SEASONAL AND SYNOPTIC SIMULATIONS OF THE JAPAN (EAST) SEA (JES) CIRCULATION

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Introduction

JES-POM, an implementation of the Princeton Ocean Model (POM) for the Japan East Sea (JES), is used here to study the response of the JES to various types of atmospheric forcing. In addition to the standard attributes of POM, it has the following special attributes: 26 sigma-levels, with concentrations near the surface and bottom; ca. 10 km horizontal resolution; smoothed ETOPO5 bottom topography that eliminates the seamounts but preserves the basin-scale topography; Levitus (1982) climatological temperature and salinity as the initial state; and, for the coefficient of the Smagorinsky lateral friction parameterization, HORCON=0.1 (See Kang (1997) for more details of the implementation and sensitivity studies). Steady throughflow forcing of 2.8 Sv is imposed. For the seasonal forcing case, the Na monthly climatological winds (on a 127×127 km grid) are used, and the seasurface temperature and salinity are relaxed to climatology with a relaxation time scale of 100 days. For the synoptic forcing case, the (PSU/NCAR) MM5 mesoscale atmospheric model's hourly winds and heat fluxes (on a 15×15 km) are used, together with seasurface salinity relaxation as before. The aim is to simulate (in particular) wintertime convection and ventilation and to validate the model simulations against available observations, especially the CREAMS I current meter arrays in the Japan Basin.

Response to Seasonal Wind-Forcing

The Na monthly wind climatology (1992) is based on 10-year (1978 thru 1987) of 12-hour synoptic weather charts. The maps of mean January, April, July, and October windstress and its curl (Fig. 1) illustrate the expected, characteristic seasonal pattern: autumn and winter winds dominate the annual mean and are associated with southeastward flows from Siberia. Throughout the year, the windstress curl is predominantly cyclonic, and which is an order of magnitude greater in winter than summer. JES-POM was run for ten years with a perpetual annual cycle of monthly climatological wind-forcing; adjustment from steady to variable forcing was accomplished in the first two years, and the last eight years were used for scientific analysis. The maps of eight-year mean windstress, seasurface height (SSH), and total streamfunction (TSF) (Fig. 2) indicate the separation of the EKWC near 38°N and the subsequent Subpolar Jet connecting to Tsugaru Strait and cyclonic gyres over the Japan Basin, Yamato Basin, Ulleung Basin, and Korean Basin (offshore of Wonsan Bay). The maps of eight-year standard deviation windstress, SSH, and TSF (Fig. 3) indicate highest (seasonal and interannual (but not for windstress)) variability occurs off the Primorye Coast for windstress, over Ulleung Basin for SSH, and over the eastern Japan Basin for TSF. (Note: though the forcing has no interannual forcing, the model output has intrinsic interannual variability, just as it has intrinsic mesoscale variability, due to dynamics internal to the model domain.) To isolate the seasonal variation in the circulation, the eight-year annual mean was subtracted from the eight-year mean TSF at mid-month (Fig. 4); for example, the mean TSF anomaly is predominantly negative on 15 January and 15 April, while it is predominantly positive on 15 July and 15 October, consistent with the seasonal variation in the windstress curl discussed above. The standard deviation of the TSF anomaly at mid-month (Fig. 5) is an indicator of interannual variability, which is concentrated in Japan Basin largely independent of season.

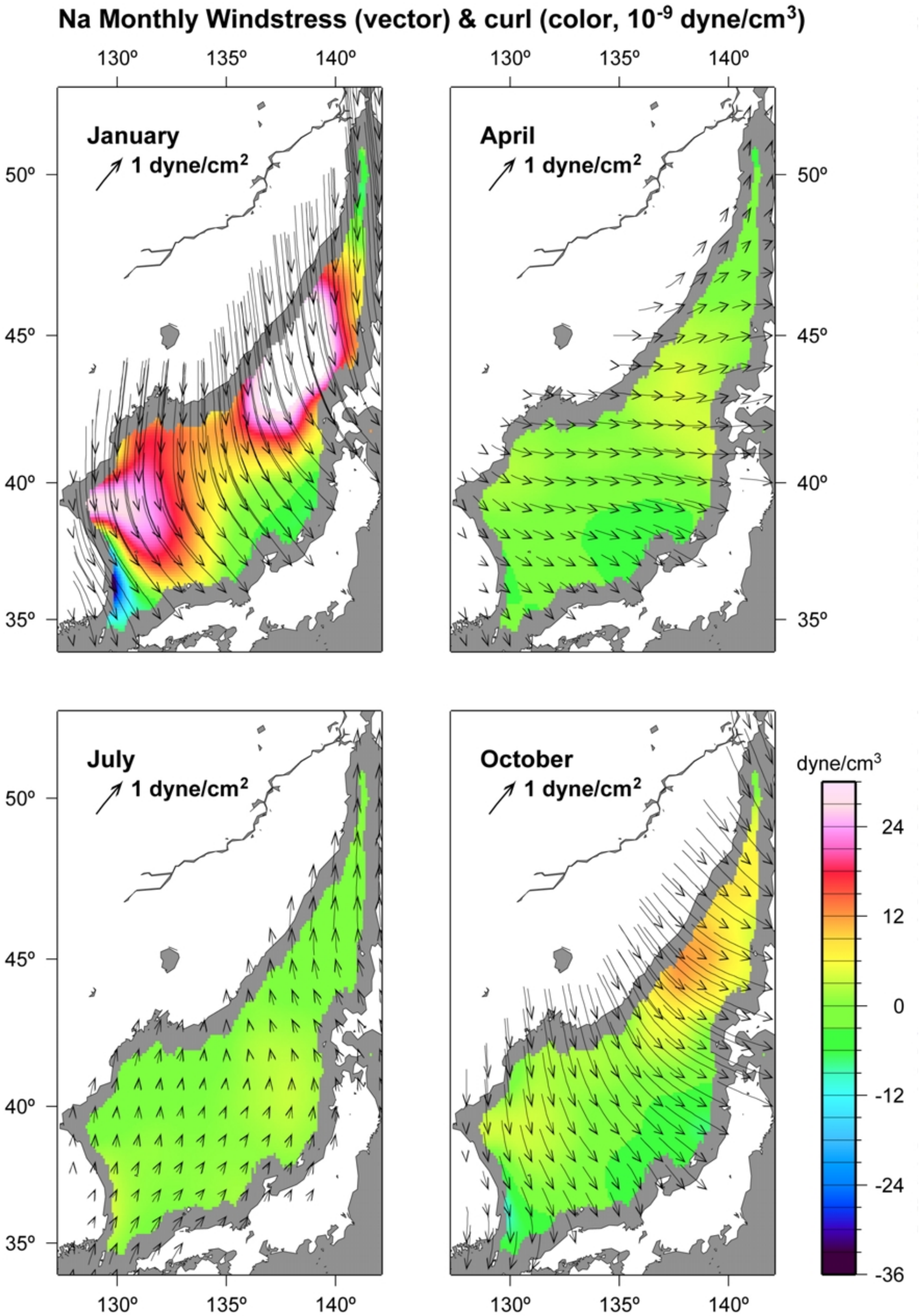

Fig. 1. Examples of Na (1992) monthly windstress climatology and its curl

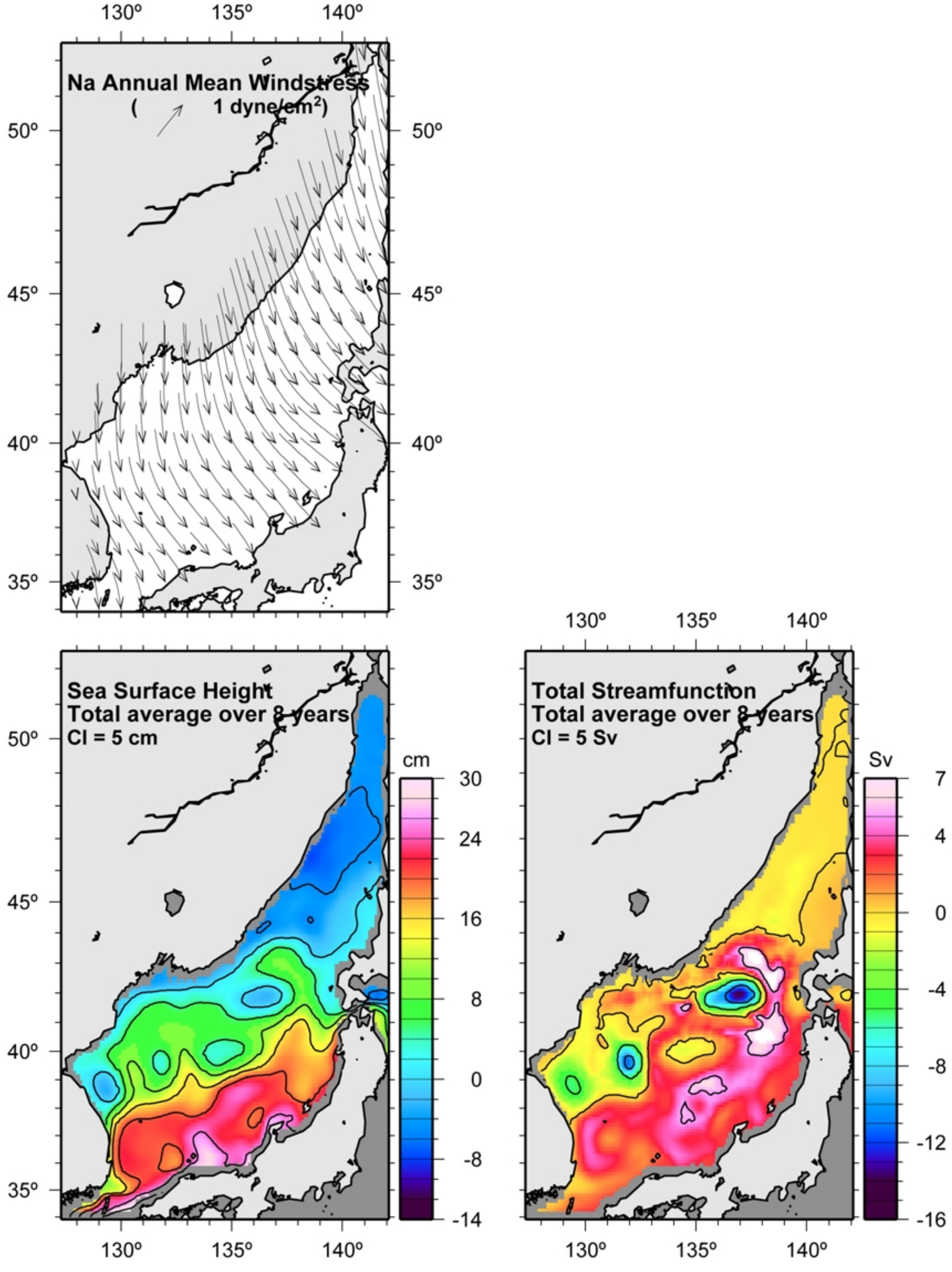

Fig. 2. Eight-year means of Na wind stress, JES-POM SSH, and JES-POM TSF

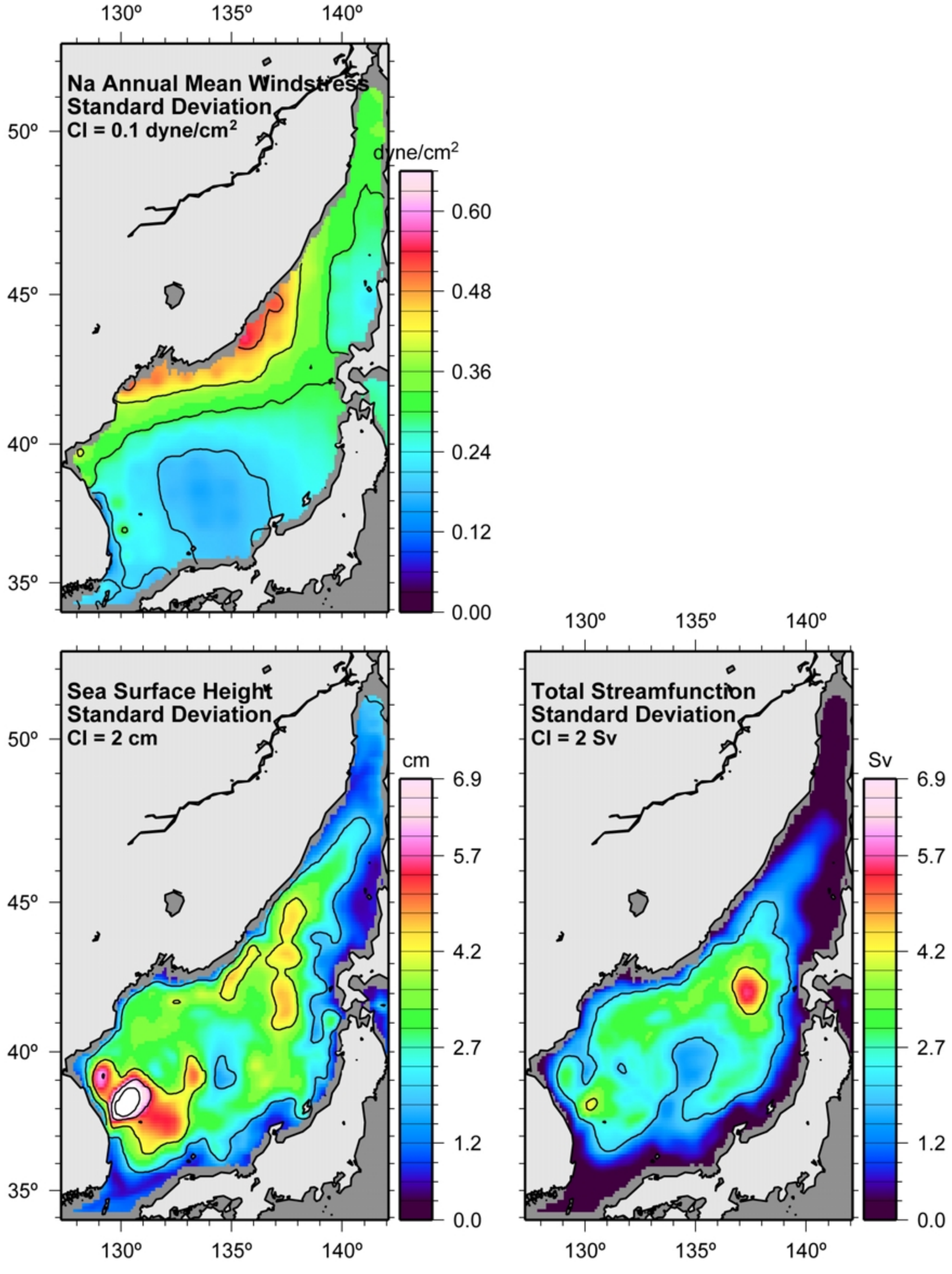

Fig 3. Same as Fig. 2, except for eight-year standard deviations

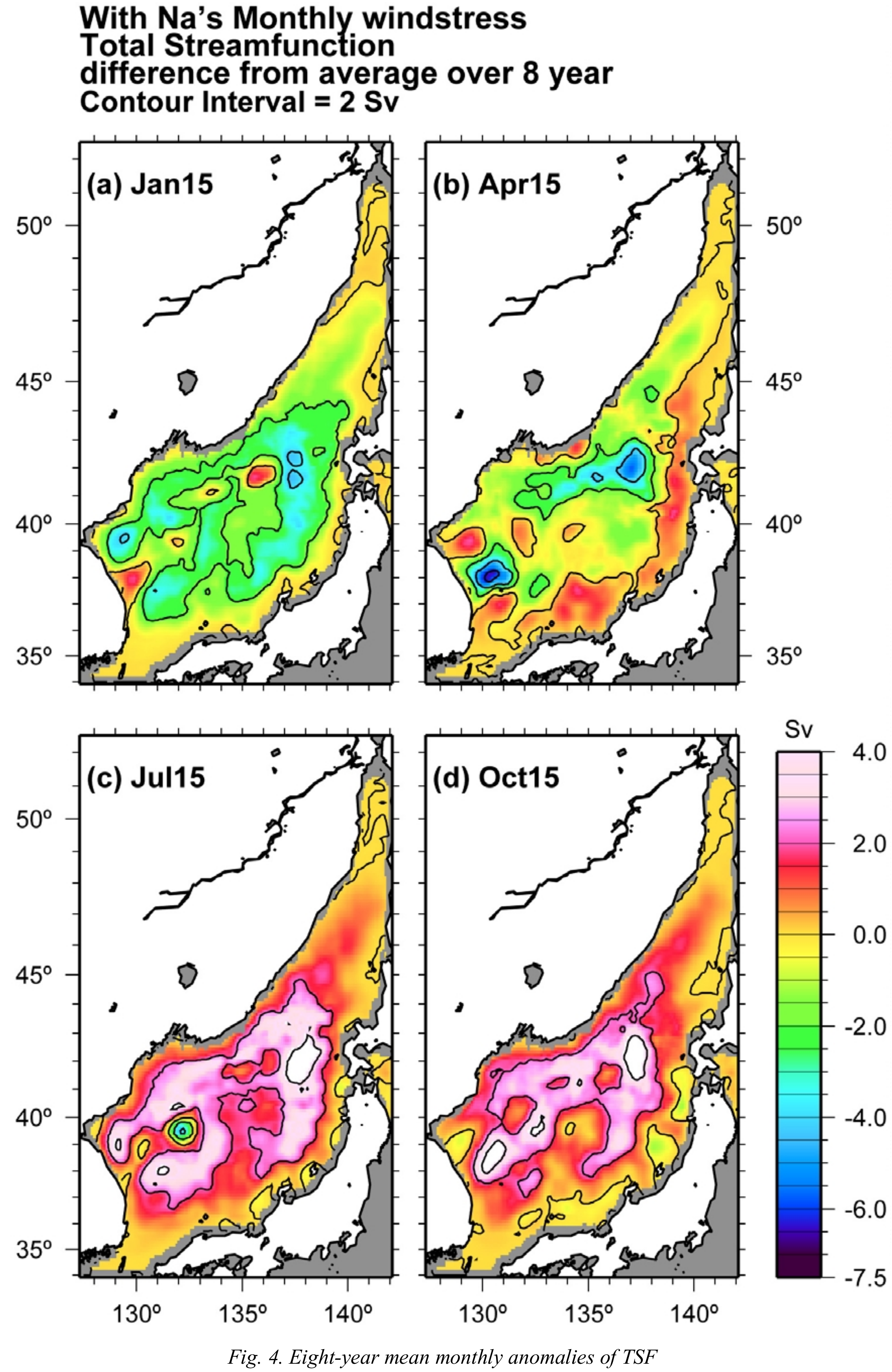

Fig. 4. Eight-year mean monthly anomalies of TSF

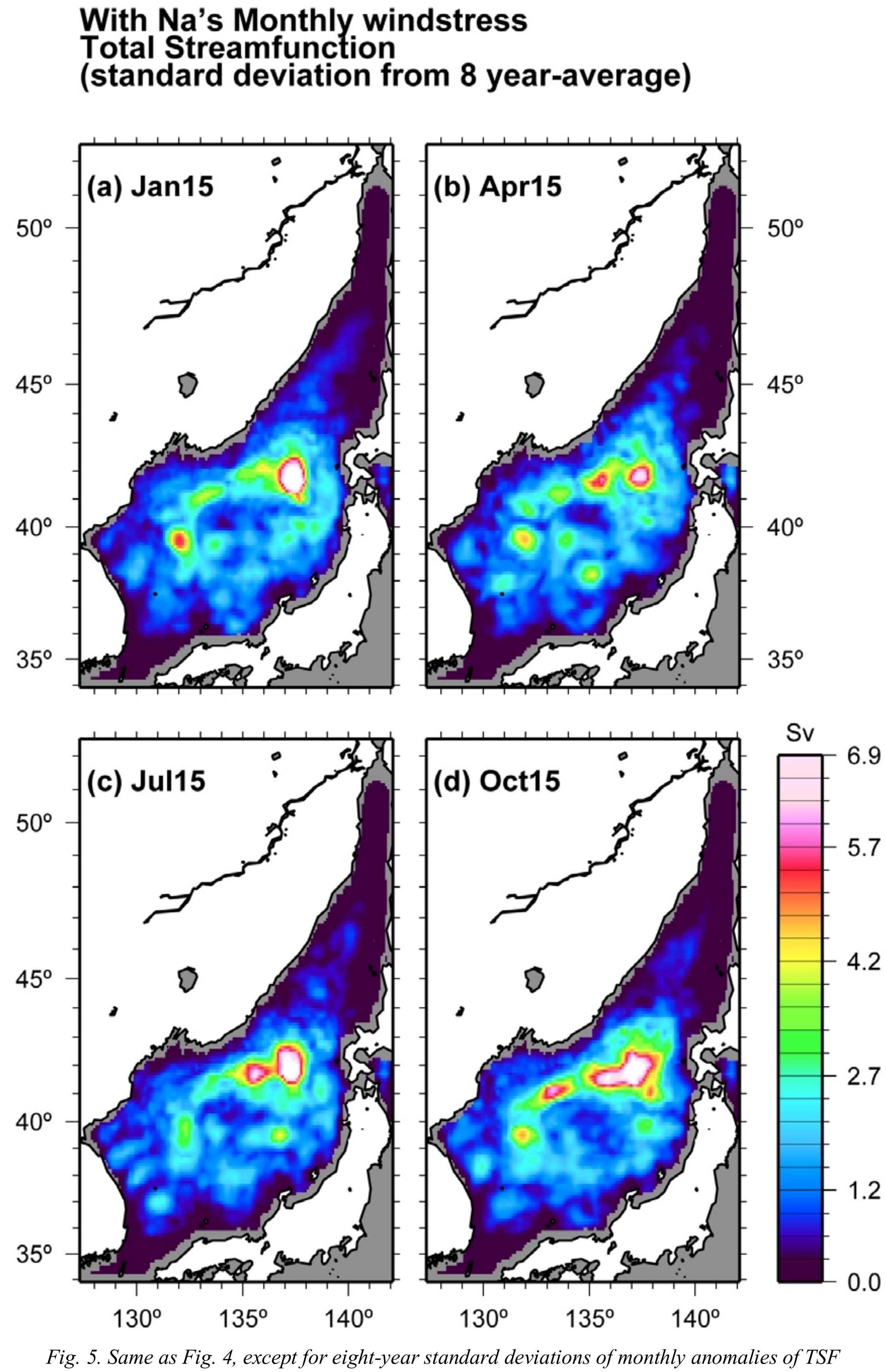

Fig. 5. Same as Fig. 4, except for eight-year standard deviations of monthly anomalies of TSF

Response to Synoptic Atmospheric Forcing

A pilot study has been conducted for the first nine days in January 1997 when two extratropical cyclone passages, and associated Siberian cold air outbreaks, occurred. JES-POM was run for three cases of wind-forcing: 12-hourly (on a 50×50 km grid by Timothy Liu, JPL) NSCAT winds (*i.e.*, winds from the scatterometer on the ADEOS satellite), 12-hourly ECMWF winds, and hourly MM5 (mesoscale atmospheric model) winds; all cases used the MM5 surface heat flux and relaxation to climatological surface salinity. The results are presented in Mooers *et al*. (2000a); only a few results are summarized here. In the region off Vladivostok of maximum surface fluxes associated with cold air outbreaks, the SST cooled by 1 °C, and the cooling penetrated to 100 m, over the course of those nine days. Also, basin-scale (largely barotropic, gravity) modes, as manifested in EOFs of SSH and TSF, were excited by the cyclone passages and may be detectable in appropriate observations.

Validation of Model Simulations Versus Observations

A preliminary validation has been conducted of a few model cases versus several of the CREAMS I moored current meters in the Japan Basin (Mooers *et al*., 2000b). Of particular concern is whether the model output exhibits convergence (in the statistical-dynamical sense; *e.g*., energy spectra) towards the observations with presumably improved (*i.e.*, more realistic) forcing. For example, for CREAMS mooring M3 at 2,100 m, a case with steady wind-forcing produced a kinetic spectrum with a slope similar to, but an energy level substantially less than, that of the observed spectrum in the mesoscale frequency band. However, the submesoscale band was grossly under-energized and the near-inertial motion was non-existent, whereas there was an energetic, narrow near-inertial peak in the observations. Surprisingly, with climatological monthly mean Na wind-forcing, the near-inertial peak and the submesoscale band closely resembled the observed, but the mesoscale band was substantially more energetic than the observed. (Presently, the comparison with a synoptic wind-forcing case is awaited.) Conversely, the variability of the model output is being explored in the depth-time domain and the vertical EOF-frequency domain. For example, the model output of the monthly mean wind-forcing case indicates that the vast majority of the kinetic energy at M3 is in the barotropic mode and surface and bottom Ekhman layers, and that the variability of the residual interior is well-represented by a few baroclinic modes. To the extent that the model is validated, due to its comprehensiveness and full coverage, these aspects of model output should be useful in more fully interpreting the inevitably limited observations, and in assessing their adequacy for various scientific and practical purposes.

Future Steps

JES ocean analyses produced by data-assimilative models are needed for diagnostic studies. However, much more work in model validation is needed first. Several of us are planning and proposing an International, Cooperative Model-Data Comparison and Analysis Project, which is open to all interested modelers and observationalists willing to participate; it will eventually lead to decade-long analyses for the JES during the CREAMS era.

Acknowledgement

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References

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