

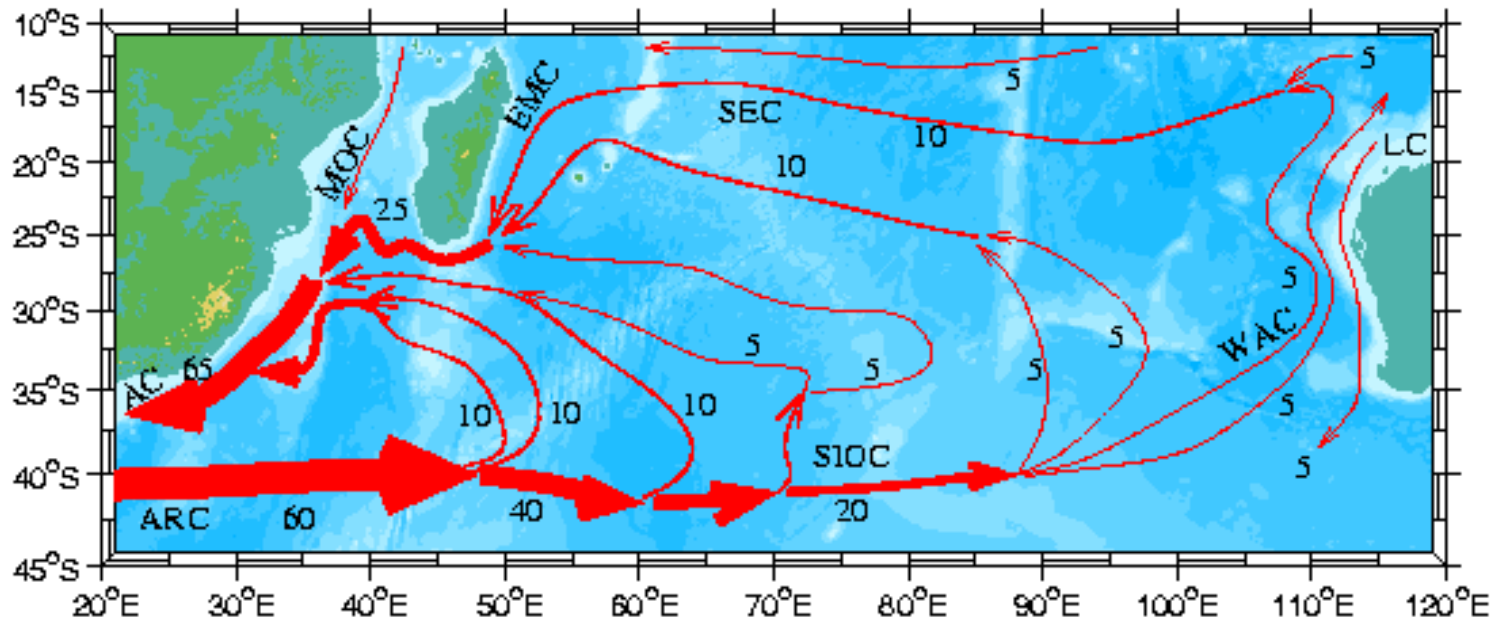
# Agulhas Leakage in the CCSM4

**Wilbert Weijer (LANL)**

**Erik van Sebille (UNSW, Sydney)**

# Agulhas Current

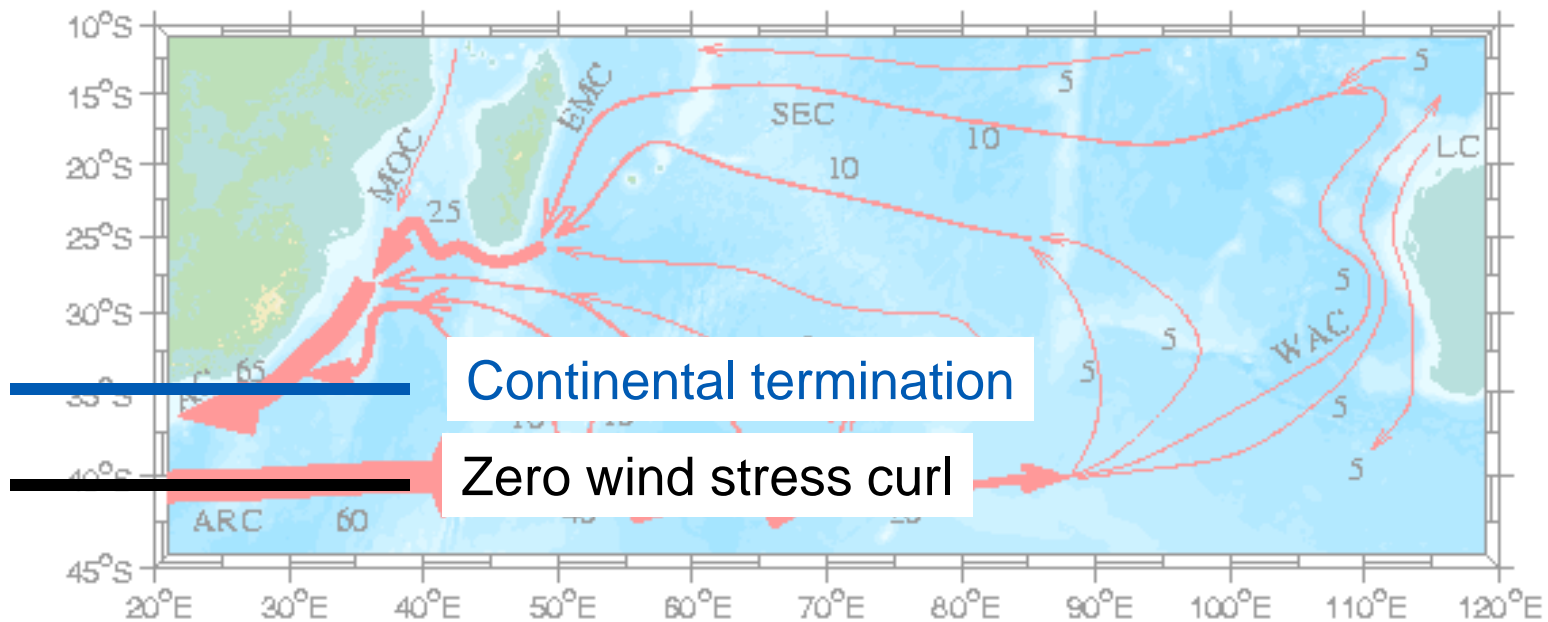
- Classical Western Boundary Current (like Gulf Stream, Kuroshio, etc.)
- Closes subtropical wind-driven gyre of South Indian Ocean



Stramma & Lutjeharms (1997)

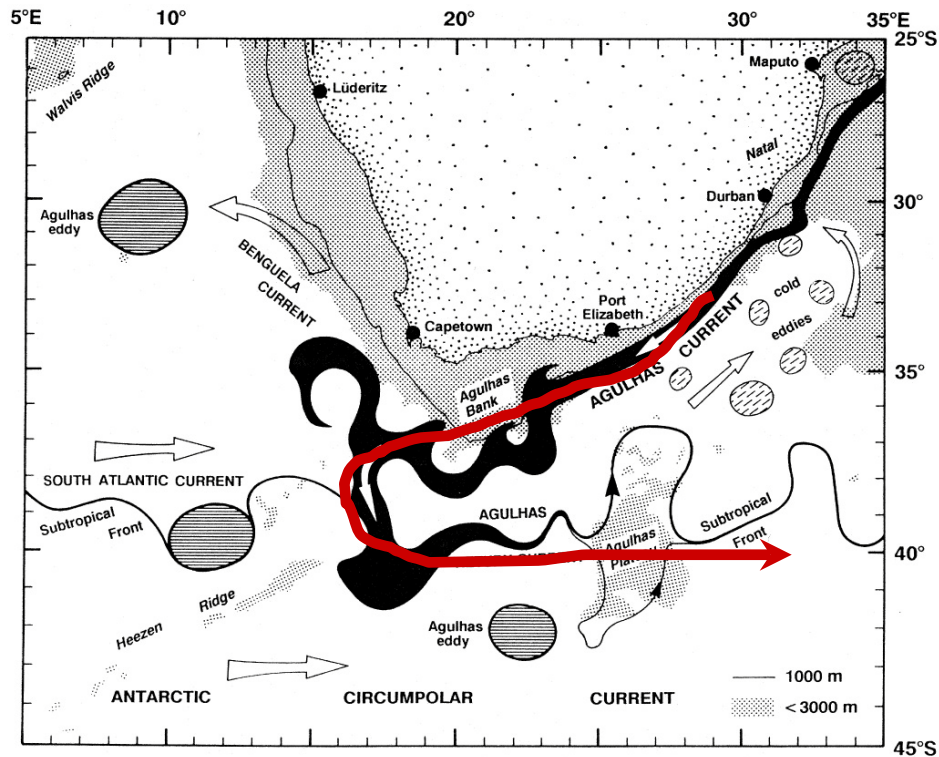
# Agulhas Current

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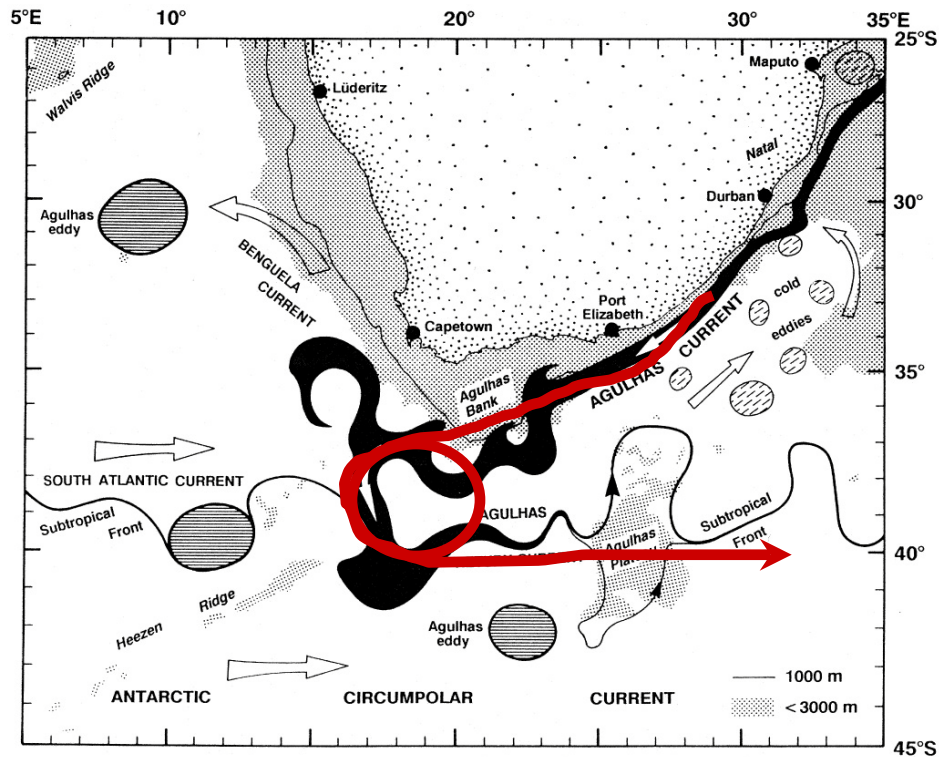
# Agulhas Current: Retroflexion

- Agulhas Current undergoes *Retroflexion*



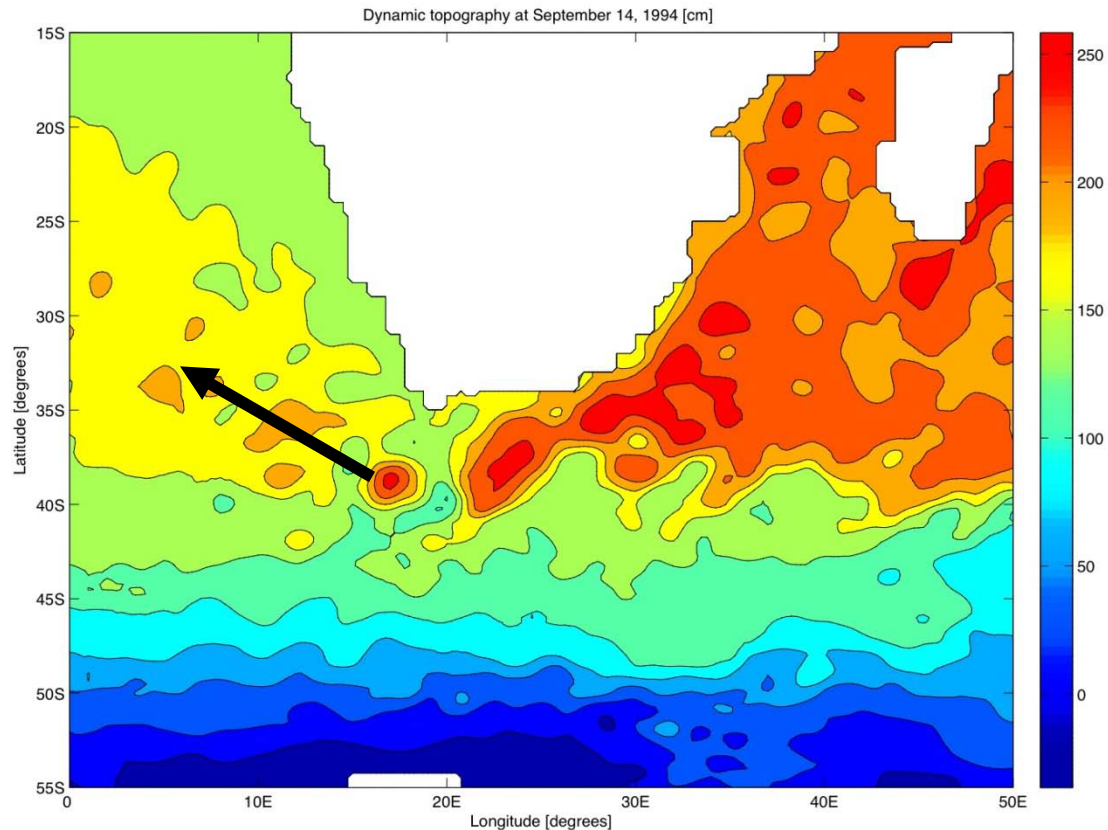
# Agulhas Current: Retroflexion

- Agulhas Current undergoes **Retroflexion**
- Retroflexion is unstable
  - Periodic shedding of **Agulhas Rings** (~ 6 rings per year)



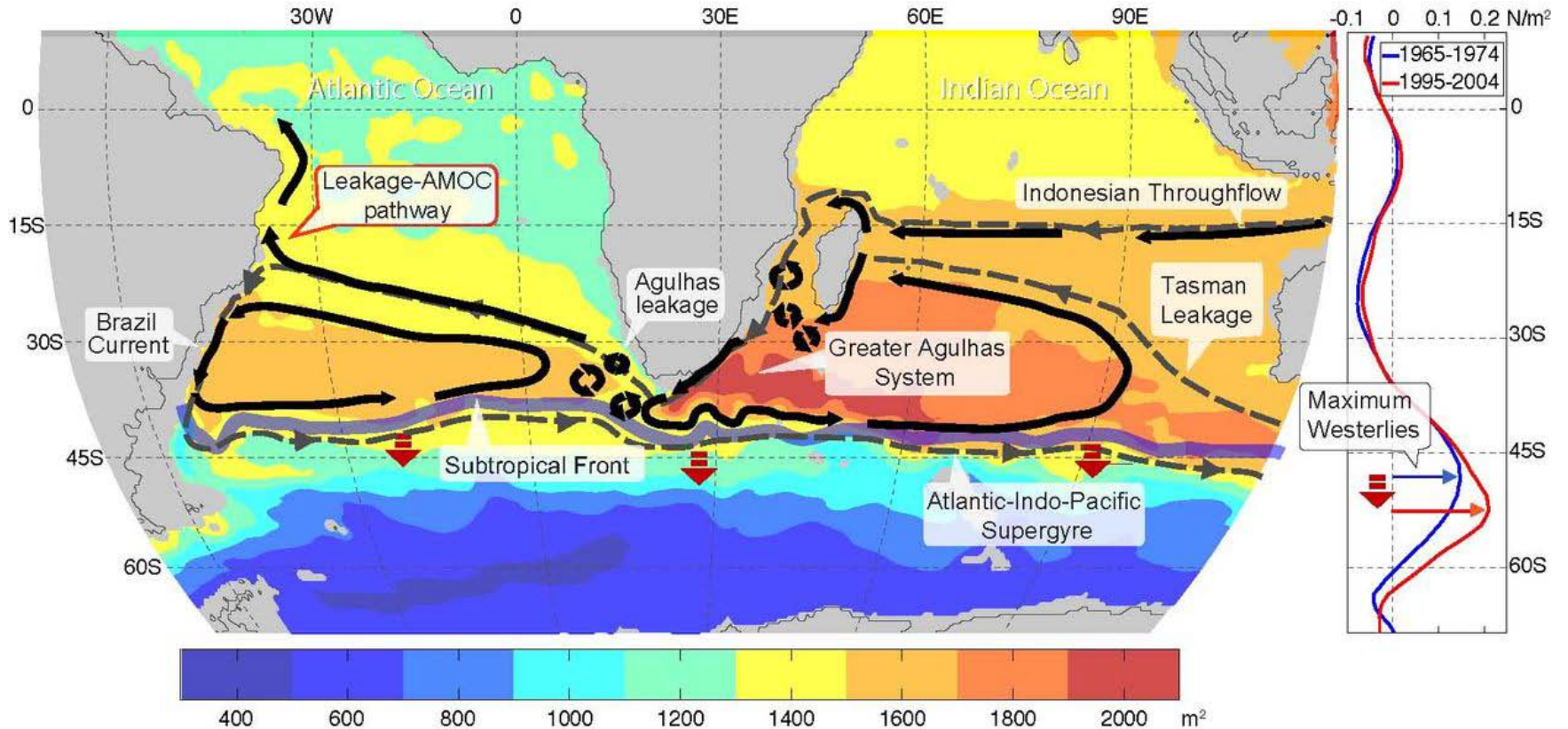
# Agulhas Leakage: Ring Shedding

- Agulhas Rings filled with warm and salty water
  - Drift into South Atlantic: *Agulhas Leakage*





# Agulhas Leakage: Super Gyre



# Agulhas Leakage: Global Impact

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- **Gordon (1985)**

- *“Such a warm water link between the Atlantic and Indian oceans would strongly influence global climate patterns”*



# Agulhas Leakage: Global Impact

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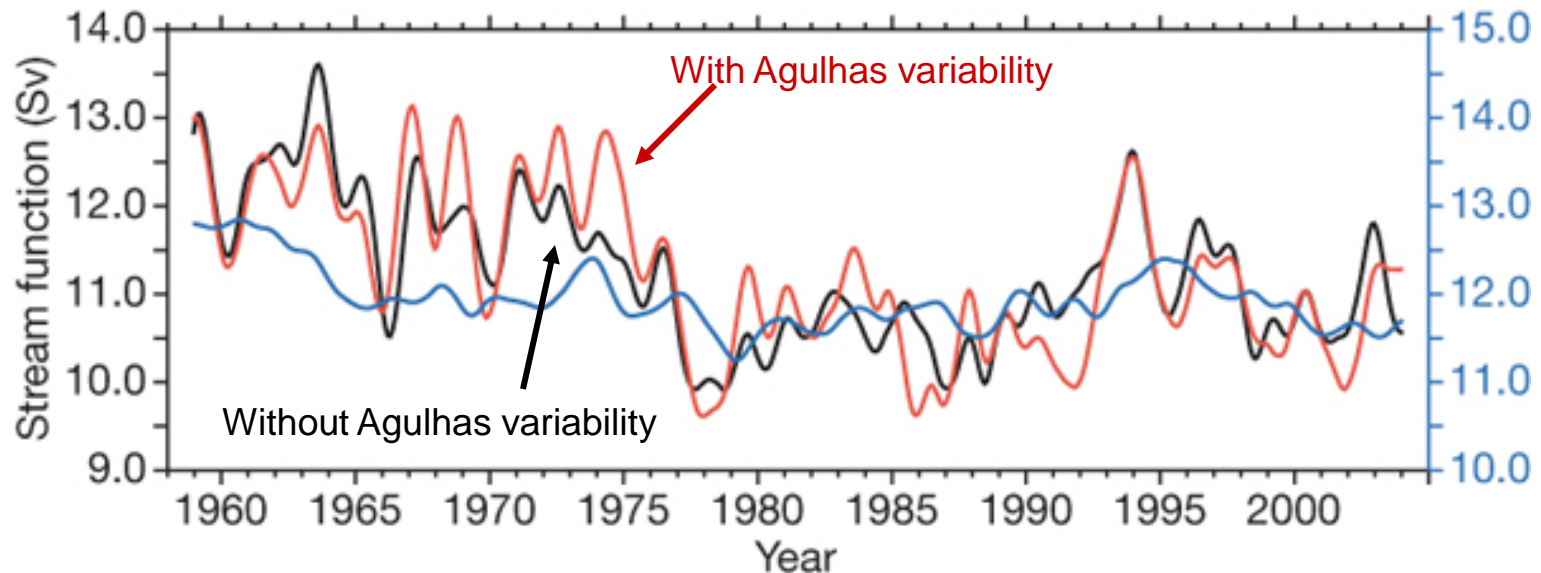
- **Weijer et al. (1999, 2001, 2002)**

- Heat and salt injection through Agulhas Leakage
  - Strengthens MOC
  - Stabilizes MOC

# Agulhas Leakage: Global Impact

## ■ Biastoch et al. (2008)

- High-resolution model of Agulhas region, nested in global model
- *“Dynamical signals from Agulhas region contribute MOC signal of same order of magnitude as those arising in the north”*



Biastoch et al. (2008)

# Agulhas Leakage: Implications

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- **How will Agulhas Leakage change in warmer climate?**
  - Poleward shift of wind belts
- **How will this affect the MOC?**

# Agulhas Leakage: Implications

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- **How will Agulhas Leakage change in warmer climate?**
  - Poleward shift of wind belts
- **How will this affect the MOC?**
- **How is Agulhas Leakage represented in state-of-the-art Climate Model?**

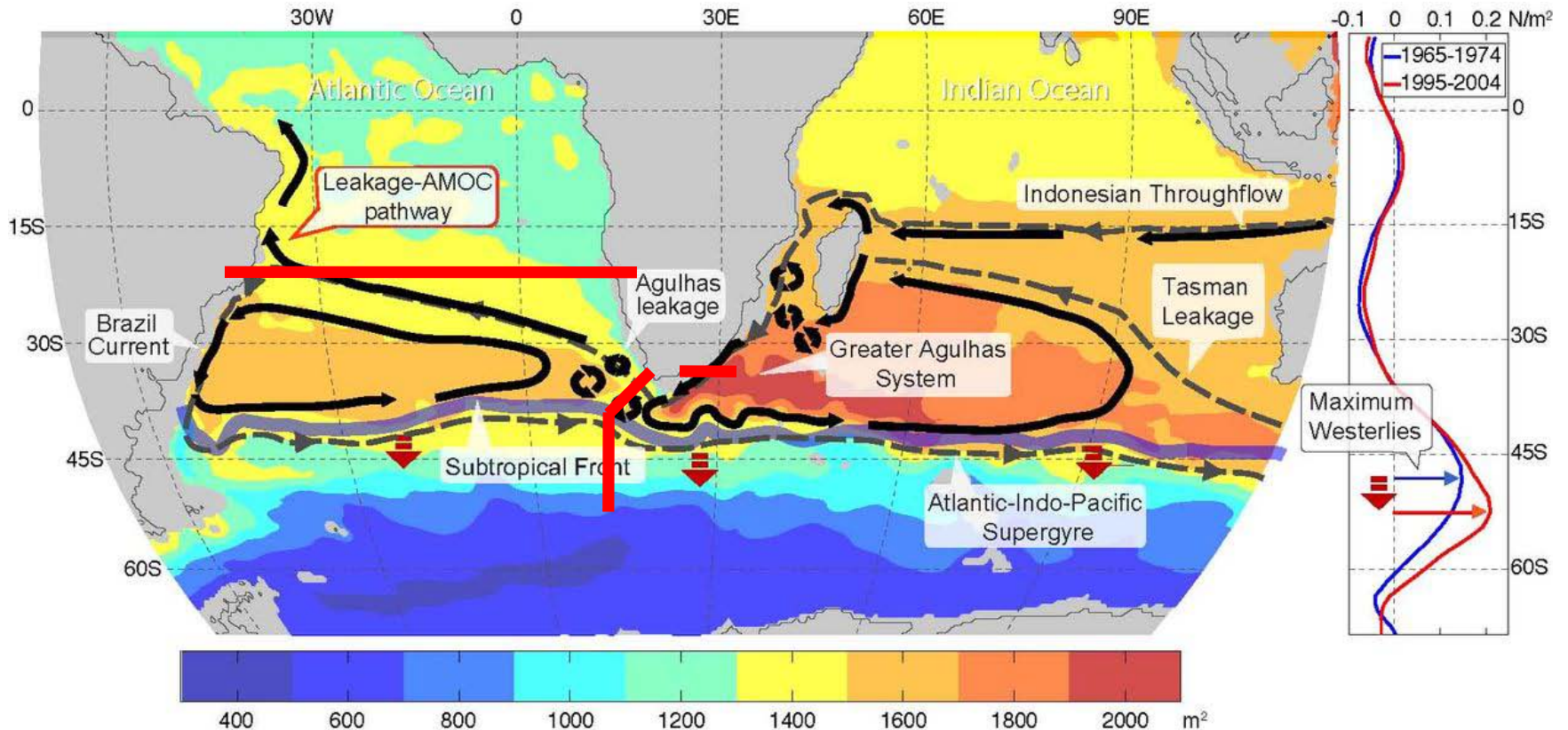
# Agulhas Leakage in CCSM4

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## ■ Lagrangian analysis

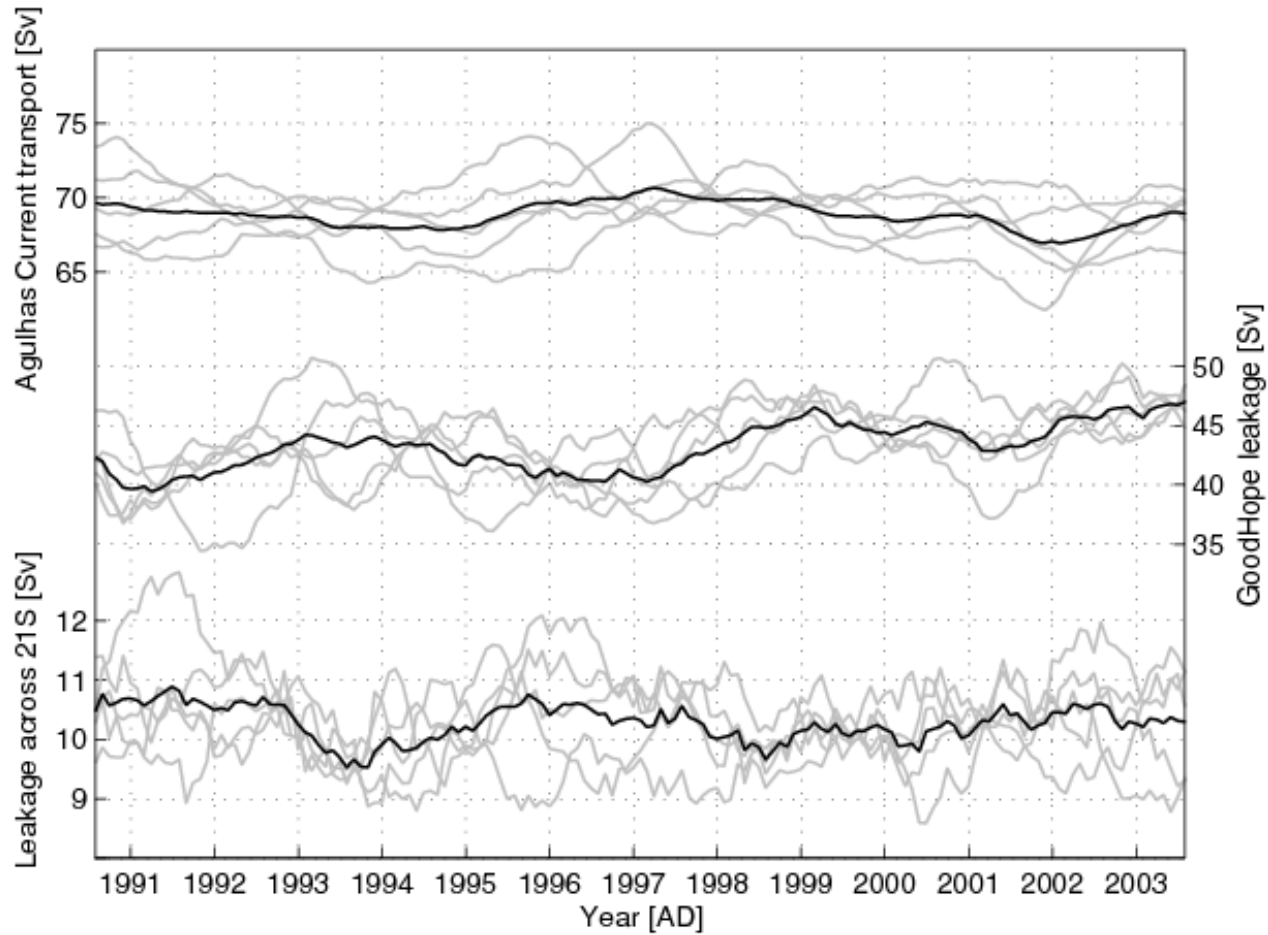
- CCSM4 20<sup>th</sup> century runs
- Monthly 3D velocity fields, 1980-2005
- Release 110,000 numerical floats in Agulhas Current
  - How many make it into South Atlantic?
  - How many make it across 21°S?

# Agulhas Leakage in CCSM4

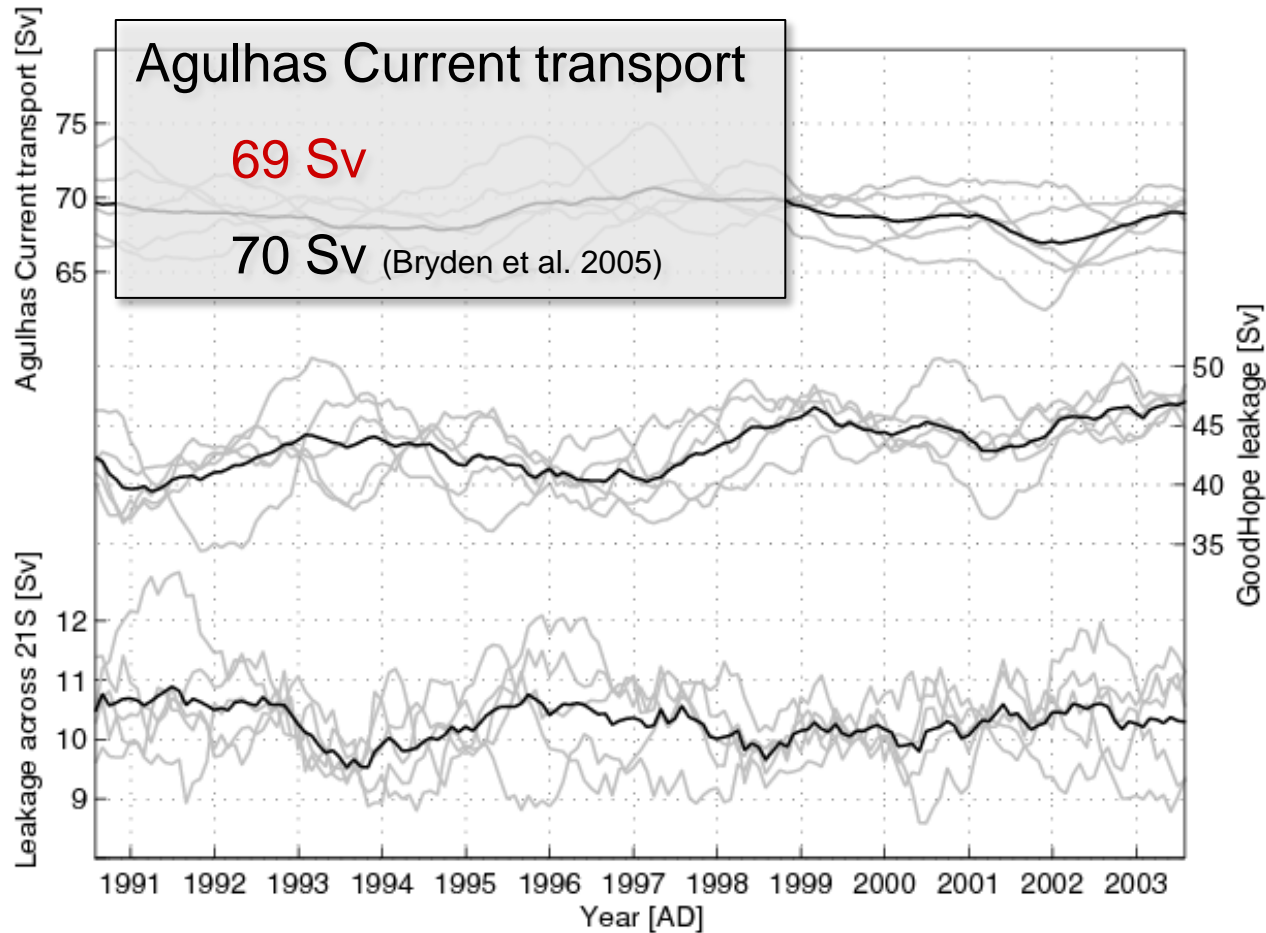




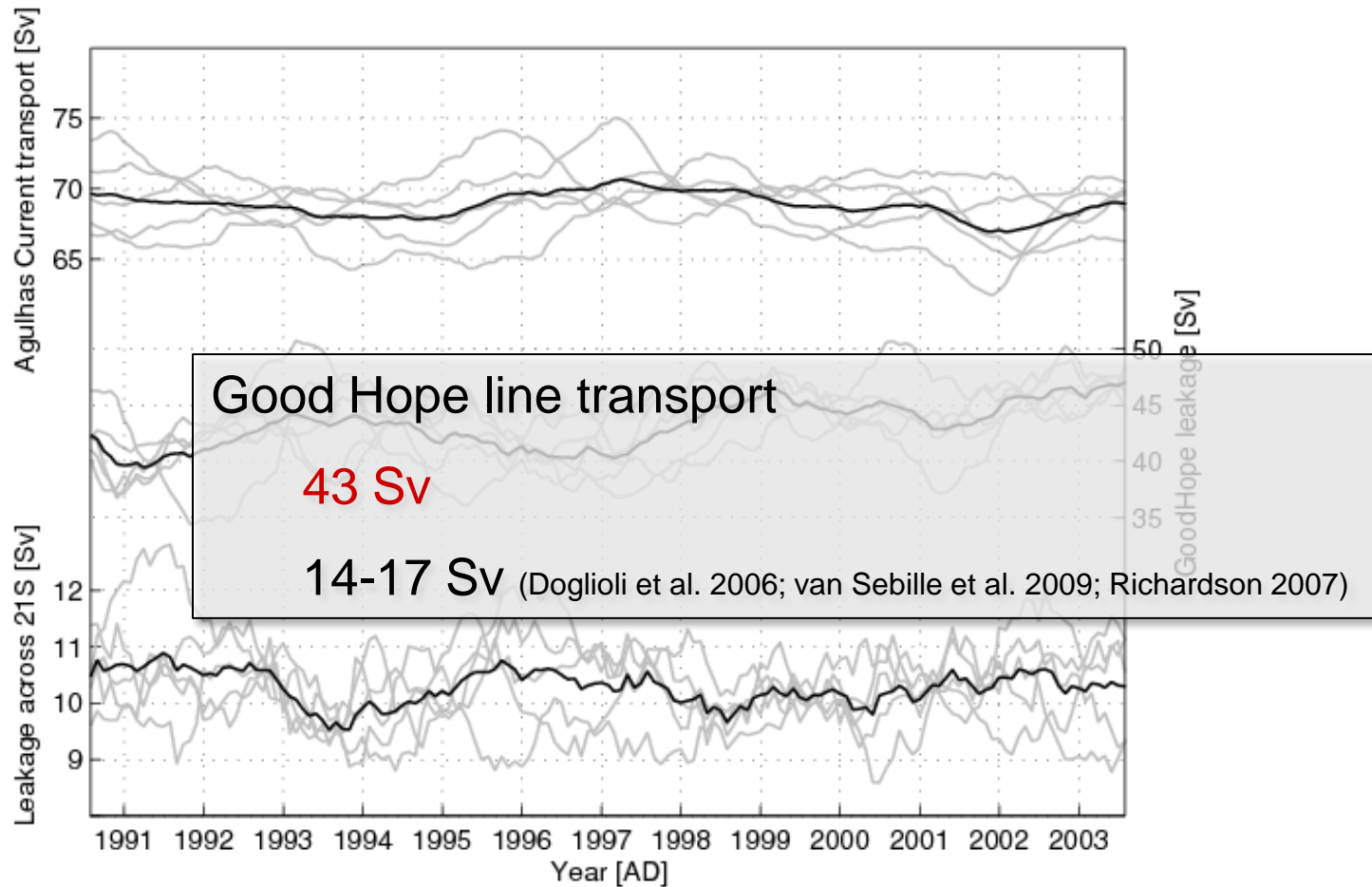
# Agulhas Leakage in CCSM4



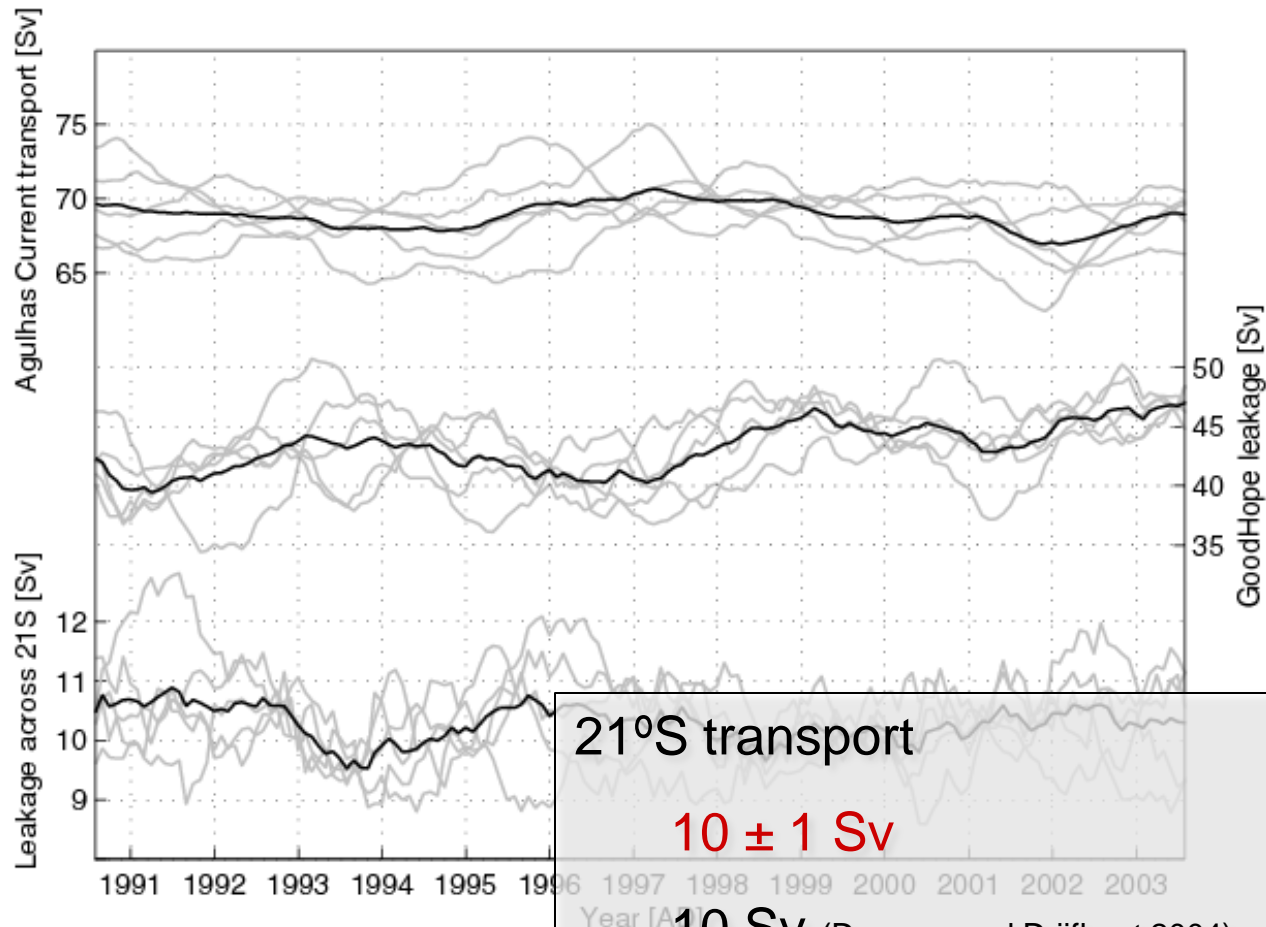
# Agulhas Leakage in CCSM4



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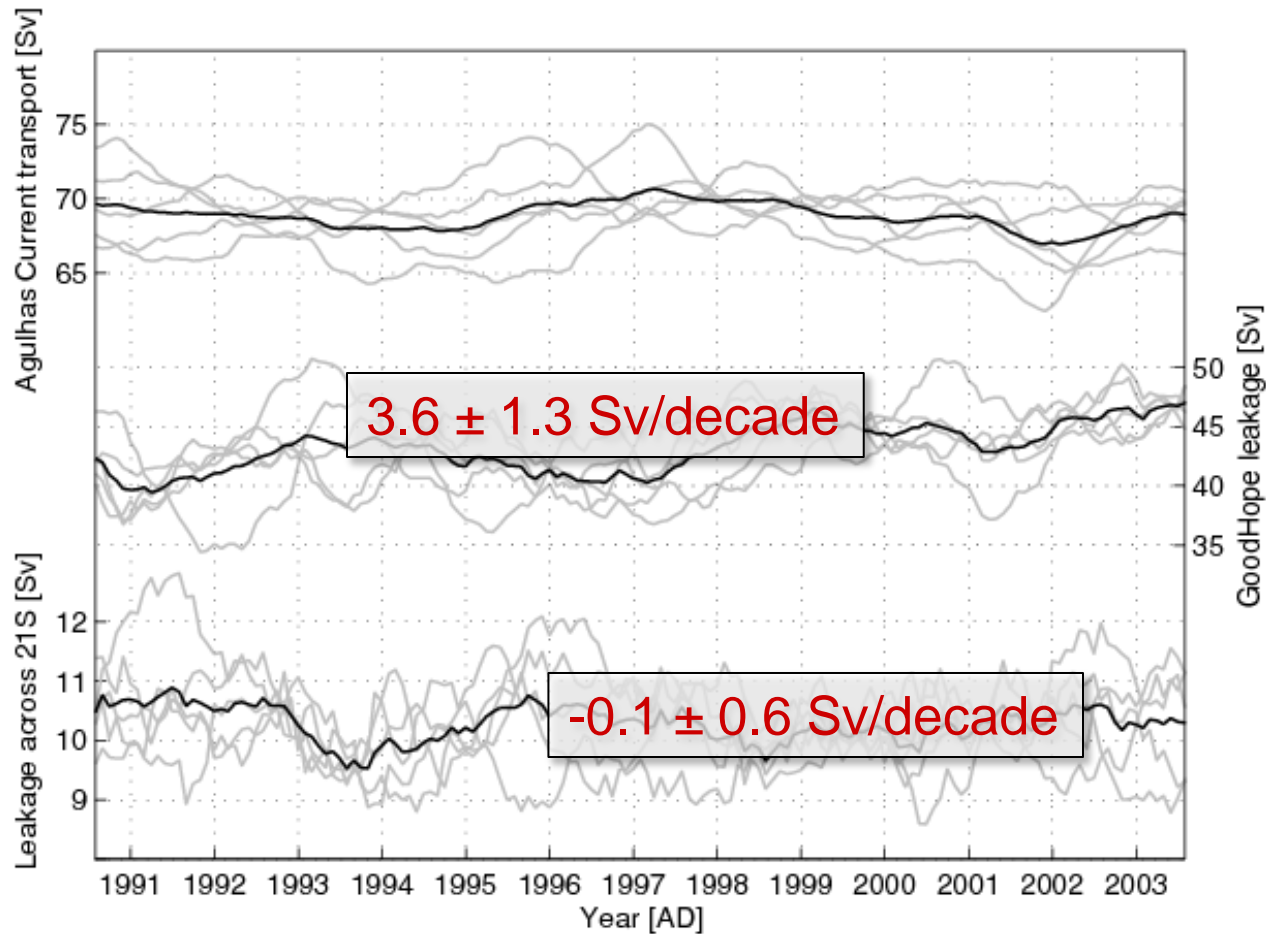
21°S transport

$10 \pm 1$  Sv

10 Sv (Donners and Drijfhout 2004)

4 Sv (Biastoch et al. 2009)

# Agulhas Leakage in CCSM4



# Agulhas Leakage in CCSM4

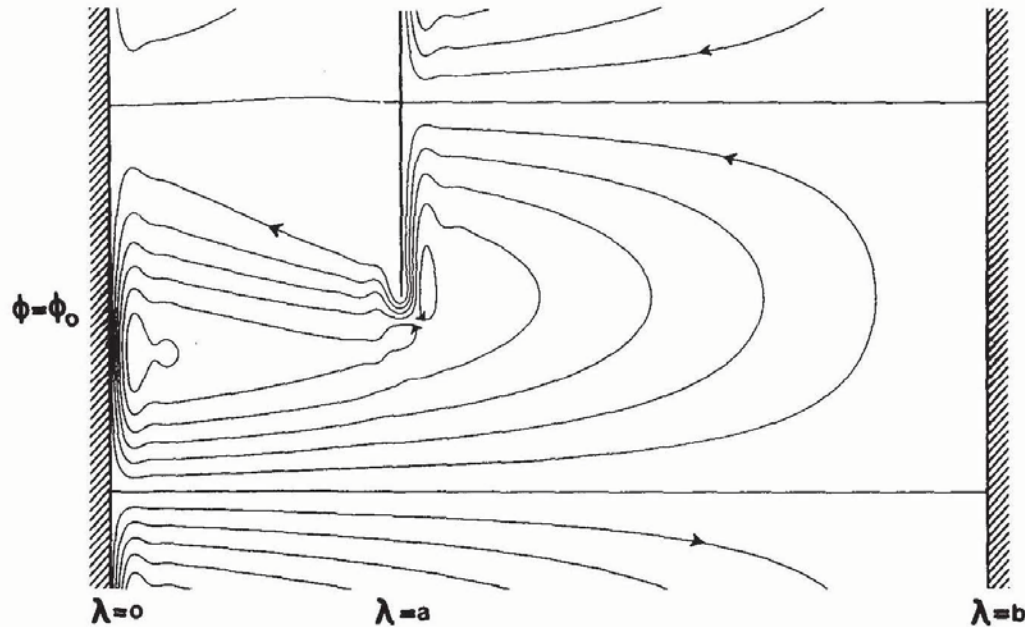
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- Agulhas Current okay
- Agulhas Leakage overestimated by factor 3
- Recirculates in super-gyre



# Agulhas Leakage in CCSM4

- Agulhas Retroflection **inertial** process
- Not captured by low-resolution  $1^\circ$  models
- Instead, leakage takes place in **viscous** boundary layer



De Ruijter (1982)

# Does Agulhas Leakage influence MOC in CCSM4?

- **Leakage influences MOC through salinity anomalies**

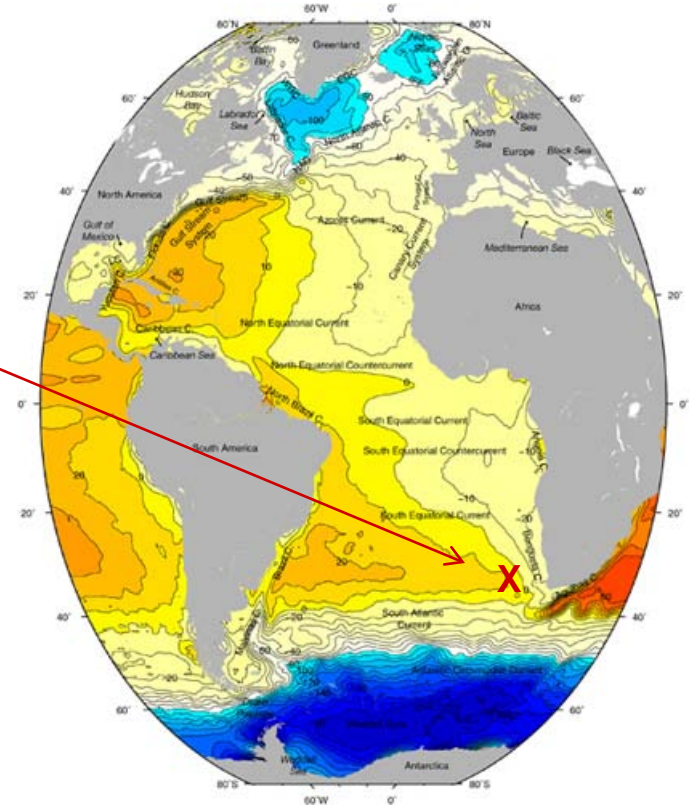
- Actual volume flux irrelevant

- **Reference time series:  $S_{34S}$**

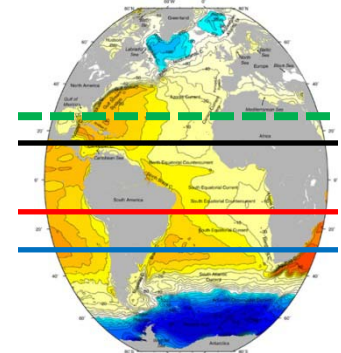
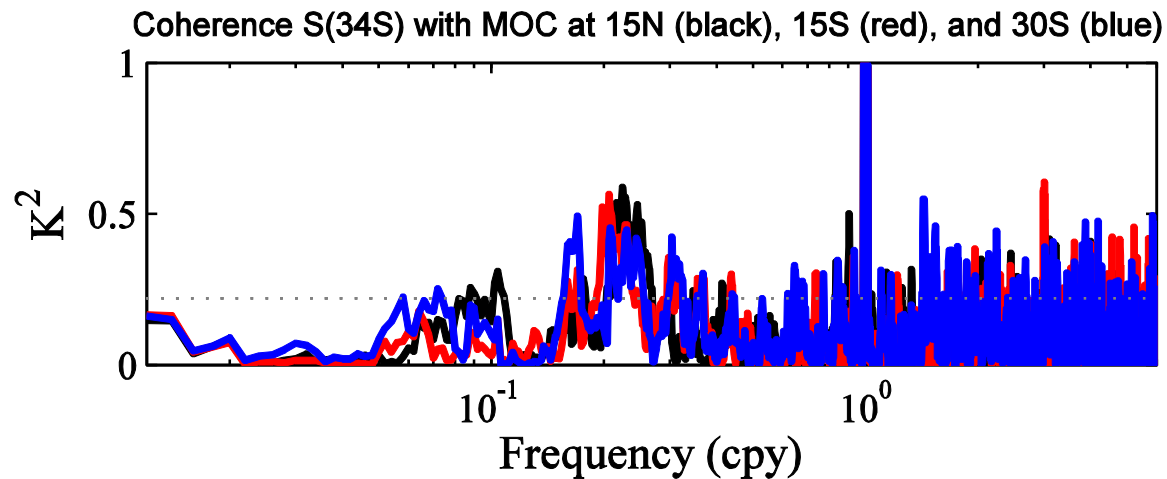
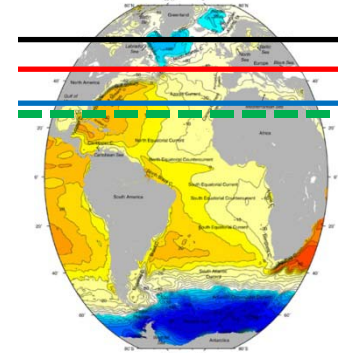
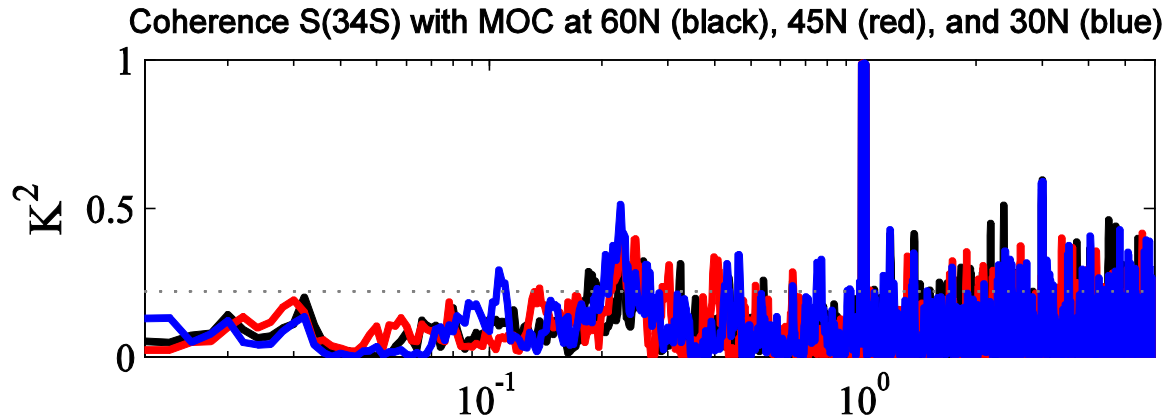
- Salinity averaged over upper 1000 m
- In southeastern South Atlantic

- **Look for**

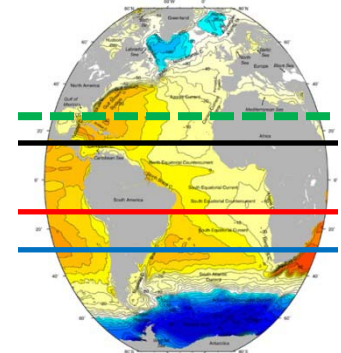
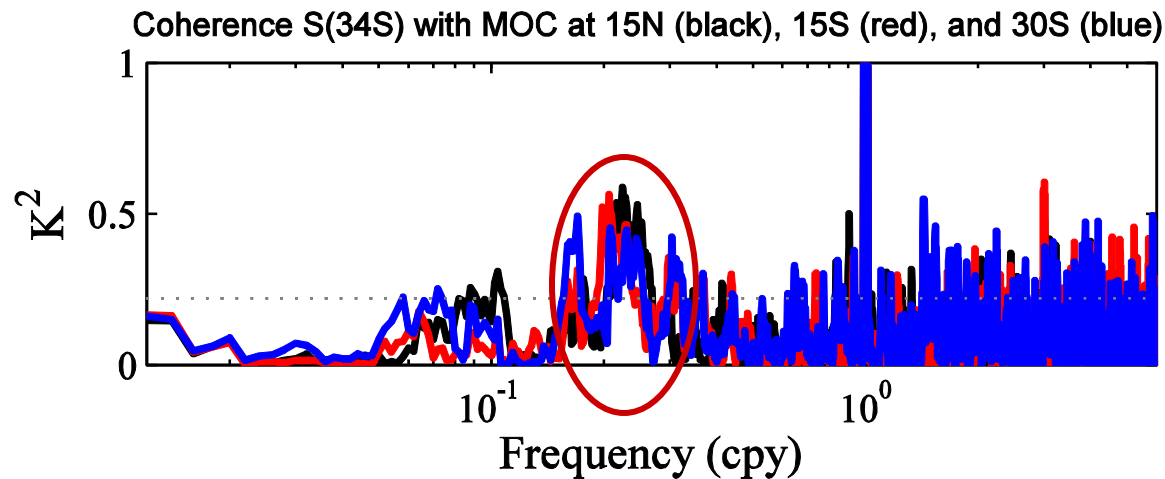
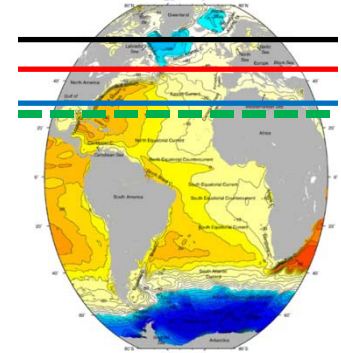
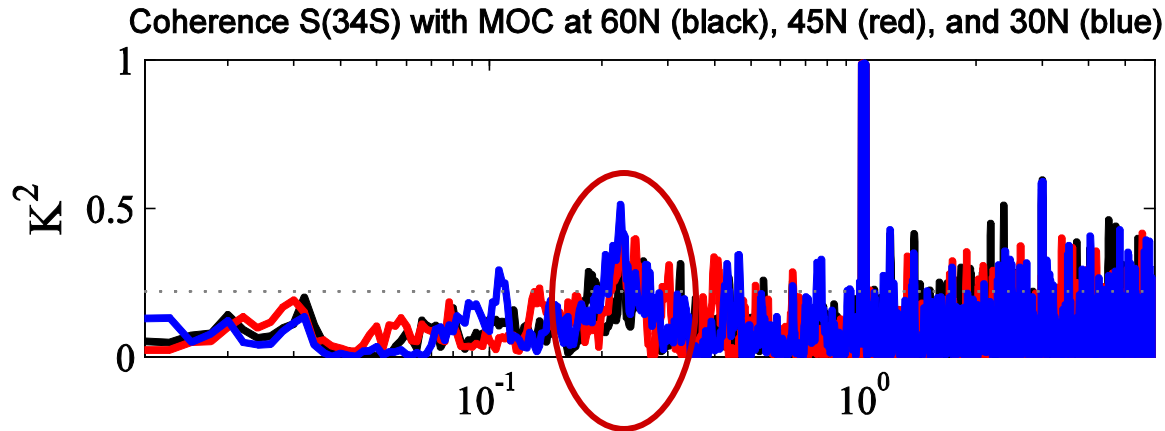
- Coherence between  $S_{34S}$  and MOC
- Correlations between  $S_{34S}$  and anywhere else



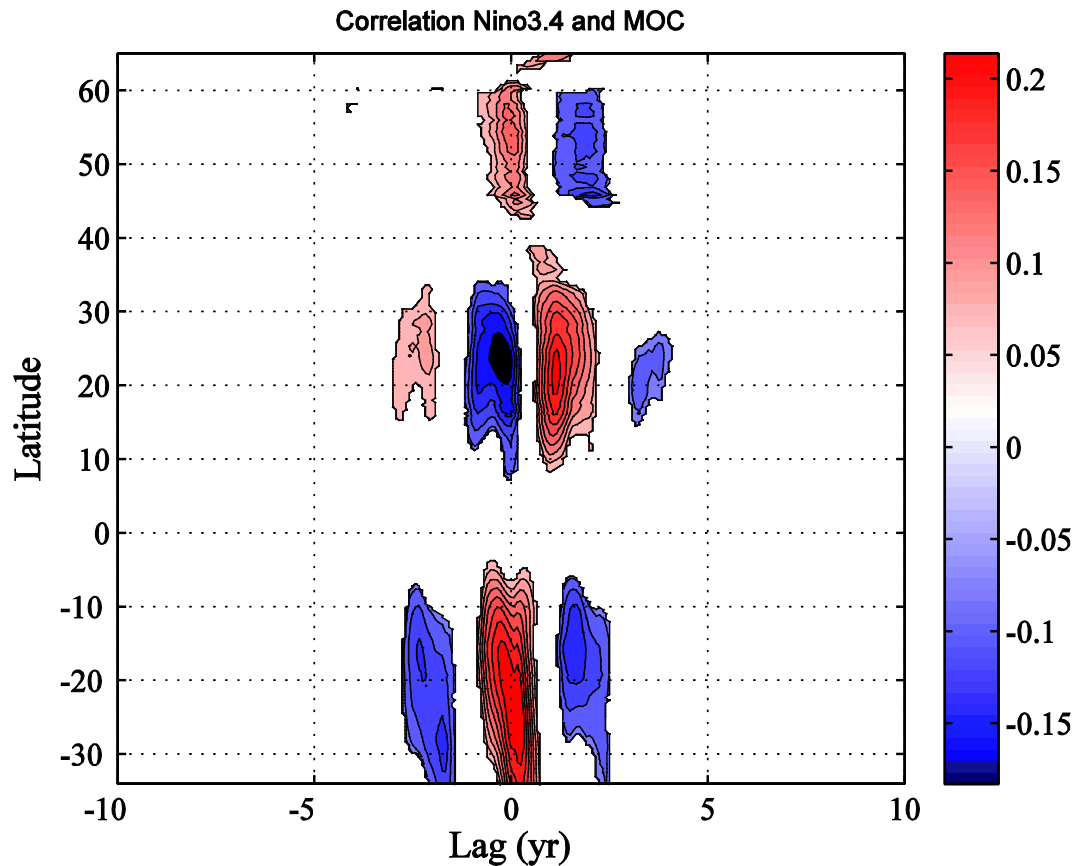
# Coherence of the AMOC with S(34S)



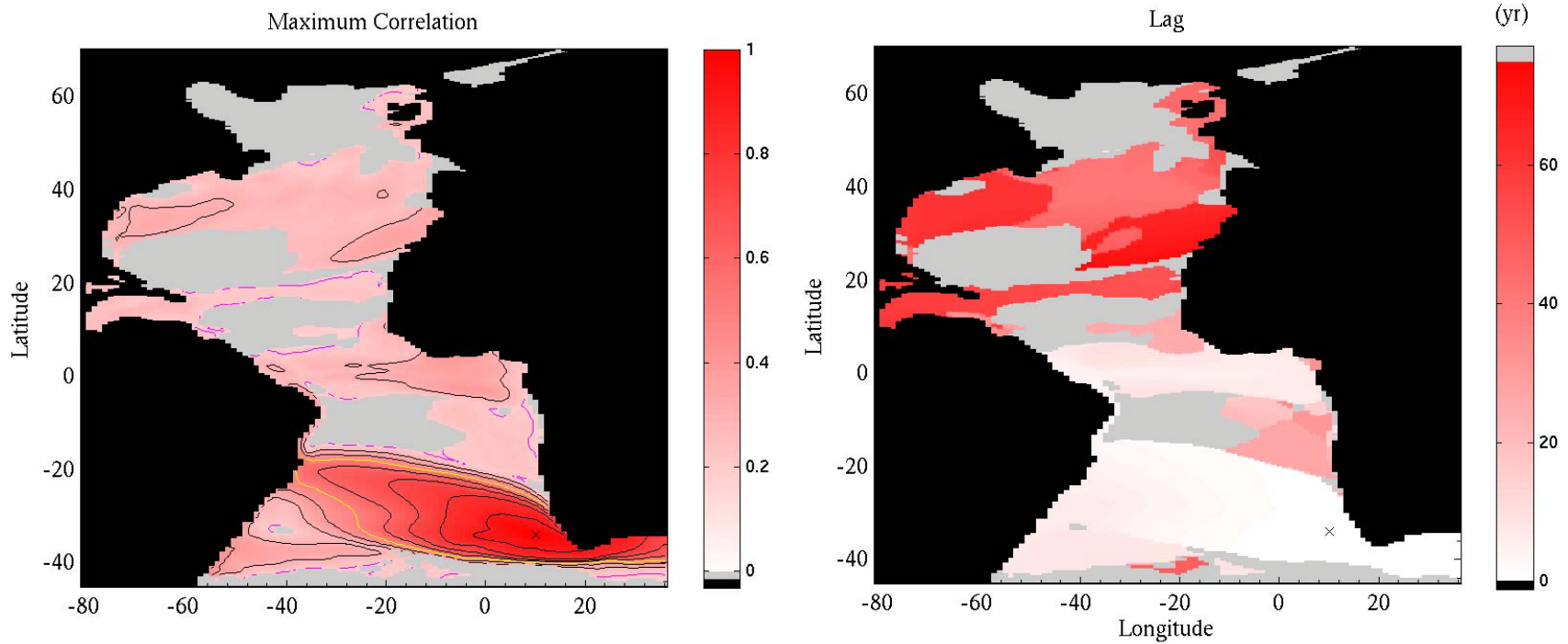
# Coherence of the AMOC with S(34S)



# Joint response to ENSO: AMOC



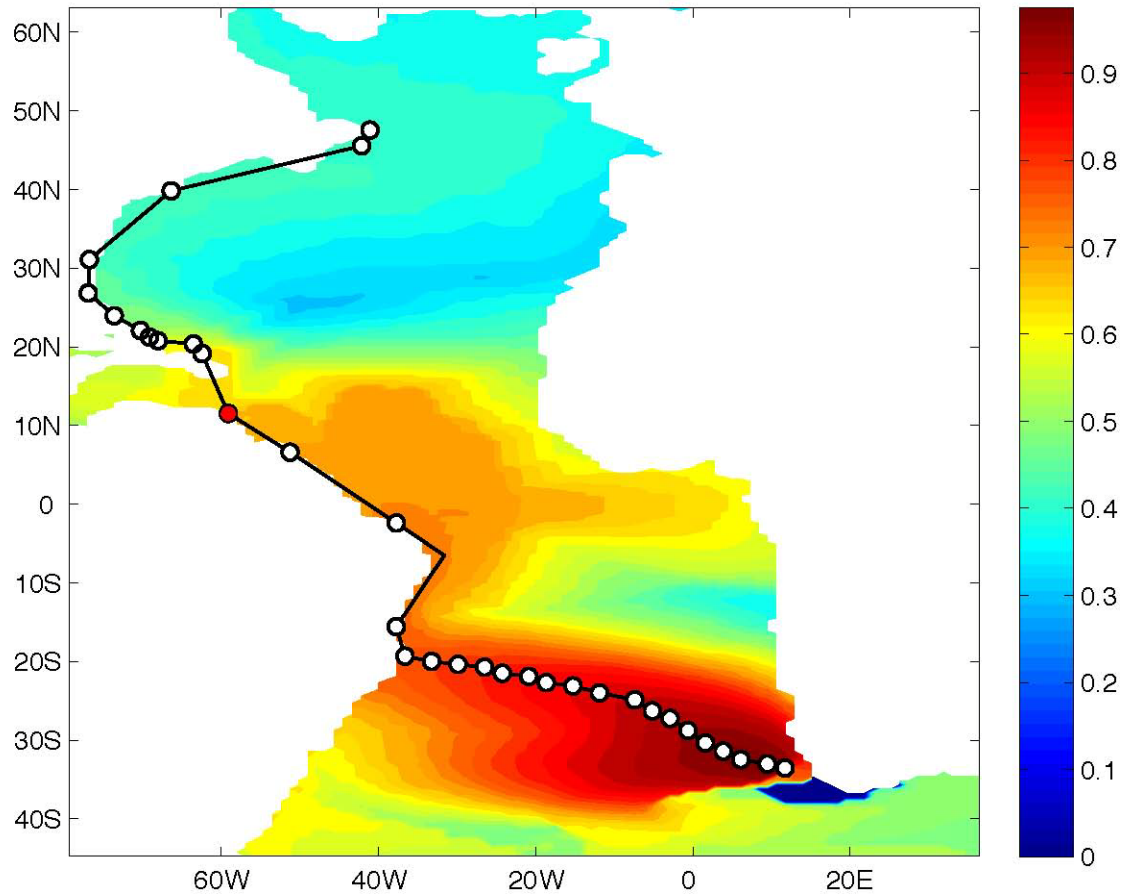
# Signal propagation: lagged correlation



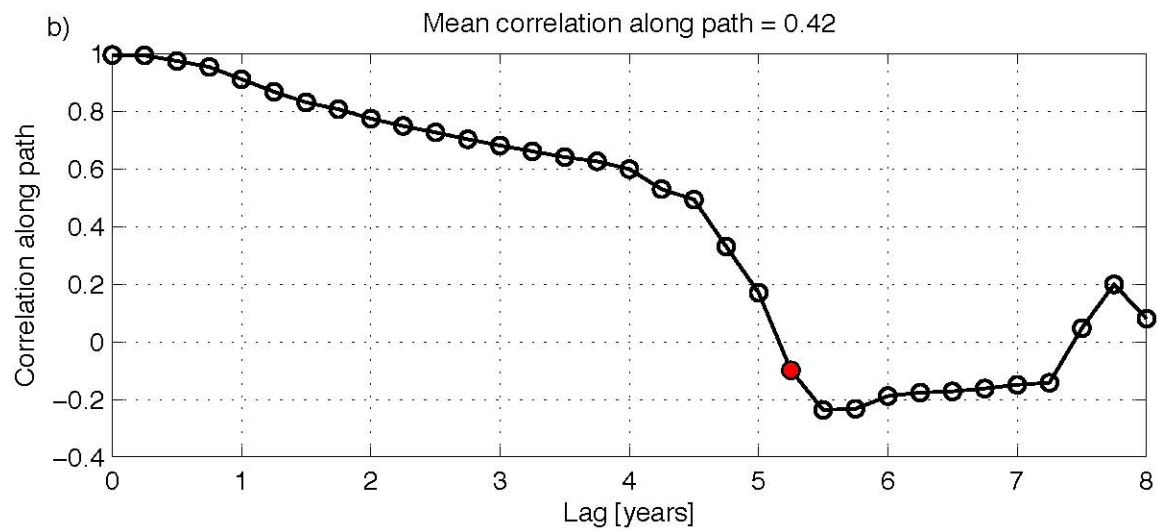


# Signal propagation: lagged correlation

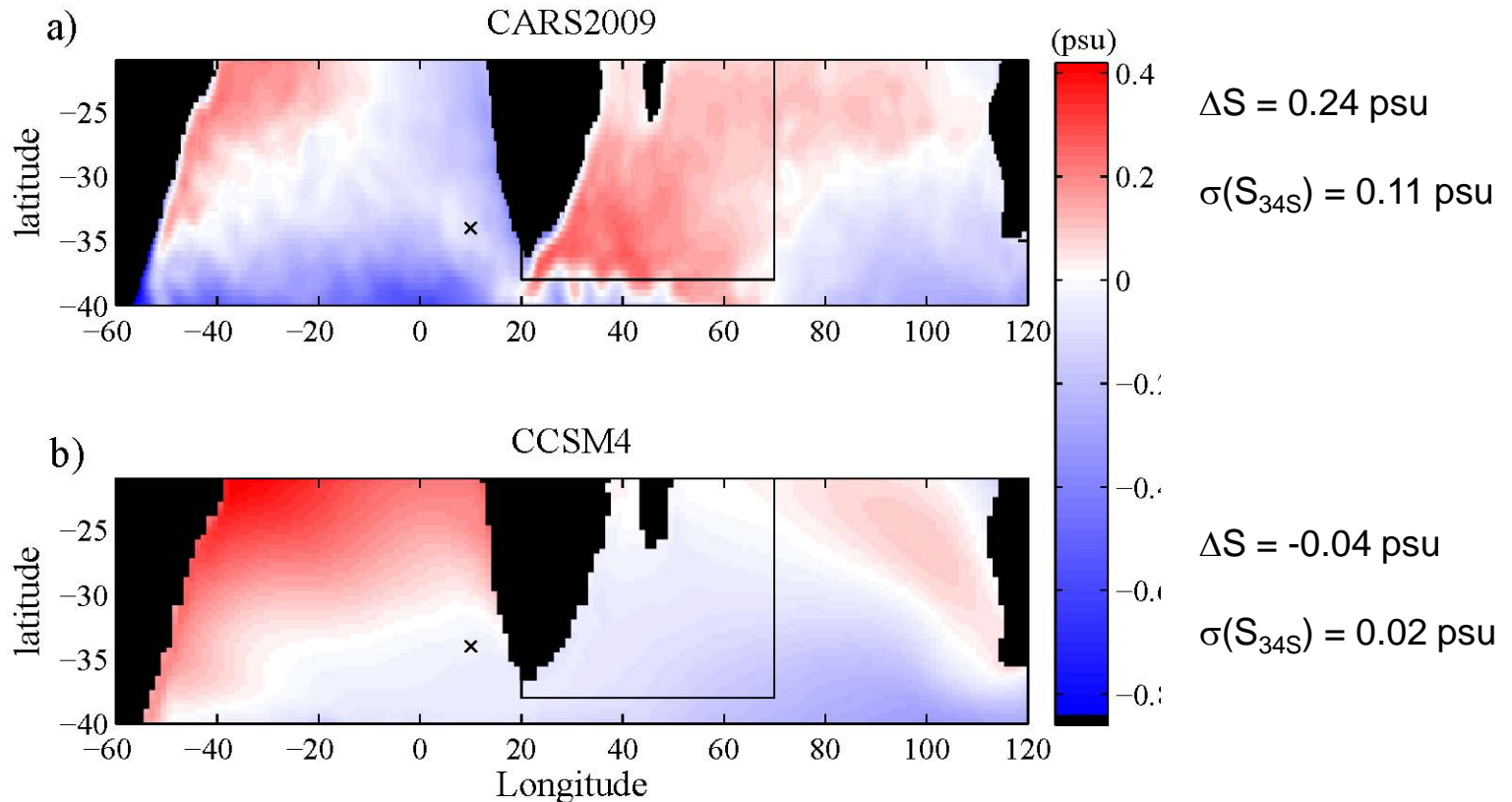
a) Mean correlation to each gridpoint with optimum path for upper 1000m signal



# Signal propagation: lagged correlation



# Signal propagation: lagged correlation

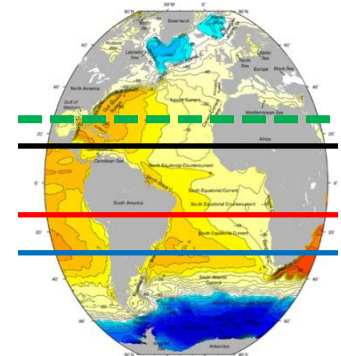
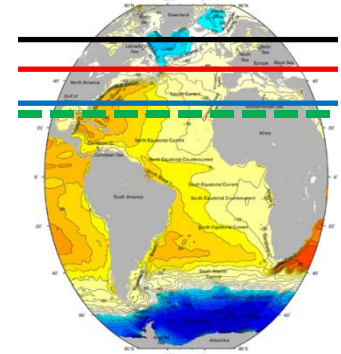
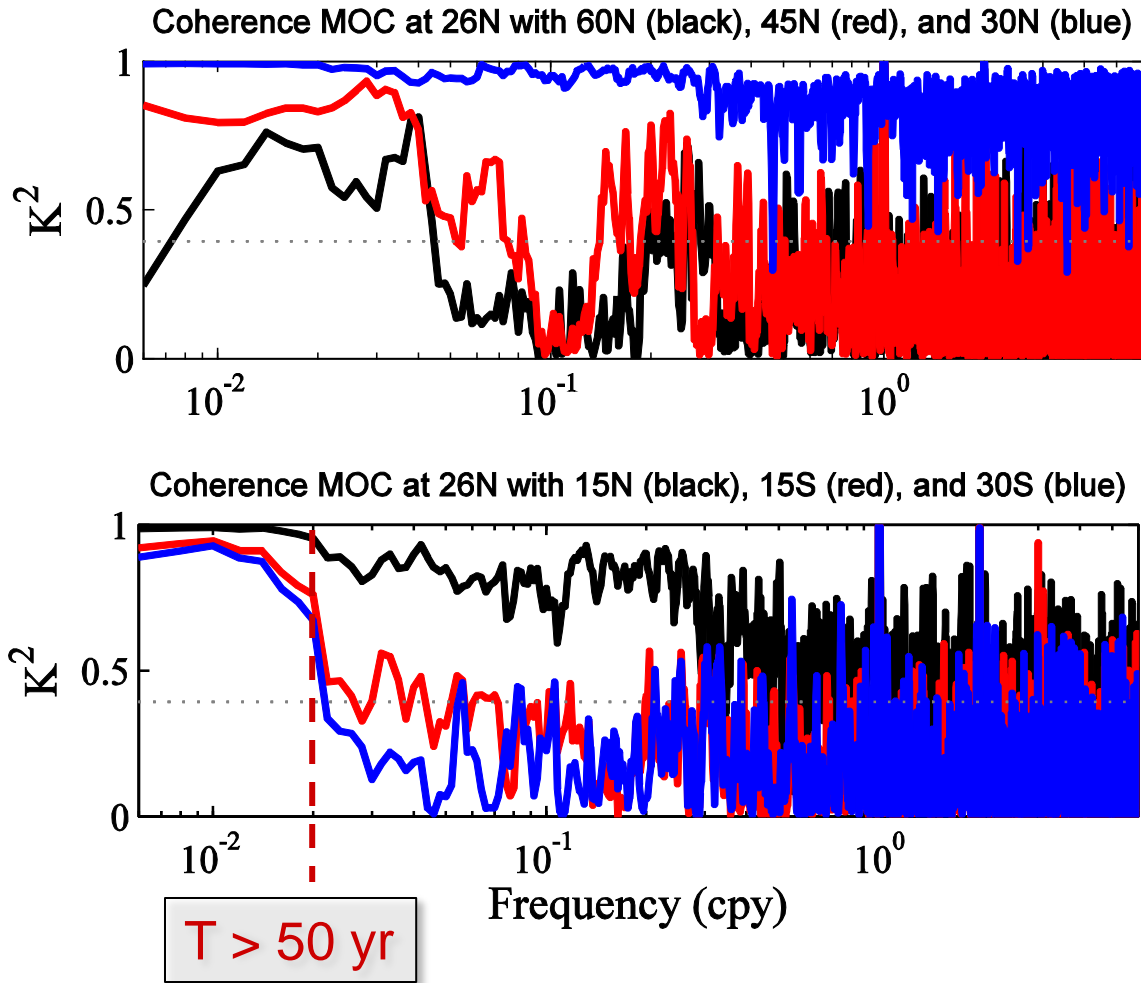


# Conclusions

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- **Agulhas Leakage too strong in CCSM4**
  - Factor of 3
  - Too strong coupling between South Atlantic and Indian Oceans (“super gyre”)
  - Salinity too homogeneous
- **No discernible impact of Agulhas Leakage variability on MOC**
  - Salinity variability too weak
  - Study is inconclusive

# Meridional Coherence of the AMOC



# Good Metric of Agulhas Leakage Impact?

