

Examination of the North Atlantic circulation

using Google Earth Engine

Structure

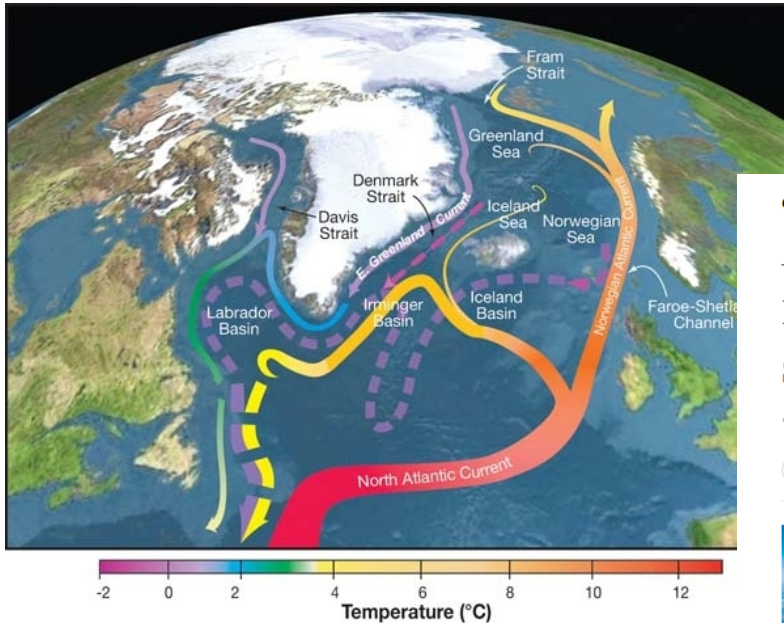
- What is the issue?
- Where are specific regions?
- What Datasets does GEE provide?
- How did we extract and evaluate the Data?
- Results
 - Our Examination
 - Papers

Changes in the circulation

<https://www.theguardian.com/environment/2021/feb/25/atlantic-ocean-circulation-at-weakest-in-a-millennium-say-scientists>

Atlantic Ocean circulation at weakest in a millennium, say scientists

Decline in system underpinning Gulf Stream could lead to more extreme weather in Europe and higher sea levels on US east coast



Climate and Environment

A critical ocean system may be heading for collapse due to climate change, study finds

'The consequences of a collapse would likely be far-reaching'

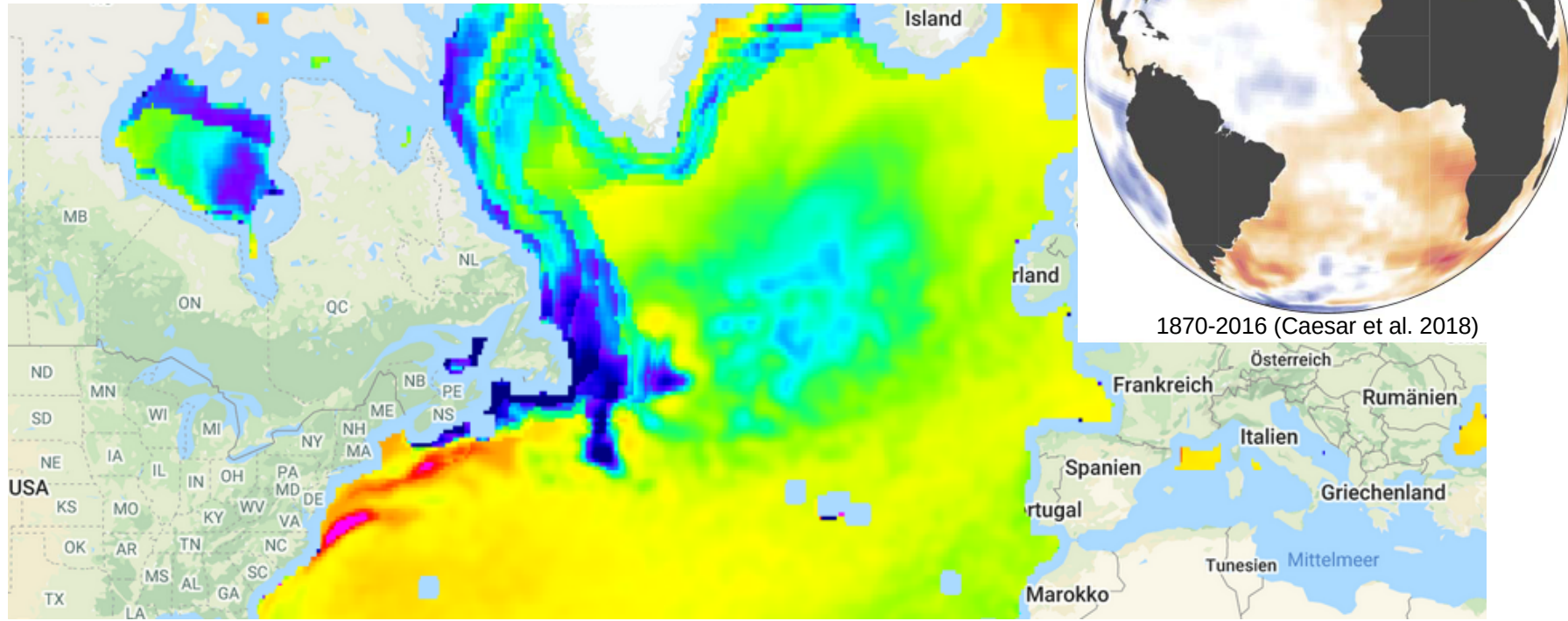
 Listen to article 4 min



MOST READ CLIMATE & ENVIRONMENT >

<https://www.washingtonpost.com/climate-environment/2021/08/05/change-ocean-collapse-atlantic-meridional/>

Regions



Temperature Difference between 1990-2000 and 2010-2020

Datasets

Spatial resolution: $1/12^\circ$

Temporal resolution:

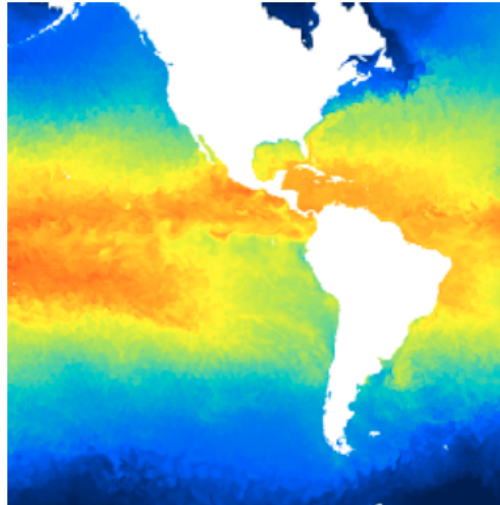
- 1992-10-02 - now
- 3h spacing

Measurements:

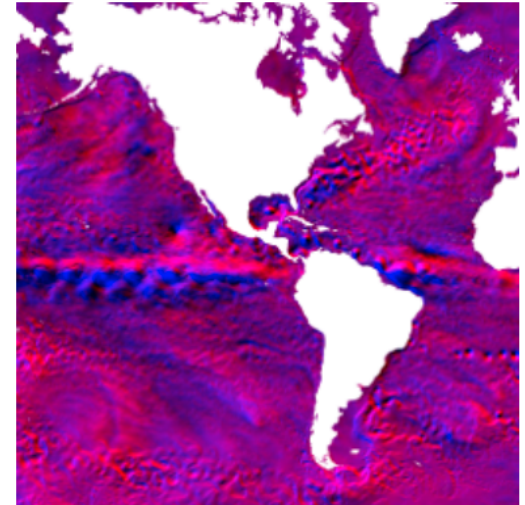
- Temperature (C)
- Salinity (psu)
- Velocity (m/s)

Depths: 0m - 5000m

HYCOM: Hybrid Coordinate Ocean Model, Water Temperature and Salinity



HYCOM: Hybrid Coordinate Ocean Model, Water Velocity



Extracting Data

A lot of Data!

(10,600 days, 8 images per day, 4*40 bands per image)

- Reduce temporal resolution: Weekly mean image (1500 images)
- Reduce spatial resolution: min, max, mean, median, variance, skewness

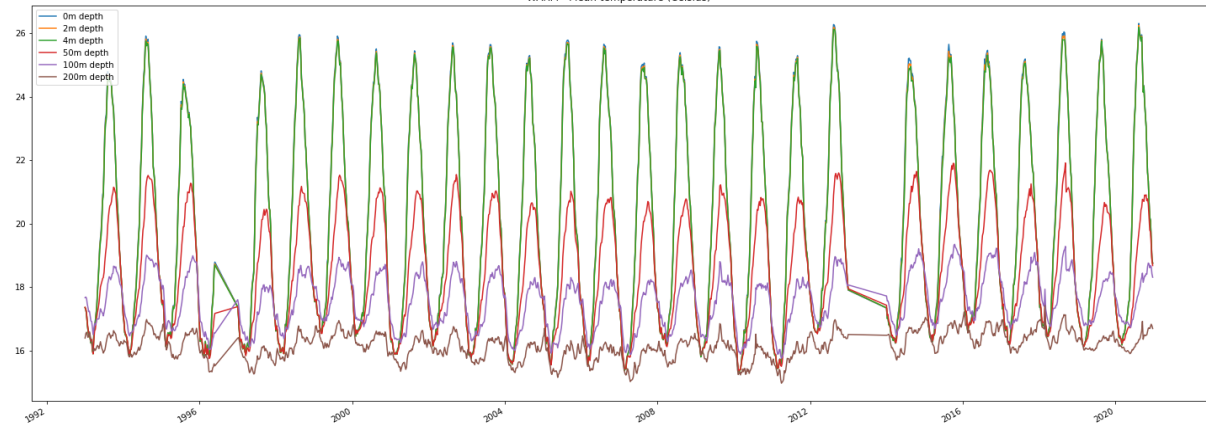
~ 1000 values per week

- 23 MB per Region

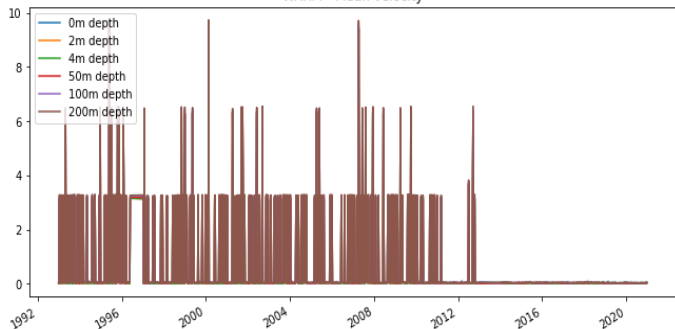


Extracting Data

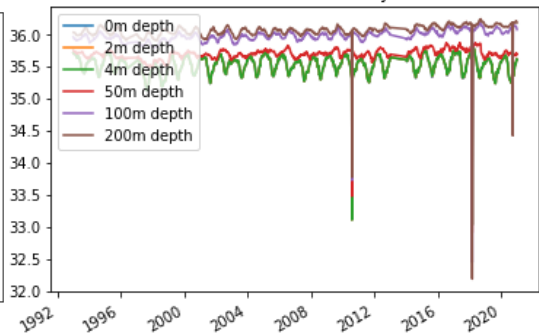
WARM - Mean temperature (Celsius)



WARM - Mean velocity



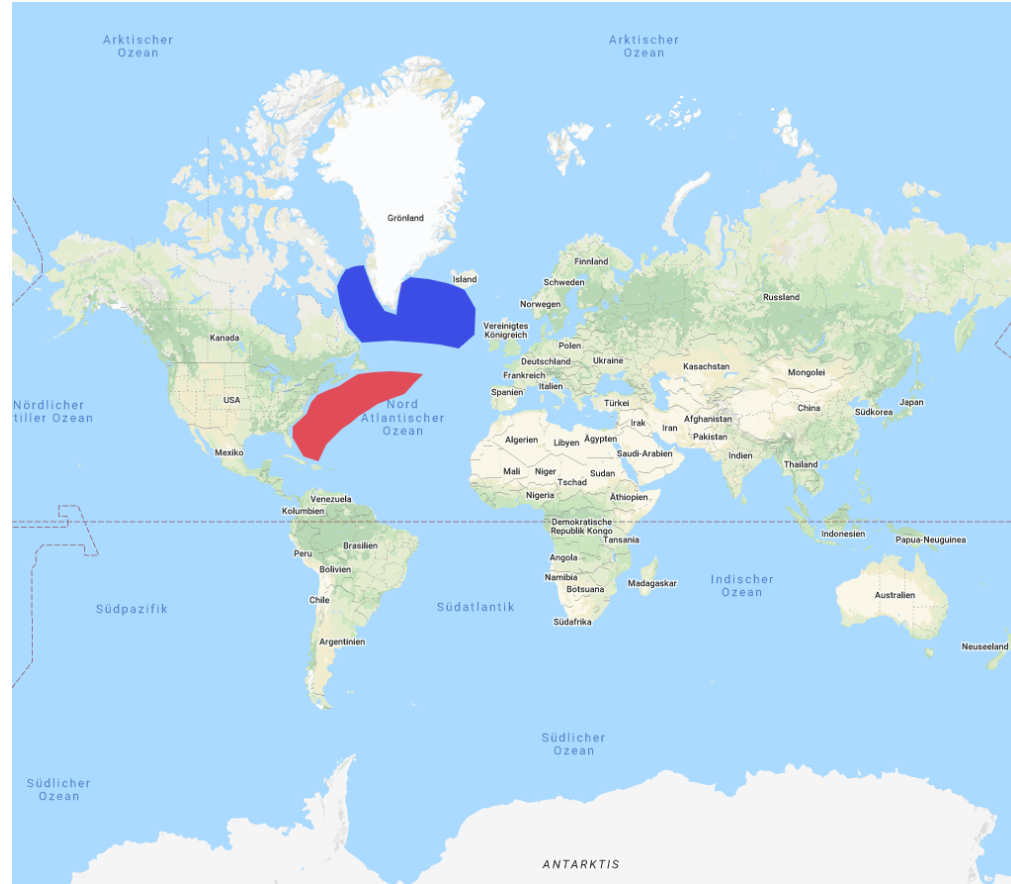
WARM - Mean salinity



998	2012-06-10 00:00:00	20.572026	35.576023	NaN
1028	2013-06-01 00:00:00	NaN	NaN	NaN
1029	2013-06-08 00:00:00	NaN	NaN	NaN
1030	2013-06-15 00:00:00	NaN	NaN	NaN
1031	2013-06-22 00:00:00	NaN	NaN	NaN
1032	2013-06-29 00:00:00	NaN	NaN	NaN
1033	2013-07-06 00:00:00	NaN	NaN	NaN
1034	2013-07-13 00:00:00	NaN	NaN	NaN
1035	2013-07-20 00:00:00	NaN	NaN	NaN
1036	2013-07-27 00:00:00	NaN	NaN	NaN
1037	2013-08-03 00:00:00	NaN	NaN	NaN
1038	2013-08-10 00:00:00	NaN	NaN	NaN
1039	2013-08-17 00:00:00	NaN	NaN	NaN
1040	2013-08-24 00:00:00	NaN	NaN	NaN
1041	2013-08-31 00:00:00	NaN	NaN	NaN
1042	2013-09-07 00:00:00	NaN	NaN	NaN
1043	2013-09-14 00:00:00	NaN	NaN	NaN
1044	2013-09-21 00:00:00	NaN	NaN	NaN
1045	2013-09-28 00:00:00	NaN	NaN	NaN
1046	2013-10-05 00:00:00	NaN	NaN	NaN
1047	2013-10-12 00:00:00	NaN	NaN	NaN
1048	2013-10-19 00:00:00	NaN	NaN	NaN
1049	2013-10-26 00:00:00	NaN	NaN	NaN
1050	2013-11-02 00:00:00	NaN	NaN	NaN
1051	2013-11-09 00:00:00	NaN	NaN	NaN
1052	2013-11-16 00:00:00	NaN	NaN	NaN

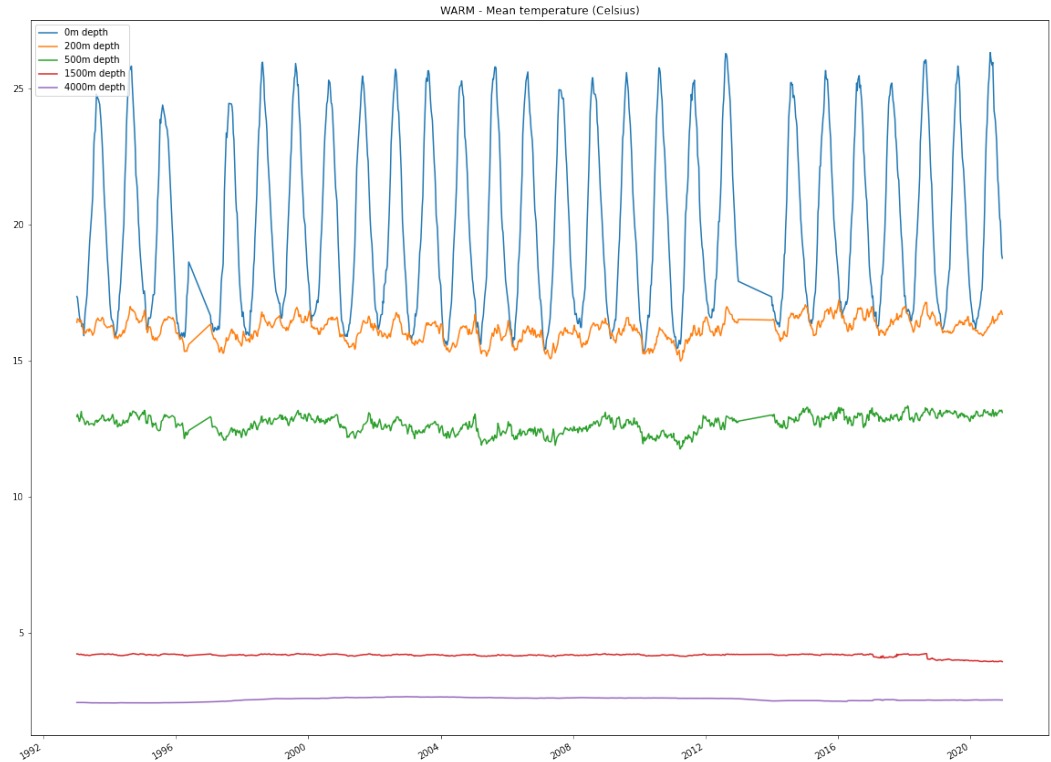
Our Results

- Temperature
- Salinity
- Velocity
- Correlations



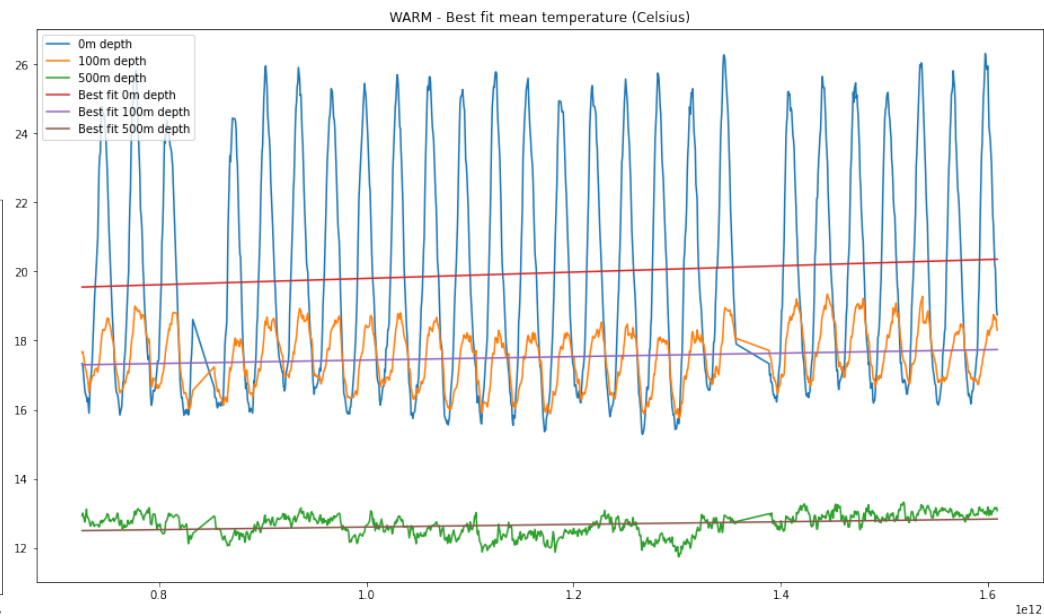
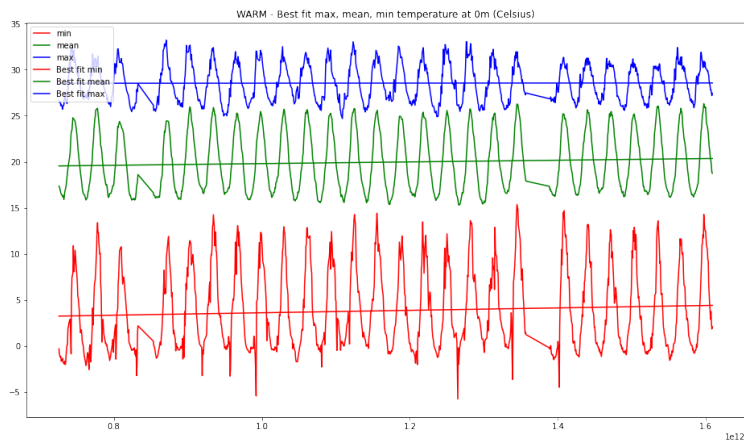
Temperature - Warm area

- Temperature varies a lot in the upper sealevels
- lower sealevels are not affected as strong
 - focus on first 500-1000m



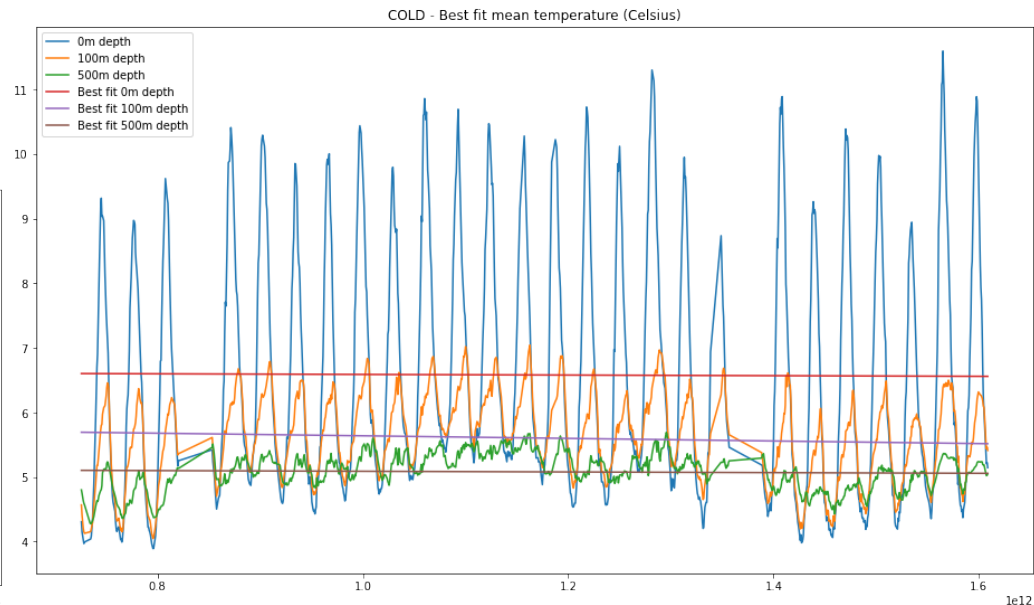
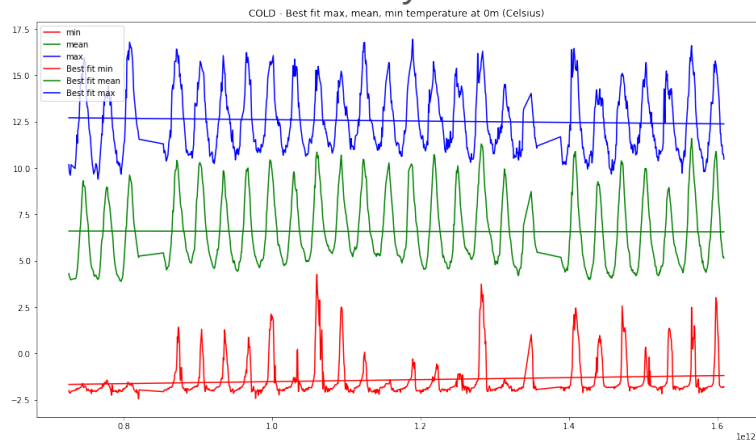
Temperature - Warm area

- Warm region becomes warmer
- Temperature of upper sealevels increases quickly



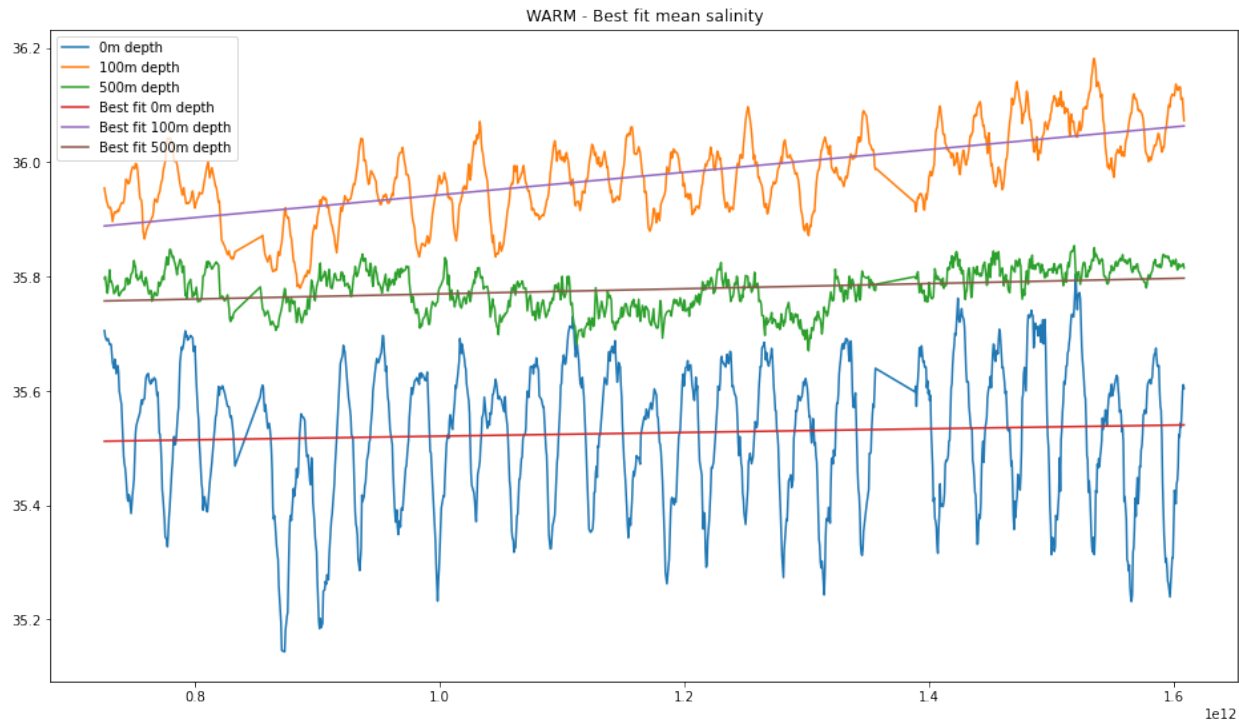
Temperature - Cold area

- cold area cools down, especially around 100m depth
- fresh Water that is not affected too much by weather



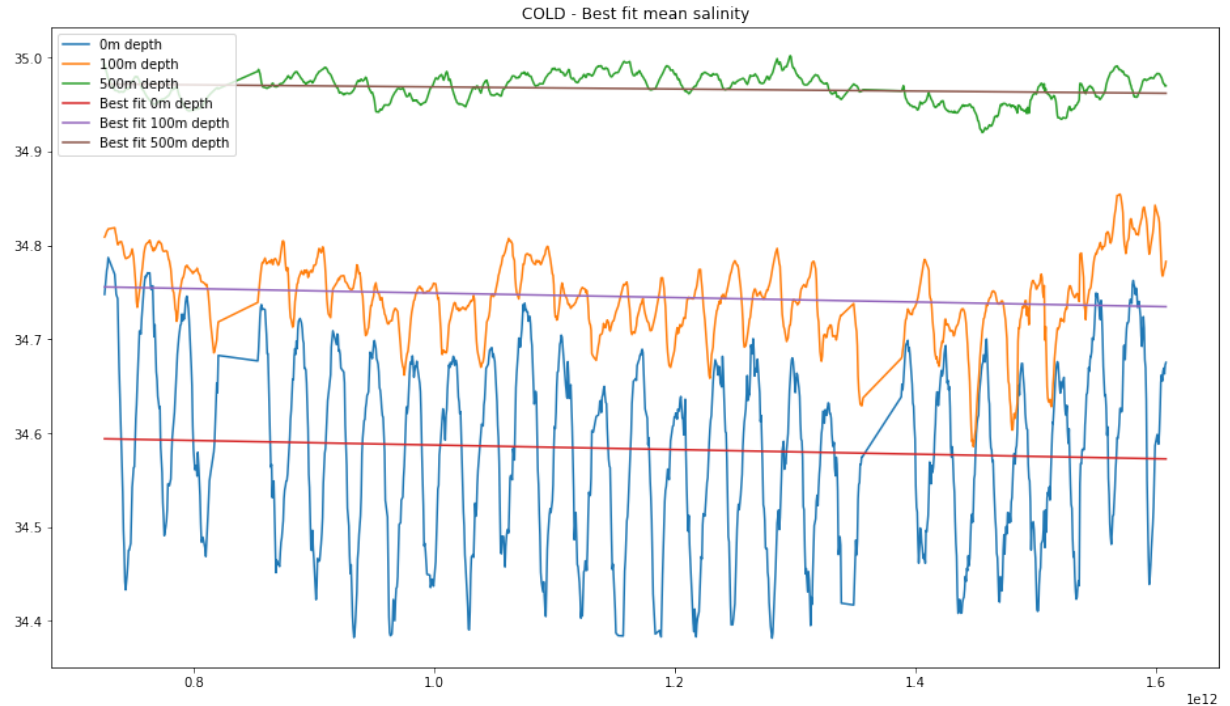
Salinity - Warm area

- Salinity generally increases
- steep slope around 100m depth



Salinity - Cold area

- Salinity decreases
 - Glaciers melt
- lower Salinity -> water is lighter and is not being pulled towards greenland



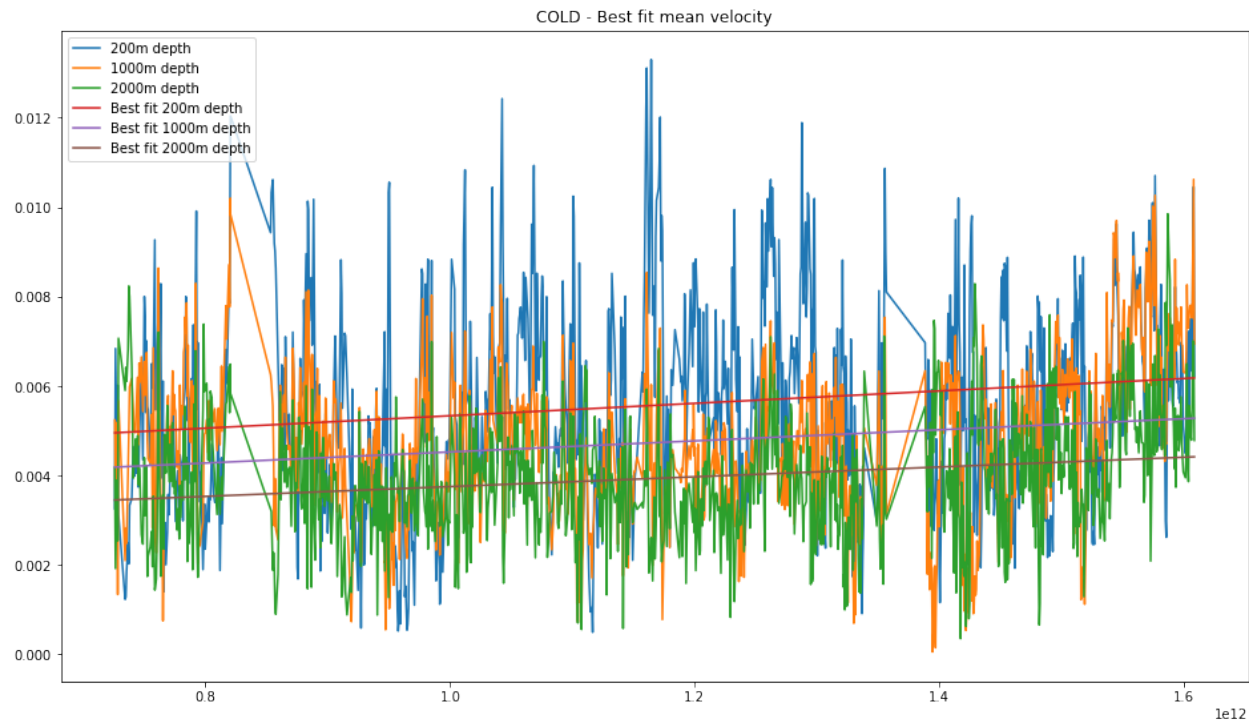
Velocity - Warm area

- velocity decreases, especially in upper areas (gulf stream becomes slower)



Velocity - Cold area

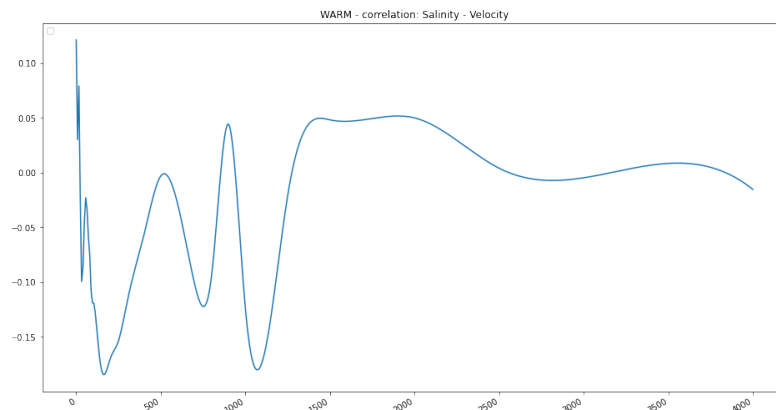
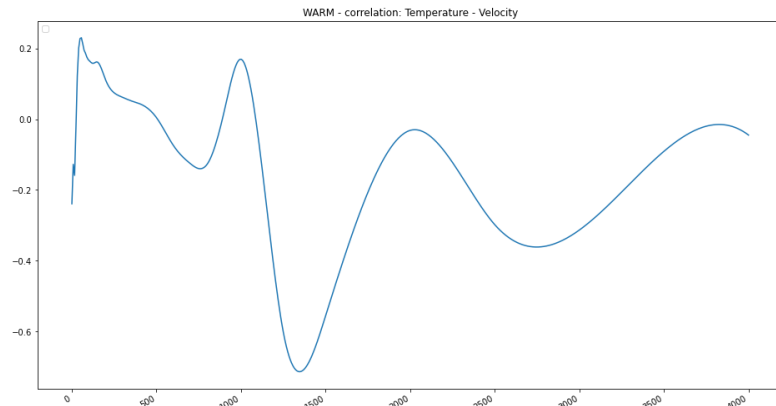
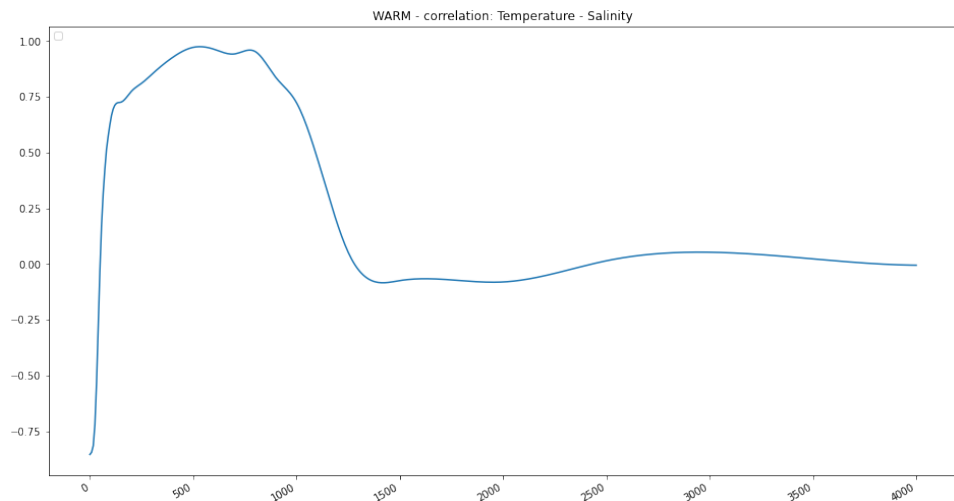
- big deviation
- graph shows upward trend
 - melting ice



Correlations - Warm area

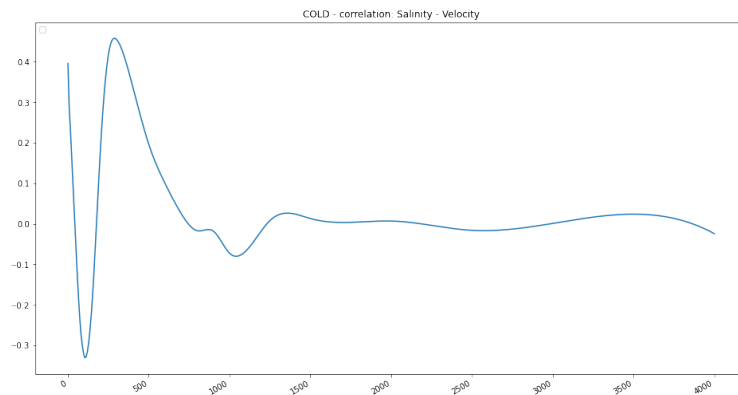
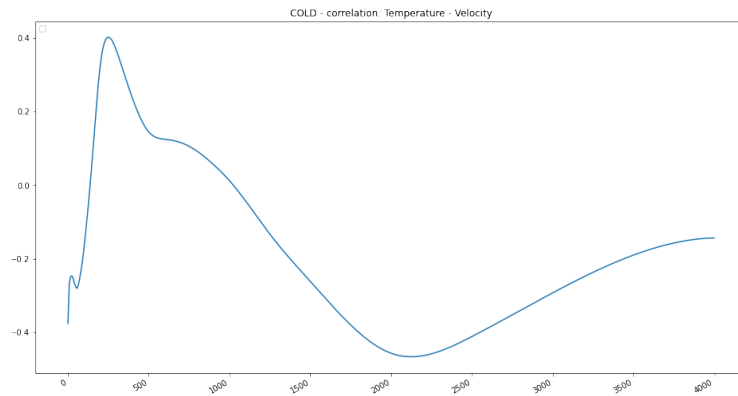
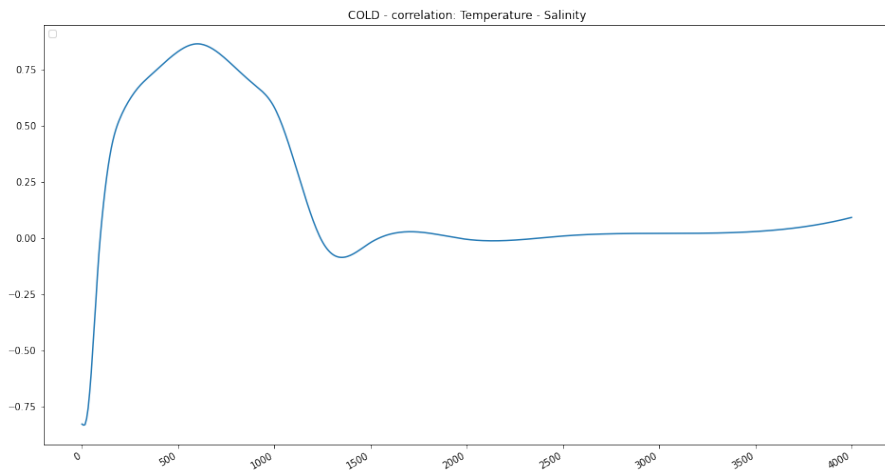
Most interesting: Temperature - Salinity

-> first anti-proportional, then colinear, then not correlated



Correlations - Cold area

- similar to warm area
- velocity correlates better
 - the correlation of velocity should not be generalized from the data of one single graph



Summary

- north: decreasing temperature and salinity
- south: increasing temperature and salinity
- higher amount of freshwater in the arctic region decreases salinity, further slowing down the gulf stream
 - would have a cooling effect on the climate around the North Atlantic region → direct warming effect is stronger
 - net result: still warming over land
 - cold patch in the ocean
- when the tipping point is reached the gulf stream may collapse

Articles

Caesar, L.; Rahmstorf, S.; Robinson, A.; Feulner, G.; Saba, V. (2018). *Observed fingerprint of a weakening Atlantic Ocean overturning circulation. Nature, 556(7700), 191–196.* doi:10.1038/s41586-018-0006-5

Chen, Xianyao; Tung, Ka-Kit (2018). *Global surface warming enhanced by weak Atlantic overturning circulation. Nature, 559(7714), 387–391.* doi:10.1038/s41586-018-0320-y