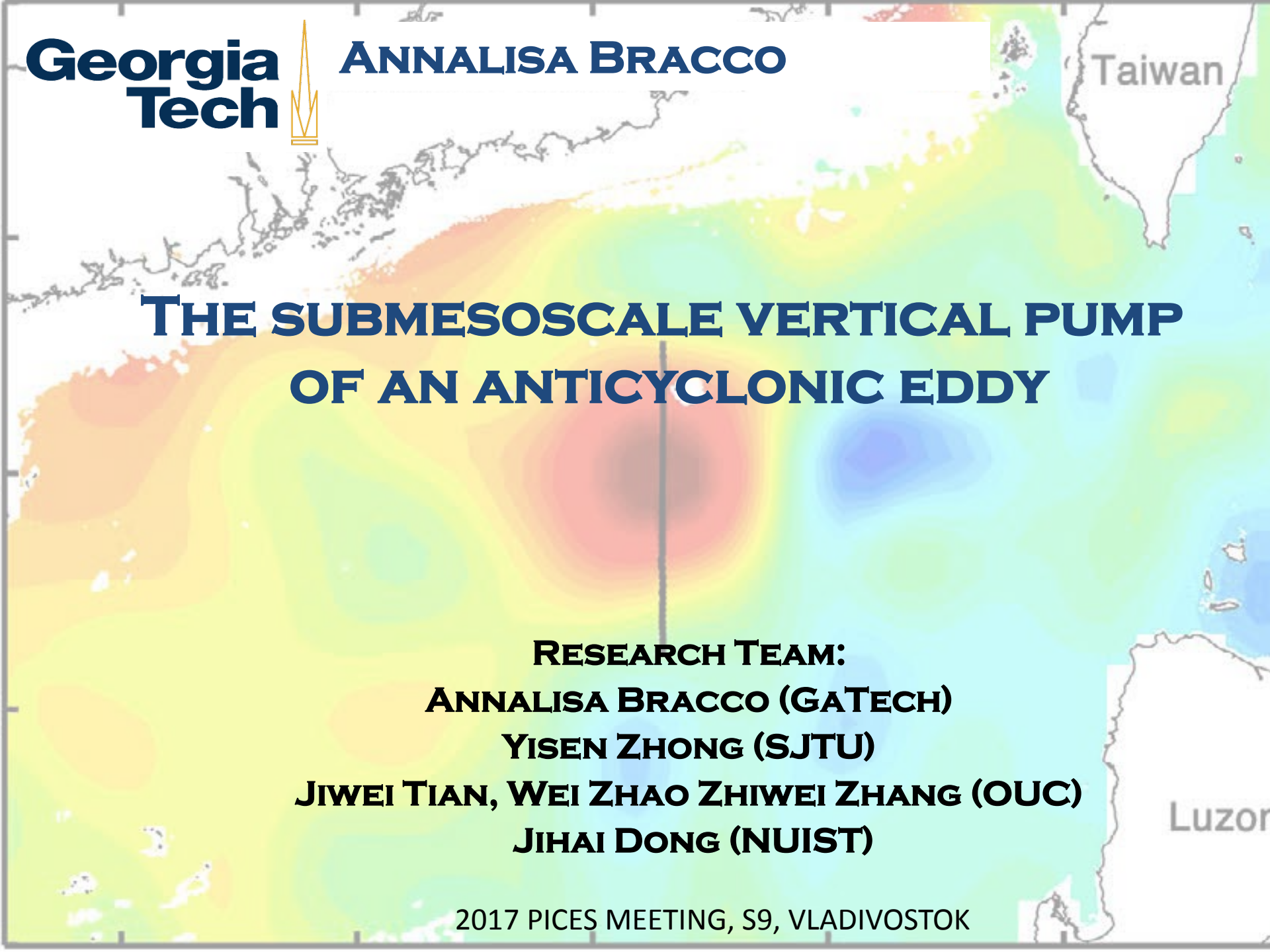

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THE SUBMESOSCALE VERTICAL PUMP OF AN ANTICYCLONIC EDDY

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2017 PICES MEETING, S9, VLADIVOSTOK

Outline

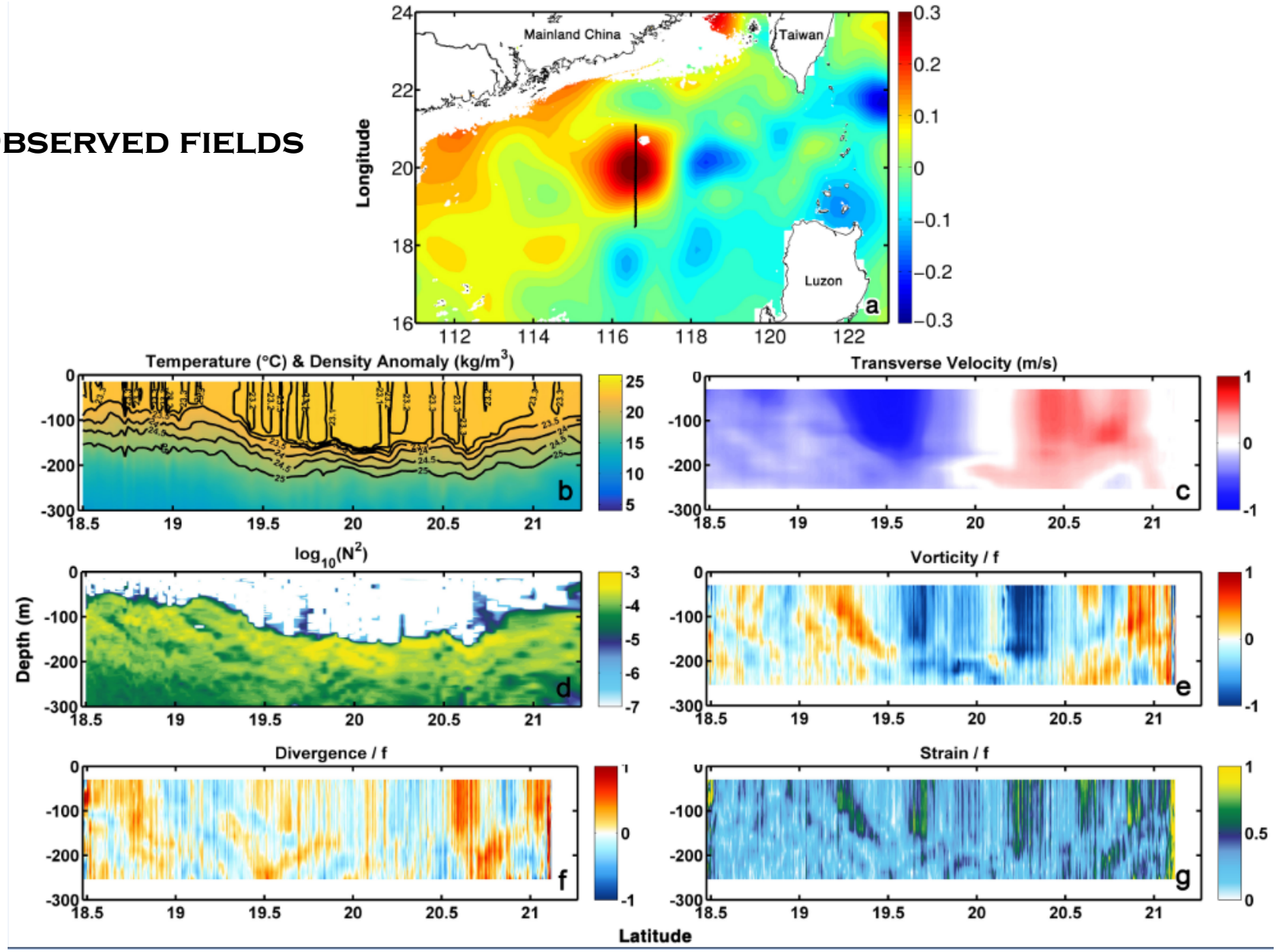
- Observations
- Modeling at different horizontal resolutions (1, 5, 10 km)
- vertical eddy transport
- Conclusions/Implications

Observations

- Submesoscale resolving survey of a 200 km diameter anticyclone in Jan. 14-16, 2014 on R/V Dongfanghong 2

- ADCP (every 250 m or less
- CTD (every 300 m)
- Microstructure MSS90 profiler
- Expendable Bathythermographs (XBT) (every 2 km)

Observed fields



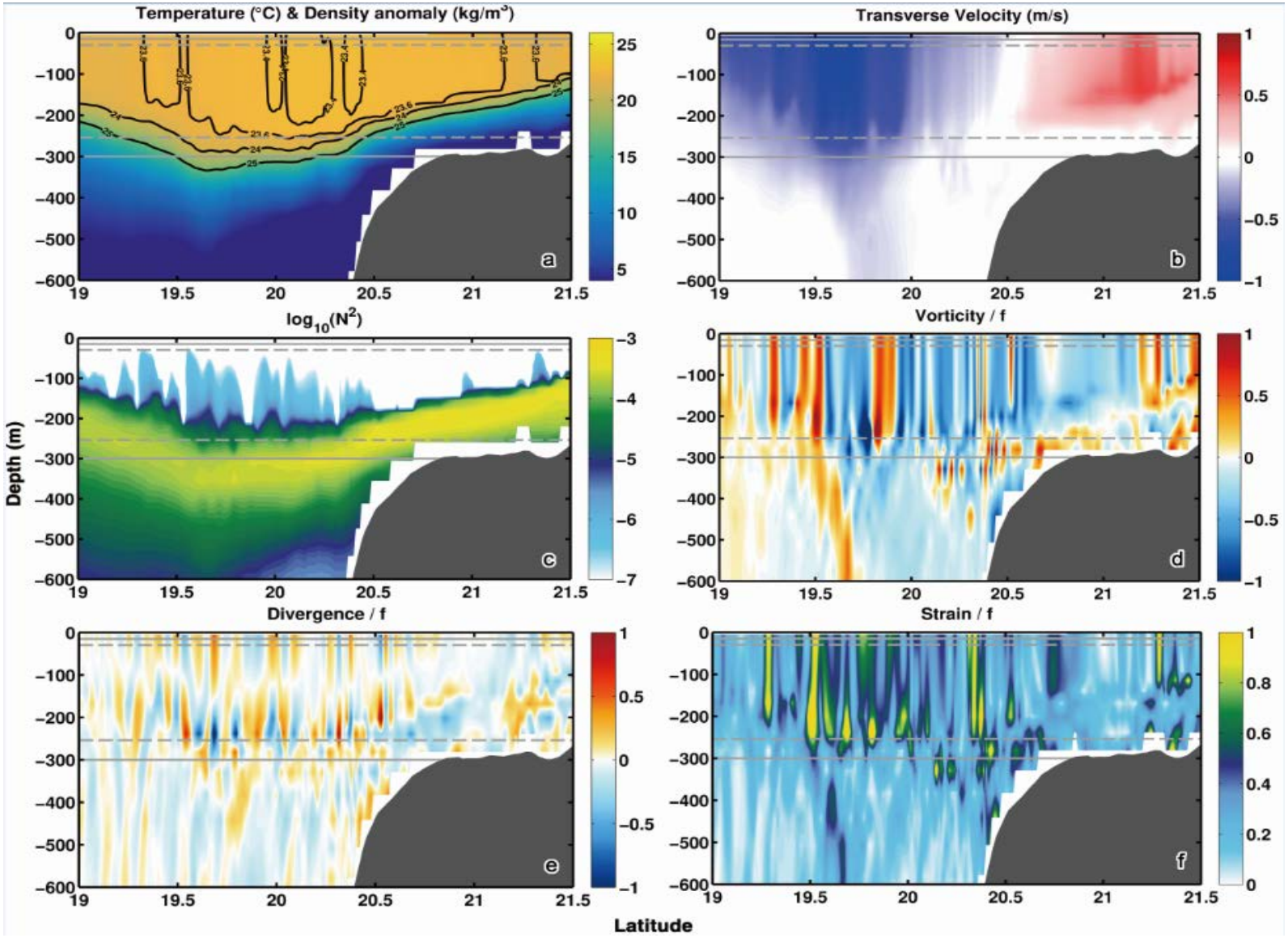
Zhong, Bracco et al, Scientific Reports, 2017

Modeling

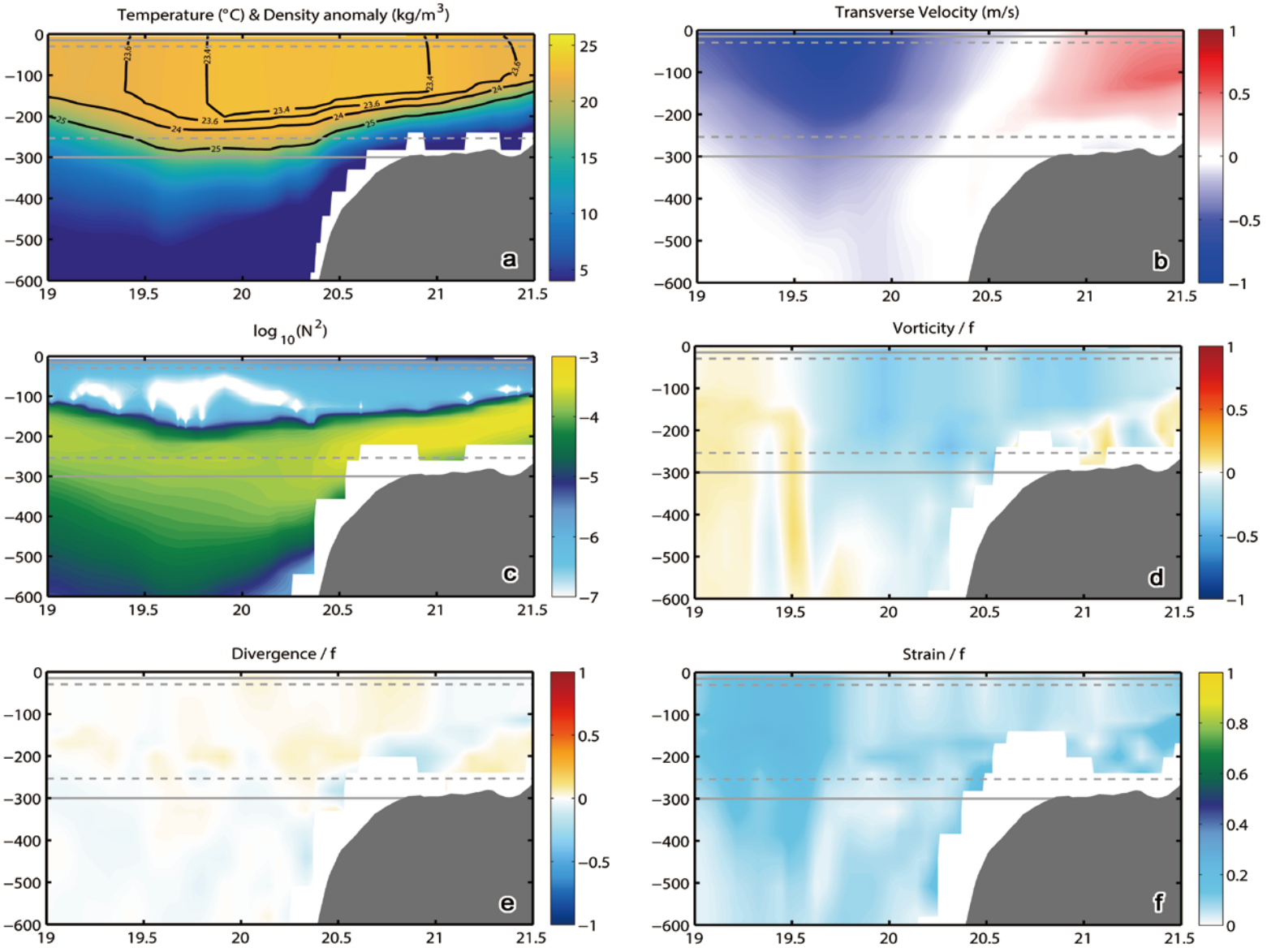
- ROMS-Agrif at three different horizontal resolutions, 10 km, 5 km (all SCS) and 1 km (nested over 113°E–122°E, 17°N–25°N). split third-order upwind scheme, harmonic viscosity, linear bottom drag and KPP

- 20 yrs spin-up
- 6-hourly QSCAT/NCEP blended satellite wind and 6-hourly NCEP heat and fresh water fluxes 2000-2008
- Comparable eddy to that observed forms in in January 2001

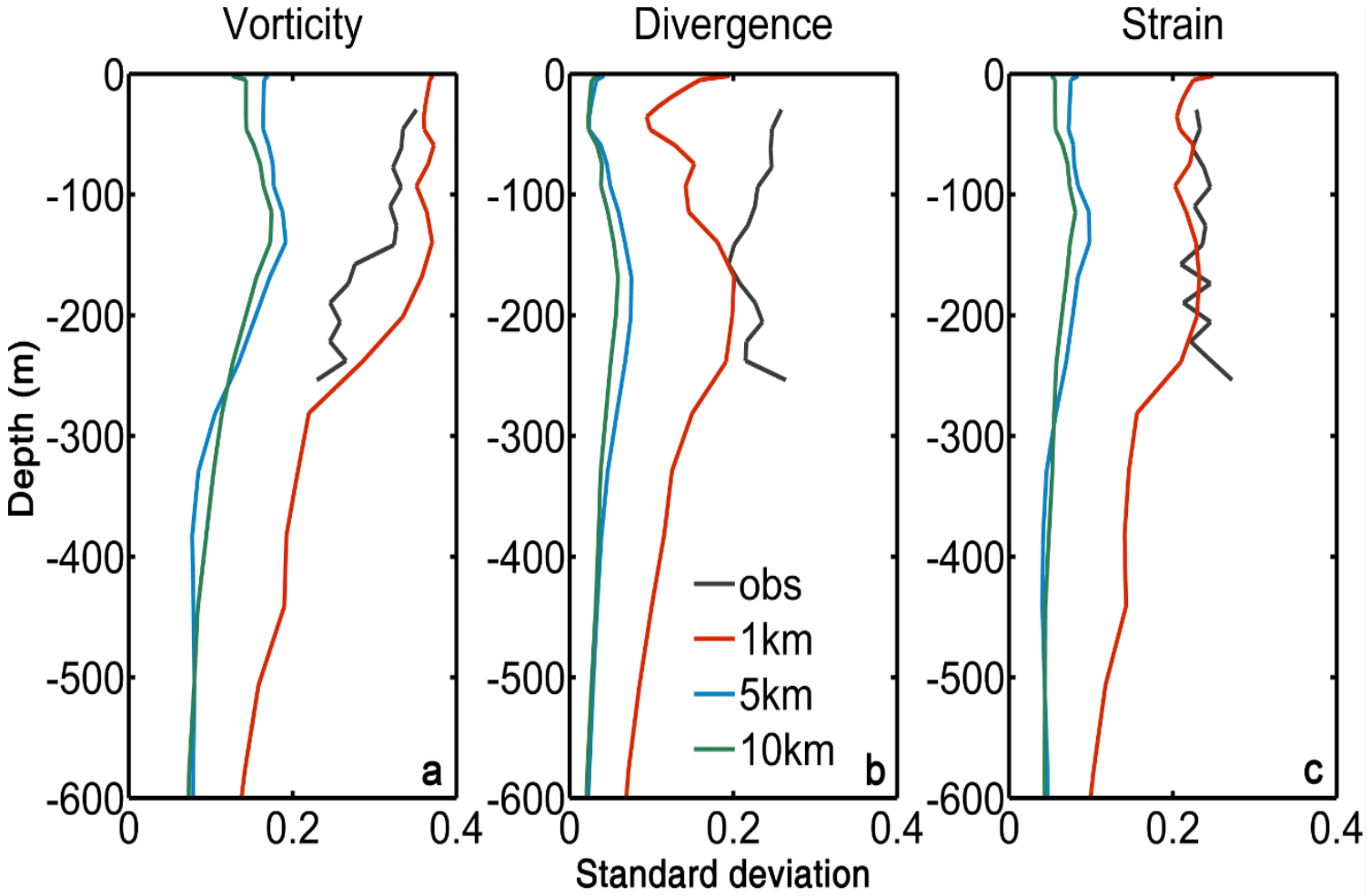
Simulated fields: 1km horizontal resolution



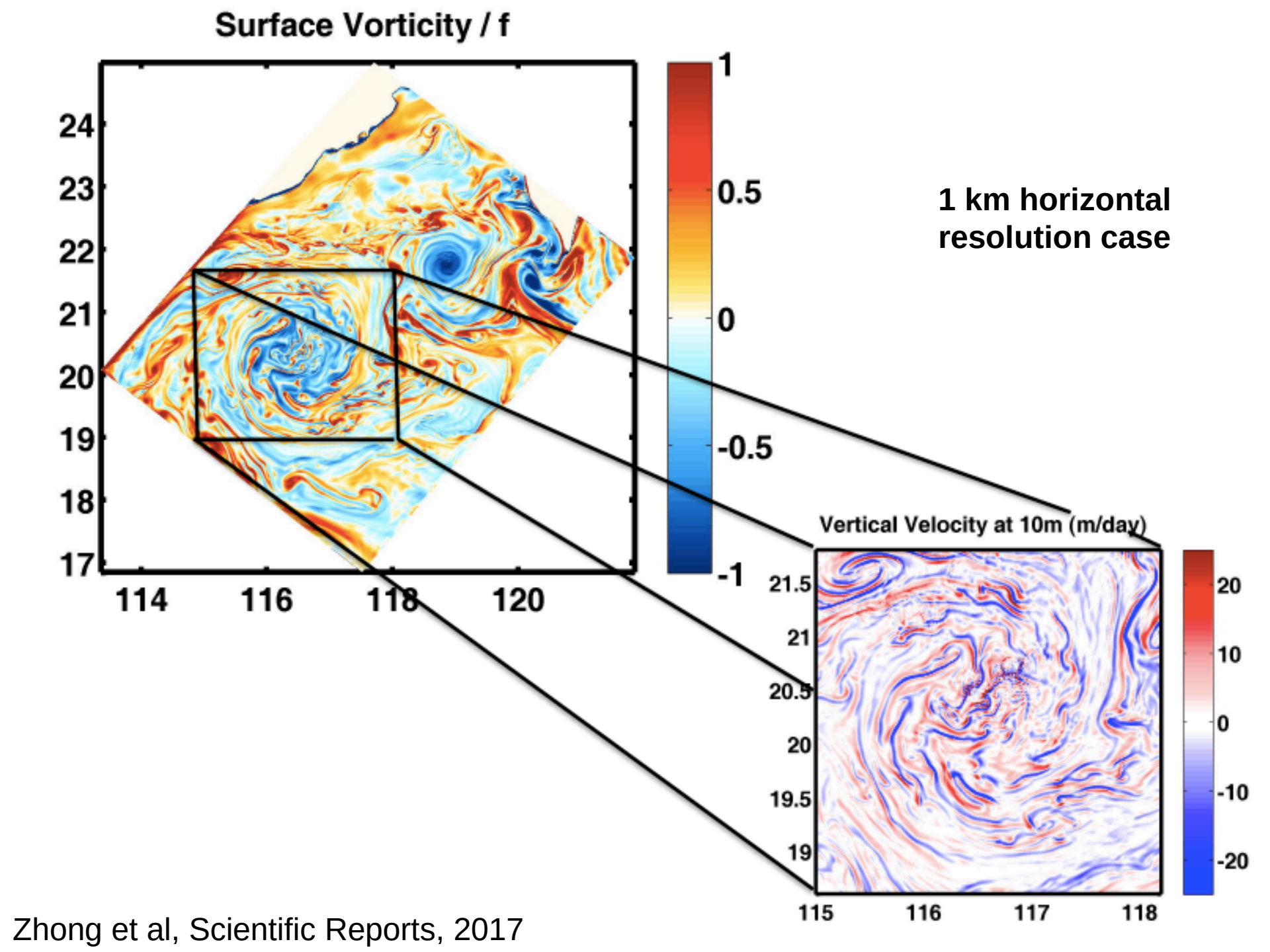
Simulated fields: 10km horizontal resolution run max for next high res. climate models



Standard deviation: modeled vs observed

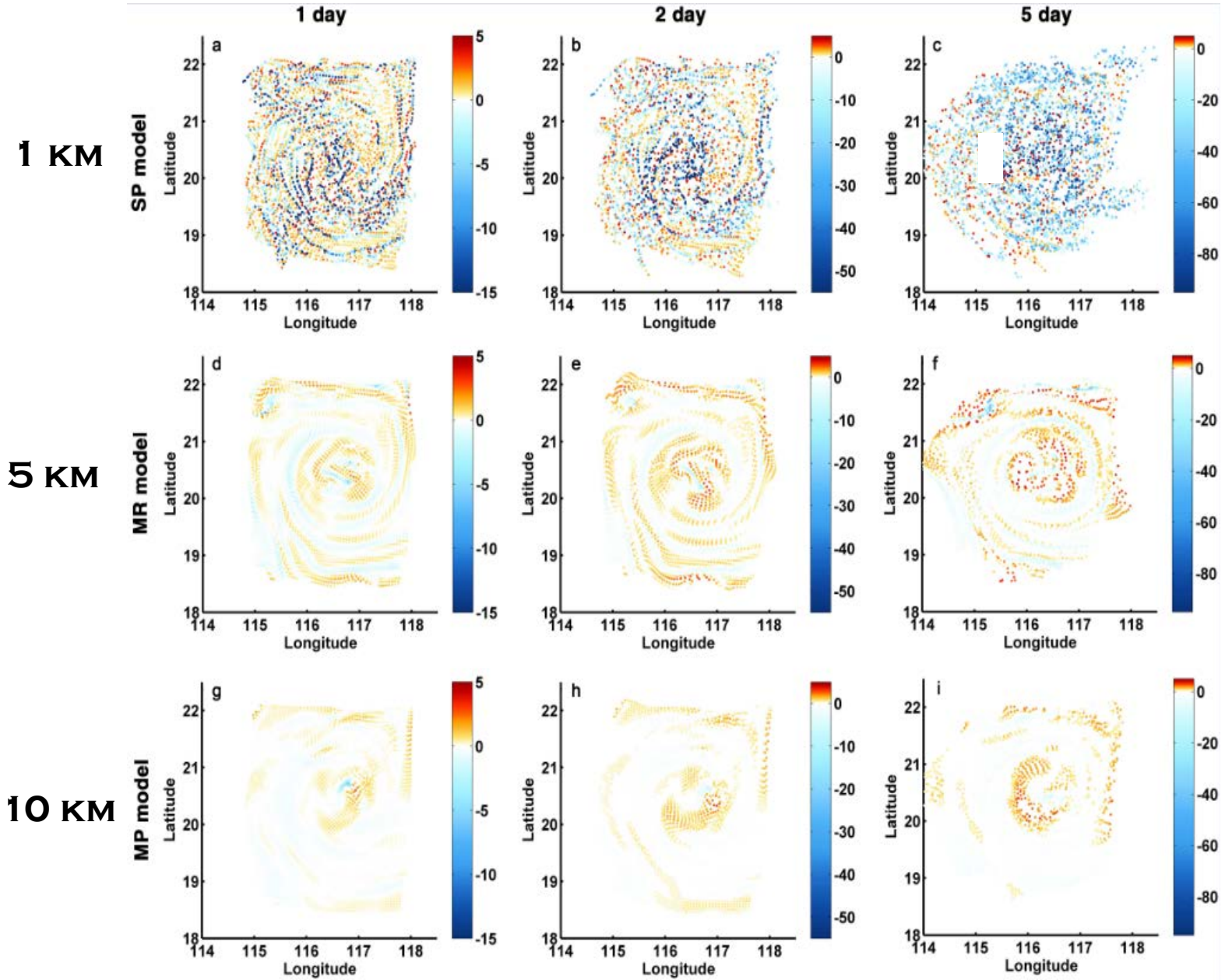


Zhong et al, Scientific Reports, 2017

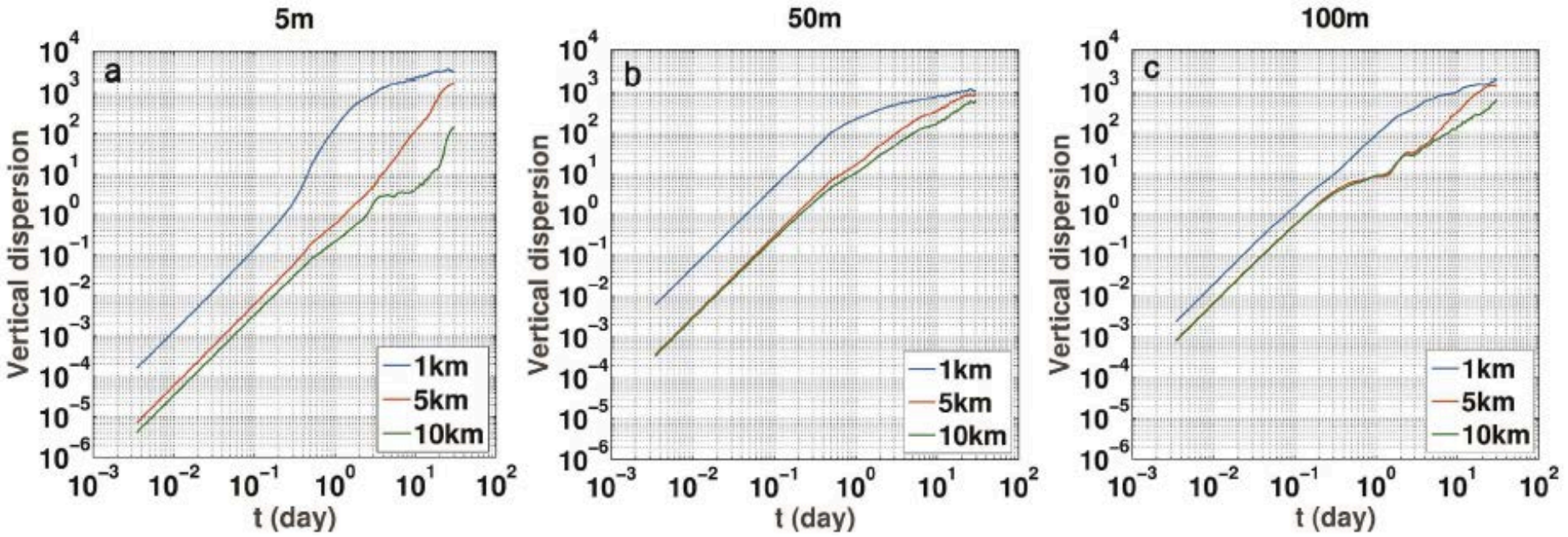


Zhong et al, Scientific Reports, 2017

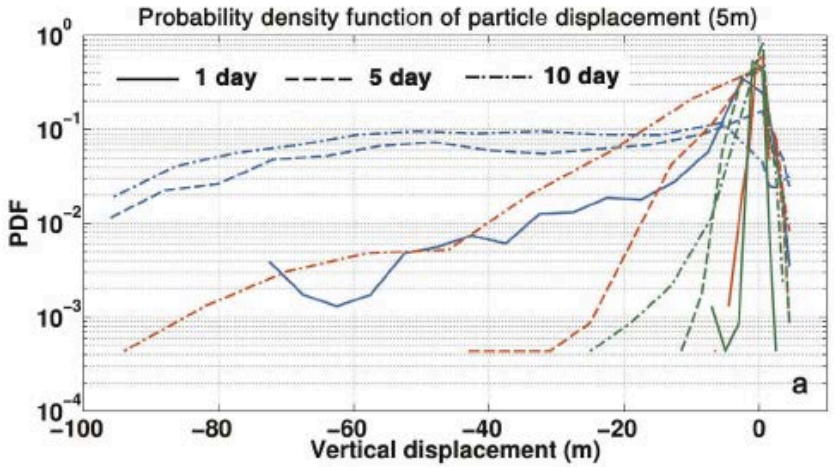
VERTICAL EDDY TRANSPORT



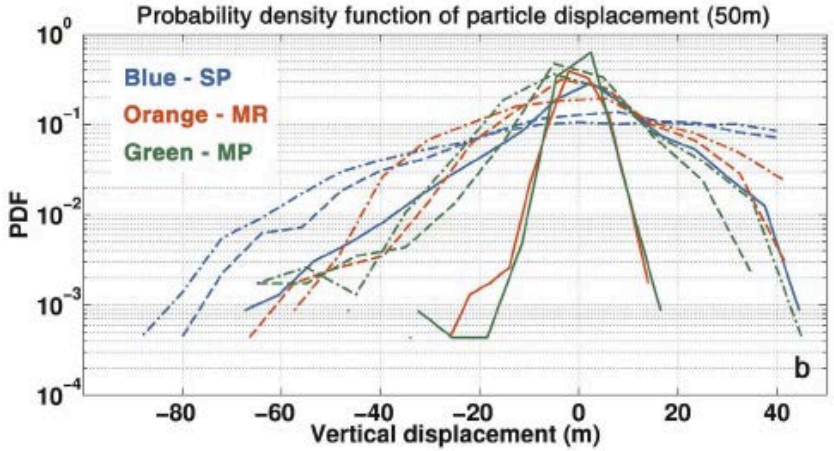
VERTICAL EDDY TRANSPORT QUANTIFIED



absolute vert. dispersion $A_z^2 = \langle [z(t) - z(t_0)]^2 \rangle$

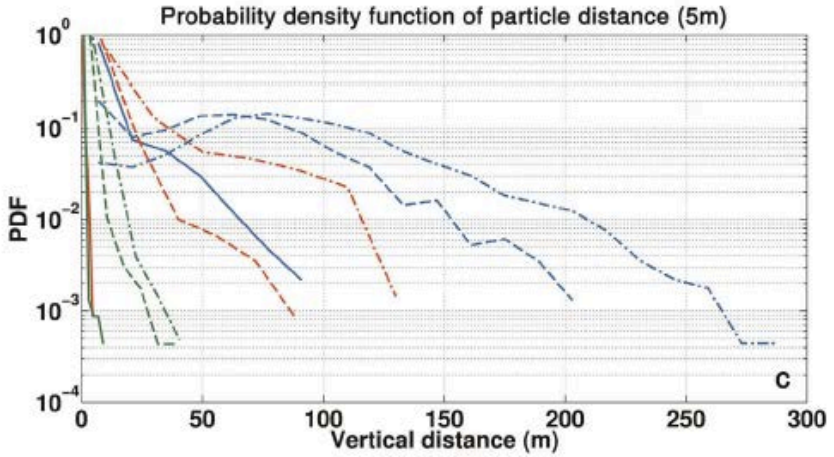


Probability density function of total vertical displacement for particles released at 5 m



and 50 m

after 1, 5, 10 days



and PDF of the total vertical distance covered by the particles released at 5 m.

Conclusions/Implications

- First observations of **strong ageostrophic motions in eddies** (here extending to ~ upper 300 m)

- Observed flow from ADCP has patches with local **Rossby number >1 and elevated strain and horizontal velocity divergence** . Consistent with the 1 km hor. res. run

- **1 km** may not be sufficient (the horizontal velocity divergence' variance remains slightly underestimated), but **good compromise** between including submesoscale dynamics and avoiding spurious overestimations of vertical velocity due to hydrostatic approx.

- In the eddy and its periphery **strong ageostrophic fronts unstable to symmetric instability**

Conclusions/Implications

- The ageostrophic vertical velocities **enhance vertical transport** at the outer edge of the eddy, and inside the eddy

- In winter **Vertical transport is three to five times greater** in the submesoscale permitting 1 km case **after 1 month**, and by **over an order of magnitude greater over ~ 1-10 days** -> **strong impact for planktonic systems**

- Eddy properties are generic (Loop Eddies in the Gulf of Mexico behaves identically)

- Potentially **large implications for global estimates of the eddy-driven vertical pump of biophysical and chemical tracers**

SCIENTIFIC REPORTS

OPEN

Observed and simulated submesoscale vertical pump of an anticyclonic eddy in the South China Sea

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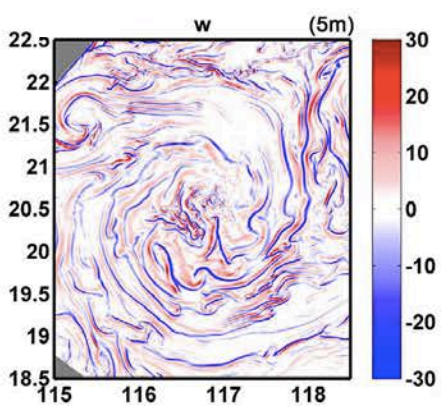
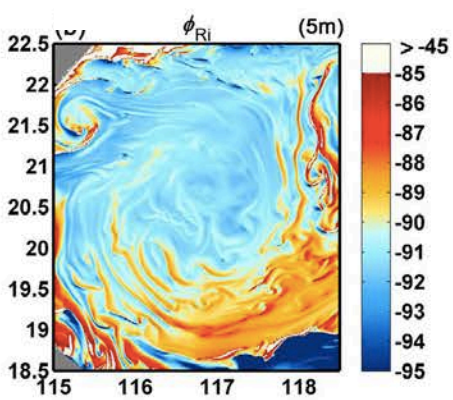
Yisen Zhong[1], Annalisa Bracco[2], Jiwei Tian[3], Jihai Dong[4], Wei Zhao[3] & Zhiwei Zhang[3]

Oceanic mesoscale eddies with typical sizes of 30–200 km contain more than half of the kinetic energy of the ocean. With an average lifespan of several months, they are major contributors to the transport of heat, nutrients, plankton, dissolved oxygen and carbon in the ocean. Mesoscale eddies have been observed and studied over the past 50 years, nonetheless our understanding of the details of their structure remains incomplete due to lack of systematic high-resolution measurements. To bridge this gap, a survey of a mesoscale anticyclone was conducted in early 2014 in the South China Sea capturing its structure at submesoscale resolution. By modeling an anticyclone of comparable size and position at three horizontal resolutions the authors verify the resolution requirements for capturing the observed variability in dynamical quantities, and quantify the role of ageostrophic motions on the vertical transport associated with the anticyclone. Results indicate that different submesoscale processes contribute to the vertical transport depending on depth and distance from the eddy center, with frontogenesis playing a key role. Vertical transport by anticyclones cannot be reliably estimated by coarse-resolution or even mesoscale-resolving models, with important implications for global estimates of the eddy-driven vertical pumping of biophysical and chemical tracers.


w
(5m)
22.5
22
21.5
21
20.5
20
19.5
19
18.5
115
116
117
118
30
20
10
0
-10
-20
-30


ϕ_{Ri}
(5m)
22.5
22
21.5
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20
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18.5
115
116
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118
> -45
-85
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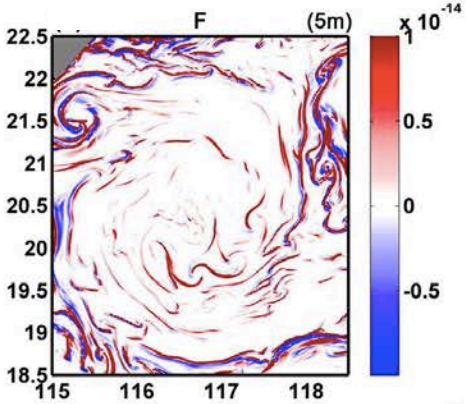
-89
-90
-91
-92
-93
-94
-95


F
(5m)
x 10^-14
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22
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19.5
19
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116
117
118
1
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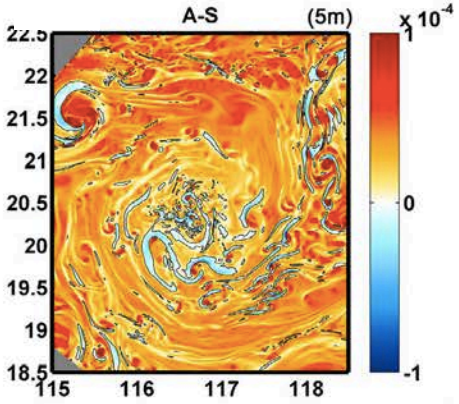
A-S
(5m)
x 10^-4
22.5
22
21.5
21
20.5
20
19.5
19
18.5
115
116
117
118
1
0
-1

THANK YOU