

NOAA

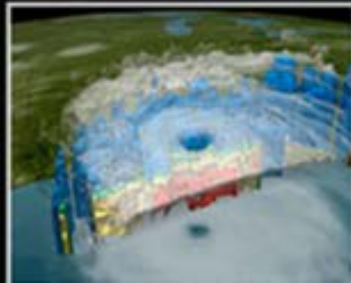
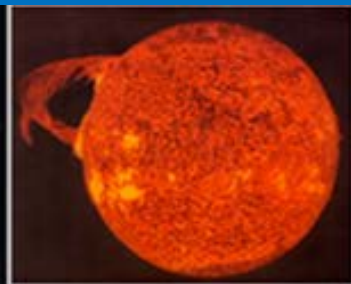
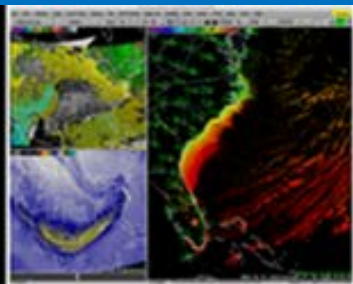
National
Weather
Service

The Global Wave Ensemble System at NCEP

NCEP Ensemble User Workshop
August 27, 2019

Jose-Henrique Alves

Oceanographer, Global Wave Model Lead, EMC/NCEP/NOAA



The GWES

- NCEP's Global Wave Ensemble System (GWES),
- Operational National Weather Service (NWS) prediction suite as stand-alone model since 2004,
 - State-of-the-art wave model WAVEWATCH III,
 - Single $\frac{1}{2}$ degree spatial resolution grid,
 - 21 wave members forced by matching GEFS members,
 - MMAB high res ice analysis,
 - 4 daily cycles [00,06,12,18]Z.
- Serves OPC, NHC, Marine WFOs, US Navy, ECCO.



GWES Products

NCEP Global Wave Ensemble Run 2016/01/12 12Z: 102h Forecast
Ensemble Tp Mean (contour,s) and Spread (shaded,s) 2016/01/16 18Z

Available via NCEP operational FTP:

- 21 individual members (12 parms)
- Ensemble mean (12 parms)
- Ensemble spread (12 parms)
- Probability exceedence (9 parms)

$[H_s]$: Mean Significant Wave Height

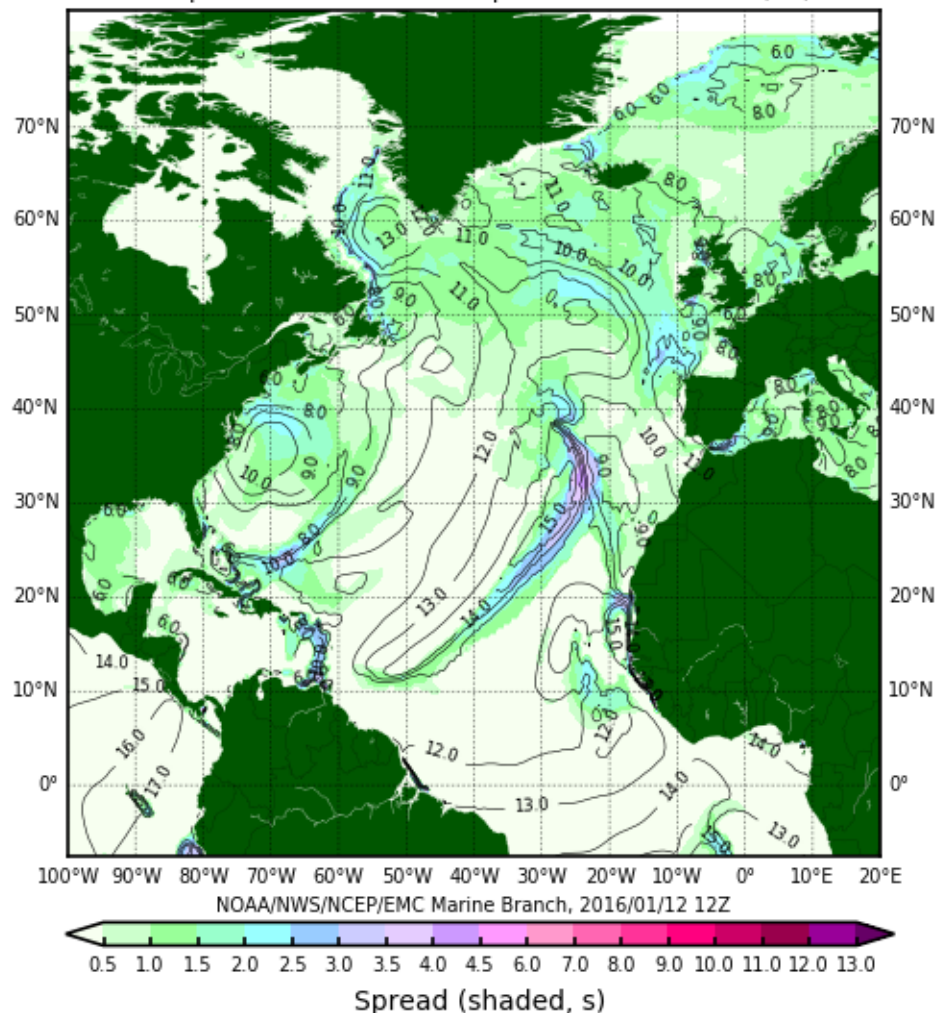
$[H_s]$ Mean (contours) + **Spread**

$[T_p]$: Mean Peak Wave Period

$[T_p]$ Mean (contours) + **Spread**

Gridded data distributed to NAWIPS:

- OPC and NHC



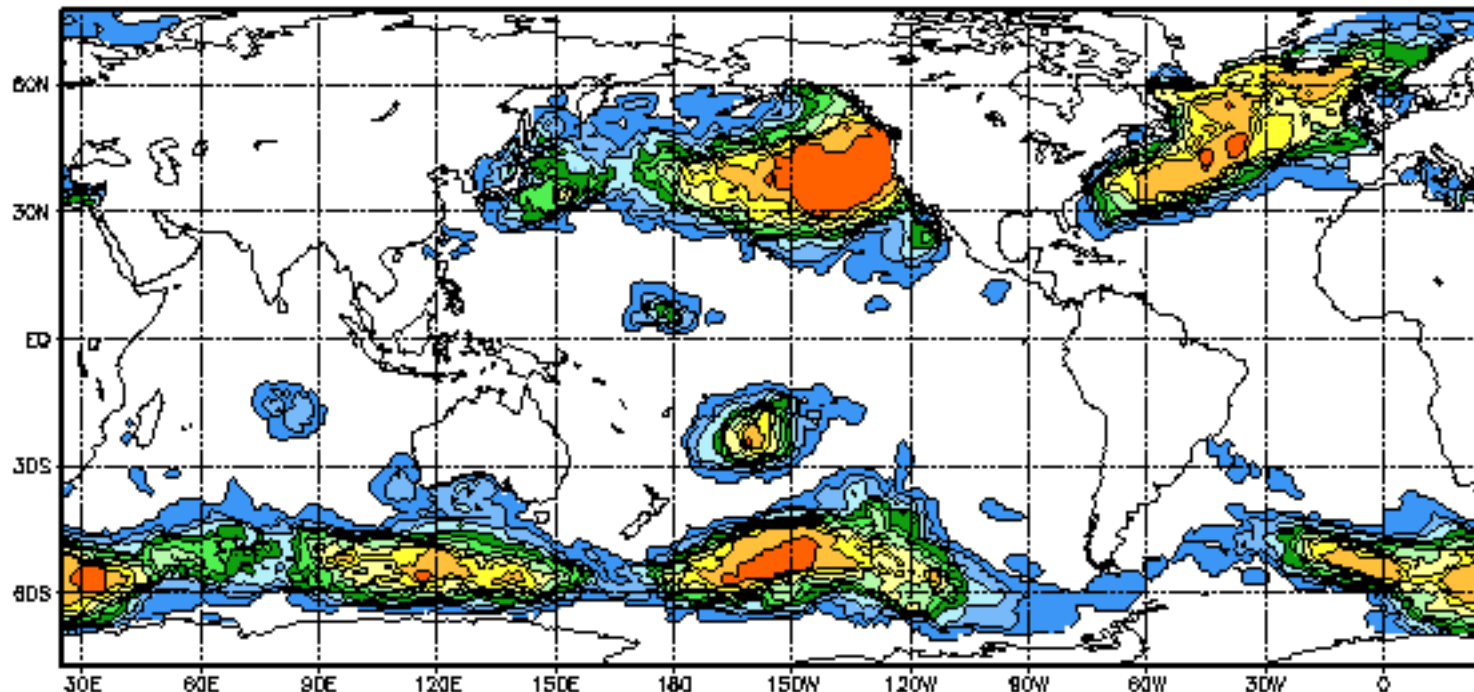
GWES Products: $P(H_s > H_t)$

$P[H_s > 4m]$: Exceedence Probability (also for U10 and T_p)

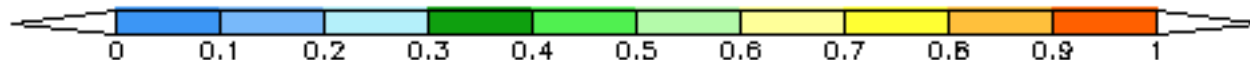
2016/01/12_00z, 168 fcast_hr

Ensemble Probability of $H_s \geq 4.0$ (m)

Valid 2016/01/19 00z

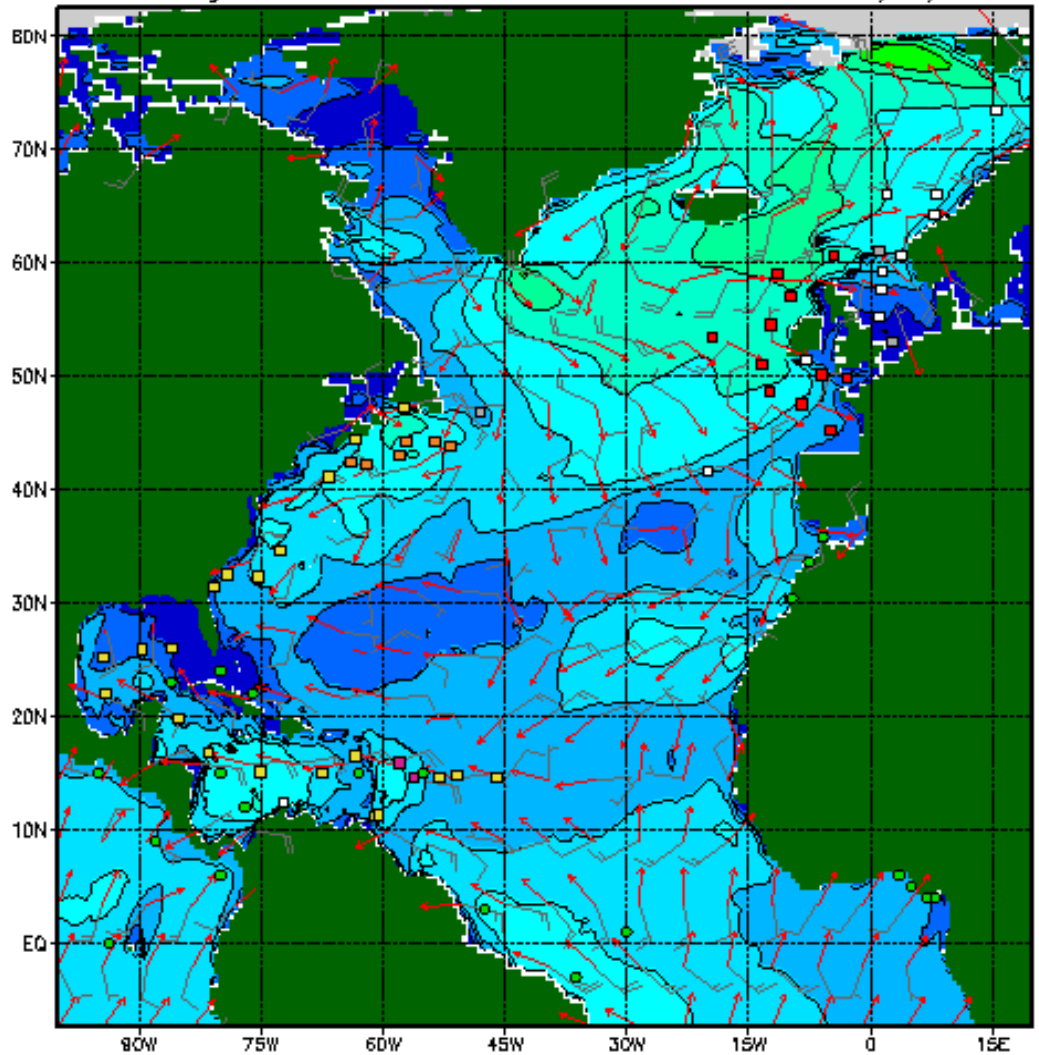


Probability Levels

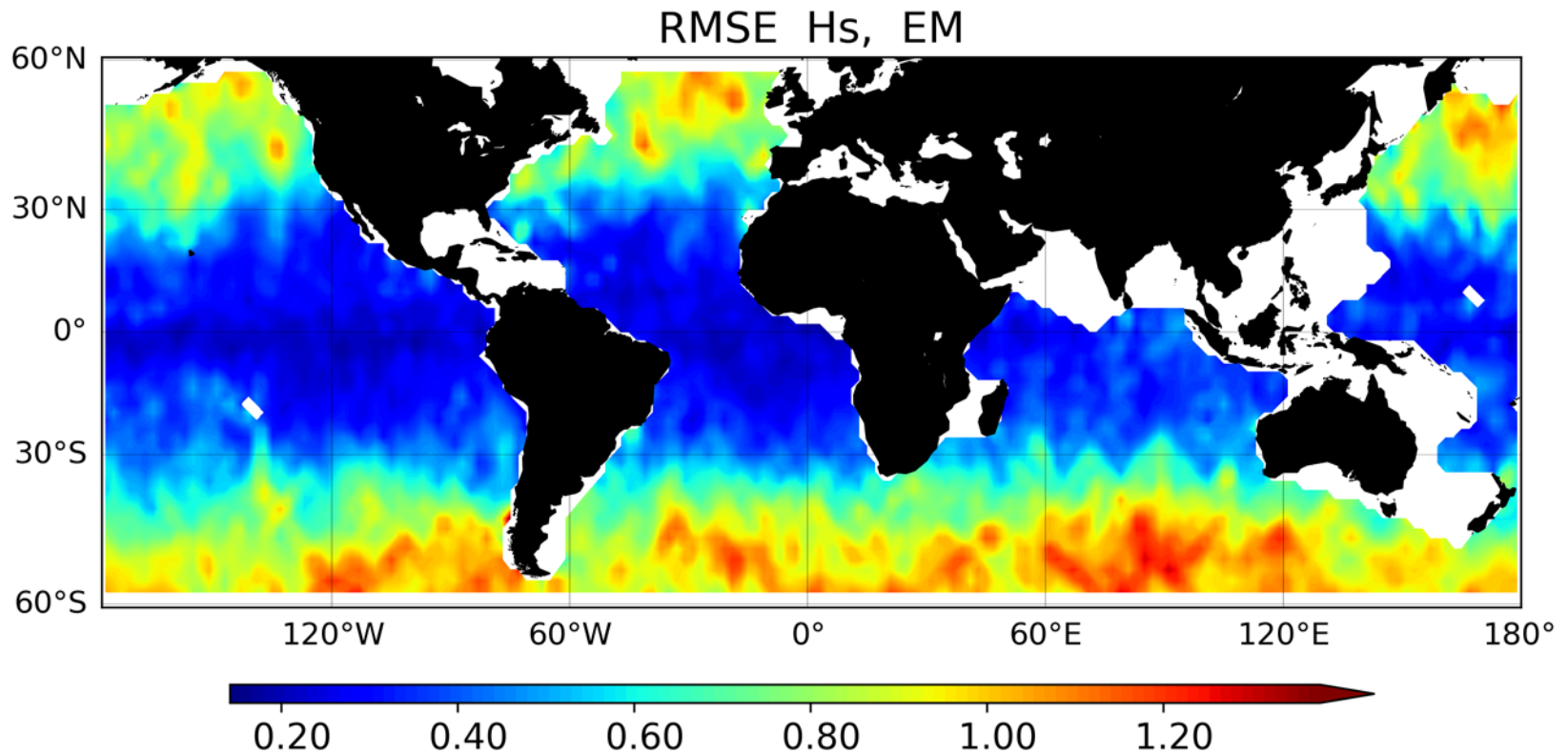


GWES Products: Point Outputs

- Spectral Bulletins and spectra at around 100 points
- Probability of exceedence bulletins at around 300 points



GWES Global RMS Error



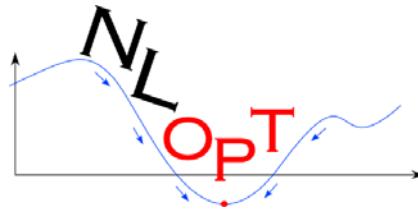
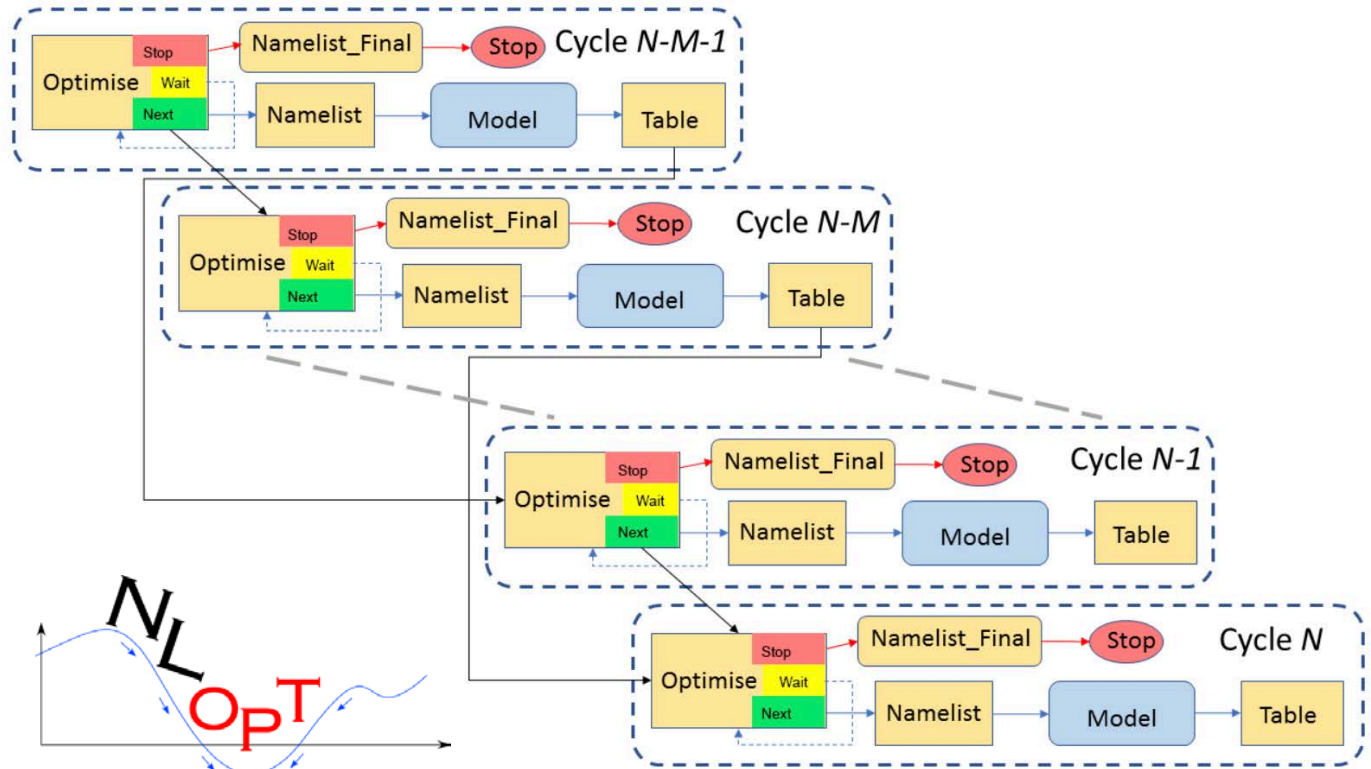
2017 Altimeter Data (SARAL, Cryosat, Jason 2/3)

The Future of the GWES

- NGGPS SIP, Project 1.2 FV3-GEFS,
- GWES will become part of GEFSv12 in 2020,
 - The first global-scale coupled system at NCEP.
- GWES → GEFSv12 wave component → GEFS-waves
 - FV3-WW3 NEMS coupling, ESMF,
 - Extensive changes to GEFS workflow,
 - Hike in grid resolution from $\frac{1}{2}$ to $\frac{1}{4}$ degree global,
 - Extended forecast range: 240h to 384h (16 days),
 - Improved source-term setting (objective optimization with FV3 surface-wind forcing),
 - New experimental products including AI/NN nonlinear ensemble averages.

Objective Source-Term Optimization

R. M. Gorman and H. J. Oliver: Automated model optimisation using Cyclops v1.0

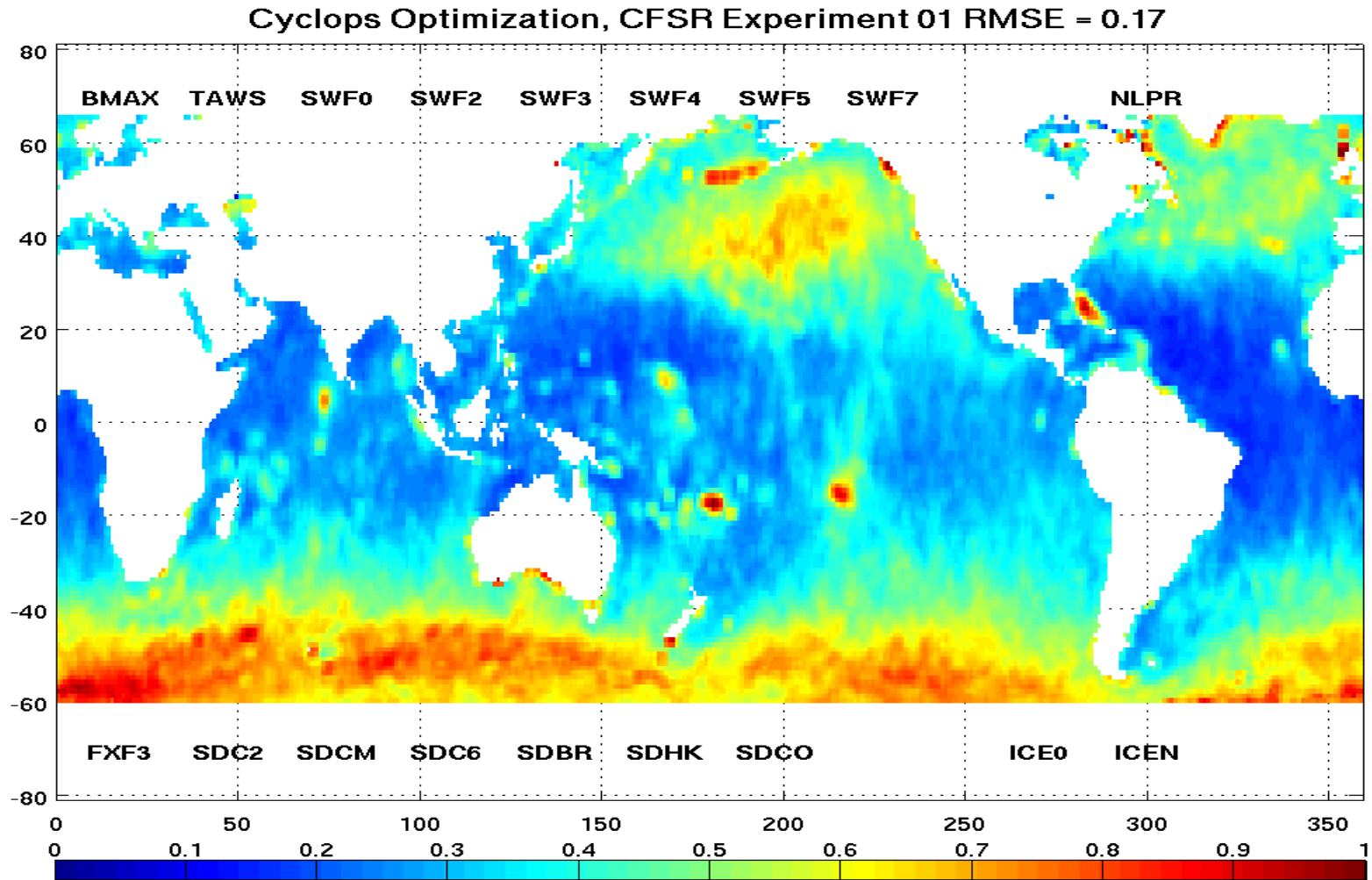


NLOpt nonlinear optimisation toolbox (Johnson, 2014).



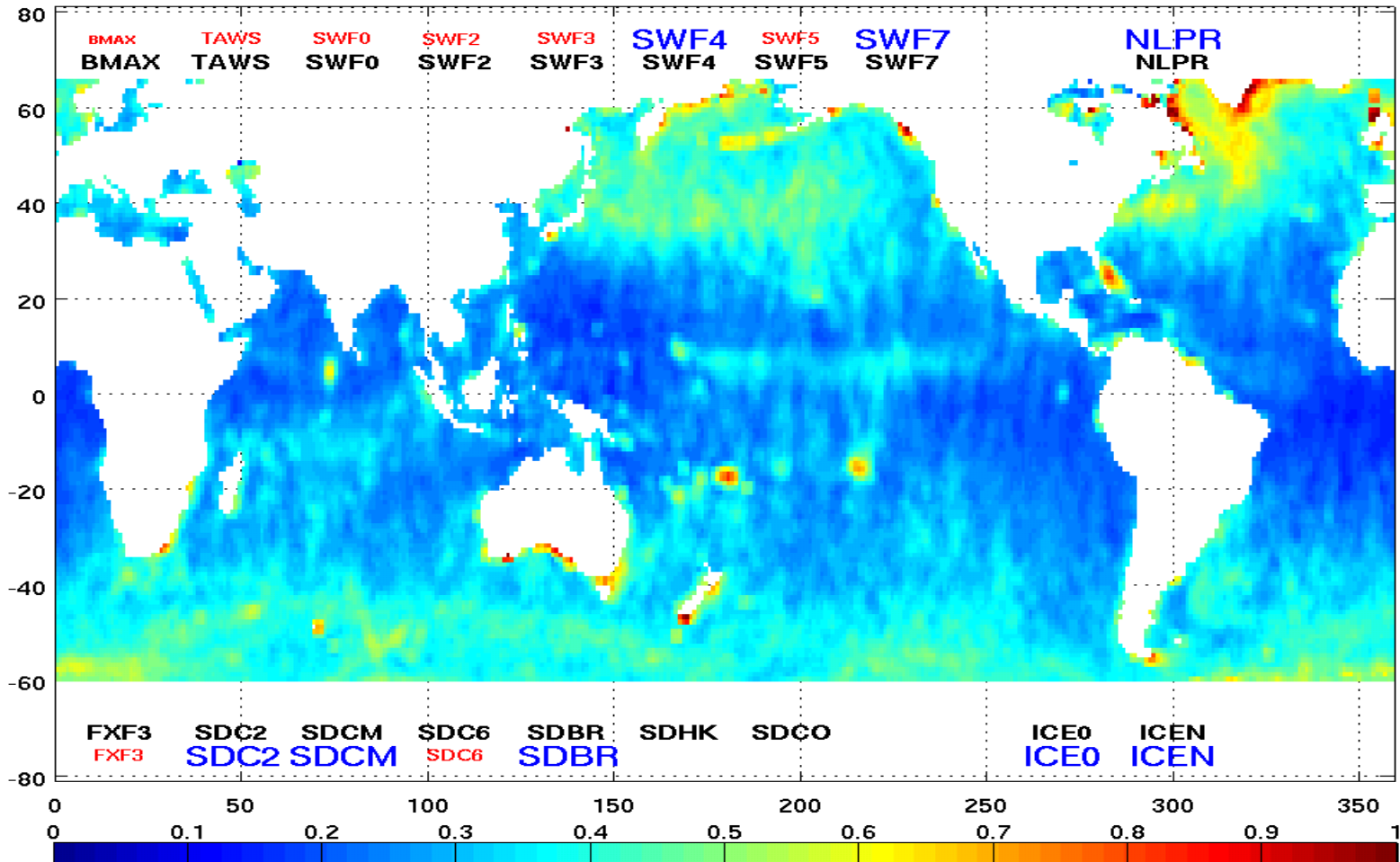
H. Oliver et al. 2019.

Objective Source-Term Optimization



Objective Source-Term Optimization

Cyclops Optimization, CFSR Experiment 45 RMSE = 0.13



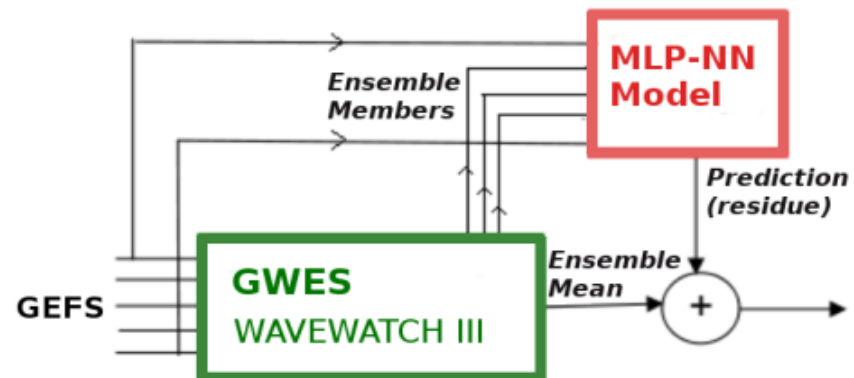
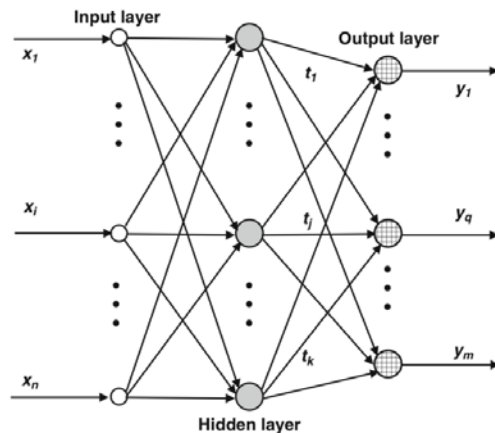
Nonlinear Wave Ensemble Averaging using Neural Networks

R. Campos AOSC/UMD, J.-H. Alves, NCEP/EMC/SRG, V. Krasnopolski, NCEP/EMC, S. Penny, AOSC/UMD
OSTI-NOAA Project Award NA16NWS4680011

- GWES provides a mean product output
- Arithmetic Ensemble Mean: $EM = \frac{1}{n} \sum_{i=1}^n x_i$



- Multilayer perceptron model (MLP-NN) with hyperbolic tangent at the activation function.



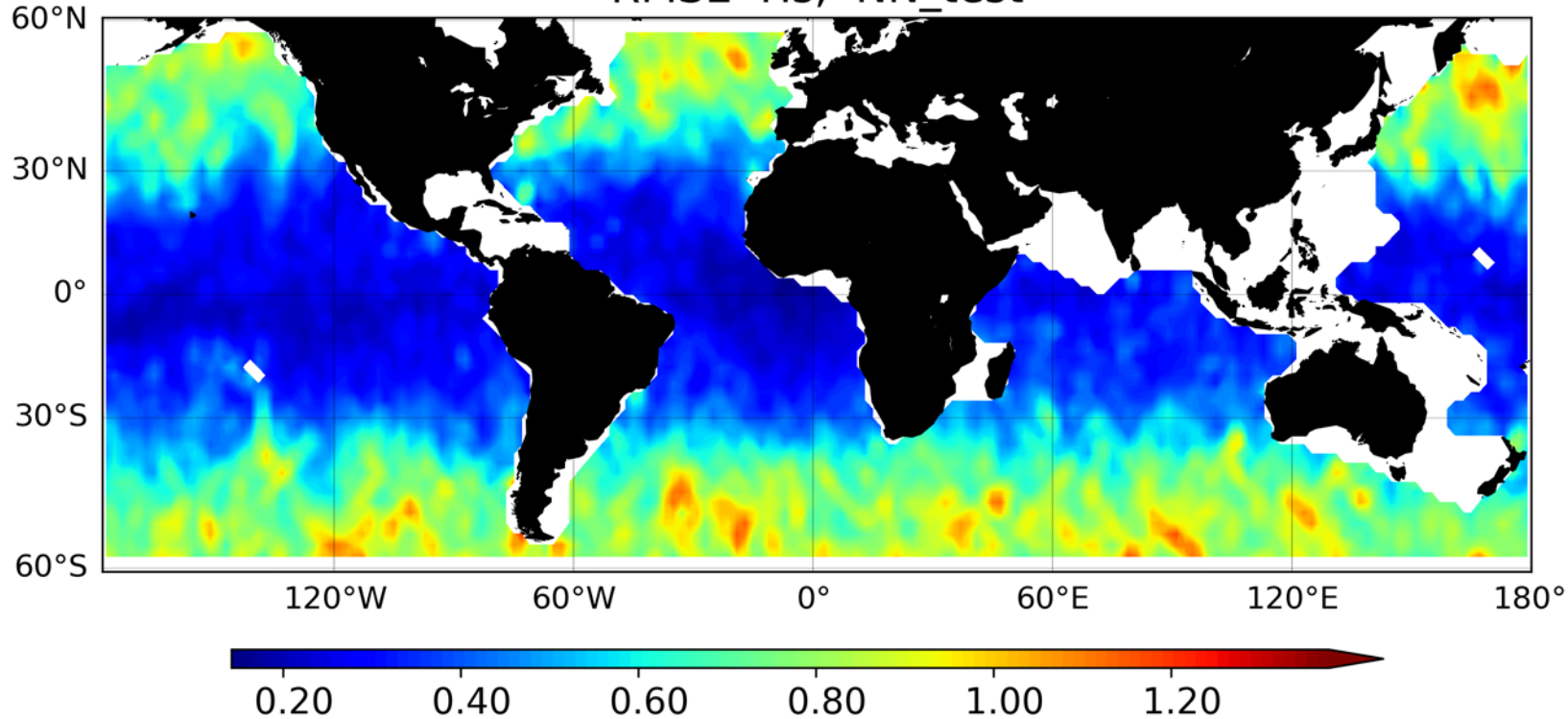


NN-Nonlinear Wave Ensemble Averaging

R. Campos AOSC/UMD, J.-H. Alves, NCEP/EMC/SRG, V. Krasnopolski, NCEP/EMC, S. Penny, AOSC/UMD
OSTI-NOAA Project Award NA16NWS4680011



RMSE Hs, NN_test



2017 Altimeter Data (SARAL, Cryosat, Jason 2/3)

GEFS-waves Implementation Schedule

		FY19				FY20			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Cycle	Task	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep
Dev	Redesign GWES Grids	█							
	Waves in GEFS Workflow		█						
	Wave Physics Optimization		█						
	Coupled Sys Benchmarking			█					
	Code Freeze Retrospectives				█				
	Retrospective Runs					█			
	Deploy AI/NN Mean Prototype					█			
	Science Evaluation						█		
T2O	Unify GEFS-GFS Waves Workflow				█				
	Add Inline Wave POST				█				
	Final GEFSv12 Coupled Sys					█			
	GEFSv12 Code Delivery								█



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