U.S. NAVAL RESEARCH LABORATORY

Impact of Dynamic Coupling from Currents to Wind Stress over the Gulf Stream

Jackie C. May
Naval Research Laboratory, Code 7321
Stennis Space Center, MS

Mark Bourassa
Department of Earth, Ocean and Atmospheric Science, Florida State University, Tallahassee, FL
Center for Ocean-Atmospheric Prediction Studies, Florida State University, Tallahassee, FL

IOVWST: 12 April 2022

Impact of Dynamic Coupling from Currents to Wind Stress over the Gulf Stream

Jackie C. May and Mark Bourassa
Naval Research Laboratory, Code 7321, Stennis Space Center, MS

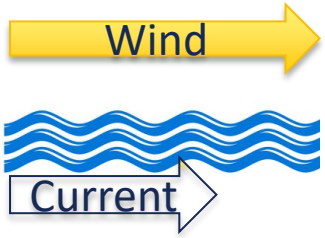
Current Feedback: Currents to wind stress

- Current feedback directly modifies the atmospheric surface winds to be relative to surface currents instead of relative to the earth

$$\vec{\tau} = \rho \overrightarrow{u_*} \left| \overrightarrow{u_*} \right|$$

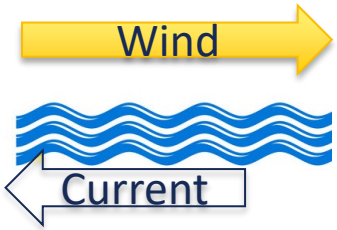
$$\overrightarrow{u_*} \left| \overrightarrow{u_*} \right| = \frac{k^2}{(\ln z/z_0)^2} \vec{U}(z) \left| \vec{U}(z) \right| G_m(z/z_0, Ri_{B0}) = C_D \overrightarrow{U_{10}} \left| \overrightarrow{U_{10}} \right|$$

current feedback: replace $\overrightarrow{U_{10}}$ with $\overrightarrow{U_{10}} - \vec{U}_{curr}$



Wind and current in same direction

- Decreased shear
- Less stress



Wind and current in opposite direction

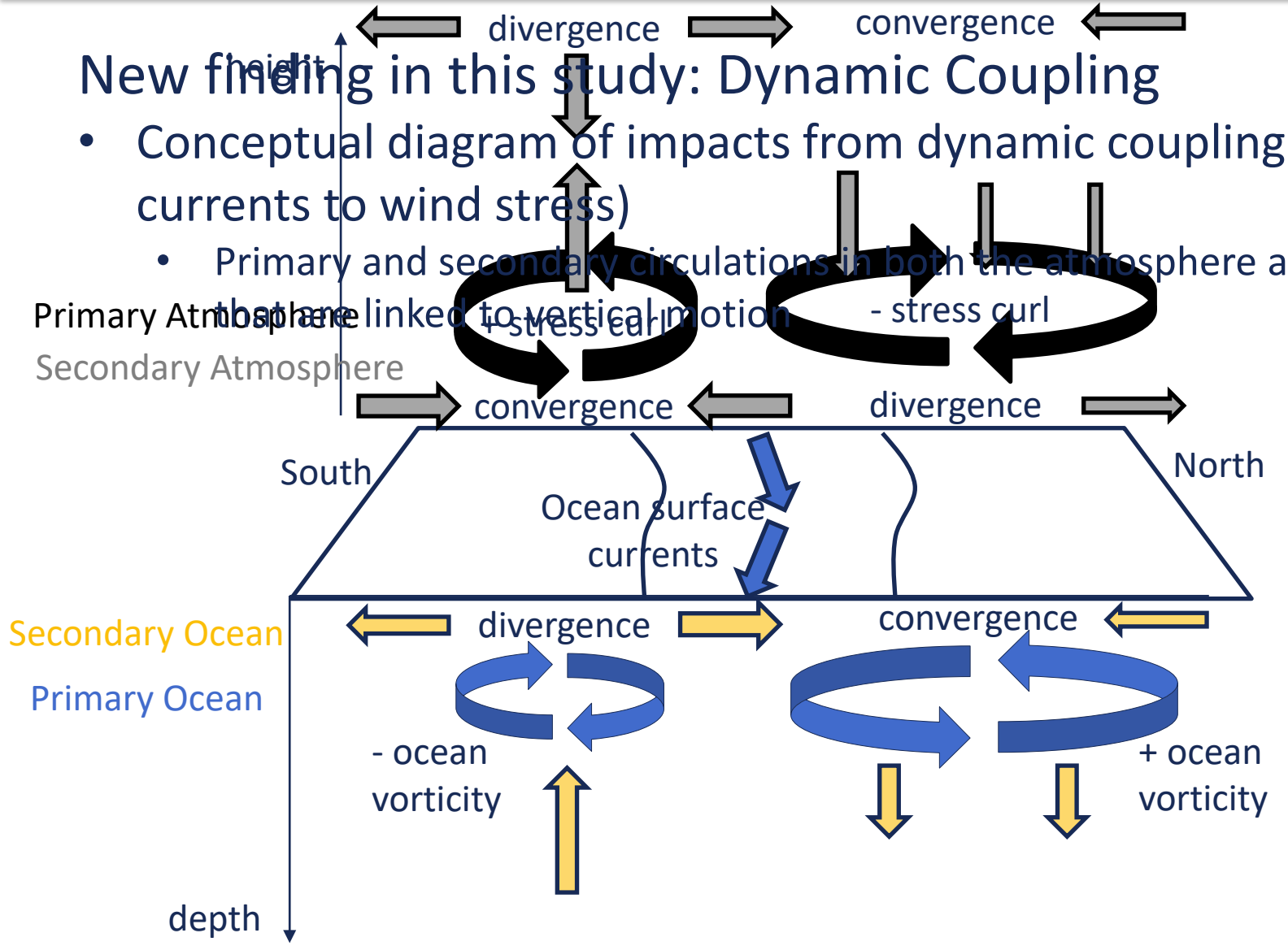
- Increased shear
- Greater stress

Impact of Dynamic Coupling from Currents to Wind Stress over the Gulf Stream

Jackie C. May and Mark Bourassa
Naval Research Laboratory, Code 7321, Stennis Space Center, MS

New finding in this study: Dynamic Coupling

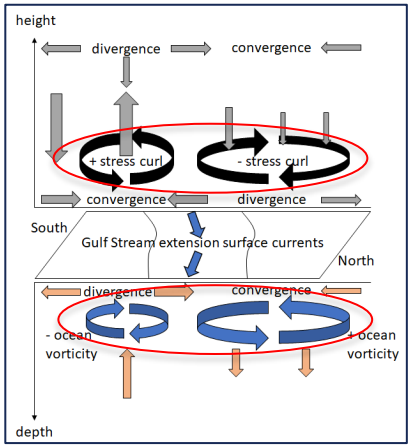
- Conceptual diagram of impacts from dynamic coupling (from currents to wind stress)
  - Primary and secondary circulations in both the atmosphere and the ocean that are linked to vertical motion

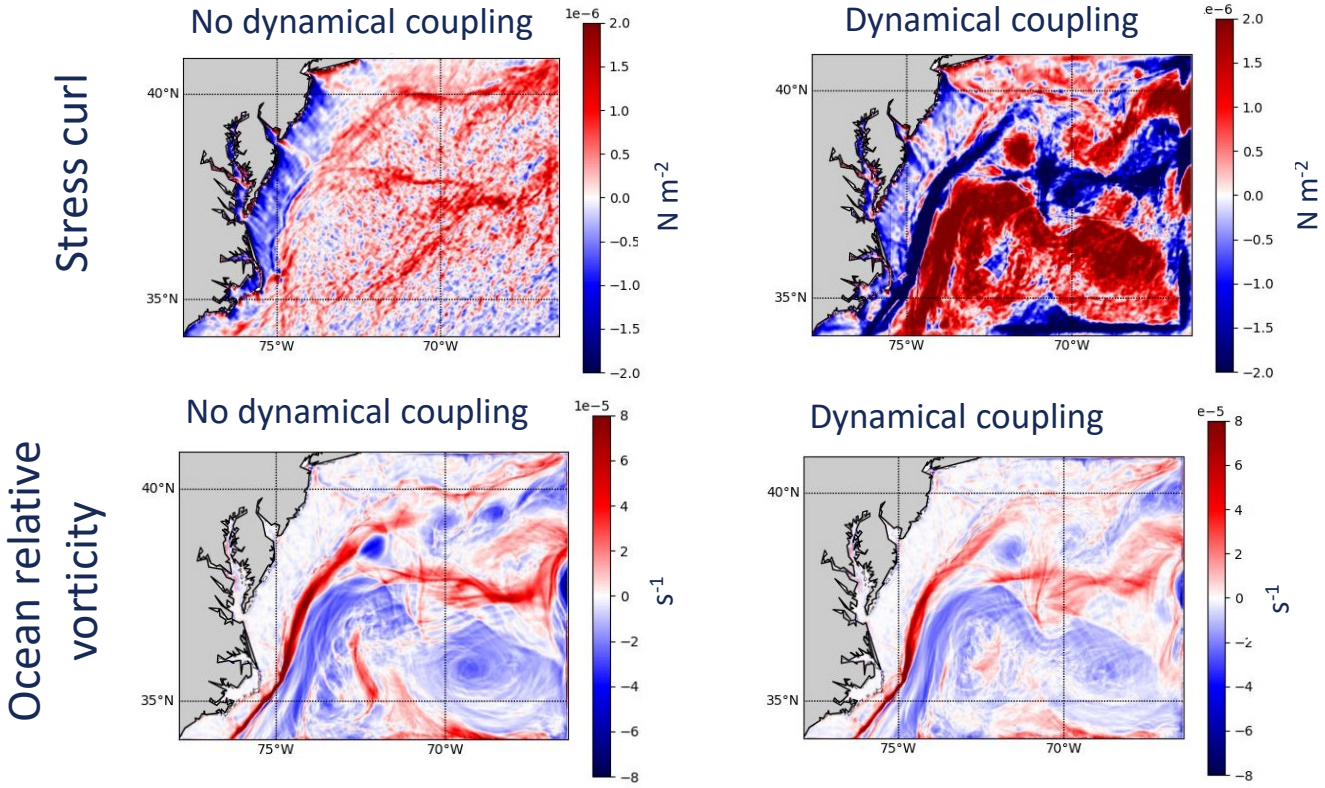


Impact of Dynamic Coupling from Currents to Wind Stress over the Gulf Stream

Jackie C. May and Mark Bourassa
Naval Research Laboratory, Code 7321, Stennis Space Center, MS

Current feedback impact (primary circulations)





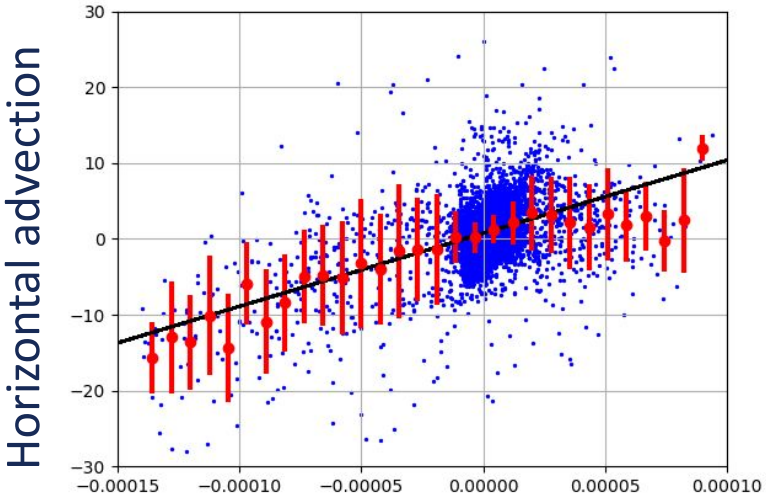
- Positive ocean vorticity to left of Gulf Stream; Negative ocean vorticity to right of Gulf Stream
- When dynamical coupling leads to: Negative stress curl to left of Gulf Stream; Positive stress curl to right of Gulf Stream

Impact of Dynamic Coupling from Currents to Wind Stress over the Gulf Stream

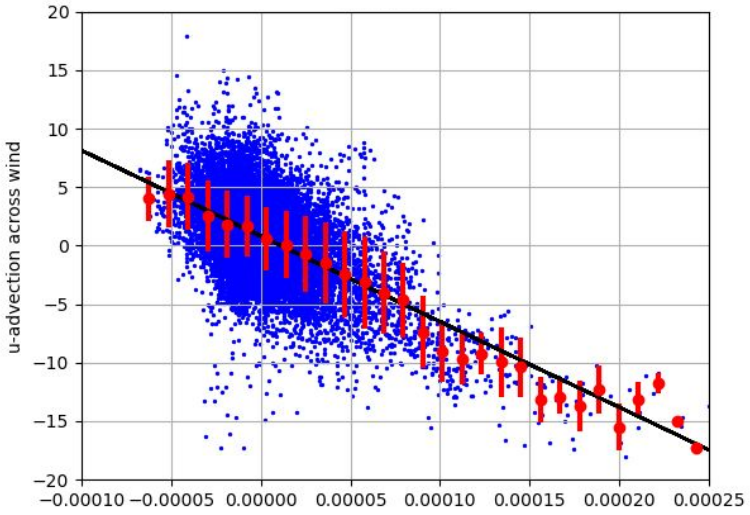
Jackie C. May and Mark Bourassa
Naval Research Laboratory, Code 7321, Stennis Space Center, MS

Physical process driving horizontal advection (surface winds)

No dynamical coupling



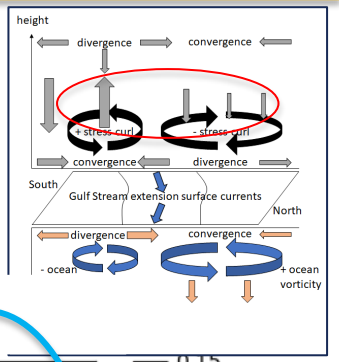
Dynamical coupling



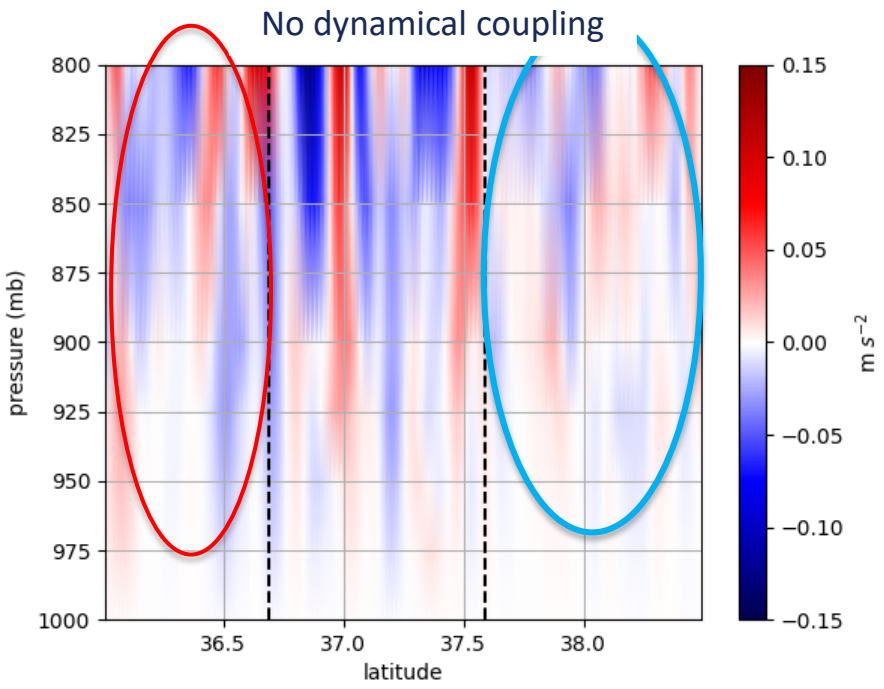
- Without dynamical coupling, horizontal advection largely explained by stress gradient
- With dynamical coupling, horizontal advection largely explained by current gradient across current direction

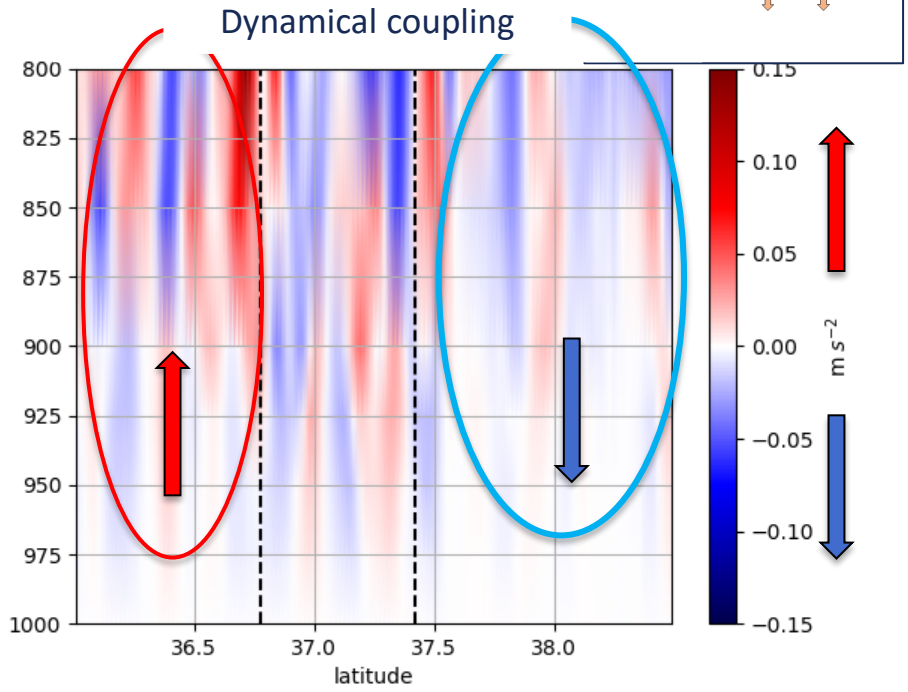
Impact of Dynamic Coupling from Currents to Wind Stress over the Gulf Stream

Jackie C. May and Mark Bourassa
Naval Research Laboratory, Code 7321, Stennis Space Center, MS



Atmospheric boundary layer vertical acceleration for average winter conditions (1 Feb 2015 00 UTC)





- Dynamical coupling leads to enhanced upward transport to right of Gulf Stream and enhanced downward transport to left of Gulf Stream