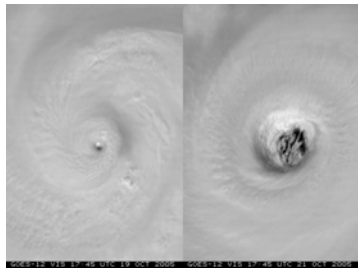
Advanced Applications of the Monte Carlo Wind Probability Model:
A Year 1 Joint Hurricane Testbed Project Update

Mark DeMaria[1], Stan Kidder[2], Robert DeMaria[2],
Andrea Schumacher[2], Daniel Brown[3], Michael Brennan[3],
Richard Knabb[4], Pablo Santos[5] and David Sharp[6]

[1]NOAA/NESDIS, Fort Collins, CO
[2]CIRA, Colorado State University, Fort Collins, CO
[3]NCEP National Hurricane Center, Miami, FL
[4]Central Pacific Hurricane Center, Honolulu, HI
[5]NOAA/National Weather Service, Miami, FL
[6]NOAA/National Weather Service, Melbourne, FL

Interdepartmental Hurricane Conference
March 2010



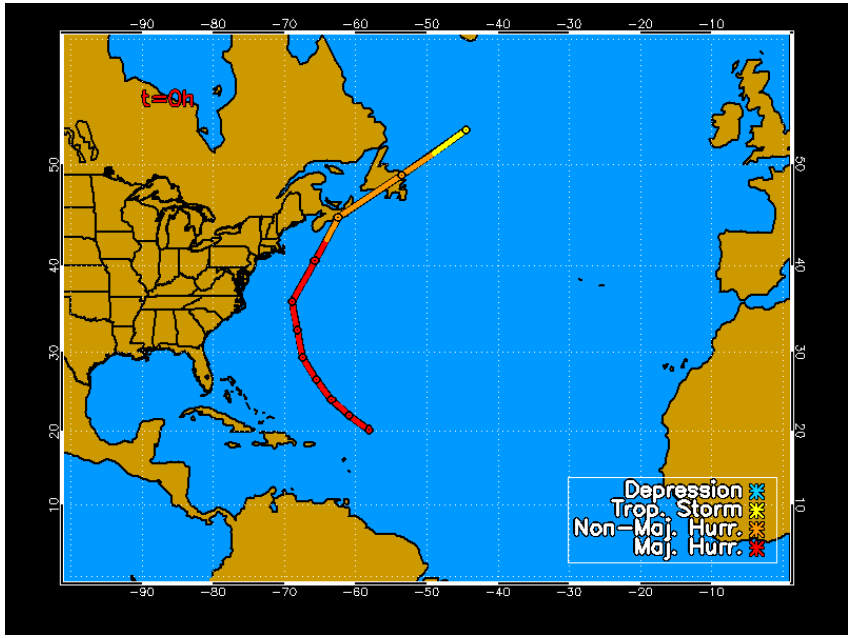
Outline

- Brief overview of the MC model
- Summary of current project tasks
- Progress report
- Plans for Year 2

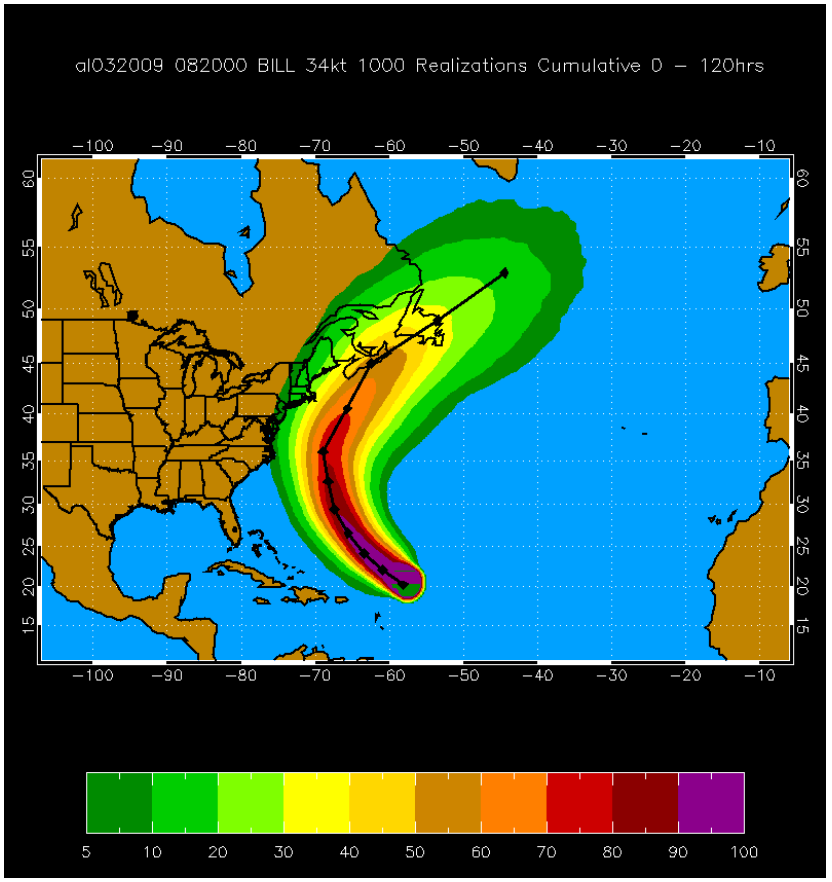
Monte Carlo Wind Probability Model

- Estimates probability of 34, 50 and 64 kt wind to 5 days
- 1000 track realizations from random sampling of NHC/CPHC or JTWC *track error* distributions
- Intensity of realizations from random sampling of NHC/CPHC or JTWC *intensity error* distributions
  - Special treatment near land
- Wind radii of realizations from radii CLIPER model and its *radii error* distributions
- Serial correlation of errors included
- Probability at a point from counting number of realizations passing within the wind radii of interest
- Replaced NHC strike probability program in 2006

MC Probability Example
Hurricane Bill 20 Aug 2009 00 UTC



1000 Track Realizations



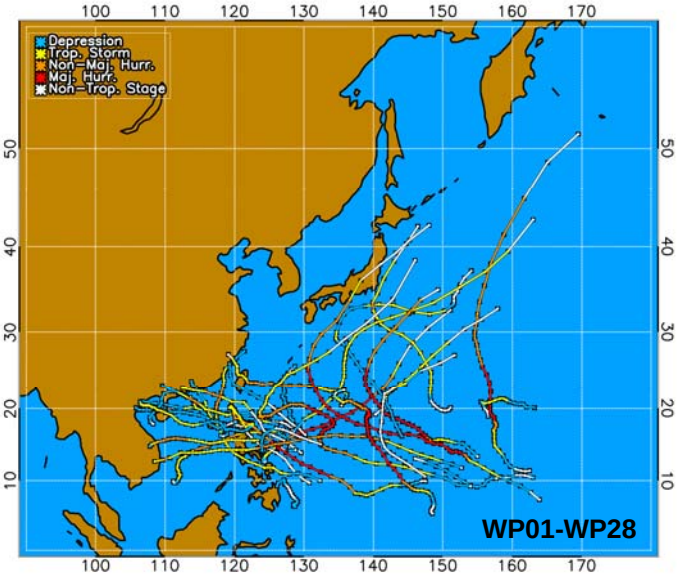
34 kt 0-120 h Cumulative Probabilities

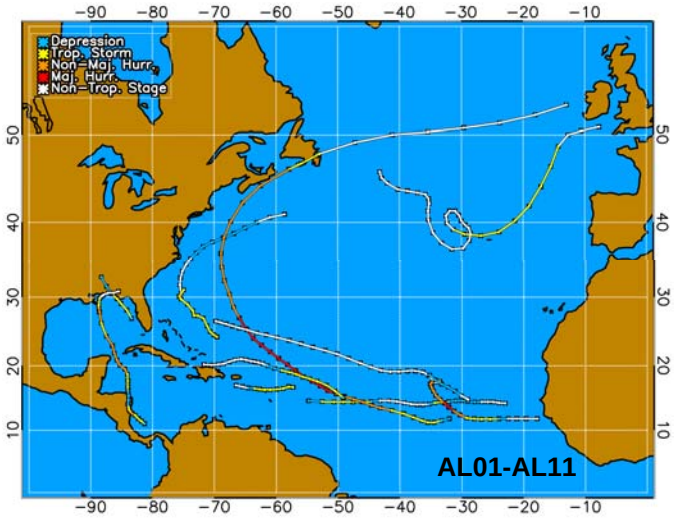
Forecast Dependent Track Errors

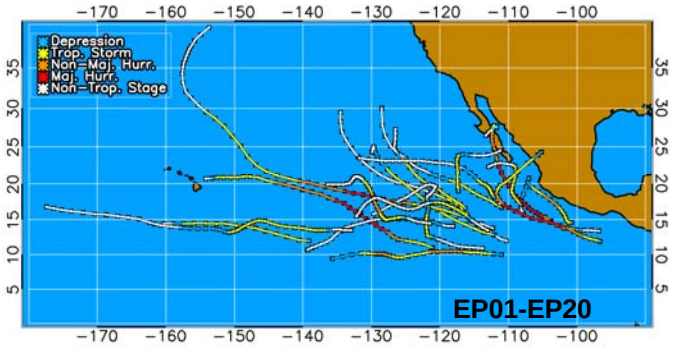
- Use GPCE input as a measure of track uncertainty
  - GPCE = Goerss Predicted Consensus Error
- Divide NHC track errors into three groups based on GPCE values
  - Low, Medium and High
- *GPCE version under evaluation by NHC*

Evaluation of GPCE Version in 2009

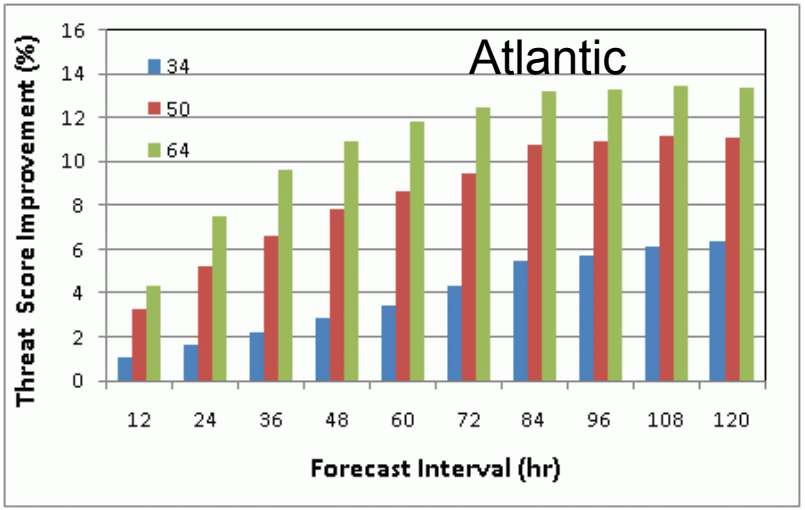
- Two evaluation metrics: Brier Score, Threat Score
- Compare operational and GPCE versions

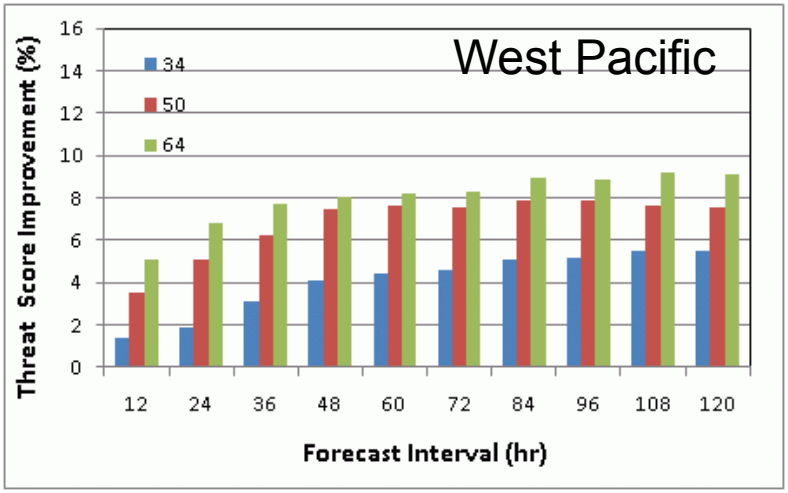


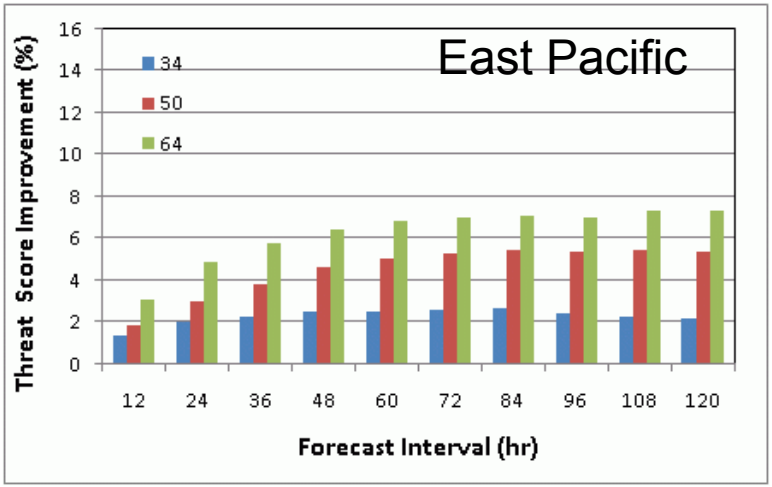




Threat Score Improvements with GPCE version





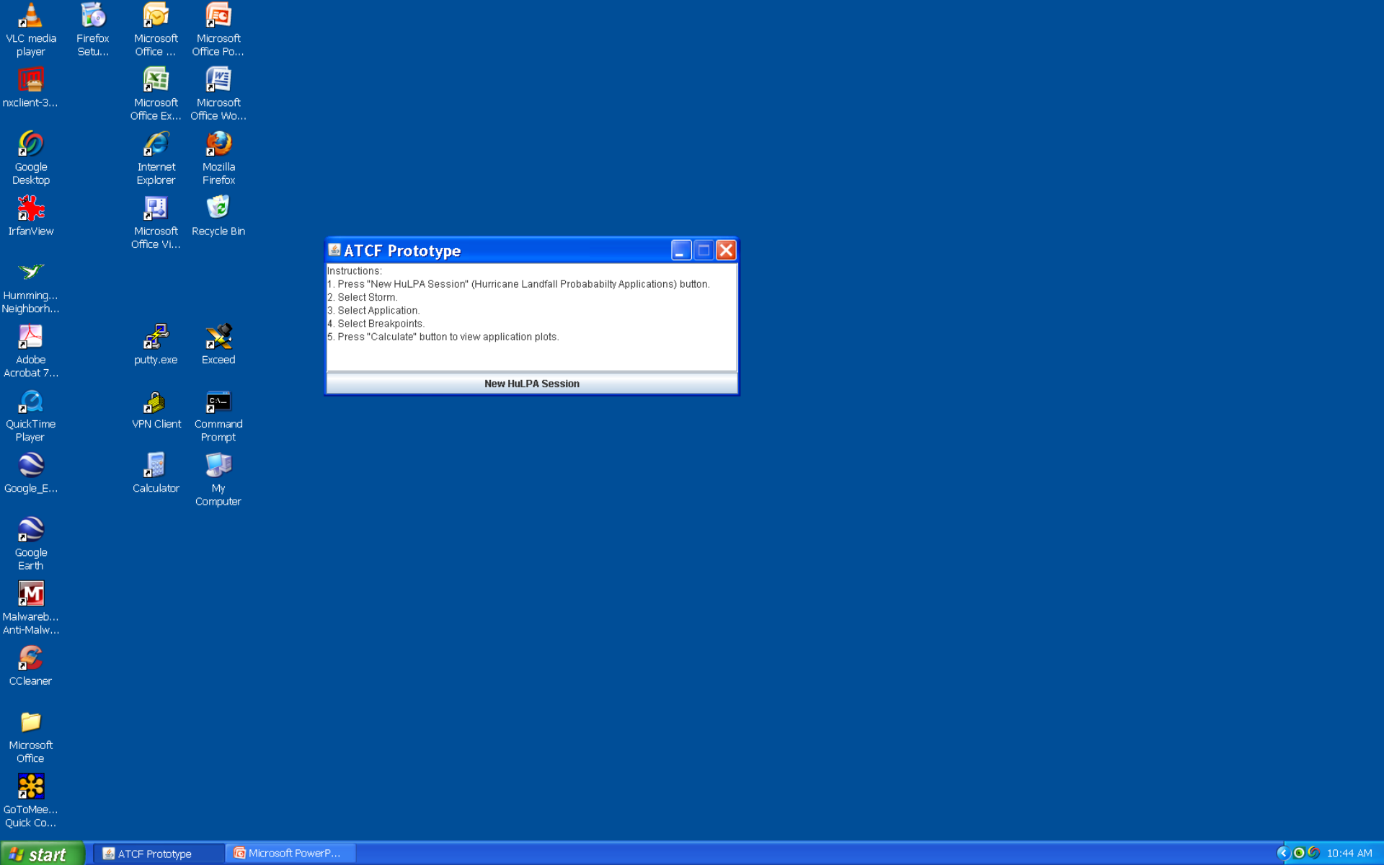


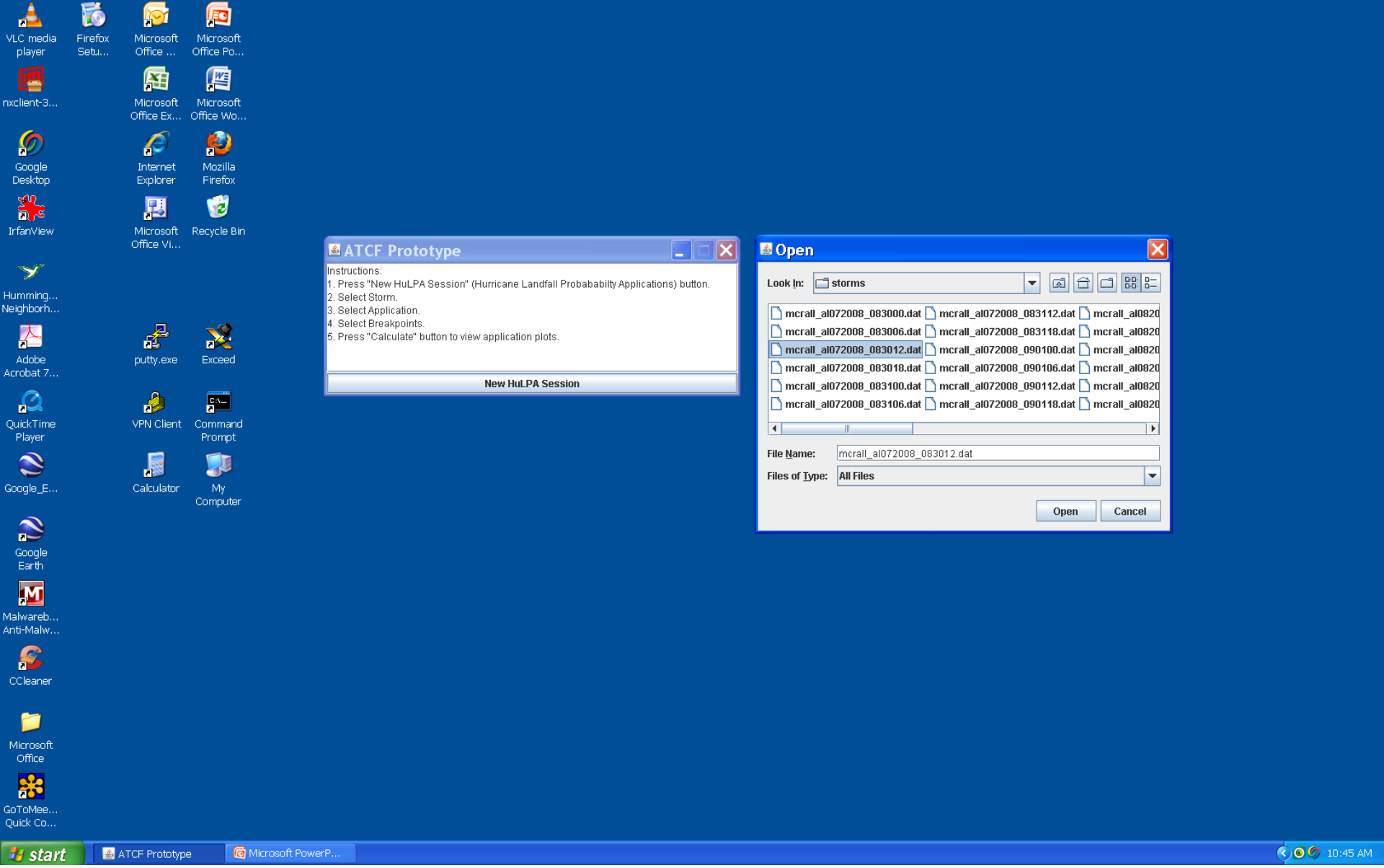
Current JHT Project Tasks

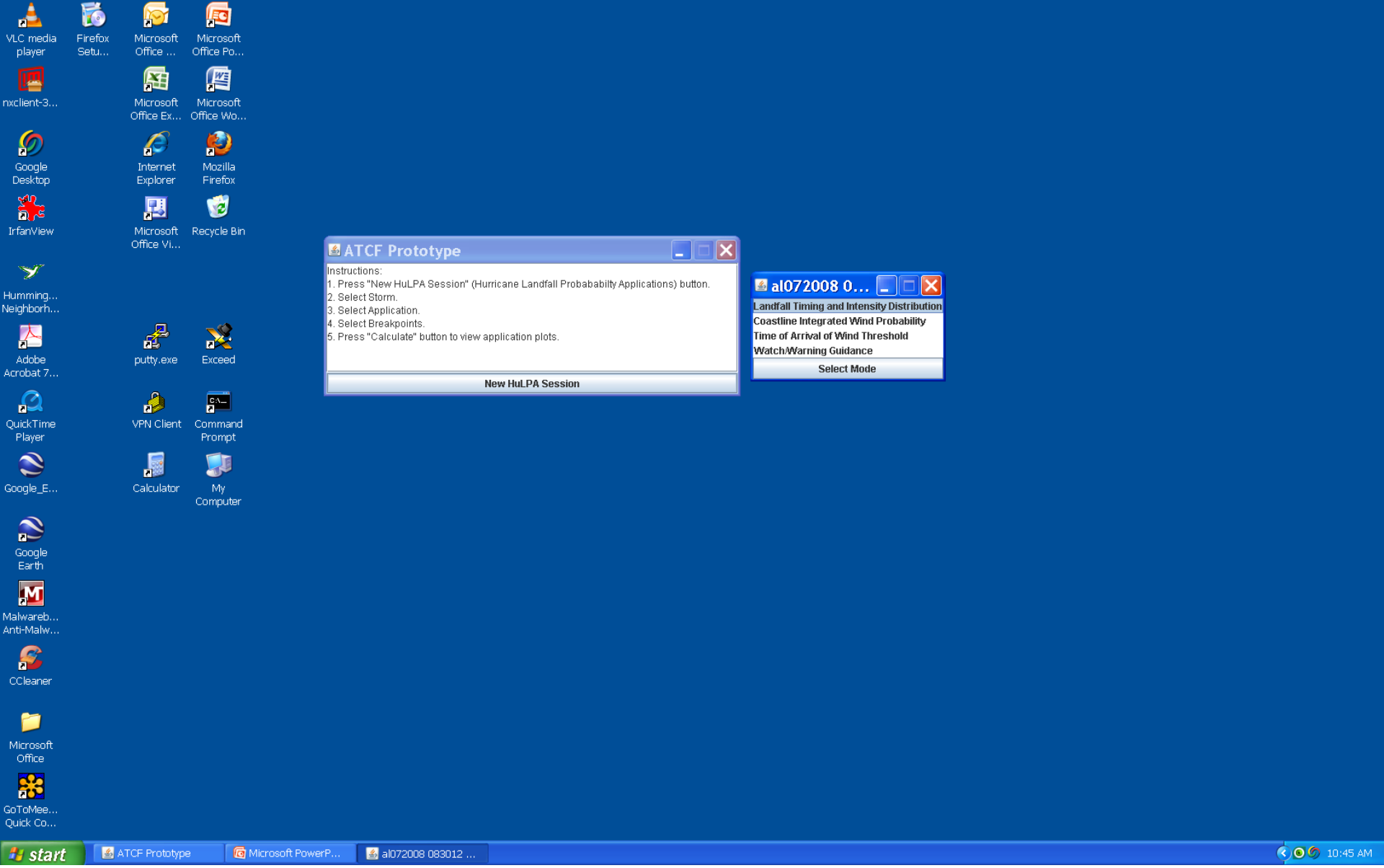
- Advanced Applications
  1. Landfall timing and intensity distributions
  2. Application to WFO local products
  3. Probabilities integrated over coastal segments
  4. Automated guidance for watch/warnings
- Model Improvements
  1. Adjust time step for small/fast storms
  2. Improve azimuthal interpolation of wind radii
  3. Improve spatial interpolation for text/grid product consistency
  4. Evaluate wind radii model

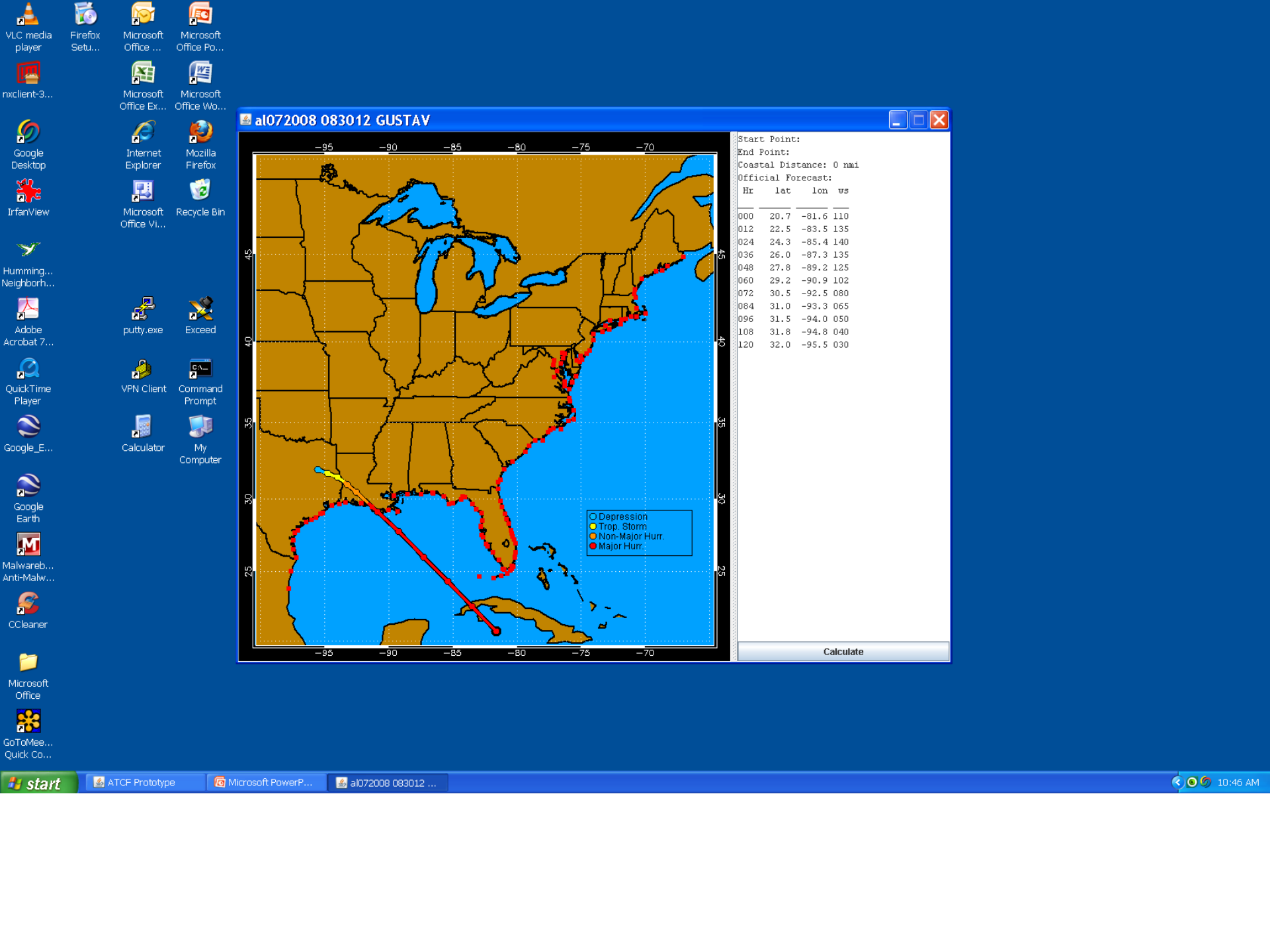
A1. Landfall timing/intensity distributions

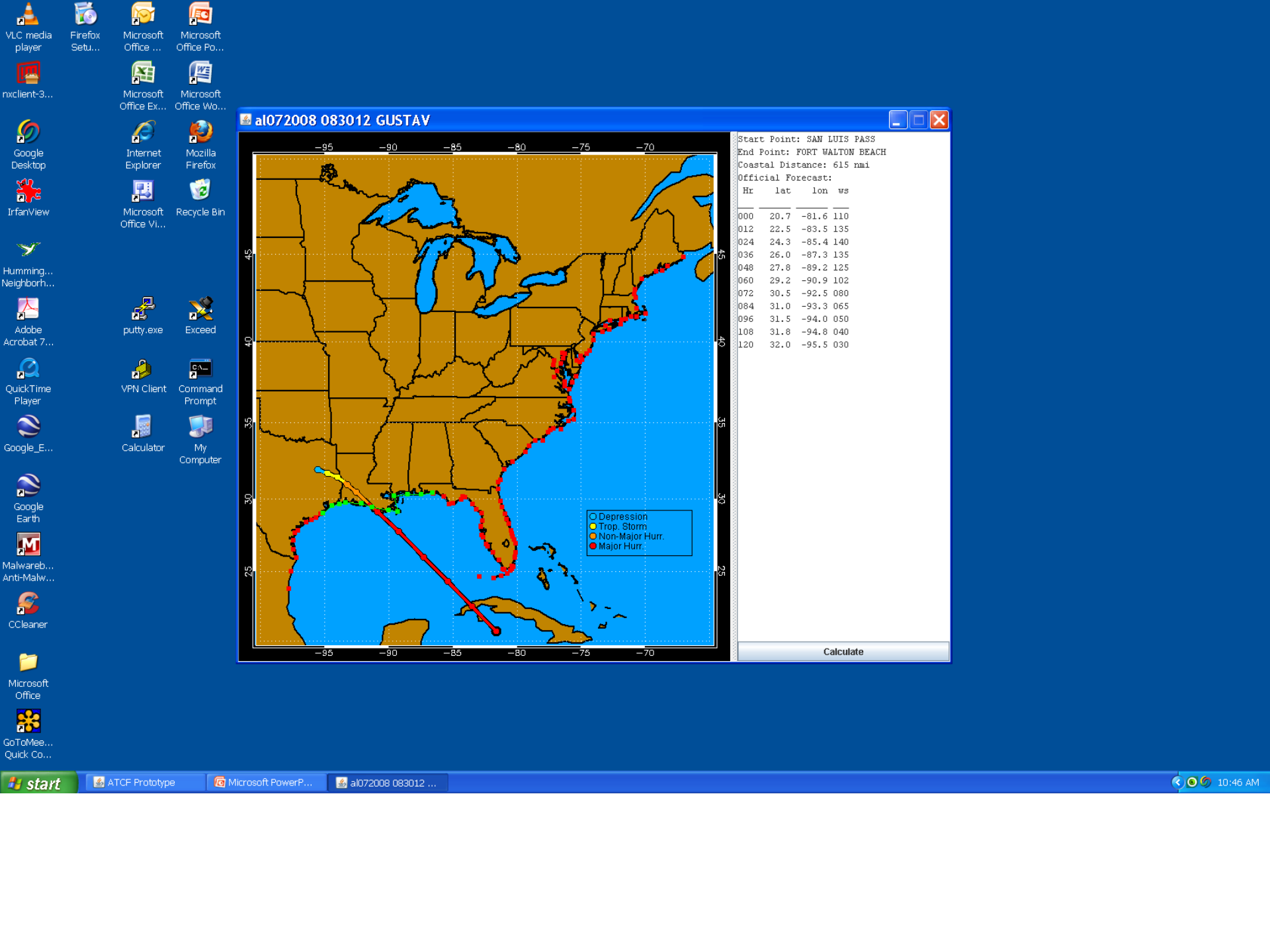
- New output file with track, intensity, radii of all 1000 realizations
- User interface written for coastal point selection
  - Hurricane Landfall Probability Applications (HuLPA)
  - Java program as ATCF prototype
- Algorithm for landfall timing distributions completed
- Algorithm for timing of 34, 50, 64 kt winds under development

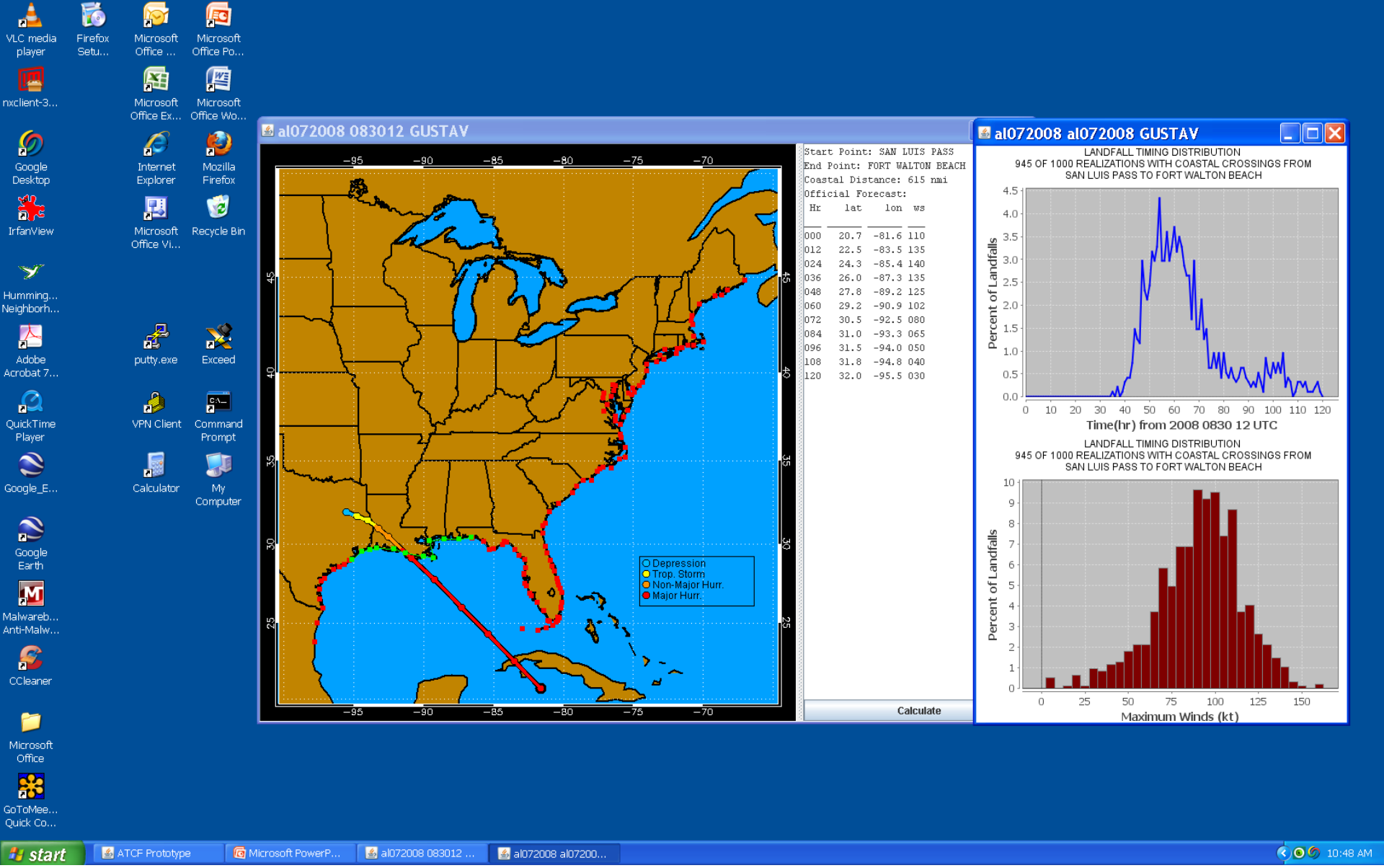

VLC media player
Firefox Setu...
Microsoft Office ...
Microsoft Office Po...
nxclient-3...
Microsoft Office Ex...
Microsoft Office Wo...
Google Desktop
Internet Explorer
Mozilla Firefox
IrfanView
Microsoft Office Vi...
Recycle Bin
Humming... Neighborh...
Adobe Acrobat 7...
putty.exe
Exceed
QuickTime Player
VPN Client
Command Prompt
Google_E...
Calculator
My Computer
Google Earth
Malwareb... Anti-Malw...
CCleaner
Microsoft Office
GoToMee... Quick Co...
ATCF Prototype
Instructions:
1. Press "New HuLPA Session" (Hurricane Landfall Probabability Applications) button.
2. Select Storm.
3. Select Application.
4. Select Breakpoints.
5. Press "Calculate" button to view application plots.
New HuLPA Session
start
ATCF Prototype
Microsoft PowerP...
10:44 AM


VLC media player
Firefox Setu...
Microsoft Office ...
Microsoft Office Po...
nxclient-3...
Microsoft Office Ex...
Microsoft Office Wo...
Google Desktop
Internet Explorer
Mozilla Firefox
IrfanView
Microsoft Office Vi...
Recycle Bin
Humming... Neighborh...
Adobe Acrobat 7...
putty.exe
Exceed
QuickTime Player
VPN Client
Command Prompt
Google_E...
Calculator
My Computer
Google Earth
Malwareb... Anti-Malw...
CCleaner
Microsoft Office
GoToMee... Quick Co...
ATCF Prototype
Instructions:
1. Press "New HuLPA Session" (Hurricane Landfall Probabability Applications) button.
2. Select Storm.
3. Select Application.
4. Select Breakpoints.
5. Press "Calculate" button to view application plots.
New HuLPA Session
Open
Look In:
storms
mcrall_al072008_083000.dat
mcrall_al072008_083006.dat
mcrall_al072008_083012.dat
mcrall_al072008_083018.dat
mcrall_al072008_083100.dat
mcrall_al072008_083106.dat
mcrall_al072008_083112.dat
mcrall_al072008_083118.dat
mcrall_al072008_090100.dat
mcrall_al072008_090106.dat
mcrall_al072008_090112.dat
mcrall_al072008_090118.dat
File Name:
mcrall_al072008_083012.dat
Files of Type:
All Files
Open
Cancel
start
ATCF Prototype
Microsoft PowerP...
10:45 AM


VLC media player
Firefox Setu...
Microsoft Office ...
Microsoft Office Po...
nxclient-3...
Microsoft Office Ex...
Microsoft Office Wo...
Google Desktop
Internet Explorer
Mozilla Firefox
IrfanView
Microsoft Office Vi...
Recycle Bin
Humming... Neighborh...
Adobe Acrobat 7...
putty.exe
Exceed
QuickTime Player
VPN Client
Command Prompt
Google_E...
Calculator
My Computer
Google Earth
Malwareb... Anti-Malw...
CCleaner
Microsoft Office
GoToMee... Quick Co...
ATCF Prototype
Instructions:
1. Press "New HuLPA Session" (Hurricane Landfall Probabability Applications) button.
2. Select Storm.
3. Select Application.
4. Select Breakpoints.
5. Press "Calculate" button to view application plots.
New HuLPA Session
al072008 0...
Landfall Timing and Intensity Distribution
Coastline Integrated Wind Probability
Time of Arrival of Wind Threshold
Watch/Warning Guidance
Select Mode
start
ATCF Prototype
Microsoft PowerP...
al072008 083012 ...
10:45 AM

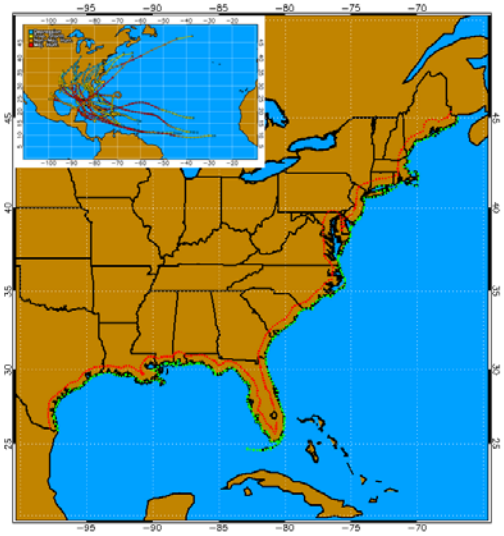

al072008 083012 GUSTAV
Start Point:
End Point:
Coastal Distance: 0 nmi
Official Forecast:
Hr lat lon ws
000 20.7 -81.6 110
012 22.5 -83.5 135
024 24.3 -85.4 140
036 26.0 -87.3 135
048 27.8 -89.2 125
060 29.2 -90.9 102
072 30.5 -92.5 080
084 31.0 -93.3 065
096 31.5 -94.0 050
108 31.8 -94.8 040
120 32.0 -95.5 030
Depression
Trop. Storm
Non-Major Hurr.
Major Hurr.
Calculate
VLC media player
Firefox Setu...
Microsoft Office ...
Microsoft Office Po...
nxclient-3...
Microsoft Office Ex...
Microsoft Office Wo...
Google Desktop
Internet Explorer
Mozilla Firefox
IrfanView
Microsoft Office Vi...
Recycle Bin
Humming... Neighborh...
Adobe Acrobat 7...
putty.exe
Exceed
QuickTime Player
VPN Client
Command Prompt
Google_E...
Calculator
My Computer
Google Earth
Malwareb... Anti-Malw...
CCleaner
Microsoft Office
GoToMee... Quick Co...
start
ATCF Prototype
Microsoft PowerP...
al072008 083012 ...
10:46 AM


al072008 083012 GUSTAV
Start Point: SAN LUIS PASS
End Point: FORT WALTON BEACH
Coastal Distance: 615 nmi
Official Forecast:
Hr lat lon ws
000 20.7 -81.6 110
012 22.5 -83.5 135
024 24.3 -85.4 140
036 26.0 -87.3 135
048 27.8 -89.2 125
060 29.2 -90.9 102
072 30.5 -92.5 080
084 31.0 -93.3 065
096 31.5 -94.0 050
108 31.8 -94.8 040
120 32.0 -95.5 030
Depression
Trop. Storm
Non-Major Hurr.
Major Hurr.
Calculate
VLC media player
Firefox Setu...
Microsoft Office ...
Microsoft Office Po...
nxclient-3...
Microsoft Office Ex...
Microsoft Office Wo...
Google Desktop
Internet Explorer
Mozilla Firefox
IrfanView
Microsoft Office Vi...
Recycle Bin
Humming... Neighborh...
Adobe Acrobat 7...
putty.exe
Exceed
QuickTime Player
VPN Client
Command Prompt
Google_E...
Calculator
My Computer
Google Earth
Malwareb... Anti-Malw...
CCleaner
Microsoft Office
GoToMee... Quick Co...
start
ATCF Prototype
Microsoft PowerP...
al072008 083012 ...
10:46 AM

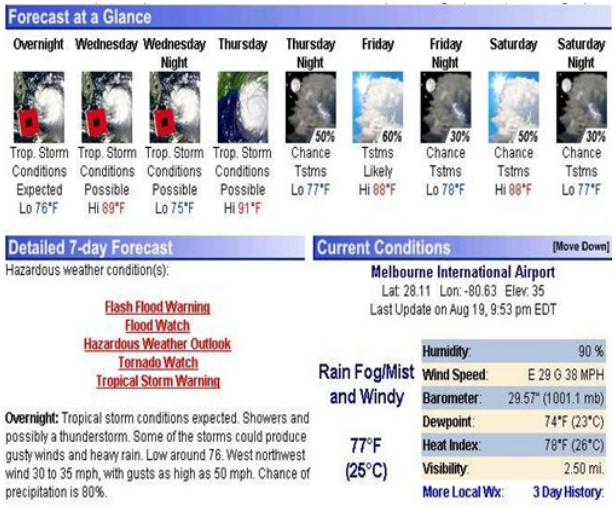

al072008 083012 GUSTAV
Start Point: SAN LUIS PASS
End Point: FORT WALTON BEACH
Coastal Distance: 615 nmi
Official Forecast:
Hr lat lon ws
000 20.7 -81.6 110
012 22.5 -83.5 135
024 24.3 -85.4 140
036 26.0 -87.3 135
048 27.8 -89.2 125
060 29.2 -90.9 102
072 30.5 -92.5 080
084 31.0 -93.3 065
096 31.5 -94.0 050
108 31.8 -94.8 040
120 32.0 -95.5 030
Calculate
Depression
Trop. Storm
Non-Major Hurr.
Major Hurr.
al072008 al072008 GUSTAV
LANDFALL TIMING DISTRIBUTION
945 OF 1000 REALIZATIONS WITH COASTAL CROSSINGS FROM
SAN LUIS PASS TO FORT WALTON BEACH
Percent of Landfalls
Time(hr) from 2008 0830 12 UTC
LANDFALL TIMING DISTRIBUTION
945 OF 1000 REALIZATIONS WITH COASTAL CROSSINGS FROM
SAN LUIS PASS TO FORT WALTON BEACH
Percent of Landfalls
Maximum Winds (kt)

A2. WFO Local Products

- Coordinated with P. Santos and D. Sharp on coastal and inland verification
  - Presented by P. Santos at 2010 AMS Conference
- Used to define thresholds for product generation
  - Threat score the most useful



2004-08 cases
400 forecasts
20 TCs



A3. Coastal integrated probabilities
A4. Watch/Warning guidance

- Coastal integrated probabilities included in HuLPA
  - Algorithm not complete yet
- Preliminary development of W/W guidance
  - Threshold method developed for hurricane warnings and watches
  - Tropical storm watches and warning under development
  - Logic needed to decide between TS, Hurricane watches and warning
  - Will be incorporated into HuLPA for testing

M1. Time Step Adjustment

- Rule of thumb

  $\Delta t \leq R_{64}/c$

  R64 = 40 nmi, c=20 kt,

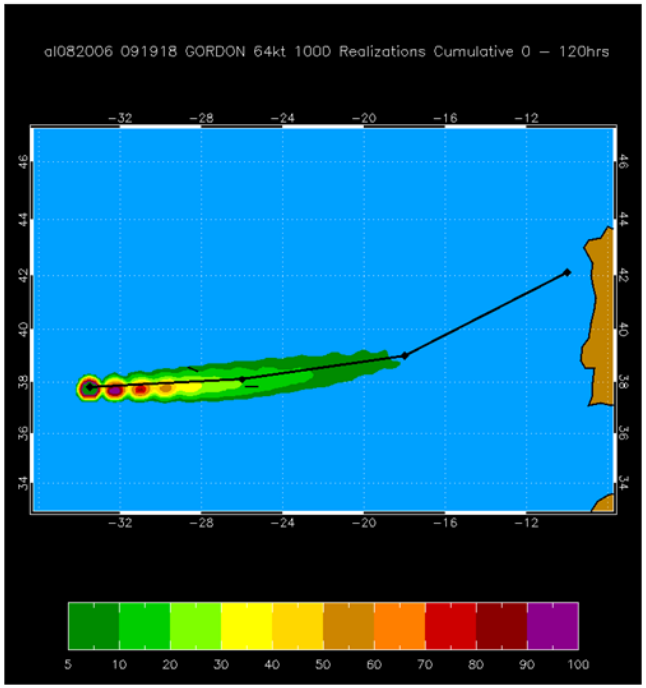
  Δt = 2 hr

- 2 hr too long for small, fast storms
- Code modified for variable time step
  - Δt = 1 hr improves noisy probability fields
  - Only increases run time by 10%
  - Δt = 1 hr needed for landfall probabilities
  - Suggest using 1 hr time step for all runs

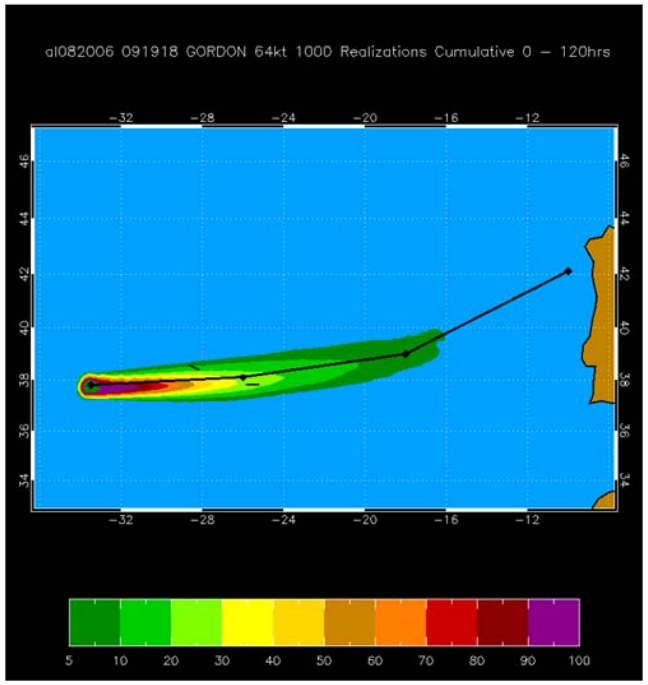
M1. Time Step Adjustment

Hurricane Gordon, 19 Sept 2006 18 UTC

R_{64} ~ 25 to 30 nmi, c = 28 kt



Δt = 2 hr



Δt = 1 hr

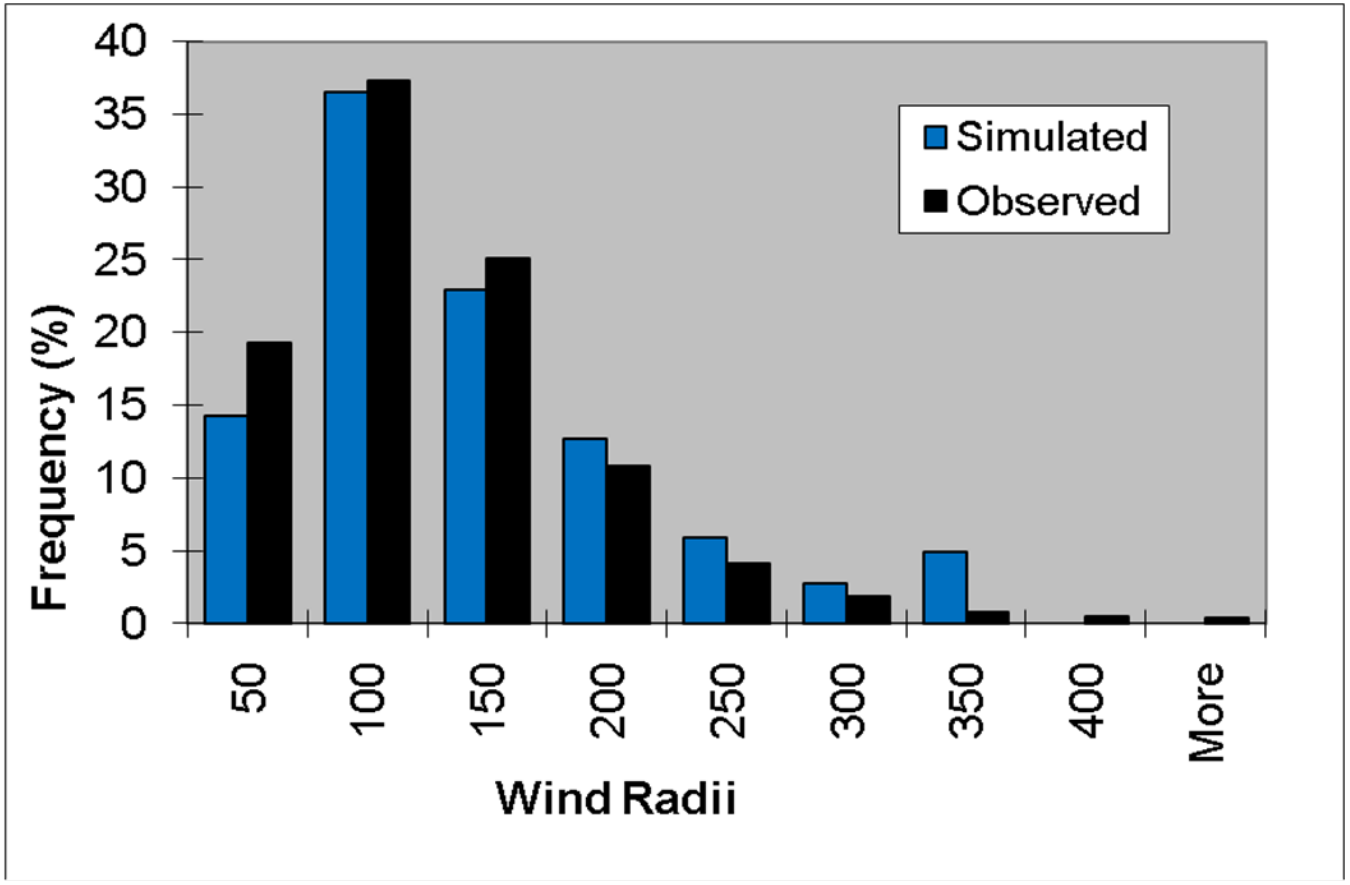
M2. Improve azimuthal radii interpolation
M3. Improve spatial interpolation

- Azimuthal interpolation
  - Results in inconsistent 34 and 50 kt probabilities in rare cases
  - Large RMW, 34 and 50 kt wind zero in most quadrants
  - Use extrapolation instead of interpolation
- Spatial interpolation
  - Inconsistency between gridded and text products in regions of high gradients
  - Increase grid resolution or include coastal points in grid interpolation routine

M4. Evaluation of Wind Radii Model

- Wind radii from climatology and persistence model and its error distributions
- Only input are track and max wind
- Should produce realistic radii distributions
  - Compare 5000 MC model radii and 1988-2008 “observed” distributions
  - Model radii from 5 representative MC model runs

M4. Evaluation of Wind Radii Model



MC model (t=72 hr) and observed distributions of 34 kt wind radii

Future Plans

- 2010 Season
  - Test 2 of 3 HuLPA products in 2010 season
    - Landfall distributions, Integrated probabilities
  - Implement reduced time step, improved azimuthal interpolation
  - Additional verifications for WFO applications
  - Continue wind radii model evaluation
- 2011 Season
  - Test watch/warning guidance
  - Improved spatial interpolation
  - Refine HuLPA as needed