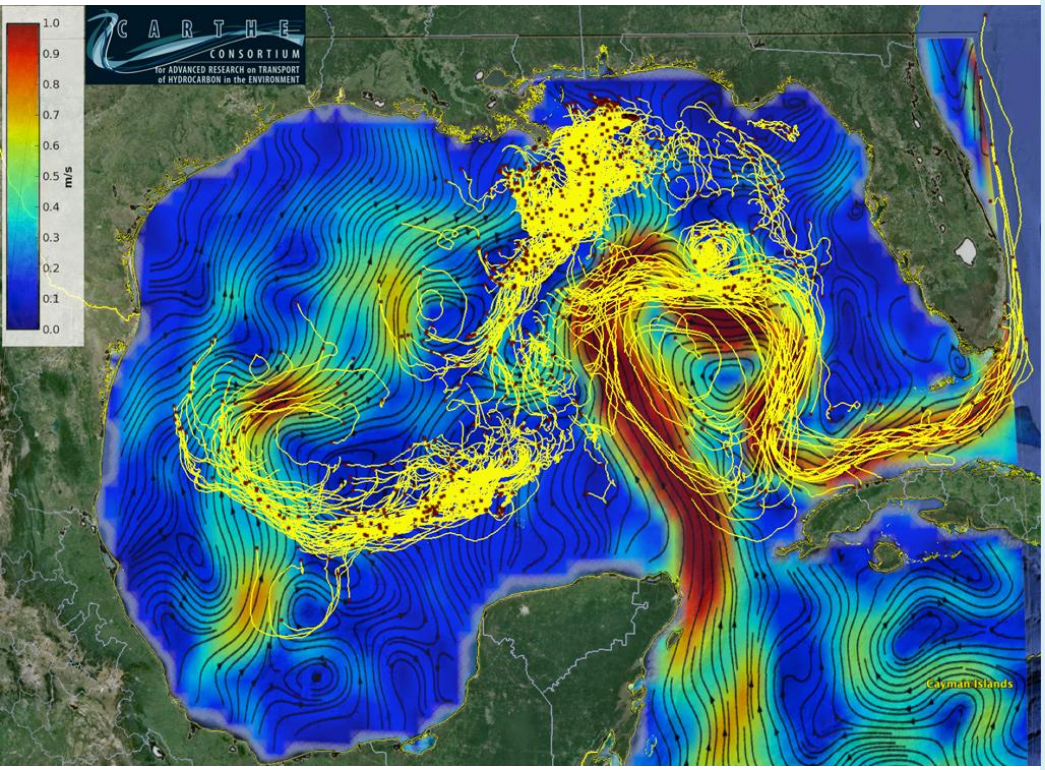
On Marine Radar Near-Surface Current Mapping

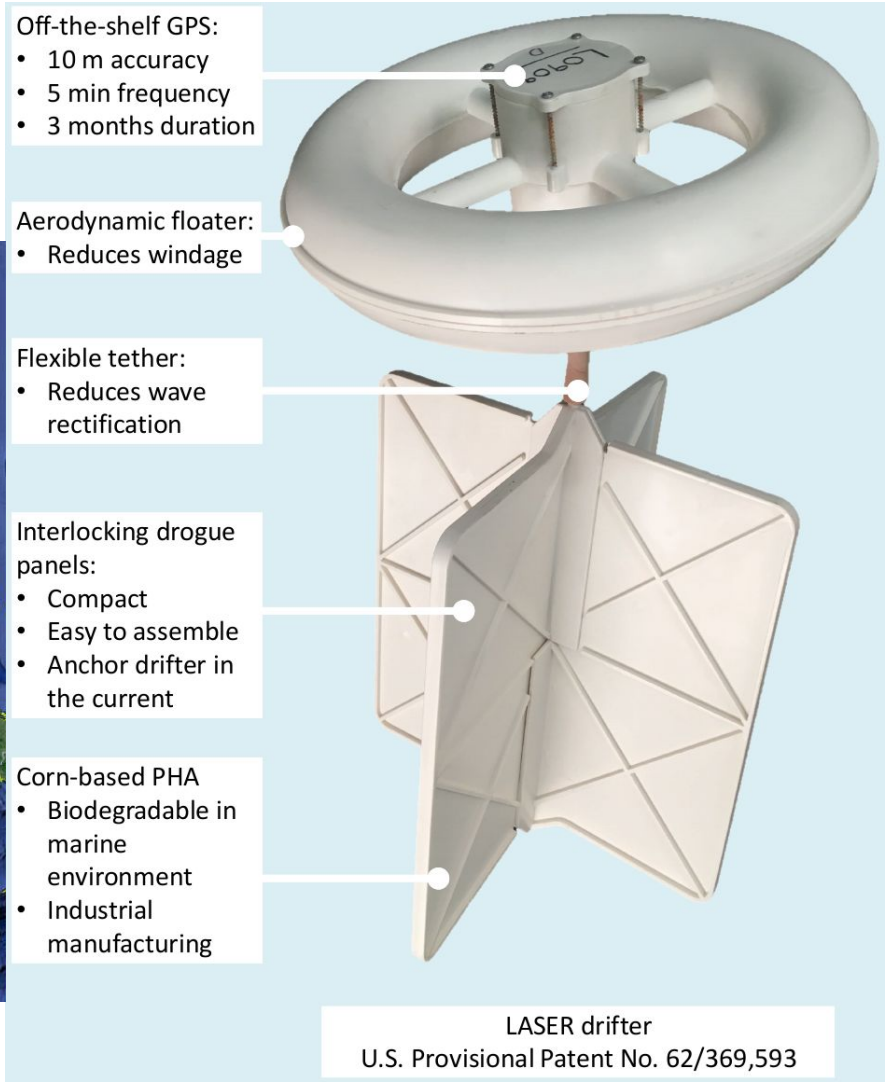
Björn Lund[1], Brian Haus[1], Jochen Horstmann[2], Hans Graber[1], and CARTHE team

[1]University of Miami, [2]Helmholtz Zentrum Geesthacht

LASER Experiment



Sources: carthe.org/blog, greenwaveinstruments.com



LASER drifter
U.S. Provisional Patent No. 62/369,593

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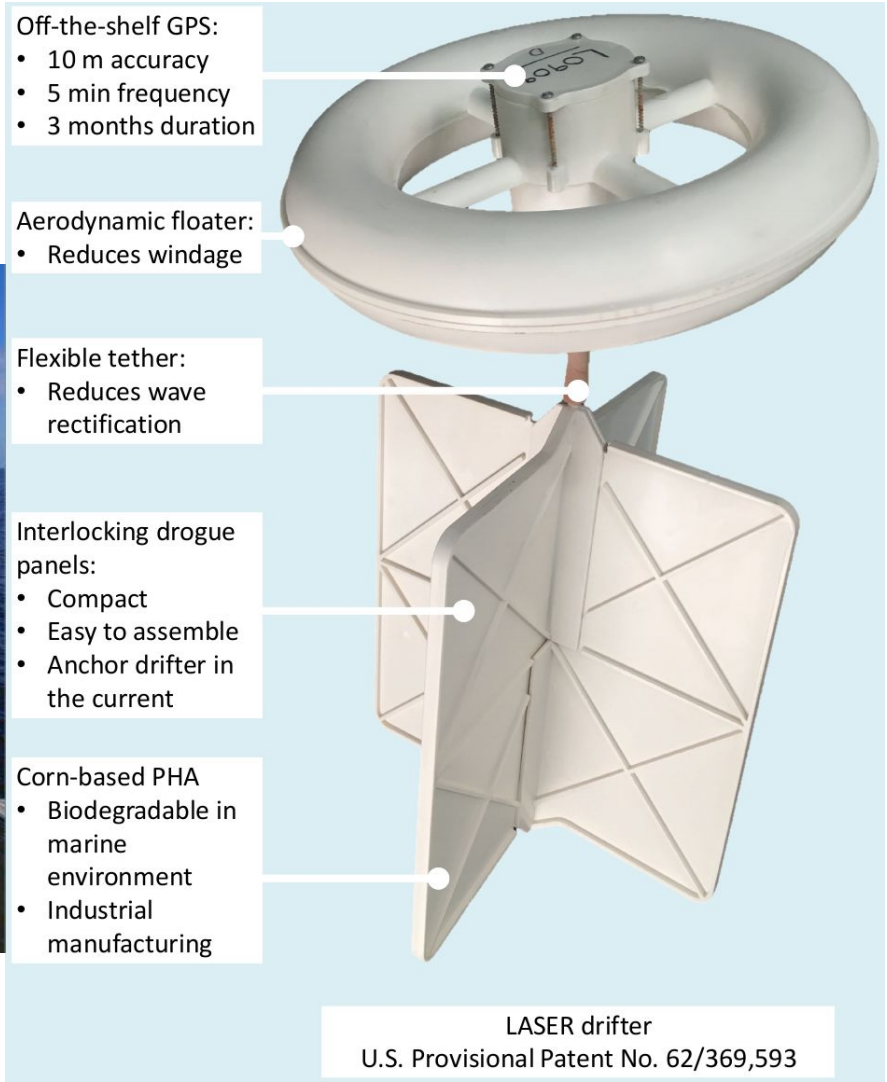

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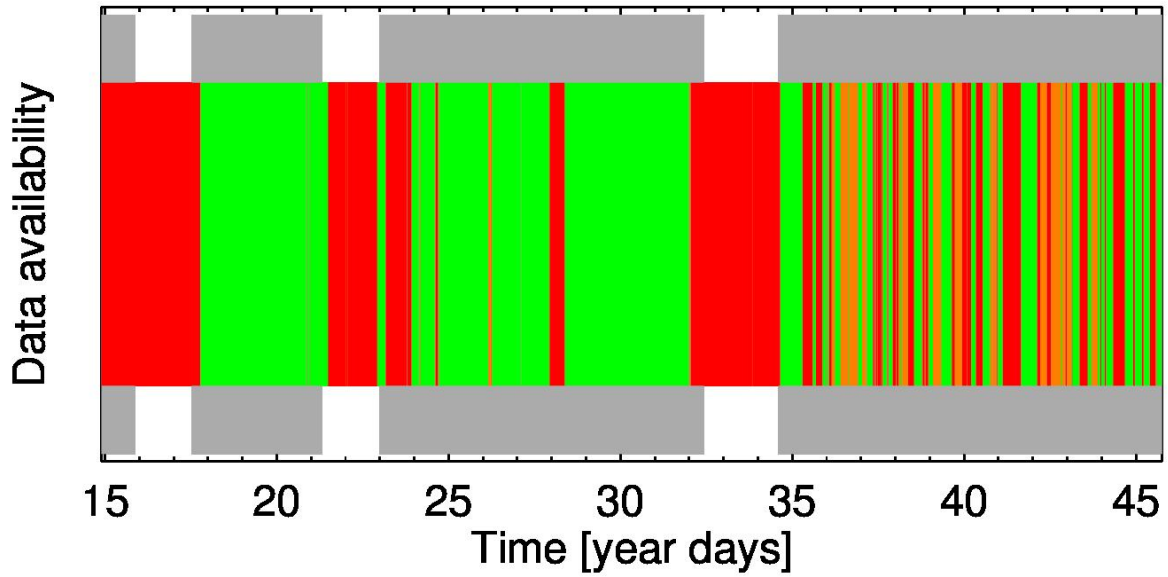
Science Marine X-band Radar Specs

- 9.4 GHz (X-band)
- 2.3 m HH polarized antenna
- 12.5 m antenna height
- 2 s antenna period
- 2 kHz pulse frequency
- 10.5 m range resolution
- Coherent on receive
- Developed at HZG

Data Overview

- Green: good data
- Orange: data corrupted and/or incomplete
- Red: system down or failed collecting data
- Gray: at sea periods



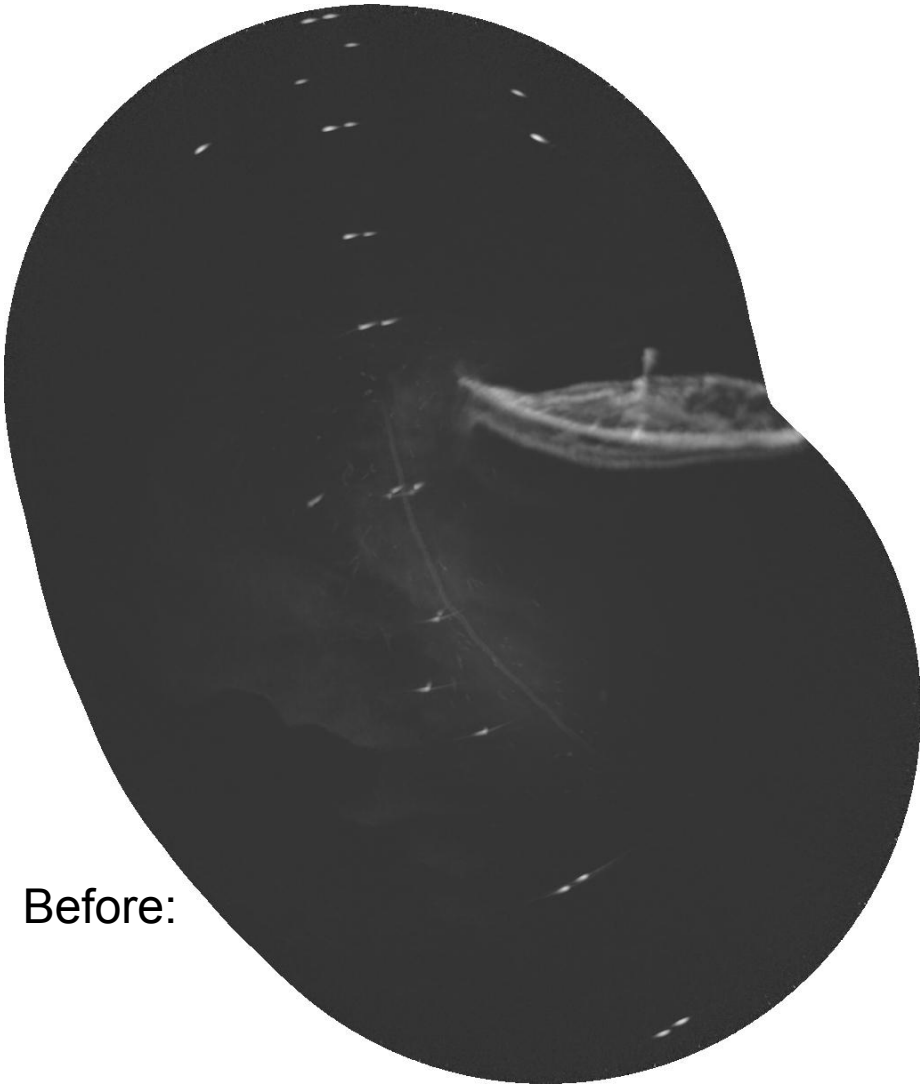
Marine Radar “Calibration”

Maximize contrast of land targets by iteratively correcting:

- Azimuthal misalignment (−2.92°)
- Range offset (−15 m)
- Temporal offset (0 s)

Based on McCann & Bell, 2015

Before:



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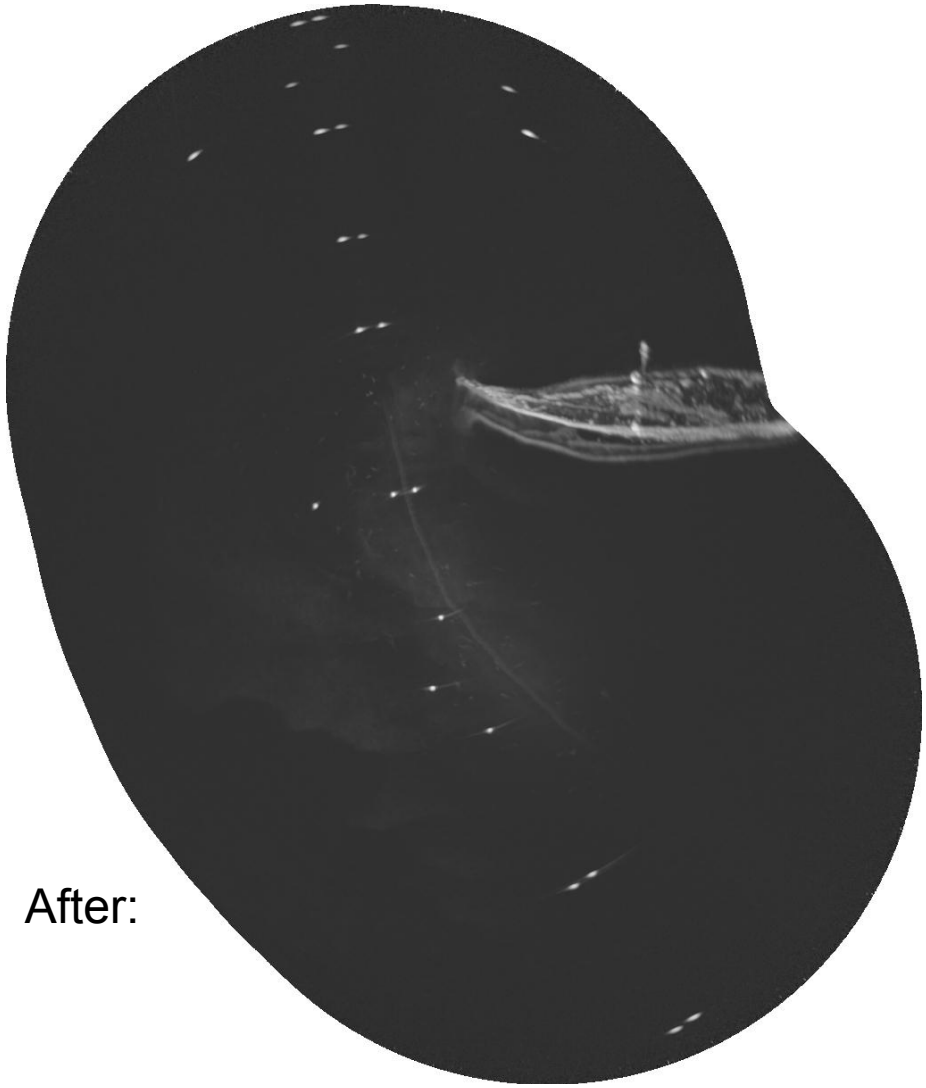
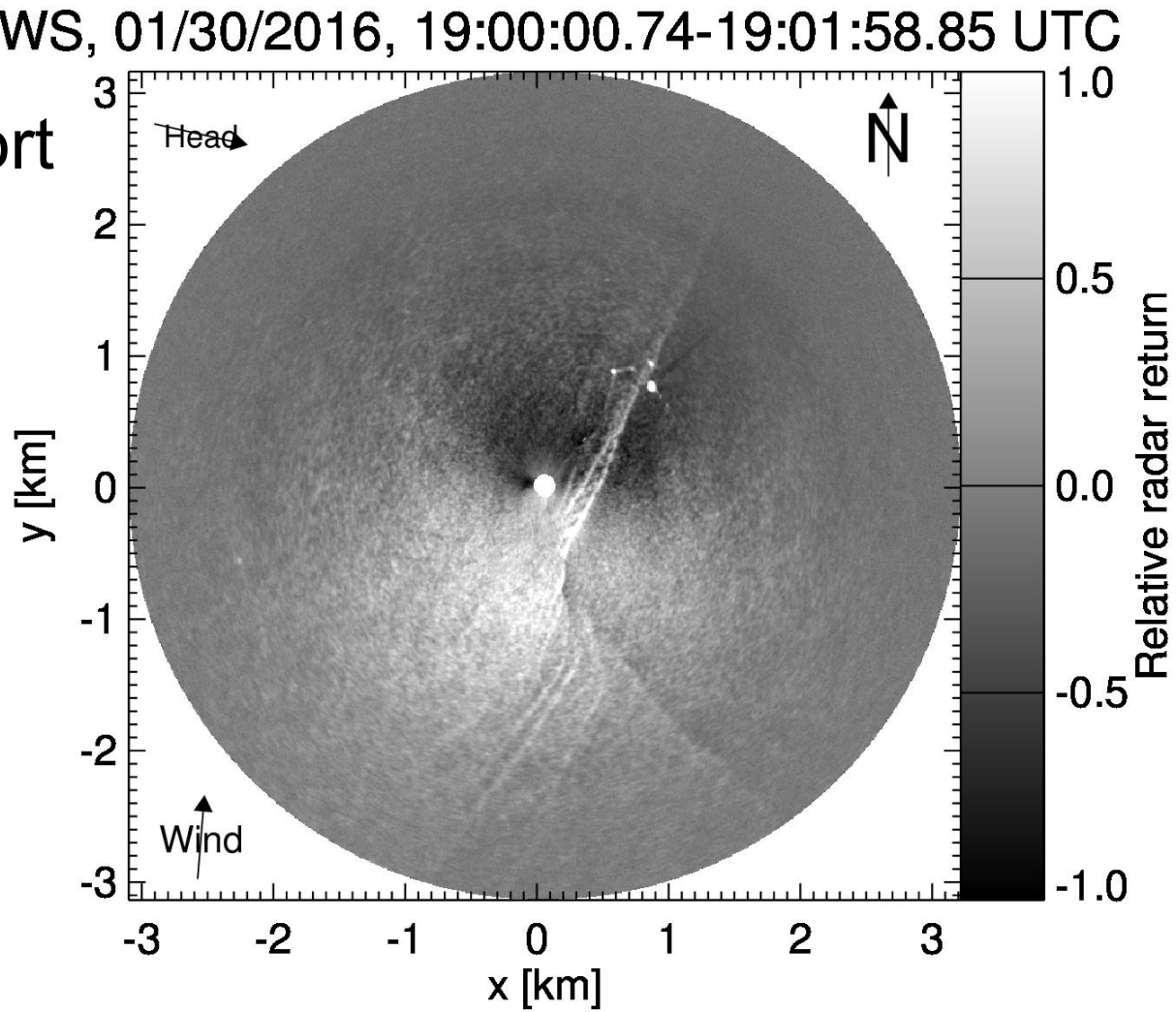
Following McCann & Bell, 2015

After:



Operational Support

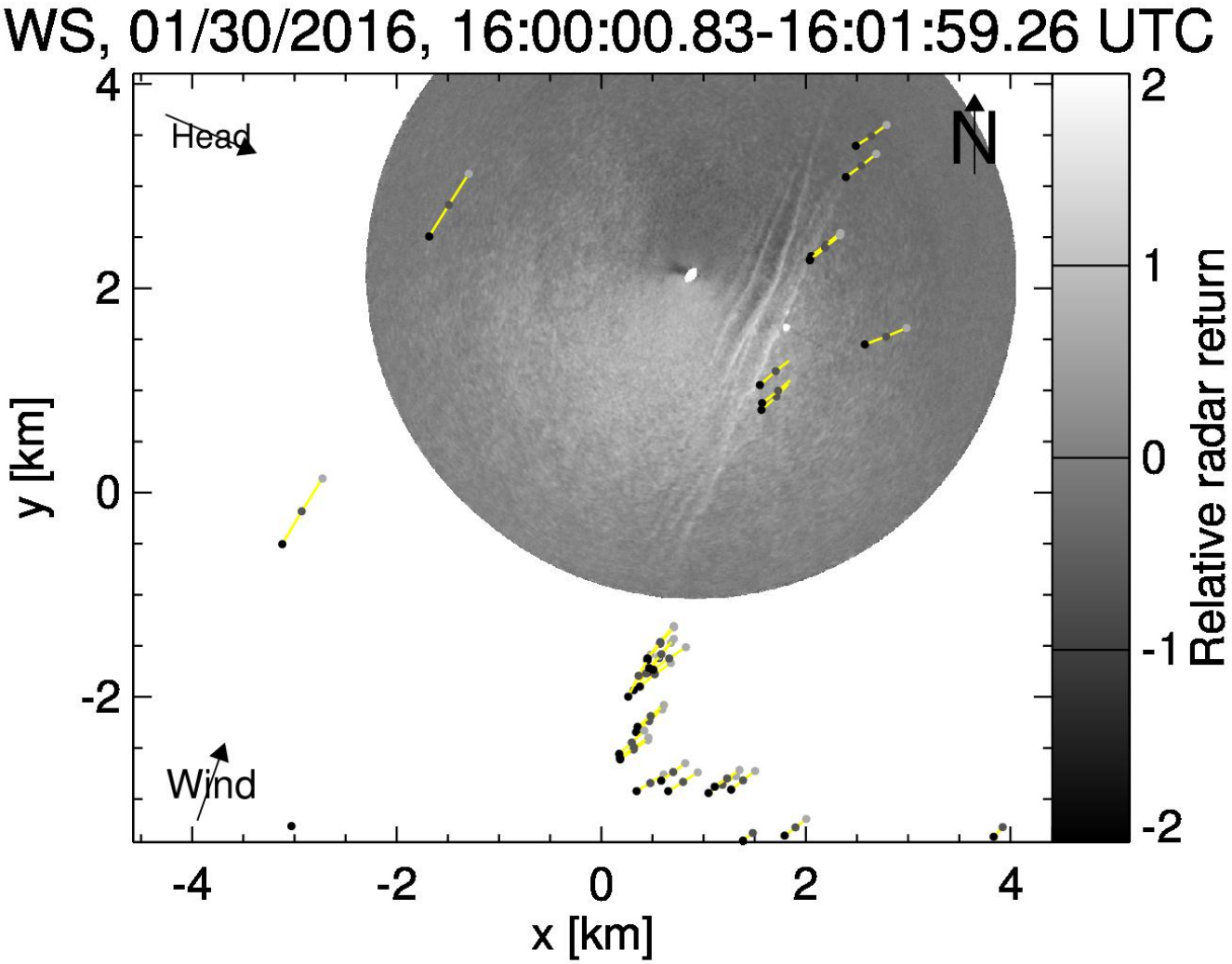
- 2-min-averaged, georeferenced, ramp-corrected, and normalized radar return
- Image shows current / salinity front, Masco 8, small boats
- Radar system not radiometrically calibrated



Current Front Evolution

Marine radar images:

- Allow tracking of frontal features
- Provide context for field work activities



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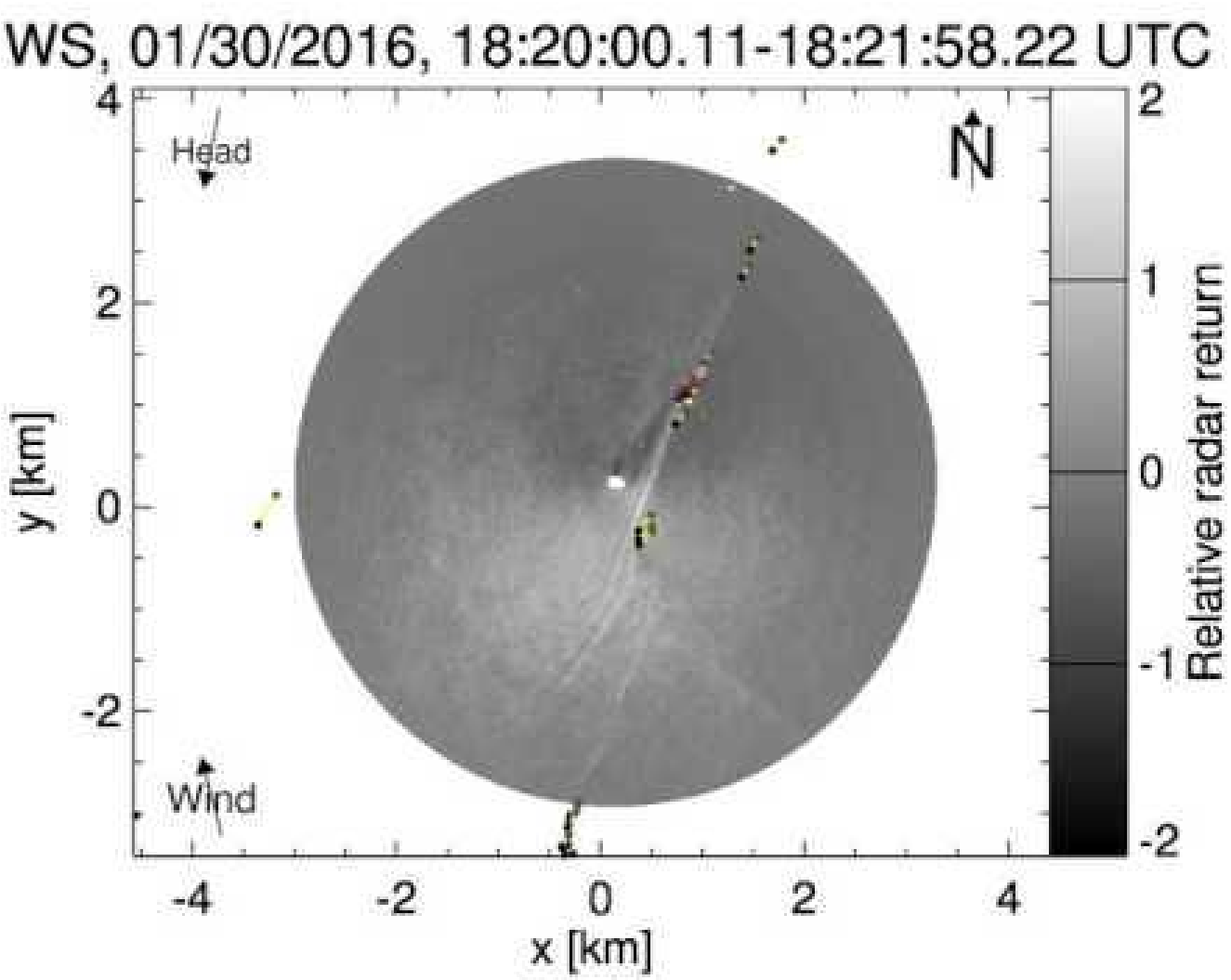
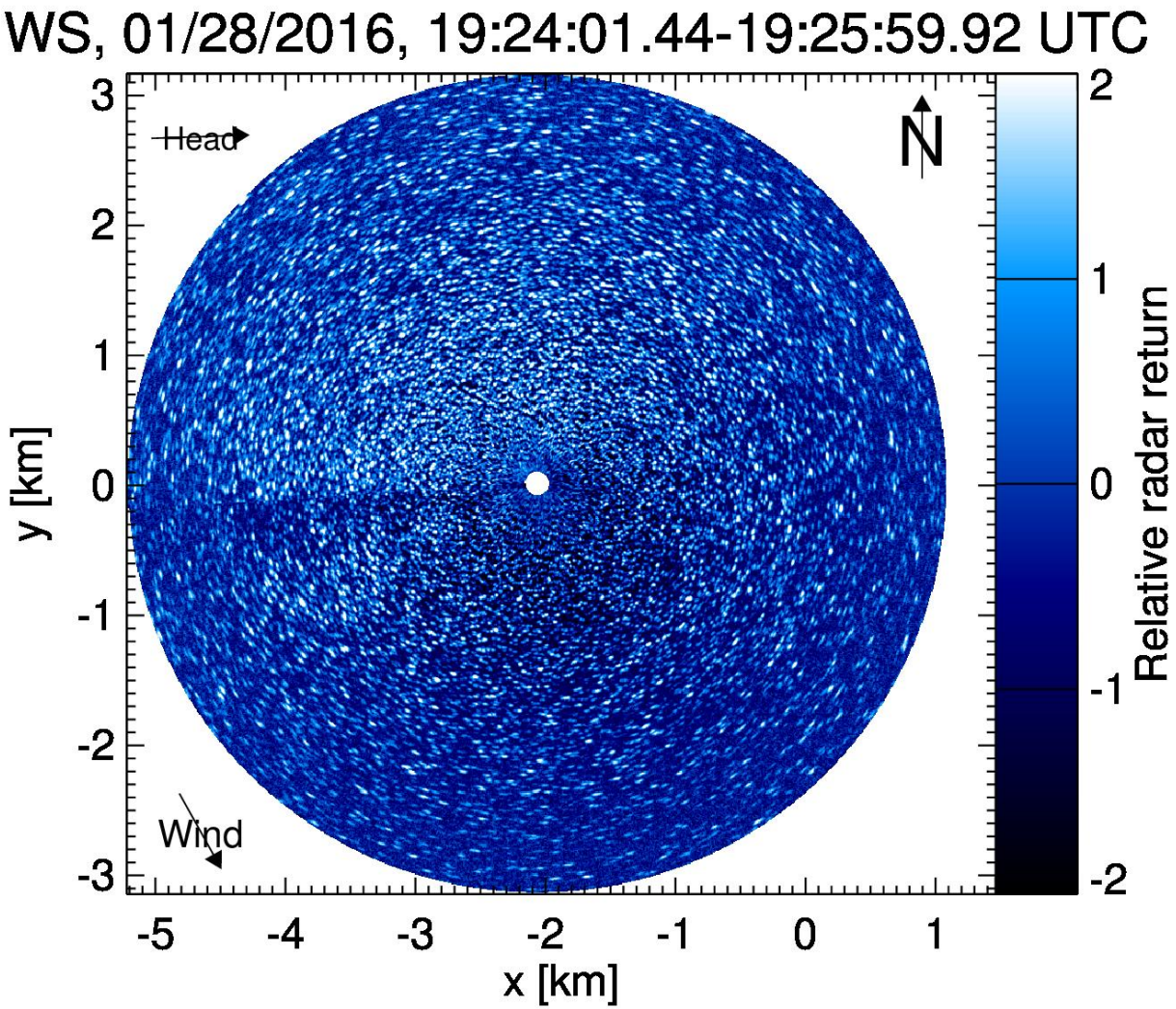


Near-surface Current Retrieval

Near-surface current mapping is based on surface wave signal:

- Convert sequence of radar images to Fourier space
- Obtain current from wave coordinates' Doppler shift, using least-squares fit



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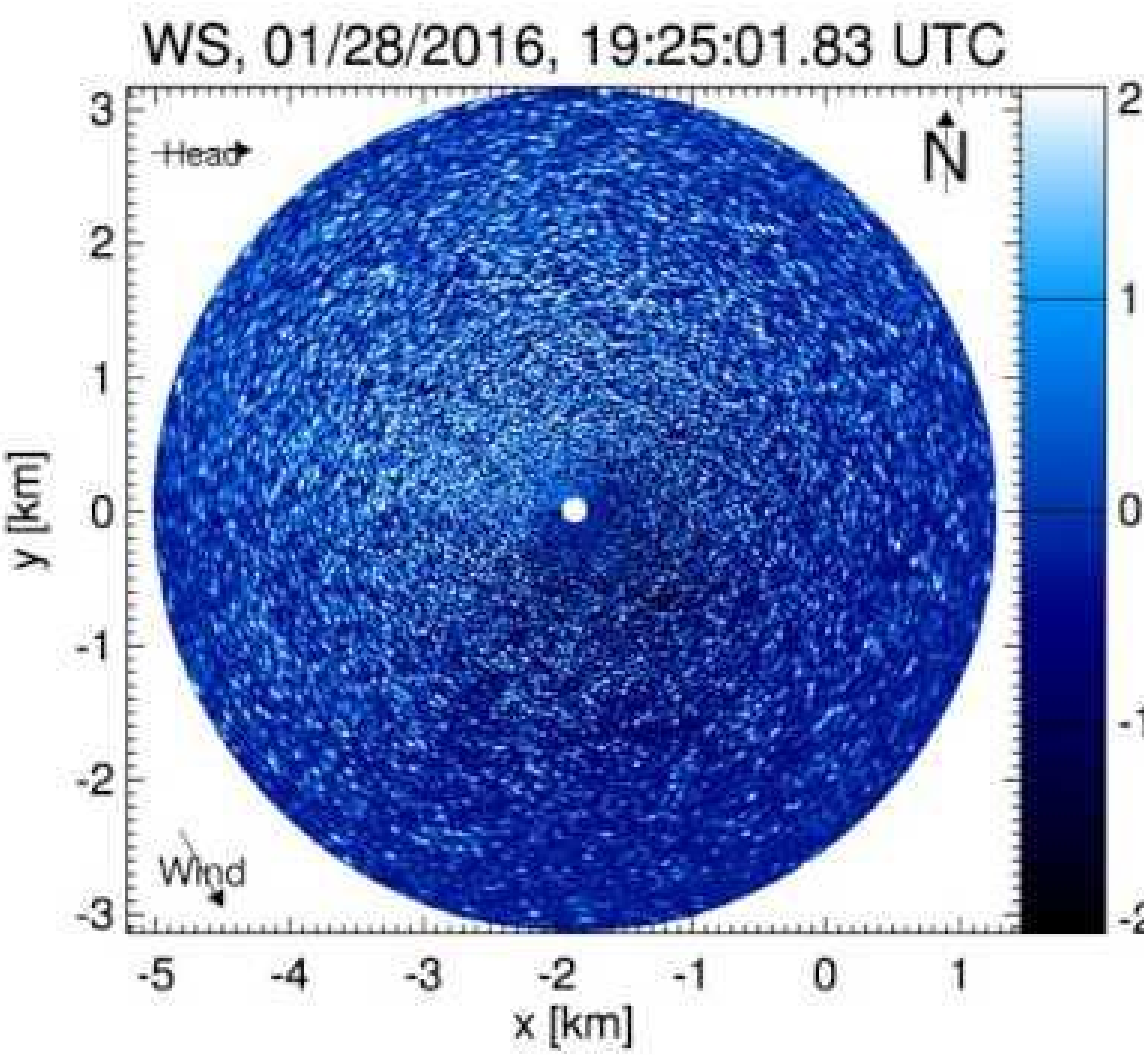

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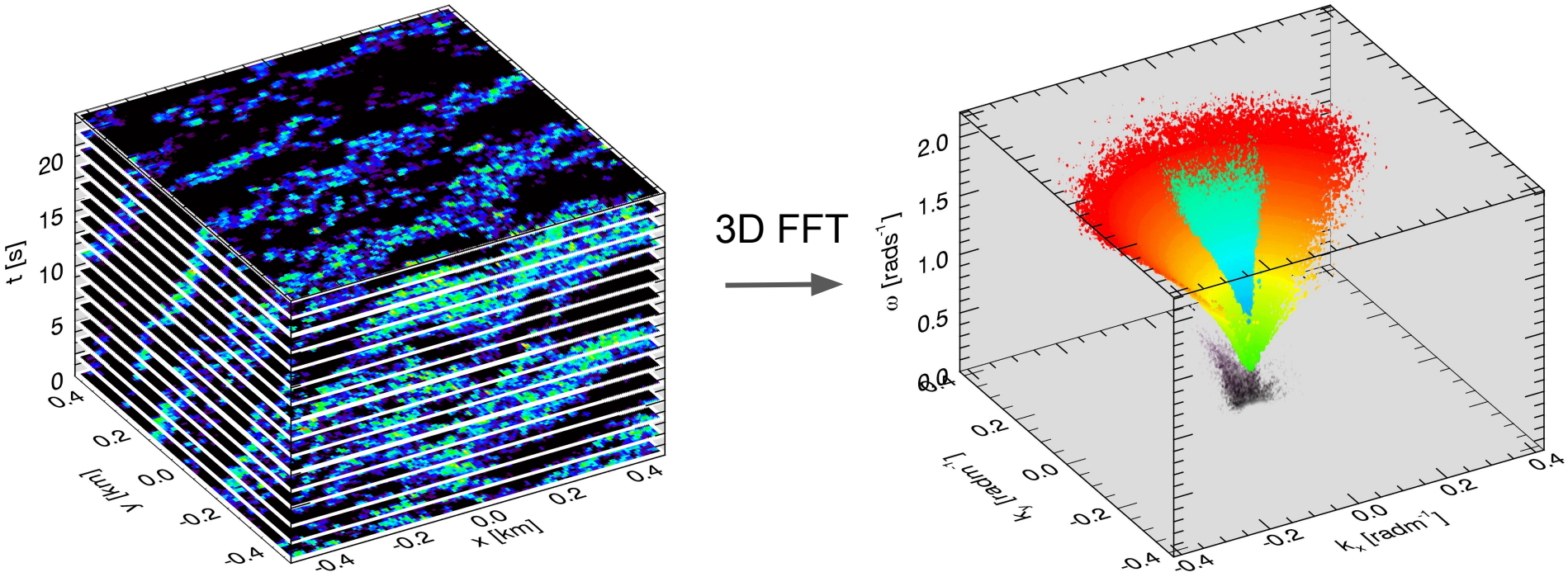
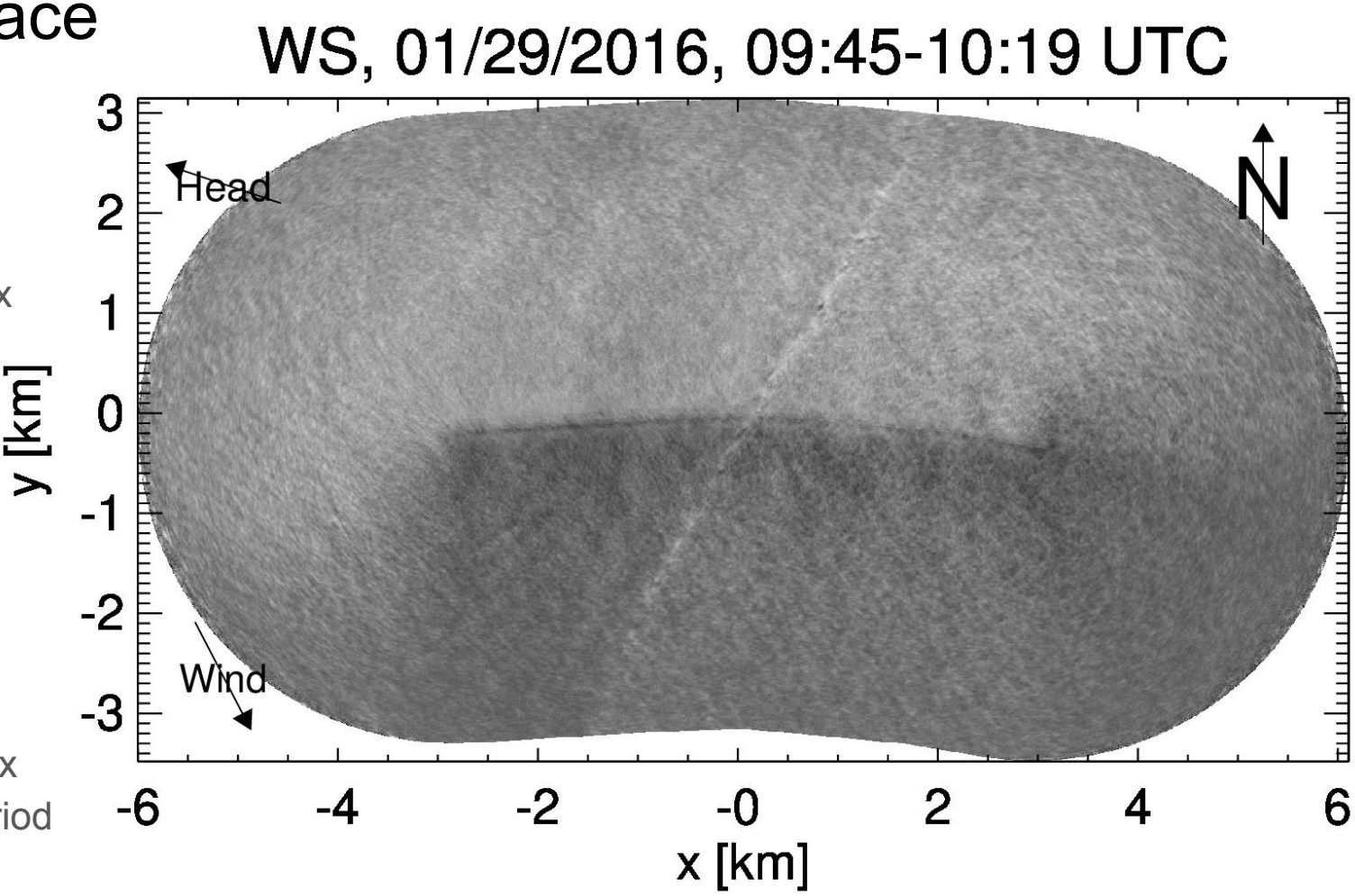


Near-surface Current Retrieval

- Analysis box radius of 476.25 m (~0.7 km^2)
- 40% max overlap between neighboring boxes
- ~30 min max analysis period



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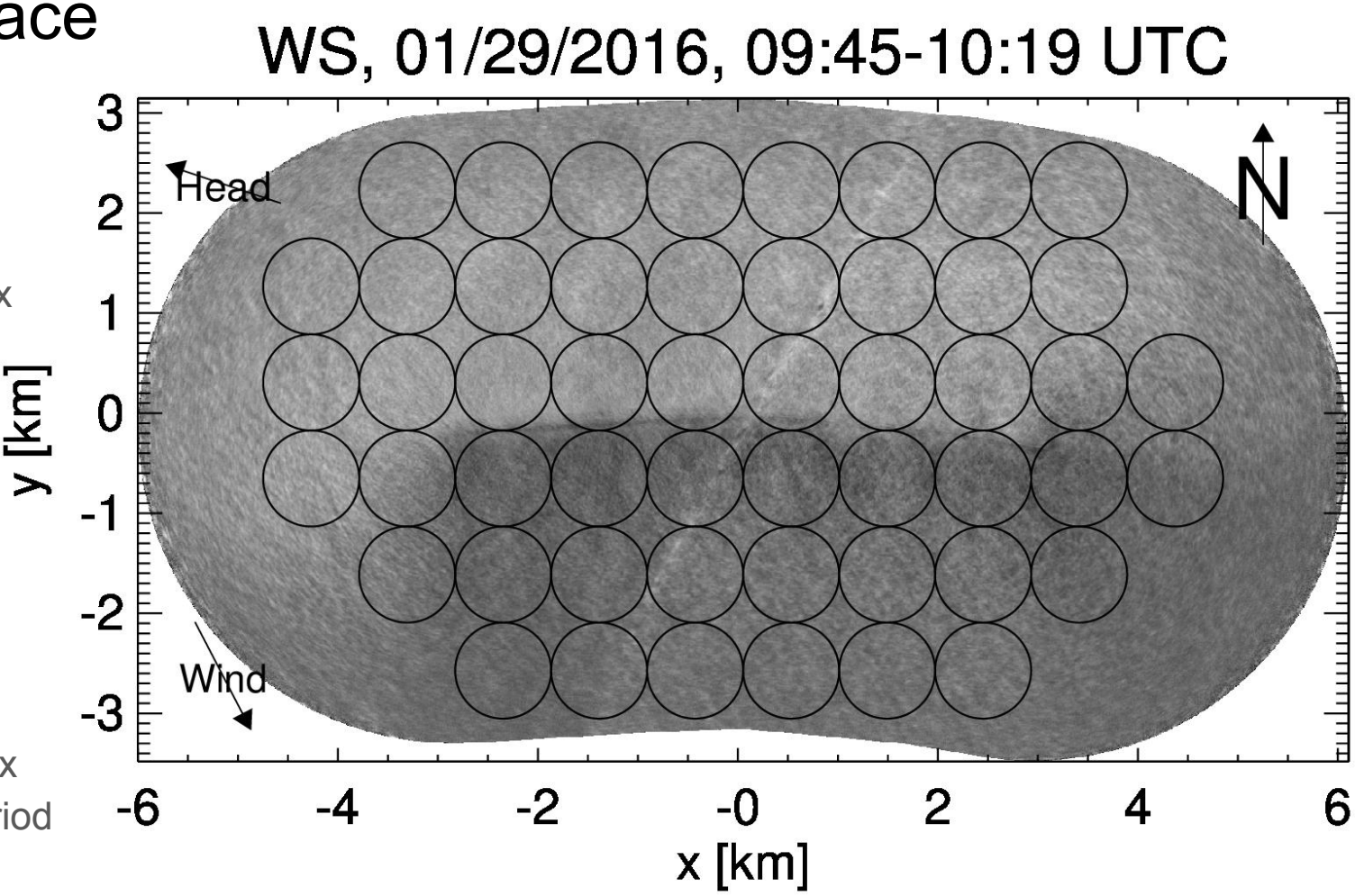

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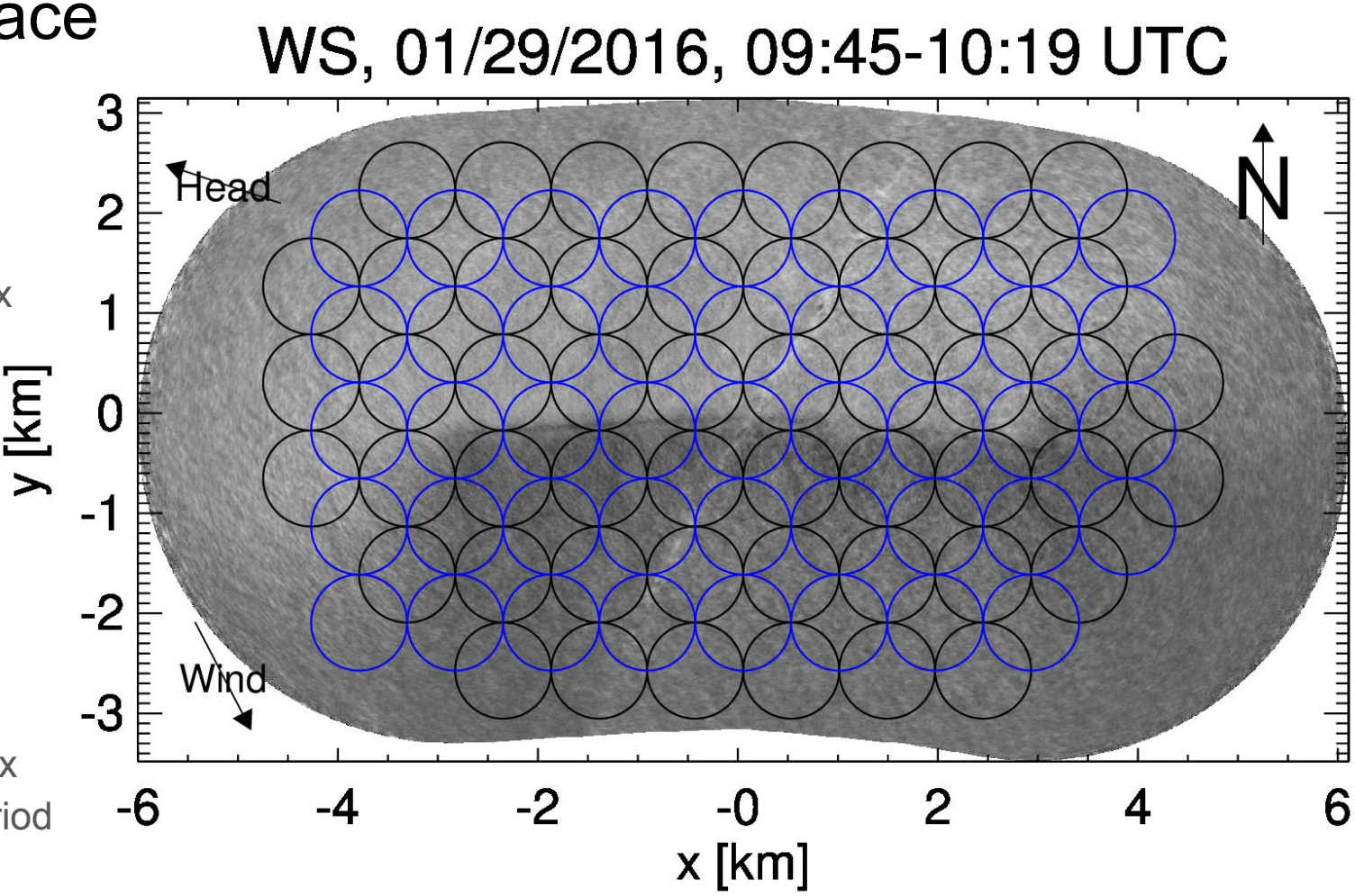

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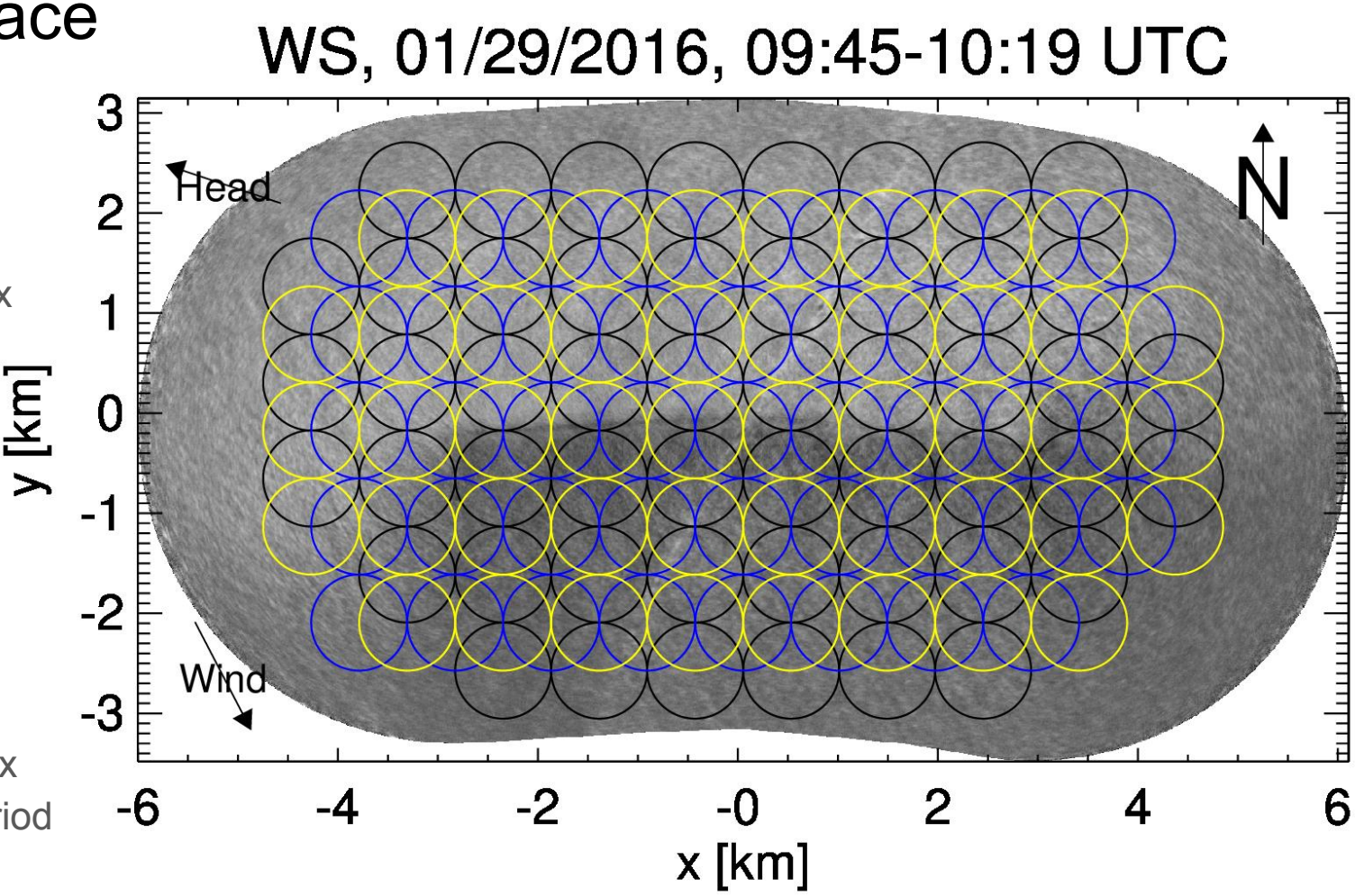

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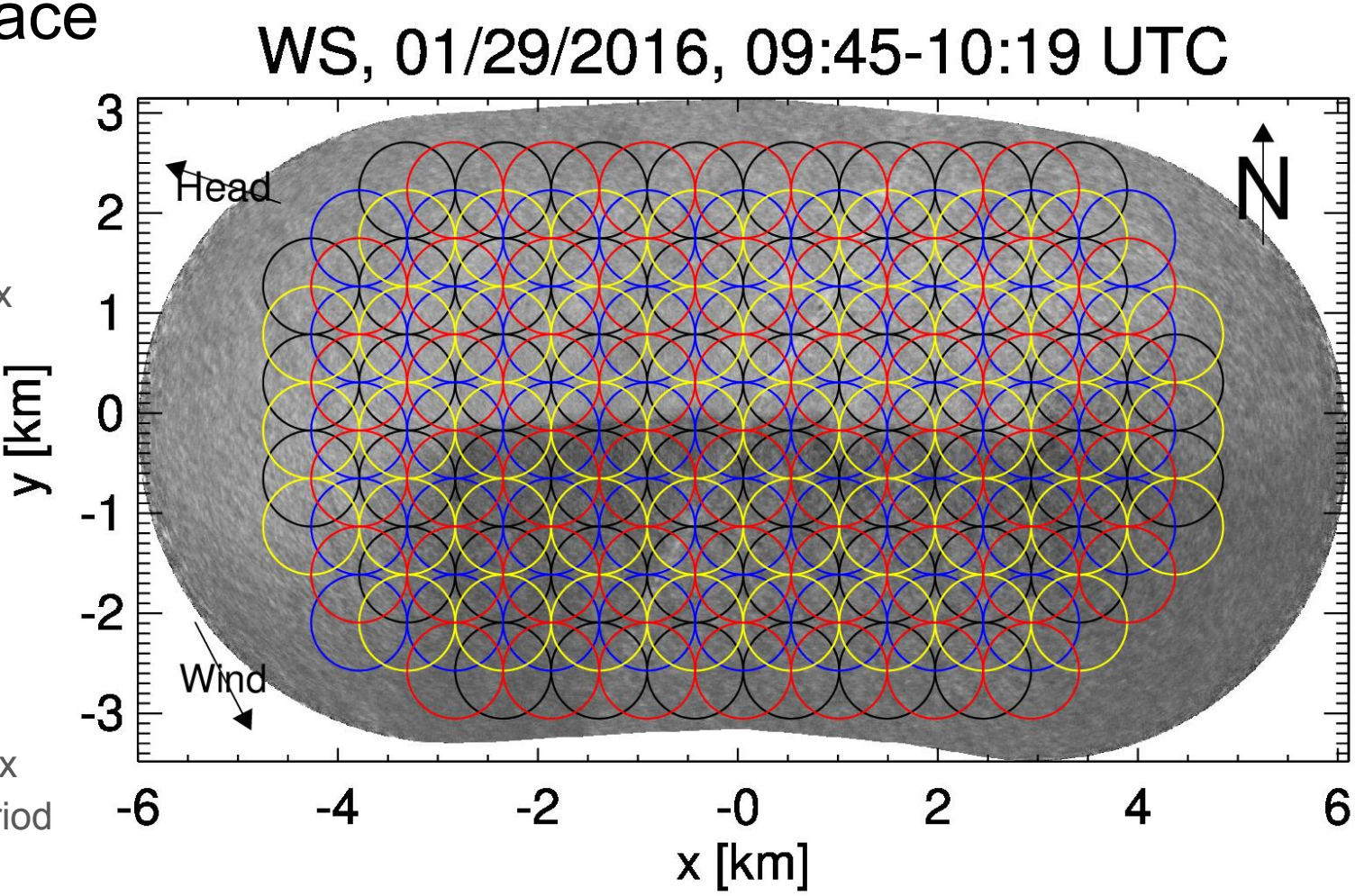

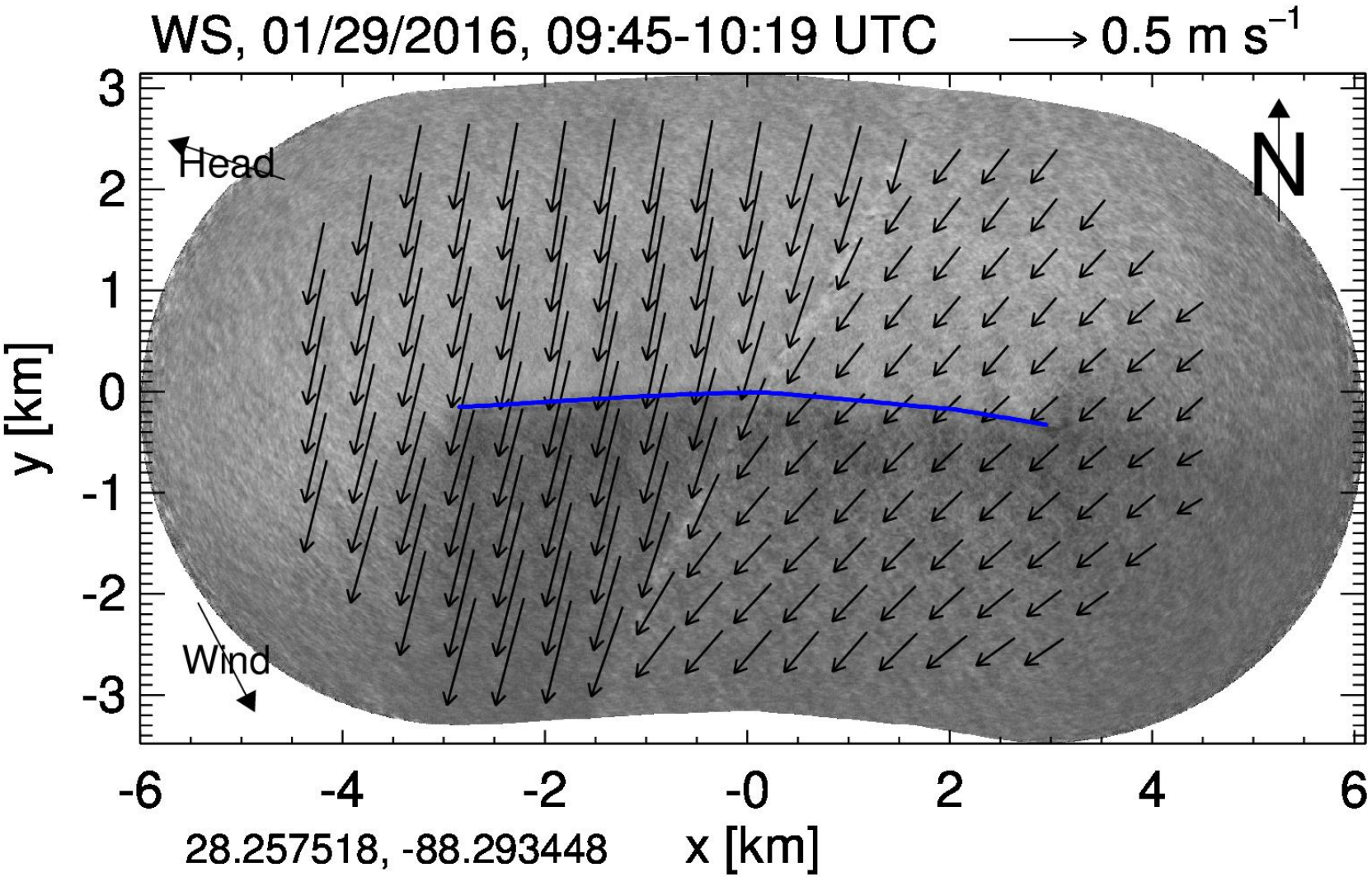
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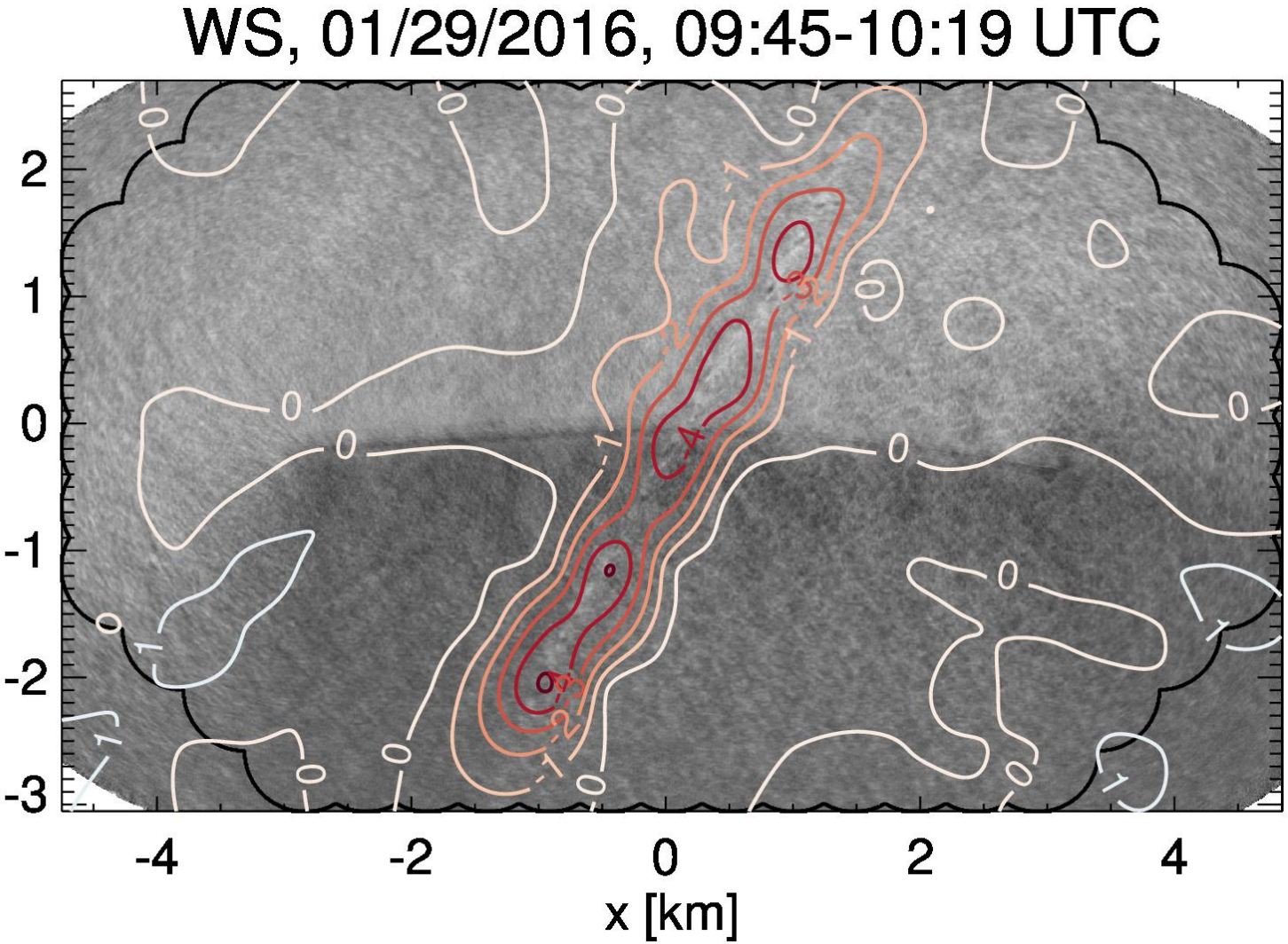
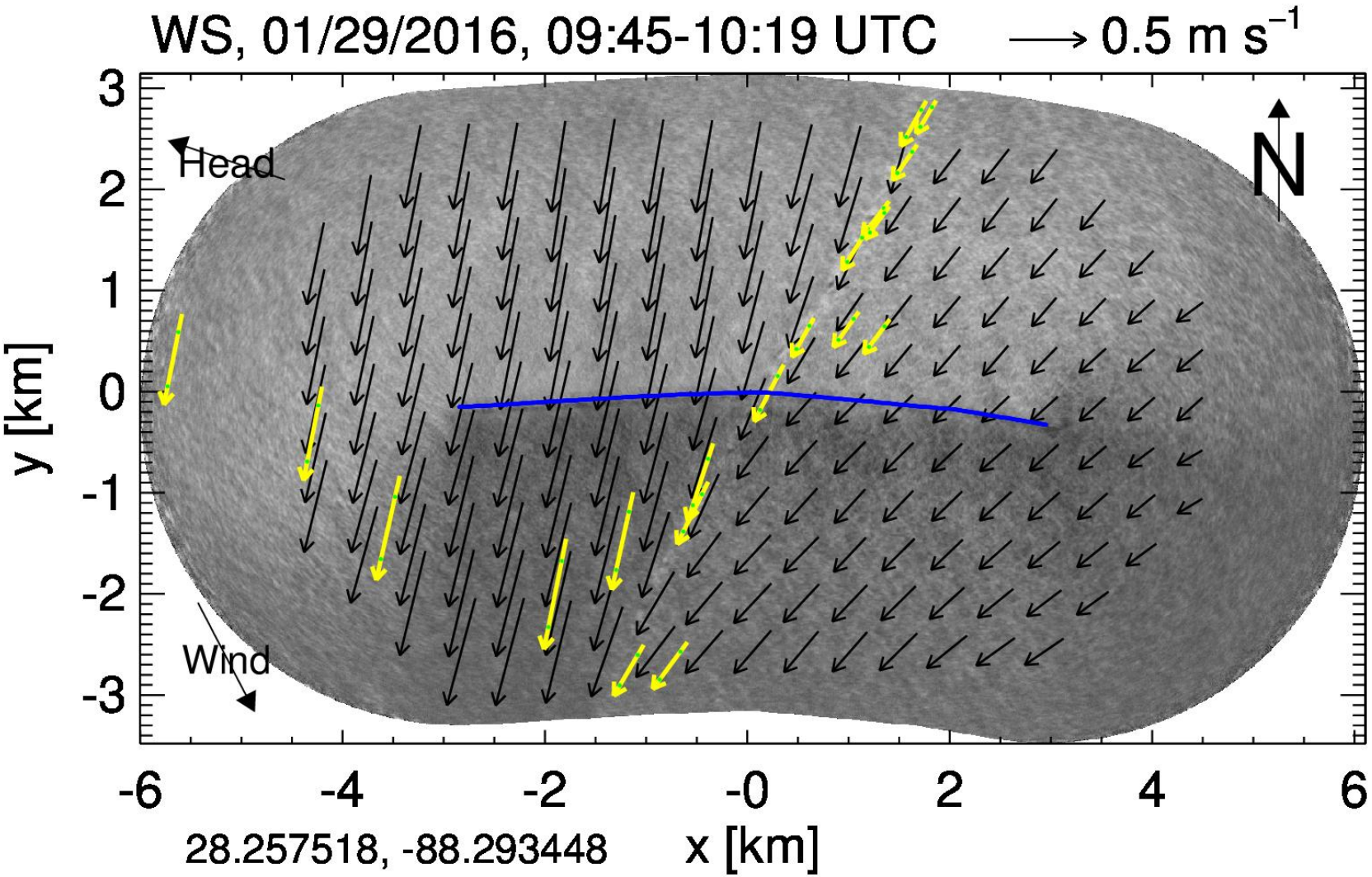
0.5 m s^{-1}
Head
Wind
N
y [km]
x [km]
3
2
1
0
-1
-2
-3
-6
-4
-2
-0
2
4
6
28.257518, -88.293448

Normalized Divergence

- Convergent flow where back-scatter intensity peaks (frontal feature)
- Red: down-welling
- Blue: up-welling

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0.5 m s^{-1}
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y [km]
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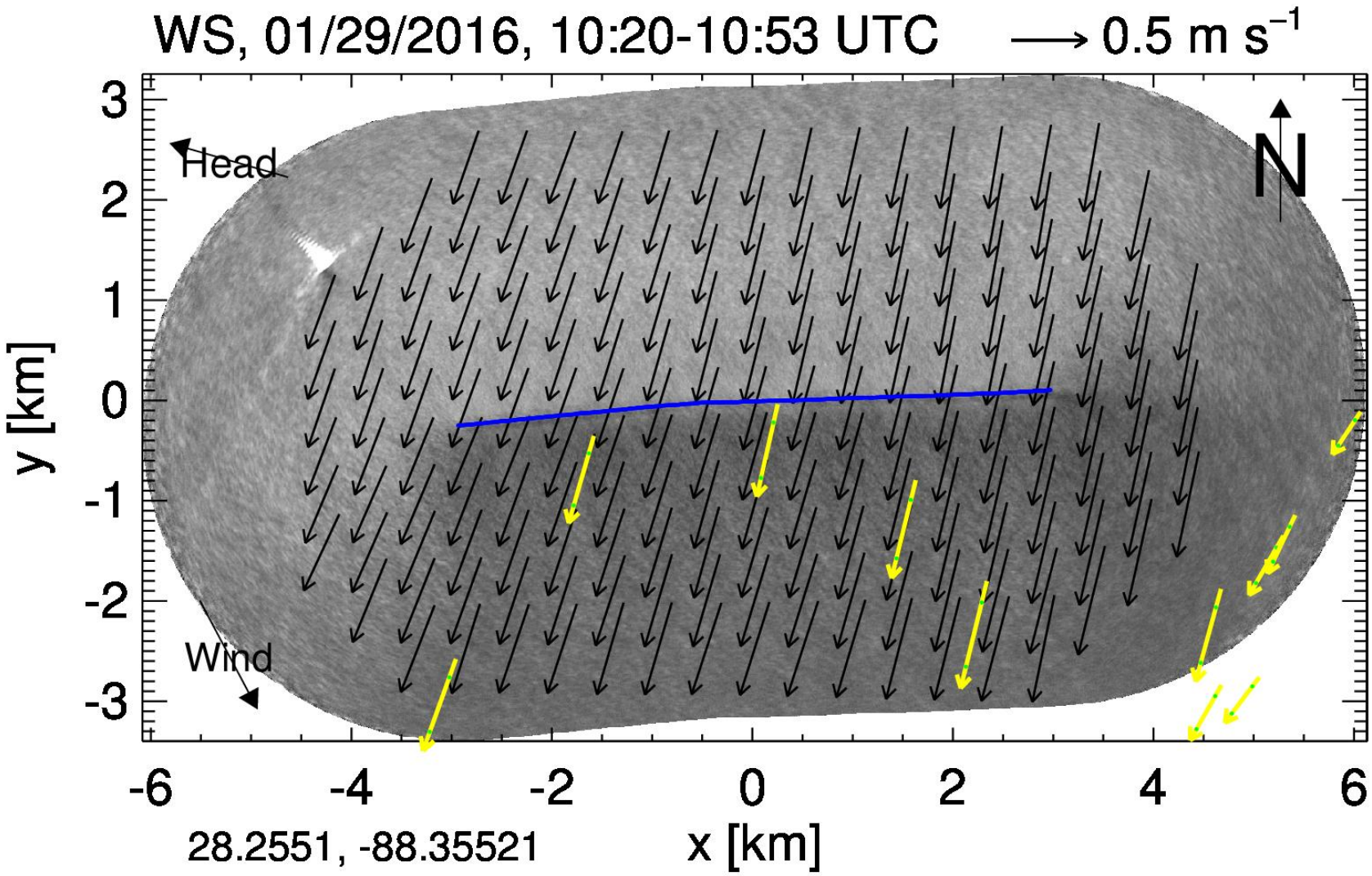
28.257518, -88.293448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Wind
N
y [km]
x [km]
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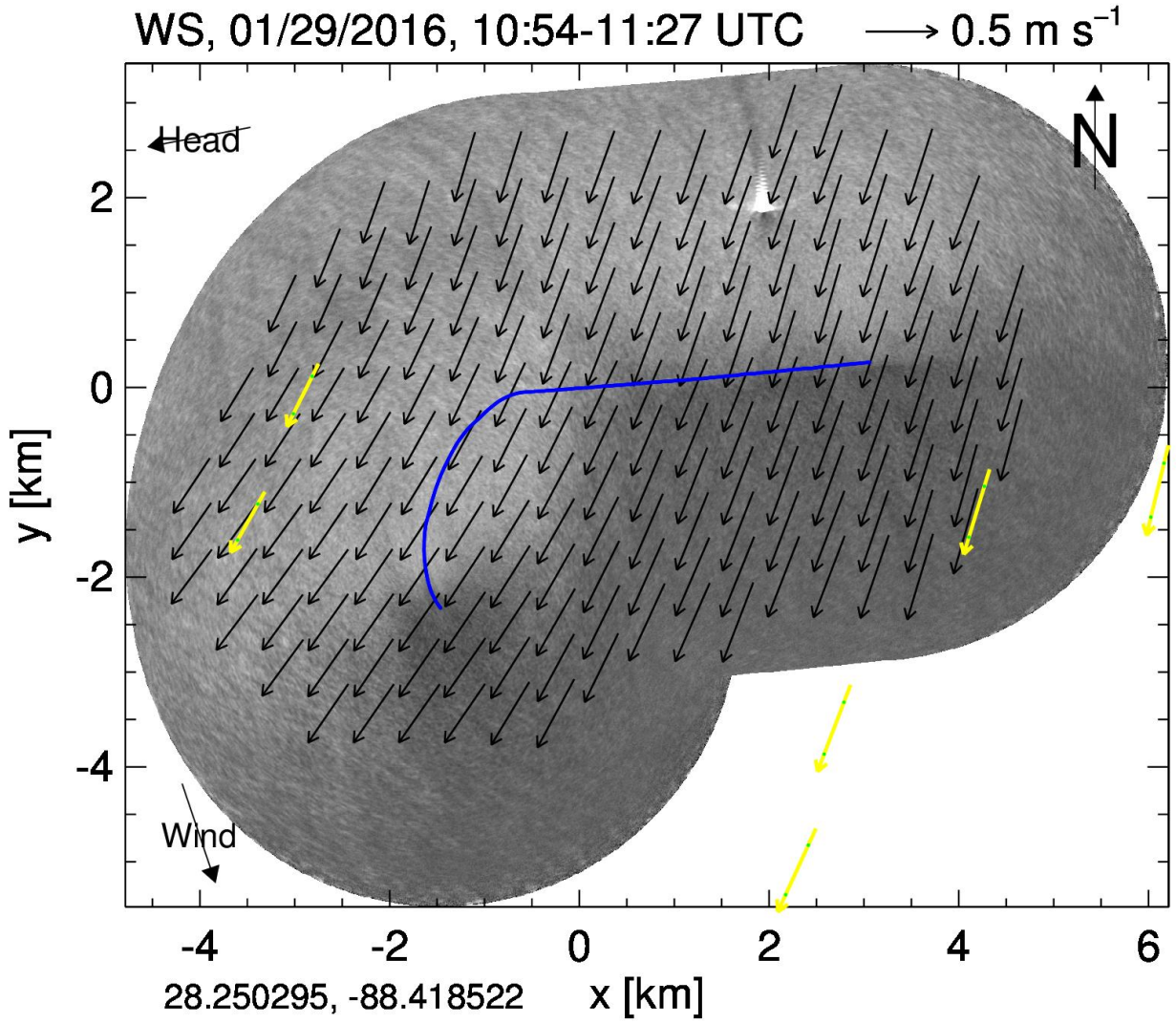
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Head
N
Wind
y [km]
x [km]
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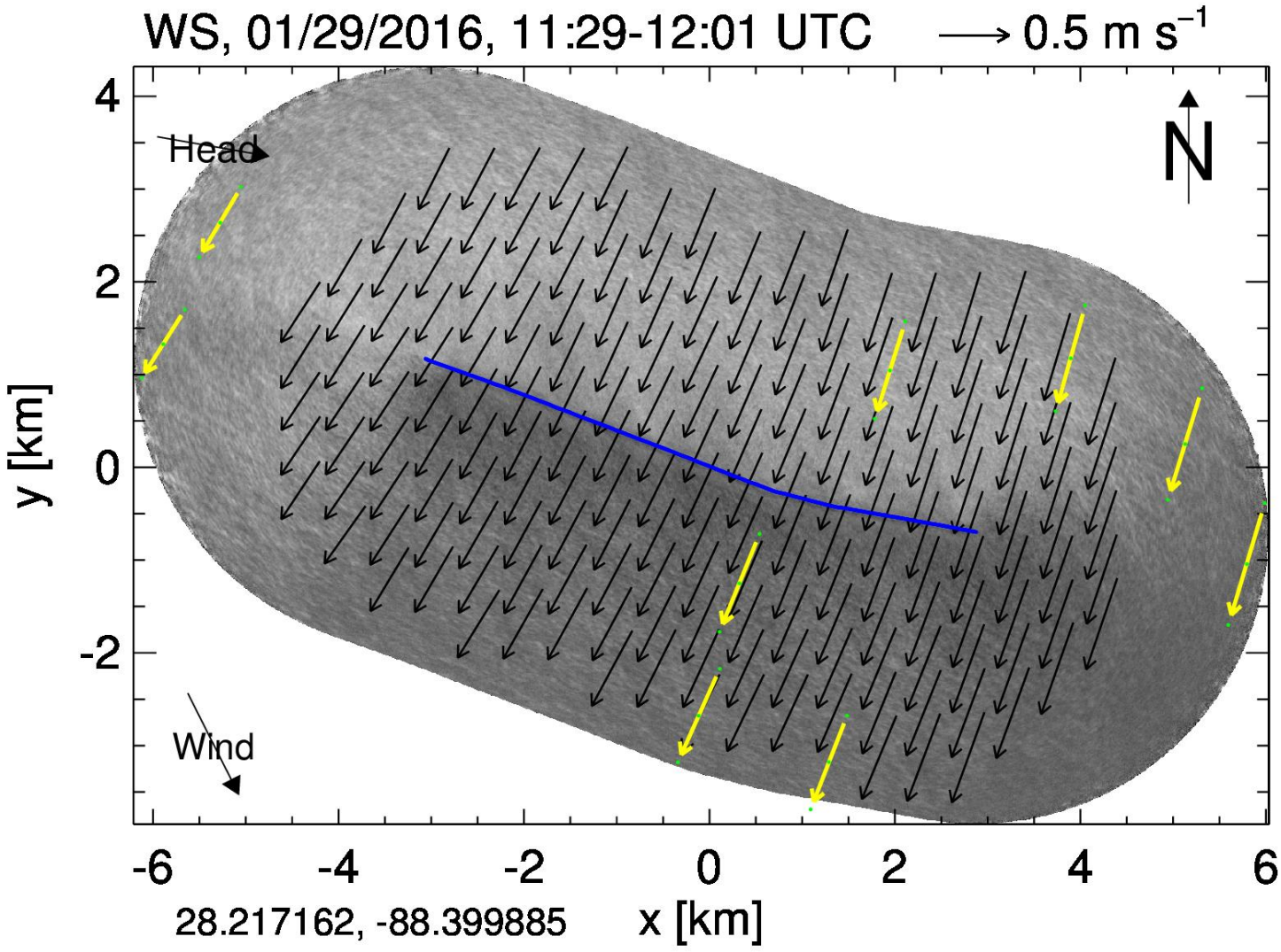
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N
Wind
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x [km]
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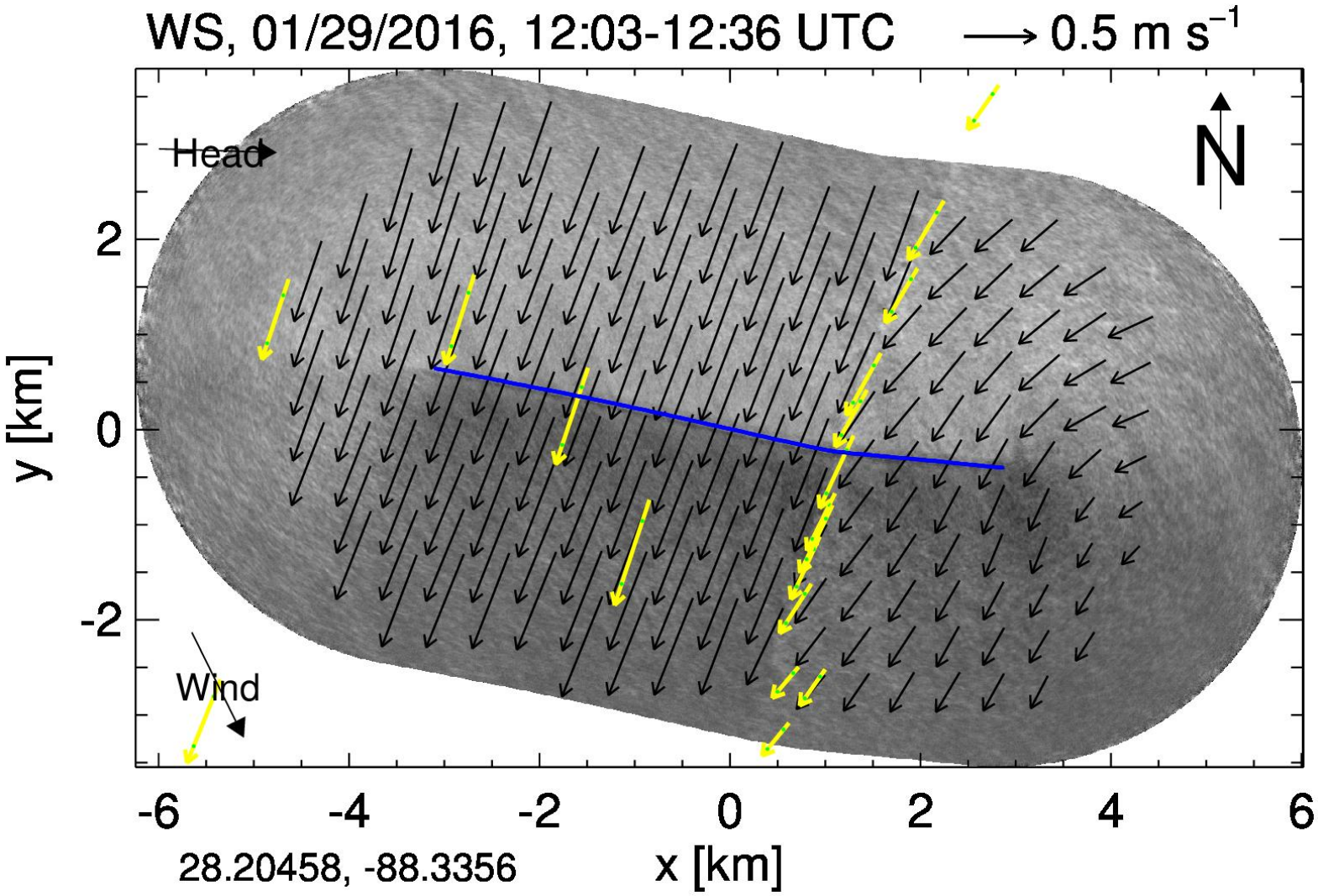
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x [km]
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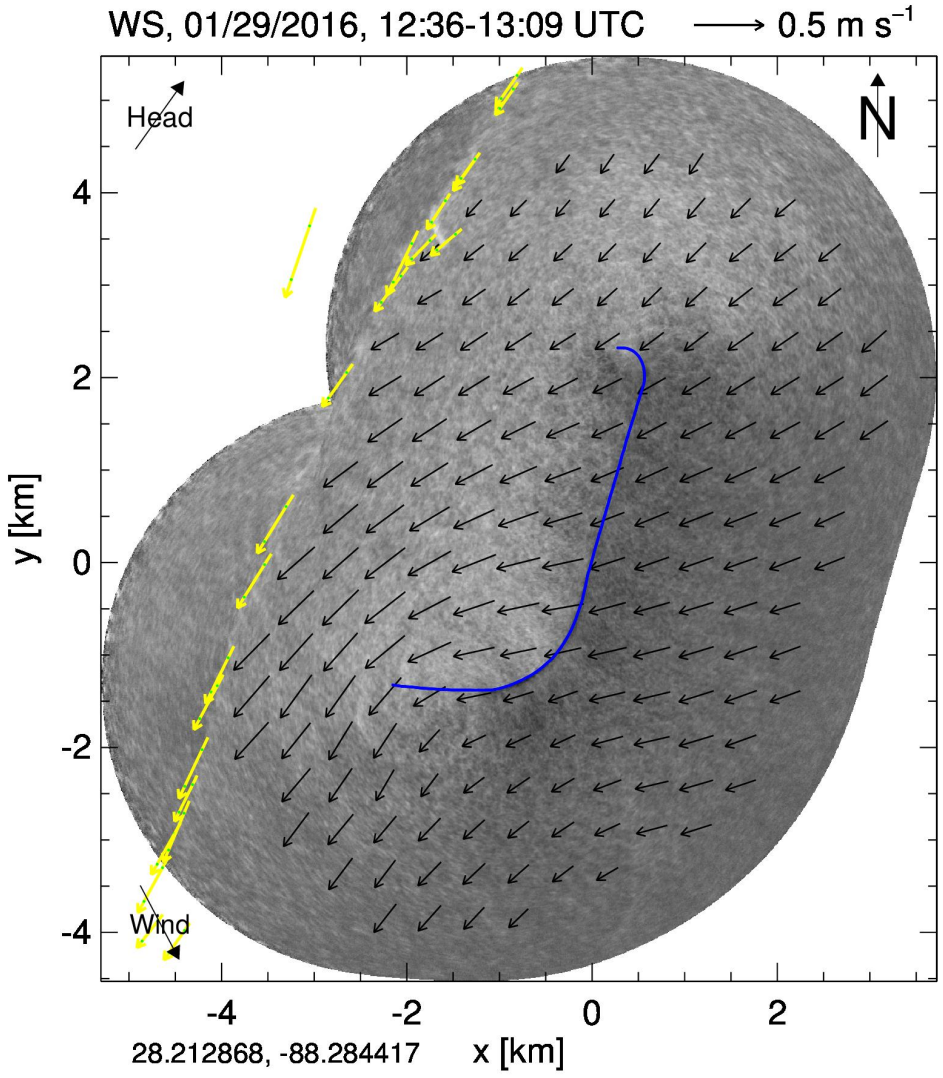
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N
Wind
y [km]
x [km]
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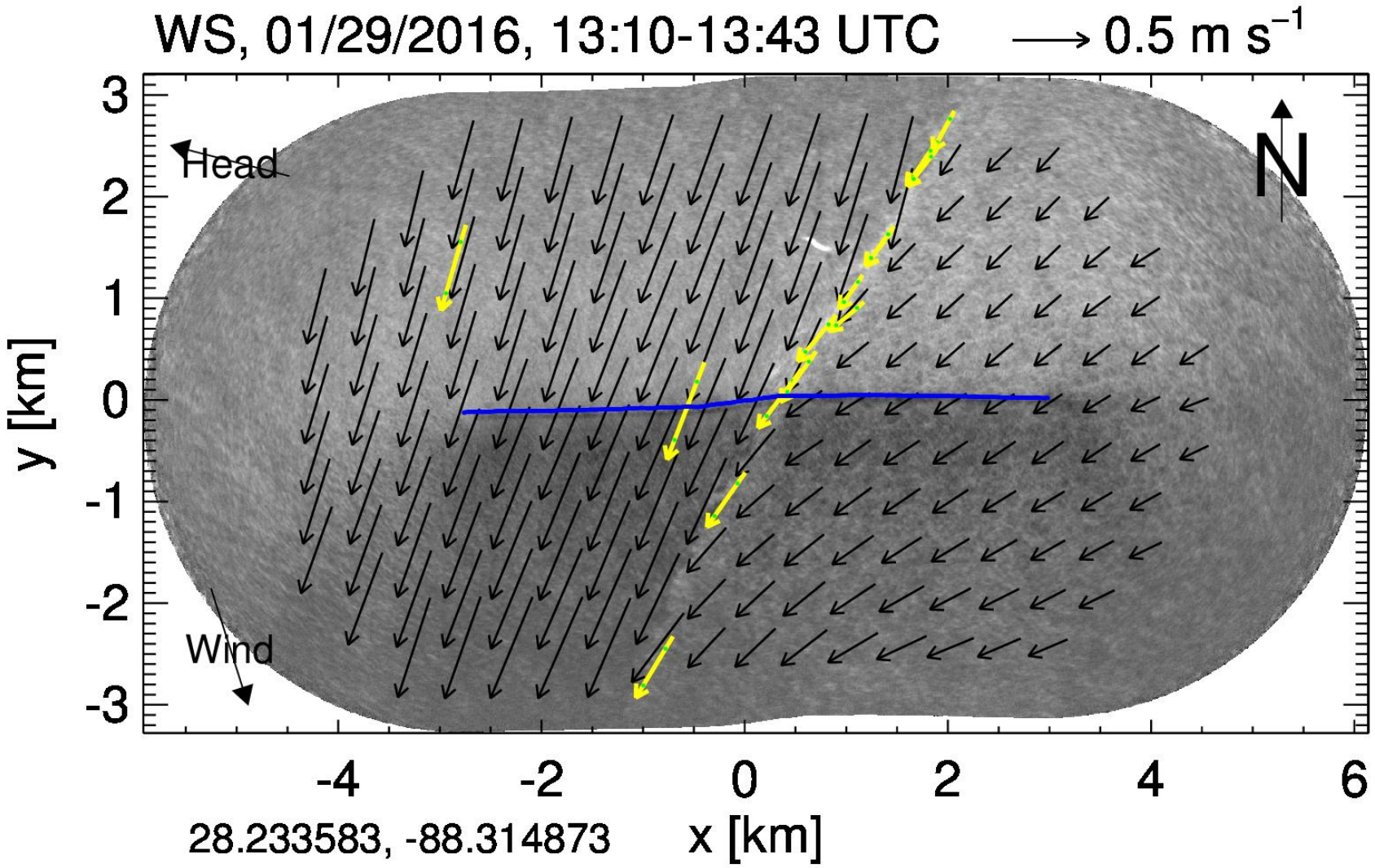
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Head
Wind
N
y [km]
x [km]
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0
-1
-2
-3
-4
-2
0
2
4
6
28.233583, -88.314873

Radar–Drifter Comparison

Analysis periods (with gaps):

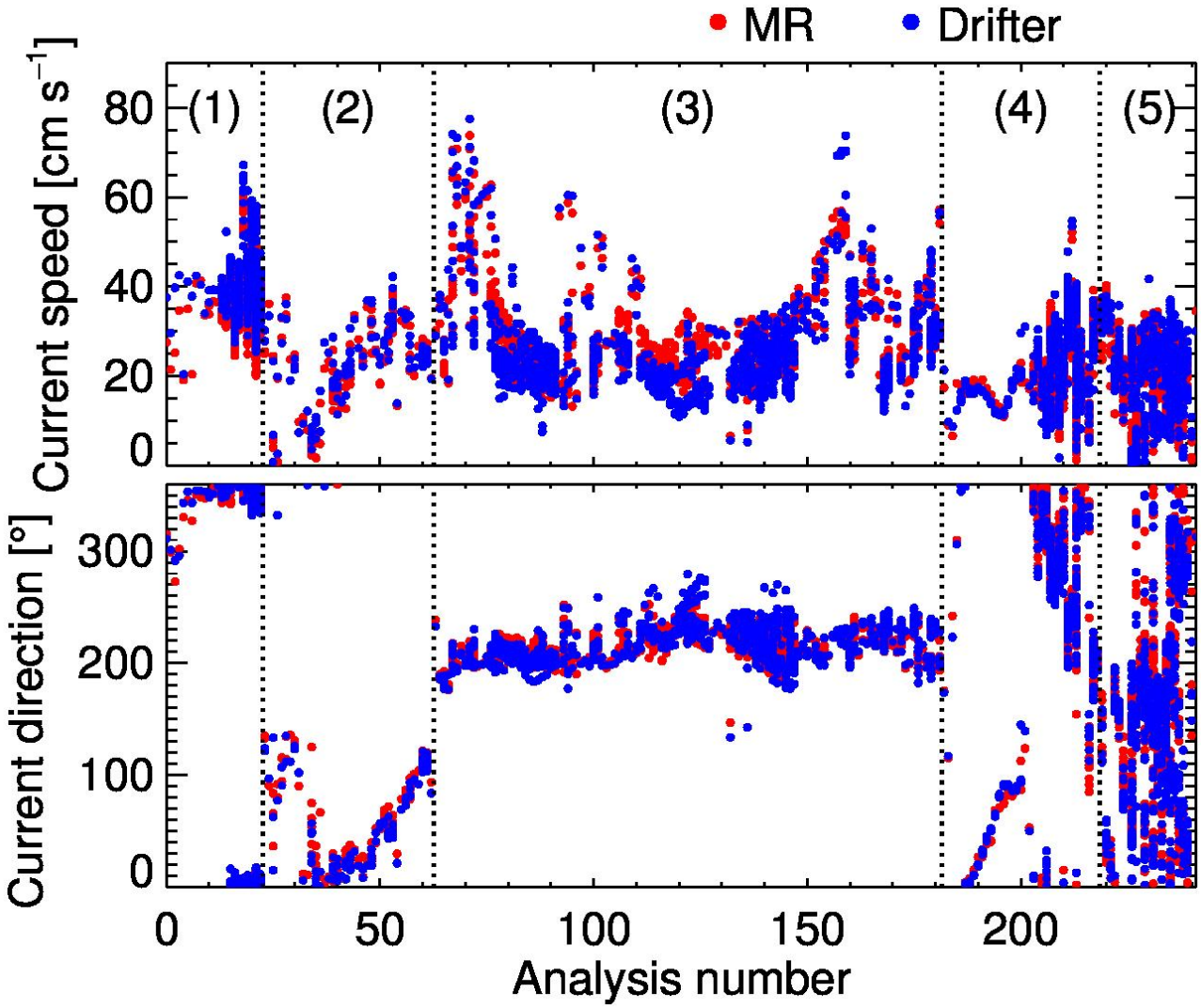
(1) 01/20, 16:00 UTC-
01/21, 19:00 UTC

(2) 01/25, 17:00 UTC-
01/26, 22:00 UTC

(3) 01/28, 17:00 UTC-
02/01, 13:00 UTC

(4) 02/06, 06:00 UTC-
02/07, 21:00 UTC

(5) 02/10, 22:00 UTC-
02/12, 19:00 UTC



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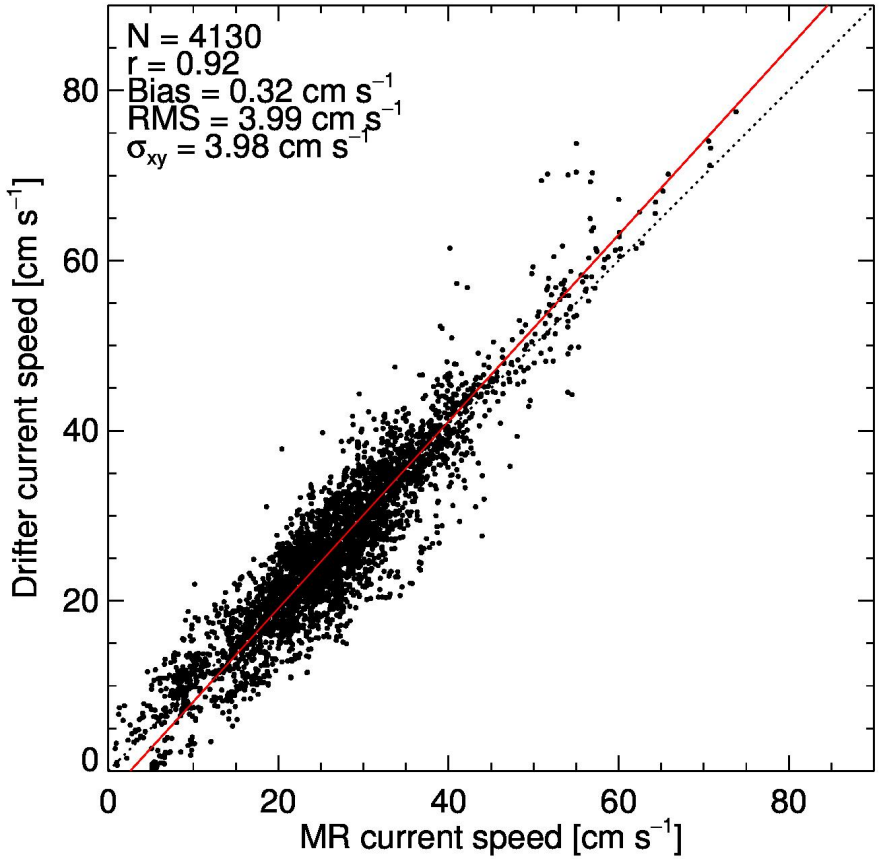

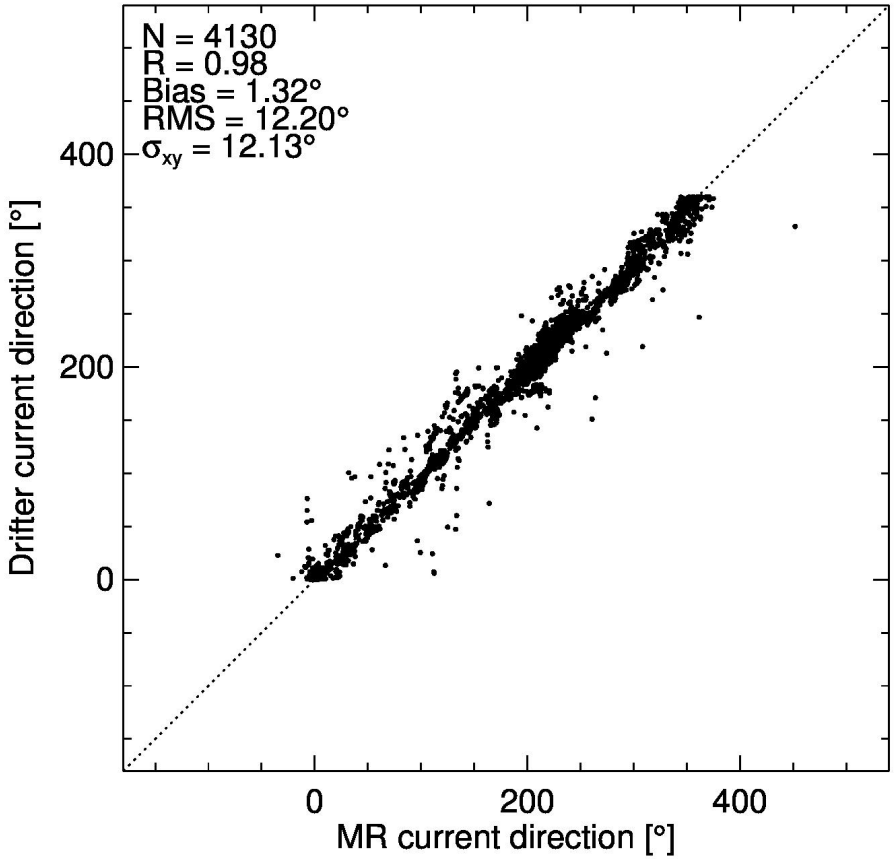

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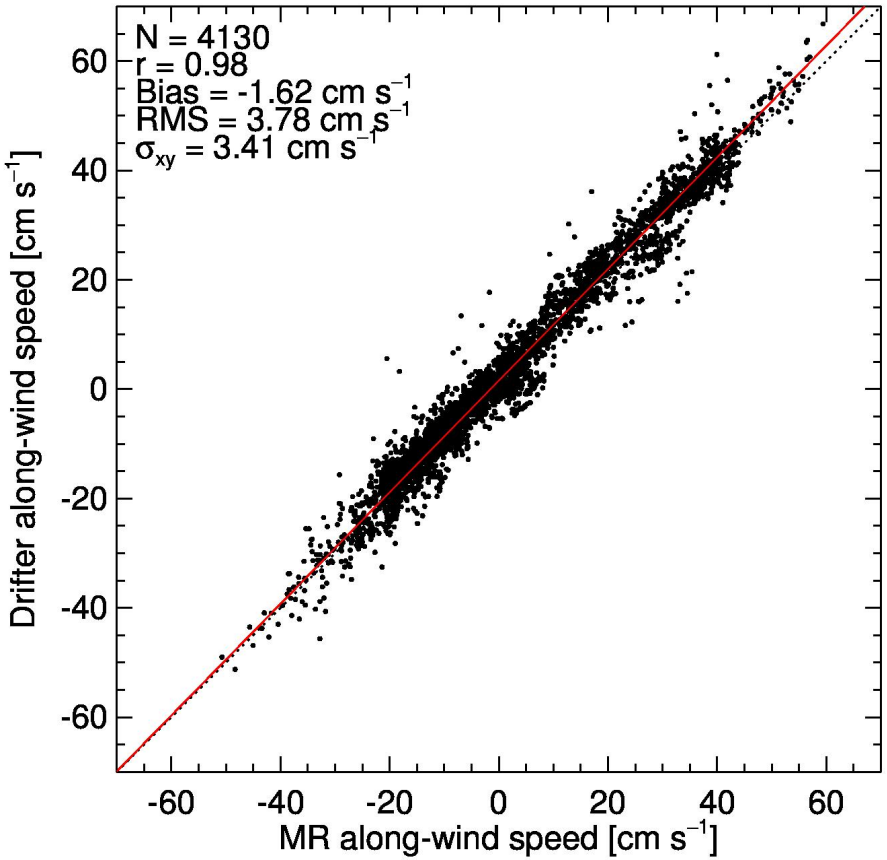

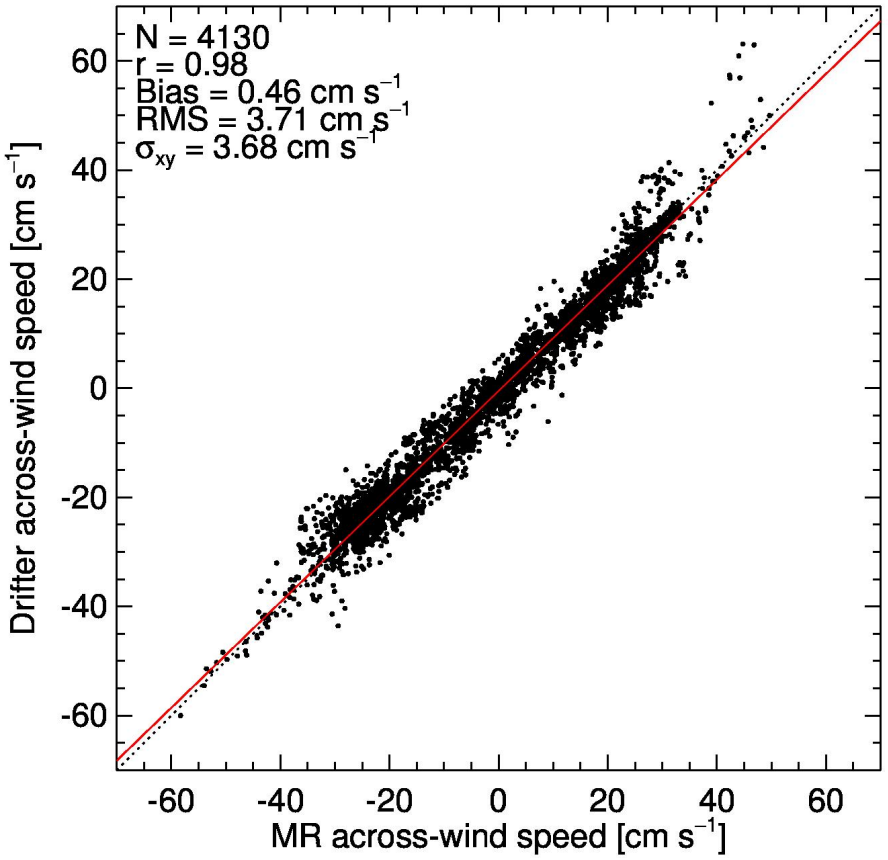

Conclusions

- “Calibrated” marine radar images show frontal features (as well as slicks, wind rows, …), guiding field work activities and providing context for data analysis
- Marine radar near-surface current maps compared against LASER drifter measurements
- For 4,130 radar–drifter data pairs (almost 6 days of data), standard deviations of differences are 4 cm s^{-1} and 12° for current speed and direction
- Part of radar–drifter differences can be explained by different sampling depths / vertical current shear
- Frontal features / bands of enhanced radar backscatter coincide with strong convergence (downwelling)