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OSSE-OSE Activities Using the Ocean Data Assimilation and Prediction System, MOVE/MRI.COM

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A. Singular Vector Analysis of Kuroshio Large Meander

Abstract

Singular Vector (SV) analysis is a way to identify the most unstable perturbations that grow up rapidly in a certain period and affect following phenomena effectively. This technique is applicable for designing an observing system. We applied SV analysis to the formation process of the Kuroshio large meander, and demonstrated that it is important to identify pressure contours crossing the temperature front of the Kuroshio in the mid-depth (500-1500m) layer southeast of Kyushu for precise prediction of the large meander formation (**Fujii et al. 2008**, *JGR* 113, C07026). This result suggests intense observation around that area is desirable for improving the forecast skill.

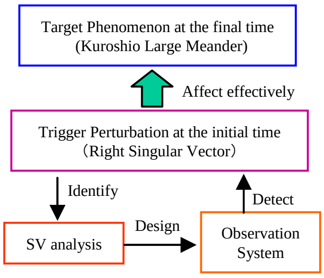
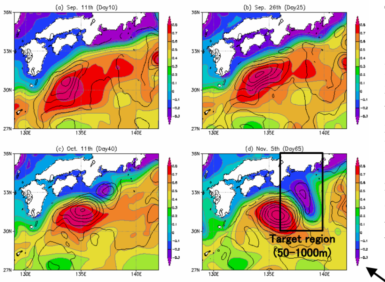


Fig.1 Schematic figure of observation system design using SV analysis.

Method



The large meander formation occurred in a free simulation run of MOVE/MRI.COM-WNP (see Dr. Ishizaki's poster, S2.8-036), shown in Fig.2, is used for the background field. We identify the trigger perturbation in Day 0-10 that leads the largest perturbed kinetic energy in the target region in Day 60-70 as the largest Right SV. Although the Kuroshio flows in the straight path in Day 10, the large meander is rapidly developed about 50 days later. Tsujino et al. (2006, *JGR* 111, C11001) showed that the lower anticyclonic eddy is remarkable before the formation of the large meander.

Fig.2 The background field. Color: SSH (m). Contour: Pressure at 1800m. Contour Interval (CI) is 2×10^3 Pa.

Linear Time evolution of the SV

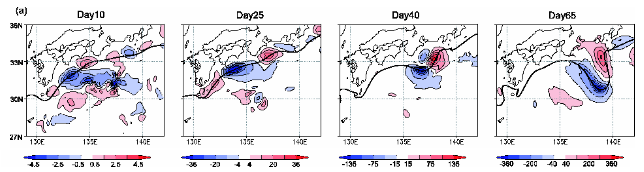


Fig. 3 Time series of SSH in the linear evolution of the SV. The thick line shows the Kuroshio Axis in the background field. The perturbation grows up rapidly (Please note that scales of shading are different from a different plot.) The negative anomaly in the southwest of the meander and the positive anomaly in the northeast of it implies that the perturbation tends to leads more development of the large meander with displacing the tip of the meander southwest.

Nonlinear evolution and the mechanism of the growth

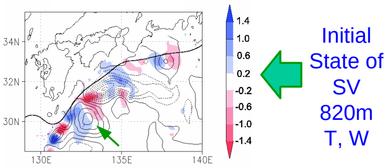


Fig.4 Perturbation fields at 820m at initial. Contour: pressure (dotted lines denote negative). Color: vertical velocity (positive means downwelling). The thick line shows the Kuroshio axis in the background field.

Anticyclonic anomaly south west of Kyushu (See the arrow) produces cold advection crossing the Kuroshio axis in the northern side and inducing the downwelling there.

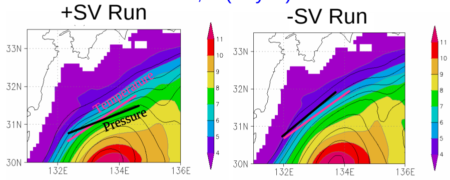


Fig.5 Initial fields at 820m in the runs where the SV is added to or subtracted from the background state (+SV and –SV runs). Contour: pressure (CI: 5×10^3 Pa). Color: Temperature (ºC).

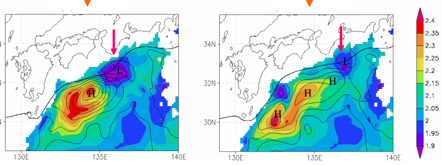


Fig.6 Pressure (contour, CI: 5×10^3 Pa) and temperature (color, ºC) at 1800m and the Kuroshio axis (thick line) in Day 25. The pressure contour crossing the isotherm at initial in +SV run (Fig. 5) causes cold advection and downwelling, which results in shrinking of vortex end enhancement of the anticyclone in the deep layer.

This anticyclone produces cold anomaly in the upstream, which, together with the Kuroshio current in the upper layer, induces baroclinic instability, and leads to the development of the meander.

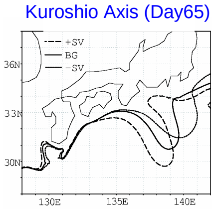


Fig.7 Kuroshio axis in Day 65 in the background field, +SV and –SV runs. The meander is developed more than the background field in +SV Run. It propagates faster to the east and goes over the Izu-Ogasawara ridge (along 139.5ºE line) in –SV Run.

B. Impacts of Ocean Observations on ENSO Forecasting

Abstract

Impacts of observation data from TAO/TRITON array and Argo floats in the JMA current ENSO forecasting system (see Dr. Soga's poster, S5.27-34) are evaluated in OSE experiments. We performed a regular assimilation run (ALL) and 2 additional runs (NTT and NAF) where data from TAO/TRITON or Argo floats are excluded from the assimilated data. NTT and NAF started from the fields of ALL in 2000/01/01. Then, we performed 11 member ensemble 13-month forecasts from the end of Jan., Apr., Jul., Oct. in 2004-2007 using the three assimilated fields. The result demonstrates the impacts of both observing system in the forecast score of SST in the central and eastern equatorial Pacific.

Name	TAO	Argo
ALL	○	○
NTT	×	○
NAF	○	×

Impacts on assimilation fields

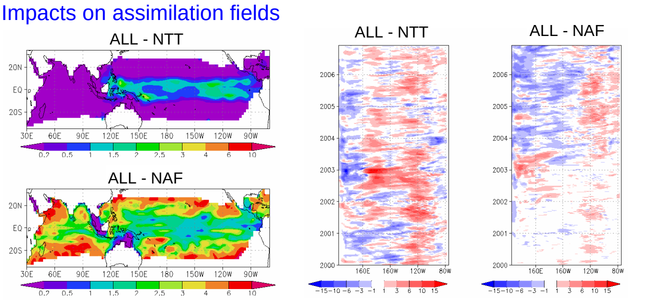


Fig.8 Left: RMSD of Z20 (m) in 2004-2007. Strength of the impacts for TAO/TRITO and Argo is similar in the equatorial Pacific, although Argo floats improves the Z20 field in the broader area.

Right: Longitude-time section of the difference of Z20 (m) between ALL and NTT or NAF. The Impact of Argo rapidly increases after 2003, while that of TAO/TRITON is decreasing. They have similar strength of the impacts after 2004.

Impacts on Forecasts

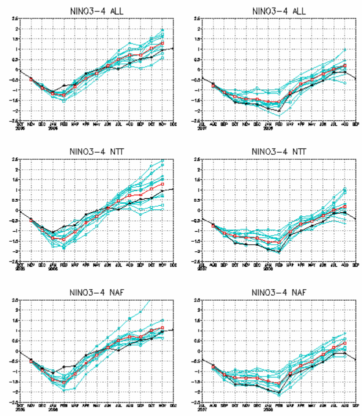
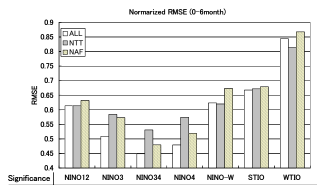


Fig.9 Time series of SST anomaly averaged in the NINO34 area (see Fig.11) in the forecasts* from 2005/10/28 and 2007/07/30 for ALL, NTT, and NAF. Black: observation. Blue: forecasts of each members. Red: ensemble mean forecast.

*The forecast bias is estimated for each initial month, each lead time, and each experiment, and removed before using the data as the forecast results in Figs. 9-11.

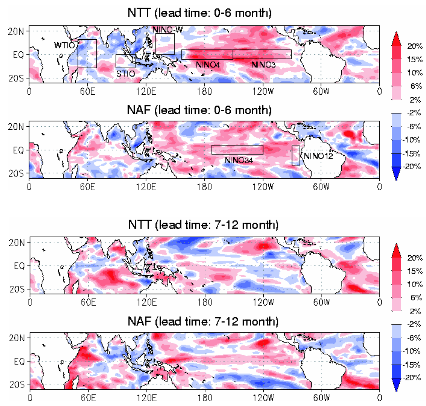


Significance	NINO12	NINO3	NINO34	NINO4	NINO-W	STIO	WTIO
NTT	50%	93%	96%	97%	47%	53%	35%
NAF	62%	89%	76%	80%	79%	57%	62%

Fig. 10 RMSEs of the 0-6 month ensemble mean forecasts* of monthly SST anomalies (0 month forecast means the forecast of the mean in the first month) averaged in NINO12, NINO3, NINO34, NINO4, NINO-W, STIO and WTIO (see Fig. 11) normalized by the RMSEs of persistence forecasts. Significance levels for the hypothesis that ALL has smaller RMSEs than NTT or NAF has are presented on the bottom of the graph.

TAO/TRITON data has a crucial impact on the forecast of SST in the eastern and central equatorial Pacific (NINO3, NINO34, NINO4) with the significance levels larger than 90%. Thus, TAO /TRITON data is essential for improving the ENSO forecast. Argo floats has large impacts not only in the eastern and central Pacific but also in NINO-W, and it has some impacts in the Indian Ocean (STIO and WTIO).

Fig. 11 Horizontal Distribution of the improved ratios for 0-6 month and 7-12 moth SST forecasts* in NTT and NAF. The ratio is calculated as the difference of the RMSE between NTT or NAF and ALL normalized by the RMSE of ALL. Positive values denotes improvements in ALL over NTT or NAF.



TAO/TRITON has crucial impacts on the 0-6 month forecast in the broad area of central and eastern tropical Pacific. The impacts, however, decreases for 7-12 month forecast.

Argo floats have impacts on the 0-6 month forecast in the western tropical Pacific and Indian ocean as well as the central and eastern Pacific. The positive impacts remains for the 7-12 month forecast in the equatorial band and the western area in the Pacific.