# Variability of the Sub-Polar Front in the Japan/East Sea During Fall and Winter 2009-2010

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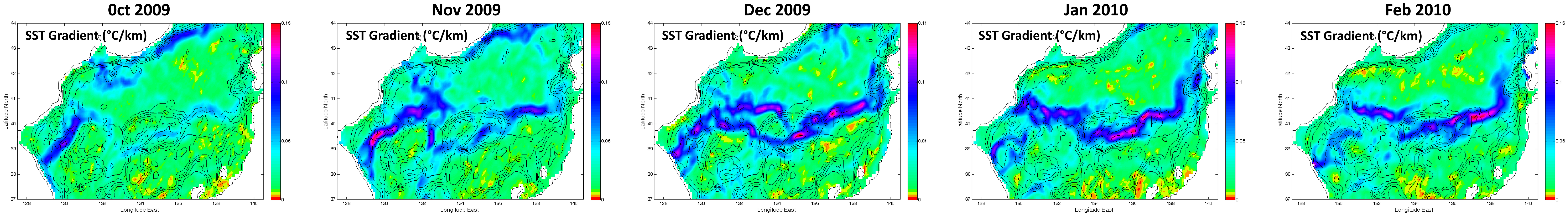



## Background

The Sub-Polar Front (SPF) in the Japan / East Sea is a well-defined boundary between warm, saline water associated with the northward flowing Tsushima Current and cold, fresher water associated with the southward flowing Liman Current. Generally oriented along 40°N, The strength of the front varies seasonally, with very strong sea surface temperature (SST) gradients in the winter, and weak gradients in the summer (Park, 2007).

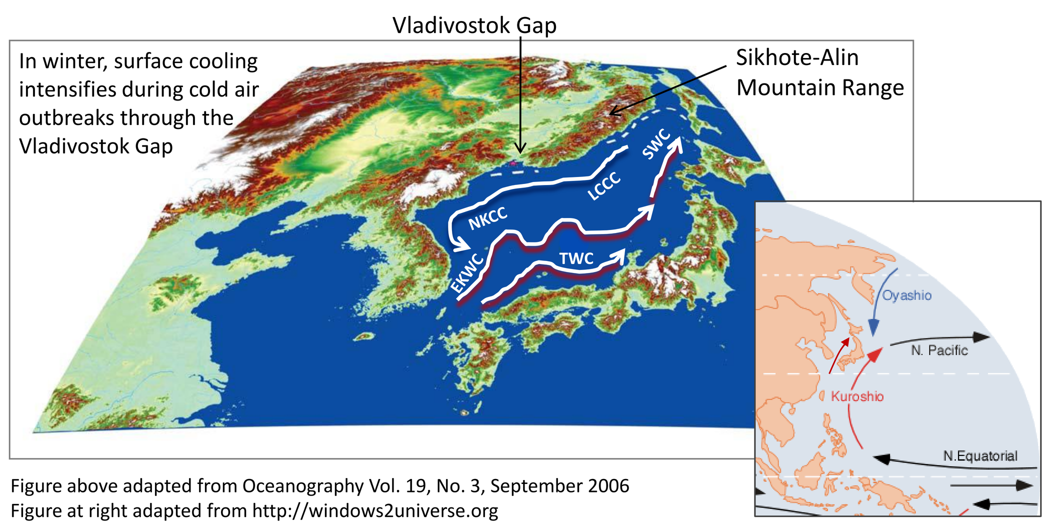


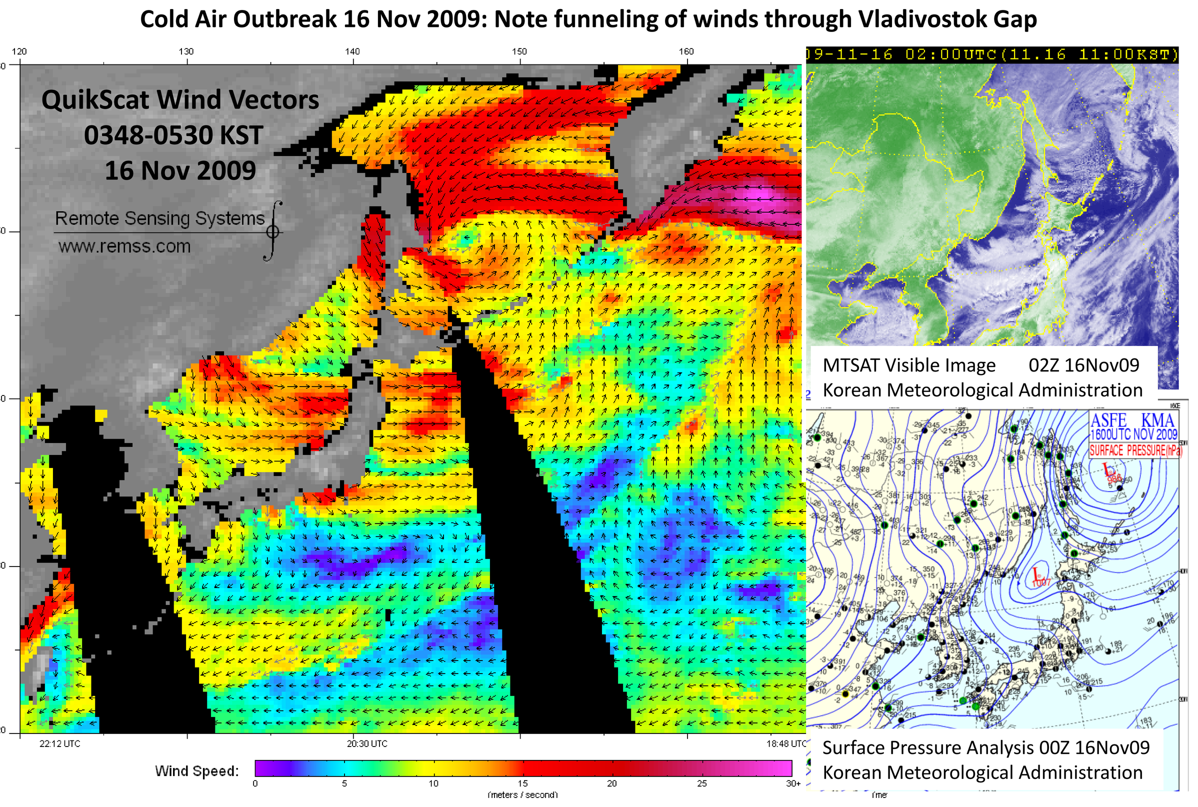

Figure above adapted from Oceanography Vol. 19, No. 3, September 2006
Figure at right adapted from http://windows2universe.org

Major Surface Currents in the Japan/East Sea include the Liman Coastal Cool Current (LCCC), the North Korea Cool Current (NKCC), the East Korea Warm Current (EKWC), the Tsushima Warm Current (TWC), and the Soya Warm Current (SWC)

The abrupt changes in temperature and/or salinity at ocean fronts and the accompanying convergence of surface currents should be considered in the planning and execution of search and rescue operations, deployment of drifting sensors, and sonar operations.

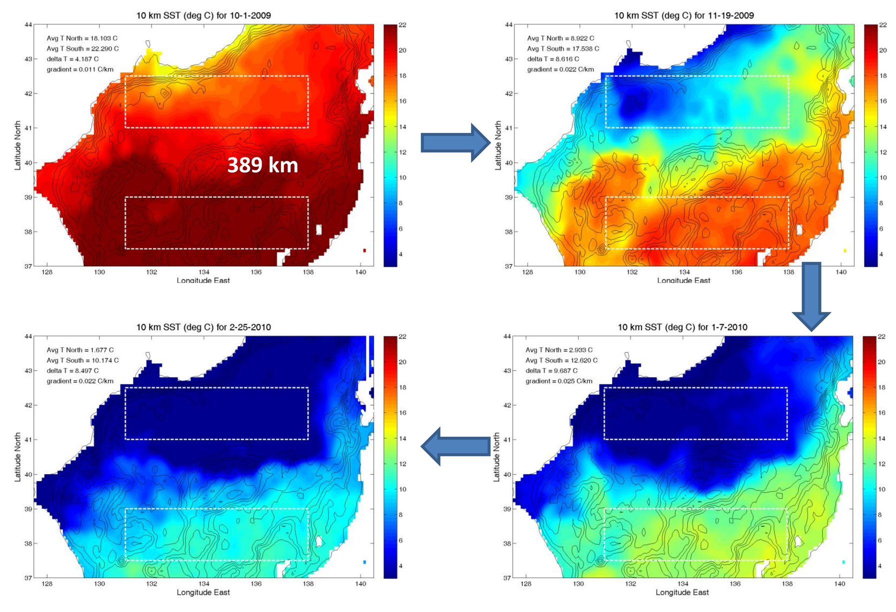
The goal of this study was to analyze variability in the strength and location of the front during October 2009 through February 2010, compare coarse and detailed calculations of the SST gradient, and examine the relation of frontal position to bathymetric features. Additional areas of interest included identification of synoptic weather conditions associated with cold-air outbreaks which contribute to strengthening of the front (Dorman et al., 2006), and the impact of the front on the spatial distribution of phytoplankton.

Cold Air Outbreak 16 Nov 2009: Note funneling of winds through Vladivostok Gap

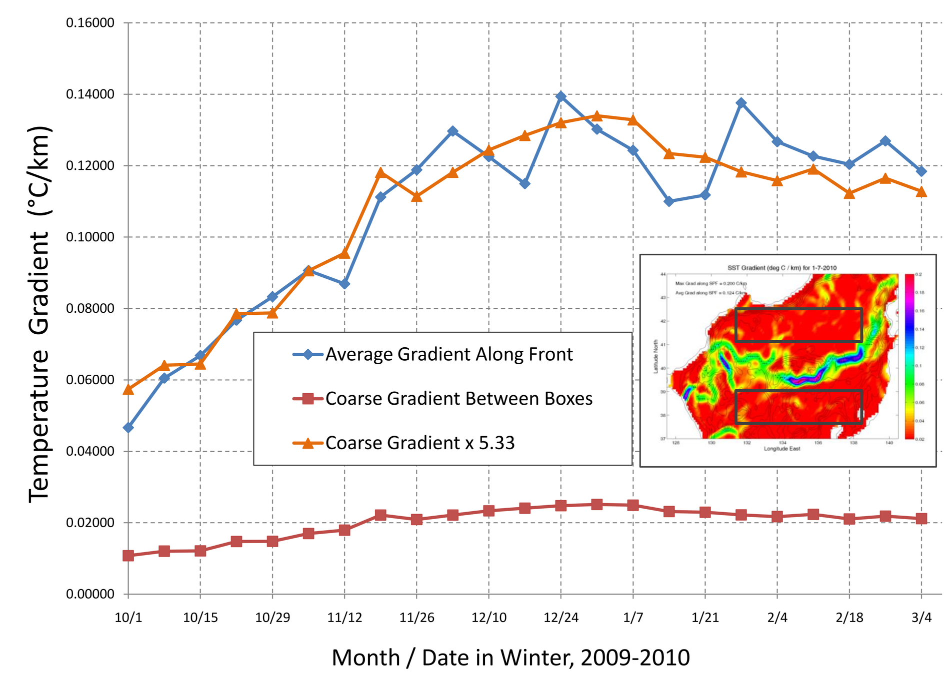



## Quantifying Frontal Strength

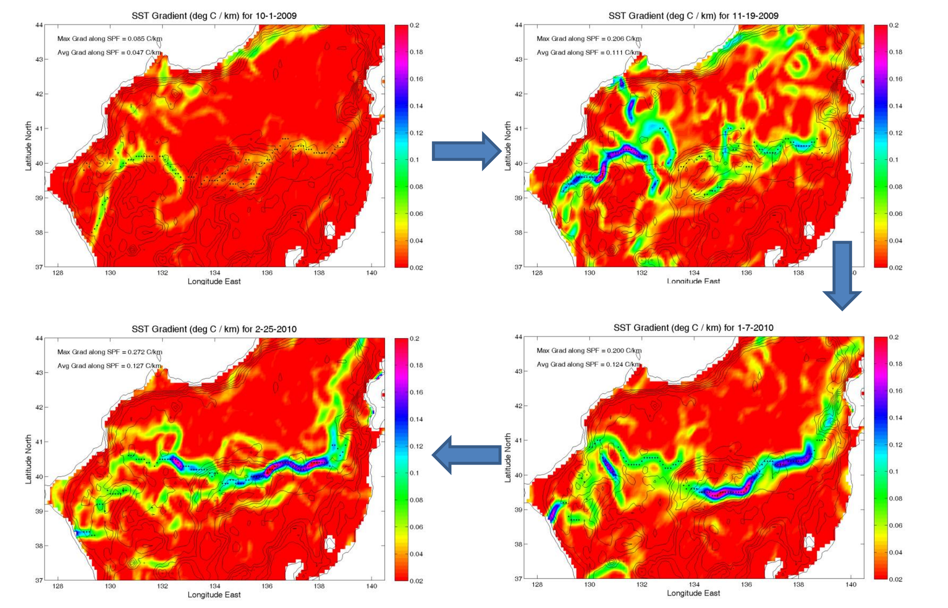
Based on 10km weekly SST data from the Naval Oceanographic Office, the SST gradient was calculated for each grid point using centered differencing. The maximum SST gradient along the front, 0.29°C/km, was observed near 137°E, 40°N during the week ending 28 Jan 2010. Finer spatial resolution would likely reveal SST gradients as strong as 1°C/km (Lee et al., 2006). The strength of the front was also estimated by computing the difference between average SST in broad rectangular areas north and south of the front, divided by the distance between center points of the boxes (389 km)). When scaled by a factor of 5.33, this simple estimate was, on average, within 7% of the more detailed calculation of the average SST gradient along the extent of the front.



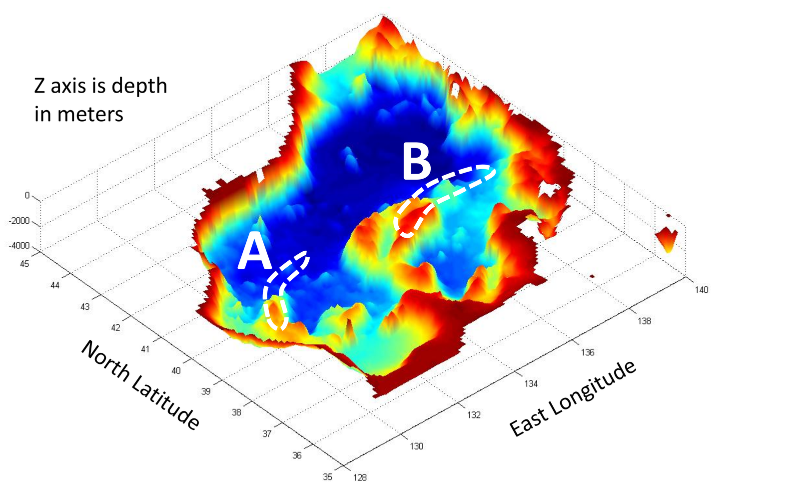

Difference in average SST in areas north and south of the front increased from 4°C in Oct 09 to nearly 10°C in mid Dec 09. The area north of the front cooled by 17°C between October and February, while the area south of the front cooled by 12°C.




Average Temperature Gradient Along Subpolar Front and Coarse Gradient Between North and South Boxes

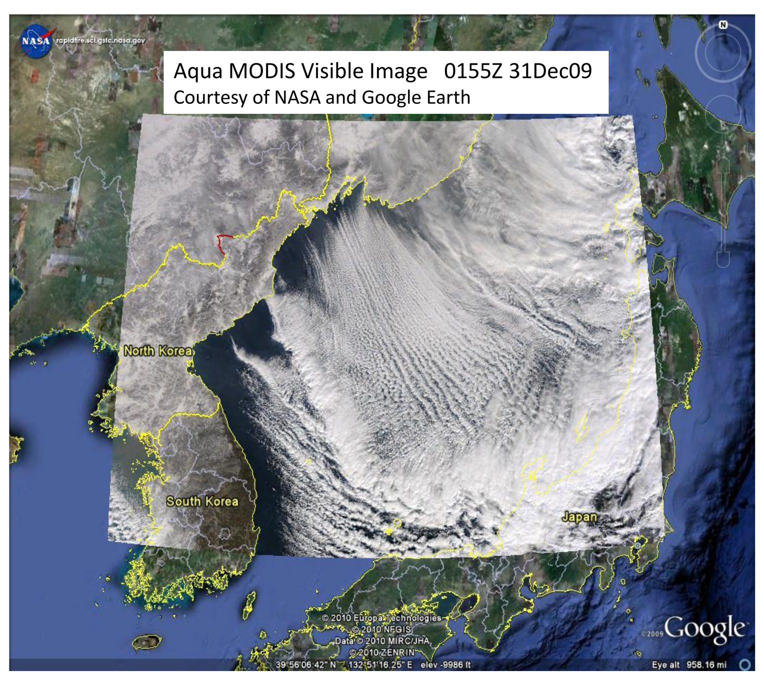


Average SST gradient along the SPF nearly tripled, from .05°C/km in Oct 09 to .14°C/km in late Dec 09. The location of the SPF was defined by the latitude of the maximum SST gradient for each longitudinal grid point between 129E and 139E.



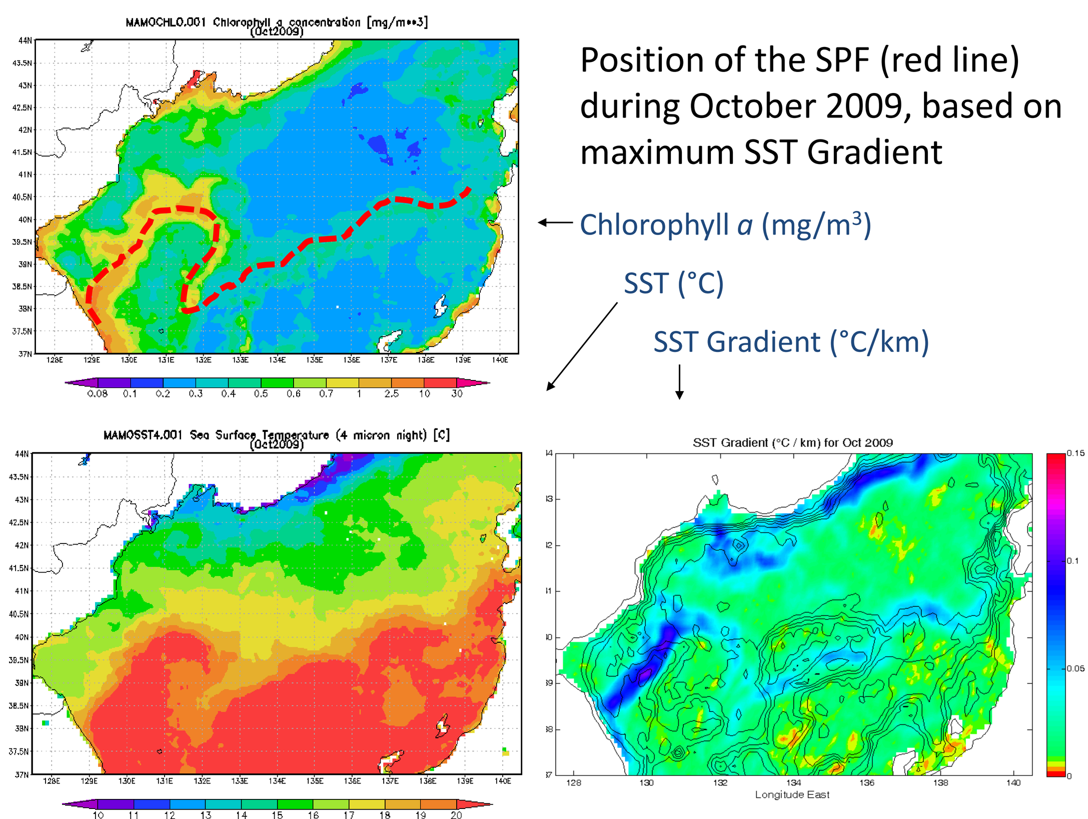

Bathymetry affects circulation and the extent of water masses in the Japan/East Sea. The strongest SST gradients were located in the vicinity of area A during Oct-Nov (along the ridge extending northeastward from East Korea Bay) and in area B during Dec-Feb (over the eastern side of Yamato Rise, and along the 3000m depth contour to the east).

Roll Clouds Associated With Cold Air Outbreak 31 Dec 2009

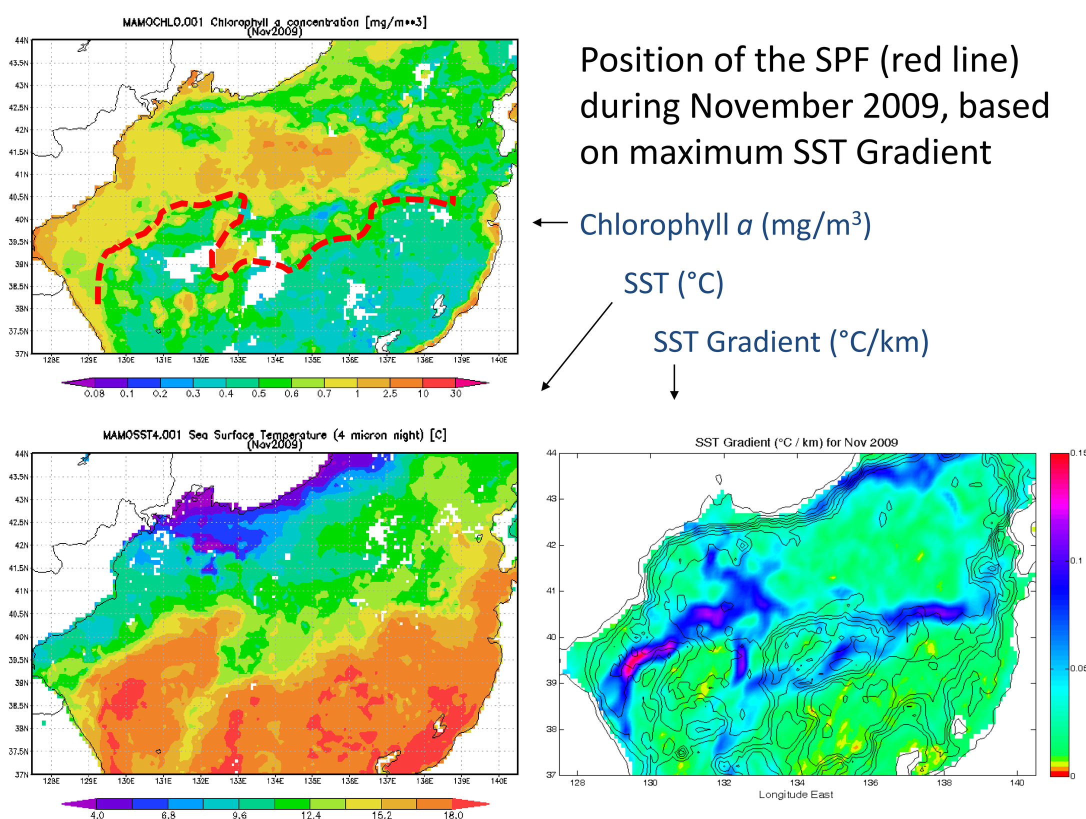



## Impact on the Spatial Distribution of Phytoplankton

Convergence of surface currents along the SPF appeared to affect the spatial distribution of phytoplankton during the Fall bloom in October and November. During October, chlorophyll *a* concentrations were relatively high along a portion of the front located east of East Korea Bay. In November, the bloom was more widespread, but most of the phytoplankton remained north of the front.




Position of the SPF (red line) during October 2009, based on maximum SST Gradient




Position of the SPF (red line) during November 2009, based on maximum SST Gradient

## Data Sources

**Naval Oceanographic Office:** 10 km AVHRR Multichannel SST for weeks ending 10/1/2009 to 3/4/2010. **NOAA National Climatic Data Center**: Surface air temperatures for Vladivostok. **NOAA National Geophysical Data Center:** ETOPO1 topography and bathymetry data. **NASA:** Aqua MODIS imagery, monthly 9km chlorophyll *a*, and QuikScat wind vectors (via *Remote Sensing Systems*). **Korean Meteorological Administration:** Surface pressure analyses and MTSAT imagery.

## References

Dorman, C. E, and seven others, 2006, Winter atmospheric conditions over the Japan/East Sea: The structure and impact of severe cold-air outbreaks, Oceanography: vol. 19, no.3, p50-63.

Lee, C.M., Thomas, L.N., and Yoshikawa, Y., 2006, Intermediate Water Formation at the Japan/East Sea Subpolar Front, Oceanography: vol. 19, no.3, p110-121.

Park, K.-A., Ullman, D., Kim, K., Chung,, J., and Kim, K.-R., 2007, Spatial and temporal variability of satellite-observed Subpolar Front in the East/Japan Sea, Deep-Sea Research I: vol. 54, p453-470.