Effect of Local Winds on Circulation and Stratification in a Large Discharge Mesotidal Estuary: the Case of the Columbia River Estuary

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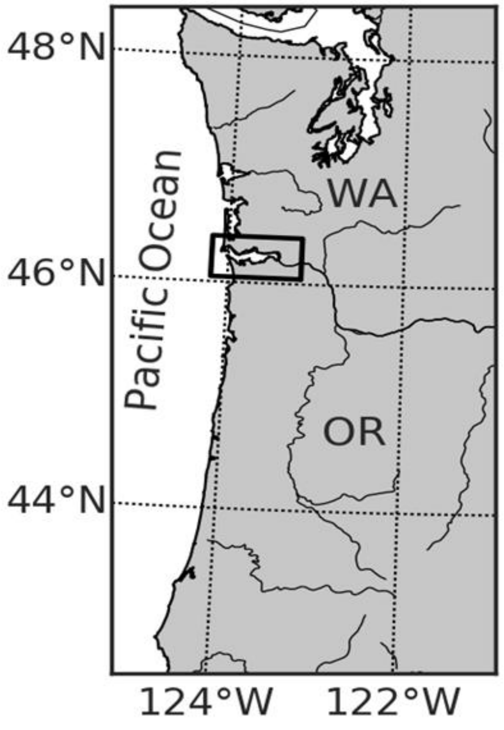
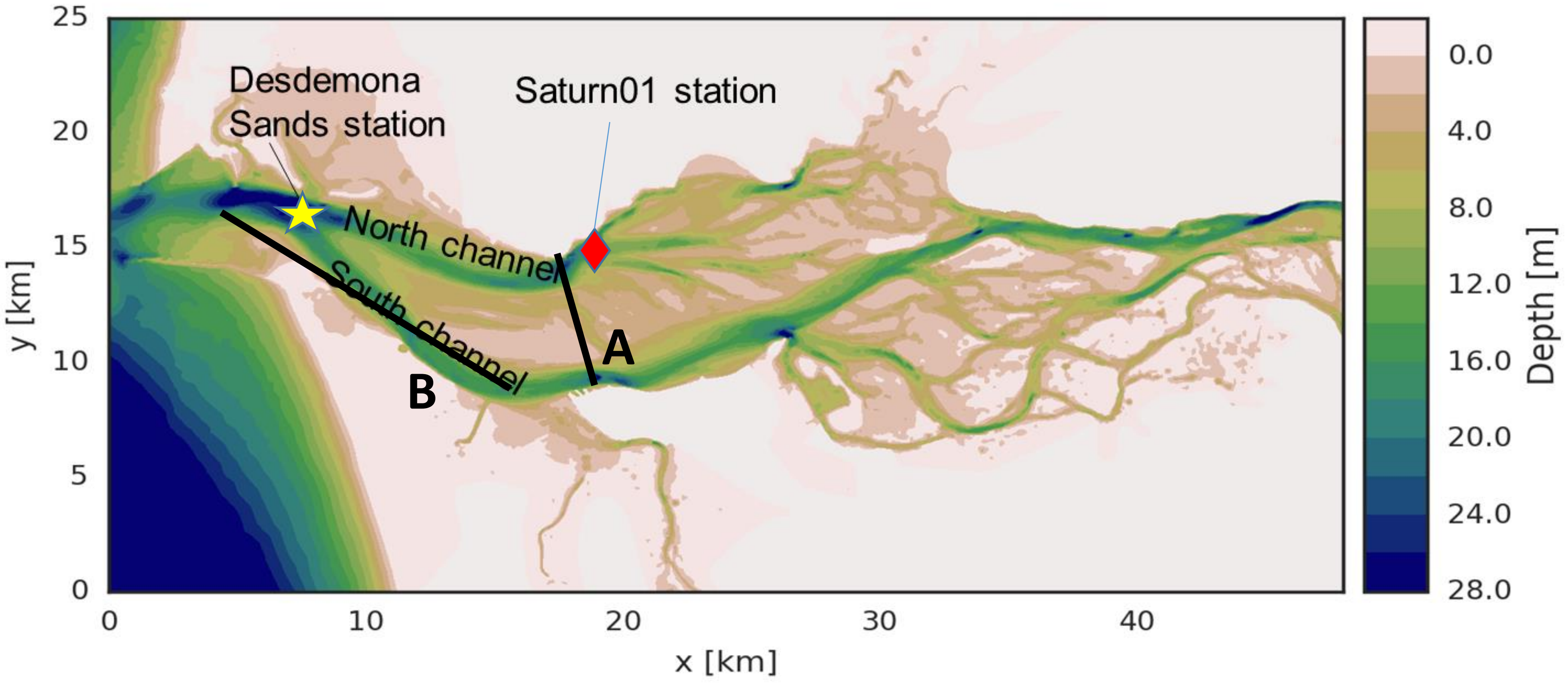
The Columbia River estuary





The Columbia River estuary is a large, high-energy environment characterized by strong tidal currents and large river flows. Freshwater discharge ranges seasonally from less than 2.000 m3/s up to more than 12.000 m3/s.

Tides are mixed semidiurnal, with the two major tidal constituents being M2 (amplitude ~0.95 m) and K1 (~0.41 m).

The estuary has an average depth of 2 m in the flats and it is characterized by two deep channels (12-15 m)

Questions

- Can we simulate local atmospheric effects in the Columbia River estuary? Do they matter?

- Are local atmospheric effects important for estuarine circulation, and, in particular, for salt intrusion and stratification?

Methodology

To address these questions, we performed 2 series of simulations with the 3D finite element model SELFE:

1) a winter storm in 2015 (Nov 17 to Dec 14)

2) the full year of 2014

Both series were based on SELFE (Zhang and Baptista 2008), with modeling choices based on Kärnä et al. 2015 and typical of CMOP's Virtual Columbia River (Baptista et al. 2015).

The simulations

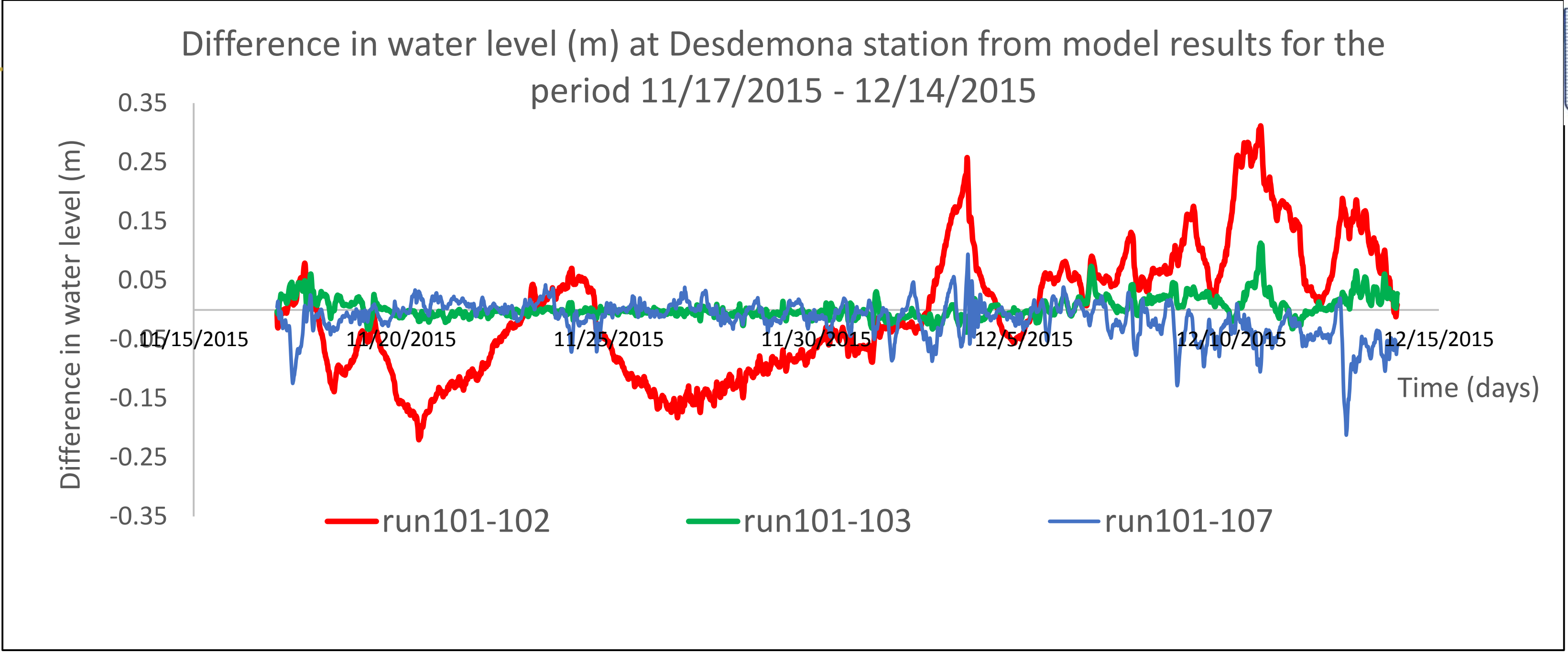
RUN	Atm. Press.		Wind	
Series 1	Shelf	Estuary	Shelf	Estuary
101	WRF4	WRF4	WRF4	WRF4
102	WRF4	Constant	WRF4	No
103	WRF4	WRF4	WRF4	No
107	NARR32	NARR32	NARR32	NARR32
Series 2	Shelf	Estuary	Shelf	Estuary
201	WRF4	WRF4	WRF4	WRF4
202	WRF4	Constant	WRF4	No
203	NARR32	NARR32	NARR32	NARR32
206	WFR4	Constant	WRF4	WRF4

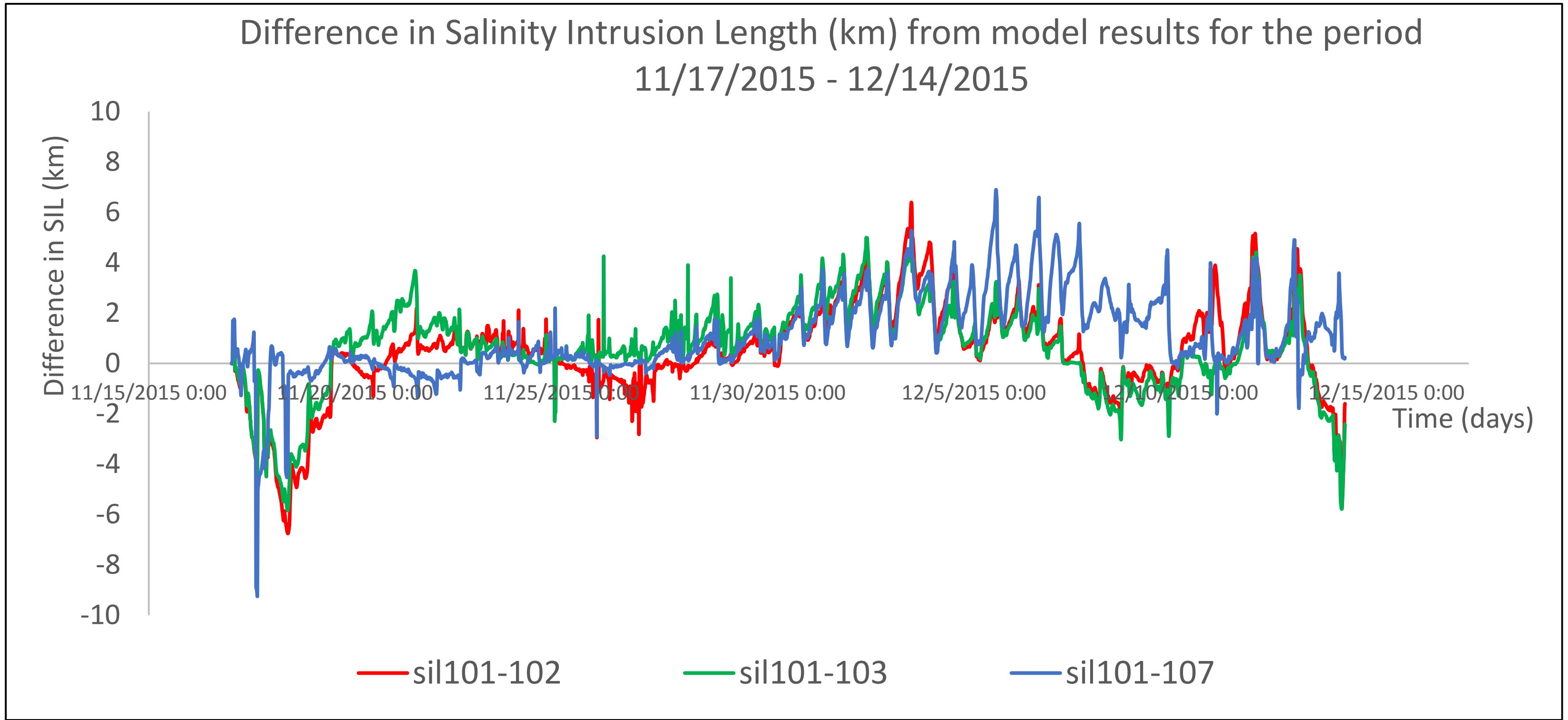
Atmospheric forcing was derived from either the University of Washington's Pacific Northwest Mesoscale Model with a 4 km resolution (henceforth: WRF4), or NOAA's North American Regional Reanalysis model with a 32 km resolution (henceforth: NARR32).

Local winds or atmospheric pressure were selectively zeroed in the estuary.

Also NAM12 and GFS28 were applied (not shown).

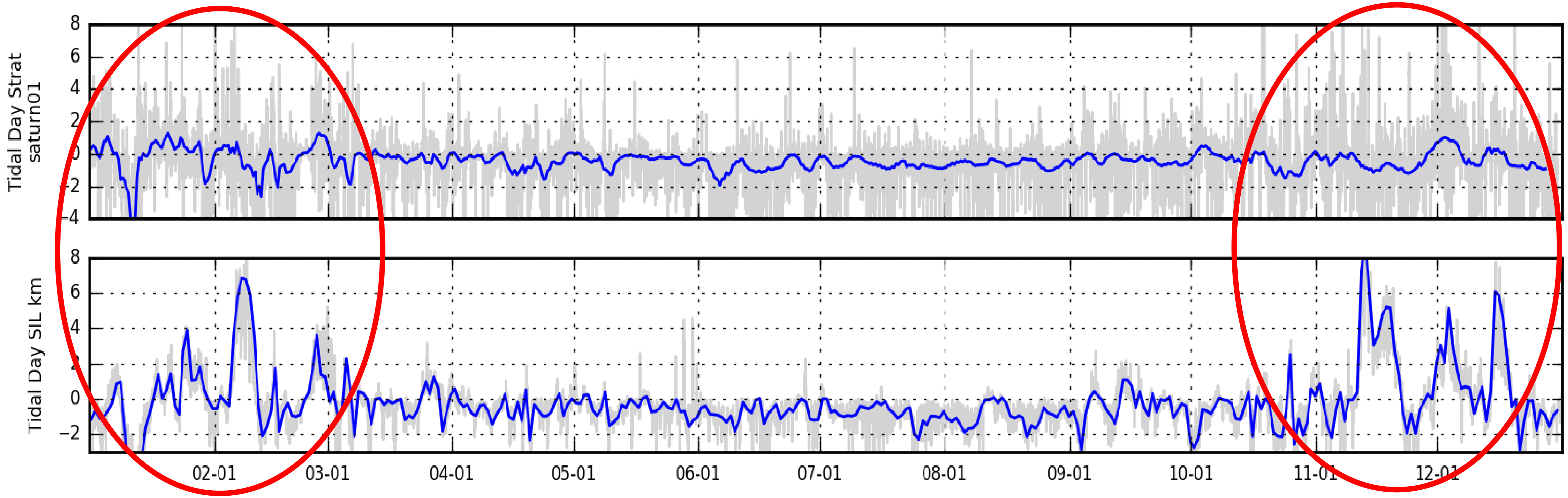
For the 2015 winter storm (Series 1), neglecting or coarsely (e.g., NARR32) representing local wind and atmospheric pressure, can substantially alter water levels (by up to ~20 cm) and salinity intrusion length (by over 5 km).





Simulations show that local atmospheric forcing is at times significant for key estuarine features, such as salt intrusion and stratification.

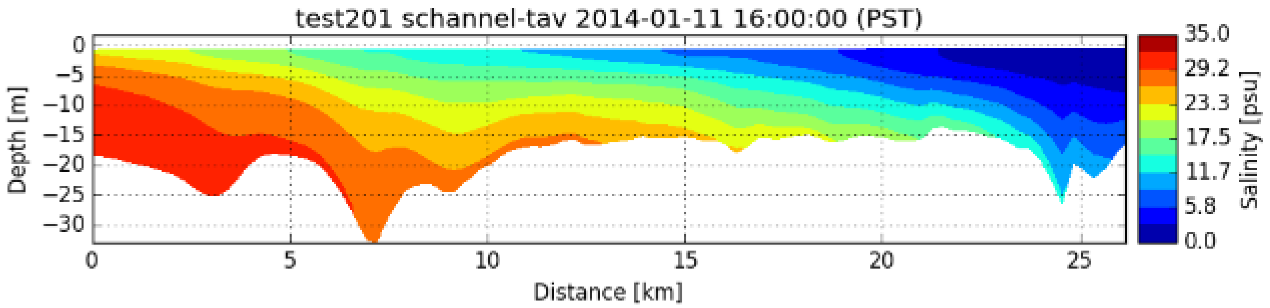
Difference in stratification and SIL between run201 and run202 at Saturn01 Time series of the year 2014

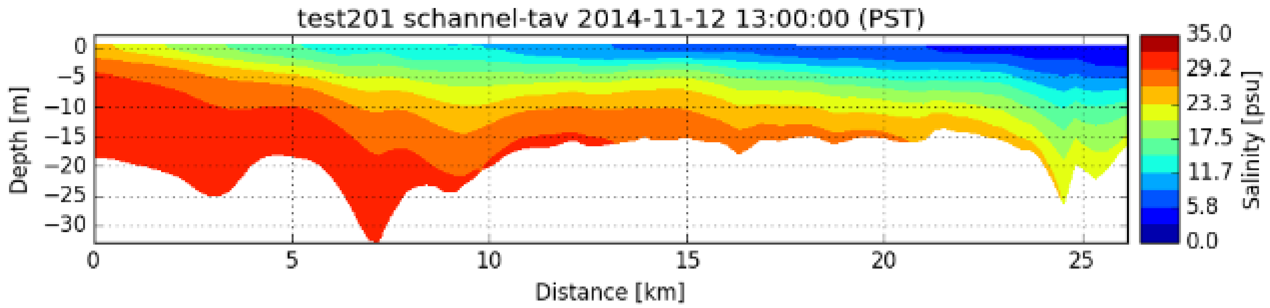


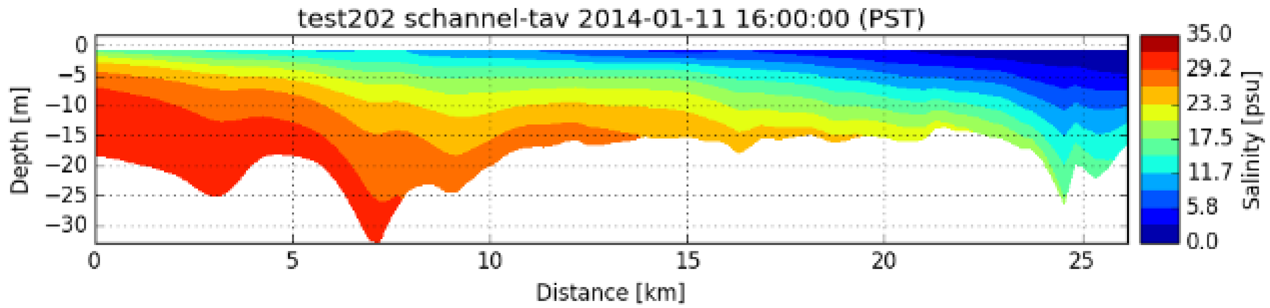
For the year 2014 (Series 2), the effect of local forcing is important estuary-wide in winter months, through the wind and atmospheric pressure fields.

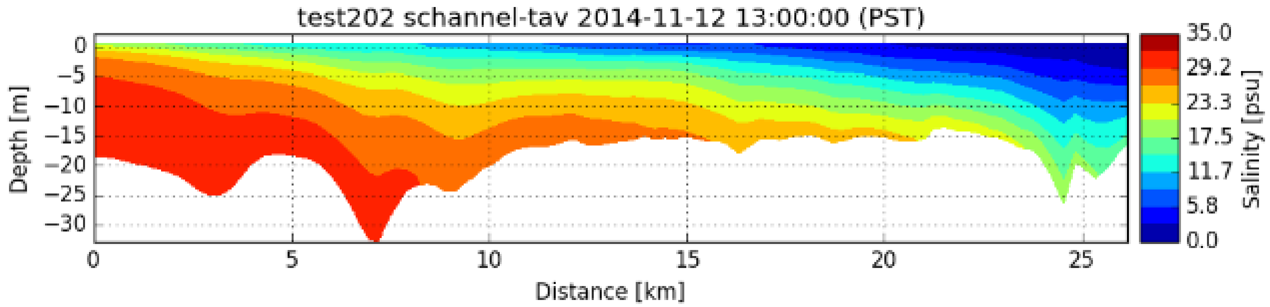
TAV Transects of salinity - B (south channel)

Case of January on the left and case of November on the right. Upper panels represent the results from run201 (WFR4) and bottom panels represent the results from run202 (NO wind)



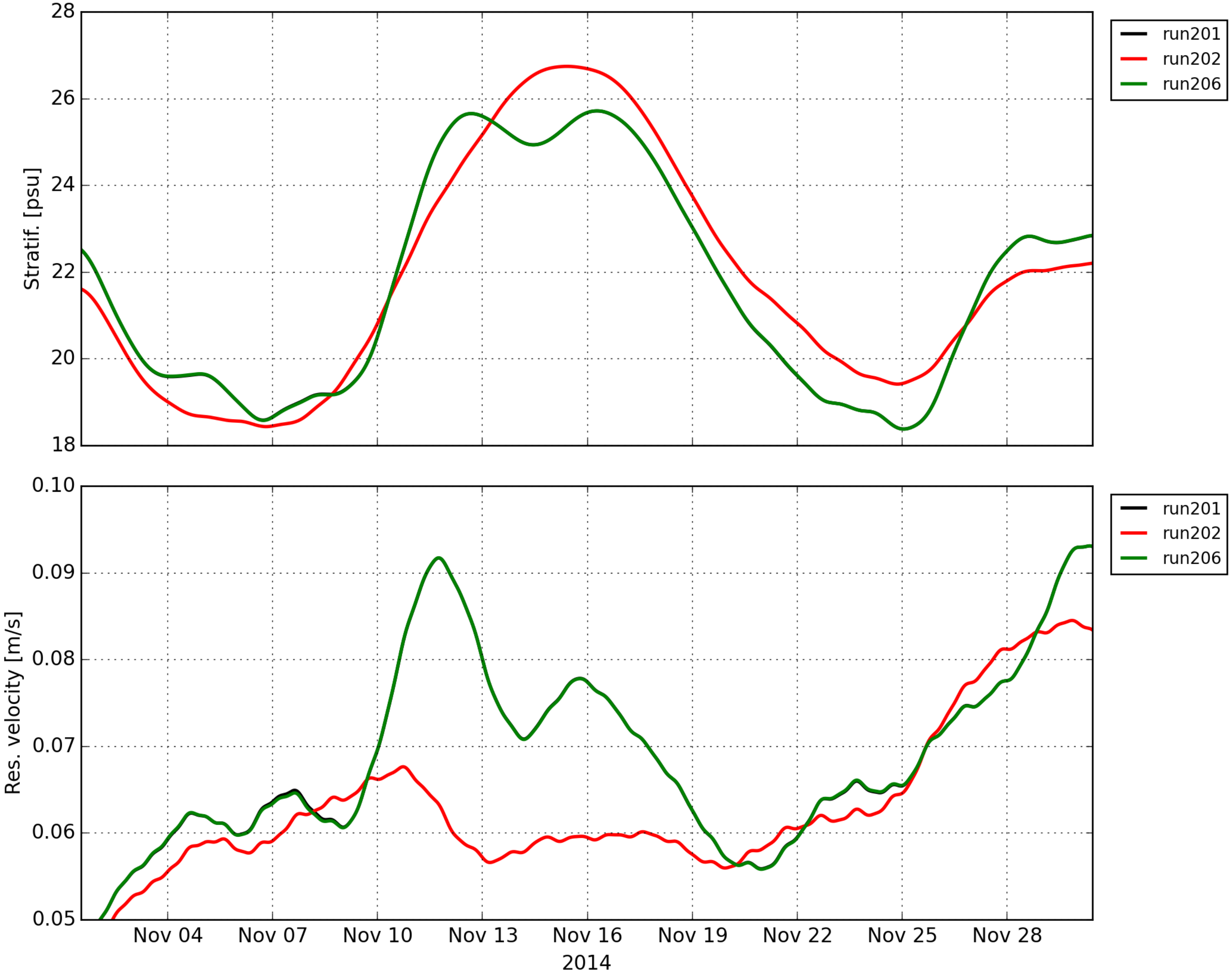






Easterly (down-estuary) winds seem to increase salinity intrusion and westerly (up-estuary) winds seem to reduce it, recalling the conceptual model proposed by Scully et al., 2005.

Time series of stratification and residual velocity computed in the cross-channel transect A, for run201, run202 and run206, in November 2014



Summary

From this modeling study we found:

- different results using a metereological model with higher resolution
- the local effect of the wind, in particular energetic Eastearly and Westerly winds on residual velocity and salinity related parameters

Important open questions for the CRE include (work in progress):

- Under what conditions do local atmospheric effects affect circulation?
- Are these conditions tied to magnitude thresholds for winds? Or to specific estuarine regimes or river discharge/tide conditions? Or a combination?

Conclusions and next steps

These findings show that atmospheric effects, especially the wind, are important for the Columbia river estuary and offer motivation for future studies to better understand the processes taking place in this coastal ecosystem with respect to atmospheric forcing.

Finally comparison with experimental data would be needed for further insight, in particular meteorological data at estuary scale would be fundamental:

- Wind speed and direction
- Atmospheric pressure
- Solar radiation

Bibliographic references

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Thank you
for your kind attention