

2nd CLIVAR Ocean Model Development Panel Meeting
« Extended meeting on forcing ocean-ice climate models »

Experiments with JRA-55 forcing dataset in NEMO global eddying configurations

Julien Le Sommer, J.M. Molines, B. Barnier



1. Model set-up, experiments and diagnostics
2. Sensitivity tests with JRA-55 forcing dataset at 0.5° resolution
3. Sensitivity tests with JRA-55 forcing dataset at 0.25° resolution
4. Wrap-up and conclusions



Two NEMO model configurations

	ORCA05.L46	ORCA025.L75
code version	NEMO v. 3.5	NEMO v.3.5
sea-ice model	LIM2	LIM2
horizontal grid	ORCA	ORCA
resolution	0.5° (cosine lat)	0.25° (cosine lat)
vertical grid	z-levels, 46	z-levels, 75
lateral closures (tracers)	iso, no GM	iso, no GM
lateral closures (momentum)	biharm	biharm
vertical closures	TKE, EVD	TKE, EVD
salinity restoring	intermediate	intermediate
bulk formulae	CORE	CORE

DRAKKAR standard global configurations (as of 2014)

ORCA025.L75 will be used in several ESMs for CMIP6

Five model experiments

▶ Two ORCA05 experiments

ORCA05-JRA	sensitivity experiment (JRA, absolute winds)
ORCA05-DFS	reference experiment (DFS5.2, absolute winds)

over period **1958-2012**, no spin-up, one pass

▶ Three ORCA025 experiments

ORCA025-JRA1	sensitivity experiment (JRA, relative winds)
ORCA025-JRA2	sensitivity experiment (JRA, absolute winds)
ORCA025-DFS	reference experiment (DFS5.2, absolute winds)

- **DFS** : DFS5.2, ERA-i + corrections (Brodeau et al. 2010, Dussin et al. 2014)
- **JRA** : JRA-55, corrected data as distributed in Mar. 2015 (v0.2)

Question : order zero difference between runs forced by JRA vs DFS ?

Focus on standard metrics for OGCM sensitivity studies

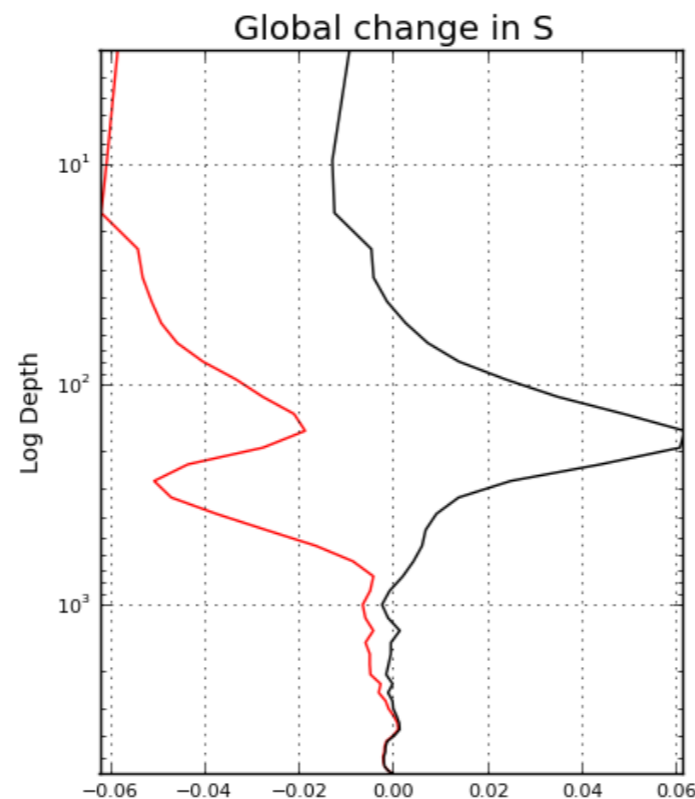
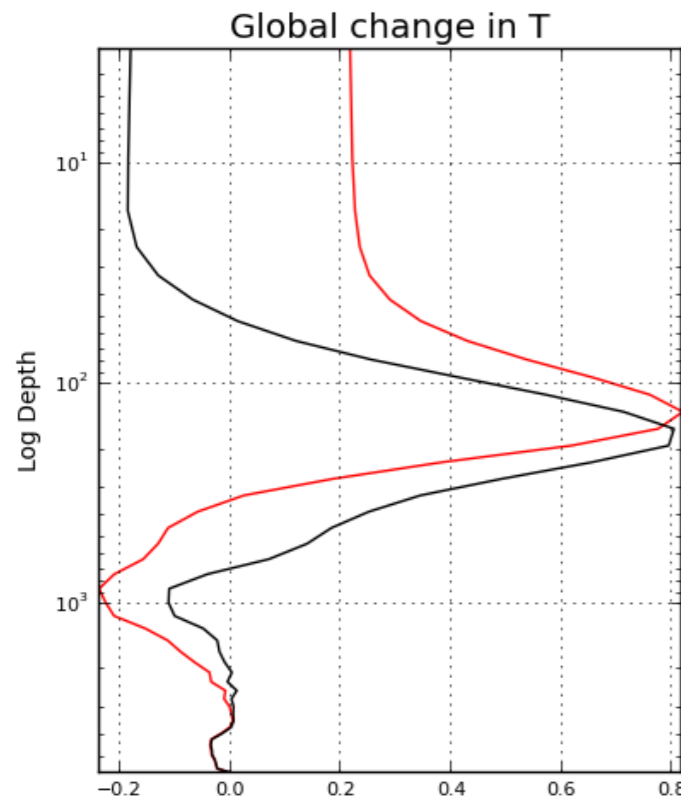
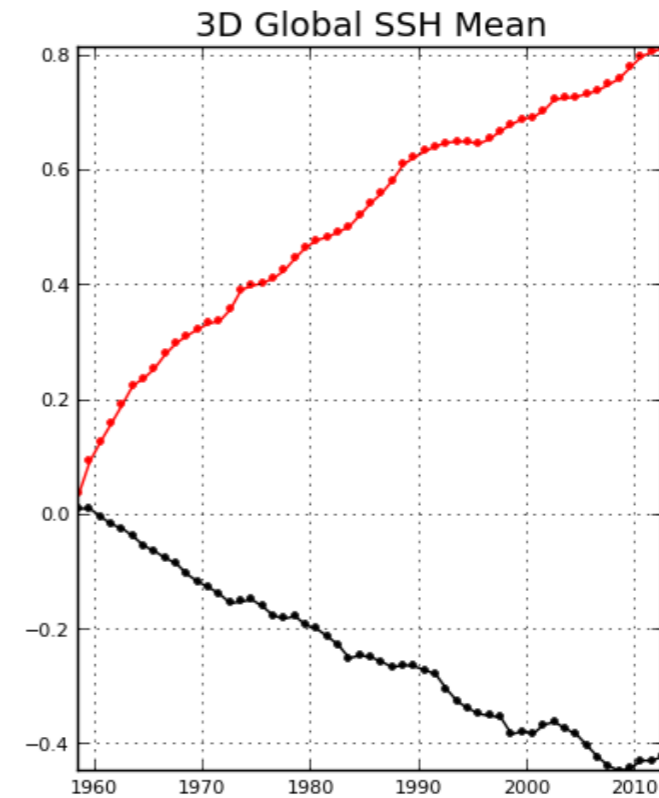
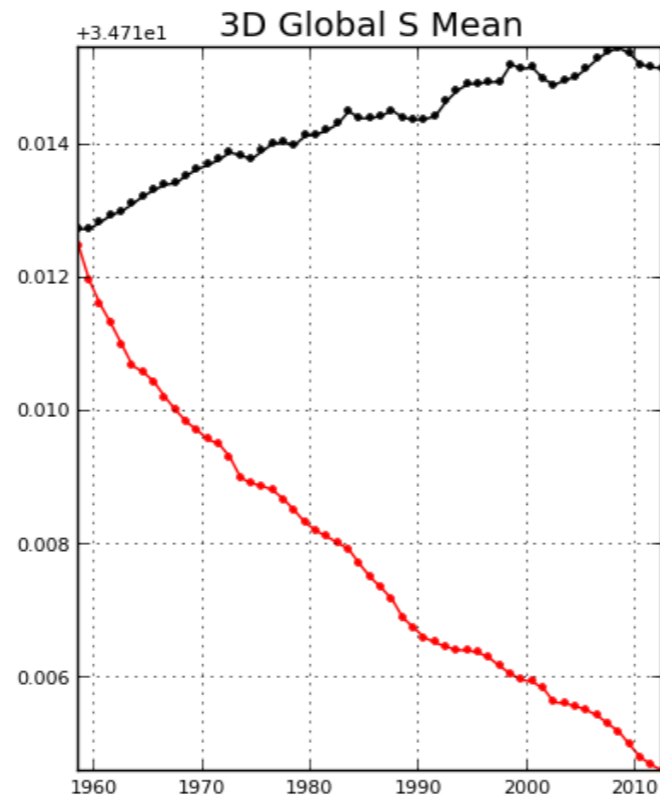
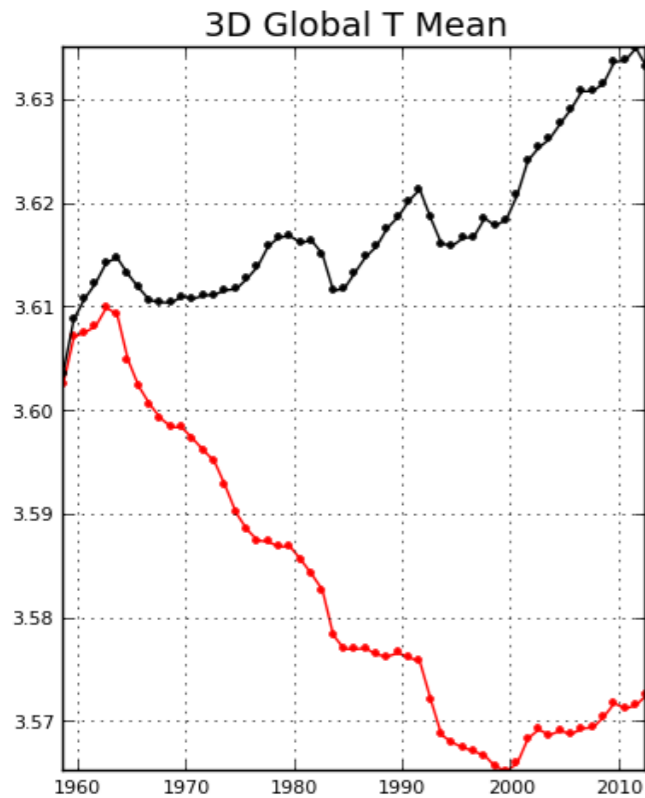
- ▶ global trends (temp, sal, ssh)
- ▶ mean circulation patterns (gyre, equatorial)
- ▶ sea-ice (concentration, thickness)
- ▶ air-sea fluxes and mixed layers
- ▶ overturning

plots based on DRAKKAR monitoring system
mostly showing averages over 2000-2007

1. Model set-up, experiments and diagnostics
2. **Sensitivity tests with JRA-55 forcing dataset at 0.5° resolution**
3. Sensitivity tests with JRA-55 forcing dataset at 0.25° resolution
4. Wrap-up and conclusions

GLOBAL TRENDS IN ORCA05

Sensitivity experiment with JRA at 0.5° resolution

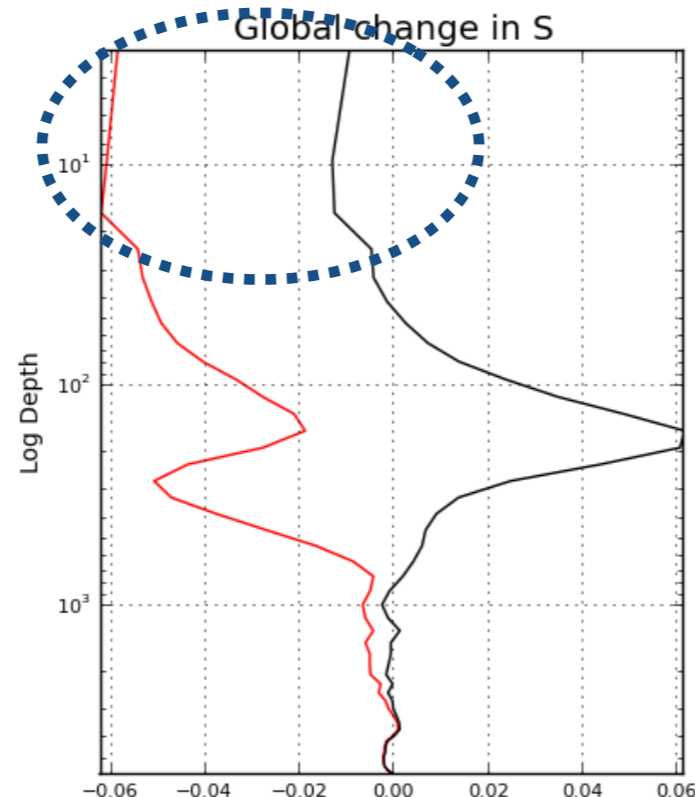
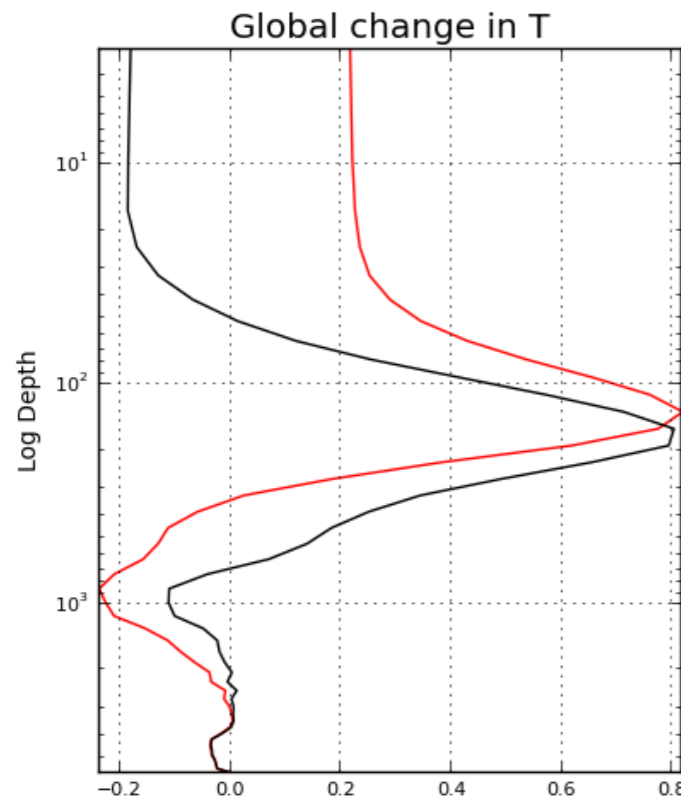
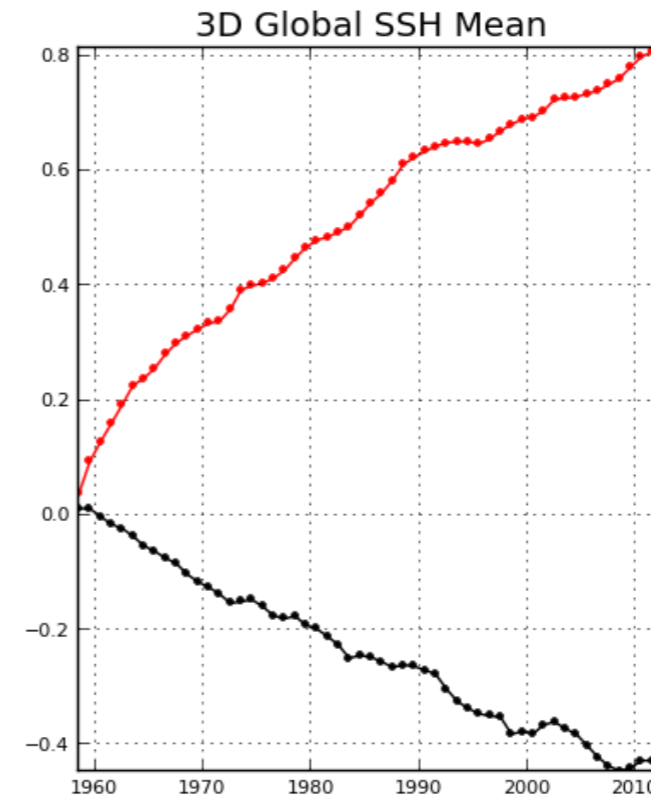
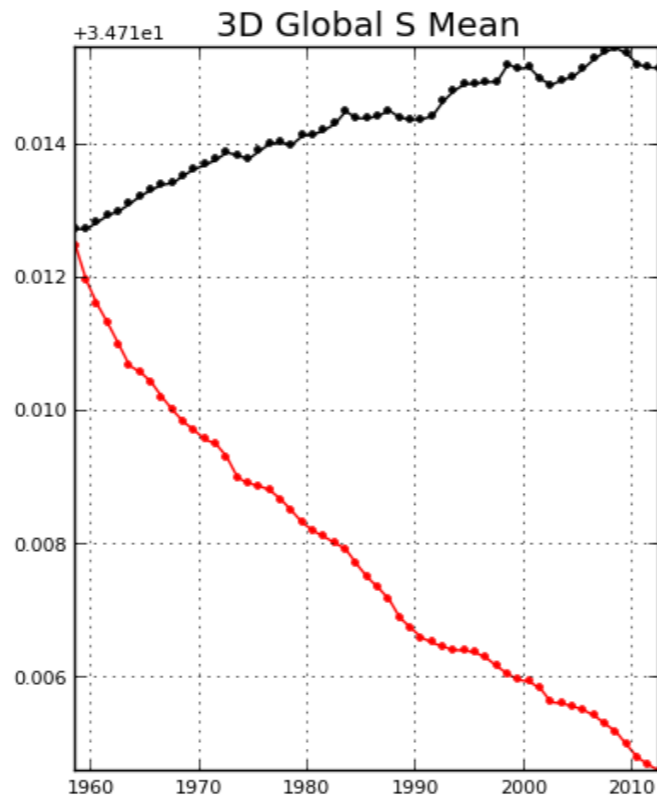
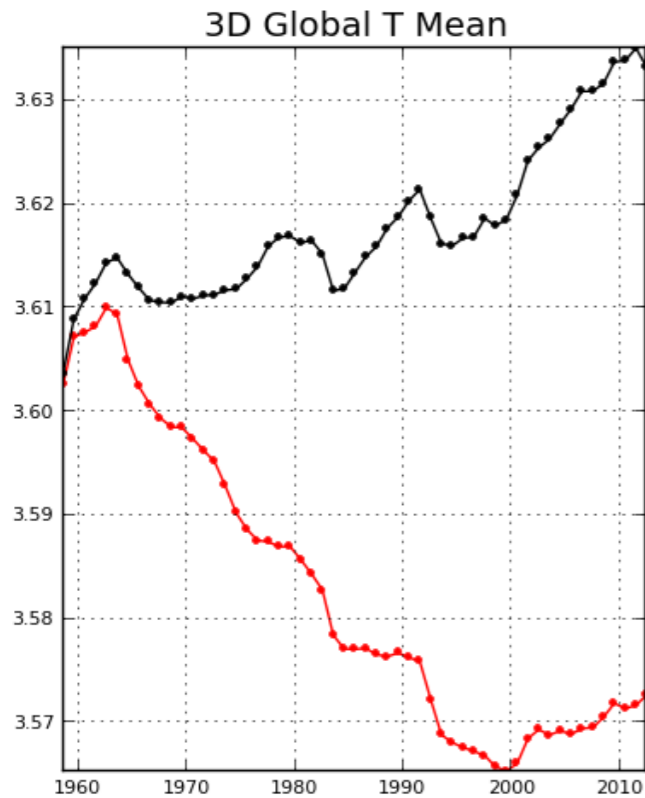


JRA : red
DFS : black

cooling, freshening

Global trends

Sensitivity experiment with JRA at 0.5° resolution



JRA : red
DFS : black

cooling, freshening

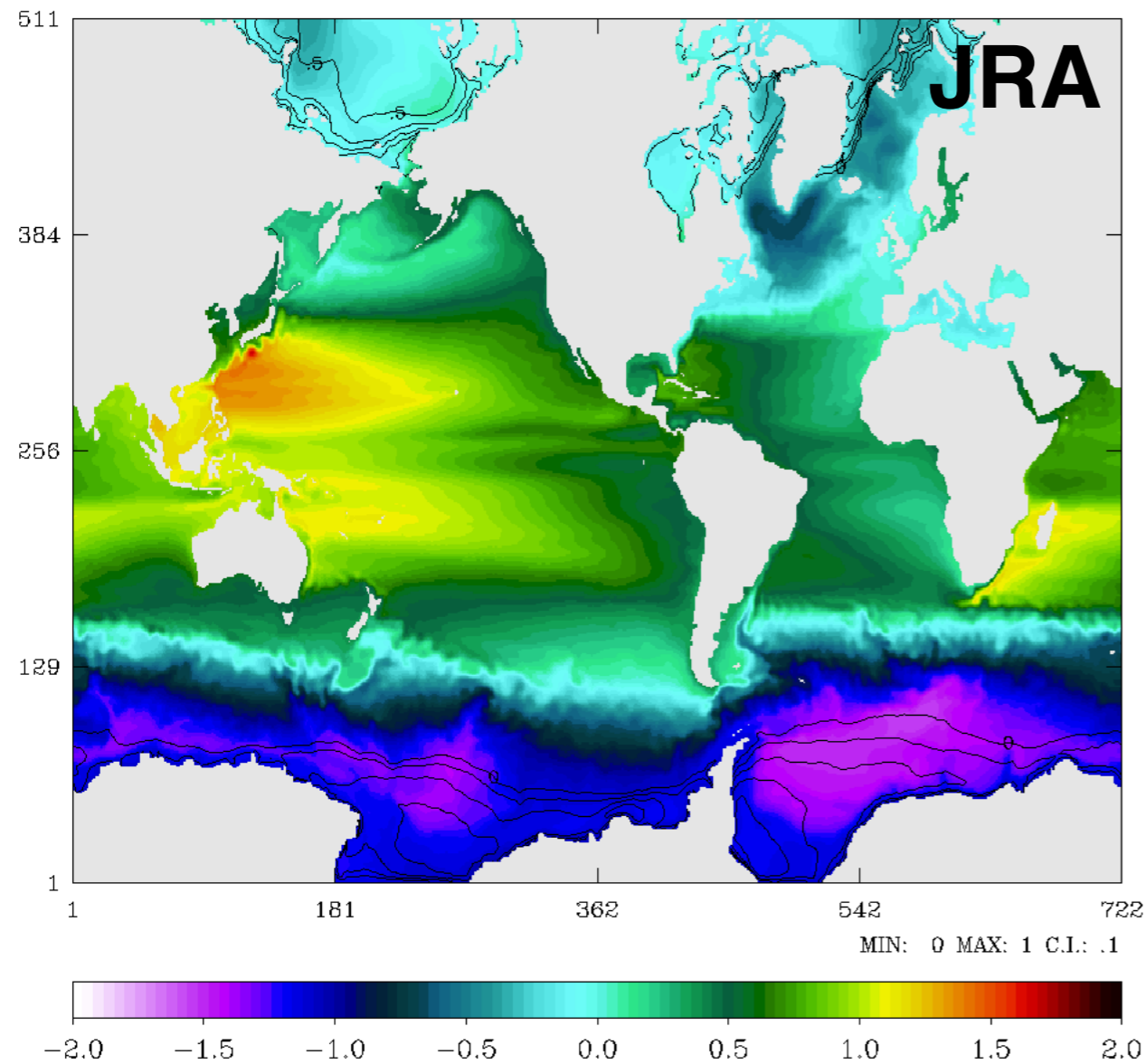
Global trends

MEAN CIRCULATION IN ORCA05

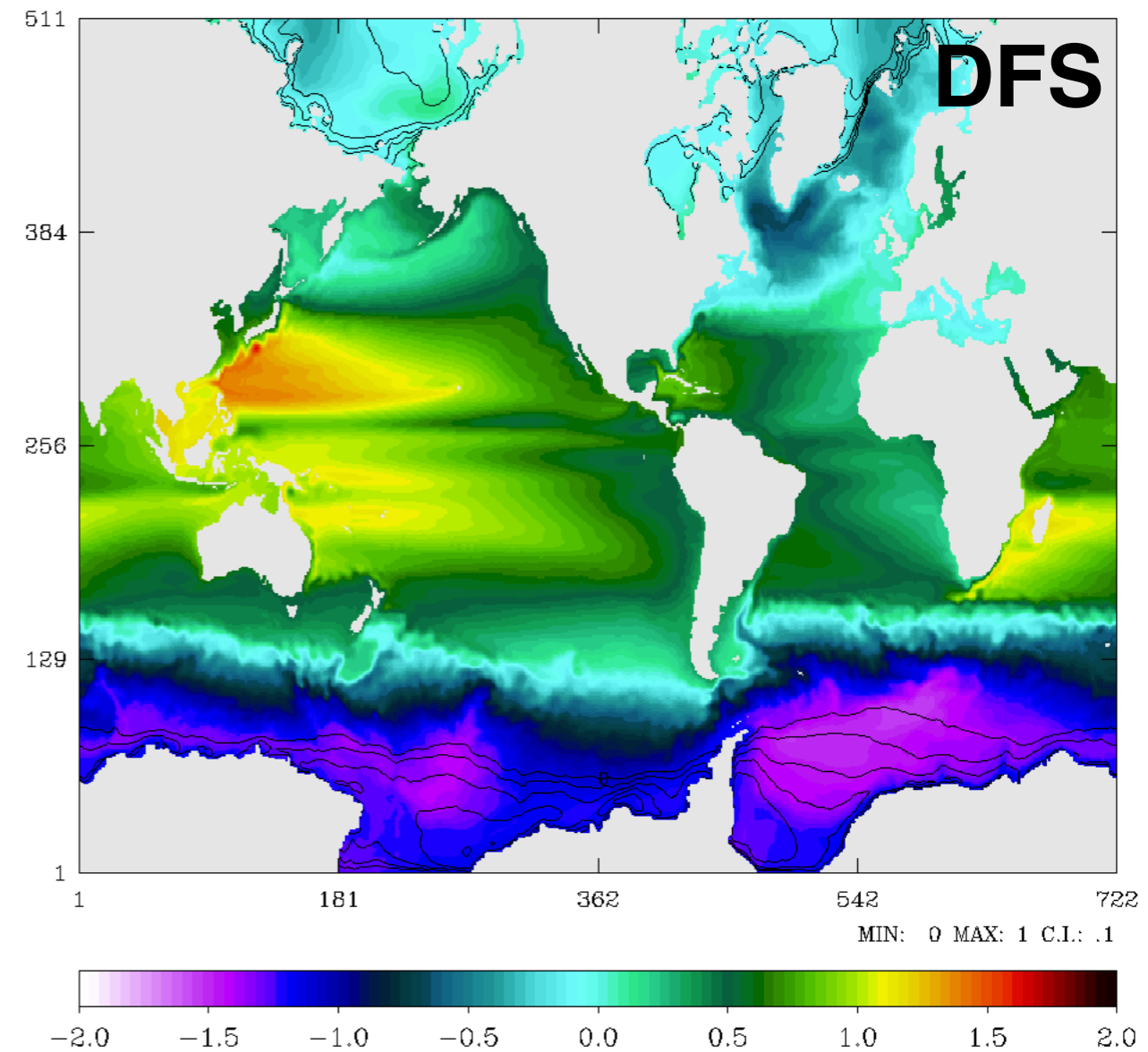
Sensitivity experiment with JRA at 0.5° resolution

Mean sea surface height

ORCA05-GJMJRA1 SSHGLp 2000-2007 DEPTH=3.05



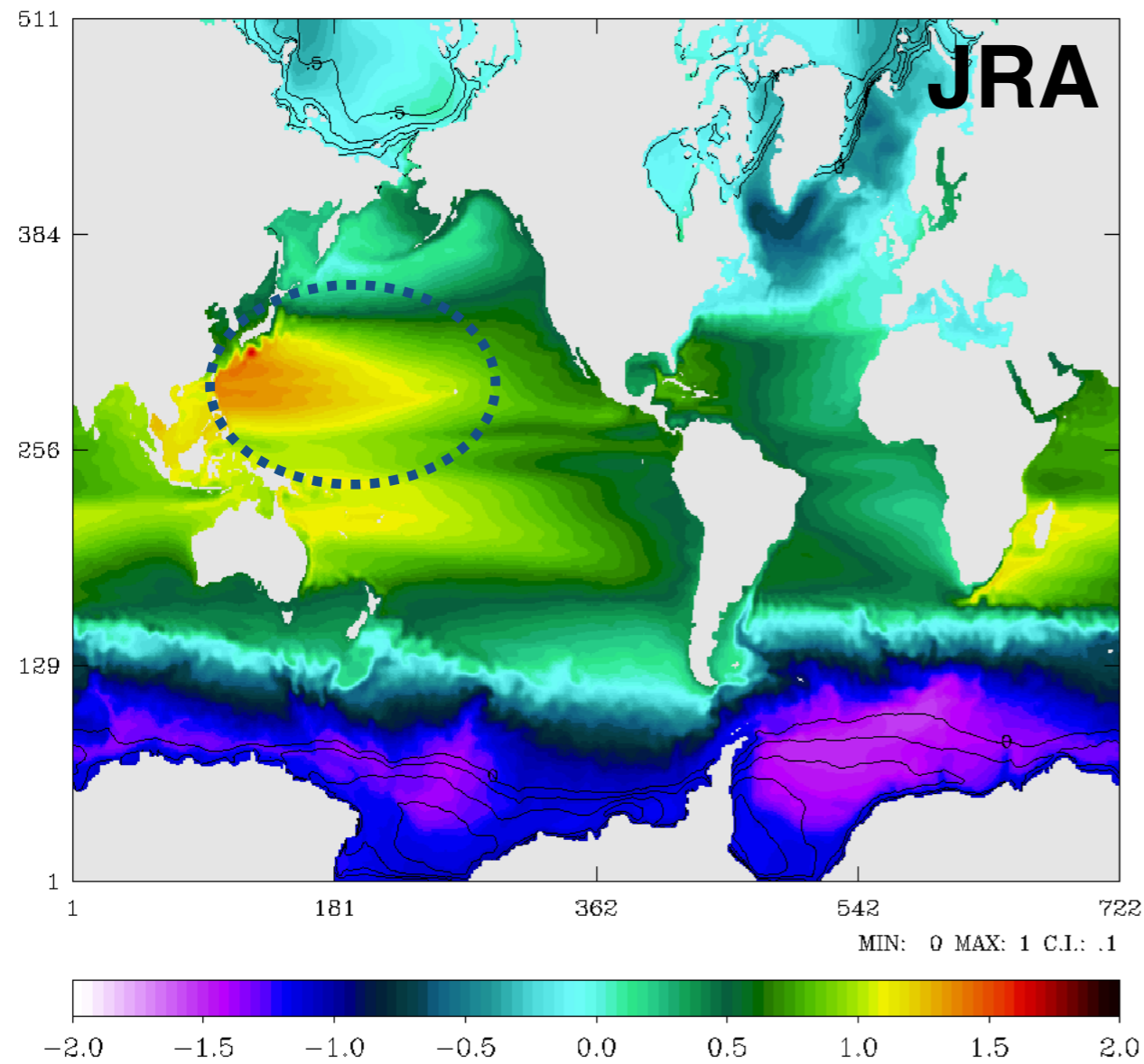
ORCA05-GJM189d SSHGLp 2000-2007 DEPTH=3.05



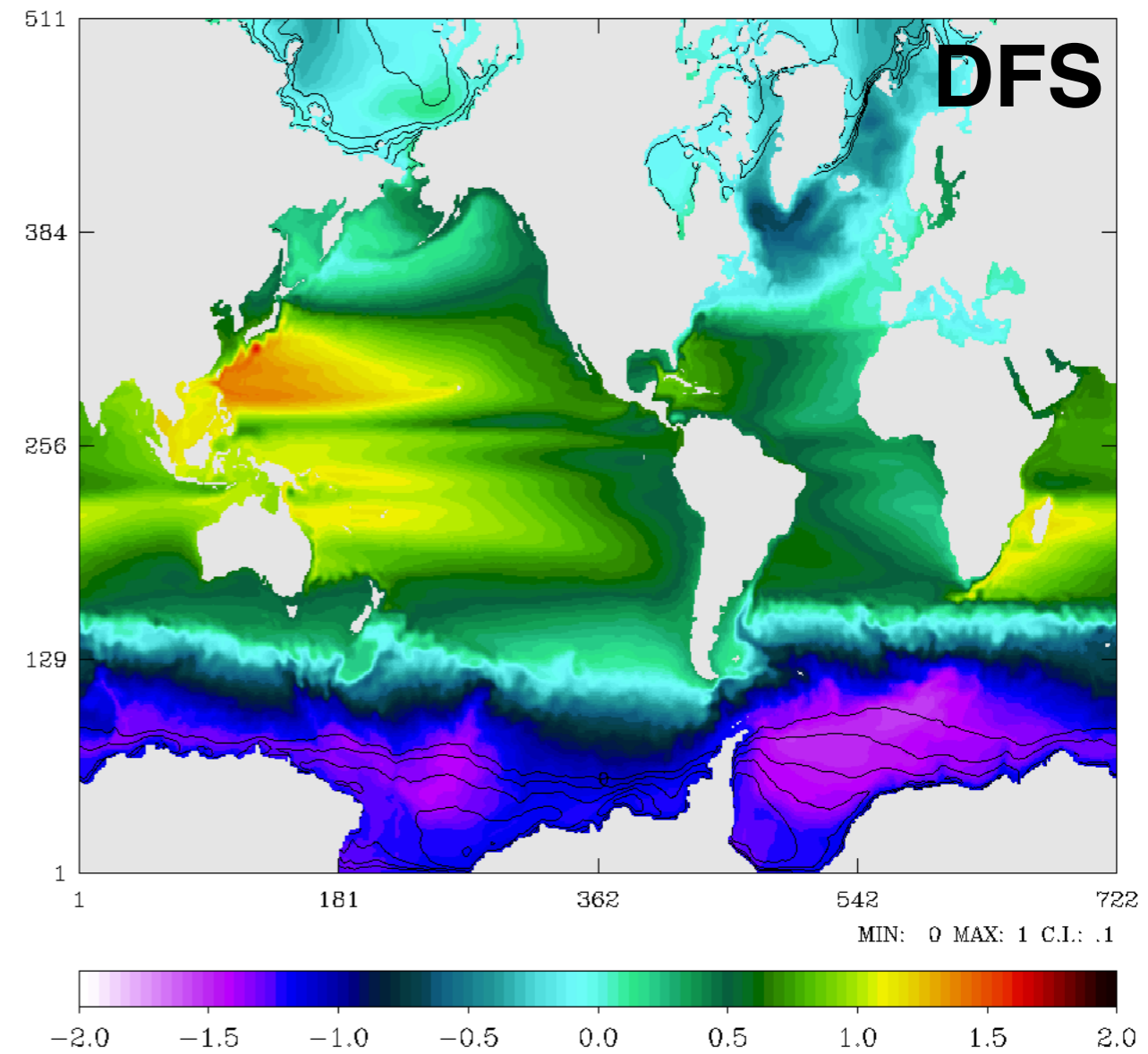
Sensitivity experiment with JRA at 0.5° resolution

Mean sea surface height

ORCA05-GJMJRA1 SSHGLp 2000-2007 DEPTH=3.05



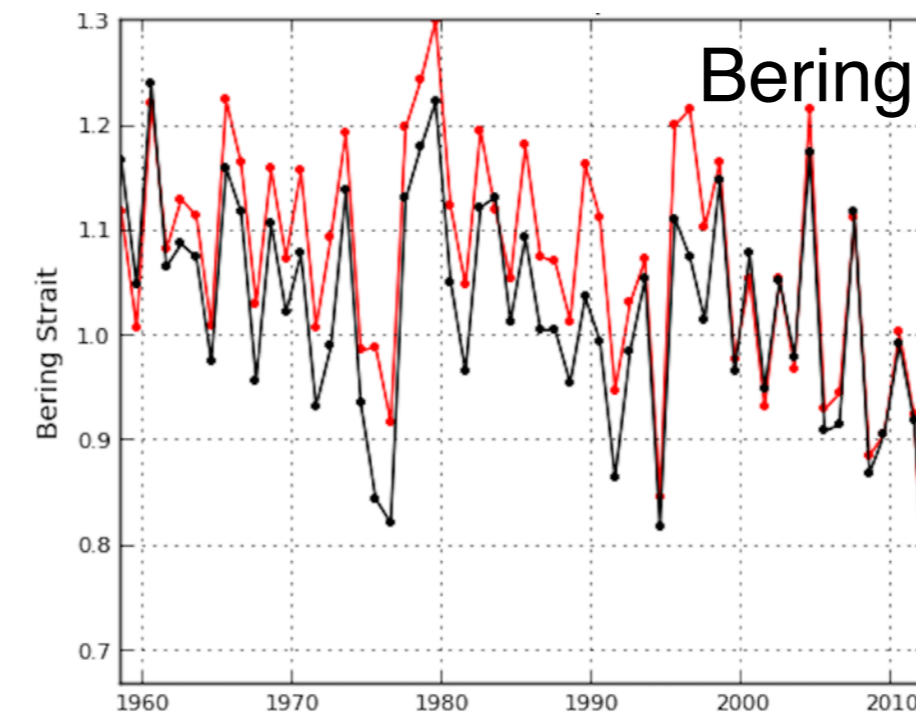
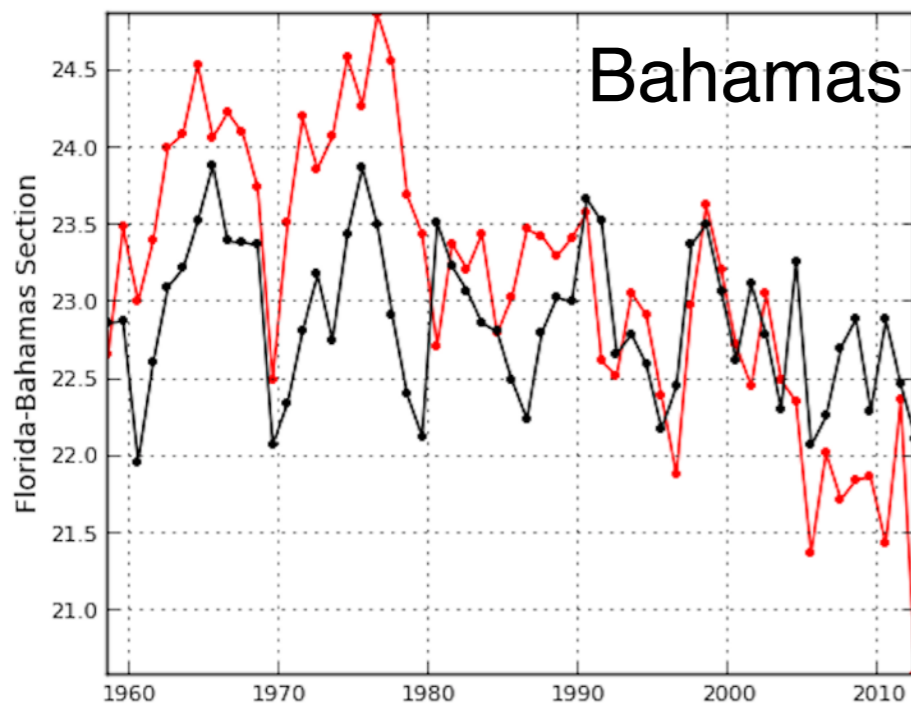
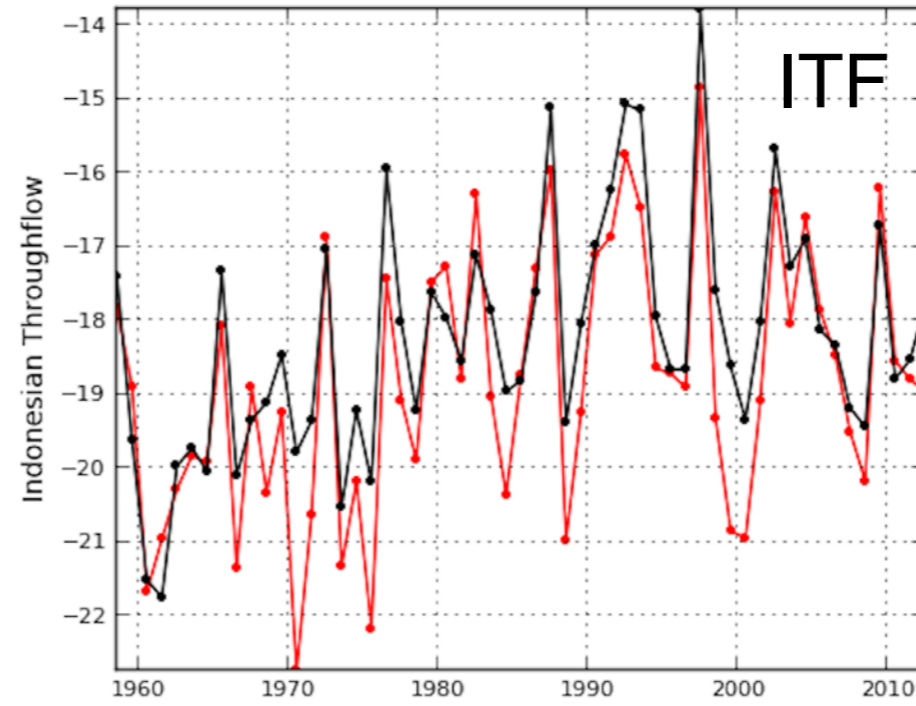
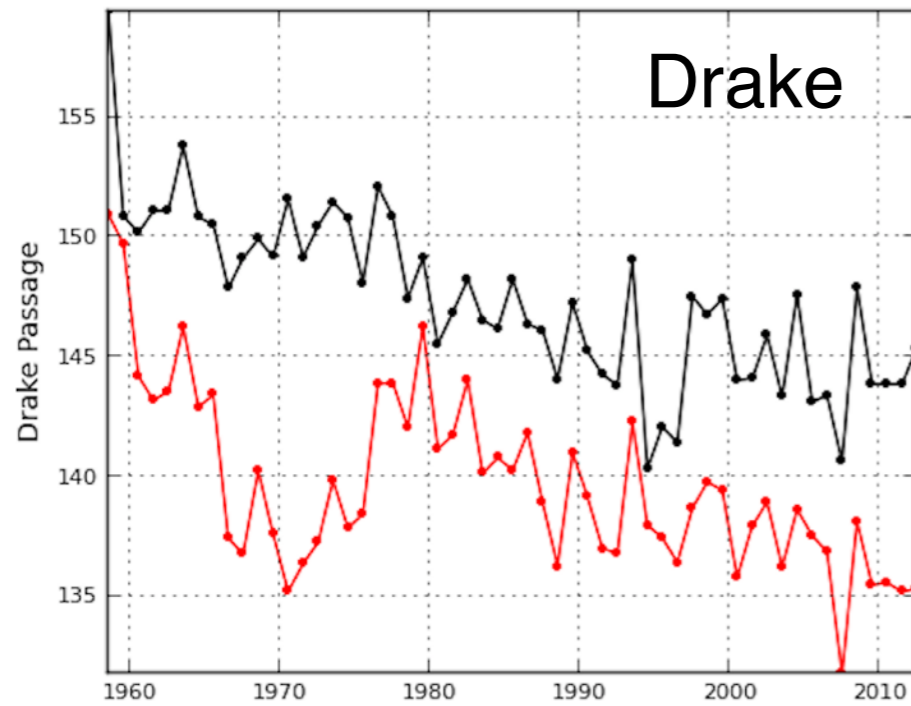
ORCA05-GJM189d SSHGLp 2000-2007 DEPTH=3.05



Sensitivity experiment with JRA at 0.5° resolution

Barotropic transport

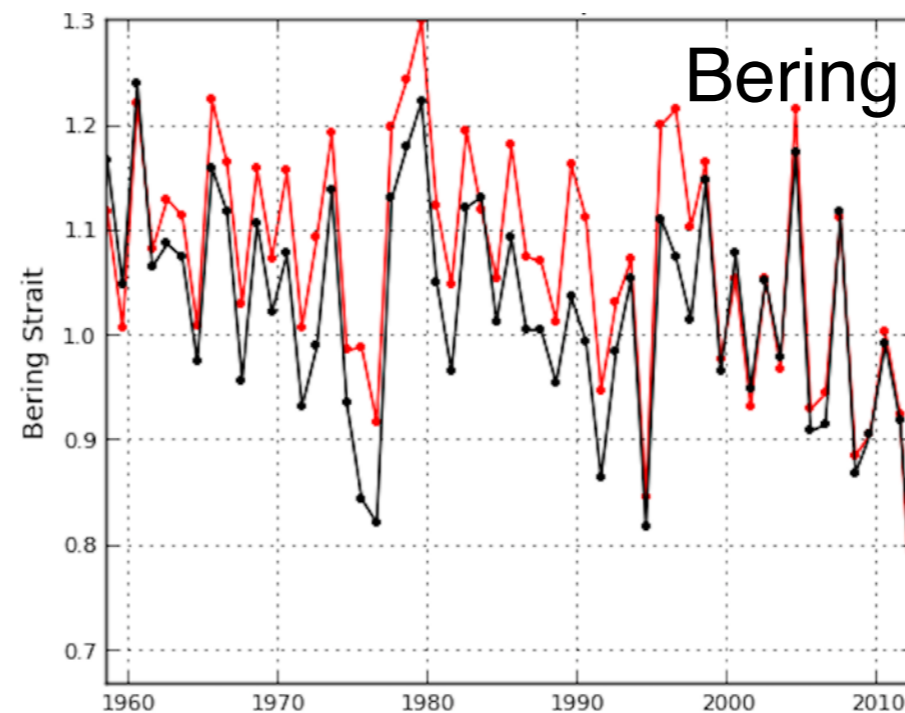
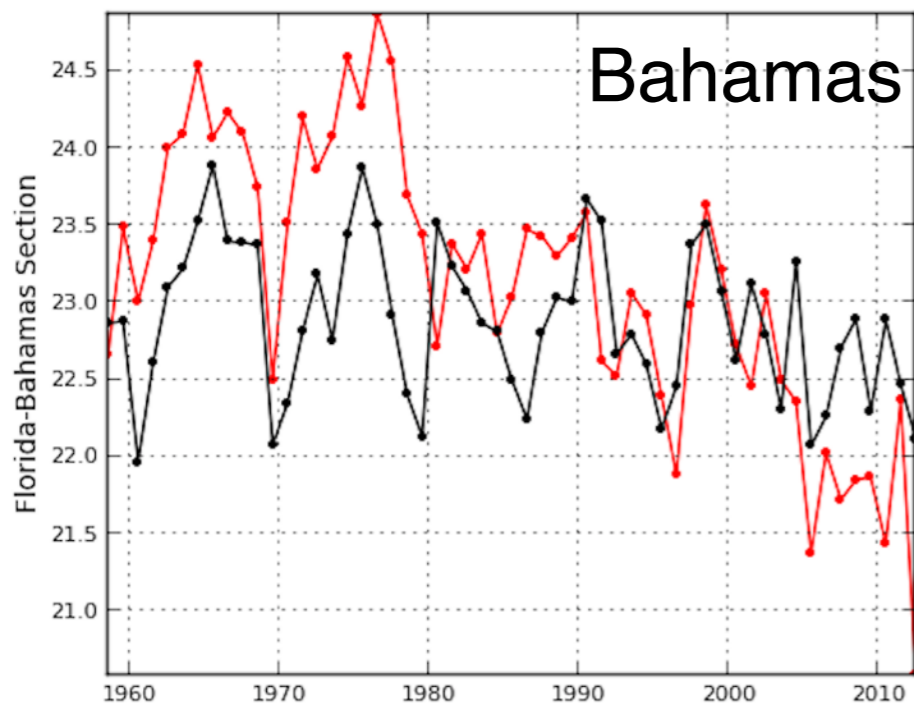
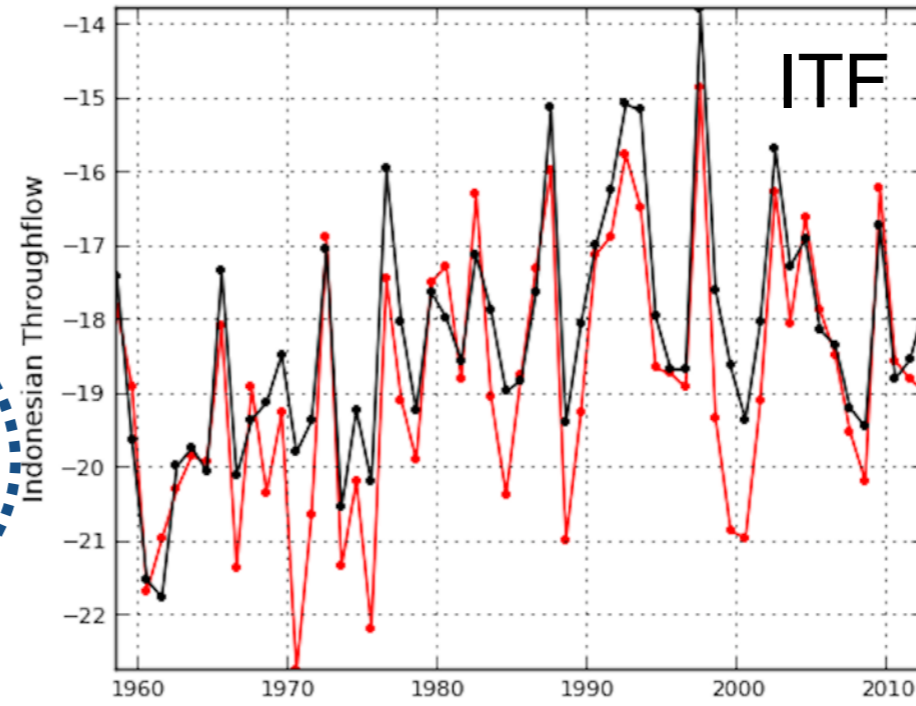
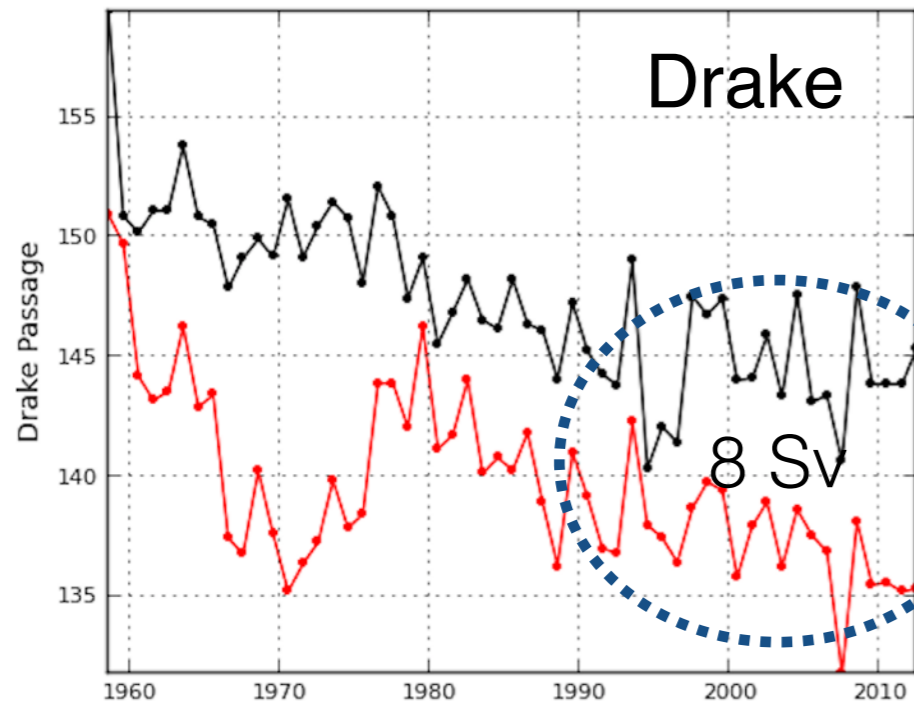
JRA : red
DFS : black



Sensitivity experiment with JRA at 0.5° resolution

Barotropic transport

JRA : red
DFS : black

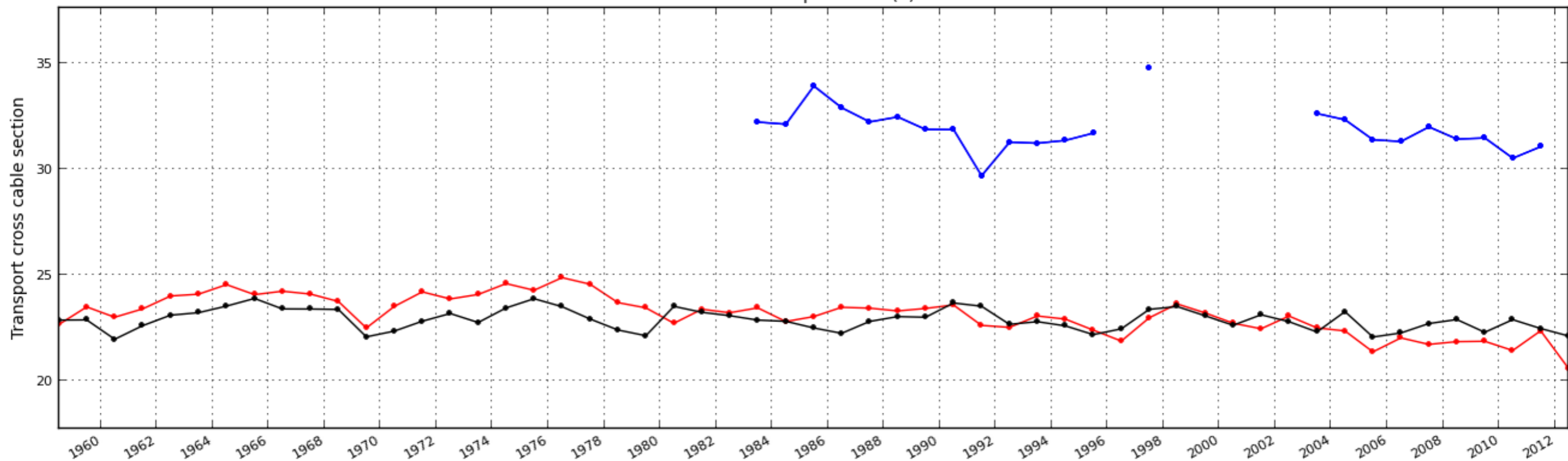


Sensitivity experiment with JRA at 0.5° resolution

Barotropic transport

cable section

Mass Transport - Obs (b)

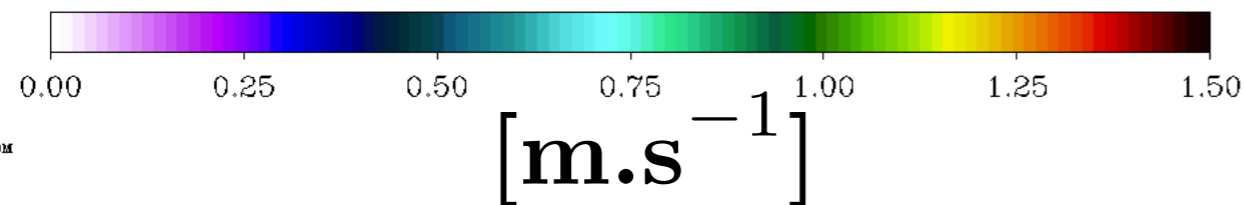
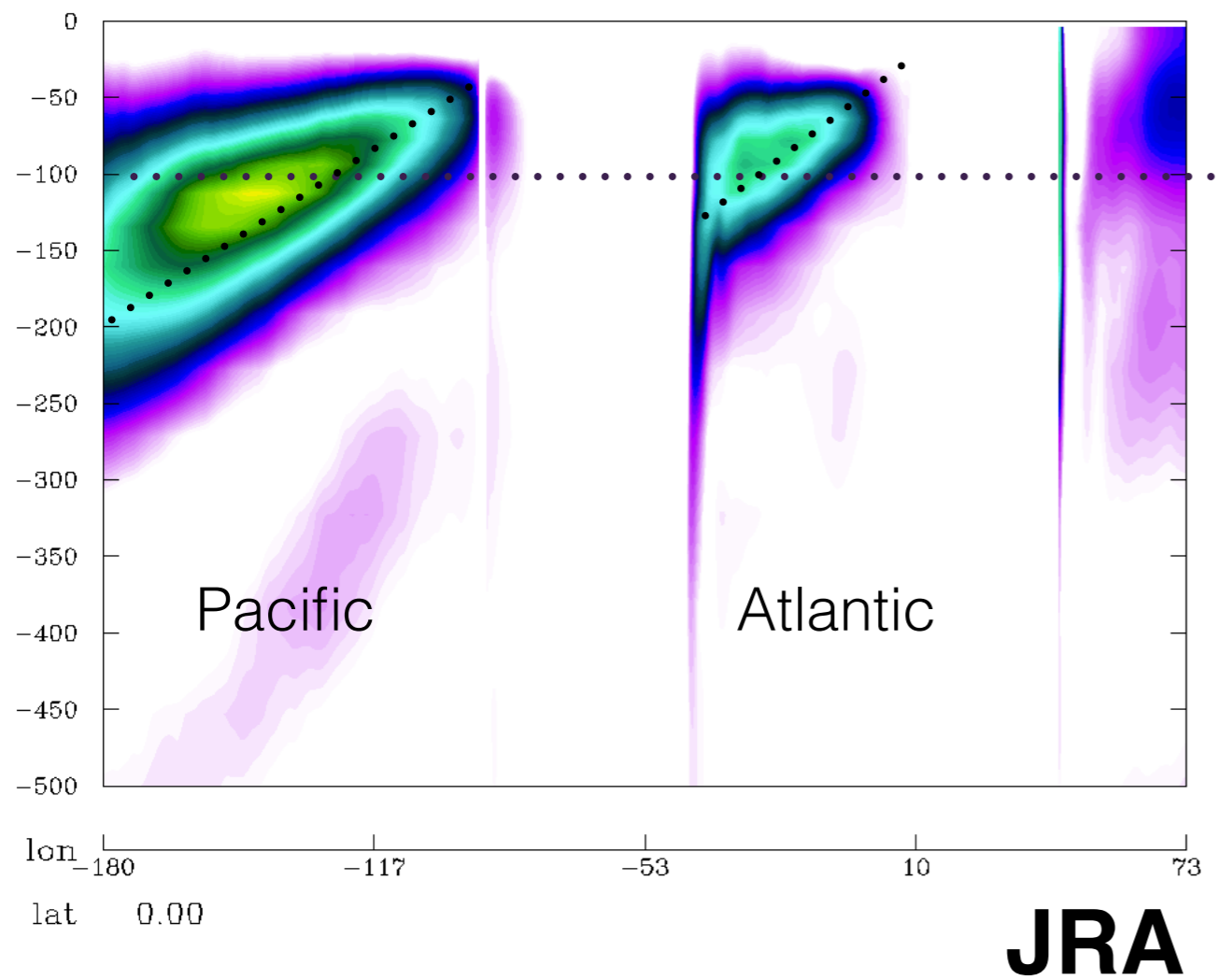


JRA : red
DFS : black
OBS : blue

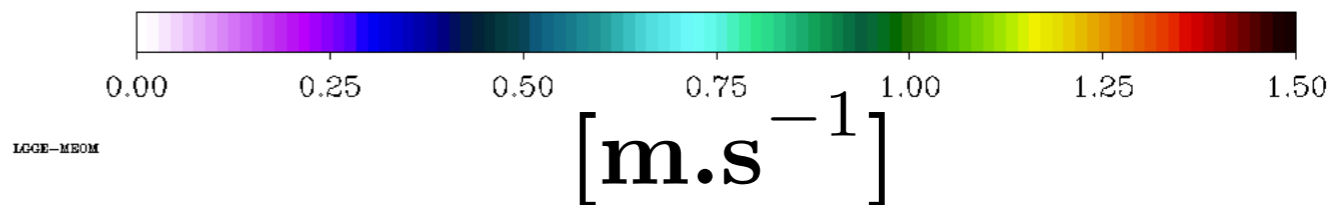
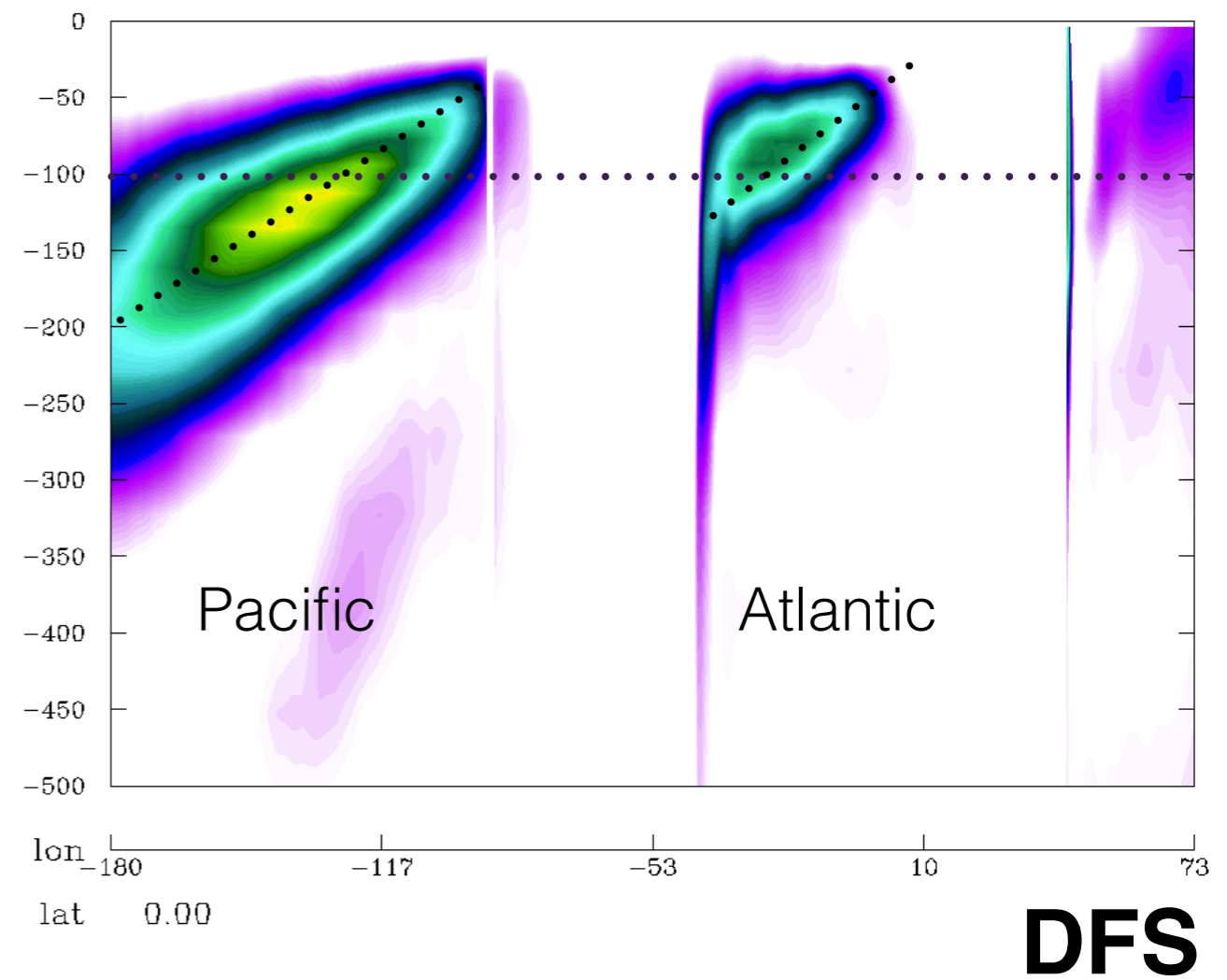
Sensitivity experiment with JRA at 0.5° resolution

Mean zonal equatorial currents

ORCA05 Uequat 2000-2007-GJMJRA1



ORCA05 Uequat 2000-2007-GJM189d



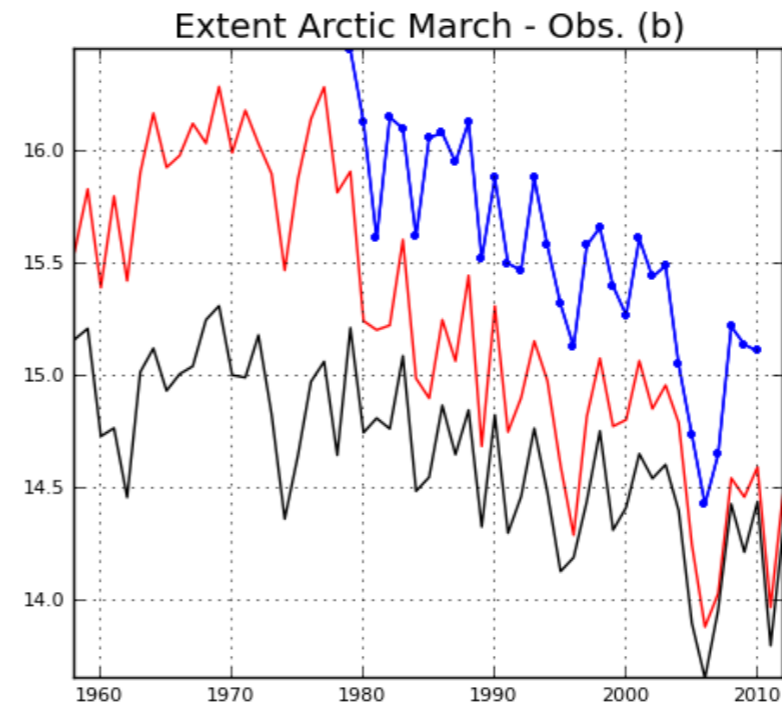
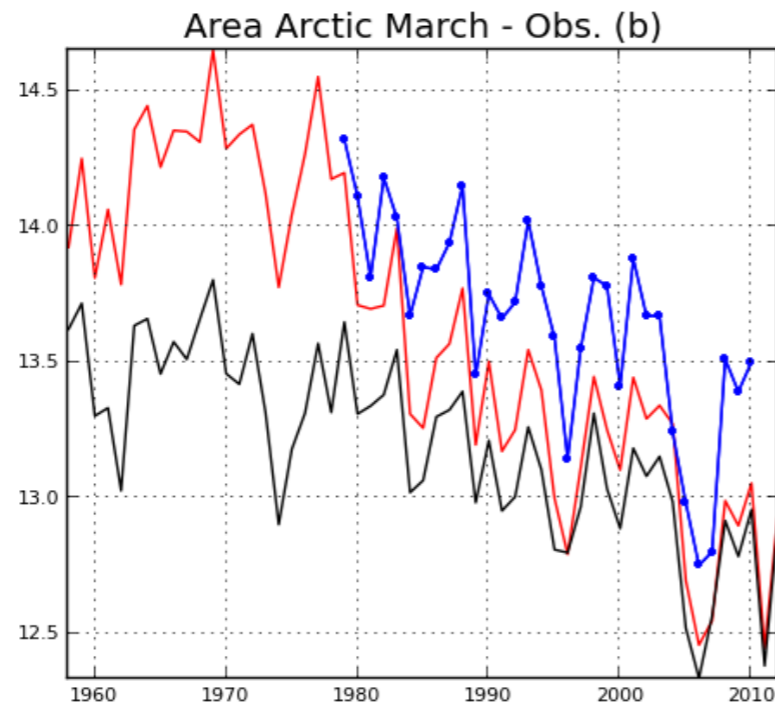
SEA ICE IN ORCA05

Sensitivity experiment with JRA at 0.5° resolution

Sea ice extent and sea ice area

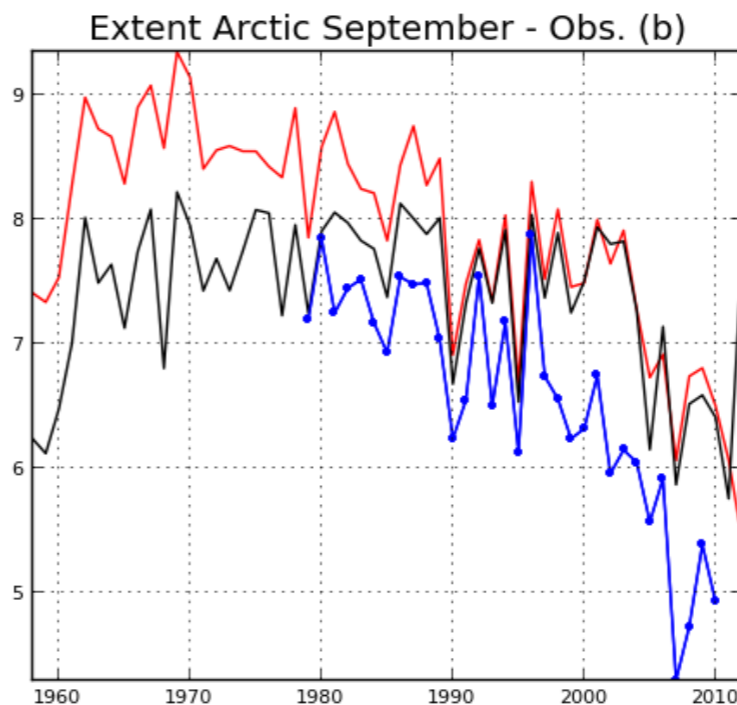
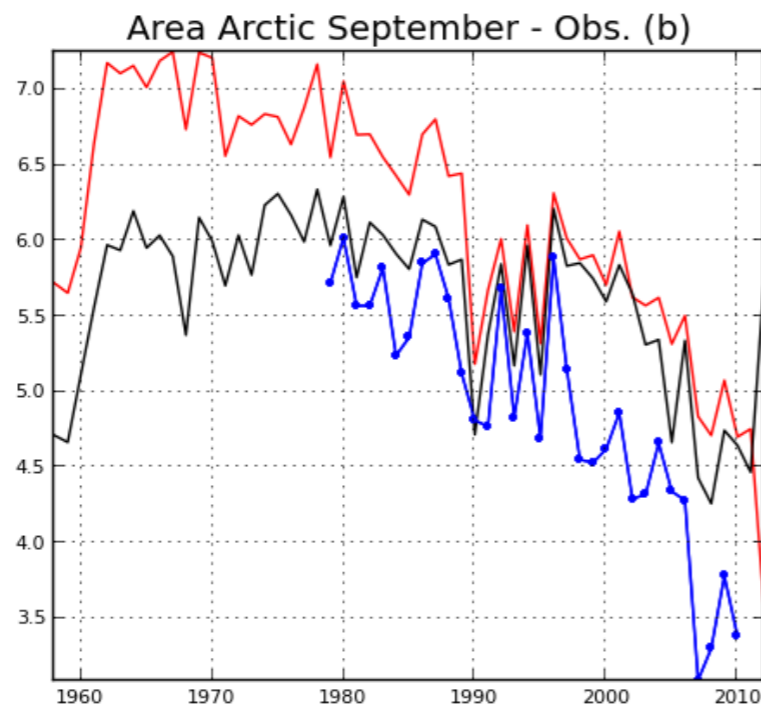
ARCTIC

Max



JRA : red
DFS : black
OBS : blue

Min



Sensitivity experiment with JRA at 0.5° resolution

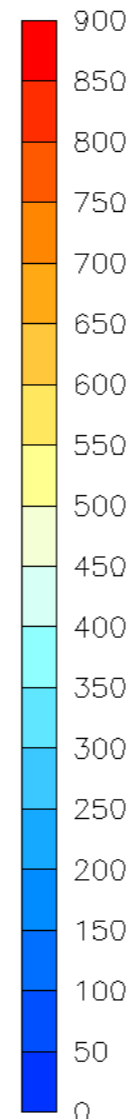
Sea ice thickness (September)

ARCTIC

Sea Ice Thicknes
Sep 2000–2007

ORCA05–GJMJRA1

JRA



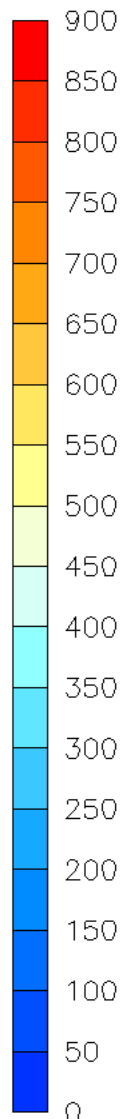
(cm)

Total area = million sq km
Volume = cubic km

Sea Ice Thicknes
Sep 2000–2007

ORCA05–GJM189d

DFS



(cm)

Total area = million sq km
Volume = cubic km

Sensitivity experiment with JRA at 0.5° resolution

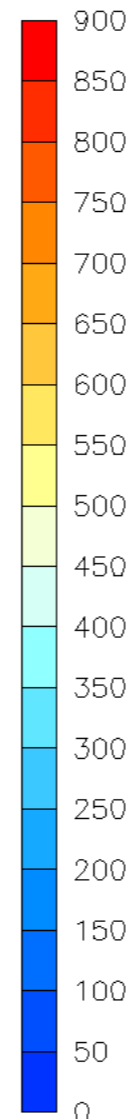
Sea ice thickness (September)

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Sea Ice Thicknes
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JRA



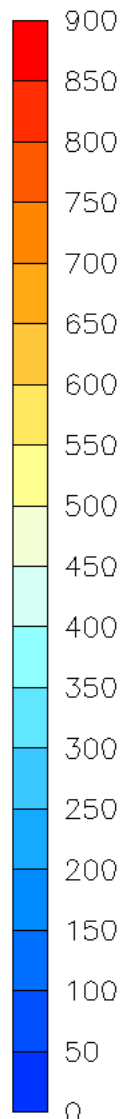
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Sea Ice Thicknes
Sep 2000–2007

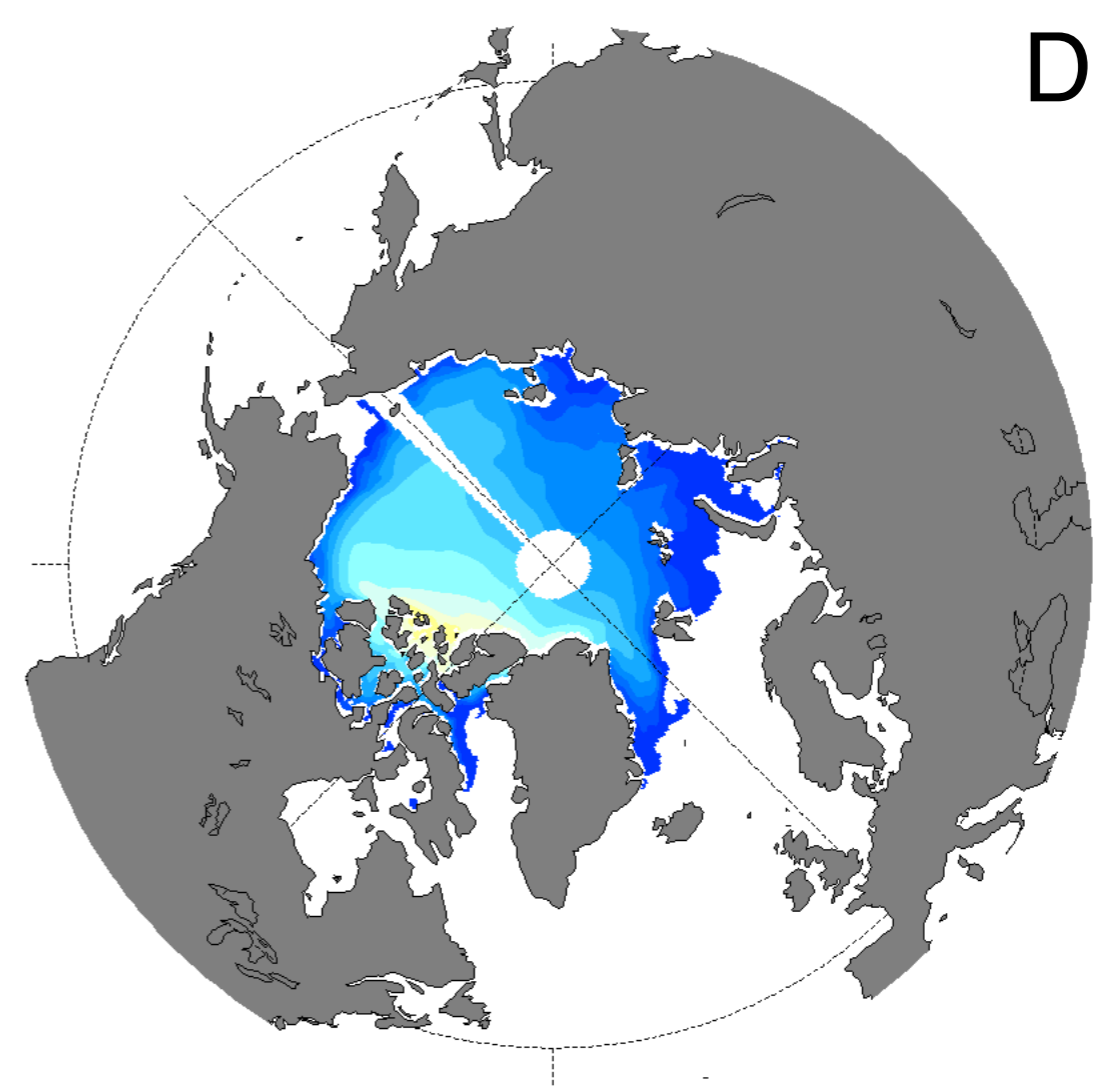
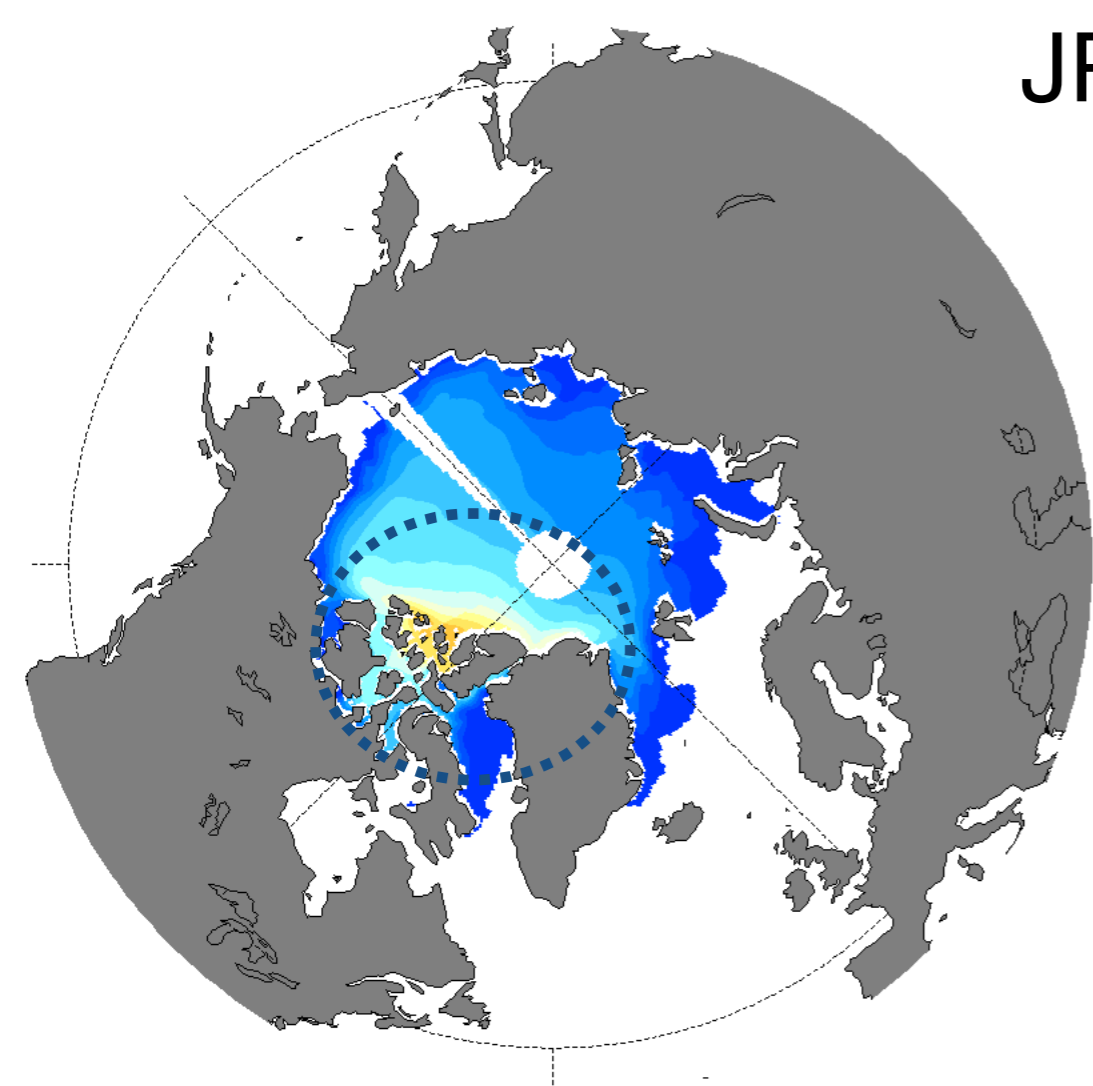
ORCA05–GJM189d

DFS



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Sensitivity experiment with JRA at 0.5° resolution

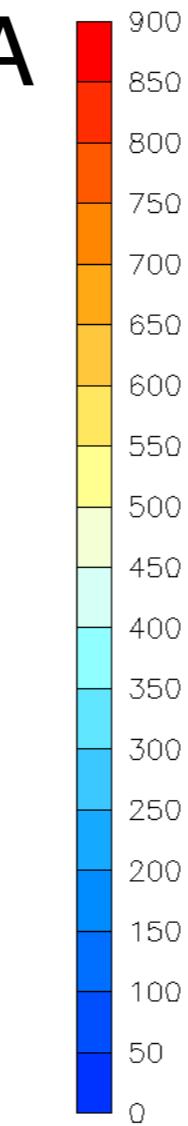
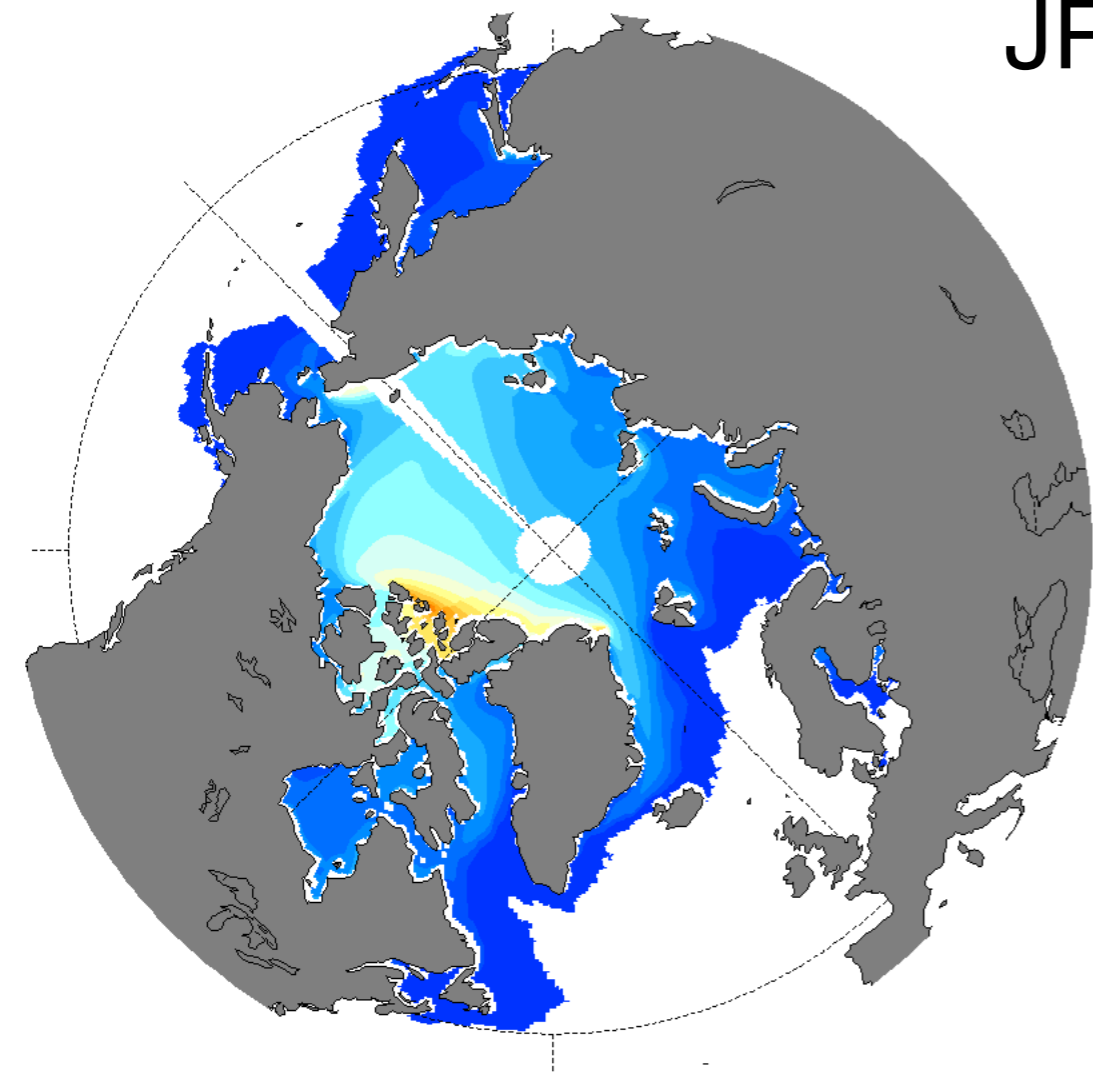
Sea ice thickness (March)

ARCTIC

Sea Ice Thicknes
Mar 2000–2007

ORCA05–GJMJRA1

JRA



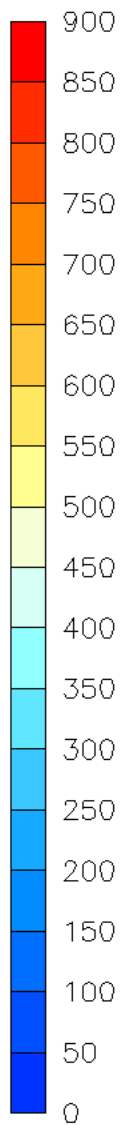
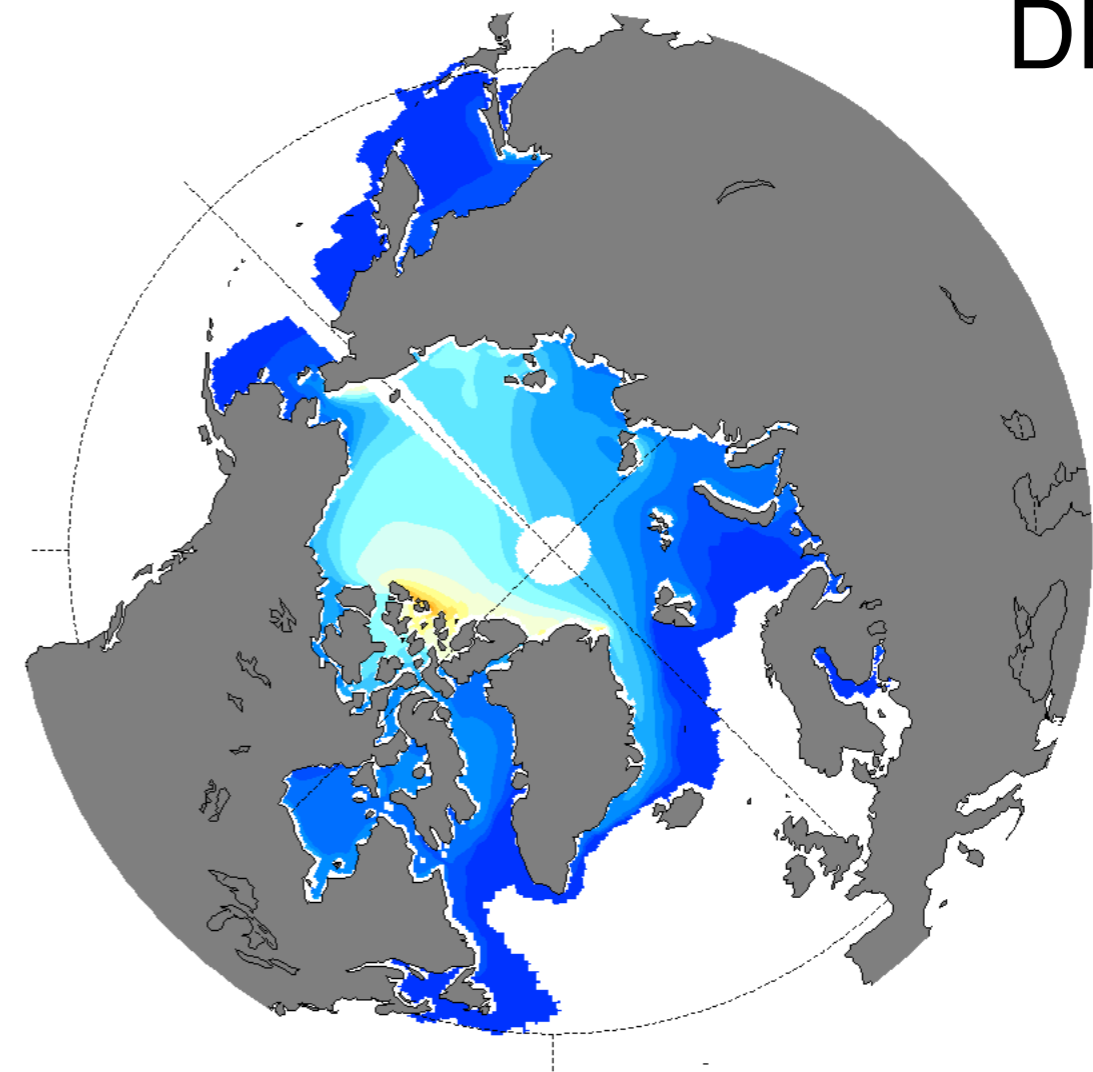
(cm)

Total area = million sq km
Volume = cubic km

Sea Ice Thicknes
Mar 2000–2007

ORCA05–GJM189d

DFS



(cm)

Total area = million sq km
Volume = cubic km

Sensitivity experiment with JRA at 0.5° resolution

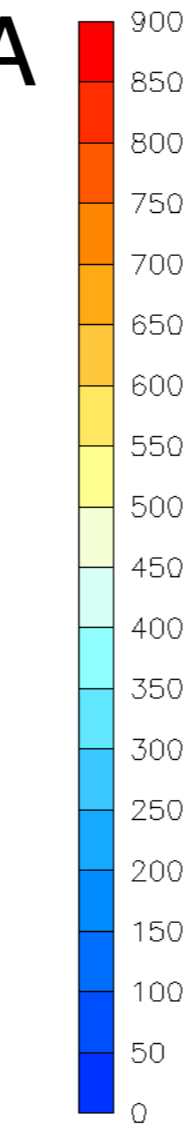
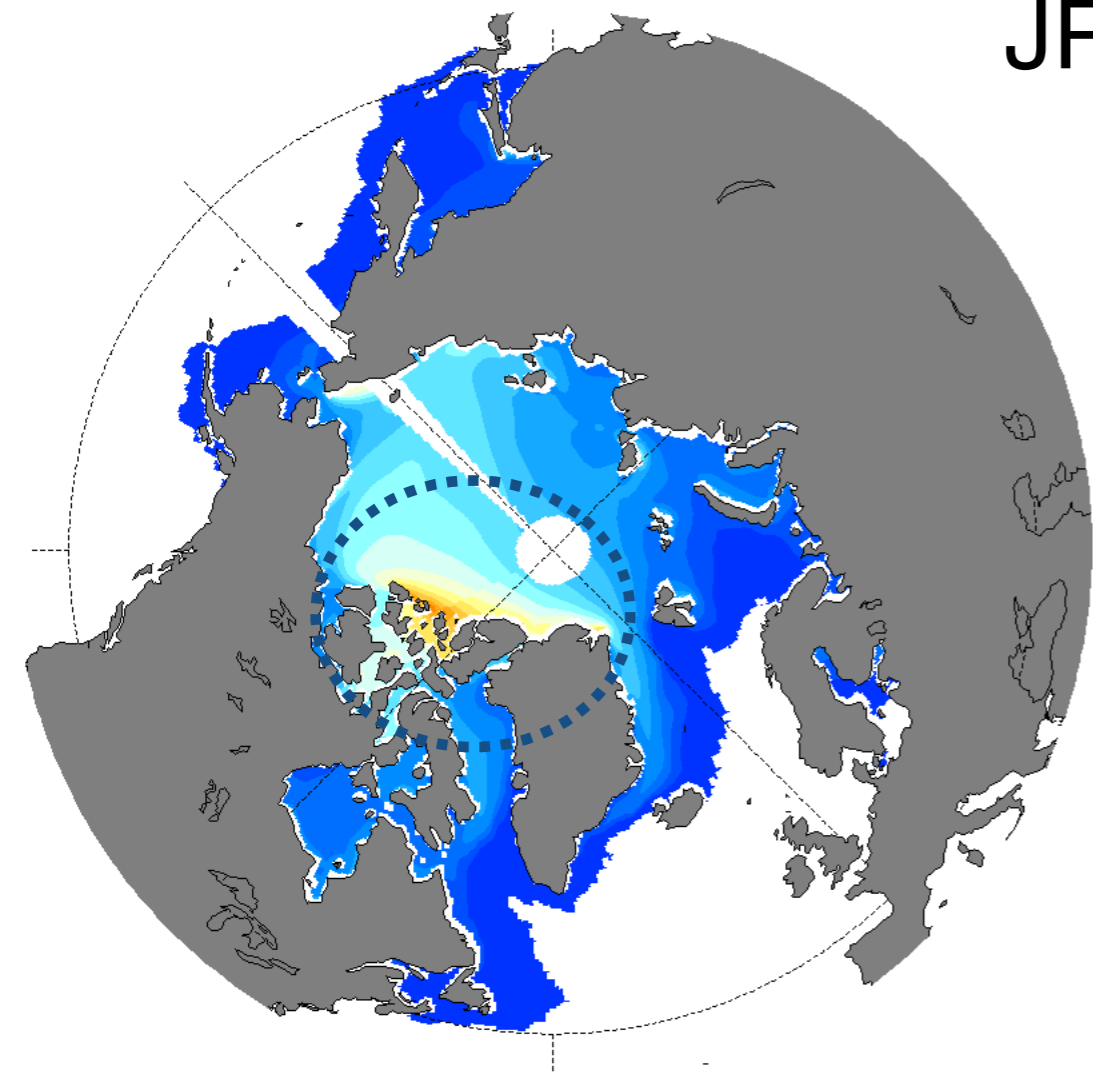
Sea ice thickness (March)

ARCTIC

Sea Ice Thicknes
Mar 2000–2007

ORCA05–GJMJRA1

JRA

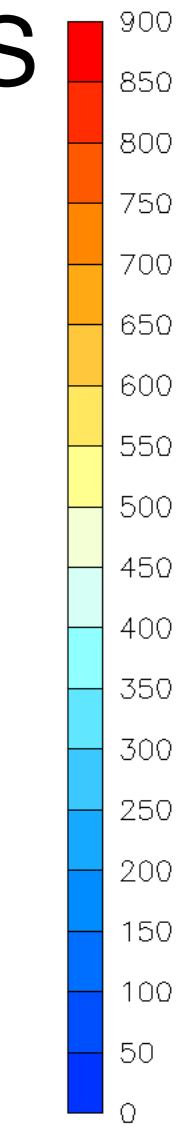
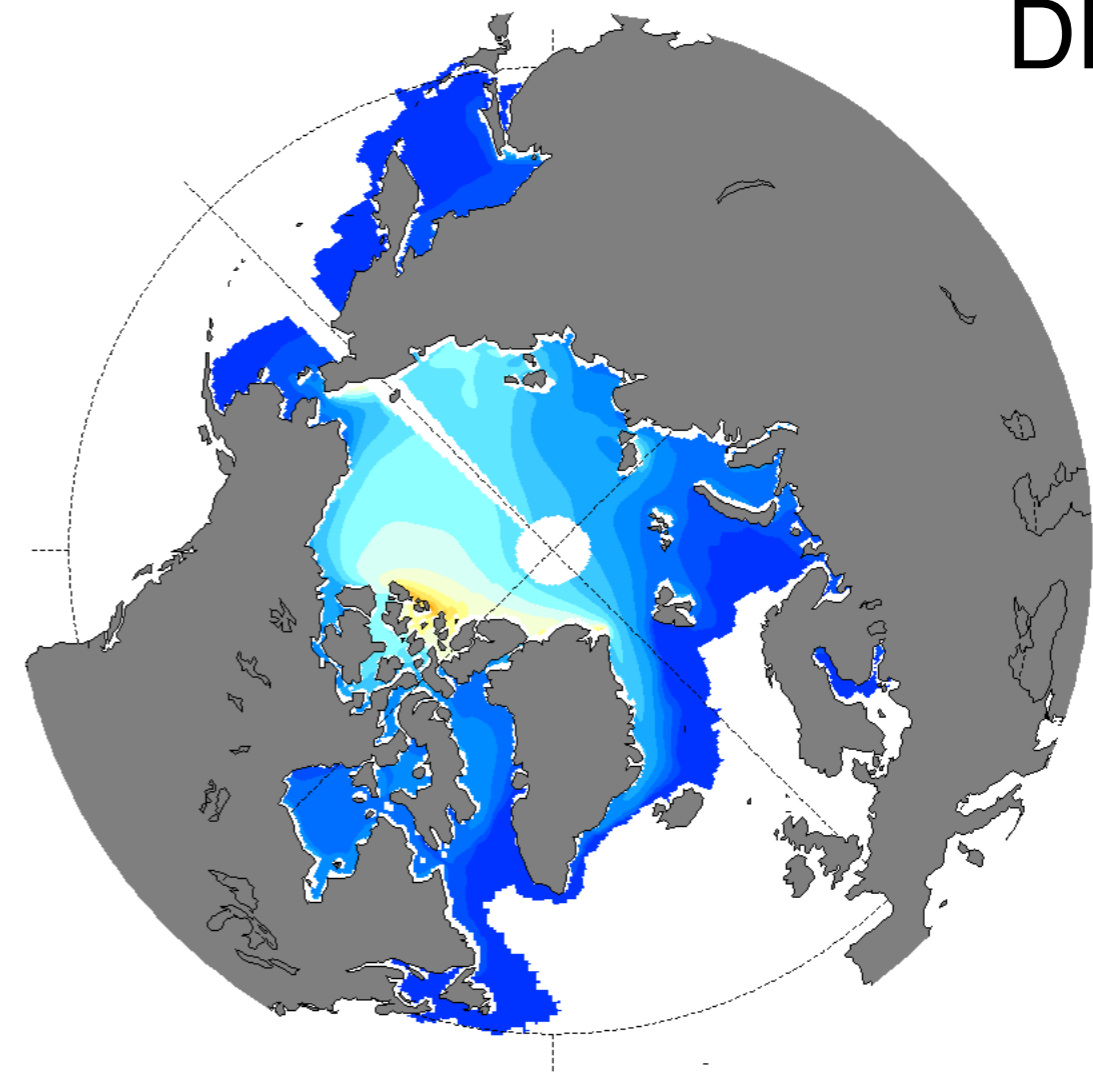


Total area = million sq km
Volume = cubic km

Sea Ice Thicknes
Mar 2000–2007

ORCA05–GJM189d

DFS



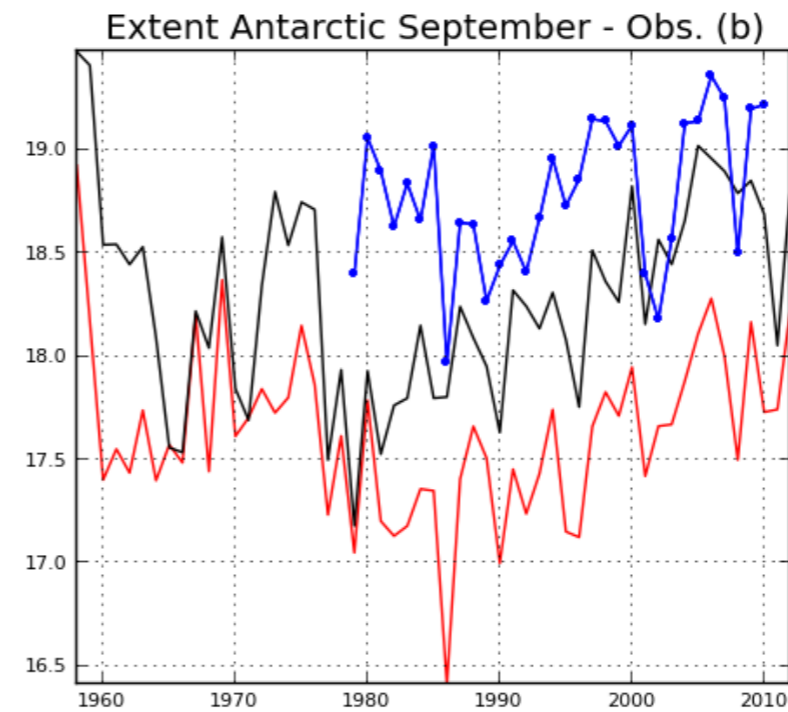
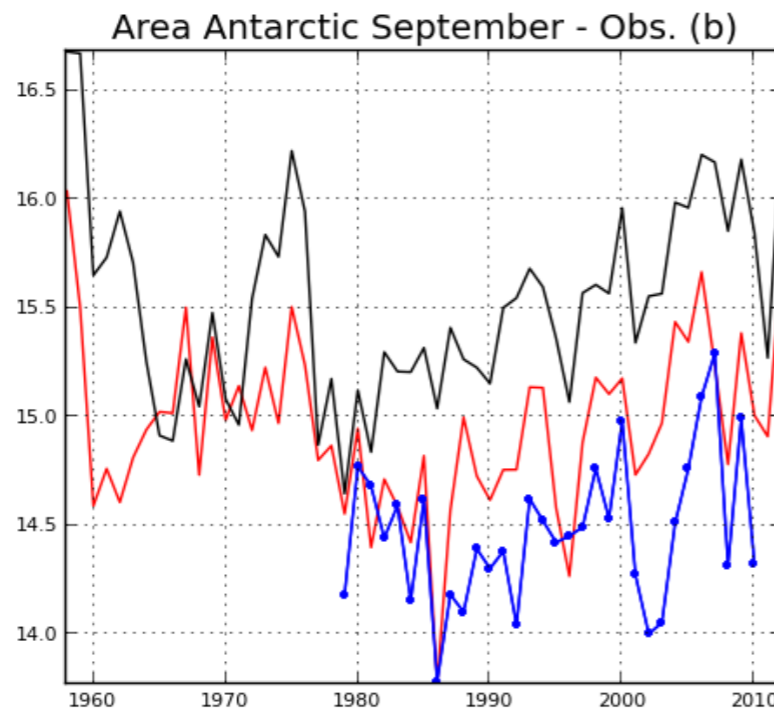
Total area = million sq km
Volume = cubic km

Sensitivity experiment with JRA at 0.5° resolution

Sea ice extent and sea ice area (Antarctic)

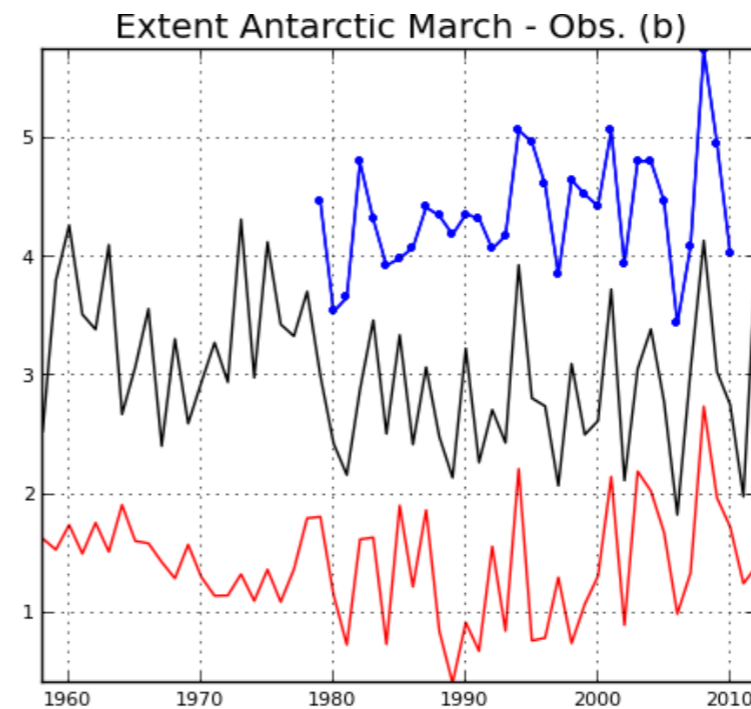
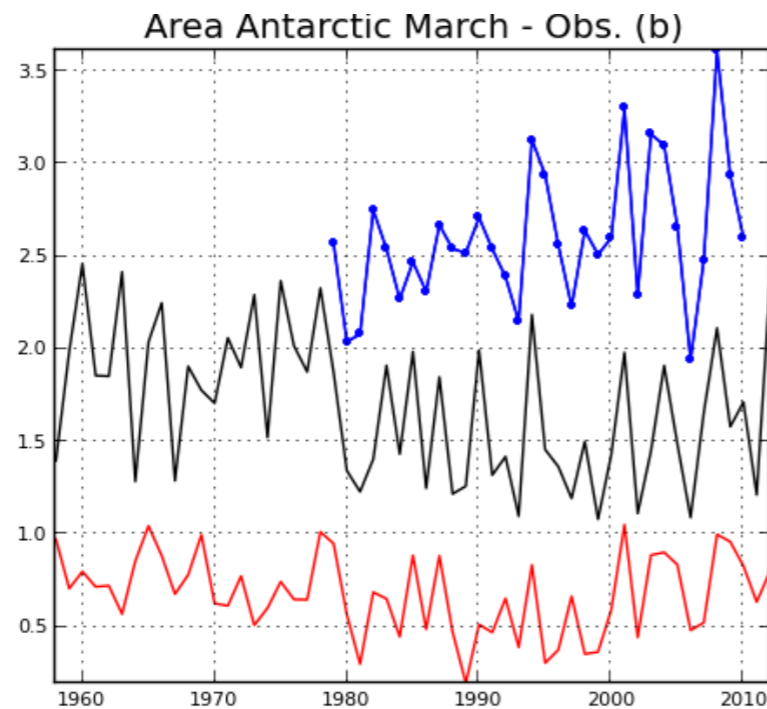
ANTARCTIC

Max



JRA : red
DFS : black
OBS : blue

Min



Sensitivity experiment with JRA at 0.5° resolution

Sea ice thickness (March)

ANTARCTIC

Sea Ice Thicknes
Mar 2000–2007

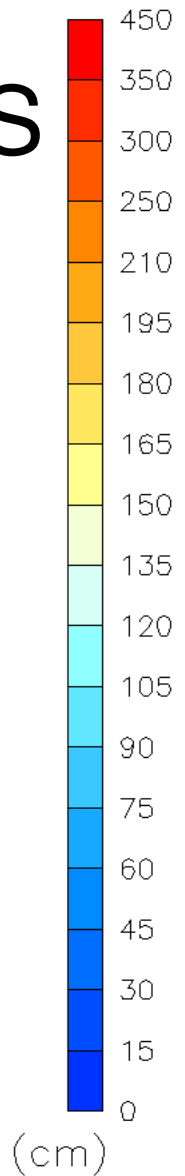
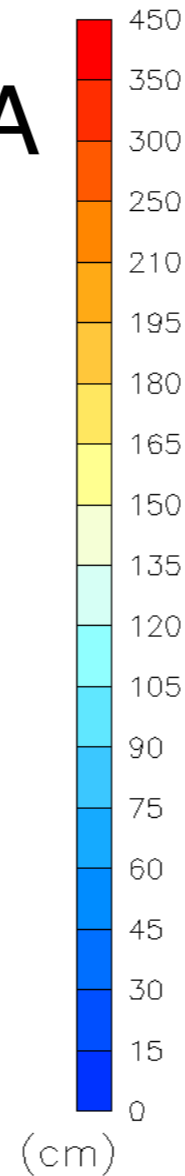
ORCA05–GJMJRA1

Sea Ice Thicknes
Mar 2000–2007

ORCA05–GJM189d

JRA

DFS



Total area = million sq km
Volume = cubic km

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Volume = cubic km

Sensitivity experiment with JRA at 0.5° resolution

Sea ice thickness (March)

ANTARCTIC

Sea Ice Thicknes
Mar 2000–2007

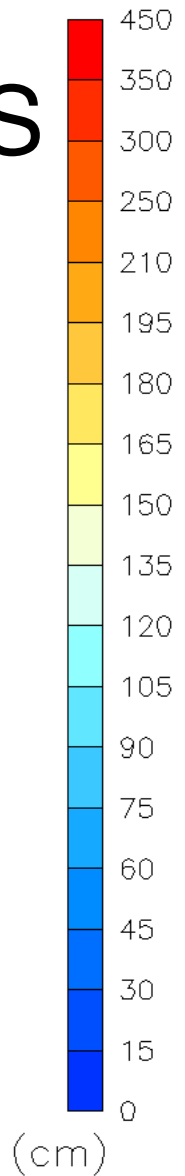
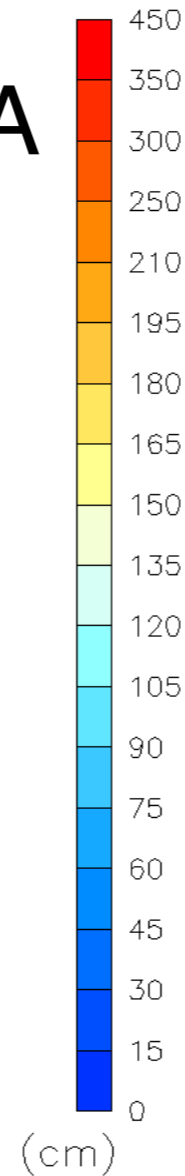
ORCA05–GJMJRA1

Sea Ice Thicknes
Mar 2000–2007

ORCA05–GJM189d

JRA

DFS



Total area = million sq km
Volume = cubic km

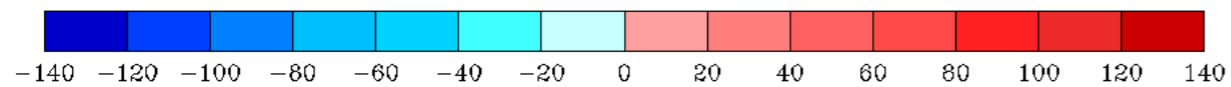
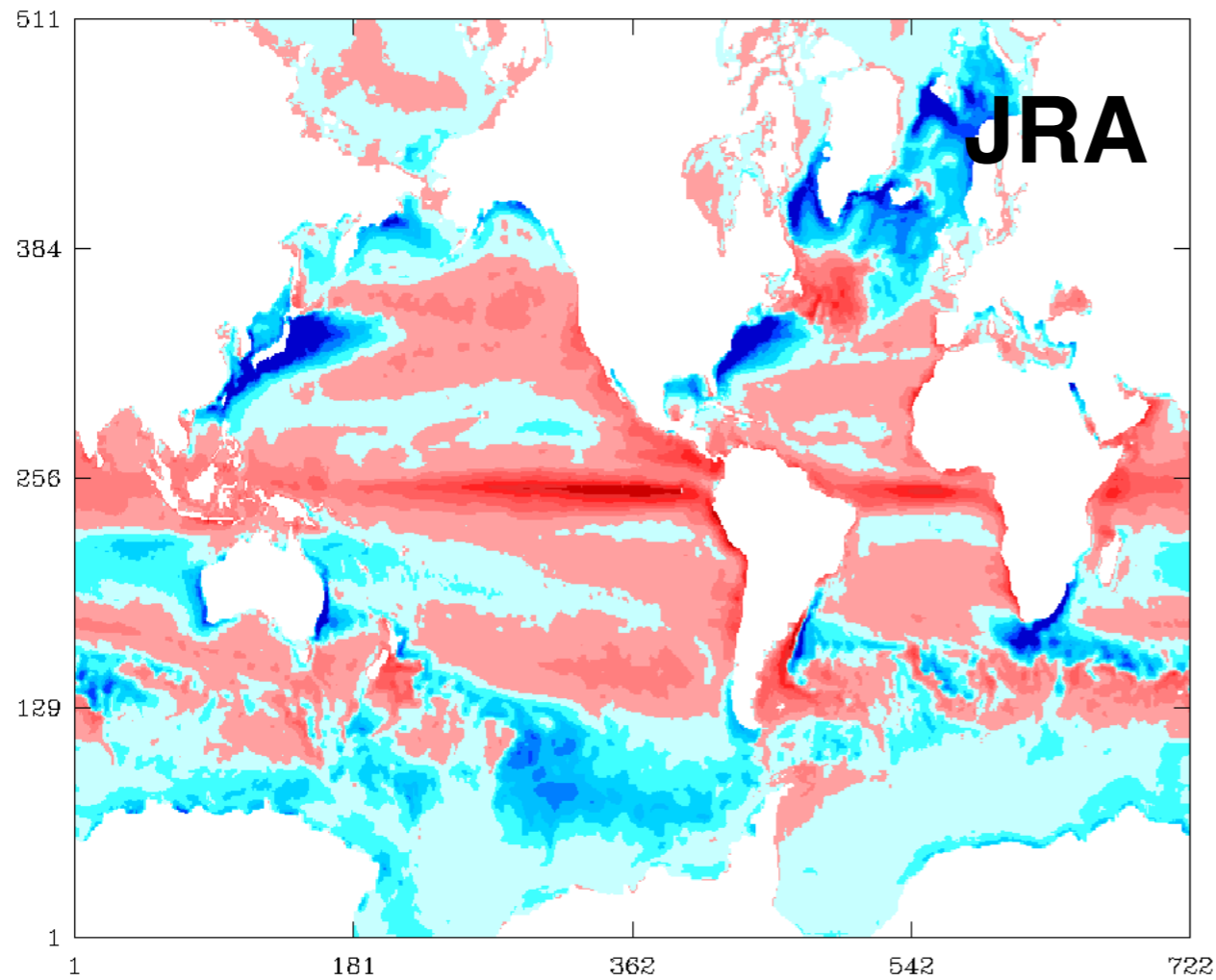
Total area = million sq km
Volume = cubic km

AIR-SEA FLUXES AND MIXED LAYER IN ORCA05

Sensitivity experiment with JRA at 0.5° resolution

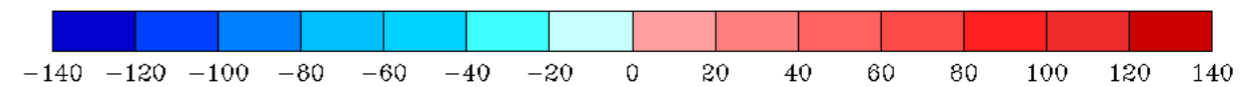
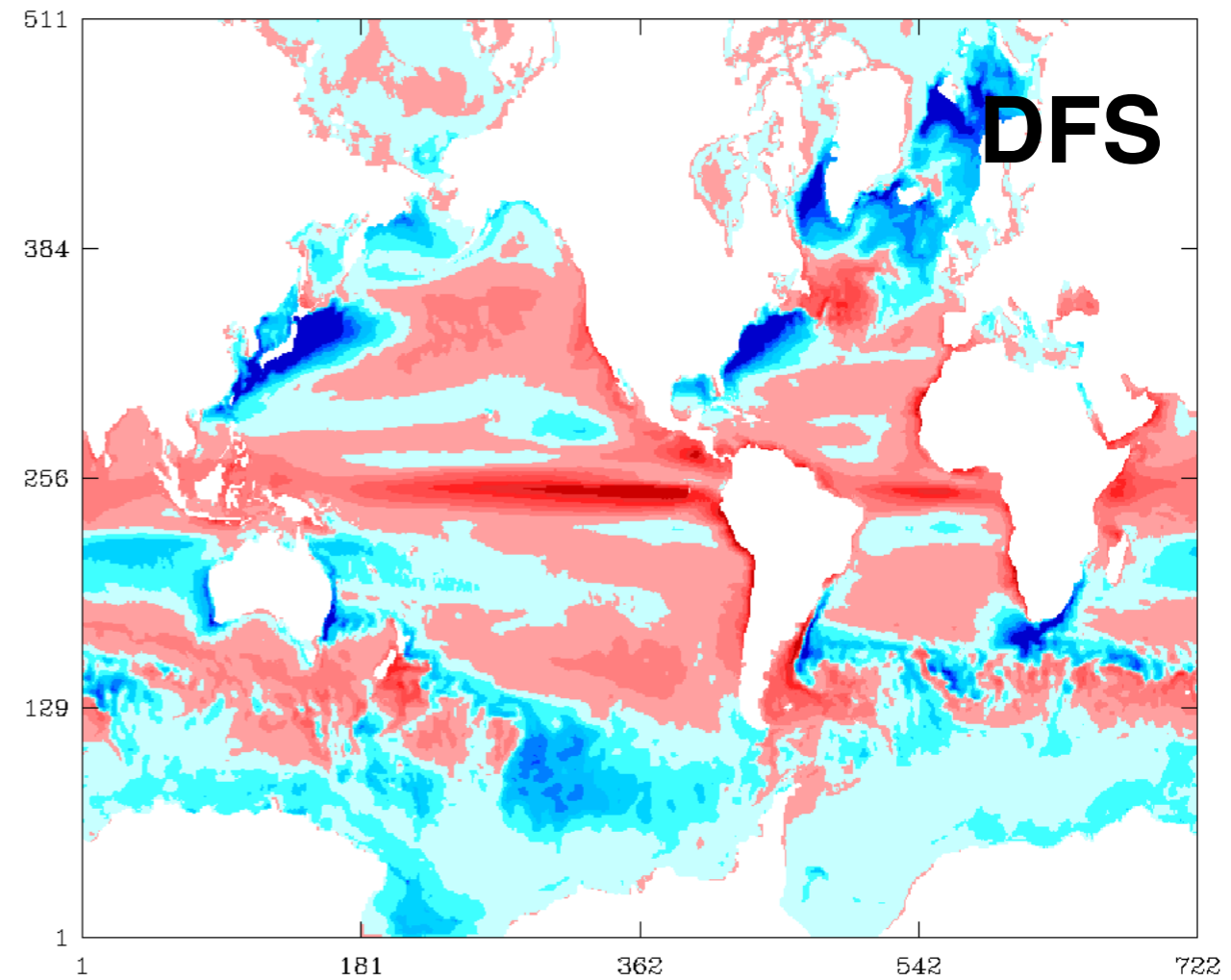
Net heat flux

ORCA05-GJMJRA1 HeatFlx 2000-2007 DEPTH=3.05



[$\text{W}\cdot\text{m}^{-2}$]

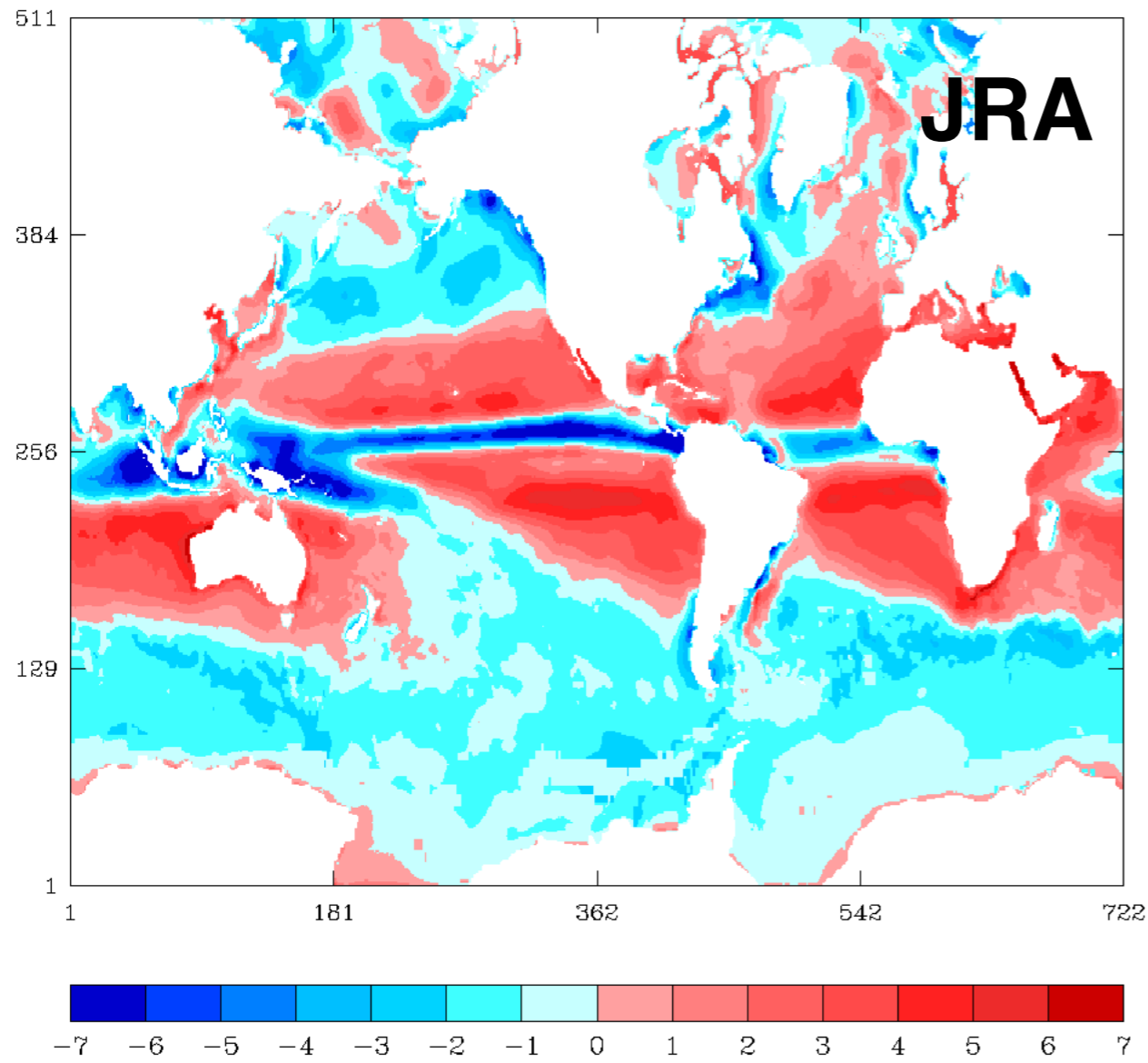
ORCA05-GJM189d HeatFlx 2000-2007 DEPTH=3.05



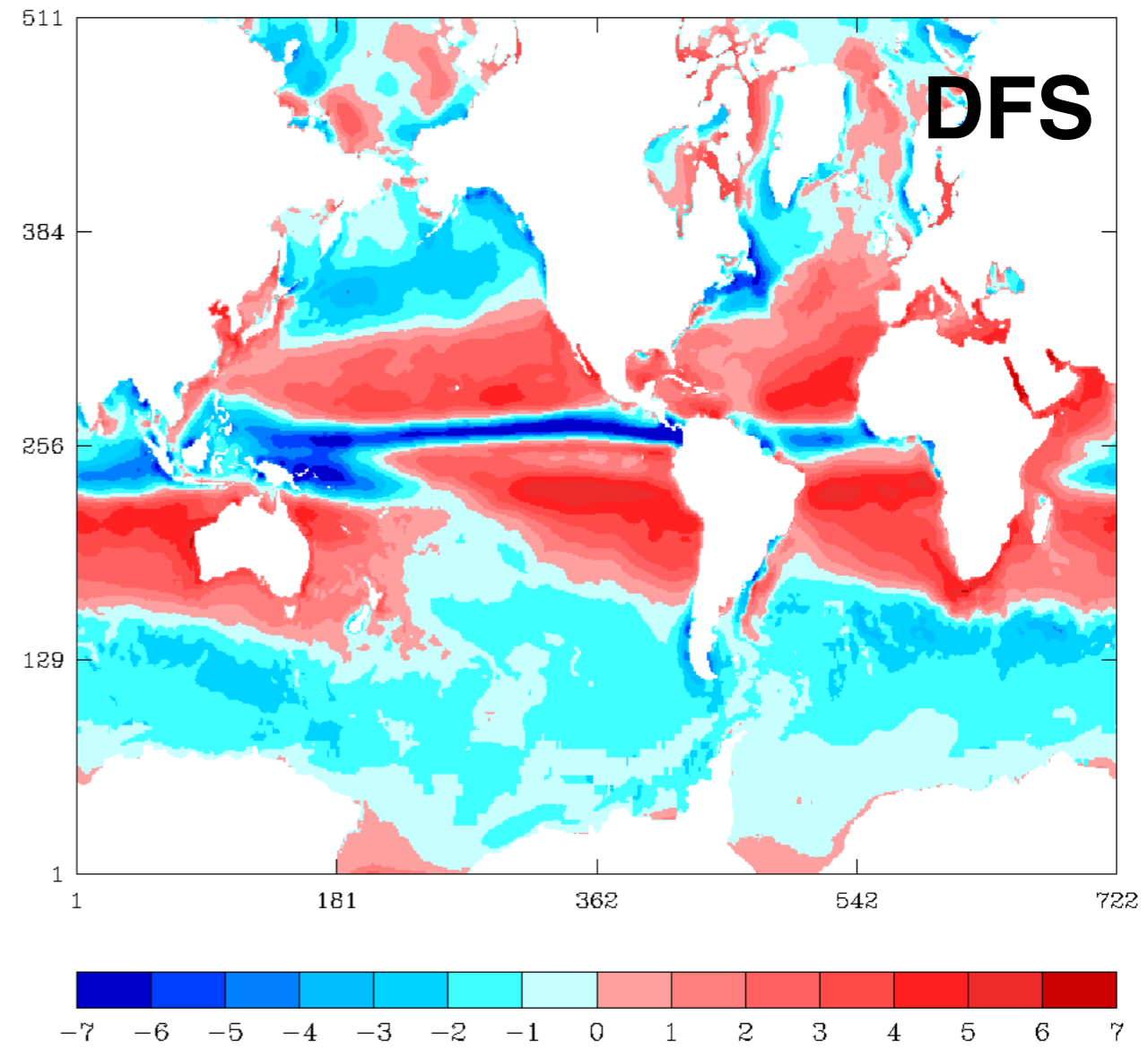
[$\text{W}\cdot\text{m}^{-2}$]

Freshwater flux

ORCA05-GJMJRA1 WaterFlx 2000-2007 DEPTH=3.05



ORCA05-GJM189d WaterFlx 2000-2007 DEPTH=3.05

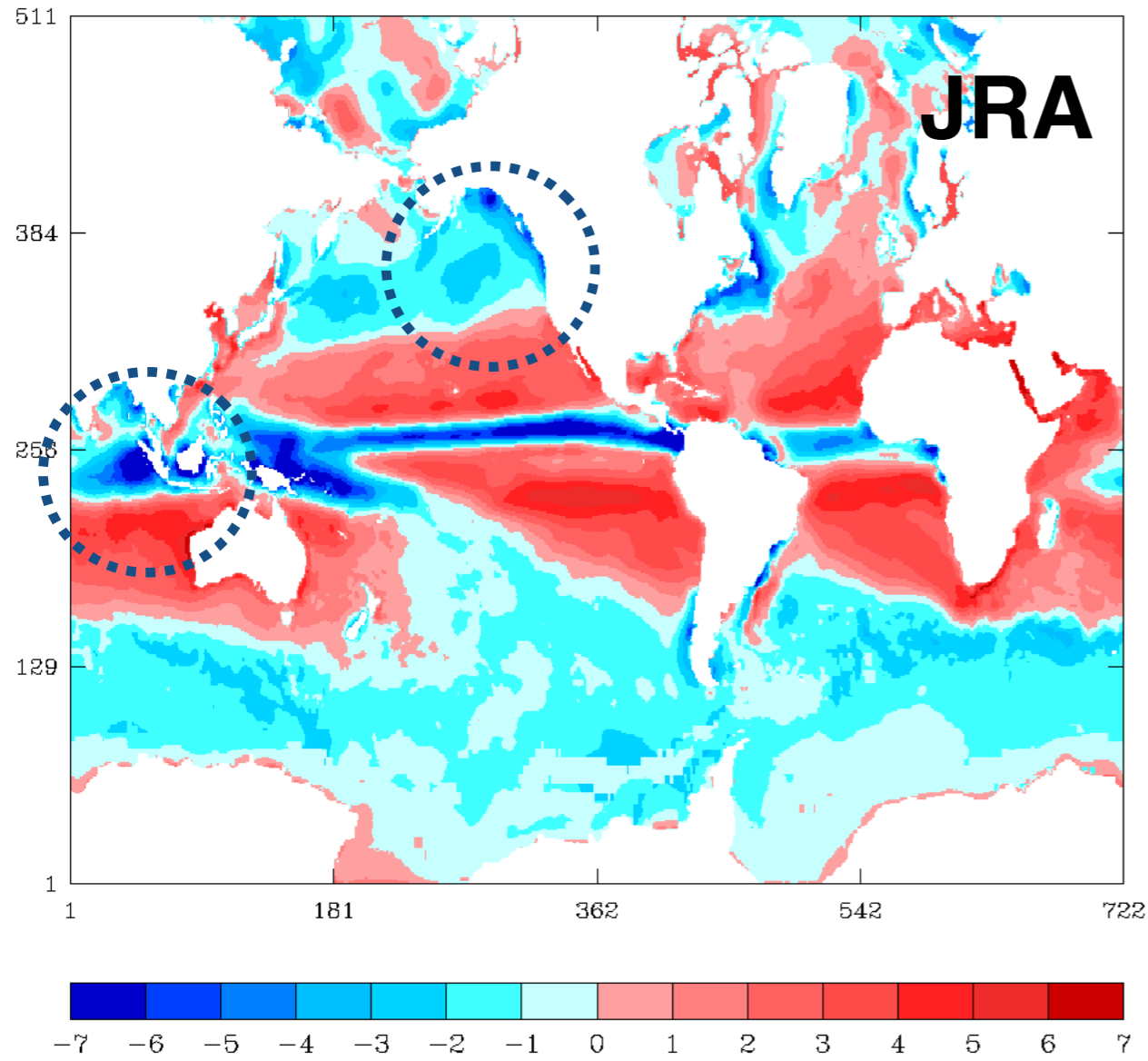


[mm.d⁻¹]

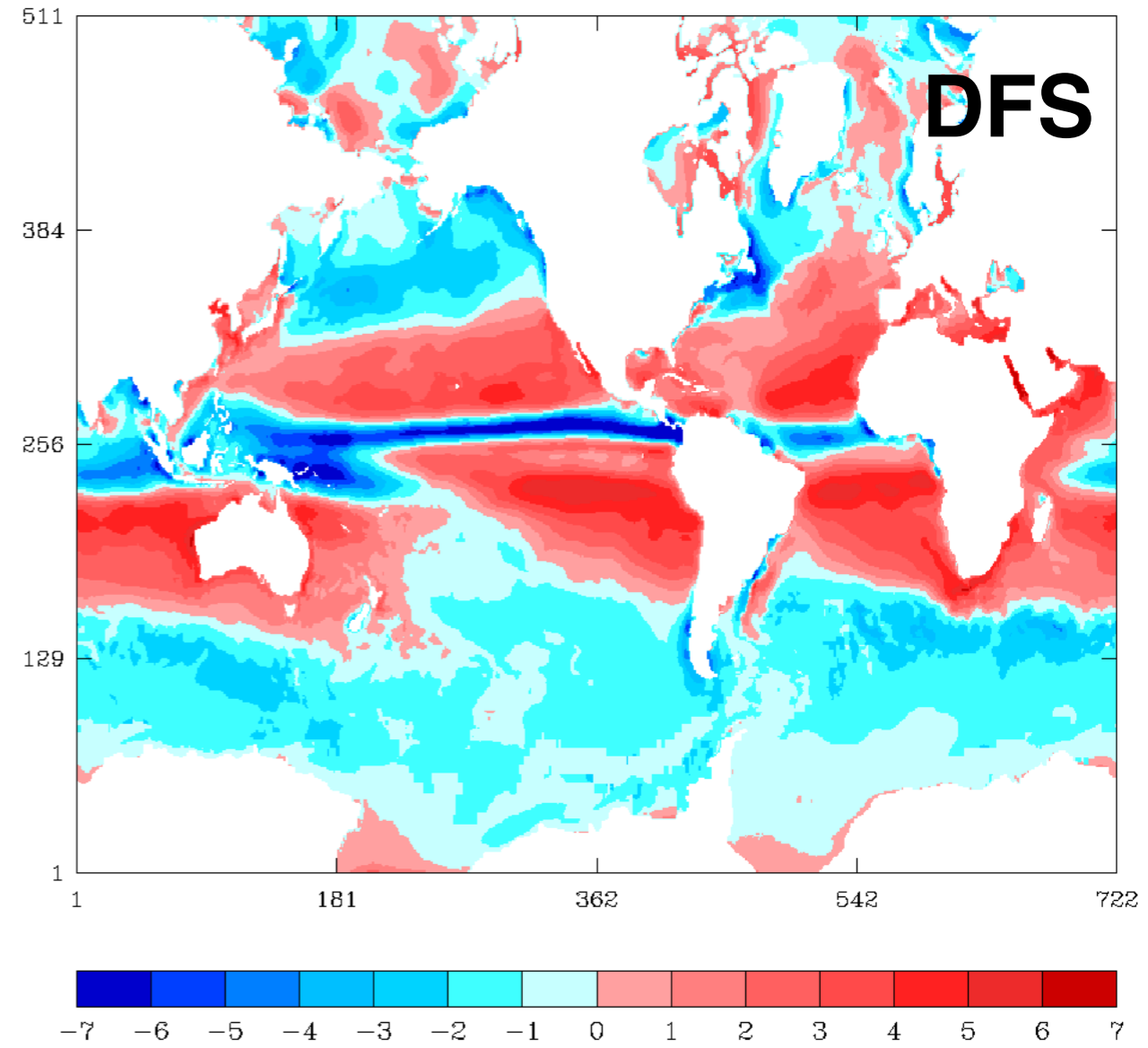
[mm.d⁻¹]

Freshwater flux

ORCA05-GJMJRA1 WaterFlx 2000-2007 DEPTH=3.05



ORCA05-GJM189d WaterFlx 2000-2007 DEPTH=3.05

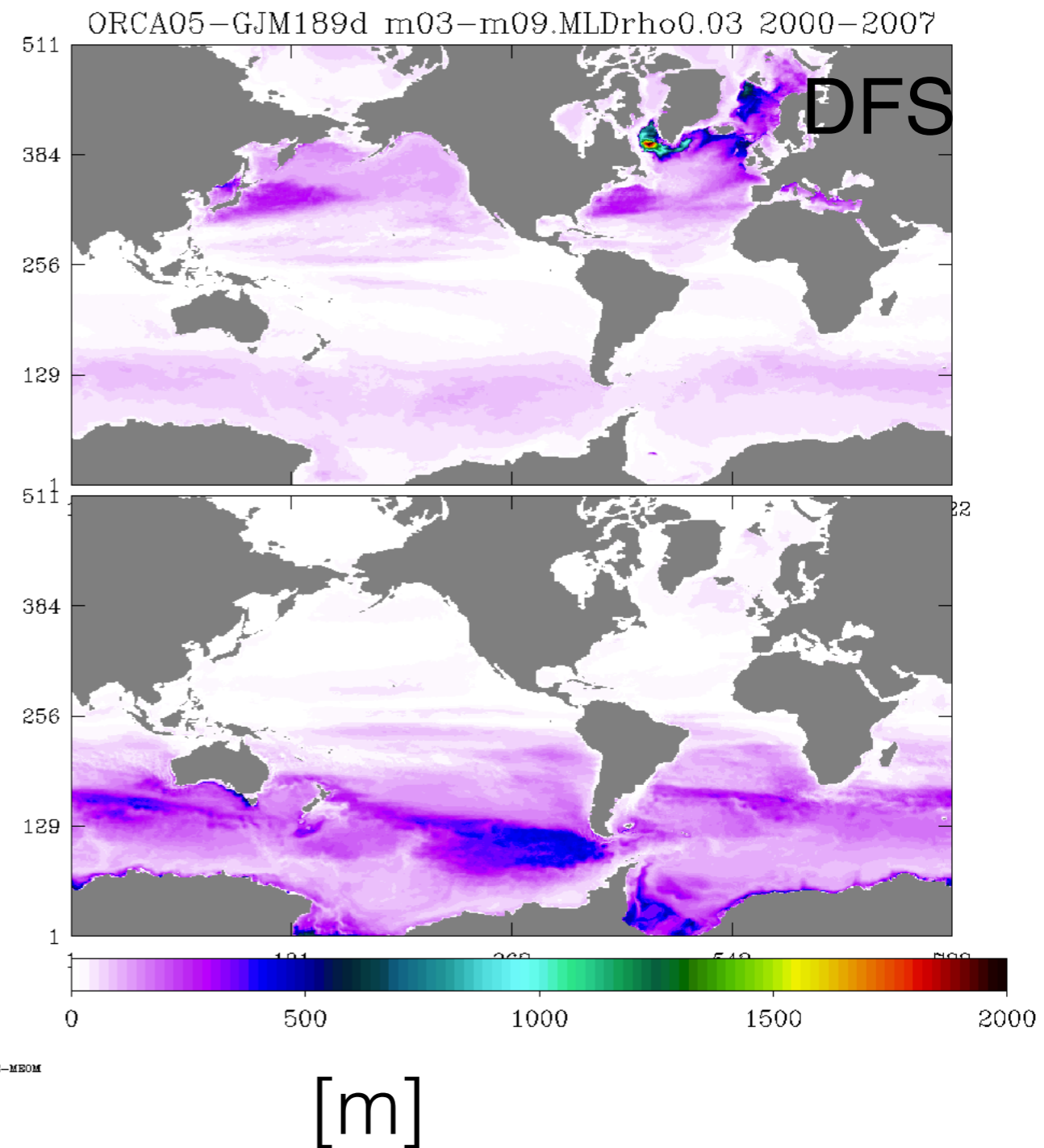
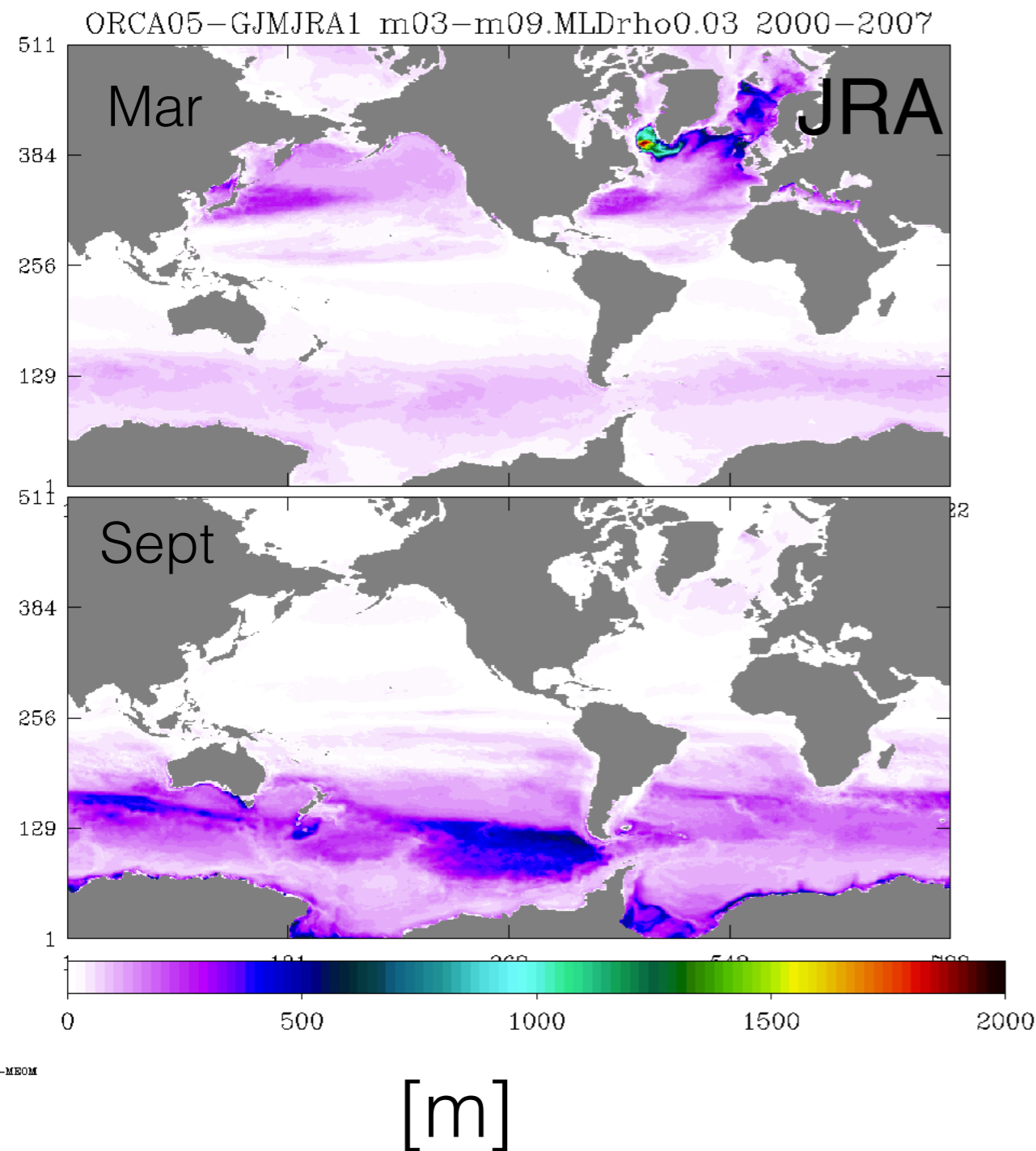


[mm.d⁻¹]

[mm.d⁻¹]

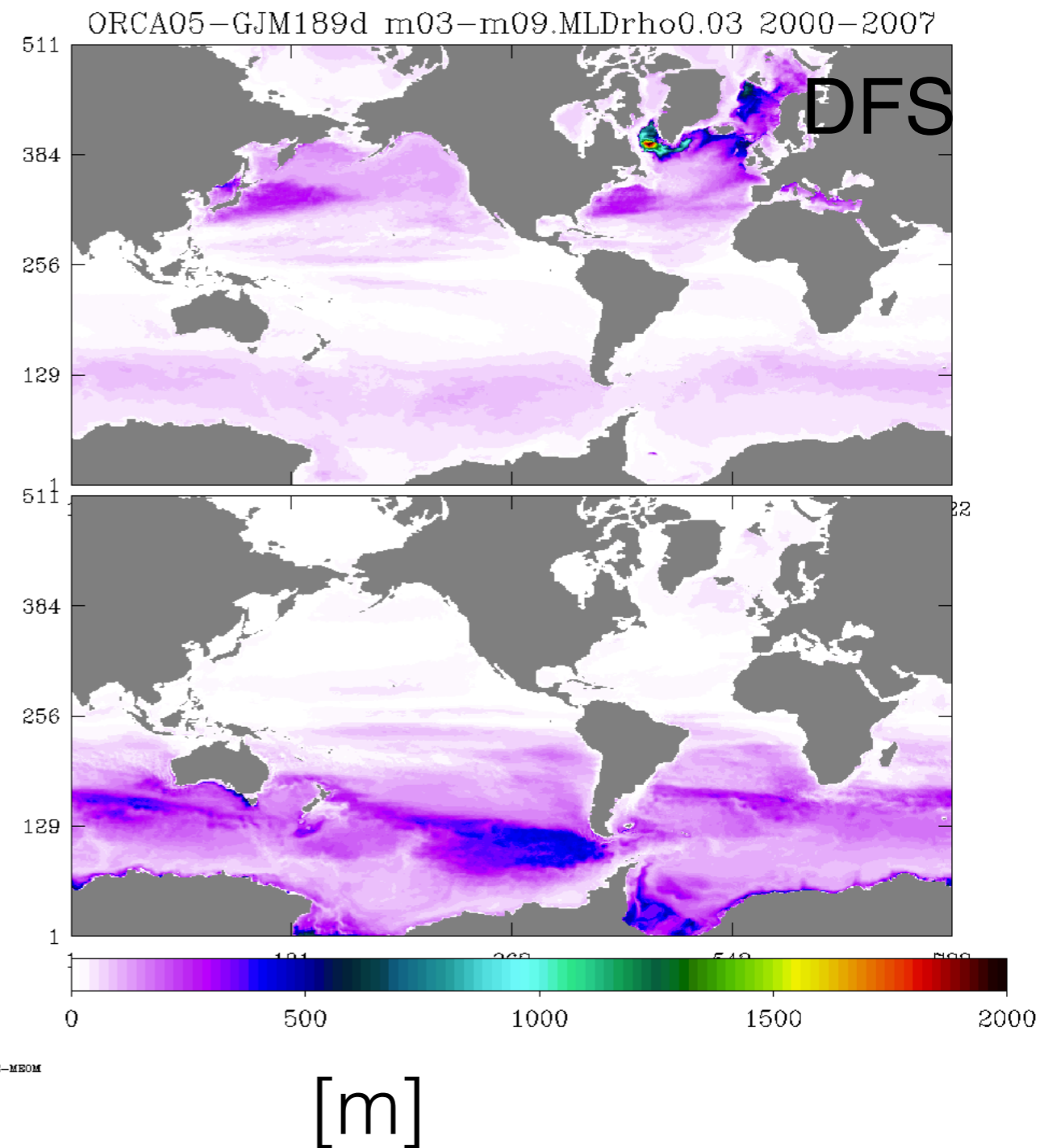
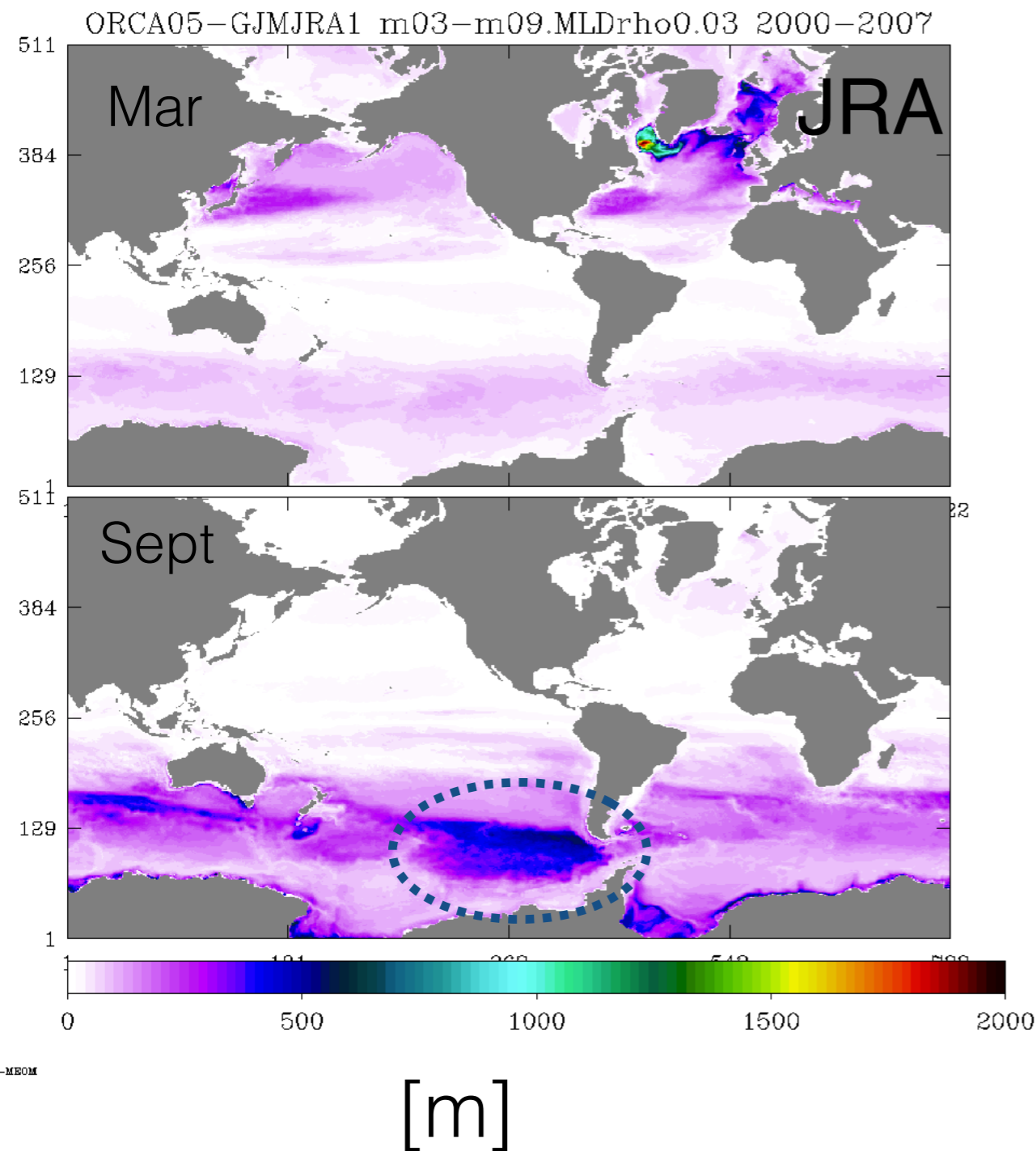
Sensitivity experiment with JRA at 0.5° resolution

Mixed layer depth



Sensitivity experiment with JRA at 0.5° resolution

Mixed layer depth



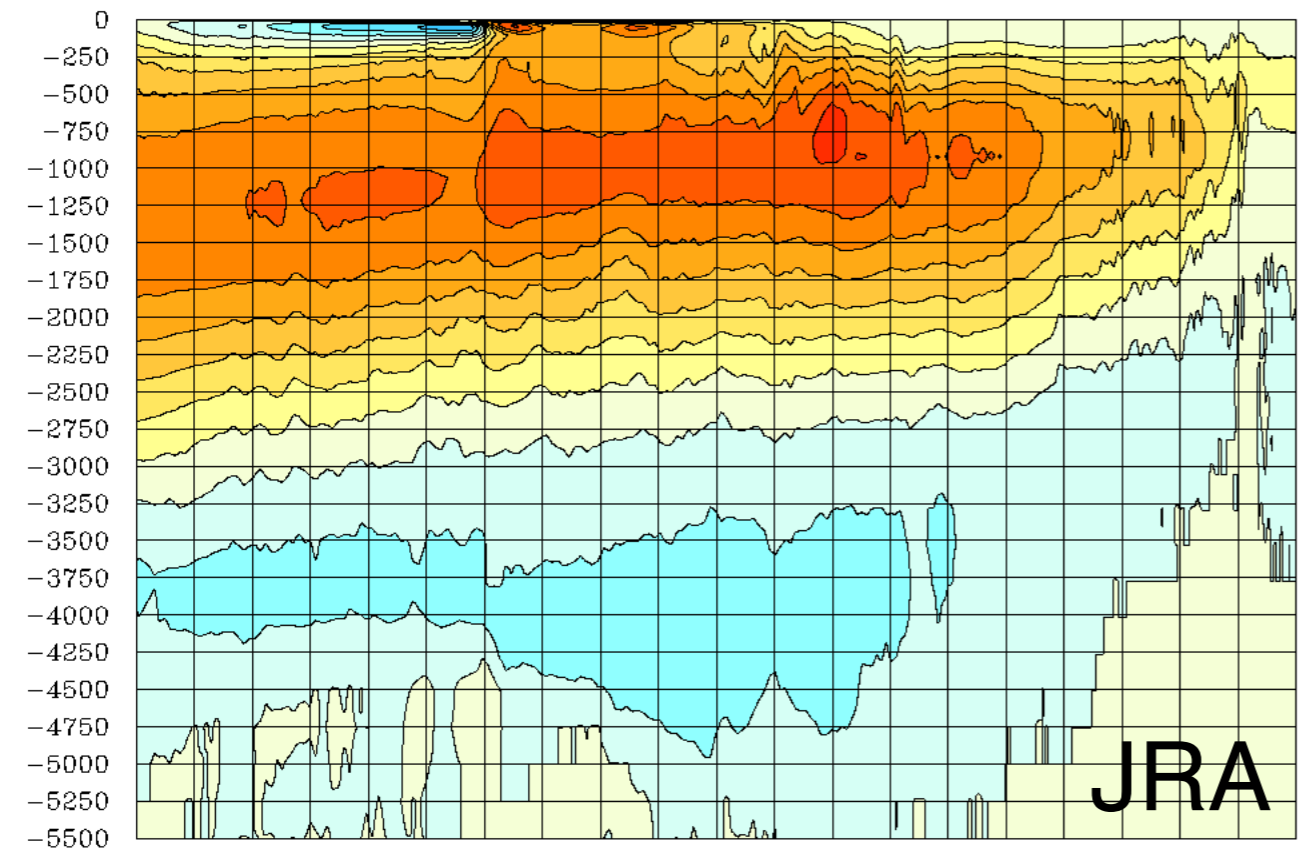
OVERTURNING IN ORCA05

Sensitivity experiment with JRA at 0.5° resolution

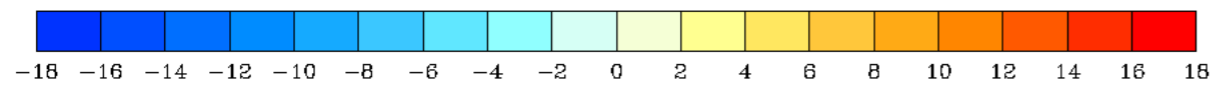
Mean overturning stream function (Atlantic)

MOC ATLANTIC (sv) ORCA05-GJMJRA1 y2000-2007

MOC ATLANTIC (sv) ORCA05-GJM189d y2000-2007

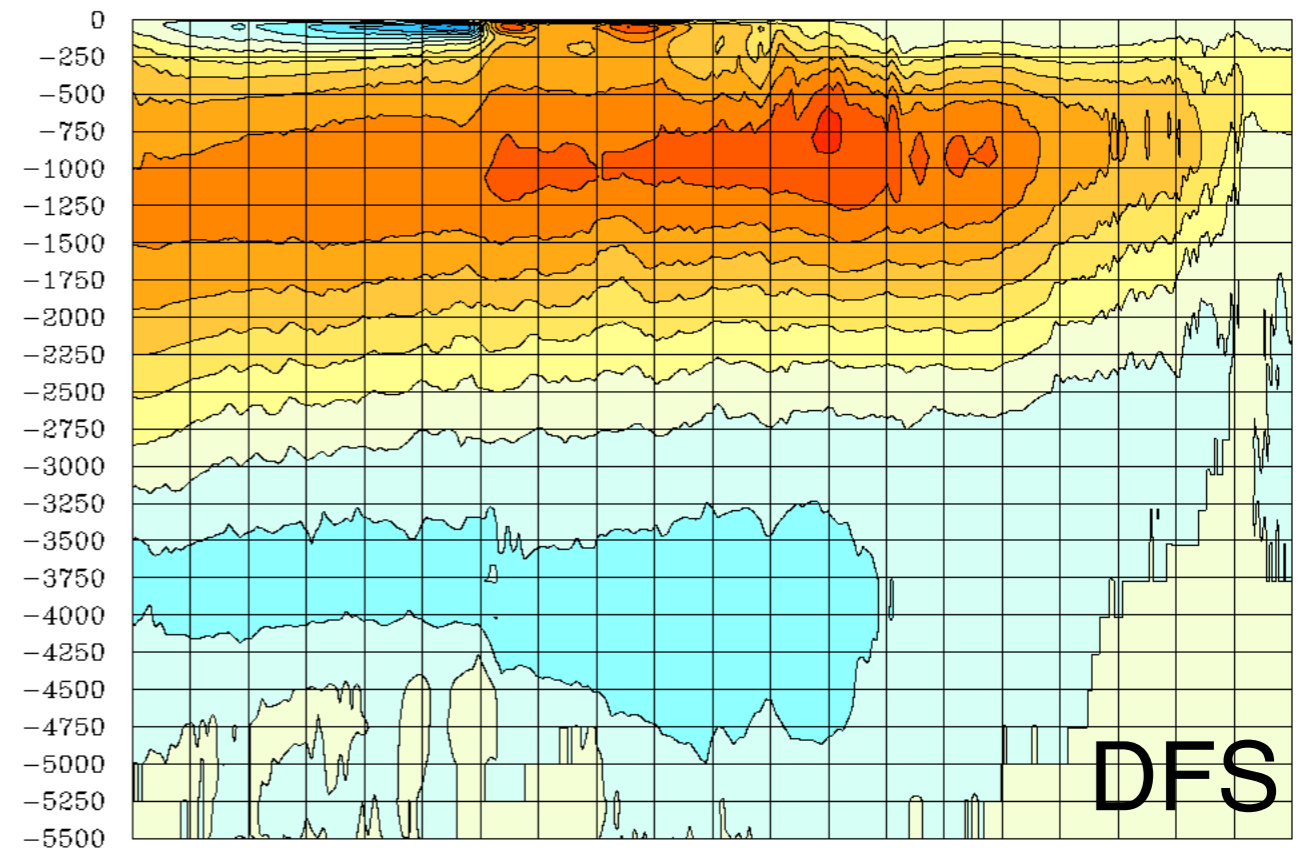


lon 0.00
lat -30 -25 -20 -15 -10 -5 0 5 10 15 20 25 30 35 40 45 50 55 60 65 70

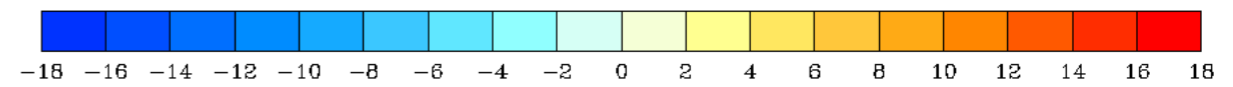


Contours de -32 a 14 par intervalles de 2

[Sv]



lon 0.00
lat -30 -25 -20 -15 -10 -5 0 5 10 15 20 25 30 35 40 45 50 55 60 65 70



Contours de -32 a 14 par intervalles de 2

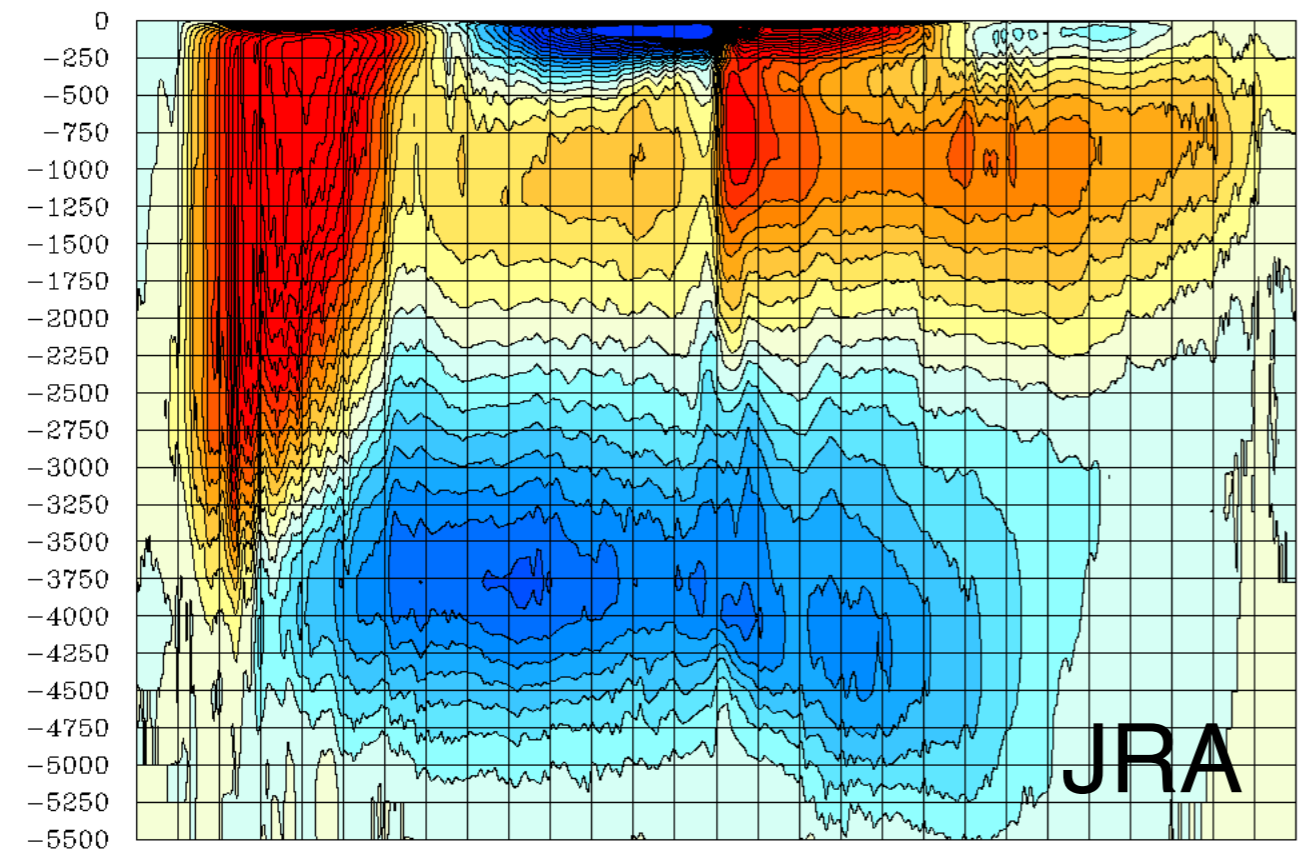
[Sv]

Sensitivity experiment with JRA at 0.5° resolution

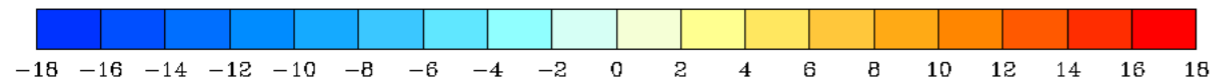
Mean overturning stream function (Global)

MOC GLOBAL (sv) ORCA05-GJMJRA1 y2000-2007

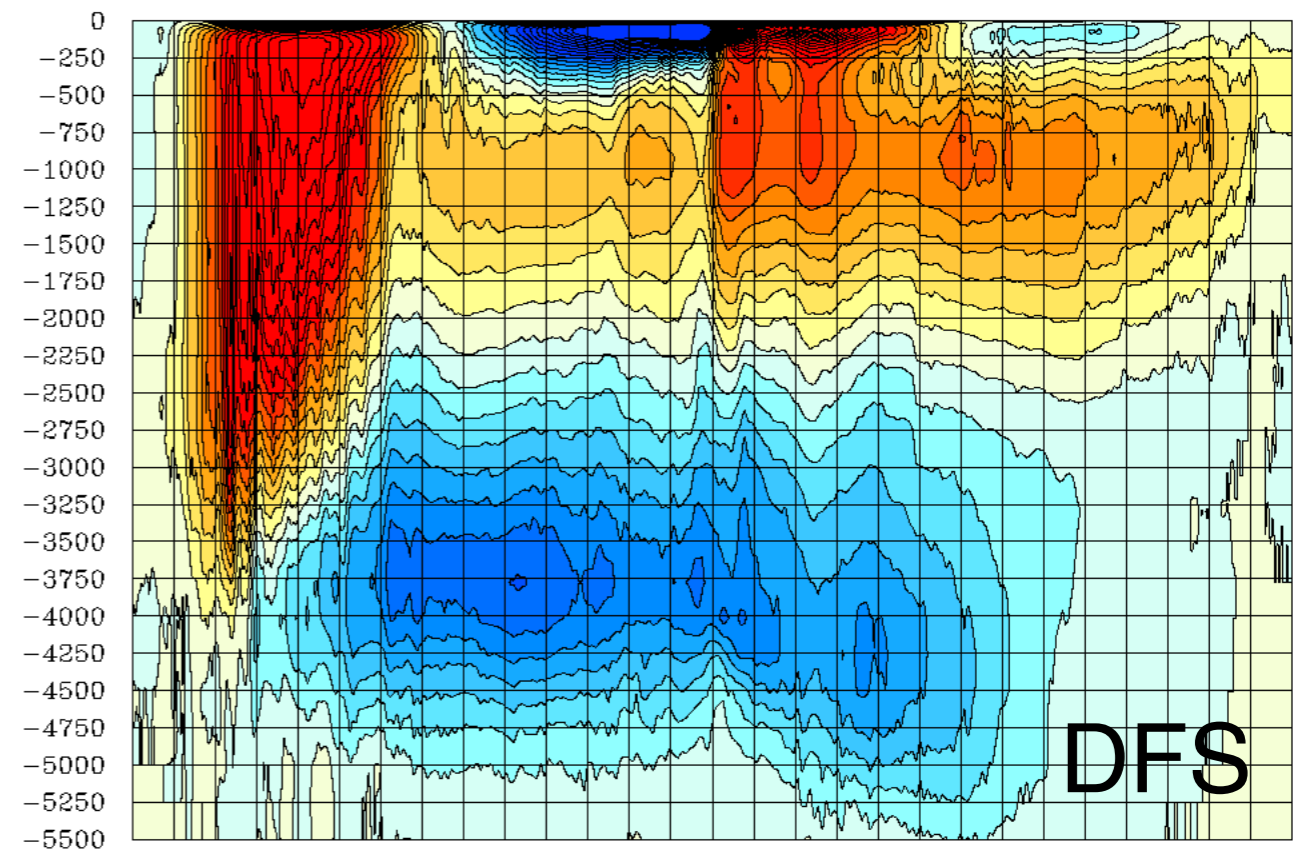
MOC GLOBAL (sv) ORCA05-GJM189d y2000-2007



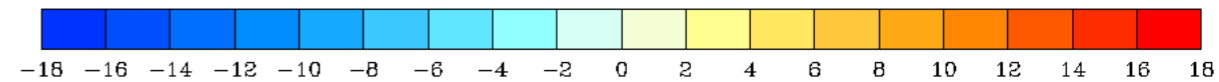
lon 0.00
lat -70 -65 -60 -55 -50 -45 -40 -35 -30 -25 -20 -15 -10 -5 0 5 10 15 20 25 30 35 40 45 50 55 60 65 70



[Sv] Contours de -32 a 52 par intervalles de 2



lon 0.00
lat -70 -65 -60 -55 -50 -45 -40 -35 -30 -25 -20 -15 -10 -5 0 5 10 15 20 25 30 35 40 45 50 55 60 65 70



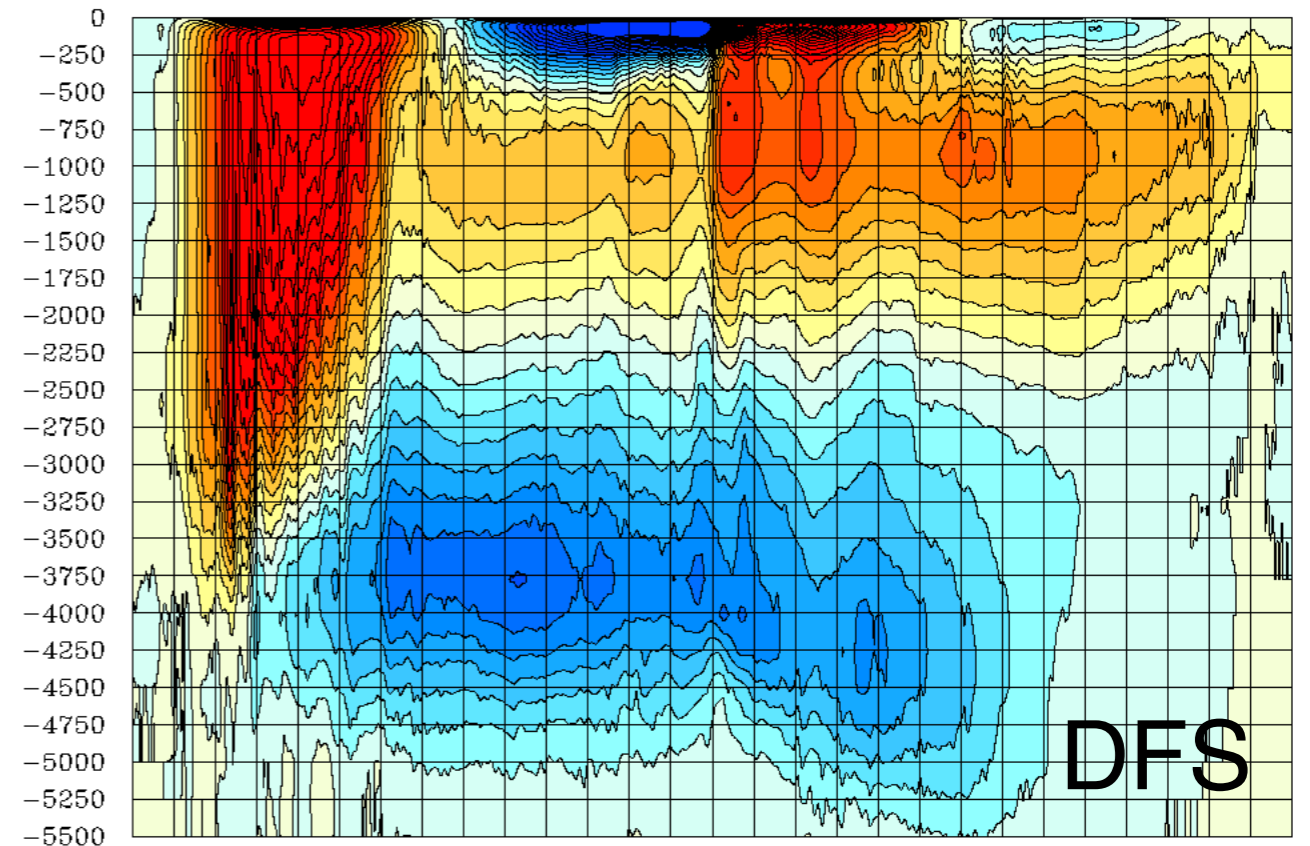
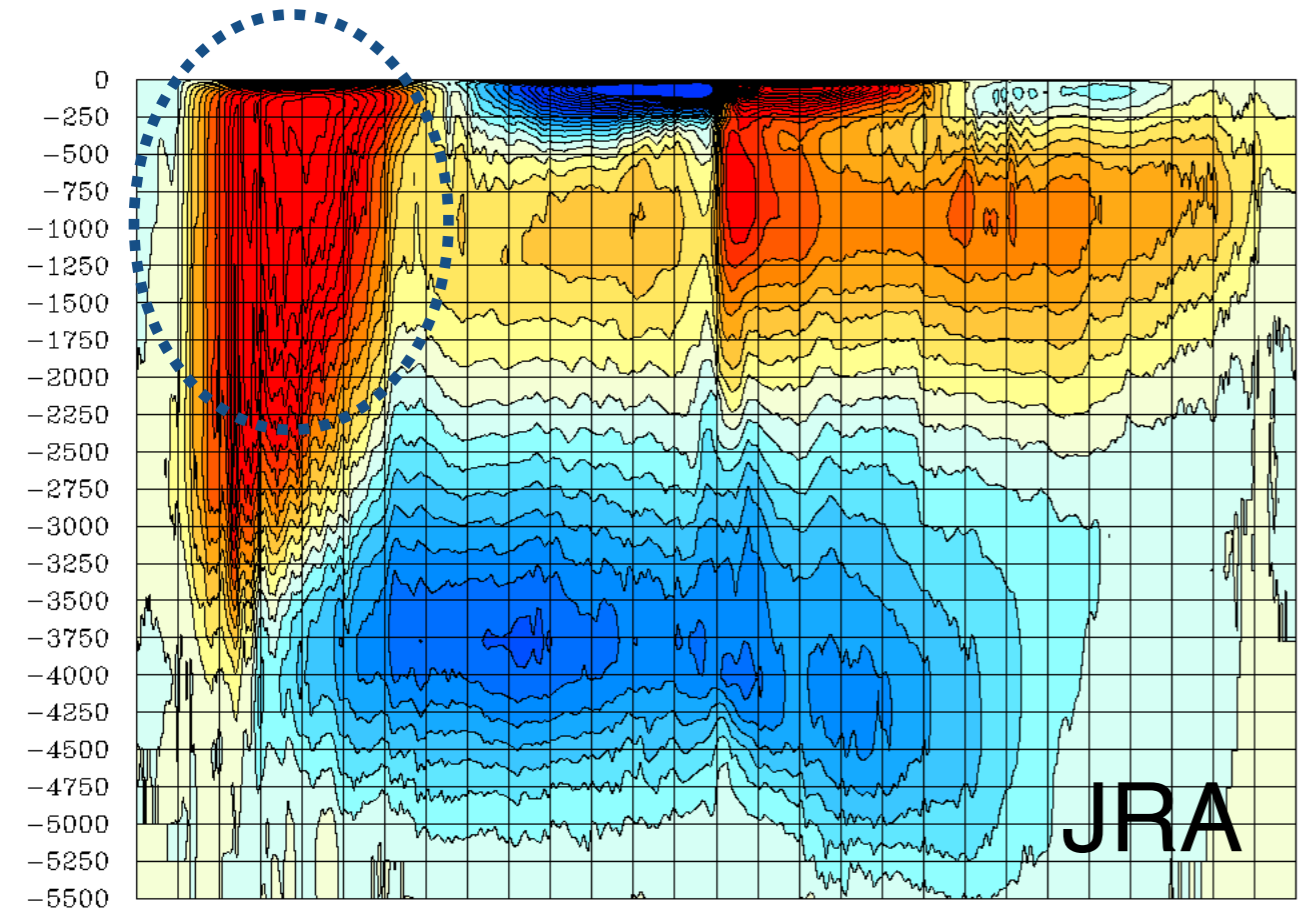
[Sv] Contours de -32 a 54 par intervalles de 2

Sensitivity experiment with JRA at 0.5° resolution

Mean overturning stream function (Global)

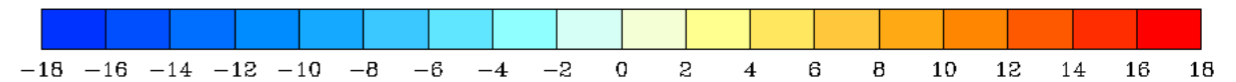
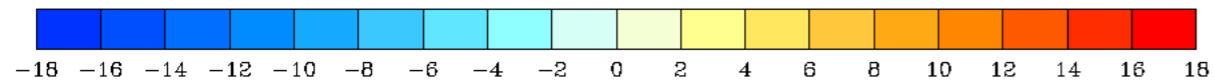
MOC GLOBAL (sv) ORCA05-GJMJRA1 y2000-2007

MOC GLOBAL (sv) ORCA05-GJM189d y2000-2007



lon 0.00
lat -70 -65 -60 -55 -50 -45 -40 -35 -30 -25 -20 -15 -10 -5 0 5 10 15 20 25 30 35 40 45 50 55 60 65 70

lon 0.00
lat -70 -65 -60 -55 -50 -45 -40 -35 -30 -25 -20 -15 -10 -5 0 5 10 15 20 25 30 35 40 45 50 55 60 65 70

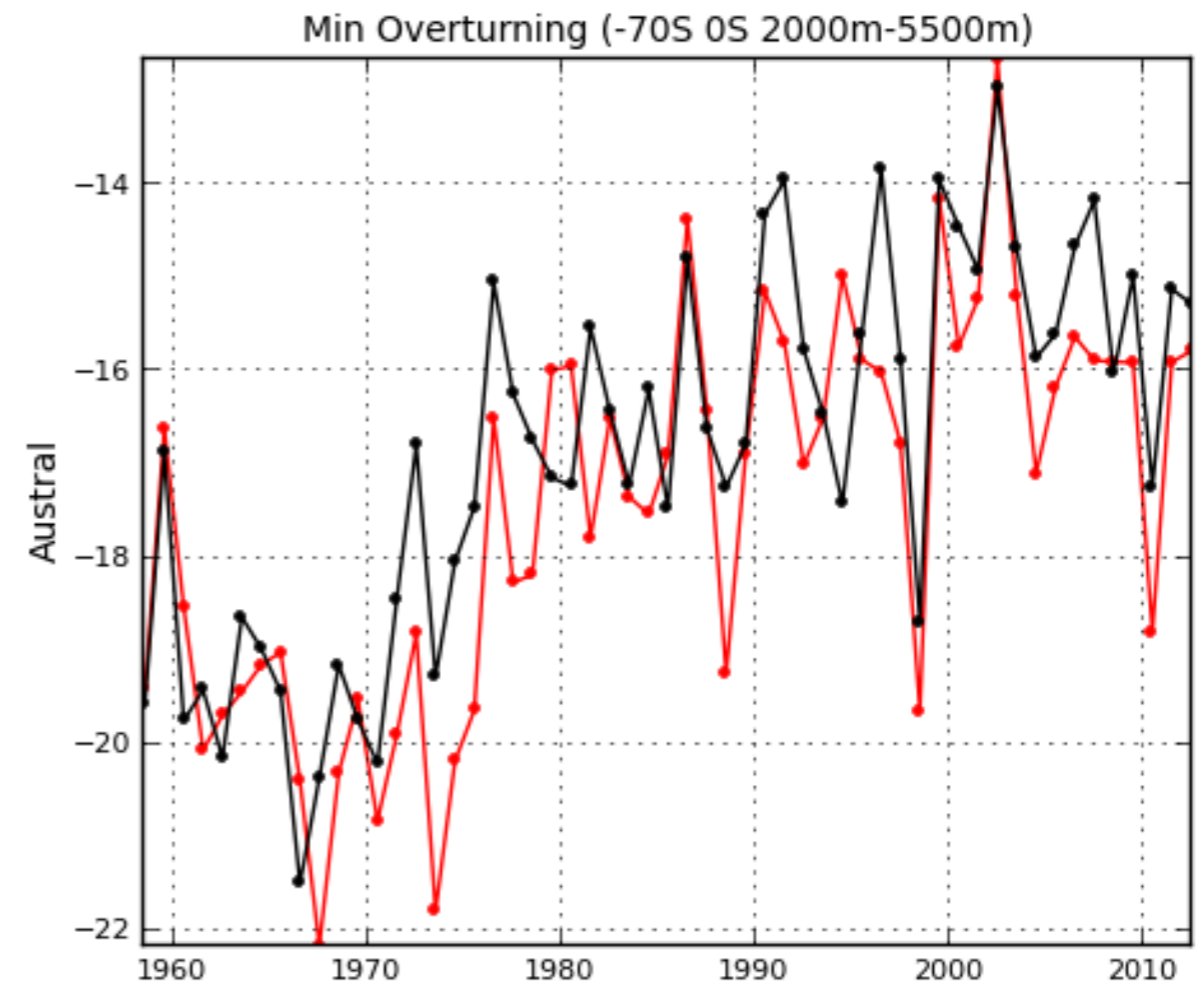
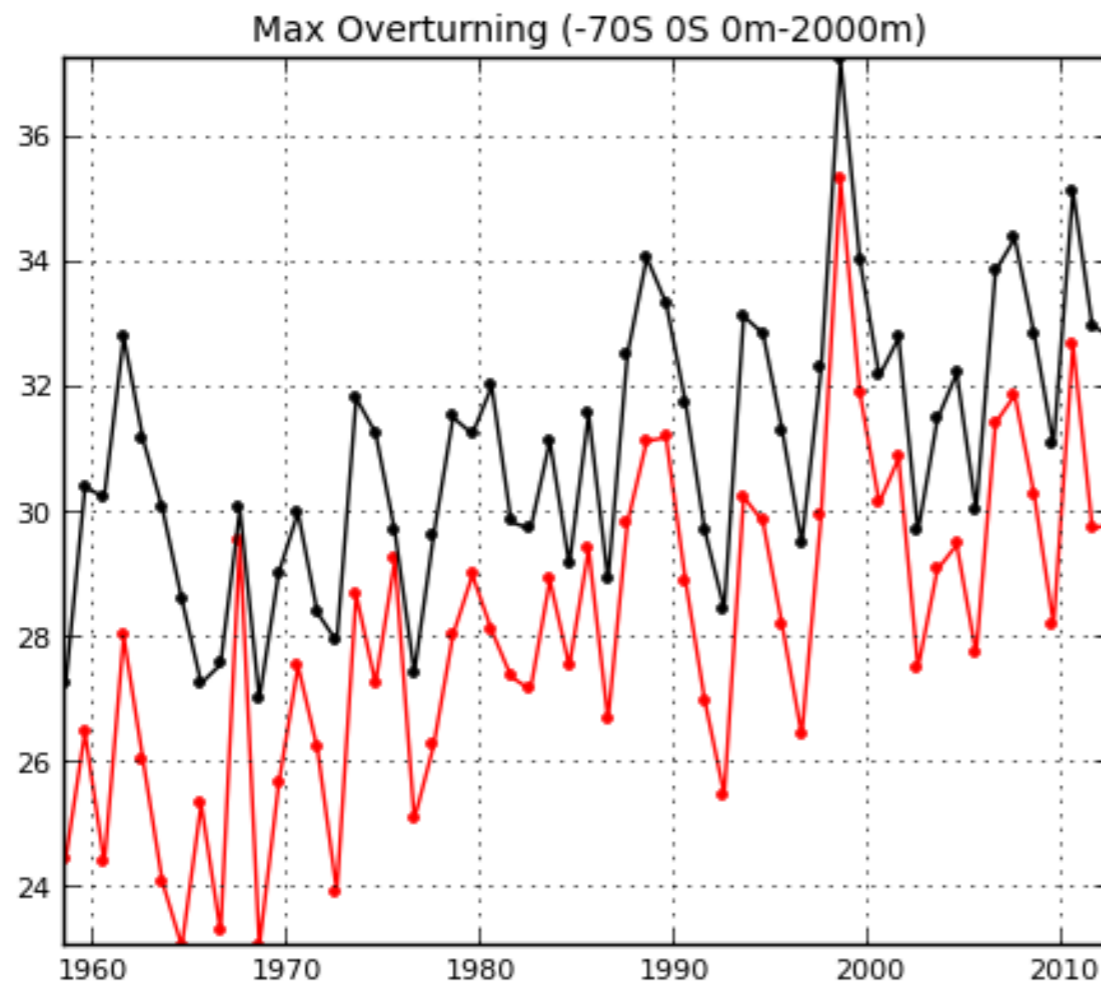


[Sv] Contours de -32 a 52 par intervalles de 2

[Sv] Contours de -32 a 54 par intervalles de 2

Sensitivity experiment with JRA at 0.5° resolution

Southern Ocean overturning stream (pressure coordinate)

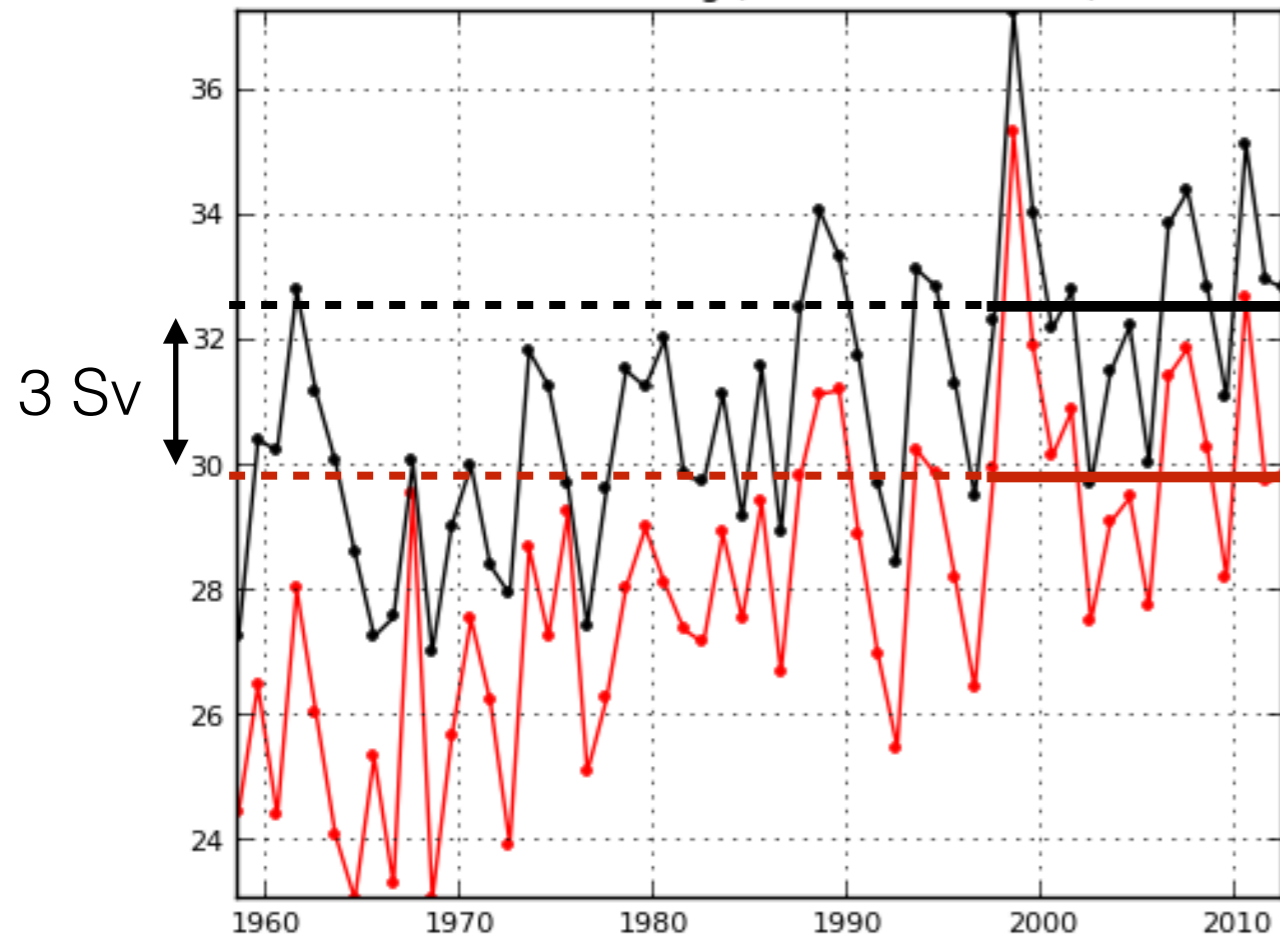


JRA : red
DFS : black

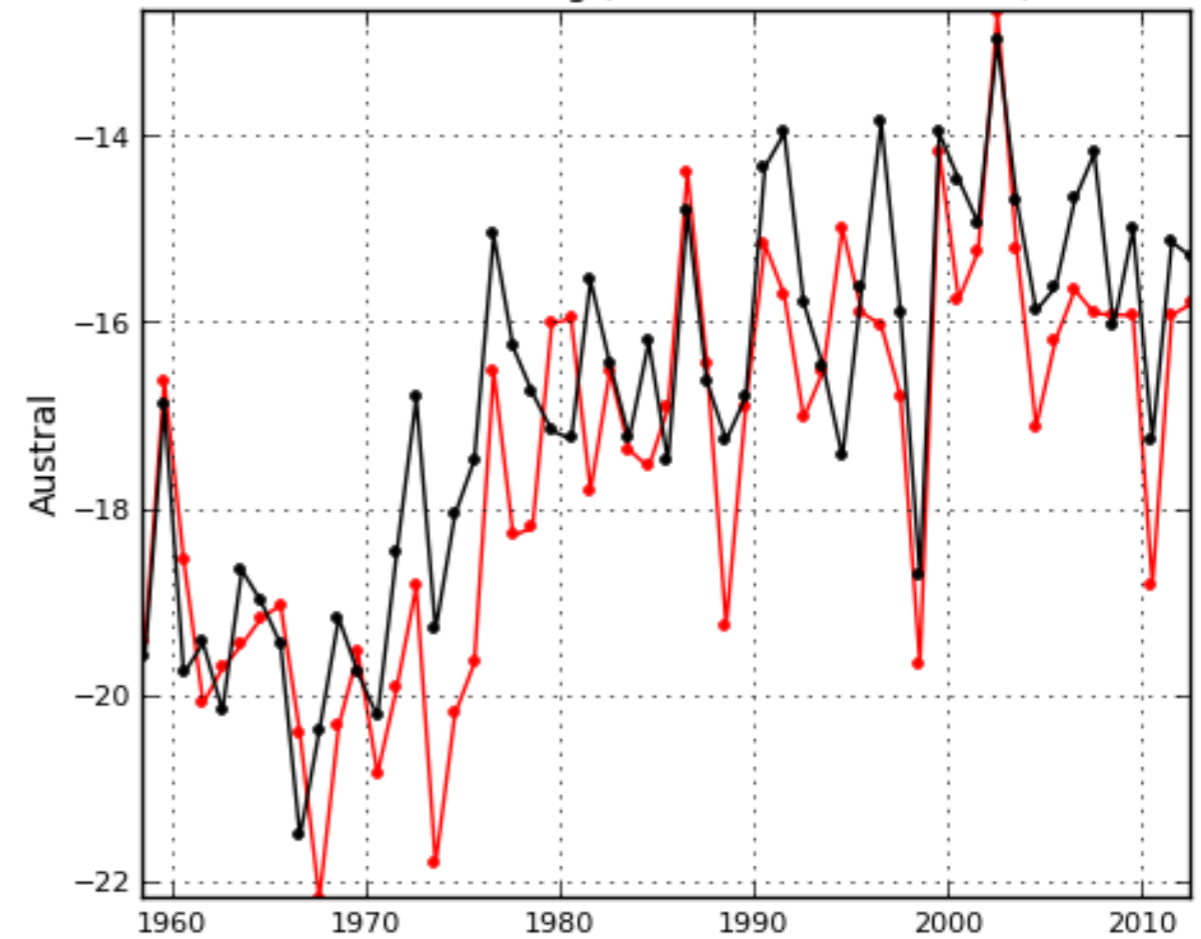
Sensitivity experiment with JRA at 0.5° resolution

Southern Ocean overturning stream (pressure coordinate)

Max Overturning (-70S 0S 0m-2000m)



Min Overturning (-70S 0S 2000m-5500m)



JRA : red
DFS : black

Sensitivity experiment with JRA at 0.5° resolution

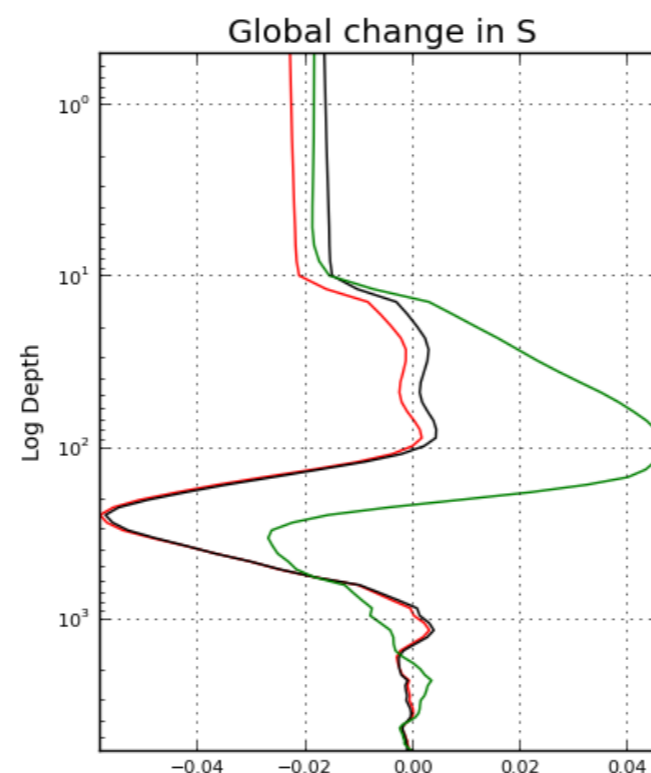
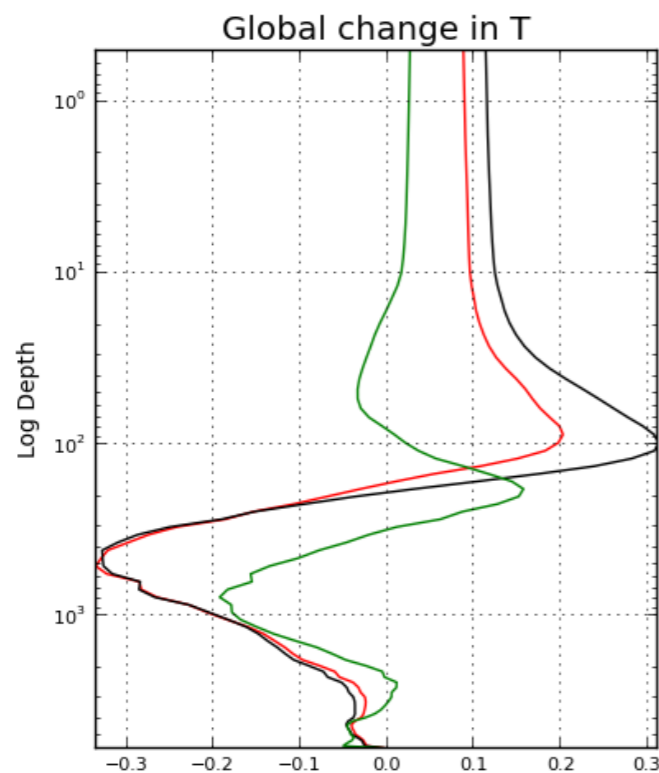
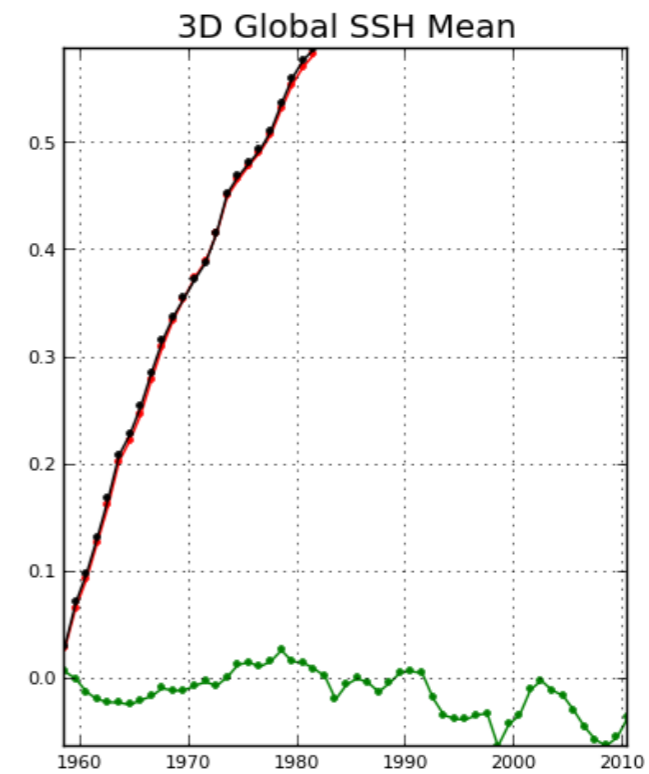
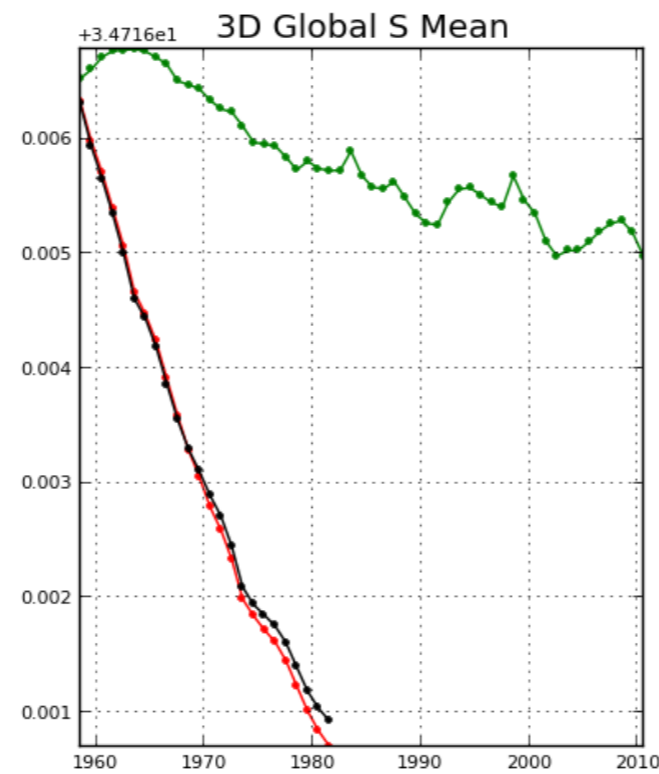
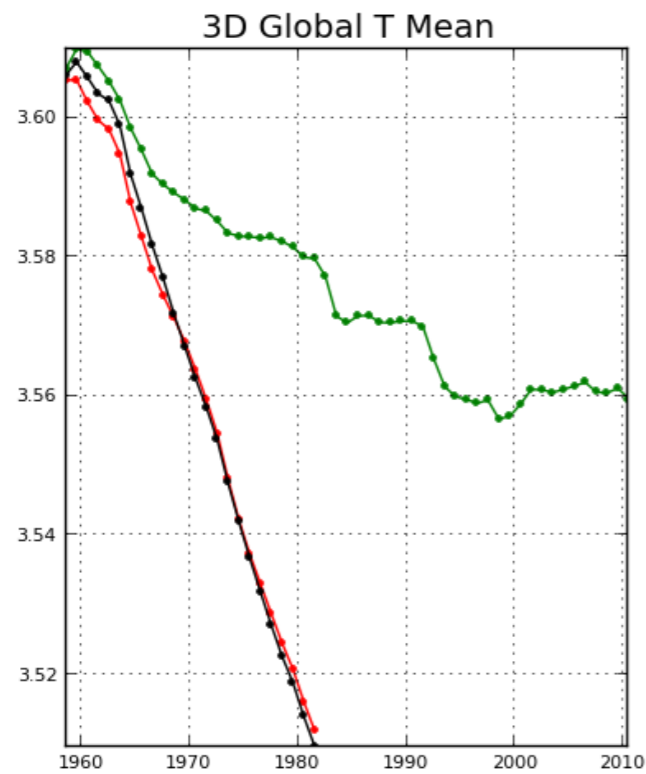
Overall, the two **simulations are very similar**, except for

- ▶ **mean circulation patterns**
 - slightly contracted subtropical gyre in the north pacific
 - weaker Drake passage transport
 - slightly shallower / less energetic equatorial jets (cf winds)
- ▶ **sea-ice**
 - weaker antarctic summer sea-ice extent (cf previous talk)
 - thinner antarctic summer sea-ice
 - slightly thicker arctic sea ice (all-year)
- ▶ **mixed layers**
 - deeper winter mixed layers in the Southern Ocean
- ▶ **overturning**
 - weaker upper cell overturning in the SO

1. Model set-up, experiments and diagnostics
2. Sensitivity tests with JRA-55 forcing dataset at 0.5° resolution
3. **Sensitivity tests with JRA-55 forcing dataset at 0.25° resolution**
4. Wrap-up and conclusions

GLOBAL TRENDS IN ORCA025

Sensitivity experiment with JRA at 0.25° resolution



JRA1 (abs) : black

JRA2 (rel) : red

DFS : green

cooling, freshening

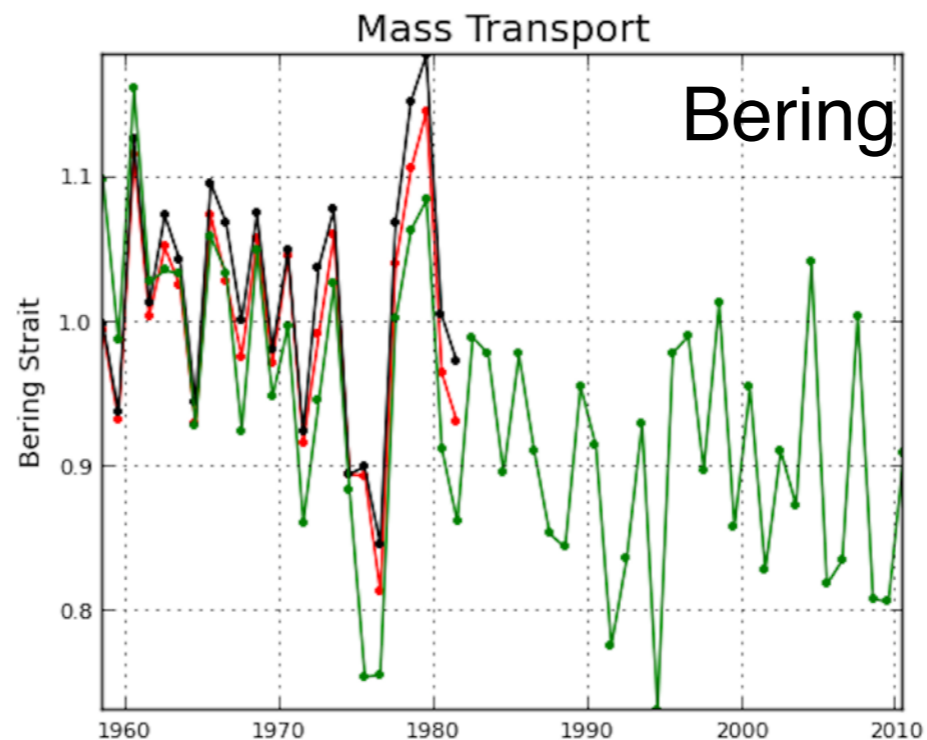
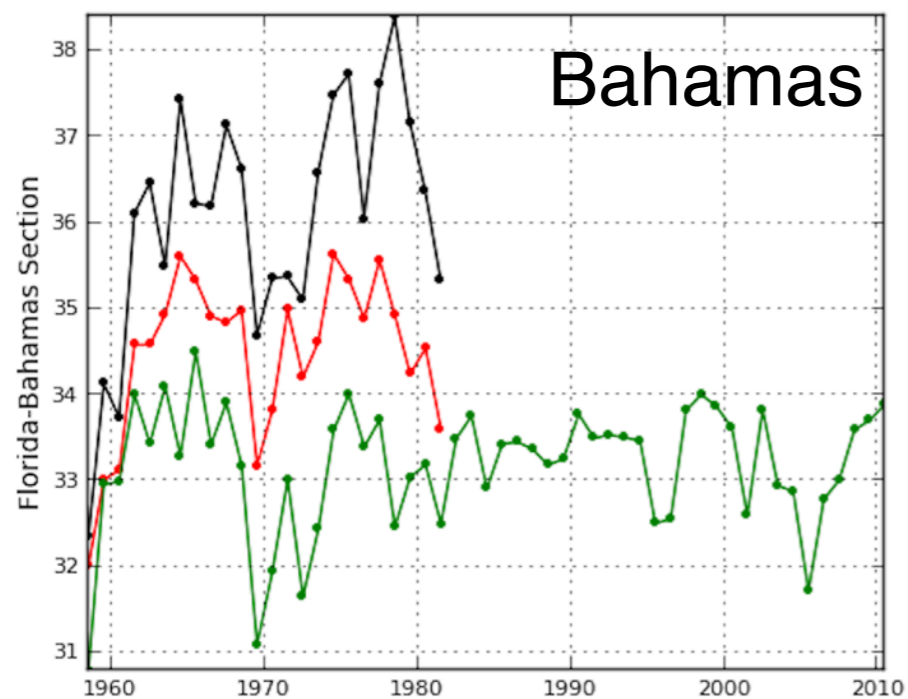
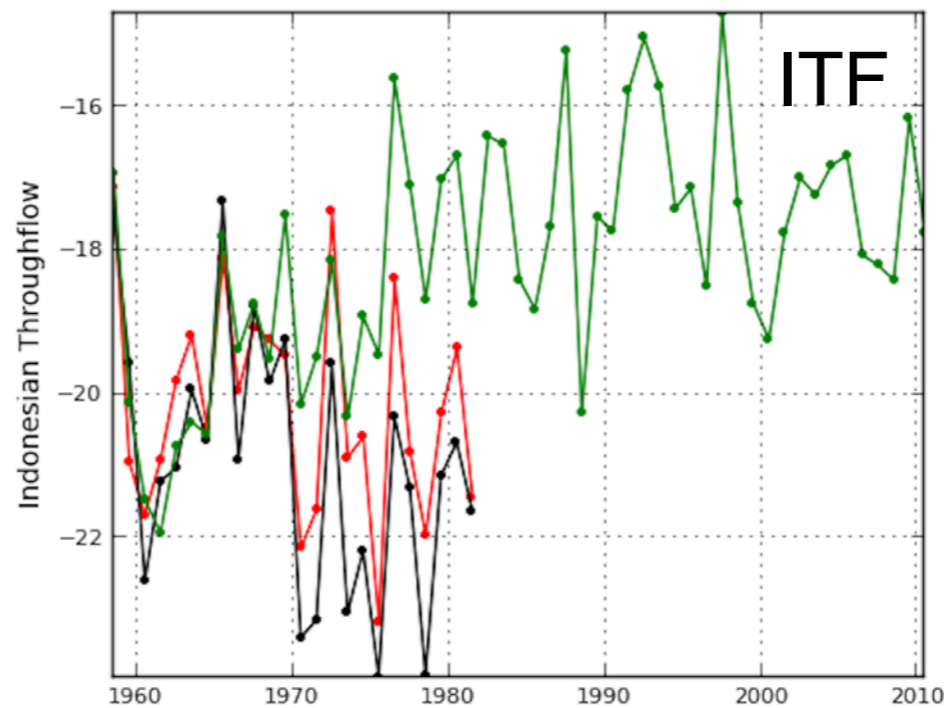
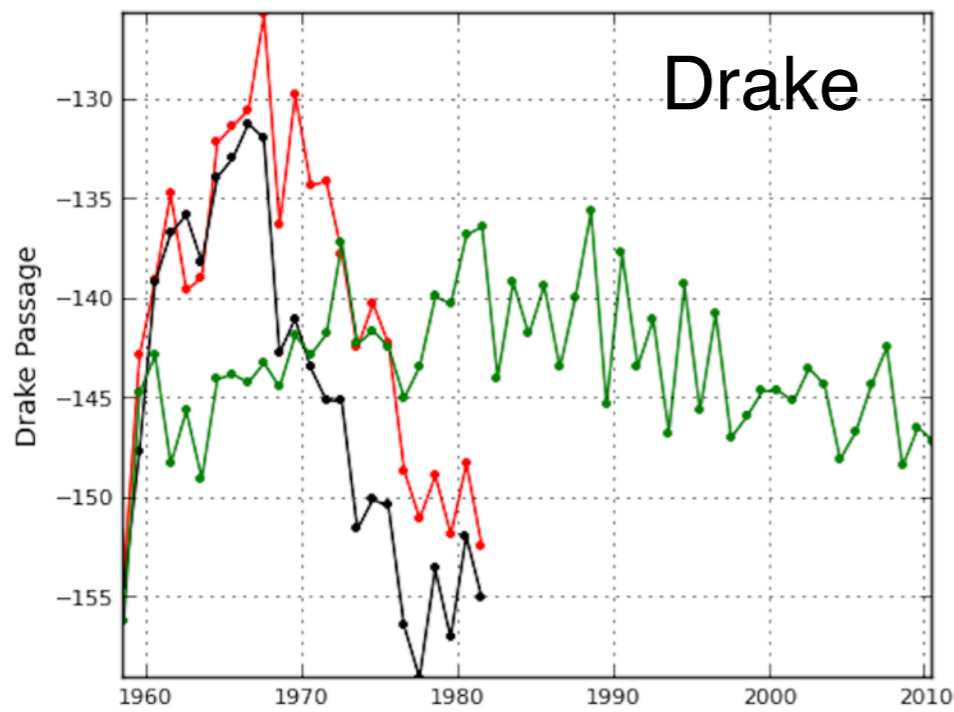
Global trends

TRANSPORTS IN ORCA025

Sensitivity experiment with JRA at 0.25° resolution

Barotropic transport

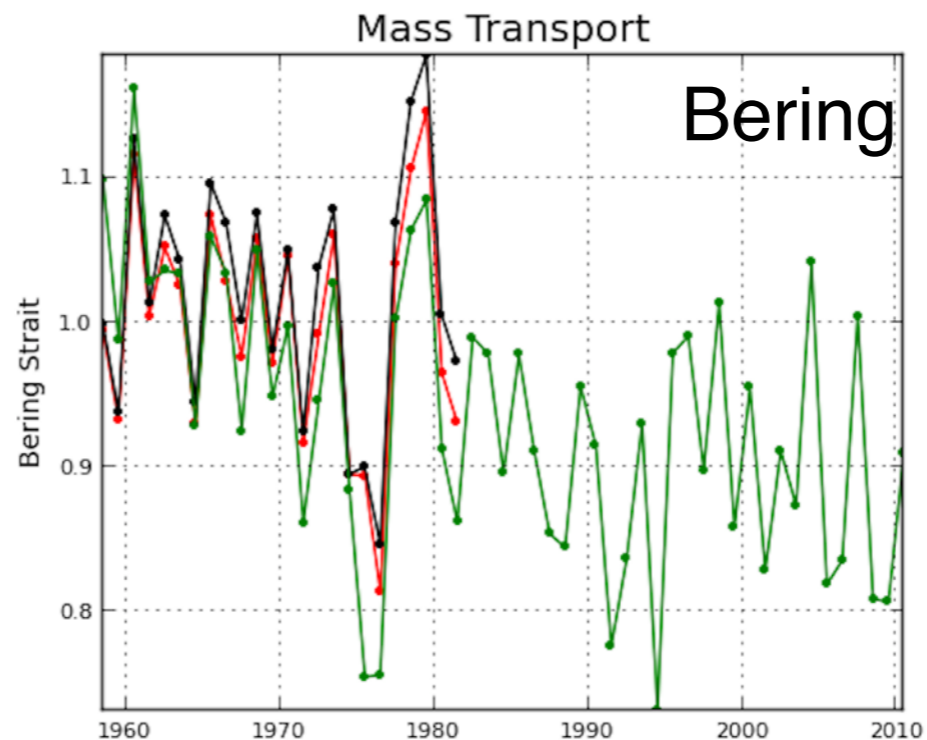
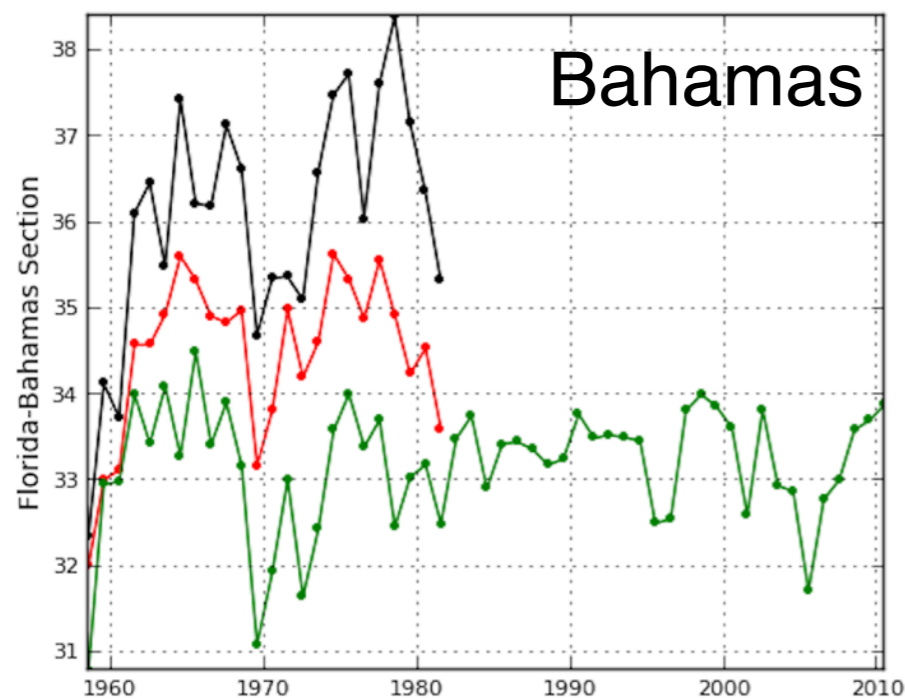
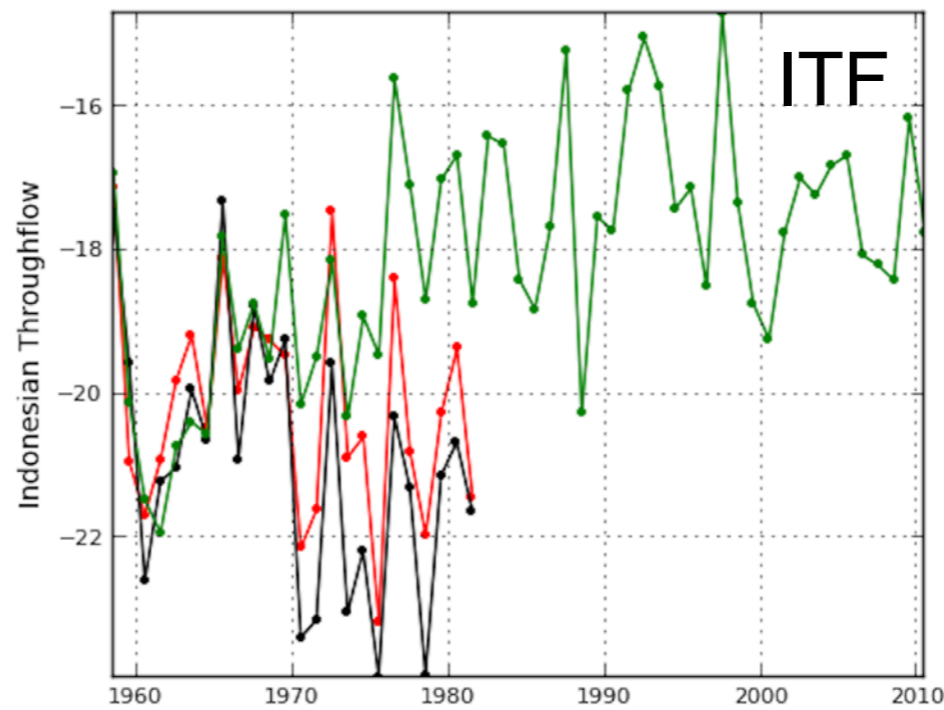
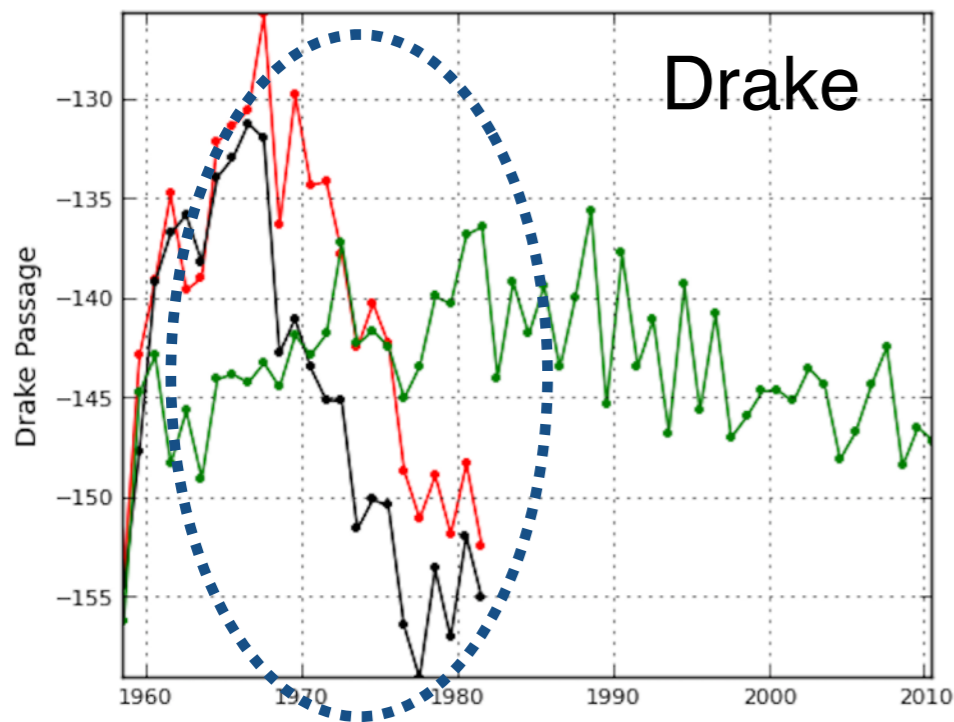
JRA1 (abs) : black
JRA2 (rel) : red
DFS : green



Sensitivity experiment with JRA at 0.25° resolution

Barotropic transport

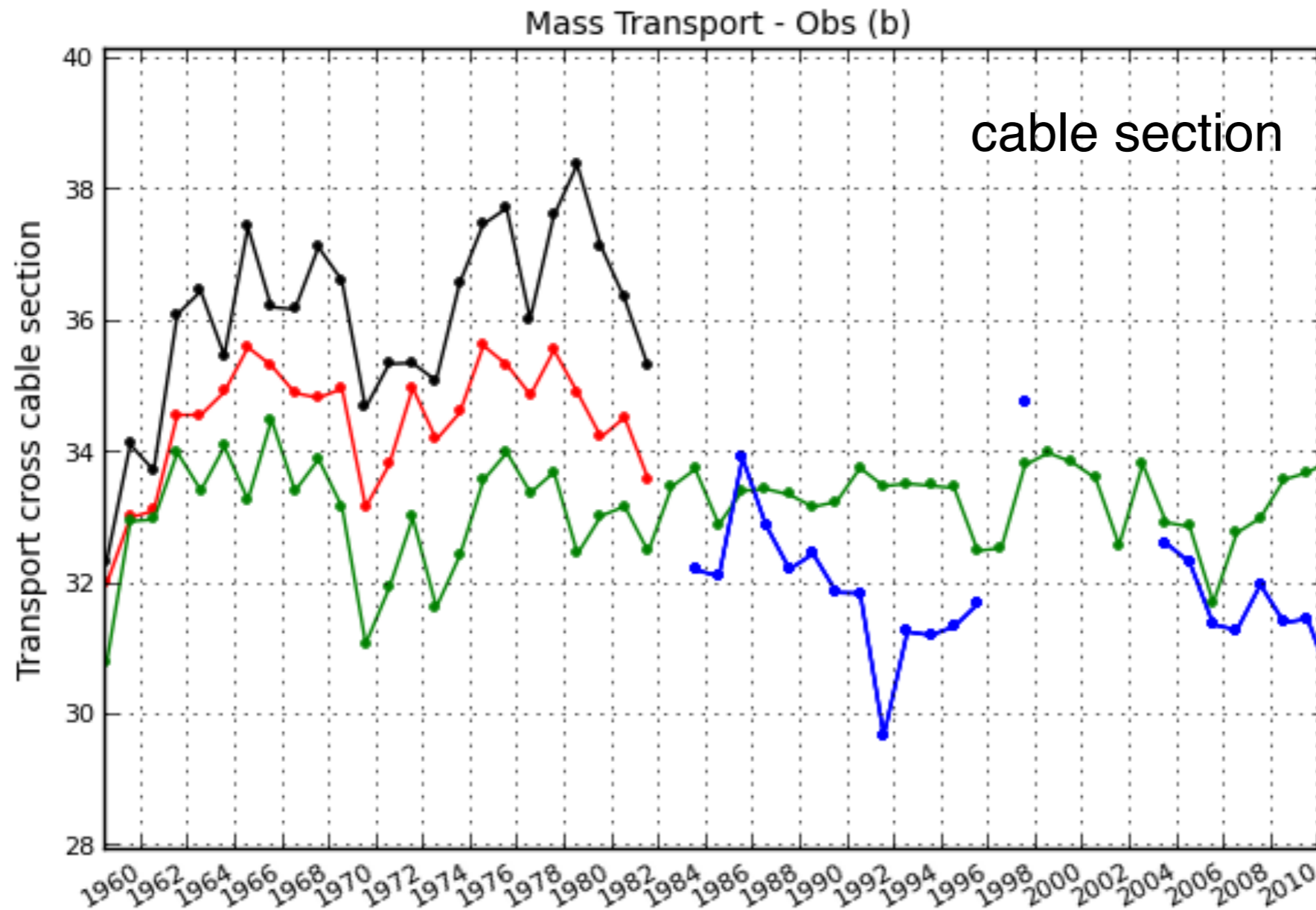
JRA1 (abs) : black
JRA2 (rel) : red
DFS : green



Sensitivity experiment with JRA at 0.25° resolution

Barotropic transport

JRA1 (abs) : black
JRA2 (rel) : red
DFS : green
OBS : blue



MIXED LAYER IN ORCA025

Sensitivity experiment with JRA at 0.25° resolution

Mixed layer depth

ORCA025.L75-GJMJRA2 m03-m09.MLDtem0.20 1958

Mar

JRA

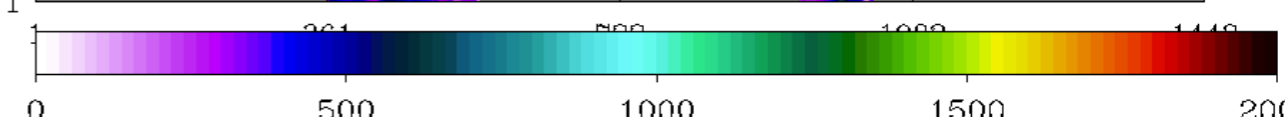
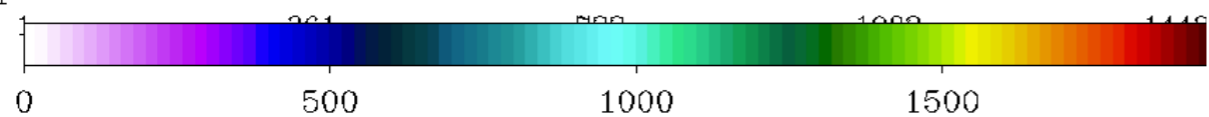
ORCA025.L75-GJM189 m03-m09.MLDrho0.03 1958

DFS

Sept

42

42



Sensitivity experiment with JRA at 0.25° resolution

Mixed layer depth

ORCA025.L75-GJMJRA2 m03-m09.MLDtem0.20 1958

Mar

JRA

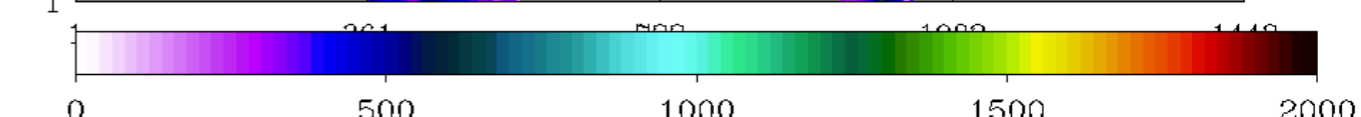
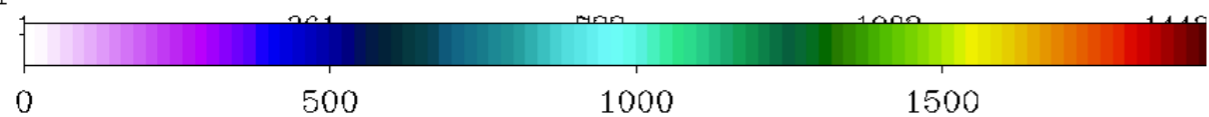
ORCA025.L75-GJM189 m03-m09.MLDrho0.03 1958

DFS

Sept

42

42

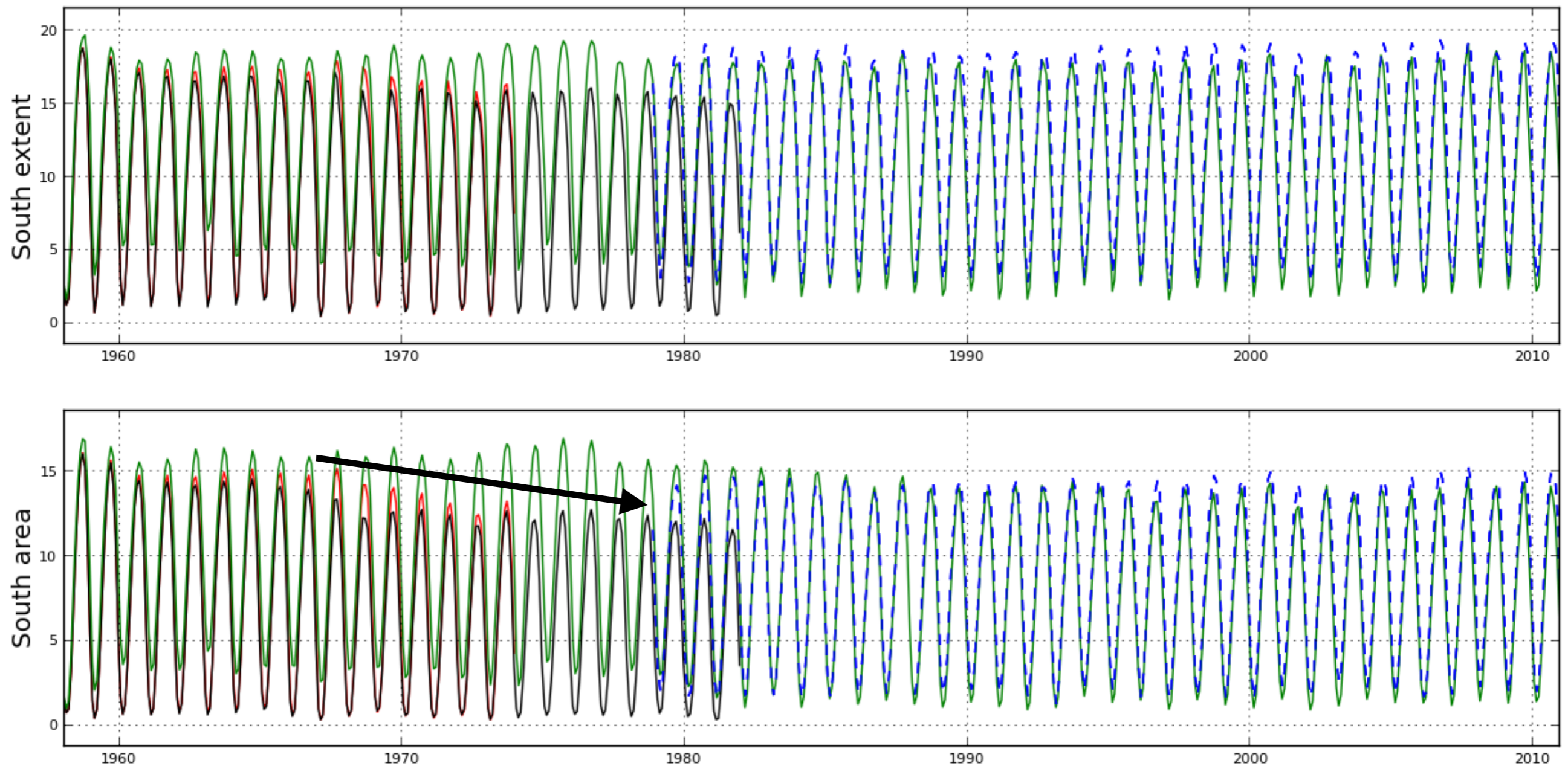


SEA ICE IN ORCA025

Sensitivity experiment with JRA at 0.25° resolution

Antarctic sea ice extent and area

JRA1 (abs) : black
JRA2 (rel) : red
DFS : green
OBS : blue



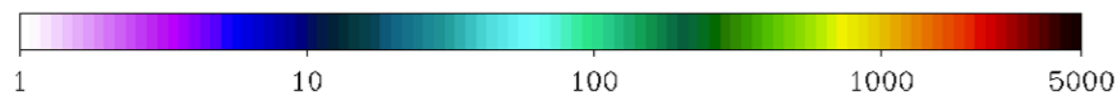
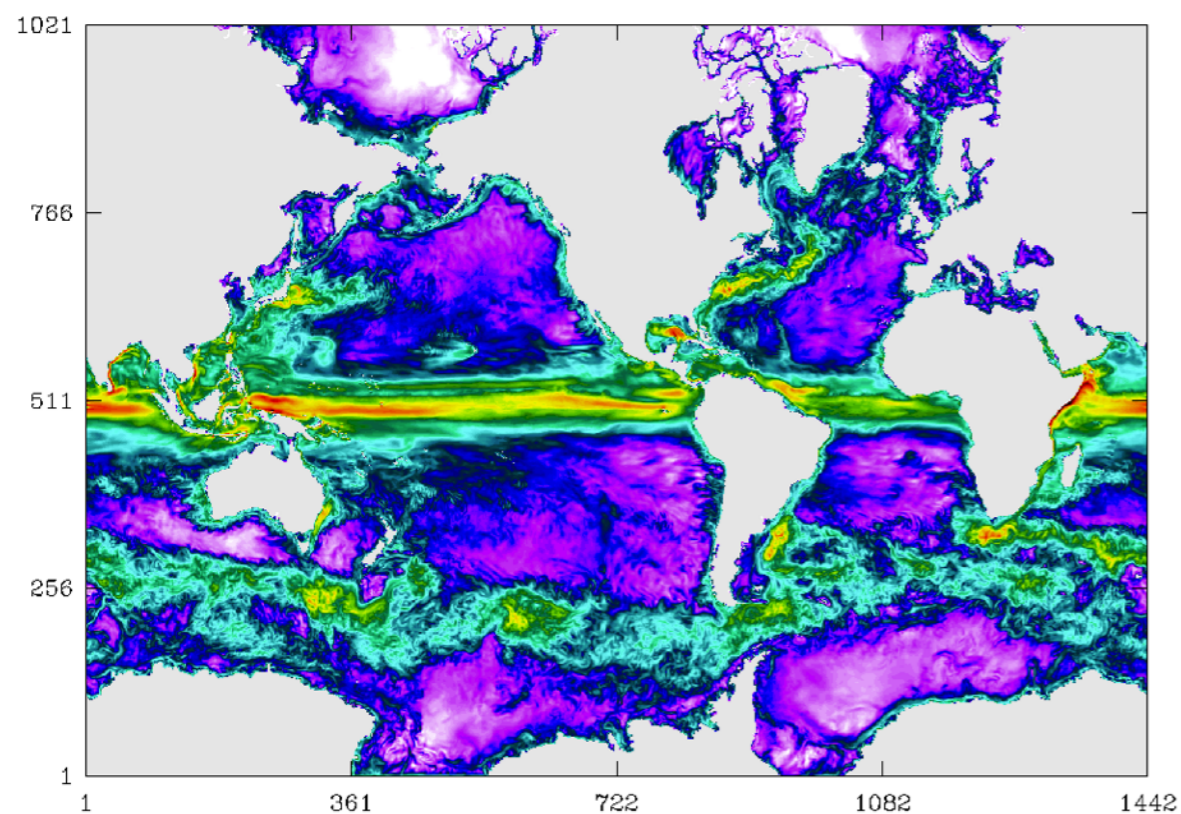
EDDY KINETIC ENERGY IN ORCA025

Sensitivity experiment with JRA at 0.25° resolution

Surface eddy kinetic energy

ORCA025.L75 EKEgl 1958 GJM JRA2 DEPTH=10.00

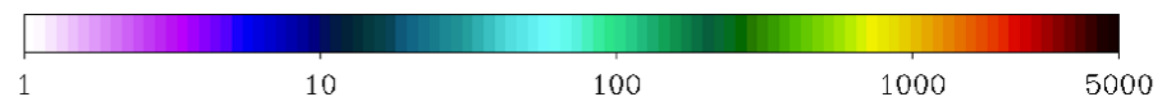
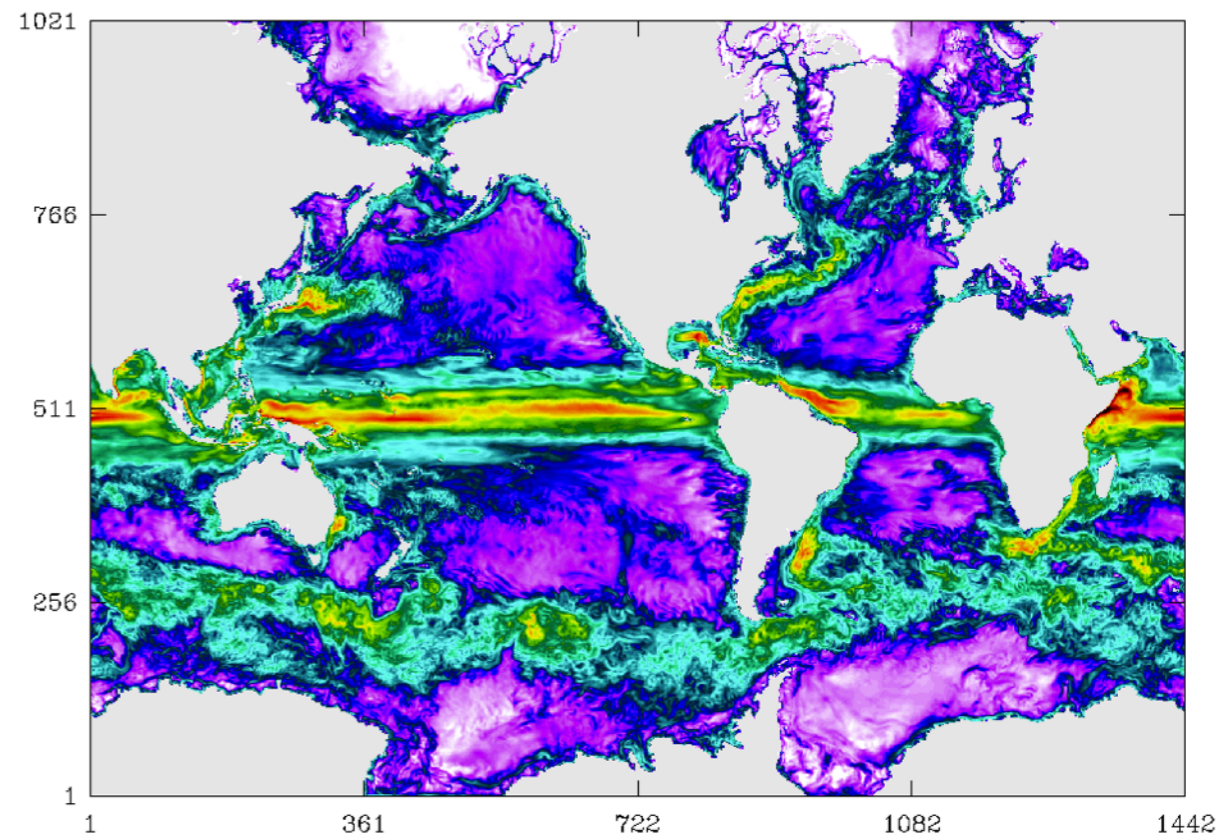
JRA2



[cm².s⁻²]

ORCA025.L75 EKEgl 1958 GJM189 DEPTH=10.00

DFS



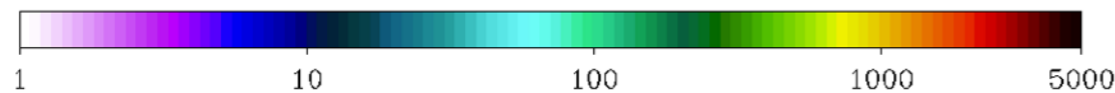
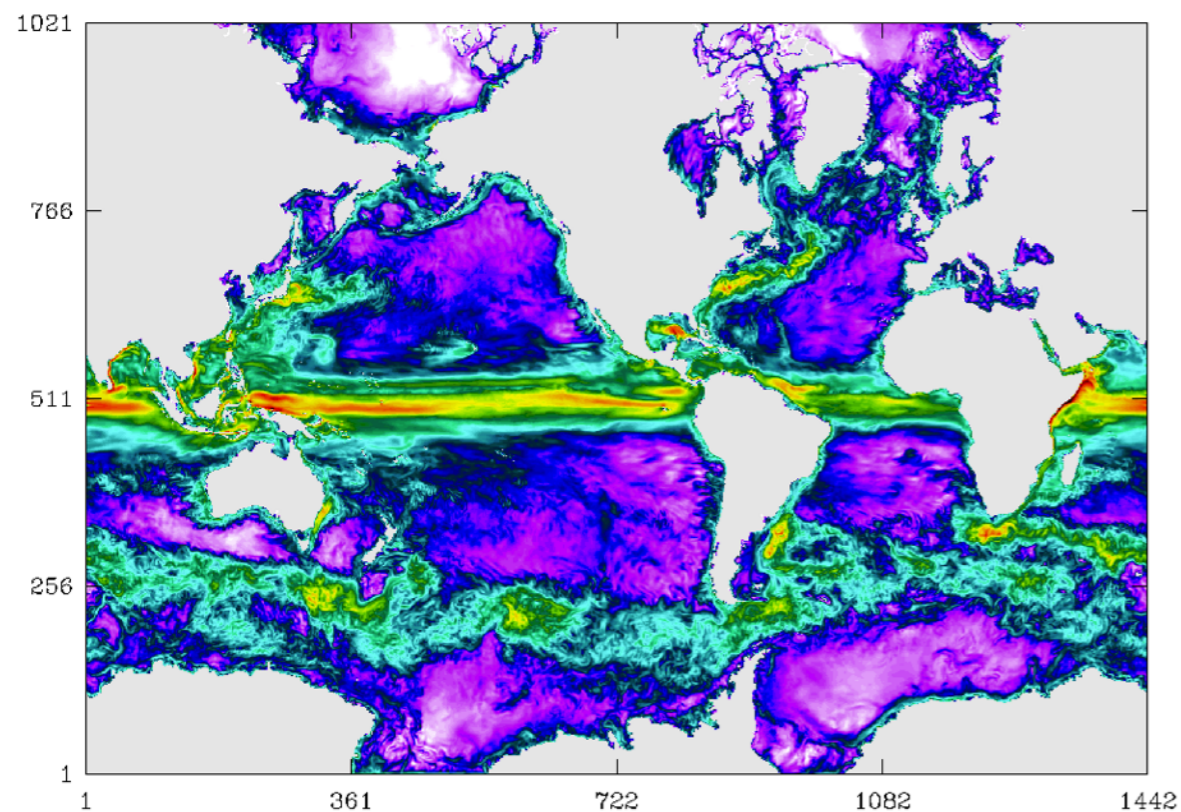
[cm².s⁻²]

Sensitivity experiment with JRA at 0.25° resolution

Surface eddy kinetic energy

ORCA025.L75 EKEgl 1958 GJMJRA2 DEPTH=10.00

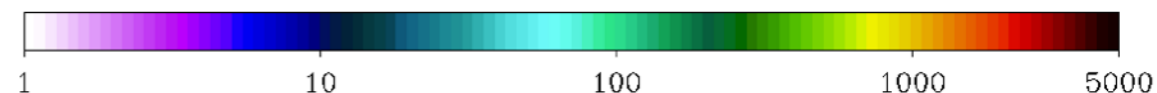
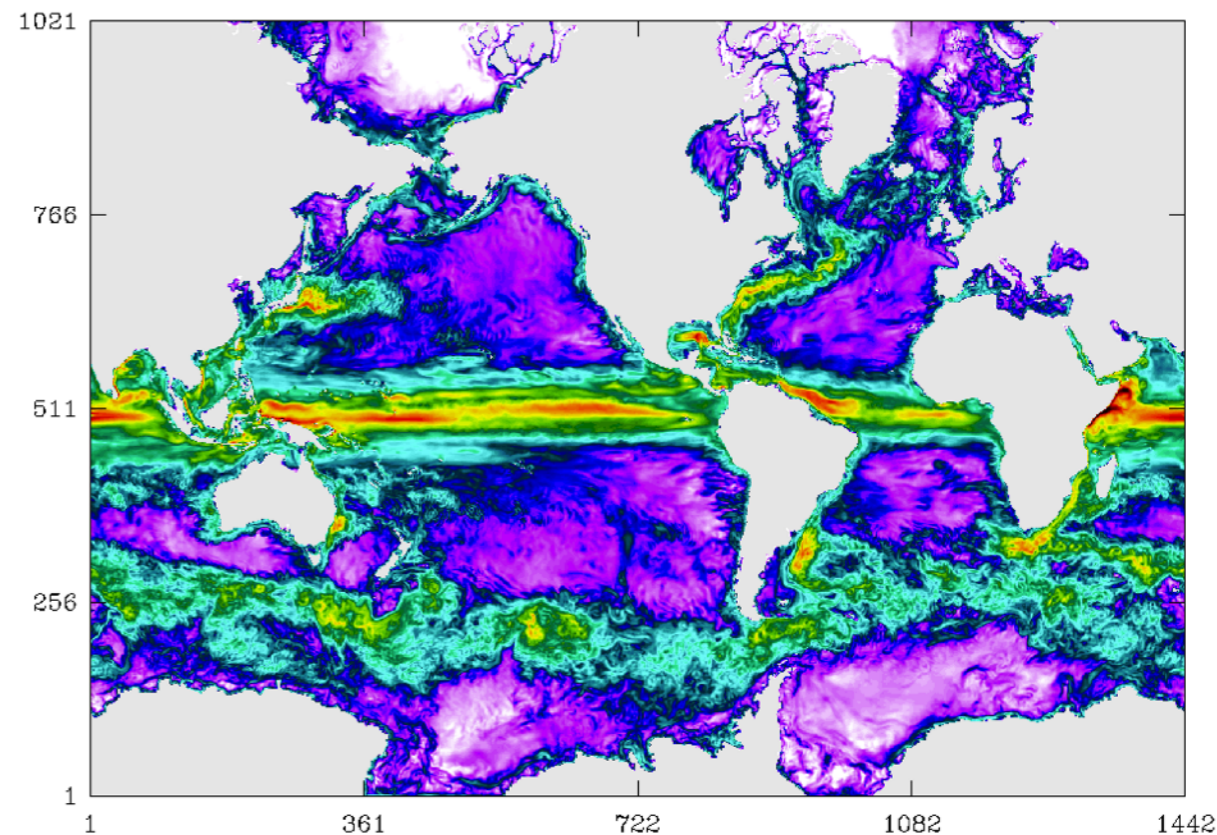
JRA2



[cm².s⁻²]

ORCA025.L75 EKEgl 1958 GJM189 DEPTH=10.00

DFS



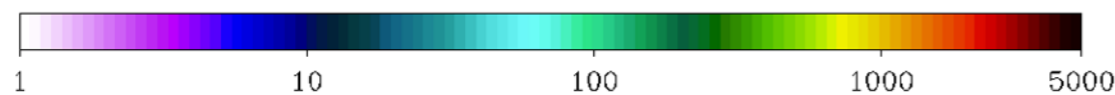
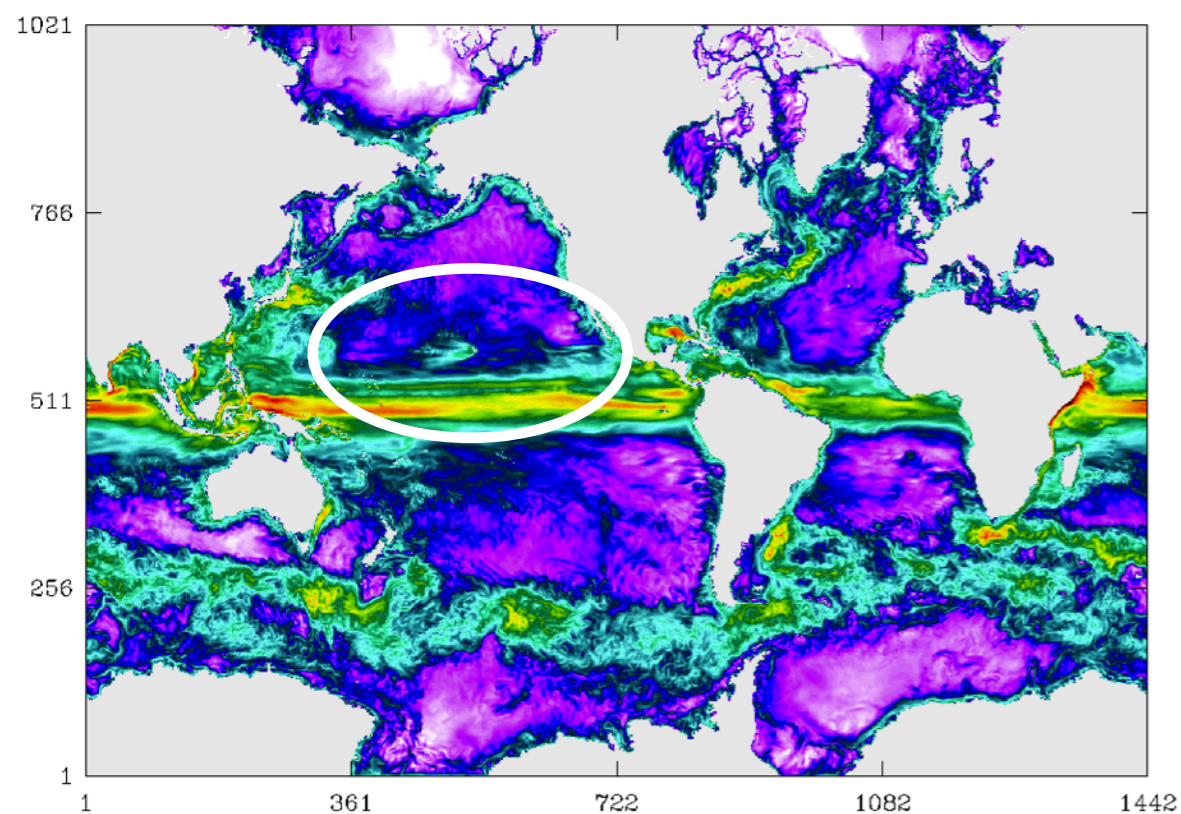
[cm².s⁻²]

Sensitivity experiment with JRA at 0.25° resolution

Surface eddy kinetic energy

ORCA025.L75 EKEgl 1958 GJM JRA2 DEPTH=10.00

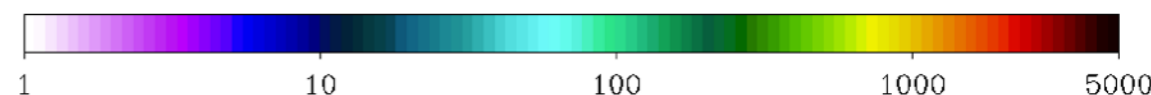
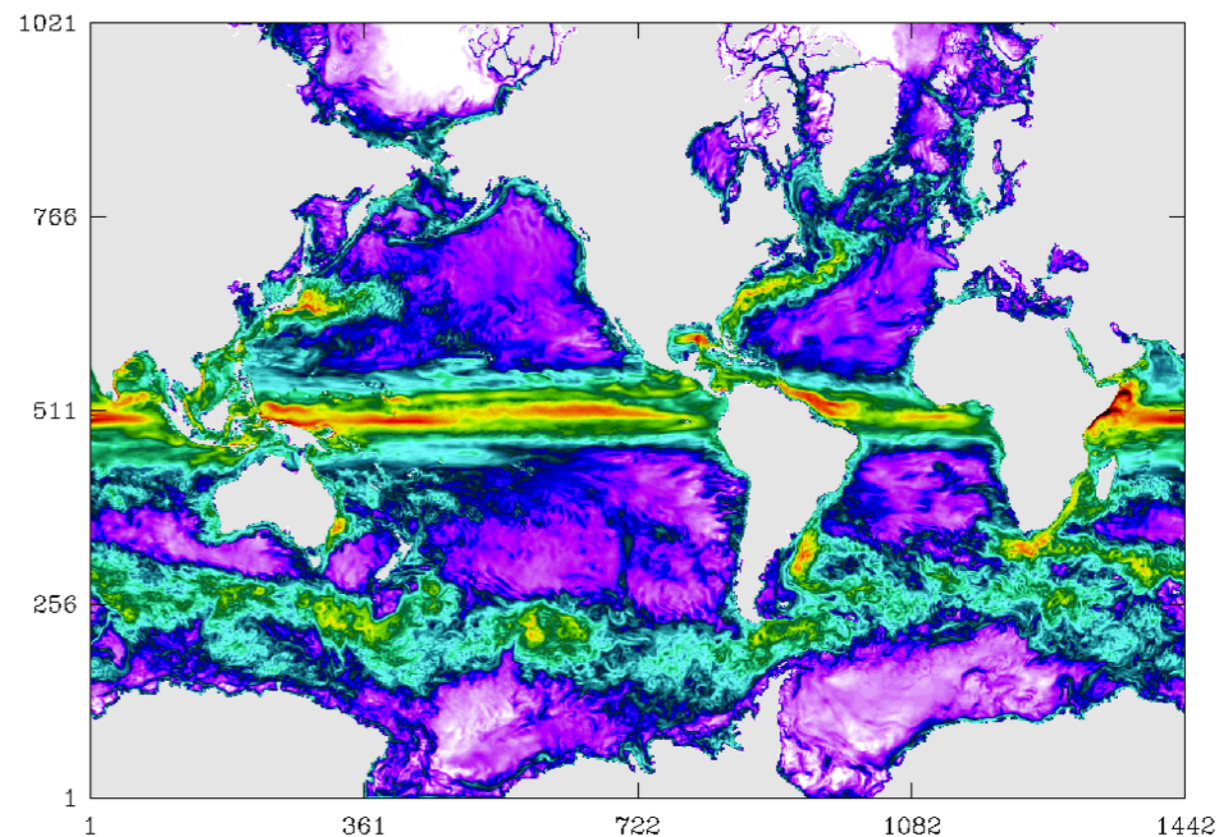
JRA2



[cm².s⁻²]

ORCA025.L75 EKEgl 1958 GJM189 DEPTH=10.00

DFS



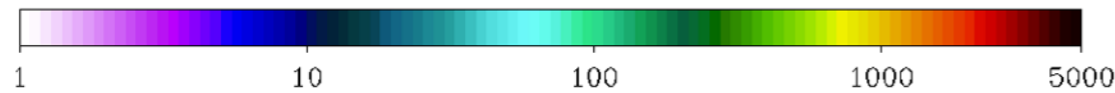
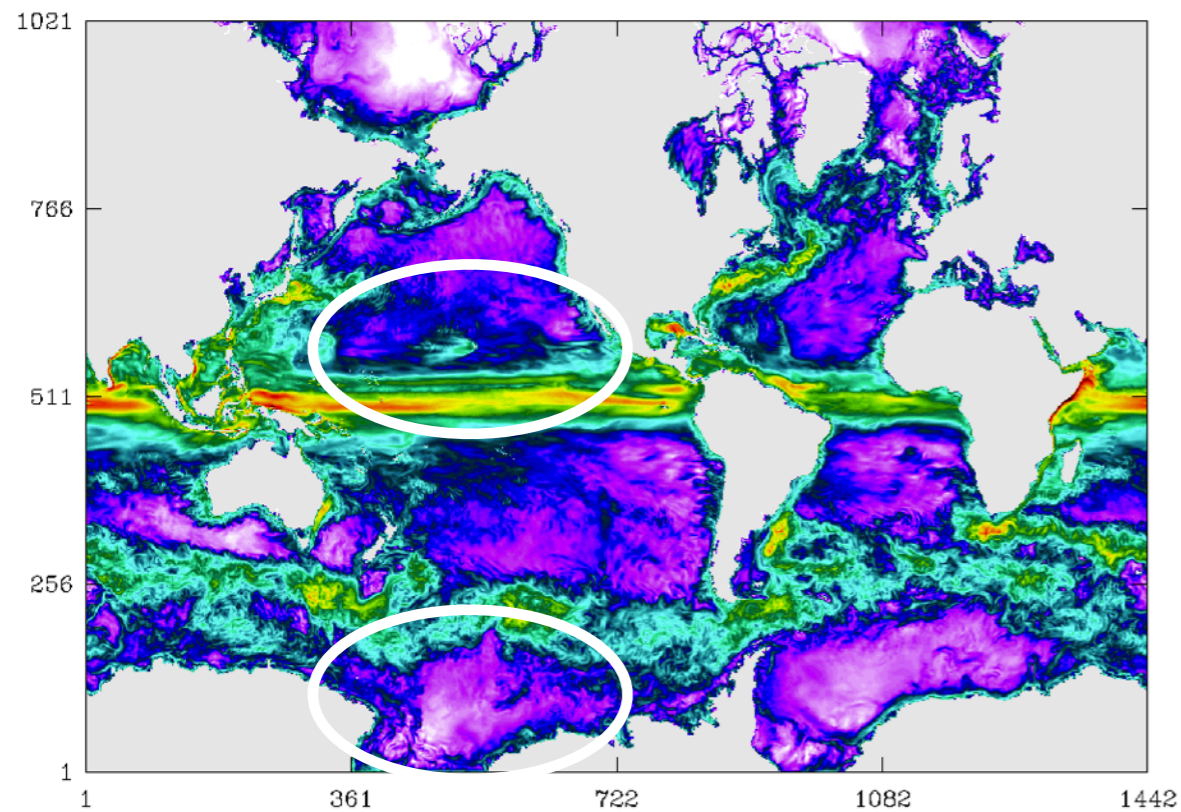
[cm².s⁻²]

Sensitivity experiment with JRA at 0.25° resolution

Surface eddy kinetic energy

ORCA025.L75 EKEgl 1958 GJM JRA2 DEPTH=10.00

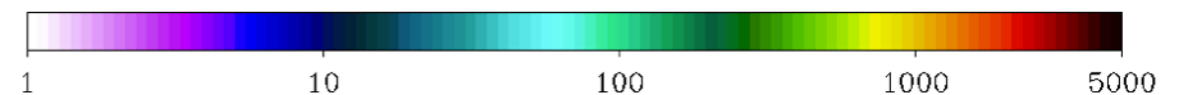
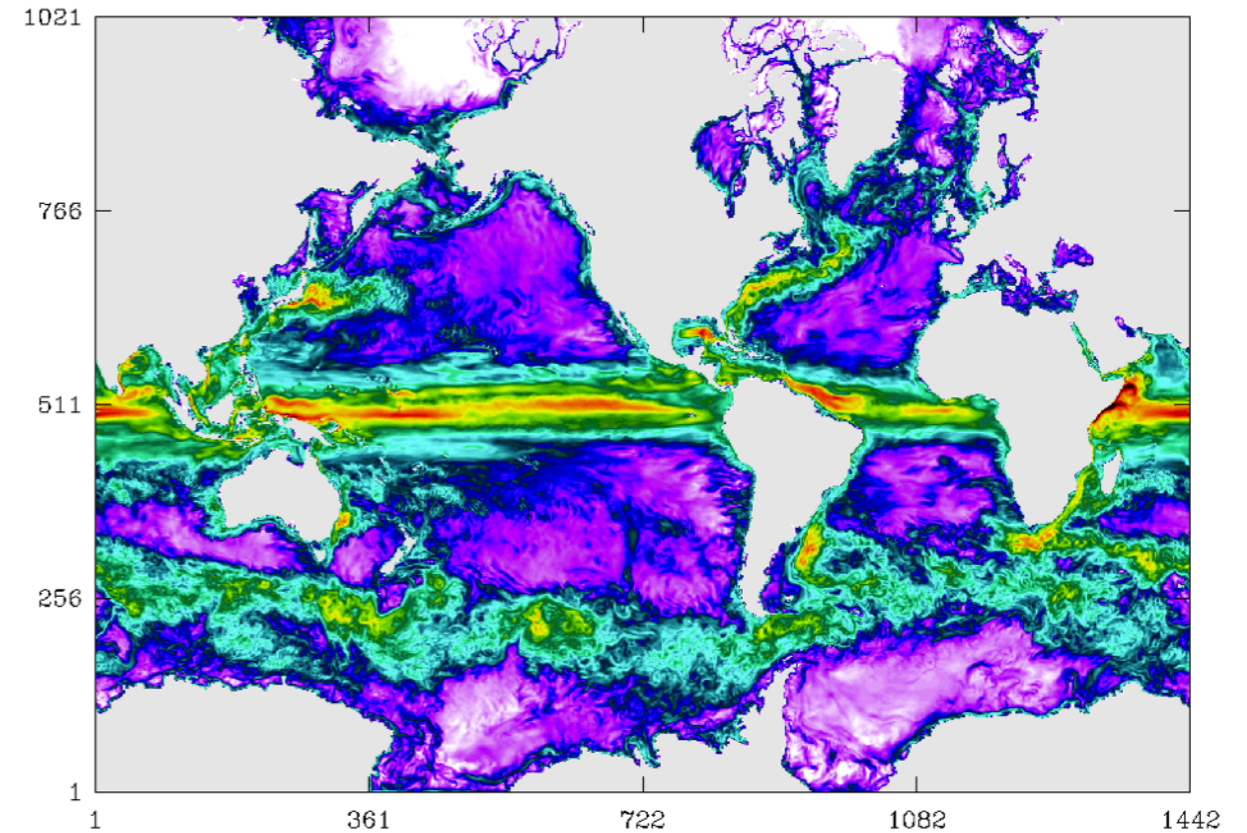
JRA2



[cm².s⁻²]

ORCA025.L75 EKEgl 1958 GJM189 DEPTH=10.00

DFS



[cm².s⁻²]

1. Model set-up, experiments and diagnostics
2. Sensitivity tests with JRA-55 forcing dataset at 0.5° resolution
3. Sensitivity tests with JRA-55 forcing dataset at 0.25° resolution
4. **Wrap-up and conclusions**

Forcing ocean/sea-ice models with JRA-55 (corrected v0.2) ?

- sensitivity to forcing depend on model configuration (resolution)
- trends not discussed here but could possibly affect multi-pass runs
- at coarse resolution, JRA-55 forced model solution is « ok »

at 0.5° resolution,

DFS and JRA lead **very similar simulations**, except for

- Southern Ocean : DP transport, mld, overturning, sea ice
- slightly less energetic pacific ST gyre and equatorial circulation

at 0.25° resolution,

DFS and JRA lead **different model solutions**

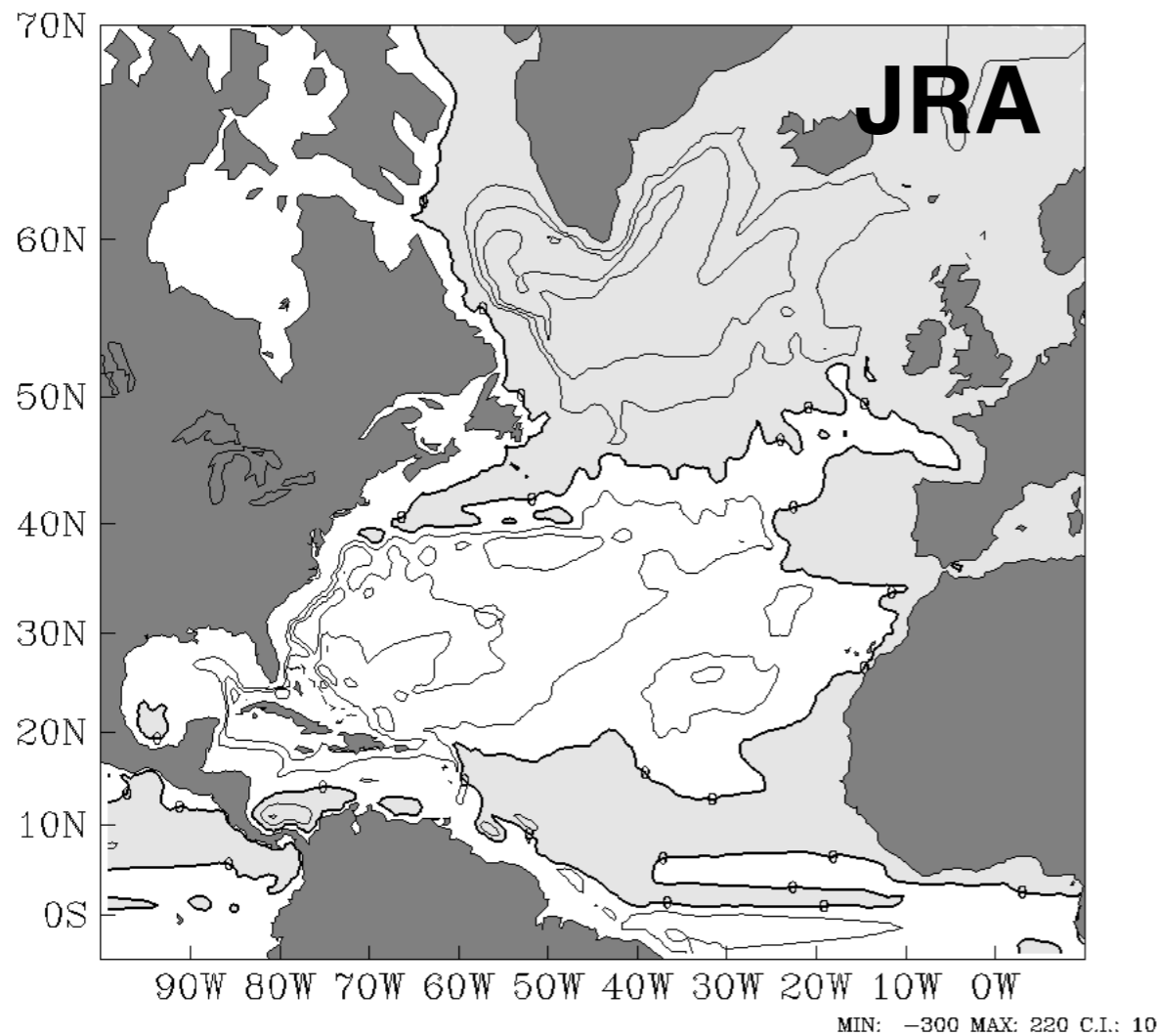
- spurious polynia in the Admunsen and the Ross seas
- possibly due to (eddy) heat advection from the boundary current
- possibly associated with surface winds (?).
- depend on the period (cf Claus Boning's results in Kiel)

EXTRA MATERIAL

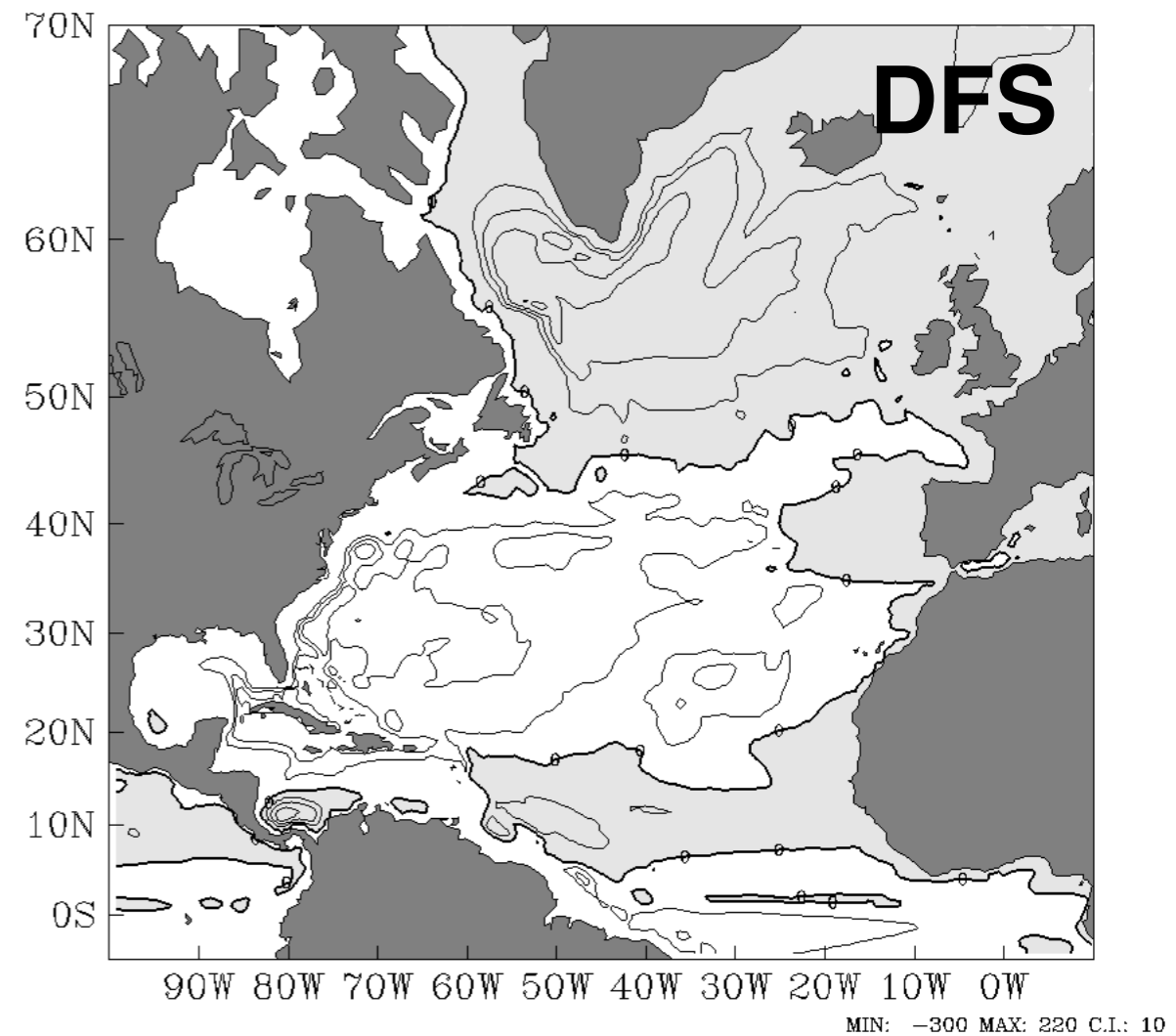
Sensitivity experiment with JRA at 0.5° resolution

Barotropic stream-function

ORCA05-GJMJRA1 PSI ATLN 2000-2007



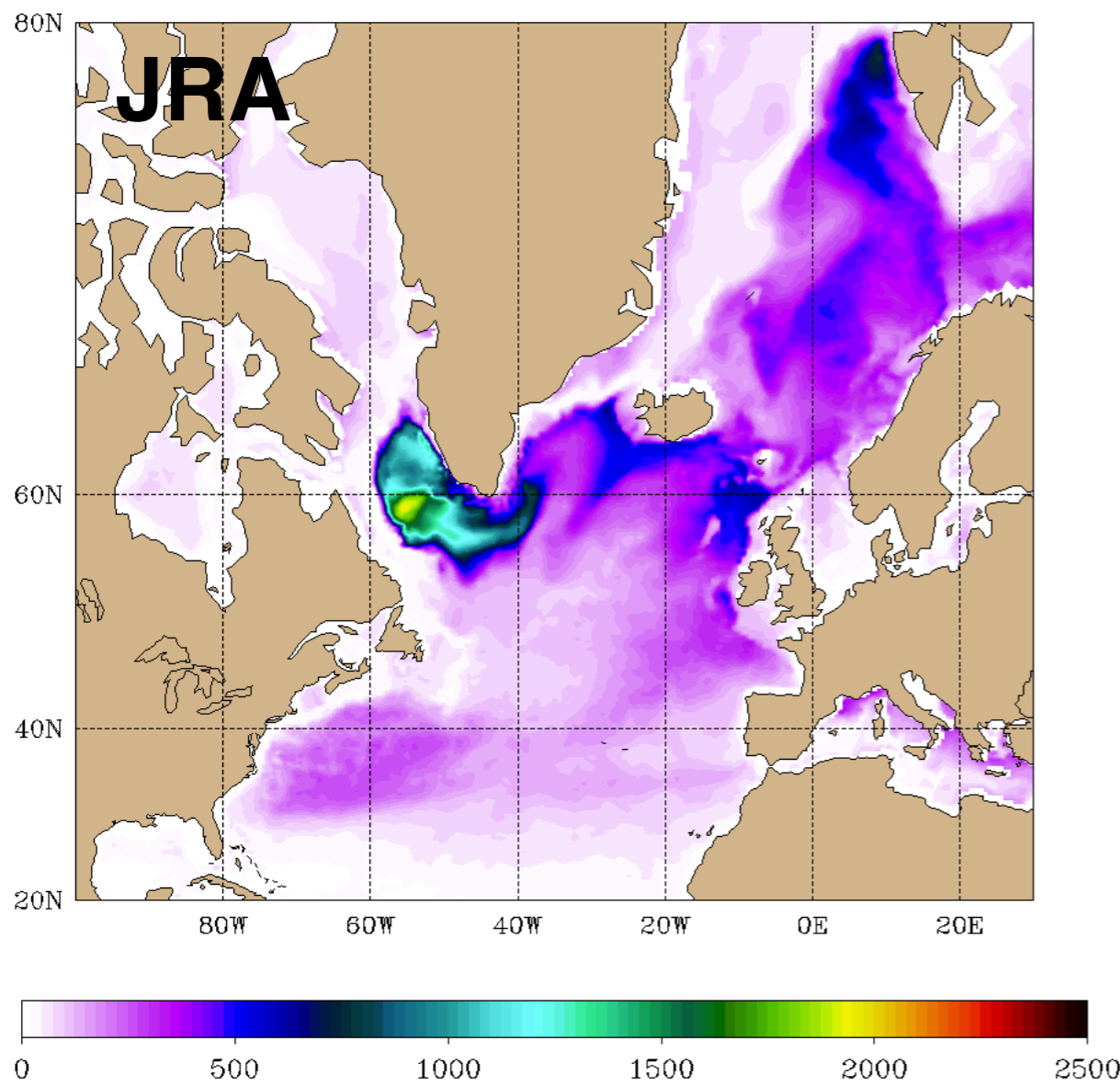
ORCA05-GJM189d PSI ATLN 2000-2007



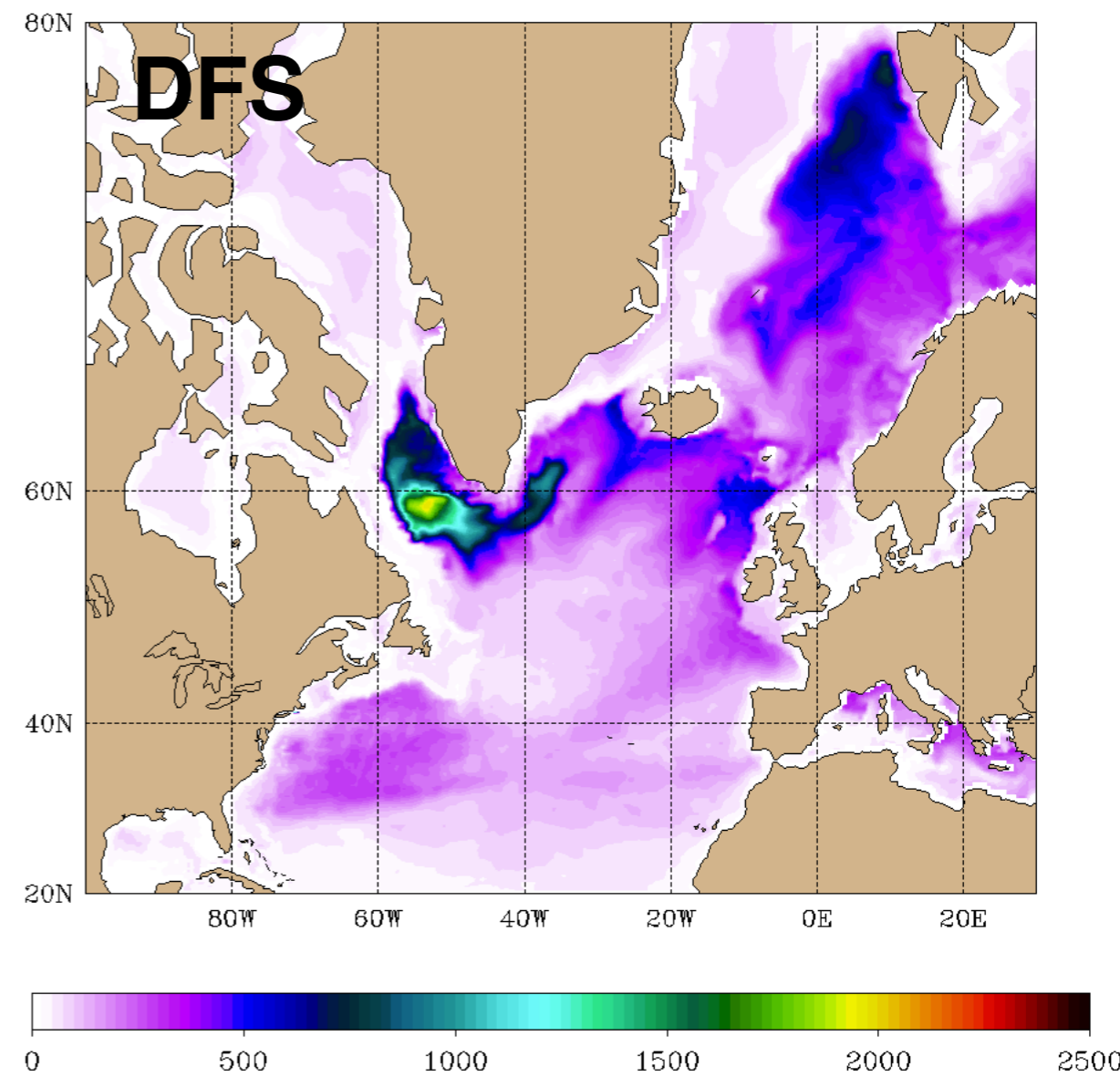
Sensitivity experiment with JRA at 0.5° resolution

Mixed layer depth

ORCA05-GJMJRA1 m03.MLDrho0.03 2000-2007

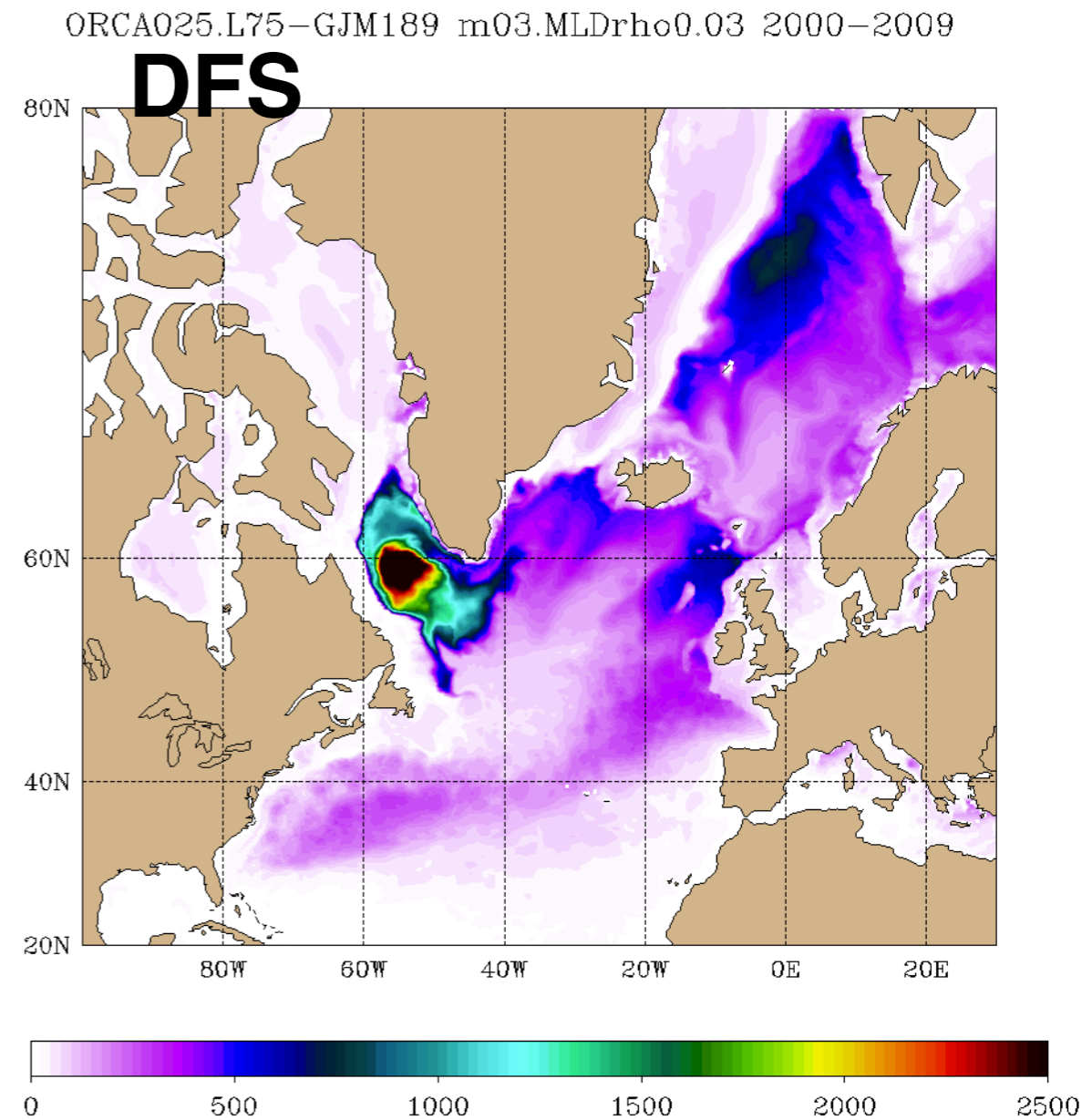
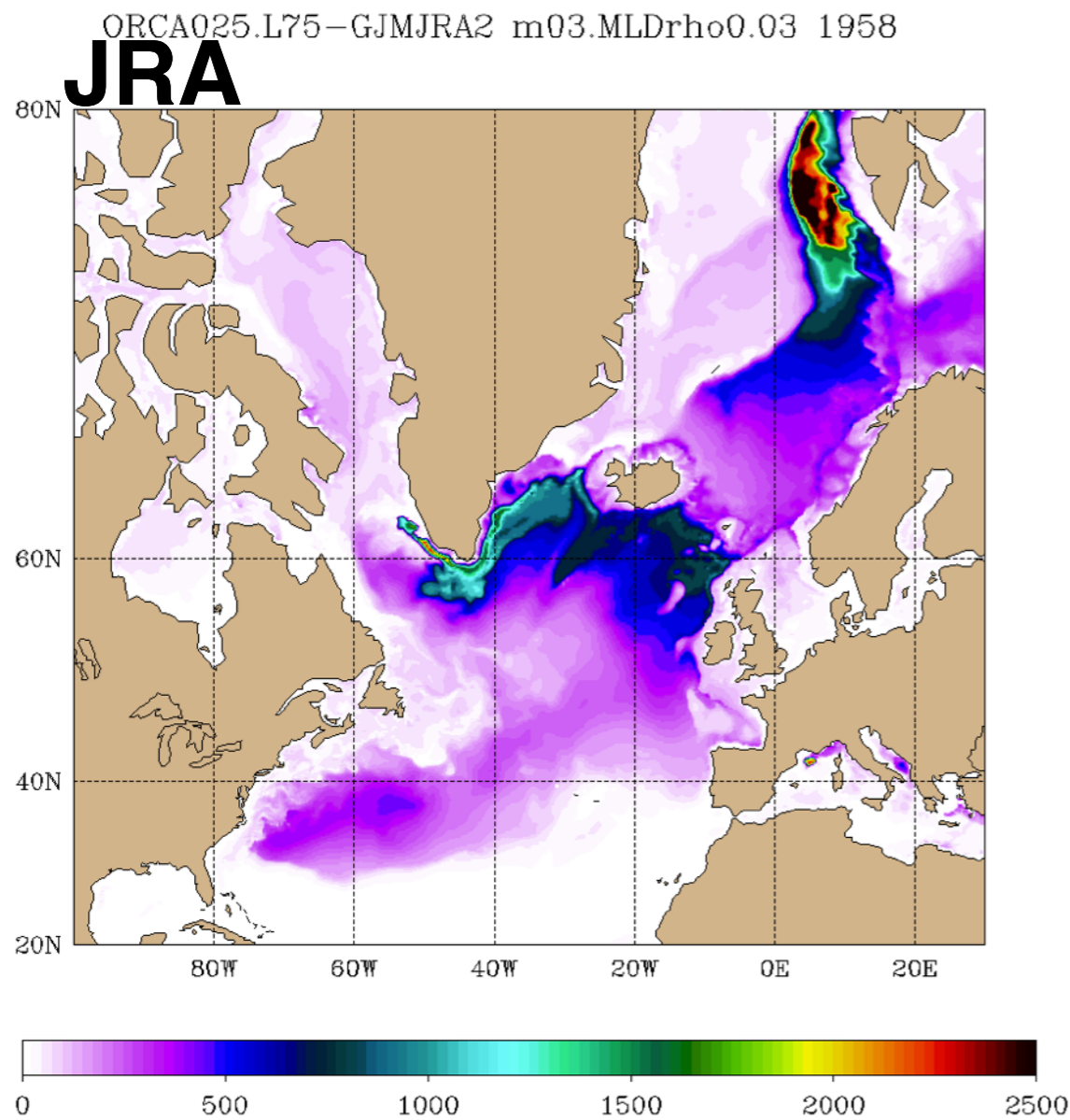


ORCA05-GJM189d m03.MLDrho0.03 2000-2007



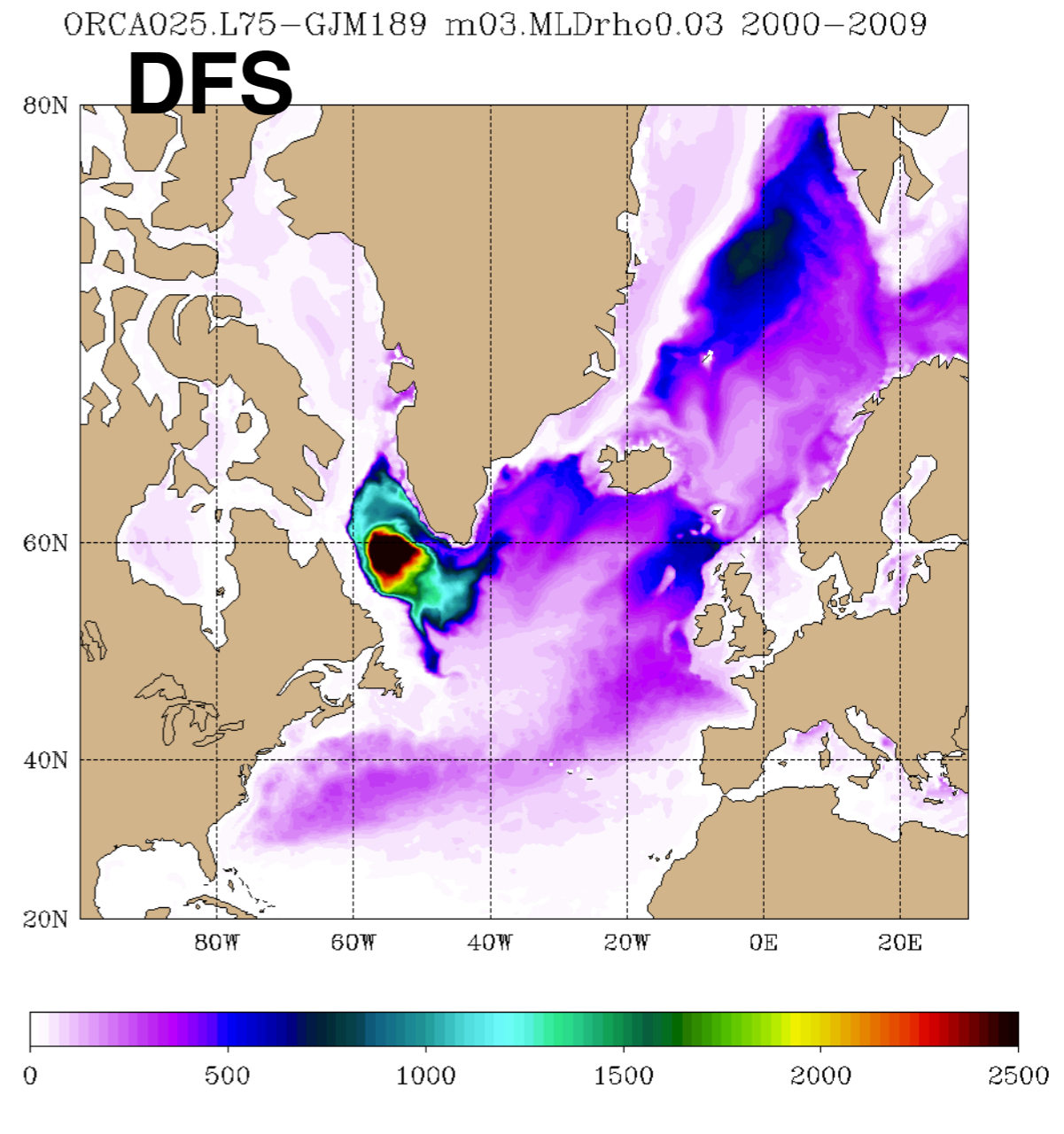
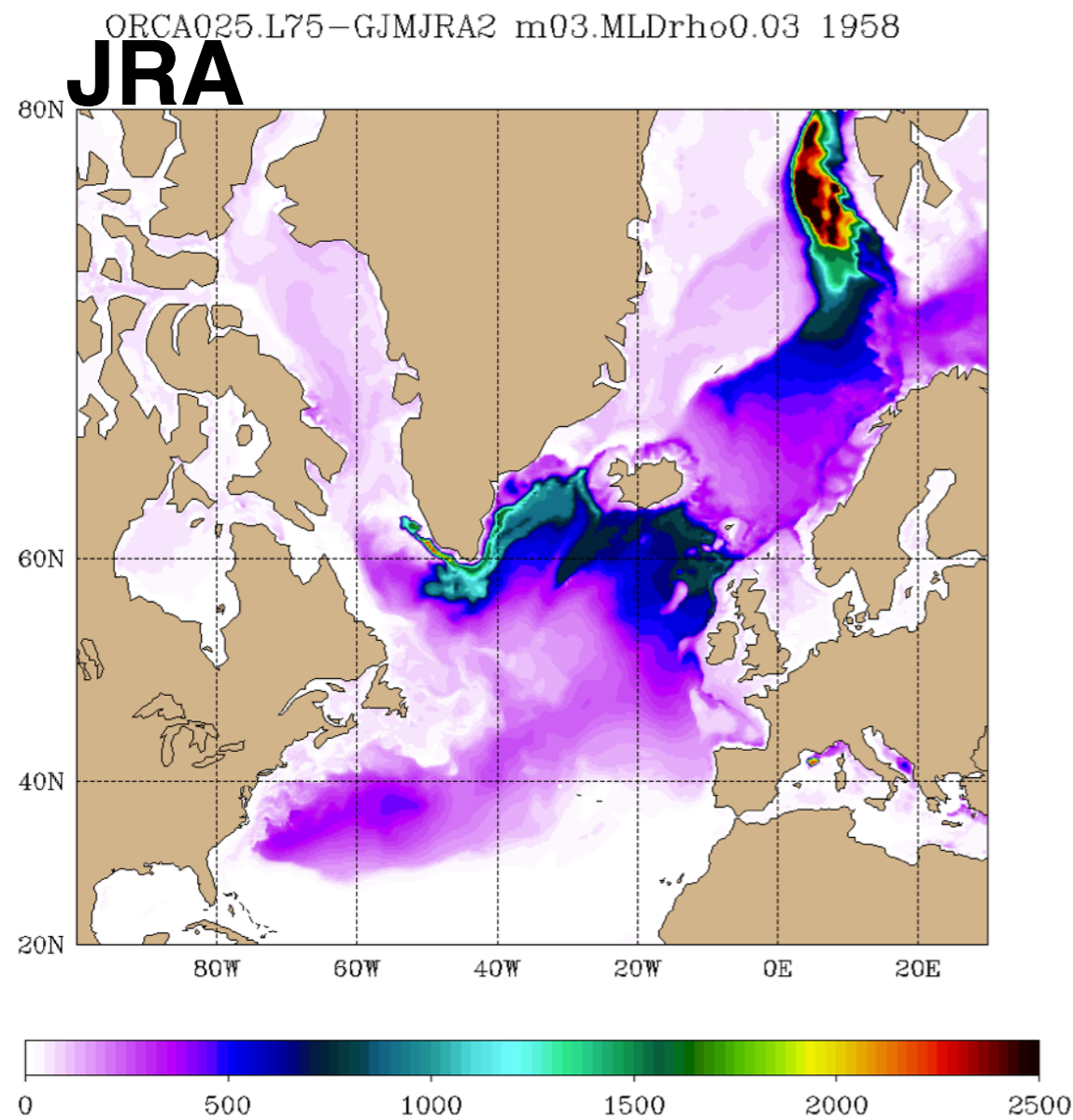
Sensitivity experiment with JRA at 0.25° resolution

Mixed layer depth



Sensitivity experiment with JRA at 0.25° resolution

Mixed layer depth



Sensitivity experiment with JRA at 0.5° resolution

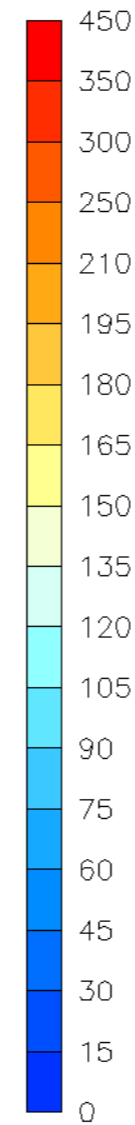
Sea ice thickness (September)

ANTARCTIC

Sea Ice Thicknes
Sep 2000–2007

ORCA05–GJMJRA1

JRA



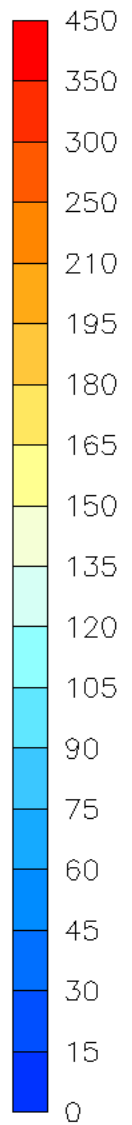
(cm)

Total area = million sq km
Volume = cubic km

Sea Ice Thicknes
Sep 2000–2007

ORCA05–GJM189d

DFS



(cm)

Total area = million sq km
Volume = cubic km

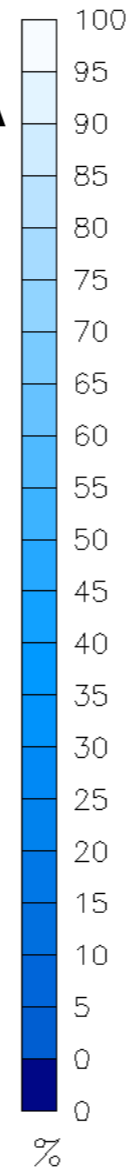
Sensitivity experiment with JRA at 0.5° resolution

Sea ice concentration (March)

Sea Ice Concentration
Mar 2000–2007

ORCA05–GJMJRA1

JRA

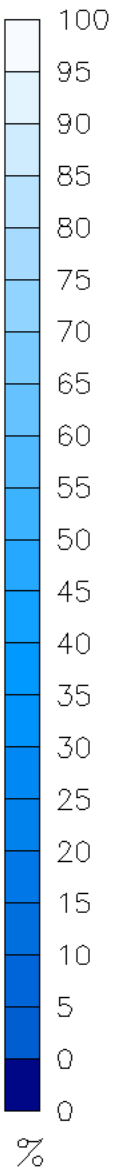


Total area = million sq km

Sea Ice Concentration
Mar 2000–2007

ORCA05–GJM189d

DFS



Total area = million sq km

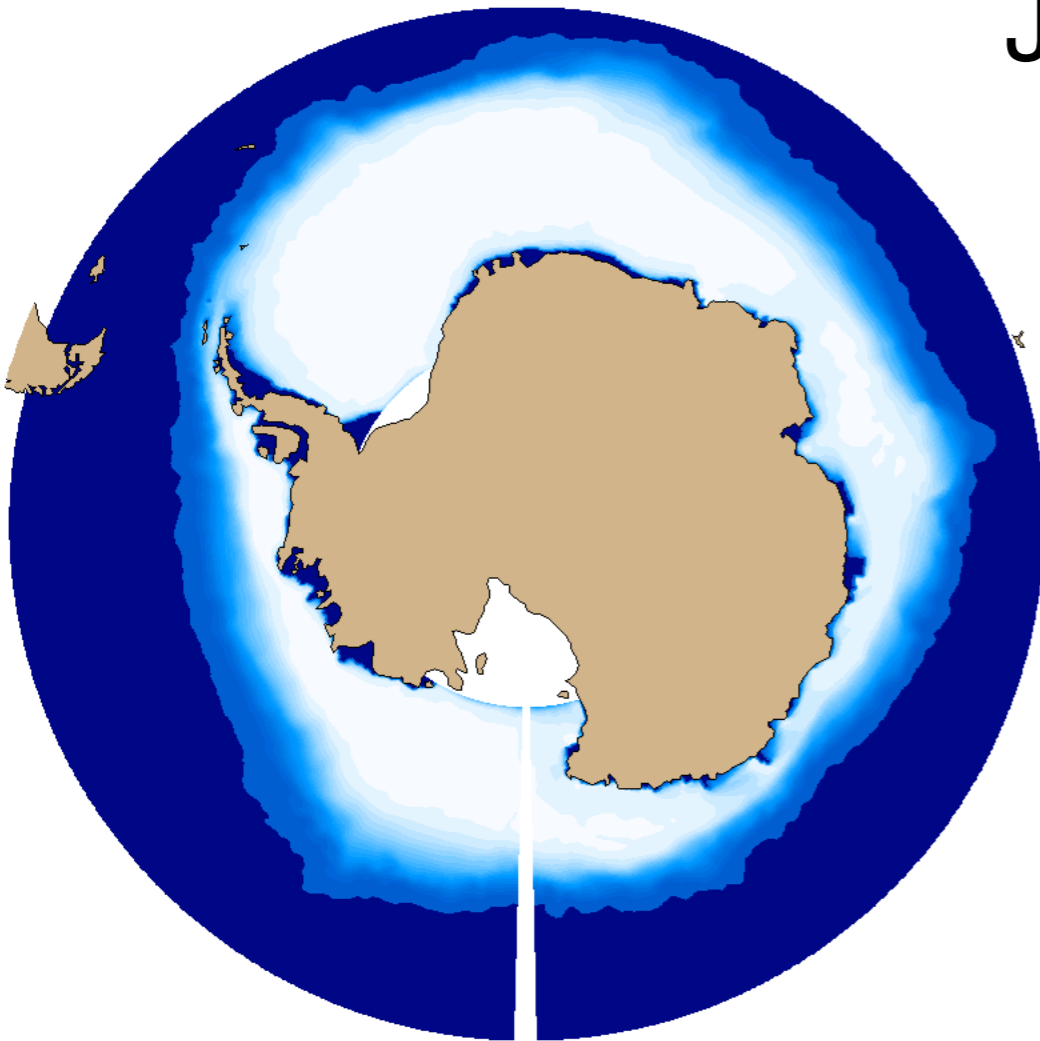
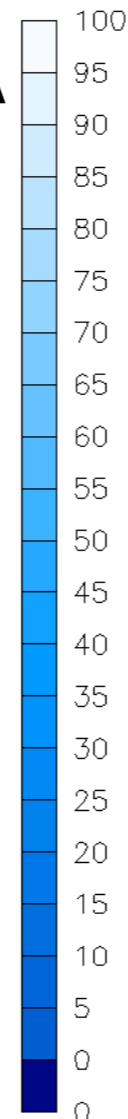
Sensitivity experiment with JRA at 0.5° resolution

Sea ice concentration (September)

Sea Ice Concentration
Sep 2000–2007

ORCA05–GJMJRA1

JRA

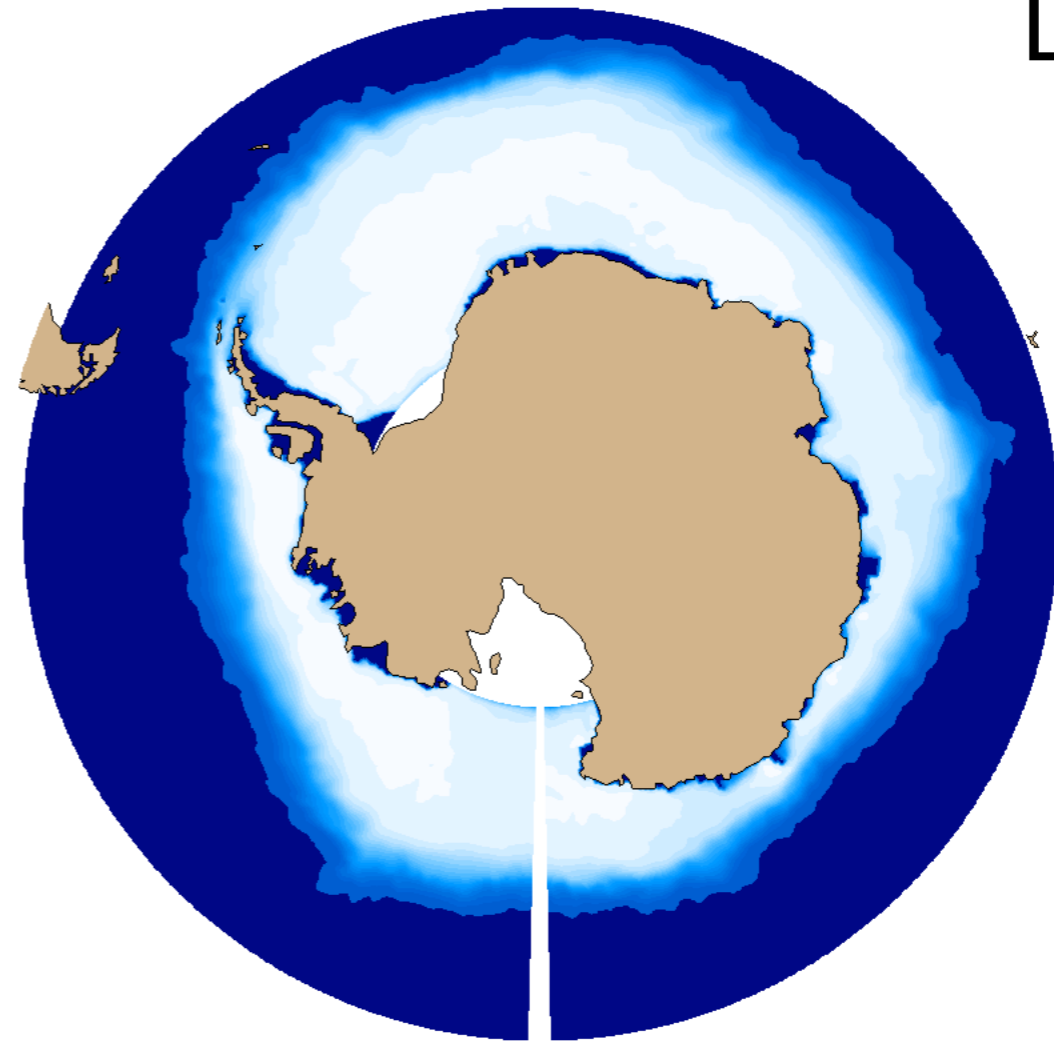
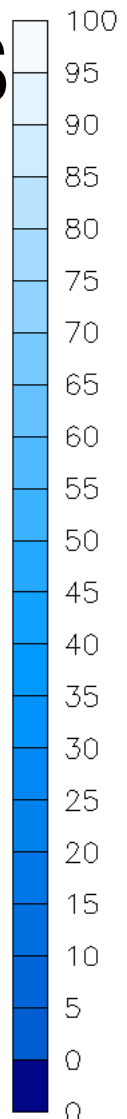


Total area = million sq km

Sea Ice Concentration
Sep 2000–2007

ORCA05–GJM189d

DFS



Total area = million sq km

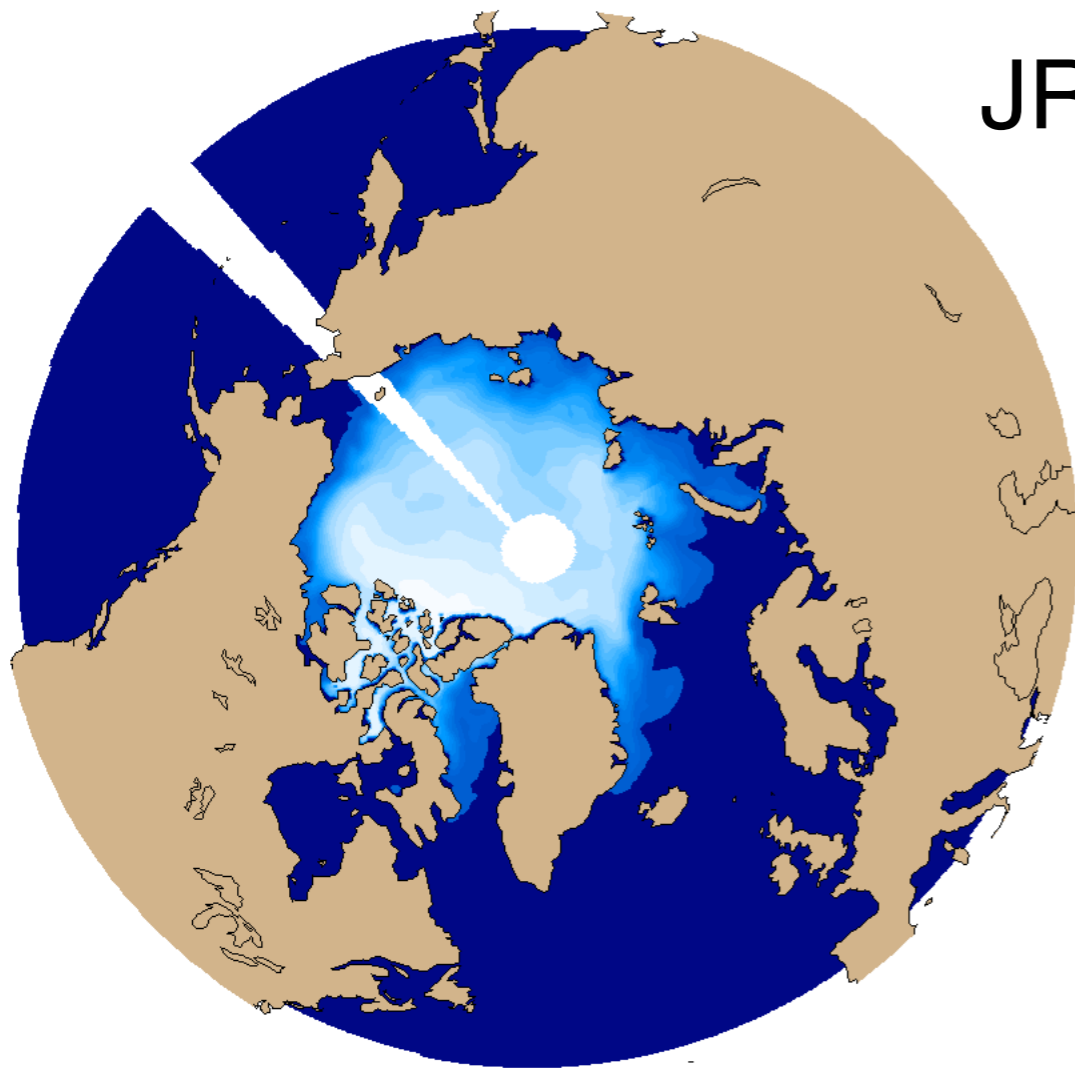
Sensitivity experiment with JRA at 0.5° resolution

Sea ice concentration (September)

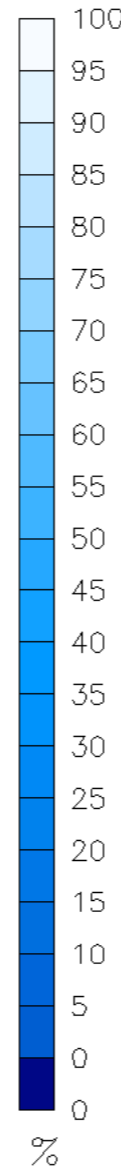
Sea Ice Concentration
Sep 2000–2007

ORCA05–GJMJRA1

JRA



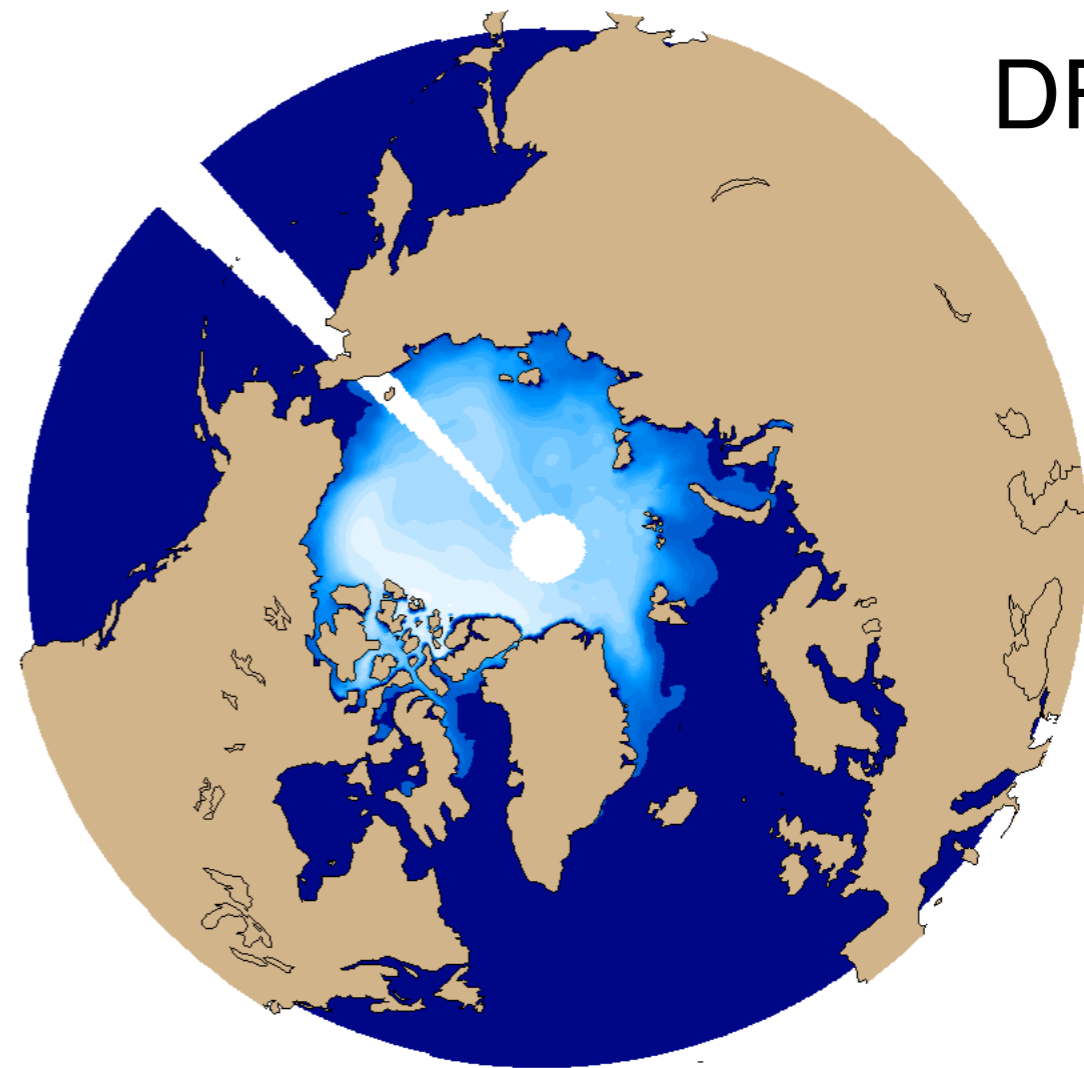
Total area = million sq km



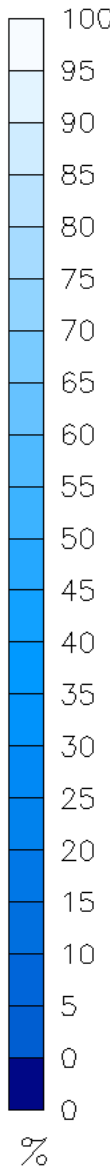
Sea Ice Concentration
Sep 2000–2007

ORCA05–GJM189d

DFS



Total area = million sq km



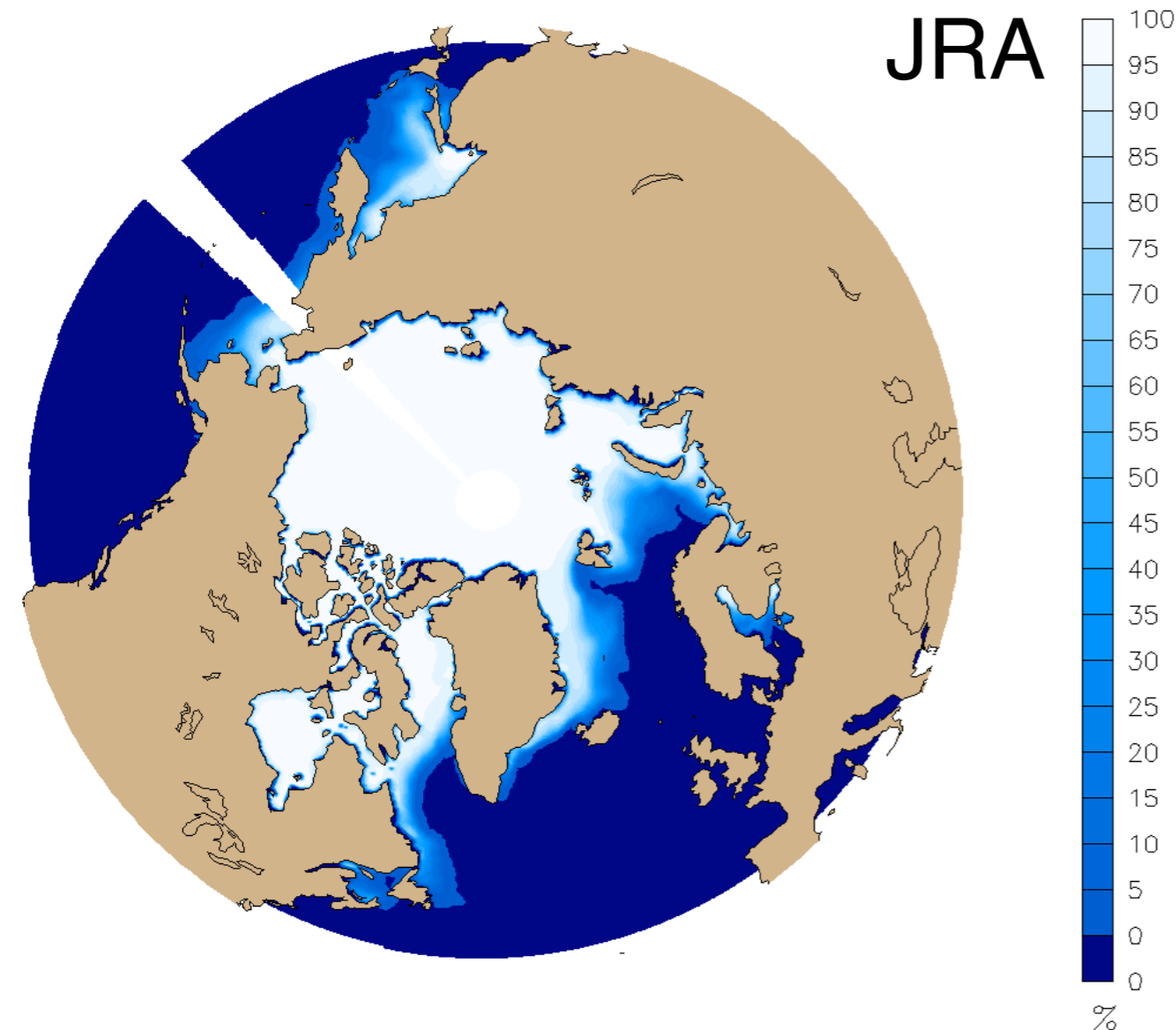
Sensitivity experiment with JRA at 0.5° resolution

Sea ice concentration (March)

Sea Ice Concentration
Mar 2000–2007

ORCA05–GJMJRA1

JRA

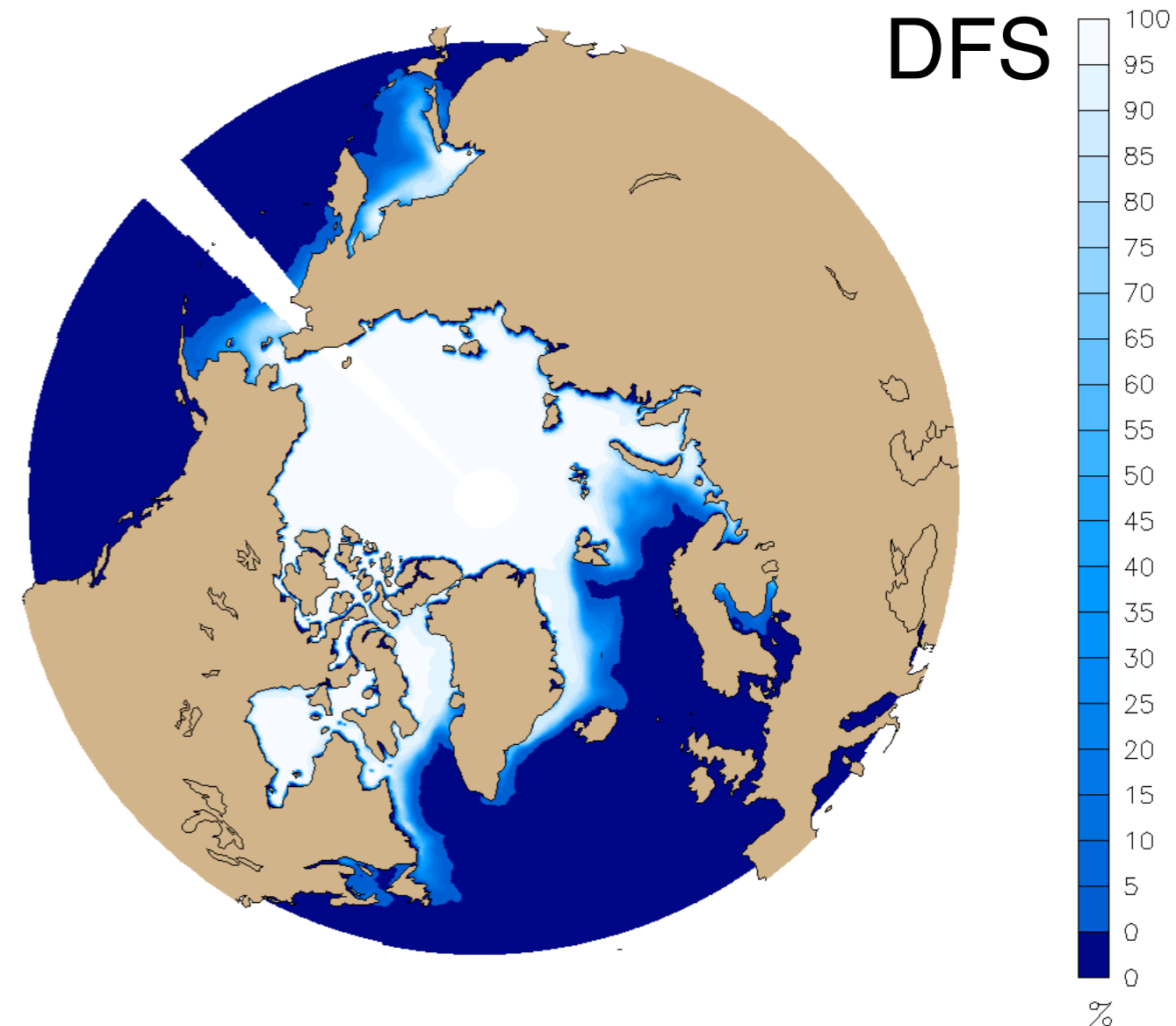


Total area = million sq km

Sea Ice Concentration
Mar 2000–2007

ORCA05–GJM189d

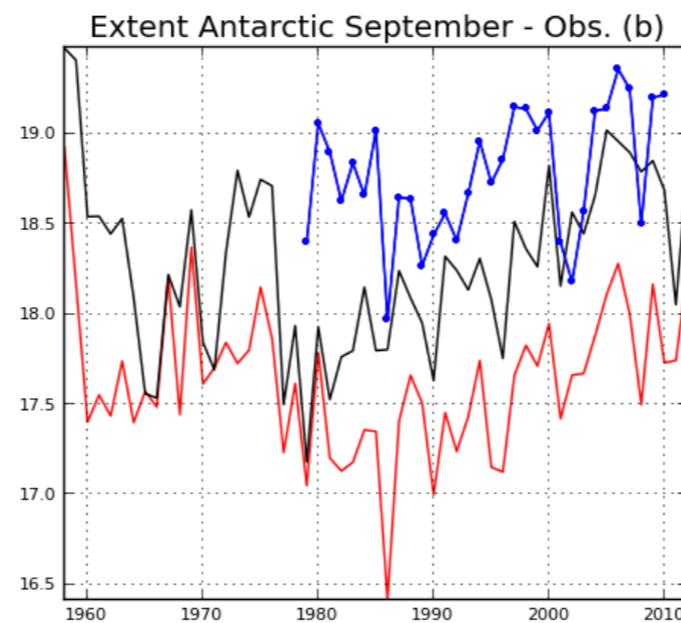
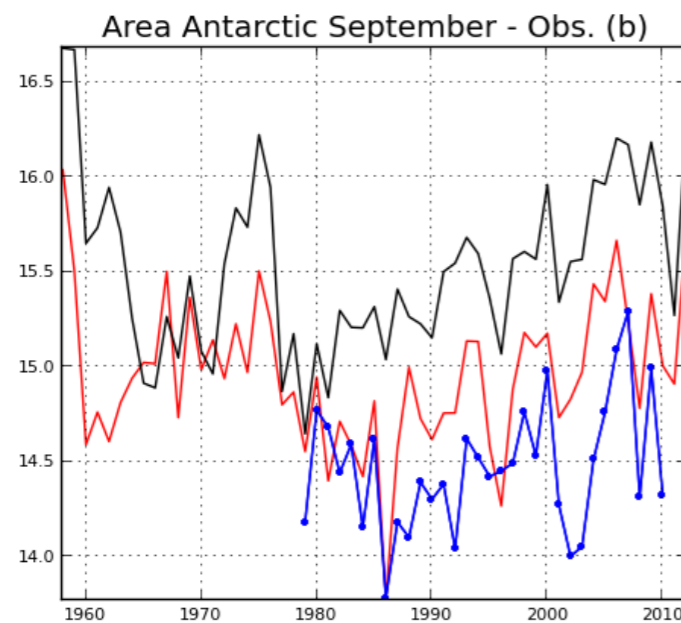
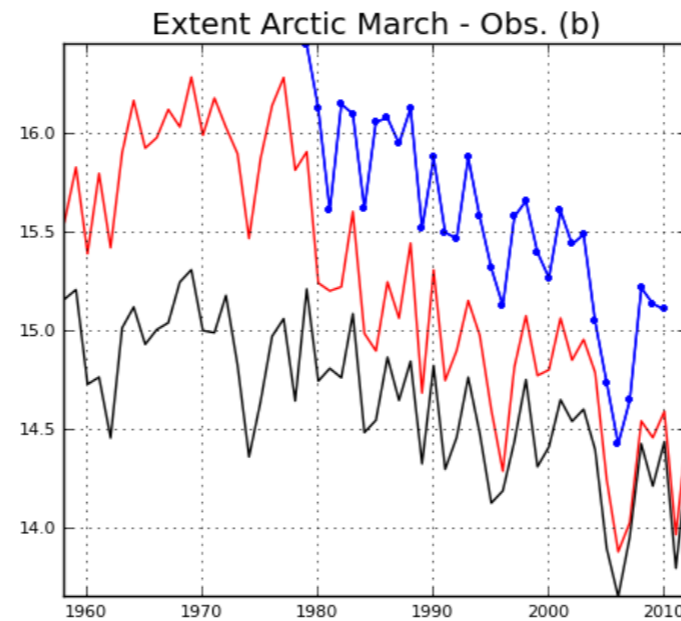
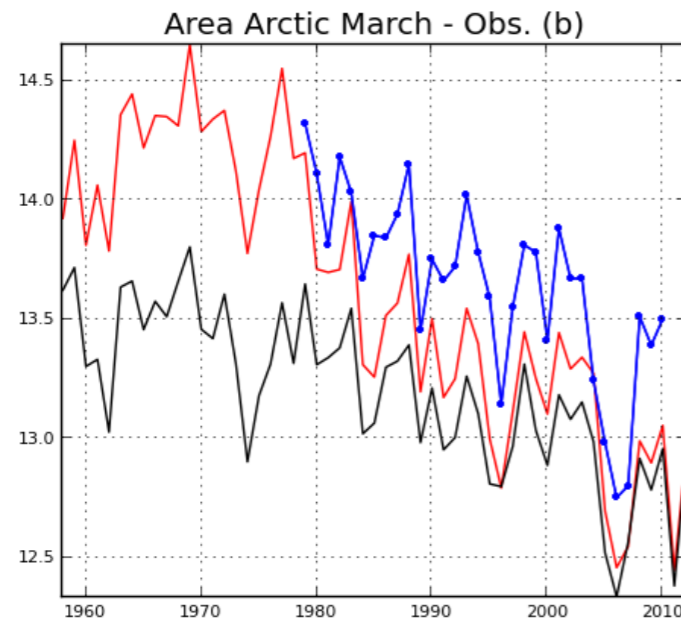
DFS



Total area = million sq km

Sensitivity experiment with JRA at 0.5° resolution

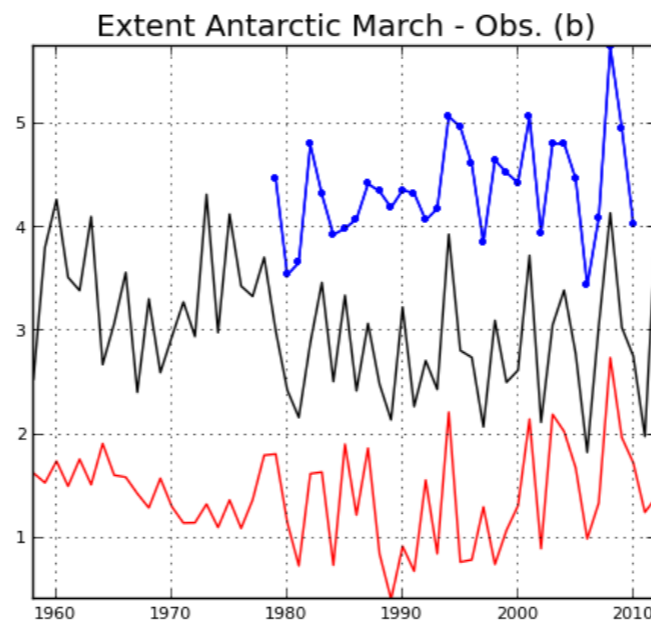
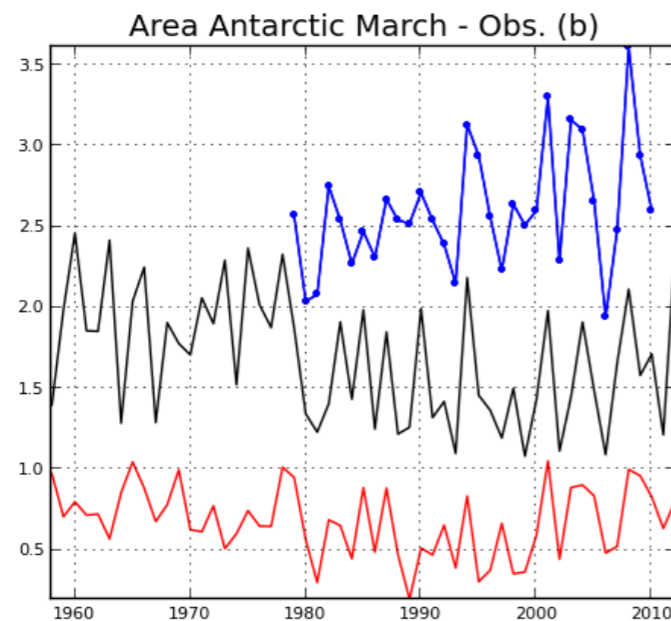
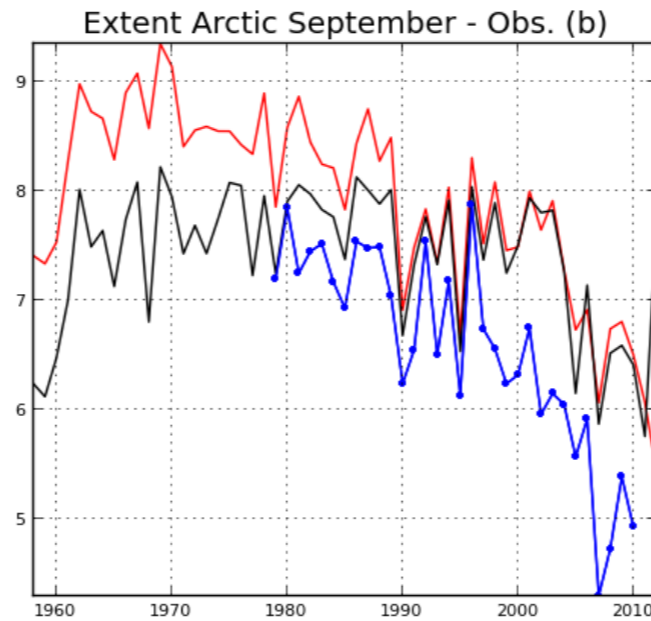
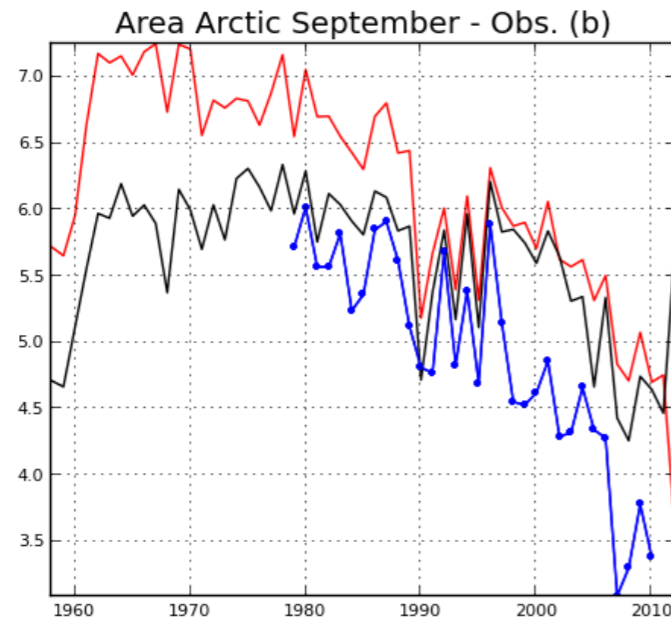
Sea ice extent and sea ice area (maximum)



JRA : red
DFS : black
OBS : blue

Sensitivity experiment with JRA at 0.5° resolution

Sea ice extent and sea ice area (minimum)



JRA : red
DFS : black
OBS : blue