Kuroshio Pathways in CCSM3: The Large Meander

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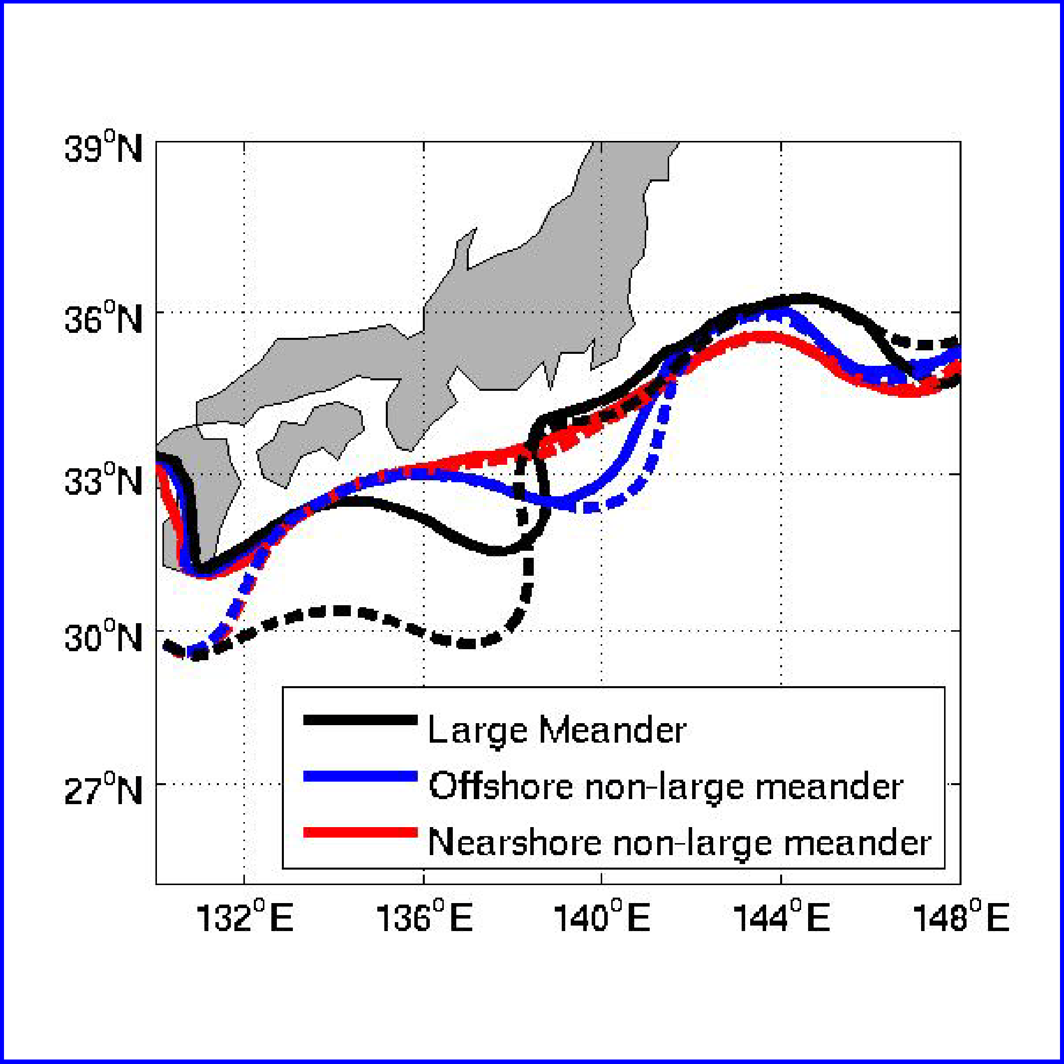
Outline

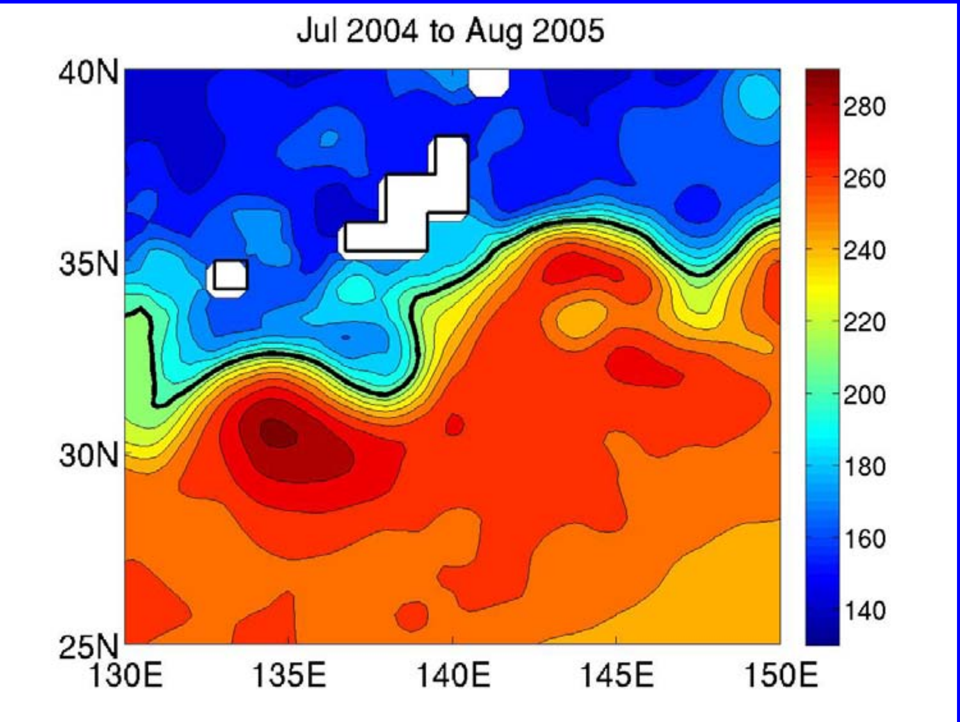
- The Large Meander (LM)
  - Definition
  - Model/data comparison
- Causes and effects of the LM
  - Transport changes
  - Shear changes
  - Trigger meander
- More on the trigger meander
- Conclusions

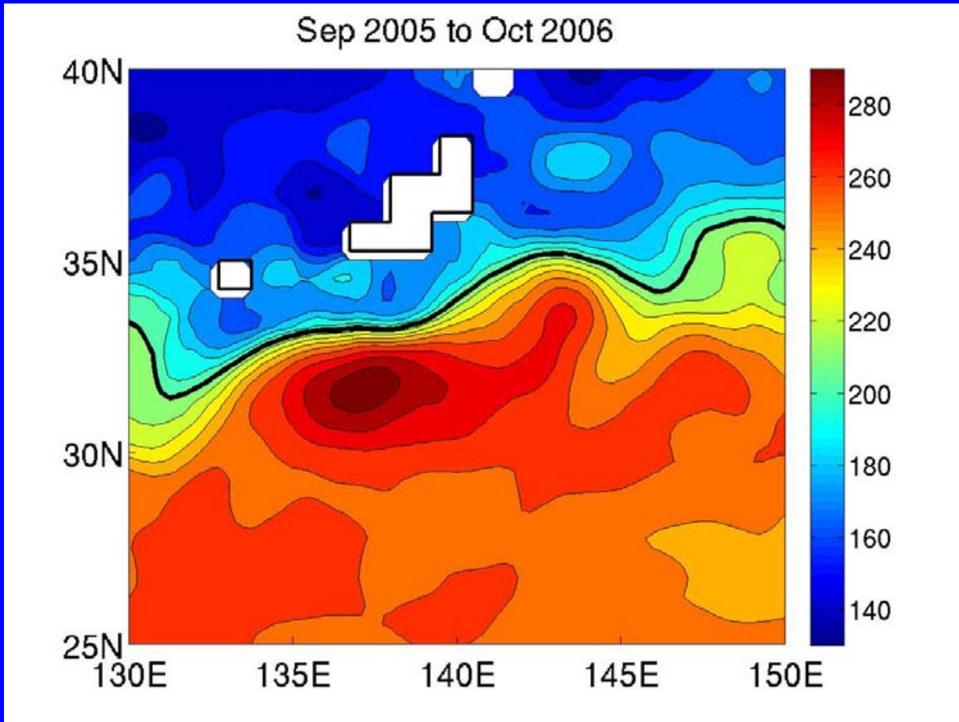
What is the Large Meander?

- The pathway of the Kuroshio as it goes past Japan has two main states: "Large Meander" and "non-Large meander".
- The different states persist for years, and the switch is abrupt (bimodal system)



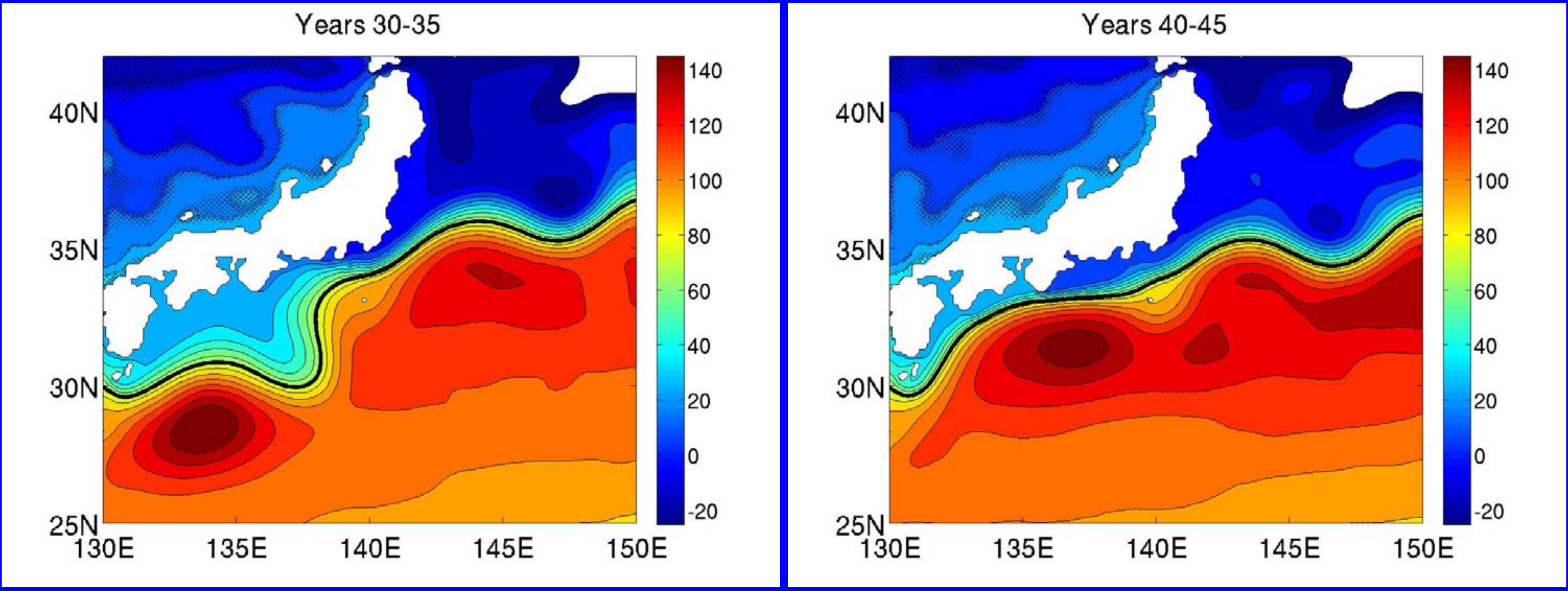
Large Meander - observed





A large meander formed in 2004, as observed by satellite altimetry (sea surface height). This LM only lasted a year – shorter than average. It is also the ONLY large meander since altimetry data became available in fall of 1992.

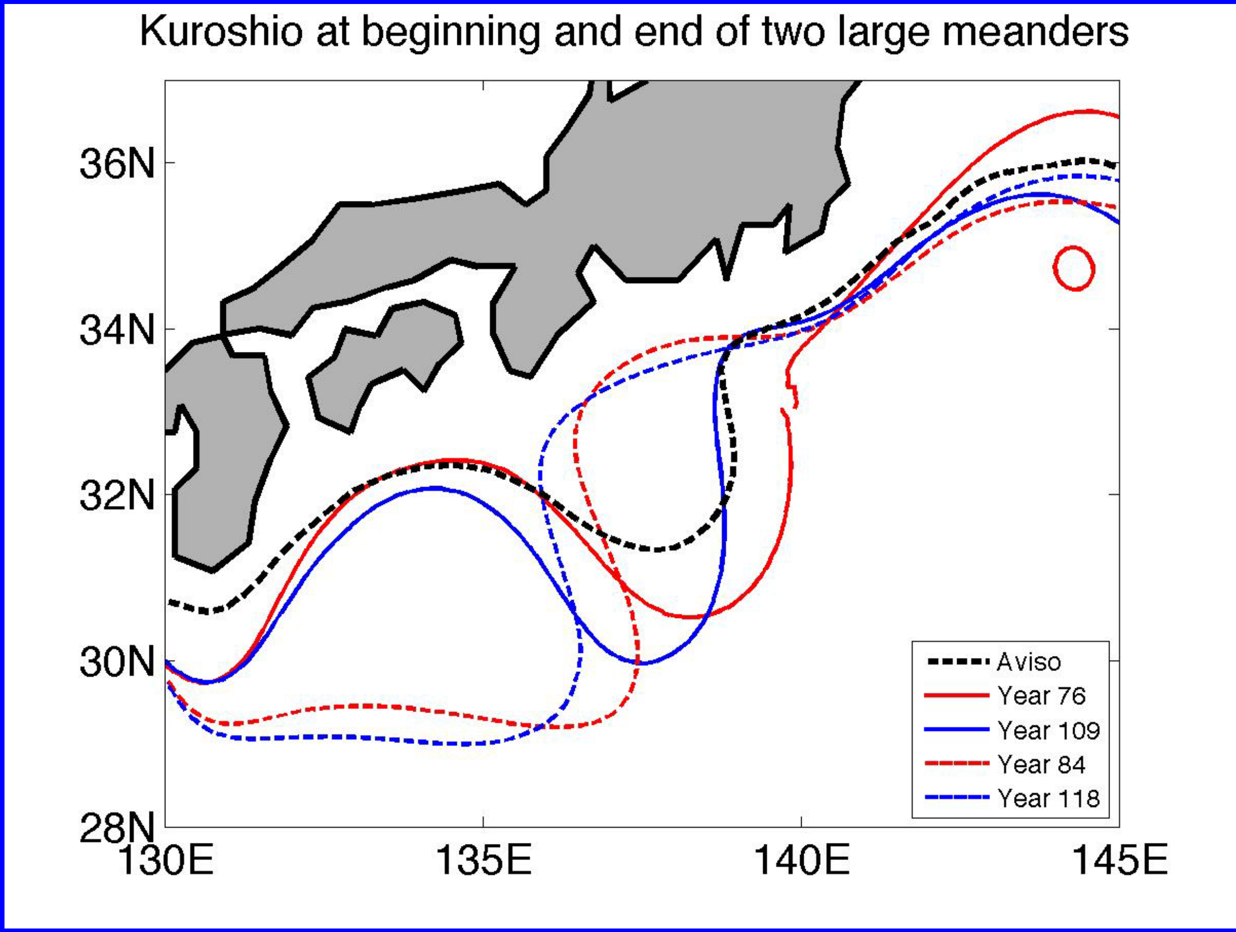
Large Meander - modeled



- CCSM3 model: 1/10°, 42 vertical levels. Run for 100 years with "normal year forcing" – same atmosphere every year. This eliminates large-scale atmospheric effects.
- Realistic-looking LM develops, and lasts for several years.

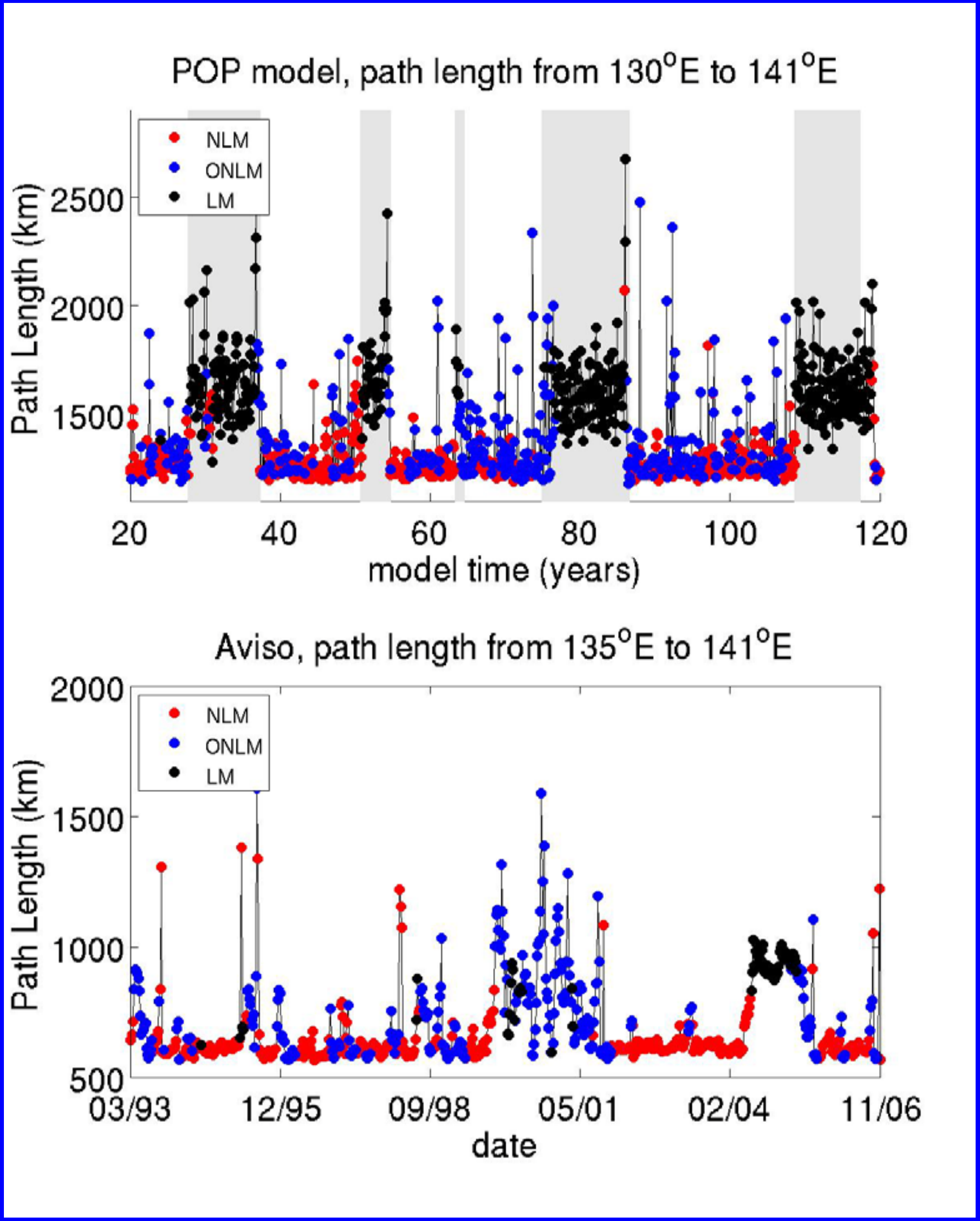
Model-Data comparison: shape

- LM in the model "evolves" – initial shape is similar to observations, but changes over time



Model-data comparison: time

- Path length is the metric we use to define what is and is not a large meander – path length is longer in LM state
- Time scale might be different in model vs. observations (note model time series is 100 years, observations cover 13 years)

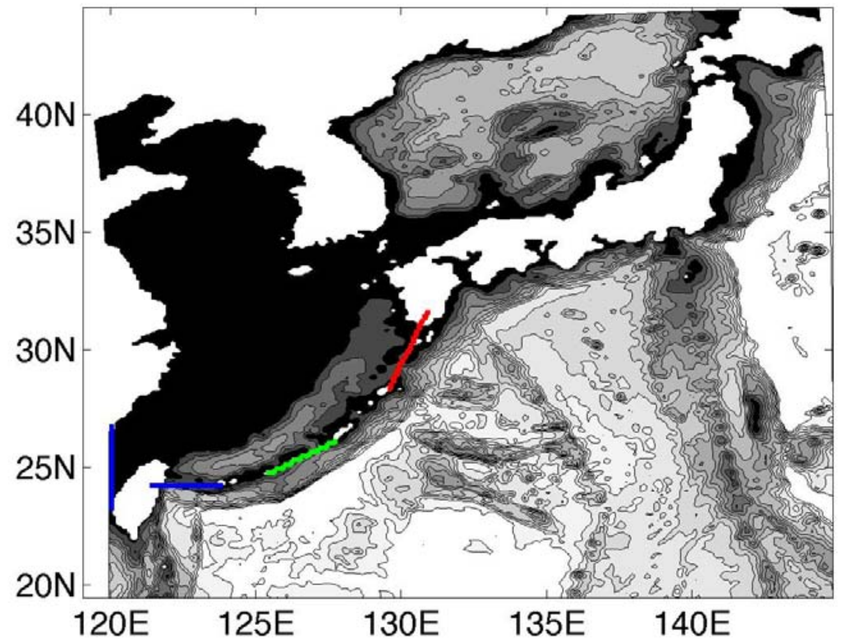


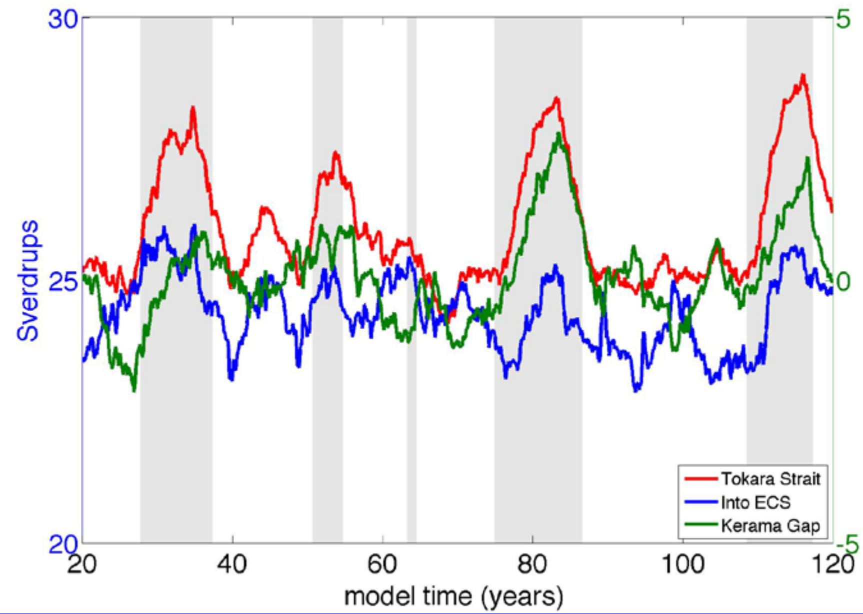
Possible causes of LM

- Changes in wind stress (large scale)
  - Not in this model!
- Changes in upstream transport
- Changes in velocity structure (shear)
- Interaction with eddies ("trigger meander")

Transport

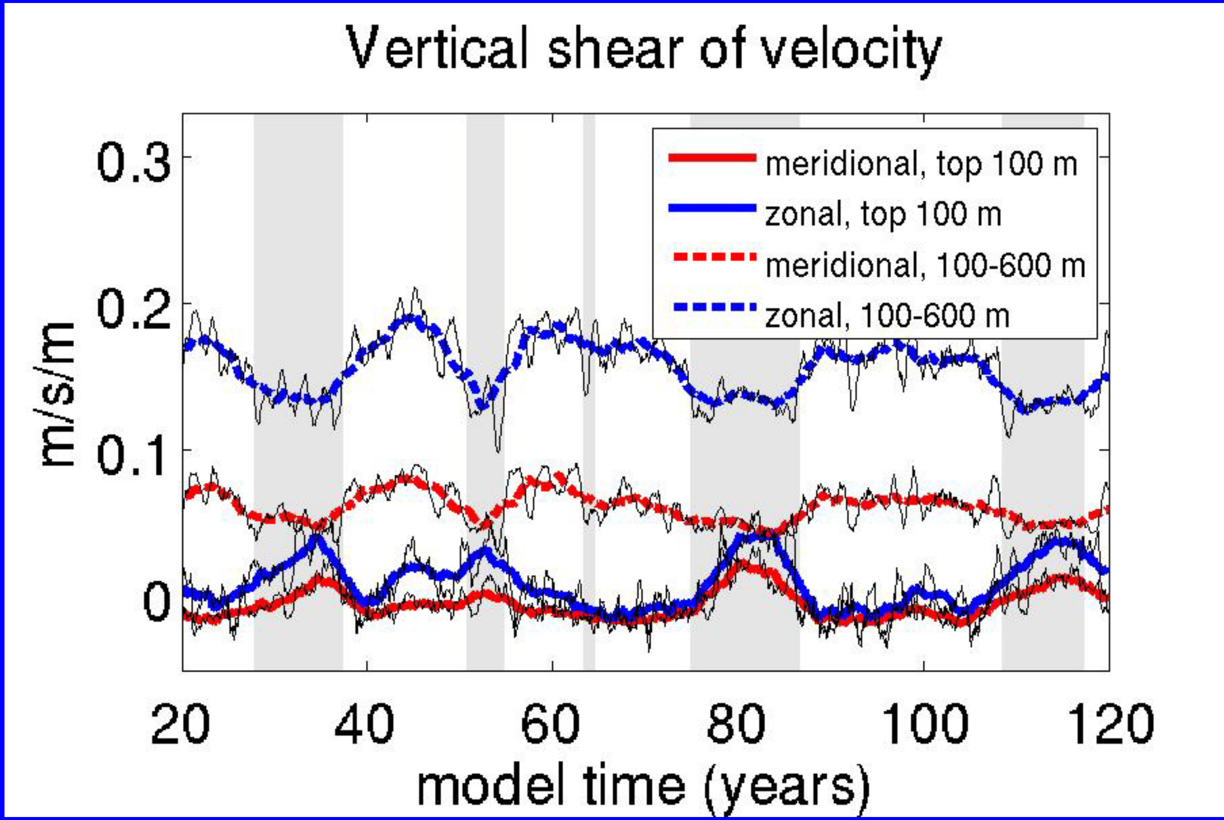
- Initial impression: increases in transport in all three locations happen during the large meander
- However, on further analysis, transport changes lag behind the large meander – response rather than cause





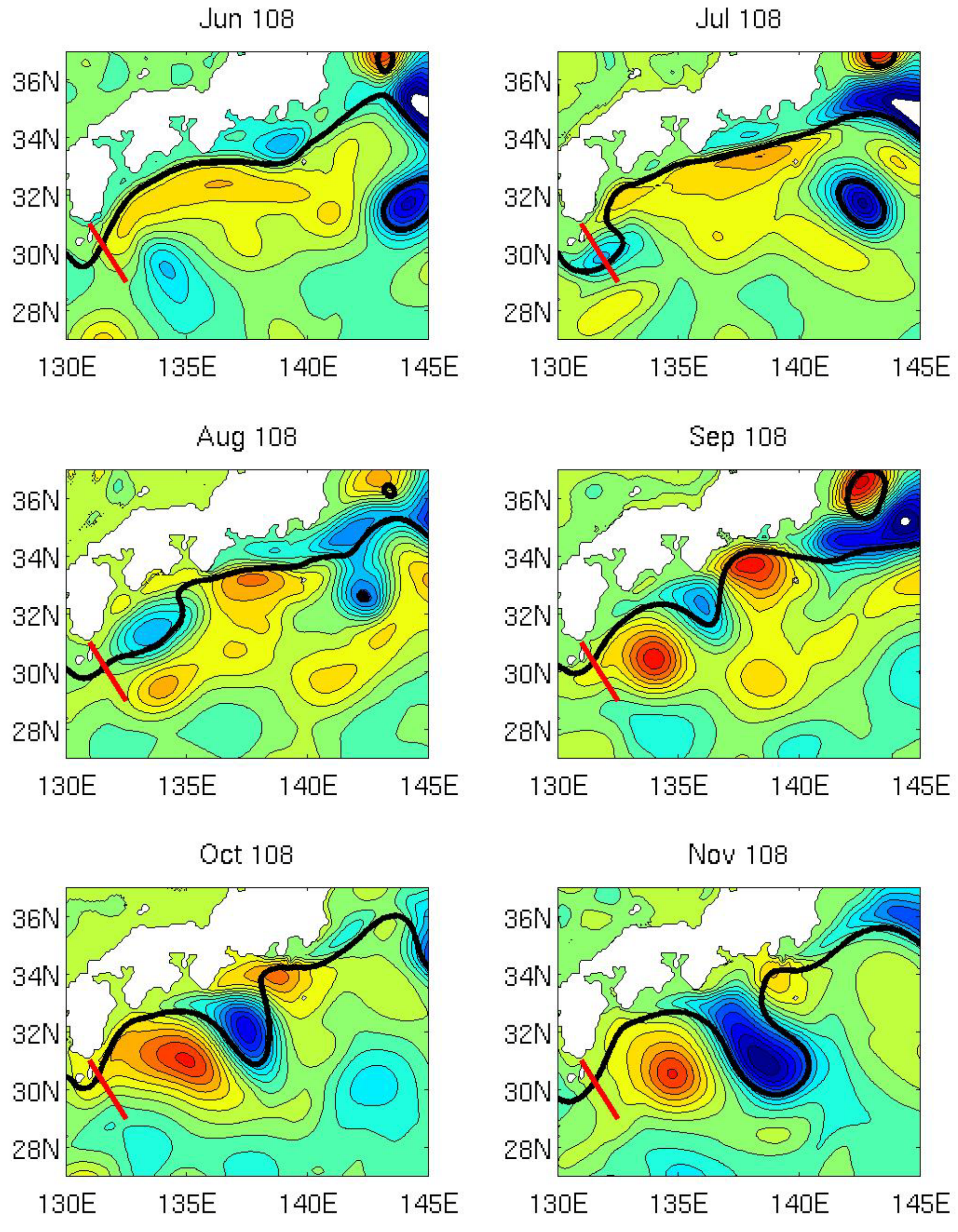
Velocity Shear

- Near surface, shear increases during LM; at mid-depth, shear decreases
  - LM affects the structure of the velocity profile
- Again – looks more like effect than cause

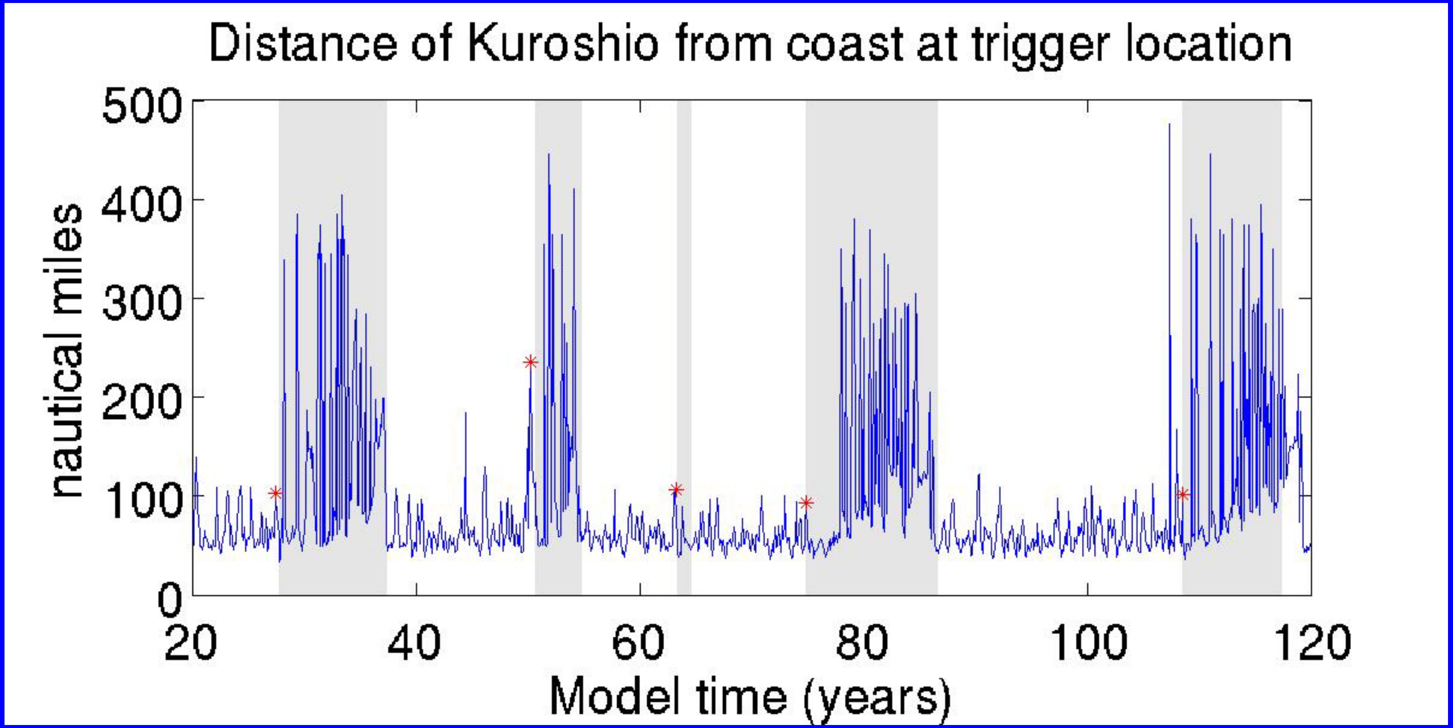


Trigger Meander

- Small eddy comes around the bottom of Kyushu, travels up coast, develops into Large meander
- Example (year 108) shown: similar examples found for each LM during 100 year time series
- Does an eddy like this always cause an LM?



Identifying the Trigger meander



- Use distance of Kuroshio from coast as a metric
- We see a "spike" in this distance before each LM (red stars in plot)
- There are a lot of non-LM-causing spikes as well

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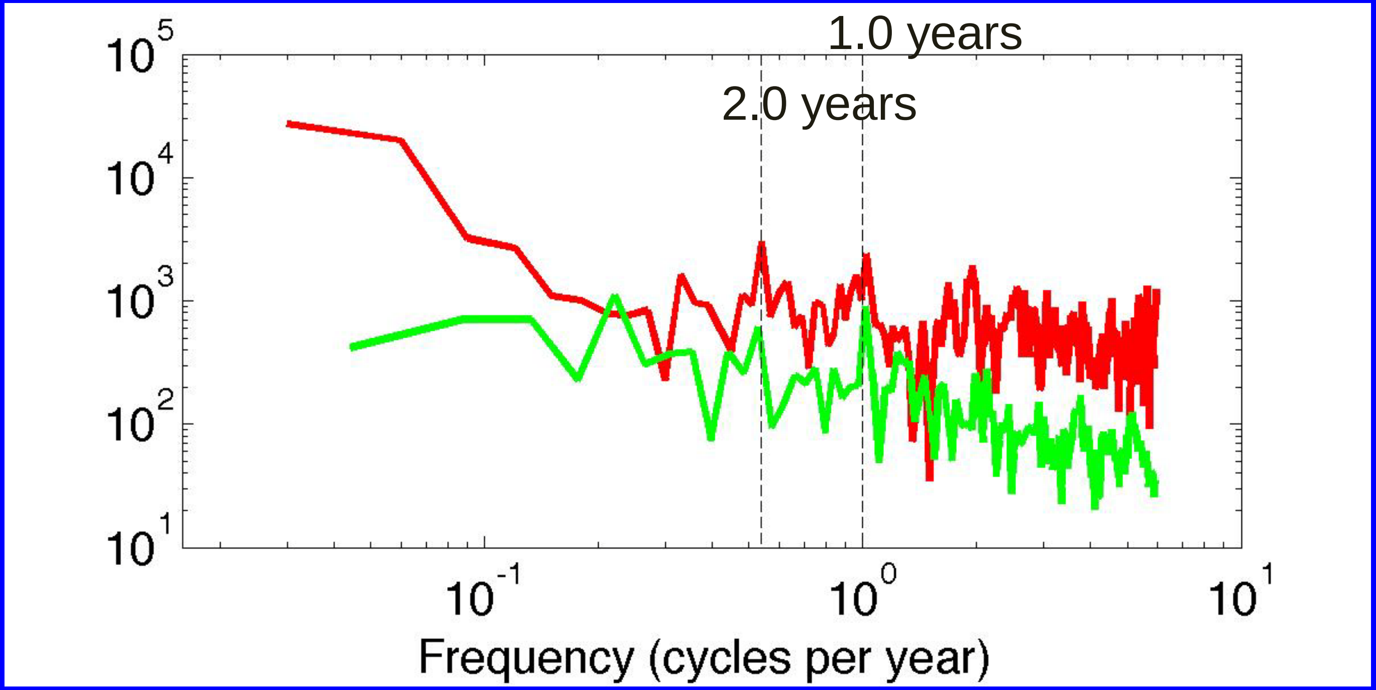

- Power spectrum analysis: red is the full time series, green is with large meanders (and thus the main low-frequency signal) removed.
- Peaks indicate dominant period of 1 year and 2 years.
- Most trigger-like meanders do NOT trigger large meanders
- Necessary but not sufficient!

Conclusions

- Large Meander exists south of Japan, both in observations and in the model
- Shape and timing are similar to observations, but could be better
- Transport and vertical shear change as a result of Large Meander
- An eddy traveling up the coast seems to trigger the Large Meander – but not every similar eddy has the same result.


THE END
Questions?