Stochastic transport in an idealized ocean-atmosphere coupled system

Long Li, Etienne Mémin, Bertrand Chapron, Noé Lahaye

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Joint work with Etienne Mémin[1], Bertrand Chapron[2] and Noé Lahaye[1]

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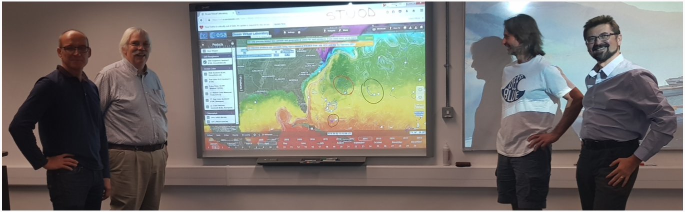
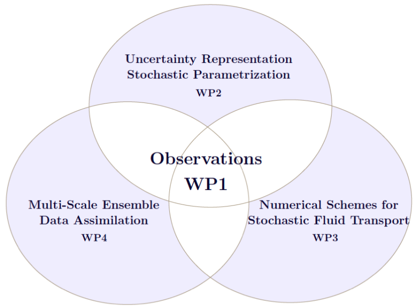
Stochastic Transport in Upper Ocean Dynamics (STUOD)



https://www.imperial.ac.uk/ocean-dynamics-synergy/



"Our approach accounts for transport on scales that are currently unresolvable in computer simulations, yet are observable by satellites, drifters and floats."

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$$\mathrm{d}\boldsymbol{X}_t = \underbrace{\boldsymbol{u}(\boldsymbol{X}_t, t)\,\mathrm{d}t}_{\text{resolved}} + \underbrace{\sum_m \boldsymbol{\xi}_m(\boldsymbol{X}_t, t)\,\mathrm{d}B_t^m}_{\text{unresolved}}$$

References: [Bauer et al., 2020a, Li, 2021]

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- Stochastic transport of tracer

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- Pathwise conservation of moments

$$\mathbb{D}_t\Theta^p = 0, \qquad \mathrm{d}_t\int_\Omega \Theta^p\,\mathrm{d}\boldsymbol{x} = 0$$

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Application to Q-GCM [Hogg et al., 2003]

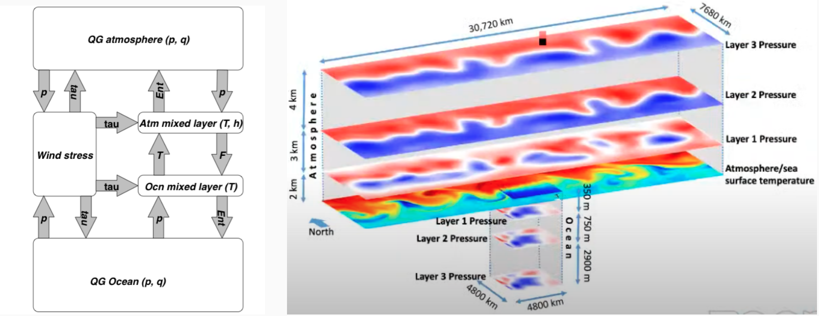

Figure 1: Model illustration from `http://www.q-gcm.org`

- Idealized midlatitude coupled model emphasizing ocean dynamics

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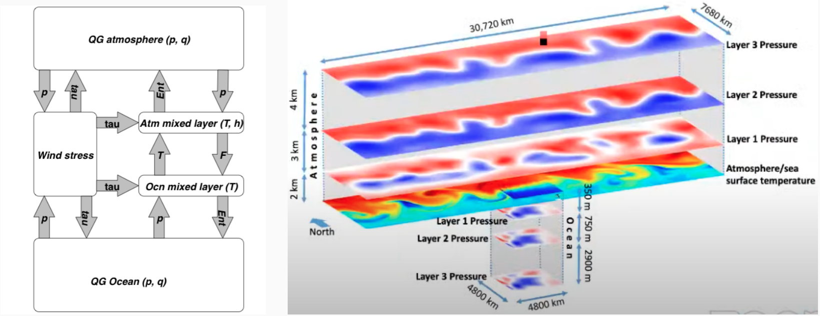

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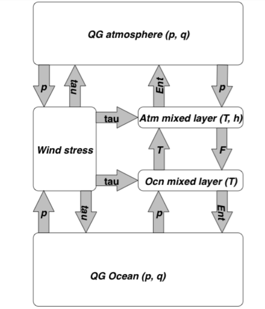

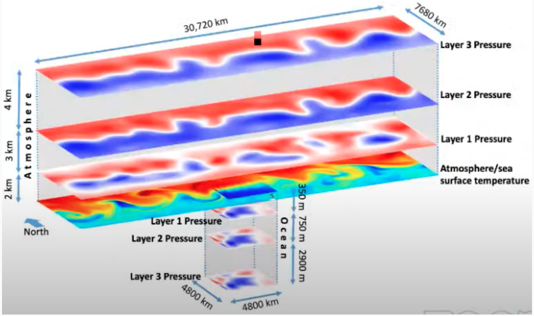

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- Idealized midlatitude coupled model emphasizing ocean dynamics
- Classical Ekman model with wind-current-depended stresses
- Our applications: stochastic transport of PV and SST for both ocean and atmosphere

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- Code available on:
  `https://github.com/matlong/qgcm_lu`
  `https://github.com/louity/qgm_pytorch`

Numerical results

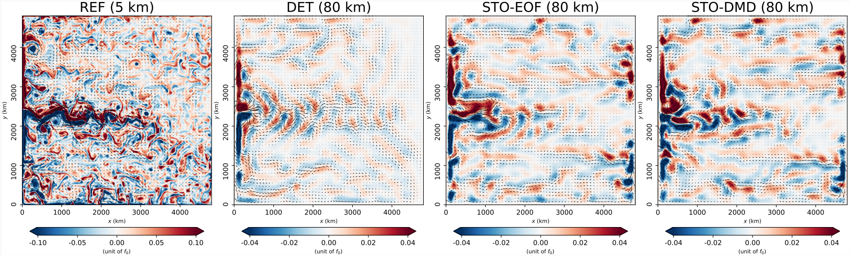

Figure 2: Snapshots of ocean upper layer relative vorticity.

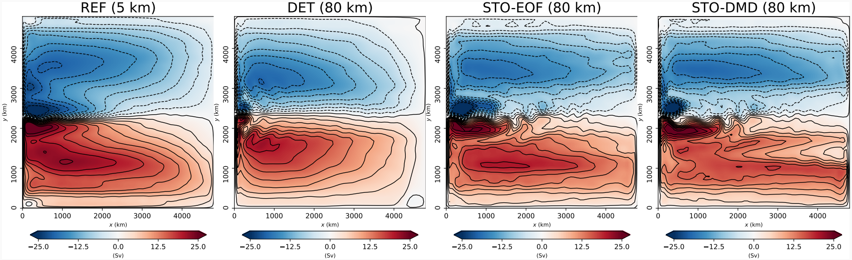

Figure 3: 40-years averages of ocean upper layer streamfunction.

Perspectives

- Energy-budget-based parameterization [Bachman, 2019, Jansen et al., 2019]

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- Air-sea interactions: SST-induced Ekman pumping, nonlinear Ekman model and random stress [Gaube et al., 2015]
- More realistic configurations: surface buoyancy conditions [Lapeyre and Klein, 2006], North Atlantic circulation (from FFT to multigrid)
- Ensemble forecasting and data assimilation

Thank you very much!

Questions?

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