

## Explanatory note on detection of statistical significance in long-term trends

Meteorological observation data, including those relating to temperature and precipitation, are subject to large amplitude fluctuations due to the influence of atmospheric and oceanic dynamics on a broad spectrum of spatial and temporal scales. To examine the possible presence of long-term climate system trends associated with global warming in consideration of natural variability, raw climate data need to be converted into suitable statistical time-series representations and subjected to statistical testing in order to highlight the likelihood of systematic temporal trends that cannot be explained by random variability alone. When the results of such testing allow reasonable conclusion that random variability is unlikely to be the sole factor at work, a change is described as statistically significant.

In this report, the likelihood of a systematic long-term change existing in a time-series representation is based on the results of statistical significance testing performed at confidence levels of 99, 95 and 90%. The following terminology summary describes each level:

| Level of confidence | Term  |
|---------------------|---|
| $\geq 99\%$         | <b>Virtually certain</b> to have increased/decreased (statistically significant at a confidence level of 99%) |
| $\geq 95\%$         | <b>Extremely likely</b> to have increased/decreased (statistically significant at a confidence level of 95%)  |
| $\geq 90\%$         | <b>Very likely</b> to have increased/decreased (statistically significant at a confidence level of 90%)       |
| $< 90\%$            | No discernible trend  |

The following statistical methods are applied for the data used in this report:

i) For statistical variables whose annual fluctuation component can be assumed to follow normal distribution

For temperature anomalies, trend-removed annual variability data are expected to approximately follow normal distribution. T-testing is performed for statistical variables assumed to be normally distributed using a coefficient of correlation between years and values.

ii) For statistical variables whose annual fluctuation component cannot be assumed to follow normal distribution

The assumption of normality may not be applicable to frequency statistics regarding weather conditions, including those for extremely warm days, tropical nights and hourly precipitation amounts exceeding 50 mm. Accordingly, non-parametric testing, which does not depend on underlying assumptions about distribution, is applied to such variables.

It should be noted that statistical tests are in theory inevitably susceptible to the establishment of false conclusions even if the results indicate a statistically significant trend. Even outcomes indicating statistical significance at confidence levels of 90, 95 or 99% imply that there are small inherent probabilities of up to 10, 5 and 1%, respectively, of the significance being erroneously detected when in fact the observed long-term change occurred by mere random chance. Conversely, when a systematic long-term change actually exists, statistical testing may

fail to detect the significance correctly. In general, test results are not considered highly stable if they are based on observation records that are temporally limited, influenced by large annual fluctuations/rare events or subject to change when new observations are added to a data sequence. Readers are encouraged to interpret the analytical results presented in the report appropriately with due note of these considerations.