Characteristics and Trends of the Campbell Plateau Meander in the Southern Ocean: 1993-2020

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Introduction

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- * The Southern Ocean is warming & freshening.
- The westerly winds that drive the Antarctic Circumpolar Current are intensifying & shifting poleward.



- Front: boundary between water masses of different properties.
- Meander: current weaving in the horizontal & vertical planes.
- Positions of fronts have not moved significantly meridionally over past three decades.
- **Characteristics** of meanders have





Motivation



Map of the gradients of sea surface height; Chapman et al. (2020)

Much has been done on Southern Ocean fronts, their characteristics and how they respond to climate change, but much less is known about meanders.

The Campbell Plateau meander:

- The only Southern Ocean standing
- meander close to a populated region, with associated industry and biodiverse ecosystems.
- ✤ Its trends were not investigated before.

Data and Methods

Upper ocean warming

Shallowing mixed layer

Using altimetry data (CMEMS AVISO) absolute dynamic topography and surface geostrophic current velocities datasets over the 1993-2020 period.



Deepening mixed later

A "local gradient maxima" method: based on Chapman (2014)

- & Chapman (2017); modified by Meyer et al. (in prep).
 - I. Calculate the absolute dynamic topography gradients in the Campbell Plateau region.
 - II. Identify the Campbell Plateau meander's daily position.
 - III. Derive the meander's time-averaged positions.
 - IV. Identify key standing peaks, troughs, and the width of the meander.
 - V. Determine the geostrophic speed of the meander.

Results

✤ The Campbell Plateau Meander can be divided into the standing part & non-standing part.

✤ Comparing with the Agulhas-Kerguelen standing meander, the overall trends are **similar**: no southward displacements ; similar mean widths and widening trends and accelerating trends.



- Meander position: standing part not moving significantly meridionally; non-standing part shifting northwards by 0.30° lat per decade.
 - Meander decadal mean and monthly positions in the 1993-2020 period



Meander amplitude: decreasing by 0.31° lat per decade upstream from the Plateau; increasing by 0.25° lat per decade downstream from the Plateau.

_ Meander decadal mean and monthly positions in the 1993-2020 period

Take-home messages

The Campbell Plateau Meander has clear trends over the past 30 years:

- Position: relatively fixed, but downstream part shifting northwards.
- Amplitude: flattening
 unstream of the Plateau



Meander width: mean value about 110 km; whole meander widening by 2.2 km per decade, mostly downstream (4.2 km per decade).



Meander speed: whole meander significantly accelerating by 0.01 m s⁻¹ per decade, mostly in the flat region downstream from the Plateau (0.02 m s⁻¹ per decade). upstream of the Plateau;
steepening downstream of the Plateau.
Width & speed: widening and accelerating, particularly downstream.
Similar trends compared to the Agulhas-Kerguelen standing meander.

Discussions

- Non-standing part significantly shifting northward: Hypothesis 1: The changes in the dynamic stability of the jet (Youngs et al., 2017; Barthel et al., 2022); Hypothesis 2: The interaction between the South Pacific gyre and Antarctic Circumpolar Current jets (Roemmich et al., 2007)
- * Increasing width: Consistent with Gille (1994); Hypothesis: changes in the volume transport of the meander that are driving the positive trend in its width changes
- Increasing speed: Consistent with recent studies (e.g. Shi et al., 2021); Hypothesis 1: Increased wind forcing; Hypothesis 2: Increased buoyancy forcing due to intensified meridional density gradients (Shi et al., 2021; Peng et al., 2022).