THE
UNIVERSITY
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GRADUATE SCHOOL
OF OCEANOGRAPHY

Kuroshio Extension Meanders: Model Data-Intercomparison

B1417

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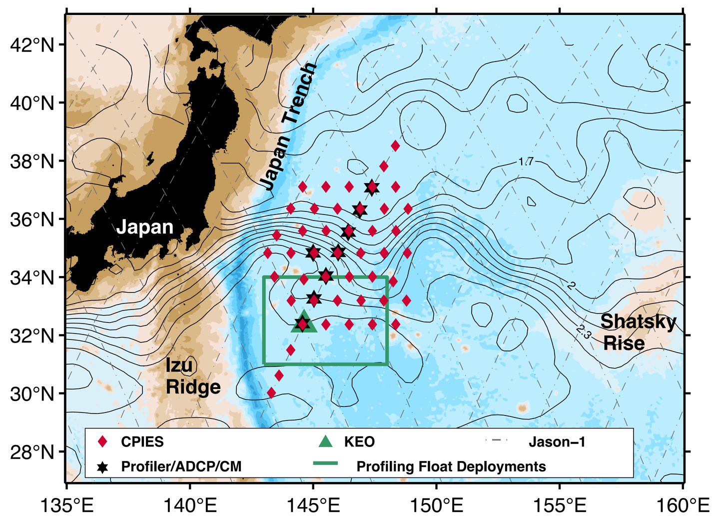
1. Introduction

Kuroshio Extension System Study (KESS) consisted of 46 CPIES that provided synoptic measurements in the Kuroshio Extension (KE) between 143°E and 149°E with mesoscale resolution. The array collected data from June 2004 to September 2005.



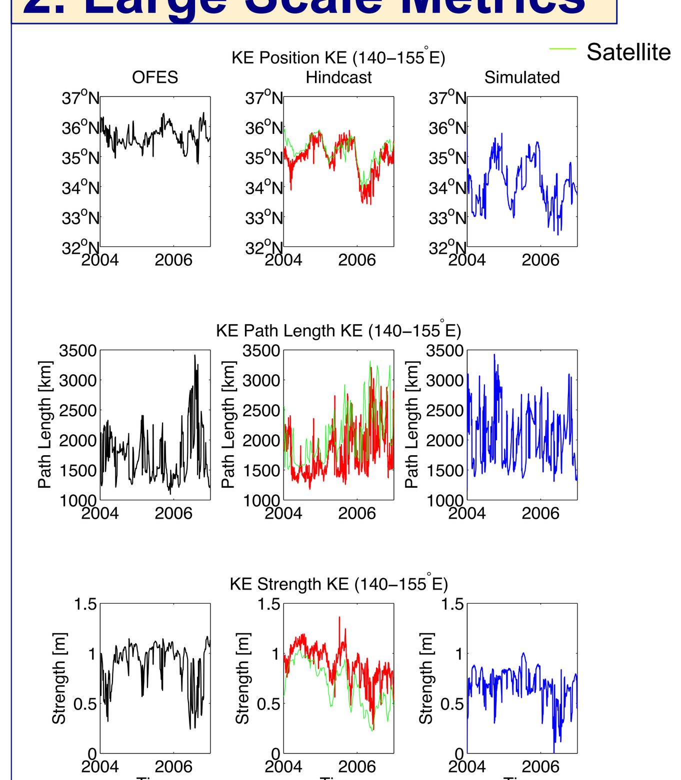
We want to quantify frequency and wavelength of KE meanders in three high-resolution ocean circulation models. Several recent studies provide quantitative metrics that can be used to test the models.

This study is timely due to the availability of two data sets: satellite sea surface height (SSH) which provides a basin-wide view and KESS which resolves full-water column meanders. In particular, we are motivated by *Tracey et al.* which indicates that baroclinic meanders with the right phasing with westward propagating deep fluctuations jointly intensify.

Here we examine the structure of KE meanders in three ocean general circulation models:

- Hybrid Coordinate Ocean Model (HYCOM)
  - 1/12° spatial resolution
  - Assimilated (Hindcast)
  - Free-running (Simulated)
- Ocean General Circulation Model for the Earth Simulator (OFES)
  - 1/10° horizontal grid

2. Large Scale Metrics



OFES: Most northern position.

Strength and path length are comparable to Hindcast.

Hindcast: Metrics are highly correlated with satellite (r > 0.9 for strength & position).

Model captures the regime shift from stable to unstable.

Simulated: The mean position is 1.26° south of Hindcast.

Weakest strength.

3. SSH Variance: Upper and Deep

The SSH variance is decomposed into baroclinic and barotropic components.

$SSH_{tot}=SSH_{BC}+SSH_{BT}$ $\quad SSH_{total} = \frac{\phi_{p_b}}{g} + \frac{p_{p_b}}{\rho_b g}$

Where g is gravity, ρ_b is bottom density, ϕ is the geopotential anomaly calculated relative to a deep pressure reference, p_r (p_r=5000dbar for HYCOM and 5200dbar for OFES).

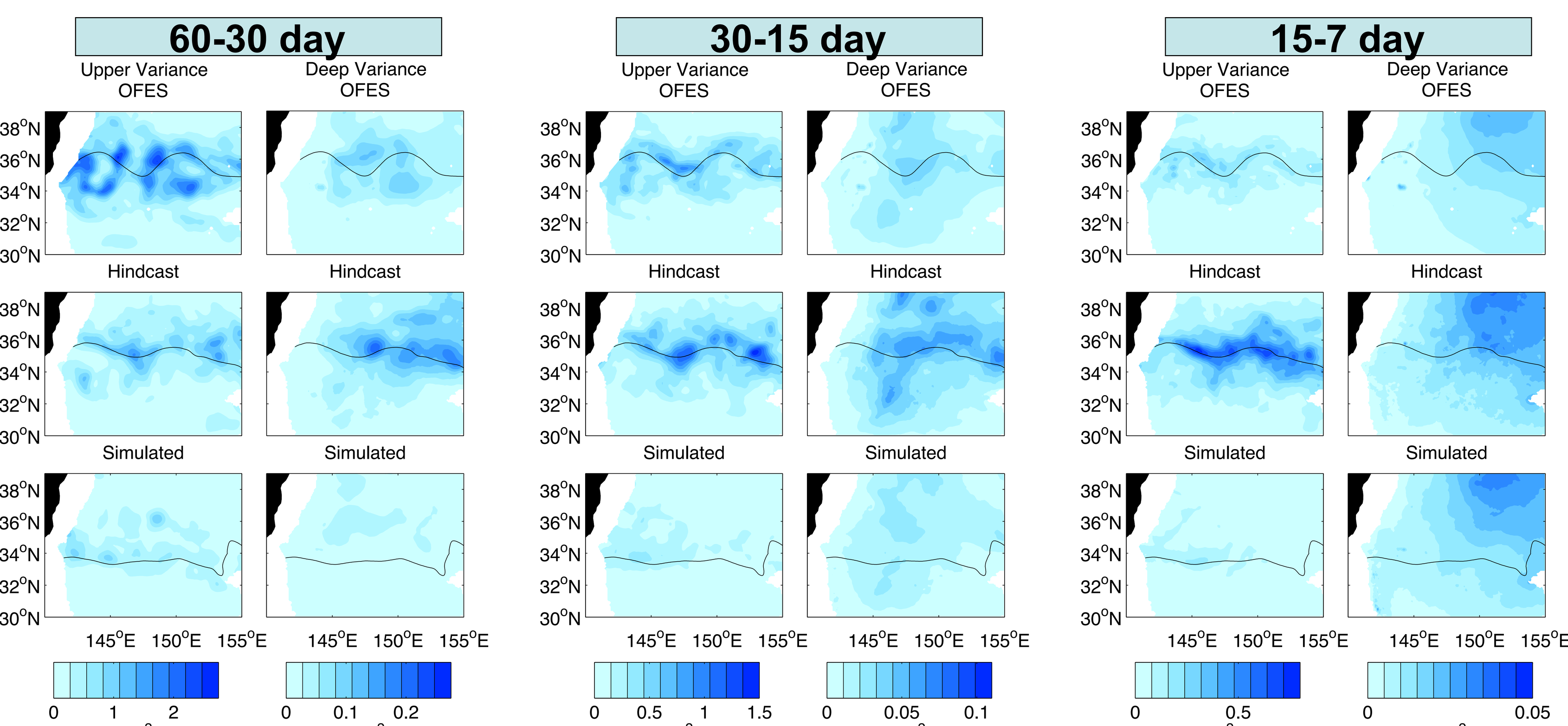
The variance of baroclinic SSH (termed '**upper**') and barotropic SSH (termed '**deep**') were calculated for 2004-2005 in 3 frequency bands: 60-30, 30-15 and 15-7 day.

Upper Variance: High along the KE (mean path for each model for 2004-2005 shown as black line).

- Simulated has the lowest variance for all frequencies (bottom panels).

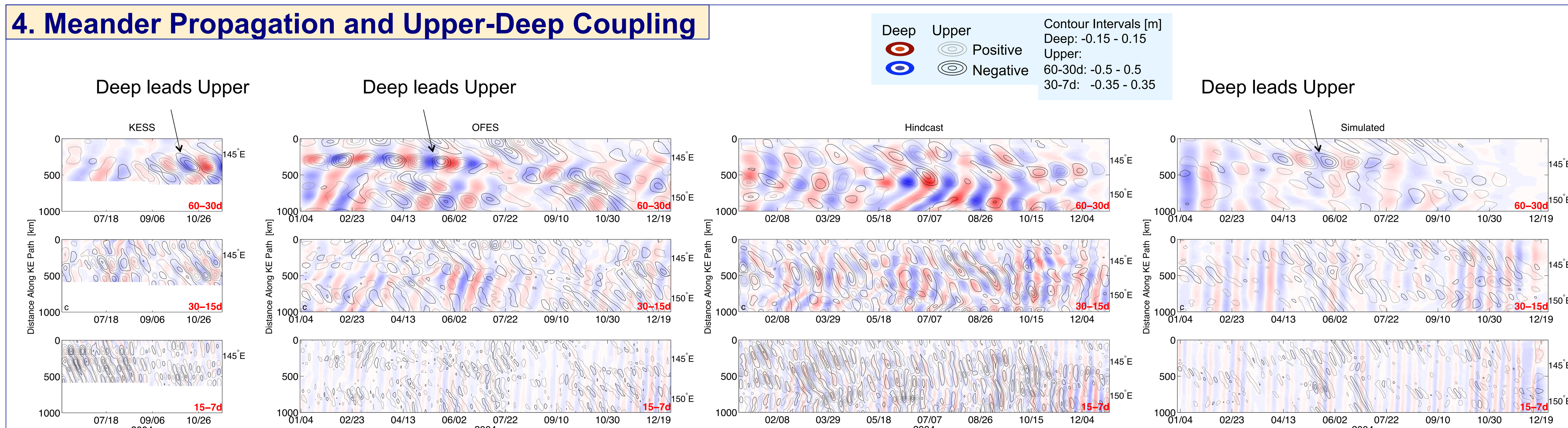
Deep Variance: Hindcast shows a ridge of high variability extending eastward from Shatsky Rise in the 60-30 and 30-15 day bands.

- In the 15-7 day band, similar spatial structure and amplitude apparent in all models.



Note: Color bars are different in each band

4. Meander Propagation and Upper-Deep Coupling



Following *Tracey et al*, SSH anomalies along the mean KE path are contoured as a function of time to determine KE displacement and hence meander amplitude, wavelength and phase speed.

The upper and deep have been band-passed filtered for three bands: 60-30 day, 30-15 day, and 15-7 day.

Westward propagation slopes ╱ while eastward slopes ╲

The propagation in the upper is mainly eastward and phase speeds vary within each band, with the fastest in the highest frequency band. The anomalies between KESS and the models are similar but they do not correspond one-to-one.

KESS results from *Tracey et al* showed "most meanders did not grow systematically downstream. Instead, meanders alternately grew and decayed as they interacted with remotely-generated deep eddies which propagated into the region from the northeast and east. Interactions have different outcomes depending on the phasing of the upper and deep anomalies".

OFES: The only model with westward deep propagation phasing consistent with baroclinic intensification.

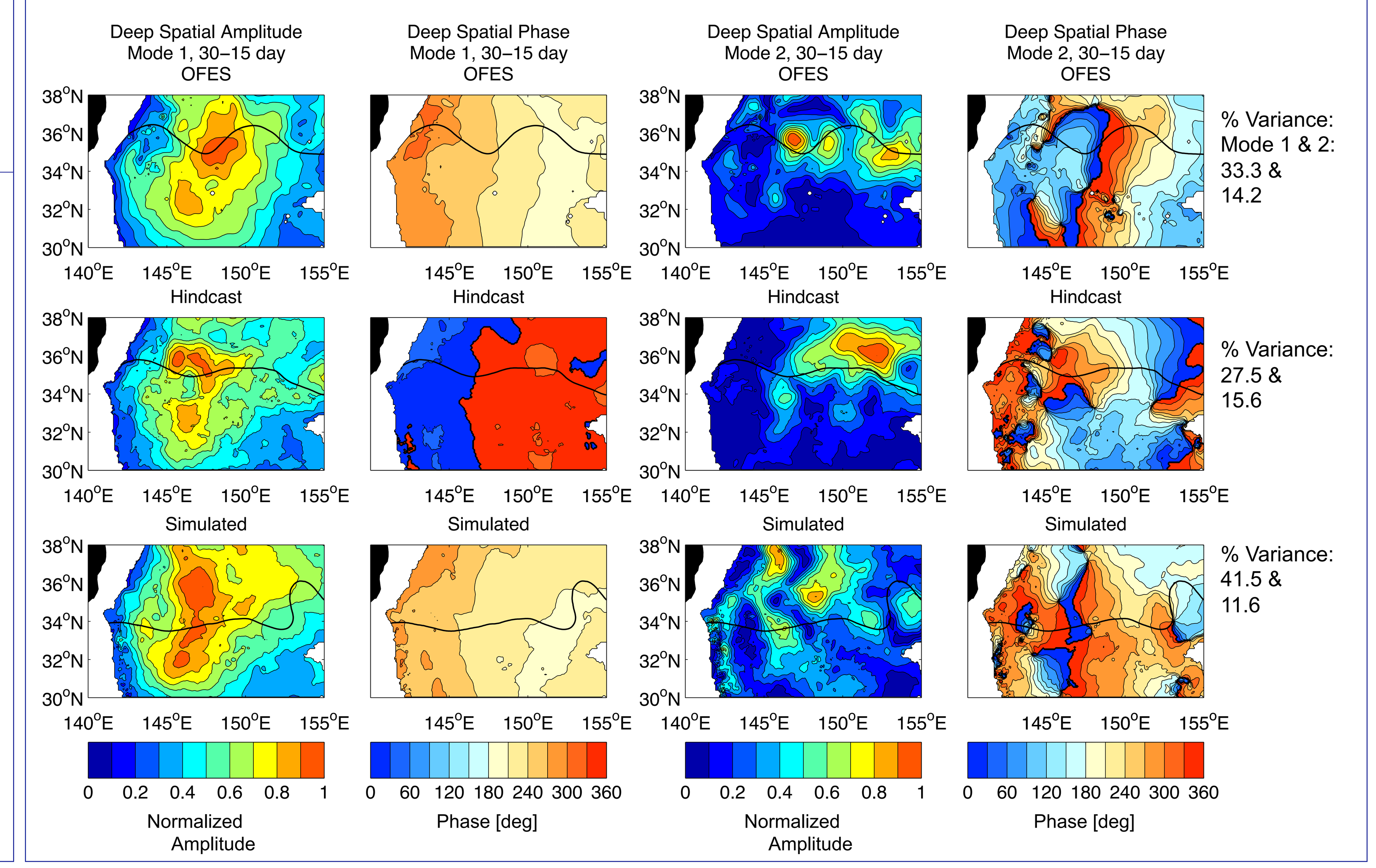
Hindcast: Deep westward propagation and growth, but the phasing is not consistent with baroclinic intensification.

Simulated: Weak amplitude in the deep. Interaction between upper and deep is also weak.

5. Deep Variability: 30-15 day band

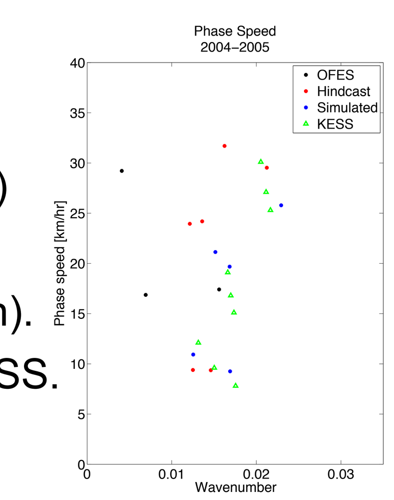
Complex EOFs were calculated using both the upper and deep fields for 2004-2005 (upper not shown).

- **Mode 1**: All the models are similar: broad-scale distribution of amplitude and phase indicates relatively fast speeds -- likely driven by atmospheric forcing.
- **Mode 2:** Westward propagation from Shatsky Rise and into KE region in OFES and Hindcast.
- Phase offset (not shown): OFES has the deep leading by 0.25 of a wavelength which is indicative of baroclinic instability. Hindcast phase is difficult to interpret, the deep field both leads and trails the upper field.



6. Phase Speed

Phase speeds are fastest in high frequencies (30 km/day,11 day period, 300km wavelength) with decreasing speeds with longer periods (10 km/day, 45 day period, 500km wavelength). Simulated values are most comparable to KESS.



7. Conclusion

- OFES represents joint intensification between upper meanders and external deep westward propagating features.
- At times Hindcast shows this development, but not consistently. We note that since Hindcast assimilates mainly upper-ocean data, deep variability generated at Shatsky Rise may not have the same propagation characteristics as observed.
- The relatively weak Simulated KE tends to intersect Shatsky Rise further south than the other models and may not generate strong deep variability at Shatsky Rise.

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Tracey, K. L., et al., 2012: Propagation of Kuroshio Extension meanders between 143°E and 149°E. *J. Phys. Oceanogr.*, In press. **See poster B1413**
Zamorski, S. E., 2012: Kuroshio Extension meanders: Model data-intercomparison. MS Thesis.