Anomalous Cold Water Detected along Mid-Atlantic Coast

PAGE 152

In July 2003, anomalous cold water along the mid-Atlantic coast affected local tourism and fishing. The cold water interfered with tuna fishing, and for 2 to 3 weeks, rockfish generally found during the fall were present in the area [*Kelly*, 2003]. Satellite data, buoy observations, and weather maps were analyzed to investigate the cause of this cold water event. The results show that the increasing westerly and southerly winds that resulted from approaching cold fronts may have induced upwelling away from and along the mid-Atlantic coast. This, combined with the southward advection of cold sea water from the North Atlantic Ocean, might have caused the anomalous cold water along the coast.

The sea surface temperature (SST) observations made by buoy 44014 (0.6 m below sea level) (http://www.ndbc.noaa.gov/) near Virginia Beach (36.61°N, 74.84° W) for the month of July 2003 show a 4°C decrease in SST from 3 to 5 July 2003. A smaller drop of 2–3°C is also found for 24–25 July 2003 (Figure 1a). The east-west (u) and south-north (v) wind components (Figure 1a) observed by buoy 44014 shows a relationship with the observed SST. In general, wind speeds during July 2003 were found to be stronger than those of July 2002.

The averaged SST observed by the Geostationary Operational Environmental Satellite (GOES) (http://podaac.jpl.nasa.gov) also shows low SST (below 22°C) during the period 3–5 July near the buoy (Figure 1b) and 24–25 July 2003 along the Virginia, Maryland, and Delaware coast (Figure 1c). The SST anomaly shows more than 1°C cooling near the buoy (Figure 1b) and mid-Atlantic coast (Figure 1c). In general, the average SSTs during July 2003 were found to be cooler than those of July 2002 (not shown).

Coastal upwelling induced by alongshore winds [*Smith*, 1968; *Clemente-Colón and Yan*, 1999] is clearly seen along the Maryland, Virginia, and North Carolina coast during

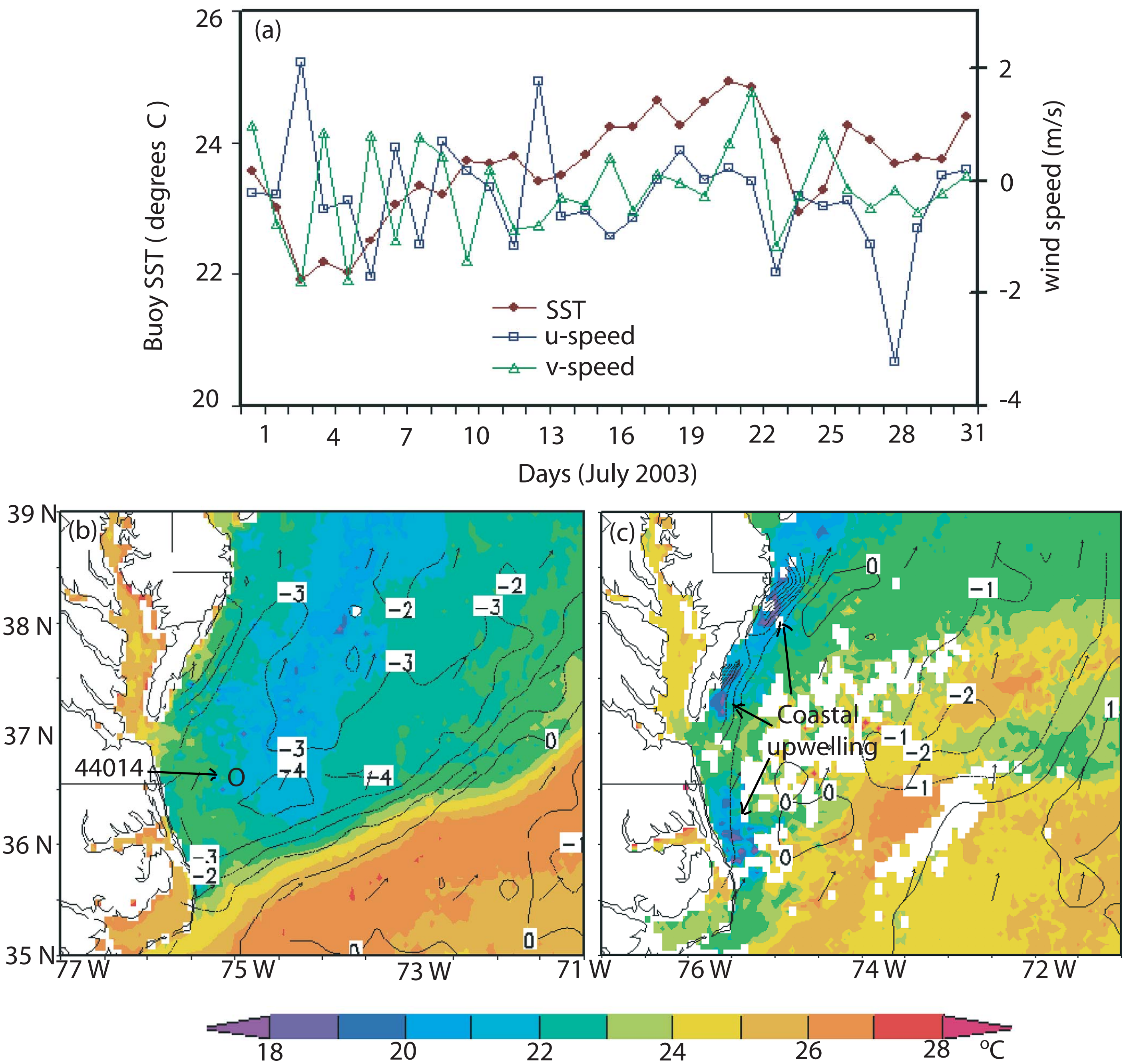

Fig. 1. (a) SST and wind speed were observed by buoy 44014 (36.61°N, 74.84°W) at Virginia Beach, Virginia, in July 2003. Averaged GOES SST (shaded) and anomaly (contour) and QuikScat sea surface wind vector are shown for (b) 3–5 July 2003 and (c) 24–25 July 2003.

24–26 July 2003; the southwesterly winds are found parallel to the coastline (Figure 1c). This is consistent with the increase of southerly wind observed by the buoy on 22 and 25 July 2003 (Figure 1a). The increase of westerly wind during 3–5 July (Figure 1a) is also a plausible cause of the SST cooling due to upwelling away from the coast [*Pond and Pickard*, 1983].

Figure 2 shows the weekly composite sea winds measured from the NASA Quick Scatterometer (QuikScat) and SST from the Advanced Very High Resolution Radiometer (AVHRR) (shaded) for the week ending 5 July 2003. Strong northerly winds are found along the northeast Atlantic Ocean merging with the northerly winds along the northwest coast of Africa. The comparison of the sea surface wind and AVHRR SST has revealed the southward advection of cold sea water from the North Atlantic Ocean and, further westward, migration to the mid-Atlantic Ocean (Figure 2). Such southward advection of cold sea water is not found during other times, including the period 24–25 July 2003.

The surface wind direction and speed are closely related to the sea level pressure pattern. The surface weather maps (http://weather.unisys.com/) have revealed the approach of cold fronts to the mid-Atlantic coastal area during 3–5 July and 24–25 July 2003. The southwesterly winds ahead of the cold front merged with southwesterly winds at the west side of the Bermuda High over the Atlantic Ocean (Figure 2) and made the speed of the westerly or southerly wind increase. The interesting increase of westerly wind on 3 July and southerly wind speed on 22 and 25 July at the time of low SST (Figure 1a) clearly shows the influence of the surface cold front, which is rarely seen during July.

The results clearly show that the anomalous cold water event during July 2003 at the Virginia coast coincided with upwelling along the coast driven by the increasing westerly and southerly winds due to the approach of surface cold fronts, combined with the southward advection of cold sea water from the North Atlantic Ocean during 3–5 July. This cold water event had a substantial adverse effect on regional tourism and fishing.

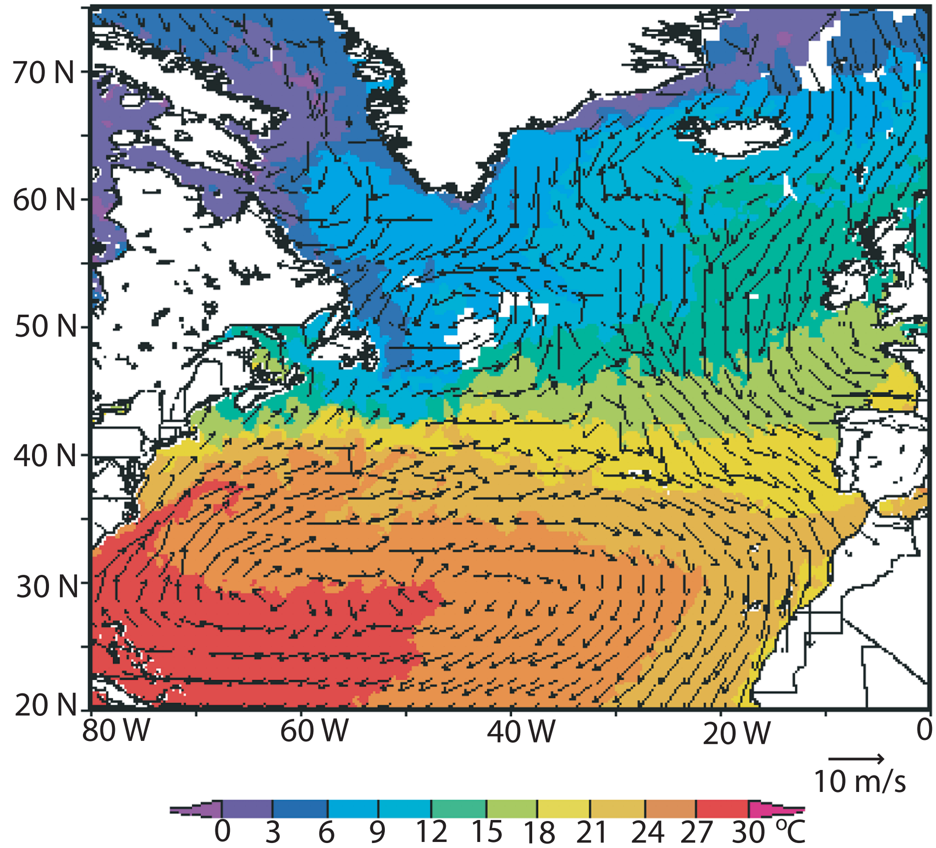

Fig. 2. Weekly composite sea surface wind vectors and AVHRR SST (shaded) for the week ending 5 July 2003.

Acknowledgments

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References

Clemente-Colón, P., and X. Yan (1999), Observations of east coast upwelling conditions in systhetic aperture radar imagery, *IEEE Trans. Geosci. Rem. Sens., 37*, 2239–2248.

Kelly, J. F. (2003), Shivering in the surf: Atlantic's sudden temperature dive a midsummer mystery for scientists, *The Washington Post*, Washington, D.C., 6 August.

Pond, S. and G. L. Pickard, (1983), *Introductory Dynamical Oceanography, 2nd ed.*, 328 pp., Pergamon Press, N.Y.

Smith, R. L. (1968), Upwelling, *Oceanogr. Mar. Biol. Annu. Rev., 6*, 11–46.

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MEETINGS

Discussions of Arctic Climate Feedback Mechanisms

PAGE 147

The Arctic Climate Impact Assessment process (ACIA; see http://www.acia.uaf.edu/) is an international project of the Arctic Council and the International Arctic Science Committee (IASC) to evaluate and synthesize knowledge on climate variability, climate change, increased ultraviolet radiation, and their consequences.

As a part of the Norwegian work within ACIA (see http://acia.npolar.no/), an international workshop on Arctic climate feedback mechanisms was held in November 2003 at the Norwegian Polar Institute. Invited talks were presented in five sessions focused on climate programs, terrestrial systems, oceans, sea ice, and atmosphere. Poster presentations and working groups were organized for four sessions in the various scientific fields, identifying the state of knowledge and challenges, and making recommendations.

Sixty people from eight countries attended the meeting. Proceedings with extended abstracts of invited talks and working group summaries will appear in the report series of the Norwegian Polar Institute in spring 2004. The findings of this workshop provide insights that will be useful for the development of work in the near future connected to climate research in the Arctic in those fields addressed in the workshop.

Climate Feedback Mechanisms

One of the aims of the ACIA process is to consider issues related to knowledge gaps and uncertainties that need to be taken into account in future research and monitoring work [*ACIA*, 2000]. This includes identifying gaps in basic knowledge and identifying fundamental data that need to be acquired to better understand climate variability and change. Uncertainties regarding the consequences of climate change lie, to some extent, in the uncertainties of feedback mechanisms, and particularly, in the depiction of these mechanisms in General Circulation Models (GCMs). These uncertainties are important and need to be considered in this context.