It's Wrong, But What Is The Risk That It's Right

Risk Mapping in the Communities of Salem Sound, MA

Geoscience Consultants, LLC.
&
Salem Sound Coastwatch

Some Potential Issues With Present SLR/Hazard Maps

- Overstatement of Confidence in Mapping Products
- Choice of 'Scenarios' in Mapping the Future
- Producing Usable/Understandable Outputs
- Time is What We Live In

> Despite warnings from water experts and climate scientists about risks to cities skepticism over sea-level projections and climate-change science has hampered planning efforts at all levels of government, the records showed. (Associated Press, Sunday, May 10, 2015)

A Technique to Help – Risk Mapping

- Outputs in Terms of Uncertainty
- Inclusive of Many 'Scenarios' in Mapping the Future
- Information Provided in Risk of Occurrence (i.e., 1% chance) Through Time

The Take-Away (hopefully): It's **not** This (my) Model; it's the result(s) of The (my) Logic

Coastal Risk Mapping in Salem Sound

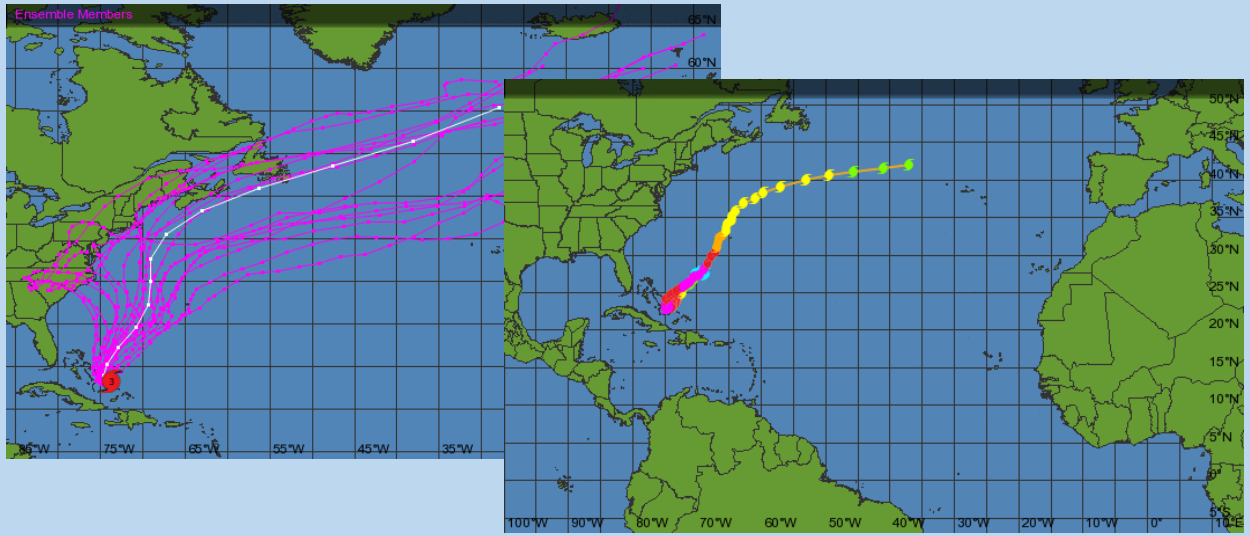
- Multiple Products
  - MHHW (Daily Tidal Flooding)
  - Shallow Coastal Flooding
  - Still Water Surge Flooding
  - Hurricane Flooding
- Model Runs Based on Time
- Data Errors Included
- Includes Multiple Scenarios (SLR & Hurricanes)
- Outputs (Presently) in 10 Year Increments
- Outputs of Risk %; not Water Depths or Wet vs. Dry

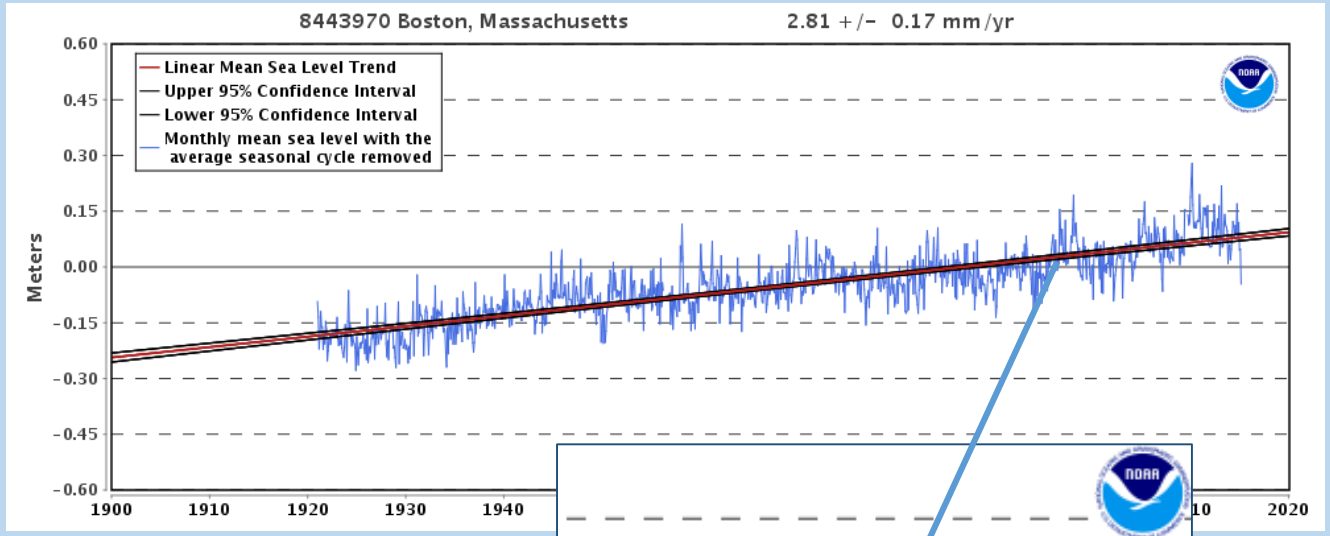
2015

2040

Logic of Process – Populations, Not Scenarios

- Simple Rules
  - No Future/Present Scenario Is Known or Correct
  - No Model of Future Is Correct
  - Don't Pretend They Are
  - Nature and Data Are Noisy
  - Measure/Assess the Error and Noise
- Include Error and Noise in Outputs

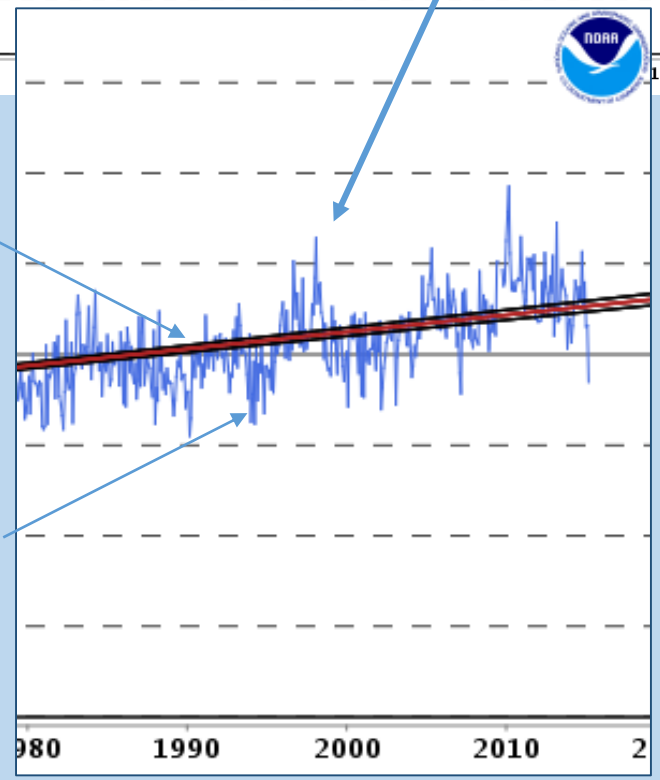




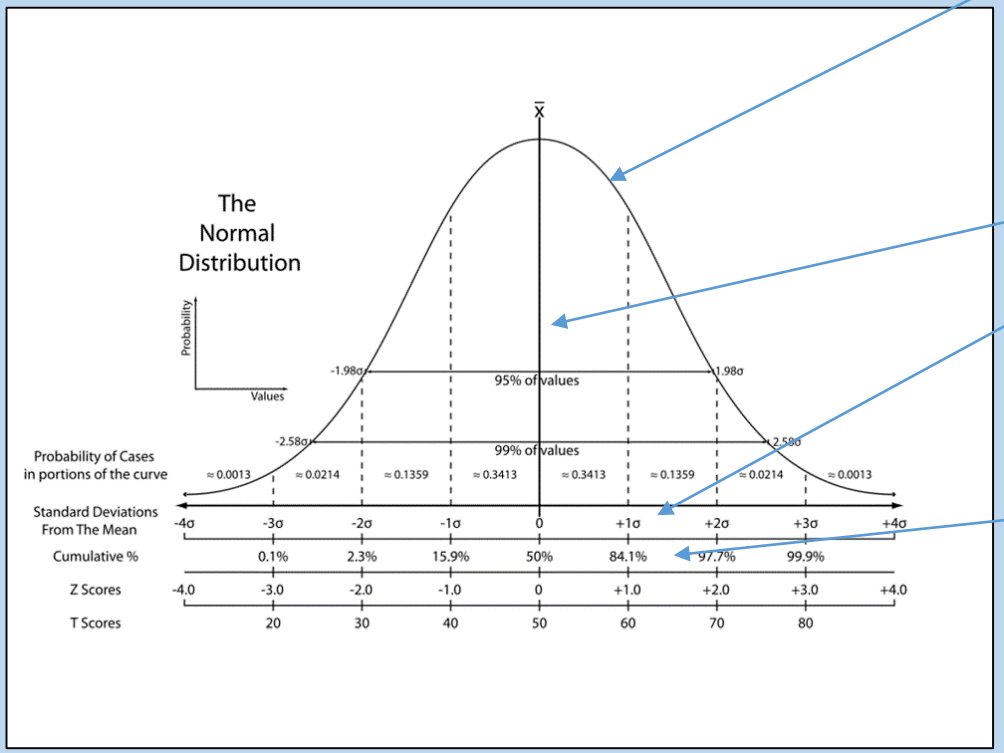
Red is Modeled

Can you Explain the Difference?

Blue is Reality to Citizens



Logic of This Process*



1. Describe the "Bell Curve" and Use Normal Statistics to Map

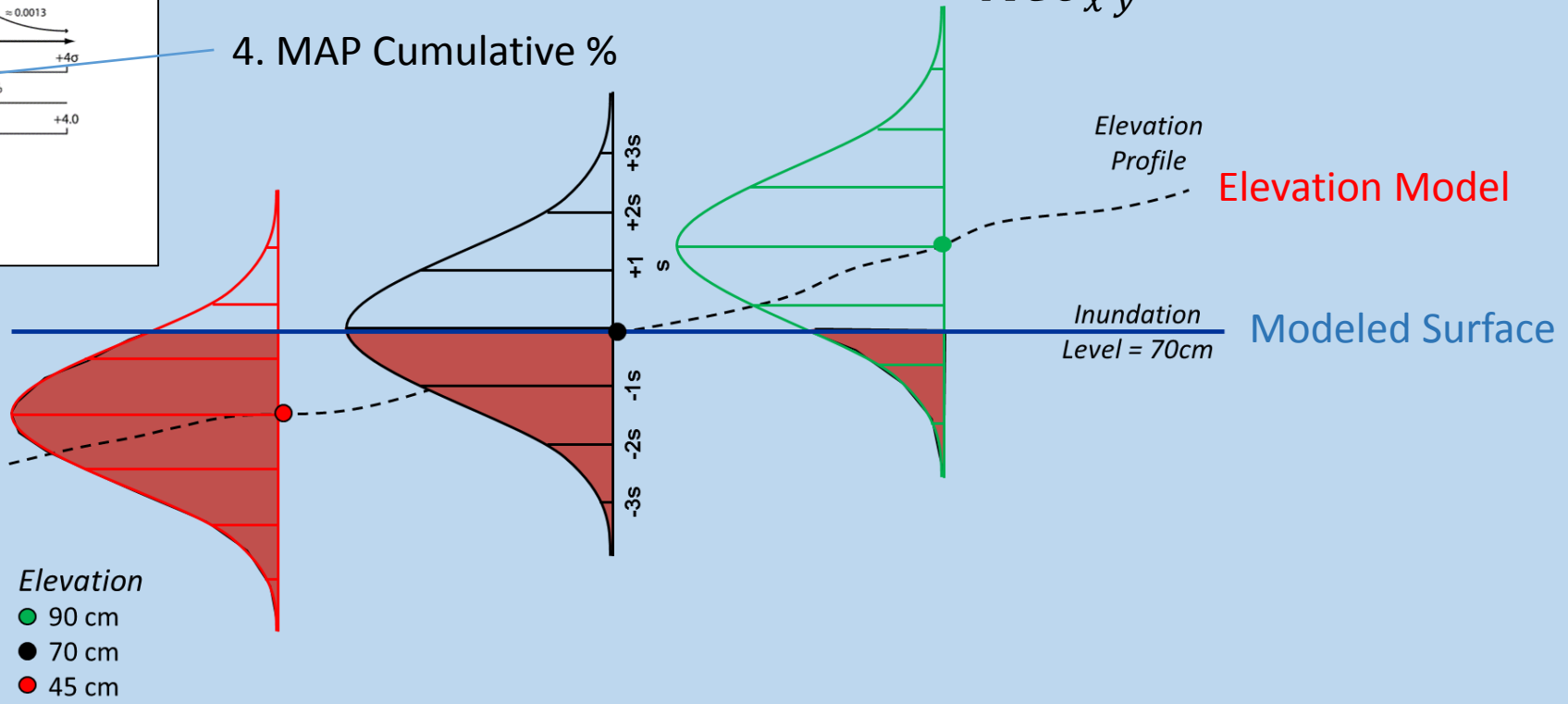
$$\text{MCU (error/noise)} = \sqrt{Lidar^2 + Tidal^2 + SLR^2 + Model\_x^2 + Model\_y^2 \ldots}$$

2. Use Mean values from Model as Modeled Surface and Elevation

3. Find the Standard Score from the Mean

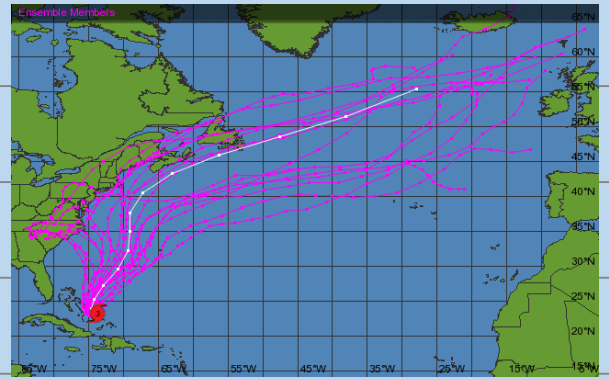
$$Standard\ Score_{x\,y} = \frac{Modeled\ Surface_{x\,y} - Elevation_{x\,y}}{MCU_{x\,y}}$$

4. MAP Cumulative %



*This example based on Natural Phenomena and Elevation being Normally Distributed and Unbiased

Base US SLR Curves and Time – NOAA, 2012



Example: 2050
Mean = 32.6 cm
Std Dev = 23.3 cm

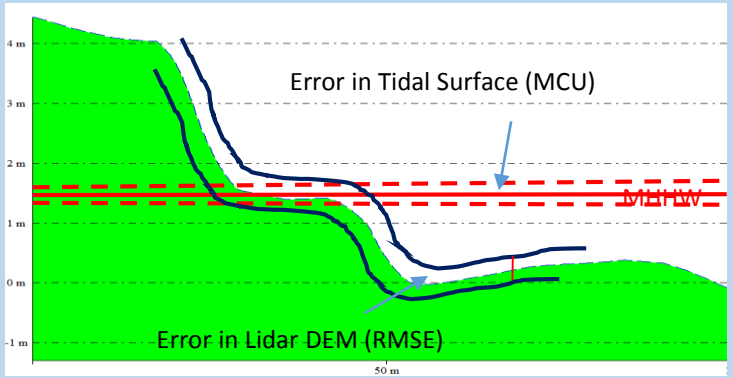
Example: 2100
Mean = 97.2 cm
Std Dev = 80.8 cm

- Large Std Dev values create 'wider' risk mapping zones – highlighting that we are really unsure of what the value will be.
- Smaller Std Dev values create narrow risk zones

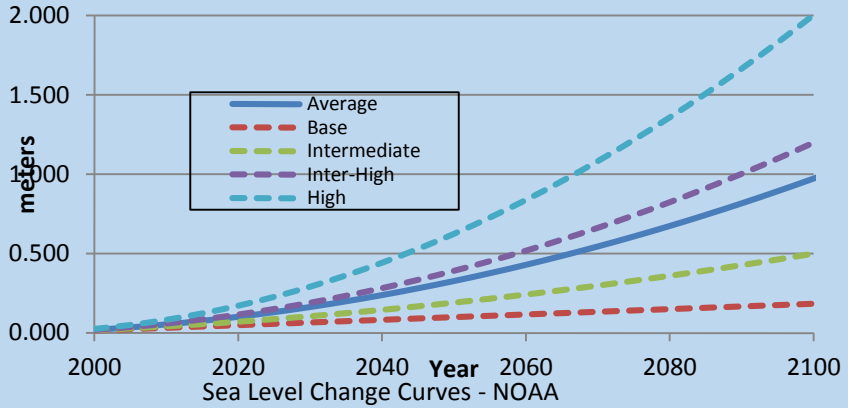
Base SLR curves come from NOAA, 2012 (http://scenarios.globalchange.gov/sites/default/files/NOAA_SLR_r3_0.pdf)

Risk Mapping Product Description & Ingredients

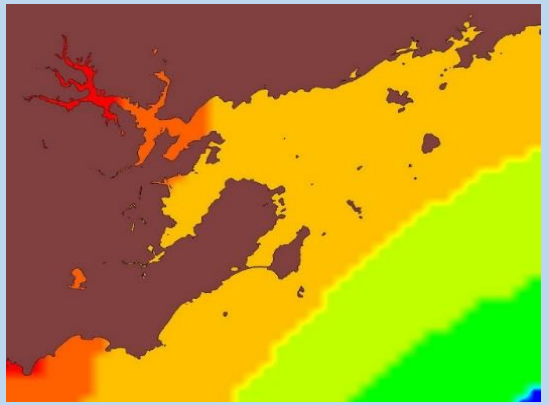
- Products
  - SLR – MHHW; Present to 2100
    - Assumes some link between low areas and ocean levels – very long duration event
    - Highlights habitat changes
  - Shallow Coastal Flooding – Present to 2100
    - Assumes no link between low areas and ocean levels – very short duration events
    - Leading edge of "un-livability" – occurring more than 3 times a year (but has been in the News lately)
  - Storm Surge (Still Water) – Present to 2100
    - Assumes no link between low areas and ocean levels – very short duration events
    - Yearly Risk values (likelihood of being inundated in one year period)- Similar to FEMA
  - Hurricane Surge (SLOSH) – Present to 2040 (Very High Uncertainty)
    - Assumes no link between low areas and ocean levels – very short duration events
    - Very rare events – helpful for Emergency Planning



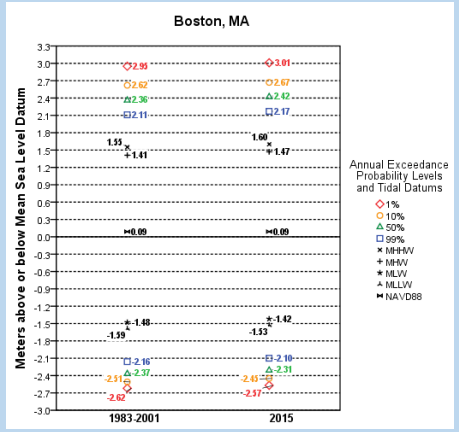
Time Zero Data



Sea Level Change Curves - NOAA

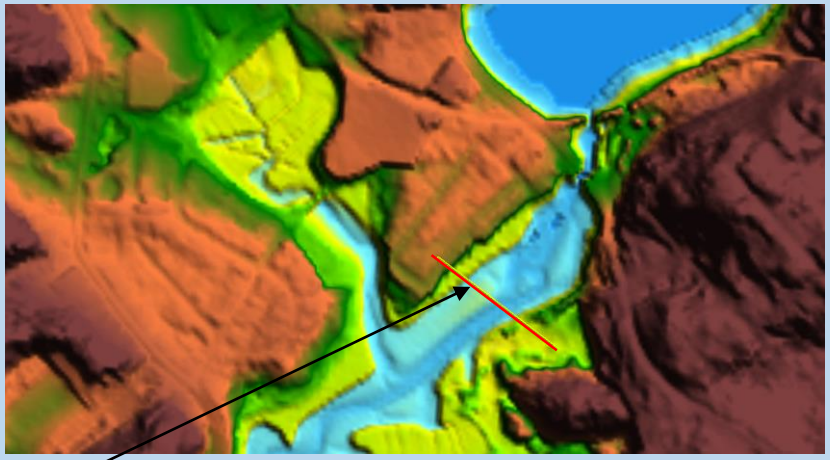


Hurricane Surge



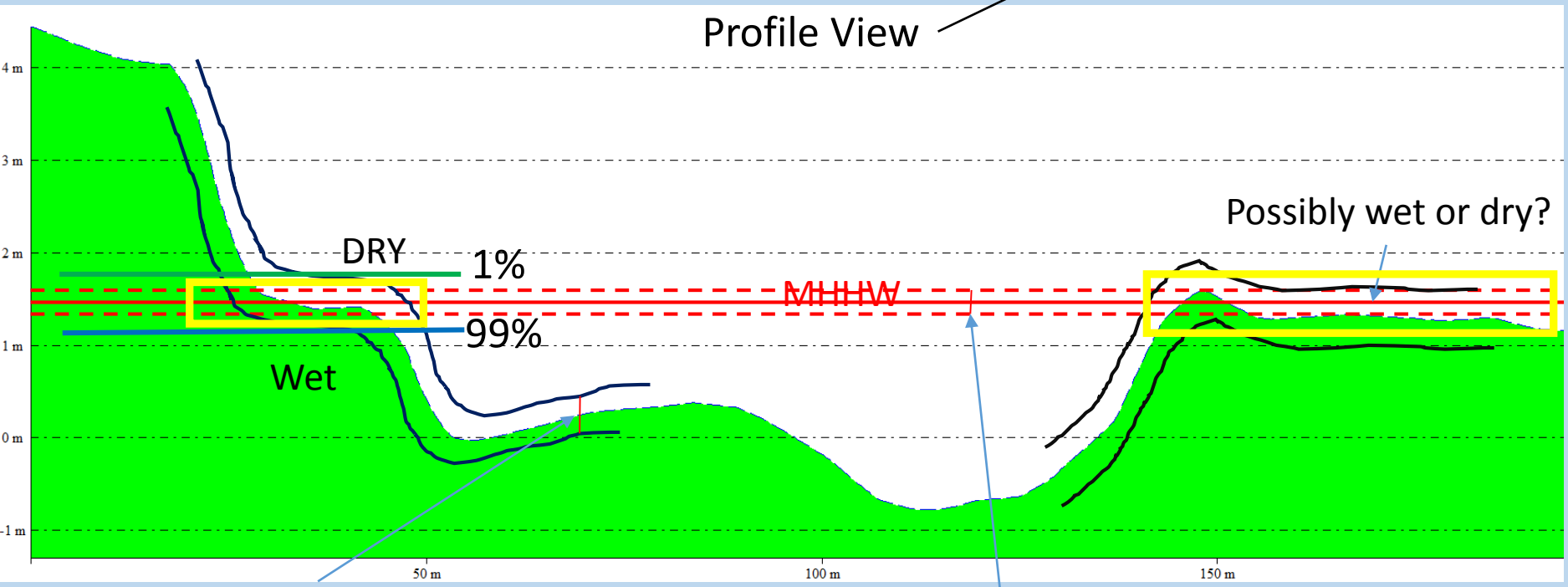
Still Water Historical Surge Data

Inundation Risk % Factors – Simple Present Day Case



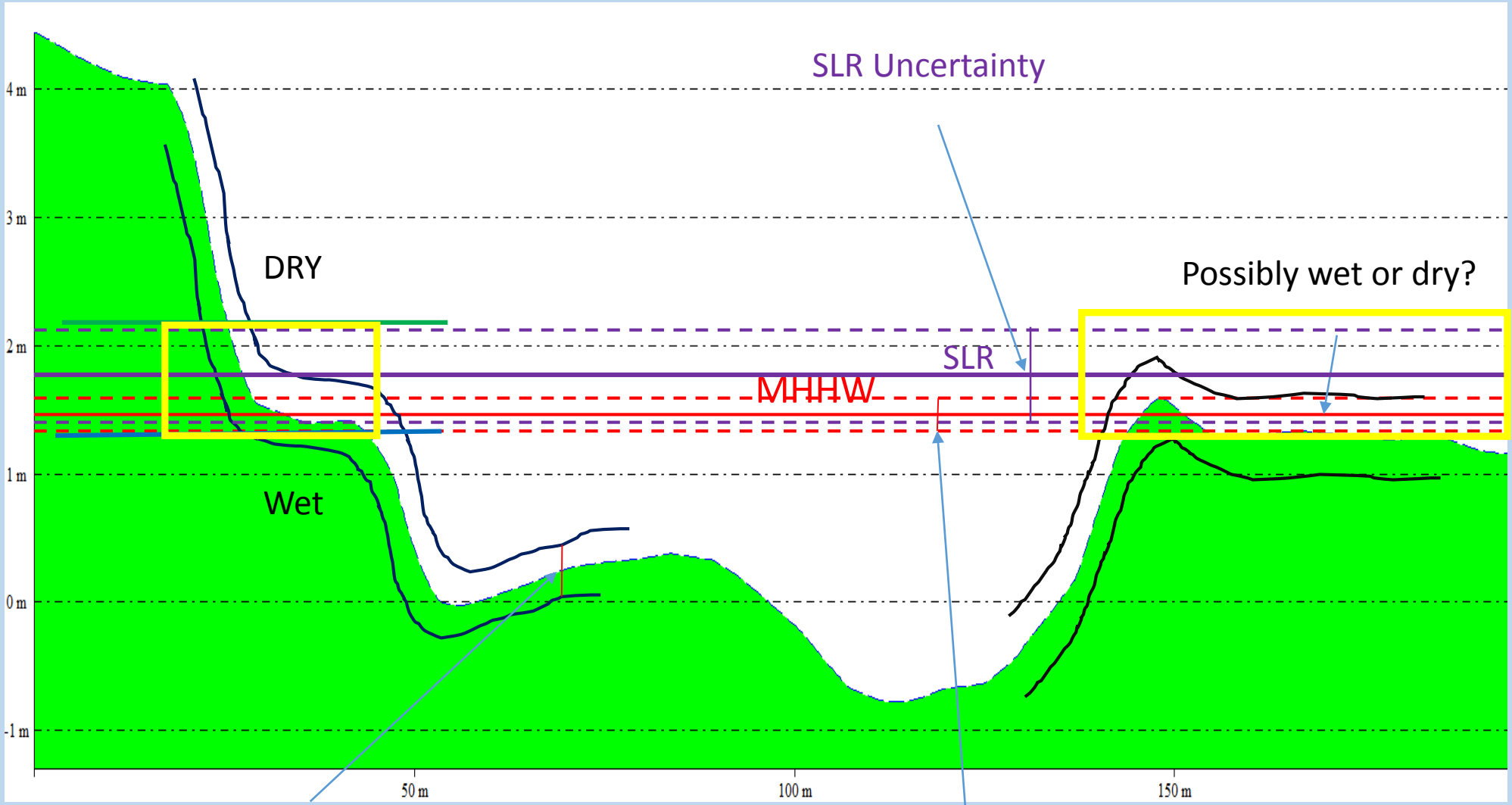
DEFINITION of 'Risk' (Investopedia)

The chance that an investment's actual return will be different than expected. Different versions of risk are usually measured by calculating the standard deviation of the historical returns or average returns of a specific investment. A high standard deviation indicates a high degree of risk.



- Use the error information along with the data to assess risk
- Risk is highlighted in areas (yellow boxes) where errors/natural variation make a high chance that the actual return will be different from the expected
- Below 99% we have low risk that the expected outcome will be 'Wet'
- Above 1% we have low risk that the expected outcome will be 'Dry'

Adding SLR – A Bit More Complex (to show anyway)

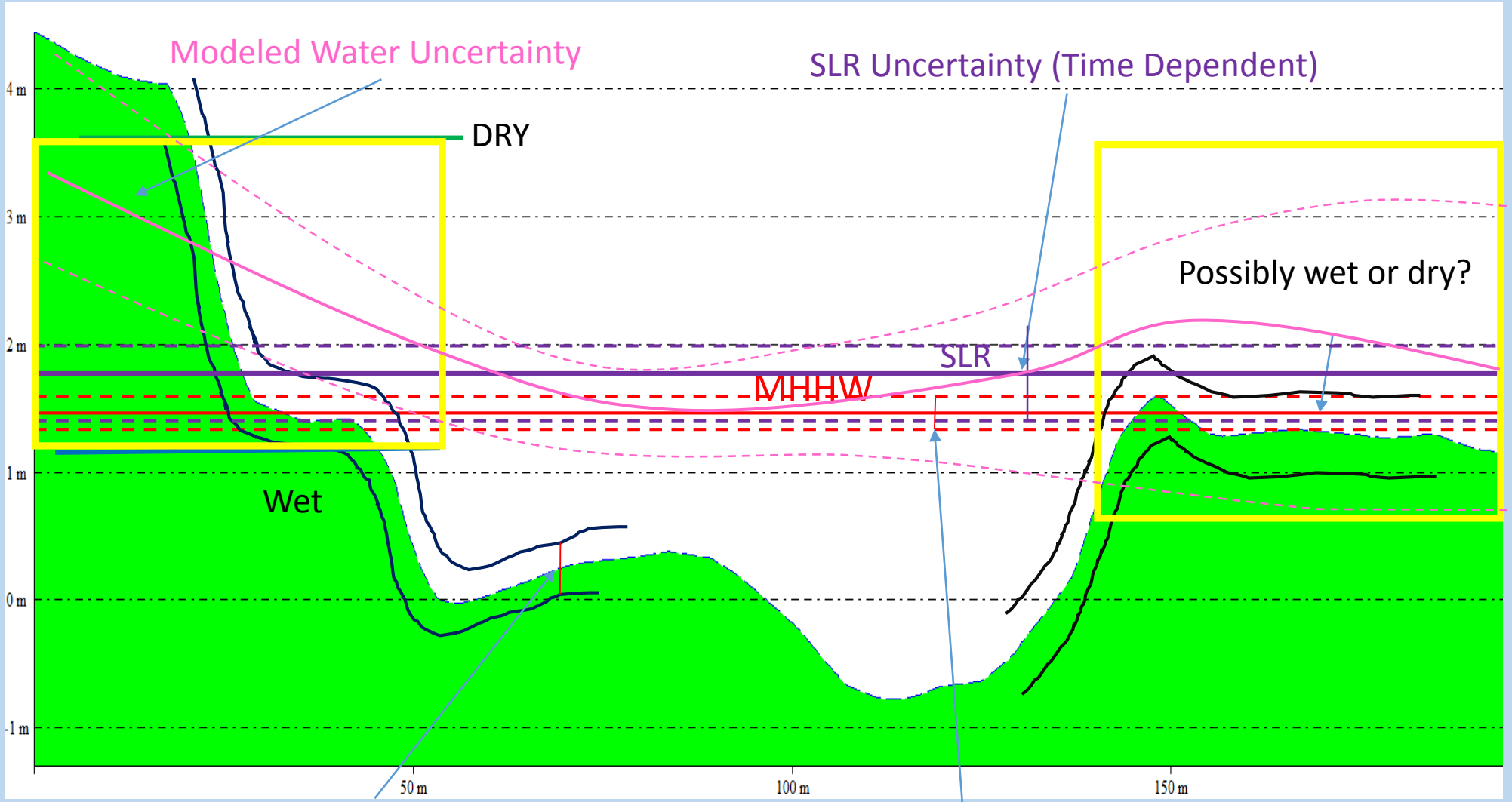


Increased Height of Yellow Boxes

Error in Lidar DEM (RMSE)

Error in Tidal Surface (MCU)

Adding Modeled Water Surface (SLOSH or Surge) – A bit of spaghetti, Sorry

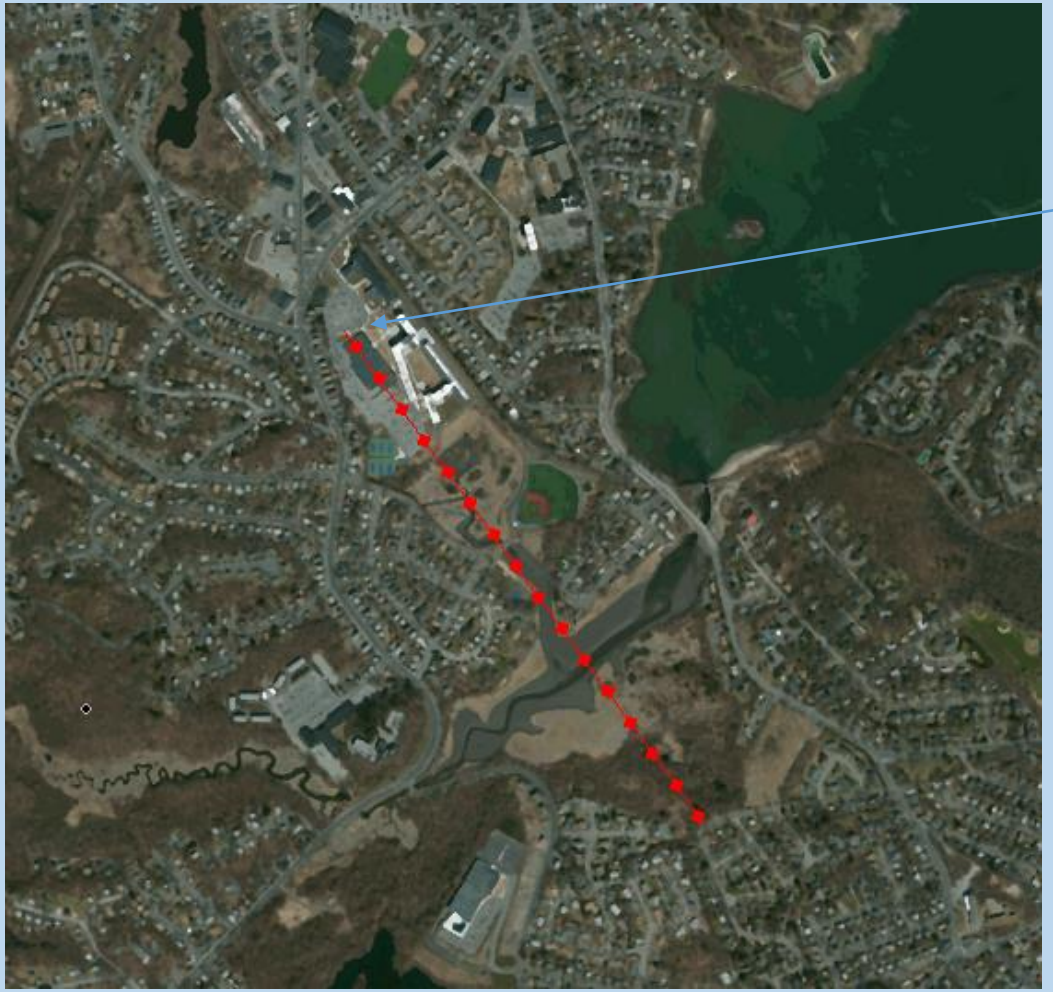


Yellow Boxes vary in Height Spatially and thus Width on a map

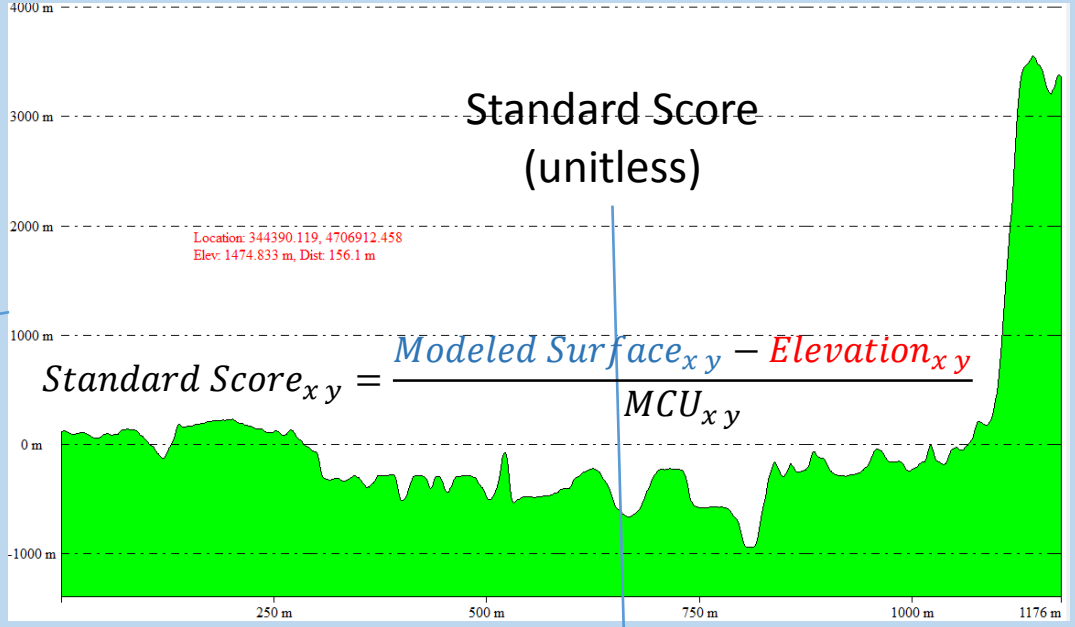
Error in Lidar DEM (RMSE) – Time Dependent

Error in Tidal Surface (MCU)

Process – Conversion of Yellow Boxes to Outputs



NW

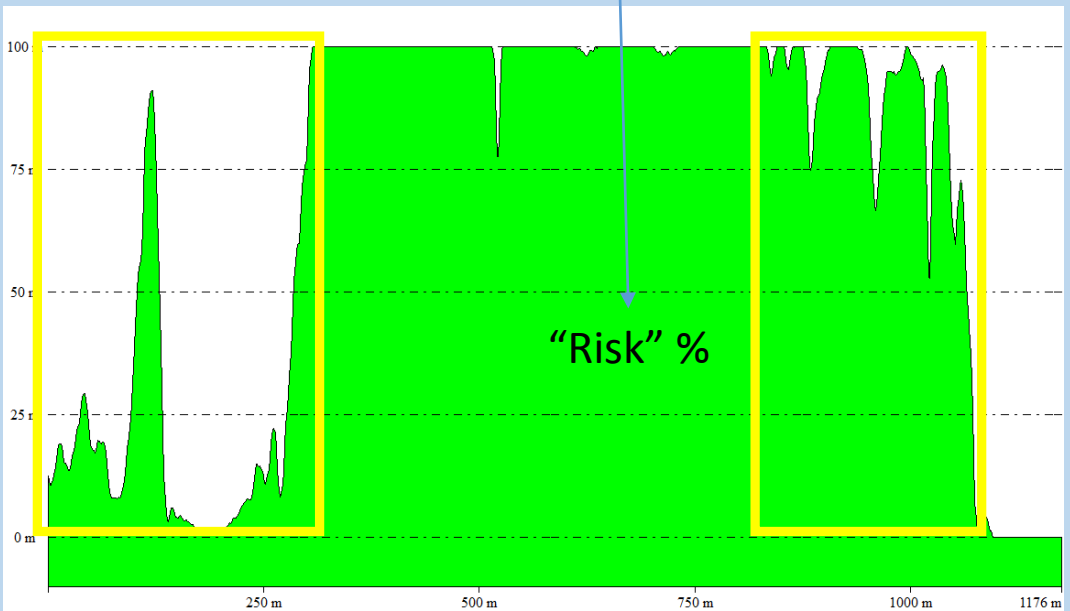


SE

Standard Score
(unitless)

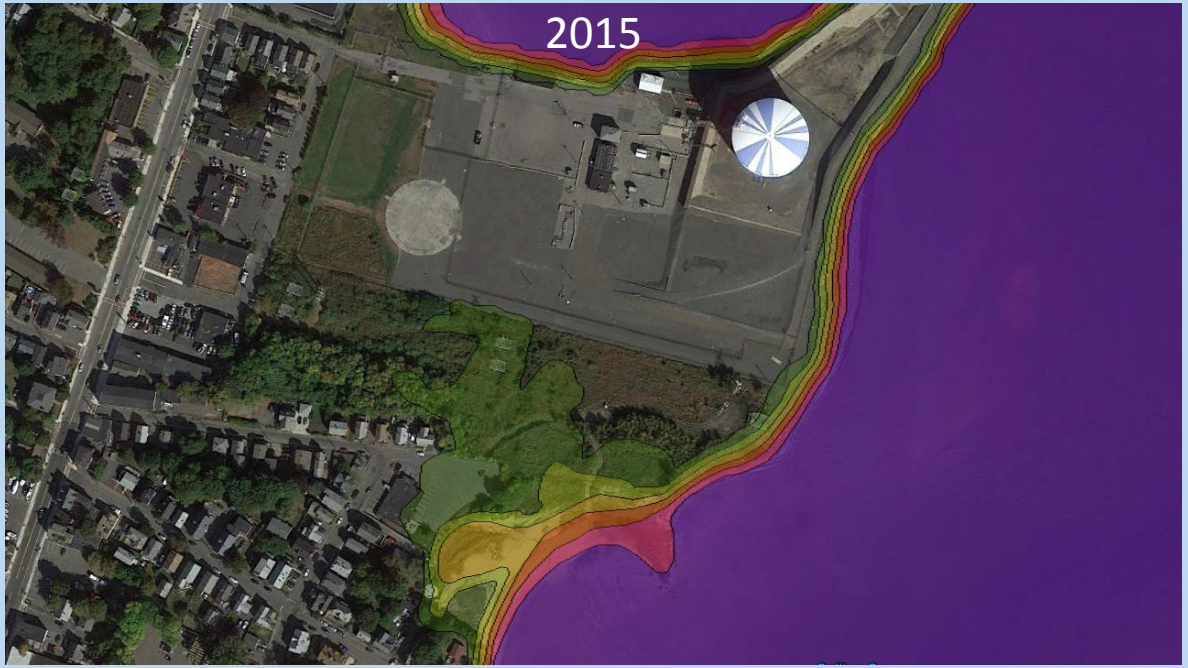
$$Standard\ Score_{x\,y} = \frac{Modeled\ Surface_{x\,y} - Elevation_{x\,y}}{MCU_{x\,y}}$$

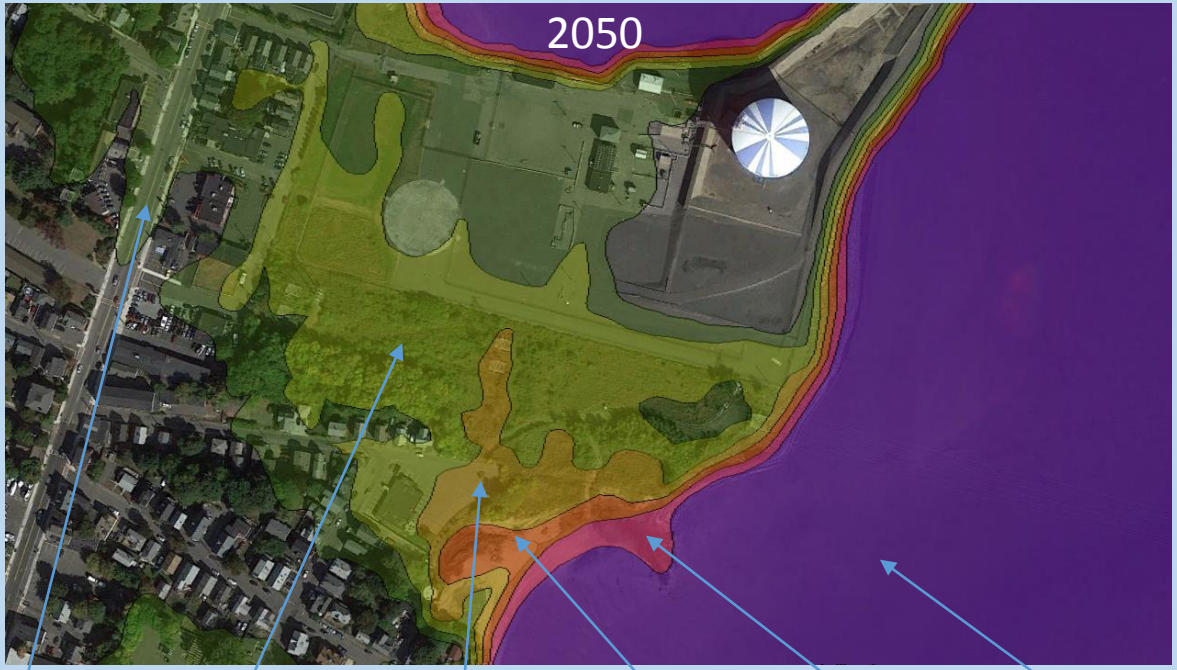
<Conversion>



"Risk" %

Example Outputs – MHHW





1% Highly Unlikely

10% Unlikely

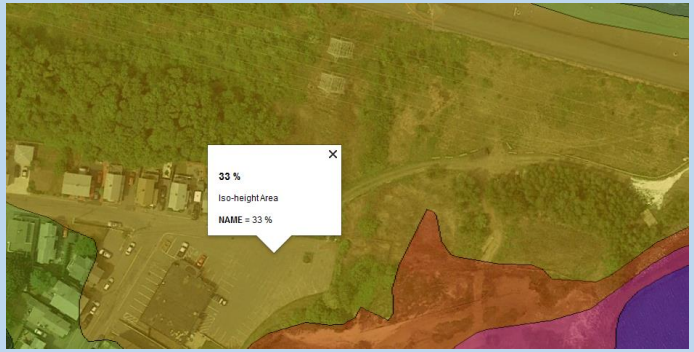
33% As Likely as Not

66% Likely

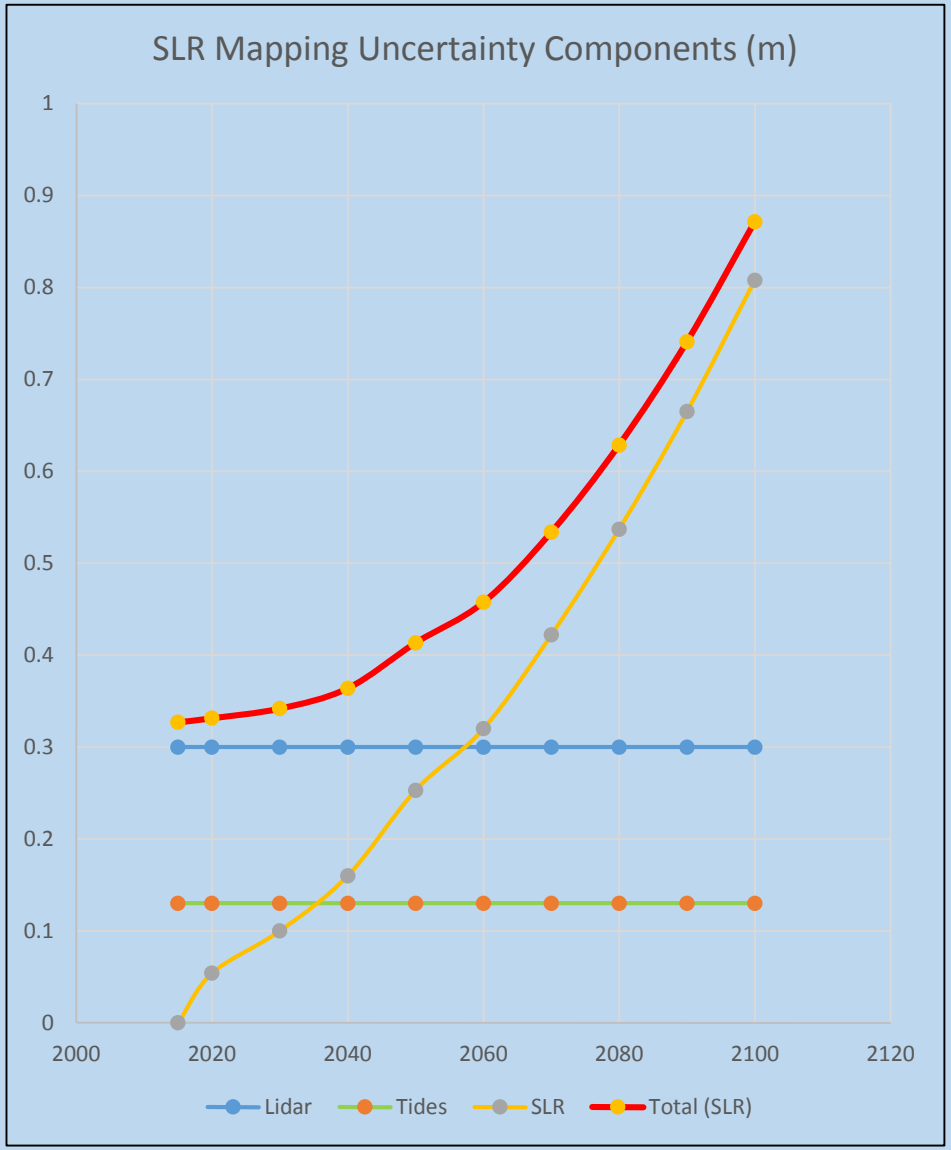
90% Very Likely

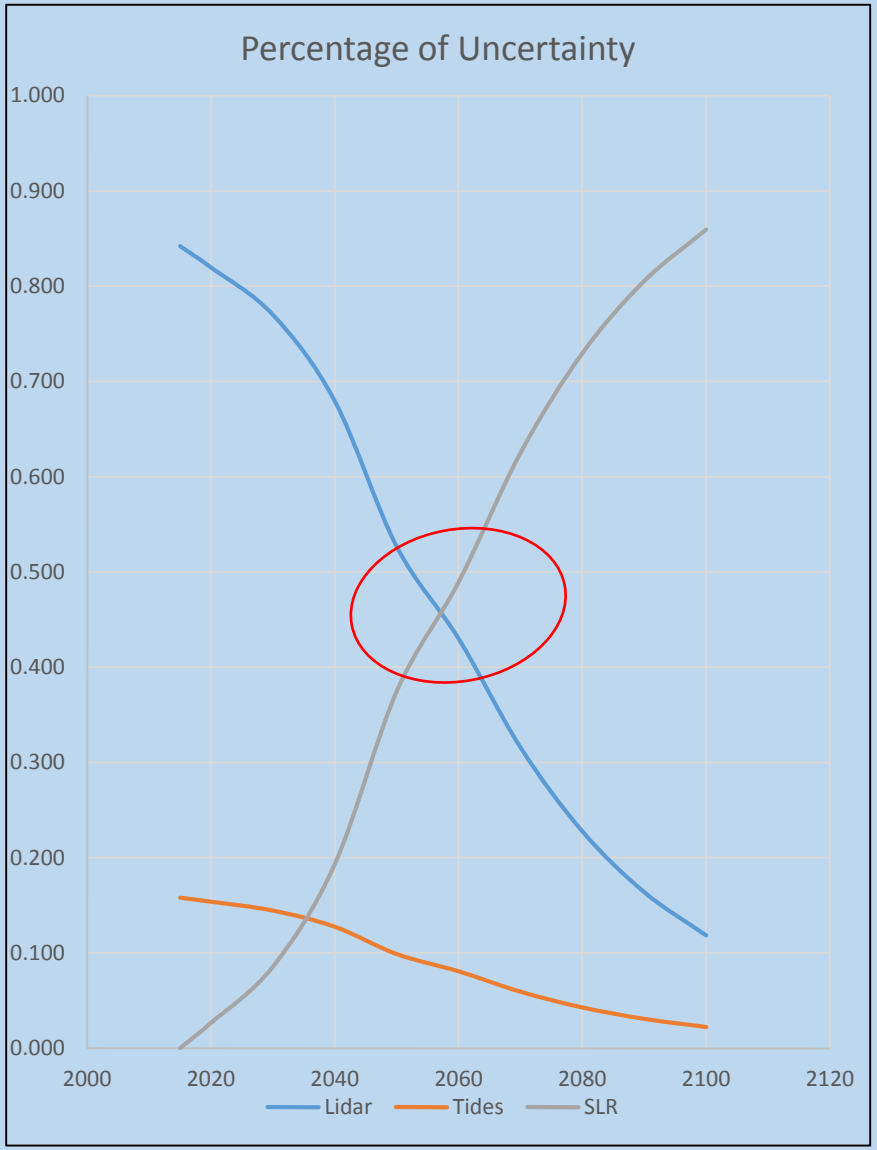
99% Certain

- Maps Color Coded for Risk, not water depths
- KMZ products are clickable for Risk%
- Risk can be described in IPCC terms for ‘likeliness’
- 33% Risk zone is where most decisions will probably need to be made
- Maps of present and future conditions



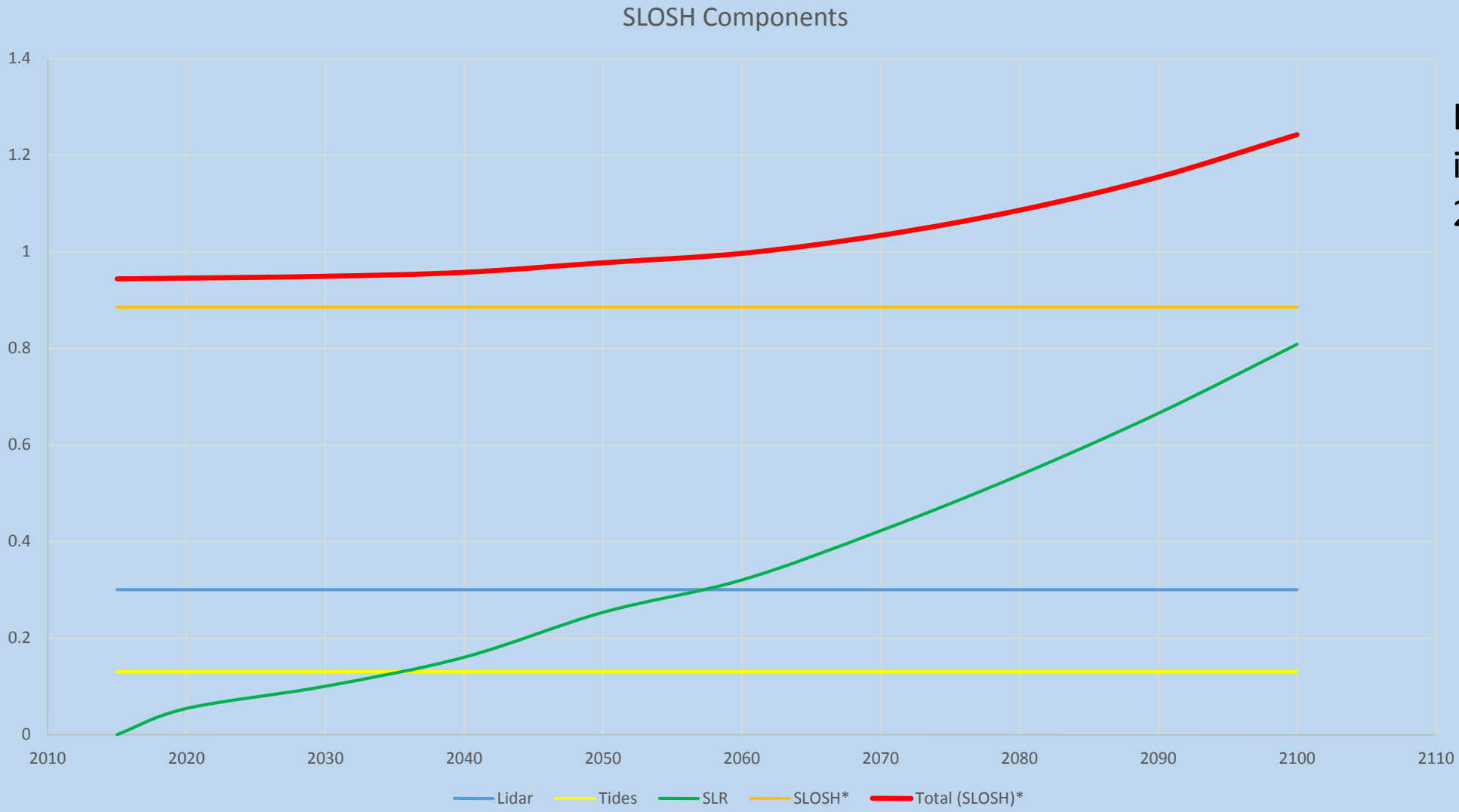
A Note on Uncertainty Components Through Time





- SLR Drives the Uncertainty Bus after around 2060
- Values based on RMSE/MCU of typical surface data products (time not added – big unknown?)
- Sure we can map SLR at 2100 but should we? (Queue Next Slide)

My SLOSH Model Uncertainty (meters)



For this model with high initial uncertainty, maybe 2100 is fine

Take Aways for Planning Level Models (hopefully)

- Time is A Big Variable
- Be Honest – Your Models Have Limitations
- Be Inclusive – You're Answer or Scenario is Wrong Anyway
- It's Not Really the Model – It's the Results of the Logic
- Spend Time on Presentation/Outreach – People Make Changes Not Models
  - THANKS SALEM SOUND COASTWATCH!

SLR 2100* (~1m)
Risk vs Deterministic

* Yeah I am a hypocrite, I am human I guess