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Flow distribution and salt water intrusion in the Rhine-Meuse river delta network

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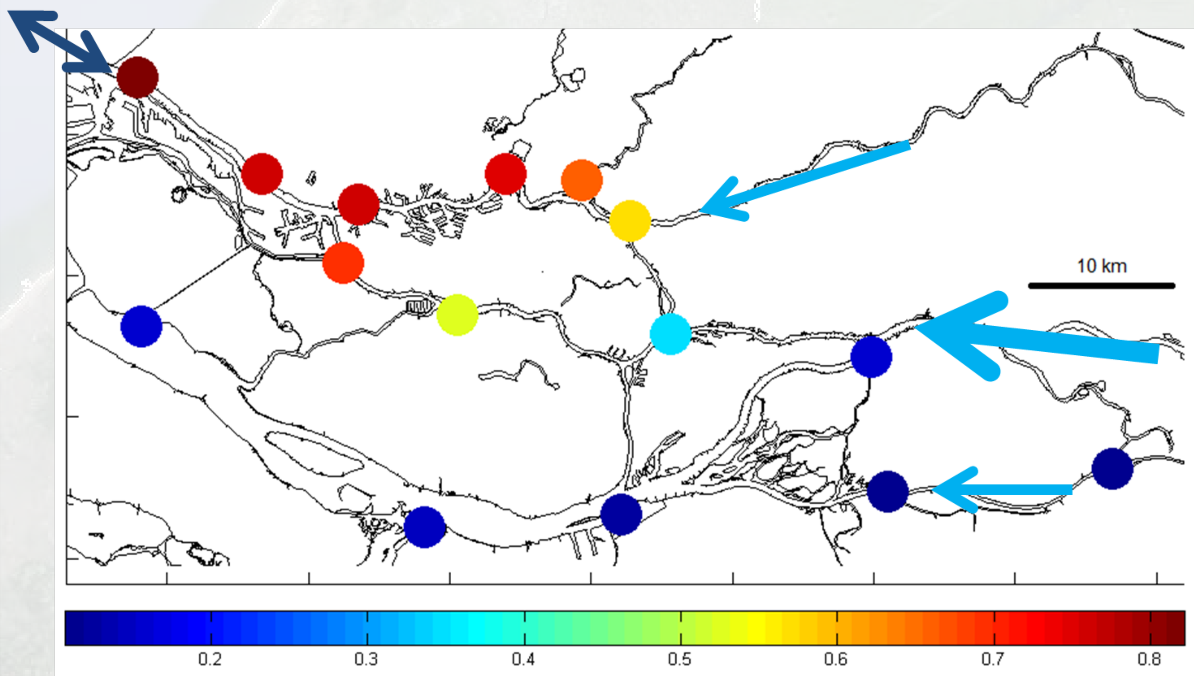
Introduction

Much is known about flow at river junctions. However, the influence of tides and salinity on flow at channel junctions is not yet fully understood, and neither is the functioning of tidal junctions in channel networks. A dataset of 13-hour flow and salinity measurements at 12 different junctions, varying from strongly stratified to well-mixed and from strong to weak tides, can provide insight into the influence and relative importance of morphology, tides and salinity.

Aim: to understand flow dynamics in a tidal river network, specifying the influence of tides, salinity and channel morphology on the flow.

Rhine-Meuse tidal river network

In the western Netherlands, the Rhine and Meuse rivers form a network. Tidal energy can enter from the north-west, but the southern estuaries of the system have been closed off and now form almost stagnant freshwater lakes. River flow enters through three river branches from the east.

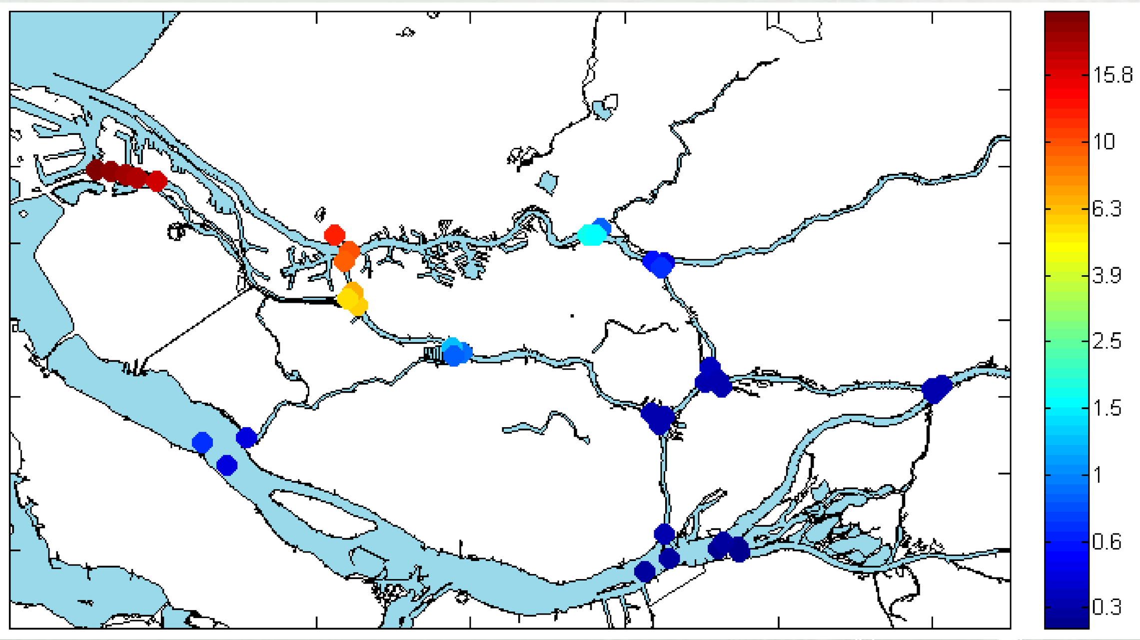


Dots represent M_2 tidal amplitudes, blue arrows river or tidal (dark) flow.

Tidal flow and salinity

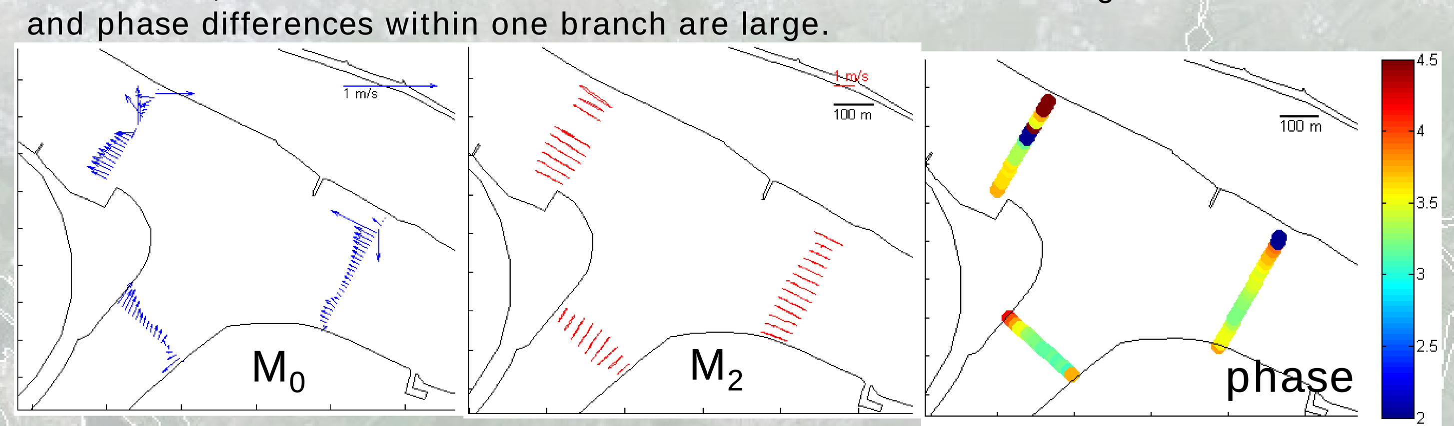
Residual flow (M_0) and a semidiurnal component (M_2) are isolated from the flow.
Close to sea flow is vertically stratified and uniform over width. Phase differences between branches are a the result of channel interaction between the junctions (black circled junction in the main picture).
Upstream, flow is horizontally sheared. The lakes in the south cause large water level gradients, generating residual flow (blue, yellow, green circled junctions), variation in tidal flow magnitude (yellow, green) and phase differences up to 180 degrees within one river branch (green).

Salinity intrusion reaches to about 30 km inland.

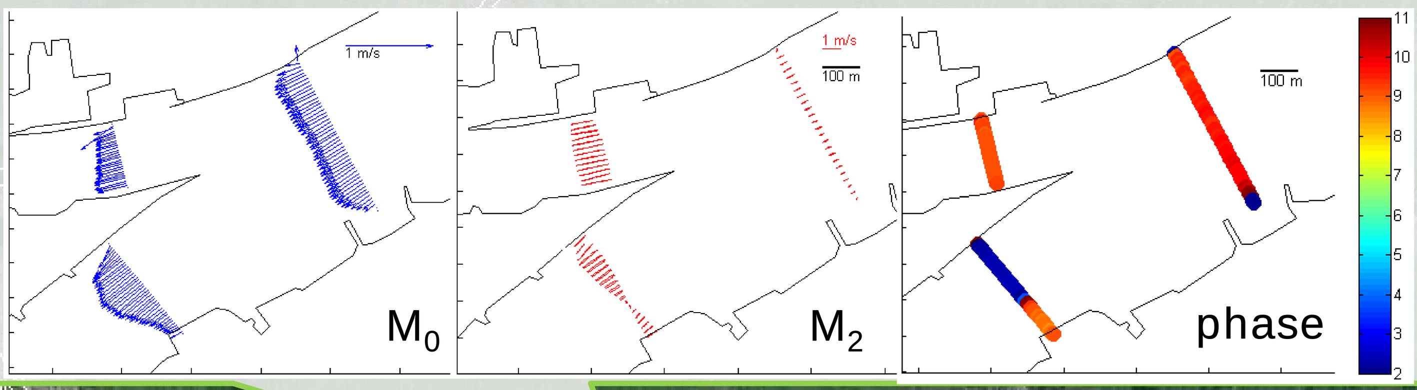


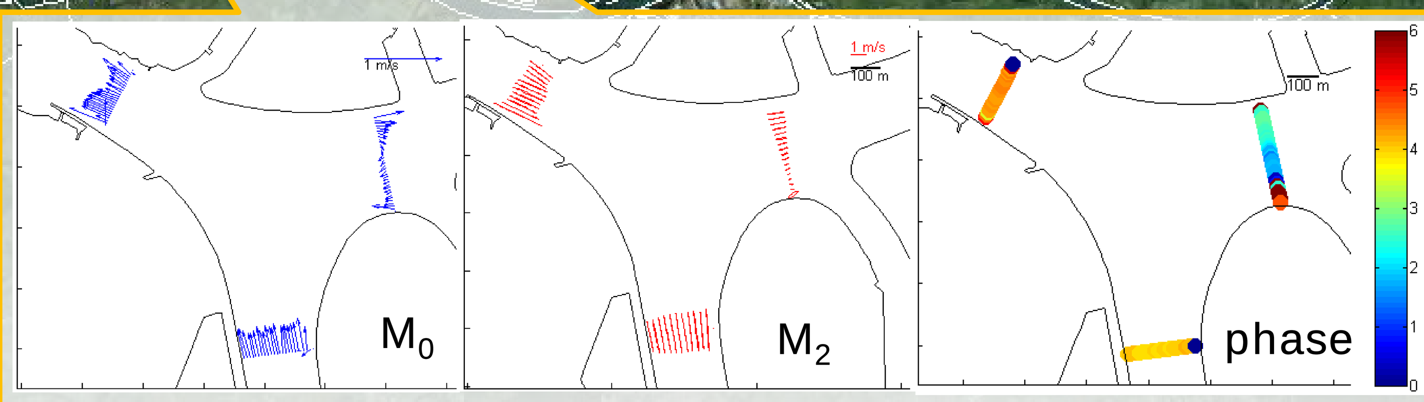
Dots represent salinity in psu, on a logarithmic scale.

More inland, flow becomes well-mixed. Residual flow features strong horizontal shear and phase differences within one branch are large.

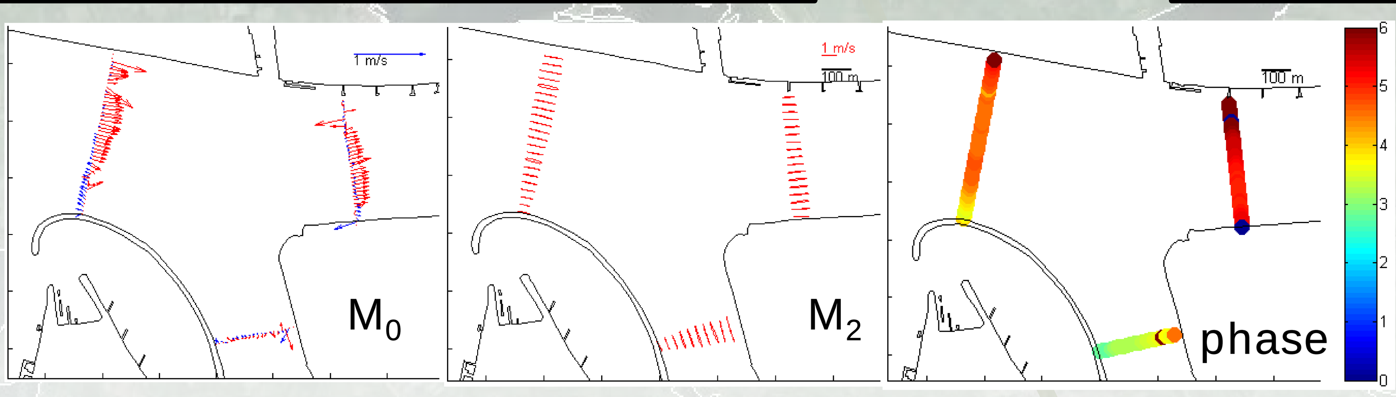


At the most landward junction, differences between branches are large. The south-western branch displays a 180-degree phase difference across the channel.

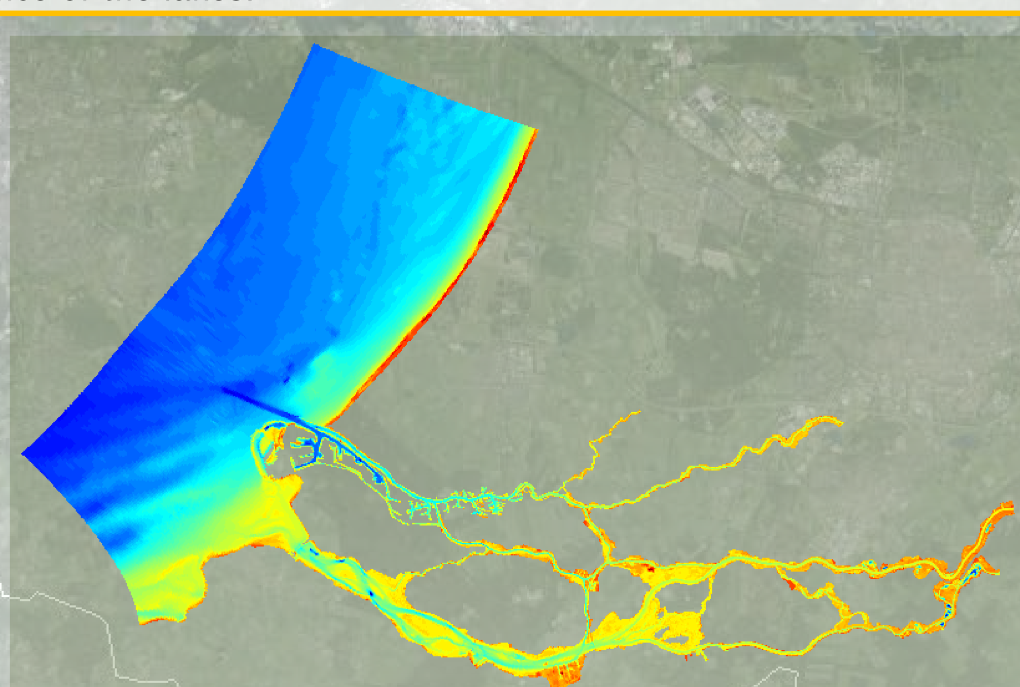




Differences in the strength of residual flow and tidal flow are large between branches as a result of the presence of the lakes.



At the most seaward junction, flow is vertically stratified. Phase differences between branches result from channel interaction between the junctions.



Next steps: models and tidal energy propagation

A Delft3D hydrodynamic model is used to gain fundamental insight in the flow patterns, discharge distribution and the role of salinity and tides. Further research will also focus on understanding phase differences between branches and junctions by revealing the tidal propagation through the network.

Conclusion: salinity, channel interaction and lakes acting as a buffer cause flow structures at channel junctions.

The flow is vertically stratified at tidal junctions nearby sea and becomes horizontally sheared at river junctions.

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