# On Regime Shift of the Kuroshio Extension System after 2018

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#### Annual maps of bi-weekly paths of the Kuroshio/KE jet



## Dynamically stable vs. unstable states of the KE system



#### Form a comprehensive index representing the KE variability



#### Regression between the KE index & basin-wide SSH anomaly field



## Quantifying the KE index using a wind-forced linear vorticity model



$$\frac{\partial h}{\partial t} - c_R \frac{\partial h}{\partial x} = -\frac{1}{\rho} \nabla \times \left( \frac{\boldsymbol{\tau}_{wind}}{f} \right)$$

#### KE-stormtrack interaction favors a delayed negative feedback loop of ~ 10 yrs



#### KE entered a *super stable* dynamic state after 2018 !



-3

1995 2000 2005 2010 2015 2020

## KE entered a *super stable* dynamic state after 2018 !



Izu Ridge

142°E

138°E

134°E

2010–2014 2018–2022

150°E

146°E

30°N

28°N

26°N

'W 126°E

130°E

- Kuroshio south of Japan is known to vacillate irregularly between a straight & large-meander (LM) paths
- Due to topographic constraint, there is a tendency for KE jet to migrate poleward when a LM takes place

#### Is the super stable KE system due to the upstream Kuroshio LM? Not really ...



 A significant portion of the + KE index after 2018 is not driven by LM, but by interior wind forcing west of the dateline !

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KE index hindcast by ECMWF ERA5 data ( it contains no *direc*t LM impact! )



- A significant portion of the + KE index after 2018 is *not* driven by LM
- Recent PDO-induced SSH signals will likely further strengthen the *super* stable KE jet!

## Does the super stable KE contribute to longevity of the on-going LM? Yes !



- After 2018, *super* stable KE system reduced eddy perturbations *east* of Izu Ridge
  → facilitates LM presence
- Persistent LM contributes to a northerly KE path, strengthening the stable KE system





20°E 130°E 140°E 150°E 160°E 170°E 180°

## What drives the super stable KE & prolonged Kuroshio LM after 2018?



- After 2017/18, wind-driven *southern* subtropical gyre weakens & *northern* subtropical gyre intensifies
- Such *concurrent & out-of-phase* sub-gyre wind curl changes are highly unique in past 70+ years



#### A positive upstream Kuroshio & KE feedback loop

(b) ERA5 Transport SF Anomalies in 2018–2022



- Dipolar anomalous wind stress curl forcing across ~32°N
- Weakening the southern subtropical gyre & upstream Kuroshio → inducive to LM path
- Strengthening the KE & positive KE index → inducive to KE's poleward migration
- Less KE eddies east of Izu Ridge + stronger RG → help stabilizing upstream LM
- Stabilized LM south of Japan → reinforces stability of the KE dynamic state

#### <u>Takeaway</u>

The new, *super stable* KE regime is a result of positive feedback between the KE & Kuroshio LM caused by anomalous sub-gyre wind forcing

# Does the super stable KE contribute to longevity of the on-going LM?



- 2014-15 vs 2017-present LMs have drastically different durations
- 2014-15 LM is terminated when KE index turned from + to -
- In mid/late 2015, eddy disturbances propagated westward across Izu Ridge from the unstable KE region, disintegrating LM path



## Does the super stable KE contribute to longevity of the on-going LM?



• After 2018, *super* stable KE system significantly reduced eddy perturbations *east* of Izu Ridge

