World Bank: Philippines Catastrophe Risk Modeling and Assessment Study
Conceptual Parametric & Modeled Loss Structures

October 28, 2014

AIR WORLDWIDE®

Earthquake

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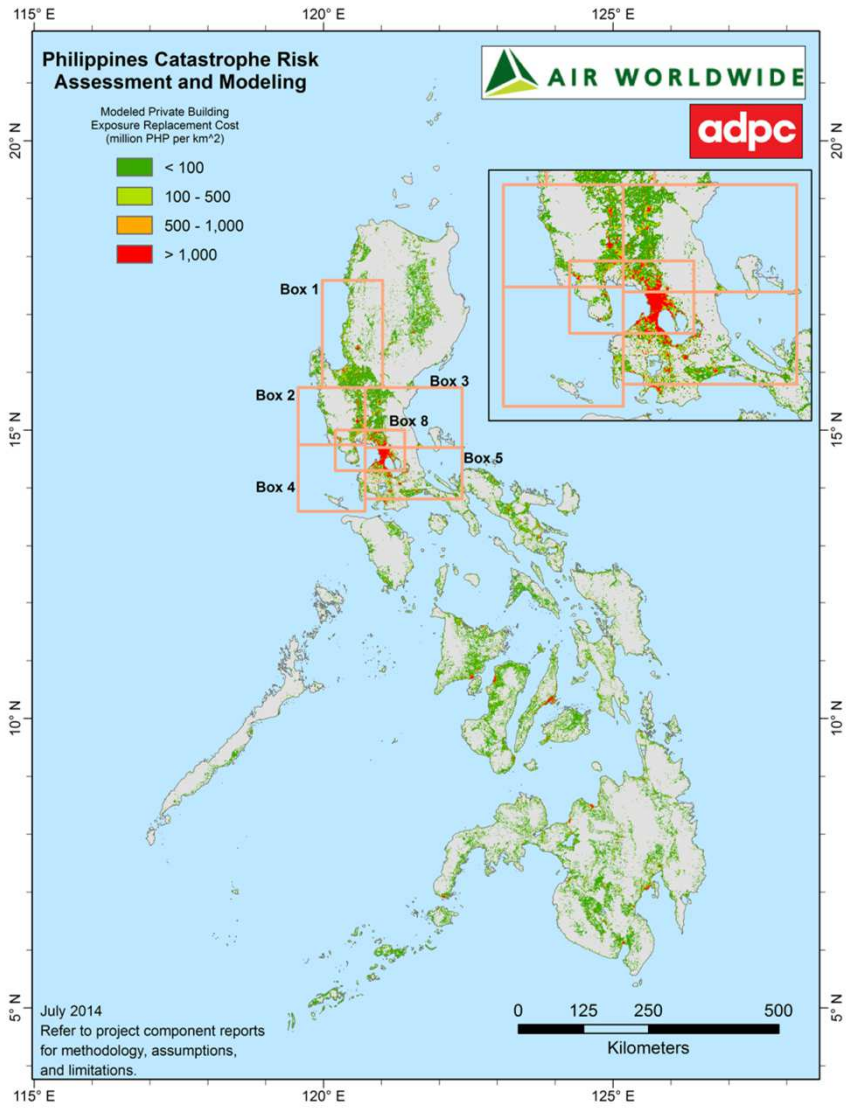
Earthquake Structure Characteristics

Box	Longitude 1	Longitude 2	Latitude 1	Latitude 2	Magnitude Threshold	Triggering Years	Triggering Probability (%)
Box 1	119.979	121.020	15.736	17.587	8.0	25	0.25
Box 2	119.562	120.718	14.748	15.736	7.1	58	0.58
Box 3	120.718	122.393	14.700	15.736	7.3	45	0.45
Box 4	119.562	120.718	13.596	14.748	7.2	98	0.98
Box 5	120.718	122.393	13.810	14.700	6.8	47	0.47
Box 8	120.200	121.400	14.300	15.000	6.6	47	0.47

Note: Only the first triggering event within a stochastic year is considered for this exhibit. Additionally, if an event triggers Box 8, and also triggers either Box 2, Box 3, Box 4 or Box 5, then the event is attributed to Box 8 only.

Earthquake Structure Characteristics



Basis Risk - Earthquake

Earthquake Structure – Number of Years				
		Modeled Loss		
		≤ 3.0% EP	> 3.0% EP	**Total**
Parametric Trigger	Yes	211	109	**320**
	No	89	9,591	**9,680**
	Total	**300**	**9,700**	**10,000**

Basis Risk = 109/320 ≈ 34%

Triggering Probability = 3.2%

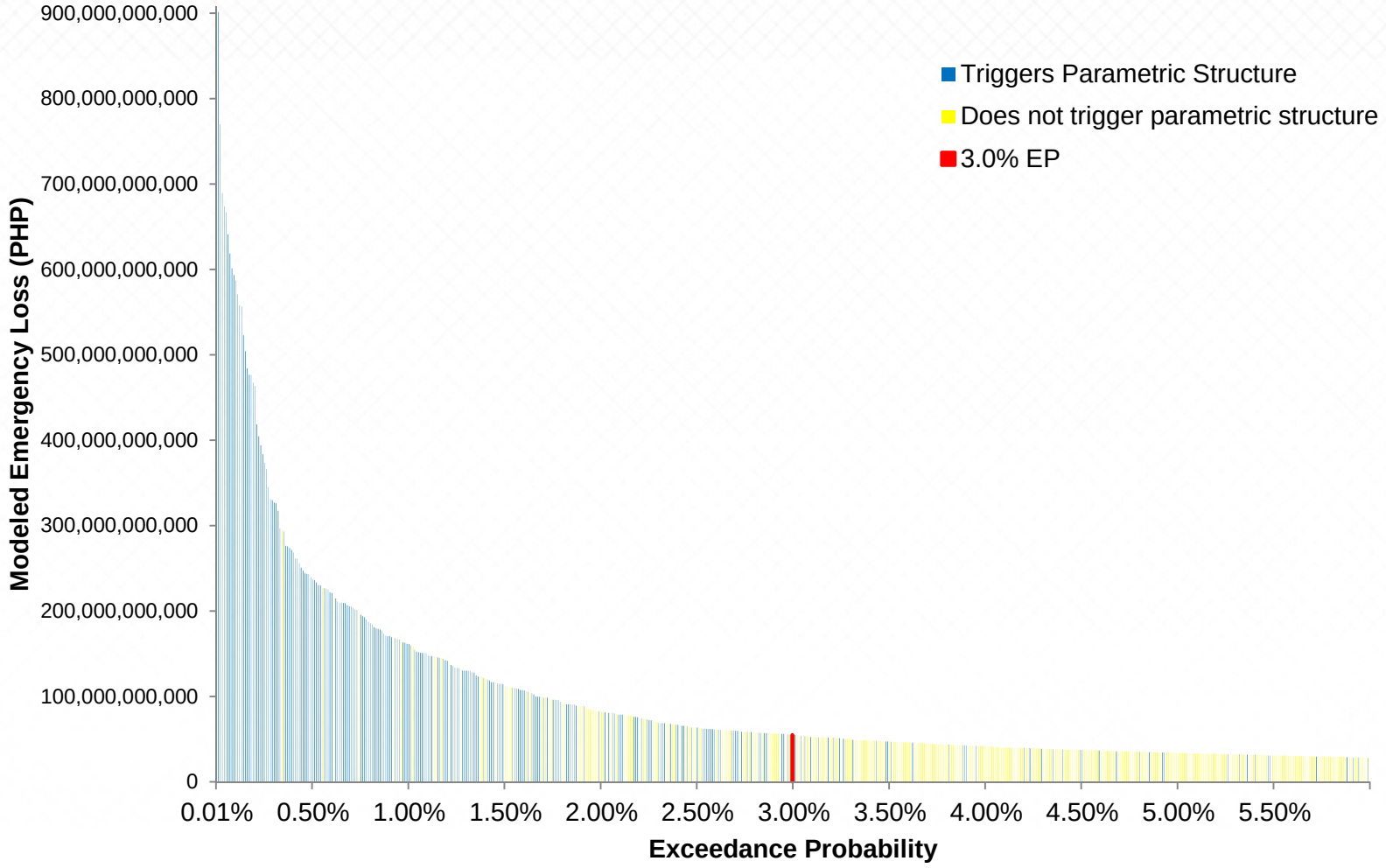
Earthquake Structure Characteristics

Magnitude Range (Mw)	Triggering Years	% Contribution	Triggering Loss (PHP Billion)	% Contribution	Modeled Loss (PHP Billion)	% Contribution
< 6.0	0	0.0%	0	0.0%	84	0.2%
6.0 – 6.5	0	0.0%	0	0.0%	416	0.8%
6.5 – 7.0	40	12.5%	2,615	6.0%	2,838	5.6%
7.0 – 7.5	88	27.5%	10,040	22.9%	11,119	22.1%
7.5 – 8.0	100	31.3%	10,389	23.7%	11,808	23.5%
> 8.0	92	28.8%	20,751	47.4%	24,071	47.8%
Total	**320**	**100.0%**	**43,795**	**100.0%**	**50,335**	**100.0%**

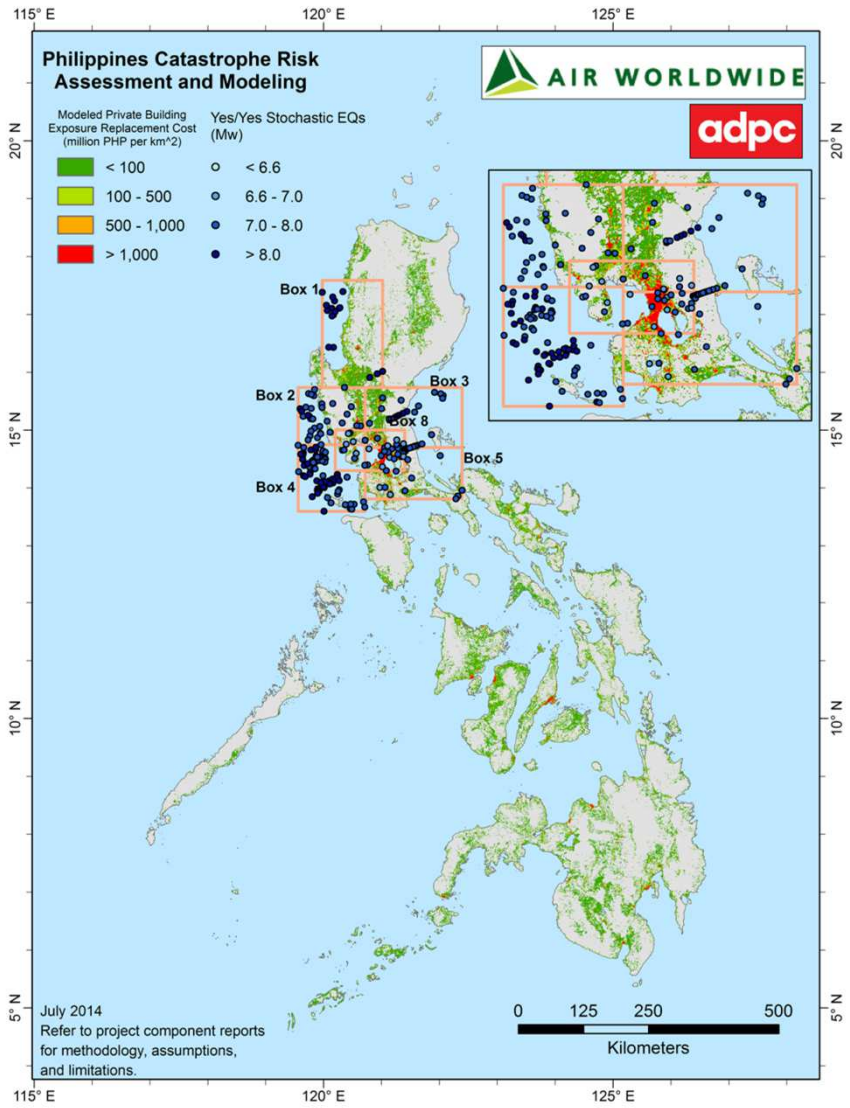
Note: : The triggering loss contribution is the modeled loss associated with the 320 triggering events, while the modeled loss is based on 307 events with ≤3% EP

Number of Modeled Loss Events Triggering the Structure	
Exceedance Probability (%)	Triggering Years
1%	94
2%	162
3%	211

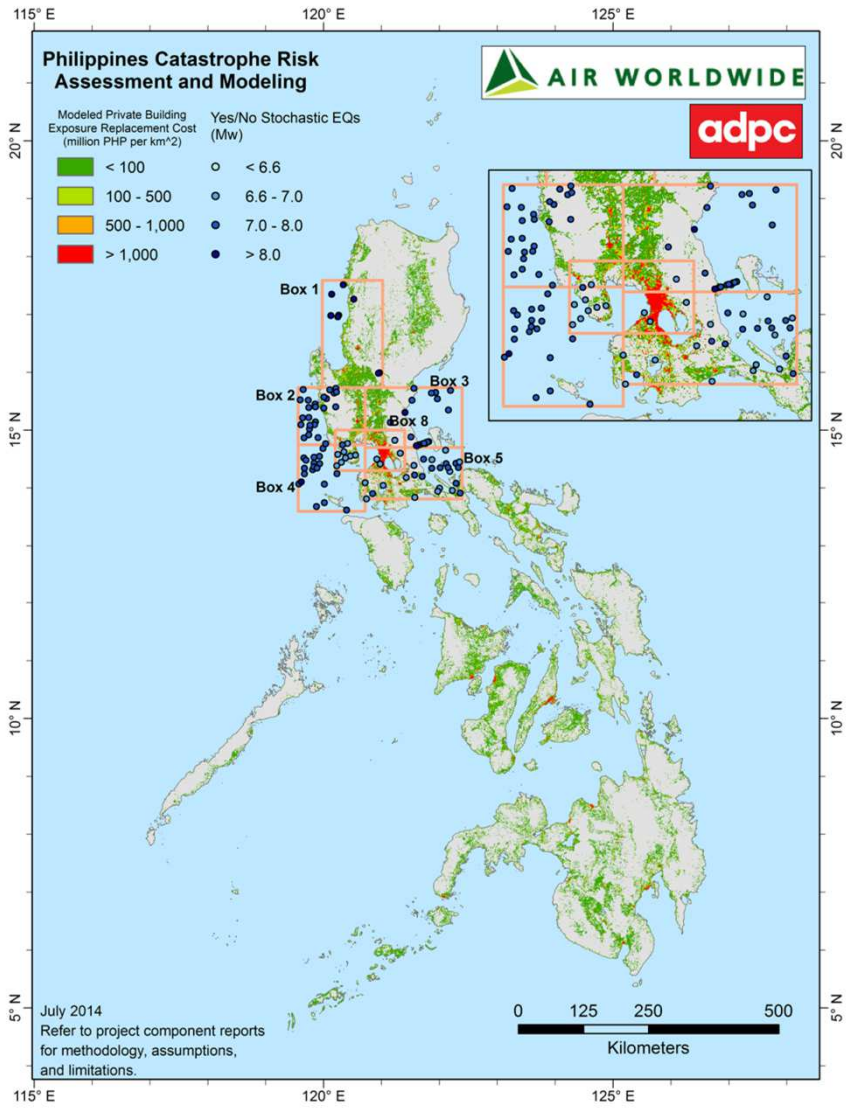
Occurrence EP Curve



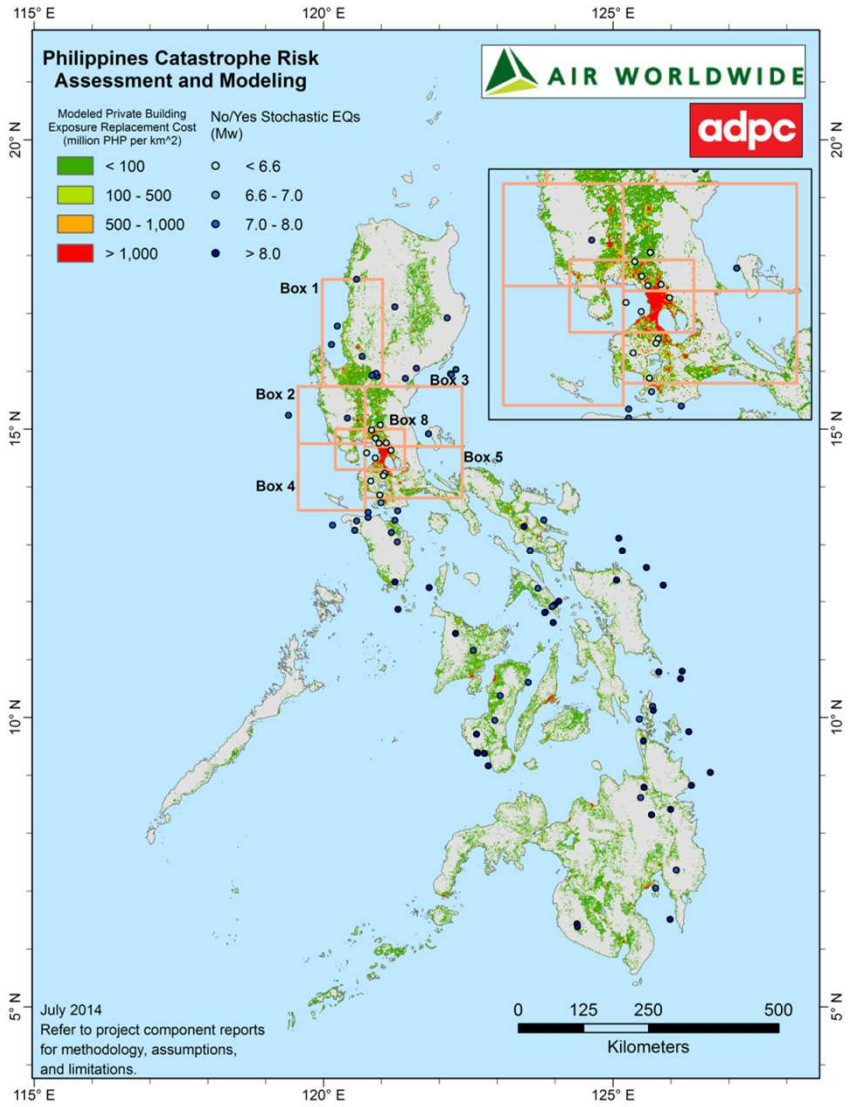
Stochastic Events: Yes Triggering and EP ≤ 3.0% (Yes/Yes)



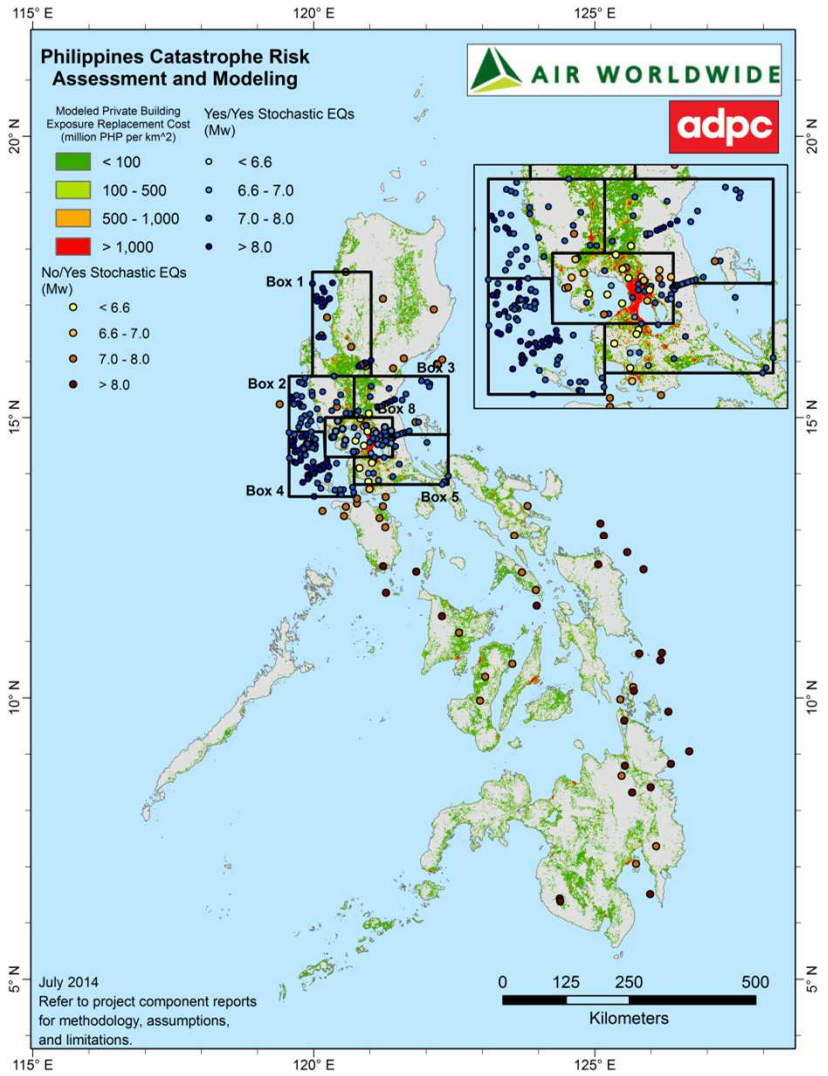
Stochastic Events: Yes Triggering and EP > 3.0% (Yes/No)



Stochastic Events: Not Triggering and EP ≤ 3.0% (No/Yes)



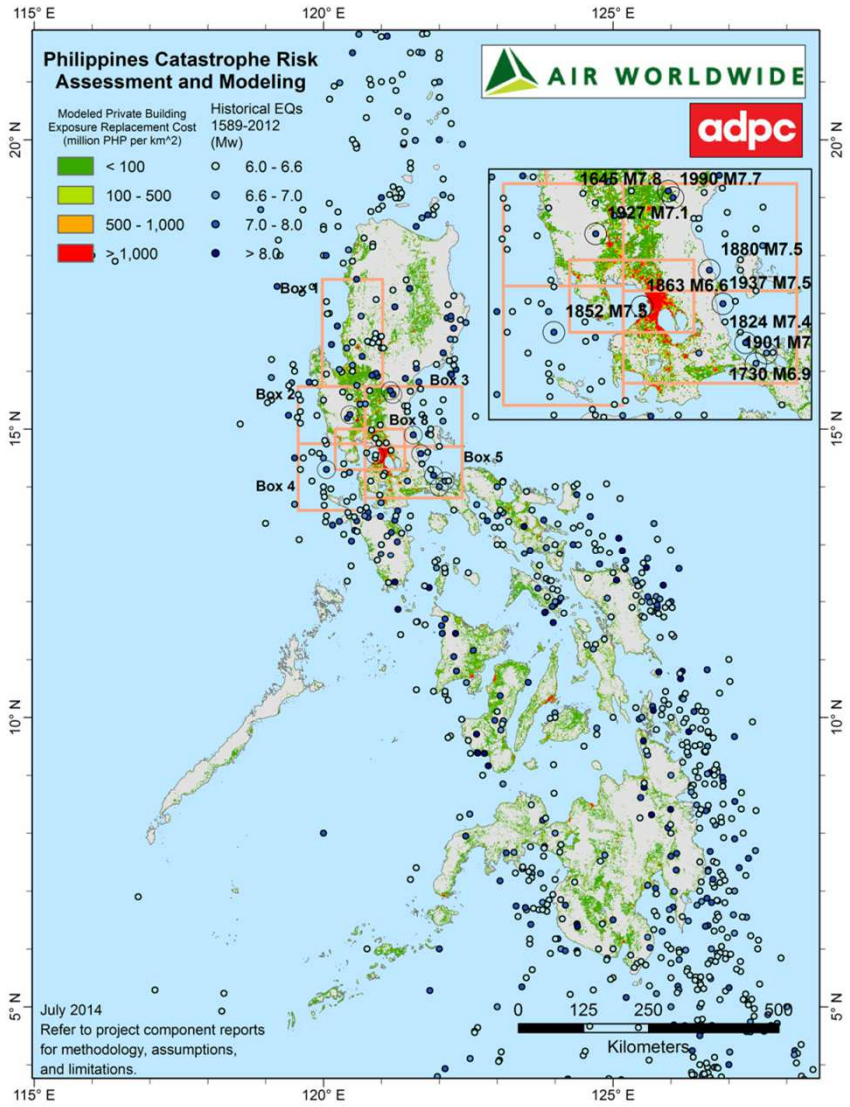
Stochastic Events: EP ≤ 3.0% (Yes/Yes + No/Yes)



Overlaid with historical events from a 424 year catalog (1589 – 2012)

- Earthquake structure would have triggered 10 times:
  - 1645 M7.8
  - 1730 M6.9
  - 1824 M7.4
  - 1852 M7.5
  - 1863 M6.6
  - 1880 M7.5
  - 1901 M7.0
  - 1927 M7.1
  - 1937 M7.5
  - 1990 M7.7 (1990 Luzon earthquake)
- Triggering probability = 2.4%
- Events prior to ≈1900 are non-instrumented and have higher parameter uncertainty
  - Triggering probability over last 100 years = 3%

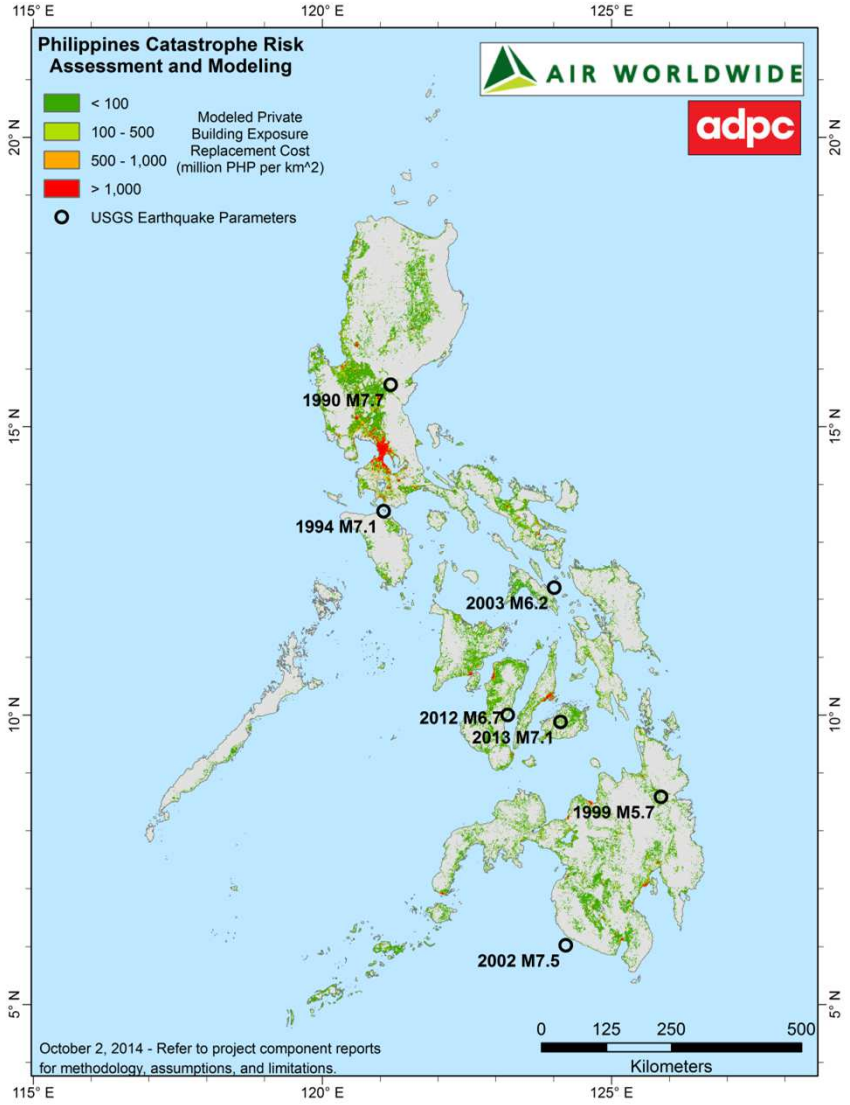
Triggering Historical Events (1589-2012)



Select Historical Earthquake Events

Earthquake Name	Year	PELC Process Emergency Loss (million PHP)
1990 July 16 M7.7 Luzon	1990	54,272.0
1994 November 15 M7.1 Mindoro	1994	18,821.7
1999 June 7 M5.7 Bayugan	1999	109.4
2002 March 6 M7.5 Palimbang	2002	4,083.1
2003 February 15 M6.2 Masbate	2003	237.9
2012 February 6 M6.7 Negros Oriental	2012	4,808.9
2013 October 15 M7.1 Bohol/Cebu	2013	13,011.2

Select Historical Earthquake Events



Tropical Cyclone

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Parametric Structure Generation

A multitude of candidate parametric structures have been analyzed, only one of which is presented in the following slides.

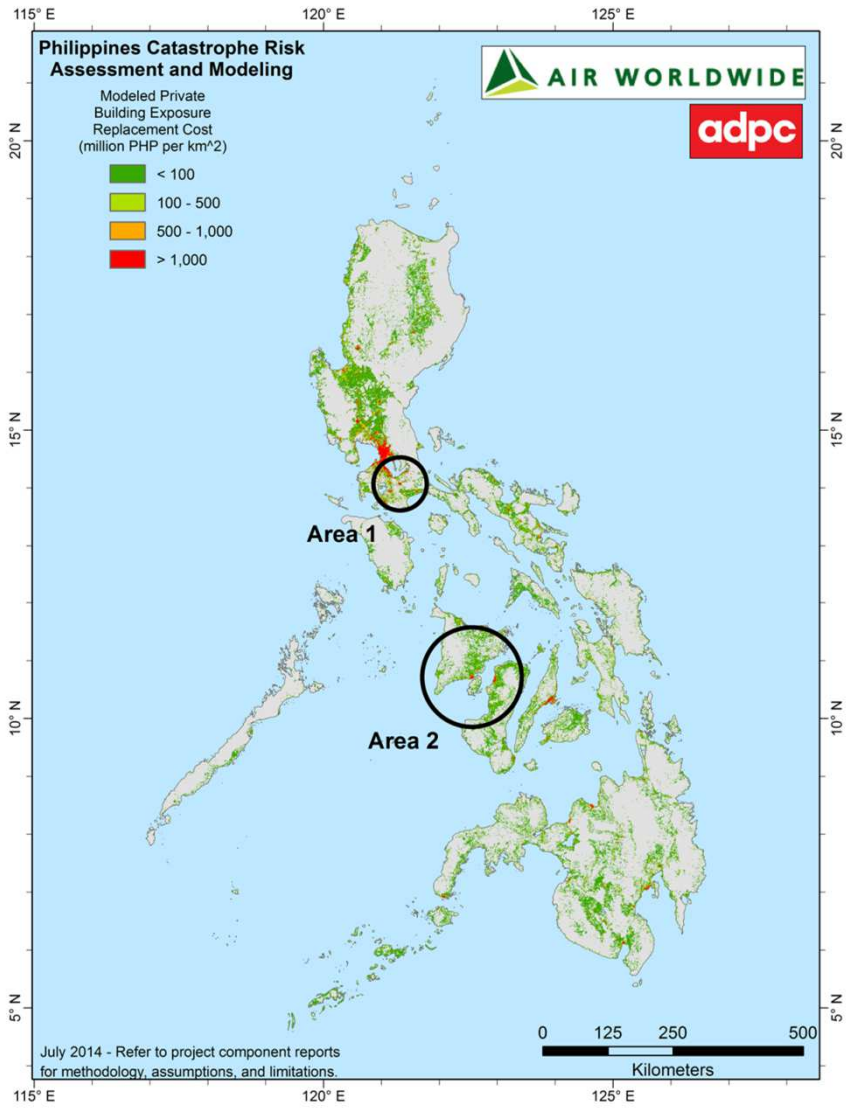
In general, the Tropical Cyclone risk in the Philippines has been difficult to define parametrically due to several factors.

1. A much higher storm frequency
2. No clear, unambiguous definition of landfall
3. Exposure concentrations, among other factors

Tropical Cyclone Structure Characteristics

Area	Longitude	Latitude	Radius (km)	Central Pressure Threshold (mb)
Area 1	121.321628	14.070326	51	942
Area 2	122.562746	10.715455	95	942

Tropical Cyclone Structure Characteristics



Basis Risk – Tropical Cyclone

Tropical Cyclone Structure – Number of Years				
		Modeled Loss		
		≤ 3.0% EP	> 3.0% EP	**Total**
Parametric Trigger	Yes	95	246	**341**
	No	205	9,454	**9,659**
	Total	**300**	**9,700**	**10,000**

Basis Risk = 246/341 ≈ 72%

Triggering Probability = 3.41%

Structure Characteristics

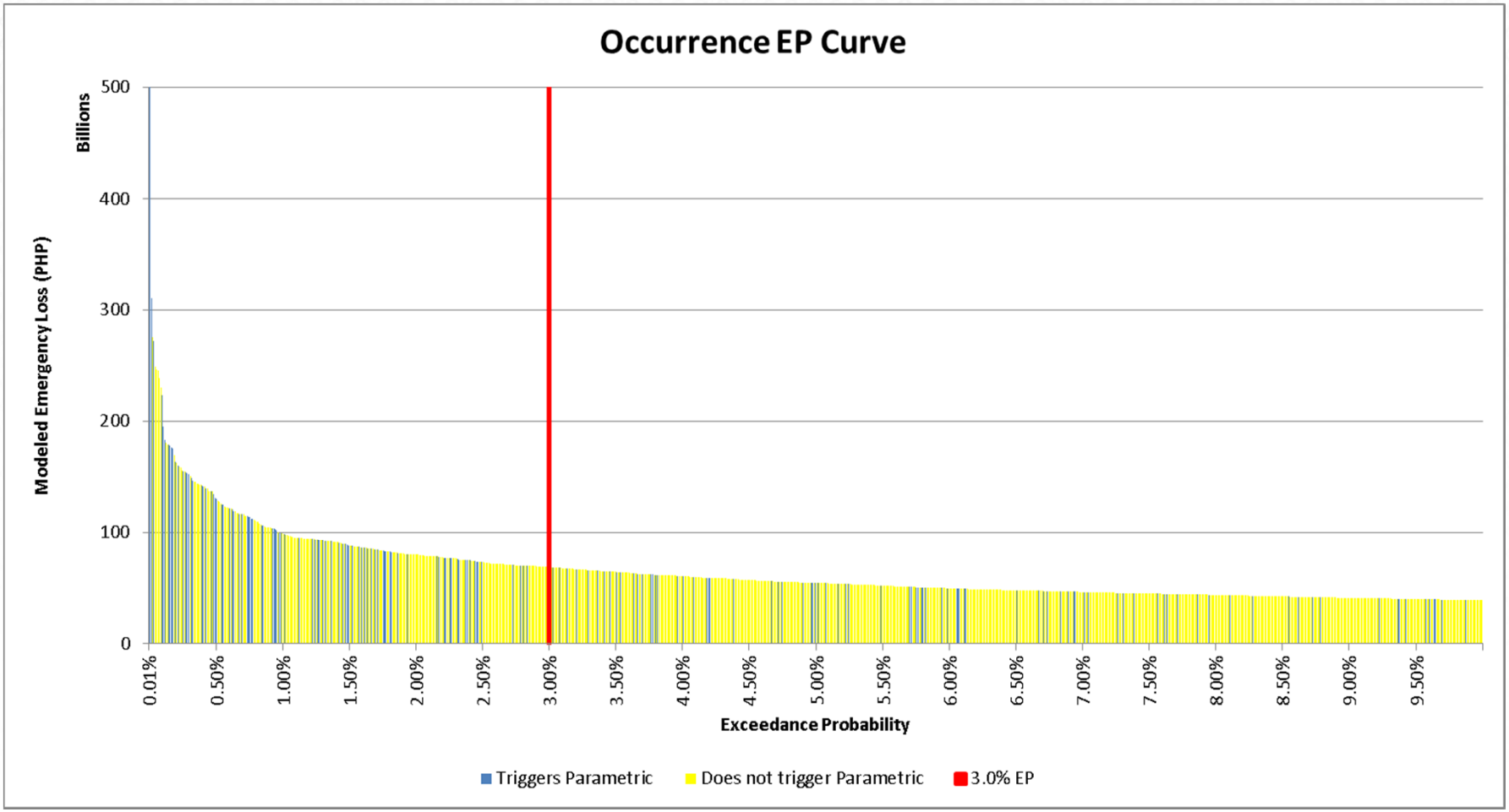
SSHS Category	% Loss Contribution (Parametric)	% Loss Contribution (Modeled)
Cat 1	0.0%	0.0%
Cat 2	1.7%	0.0%
Cat 3	17.4%	0.0%
Cat 4	31.0%	30.5%
Cat 5	49.9%	69.5%

Structure Characteristics

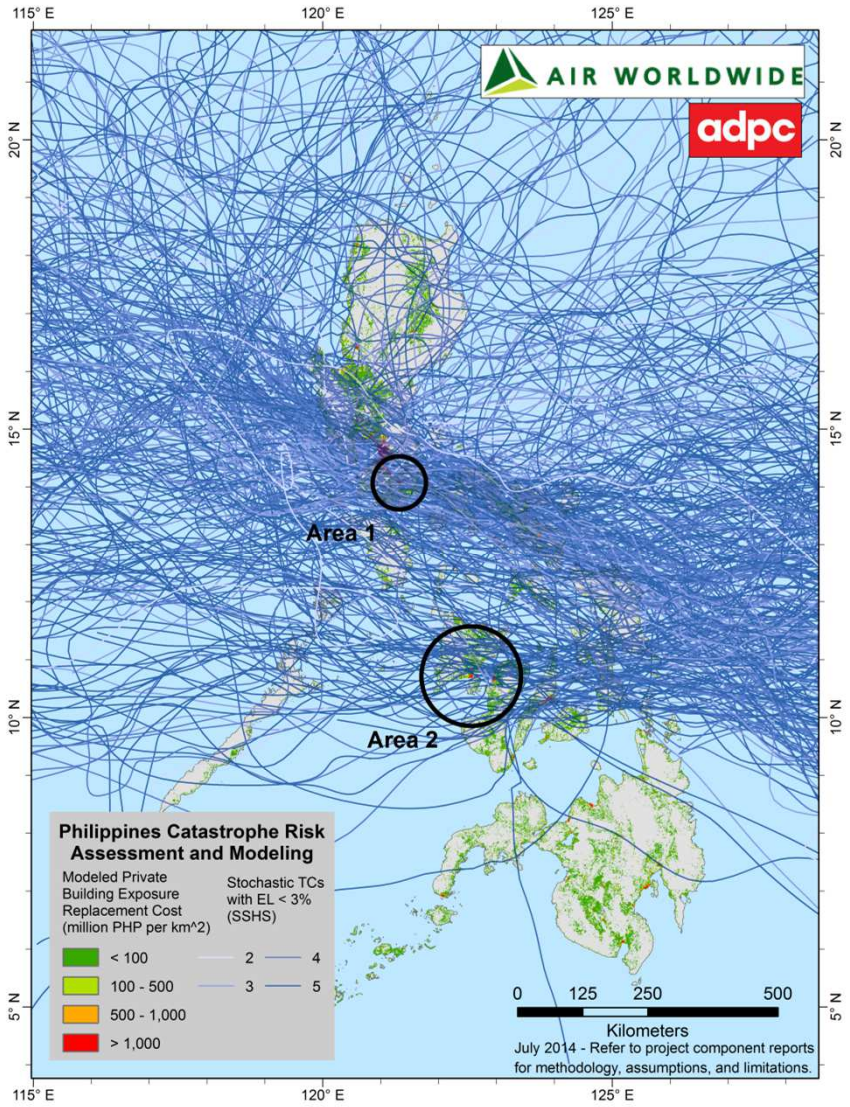
	First 1% EP		First 2% EP		First 3% EP		First 4% EP	
SSHS Category	Number of Events	Emergency Loss (PHP Billion)	Number of Events	Emergency Loss (PHP Billion)	Number of Events	Emergency Loss (PHP Billion)	Number of Events	Emergency Loss (PHP Billion)
Cat1	0	0	0	0	0	0	0	0
Cat2	1	122	3	294	6	519	12	907
Cat3	17	2,435	35	4,017	55	5,469	84	7,329
Cat4	25	3,659	60	6,731	101	9,722	133	11,753
Cat5	57	8,454	102	12,480	138	15,138	171	17,240
Total	100	14,670	200	23,521	300	30,849	400	37,229

Overall Distribution in Catalog (Latitude: 5 to 19; Longitude: 119 to 127)		
SSHS Category	Number of Events	% of Total
Cat1	53,809	56.8%
Cat2	16,599	17.5%
Cat3	13,965	14.7%
Cat4	7,351	7.8%
Cat5	3,085	3.3%
Total	94,809	100.0%

Occurrence EP Curve

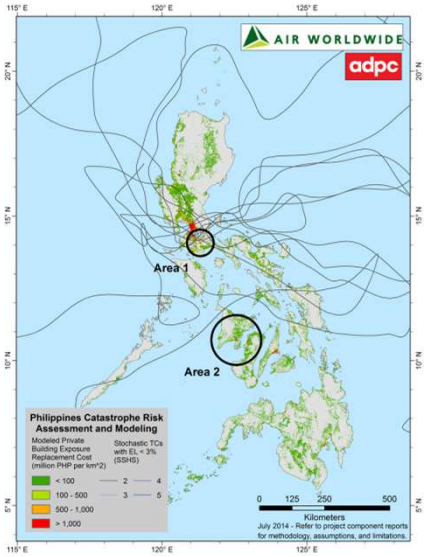


All Stochastic Events with EP ≤ 3.0%

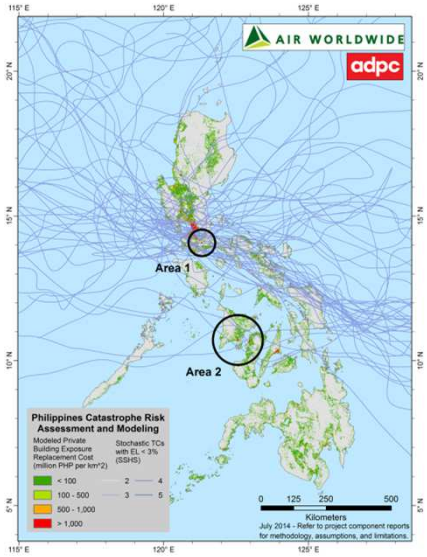


Stochastic Events with EP ≤ 3.0% (by SSHS)

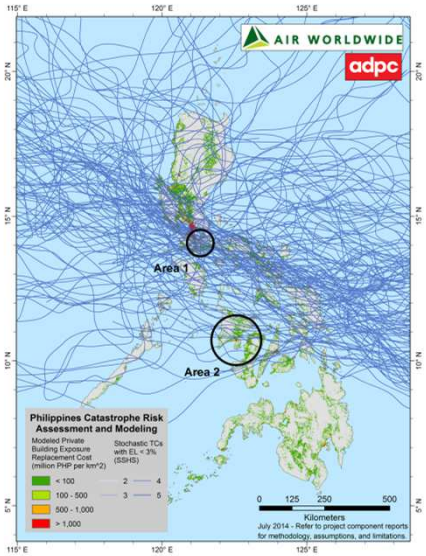
Cat 2



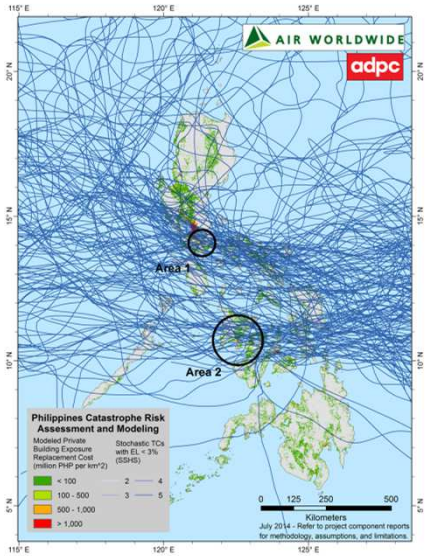
Cat 3



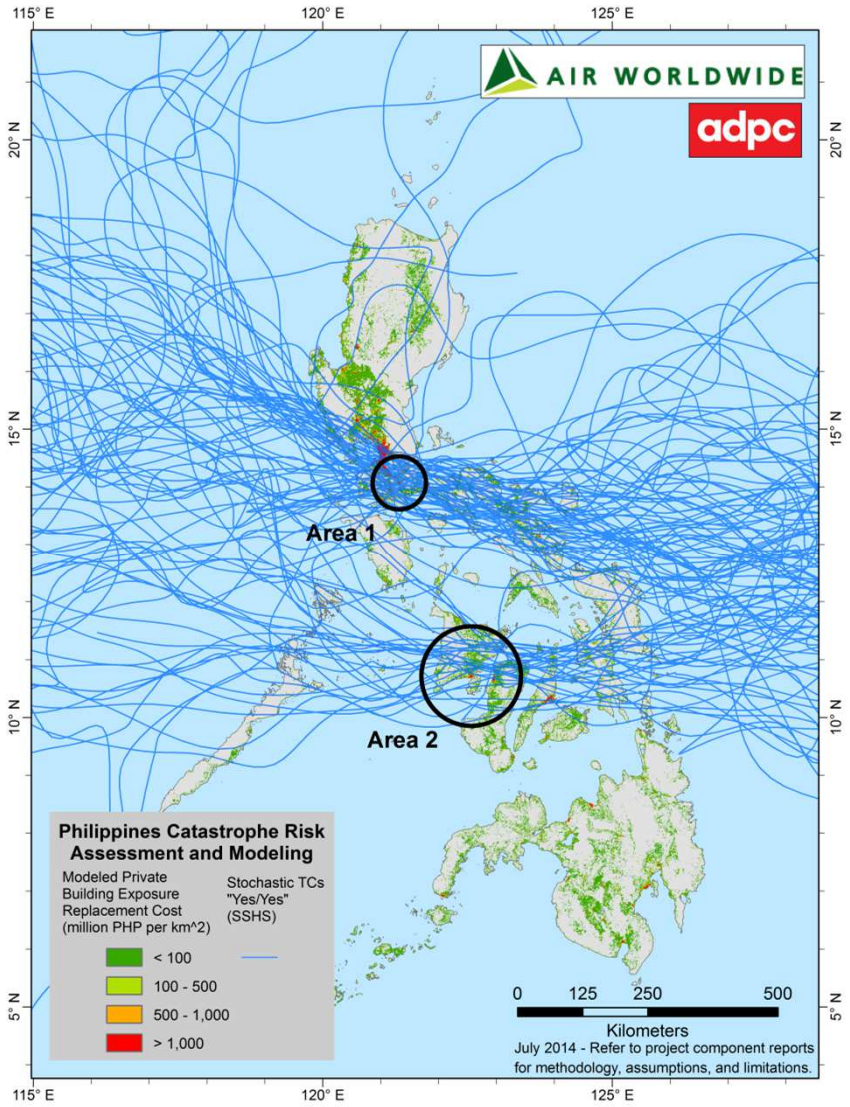
Cat 4



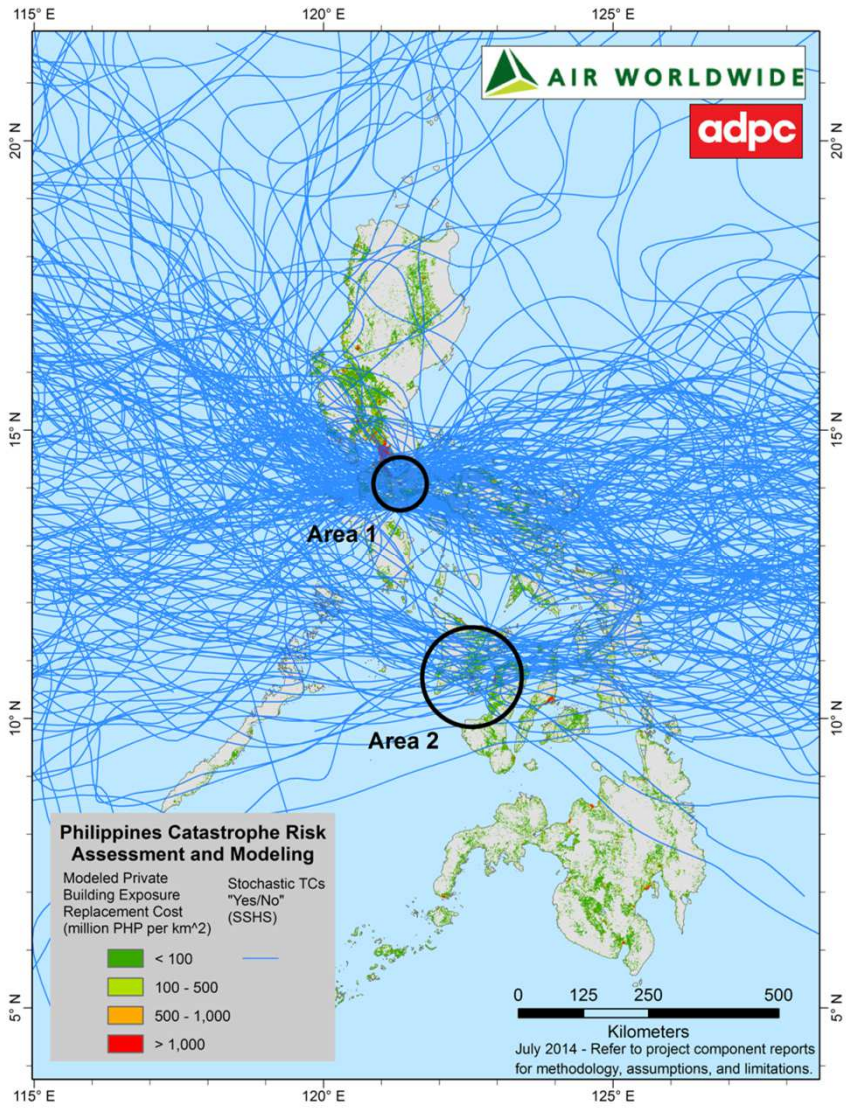
Cat 5



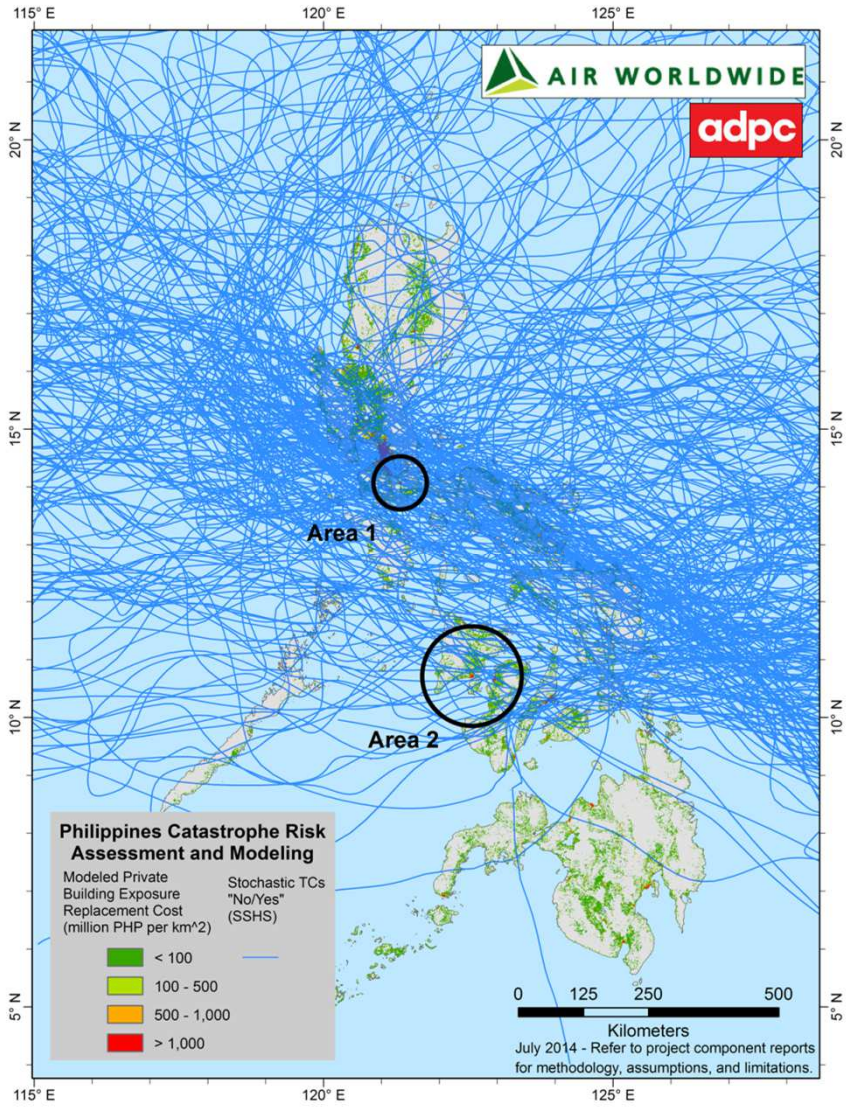
Stochastic Events: Yes Triggering and EP ≤ 3.0% (Yes/Yes)



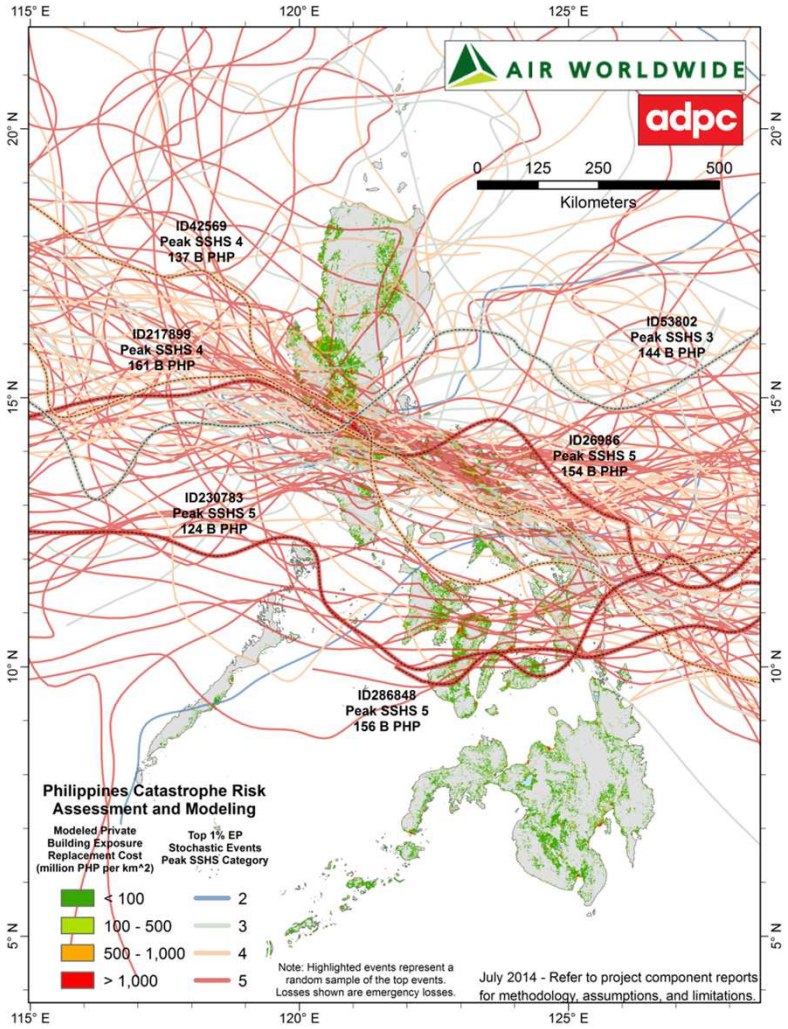
Stochastic Events: Yes Triggering and EP > 3.0% (Yes/No)



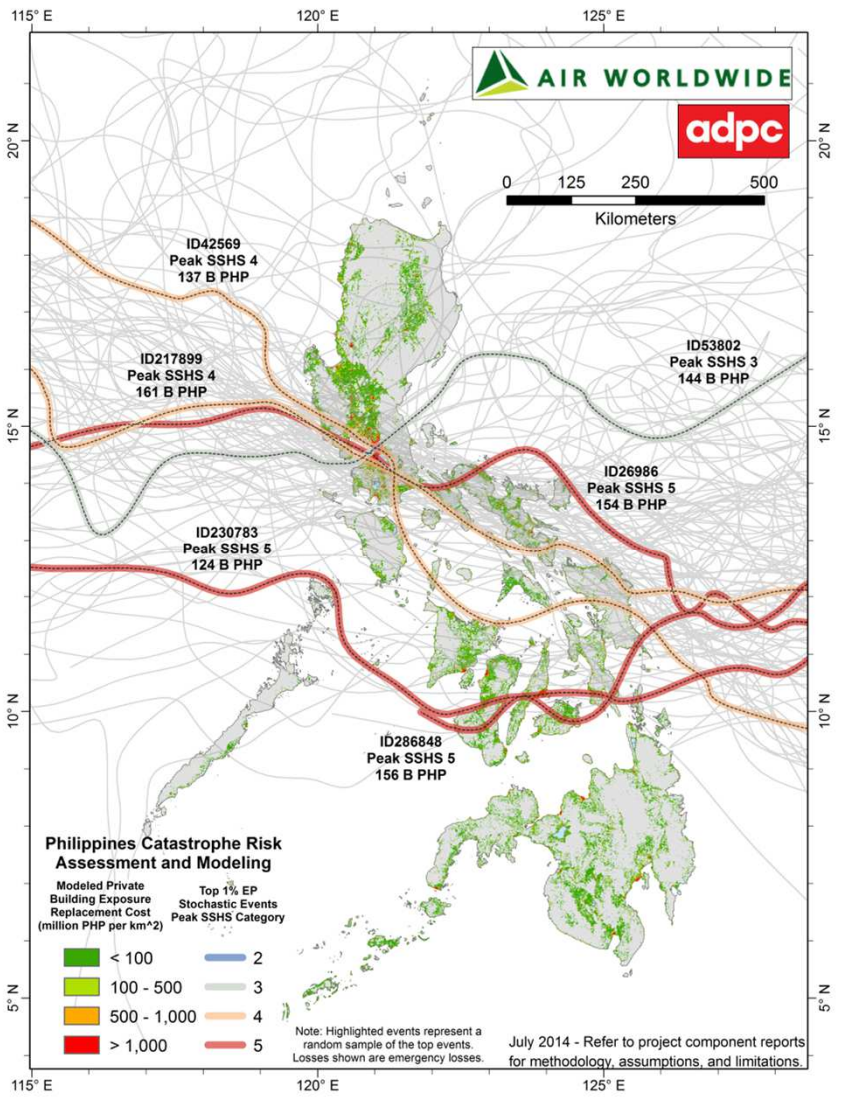
Stochastic Events: Not Triggering and EP ≤ 3.0% (No/Yes)



Stochastic Events: EP ≤ 1.0%



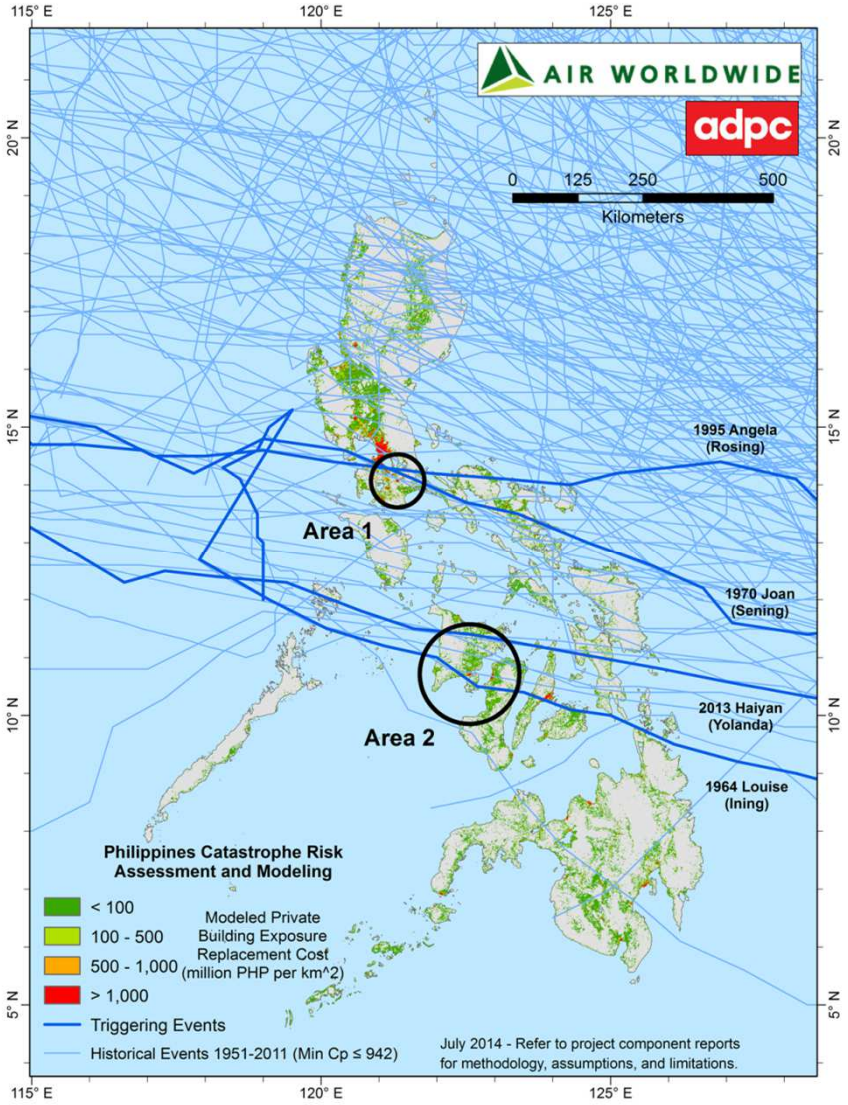
Select Stochastic Events: EP ≤ 1.0%



Overlaid with historical events from 63 year catalog (1951-2013)

- Tropical cyclone parametric structure would have triggered 4 times:
  - 1964 Louise (Ining)
  - 1970 Joan (Sening)
  - 1995 Angela (Rosing)
  - 2013 Haiyan (Yolanda)
- Triggering probability = 6.3%

Triggering Historical Events (1951-2013)



Modeled Loss Structures

Potential Modeled Loss Structures

	Binary Payout	Stepped Payout A	Traditional Modeled Loss Payout
Attachment Point (Billion PHP)	68.49 (3.0% EP)	59.57 (4.0% EP)	53.78 (5.0% EP)
Exhaustion Point (Billion PHP)	None	None	85.3 (1.65% EP)
Payout	100% of Principal for events with modeled loss above attachment	50% of Principal for events with modeled loss between 59.57 B PHP (4.0% EP) and 80.20 B PHP (2.0% EP); 100% of Principal for events with modeled loss greater than 80.20 B PHP	Percentage of Principal equal to $\frac{Modeled\ Loss\ -Attachment}{Exhaustion\ -Attachment}$ Capped at 100%
Expected Loss	3.0%	3.0%	3.0%

Stepped Payout Structure B

- **100% Coverage Limit = USD 200 million**

	Exceedance Probability	Modeled Emergency Loss (PHP)	Expected Payout (USD)
Step 1	4.50%	56,114,598,479	66,666,667
Step 2	3.00%	68,490,368,271	133,333,333
Step 3	1.50%	87,871,531,408	200,000,000

- 33.3% of principal for modeled loss between 56.1B (4.5% EP) and 68.5B (3.0% EP)
- 66.7% of principal for modeled loss between 68.5B (3.0% EP) and 87.9B (1.5% EP)
- 100% of principal loss for modeled loss greater than 87.9B (1.5% EP)

Stepped Payout Structure B

Risk Metric	
Attachment Probability	4.50%
Expected Loss	3.02%
Exhaustion Probability	1.56%

SS Category	Contribution to Loss
CAT 1	0.0%
CAT 2	2.0%
CAT 3	16.4%
CAT 4	34.5%
CAT 5	47.1%

Stepped Payout Structure C

- **100% Coverage Limit = USD 200 million**

	Exceedance Probability	Modeled Emergency Loss (PHP)	Expected Payout (USD)
Step 1	5.00%	53,780,302,939	66,666,667
Step 2	3.00%	68,490,368,271	133,333,333
Step 3	1.00%	99,515,662,138	200,000,000

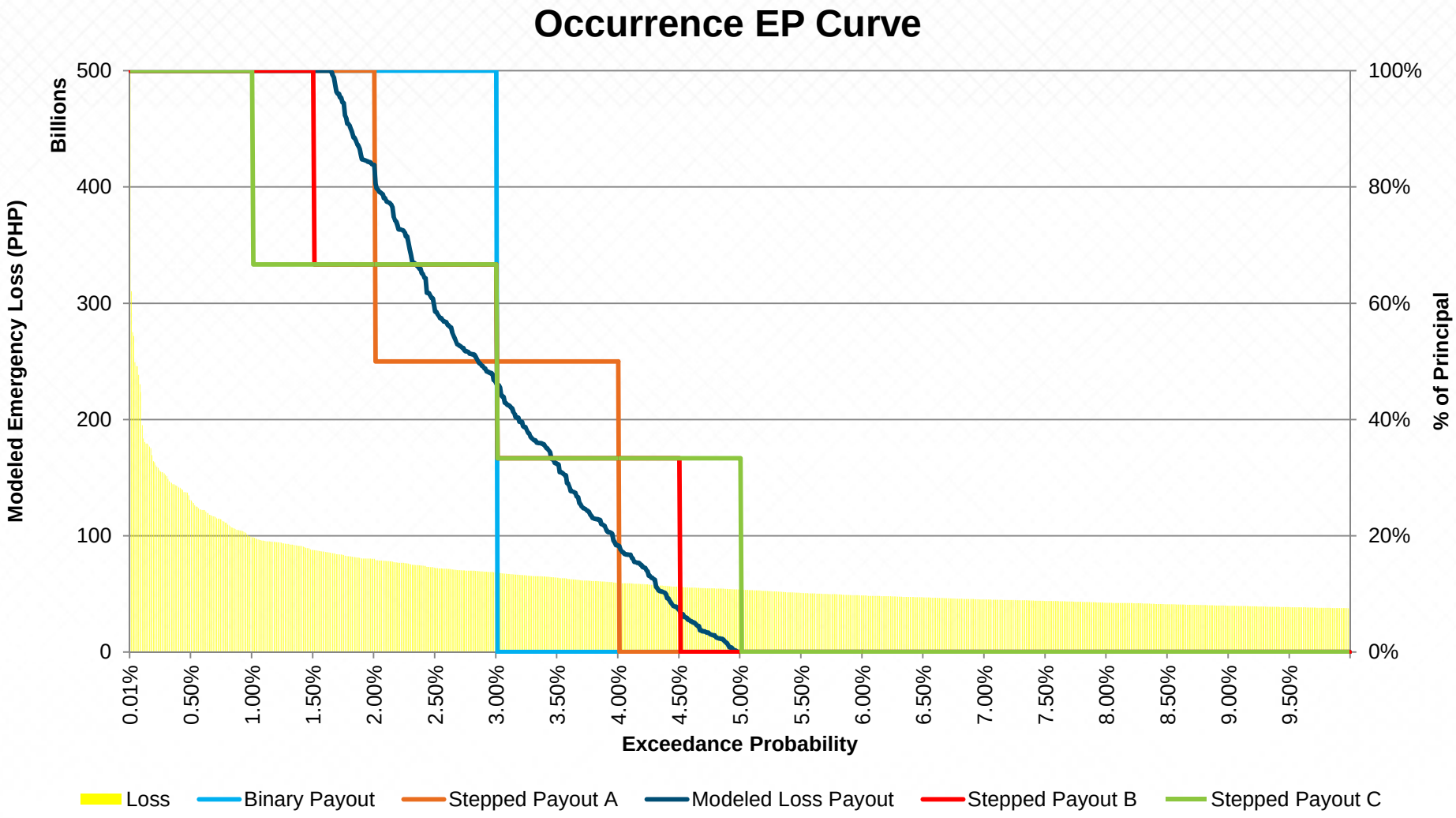
- 33.3% of principal for modeled loss between 53.8B (5.0% EP) and 68.5B (3.0% EP)
- 66.7% of principal for modeled loss between 68.5B (3.0% EP) and 99.5B (1.0% EP)
- 100% of principal loss for modeled loss greater than 99.5B (1.0% EP)

Stepped Payout Structure C

Risk Metric	
Attachment Probability	5.00%
Expected Loss	3.04%
Exhaustion Probability	1.10%

SS Category	Contribution to Loss
CAT 1	0.0%
CAT 2	2.2%
CAT 3	17.4%
CAT 4	34.5%
CAT 5	45.9%

Payout Percentages Compared to Modeled Loss



Stepped Payout Structure D

- **100% Coverage Limit = USD 200 million**

	Exceedance Probability	Modeled Emergency Loss (PHP)	Expected Payout (USD)
Step 1	4.00%	59,570,810,854	100,000,000
Step 2	3.00%	68,490,368,271	150,000,000
Step 3	1.00%	99,515,662,138	200,000,000

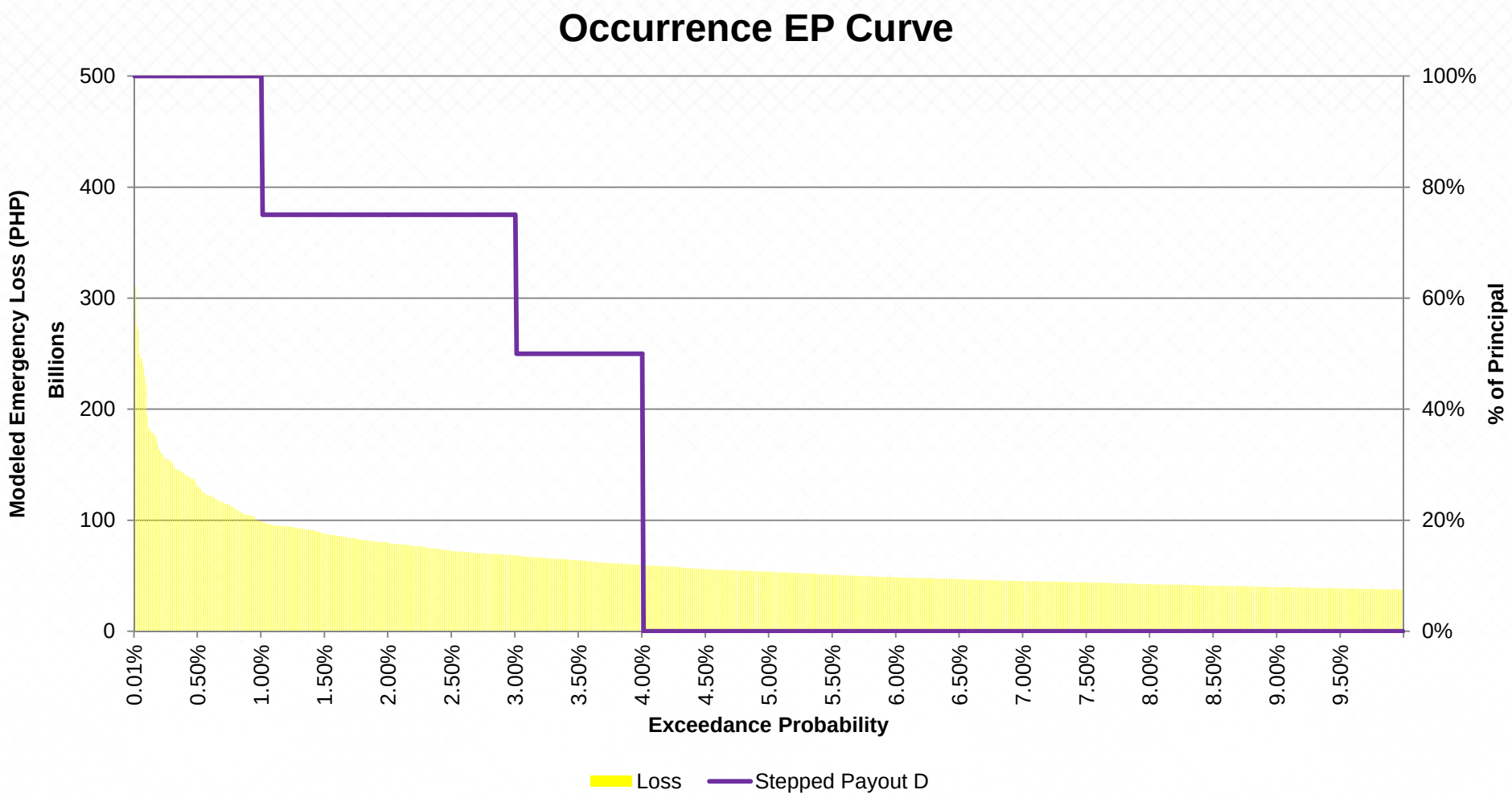
- 50% of principal for modeled loss between 59.6B (5.0% EP) and 68.5B (3.0% EP)
- 75% of principal for modeled loss between 68.5B (3.0% EP) and 99.5B (1.0% EP)
- 100% of principal loss for modeled loss greater than 99.5B (1.0% EP)

Stepped Payout Structure D

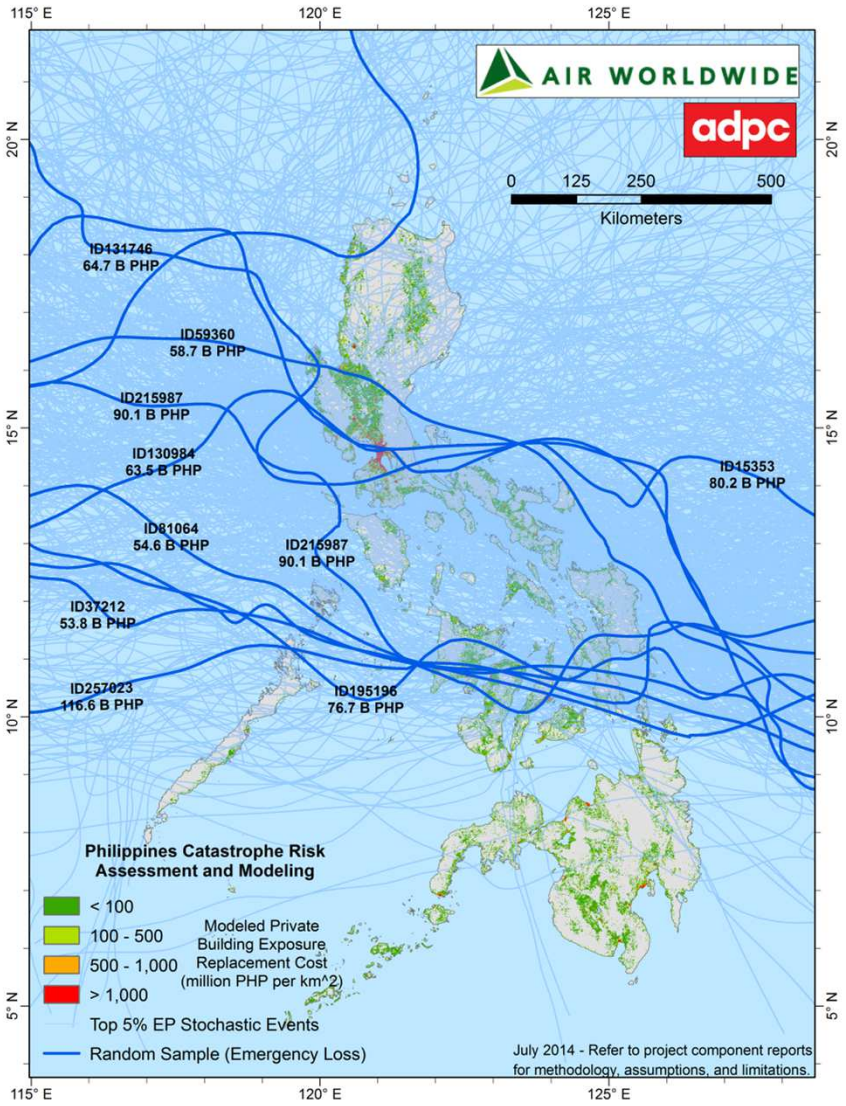
Risk Metric	
Attachment Probability	4.00%
Expected Loss	3.02%
Exhaustion Probability	1.06%

SS Category	Contribution to Loss
CAT 1	0.0%
CAT 2	2.2%
CAT 3	16.9%
CAT 4	34.0%
CAT 5	46.9%

Stepped Payout Structure D



Sample Stochastic Paths in top 5% of EP Curve



Select Historical Cyclone Events

Cyclone Name	Year	PELC Process Emergency Loss (million PHP)	Historical Catalog Emergency Loss (million PHP)
Mike	1990	39,019.5	42,419.1
Fengshen	2008	44,695.2	10,266.1
Ketsana	2009	1,234.8	1,857.0
Parma	2009	3,311.5	4,282.8
Megi*	2010	30,022.7	-
Bopha	2012	5,322.3	3,080.1
Haiyan	2013	70,242.8	70,072.2
Rammasun	2014	63,077.0	52,725.9

***** Modeled Emergency Loss for Megi not produced since event parameters were not available at the time of the model release

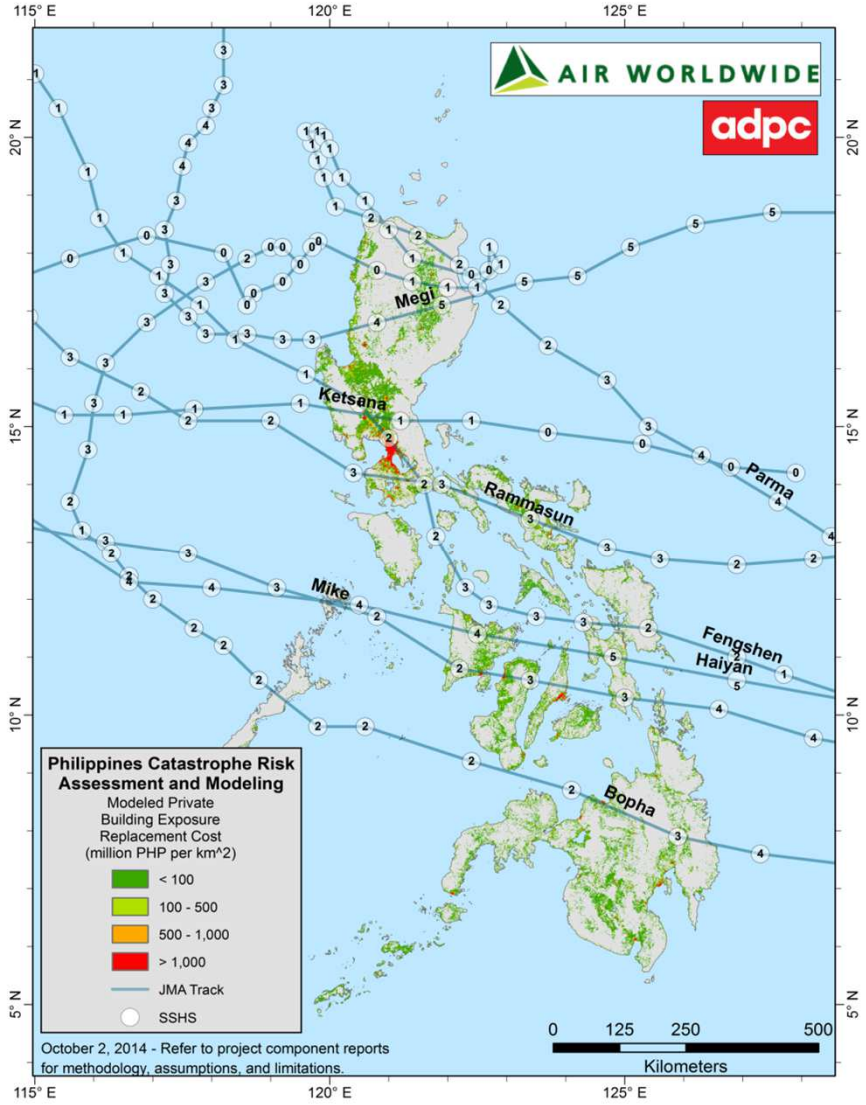
Select Historical Events by LOB

Cyclone Name	Year	Modeled Loss (Millions PHP)		
		Residential	Commercial and Industrial	Government Assets
Mike	1990	154,487.5	19,668.5	10,274.9
Fengshen	2008	39,993.0	3,405.2	1,236.8
Parma	2009	16,342.4	1,150.2	1,128.4
Ketsana	2009	7,071.9	815.7	186.3
Megi	2010	-	-	-
Bopha	2012	12,132.7	932.3	326.8
Haiyan	2013	257,700.0	24,681.9	22,279.7
Rammasun	2014	185,013.2	38,013.2	6,216.8

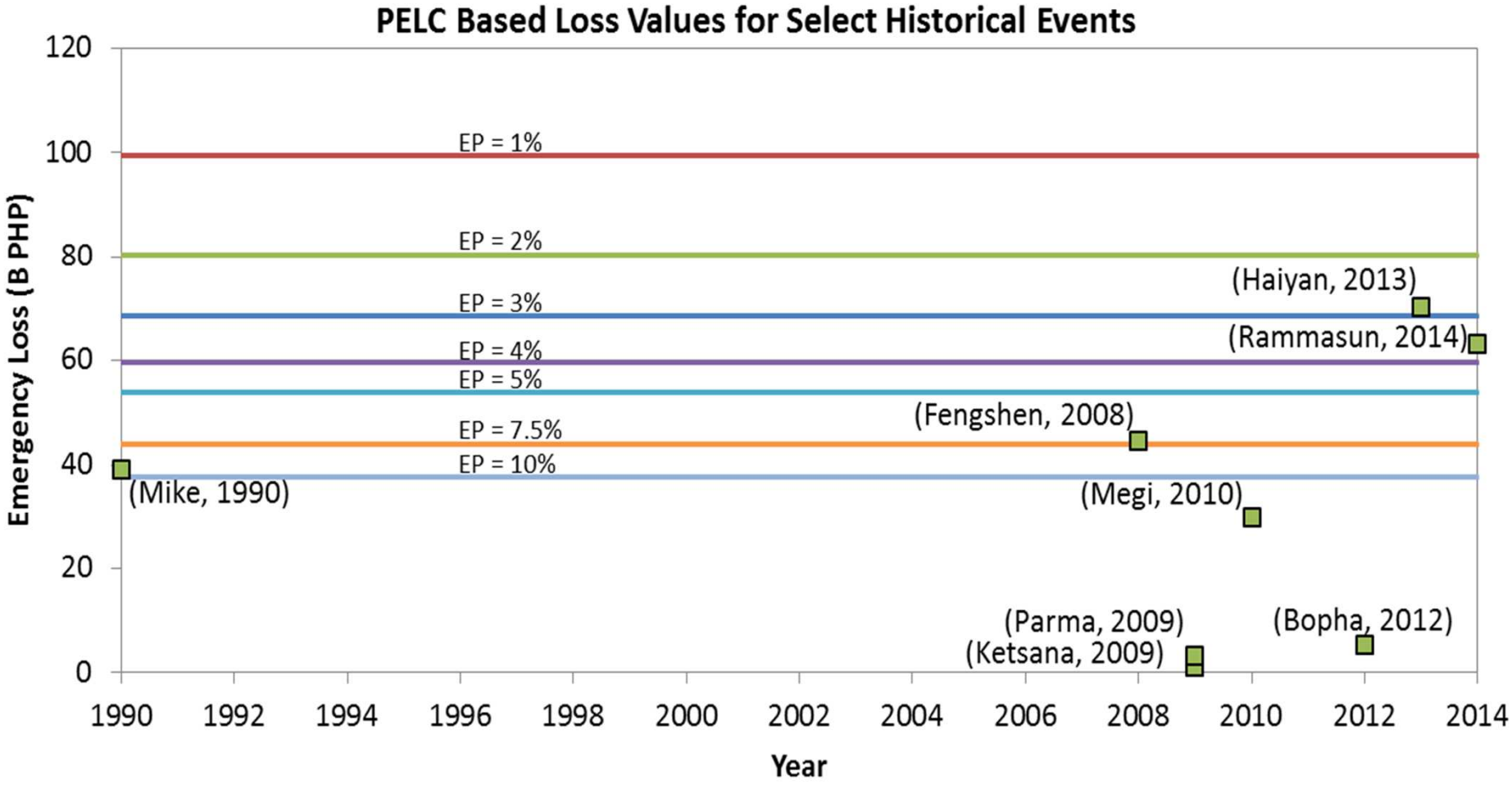
Select Historical Events: PELC Process by LOB

Cyclone Name	Year	Modeled Loss (Millions PHP)		
		Residential	Commercial and Industrial	Government Assets
Mike	1990	140,830.4	20,058.2	8,761.6
Fengshen	2008	167,826.1	21,301.8	5,199.2
Parma	2009	12,726.1	845.0	826.6
Ketsana	2009	4,607.9	617.4	143.5
Megi	2010	116,390.8	9,592.6	4,550.0
Bopha	2012	21,196.3	1,455.7	488.6
Haiyan	2013	260,334.1	22,573.6	22,495.8
Rammasun	2014	224,918.4	41,221.0	8,108.5

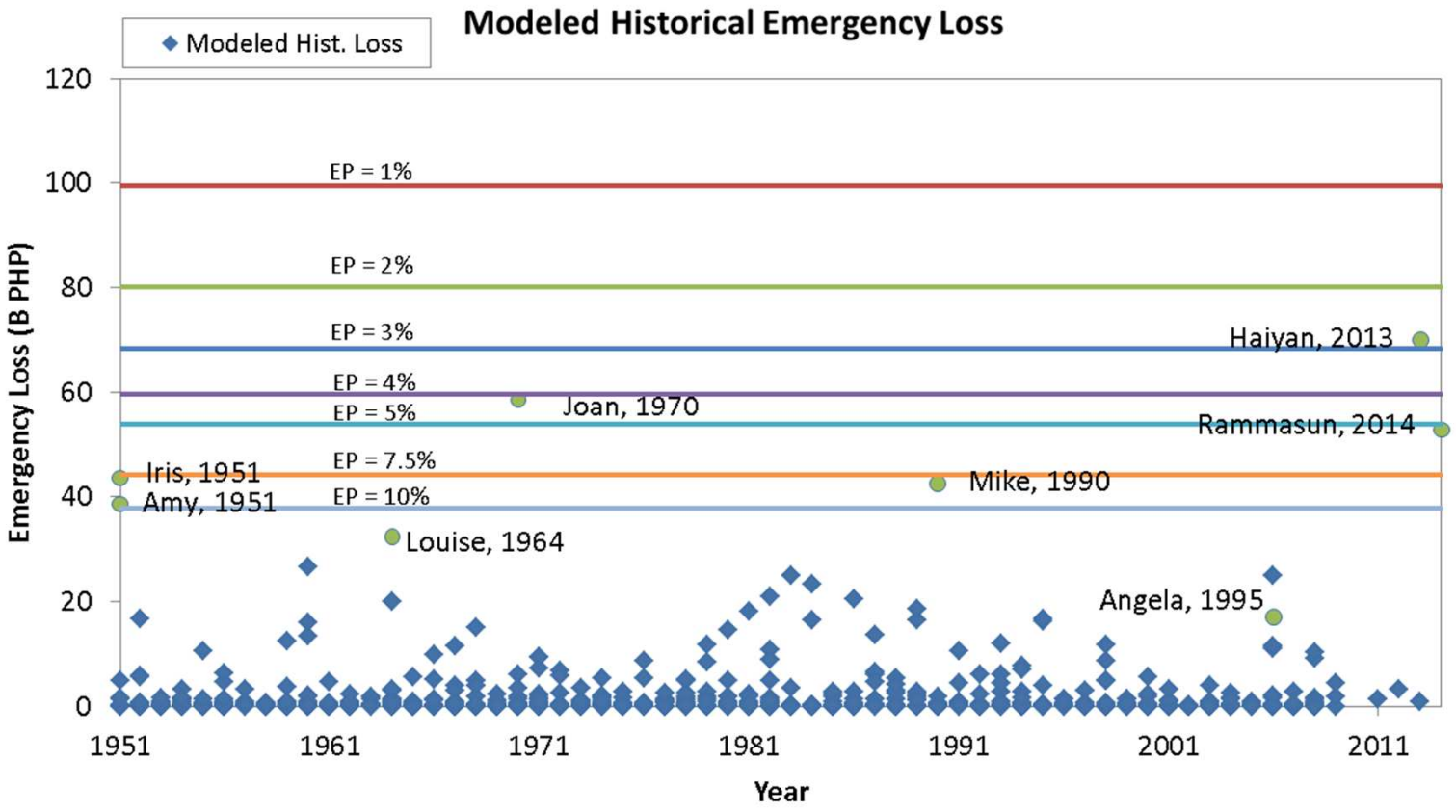
Select Historical Cyclone Events



Select Historical Cyclone Events



Modeled Historical Emergency Loss 1951-2014



AIR Tropical Cyclone Model

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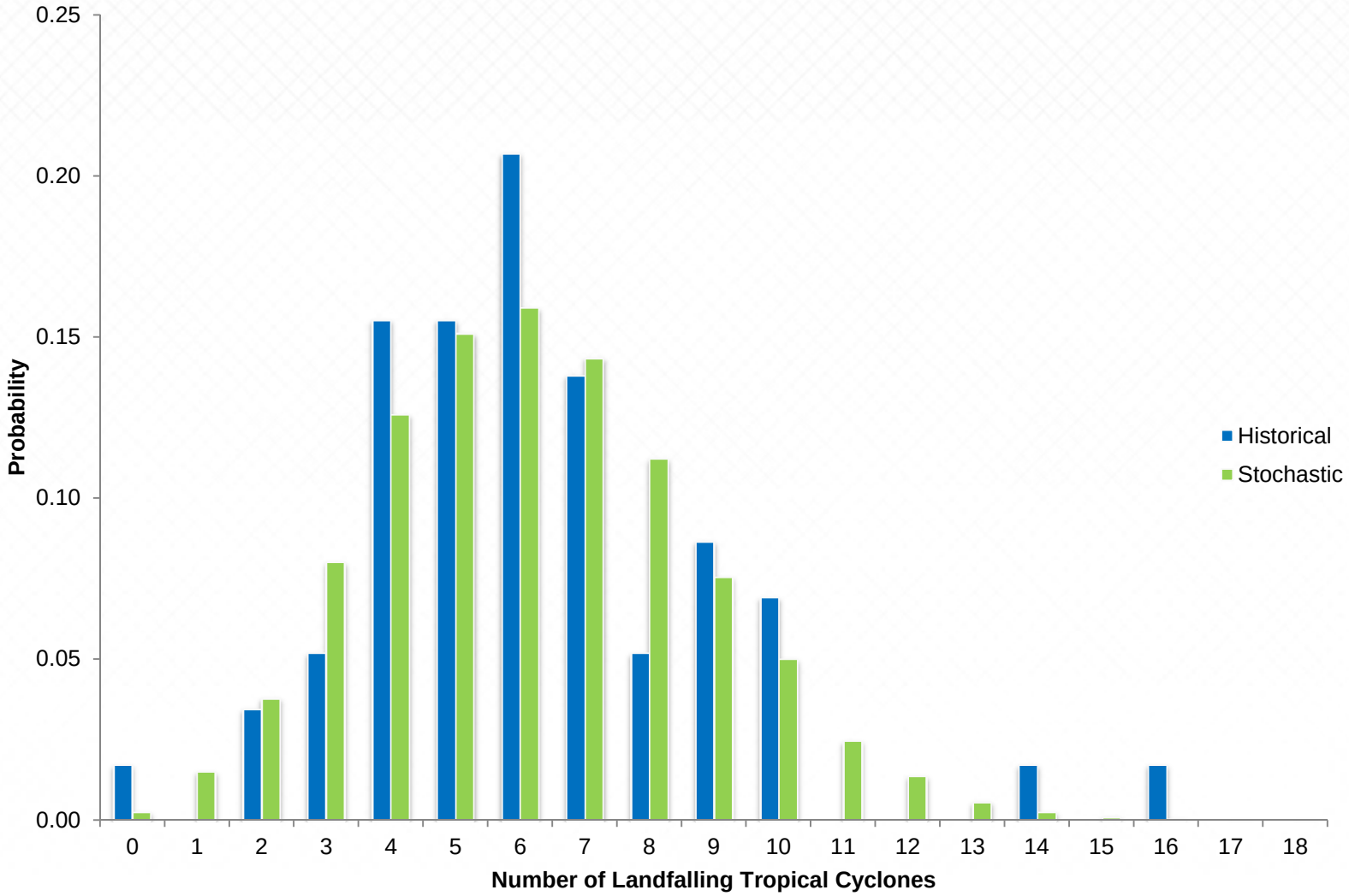
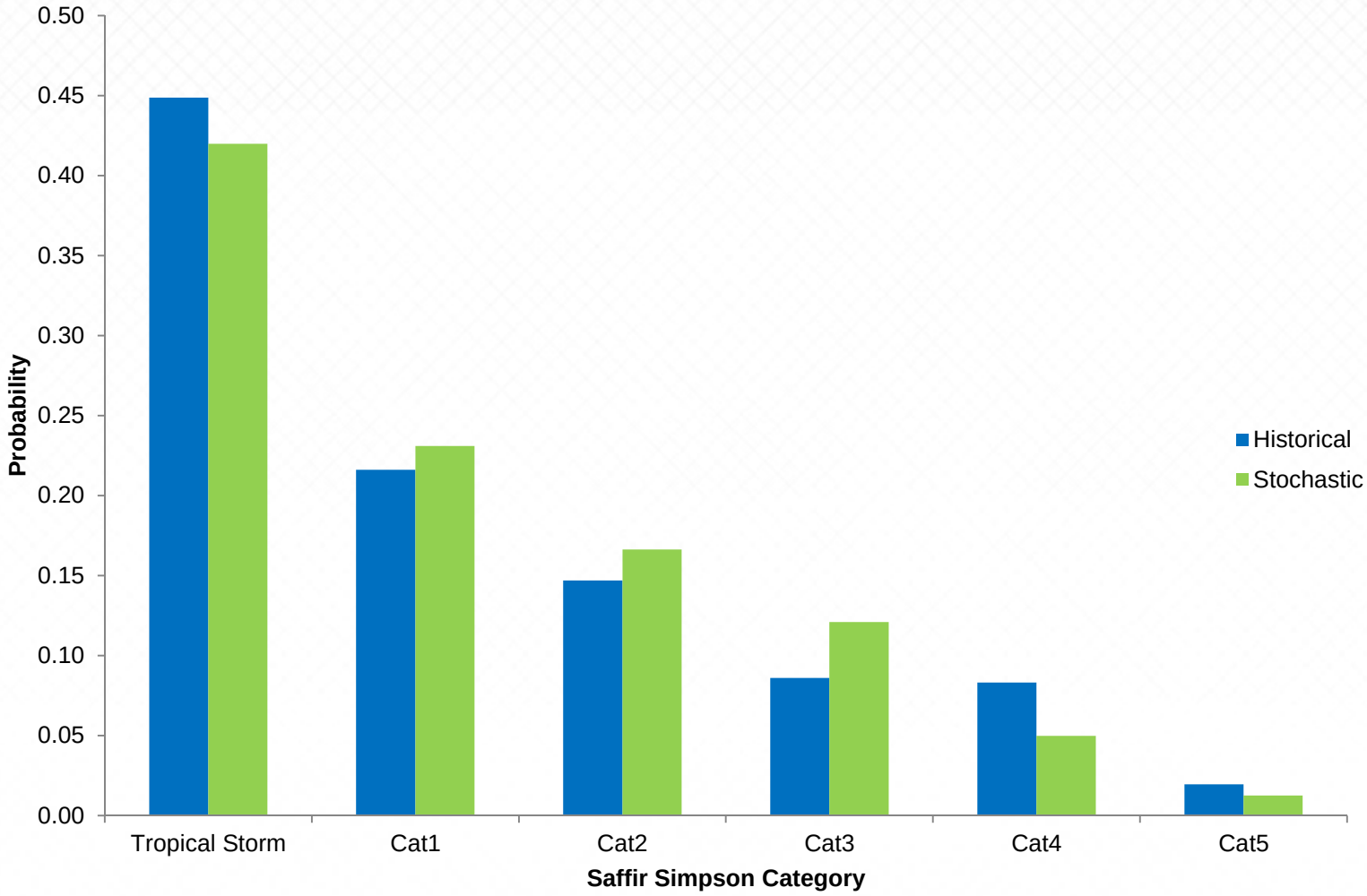
Tropical Cyclone Frequency – Stochastic vs Historical



Tropical Cyclone Intensity – Stochastic vs Historical



***If an event has multiple landfalls, we select the intensity of the first landfall**

Appendix - Questions

Questions – Reset Mechanism

Q. With regards to the Reset Mechanism, does AIR anticipate using the Escrow model or the latest available model?

A. Since a model was developed specifically for this transaction, and there will be significant model update in the 2015/2016 timeframe, an escrowed model may be more favorable.

Q. Could exposure be updated during a Reset?

A. Additional exposure can be provided to help more closely match modeled loss with reality for any events that occur in future risk periods. The attachment and exhaustion amounts would be recalculated so that the risk profile would stay the same with the updated notional exposure. The updated exposure would also be used for any PELC processes going forward.

Q. For the Earthquake parametric structure, as part of the Reset Mechanism, would the Philippines Department of Finance be allowed to modify the risk profile? How would this affect the coupon payment?

A. If allowed to float, the risk profile would be updated at reset according to any new modeling results and the following coupon is usually adjusted via a specified sliding scale of some sort. If not allowed to float, the parametric structure (in part or in whole) is modified to keep the same risk profile under the new model. However, an escrowed model would make this a non-question as these metrics would remain the same under the new model.

Questions – General Model

Q. AIR has used a factor of 23% to translate Gross Loss to Emergency Loss. Is this factor consistent for Residential, Commercial and Governmental Assets?

A. The same 23% factor is applied to the modeled losses from all three types of exposure.

Q. AIR mentions there will be a significant model update in 2015/2016. How significant will the targeted model update actually be and what changes can we expect in terms of perils and return periods?

A. The model update for the 2015-2016 timeframe refers to our commercially available software. We are planning to incorporate the updates made for this more bespoke Philippines model as part of the larger update to our South East Asia Model. There are still additional updates that are being considered such as whether or not storm surge will be included. However the entire scope of updates is still not completely determined. Because these updates are still under development, it is not possible for us to comment on expected impacts on return periods at this time.

Q. Can AIR specify when in 2015/2016 they are actually planning to launch the update?

A. The timing for the update is currently no earlier than January 1, 2016.

Questions – Post Event Loss Calculation (PELC)

Q. What is the data source and fall back data source to be used in the Post Event Loss Calculation (PELC)?

A.

Data Type	Primary Reporting Agency	Back-Up Reporting Agency
Earthquake	United States Geological Survey (USGS)	Global Centroid-Moment-Tensor (CMT) Project
Typhoon (Location and Intensity)	Japan Meteorological Agency (JMA)	Joint Typhoon Warning Center (JTWC)
Typhoon (Precipitation)	Tropical Rainfall Measurement Mission (TRMM)	Default Modeled Average

Q. In the unlikely event that the primary and back-up reporting agency is unable to provide the data, can AIR clarify which additional data sources would be available for the Philippines?

A. In general, the PELC currently states a primary, secondary and/or model provided/ generated defaults. We feel that this is an adequate chain of contingencies to perform the PELC. Additionally, we also provide locations for obtaining the data as well as possible workarounds.

However, additional contingent data providers could be added to the process. Please note this will incur significant processing time for formatting, validations, and negotiating terms of use with said data providers.

Questions – Post Event Loss Calculation (contd.)

Q. In connection with the issue above, could we know the recommended default values, and how these default values would be calculated?

Parameter	Data Collection Time Interval	Primary Source	Back-Up Source
Location & Central Pressure (mb)	6-hourly storm track or higher	JMA (1)	JTWC (2)
Environmental Pressure (mb)	Once at 1st landfall	NCEP/NCAR: NNRP (3)(4)	Default (1008 mb) (4) (8)
Storm Wind Radii (km) (5)	6-hourly storm track or higher	JMA (1)	AIR Model (6)
Radius of Maximum Wind (km) (5)	6-hourly storm track or higher	Willoughby Algorithm using JMA Radii(6)	AIR Model (6)
Maximum Precipitation Rate (mm/hr)	Once at 1st landfall	TRMM (QA'd or near-real-time) (6)	Default (17.5 mm/hr) (8)
Precipitation Radius (km)	Once at 1st landfall	TRMM (QA'd or near-real-time) (7)	Default (320 km) (8)
Landfall Time and Location	Once at 1st landfall	JMA (1)	JTWC (2)

The latest Typhoon Event Parameters for the event of interest are searched and retrieved from the following sources:

- Japan Meteorological Agency (JMA) Track Data available at: http://agora.ex.nii.ac.jp/digital-typhoon/index.html.en
- Joint Typhoon Warning Center (JTWC) Track Data available at: http://www.nrlmry.navy.mil/tcdat/
- National Center for Environmental Prediction (NCEP) – National Center for Atmospheric Research (NCAR) Reanalysis Project (NNRP) available at: http://www.esrl.noaa.gov/psd/data/composites/hour/
- The Philippines Cyclone PELC procedure adjusts the Environmental Pressure figures shown in the table above by 2 mb to account for any potential error in the contour intervals NCEP/NCAR: NNRP provides.
- Storm Wind Radii and Radius of Maximum Wind should be collected and entered into the model in km, but upon analysis, the model will automatically convert km to miles.
- Radius of Maximum Wind (Rmax) is generated by the model as a function that relates Rmax to central pressure and latitude.
- If storm wind radii are collected from the primary source, Rmax will be adjusted according to the Willoughby Algorithm.
- If storm wind radii are not collected from the primary source, no adjustment will be made to the Rmax generated by the model.
- Tropical Rainfall Measuring Mission (TRMM) QA'd data will be used if available. If not, TRMM near-real-time data will be used.
- TRMM (QA'd) available at: http://gdata1.sci.gsfc.nasa.gov/daac-bin/G3/gui.cgi?instance_id=TRMM_3-Hourly&selectedMap=Blue%20Marble&
- TRMM (near-real-time) available at: http://disc2.nascom.nasa.gov/Giovanni/tovas/realtime.3B42RT.2.shtml
- Default values are based on statistical analysis of historical data for the Philippines region.

Questions – Post Event Loss Calculation (contd.)

Q. AIR's research suggests that the information published tends to be fairly stable within about 7 days of an event. Our experience from Muteki Re, a cat bond which was triggered by the Tohoku earthquake in March 2011, is that reporting agencies can take up to 14 days to provide stable information. While time-to-payout is key for PhGov, we need to be careful here to strike the optimal balance and would therefore recommend to extend this timeframe to at least 14 days.

A. AIR has no issues with any timeline that is longer than 7 days.

Questions – Historical Losses

Q. Could AIR explain the source of the difference between historical and PELC losses, particularly for Fengshen?

A. Since The Fengshen event occurred and was processed by our research team very close to internal model release deadlines, and was subject to a good amount of modification as part of the validation process given what was being reported regarding the damage on the ground from the event. Note that historical events are subjected to significant review and represent a best view consistent with the model vintage; for the Philippines we are now using a significantly updated model. A reanalysis of the event today using the earlier vintage of the model would reduce the difference between modeled historical and PELC losses. The PELC process would not implement any of these subjective modifications and use the data directly obtained from the JMA. In any case, even though the JMA parameters result in higher modeled losses, the event still would not have triggered any of the modeled loss structures proposed in the presentation. Note that the PELC and modeled historical loss values are in good agreement for other major storms with no bias evident in the PELC based results.

Q. Are historical losses computed using both the older model as well as the old input parameters or just the old input parameters?

A. The historical numbers are computed using the new model, but using the old input parameters.

Questions – Historical Losses (contd.)

Q. Could AIR provide investors with a split up of historical catalog losses and PELC emergency losses by line of business?

A. Please see slides 45 and 46.

Q. Comparison of the modeled vs historical frequencies looks very insightful. Could you provide some insight into how AIR produced these numbers and if AIR could produce a similar overview using Central Pressure?

A. The frequencies are produced using the storms that landfall in the Philippines. The Saffir Simpson categories are produced by mapping central pressure of the storm at the first Philippines landfall to a Saffir Simpson category, thus the exhibit would be the same just labelled different. This mapping is as follows:

Category 1: 980-994 mb; Category 2: 965-979 mb; Category 3: 945-964 mb; Category 4: 920-944 mb; Category 5: Less than 920 mb;