



National  
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# Seasonal differences in the persistence of SST's Response to the North Atlantic Jet Stream

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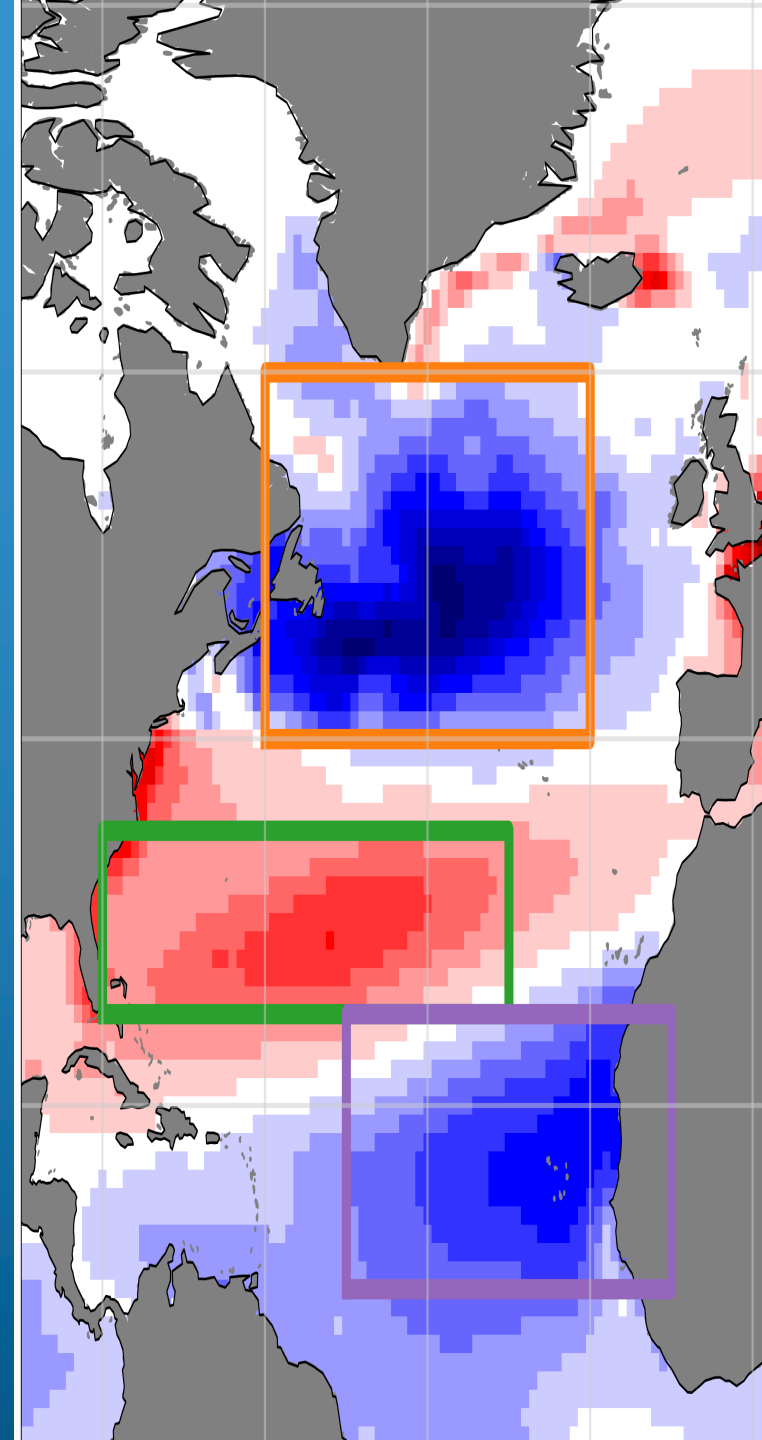
National Oceanography Centre, Southampton UK

**Ben Harvey, Jon Robson**

University of Reading, Reading UK

**Tom Bracegirdle**

British Antarctic Survey, Cambridge UK



# Motivation

- The North Atlantic atmospheric variability is well known to leave an imprint on the North Atlantic Sea Surface Temperature (SST) in the form of a tripolar pattern. (e.g. Visbeck et al. 2003)
- The majority of the existing research has focuses on the ocean response to winter atmospheric variability. (e.g. Ma et al. 2020)
- Here we investigate the response of the North Atlantic SSTs to the strength and position of the North Atlantic Jet Stream in both the **winter and summer seasons**, with a focus on **persistence of the SST anomalies**.

# Data and Analysis

- Data CMIP6 piControl with 14 models/ensemble members:

ACCESS-CM2 (r1i1p1f1), CAMS-CSM1-0 (r1i1p1f1), CESM2-WACCM (r1i1p1f1), CMCC-CM2-SR5 (r1i1p1f1), CNRM-CM6-1 (r1i1p1f2), CNRM-ESM2-1 (r1i1p1f2), CanESM5 (r1i1p1f1), CanESM5 (r1i1p2f1), HadGEM3-GC31-LL (r1i1p1f1), MPI-ESM1-2-LR (r1i1p1f1), UKESM1-0-LL (r1i1p1f2), HadGEM3-GC31-MM (r1i1p1f1), IPSL-CM6A-LR (r1i1p1f1), IPSL-CM6A-LR (r1i2p1f1)

- Atlantic Jet Indices are computed between 60°W and 0° from seasonal means:

- Jet Strength - maximum zonal velocity

- Jet Latitude - latitude with maximum zonal velocity

- All results show difference between stronger jet and weaker jet:

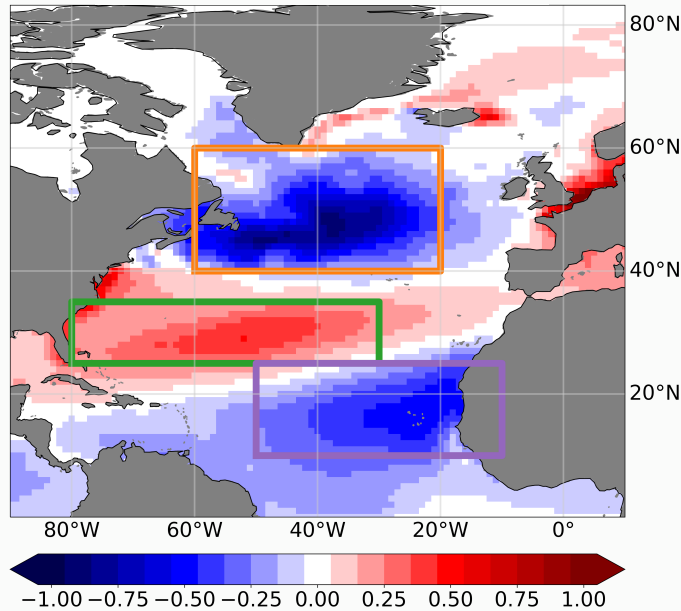
- stronger jet -> all times when the jet strength is  $> \text{mean} + 1 \text{ standard deviation}$
- weaker jet -> all times when the jet strength is  $< \text{mean} - 1 \text{ standard deviation}$

- Here we focus on winter (DJF) and summer (JJA) jet.

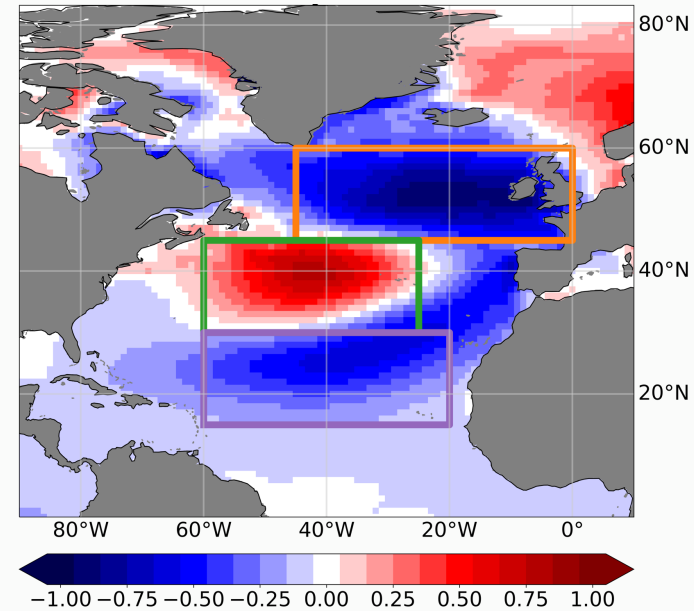
- winter jet strength mean is 10.2 m/s, standard deviation 1.9 m/s
- summer jet strength mean is 6.2 m/s and standard deviation 1.0 m/s

# SST Response to Jet Stream Changes

Winter Jet Strength



Summer Jet Strength



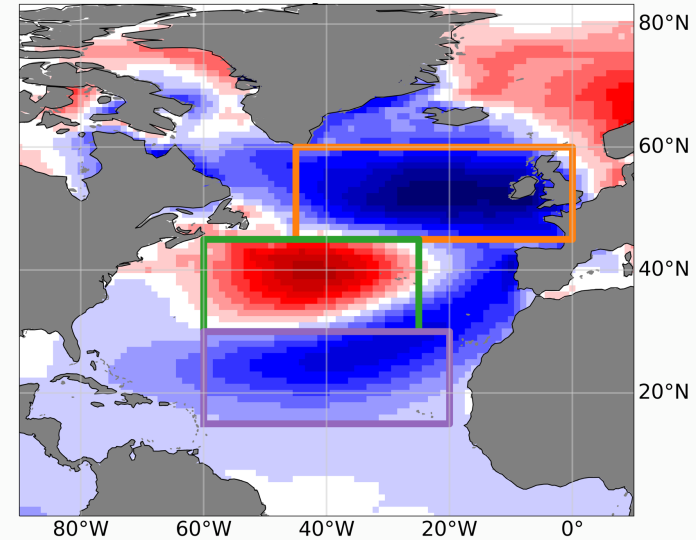
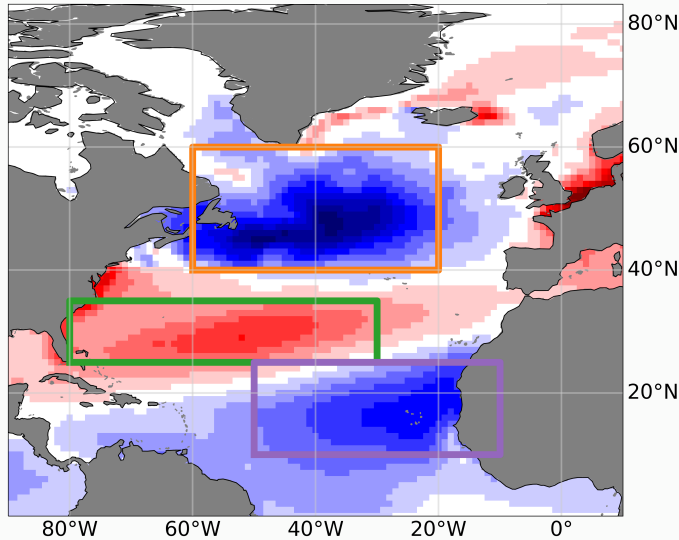
- In both summer and winter the SST responds with a tri-polar pattern to changes in the jet strength.
- Summer response is slightly further North and more horseshoe shaped while the winter response is has more of a banded structure.
- Amplitude of the tri-polar SST pattern is very similar in the winter and summer, especially in the Northern most box, despite the variability of the winter jet being almost double that of the summer jet.

# SST Response to Jet Stream Changes

Winter Jet Strength

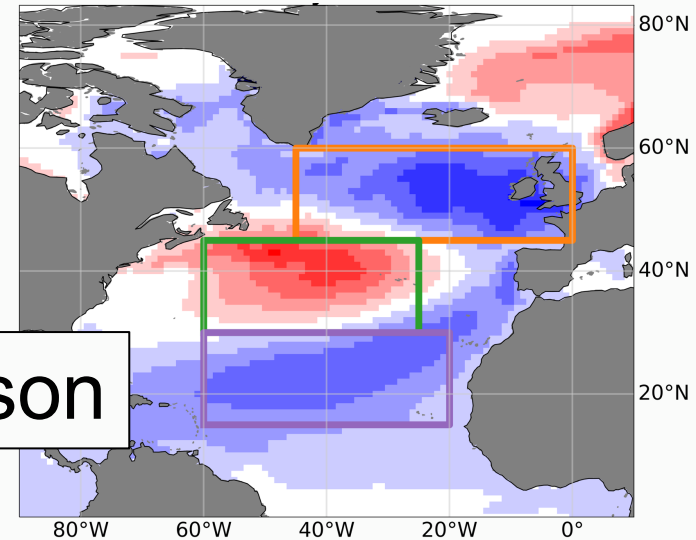
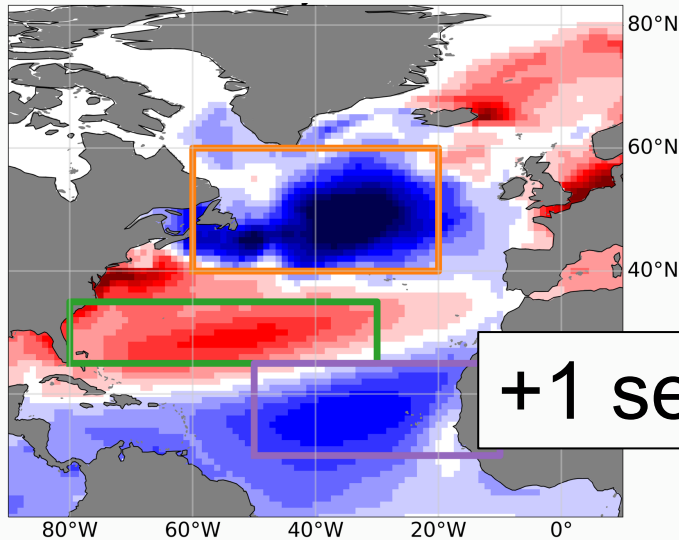
Summer Jet Strength

DJF  
+0 years



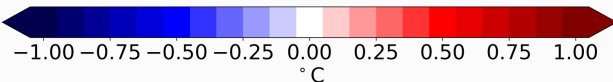
JJA  
+0 years

MAM  
+0 years



SON  
+0 years

+1 season

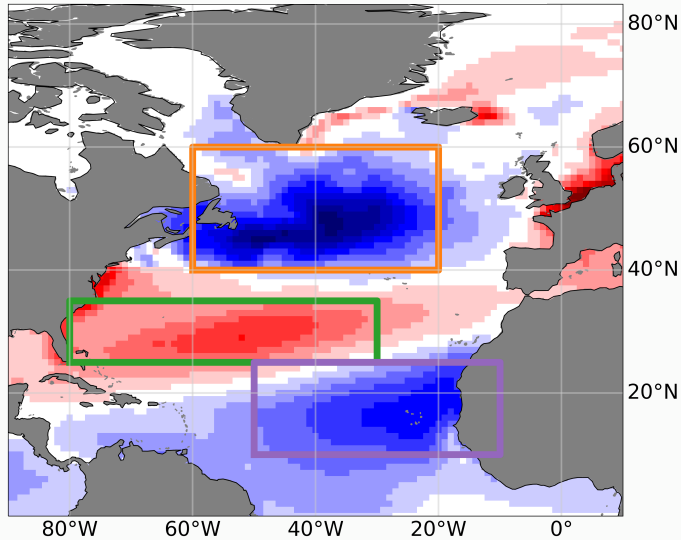


# SST Response to Jet Stream Changes

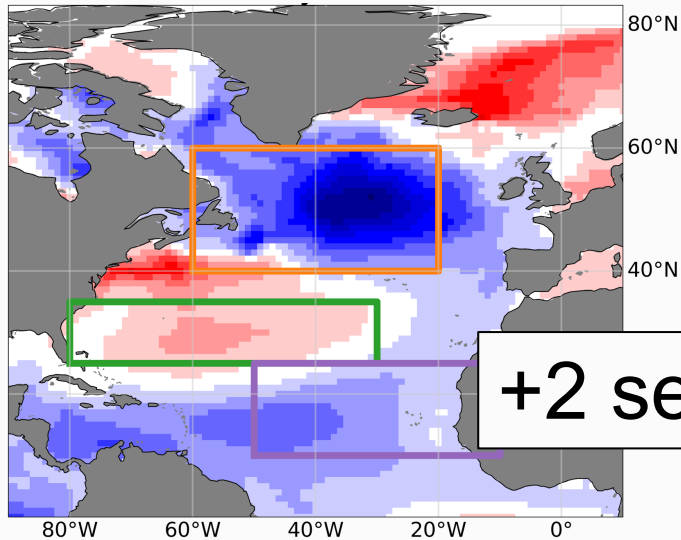
Winter Jet Strength

Summer Jet Strength

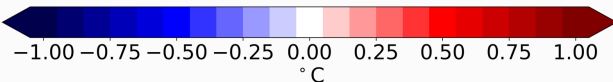
DJF  
+0 years



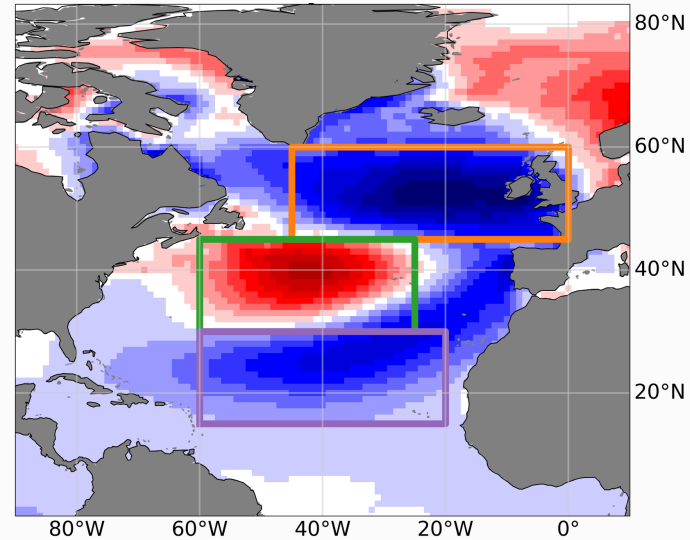
JJA  
+0 years



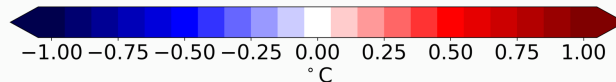
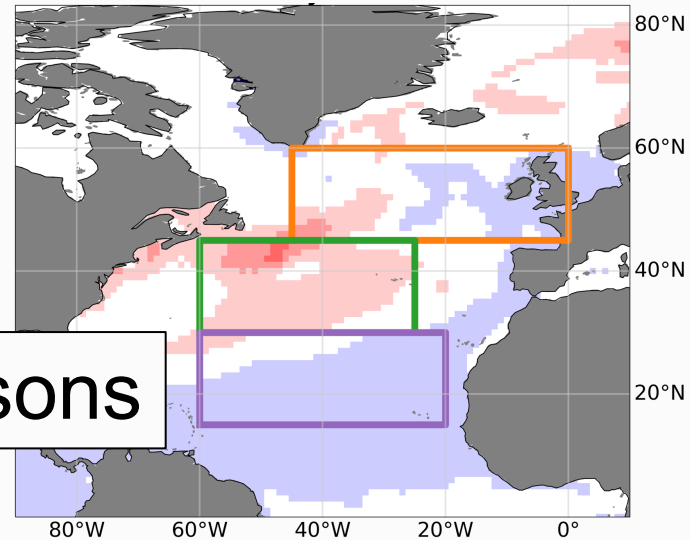
+2 seasons



JJA  
+0 years



DJF  
+0 years

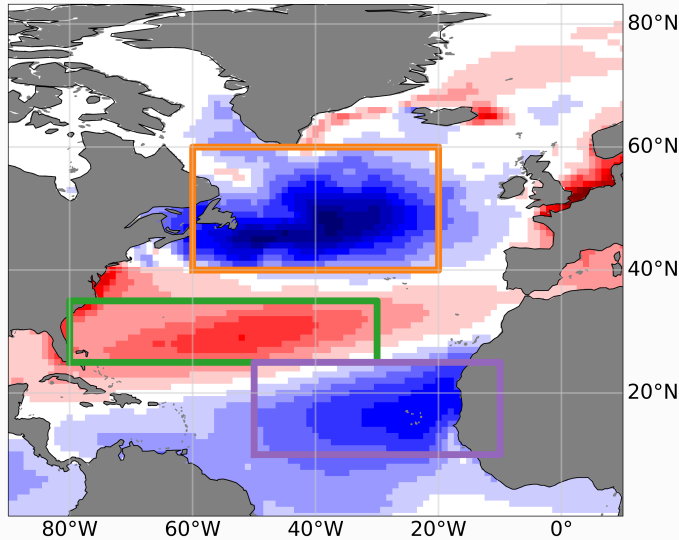


# SST Response to Jet Stream Changes

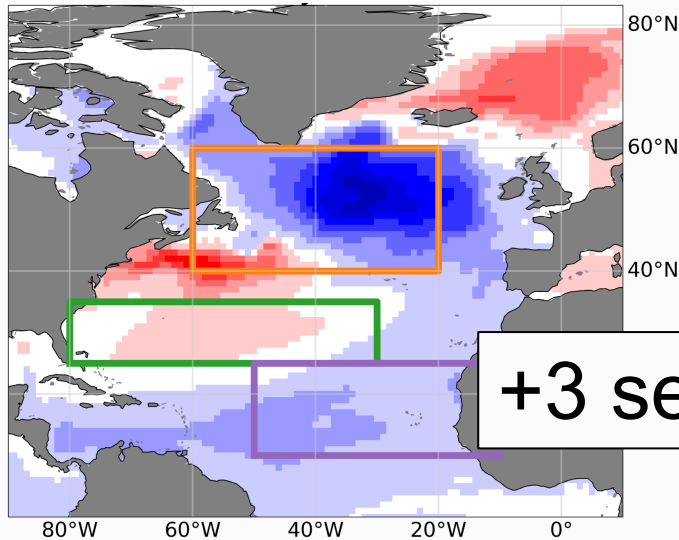
Winter Jet Strength

Summer Jet Strength

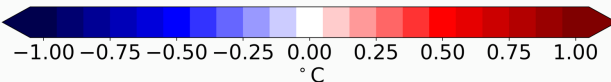
DJF  
+0 years



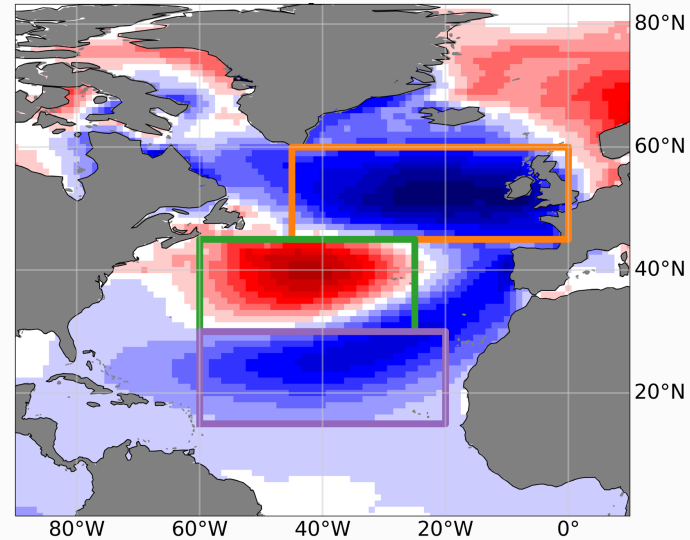
SON  
+0 years



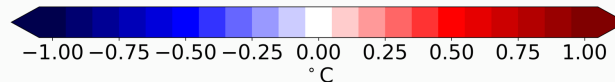
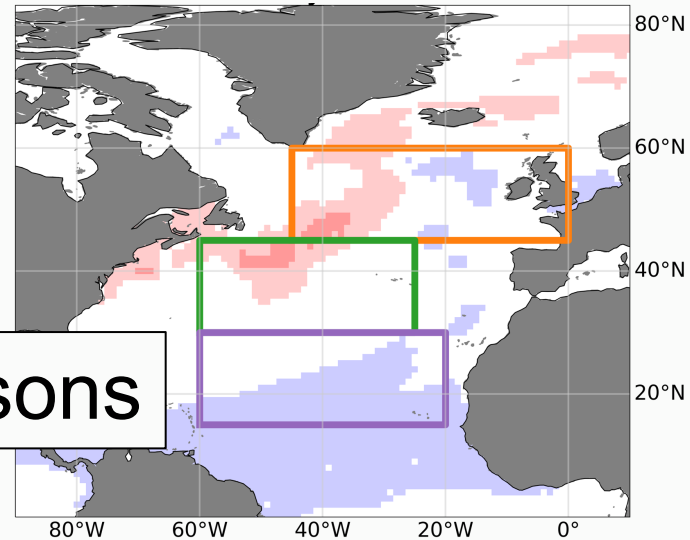
+3 seasons



JJA  
+0 years



MAM  
+0 years

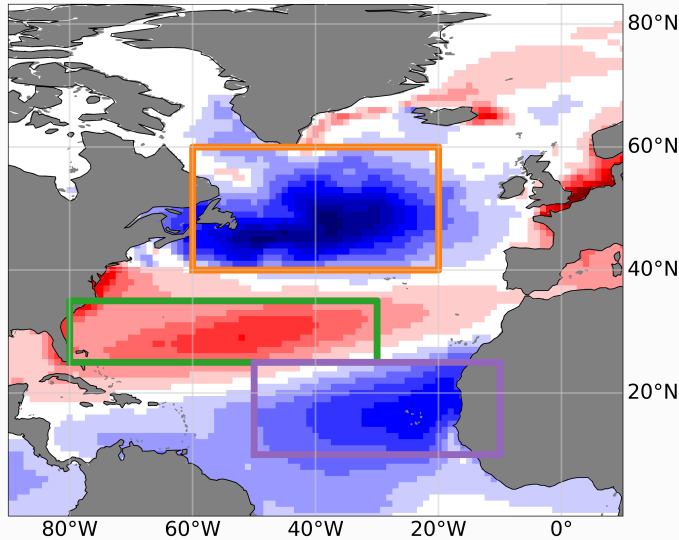


# SST Response to Jet Stream Changes

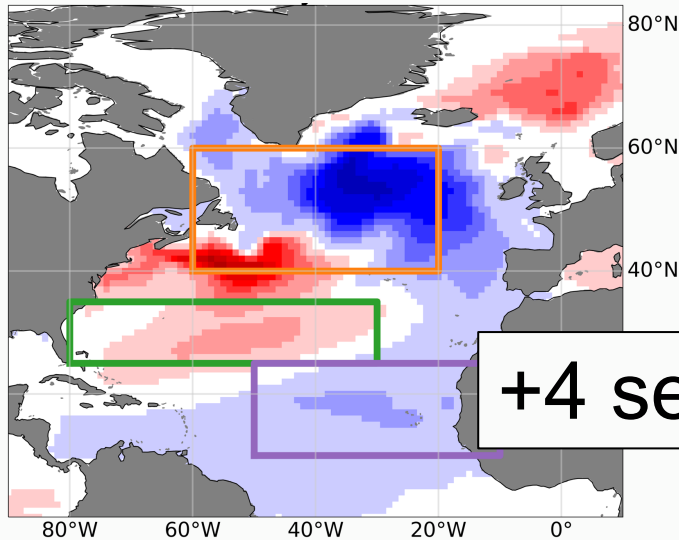
Winter Jet Strength

Summer Jet Strength

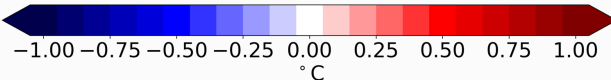
DJF  
+0 years



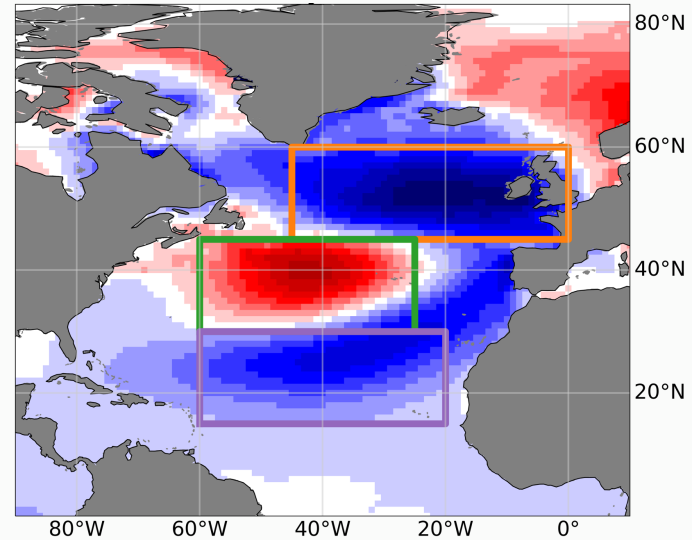
DJF  
+1 year



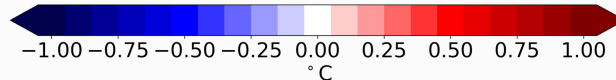
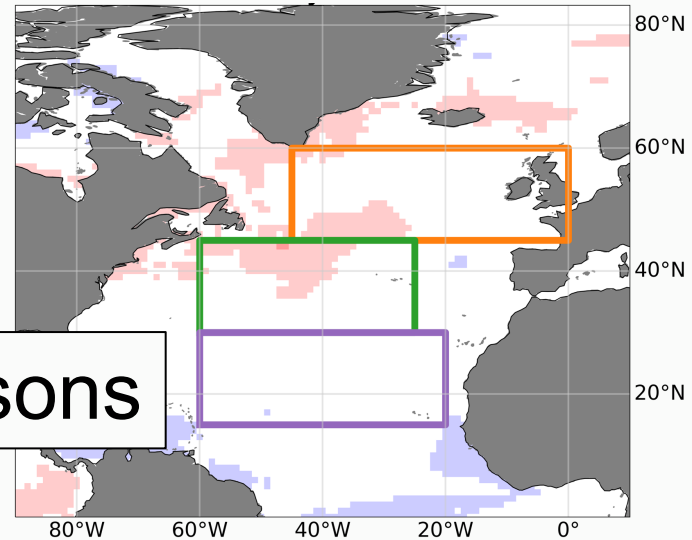
+4 seasons



JJA  
+0 years



JJA  
+1 year

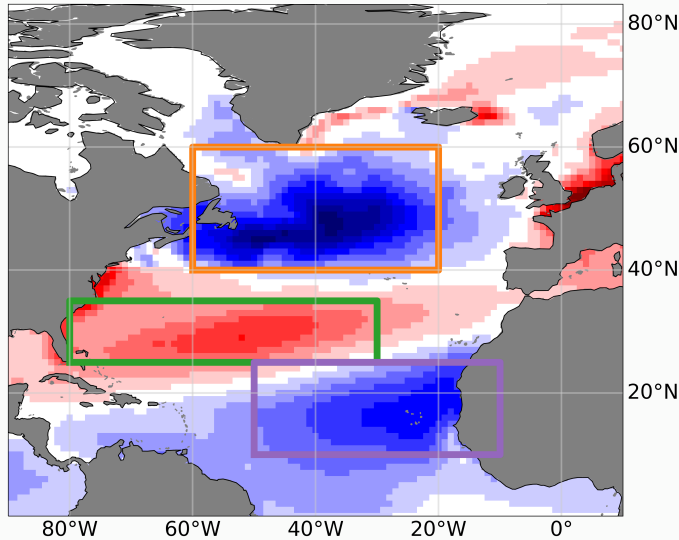


# SST Response to Jet Stream Changes

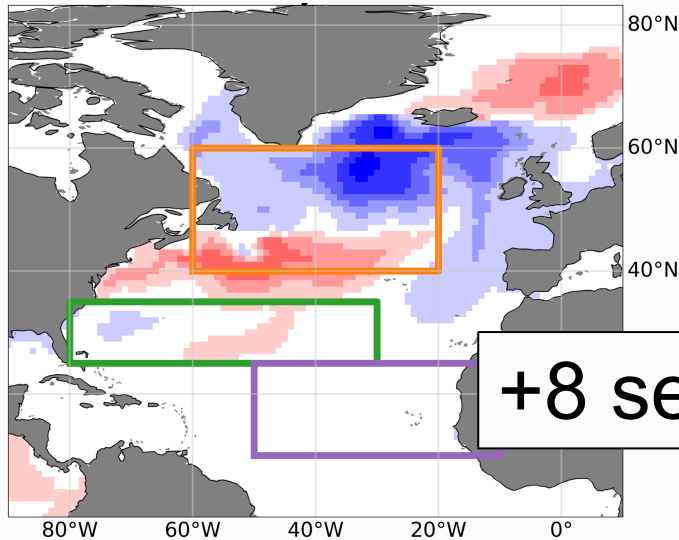
Winter Jet Strength

Summer Jet Strength

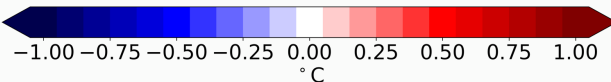
DJF  
+0 years



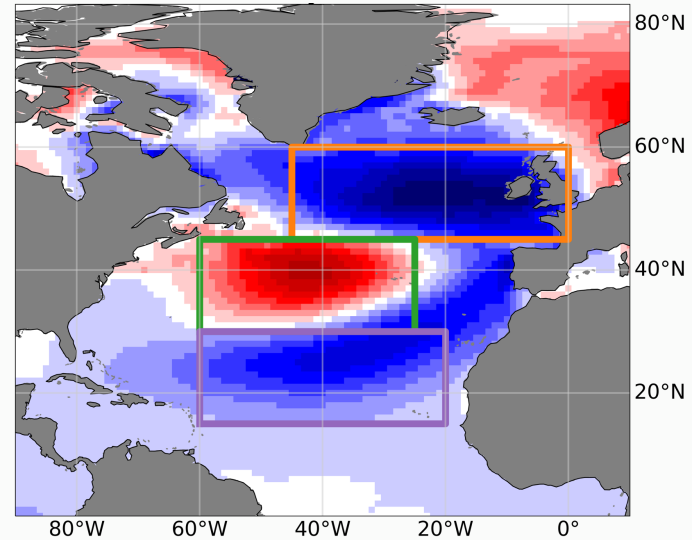
DJF  
+2 years



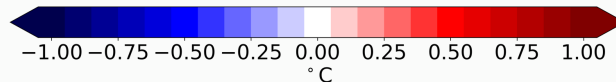
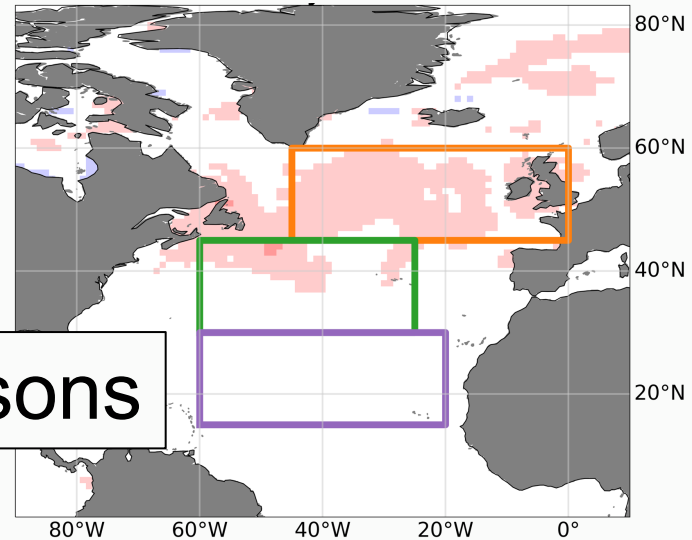
+8 seasons



JJA  
+0 years



JJA  
+2 years

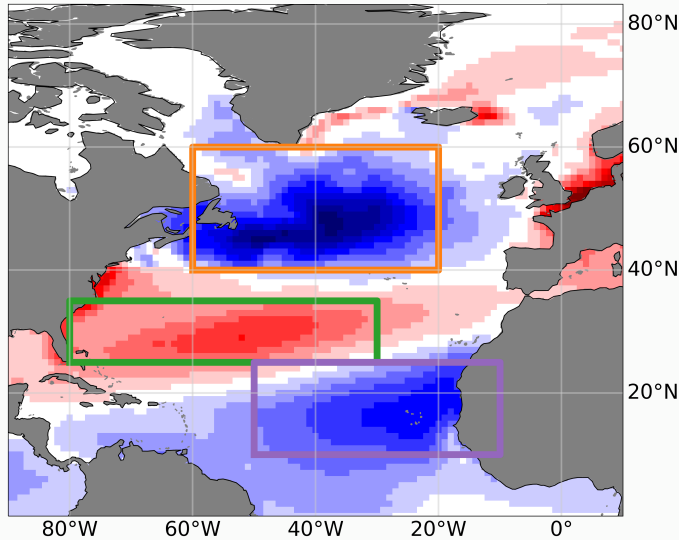


# SST Response to Jet Stream Changes

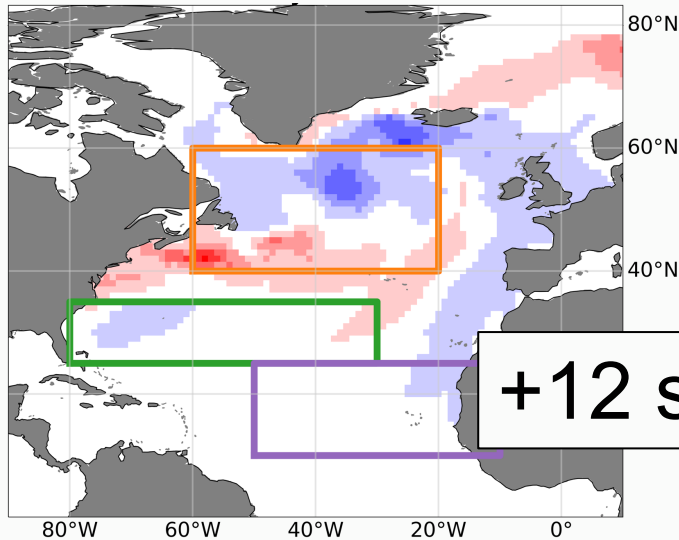
Winter Jet Strength

Summer Jet Strength

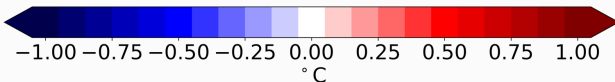
DJF  
+0 years



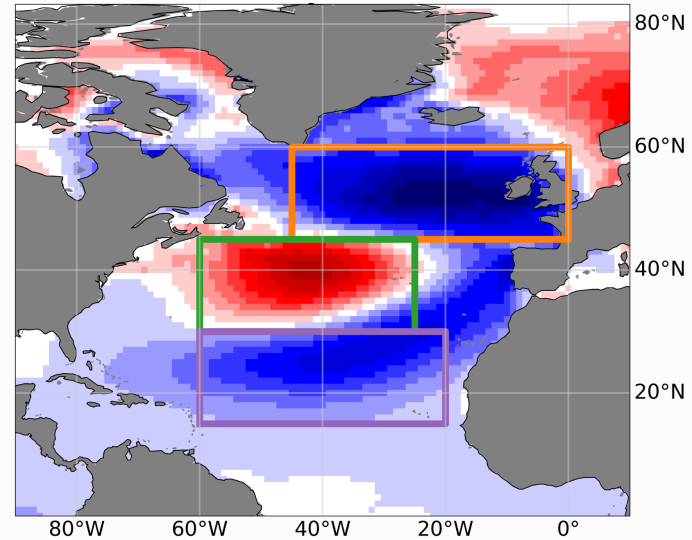
DJF  
+3 years



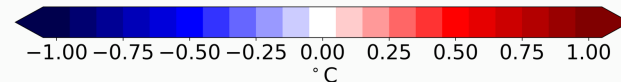
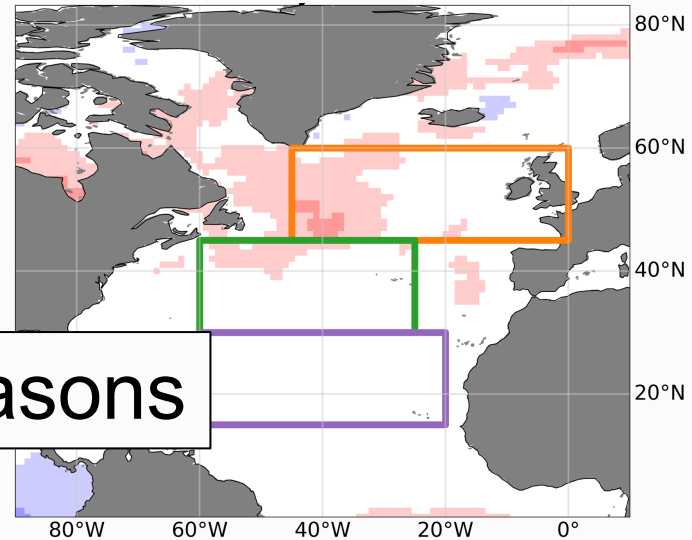
+12 seasons



JJA  
+0 years

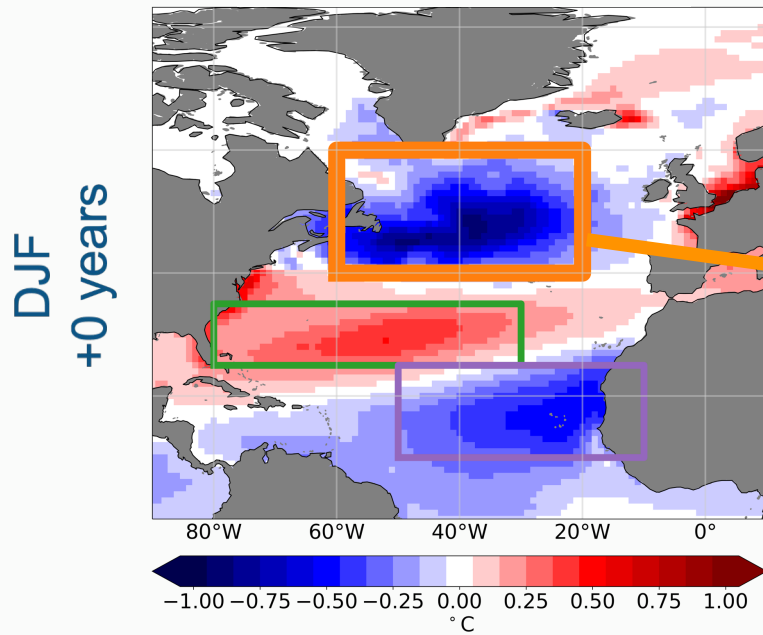


JJA  
+3 years

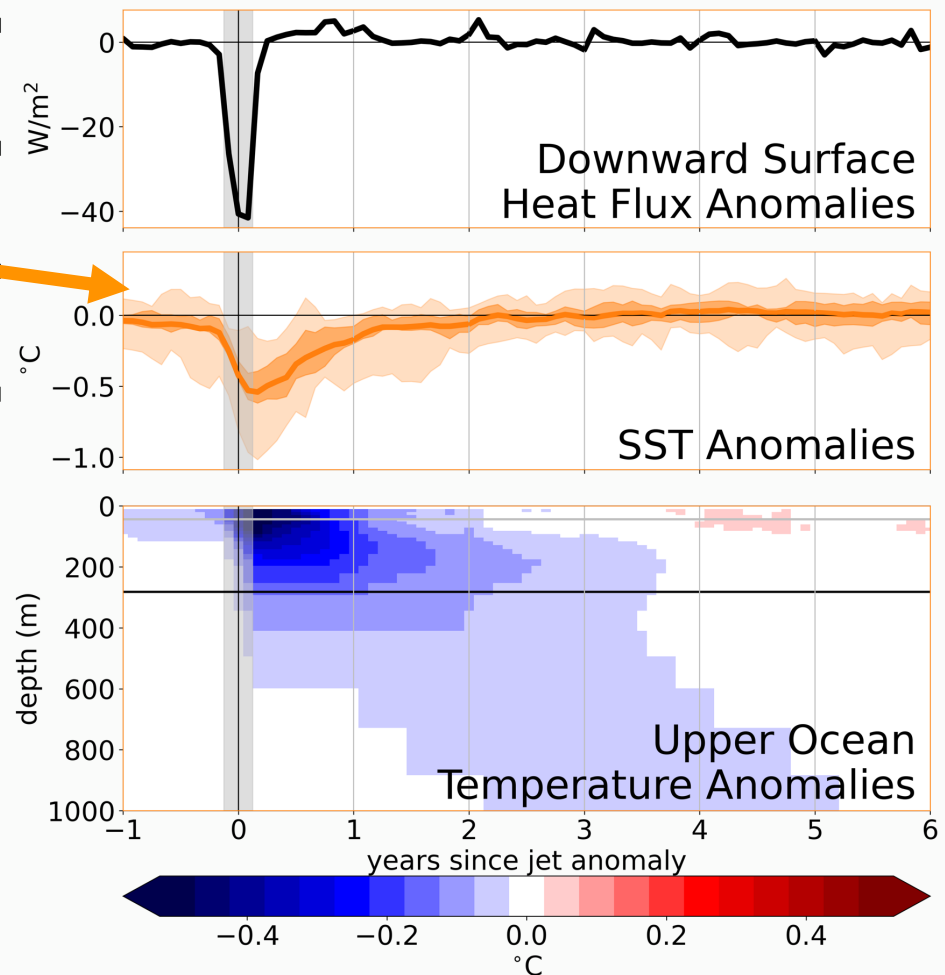


# SST Response to Winter Jet

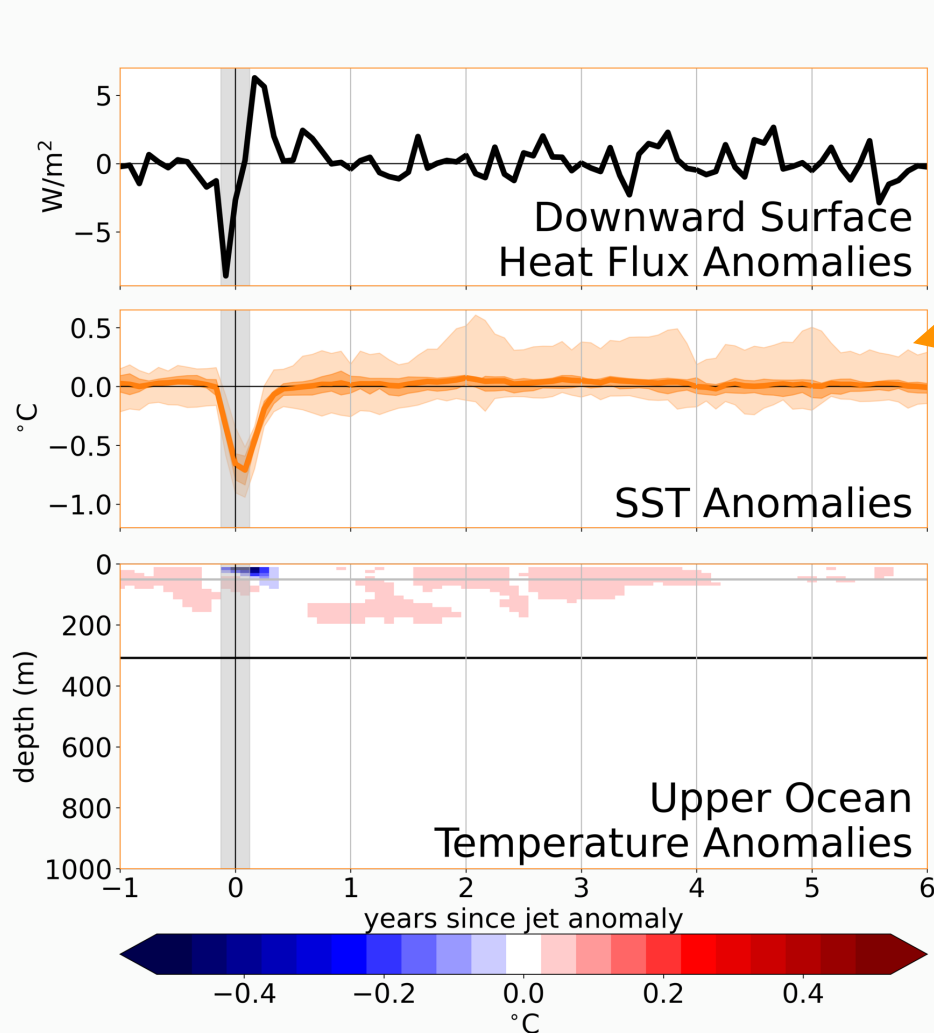
## Winter Jet Strength



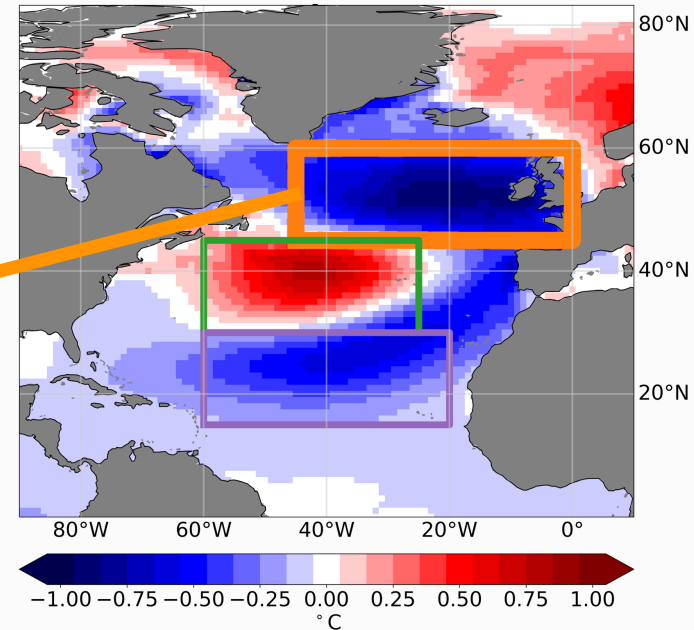
- Surface heat flux anomaly occurs at same time as jet strength anomaly.
- Majority of temperature anomaly occurs above the annual maximum mixed layer depth, and propagates deeper over the next several years.



# SST Response to Summer Jet



Summer Jet Strength



+0 years  
JJA

- SST anomaly dissipates quicker than in winter.
- Surface heat flux changes are a lot weaker relative to winter, but they reverse sign.
- Temperature changes are above the minimum annual mixed layer depth and don't extend below.

# Conclusions

- For both the winter and summer the North Atlantic SSTs respond to changes in the Atlantic Jet Stream with a tripolar SST pattern of similar magnitude.
- The SST response to winter jet persists the longest with the northern most imprint on the SSTs lasting over 2 years and reaching depth below the winter mixed layer, while the summer response is much shallower and mostly dissipated by the end of the first year.
- Initial analysis indicates that in the winter the SST tripolar pattern is generated by a rapid change in the surface heat flux and dissipated through ocean processes. While in the summer the initial surface heat flux response is reversed in the following months.



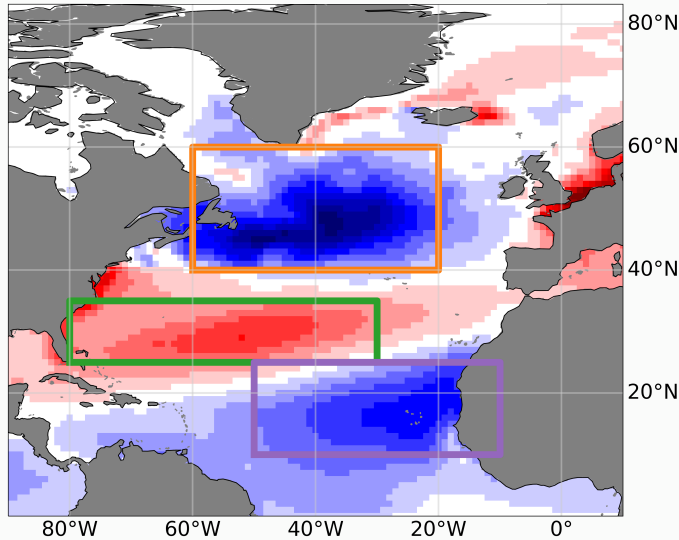


# SST Response to Jet Stream Changes

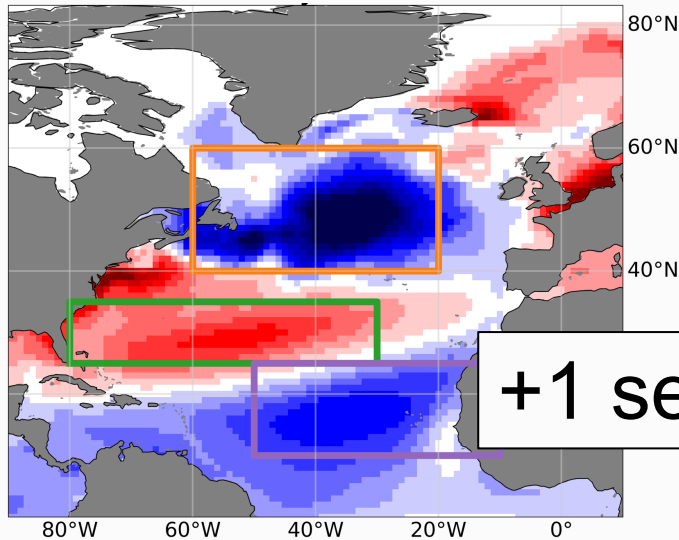
Winter Jet Strength

Summer Jet Strength

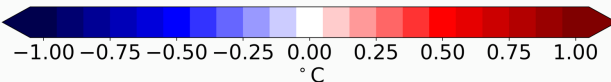
DJF  
+0 years



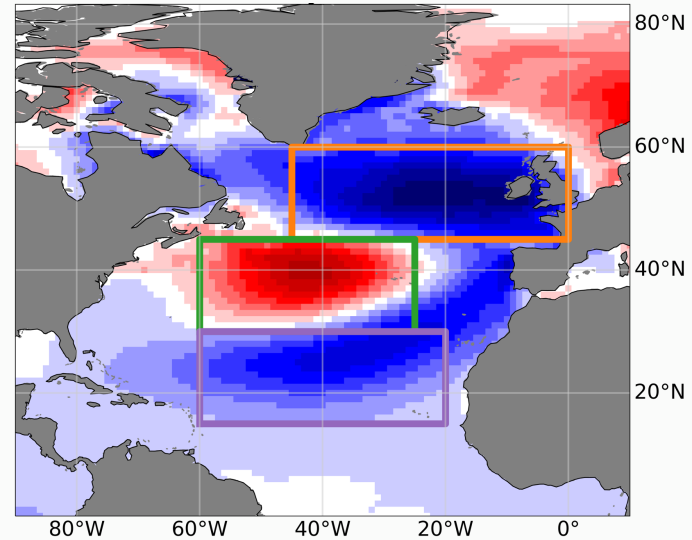
MAM  
+0 years



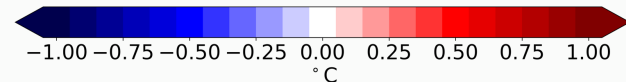
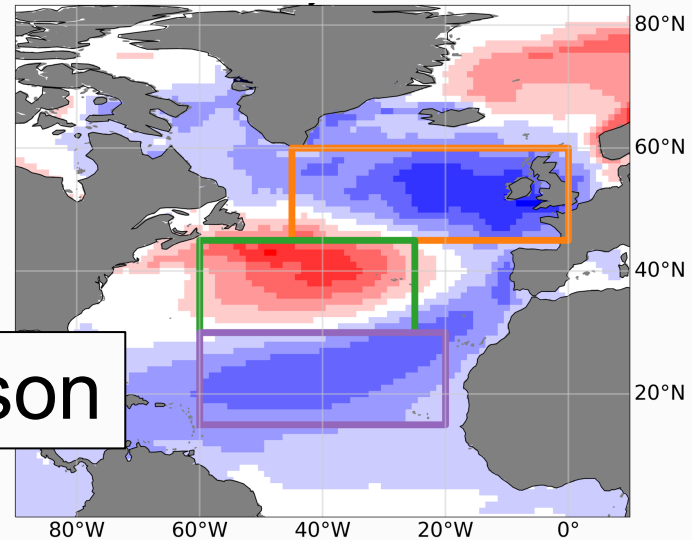
+1 season



JJA  
+0 years



SON  
+0 years

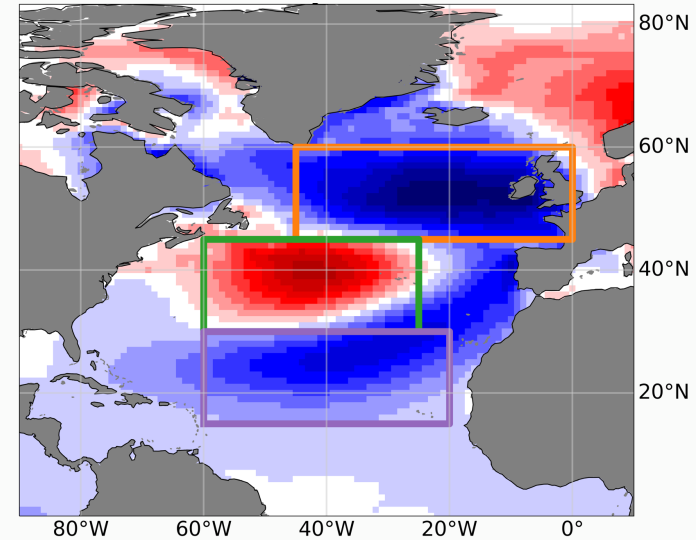
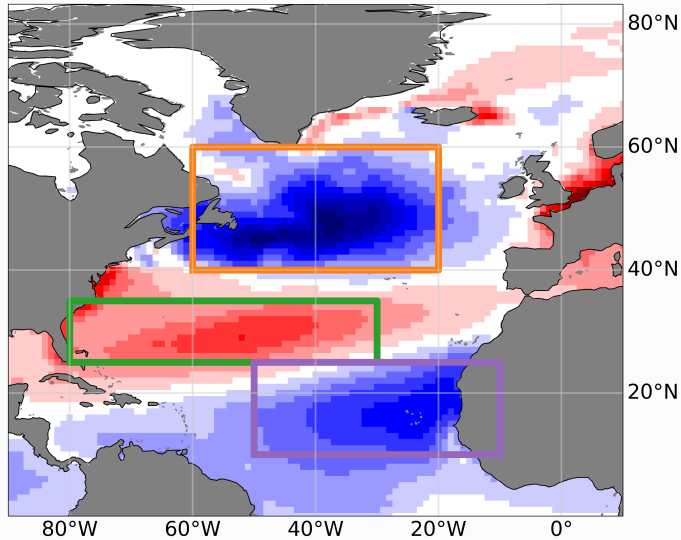


# SST Response to Jet Stream Changes

Winter Jet Strength

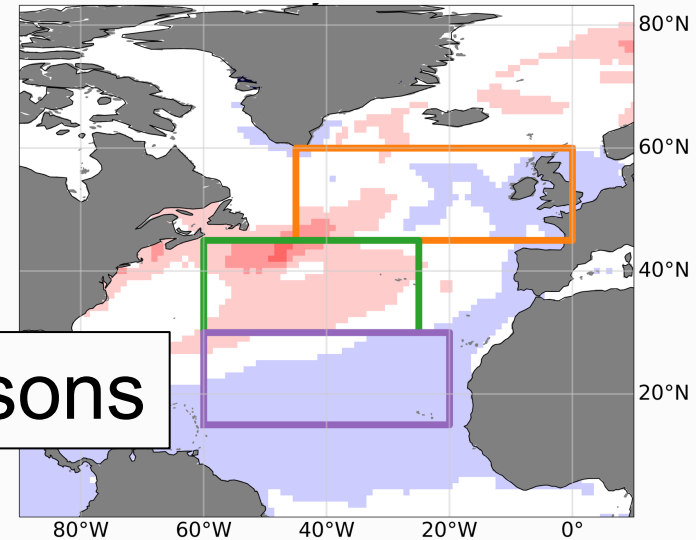
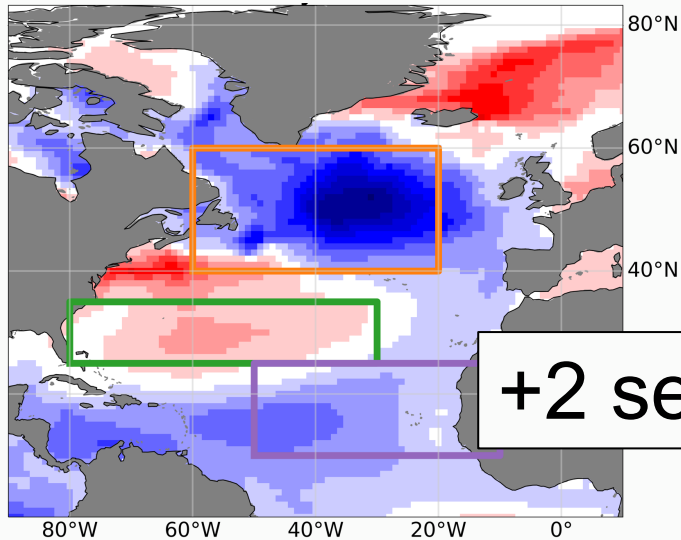
Summer Jet Strength

DJF  
+0 years



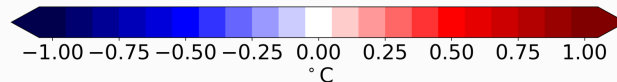
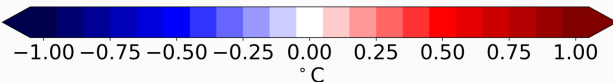
JJA  
+0 years

JJA  
+0 years



DJF  
+0 years

+2 seasons

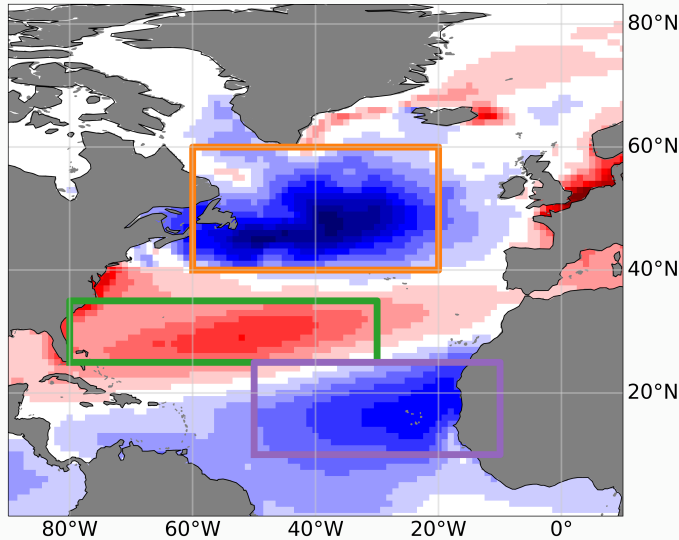


# SST Response to Jet Stream Changes

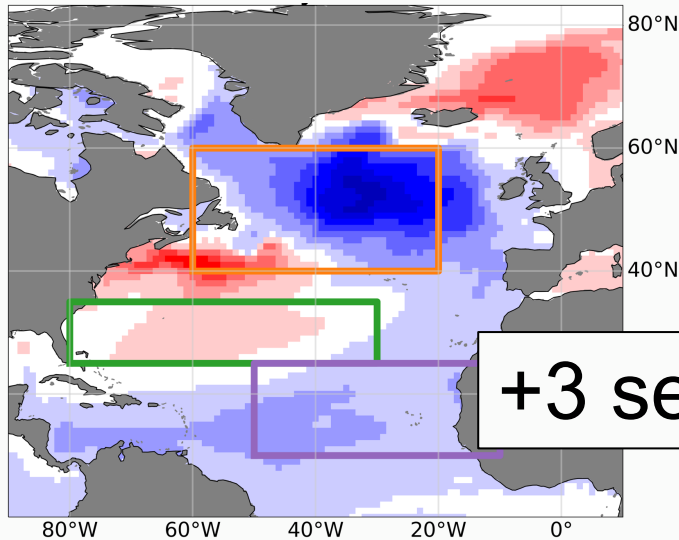
Winter Jet Strength

Summer Jet Strength

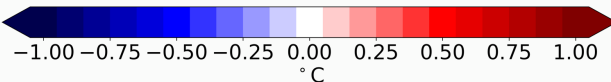
DJF  
+0 years



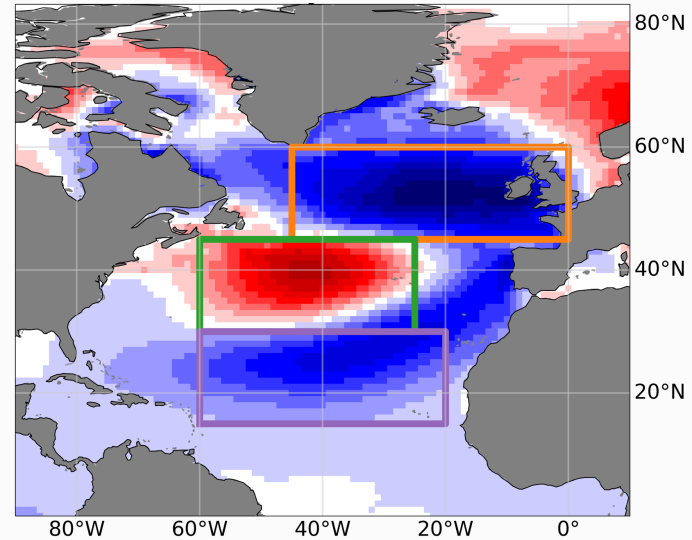
SON  
+0 years



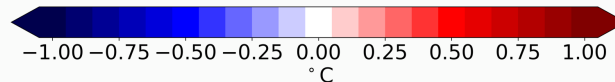
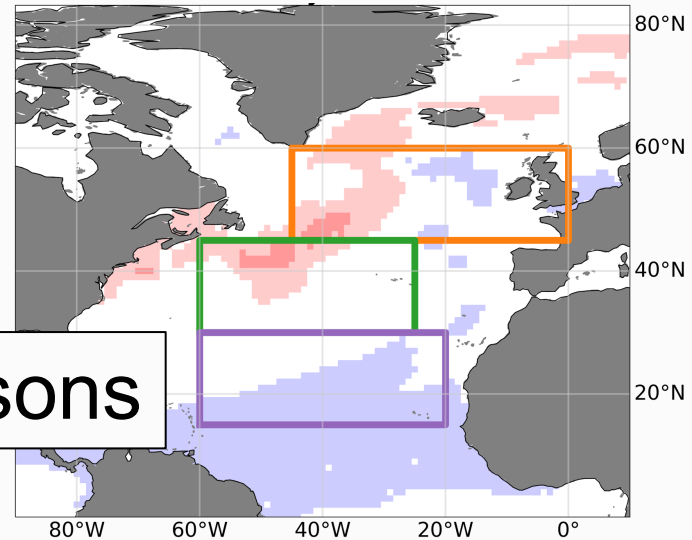
+3 seasons



JJA  
+0 years



MAM  
+0 years

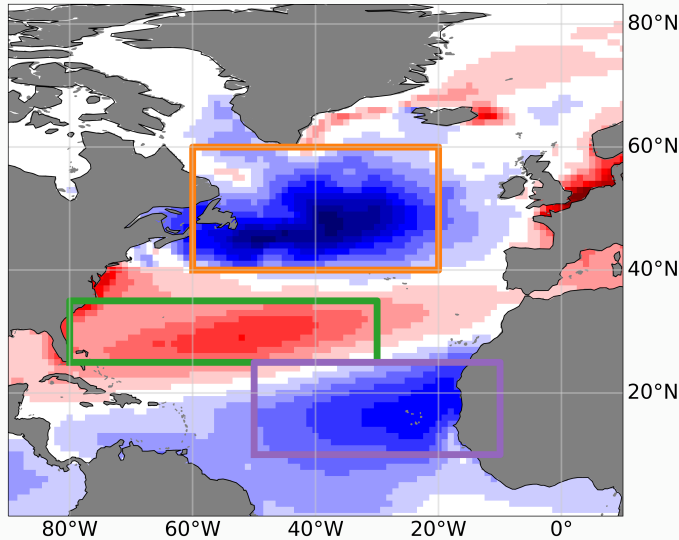


# SST Response to Jet Stream Changes

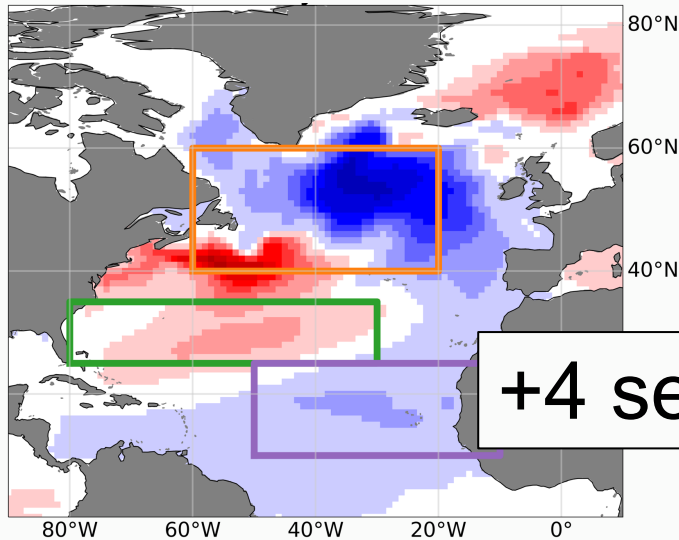
Winter Jet Strength

Summer Jet Strength

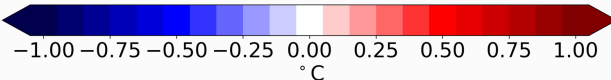
DJF  
+0 years



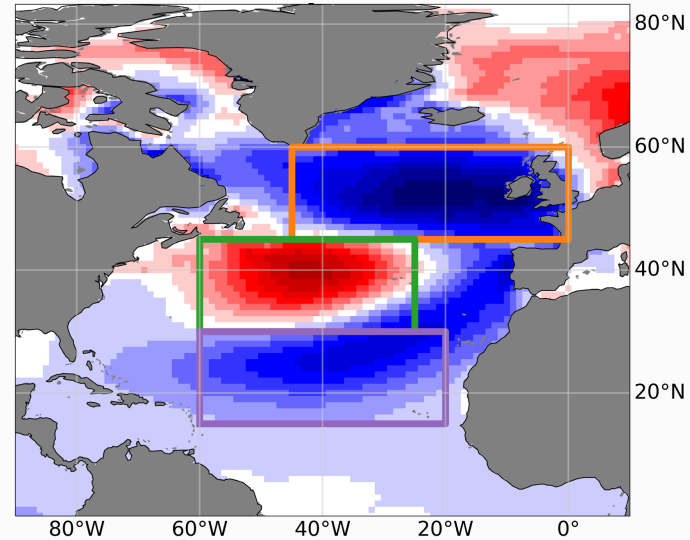
DJF  
+1 year



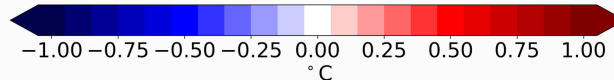
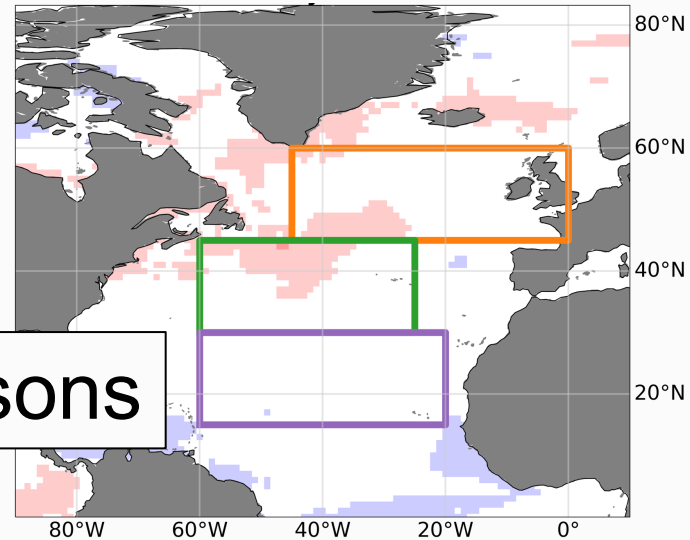
+4 seasons



JJA  
+0 years



JJA  
+1 year

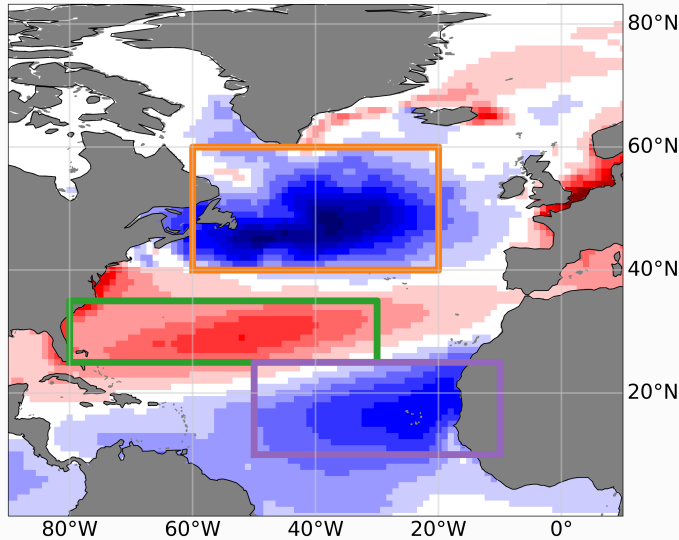


# SST Response to Jet Stream Changes

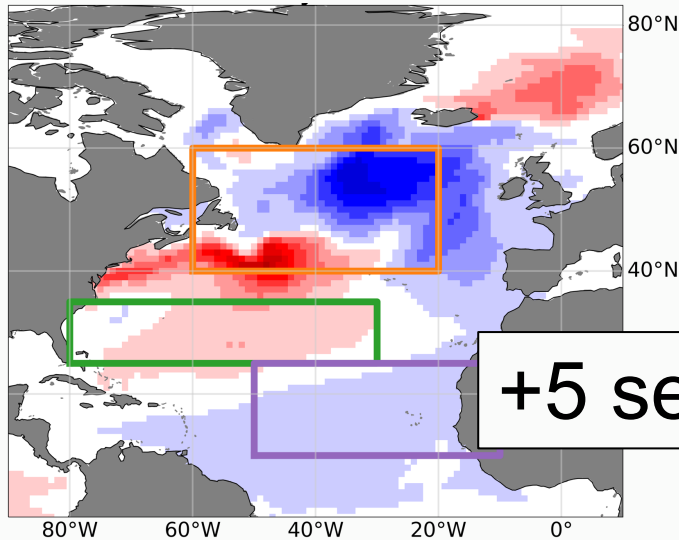
Winter Jet Strength

Summer Jet Strength

DJF  
+0 years

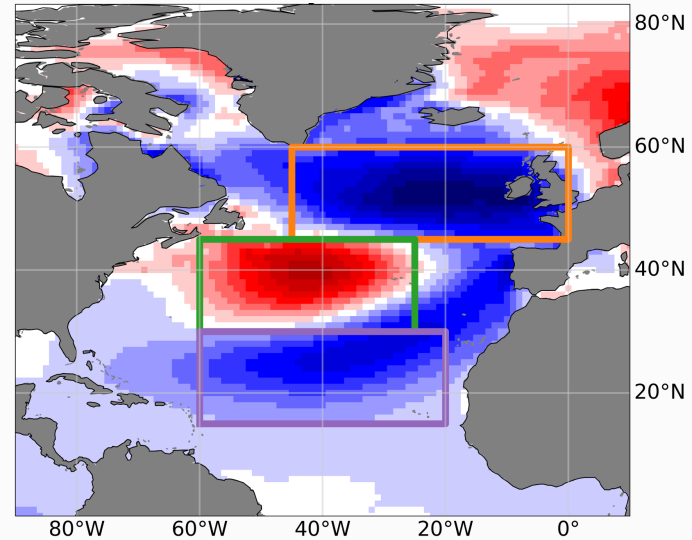


MAM  
+1 year

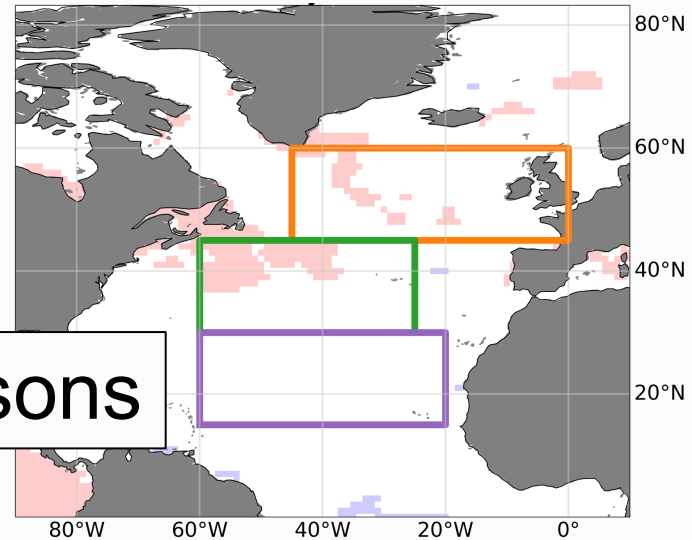


+5 seasons

JJA  
+0 years



SON  
+1 year

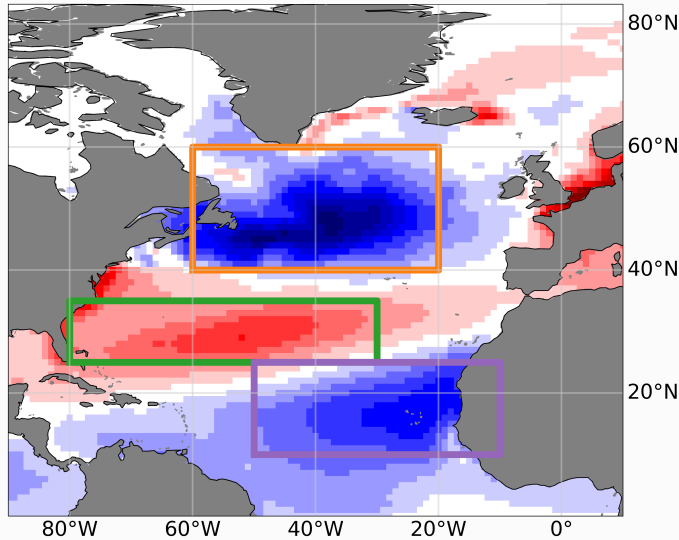


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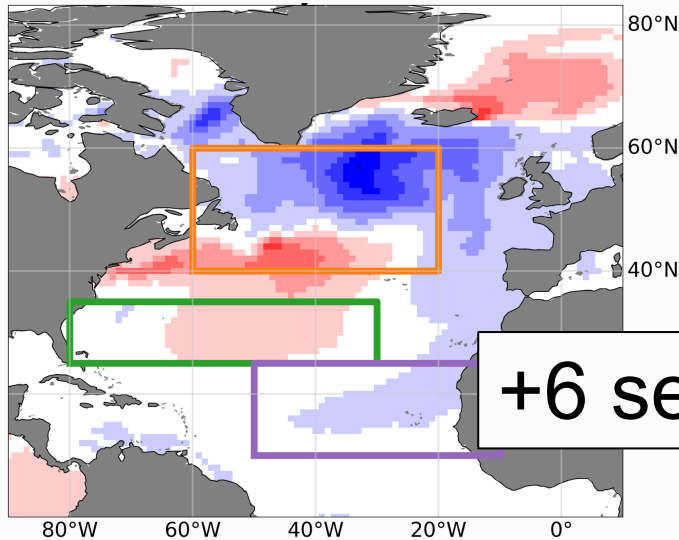
Winter Jet Strength

Summer Jet Strength

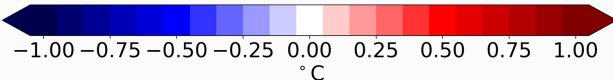
DJF  
+0 years



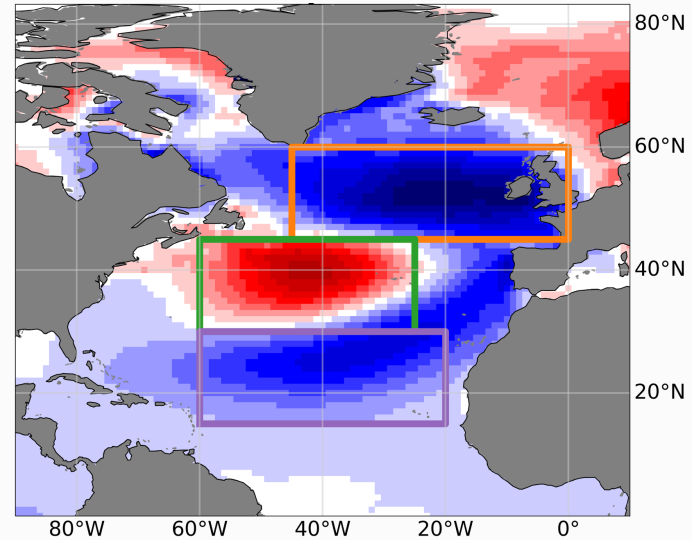
JJA  
+1 year



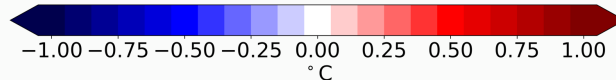
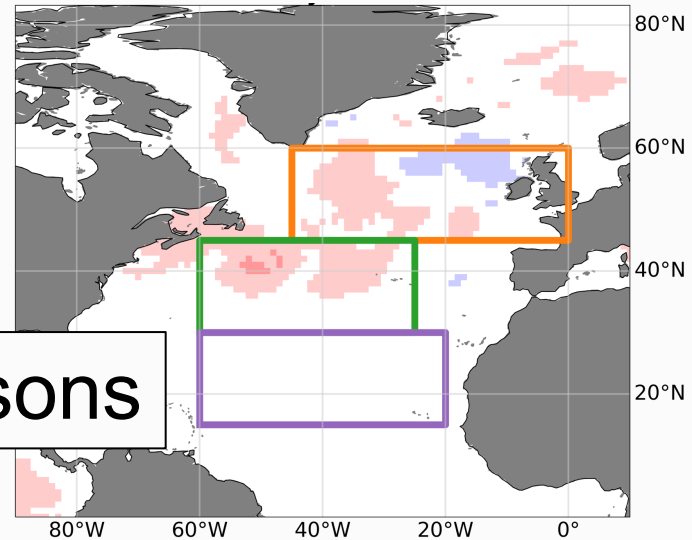
+6 seasons



JJA  
+0 years



DJF  
+1 year

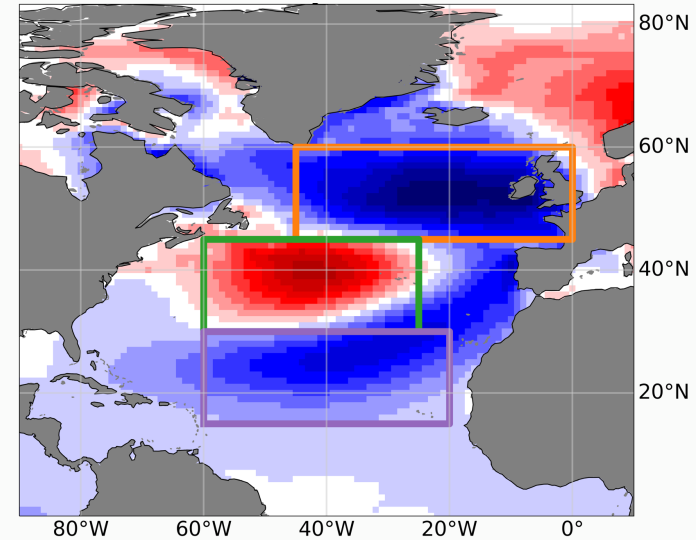
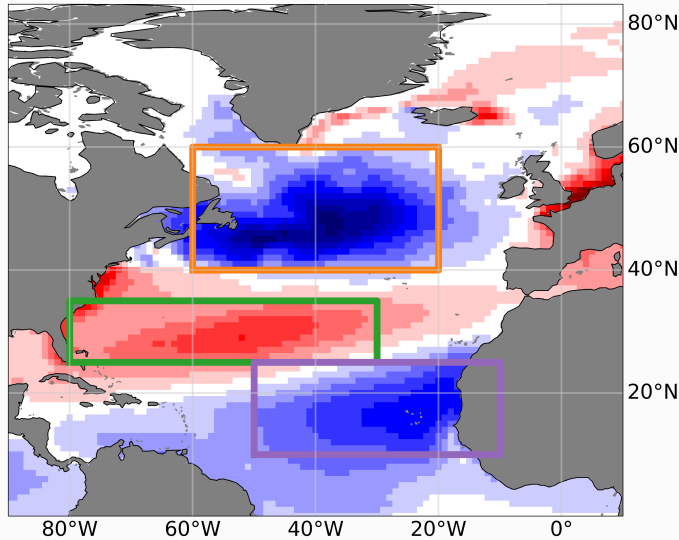


# SST Response to Jet Stream Changes

Winter Jet Strength

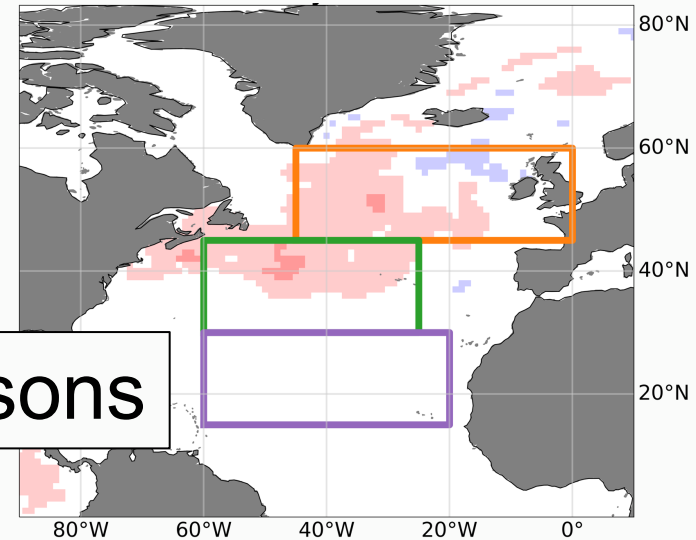
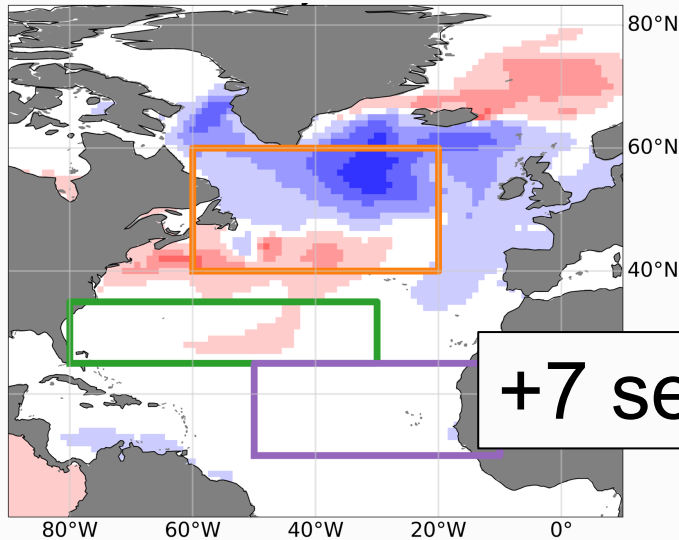
Summer Jet Strength

DJF  
+0 years



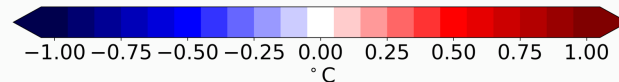
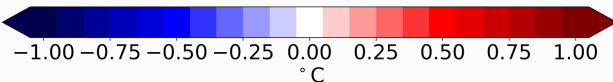
JJA  
+0 years

SON  
+1 year



MAM  
+1 year

+7 seasons

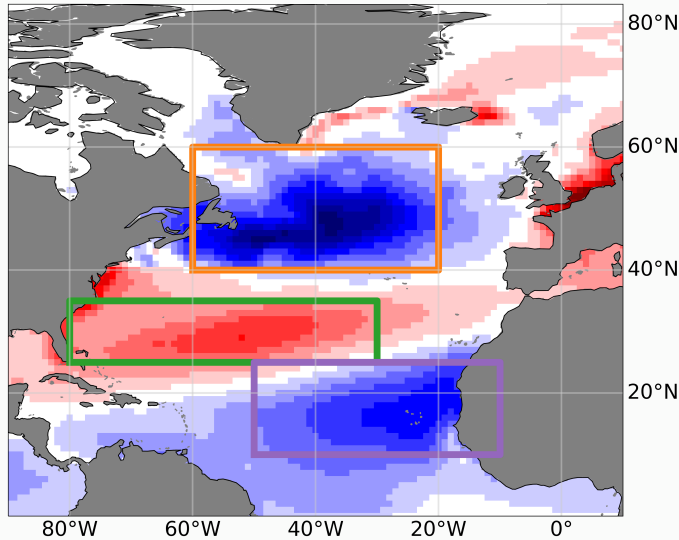


# SST Response to Jet Stream Changes

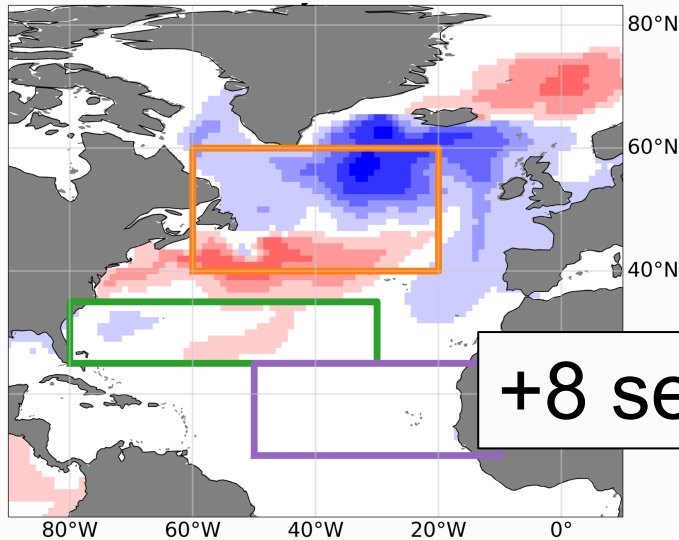
Winter Jet Strength

Summer Jet Strength

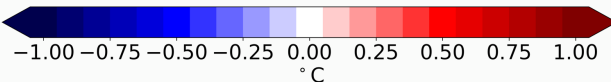
DJF  
+0 years



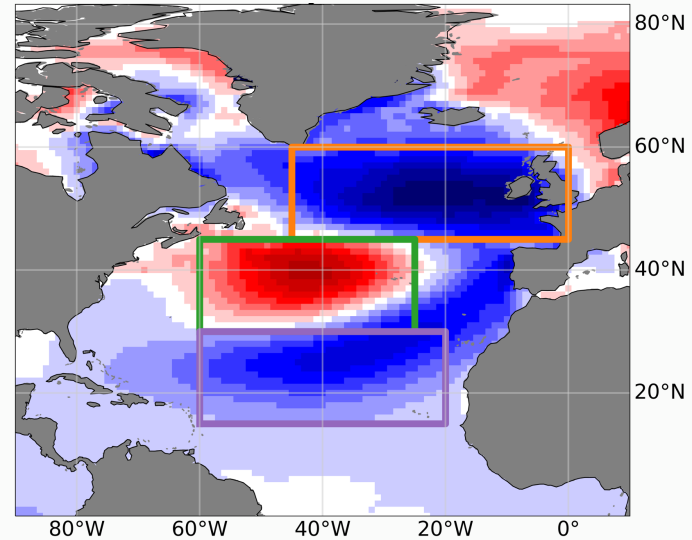
DJF  
+2 years



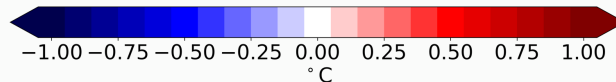
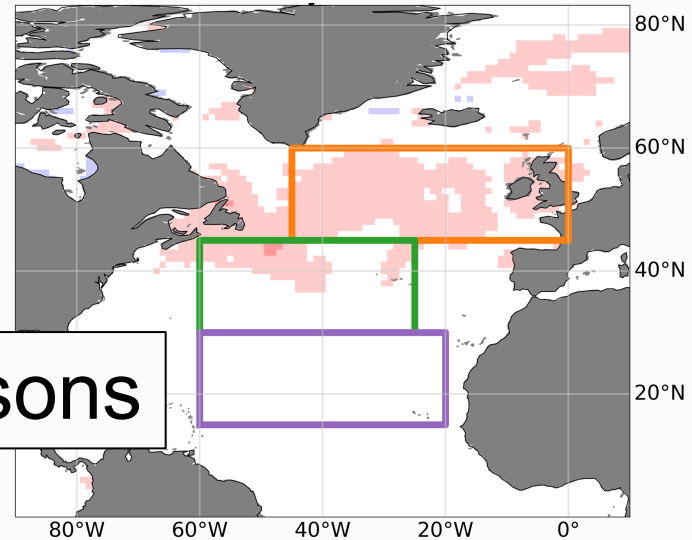
+8 seasons



JJA  
+0 years



JJA  
+2 years

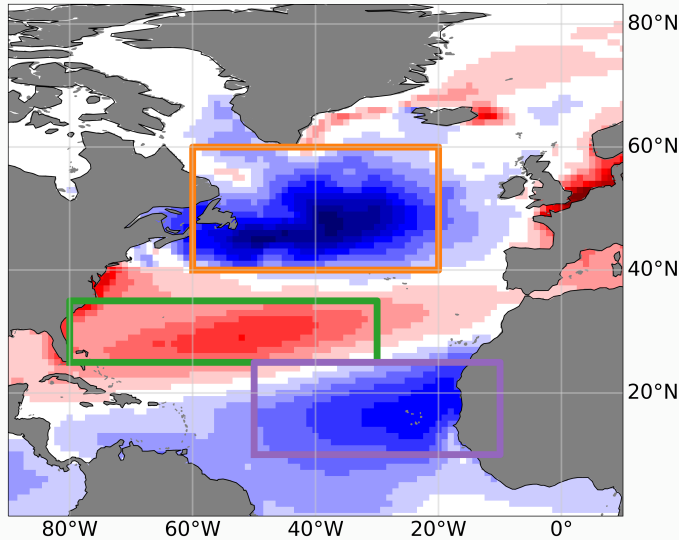


# SST Response to Jet Stream Changes

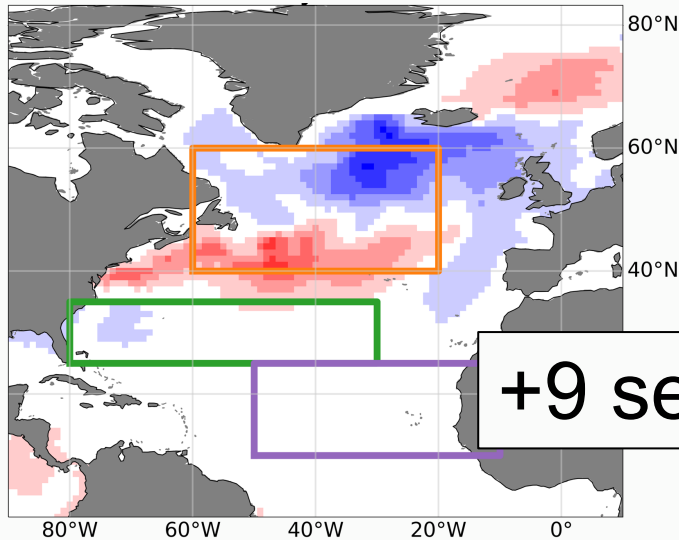
Winter Jet Strength

Summer Jet Strength

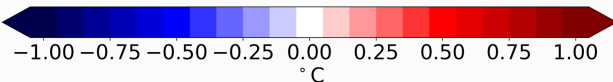
DJF  
+0 years



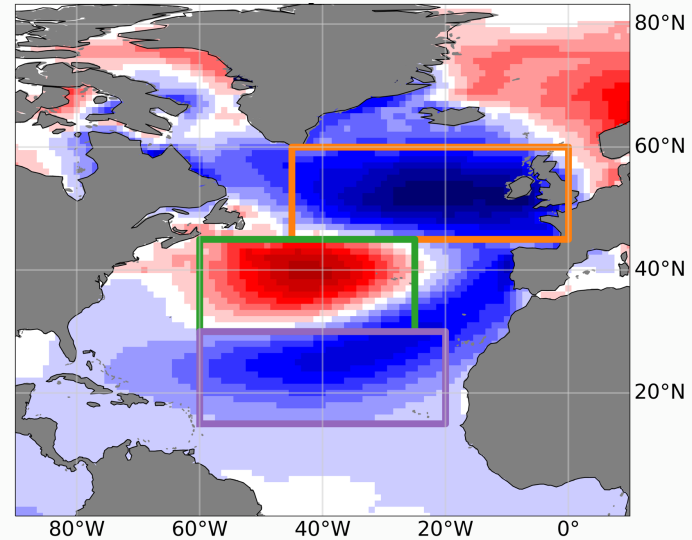
MAM  
+2 years



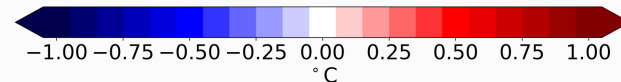
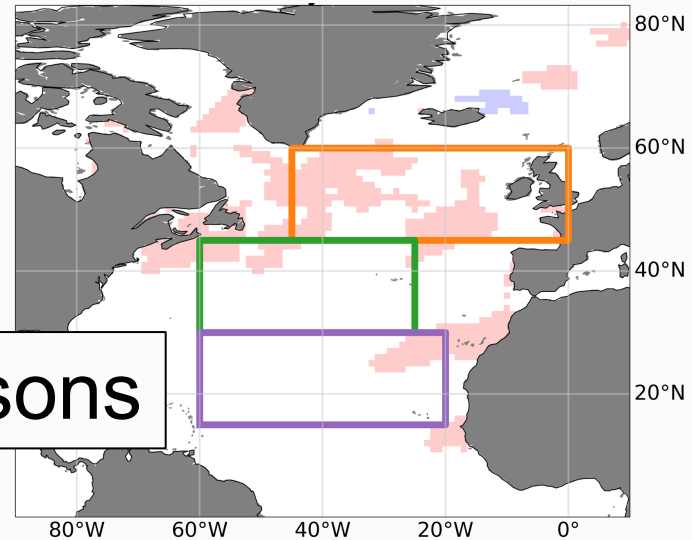
+9 seasons



JJA  
+0 years



SON  
+2 years

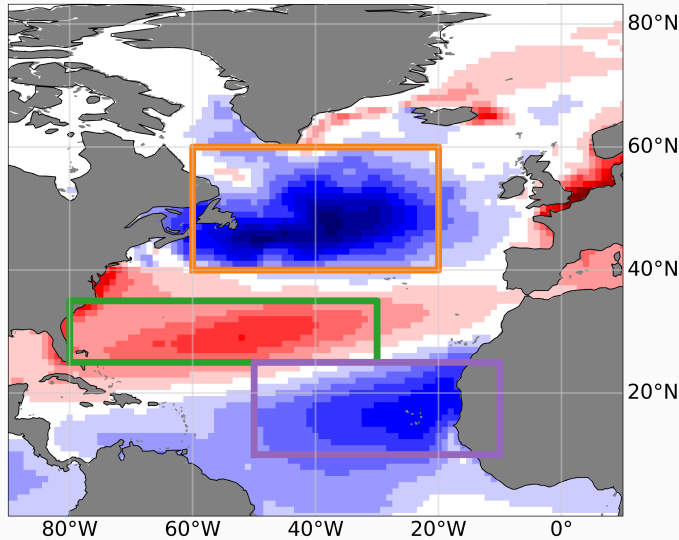


# SST Response to Jet Stream Changes

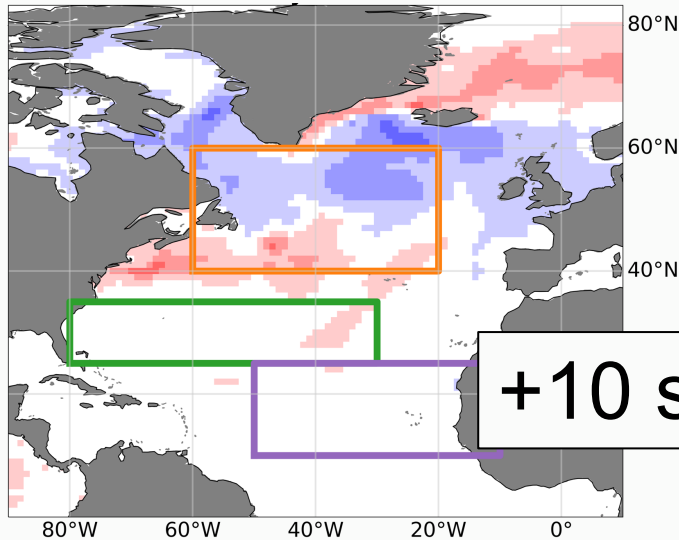
Winter Jet Strength

Summer Jet Strength

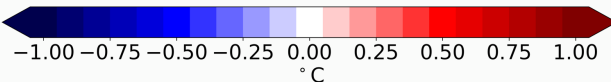
DJF  
+0 years



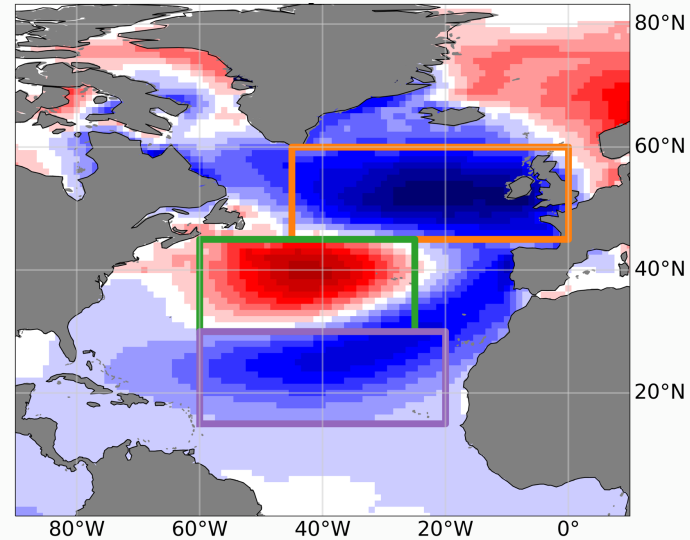
JJA  
+2 years



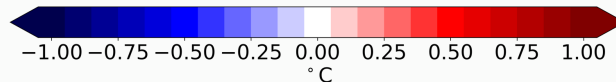
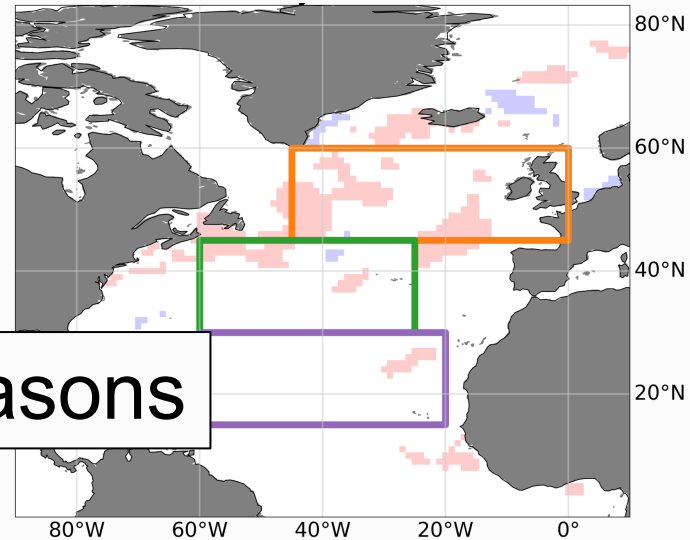
+10 seasons



JJA  
+0 years



DJF  
+2 years

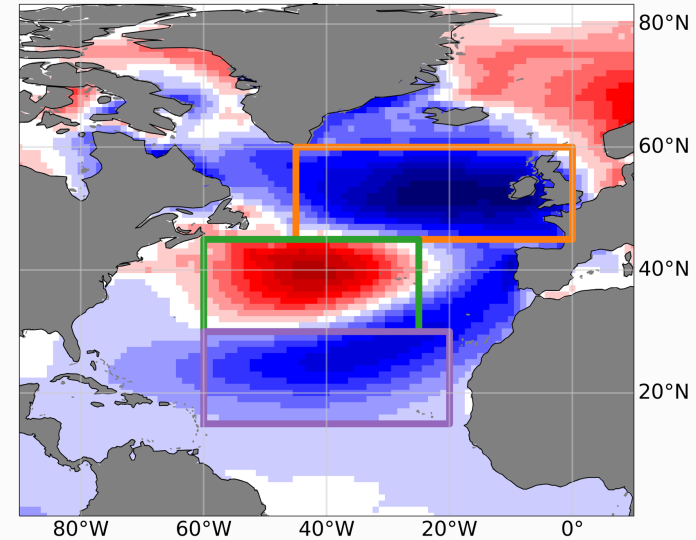
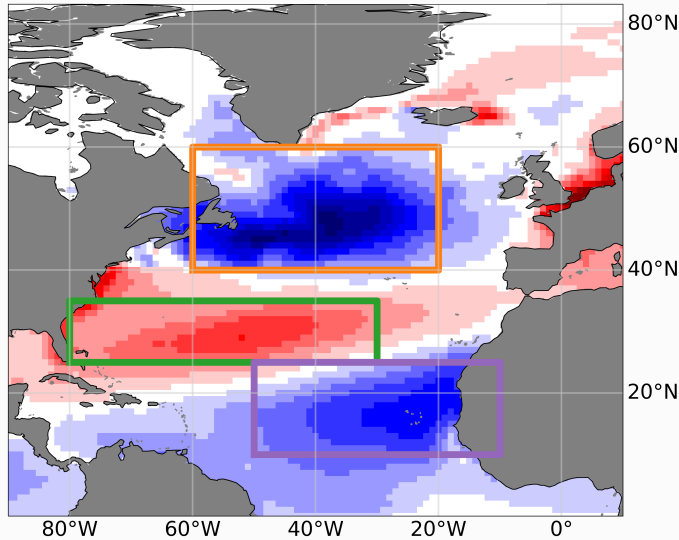


# SST Response to Jet Stream Changes

Winter Jet Strength

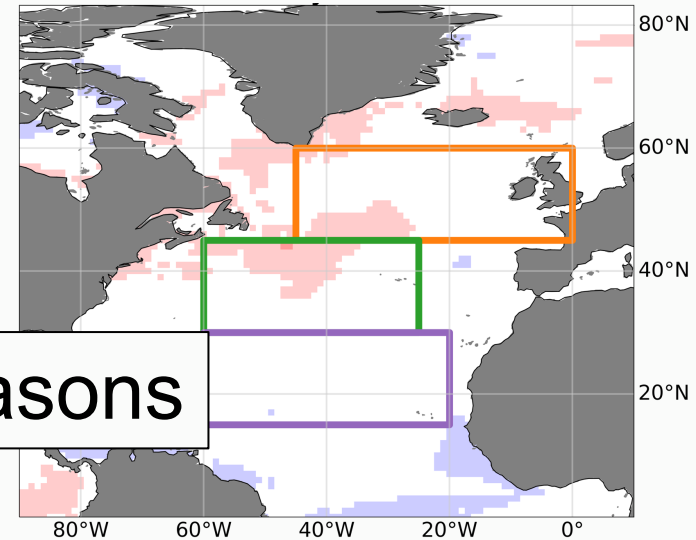
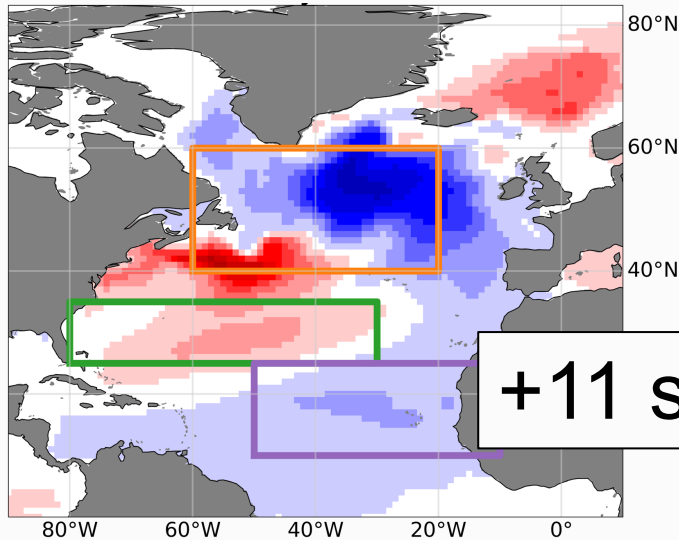
Summer Jet Strength

DJF  
+0 years



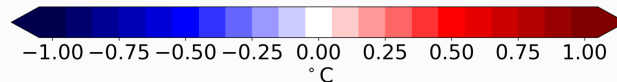
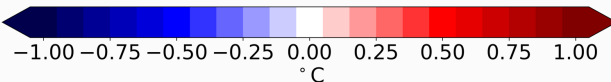
JJA  
+0 years

SON  
+2 years



MAM  
+2 years

+11 seasons

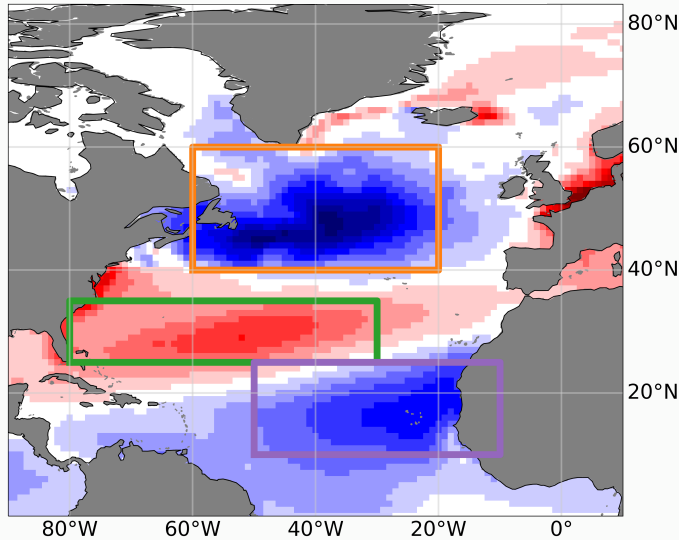


# SST Response to Jet Stream Changes

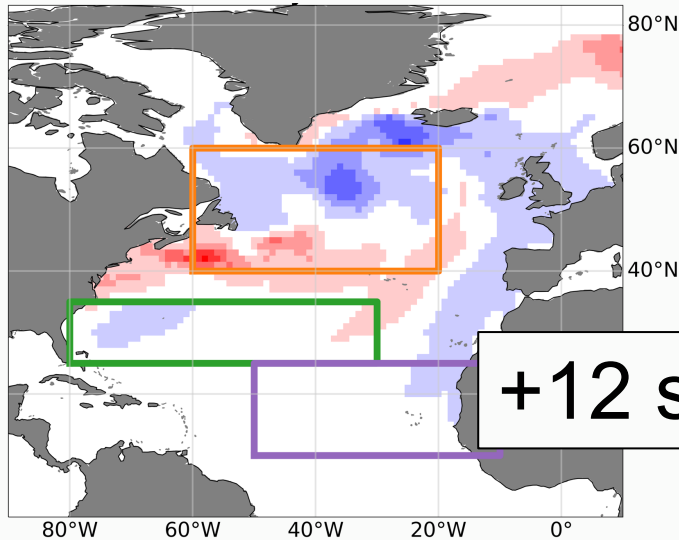
Winter Jet Strength

Summer Jet Strength

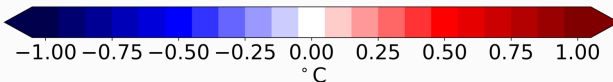
DJF  
+0 years



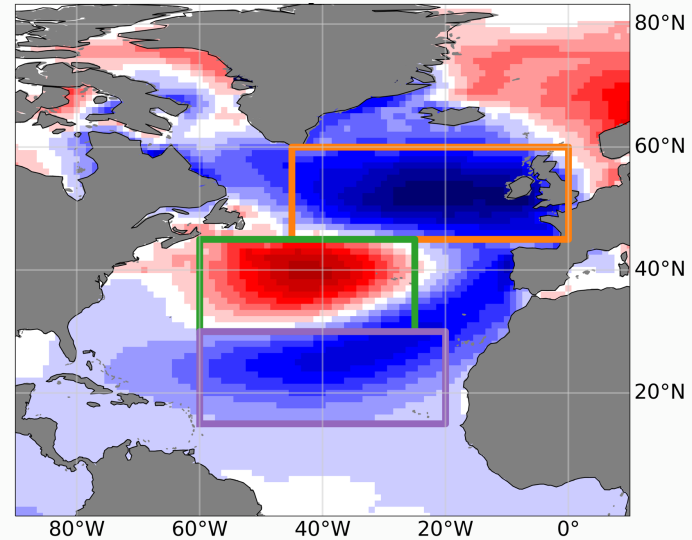
DJF  
+3 years



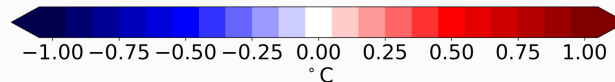
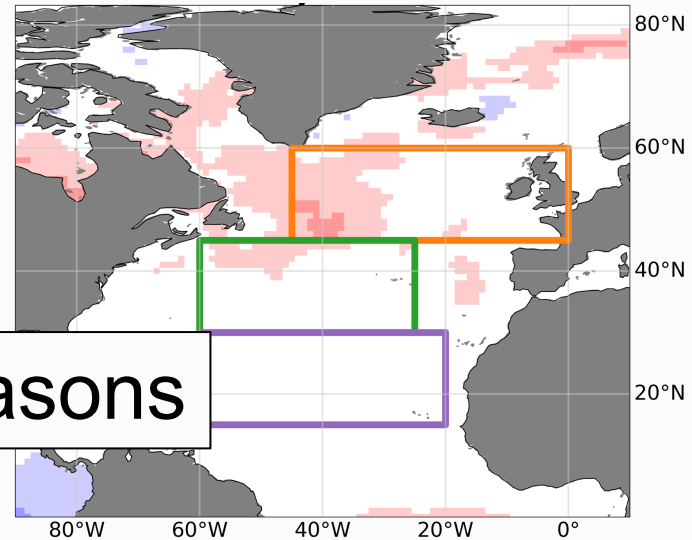
+12 seasons



JJA  
+0 years

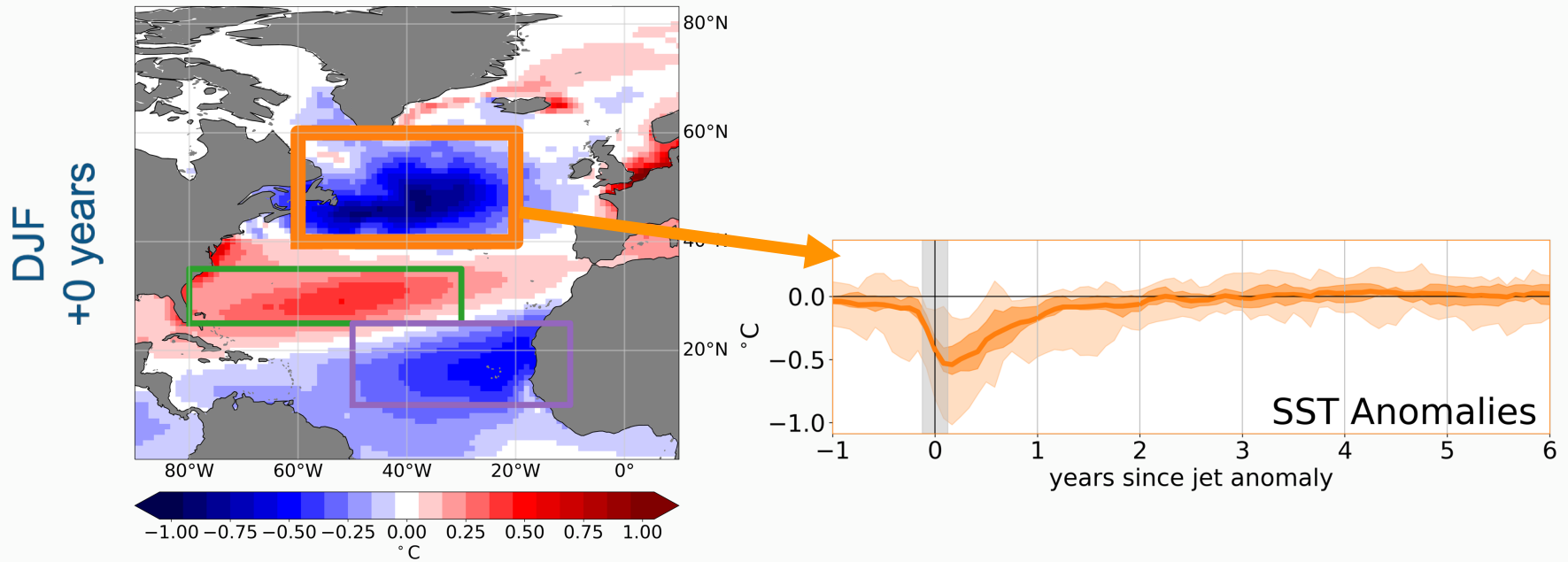


JJA  
+3 years



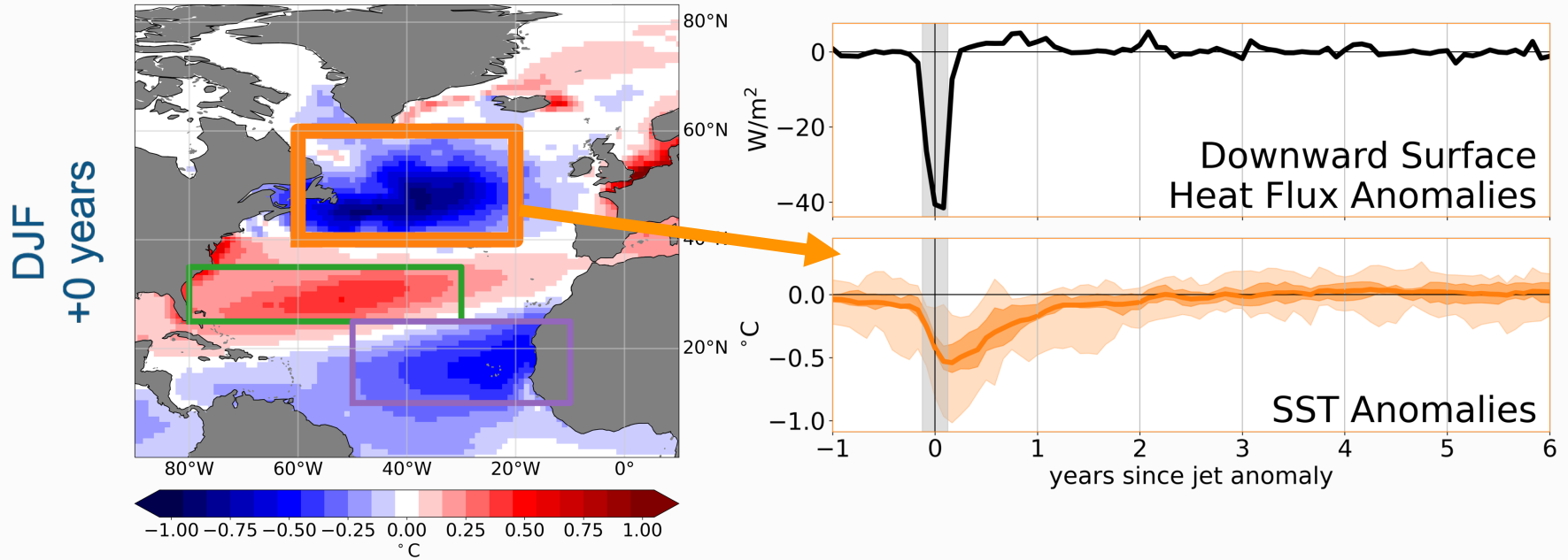
# SST Response to Winter Jet

## Winter Jet Strength



# SST Response to Winter Jet

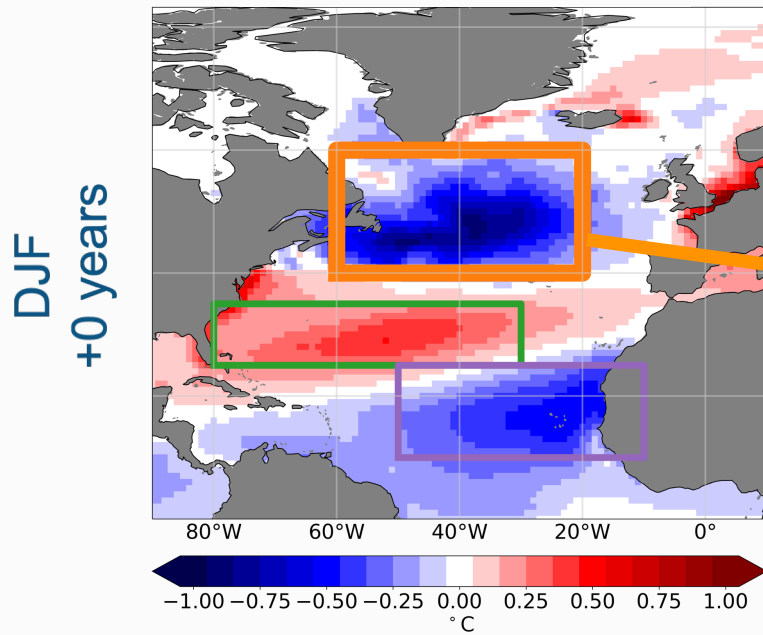
## Winter Jet Strength



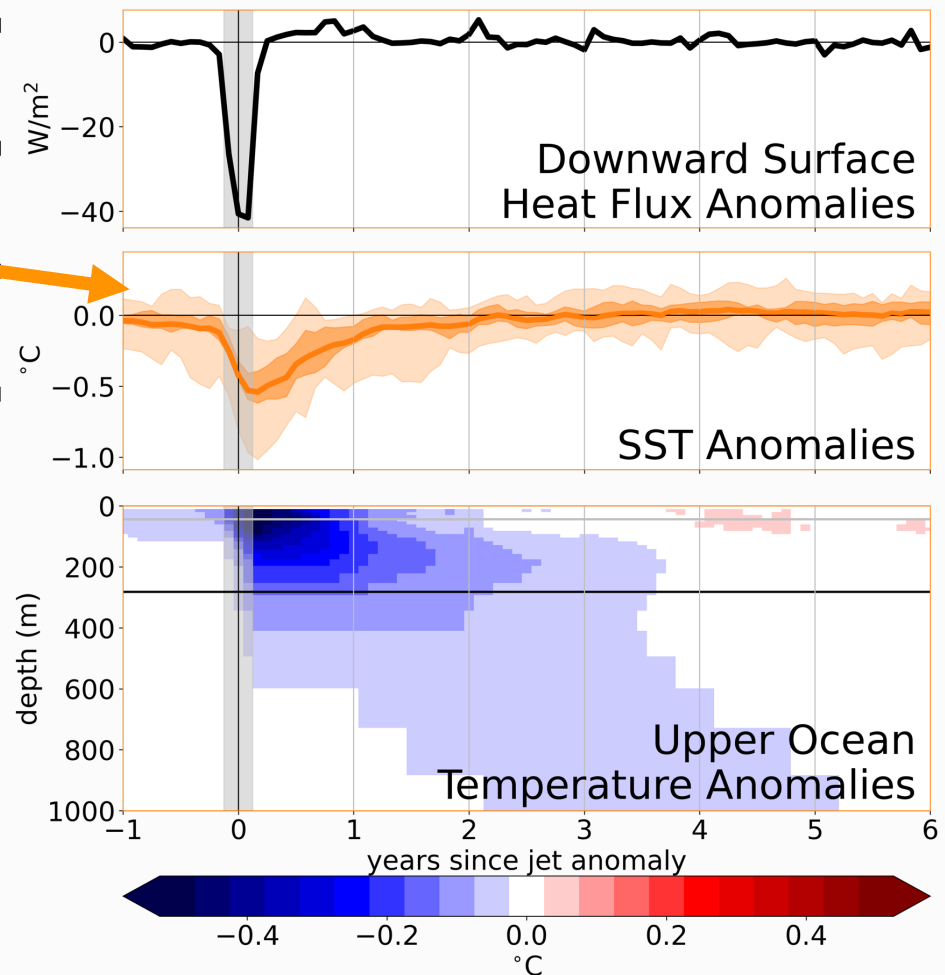
- Surface heat flux anomaly occurs at same time as jet strength anomaly.

# SST Response to Winter Jet

## Winter Jet Strength



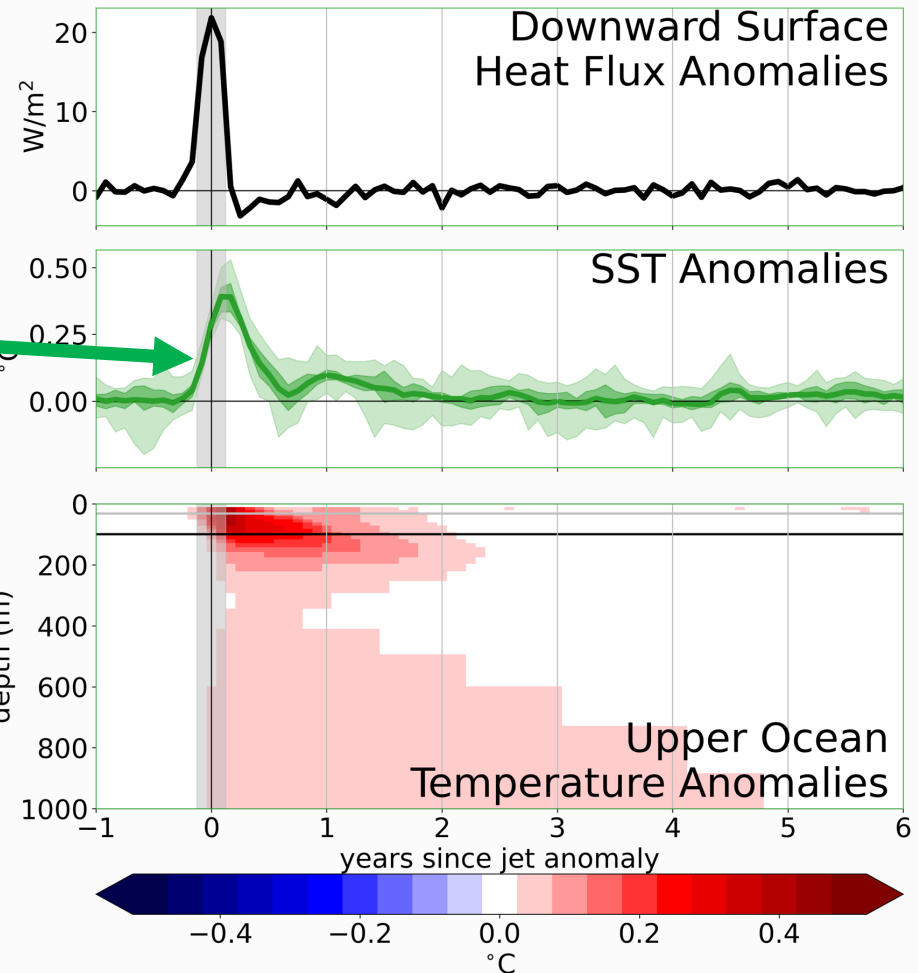
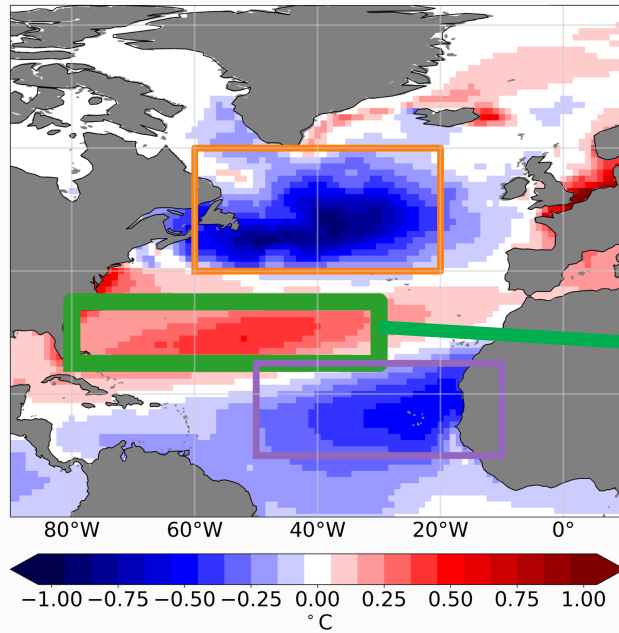
- Surface heat flux anomaly occurs at same time as jet strength anomaly.
- Majority of temperature anomaly occurs above the annual maximum mixed layer depth, and propagates deeper over the next several years.



# SST Response to Winter Jet

Winter Jet Strength

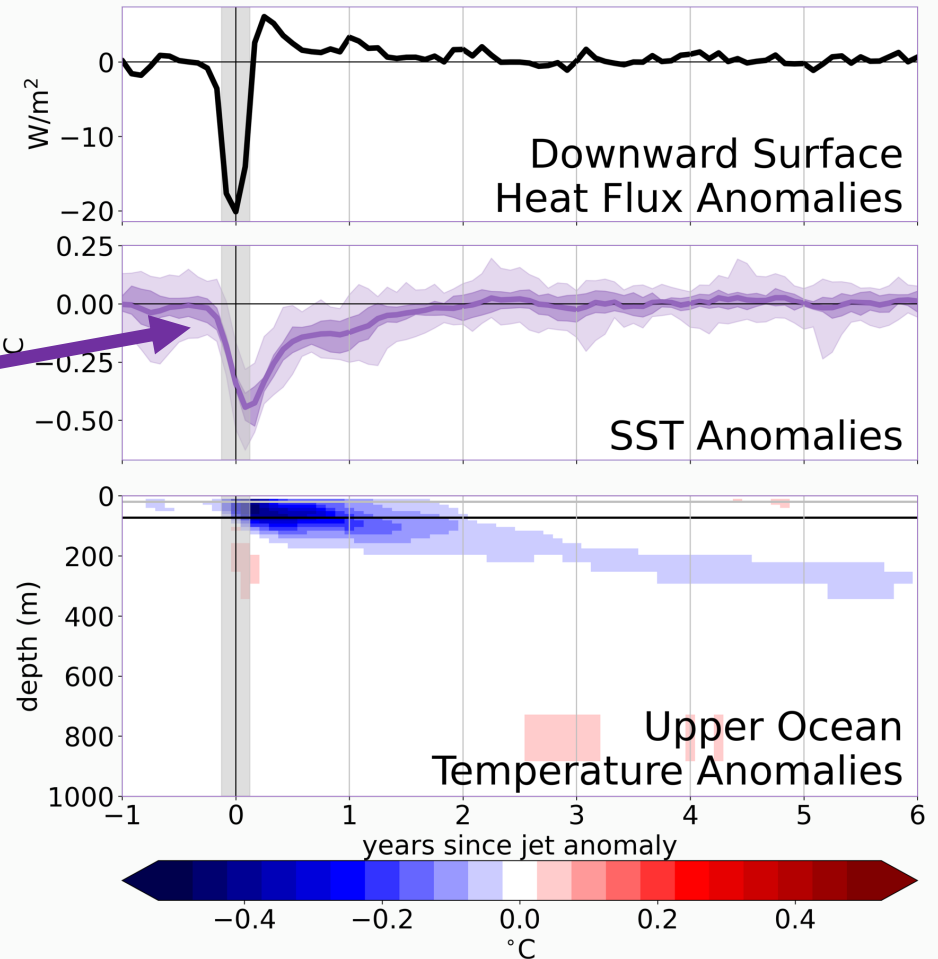
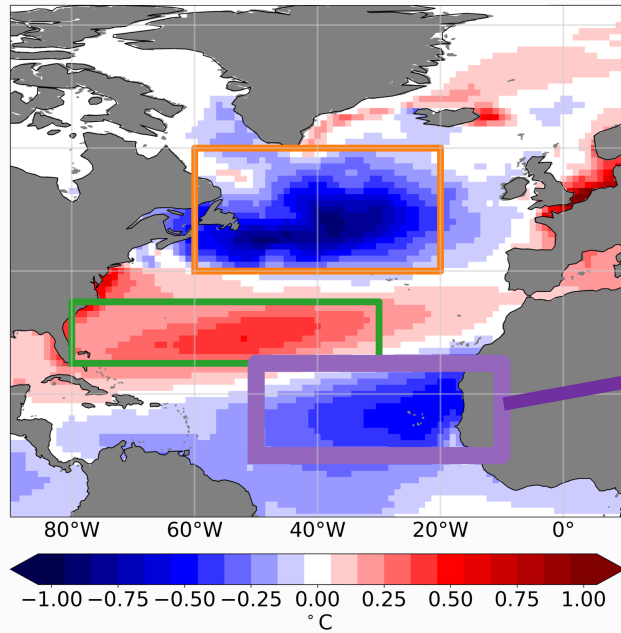
DJF  
+0 years



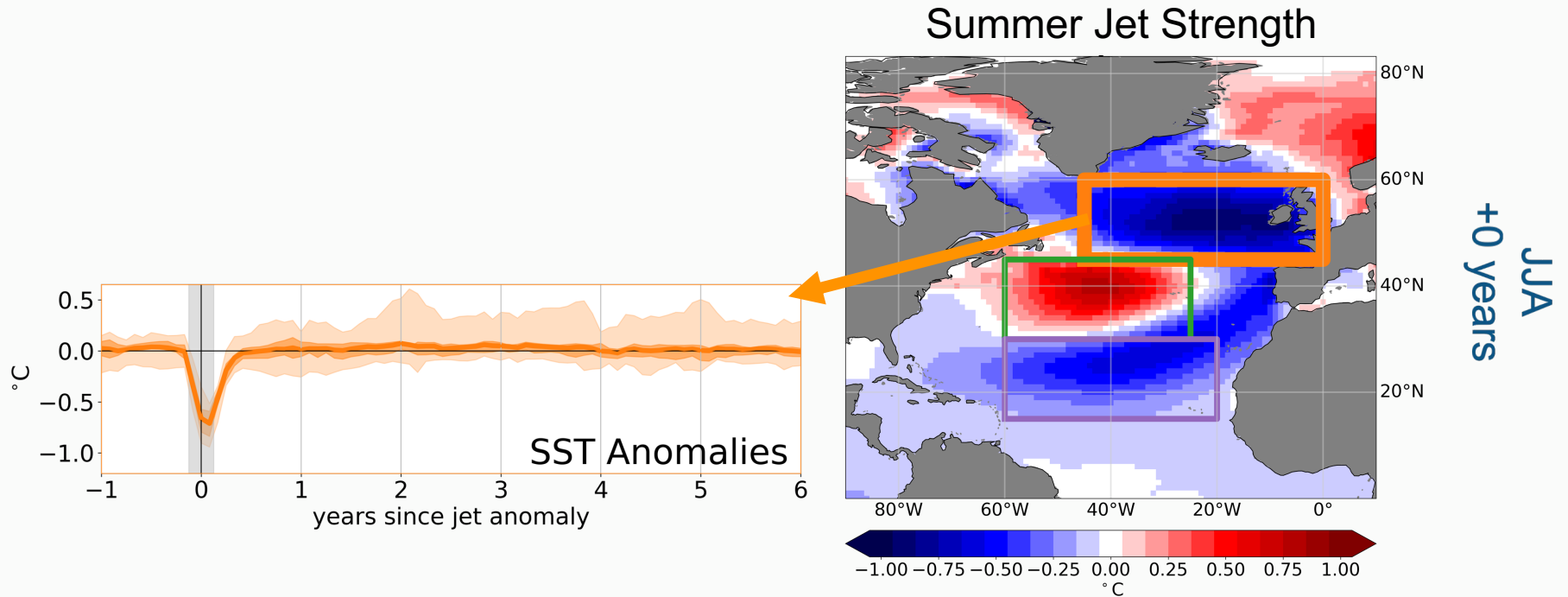
# SST Response to Winter Jet

Winter Jet Strength

DJF  
+0 years

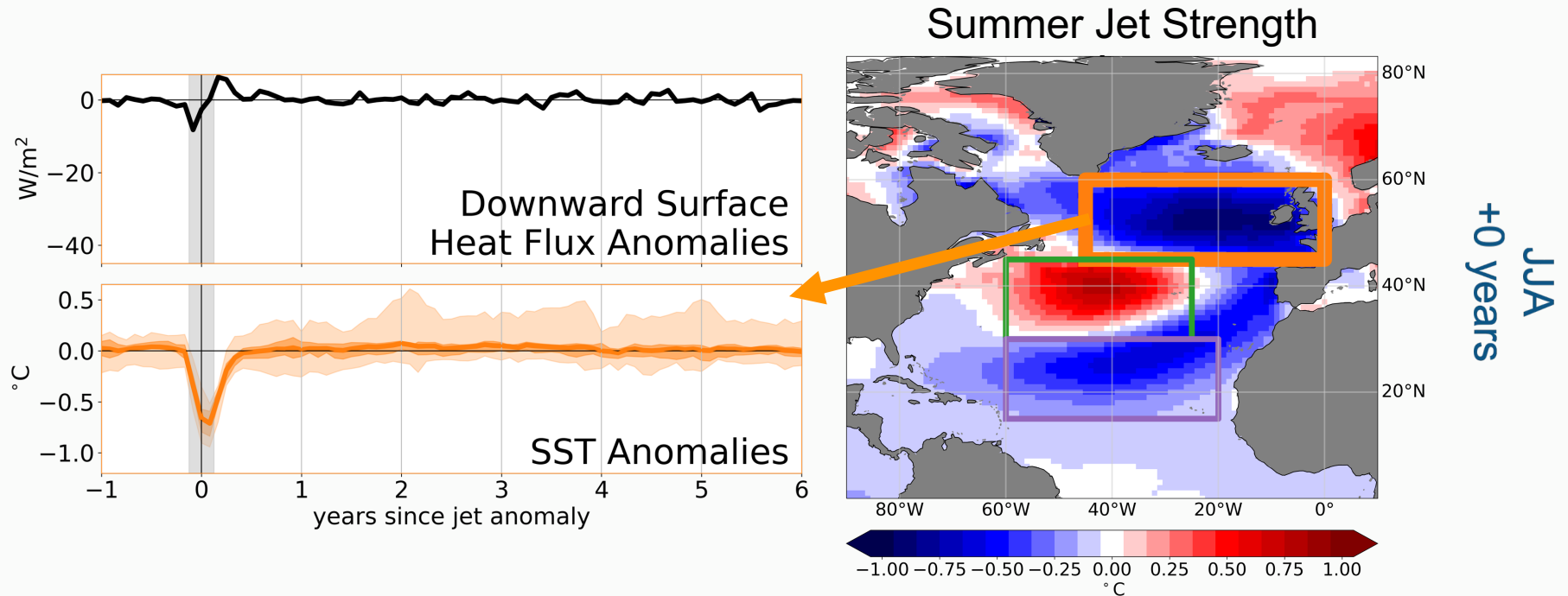


# SST Response to Summer Jet



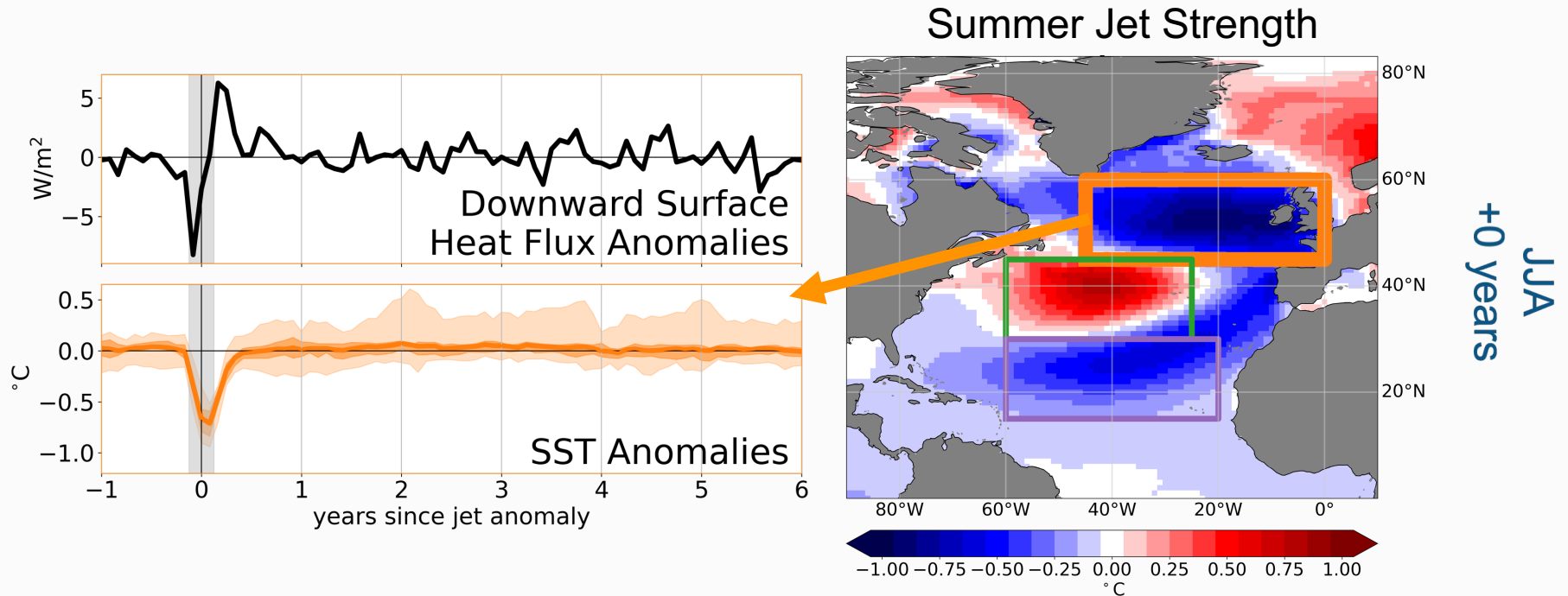
- SST anomaly dissipates quicker than in winter.

# SST Response to Summer Jet



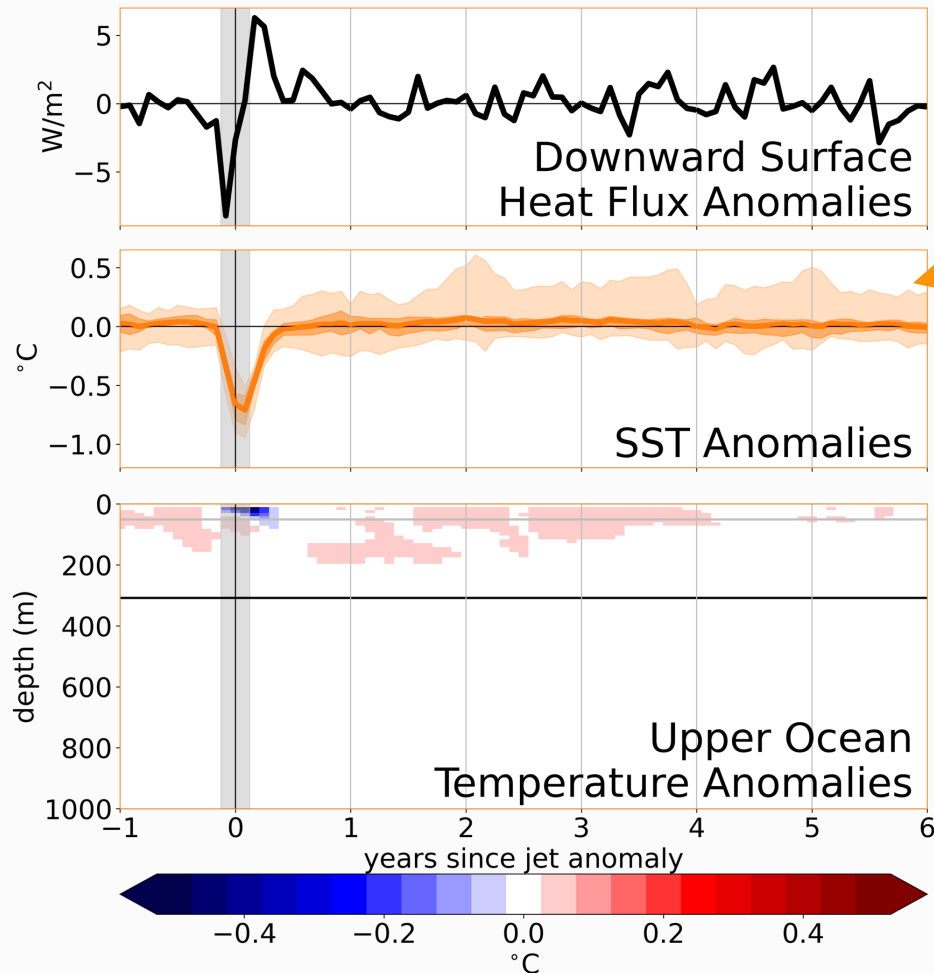
- SST anomaly dissipates quicker than in winter.
- Surface heat flux changes are a lot weaker relative to winter

# SST Response to Summer Jet

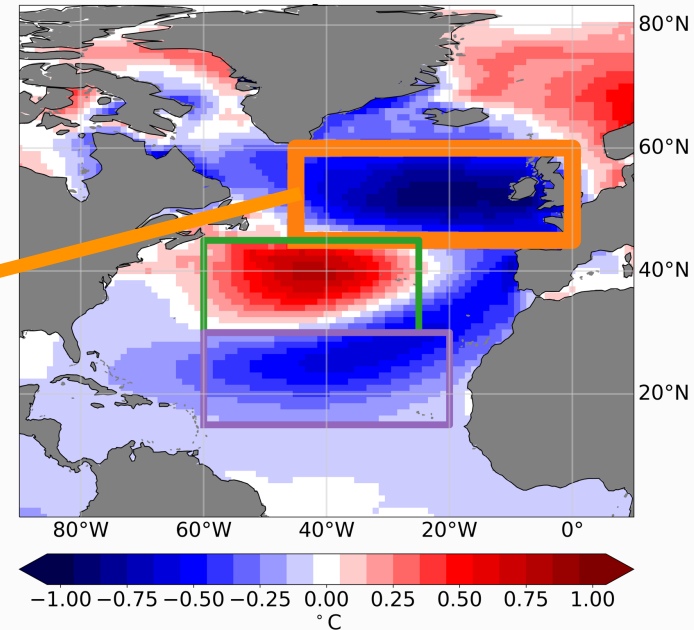


- SST anomaly dissipates quicker than in winter.
- Surface heat flux changes are a lot weaker relative to winter, but they reverse sign.

# SST Response to Summer Jet



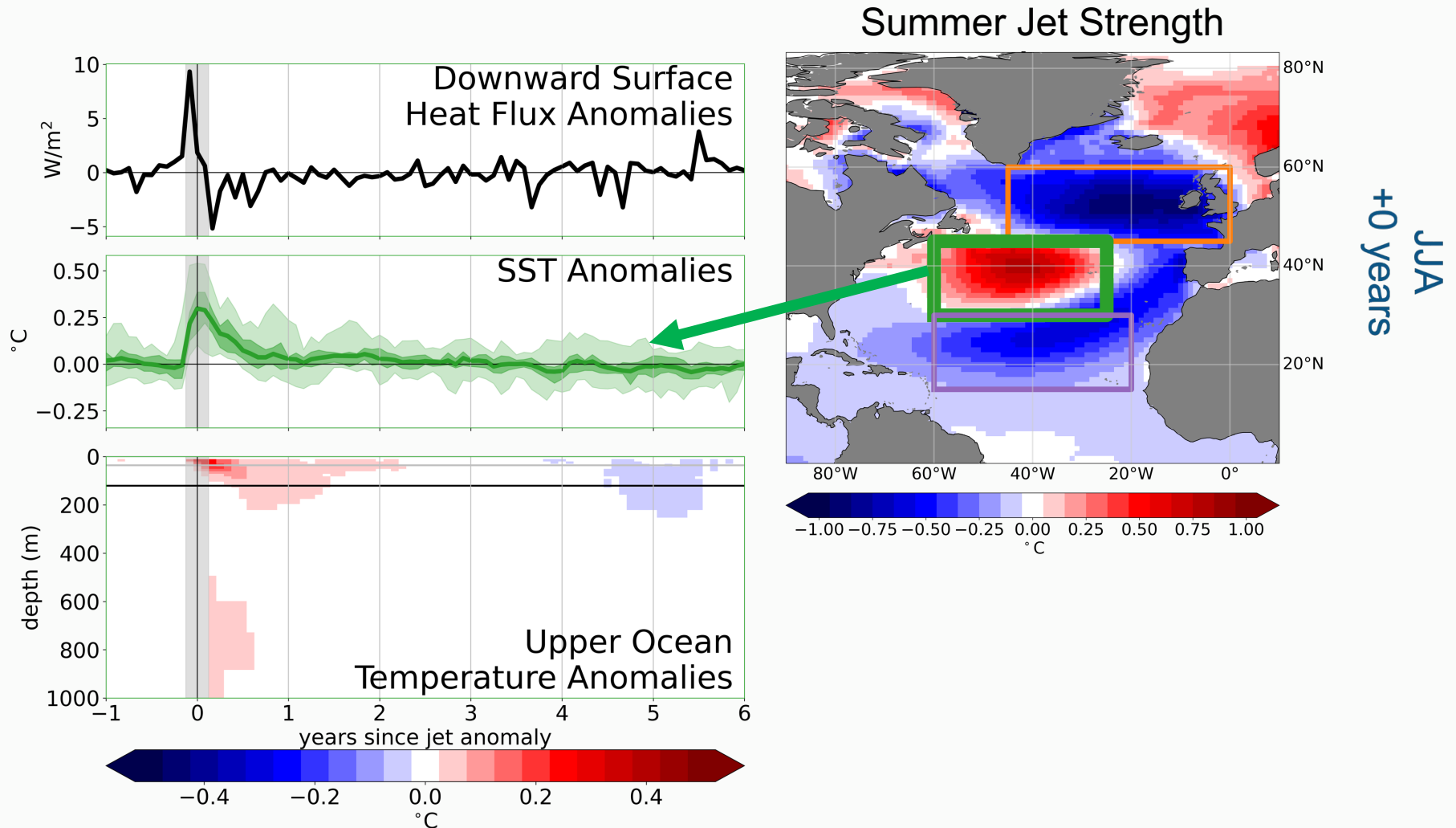
Summer Jet Strength



+0 years  
JJA

- SST anomaly dissipates quicker than in winter.
- Surface heat flux changes are a lot weaker relative to winter, but they reverse sign.
- Temperature changes are above the minimum annual mixed layer depth and don't extend below.

# SST Response to Summer Jet



# SST Response to Summer Jet

