Toward a global atlas of eddy spiceness diagnosed from Argo data

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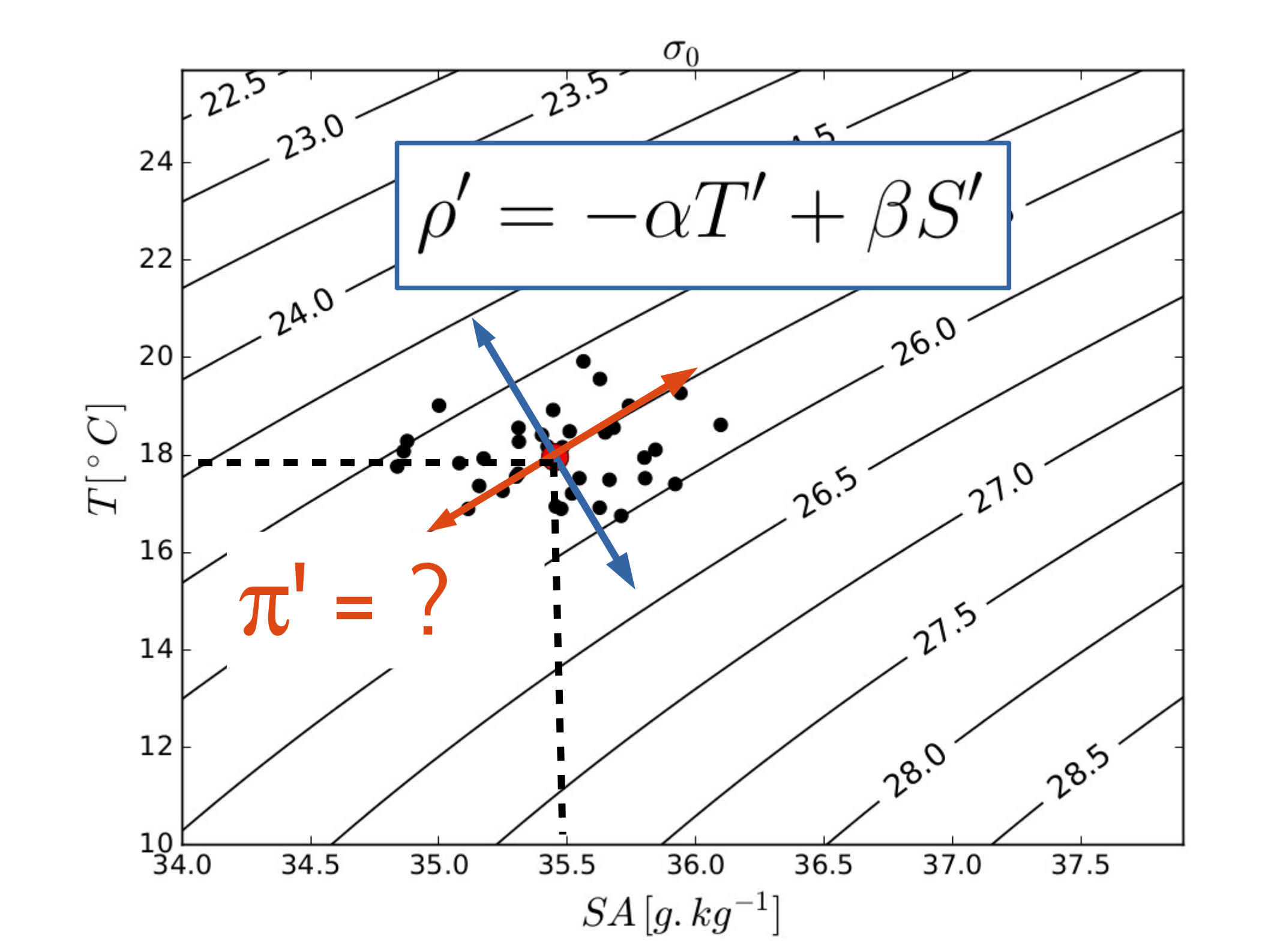
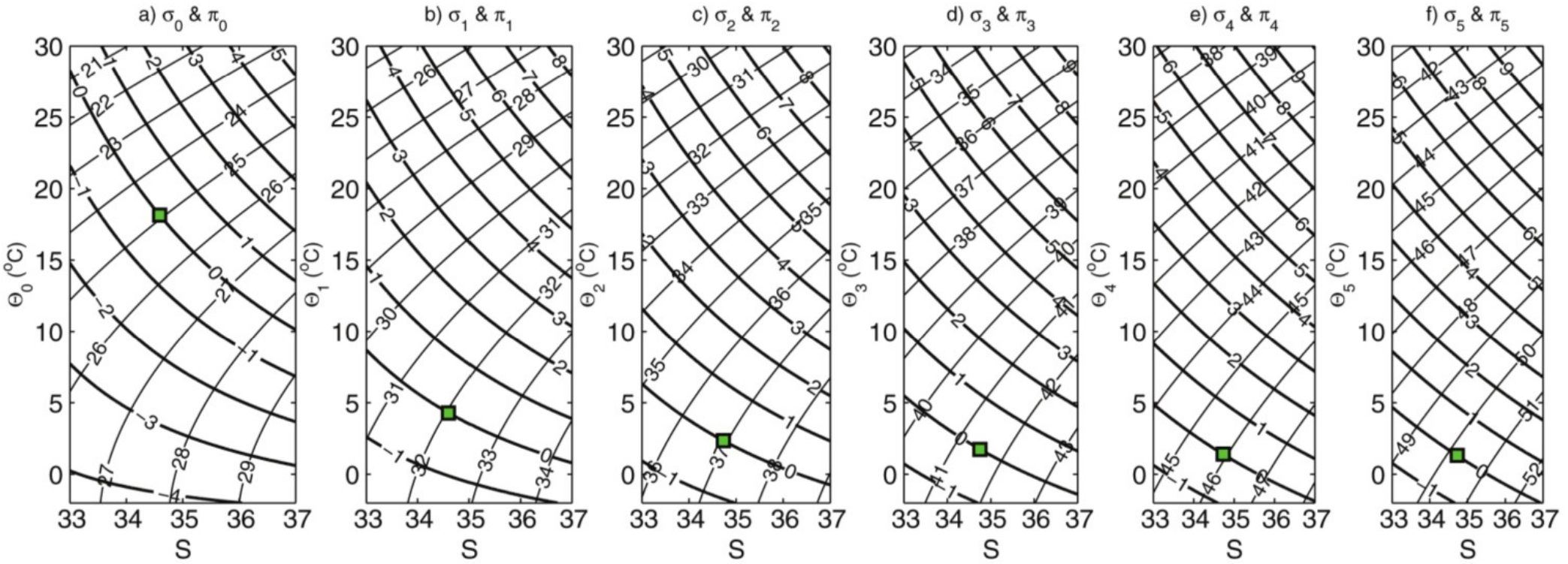
Equipe Océan-Climat– LOPS – Jan 10th 2017


σ_0
22.5
23.0
23.5
24.0
26.0
26.5
27.0
27.5
28.0
28.5
$\rho' = -\alpha T' + \beta S'$
$\pi' = ?$
$T\,[^\circ C]$
$SA\,[g.\,kg^{-1}]$
10
12
14
16
18
20
22
24
34.0
34.5
35.0
35.5
36.0
36.5
37.0
37.5

$\pi = f(S,\theta)$

- Huang JMR 2011 : spicity
  - Absolute spice
  - Compare water masses
  - The zero value is arbitrary

$$\pi(S,\Theta) = a_1 + a_2 S + a_3 \Theta + a_4 S^2 + a_5 S\Theta + a_6 \Theta^2 + a_7 S^3 + a_8 S^2\Theta + a_9 S\Theta^2 + a_{10}\Theta^3 + a_{11} S^4 + a_{12} S^3\Theta + a_{13} S^2\Theta^2 + a_{14} S\Theta^3 + a_{15}\Theta^4 + a_{16} S^5 + a_{17} S^4\Theta + a_{18} S^3\Theta^2 + a_{19} S^2\Theta^3 + a_{20} S\Theta^4 + a_{21}\Theta^5 + a_{22} S^6 + a_{23} S^5\Theta + a_{24} S^4\Theta^2 + a_{25} S^3\Theta^3 + a_{26} S^2\Theta^4 + a_{27} S\Theta^5 + a_{28}\Theta^6$$

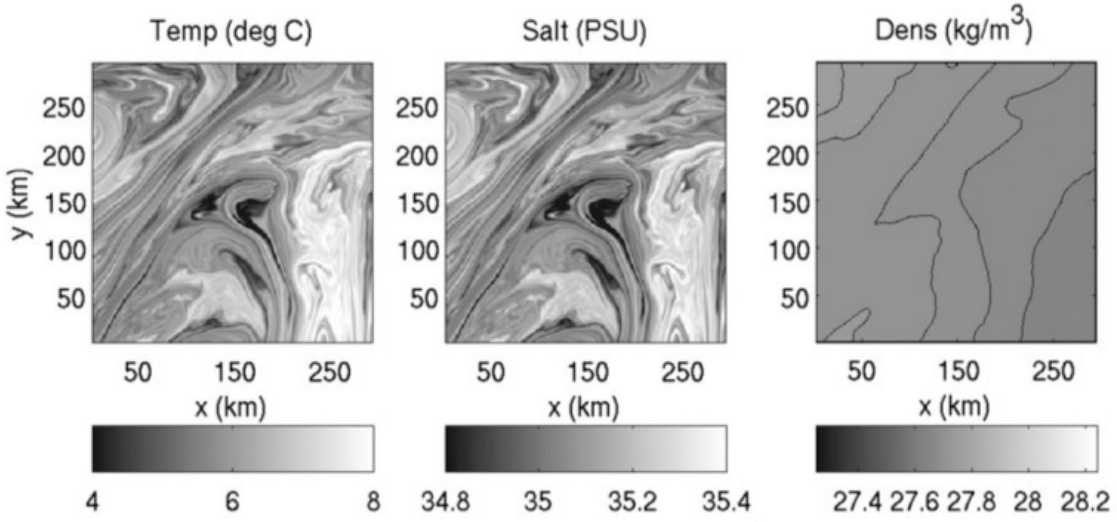


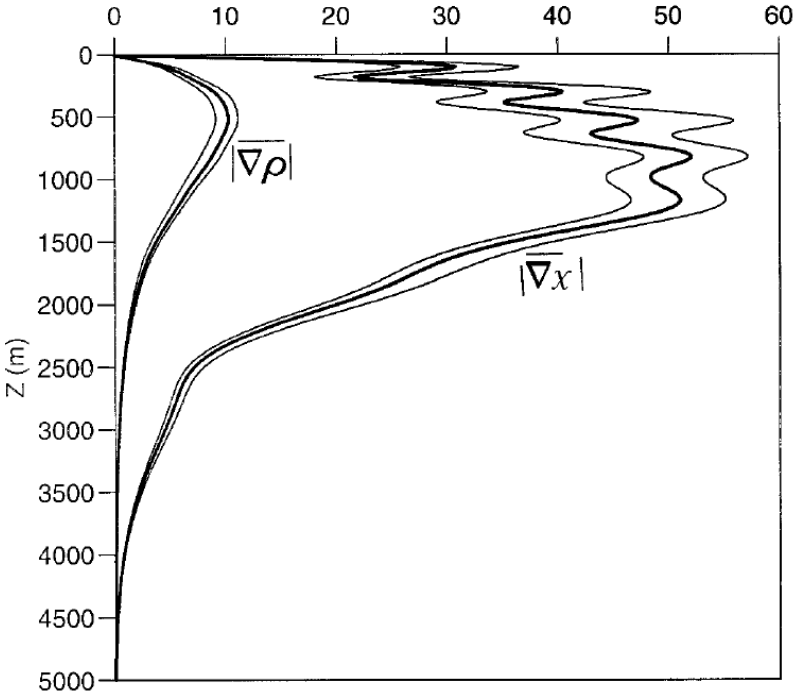
Spicity defined as a set of ρ-orthogonal lines

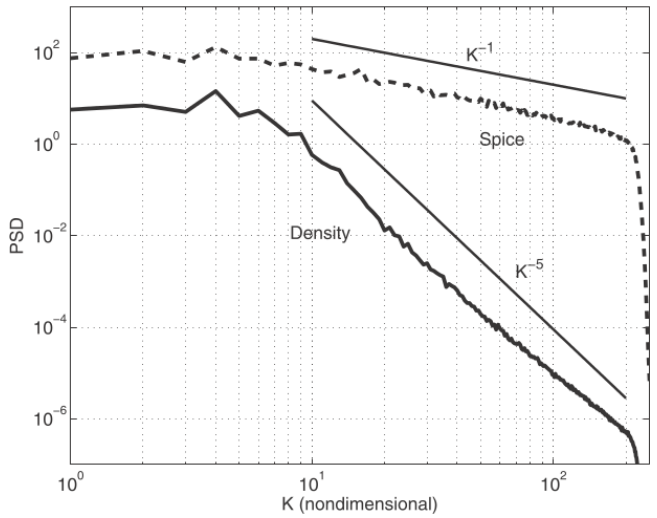
Spice as passive tracer

- Klein et JMR1998
- Smith and Ferrari JPO2009

$$\pi' = \alpha T' + \beta S'$$







Density and spice obey different dynamics
=> mixing acts very differently
(blurred in a T-S view)

My approach

$$\overline{\rho'^2} = \alpha^2 \overline{T'^2} + \beta^2 \overline{S'^2} - \underbrace{2\alpha\beta \overline{T'S'}}_{\overline{\pi'^2}}$$

If $\overline{T'S'} > 0$

Variance decomposition :

$$\overline{\rho'^2} + \overline{\pi'^2} = \alpha^2 \overline{T'^2} + \beta^2 \overline{S'^2}$$

- Measure of the variability (eddy, waves)
- Not an absolute spiceness

Methodology

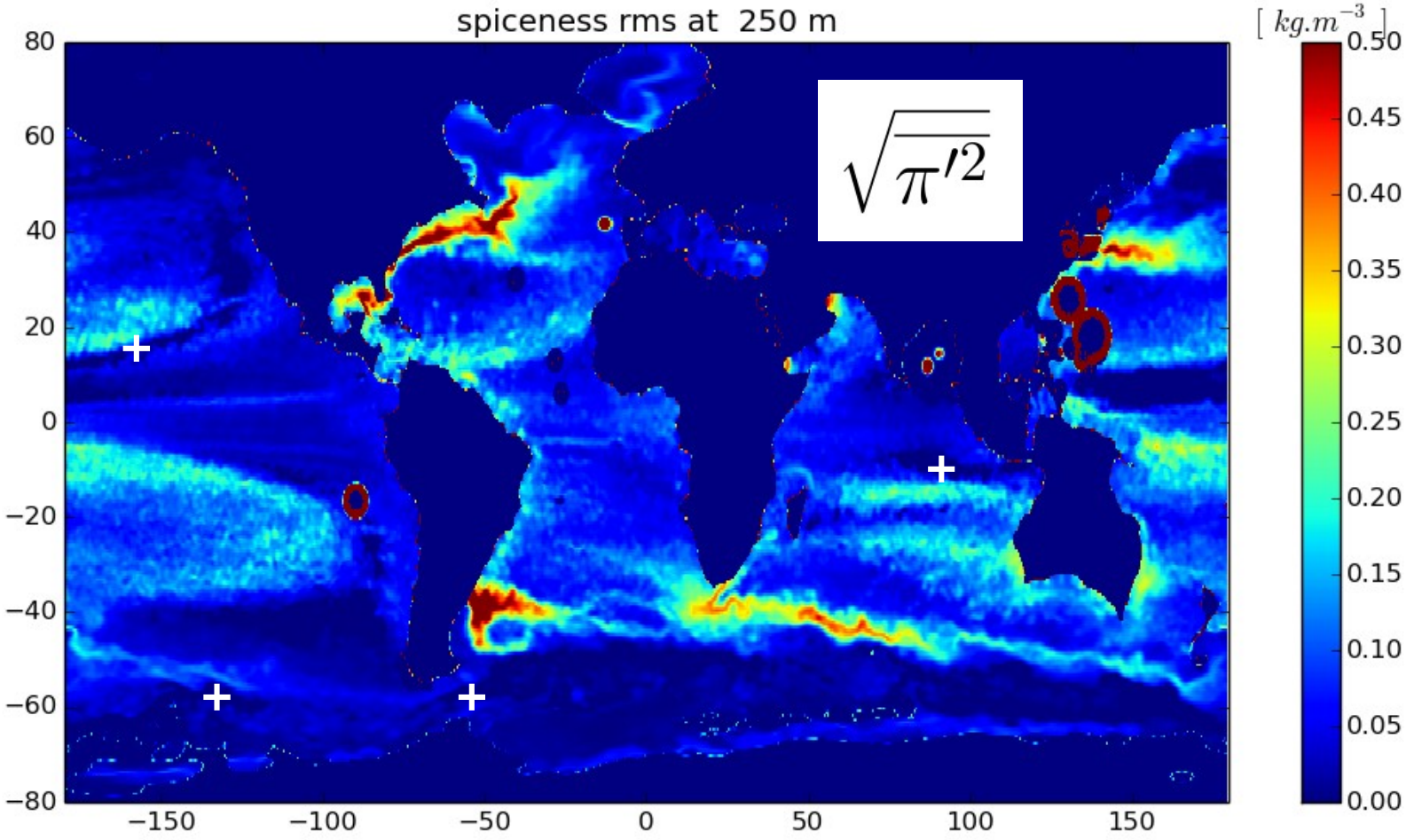
- As in Roullet et al. GRL2014
- Vertically interpolate Argo profiles at referenced z
- Define the time average operator at point **x**=(lon,lat,z) using Argo profiles at $\mathbf{x}_i$

$$\overline{[\phi]} = \frac{\sum_i w_i \phi_i}{\sum_i w_i}$$

with weight based on the spherical distance || . ||

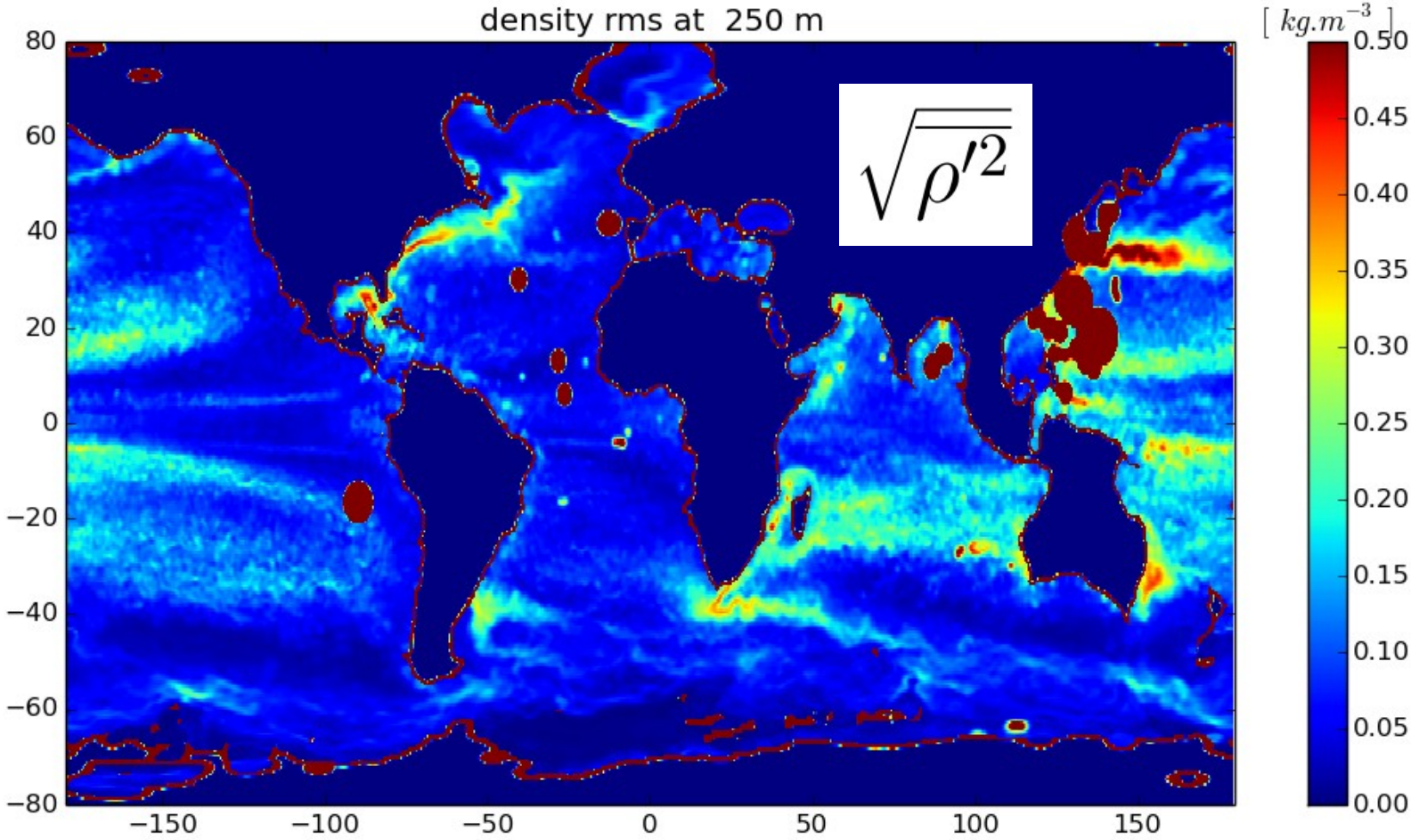
$$w_i = \exp(-||\mathbf{x} - \mathbf{x}_i||^2/(2\sigma^2))$$

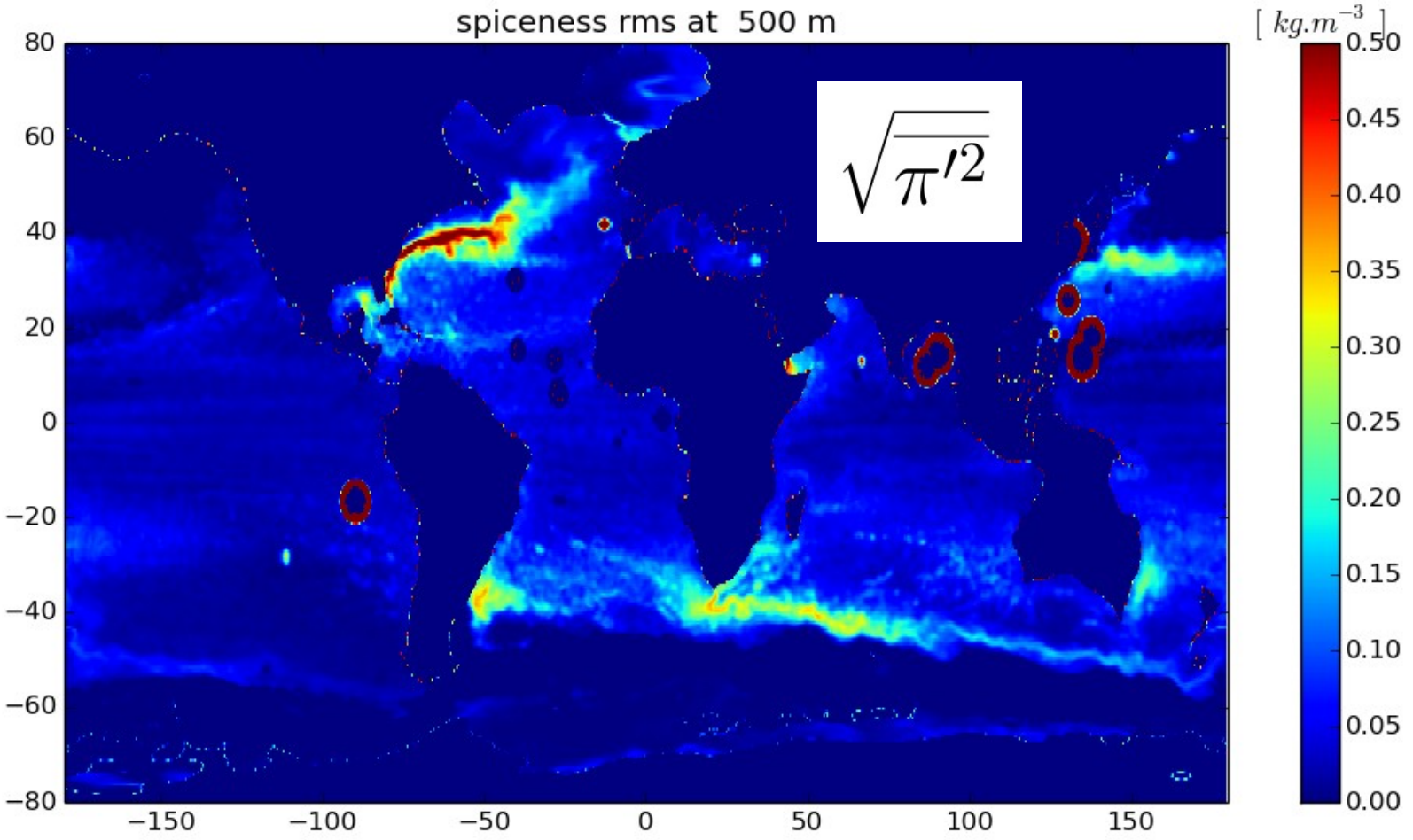
σ sets the spatial resolution of the atlas (0.5°)



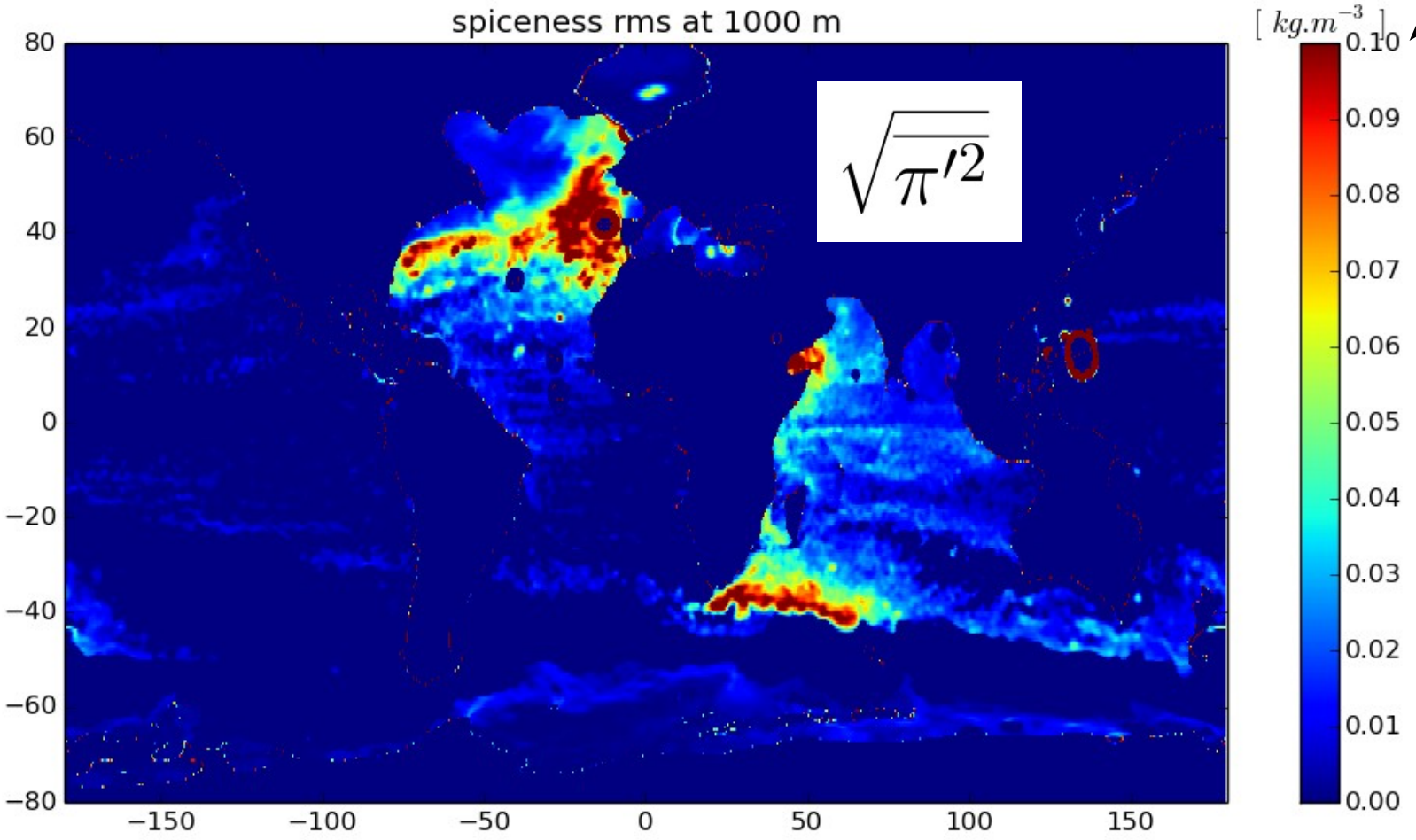
T-S correlation is remarkably positive except at some rare locations (white)

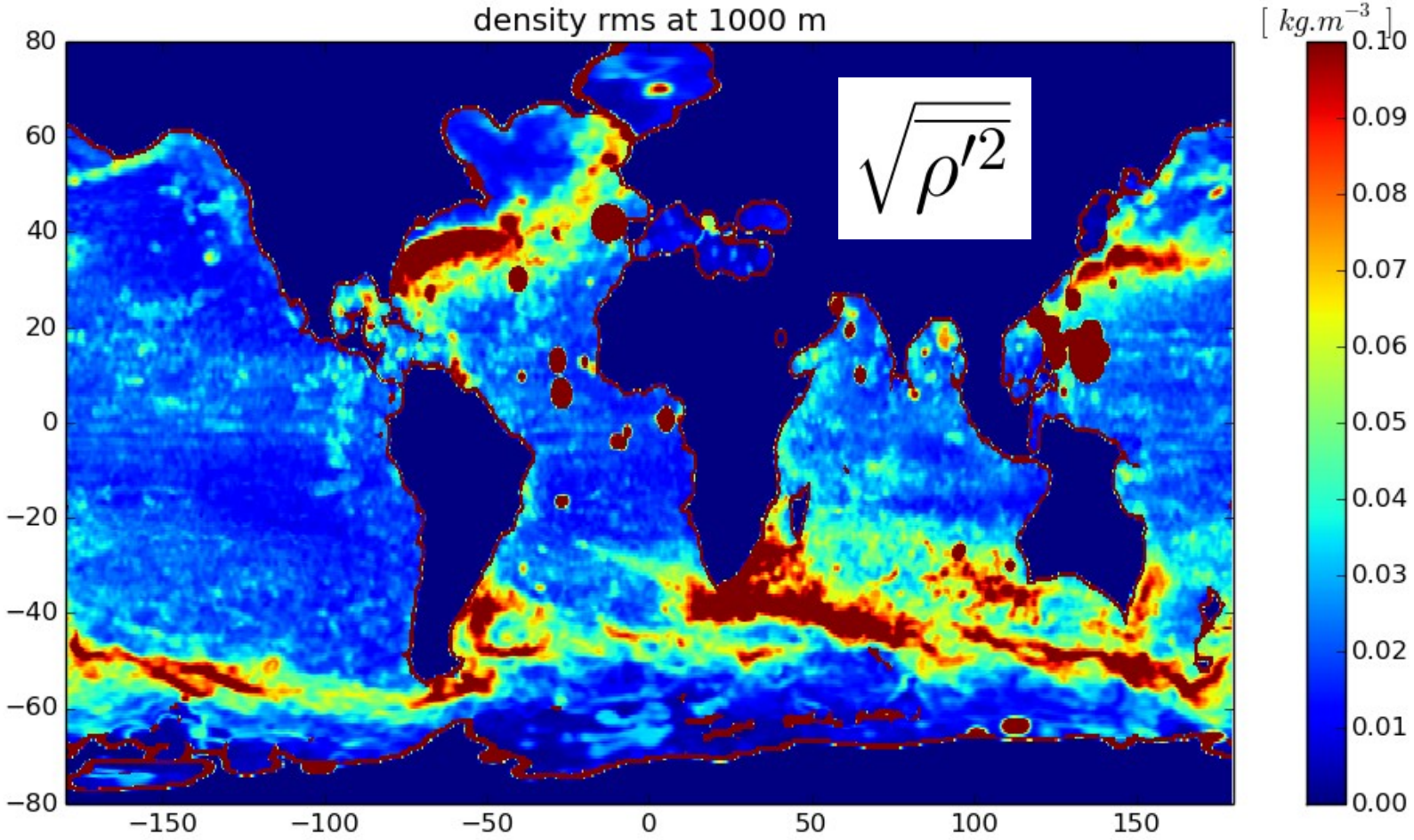
(=> $\overline{\pi'^2}$ negative)


density rms at 250 m
$\sqrt{\overline{\rho'^2}}$
[$kg.m^{-3}$]
80
60
40
20
0
−20
−40
−60
−80
−150
−100
−50
0
50
100
150
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00


spiceness rms at 500 m
$\sqrt{\overline{\pi'^2}}$
$[\ kg.m^{-3}\ ]$
80
60
40
20
0
−20
−40
−60
−80
−150
−100
−50
0
50
100
150
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00

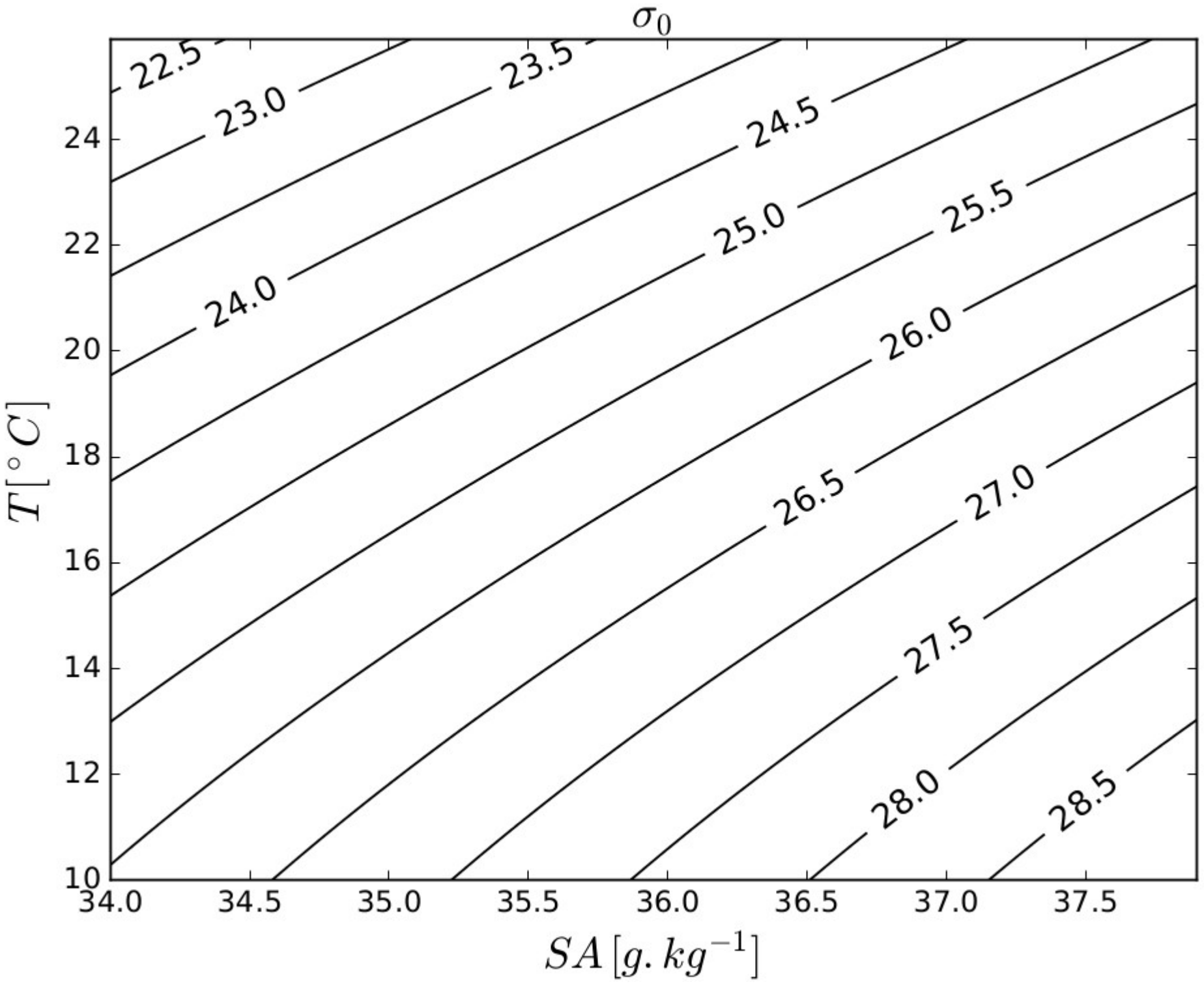
Scale is smaller




density rms at 1000 m
$\sqrt{\overline{\rho'^2}}$
[$kg.m^{-3}$]
80
60
40
20
0
−20
−40
−60
−80
−150
−100
−50
0
50
100
150
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00

Conclusion

- Geophysical signal in $\overline{\pi'^2}$, large-scale coherent features
- Smaller eddy spiceness in the Pacific
- At 1000m $\overline{\pi'^2}$ and $\overline{\rho'^2}$ have different patterns
- As is, the statistics blends iso- and vertical fluctuations: could be improved
- Applications of such atlas :
  - Validation of interior model dynamics
  - Dual interpretation of (T,S) water masses=> (rho,spice)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22
20
18
16
14
12
10
$T[^\circ C]$
34.0
34.5
35.0
35.5
36.0
36.5
37.0
37.5
$SA\,[g.\,kg^{-1}]$