A reduction of the ocean heat transport towards Antarctic ice shelves by seafloor roughness

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1. Introduction

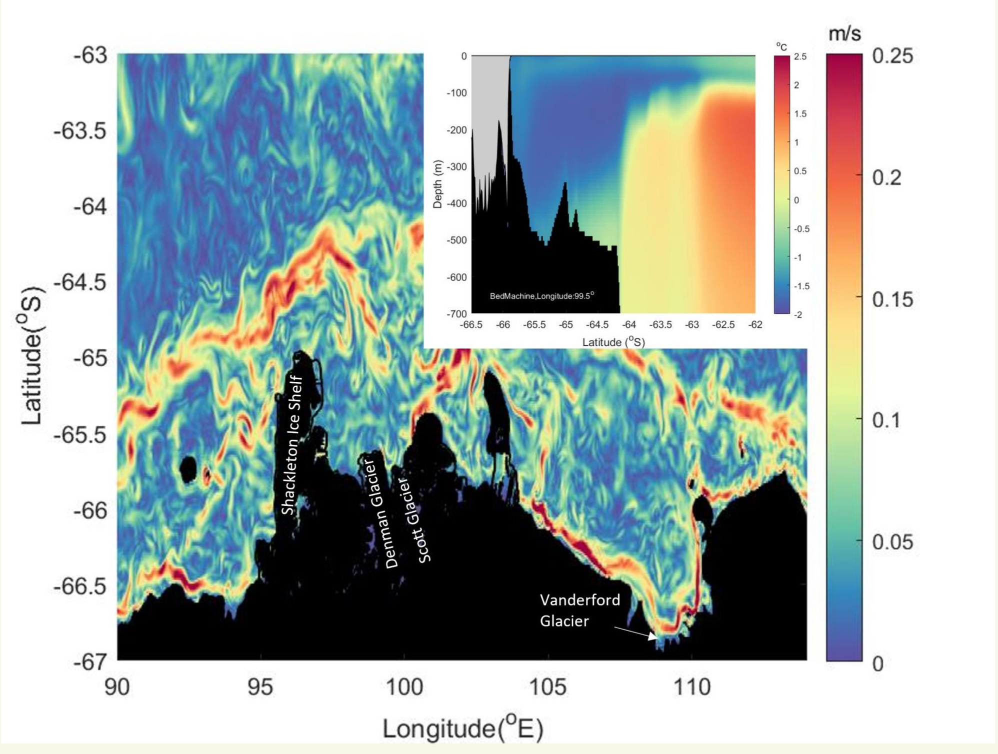

Fig 1. The snapshot of the speed (m/s) at 100 m depth and the inset figure shows the temperature (°C) section at 99.5°.

- Denman Glacier: **2nd** largest sea-level contributor in the East Antarctica.
- **Basal melt** - principal reason for the ice shelf melting.
- **Circumpolar Deep Water (CDW)** intrusions onto the shelf - the primary driver for basal melting.
- Ocean circulation is strongly controlled by the bathymetry, which affects the heat transport to the glacier.

2. Methods

- ❑ **MITgcm**
- ❑ Resolution: 1.2-1.4km resolution
- ❑ Vertical: 160 vertical levels
- ❑ Boundary condition: **ACCESS-OM2-01** global ocean model
- ❑ Repeat atmospheric forcing: JRA55v1.3 external forcing
- ❑ Tides: TPXO9v4 tides
- ❑ Ice shelf: Ice Shelf package in MITgcm, geometry from BedMachine Antarctica, thermal dynamics
- ❑ Sea ice: dynamics and thermal dynamics
- ❑ Bathymetry data: SRTM15_PLUS, BedMachine Antarctica

3. Results and discussion

Bathymetry

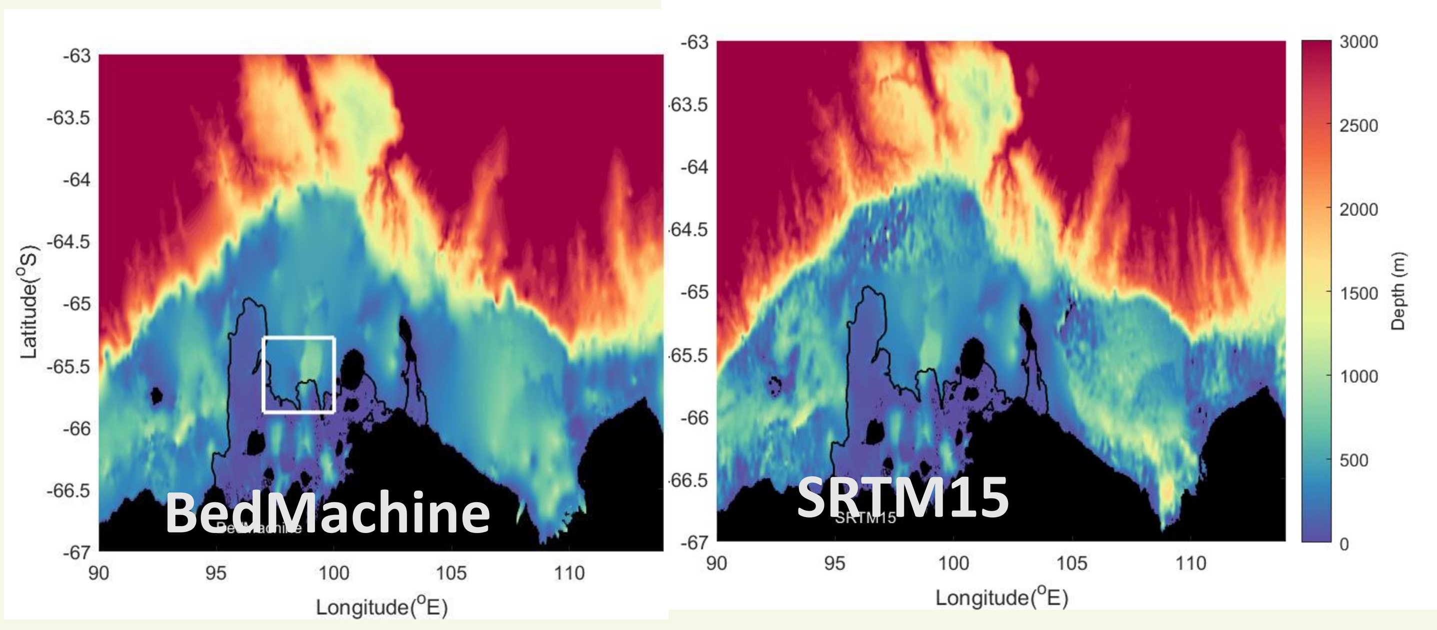

Fig 2. The bathymetry of the BedMachine and SRTM15 (m). White box indicates the glacier region in TS diagrams.

- Roughness (small-scale topographic features) is the main difference between the two bathymetries.

Ocean circulation

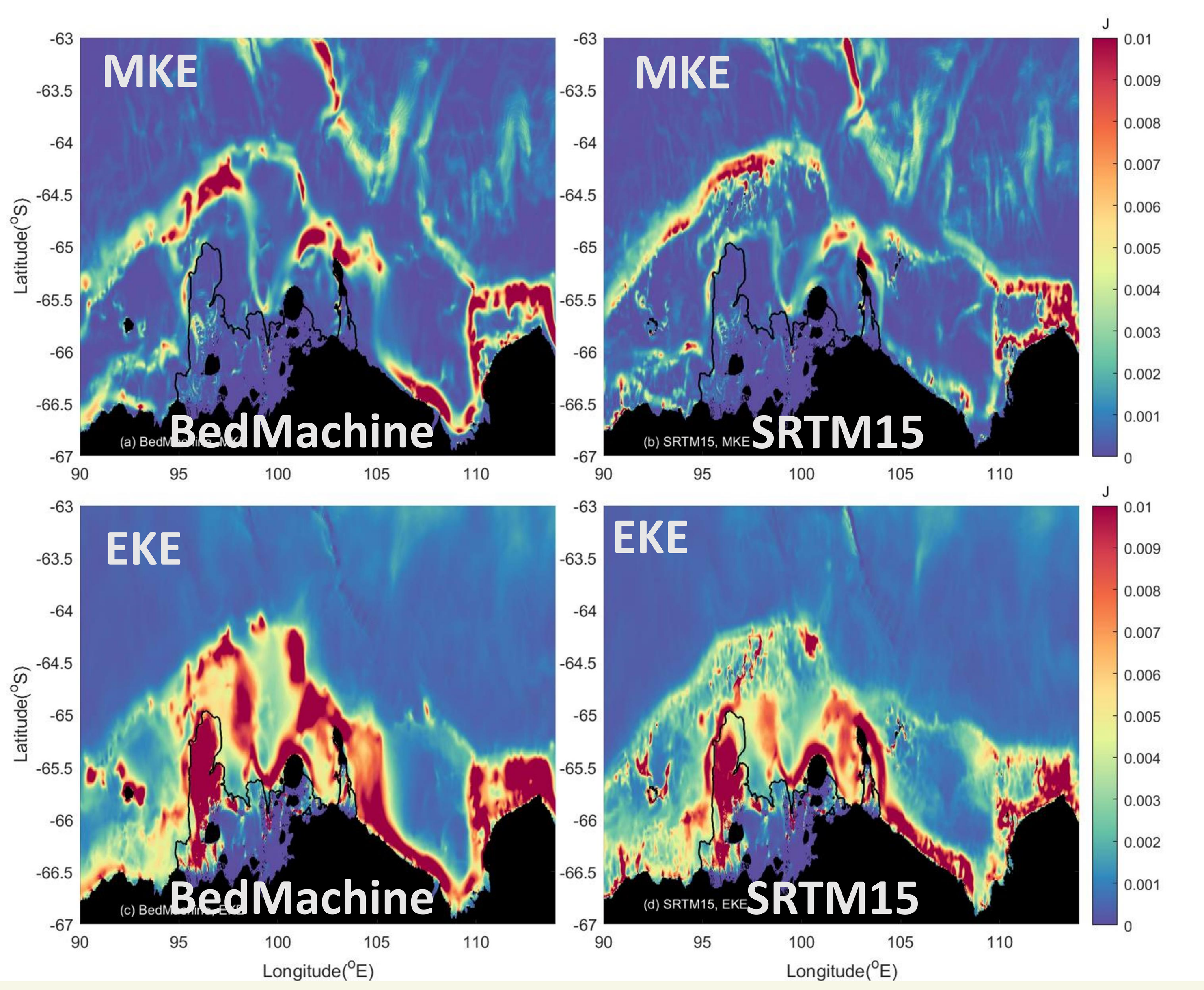

Fig 3. MKE (J) and EKE (J) of the BedMachine and SRTM15.

- MKE is mainly enhanced near the Antarctic Slope Current (ASC), while EKE is enhanced near the coastline.
- The strength of the variability (eddies) in BedMachine is higher than that in SRTM15.
- Eddies dissipate more in SRTM15.

Melt rate

Table 2. The melt rate (Gt/year) of the BedMachine and SRTM15.

	Melt rate
BedMachine	30 Gt/year
SRTM15	26 Gt/year

- A lack of topographic roughness in the Bedmachine dataset leads to up to **15% (4 Gt/year)** increase in the ice shelf melting rates in the Denman region.

Glacier region TS diagram

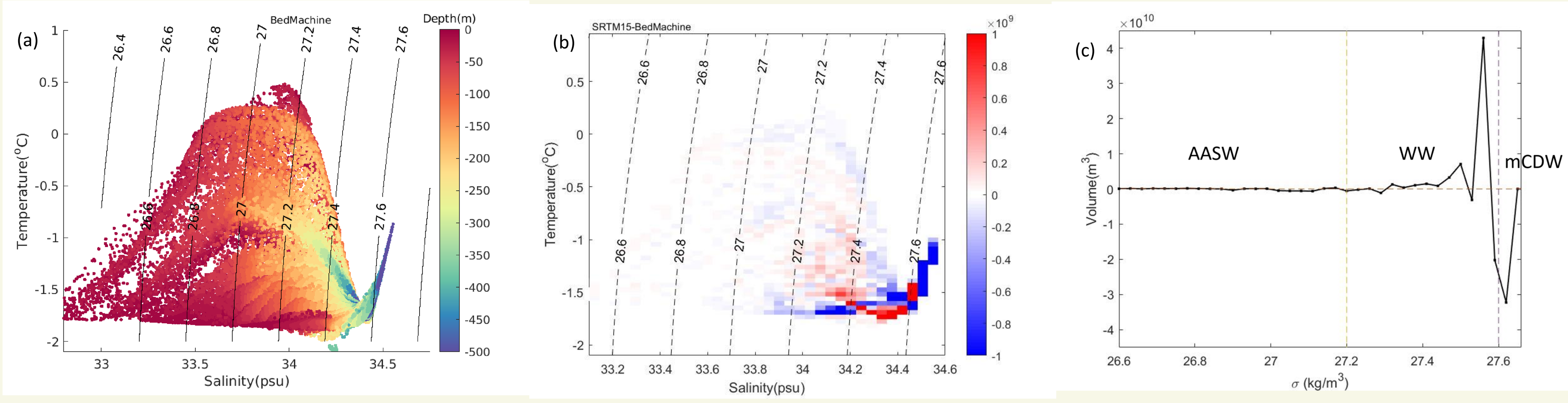

Fig 5. (a) TS diagram in the glacier region. The colour indicates the depth. (b) The volume difference of the SRTM15 and BedMachine in the TS diagram. (c) The volume difference of the SRTM15 and BedMachine changes with density (kg/m³).

Region: White box in the BedMachine Bathymetry (Fig 2).

Table 1. The water mass compositions in BedMachine and SRTM15.

	ρ -1000 (kg/m³)	BedMachine	SRTM15
AASW	26.6 – 27.2	6%	6%
WW	27.2 – 27.6	72%	89%
MCDW	27.6– 27.64	22%	5%

- mCDW in SRTM15 is reduced about 4 times.

Heat transport

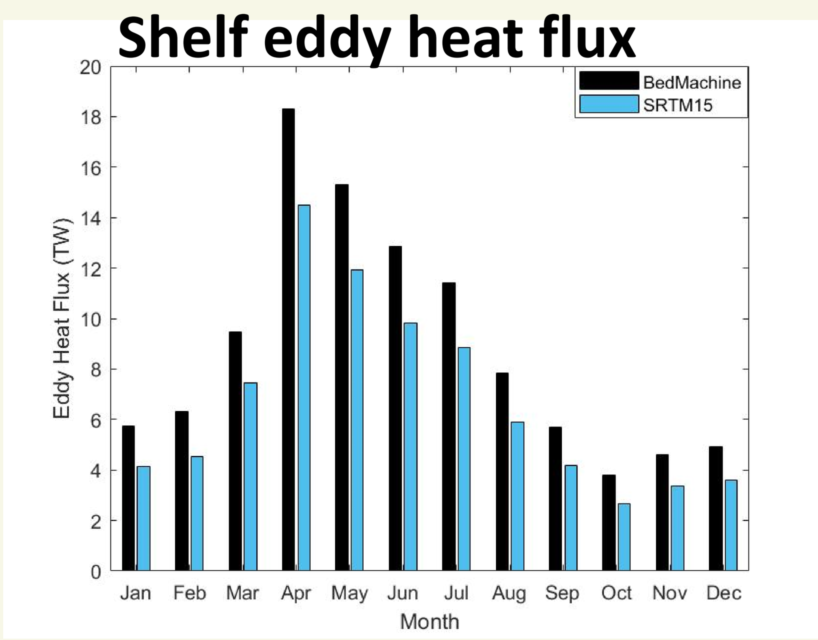

Fig 4. Monthly Eddy heat flux (TW) of the BedMachine and SRTM15 around the shelf.

- Compared with mean heat flux (not shown), eddy heat flux plays a dominant role in the on-shelf ocean heat transport.
- Heat transport changes with seasons.
- SRTM15 has smaller heat flux than BedMachine.

4. Take home message

- Two available bathymetry datasets are different in their representation of small-scale roughness (abyssal hills).
- Topographic roughness effectively dissipates eddies, which appear to be the main contributor to the heat transport towards ice shelf cavities in the Denman region, leading to 15% (4 Gt/year) increase in the ice shelf melting rates.
- Topographic roughness on O(1-50km) scales is absent in most Antarctic shelf bathymetry products and not resolved in global models, and thus it’s role for the shelf circulation and heat transports is overlooked.