Implementation of the Reduced Order Information Filter
ROIF
Data Assimilation Scheme in HYCOM

An Update on Tuning Experiments in Progress
&
Computational Performance

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Reduced Order Information Filter

Information Filter:

- Algebraically same as the Kalman Filter
- Propagates the Information Matrix which is the inverse of the Covariance matrix
- Often a convenient form to circumvent computational and numerical difficulties associated with Kalman Filter recursion

Reference: Chin, Mariano & Chassignet 1999.
Reduced Order Information Filter

- Gaussian Markov Random Field (GMRF) is used to parameterize the Information Matrix
- A regression operator encodes the correlation in the error process

\[ e_j = \sum_{i \in Z} \alpha_{ij} e_{j-i} + v_j \]

MRF order 2 Neighborhood
Reduced Order Information Filter

- Regression operator implies a sparse Information matrix
- Degree of sparseness is the order of the spatial/diagnostic model
- MRF order = 2 => Penta diagonal Information Matrix
- $O(N^2)$ Information Matrix approximated with $O(n \times N)$ elements Reduced Order Information Matrix
Twin Experiments with 1/12° HYCOM configured for Gulf of Mexico
GOMd0.08 Configuration:

Configuration:
- 1/12° horizontal grid (258x175 pts; 6.5km average spacing)
- 89 to 98 W Longitude and 8 to 31 N Latitude
- 20 vertical layers
- Forcing from NOGAPS/FNMOC
- Monthly River Runoff
- Relaxation of U,V,T,S to 1/12 N. Atlantic Model
Twin Experiments Configuration

- Used **GOMd0.08 package** from the HYCOM FTP site

- **Truth** – Output from running the GOMd0.08 package as configured – Aug 1999 – Dec 2000

- **Reference** – Run the GOMd0.08 configuration, no assimilation without the restart file

- **ROIF – TP Assimilation** – Run the GOMd0.08 model with assimilation of SSH sampled under TP tracks from the Truth run without a restart file

- **ROIF – Random Assimilation** - Run the GOMd0.08 model with assimilation of SSH sampled randomly from the Truth run without a restart file (same no of data pts as the TP run)
Domain and Topex/Poseidon Tracks and Random Sampling Locations
Twin Experiments with ROIF
Twin Experiments with ROIF
Twin Experiments with ROIF
Twin Experiments with ROIF
Multi-Layer ROIF & ROIF-vd

- A full multi-layer version of ROIF will use a vector GMRF.
- We use a simpler implementation called ROIF-vd, vertically decoupled.
- A single layer ROIF runs in each layer.
- This version does not update the vertical correlations dynamically. The vertical correlations must be externally supplied.

- We are currently using statistics extracted from a 2x2 degree North Atlantic Run to vertically distribute the SSH signal.
- Results are expected to be much better when we have the statistics from the 1/12° GOM truth run.
ROIF Computational Performance

- **CPU Time**: ~3X as the free model
- **Storage**: ~6X as the free Model

### Timer Statistics

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<th>Function</th>
<th>Calls</th>
<th>Time</th>
<th>Time/Call</th>
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(normal)  
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Open Mp/MPI Implementation

![Graph showing Wall Clock Time (s) vs No of Processors for different implementations: Cyan - no assimilation, Red - ROIF-OpenMP, Green - ROIF-MPI.]