

ADJOINT SENSITIVITY TESTS IN ROMS

HA JOON SONG AND ANEESH C. S.

1. ADJOINT SENSITIVITY ANALYSIS

1.1. Steps for the Nonlinear Model Run. -

These are a list of steps to run an example test case of the Nonlinear ROMS for the Southern California Bight region (Katie Chhak and Manu's example domain).

- Create grid, initial, forcing and boundary condition files for the region you intend to model in ROMS using RNT toolbox or IRD toolbox. (ex. scb20-grid.nc, scb20-init.nc, scb20-forc.nc, scb20-bry.nc)
- Example Grid with Bathymetry values:

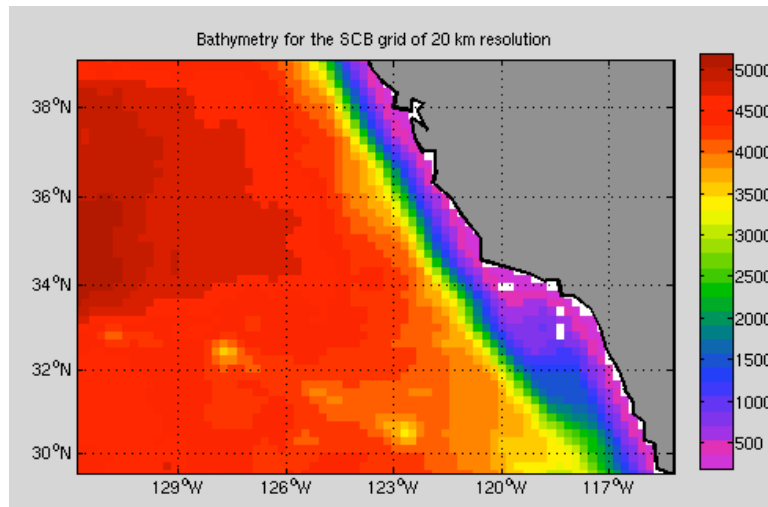


FIGURE 1. Bathymetry of the SCB grid with a 20 km resolution

- Initial SST field for the Nonlinear Forward ROMS model run for the Southern California Bight (SCB) domain is shown in Fig (2)
- Once we have these files, we have to add the biological variables NO3, Phytoplankton, Zooplankton and Detritus data to the initial and boundary files with values of zero at all grid points. We use the matlab code "prep_fwd.m" to generate the new fwd model initial and boundary files. It uses the rnc.CreateIniFile and rnc.CreateBryFile matlab scripts from the RNT toolbox.

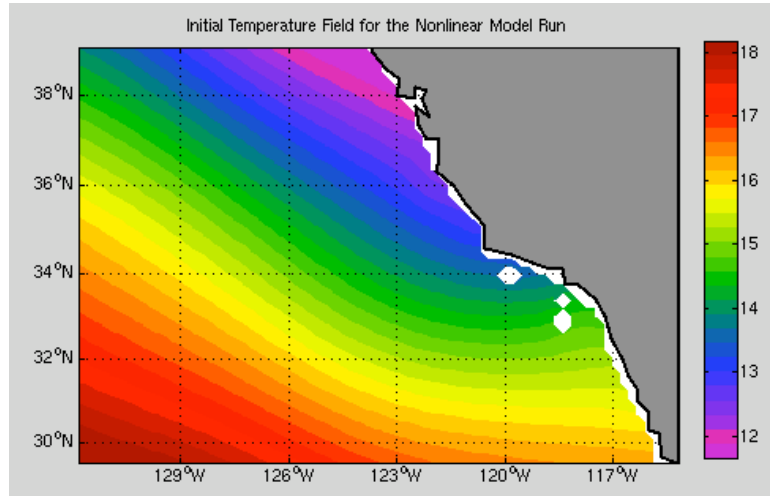


FIGURE 2. Initial SST for the nonlinear ROMS model run in the SCB domain

- To generate the standard input file (ex.: scb20.in) we again use the matlab code " prep_fwd.m " with giving the appropriate values for the variables:
 - DSTART='15';
 - IN_FILE='scb20.in';
 - infile='scb20-init-npzd.nc';
 - bryfile='scb20-bry-npzd.nc';
 - NTIMES='1800';
 - OUTPUT_DIR='.';
 - NHIS='300';
 - NAVG='300';
 - NADJ='300';
- To compile the Nonlinear ROMS executable from the (Manu&Chhak) ROMS source code, we need to change the following option in the (\$ROMS_root_directory)/ROMS/Include/cppdefs.h file:
 - #undef AD_SENSITIVITY
 - #define NL_MODEL
- Compile the Nonlinear ROMS executable and run the model forward in time for as long as you want the adjoint sensitivity test to be done.
- SST field from the example model run of the SCB domain is shown in Fig (3)

1.2. Steps for the Adjoint Model Run.

- The output history file from the forward model run is needed as an input file for the ROMS Adjoint model run.
- Create the input file for the adjoint model run using the script "prep_adj.m ". It computes the ocean_time steps stored in the output history file of the forward

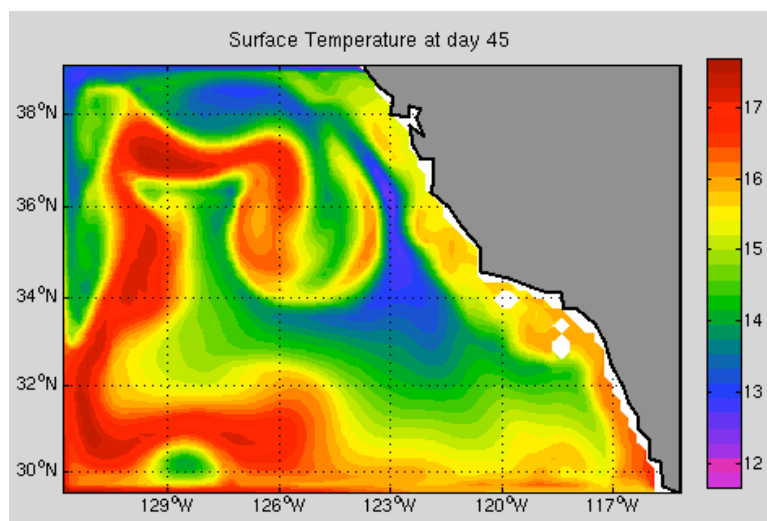


FIGURE 3. SST of the Southern California Bight domain after a forced nonlinear run of 30 days

model run and creates the adjoint initial condition file with the required variables with a value of 0 at every grid point at every time step. The adjoint model initial condition is set to 0 as we calculate the adjoint sensitivity value $\frac{dJ}{d(\text{tracer})}$ using the Adjoint ROMS only for a perturbed tracer field.

- This initial file is then copied to the adjoint forcing file by the matlab script "prep_adj.m". The adjoint forcing file is then modified to have a perturbed tracer field at regions of interest at time steps at which we need to force the adjoint run. In the SCB test case the adjoint tracer is added at every time step from the initial time of the adjoint model until the end of the fourth output time record is written.
- To generate the new grid file for the Adjoint model run with new scope (Masking values for the adjoint tracers) values, we run the matlab script radj_add_scope.m with the input parameters. The matlab command is:

```
>> radj_add_scope (scb20-grid.nc, scb20-grid-adj.nc);
```

- Generate the standard input file adj.in using the matlab script "prep_adj.m" which reads the script gen-in-adj
- To compile the Adjoint Nonlinear ROMS executable from the (Manu&Chhak) ROMS source code, we need to change the following option in the $(\$ROMS_root_directory)/ROMS/Include/cppdefs.h$ file:
 - #define AD_SENSITIVITY
 - #undef NL_MODEL
- Compile the Adjoint ROMS executable and run the adjoint model backward in time for as long as you want the adjoint sensitivity test to be done.

- Surface adjoint sensitivity at four different output time records of the ROMS Adjoint model of the SCB domain is plotted in Fig (4). The first panel shows the region in the domain where the tracer perturbation was added at the initial time step. The remaining 3 panels show the evolution of the Adjoint sensitivity of the model cost function with respect to this tracer at 3 different time records of the adjoint model output.

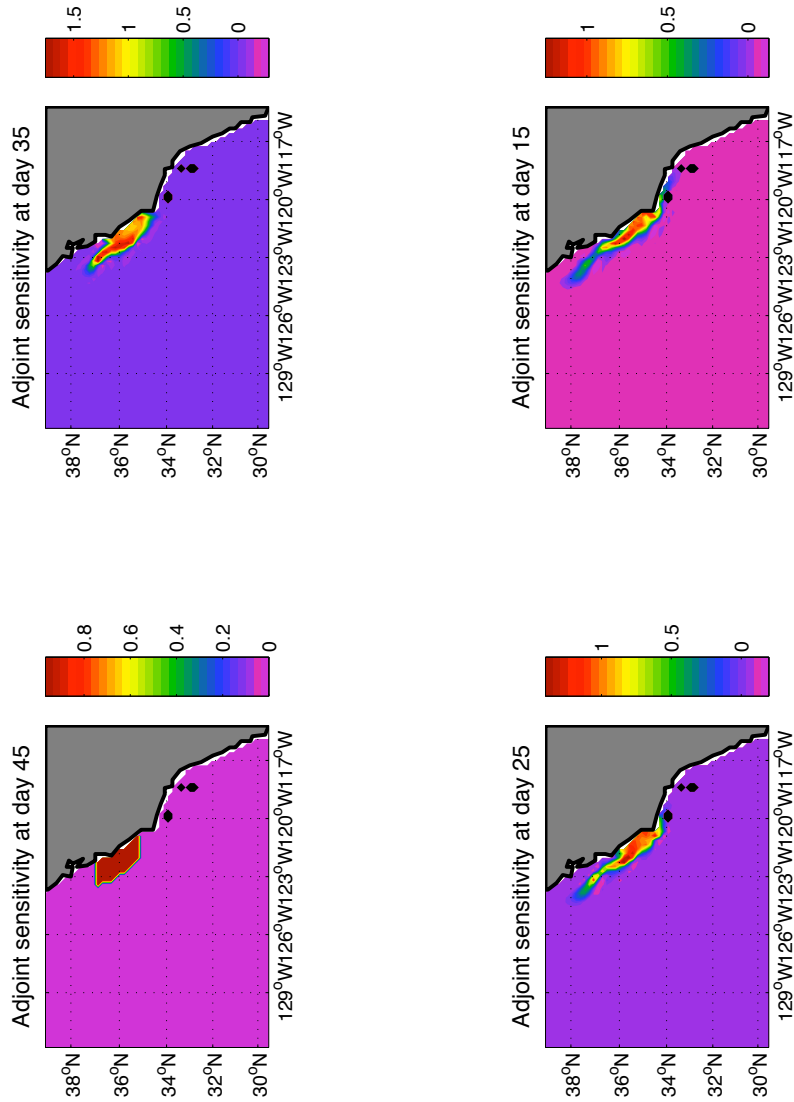


FIGURE 4. Surface adjoint sensitivity of the Southern California Bight domain at Day 45, Day 35, Day 25 and Day 15