Influence of mesoscale on larger scales mean state and variability and other layman thoughts...

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- **informal** > please interrupt me for questions
- main interest : **mechanisms of multidecadal variability in the North Atlantic**

> I will not address the points raised by Patrice in his program, but

1. sensitivity of ocean models to surface forcing and other parameters
2. sensitivity of ocean models to horizontal resolution in the 1°-1/10° range

Caution

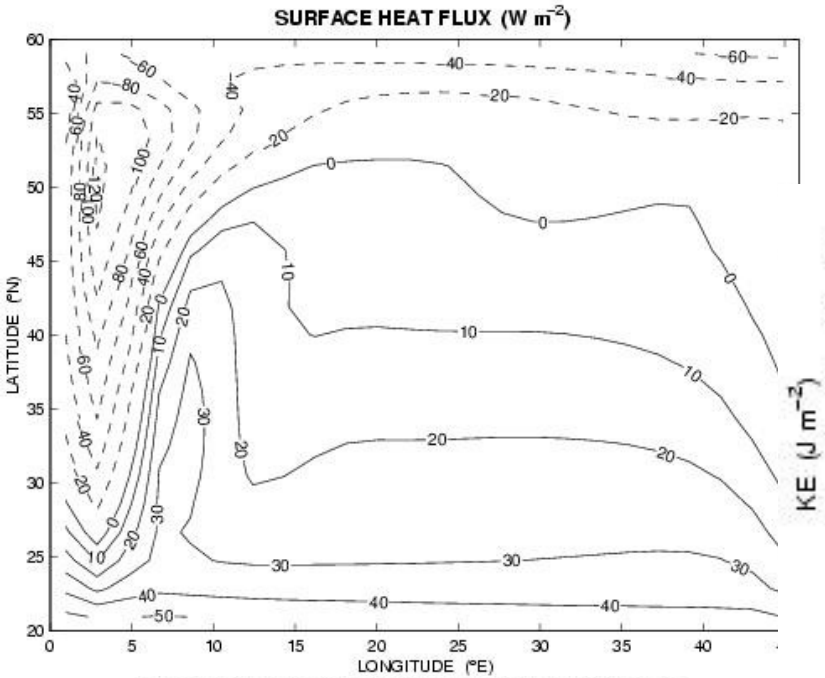
We have mostly worked in **idealized settings** ("GFD" approach) meaning rectangular geometry, flat bottom, constant surface forcing, so our conclusions may not apply to the real ocean... maybe it gives some hints for more complex and realistic simulations... maybe !

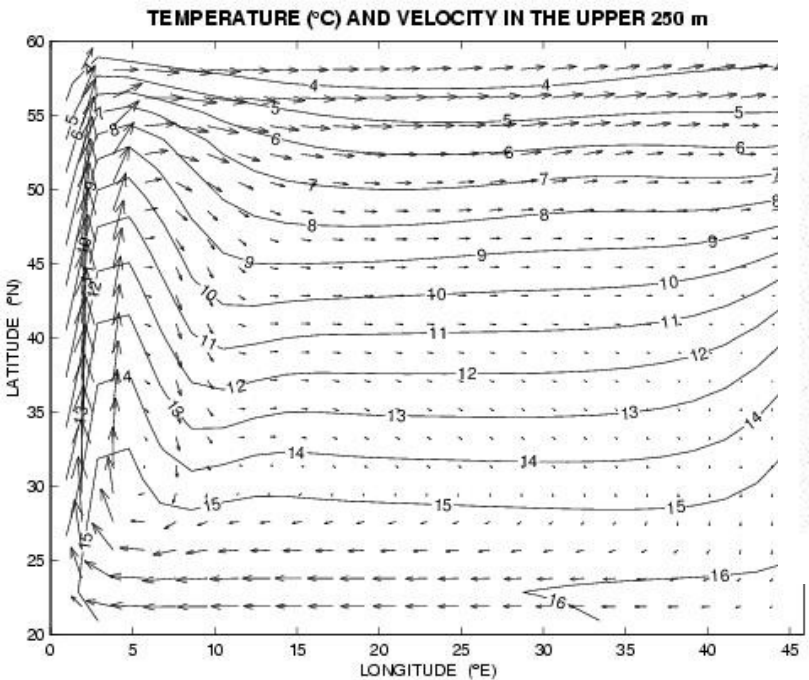
‘Essentially, all models are wrong, but some are useful’

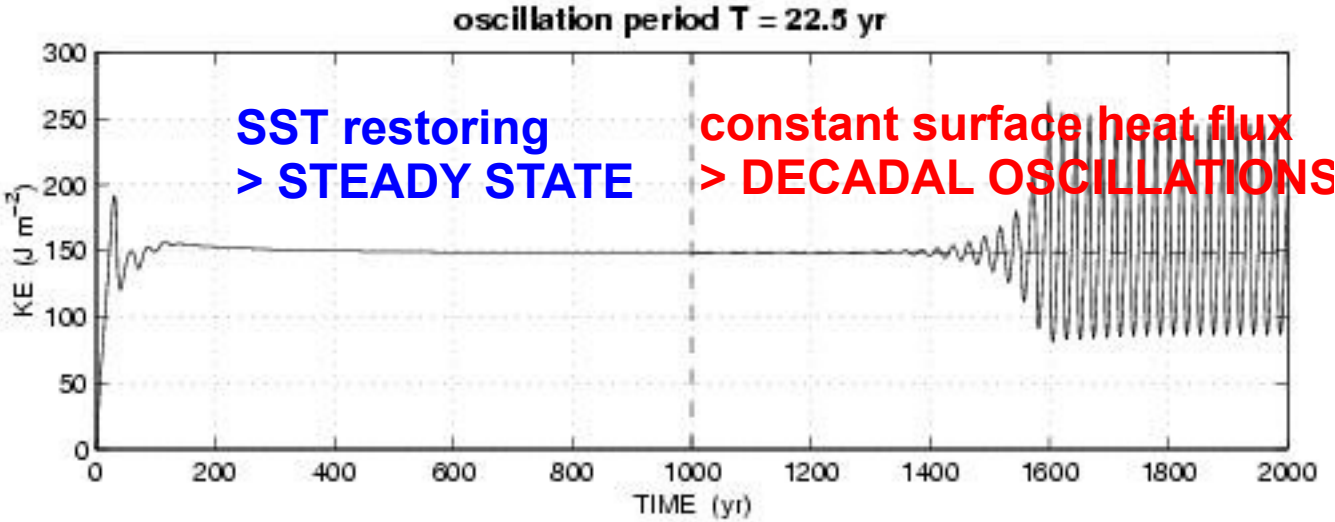
George E. P. Box (1919 – 2013), statistician

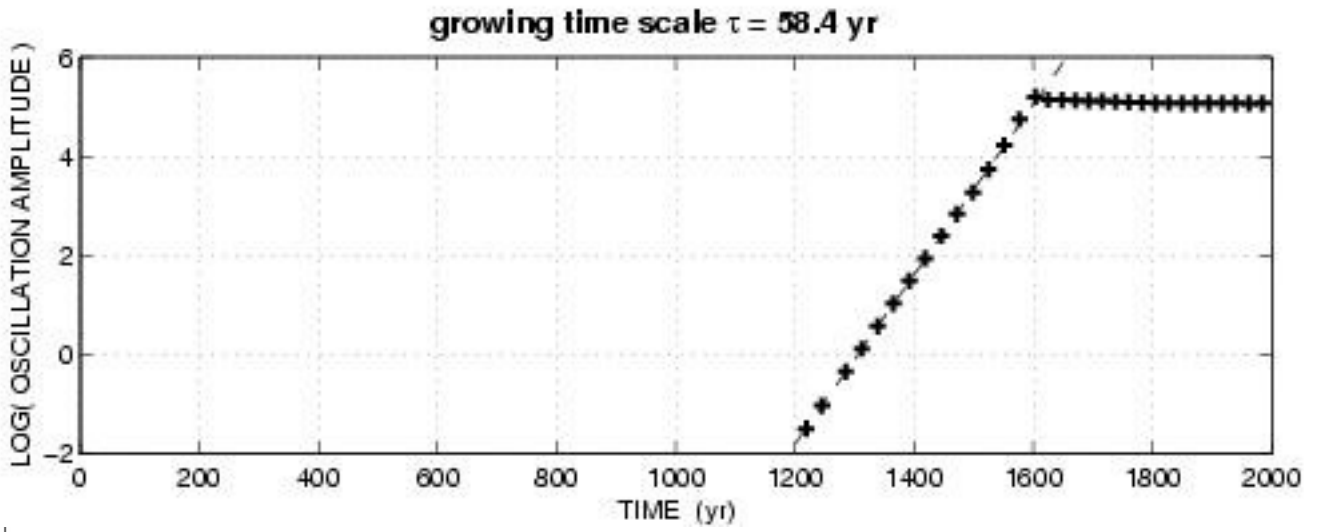
1. Sensitivity of ocean models to surface forcing

res.1°,T only, no wind, surface temp. forcing: restoring>flux



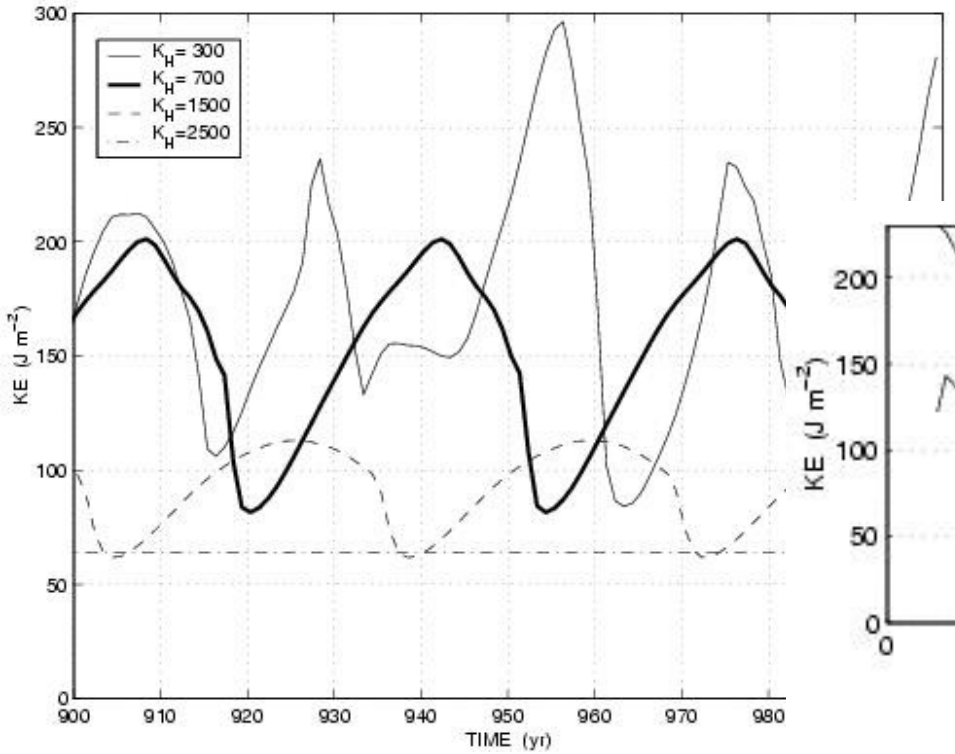


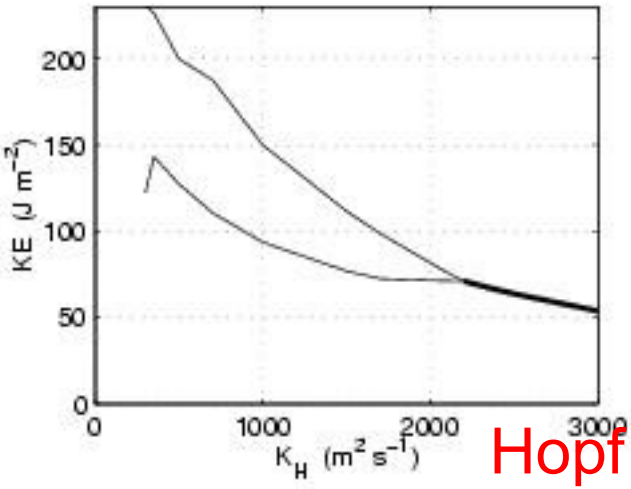


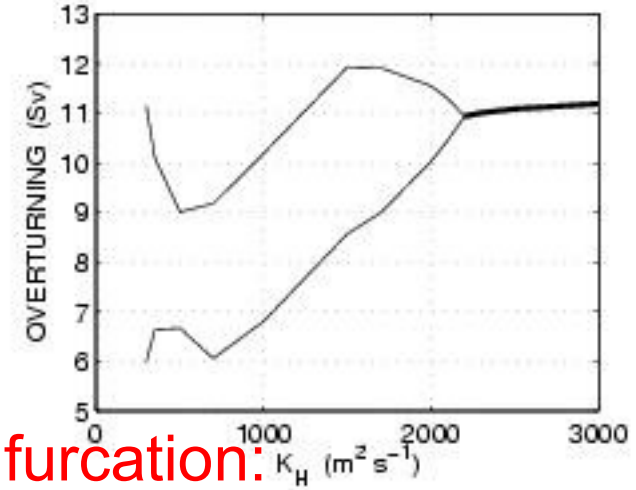


Huck&Vallis2001Tellus

1. Sensitivity of ocean models to surface forcing **and other parameters...** "dynamical system theory"

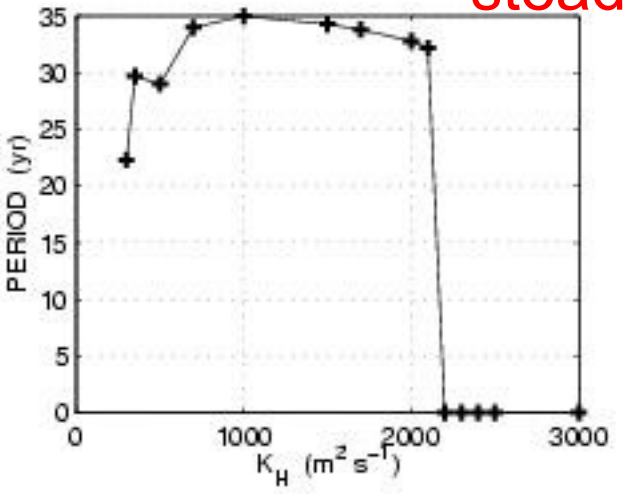


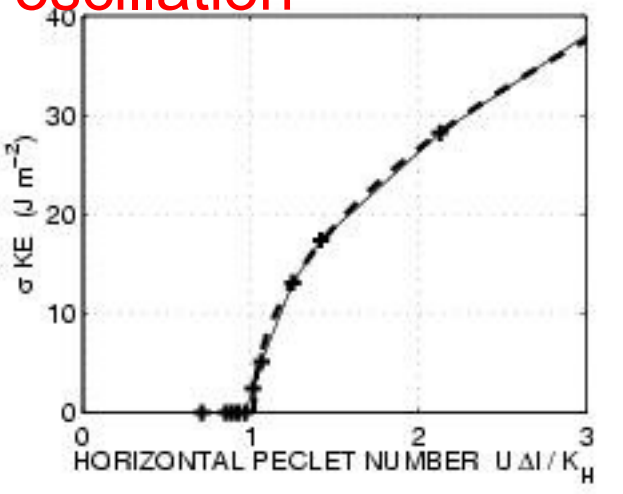




Hopf bifurcation: steady>oscillation

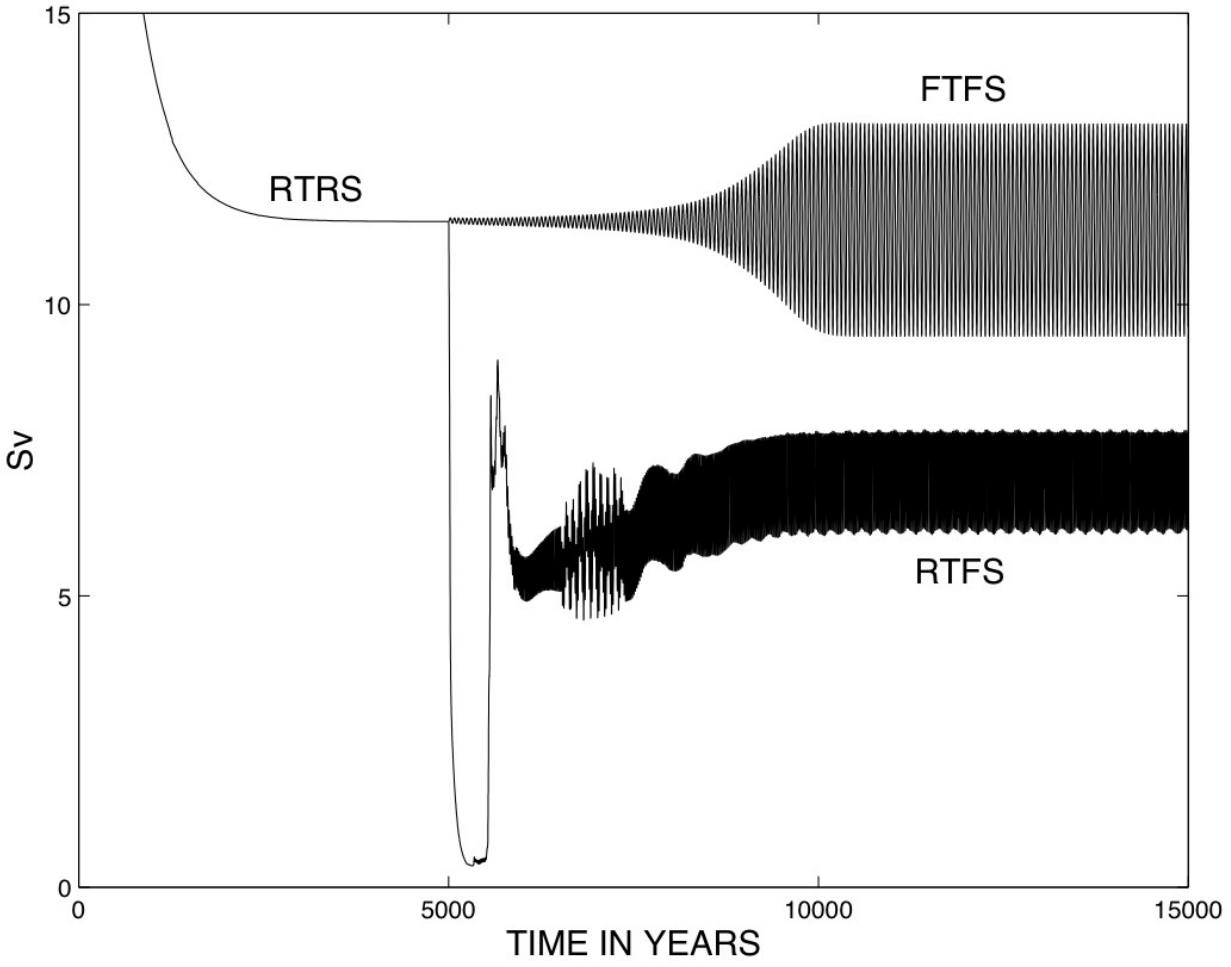
bifurcation diagrams: how do you know where you are in parameter space?

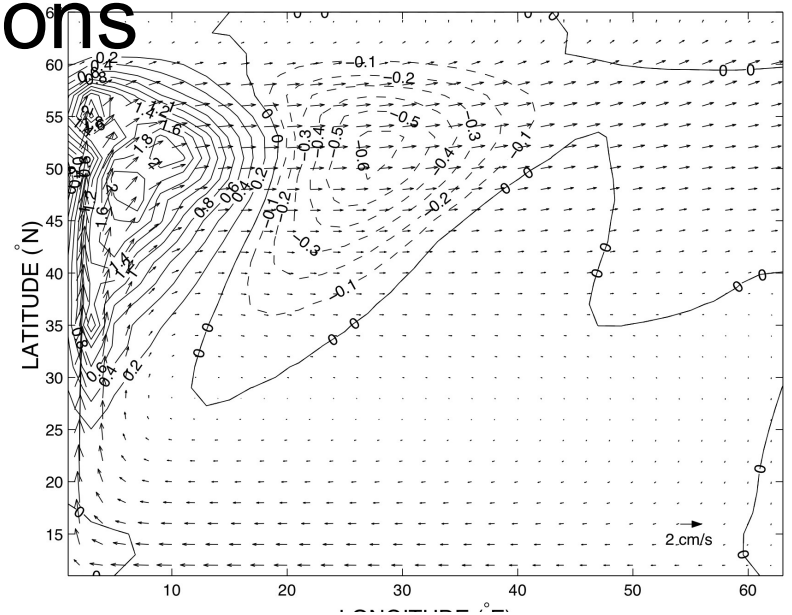


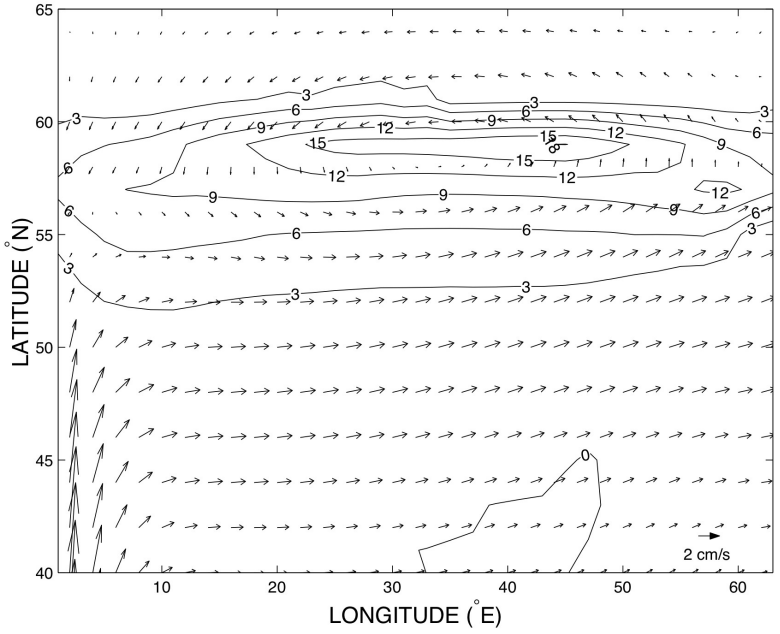


control parameter : horizontal eddy diffusivity

with salinity, 4 combinations for surface forcing:
RT=SST restoring, FT=constant heat flux
RS=SSS restoring, FS=constant freshwater flux
►RTFS=mixed boundary conditions







2. sensitivity of ocean models to horizontal resolution in the 1°-1/10° range

series of FT numerical simulations with ROMS spanning an order of magnitude in horizontal resolution, from 160 km (L20) to 80, 40, 20 and finally 10 km (L40) - implicit diffusivity&viscosity

for 3 values of diapycal diffusivity 10^{-4} 3.10^{-5} 10^{-5} m^2/s controlling the MOC intensity

several centuries long > multidecadal variability

►most fundamental changes in the mean flow

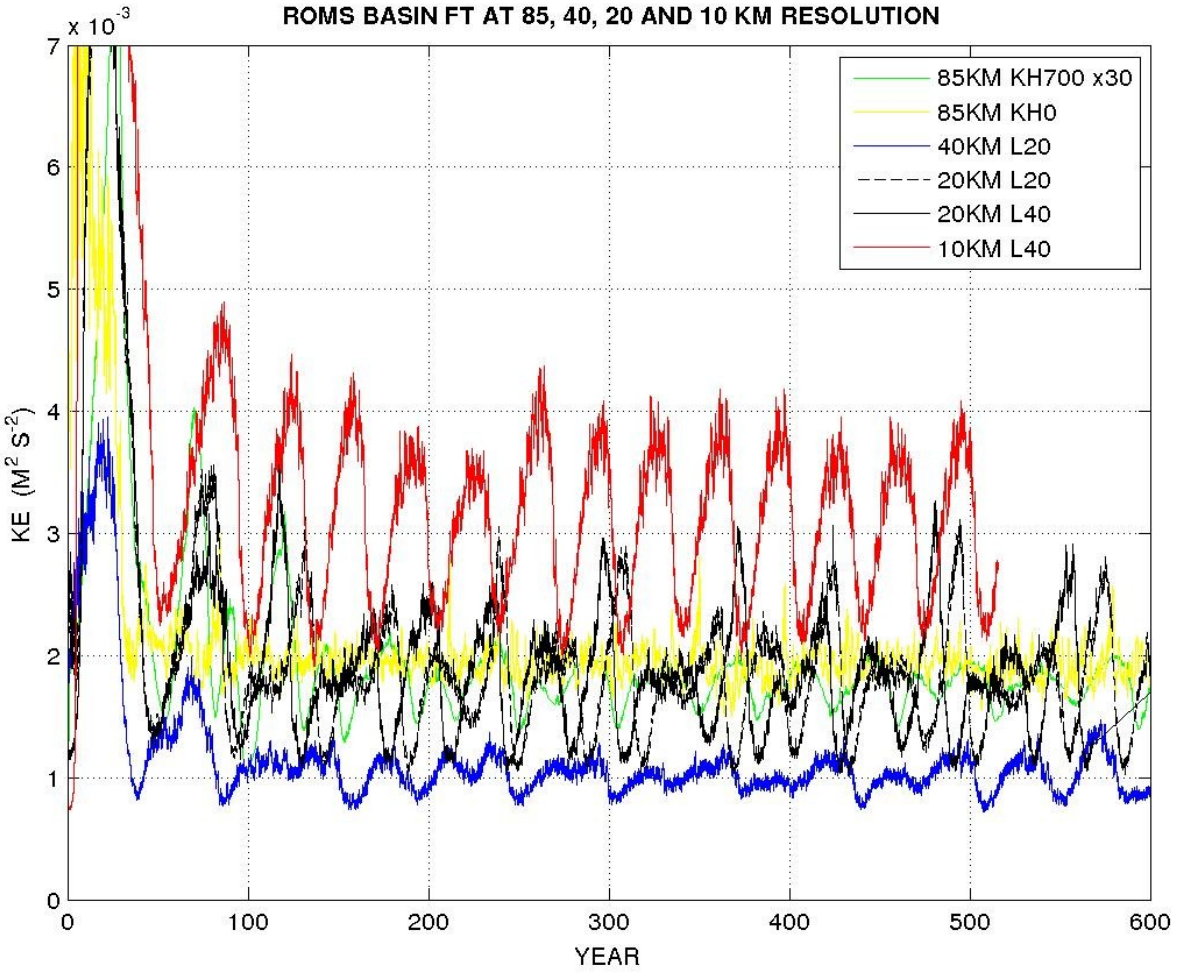
►less fundamental changes in variability, linked to large-scale baroclinically-unstable Rossby waves

[Huck&al2015JPO]

Recall forcing is only **constant** surface heat flux f(lat)

►energetic spin-up > 50 yr

►large amplitude multidecadal variability in KE, PE, MOC, SST...



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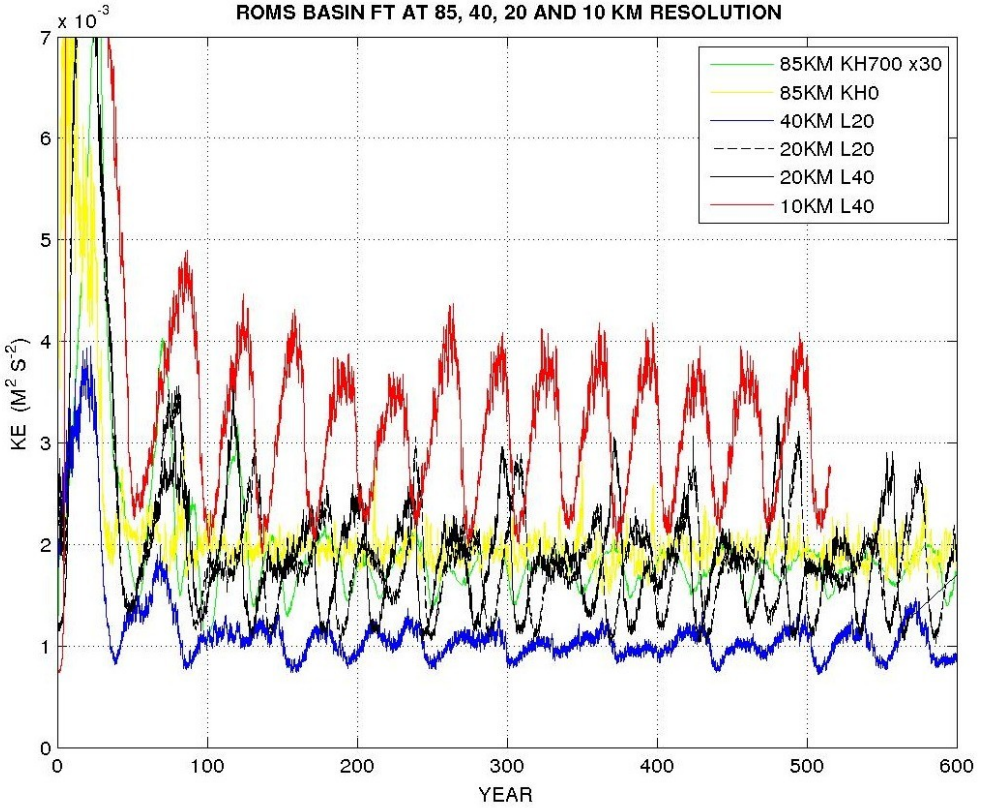
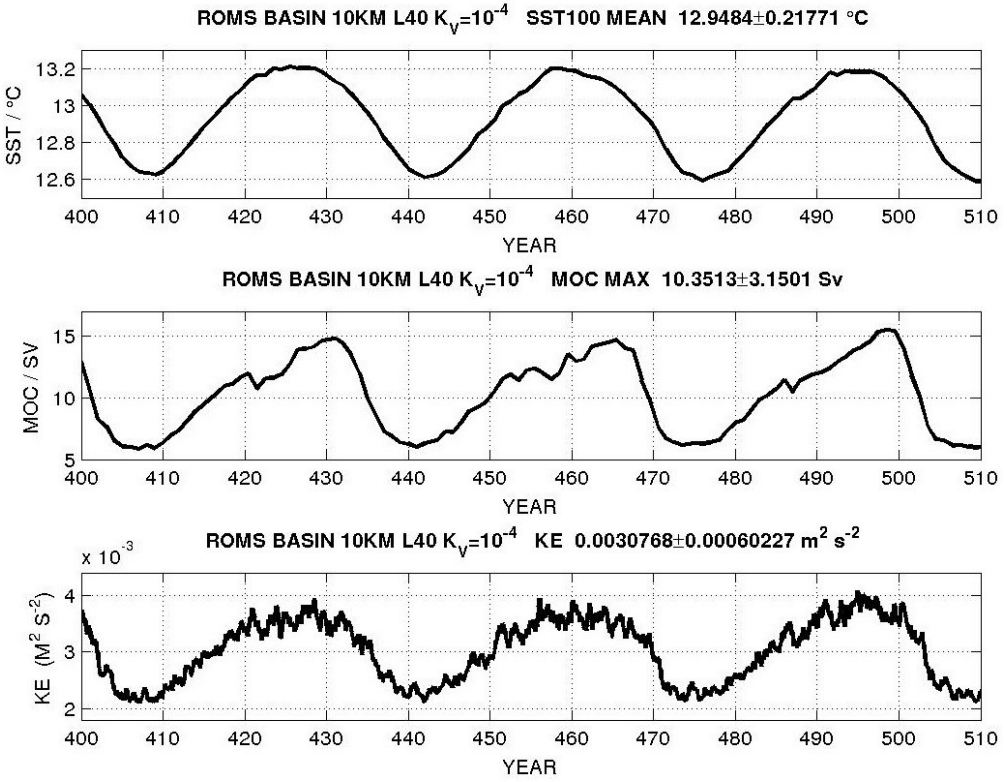
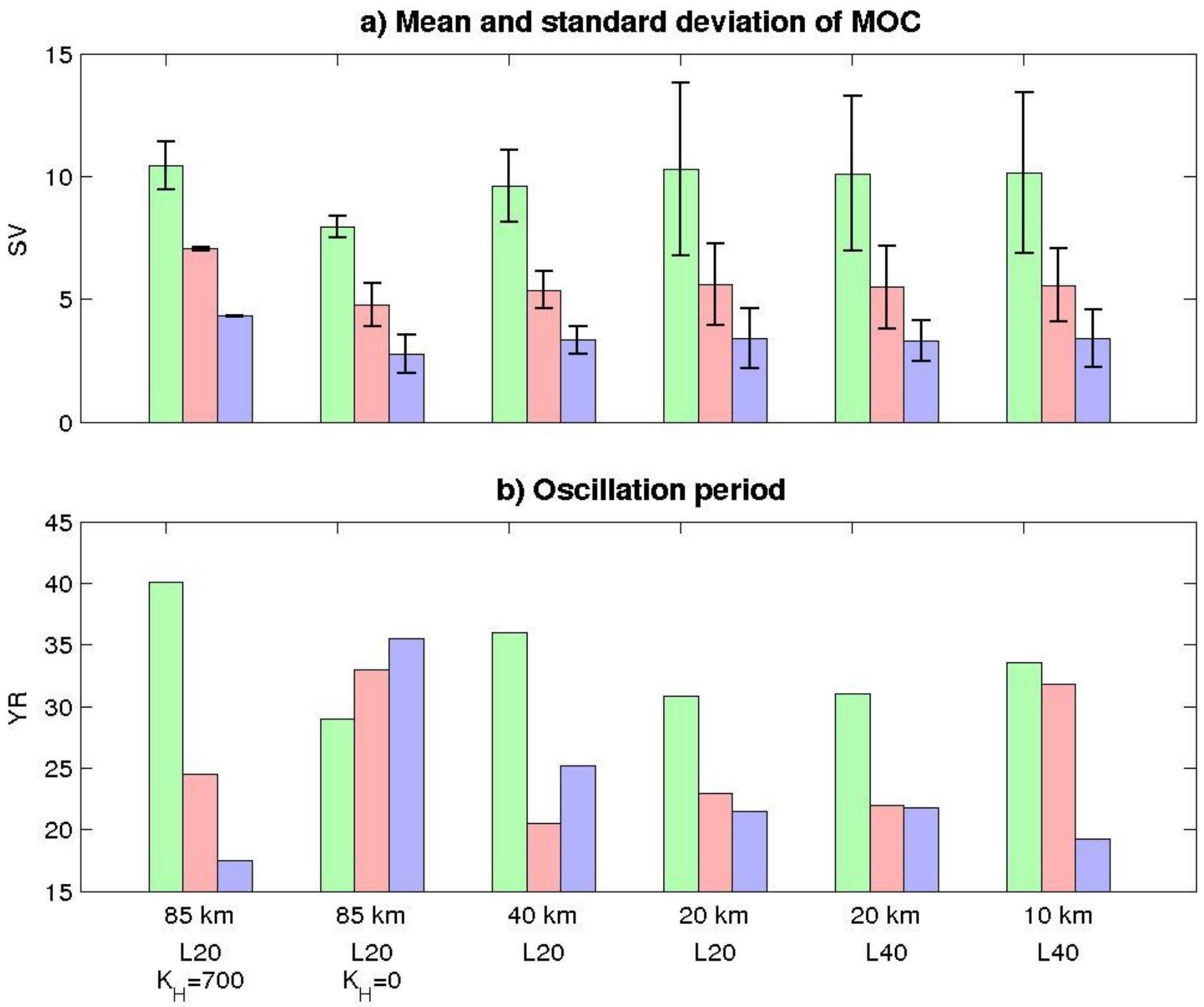




Huck&al2015JPO


a) Mean and standard deviation of MOC
SV
15
10
5
0
b) Oscillation period
YR
45
40
35
30
25
20
15
85 km
L20
K_H=700
85 km
L20
K_H=0
40 km
L20
20 km
L20
20 km
L40
10 km
L40

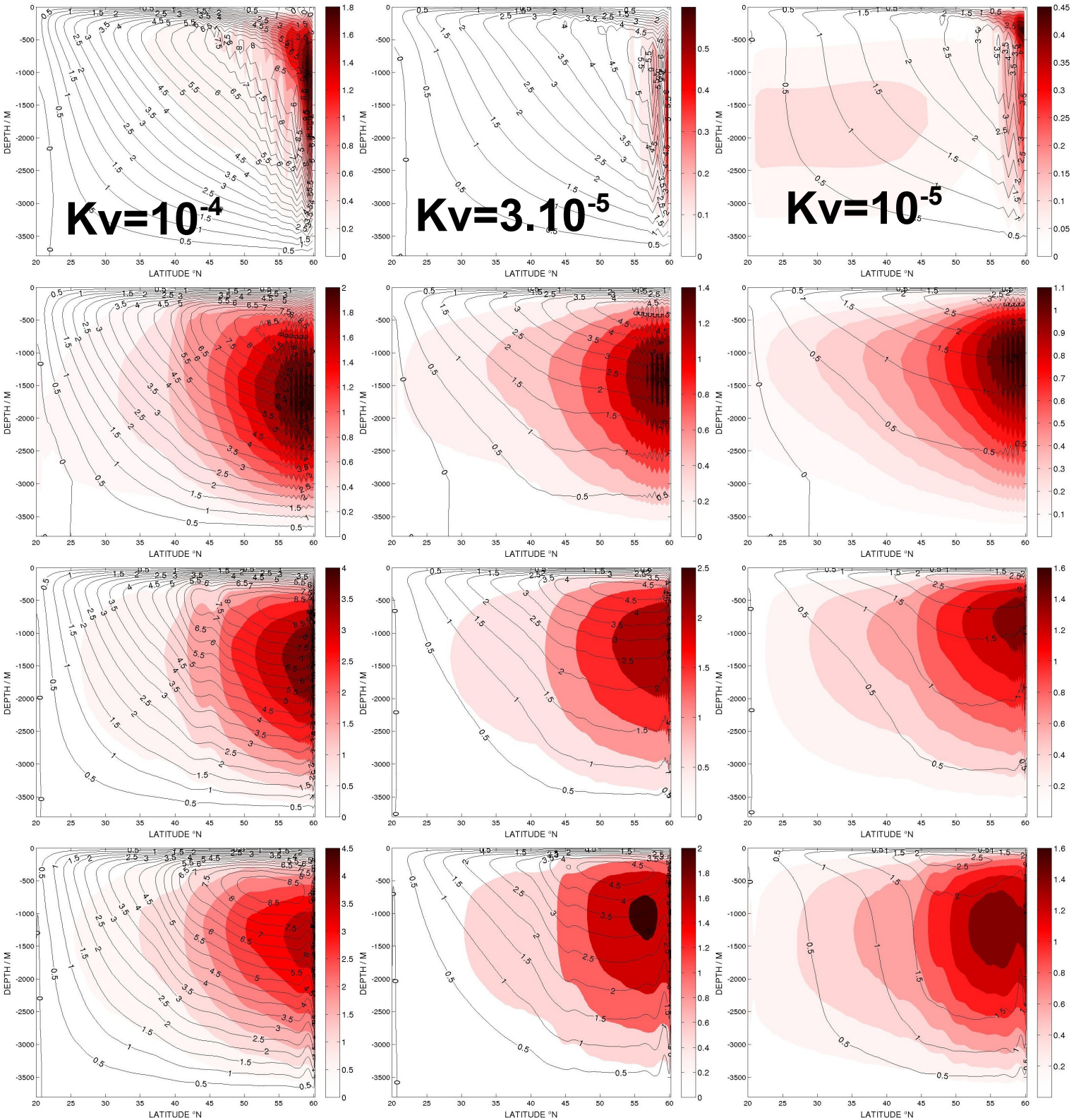
85km

MOC / Sv
mean: contour
std: color

40km

20km

10km



SST

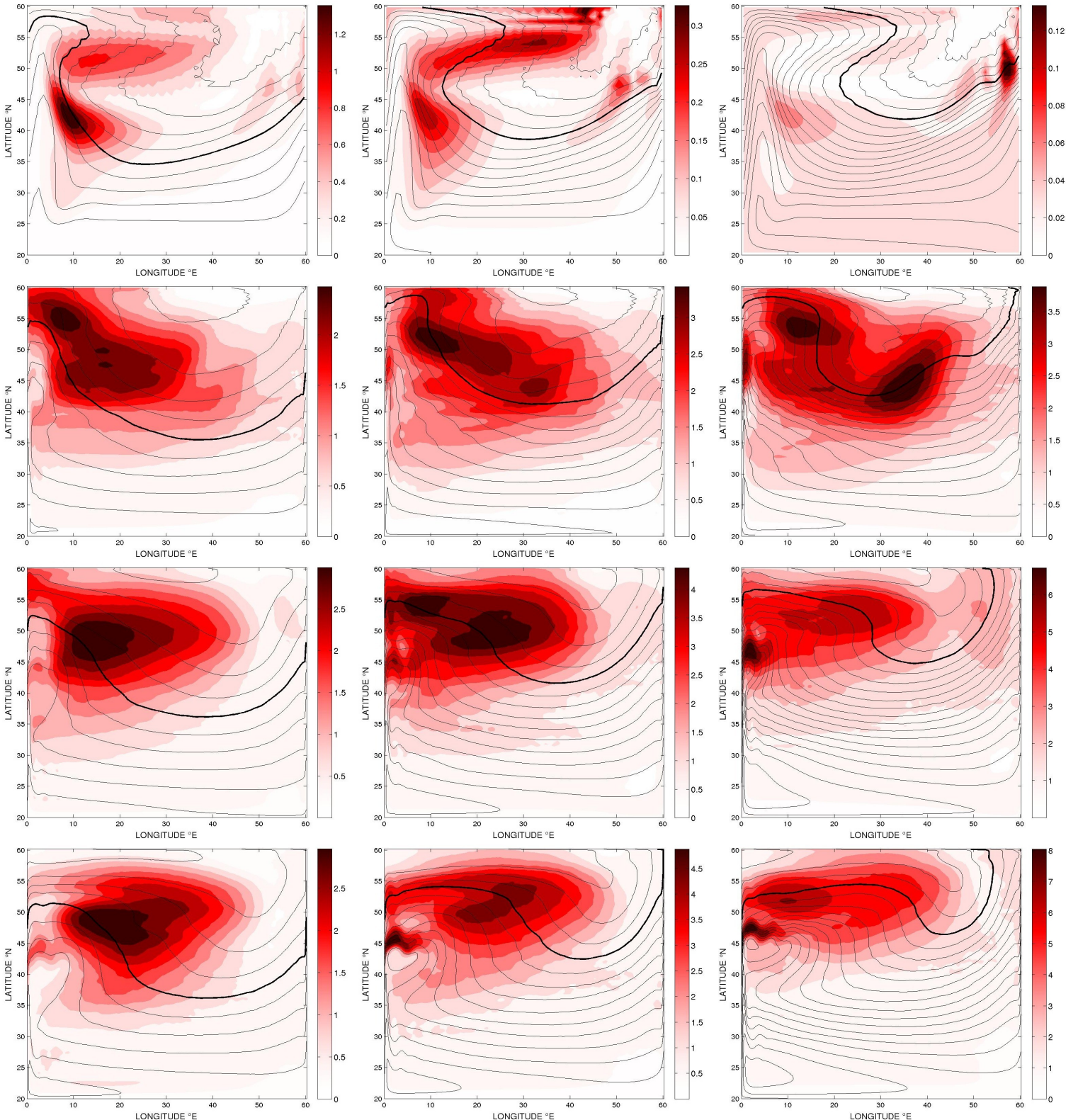
mean: contour
std: color
computed on
annual means

85km

40km

20km

10km



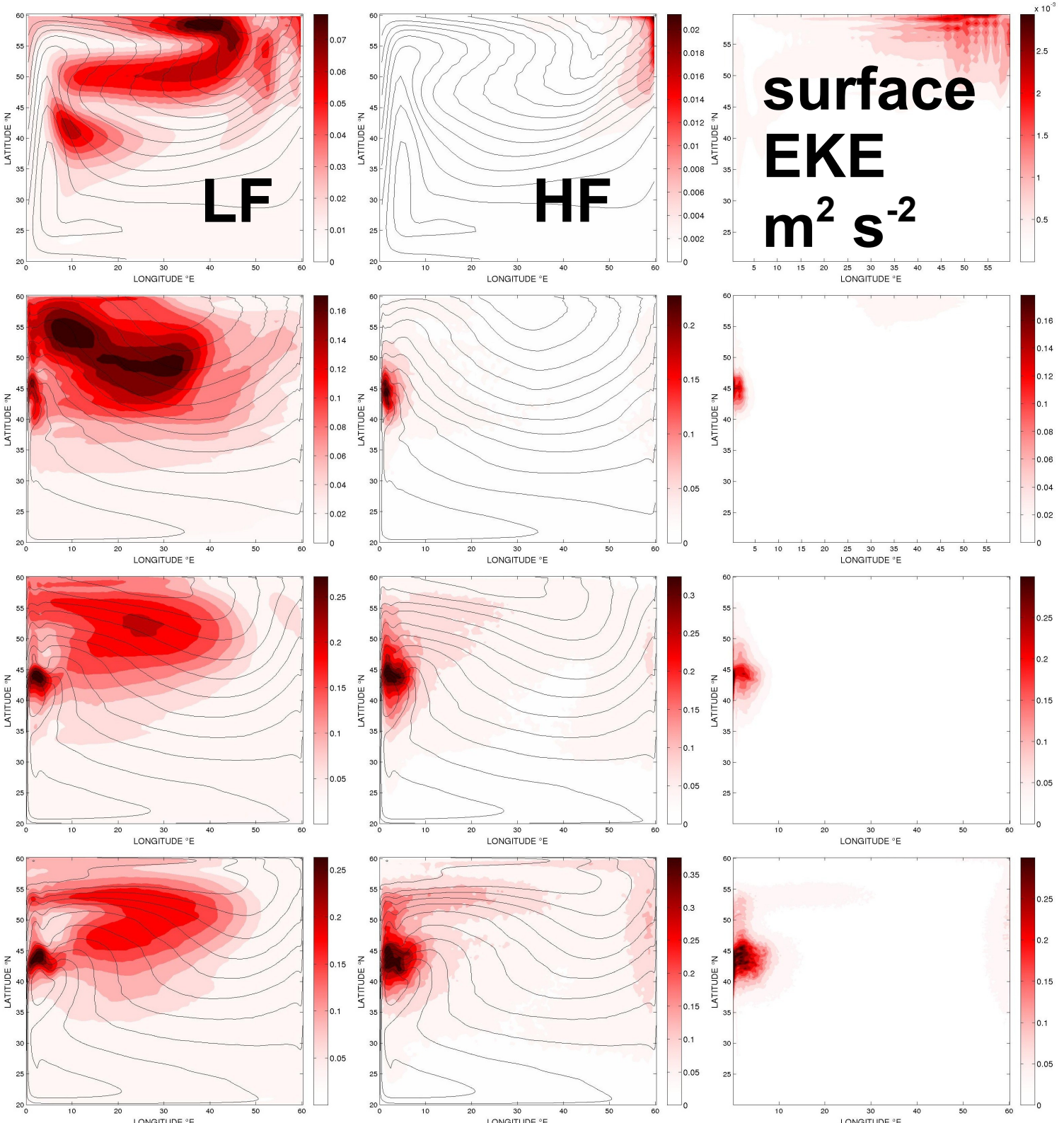
SSH / m
mean: contour
std: color
Kv=10^{-4} m^2/s

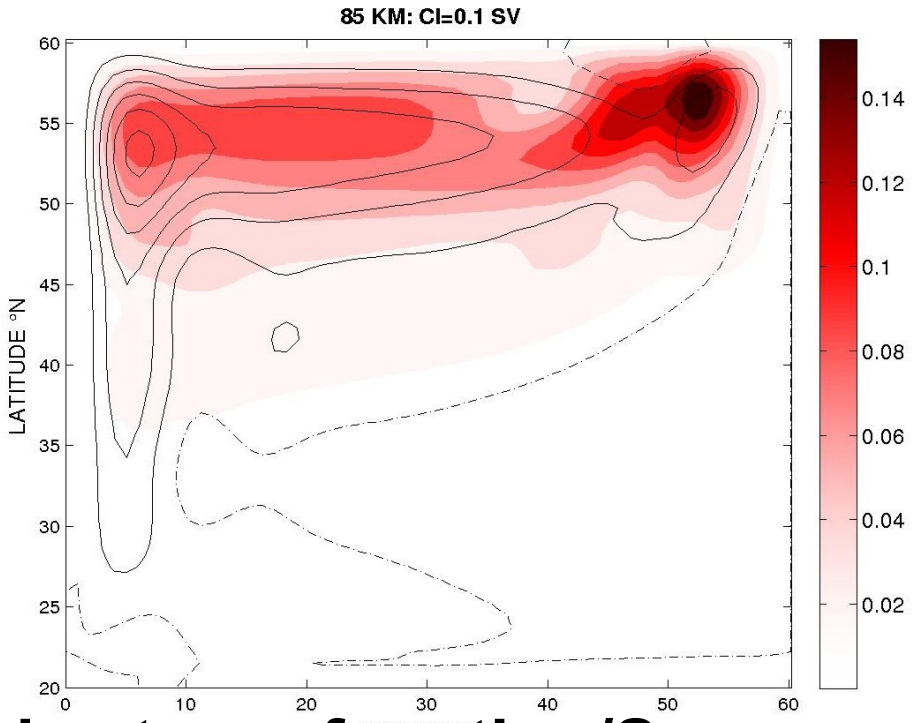
85km

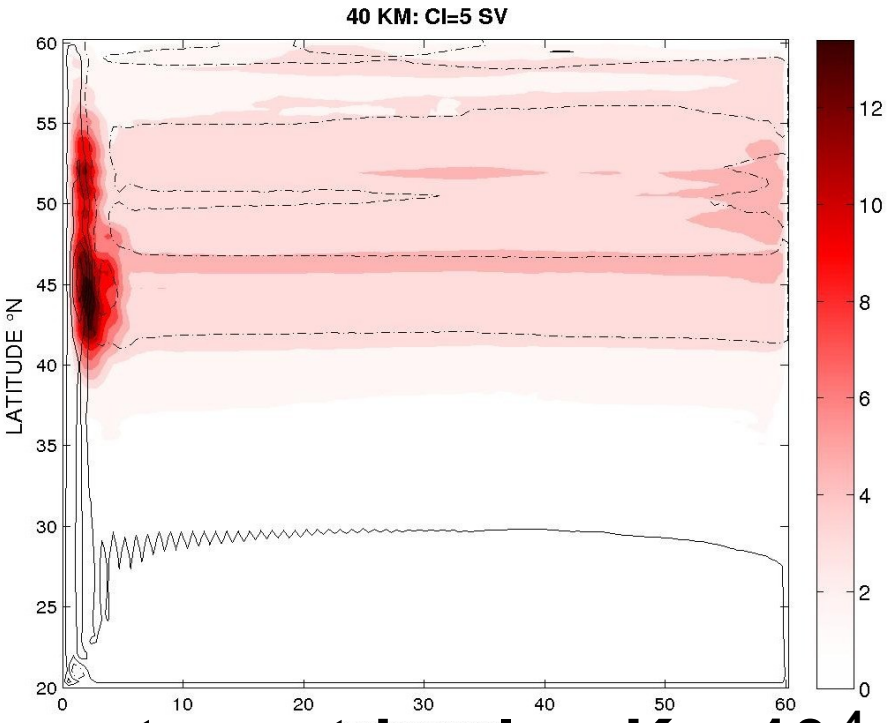
40km

20km

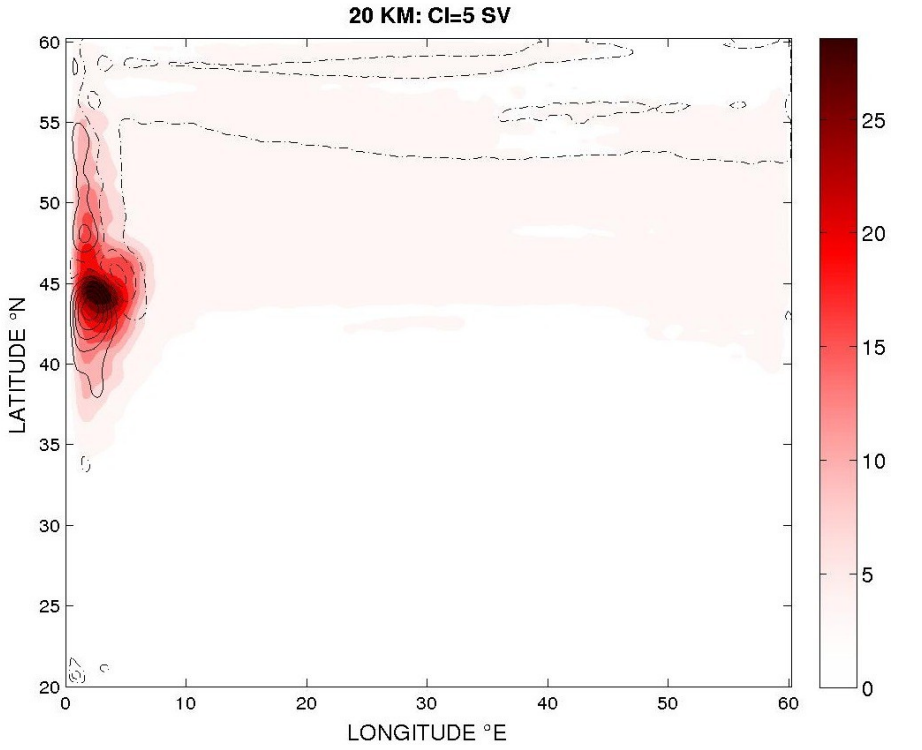
10km

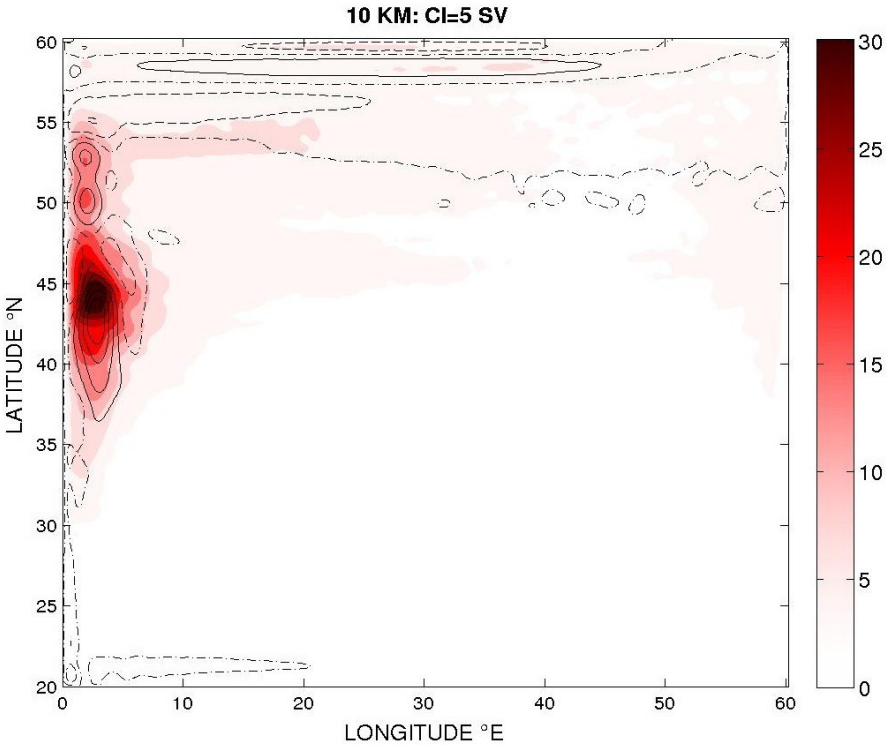


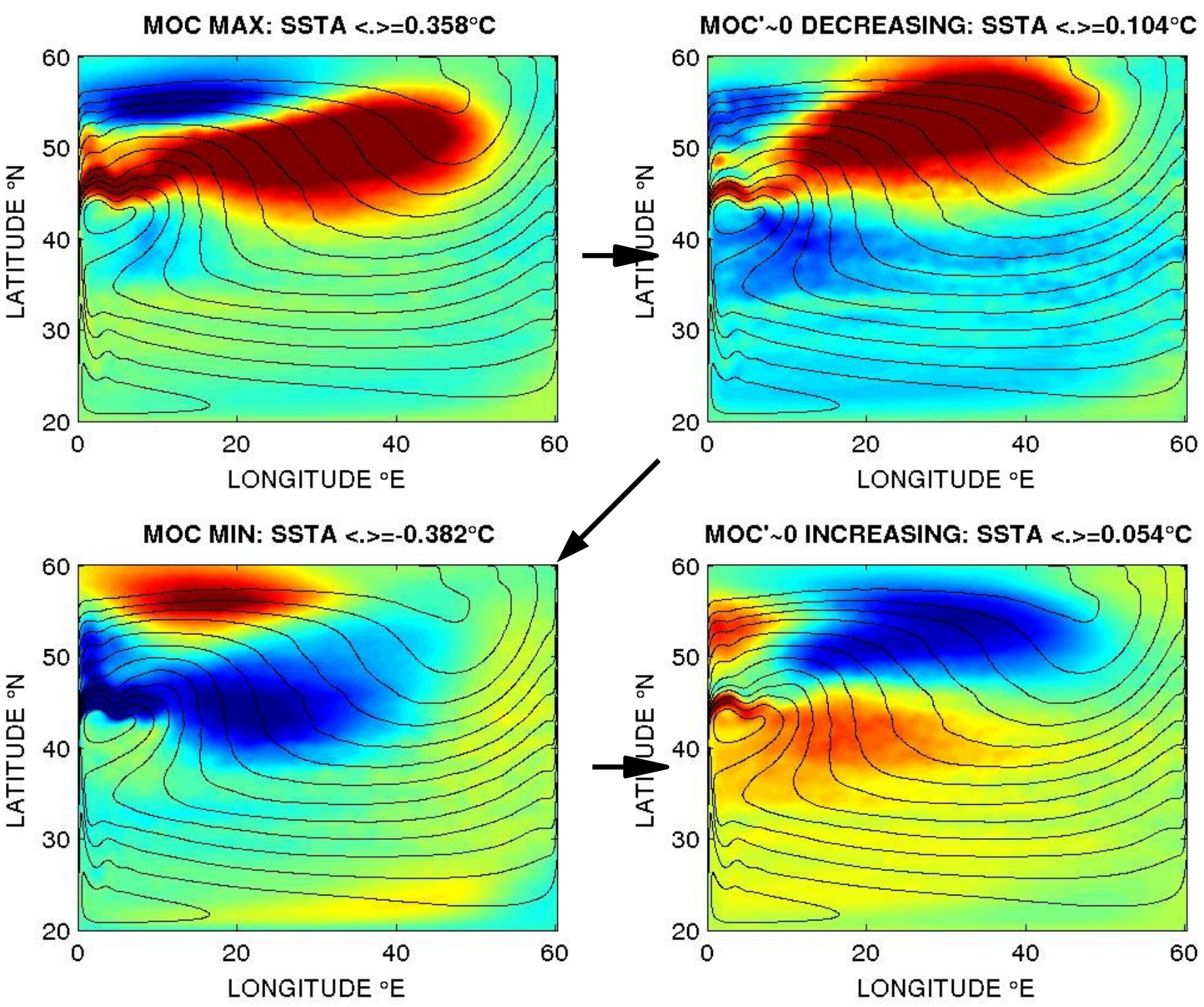




Barotropic streamfunction/Sv mean:contour std:color Kv=10^{-4} r







10km experiment, Kv=3.10^{-5} m^2/s ► A flavor of the AMO?

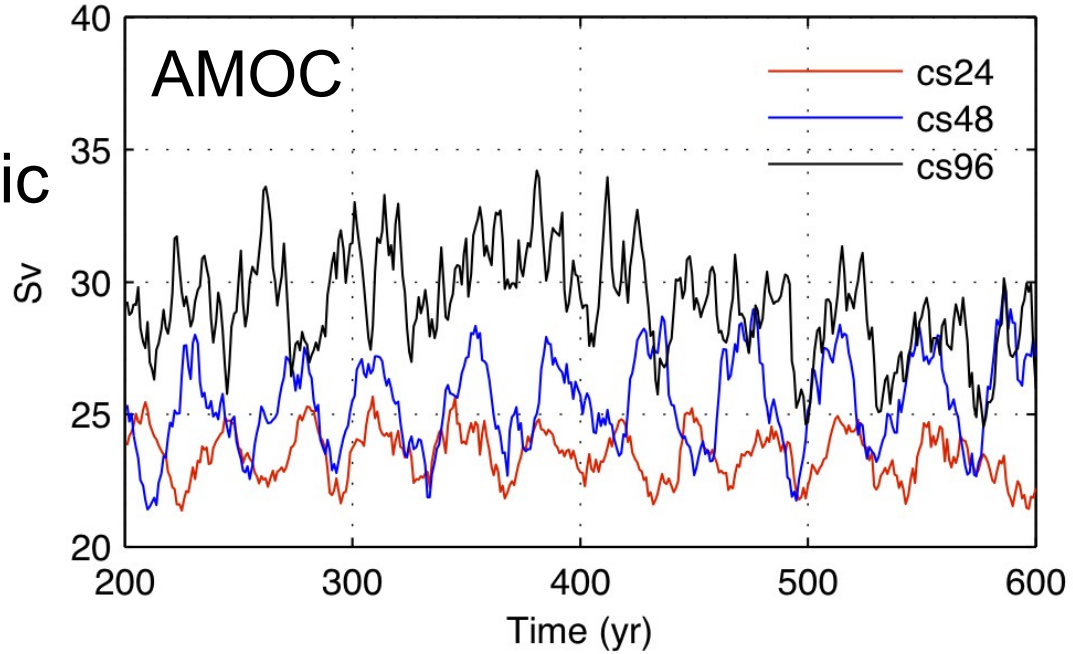
Perspectives: coupled experiments at increasing oceanic and atmospheric resolution

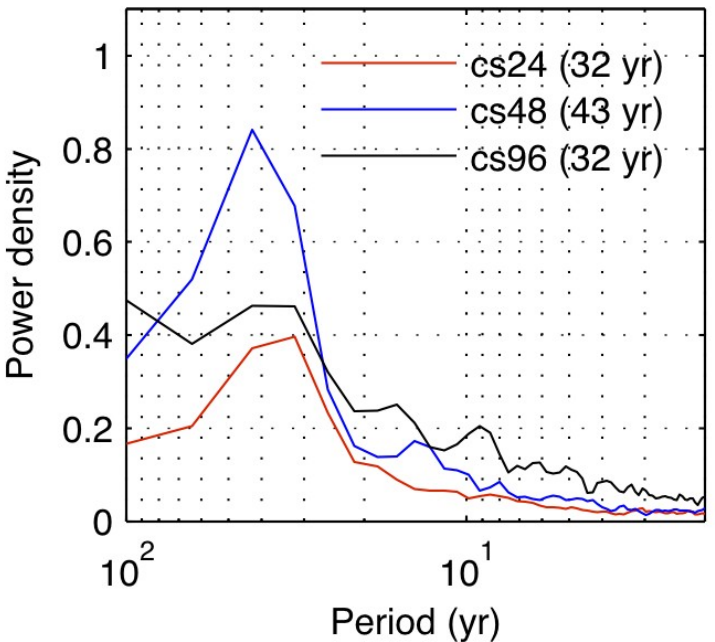
MITGCM aquaplanet coupled configuration with 2 (small Atlantic and large Pacific) ocean basins at 4°, 2° and 1° resolution

so mostly resolving better the atmospheric synoptic variability, not the oceanic mesoscale...

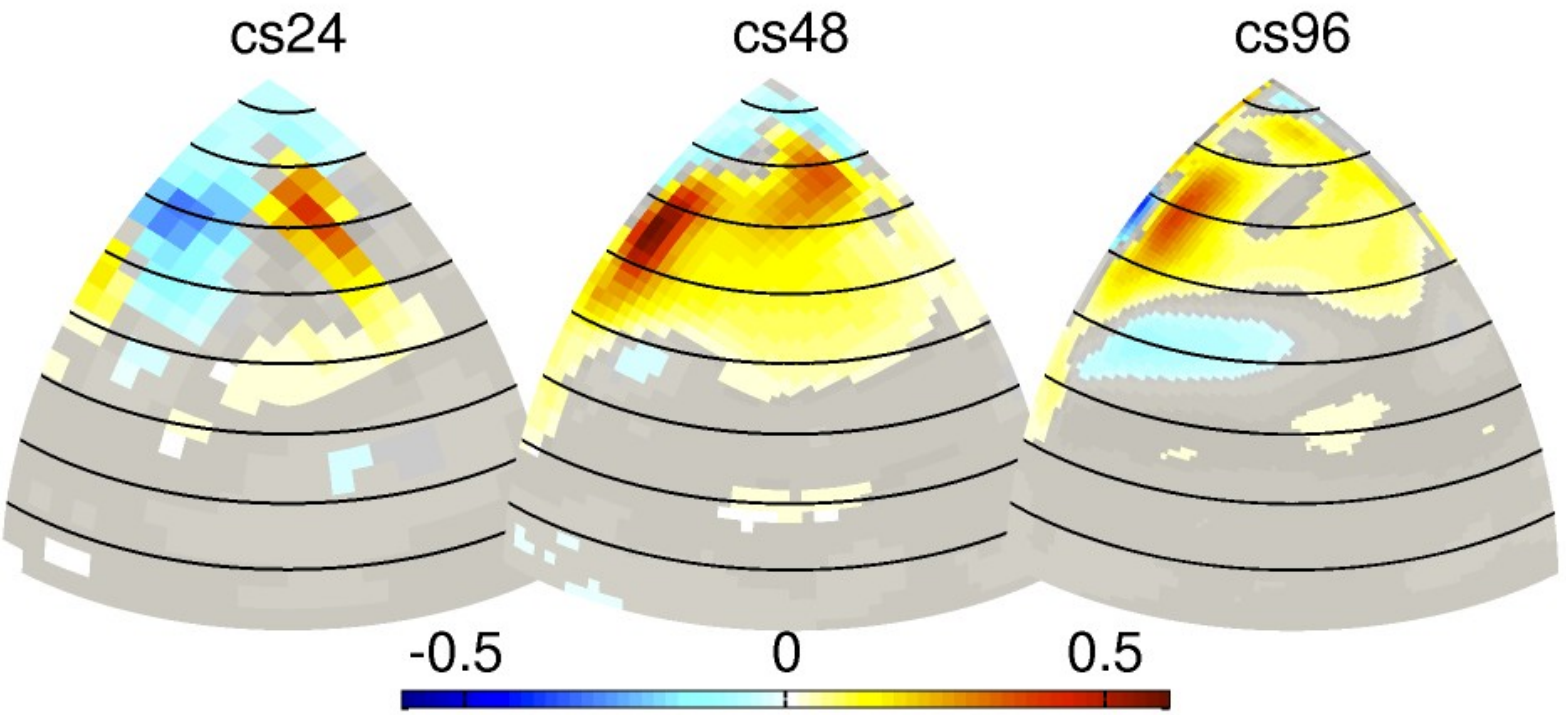
AMOC multidecadal variability of oceanic origin, but perturbed by atmospheric "NAO" interannual variability at 1° resolution

Quentin Jamet PhD 2015 (Jamet&al2016CDinpress)

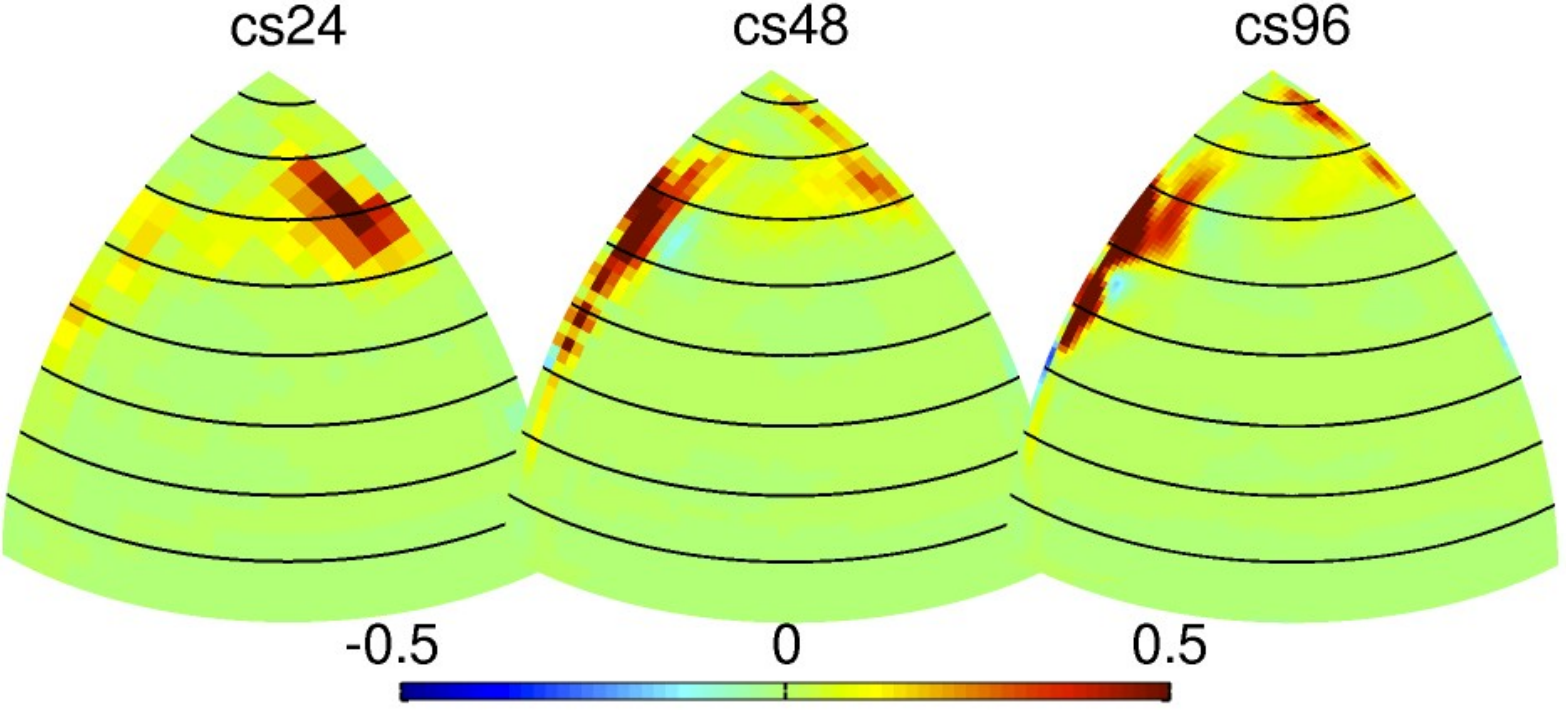




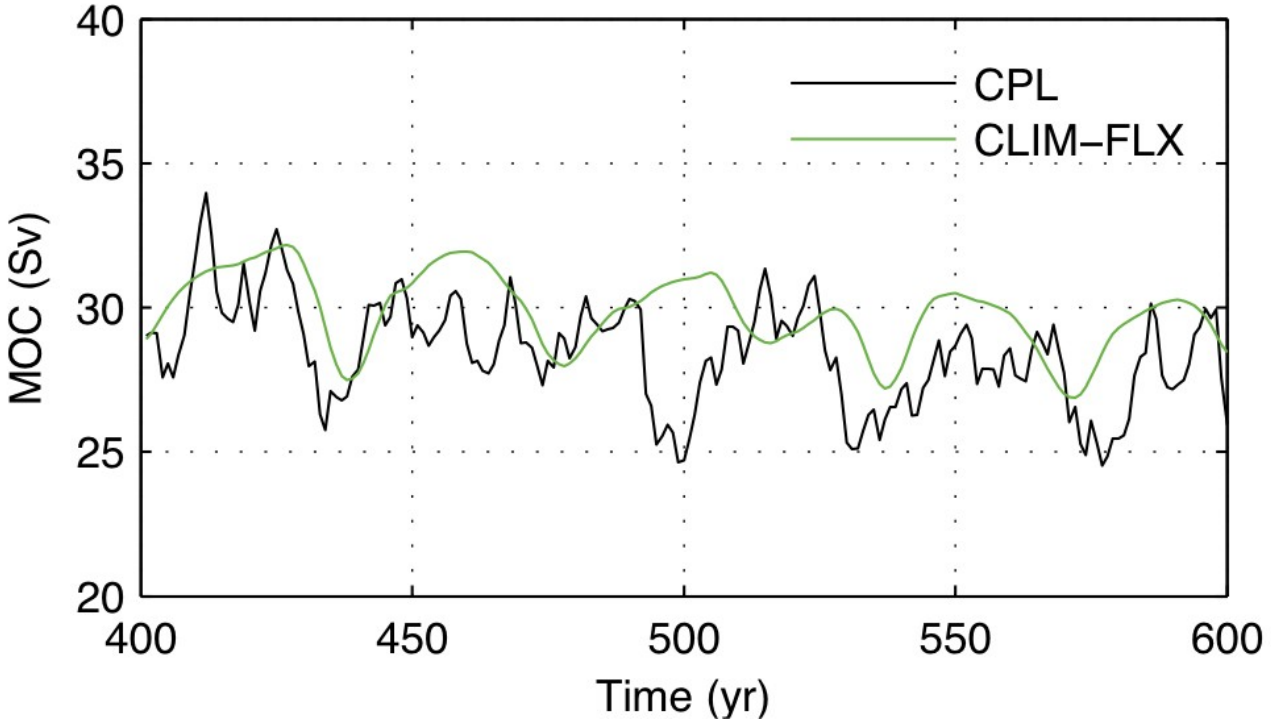
SSTA / K associated with 1std of AMOC



baroclinic instability eddy fluxes $-\overline{u'T'}\,\mathrm{grad}\overline{T}$ ($K^2\,yr^{-1}$)

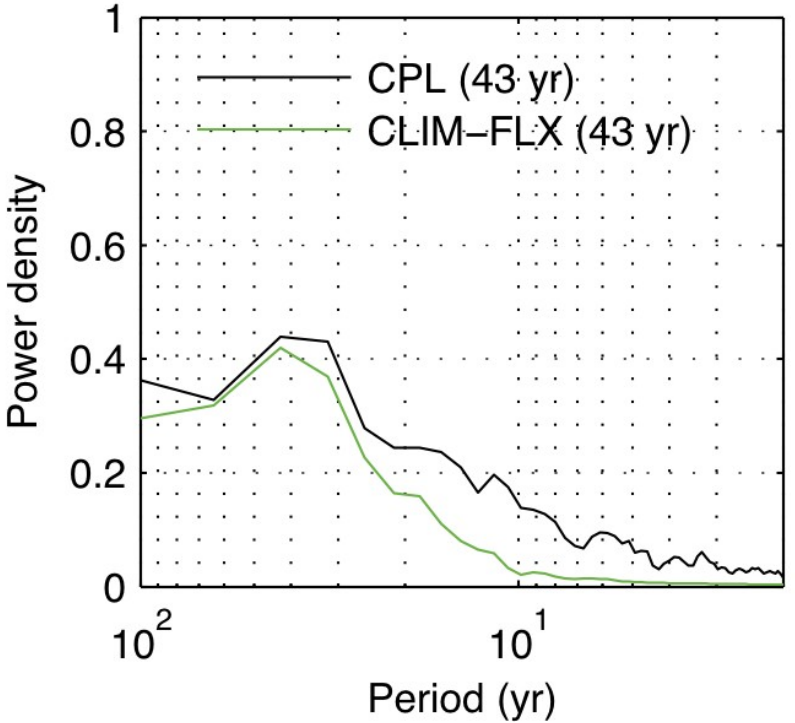


coupled vs forced oceanic experiment 1°



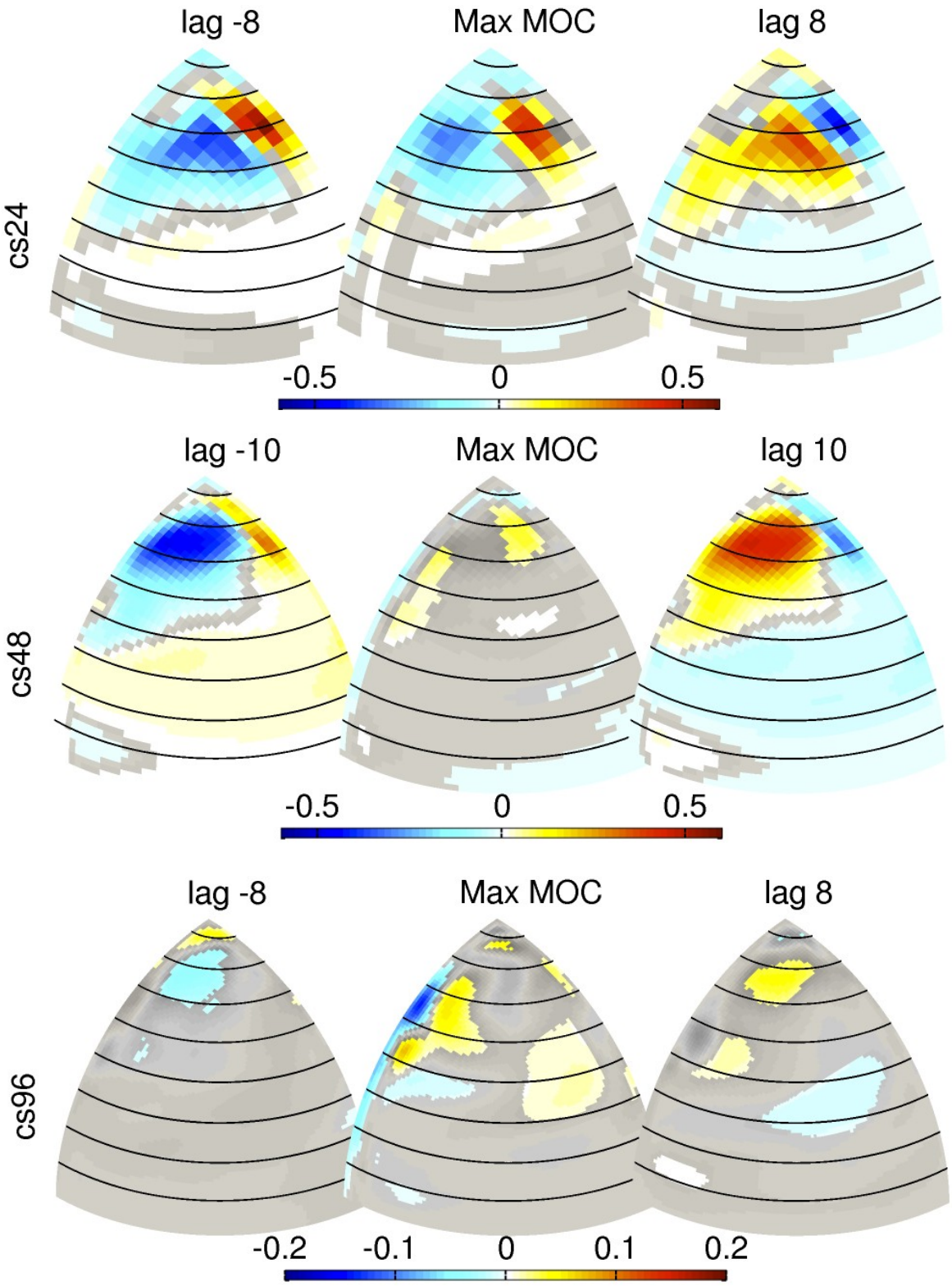
►oceanic mechanism for multidecadal oscillation

but atmospheric influence on interannual timescales



T0-1000m / K anomaly associated with 1std of AMOC

shaded if not statistically significant at 5% level



Other concerns...

My (and others) main concern with eddy viscosity parametrization in numerical simulations:

use of proper constant coef Laplacian viscosity (low scale selectivity but well-posed, expect convergence of the results with increasing resolution...) vs higher order variable coef viscosity (maybe implicit, pragmatic choice, no physical basis)... : to what extent solutions are physical and converge???

maybe we generate too much eddies, too persistent, with unphysical properties... could that feedback uncorrectly on scales interaction and finally on the mean state?

Validation of submesoscale resolution experiments?

- use of surface restoring should prevent from validating experiments from surface fields...

  ►eg 1000m mean velocity and EKE from Argo floats displacements (Ollitrault&ColindeVerdière2014JPO)

- how todays altimetry tracks and processing affects the level of EKE, spectrum... ??? (LeTraon&al2008JPO)

  ►eg reproduce same tracks&processing in model outputs to compare the same thing? (who does that?)

- Lorenz energy cycle at submesoscale?

  ►how does resolving submesoscale and associated instabilities affects the energy cycle between KE/PE?

Thank you for your attention

and sorry if I was just off the subject,

I am the outlier here!