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STEM Connections

Using Environmental Intelligence to Develop Resilience Strategies

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Advanced Baseline Imager

ABI is the primary instrument on GOES-R for imaging Earth's weather, oceans and environment.

-16 different spectral bands (compared to five on current GOES).
-three times more spectral information.
-four times the spatial resolution.
-five times faster temporal coverage than the current system.

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Objectives include but not limited to:

-Identify features at different resolutions.
-Approximate the area of a particular feature.
-Define image analysis.
-Apply remote sensing, in-situ data, and numerical modeling.
-Construct a wind field map.
-Develop a natural hazard mitigation plan.

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Activity

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8x5
16x10
32x20
64x40
128x80
1920x1080

Each consecutive image is 4x resolution of previous image

AREA of coverage: 3500km x 2200km

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-Determine the area of coverage per pixel at each resolution.
-Determine the area and diameter of hurricane

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For the 128x80 image:

3500km/128 OR 2200km/80

~ 27 km/pixel

eye is ~27 km in radius

COUNT PIXELS!!!

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For the 128x80 image:

3500km/128 x 2200km/80

~ 729 km^2/pixel

eye is ~ 2900 km^2

COUNT PIXELS!!!

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Using the equation for the area of a circle whose radius is 27 km is 2300km^2

not 2900 km^2

why?

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RESOLUTION!!!

Use image analysis software, such as ImageJ, to count pixels for you.

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Hurricane Wind Field Modeling and Natural Hazard Mitigation Planning

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Dr. S.A. Hsu, Coastal Studies Institute at Louisiana State University, and Adele Babin, Naval Oceanographic Office.

“Estimating the Radius of Maximum Winds via Satellite during Hurricane Lili (2002) Over the Gulf of Mexico”.

$$R = r\left(\frac{V_r}{V_{max}}\right)^{\left(\frac{1}{x}\right)}$$

-A discernible eye is necessary (IR temperature within eye is positive)

-Additional case studies required.

$$R = r\left(\frac{V_r}{V_{max}}\right)^{\left(\frac{1}{x}\right)}$$

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Initial investigations included Hurricane Lili and Hurricane Katrina

$$R = r\left(\frac{V_r}{V_{max}}\right)^{\left(\frac{1}{x}\right)}$$

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- R is Radius of Maximum Wind (RMW)
- V_{max} is maximum wind at R
- x varies with height from 0.5 for surface to 0.7 for higher elevations)
- r test radius
- V_r is wind speed at r

$$R = r\left(\frac{V_r}{V_{max}}\right)^{\left(\frac{1}{x}\right)}$$

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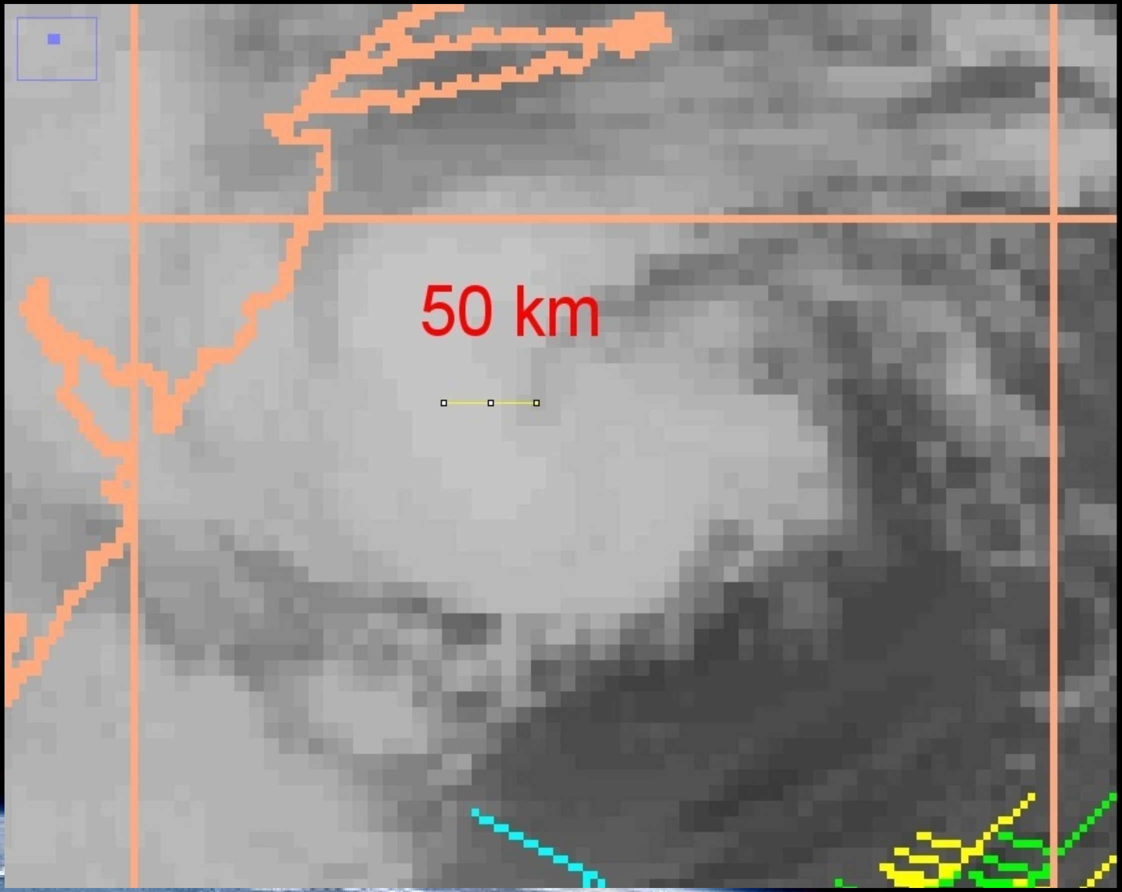
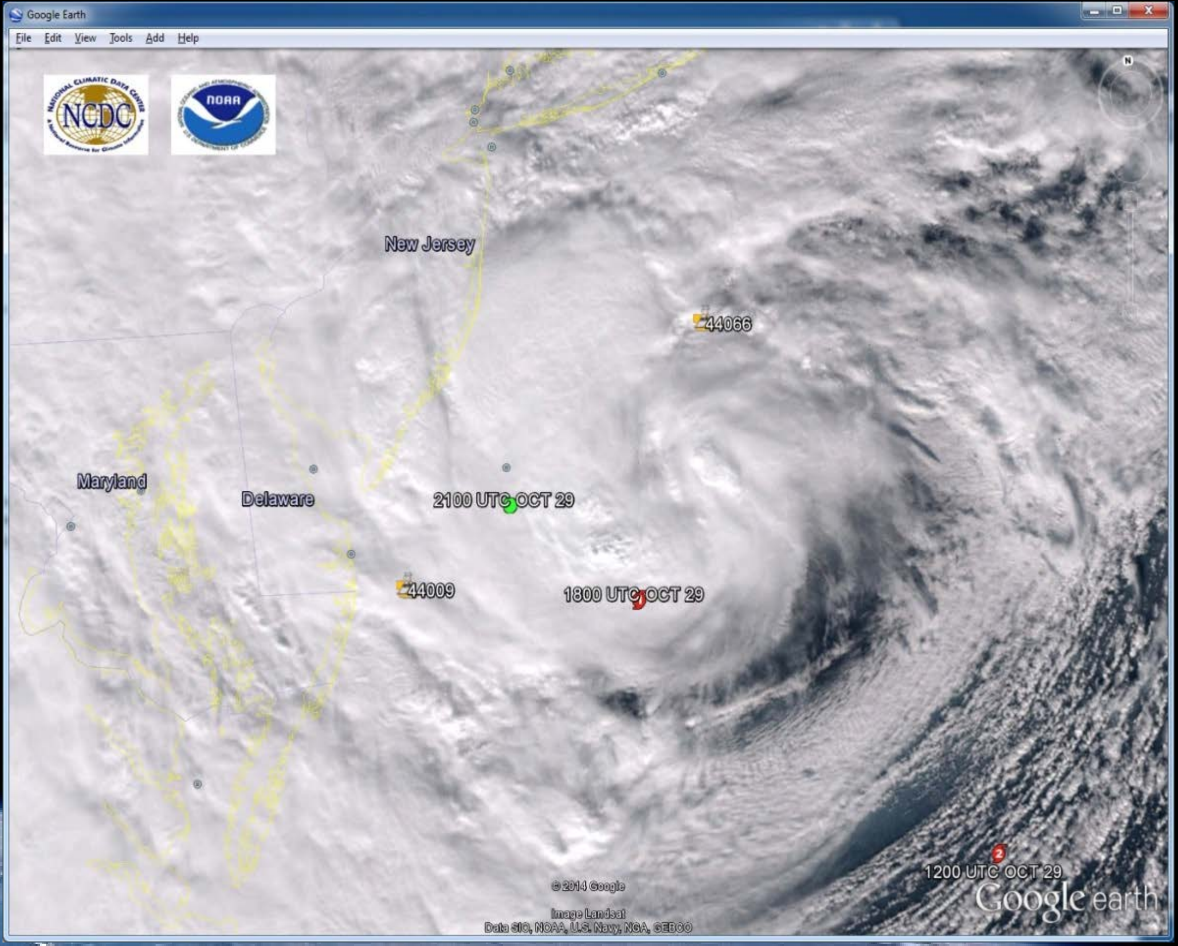
Hurricane Sandy
GOES-12 IR on 10/29/2012
1800Z
4km/pixel resolution
RMW ~ 50km(warmest to coldest high altitude cloud tops, intense convection)

ImageJ



Google Earth
-NOAA’ s National Data Buoy Center (NDBC)
-National Hurricane Center Sandy Track
-natural-color image of Sandy acquired by the Visible Infrared Imaging Radiometer Suite (VIIRS) on the Suomi NPP satellite



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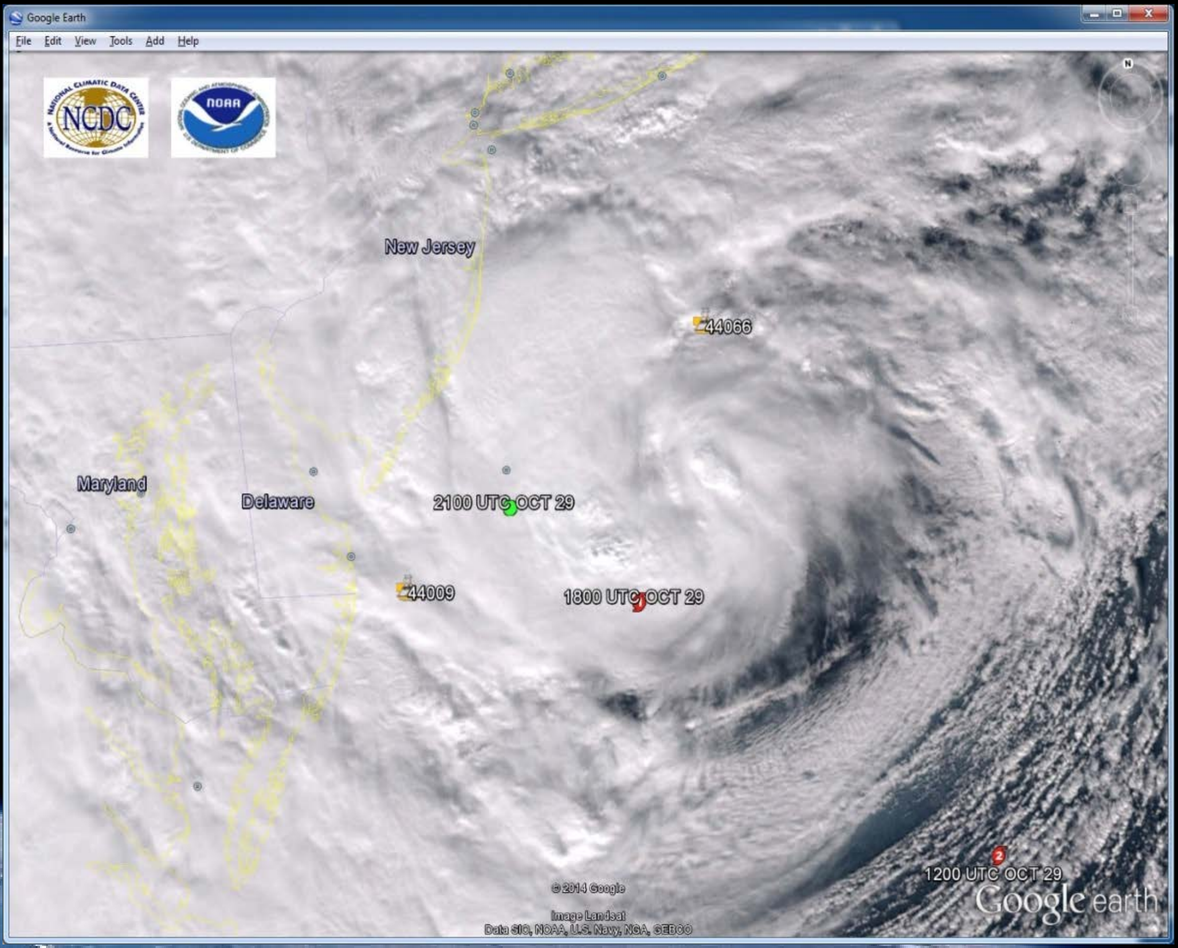
Test from 1800Z

-Buoy 44009, V & r test
135km, 22m/s, V_{max} = 41 m/s,
R = 56km (50 km?)

-Buoy 44066 lacked sufficient data



The team considered a set of V_r at 20 knot increments. Eq. 1 is used to solve for each distance from storm location at 1800Z. A Nowcast wind field map is then constructed drawing concentric circles around the storm center for each r.

In order to construct a forecast map, the team simply considered the actual track of Sandy as a "projected path". They chose 2100Z as a point along this "projected path". It was assumed that the intensity of the hurricane would remain the same. (SST?)

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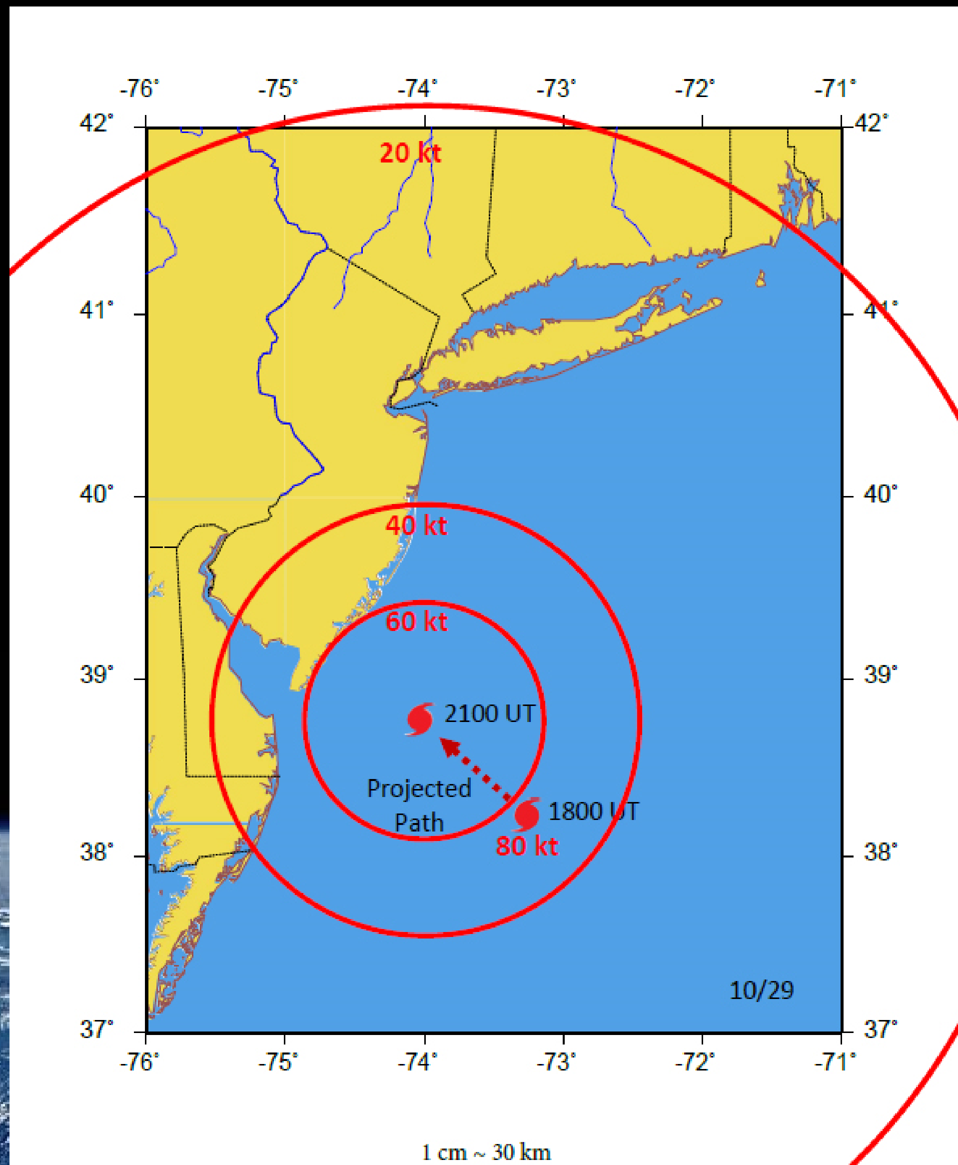

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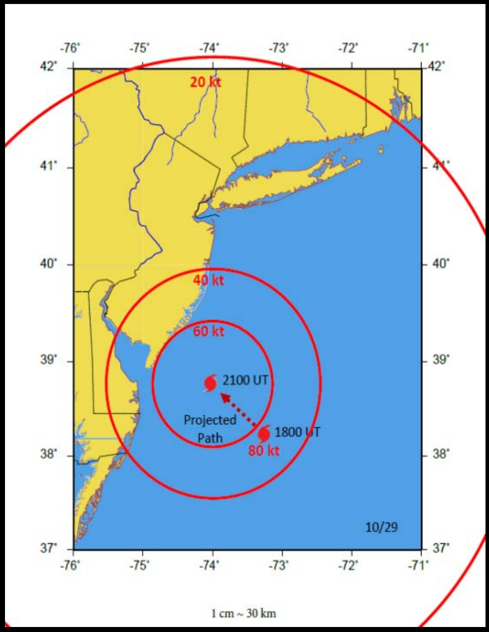

Beaufort Wind Scale (Estimated wind speeds)						
Beaufort number	Wind speed kt	km/h	Mph	Mean wind speed (kt / km/h / mph)	Description	Land conditions
0	0	0	**0**	0 / 0 / **0**	Calm	Calm. Smoke rises vertically.
1	1-3	1-6	**1-3**	2 / 4 / **2**	Light air	Wind motion visible in smoke.
2	4-6	7-11	**4-7**	5 / 9 / **6**	Light breeze	Wind felt on exposed skin. Leaves rustle.
3	7-10	12-19	**8-12**	9 / 17 / **11**	Gentle breeze	Leaves and smaller twigs in constant motion.
4	11-15	20-29	**13-18**	13 / 24 / **15**	Moderate breeze	Dust and loose paper is raised. Small branches begin to move.
5	16-21	30-39	**19-24**	19 / 35 / **22**	Fresh breeze	Smaller trees sway.
6	22-27	40-50	**25-31**	24 / 44 / **27**	Strong breeze	Large branches in motion. Whistling heard in overhead wires. Umbrella use becomes difficult.
7	28-33	51-62	**32-38**	30 / 56 / **35**	Near gale	Whole trees in motion. Effort needed to walk against the wind.
8	34-40	63-75	**39-46**	37 / 68 / **42**	Gale	Twigs broken from trees. Cars veer on road.
9	41-47	76-87	**47-54**	44 / 81 / **50**	Severe gale	Light structure damage.
10	48-55	88-102	**55-63**	52 / 96 / **60**	Storm	Trees uprooted. Considerable structural damage.
11	56-63	103-119	**64-73**	60 / 112 / **70**	Violent storm	Widespread structural damage.
12	64-80	120	**74-95**	73 / 148 / **90**	Hurricane	Considerable and widespread damage to structures.

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Conclusion

Environmental intelligence gathering using remote sensing and in-situ data collection, image analysis, and mathematical modeling is implemented in the design and construction of a wind field map. Furthermore, the wind field map is used as part of a broader mitigation plan for a locale as an exercise in resilience strategies. Obvious limitations in the method are the lack of high resolution satellite imagery (4 km IR) and the lack of complete, available data (station 44066). A discernible eye within the storm is also required; however, this may be at least partly resolved with higher resolution imagery.

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The ABI on GOES-R, providing higher spatial resolution, will allow us to resolve finer details such as the eye of a storm, as well as pinpointing more precisely the location of high altitude cloud-tops near the eye and warmer sections within the eye.

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In addition, since the ABI will provide finer temporal resolution, students will be able to better approximate, a storms rotational velocity and thus be able to derive/predict the RMW, that otherwise, would normally be acquired by nearby buoy stations or aircraft reconnaissance.

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References

Hsu, S.A., Adele Babin, 2005: *Estimating the Radius of Maximum Winds via Satellite during Hurricane Lili (2002) Over the Gulf of Mexico*. NWA Electronic Journal of Operational Meteorology (2005-EJ3).

Hsu, S. A., 2003: Nowcasting the wind speed during a hurricane at sea. *Mariners Weather Log*, Vol.47, No. 1, 10-11

National Data Buoy Center http://www.ndbc.noaa.gov/
National Climactic Data Center http://www.ncdc.noaa.gov/

Space Science Engineering Center at
University of Wisconsin http://www.ssec.wisc.edu/

National Hurricane Center http://www.nhc.noaa.gov/
National Weather Service http://www.weather.gov/
NASA Earth Observatory http://earthobservatory.nasa.gov/

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