Variabilité Atlantique Multidécennale

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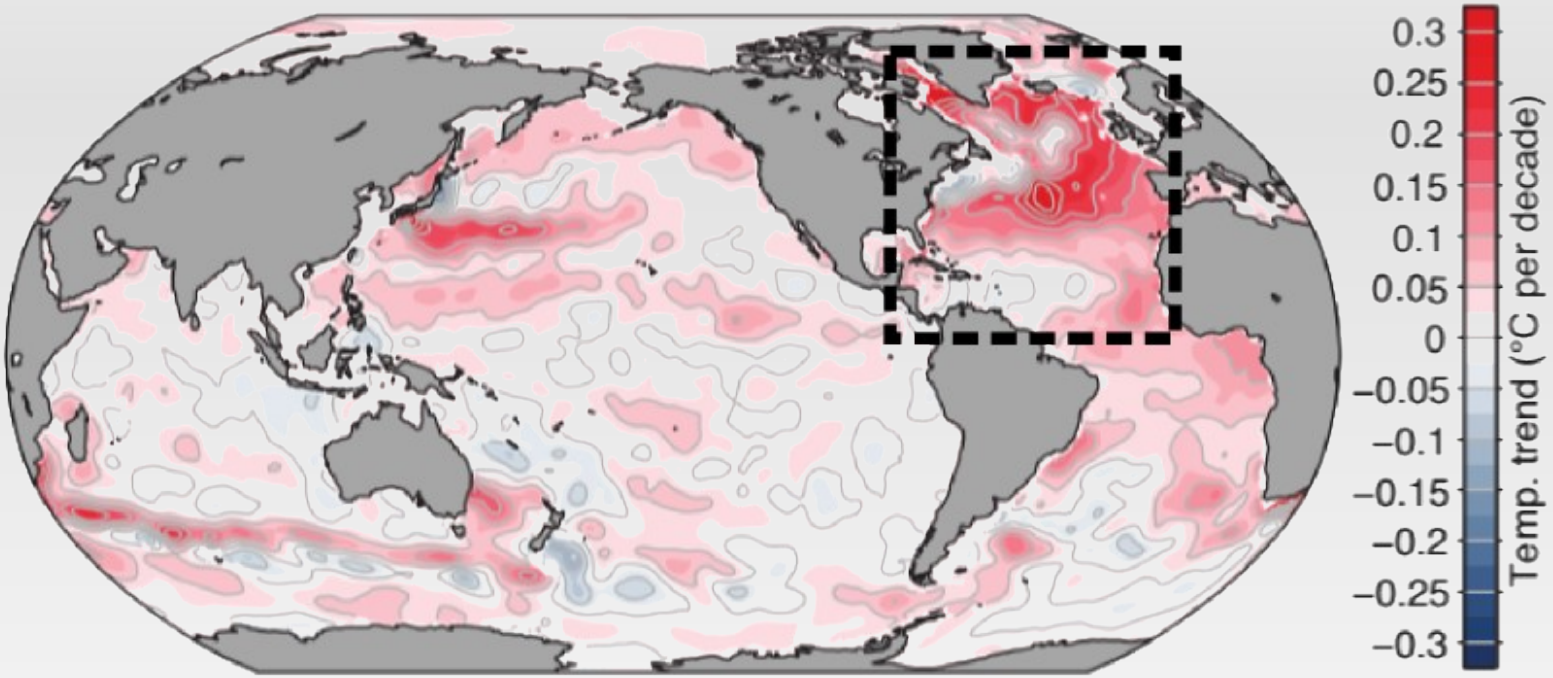
Variabilité Atlantique Multidécennale

- Fin du XX^{ième} siècle : réchauffement du climat lié aux activités humaines



Tendance observée des températures océaniques de surface (0-700m) entre 1971-2010
[5^{ième} rapport d'évaluation du GIEC]

➔ **Atlantique Nord** : tendance très supérieure (max = 0.3 °C/décennie)

➔ De 1971 à 2010 : tendance pour $T_{0\text{-}700m}$ = *~O(1.0°C)*

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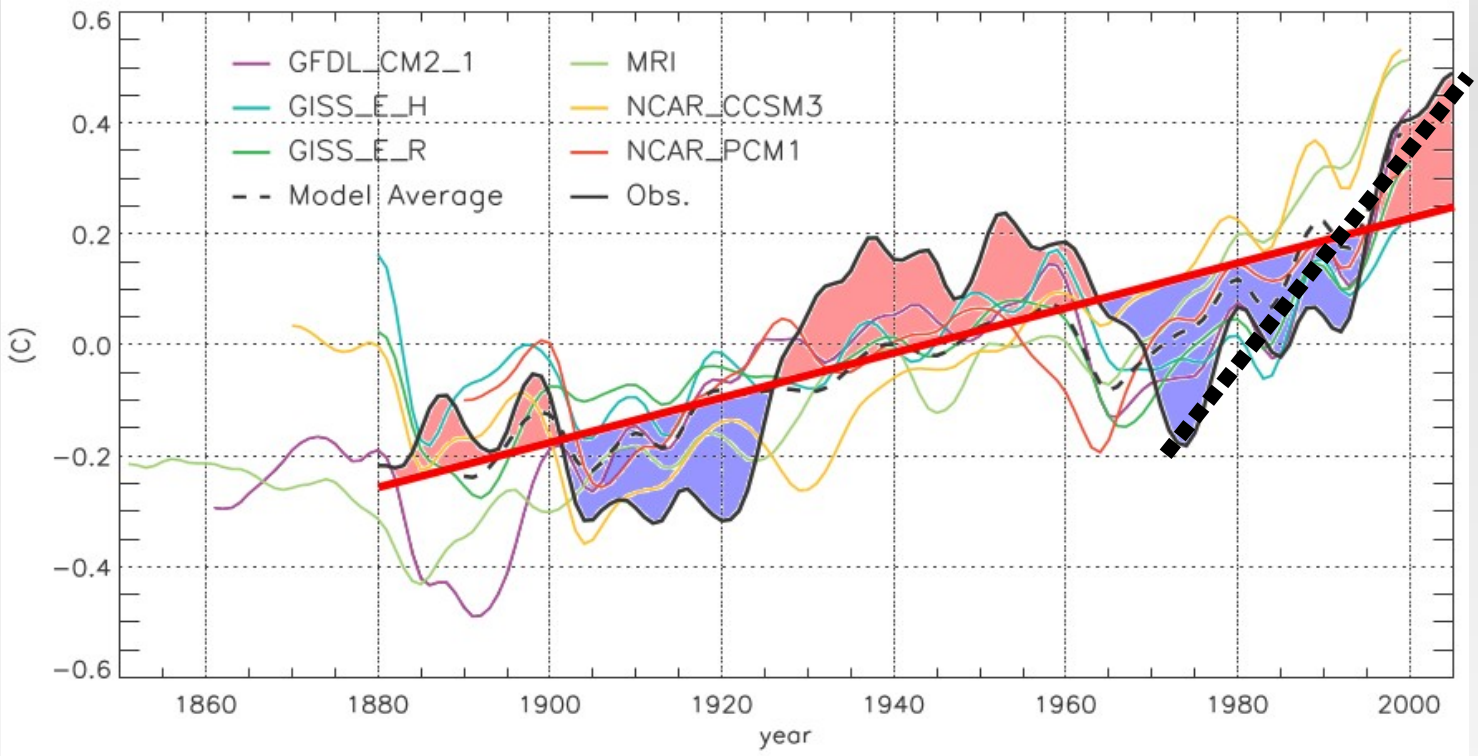
- Variabilité des SST *(Sea Surface Temperature)* de l'**Atlantique Nord**



Anomalies des SST de l'Atlantique Nord par rapport à la moyenne à long terme (1900-2000), filtrées à 10 ans
[Ting et al., JC 2009]

- Superposition d'un **cycle naturel de variabilité** et d'une **tendance à long terme**

➔ **Nécessité de comprendre cette variabilité basse fréquence**

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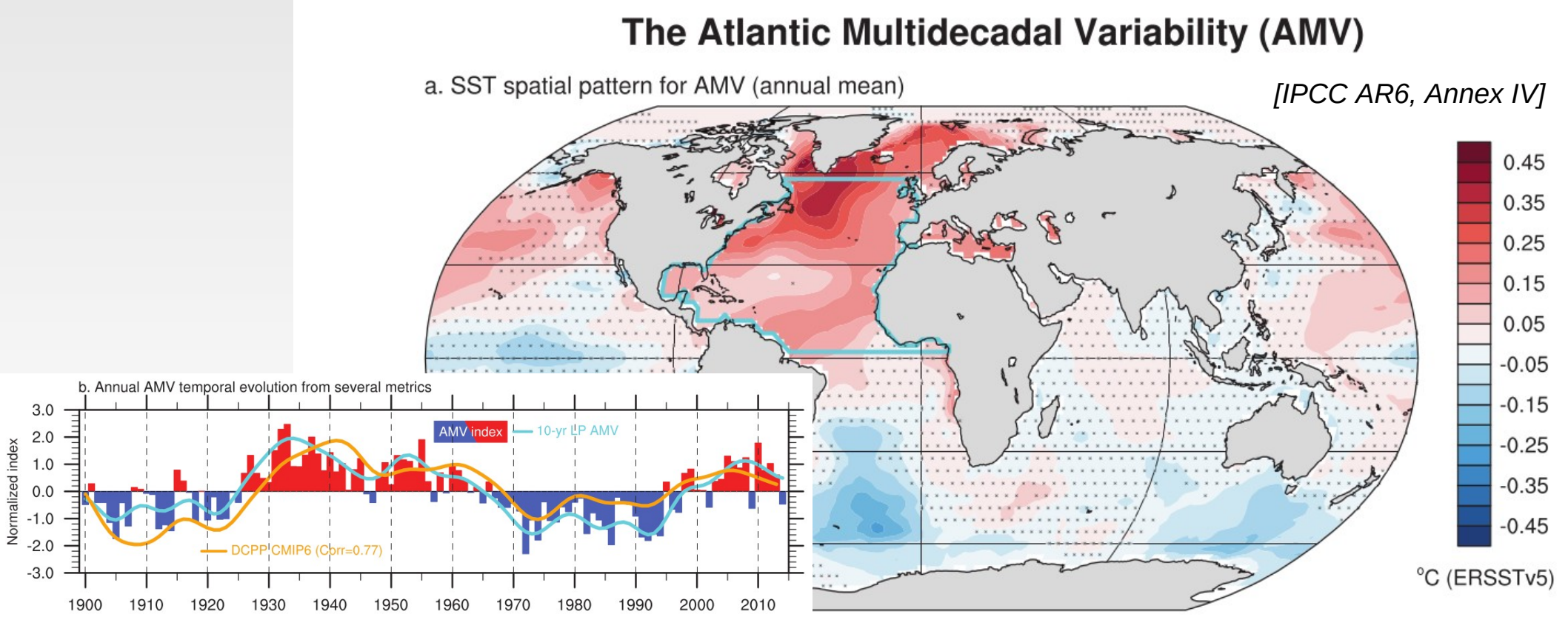
- Début années 90 : première mise en évidence d'une variabilité **Basse Fréquence** (BF) des SST de l'Atlantique Nord (**65-70 ans**)

$$AMV = \langle SST^{10\,ans}_{detrend.} \rangle_{Atl.\,Nord}$$

- Reconstruction sur **8000 ans** avec des *proxy*
  [Knudsen et al., Nat. 2011]

  ➔ ***Atlantic Multidecadal Variability*** (AMV)
  [Schlesinger & Ramankutty, Nat. 1994 ; Kerr, Sci. 2000]



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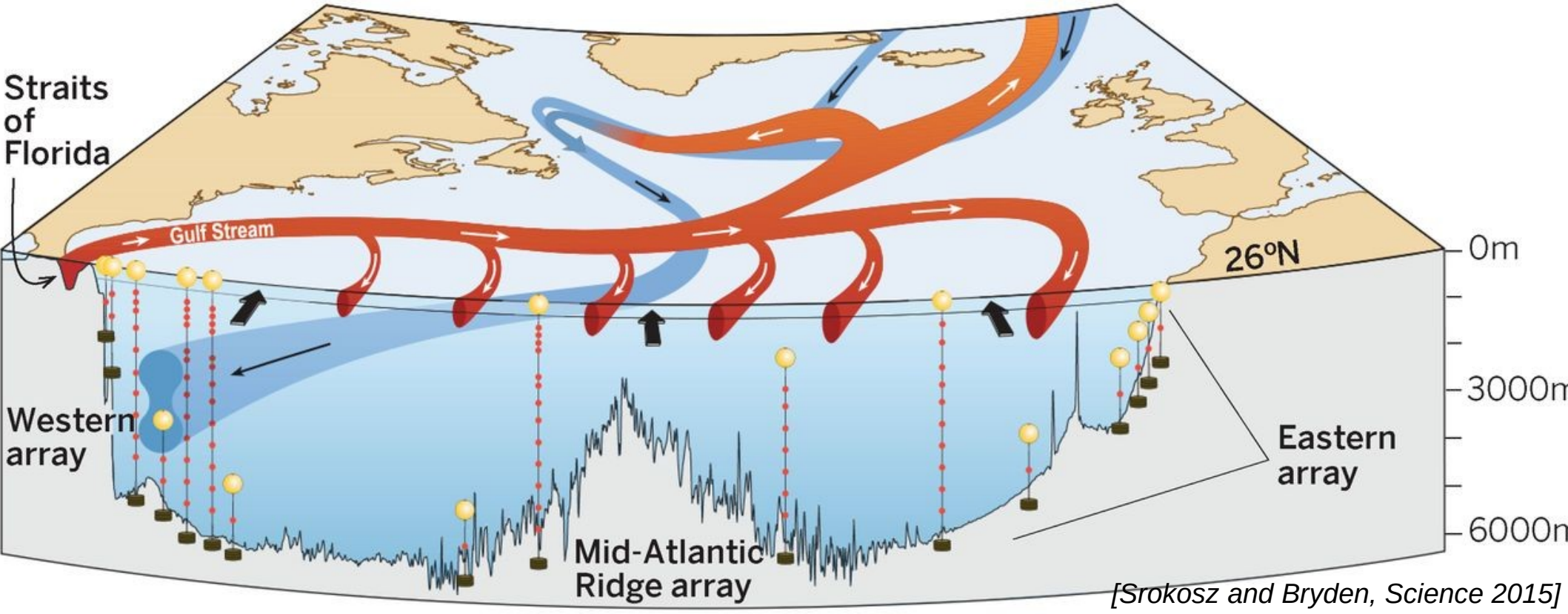
$$AMOC(y,z) = \int_{x_w}^{x_e} \int_{-h}^{z} v \, dz' \, dx$$

- Circulation interne de l'océan dans le plan (y-z) :
  Atlantic Meridional Overturning Circulation (**AMOC**)



[Srokosz and Bryden, Science 2015]

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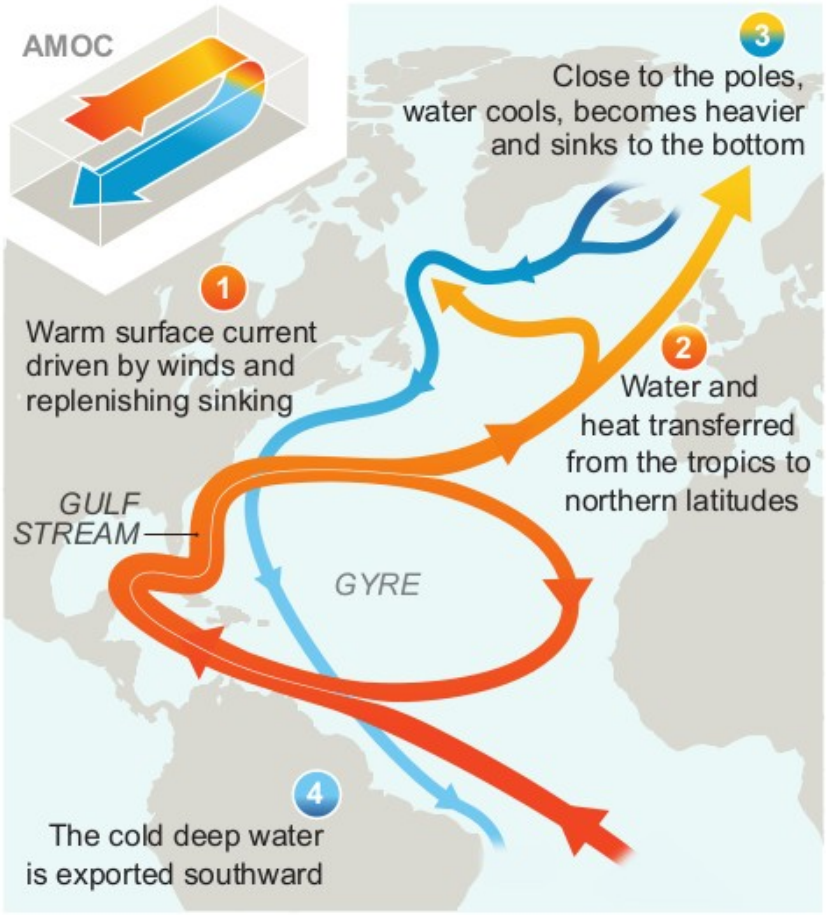
FAQ 9.3: **Will the Gulf Stream shut down?**

The Gulf Stream, a warm current, is expected to weaken but not cease. This slowdown will affect regional weather and sea level.

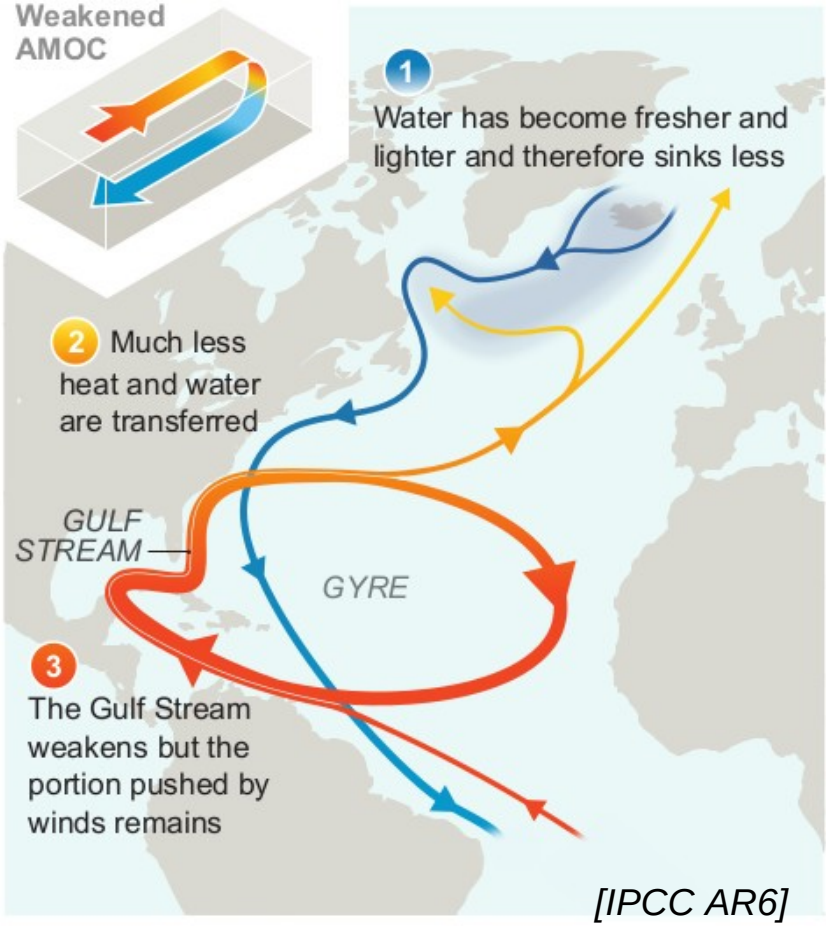
Today

The Gulf Stream is part of both the horizontal, subtropical gyre and the vertical, Atlantic Meridional Overturning Circulation (AMOC)



In a warmer world

Climate change weakens the AMOC, which slows the Gulf Stream down



[IPCC AR6]

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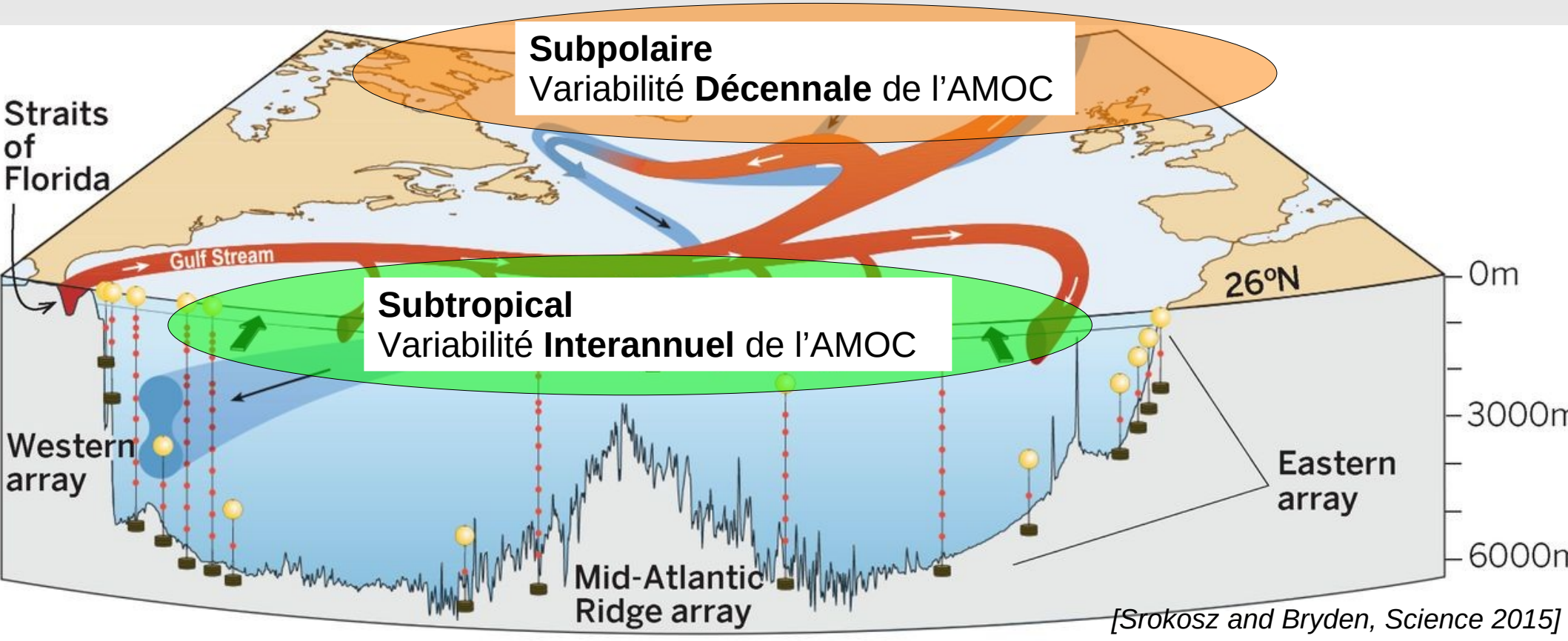

[Srokosz and Bryden, Science 2015]

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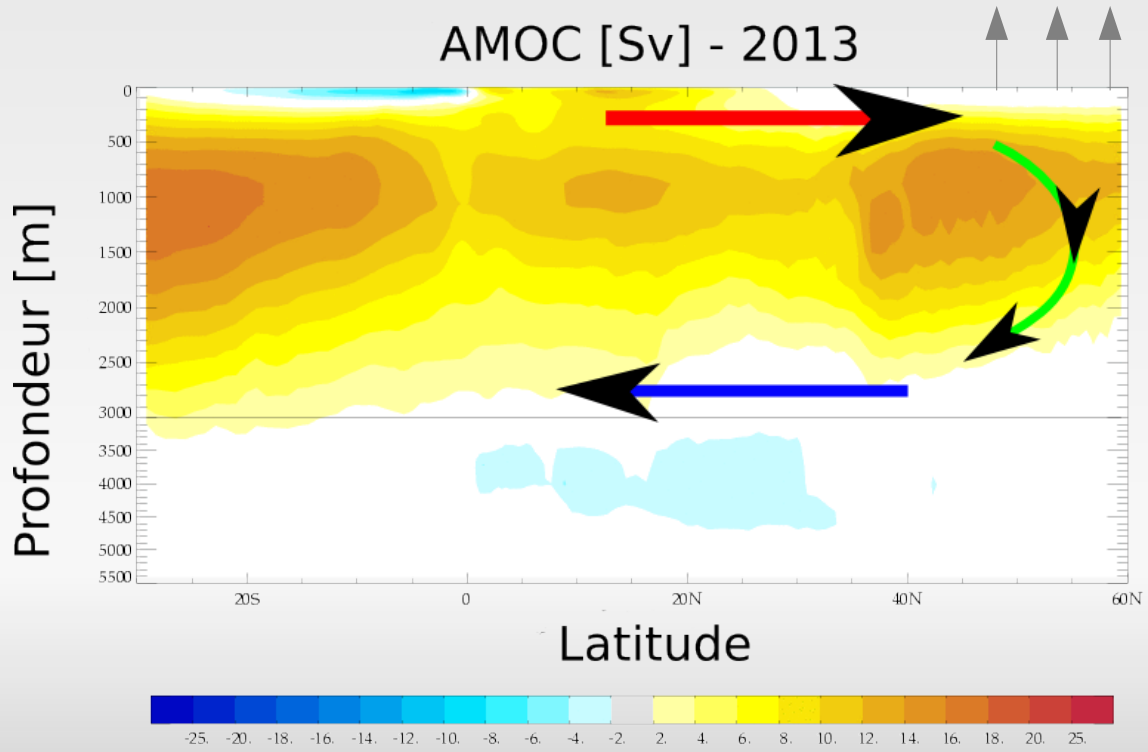
$$AMOC(y,z) = \int_{x_w}^{x_e} \int_{-h}^{z} v \, dz' \, dx$$

- Circulation interne de l'océan dans le plan (y-z) :
  Atlantic Meridional Overturning Circulation (**AMOC**)
- Réalise un transport de chaleur (*Oceanic Heat Transport*, **OHT**) vers le nord dans tout l'Atlantique [Roemmich & Wunsch, DSR 1985]



*Circulation Méridienne de Retournement (**AMOC**) moyenne de l'Atlantique pour l'année 2013 (réanalyses ORAS4, ECMWF)*

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- Lien supposé **AMV / AMOC** via **OHT**
  aux échelles de temps multidécennales
  [Knight et al., GRL 2005; Zhang et al., RG 2019] :
  - Supposons **MOC$^+$** → transport plus important (**OHT$^+$**)
  - En surface **OHT$^+$** → **SST$^+$** dans l'Atlantique Nord
  - **SST$^+_{BF}$** → **AMV$^+$**

➔ Les impacts de l'AMV sur le climat des régions bordant l'Atlantique Nord sont nombreux
(ITCZ, moussons au Sahel, ouragans, …, moyenne global des SST)

➔ Études sur **AMV**
= comprendre la variabilité basse fréquence de la **AMOC**

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- ‘*predictive skills*’ des modèles de climat actuel pour l’AMV

	NAM	SAM	ENSO	IOB	IOD	AZM	AMM	PDV	AMV
Past changes since the start of observations	1960s 1990s 2010s Boreal winter	1950s 2000s Austral summer	1400–1850 Since 1950s	Within proxy-inferred variability range	Within proxy-inferred variability range	*Limited evidence*	*Limited evidence*	Dominated by multi-decadal fluctuations	Dominated by multi-decadal fluctuations
	{2.4.1.1}	{2.4.1.2}	{2.4.2}	{2.4.3}	{2.4.3}	{2.4.4}	{2.4.4}	{2.4.5}	{2.4.6}
CMIP5 and CMIP6 model performance	High performance	High performance	Medium performance	Medium performance	Medium performance	Low performance	Low performance	Medium performance	Medium performance
	{3.7.1}	{3.7.2}	{3.7.3}	{3.7.4}	{3.7.4}	{3.7.5}	{3.7.5}	{3.7.6}	{3.7.7}
Human influence on the observed changes	No robust evidence	Contributed through GHG (all seasons) & ozone (DJF)	*Low agreement*	No robust evidence	Not detected	No robust evidence	No robust evidence	Not detected	Contributed through aerosols
	{3.7.1}	{3.7.2}	{3.7.3}	{3.7.4}	{3.7.4}	{3.7.5}	{3.7.5}	{3.7.6}	{3.7.7}
Near-term future changes (2021–2040)	Internal variability dominates	All seasons except DJF	Internal variability dominates	No robust evidence	No robust evidence	No robust evidence	No robust evidence	*Limited evidence*	+ – Phase shift from + to –
	{4.4.3.1}	{4.4.3.1}	{4.4.3.2}	{4.4.3.3}	{4.4.3.3}	{4.4.3.4}	{4.4.3.4}	{4.4.3.5}	{4.4.3.6}
Mid-to-long-term future changes (2041–2100)	SSP5-8.5 SSP3-7.0 DJF SSP1-2.6 SSP1-1.9	SSP5-8.5 SSP3-7.0 All seasons SSP1-1.9 DJF	Increase in precipitation variance	No robust evidence	increase in extreme positive events	No robust evidence	No robust evidence	Decrease in variance	No changes
	{4.3.3.1; 4.5.3.1}	{4.3.3.1; 4.5.3.1}	{4.3.3.2; 4.5.3.2}	{4.5.3.3}	{4.5.3.3}	{4.5.3.4}	{4.5.3.4}	{4.5.3.5}	{4.5.3.6}

low confidence *medium confidence* *high confidence*

more likely than not *likely* *very likely*

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- ‘*predictive skills*’ des modèles de climat actuel pour l’AMV

”*The AR5 assessed with high confidence that initialized predictions can improve the skill for temperature over the North Atlantic, in particular in the sub-polar branch of AMV, compared to the projections, for the first five years.*

...

Since AR5, near-term initialized predictions, both multi-model (Bellucci et al., 2015a; García-Serrano et al., 2015; D.M. Smith et al., 2019) and single-model ensembles (Marotzke et al., 2016; Simpson et al., 2018; Yeager et al., 2018; Hermanson et al., 2020; Bilbao et al., 2021), confirm substantial skill in hindcasting ***North Atlantic SST*** *anomalies on a time range of* ***eight to ten years****.*

…

In summary, ***the confidence in the predictions of AMV and its effects is medium.*** *However, there is* ***high confidence*** *that the AMV skill over* ***five-to-eight-year lead times*** *is improved by using* ***initialized predictions****, compared to non-initialized simulations.”*

[IPCC AR6, Chapt. 4.4.3.6]

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”Based on paleoclimate reconstructions and model simulations, AR5 assessed that AMV is unlikely to change its behaviour in the future. However, AMV fluctuations over the coming decades are likely to influence regional climate, enhancing or offsetting some of the effects of global warming.

…

In conclusion, on the basis of paleoclimate reconstructions and CMIP5 model simulations, there is low confidence that the AMV is not expected to change in the future.”

[IPCC AR6, Chapt. 4.5.3.6]

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”*To summarize, results from CMIP5 and CMIP6 models together with new statistical techniques to evaluate the forced component of modelled and observed AMV, provide robust evidence that external forcings have modulated AMV over the historical period. In particular, anthropogenic and volcanic aerosols are thought to have played a role in the timing and intensity of the negative (cold) phase of AMV recorded from the mid-1960s to mid-1990s and subsequent warming (medium confidence). However, there is low confidence in the estimated magnitude of the human influence.*”
[IPCC AR6, Chapt. 3]