ATOC 185 FINAL REVIEW

TOPICS
POINTS/SUBTOPICS
STATS

CLIMATE CHANGE

- EVENTS INCLUDE
  - HEAT WAVES
  - DROUGHTS
  - FLOODING
- 2003 EUROPEAN HEAT WAVE – 30,000 DEAD
- CANADA'S MOST COSTLIEST DISASTERS USUALLY DROUGHT
  - 01-02 DROUGHT: $5 BILL
  - 98 ICE STORM: $4.2 BILL
  - 78-80 DROUGHT: $2.5 BILL
  - 88 DROUGHT: $1.8 BILL
  - 84 DROUGHT: $1 BILL
  - 96 FLOOD: $1 BILL
- EARTH INHABITABLE CAUSE OF PROPER SUNLIGHT
  - VENUS → 450°C
  - EARTH → 13°C
  - MARS → -53°C
- GREEN HOUSE EFFECT
  1. RADIATION PASSES THROUGH CLEAR ATMOSPHERE
  2. MOST RADIATION ABSORBED, SOME IS REFLECTED BACK INTO ATMOSPHERE
  3. INFARED IS EMITTED FROM EARTH
  4. SOME RADIATION PASSES THROUGH ATMOSPHERE, SOME IS RE-EMITTED BY GHG.
- GHG's
  - WATER VAPOUR H_2O
  - CARBON DIOXIDE CO_2
  - METHANE CH_4
  - NITROUS OXIDE N_2O
  - OZONE O_3
  - FREON - 11 CCL_3F
  - FREON - 12 CCL_2F_2
- PROBLEMS ASSESSING CLIMATE CHANGE
  - RECORDS GO BACK ONLY 150 YEARS.
  - DATA IS INCONSISTENT
  - PROXY DATA (TREE RINGS, ICE CORES, FOSSIL POLLEN, OCEAN SEDIMENTS)
- CAUSES
  - SUN SENSITIVITY
  - THERMO CIRCULATION
  - OCEAN CURRENTS
  - ORBIT
  - VOLCANOES
  - SNOW COVER
- WARM REGIME
  - NATURALLY REOCCURING?
  - HIGH LEVEL CONFIDENCE NO - WARMEST LAST 400 YEARS
  - HIGH CORRELATION HUMAN ACTIONS AND GHG

- ETHICS - LEAST CONTRIBUTER ARE HIGHEST IMPACT
  - ECONOMIC IMPROVEMENT V.S. POOR GHG
  - BENIFIT NOW, COST ON FUTURE
- TROPICAL CYCLONES AND CLIMATE CHANGE
  - 1980 - 1990 ⟶ 16 CAT 3+
  - 1996 - 2006 ⟶ 40 CAT 3+
  - * - INCREASE IN STORM INTENSITIES FROM CLIMATE CHANGE MAY KILL MANY.
- JUNE/JULY 2012 HEATWAVE - 3000 TEMPERATURE RECORDS BROKEN.
  - DENVER 41°C
  - CHICAGO 37.8°C (3 DAYS)
  - TORONTO 35°C (3 times)
  - NUNAVUT 17.8°C (+8° ABOVE NORMAL)
- HIGH TEMP's CAUSE
  - WARM WATER
  - DROUGHT
  - FIRE
  - FUEL FOR STORMS
- RECENT EXTREMES
  - EUROPEAN HEAT WAVES (2003) - 30,000 DEAD AND GLACIER LOSS
  - PAKISTAN FLOODS (2010) - 6 MIL HOMELESS. WORST IN 80 YEARS. 16,000 DEAD. 42cm RAIN IN 4 DAYS.
  - RUSSIAN HEAT WAVE (2010) - AND FIRES. 7,000 KILLED. $15 MIL DAMAGE. 30% CROPS RUINED.
  - YEAR OF THE TORNADO (2011) - EXTREME TORNADO EVENTS.
  - SUMMER IN MARCH (2012) - N.S. 29.2°, TORONTO 26°, WINDSOR 28.4°, OTTAWA 27.4°, SAINT JOHN 25.4°, HALIFAX 25.8°
- SINCE 1950 INCREASE IN...
  - HEAT WAVES
  - WARM NIGHTS
  - DROUGHT REGIONS
  - EXTREM RAIN EVENTS
  - TROPICAL STORMS
  - WINTER STORMS.
- WEATHER - THE STATE OF THE ATMOSPHERE W.R.T. WIND, TEMP, CLOUDS, MOISTURE ET.C.
- CLIMATE - GENERALLY PREVAILING WHEATER CONDITIONS OF A REGION THROUGHOUT THE YEAR, AVERAGED OVER MANY YEARS.

* CLIMATE CHANGE IS LIKE STERDIDS IN BASEBALL.

- GLOBAL WARMING AND EXTREMES

  HIGHER GLOBAL TEMP ⟶ MORE EVAPORATION ⟶ MORE WATER VAPOUR ⟶ HIGHER MOISTURE

- FUTURE PROJECTIONS
  - DRY AREAS DRIER
  - POLEWARD SHIFT IN STORM TRACKS
  - INTENSITY OF DROUGHT, HEATWAVES, PRECIPITATION WILL INCREASE
  - FEWER COLD EXTREMES
  - POLAR REGIONS WARMER
- HUMAN DEVELOPMENT W.R.T EXTREME EVENTS
  - LAND DEVELOPMENT
  - OVER-POPULATION
  - ENERGY USE/PRODUCTION
  - PUBLIC HEALTH
- MITIGATION
  - REDUCE GHG EMISSION
  - BETTER FORECASTING
  - STREAMLINE WATCH/WARNING
  - OUTREACH/AWARENESS PROGRAMS
  - REDUCE POVERTY
  - WHEATHER-PROOF STRUCTURE

MASS MOVEMENTS - WHEN GRAVITY EXCEEDS SLOPE STRENGTH MATERIAL

- EVENTS INCLUDE
  - LANDSLIDES
  - DEBRIS AVALANCHES
  - DEBRIS FLOWS
- PRECIPITATED BY
  - EARTHQUAKES
  - FLOODS
  - SUDDEN STORMS
- TYPES OF MOVEMENTS
  - SLIDES - MOVE AS COHERENT SINGLE UNIT (ROCKSLIDE, LANDSLIDE, SLUMPS)
  - FLOWS - MOVES LIKE VISCOUS FLUID.
    - SPREAD WHEN UNCONFINED → LATERALLY FROM CANYON
- ARMERO - GLACIAL LAHARS 2-5 METERS LEFT 25,000 DEAD.
- TYPES OF FLOWS
  - CREEP - SLOW PROCESS
  - DEBRIS FLOWS - WATER AND DEBRIS (FAST OR SLOW, LAHARS)
  - DEBRIS AVALANCHE: WHOLESALE COLAPSE WHEN VOLCANO FAILS. (HIGH MOBILITY, HIGH VELOCITY).
- LAHARS - MELTING SNOW AND ICE AT SUMMIT. CAN BE HOT AND ACIDIC. VERY MOBILE.
- FLOW TRANSFORMATION - LANDSLIDE → DEBRIS AVALANCHE → DEBRIS FLOW.
- MUDFLOWS - MISNOMER. MUST BE FINE GRAINED MATERIAL PRESENT.
- SUBAQUEOUS FLOWS
  - SECTOR COLAPSE OF OCEAN VOLCANOES
  - SUBMARINAL LAND SLIDES
  - TURBIDITY CURRENTS

- SHEAR - F_s = SAFETY FACTOR = SHEAR STRENGTH / SHEAR STRESS = <1 UNSTABLE
  - STRENGTH - INTERNAL RESISTANCE TO MOVEMENT
  - STRESS - FORCE CAUSING MOVEMENT
- CAUSES OF LAND SLIDES
  - STEEPNESS
  - BEDDING PLANES
  - LACK OF VEGETATION
  - NATURE OF MATERIALS
  - FRAGMENTATION
- LANDSLIDE TRIGGERS
  - FLOODS
  - MAY BLOCK RIVERS (FLOODING)
  - EARTHQUAKES
  - MAY CAUSE TSUNAMIS
- GROS VENTRE (1925) - PARALLEL TO SLOPE. RAIN AND SNOWMELT INSTABILITY. TRIGGER UNKNOWN
  - $3.7 \times 10^7 m^3$ AT 80 KM/HR. 30m UP OPPOSITE BANK. CAUSED LAKE DAM.
- VAIONT ITALY (1963) - PARALLEL TO SLOPE. CLAY-RICH SHALE. DAM FILLED PRESSURE INCREASE. 6.5x GROS VENTRE AT 110 KM/HR. 140 m UP OPPOSITE BANK. SPILLOVER 70 m HIGH. FLOOD WATER KILLED 2,000. CREATED TSUNAMI DESTROY CASSO. BOUNCE BACK KILLED 1,000
- CASITA VOLCANO, NICARAGUA (1998)
  - RELATED TO HURRICANE MITCH. SUMMIT WAS ROTTEN. MITCH DUMPED 36 FT RAIN. PARTIAL COLLAPSE. DEBRIS AVALANCHE → LAHAR. LAHARS TRAVELLED 15 KM KILLING 2,500.
- MITIGATION
  - LAHAR WARNING (ACOUSTIC FLOW)
  - WEATHER FORECASTS
  - MONITOR RAINFALL.
- PLANNING
  - AVOID STEEP SLOPS
  - AVOID HAZARDOUS AREAS
  - RESTRICT HUMAN ACTIVITIES.
  - USE HAZARD MAPS.
- ENGINEERING SOLUTIONS
  - RESTRAINING DEVICES
  - DRAINAGE PIPES.
  - GRADING OF SLOPES.
  - DIVERSION WALLS.

TORNADOES - HIGHER NUMBER FATALITIES. LESS ECONOMIC LOSS.

- LIKELY DUE TO - 1) WARNING TIME
  2) CATASTROPHIC NATURE OF DAMAGE.

* WEAK TORNADOES HAVE HURRICANE STRENGTH WINDS.

- TORNADO FATALITIES
  - YEARLY IS DECREASING WHILE # OF TORNADO REPORTS INCREASE
  - SUMMER 2011 498 KILLED IN USA.

- TORNADO: VIOLENT ROTATION BETWEEN A CLOUD AND EARTHS SURFACE. WIND SPEEDS MAY REACH 200 MPH AND IN EXTREMES 300 MPH.

FUJITA SCALE

F SCALE	¼ MILE MPH	3s GUST MPH
F0	40-72	45-78
F1	73-112	79-117
F2	113-157	118-161
F3	158-207	162-209
F4	208-260	210-261
F5	261-318	262-317

ENHANCED FUJITA SCALE

EF SCALE	3s GUST MPH
EF0	65-85
EF1	86-109
EF2	110-137
EF3	138-167
EF4	168-199
EF5	200-234

- SIZE, TRACK AND STRENGTH
  - WEAK TORNADOES - EXCLUSIVELY SMALL
  - POWERFUL TORNADOES - BIG OR SMALL
  - LONG LIVED TORNADOES - ANY EF > 0
- MEASURING WIND SPEED
  - DOPPLER RADAR
- WHEN AND WHERE - 85% OF TORNADOES OCCUR IN N.A.
  - CAUSE - WARM MOIST AIR
    - COLD AIR SOURCE
    - MOUNTAIN RANGES ORIENT NORTH SOUTH
  - WHEN - SPRING AND SUMMER EVENINGS.
- TORNADO ALLEY - NORTHEAST - SOUTHWEST ORIENTATION, CORRESPONDING TO STRONG FRONTS. ORIENTATION TO UPPER-LEVEL "JET STREAM"
  - INCLUDES: TEXAS, OKLAHOMA, NEBRASKA, IOWA, MISSOURI, ILLINOIS, INDIANNA, MISSISSIPPI, FLORIDA.
  - MOST TORNADOS BUT NOT MOST FATALITIES.
- ALL TORNADOES FORM IN THUNDERSTORMS
  - FOUND IN - LANDFALLING HURRICANES
    - SUPERCELL HURRICANES
    - SQUALL LINES AHEAD OF COLD FRONTS
- THUNDER STORMS
  - DEFINED BY ITS SCALE (SMALL AND SHORT-LIVED)
  - TYPICALLY 5-10 Km VERTICALLY AND HORIZONTALLY
  - LAST 30-60 MIN
- FORMATION
  1) - SOURCE OF MOISTURE
  2) - CONDITIONALLY UNSTABLE ATMOSPHERE
  3) - MECHANISM FOR UPDRAFT (FORCED LIFT OR HEATING)

- MOISTURE - GULF OF MEXICO
- COOL DRY AIR - PLAINS OR ROCKIES

- LIM
  - ↳ LIFT + INSTIBILITY + MOISTURE

- LAPSE RATE - CHANGE IN TEMP WHILE MOVING UP EARTHS ATMOSPHERE
  - RATE AT WHICH TEMP DECREASES WITH HEIGHT. C°/Km

- STABILITY - TENDENCY TO RESIST VERTICAL MOTIONS. WITH HEIGHT COMES LOWER PRESSURE. VOLUME BECOMES LARGER. RELATED TO LAPSE RATE.

- SATURATION - CONDENSATION RELEASE LATENT HEAT
  - EXPANSION INDUCES COOLING.
  - MOIST ADIABATIC LAPSE RATE - TEMP CHANG MOIST AIR < TEMP CHANGE DRY AIR.

- TRIGGER - ANYTHING CAUSING LIFT MAY TRIGGER T-STORM.
  - TORNADO TRIGGERS FROM ROCKIES (MOVE NORTHWARD SPRING TO SUMMER).

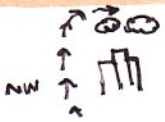
THUNDERSTORM STAGES

1) - CUMULUS (WARM, PLUME, UPDRAFT)
2) - MATURE (UPDRAFTS AND DOWNDRAFTS)
3) - DISSIPATING (PRECIPTATION ENDS UPDRAFT)

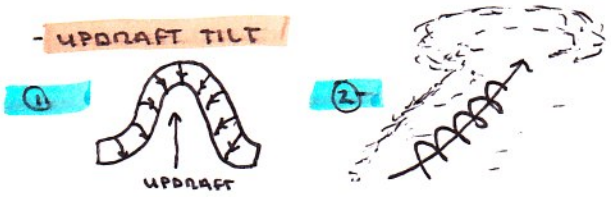
- AIRMASS T-STORMS ≠ TORNADOES
  - WATER SUPPRESSES UPDRAFT
  - NO INHERENT ROTATION

- SPEED SHEAR

- DIRECTION SHEAR



- UPDRAFT TILT



- TILT 1) - REMOVES UPDRAFT FROM PRECIPITATION. NOW A SUPERCELL
  2) - ROTATION PRODUCES LOW PRESSURE. NOW A MESOCYCLONE.
  3) - 10% OF TIME GETS STRETCHED AND CONCENTRATED TO TORNADO.

- FORECASTING - BASED ON PATERN RECOGNITION.
  - LOCATION IS TOO SOPHISTICATED.
  - FORCAST PROBABILITY IN GENERAL REGION

- NOV 10-11, 2002 - 88 TORNADOES ALABAMA TO PENNSYLVANIA.
  - 36 FATALITIES.
  - MOST EXPENSIVE RECENT YEARS.

- CANADA - REGINA (1912) - 28 DEAD, HUNDREDS INJ
  - EDMONTON (1987) - 27 DEAD, HUNDREDS INJ. WIND 420 Km/HR. 300 HOMES GONE $330 MIL IN DAMAGE. 1 HOUR
  - WINDSOR (1946) - 17 DEAD, HUNDREDS INJ
  - PINE LAKE, AB (2000) - 12 DEAD, 140 INJ

- TORNADO WARNING - TORNADO BELIEVED TO BE IN AREA. (DOPPLER OR SPOTTER)
  - EARLIEST WARNING 1 HOUR BEFORE.
- TORNADO WATCHES - CONDITIONS FAVORABLE FOR TORNADO.
  - UP TO 12 HOURS IN ADVANCE.

- SAFETY MEASURES - LISTEN TO WEATHER RADIO
  - MOVE TO SHELTER (BASEMENT)
  - MOVE TO INTERIOR ROOMS (AVOID WINDOWS)
  - LOW ELEVATION OUTSIDE (AWAY FROM OBJECTS)
  - SKYSCRAPERS DON'T PREVENT
  - OVERPASS NOT SAFE
  - TORNADOS MOVE ALL DIRECTIONS

TSUNAMIS - WAVE GENERATED BY DISPLACEMENT OF SEA FLOOR OR OCEAN MASS.
- JAPANESE FOR "HARBOUR WAVE"

- HAZARD AND RISK
  - LITTLE OR NO WARNING.
  - 4,000 KILLED BETWEEN 1990 - 2000
  - 250,000 KILLED IN 2004
  - MAINLY IN SUBDUCTIVE ZONES
- LOCALLY GENERATED TSUNAMIS
  - TRAVEL VERY FAST
  - MANY LARGE COSTAL CITIES.
- STRUCTURE
  - WAVE LENGTH - λ CAN BE > 200 KM (NORMAL OCEAN 100 m)
- VELOCITY = $\frac{\lambda}{\text{PERIOD (T)}} = (gd)^{1/2}$ m/s
  - WHERE d = depth
    $g = 9.81\ m/s^2$
- SHALLOW WATER - FEEL OCEAN BOTTOM (TSUNAMI $d < \frac{1}{2}\lambda$). WAVES PILE UP. λ DECREASE. AMPLITUDE INCREASE.
- DEEP WATER - TRAVEL FASTER. UP TO 1,000 KM/HR.
- DISTANCE - DISTANT - TIME TO WARN PEOPLE
  - LOCAL - IN SUBDUCTIVE ZONES 15-30 MIN.
- AMPLITUDES - SHALLOW WATER - 40 m+
  - DEEP WATER - 1 m
- ARRIVAL - WAVE WILL BREAK WHEN $H > \frac{1}{7}\lambda$
  - 75% TSUNAMIS DO NOT BREAK
- WAVE RUN UP DEPENDS ON
  - WATER DEPTH
  - SEA FLOOR PROFILE
  - SHAPE OF COASTLINE.
- SUBDUCTION ASSOCIATION
  - RUPTURE OF SEA FLOOR
  - SEDIMENT SLUMPS IN TRENCH
- LANDSLIDES -
  - CAN OCCUR IN WATER BODIES
  - SUBMARINE LANDSLIDES CAN CAUSE 400m WAVEUP
- METEORITE IMPACT
  - TERMINAL CRETACEOUS EVENT
  - HUNDREDS OR THOUSAND m HEIGHT

- NOTABLES - DEC 26, 2004 - 250,000 DEAD
  MAR 11, 2011 - 21,000 DEAD (JAPAN)
- CAUSES OF TSUNAMIS
  - EARTHQUAKES (LARGER QUAKE, LARGER TSUNAMI)
  - VOLCANIC ACTIVITY
  - LAND SLIDES (CAUSE WATER DISPLACEMENT)
  - METEORITE IMPACTS
- VOLCANIC ACTIVITY
  - DISPLACEMENT OF ROCK
  - SUBMARINE CALDERA COLLAPSE
  - PYROCLACTIC FLOWS INTO WATER
  - DEBRIS AVALANCH INTO WATER

- ALASKA (1964)
  - MAG 9.2. 4-5 MIN.
  - SUBDUCTION REGION
  - 114 KILLED.
  - AVALANCHE AND LANDSLIDE TSUNMIS ALSO.
  - VALDEZ, SEWARD, WHITTIER - SUBMARINE LANDSLIDES CAUSING TSUNAMIS
    - UNCONSOLIDATED SEDIMENT RUPTURED GAS LINES (FIRE).
    - TSUNAMI CARRIED BURNING OIL INLAND.
    - VALDEZ - 67m RUNUP. TOOK 2-3 MINUTES. 30 DEAD.
      - $15 MILL IN DAMAGE (KODIAK)
    - DISTANT EFFECT IN WEST CANADA AND USA.

- TSUNAMI GENERATION
  - 1) LARGE VERTICAL MOVEMENT (FAULT)
  - 2) SLUMPING OF MATERIAL

- KRAKATOA (1883)
  - SUBMARINE VOLCANO. TOP EXPOSED.
  - CALDERA COLLAPSE
  - 36,000 KILLED IN JAVA AND SUMMATRA.
  - 3 GREAT WAVES. 165 VILLAGES DESTROYED.
  - WAVES 7,000 KM AWAY. 40 METERS HIGH.

- UNZEN, JAPAN (1792)
  - COLLAPSE CAUSING DEBRIS AVALANCHE
  - WAVE KILLED 14,000 - 15,000

- GRANDBANKS (1929)
  - MAG. 7.2 EARTHQUAKE (SUBMARINE LANDSLIDE)
  - 200 km^3 FLOW AT 70 KM/HR.
  - FLOW CUT 12 TRANSATLANTIC CABLES IN 28 PLACES.
  - WAVE 5m HIGH. 27 PEOPLE DEAD IN NEWFOUNDLAND.

- HAZARDS
  - FLOODING
  - WAVE ON COSTAL STRUCTURES
  - WAVE CAN REMOBILIZE OBJECTS
  - CAN CAUSE DRAWDOWN

- DRAWDOWN
  - RELEASE OF DISOLVED GASES.
  - POTENTIAL IGNITION.

- MOVEMENT MAGNITUDES
  - (FAULT SLIP) x (FAULT AREA) x (RIGIDITY OF ROCKS)

- WARNING TIMES
  - 750 KM IS 1 HOUR WARNING
  - VERY LITTLE WARNING TIME.

- WARNING SYSTEM
  - BASED ON QUAKE DATA
  - PACIFIC-WIDE WARNINGS - 1 HOUR NOTICE
  - LOCAL NETWORKS - < 1 HOUR NOTICE

- RESPONSE TO TSUNAMIS
  - GOOD PLANNING AND PREP
  - TRAINING, EDUCATION AND INFORMATION
  - EFFICIENT INFO TRANSMISSION

- PERSONAL MITIGATION
  - RUN DON'T WALK
  - WARN OTHERS
  - USE HAZARD MAPS

- ICE STORMS

- ACCUMULATION OF FREEZING RAIN
- AMONG MOST DEVASTAING EVENTS
- HAULT TRANSPORTATION AND CUT POWER.

- FORECASTING

- OCCUR IN NARROW BANDS (10 TO 160 km)
- CHANGES IN TEMP, WIND SPEED OR MOISTURE

- SUPERCOOLED WATER

- WATER WILL ONLY FREEZE A 0°C WITH ICE NUCLEI.
- VERY LITTLE ICE NUCLEI ABOVE -10°C.
- WHEN TEMP < 0° WATER IS SUPERCOOLED.
- WHEN SUPERCOOLED DROPS CONTACT SURFACE THEY FREEZE INSTANTLY.

- CONDITIONS FOR ICE STORMS

- NORTH OF WARM FRONT AND WEST OF SURFACE CYCLONE (72% OF EVENTS)
- NORTH OF COLD FRONT HIGH PRESSURE SYSTEM (52% OF EVENTS)

- CYCLONE DEVELOPMENT

1) - BOUNDRY OR FRONT SEPARATES WARM FROM COLD.
2) - UPPER LEVEL DISTURBACE (JET STREAM) MOVES OVER FRONT.
3) - FRONT DEVELOPES A KINK AND ORGANIZES THE SYSTEM.

- TEMP STRUCTURE

- DURING FREEZING RAIN, TEMP INCREASES WITH HEIGHT AT SURFACE
- FARTHER ABOVE TEMP DECREASES WITH HEIGHT.
- THIS IS CALLED INVERSION.

- ATMOSPHERIC STABILITY

- ICE STORMS REQUIRE STABLE ATMOSPHERE WITH COLD AIR UNDER WARM AIR.

- SEVERITY OF ICE STORMS

- PERSISTENCY
- INTENSITY
- PHASE (SUPERCOOLED WATER)
- LOCATION.

- ICE STORM (1998)

1) 3 WARM AIR MASSES MOVE INTO ON AND QC.
2) STATIONARY COLD FRONT FORCES WARM AIR TO RISE.
3) PRECIPITATION FALLS

- LASTED 5 DAYS (93% LAST LESS THAN 5 HOURS)
- FREEZING RAIN LASTED 80 HOURS.

- 1998 INTENSITY

- OTTAWA 85 mm
- KINGSTON 73 mm
- CORNWALL 108 mm
- MONTREAL 100 mm

- IMPACT OF 1998 ICE STORM

- 25+ FATALITIES
- 900,000 WITH NO POWER IN QUEBEC
- 100,000 IN SHELTERS.
- 120,000 KM TELEPHONE LINES
- 30,000 WOODEN POLES ($3,000)
- MASSIVE LIVESTOCK LOSS
- MILLIONS MOBILE LIVING
- 14,000 TROOPS DEPLOYED
- MILLIONS OF DOWNED TREES
- 130 TRASFORMER TOWERS ($100,000)
- POWER GRID REBUILT
- MAPLE SYRUP DESTROYED.

- CLIMATOLOGY OF ICE STORMS

- ST. LAWRENCE RIVER VALLEY.
- EASTERN GREAT LAKES
- MISSIPPI RIVER
- NEWFOUND LAND
- EASTERN APPALACHANS
- EAST OF CASCADE MOUNTAINS.

- ST. LAWRENCE VALLEY

- MOST HIGH WINDS ASSOCIATED WITH WESTERLY FLOW
- COLD LOW PRESSURE AIR DRAINS DOWN VALLEY WHLE WARM AIR RIDES ABOVE

- MITIGATION

- LISTEN TO MEDIA FOR WARNINGS

- SAFETY MEASURES

- CLOSE UNEEDED ROOMS
- STUFF TOWELS IN CRACKS
- COVER WINDOWS
- EAT AND DRINK TO MAINTAIN ENERGY.
- WEAR LAYERS (AVOID OVERHEATING)
- USE SAFE ALTERNATIVE HEAT SOURCES.

HURRICANE SANDY

OCTOBER 25TH, 2012

- WIDE WINDFIELD AS IT APPROACHED FLORIDA.
- PASSING FLORIDA APPEARED TO BE HEADING EAST TO SEA.
- TAKEN BY GULF STREAM CAUSING HURRICANE FORCE WINDS ALONG NEW JERSEY AND DELEWARE.
- DAMAGING WINDS EXPECTED FAR OFF COAST AND POTENTIAL SNOW FALL

RESPONDING TO FORECAST

- 4 OR 5 DAYS AWAY. SYSTEM COULD BE CATASTROPHIC OR NOTHING.
- RUN MODEL OVER AND OVER AND SEE LIKELY LOCATION OF CORE.

SANDY HITS NEW YORK/NEW JERSY OCT 29TH

- NOVA VIDEO
- PREDICTION OF NEW YORK ONLY 8 DAYS PRIOR.
- OCT 25TH BECOMES CAT 2
- NO BERMUDA LOW ALLOWED SANDY TO STAY ALONG COAST.
- WARM SST's.
- SANDY MORPHED WITH NORTHEASTERN. NOW SUPERSTORM.
- HIGH PRESSURE FROM NORTH DIRECTED JET STREM WEST PUCLING SANDY INLAND.
- LANDFALL IN 12 HOURS

- POWER CUT IN STATON ISLAND TO PREVENT ELECTRICAL FIRES.
- EXPLOSION LEAVES 3 MIL WITH NO POWER.
- PARTS OF NY UNDER 14 FEET WATER FROM STORM SURGE.
- 20,000 911 CALLS AN HOUR
- 4 DAYS AFTER STORM POWER TURNED BACK ON.

LESSONS FROM SANDY

- GLOBAL WARMING INCREASED INTENSITY AND PILES ON STORM SURGE.
- MEDIA FOCUSED WIND AND RAIN. STORM SURGE REAL PROBLEM.

AVALANCHES

- FLOWS UNDER INFLUENCE OF GRAVITY.
- CHANNELED OR UNCONFINED.

- DIRECT EFFECT
  - IMPACT
  - BURRIAL
- INDIRECT EFFECT
  - GENERATED TSUNAMIS

- ZONES
  1) STARTING ZONES
     - SURFACE FAILURE (LOOSE SNOW)
     - FAILURE AT DEPTH (SLAB)
  2) AVALANCH TRACK
     - INTERNAL STRUCTURE
       - HEAD → BODY → TAIL.
       - LOW DENSITY PART - HIGH HAZARD.
       - OVERLYING DILUTE PART - ALSO HAZARDOUS.
     - FLOW AVALANCHE
       - VELOCITIES UP TO 216 KM/HR
       - FLOW HEIGHTS 5-10 m.
       - GRANULAR FLOW
       - HIGH DENSITY CORE (HEAT HERE MAY CAUSE ICE UNDERWAY)
     - AIRBOURN POWDER
       - VELOCITIES UP TO 360 KM/HR.
       - THICKNESS 100 METERS.
       - DENSER CORE
       - MAY DEVELOP FROM FLOW AVALANCHE
  3) RUN OUT
     - POWDER AVALANCHES - FLOW AROUND OBSTACLES
     - FLOW AVALANCHES - DO NOT

- MITIGATION
  - AVOID STEEP SLOPES
  - CLOSE HIGH HAZARD AREAS.
  - SET OFF CHARGES IN BAD AREAS.
  - USE HAZARD MAPS
- ENGINEERING
  - REFORESTATION - STABILIZE SLOPS
  - HIGHWAYS - SAFE LOCATIONS

- EXAMPLES
  - DEFLECTORS
  - ARRESTORS
  - SPLITTERS
  - MOUNDS
  - SNOW SHEDS

FINAL LECTURE

- PREDICTION
  - NO DIRECT ANSWER (GOOD/BAD)
  - NO DISASTERS CREATED EQUALLY.
  - TRACKING SADNY ACCURATE. FLOOD PREDICTIONS INNACURATE.
  - ECONOMIC LOSS OR HUMAN LOSS?
  - POOR WITH EARTHQUAKES.
  - GOOD WITH TSUNAMIS AFTER QUAKES.
- HUMAN INFLUENCE
  - POSITIVE AND NEGATIVE
  - POPULATION INCREASE ⟶ MORE PEOPLE AT RISK
  - GLOBAL WARMING IS GLOBALLY ACCEPTED.
  - AVERAGE TEMP IS INCREASING.
  - HURRICANE ANDREW WAS A WAKE-UP CALL
- INCREASE SSTs
  - INCREASE STRENGTH OF TROPICAL CYCLONES.
  - 2005 MOST ACTIVE HURRICANE SEASON
- HUMAN ACTION
  - WILD FIRES
  - WEST HAMPTONS
- CONCLUSION
  - METEOROLOGICAL EVENTS LIKELY TO INCREASE.
  - IMPACT LIKELY TO INCREASE BECAUSE OF POPULATION AND VULNERABILITY.
    - MORE PEOPLE NEAR COAST
    - LACK OF MONEY FOR PROPER HOUSING
    - POOR EDUCATION ABOUT NATURAL HAZARDS AND THREATS.