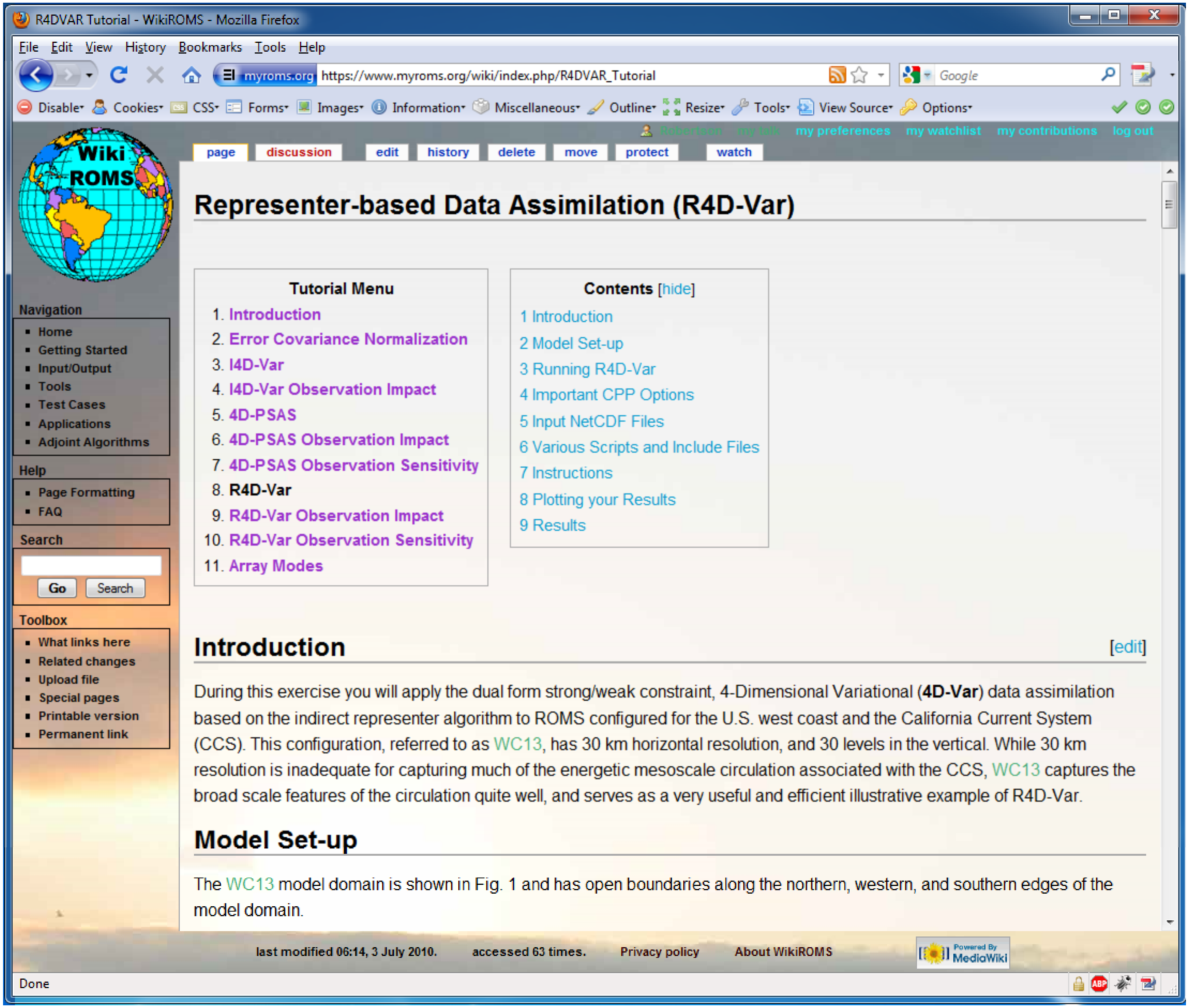
Tutorial 5: Explanation of CPP Options, ocean.in, and r4dvar.in

Tutorial 5: Explanation of CPP Options, ocean.in, and psas.in

R4D-Var Tutorial Wiki Page



WC13 C-preprocessing Options

(Basic Configuration)

Momentum Equations Options:

```
#define UV_ADV             including advection terms
#define UV_COR             including Coriolis term
#define DJ_GRADPS          splines density Jacobian PGF
#define UV_QDRAG           quadratic bottom friction
#define UV_VIS2            harmonic horizontal mixing
#define MIX_S_UV           mixing along s-levels
```

Tracers Equations Options:

```
#define TS_U3HADVECTION    3rd-order Upstream H. advection
#define TS_C4VADVECTION    4th-order Centered V. advection
#define TS_DIF2            harmonic horizontal mixing
#define MIX_GEO_TS         mixing along geo-potentials
#define SALINITY           including salinity
#define NONLIN_EOS         nonlinear equation of state

#define ANA_BTFLUX         analytical bottom Temp flux
#define ANA_BSFLUX         analytical bottom Salt flux
```

Vertical Turbulent Mixing Parameterization:

```
#define GLS_MIXING         Generic Length Scale Mixing
#ifdef GLS_MIXING                 (K-omega)
# define N2S2_HORAVG       smoothing of buoyancy/shear
# define KANTHA_CLAYSON    stability function
#endif
```

Atmospheric Boundary Layer Parameterization:

```
#define BULK_FLUXES        Air/sea COARE bulk fluxes

#define DIURNAL_SRFLUX     imposing local diurnal cycle
#define SOLAR_SOURCE       solar radiation source term
#define LONGWAVE_OUT       compute outgoing long wave rad
#define EMINUSP            compute E-P
```

Model Configuration Options:

```
#define SOLVE3D            solve 3D primitive equations
#define CURVGRID           curvilinear grid
#define MASKING            land/sea masking
#define SPHERICAL          spherical grid
#define PROFILE            time profiling

#define SPLINES            parabolic splines
                             reconstruction
```

Lateral Boundary Conditions:

```
#define EASTERN_WALL       closed eastern wall condition

#define WEST_FSCHAPMAN     free-surface, Chapman
#define WEST_M2FLATHER     2D momentum, Flather
#define WEST_M3CLAMPED     3D momentum, clamped
#define WEST_TCLAMPED      tracers, clamped condition

#define NORTH_FSCHAPMAN    free-surface, Chapman
#define NORTH_M2FLATHER    2D momentum, Flather
#define NORTH_M3CLAMPED    3D momentum, clamped
#define NORTH_TCLAMPED     tracers, clamped

#define SOUTH_FSCHAPMAN    free-surface, Chapman
#define SOUTH_M2FLATHER    2D momentum, Flather
#define SOUTH_M3CLAMPED    3D momentum, clamped
#define SOUTH_TCLAMPED     tracer, clamped

#define SPONGE             enhanced viscosity/diffusion
                             areas
```

WC13 C-preprocessing Options

(R4D-Var Configuration)

Algorithm:

```
#define W4DVAR              dual form strong/weak constraint indirect representer algorithm
#define POSTERIOR_EOFS      estimate posterior error analysis error
#define POSTERIOR_ERROR_I   estimate initial conditions posterior analysis error
```

Control Vector:

```
#define ADJUST_BOUNDARY     open boundary conditions increments
#define ADJUST_STFLUX       surface tracer flux increments
#define ADJUST_WSTRESS      surface wind stress increments
```

Error Covariance Modeling:

```
#define VcONVOLUTION        Vertical correlation modeling
#define IMPLICIT_VCON       Implicit vertical diffusion operator
#define BALANCE_OPERATOR    Multivariate balance constraint
#ifdef BALANCE_OPERATOR
# define ZETA_ELLIPTIC      SSH elliptic equation method
#endif
```

Prior:

```
#define FORWARD_READ        read basic state linearization in TLM and ADM files
#define FORWARD_WRITE       writing basic state by the NLM
#define FORWARD_MIXING      processing basic state vertical mixing coefficients
#define NL_BULK_FLUXES      surface kinematic fluxes from nonlinear model
#define RPM_RELAXATION      include relaxation term using previous Picard iteration solution
```

I/O :

```
#define OUT_DOUBLE          double precision data in output NLM, TLM, RPM, and ADM
```

WC13 C-preprocessing Options
(4D-PSAS Configuration)

Algorithm:

```
#define W4DPSAS               dual form strong/weak constraint 4D-PSAS
#define POSTERIOR_EOFS        estimate posterior error analysis error
#define POSTERIOR_ERROR_I     estimate initial conditions posterior analysis error
```

Control Vector:

```
#define ADJUST_BOUNDARY       open boundary conditions increments
#define ADJUST_STFLUX         surface tracer flux increments
#define ADJUST_WSTRESS        surface wind stress increments
```

Error Covariance Modeling:

```
#define VcONVOLUTION          Vertical correlation modeling
#define IMPLICIT_VCON         Implicit vertical diffusion operator
#define BALANCE_OPERATOR      Multivariate balance constraint
#ifdef BALANCE_OPERATOR
# define ZETA_ELLIPTIC        SSH elliptic equation method
#endif
```

Prior:

```
#define FORWARD_READ          read basic state linearization in TLM and ADM files
#define FORWARD_WRITE         writing basic state by the NLM
#define FORWARD_MIXING        processing basic state vertical mixing coefficients
#define NL_BULK_FLUXES        surface kinematic fluxes from nonlinear model
```

~~#define RPM_RELAXATION   include relaxation term using previous Picard iteration solution~~

I/O :

```
#define OUT_DOUBLE            double precision data in output NLM, TLM, RPM, and ADM
```

Include File: wc13.h

```
/*
** svn $Id: wc13.h 476 2010-06-26 20:25:30Z arango $
*******************************************************************************
** Copyright (c) 2002-2010 The ROMS/TOMS Group                              **
**   Licensed under a MIT/X style license                                   **
**   See License_ROMS.txt                                                   **
*******************************************************************************
**
** Options for the California Current System, 1/3 degree resolution.
**
** Application flag:   WC13
** Input script:       ocean_wc13.in
**                     s4dvar.in
**
** Available Drivers options: choose only one and activate it in the
**                            build.sh script (MY_CPP_FLAGS definition)
**
**  AD_SENSITIVITY            Adjoint Sensitivity Driver
**  AFT_EIGENMODES            Adjoint Finite Time Eigenmodes
**  ARRAY_MODES               Stabilized representer matrix array modes
**  CLIPPING                  Stabilized representer matrix clipped analysis
**  CORRELATION               Background-error Correlation Check
**  GRADIENT_CHECK            TLM/ADM Gradient Check
**  FORCING_SV                Forcing Singular Vectors
**  FT_EIGENMODES             Finite Time Eigenmodes
**  IS4DVAR                   Incremental, strong constraint 4DVAR
**  NLM_DRIVER                Nonlinear Basic State trajectory
**  OPT_PERTURBATION          Optimal perturbations
**  PICARD_TEST               Picard Iterations Test
**  R_SYMMETRY                Representer Matrix Symmetry Test
**  SANITY_CHECK              Sanity Check
**  SO_SEMI                   Stochastic Optimals: Semi-norm
```

ROMS Standard Input Parameters

```
    NtileI == 2             ! I-direction partition
    NtileJ == 2             ! J-direction partition
. . .
    NTIMES == 192           ! Number of time-steps (4 days)
        DT == 1800.0d0      ! Number of time-steps (48 steps per day)
. . .
    Nouter =  1             ! Number of 4D-Var outer loops
    Ninner =  50            ! Number of 4D-Var inner loops
. . .
   LDEFOUT == T             ! Switch to create new history files
      NHIS == 48            ! Steps between writing of NLM data (daily)
   NDEFHIS == 0             ! Steps between creation of new NLM files
. . .
 LcycleTLM == F             ! Switch to recycle records in TLM file
      NTLM == 48            ! Steps between writing of TLM data (daily)
   NDEFTLM == 0             ! Steps between creation of new TLM files
 LcycleADJ == T             ! Switch to recycle records in ADM file
      NADJ == 192           ! Steps between writing of ADM data (strong constraint)
   NDEFADJ == 0             ! Steps between creation of new ADM files
      NSFF == 48            ! Steps between adjustment of surface fluxes (daily)
      NOBC == 48            ! Steps between adjustment of open boundary (daily)
. .
   APARNAM =  r4dvar.in     ! R4D-Var standard input parameters
```

ROMS Standard Input Parameters

```
    NtileI == 2             ! I-direction partition
    NtileJ == 2             ! J-direction partition
. . .
    NTIMES == 192           ! Number of time-steps (4 days)
        DT == 1800.0d0      ! Number of time-steps (48 steps per day)
. . .
    Nouter =  1             ! Number of 4D-Var outer loops
    Ninner =  50            ! Number of 4D-Var inner loops
. . .
   LDEFOUT == T             ! Switch to create new history files
      NHIS == 48            ! Steps between writing of NLM data (daily)
   NDEFHIS == 0             ! Steps between creation of new NLM files
. . .
 LcycleTLM == F             ! Switch to recycle records in TLM file
      NTLM == 48            ! Steps between writing of TLM data (daily)
   NDEFTLM == 0             ! Steps between creation of new TLM files
 LcycleADJ == T             ! Switch to recycle records in ADM file
      NADJ == 192           ! Steps between writing of ADM data (strong constraint)
   NDEFADJ == 0             ! Steps between creation of new ADM files
      NSFF == 48            ! Steps between adjustment of surface fluxes (daily)
      NOBC == 48            ! Steps between adjustment of open boundary (daily)
. .
   APARNAM =  psas.in       ! 4D-PSAS standard input parameters
```

Standard Input File: ocean_wc13.in

```
      RSTNAME == wc13_rst.nc
      HISNAME == wc13_his.nc
      TLMNAME == wc13_tlm.nc
      TLFNAME == wc13_tlf.nc
      ADJNAME == wc13_adj.nc
      AVGNAME == wc13_avg.nc
      DIANAME == wc13_dia.nc
      STANAME == wc13_sta.nc
      FLTNAME == wc13_flt.nc

! Input ASCII parameter filenames.

      APARNAM =  r4dvar.in
      SPOSNAM =  stations.in
      FPOSNAM =  floats.in
      BPARNAM =  bioFasham.in
      SPARNAM =  sediment.in
      USRNAME =  MyFile.dat

!
!  GLOSSARY:
!  =========
!
!------------------------------------------------------------------------------
! Application title (string with a maximum of eighty characters) and
! C-preprocessing flag.
!------------------------------------------------------------------------------
!
!  TITLE       Application title.
!
!  MyAppCPP    Application C-preprocessing option.
!
```

4D-Var Parameters: Normalization

```
Nmethod   == 0                  ! normalization method
Nrandom   == 5000               ! randomization iterations
. . .
LdefNRM   == F F F F            ! Create a new normalization files
LwrtNRM   == F F F F            ! Compute and write normalization
. . .
CnormI(isFsur) =  T             ! 2D variable at RHO-points
CnormI(isUbar) =  T             ! 2D variable at U-points
CnormI(isVbar) =  T             ! 2D variable at V-points
CnormI(isUvel) =  T             ! 3D variable at U-points
CnormI(isVvel) =  T             ! 3D variable at V-points
CnormI(isTvar) =  T T           ! NT tracers
. . .
CnormB(isFsur) =  T             ! 2D variable at RHO-points
CnormB(isUbar) =  T             ! 2D variable at U-points
CnormB(isVbar) =  T             ! 2D variable at V-points
CnormB(isUvel) =  T             ! 3D variable at U-points
CnormB(isVvel) =  T             ! 3D variable at V-points
CnormB(isTvar) =  T T           ! NT tracers
. . .
CnormF(isUstr) =  T             ! surface U-momentum stress
CnormF(isVstr) =  T             ! surface V-momentum stress
CnormF(isTsur) =  T T           ! NT surface tracers flux
. . .
NRMnameM == wc13_nrm_m.nc       ! model error (weak constraint)
NRMnameI == wc13_nrm_i.nc       ! initial conditions
NRMnameB == wc13_nrm_b.nc       ! open boundary conditions
NRMnameF == wc13_nrm_f.nc       ! surface forcing (wind stress and net heat flux)
```

4D-Var Parameters: Decorrelation Scales

Horizontal and vertical stability and accuracy factors (< 1):

```
!                  IC       Model    OBC      Sur For

         Hgamma =  0.5      0.5      0.5      0.5          ! horizontal operator
         Vgamma =  0.0005   0.0005   0.0005   0.0005       ! vertical operator
```

Initial conditions correlations (m):

```
HdecayI(isFsur) ==  50.0d+3                                ! free-surface
HdecayI(isUbar) ==  50.0d+3                                ! 2D U-momentum
HdecayI(isVbar) ==  50.0d+3                                ! 2D V-momentum
HdecayI(isUvel) ==  50.0d+3                                ! 3D U-momentum
HdecayI(isVvel) ==  50.0d+3                                ! 3D V-momentum
HdecayI(isTvar) ==  50.0d+3   50.0d+3                      ! 1:NT tracers

VdecayI(isUvel) ==  30.0d0                                 ! 3D U-momentum
VdecayI(isVvel) ==  30.0d0                                 ! 3D V-momentum
VdecayI(isTvar) ==  30.0d0    30.0d0                       ! 1:NT tracers
```

Surface forcing correlations (m):

```
HdecayF(isUstr) == 100.0d+3                          ! surface U-momentum stress
HdecayF(isVstr) == 100.0d+3                          ! surface V-momentum stress
HdecayF(isTsur) == 100.0d+3  100.0d+3                ! 1:NT surface tracer flux
```

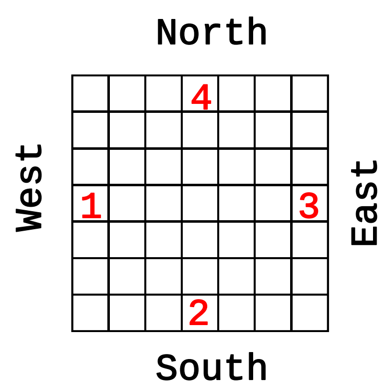
4D-Var Parameters: Decorrelation Scales

Open boundary conditions correlations (m):

```
!                     1: west   2: south   3: east   4: north

HdecayB(isFsur) == 100.0d+3 100.0d+3 100.0d+3 100.0d+3    ! free-surface
HdecayB(isUbar) == 100.0d+3 100.0d+3 100.0d+3 100.0d+3    ! 2D U-momentum
HdecayB(isVbar) == 100.0d+3 100.0d+3 100.0d+3 100.0d+3    ! 2D V-momentum
HdecayB(isUvel) == 100.0d+3 100.0d+3 100.0d+3 100.0d+3    ! 3D U-momentum
HdecayB(isVvel) == 100.0d+3 100.0d+3 100.0d+3 100.0d+3    ! 3D V-momentum
HdecayB(isTvar) == 4*100.0d+3  4*100.0d+3                 ! 1:NT tracers

VdecayB(isUvel) ==  30.0d0   30.0d0   30.0d0   30.0d0     ! 3D U-momentum
VdecayB(isVvel) ==  30.0d0   30.0d0   30.0d0   30.0d0     ! 3D V-momentum
VdecayB(isTvar) == 4*30.d0  4*30.d0                       ! 1:NT tracers
```

Boundary edges to adjust (logical switches):

```
!                  1   2   3   4

   Lobc(isFsur) == T   T   F   T          ! free-surface
   Lobc(isUbar) == T   T   F   T          ! 2D U-momentum
   Lobc(isVbar) == T   T   F   T          ! 2D V-momentum
   Lobc(isUvel) == T   T   F   T          ! 3D U-momentum
   Lobc(isVvel) == T   T   F   T          ! 3D V-momentum

   Lobc(isTvar) == T   T   F   T  \
                   T   T   F   T
```



4D-Var Parameters: Balance Operator

SSH, elliptic solver:

```
     Nbico == 200                       ! biconjugate gradient iterarion
```

SSH, integration of hydrostatic equation:

```
 LNM_depth == 1000.0d0                  ! level of no motion (m, positive)

 LNM_flag  =  1                         ! Integration flag

                                          [0] integrate from bottom to surface
                                          [1] integrate from LNM to surface or
                                              from local depth, if shallower
```

Balanced salinity empirical T-S relationship:

```
  dTdz_min == 0.001d0                   ! minimun dT/dz (Celsius/m)
  ml_depth == 100.0d0                   ! mixed-layer depth (m; positive)
```

State Variables switches:

```
balance(isSalt) =  T                    ! salinity
balance(isFsur) =  T                    ! free-sruface
balance(isVbar) =  F                    ! 2D momentum (ubar, vbar)
balance(isVvel) =  T                    ! 3D momentum (u, v)
```

Other 4D-Var Parameters

Lanczos algorithm parameters:

```
        GradErr = 1.0d-4              ! Upper bound on the relative error of the
                                        gradient
       HevecErr = 1.0d-1              ! Maximum error bound on Hessian eigenvectors
     LhessianEV = T                   ! Compute approximated hessian eigen pairs
```

Preconditioning:

```
       Lprecond = F                   ! Limitted-Memory Preconditioner: Spectral
          Lritz = T                   ! Limitted-Memory Preconditioner: Ritz
        NritzEV = 0                   ! If preconditioning, number of eigenvectors
                                        if NritzEV = 0, use HevecErr
```

Weak constraint:

```
      LhotStart = T                   ! Hot start in subsequent outer loops
         NpostI = 50                  ! Posterior error analysis Lanczos iterations
           Nvct = 50                  ! Stabilized representer matrix eigenvector
                                        to process
      tl_M2diff == 0.0d0              ! RPM relaxation (m2/s), 2D momentum
      tl_M3diff == 0.0d0              ! RPM relaxation (m2/s), 3D momentum
       tl_Tdiff == 0.0d0  0.0d0       ! RPM relaxation (m2/s), tracers
```

Other 4D-Var Parameters

Lanczos algorithm parameters:

GradErr = 1.0d-4 ! Upper bound on the relative error of the gradient

HevecErr = 1.0d-1 ! Maximum error bound on Hessian eigenvectors

LhessianEV = T ! Compute approximated hessian eigen pairs

Preconditioning:

Lprecond = F ! Limitted-Memory Preconditioner: Spectral

Lritz = T ! Limitted-Memory Preconditioner: Ritz

NritzEV = 0 ! If preconditioning, number of eigenvectors if NritzEV = 0, use HevecErr

Weak constraint:

LhotStart = T ! Hot start in subsequent outer loops

NpostI = 50 ! Posterior error analysis Lanczos iterations

Nvct = 50 ! Stabilized representer matrix eigenvector to process

~~tl_M2diff == 0.0d0 ! RPM relaxation (m2/s), 2D momentum~~

~~tl_M3diff == 0.0d0 ! RPM relaxation (m2/s), 3D momentum~~

~~tl_Tdiff == 0.0d0 0.0d0 ! RPM relaxation (m2/s), tracers~~

R4D-Var Parameters File: r4dvar.in

```
! If weak constraint 4DVar, set number of iterations in the Lanczos
! algorithm used to estimate the posterior analysis error covariance
! matrix.

         NpostI = 50

! If weak constraint 4DVar, set diffusive relaxation coefficients (m2/s)
! used to relax representer tangent linear solution to privious Picard
! iteration linearized trajectory.

      tl_M2diff ==   0.0d0                ! 2D momentum
      tl_M3diff ==   0.0d0                ! 3D momentum

       tl_Tdiff ==   0.0d0  0.0d0         ! NT tracers

! Switches (T/F) to create and write error covariance normalization
! factors for model, initial conditions, boundary conditions, and
! surface forcing. If TRUE, these factors are computed and written
! to NRMname(1:4) NetCDF files. If FALSE, they are read from NRMname(1:4)
! NetCDF file. The computation of these factors is very expensive and
! need to be computed only once for a particular application provided
! that grid land/sea masking, and decorrelation scales remains
! the same. Notice that four values are needed (1=initial conditions,
! 2=model, 3=boundary conditions, 4=surface forcing) per each nested
! grid, [1:4,1:Ngrids].

        LdefNRM == F F F F                ! Create a new normalization files
        LwrtNRM == F F F F                ! Compute and write normalization

! Switches to compute the correlation normalization coefficients for
! model error covariance.
```

R4D-Var Job Script: job_r4dvar.sh

1. Set path definition to one directory up in the tree.

```
set Dir = `dirname ${PWD}`
```

2. Set string manipulations perl script.

```
set SUBSTITUTE = ${ROMS_ROOT}/ROMS/Bin/substitute
```

3. Copy nonlinear model initial conditions file.

```
cp -p ${Dir}/Data/wc13_ini.nc wc13_ini.nc
```

4. Copy representer model intial conditions file, same as nonlinear model

```
cp –p ${Dir}/Data/wc13_ini.nc wc13_irp.nc
```

5. Copy representer model initial conditions file.

```
cp -p ${Dir}/Data/wc13_ini.nc wc13_irp.nc
```

6. Set model, initial conditions, boundary conditions and surface forcing error covariance standard deviations files.

```
set STDnameM = ../Data/wc13_std_m.nc
set STDnameI = ../Data/wc13_std_i.nc
set STDnameB = ../Data/wc13_std_b.nc
set STDnameF = ../Data/wc13_std_f.nc
```

7. Set initial conditions, boundary conditions and surface forcing error covariance normalization factors files.

```
set NRMnameM = ../Data/wc13_nrm_m.nc
set NRMnameI = ../Data/wc13_nrm_i.nc
set NRMnameB = ../Data/wc13_nrm_b.nc
set NRMnameF = ../Data/wc13_nrm_f.nc
```

8. Set observations file.

```
set OBSname = wc13_obs.nc
```

7. Get a clean copy of the observation file. This is really important since this file is modified.

```
cp -p ${Dir}/Data/${OBSname} .
```

8. Modify 4D-Var template input script and specify above files.

```
set R4DVAR = r4dvar.in
if (-e $R4DVAR) then
  /bin/rm $R4DVAR
endif
cp s4dvar.in $R4DVAR

$SUBSTITUTE $R4DVAR ocean_std_m.nc $STDnameM
$SUBSTITUTE $R4DVAR ocean_std_i.nc $STDnameI
$SUBSTITUTE $R4DVAR ocean_std_b.nc $STDnameB
$SUBSTITUTE $R4DVAR ocean_std_f.nc $STDnameF
$SUBSTITUTE $R4DVAR ocean_nrm_m.nc $NRMnameM
$SUBSTITUTE $R4DVAR ocean_nrm_i.nc $NRMnameI
$SUBSTITUTE $R4DVAR ocean_nrm_b.nc $NRMnameB
$SUBSTITUTE $R4DVAR ocean_nrm_f.nc $NRMnameF
$SUBSTITUTE $R4DVAR ocean_obs.nc   $OBSname
$SUBSTITUTE $R4DVAR ocean_hss.nc   wc13_hss.nc
$SUBSTITUTE $R4DVAR ocean_lcz.nc   wc13_lcz.nc
$SUBSTITUTE $R4DVAR ocean_mod.nc   wc13_mod.nc
$SUBSTITUTE $R4DVAR ocean_err.nc   wc13_err.nc
```

4D-PSAS Job Script: job_psas.sh

1. Set path definition to one directory up in the tree.

```
set Dir = `dirname ${PWD}`
```

2. Set string manipulations perl script.

```
set SUBSTITUTE = ${ROMS_ROOT}/ROMS/Bin/substitute
```

3. Copy nonlinear model initial conditions file.

```
cp -p ${Dir}/Data/wc13_ini.nc wc13_ini.nc
```

4. ~~Copy representer model intial conditions file, same as nonlinear model~~

~~cp -p ${Dir}/Data/wc13_ini.nc wc13_irp.nc~~

5. Copy representer model initial conditions file.

```
cp -p ${Dir}/Data/wc13_ini.nc wc13_irp.nc
```

6. Set model, initial conditions, boundary conditions and surface forcing error covariance standard deviations files.

```
set STDnameM = ../Data/wc13_std_m.nc
set STDnameI = ../Data/wc13_std_i.nc
set STDnameB = ../Data/wc13_std_b.nc
set STDnameF = ../Data/wc13_std_f.nc
```

7. Set initial conditions, boundary conditions and surface forcing error covariance normalization factors files.

```
set NRMnameM = ../Data/wc13_nrm_m.nc
set NRMnameI = ../Data/wc13_nrm_i.nc
set NRMnameB = ../Data/wc13_nrm_b.nc
set NRMnameF = ../Data/wc13_nrm_f.nc
```

8. Set observations file.

```
set OBSname = wc13_obs.nc
```

7. Get a clean copy of the observation file. This is really important since this file is modified.

```
cp -p ${Dir}/Data/${OBSname} .
```

8. Modify 4D-Var template input script and specify above files.

```
set PSAS = psas.in
if (-e $PSAS) then
  /bin/rm $PSAS
endif
cp s4dvar.in $PSAS
```

```
$SUBSTITUTE $PSAS ocean_std_m.nc $STDnameM
$SUBSTITUTE $PSAS ocean_std_i.nc $STDnameI
$SUBSTITUTE $PSAS ocean_std_b.nc $STDnameB
$SUBSTITUTE $PSAS ocean_std_f.nc $STDnameF
$SUBSTITUTE $PSAS ocean_nrm_m.nc $NRMnameM
$SUBSTITUTE $PSAS ocean_nrm_i.nc $NRMnameI
$SUBSTITUTE $PSAS ocean_nrm_b.nc $NRMnameB
$SUBSTITUTE $PSAS ocean_nrm_f.nc $NRMnameF
$SUBSTITUTE $PSAS ocean_obs.nc   $OBSname
$SUBSTITUTE $PSAS ocean_hss.nc   wc13_hss.nc
$SUBSTITUTE $PSAS ocean_lcz.nc   wc13_lcz.nc
$SUBSTITUTE $PSAS ocean_mod.nc   wc13_mod.nc
$SUBSTITUTE $PSAS ocean_err.nc   wc13_err.nc
```

R4D-Var Job Script File: job_r4dvar.sh

```
#!/bin/csh -f
#
# svn $Id: job_r4dvar.sh 474 2010-06-25 20:19:44Z arango $
#######################################################################
# Copyright (c) 2002-2010 The ROMS/TOMS Group                         #
#   Licensed under a MIT/X style license                              #
#   See License_ROMS.txt                                              #
#######################################################################
#                                                                     #
# Strong/Weak constraint R4D-Var job script:                          #
#                                                                     #
# This script NEEDS to be run before any run:                         #
#                                                                     #
#   (1) It copies a new clean nonlinear model initial conditions      #
#       file. The nonlinear model is initialized from the             #
#       background or reference state.                                #
#   (2) It copies representer model initial condition, same as        #
#       nonlinear model.                                              #
#   (3) Specify model, initial conditions, boundary conditions, and   #
#       surface forcing error convariance input standard deviations   #
#       files.                                                        #
#   (4) Specify model, initial conditions, boundary conditions, and   #
#       surface forcing error convariance input/output normalization  #
#       factors files.                                                #
#   (5) Copy a clean copy of the observations NetCDF file.            #
#   (6) Create 4D-Var input script "r4dvar.in" from template and      #
#       specify the error covariance standard deviation, error        #
#       covariance normalization factors, and observation files to    #
#       be used.                                                      #
#                                                                     #
#######################################################################
```

Compile: build.sh

1. Set a local environmental variable to define the path to the directories where all this project's files are kept.

```
setenv MY_ROOT_DIR          /home/arango/ocean/toms/repository
setenv MY_PROJECT_DIR       ${PWD}
```

2. Location of your ROMS source code.

```
setenv MY_ROMS_SRC         ${MY_ROOT_DIR}/branches/arango
```

3. Buld script invoked CPP options.

```
setenv MY_CPP_FLAGS "-DW4DVAR“
setenv MY_CPP_FLAGS "${MY_CPP_FLAGS} -DPOSTERIOR_EOFS”
setenv MY_CPP_FLAGS "${MY_CPP_FLAGS} -DPOSTERIOR_ERROR_I"
```

4. Compiler selection environment variables.

```
setenv USE_MPI            on
setenv USE_MPIF90         on
setenv FORT               pgi
```

5. Use custom library paths.

```
#setenv USE_MY_LIBS        on
```

Libraries for PGI

```
if ($?USE_MY_LIBS) then
  switch ($FORT)
    case "pgi"
      setenv ARPACK_LIBDIR      /opt/pgisoft/serial/ARPACK
      if ($?USE_MPI) then
        setenv PARPACK_LIBDIR   /opt/pgisoft/mpich/PARPACK
      endif

      if ($?USE_NETCDF4) then
        if ($?USE_MPI) then
          setenv NETCDF_INCDIR  /opt/pgisoft/mpich/netcdf4/include
          setenv NETCDF_LIBDIR  /opt/pgisoft/mpich/netcdf4/lib
          setenv HDF5_LIBDIR    /opt/pgisoft/mpich/hdf5/lib
        else
          setenv NETCDF_INCDIR  /opt/pgisoft/serial/netcdf4/include
          setenv NETCDF_LIBDIR  /opt/pgisoft/serial/netcdf4/lib
          setenv HDF5_LIBDIR    /opt/pgisoft/serial/hdf5/lib
        endif
      else
        setenv NETCDF_INCDIR    /opt/pgisoft/serial/netcdf3/include
        setenv NETCDF_LIBDIR    /opt/pgisoft/serial/netcdf3/lib
      endif
    breaksw
```

Compile: build.sh

1. Set a local environmental variable to define the path to the directories where all this project's files are kept.

```
setenv MY_ROOT_DIR          /home/arango/ocean/toms/repository
setenv MY_PROJECT_DIR       ${PWD}
```

2. Location of your ROMS source code.

```
setenv MY_ROMS_SRC         ${MY_ROOT_DIR}/branches/arango
```

3. Buld script invoked CPP options.

```
setenv MY_CPP_FLAGS "-DW4DPSAS"
setenv MY_CPP_FLAGS "${MY_CPP_FLAGS} -DPOSTERIOR_EOFS"
setenv MY_CPP_FLAGS "${MY_CPP_FLAGS} -DPOSTERIOR_ERROR_I"
```

4. Compiler selection environment variables.

```
setenv USE_MPI            on
setenv USE_MPIF90         on
setenv FORT               pgi
```

5. Use custom library paths.

```
#setenv USE_MY_LIBS        on
```

Libraries for PGI

```
if ($?USE_MY_LIBS) then
  switch ($FORT)
    case "pgi"
      setenv ARPACK_LIBDIR      /opt/pgisoft/serial/ARPACK
      if ($?USE_MPI) then
        setenv PARPACK_LIBDIR   /opt/pgisoft/mpich/PARPACK
      endif

      if ($?USE_NETCDF4) then
        if ($?USE_MPI) then
          setenv NETCDF_INCDIR  /opt/pgisoft/mpich/netcdf4/include
          setenv NETCDF_LIBDIR  /opt/pgisoft/mpich/netcdf4/lib
          setenv HDF5_LIBDIR    /opt/pgisoft/mpich/hdf5/lib
        else
          setenv NETCDF_INCDIR  /opt/pgisoft/serial/netcdf4/include
          setenv NETCDF_LIBDIR  /opt/pgisoft/serial/netcdf4/lib
          setenv HDF5_LIBDIR    /opt/pgisoft/serial/hdf5/lib
        endif
      else
        setenv NETCDF_INCDIR    /opt/pgisoft/serial/netcdf3/include
        setenv NETCDF_LIBDIR    /opt/pgisoft/serial/netcdf3/lib
      endif
    breaksw
```

Build Script: build.sh

```
#
# Sometimes it is desirable to activate one or more CPP options to run
# different variants of the same application without modifying its header
# file. If this is the case, specify each options here using the -D syntax.
# Notice also that you need to use shell's quoting syntax to enclose the
# definition.  Both single or double quotes works. For example, to write
# time-averaged fields set:
#
#    setenv MY_CPP_FLAGS "-DAVERAGES"

 setenv MY_CPP_FLAGS "-DW4DVAR"
 setenv MY_CPP_FLAGS "${MY_CPP_FLAGS} -DPOSTERIOR_EOFS"
 setenv MY_CPP_FLAGS "${MY_CPP_FLAGS} -DPOSTERIOR_ERROR_I"

# Other user defined environmental variables. See the ROMS makefile for
# details on other options the user might want to set here. Be sure to
# leave the switched meant to be off set to an empty string or commented
# out. Any string value (including off) will evaluate to TRUE in
# conditional if-stamentents.

 setenv USE_MPI              on
 setenv USE_MPIF90           on
 setenv FORT                 pgi

#setenv USE_OpenMP           on

#setenv USE_DEBUG            on
 setenv USE_LARGE            on
 setenv USE_NETCDF4          on

# Activate Data Access Protocol (like OPeNDAP) support for input
# NetCDF files.  This is only possible for NetCDF library version
```