BLENDING PARAMETRIC HURRICANE SURFACE FIELDS INTO CMC FORECASTS AND EVALUATING IMPACT ON THE WAVE MODEL FOR HURRICANE JUAN

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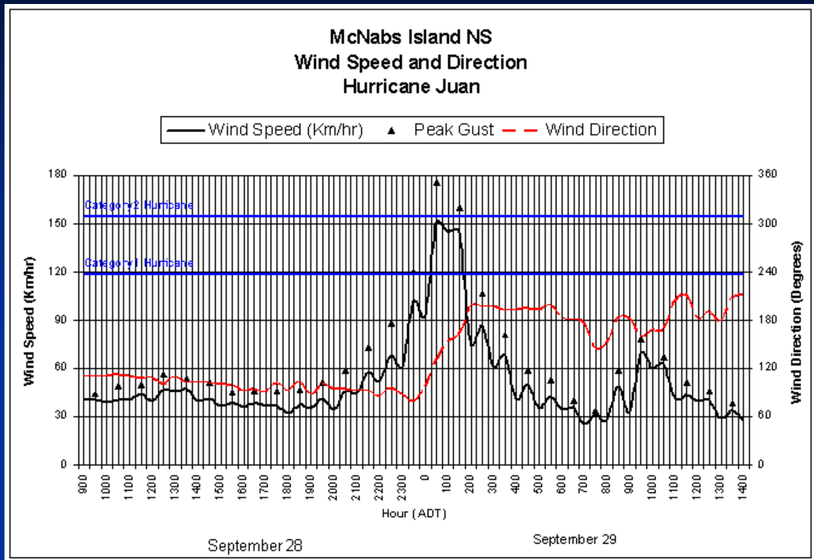
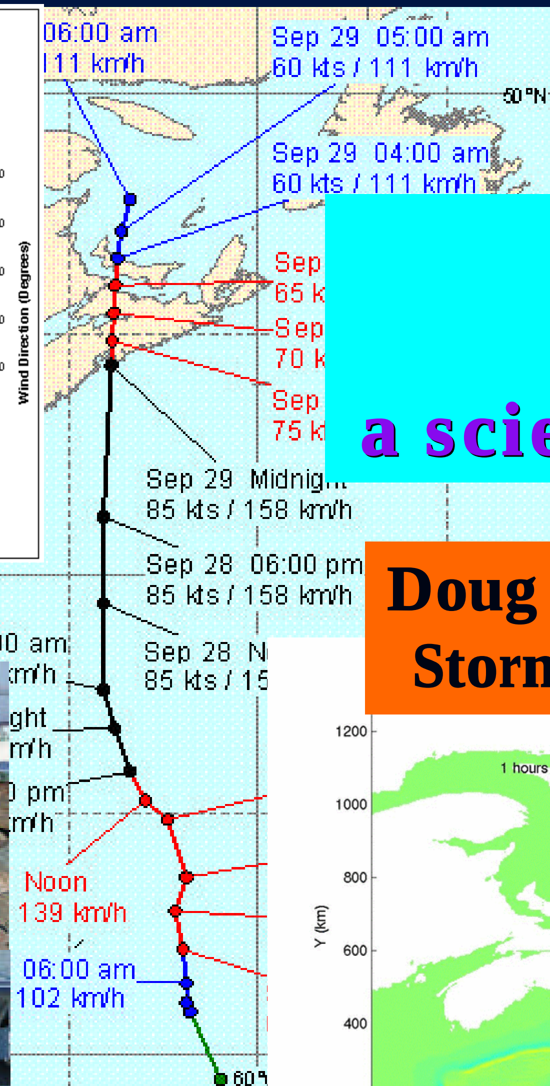
Towards an operational hurricane surge/wave forecast system

- In the longer term, improvements in observations, data assimilation and NWP forecast systems should produce more accurate hurricane and ET forecasts.
- In search of practical improvements in the shorter term, we propose to blend parametric hurricane wind and pressure fields based on Canadian Hurricane Centre trajectory forecasts into the operational surface fields used as input for the storm surge model and the wave model.
- Because of the high unpredictability nature of hurricanes, a human intervention tool is needed. The Canadian Hurricane Centre forecast trajectory becomes the official and final hurricane forecast (track and intensity) for various users.
- SWIM has been developed to supply wave and storm surge forecast guidance for forecasters when hurricanes or TCs affects the Canadian waters of responsibility.

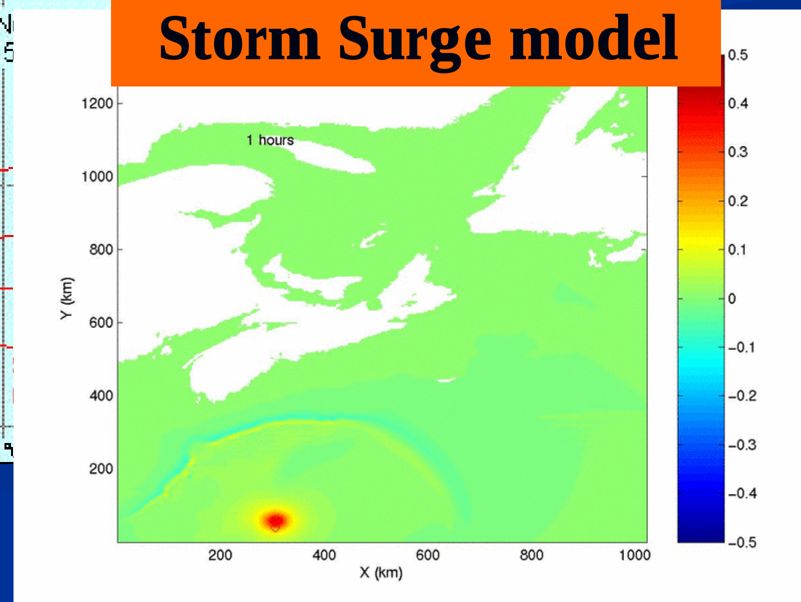
Hurricane Juan : a disaster



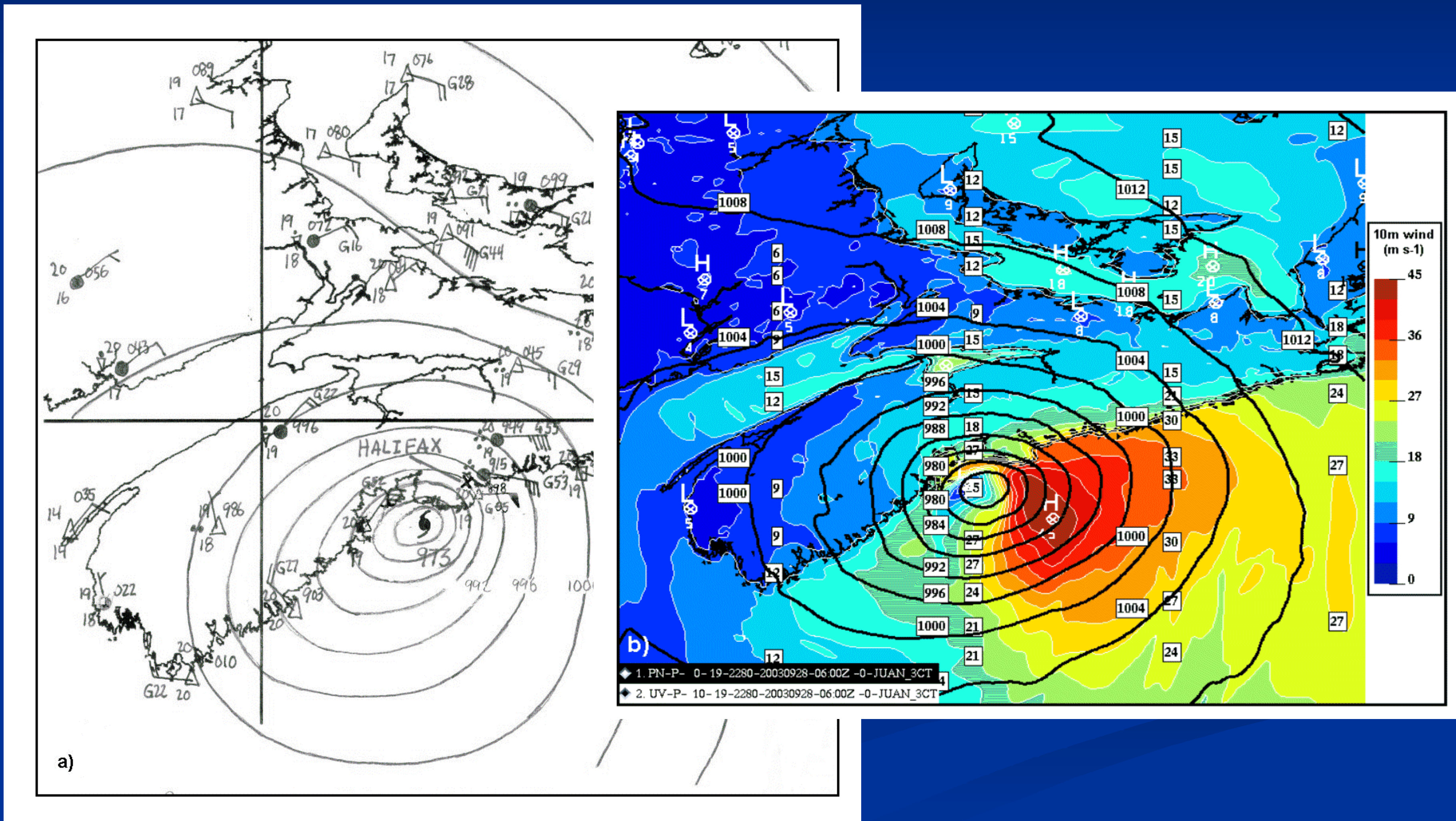


but
also
a scientific trigger

Doug Mercer's work
Storm Surge model

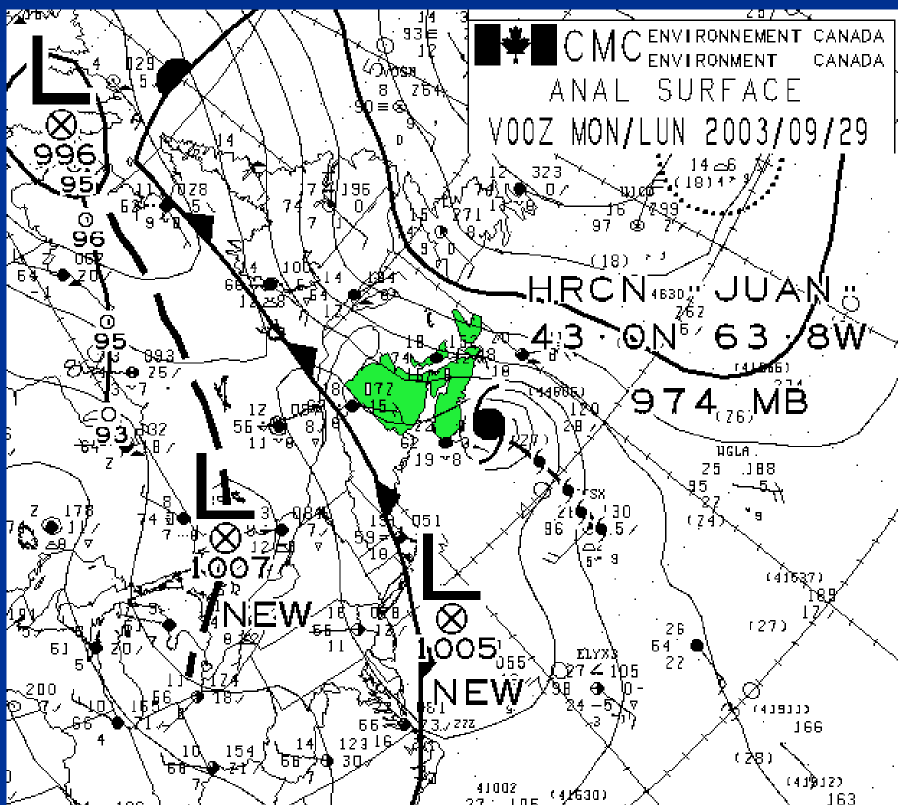


3D vortex insertion: C. Fogarty's Work

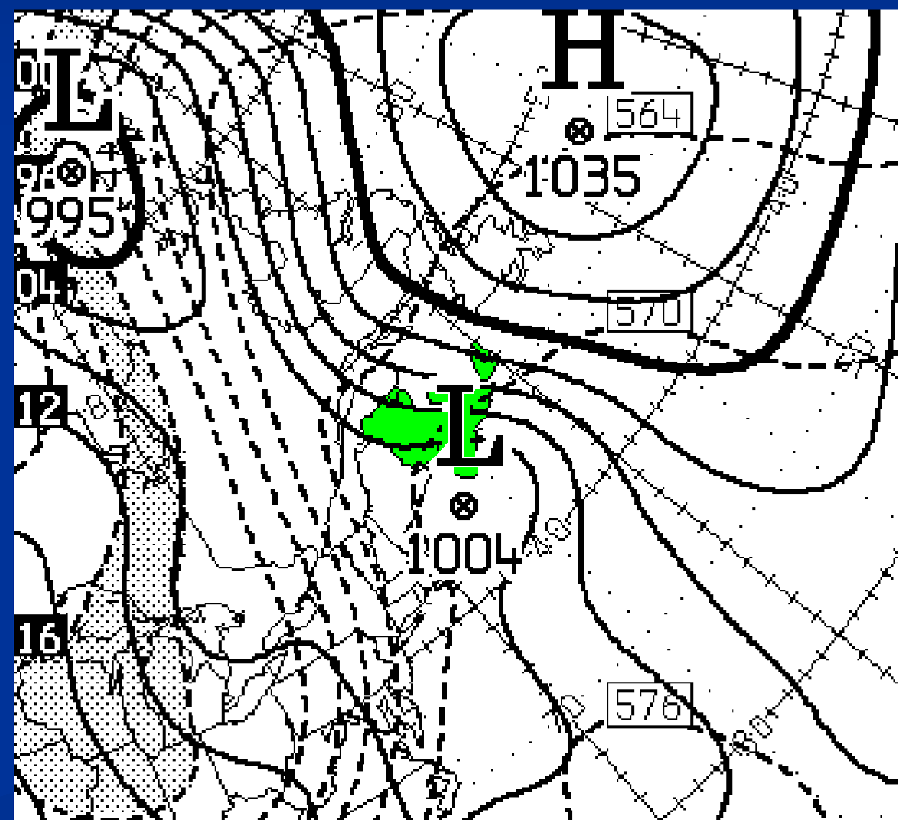


Weakness in the operational GEM forecast

00Z Monday 2003/09/29

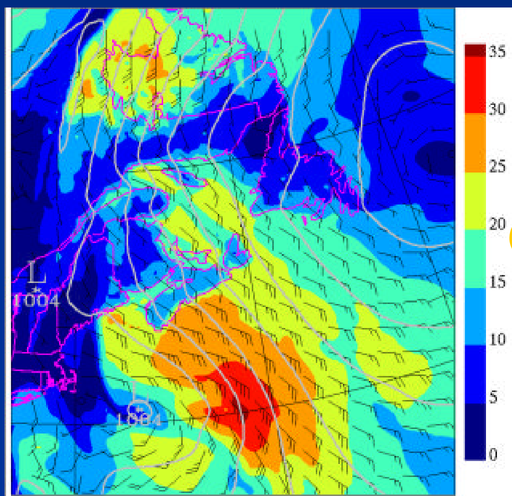


GEM 24HR
V00Z Monday 2003/09/29

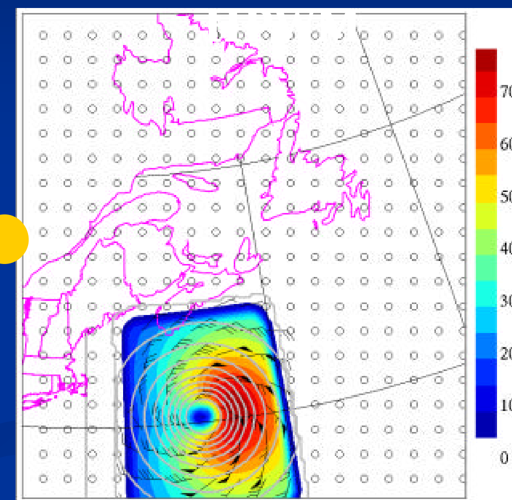


Blending a hurricane parametric wind field into the operational GEM surface wind forecast

GEM wind forecast

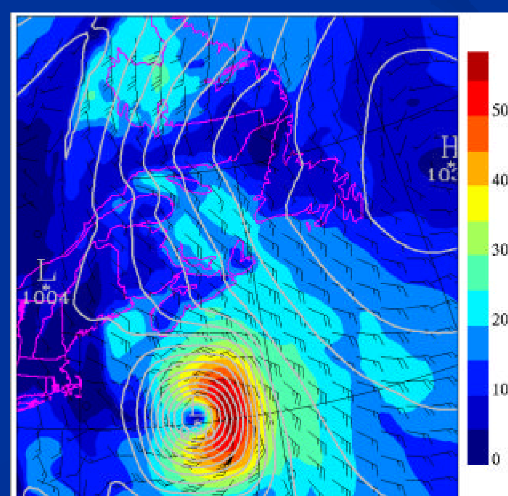


Hurricane Parametric wind model

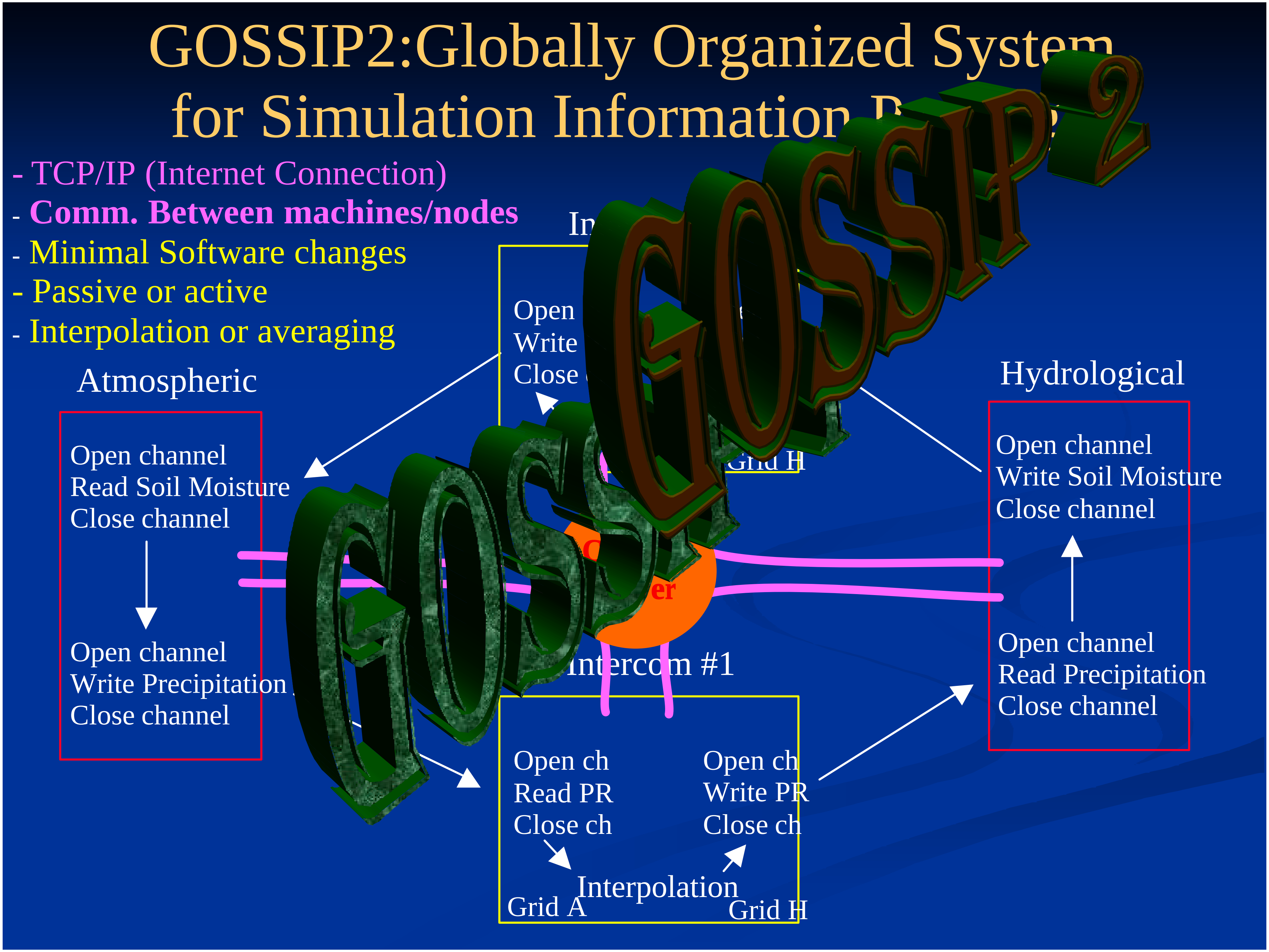


COUPLED SYSTEM

GEM wind with Hurricane Attitude



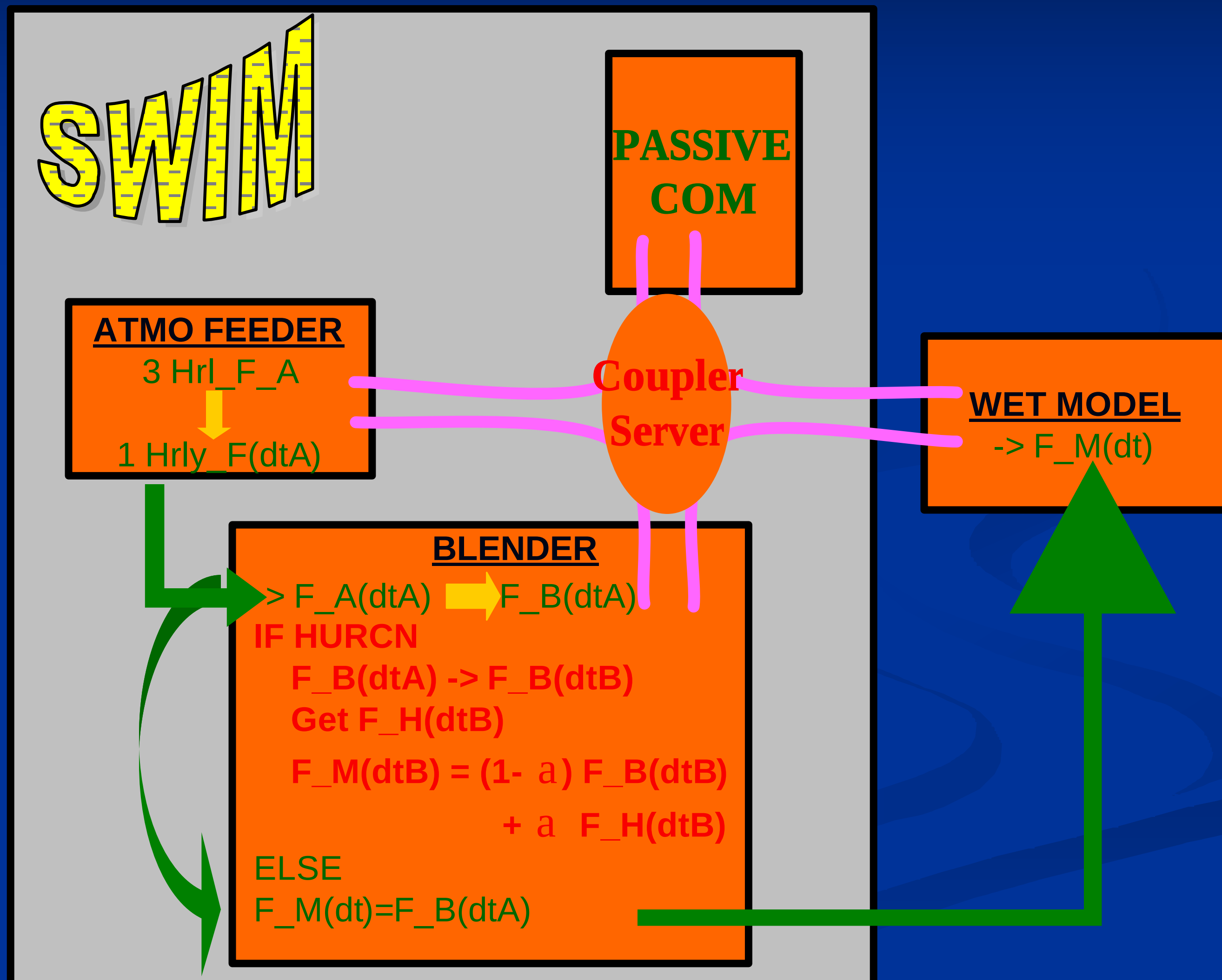
INPUTS for WET models
- **Wave**
- **Storm surge**
- **Ocean**



GOSSIP2:Globally Organized System
for Simulation Information P
- TCP/IP (Internet Connection)
- Comm. Between machines/nodes
- Minimal Software changes
- Passive or active
- Interpolation or averaging
Atmospheric
Open channel
Read Soil Moisture
Close channel
Open channel
Write Precipitation
Close channel
In
Open
Write
Close
Grid H
Hydrological
Open channel
Write Soil Moisture
Close channel
Open channel
Read Precipitation
Close channel
er
Intercom #1
Open ch
Read PR
Close ch
Open ch
Write PR
Close ch
Interpolation
Grid A
Grid H
GOSSIP
GOSSIP 2

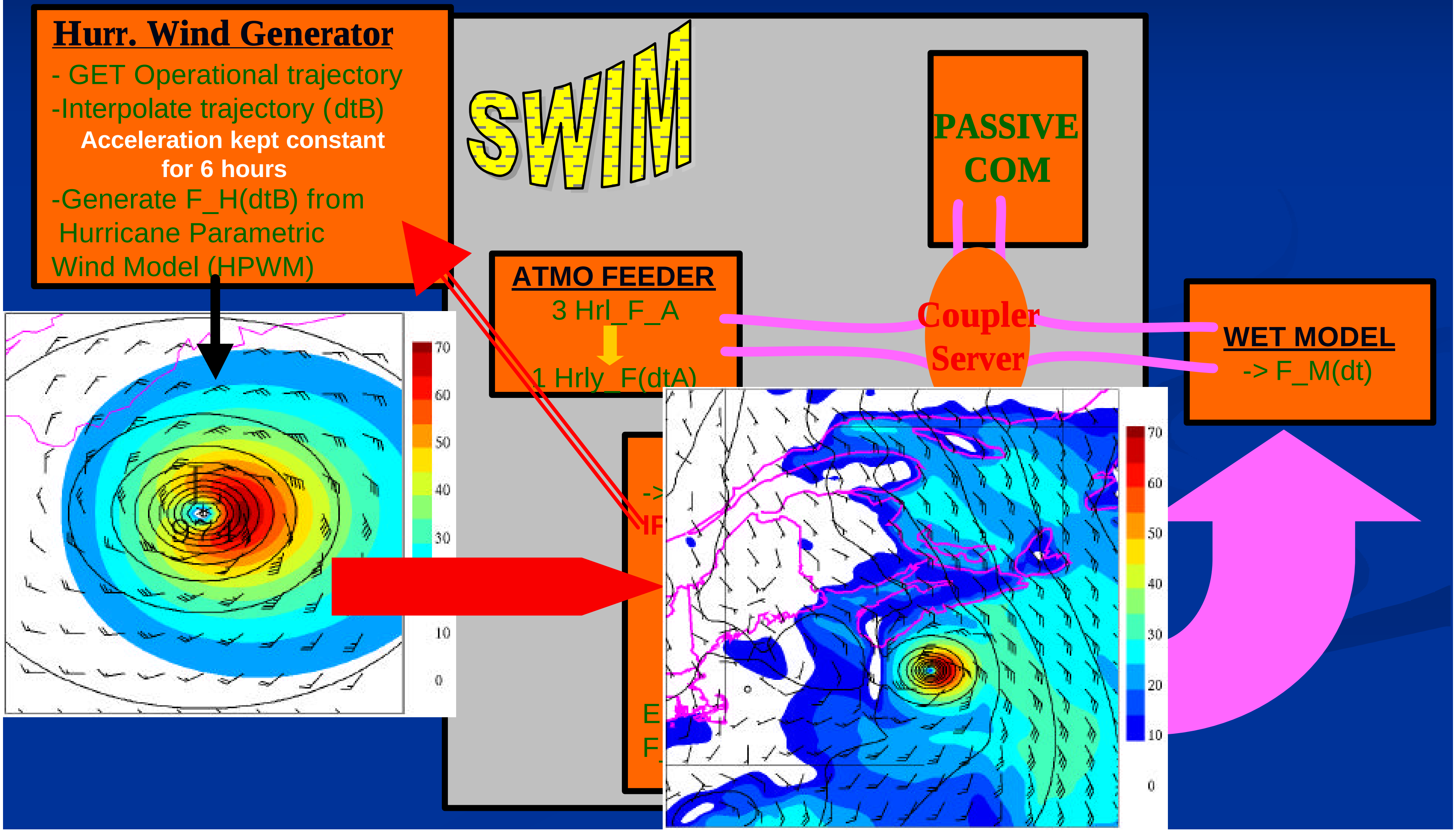
SWIM: Surface Wind Interpolator and Modifier

NO HURRICANE CASE



SWIM: Surface Wind Interpolator and Modifier

HURRICANE CASE



Hurricane Parametric Wind Model (HPWM)

SLOSH Model (Jelesnianski et al. 1992)

Empirical: Curve Fitting method

$$V = V_m \frac{2RR_m}{(R_m^2 + R^2)}$$

$$V_T = V_{Storm} \frac{RR_m}{(R_m^2 + R^2)}$$

Holland Model (Holland 1980)

Gradient Wind Speed

$$V = \left\{ \left(\frac{R_m}{R}\right)^B \frac{B(P_n - P_c)}{r} \exp\left[-\left(\frac{R_m}{R}\right)^B\right] + \frac{R^2 f^2}{4} \right\}^{\frac{1}{2}} - \frac{Rf}{2}$$

$$B = er \frac{V_m^2}{(P_n - P_c)}$$

$$V_T = V_{Storm}$$

Adjustments of modeled winds

- corresponds to mean boundary layer or gradient wind above the surface

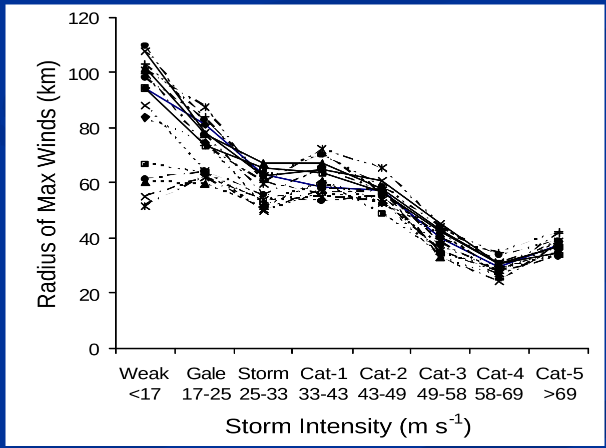
-Adjusted to 10-m elevation with

$V_{10} = K_m V$

Km -> [70-85] %

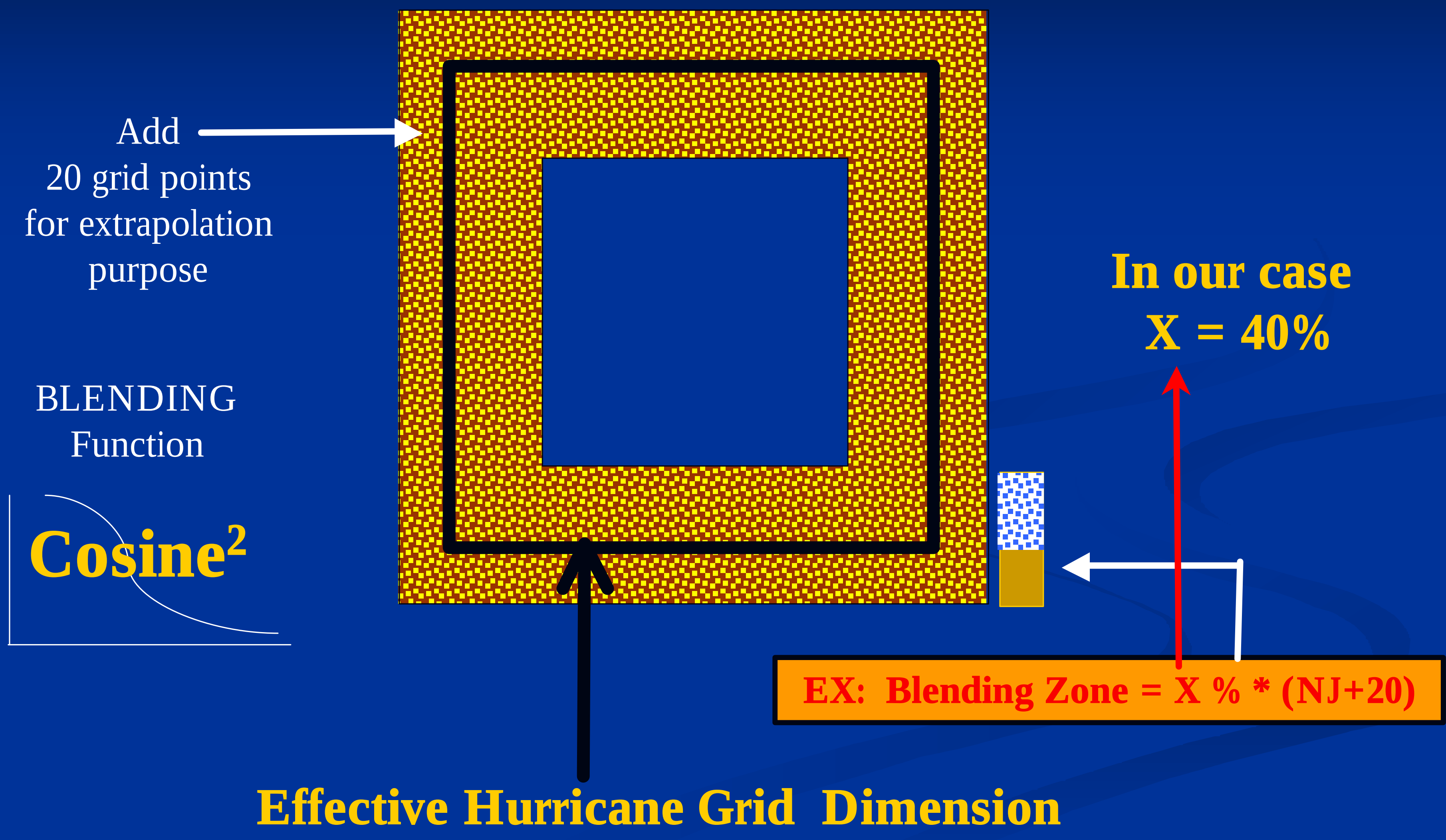
In our case Km = 75%

Atlantic HPWM particularity (Allan MacAfee's work)



- Radius of maximum winds (R_m) curves, extracted along radial profiles from the storm center at 22.5° intervals, for different classes of storm intensity. (Storm data: HRD gridded winds for 389 storms from 1998–2003).
- Vary with latitude

Blending Process



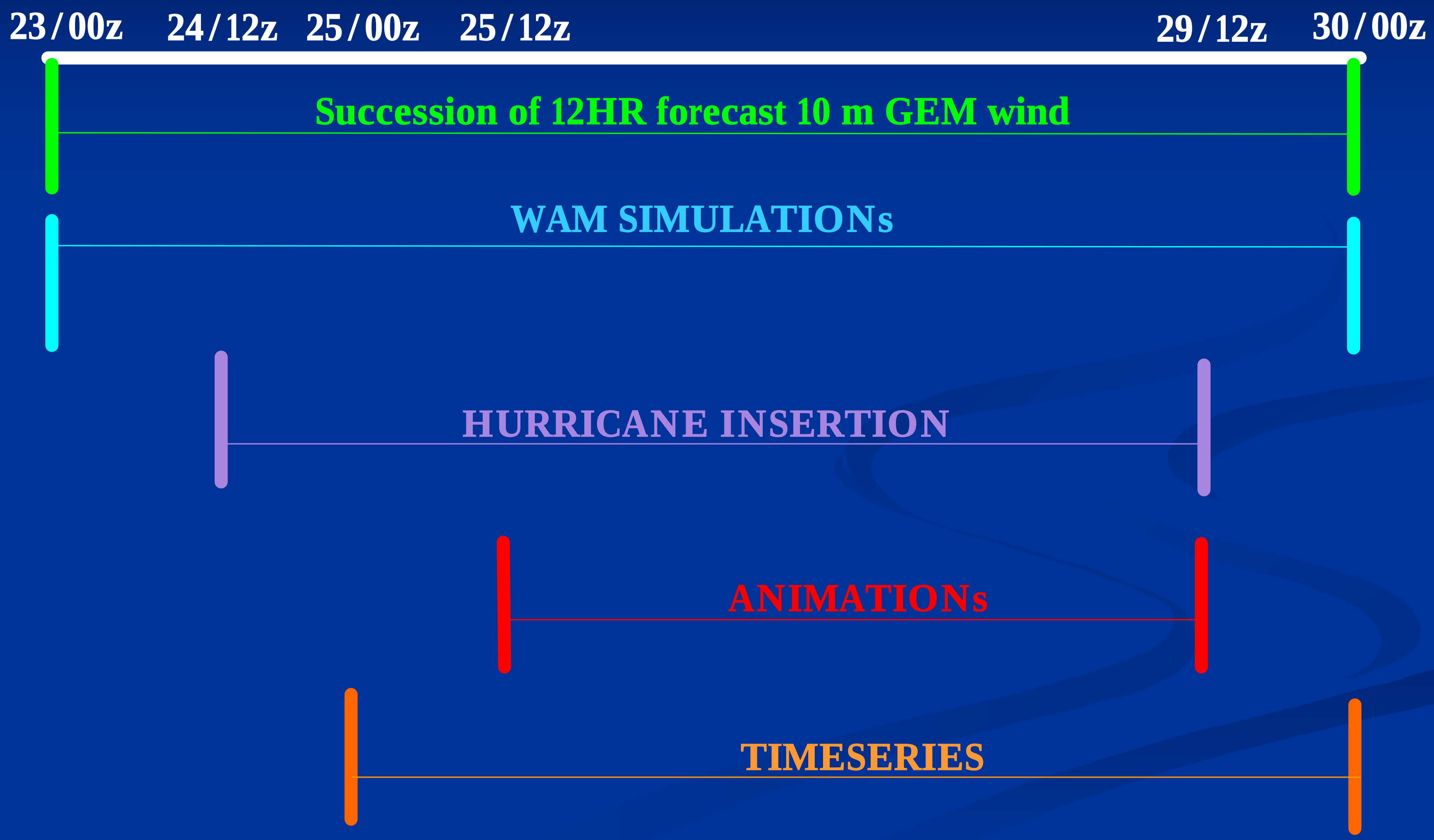
Experiments done

v : SWIM
v : WAM

		WRes: 0.5 deg	WRes:0.1 deg
No Hurricane	3 Hrly wind	v : 720 s	v : 240 s
	Hrly wind	v v : 720 s	v v : 240 s
Hurricane	10 Deg	v	v
Grid	7 Deg	v	v
Dimension	5 Deg	v	v
Blending	30 %	v	
Factor	40 %	v	v
Wind Input	Hrly wind	v v	v v
	15 min. wind	v v : 450 s	v v : 225 s
Hurricane	Holland	v v	v
Wind Model	SLOSH	v v	v v

Simulation/Results Timeline

September 2004

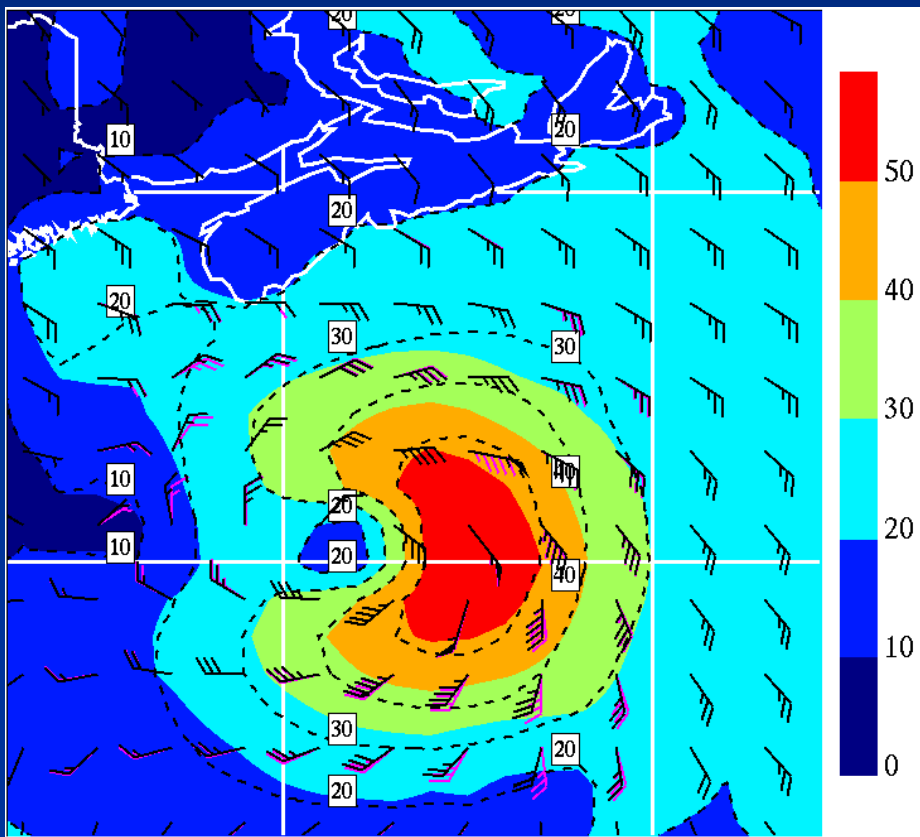


Wind Field Trial Zones

28 September 2003 valid at 1800 UTC

Blending Zone

30 % vs 40 %

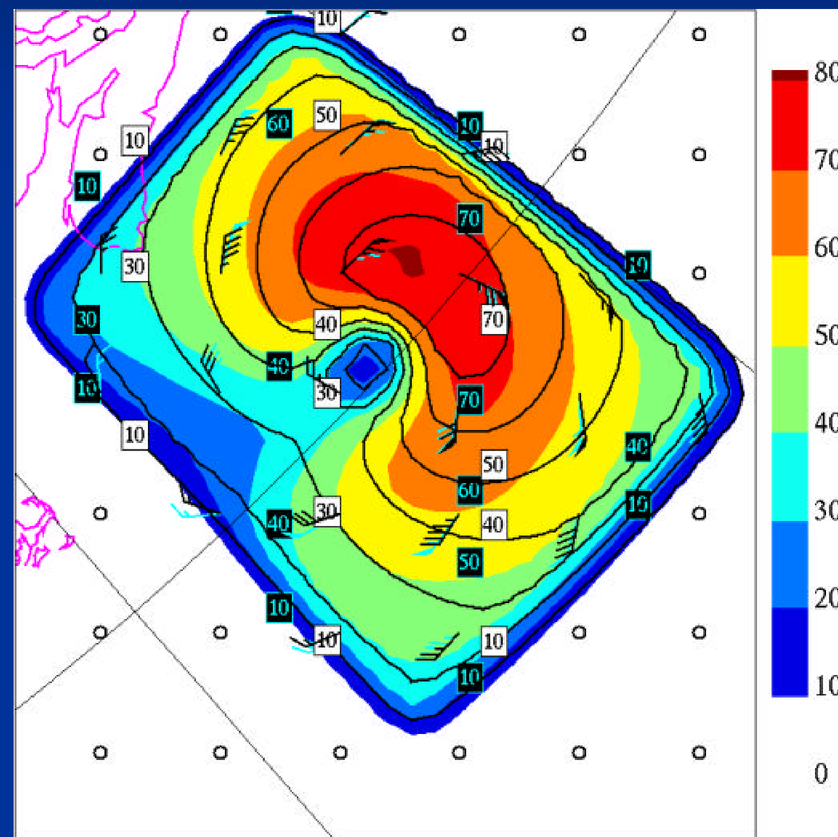


Color : 40 %

Dashed : 30 %

HPWM

Holland vs SLOSH



Color / Magenta : SLOSH

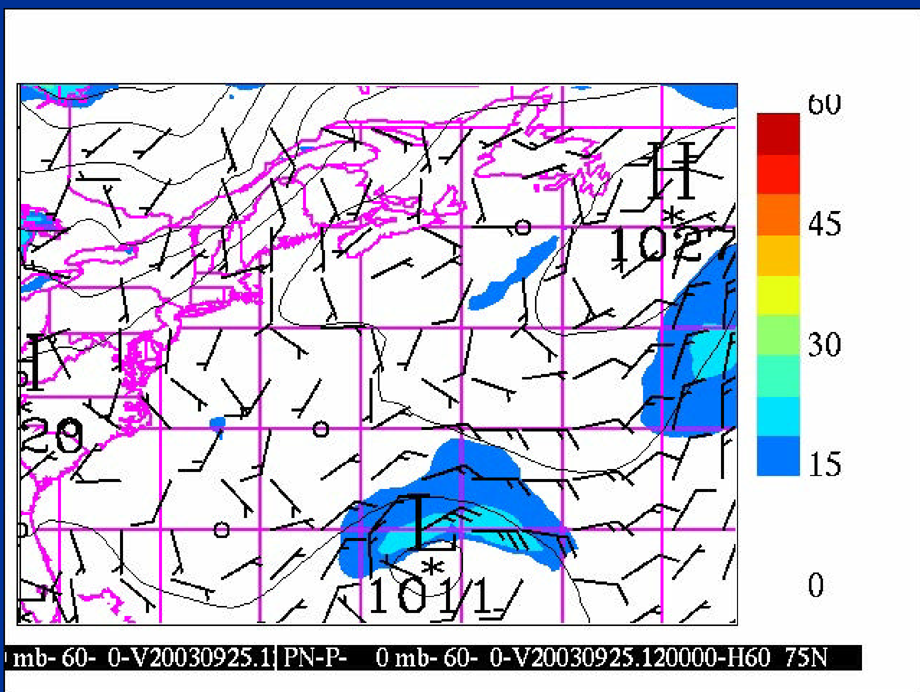
Black / White : Holland

Wind Fields

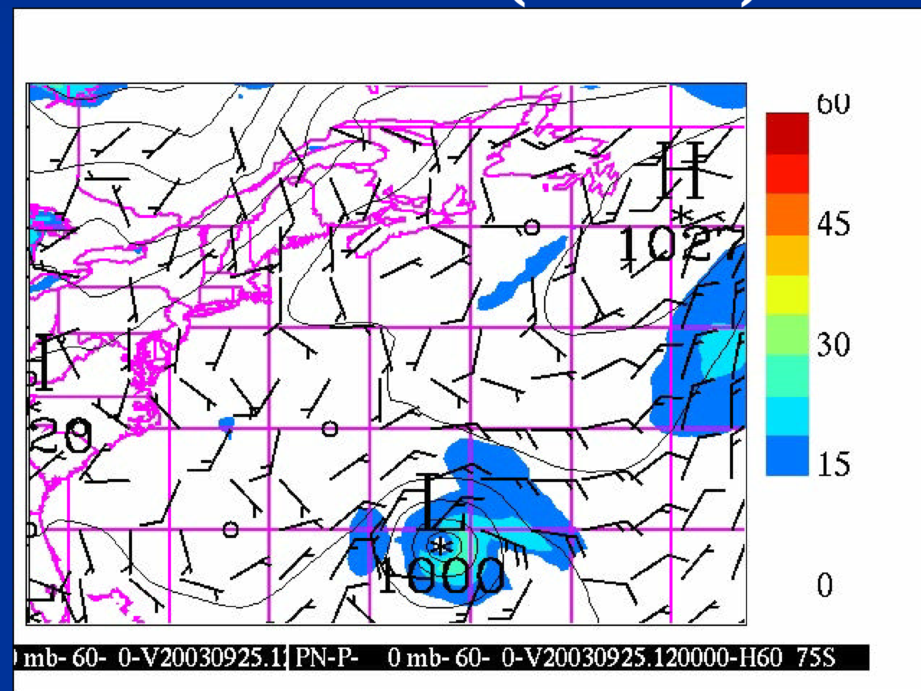
Sep 25/12z - 29/12z

Wind Input : 60 minutes
WAM grid : 0.5 deg

No Hurricane

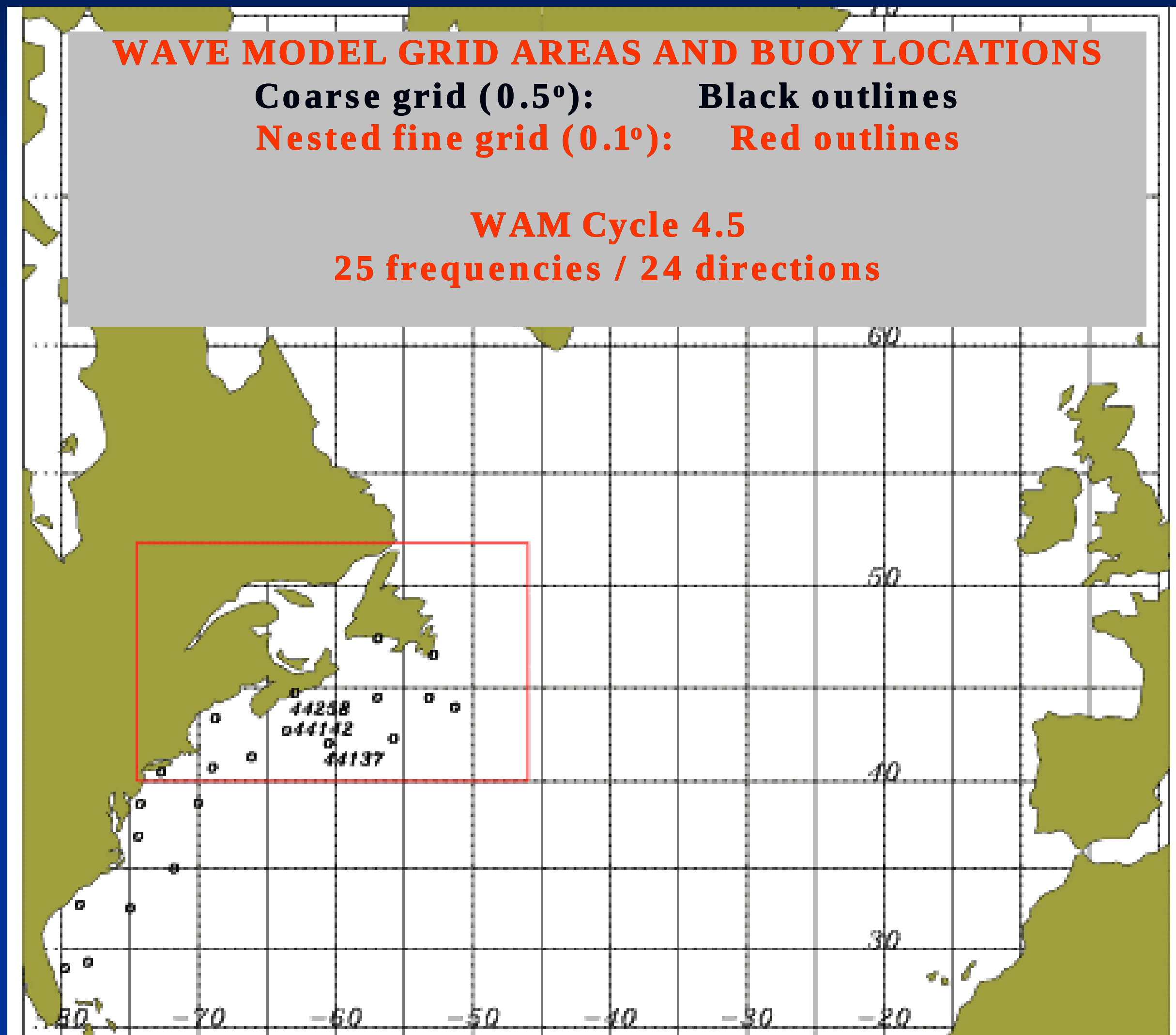


Hurricane (SLOSH)



Color : Wind Speed (5 knots)
Black lines : isobars

Wave Fields
Buoy Timeseries



Wave Fields

Sep 25/12z - 29/12z

Wind Input : 60 minutes
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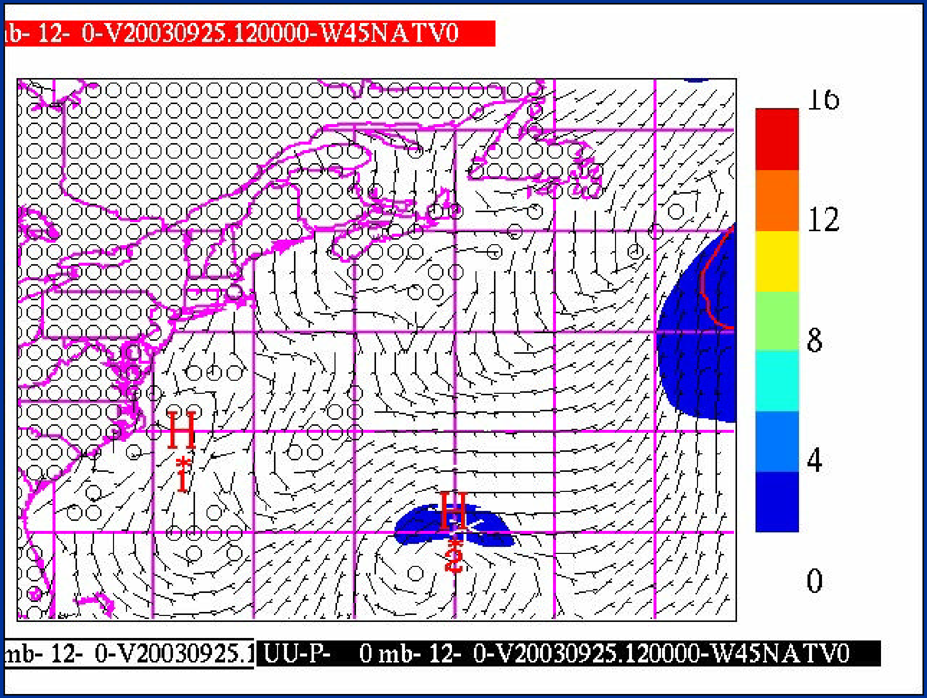
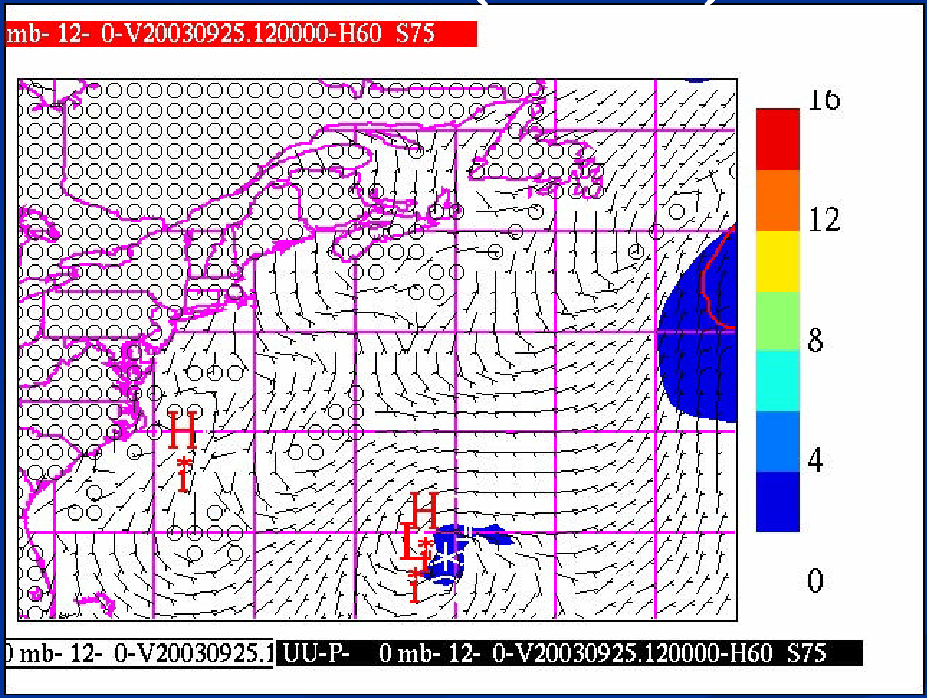
No Hurricane



Hurricane (SLOSH)

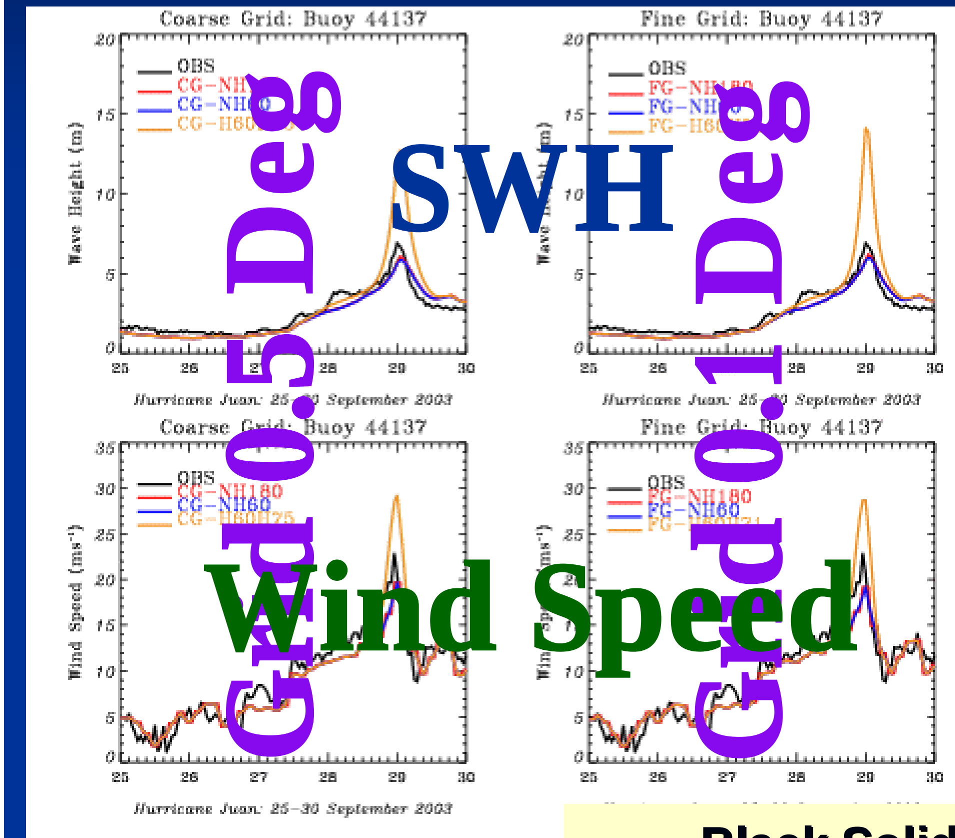


Color : Sig. Wave Height (2 m)
Black line : Swell Height (2 m)
Windbarb in knots

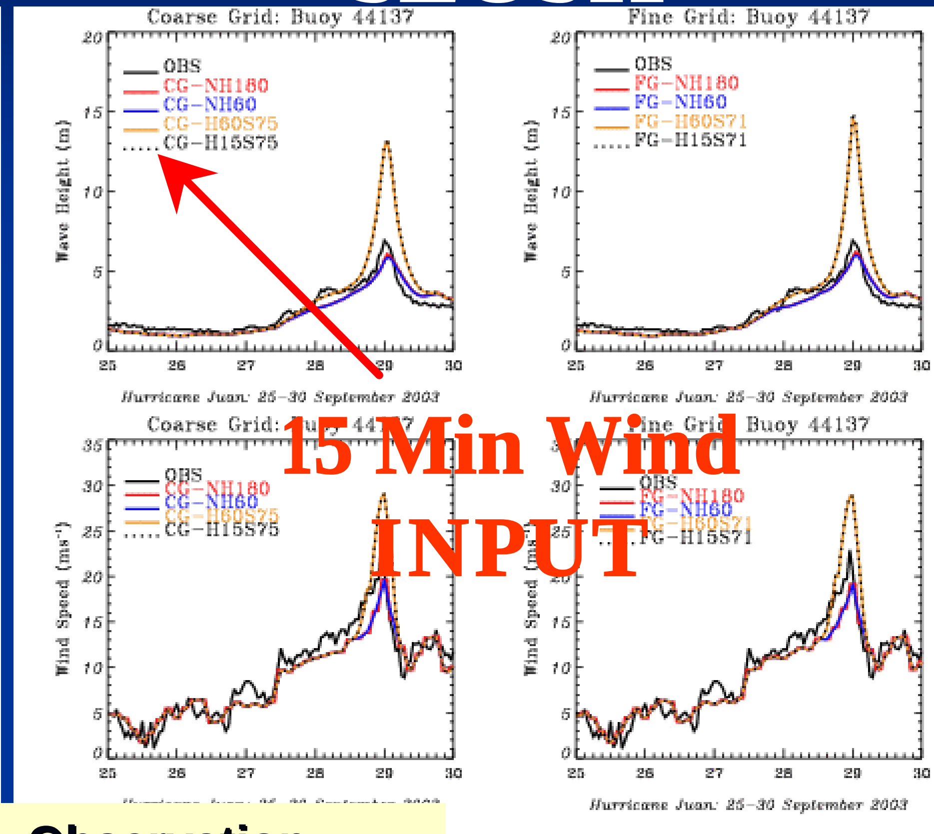
RESULTS : Wave fields

Buoy 44137

Holland



SLOSH

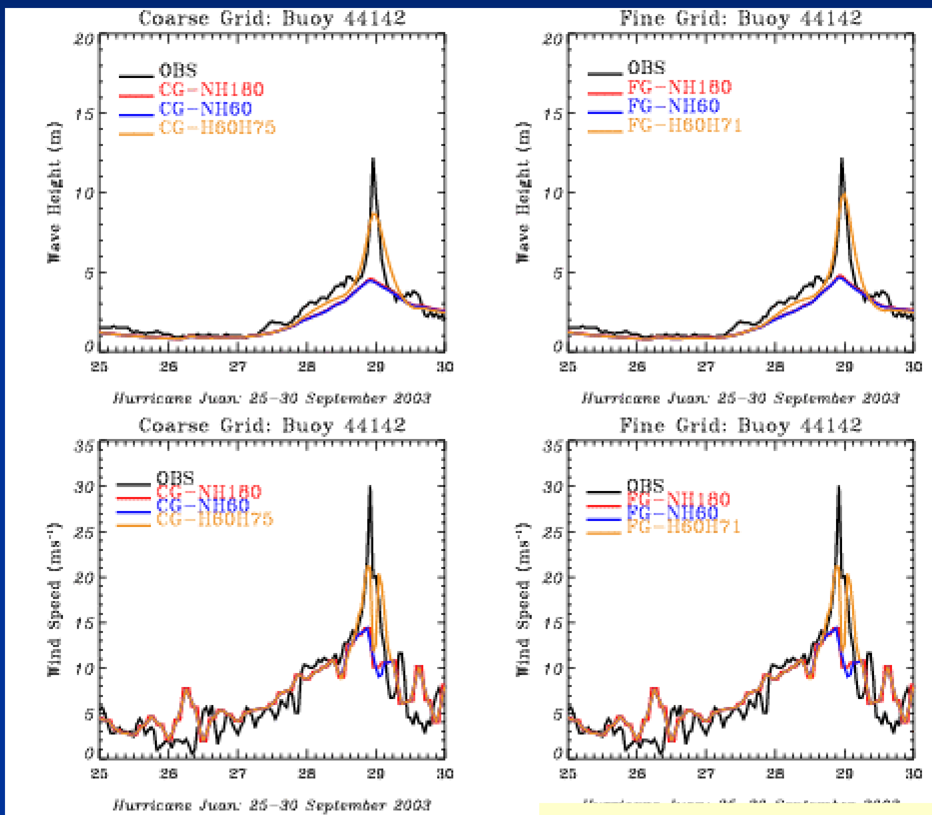


Black Solid: Observation
Red : No Hurricane 3 Hourly
Blue: No Hurricane Hourly
Yellow : With Hurricane Hourly
Dashed : With Hurricane 15 m wind

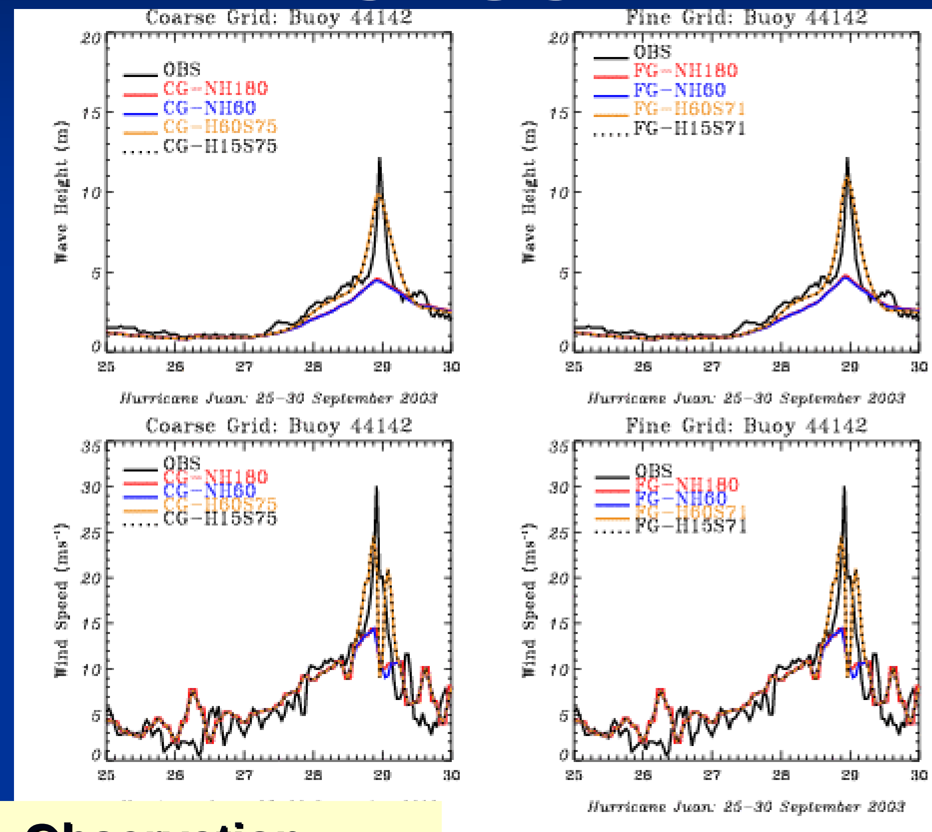
RESULTS : Wave fields

Buoy 44142

Holland



SLOSH

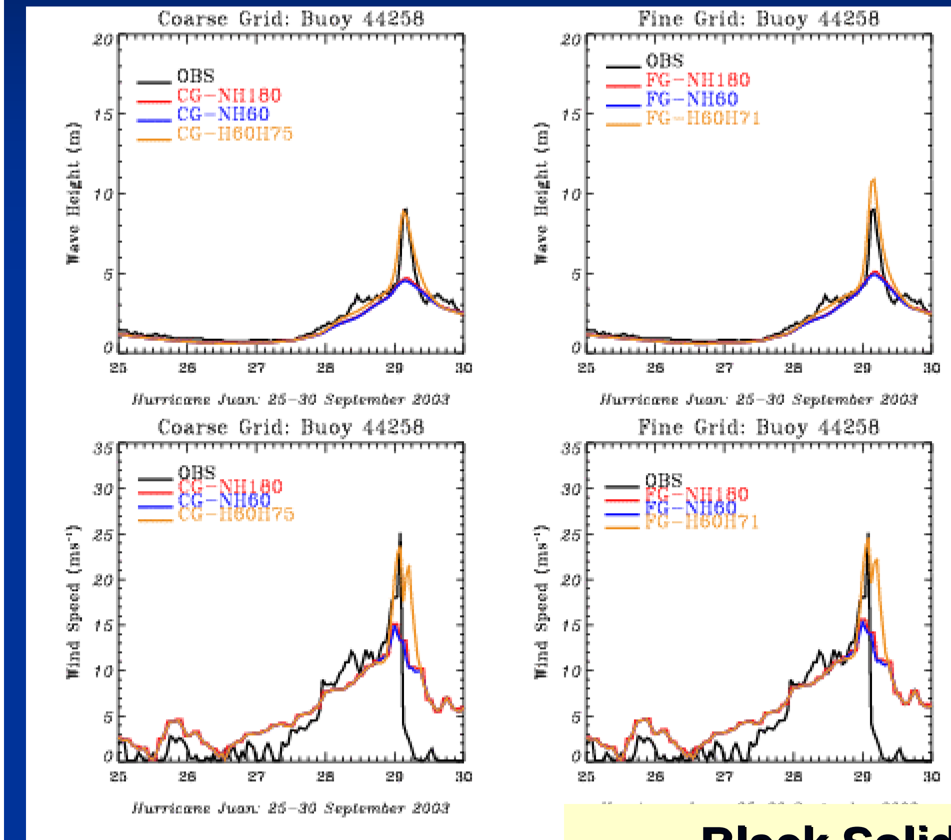


Black Solid: Observation
Red : No Hurricane 3 Hourly
Blue: No Hurricane Hourly
Yellow : With Hurricane Hourly
Dashed : With Hurricane 15 m wind

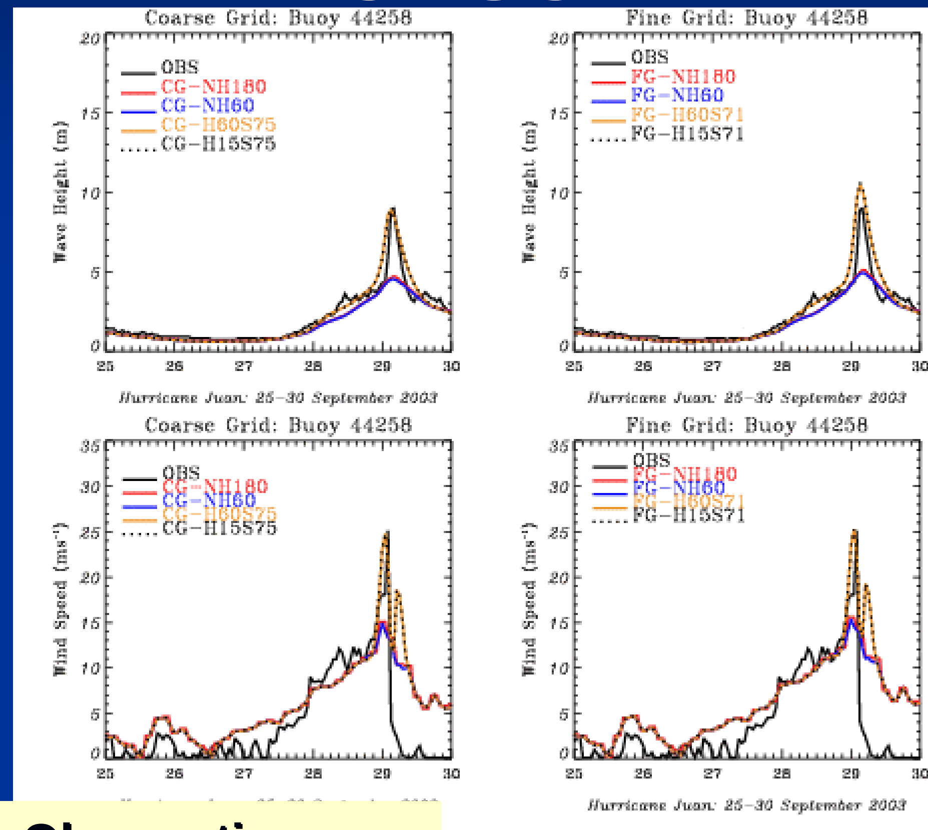
RESULTS : Wave fields

Buoy 44258

Holland



SLOSH



Black Solid: Observation
Red : No Hurricane 3 Hourly
Blue: No Hurricane Hourly
Yellow : With Hurricane Hourly
Dashed : With Hurricane 15 m wind

CONCLUSIONS

- Insertion of Hurricane wind field in Regional GEM forecast gives a more realistic wind/wave forecast reflecting the presence of an intense and compact wind system.

- Overall, explainable overestimation
  - for buoy 44258 very good results

- Wind input frequency does not seem to bring significant changes

- Difference in the results depend a lot on the “tweaking” part
  - Domain of the hurricane parametric wind model
  - Hurricane model (SLOSH has performed slightly better)
    - The location and the extension of the max wind core
  - The wind adjustment (V10 = ?* V)
  - Blending function (artificial)

- Overall, SWIM could help the forecaster by supplying product where the forecast wind field, used by a wet model, has a hurricane or TC signature in it.

FUTURE WORK ON SWIM

- SWIM still in a prototype mode
  - SWIM has been shown to be a valuable tool to integrate hurricane parametric wind in a wind field forecast from numerical model.
  - Transfer to operation = still some work to be done
  - Exploit the Modifier part of SWIM (surface wind adjustor, downscaling wind module, SFIM (Surface Field Interpolator and Modifier) development ??)

- Improving the hurricane parametric wind model settings (Juan case and others)

- Improving insertion method (replace the blending function)
  - Hurricane perturbed environmental field : remove the analysed vortex and replace it by the specified vortex
  - Multiple insertions

- Test with wave / surge model in a real coupled system

- Operational implementation (next "Canadian" hurricane season ??)