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Mesoscale eddy characteristics in the Labrador Sea from observations and a 1/60° numerical model

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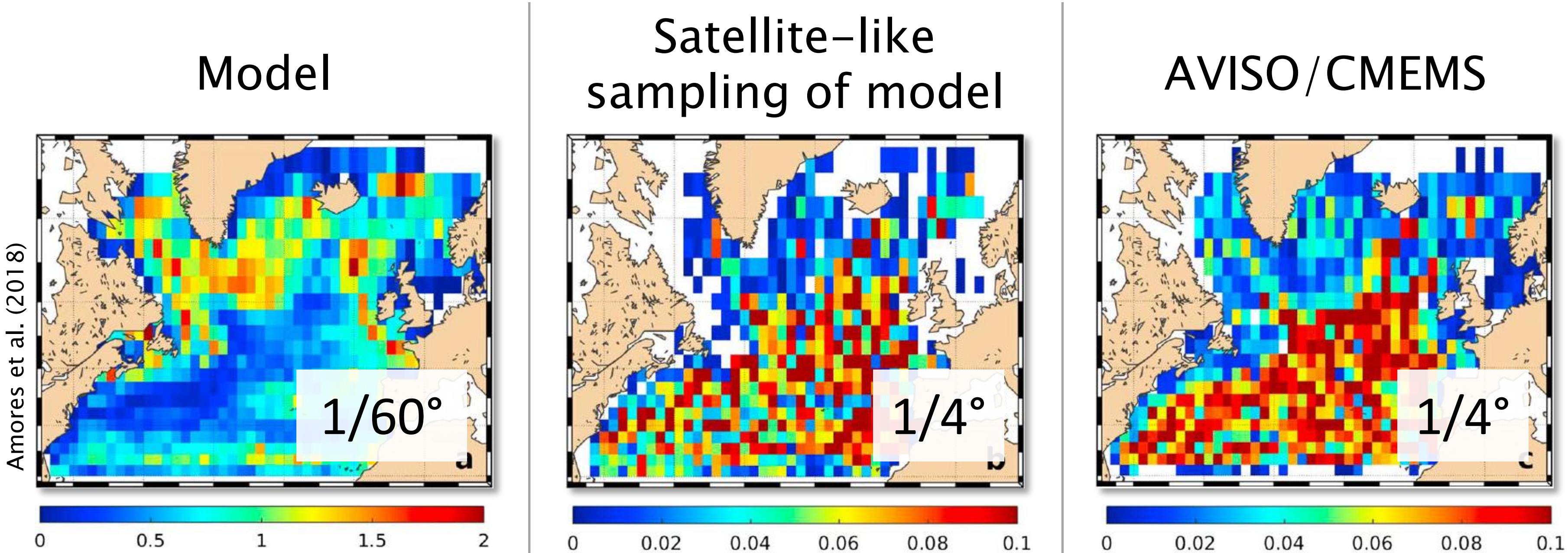
Motivation Capability of altimetry to resolve eddy field

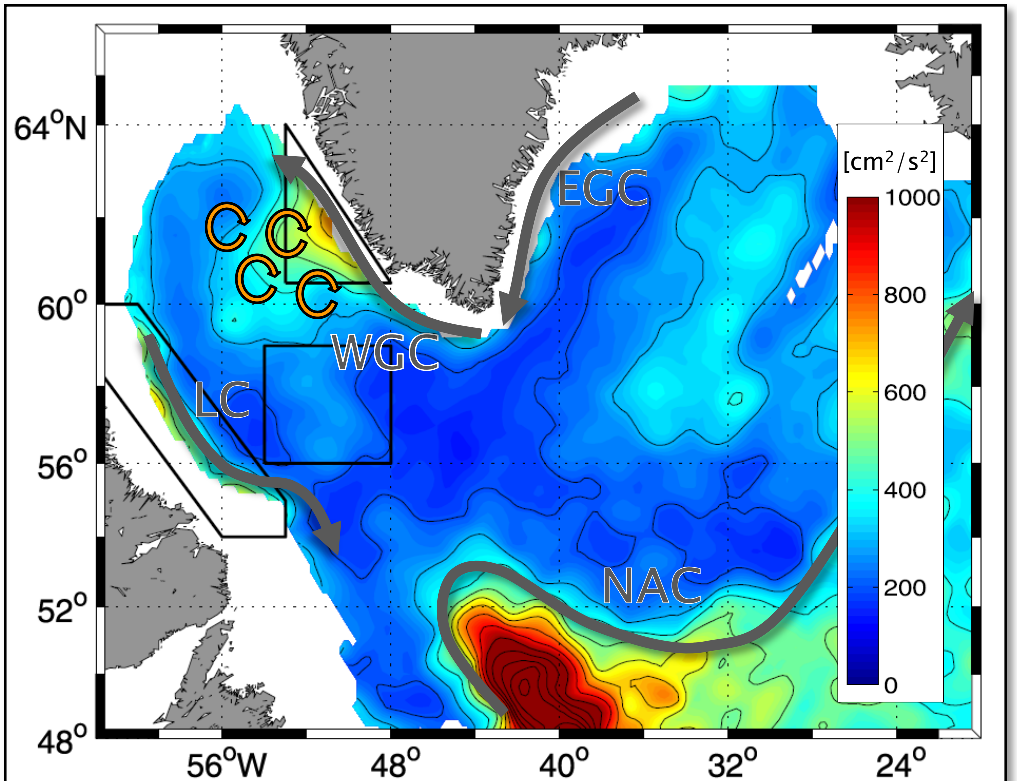


Number of eddies per degree² and per day

→ Only 6% of North Atlantic eddies are captured by present day altimetry

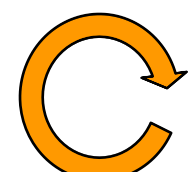
Eddy kinetic energy in the Labrador Sea

High-latitude, small Rossby radius ocean: ~10km



Brandt et al. (2004)

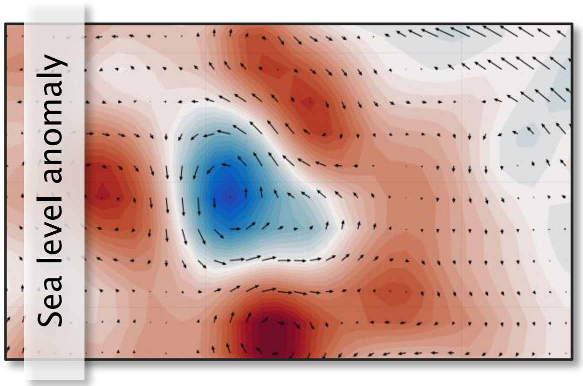
- Elevated levels of EKE in the northern Labrador Sea due to WGC instabilities
- Eddy generation hot spot
- Irminger rings



10-35km radius
Anticyclonic warm, salty lens

Data Observation and model data used in this study

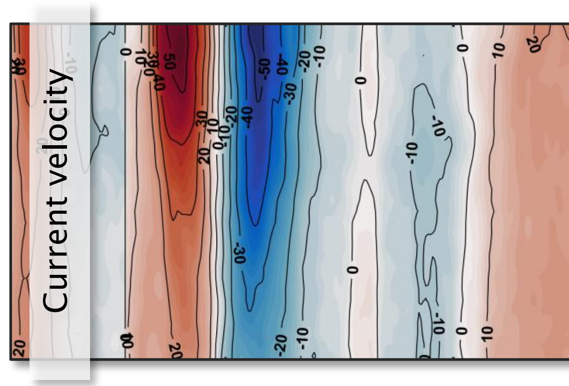
Altimetry



AVISO/CMEMS

- Near-real time gridded and along-track SLA data

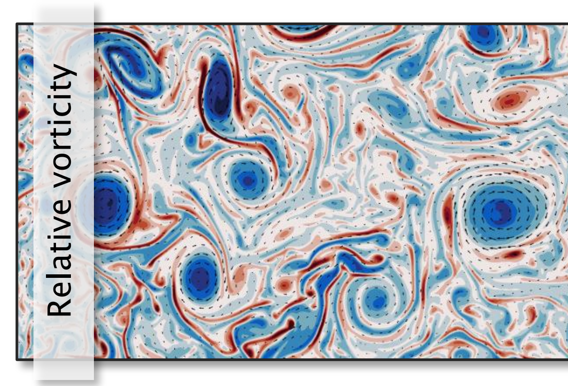
Ship-based



Vessel-mounted current profiler

- Continuous upper-ocean velocity sampling
- 1-min temporal resolution (MSM74, MSM40)

Model



Submesoscale permitting NATL60

- 1/60° global resolution; ~1km grid-box spacing
- 300 vertical levels

Methods Eddy characterisation method

<u>Assumption</u> Eddies are axisymmetric and nontranslating

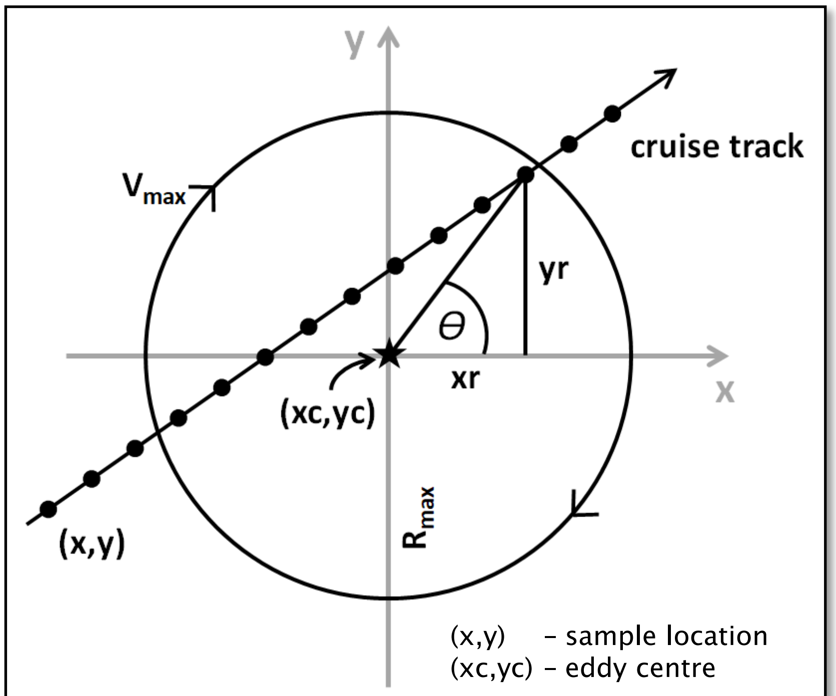
<u>Eddy reconstruction</u> Applying a nonlinear, damping Gauss–Newton algorithm in the framework of a cyclindrical coordinate system (based on Castelao and Johns, 2011)

$$\left|\vec{V}\right| = \underbrace{\boxed{-u\sin(\theta) + v\cos(\theta)}}_{V_\theta} + \epsilon$$

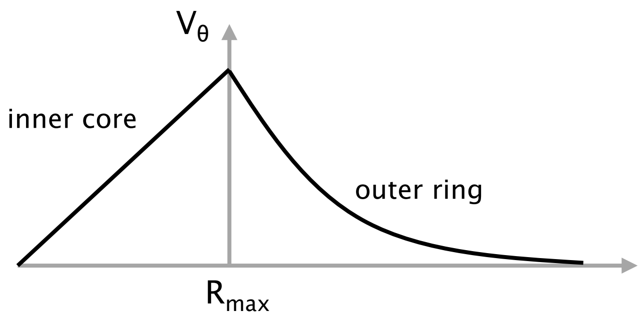
$$\theta = \arctan(y_r/x_r)$$

$$y_r = y - y_c$$

$$x_r = x - x_c,$$



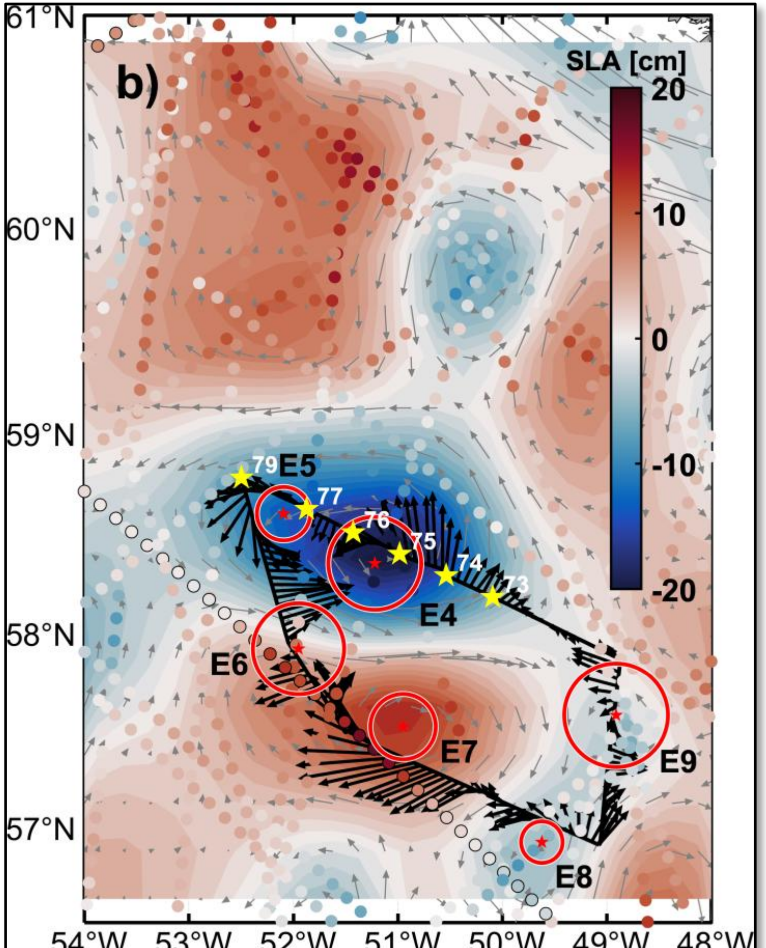
Idealised vortex



Derived eddy properties

- Maximum radius (R_{max})
- Maximum azimuthal velocity (V_{max})
- Exponential decay rate (λ)
- Sea surface height (η_0)
- Rossby number (Ro)
- Relative vorticity (ζ_{in})
- Azimuthal velocity for solid-body rotation (V_{sb})

Results I Altimeter vs. Ship-based observations



Upper 300m mean velocity vector (ship-based)

CTD station

Altimeter derived surface velocity field

Along-track SLA

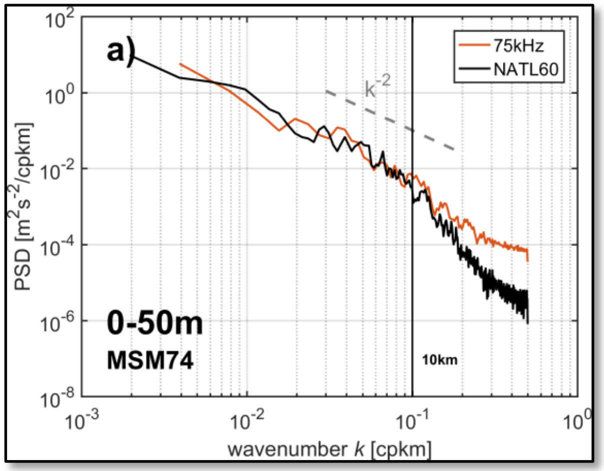
Gauss-Newton derived eddy centre and radius

Optimally interpolated SLA from along-track data

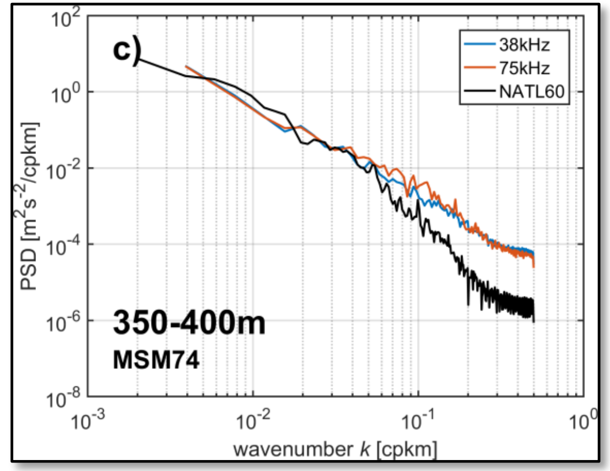
➔ Aliased altimeter-based measurements introduce distortion of mesoscale eddy field

Results II Eddy characteristics: Observations vs. Model

mixed layer



pycnocline



→ Good representation of mesoscale flow regime in the mixed layer

→ Model underrepresentation in the pycnocline at scales <50km

NATL60 eddies

R_{max} = 15km
25% smaller in radius

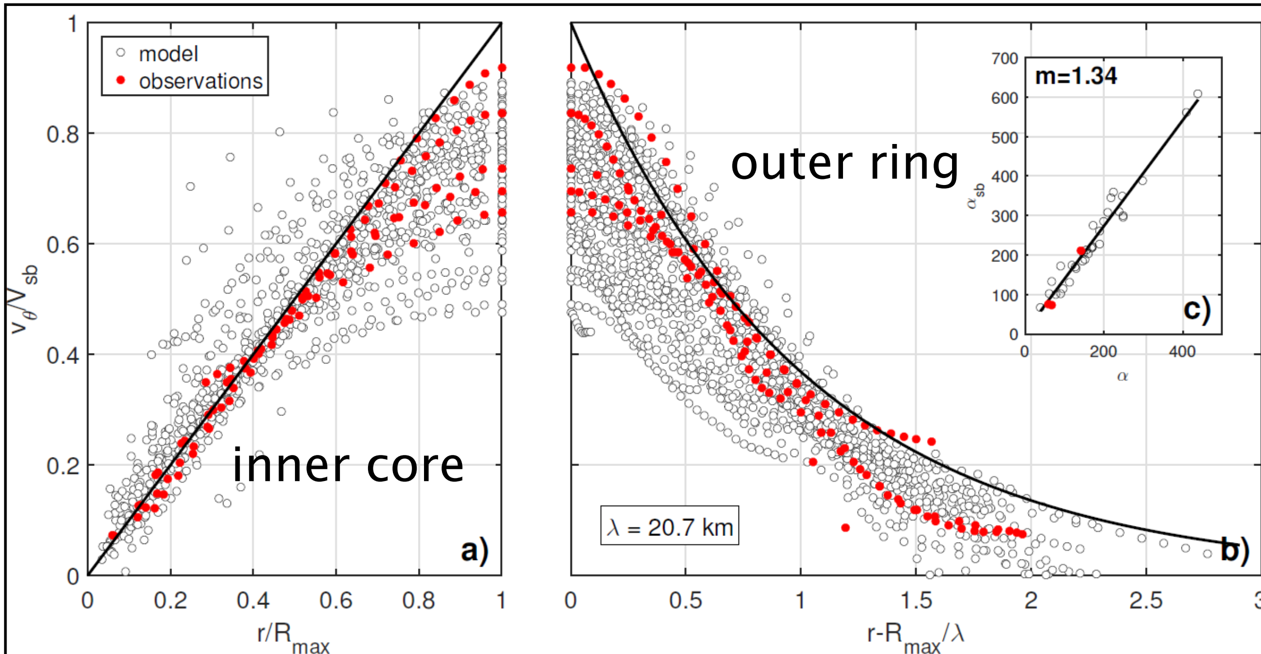
V_{max} = 42cm/s
15% larger in azimuthal velocity

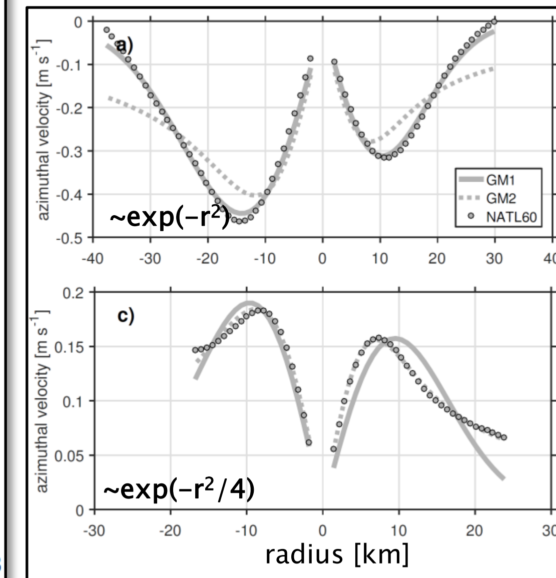
Ro = 0.22
>20% larger in Rossby number

$\zeta_{in} = 5.57 \cdot 10^{-5}$ 1/s
>20% larger in relative vorticity

→ Modelled eddies are more nonlinear than observed eddies

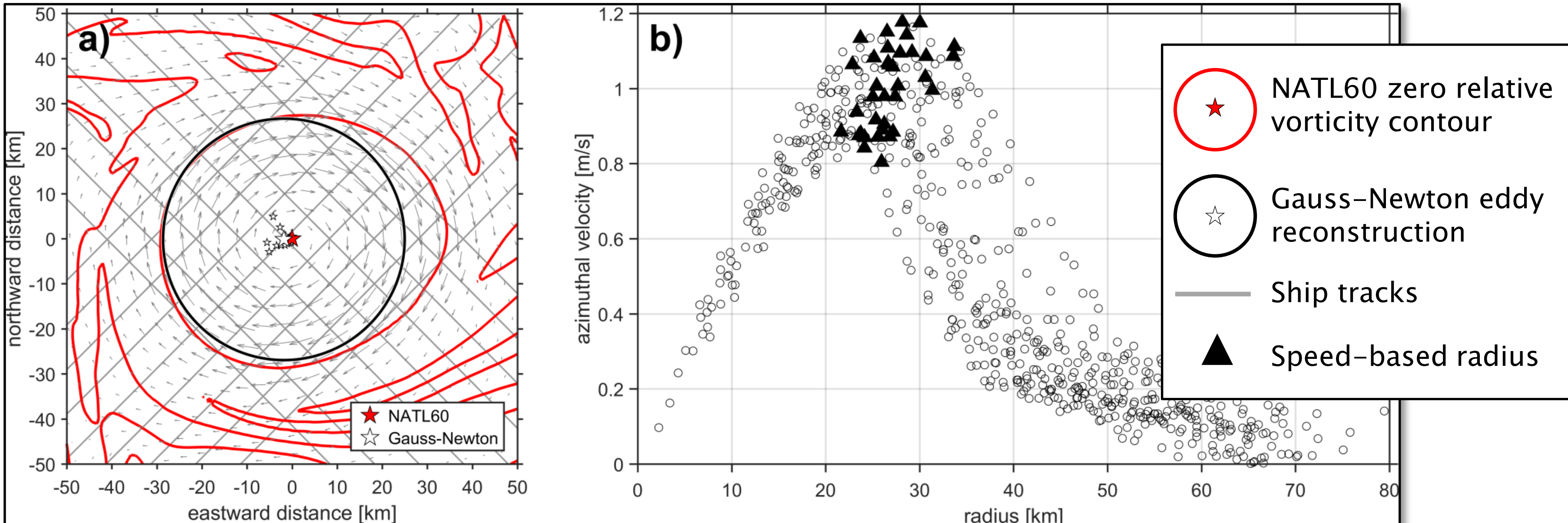
Results III Eddy radial velocity structure (Upper 300m mean)





- Gaussian-shaped velocity structure
- Large deviation from solid-body rotation at eddy rim

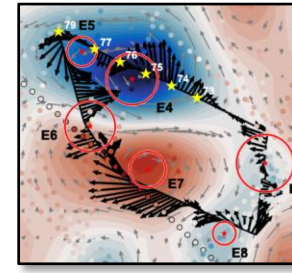
Results IV Skill assessment of eddy characterisation

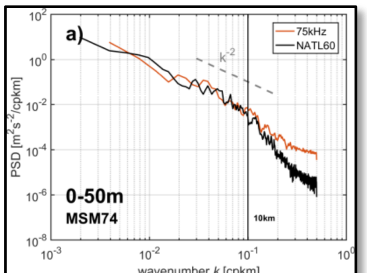


- Eddy centre estimate and derived properties depend on the ship track through the eddy
- In most cases, the estimated eddy characteristics do not deviate from each other by more than 10%

Summary and Conclusion

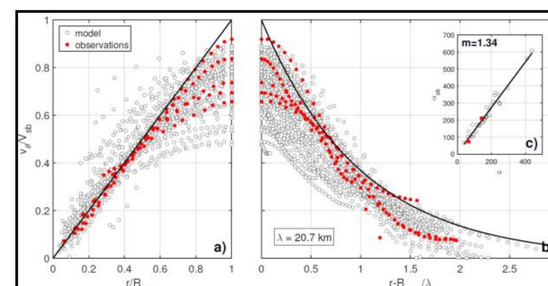
Ship-based eddy reconstruction provides new insight in eddy characterisation (centre, radius, vorticity, etc.)





Submesoscale permitting NATL60 creates a mesoscale flow regime close to the observed. NATL60 eddies are smaller in radius and larger in azimuthal velocity

Observed and modelled horizontal velocity structure feature a Gaussian shape with large deviations to solid-body rotation



References

Thank you for your attention!

Amores, A., Jordà, G., Arsourze, T., and Le Sommer, J. (2018). Up to what extent can we characterize ocean eddies using present-day gridded altimetric products? *Journal of Geophysical Research: Oceans*, 123(10), 7220–7236. https://doi.org/10.1029/2018JC014140

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