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Southern Hemisphere Oceans in a Changing Climate

Projected changes in Tasman Sea marine climate, extremes, circulation and eddies in a future climate

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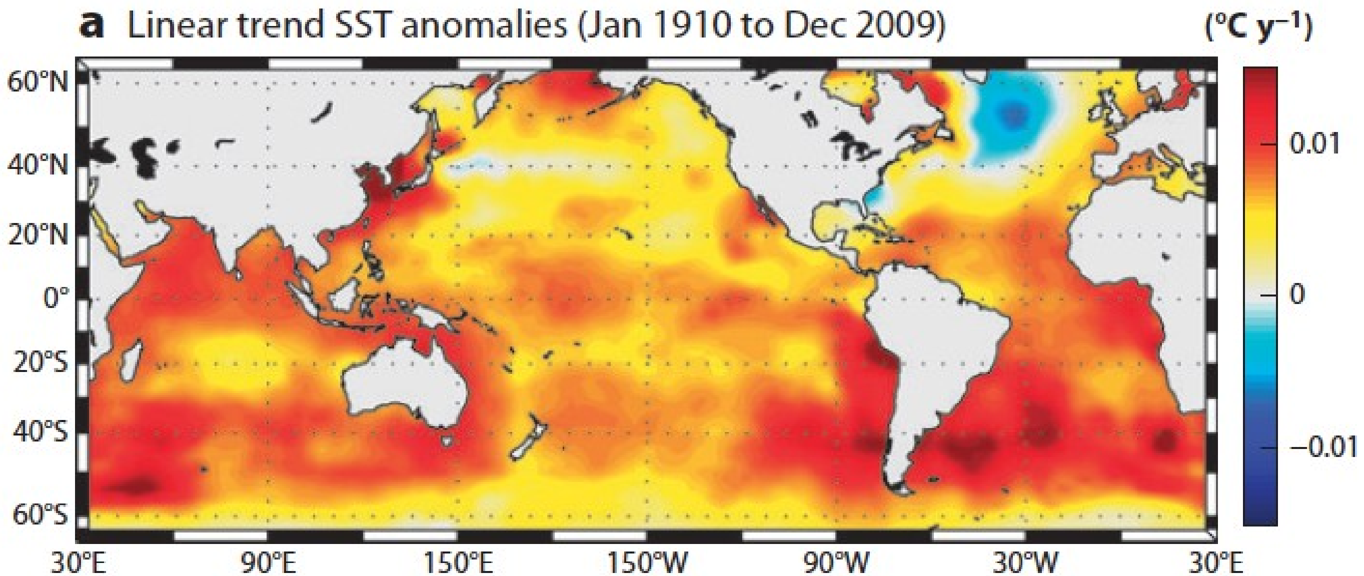
translatingnatureintoknowledge

Marine climate change

- The Earth is warming at an unprecedented rate
- The ocean, particularly the upper ocean, is no exception...
  ...global SST trend ~0.6°C/century [IPCC-AR4]
- The warming of the ocean is not spatially uniform – **hotspots**

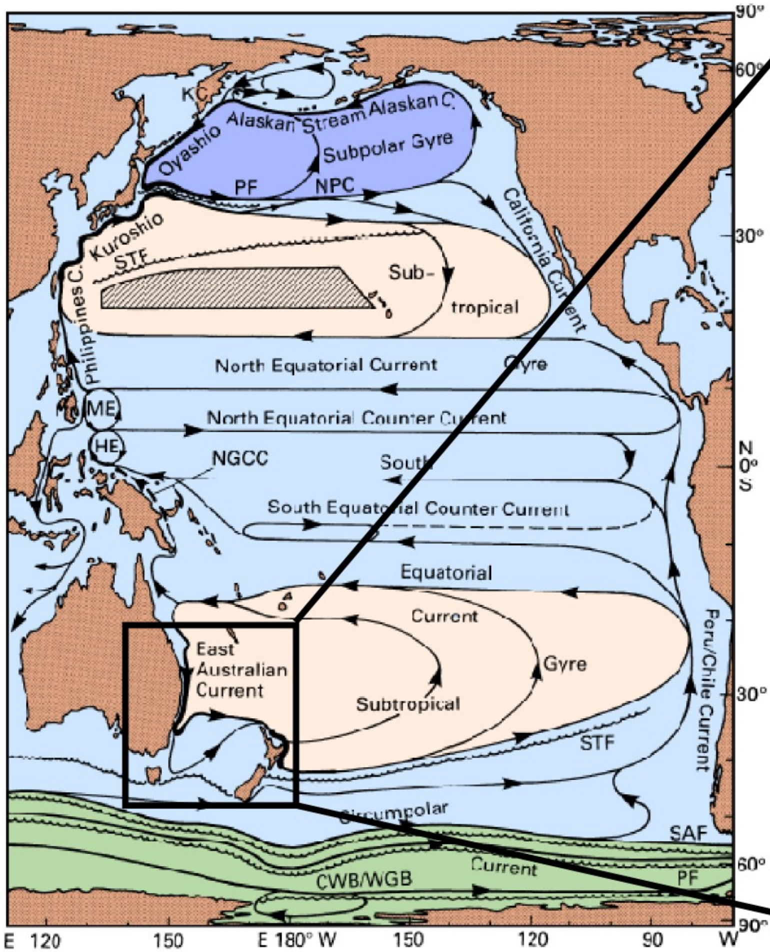


Chavez et al., 2011

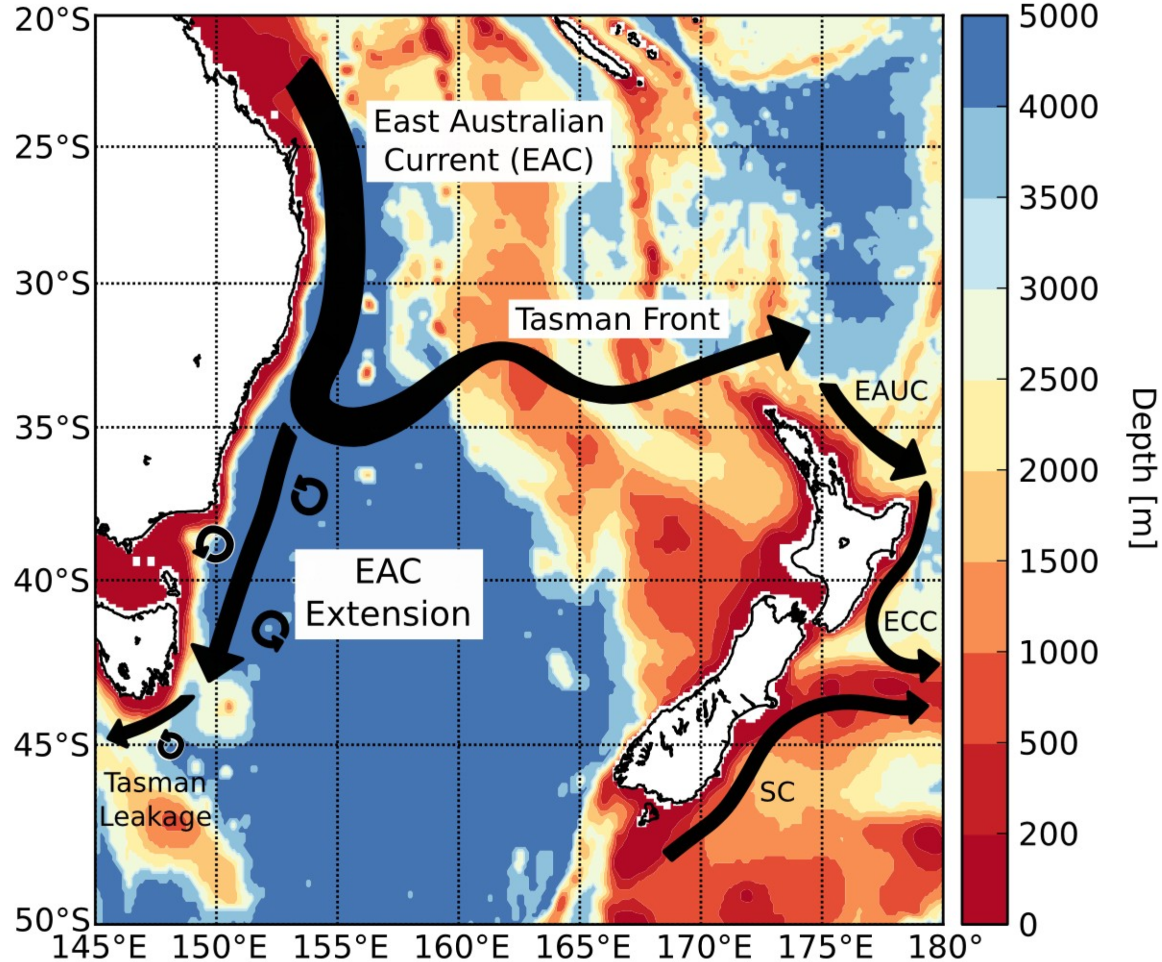
Southeastern Australia

- **Regional oceanography of the Tasman Sea**

western boundary current, eddy-rich region, complex bathymetry



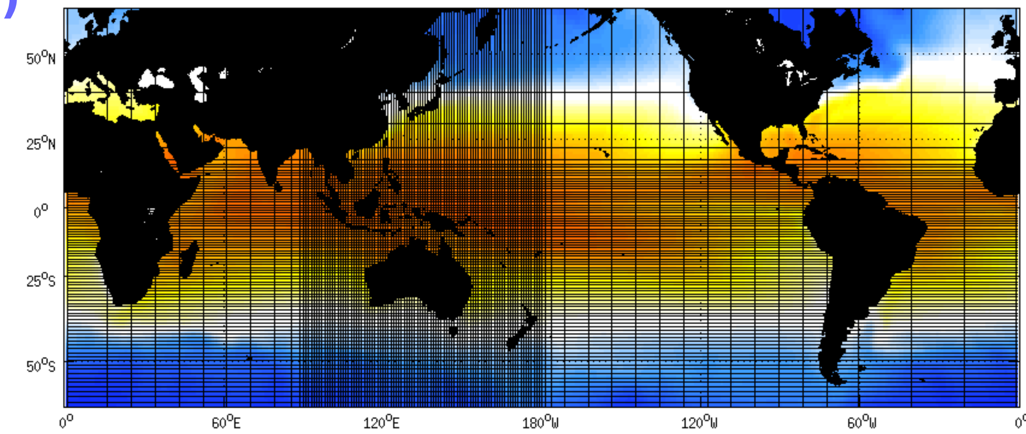
[Tomczak and Godfrey, 1994]



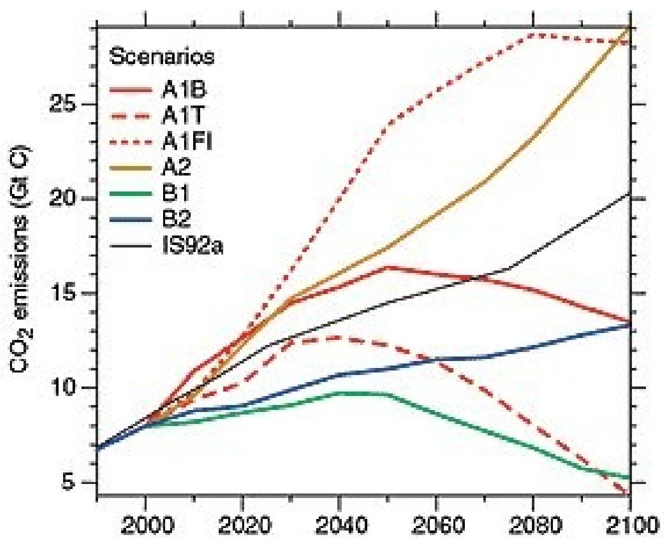
Ocean Modeling

- Eddy-resolving dynamical downscaling in Australia region **Chamberlain et al. (2012)**.
- Two <u>ocean model runs</u> using Ocean Forecasting Australia Model (**OFAM**; 70°S–70°N, $1/10^{\circ}$ resolution around Australasia)
- Forcings representative of:
  - **1990s (CTRL run)**, and
  - **2060s (A1B run)**
- Control run forced by **historical reanalysis**
- **Climate change simulation** CSIRO Mk3.5 GCM run using A1B emissions scenario
- Models represent well general circulation and temperature distribution around Australia, including seasonality **[Sun et al, 2012; Matear et al., 2013]**

OFAM grid with mean SST



Climate change emissions scenarios

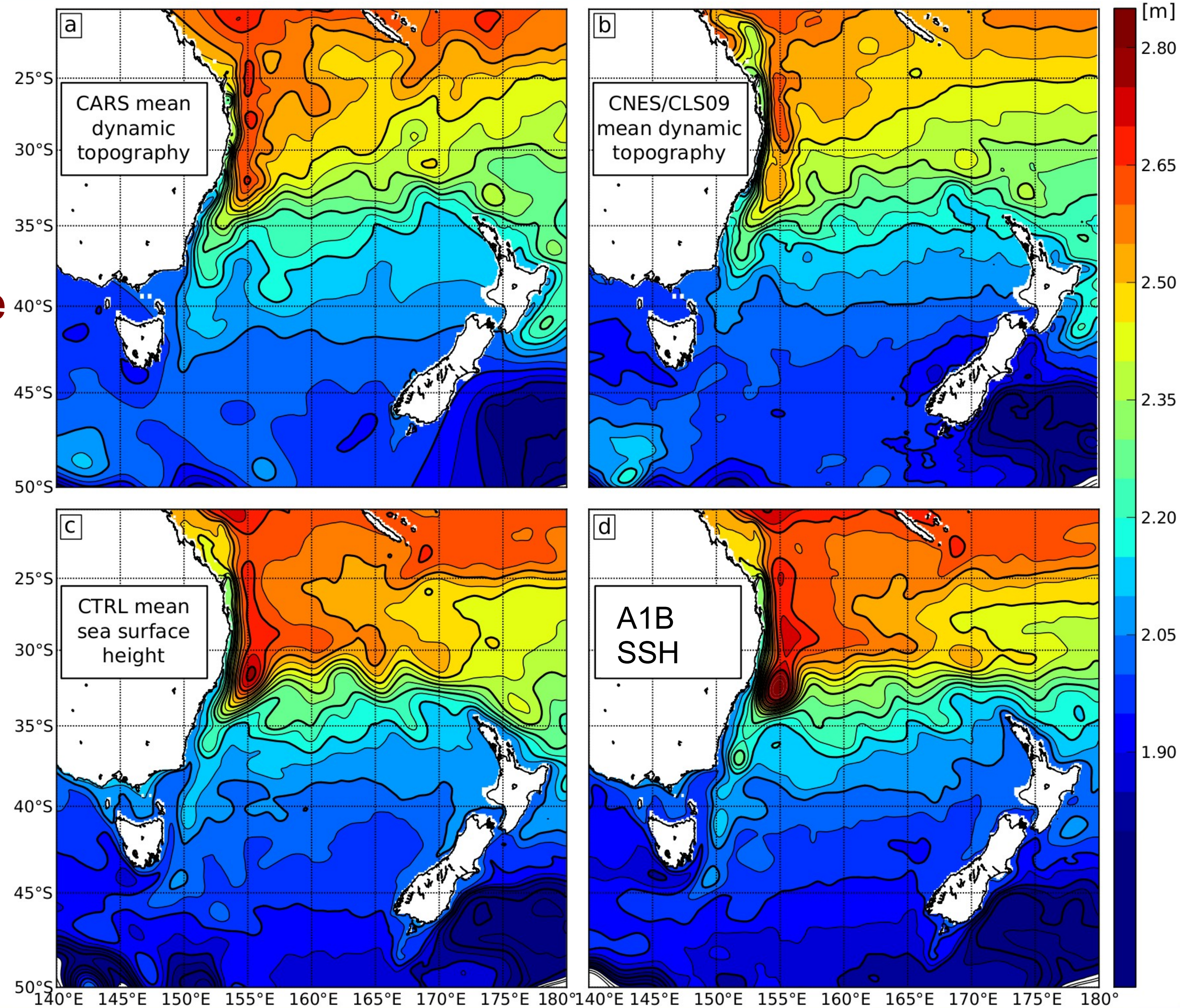


Mean Circulation

Model simulated surface mean dynamic topography

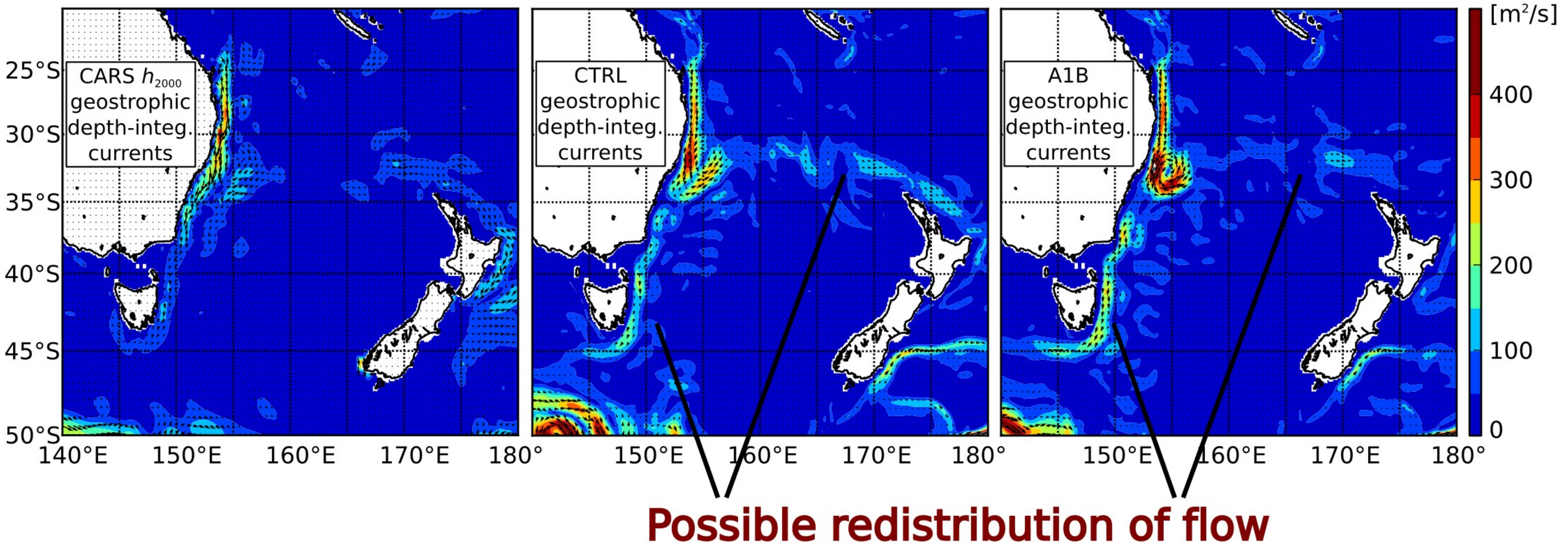
(indicative of surface geostrophic flow)

consistent with observations



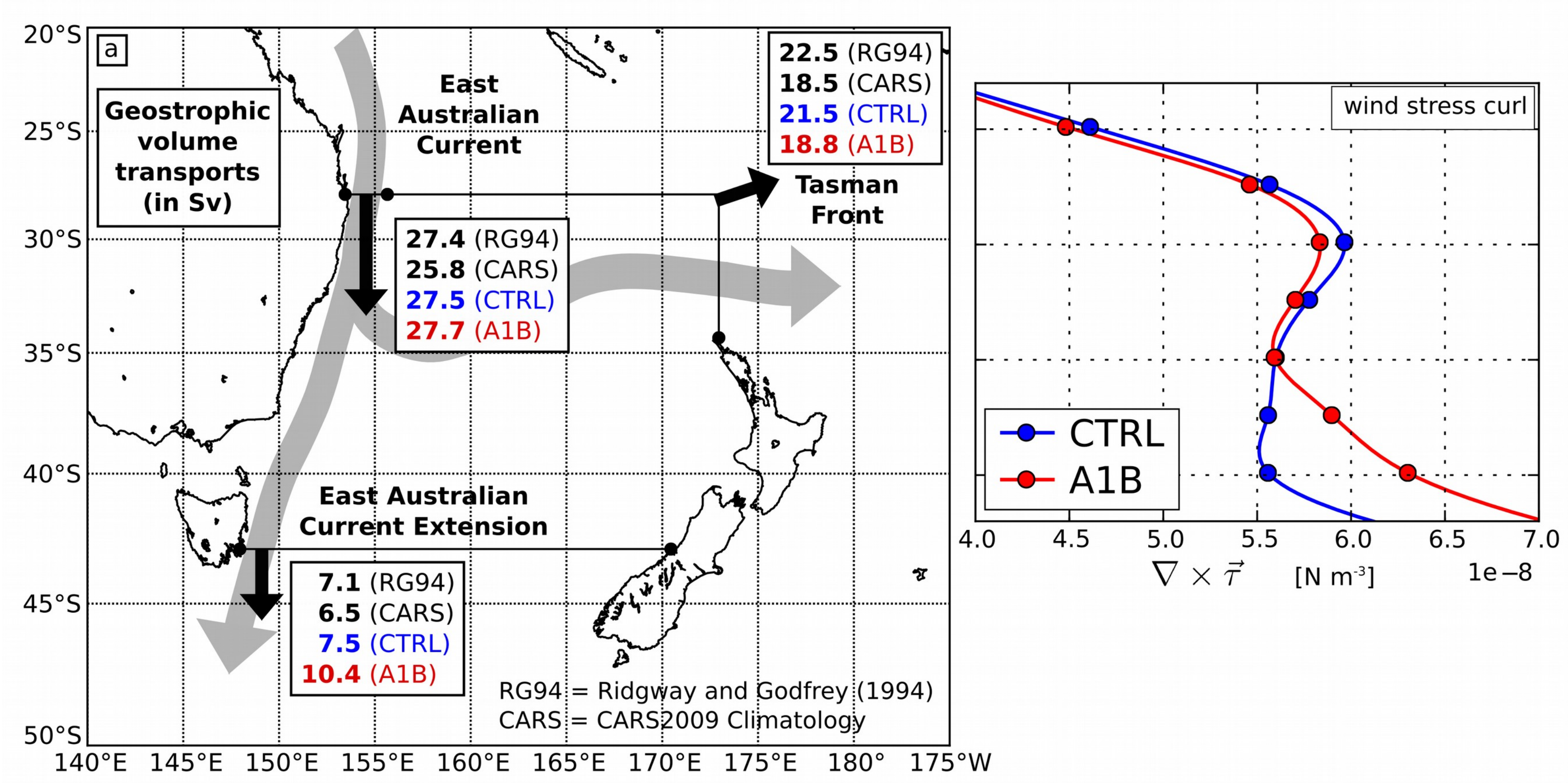
Mean Circulation

- Observed and model simulated mean circulation



Mean Circulation

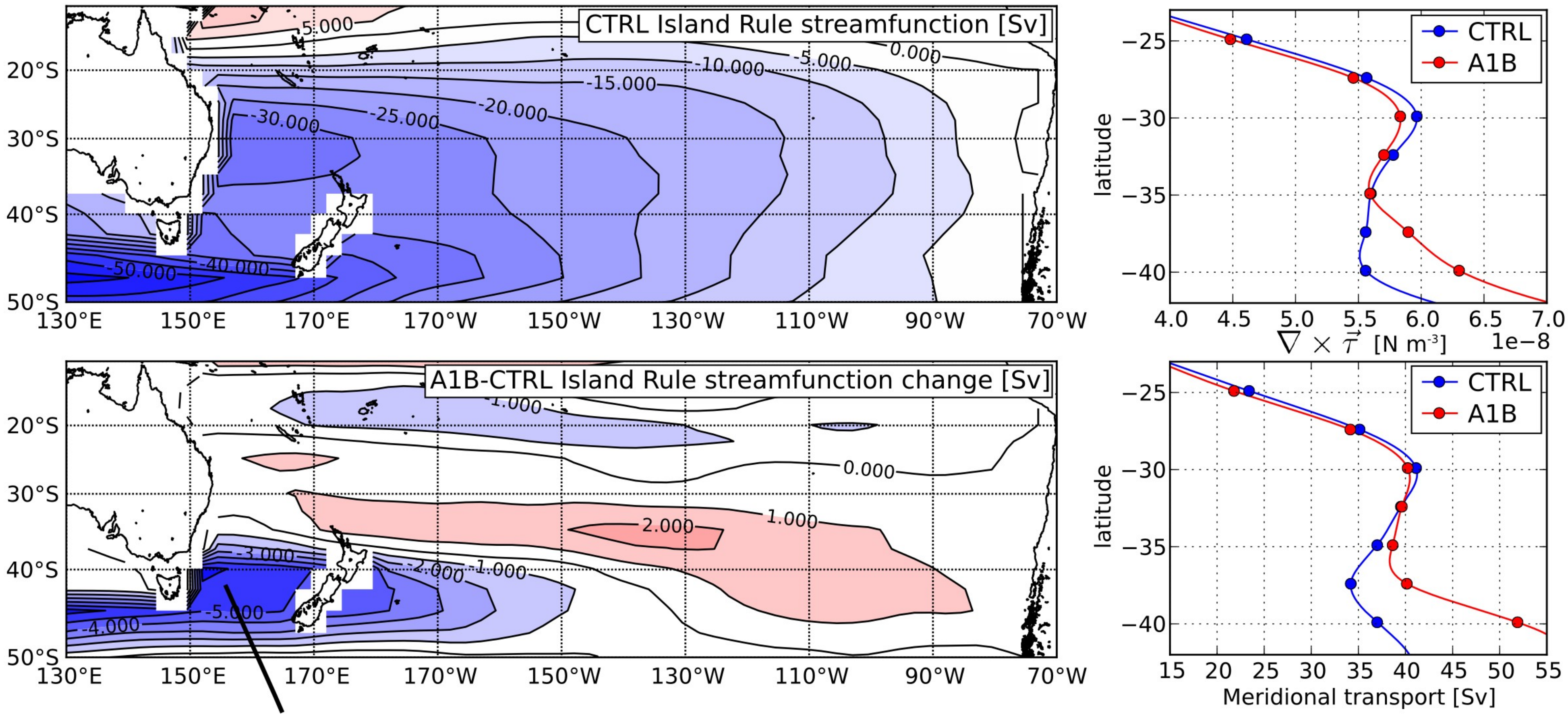
- Redistribution of flow through the Tasman Sea



- Enhanced EAC extension and reduced flow along Tasman Front, consistent with basin-wide changes in wind stress curl

Wind-driven Circulation

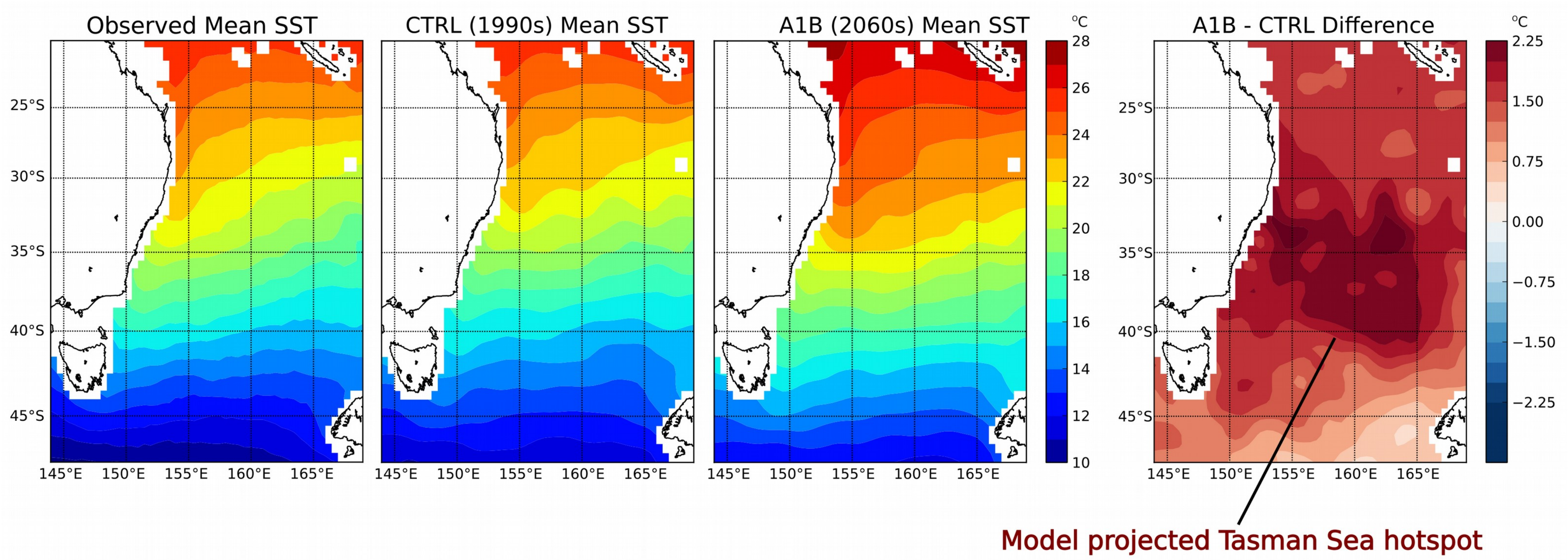
- Island Rule stream function for CTRL (1990s) winds, and change for A1B (2060s) wind



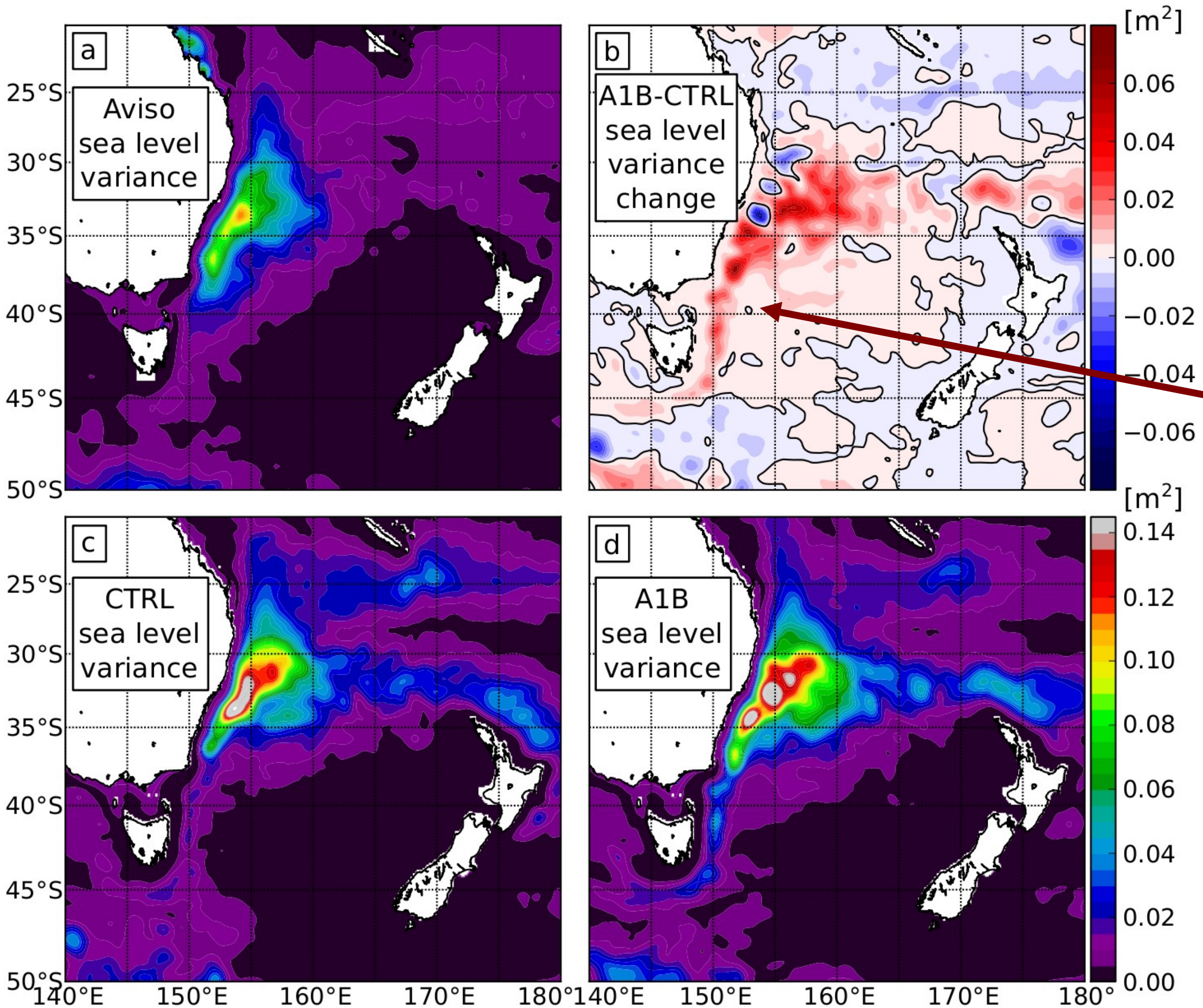
circulation changes at high latitudes in the Tasman Sea (EAC extension)

Mean SST

- Model simulated mean SST



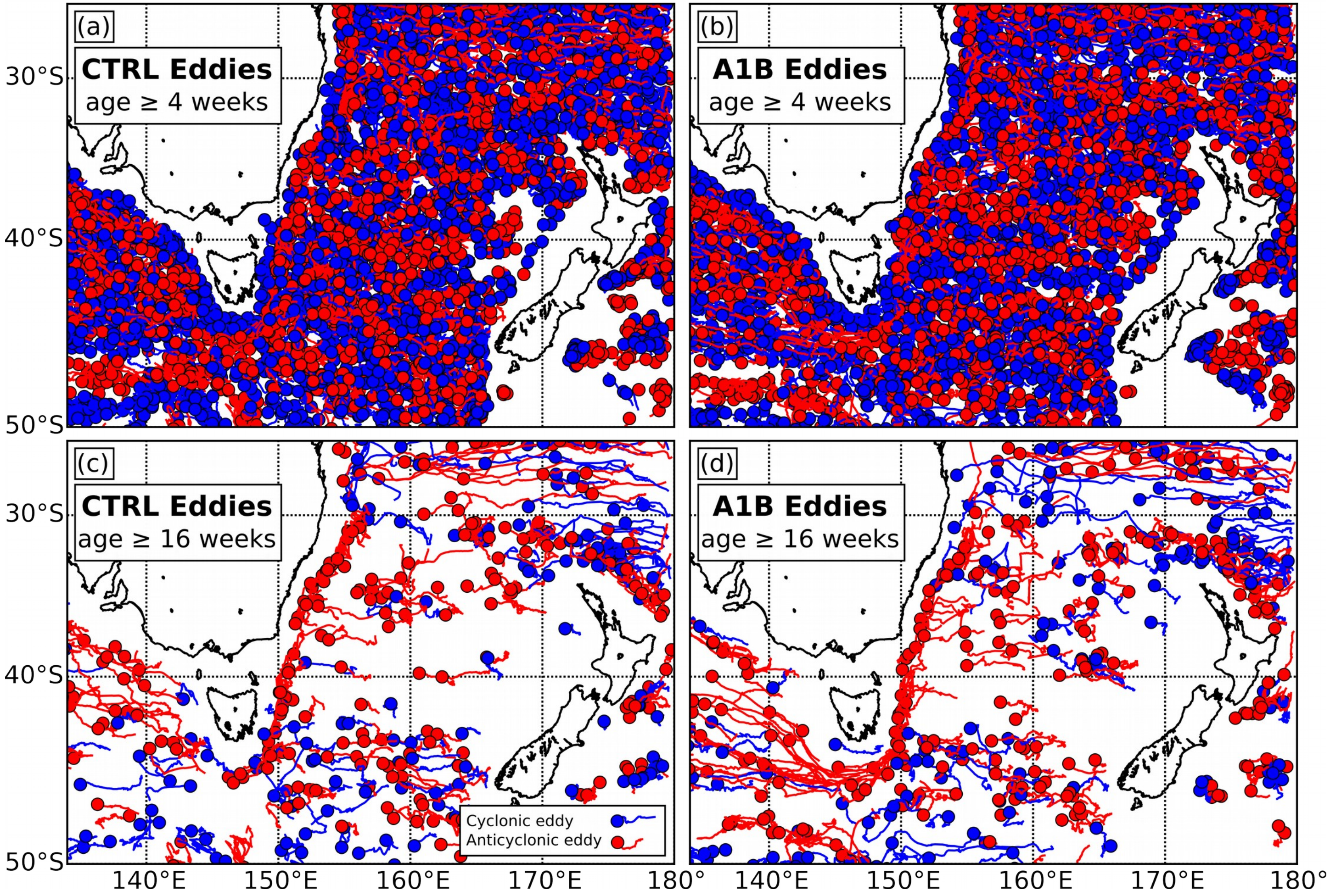
Eddy Kinetic Energy



- Sea level variance (~eddy kinetic energy) consistent between model and observations
- Significant increase in eddy kinetic energy in EAC Extension region, where flow is not steady but in fact consists of a train of mesoscale eddies...

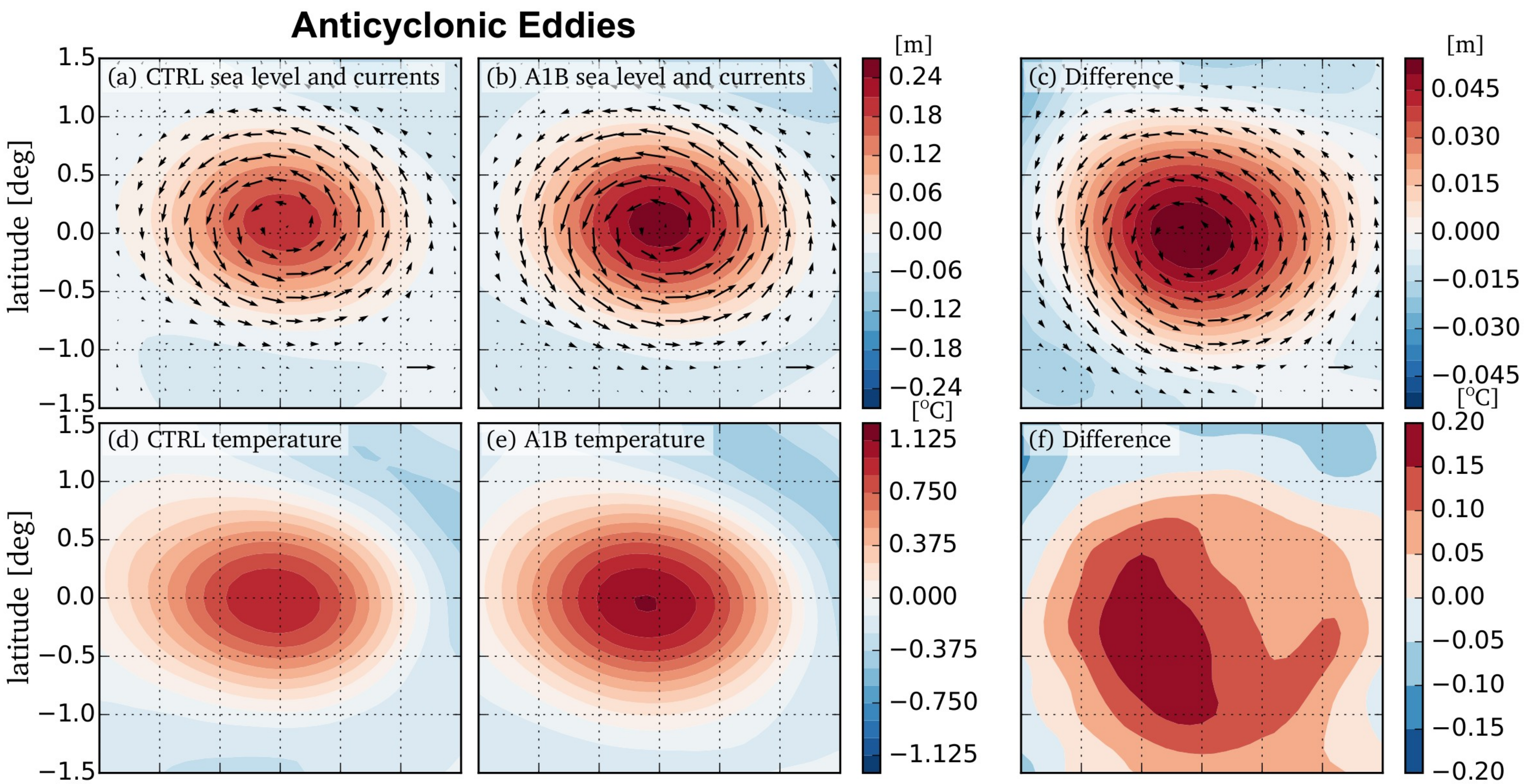
Eddy Statistics

Cyclonic (blue) and **anticyclonic (red)** eddies tracked using Chelton et al. (2011) sea level algorithm:



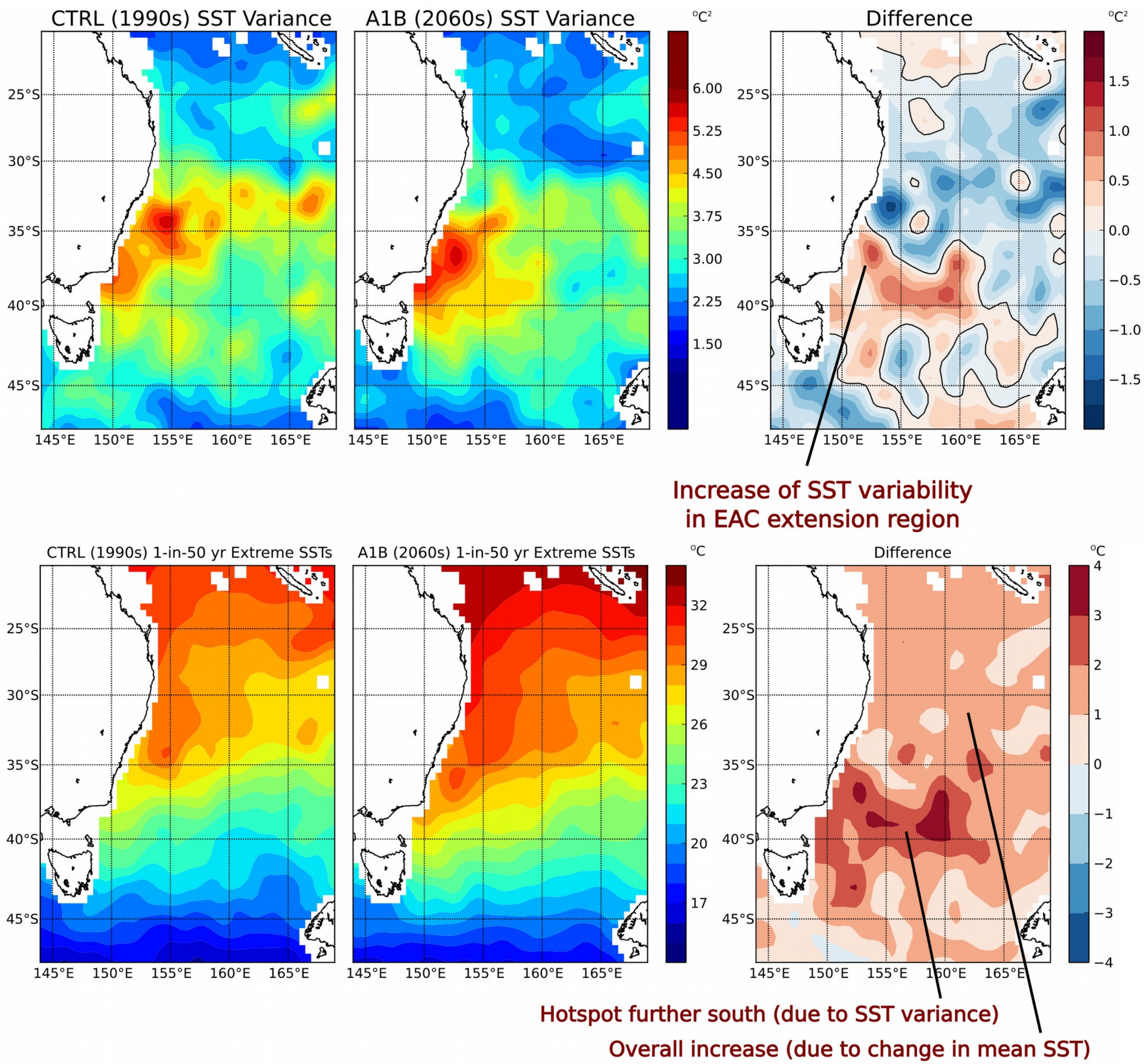
Significant **increase** in number of long-lived **anticyclonic (warm core) eddies** in EAC Extension region, and possibly an increase in eddies passing through the Tasman Leakage

Composite Eddies



- 2060s Anticyclonic eddies are **larger**, with **stronger currents** and **warmer anomalies**
- Leads to nearly **doubling** of eddy-related **heat transport** in EAC extension (upper 200 m)

SST Variance => Extremes



- There is also an associated increase in SST variance in same region
- Projected change in extreme SSTs (50-year return levels) is due to a combination of the changes in mean and variance

Conclusions

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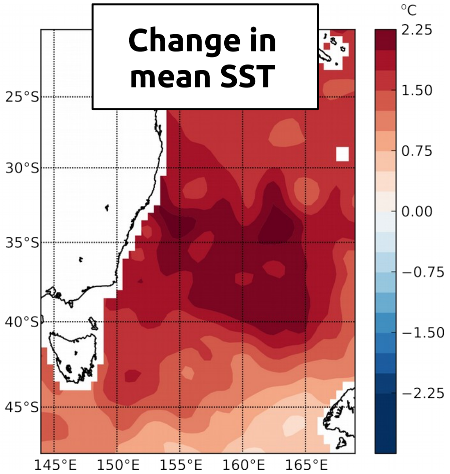
  - **Tasman Sea SST hotspot**



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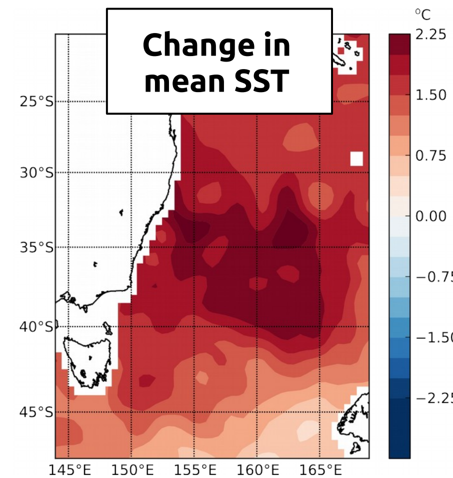

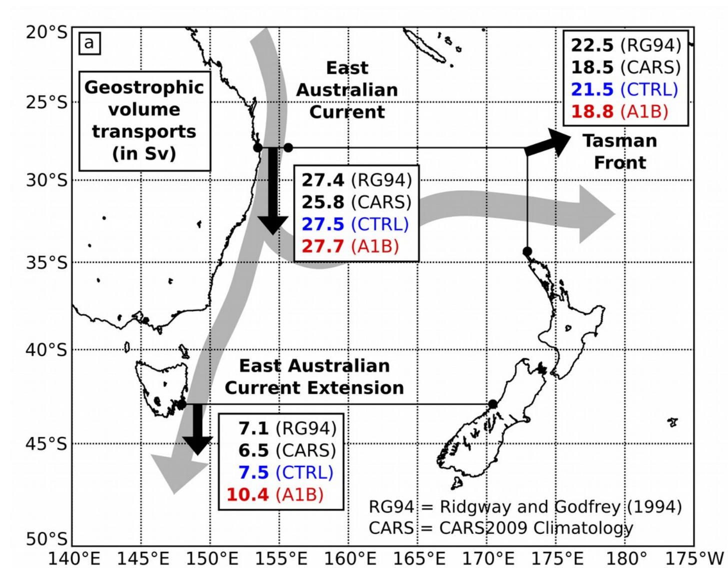

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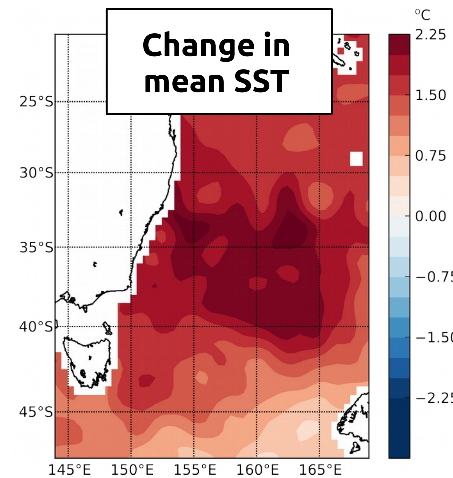

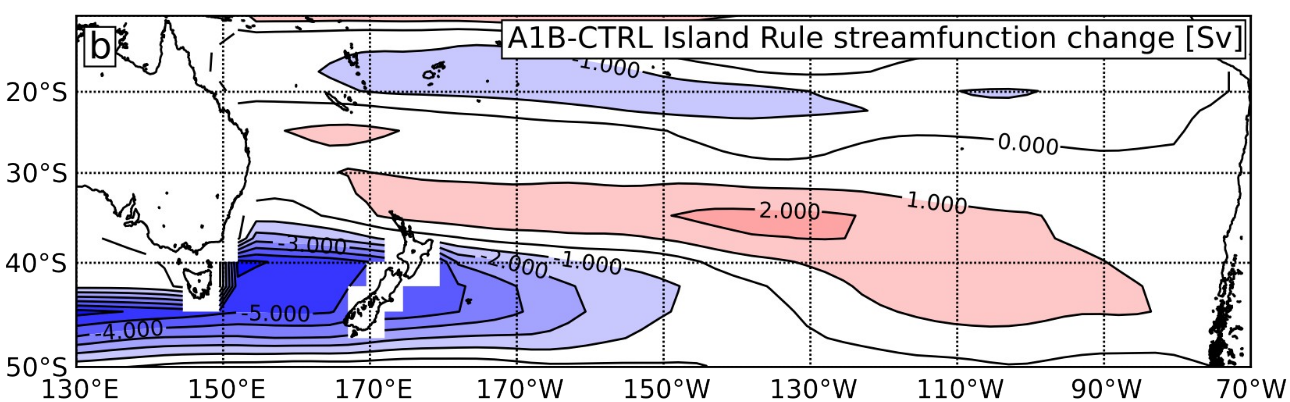

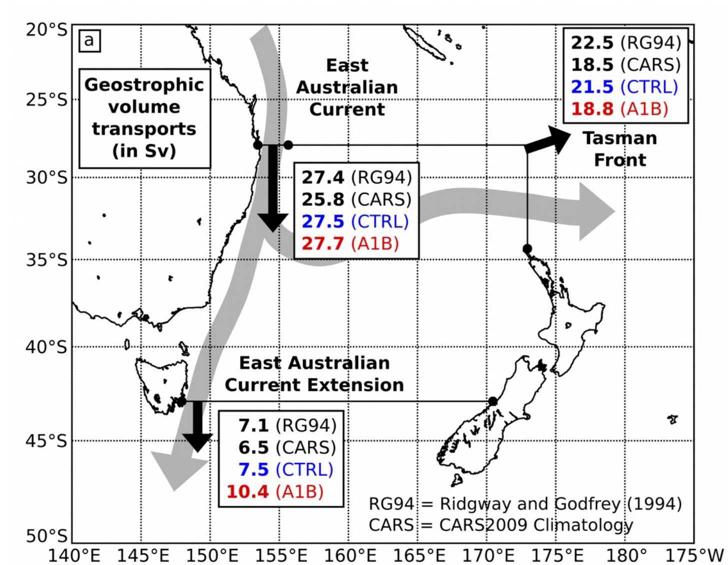

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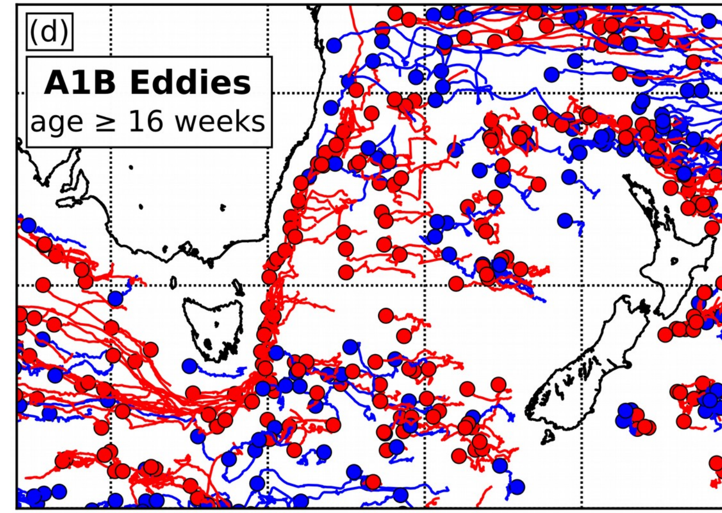

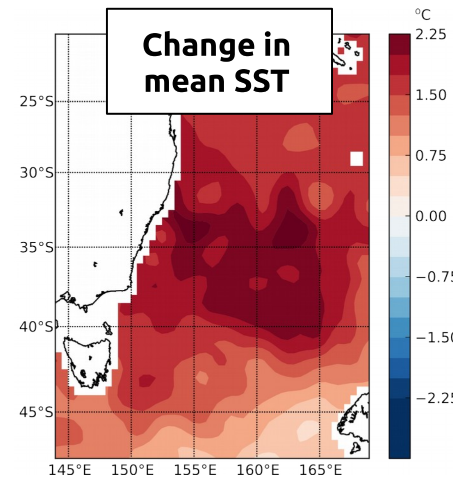

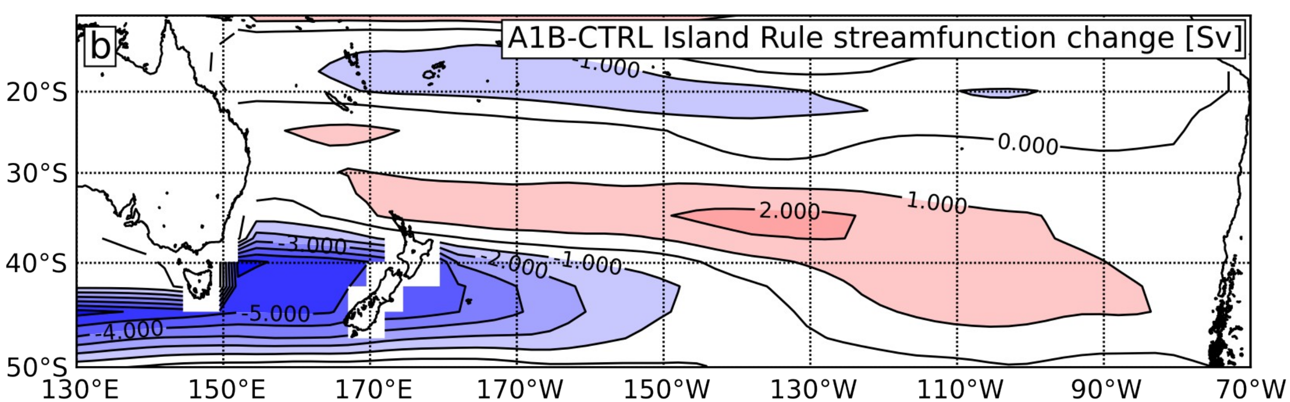

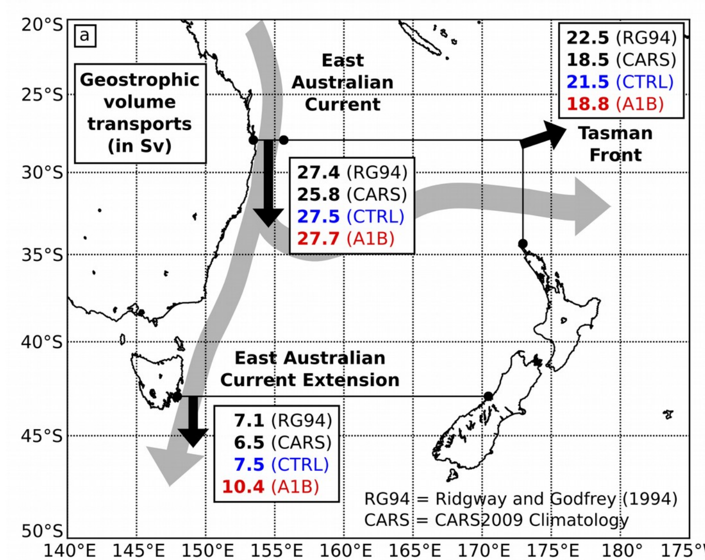

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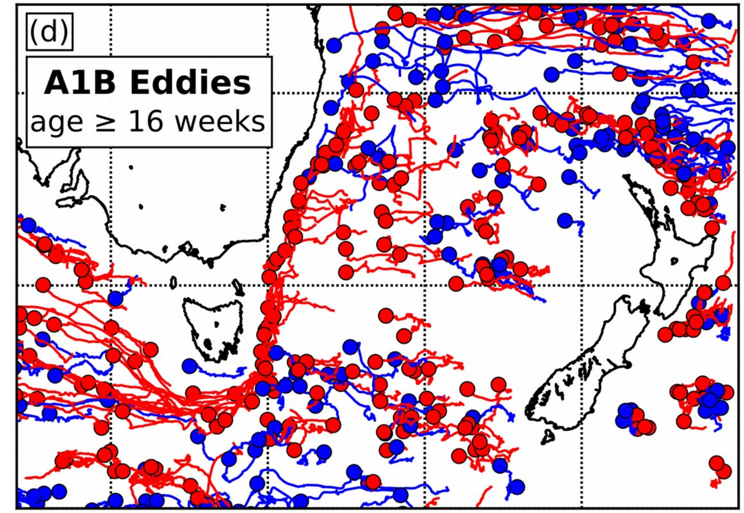
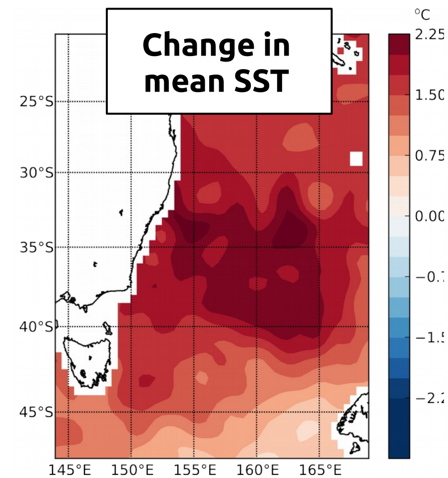
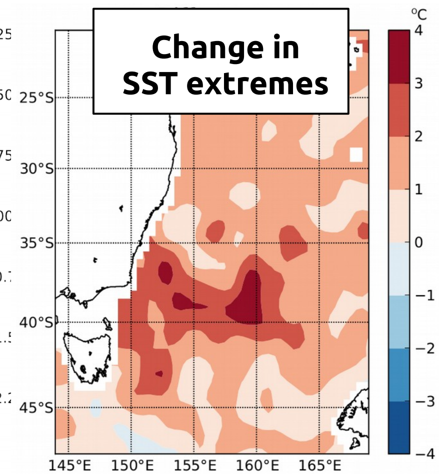
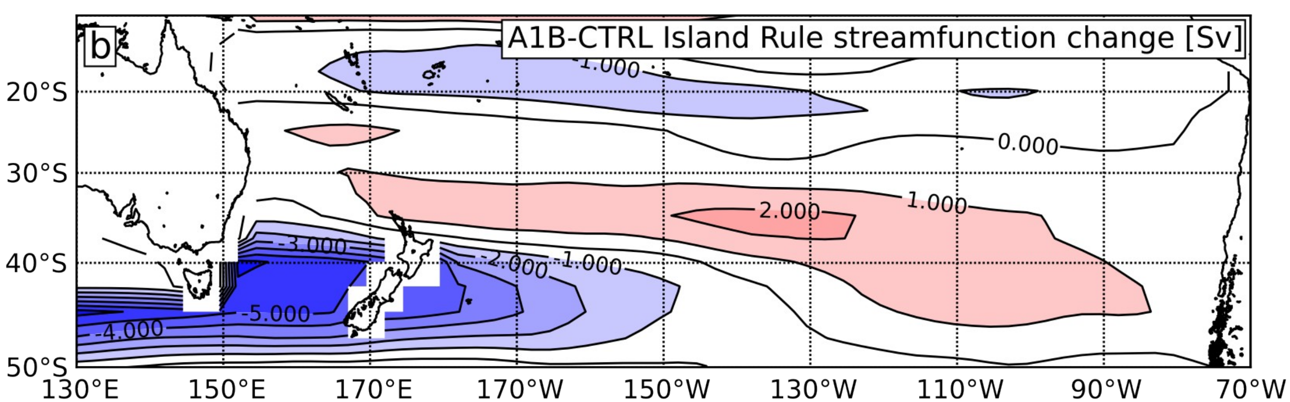
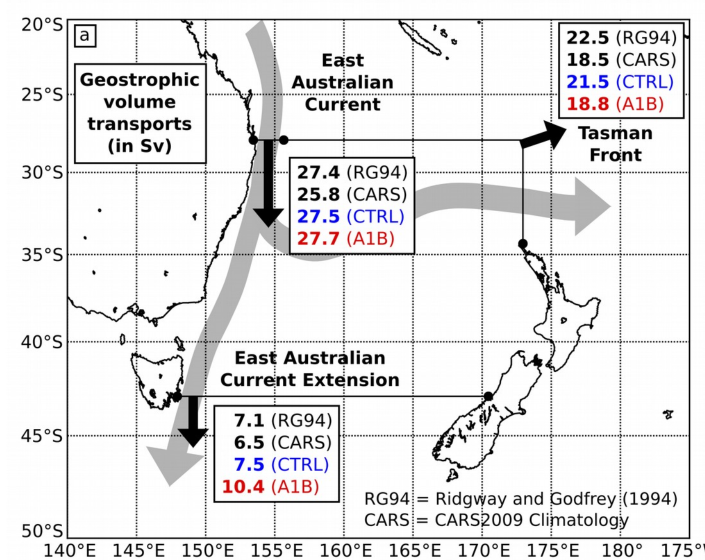
- Projected changes in **SST extremes** due to a combination of changes in SST mean, variance, skewness, etc …











Acknowledgements

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Publications

Oliver, E. C. J. and N. J. Holbrook (2014), Extending our understanding of South Pacific gyre 'spin-up': Modeling the East Australian Current in a future climate, Journal of Geophysical Research, 119, pp. 2788-2805

Oliver, E. C. J., S. J. Wotherspoon, M. A. Chamberlain and N. J. Holbrook (2014), Projected Tasman Sea extremes in sea surface temperature through the 21st century, Journal of Climate, 27 (5), pp. 1980-1998

Oliver, E. C. J., S. J. Wotherspoon and N. J. Holbrook (2014), Estimating extremes from global ocean and climate models: A Bayesian hierarchical model approach, Progress in Oceanography, 122, pp. 77-91

Oliver , E. C. J., T. J. O'Kane and N. J. Holbrook, Projected changes to Tasman Sea eddies in a changing climate, Journal of Geophysical Research, *Accepted for publication*

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