Improved near-shore ocean predictions from trawl-resistant bottom mounted platforms and super-ensembles techniques

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1. DART06B EXPERIMENT (AUG 2006) AIM: IMPROVE MONITORING & PREDICTION SKILLS ON SMALL-SCALE DYNAMICS

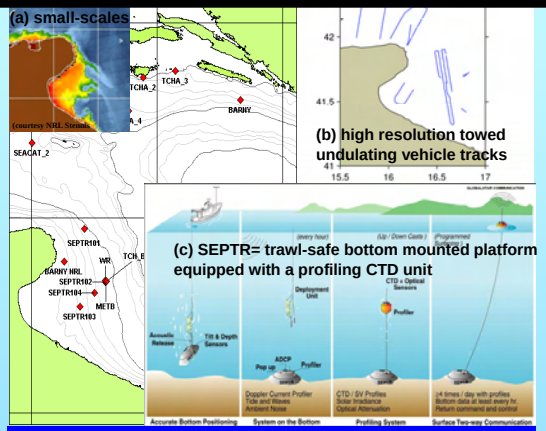

Fig. 1 DART06 area of interest: (a) MODIS ocean colour chlorophyll small-scale filaments (b) high resolution Aquashuttle towed undulating vehicle track (c) SEPTR operation schematic. Following results relate to SEPTR 104 (station B75) location.

2. WHICH MODEL IS BEST?

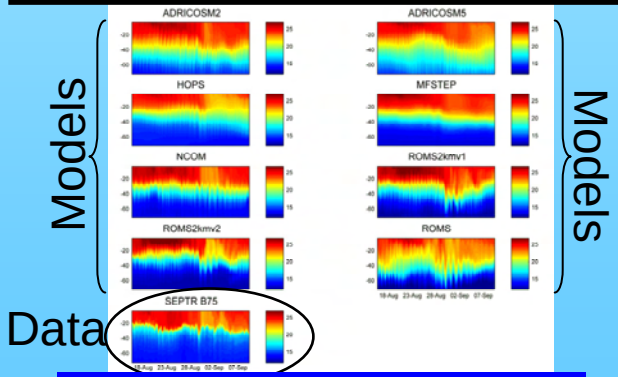

Fig. 2 Time series of temperature (ºC) of various models and SEPTR data illustrating the difficulty of any objective selection of a particular model to rely on.

3. USE OPTIMAL COMBINED SKILLS = MULTI-MODEL SUPER-ENSEMBLE

$$\begin{bmatrix} m_{1,1} & \cdots & m_{1,N} \\ \vdots & \vdots & \vdots \\ m_{M,1} & \cdots & m_{M,N} \end{bmatrix} * \begin{bmatrix} w_1 \\ \vdots \\ w_N \end{bmatrix} = \begin{bmatrix} d_1 \\ \vdots \\ d_M \end{bmatrix}$$

Fig. 3 Example of linear regression technique aiming at finding at a given location an optimal combination (i.e. a set of weights w) of N models m which best agrees with M past data d.

Multi-model Super-Ensemble (SE) aiming at combining optimally different models have been shown to improve significantly atmospheric weather predictions. In the coastal ocean, prediction skills are still low due to high dynamics, the presence of small-scales processes, the lack of real-time data and limited reliability of operational models which prevented the proper application of the SE method so far. Here, we report improved prediction skills and reduced uncertainty from state-of-the-art super-ensemble techniques based on a unique combination of SEPTR [a trawl-resistant bottom mounted platform transmitting in near real-time] data and a series of eight operational models ran during an experiment in a coastal area in the Adriatic Sea.

4. FORECAST ERRORS

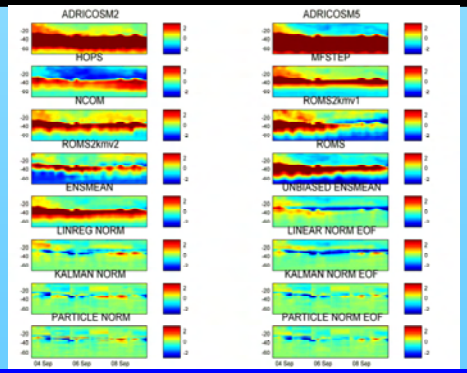

Fig. 4 From top to bottom and left to right: 24hours forecast errors (running 24 hours window for 6 days) for individual models, ensemble mean, unbiased ensemble mean, linear regression, linear regression with regularization (EOF – 5%), dynamic weights (Kalman filter), dynamic weights (Kalman filter) with regularization (EOF – 5%), particle filter and particle filter with regularization (EOF – 5%).

5. INCREASED SE COMPLEXITY = INCREASED SKILL

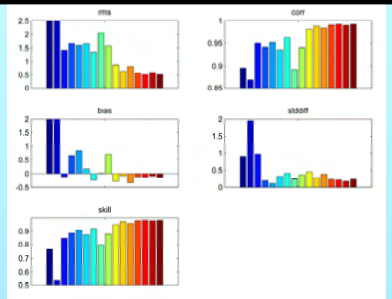

Fig. 5 Error statistics for 24 hours predictions: RMS error, correlation, bias, energy difference and Taylor skill for all models. From left to right: 8 individual models, ensemble mean, unbiased ensemble mean, linear regression, linear regression with regularization (EOF – 5%), dynamic weights (Kalman filter), dynamic weights (Kalman filter) with regularization (EOF – 5%), particle filter and particle filter with regularization (EOF – 5%).

6. INCREASED COMPLEXITY = DECREASED UNCERTAINTY

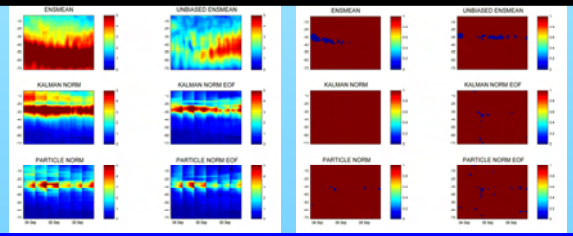

Fig. 6 Left: Uncertainty as derived from ensemble spread, unbiased ensemble spread, Kalman filter error covariance without and with regularization and particle filter ensemble spread without and with regularization. Right: a posteriori verification if true SEPTR data lies (red=success) between forecast+/-3*uncertainty. Failure rates for the different examples are respectively 3.23, 3.28, 0.05, 0.94, 0.91 and 1.43%.

CONCLUSION:

- IMPROVED PREDICTION SKILL: 92 (BEST MODEL) to 98% (PART. FILTER)
- REDUCED UNCERTAINTY (BY-PRODUCT): 1.4 (SPREAD) TO 0.3 °C (PART. FILTER)