SC2-032

Volume transport variations in the Taiwan Strait in relation with the cross- and along-strait pressure gradients

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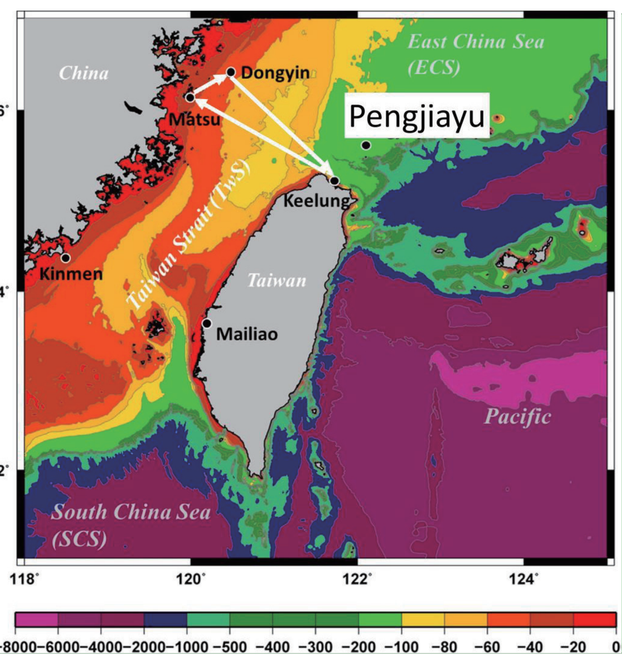
1. Introduction

- In many straits, ocean dynamics are generally complicated (*e.g.* due to shallow and narrow topography, or faster speed).
- Recently, new altimeter products have been produced in coastal area where standard products are not reliable. But **are they really useful even in straits, with temporally and spatially sparse sampling?**
- In this study, coastal altimeter data are used to study ocean dynamics in **Taiwan Strait**.



Taiwan Strait

- between Chinese mainland and Taiwan island (Fig.1)
  Shallow (~60m) and moderate (~150km) width
- ADCP at the bottom of TaiMa ferry has been deployed since 2009, which measures daily volume transport (Q_{adcp}) across the Strait (Chen *et al.*, 2016)

Fig.1 Taiwan Strait and regular route of TaiMa ferry; positions of the tide gauge stations (Kinmen and Mailiao) and the weather station (Pengjiayu) are also shown

2. Data and Method

[Volume transport Q_{adcp}]

- From 4-year daily ADCP data on TaiMa ferry (209/01-2012/12)
- Tidal current removed by TPXO model (Chen *et al.*, 2016)
- Vertically and horizontally integrated along-strait velocity component (u)
- Current in the Strait is nearly barotropic (Chen *et al.*, 2016)

- Q_{adcp} has a clear seasonality

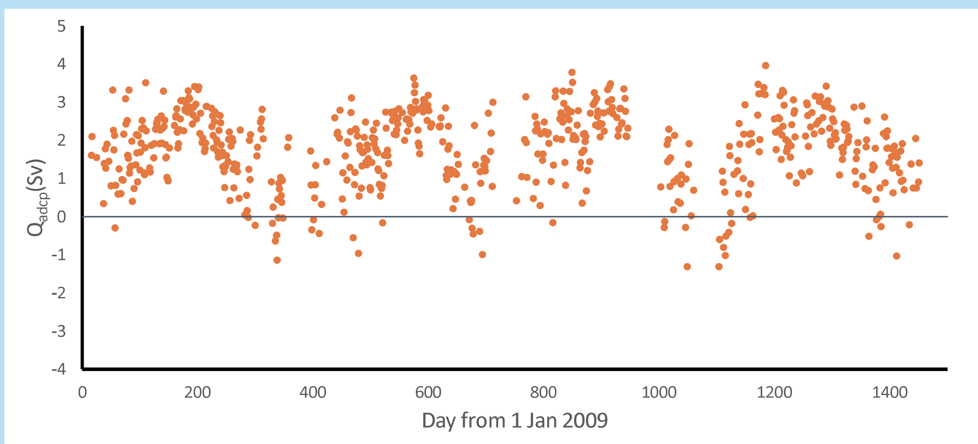


Fig2 Time series of the volume transport Q_{adcp}

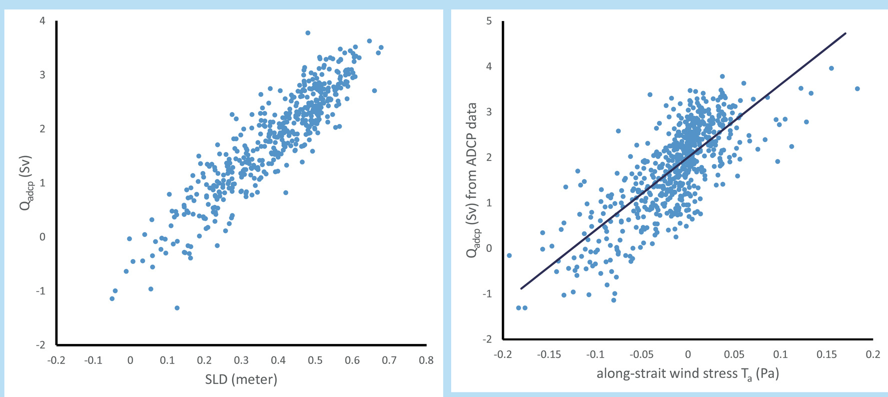


Fig3 Scatter plots for Q_{adcp} and SLD (left) or along-strait wind stress τ_a (right)

- Q_{adcp} and the sea level difference (SLD) across the Strait (Mailiao-Kinmen) are very well correlated (Fig.3)
- Q_{adcp} and along-strait wind component (τ_a) at Pingjiayu station are also well correlated, although less significant than SLD (Fig.3)
  - Correlation is largest at the along-strait wind direction and with 8 hours delay (Fig.4)
  - Temporal changes of Q_{adcp} are insignificantly correlated with SLD and τ_a (not shown)

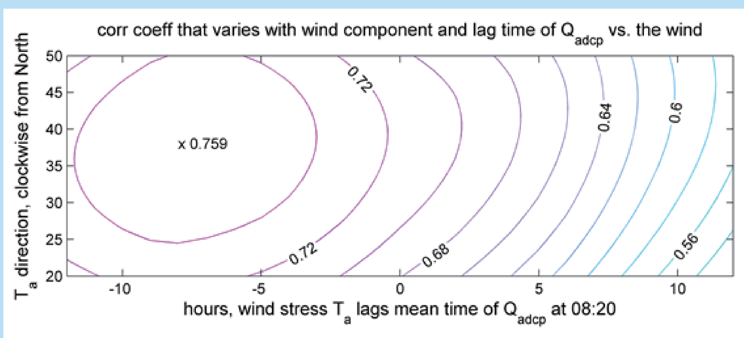


Fig4 Correlation coefficients between Q_{adcp} and the wind stress component in various directions and with various temporal lags.

Assuming that

- current and wind stress in the cross-strait direction (y) is negligible,
- topographic friction is a linear function of the along-strait velocity u,
- temporal variations are small,

then the vertically and horizontally integrated momentum equations become

$$rQ_{adcp} = -gD\frac{\partial h}{\partial x}W + \frac{\tau_a}{\rho}W \quad .....(A)$$

$$fQ_{adcp} = -gD\Delta h \quad .....(B)$$

where D and W are the depth and the width, respectively, and r the friction coefficient; these explains better correlation of Q_{adcp} with SLD than the wind stress τ_a alone.

We separate the wind-correlated component Q_w and the remaining Q_o from Q_{adcp}; namely,

$$rQ_w = \frac{\tau_a}{\rho}W \quad .....(A1)$$

$$rQ_o = -gD\frac{\partial h}{\partial x}W \quad .....(A2)$$

To estimate Q_w, seasonal components are first removed both from Q_{adcp} and τ_a since Q_o would include a seasonal component that may have significant correlation with τ_a. The Q_w component are then linearly estimated from τ_a to produce Q_o (Fig.5).

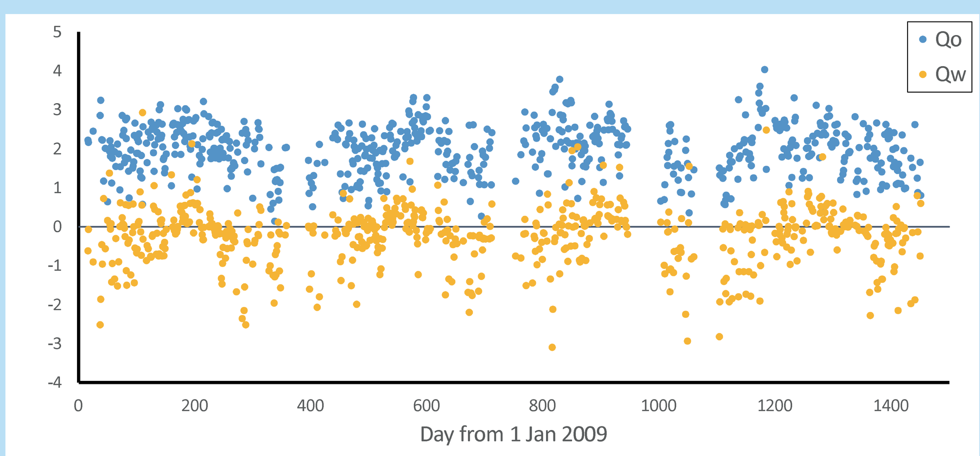


Fig5 Time series of Q_o and Q_w.

[Coastal Altimetry data]

- Along-track Jason-2 S-GDR from AVISO Path 51 (along-strait) and 164 (cross-strait)
  - New waveform algorithm for coastal areas is applied (Wang and Ichikawa, *in prep.*)
  - Detided by harmonic analysis (M_2, S_2, K_1, O_1, N_2, K_2, P_1 + S_a, S_{sa}) (Yanagi *et al.*, 1997)
  - Band-pass filter (50-120 days) and spatial 30-km smooting are applied to SSHA.

Correlation coefficients between the SSHA and Q_{adcp}, Q_o and Q_w will be calculated at each point along the paths.

3. Results

- Correlation coefficients along Path 51 are plotted in Fig. 6. Obviously, Q_w has no significant correlation with SSHA, and thus Q_{adcp} and Q_o become similar.
- For Q_o, significant negative correlations are found in the northern end of the central axis of the Strait. Meanwhile, significant positive correlations are found to the south of Taiwan, which suggests consistent along-track pressure gradient in Eq. (A2).
- Also note that positive correlation is limited only in the shallower region.

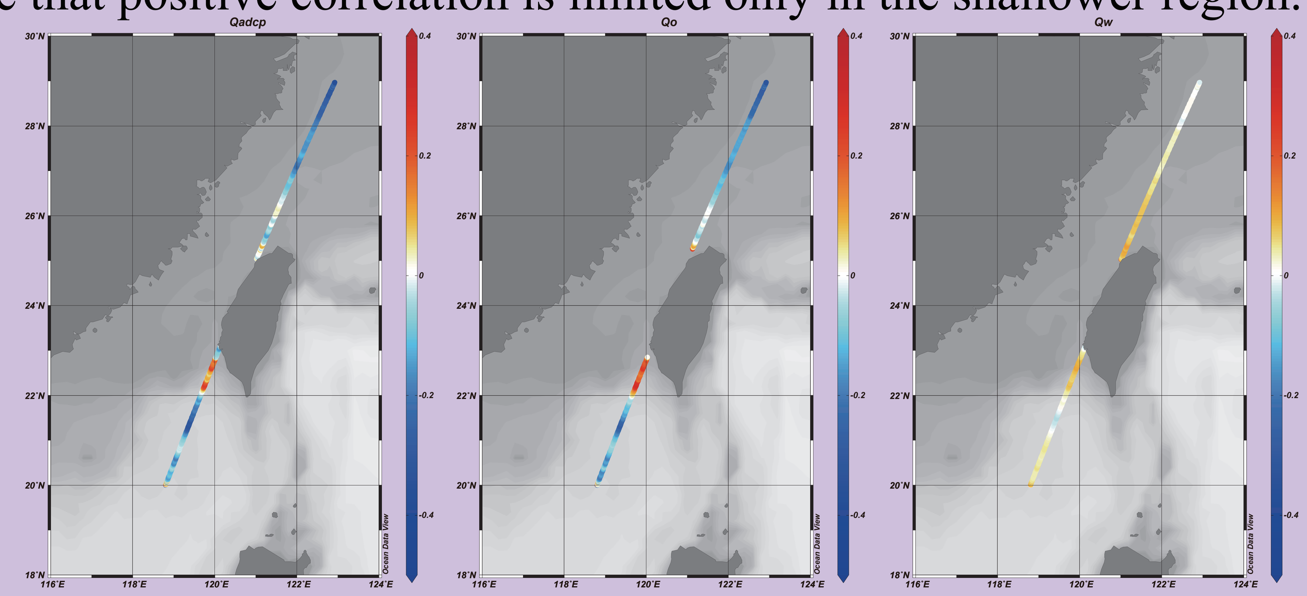


Fig.6 Correlation coefficient with Q_{adcp}, Q_o and Q_w along the Jason-2 Path 51. Positive and negative correlations are coloured by red and blue, respectively. Background gray contour represents bottom topography.

- Along Path 164, consistent cross-strait pressure gradient with Eq. (B) is confirmed in Fig. 7 Q_{adcp}, but less significant both in Q_w and Q_o. This would be because both Q_w and Q_o contribute to the cross-strait pressure gradient, independently.

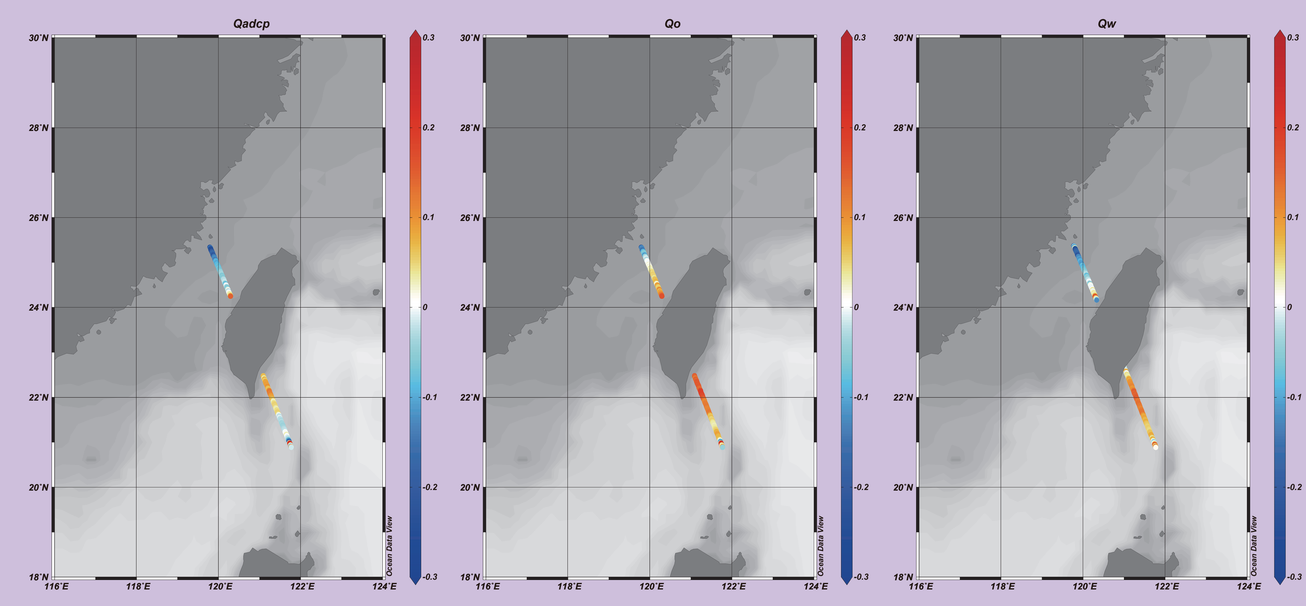


Fig.7 Same as Fig.6 but for path 164.

4. Summary and Discussion

- Volume transport in the Taiwan Strait (Q_{adcp}) determined from ADCP on TaiMa ferry is separated into wind-induced component Q_w and the other component Q_o.
- Correlations are calculated with the along-strait and cross-strait coastal SSHA data, which are consistent with the simple ocean dynamics
  - Coastal altimeter data allow us to examine depth-dependency of the correlation distribution within the Strait
  - However, data very close to lands are missing; cross-strait correlations are less significant than the tide-gauge SLD.
  - Along-track distribution is not enough to represent pressure gradients of the whole Strait. Wide-swath altimetry such as SWOT (and COMPIRA) would be very useful.

References

Chen et al. (2016), *Cont. Shelf. Res.* , 114, 41-53.
Yanagi et al. (1997), *J. Oceanogr.*, 53, 303-309.