Risk based adaptation of infrastructures to floods and storm surges induced by climate change.

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Strategic Research and Innovation – DNV GL

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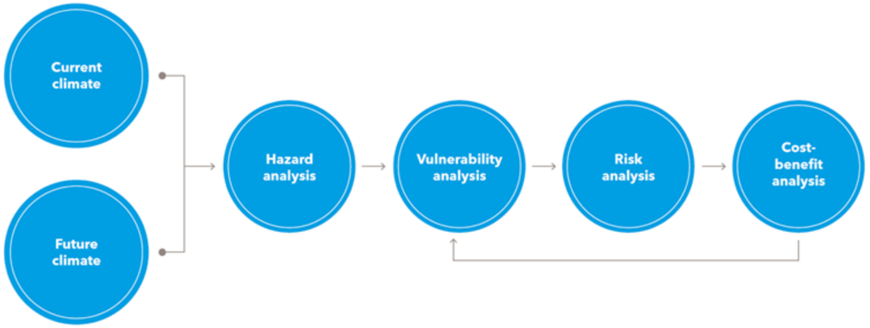
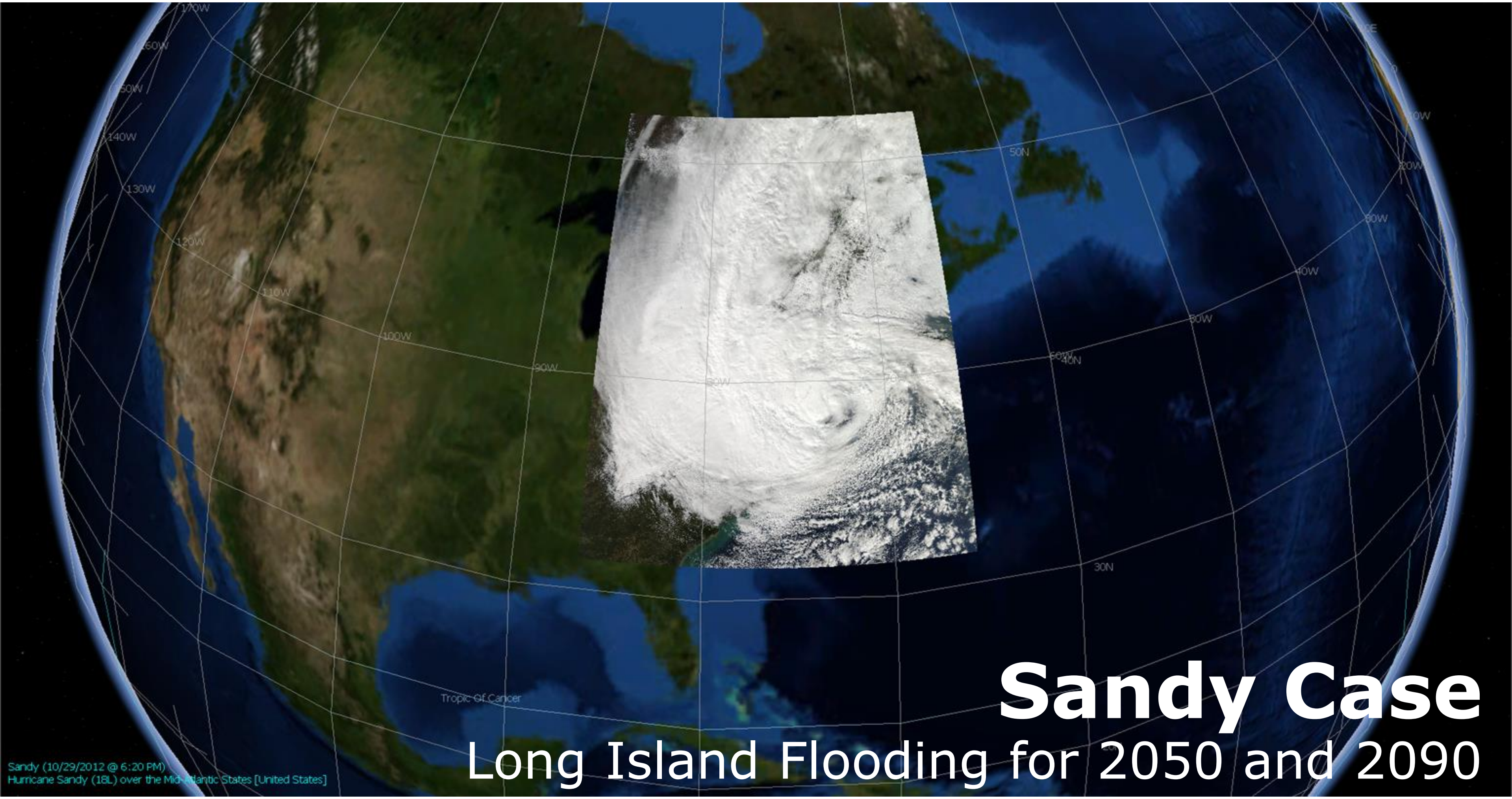
DNV GL Research & Innovation – Climate Change Adaptation Program

Our goal at DNV GL Research & Innovation is to enable business and society to adapt to risks shaped by present and future climate. We are applying our risk assessment framework to help decision makers understand how to better manage climate risks.



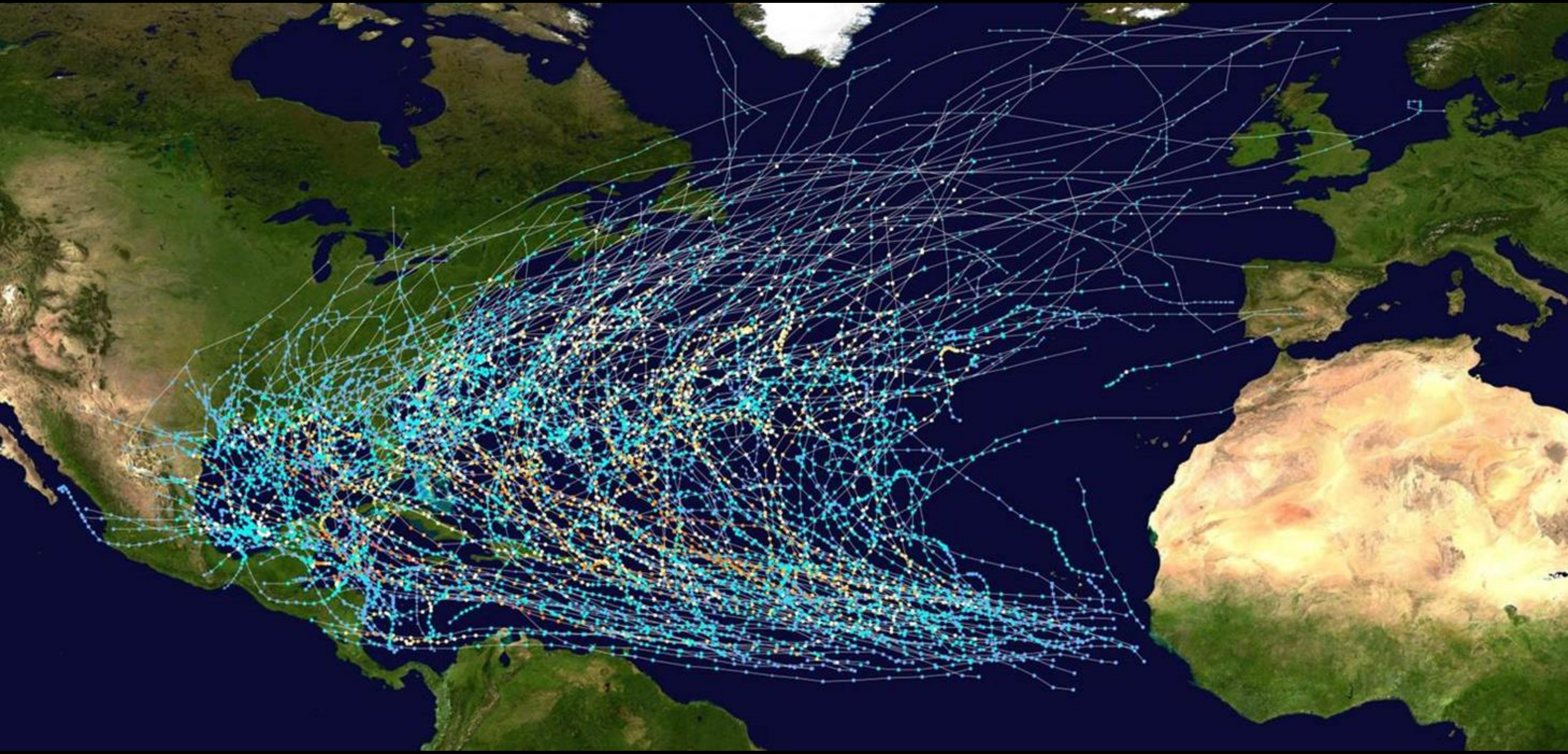
http://www.dnvgl.com/technology-innovation/strategic-projects/climate-adaptation/


SELECTED EXTREME
WEATHER EVENTS
2012 - 2013



Sandy Case

Long Island Flooding for 2050 and 2090



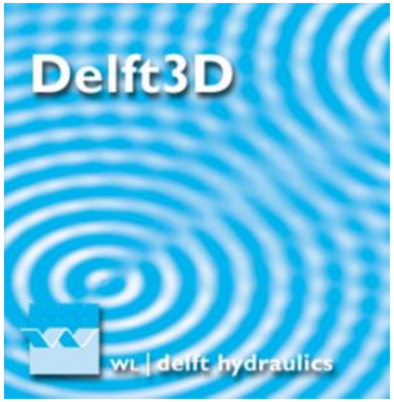
Storm Surge Model – DELFT 3D

Governing equations:

- Continuity equation

$$\frac{\partial \zeta}{\partial t} + \frac{1}{\sqrt{G_{\xi\xi}}\sqrt{G_{\eta\eta}}}\frac{\partial\left[(d+\zeta)U\sqrt{G_{\eta\eta}}\right]}{\partial \xi} + \frac{1}{\sqrt{G_{\xi\xi}}\sqrt{G_{\eta\eta}}}\frac{\partial\left[(d+\zeta)V\sqrt{G_{\xi\xi}}\right]}{\partial \eta} = Q$$

where ζ is the water level above some horizontal plane of reference, t is the time factor, $G\xi\xi$ and $G\eta\eta$ are the coefficients used to transform curvilinear to rectangular co-ordinates, d is the depth below some horizontal plane of reference, U and V are the depth-averaged velocities in ξ- and η-direction respectively and with Q representing the contributions per unit area due to the discharge or withdrawal of water, precipitation and evaporation.

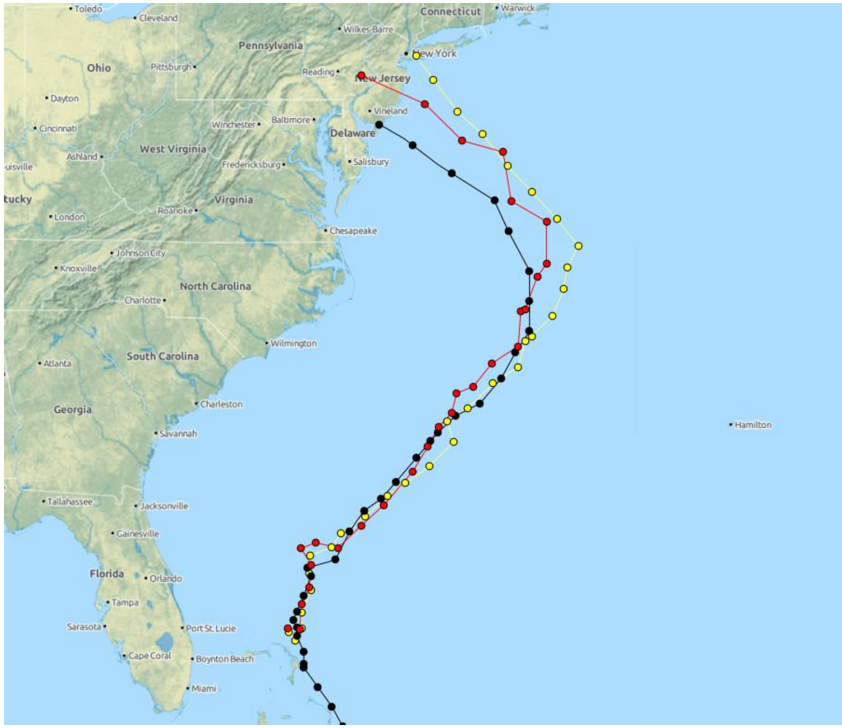


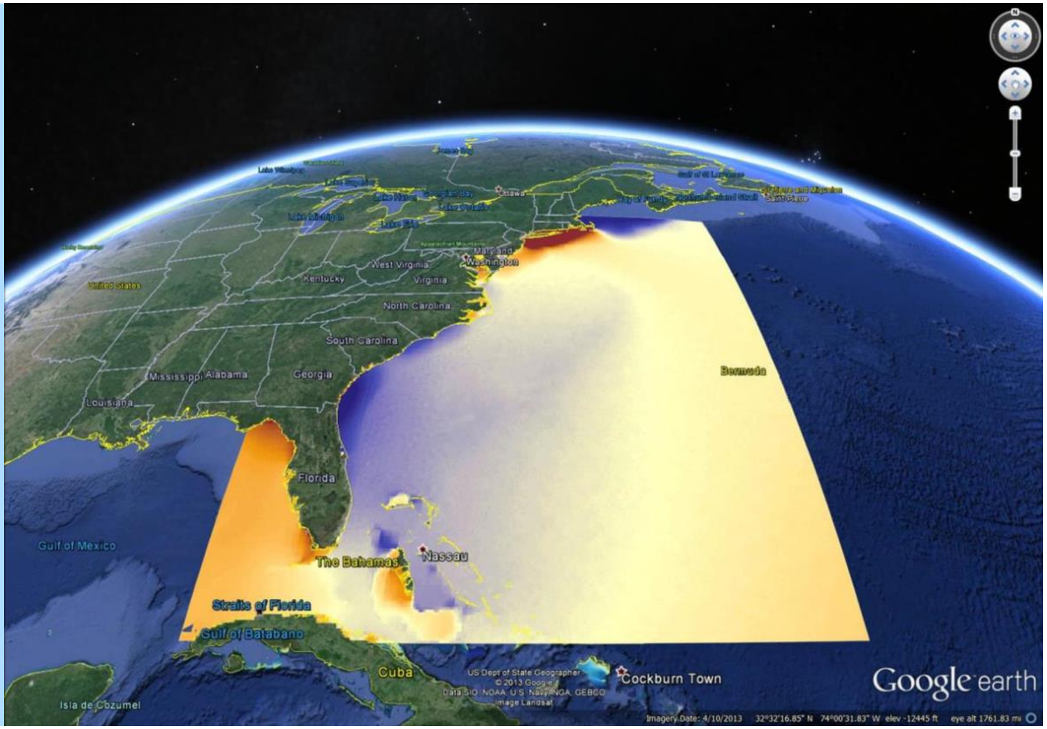
$$\frac{\partial u}{\partial t} + \frac{u}{\sqrt{G_{\xi\xi}}}\frac{\partial u}{\partial \xi} + \frac{v}{\sqrt{G_{\eta\eta}}}\frac{\partial u}{\partial \eta} + \frac{\omega}{d+\zeta}\frac{\partial u}{\partial \sigma} - \frac{v^2}{\sqrt{G_{\xi\xi}}\sqrt{G_{\eta\eta}}}\frac{\partial\sqrt{G_{\eta\eta}}}{\partial \xi} +$$
$$+ \frac{uv}{\sqrt{G_{\xi\xi}}\sqrt{G_{\eta\eta}}}\frac{\partial\sqrt{G_{\xi\xi}}}{\partial \eta} - fv = -\frac{1}{\rho_0\sqrt{G_{\xi\xi}}}P_\xi + F_\xi + \frac{1}{(d+\zeta)^2}\frac{\partial}{\partial \sigma}\left(\nu_V\frac{\partial u}{\partial \sigma}\right) + M_\xi$$

$$\frac{\partial v}{\partial t} + \frac{u}{\sqrt{G_{\xi\xi}}}\frac{\partial v}{\partial \xi} + \frac{v}{\sqrt{G_{\eta\eta}}}\frac{\partial v}{\partial \eta} + \frac{\omega}{d+\zeta}\frac{\partial v}{\partial \sigma} + \frac{uv}{\sqrt{G_{\xi\xi}}\sqrt{G_{\eta\eta}}}\frac{\partial\sqrt{G_{\eta\eta}}}{\partial \xi} +$$
$$- \frac{u^2}{\sqrt{G_{\xi\xi}}\sqrt{G_{\eta\eta}}}\frac{\partial\sqrt{G_{\xi\xi}}}{\partial \eta} + fu = -\frac{1}{\rho_0\sqrt{G_{\eta\eta}}}P_\eta + F_\eta + \frac{1}{(d+\zeta)^2}\frac{\partial}{\partial \sigma}\left(\nu_V\frac{\partial v}{\partial \sigma}\right) + M_\eta$$

where u, v and w are the flow velocities in the ξ -, η - and z-direction respectively, f is the Coriolis parameter, ρ_0 is the reference density of water, $P\xi$ and $P\eta$ is the gradient hydrostatic pressure in ξ- and η-direction respectively, $F\xi$ and $F\eta$ is the turbulent momentum flux in ξ- and η -direction respectively, ν_V is the vertical eddy viscosity coefficient and $M\xi$ and $M\eta$ are the sources and sinks in ξ - and η -direction respectively.

Tracks and Storm Surge for 2012 – 2050 - 2090





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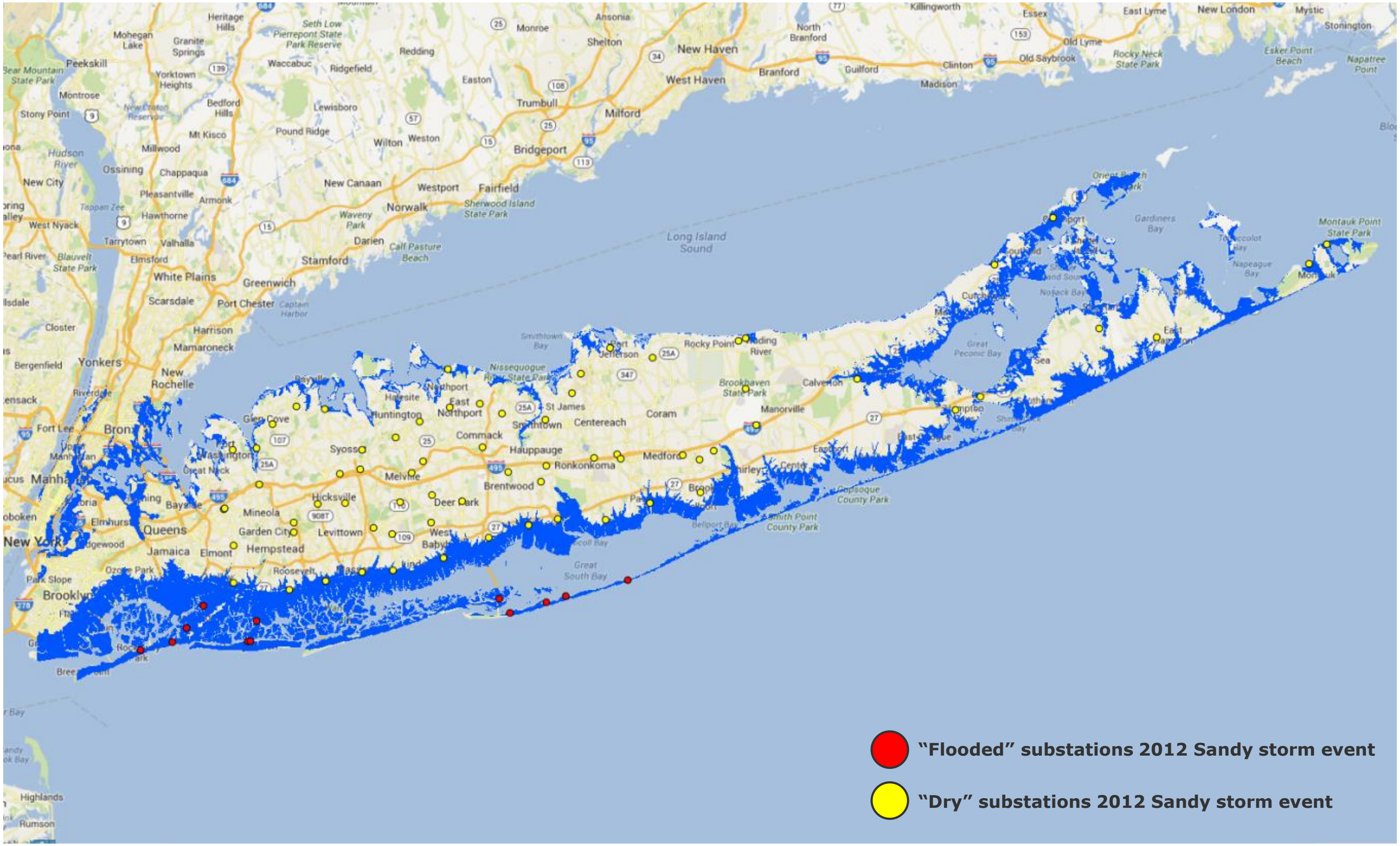
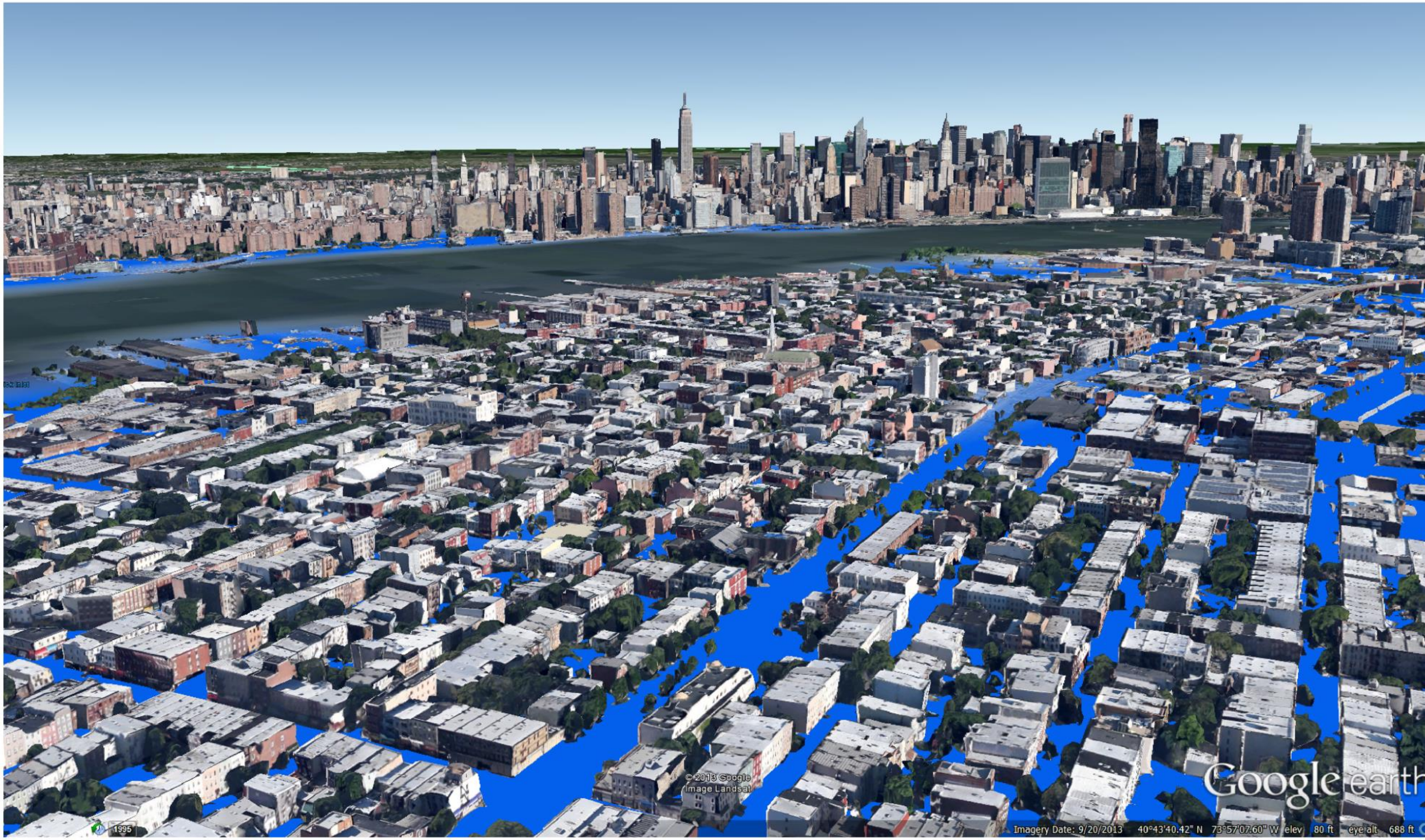
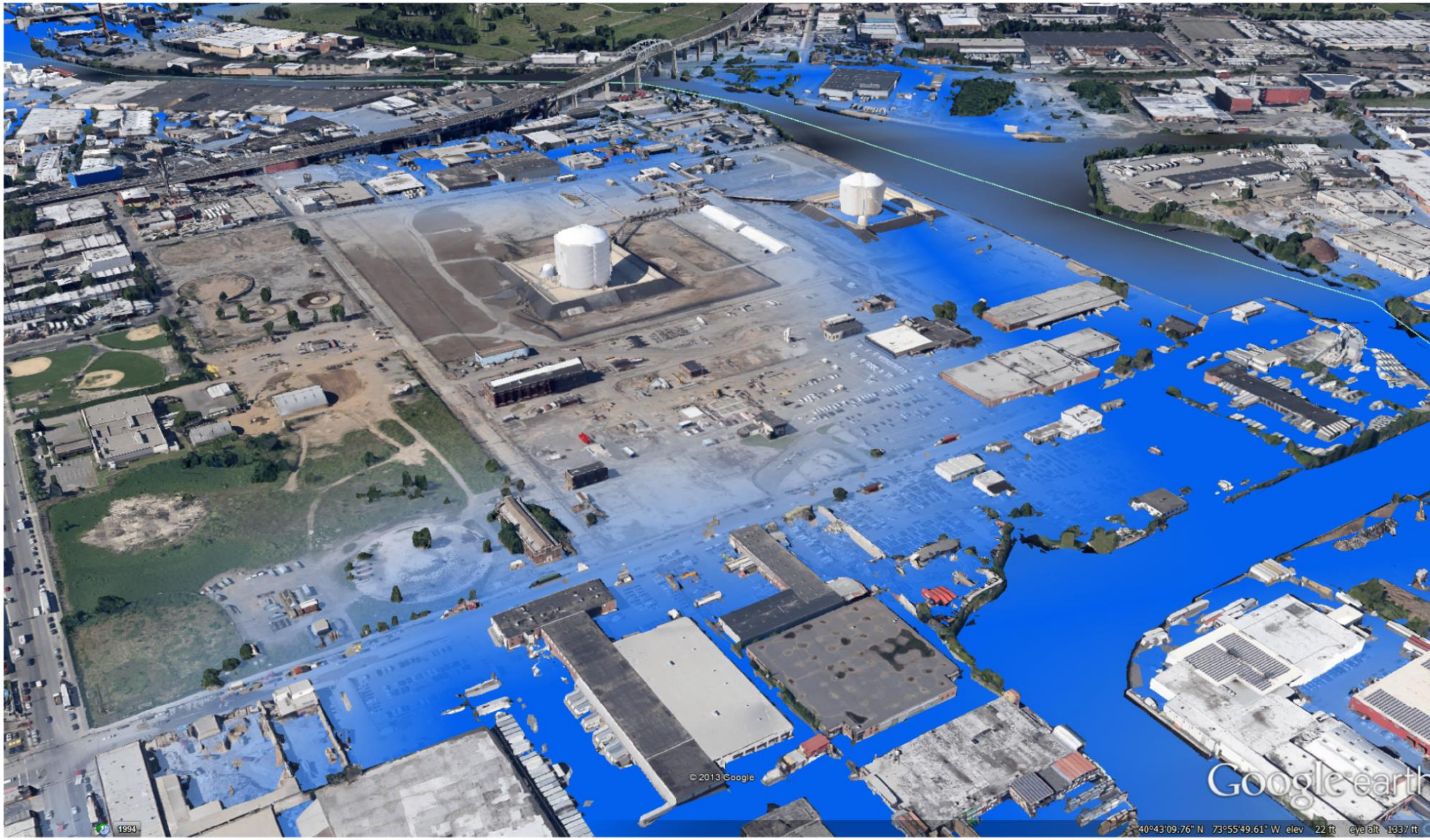
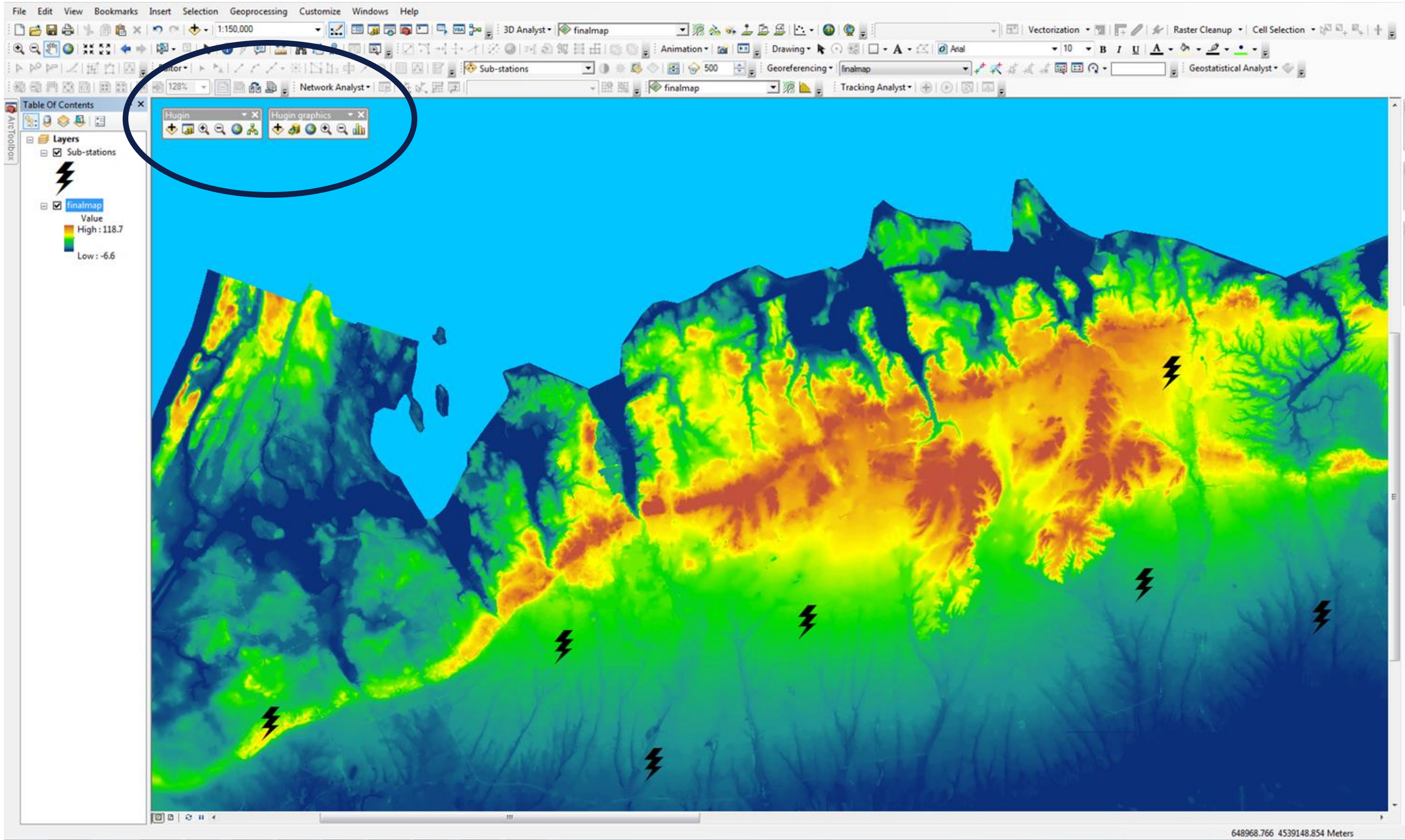
Flooded areas 2012 – 2050 (SLR 0.45 m) – 2090 (SLR 0.90 m)




©2013 Google
Image Landsat
Google earth
1995
Imagery Date: 9/20/2013 40°43'40.42" N 73°57'07.60" W elev 80 ft eye alt 688 ft

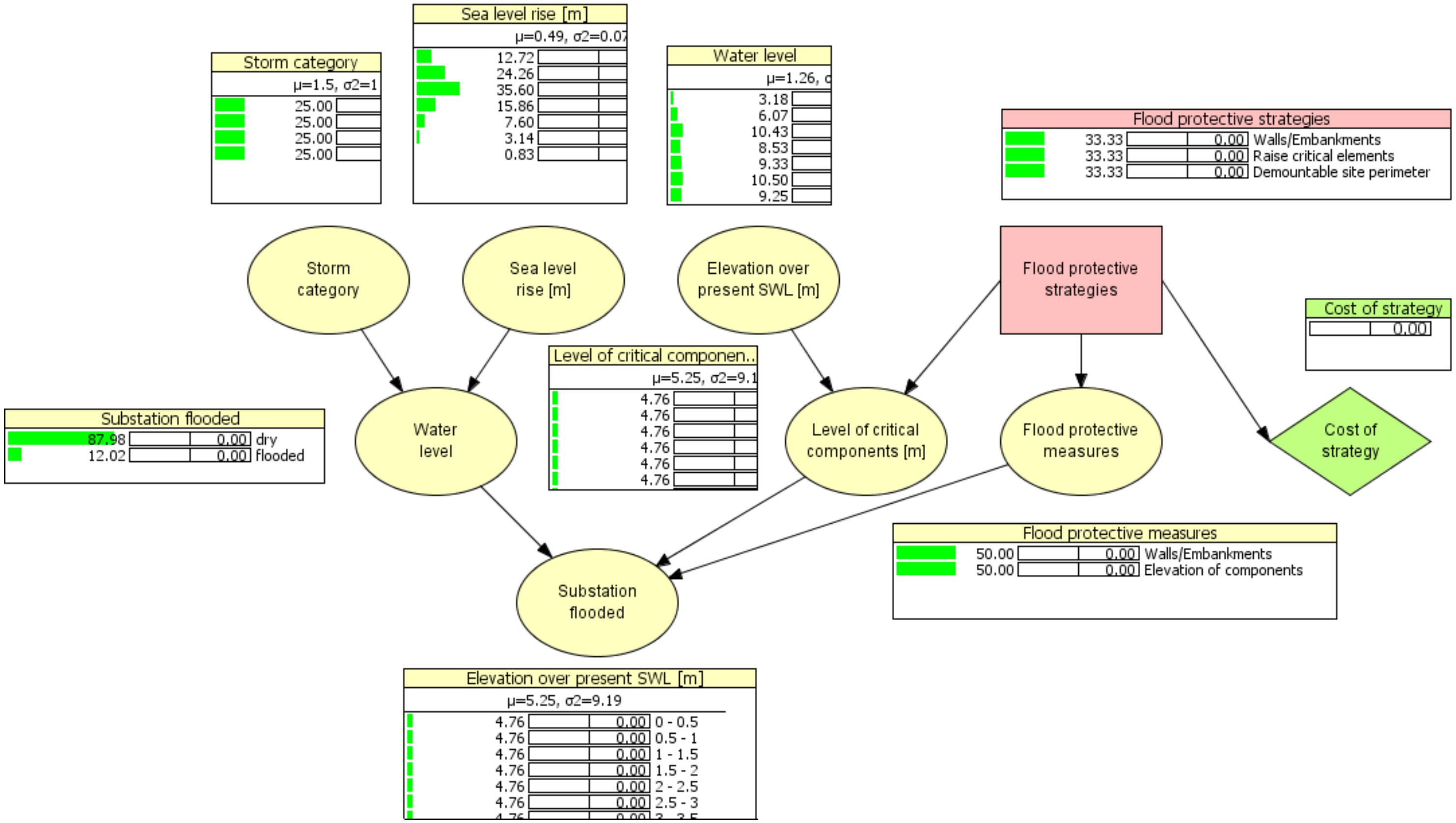

© 2013 Google
Google earth
1994
40°43'09.76" N 73°55'49.61" W elev 22 ft eye alt 1337 ft

Linking Hugin to ArcGis - A Bayesian Network approach to spatially distributed features.



Toolboxes created in an ARCGIS environment. A HUGIN API is linked to the Visual Basic programming language using ESRI’s Visual Basic platform available in the ArcGIS environment.

Vulnerability and consequence estimation in the HUGIN environments



Once the height of the flood was calculated within GIS, this is automatically processed by the HUGIN Bayesian inference engine. The engine is called directly within ARCGIS via the HUGIN's set of APIs and the results are directly displayed on ARCMap, showing the probability of flood depending for the different substations considered.

Thanks for your attention

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