Mapping the Northeastern Chukchi Sea Surface Currents and Their Dynamical Response Under Different Environmental Conditions

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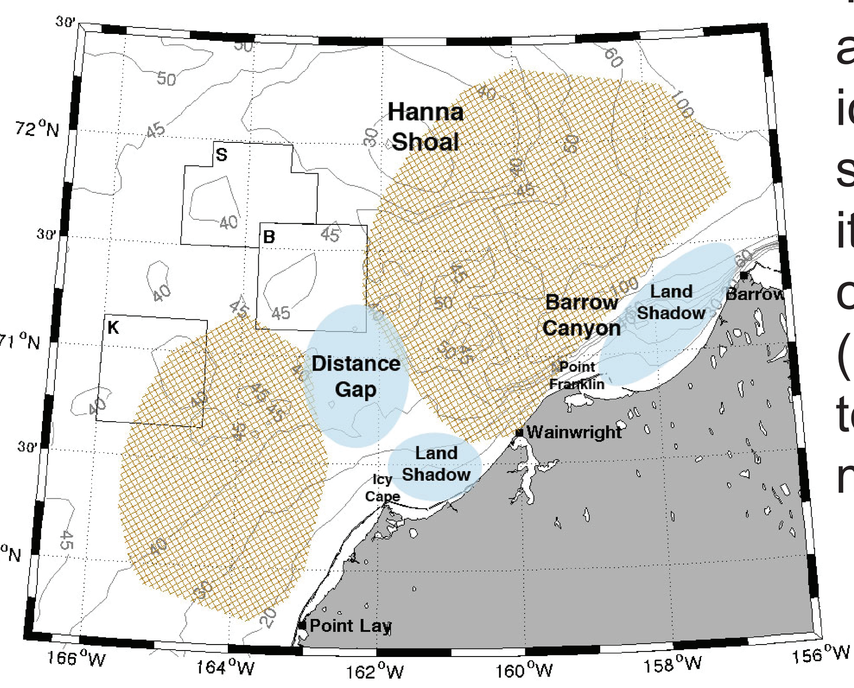
Motivation



Three high-frequency radars (HFR) deployed along the northwest Alaskan coast during the ice-free season in 2010 made near real-time surface current measurements. However, limitations of HFR's location and signal strength cause several perminant and intermittent gaps (Fig.1). The challenge of utilizing these data is to mitigate noise, fill the gaps and reconstruct major sea surface current patterns.

Fig.1, map of HFR locations (black square) and their ideal coverage

Sampling strategy of HFR

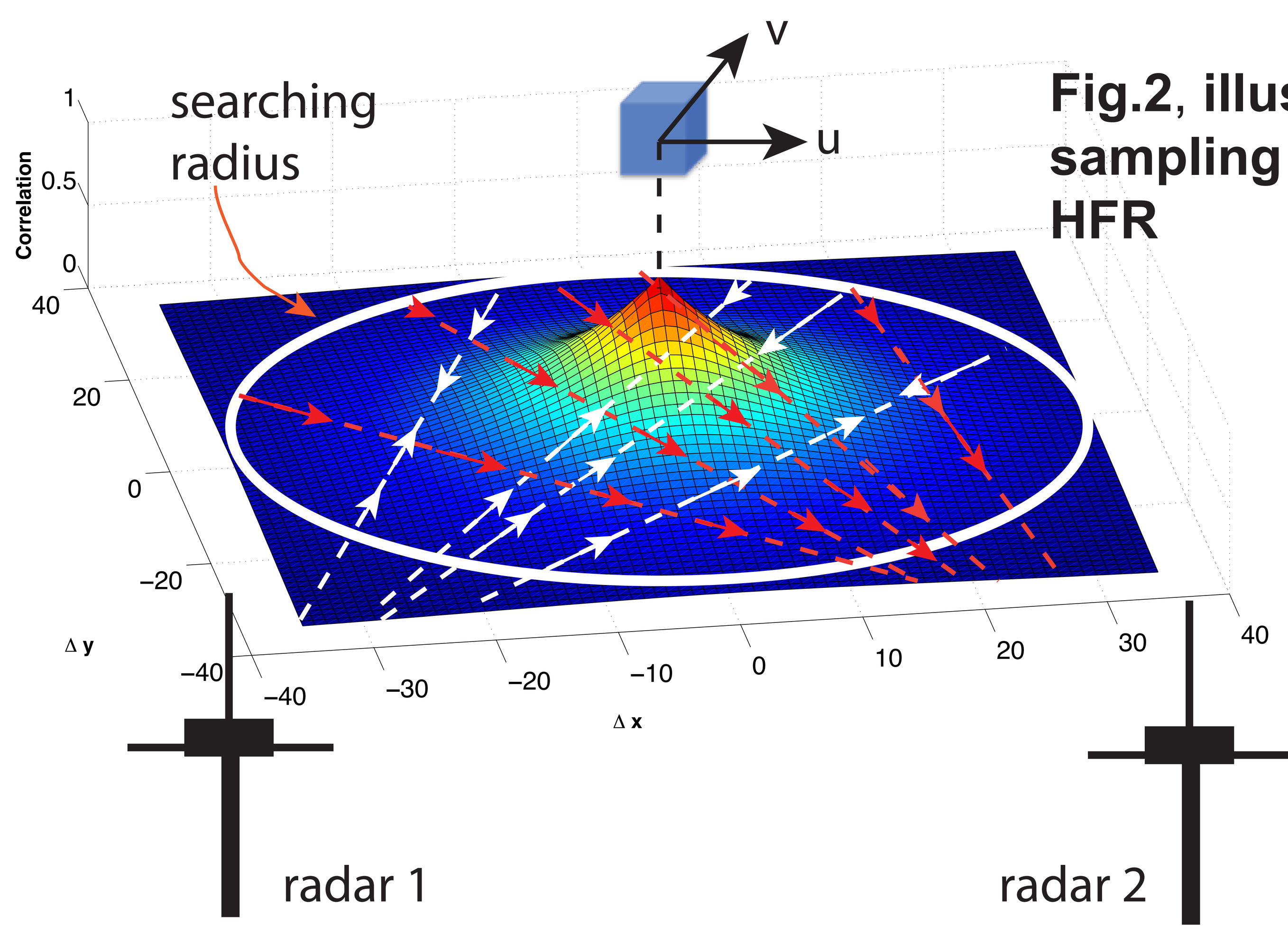


Fig.2, illustration of sampling strategy of HFR

Within the searching radius, the radial velocity components are measured from different HFR. Within a specific period for temporal averaging, these radials are used to estimate current vectors. When these radials are treated as equally weighted, estimates can be made by least-squares method (LS). However, for those radials far away from the center, their contributions to estimates should be smaller. Therefore, radials should be weighted according to the relationship of the spatial correlation function. This method is called optimal interpolation and is applied to the HFR data here

Optimal interpolation (OI)

Kim et al (2007, 2008) introduced OI on HFR data in California. We follow their method to calculate signal variance, error variance and decorrelation length scale. This information is a priori knowledge for OI. An example OI is follows:

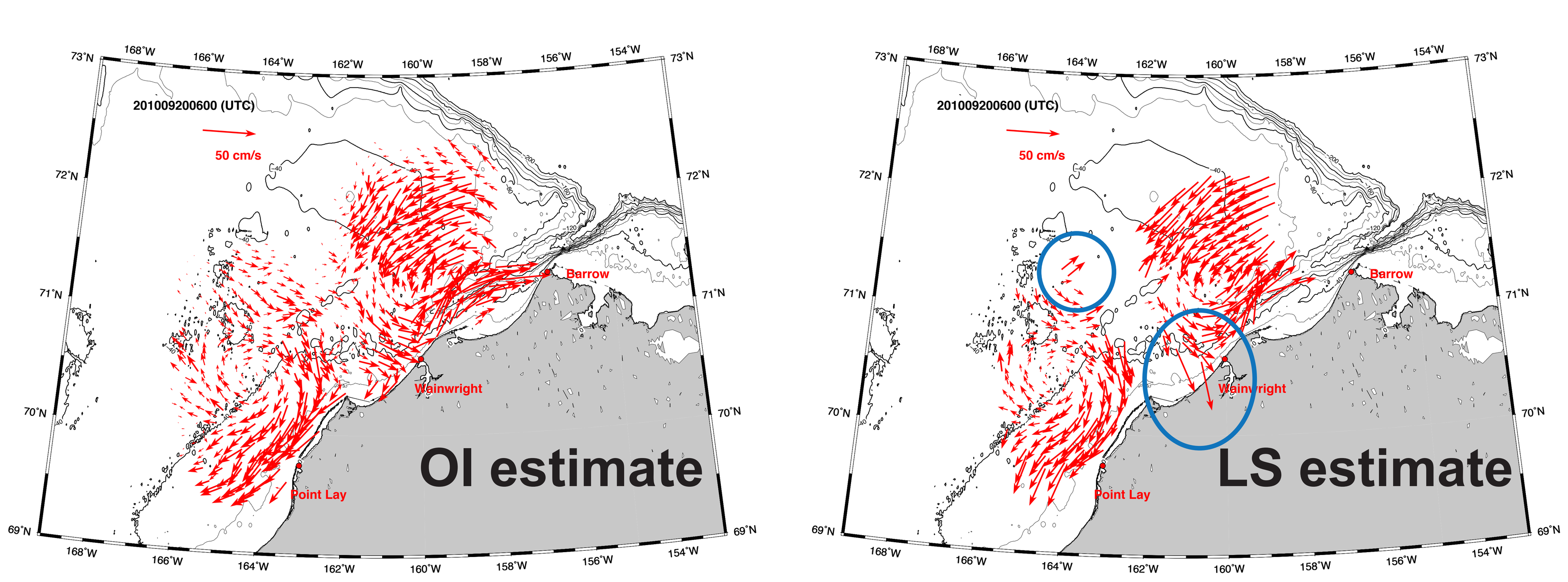


Fig.3, comparison between OI and LS estimates.

An example of two eddies estimated by LS and OI methods on 2010 HFR data is shown in Fig.3. Spurious current vectors seen in the LS estimate (blue circle) are removed in the OI estimate. Moreover, OI estimate has larger data coverage.

Error analysis

We compute an analytical surface current field of two eddies propagating southward in the northeastern Chukchi Sea. This flow field is then projected onto radial directions for each radar. The resulting radials are used to estimate current vectors using OI. This approach help us evaluate the limitation of OI by comparing the OI estimates and the known analytical field. This assesment is conducted by computing the skill score (Warner et al., 2005) of OI and the resulting phase shift (Shay et al., 2007) (Fig.4).

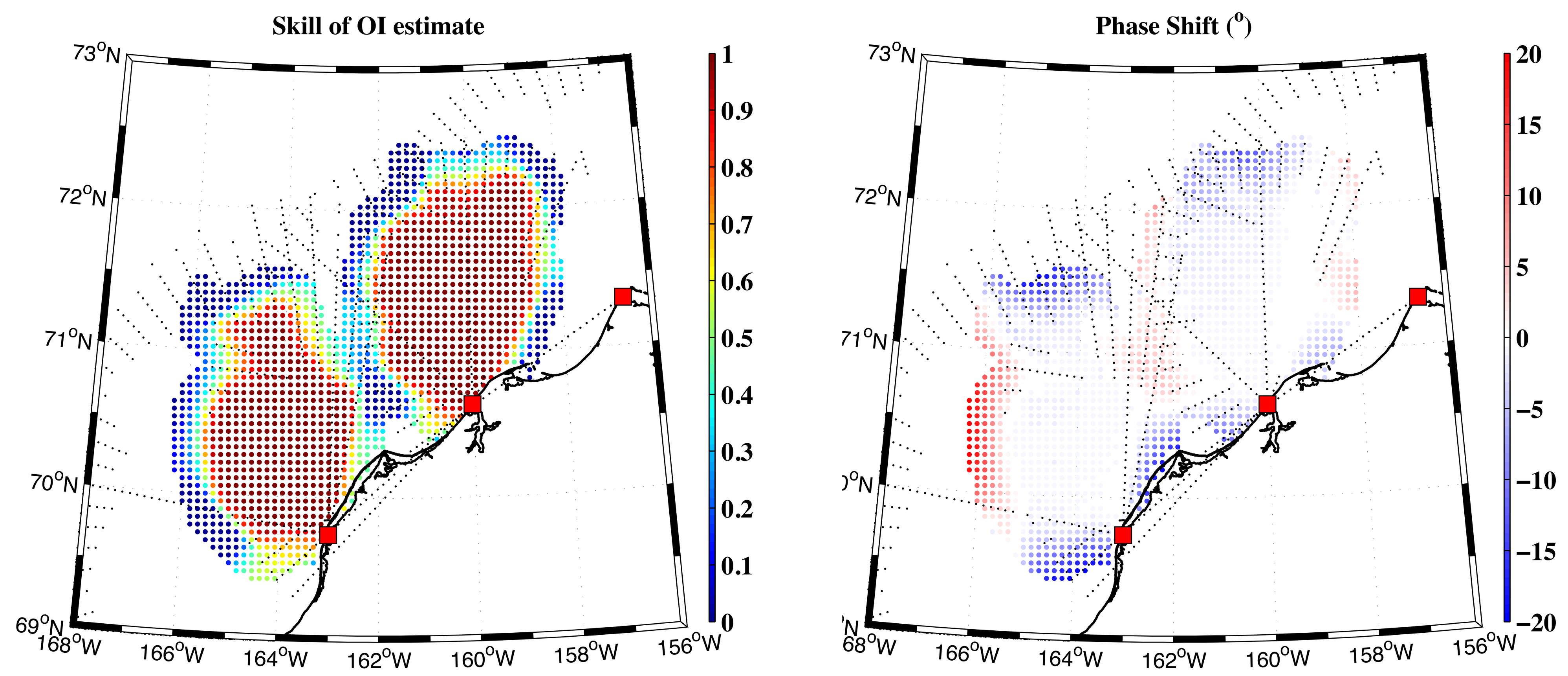


Fig.4, spatial distribution of skill of OI estimates (L) and resulting phase shift (R). Black dots indicate locations of permanent gaps of raw data.

We find the spatial distributions of skill and phase shift of OI estimates are controlled by: 1) available radials (AR) in the averaging radius, 2) ratio of overlapping radials (ROR) in the searching radius and 3) condition number (CN) of the weighting matrix (Fig.5).

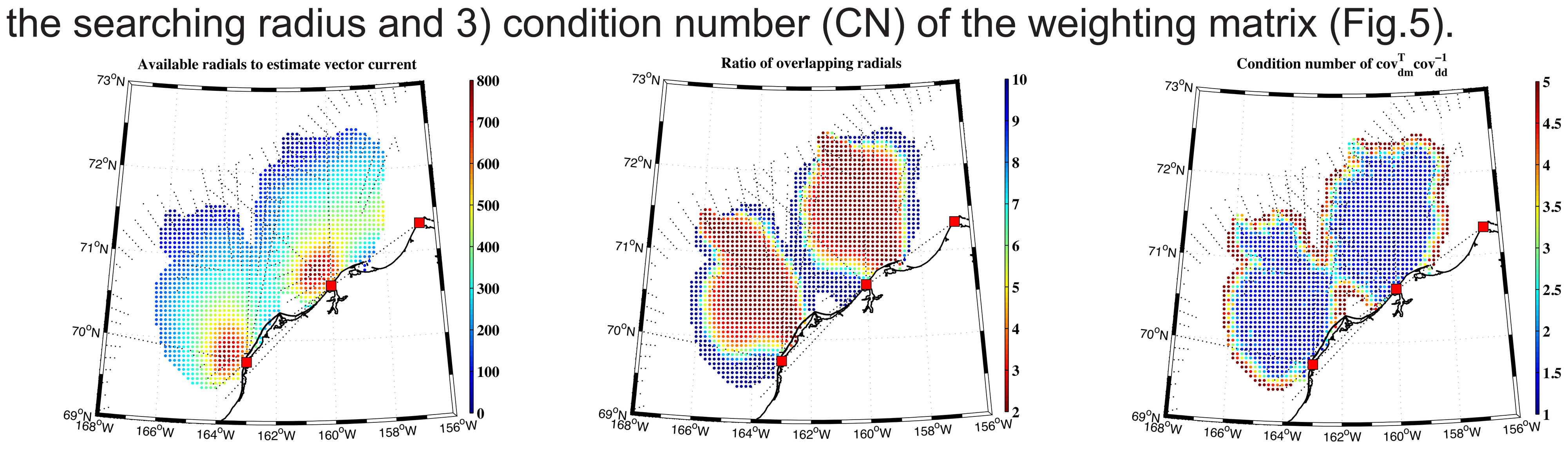
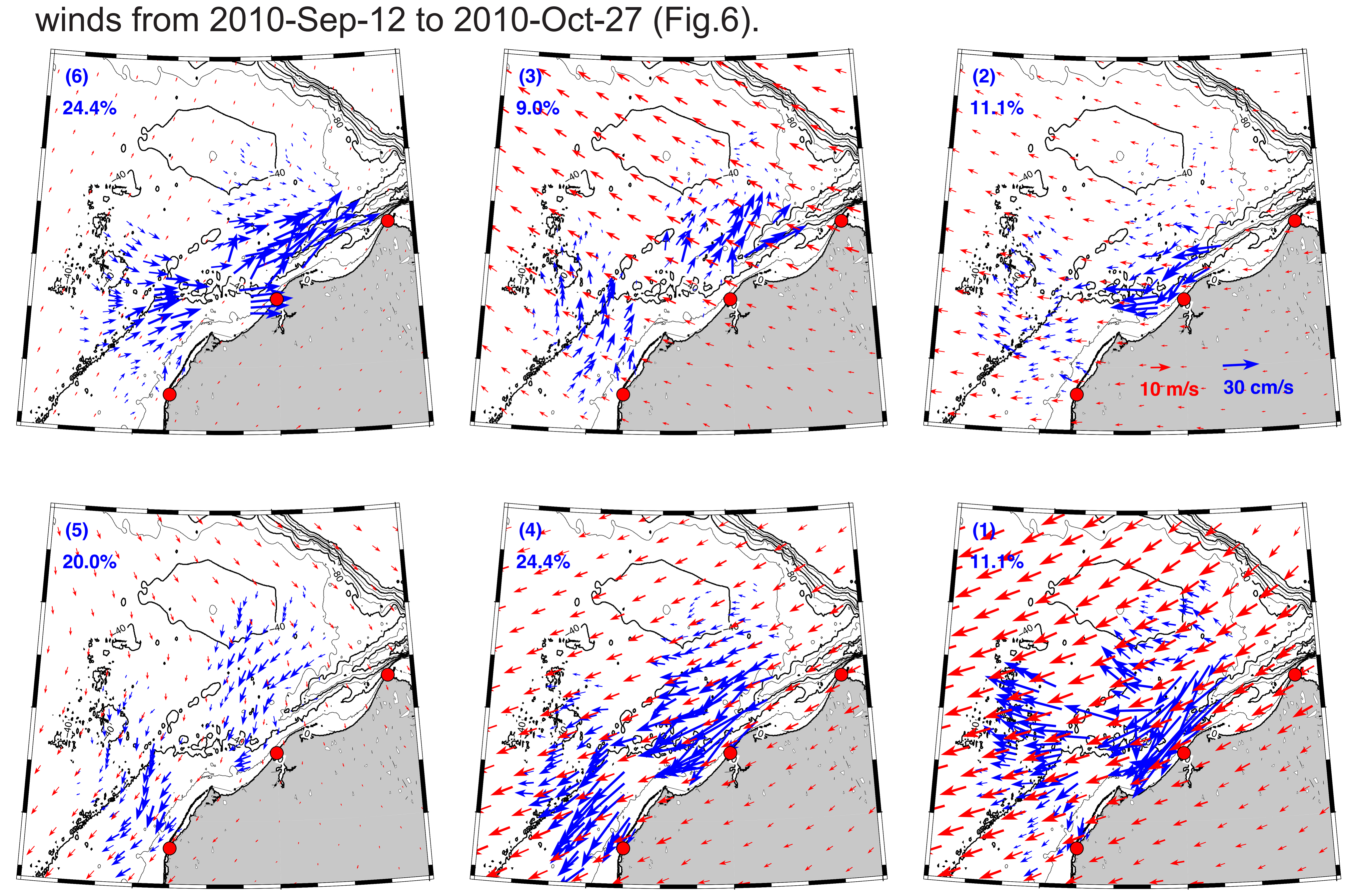


Fig.5, spatial distribution of AR (L), ROR (M) and CN (R) of OI estimates.

Major sea surface current patterns

We apply Self-Organizing Map (SOM) (Mihanović et al., 2011) on HFR and wind velocities to extract six circulation patterns. The data set comprises 45 daily averaged surface currents with OI skill score larger than 0.6 and daily averaged regional NARR winds from 2010-Sep-12 to 2010-Oct-27 (Fig.6).



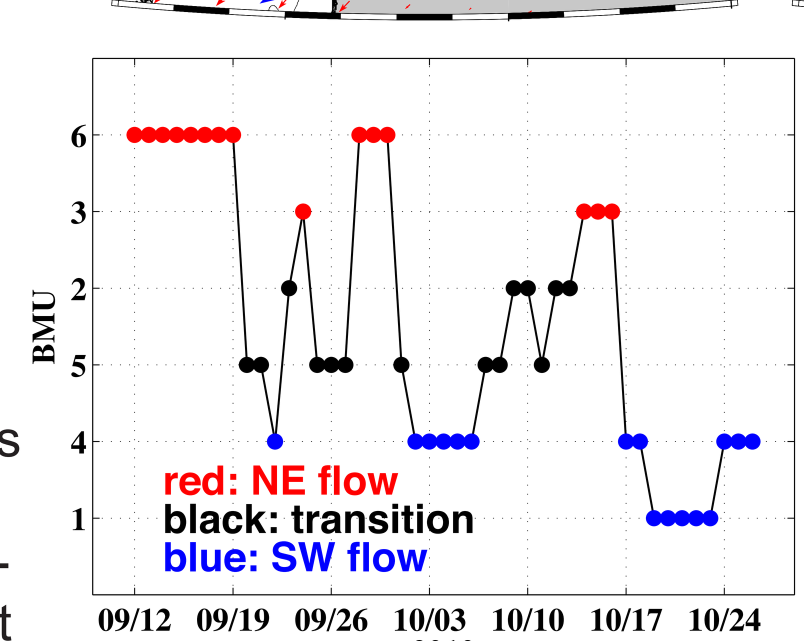


Fig.6, patterns of surface currents (blue) and corresponding winds (red) (Above). Best-Match-Units (BMU) and frequency of occurrence are shown in the top left corner, and time series of corresponding BMU (Left).

SOM shows northeastward (NE) flow appears when winds are weak or from the east, flow reversal (SW flow) occurs when wind speeds are larger than 10 m/s. Flow is transitioning during wind relaxation. SOM may be useful in search and rescue operations and oil spill response.

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