Sea Level Monitoring in the coastal zone: impact of retracking and correction choices

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ESA Sea Level Climate Change Initiative (SL_cci) Phase II

Rationale

The impact of Sea Level Rise (SLR) is maximum at the coast, but altimeter data in the coastal zone have traditionally been flagged out

COAST SLR rate from tide gauges	….GAP….	OPEN OCEAN SLR rate from altimetry

Progress in coastal altimetry in the last 10 years has been steady

- see coastal altimetry session on Wednesday, and summary of 10th Coastal Altimetry Workshop on Friday

- new retrackers such as ALES
- new corrections as GPD+ Wet Tropo

→ more/better valid measurements

In this work we extend the SLR measurements towards the coast (and see whether they make sense)

"can we fill the gap?"

Aim, reworded

Achieve closure of the open ocean vs coast SLR rate problem

- in perspective this could help estimate vertical land movement:

VLM = rate(TG) – rate(alt)

this may also help to detect and characterize local processes that impact significantly on the local SLR

Study strategy

We evaluate:

- The impact of the ALES retracker on SLR rate estimation in coastal zone
- The impact of correction choices on SLR rate estimation in coastal zone

we take as reference for the comparison SLR rates from several datasets:

- the gridded SL_cci v2.0 products
- SGDR (with the MLE4 retracker)
- RADS

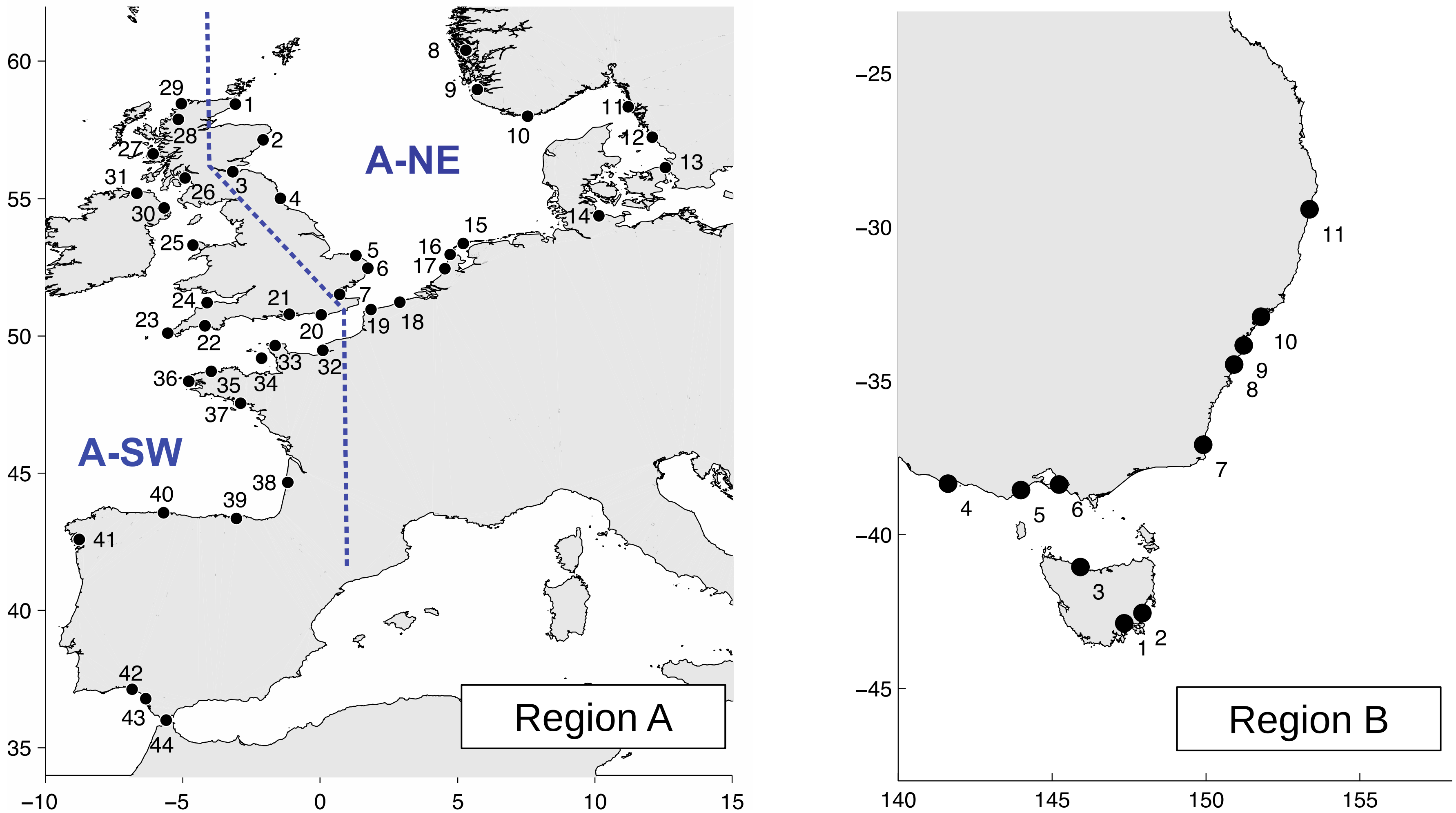
Methodology:

- compute along-track SLR rates on reference orbits, with various retracker/correction choices
- bin and analyse results **as a function of distance from coast**
- also compare with TG-derived rates at the coast

Two separate regions (Western European coast from Gibraltar to Scandinavia, and Southeast Australia)

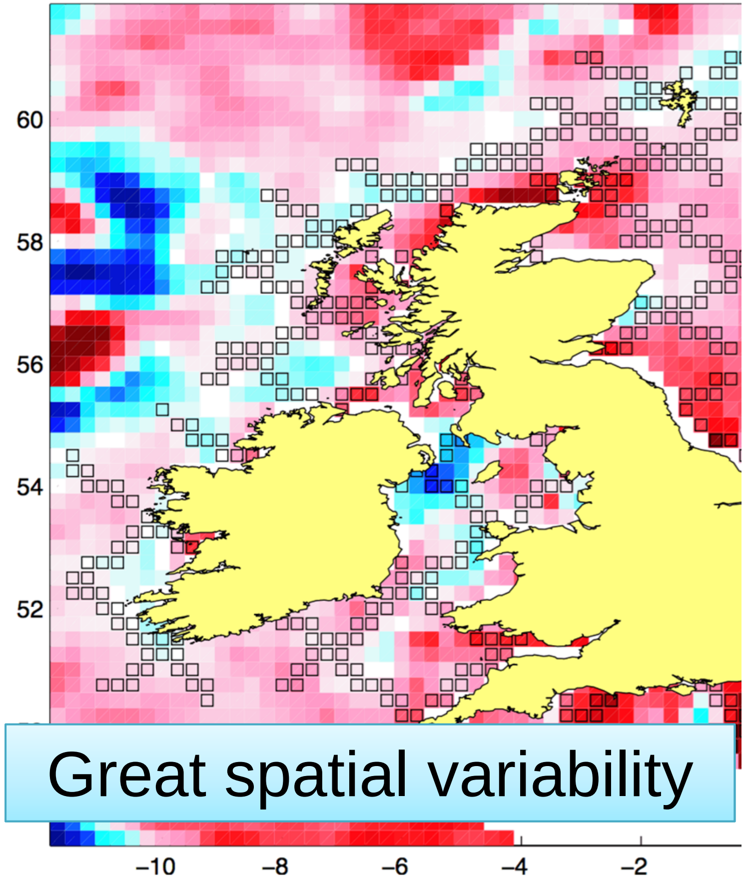
Caveat: J1+J2 only (so 2002-2015, noisier rates but still representative of coastal capability and impact of choices)

Regions of study



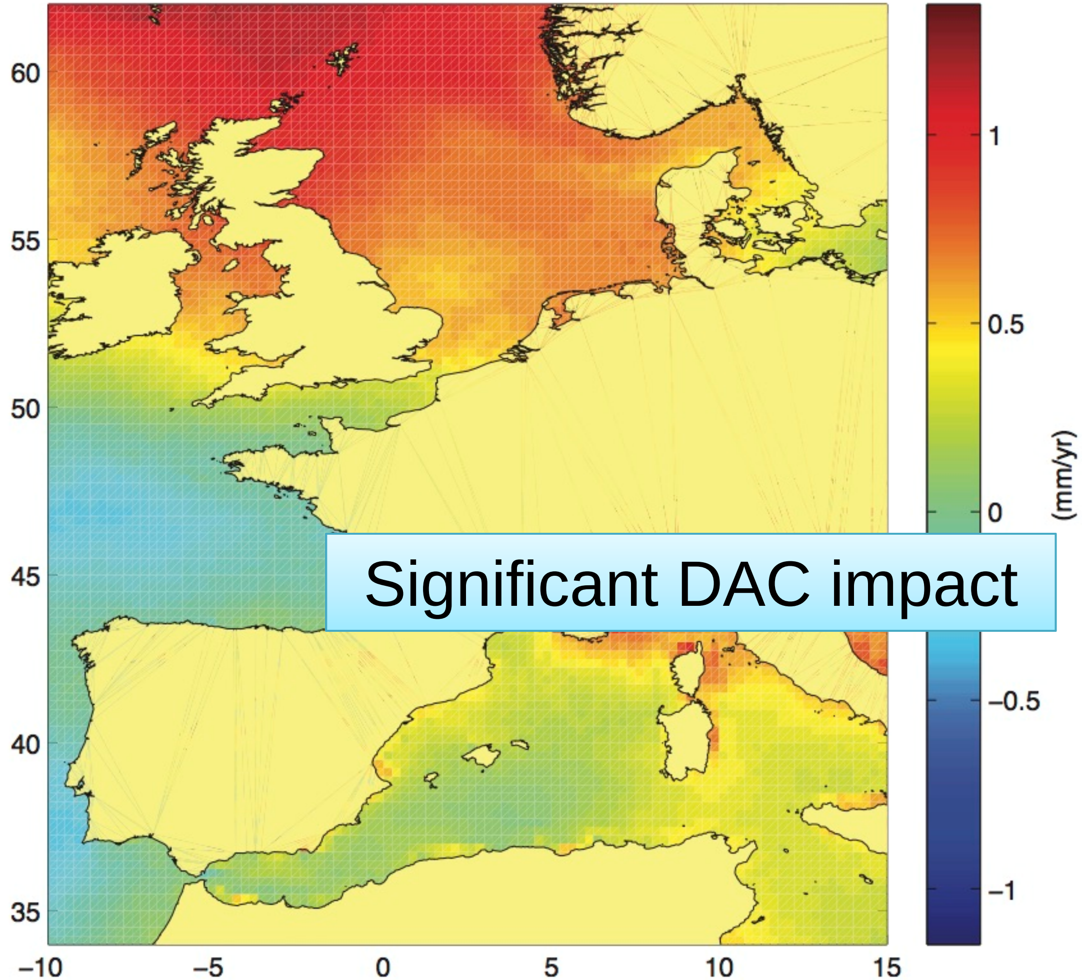
Some challenges

SLR trends, SL_cci v2.0, 2002



Great spatial variability

Dynamic Atmosperic Correction (DAC) contribution to Sea Level variation over 2002-2015



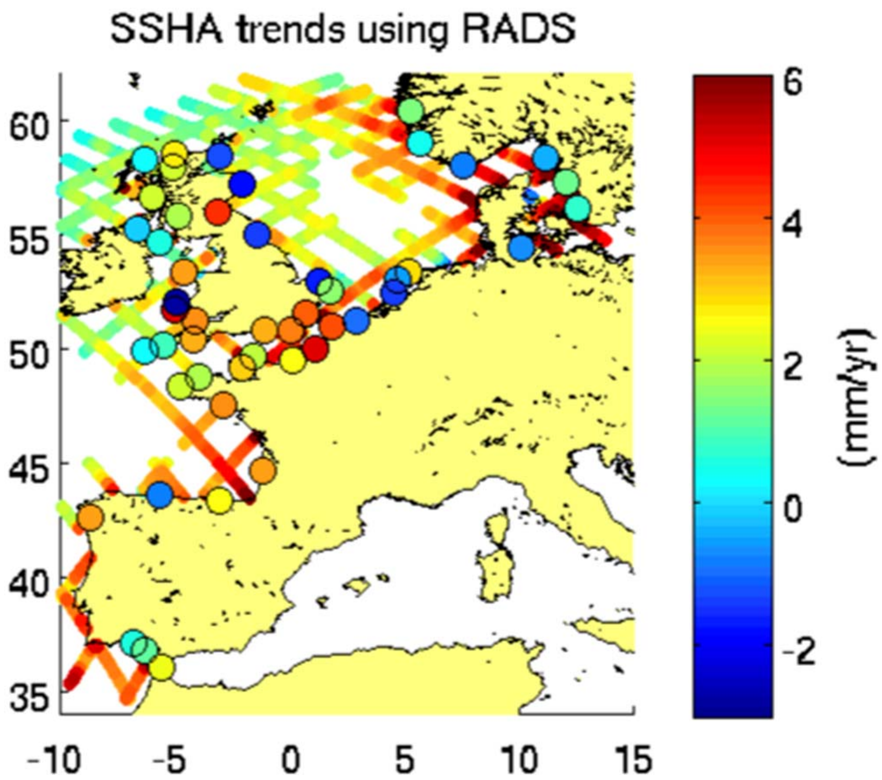
Significant DAC impact

+ local effects at TGs
(including VLM)

Some challenges

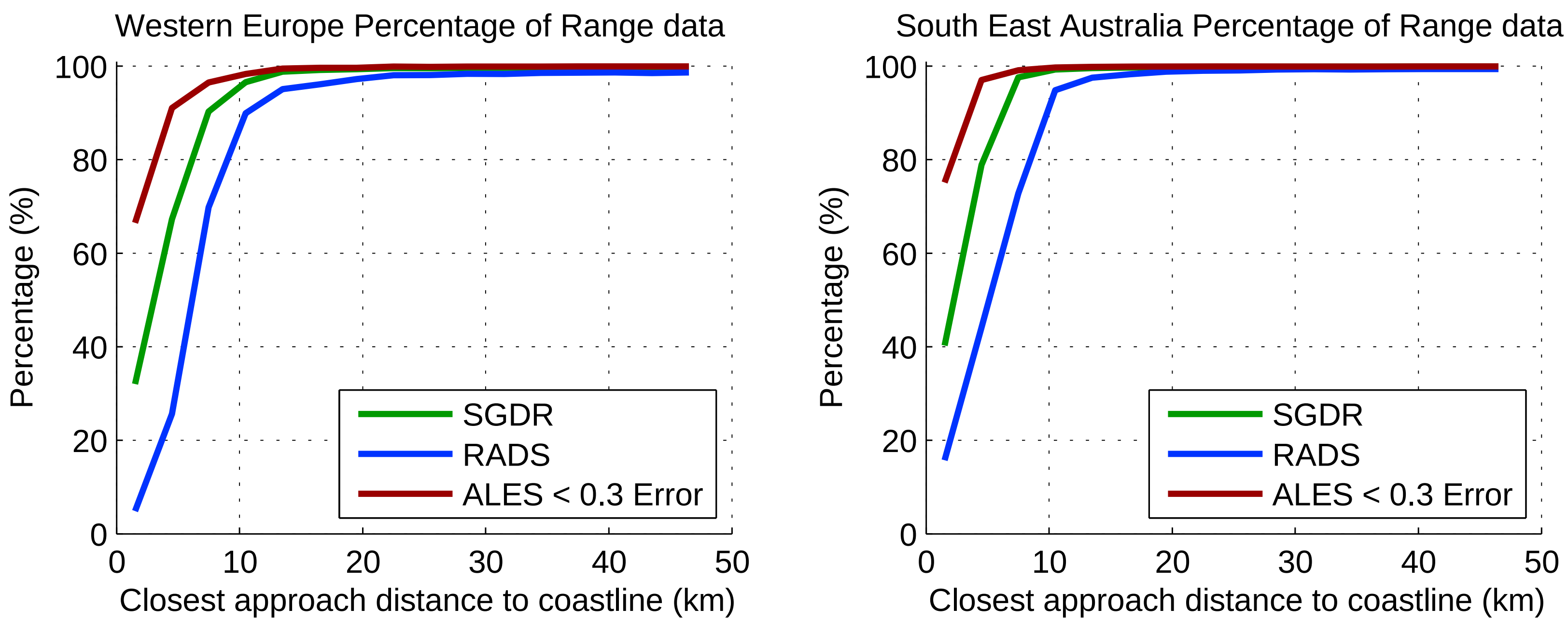
→ comparison at the level of individual tide gauges is often problematic

instead we decided to compare statistics derived from a number of tide gauges and a number of tracks over wide regions



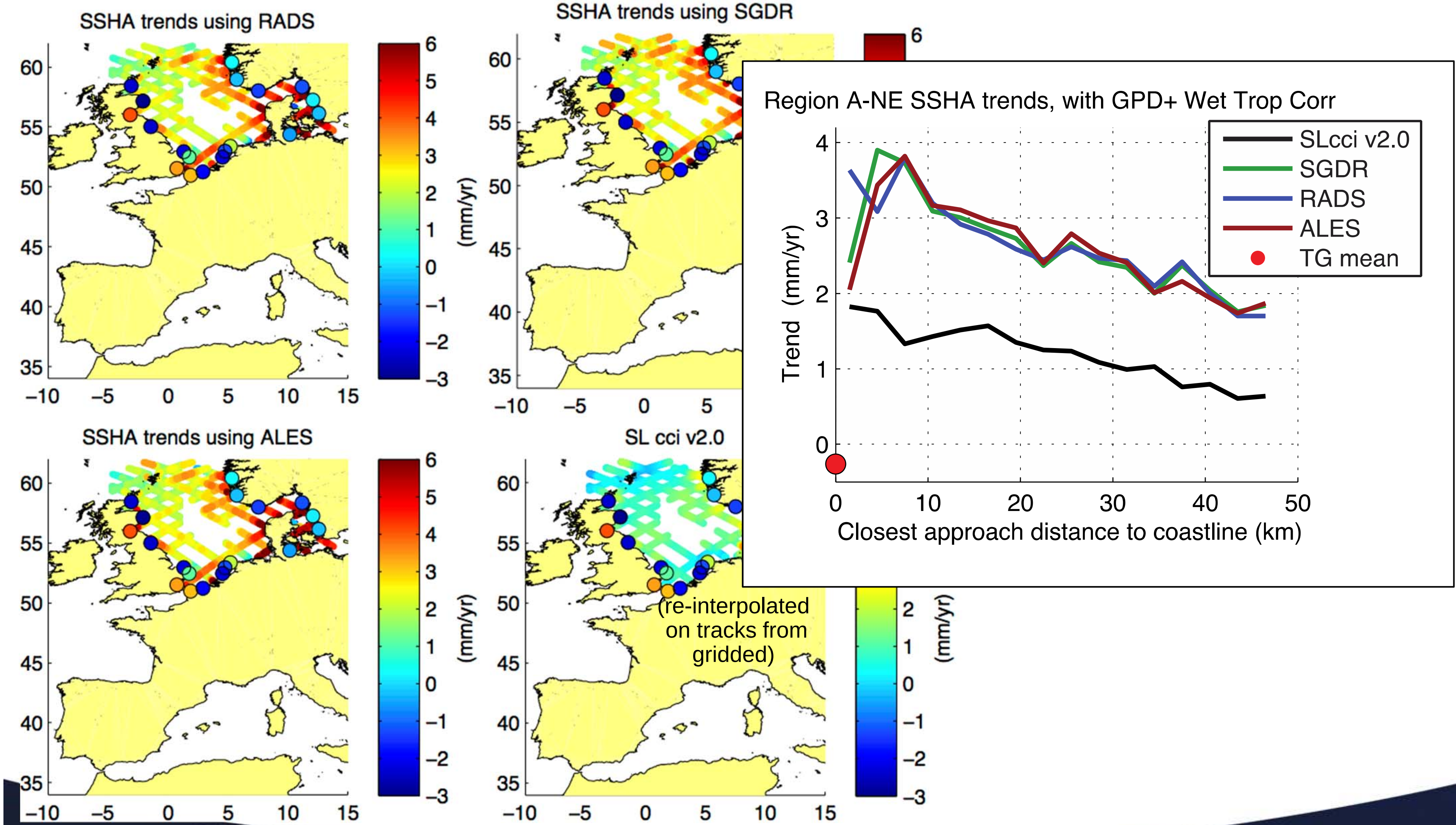
Results - impact of retracking

First on the number of valid measurements

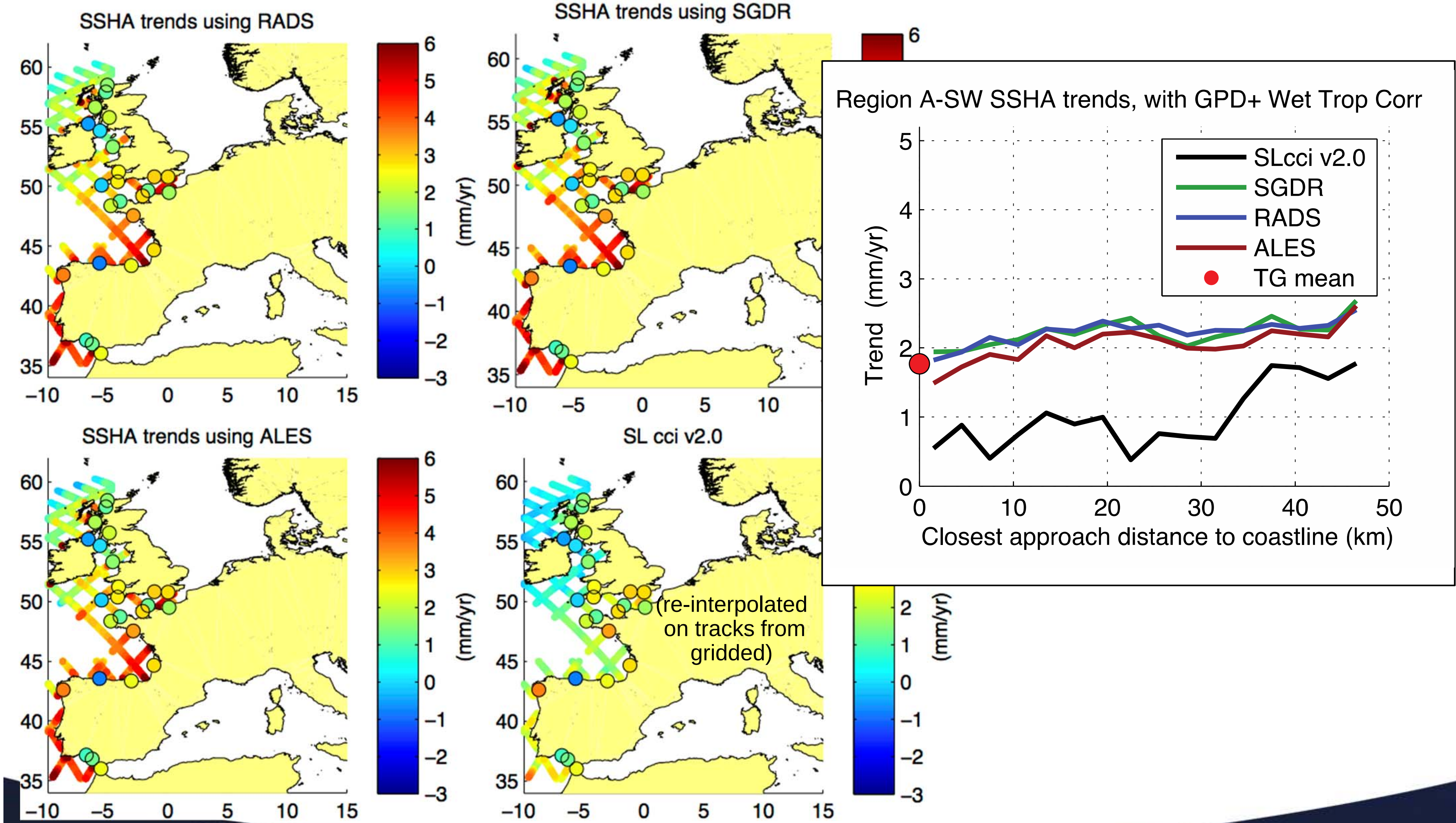


ALES (with a fairly stringent threshold on 'error', i.e. retracking misfit) **recovers significantly more measurements** in the last 10 km

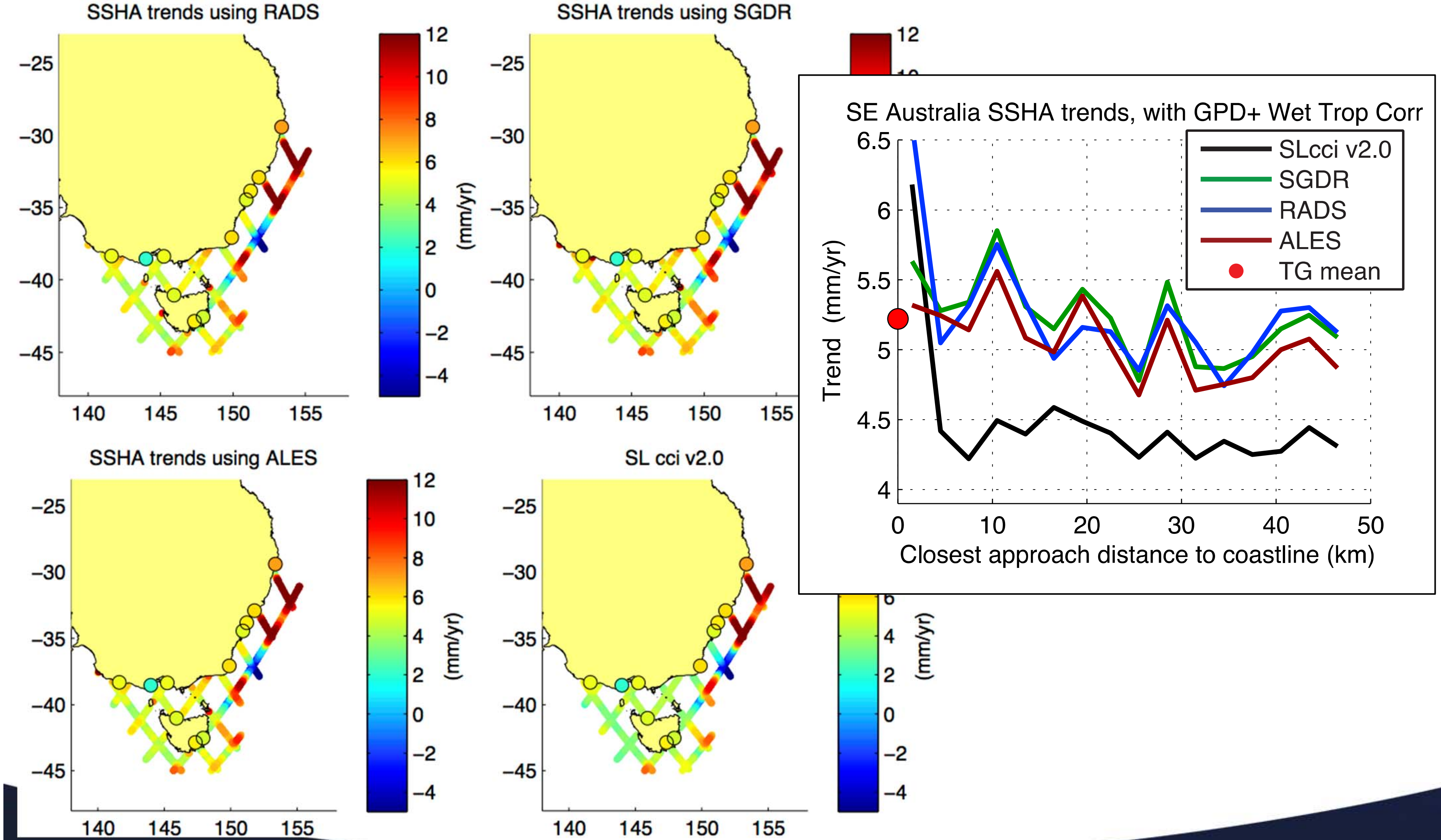
Region A-NorthEast



Region A-SouthWest



Region B – SouthEast Australia



Impact of correction choices

We investigated two corrections: **Wet Tropospheric** (particularly crucial for coastal altimetry) and **Dry Tropospheric**

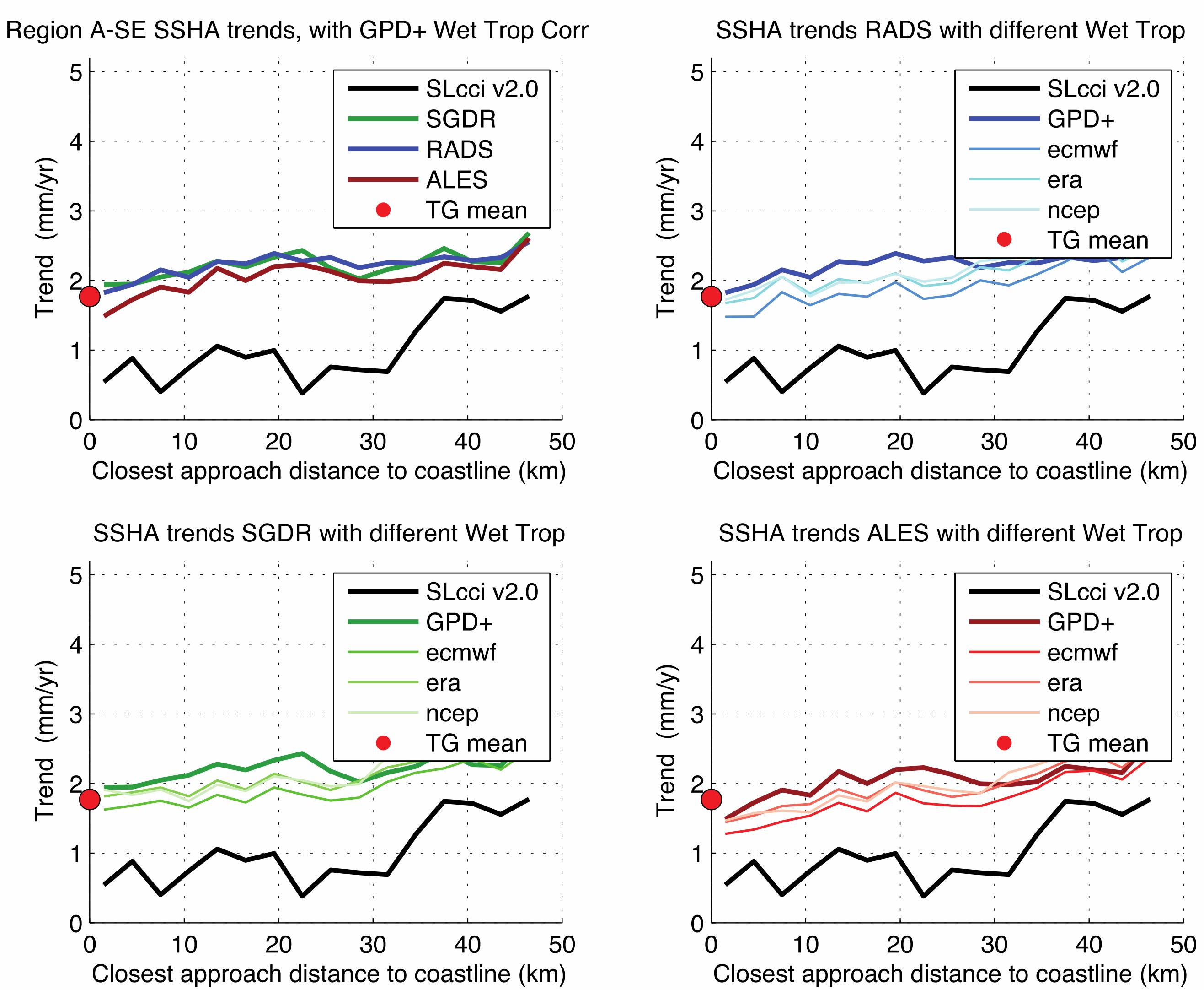
Note: **both should be provided at 20 Hz**, not re-interpolated from 1 Hz. This is due to the height dependence of these corrections and is significant in places where the coast is steep (Joana Fernandes, pers. comm., finding from the ESA SHAPE Project)

The choice of Wet Tropo has an impact up to 0.5 mm/yr in the last 30 km – with GPD+ giving the largest rates

Combination of GPD+ and ALES retracking does a good job w.r.t. TG – with significantly more valid measurements.

The various Dry Tropo make little difference (<0.3 mm/yr)

Example for Wet Tropo – Region A-SW



Conclusions

Specialized retrackers (such as ALES) and improved corrections (such as GPD+) are capable to yield SLR rates that are consistent with the other datasets, and with significantly more valid measurements in the last 10 km

→ we have started to 'fill the gap'

There is scope for further research though

- extend study to more regions
- include SAR mode altimetry
- look at other corrections – particularly important is SSB (changes in coastal wave climate may impact our SLR rates!)
- investigate spatial trends of SLR rates where they happen → links to long-term changes in coastal circulation

All these to be carried out in SL_cci extension (bridging contract + new ITT next year) and as cross-ECV activities.

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A few extra slides

TG results – Region A-NE

SUBREGION A-NE

# on map	Tide Gauge Station	PSMSL ID	Longitude	Latitude	2002-15 TG trend mm/yr	95% C.I.	% of missing data	GIA corr. mm/yr	TG-GIA mm/yr
1	WICK	1109	-3.09	58.44	-3.17	±1.79	13.17	-0.82	-2.35
2	ABERDEEN I	361	-2.08	57.14	-3.87	±1.65	11.38	-0.81	-3.06
3	LEITH II	1526	-3.18	55.99	3.18	±1.66	12.57	-0.89	4.07
4	NORTH SHIELDS	95	-1.44	55.01	-2.82	±1.57	4.19	-0.39	-2.43
5	CROMER	1632	1.30	52.93	-2.12	±1.97	9.58	0.08	-2.20
6	LOWESTOFT	754	1.75	52.47	1.13	±2.00	1.20	0.05	1.08
7	SOUTHEND	334	0.72	51.51	3.30	±2.48	5.99	-0.08	3.38
8	BERGEN	58	5.32	60.40	-1.00	±1.60	0.00	-1.34	0.34
9	STAVANGER	47	5.73	58.97	-1.43	±1.61	0.00	-1.12	-0.31
10	TREGDE	302	7.55	58.01	-2.35	±1.30	0.00	-0.97	-1.38
11	SMOGEN	179	11.22	58.35	-3.87	±2.51	0.00	-2.61	-1.26
12	RINGHALS	2111	12.11	57.25	-1.16	±2.79	0.00	-1.32	0.16
13	VIKEN	2110	12.58	56.14	-0.70	±3.01	0.00	-0.45	-0.25
14	KIEL-HOLTENAU	789	10.16	54.37	-0.27	±2.47	0.00	0.23	-0.50
15	WEST-TERSCHELLING	236	5.22	53.36	2.44	±2.48	0.00	0.41	2.03
16	DEN HELDER	23	4.75	52.96	-0.97	±2.38	0.00	0.29	-1.26
17	IJMUIDEN	32	4.55	52.46	-2.03	±2.30	0.00	0.15	-2.18
18	OOSTENDE	413	2.92	51.23	-2.00	±1.86	0.00	-0.09	-1.91
19	CALAIS	455	1.87	50.97	2.95	±1.53	14.37	-0.12	3.07
								Mean	**-0.26**
								Median	**-0.50**

TG results – Region A-SW

SUBREGION A-SW

# on map	Tide Gauge Station	PSMSL ID	Longitude	Latitude	2002-15 TG trend mm/yr	95% C.I.	% of missing data	GIA corr. mm/yr	TG-GIA mm/yr
23	NEWLYN	202	-5.54	50.10	0.13	±1.41	10.78	0.24	-0.11
24	ILFRACOMBE	1214	-4.11	51.21	2.62	±1.61	8.98	0.03	2.59
25	HOLYHEAD	5	-4.62	53.31	1.23	±1.75	12.57	-0.36	1.59
26	MILLPORT	755	-4.91	55.75	1.10	±2.01	6.59	-1.01	2.11
27	TOBERMORY	1491	-6.06	56.62	0.78	±1.72	10.18	-1.06	1.84
28	ULLAPOOL	1112	-5.16	57.90	0.18	±1.62	1.80	-0.96	1.14
29	KINLOCHBERVIE	1775	-5.05	58.46	0.80	±2.02	12.57	-0.80	1.60
30	BANGOR	1856	-5.67	54.66	-0.66	±1.62	13.77	-0.75	0.09
31	PORTRUSH	1867	-6.66	55.21	-1.42	±1.49	5.99	-0.84	-0.58
32	LE HAVRE	453	0.11	49.48	1.56	±1.43	0.00	-0.18	1.74
33	CHERBOURG	467	-1.64	49.65	1.23	±1.22	1.20	-0.08	1.31
34	ST HELIER (JERSEY) 2	1795	-2.12	49.18	2.82	±1.56	0.00	-0.05	2.87
35	ROSCOFF	1347	-3.97	48.72	1.36	±1.38	2.99	0.14	1.22
36	LE CONQUET	1294	-4.78	48.36	2.40	±1.47	0.60	0.24	2.16
37	LE CROUESTY	1921	-2.90	47.54	3.46	±1.97	2.99	0.05	3.41
38	ARCACHON-EYRAC	1918	-1.16	44.67	2.77	±1.94	13.77	-0.13	2.90
39	BILBAO	1806	-3.05	43.35	2.26	±1.08	0.60	-0.15	2.41
40	GIJON II	1871	-5.70	43.56	-0.92	±1.27	1.80	-0.04	-0.88
41	VILLAGARCIA	1897	-8.77	42.60	3.63	±1.86	3.59	-0.08	3.71
42	HUELVA	1883	-6.83	37.13	0.69	±1.64	0.00	-0.19	0.88
43	BONANZA	1809	-6.34	36.80	1.04	±1.51	4.19	-0.19	1.23
44	TARIFA	488	-5.60	36.01	2.27	±1.15	0.00	-0.17	2.44
								Mean	**1.77**
								Median	**1.84**

TG results – Region B

# on map	Tide Gauge Station	PSMSL ID	Longitude	Latitude	2002-15 TG trend mm/yr	95% C.I.	% of missing data	GIA corr. mm/yr	TG-GIA mm/yr
1	HOBART	838	147.34	-42.88	5.60	±1.59	15.57	-0.18	5.78
2	SPRING BAY	1216	147.93	-42.55	4.51	±1.11	0.60	-0.18	4.69
3	BURNIE	683	145.91	-41.05	4.60	±1.17	0.00	-0.26	4.86
4	PORTLAND	1547	141.61	-38.34	5.15	±1.75	0.00	-0.15	5.30
5	LORNE	1836	143.99	-38.55	1.71	±1.78	1.80	-0.27	1.98
6	STONY POINT	1033	145.22	-38.37	4.82	±1.88	0.00	-0.33	5.15
7	EDEN	833	149.91	-37.07	5.97	±1.42	1.20	-0.17	6.14
8	PORT KEMBLA	831	150.91	-34.47	4.77	±1.41	0.00	-0.22	4.99
9	SYDNEY, FORT DENISON 2	196	151.23	-33.85	5.42	±1.44	0.00	-0.22	5.64
10	NEWCASTLE V	837	151.79	-32.92	5.72	±1.68	0.00	-0.22	5.94
11	YAMBA	310	153.36	-29.43	6.74	±2.22	2.40	-0.22	6.96
								Mean	**5.22**
								Median	**5.30**

Correction choices

	SGDR		RADS		ALES	
	J1	J2	J1	J2	J1	J2
Orbit	GDR-E alt_20hz	GDR-E recomputed (see text)	GDR-E from SGDR (alt_20hz)	GDR-E recomputed (see text)	GDR-E from SGDR (alt_20hz)	GDR-E recomputed (see text)
Range	range_ku		range_ku		ALES	
Iono	GIM (Iijima et al., 1999)					
Sea State Bias	CLS					
Tide-Ocean	FES12					
Tide-Solid	Cartwright-Tayler-Edden (Cartwright and Tayler 1971, Cartwright and Edden 1973)					
Tide-Load	GOT4.10					
Tide-Polar	Wahr, 1985					
Dynamic+IB	MOG2D					
MSS	DTU15					
Ref Frame Offset	+22.3 mm	-18 mm	+83 mm	-18 mm	+22.3 mm	-18 mm

Table 3 - Corrections that are used for the sea level (SSHA) calculation. In blue the corrections natively available at 20-Hz. In red those corrections that are fetched from RADS at 1 Hz and then interpolated to 20 Hz.

Effect of recomputation of GDR-E orbit: negligible