Remote Forcing (Connections) of the Benguela Current System: An Altimetric-Lagrangian Investigation

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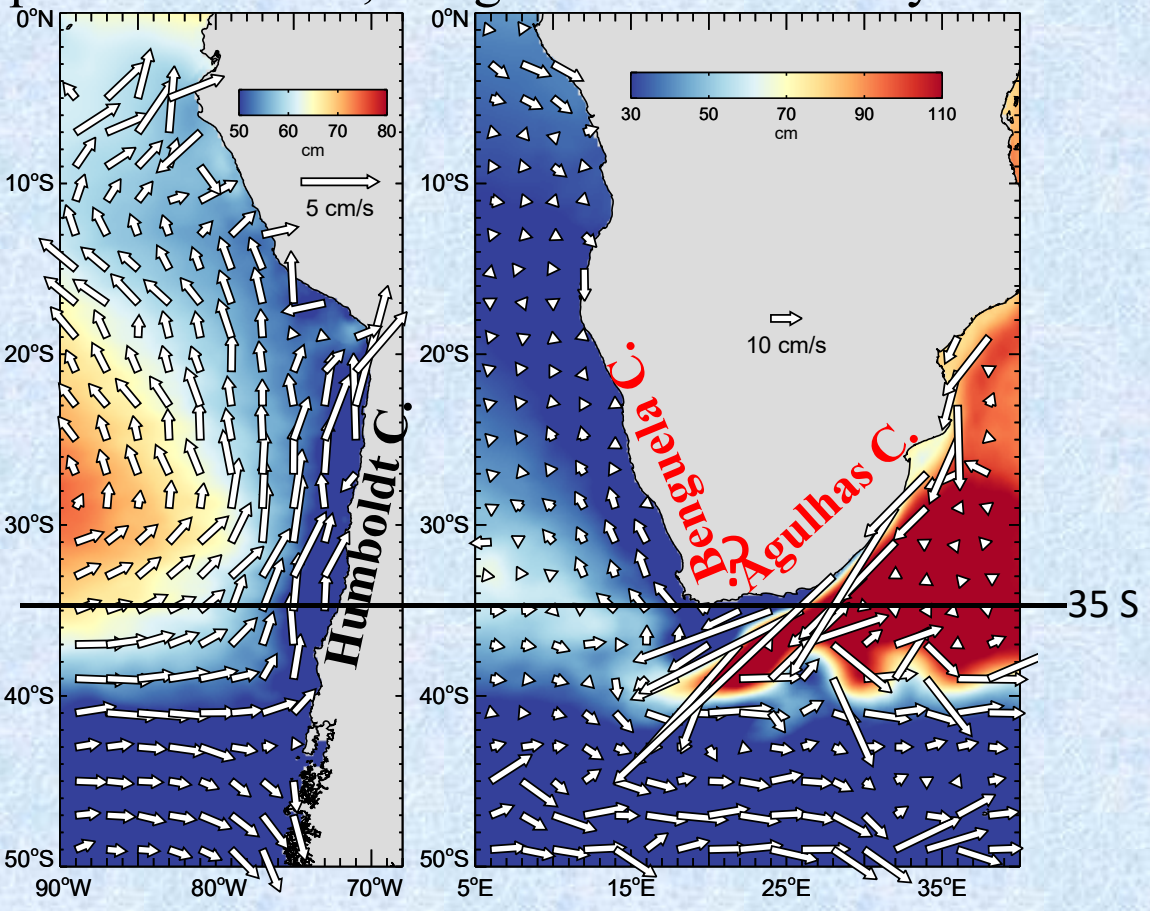
Unique Properties of the Benguela:

- An EBC Connects to a WBC
- An EBC with warm water on two ends

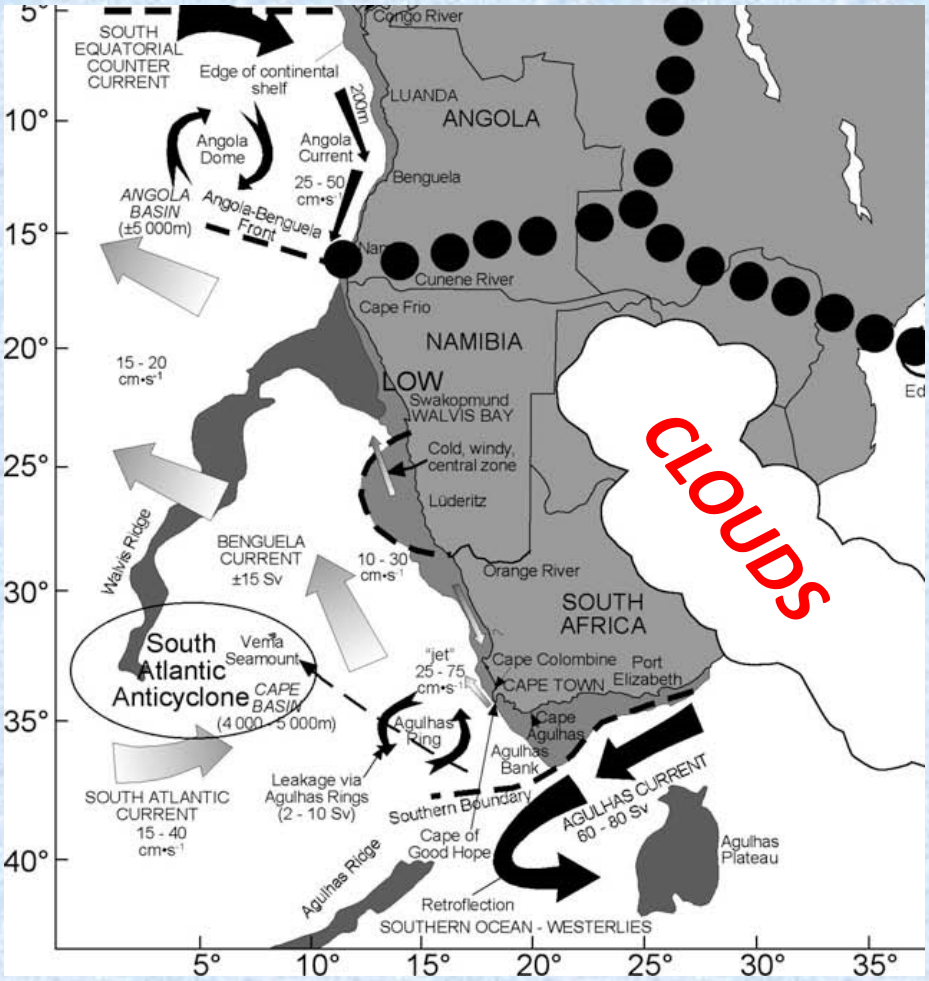
Questions:

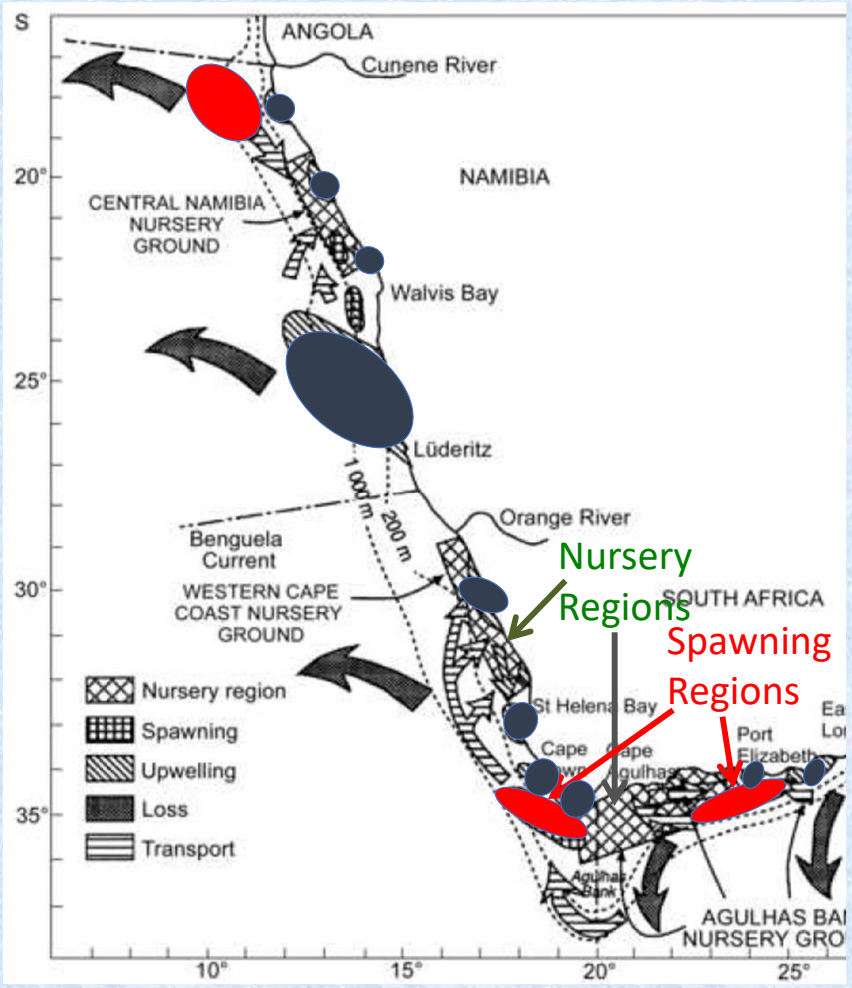
1) Can coherent Lagrangian paths be created from Eulerian altimeter velocity fields?
2) Does water move directly from the Agulhas to the Benguela?
3) Can altimeter-derived paths show realistic differences in pathways on seasonal and interannual timescales?

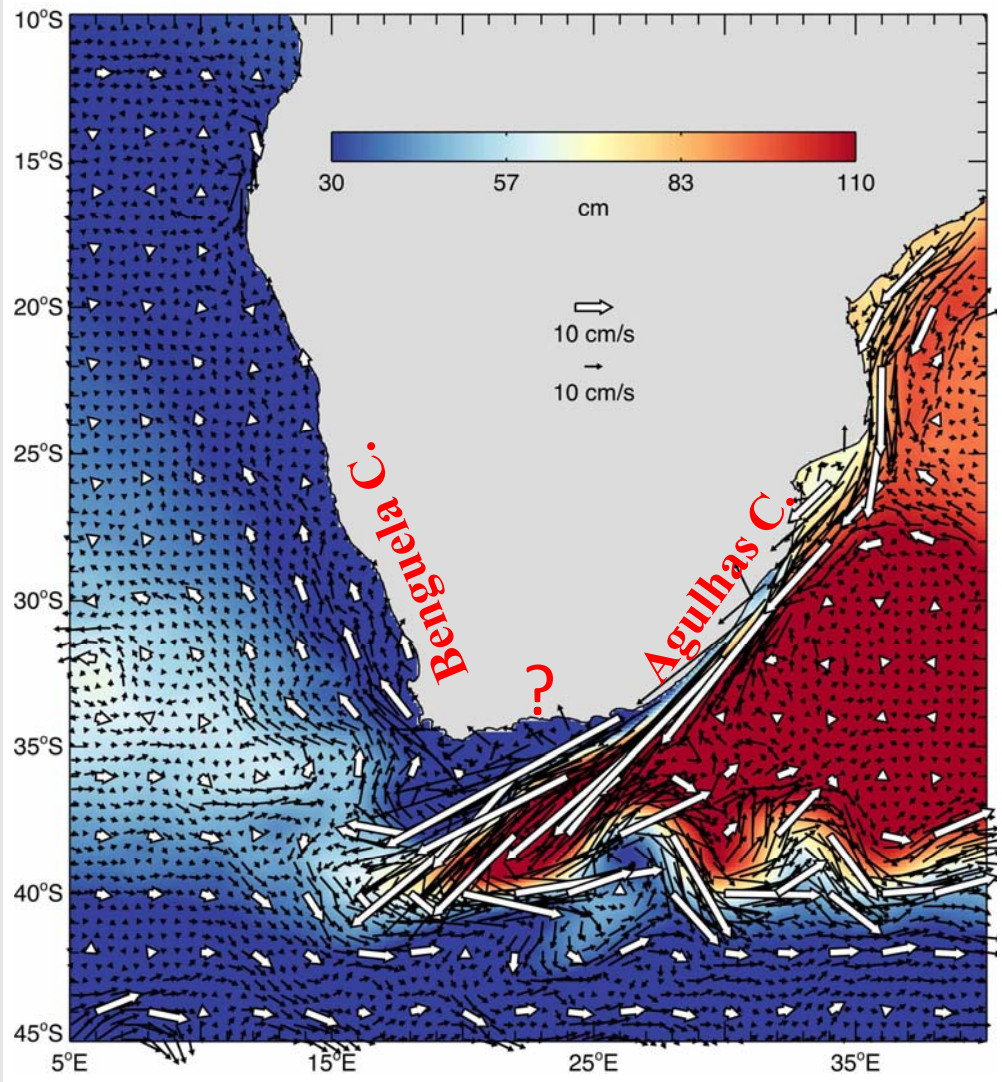


"The Benguela is the only EBC with connections to a WBC. What type of connections are expected? "

* Anticyclonic 'Agulhas Rings' from the Retroflection interact with the coastal ocean off SW Africa.
* Water is transported directly ('leaking') from the westward Agulhas Current into the equatorward Benguela Coastal Current, moving larval fish from spawning regions to the western nurseries.







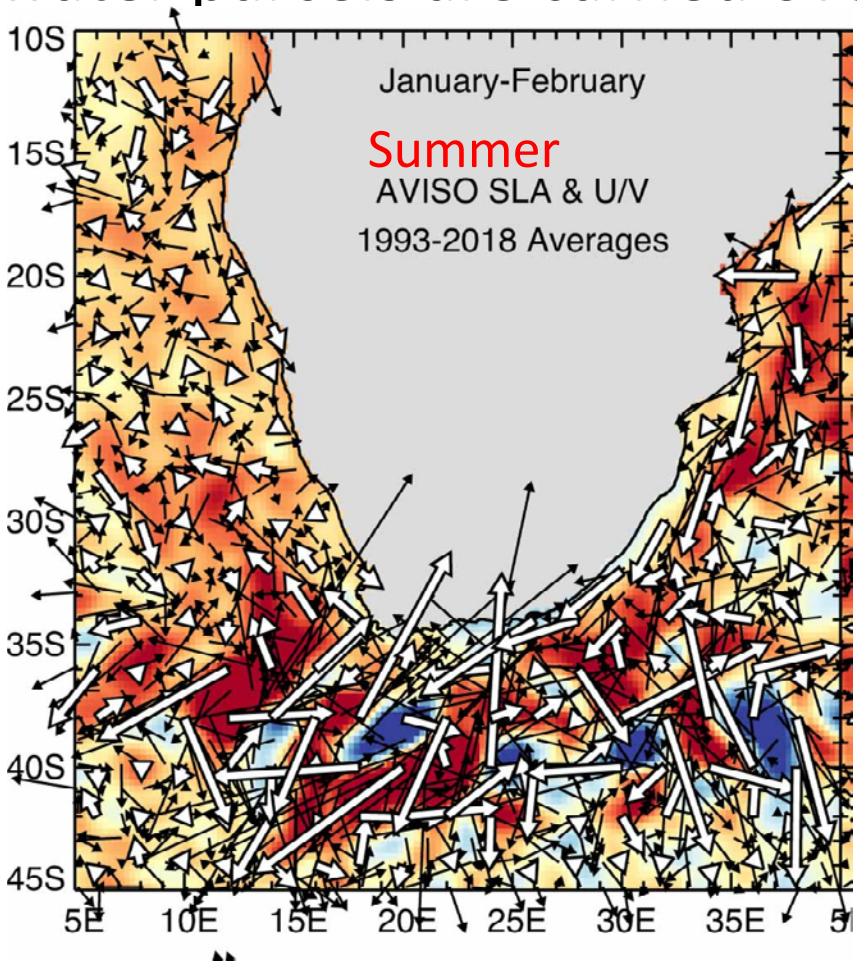
Temporal Mean (CLS18 MDT): Within 150 km of the coast along the west coast, flow is equatorward south of 20°S. Along the south and east coast, it is poleward and westward. The inside of the Agulhas C. seems to connect to the offshore region of the Benguela C at the SW corner of the continent. Do water parcels move directly from the Agulhas (Bank) to the Benguela?

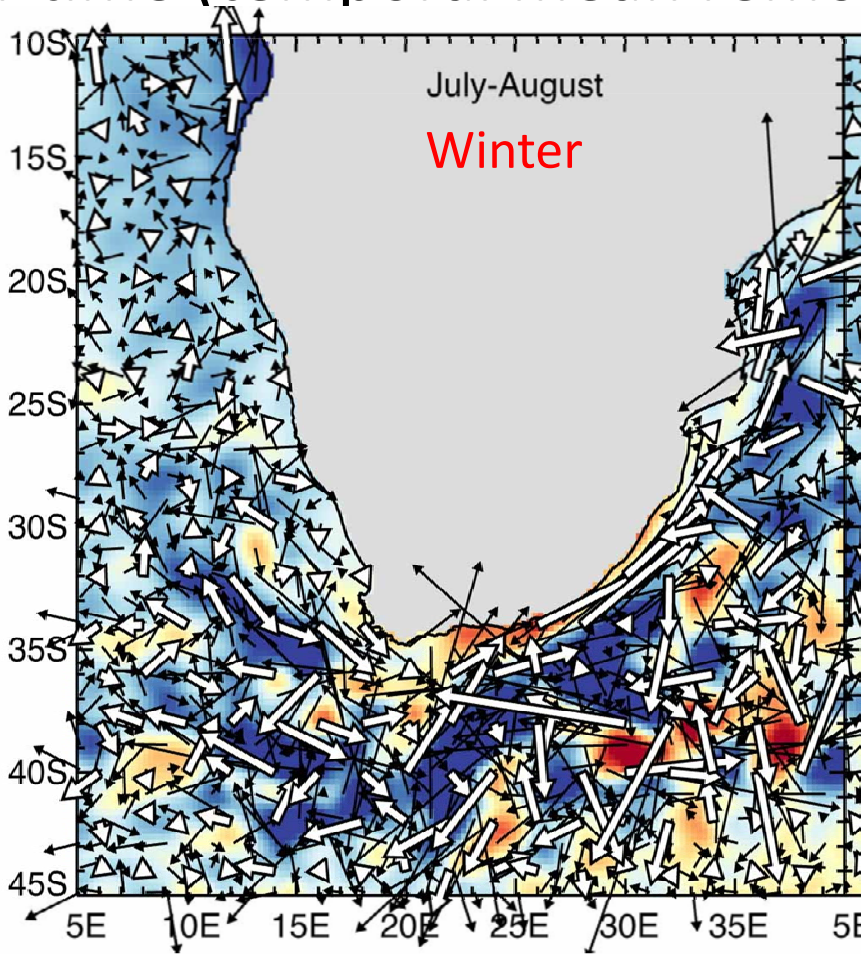
See poster: ROMS results by Combes et al.

See MDT talk by S. Mulet Thursday 9:30.

Rio M-H, S. Mulet, H. Etienne, G. Dibarboure, N. Picot. The new CNES-CLS18 Global Mean Dynamic Topography. In prep.

Standard Eulerian maps, even of long-term (25-year) mean SLA height and velocity seasonal cycles can be difficult to interpret in terms of where water parcels are carried over time (temporal mean removed).

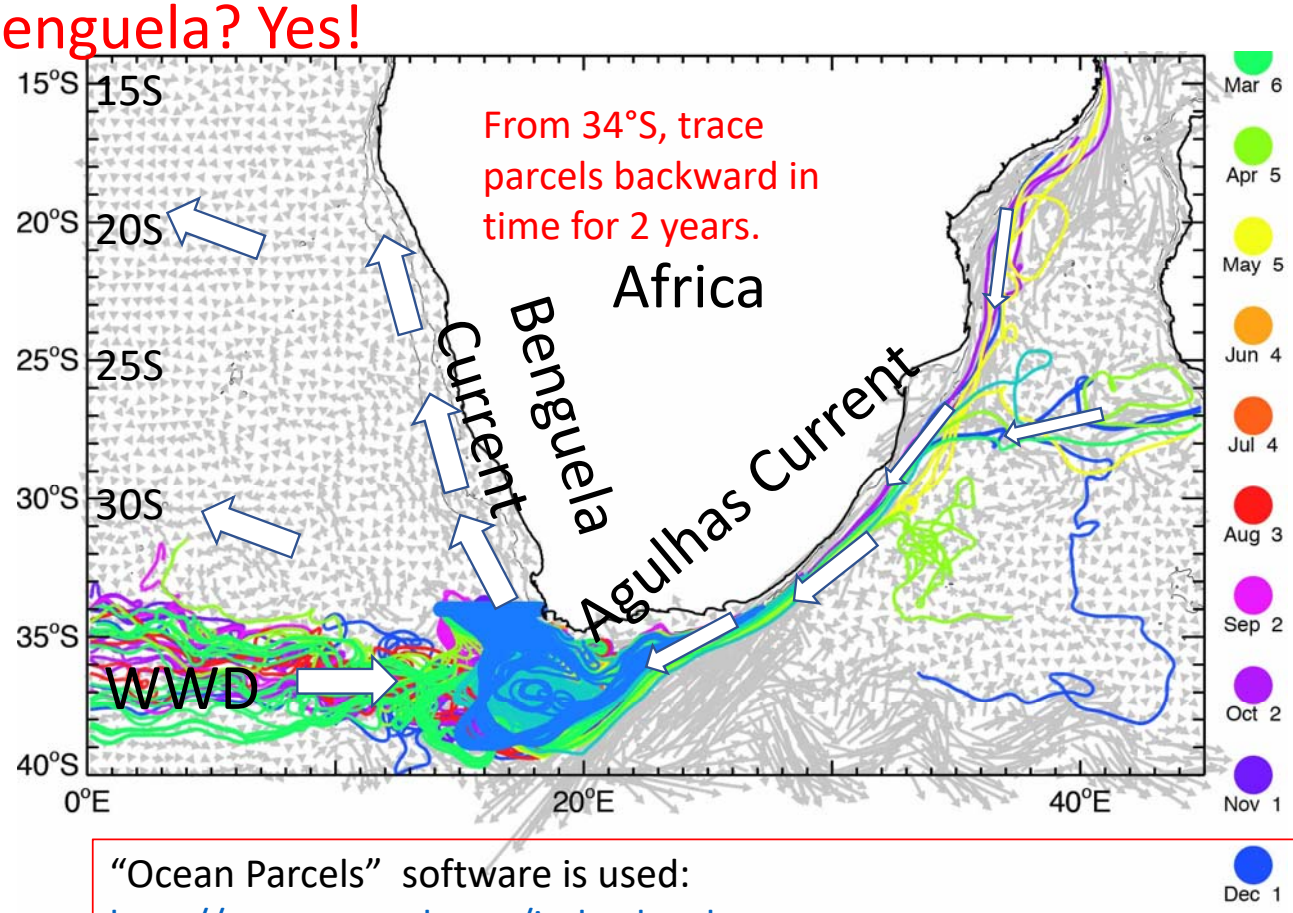


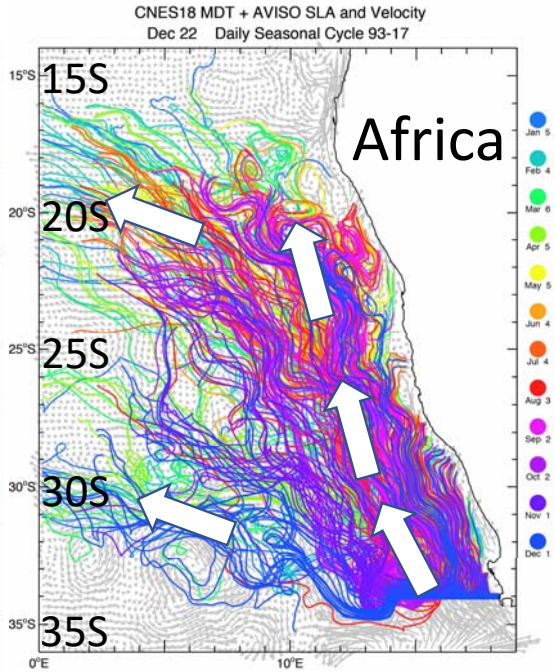


34°S Lagrangian trajectories based on daily seasonal altimeter geostrophic velocities.

Do water parcels move directly from the Agulhas to the Benguela? Yes!

From 34°S, trace parcels forward in time for 2 years.





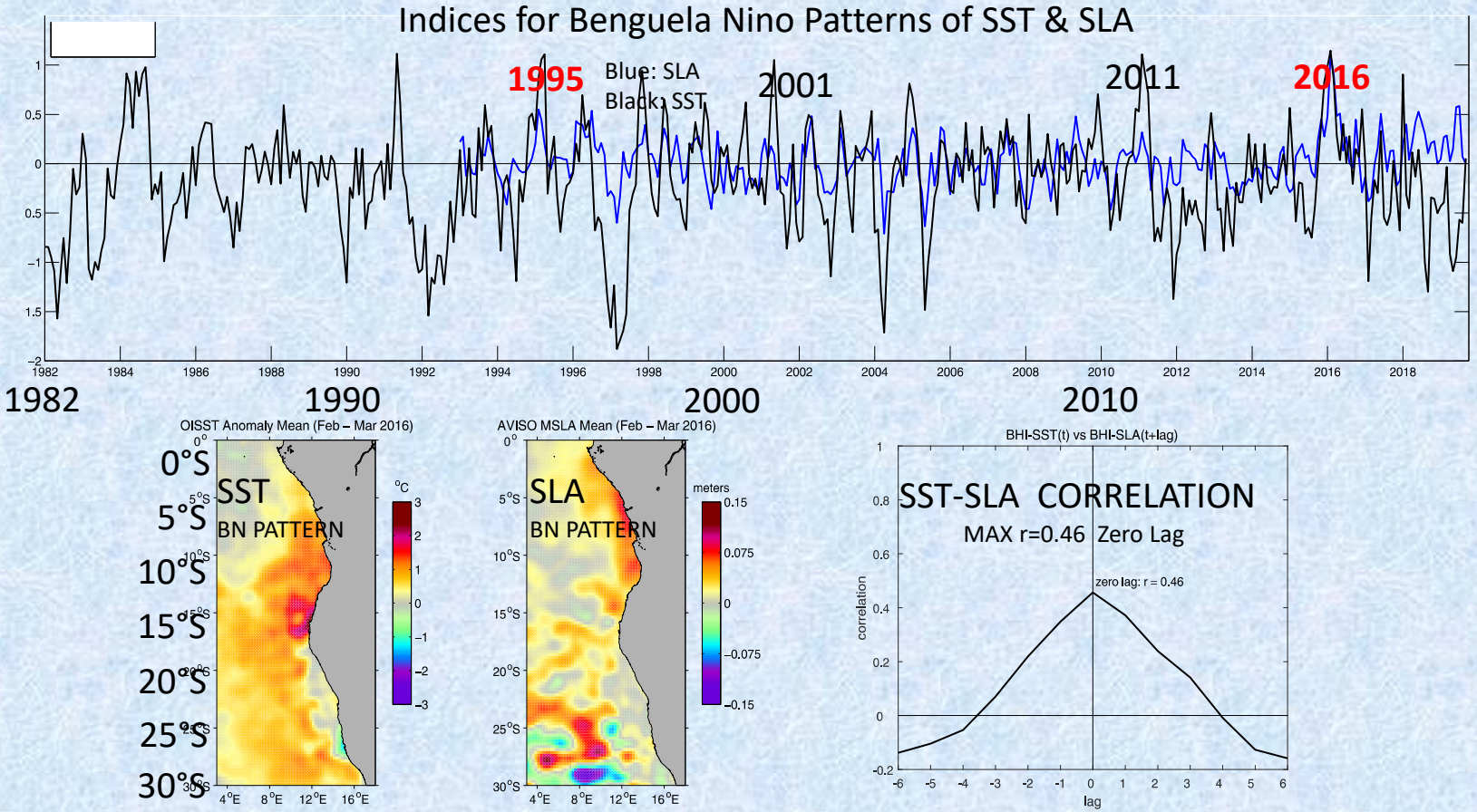
Starting at 34°S, maps the entire Benguela and its connections to the WBC, WWD & SEC. ***The long-term mean must be included.***

"Ocean Parcels" software is used:
http://oceanparcels.org/index.html

The most recent release is described in this ms:
https://www.geosci-model-dev.net/12/3571/2019/gmd-12-3571-2019.html

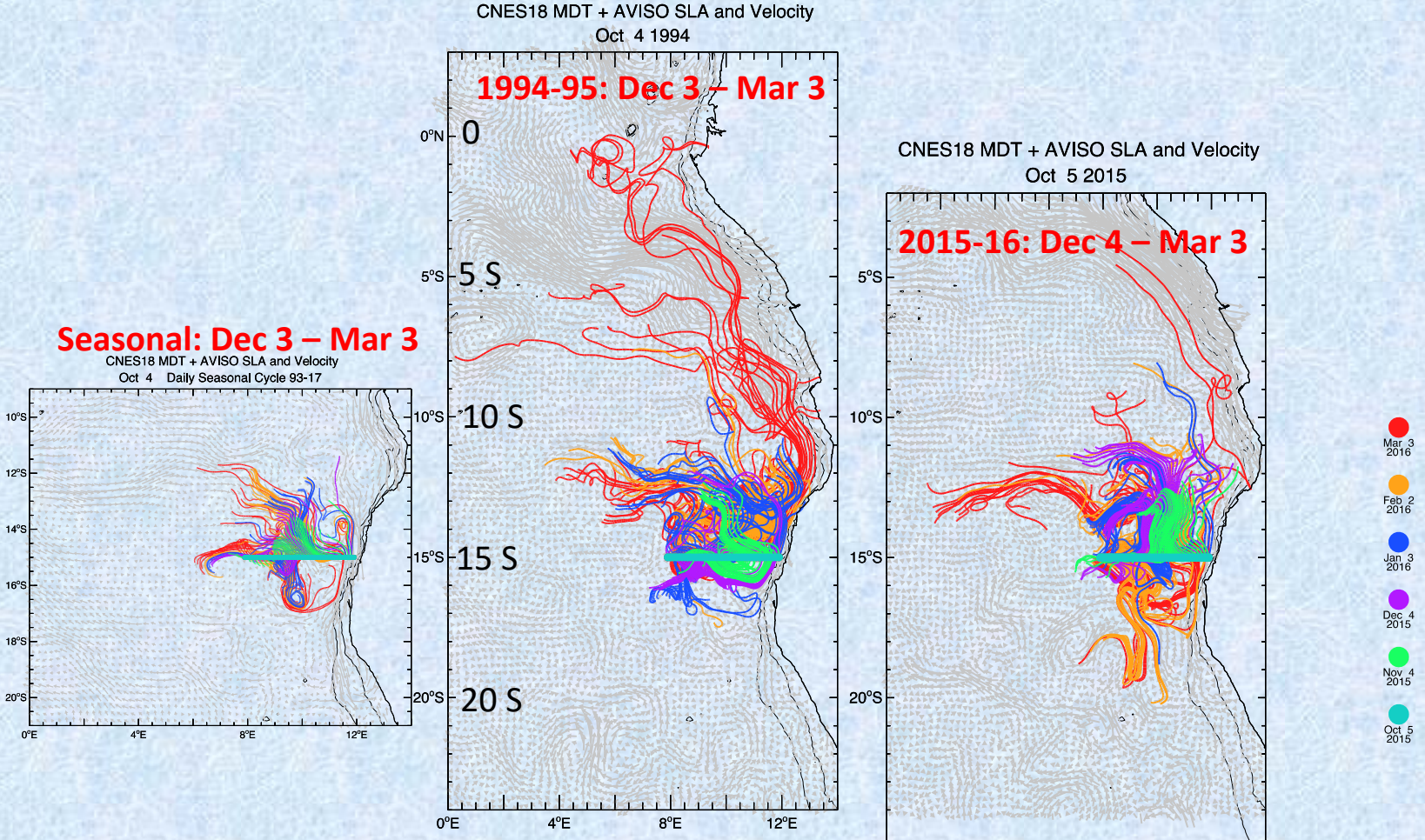
Interannual Analyses: Changes in Pathways

- Marine Heat Waves: “Benguela Ninos” bring anomalous warm water to the northern Benguela. What is the role of transports?



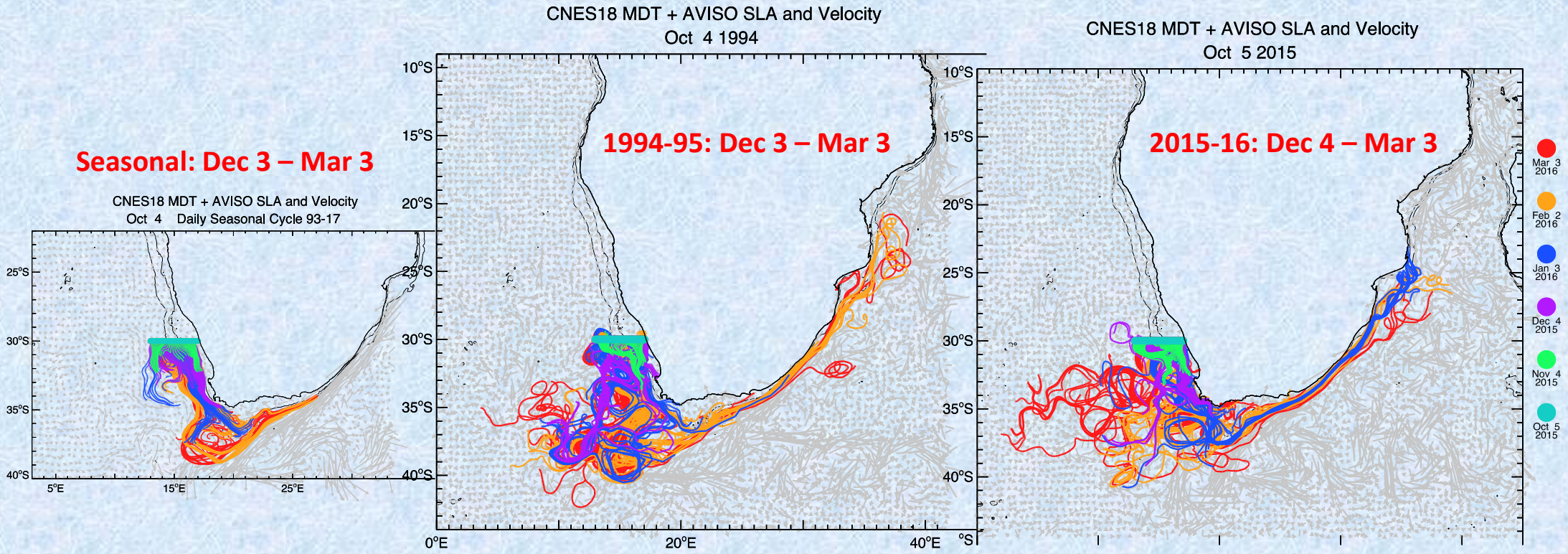
Interannual Analyses: Changes in Pathways

- Marine Heat Waves: “Benguela Ninos” bring anomalous warm water to the northern Benguela. What is the role of transports and the southern Benguela?



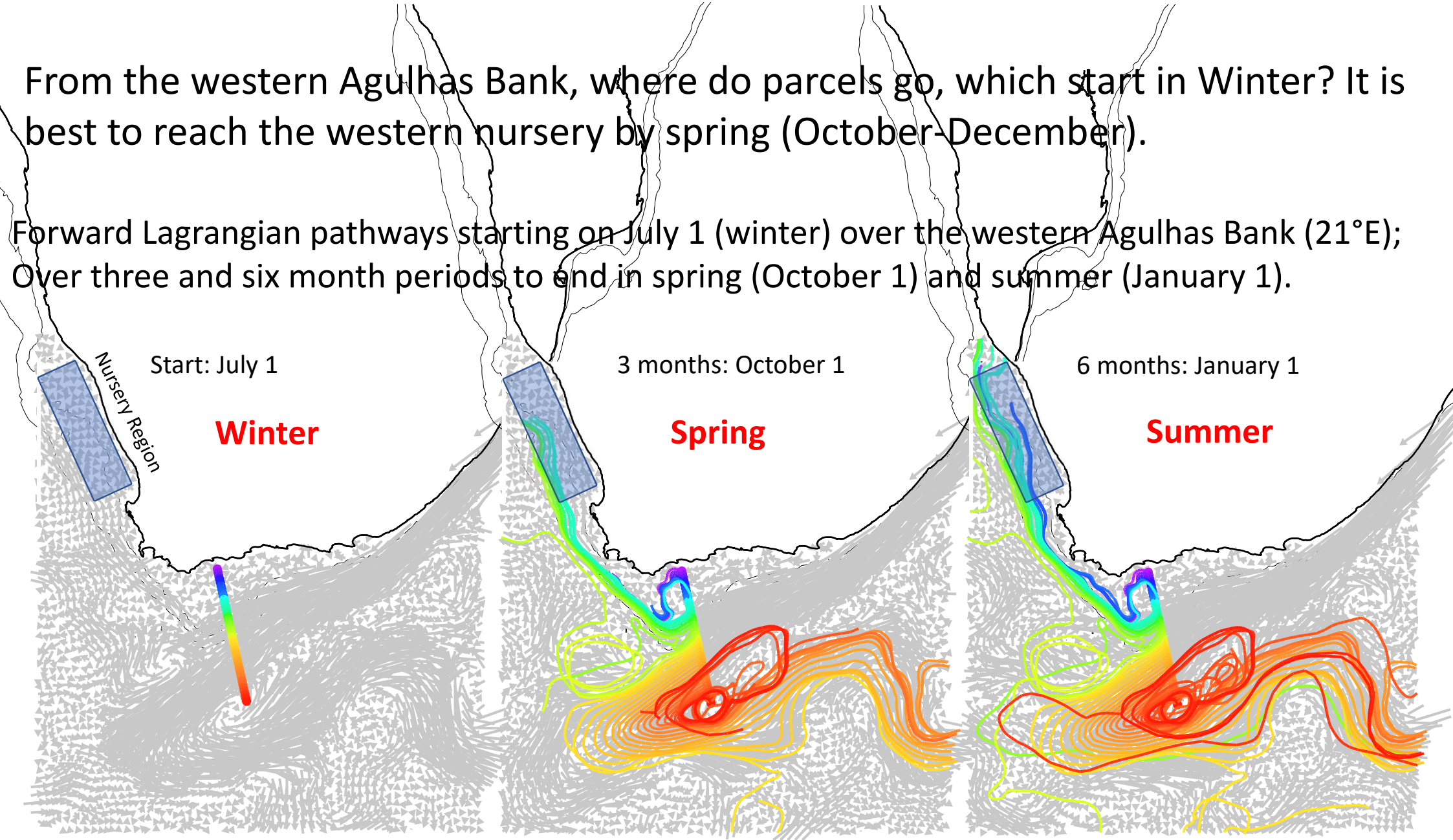
Example Future Analyses: Changes in Pathways

- Marine Heat Waves: “Benguela Ninos” bring anomalous warm water to the northern Benguela. What is the role of transports and the southern Benguela?



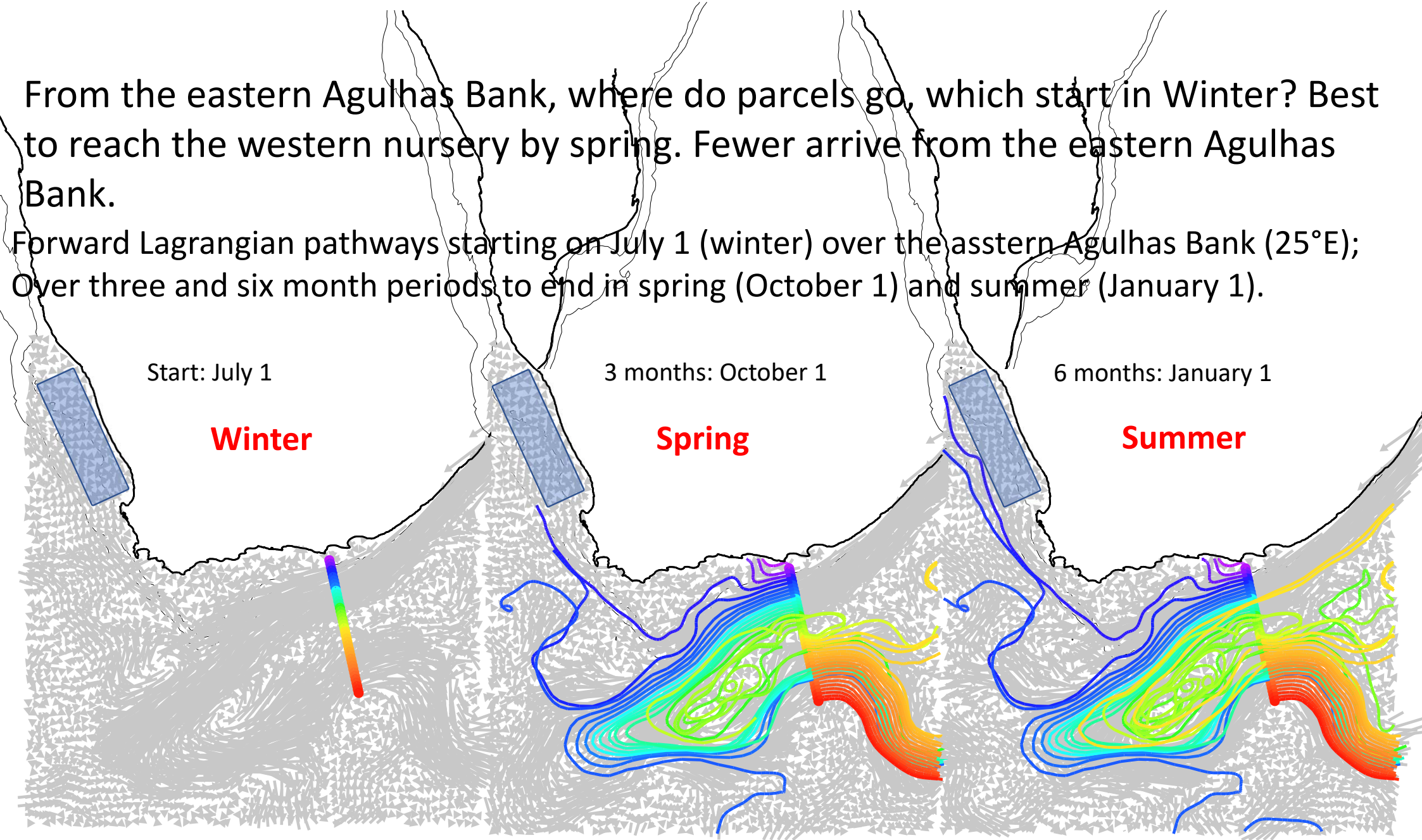
From the western Agulhas Bank, where do parcels go, which start in Winter? It is best to reach the western nursery by spring (October-December).

Forward Lagrangian pathways starting on July 1 (winter) over the western Agulhas Bank (21°E); Over three and six month periods to end in spring (October 1) and summer (January 1).



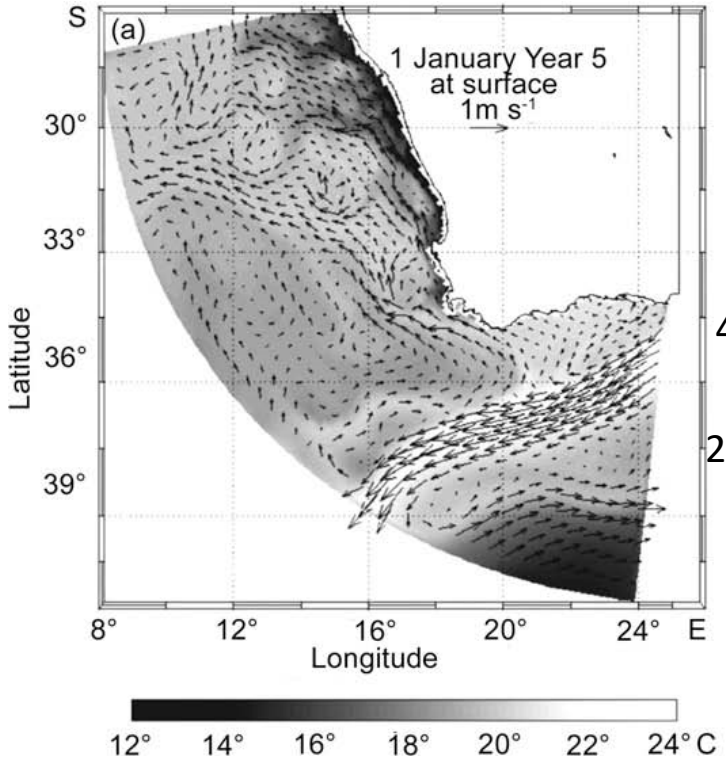
From the eastern Agulhas Bank, where do parcels go, which start in Winter? Best to reach the western nursery by spring. Fewer arrive from the eastern Agulhas Bank.

Forward Lagrangian pathways starting on July 1 (winter) over the asstern Agulhas Bank (25°E); Over three and six month periods to end in spring (October 1) and summer (January 1).

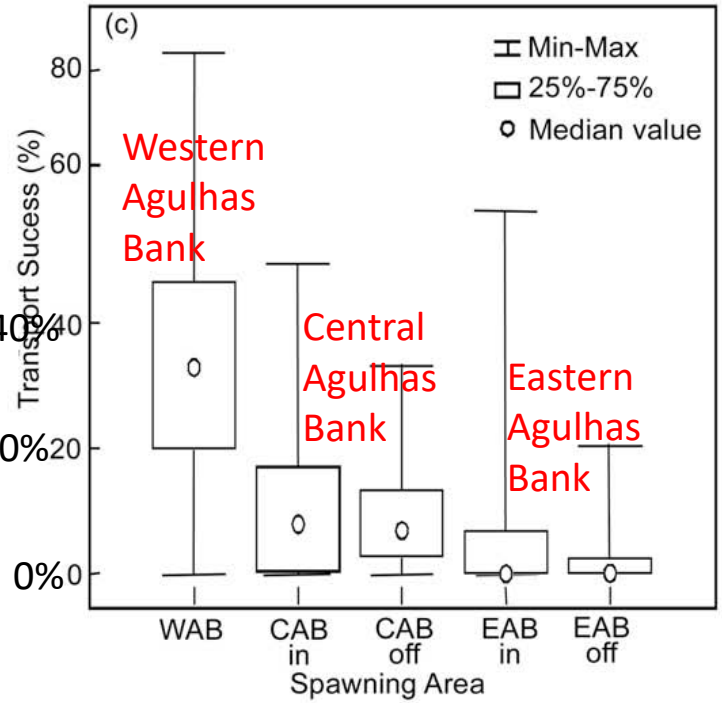


Previous Model and Observational Results (Van der Lingen and Huggett, 2003)

An “Individual-Based Model” of fish egg transport resulted in the the greatest per cent of transport success for eggs spawned over the western Agulhas Bank, the least success for those spawned over or along the eastern Agulhas Bank. The altimeter-derived seasonal trajectories are consistent with these results.



% Success Reaching Nursery



Summary

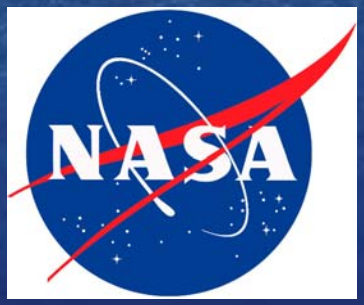
1) [*Methodological]:* Can coherent Lagrangian pathways be created from Eulerian (gridded) seasonal altimeter velocity fields? Yes.

2a): Do water parcels move directly from the Agulhas Current to the Benguela Current? Yes, consistent with new ROMS model results and previous studies.

2b) From the Agulhas Bank? Yes, consistent with previous model results.

3) Can altimeter-derived paths show realistic differences in pathways on seasonal and interannual timescales? Yes.

Thank You!



(NASA and Eric L.) for supporting altimeter-based oceanographic research for many years!

JPL, CNES, CLS, AVISO for quality data products.

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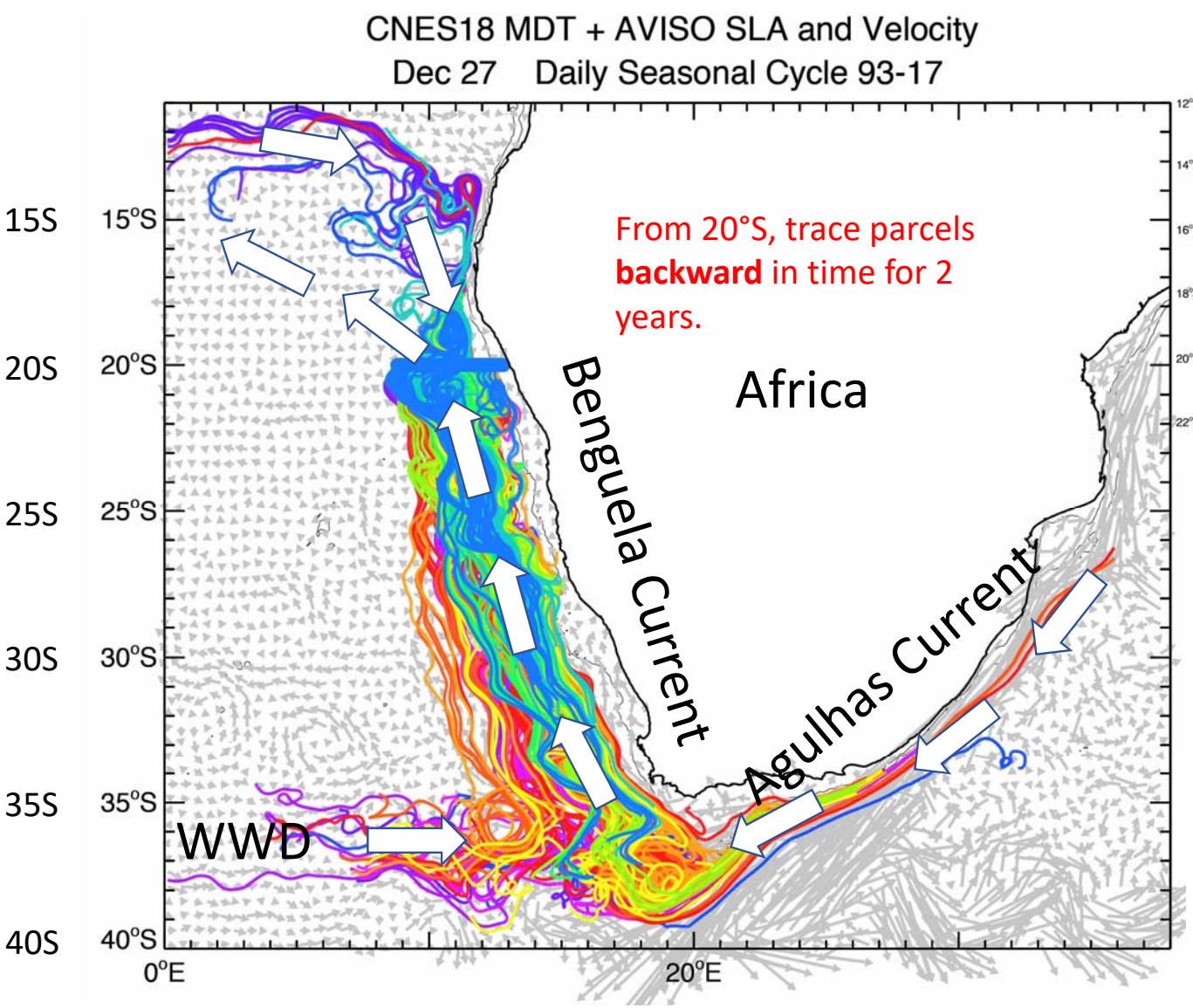
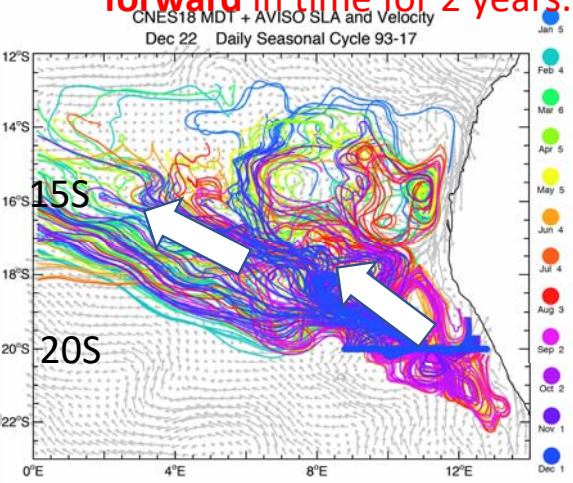
20°S Lagrangian trajectories based on daily seasonal altimeter surface geostrophic velocities.



From 20°S, trace parcels **forward** in time for 2 years.

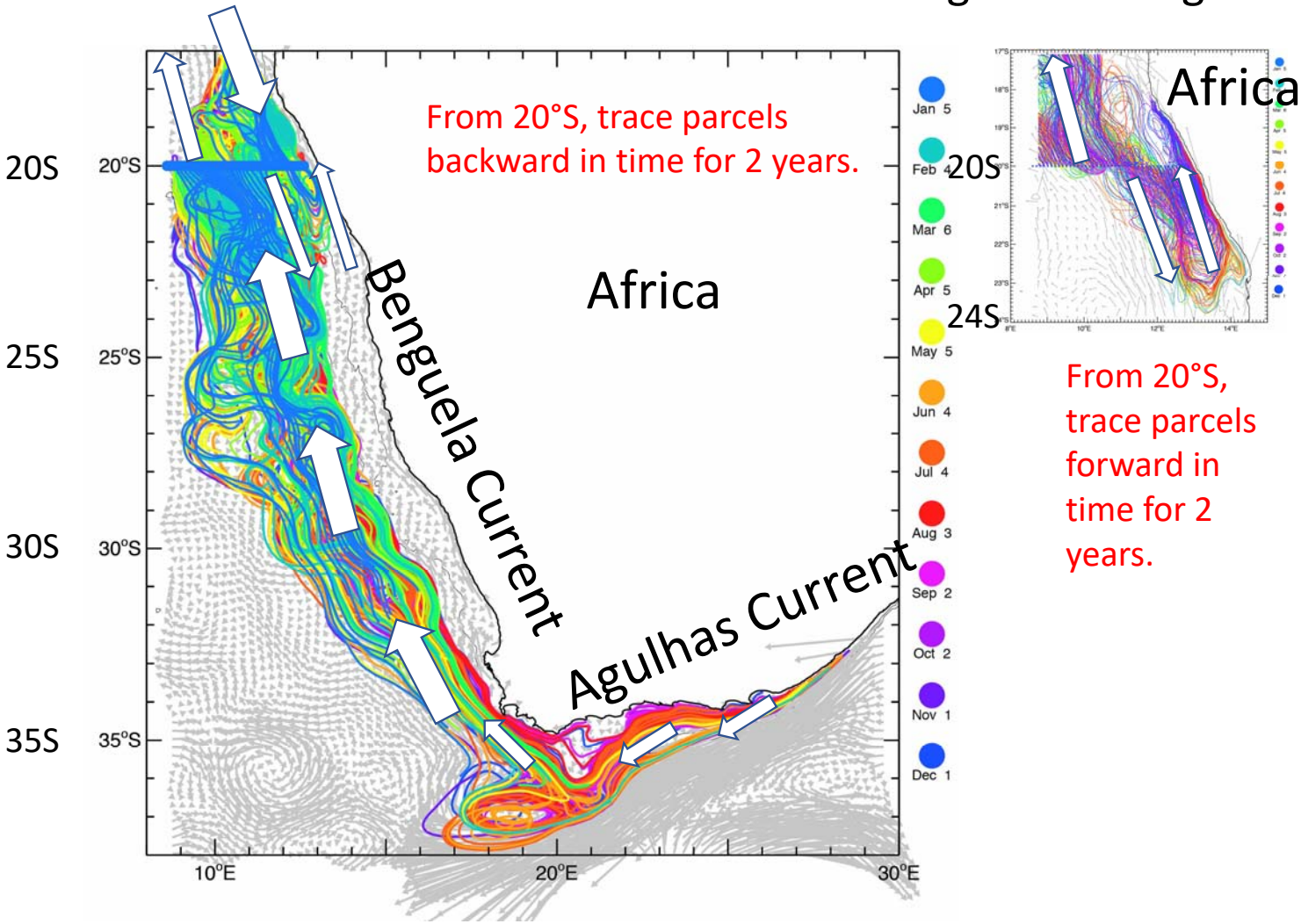


Colors= Release Month

Starting at 20°S, release parcels and track them backwards and forward for 2 years. The Water parcels clearly pass from the Agulhas to the Benguela Current. ***This does not occur if we exclude the long-term mean and use only seasonal anomalies.***

20°S Lagrangian paths based on daily seasonal ROMS MODEL surface geostrophic velocities.

Starting at 20°S, release parcels and track them backwards and forward for 2 years. The mode trajectories also show a clear connection between Benguela and Agulhas Currents.



From 20°S, trace parcels forward in time for 2 years.

Experiment in the Humboldt Current.

35°S & 21°S, backward integration in time.

Lagrangian trajectories based on daily seasonal (25-year mean) altimeter surface geostrophic velocities. Parcels move from the West Wind Drift into the equatorward boundary current. Colors=Release Mo.

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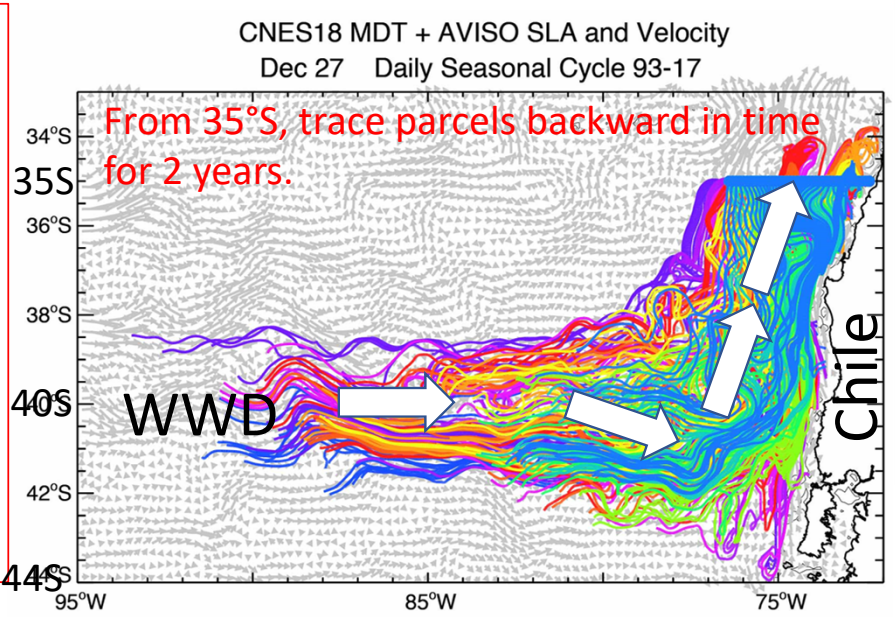

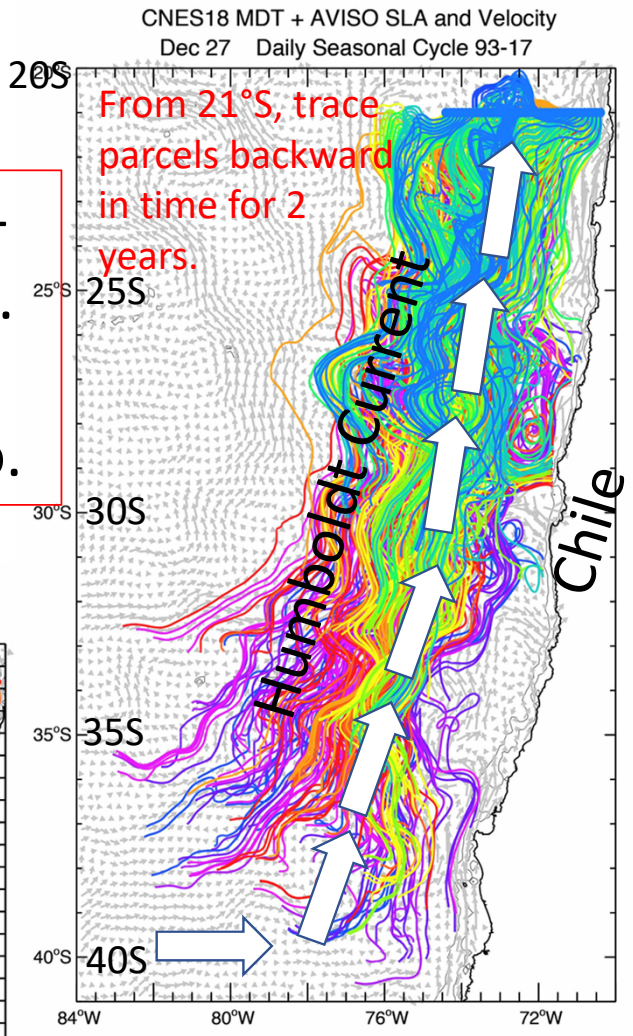

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An “Individual-Based Model” of fish egg transport resulted in the the greatest per cent of transport success for eggs spawned over the western Agulhas Bank, the least success for those spawned over or along the eastern Agulhas Bank. Observations in the western nursery area revealed peak egg abundance in spring (October-January), maximum in December. The altimeter-derived seasonal trajectories are consistent with these results.