# IAEA SAFETY STANDARDS
# Safety Guide on Hydrological and Meteorological Events DS417

Regional Workshop on Volcanic, Seismic, and Tsunami Hazard Assessment Related to NPP Siting Activities and Requirements
June 13-17, Jakarta, Indonesia

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International Atomic Energy Agency

# Presentation Outline



- DS417 Criteria
  - Meteorological Data Sources
  - Meteorological Hazard Assessment
  - Determination of Design Basis Parameters
  - Changes of the Hazard with Time
  - Monitoring and Warning Systems

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# DS417: Background



- Links guidance on phenomena with casual relationship and related effects
- Incorporates new knowledge and experience
  - Occurrences of extreme meteorological events
  - Recent experience from Member States in the application of IAEA Safety Standards
- Update guidance on climate variability and change
  - Intergovernmental Panel on Climate Change
- Integrate the approaches used for evaluating meteorological hazards for all nuclear installations

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# DS417: Objective & Scope



- Provide guidance on complying with safety requirements on assessing the hazards associated with meteorological phenomena that may affect the safety of nuclear installations
  - Site selection and evaluation
  - Design of new installations
  - Operational stages of existing installations

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# DS417: General Considerations



- Meteorological phenomena may effect:
  - A large number of SSCs simultaneously and lead to the risk of common cause failure
    - Loss of off-site and emergency power supplies
  - Communication and transport networks around the site
    - Isolating the site in an emergency, with consequent difficulties in communication and supply
    - Making emergency planning escape routes difficult or impassable

# DS417: General Considerations



- Extreme values of the following meteorological variable should be considered:
  - Air temperature
  - Precipitation
  - Wind speed
  - Snow pack
- Rare meteorological phenomena that should be considered:
  - Lightning
  - Tornadoes
  - Tropical Cyclones
  - Waterspouts

# DS417: General Considerations



- Other possible meteorological phenomena with potential adverse effects that should be considered:
  - Dust storms and sandstorms
  - Hail
  - Freezing precipitation (ice storms)
- High intensity winds (tropical storms, tornadoes) may produce flying debris and projectiles

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# DS417: General Considerations



- Changes of the Hazard with Time
  - Climate variability and change
- Methods for Assessment of Hazards
  - Two broad categories:
    - Deterministic methods
    - Probabilistic methods
      - Generalized Extreme Value (GEV) approach
      - Peak-Over-Threshold (POT) method
  - An estimate should be made of the frequency of exceedence associated with the design basis scenarios
    - The annual frequency of exceedence for defining the design-basis hazard typically is indicated by the Regulatory Body

# DS417: Met Hazards Assessment



## General Procedure

**Obtain representative data series available for the region**
**Evaluate its quality (representativeness, completeness, QA/QC)**

↓

**Select the most appropriate statistical distribution**
**(Gumbel, Frechet, Weibull)**

↓

**Process the data to estimate Mean Recurrence Interval (MRL)**

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# DS417: Extreme Air Temperature



## Design Basis Parameters

| Site Parameter | Criterion | Use |
|---|---|---|
| Maximum dry-bulb & coincident wet-bulb | 1% annual exceedance | Cooling / AC |
| | 100-yr MRI | (a) |
| Maximum non-coincident wet-bulb | 1% annual exceedance | Evaporative Cooling |
| | 100-yr MRI | Evaporative Cooling |
| Minimum dry-bulb | 99% annual exceedance | Heating |
| | 100-yr MRI | (a) |

(a) Maximum and minimum 100-yr MRI criteria can be used for the operational design of equipment to ensure continuous operation and serviceability, structural analysis of thermal loads on building and structures, etc.

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# DS417: Extreme Wind Speeds



## Design Basis Parameters

| Site Parameter | Criterion | Use |
|---|---|---|
| 3-sec gust[a] | 100-yr MRI | Wind loads |

(a) This site parameter should account for the occurrence of tropical cyclones for those sites that are susceptible to such phenomena

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# DS417: Extreme Precipitation



## Design Basis Parameters

| Site Parameter | Criterion | Use |
|---|---|---|
| Local Intense Precipitation[(a)] | PMP | Water drainage system design and flooding evaluations |
| | 100-yr MRI | |

(a) The depth of rainfall for a specified duration and surface area (e.g., cm/hr-km$^2$)

# DS417: Extreme Snow Pack



## Design Basis Parameters

| Site Parameter | Criterion | Use |
|---|---|---|
| Ground snow pack weight | 100-yr MRI | Roof loads |

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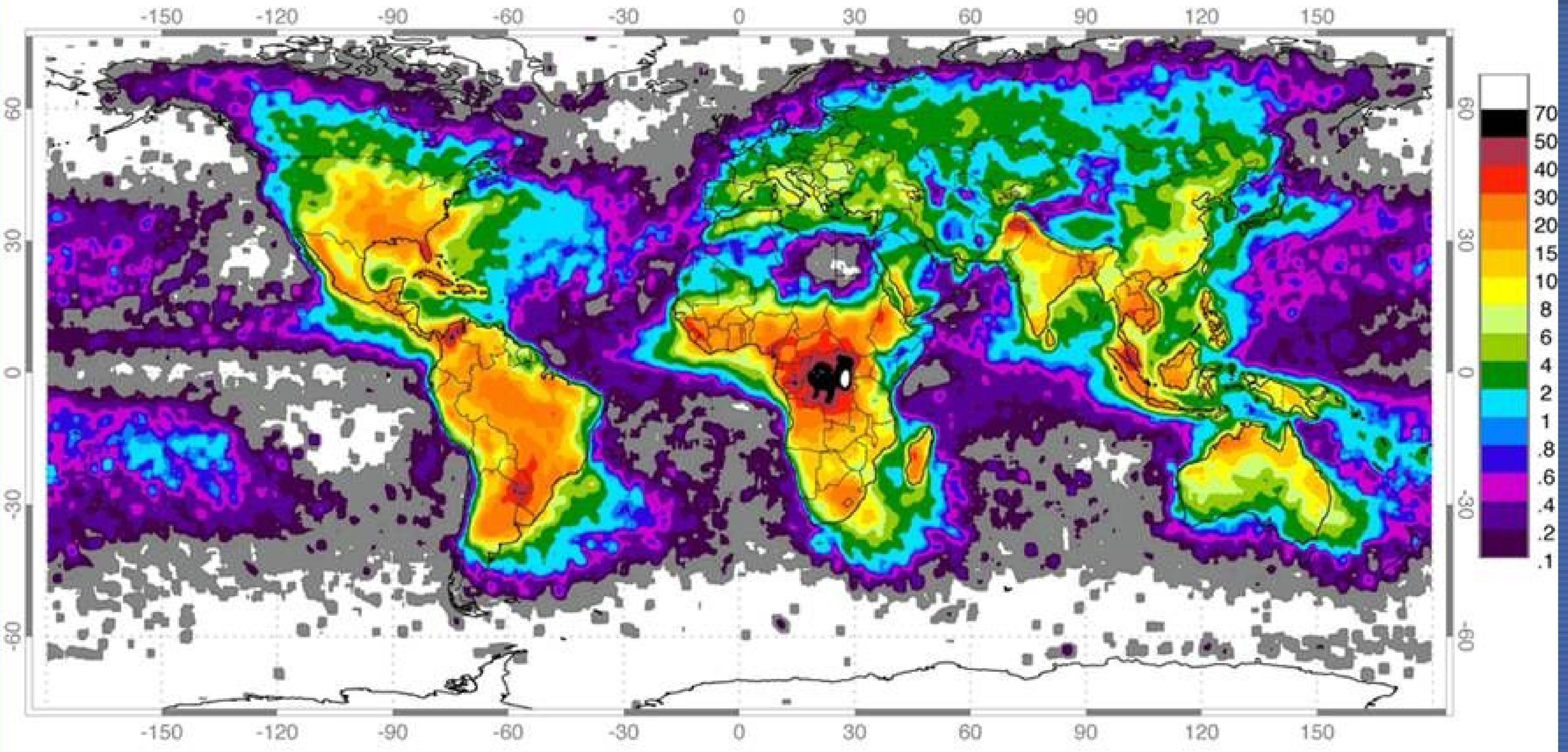
# Lighting Flashes Per Square Km Per Year






**Low Resolution Full Climatology Annual Flash Rate**

Global distribution of lightning April 1995-February 2003 from the combined observations of the NASA OTD (4/95-3/00) and LIS (1/98-2/03) instruments.

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# DS417: Lightning



## Design Basis Parameters

| Site Parameter | Criterion | Use |
|---|---|---|
| Lightning Strike Frequency | Lightning strikes per year | Design of lightning protection systems |

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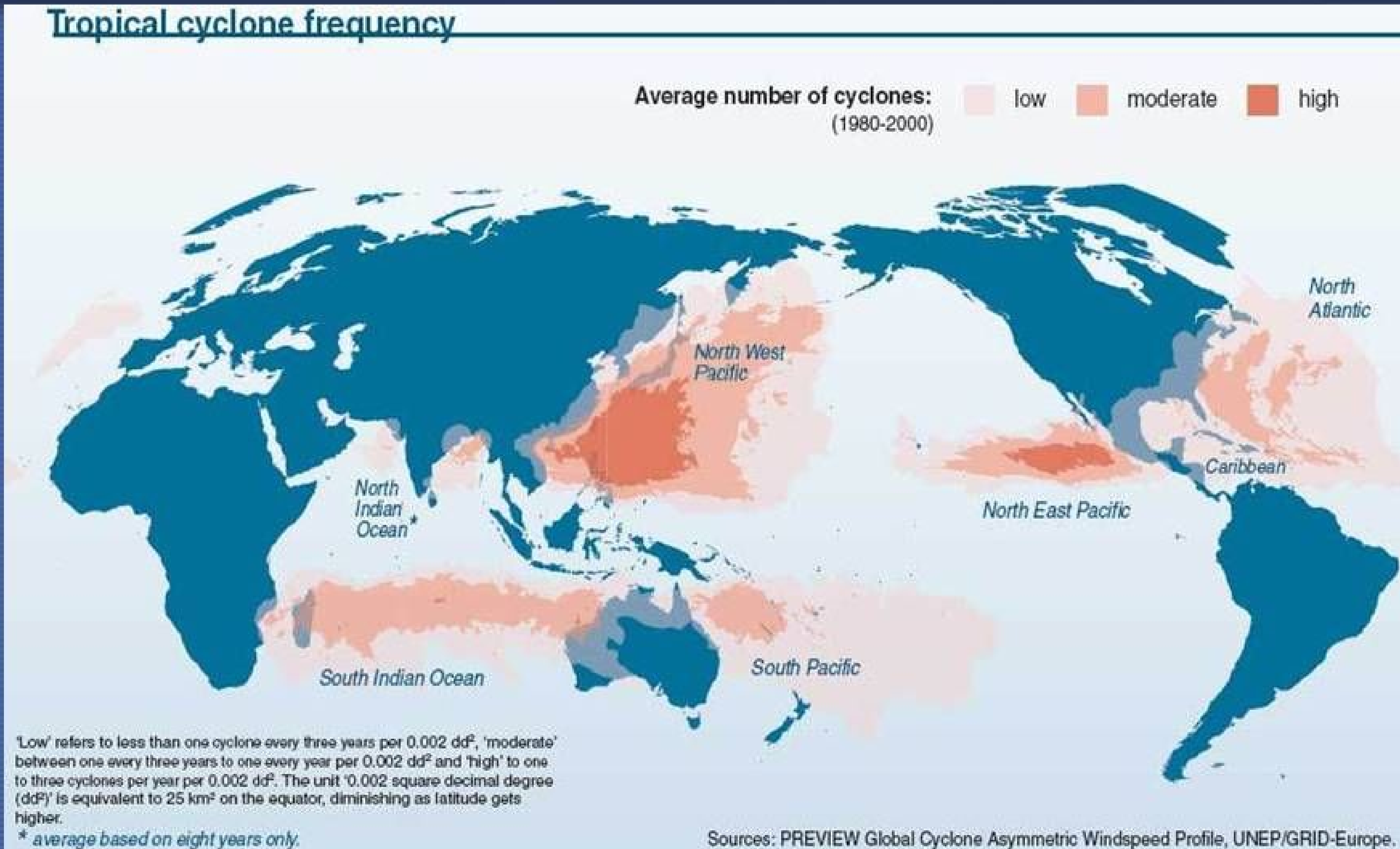
# Tropical Cyclone Frequency



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# Tornadoes



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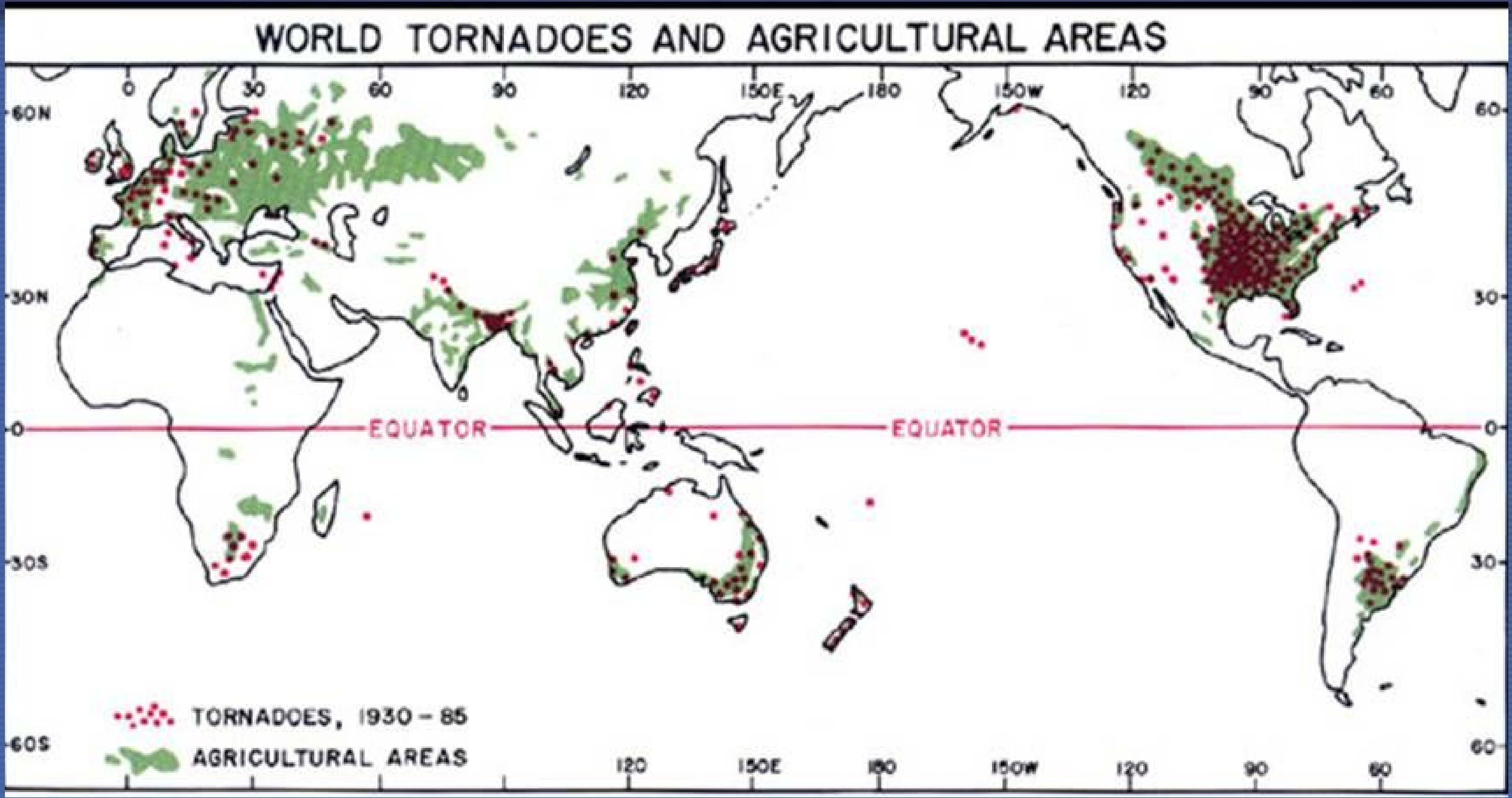
# World Map of Tornado Occurrence






Windows to the Universe team. World Map of Tornado Occurrence and Agriculture Production. Boulder, CO: © The Regents of the University of Michigan, Last modified prior to September, 2000. Online. Available: http://www.windows.ucar.edu . Accessed 10 Jan 2010.

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# DS417: Tornadoes



## Design Basis Parameters

| Site Parameter | Criterion | Use |
|---|---|---|
| Maximum Wind Speed | 10,000-yr MRI | Wind Loading |
| Pressure Drop | 10,000-yr MRI | Structure strength |
| Rate of Pressure Drop | 10,000-yr MRI | Structure vents |

Pressure drop and rate of pressure drop are a function of the maximum wind speed and assumed tornado radius, rotational speed, and translational speed

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# High Wind Speed Missiles



# DS417: Tornado Missiles



## Design Basis Parameters

| Site Parameter | Criterion | Use |
|---|---|---|
| Massive Missile (e.g., automobile) | 10,000-yr MRI | Resistance to gross failure |
| Rigid Missile (e.g., pipe) | 10,000-yr MRI | Resistance to missile penetration |
| Small Rigid Missile (small sphere) | 10,000-yr MRI | Configuration of openings |

Missile speeds are calculated as a function of wind speed, cross-sectional area, and weight

# DS417: Waterspouts



- Waterspouts may transfer large amounts of water to land
- Two categories
  - Tornadic
  - Fair weather
- National Meteorological Services have begun to identify and record waterspouts
- Hazard assessment based on frequencies and range of intensities
  - Used in the design of drainage systems

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# Waterspouts



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# Dust Storms and Sandstorms



# DS417: Hail



- Form of precipitation consisting of balls of irregular lumps of ice (hailstones)
  - 5 to 150 mm in diameter
- Associated with strong thunderstorms
  - Interior of continents
  - Mid-latitudes (higher elevations in tropics)
  - Summer months, afternoon and evening
- Hazard assessment
  - Probable maximum hail size based on historic records

# Hail



# DS417: Freezing Precipitation (Ice Storms)



- Formation of ice around structures caused by freezing rain, snow, and in-cloud icing
- Used in the design of ice-sensitive structures
  - Static and dynamic response to wind
- Hazard assessment based on local records and experience

# Freezing Precipitation - Ice Storm



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# DS417: Freezing Precipitation (Ice Storms)



## Design Basis Parameters

| Site Parameter | Criterion | Use |
|---|---|---|
| Ice Thickness and Concurrent Wind Speed | 100-yr MRI | Design of ice sensitive structures |

# DS417: Changes of the Hazard with Time



- Meteorological hazards may change over time due to:
  - Regional climate change associated with global climate change
  - Changes of land-use in the area around the site
- Major effects:
  - Changes in air and water temperatures
  - Changes in frequency and intensity of phenomenon
- Regional climate variability and change should be considered for the planned life time of an installation (e.g., 100 years)
  - Additional safety margin should be considered in the design
  - Periodic re-evaluation of design parameters should be performed

# AR4: Geographical Pattern of Surface Warming



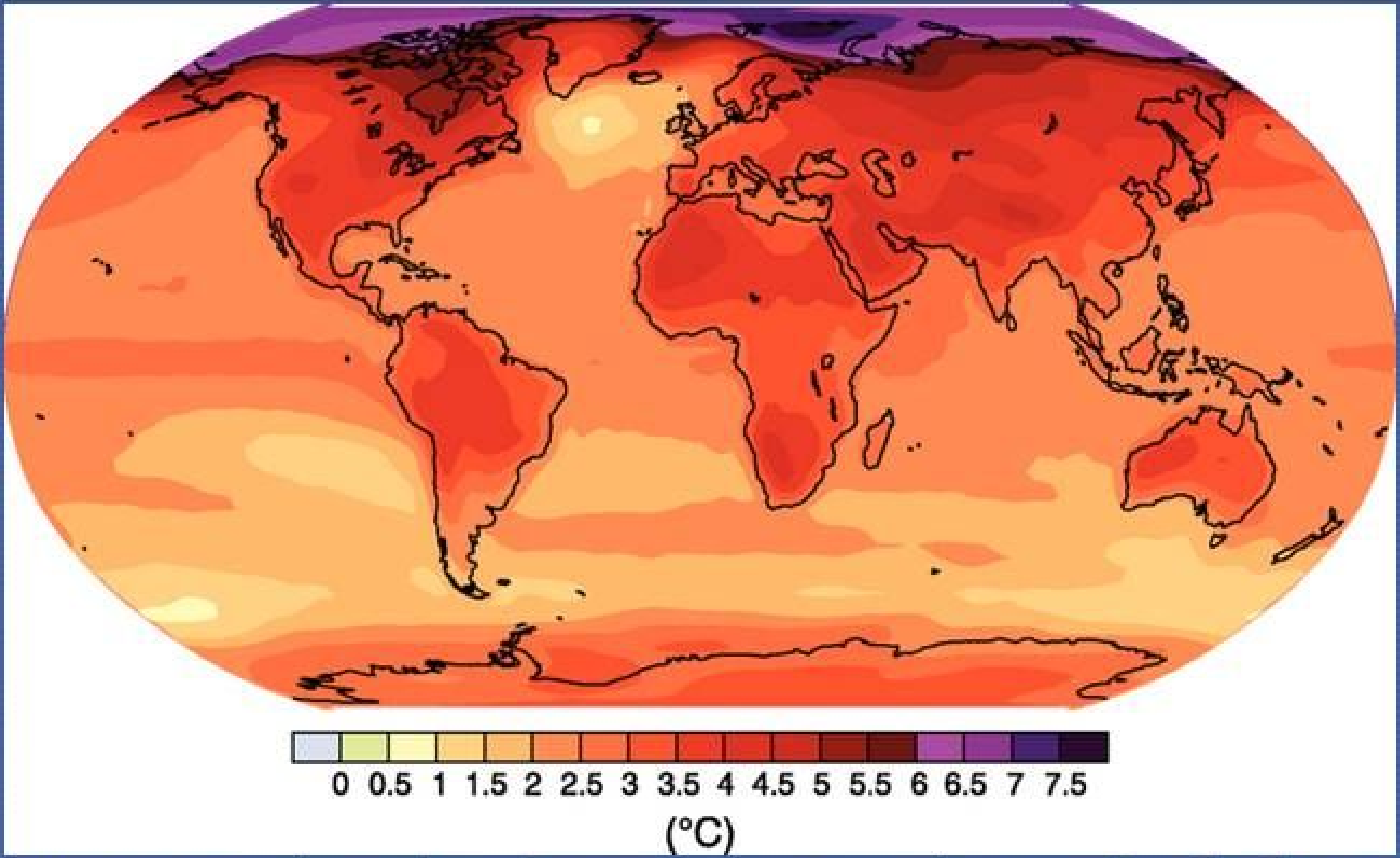


Figure SPM.6. Projected surface temperature changes for the late 21st century (2090-2099). The map shows the multi-AOGCM average projection for the A1B SRES scenario. Temperatures are relative to the period 1980-1999.

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# DS417 Climate Change



- IPCC AR4 (2007) Likelihood of Future Trends
  - Virtually Certain (>99% probability)
    - Warmer and fewer cold days and nights
    - Warmer and more frequent hot days and nights
  - Very Likely (>90% probability)
    - Increase frequency of warm spells and heat waves
    - Increase frequency of heavy precipitation events
  - Likely (>66% probability)
    - Areas affected by drought increase
    - Intense tropical cyclone activity increases
    - Changes in frequency, position, and intensity of extra-tropical cyclones

# DS417: Monitoring and Warning



- Continuous monitoring is a requirement for any meteorological event proven to be a significant hazard
- Monitoring should be performed from the site selection studies phase until the end of operational phase
  - Validate design basis parameters
  - Support periodic revision of the site hazard
    - consequence of global climate change
  - Provide warnings for operators and emergency managers
- Warning system should be used in connection with forecasting models
  - Arrangements should be made to receive warnings on severe weather from national warning systems reliably and on time

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**Thank you for your attention**