

# Submesoscale Impacts on Mesoscale Agulhas Dynamics

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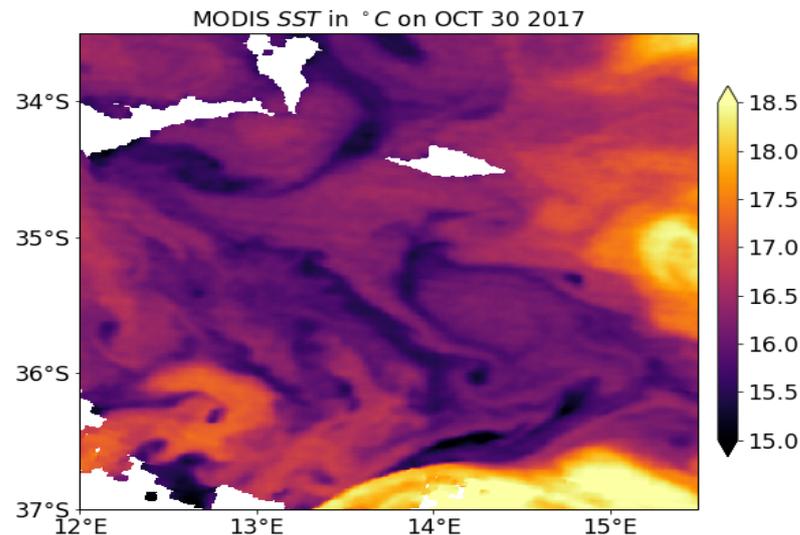
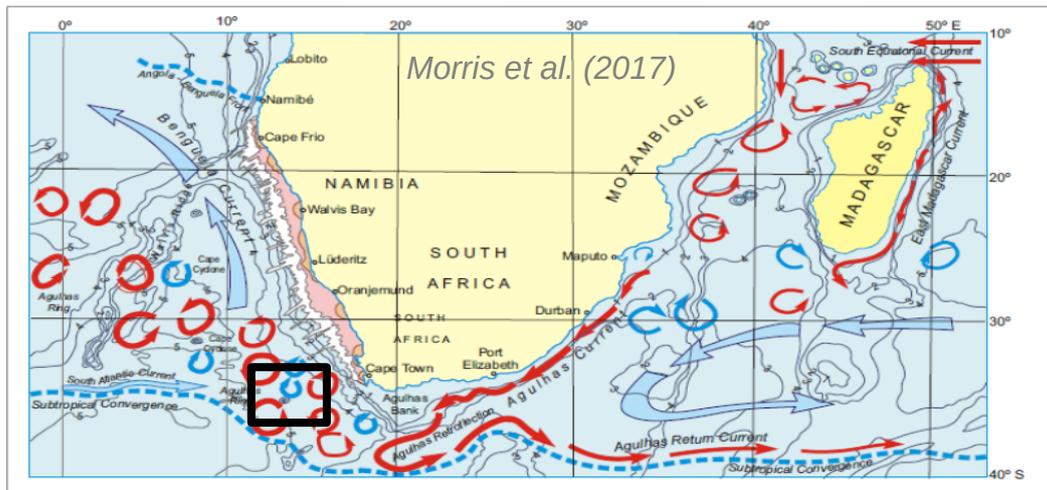
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Centre for Materials and Coastal Research



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# Which impact do Submesoscale Dynamics have on Mesoscale Agulhas Dynamics?



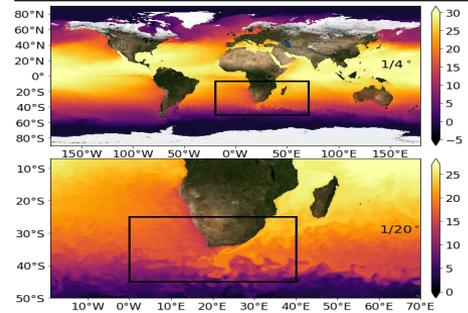
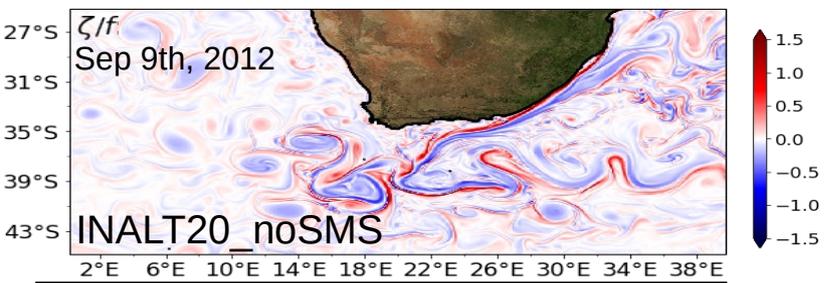
Submesoscale dynamics drive a strong lateral exchange of Agulhas rings with their surrounding. (Capuano et al. (2018), Sinha et al. (2019))

What is their impact on the dynamics of the large mesoscale eddies?



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# The Model Configurations (integrated 2010 – 2017 from the same 30 year spin-up)



$1/4^\circ$

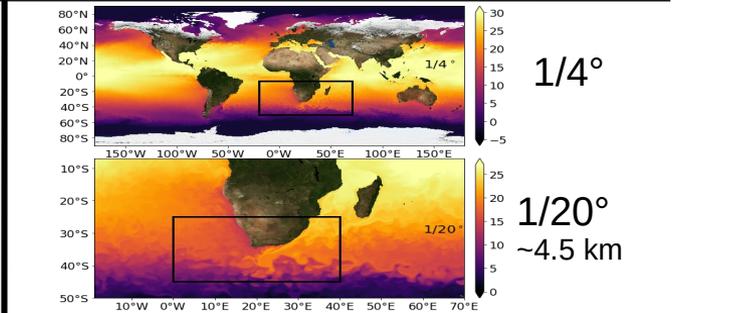
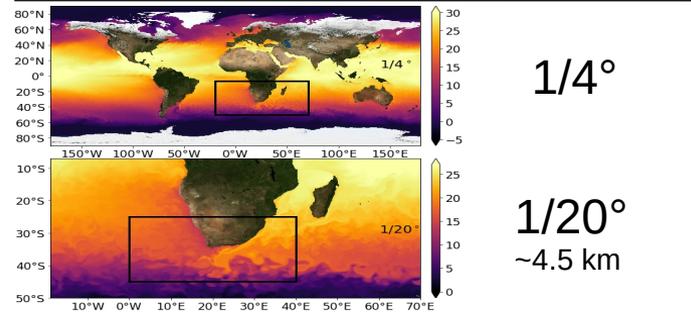
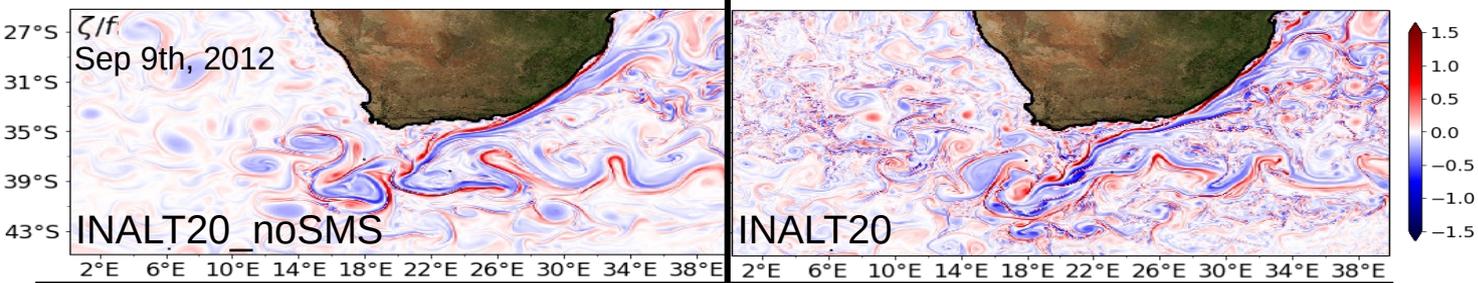
$1/20^\circ$   
~4.5 km

TVD/VI advection schemes  
+explicit diffusion



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# The Model Configurations (integrated 2010 – 2017 from the same 30 year spin-up)



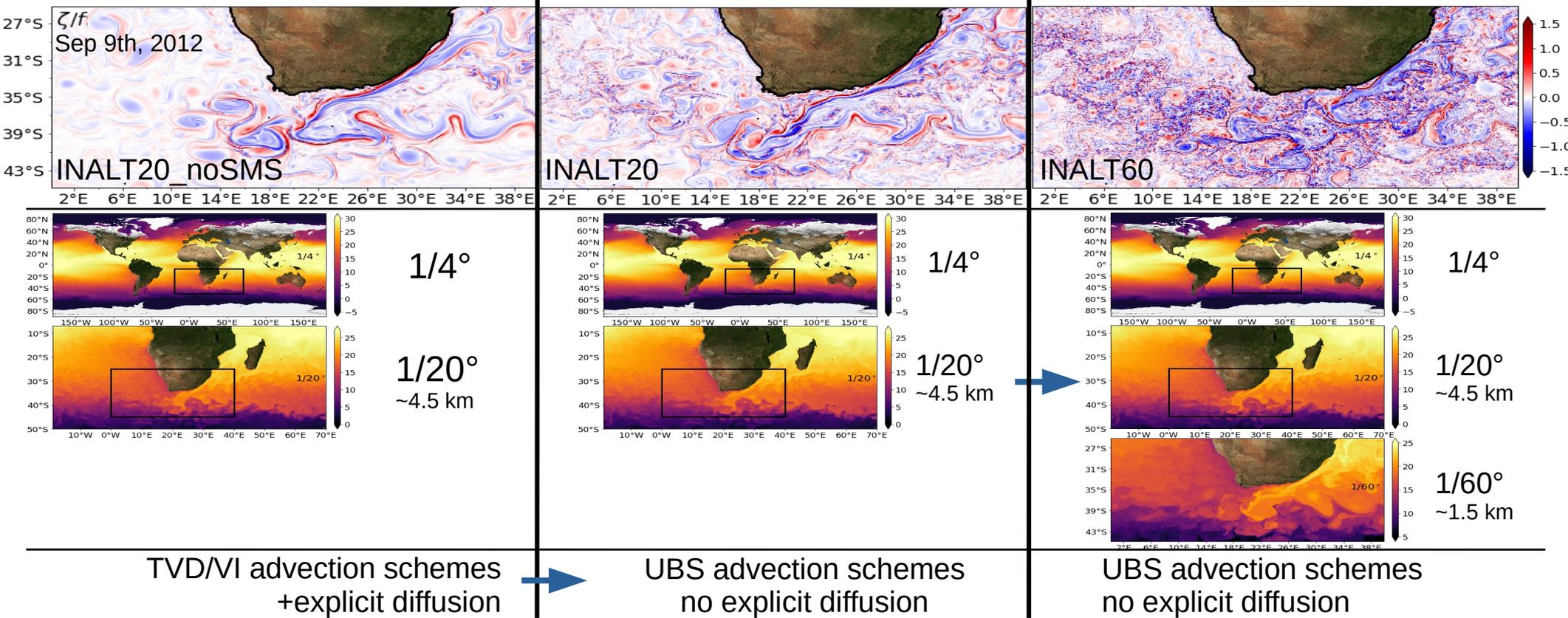
TVD/VI advection schemes  
+explicit diffusion



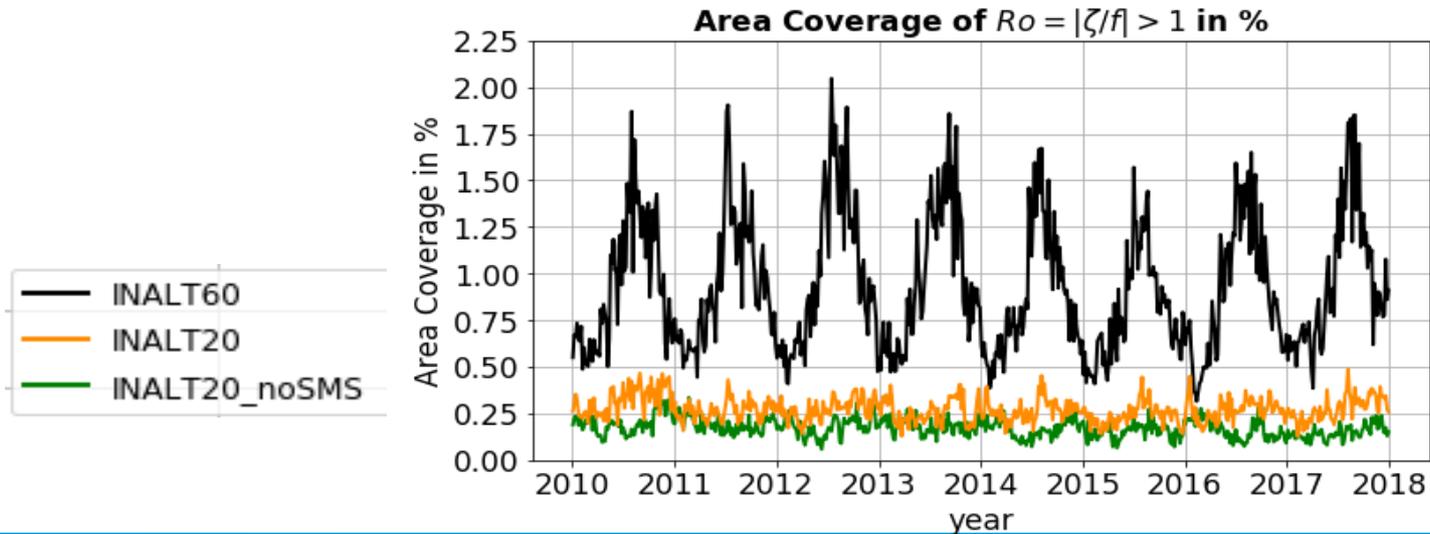
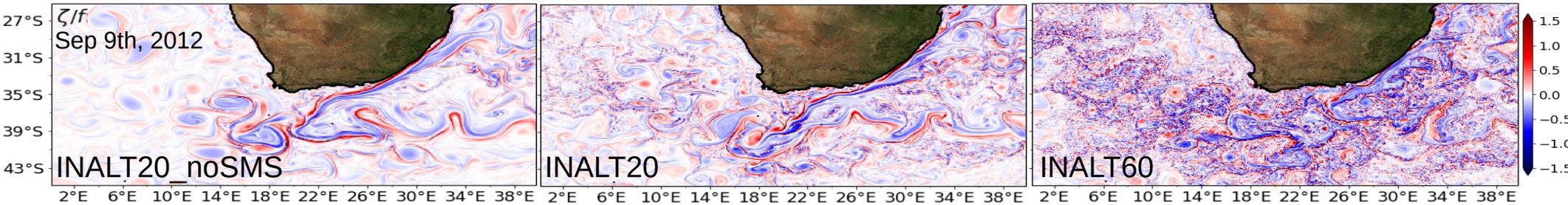
UBS advection schemes  
no explicit diffusion

# The Model Configurations

(integrated 2010 – 2017 from the same 30 year spin-up)

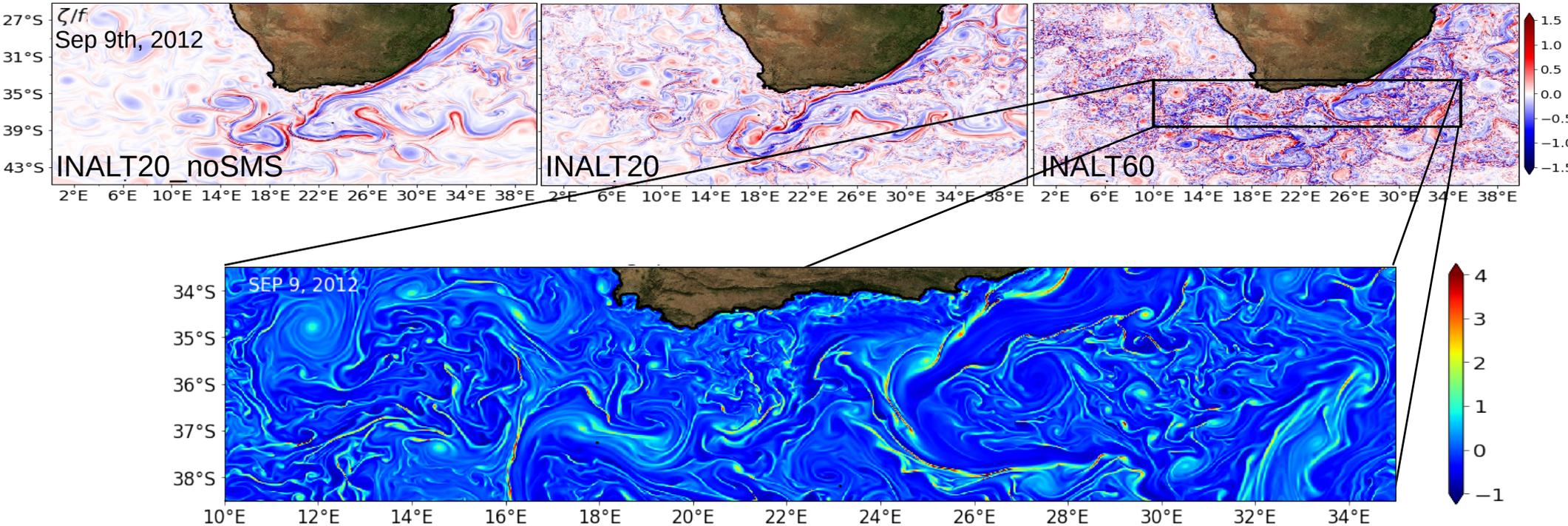


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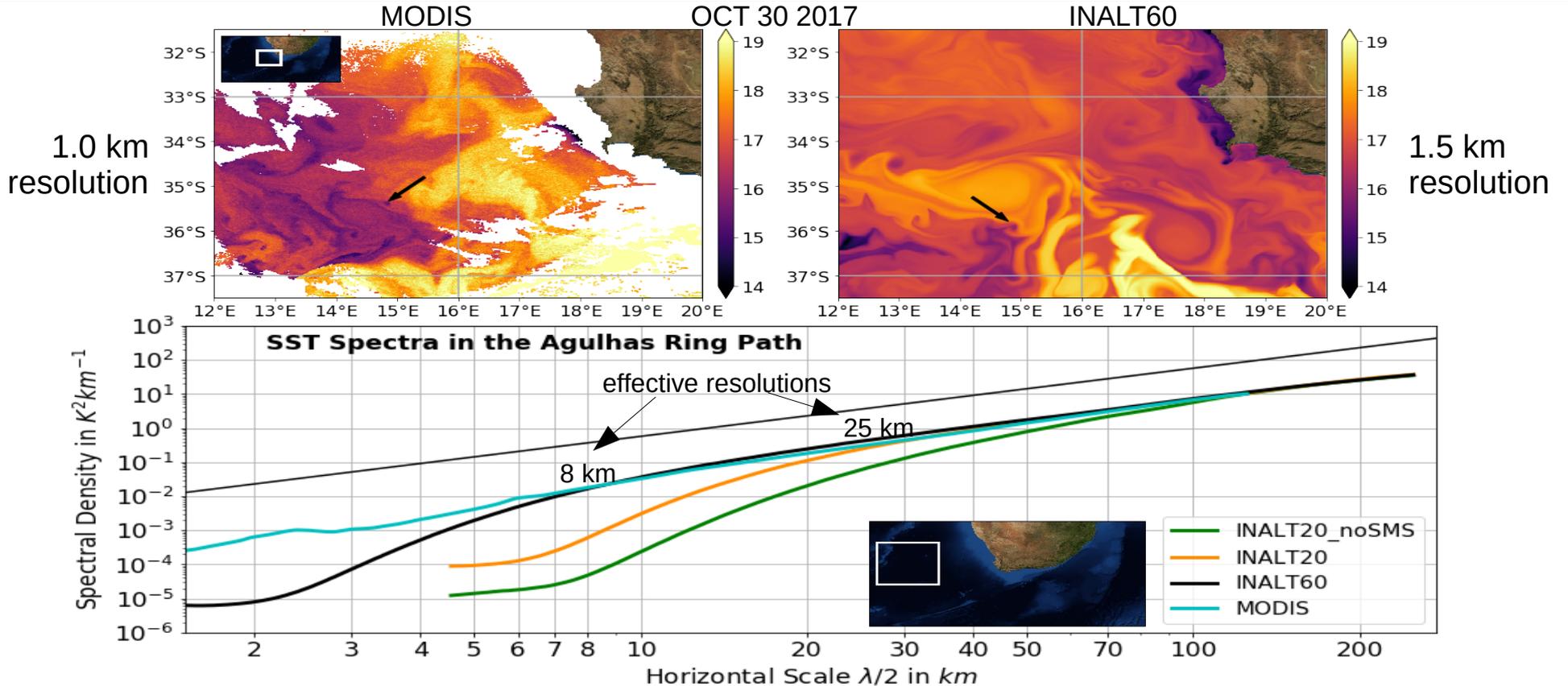
# The Model Configurations

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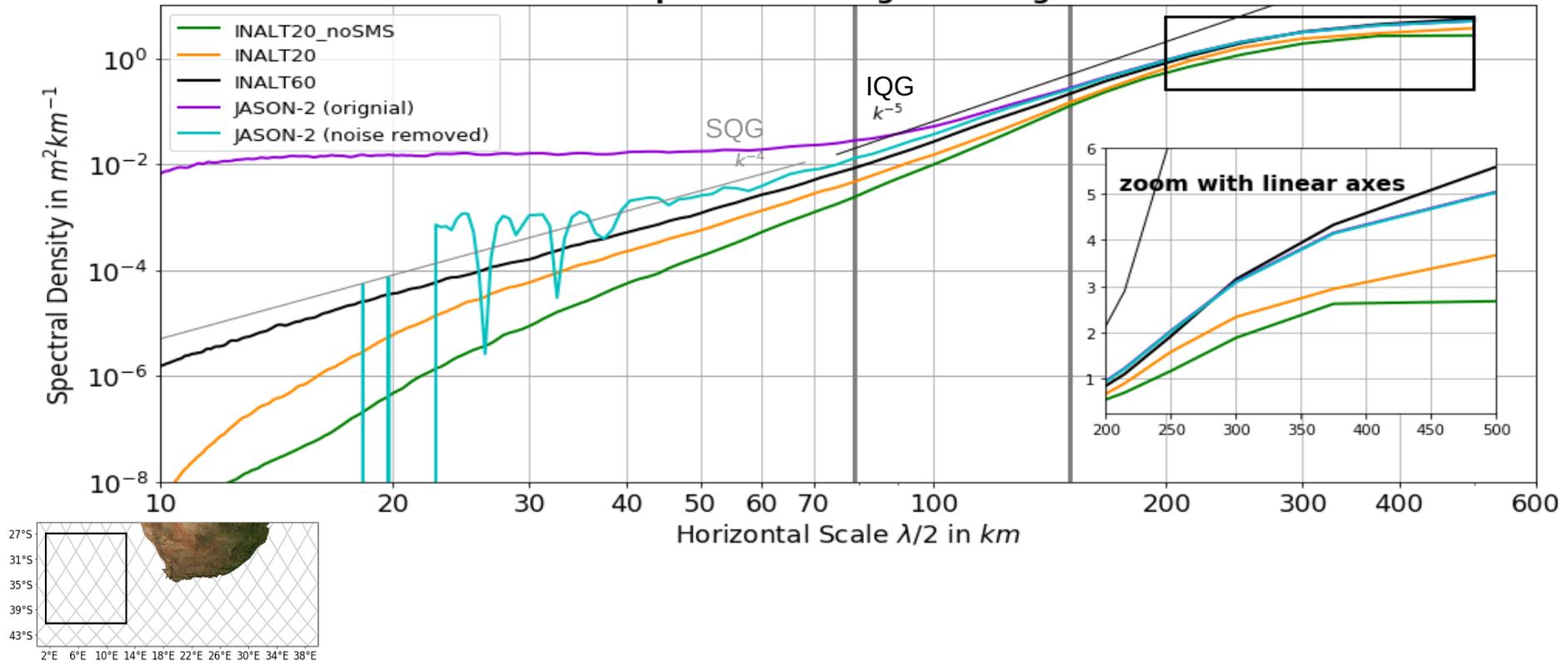
How can we validate the submesoscale dynamics?

# How can we validate the submesoscale dynamics? Time-Mean SST Spectra from MODIS Swaths!



# How can we validate the mesoscale dynamics? Time-Mean SSH Spectra from JASON-2 tracks!

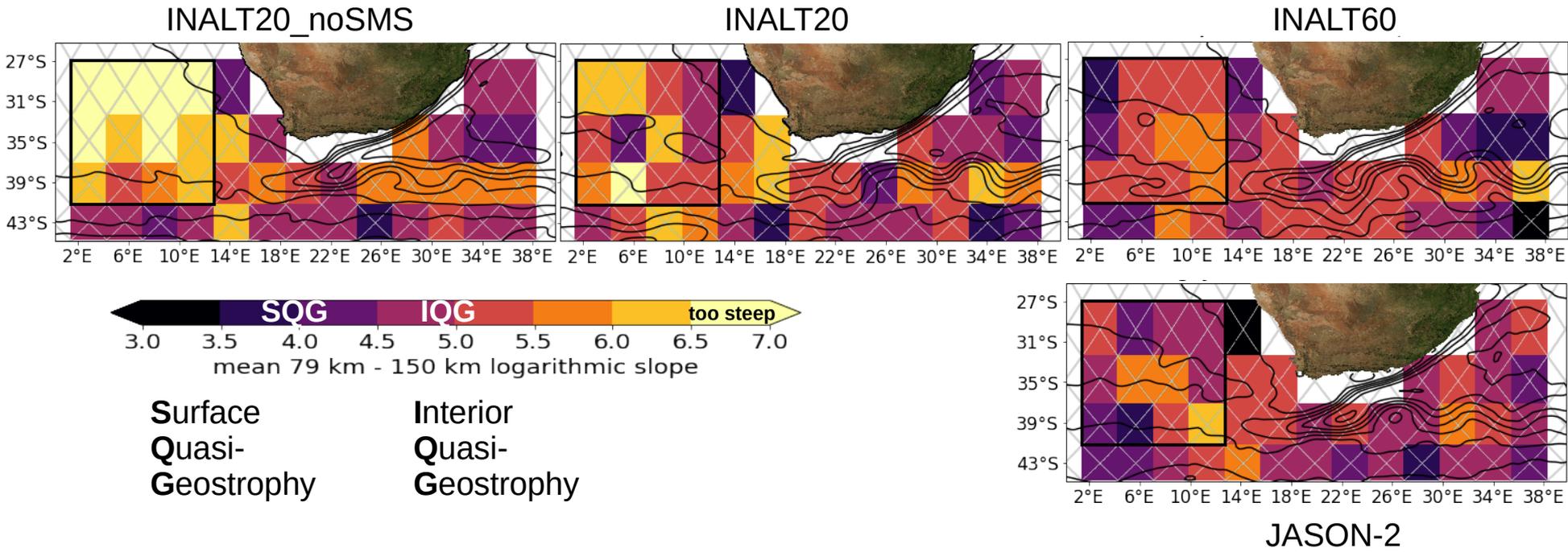
SSH Spectra in the Agulhas Ring Path



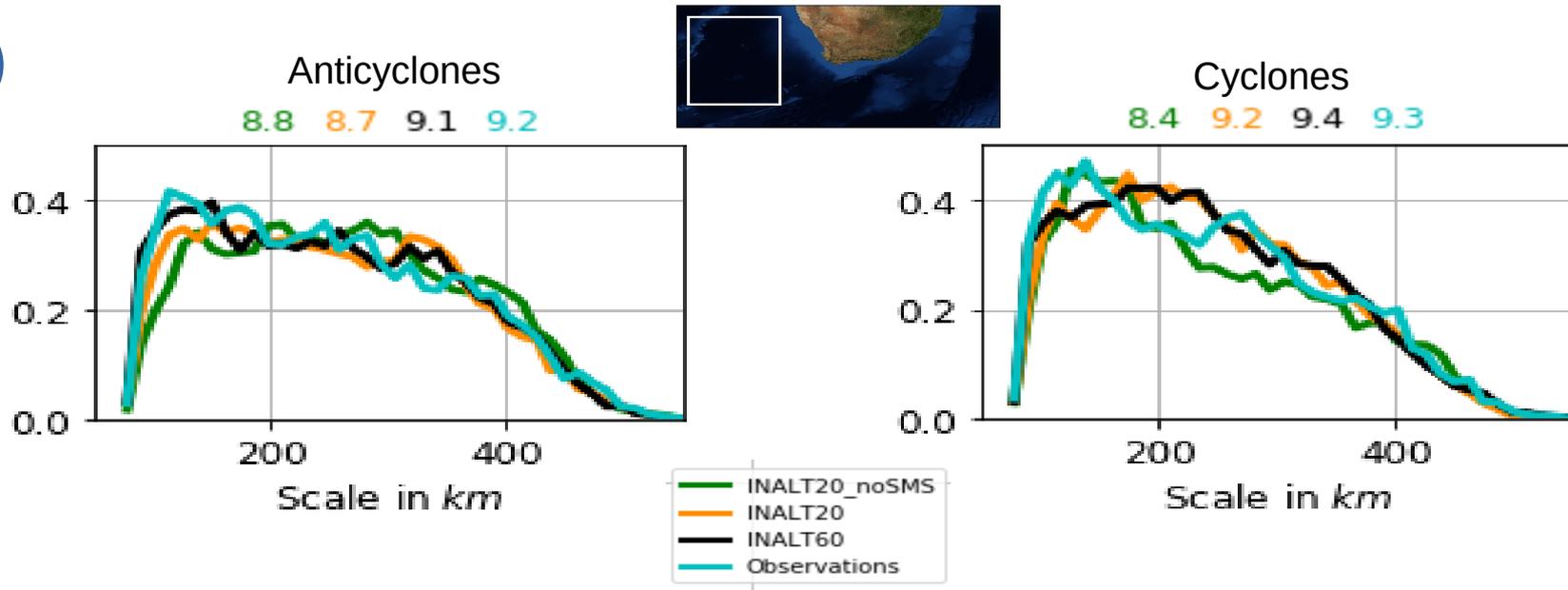
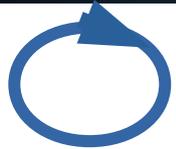
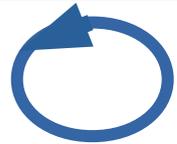


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# Time-Mean SSH Spectral Slope $n$ for $k^{-n}$ (79 – 150 km)

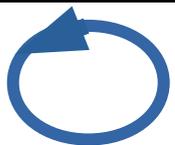


# SSH-based Eddy Detection following Chelton et al. (2011)



Scale of the eddies ~ diameter of a circle with the same area

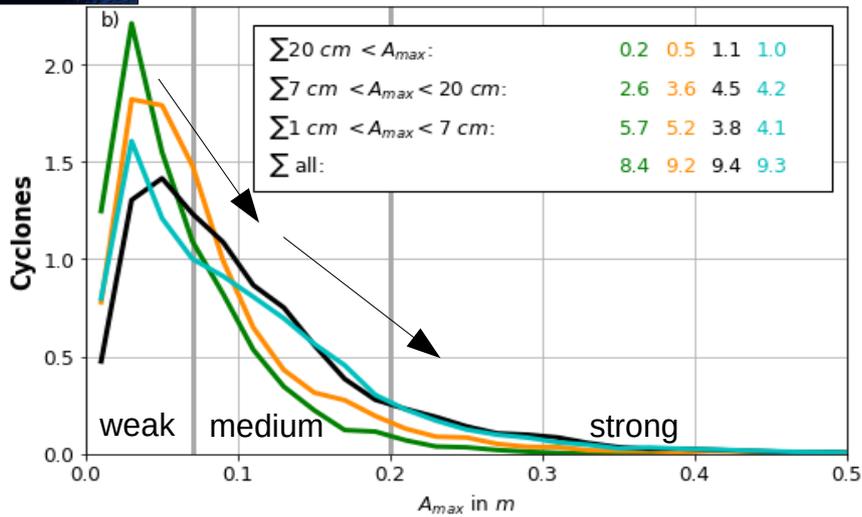
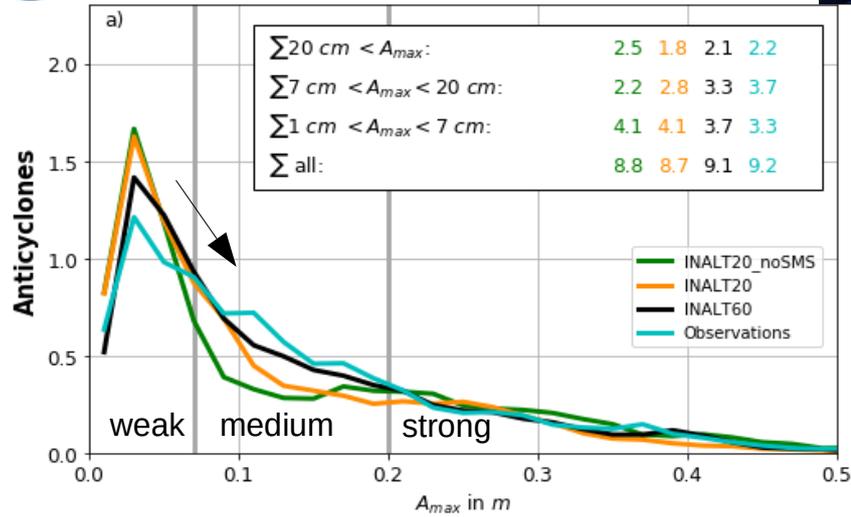
The improvements can be mainly attributed to a strengthening of the eddies



### Anticyclones



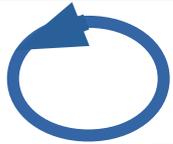
### Cyclones





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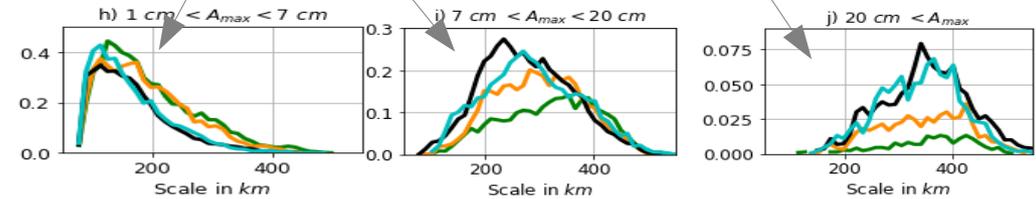
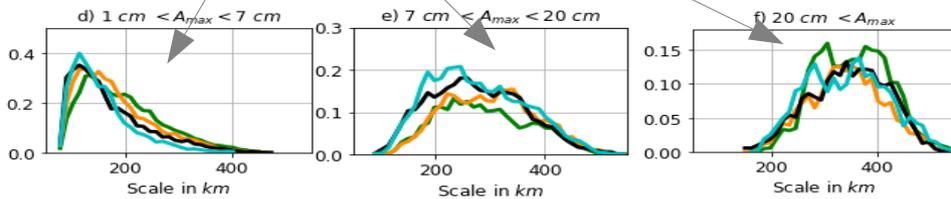
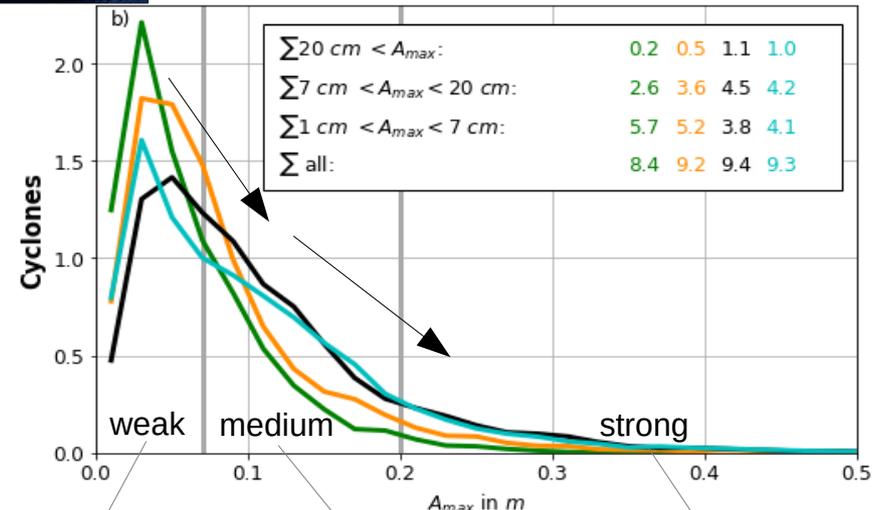
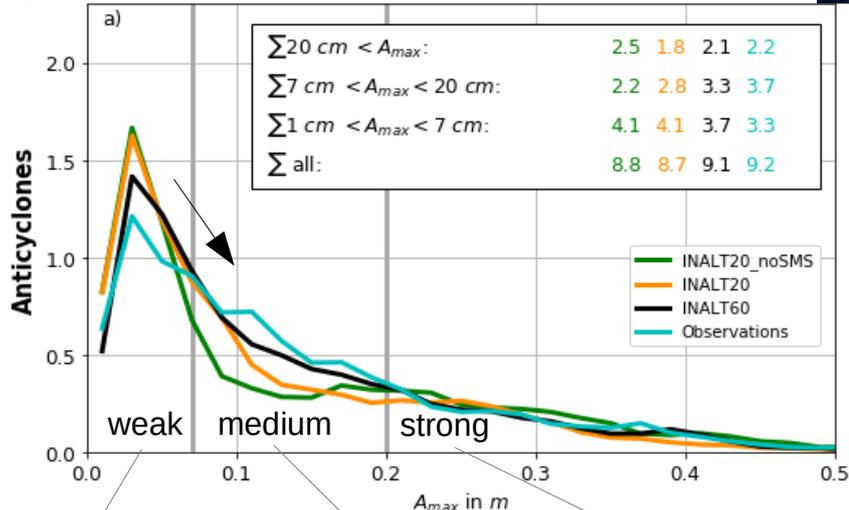
In particular large amplitude cyclones are much better represented in INALT60



### Anticyclones



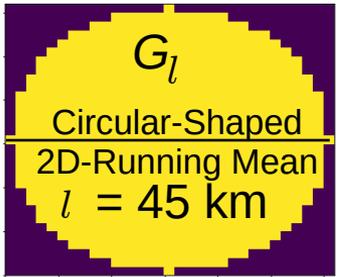
### Cyclones



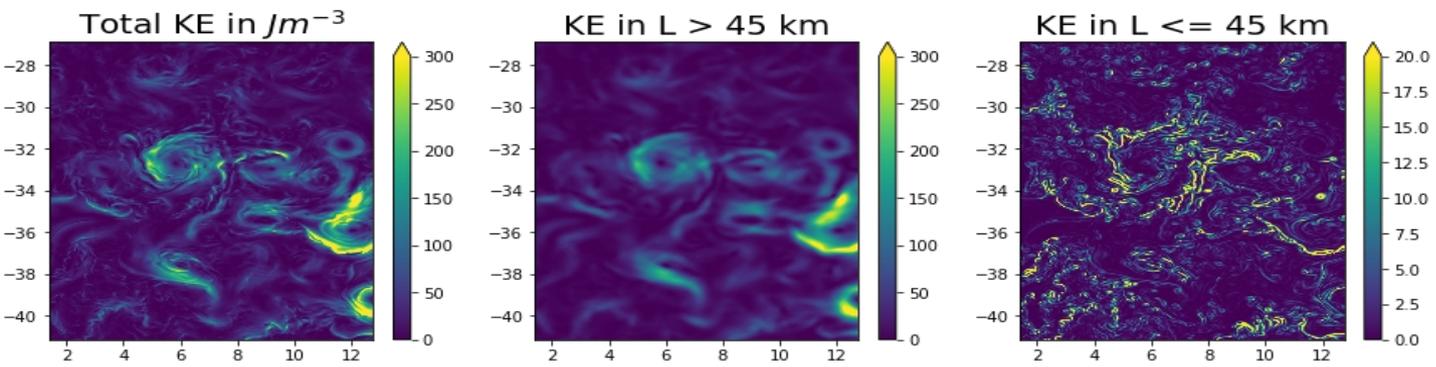
# Scale Energy Transfer – The Coarse-Graining Approach

Spatially Filtering  
the Navier-Stokes Equations

$$\bar{f}_\ell(\mathbf{x}) = G_\ell * f$$
$$f'_\ell(\mathbf{x}) = f(\mathbf{x}) - \bar{f}_\ell(\mathbf{x})$$



Leonard (1974), Germano (1992)  
Eyink & Aluie (2009)  
Aluie et al. (2018)

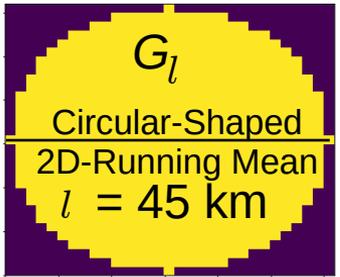


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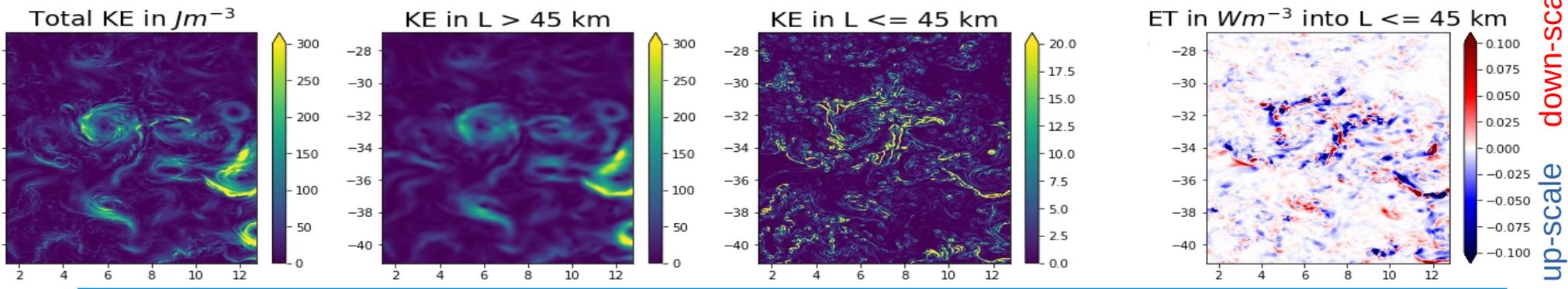


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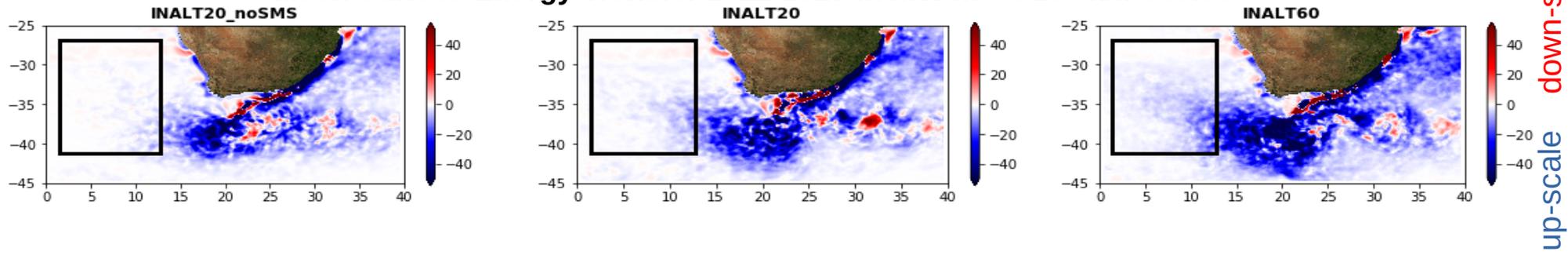
→ KE Budget for Scales  $> l$   
→ Scale Energy Transfer

$$ET(\mathbf{x}, t, l) = -\rho_0 [\bar{u}_x(\bar{u}^2 - \bar{u}^2) + (\bar{u}_y + \bar{v}_x)(\bar{u}\bar{v} - \bar{u}\bar{v}) + \bar{v}_y(\bar{v}^2 - \bar{v}^2)]$$



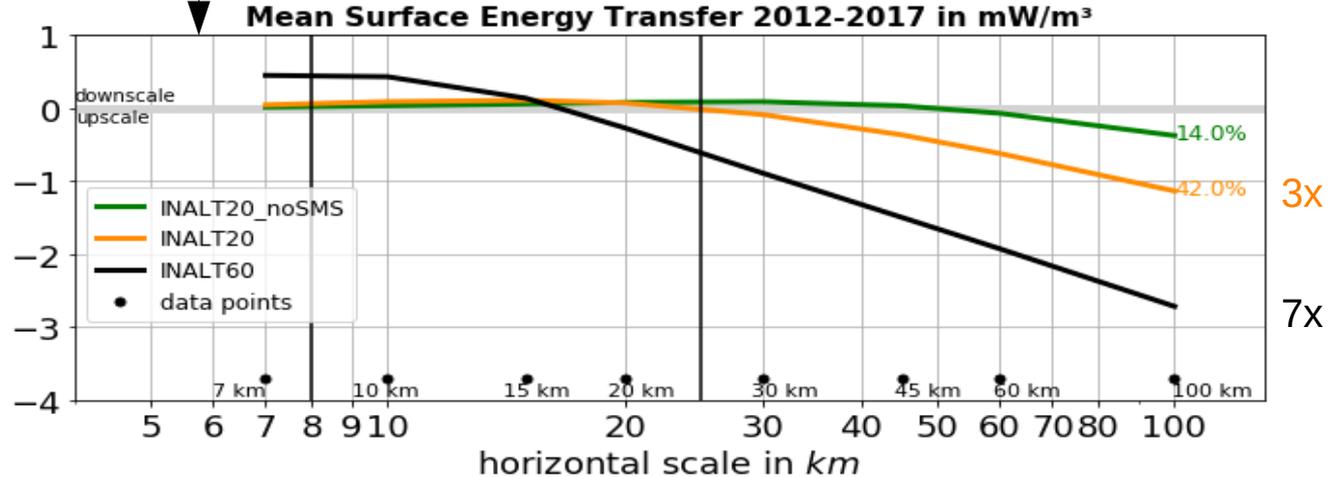
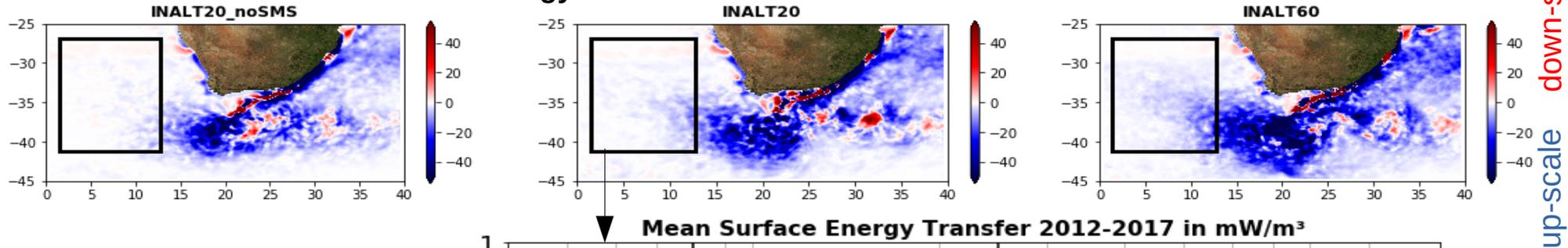
# Seven times more kinetic energy transfer into the mesoscales

### Mean Surface Energy Transfer 2012-2017 in $\text{mW/m}^3$ at 100 km Scales

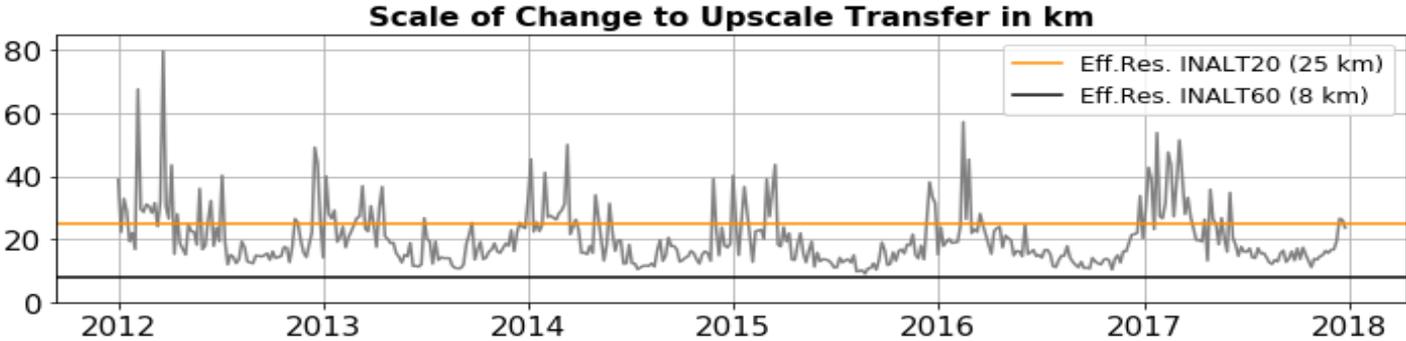
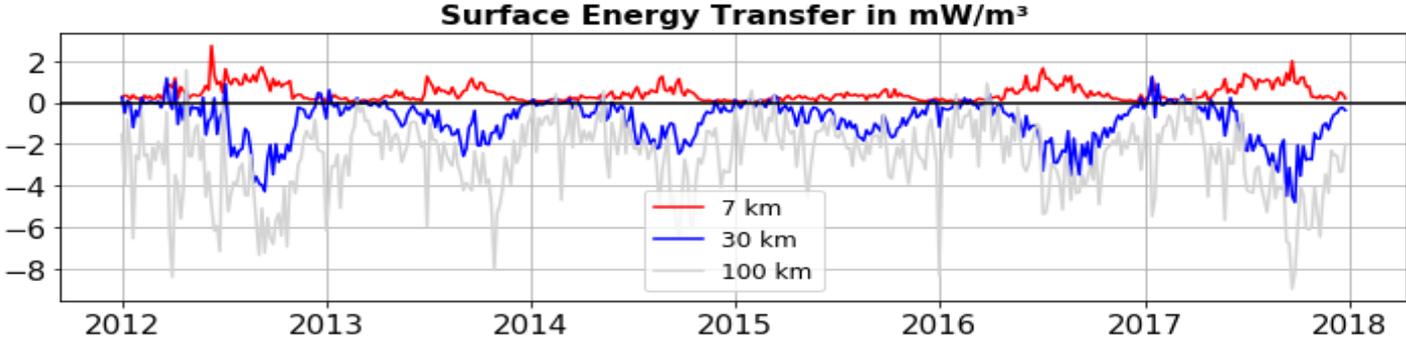


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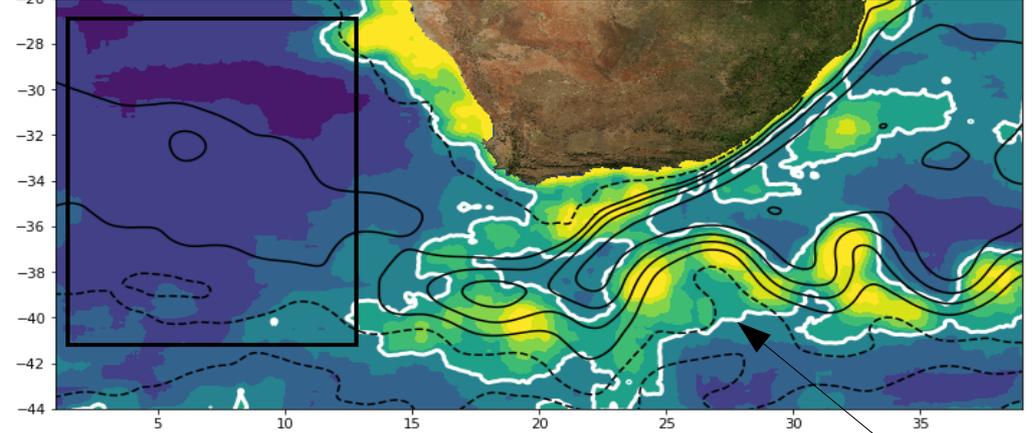
# Seasonality of the energy transfer and its scale of change to upscale transfer



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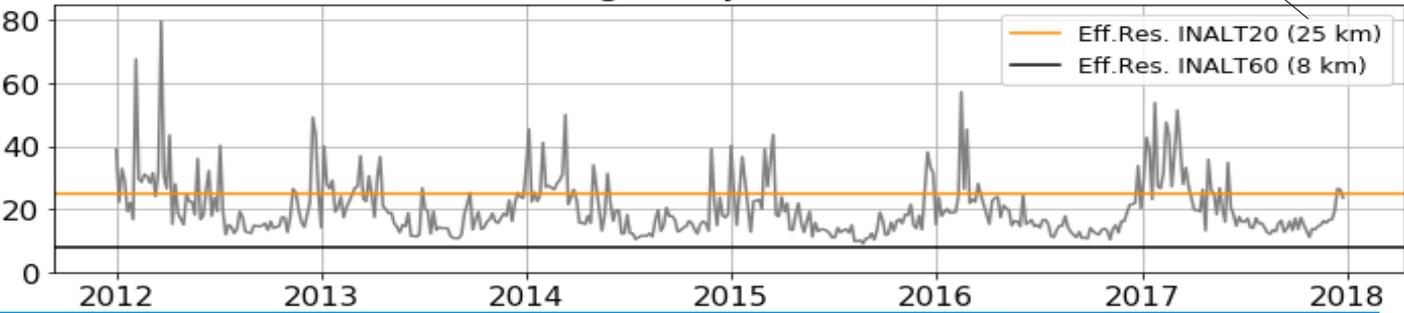
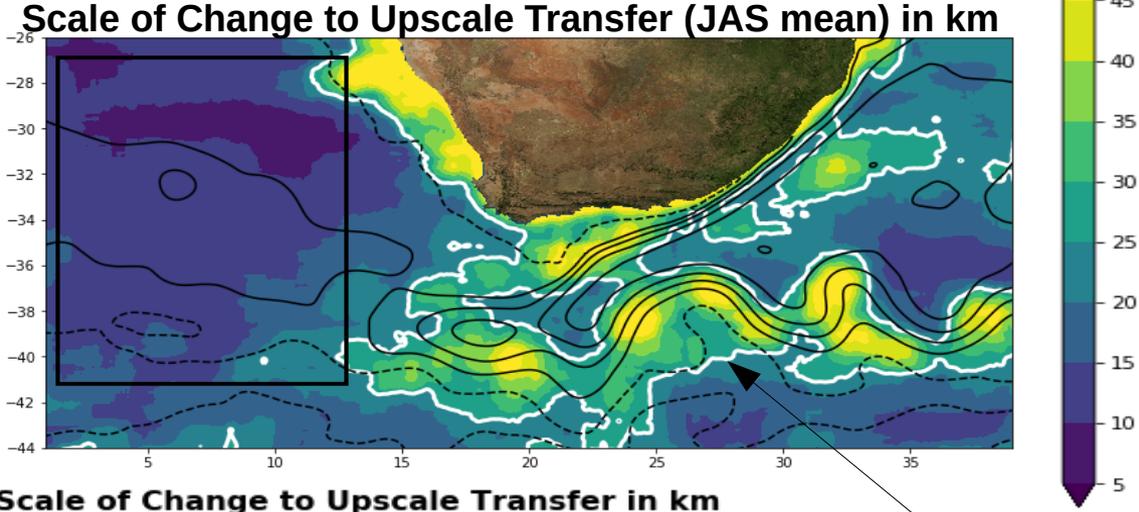
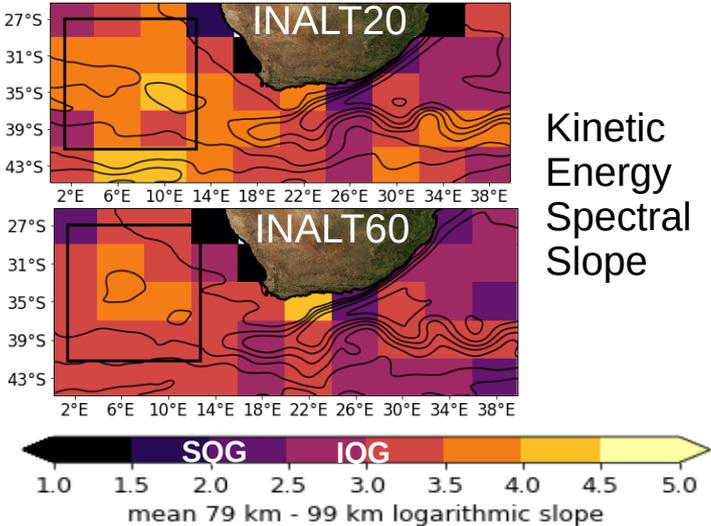
### Scale of Change to Upscale Transfer (JAS mean) in km



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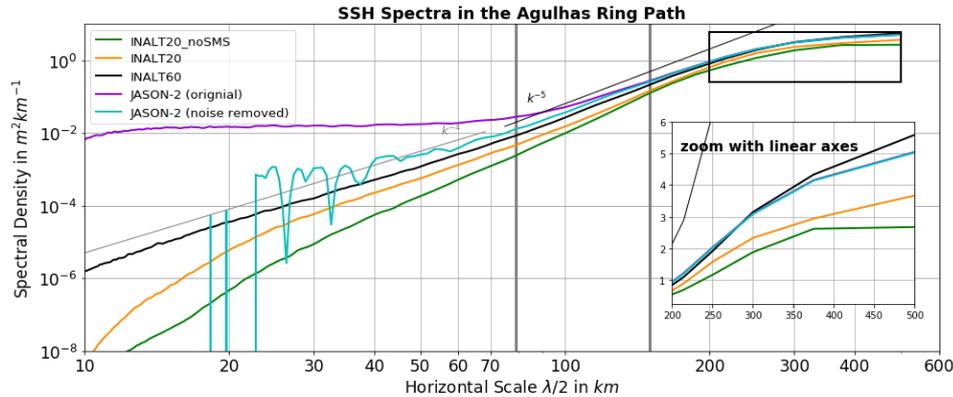


# Seasonality of the energy transfer and its scale of change to upscale transfer

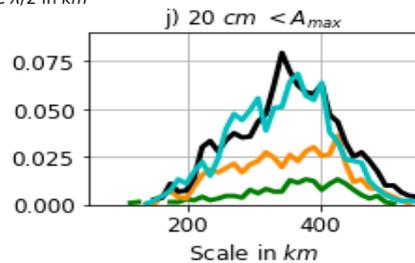


# Conclusion

The representation of mesoscale eddies in the Agulhas ring path improves strongly with the resolution of submesoscale flows -



Mesoscale eddies are found to strengthen - in particular the cyclones.

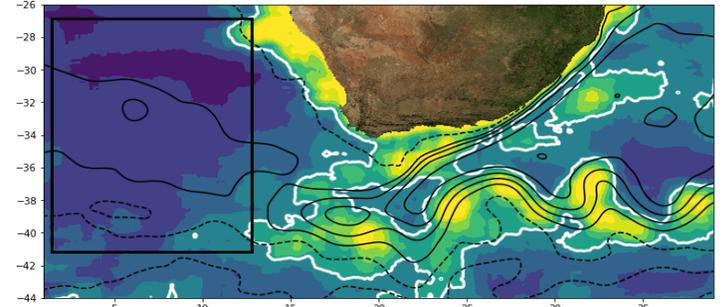
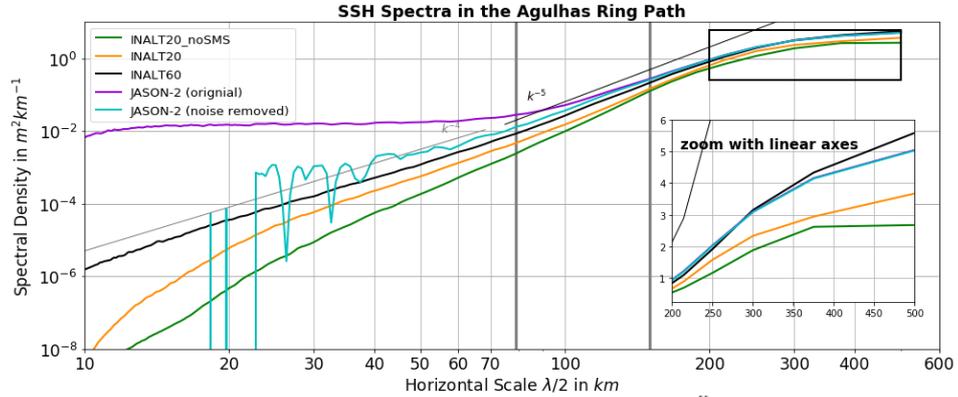


*Submesoscale Impacts on Mesoscale Agulhas Dynamics*  
Ocean Modelling, soon

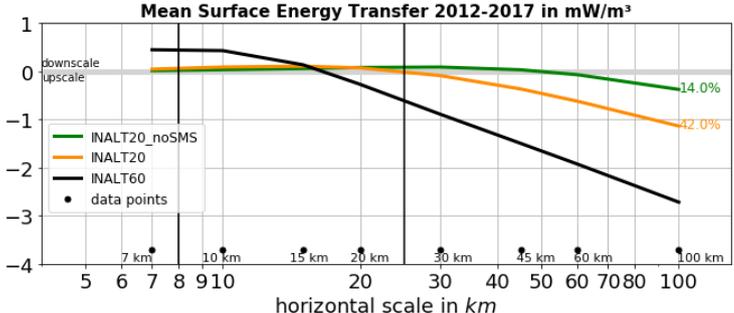
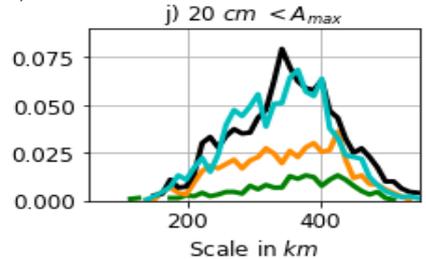
# Conclusion

The representation of mesoscale eddies in the Agulhas ring path improves strongly with the resolution of submesoscale flows -

The gap to the observations might be closed due to the full resolution of the upscale energy cascade.



Mesoscale eddies are found to strengthen - in particular the cyclones.



*Submesoscale Impacts on Mesoscale Agulhas Dynamics*  
Ocean Modelling, soon

*Scale Energy Transfer in the Greater Agulhas region*  
in preparation