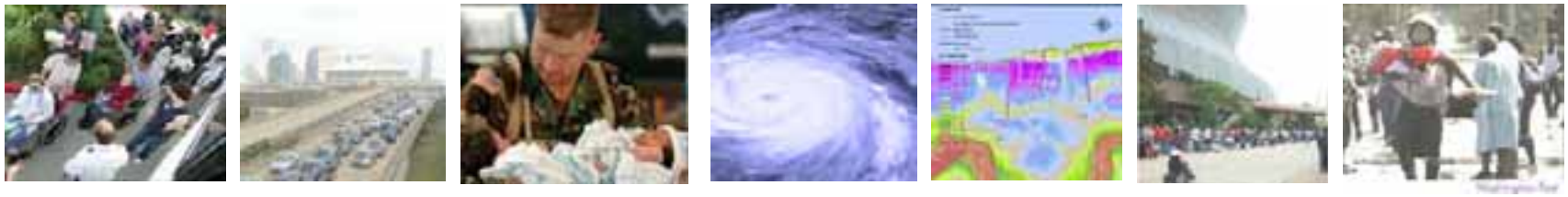

HURRICANE MODELS IN A GIS: SUPPORTING MEDICAL SPECIAL NEEDS PLANNING IN COASTAL LOUISIANA

This research was supported by the Louisiana Board of Regents through the Millennium Trust Health Excellence Fund, Contract: HEF(2001-06)-01

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ESRI Public Health GIS Conference
Scottsdale, AZ - Oct 9, 2007

Introduction – Medical Special Needs (MSN)

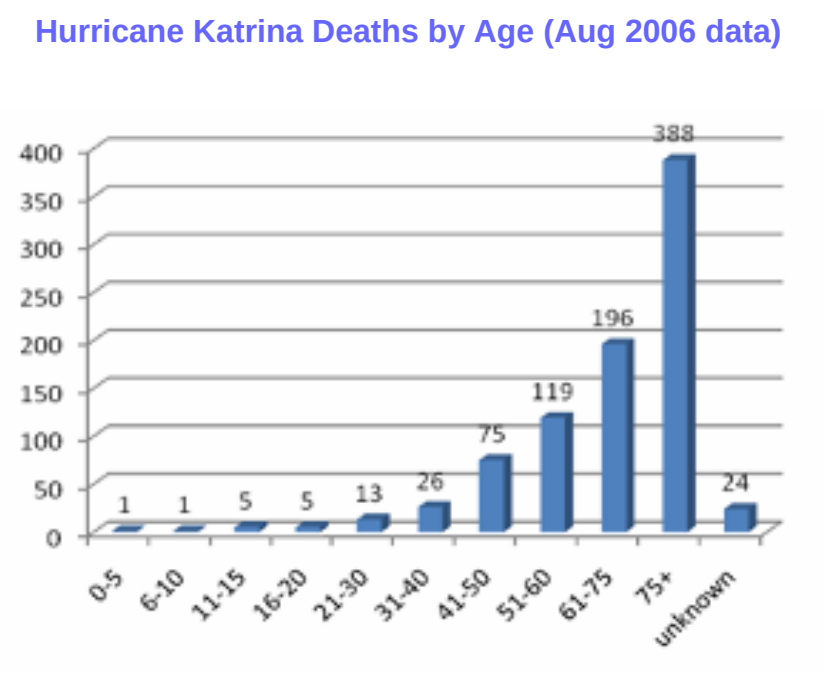
- **Categories of medical special needs or MSN are often overlapping**
- MSN can include "…individuals in the community with **physical, mental or medical care needs** who may require assistance before, during and/or after a disaster or emergency after exhausting their usual resources and support network. (USFA EMI 2003, p 1.3)"
- Can be found in their own residence, in adult day service programs, assisted living facilities, foster and group homes, long term care facilities, and hospitals (ibid).
- Will "have physical or mental conditions that limit their ability to function on their own…" (Bridges and Garcie 2006, p. 4), and **may additionally include many more individuals**, including **medically-dependant children** (particularly under age 5, who are more susceptible to communicable disease risks) totally dependent on adults for their care; **pregnant women**; the **elderly**; the **disabled**; the **medically-fragile** or **immuno-compromised**; and other age groups with medical or mental conditions **requiring medication and varying levels of care; some of which may be critical**. Many of these individuals may be in poverty and will be considered to have **critical transportation needs**, since they can not "provide for or arrange their own transportation or sheltering outside a risk area" (ibid).

Introduction – Hospital and Nursing Home Fatalities, Hurricane Katrina

- Recent hurricane events in Louisiana have emphasized the **severe vulnerability of Medical Special Needs (MSN) patients during flood disasters**
  - Approximately 37 area hospitals and 34 area nursing homes had to be evacuated after Hurricane Katrina (2005) made landfall (LA DHH 2007)
  - Approx 21 hospitals had to be evacuated after Hurricane Rita (2005). 24 nursing homes had left prior (LA DHH 2007)
  - Hurricane Katrina (2005) in Louisiana resulted in:
    - **Over 85 hospital fatalities**
    - **Over 65 nursing home fatalities**

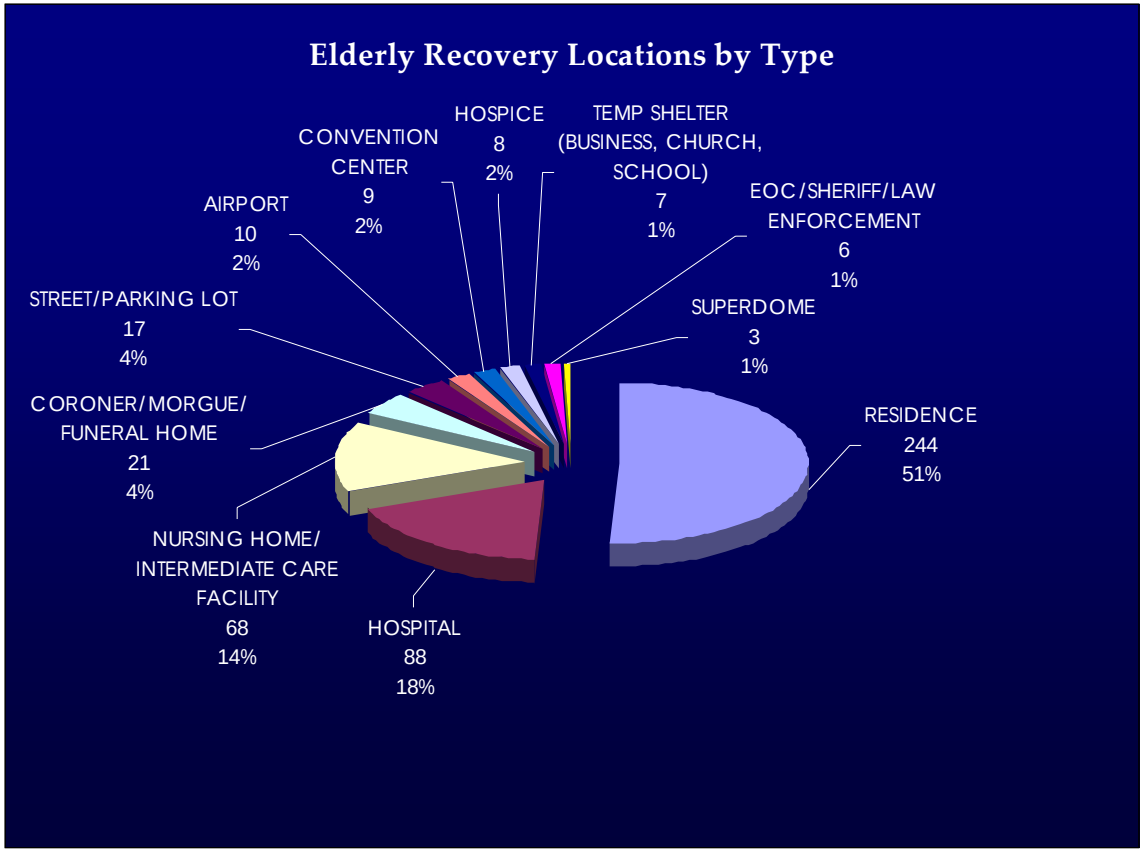
    (LA DHH, Medical Examiner's Office, 2006)

Introduction – Elderly Hurricane Fatalities, Hurricane Katrina



- Preliminary data from Hurricane Katrina indicate a **positive association between age and mortality**
- **Elderly** Louisiana residents were disproportionately affected, with **over 400 fatalities > age 70** (853 of 1464 records in Louisiana, LA DHH Medical Examiner dataset 2006)

Introduction – Elderly Hurricane Fatalities, Hurricane Katrina (cont'd)



Elderly recovery locations were primarily identified as residences, but also included hospitals, nursing homes and intermediate care facilities (Aug 06 LA DHH State Med Exam dataset)

Introduction - Chronic Medical Conditions, Hurricane Katrina 2005

- Individuals with **chronic medical conditions** were the most common types of patients treated following the disaster, in both emergency medical care and shelter settings (CDC MMWRs 2006, LA DHH 2005, 2007)
  - Heart conditions
  - Diabetes
  - Asthma
  - Mental health diseases
- "…41% of all Houston shelter residents reported chronic health conditions such as heart disease, hypertension, diabetes, or asthma." (Houston shelter surveys, Brodie et al 2006)
- CDC MMWRs indicate "…during Sept 1-22, chronic illness (e.g., diabetes, asthma, emphysema, and cardiovascular disease) was the most commonly reported category in evacuation centers (ECs)… injury, and mental illness were also reported (2006)".

Introduction – Emergency Medical Conditions, Hurricane Katrina

- Indications of **high MSN populations** and **unmet transportation needs** following Hurricane Katrina (Superdome, Convention Center, Hospitals and Nursing Homes)

- <u>EVACUATION QUESTION</u>: Why didn't MSN residents leave the risk area?
  - **Identify problems that MSN patients faced with both evacuation and sheltering in place**

Introduction – Sheltering Risks: Hurricanes in Coastal Louisiana

MSN Hurricane Sheltering in Place: Residents decide to stay - based on patient vulnerability and numerous other factors - yet:

- Low elevations and other coastal factors expose facilities to **serious storm surge and rainfall flooding in Coastal LA**, and **few have been designed to withstand high winds**
- In coastal Louisiana, **levee breaches or hazardous chemical releases**
- **Medical Infrastructure being rebuilt along both east and west coastal areas of Louisiana post-2005 storms – access not back to normal**
- Hurricanes can **rapidly intensify**, **shift in track**, **spawn tornadoes**, **bring extreme rainfall**
- Downed trees and power lines may block access routes and **disrupt electrical utilities, water supply and communication**

Objectives:

1. **Identify Risks Associated with Evacuation vs. Sheltering in Place in Coastal Louisiana**
2. **Determine Threshold Storm Events**: What is the current hurricane risk? Can anyone safely shelter in Coastal Louisiana for Hurricanes?
3. **Incorporate Hurricane Modeling and Research into a GIS** Environment in Support of MSN Planning
4. **Explore Ways to Visualize the Science and Clearly Communicate Risk to MSN Decision-makers** to Assist in Hurricane Evacuation and Sheltering Planning. Focus on Technologies Accessible to Hospitals, Nursing Homes, and Families.

MSN **Evacuation** vs. Sheltering in Place

- Requires Careful Planning, Sufficient Time before the onset of tropical storm force winds, rain, and congested roadways
- Costly
- Highly dependant on well-trained staff, available resources (transportation and supplies)
- Risks include
  - Transport Injuries
  - Long Commutes
  - Heat exposure (less often, dehydration)
  - Lack of immediate access to medical care, medicines or appropriate levels of care (in transit or in receiving facilities)
  - Stress

References: Dosa et al 2007, DHHS / OIG 2006, Bascetta / GAO 2006, Gray and Hebert 2007, Klein and Nagel 2007, Mutter and R'id 2007, Kuba et al 2004

MSN Evacuation vs. **Sheltering in Place**

- Injury
  - Storm injuries or death from drowning, wind hazards
  - Untreated medical conditions, non-functioning medical equipment
- Unmet basic needs
  - Heat exposure
  - Dehydration
  - Lack of caregivers or appropriate levels of medical or general care
- Isolation
  - Emergency responders can not reach MSN patients
- Stress

References: Dosa et al 2007, Gray and Hebert, 2007, Mutter and R'id 2007, Fernandez et al 2002).

Lit Review – Why Don't MSN Patients Leave the Risk Area?

Hospitals and Nursing Homes in a Hurricane Emergency

- Nursing Homes: **Unable to secure space in alternate facilities**, **transportation contracts fell through**, **communication issues** (DHHS/OIG)
- **Problems with alternative sites, appropriate care at shelters, if accepted** (e.g., gymnasium mattresses, locking doors)
- **Shadow evacuation** (Wells/M2MEDIA360, Cutter 2006, others)
- "Substantial difficulty in transporting frail residents (*Dosa et al 2007*)" *Kuba et al 2004, Prats 2003*
- Hospitals and nursing homes 100-300 patients, **resource intensive – injury, medical complications**
- Hospitals often discharge ambulatory and stable patients ahead of a storm, in anticipation of a surge of new patients
- **Hospitals as "refuges," admissions secondary to storm,** e.g., nursing home patients and other MSN individuals from the community (Gray and Hebert 2007)
- Remaining hospital patients are generally not stable enough or able to be easily moved
- Other facilities and in residences throughout community house elderly, critical care, and medically fragile patients (Kirkpatrick and Bryan 2007); the physically and mentally disabled; and others requiring varying levels of medical support.

Lit Review – Why Don't MSN Patients Leave the Risk Area?

Elderly Vulnerabilities in a Hurricane Emergency

- **Sensory impairments**, **mobility disabilities**, and **potential language or cultural barriers** (Lapolla et al 2003). Often have "**memory disorders, such as Alzheimer's or senility**;" These will complicate their ability to receive communication, evaluate risk, and physically evacuate.
- At risk of "**transfer trauma** if they are forced to leave their homes. Many studies have shown that **dislocation without care can cause illness and even death in senior citizens** (ibid)."
- Elderly may experience **dementia, delayed response syndrome** (slow response in a crisis and poor understanding of impending danger), and **fear of institutionalization** (being transferred to a nursing home) when emergency responders attempt to assist them in a rescue situation (Missouri SEMA 2007)
- They are often "**more susceptible to heat and cold**, creating potential crisis situations when air conditioning and heat are not available," (ibid)
- **Nearly half (46.6 percent) of the household population 65 years and over in Louisiana had some form of disability** (2005 US Census Bureau survey)
- **Very elderly are often medically fragile patients**, may be totally dependent; have difficulty swallowing; require electrical equipment to sustain life; be insulin-dependent diabetics unable to monitor their own blood sugar or self-inject; require continuous IV therapy; require critical medications and labs requiring daily monitoring (Lapolla et al 2003).

Lit Review – Why Don't MSN Patients Leave the Risk Area?

Disability Vulnerabilities in a Hurricane Emergency

- **Over 20 percent of residents in Louisiana aged 5 years and older have some type of disability**, including physical, employment (preventing them from working), mobility, mental, sensory and self care disabilities, respectively (St. Bernard Parish Health Profile 2004).
- **Over 20 percent of Louisiana households have at least one child with a special health care need** (2000 Census data)
- **Disability types include (1) Sensory**: including the blind, deaf, or individuals with varying levels of loss of sight or hearing; **(2) Mobility**: those with limited stamina, or who use mobility aids such as a cane, wheelchair, walker, scooter, or crutches; e.g., individuals with Cerebral Palsy, Multiple Sclerosis or Muscular Dystrophy **(3) Mental**: including the mentally ill, developmentally disabled (e.g., Autism), those with traumatic brain injury, and learning or cognitive disability; and **(4) Medical**: renal dialysis patients, diabetics, oxygen or respirator-dependent (USFA EMI 2003, US DOJ 2004). Disabled residents have higher rates of chronic medical conditions, emergency room visits and "hospitalization for a primary disabling condition (ibid)."
- **Transportation for individuals with disabilities may be disrupted** due to overcrowding, blocked streets or sidewalks, or systems that are closed on account of the impending storm. **Many people with disabilities cannot use usual modes of transportation**, require lift-equipped school or transit buses (USDOJ 2004).

Lit Review – Why Don't MSN Patients Leave the Risk Area?

Other MSN Patients, residential or community care settings in a Hurricane Emergency

- Evacuation problems, and attitudes, e.g., Eisenman et al (2007). Residents in the risk area:
  - **EXPRESSED CONFUSION**
    - Did not hear from emergency management where to go
    - Heard mixed messages, to go or stay
  - **HAD MEDICAL ISSUES**
    - Not healthy enough to drive very far
    - On medication that hindered ability to drive
    - Had mobility or medical disabilities such that their families would not leave them behind
  - **DID NOT HAVE RESOURCES**
    - Not having enough room in the car for everyone
  - **EXPRESSED FEAR OR INABILITY TO MAKE THE TRIP**
    - Fear of leaving homes because of robbery or looting
    - Elderly decided to shelter in place after hearing media reports of highway accidents and running out of gas
    - Difficult for MSN, especially elderly to navigate the info points and traffic congestion, sheltering
    - **??? RESIGNATION, STUBBORNESS, NOT CONVINCED OF RISK???**
    - Older residents that had made it through Betsy and Camille just weren't evacuating

Lit Review – Why Don't MSN Patients Leave the Risk Area?

Other MSN Patients, residential or community care settings in a Hurricane Emergency (cont'd)

- Evacuation problems, and attitudes, recurring themes, shelter surveys (*Brodie et al 2006*). Reasons shelter residents did not evacuate:
  - **DID NOT HAVE RESOURCES**
    - "lack of transportation"
  - **??? RESIGNATION, STUBBORNESS, NOT CONVINCED OF RISK???**
    - "underestimation of the storm"
  - **HAD MEDICAL ISSUES**
    - "12% interviewed listed being physically unable to leave as the main reason they stayed behind"
    - *Gray and Hebert 2007*: Many hospital patients cannot be discharged prior to a storm and evacuated without significant planning and time, such as those:
      - "recovering from surgery or debilitated by disease"
      - "dependant on medical assistance to breathe… demented patients, newborn babies"
      - others, including hospital patients "requiring dialysis and those transferred from nursing homes.", p. 285)
      - Recently discharged from hospital
      - Loss of personal care attendants

Objectives:

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2. **Determine Threshold Storm Events**: What is the current hurricane risk? Can anyone safely shelter in Coastal Louisiana for Hurricanes?
3. **Incorporate Hurricane Modeling and Research into a GIS** Environment in Support of MSN Planning
4. **Explore Ways to Visualize the Science and Clearly Communicate Risk to MSN Decision-makers** to Assist in Hurricane Evacuation and Sheltering Planning. Focus on Technologies Accessible to Hospitals, Nursing Homes, and Families.

Research Methods – Selecting and Modeling Threshold Storms

- **Threshold Storm Event:** *Flood and wind levels unsafe for sheltering in place without significant mitigation measures – MSN patients recommended to evacuate*
- **Relevant to model lower order storms** which commonly make landfall in Louisiana (**Cat 1 and 2**)
  - Tropical storms are less likely to cause severe storm surge flooding (or substantial wind damage)
  - Category 4 hurricanes assumed to trigger major medical evacuation
- **Category 1-3 level storms chosen for analysis for MSN planning**
  - Identify hurricane risks of coastal MSN facilities south of the interstates at risk of storm surge and other
- MSN facilities – are any safe to shelter in place? Under what conditions?

Physical Aspects of Hurricanes

Table 1. Total recorded hurricane strikes in Louisiana (1905-2005)

	Maximum Wind Speed (in knots)	Total
TS	<64	39
CAT1	64-82	13
CAT2	83-95	7
CAT3	96-113	5
CAT4	114-135	5
CAT5	>135	2
		71

(NOAA CSC historical hurricane record: http://www.csc.noaa.gov/id/downloads.html)

- Hurricane Modeling: **Likely** Hurricanes vs. only Worst Case – what to expect next for MSN planning
- Katrina and Rita – 2 major hurricanes in 2005, historically rare
- Referenced NOAA CSC Historical Track data in GIS

Physical Aspects of Hurricanes

TABLE 6. Intensification or Downgrade to Landfall (Louisiana benchmark storms)

STORM	L-48	TRANS1	TRANS2	TRANS-3	L-HR	TREND	DATE RANGE	YEAR
*AUDREY	1	2			4	*INT-3	6/25-6/27	1957
HILDA	2	3	4		3	INT-1	10/1-10/3	1964
BETSY	3				4	INT-1	9/8-9/10	1965
EDITH	1				2	INT-1	9/14-9/16	1971
*CARMEN	1	2	3	4	3	*INT-2	9/5-9/7	1974
BOB	TD				1	INT-1	7/9-7/11	1979
DANNY	TD				1	INT-1	8/13-8/15	1985
*ELENA	1	(looped)			3	*INT-2	8/31-9/2	1985
ANDREW	4				4	SAME	8/24-8/26	1992
LILI	2	4			2	SAME	10/1-10/3	2002
IVAN	5	4			3	DEG-2	9/14-9/16	2004
*KATRINA	2	3	4	5	4	*INT-2	8/27-8/29	2005
RITA	5	4			3	DEG-2	9/22-9/24	2005

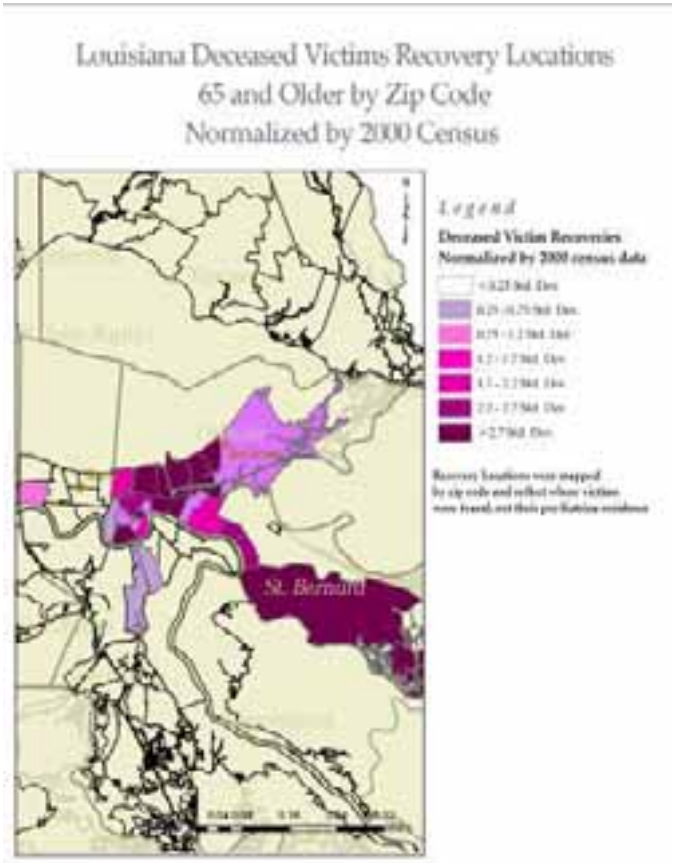
* four storms have intensified by more than one category from 48 hours to landfall over the past few decades.
TRANS=transition, L-HR=landfall, INT=intensification, DEG=degraded.

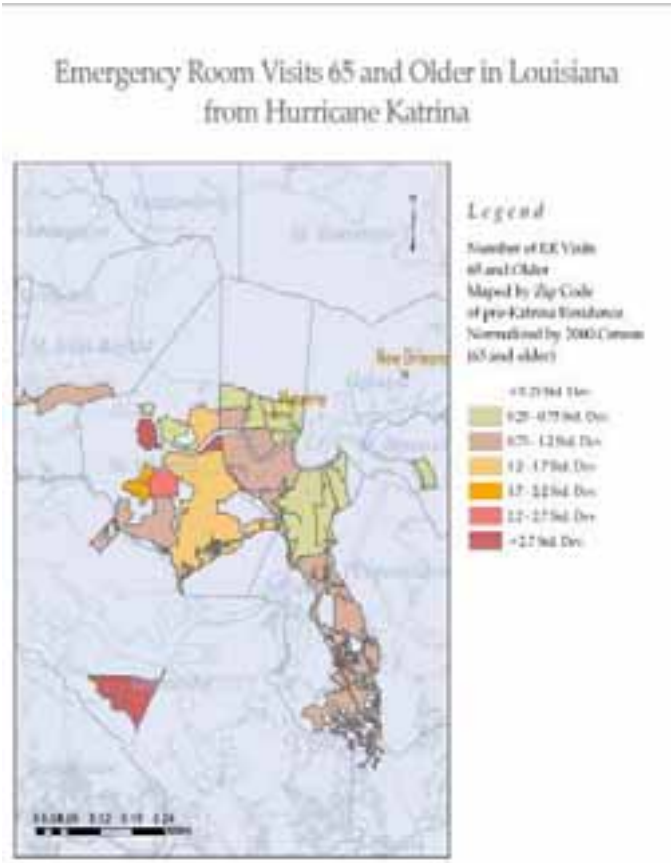
- Review of LA Historical hurricanes 1905-2005 for context, specifically in LA
  - hurricane strikes (intensities, size, frequency, landfall location)
  - ***rapid intensification – a real problem in MSN planning***
  - track direction, forward tracking speed
  - tornadoes, rainfall
  - increased hurricane activity? Megastorms?

Physical Aspects of Hurricanes

- ***Tropical storms and Category 1-2 hurricanes twice as likely to make landfall as a major hurricane***
- Second and third strikes rare in any given year
- Storms generally track N, then NW – surge models
- Hurricane speed 11-12.5 mph in Gulf on approach (Landsea 2007)
- Tornadoes in right front quadrant but also in rainbands, first 150 miles of coast (NOAA 1999), rainfall varies
- Many variables that will intensify or degrade a hurricane, speed up (pressure, systems, steering currents) or slow down (cyclone, shallow coastal waters) (Keim, Romolo 2007)
- ***LOOP Current effects are pivotal in hurricane rapid intensification (Walker 2007)***
- FUTURE STORMS: Currently in a period of increased hurricane activity (Landsea 2007), which could last 20 more years
- Land loss and coastal erosion are increasing hurricane risk but difficult to quantify (van Heerden 2007, 2004)
- Climate change may increase hurricane intensity but only slightly (Knutson, Emmanuel); precipitation increases (IPCC 2004)

Health Aspects of Hurricanes – Elderly Exposures Hurricane Katrina





Elderly from the impact area appear to have had to been transported long distances for care; likely area hospitals were already at capacity with patients from the surrounding area (LA DHH datasets, State Med Examiner, State Epidemiologist 2005-06)

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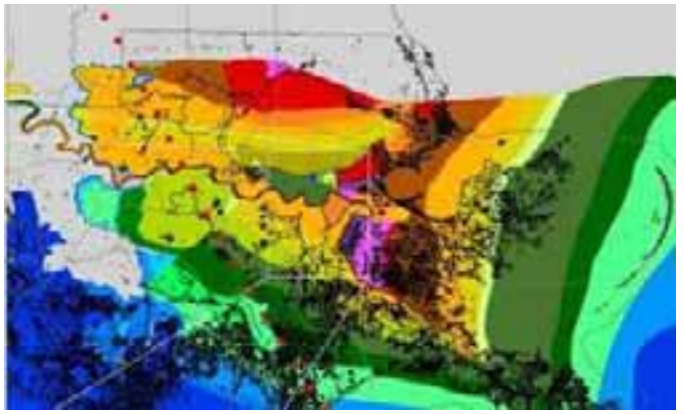
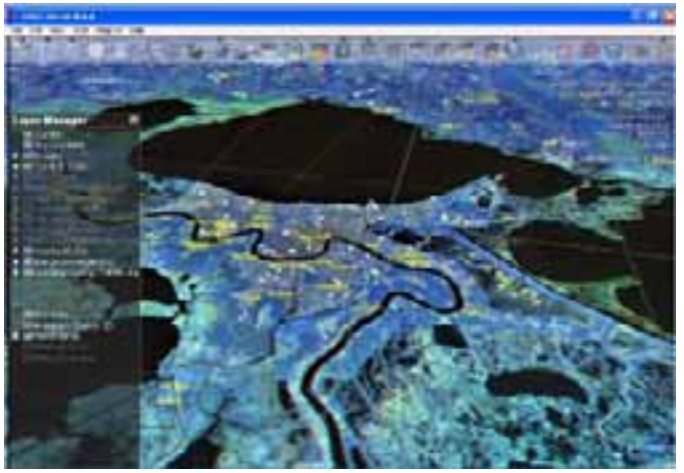
Research Methods: Hurricane Modeling and GIS: State of the Technology

- *NOAA PRODUCTS (SLOSH, COASTAL RISK ATLAS)*
- *LSU AND LOUISIANA STATE RESEARCH MODELS (ADCIRC, GIS DATA)*
- *FEMA HAZUS*
- *HURREVAC*
- *ONLINE GIS RESOURCES IN LA (ATLAS, LAGIC)*
- *OTHER ONLINE RESOURCES (ESRI, NGA Earth, NASA WorldWind, Google Earth)*



Above: SLOSH contours, Hurricane Pam 2004, Binselam, LSU.
Below: NASA WorldWind 1.4



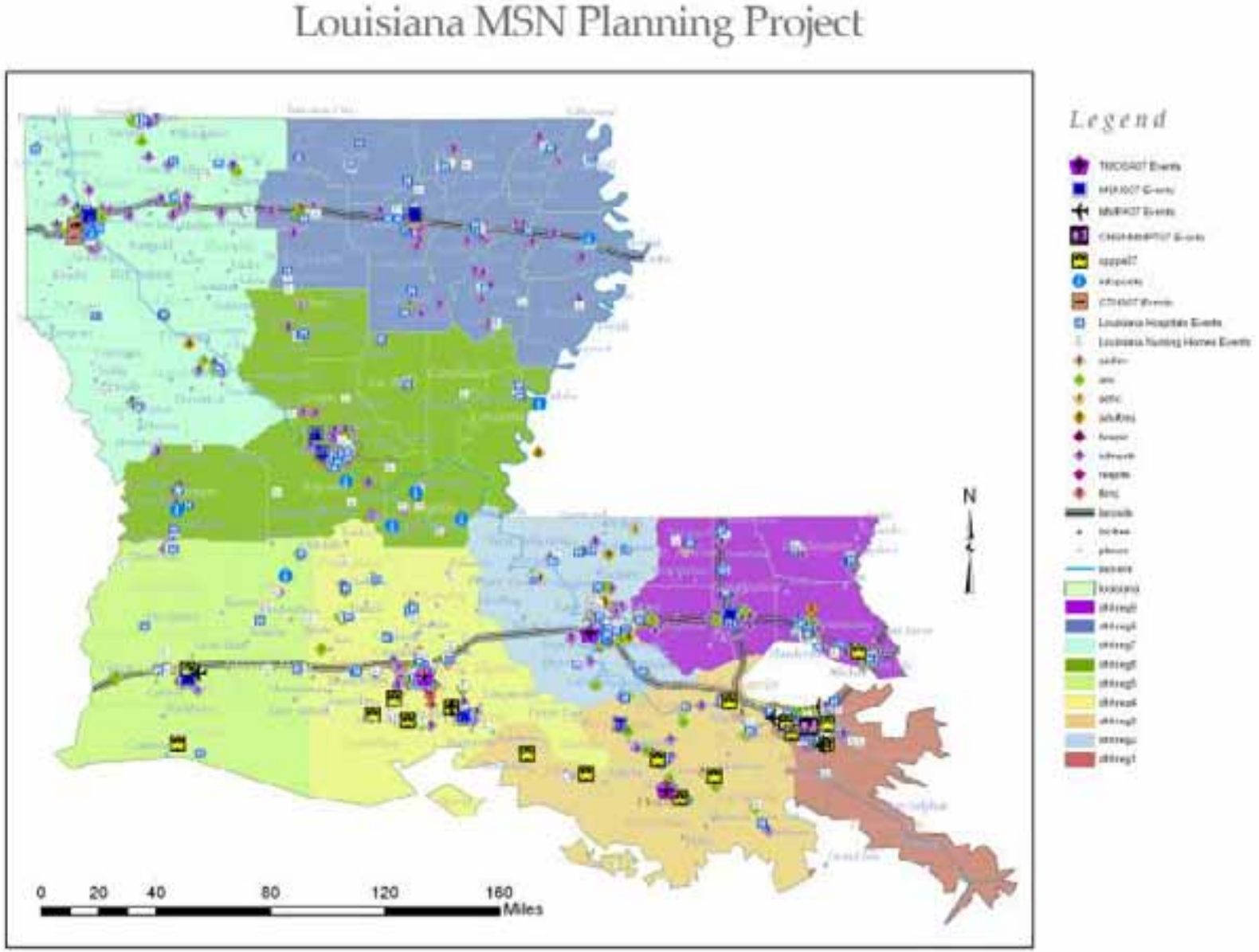
Mapping MSN facilities

- Hospitals (with hurricane season 2007 census estimates)
- Nursing homes (with hurricane season 2007 census estimates)
- Hospice – places where end of life care is provided to the terminally ill. This can be an inpatient setting or a patient's residence;
- Adult day care (ADC) – facilities where there are 10 or more functionally-impaired adults throughout the day;
- Adult hospital day care (AHDC) – facilities that provides direct professional medical supervision and/or personal care supervision to the physically and/or mentally impaired;
- Adult residential settings - 24 hour residences that provide personal assistance, lodging and meals for compensation to at least 2 adults;
- Early infant intervention (EINF) – facilities that provide care, supervision, treatment, and therapy to children who are developmentally delayed and may have a serious disabling condition;
- Intermediate care facilities for persons with mental retardation (ICF/MR); also Intermediate Care facilities for persons with Developmental Disabilities, (ICF/DD) – facilities which provide health or rehabilitation services to individuals with mental retardation or related conditions;
- Respite care – facilities that provide temporary care and supervision of a person with a disability or infirm elderly;
- Traumatic brain injury facilities – facilities that provide rehabilitative treatment, personal assistance and supervision to adults who suffer from brain injury in an inpatient, outpatient, or apartment living setting;

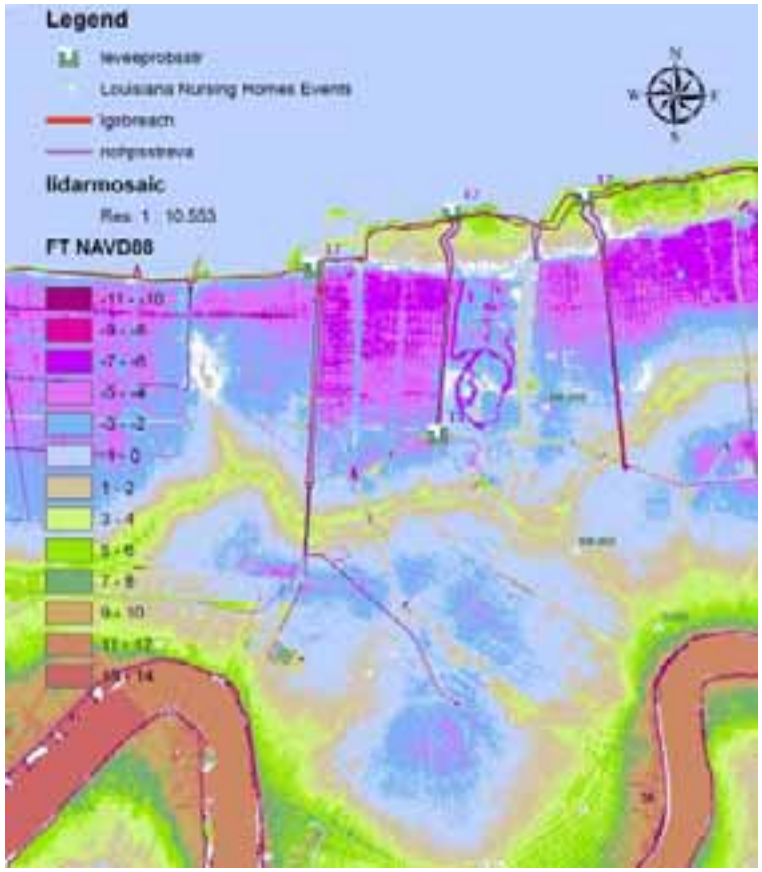
Mapping MSN Facilities - Critical MSN Transportation, Evacuation & Sheltering locations

- Temporary Medical Operations Staging Areas (T-MOSAs)
- Medical Special Needs Shelters (MSNS)
- Medical Marshalling Points (MMPs) - airfields that have been identified for the evacuation of medical patients
- Coastal Parish Pick-up Points (CPPP) - pick-up points in the coastal parishes for individuals needing assistance with further transportation to a shelter
- Medical Special Needs Medical Marshalling Point - Union Passenger Terminal; the Amtrak station in New Orleans, MSN needs patients triaged for further care and transported on trains to MSNS, MMPs or TMOSAs;
- Critical Transportation Needs Shelters (CTNS) – new shelters designated for those who don't have transportation or a place to stay during the storm
- Information points - stations along the hurricane evacuation route where evacuees can obtain important information on evacuation and sheltering.

MSN Facilities in GIS

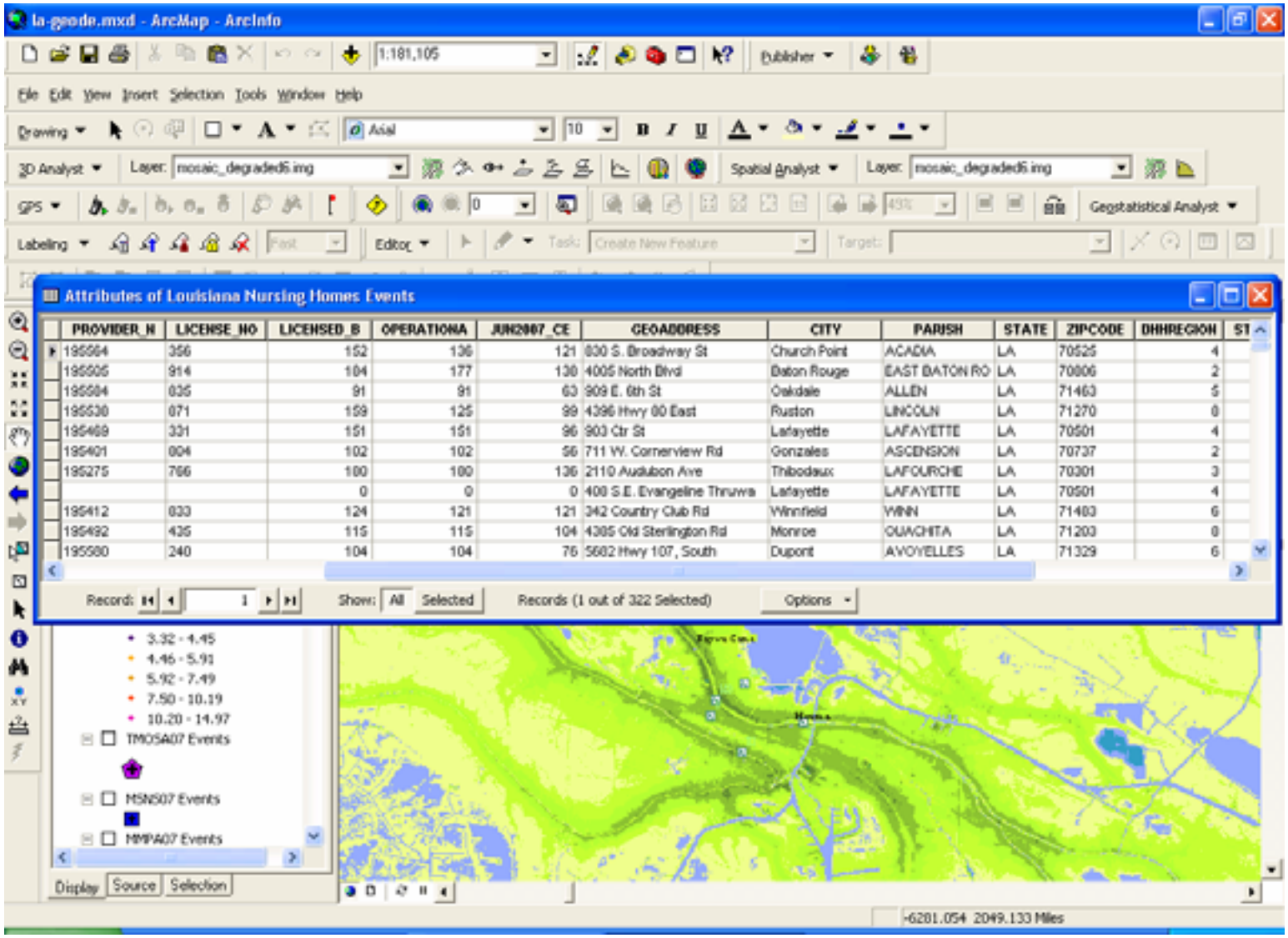


MSN Facilities in GIS – with HPS, Katrina Levee Breaches, Current Problems (2007)

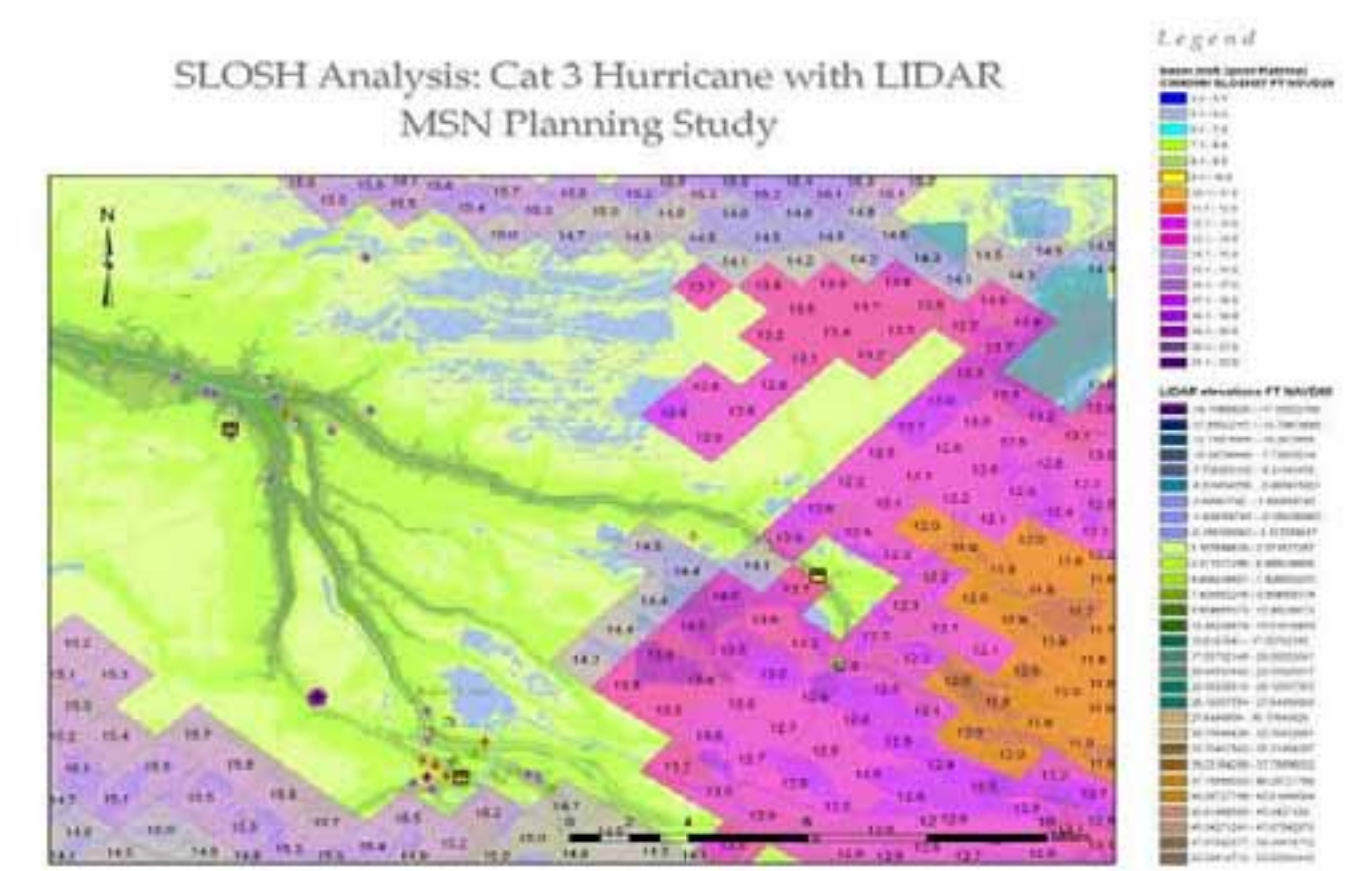


References: (Schleifstein / Times Picayune, 2007)

MSN Facilities in GIS

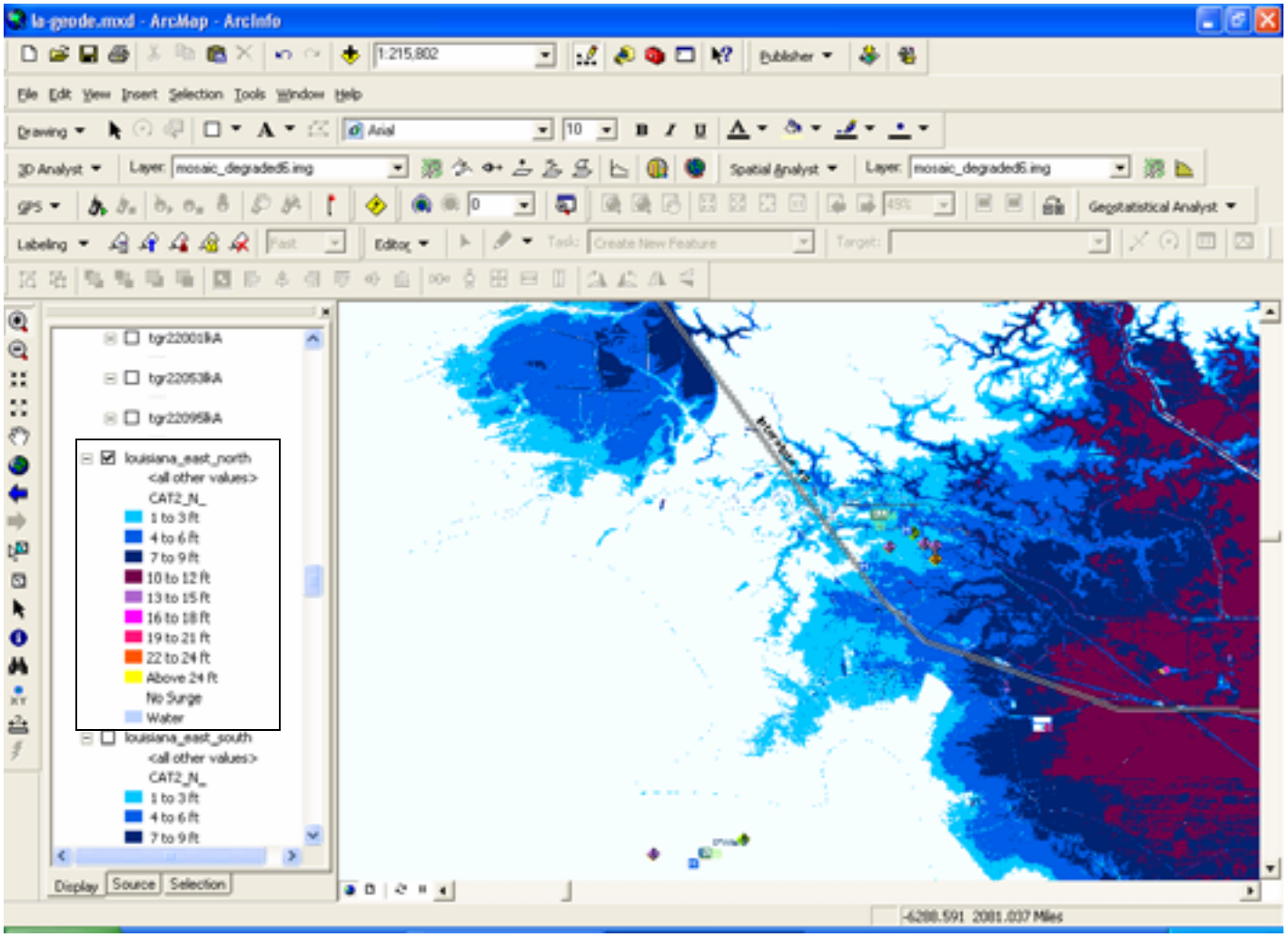


Methods – Integration of SLOSH models, LIDAR Mosaic into GIS



What we really need to visualize is maximum depth of water at the facility. Also, ***really need to understand the limitations of surge models, including overland surge beyond shoreline****, how grid cells are calculated, data used in the model*

Methods – Integration of SLOSH contours (Binselam), ADCIRC



Methods – Wind (cont'd)

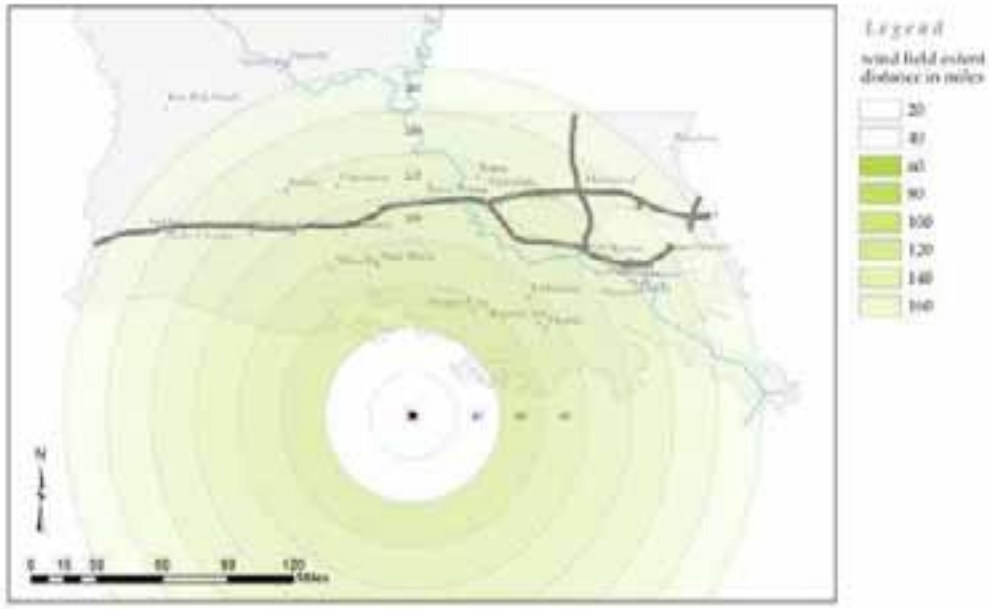
- Saffir-Simpson winds (wind speeds over water) require a conversion method to represent wind speeds over land (Vickery et al 2000, Easley 2003, Gregg 2006).
- Further conversion necessary to measure "peak gust," which is how structural engineers will determine damage, likelihood of collapse
- Wind speeds will dissipate once they make landfall to varying degrees, based on the storm size, forward tracking speed and other factors (Kaplan and Demaria 1995, Robbins 2004).
- Pressure exerted by winds on a structure in a hurricane does not increase proportionally to velocity, or windspeed. Aerodynamic equations reveal that wind force is proportional to the *square* of the velocity:

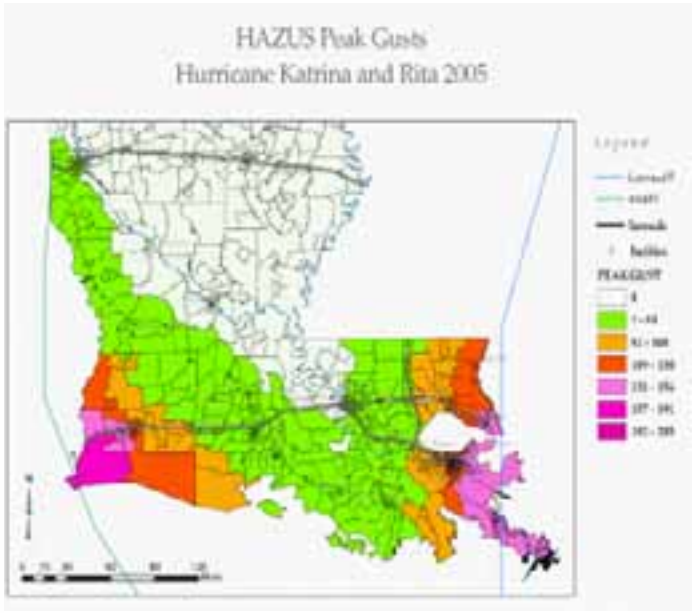
$$F_w = \tfrac{1}{2} \rho C f A V^2$$

where Fw = the force of the wind on a surface
ρ = the density of the air
Cf = force coefficients (drag, lift, etc.)
V = wind velocity (3-second gust at 33')
A = projected area normal to wind

As windspeeds increase, the wind force increases exponentially (ASCE 2005, Friedland pers comm 2007, English pers comm. 2007).

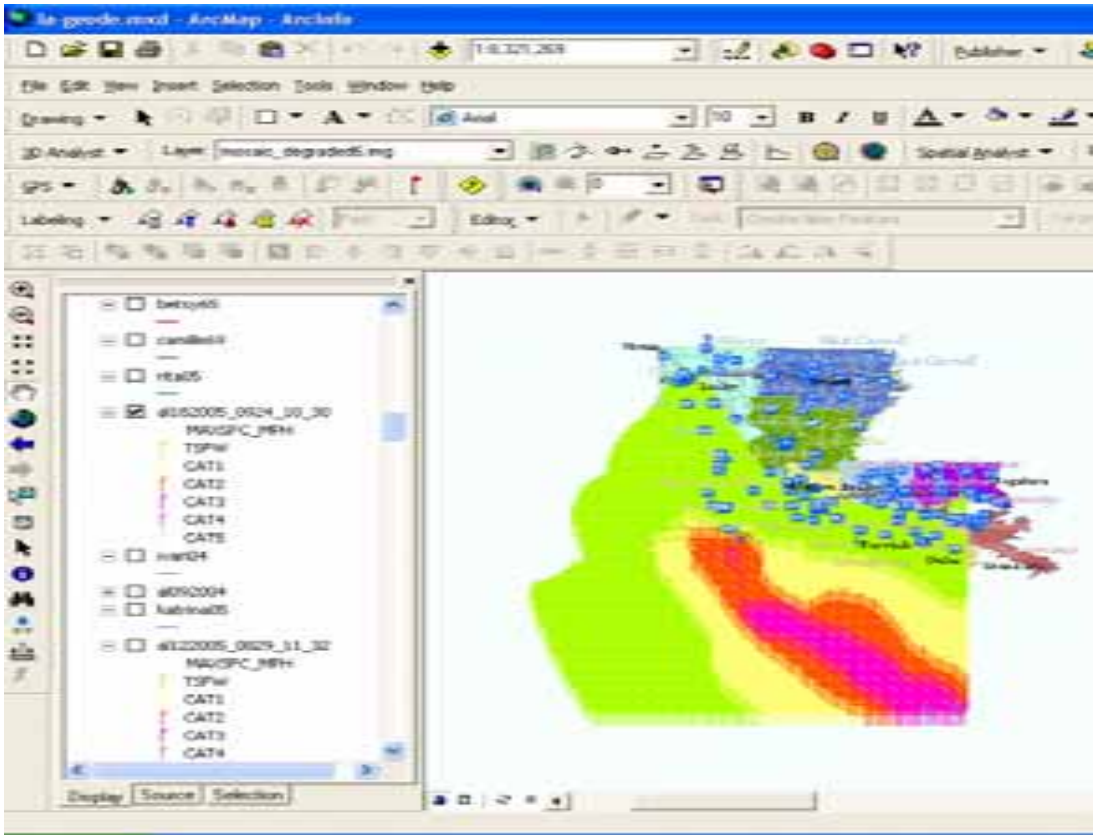
Methods – Wind Discussion





Although hurricane size and other storm characteristics will vary, ***peak gusts will be realized at most MSN facilities south of the interstate*** *for any hurricane approaching the Louisiana coast (Friedland, pers comm 2007). The possibility of shift in track at 48 hours out will not allow for many exclusions of facilities from wind risk.*

Future Directions: Better Integration of Wind Fields



- NOAA HRD, NWS Products, other weather services (HURRMAP), FEMA HAZUS, etc…

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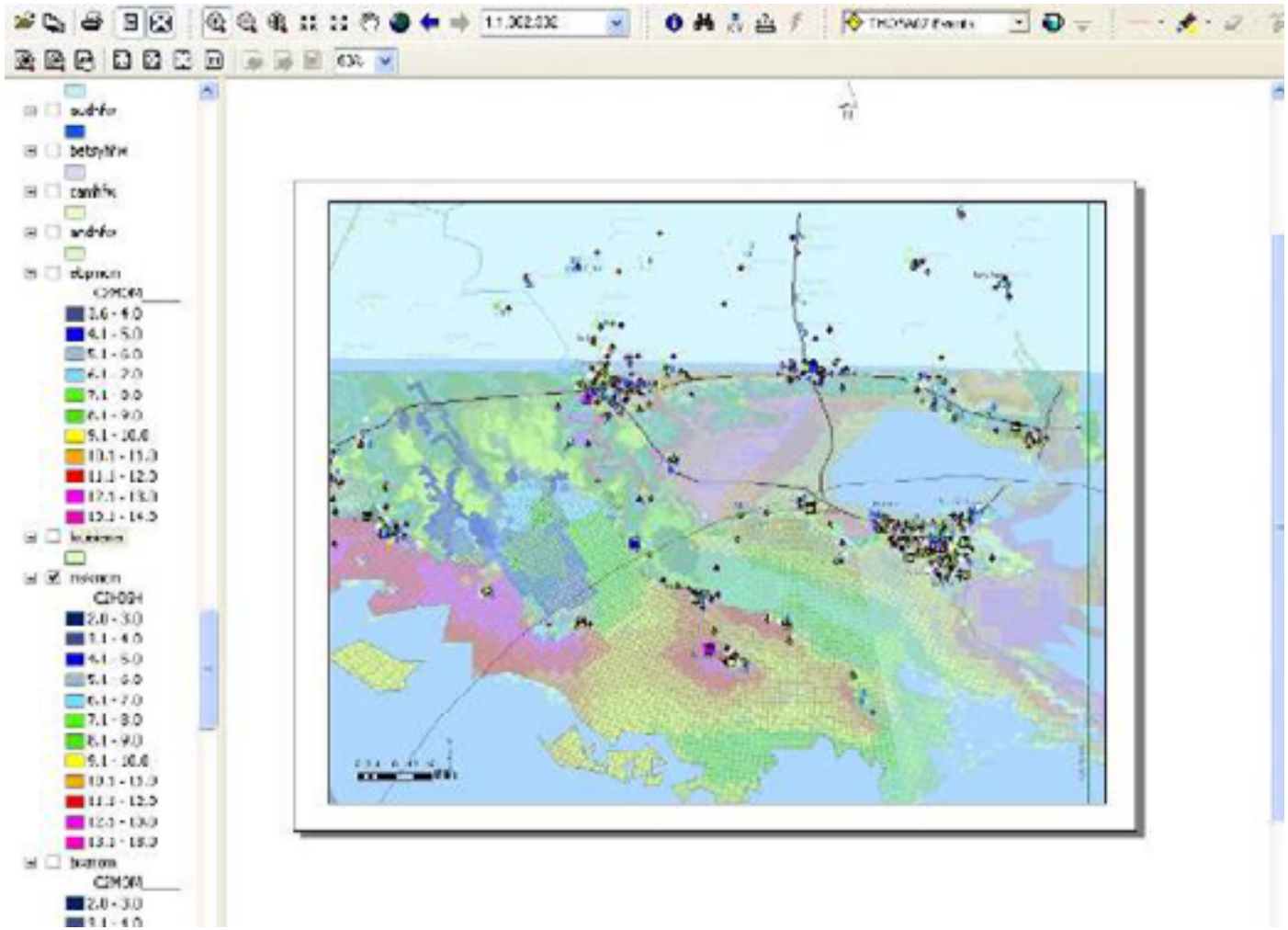
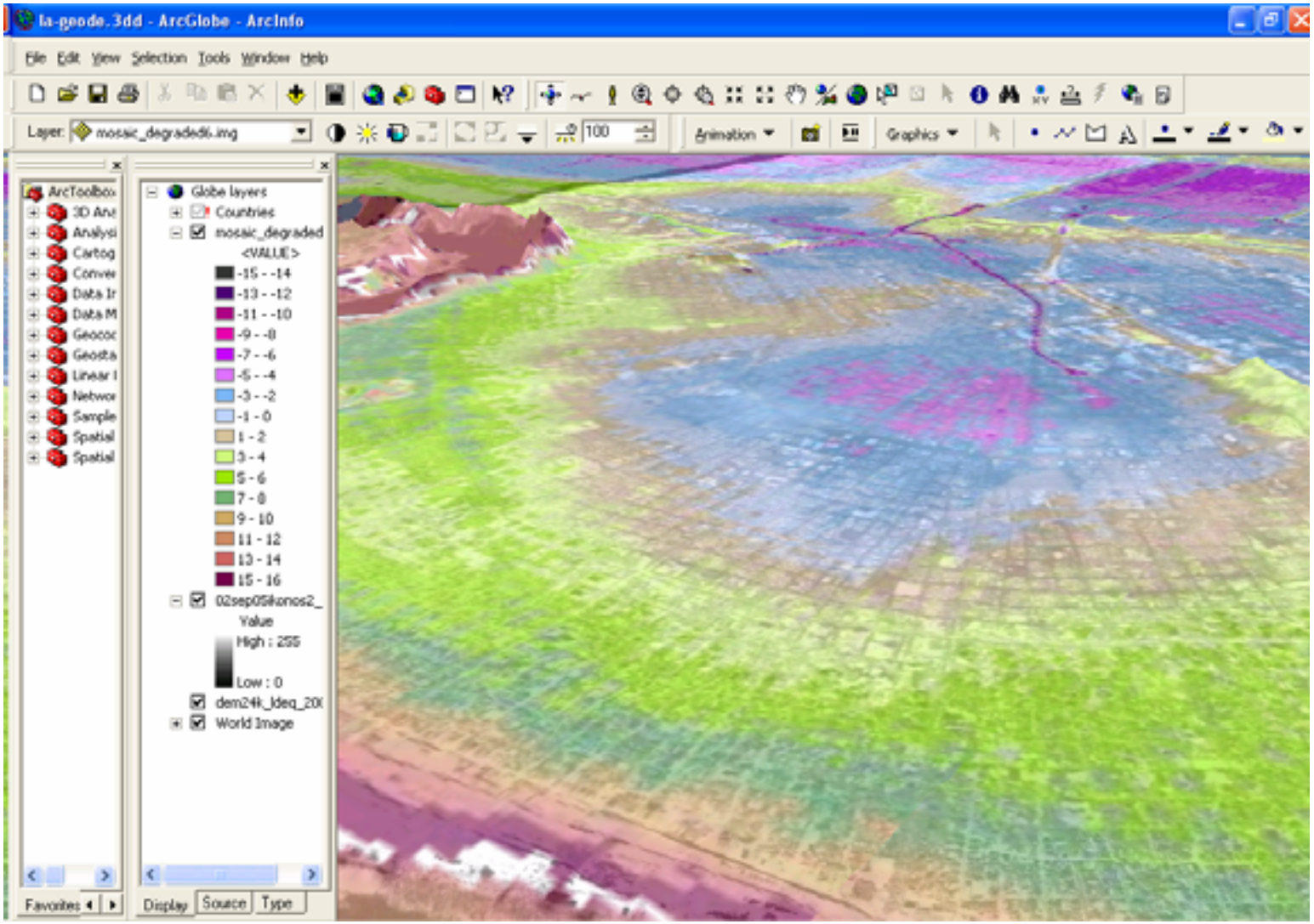
Methods – Publishing Map Files, Sharing Data layers online (Imagery viewers, Servers)



ArcGlobe, 3D in our future



Results

- Assuming
  - (1) The New Orleans HPS (West Bank and East Bank) remains intact and all pumps are operational;
  - (2) Excluding potential increased surge risk from hurricanes such as Rita (2005), that have not been incorporated into the current SLOSH version; and
  - (3) without considering sheltering above the first floor of any multi-level structures or mitigation (these may be subtracted from the totals if facilities are adequately designed and prepared to shelter in place):
  - *Looking at the storm surge data only, without accounting for added risk factors*

Results – Tallied by City

Table 9. Estimated number of evacuating facilities and/or patients as a result of updated SLOSH storm surge modeling for Category 2 hurricanes[11].
Threshold storm event: CATEGORY 1 HURRICANE or Less

CITY	HOSPITALS	HOSP_PATIENTS	NURS_HOMES	NH_PATIENTS	HOSPICE	ASC	AHBC	ADULTRES	EMS	ICF/MR	RESPITE	TBI
ABBEVILLE	2	52	2	154				2		1		
BELLE CHASSE			1	112						3		
BERWICK						1						
BOUTTE						1				1		
CAMERON	1	10										
CHACKBAY										1		
CUT-OFF	1	25	1	106		1				1		
DELCAMBRE										1		
DESTREHAN			7	132						1		
ERATH			1	105		1						
FRANKLIN	1	8	1	123						1		
GALLIANO										1		
GARYVILLE										1		
GONZALES	2	60	1	174		1		1		3		
GRAY						1						
GRETNA	1	22	1	65		6		1		5		
GUEYDAN			1	66								
HARVEY			2	185						6		
HOUMA	3	261	5	381		3		4		5	1	
JEANERETTE			1	99								
KAPLAN			1	109								
LAKE CHARLES										1		
LAPLACE	2	51	1	99				1		2		
LOCKPORT										1		
LOCKPORT						1						
LULING	1	33	2	91								
LUTCHER	2	11	1	52		1						
MANDEVILLE										1		
MARRERO	2	200	3	285				1				
MORGAN CITY	1	40	1	70				1				

[11] Assumes New Orleans HPS (West Bank and East Bank) intact and all pumps operational; does not account for increased surge risk from Hurricane Rita (2005); does not consider sheltering above the first floor of the facility in multi-level structures or further mitigation.

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First Set of Results - Storm Surge Events Affecting MSN Facilities

- Cat 1
  - estimated 22 coastal Louisiana facilities impacted seriously enough to warrant an evacuation
    - 7 hospitals, 179 patients
    - 3 nursing homes, 305 patients
    - 484 total patients in the coastal parishes would be estimated to require transport and evacuation to alternate facilities or shelters
- ***Need to compare all with SLOSH contour layer***

First Set of Results - Storm Surge Events Affecting MSN Facilities

- Cat 2
  - estimated 165 coastal Louisiana facilities impacted seriously enough to warrant an evacuation
    - 23 hospitals, 1,051 patients
    - 38 nursing homes, 3,513 patients
    - 4,564 total patients in the coastal parishes would be estimated to require transport and evacuation to alternate facilities or shelters

First Set of Results - Storm Surge Events Affecting MSN Facilities

- Cat 3
  - estimated 251 coastal Louisiana facilities impacted seriously enough to warrant an evacuation
    - 33 hospitals, 1,589 patients
    - 55 nursing homes, 5,133 patients
    - 6,722 total patients in the coastal parishes would be estimated to require transport and evacuation to alternate facilities or shelters

Results - Storm Surge Events Affecting Critical Medical Evacuation, Transportation and Sheltering Assets

- CPPPs should be evacuated promptly. 4, 9 and 13 will need to be fully evacuated at Cat 1, 2 and 3 levels, respectively, to avoid storm surge risks
- At Category 3 hurricane levels, 3 MMPs are at risk of surge flooding. Sites may not be useable if approaching storms are likely to intensify at smaller storm categories
- 2 MSNS are in surge risk areas, one at Cat 2 levels and one at Cat 3. Sites may not be useable if approaching storms are likely to intensify at smaller storm categories
- 1 T-MOSA may experience surge flooding by Cat 2 levels. This may indicate some risk when setting up this MSNS for any storm events stronger than a tropical storm, which likely would not warrant many evacuees.
- CTNS shelters are located in northern Louisiana and indicated no surge risks

Preliminary Results – Wind Risk based on the 2005 Data

- Saffir-Simpson maximum sustained wind values over water (1-min) when converted, reveal upper gusts of 108, 130 and 156 mph for Category 1, 2 and 3 hurricanes respectively, as hurricanes approach land.
- According to the 2005 HAZUS data, all three Categories of HFW (1-3) have the potential to exceed sixty percent of MSN structures sustaining at least moderate damage, although this will most directly impact the facilities in the hurricane path
- ***Whatever facilities surge does not jeopardize, HFW will…***

Results – Levee Breach, New Orleans East Bank

- ***SLOSH and ADCIRC models have shown overtopping from Katrina advisories (east and west), Hurricane Pam exercise (2004), and in recent analyses in progress***
  - Slow moving Cat 2s or above west of airport could inundate east and west bank of New Orleans, due to MRGO levee problems (unarmored, soils)
  - Storms east of Mississippi and west of Morgan City have potential to flood the West Bank
  - Slow moving 2 or above east of New Orleans could still stress eastern levees enough to cause some flooding
  - Canals in NO cannot withstand over 6 ft surge; pumping capacities in question (van Heerden 2007)

Results – Levee Breach, New Orleans East Bank

- 23 hospitals in New Orleans, (9 closed). The remaining 14 house as many as 1,431 patients according to the 2007 census data. Two hospitals have over 100 patients each, one with over 200 and two others have over 300 patients each.
- 18 nursing homes (4 closed) with 1,282 patients
- Over 100 other MSN facilities located within New Orleans (east bank) which could be additionally impacted by levee breach or flood inundation
- 6 critical MSN locations: two MMP-As (airfields), three CPPPs and the MMP-T (Amtrak Union Passenger Terminal).
- MSN individuals in residences are not included in this count, but elderly counts may be estimated with census data; e.g., there are an estimated 21,032 elderly (over 65) in Orleans Parish (US Census 2006).

Results – Levee Breach, New Orleans West Bank

- 4 hospitals (1 closed). The remaining 3 house as many as 319 patients according to the 2007 census data. One hospital has over 200 patients.
- 14 nursing homes (2 closed) with 1,156 patients
- Over 40 other MSN facilities could be additionally impacted by levee breach or flood inundation
- 3 critical MSN locations: 2 CPPPs and an MMP-A
- MSN individuals in residences are not included in this count, but elderly counts may be estimated with census data; Jefferson Parish has three times the estimated elderly population as New Orleans, at 66,265 individuals (US Census 2006).

Results – GIS Data and Analysis Limitations

- Due to SLOSH resolution 1 mi by 1 mi, urban areas, levees and canals were subject to flood interpretation
- Multi-level structures such as hospitals were still included in surge risk determinations as recommended to evacuate. Some hospitals and other multi-level structures may be adequately equipped to shelter in place on upper floors. The location of the generator would be an important consideration for future work, but could not be include in the scope of the current study
- Manual and visual interpretation of flood and wind risks were limited in the current study, but should be explored in the future with a script or program that will eliminate tedious tallying and provide immediate counts

Threshold Storm Events: Tropical Storms?!?

- Current hurricane risk
  - Coastal Louisiana MSN patients south of the interstates are at ***extreme risk of storm surge flooding and high winds from hurricanes***. Evacuation decisions must be made by L-48 or before to be effective. Regardless of the statistics of major hurricane strikes in Louisiana, ***any*** tropical storm that enters the Gulf of Mexico has the potential to rapidly intensify into a higher order storm within 48 hours, shift in track, spawn tornadoes, and produce extreme rainfall and flood conditions.
- Can anyone safely shelter in Coastal Louisiana for Hurricanes?
  - No, not without accepting varying levels of risk, unless substantial mitigation measures are applied. ***Regardless of the health risks associated with evacuation, sheltering in place in Coastal Louisiana for MSN patients is unsafe and will place human lives at risk.*** Early evacuation should be the focus of MSN planning, with the goal of reducing evacuation risks. Better technologies, strategies and mitigation measures to reduce the risks of MSN populations sheltering in place for hurricanes would be necessary to make sheltering in place a conservative option.

Conclusions and Discussion

- MSN populations can begin to be quantified in a GIS for regional areas such as coastal Louisiana
- Hurricane research and modeling can be incorporated into a GIS along with facility-specific MSN data to explore hurricane risk
- MSN Planning tools can be built in a GIS to aid decision-makers in MSN transportation, evacuation and sheltering plans
- GIS map files can be designed and made available to local MSN decision-makers, ranging from hospital and nursing home administrators to individuals with MSN in individual and group residences, to relay current information on hurricane risk, in an interactive tool that is designed to be easy to use and understand – ***further interaction with stakeholders and study needed***
- In 2007, coastal Louisiana MSN facilities and residences are at serious risk from even smaller order hurricanes. This data could be useful at all levels for planning.

Conclusions and Discussion

- Planning for coastal Louisiana MSN facilities or residents to shelter in place involves serious risk. This risk must be balanced against the risks of evacuation. While the science as presented does not support sheltering in place for most storm events as the best option, improved prediction technology and other advancements, as well as mitigation and other factors, could make sheltering in place more desirable.
- Specifically, future directions could involve the delineation of risk zones in a GIS longitudinally, as well as parallel to the coast, employing high resolution storm surge models and wind estimates.
- All storm events will have unknowns and therefore hold some risk, particularly regarding rapid intensification, shift in track, tornadoes and excessive rainfall. However, given all current considerations, MSN planning now should be conservative (in terms of human life, not necessarily financially), and focus on early evacuation instead of trying to offset evacuation risks with so many hazards and so few viable sheltering options.

Future Directions

- New census data to map MSN and chronic illnesses in coastal areas
- Hypothetical storm surge in high resolution (ADCIRC)
- Scripts, models to create reports and highlight at-risk facilities by priority levels – ***tally affected patients and populations***
- Time series animations of storm surge and wind, other risks at H-Hour
- 3-D fly through to facilities, links to photos, floor-plans, real-time census and evacuations