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

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

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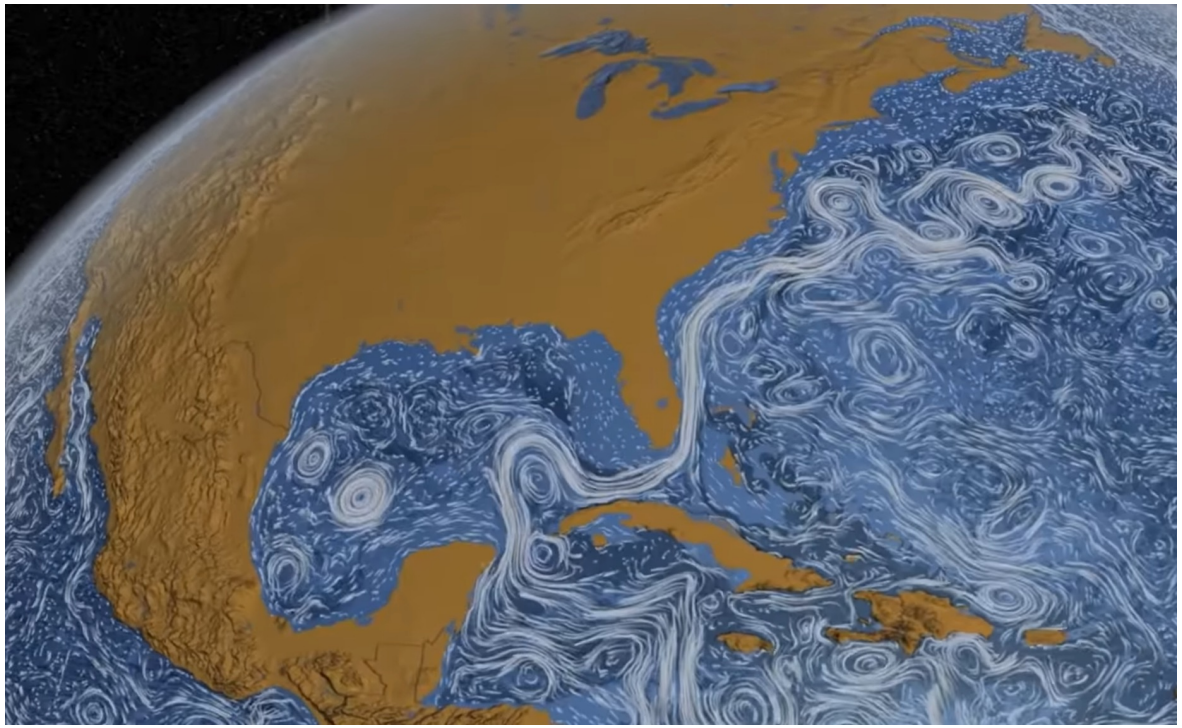

https://www.nasa.gov/topics/earth/features/perpetual-ocean.html

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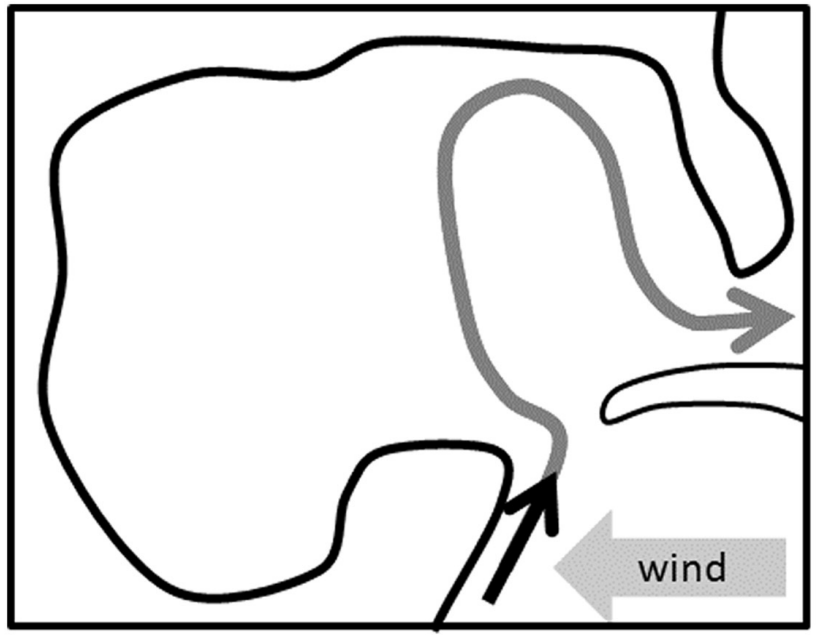
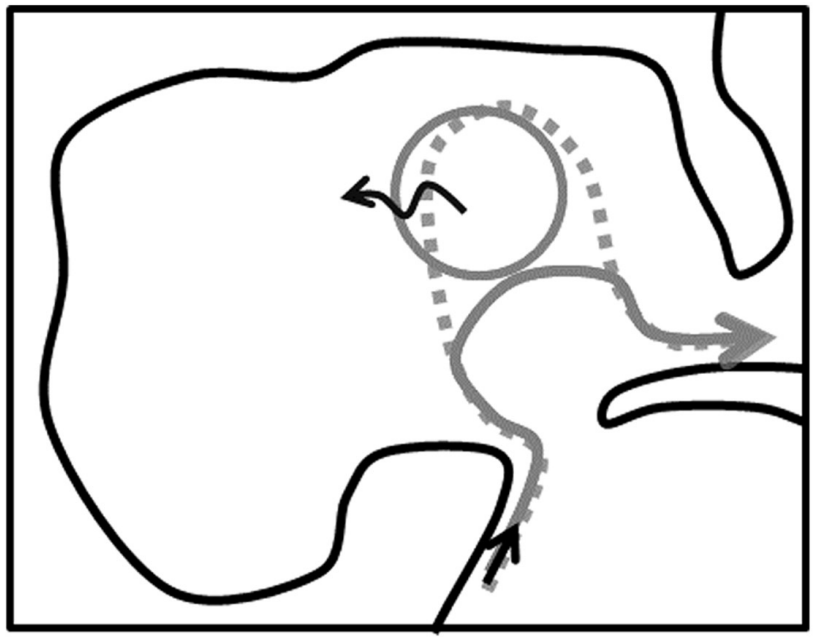
Gulf of Mexico Loop Current: Canonical States

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.

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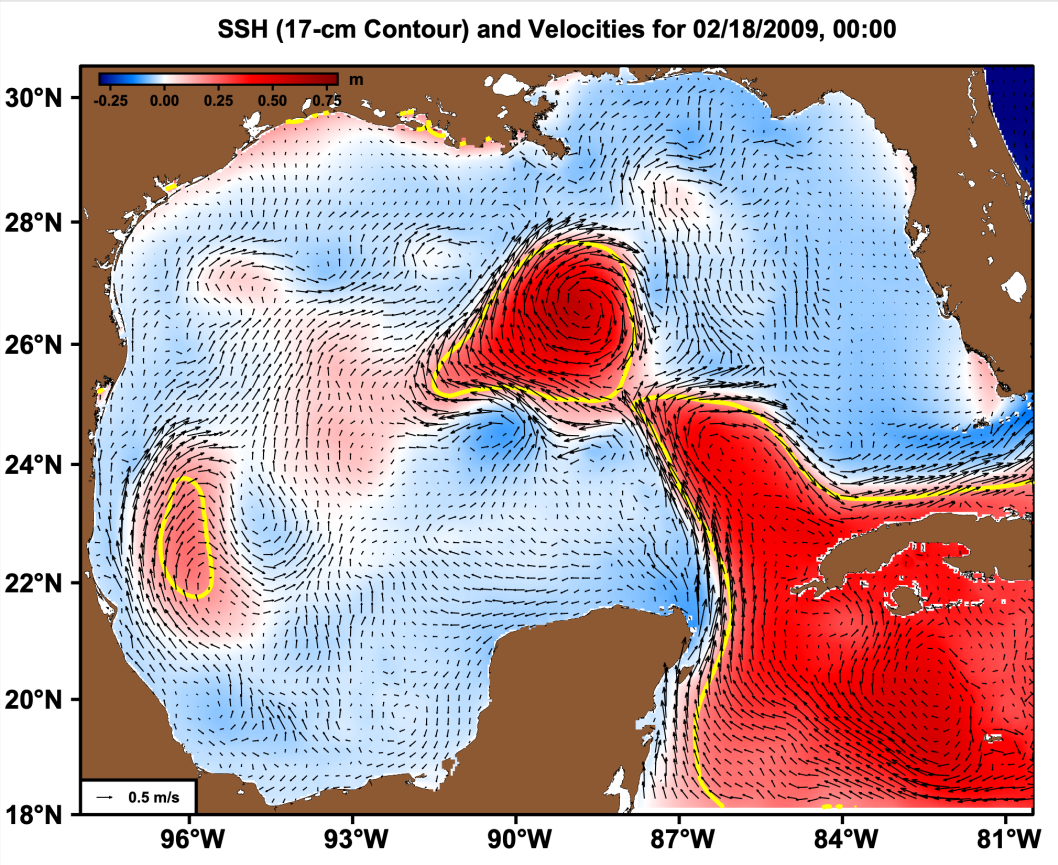
Classic Tool: Sea Surface Height Contour as Proxy



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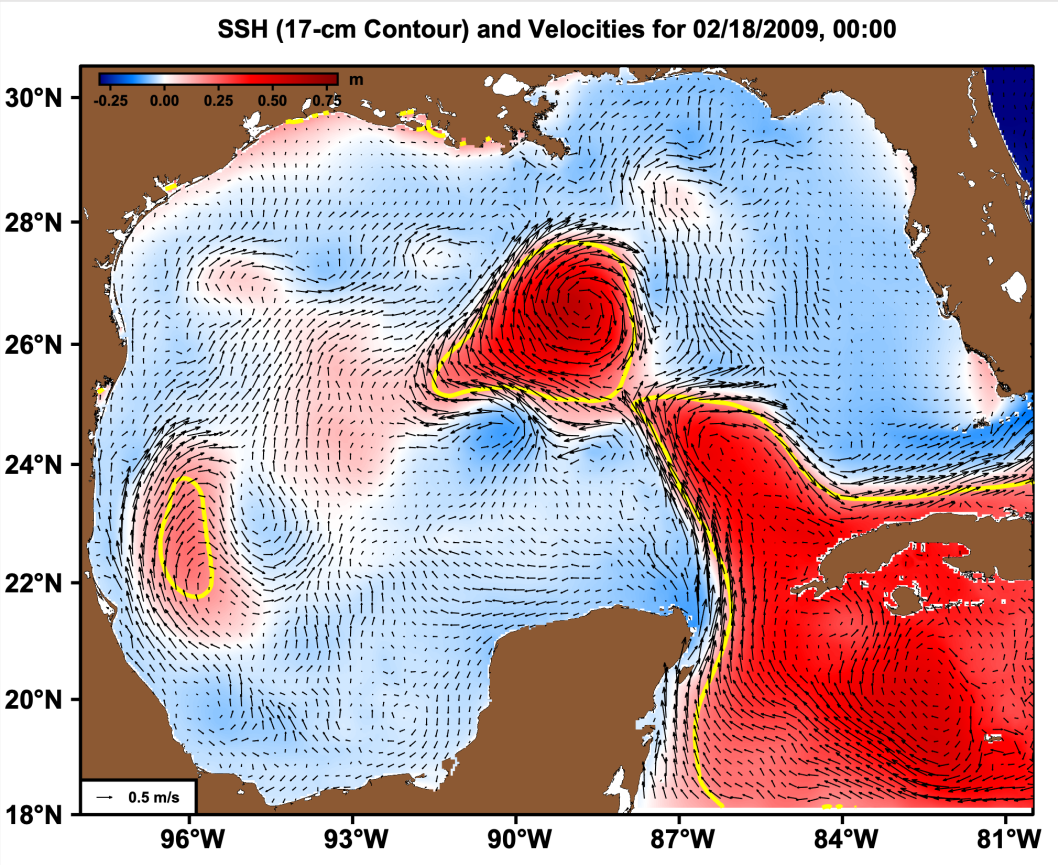
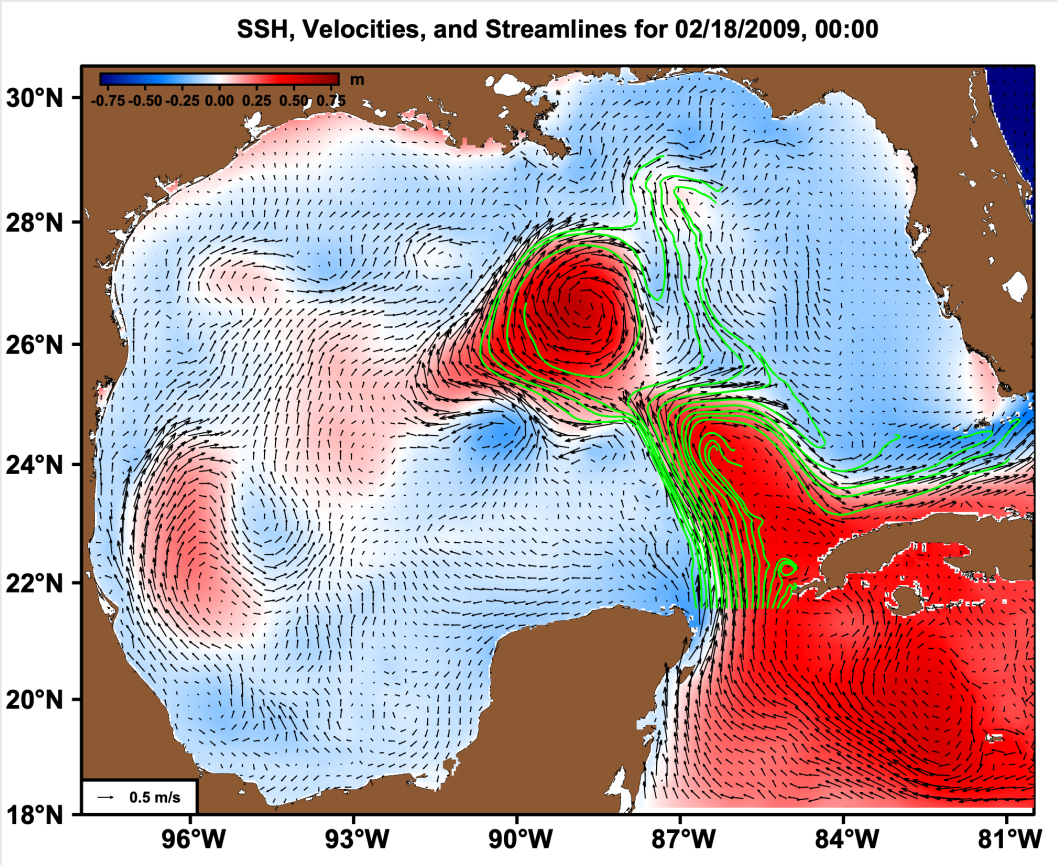




- SSH contour doesn't always reflect streamlines.

Better Tool: Lagrangian Rigidity Deficit

Metric for how close the flow is to a rigid transformation

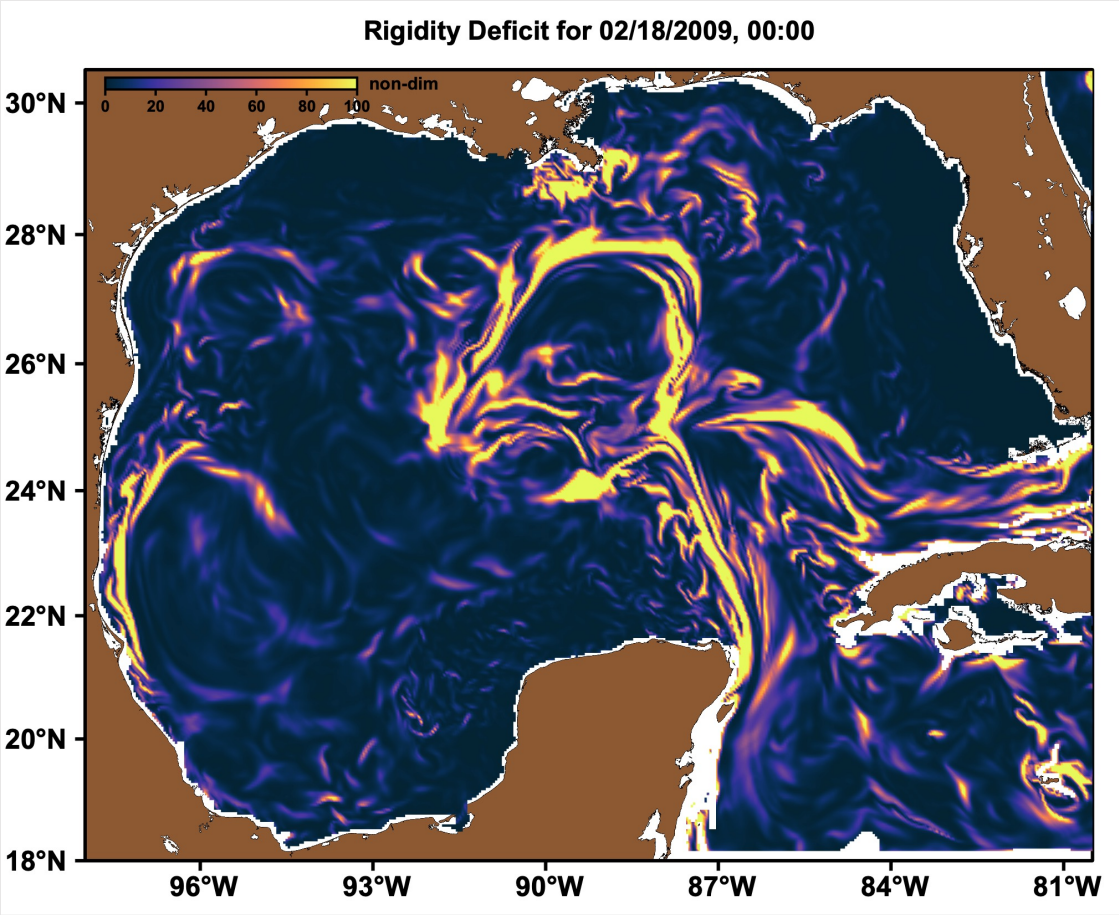
- Let ϕ be the flow map from initial position $\mathbf{x}_o$ to final position $\mathbf{x} = \phi(\mathbf{x}_o, T)$.

  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.

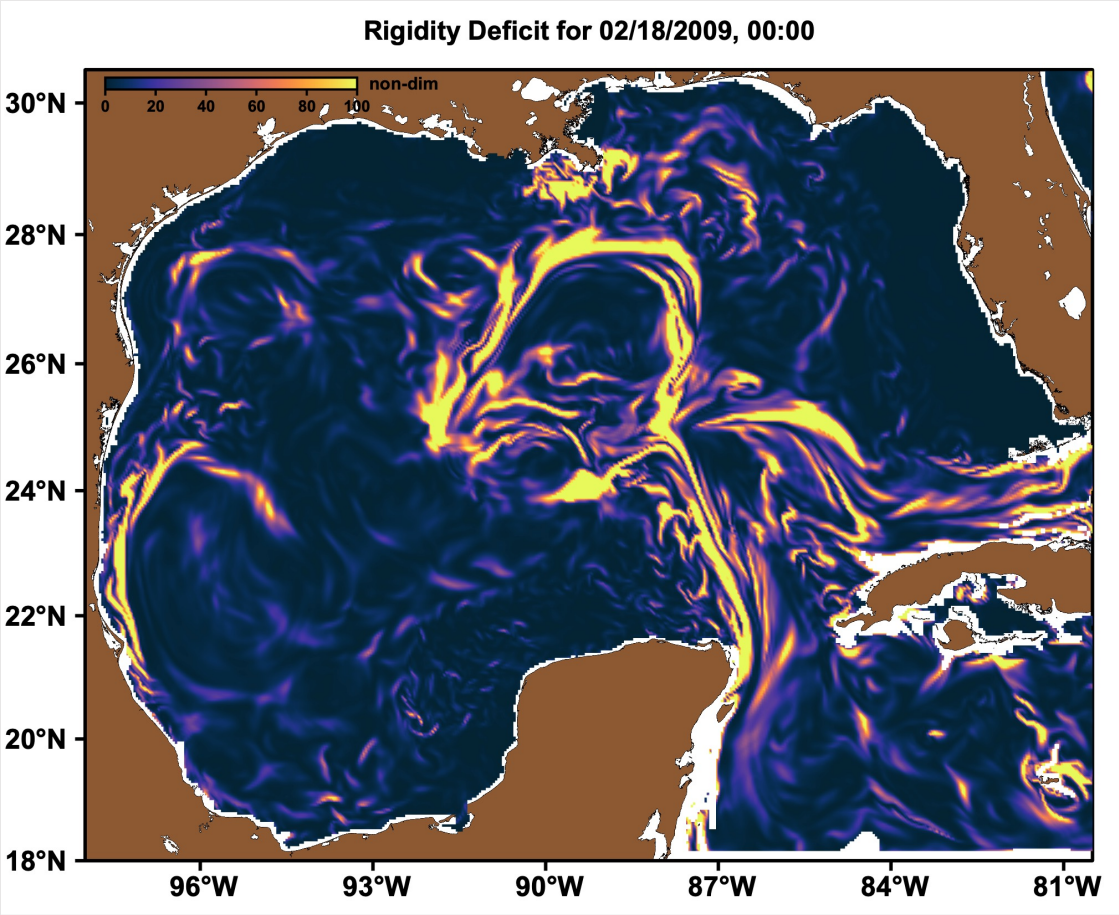
$$R_0^T(\mathbf{x}) = \sum_{j=1}^{n} \frac{\left(1 - \lambda_j^{(0,T)}(\mathbf{x})\right)^2}{\lambda_j^{(0,T)}(\mathbf{x})}$$

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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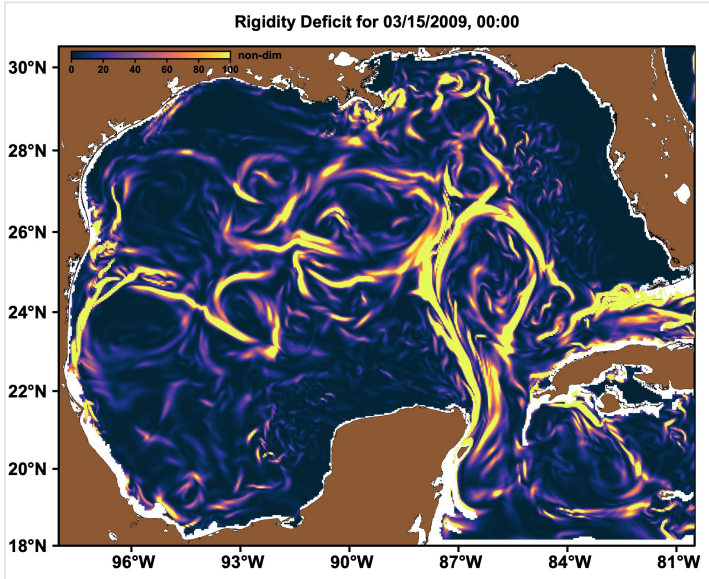

Thank you!