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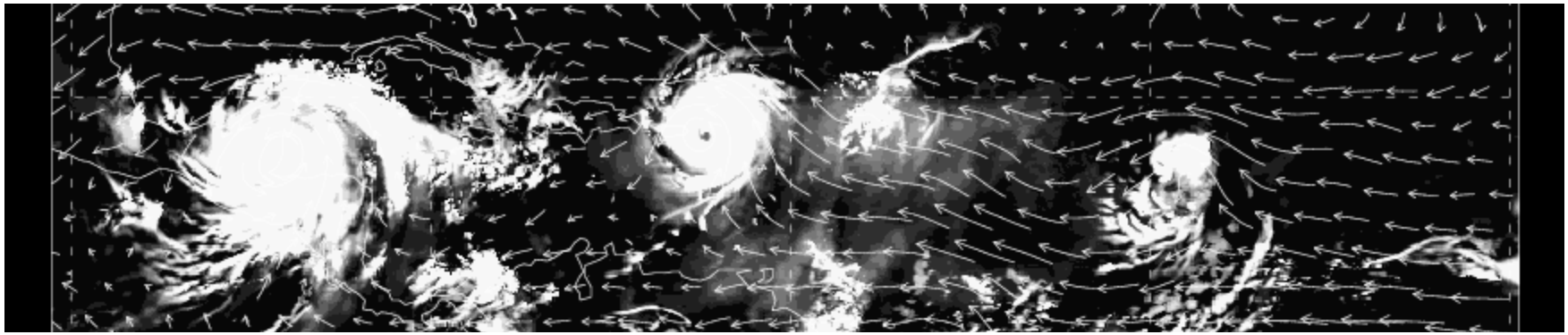
Wave Energy Accumulation and Tropical Cyclogenesis



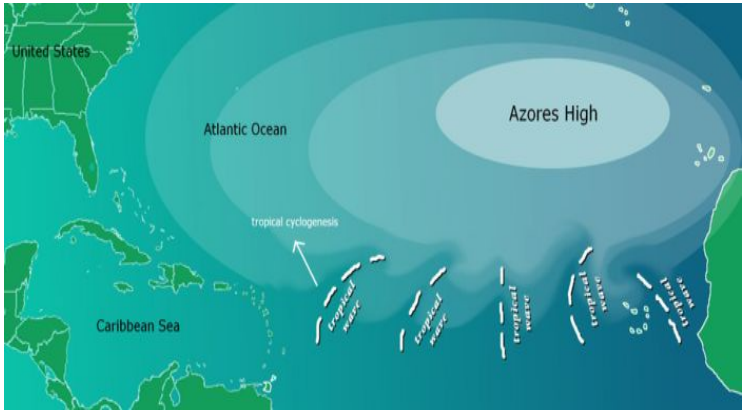
James Done

Greg Holland, Stefan Tulich, Cindy Bruyère and Asuka Suzuki-Parker

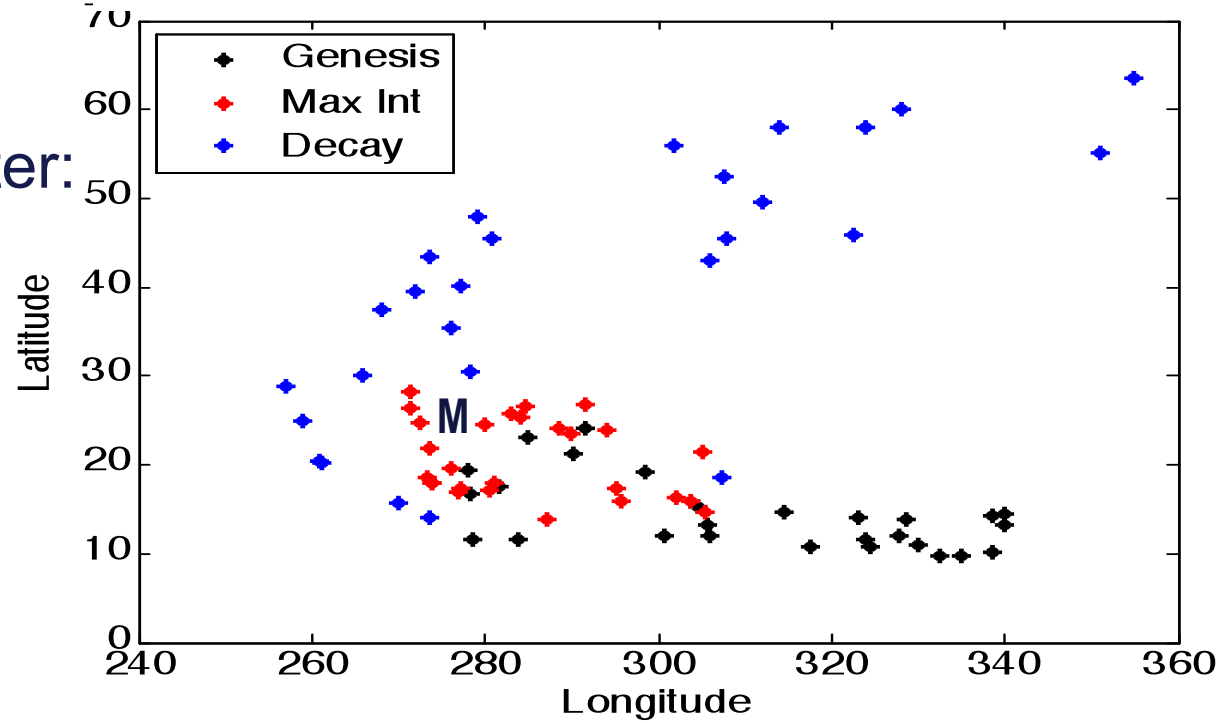
National Center for Atmospheric Research Earth System Laboratory

North Atlantic Storms

African easterly waves are associated with ~60% of Atlantic tropical cyclones, and almost all category 4 and 5 hurricanes.



All Atlantic storms that achieved Cat 3 or greater: 1930-2007.



Wave Energy Accumulation

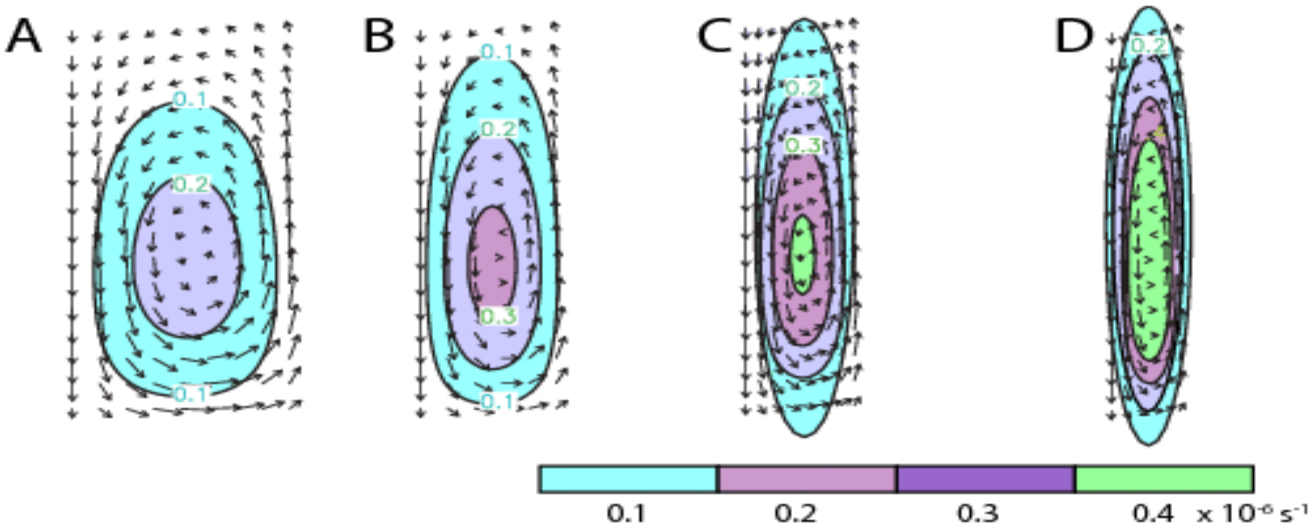
Webster and Chang (1989):
where U is the background zonal flow,
k is the zonal wavenumber

$$\frac{dk}{dt} = -k\frac{dU}{dx}$$

In terms of energy density of a wave (E):

$$\frac{dE}{dt} = -E\frac{dU}{dx}$$

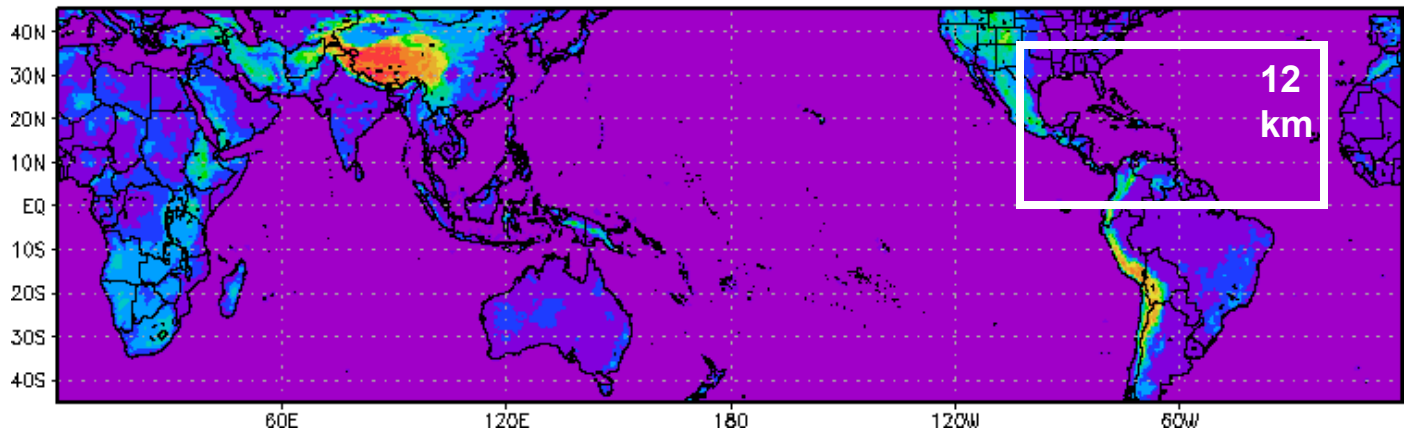
If a wave enters a region of negative stretching deformation it will decrease zonal scale and become more energetic.



Hypothesis

Variability of *U* alters wave characteristics such that energy moves to smaller scales, thereby enhancing, or even driving, tropical cyclone genesis.

Tropical Channel WRF

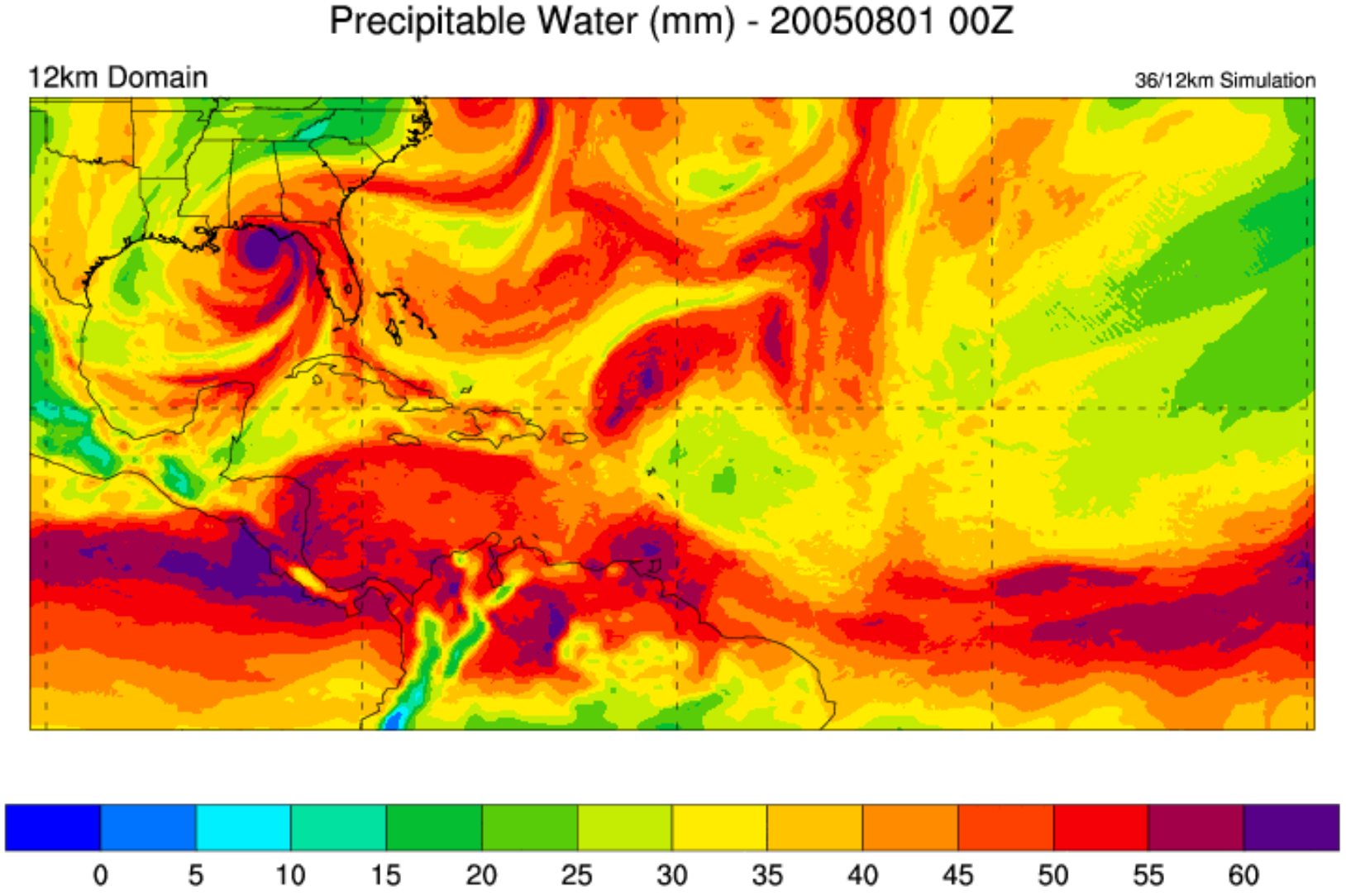


Forcing data:
NCEP/NCAR Reanalysis
Reynolds SST

Domains:
Parent domain 36km:
Jan 2000 – Jan 2006

2-way nested domain 12km:
May – Dec 2005

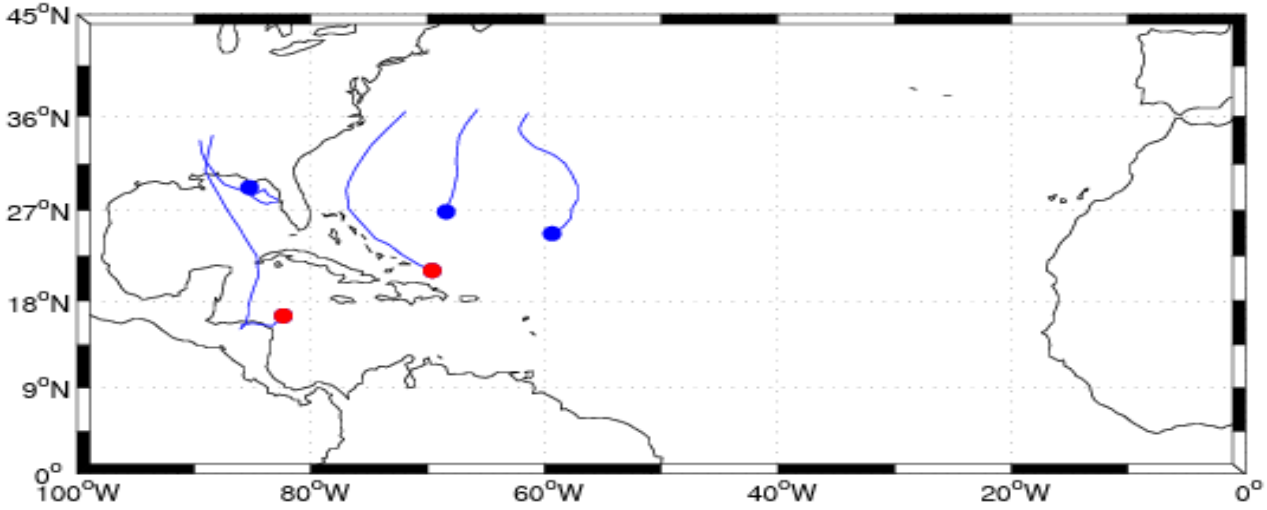
Atlantic Nest: Aug 2005



Storm Tracks

June and July:

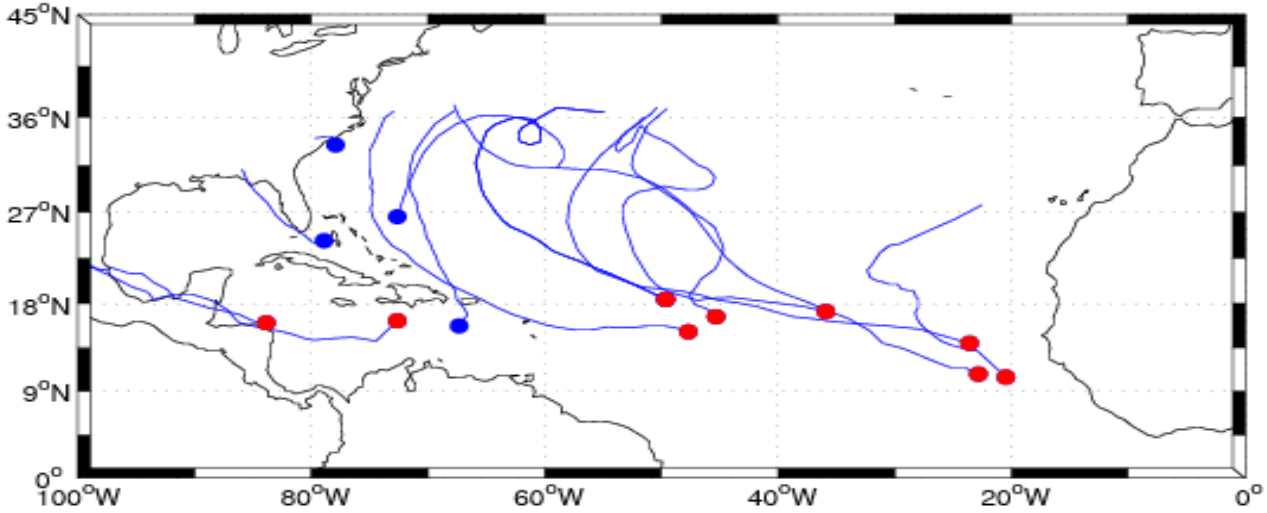
5 Storms



August and

September:

13 Storms



Red dot: cyclones that formed within an easterly wave

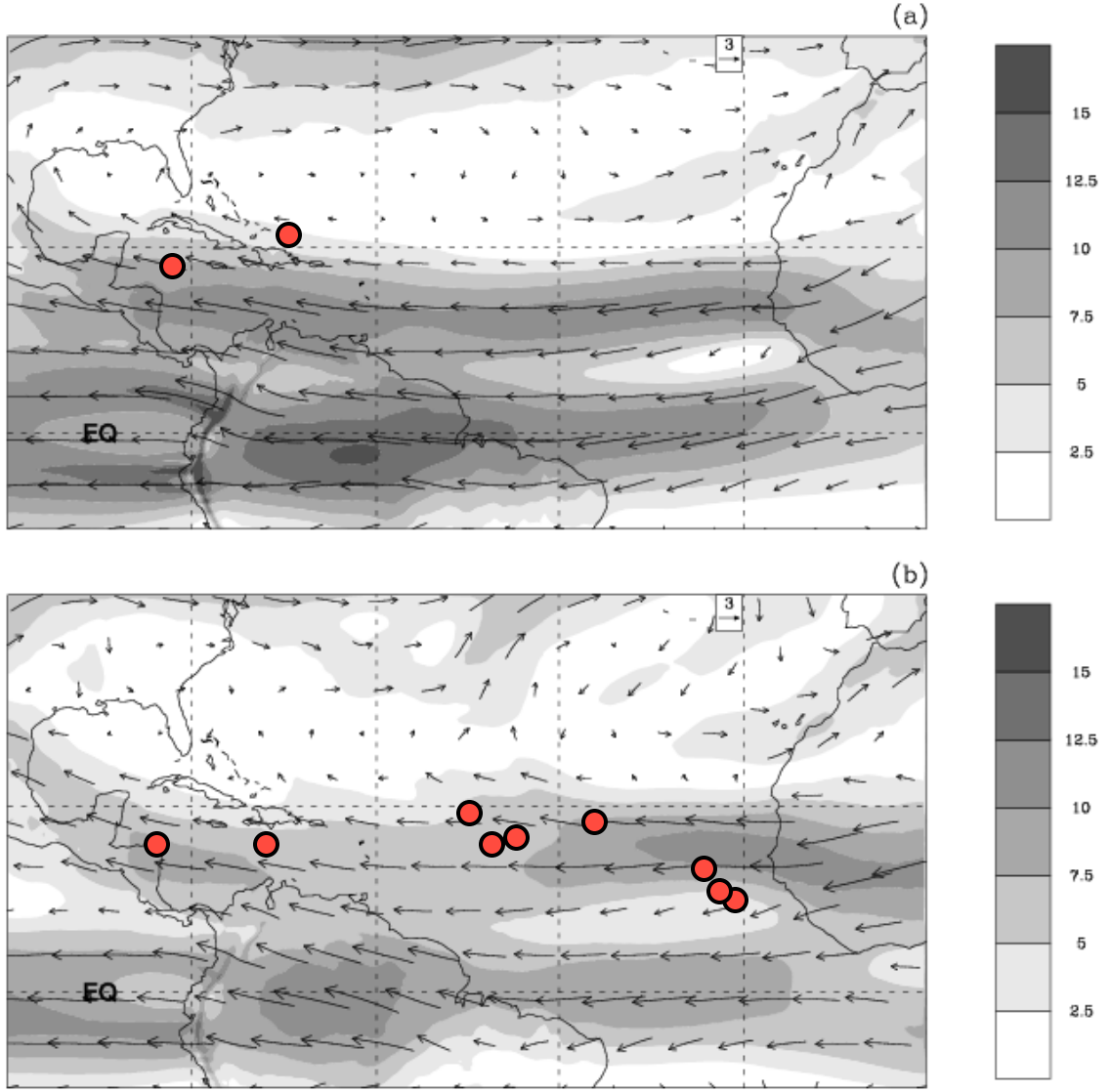
Blue dot: cyclones that did not form within an easterly wave.

Wind Speed and Vectors at 700hPa

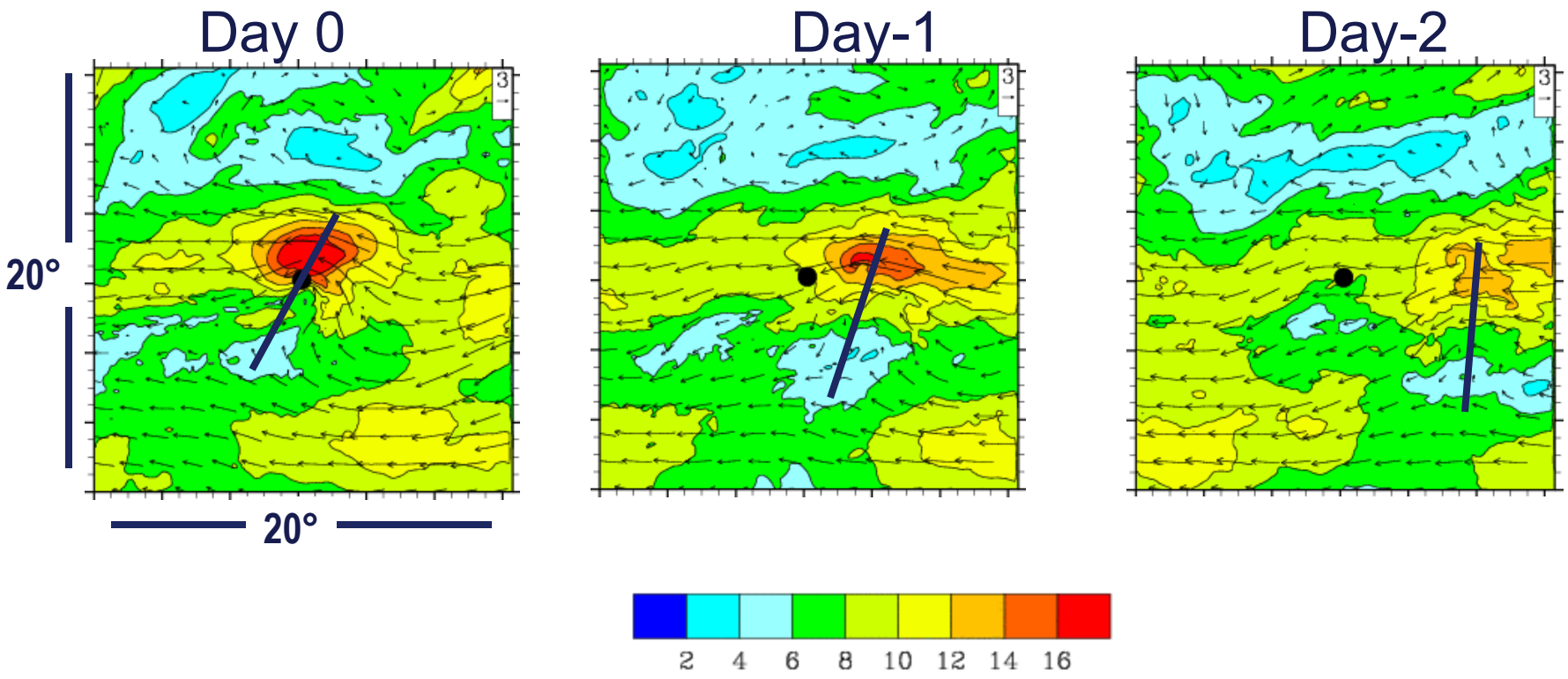
June and July

August and

September

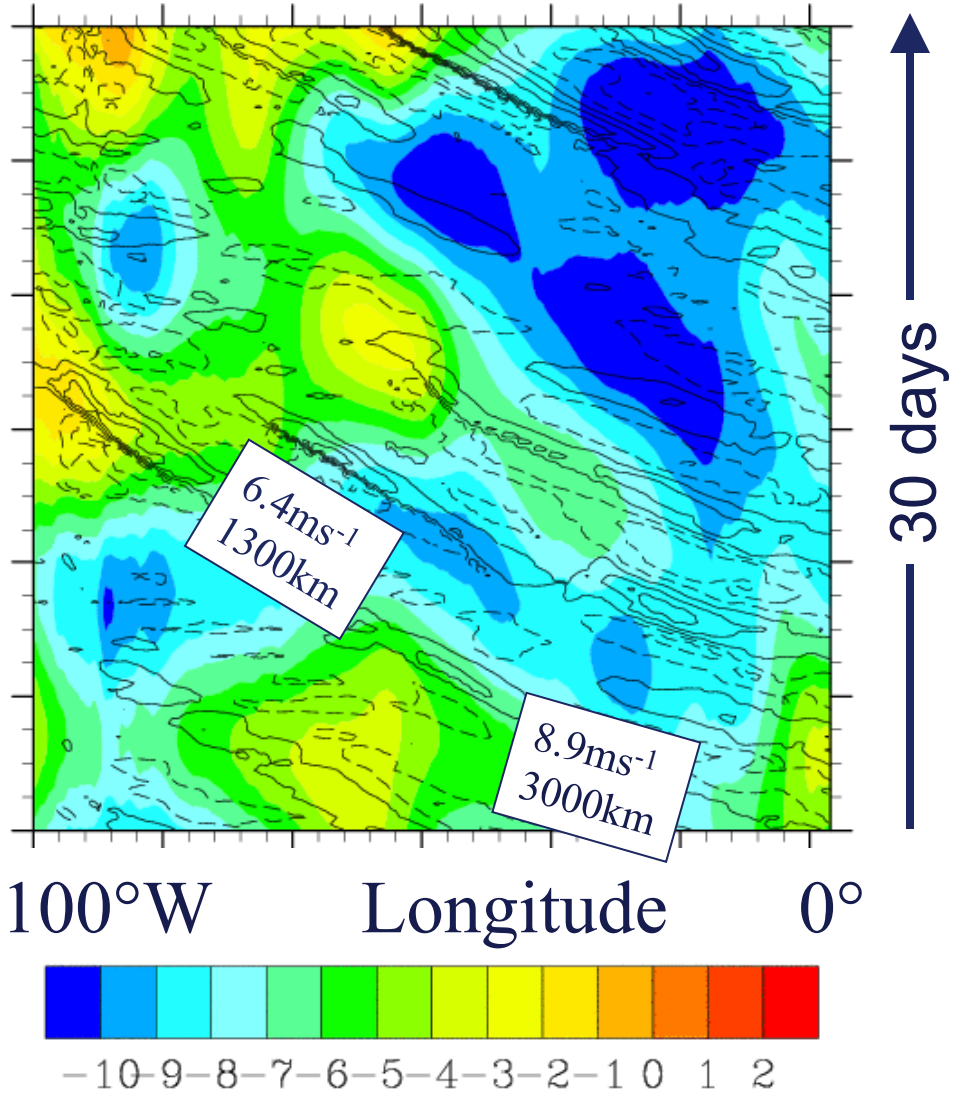


Composite Wind Speed (ms^{-1}) and vectors.



Identifying Wave Accumulation

Hovmöller of:
U (ms^{-1},colors);
V' (contours)
averaged over 10° latitude



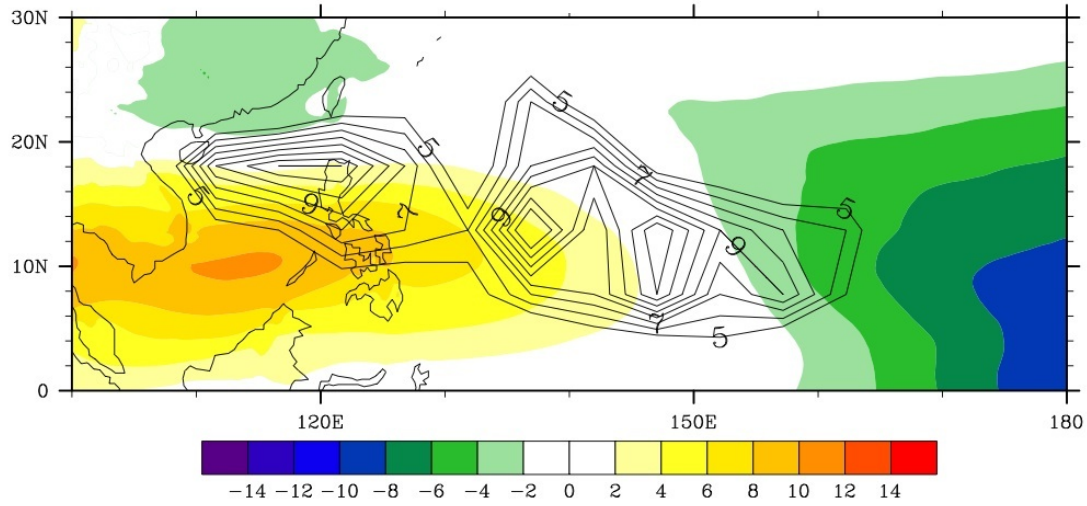
Tropical North Pacific

850hPa Zonal wind
Aug-Sept-Oct
2000-2005 average
(colors)

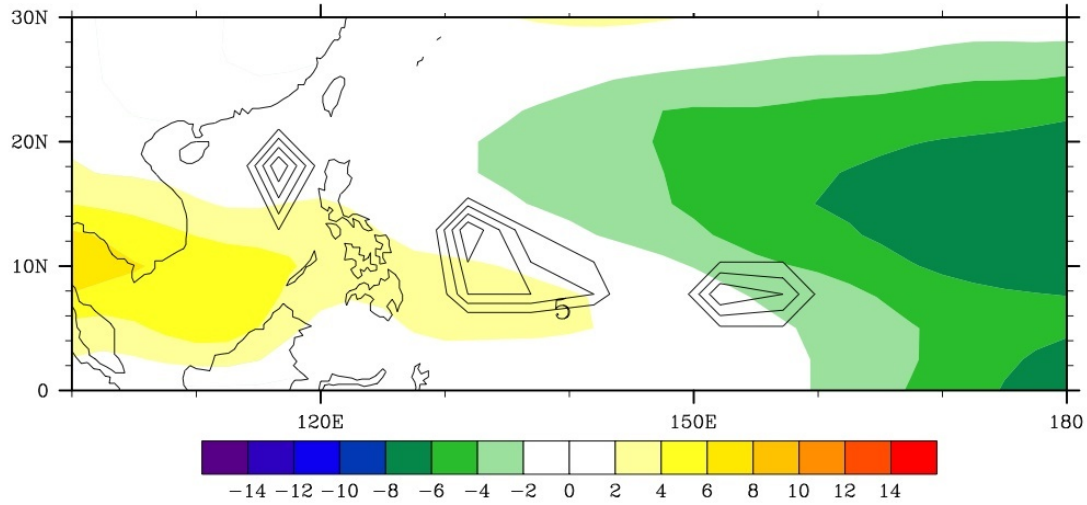
Genesis density
(black contours)

Strong forcing for
wave accumulation.

Model



Observation



Idealized WRF Experiments

Aim: Determine importance of wave energy accumulation for cyclogenesis under idealized conditions.

Planned experiments using idealized WRF:

Stage 1: Dry dynamics.

Track Rossby wave properties through different background flow scenarios and identify wave energy accumulation.

Stage 2: Include moist physics.

What is the importance of wave energy accumulation for changing wave characteristics relative to other processes including deep moist convection?

Is tropical cyclone formation sensitive to the magnitude of stretching deformation across the observed range of magnitudes?

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Summary

Hypothesis: Wave energy accumulation enhances or even drives tropical cyclogenesis.

Tropical Channel WRF: Challenging to identify wave energy accumulation in full physics and dynamics model.

Next Step: Determine importance of wave energy accumulation for cyclogenesis under idealized conditions.