The impact of stochastic mesoscale weather systems on the Atlantic Ocean

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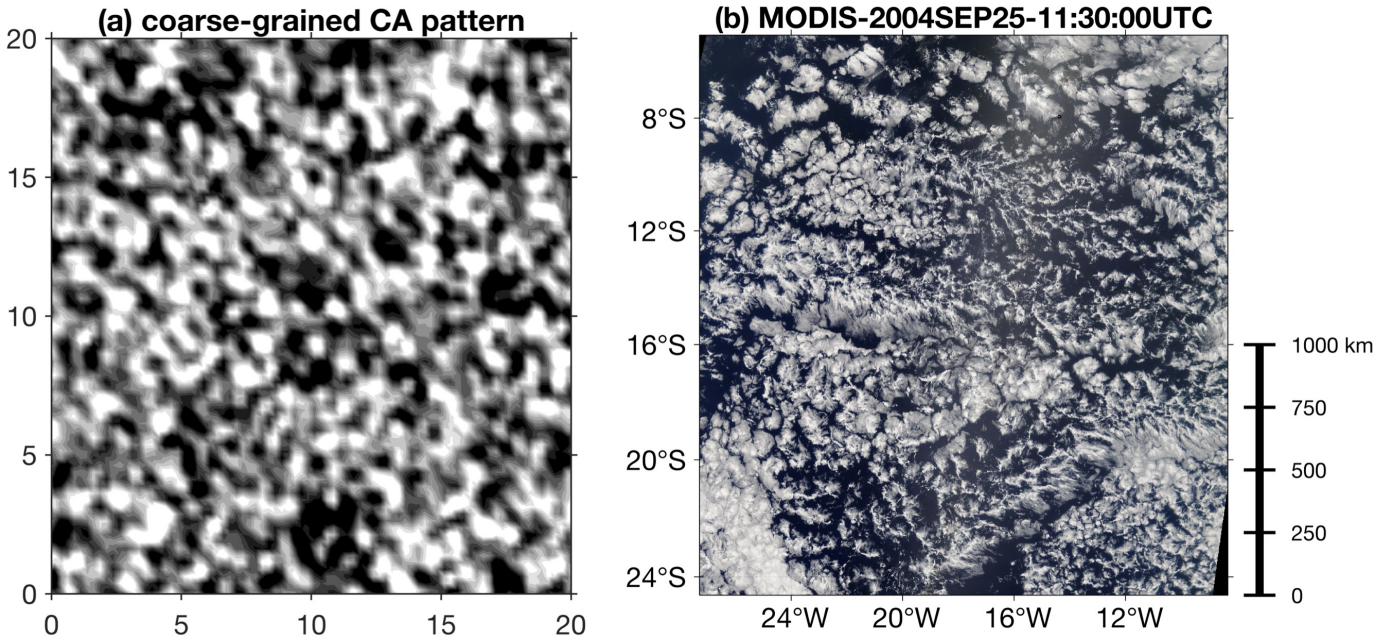

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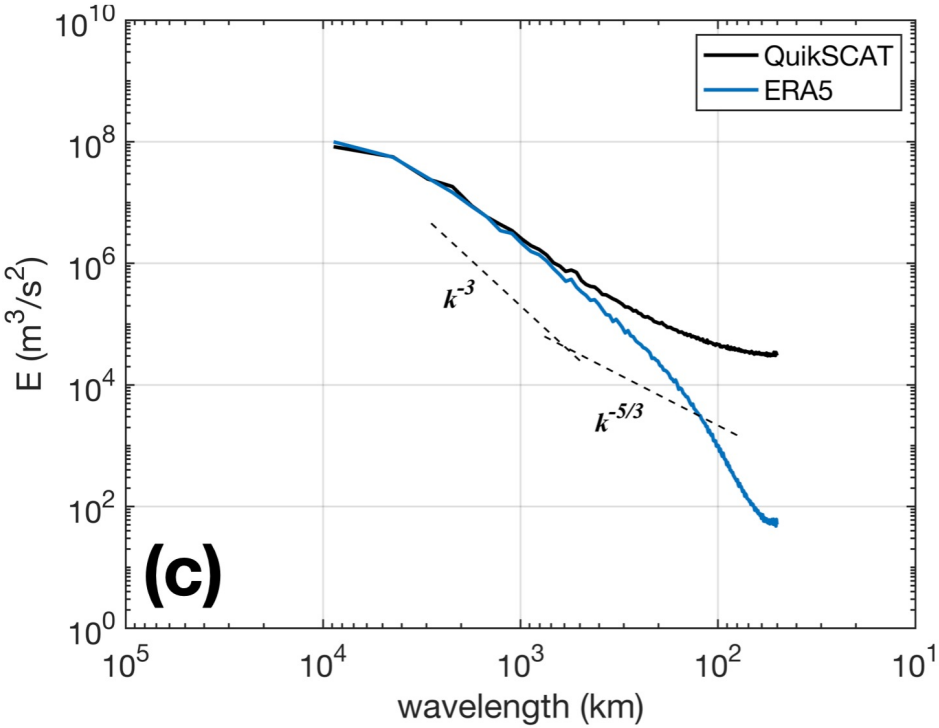
Motivation

- Grid size dictates a limit to what can be resolved in numerical models
- Mesoscale weather systems are not represented in climate models
  - ‘Missing’ polar lows enhance deep-water formation in the Nordic Seas (Condron and Renfrew 2013, Nature Geoscience)
  - Tropical cyclones, mesoscale convective systems, squall lines, …
- What is the impact on the ocean?



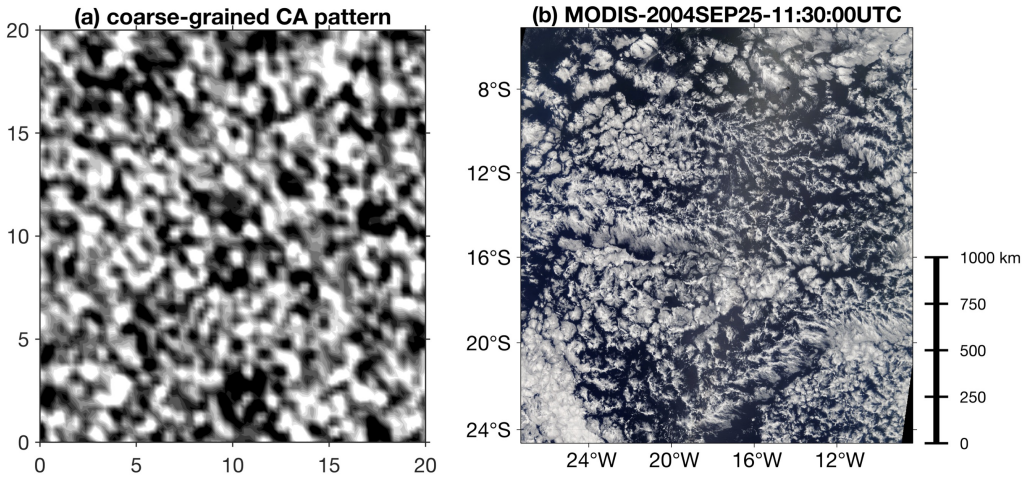
Effective resolution 400-500 km

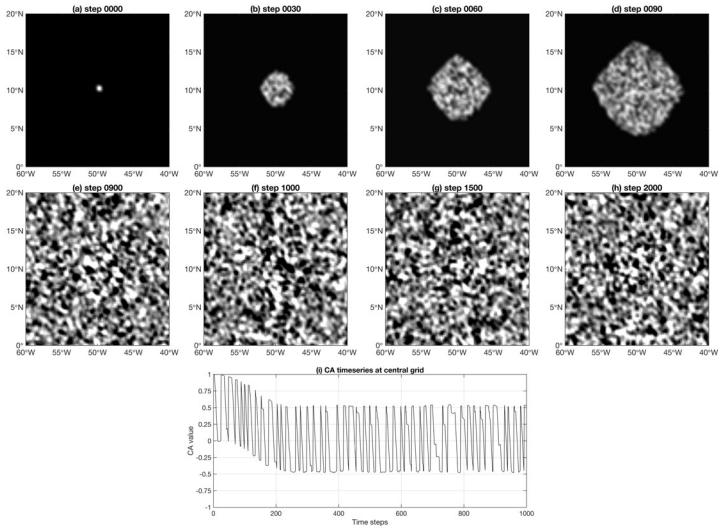
Parameterizing mesoscale weather systems

- We've developed a stochastic parameterization for generic mesoscale atmospheric variability
- Uses cellular automata to produce realistic looking fields
  - Added as velocity perturbations
  - New surface flux fields

$$u_{ERA5-CA} = u_{ERA5} + CA(x, y, t) \times \sigma_{ERA5} \times \alpha(t),$$

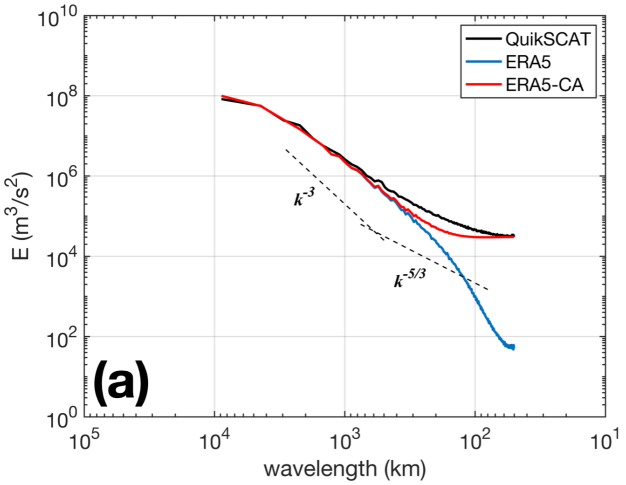
$$v_{ERA5-CA} = v_{ERA5} + CA(x, y, t) \times \sigma_{ERA5} \times \alpha(t).$$

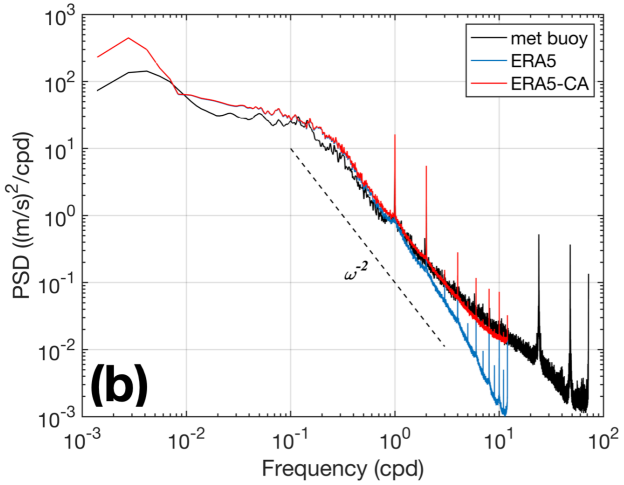


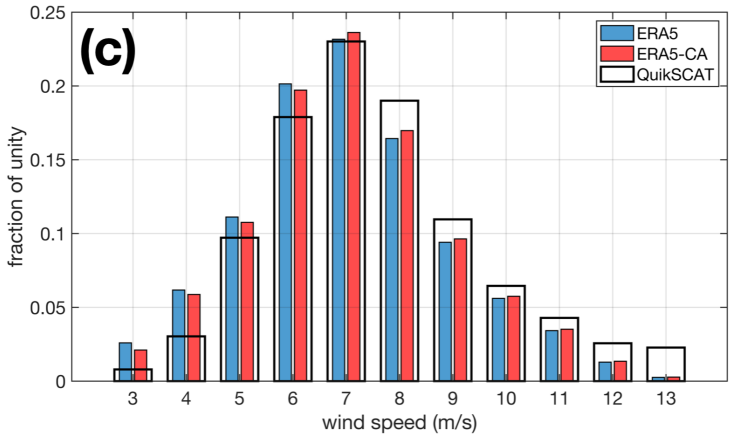


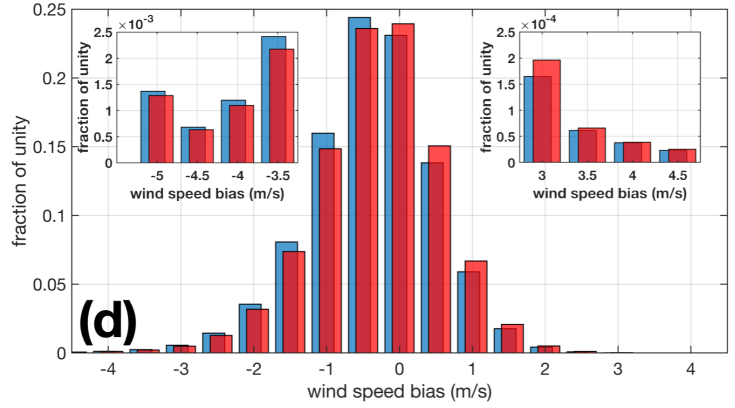
Improving the winds

- Effective resolution for winds is now Δx
- Improves wind speed distribution
- Reduces the low wind speed bias
- Average change (0.07 m s^{-1}) is within observational uncertainty





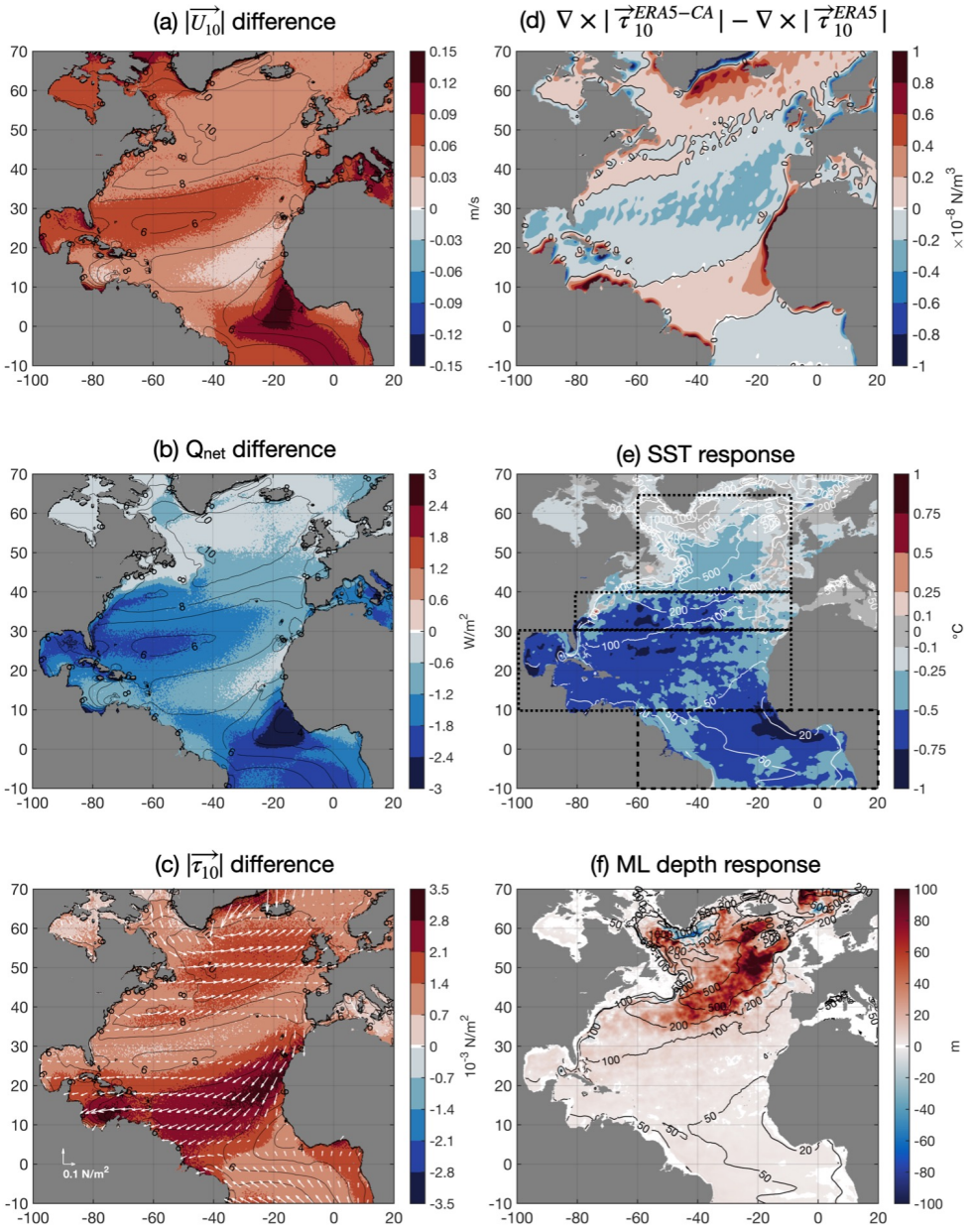




Impacts on the surface ocean

- MITgcm – Atlantic Ocean
- 1/10º and 50 levels
- Ensemble of 20-year simulations
- CONTROL – ERA5 forcing
- PERTURBATION – ERA5-CA forcing

- Coherent patterns of change
  - Surface cooling few W m^{-2}
  - Enhancement in wind stress
    - Subtropical and subpolar gyres
  - Reduction in SST
    - Especially where ML shallow (tropics & subtropics) and in summer
  - Deeper mixed layer in subpolar gyre



Impacts on ocean circulation

Representing mesoscale weather leads to:

- A stronger subpolar gyre
  - In all three PERTURB simulations
  - Statistically significant
- A stronger AMOC transport
  - by ~1 Sv
  - Statistically significant
- Enhanced northward heat transport

- *Ocean impacts consistent with higher resolution models*
  - *Similar to idealized NAO+ experiments*
- *A 'cheap' way of representing mesoscale atmospheric variability in climate models*

See Zhou, Renfrew and Zhai, *J. Climate*, under revision