meteorological studies using an ice accretion model to estimate ice loads have been performed for high-voltage transmission lines in Alaska (Gouze and Richmond 1982a and 1982b, Richmond 1985, 1991, and 1992, and Peterka et al. 1996). Estimated 50-yr mean recurrence interval accretion thicknesses from snow range from 1.0 to 5.5 in. (25 to 140 mm), and in-cloud ice accretions from 0.5 to 6.0 in. (12 to 150 mm). The assumed accretion densities for snow and in-cloud ice accretions, respectively, were 5 to 31 lb/ft$^3$ (80 to 500 kg/m$^3$) and 25 lb/ft$^3$ (400 kg/m$^3$). These loads are valid only for the particular regions studied and are highly dependent on the elevation and local terrain features.

In Hawaii, for areas where freezing rain (Wylie 1958), snow, and in-cloud icing are known to occur at higher elevations, site-specific meteorological investigations are needed.

Local records and experience should be considered when establishing the design ice thickness, concurrent wind speed, and concurrent temperature. In determining equivalent radial ice thicknesses from historical weather data, the quality, completeness, and accuracy of the data should be considered along with the robustness of the ice accretion algorithm. Meteorological stations may be closed by ice storms because of power outages, anemometers may be iced over, and hourly precipitation data recorded only after the storm when the ice in the rain gauge melts. These problems are likely to be more severe at automatic weather stations where observers are not available to estimate the weather parameters or correct erroneous readings. Note also that (1) air temperatures are recorded only to the nearest 1 °F, at best, and may vary significantly from the recorded value in the region around the weather station; (2) the wind speed during freezing rain has a significant effect on the accreted ice load on objects oriented perpendicular to the wind direction; (3) wind speed and direction vary with terrain and exposure; (4) enhanced precipitation may occur on the windward side of mountainous terrain; and (5) ice may remain on the structure for days or weeks after freezing rain ends, subjecting the iced structure to wind speeds that may be significantly higher than those that accompanied the freezing rain. These factors should be considered both in estimating the accreted ice thickness at a weather station in past storms and in extrapolating those thicknesses to a specific site.

In using local data, it must also be emphasized that sampling errors can lead to large uncertainties in the specification of the 50-yr ice thickness. Sampling errors are the errors associated with the limited size of the climatological data samples (years of record). When local records of limited extent are used to determine extreme ice thicknesses, care should be exercised in their use.

A robust ice accretion algorithm will not be sensitive to small changes in input variables. For example, because temperatures are normally recorded in whole degrees, the calculated amount of ice accreted should not be sensitive to temperature changes of fractions of a degree.

### C10.1.2 Dynamic Loads

While design for dynamic loads is not specifically addressed in this edition of the standard, the effects of dynamic loads are an important consideration for some ice-sensitive structures and should be considered in the design when they are anticipated to be significant. For example, large amplitude galloping (Rawlins 1979 and Section 6.2 of Simiu and Scanlan 1996) of guys and overhead cable systems occurs in many areas. The motion of the cables can cause damage due to direct impact of the cables on other cables or structures and can also cause damage due to wear and fatigue of the cables and other components of the structure (White 1999). Ice shedding from the guys on guyed masts can cause substantial dynamic loads in the mast.

### C10.1.3 Exclusions

Additional guidance is available in ASCE (1982) and CSA (1987 and 1994).

## C10.2 DEFINITIONS

**FREEZING RAIN:** Freezing rain occurs when warm moist air is forced over a layer of subfreezing air at the earth's surface. The precipitation usually begins as snow that melts as it falls through the layer of warm air aloft. The drops then cool as they fall through the cold surface air layer and freeze on contact with structures or the ground. Upper air data indicates that the cold surface air layer is typically between 1,000 and 3,900 ft (300 and 1,200 m) thick (Young 1978), averaging 1,600 ft (500 m) (Bocchieri 1980). The warm air layer aloft averages 5,000 ft (1,500 m) thick in freezing rain, but in freezing drizzle the entire temperature profile may be below 32 °F (0 °C) (Bocchieri 1980).

Precipitation rates and wind speeds are typically low to moderate in freezing rain storms. In freezing rain the water impingement rate is often greater than the freezing rate. The excess water drips off and may