Improving Hurricane Model Physics:

Why do we need explicit coupling with a wave model?

Coupling Between Atmosphere and Ocean in Hurricane Models

Atmospheric Model

Wind speed (U_a)
Temperature (T_a)
Humidity (q_a)

Momentum flux (τ)
Sensible heat flux (Q_H)
Latent heat flux (Q_E)

Air-Sea Interface

SST (T_s)

Momentum flux (τ)

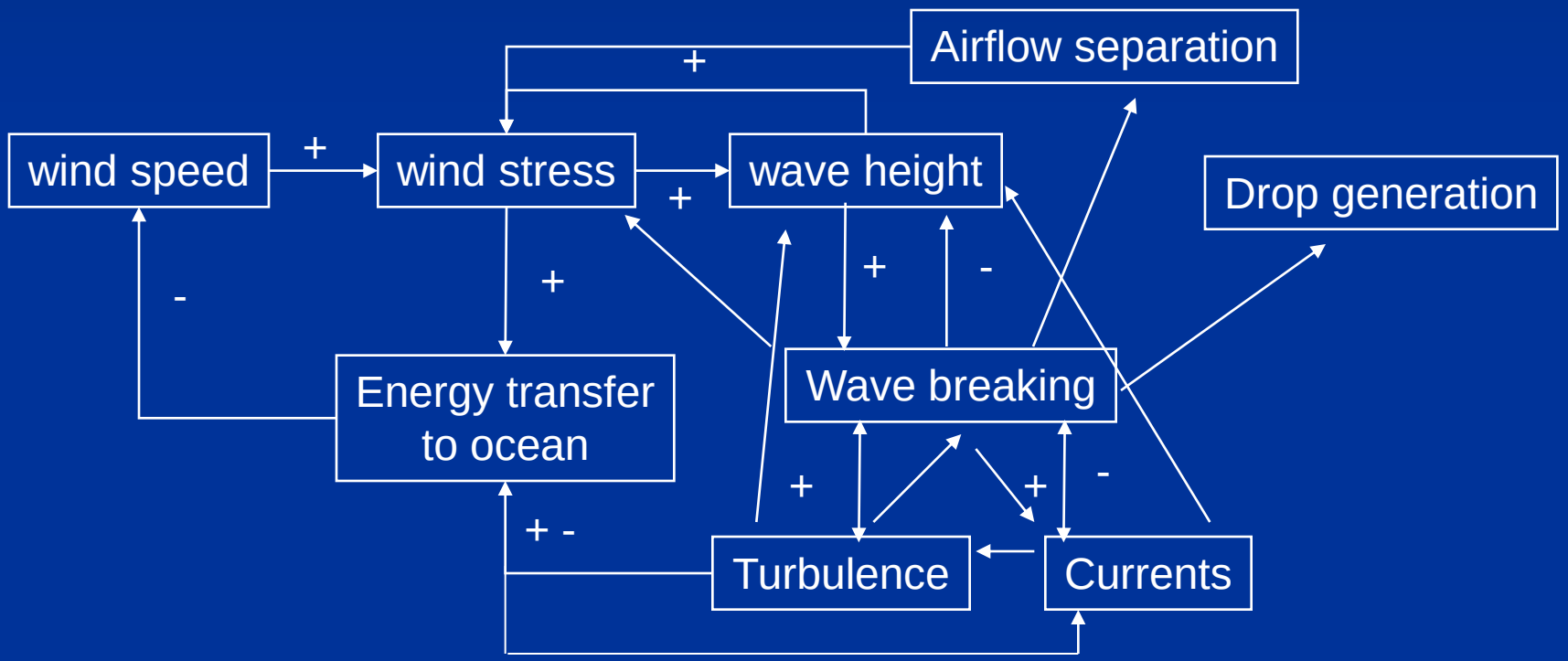
Ocean Model

$$\tau = \rho_a C_D U_a^2$$

$$Q_H = C_H (U_a - U_s)(T_a - T_s)$$

$$Q_E = \frac{L_V}{C_P} C_E (U_a - U_s)(q_a - q_s)$$

Momentum flux and drag at the ocean surface



Traditional assumptions of air-sea flux parameterizations are not valid in hurricane conditions

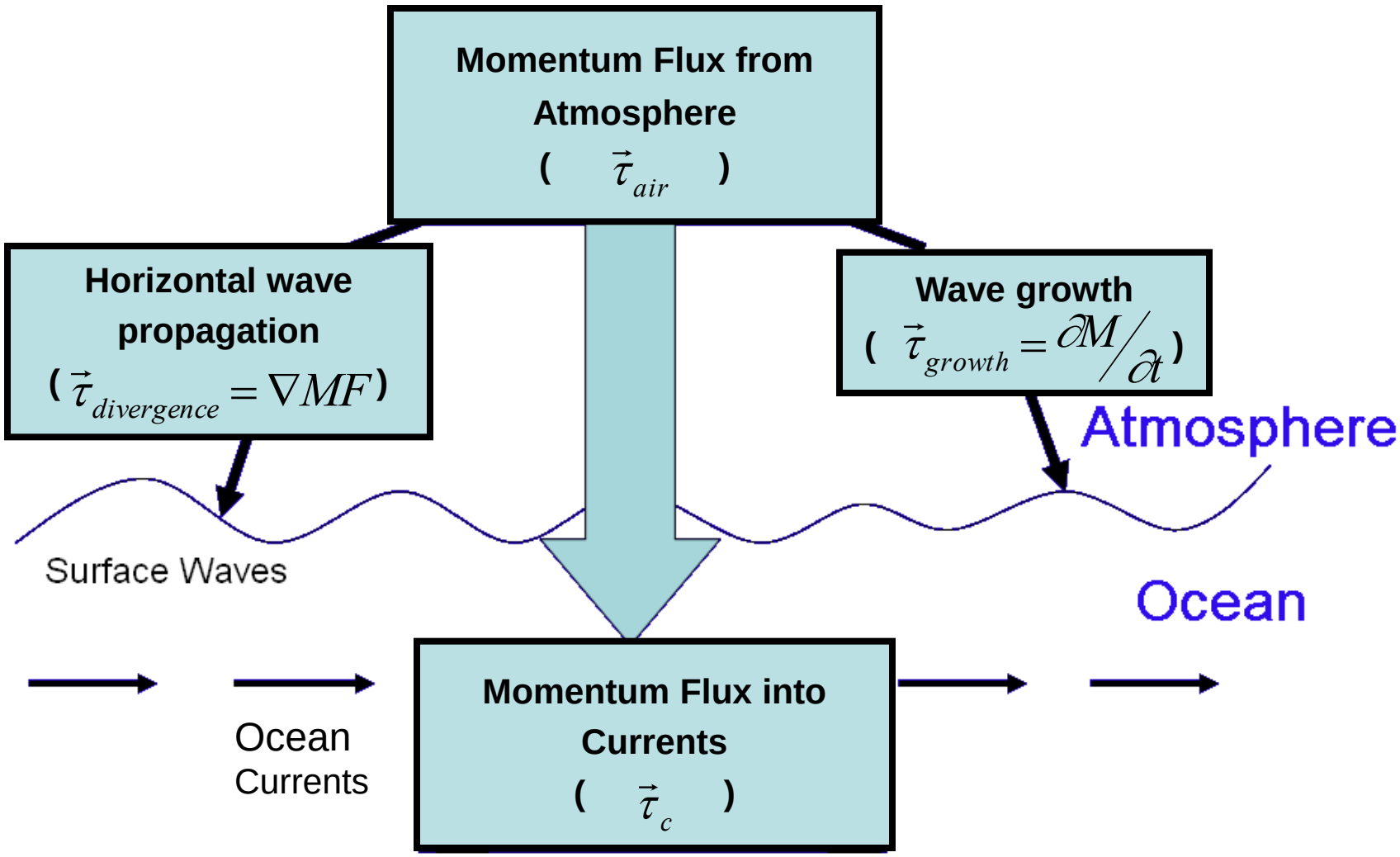
- Momentum and enthalpy exchange coefficients are function of *wind speed* only - sea state dependence is neglected

- Momentum flux into currents is identical to wind stress - momentum gained/lost by surface waves is neglected

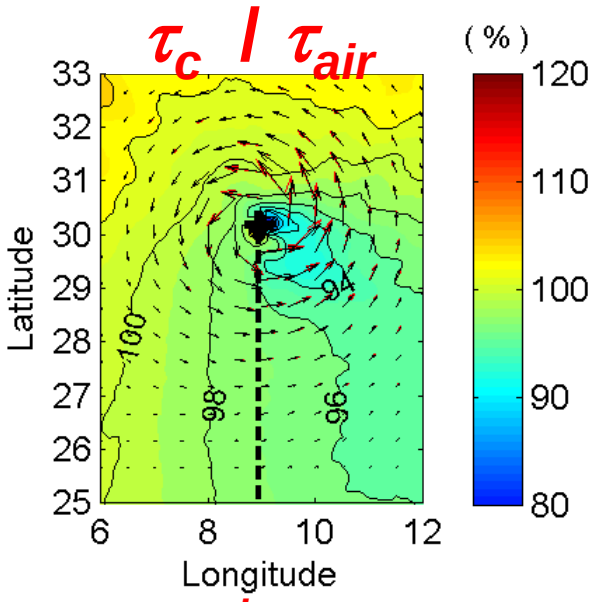
- Also neglected:
  - Wind-wave-current interaction
  - Sea spray effects

Momentum Flux Budget at Air-Sea Interface

$$\vec{\tau}_{air} = \vec{\tau}_c + \vec{\tau}_w \qquad \vec{\tau}_w = \left(\vec{\tau}_{growth} + \vec{\tau}_{divergence}\right)$$

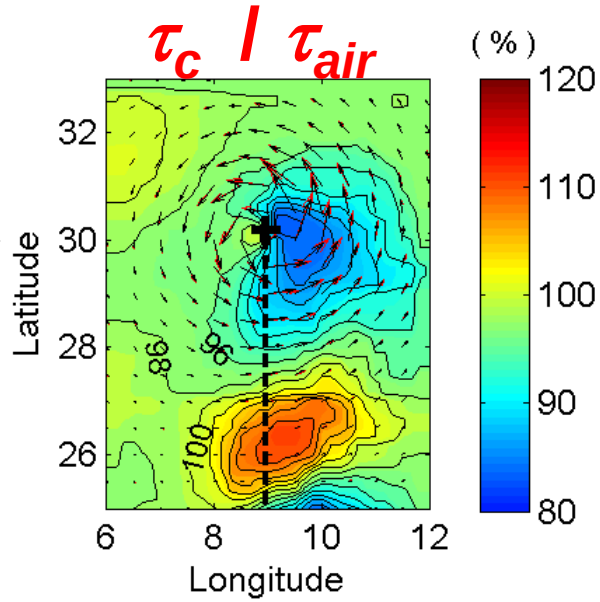


Waves can reduce momentum flux into ocean as much as 20% relative to wind stress



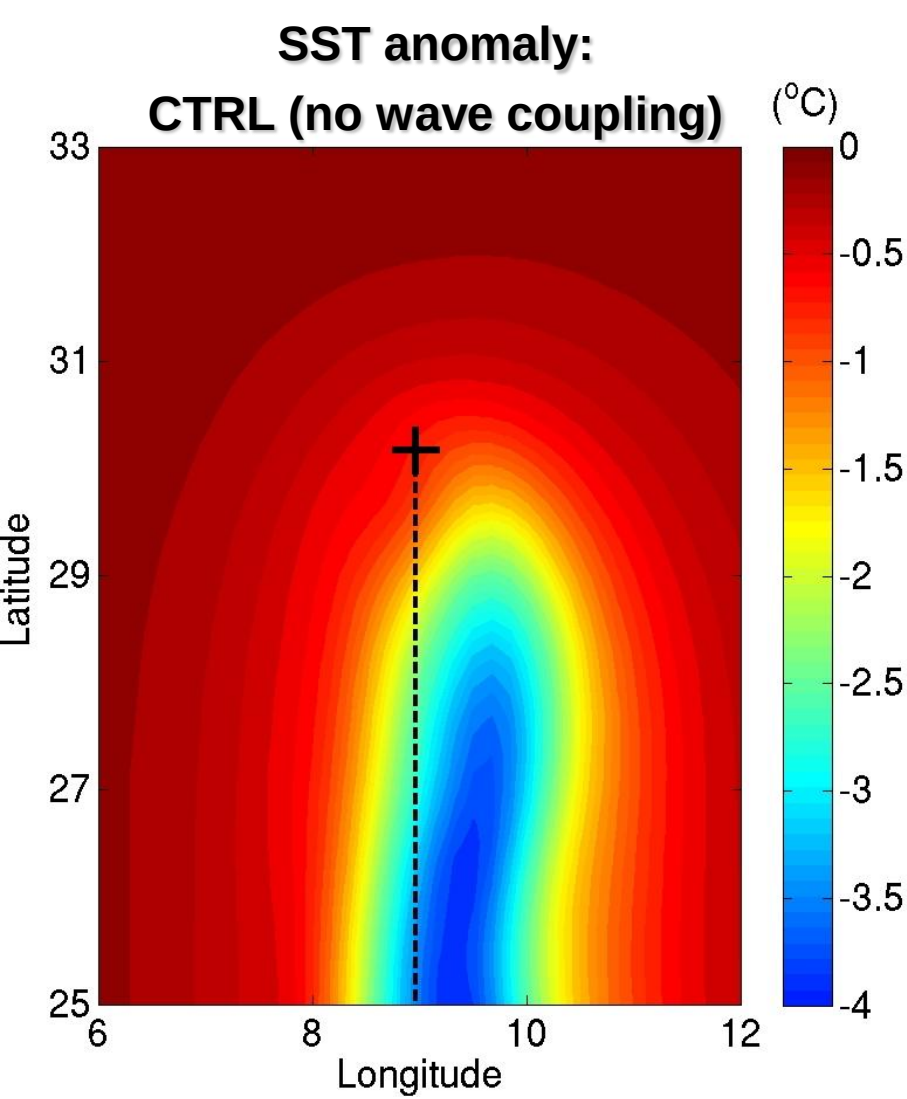
Effect of waves (flux budget)

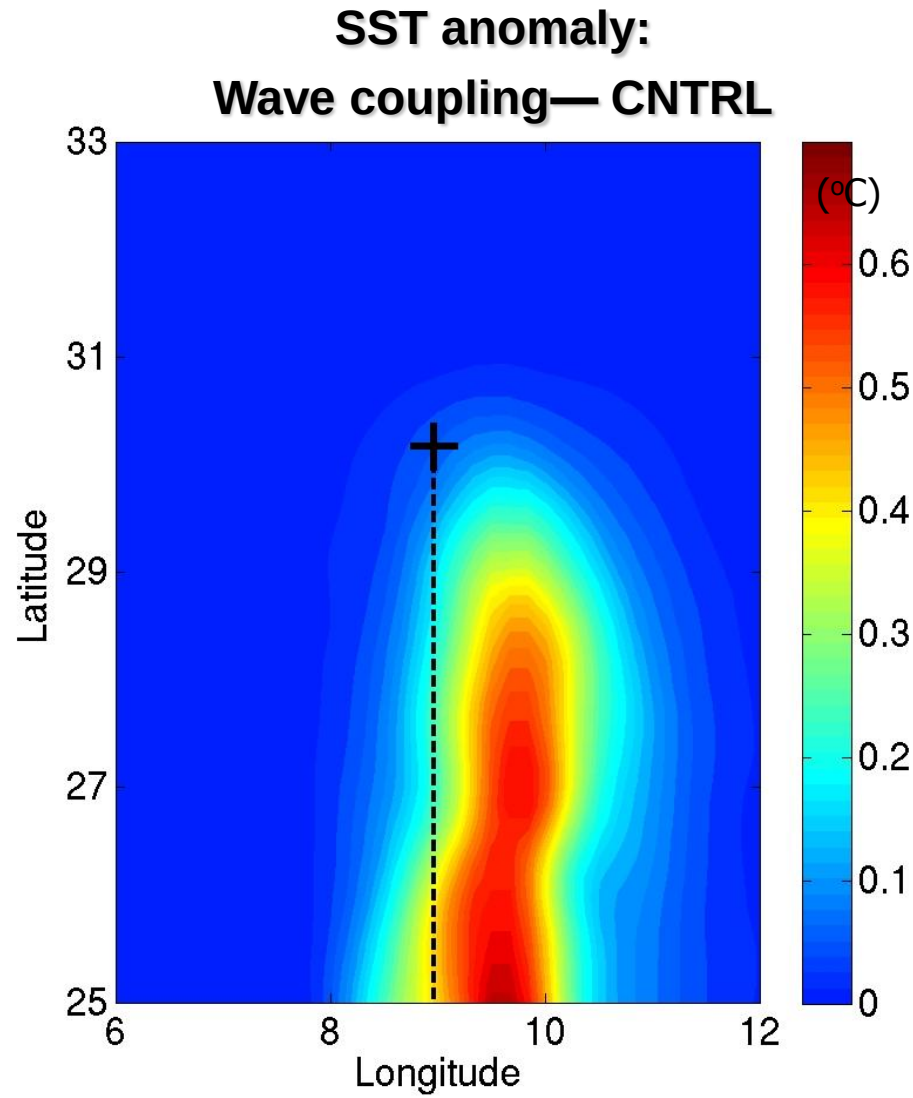
Effect of wind-wave-current interaction



Fan, Ginis, Hara (2009)

Hurricane-induced ocean cooling is reduced due to wind-wave-current interaction





Fan, Ginis, Hara (2009)