Losses from your ILS Portfolio? Well, what did you expect?

Abstract

Insurance Linked Securities [ILS] are unique instruments in the fixed income world. Each bond comes with a specific modeled risk analysis that gives a measure of how the bond will react to (usually 10,000) possible future natural catastrophe scenarios. These are summarized by familiar metrics including the probability of some loss and the expected level of loss. The risk analysis is provided to investors by independent third-party modelers of natural catastrophes. The market has been around for some two decades, and while still small, continues to grow. During those two decades several real natural catastrophes have occurred and the investors in ILS have suffered loss.

This paper asks the question, did the realized losses that have occurred to investors correspond to the expectations promised in the initial offerings of the bond? More briefly did ex post outcomes match ex ante expectations. The question is non-trivial, not least because it is harder than one might suppose to measure either the ex-ante expectations, or the ex post results. Coverage in the bonds is multi-year but the expectation is usually perceived for a single year. In insurance-speak there is multi-year coverage but only a single limit. On the ex post side, one of the characteristics of insurance is that even though an event is known to have taken place it may take many years to recognize the loss. This paper looks at the empirical evidence to date.

Key Words – Insurance-Linked Securities, ILS, Cat Bonds, Catastrophe Bonds, Expected Loss, Probability of Loss, Risk, Accumulation of Loss, Risk Profile, Wildfire, Modeled Loss, Standard Sea Surface Temperatures, Warm Sea Surface Temperatures.

Losses from your ILS Portfolio? What did you expect?

Our belligerent title is intentionally provocative. The ILS market (and the larger reinsurance market itself) is reeling from high catastrophe losses from 2017 and 2018. Aon records that 2017 and 2018 are the highest back-to-back loss years ever experienced in the traditional reinsurance market. And, worse, those losses are still developing. It is similarly the case in the ILS market, our chosen petri dish for commentary and analysis.

It is not our intention to rub salt in the wound, rather, it is to stand back and ask the question – are these losses exceptional – or, if you will, are these actual losses out of line with what models would have led us to expect? We have addressed the question in previous papers and concluded that "what you see, is what you get". Our answer then was that the accumulated losses experienced by the market are consistent with what the models predicted, i.e., consistent with the "expected" losses associated with ILS risk analysis. To cut to the chase this time, we are still persuaded that the statement is basically true, but there is a qualifier – there is growing evidence, or at least a minimum a case can be made, that models are under-estimating real losses. If true, the result is "what you see is only part of what you might get".

Our description of the analysis proceeds from the top down. First, we present the basic conclusions about catastrophe models vs. mounting catastrophe losses. Next, we unpack the analysis upon which those summary numbers are based. That exposition reveals the uncertain and challenging nature of building the estimates themselves. We readily concede that others could come to justifiably different numbers by making slightly different rules for their inputs into their arithmetic[1]. Next, we look for consistence of other aspects of models – implied frequency and severity of loss and

[1] In the text of the paper we will round our estimates to $ millions. Where tables are given they may be with full numbers. The practice is intended to convey the idea that the precise number is less important than the order of magnitude.

consistency with implied risk profiles – which provide collateral evidence for the model's "correctness". Then we turn our attention to a discussion of non-modeled losses and less-well-modeled losses - suggesting model deficiencies. A case in point is the wildfire losses and their impact on both actual and "expected" losses this past two years. All the above is done for the total ILS market. However, 8% of that market is conducted by one company – USAA via its Residential Re issues - and we conclude with a case study of its ILS issues and their losses.

In all this effort we are assisted and informed by the models of AIR Worldwide. They have extended their model analyses to us for a number of years and we are grateful. Thank you. Please note, however, any errors, omissions or misinterpretations of that data is solely the responsibility of ourselves.

Finally, the period under study is 2002 – 2018, a period of 18 years. The ILS market started some 5 years before, in 1996. That period was characterized by a variety of experimental transactions, both large and small, both good and bad, both well modelled and some less so. We have chosen to concentrate on the post 2001 period where some regular ILS patterns and standards have prevailed. We also emphasize that our investigation is confined to catastrophe ILS and corresponding losses. We do not consider Mortality, Liability or other ILS nor do we

Figure 1

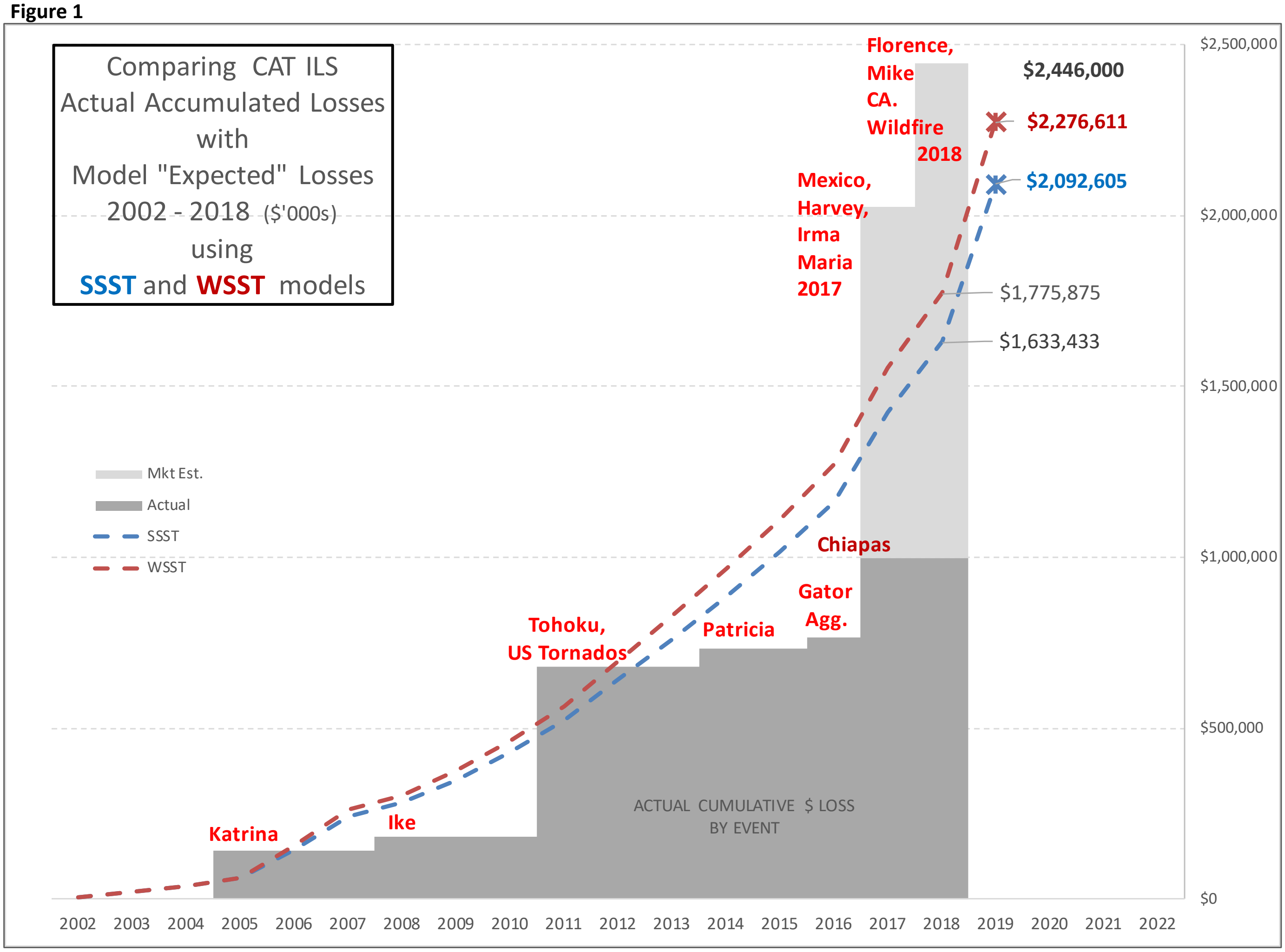
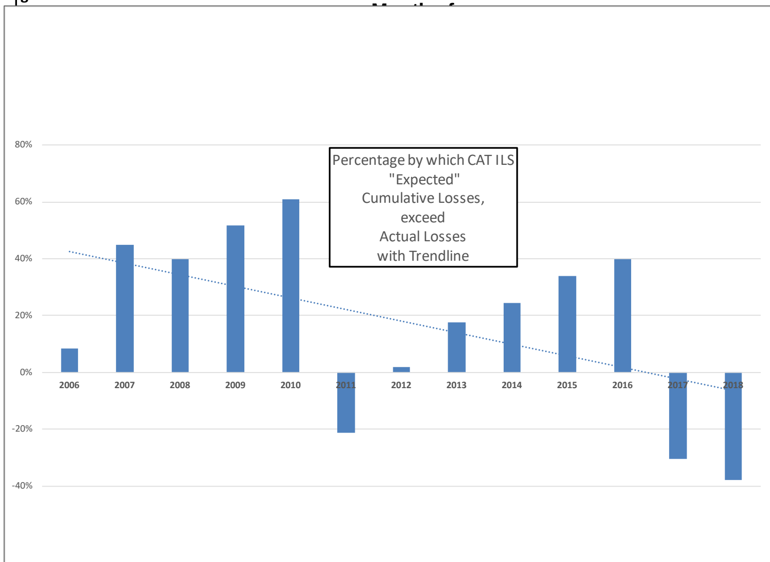


Table 1

Figure 2



						Estimated Loss as a % of Par	Estimated Loss USD million	Assumed Interim Loss Payments	Loss Triggering Event
						76%	$144		Hurricanes Katrina, Wilma
						57%	$38		Hurricane Ike
						100%	$300		Tohoku Earthquake
						100%	$100		US Windstorms - Tornado Loss
						100%	$100		US Windstorms - Tornado Loss
						50%	$50		Hurricane Patricia
						100%	$30		Hurricane Irma
						18%	$35		Aggregate Loss
						100%	$50		Harvey, Irma, CA WF Aggregate Loss
						100%	$150		Chiapas EQ
						80%	$997		
						ices Less than or equal to $80 .. 'Impaired' Deals			
						35%	$53		Harvey, Irma, Maria Aggregate Loss
Loma Re 2013-1 C	12/30/13	Aug-17+	01/08/18	01/09/19	17.29%	45%	$29		Harvey, Irma, Maria Aggregate Loss
Residential Re 2014-1 10	05/22/14	Aug-17+	06/06/18	03/06/19	14.98%	100%	$80		Harvey, Irma, CA WF Aggregate Loss
Residential Re 2015-1 10	05/29/15	Aug-17+	06/06/19		11.00%	90%	$45		Harvey, Irma, CA WF Aggregate Loss
Residential Re 2016-1 10	05/11/16	Aug-17+	06/06/20		11.55%	100%	$65		Harvey, Irma, CA WF Aggregate Loss
Casablanca Re 2017-1 C	06/01/17	Aug-17	06/04/20		16.00%	55%	$5	$2	Harvey, Irma, CA WF Aggregate Loss
Residential Re 2013-2 1*	12/02/13	Aug-17+	12/06/17	03/06/19	20.00%	65%	$13		Harvey, Irma, CA WF Aggregate Loss
Blue Halo 2016-1 B	06/16/16	Sep-17+	06/21/19		19.75%	65%	$36		Irma, Florence
Citrus Re 2015-1 B	04/08/15	Sep-17	04/09/18	04/09/20	6.00%	50%	$66	$35	Irma
Citrus Re 2016-1 D	02/24/16	Sep-17	02/25/19		7.85%	40%	$82	$37	Irma
Citrus Re 2016-1 E	02/24/16	Sep-17	02/25/19		11.03%	100%	$100	$100	Irma
Citrus Re 2017-1-A	03/13/17	Sep-17	03/18/20		5.23%	60%	$113	$95	Irma
Citrus Re 2017-2 B	05/11/17	Sep-17	03/18/20		10.75%	100%	$35	$35	Irma
Manatee Re 2016-1 C	03/10/16	Sep-17	03/13/19		16.25%	100%	$20		Irma, Maria
Caelus Re V 2017-1 B	05/04/17	Sep-17+	06/05/20		4.50%	85%	$139	$75	Maria
Caelus Re V 2017-1 C	05/04/17	Sep-17+	06/05/20		6.00%	100%	$75		Maria
Caelus Re V 2017-1 D	05/04/17	Sep-17+	06/05/20		9.25%	100%	$75		Maria
Cal Phoenix 2018-1	08/02/18	Nov-18+	08/13/21		7.50%	93%	$186		California Wildfires
Caelus Re V 2018-1 C	05/10/18	Nov-18+	06/07/21		7.50%	40%	$70		California Wildfires
Caelus Re V 2018-1 D	05/10/18	Nov-18+	06/07/21		10.50%	70%	$53		California Wildfires
Frontline 2018-1 B	06/26/18	Nov-18	07/06/22		11.75%	30%	$30		Hurricane Michael
Residential Re 2018 I 11	05/14/18	Nov-18+	06/06/19		11.75%*	80%	$80		California Wildfires
Number of Issues with M-T-M Losses		22				73%	$1,449		
Total Issues with a Loss		32				75%	$2,446		

* Spread: Issued at a discount; discount amount shown.
* Residential Re 2013-2 1: $60 million returned to investors, $20 million extended.

consider losses to catastrophe ILS caused by financial loss[2].

Principal Conclusions

The ILS loss story since 2002 –2018 is captured in two exhibits – Table 1 and Figure 1.

Table 1 shows known and estimated losses to the ILS market portfolio from 2002 to the end of 2018. The table details the events and timings that cause loss, together with the specific ILS that are were affected by events and amounts of each loss. Those individual known losses total to $2,446 million. We return to examine the Table detail momentarily, but in order to see the big picture consider Figure 1.

[2] Our universe under exam in 2002 –2018 is 638 catastrophe issues. It should be noted that the total count of all types of ILS issued since inception of the market is over 900 and is well on its way to exceeding 1,000 before end 2020.

The corresponding total number, $2,446 million, is also shown on Figure 1. The shaded block pattern shows the events that have accumulated to known total loss. The prior losses have risen step-by-step over time from events like Hurricane Katrina, Hurricane Ike, the Tohuku Tsunami and Hurricane Patricia to the losses from the events of 2017 and 2018.

Super-imposed on the block diagram of Figure 1 is an accumulation of losses that model output would have led you to "expect" from the 2002-2018 portfolio (see dashed lines). Naturally, expected loss growth is smoother than the lumpy loss step events of reality. The growth line is derived in part from the weighted average of the initial expected loss on all issues made in each calendar year multiplied by the sum of the amount of limit issued in that year. It is smoother but has its own smaller lumpiness, when the market issues consisted of more or fewer bonds and/or when the issues were of higher or lower than average risk.

Anyway, the range of expected losses shown on the graph is a range between $2,092 million and $2,276 (see asterisked point markers). The range exists because two expected loss numbers are given with each risk analysis – The Standard Sea Surface Temperature [SSST] model and the Warm Sea Surface Temperature [WSST] model which we have discussed before.

The gap between actual accumulated loss of $2,446 and the conservative WSST expectation of loss of $2,276 is the number that speaks to the question in the title of the paper. Is what you got, close to what you might have expected? Actual loss exceeds expected loss by 7.5%. At first blush they seem close, but after 18 years wouldn't you have expected them to get closer? Figure 2 certainly shows that the relative gaps that have emerged between actual and expected in the past have been wider, and that the divergence trend is getting smaller. However, after 18 years, shouldn't such divergences begin to get even closer?

Notwithstanding, based solely on these numbers one could feel justified in concluding, as we have in the past, that the models work well. Actual losses are not wildly divergent from you would have expected – *what you see, is what you get.*

Before fully endorsing that conclusion, however, it is worth digging a little deeper into how those totals were derived. Both the "actual" loss and the "expected" loss estimated totals can (and will?) be challenged. Exposing that discussion reveals some growing concerns about model expectations.

Estimating the losses that one would expect from the 2002-2018 ILS Portfolio

The weighted average expected loss [EL] from each year of issuance and the amount of issuance in each year is listed in

Table 2

Characteristics of Annual ILS Issuance

2002 - 2018

DATE	Ann Total	Wghtd EL SSST	$EL
2002	$956,400	0.76%	$7,305
2003	$1,720,490	0.87%	$14,996
2004	$1,142,800	1.32%	$15,057
2005	$1,588,000	1.54%	$24,402
2006	$4,581,250	1.84%	$84,215
2007	$7,031,194	1.39%	$97,681
2008	$2,636,400	1.46%	$38,542
2009	$3,397,985	1.99%	$67,533
2010	$4,798,948	1.66%	$79,861
2011	$4,270,209	2.16%	$92,141
2012	$5,855,378	2.08%	$121,660
2013	$7,381,745	1.60%	$118,394
2014	$8,125,600	1.54%	$125,434
2015	$6,317,680	2.06%	$130,428
2016	$5,590,000	2.63%	$146,749
2017	$10,290,500	2.54%	$261,241
2018	$9,594,000	2.17%	$207,792
	$85,278,579		$1,633,433
[Comparable loss estimate using WSST EL's]			$1,775,875
PLUS			
Outstanding end 2018	$19,940,680	2.30%	$459,172
	$105,219,259	SSST EL's	$2,092,605
[Comparable loss estimates using WSST EL's]			$2,276,611

Table 2. Multiplying those numbers and summing them gives the starting point for our calculation. The estimated numbers of $1,633 (SSST case) and $1,776 (WSSST case) are based on actual issuance during the period and actual EL's. If we stopped there, the difference between actual and expected would be large and concerning. However, we believe these numbers do not fully reflect the character of ILS, which is that they are multi-year coverages, with an average maturity of around 3.5 years. The simple calculation assumes that each ILS is single year coverage and that it ends in 2018.

To take a breath, the simple calculation is, in baseball terms, low and outside.

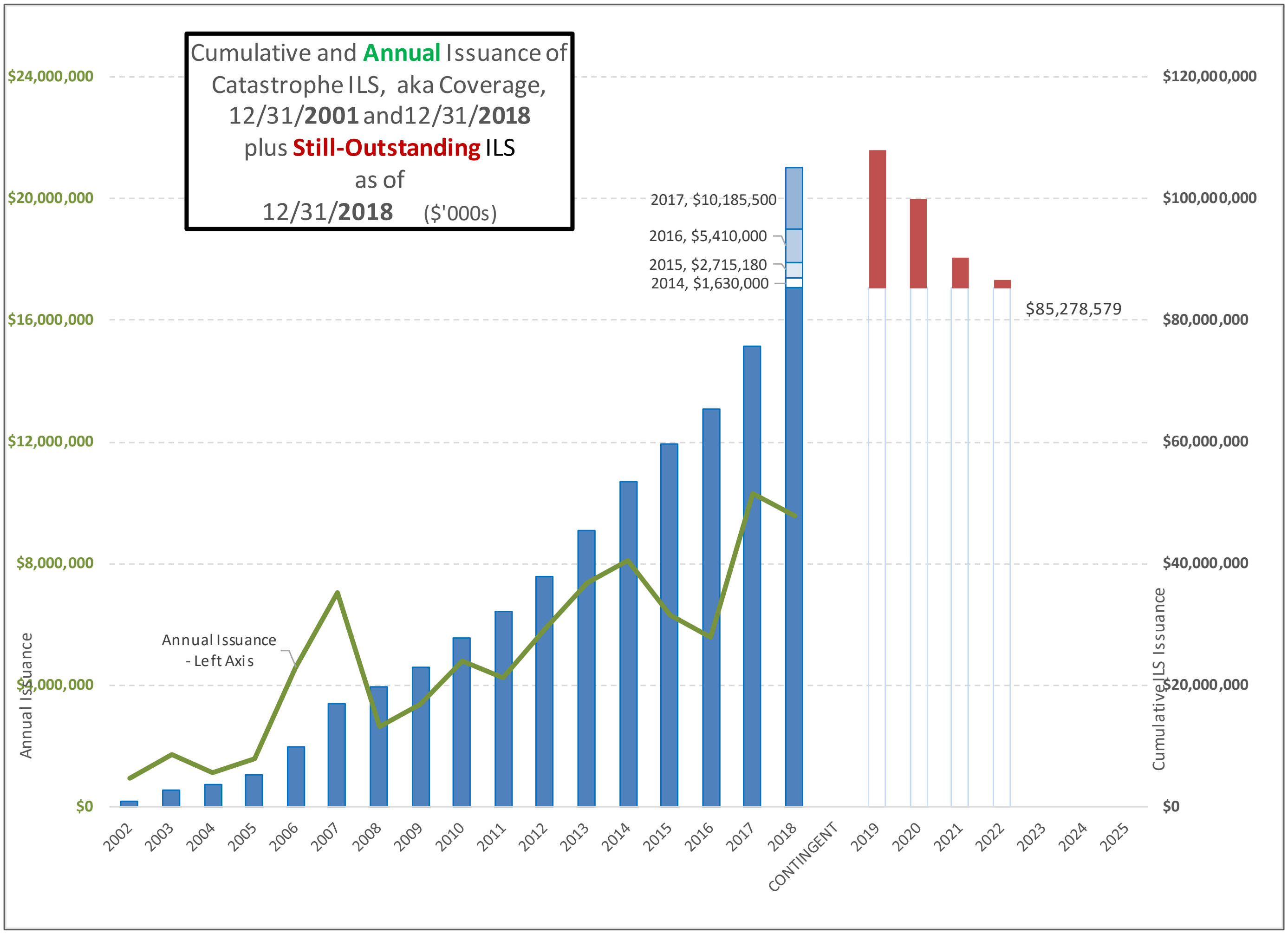
There are deals with exposures beyond 2018 that we expect to have losses. Those inure to our expectations from the portfolio. At the end of 2018, there are ILS still outstanding that were issued in 2014, 2015, 2016 and 2017 that still have expected loss attached to them. We must add the losses expected to accrue to all bonds still outstanding at the end of 2018 to our simple calculation. Figures 3 is intended to illustrate the point. The solid blue bars show the total cumulative issuance each year to the end of 2018 – a total of $85,279 million. Stacked above it are bonds still outstanding from issuance in 2014 ($1.6 billion), from 2015 ($2.7 billion), from 2016 ($5.4 billion) and from 2017 ($10.2 billion). With these conditional estimates the total coverage is $19.9 billion over and above the $85.3 billion for a grand total of $105.2 billion. Note also that the bars to the right of the 2018 column show how those still-outstanding bonds will mature over the next 5 years.

With the addition of the still-outstanding numbers, the losses expected from the 2002-2018 portfolio are therefore between $2,092 million and $2,276 million as previously reported.

We ourselves have struggled with the correctness of this approach – Are we double counting? Isn't there only one limit per ILS or tranche? How else do you take account of multi-year benefits? But in the end we believe it is correct. We suggest an analogy that may be helpful.

Consider if you were asked, in 2018, to estimate the average lifespan of everybody in the USA born between 1950 and 2018. What we have done and displayed in Figure 1 (and detailed in Table 2) is the equivalent of multiplying the number of people born in, say, 1951 by life expectancy at birth - say it was 65 years - taking a weighted average, and summing the results. It is a decent estimate. It certainly takes account of two important features of life – we each only have one, and it

Figure 3



will be finite, plus, since we take each different year's life expectancy it recognizes that life expectancies have grown. They are higher for millennials that they were for baby-boomers. However, what it does not recognize is that some people born in 1950, expecting to live to 65 are now 68 and have a new conditional (or contingent) life expectancy of say, 17 years. That must be added to all the life expectancies of deceased people to get a good estimate today of how long that whole cohort of people were expected to live.

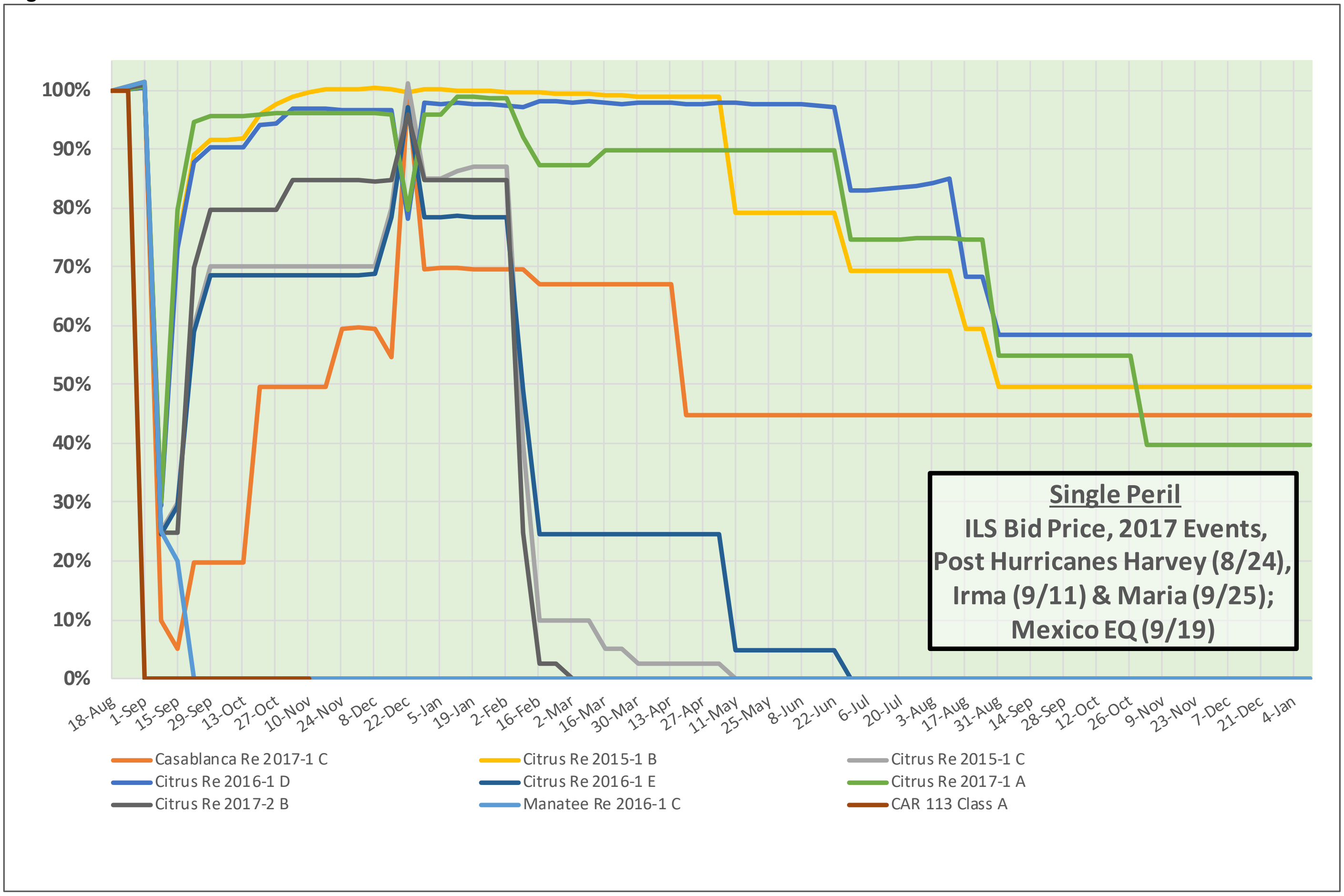
So much for the "expected" side of the calculation, perhaps it will be more clear-cut calculating the "known". It is not.

Known or Actual Losses

Table 1 and Figure 1 show known and actual losses at $2,446 million. Closer inspection shows that the Table is divide into two sections and the bar chart part of Figure 1 reflects this with different shading.

The top part of Table 1 (the heavier shaded part of Figure 1) represents true known losses. They will not change. Ten ILS

Figure 4



suffered $997 million of loss in the period 2002 –2018.

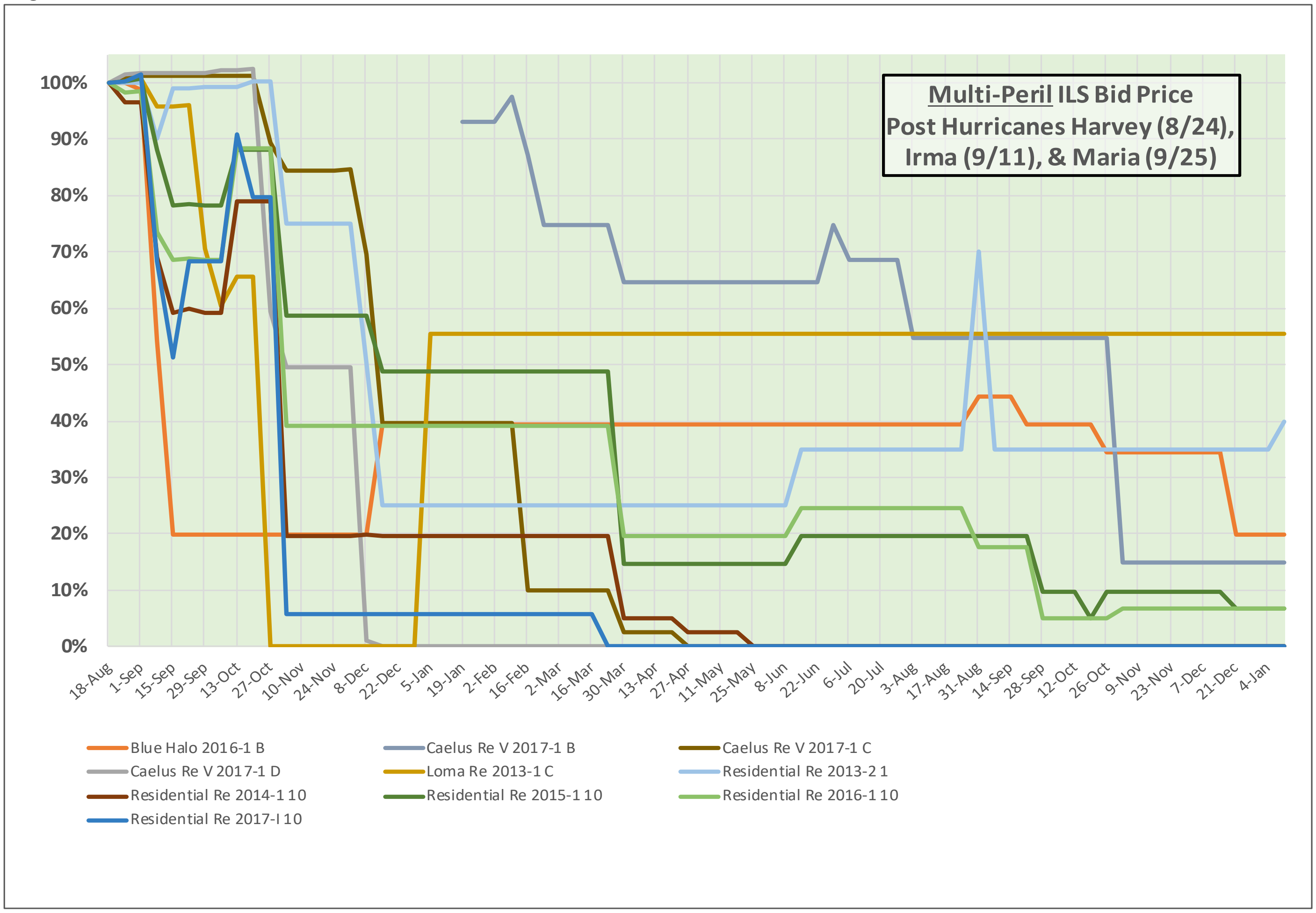
But other ILS, in the estimation of the secondary market for ILS, have also suffered a loss. 'Trouble is, no one is quite sure exactly what the final size of the loss will be. The lighter shaded blocks in Figure 1 represent that part of the loss that is known or actual but not final.

When ILS do encounter loss, their price is reduced. The lower the price, the bigger the market thinks the loss will be. Table 1 lists all ILS that have a secondary price that has been quoted at or below $80. We have consistently used the $80 cut-off as a filter to single out serious loss potential. Note, however, it is an arbitrary number, others may use a different filter or standard.

Based on that filter, 22 ILS face serious loss potential for recent catastrophic events. How much loss? We take the latest ILS market price indication as the best neutral estimator. It shows a total loss from the 22 deals of $1,449 million, which when added to our known loss of $997 million given the actual total of $2,446 million previously cited.

This figure is also very challengeable and will change. In fact, the market changes its mind quite often, and often quite radically, about what probable loss is. The evidence of this found by tracking price indications of subject ILS since the 2017 and 2018 events. The Single-peril ILS price indications are shown in Figure 4 and Multiperil ILS in Figure 5. Clearly and dramatically prices plunged during the Harvey, Irma, Maria

Figure 5



period in September 2017. When the storms passed, and more mature reflection prevailed prices rebounded. By year-end some were almost back to par. Did year-end accounting concerns trump realistic loss estimates? If this were a truly liquid, well informed and traded market one would not raise those suspicions. But they linger.

After the beginning of 2018, however, the market apparently got sober, got more data or got more realistic. Prices drifted lower, then much lower. The pattern is repeated in both classes of ILS identified and accelerated by the close of 2018.

Several of the ILS in Table 1 imply a total loss – priced at $0. One could argue that they should be moved to the top part of the Table as certain losses. However, Kamp Re, stands as sentinel against too early a decision. ILS historians will know that it was priced at $0 for many years, before finally closing at $24.

Collateral Support for the Models – closer inspection of Table 1

Modeling companies such as AIR Worldwide do not just give expected loss (SSST and WSST) as the sole output of their risk analysis, even though it probably is the most sought and cited statistic. They also give the frequency of loss and full loss profiles, which are given for each transaction but probably just as valuable when aggregated for the whole market.

Table 3

CAT ILS COVERAGE post 2001

	Total ILS Issued 12/31/2001 - 12/31/2018	Total ILS Still-Outstanding at-12/31/2018	Overall Coverage post 2001 as of 12/31/2018
Amount of ILS Coverage	$85,278,579	$19,940,680	$105,219,259
# of Issue Tranches	638	118	
Wgtd Average Spread at Issue	6.13%	7.83%	6.45%
SSST			
Wgtd Average Expected Loss	1.92%	2.30%	1.99%
Avg Probability of 1st $ Loss	3.22%	3.91%	
Exp Loss given some Loss	76%	77%	76%
Expected # of Losses	21	5	25.1
$ Expected Loss	$1,633,433	$459,172	$2,092,605
WSST			
Average Expected Loss	2.08%	2.51%	2.16%
Avg Probability of 1st $ LossL	3.52%	4.31%	
Exp Loss given some Loss	76%	77%	76%
Expected # of Losses	22	5	27.5
$ Expected Loss	$1,775,875	$500,736	$2,276,611

The average probability of loss on all ILS issued between 2002 and 2018 was 3.22%. Since that was composed of 638 different ILS or tranches, we would expect that to translate to 21 (=3.22%*638) tranches encountering a loss of some magnitude[3]. To this we need to add the possibility of loss on the $19,940 million (or 118 tranches) of still-outstanding ILS, which equals another 5 deals expected to become loss impaired (=3.91%*118). In total we would expect from the models just over 21 deals to have losses (SSST case) or 28 deals (WSST case). In Table 1 we see actual or known losses of 32. On this score the models are underestimating experience. The details of these calculations are laid out in Table 3.

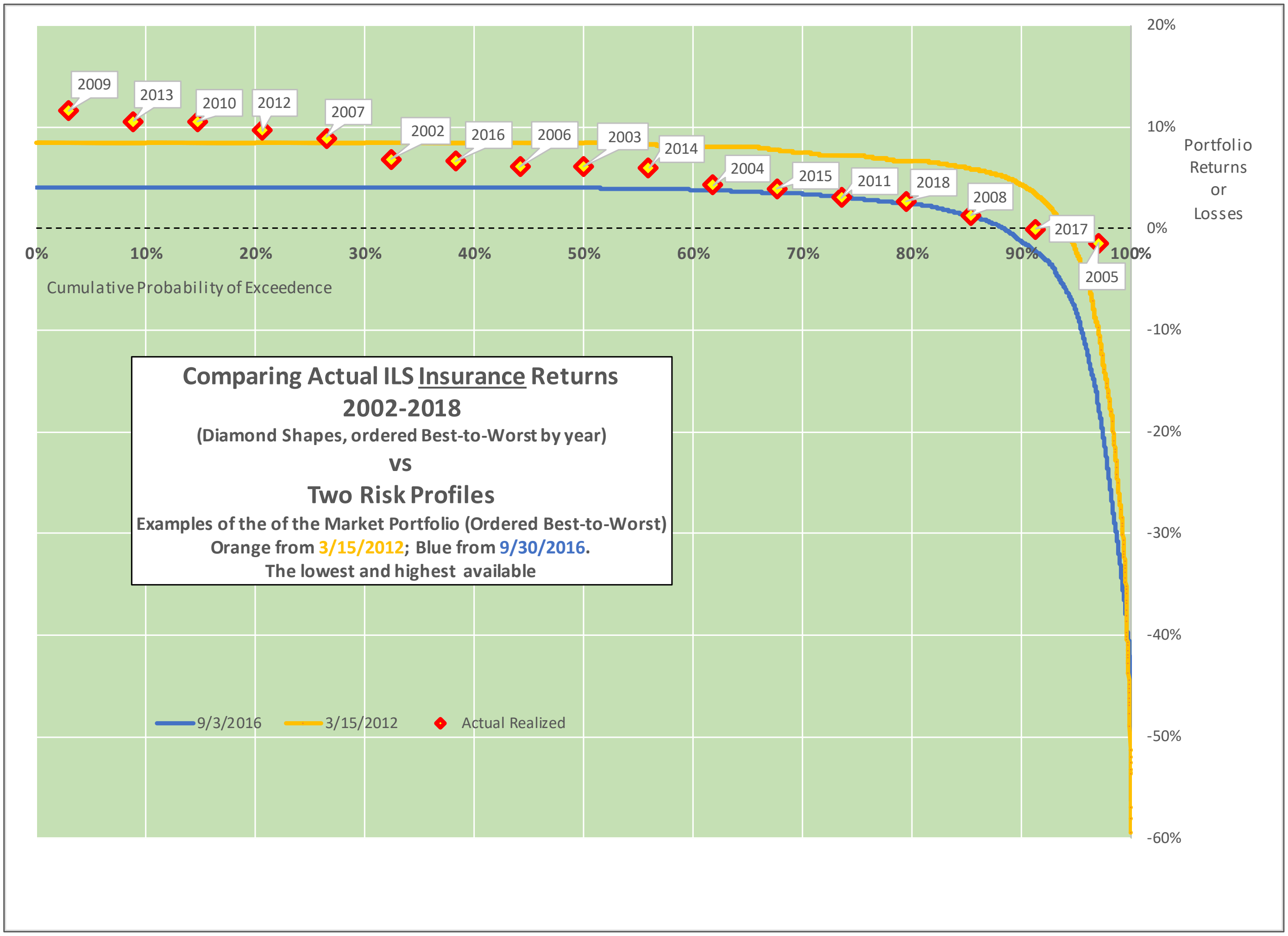
Another dimension of the model prediction, which is an integral part of the model analysis, is the severity of loss. When a loss happens, it may be total but can be partial. The models would predict that given that a loss has happened, the conditional expected loss (its severity) is 76% (see again to Table 3). Actual loss shown in Table 1 is 75% of limit. In this measure, the models are entirely consistent with observation.

Another cross-referencing measure of how well the models do is to compare historical annual insurance returns over time with what the risk profiles suggest would be the shape of returns in the range of annual analyses. AIR Worldwide has helped us calculate this measure every year since 2011 (but not back to 2002). In that time, prospective return profiles have ranged quite a bit. The high return profile in that period was 2012; the low profile was 2016. In Figure 6 the blue line represents 2016 and the orange profile represents 2012. The best-to-worst historical insurance returns, if the character of one year with another is equally likely, aligns well between the two profiles. The only years that are outside the range are the post Katrina years and the post financial crisis year, when the profiles were not available to us. They are all "hard market" years and, if available, would almost certainly capture those years as well.

Yet another very broad brush of model-against-reality test would be the perils that are expected to cause loss. A look at the data suggests that 60% of the losses could be expected to be generated from peril of US

[3] Note that the formula for our frequency estimate is over-simplified. It assumes independent tranches. Correlation between tranches would contradict that assumption (California Wildfire makes a good example) and would have the numbers somewhat higher.

Figure 6



Wind and Windstorm, 20% from the peril of Earthquake around the world and the remaining 20% would come from loss due to European and Japanese Wind (11%) and "Other" (9%). Indeed, in Table 1, 63% ($1,551 million) of actual $2,446 million of loss comes from US Wind and Windstorm, 21% ($500 million) does come from Earthquake, none from European or Japanese Wind leaving 16% from "Other". Two major perils are consistent with model; "Other" is anomalously high, European and Japanese wind anomalously low. The biggest cited item in Table 1 that would be in "Other" is California Wildfire and deserves its own discussion.

California Wildfire – A Non-Modeled or a Less-well Modeled Peril?

Of the ILS losses listed in Table 1, four ILS list California Wildfire as the exclusive cause of loss. Another six list it as a contributing cause of loss in aggregation covers. Here the actual loss outweighs considerably what the models would have predicted. We do not have a long record to test these observations, but we do have two pieces of recent evidence that suggest some other things to consider about expected loss numbers in general and about Wildfire in particular.

The first is simply the fact that during the period under study ELs do not stay constant at prospectus levels as we have implicitly assumed in the calculations in Table 2 and 3. In some cases one modeling company will re-model prospectus-listed ELs done by a competitor to harmonize with their own estimates.

Second, during this period, all modeling companies will have updated their models to embrace new information or technologies – as we should hope they would. The implication, however, is that if you are still evaluating a deal by its original EL, after a known model update, you are certainly out of date and possibly wildly mis-estimating expected losses and more importantly mis-pricing an ILS whose EL has been subject to revision. Keeping up with the markets also means keeping up with the models. The example of Wildfire modeling serves to make the point.

Table 4

Wildfire Exposed ILS*						
	Q1 2018		Q3 2018		Change Q1 to Q3	
	Probability of Loss	CEL**	Probability of Loss	CEL**	Probability of Loss	CEL**
ILS with WF Presumed Loss						
Res Re 2015-I 10	1.18%	43.00%	2.50%	48.50%	1.32	5.50
Res Re 2016-I 10	2.12%	33.60%	3.80%	38.30%	1.72	4.70
Other WF Exposed ILS (Selected)						
Caelus V 2017-I B	0.44%	27.80%	0.50%	45.10%	0.06	17.30
Caelus V 2017-I C	0.71%	50.20%	0.90%	51.00%	0.19	0.80
Caelus V 2017-I D	1.21%	47.50%	1.60%	57.90%	0.39	10.40
Espada	1.59%	5.80%	3.00%	9.50%	1.41	3.70
Res Re 2014-II 4	0.02%	55.80%	0.00%	78.00%	-0.02	22.20
Res Re 2015-I 11	0.65%	14.90%	1.50%	21.80%	0.85	6.90
Res Re 2016-I 10	2.12%	33.60%	3.80%	38.30%	1.68	4.80
Res Re 2016-I 11	0.17%	68.80%	1.50%	21.80%	1.33	-47.00
Res Re 2016-II 4	0.02%	55.80%	0.00%	78.00%	-0.02	22.20
Res Re 2017-I 11	0.65%	14.90%	1.50%	21.80%	0.85	6.90
Res Re 2017-I 13	0.14%	10.10%	0.10%	20.00%	-0.04	9.90
Average	0.85%	35.52%	1.59%	40.77%	0.75	5.25

*ILS analyzed in both Q1 and Q3 2018.
**Conditional Expected Loss - Expected loss if a loss is incurred.

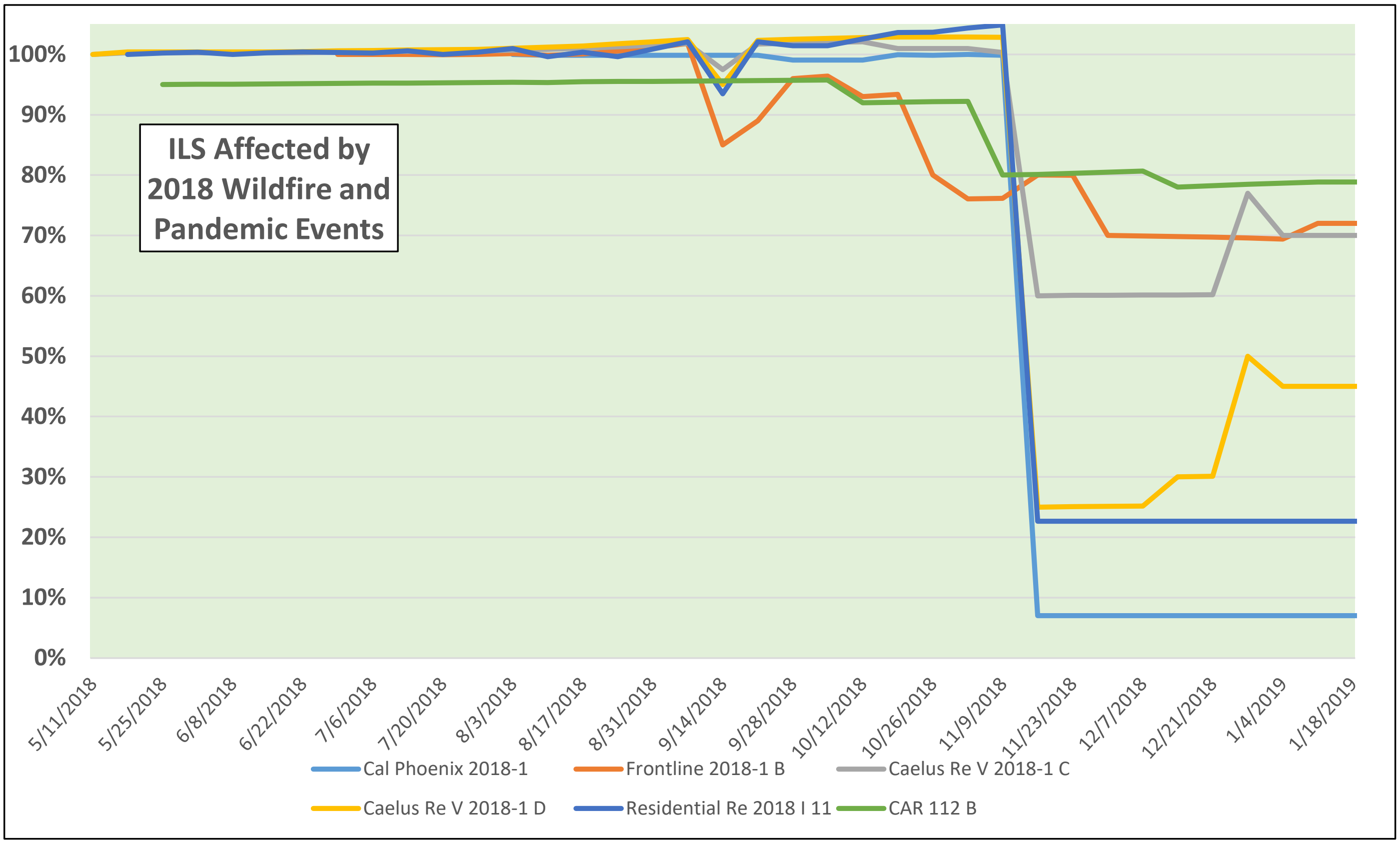
During mid-2018, AIR Worldwide revised its California Wildfire Model[4] to the benefit of those who paid attention (or subscribed). Fortunately for our purposes, several deals that had Wildfire exposure were valued in the first quarter of the year, and again after the model revision, in the third quarter of the year – each of which were available to us. The contrast of expectation (though it may not all be in Wildfire) under old and new models is thereby revealed. It is shown in Table 4.

Thirteen ILS are listed in Table 4. Two are presumed to have a Wildfire loss, the rest have the exposure but not yet the occasion of loss. We divide the changes in risk assessment between the old model and the new model into two components. First, the revised frequency or probability of loss; second, the revised conditional expected loss (expected severity). Obviously, the product of those two is the expected loss or EL.

Taking note of the two deals thought to have experienced a loss, we see that the probability of loss was revised up from 1.18% and 2.12% to 2.50% and 3.80% on, respectively, Residential Re 2015-1 10 and Residential Re 2016-1 10. In other words, there was almost double (*2.1 and *1.8 times) the chance of a loss after remodeling on those deals. Similarly, if there is a loss, it is now expected to be a 5-percentage point larger severity than originally thought. Multiply the two out and the expected loss has jumped from around 50-70 basis points to double those amounts. The other deals in the table show similar revisions, although we should note that it was not always in an adverse direction.

[4] AIR updated their wildfire model and added eleven states to their wildfire modeling.

Figure 7



One deal not shown in the table is Res Re 2018-I 11. It was issued after our Q1 analysis, but before the AIR re-model and its prospectus EL was 7.30%. After, remodeling (and available by Q3) the revised EL was now 10.44%. That is a remarkable demonstration of the need to keep up with models and market.

Mr. Market's estimate of actual losses from Wildfire are shown in the price graph shown in Figure 7. They display the same uncertainty and recalibration of loss that Figure 4 and 5 did for the 2017 catastrophe losses

To conclude our observations on Wildfire, we draw attention in Table 5, to the definition of what constitutes a Wildfire loss as presented in several of the

Table 5

Issue	Reporting Agency	WF description in Investor Presentation
Caelus 2016	PCS	Any event that is identified as a "catastrophe" and assigned a catastrophe code by PCS, where the storm family (or equivalent description) identified by PCS with respect to such catastrophe is "wildland fire" (or any similar designation made by PCS) and includes all ensuing damage caused thereby, resulting therefrom, or as a consequence thereof. In the event that PCS does not exist and there is no replacement reporting agency available as determined by the Calculation Agent to classify the event as a Wildfire, then such event will be deemed a Wildfire only if the Ceding Insurer has assigned a catastrophe code to such event
Caelus 20017, 2018	Third Party reporting agency	Any wildfire event (or an event of a similar description) that is reported as such by a Third Party Reporting Agency and assigned a catastrophe code by the Ceding Insurer in a manner consistent with its claims procedures and financial reporting, and includes all ensuing damage caused thereby, resulting therefrom, or as a consequence thereof, including by way of example mudslides. The duration of a Wildfire will be any period of 240 consecutive hours as determined by the Ceding Insurer; provided that the Ceding Insurer has assigned a catastrophe code to such event in a manner consistent with its claims procedures and financial reporting
Cal Phoenix 2018-1	Wildfire Reporting Agency	Any Wildfire with a Date of Loss during the Risk Period where such Wildfire originates from or is caused by, in whole or in part, a power or transmission or distribution system, operated and/or owned by the Insured, as reported by the Wildfire Reporting Agency, regardless of how the fire or series of fires spread involving two or more individual risks
Residential Re Issues	PCS	Any event that is identified as a catastrophe and assigned a catastrophe code by PCS, where the storm family (or equivalent description) identified by PCS with respect to such catastrophe is "wildland fire" (or any similar designation made by PCS).

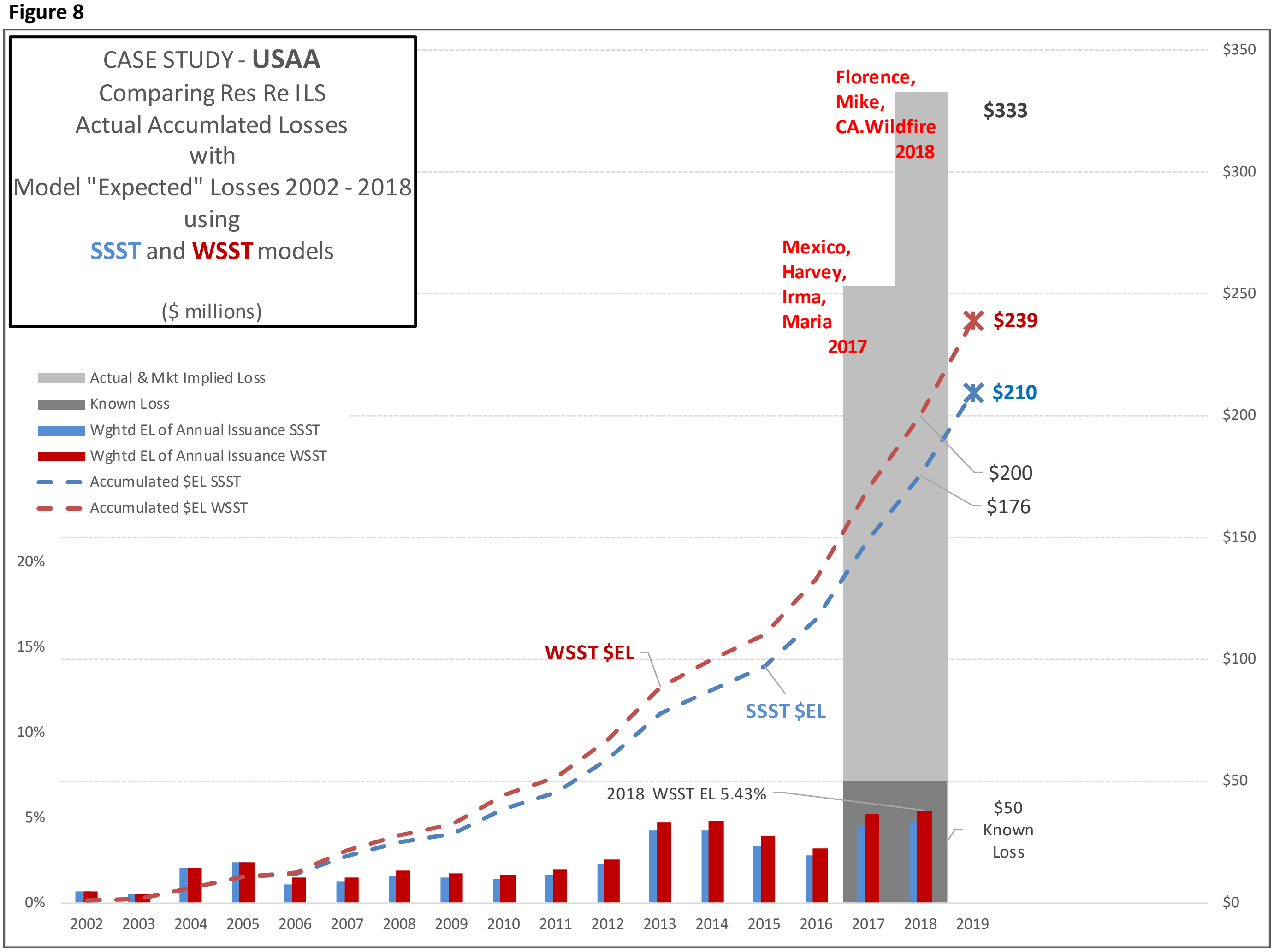
PPMs. Most, but not all call for the identification of a Wildfire event by an independent or third-party entity. Some specify the entity, some do not. Some have an "hour's" clause, some do not. It is fair to say that the modeling is difficult as much as anything because of the shifting of definition as much as experience. We are not as confident about the Wildfire models as we are, for example, of the US Wind models. It may be one reason for divergences between actual and modeled losses.

CASE STUDY – USAA and the Residential Re Issues

USAA proved that the ILS market was viable with its initial, then-monster, issues in the late 1990s. It has been a stalwart of the market ever since. Roughly speaking it controls 8% of the market by limit and 10% of the market by count. It is by far and away the largest issuer of indemnity ILS. Their actions are worthy of study and we have made a practice of that since we started writing about the market in 1990s. Typically we comment during our Q1 Annual Report on the market. But a discussion of losses cannot but provoke a look at USAA. Are the observations we have made on the whole market consistent with what we see in USAA? Yes, and more so.

In the 20 years USAA has been issuing Res Re securities it has failed to make a recovery until the losses of 2017 and 2018. If we had checked actual ILS vs expected ILS losses at USAA any year before 2017 there would have been wide divergence – expected losses far exceeded recoveries because there

Figure 8



were none. Now, however, that relationship seems to have righted.

Since 2002 USAA has issued 65 separate tranches[5] with an overall expected loss of 2.65% and an average probability of loss 4.82%. Given that the overall issuance was an aggregate limit of $6,641 million, with $1,870 million still-outstanding we would anticipate that losses on the Res Re portfolio would be $210 million (SSST case) to $239 million (WSST case). Separating out the Res Re deals from Table 1 shows a total expected recovery (or conversely actual investor loss) of $333 million. Actual loss exceeds expected loss. In contrast with the whole market, however, the actual exceeds expected by 40%. Incidentally, we employ all the same assumptions as we did in the market analysis so that Figure 8 takes on the same appearance as Figure 1 – it is a microcosm of it – representing 65 Res Re deals rather than 638 deals market-wide. While it is a microcosm, it is not a duplicate of the market as a whole. There is a considerable difference between a 40% divergence and a 7.5% divergence.

We have in the past noted[6] that Res Re deals have over time added more and more causes of loss to the ILS exposures. A brief summary is shown in Table 6. Some of these have simply added geographic zones, others seemingly inconsequential perils – meteor strike, volcanic eruption – but they betoken a trend. Further, they are mostly non-modeled losses. So far, no meteor has struck, and no loss has been detected, but it is possible that other losses have been added that have not been modeled and may be adding to aggregations of loss in small unseen ways.

Table 6

Changes in Structure and Key Terms of Residential Re Issues

	Loss Form	**Peril Determination**
1997	Occurrence	US Gulf, East Coast Hurricane (With Class 3 Event Trigger)
1998	Occurrence	US Gulf, East Coast Hurricane
2003	Occurrence	US Gulf, East Coast, Hawaii Hurricane, US Earthquake
2007	Occurrence	US Gulf, East Coast, Hawaii Hurricane, US Earthquake; Class 3 ex Florida; Classes 4 & 5 have $25million deductible.
2008	Two Classes Occurrence, One Class Aggregate	Class 1 & 2: US Gulf, East Coast, Hawaii Hurricane, US Earthquake; Class 4: also CA Wildfire, US Thunderstorm, Winter Storm
2010-I	Three Classes Occurrence, One Class Aggregate	US Gulf, East Coast, Hawaii Hurricane, US Earthquake, CA Wildfire, US Thunderstorm, Winter Storm
2014-I	Two Classes Aggregate	Added Volcanic and Meteorite
Espada (2016)	Aggregate	Added "Other Natural Perils"
2018-I	Aggregate	No subrogation; added APD

California Wildfire is perhaps prosecution exhibit number 1.

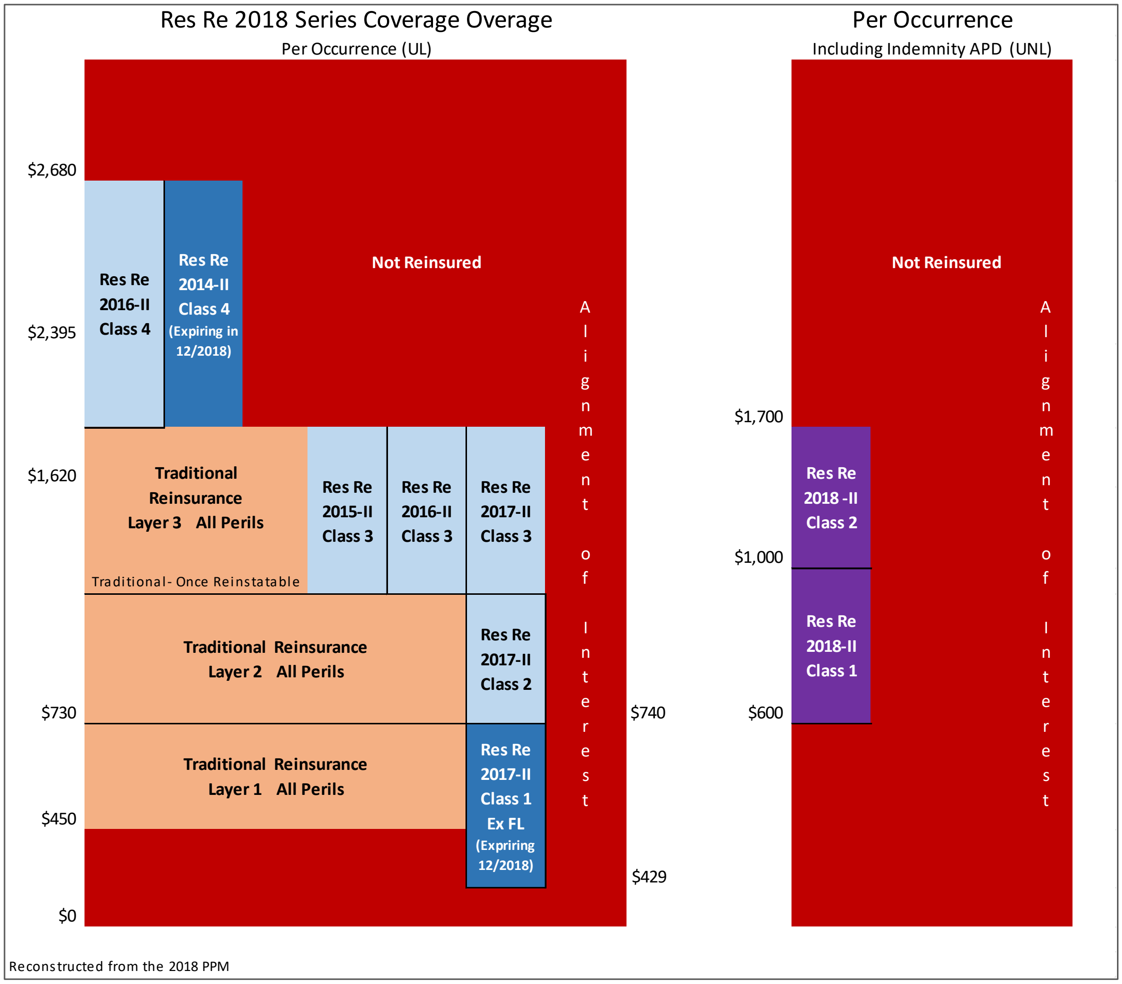
Another example of shifting exposures is illustrated by the specifications accompanying the issue of the Res Re 2018 II issue. The Loss Tower diagram, reconstructed in Figure 9, shows the expiring Res Re 2014 II and Res Re 2017 II issues (dark blue), expiring at the end of 2018. Also, it shows Res Re 2018 I and II (quasi-replacement) issues (purple) which cover a different exposure – it includes APD (Auto Physical Damage) not explicitly covered before.

A final item on our list of Res Re shifts is also telling. It was an item excluded in the PPM beginning in 2018 and then its omission was confirmed later by clarifying press

[5] There has been a total of 71 Res Re issues since inception.

[6] See for example our 2016 Annual Report showing shifting Terms and Conditions on Res Re issues.

Figure 9



Reconstructed from the 2018 PPM

release[7]. USAA will no longer credit bond holders with the benefit of recouping of any losses obtained by subrogation to their ILS loss calculation. This may or may not be small potatoes, but it is, like meteors and their ilk, an expansion of coverage for the benefit of USAA, to the detriment of ILS investors.

Investors have built up confidence in indemnity issues by USAA to the point that they are the biggest issuer of such bonds. And there has been a comforting alignment of interest because USAA is always alongside them on the ceded exposure (see, e.g., Figure 9). Their Loss Tower, disclosed to all investors in the PPM, shows USAA takes part of the risk for the same layers as does the investors. Theoretically, if that aligned risk were reinsured away or retroceded away on USAA's behalf, but not inuring to the benefit of ILS investors, the supposed alignment would no longer exist. This has not happened, risks are still aligned. However, the absence of subrogation benefits to investors is a tiny step in that direction. It is something to put on the watch list along with the addition of more non-modeled losses.

Concluding Remarks

We are, perhaps, trying readers' patience by asking repeatedly the same question after each of a series of recent catastrophic events and coming to the same answer. Essentially, do the models predict the losses we experience? Answer, Yes. However, this is a question that can only be answered over a time horizon – the longer the better – to let the statistics assert themselves. We believe it is a question worth repeating, but answering that question is - we hope we have demonstrated - a non-trivial exercise. The

[7] Reported in Trading Risk January 17, 2019.

analysis gets more, not less intriguing, more, not less revealing.

Among the conclusions we might draw from our analysis are the following. First, in the market as a whole, actual losses are broadly as predicted. In some sectors of the market however, e.g., those associated with Wildfire, there has been a wide divergence. To generalize, investors should be aware of non-modeled perils or less-well-modeled perils in the exposures described. If they find the 7.5% underestimate credible, perhaps they should mentally add that to modeled expectation. However, we caution that our analysis is not final. What we have described as known and actual may change, even the expected calculation could shift. The 7.5% is our present conclusion.

A second conclusion is that there is ample evidence that the market is consistently using WSST numbers in their analysis. Adherence to SSST numbers would dramatically widen divergences. Sea surface temperatures do affect frequency and severity of cat losses. The market is pricing that "climate change" effect into its calculus.

Thirdly, and finally, market commentators are often quick to criticize the modelers after a particular storm or earthquake, usually to say how poor the estimate was. It's true, numbers for any particular event can be hit or miss. But the real question is whether the statistics over time are consistently proving to be true. Tossing a coin once does not lead to a conclusion about bias, tossing it 638 times will be more informative. That should also serve as a caution about our comments on the Res Re issues. There is a wide divergence at present but looking back (refer to Figure 2) that was true of the whole ILS market when it had only issue 65 ILS.