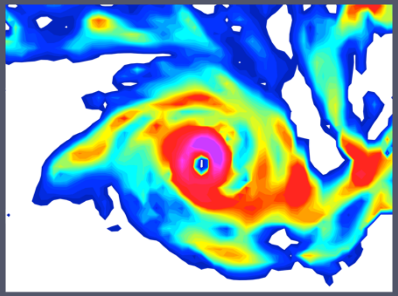
Ocean feedback to tropical cyclone intensity



in a multidecadal coupled simulation of the South Pacific

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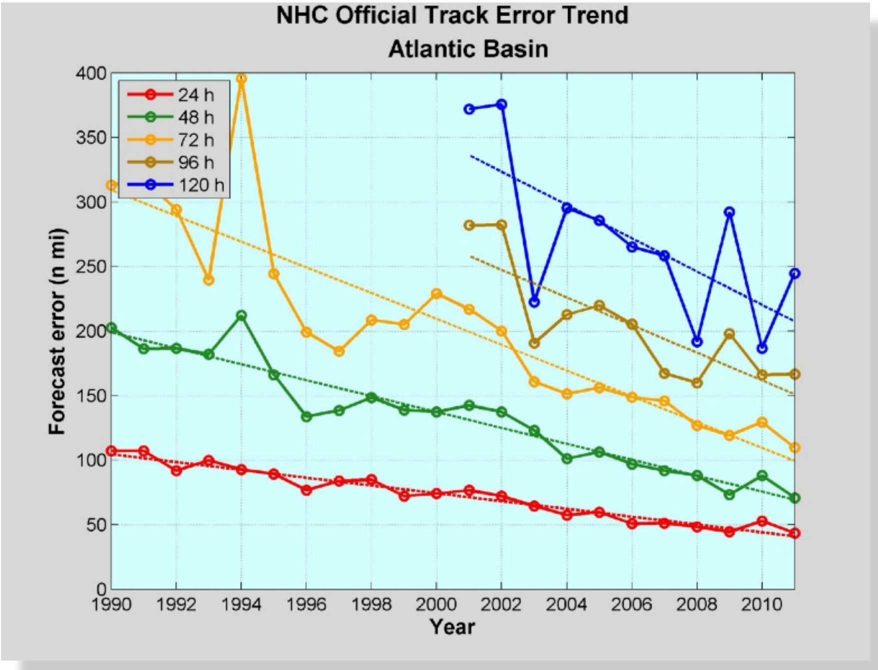
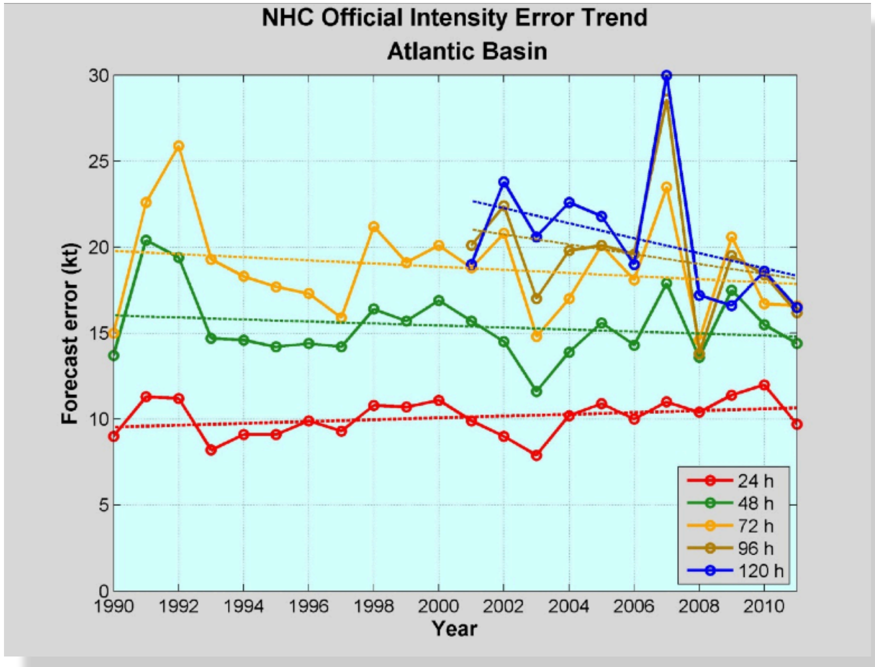
Introduction: TC forecast errors

TRACK



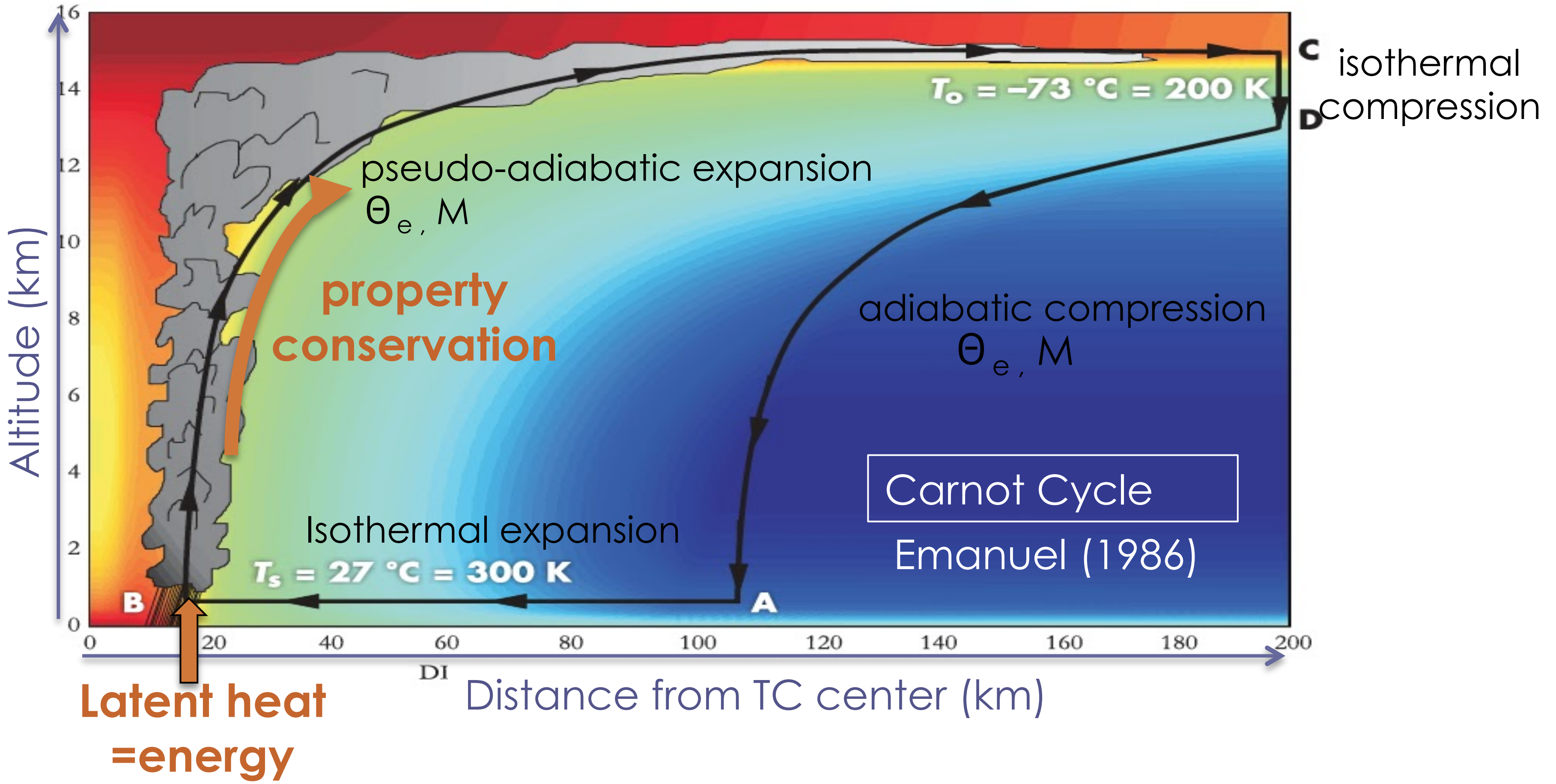
INTENSITY



✓Track forecast improved
✓Intensity forecast did not improve:

- Ocean feedback?
- TC intensification models?

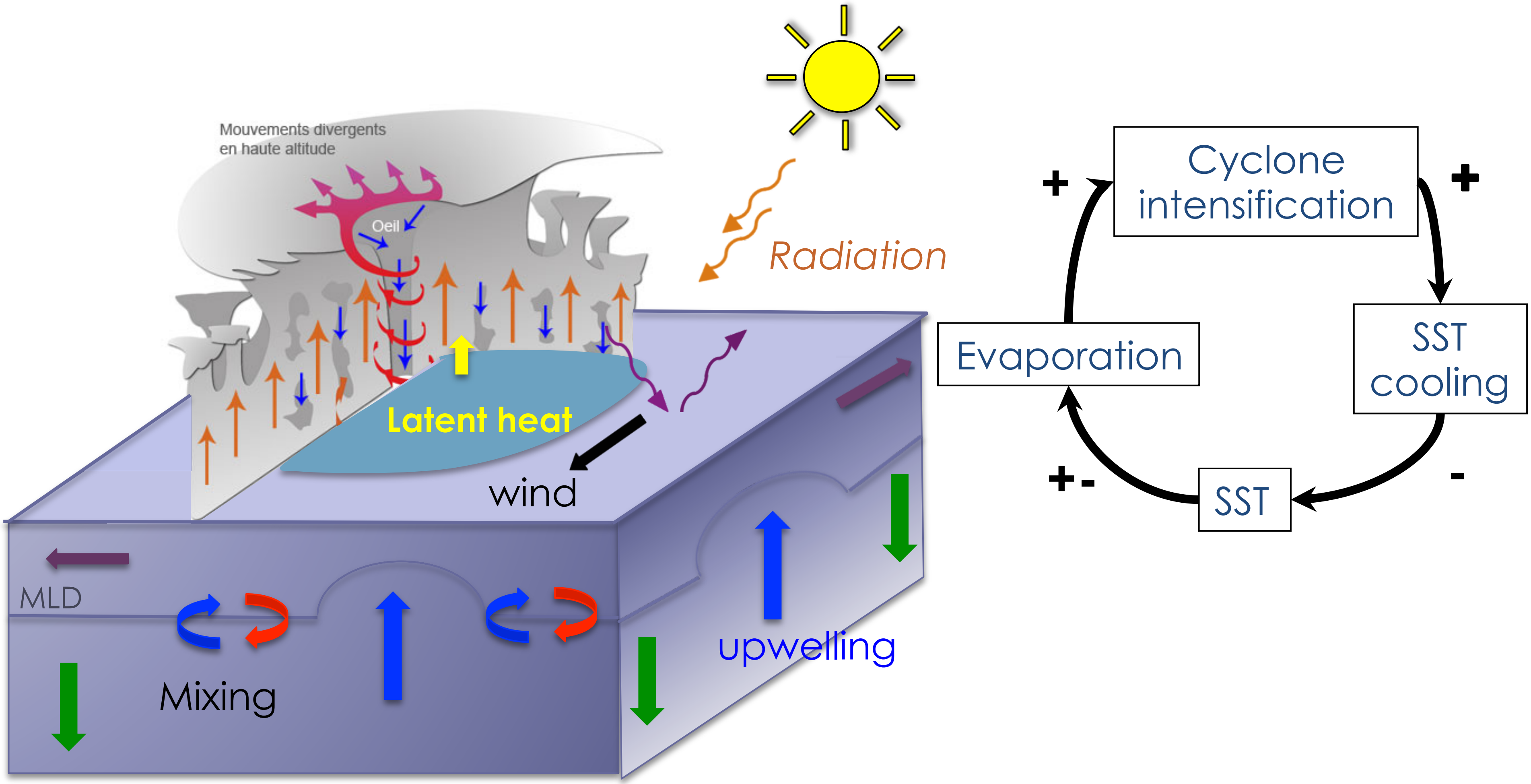
Introduction: TC thermodynamic model



✓ Maximum Potential Intensity:

$$V_m{}^2 = \frac{C_H}{C_D}\frac{T_S - T_O}{T_O}\left(H_S^* - H_A\right)$$

Introduction: ocean response



Jullien et al., 2012, JPO
Vincent et al., 2012, JGR

Introduction: ocean feedback

✓ Sensitivity of cyclone intensity to a local SST reduction under its eyewall can be calculated (Schade, 2000, Holland, 1997):

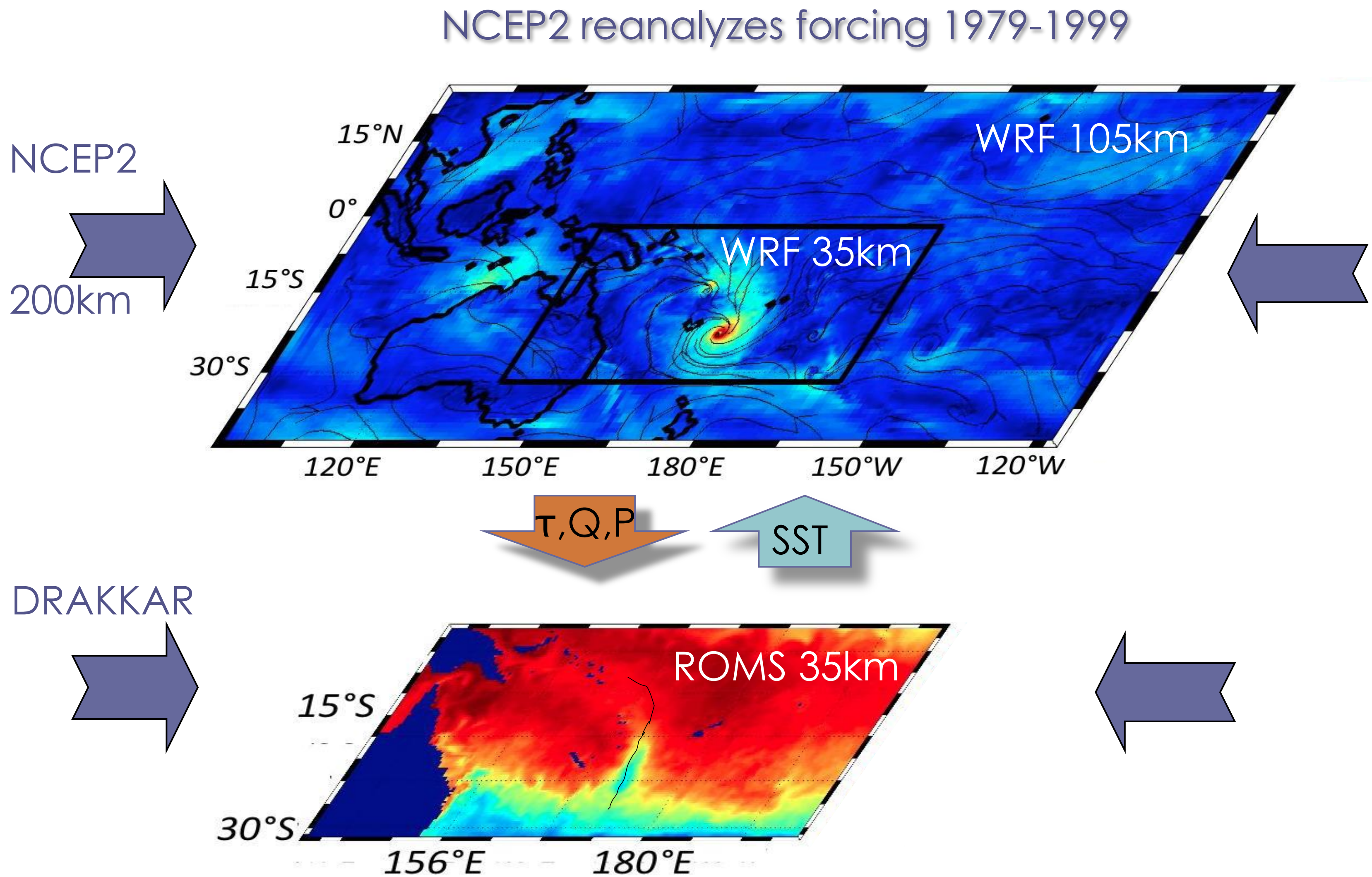
$$\frac{\partial P_C}{\partial SST_C} = \frac{\Delta P_{MPI}}{\Delta SST_{\max}} = f\left(SST_A, RH_A, T_O\right)$$

P_{MPI} TC pressure of max potential intensity
ΔSST_{max} maximum possible SST cooling.

⇒ Linear relation to cooling given by ambient conditions

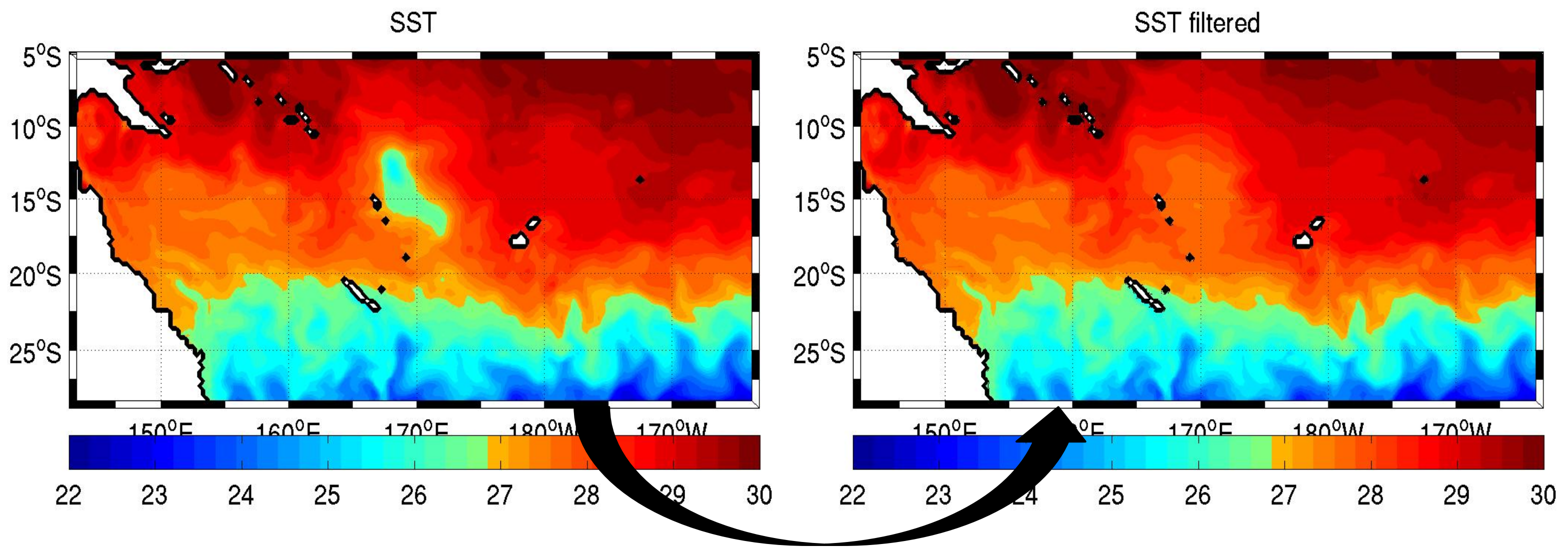
Schade (2000)	21-45 hPa/°C	Theory
Bender and Ginis (1993,2000)	**2-13 hPa/°C**	**Event/idealized studies from coupled models**

ROMS-WRF coupled model



Twin coupled/forced experiments

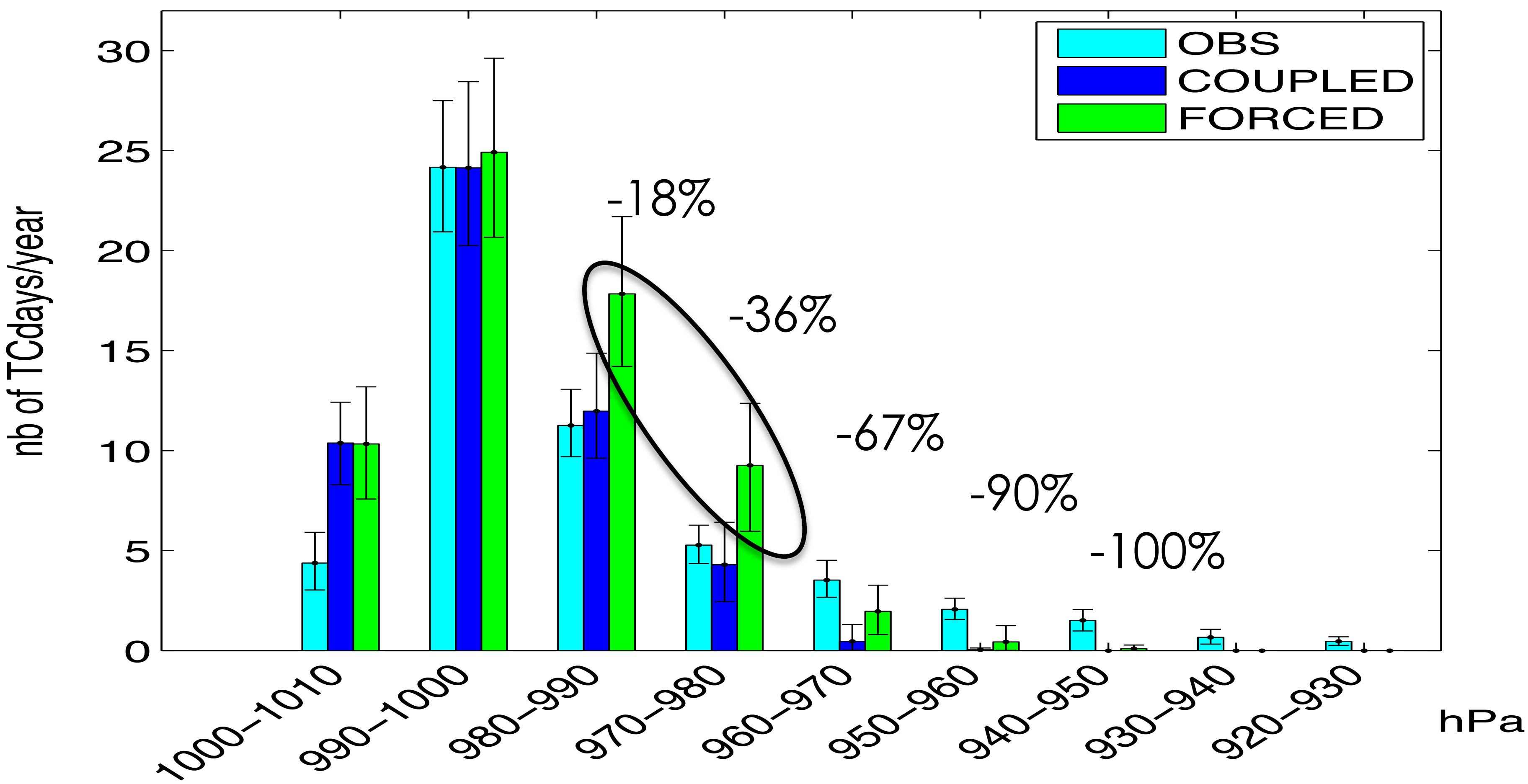
COUPLED　　　　　　　　　　FORCED



TC-induced cold wake removed

Forced atmospheric simulation has no feedback from the TC cold wake but everything else is the same.

Feedback on TC intensity

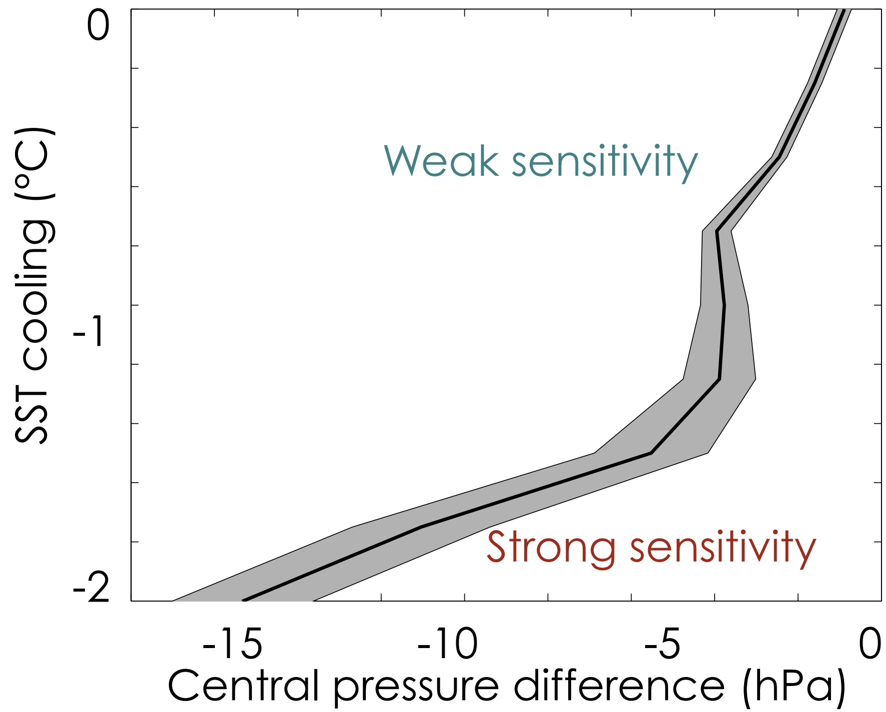


Too many moderate-to-strong cyclones in the forced model

Intensity sensitivity to cooling

TC intensity sensitivity is:

- ✓ strongly nonlinear: high for strong cooling only
- ✓ much lower than predicted by theory and comparable to model test cases



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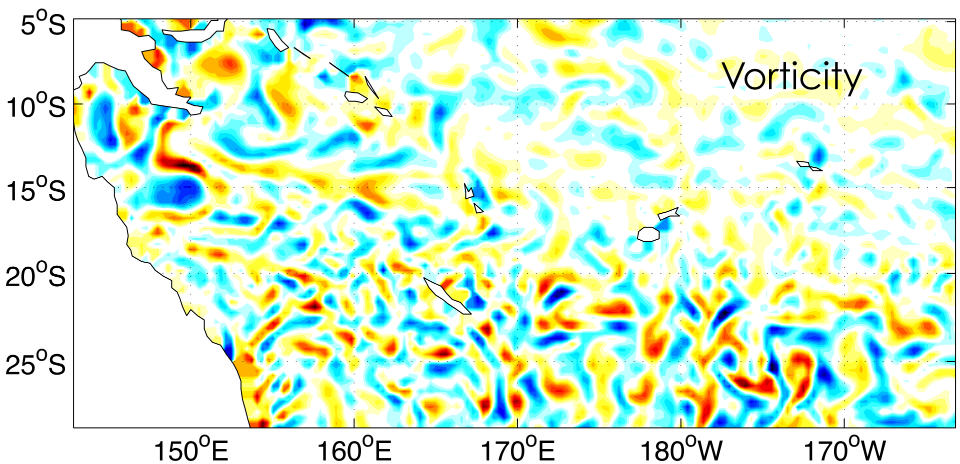
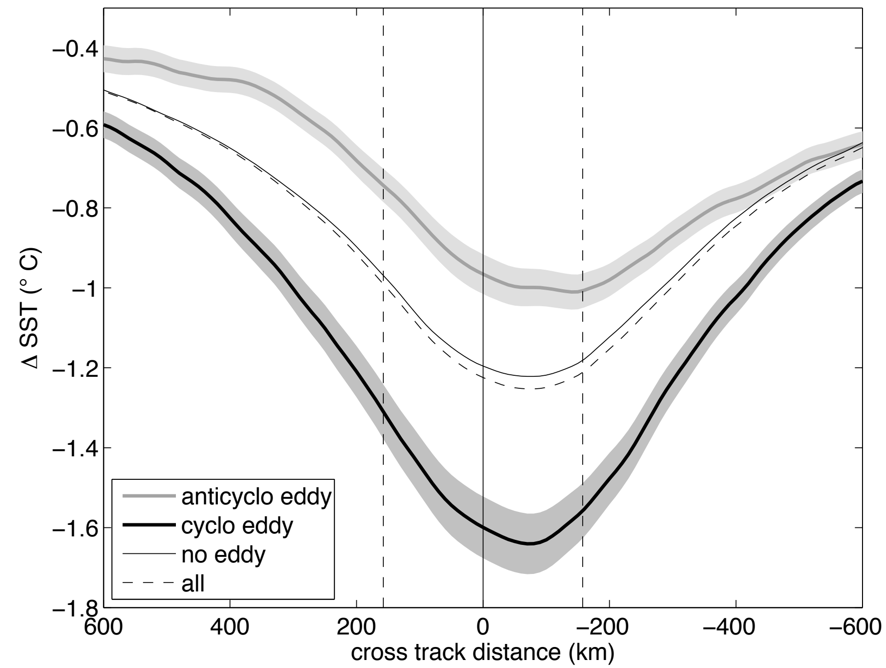
Jullien et al. (2014)	**0-15 hPa/°C**	**Realistic TC distribution**

Cooling sensitivity to ocean structure

Effect of mesoscale activity



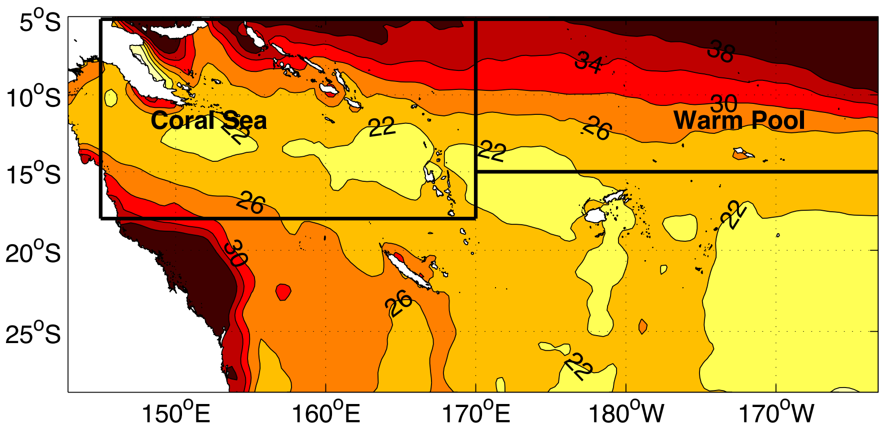


Mesoscale activity modifies the ocean response by up to 50%:

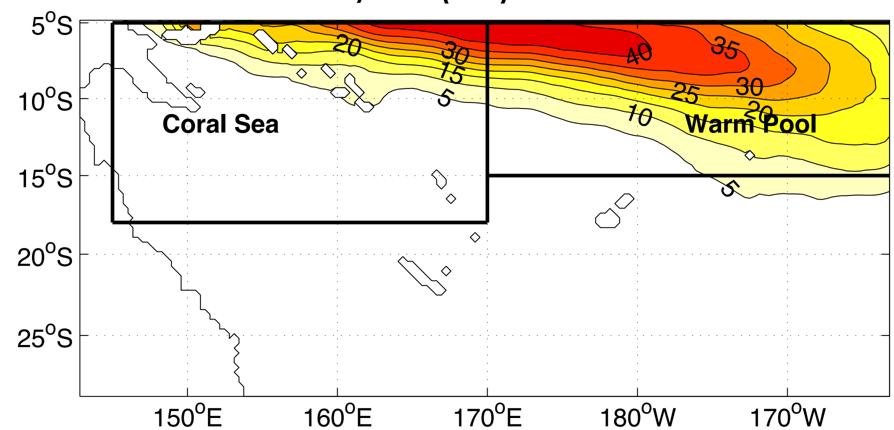
- ✓ Anticyclonic eddies damp SST cooling
- ✓ Cyclonic eddies enhance SST cooling

Cooling sensitivity to ocean structure

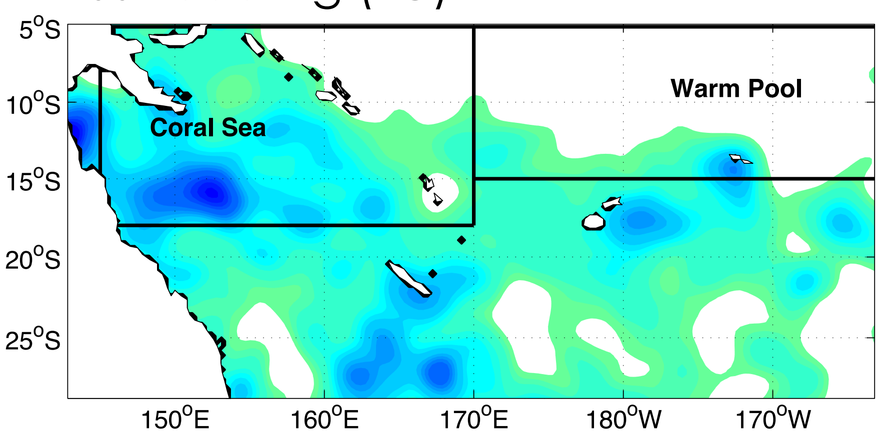
MLD (m)



Barrier layer (m)



SST cooling (°C)



Large-scale ocean stratification strongly modulates the cooling:

- ✓ Coral sea: shallow MLD => strong cooling
- ✓ Warm pool: deep MLD and thick BL => weak cooling

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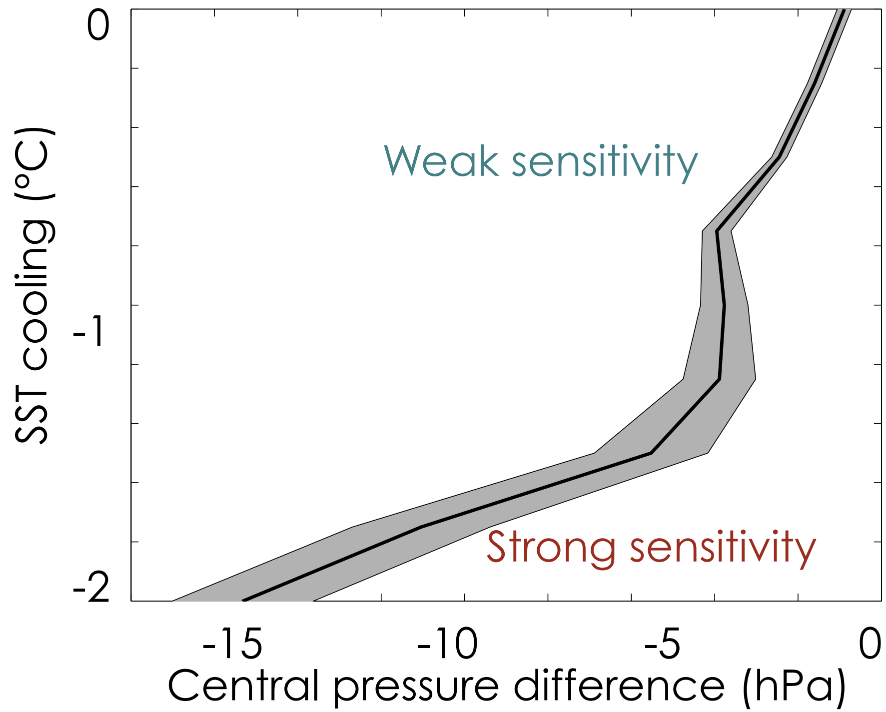

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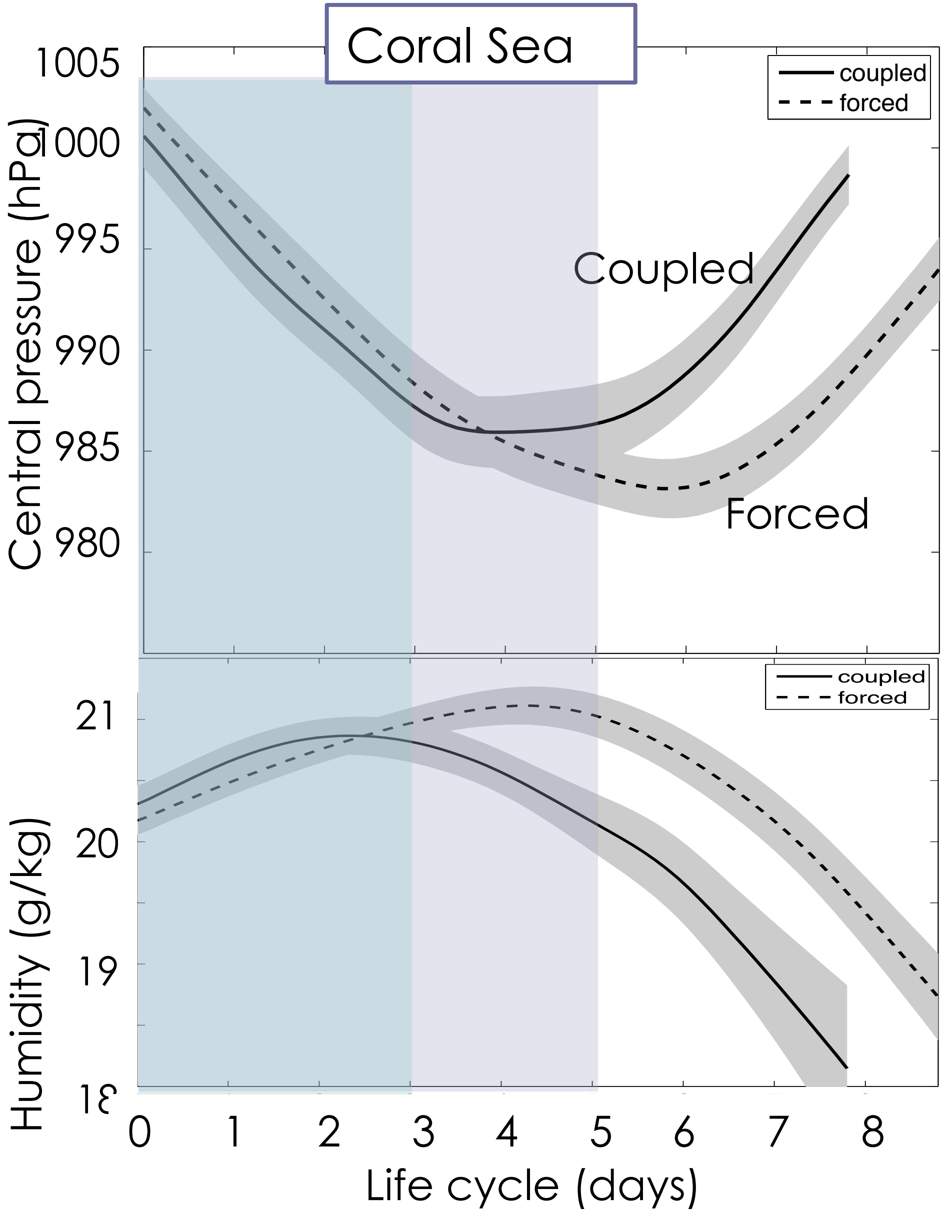
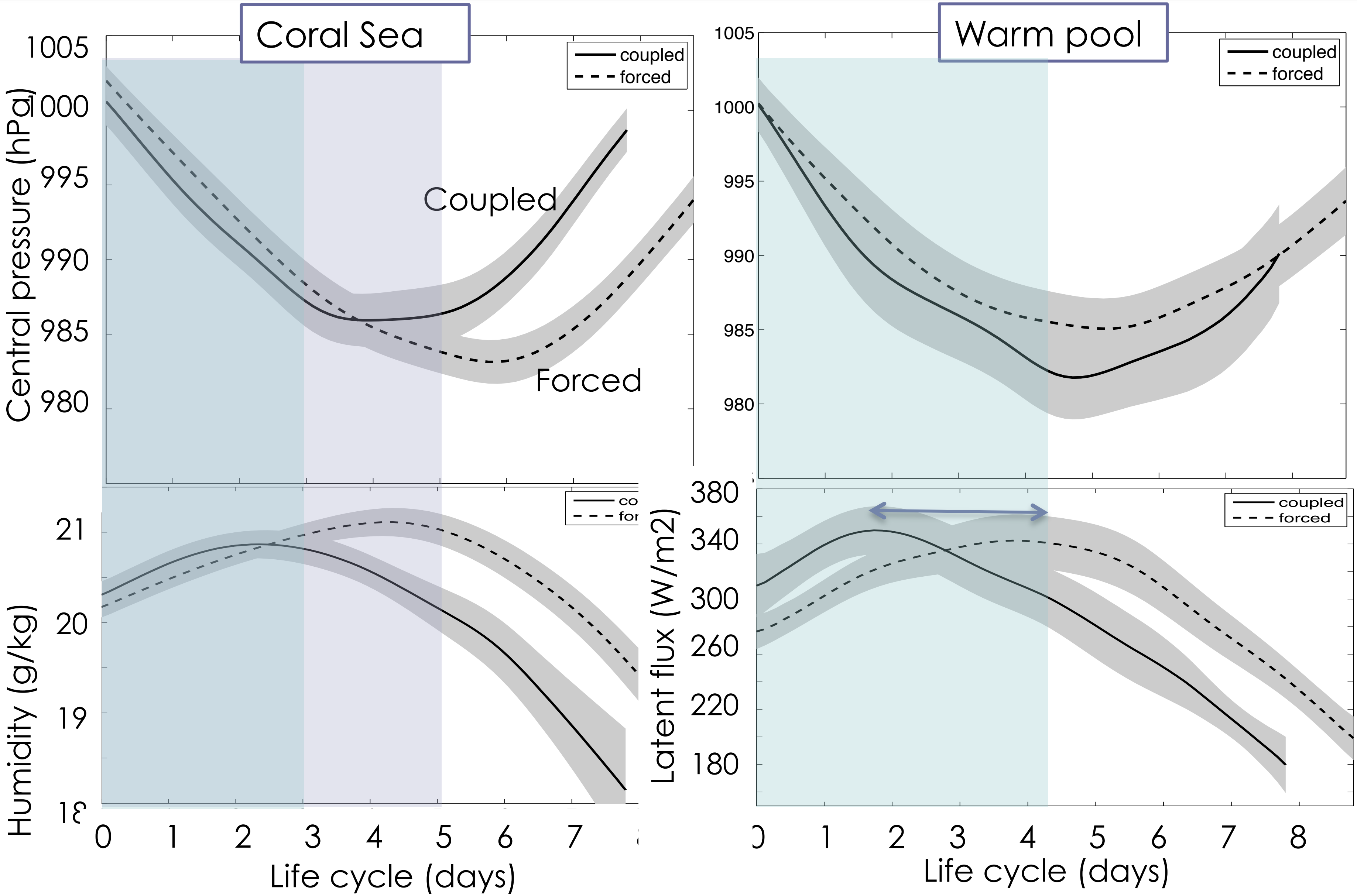
Intensification process

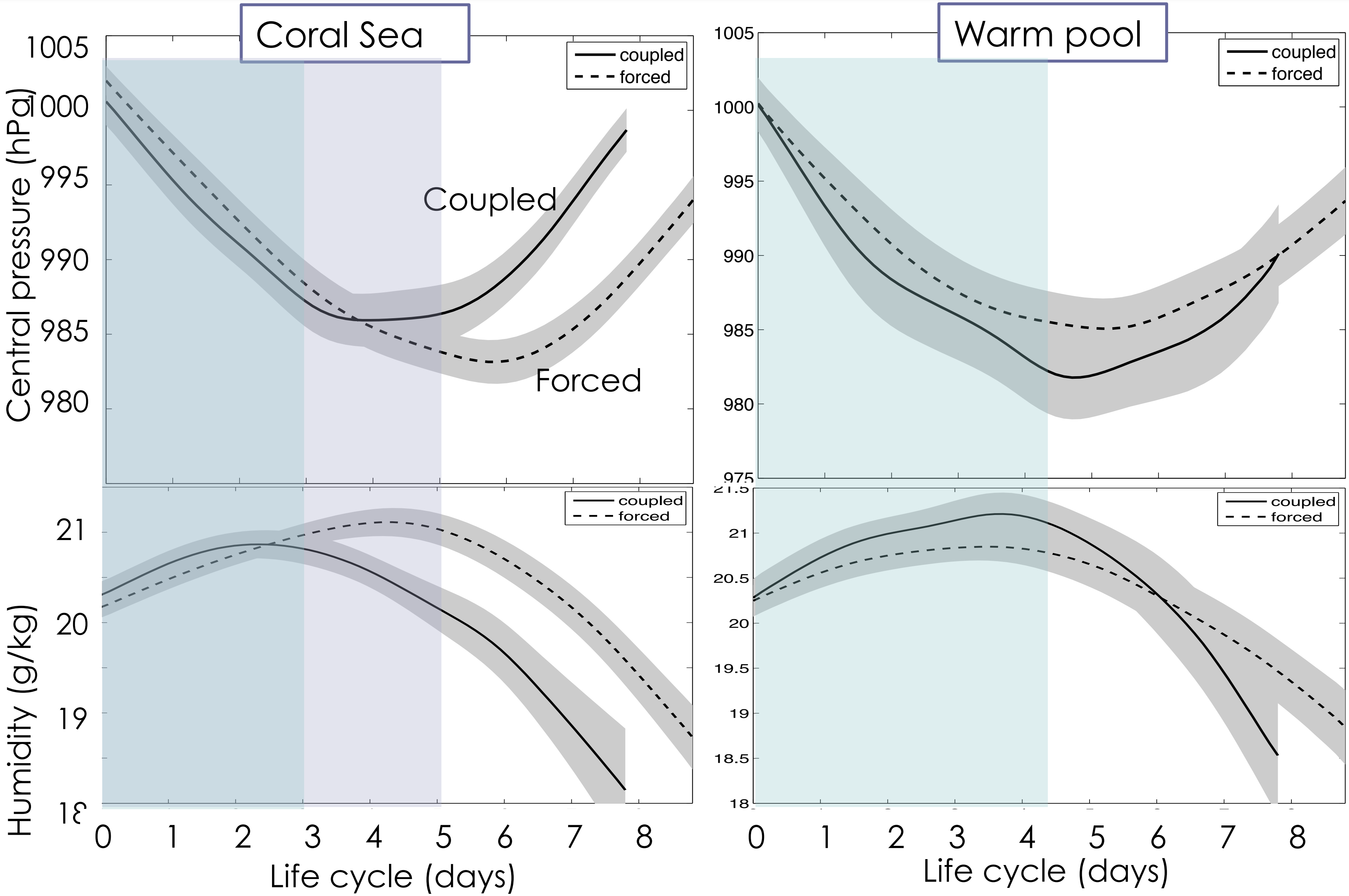


- ✓ TC intensity is limited in the coupled simulation
- ✓ LH flux starts decreasing 2 days before TC intensity
- ✓ Humidity is well correlated with TC intensity => humidity convergence

Intensification process

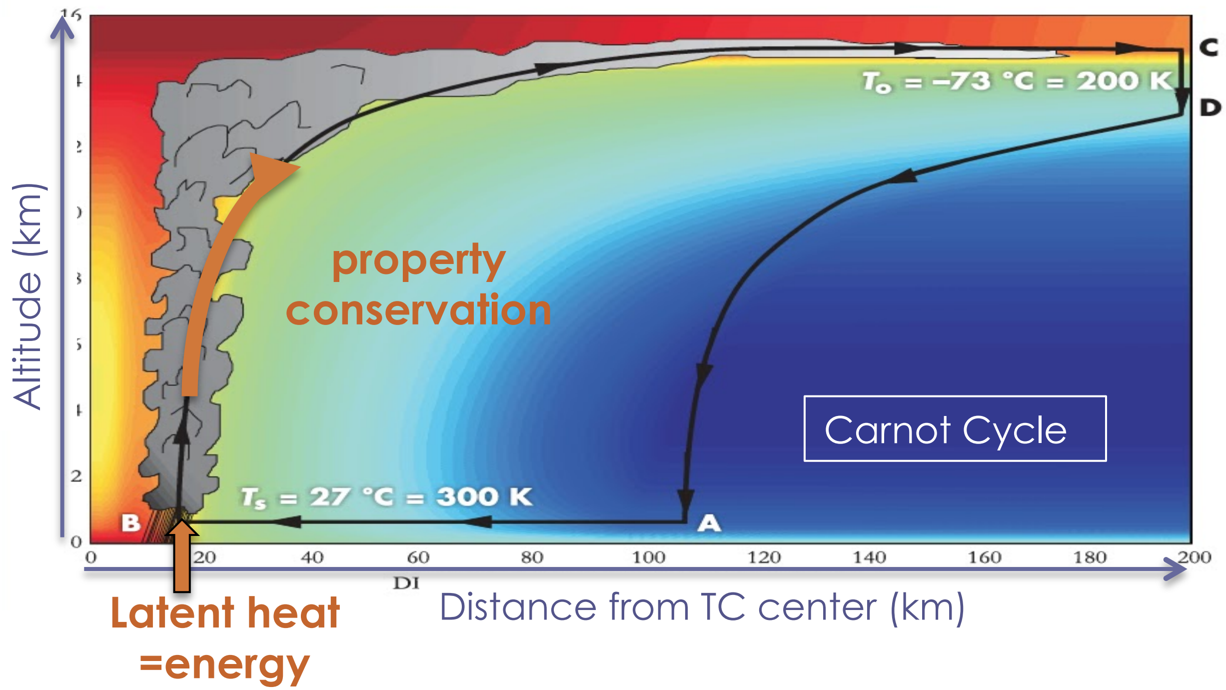


Intensification process



On the paradigms of intensification

- ✓ Thermodynamic mechanism at fault (see also Montgomery et al., 2009)
- ✓ The effect of SST is not instantaneous but accumulated over time



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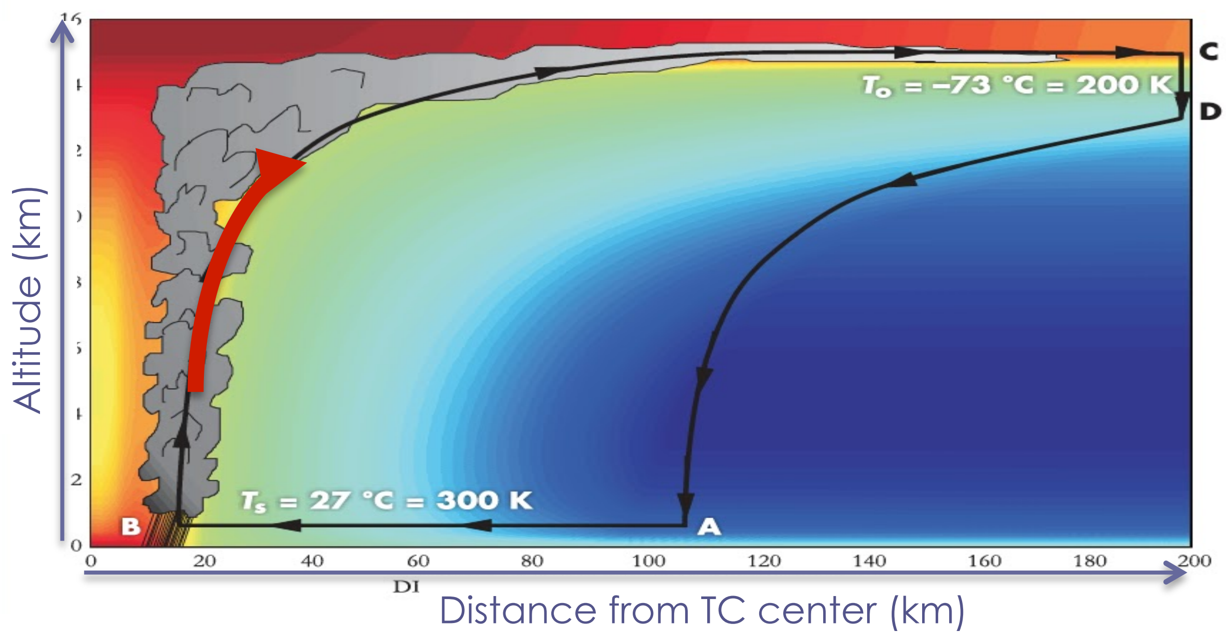

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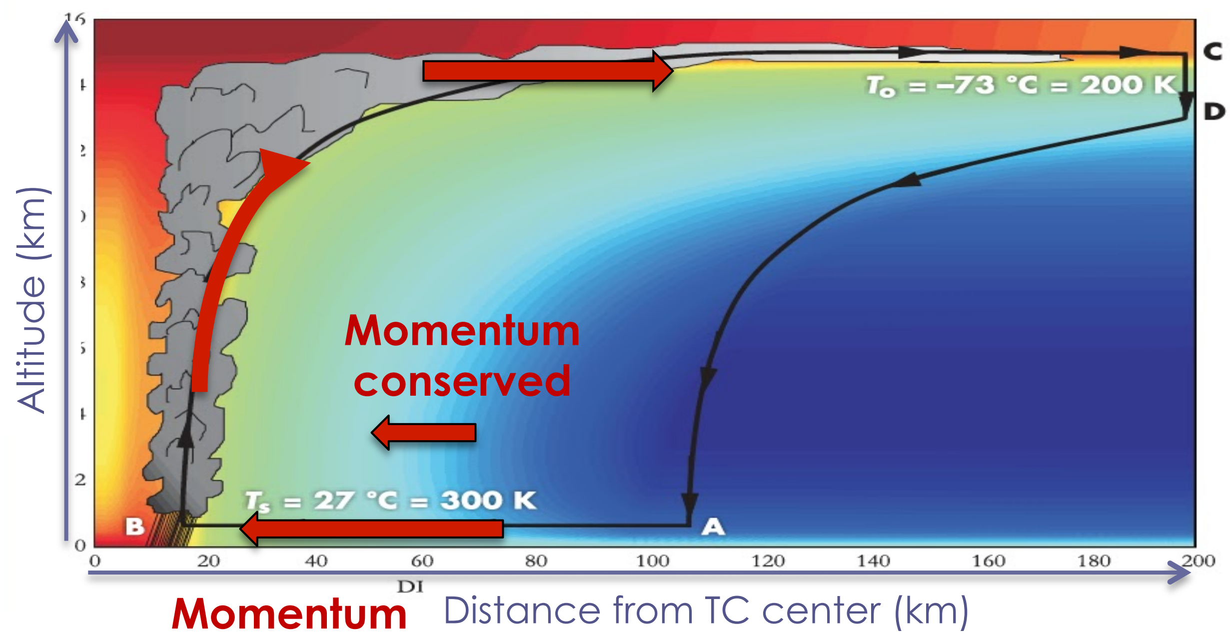

Momentum not conserved
M and q convergence = energy

✓Role of macro-scale processes and the secondary circulation (Smith et al., 2009) => revisit the cooperative WISHE/CISK theory

Summary & perspectives

- ✓ SST cooling is strongly nonlinear and modulated by the oceanic structure (forecasting issue)
- ✓ Feedback is weaker in realistic simulations than in the thermodynamic theory
- ✓ Role of macro-scale advection that controls the input of heat and angular momentum in the inner-core region past the early intensification phase (after 2 days)
- ✓ What about:
  - ✓ intra-eyewall dynamics?
  - ✓ role of vortex-vortex interactions (forecasting issue)?

Ref: Jullien et al., 2014 Clim. Dyn. doi:10.1007/s00382-014-2096-6