EGU General Assembly

High-resolution combined global gravity field modelling:

The d/o 5,400 XGM2020 model

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1.1 Outline

- **XGM2020** is the follow-on **global gravity field model** to XGM2019:
  - Basic **combination strategy** with satellite model is **unchanged**
  - NEW: **ground dataset** was recompiled over the whole spectrum
  - NEW: **altimetric gravity anomalies** are calculated inhouse (from DTU18 MSS)
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- **Main improvements** of the new model are to be expected over the **open ocean**

- **Over land**, the data situation is **unchanged** and is unlikely to improve until the publication of EGM2020

2.1 Ground data processing – Data sources

- Different data sources for **land** and **ocean**:

spatial region / *spectral band*

	land	**ocean**
d\o 0 → d\o 719	NGA collocation Pail et al., 2018	OGMOC[1] mean dynamic topography + DTU18 MSS mean sea surface Andersen et al., 2018
d\o 720 → d\o 5400	EARTH 2014 topo. model Rexer et al., 2017	

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- **Spatial tapering**
  30[km] linear transition from coastline, towards the ocean
  (coastlines from GSHHS, Wessel and Smith 1996, omitting islands smaller than 10[km²])

- **Spectral tapering**
  stick-together in the (pseudo) spheroidal-harmonic domain
  (using the geometry of the TOPEX ellipsoid)

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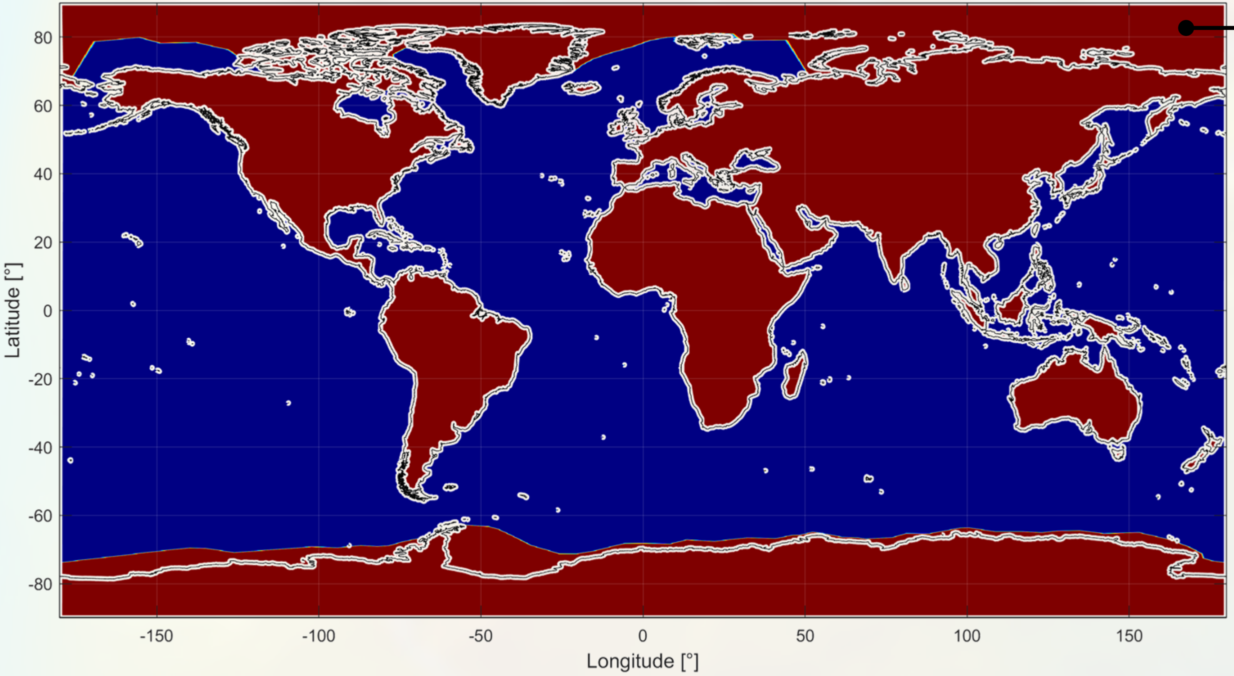
2.2 Ground data processing – Spatial tapering

- Tapering map for **land** and **ocean**:



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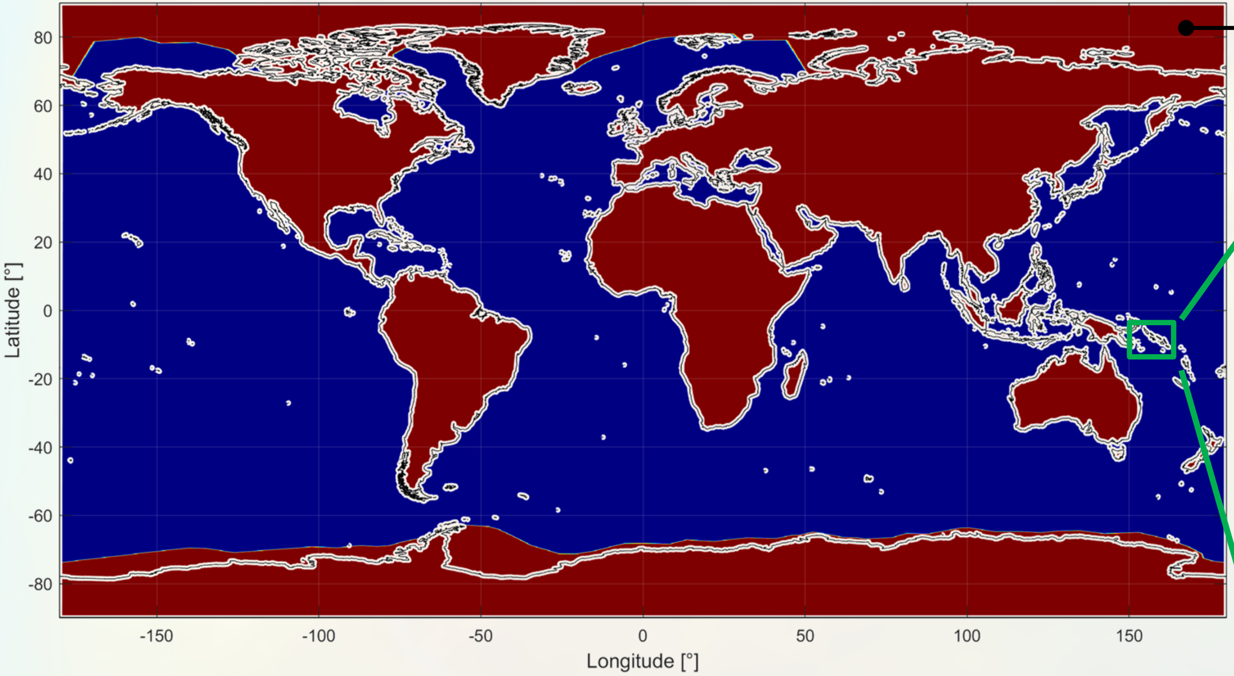

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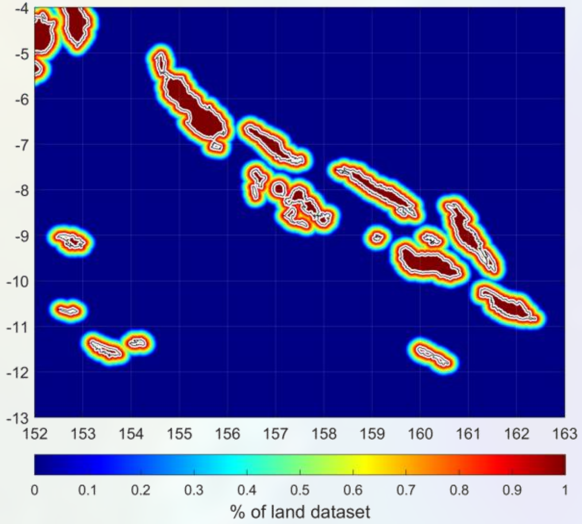
Solomon sea



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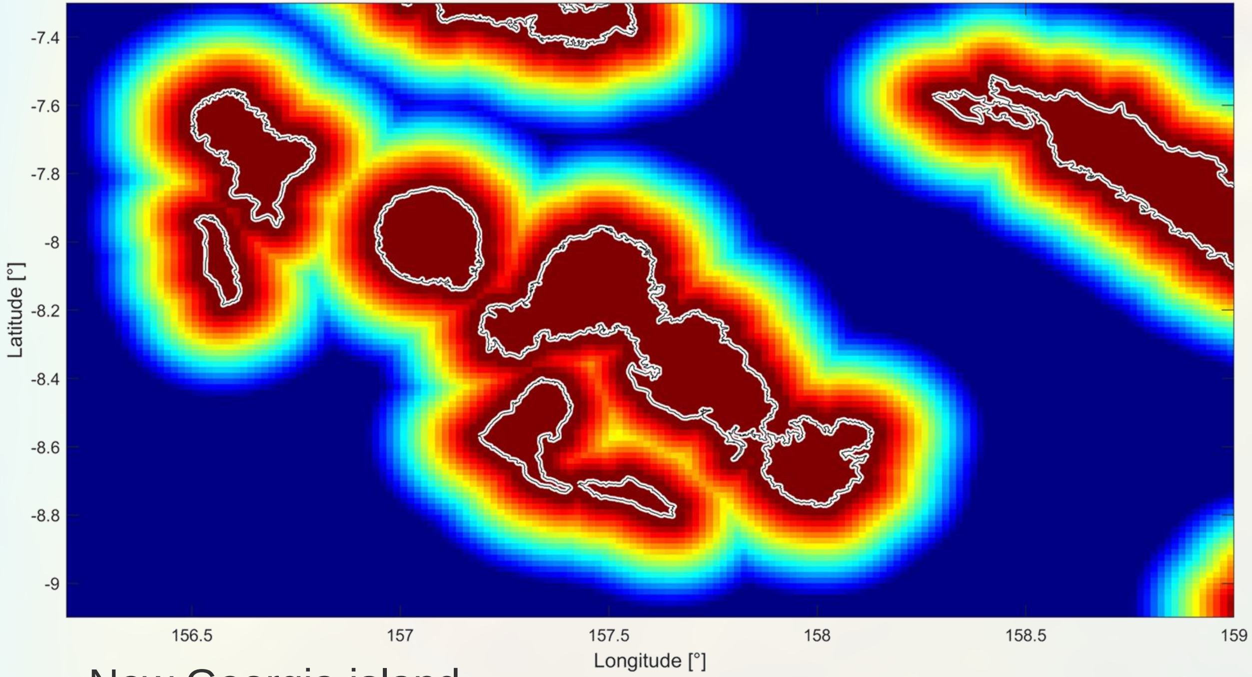

New Georgia island

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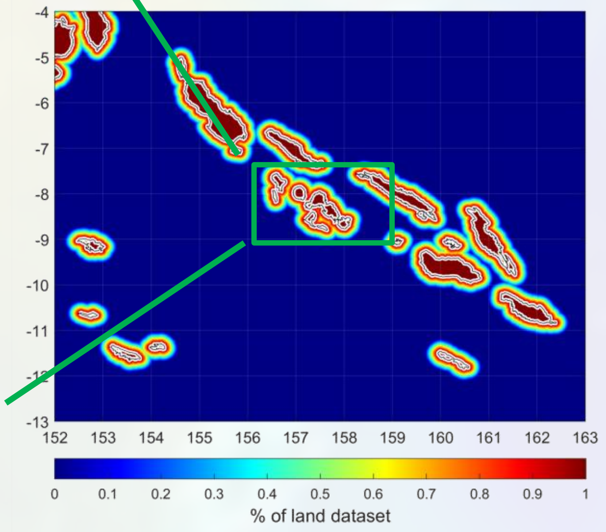

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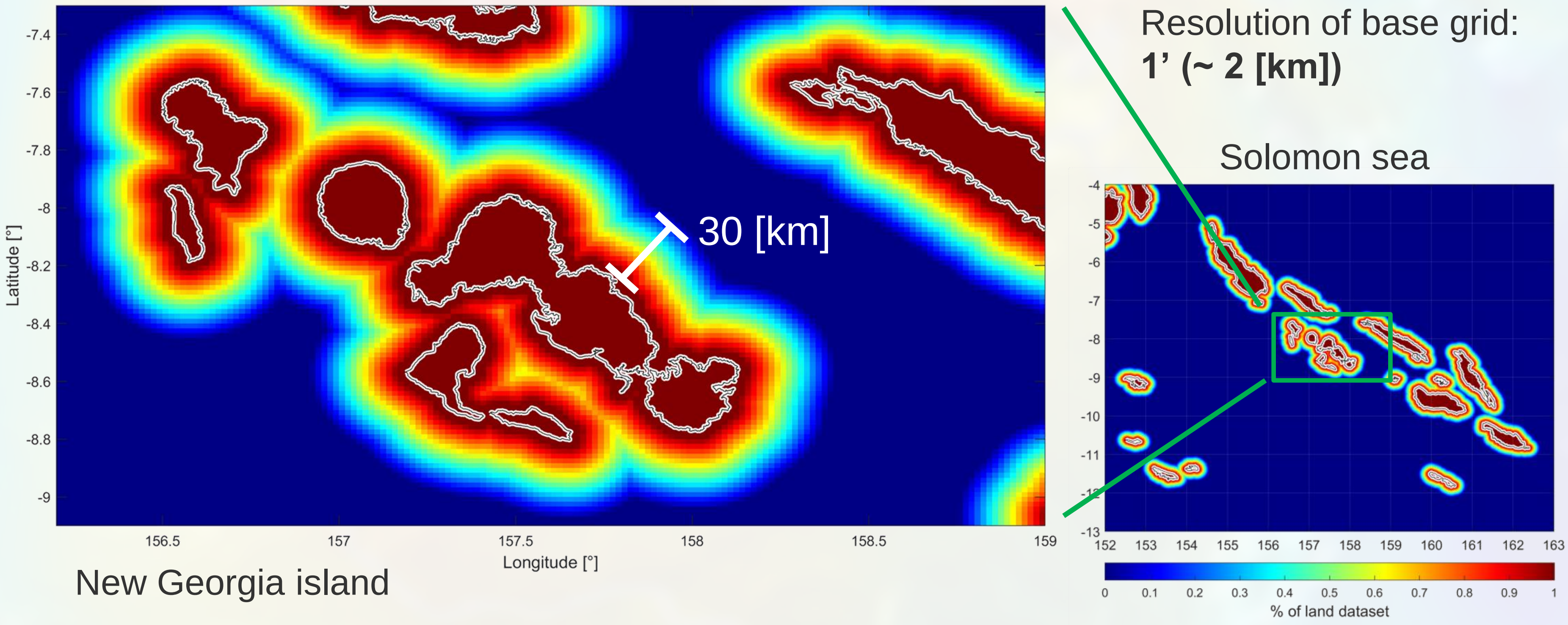
- Different data sources for **land** and **ocean**:

Resolution of base grid:
1’ (~ 2 [km])



New Georgia island

2.3 Ground data processing – Altimetric gravity

- Altimetric gravity anomalies are derived by performing a **rigorous spheroidal harmonic analysis** (**EHA**) of the ocean's geoid: (first time ever!)
  - the ocean's geoid $\mathbf{N}_{Ocean}$ (=height anomalies) is derived by:

$$\mathbf{N}_{Ocean} = \mathbf{MSS}_{DTU18} - \mathbf{MDT}_{OGMOC}$$

  - over **land** **XGM2019**-derived height anomalies are filled in

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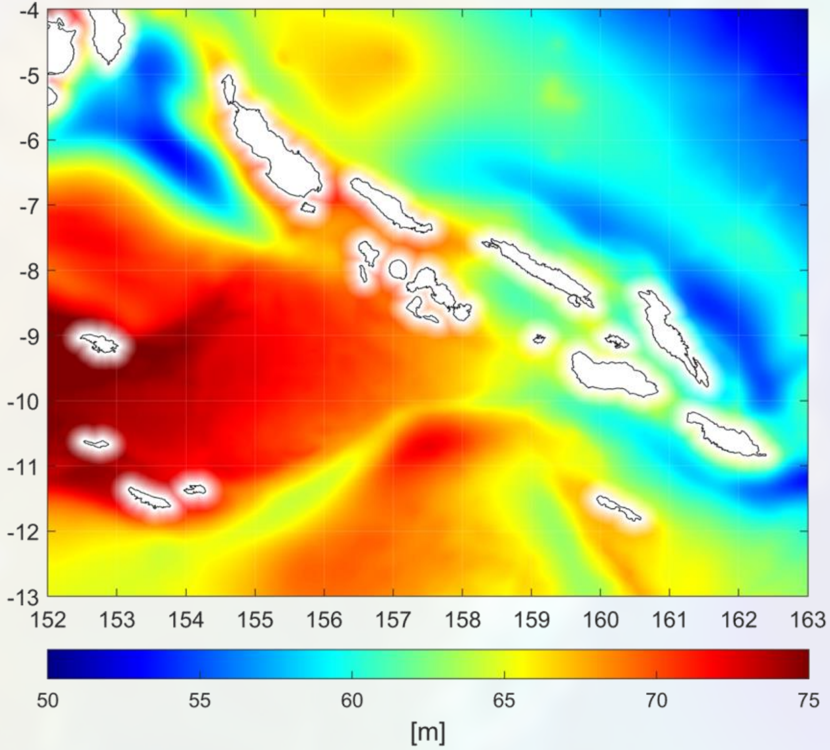
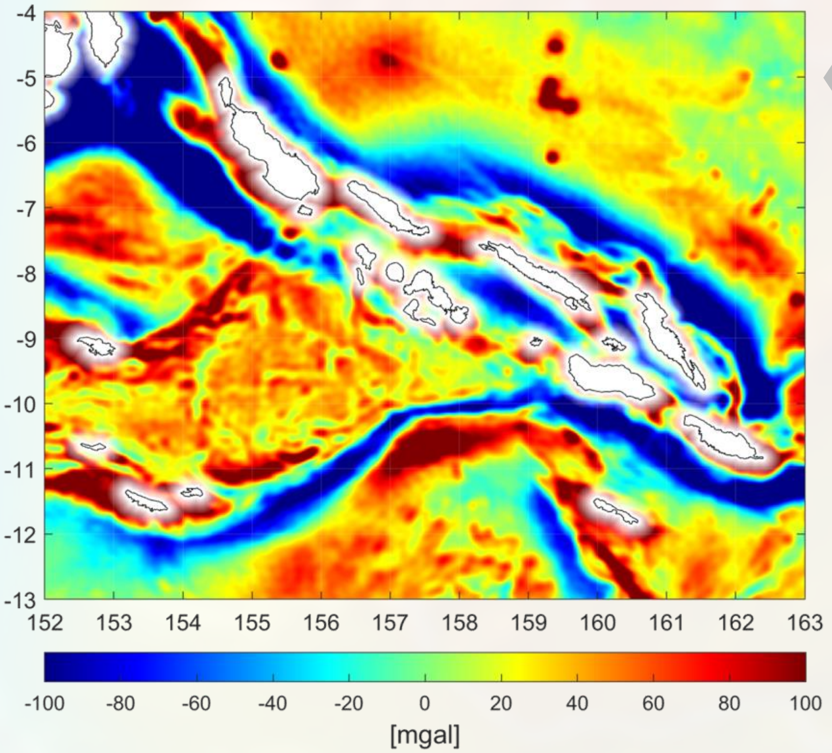
  - **analysis** is implemented through a **block-diagonal LSA** approach
  - spectrum is estimated up to **d/o 10,700** using the spheroidal harmonic identity to **Bruns' approximation**
  - Aliasing is avoided through the newly developed **SLASH** (**S**patial **L**ow pass – **A**nalysis – **S**pectral **H**igh pass) filter strategy
  - due to **very high noise** within the **MSS** in the higher frequencies, the final spectrum is **limited to d/o 5,480**

Ocean's geoid $\mathbf{N}_{Ocean}$ (MSS-MDT)



2.3 Ground data processing – Altimetric gravity (2)

Altimetric gravity anomalies (**IAPG19**)



EHA

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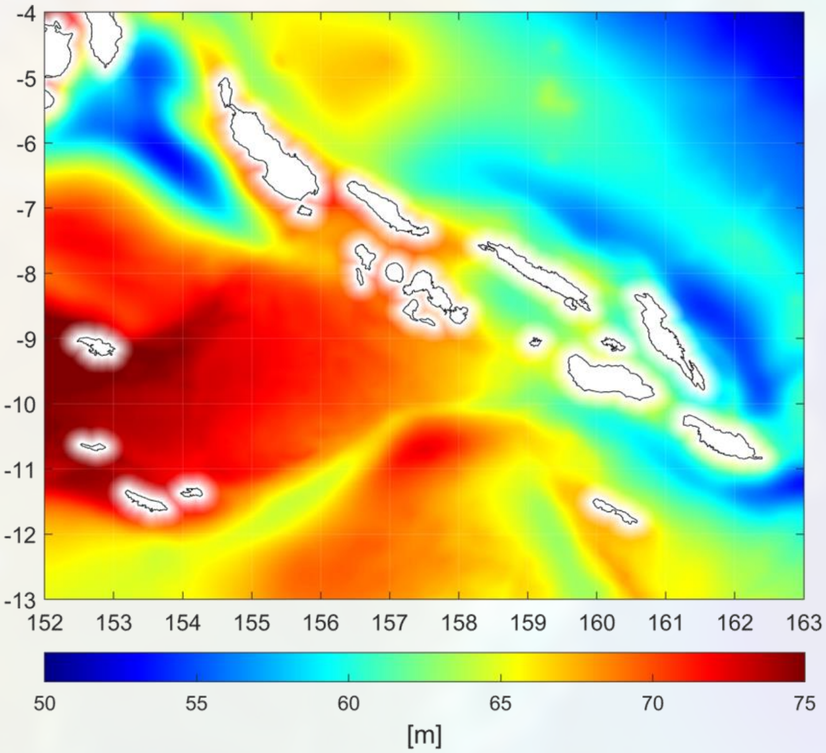

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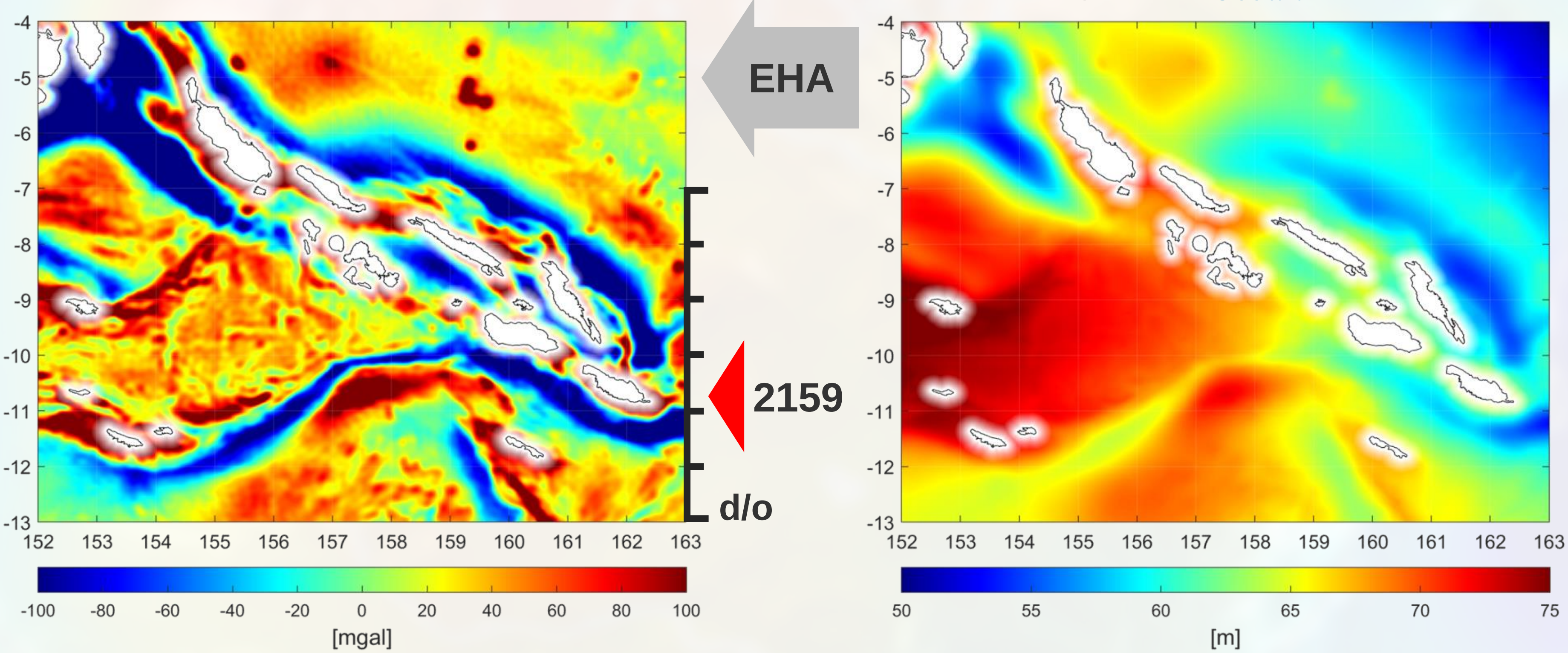

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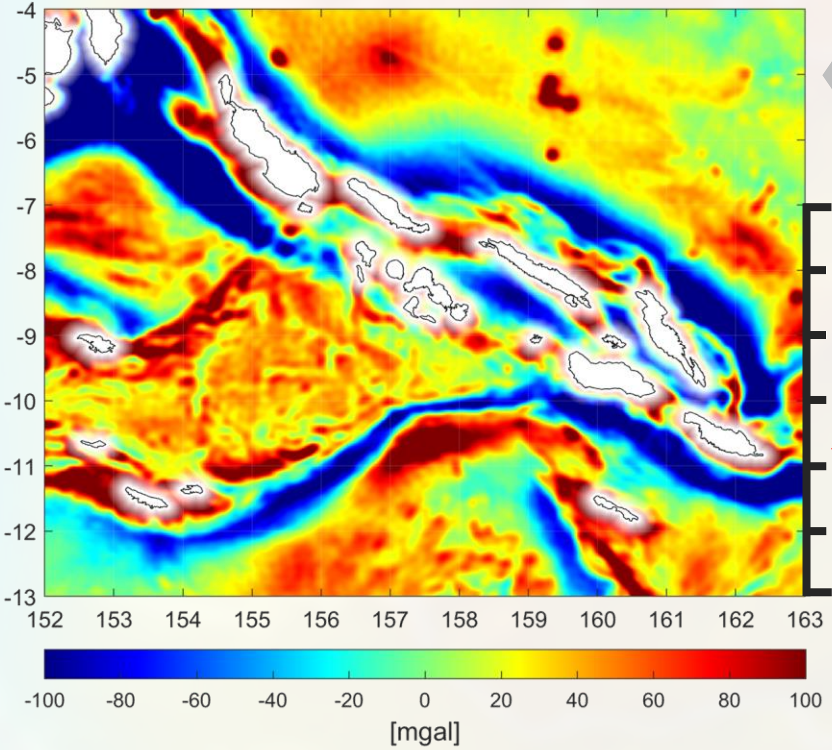
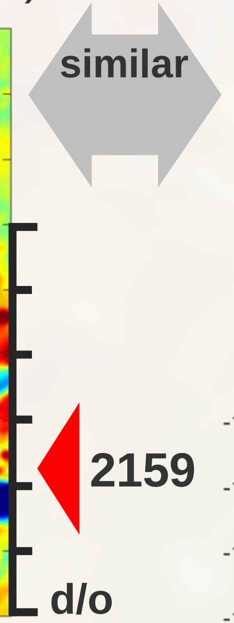
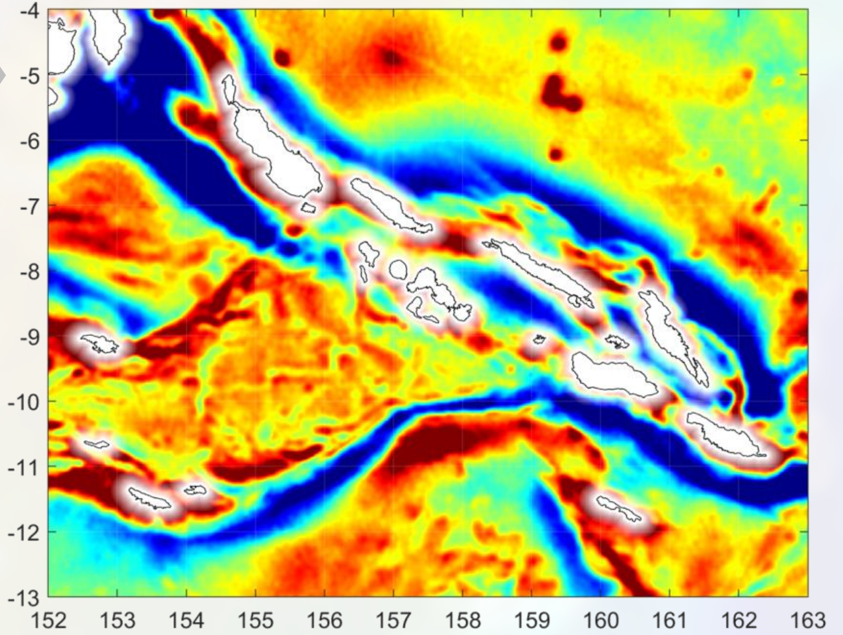




Comparison: **DTU13** gravity anomalies



Solomon Sea

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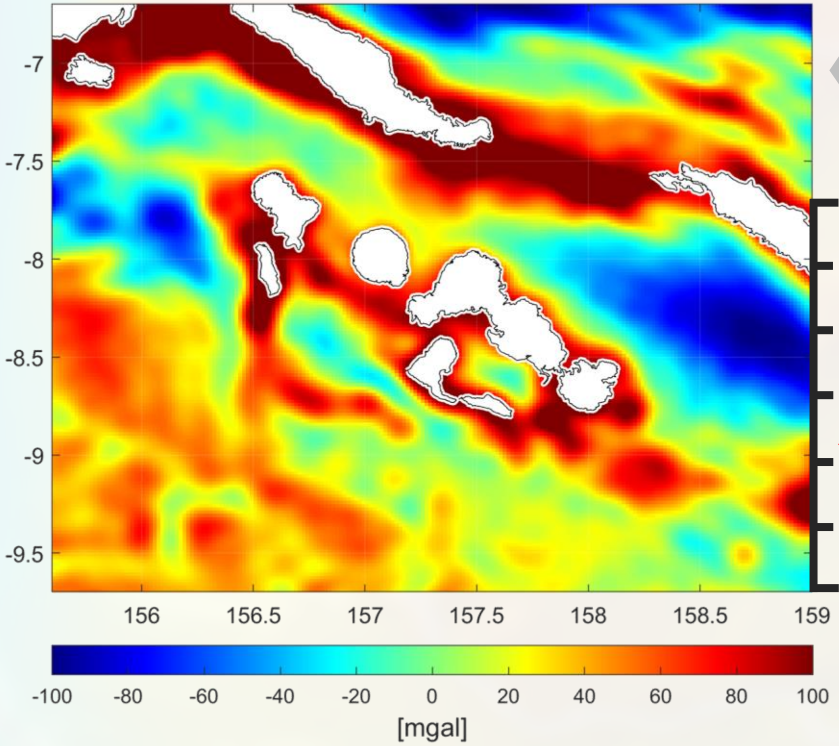

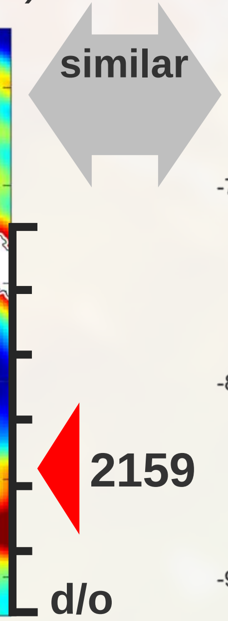

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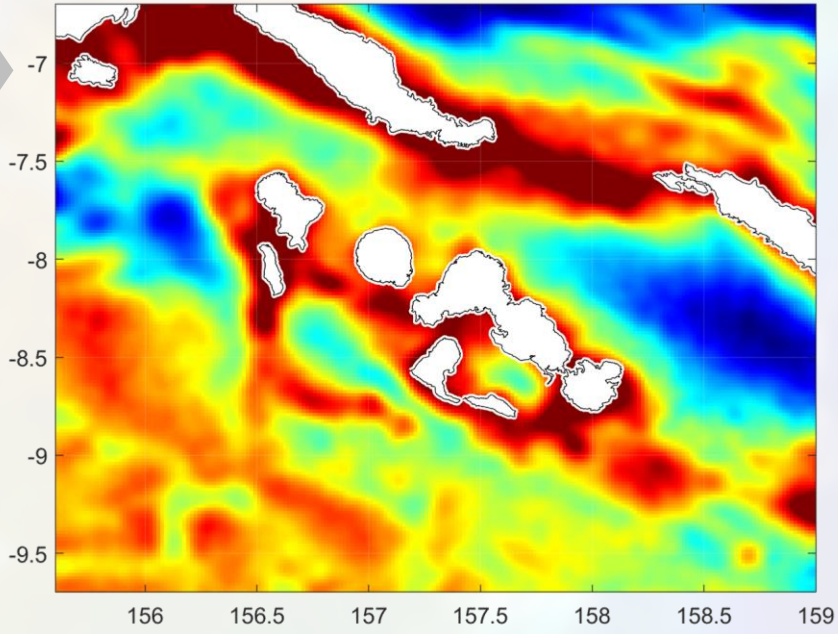

New Georgia Island

2.3 Ground data processing – Altimetric gravity (5)

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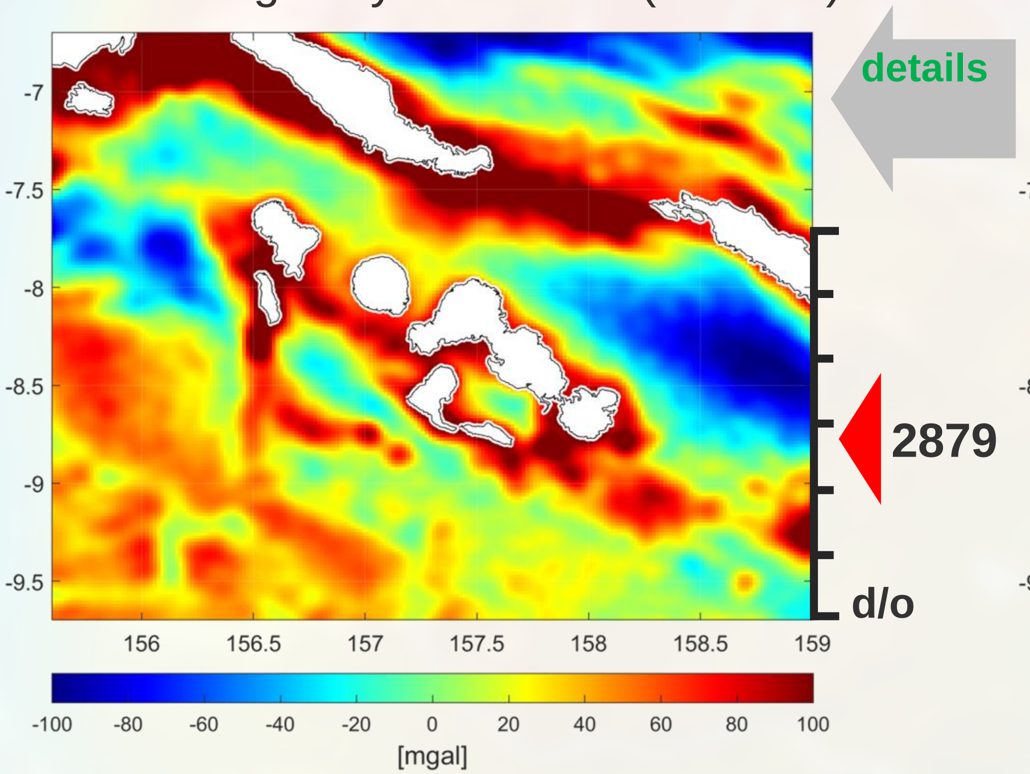

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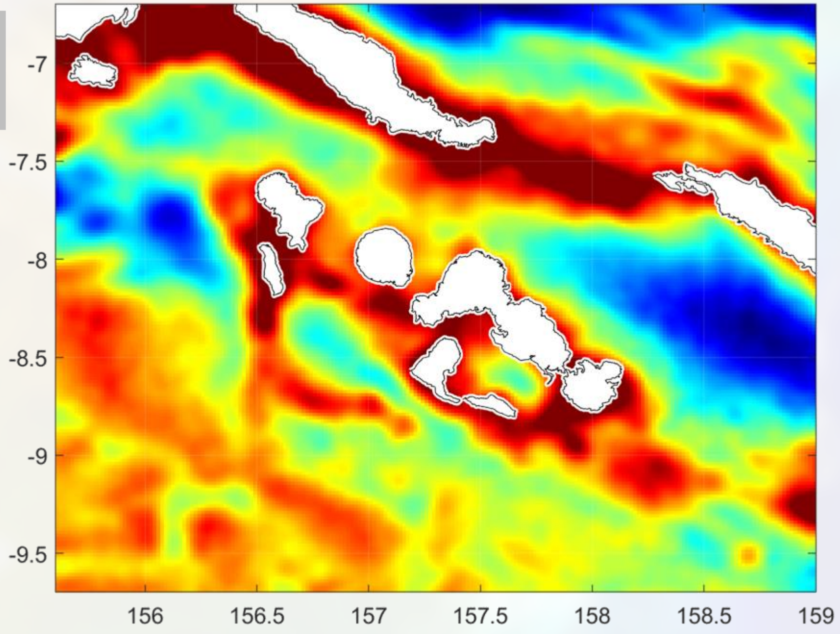

New Georgia Island

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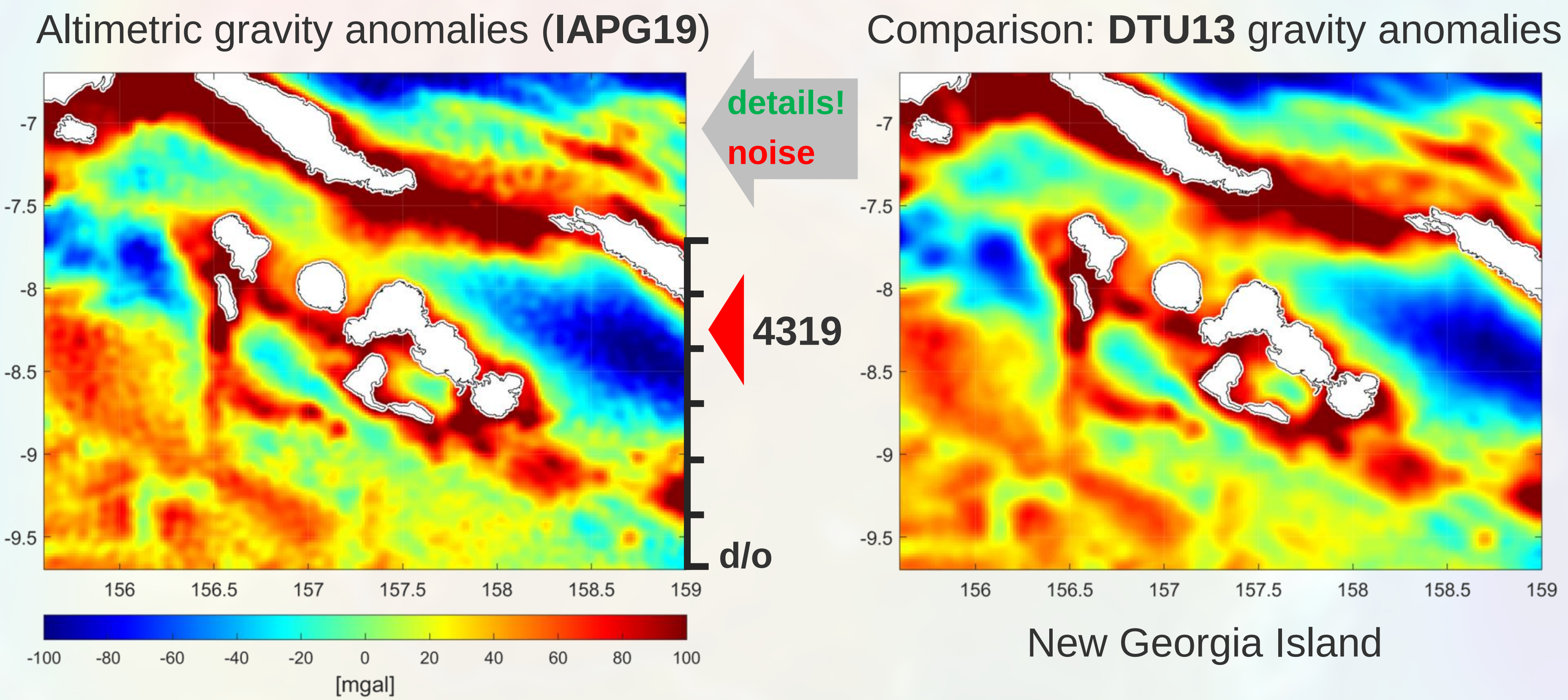

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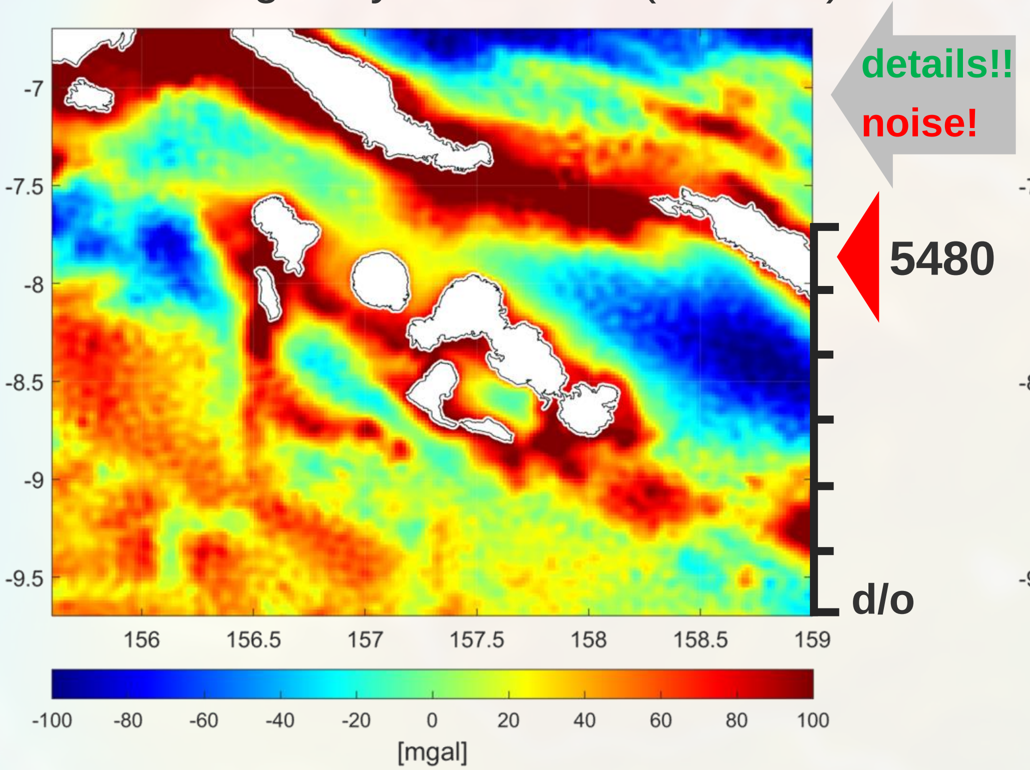

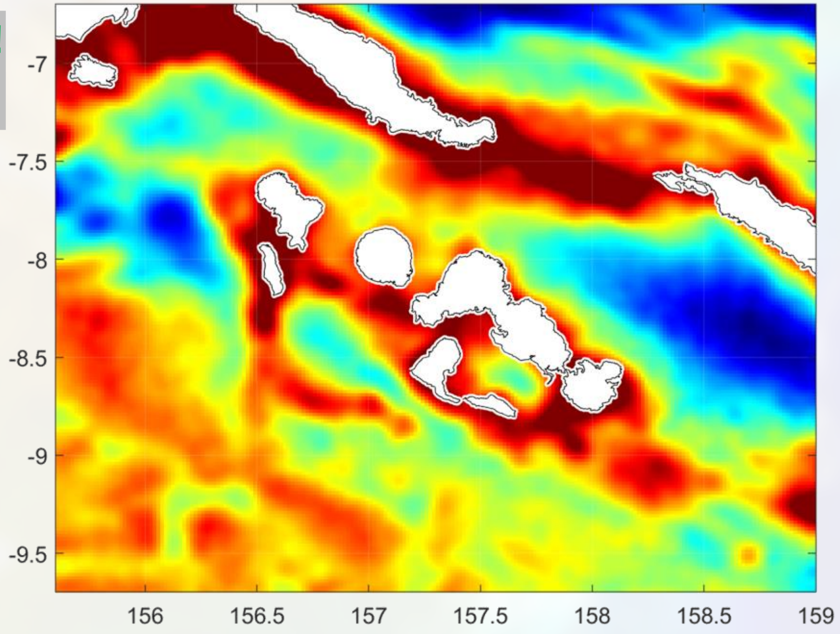

New Georgia Island

2.4 Ground data processing – Final steps

- Having the **altimetric** gravity anomalies, the **final ground dataset** for the combination is obtained by:
  - **replacing** gravity anomalies over **land** with **NGA data** and **topographic information**, applying the same tapering as before
  - (as **anti-aliasing** method the **SLASH filter** approach is used again)

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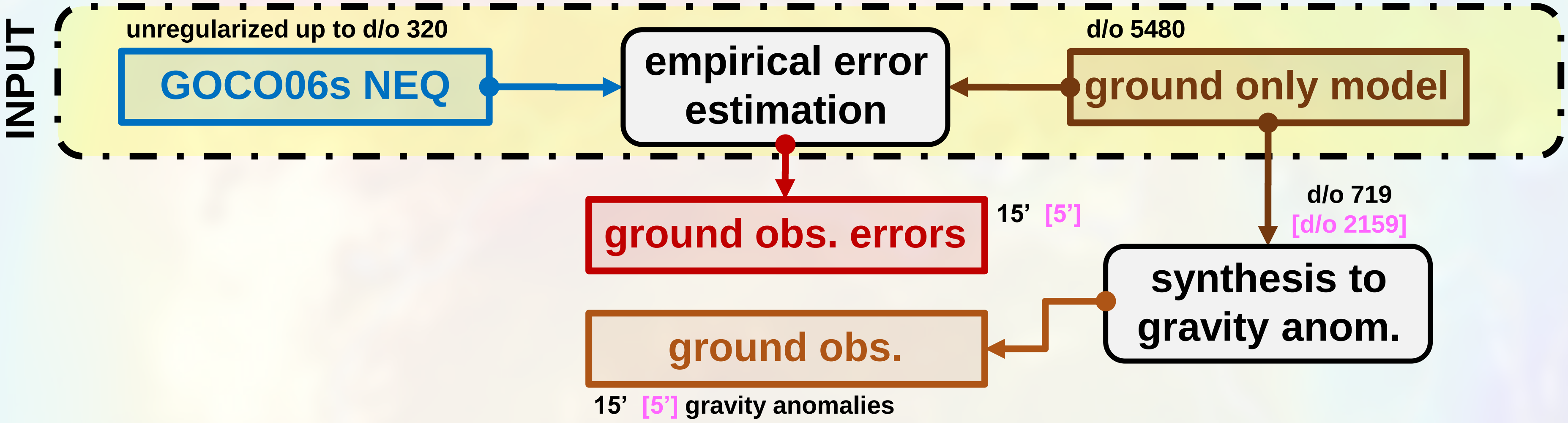
  - **replacing** gravity anomalies over **land** with **NGA data** and **topographic information**, applying the same tapering as before
  - (as **anti-aliasing** method the **SLASH filter** approach is used again)
  - **analyzing** the resulting grid in the EH domain, up to d/o 10,700, limiting it again **to d/o 5,480** ➡ **ground-only model**
  - synthesis of the **ground-only model** up to **d/o 719** [d/o 2159] on a **15'** [5'] **grid**, forming the **final ground dataset** for the combination with the satellite model

3.1 XGM2020 calculation – Overview



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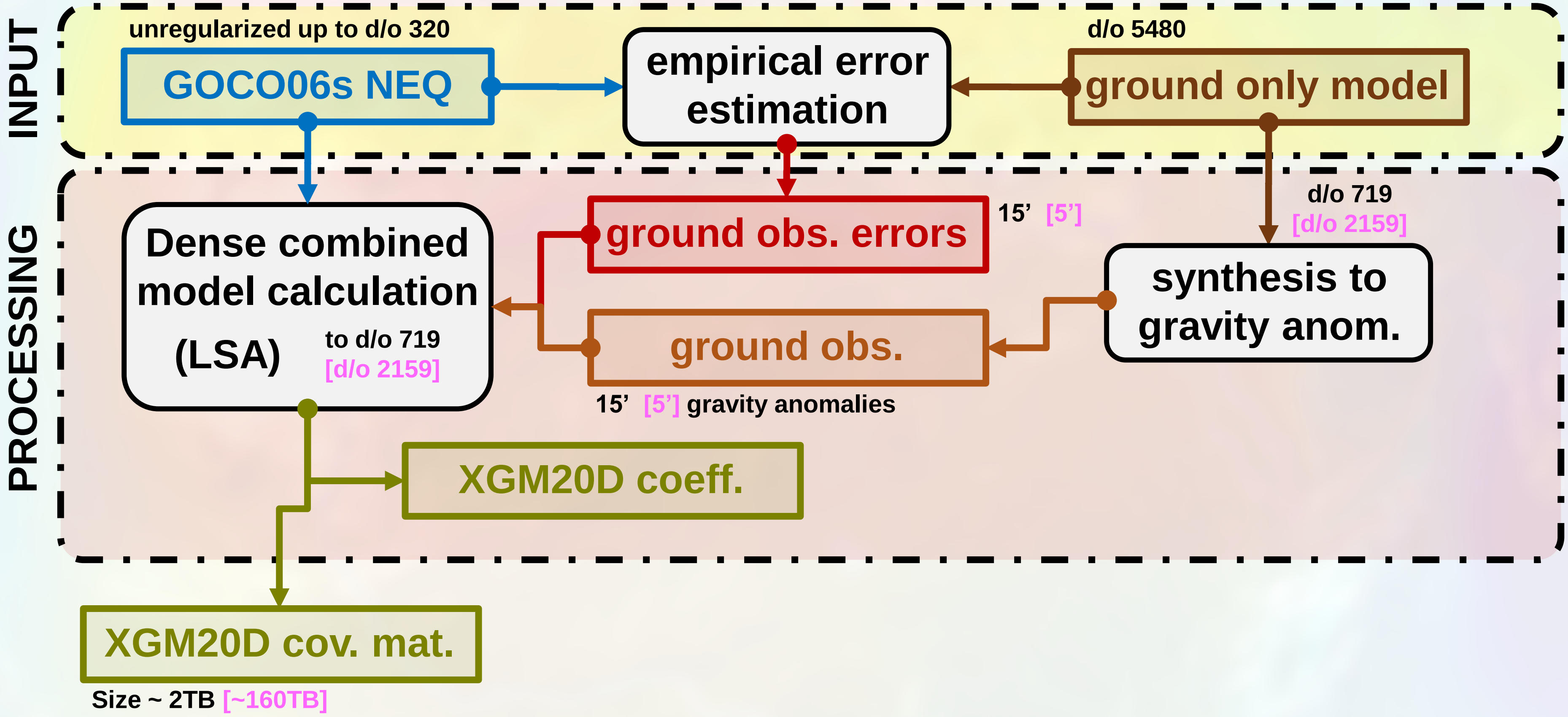

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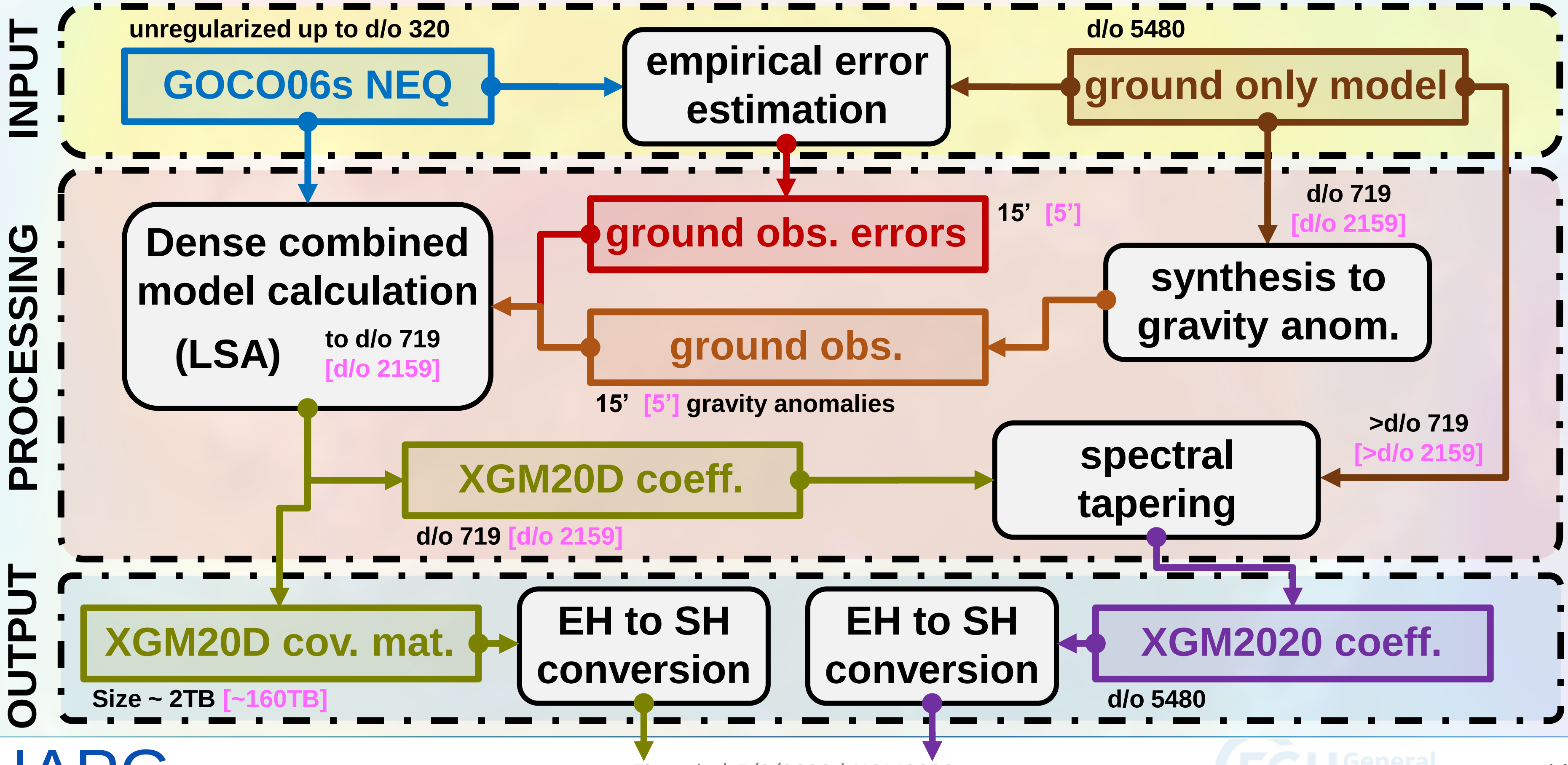
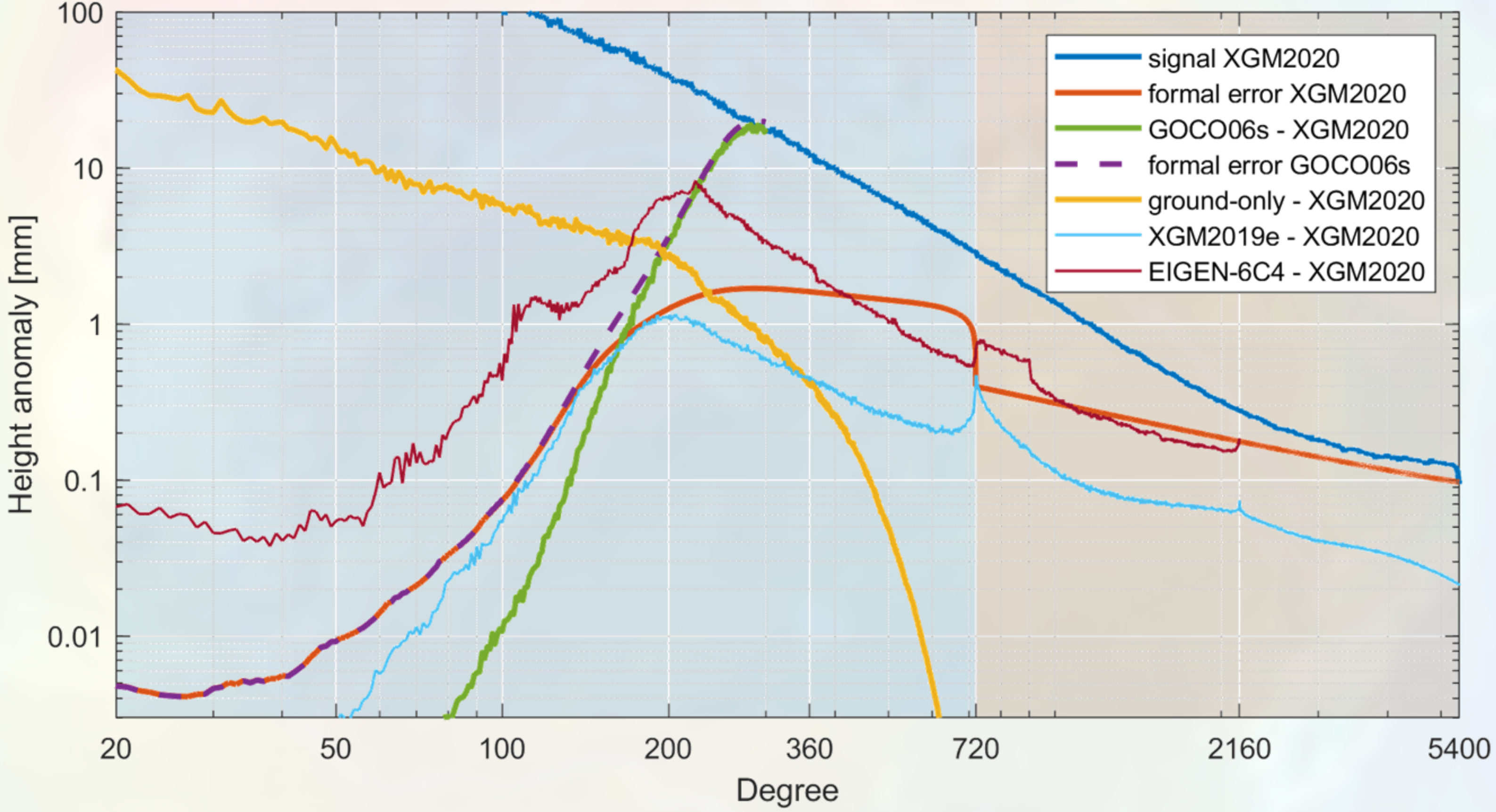


3.2 XGM2020 calculation – Degree errors



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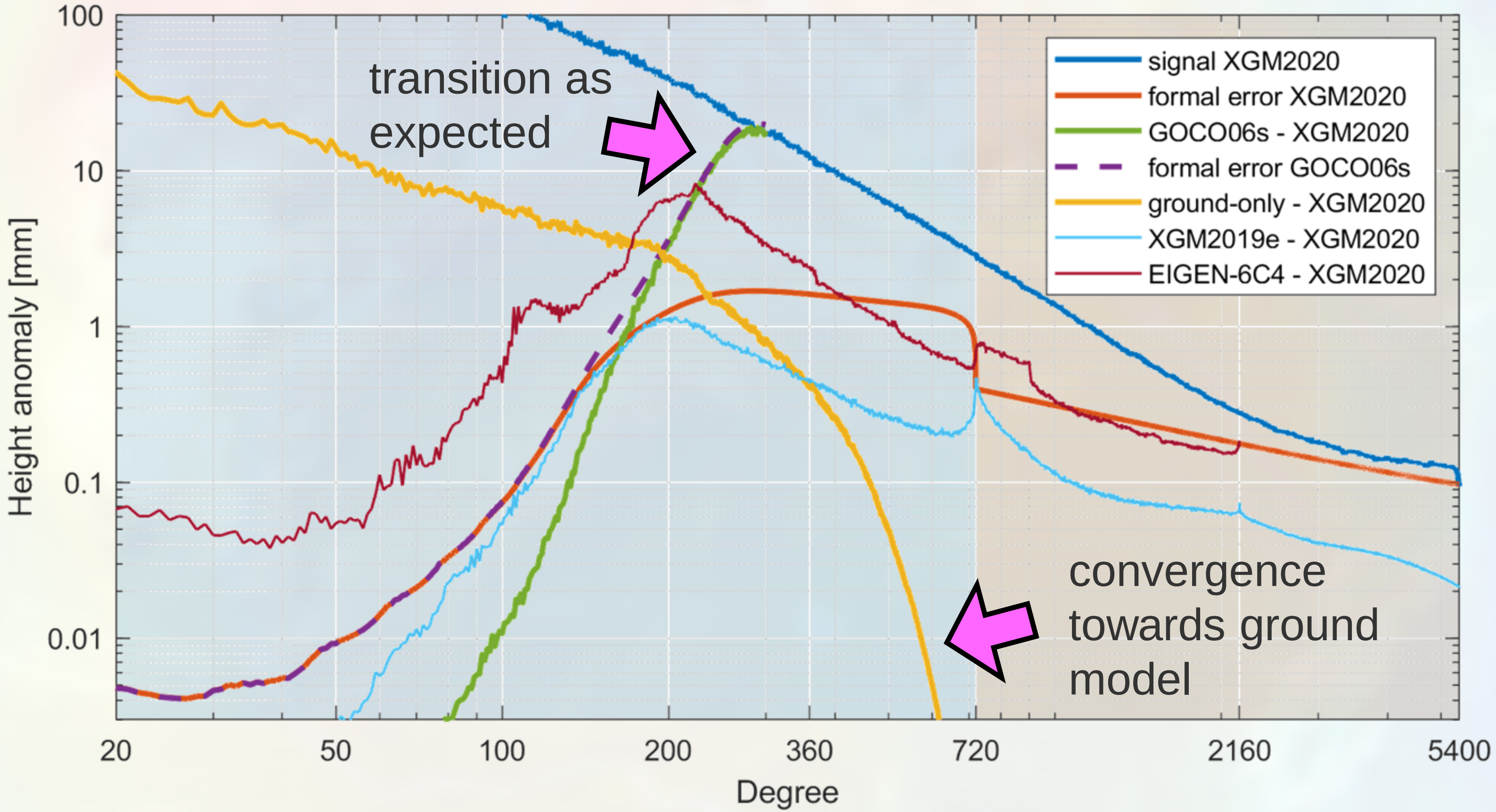
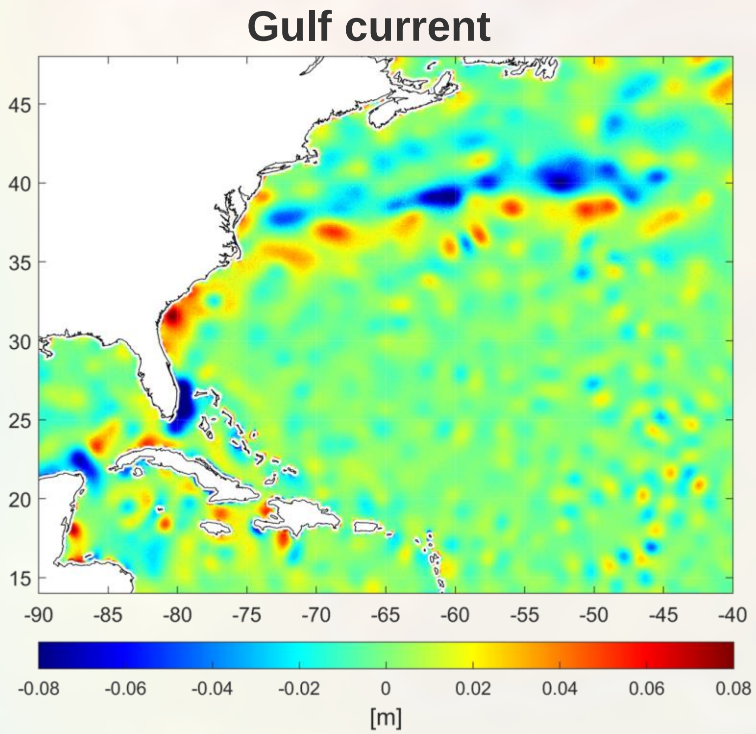
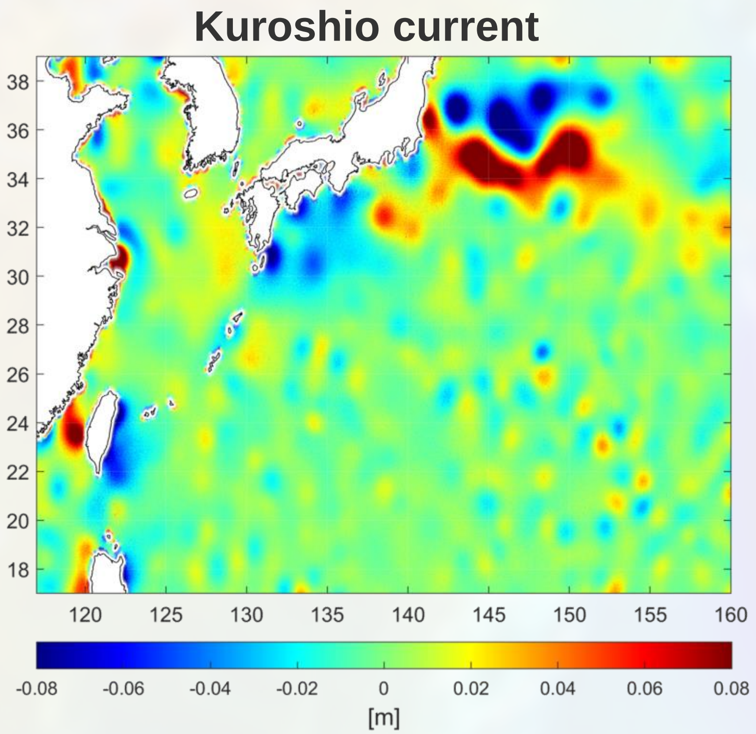


4.1 XGM2020 validation – MDT

- Difference between **input MDT** and **output MDT** ($\mathbf{MSS}_{DTU18} - \mathbf{N}_{XGM20}$):





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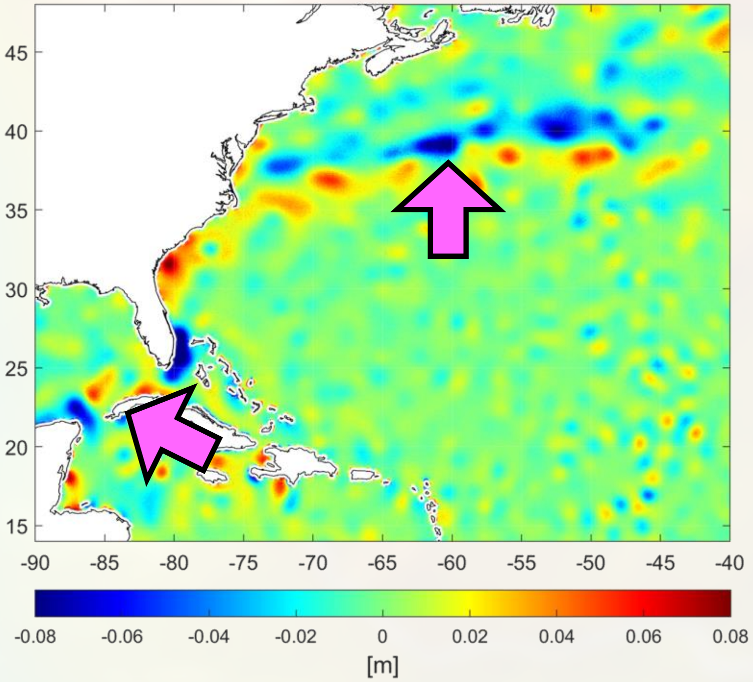
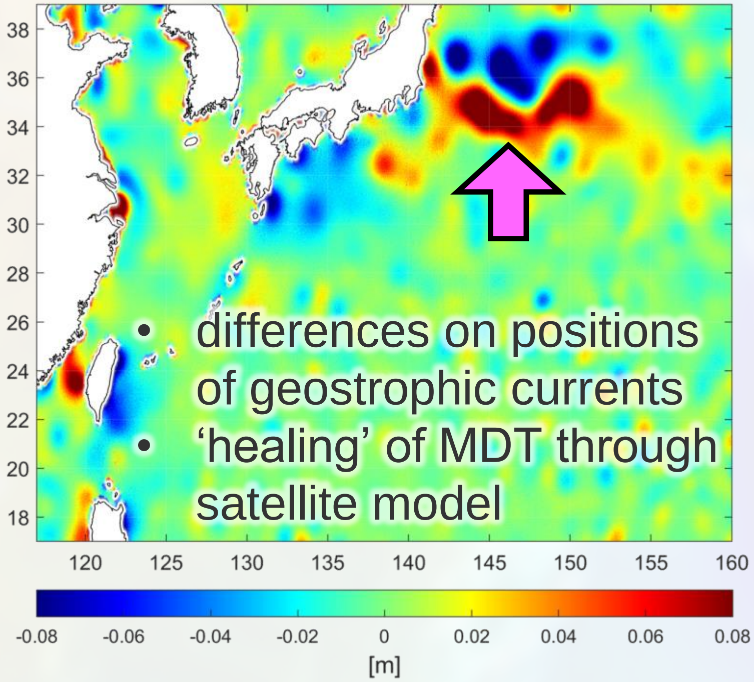


Kuroshio current

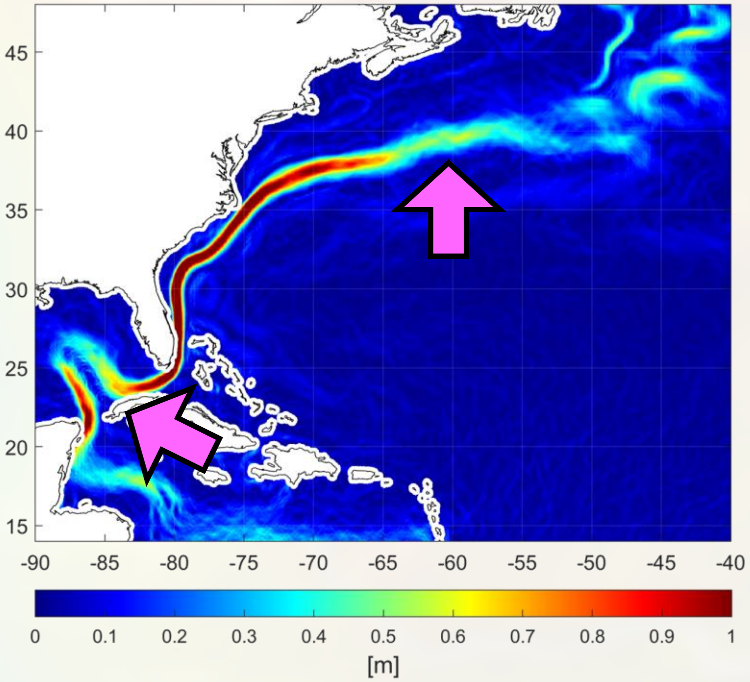


- differences on positions of geostrophic currents
- ‘healing’ of MDT through satellite model

4.2 XGM2020 validation – Geostrophic currents

- **Geostrophic currents** derived from **input MDT** (OGMOC):

Gulf current



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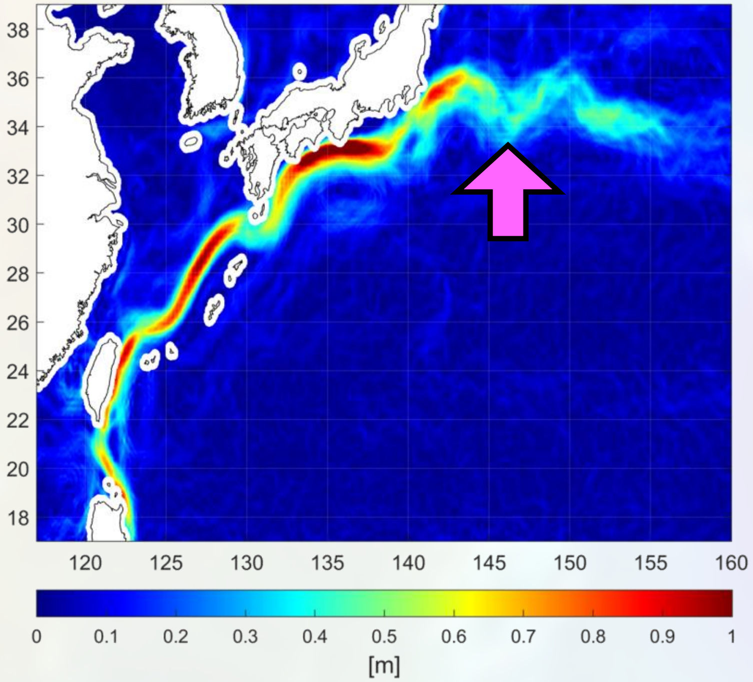
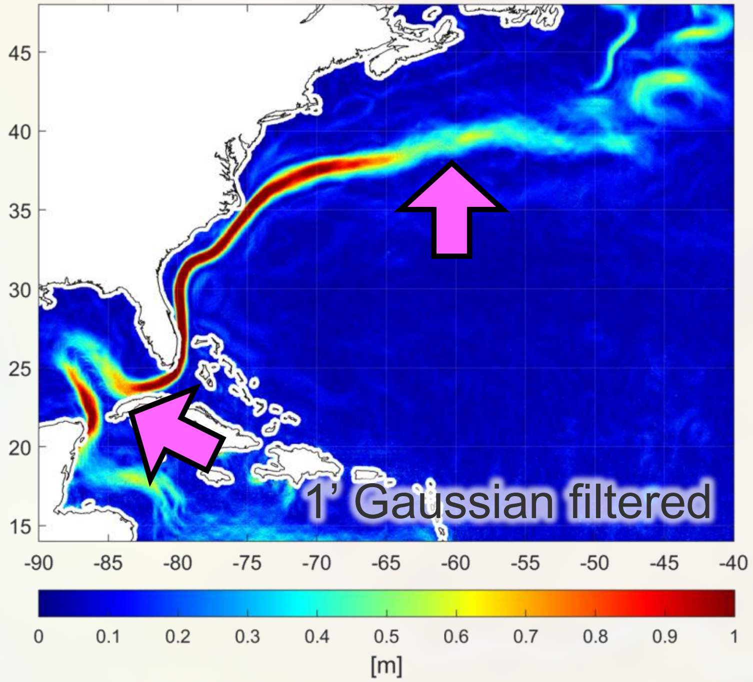


4.2 XGM2020 validation – Geostrophic currents (2)

- **Geostrophic currents** derived from **output MDT** ($\mathbf{MSS}_{DTU18} - \mathbf{N}_{XGM20}$):

Gulf current



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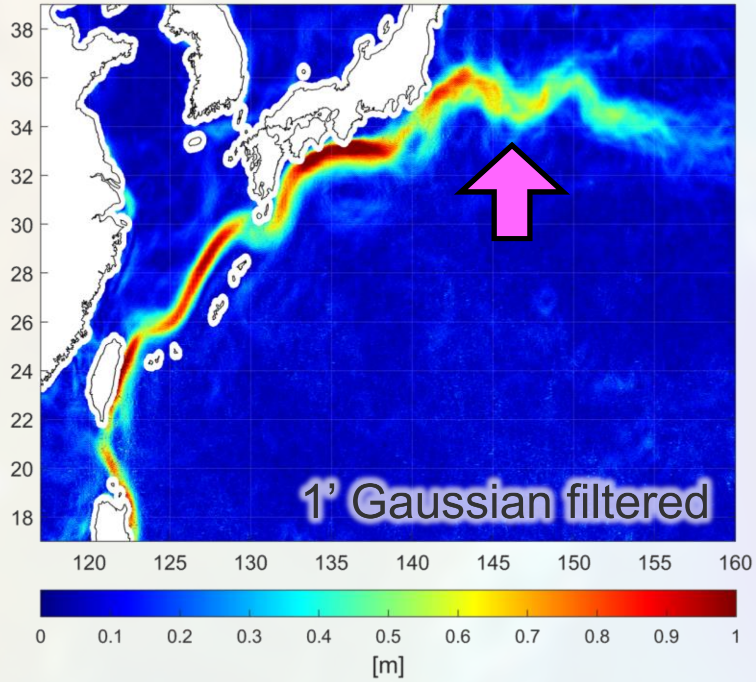

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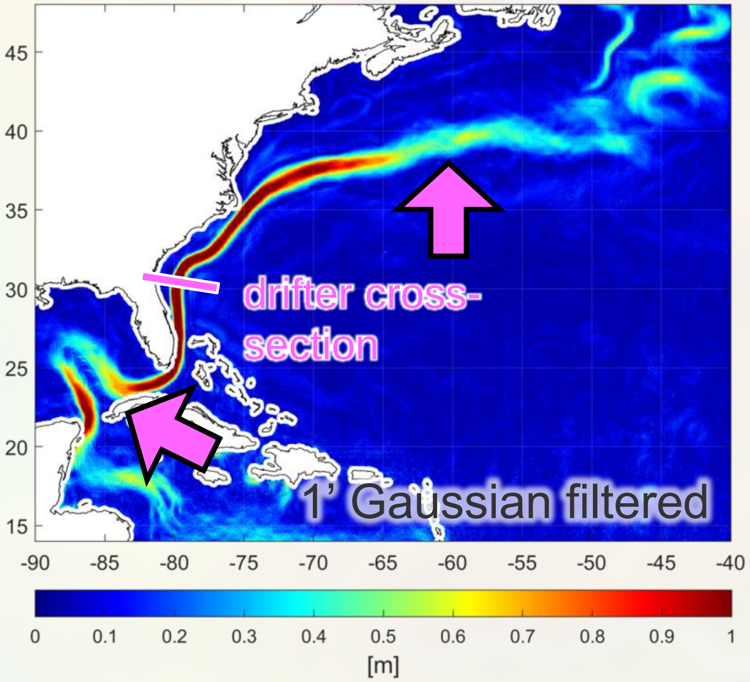

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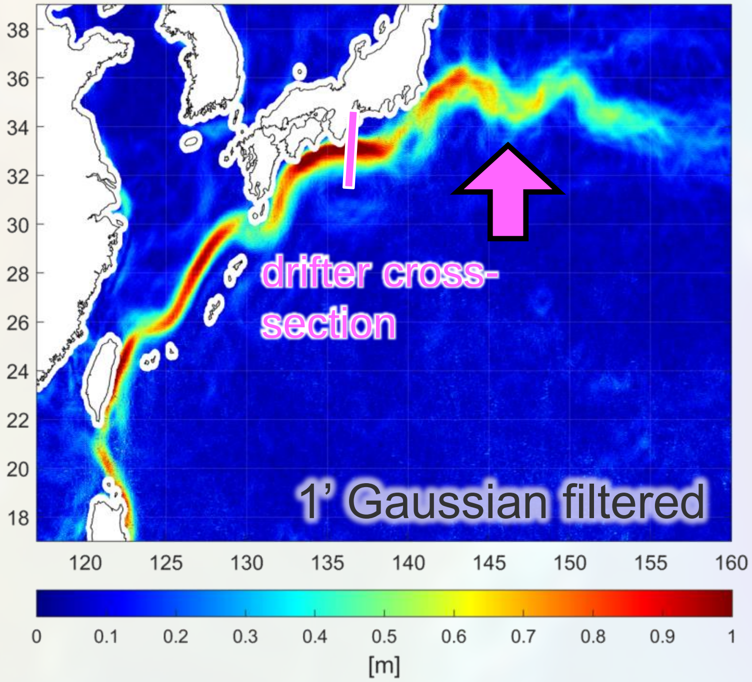
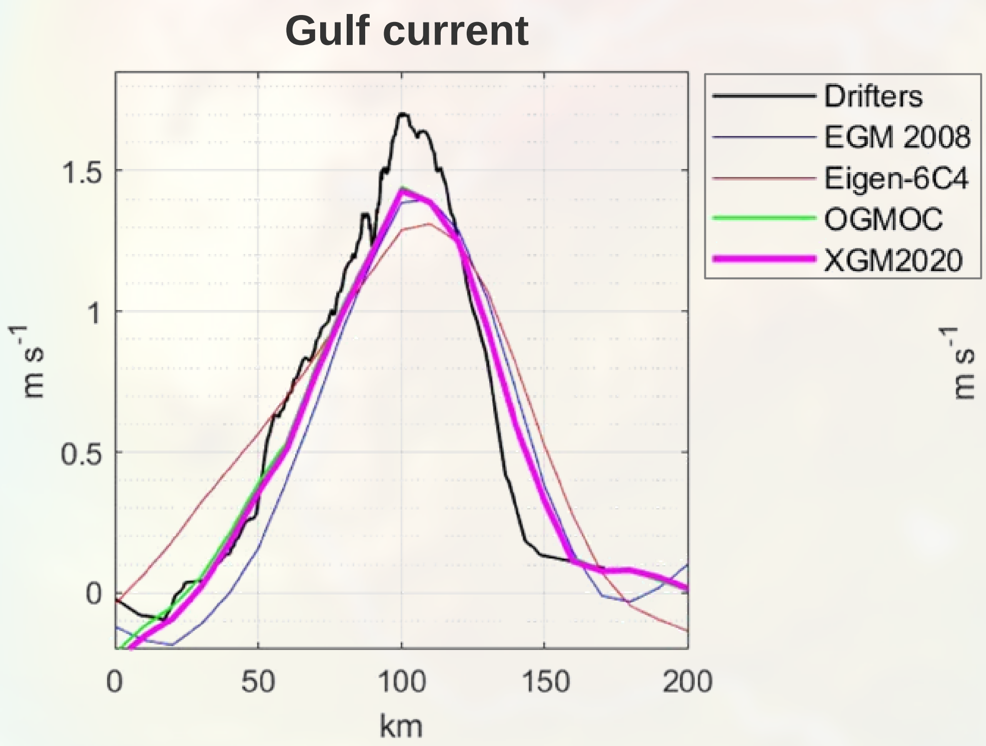
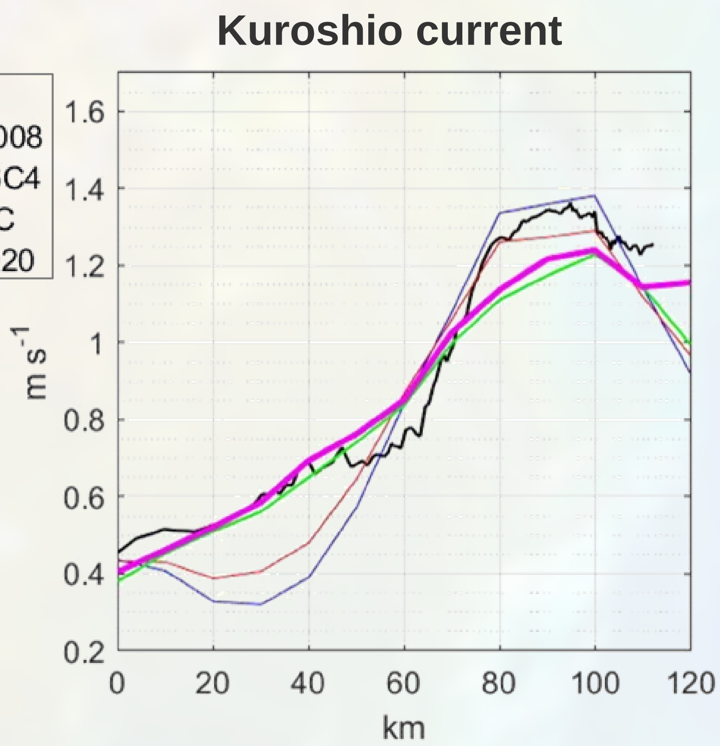


4.3 XGM2020 validation – Drifter velocities

- Drifter cross-section comparisons:

(MDTs were spectrally limited to d/o 520 except the OGMOC and XGM2020 MDT, **courtesy of *Frank Siegismund***)





4.4 XGM2020 validation – Conclusions

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  - Ability to **fully reproduce** input **MDT** and **refine** it within the satellite wavelengths
  - **LSA combination** method has a **high level of maturity**

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  - **LSA combination** method has a **high level of maturity**
- **Cons:**
  - **Land-Ocean tapering** far from being perfect – but: no other data available...
  - Over **land, gravity** not further improvable – waiting for new data (EGM2020?)
  - **OGMOC MDT** not able to fully reproduce drifter speeds (better MDT needed?)