

Stratification in Delaware Bay

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Robert Chant

Delaware Estuary
Science and
environmental summit
Jan 27-30 2013



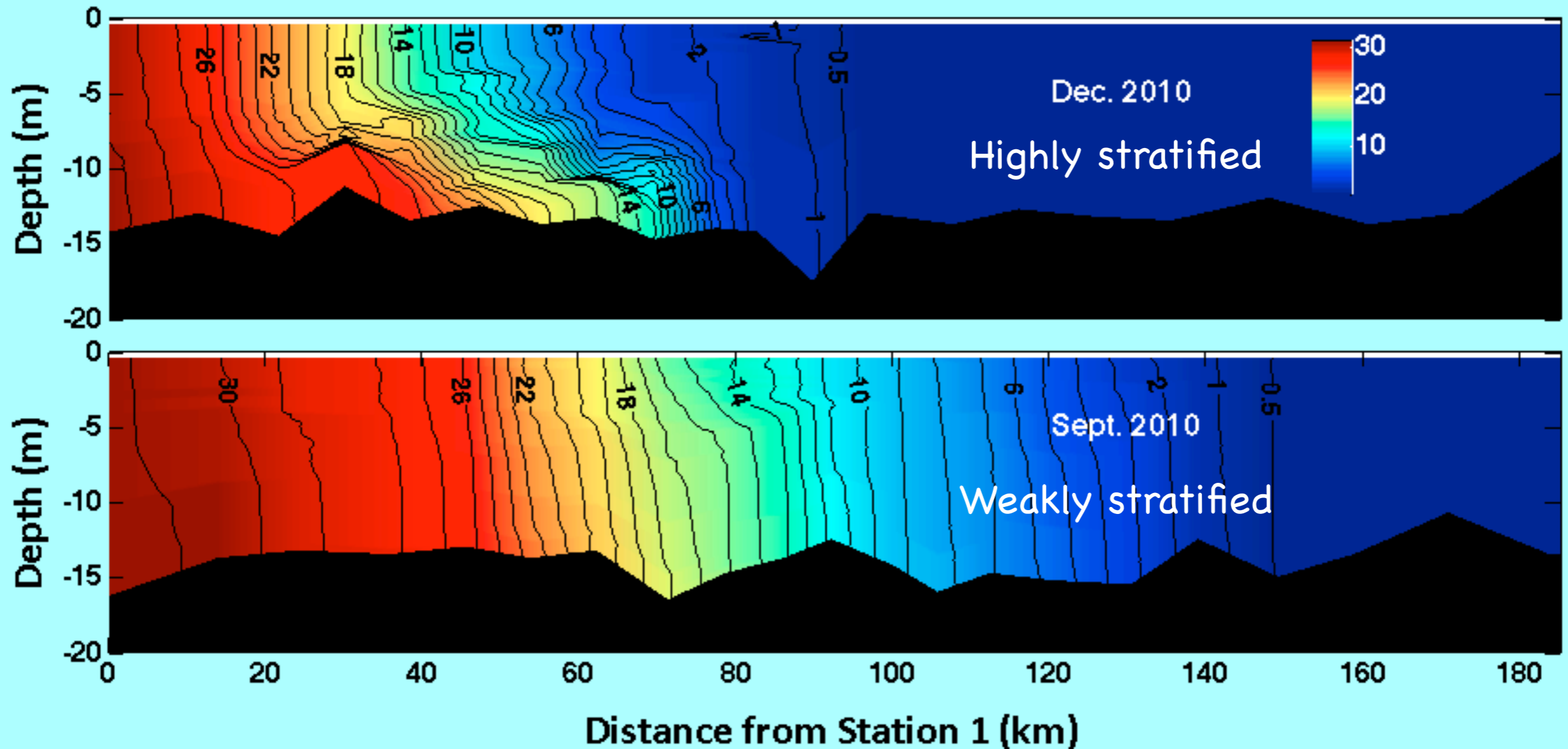
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THE STATE UNIVERSITY
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This work has been
supported by NSF,
Rutgers University and
a Dupont fellowship.

Stratification

Formation of layers of water of different densities that act as barriers for water mixing.

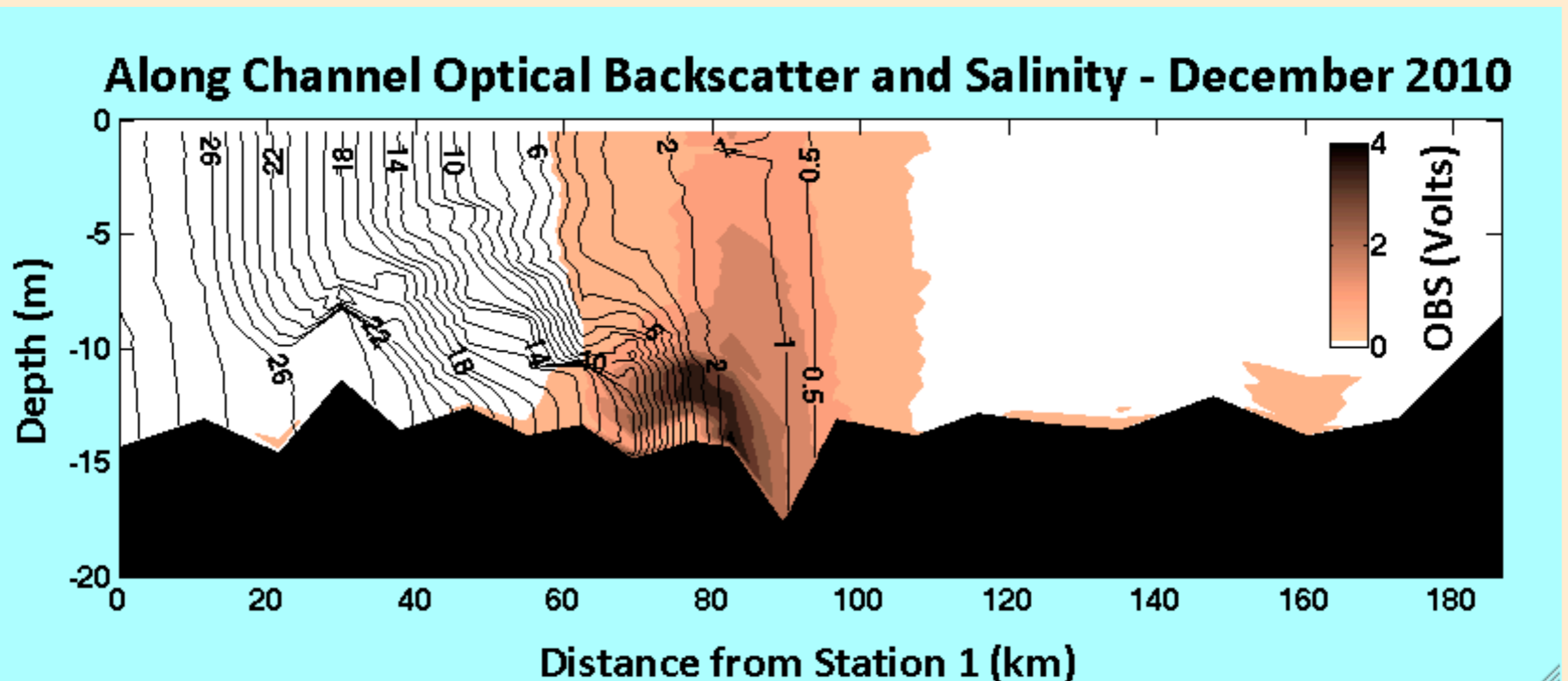
Along Channel Salinity



Why is stratification important?

Physical aspects:

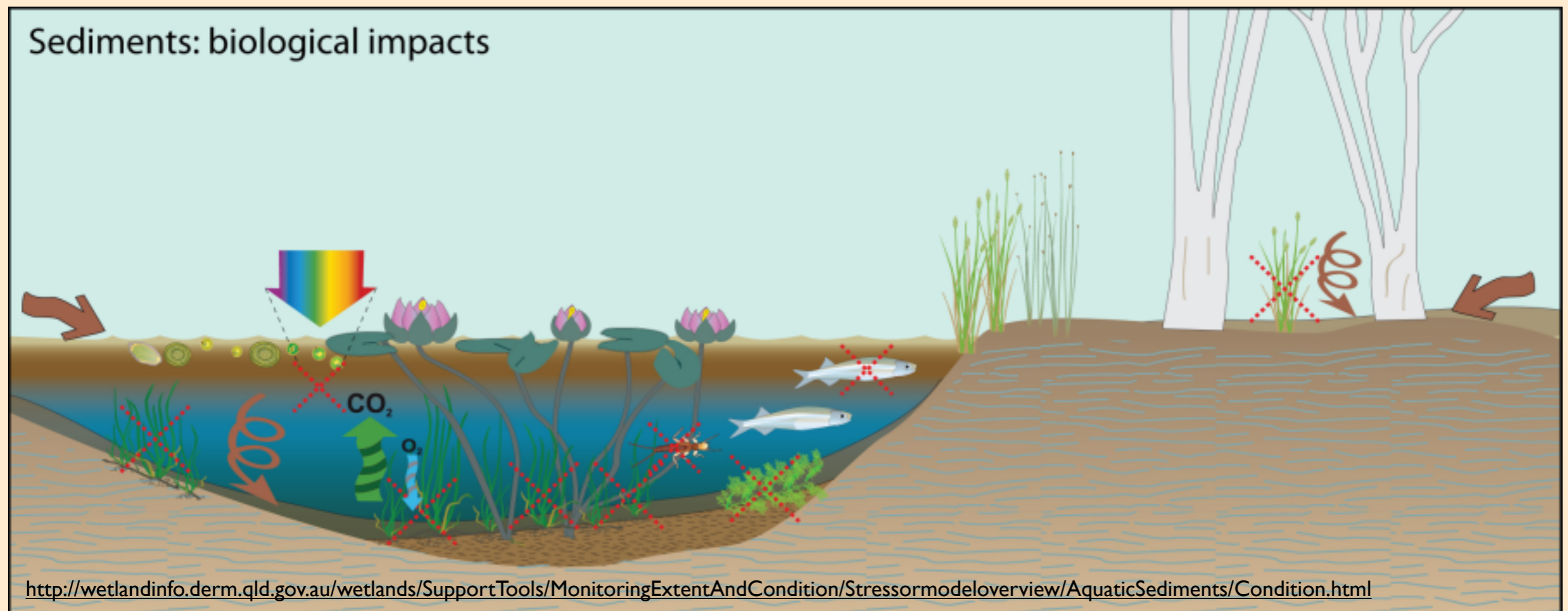
- It controls the time variability of salt fluxes and it affects the salt intrusion length.
- It determines the extent of sediments in the water column.



Why is stratification important?

Biological aspects:

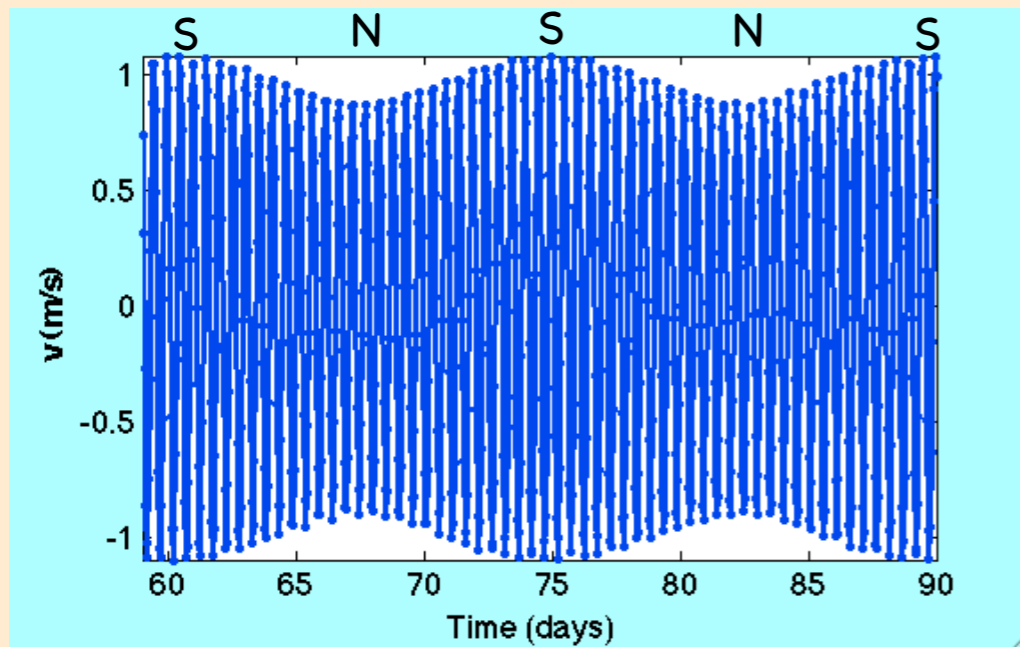
- Affects dissolved oxygen concentration.
- Sediments decrease the light penetration in the water column inhibiting photosynthesis.
- Toxicants and nutrients attach to sediments and are easily transported.



What controls stratification in estuaries?

River discharge and tides

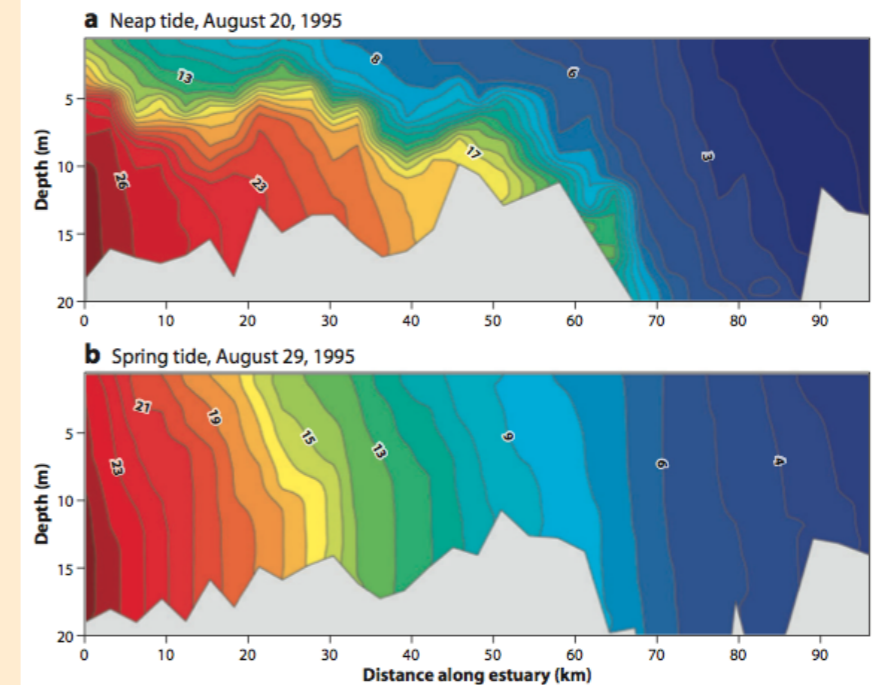
Spring-neap cycle



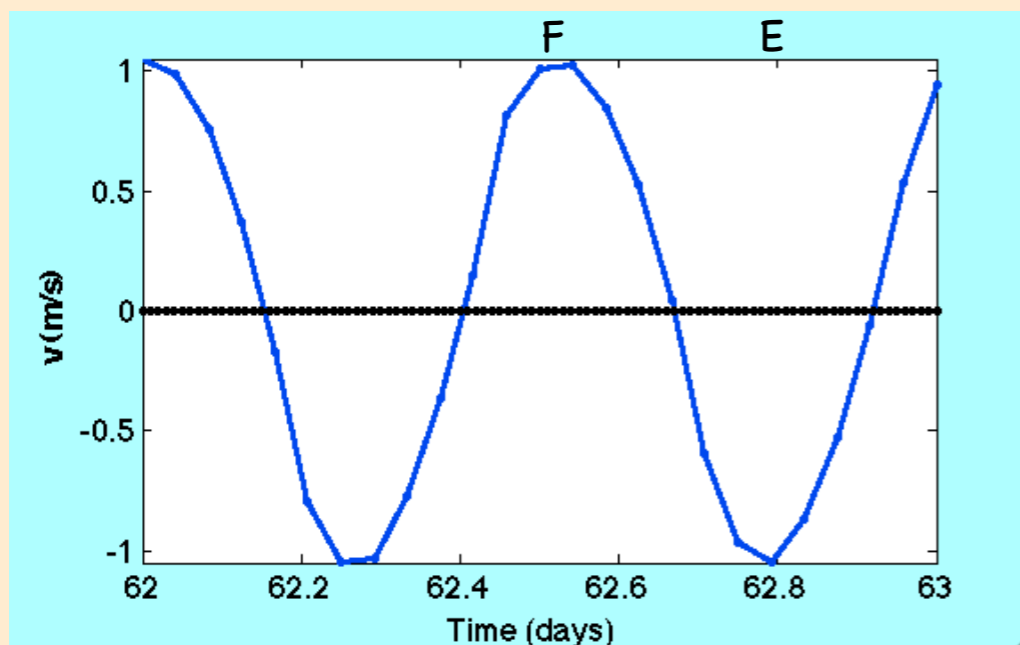
Neap

Spring

MacCready and Geyer 2010



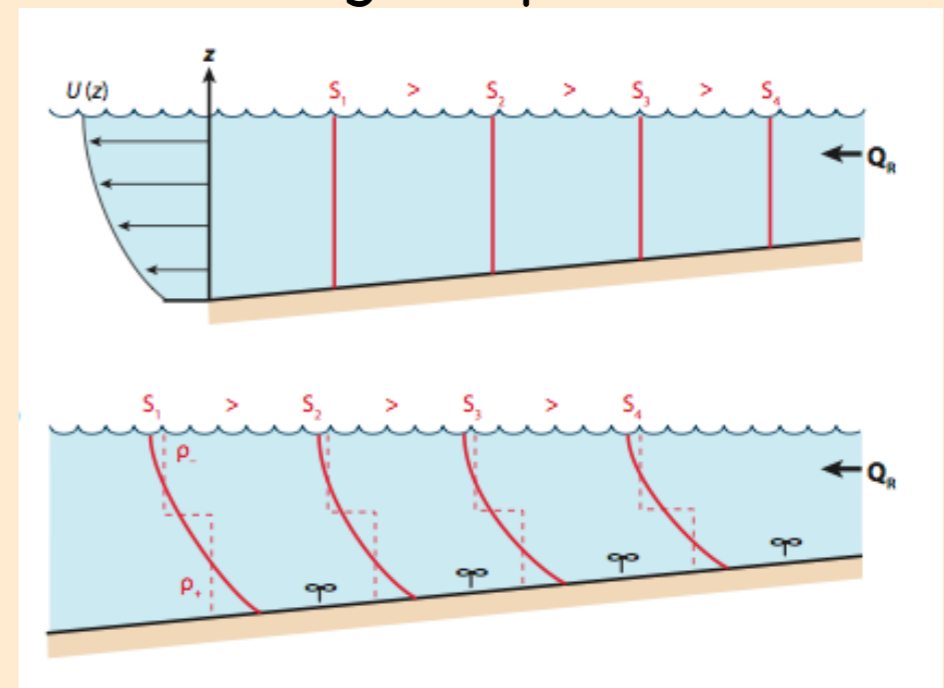
tidal cycle: flood-ebb



Flood

Ebb

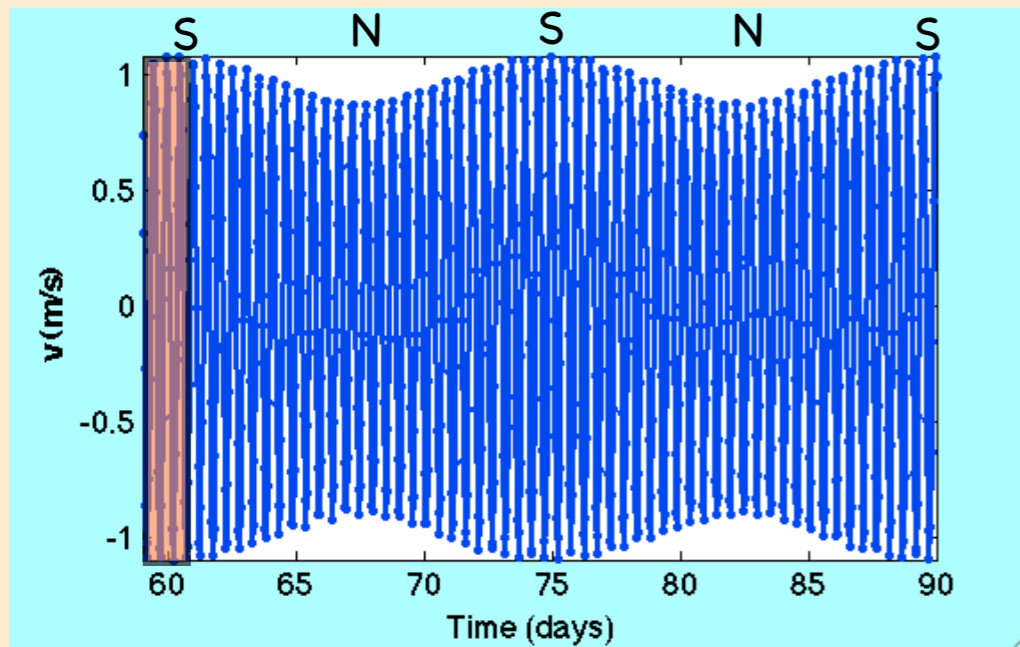
tidal straining (Simpson et al. 1990)



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River discharge and tides

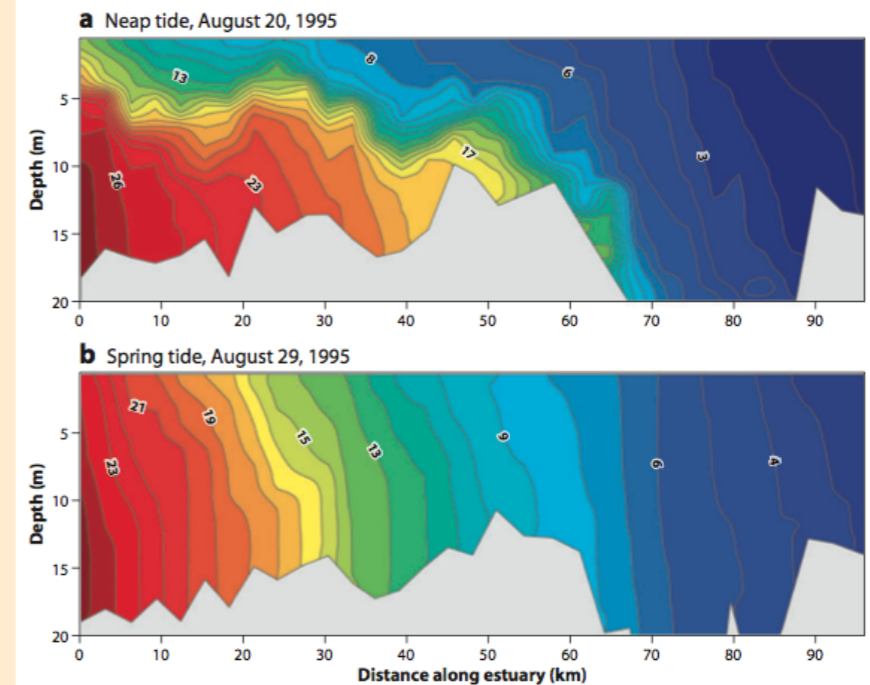
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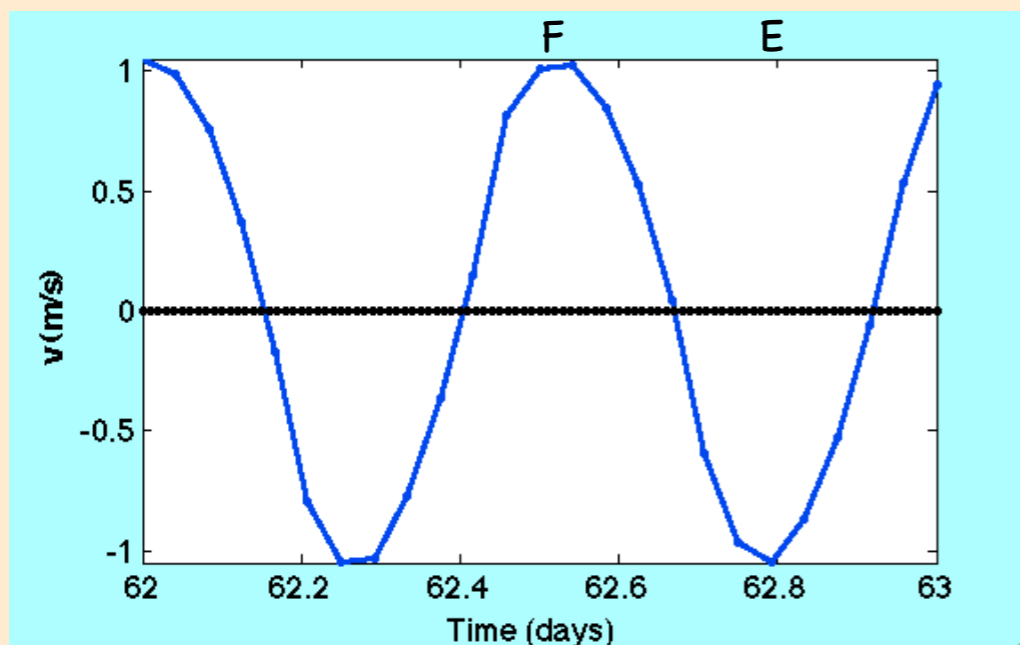
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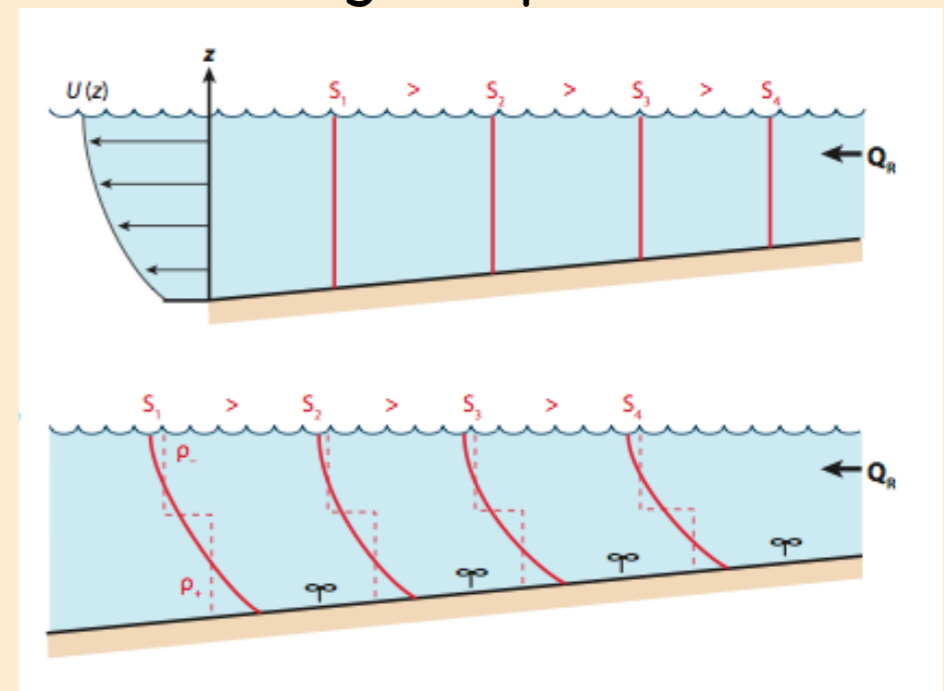
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Flood

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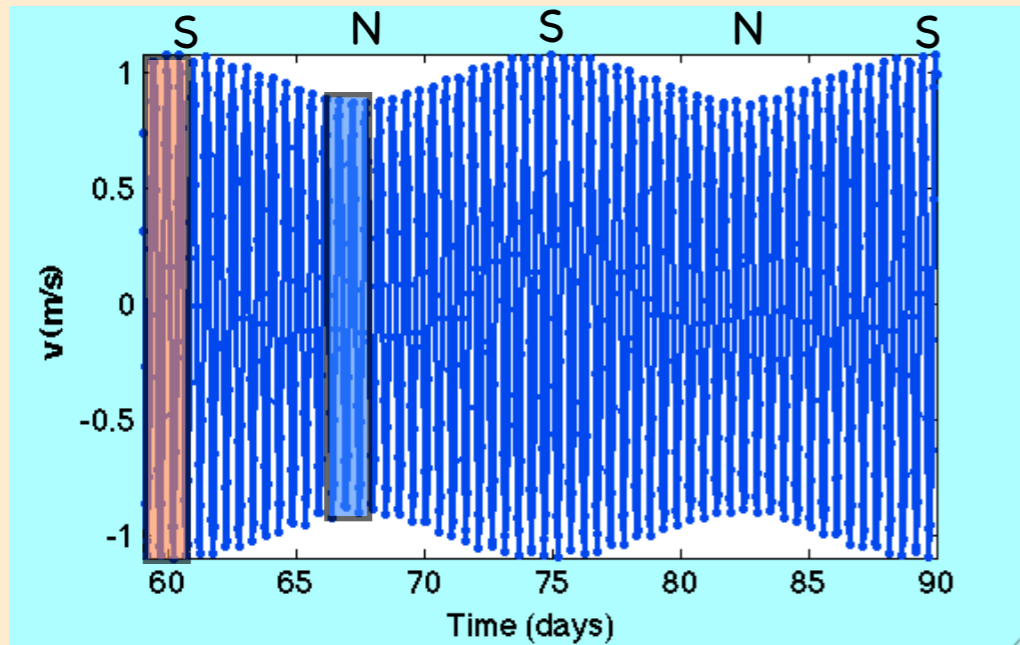
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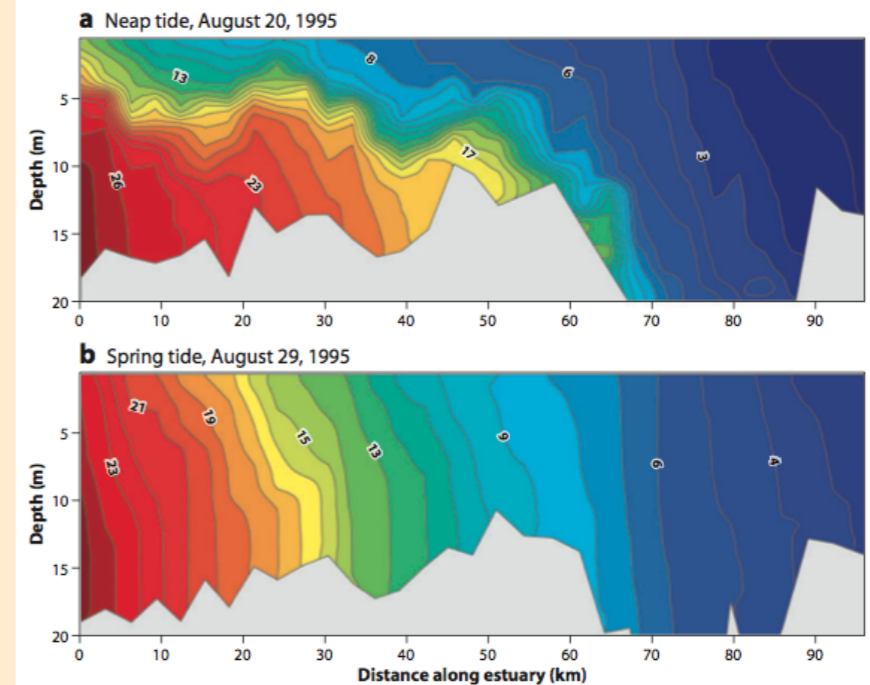
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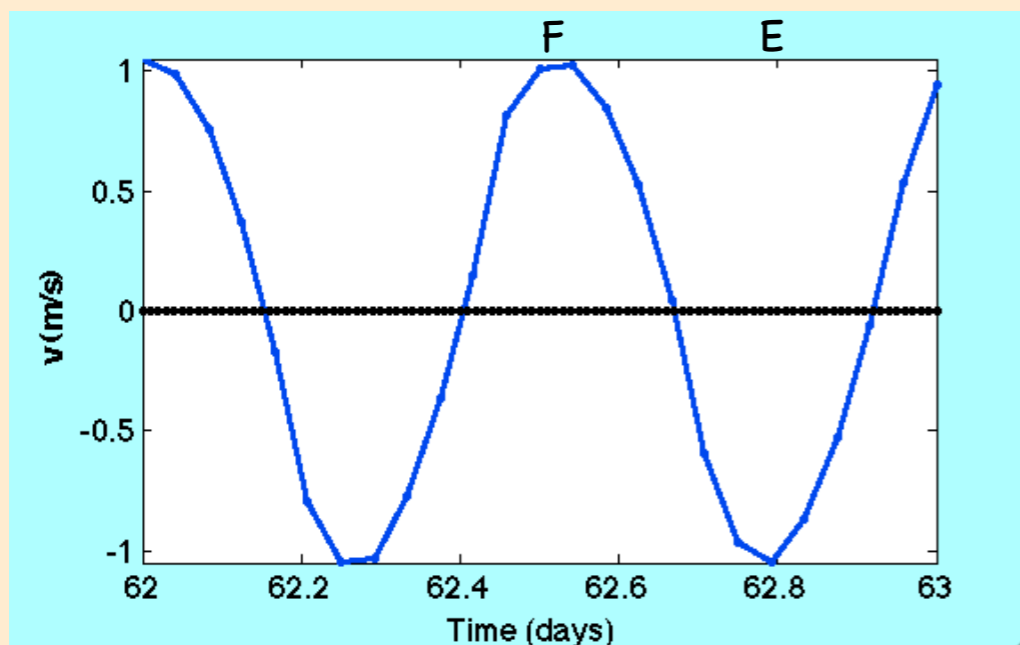
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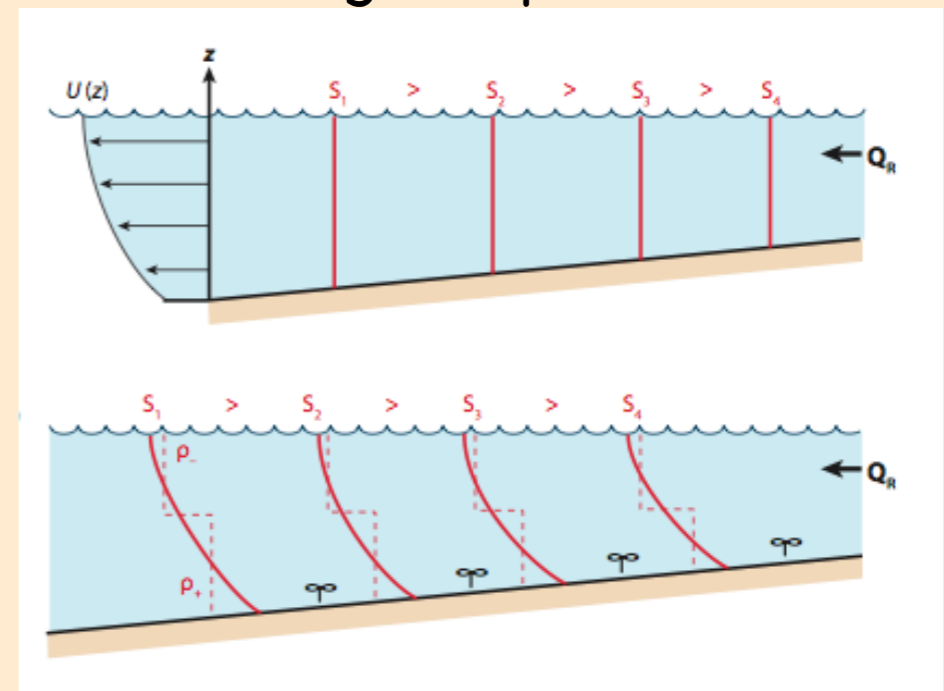
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Flood

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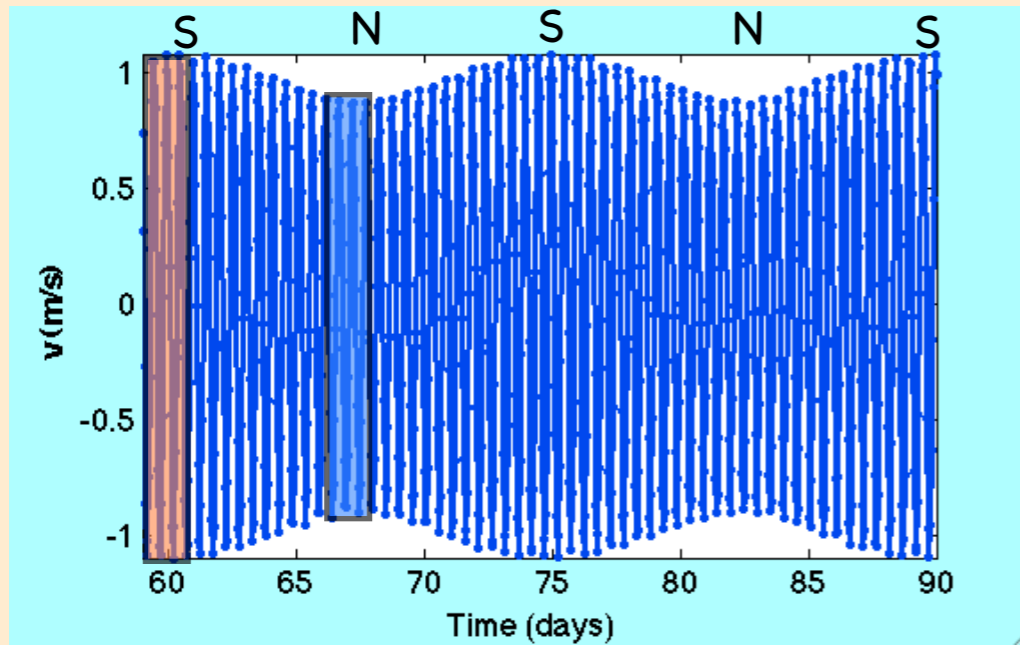
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What controls stratification in estuaries?

River discharge and tides

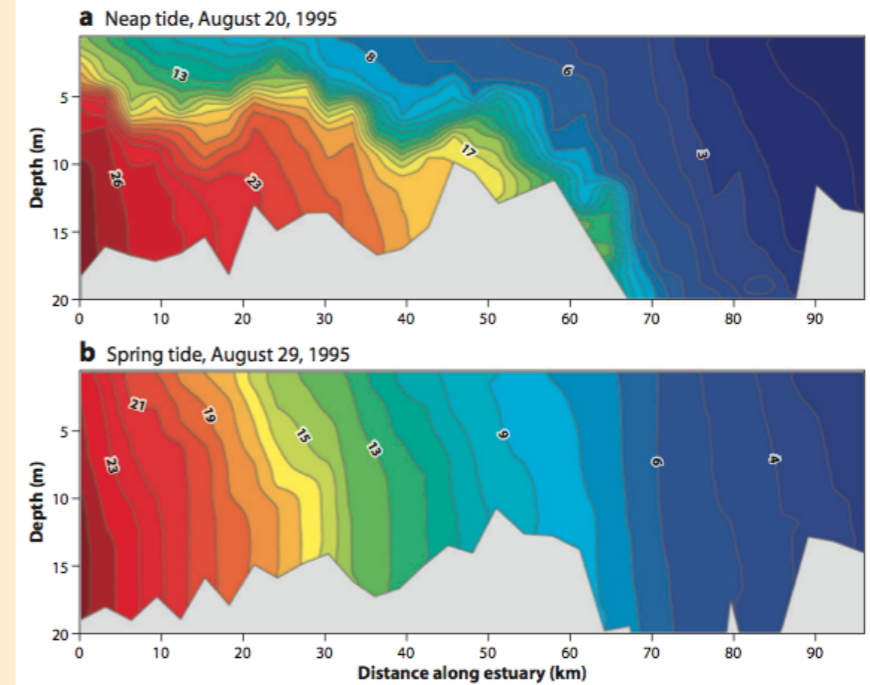
Spring-neap cycle



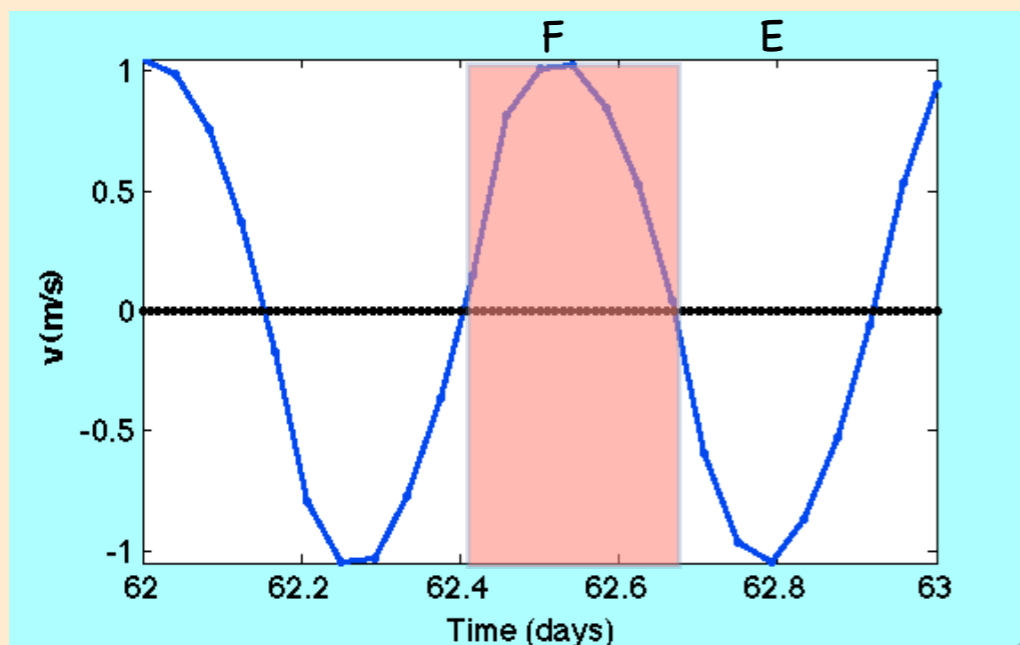
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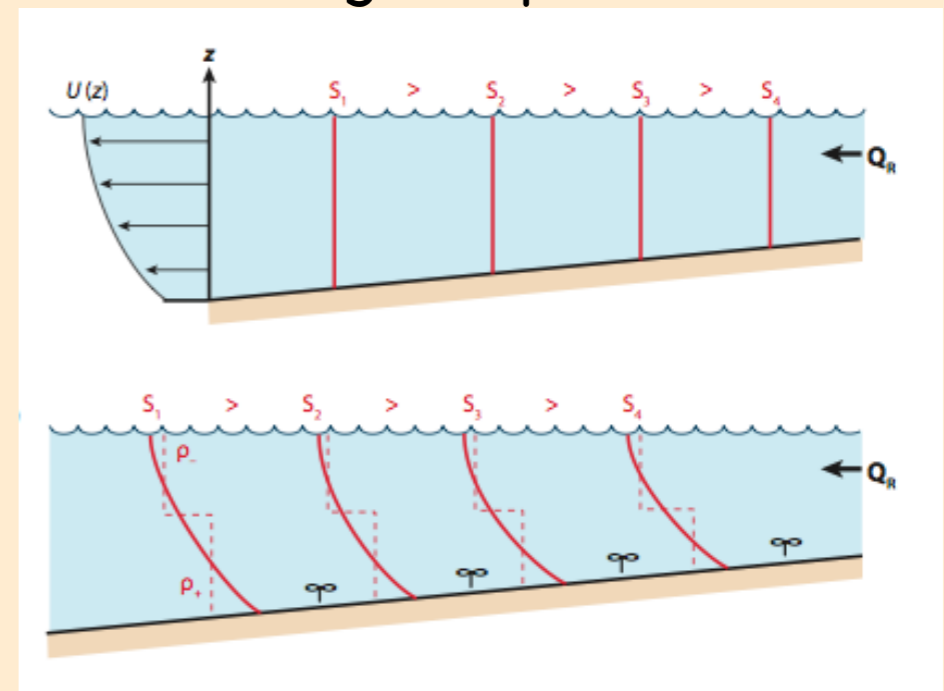
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Flood

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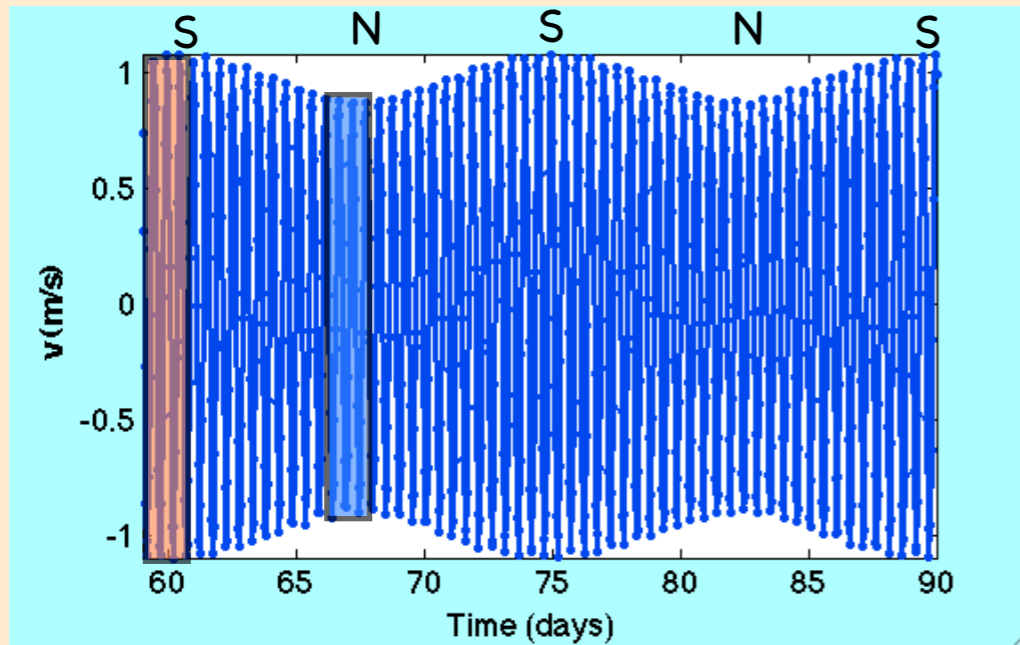
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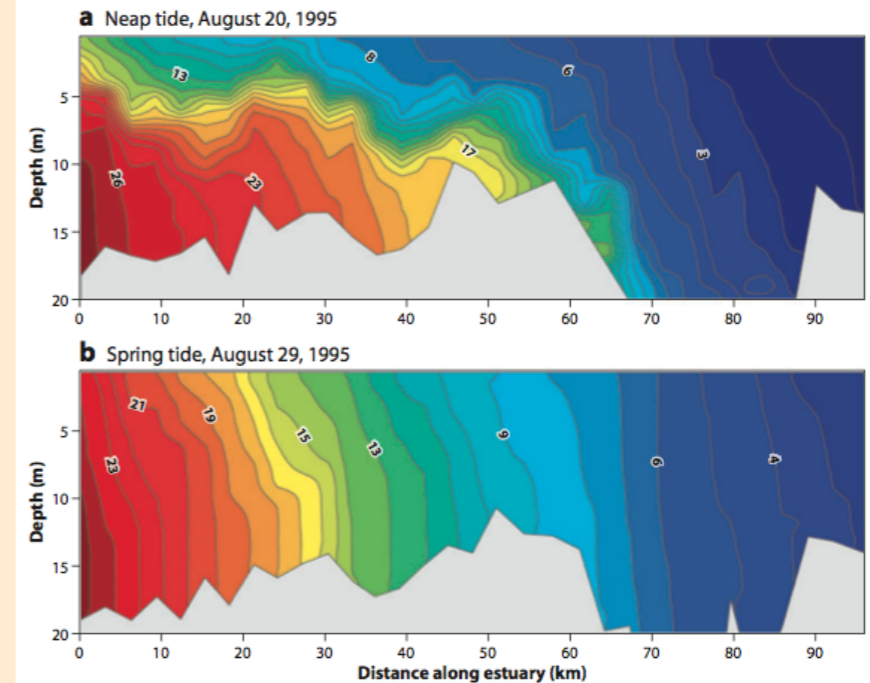
Spring-neap cycle



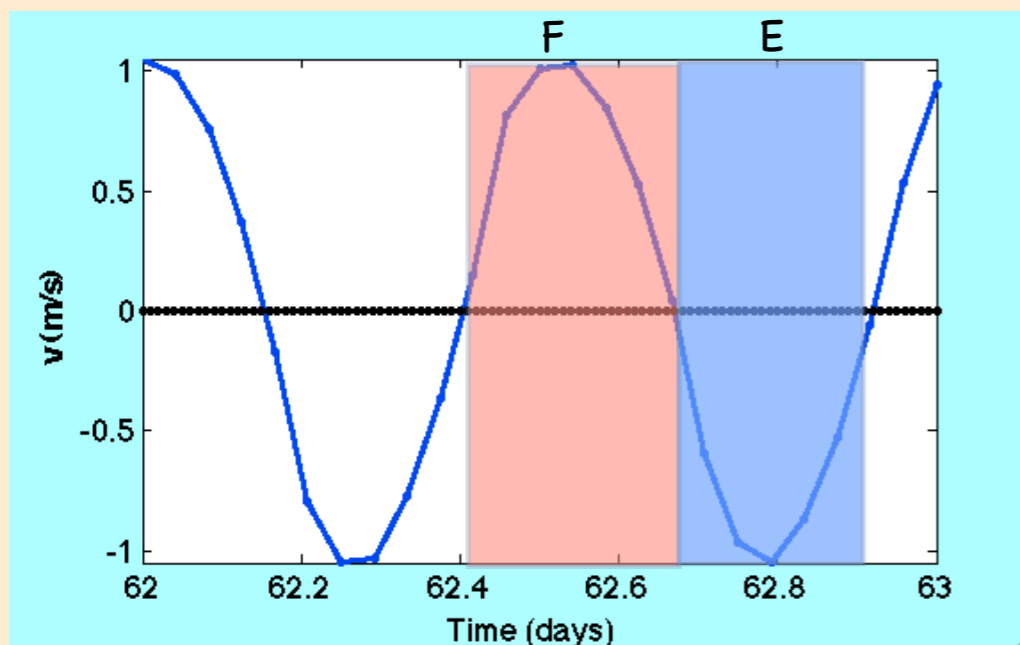
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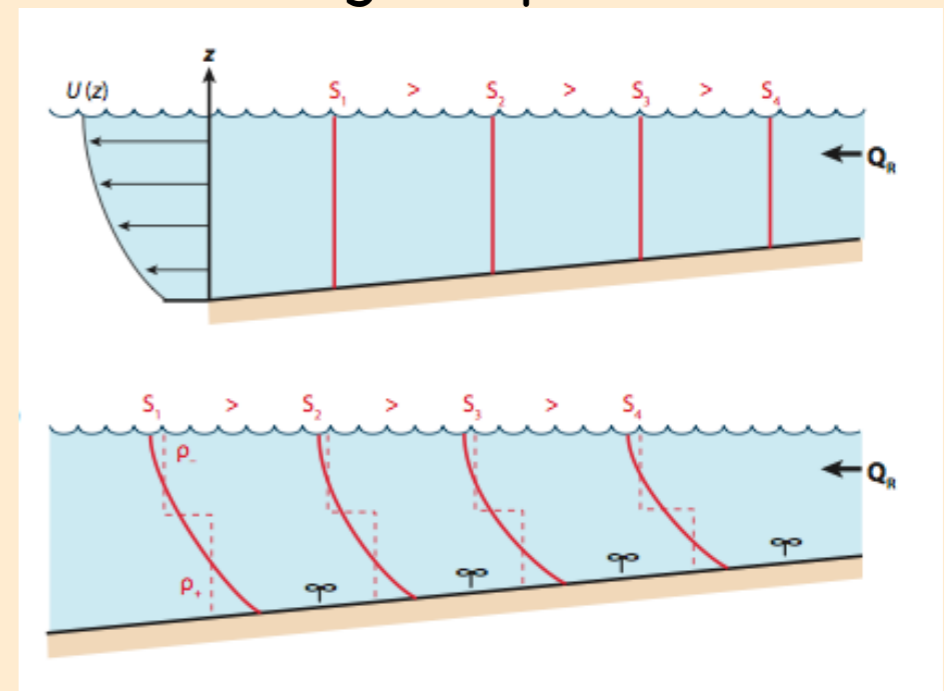
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Flood

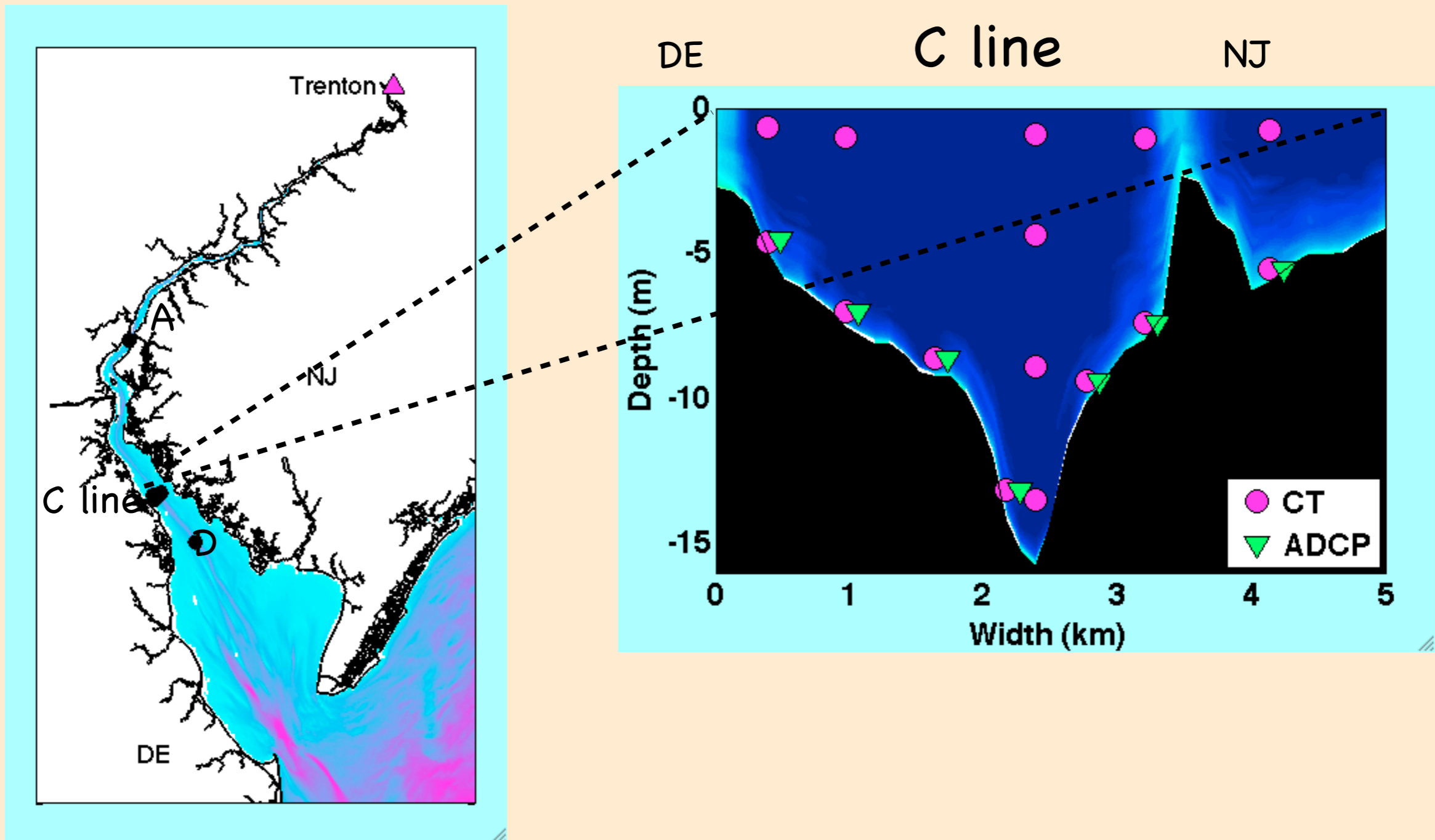
Ebb

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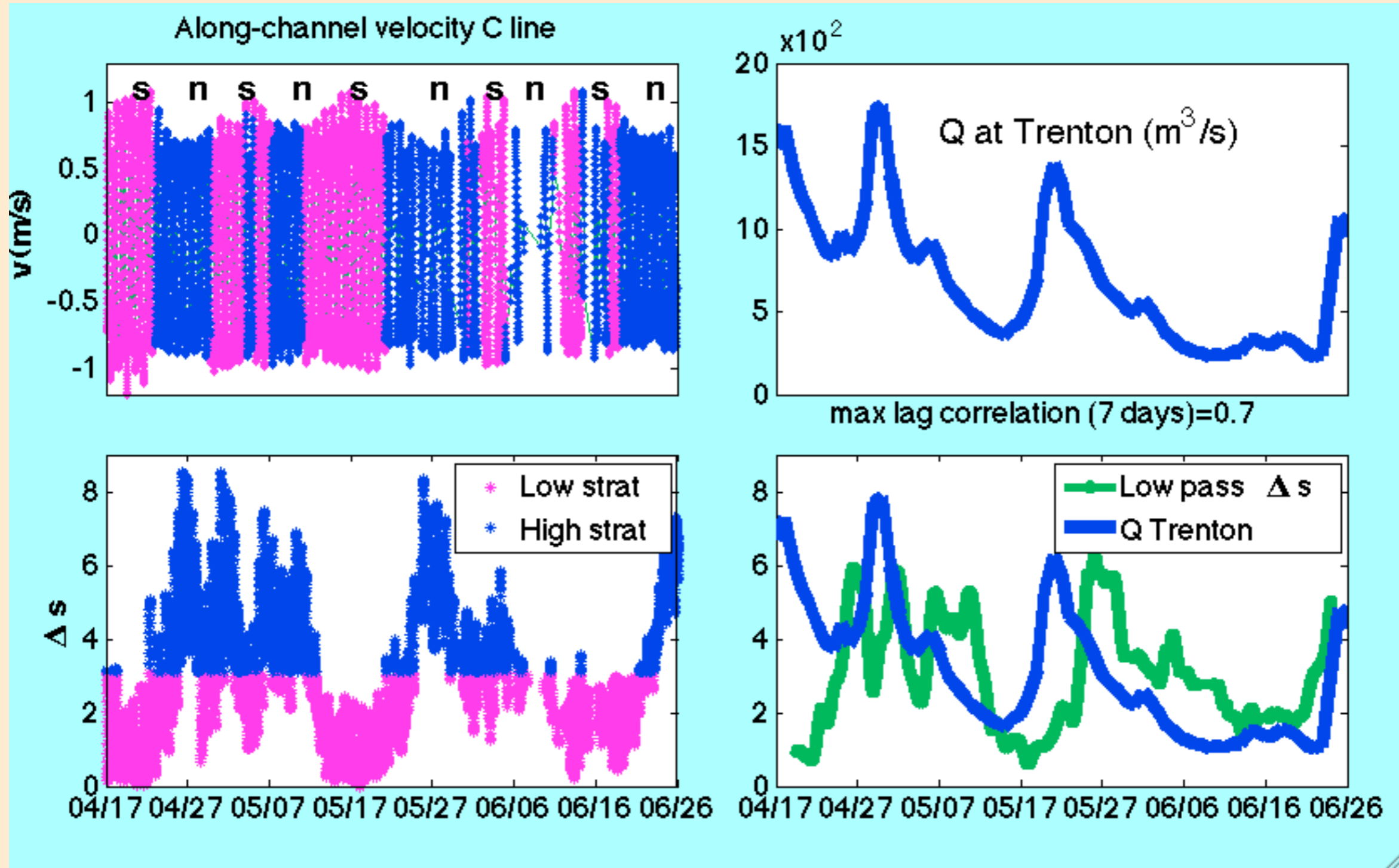


Methods

- Mooring arrays (March–June and July–Sept 2011) with CT sensor and current profilers.
- Cross-channel tidal surveys along the C line.

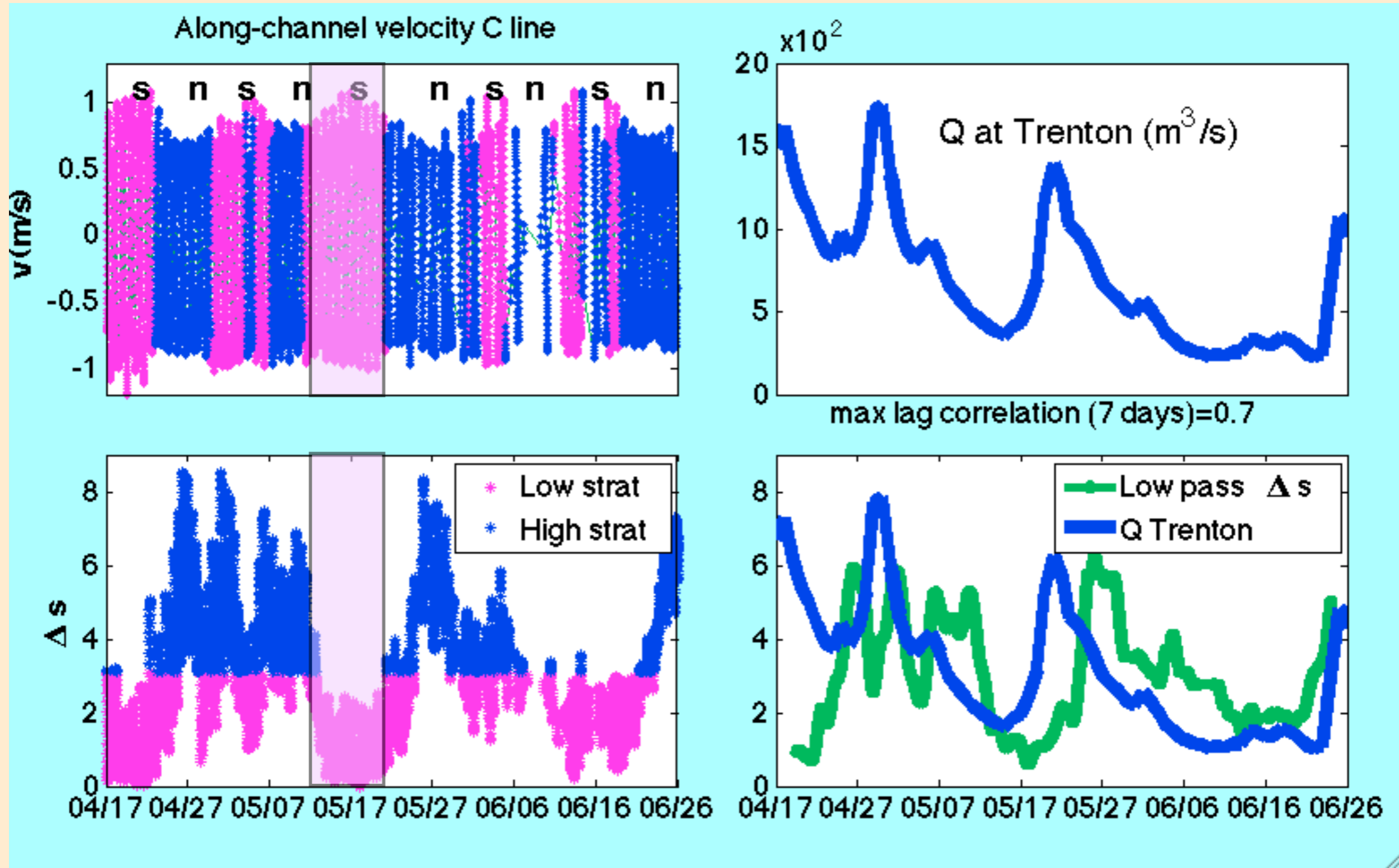


Results: Mooring data



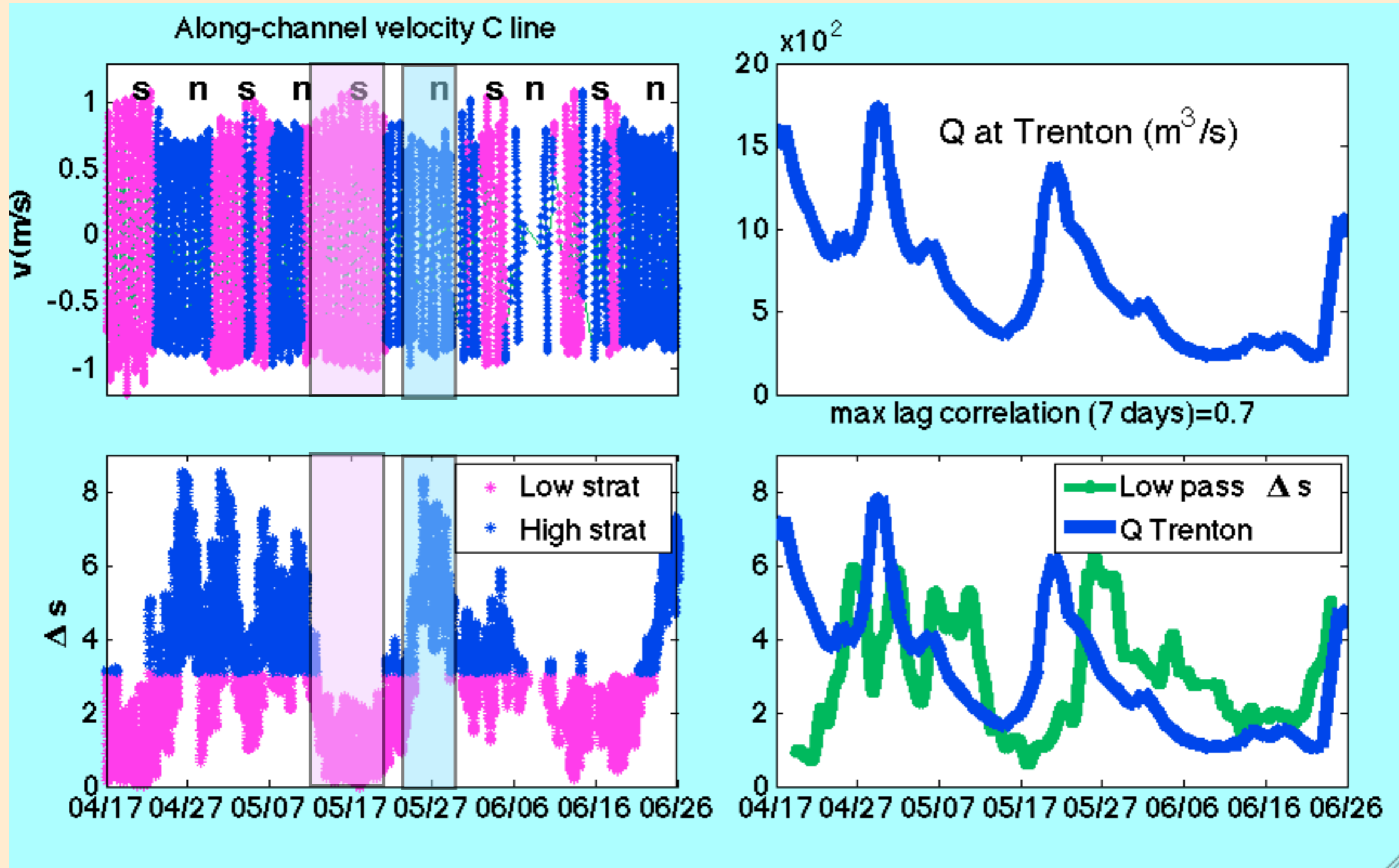
The subtidal variability in stratification is controlled not only by the spring-neap cycle but also by river discharge.

Results: Mooring data



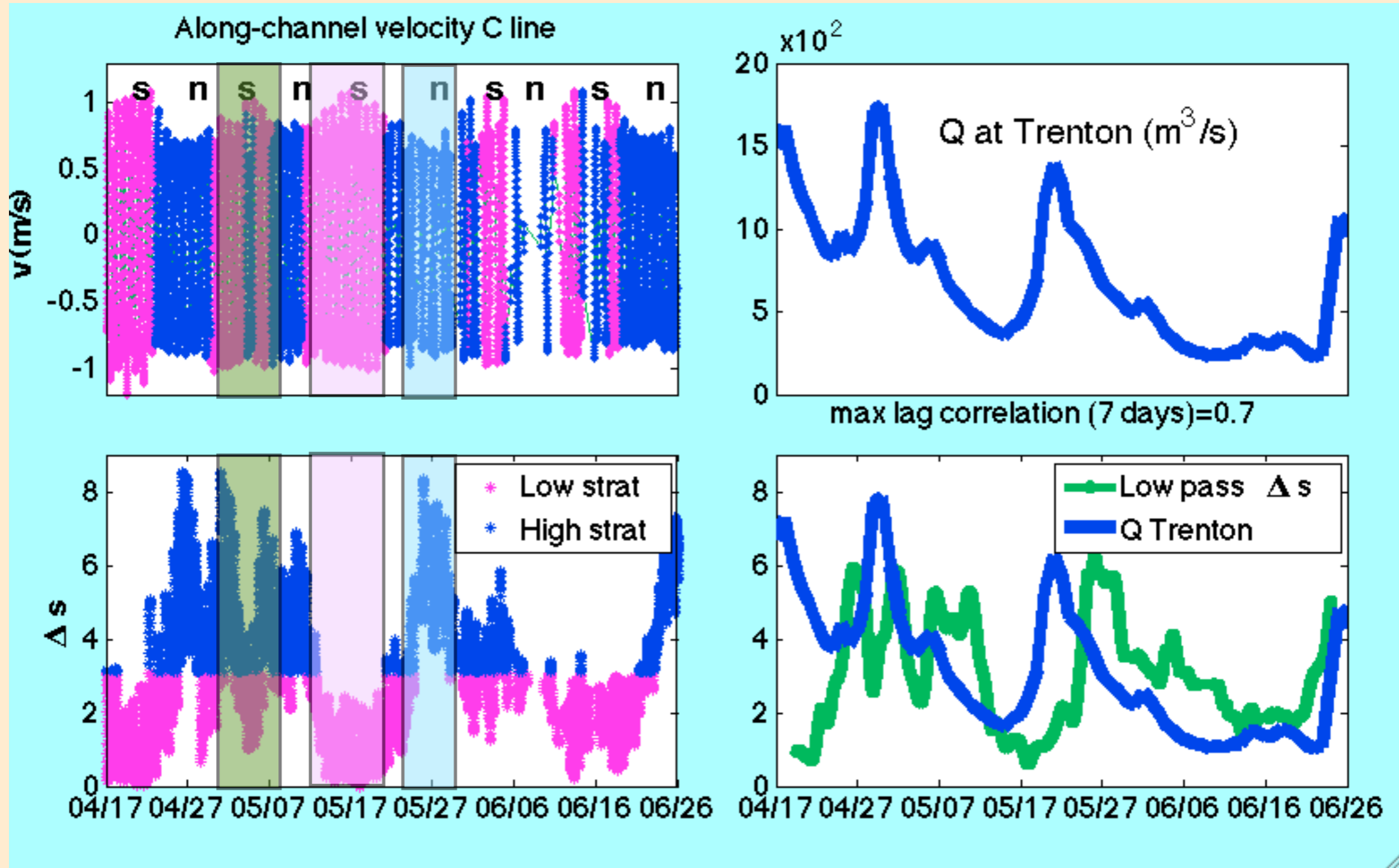
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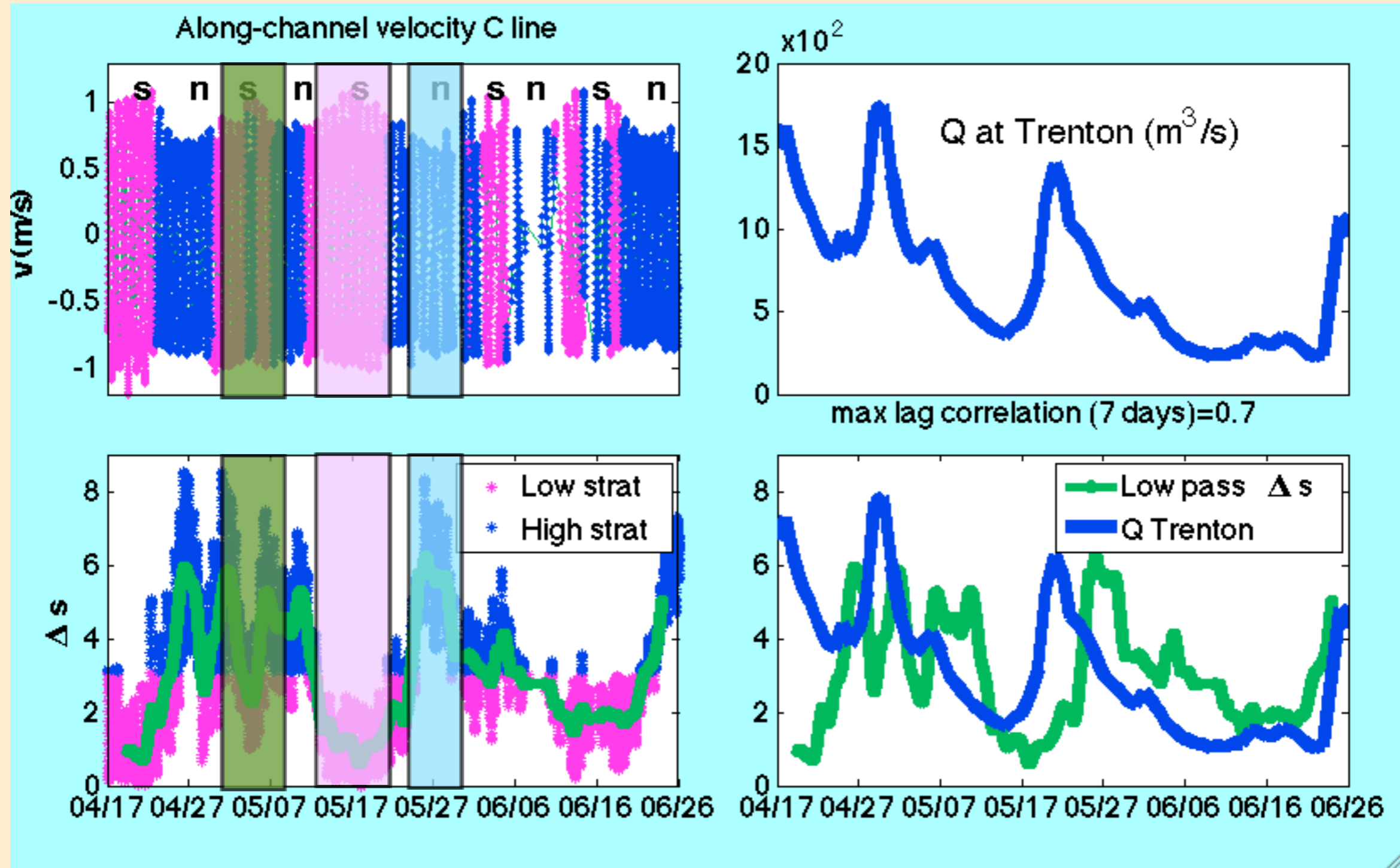
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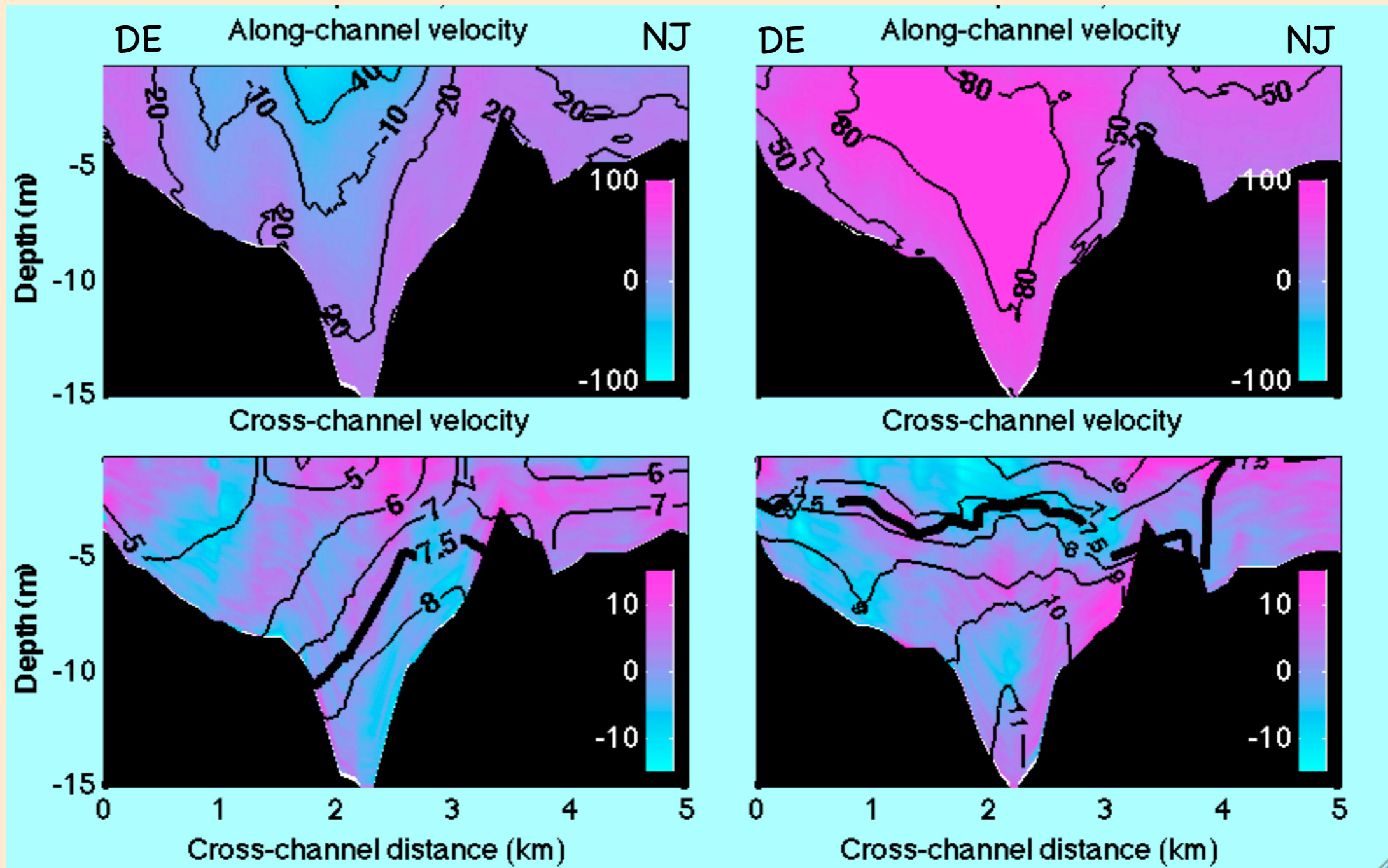


The subtidal variability in stratification is controlled not only by the spring-neap cycle but also by river discharge.

Results: Tidal Cycle surveys

Beginning of flood

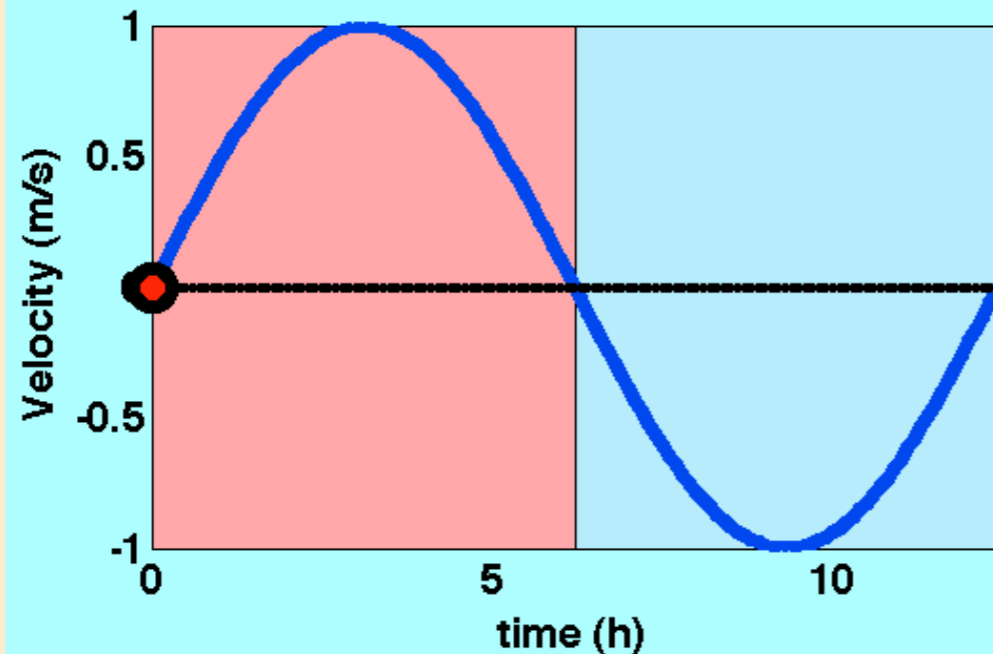
Towards end of flood



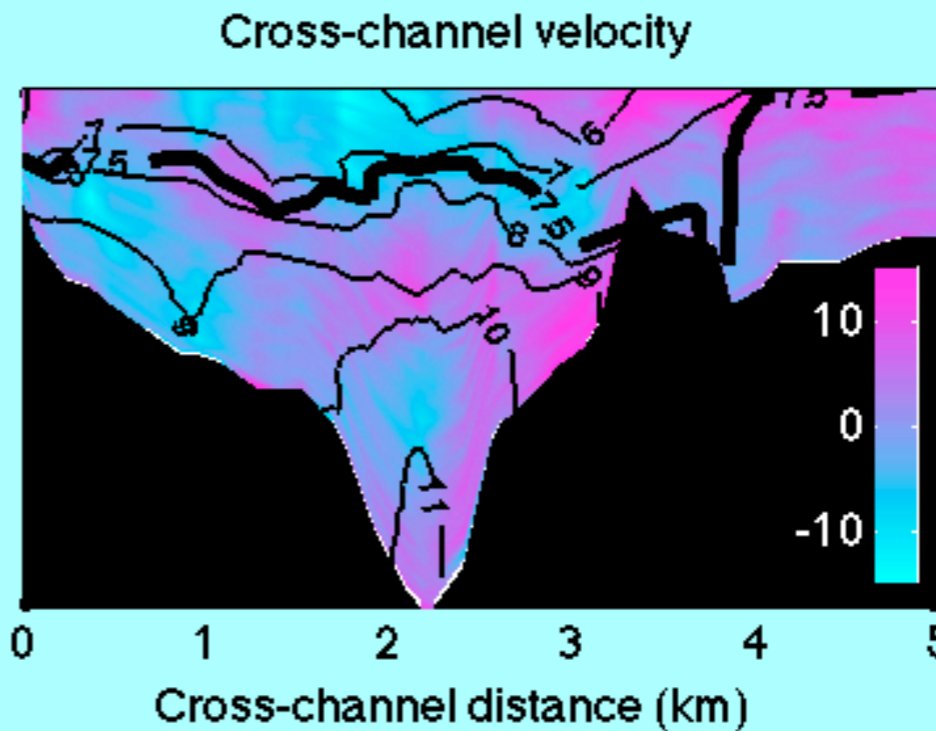
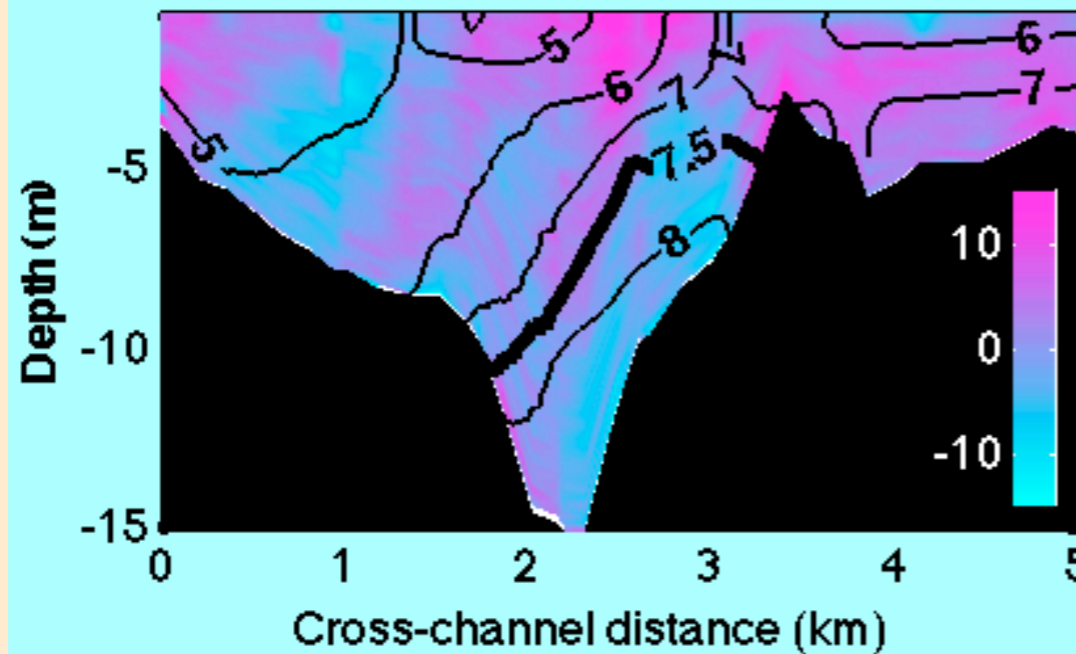
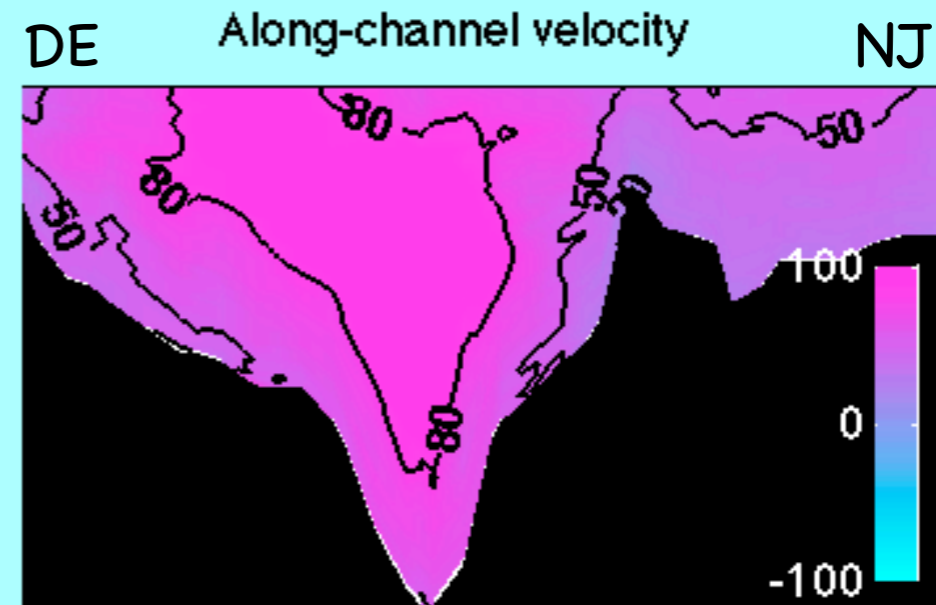
Stratification is reduced at the end of ebb and increased at the end of the flood tide.

Results: Tidal Cycle surveys

Beginning of flood

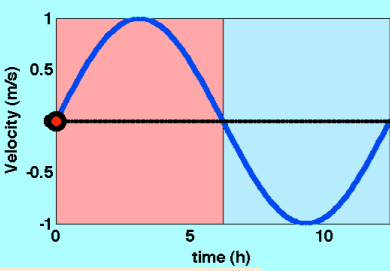


Towards end of flood



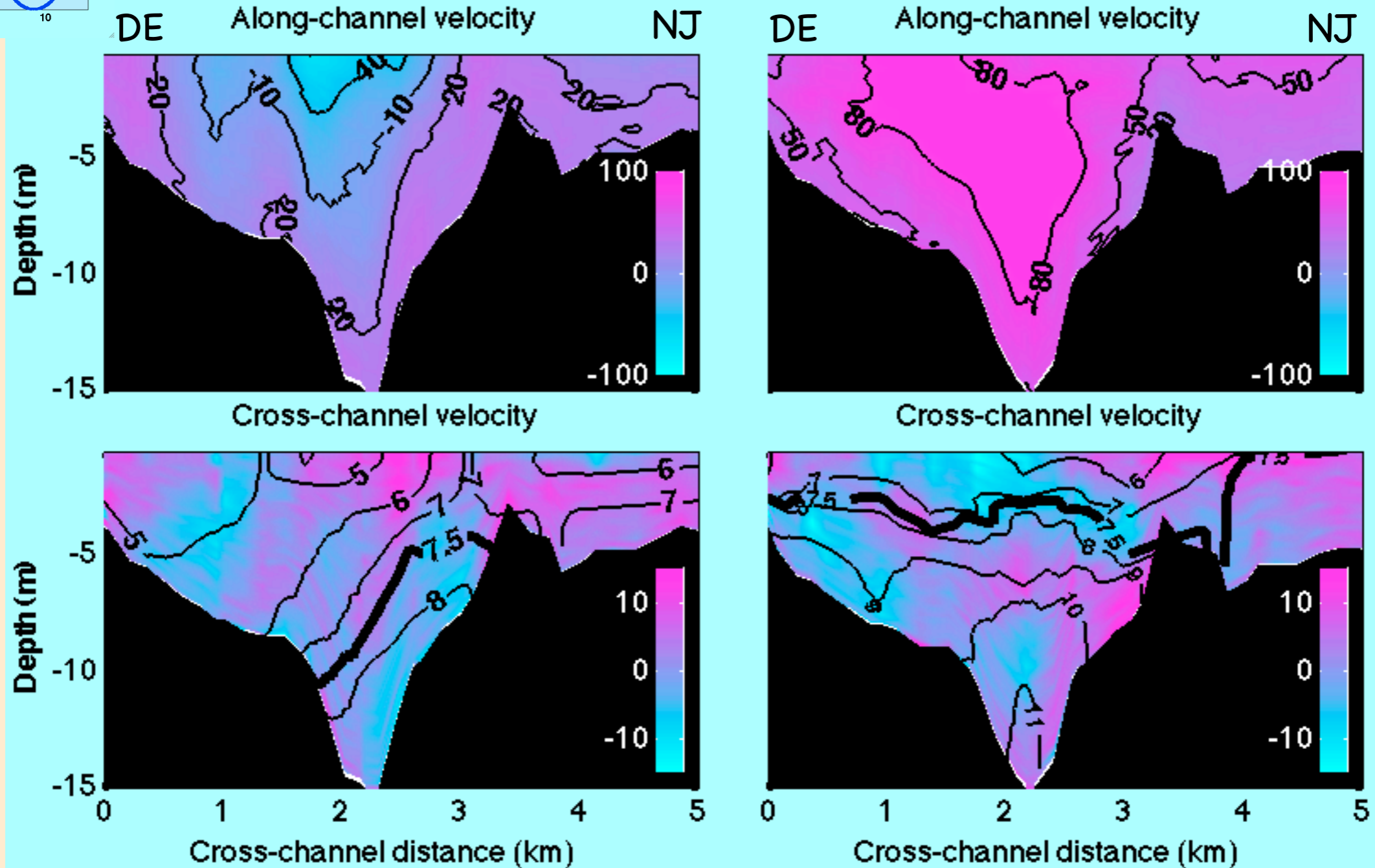
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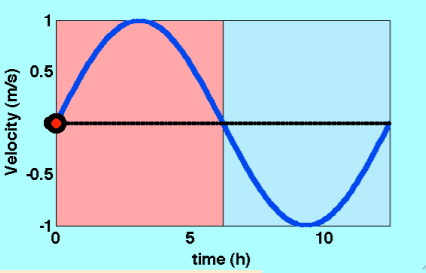
Beginning of flood

Towards end of flood



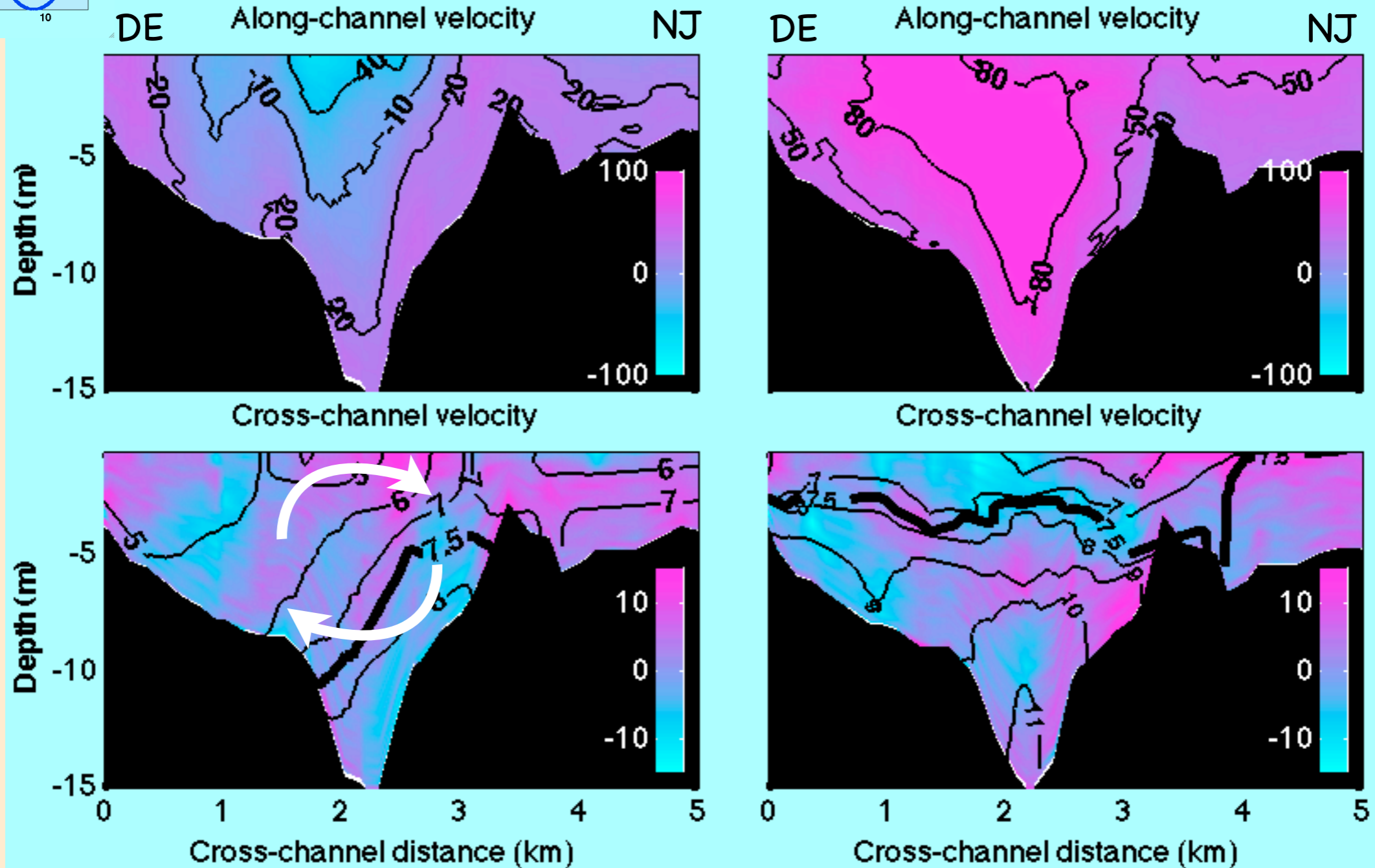
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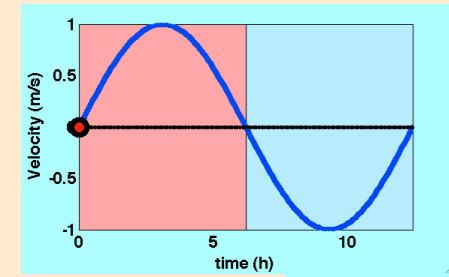
Beginning of flood

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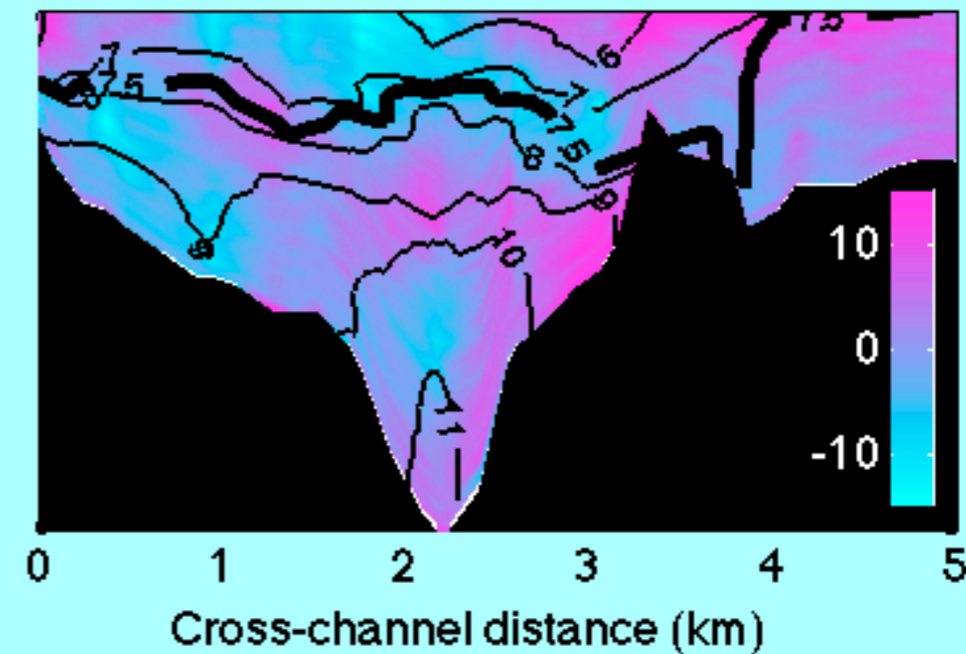
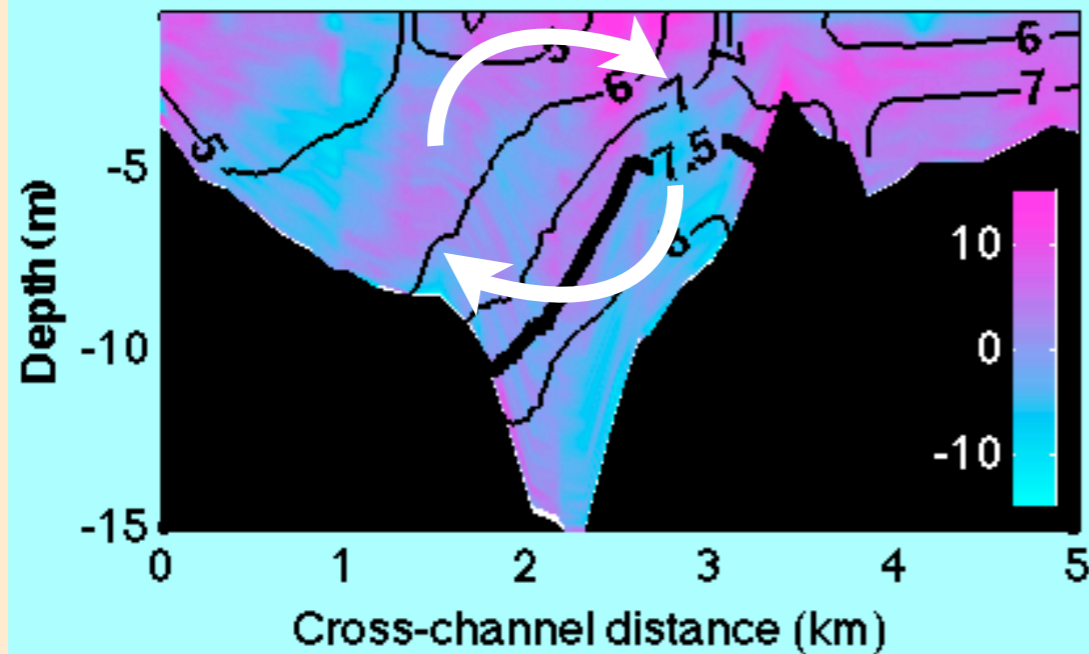
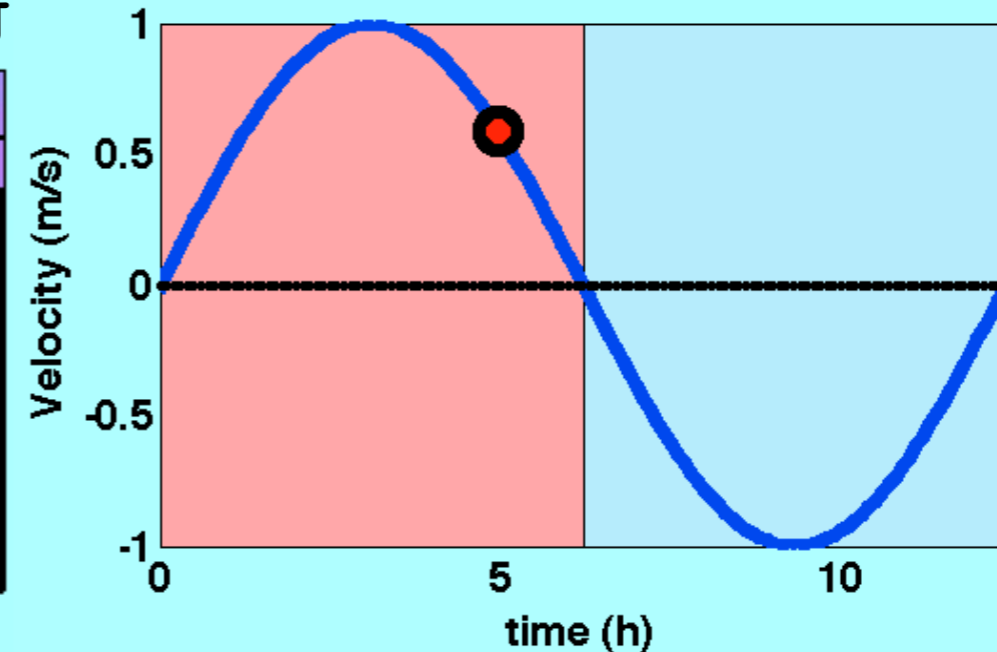
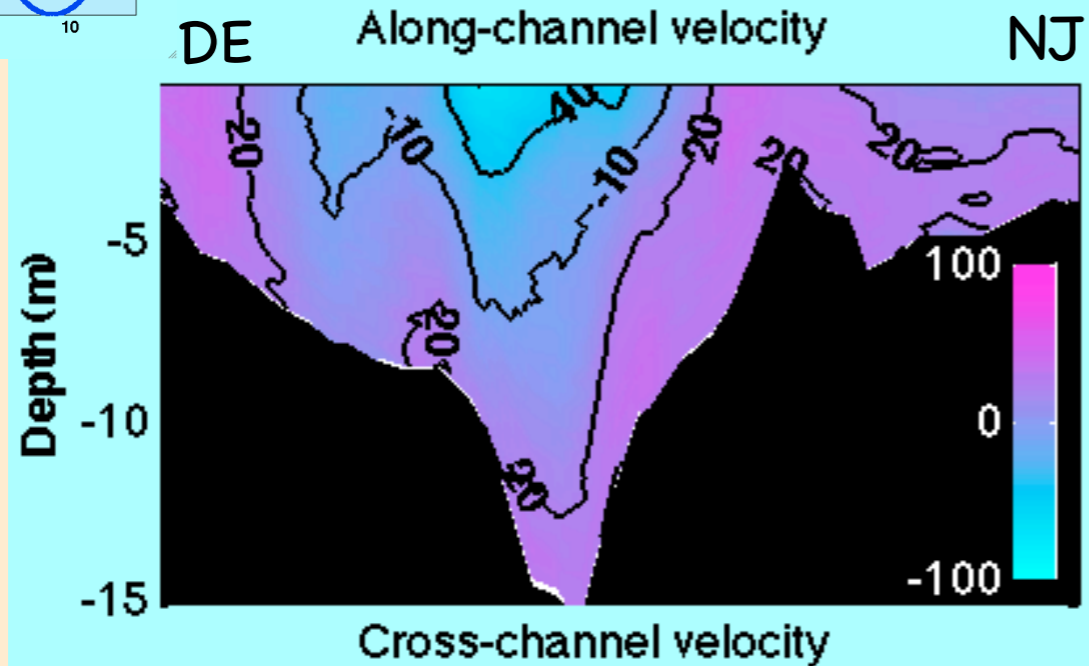
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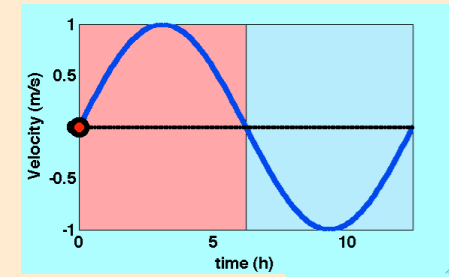
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Towards end of flood

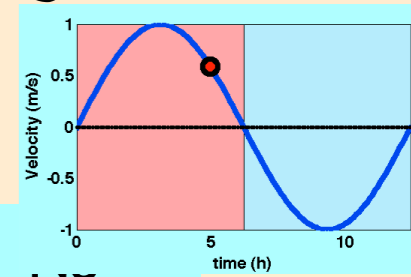


Stratification is reduced at the end of ebb and increased at the end of the food tide.

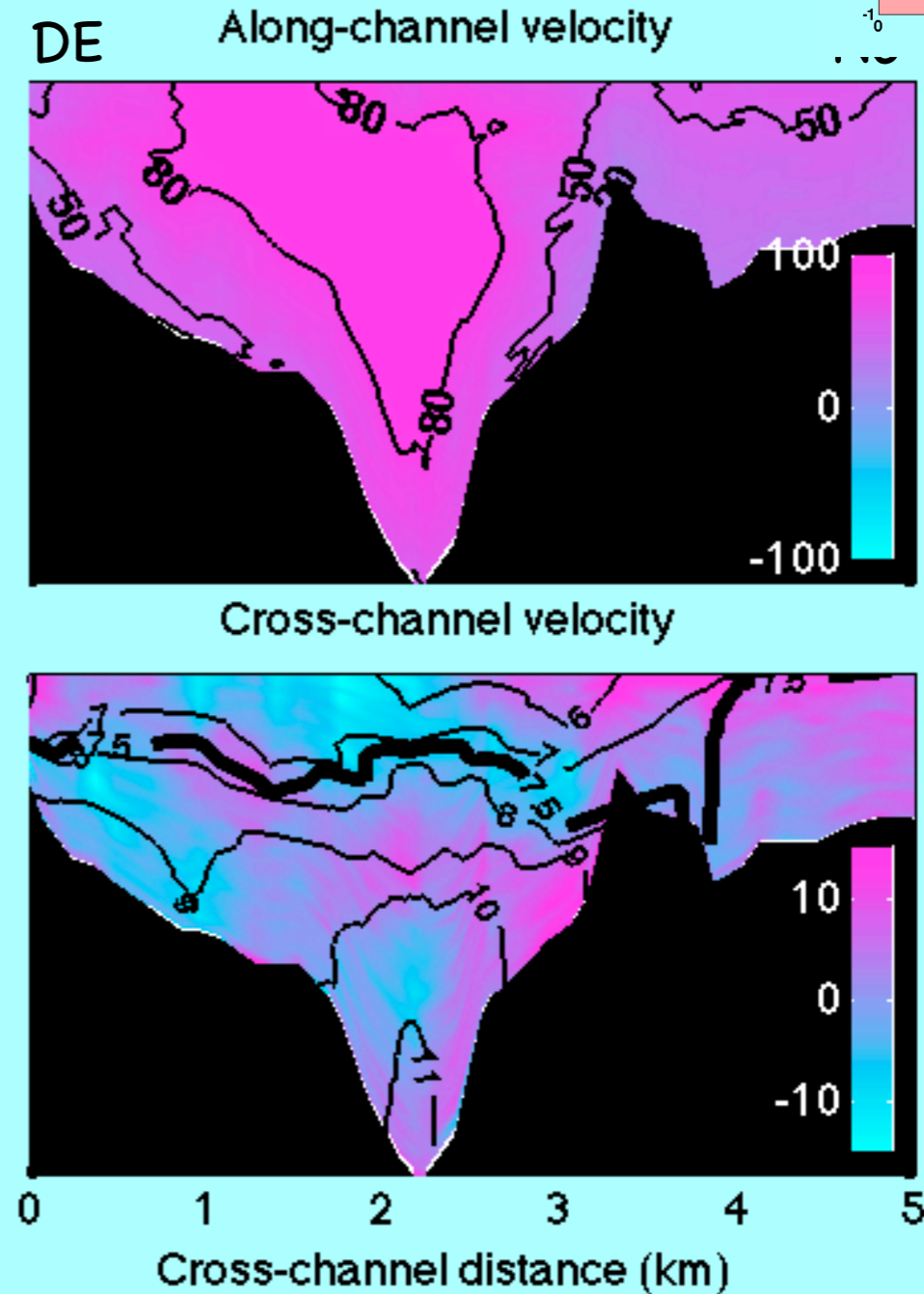
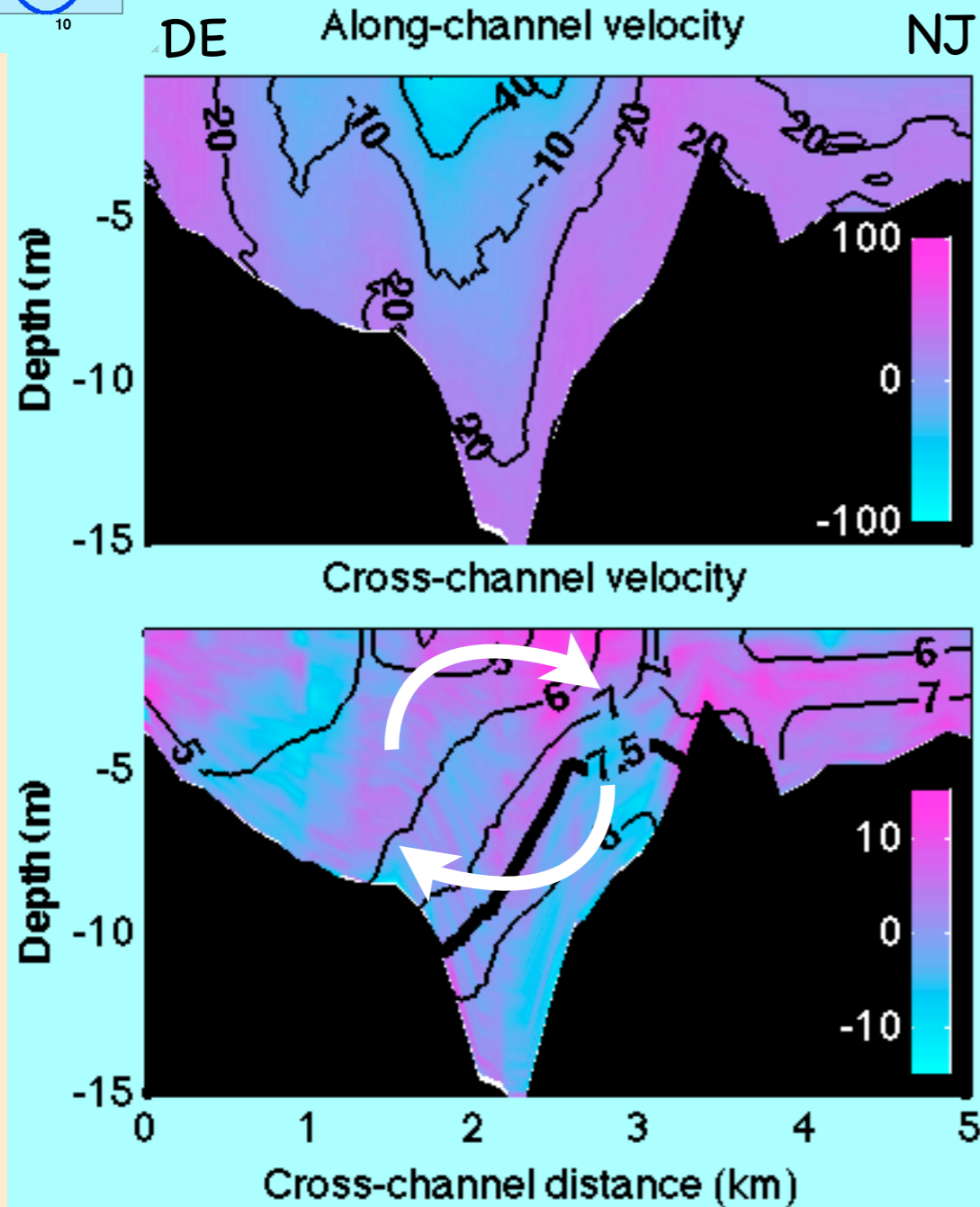
Results: Tidal Cycle surveys



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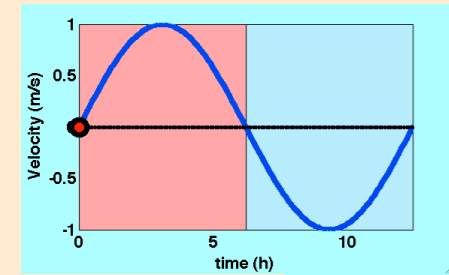


Towards end of flood



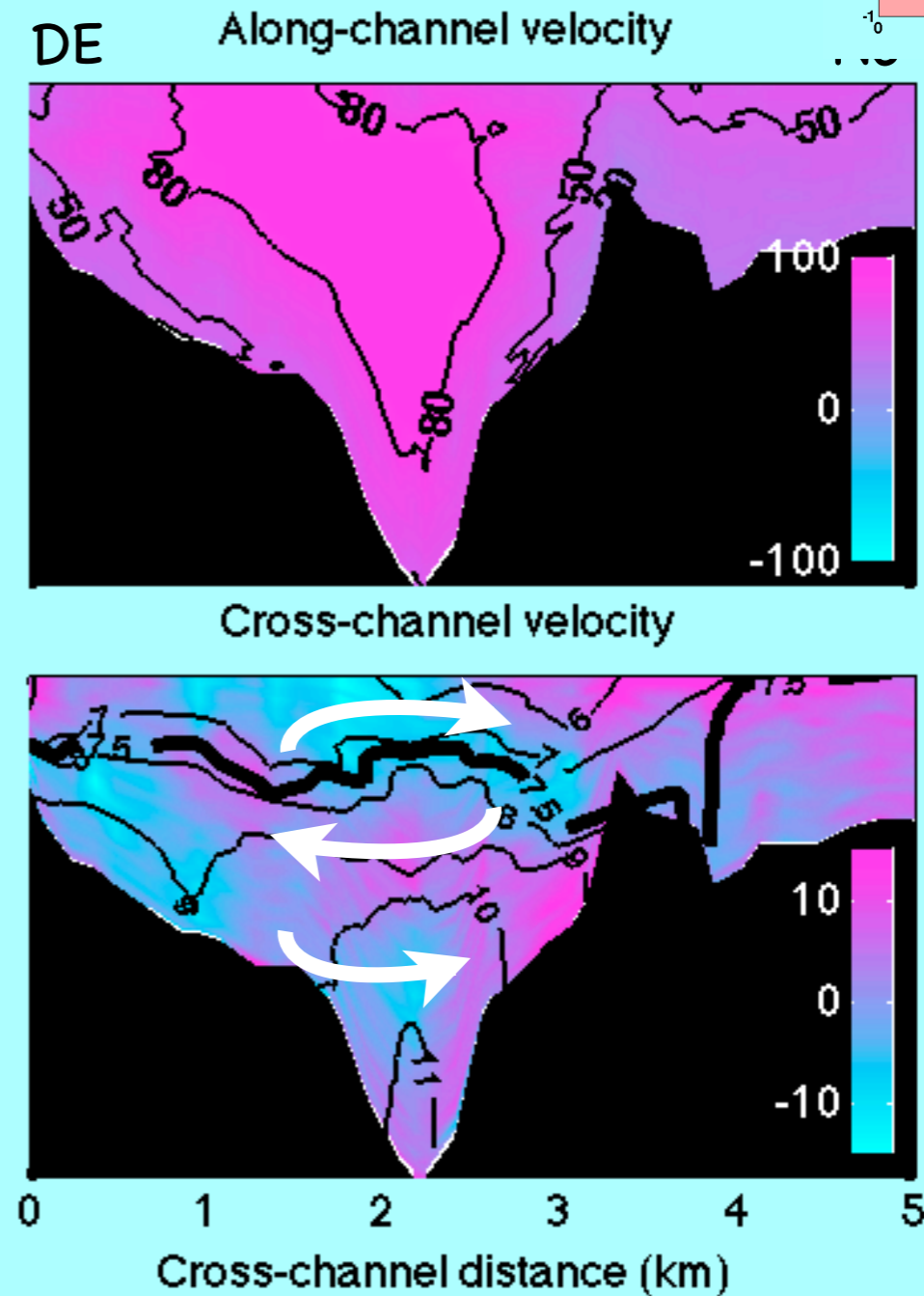
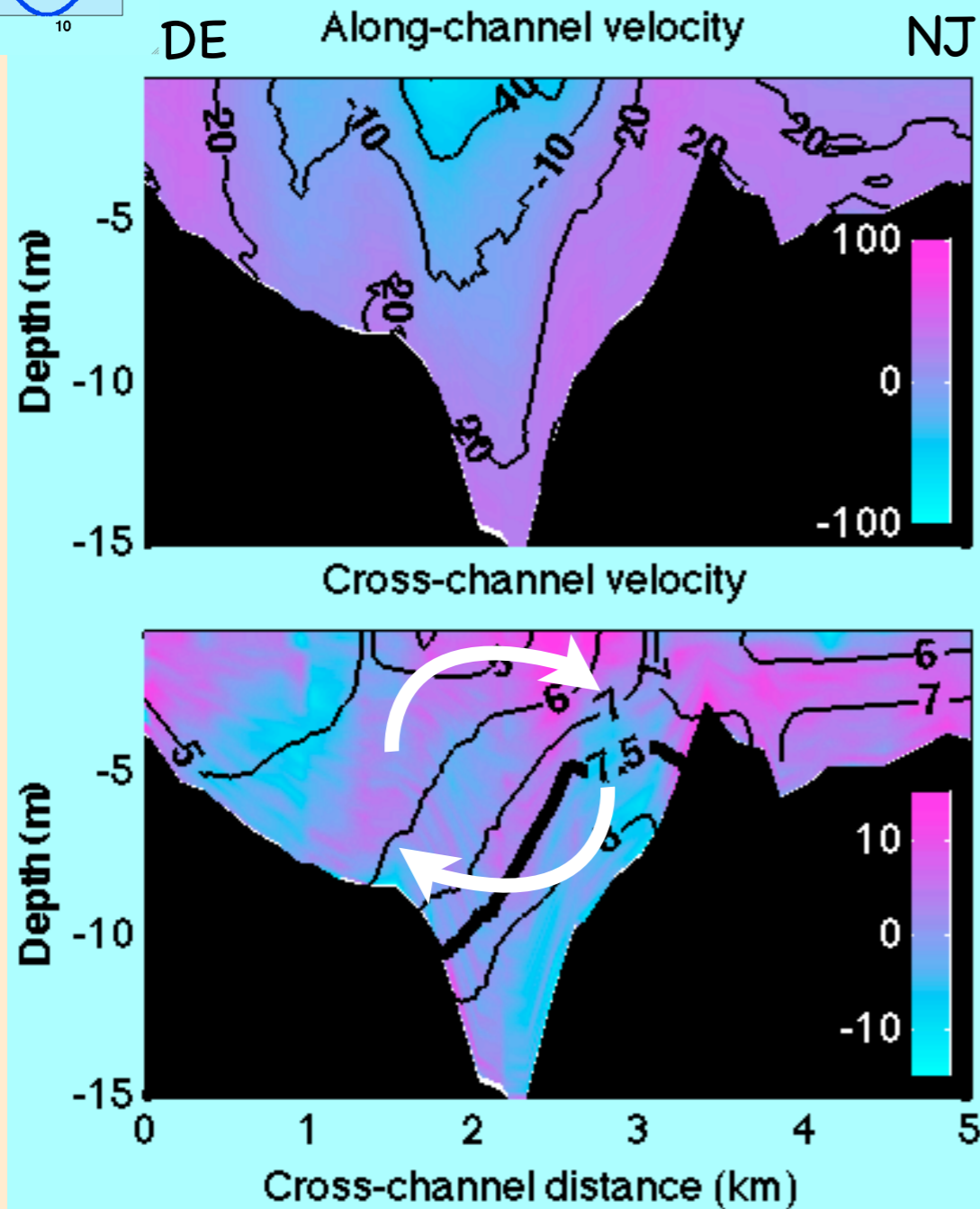
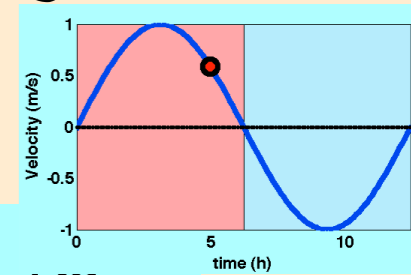
Stratification is reduced at the end of ebb and increased at the end of the food tide.

Results: Tidal Cycle surveys



Beginning of flood

Towards end of flood

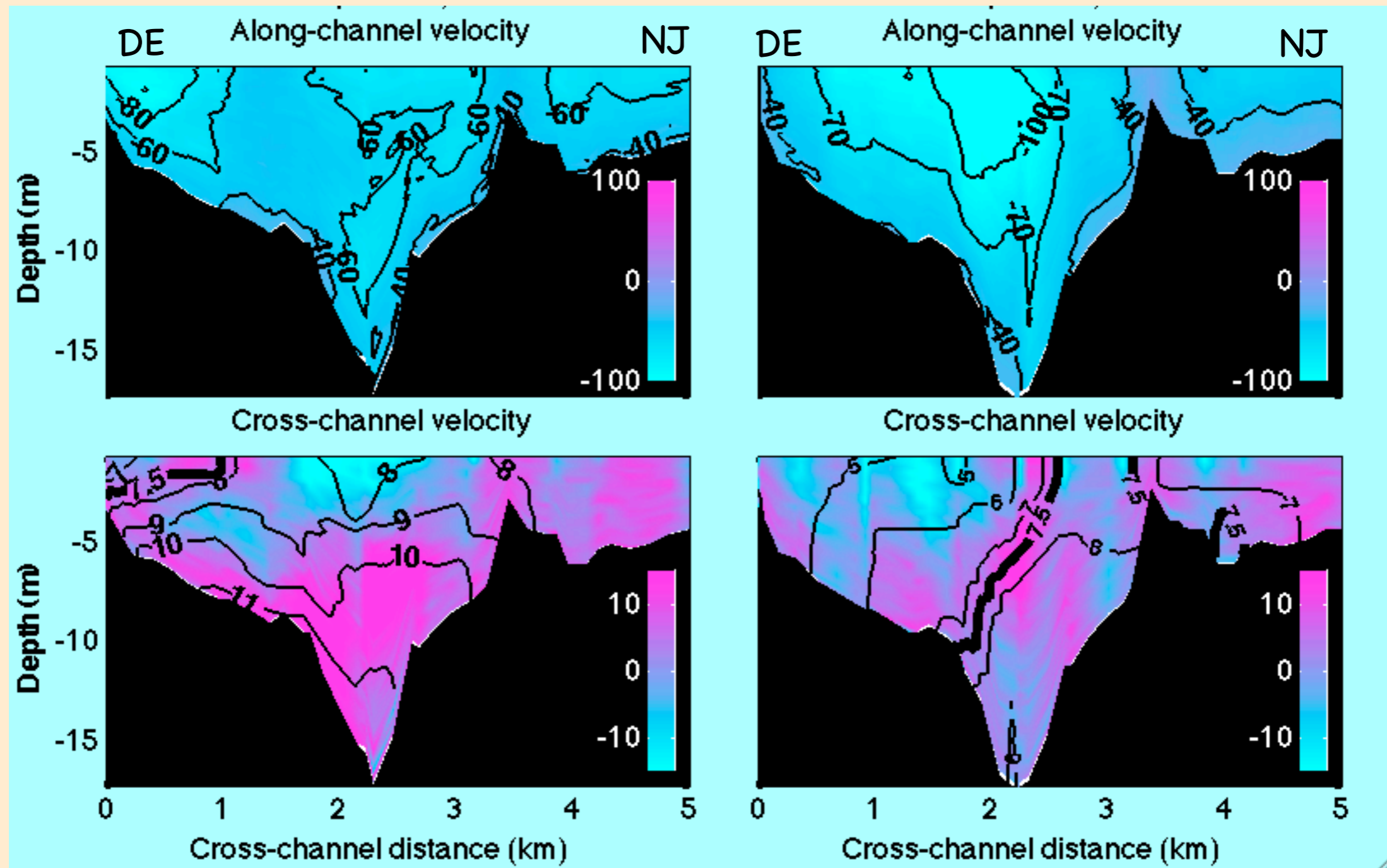


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Results: Tidal Cycle surveys

Beginning of ebb

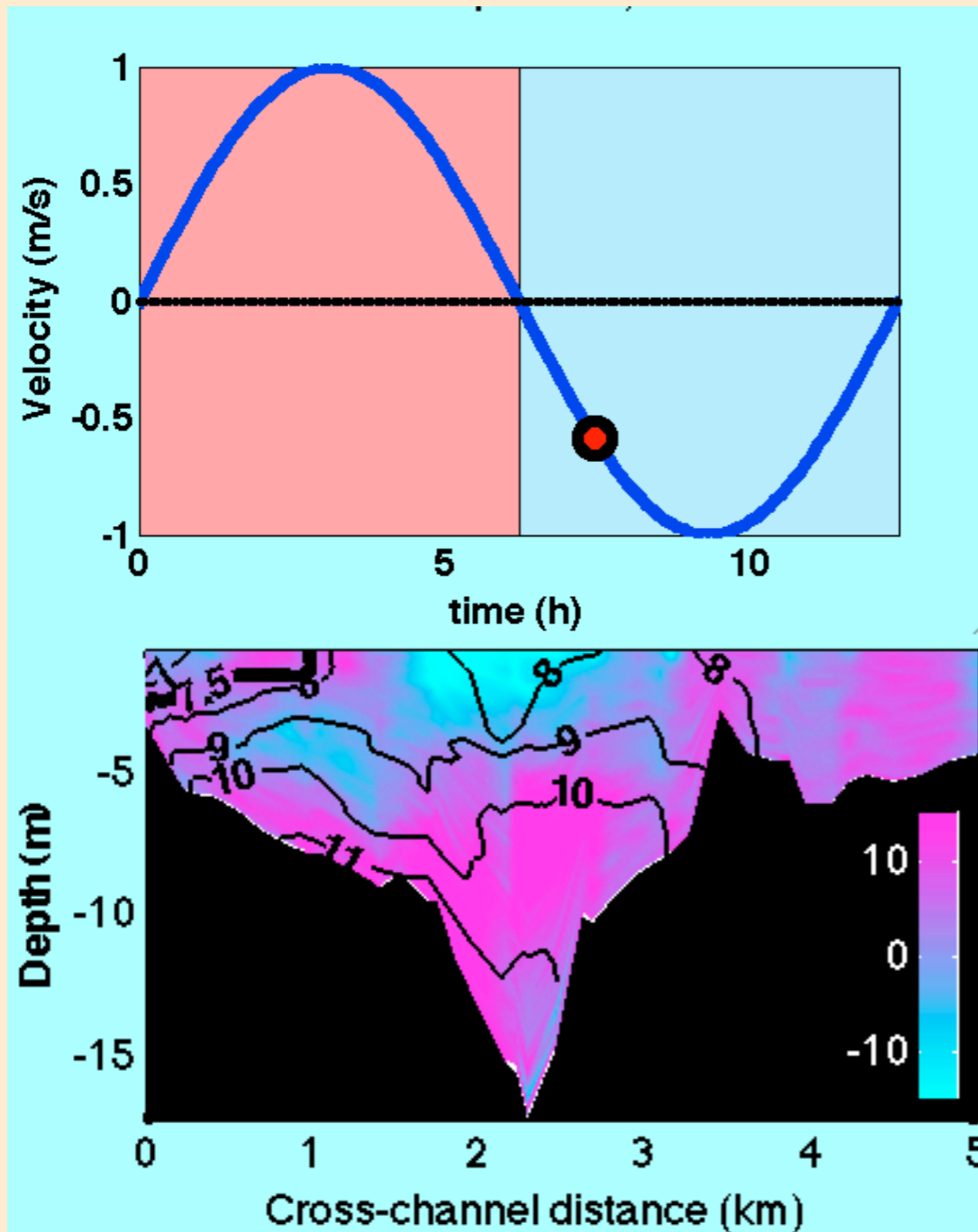
Towards end of ebb



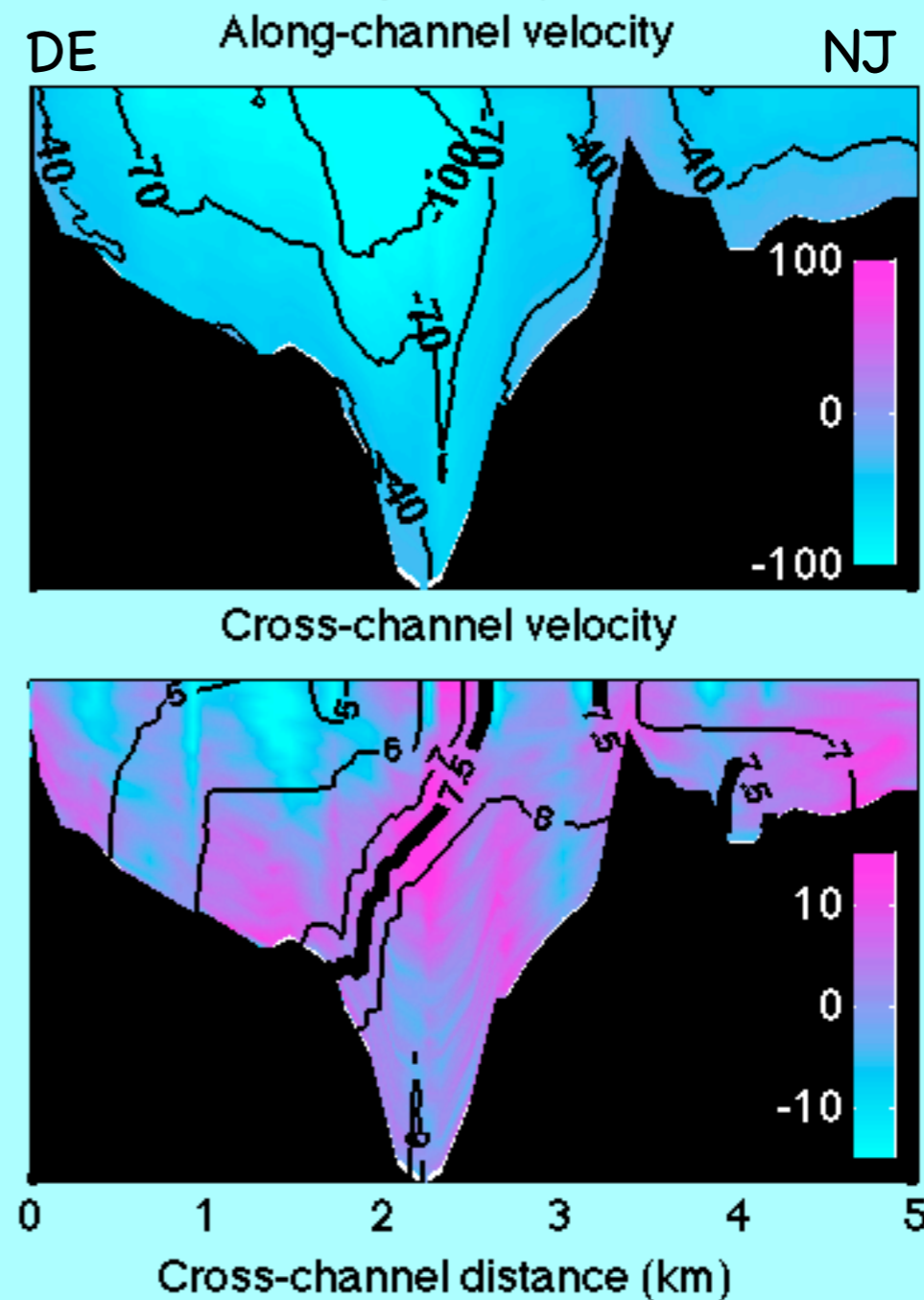
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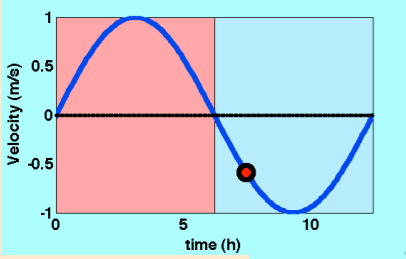


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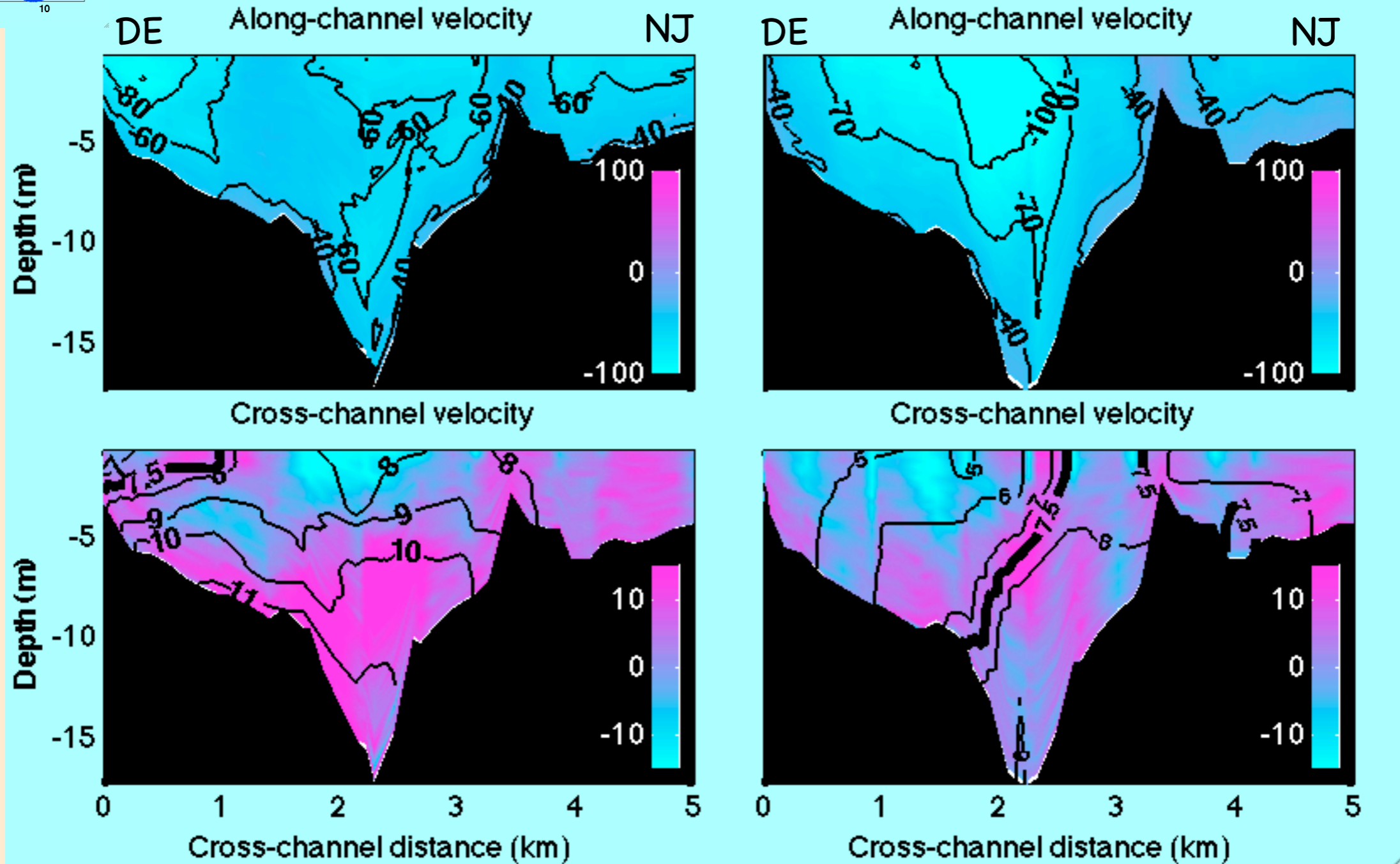
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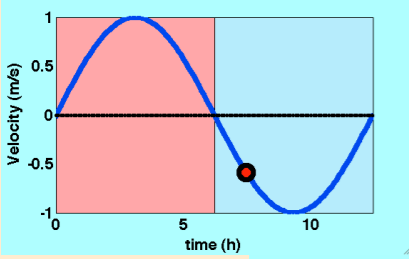
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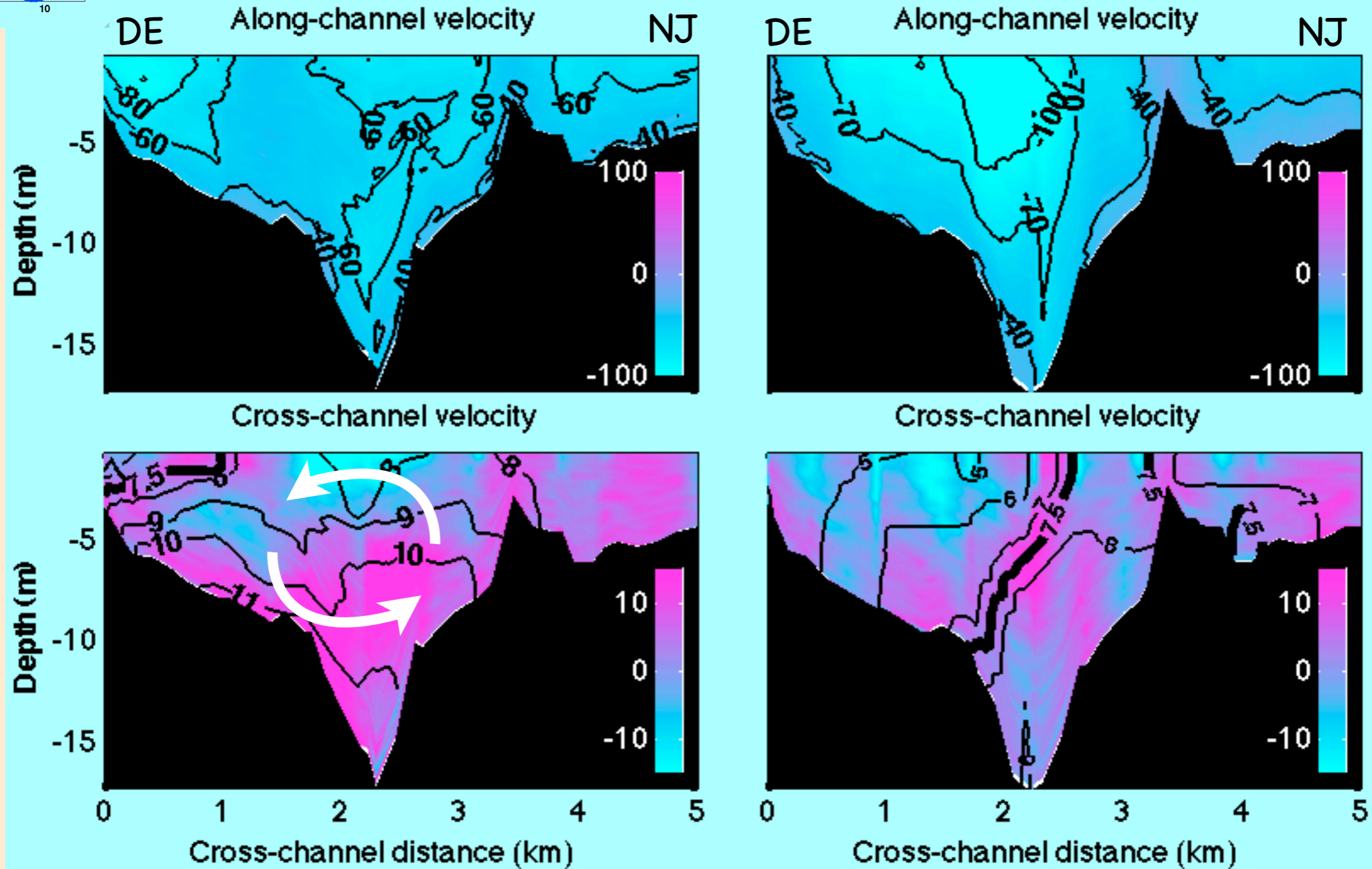
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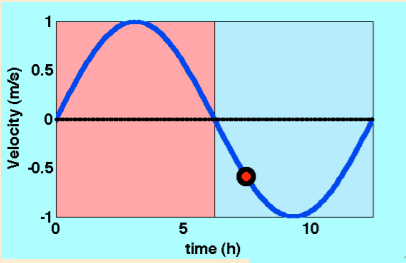
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Towards end of ebb



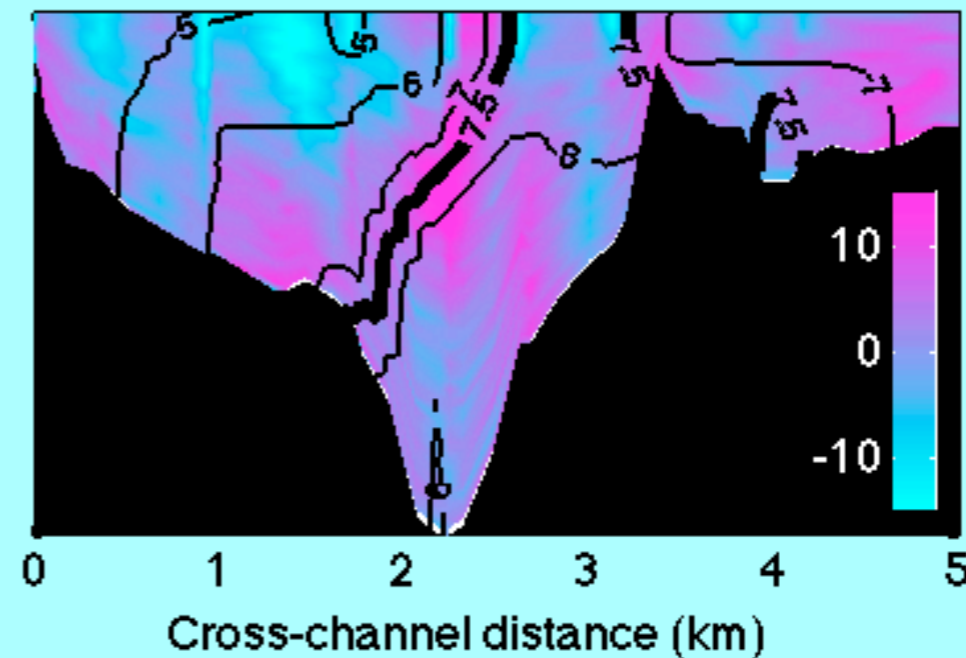
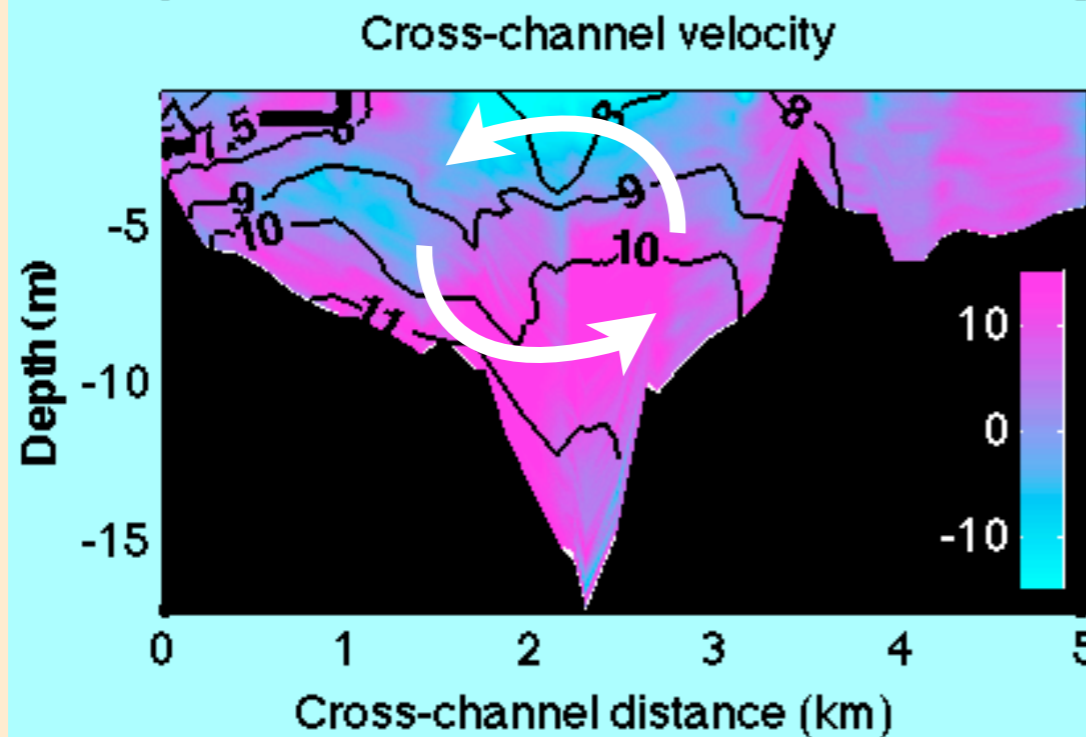
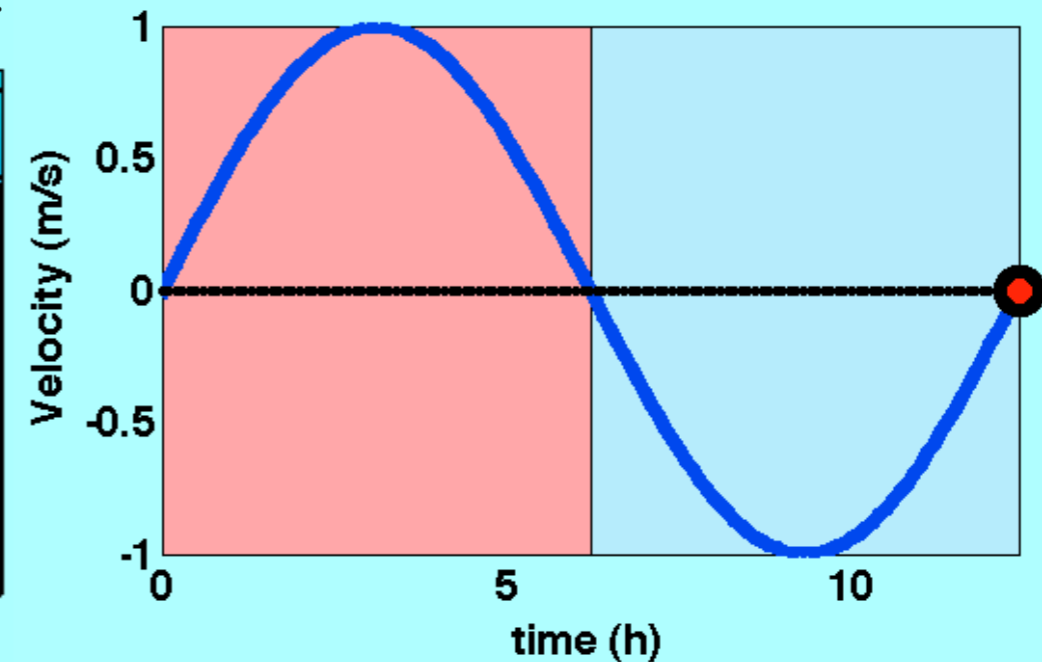
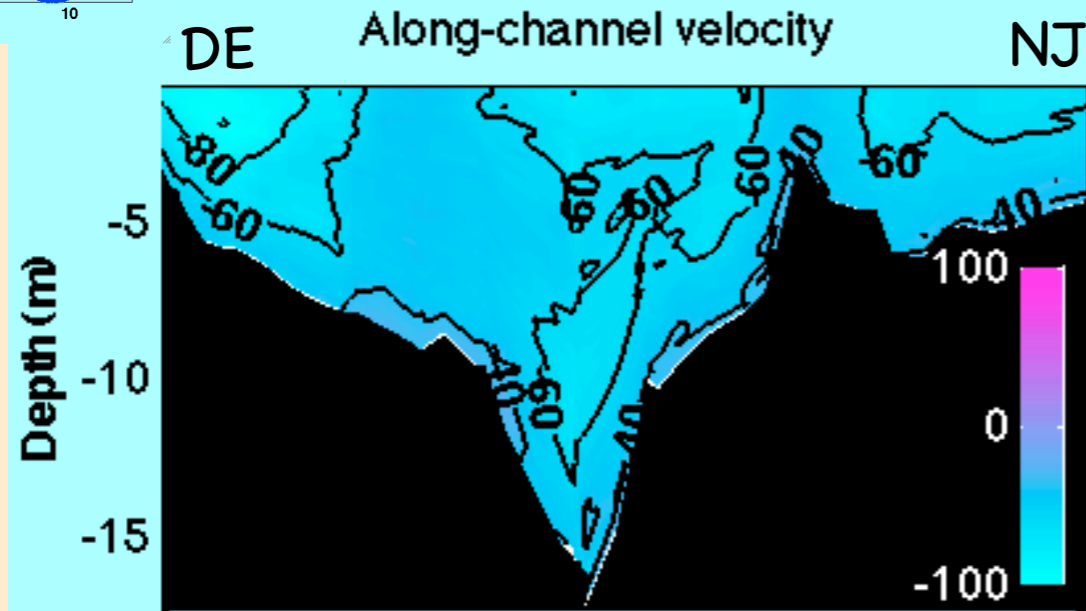
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Results: Tidal Cycle surveys



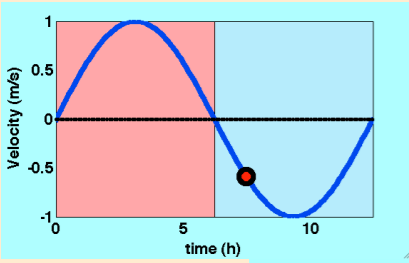
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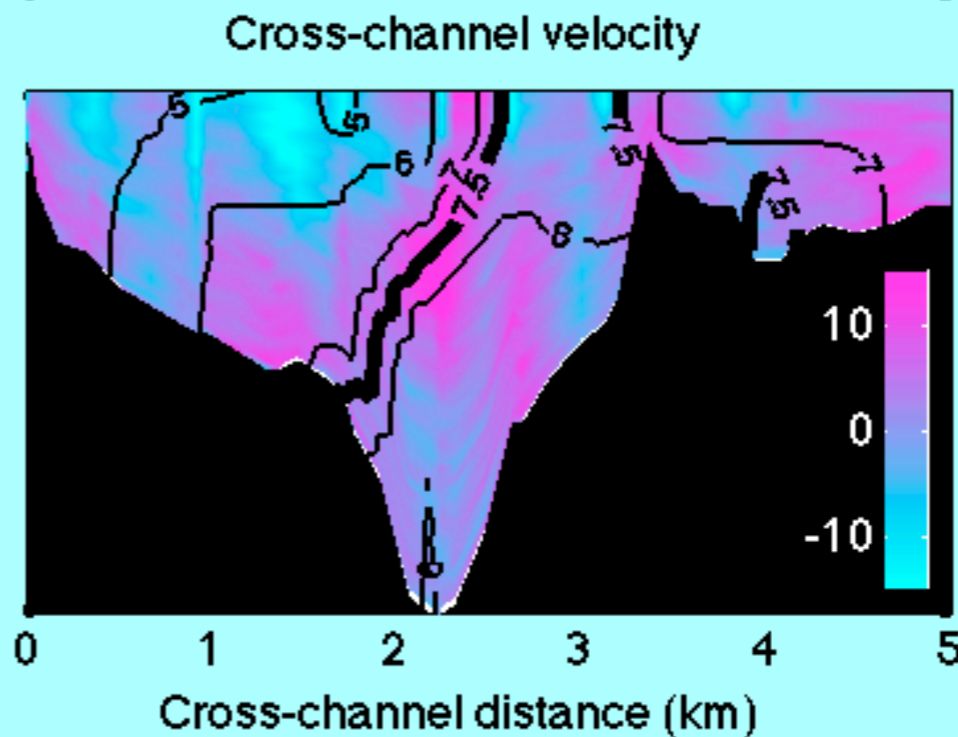
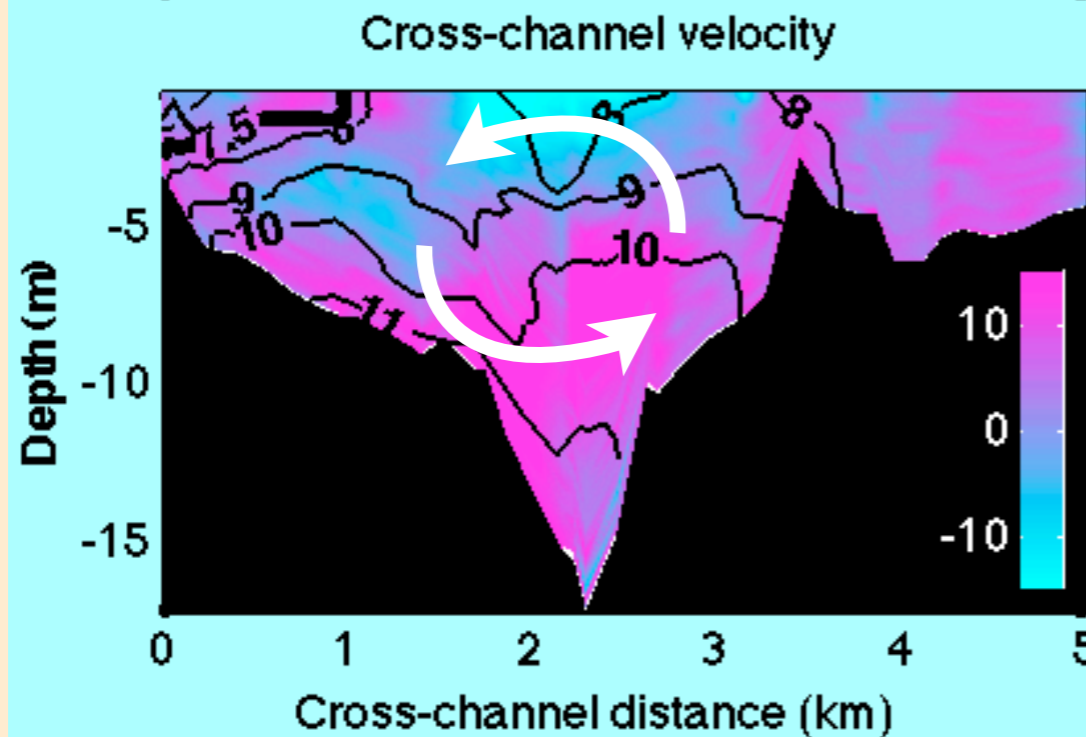
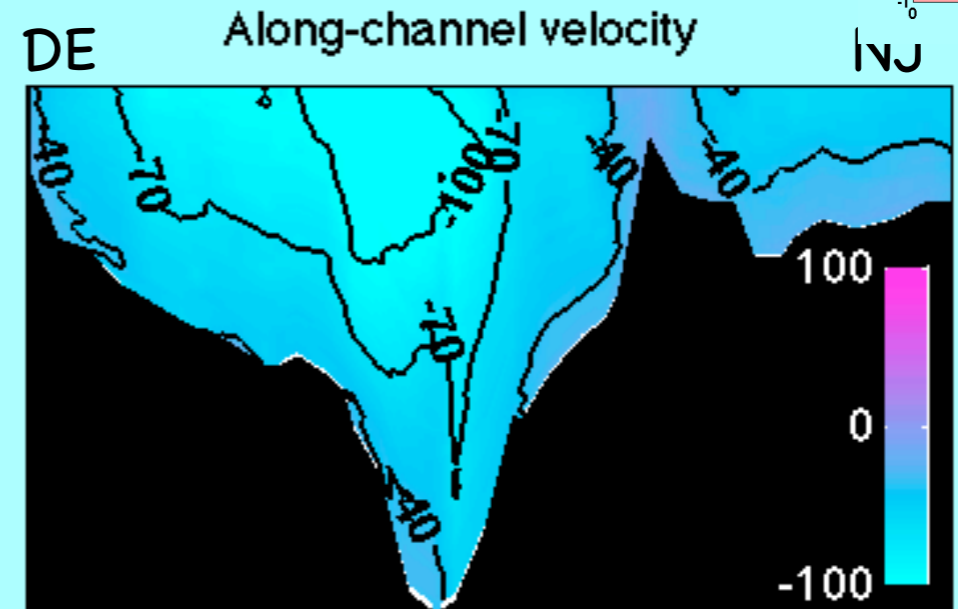
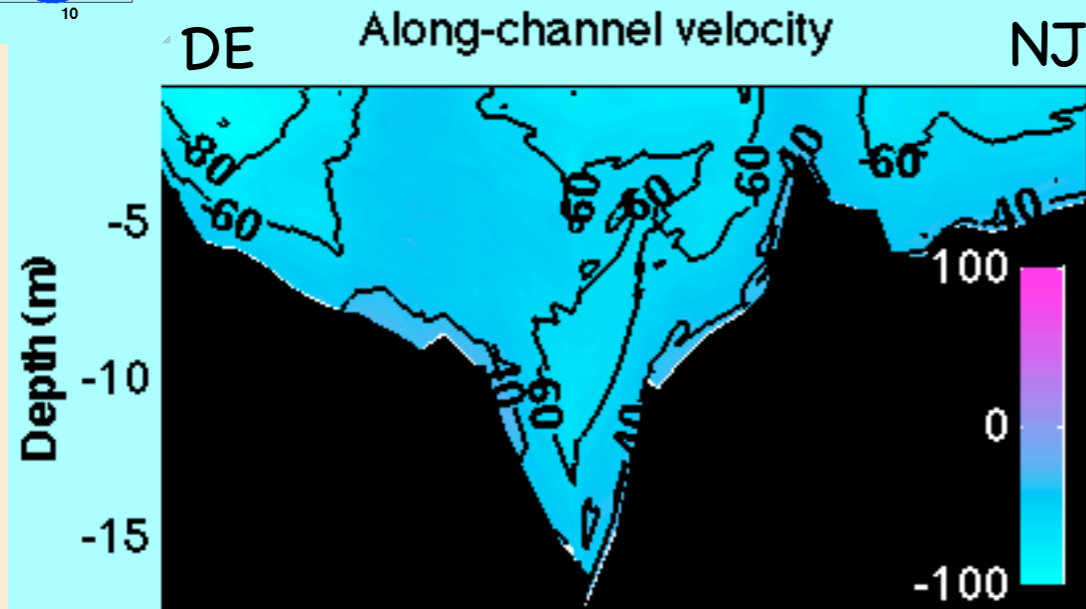
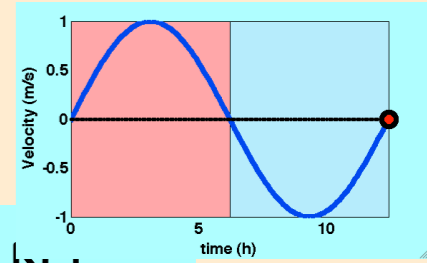
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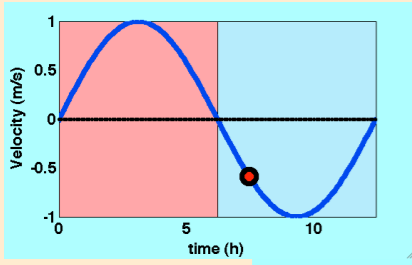
Beginning of ebb

Towards end of ebb

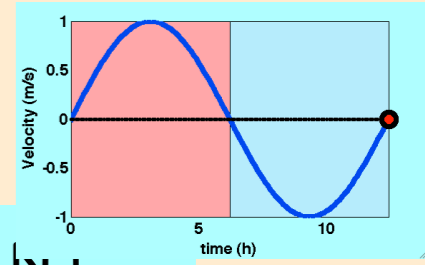


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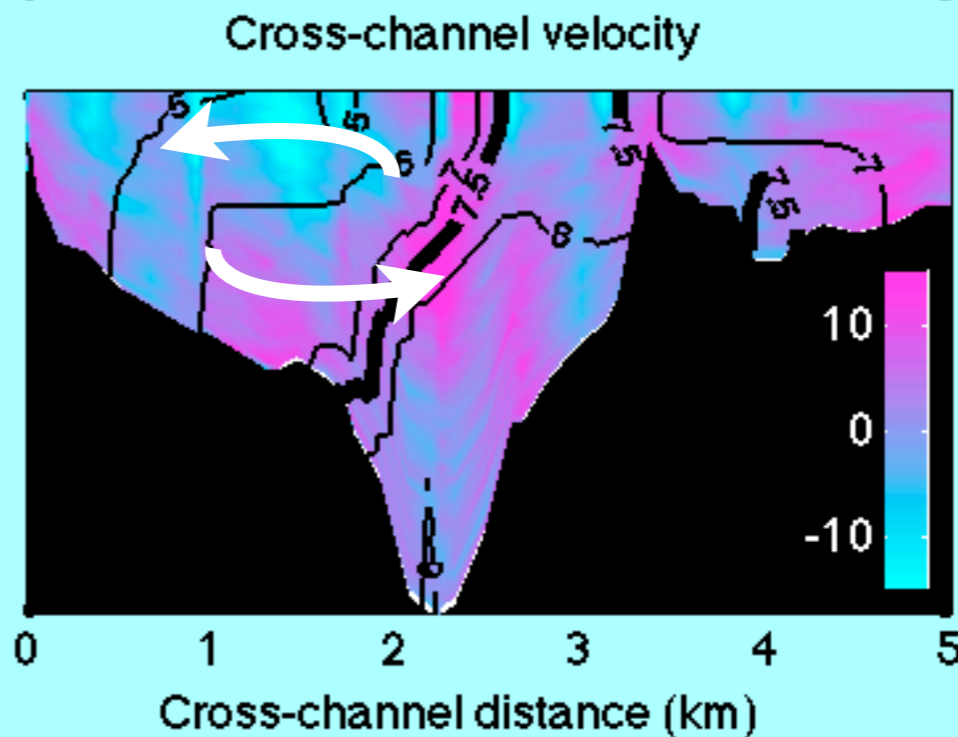
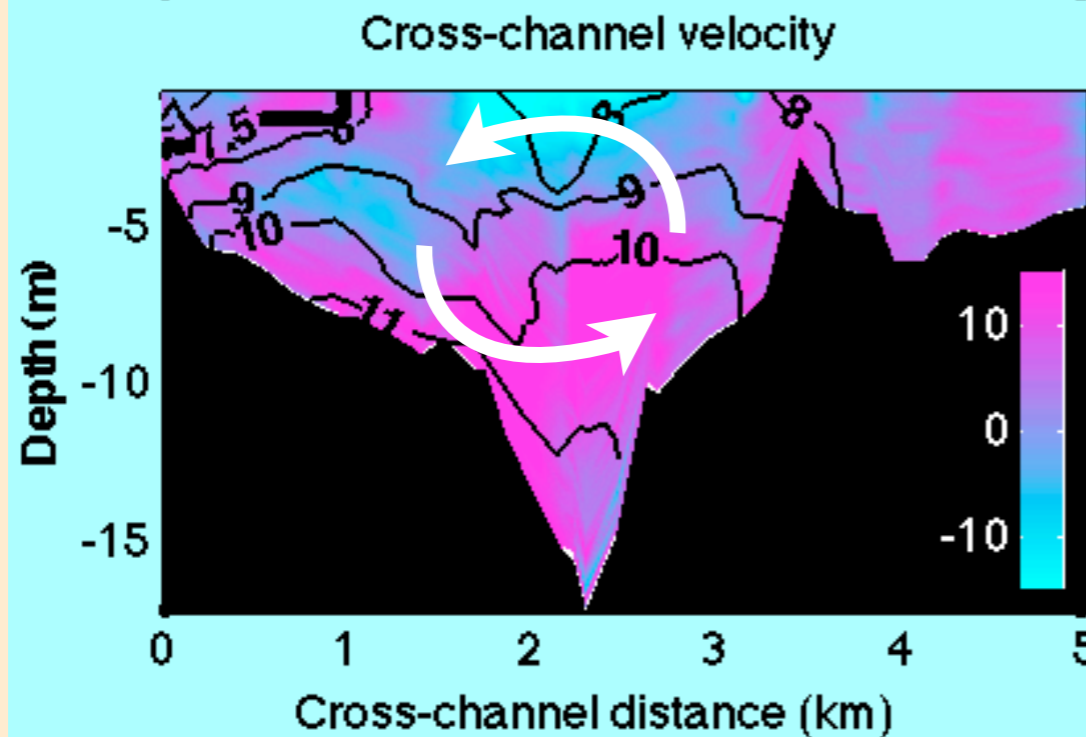
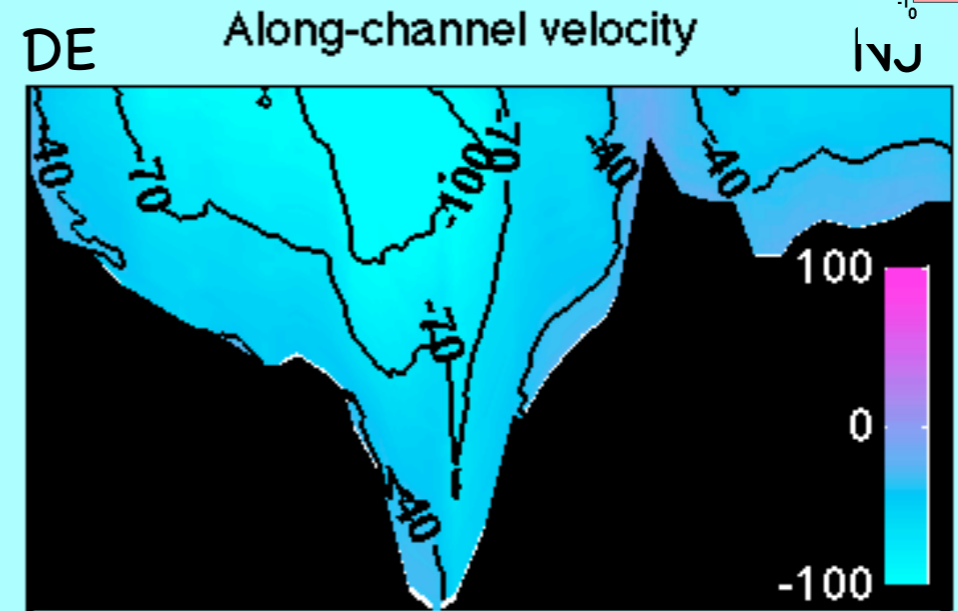
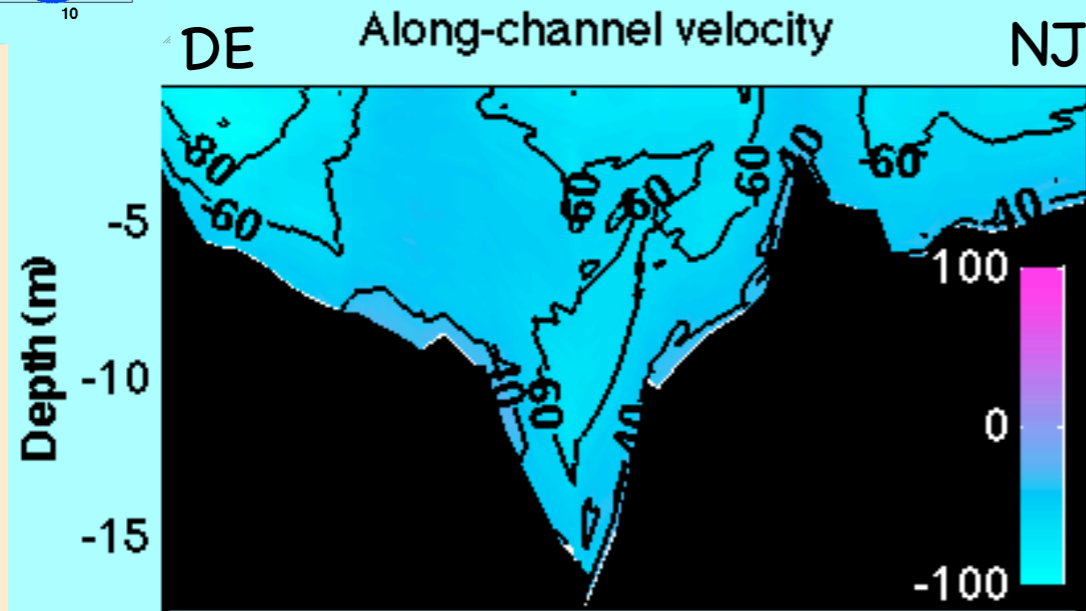
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Beginning of ebb

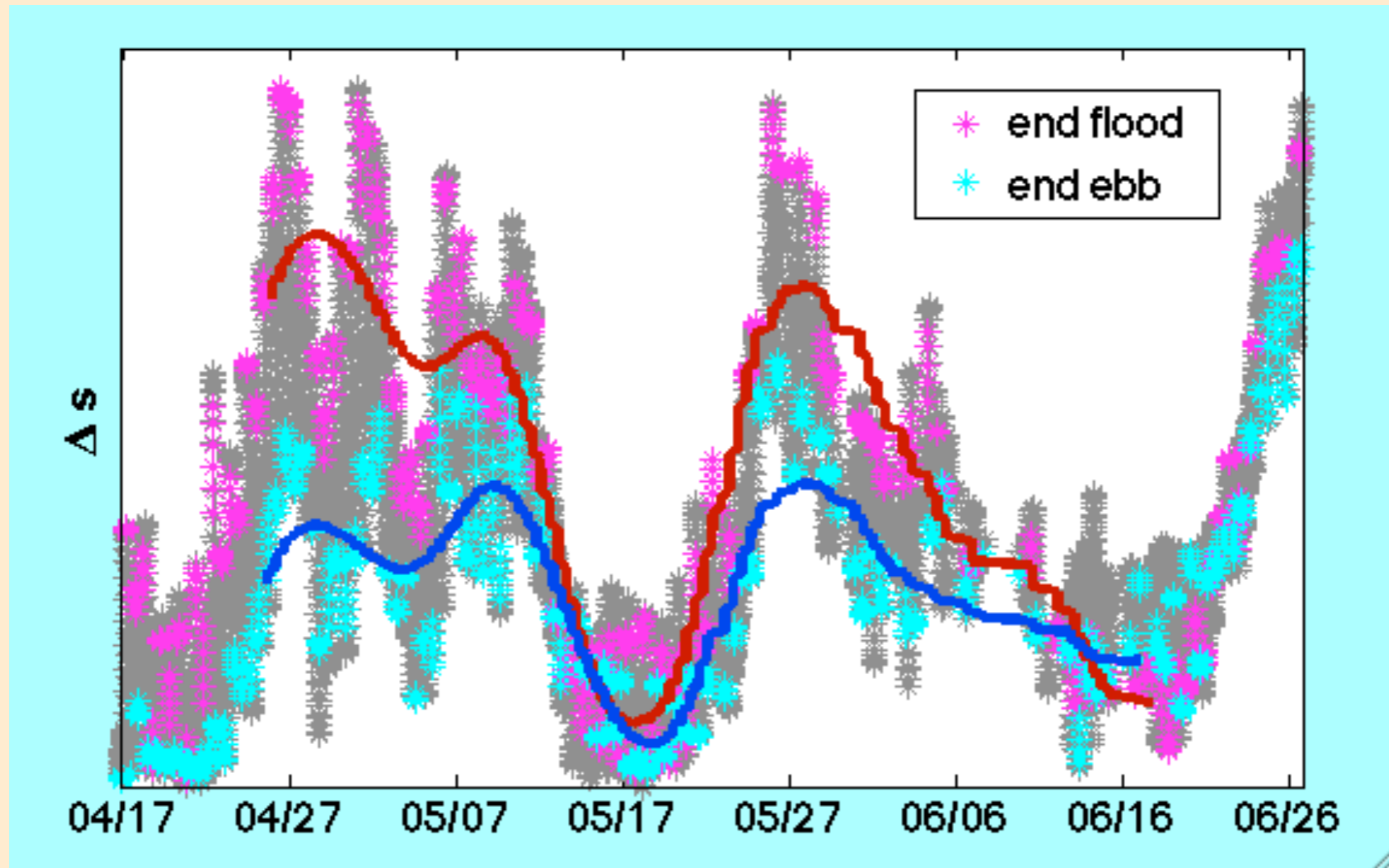


Towards end of ebb



Stratification is reduced at the end of ebb and increased at the end of the flood tide.

Mooring data: tidal variability in stratification

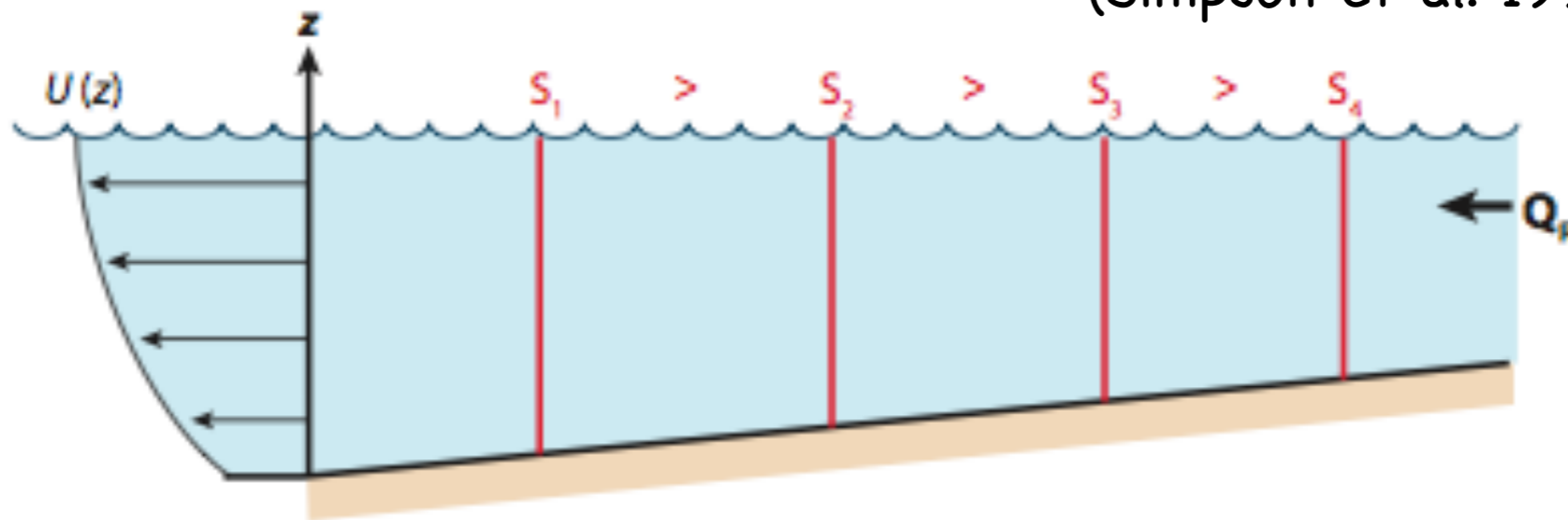


Stratification is reduced at the end of ebb and increased at the end of the food tide but only for periods of high stratification.

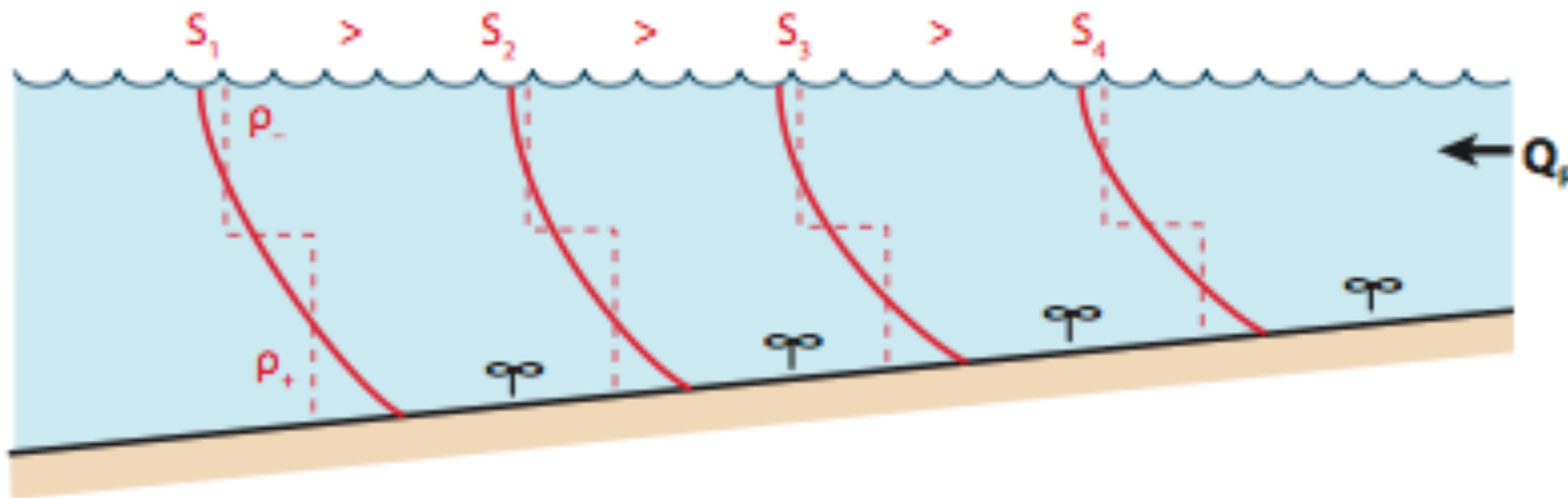
The observed tidal variability in stratification is contrary to the one expected from the tidal straining mechanism .

(Simpson et al. 1990)

End of flood

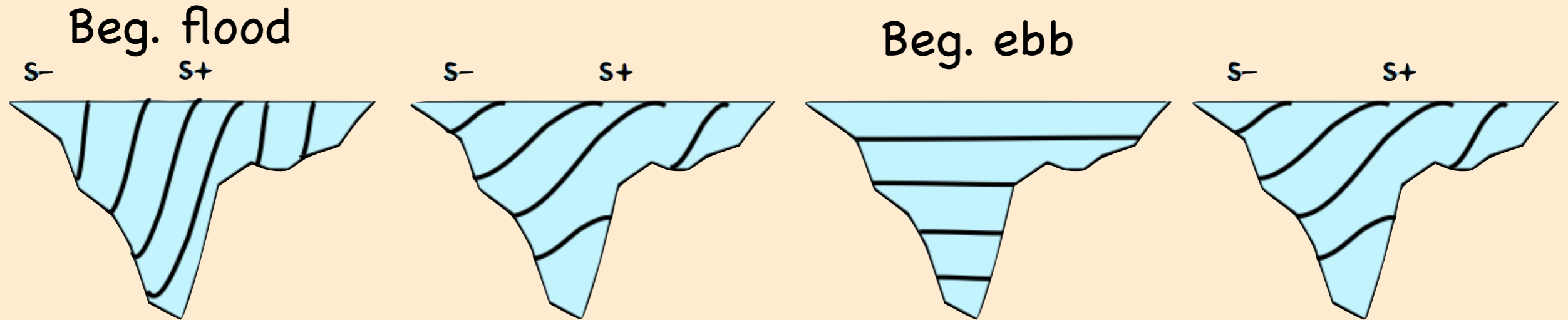


End of ebb

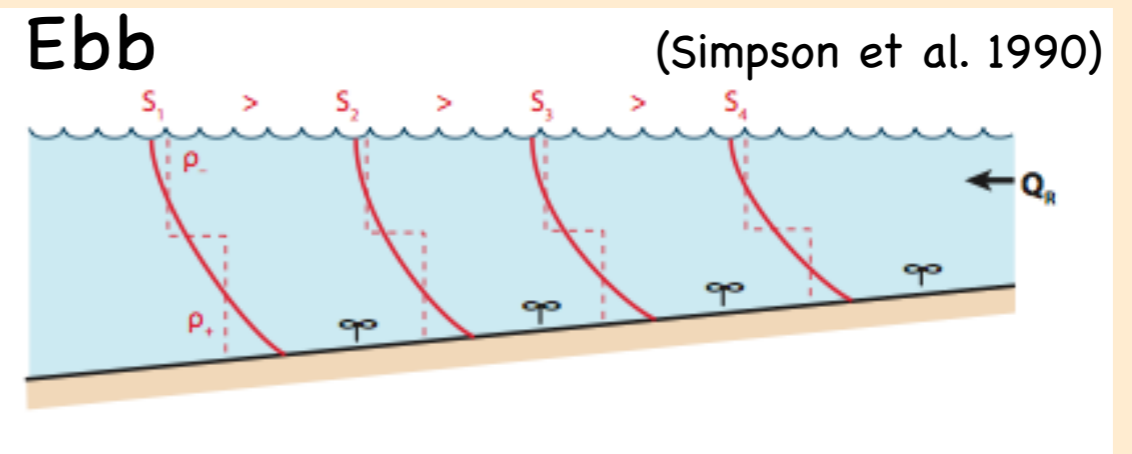
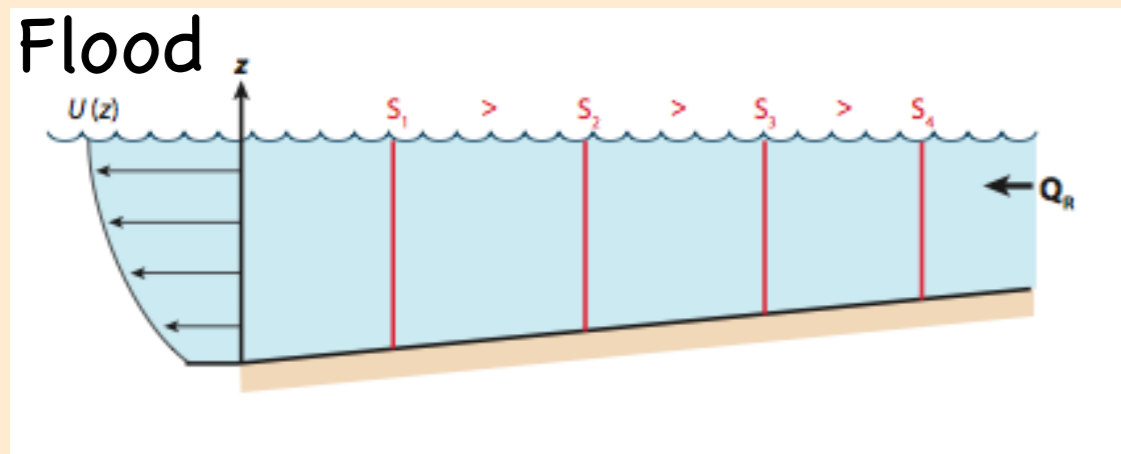


What causes this tidal variability in stratification?

Cross-channel straining



Along-channel straining

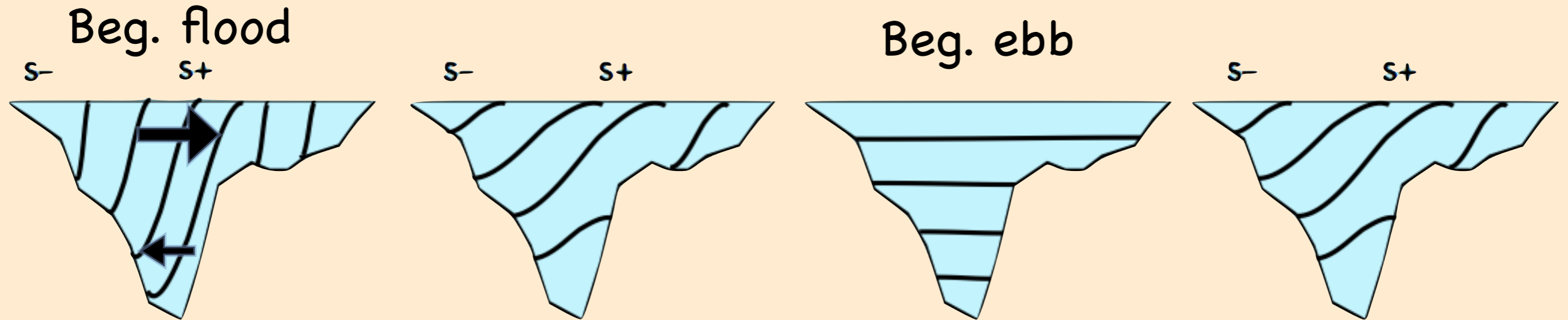


(Simpson et al. 1990)

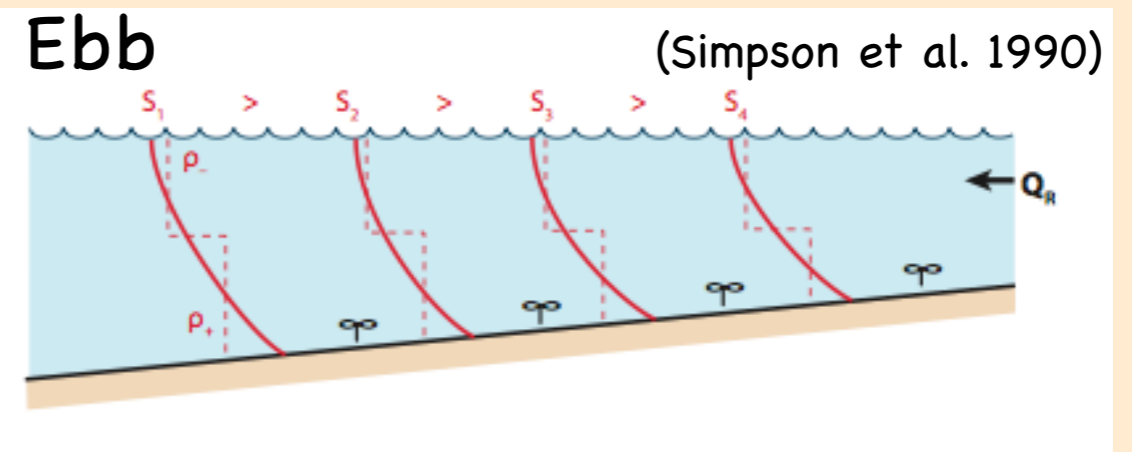
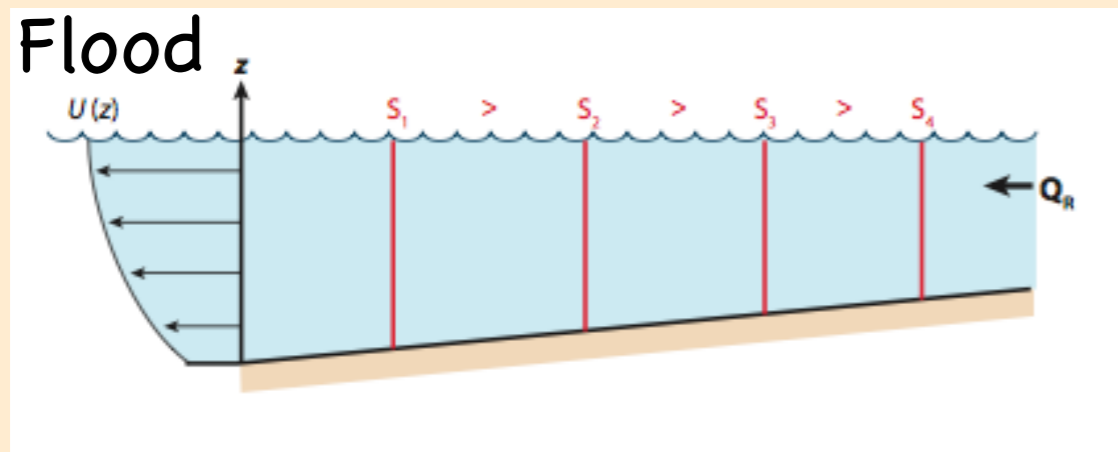
The adjustment of the isohalines during the flood stratifies the water column but subsequently the cross-channel flows strain the isohalines during the ebb reducing stratification.

What causes this tidal variability in stratification?

Cross-channel straining



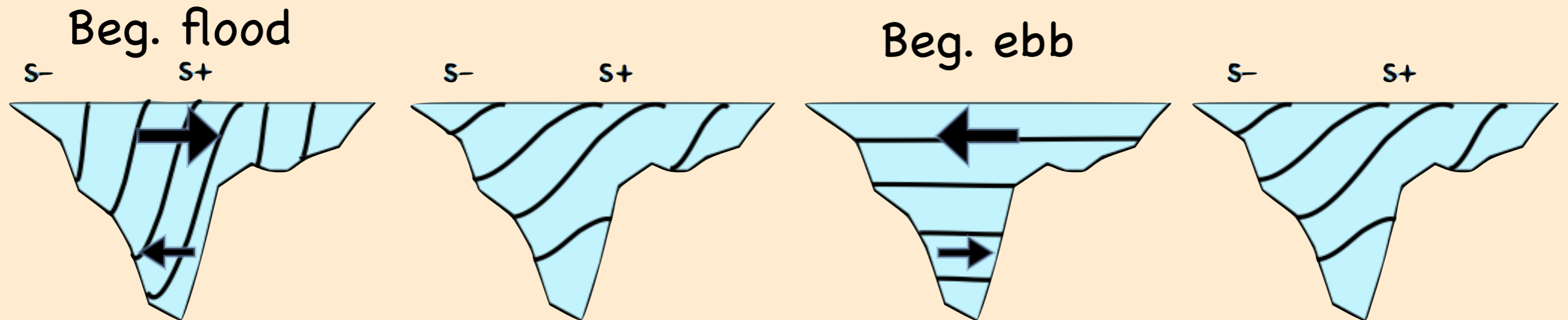
Along-channel straining



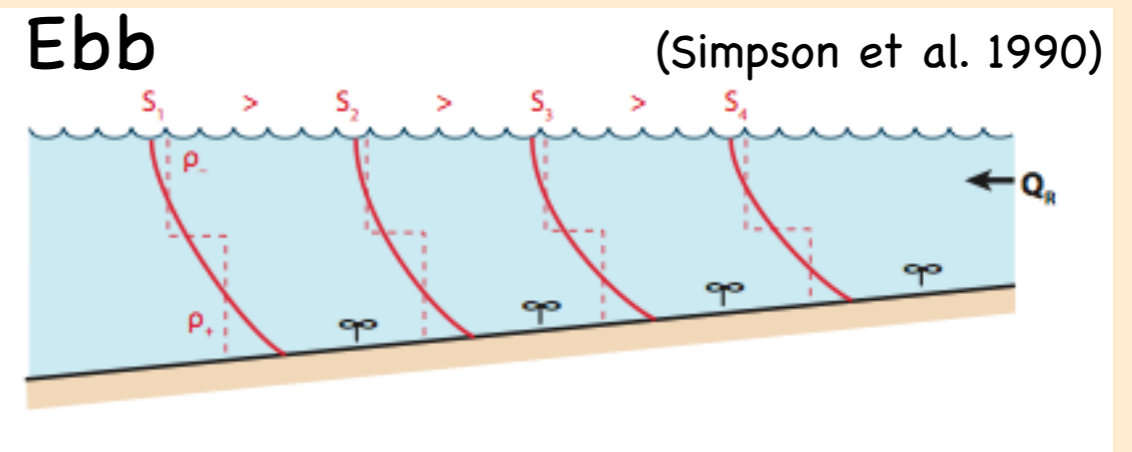
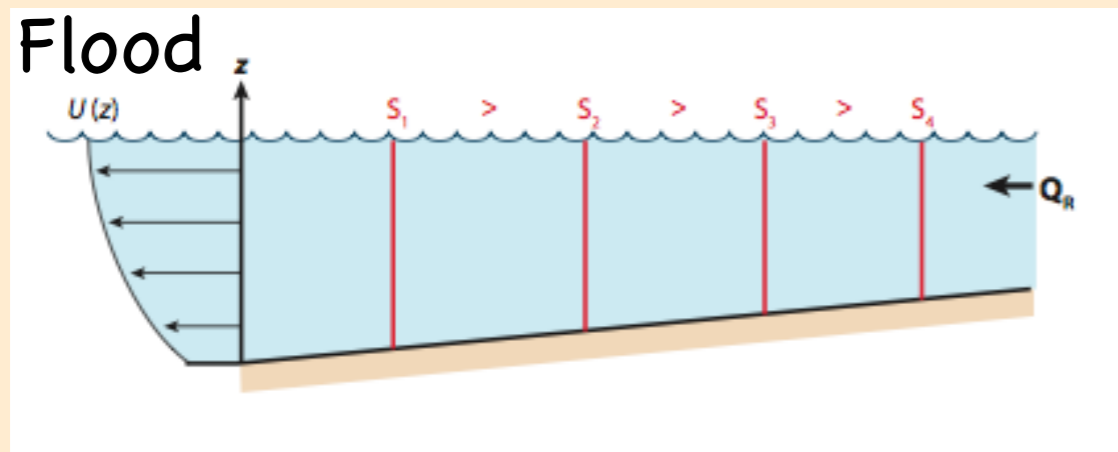
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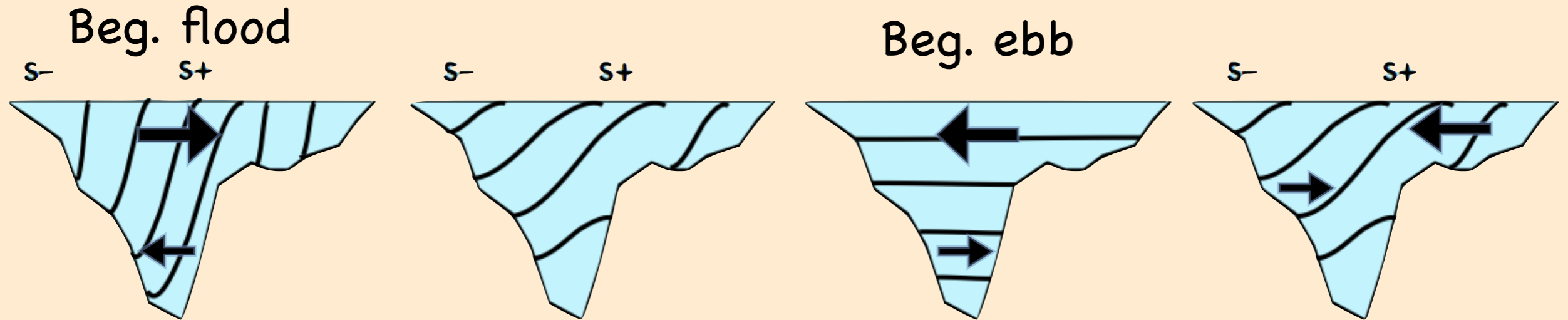
Along-channel straining



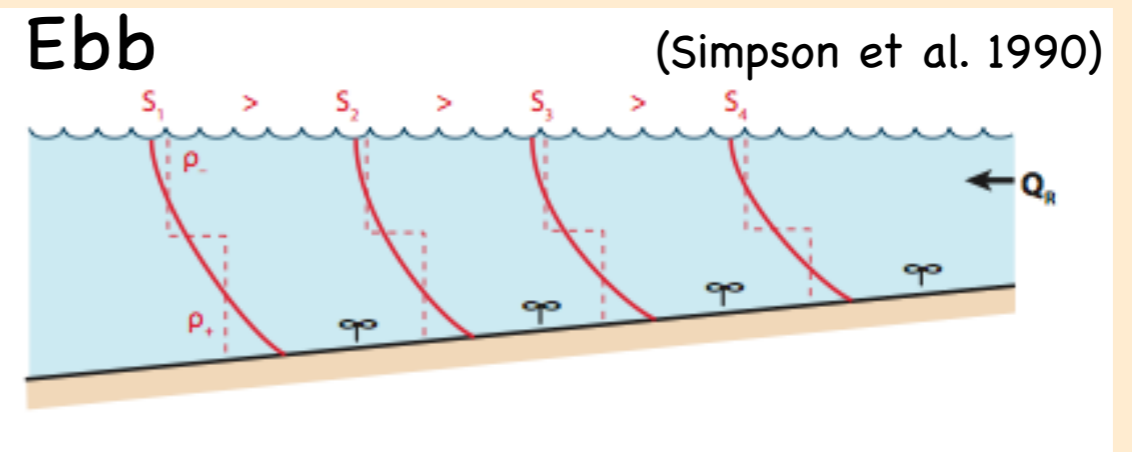
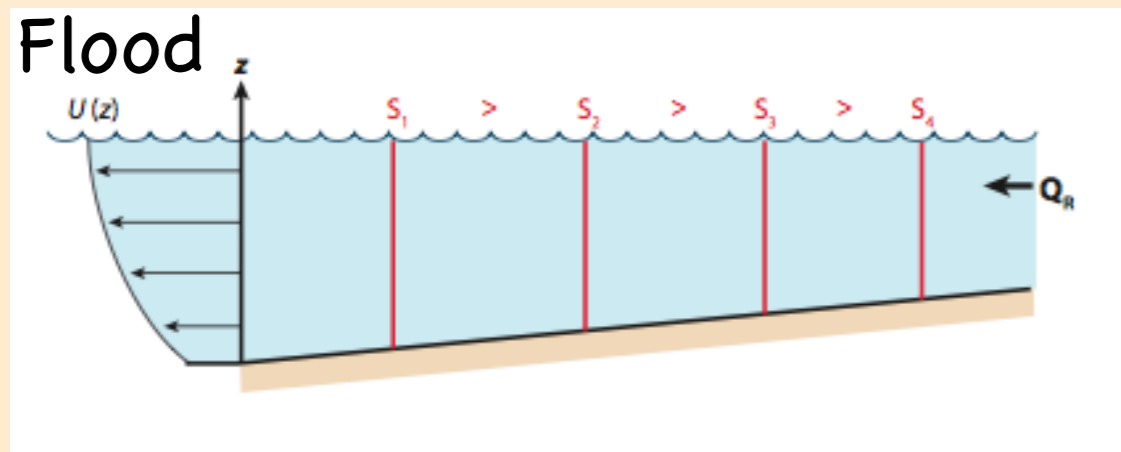
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Along-channel straining



(Simpson et al. 1990)

The adjustment of the isohalines during the flood stratifies the water column but subsequently the cross-channel flows strain the isohalines during the ebb reducing stratification.

Conclusions

- The subtidal variability in stratification is controlled by the spring-neap cycle but also by river discharge.
- The tidal variability is controlled by the straining of the isohalines by the cross-channel flows during the ebb and the subsequent adjustment during the flood tide.