

# Water Level Calculations

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*2019-12-18*

From the spreadsheet on google drive where people entered information about their “local” sea level rise rates, I have:

- saved it to the same directory as the general data transformations on my computer
- added a column (“set start”) with the year of first SET readings
- used the given NWLON station IDs to download mean monthly sea level readings from COOPS (saved in the same directory)

Here, I loop through all of the saved files and generate output for each reserve/NWLON station:

- long-term SLR rate and confidence interval, as a check on methodology. These should match the rates reported by COOPS.
- short-term water level change: starting with the year that SETs were first read at the given reserve.

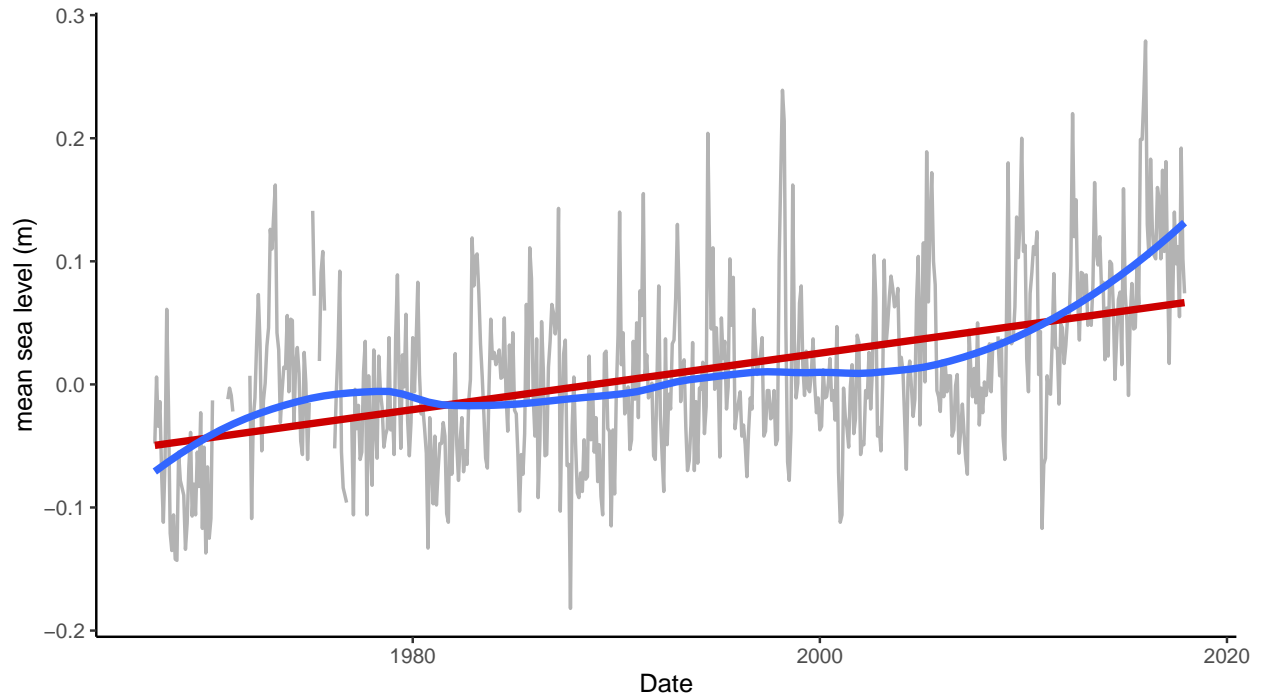
The statistical method used is an ARIMA, order (1,0,0), regressed on date. This method accounts for the fact that we’re looking a time-series and autocorrelation exists in the data. Confidence intervals were retrieved using base R’s `confint()` function.

There is a summary table of rates at the end. Graphs are generated in the loop through stations and the table has to come after everything has been read. Scroll to that if you only want numbers.

There are two graphs for each reserve. The gray line represents monthly sea level data. The red line is a linear regression on monthly sea level, generated automatically by `ggplot2::geom_smooth()`. The slope may not *exactly* match ARIMA output but should be extremely close (the bigger difference between methods is in the confidence intervals). The blue line is a LOESS smooth, also generated by `ggplot2::geom_smooth()`, with a span set to 0.5. The second graph is the same as the first, with the addition of an orange line representing linear short-term change over the time of SET readings.

# Monthly Mean Sea Level for APA; NWLON station 8728690

Red = lm smooth; Blue = loess smooth, span 0.5  
long-term change: 2.23 mm/yr



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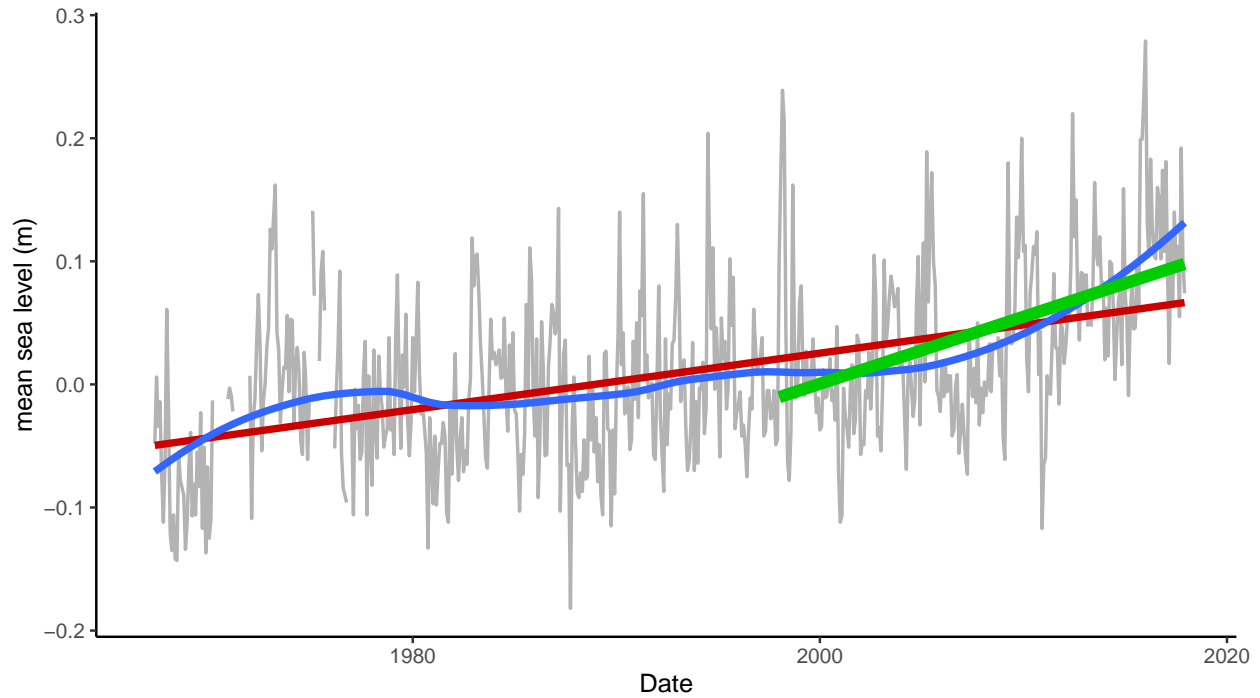
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### Monthly Mean Sea Level for APA; NWLON station 8728690

Red = lm smooth; Blue = loess smooth, span 0.5; Green = lm for 1998–2017  
long-term change: 2.23; 19-yr change: 5.22

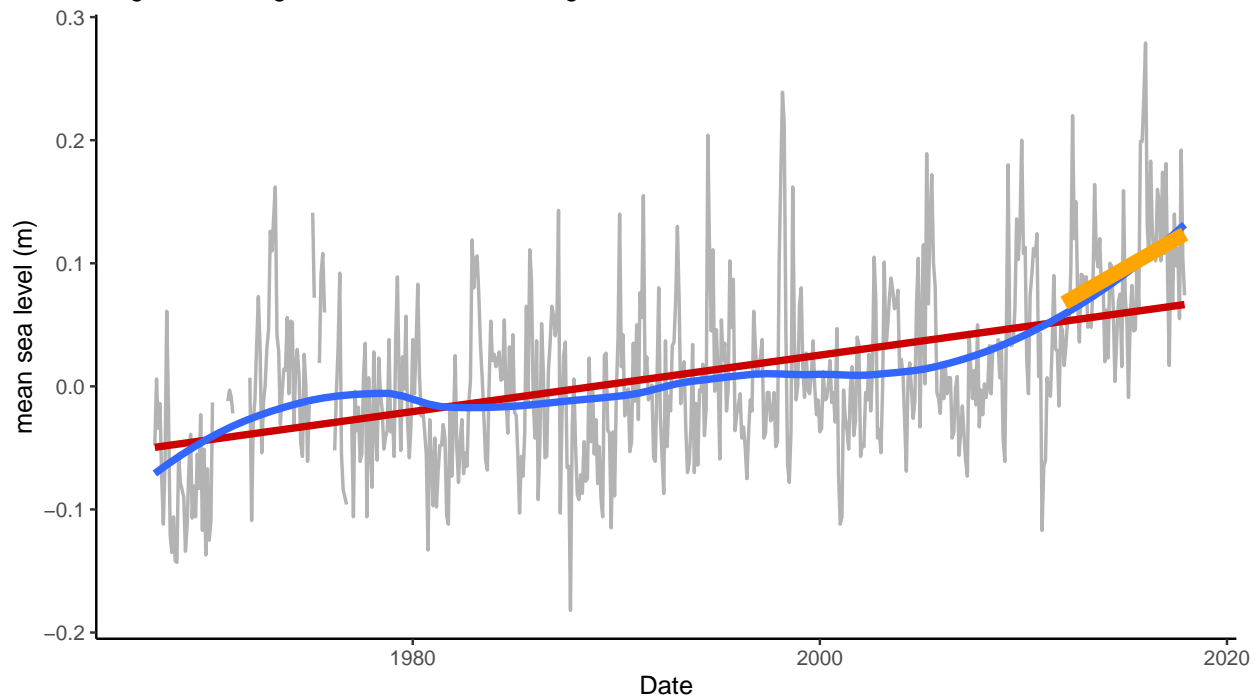


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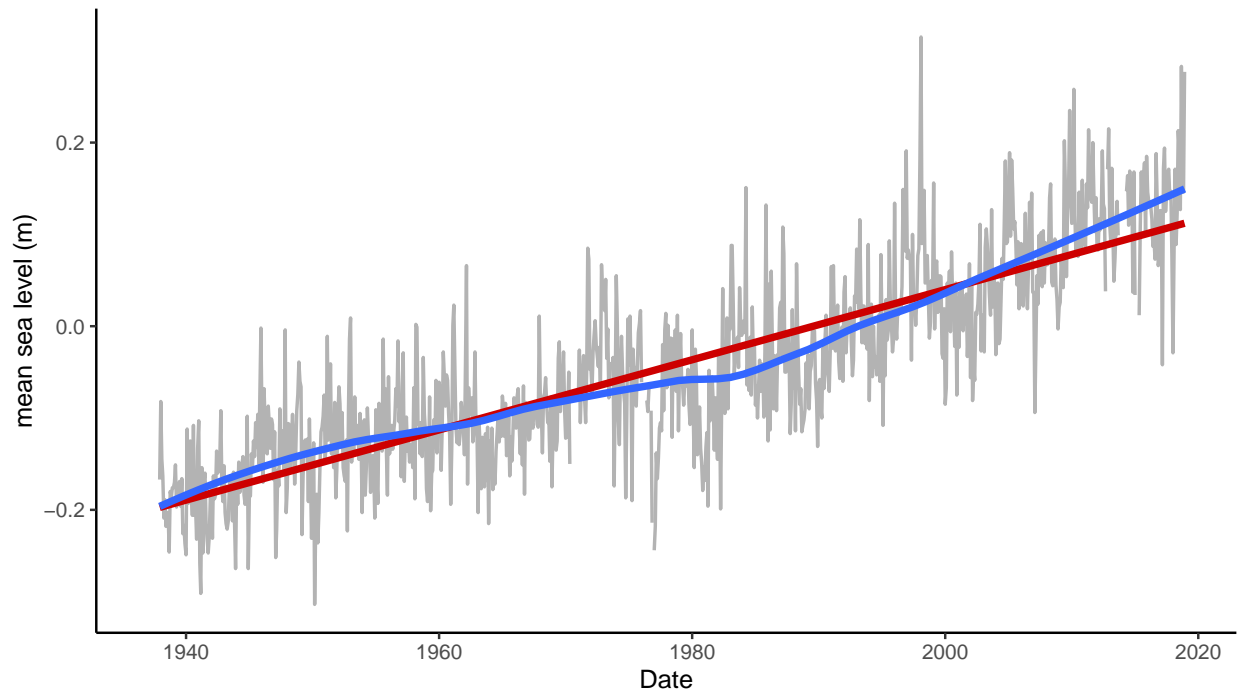
### Monthly Mean Sea Level for APA; NWLON station 8728690

Red = lm smooth; Blue = loess smooth, span 0.5; Orange = lm for 2012–2017  
long-term change: 2.23; short-term change: 9.5



# Monthly Mean Sea Level for CBM; NWLON station 8577330

Red = lm smooth; Blue = loess smooth, span 0.5  
long-term change: 3.83 mm/yr



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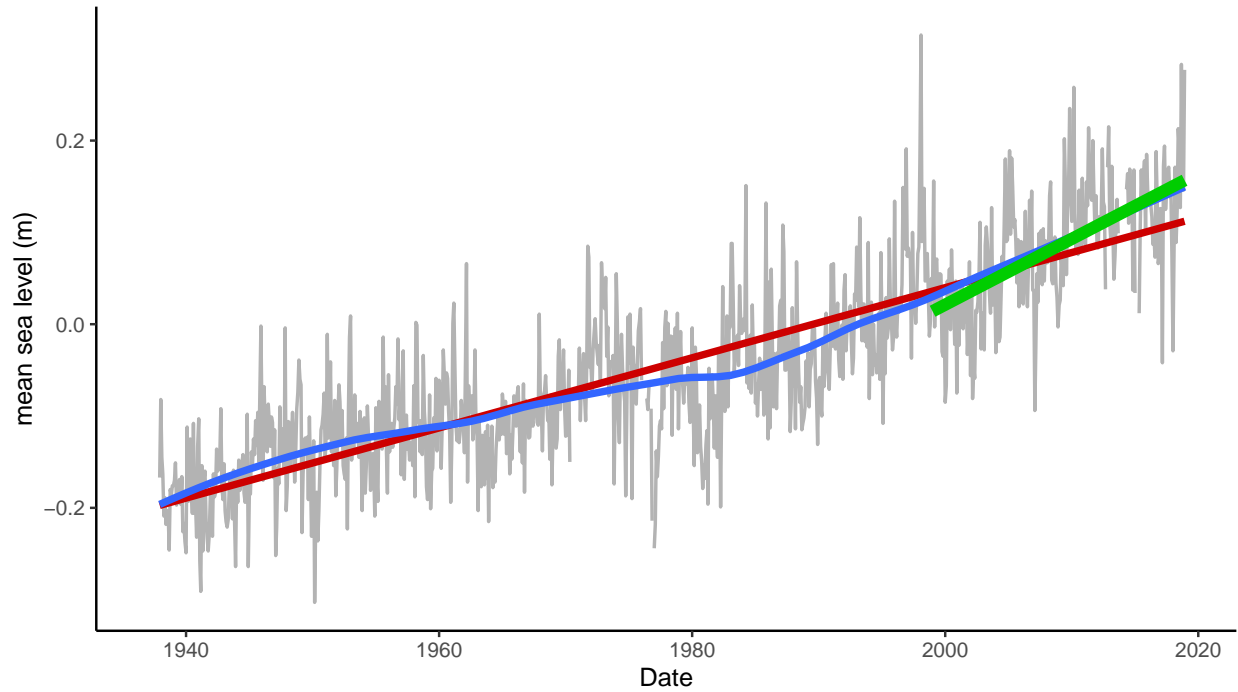
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### Monthly Mean Sea Level for CBM; NWLON station 8577330

Red = lm smooth; Blue = loess smooth, span 0.5; Green = lm for 1999–2018  
long-term change: 3.83; 19-yr change: 7.15

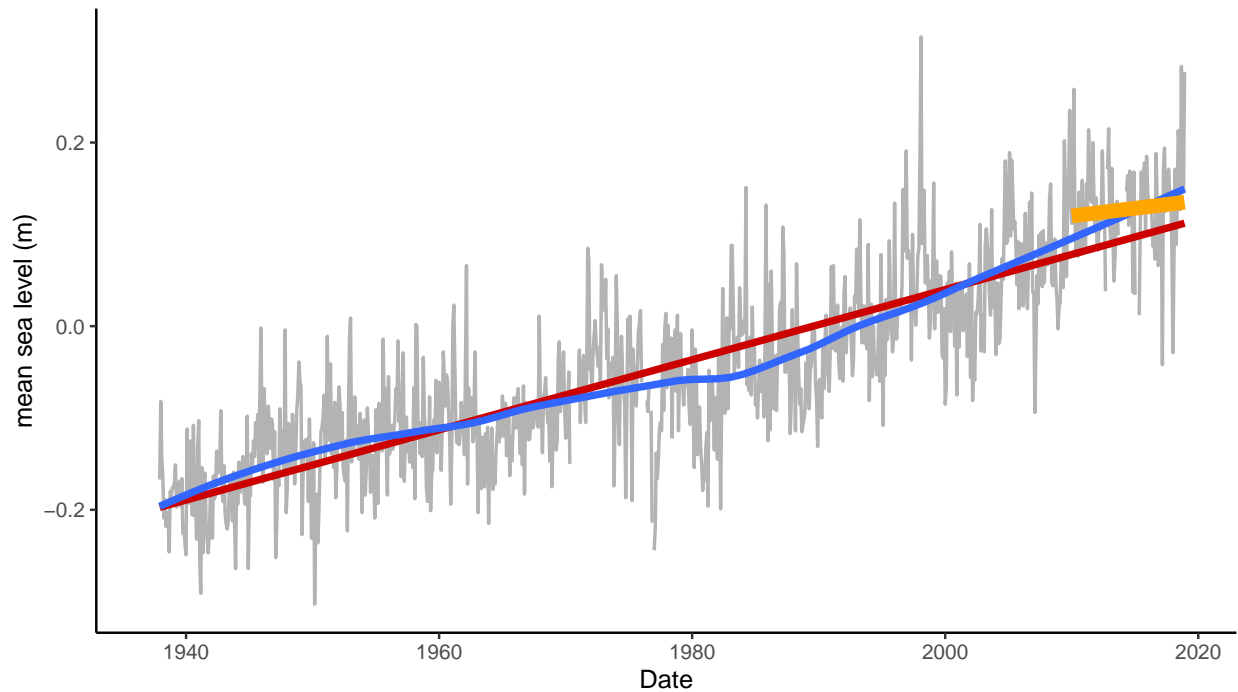


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### Monthly Mean Sea Level for CBM; NWLON station 8577330

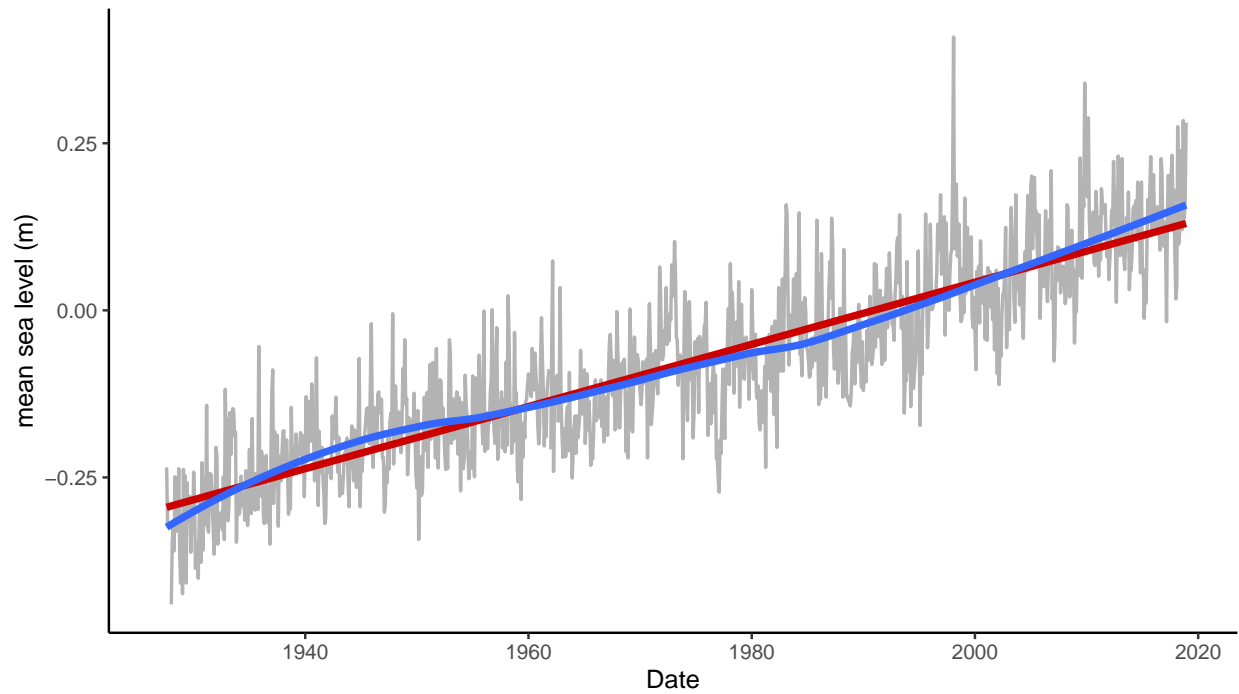
Red = lm smooth; Blue = loess smooth, span 0.5; Orange = lm for 2010–2018  
long-term change: 3.83; short-term change: 1.79



# Monthly Mean Sea Level for CBV; NWLON station 8638610

Red = lm smooth; Blue = loess smooth, span 0.5

long-term change: 4.66 mm/yr



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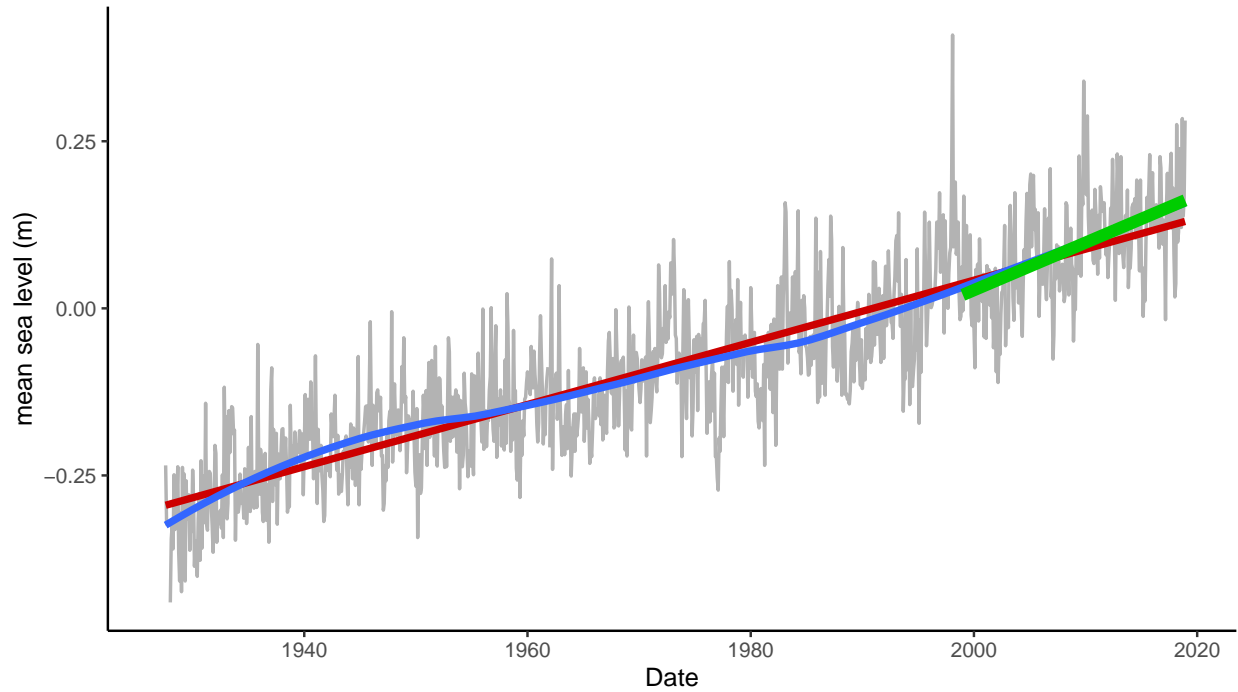
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### Monthly Mean Sea Level for CBV; NWLON station 8638610

Red = lm smooth; Blue = loess smooth, span 0.5; Green = lm for 1999–2018  
long-term change: 4.66; 19-yr change: 7.19

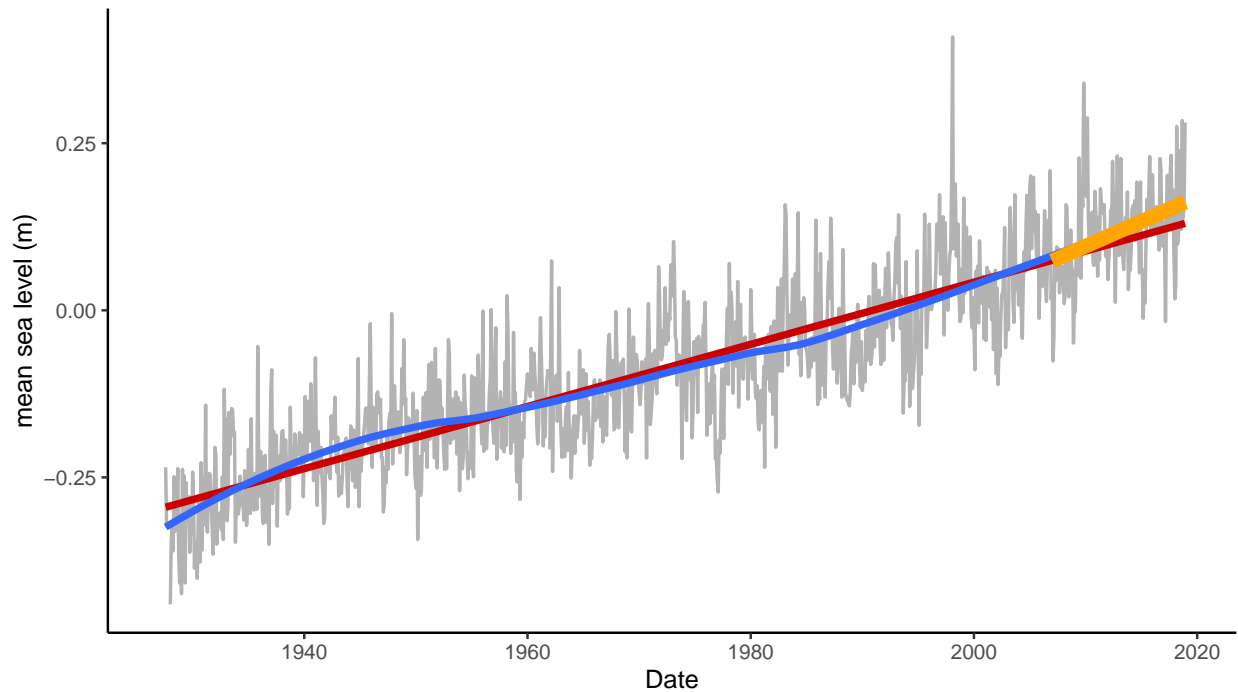


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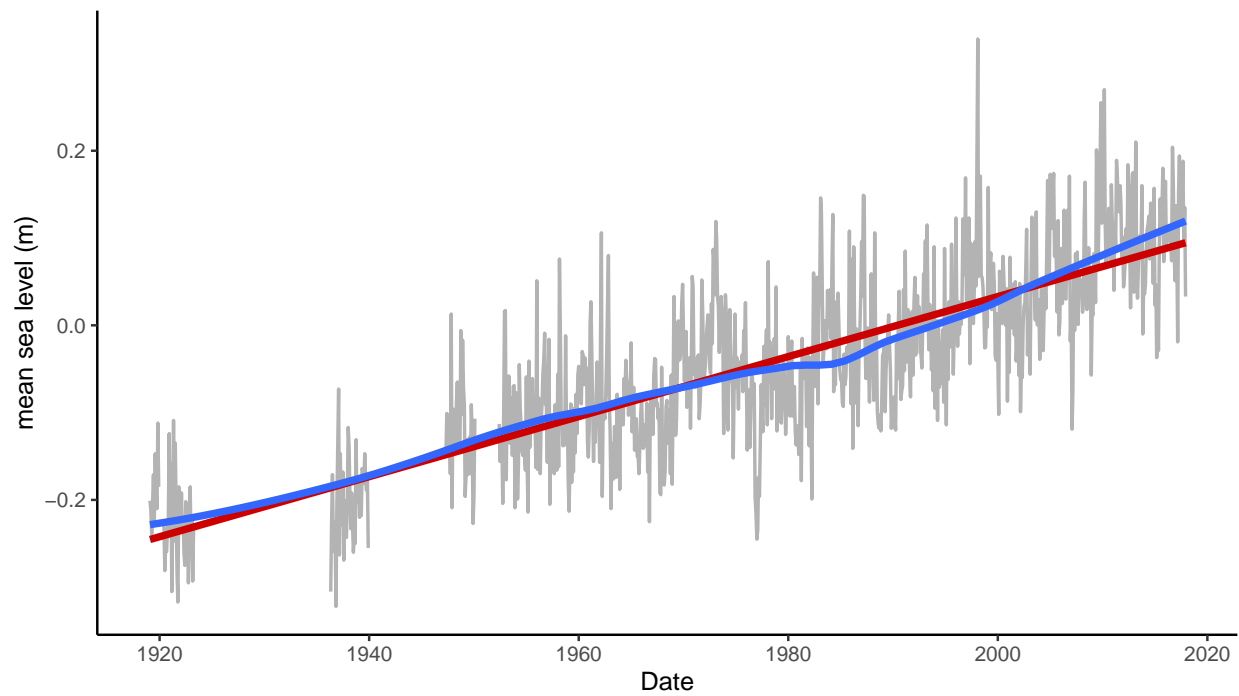
### Monthly Mean Sea Level for CBV; NWLON station 8638610

Red = lm smooth; Blue = loess smooth, span 0.5; Orange = lm for 2007–2018  
long-term change: 4.66; short-term change: 7.65



# Monthly Mean Sea Level for DEL; NWLON station 8557380

Red = lm smooth; Blue = loess smooth, span 0.5  
long-term change: 3.44 mm/yr



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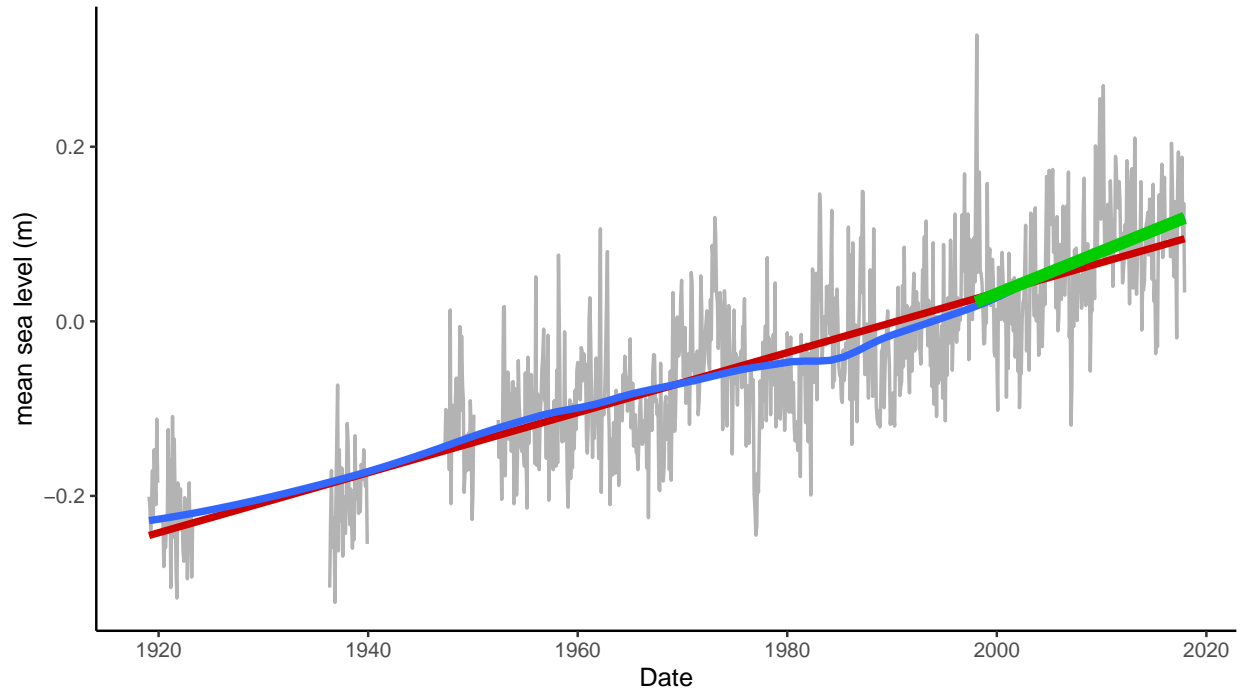
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### Monthly Mean Sea Level for DEL; NWLON station 8557380

Red = lm smooth; Blue = loess smooth, span 0.5; Green = lm for 1998–2017  
long-term change: 3.44; 19-yr change: 4.69

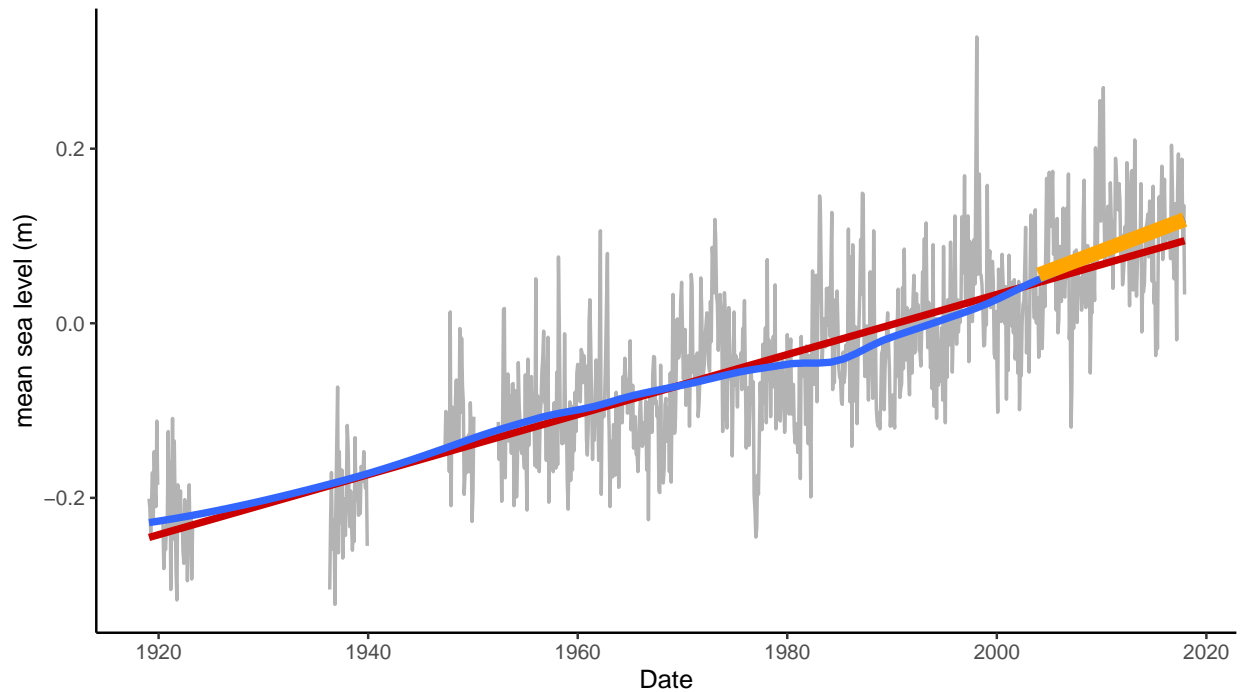


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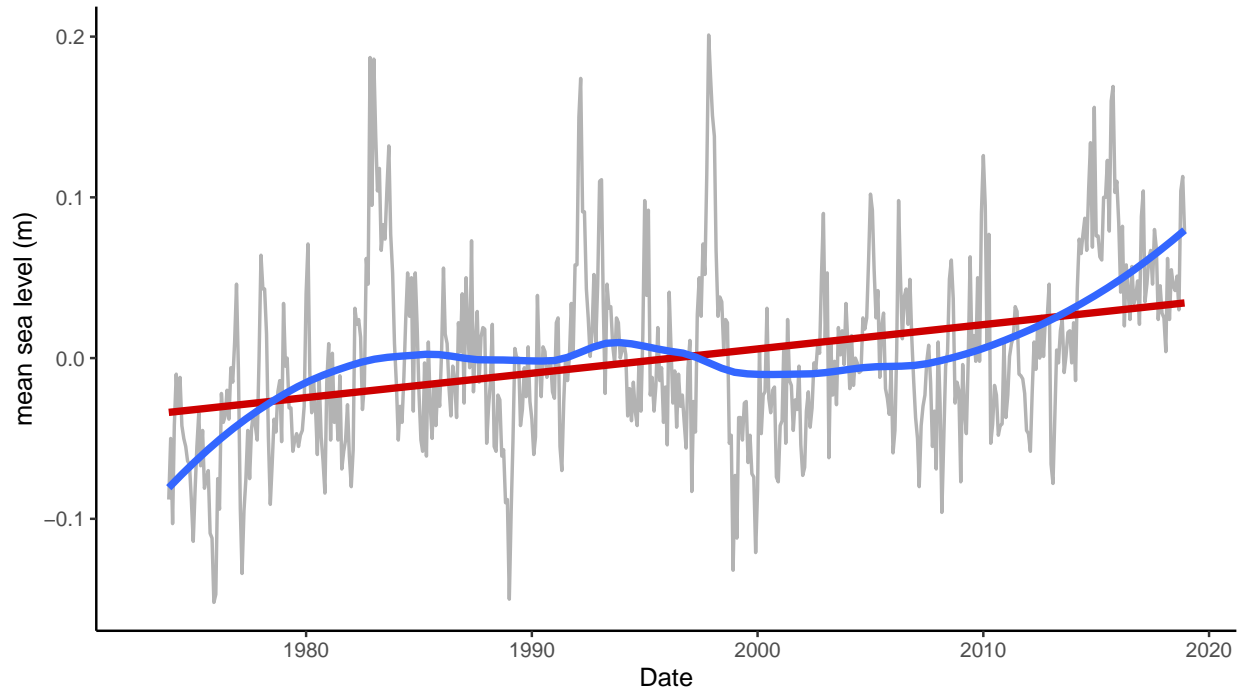
### Monthly Mean Sea Level for DEL; NWLON station 8557380

Red = lm smooth; Blue = loess smooth, span 0.5; Orange = lm for 2004–2017  
long-term change: 3.44; short-term change: 4.56



# Monthly Mean Sea Level for ELK; NWLON station 9413450

Red = lm smooth; Blue = loess smooth, span 0.5  
long-term change: 1.57 mm/yr



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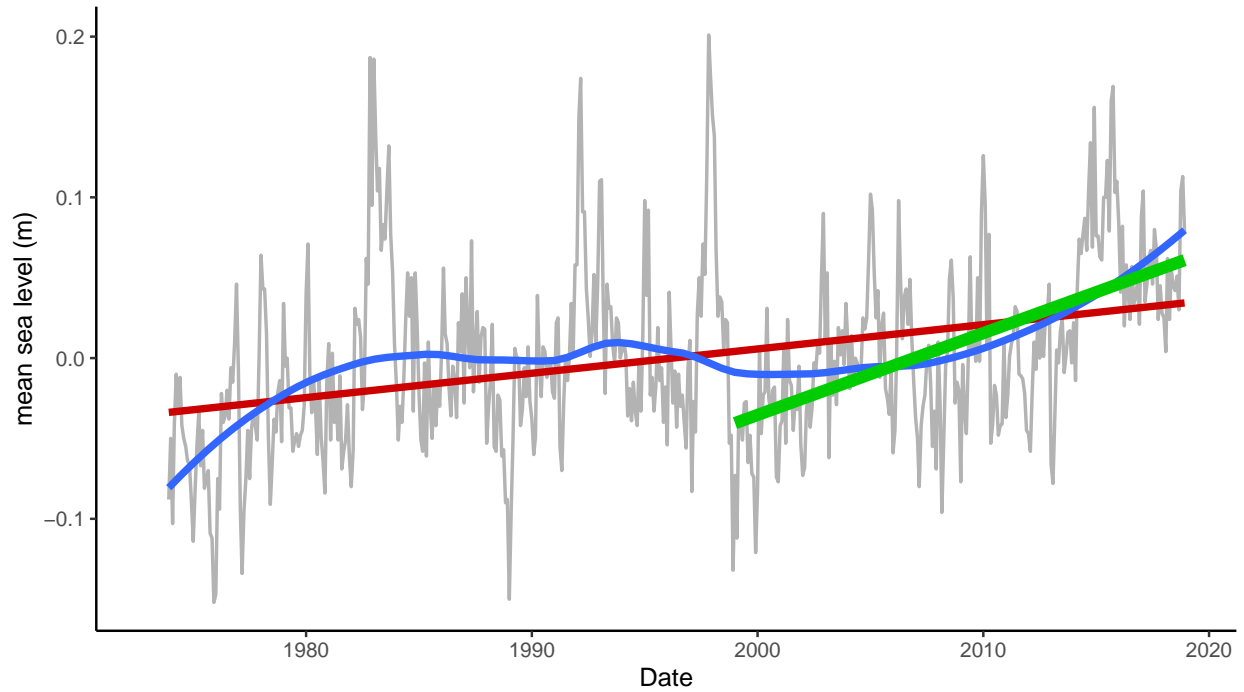
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### Monthly Mean Sea Level for ELK; NWLON station 9413450

Red = lm smooth; Blue = loess smooth, span 0.5; Green = lm for 1999–2018  
long-term change: 1.57; 19-yr change: 5.19

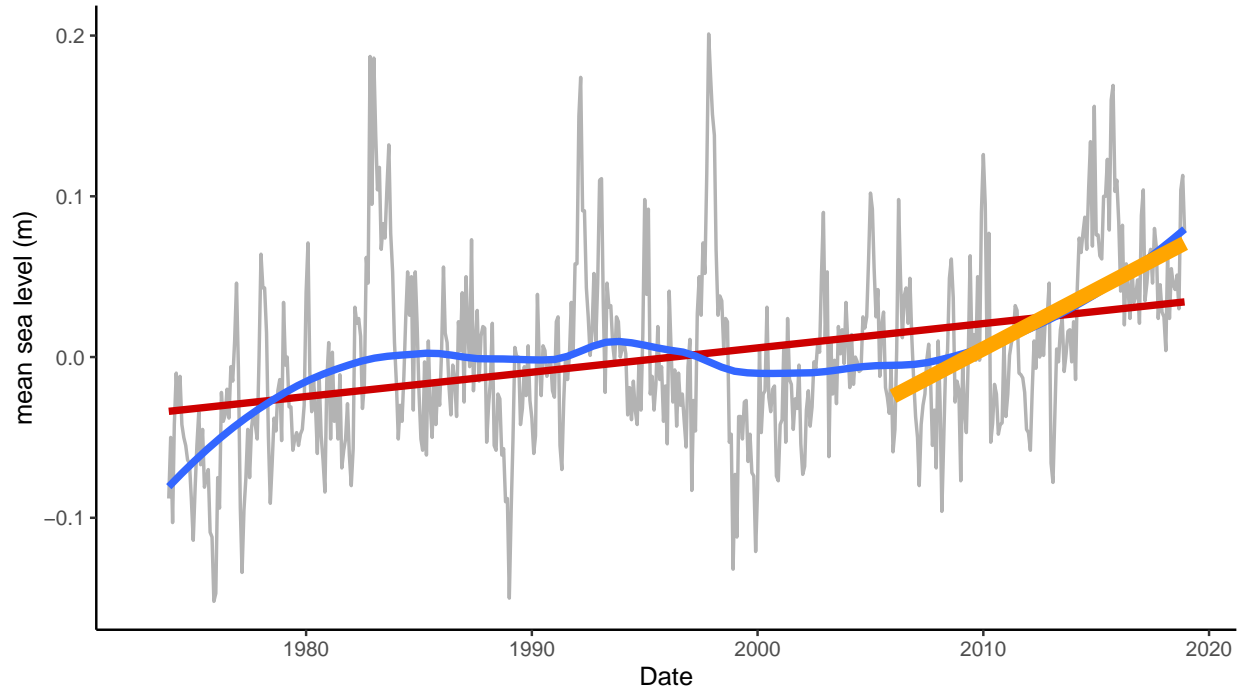


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### Monthly Mean Sea Level for ELK; NWLON station 9413450

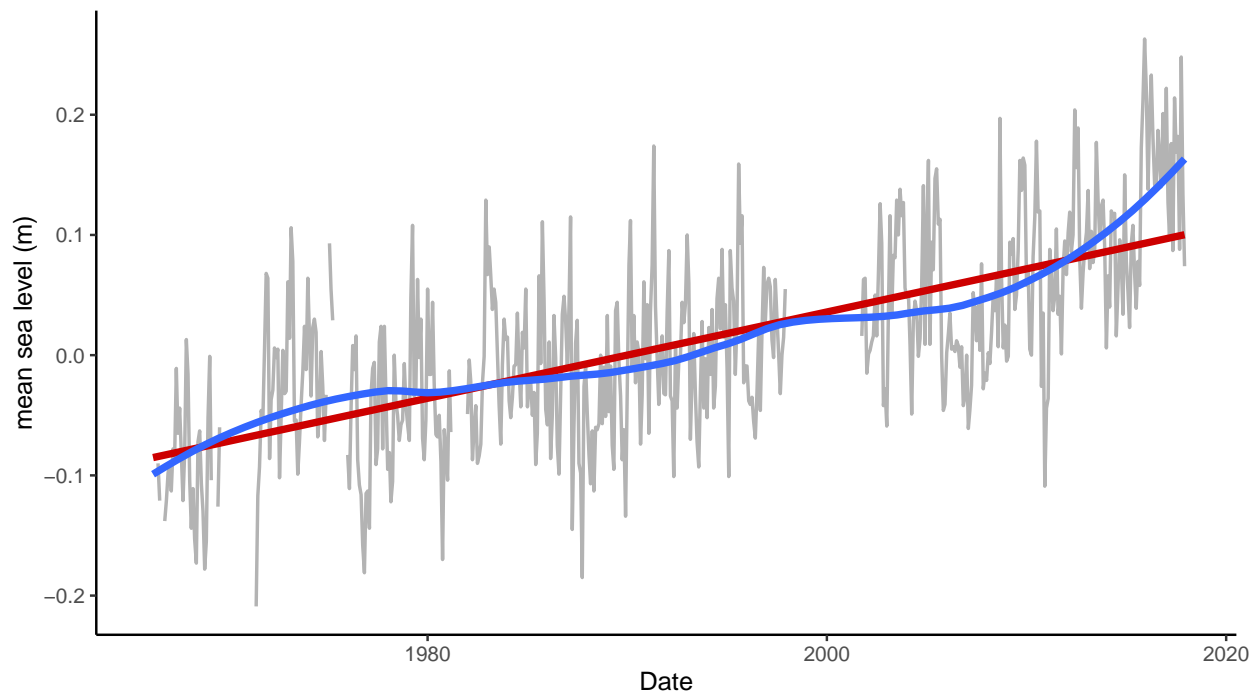
Red = lm smooth; Blue = loess smooth, span 0.5; Orange = lm for 2006–2018  
long-term change: 1.57; short-term change: 7.57



# Monthly Mean Sea Level for GND; NWLON station 8735180

Red = lm smooth; Blue = loess smooth, span 0.5

long-term change: 3.62 mm/yr



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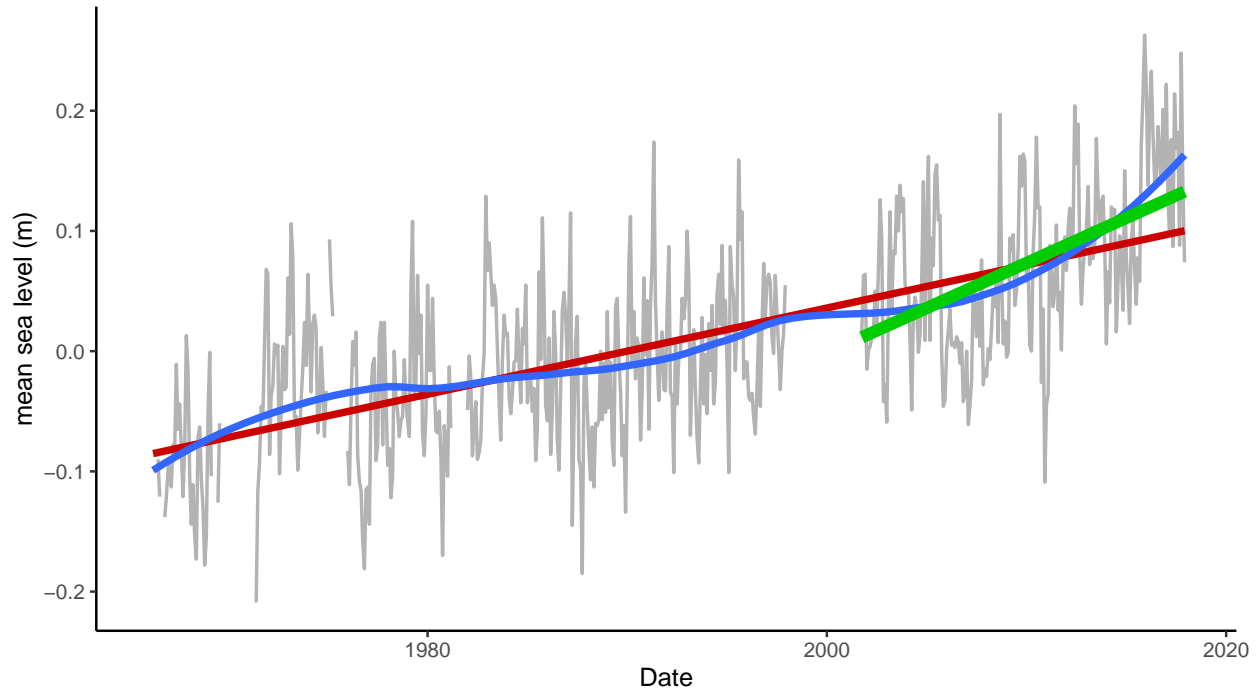
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### Monthly Mean Sea Level for GND; NWLON station 8735180

Red = lm smooth; Blue = loess smooth, span 0.5; Green = lm for 1998–2017  
long-term change: 3.62; 19-yr change: 7.37

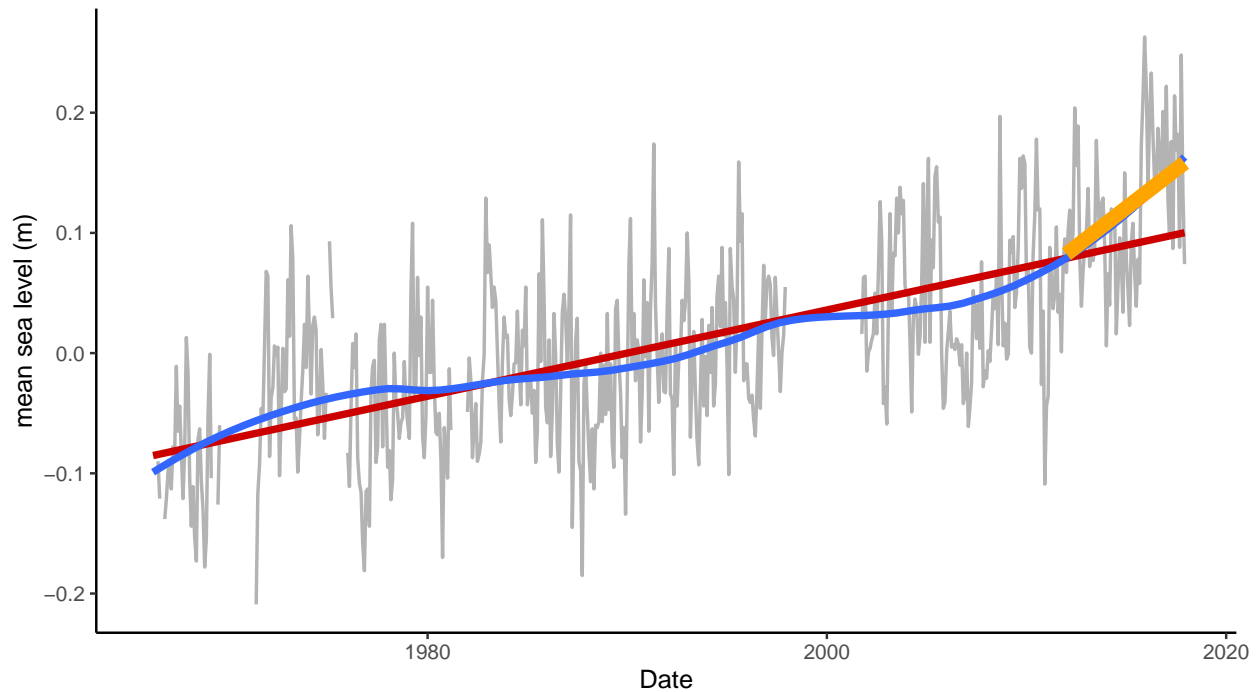


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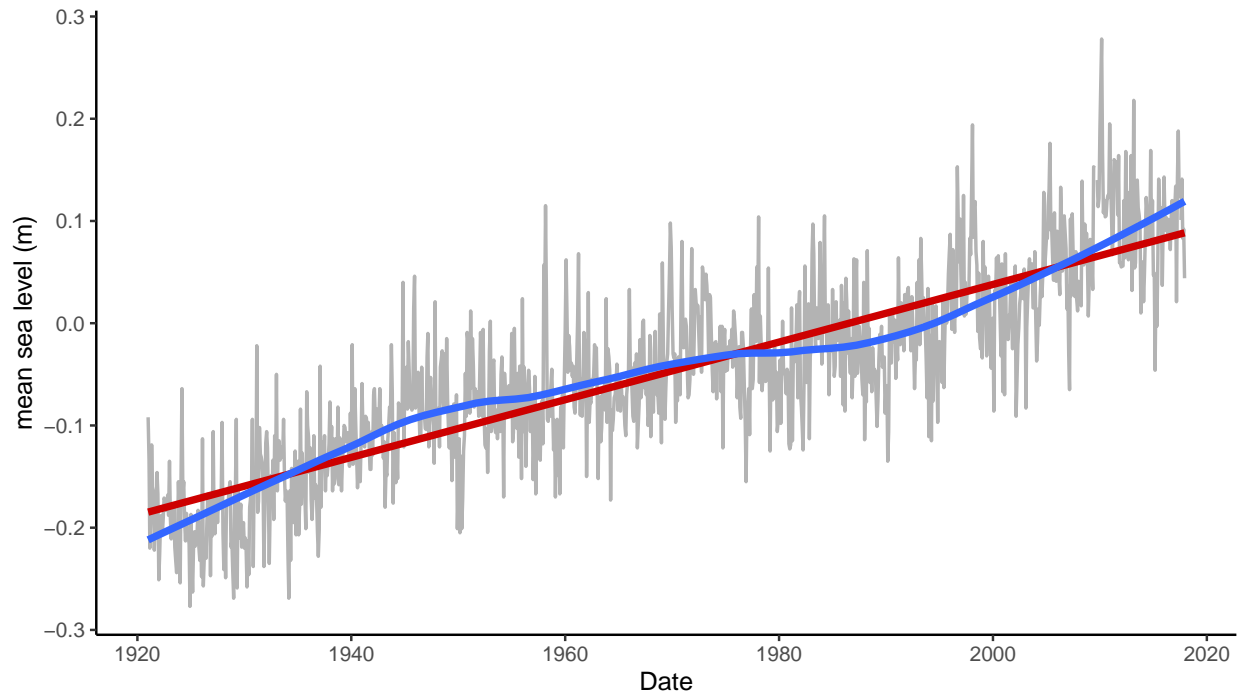
### Monthly Mean Sea Level for GND; NWLON station 8735180

Red = lm smooth; Blue = loess smooth, span 0.5; Orange = lm for 2012–2017  
long-term change: 3.62; short-term change: 12.25



# Monthly Mean Sea Level for GRB; NWLON station 8443970

Red = lm smooth; Blue = loess smooth, span 0.5  
long-term change: 2.82 mm/yr



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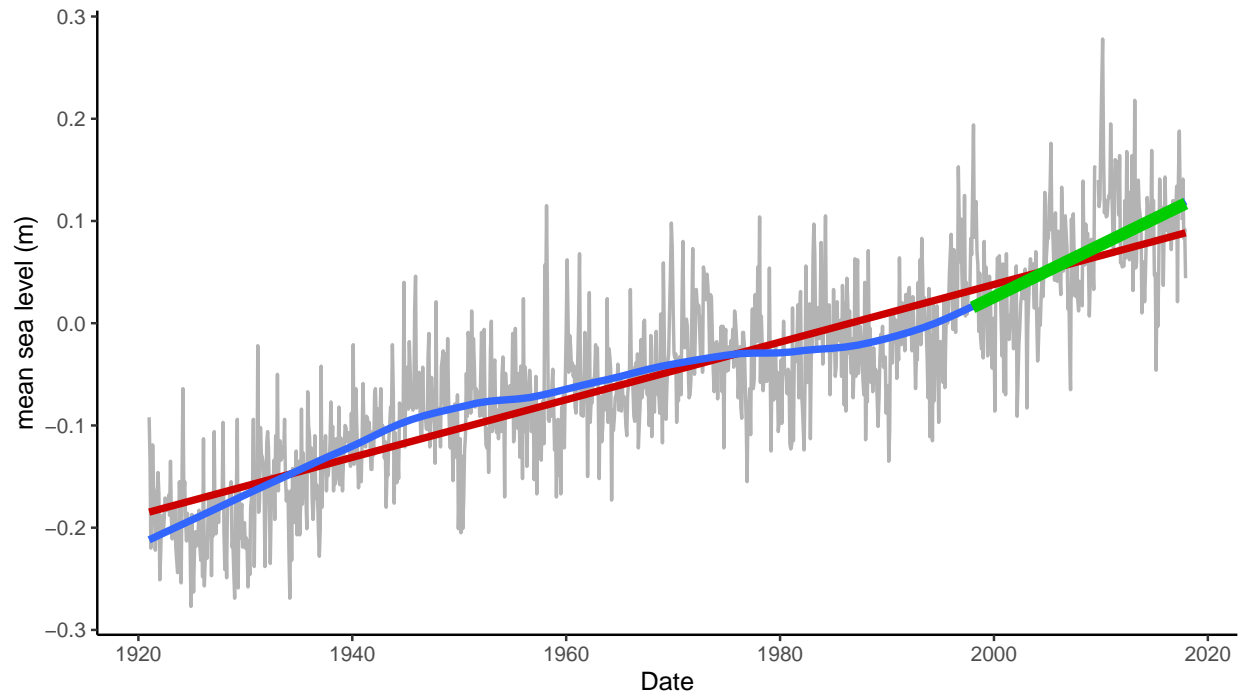
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### Monthly Mean Sea Level for GRB; NWLON station 8443970

Red = lm smooth; Blue = loess smooth, span 0.5; Green = lm for 1998–2017  
long-term change: 2.82; 19-yr change: 4.92

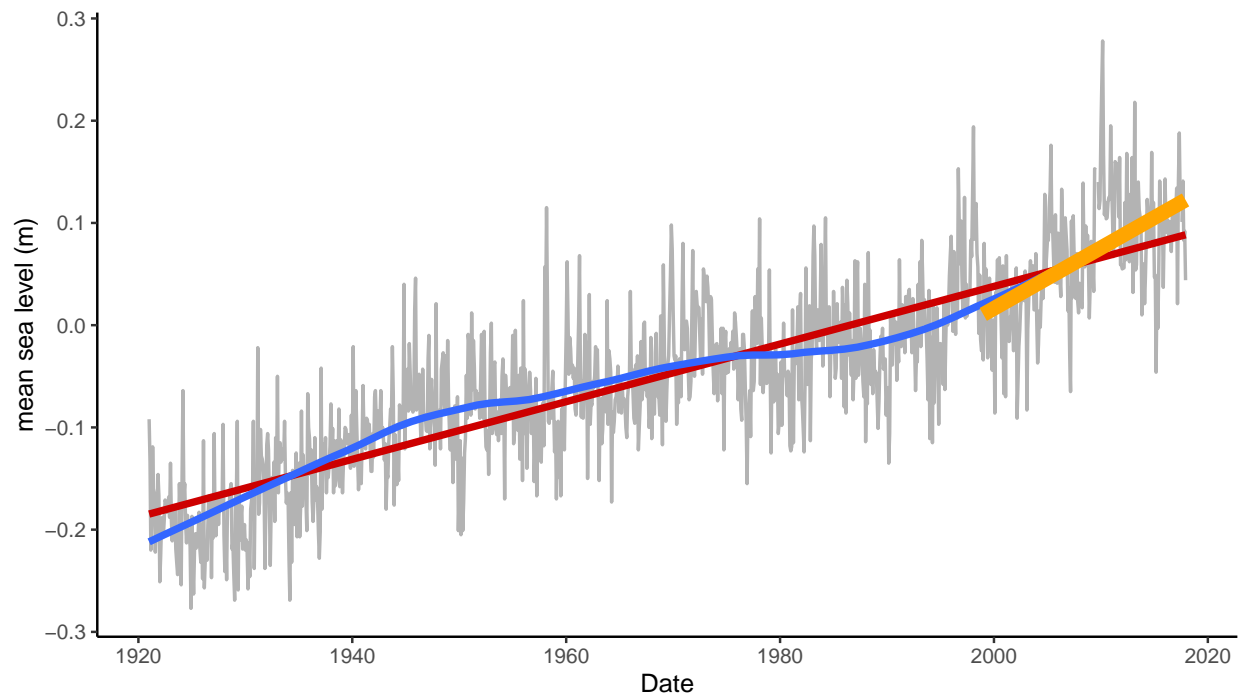


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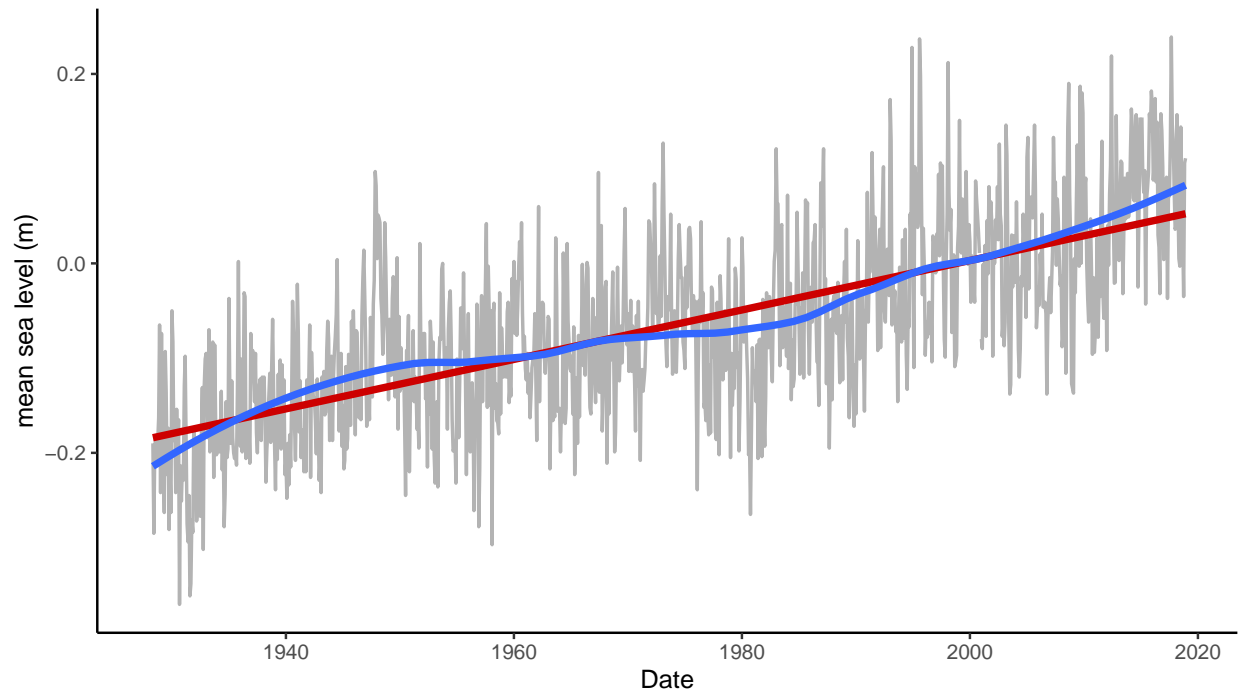
### Monthly Mean Sea Level for GRB; NWLON station 8443970

Red = lm smooth; Blue = loess smooth, span 0.5; Orange = lm for 1999–2017  
long-term change: 2.82; short-term change: 5.89



# Monthly Mean Sea Level for GTM; NWLON station 8720218

Red = lm smooth; Blue = loess smooth, span 0.5  
long-term change: 2.62 mm/yr



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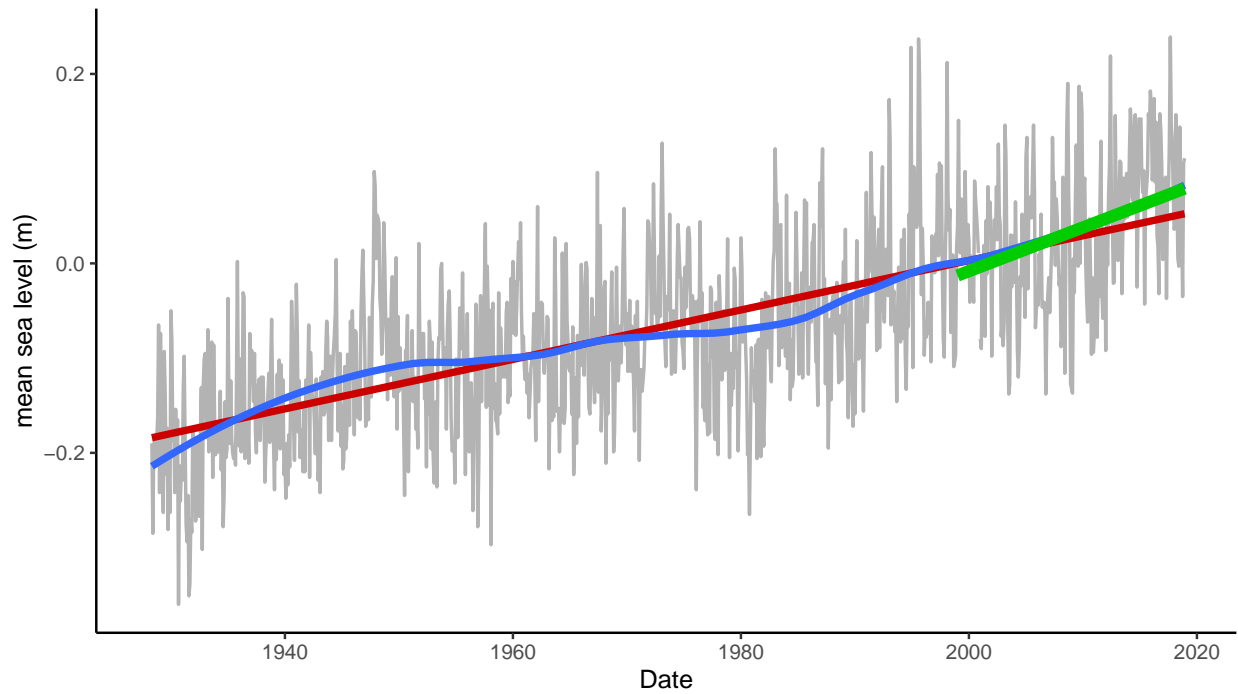
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### Monthly Mean Sea Level for GTM; NWLON station 8720218

Red = lm smooth; Blue = loess smooth, span 0.5; Green = lm for 1999–2018  
long-term change: 2.62; 19-yr change: 4.66

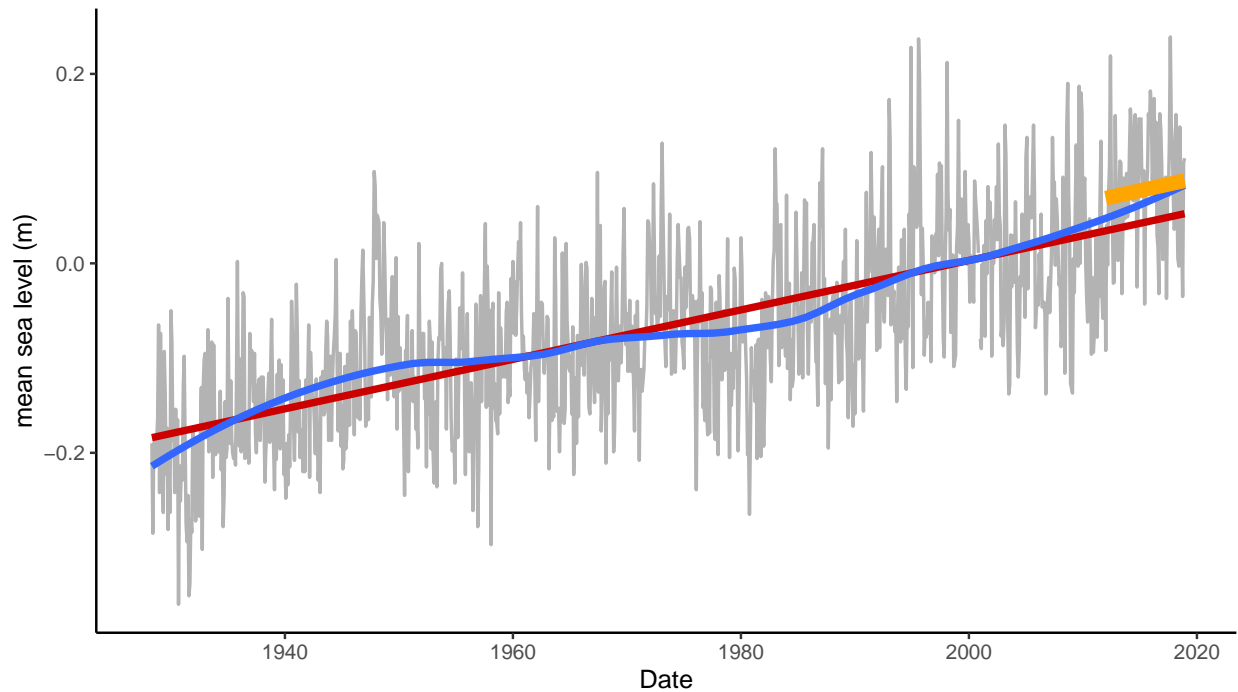


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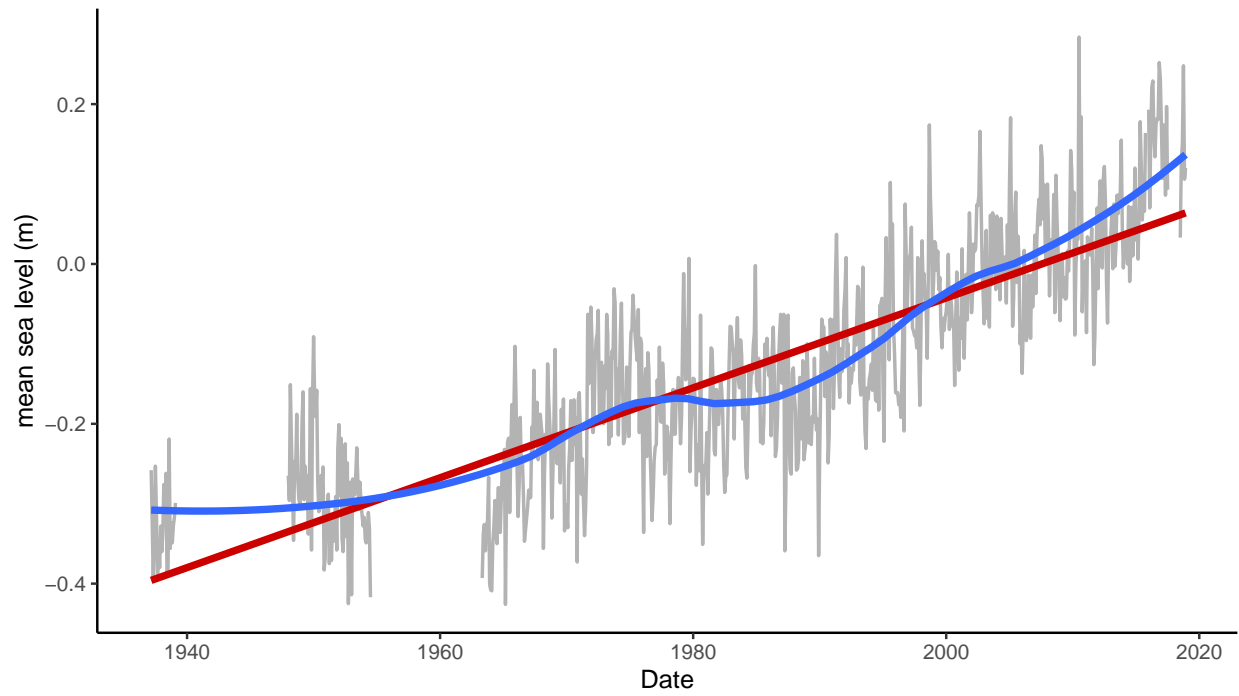
### Monthly Mean Sea Level for GTM; NWLON station 8720218

Red = lm smooth; Blue = loess smooth, span 0.5; Orange = lm for 2012–2018  
long-term change: 2.62; short-term change: 3.38



# Monthly Mean Sea Level for MAR; NWLON station 8774770

Red = lm smooth; Blue = loess smooth, span 0.5  
long-term change: 5.63 mm/yr



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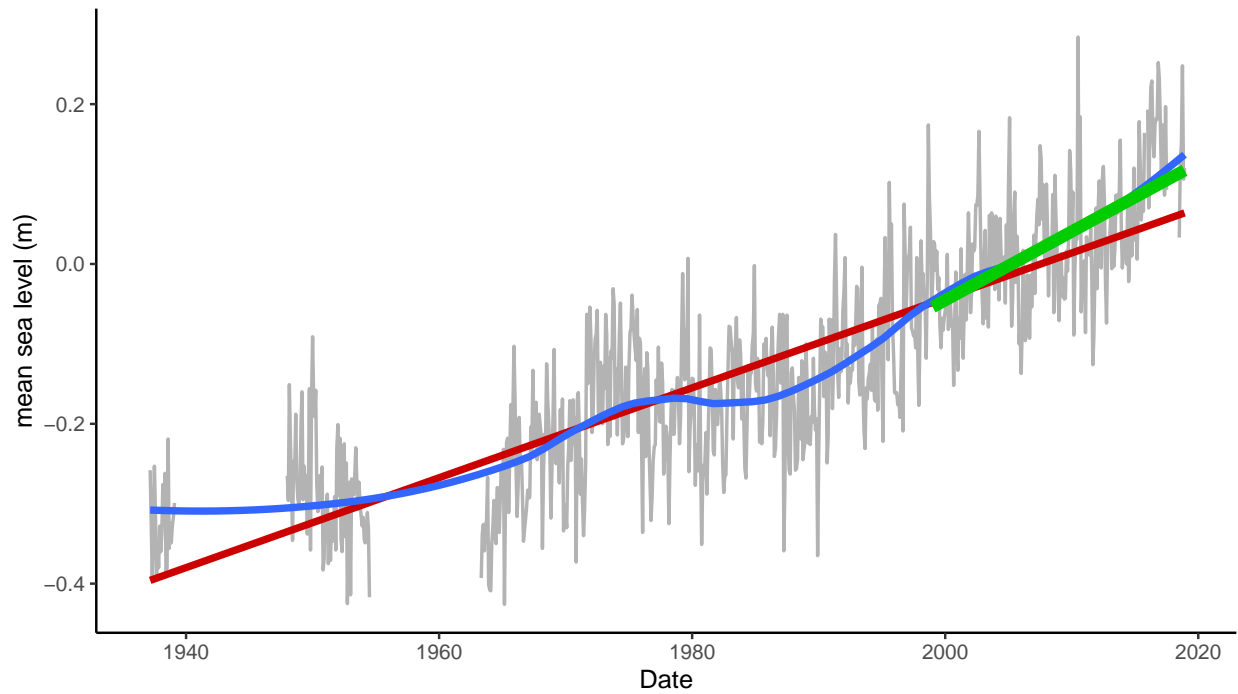
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### Monthly Mean Sea Level for MAR; NWLON station 8774770

Red = lm smooth; Blue = loess smooth, span 0.5; Green = lm for 1999–2018  
long-term change: 5.63; 19-yr change: 8.57

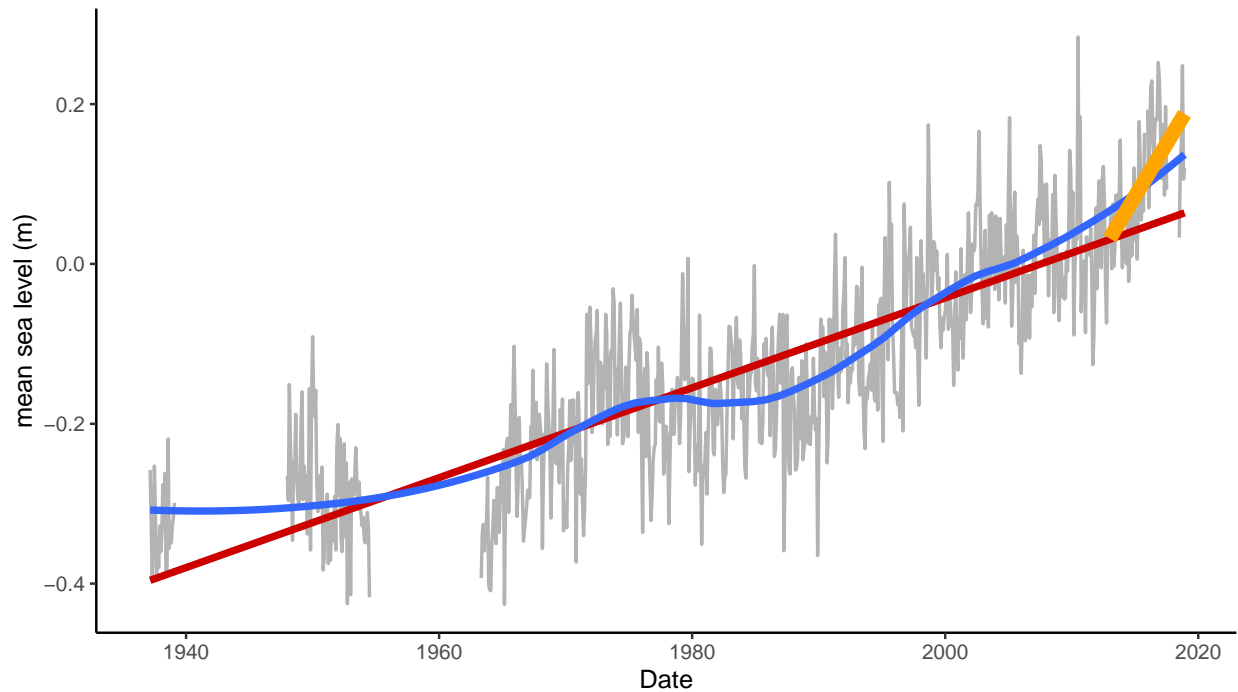


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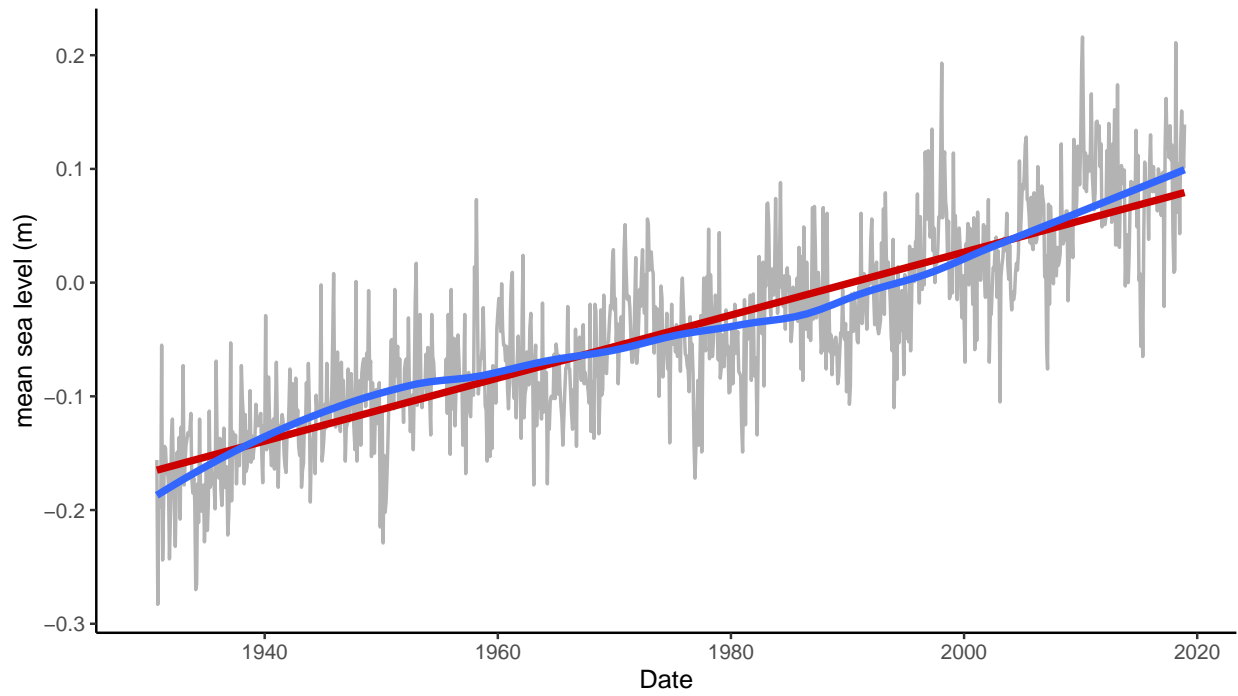
### Monthly Mean Sea Level for MAR; NWLON station 8774770

Red = lm smooth; Blue = loess smooth, span 0.5; Orange = lm for 2013–2018  
long-term change: 5.63; short-term change: 24.17



# Monthly Mean Sea Level for NAR; NWLON station 8452660

Red = lm smooth; Blue = loess smooth, span 0.5  
long-term change: 2.77 mm/yr



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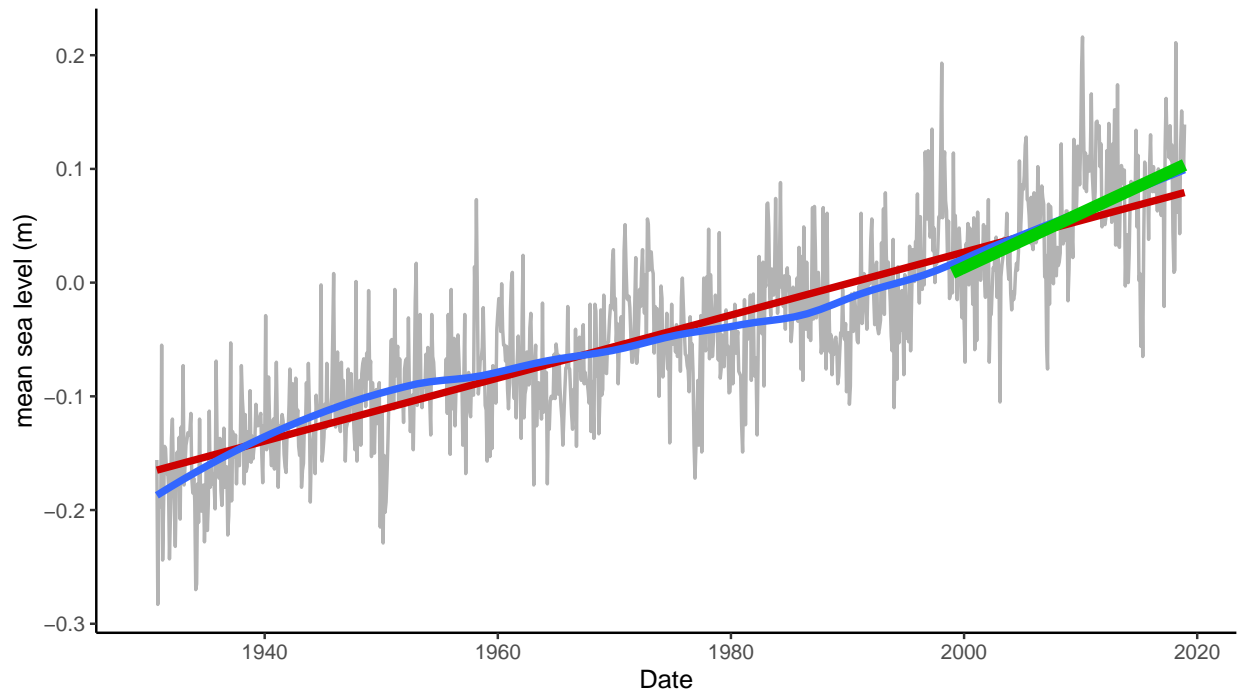
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### Monthly Mean Sea Level for NAR; NWLON station 8452660

Red = lm smooth; Blue = loess smooth, span 0.5; Green = lm for 1999–2018  
long-term change: 2.77; 19-yr change: 4.81

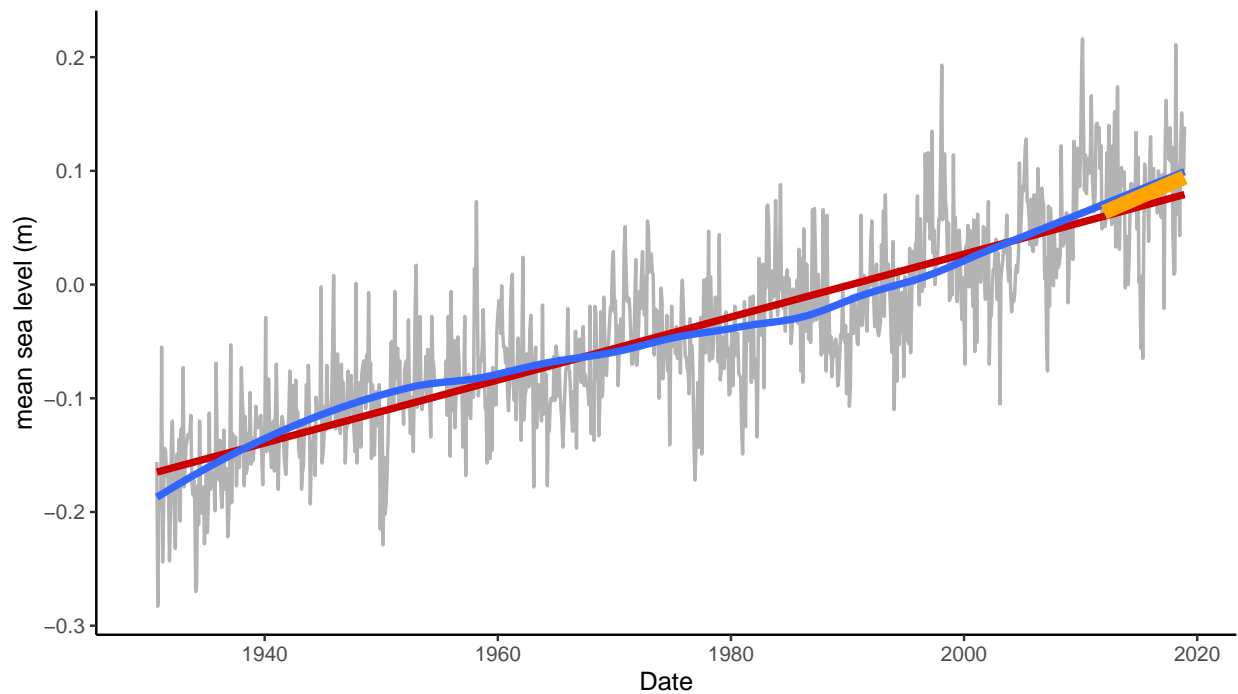


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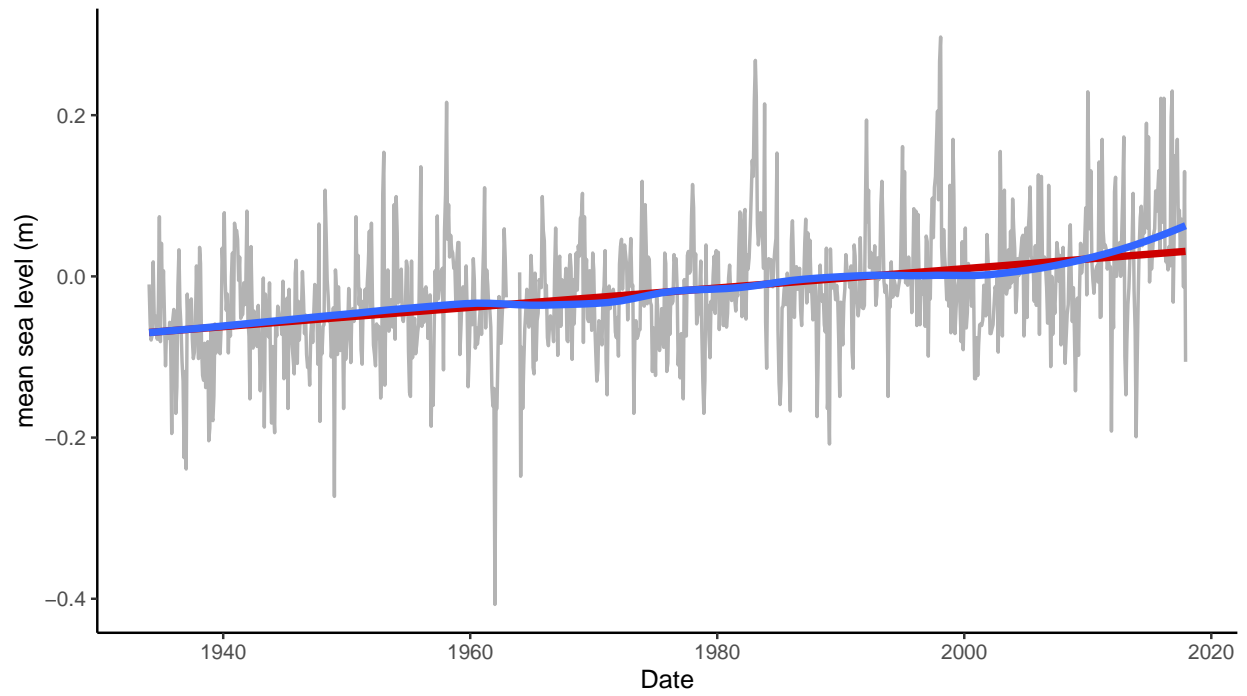
### Monthly Mean Sea Level for NAR; NWLON station 8452660

Red = lm smooth; Blue = loess smooth, span 0.5; Orange = lm for 2012–2018  
long-term change: 2.77; short-term change: 4.64



# Monthly Mean Sea Level for PDB; NWLON station 9449880

Red = lm smooth; Blue = loess smooth, span 0.5  
long-term change: 1.19 mm/yr



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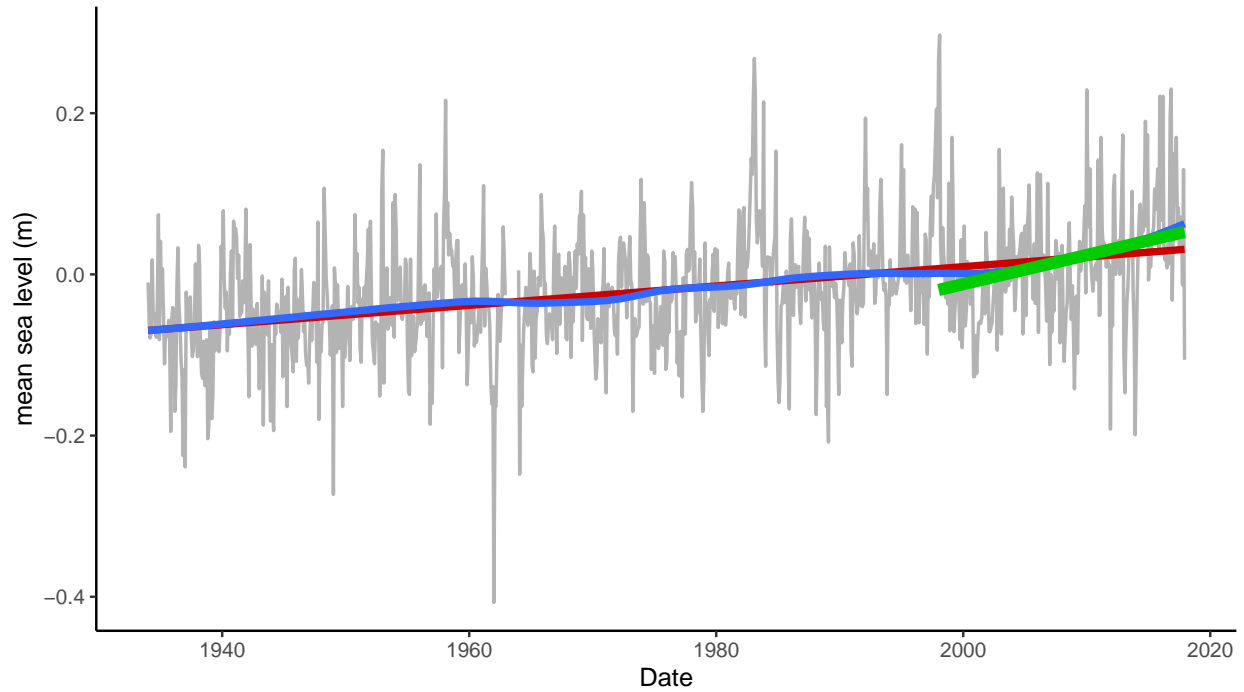
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### Monthly Mean Sea Level for PDB; NWLON station 9449880

Red = lm smooth; Blue = loess smooth, span 0.5; Green = lm for 1998–2017  
long-term change: 1.19; 19-yr change: 3.31

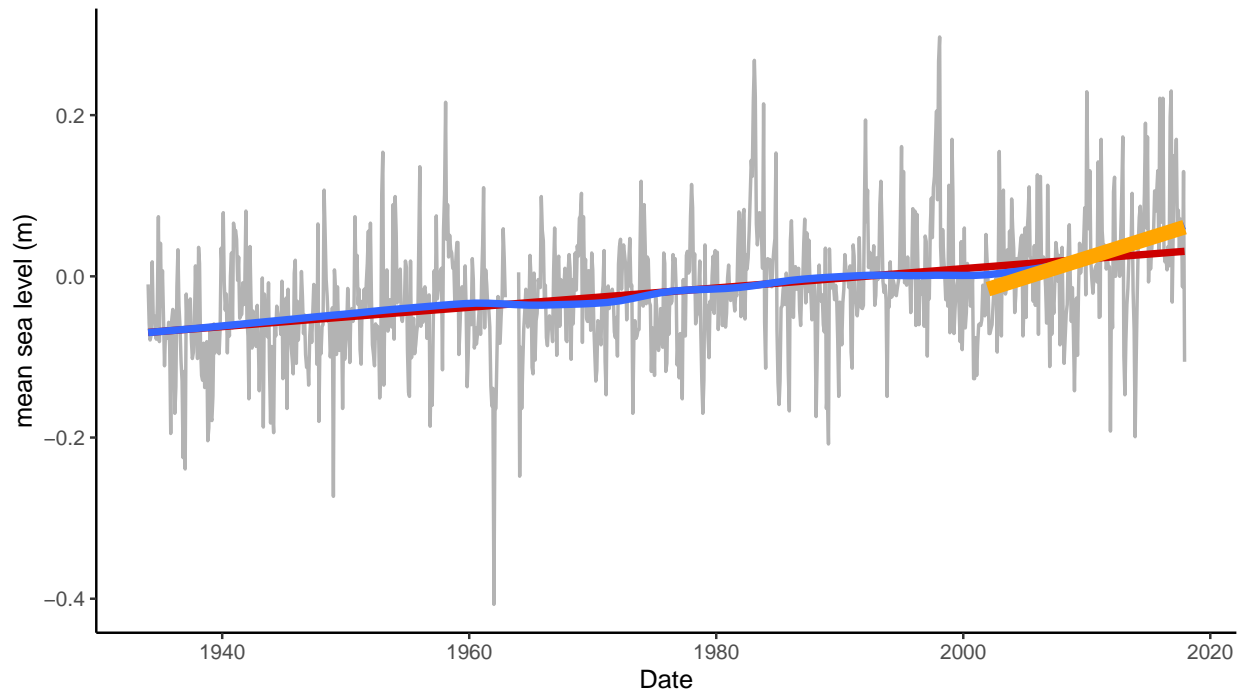


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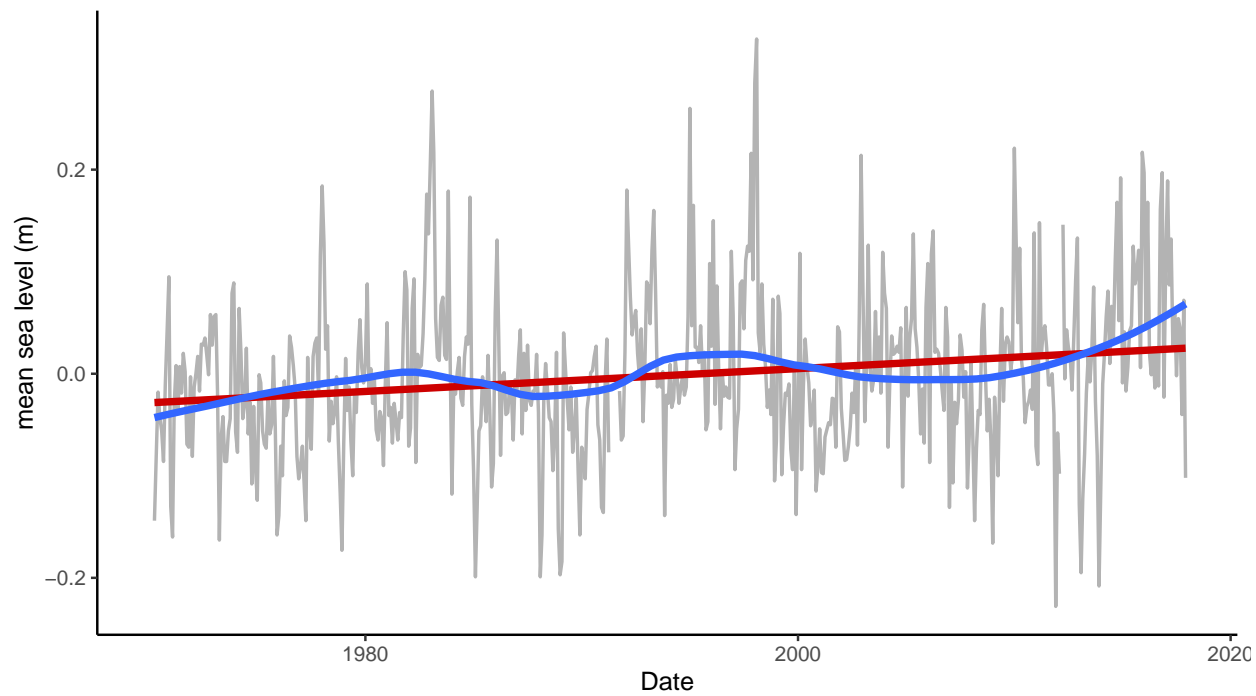
### Monthly Mean Sea Level for PDB; NWLON station 9449880

Red = lm smooth; Blue = loess smooth, span 0.5; Orange = lm for 2002–2017  
long-term change: 1.19; short-term change: 4.7



# Monthly Mean Sea Level for SOS; NWLON station 9432780

Red = lm smooth; Blue = loess smooth, span 0.5  
long-term change: 1.12 mm/yr



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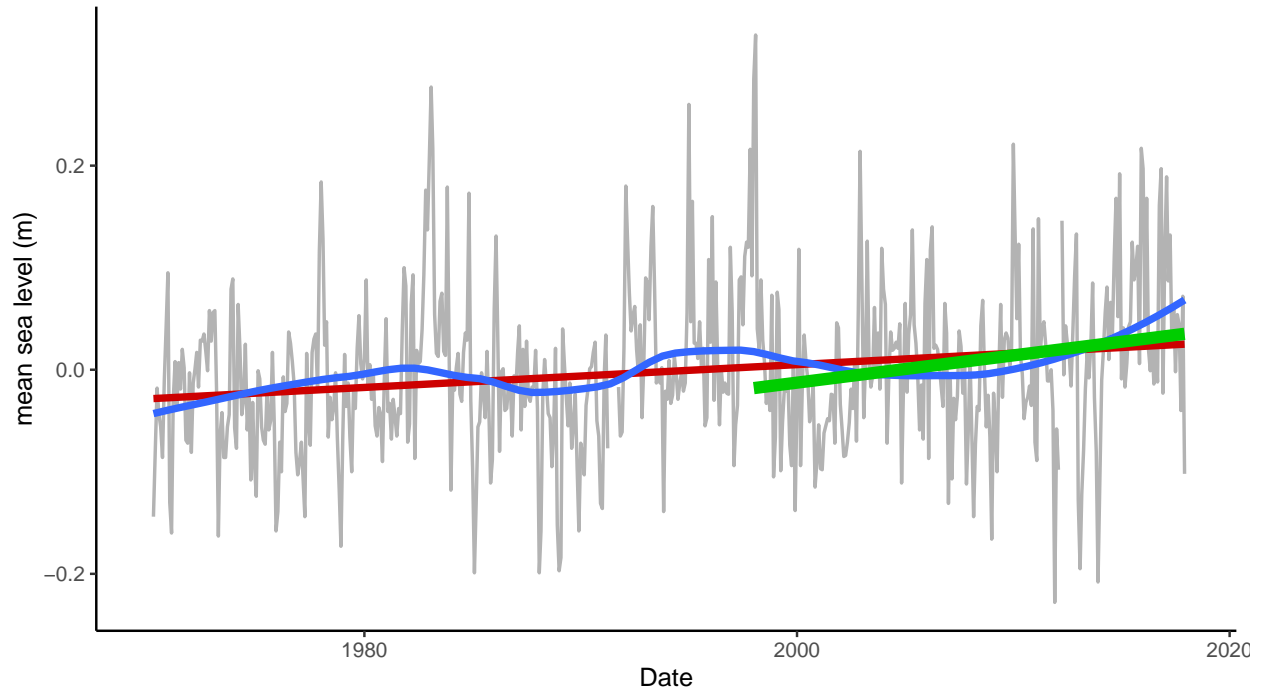
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### Monthly Mean Sea Level for SOS; NWLON station 9432780

Red = lm smooth; Blue = loess smooth, span 0.5; Green = lm for 1998–2017  
long-term change: 1.12; 19-yr change: 2.31

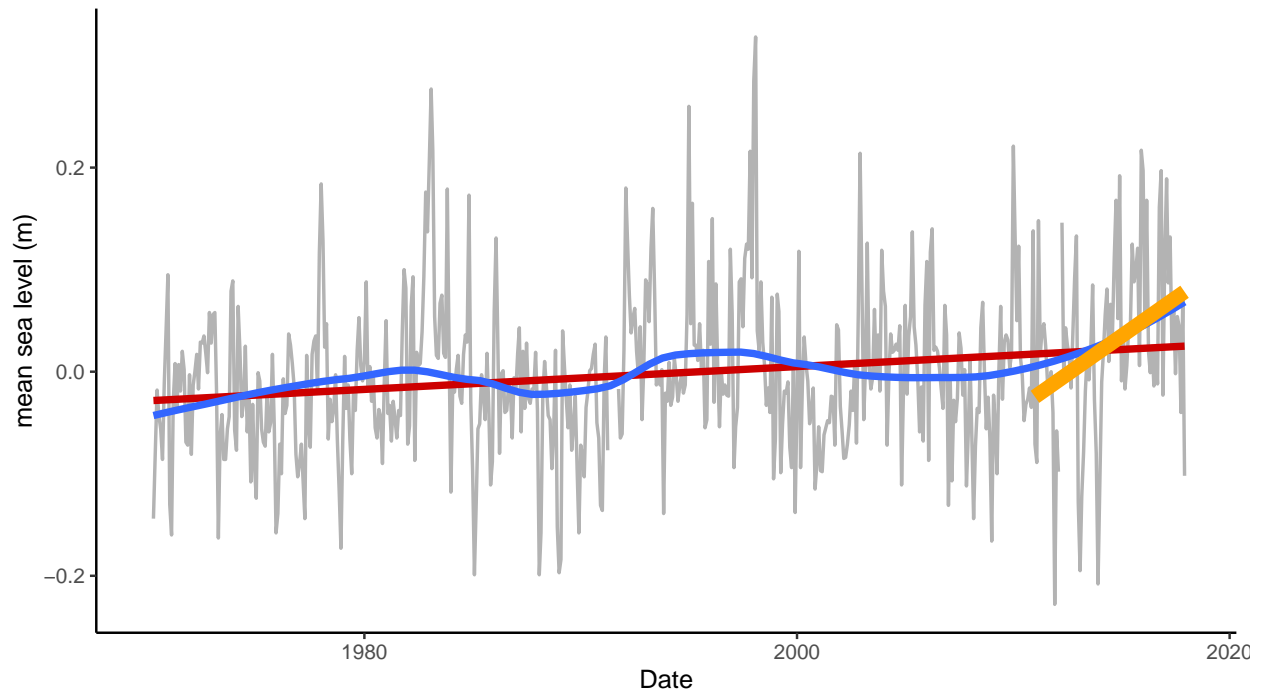


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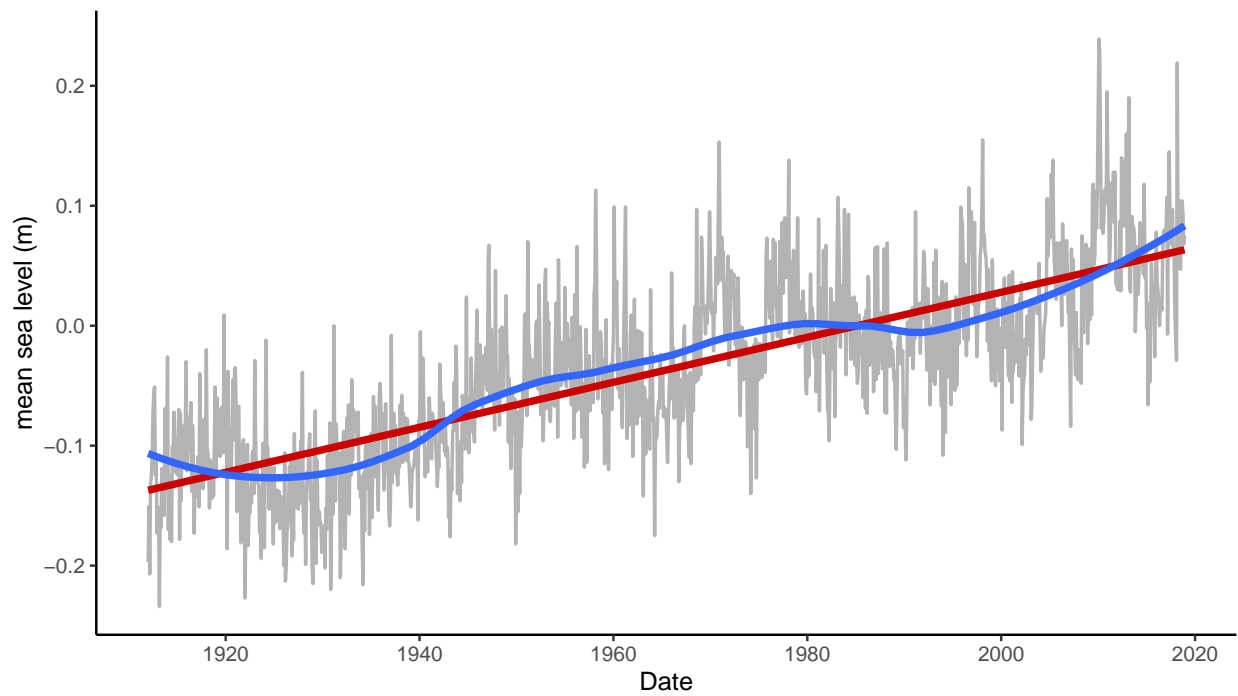
### Monthly Mean Sea Level for SOS; NWLON station 9432780

Red = lm smooth; Blue = loess smooth, span 0.5; Orange = lm for 2011–2017  
long-term change: 1.12; short-term change: 14.04



# Monthly Mean Sea Level for WEL; NWLON station 8418150

Red = lm smooth; Blue = loess smooth, span 0.5  
long-term change: 1.88 mm/yr



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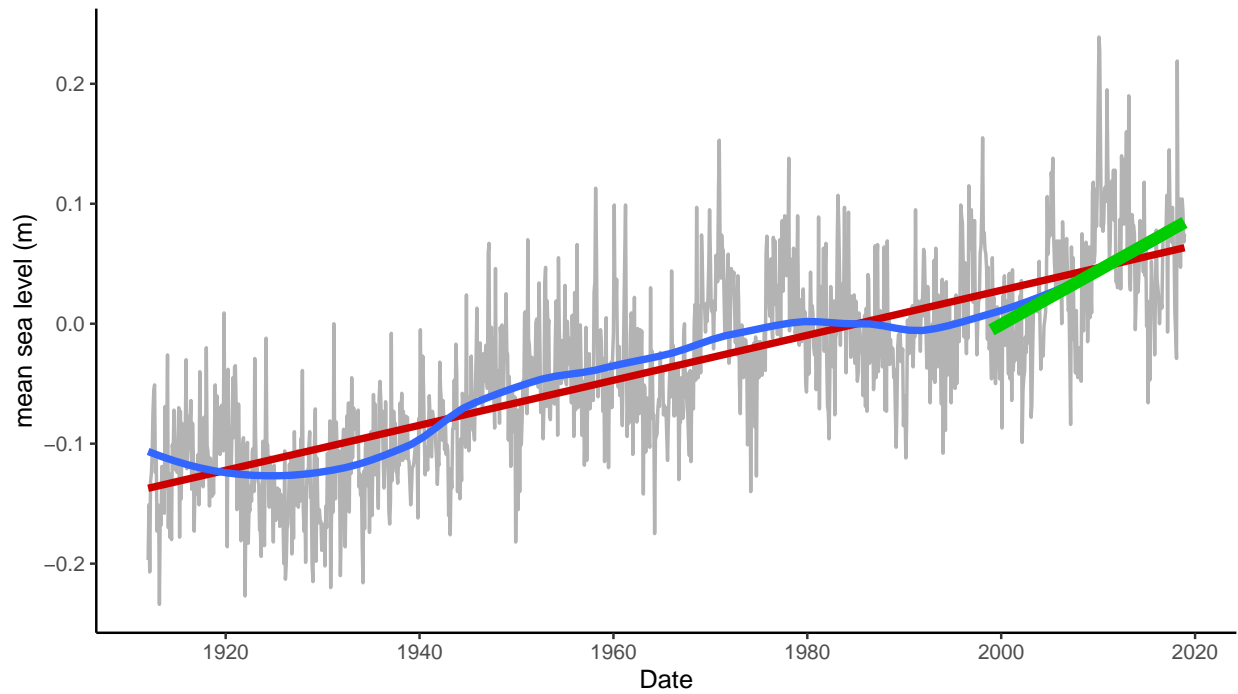
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### Monthly Mean Sea Level for WEL; NWLON station 8418150

Red = lm smooth; Blue = loess smooth, span 0.5; Green = lm for 1999–2018  
long-term change: 1.88; 19-yr change: 4.54

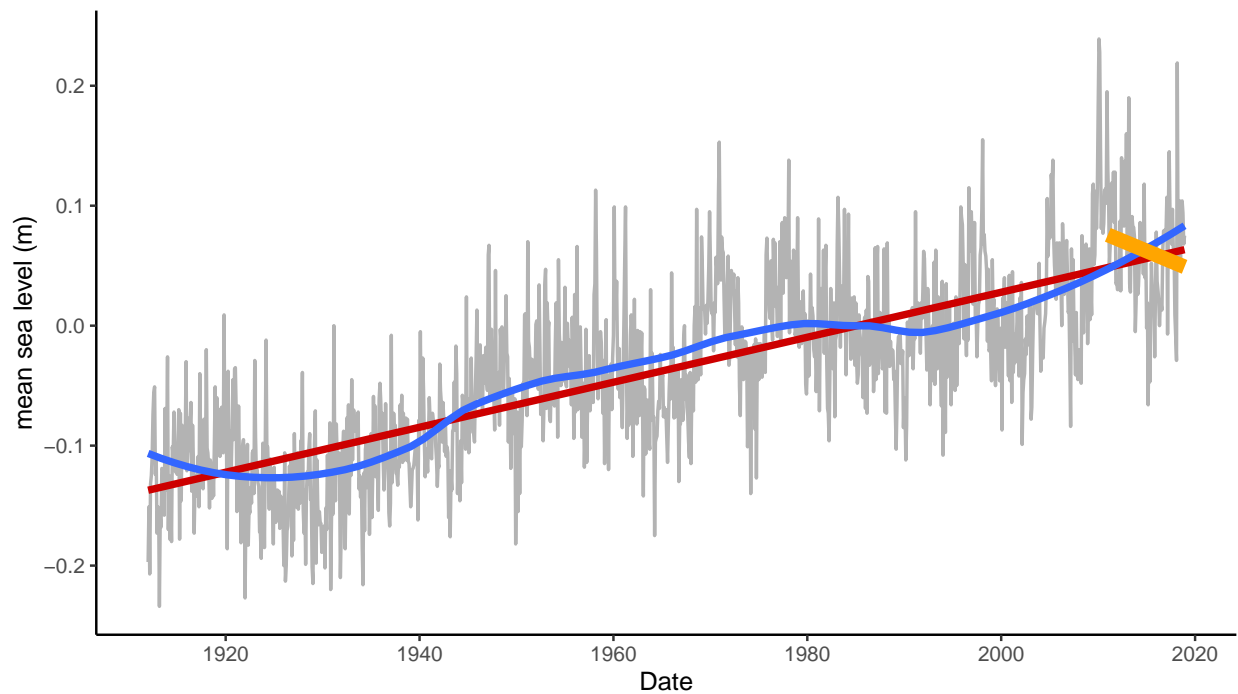


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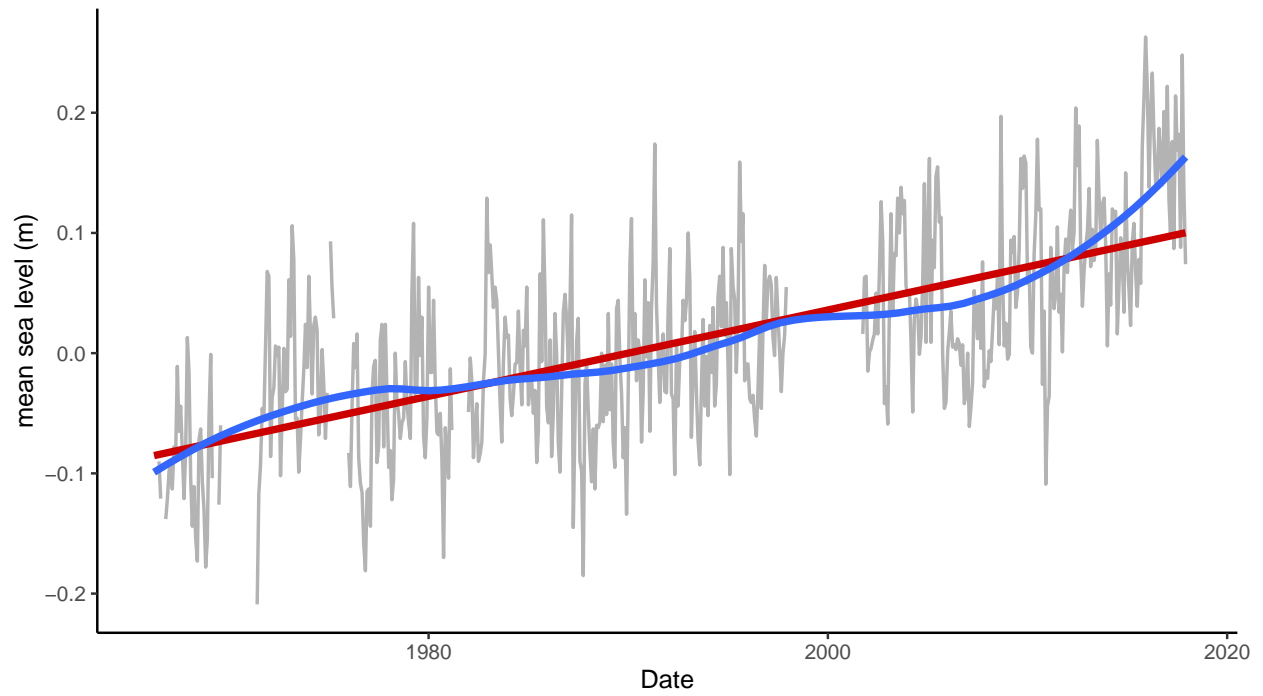
### Monthly Mean Sea Level for WEL; NWLON station 8418150

Red = lm smooth; Blue = loess smooth, span 0.5; Orange = lm for 2011–2018  
long-term change: 1.88; short-term change: -3.47



# Monthly Mean Sea Level for WKB; NWLON station 8735180

Red = lm smooth; Blue = loess smooth, span 0.5  
long-term change: 3.62 mm/yr



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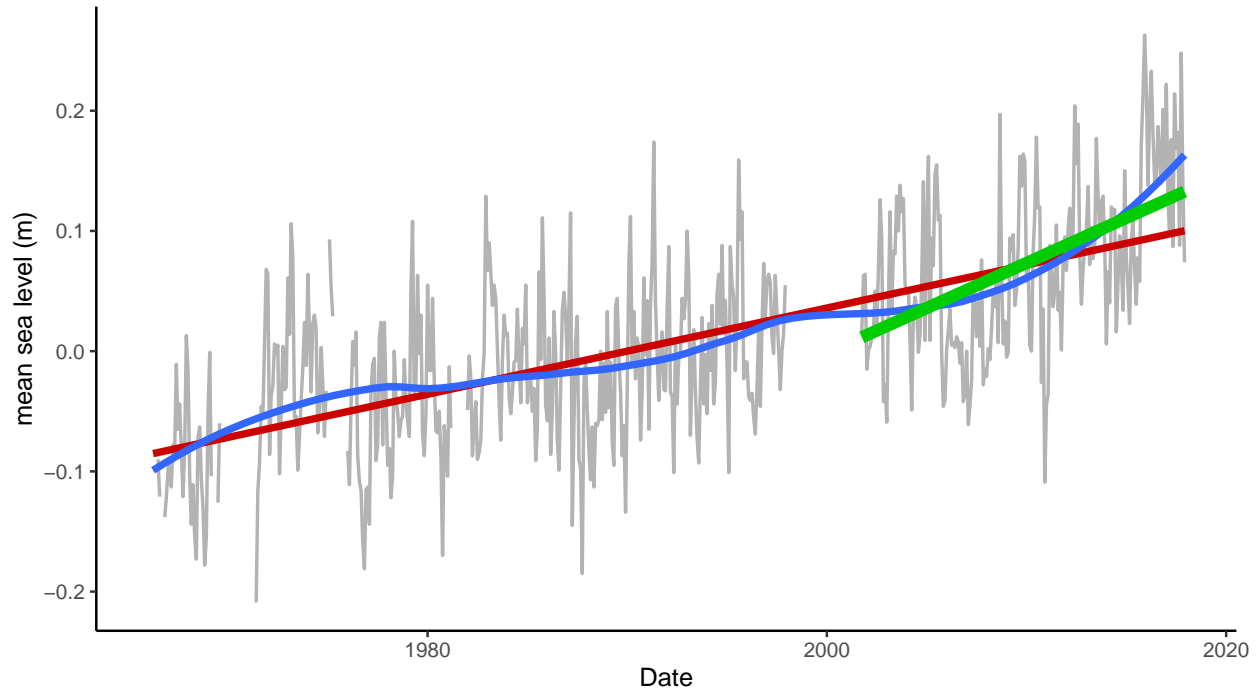
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### Monthly Mean Sea Level for WKB; NWLON station 8735180

Red = lm smooth; Blue = loess smooth, span 0.5; Green = lm for 1998–2017  
long-term change: 3.62; 19-yr change: 7.37

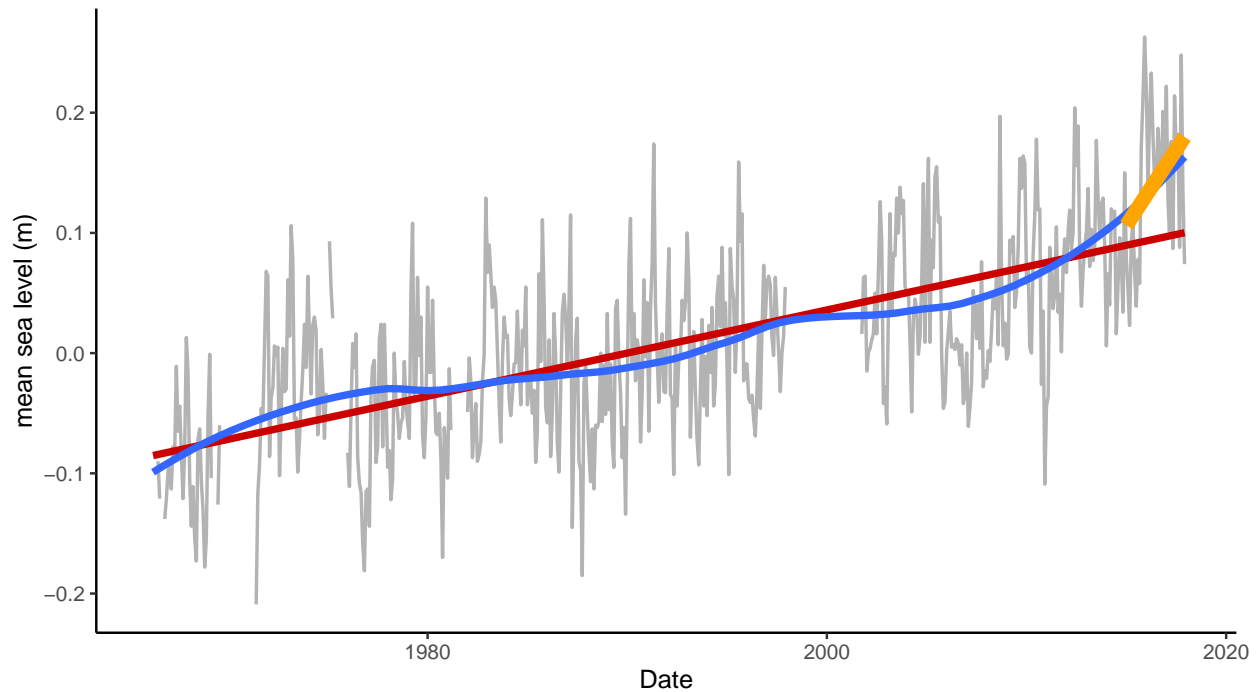


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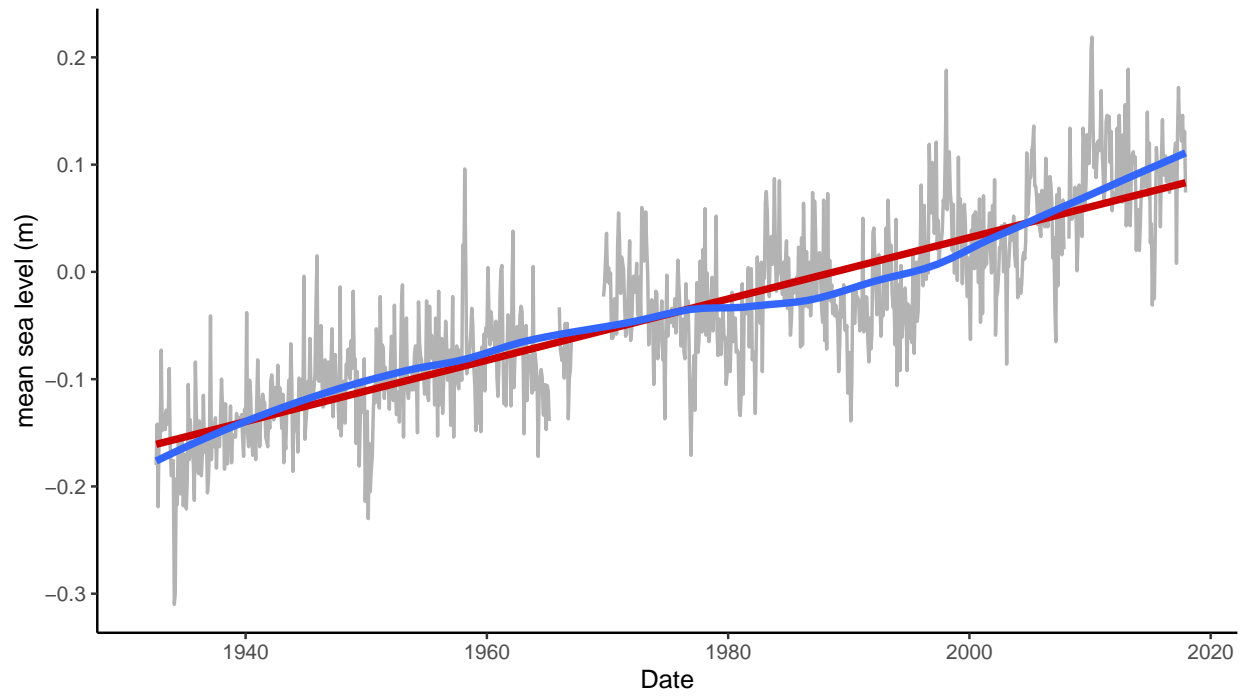
### Monthly Mean Sea Level for WKB; NWLON station 8735180

Red = lm smooth; Blue = loess smooth, span 0.5; Orange = lm for 2015–2017  
long-term change: 3.62; short-term change: 22.92



# Monthly Mean Sea Level for WQB; NWLON station 8447930

Red = lm smooth; Blue = loess smooth, span 0.5  
long-term change: 2.86 mm/yr



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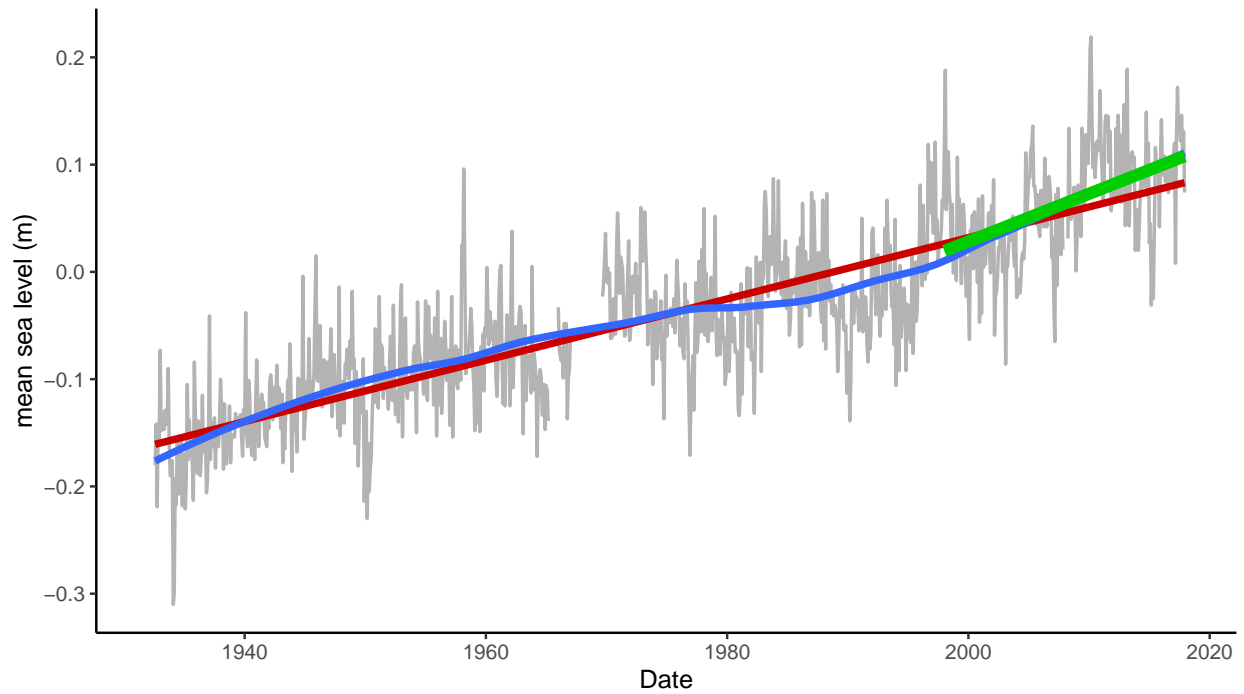
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### Monthly Mean Sea Level for WQB; NWLON station 8447930

Red = lm smooth; Blue = loess smooth, span 0.5; Green = lm for 1998–2017  
long-term change: 2.86; 19-yr change: 4.32

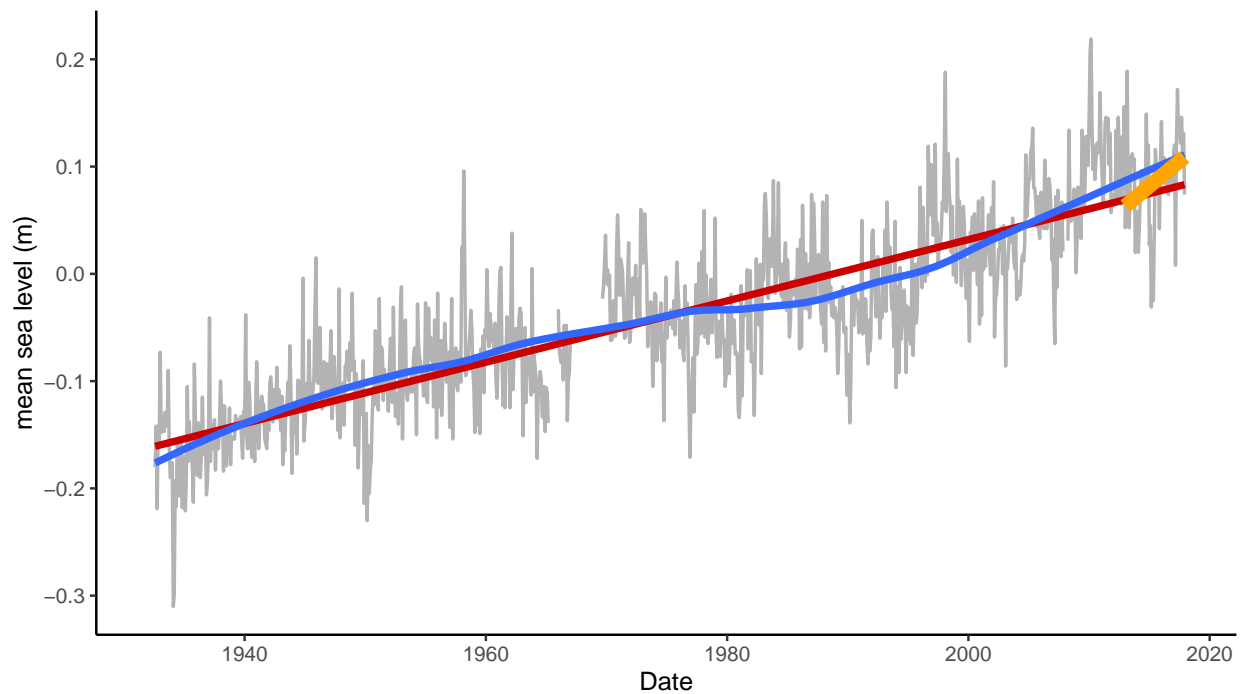


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### Monthly Mean Sea Level for WQB; NWLON station 8447930

Red = lm smooth; Blue = loess smooth, span 0.5; Orange = lm for 2013–2017  
long-term change: 2.86; short-term change: 9.23



## Rates

LT = long-term; yr19 = 19-year; ST = short-term

All rates in mm/yr

Reserve	LT change	LT CI	19-yr change	19-yr CI	ST change	ST CI	LT dates	19-yr dates	ST dates
APA	2.234	1.6-2.87	5.223	2.65-7.79	9.495	-1.15-20.14	1967-2017	1998-2017	2012-2017
CBM	3.826	3.59-4.06	7.146	5.47-8.82	1.788	-2.61-6.19	1937-2018	1999-2018	2010-2018
CBV	4.658	4.44-4.88	7.186	5.19-9.19	7.646	3.23-12.06	1927-2018	1999-2018	2007-2018
DEL	3.439	3.2-3.68	4.688	2.66-6.71	4.563	1.3-7.82	1919-2017	1998-2017	2004-2017
ELK	1.573	0.75-2.4	5.187	3.31-7.06	7.567	3.83-11.3	1973-2018	1999-2018	2006-2018
GND	3.621	3.03-4.22	7.373	4.2-10.55	12.250	1.59-22.91	1966-2017	1998-2017	2012-2017
GRB	2.818	2.66-2.98	4.917	3.02-6.81	5.891	4.07-7.72	1921-2017	1998-2017	1999-2017
GTM	2.616	2.36-2.87	4.662	2.19-7.13	3.380	-5.78-12.54	1928-2018	1999-2018	2012-2018
MAR	5.628	5.15-6.11	8.568	6.08-11.05	24.168	11.49-36.84	1937-2018	1999-2018	2013-2018
NAR	2.769	2.61-2.93	4.808	3.32-6.3	4.641	-1.82-11.1	1930-2018	1999-2018	2012-2018
PDB	1.189	0.91-1.46	3.308	0.9-5.71	4.695	1.74-7.66	1934-2017	1998-2017	2002-2017
SOS	1.118	0.35-1.89	2.305	-0.4-5.01	14.042	1.3-26.78	1970-2017	1998-2017	2011-2017
WEL	1.878	1.73-2.02	4.539	2.55-6.53	-3.473	-9.09-2.14	1912-2018	1999-2018	2011-2018
WKB	3.621	3.03-4.22	7.373	4.2-10.55	22.919	-8.16-54	1966-2017	1998-2017	2015-2017
WQB	2.858	2.68-3.03	4.325	2.76-5.89	9.230	0.09-18.37	1932-2017	1998-2017	2013-2017

