

reports (Doswell and Burgess, 1988; Grazulis, 1993; Grazulis *et al.*, 1998). On the other hand, severe tornadoes are not easily overlooked. Restricting the analysis to very strong and violent tornadoes results in a much different assessment (Figure 2.38) showing little long-term change, though some years like 1974 show a very large number of tornadoes. Furthermore, consideration of the number of days with tornadoes, rather than number of tornadoes, reduces the artificial changes that result from modern, more detailed damage surveys (e.g., Doswell and Burgess, 1988). The data set of “significant” tornado days developed by Grazulis (1993) shows a slow increase in number of days with significant tornadoes from the early 1920s through the 1960s, followed by a decrease since that time.

2.7.4 Summary

Based on new analyses since the SAR, it is likely that there has been a widespread increase in heavy and extreme precipitation events in regions where total precipitation has increased, e.g., the mid- and high latitudes of the Northern Hemisphere. Increases in the mean have often been found to be amplified in the highest precipitation rates total. In some regions, increases in heavy rainfall have been identified where the total precipitation has decreased or remained constant, such as eastern Asia. This is attributed to a decrease in the frequency of precipitation. Fewer areas have been identified where decreases in total annual precipitation have been associated with decreases in the highest precipitation rates, but some have been found. Temperature variability has decreased on intra-seasonal and daily time-scales in limited regional studies. New record high night-time minimum temperatures are lengthening the freeze and frost season in many mid- and high latitude regions. The increase in global temperatures has resulted mainly from a significant reduction in the frequency of much below normal seasonal mean temperatures across much of the globe, with a corresponding smaller increase in the frequency of much above normal temperatures. There is little sign of long-term changes in tropical storm intensity and frequency, but inter-decadal variations are pronounced. Owing to incomplete data and relatively few analyses, we are uncertain as to whether there has been any large-scale, long-term increase in the Northern Hemisphere extra-tropical cyclone intensity and frequency though some, sometimes strong, multi-decadal variations and recent increases were identified in several regions. Limited evidence exists for a decrease in cyclone frequency in the Southern Hemisphere since the early 1970s, but there has been a paucity of analyses and data. Recent analyses of changes in severe local weather (tornadoes, thunder days, lightning and hail) in a few selected regions provide no compelling evidence for widespread systematic long-term changes.

2.8 Are the Observed Trends Internally Consistent?

It is very important to compare trends in the various indicators to see if a physically consistent picture emerges, as this will critically affect the final assessment of our confidence in any such changes. A number of qualitative consistencies among the

various indicators of climate change have increased our confidence in our analyses of the historical climate record: Figure 2.39a and b summarises the changes in various temperature and hydrological indicators, respectively, and provides a measure of confidence about each change. Of particular relevance are the changes identified below:

- Temperature over the global land and oceans, with two estimates for the latter, are measured and adjusted independently, yet all three show quite consistent increasing trends (0.52 to 0.61°C/century) over the 20th century.
- The nearly worldwide decrease in mountain glacier extent and mass is consistent with 20th century global temperature increases. A few recent exceptions in maritime areas have been affected by atmospheric circulation variations and related precipitation increases.
- Though less certain, substantial proxy evidence points to the exceptional warmth of the late 20th century relative to the last 1,000 years. The 1990s are likely to have been the warmest decade of the past 1,000 years over the Northern Hemisphere as a whole.
- Satellite and balloon measurements agree that lower-tropospheric temperatures have increased only slightly since 1979, though there has been a faster rate of global surface temperature increase. Balloon measurements indicate a larger lower-tropospheric temperature increase since 1958, similar to that shown by global surface temperature measurements over the same period. Balloon and satellite measurements agree that lower-stratospheric temperatures have declined significantly since 1979.
- Since 1979, trends in worldwide land-surface air temperature derived from weather stations in the Northern Hemisphere, in regions where urbanisation is likely to have been strong, agree closely with satellite derived temperature trends in the lower troposphere above the same regions. This suggests that urban heat island biases have not significantly affected surface temperature over the period.
- The decrease in the continental diurnal temperature range since around 1950 coincides with increases in cloud amount and, at least since the mid-1970s in the Northern Hemisphere, increases in water vapour.
- Decreases in spring snow cover extent since the 1960s, and in the duration of lake and river ice over at least the last century, relate well to increases in Northern Hemispheric surface air temperatures.
- The systematic decrease in spring and summer Arctic sea-ice extent in recent decades is broadly consistent with increases of temperature over most of the adjacent land and ocean. The large reduction in the thickness of summer and early autumn Arctic sea ice over the last thirty to forty years is consistent