An intercomparison of state-of-the-art wave models in the NW Atlantic

R. Padilla,W. Perrie, B.Toulany and P. Smith Zhang W, and Jiménez–Hernández S.

Bedford Institute of Oceanography
Instituto de Investigación en Ingeniería UAT

CONTENT

Importance of reliable wave models and forecasts:

- Marine forecasting :marine operations, oil and gas, . ..
- Offshore design criteria (Hindcasting)
- Search and rescue (SAR)
- Transport and dispersion of dissolved and suspended matter
- Accurate estimates of coastal erosion
- Ship routing
- Design and protection of ports and harbors
- Safety of coastal settlements.

Waves have impact on most of the coastal processes : Physical (Tides, Surges, air-sea), Geological, . . Biological, . .

OBJECTIVES

To evaluate three wave models and determine which perform best in shallow waters to forecast waves at the Gulf of Maine

Compare 3 operational wave models

- **WAMC4-PROMISE**
- **WAVEWATCH-III Ver. 2.22**
- **SWAN-C3 Ver. 40.20**

Validation *in situ* measurements: DWR, ADCP AND NWR

Wave-parameters (time series: Hs, Tp).

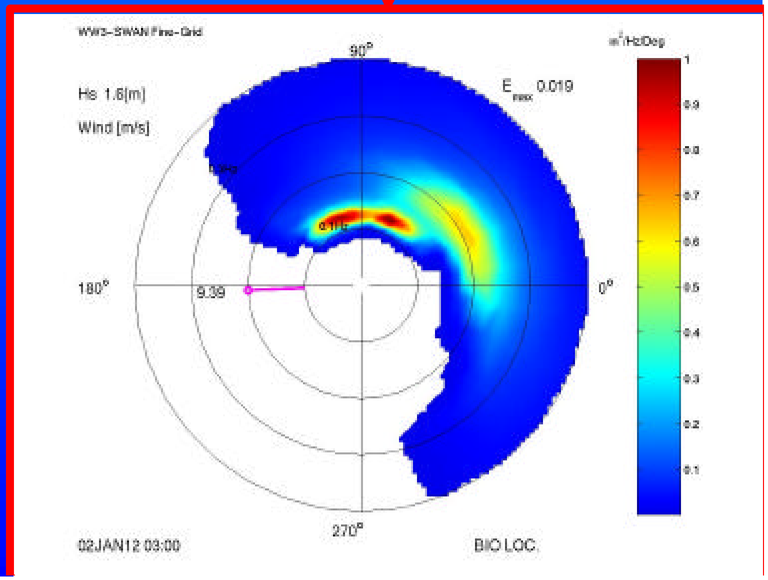
Numerical Wave Models

Phase Resolving

Sea Surface Description in time and geographical space

Phase Averaged

Sea Surface Description in function of the spectral energy density



Action Balance Equation

$$\frac{\partial N}{\partial t} + \frac{\partial}{\partial x}(c_x N) + \frac{\partial}{\partial y}(c_y N) + \frac{\partial}{\partial s}(c_s N) + \frac{\partial}{\partial q}(c_q N) = \frac{S_{tot}}{s}$$

WW3 and WAM

Explicit Scheme

CFL-Criterion

Global-Regional

Deep water

$$S_{tot} = S_{in} + S_{nl4} + S_{wc}$$

Shallow water

$$+ S_{bf} + S_{nl3} + S_{bk} + ...$$

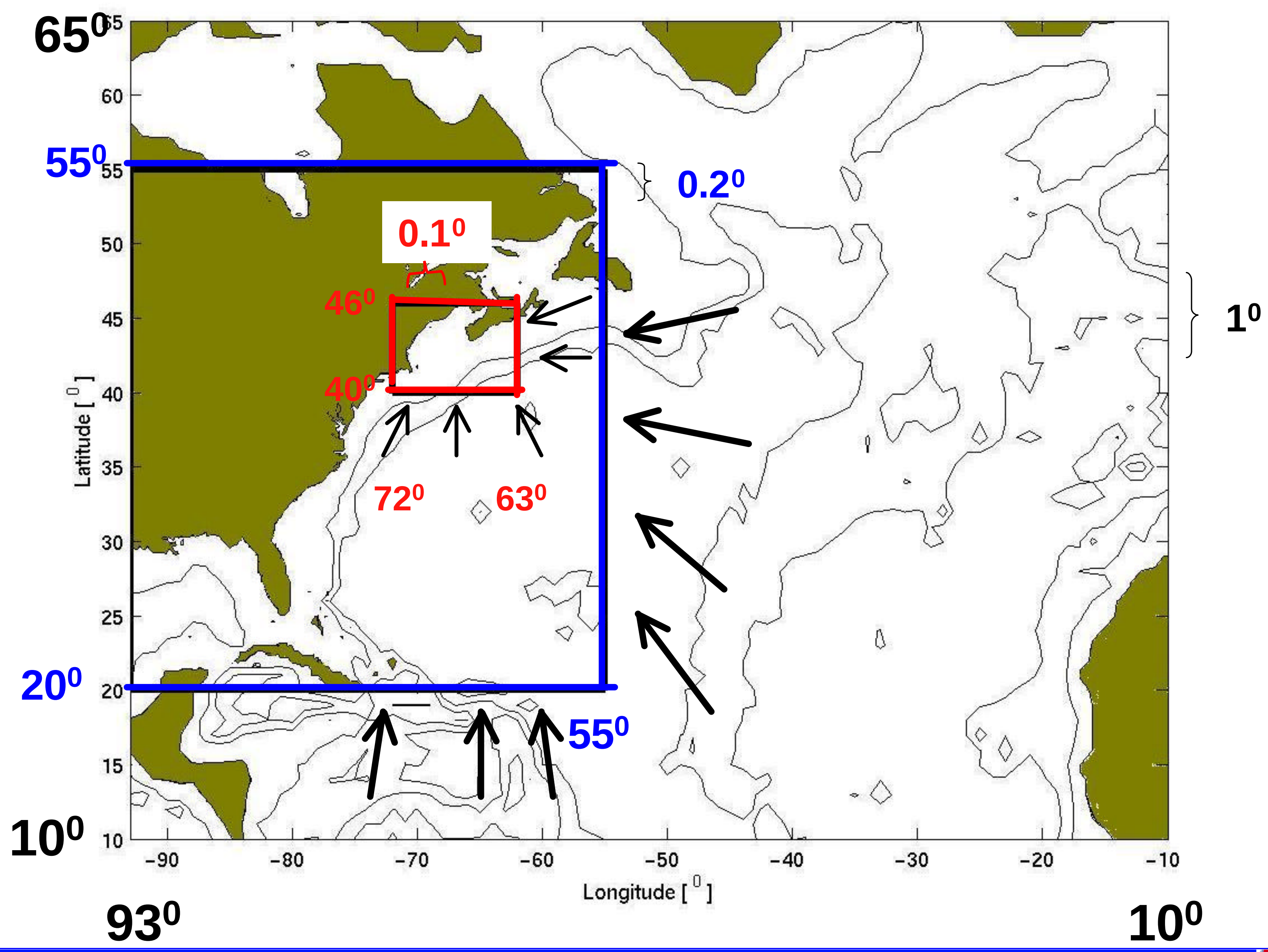
SWAN

Implicit Scheme

No CFL-Criterion

Regional-Laboratory

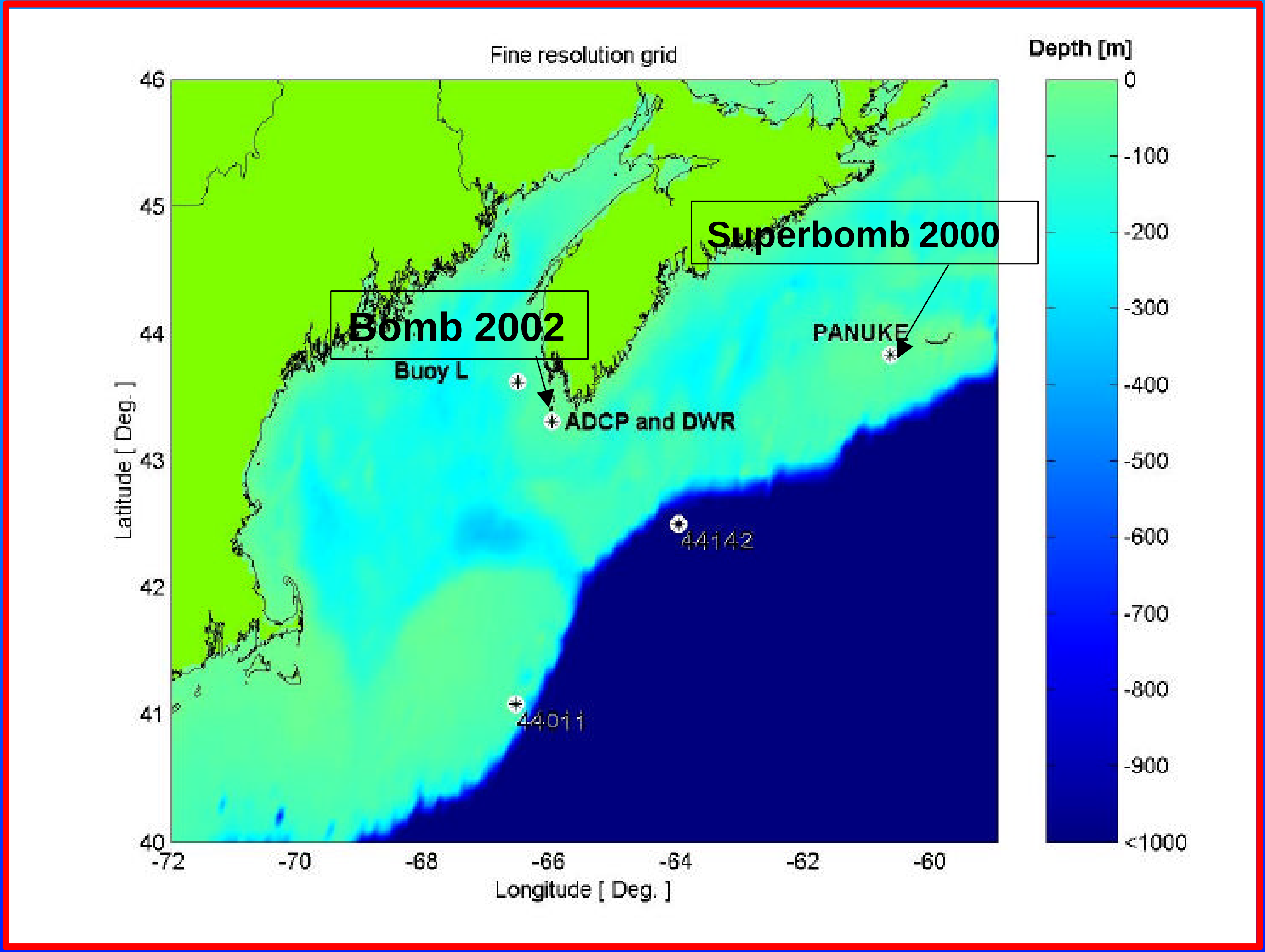
GRID SYSTEM



65⁰
55⁰
0.2⁰
0.1⁰
46⁰
40⁰
72⁰
63⁰
1⁰
20⁰
55⁰
10⁰
93⁰
10⁰
Latitude [⁰]
Longitude [⁰]

3. Numerical wave models and Set-up

GULF OF MAINE



WIND and WAVE DATA

WIND

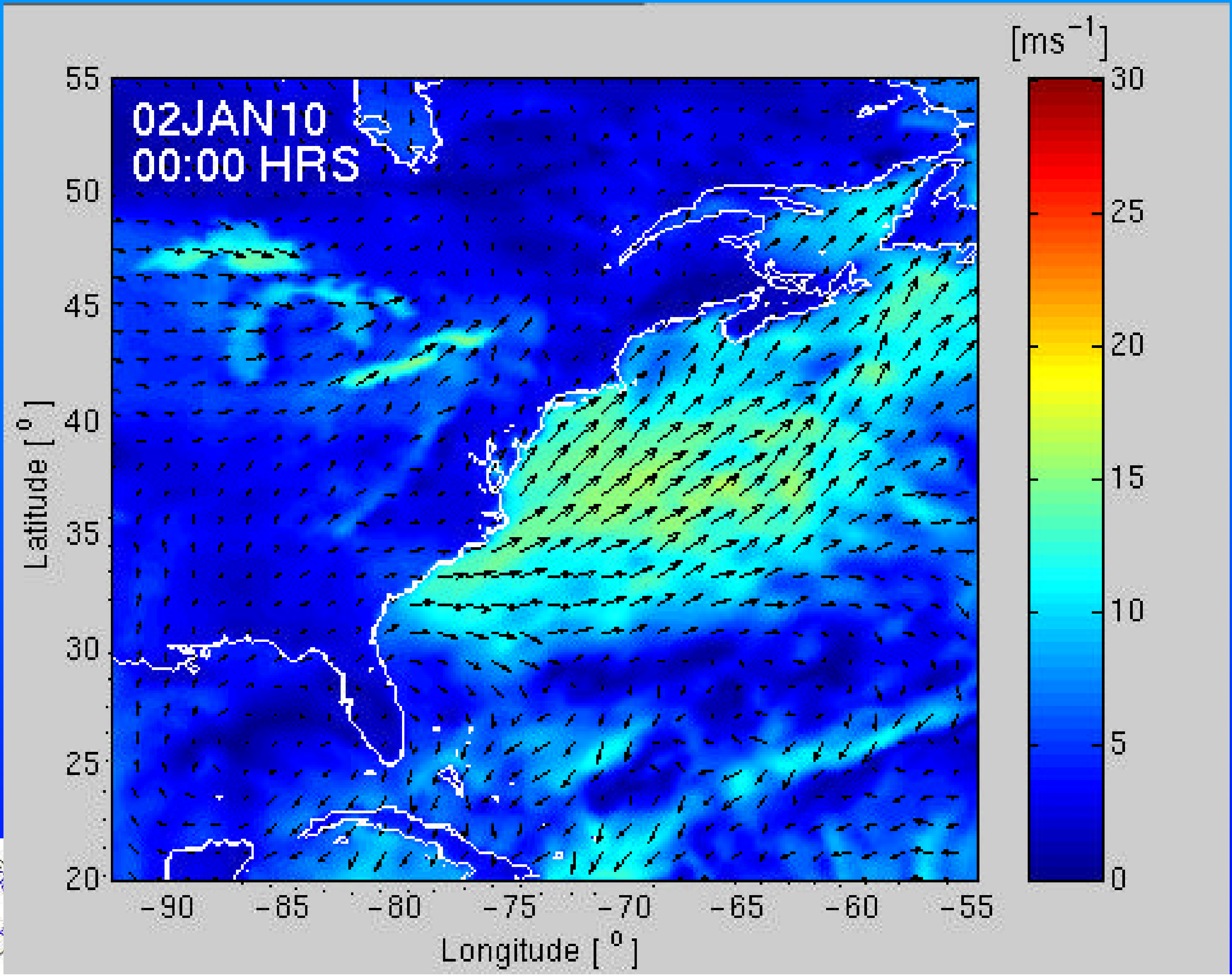
Storm	Model	?t [hrs]	Resolution[deg]
Jan/2002	NOGAPS-COAMPS	6	1 – 0.2
Jan/2000	MC2	6, 1	0.2

Waves

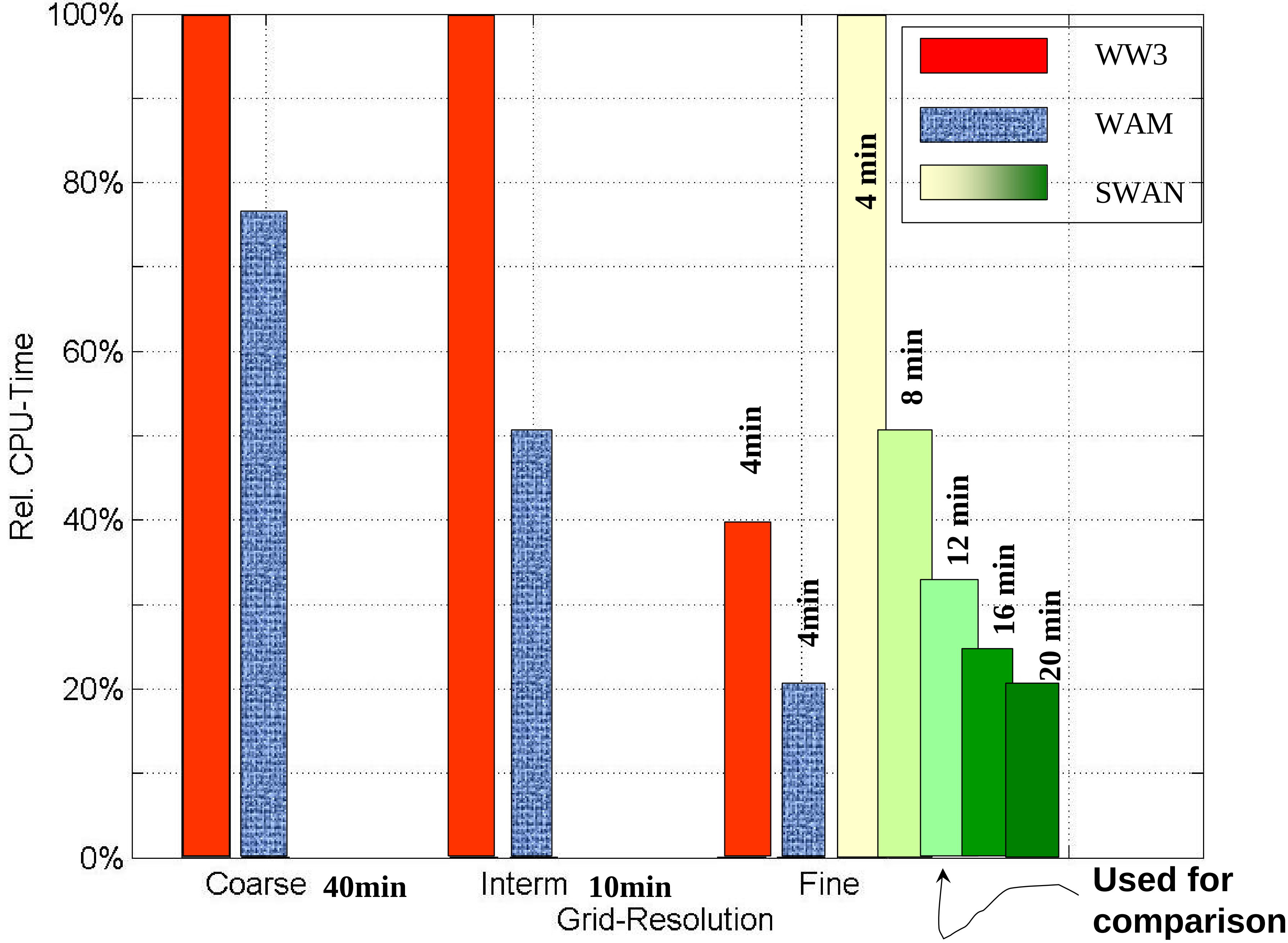
Storm	Device	?t [hrs]	
Jan/2002	ADCP-Buoy (DWR)	2 – 0.3	
Jan/2000	NDBC –Buoys (WR)	1	

4. The bomb of January 2002

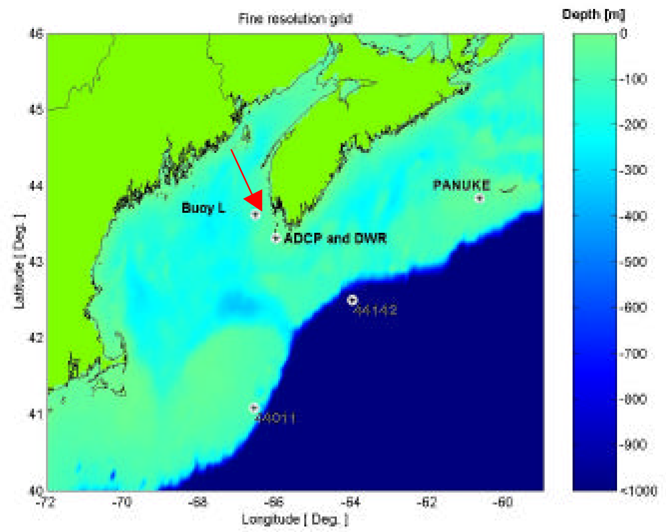
Bomb of January 2002
WIND FIELDS

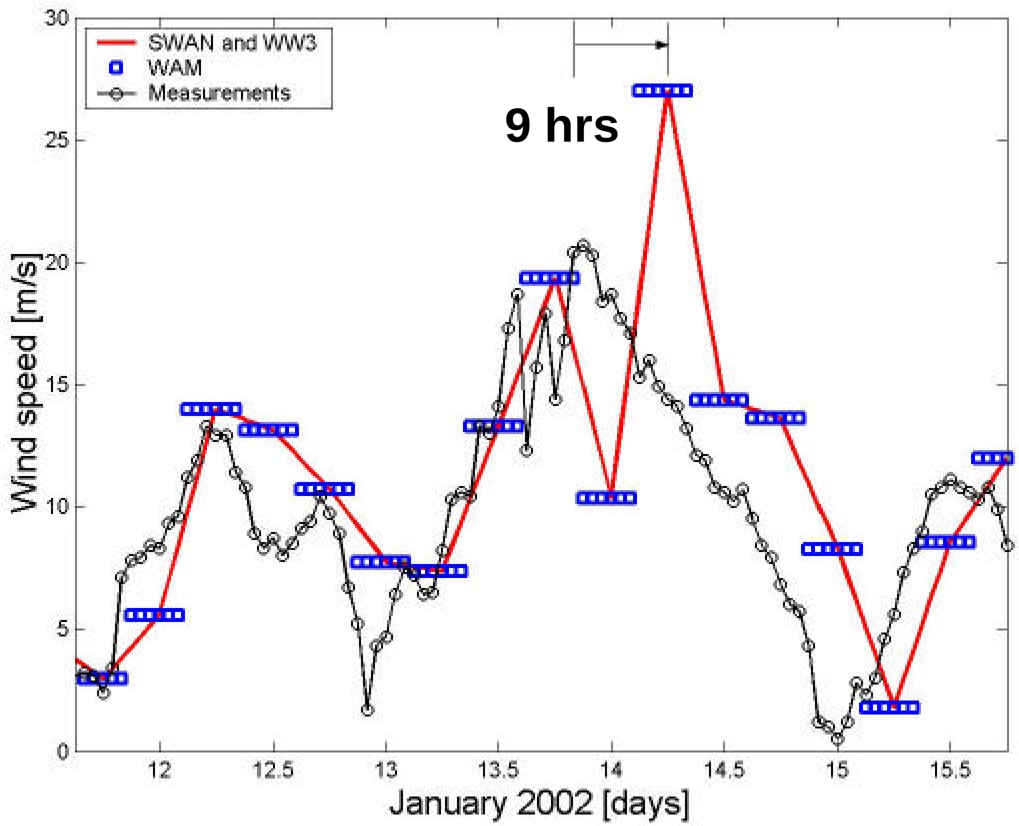


CPU in Bomb of January 2002



4. The bomb of January 2002





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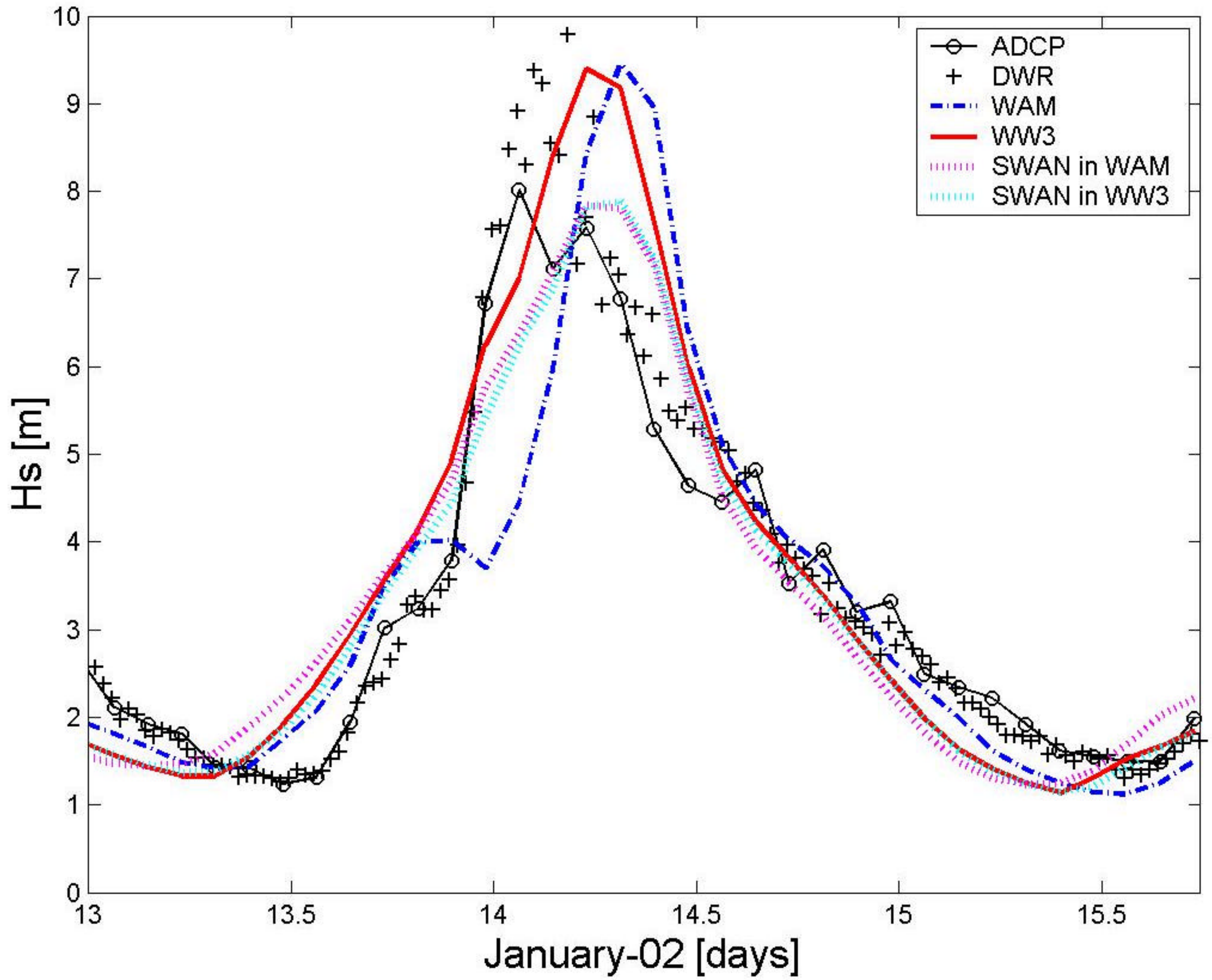
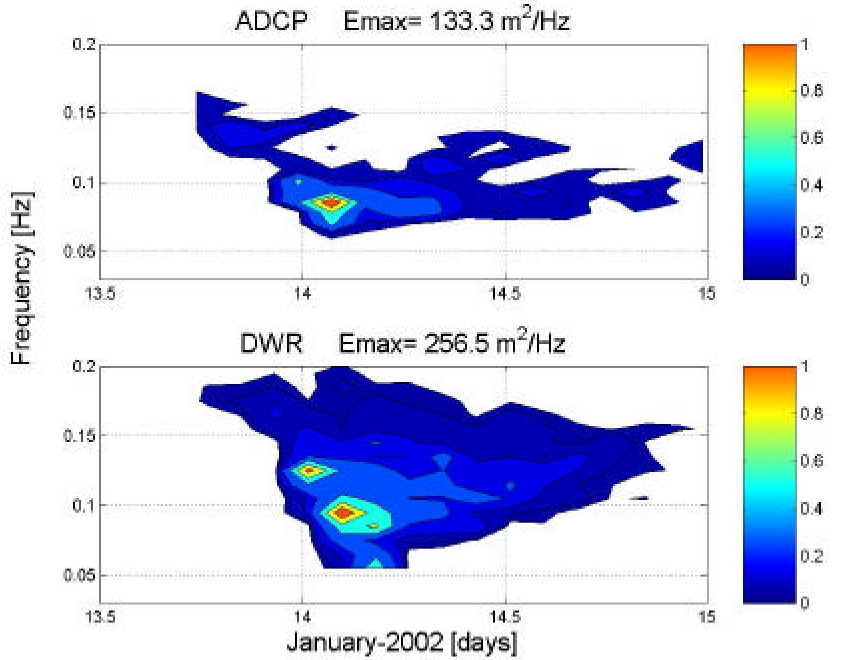
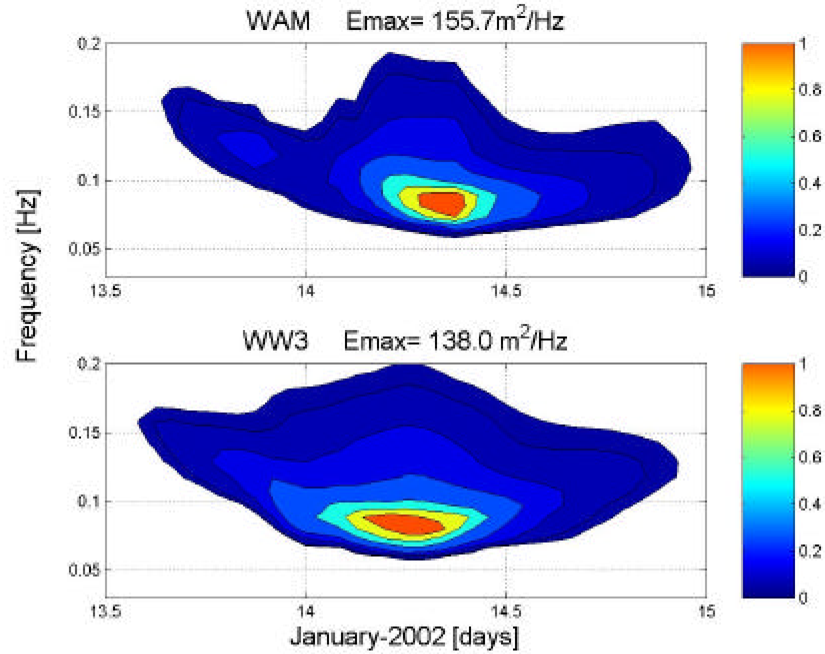
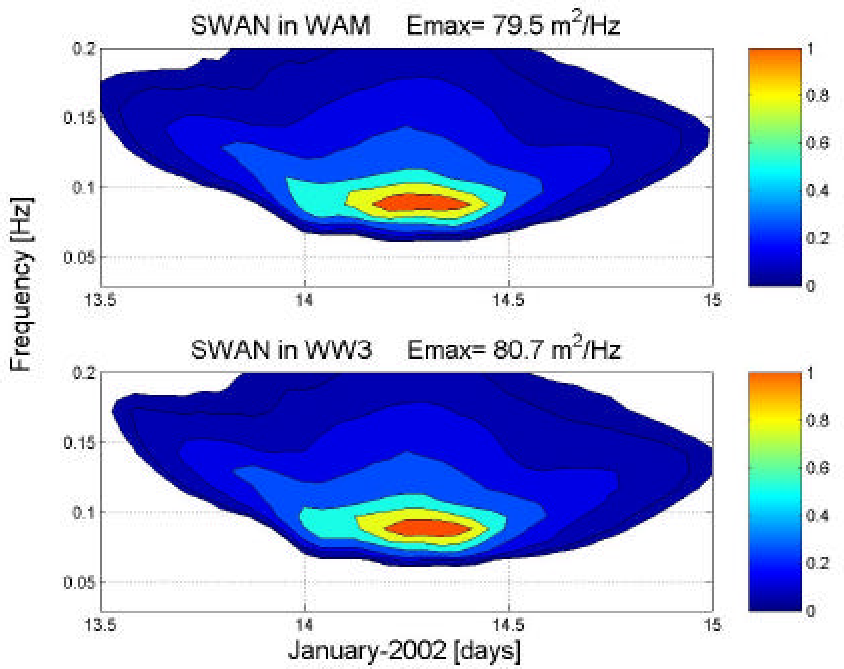


4. The bomb of January 2002







4. The bomb of January 2002

Table 5: Statistics comparing Hs and T_P from the three wave models against the mean measurements from the DWR and ADCP.

	Hs [m]				T_p [s]			
Model	bias [m]	si [-]	rmse [m]	ioa [-]	bias [s]	si [-]	rmse [s]	ioa [-]
WAM	0.05	0.36	1.04	0.92	1.28	0.32	2.73	0.59
WW3	0.06	0.25	0.74	0.97	1.66	0.28	2.40	0.66
SWAN in WAM	0.41	0.25	0.73	0.96	1.35	0.22	1.89	0.74
SWAN in WW3	0.12	0.23	0.66	0.97	1.82	0.31	2.54	0.64

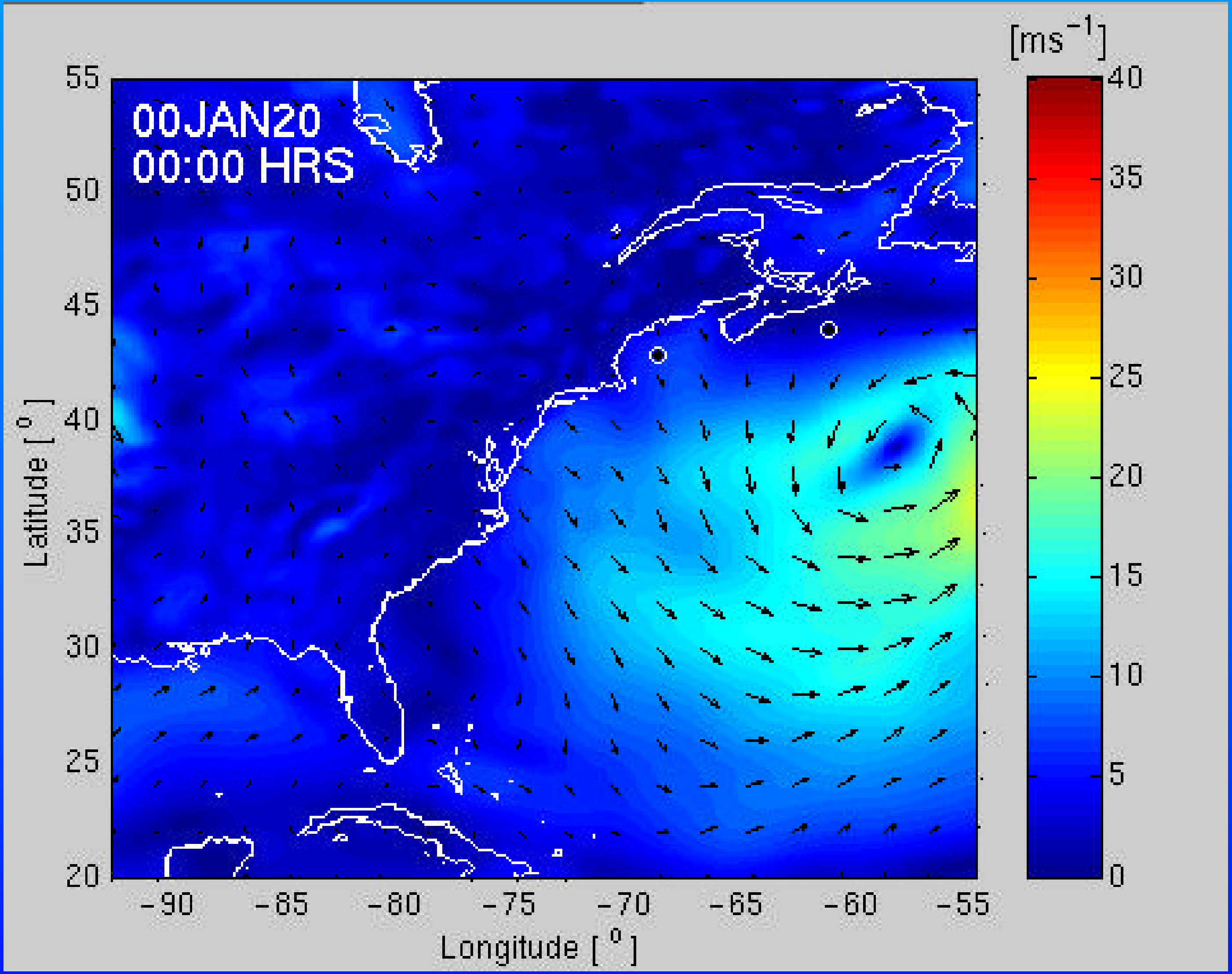
Index of agreement - *ia*
potential variance - *pe*

Normally 0< ioa<1

$$ioa = 1 - \frac{rmse^2}{pe} = 1 - \frac{\sum_i |y_i - x_i|^2}{\sum_i \left(|y_i - \bar{X}| + |x_i - \bar{X}|\right)^2}$$

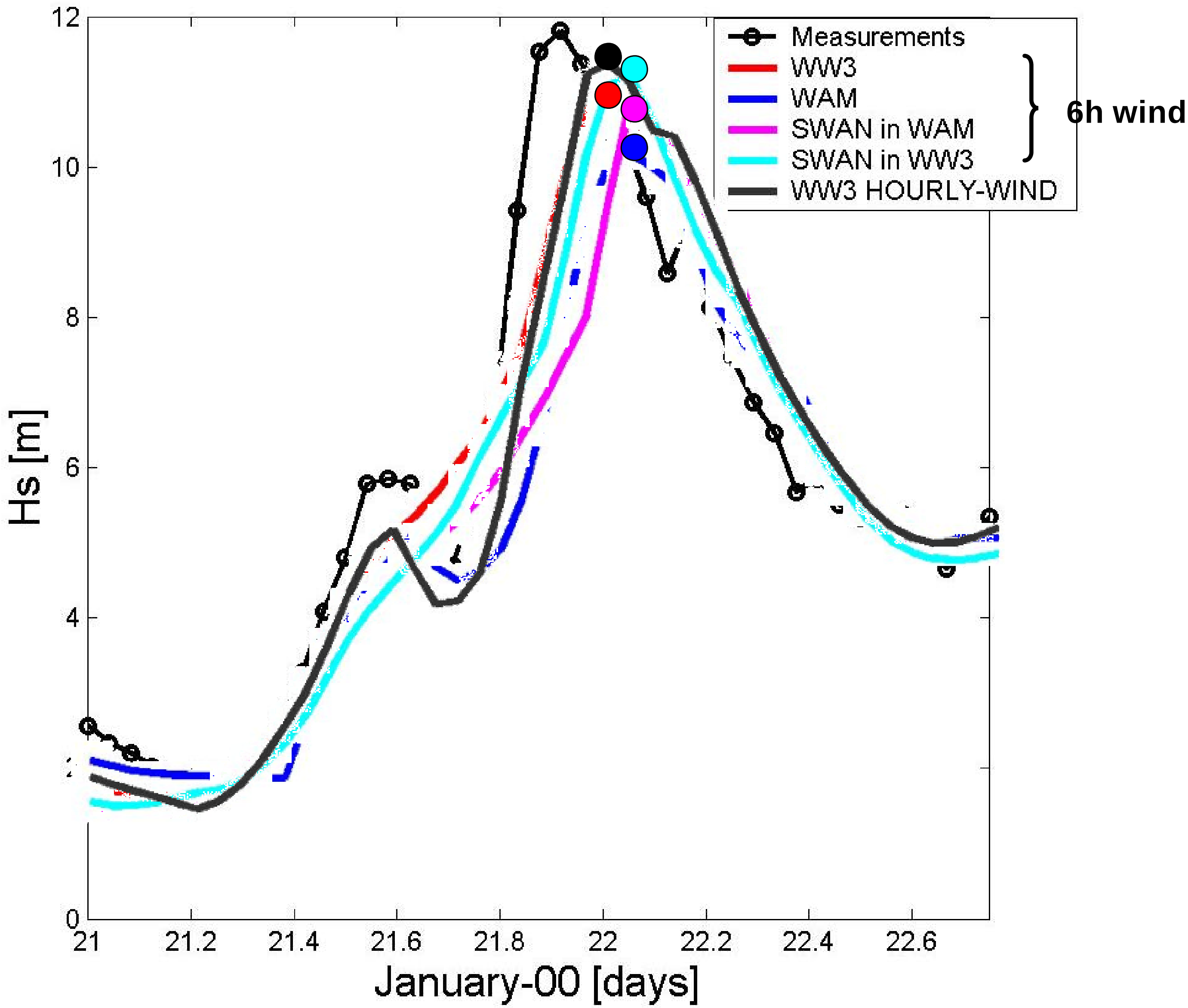
4. The super bomb of January 2002

Superbomb of January 2000
WIND FIELDS



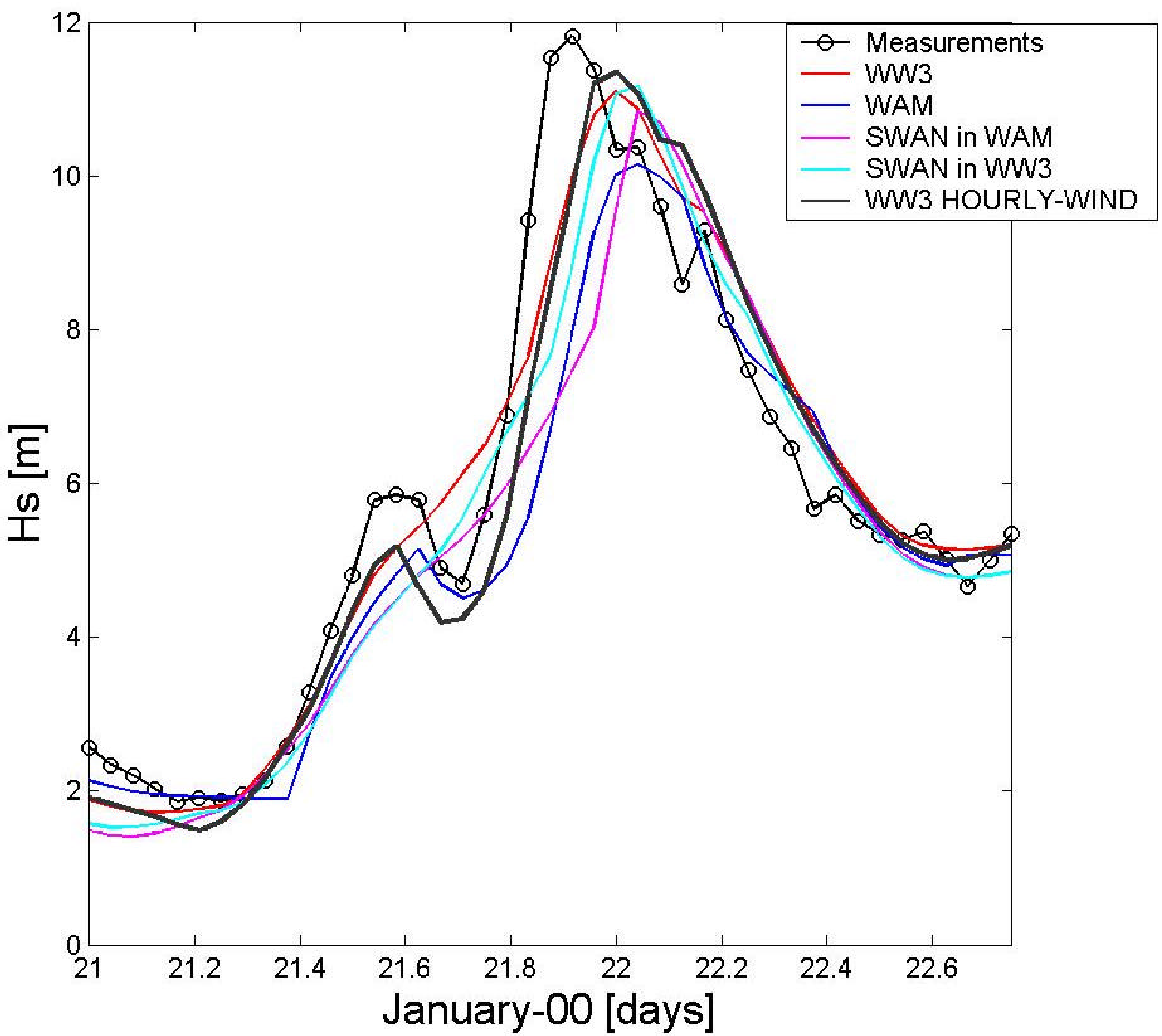
4. The super bomb of January 2002

PANUKE



4. The super bomb of January 2002

PANUKE



Combining four locations

Hs

Model	bias [m]	si [-]	rmse [m]	ioa [-]
WAM	0.92	0.28	1.37	0.88
WW3	0.67	0.20	1.06	0.92
SWAN in WAM	1.09	0.27	1.40	0.89
SWAN in WW3	0.96	0.24	1.29	0.89
WW3-1HW	0.87	0.20	1.22	0.90

Tp

Model	bias [s]	si [-]	rmse [s]	ioa [-]
WAM	1.11	0.24	2.31	0.72
WW3	1.05	0.21	2.00	0.78
SWAN in WAM	1.36	0.63	2.06	0.76
SWAN in WW3	1.43	0.24	2.21	0.75
WW3-1HW	0.89	0.19	1.87	0.80

Conclusions

•Six hourly winds are not proper for wave models in fast moving storms

•Against measurements, the overall model performance

Better → good

WW3 SWAN → WAM

•CPU-Times

Cheap → Expensive

WAM
SWAN → WW3

Conclusions

- **SWAN performs (a little) better nested in WW3, than in WAM**

- **Disk usage and CPU time can increase drastically in shallow water**

SWAN allows change of spectrum-resolution during nesting, WW3 and WAM do not

THE END

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