ALBATROSS

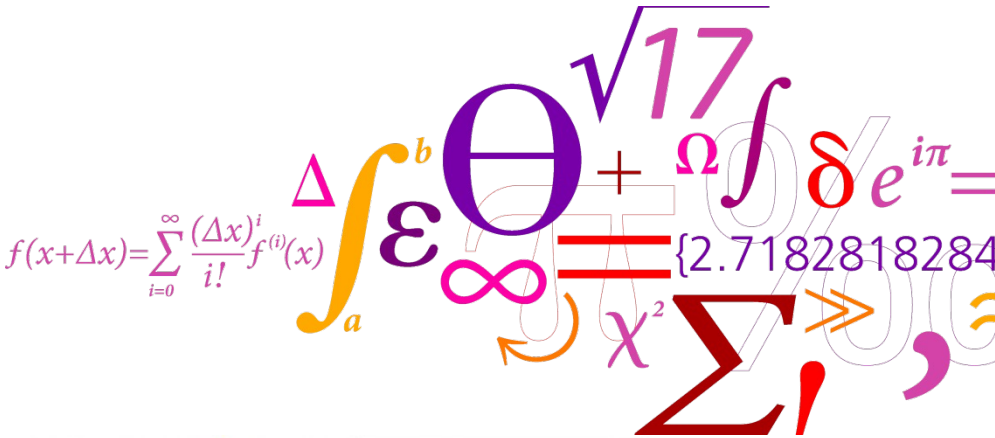
IUGG BERLIN 2023
THE 28TH GENERAL ASSEMBLY OF THE INTERNATIONAL UNION OF GEODESY AND GEOPHYSICS

Polar Ocean Tides Revisited

Arctic and Antarctic ocean tides from Cryosat-2

Ole Baltazar Andersen (DTU)
Stine Kildegaard Rose (DTU)
Mike G. Hart-Davis (TUM)

Contribution to
ESA ALBATROSS project



DTU Space
National Space I

NOVELTIS DTU earthsciences UCL esa

Cryosat-2 Orbit parameters

With ESA official
369 days repeat

	Jason-3	Saral AltiKa	Cryosat-2	Sentinel 3A/3B
M2	61.75	95.33	8487.00	155.25
S2	58.74	∞	∞	∞
K1	179.00	341.86	4647.46	341.86
Annual	365	365	33671	365

Table 2: Alias periods given in days.

Zaron et al. 2018

TABLE 1. *CryoSat-2* orbit parameters.

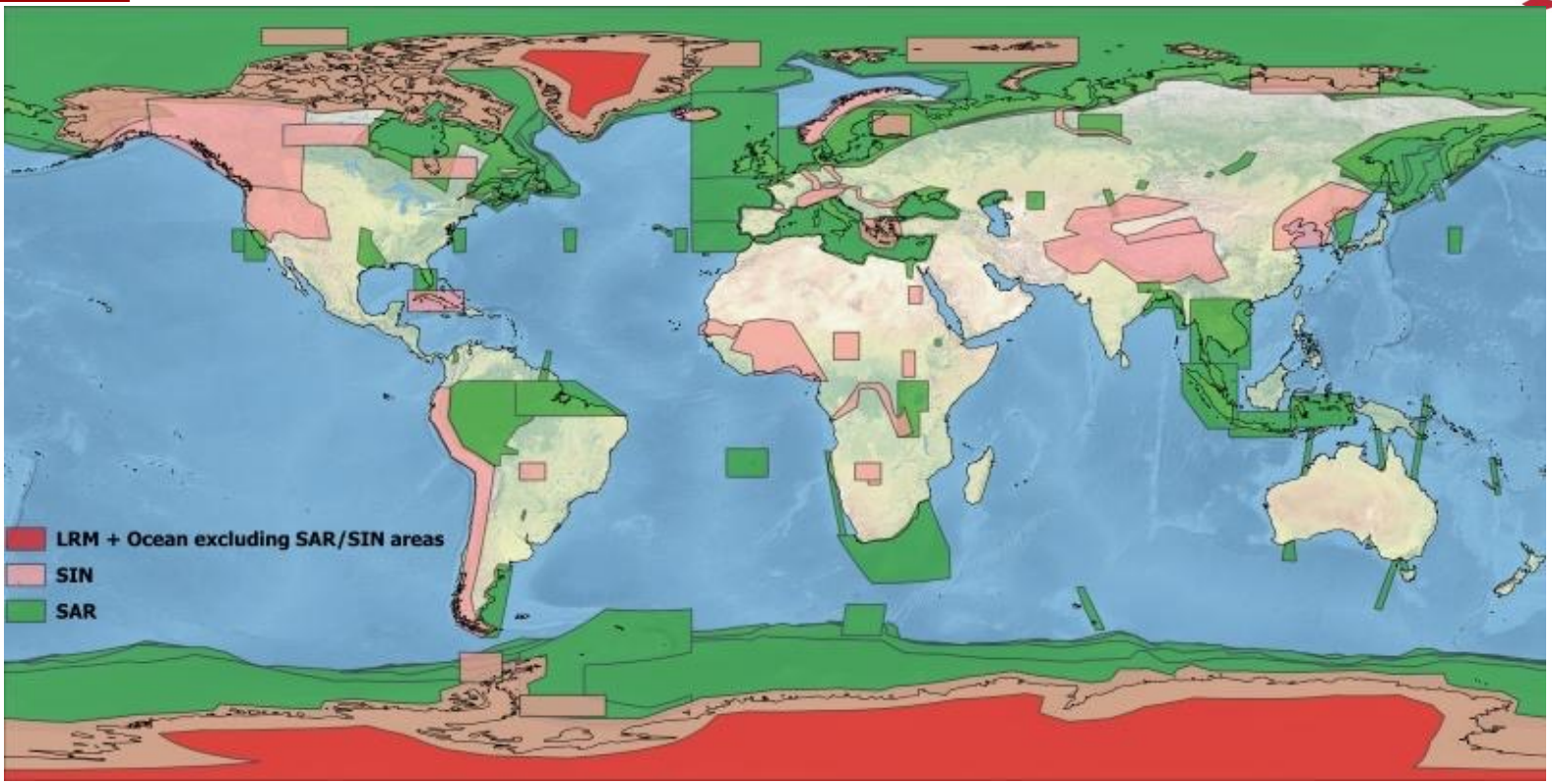
Orbit attribute	Value
Altitude	717.242 km
Inclination	92°
Repeat cycle	368.24 days
Orbits per cycle	5344
Track spacing at equator	7.5 km
Pseudosubcycles	28.33 days, 2.18 days
Orbit period	1.654 h
Mean local solar time drift	$-179.21\,\mathrm{s\,day^{-1}}$
Longitude of ascending node	309.37°

C2 – Real Tidal Aliasing

	Sample interval Δt (days)				
	368.2396	28.9410	19.4246	7.5180	1.9983
M_2	800	371	42	16	14
S_2	768	245	129	209	576
K_2	743	715	438	98	267
N_2	2095	225	113	30	9
K_1	1486	1430	41	16	535
O_1	1262	294	347	638	14
P_1	1591	209	52	15	277
Q_1	5106	195	55	26	9
NO_1	3170	962	86	28	29
MO_3	2187	164	47	16	7
MK_3	1734	500	1682	115	15
M_4	4633	185	288	140	7

Zaron et al. 2018

Cryosat -2 reprocessing using ESA GPOD



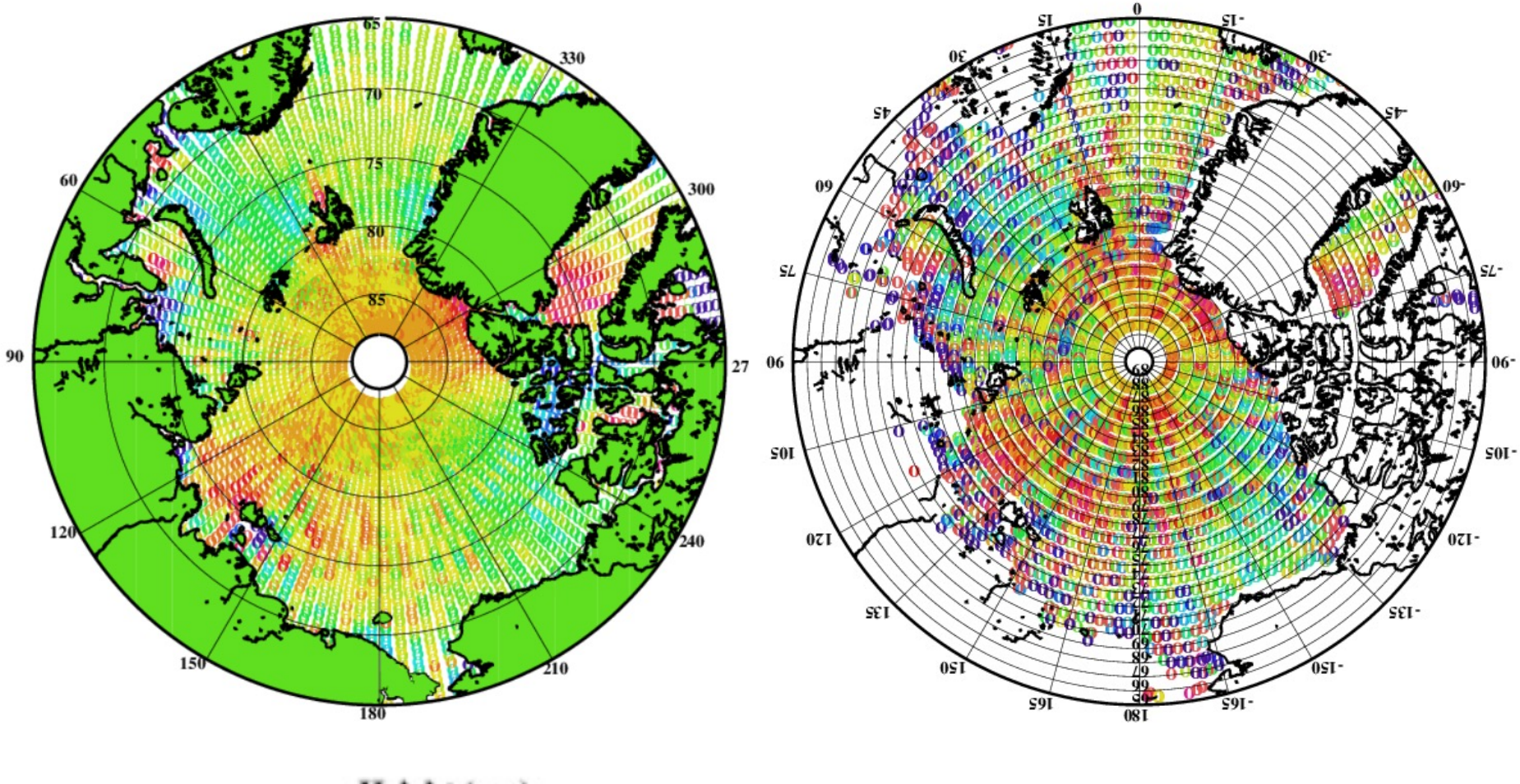
SAMOSA+ modification to SAMOSA retracking model by Dinardo, S (2018)
Works over SAR and SARin region (most of Arctic and Antarctic)
Operate over specular scattering surfaces as ice and robust to off-nadir returns from ice

Solving for SSH, SWH and Wind Speed enables the determination of SSB

Arctic Ocean M2 cosine FES2014 residuals Importance of Retracker

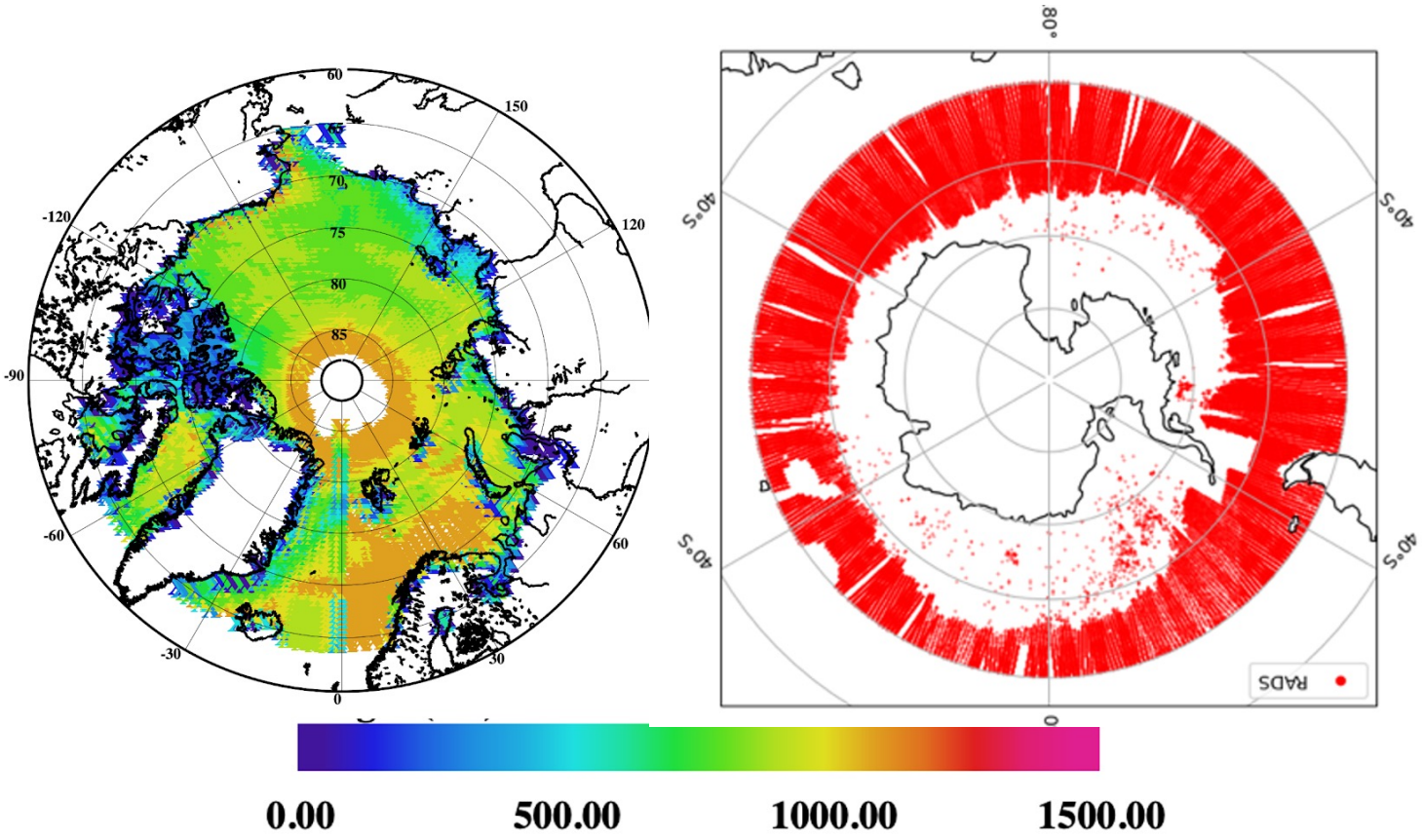
Physical SAMOSA+.

Empirical Threshold rtrk



SAMOSA+ Retracker (2010-2019)

- SAR+SARin physical Retracked (>80% of the region) by ESA GPOD service
- We compute and apply Sea State Bias to SAR+SARin data
- LRM from RADS 1 Hz products
- Add other satellites when available and when it improve solution (SA/N1+Jasons)



Method

- Remove/restore wrt FES2014b ocean tide model.
  - Remove Elastic Ocean tide.
  - Compute EO residuals
  - Restore loading residuals and FES2014b ocean tide constituents.

- Averaging 20 Hz SLA anomalies witin 0.5 x 3 degree cells (shifted)
  - Use C2 (LRM,SAR,SAR)
  - ?????

- Accuracy of MSS is an issue (track to track)
  - We apply DTU21MSS to minimize (Based on SAMOSA retracked data).

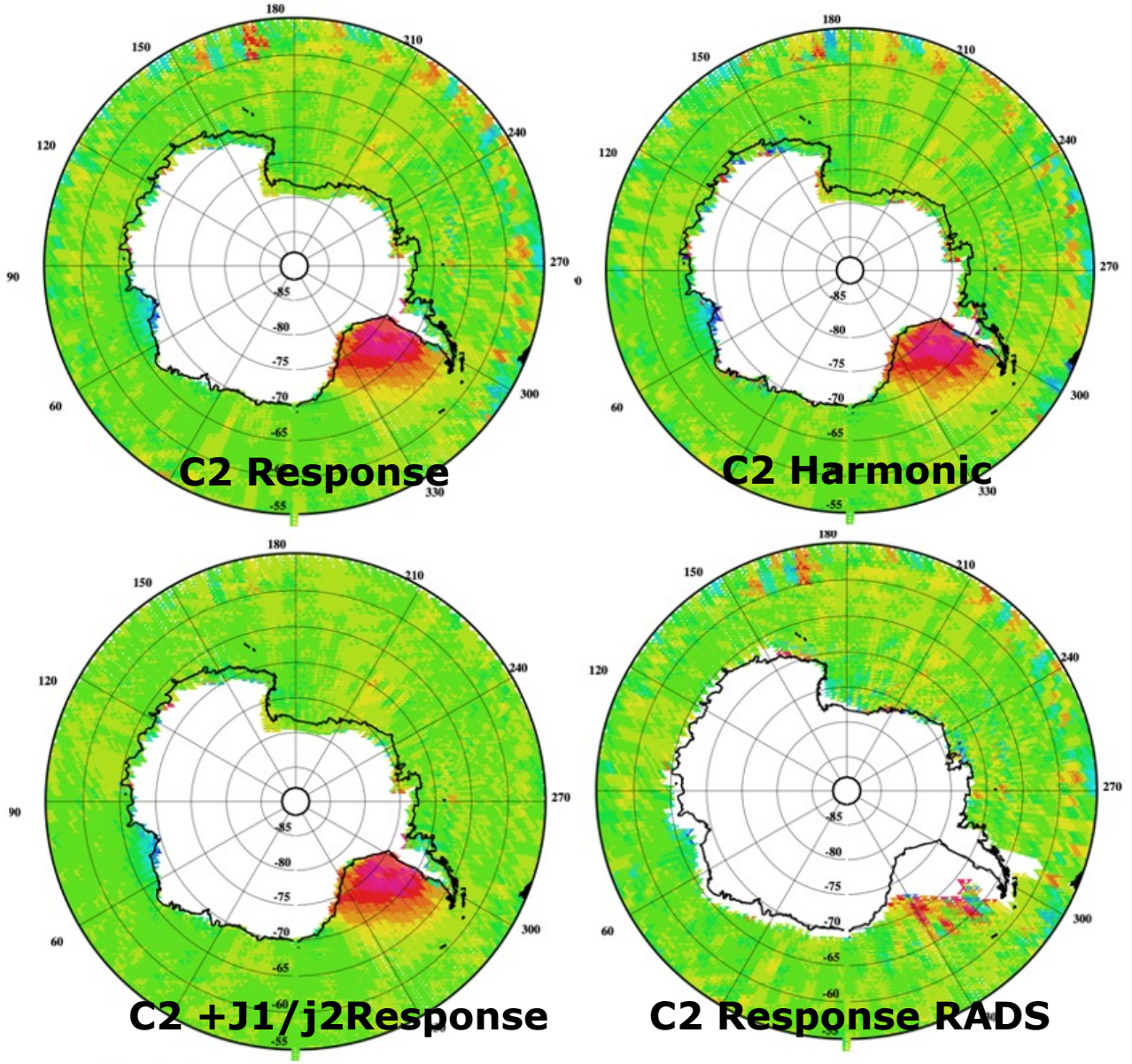
- Use Response method (Added harmonic prediction of non-linear (M4, MS4)

$$h(t) = \sum_{m=1}^{2}\sum_{k=-K}^{K}[u_k\, a^m(t-\Delta k) + v_k\, b^m(t-\Delta k)] \quad \text{(diurnal, semidiurnal)} \qquad \text{12 param}$$

$$+ \sum_{n=1}^{N}[H1_n \cos(\sigma_n t) + H2_n \sin(\sigma_n t)] \quad \text{(shallow water)} \qquad \text{4 param}$$

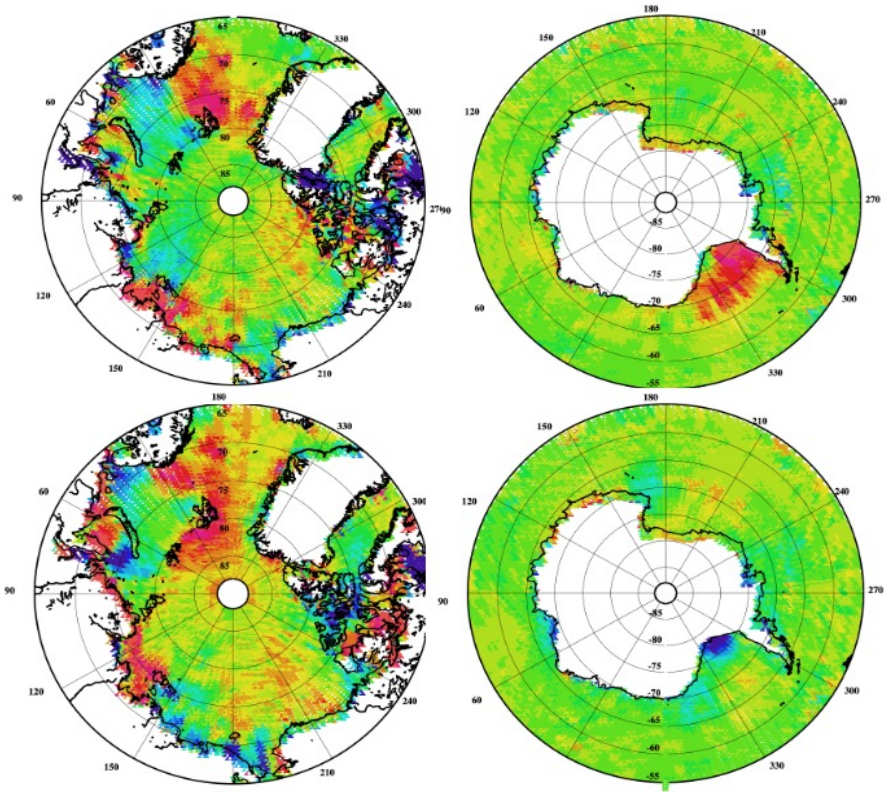
$$+ H1_{ann} \cos(\sigma_{ann} t) + H2_{ann} \sin(\sigma_{ann} t) \quad \text{(annual variation)}. \qquad \text{2 param}$$

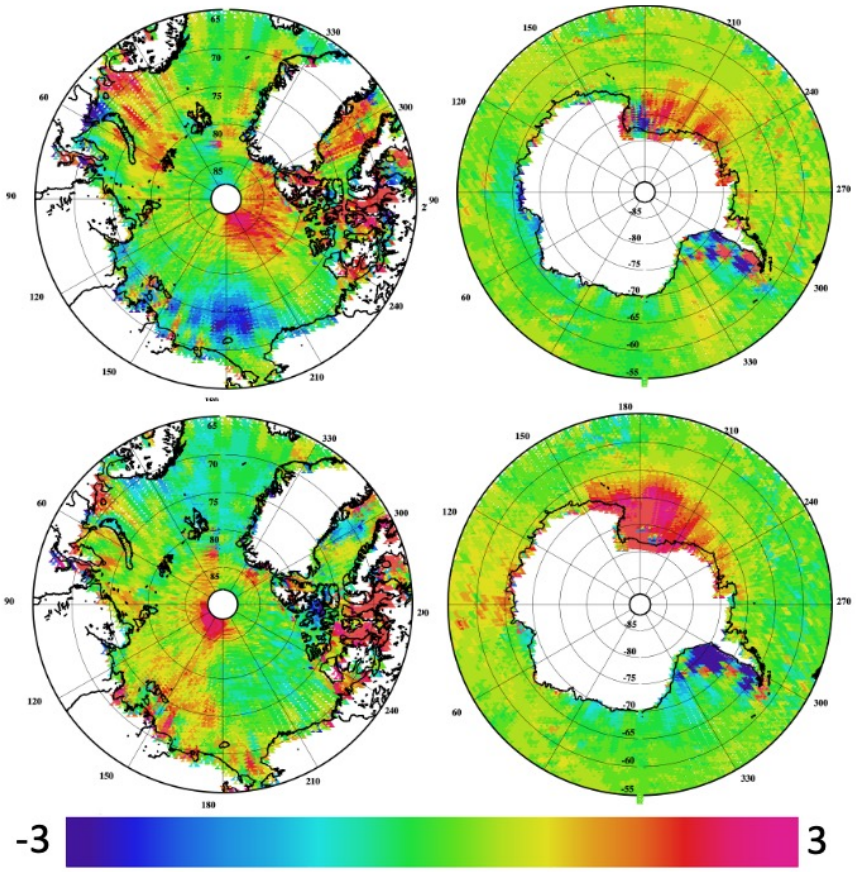
M2 cosine


C2 Response
C2 Harmonic
C2 +J1/j2Response
C2 Response RADS
-5
5

S2

K1

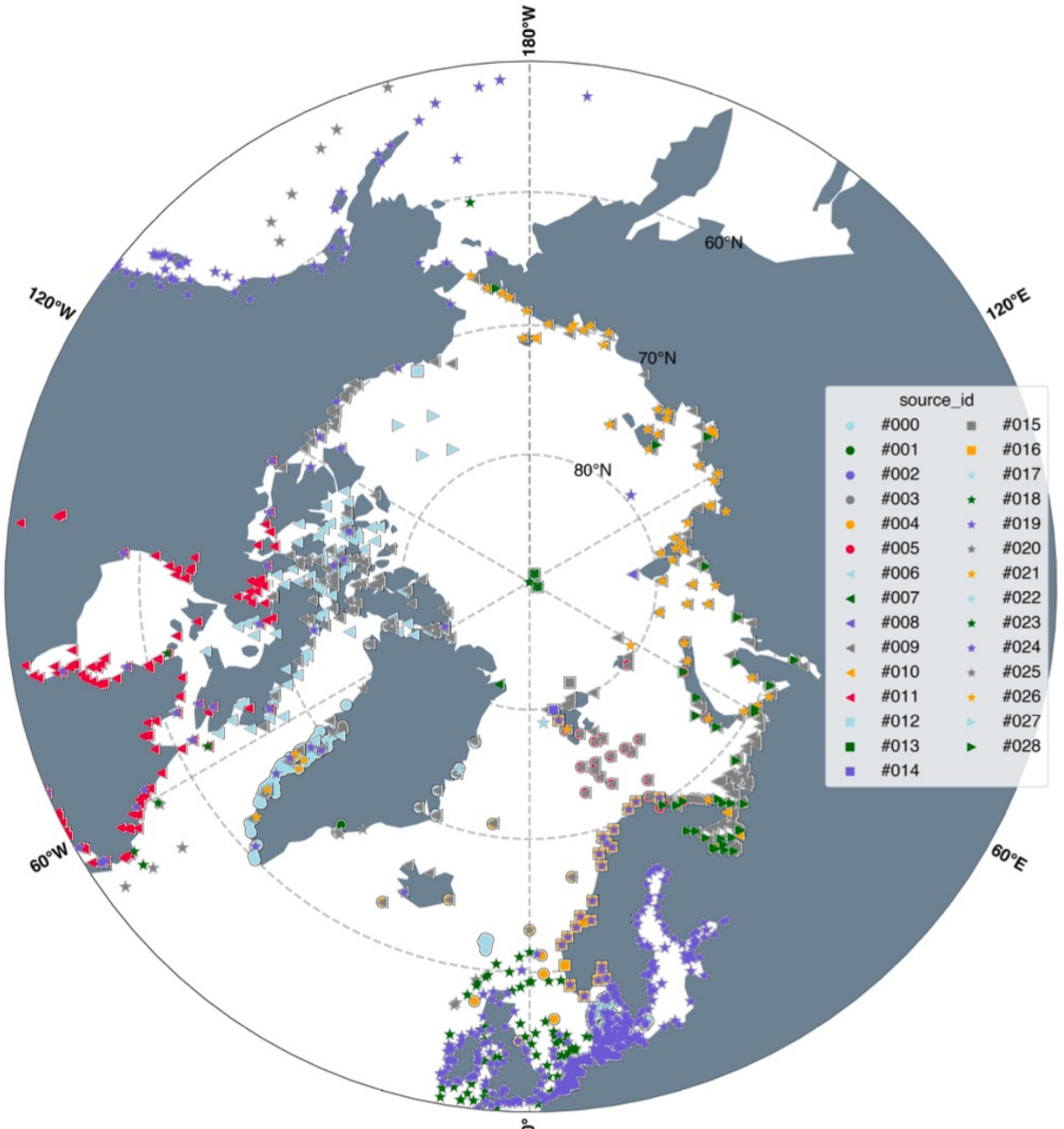




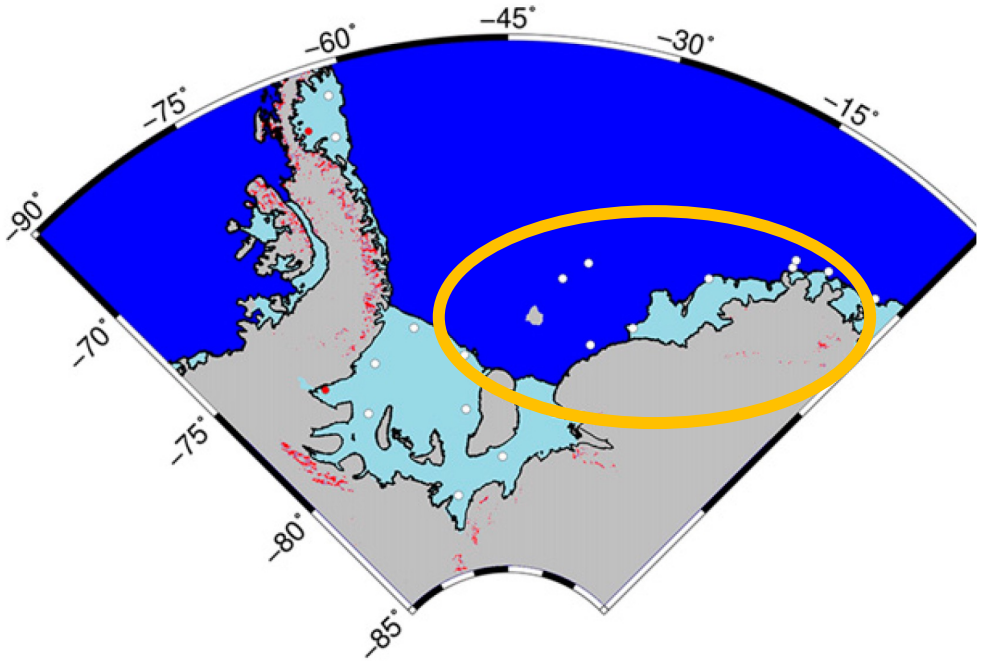
ArcTiCA new tidal dataset

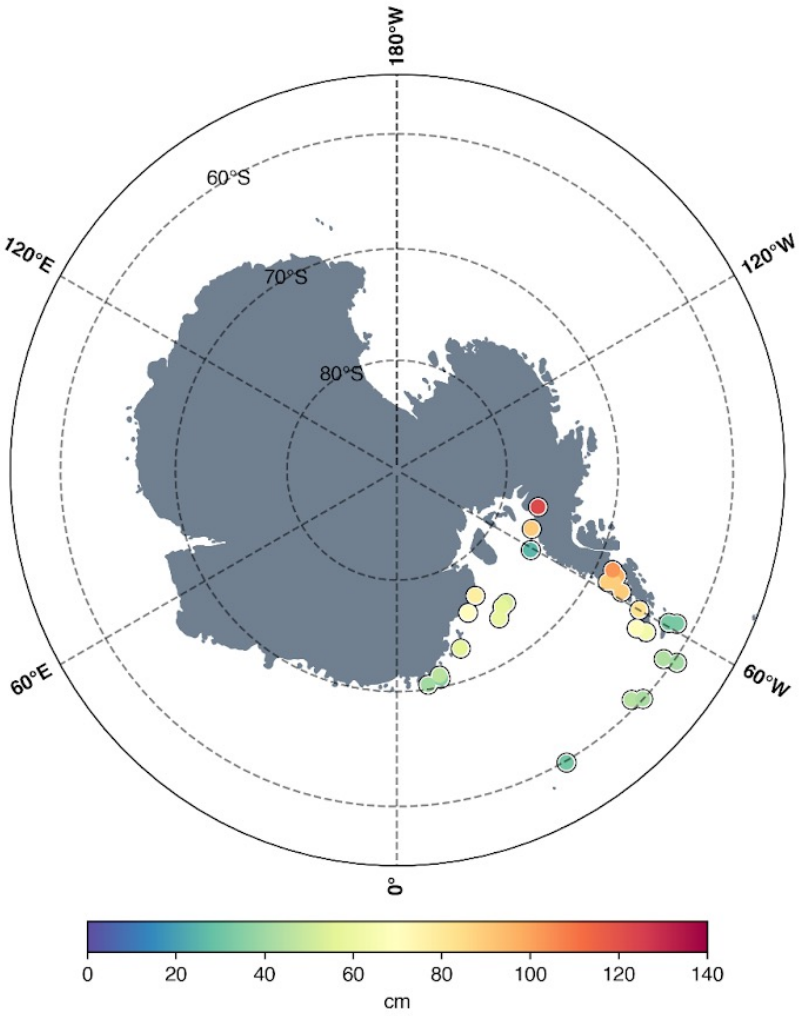
- *Mike Hart-Davis, Susan L*
Ray, Ole Andersen, Laurie F
& Denise Dettmering. (202
Constituent Atlas (ArcTiCA)
elevation constituents for t
1800 through present day.
Center. doi:10.18739/A2D7
-
-
- https://arcticdata.io/cata
739/A2D795C4N

Used 137 station



28 Tide gauges in Weddel Sea

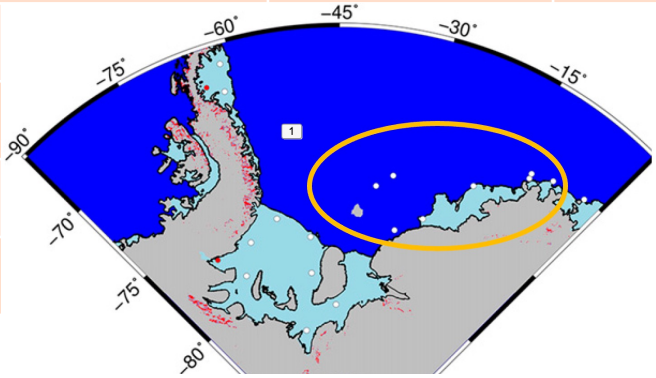




Stations by L. Padmam/M. King et al.
Compiled by Zaron.

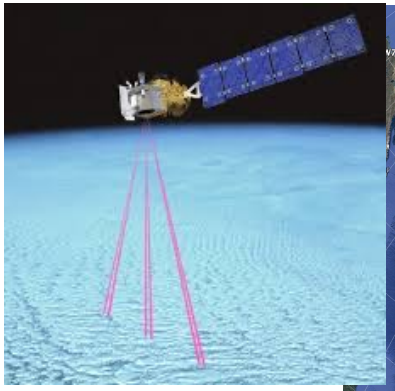
RMSVE. Comparison (28 stations). Zaron+King+Padman

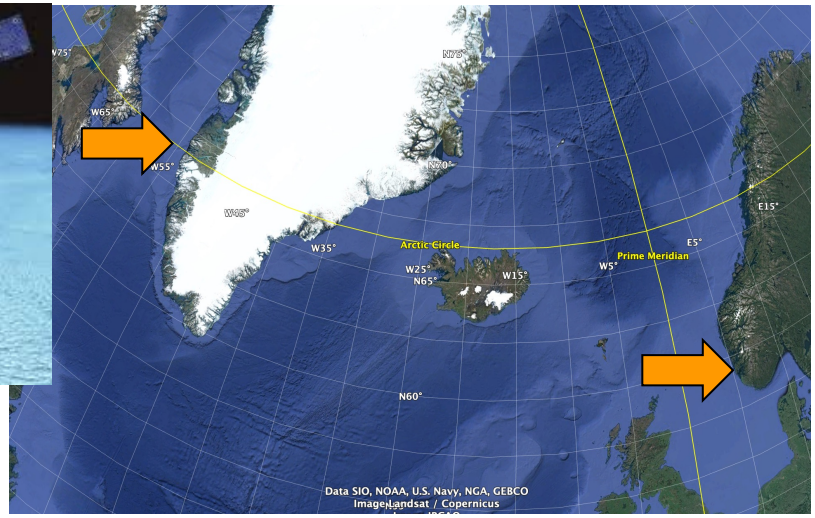
	FES2014 (cm)	GOT 4.10	CATS08	Zaron 2018	"DTU22" (cm)
M2	4.51	4.3	4.5	3.9	3.88
S2	4.43	8.8	7.6	6.8	2.76
K1	6.04	4.5	2.4	2.8	2.43
O1	6.69	5.6	1.2	2.1	2.61
8 selected					
M2	4.65				2.39
S2	4.62				2.69
K1	5.19				2.51
O1	6.01				2.44



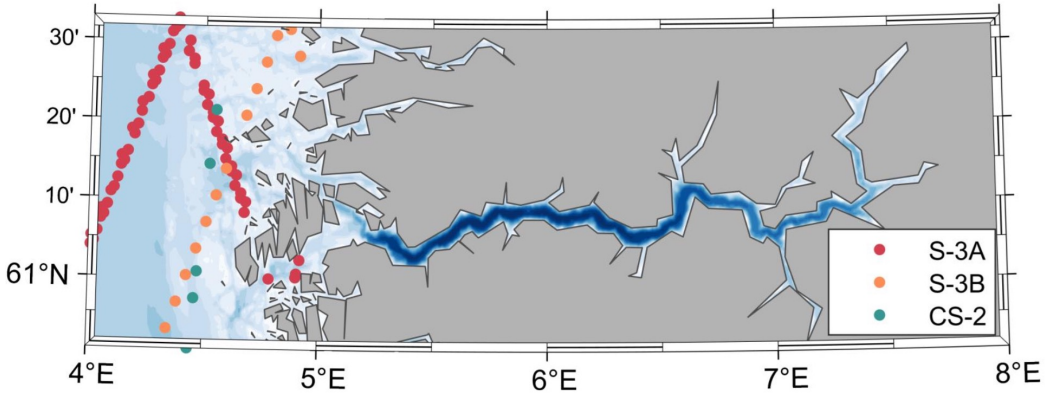
Numbers from GOT4.10/CATS08/Zaron are from Zaron et al. Table 5

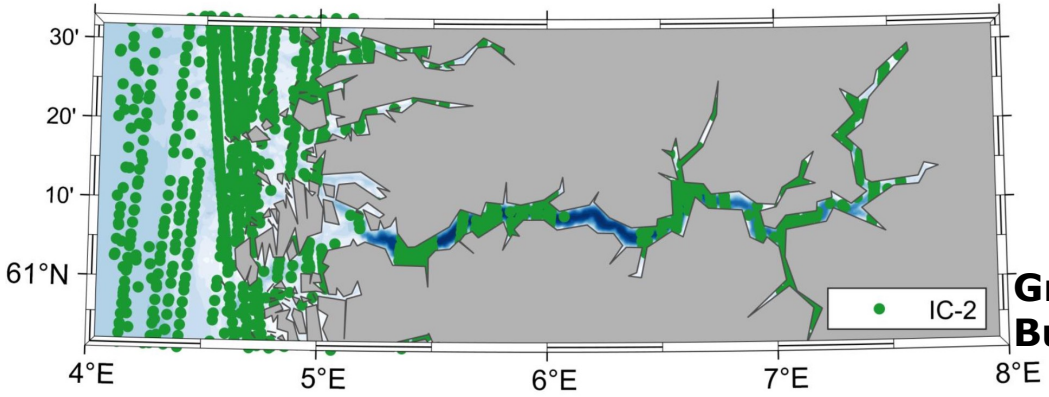
Coastal revolution with ICESAT-2 laser

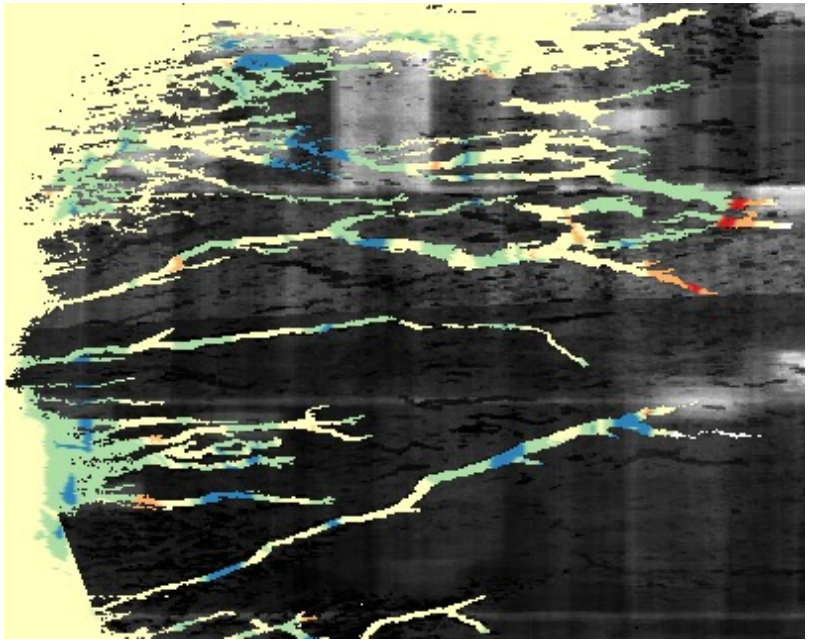




Footprint 17 meters







Greenland: "Perfect" coastal coverage
But no tide models (GOT4.8) available

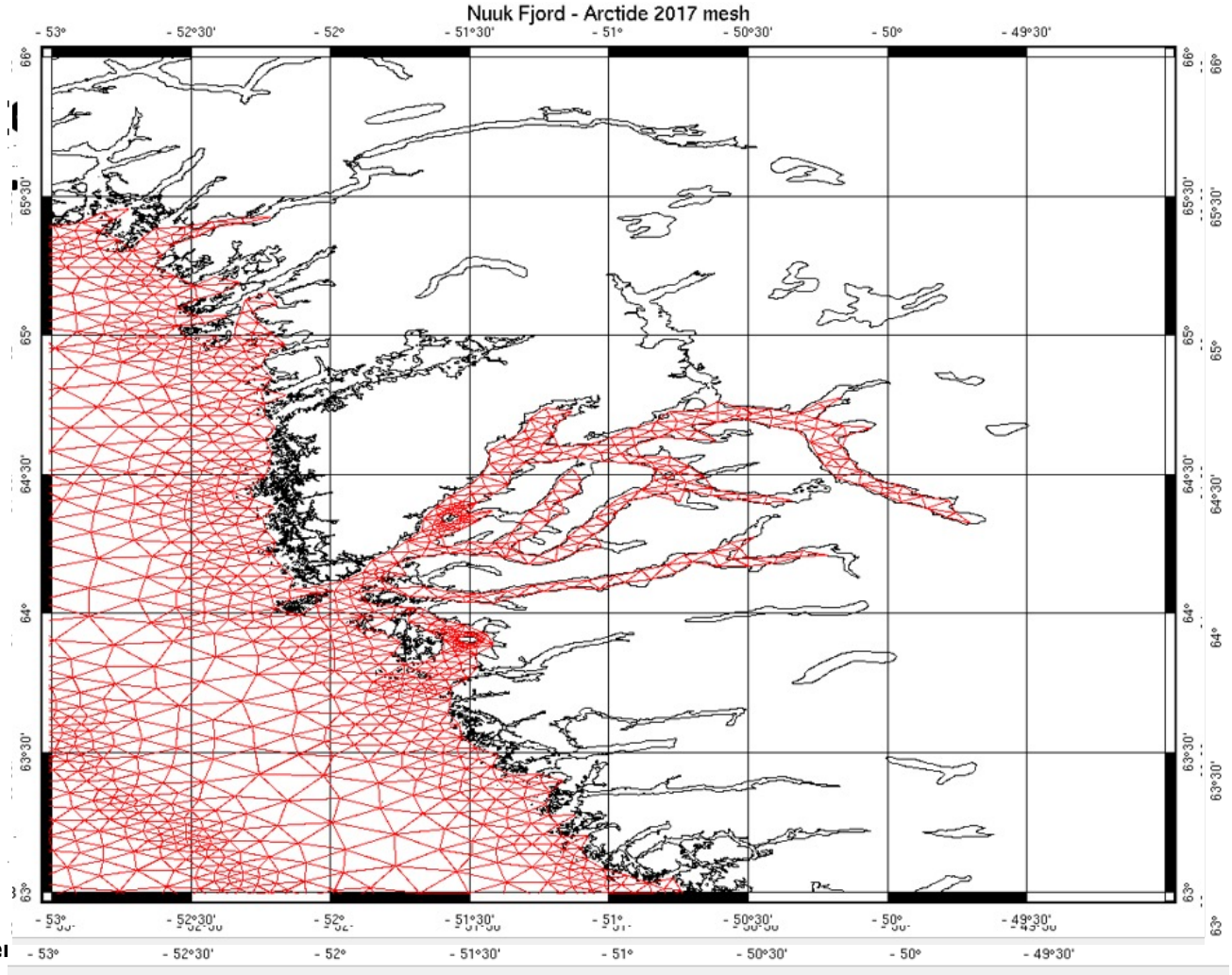
Tomic and Andersen, Rem Sens 2023, submitted.

Vrettou and Andersen

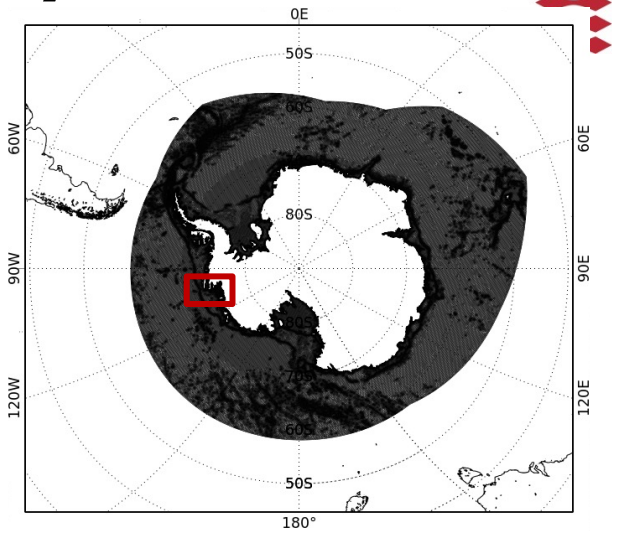
Will FES2022 help us

Our definition
Of Coastline is
in-adequate

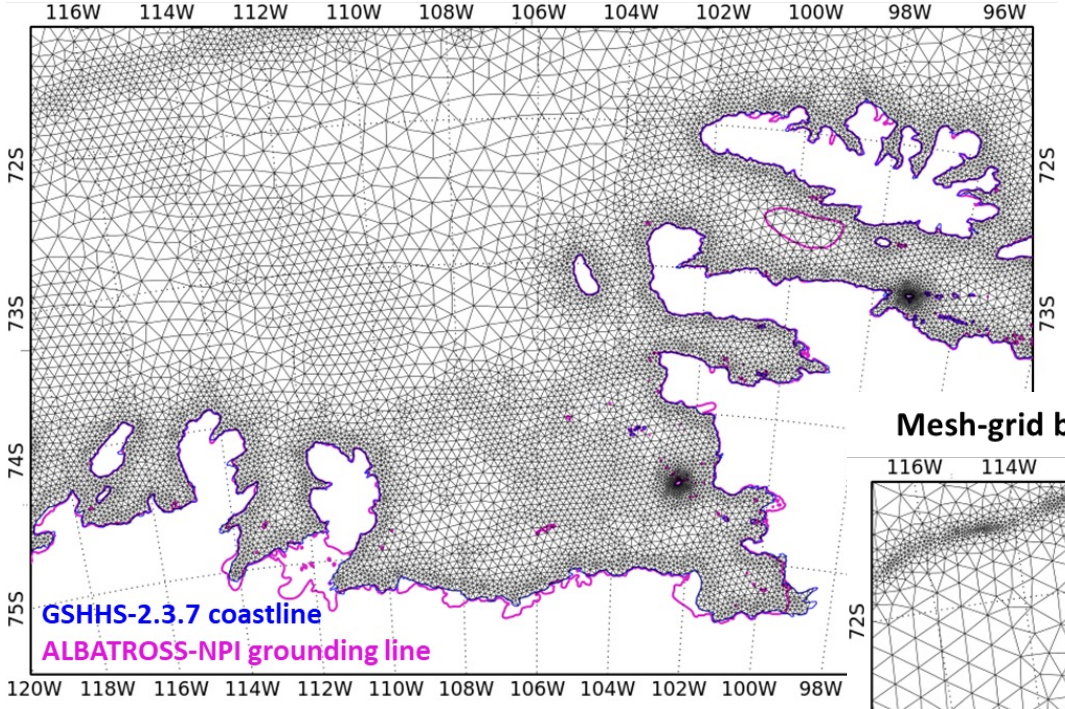
Out Bathymetry
Information is
In-adequate



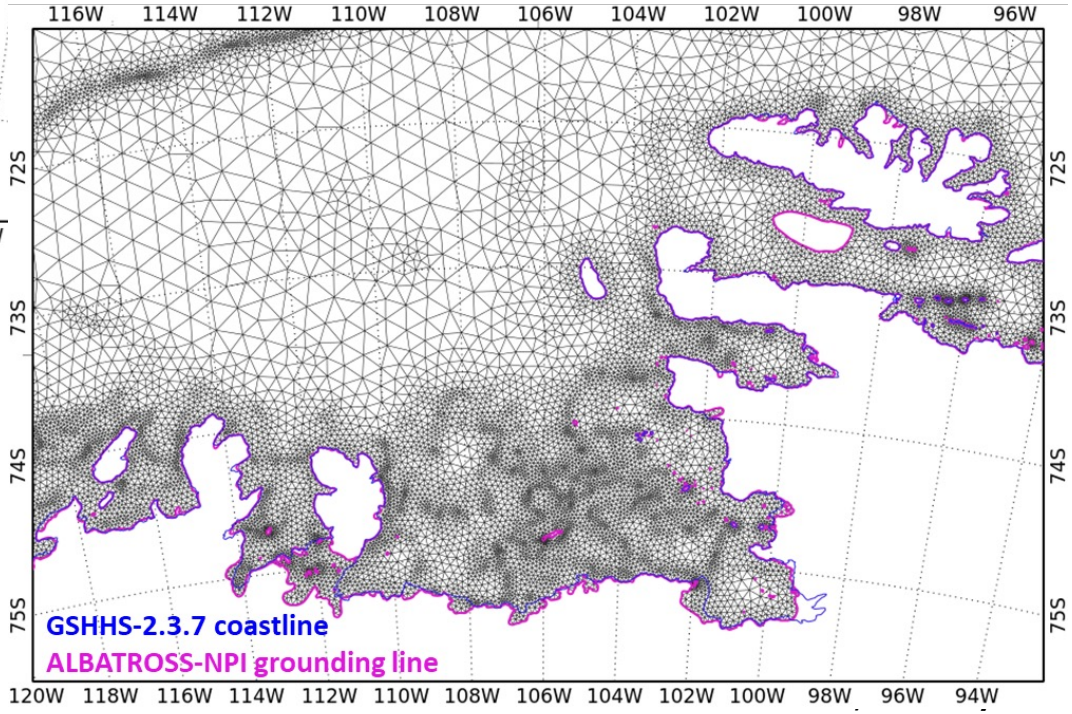
Local Models the way forward?



Mesh-grid based on GSHHS-2.3.7 coastline



Mesh-grid based on ALBATROSS-NPI new grounding line/coastline



Noveltis in Albatross

800 m at the coast

800 m – 4 km on the shelf

Conclusions

Cryosat-2's 3.68.24 days repeat is great for tidal prediction.

Important to maintain and develop independent validation dataset

Important that ESA HAS chosen to launch CRISTAL in similar orbit to Cryosat-2

As SARAL and Sentinel 3 are Synsyncronous (Bad S2)

Thanks to ESA for supporting the the Albatross project.
Thanks to ESA GPOD service -> Earth Console

Data and model availability

Binned altimetric anomalies (DIY tide model and methodology)

Estimated constituents at point locations (24 major constituents)

DTU22 ocean tide model.

Data.dtu.dk (briefly).

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