Session 6: Computational Issues

1. Computational Issues in Data Assimilation for Operational NWP
   ***(Andrew Lorenc**, Met Office)*
2. Computational Issues for a Variational System
   ***(Yoshiaki Sato**, NOAA/NCEP)*
3. Computational Issues: EnKF
   *(**Jeff Whitaker**, NOAA/ESRL)*

WWRP/THORPEX Workshop on 4D-Var and EnKF Inter-comparisons
Buenos Aires, Argentina 10-13 November 2008

Discussion Topics for Session 6: Computational Issues

Compiled by Ron Gelaro, based on input from the session speakers and other scientists

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Discussion Issues for Session 6: Computational Issues

Over-arching Questions - I

Looking Ahead:

In the foreseeable future, computing power will increase by increasing the number of processors, not their speed. In the old (vector) days only speed increased, followed by a period when both speed and number increased. Now we are entering the multi-core era and the rules are changing again.

We will take advantage of new machines by increasing the size of the problem. But the same size problem will not run much faster on the new machines than it did on the old ones. (It will run much cheaper, but not much faster.) Ideally, we might hope to reach the "weak scaling" limit.

(Max Suarez, personal communication)

How are the EnKF and 4D-Var expected to scale as the number of processors reaches into the thousands, or even tens of thousands?

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Over-arching Questions - II

How is the computational cost (and parallel scaling) of the EnKF and 4D-Var affected as the <u>resolution</u> of the forecast model increases?

- If the outer loop in 4D-Var is at the weak scaling limit, will lower-resolution inner loops waste processors?
  - If so, can these "extra" processors be used creatively; e.g., multiple minimizations, cache data, temporal domain decompositions (*ref: Y. Trémolet*)

- Increasing degrees of freedom generally implies the need to increase ensemble size in the EnKF.
  - At the same time, would localization length scales need to be shortened significantly to deal with smaller scale features?

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Over-arching Questions - III

How is the computational cost (and parallel scaling) of the EnKF and 4D-Var affected as the <u>number of observations</u> assimilated increases?

● Will EnKF become impractical; will severe localization help?
(*ref: P. Houtekamer*)

● Will sequential processing of obs on many more processors in EnKF severely limit scalability and the ability to perform QC?

● Will the number of inner loop iterations need to increase in 4D-Var, leading to larger differences in inner and outer loop resolutions and less efficient use of more processors?

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Specific Questions from Session Talks - I

Andrew Lorenc:

● In 10~20 years we will be able to run global ensembles at resolutions such that the initial errors are non-Gaussian. What will (we) do?

● It took global-scale NWP 20 years to learn how to use satellite soundings well. How long will it take with radar?

● Will the quasi-linear 4D-Var or EnKF methods work OK for operational convective-scale NWP, or are non-Gaussian methods really needed?
(*ref M. Bocquet*)

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Specific Questions from Session Talks - II

Yoshi Sato:

● Is 3D-Var + flow dependent background errors a good (the best?) practical compromise between cost and performance?

Jeff Whitaker:

● What is the most efficient algorithm for computing the analysis increment in the EnKF as the number of processors and/or the number of observations to assimilate increases?