LANDIS-II v

Extension User Guide

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# Introduction

This document describes the extension for the LANDIS-II model. For information about the model and its core concepts, see the *LANDIS‑II Conceptual Model Description.*

Base Hurricane models tropical cyclones of varying strength making landfall on the US east coast in Virginia, North Carolina, South Carolina, or Georgia. The model is concerned only with sustained wind. Rainfall, storm surge, tornadoes, or inland flooding are not modelled.

Mortalities are computed based on the maximum wind speed of the entire event. Though wind speeds in reality vary over the duration the event, only the maximum wind speed is considered for mortality computation.

The terms "hurricane", "tropical cyclone", and "storm" are used interchangeably in this documentation.

## Hurricane Disturbances

During a hurricane time step, multiple tropical cyclone events may occur on the landscape. A storm which is generated by the model may hit the study area, but it may miss it. If a storm passes far enough away from the study area such that the maximum wind speed is too low, no damage is computed.

For any year, the number of tropical cyclones which are to strike on the east coast is randomly generated.

For each storm, initiation parameters are created: Landfall Latitude, Maximum Wind Speed at Landfall, and Storm Track Heading.

Based on these initiation parameters, a Maximum Wind Speed Field is generated on a continental grid, which is then used to compute maximum wind speed for each site of the study area.

Cohort mortality probabilities are computed based on cohort species and age compared to the maximum wind speed based on the Wind Speed Vulnerabilities table.

### Climate Change

Version 1.0 does not provide a way to allow storm occurrence probabilities to change over time or to allow maximum wind speed over time.

## Major Releases

### Version 0.1

The initial release of Base Hurricane.

## Minor Releases

## References

~~Mladenoff, David J., and Hong S. He. "Design, behavior and application of LANDIS, an object-oriented model of forest landscape disturbance and succession." Spatial modeling of forest landscape change: approaches and applications. Cambridge University Press, Cambridge, UK (1999): 125-162.~~

## Acknowledgements

Funding for the development of LANDIS-II has been provided by the United States Department of Defense.

# Input File

The input parameters for this extension are specified in one input file. This text file must comply with the general format requirements described in section 3.1 Text Input Files in the LANDIS-II Model User Guide.

## LandisData

This value of this parameter must be "Base Hurricane".

## Timestep

This parameter is the timestep of the hurricane extension. Value: integer > 0. Units: years.

## Storm Occurrence Probabilities

The number of storms which make landfall on the east coast of the United States has varied over the past three decades with the number ranging from zero to two. The user controls the likelihood of storm occurrences with the Storm Occurrence Probabilities table, formatted as follows:

>> Likelihood a given year will have this number of storms

>> On the US southeastern seaboard, based on 1979 -- 2018.

>> For climate change, adjust this table

StormOccurrenceProbabilities

>> Storms

>> Per

>> Year Probability << Sum must = 1.0

0 0.60

1 0.33

2 0.06

3 0.01

## Input Units English

The instruction, InputUnitsEnglish, is optional. When present, it directs the model to interpret all wind speeds in the input file as statute miles per hour. It is a single word with no other parameters.

If the instruction is omitted, wind speeds in the input file are interpreted as kilometers per hour.

This instruction only impacts interpretation of speed in the Base Hurricane input file.

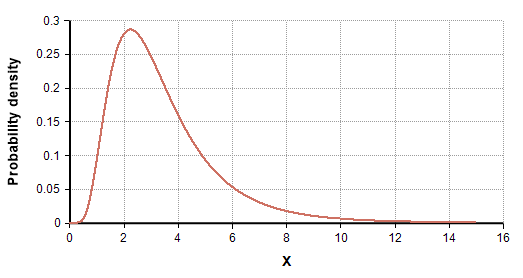
Internally all wind speeds are converted to kilometers per hour.

## Modelling of Landfall Wind Speed

An important controlling parameter for the model is the maximum wind speed of the storm when it makes landfall. After landfall the wind speeds are assumed to decrease.

Each storm is assigned a random landfall wind speed on a log-normal distribution. The scale of these values is determined by three parameters set in the input file: LowBoundLandfallWindSpeed, ModeLandfallWindSpeed, and HighBoundLandfallWindSpeed.

The distribution is depicted in Figure 1 with labels for the three controlling values.



High Bound

Landfall Wind Speed

Mode Landfall Wind Speed

Low Bound

Landfall Wind Speed

Probability

Wind Speed

Figure 1: Log-Normal Distribution of Randomly Generated Landfall Wind Speed Values

Note that the image[[1]](#footnote-1) for Figure 1 has been modified by revising the axes and adding labels.

### Low Bound Landfall Wind Speed

This is the lowest wind speed that a tropical cyclone may have.

### Mode Landfall Wind Speed

This is the most frequent wind speed that a tropical storm may have.

### High Bound Landfall Wind Speed

This is the highest wind speed that a tropical storm may have.

## Locating Study Area on the Continental Grid

Some hurricanes strike the east coast of the United States but follow a course that is harmless to a given study area. To simulate this, storms are created to make landfall at a random latitude between 30.7° and 38.45°. The storm center then progresses inland along a straight line at a randomized heading between 280° and 360° (Azimuth).

Given this approximation of a continent-sized grid, the study area must be located in reference to this. To accomplish this, the input file contains two parameters for establishing the location of the study area by fixing its center point on the grid. This is done by setting a value for Center Point Latitude and Center Point Distance Inland.

All values are shown graphically in Figure 2.

### Center Point Latitude

Latitude of the center point of the study area.

### Center Point Distance Inland

Distance from the study area center point to the nearest point on the Atlantic seaboard coast. Units are kilometers (or Miles if InputUnitsEnglish is set.)

Storm

Center

Track

Center Point

Latitude

Center Point

Distance Inland

Study

Area

Virtual Coastline

Figure 2: Schematic showing how study area relates to random storm events

The virtual coastline is set to strike a 45° angle at all points. The wind speeds encountered at the study area depend on the distance of each site from the center line of the storm. If the storm is far enough from the study site, no impacts are modelled.

## Wind Speed Vulnerabilities

High winds kill cohorts at different rates according to species and age. To represent this, the mortality probabilities are entered into the Wind Speed Vulnerabilities table, a segment of which is depicted here.

WindSpeedVulnerabilities

>> Species MaxAge Mortality Probabilities

LobPine 10 60:0.1 75:0.25 95:0.4 110:0.6 125:0.75 140:1.0

LobPine 30 60:0.15 75:0.30 95:0.5 110:0.65 125:0.80 140:1.0

LobPine 60 60:0.1 75:0.25 95:0.4 110:0.6 125:0.75 140:1.0

Column 1 contains the name of the species. This should be consistent with species names in the species txt file.

Column 2 contains the maximum cohort age in years for the given table row. The final row for any species should have a very high age (such as 999) to represent the oldest cohorts.

Column 3 and following contain colon-delimited pairs of values where the first number is the wind speed and second number is the probability of mortality. For example, a value of "60:0.1" means that site wind speeds of less than 60 kph (or mph if set to English) result in 10% cohort mortality.

## MapNames

This file parameter is the template for the names of the wind severity output maps. The parameter value must include the variable “timestep” to ensure that the maps have unique names (see section 3.1.8.1 Variables in the LANDIS-II Model User Guide). The user must indicate the file extension. The user must also include sub-directory name(s) as needed.

## LogFile

The file parameter is the name of the extension’s event log file.

# Output Files

~~The wind extension generates two types of output files: a) a map of wind severity for each time step, and b) a log of wind events for the entire scenario.~~

## Wind Severity Maps

~~The map of wind severity uses a code of 0 for non-active sites, 1 for active and not disturbed sites, [wind severity + 1] for all disturbed sites. A map is produced for each wind time step.~~

## Wind Event Log

~~The event log is a text file that contains information about every event over the course of the scenario: year, initiation cell coordinates, total event size (number of sites), number of damaged sites, number of cohorts killed total, mean wind severity across all sites. The information is stored as comma-separated values (CSV).~~

# Example File

LandisData "Base Hurricane"

Timestep 2

>> Likelihood a given year will have this number of storms

>> On the US southeastern seaboard, based on 1979 -- 2018.

>> For climate change, adjust this table

StormOccurrenceProbabilities

>> Storms

>> Per

>> Year Probability << Sum must = 1.0

0 0.60

1 0.33

2 0.06

3 0.01

InputUnitsEnglish

>> Max Wind Speed at Landfall is on a log normal distribution

LowBoundLandfallWindSpeed 42 >> mph

>> For climate change, adjust these two upwards

ModeLandfallWindSpeed 74 >> mph

HighBoundLandfallWindSpeed 150 >> mph Values greater than this are recomputed, so it truncates here.

>> Study area location (Center point of the raster)

>> These are for Fort Bragg

CenterPointLatitude 35.11 << decimal degrees

CenterPointDistanceInland 100 << miles

WindSpeedVulnerabilities

>> Species MaxAge Mortality Probabilities

LobPine 10 60:0.1 75:0.25 95:0.4 110:0.6 125:0.75 140:1.0

LobPine 30 60:0.15 75:0.30 95:0.5 110:0.65 125:0.80 140:1.0

LobPine 60 60:0.1 75:0.25 95:0.4 110:0.6 125:0.75 140:1.0

LobPine 90 60:0.1 75:0.25 95:0.4 110:0.6 125:0.75 140:1.0

LobPine 999 60:0.1 75:0.25 95:0.4 110:0.6 125:0.75 140:1.0

LongleafPine 10 60:0.1 75:0.25 95:0.4 110:0.6 125:0.75 140:1.0

LongleafPine 30 60:0.1 75:0.25 95:0.4 110:0.6 125:0.75 140:1.0

LongleafPine 60 60:0.1 75:0.25 95:0.4 110:0.6 125:0.75 140:1.0

LongleafPine 90 60:0.1 75:0.25 95:0.4 110:0.6 125:0.75 140:1.0

LongleafPine 999 60:0.1 75:0.25 95:0.4 110:0.6 125:0.75 140:1.0

ShortPine 10 60:0.1 75:0.25 95:0.4 110:0.6 125:0.75 140:1.0

ShortPine 30 60:0.1 75:0.25 95:0.4 110:0.6 125:0.75 140:1.0

ShortPine 60 60:0.1 75:0.25 95:0.4 110:0.6 125:0.75 140:1.0

ShortPine 90 60:0.1 75:0.25 95:0.4 110:0.6 125:0.75 140:1.0

ShortPine 999 60:0.1 75:0.25 95:0.4 110:0.6 125:0.75 140:1.0

SlashPine 10 60:0.1 75:0.25 95:0.4 110:0.6 125:0.75 140:1.0

SlashPine 30 60:0.1 75:0.25 95:0.4 110:0.6 125:0.75 140:1.0

SlashPine 60 60:0.1 75:0.25 95:0.4 110:0.6 125:0.75 140:1.0

SlashPine 90 60:0.1 75:0.25 95:0.4 110:0.6 125:0.75 140:1.0

SlashPine 999 60:0.1 75:0.25 95:0.4 110:0.6 125:0.75 140:1.0

WhiteOak 10 60:0.1 75:0.25 95:0.4 110:0.6 125:0.75 140:1.0

WhiteOak 30 60:0.1 75:0.25 95:0.4 110:0.6 125:0.75 140:1.0

WhiteOak 70 60:0.1 75:0.25 95:0.4 110:0.6 125:0.75 140:1.0

WhiteOak 110 60:0.1 75:0.25 95:0.4 110:0.6 125:0.75 140:1.0

WhiteOak 999 60:0.1 75:0.25 95:0.4 110:0.6 125:0.75 140:1.0

TurkeyOak 10 60:0.1 75:0.25 95:0.4 110:0.6 125:0.75 140:1.0

TurkeyOak 30 60:0.1 75:0.25 95:0.4 110:0.6 125:0.75 140:1.0

TurkeyOak 70 60:0.1 75:0.25 95:0.4 110:0.6 125:0.75 140:1.0

TurkeyOak 110 60:0.1 75:0.25 95:0.4 110:0.6 125:0.75 140:1.0

TurkeyOak 999 60:0.1 75:0.25 95:0.4 110:0.6 125:0.75 140:1.0

SweetGum 10 60:0.1 75:0.25 95:0.4 110:0.6 125:0.75 140:1.0

SweetGum 30 60:0.1 75:0.25 95:0.4 110:0.6 125:0.75 140:1.0

SweetGum 60 60:0.1 75:0.25 95:0.4 110:0.6 125:0.75 140:1.0

SweetGum 90 60:0.1 75:0.25 95:0.4 110:0.6 125:0.75 140:1.0

SweetGum 999 60:0.1 75:0.25 95:0.4 110:0.6 125:0.75 140:1.0

RedMaple 10 60:0.1 75:0.25 95:0.4 110:0.6 125:0.75 140:1.0

RedMaple 30 60:0.1 75:0.25 95:0.4 110:0.6 125:0.75 140:1.0

RedMaple 60 60:0.1 75:0.25 95:0.4 110:0.6 125:0.75 140:1.0

RedMaple 90 60:0.1 75:0.25 95:0.4 110:0.6 125:0.75 140:1.0

RedMaple 999 60:0.1 75:0.25 95:0.4 110:0.6 125:0.75 140:1.0

TulipTree 10 60:0.1 75:0.25 95:0.4 110:0.6 125:0.75 140:1.0

TulipTree 30 60:0.1 75:0.25 95:0.4 110:0.6 125:0.75 140:1.0

TulipTree 60 60:0.1 75:0.25 95:0.4 110:0.6 125:0.75 140:1.0

TulipTree 90 60:0.1 75:0.25 95:0.4 110:0.6 125:0.75 140:1.0

TulipTree 999 60:0.1 75:0.25 95:0.4 110:0.6 125:0.75 140:1.0

>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>

MapNames hurricane/mortalities-{timestep}.gis

LogFile hurricane/hurlog.csv

1. From <http://wiki.analytica.com/index.php?title=File%3ALogNormal(median%3D3,stddev%3D2).png>, accessed July 31, 2019. [↑](#footnote-ref-1)