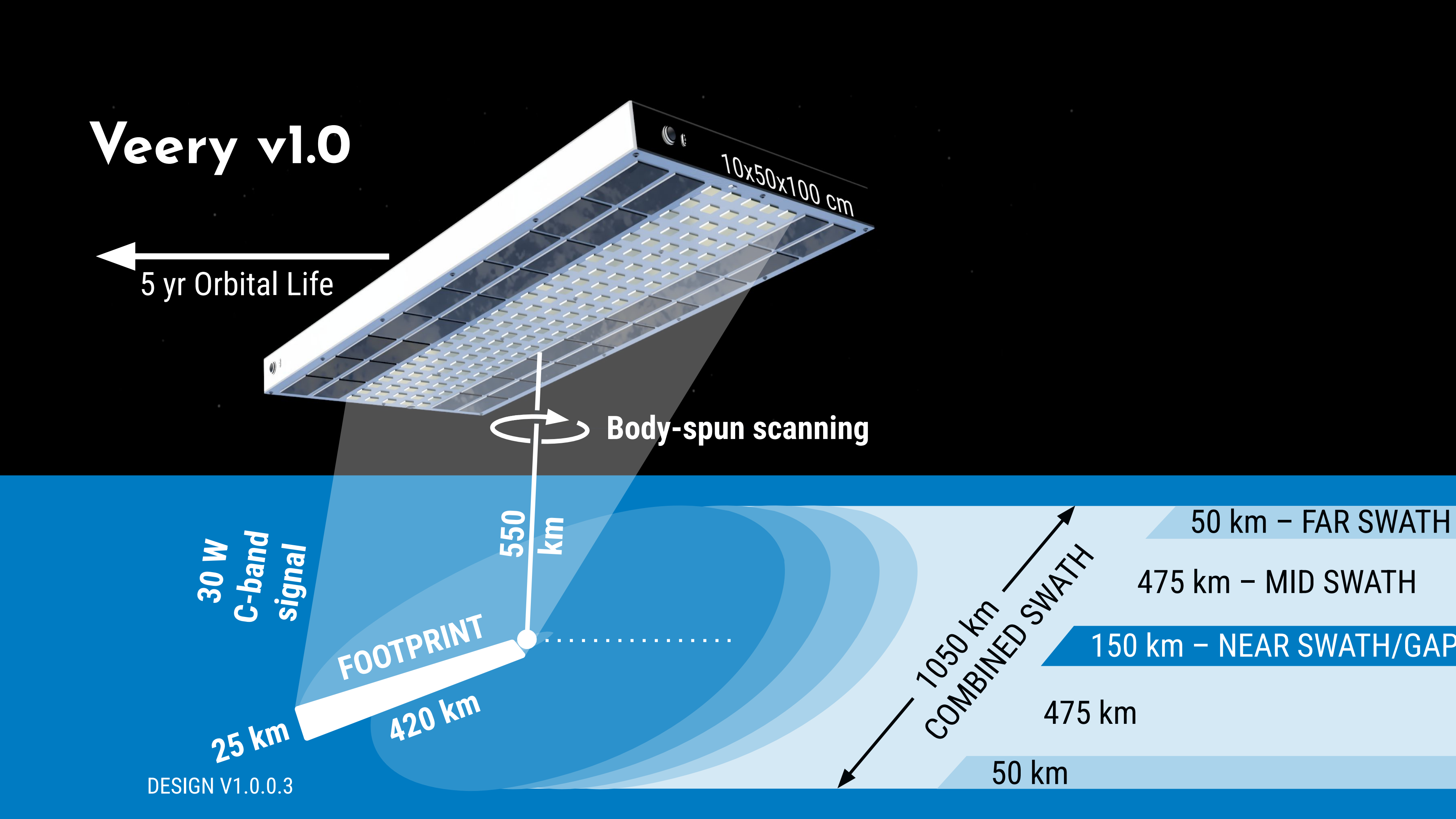
Patrick Walton, Alex Laraway – Care Weather
David Long – BYU / Care Weather

PERFORMANCE	TARGET
Speed Accuracy	<2 m/s
Direction Accuracy	<20°
Dynamic Range	3-27 m/s
Spatial Resolution	25 km
Worst Case Latency	<2 hrs
Swath	>1000 km
Global Refresh	1 hrs

Objective

Commercially-viable hourly refresh of global ocean surface vector winds (OSVW) with high performance.

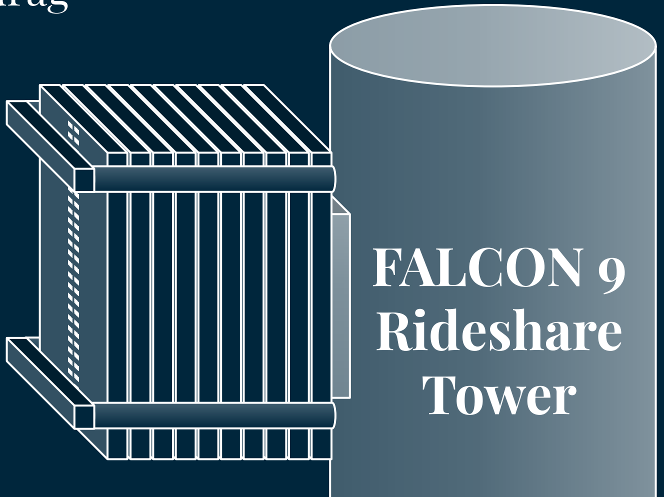
Hourly refresh requires much lower cost.



Veery v1.0
10x50x100 cm
5 yr Orbital Life
Body-spun scanning
550 km
30 W C-band signal
FOOTPRINT
25 km
420 km
DESIGN V1.0.0.3
1050 km COMBINED SWATH
50 km – FAR SWATH
475 km – MID SWATH
150 km – NEAR SWATH/GAP
475 km
50 km

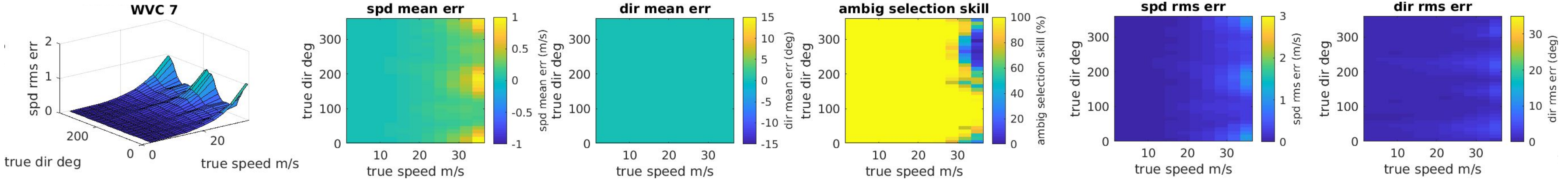
Orders of magnitude lower cost

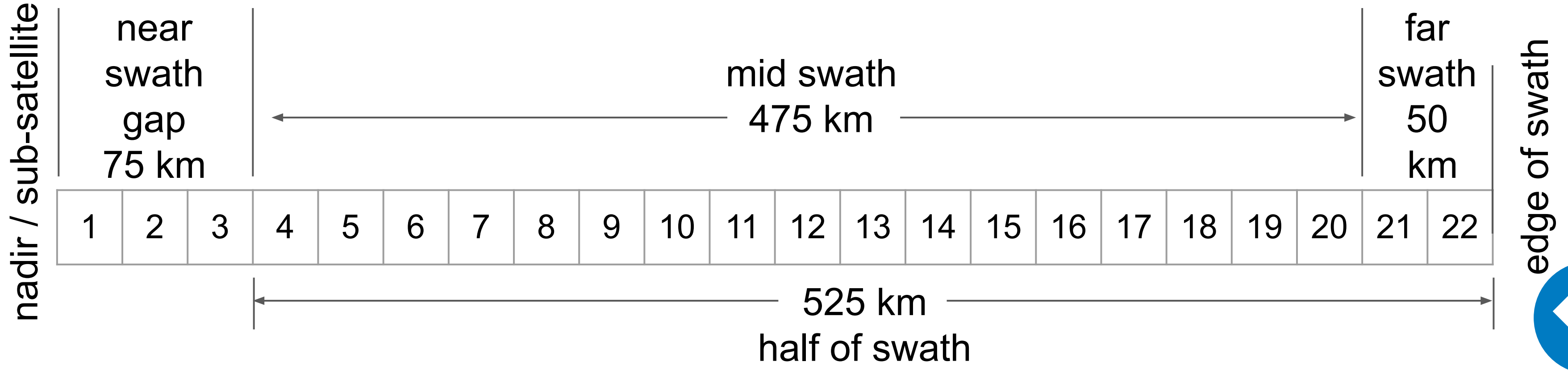
- Iteration and vertical integration (see poster)
- Eliminate bulky hardware
  - Active cooling systems ⇒ proprietary passive thermal management
  - Slip rings ⇒ body-spun scanning
  - Deployables ⇒ body mount array antenna
  - Thrusters ⇒ aerodynamic flight, differential drag
- Stackability (pictured)
  - 5-10 satellites in a single rideshare slot.
- Aerodynamic at Low Orbit
  - Loss ($L \sim d^4$) ⇒ ½ d = 1/16 L
- Flat surface area to mass ratio
  - 8X body-mount solar panel for same mass



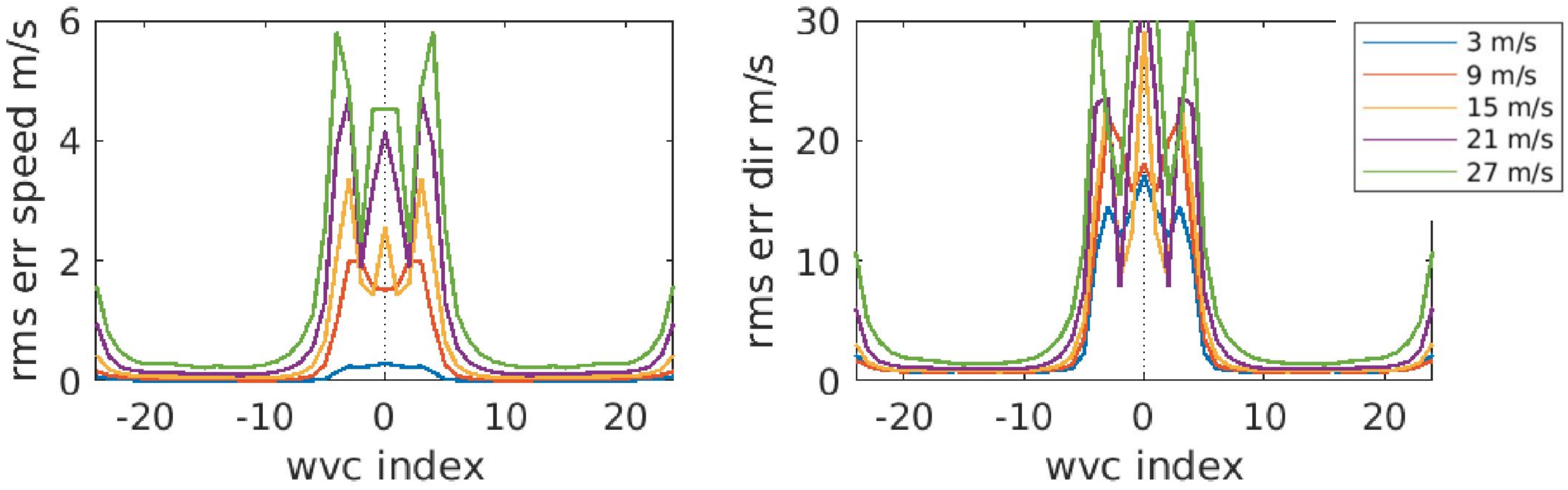
Compass Simulation Methodology

- Calculate measured backscatter across a 3–27 m/s range of winds speeds and compass directions for each 25 km cell.

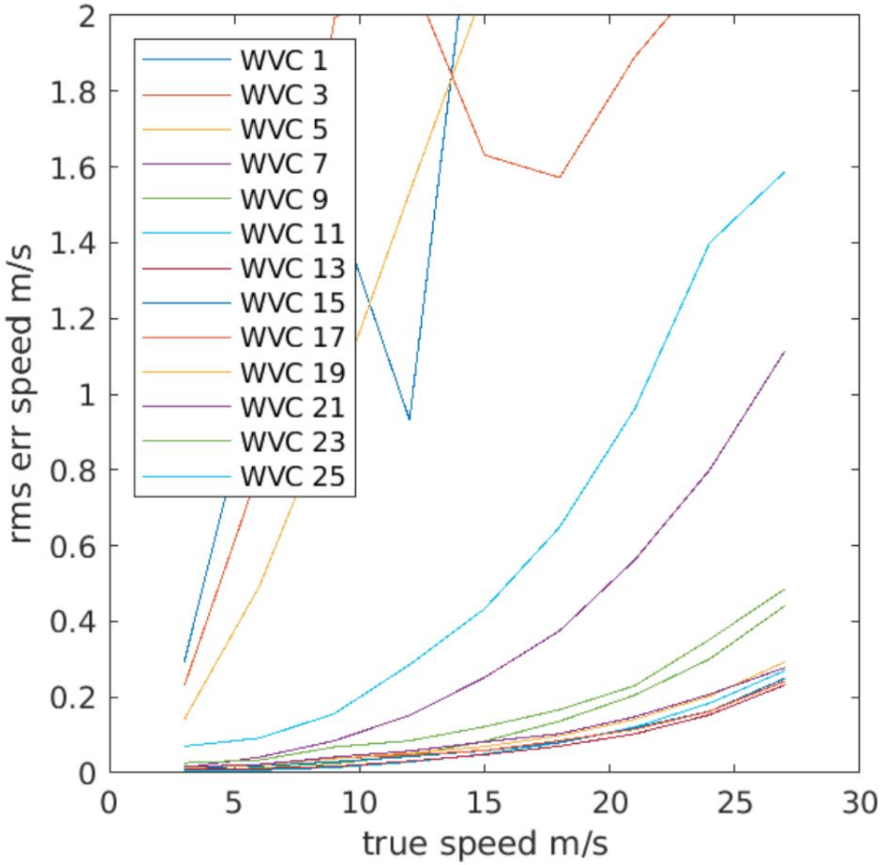


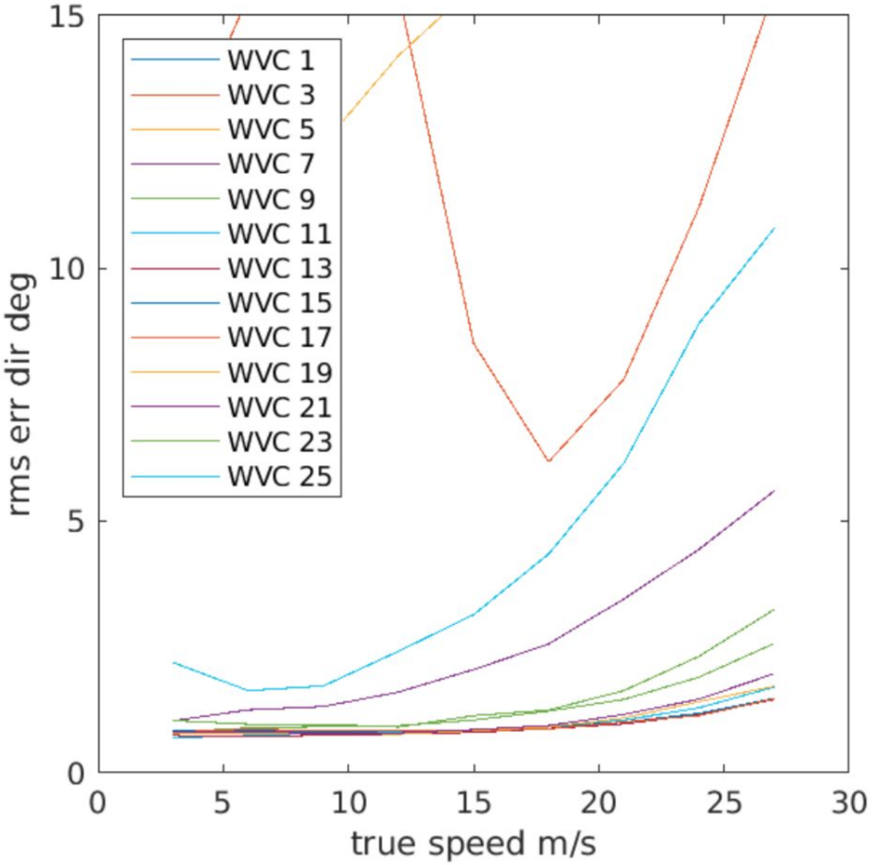


Simulated Accuracy Across the Swath

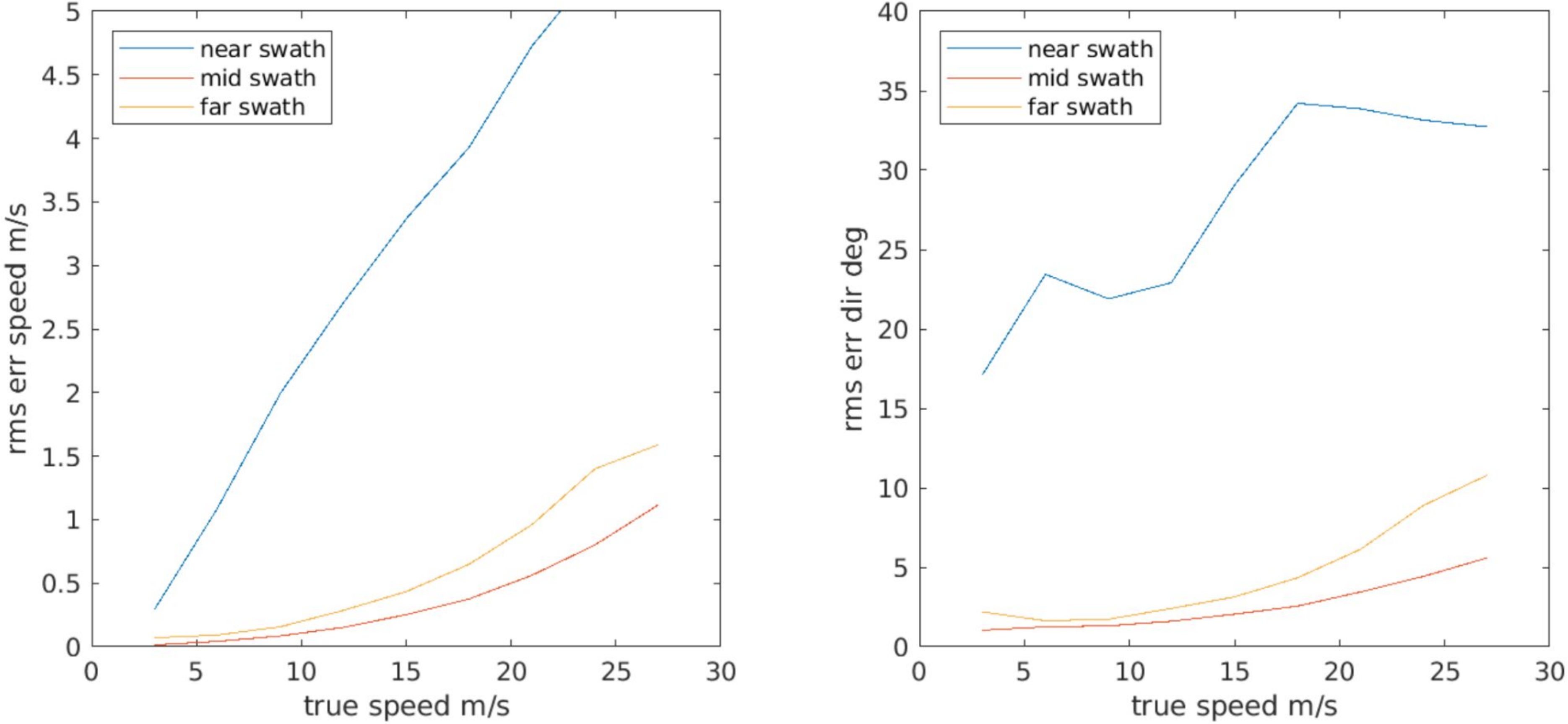


Simulated Accuracy vs. True Wind Speed

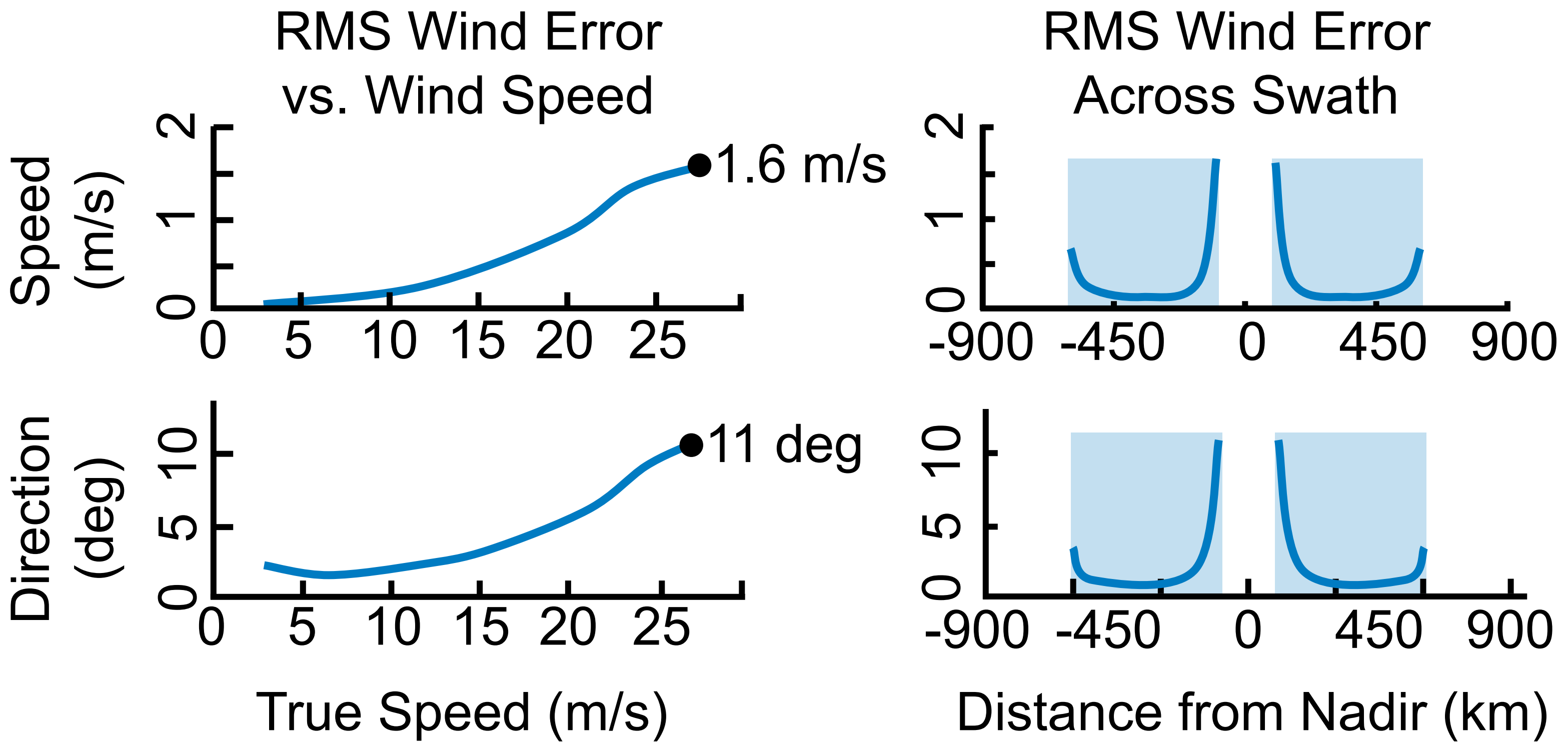




Simulated Accuracy vs. True Wind Speed



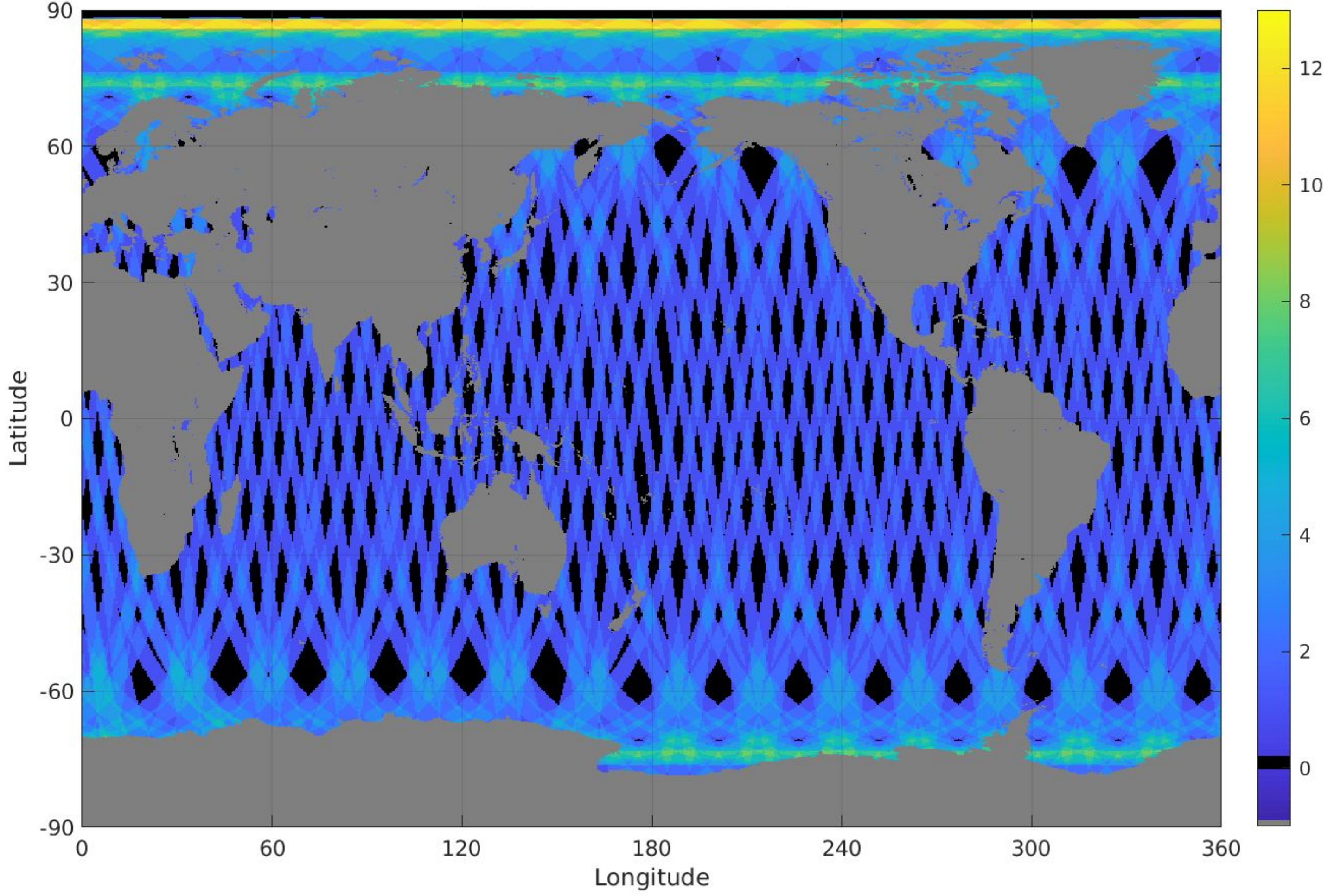
Accuracy Summary

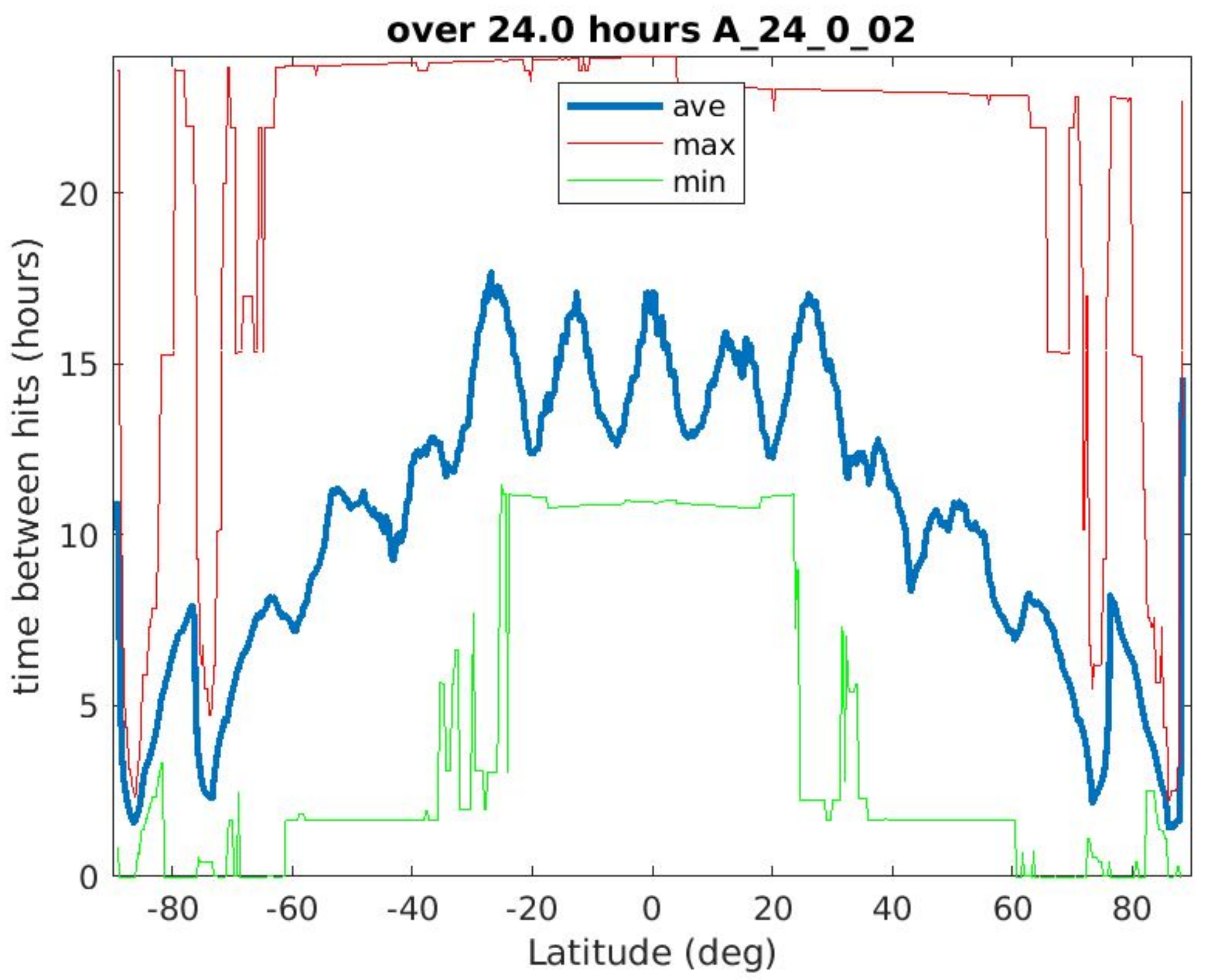


Refresh Simulation Methodology

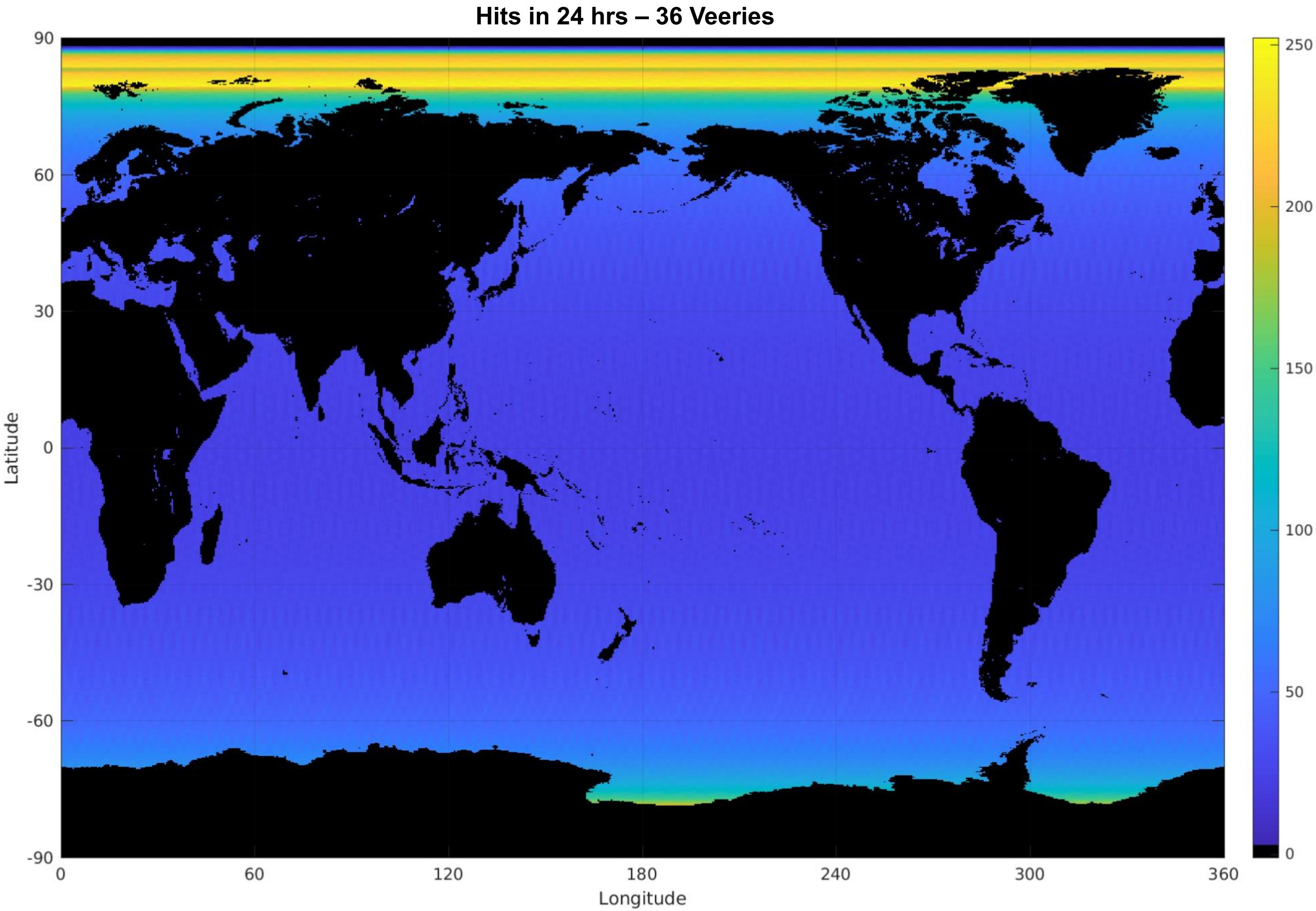
- Simulate swaths over 24-hr period
- Calculate statistics for time between visits for each cell.
- For Veery, evenly space satellites in LTAN.

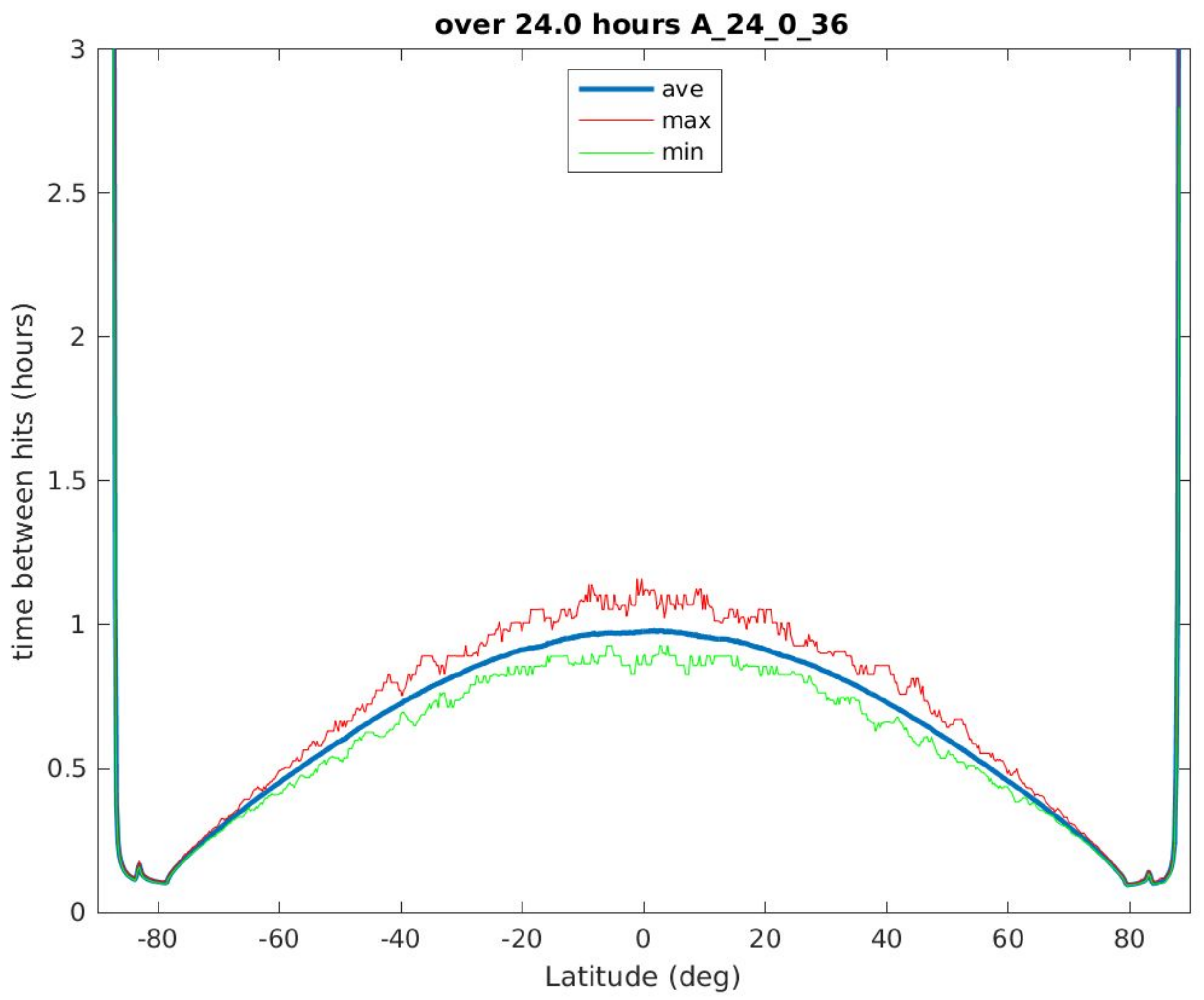
Hits in 24 hrs – 2 ASCATs



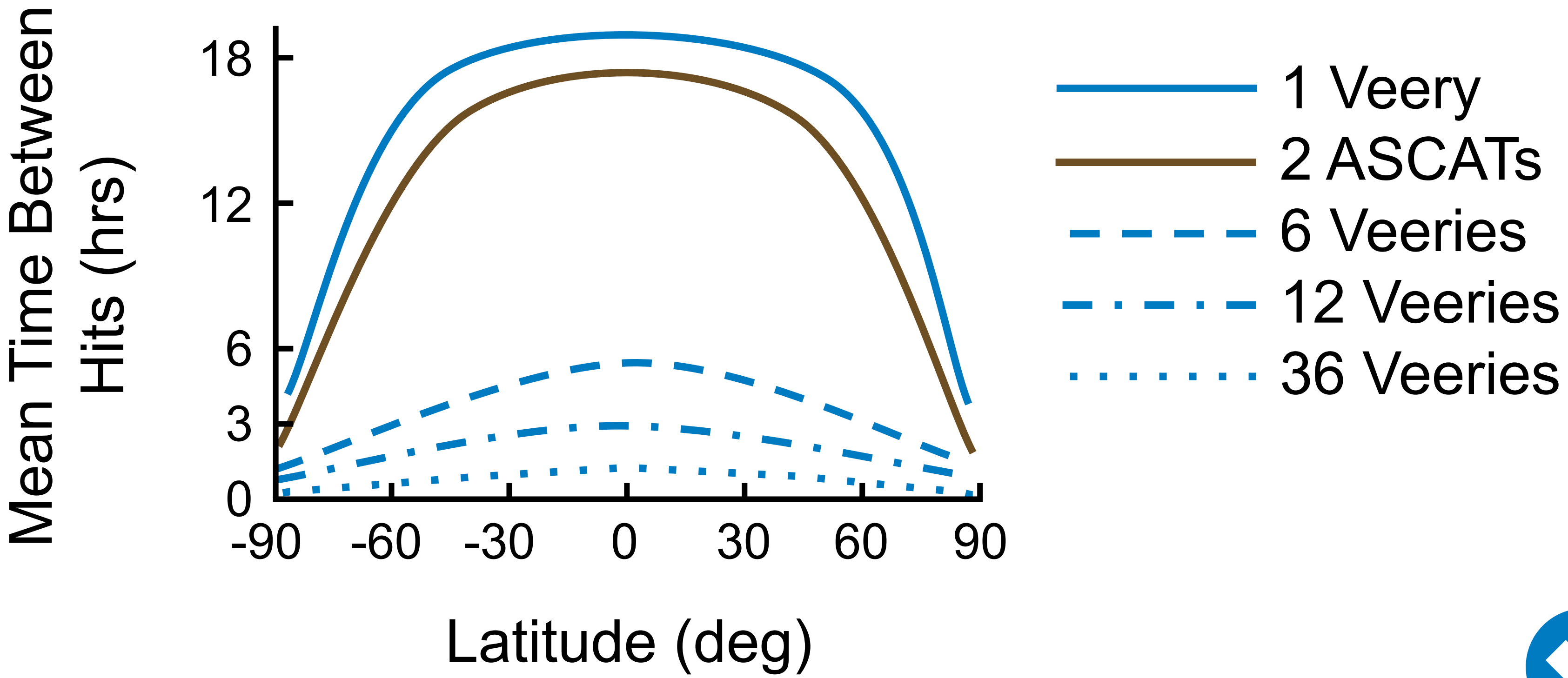


over 24.0 hours A_24_0_02
ave
max
min
time between hits (hours)
0
5
10
15
20
-80
-60
-40
-20
0
20
40
60
80
Latitude (deg)


Hits in 24 hrs – 36 Veeries
Latitude
Longitude
90
60
30
0
-30
-60
-90
0
60
120
180
240
300
360
250
200
150
100
50
0

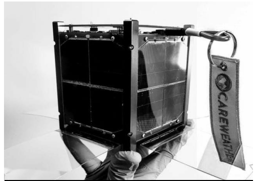

over 24.0 hours A_24_0_36
ave
max
min
time between hits (hours)
3
2.5
2
1.5
1
0.5
0
-80
-60
-40
-20
0
20
40
60
80
Latitude (deg)

Refresh vs. Latitude Summary



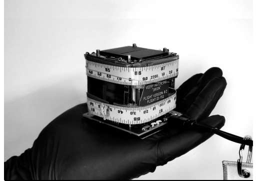
Iterative Development Approach

- Flight qualification of subset of the system is in progress.
- See poster for more details.



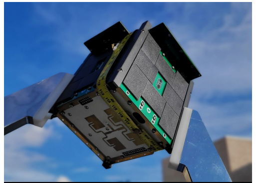
V0.1
Launched 2021

Minimum Viable Satellite



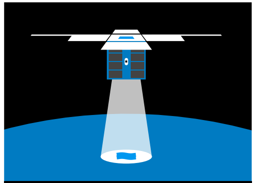
V0.2
Launched 2022

Satellite Bus Improvements



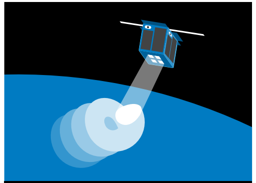
V0.3, Launched 3/2024

Minimum Viable Radar



V0.4, Launching 10/2024

Wind Speed Radar



V0.5
Launching 2025-H1

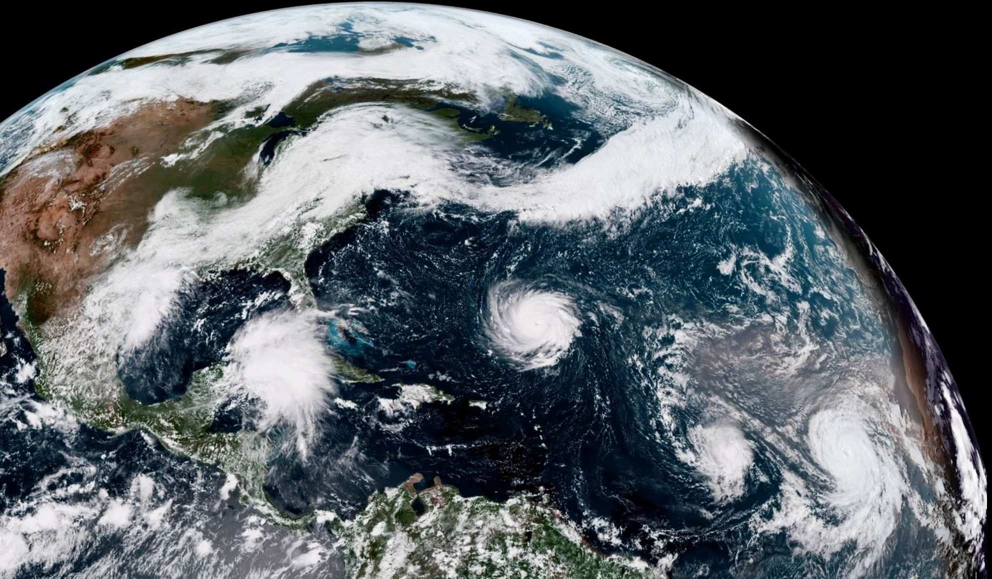
Prototype Scatterometer

V1.0
Launching 2026

Full-scale Scatterometer

Acknowledgments

This material is based upon work supported by National Science Foundation Grant No. 2304609.



Contact

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Compass Simulation Approach

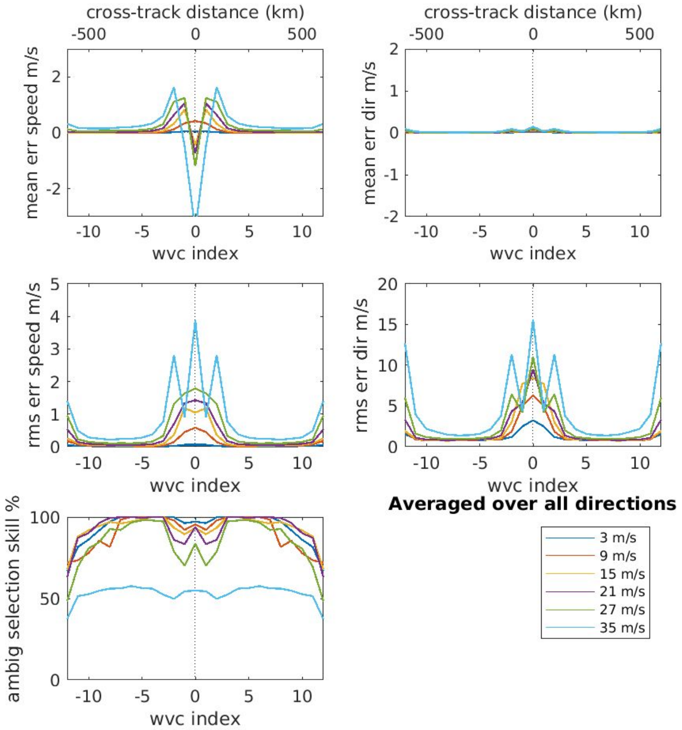
For each WVC over swath, compute geometry, Kp coefficients, etc. for each measurement (1000's)
  For each wind speed 3:3:27 m/s
    For each wind direction "around the compass" 0:5:360 deg
      Compute "true" Sigmao from GMF for each measurement
        For each realization (25) of independent noise
          Pre-average in incidence and azimuth bins to ~100 measurements
          Retrieve wind using MLE
          Select closest ambiguity to true, compute wind error
      Compute wind error statistics for speed and direction

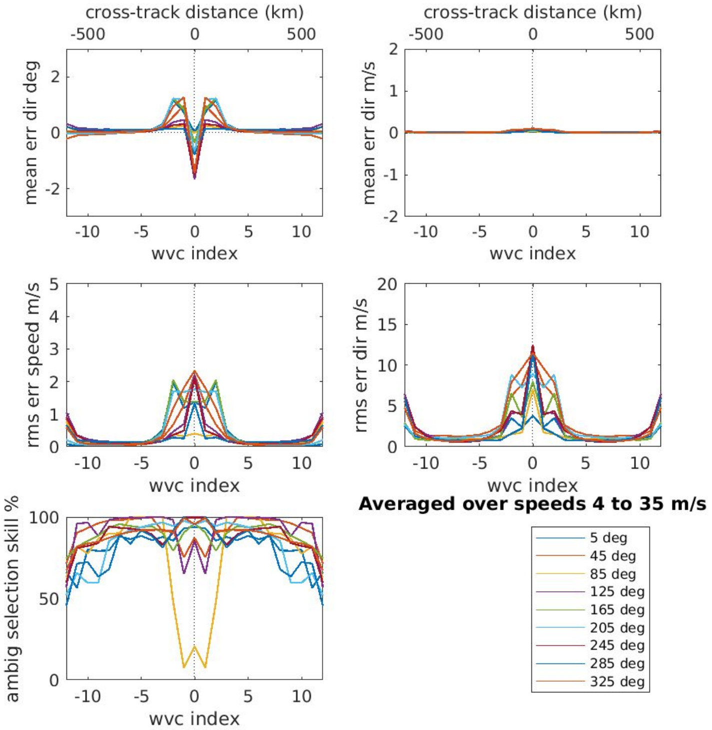
Plot statistics versus swath position, wind speed

Compass Simulation Methodology

- Compute instrument geometry, including signal processing
  - Assume uniform sigma_0 over WVC
  - 25 & 50 km WVCs
  - Kpc computed from SNR and sigmao, communication noise independent
  - Rotating fan beam provides 1000's of low-SNR measurements for each WVC with wide azimuth, incidence angle variation – leads to low Kpc
  - Kpr=0 (calibration error)
  - No rain, fixed atmospheric attenuation
- CMOD5 for forward/reverse GMF
  - Kpm=0.17 (GMF modelling variance) with independent measurement (recognized to be optimistic)
- MLE retrieval including 1/log(Kpc) term
  - 1/log(Kpc) term does not make much difference
  - Well-validated retrieval code with 2-4 ambiguities
- Ideal ambiguity selection (ambiguity closest to true chosen)

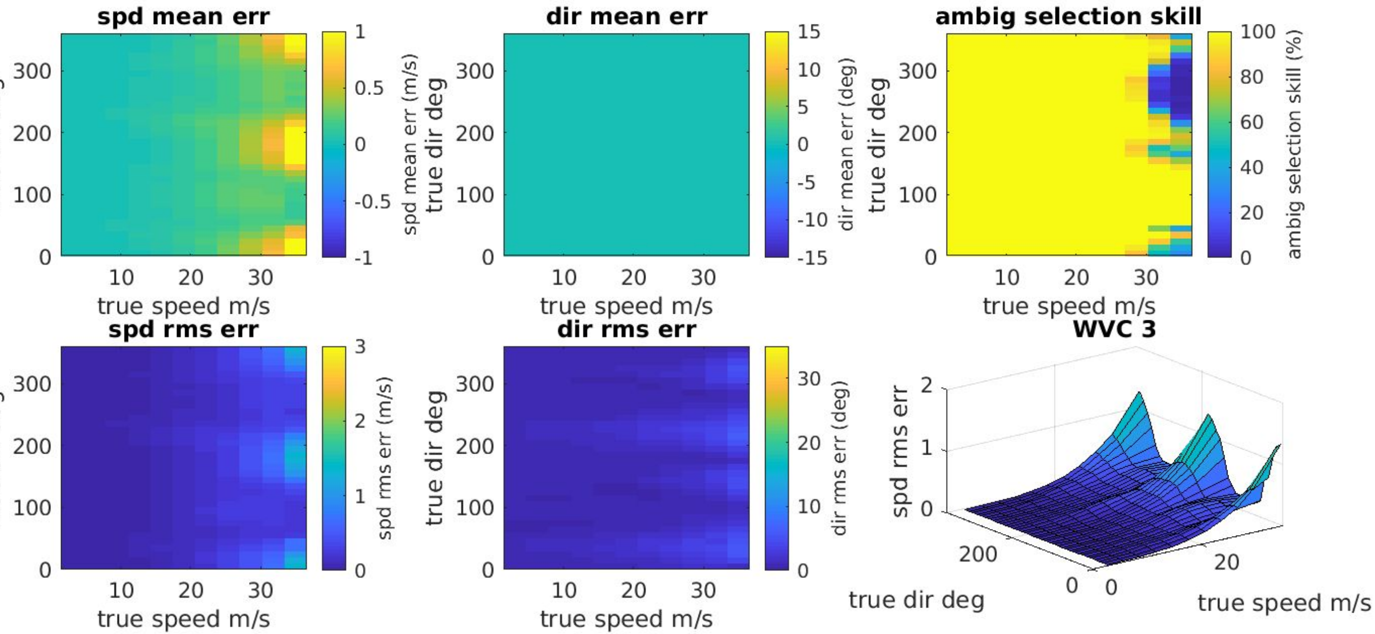
Compass Simulation "Mustache Plots"





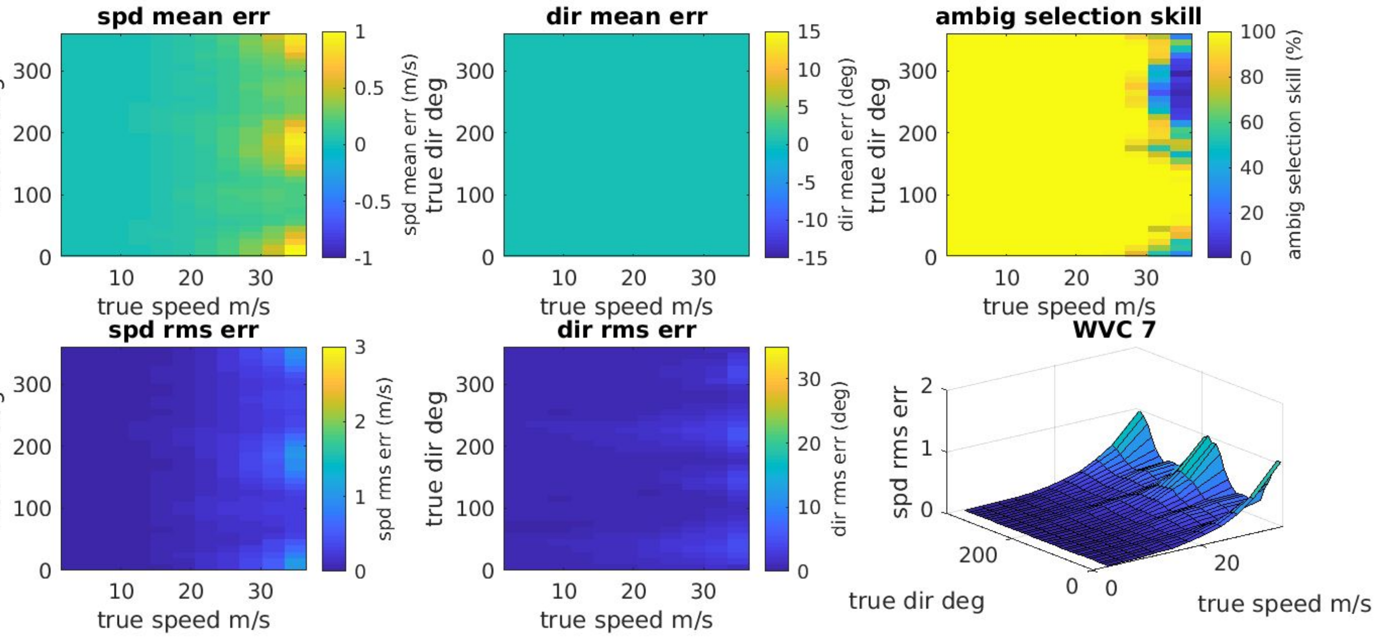
Far-swath

Performance over speed, direction and swath



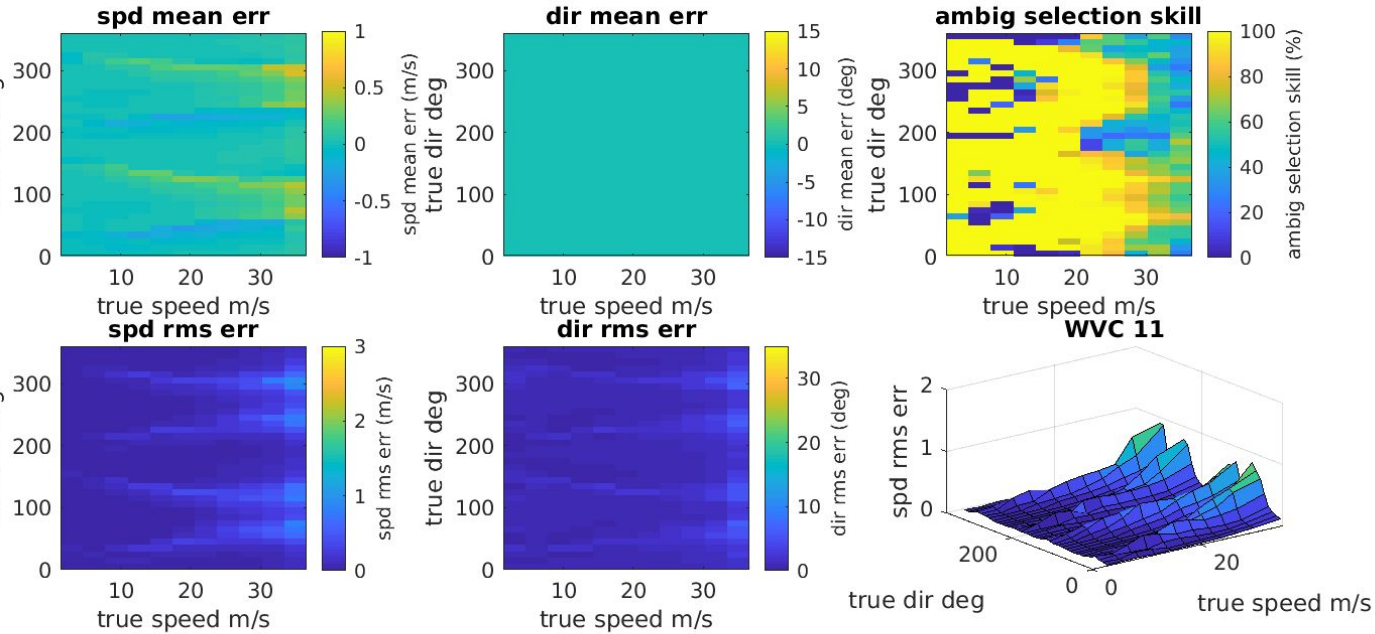
Mid-swath

Performance over speed, direction and swath



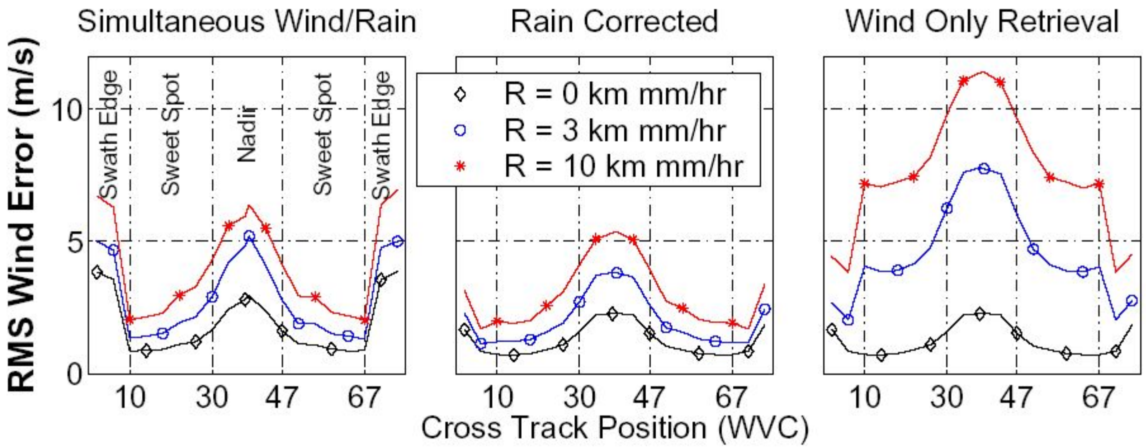
Far-swath

Performance over speed, direction and swath



Monte Carlo Compass Statistics

RMS Error at true wind speed = 7 m/s



- New methods improve wind retrieval for significant rain
- Wind-only better than simultaneous wind/rain retrieval for zero rain rate
- Simultaneous retrieval poor at swath edges
- Simultaneous and rain-corrected wind estimates very similar