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厦门大学

硕士学位论文

冬、春季台湾海峡浙闽沿岸水的时空变动特征研究

Temporal and spatial variation of Zhe-Min Coastal Water in the Taiwan Strait in winter and spring

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摘要

台湾海峡是沟通东海与南海的唯一通道，也是我国南、北海运的重要航道。浙闽沿岸水是台湾海峡西侧主要流系，也是我国东南沿海环流系统的重要组成部分，它与海峡暖流水在季风控制下彼此消长，对海峡的环流结构、水团组成和海洋生态等有着相当重要的影响。

本文主要利用 1981 年至 2016 年间不同时间段的 AVHRR、MODIS 遥感海表温度时序列数据，以温度阈值法和温度空间距平法为基础建立了台湾海峡浙闽沿岸水的表征方式，并分别定义其影响范围及强度指数。分析了自上个世纪八十年代以来冬、春季台湾海峡浙闽沿岸水的时空变动特征，并从风场、热通量、黑潮、径流量、表层流强度、海表气温等因子入手，初步探讨浙闽沿岸水变动的影响因素。主要研究成果表明：

首先，基于现场观测发现当冬、春季台湾海峡上层水体（20 米以浅）的温度分别小于 20℃、21℃时，其变化与盐度、营养盐含量呈明显的线性正、负相关关系。故而本论文以温度为主要因子，利用容易获取并已形成长时间序列的遥感 SST 数据，建立了温度阈值法和温度空间距平法的浙闽沿岸水表征方式，其中前者主要以 17℃（冬）、21℃（春）等温线为其水边界；后者则在冬春季均以其空间距平场的-2℃等值线为水边界。分析表明在体现浙闽沿岸水相对的变动趋势上，两种表征方式并没有显著性差异。

接着，分析发现自上个世纪 80 年代以来，台湾海峡冬、春季 SST 经历了增暖—变冷阶段，以 1998/1999 年为拐点，之前和之后的冬季年变化率分别为 0.12℃/年和-0.27×10^{-3}℃/年，而春季分别为 0.13℃/年和-0.07℃/年，尤其是在 2000 年后整体变冷趋势更为显著，冬季年变化率为-0.04℃/年，春季为-0.05℃/年，而且台湾海峡西北部 SST 的变化幅度较东南部明显，同时与冬季相比，春季的变化幅度也更为显著。此外，台湾海峡冬季 SST 的变动明显受到 ENSO 事件的影响，在 El Nino 事件的影响下，其 SST 会变得更暖。分析表明，浙闽沿岸水影响范围及强弱的变动是调控冬春季台湾海峡 SST 最为主要的因素，但在 El Nino 年，海峡内冷暖水团强弱变动的影响作用将变得更为显著。

与 SST 变动趋势类似，上个世纪 80 年代以来台湾海峡浙闽沿岸水的影响范

围和强度同样以 1998/1999 年为拐点，经历了减弱—增强两个变化阶段，尤其是 2002 年以来的春季，增强趋势最为显著；从浙闽沿岸水影响范围的空间变化看，与 1981-1998 年相比，1999-2009 年间浙闽沿岸水主要是往东和往南扩展，而 2002-2016 年间浙闽沿岸水则主要沿着福建近海向南扩展，向东扩展并不明显。分析表明冬春季浙闽沿岸水的时空变动特征是局地东北风场、海气相互作用、流场变化以及径流量等多种因素共同作用的结果，尤其是进入 21 世纪，影响台湾海峡的东北风显著增强，整个海峡净热通量属于失热状态、南向平流输运量增加、黑潮暖水入侵减弱、河流径流量增加，以上种种因素均有利于浙闽沿岸水影响范围及强度的增加，进而导致台湾海峡 SST 在近年来有变冷的趋势。

关键词：浙闽沿岸水；台湾海峡；SST；卫星遥感；时空变动

Abstract

Taiwan Strait is the only channel to connect the East China Sea with the South China Sea, also is the significant seaway for transport between the north and south in China. Zhe-Min Coastal Water is the main currenton the west side of Taiwan Strait and the main component of the circulation system on the southeastern coast of China. By the controlling of the monsoon, the relative influence between the Zhe-Min Coastal Water and the South China Sea Warm Current/Kuroshio Branch Water has significant influence on the water circulation structure, composition of water masses and marine ecosystem.

This paper mainly use the sea surface temperature data indifferent time periodsobserved from AVHRR, MODIS in 1981-2016. The characterization method for Zhe-Min Coastal Water in the Taiwan Strait is established rely on the temperature threshold method and temperature space anomaly method, and to calculate the areal and intensity index of the water by these two methods. We analyze the features of spatial and temporal variation of Zhe-Min coastal water in the Taiwan Strait in winter and spring since last century eighty's. And then according to the factors including wind, heat flux, Kuroshio, runoff, intensity of surface current, air temperature on sea surface, we simply discuss the influence factors of the variation of Zhe-Min Coastal Water. The main research results show that:

Firstly, according to the results of voyage survey, we found thatwhen the temperature of the upper water of Taiwan Strait (depth≤20m) in winter and spring was less than 20℃and 21℃respectively, there was a significant linear positive(negative) correlation between temperature and salinity(nutrient). So this research utilizes the temperature as the primary influential factor and the sea surface temperature (SST) data of remote sensing which has long time observation and easier access to construct the characterization methods for Zhe-Min Coastal Water base on the temperature threshold method and temperature space anomaly method. The former mainly use 17℃ (winter), 21℃(spring) isotherm for its water boundary, and the latter uses -2℃ isotherm both in winter and spring. The result indicates that there is no significant

differences between these two methods in reflecting the relative variation trend of Zhe-Min Coastal Water.

Secondly, our analysis identifies thatSST in the strait in winter and spring experienced the warming and cooling phase in Taiwan Strait since1980s. Before andafter theshift time of 1998/1999, the annual variation of SST in the strait was respectively 0.12℃/year and -0.27*10-3℃/year in winter, and 0.13℃/year and -0.07℃/year in spring. Especially after 2000, the overall cooling trend is more significant, the winter was -0.04℃/year and the spring was -0.05℃/year. These cooling trends occurred in the northwest of Taiwan strait is more obvious than in the southeast, and compared to the winter, the variation in spring is more significant. In addition, the variation of winter SST in Taiwan Strait was sharply affected by ENSO, andthe SST became warmer by the effect of El Nino events. Further analysis shows that the range and the strength of Zhe-Min Coastal Water is the most important factor to control the SST in the strait in winter and spring, however in El Nino year, the effect of the relative strength variation between cold and warm water masses would be more significant.

Finally,similar to the trend of SST, the range and strength of Zhe-Min Coastal Water also had the shift time of 1998/1999 and changed from the warming to the cooling, especially in the spring of 2002, its enhancement trend is most significant. Base on the spatial variation of the influence range ofZhe-Min Coastal Water, the Zhe-Min Coastal Water mainly extended to the east and south from 1999 to 2009 compared with 1981-1998, and it mainly expanded southward along the inshore area of Fujian but the eastward extension was not obvious. Our result indicates that the temporal and spatial distribution of Zhe-Min Coastal Water in winter and spring resultes from the combined effect and action of multiple factors ,such as local northeast wind, sea-air interaction, currents,runoff and so on. Especially after entering the21th Century, the northeast wind impacted on the strait significantly enhanced, the net heat flux in the whole straitwas in the state of heat loss, the southward advection transport increased,the intrusion of warm water from the Kuroshio weakened, the rive runoff also increased. All of factors promote the