P1.4 MONITORING SAHARAN DUST EVENTS USING INTEGRATED OBSERVING SYSTEMS

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1. INTRODUCTION

Each year, several hundred million tons of African dust are transported across the tropical North Atlantic (Prospero et al., 1996). There is a hypothesis that the decline of Caribbean coral reefs is linked to the increase in transport and deposition of African dust with global warming and continued desertification of the Sahel region (Shinn et al., 2000). Recently, Karyampudi et al. (1997) have shown that Saharan dust outbreaks may influence the genesis of tropical cyclone over eastern Atlantic.

In the summer months, large-scale Saharan dust events are more abundant than in wintertime due to intense solar heating, and dust concentrations are mostly confined to the Saharan air layer (SAL) (from ~2 km to ~5 km) (Karyampudi et al., 1999). In this paper, a massive Saharan dust event which occurred during wintertime was studied using space-based multi-sensor observations. This dust plume resided in relatively low levels within the marine boundary layer, and was carried around by low level winds. Furthermore, this dust plume caused the decrease in the outgoing longwave radiation (OLR) at the top of atmosphere (TOA).

2. DATA

In this study, dust plumes and clouds were identified from SeaWiFS true color images provided by Distributed Active Archive Center (DAAC) at NASA Goddard Space Flight Center. The High Resolution Picture Transmission (HRPT) data at 1-km resolution obtained at HCAN station was used for this reported event. Ocean surface winds at 25-km resolution measured by NASA QuikSCAT scatterometer were provided by the Physical Oceanography DAAC at Jet Propulsion Laboratory. Daily Interpolated OLR data at 2.5^ox2.5^o grids derived from various NOAA weather satellites were provided by the NOAA-CIRES Climate Diagnostics Center. The daily averaged total water vapor was derived from the Special Sensor Microwave Imager (SSMI) on F-11, F-13, F-14, and F-15 satellites. SSMI water vapor data were produced by Remote Sensing Systems.

3. RESULTS

On 26 February 2000, a massive duststorm emanated from the northwest African desert in Morocco and Western Sahara, and was transported over 1000 miles into Atlantic by strong eastly winds. The color picture in Fig. 1 is the true color image (resolution is 1-km) taken by SeaWIFS HRPT HCAN station on February 26, 2000. When the Saharan dust plume passed over the Canary Islands, the islands of Fuerteventura (peak elevate 800 m) and Lanzarote (peak elevate 650 m) are fully immersed within the dust layer. However, the dust plume was deflected around Gran Canaria Island (peak elevate 1950 m) and was fully blocked by Tenerife (peak elevate 3700 m). This orographic effect suggests that the dust plume resided within the marine boundary layer for this wintertime event. For summertime events, however, it has been reported that dust concentrations are several times higher within the SAL than in the marine boundary layer (Prospero and Carlson, 1972).

QuikSCAT surface wind observations on February 26 were shown in Fig. 2. There were unusually strong eastly winds compared to the normal northeastly winds (e.g., normal winds on March 26, 2000 shown in Fig. 5) off the coast of northwest Africa. The orographic effect on ocean surface winds were also observed by QuikSCAT. The low elevations of Fuerteventura and Lanzarote islands seemed to have little impact on the surface winds. However, eastly upwinds were completely blocked by Gran Canaria and Tenerife islands which have high mountains, as a result, winds went around these two islands with lower speeds, and on the west of the Tenerife Island, a plume with convergent winds was formed.

QuikSCAT measurements in Fig. 2 indicated that there was a cyclonic flow located at near 19^oW and 27^oN. This feature was confirmed by the cyclonic

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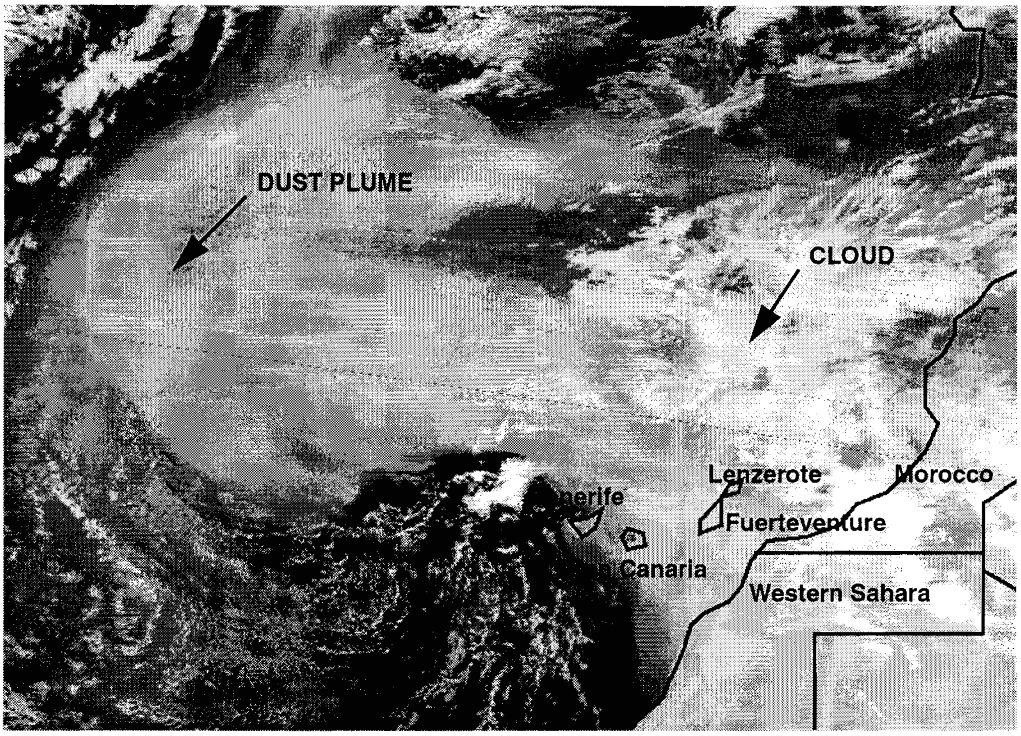

Figure 1. On February 26, 2000, a huge Saharan duststorm was identified in SeaWIFS high resolution (1-km) true color image collected from HRTP HCAN station. The latitude and longitude are labeled in Fig. 2.

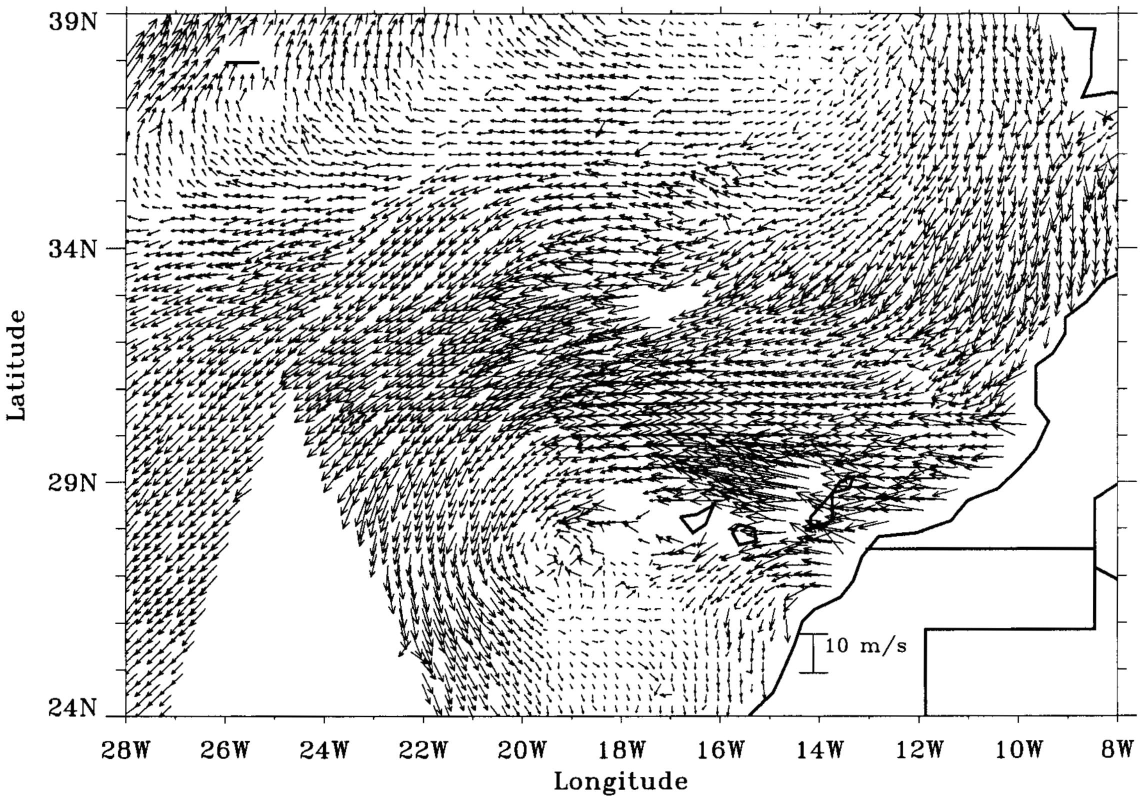

Figure 2. On February 26, 2000, QuikSCAT observed strong eastly winds off the coast of Morocco and Western Sahara. The data are averaged daily observations on swaths at 25-km resolution.

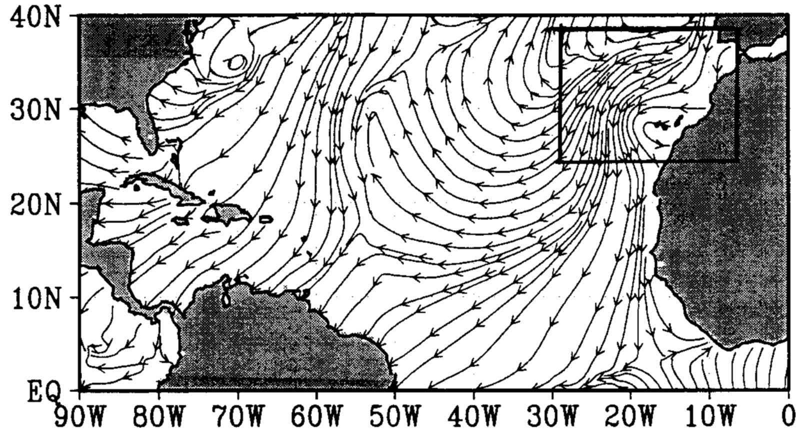

Figure 3. Streamlines over the Atlantic ocean derived from the surface wind observations by QuikSCAT on February 26, 2000. The box on the upper right corner is the region shown in Figures 1 and 2.

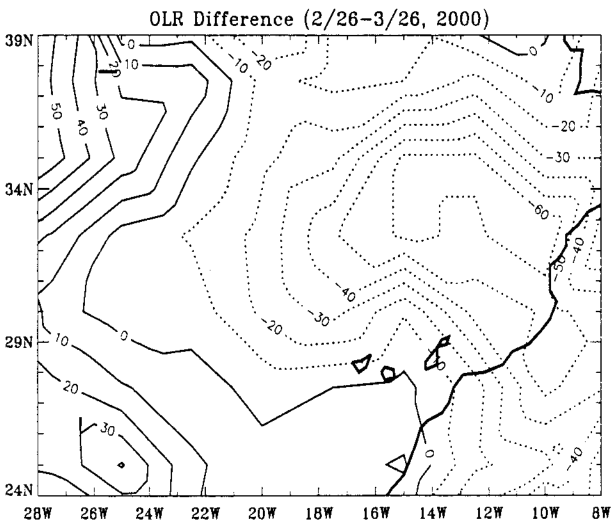

Figure 4. Differences of Out-going longwave radiation (OLR) at the top of the atmosphere (TOA) between 26 February 26 and 26 March 2000. The contour interval is10 w/m^2.

curvature of the dust plume to the north of it (see Fig. 1). An anticyclonic mean flow was located at the northeastern Atlantic (partially shown in Fig. 3), therefore, the north part of this dust plume subsequently underwent an anticyclonic rotation as the plume migrated westward over the Atlantic. By March 4th, the cloud of dust had reached the northeast coast of South America and Caribbean Sea, which could be foreseen in the QuikSCAT wind streamline map in Fig. 3. The consistence between the dust migration path and surface wind flows further supports the argument that this dust layer was mainly confined in the lower levels of the atmosphere.

The change in daily TOA OLR measurements due to this Saharan dust plume was demonstrated in Fig. 4 which is the OLR difference between 26 February and 26 March 2000. In the plotted region in Fig. 4, on March 26 it was near "cloud-free" which was confirmed by clear-sky conditions in SeaWiFS true color images in most areas except some clouds at the western boundary, and was relatively "dry" confirmed by low SSMI water vapor amount (figures are not shown here). On February 26, in most areas it was "dry" and "cloud-free" except the cloud cluster located off Morocco coast (in Fig. 1), accompanied by high SSMI water vapor amount (not shown here). Since both water vapor and clouds have large contributions to OLR estimates, it is important to separate them from those caused by dust. As seen in Fig. 4, a reduction in OLR was as much as 10-50 w/m^2 due to the dust plume on February 26, and more reductions in OLR were seen over the cloud cluster mentioned above. The increase in OLR near western boundary was due to the high cloud amount on March 26. The decrease in OLR due to dust layer was also reported by Hsu et al. (2000) using TOMS aerosol observations and ERBE OLR measurements.

Besides causing air pollution in Southeastern United States (Prospero, 1999), Saharan dust events have been linked to the decline of the coral reefs in the Caribbean according to recent studies by the U.S. Geological Survey and other researchers. Some studies have suggested that Sahelian Dust may play a role in

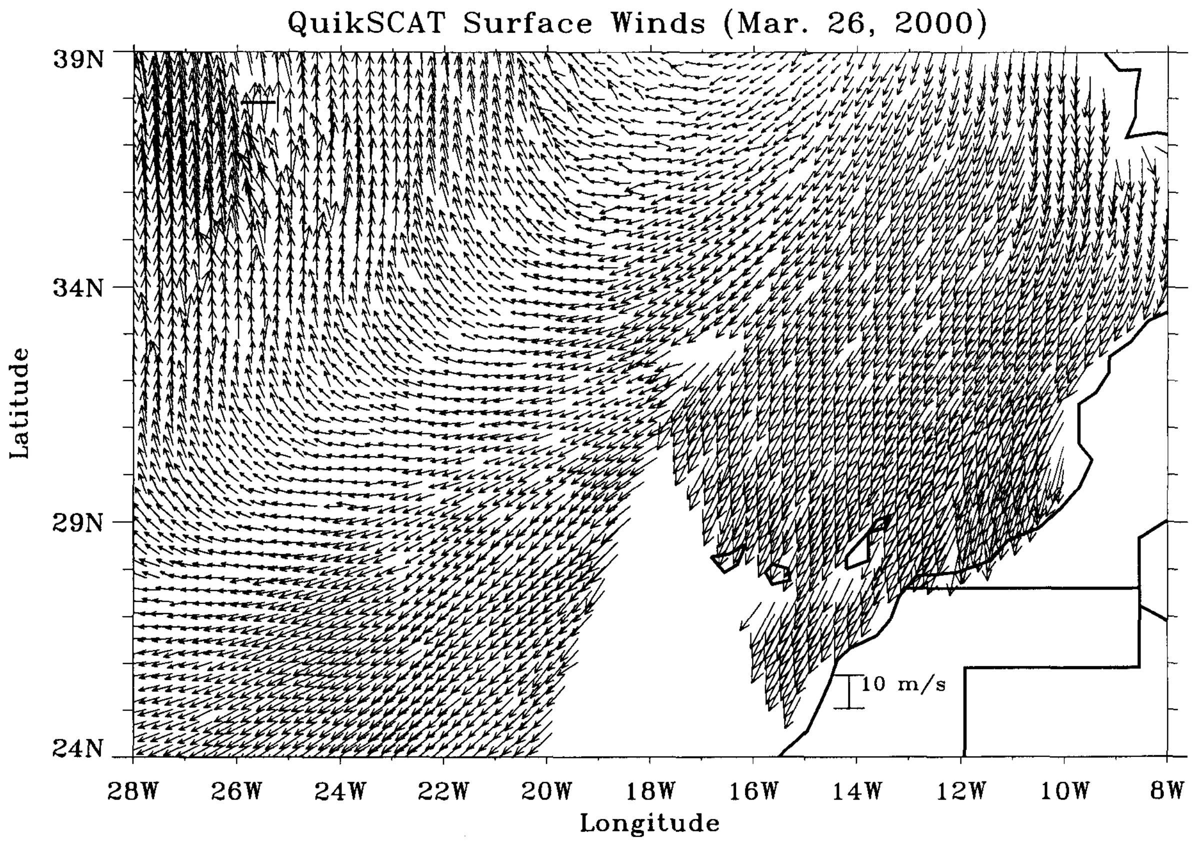

Figure 5. QuikSCAT surface winds on 26 March 2000 under near "cloud-free" and "aerosol-free" conditions.

determining the frequency and intensity of Hurricanes formed in the eastern Atlantic Ocean. By continuously monitoring Saharan dust events using multi-sensor observing systems, especially the recently launched QuikSCAT and EOS Terra, we will be able to assess the impact of African duststorm on the regional and global scales.

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REFERENCE

Hsu, N.C., J.R. Herman, C. Weaver, Determination of radiative forcing of Saharan dust using combined TOMS and ERBE data, *J. Geophys. Res., 105,* 20,649-20,661, 2000.

Karyampudi, V.M., J. Simpson, S. Palm, and H. Pierce, Lidar observations of Saharan dust layer and its influence on tropical cyclogenesis, *Proc. on 22 nd Hurricanes and Tropical Meteorology, Fort Collins, CO, Amer. Meteor. Soc.*, 59-60, 1997.

Karyampudi, V.M, S.P. Palm, J.A. Reagen, H. Fang, W.B. Grant, R.M. Hoff, C.M Moulin, H.F. Pierce, O. Torres, E.V. Browell, and S. H. Melfi, Validation of the Saharan dust plume conceptual model using lidar, Meteosat, and ECMWF data, *Bull. Amer. Meteor. Soc. 80*, 1045-1075, 1999.

Prospero, J.M, and T.N. Carlson, Vertical and aerial distribution of Saharan dust overt the western equatorial North Atlantic OCean, *J. Geophys. Res, 77,* 5255-5265, 1972.

Prospero, J.M, K. Barrett, T. Church, F. Dentener, R.A. Duce, H. Galloway, Levy II, J. Moody, and P. Quinn, Atmospheric deposition of nutrients to the North Atlantic basin, *Biogeochem., 35,* 27-73, 1996.

Prospero, J.M, Long-term measurements of the transport of African mineral dust to the southeastern United States: Implications for regional air quality, *J. Geophys. Res., 104,* 15,917-15,927, 1999.

Shinn, E.A., G.W. Smith, J.M. Prospero, P. Betzer, M.L. Hayes, V. Garrison, and R.T. Barber, African dust and the demise Caribbean coral reefs, *Geophys. Res. Lett. 27,* 3029-3032, 2000.