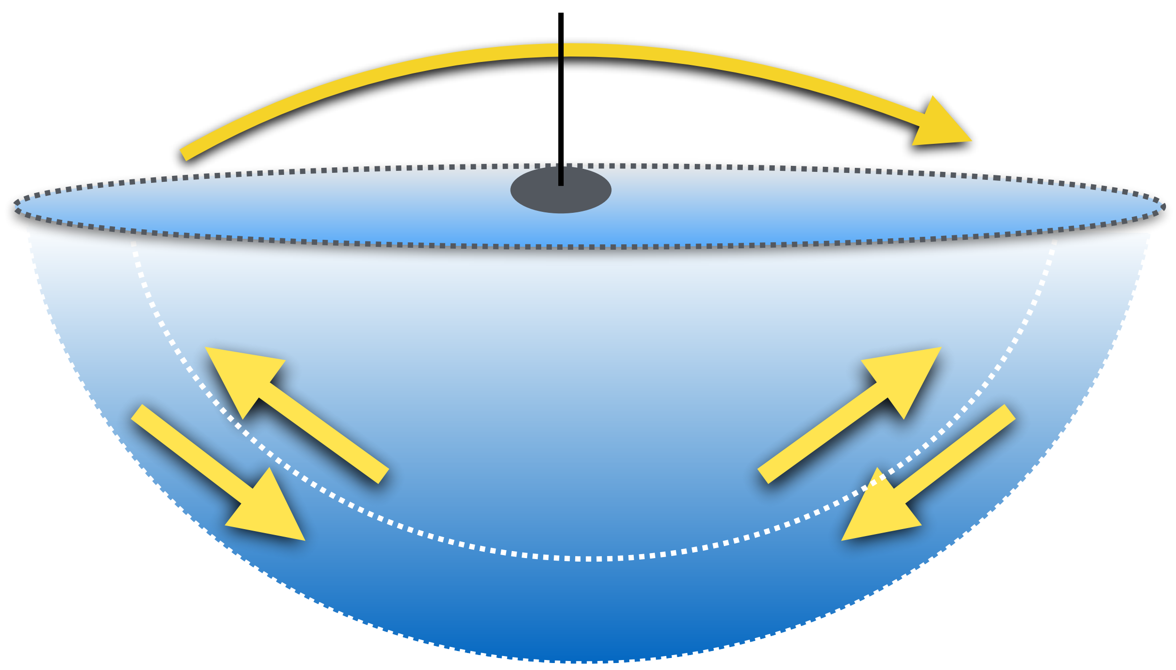
Revisiting symmetric instability in the oceans

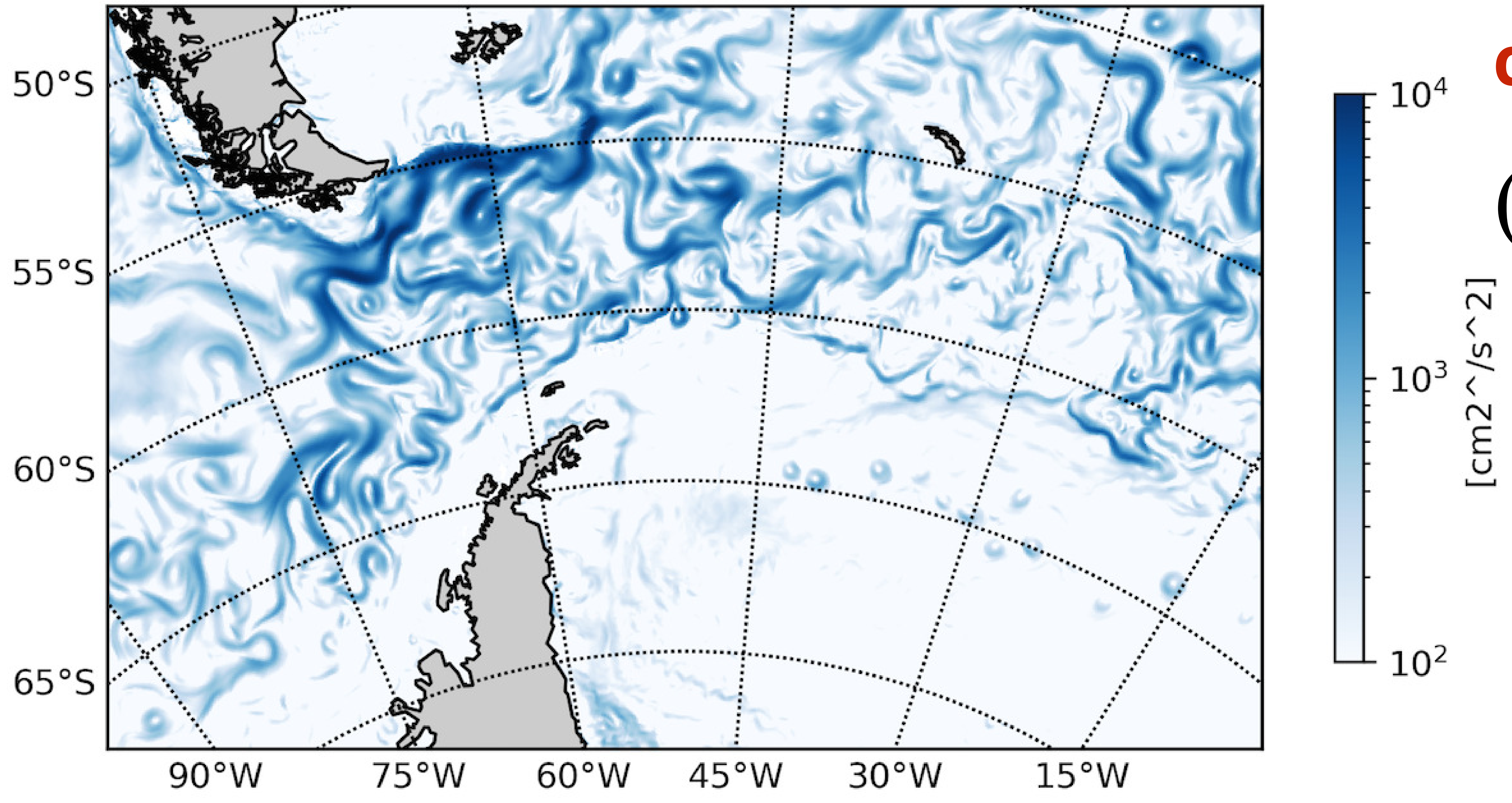
doi:10.1175/JPO-D-19-0265.1

doi:10.1175/JPO-D-20-0258.1



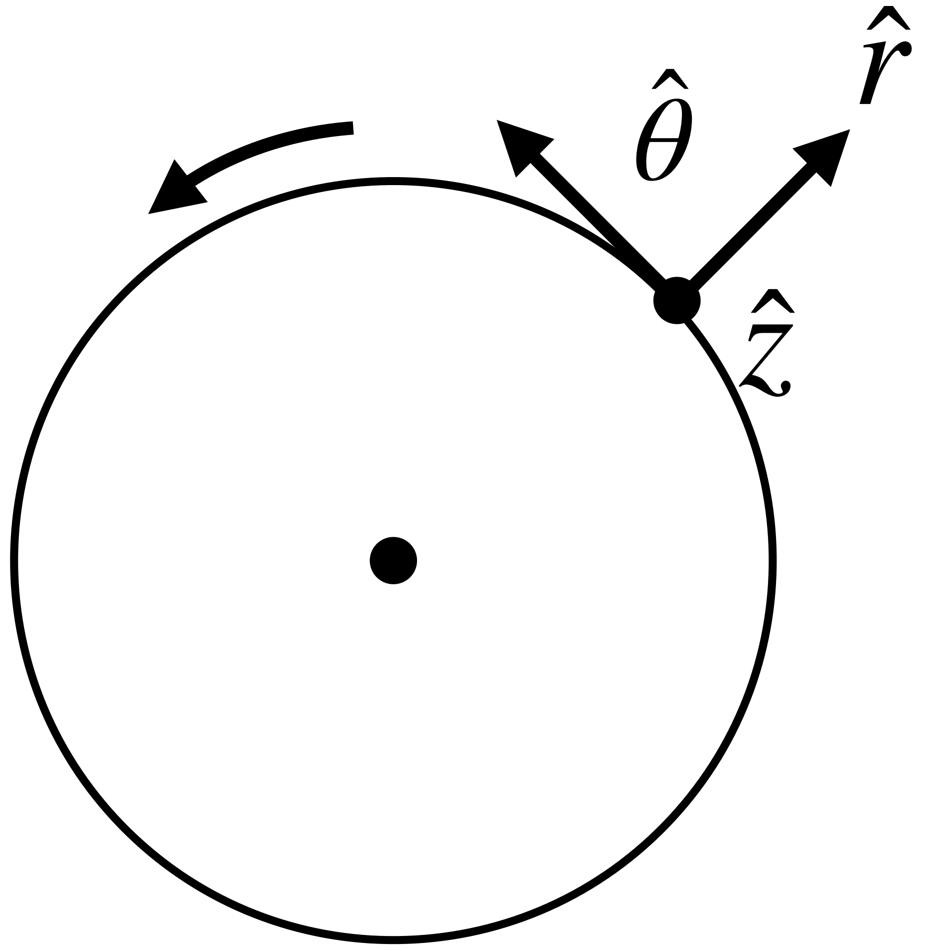
Symmetric instability

Antarctic Circumpolar Current (ACC)



When does the curvature term matter?

$$(f + 2\overline{v}/r)\partial_z \overline{v} = \partial_r \overline{b}$$



Most theory assumes thermal wind balance (Hoskins 1974)
Wouldn't **gradient wind balance** be a better approximation?
Particularly for small scales (**i.e. submesoscales**) and **strong current systems**?

Changes in stability introduced by curvature …

Thermal wind balance (TWB)

$$f\partial_z\overline{v} = \partial_r\overline{b}$$

Relevant instability criteria

$$fq < 0 \text{ (dim.)} \implies q' < 0 \text{ (non. dim.)}$$

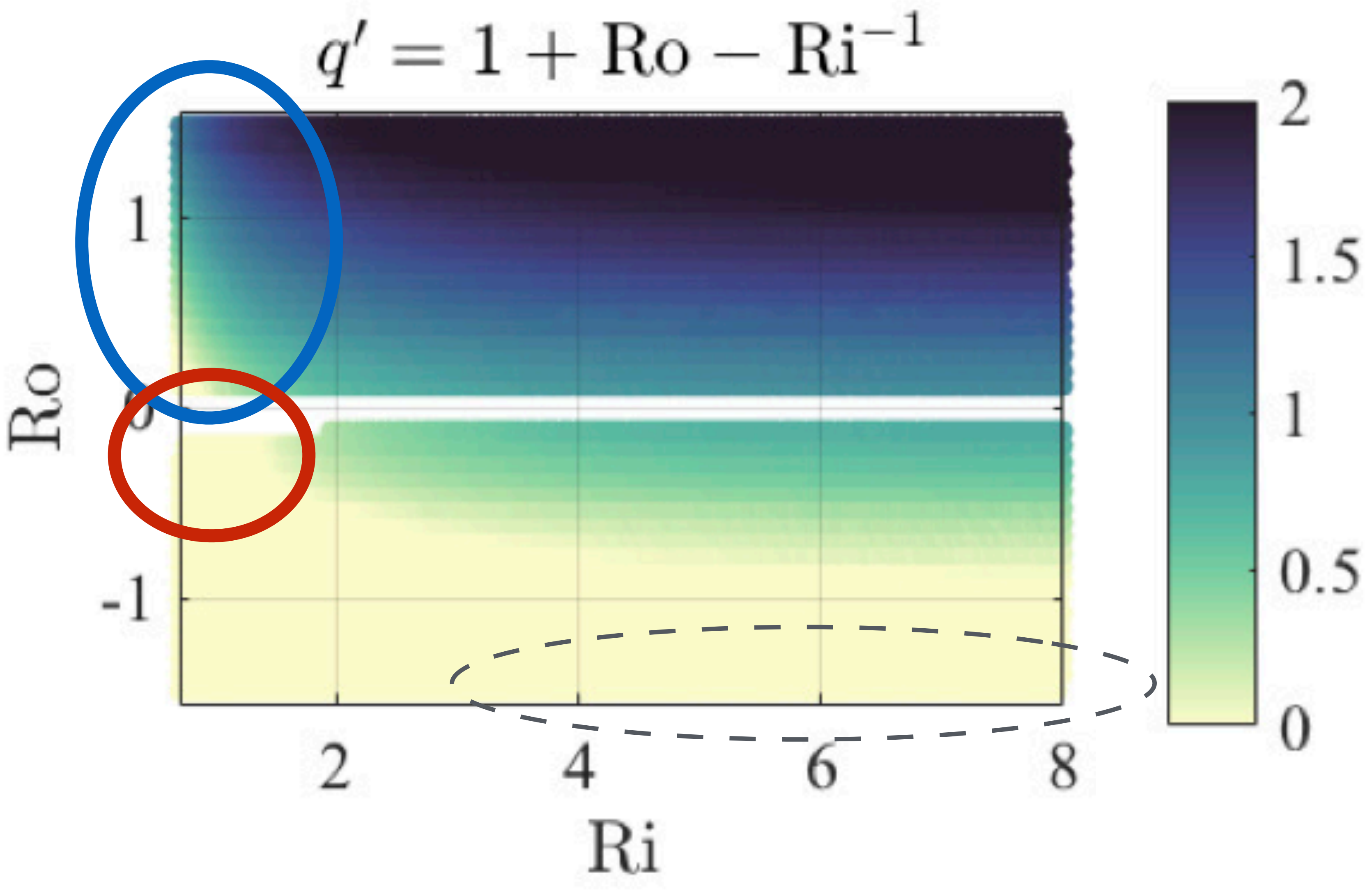
Gradient wind balance (GWB)

$$f(1+\text{Cu})\partial_z\overline{v} = \partial_r\overline{b}, \text{ where Cu} = 2\overline{v}/(fr)$$

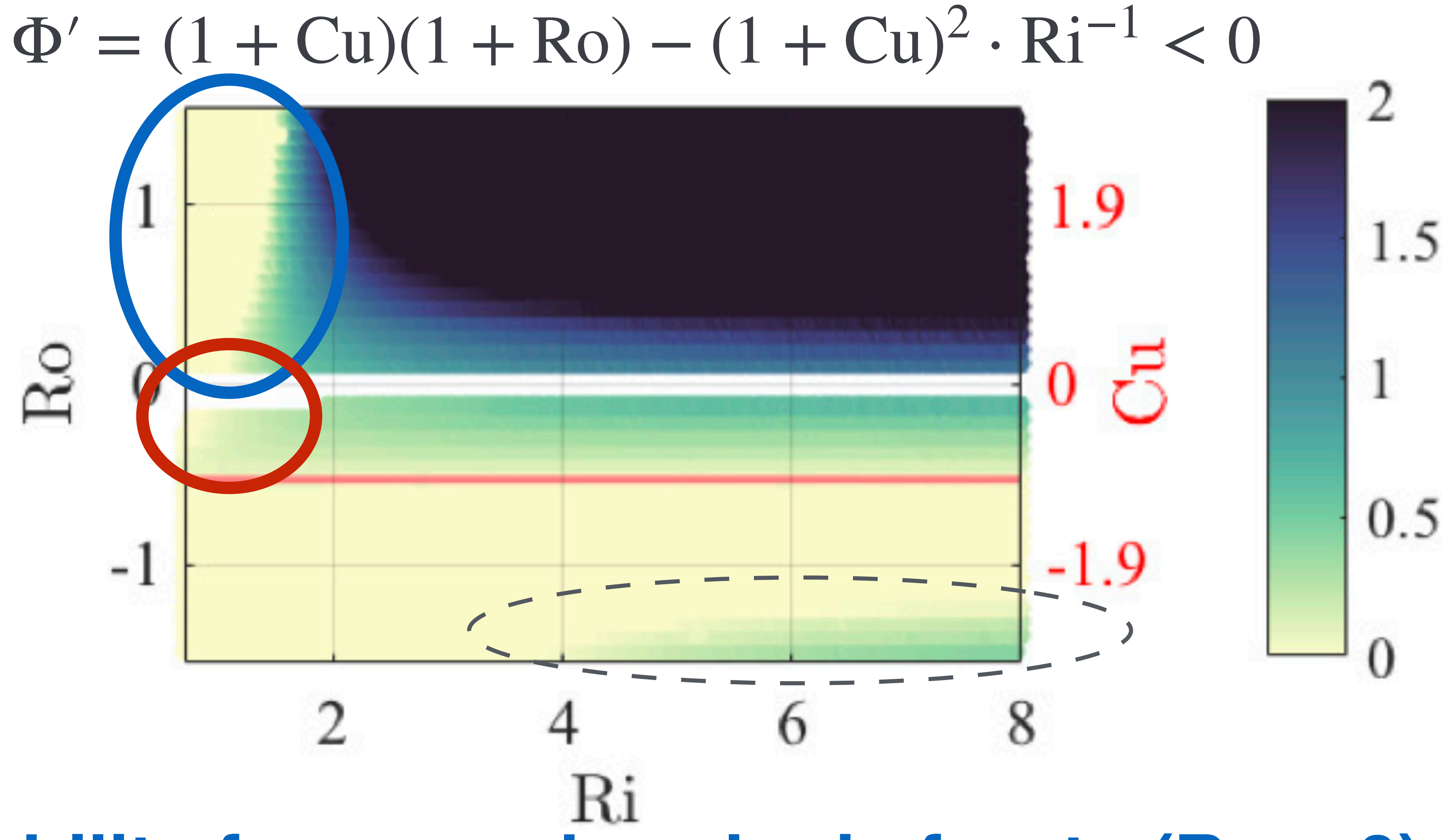
Relevant instability criteria

$$(1+\text{Cu})fq < 0 \text{ (dim.)} \implies \Phi' = L'q' < 0 \text{ (non. dim.)}$$

No curvature



With curvature



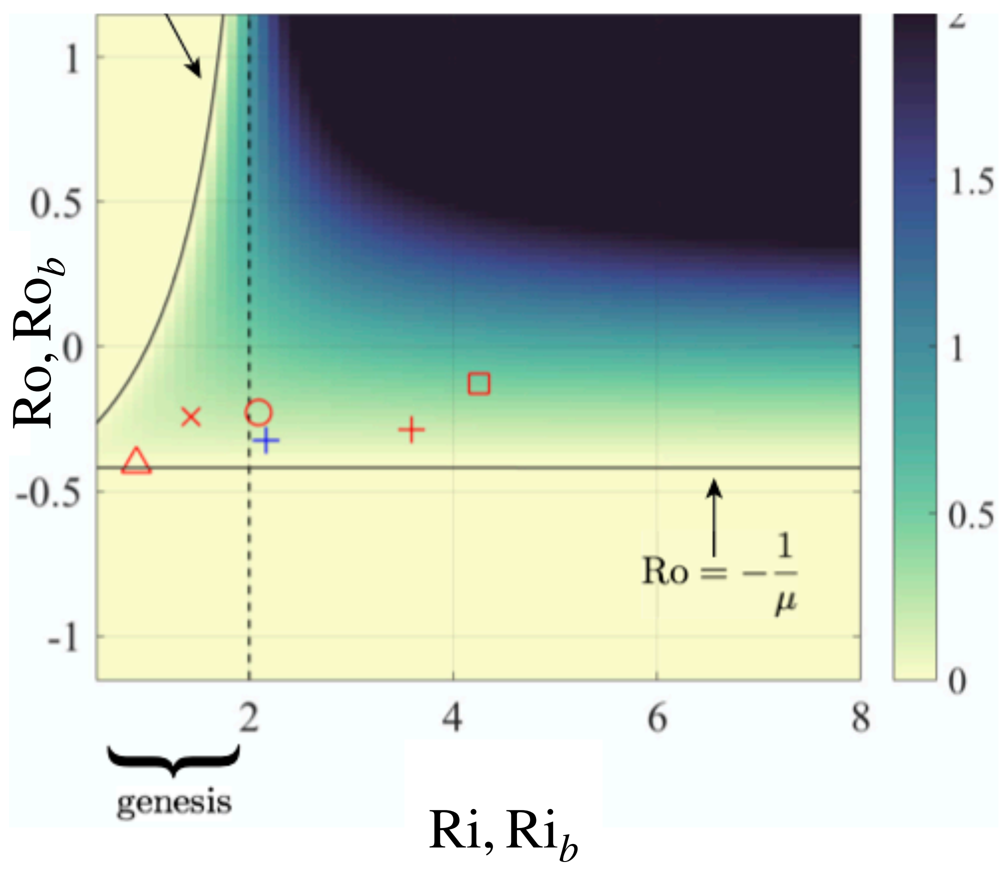
Occurs at low Ri
(i.e. symmetric instability)

1. **Pronounced decrease in stability for curved cyclonic fronts (Ro > 0).**
2. **Marginal increase in stability for curved, anticyclonic fronts (Ro < 0).**
3. Stability for for really strong anticyclones (Ro < -1).Occurs for negative PV!

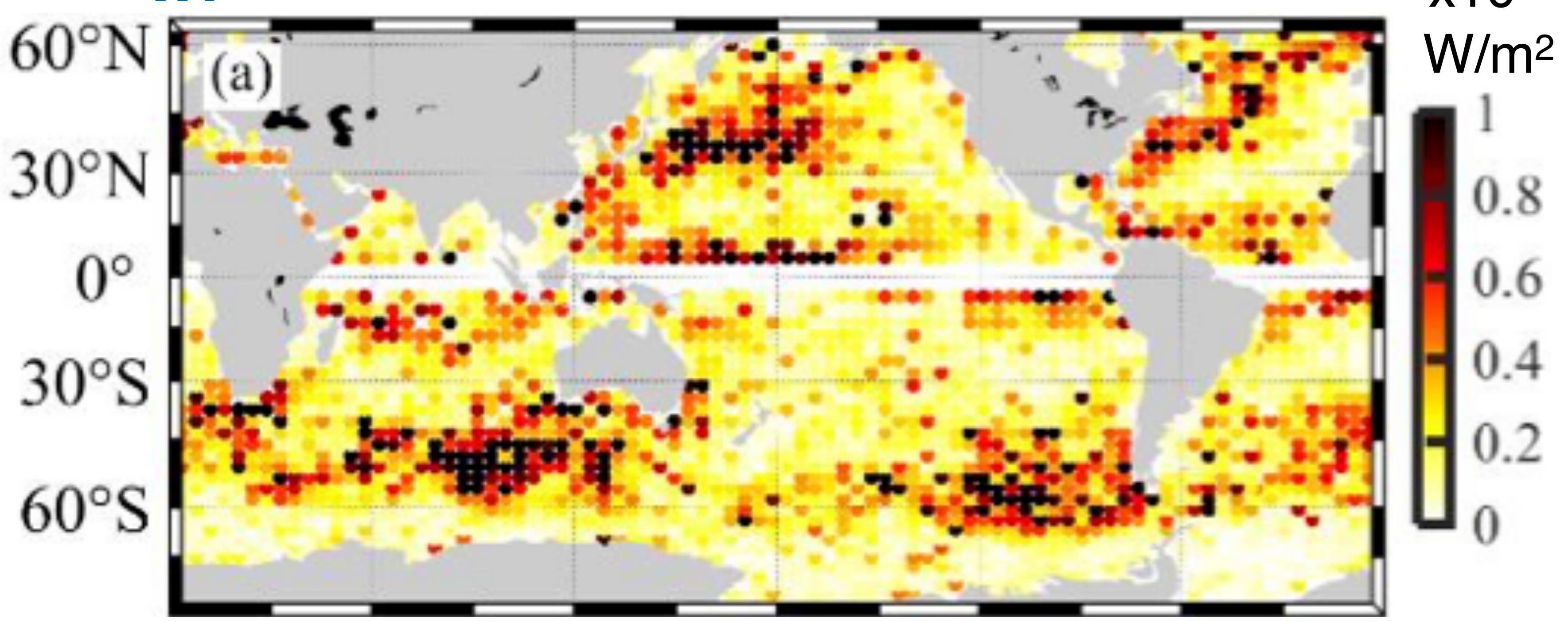
Potential Implications

- Ocean circulation
- Ocean-atmosphere exchange
- Tracer flux between boundaries and interior ocean
- Transport of water masses (**think biogeochemistry!**)
- Representation of these within Earth System models

Changes in symm. instability

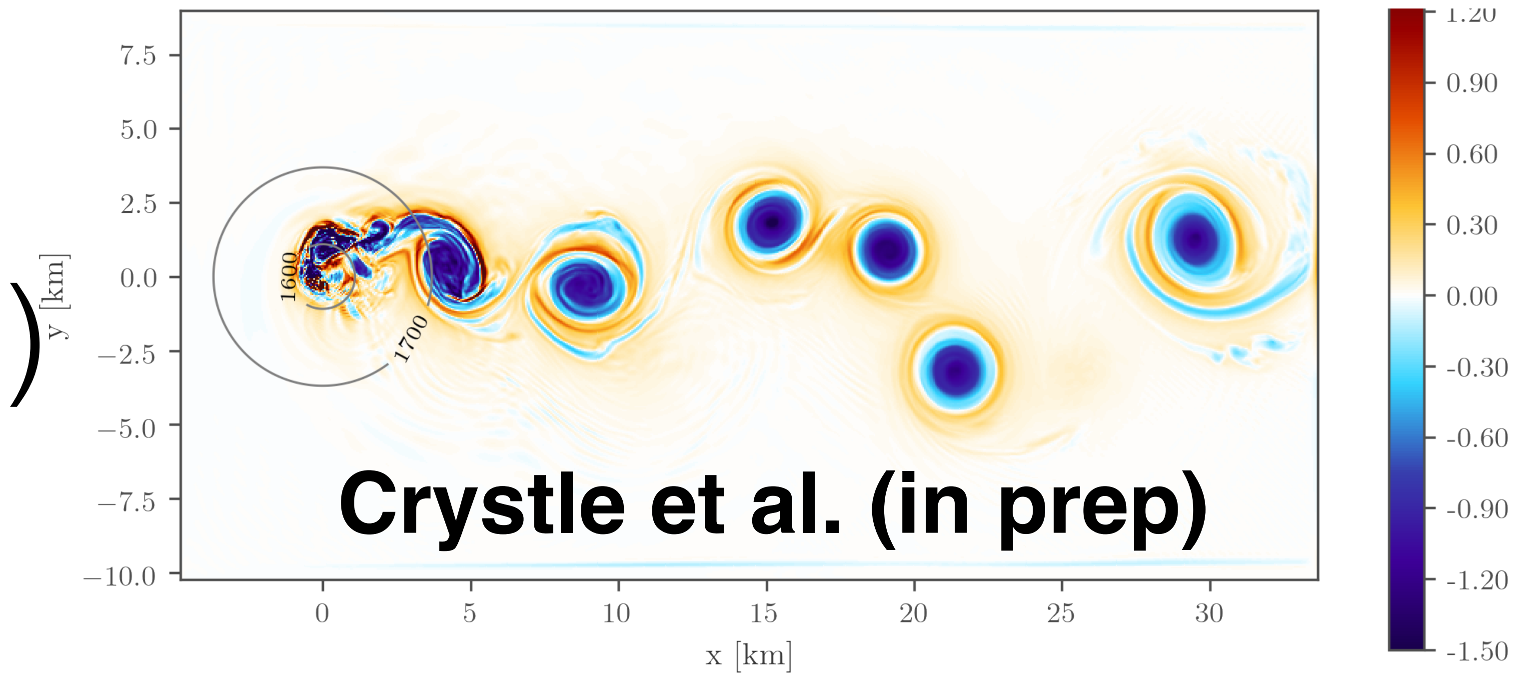


Energy loss from ocean circulation in winter



Dong et al. 2020, *in review*

Vortex Generation by Hydrothermal Vents



Crystle et al. (in prep)

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