ROIF Optimization and Parallelization
An Update
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ROIF (beta version) Package

Overview

- A data assimilation scheme based on Kalman Filter
- The current version assimilates Sea Surface Height data
- Consists of 5 main subroutines
- Implemented in approximately 1000 lines of fortran-77 code
Computational Details

- The key data structures are the information matrix and information vector.
- The information matrix is represented by a 7-dimensional array: \( a(i,j,mw,nw,iww,jww,k) \)
- The information vector is represented by a 4-dimensional array: \( p(i,j,iw,k) \)
- Two compute intensive subroutines operate on these data structures.
The computational kernel

- Two main computational subroutines are the `roifPredict.f` and `roifUpdate.f` routines.
- `roifPredict.f` updates the information data structures every time step.
- `roifUpdate.f` updates the model variables less frequently.
- `roifUpdate.f` is the most compute intensive and it involves the information matrix-vector multiplication.
Optimization of the Serial code

- A code slice showing the vector-matrix multiplication

```plaintext
do k=1,maxV
do iw=1,3
  do j=1,jdm
    do i=1,idm
      do jw=1,3
        do nw=-maxW,maxW
          jo=j+nw
          if((j0.ge.1) .and. (j0.le.jdm)) then
            do mw=-maxW,maxW
              io=i+mw
              if((i0.ge.1) .and. (i0.le.idm)) then
                if (A(i,j,mw,nw,iw,jw,k). ne .0) then
                  w(i,j,iw,k)=w(i,j,iw,k)+A(i,j,mw,nw,iw,jw,k)*p(io,jo,iw,k)
```
Optimization of the Serial Code

- Following discussions with Drs. Iskandarani and Wallcraft, the information Matrix data structure was changed to a 6-dimensional array and the indices reordered:
  \[ A(mw,jw,i,j,iw,k) \]

- The if conditionals were also eliminated.

- The resulting vector-matrix runs 60% faster and uses less memory, and the overall code runs 3 times faster.
Parallelization

- The new data structure for the information matrix is better suited for tiling since the indexing is similar to the other tiles arrays.
- The tiled data structure needs to be updated in only two twice overall once in the roifPredict.f and once in roifUpdate.f.
- Work in progress to write the communication routines for the new versions of roifpredict.f and roifUpdate.f that will be available soon.
Status and Future Plans

- The serial code with the new data structure runs 50% faster and uses less memory.
- The serial code is well optimized and is ready for SPMD parallelization.
- Once the new version of ROIF package becomes available, we intend to complete the parallelization in collaboration with Dr. Wallcraft.