f. Tropical cyclones

1) Overview—H. J. Diamond and C. J. Schreck

The IBTrACS dataset comprises historical tropical cyclone (TC) best-track data from numerous sources around the globe, including all of the WMO Regional Specialized Meteorological Centers (RSMC; Knapp et al. 2010). IBTrACS represents the most complete compilation of global TC data and offers a unique opportunity to revisit the global climatology of TCs. Using IBTrACS data (Schreck et al. 2014) a 30-year average value for storms (from WMO-based RSMC numbers) is noted for each basin.

The tallying of the global TC numbers is challenging and involves more than simply adding up basin totals, because some storms cross TC basin boundaries, some TC basins overlap, and multiple agencies are involved in tracking and categorizing the TCs.

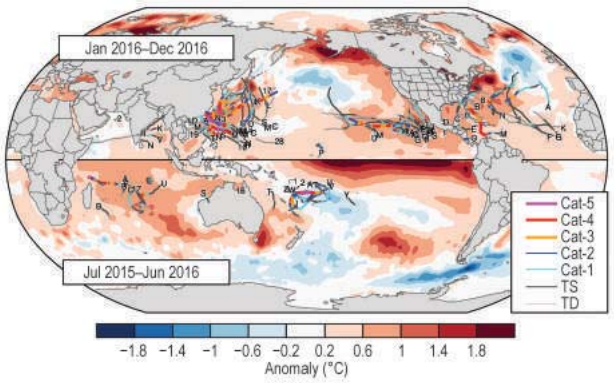

Fig. 4.20. Global summary of TC tracks with respect to SST anomalies (°C) for the 2016 TC season.

Compiling the activity using preliminary IBTrACS data over all seven TC basins (Fig. 4.20), the 2016 season (2015/16 in the Southern Hemisphere) had 93

SIDEBAR 4.1: RECORD-SETTING NORTH ATLANTIC HURRICANE MATTHEW—P. J. KLOTZBACH

The 2016 North Atlantic hurricane season was the first above-average Atlantic hurricane season based on the NOAA definition since 2012. The most notable storm of 2016, in terms of intensity, longevity, damage, and fatalities was Hurricane Matthew. Matthew formed from a tropical wave as it neared the Lesser Antilles, and over the course of the following 12 days, it cut a path of devastation across portions of Hispaniola, Cuba, the Bahamas, and then along the U.S. southeast coast before finally becoming post-tropical. In this sidebar, several of Hurricane Matthew's most notable meteorological records are highlighted. All statistics for Matthew listed are from the operational b-decks, which are utilized to initialize the numerical model guidance on tropical cyclones in real-time every six hours. The b-decks are available at http://ftp.nhc.noaa.gov/atcf/btk. Historical statistics are calculated from the HURDAT2 database, which provides six-hourly estimates of historical Atlantic tropical cyclone wind speeds, pressures, and locations since 1851 (Landsea and Franklin 2013).

After being named a tropical storm on 28 September, Matthew steadily intensified. Beginning 30 September, however, Matthew rapidly intensified, reaching category 5 strength with one-minute sustained winds of 140 kt (72 m s^{-1}) on 1 October (Fig. SB4.1). In the 24 hours leading up to reaching category 5 strength, Matthew intensified by 70 kt (36 m s^{-1}), the third fastest 24-hour intensification in the Atlantic basin on record, trailing only the 24-hour rapid intensification rates of Hurricane Wilma (2005) and Hurricane Felix (2007). Matthew was also the first category 5 hurricane in the Atlantic basin since Hurricane Felix (2007). In addition, it reached category 5

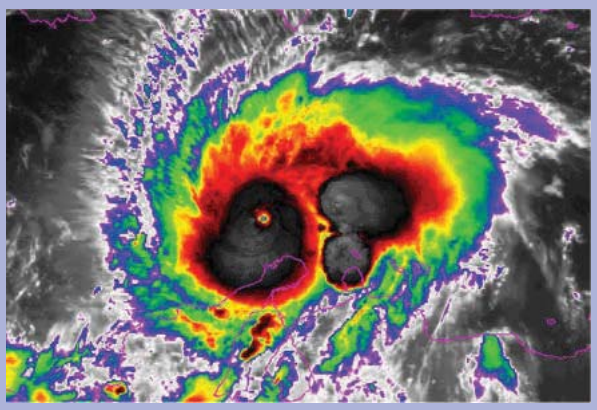

Fig. SB4.1. Infrared satellite image of Hurricane Matthew from GOES-East at near peak intensity at 0800 UTC 1 Oct 2016.

intensity at an unusually low latitude for an Atlantic hurricane: Matthew became a category 5 at 13.3°N, the lowest latitude Atlantic category 5 hurricane on record, breaking the old record of 13.7°N set by Hurricane Ivan (2004).

While Matthew only maintained category 5 intensity for 12 hours, it was notable for its longevity at category 4–5 strength, especially during the latter part of the Atlantic hurricane season. Matthew was a category 4–5 hurricane for 102 hours in October, the longest an Atlantic hurricane has maintained that intensity on record during October. Due to its intense nature and slow movement, Matthew generated the most ACE (Bell et al. 2000) by any Atlantic tropical cyclone on record in the eastern Caribbean (≤20°N, 75°–60°W). Matthew was also a major hurricane for over seven days, the

named storms (wind speeds ≥ 34kt or 17 m s^{-1}), which is above the 1981–2010 average of 82 TCs (Schreck et al. 2014), but eight fewer than the 2015 total of 101 TCs (Diamond and Schreck 2016). The 2016 season also featured 58 hurricanes/typhoons/cyclones (HTC; wind speeds ≥ 64kt or 33 m s^{-1}), which is above the 1981–2010 average of 46 HTCs (Schreck et al. 2014). Twenty storms reached major HTC status (wind speeds ≥ 96kt or 49 m s^{-1}), which is near the long-term average of 21. In Sections 4f2–4f8, the 2016 seasonal activity is described and compared to the historical record for each of the seven WMO-defined hurricane basins. For simplicity, all counts are broken down by the United States' Saffir–Simpson scale. Figure 4.20 depicts the overall picture of global TCs during 2016. The North Atlantic hurricane season was above normal (Section 4f2), and both the central and eastern North Pacific hurricane seasons were well above normal (Section 4f3).

Globally, four storms achieved Saffir–Simpson category 5 during the year (four fewer than in 2015, and three fewer than in 2014): (a) Hurricane Matthew in the North Atlantic; (b) Supertyphoon Meranti in the western North Pacific; (c) Cyclone Fantala in the South Indian Ocean; and (d) Tropical Cyclone Winston in the Southwest Pacific. Matthew was the costliest hurricane ($10 billion U.S. dollars in damages) to strike the U.S. since Hurricane Sandy in 2012. Sidebar 4.1 recounts several of the records that Matthew broke. Supertyphoon Meranti, with maximum sustained winds of 165 kt (85 m s^{-1}), was the most intense tropical cyclone of the year globally. Sidebar 4.2 describes an unusual situation where Taiwan was impacted by four major typhoons, including

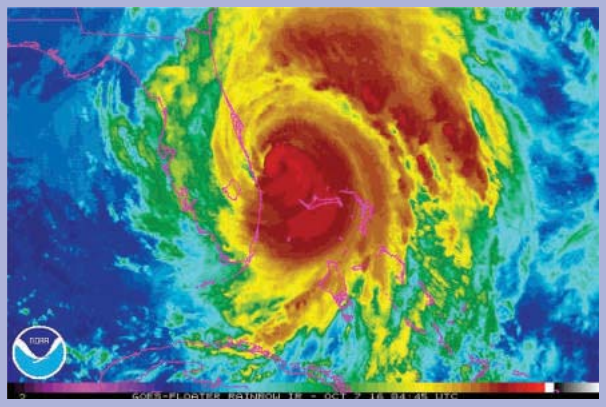

Fig. SB4.2. Infrared satellite image of Hurricane Matthew from GOES-East near its closest approach to the east coast of Florida at 0445 UTC 7 Oct 2016.

longest-lived major hurricane to form in the Atlantic after 25 September on record.

Matthew made landfall in Haiti as a category 4 hurricane on 4 October, becoming the first category 4 storm to hit Haiti since Cleo in 1964. While the final death toll from Matthew in Haiti may never be fully known, the National Hurricane Center reports (www.nhc.noaa.gov/data/tcr/AL142016_Matthew.pdf) that Matthew was responsible for 585 direct fatalities across four countries with 546 of those occurring in Haiti. Matthew then made landfall in Cuba as a category 4 hurricane, becoming the first category 4 hurricane to hit Cuba since Ike in 2008. Next, Matthew struck the Bahamas, battering the island chain also as a category 4 hurricane. In the process, Matthew became the first hurricane in the historical record (back to 1851) to make landfall at category 4 intensity in Haiti, Cuba, and the Bahamas.

Matthew tracked within 100 miles of the east coast of Florida (Fig. SB4.2), threatening to break the record-long U.S. landfalling major hurricane drought that has existed since October 2005 when Hurricane Wilma made landfall (Hart et al. 2016). It eventually made landfall along the central South Carolina coast as a weakening category 1 hurricane. Matthew was the first hurricane to make landfall in South Carolina since Gaston in 2004 and the first to make landfall north of Georgia during October since Hazel in 1954.

While the center of Matthew remained offshore of both Florida and Georgia, storm surge and heavy rainfall caused significant flooding in northeast Florida and along the entire coastline of Georgia. The eastern portions of both South and North Carolina suffered significant damage due to the combination of storm surge and heavy rainfall. Matthew was responsible for nearly 50 deaths in the United States, and total insured and uninsured damage from the storm was estimated at approximately $10 billion (U.S. dollars; www.ncdc.noaa.gov/billions).

Matthew was certainly the most notable storm in the Atlantic in 2016, as it was the longest-lived hurricane, the most intense storm, and the most damaging and destructive storm of the season. To put its longevity and intensity into perspective, while Matthew was one of 15 storms that formed in the Atlantic in 2016, it singlehandedly was responsible for 35% of the total amount of ACE generated by Atlantic tropical cyclones in 2016.