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Identification of Loop Current Ring Separation Events in the Gulf of Mexico

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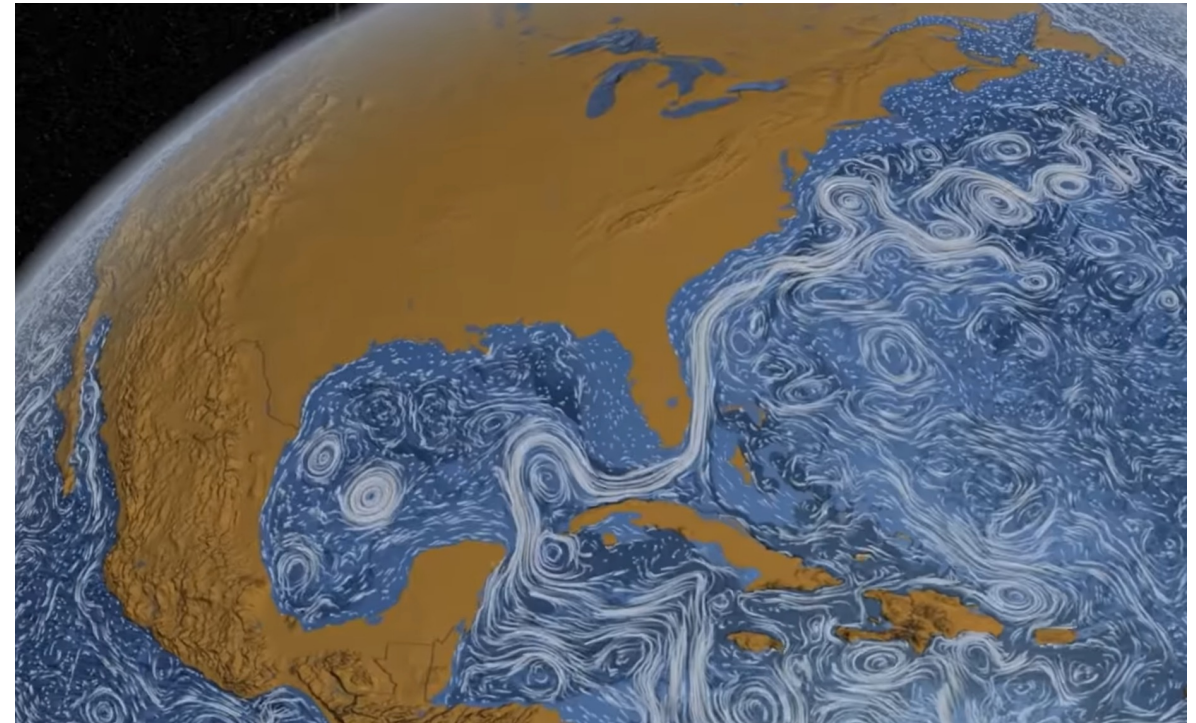
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Identification of Loop Current Ring Separation Events in the Gulf of Mexico

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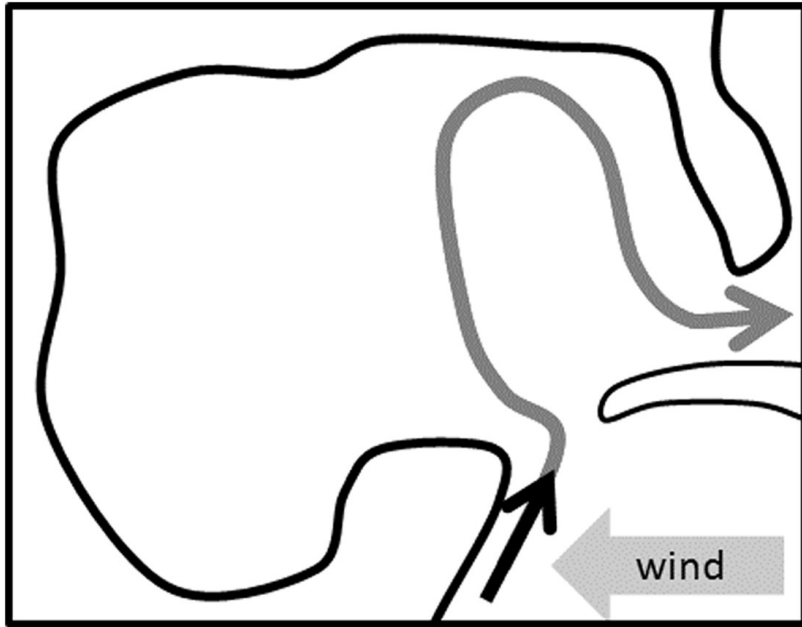
*huntleyh@rowan.edu



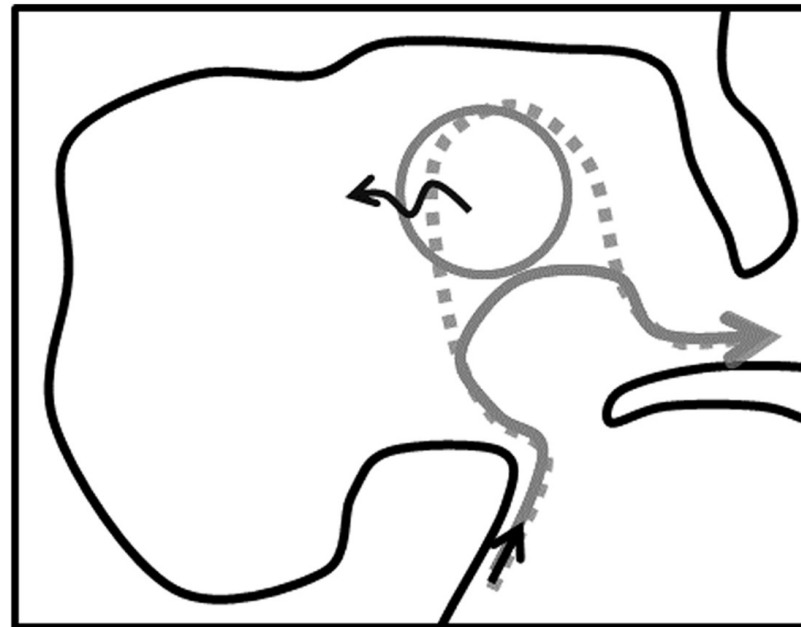
<https://www.nasa.gov/topics/earth/features/perpetual-ocean.html>

Gulf of Mexico Loop Current: Canonical States

Extended State



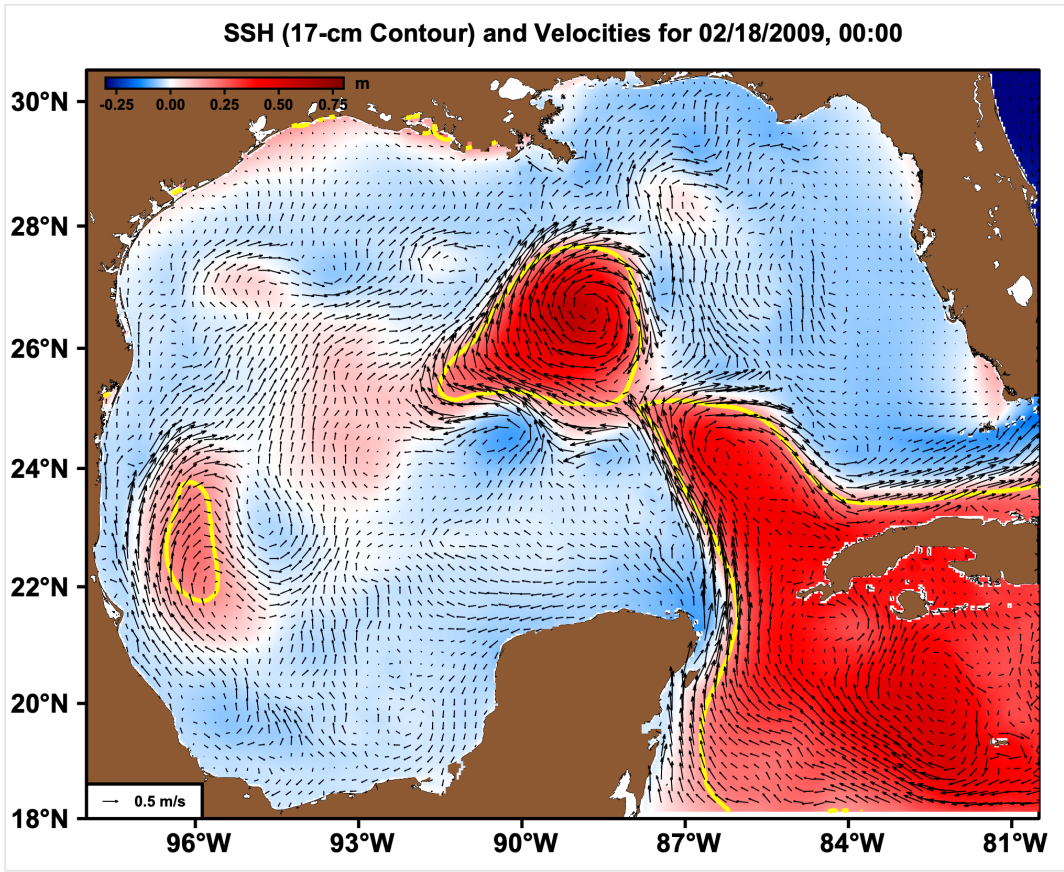
Retracted State with Detached Ring



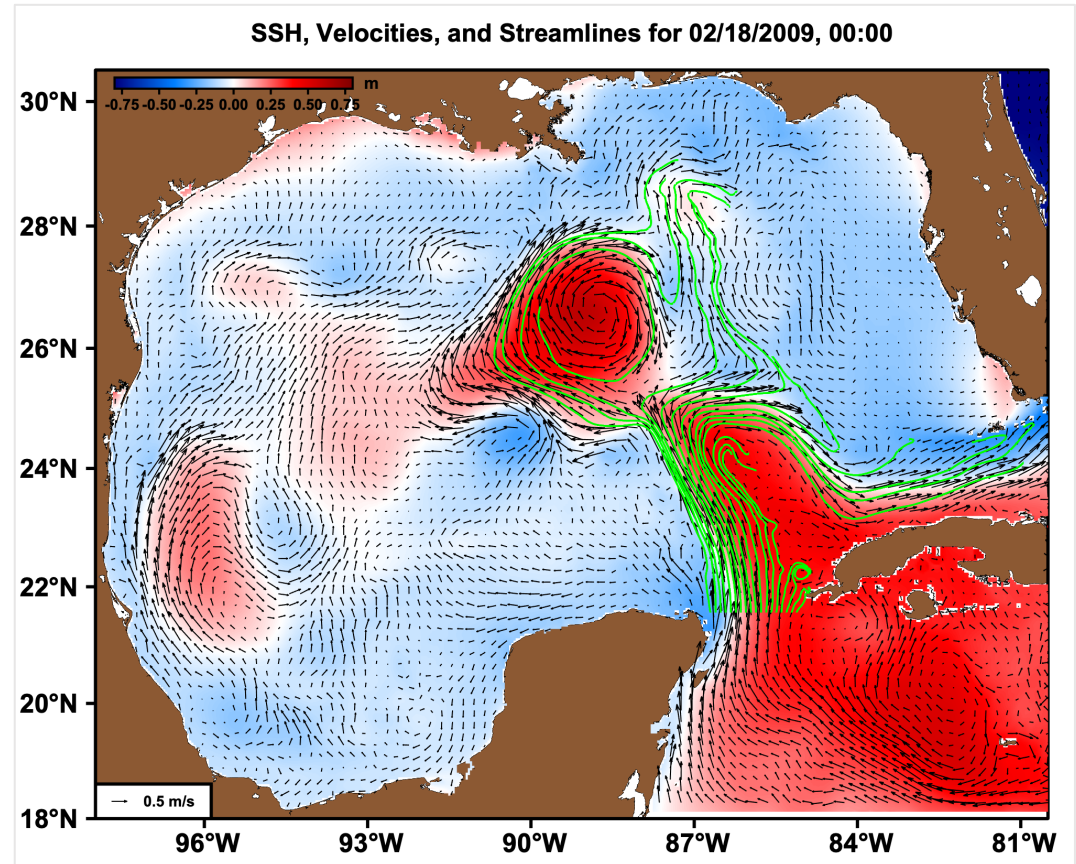
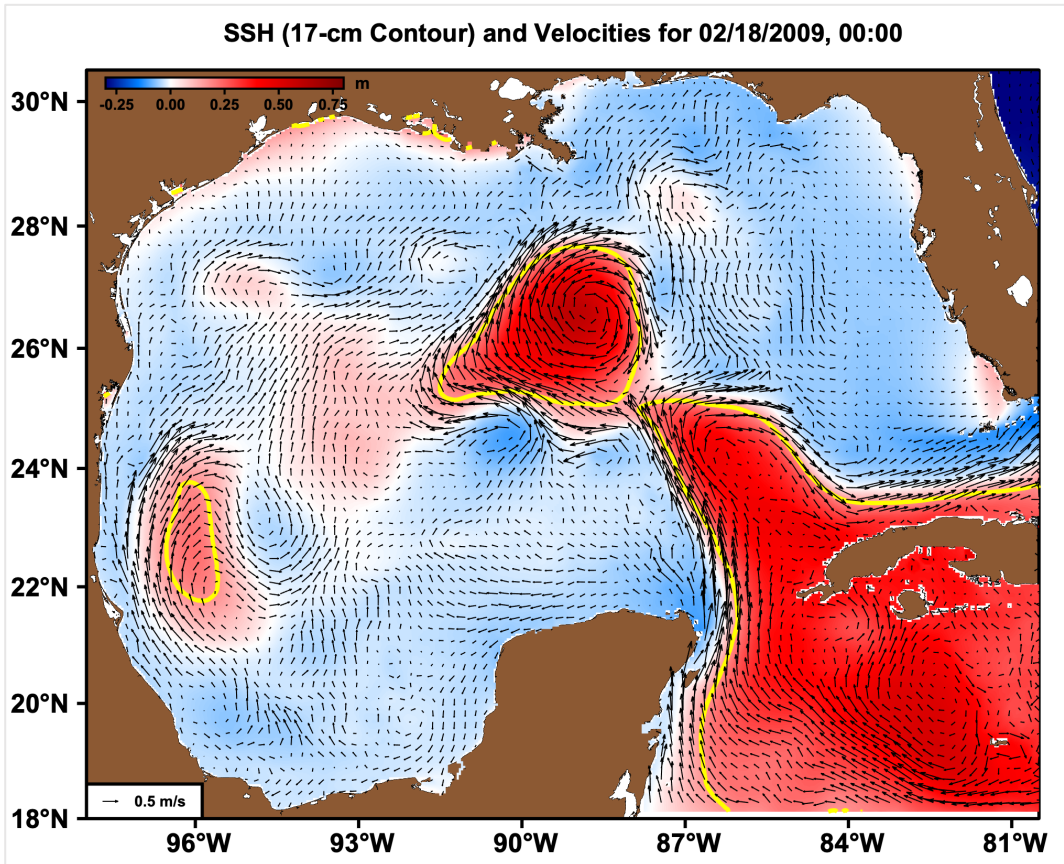
From Chang and Oey, 2013.

Loop Current Rings (LCRs) change the connectivity of the eastern Gulf and impact transport throughout the basin.

Classic Tool: Sea Surface Height Contour as Proxy



Classic Tool: Sea Surface Height Contour as Proxy



➤ SSH contour doesn't always reflect streamlines.

Better Tool: Lagrangian Rigidity Deficit

Metric for how close the flow is to a rigid transformation

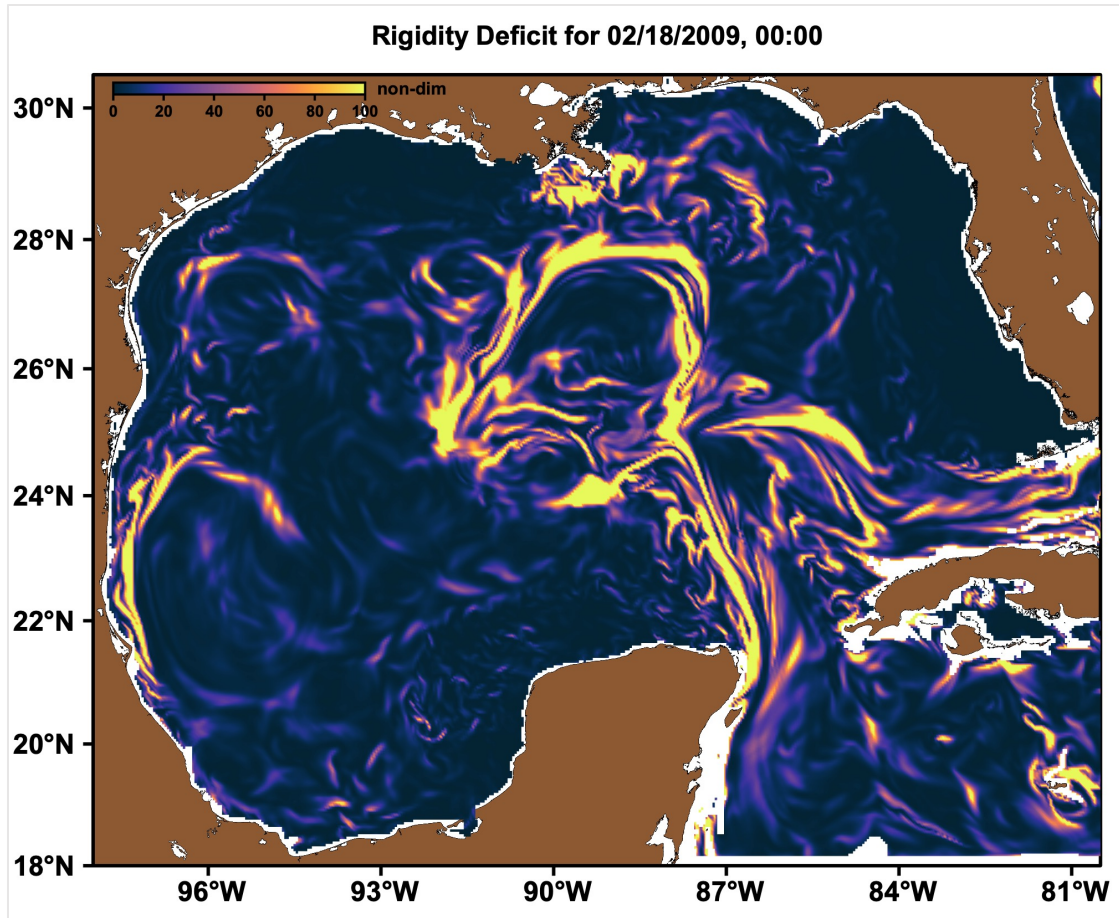
- Let ϕ be the flow map from initial position \mathbf{x}_o to final position $\mathbf{x} = \phi(\mathbf{x}_o, T)$.

Then the Cauchy-Green deformation tensor is given by $G = \frac{\partial \phi}{\partial \mathbf{x}_o} \left(\frac{\partial \phi}{\partial \mathbf{x}_o} \right)'$

- A rigid transformation is characterized mathematically by a deformation tensor with eigenvalues $\lambda_j^{(0,T)}$ equal to 1.
- A rigidity deficit can be calculated as a function of how far the eigenvalues of the Cauchy-Green deformation tensor are from 1.

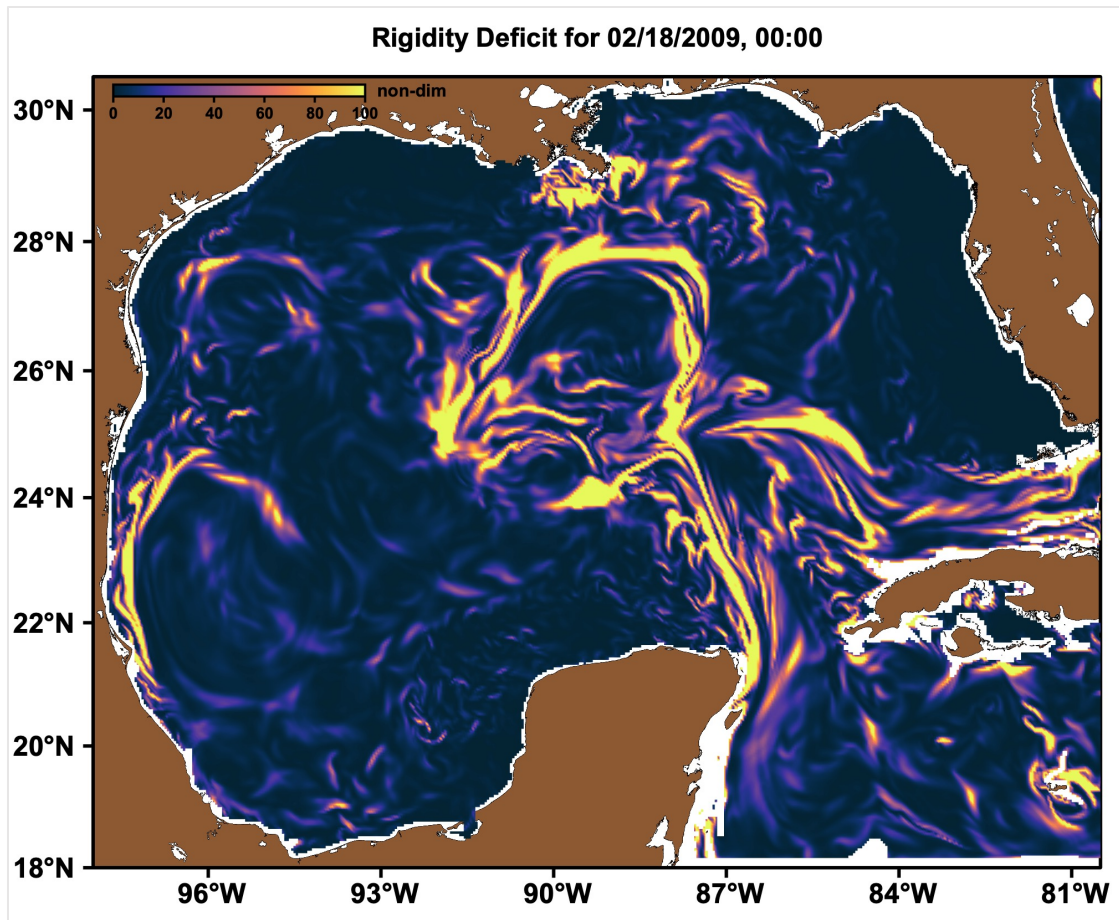
$$R_0^T(\mathbf{x}) = \sum_{j=1}^n \frac{\left(1 - \lambda_j^{(0,T)}(\mathbf{x})\right)^2}{\lambda_j^{(0,T)}(\mathbf{x})}$$

Rigidity Deficit Application

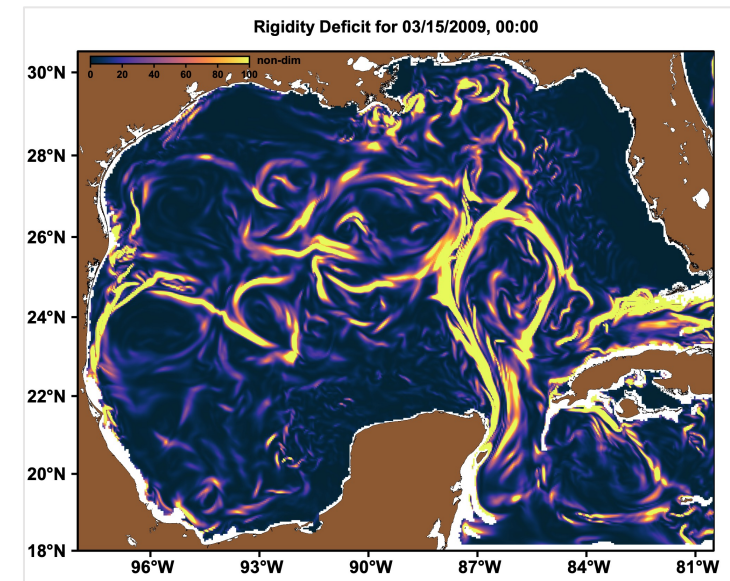


- Low RD (black) indicates coherent flow:
 - Coherent eddy has formed.
- High RD (yellow) indicates flow boundaries:
 - Loop Current is still connected to the Ring

Rigidity Deficit Application



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Thank you!

