A new Arctic 25-year Altimetric Sea-level Record (1992-2016) and Initial look at Arctic Sea Level Budget Closure

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Contribution to the ESA SL_CCI initiative

DTU Space
National Space Institute

Outline

- Arctic Ocean

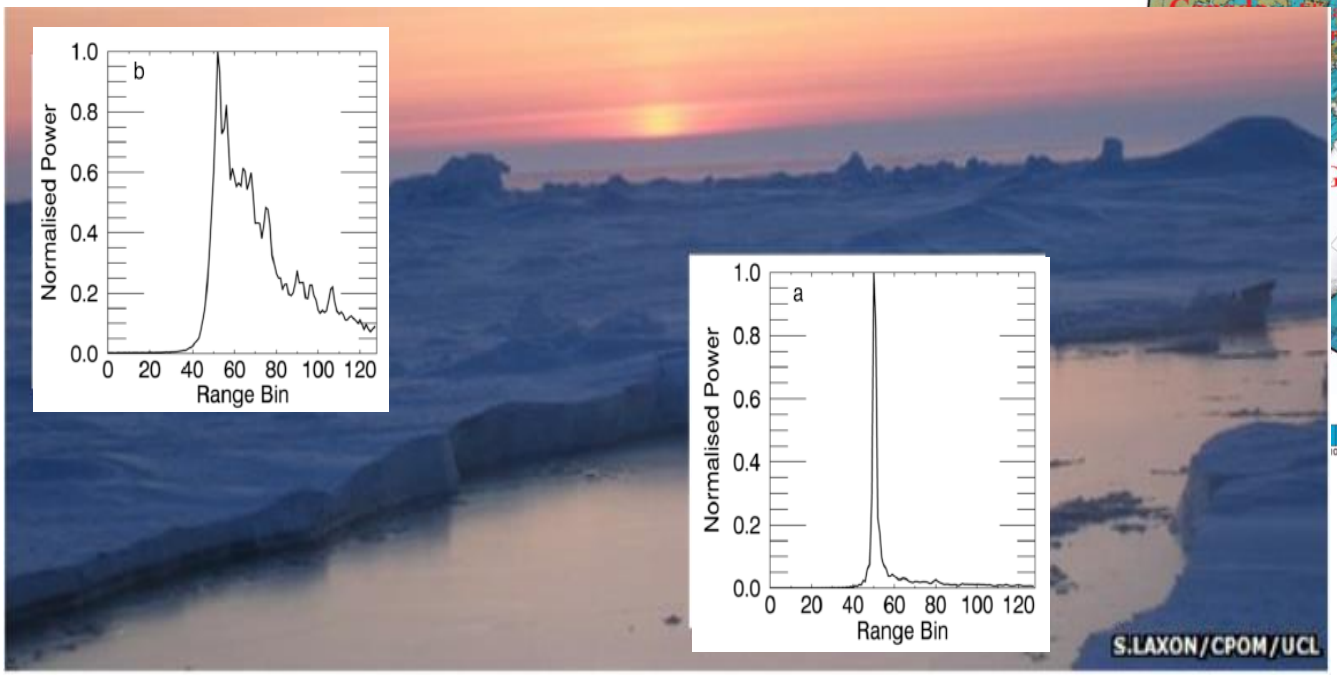
- 25 years Arctic Sea Level Products
  - DTU (reprocessed but largely un-retracked)
  - DTU/TUM (ALES+ retracked, REAPER and in house processed)

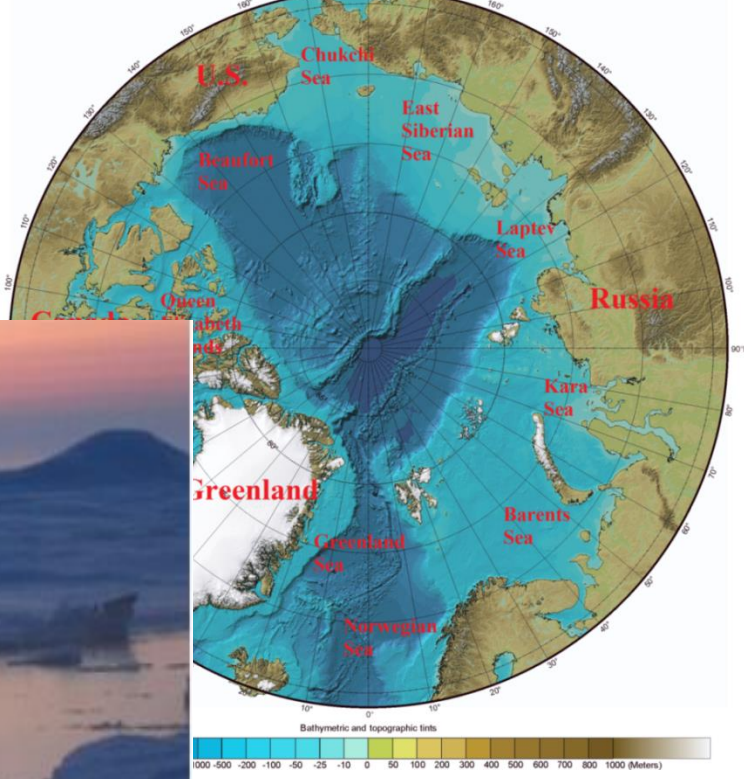
  - Annual signal
  - Linear Arctic Sea level change.

  - Preliminar Arctic sea level budget closure

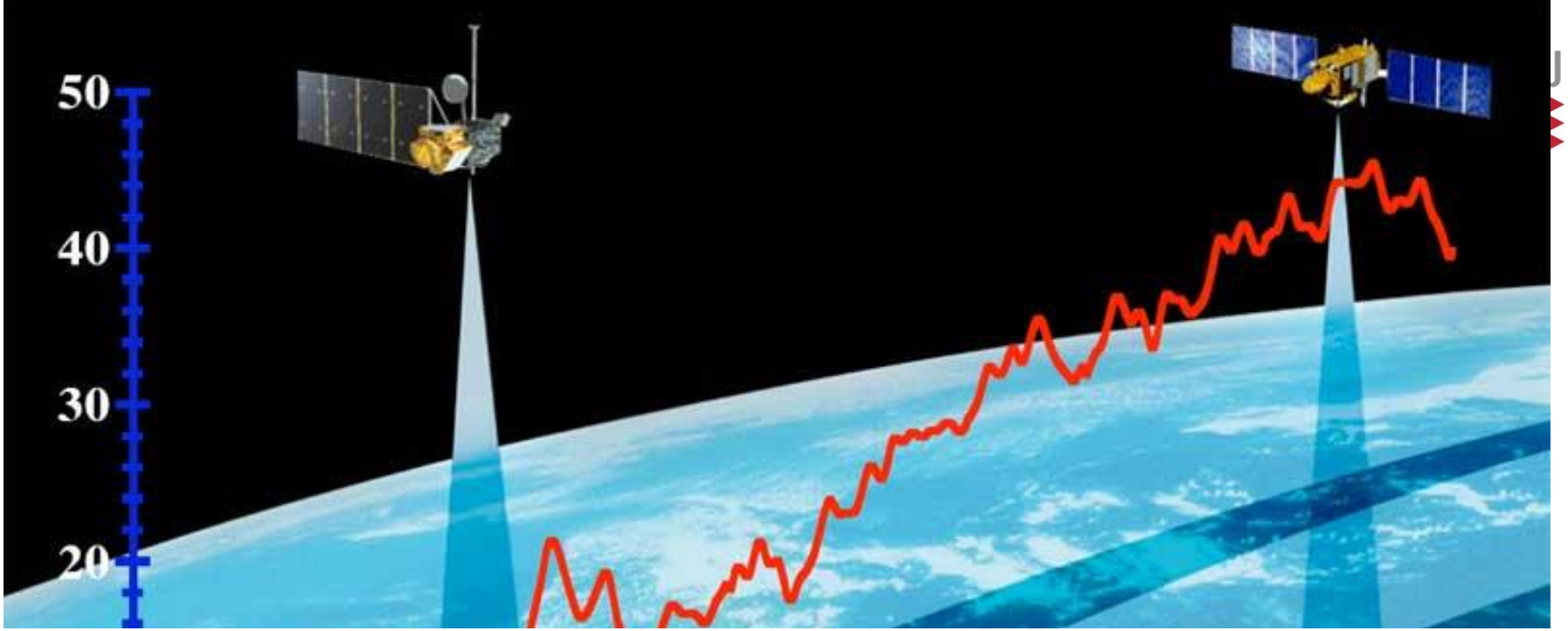
  - Conclusion

Arctic Ocean –

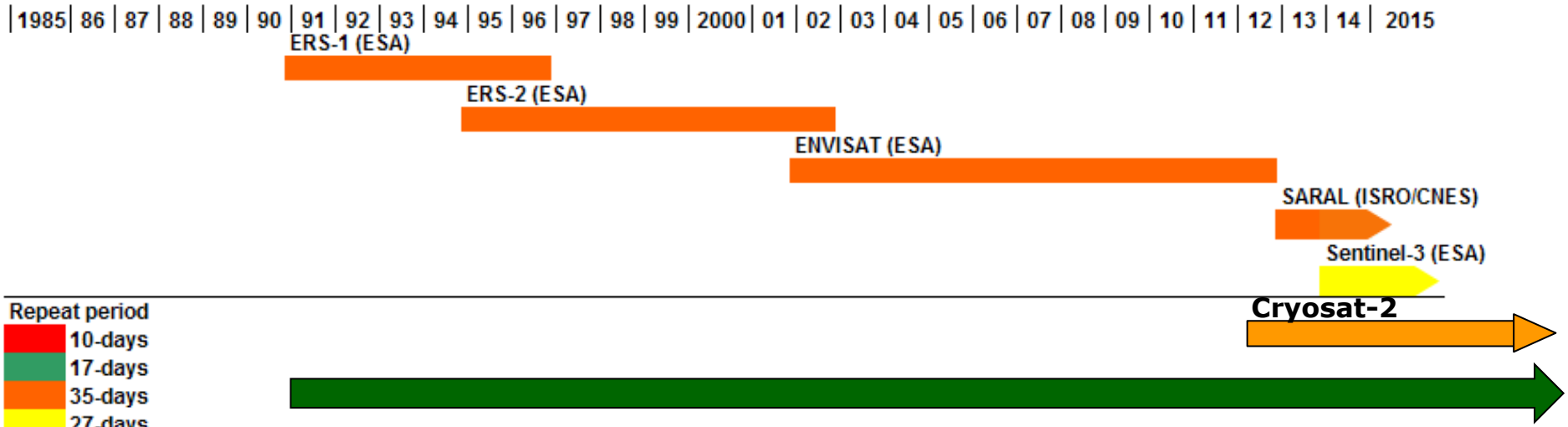




Arctic Ocean challenges:
Seasonal to permanent ice cover
Radiometer+altimeter observations are affected by ice
Ocean tide models less accurate (sun-syncronous ERS/ENVISAT/C2/S3)
Retracking is challenging
Residual orbit errors



General Timeline for Satellite Radar Altimeters with Short Repeat Periods



Two Arctic Sea level products

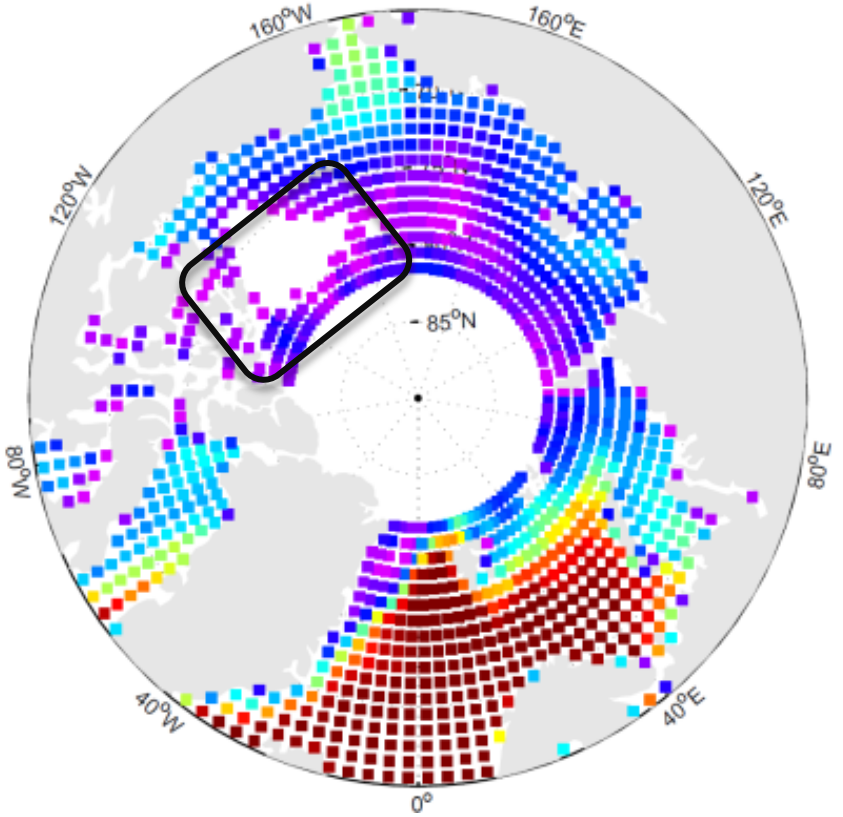
DTU sea level product (ESA-SLcci_ECV Version 2 – G21A-0979)

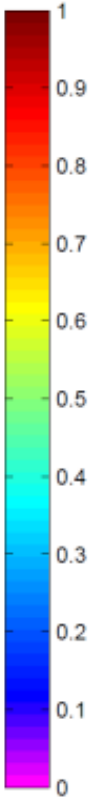
- Covers Arctic Ocean (68N-82N -> 1991-2015)
- Gridded: Spatial res: 0.5 degree, Temporal: 3 Days/1 month.
- NO RETRACKING of ERS/ENVISAT(Brown/Haines retracked).
- In stead: Tailored Arctic reprocessing of RADS data.
- Retracking of Cryosat-2 Baseline B/C SAR data (DTU-LARS).
- Data available from ftp.space.dtu.dk/pub/ARCTIC_SEALEVEL
- Pros: consistent data, Cons: Not adequate data.

NEW DTU/TUM product (ESA-Slcci_ECV V3?)

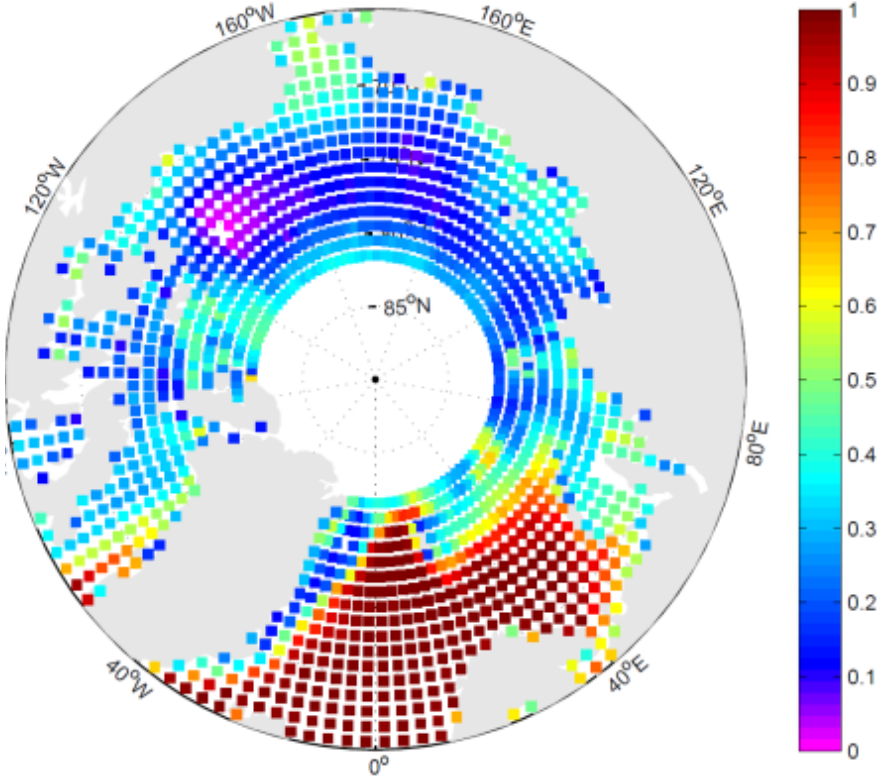
- ALES+ RETRACKING of ERS-2 and ENVISAT.
- Retracking of Cryosat-2 Baseline B/C SAR data (DTU-LARS).
- REAPER retracking of ERS-1.
- Data will be available during spring 2017.
- Pros: More data

DTU Sea Level Product – reprocessed (ESA-SLcci_ECV V2)





RADS available default data
Relative to DTU13 MSS



DTU - Reprocessed data allowing for low SWH+few 20Hz obs and using model corrections (wet) relative to DTU13 MSS

Western Arctic/Beaufort: average data increases of 383%.
(74N-80.5N, 130W-180W) on average data increase of 130 %

DTU/TUM Sea level product:

ALES+ : ALES extension to peaky waveforms

ALES (non-peaky waveforms):

1. Leading Edge Detection

2. First retracking (leading edge only)

3. Subwaveform extension

4. Second retracking of the extended subwaveform

ALES (peaky waveforms):

1. Leading Edge Detection

1a: External estimation of trailing edge slope*

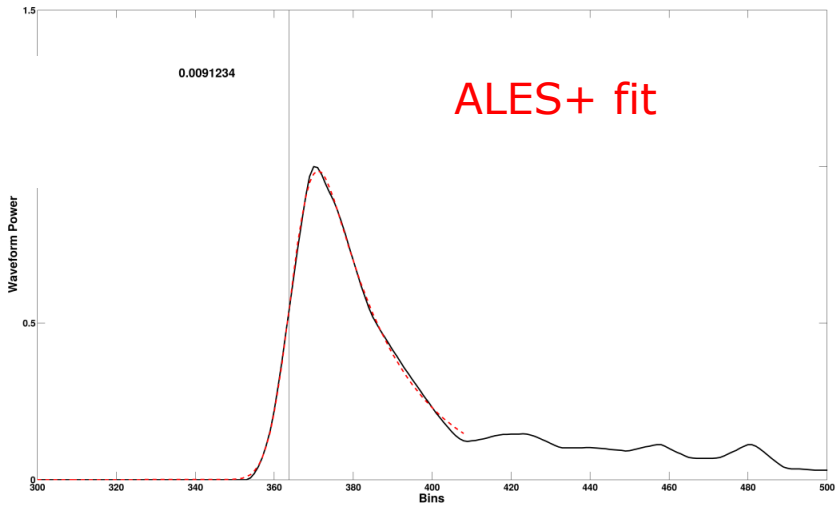
2. First retracking (leading edge only)

3. Subwaveform extension

4. Second retracking of the extended subwaveform

*1a: Brown-Hayne simplified model with trailing edge slope as 4th unknown (similar to CLS solution proposed in CCI)

Retracking Considerably increases number of retrieved SLA valuable to complete time series.



Zoom on an 8x oversampled peaky waveform

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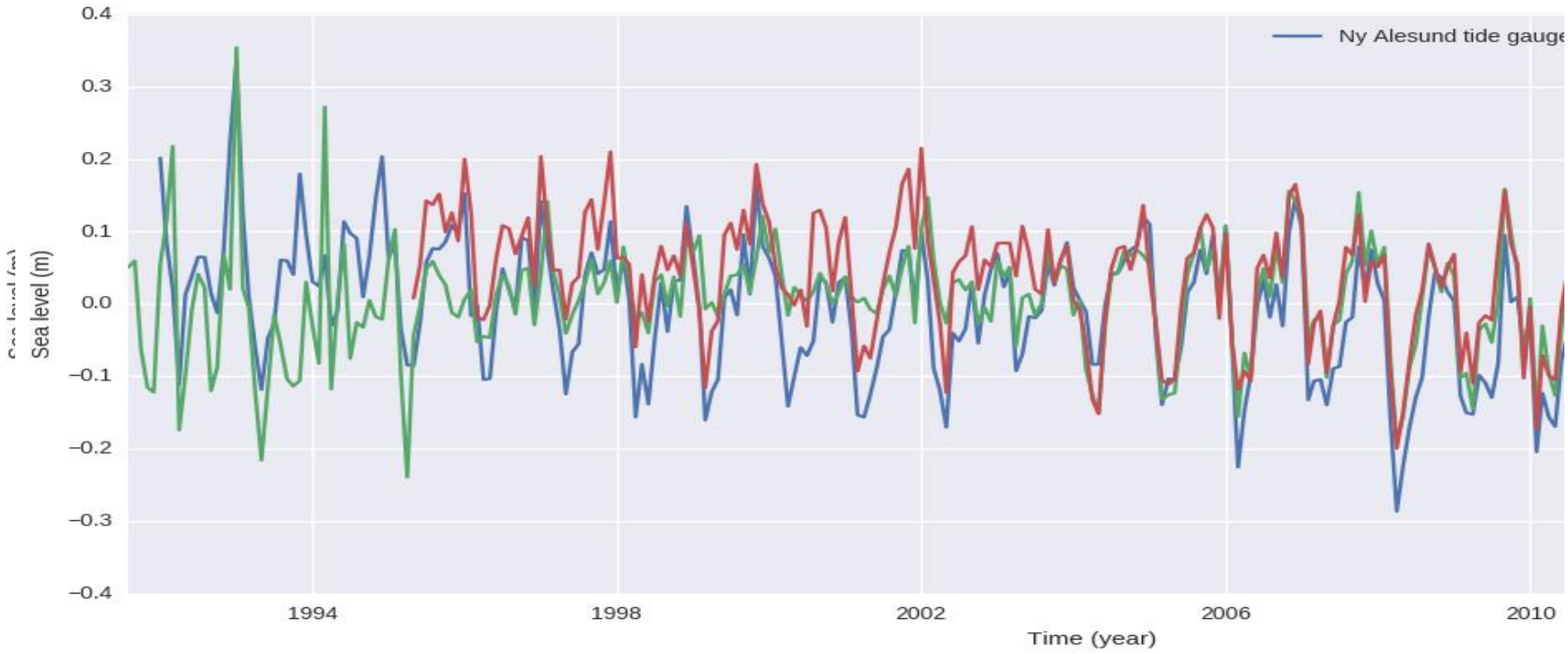
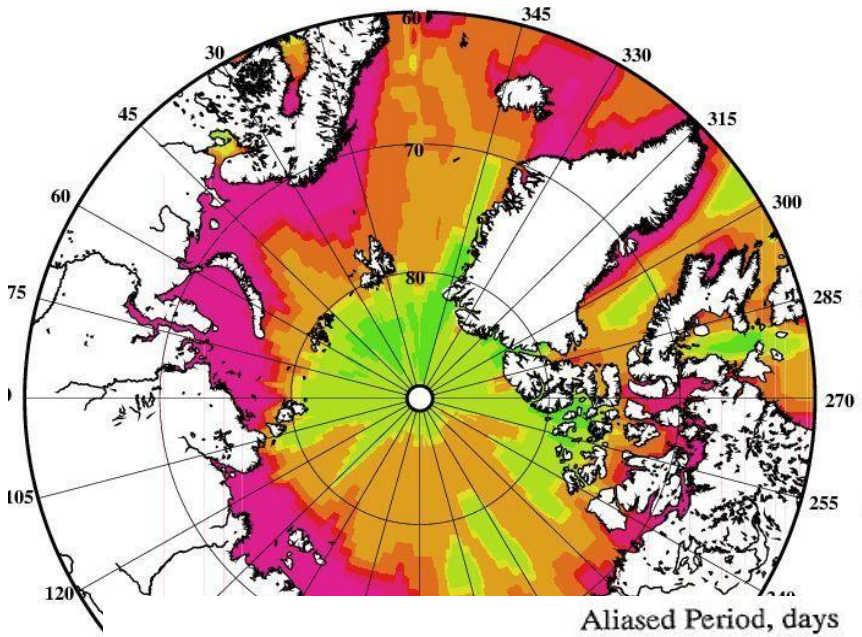
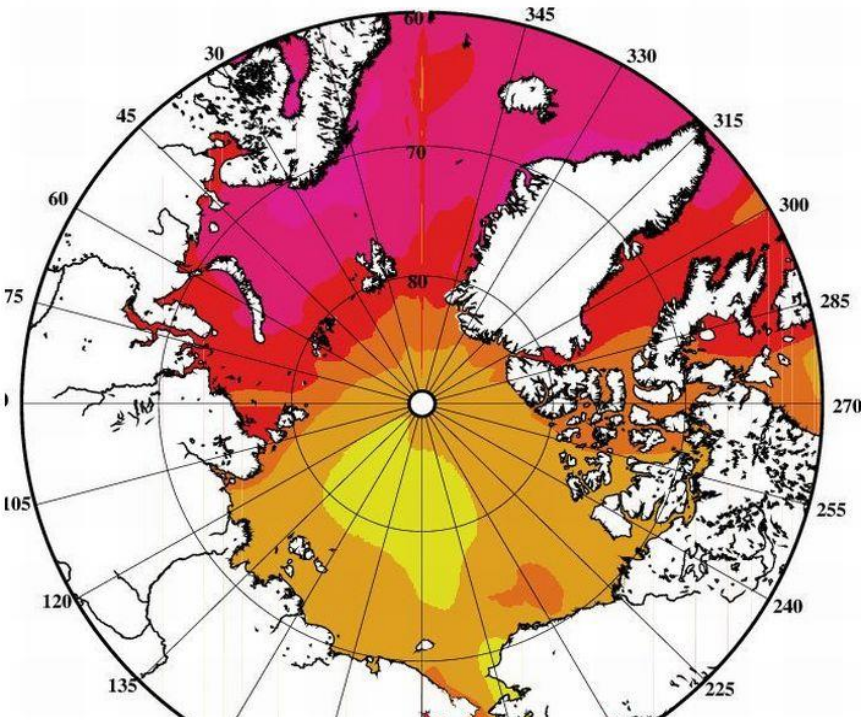
Comparison with Svalbard Tide gauge



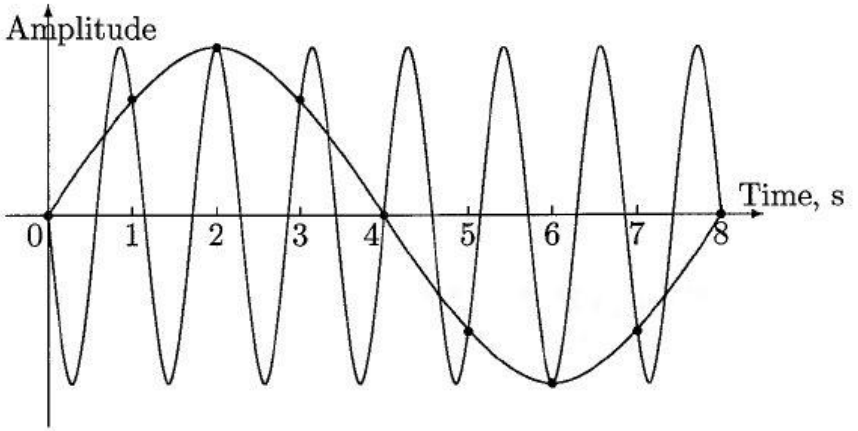
The Annual Signal in the Arctic





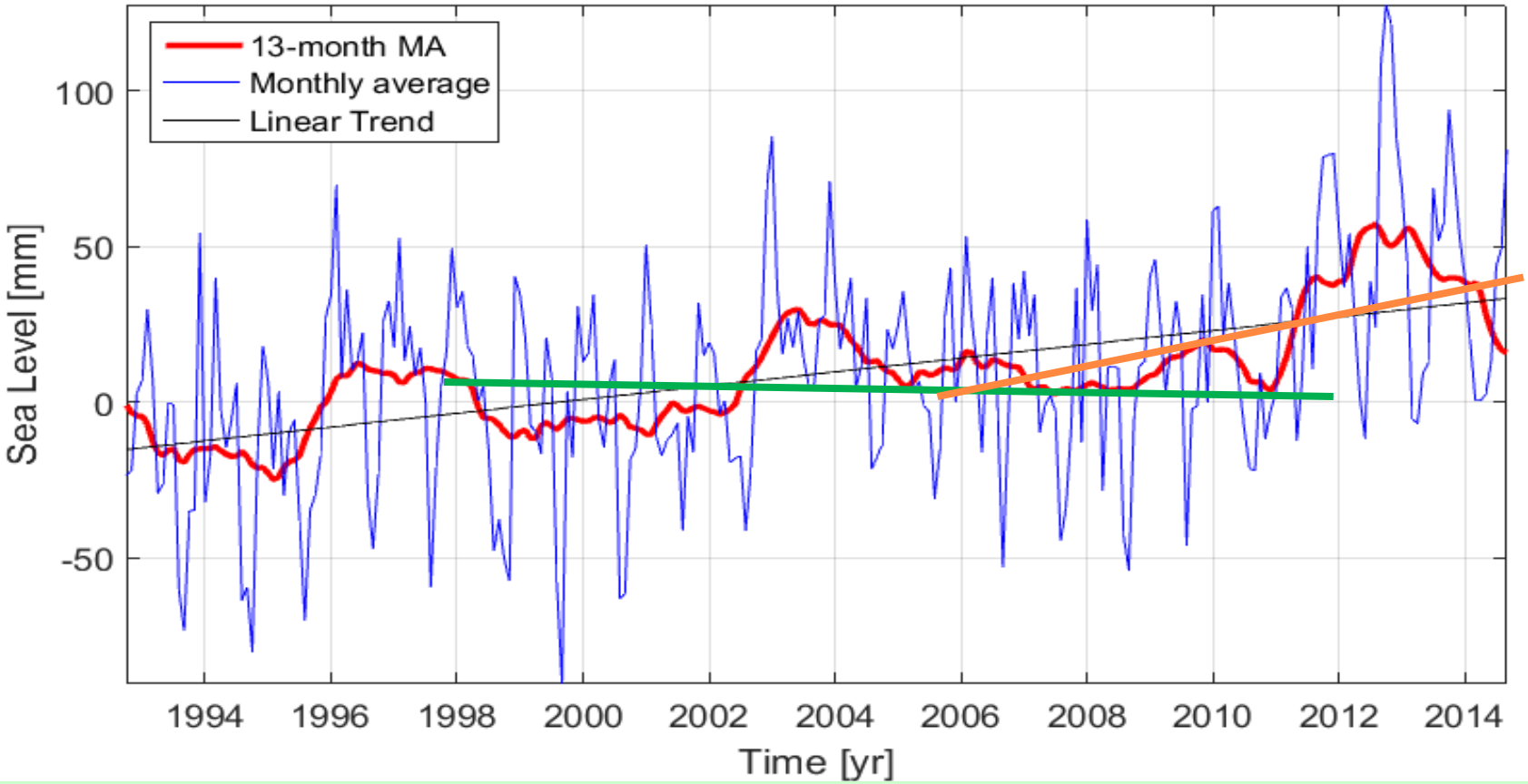
Aliased Period, days

Tides	Tidal Period, hours	ERS 1 35-Day Repeat Orbit
M_2	12.42	−95
S_2	12.00	∞
N_2	12.67	97
K_2	11.97	183
O_1	25.82	−75
P_1	24.07	−365
K_1	23.93	365
Q_1	26.87	133
M_m	661.30	130
M_f	327.84	−80
S_{sa}	4383.00	183



level

Arctic Sea Level trend (68° N – 82° N)



Average linear trend 2.2 mm/year. Large inter-annual variations (AO driven)

Initial Arctic regional sealevel budget.

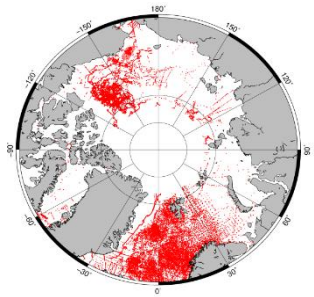
The sea level budget may be expressed as height changes using the main components of sea level change:

$$\Delta SSH = \Delta SH + \Delta OM$$

SSH = sea surface height, SH = steric height,
OM = ocean mass from GRACE (JPL-MASCONS)

Steric signal from NOAA model -> 2005-2015 period.

No ARGO data available



Closing the Arctic Sea Level budget (2005-2015 -> "first attempt")

Components	Linear trend (2005 – 2015) [mm/y]
Sea level (Altimetry)	4.34 ± 2.44
Mass (GRACE)	3.85 ± 0.87
Total steric (NOAA)	0.09 ± 0.36
Thermosteric	0.33 ± 0.32
Halosteric	-0.24 ± 0.14
GRACE + steric	3.94 ± 0.94

Sea level budget closure within 0.5 mm/year (68N-82N)

During 2005-2010 large halosteric component found (0.9 mm/year).

Summary and availability.

- The DTU reprocessed sea level product available (ftp.space.dtu.dk/pub/ARCTIC_SEALEVEL)
- The DTU/TUM retracked sea level product will shortly be available.
- The Annual signal is heavily influenced by atmospheric pressure
- The linear sea level trend has large inter-annual variations (AO driven).
- First attempt to close Arctic Sea level budget closes at < 0.5 mm/year
- Check out ESA SL-cci ECV poster Tuesday at **G21A-0979**