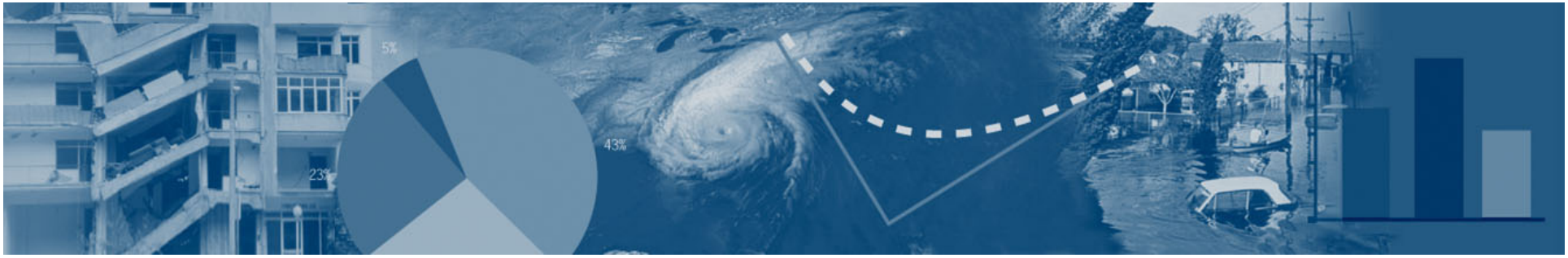


Catastrophe Bond Risk Modelling

Dr. Paul Rockett

Manager, Risk Markets

6th December 2007

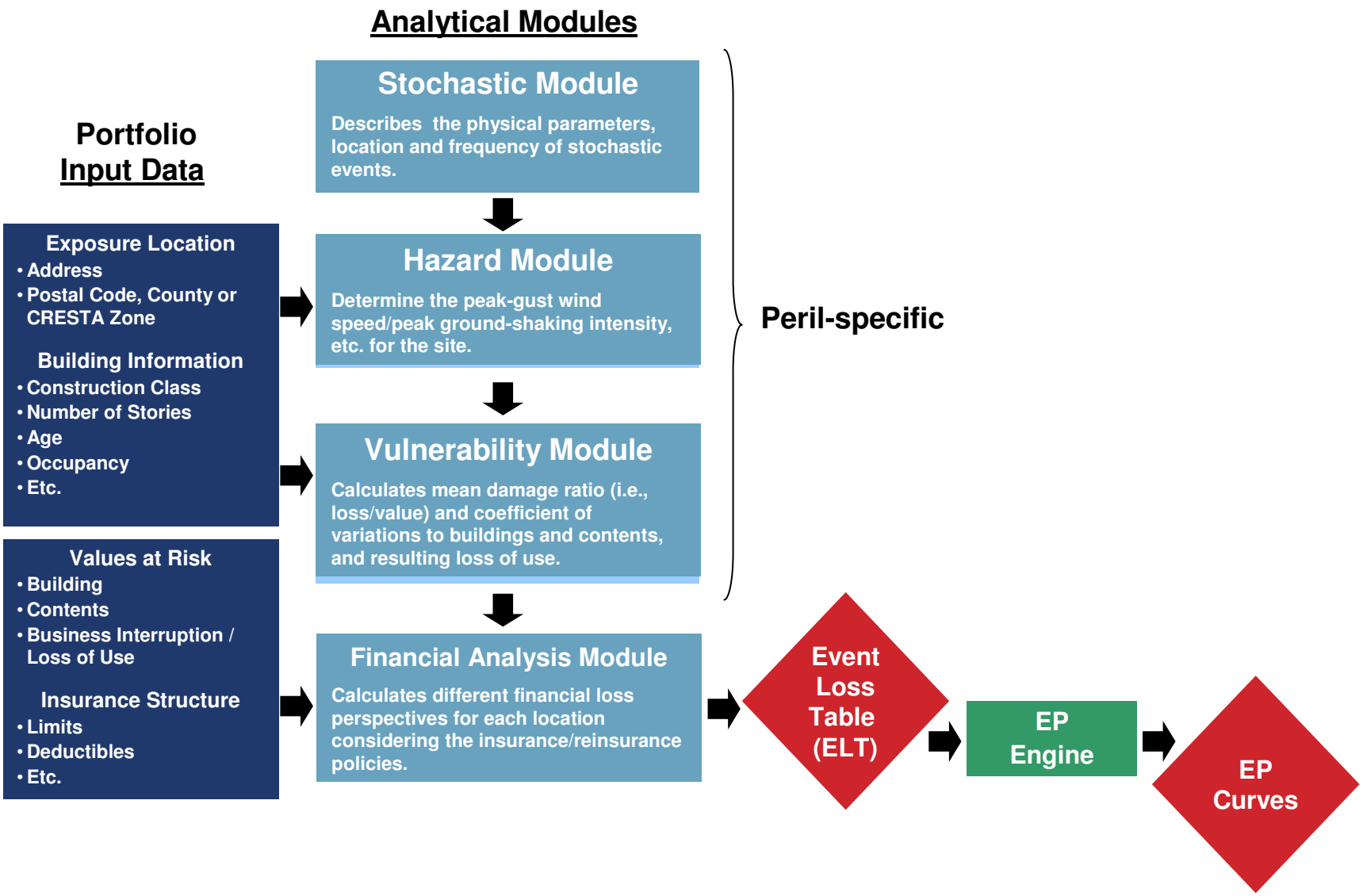
Bringing Science to the Art of Underwriting™

RMS CONSULTING

Agenda

- Natural Catastrophe Modelling
- Index Linked Securities
- Parametric Catastrophe Bonds
- Flood Example: Blue Wings Ltd
- Wind Example: Blue Fin Ltd
- Hurricane Example: WindX
- Catastrophe Model Data Requirements
- Conclusion

Natural Catastrophe Models



Insurance Linked Securities

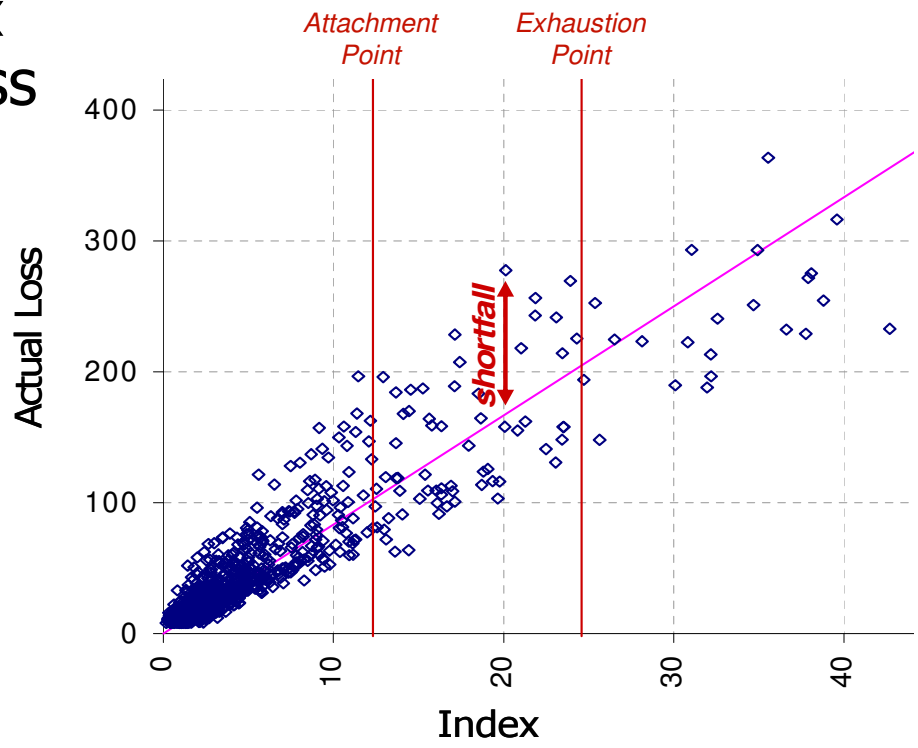
- Indemnity
  - Payment: Actual loss (claims recovery)
  - Priced: Cedant data, Nat Cat Model, full EP curve
- Modelled Loss
  - Payment: Modelled event loss from Cat Model
  - Priced: Cedant data, Nat Cat Model, full EP curve
- Industry Index
  - Payment: Proportion of actual industry loss
  - Priced: Industry data, Nat Cat Model, full EP curve
- Parametric
  - Payment: Depends on event parameters (wind speed etc)
  - Priced: Nat Cat Model, hazard return periods

Parametric Covers

- 1. Model the cedant's input data
- 2. Extract the hazard data by location per event
  - Wind speed, flood depth, pressure/track
- 3. Create a Parametric Index Trigger relating hazard to loss
- 4. Weight according to exposure/vulnerability etc
- Index Formula (Wind):

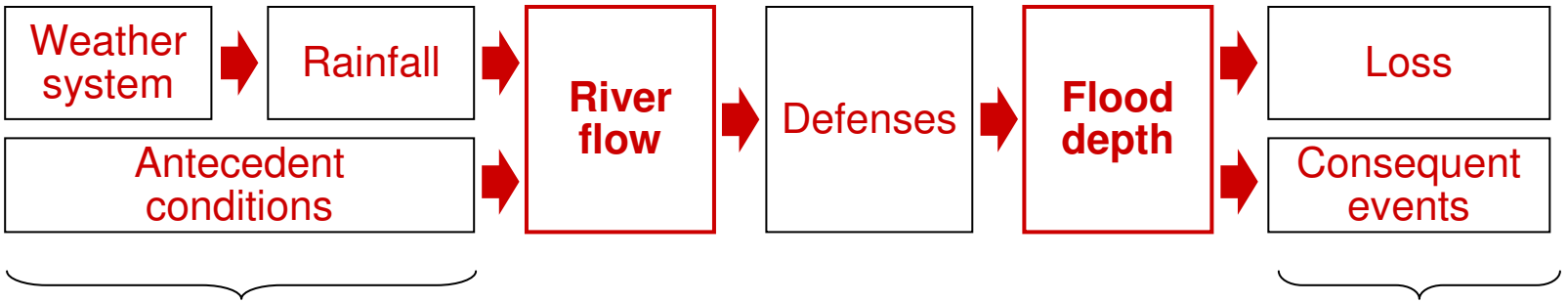
$$I = \sqrt[3]{\sum_{i=1}^{n} w_i \cdot \max(v_i - v_0, 0)^3}$$

- Event Definition



Selecting the Trigger: Blue Wings UK Flood

Loss Event Chain



- Weather system not readily parameterized by published sources
- Rainfall gauges (issues)
- Too far removed from loss due to antecedent conditions and subsequent hazard module random variables.

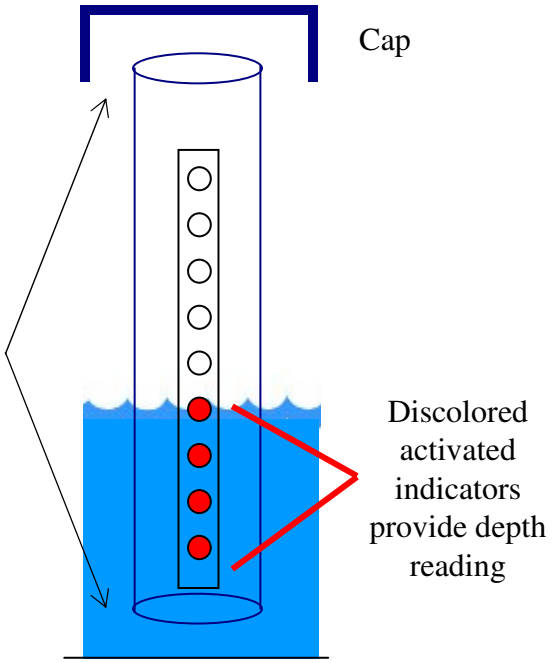
- Defense failure subjective and political

- No PCS-equivalent for industry loss reporting in the UK
- Consequent events not reliably reported, geographically ill-defined, and relationship to loss impossible to model

Measurement Design

How did they know I dropped my phone in the bathtub?

How can we know that the flood was 12 feet deep?



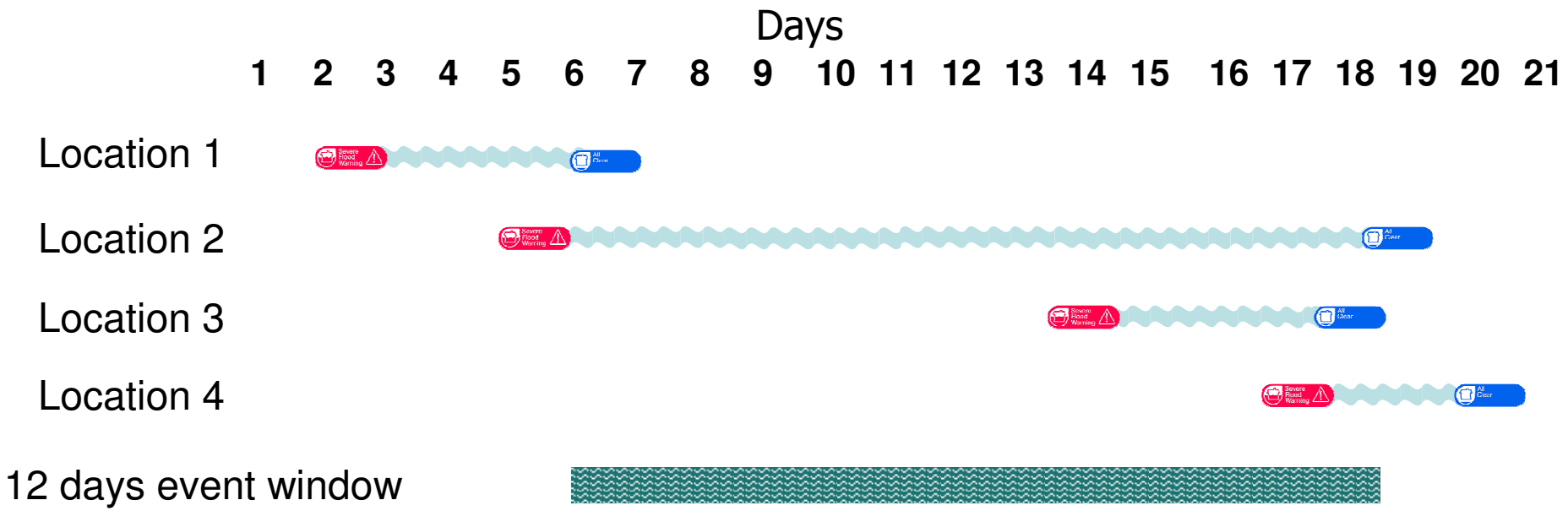
- Technology in use for hydrological applications (and cell phones)
- Require routine servicing
- Low cost (<$500/unit)

Low Tech but Objective and Robust

- Objectivity/impartiality
- Robustness
- Timely data availability
- Historical data for validation
- Simple/transparent event definition and calculation

Event Definition

How do we know when one event ends and another one starts?



First EA/SEPA Severe Flood Warning

All Clear or deemed all clear

Reference Location Flood Period

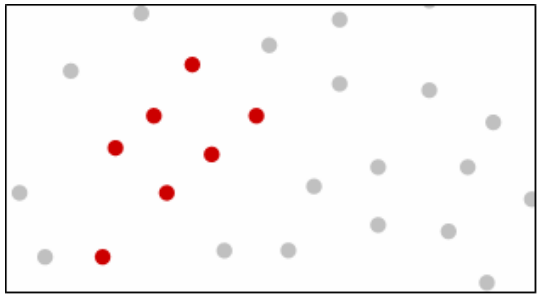
Blue Fin Ltd: European Parametric Wind Bond

- Large insurer with significant European windstorm risk
- Portfolio modelled in RiskLink
- Losses correlated with postcode wind speeds
- Every postcode assigned a weight
- Used WMO coded Meteorological stations; in an event wind speeds smoothed with Barnes algorithm
- Event Definition: Windstorm Core

Blue Fin Ltd: Data Issues

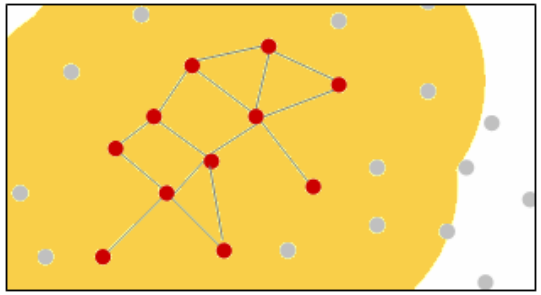
- Event Definition: No official agency names storms
- Calibration of wind speeds to 3-second gust (France)
- Instrument/site corrections
- Each Met Office had to be contracted separately to supply the data following an event
- Historical data expensive

RMS European Windstorm Definition



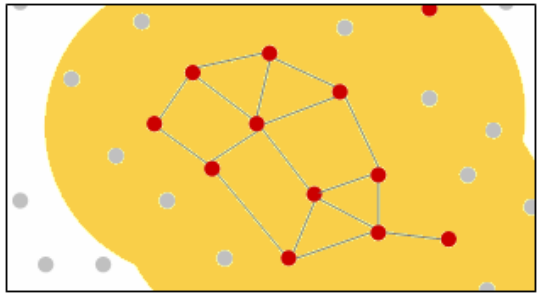
T=0 : First significant wind speed observations

- Windstorm Core requires a single station and four of its neighboring stations to have recorded Peak Wind Speeds above 27m/s
- None formed yet



T=1: The Event Occurrence Time

- The first Windstorm Core forms
- A Windstorm Footprint is defined as the geographic area within a distance of 250km of any station constituting the Windstorm Core



T=2: The Windstorm Core evolves

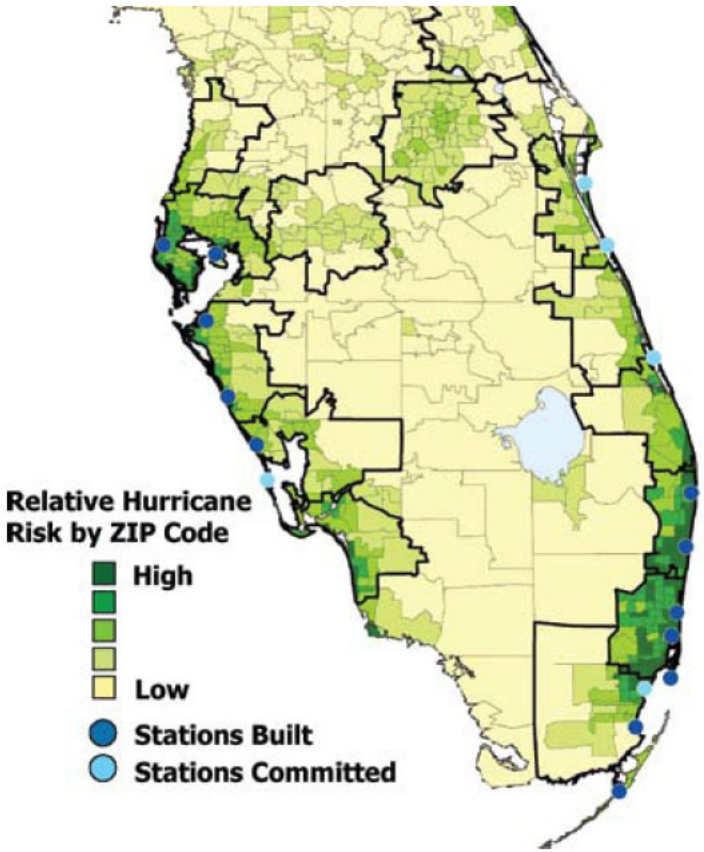
- New stations are included in the Windstorm Core, old ones are excluded, and so the Windstorm Footprint develops

Storm is defined over a period 5-hours before and 6-hours after the last core ends and the highest wind speed in the footprint over that time is included

Windstorm Recording Station, Peak Wind Speed < 27m/s
Windstorm Recording Station, Peak Wind Speed > 27m/s
Windstorm Recording Stations forming a Windstorm Core
Windstorm Footprint

Hurricane – WindX Solution

- Peak gust wind speeds correlate best with damage
- Hurricane force winds typically wreck anemometers (flying debris, malfunction, …)
- Could use track data
  - significant basis risk
- Solution: Erection of expertly sited hardened weather stations with high-tech instruments
- 50 in place for 2008 season
- Event Definition: Named Storm



CAT Model Requirements: Wind

Peril	Observations	Data source	Data improvements	Use at RMS
Europe Windstorm	All parameters	NCEP reanalysis data (e.g. surface temperature to force MM5)	Higher resolution re-analysis e.g. ECMWF ERA40 (at a viable cost)	Model construction
	Surface pressure	NCEP, UKMO, Deutsche Wetterdienst surface pressure maps.	Better availability of station data	Model construction
	Wind (speed and direction)	Real time: WMO (via UKMO), other providers on an ad hoc basis	Faster release of data, consistency in format of data amongst Met Agencies Denser WMO network to better capture complex storm footprint. Less expensive hourly data Improved homogeneity in historical data	Post catastrophe loss estimates
		Historical data: from various Met agencies		Model construction
US Hurricane	Wind (speed and direction)	HURDAT, METAR, C-MAN, FL coastal monitoring, Texas Tech wind Observations, Miami Hurricane Research Division observations	More comprehensive spatial coverage	Model construction, post catastrophe loss estimation
	Sea surface temperature	Observations, IPCC model output	Better coverage, especially subsurface	Model construction, future hurricane rate calculation

CAT Model Requirements: Flood

Peril	Observations	Data source	Data improvements	Use at RMS
Worldwide Flood	Surface Meteorology (including radiation)	GSWP II, NCEP Reanalysis	Higher resolution re-analysis e.g. ECMWF ERA40 at a viable cost	Model forcing
	Observed monthly precipitation	GPCC, CRU	Longer period, higher resolution, more stations	Model forcing
	Observed daily precipitation	National Weather Services		Model forcing
	River discharge data, flood zone, river defence data	National Agencies	Better availability	Model calibration and validation

Conclusion

- Weather based parametric deals have the most direct link to meteorological data
- To be used as a trigger, this data must be
  - Measurable objectively
  - Reliable
  - Very difficult to manipulate
- Have a mechanism to be able to separate events
- All ILS deals are underpinned by catastrophe models
- CAT models have very high data requirements