

4D-Var Workshop Agenda

Lecture schedule at a glance:

Day 1 "4D-Var: Some Basics" - Monday, 29 July:

Lecture 1 (Moore, 75 mins)

Lecture 2 (Moore, 90 mins)

Day 2 "Dual 4D-Var and Observing System Simulation Experiments" - Tuesday, 30 July:

Lecture 3 (Moore, 90 mins)

Day 3 "Observation Impacts and Sensitivity" - Wednesday, 31 July:

Lecture 5 (Moore, 90 mins)

Lecture 6: The MARACOOS analysis-forecast system (Wilkin, 45mins)

Day 4 "More on Observation Sensitivity and Array Modes" - Thursday, 1 August:

Lecture 7 (Moore, 90 mins)

Lecture 8: The West Coast Ocean Forecasting System (WCOFS) (Xu, 45mins)

Day 5 "Running Your Own Application" - Friday, 2 August:

Lecture 9: The CeNCOOS and PaclOOS analysis-forecast systems (Moore, 45 mins)

Full program of lectures, tutorials, exercises and homework:

Day 1 "4D-Var: Some Basics" - Monday, 29 July:

8:00am: Registration and computer set-up

9-9:15am: Welcome

Workshop overview and objectives (Moore, 15 mins)

9:15-10:30am:

Lecture 1 (Moore, 75 mins)

- 4D-Var concepts
- primal 4D-Var
- incremental approach used in ROMS (I4D-Var)
- the ROMS I4D-Var algorithm

10:30-11am: Break

11-12:30pm:

Lecture 2 (Moore, 90 mins)

- the conjugate gradient and Lanczos algorithms
- preconditioning
- covariance modeling
- background quality control

12:30 -2pm: Lunch

2-4:30pm: I4D-Var exercises and tutorials

Tutorial 1: Explanation of cpp options, ocean.in, s4dvar.in (Arango, 30 mins)

Run **Exercise 1** - I4D-Var

Using a 30 km resolution model of California Current system (CCS), running I4D-Var, with 1 outer-loop, 25 inner-loops, 4 day assimilation cycle, and observations in the form of SST, SSH, Argo and hydrographic sections.

Tutorial 2: Multiple outer loops (Moore, 15 mins)

Run **Exercise 2** - I4D-Var with multiple outer-loops

Same as exercise 1, but running multiple outer-loops

Tutorial 3: Discussion of exercises 1 and 2 (Moore, 30 mins)

4D-Var output, comparison of circulation from exercises 1 and 2

Tutorial 4: Calculation of prior error standard deviations (Arango & Moore, 30 mins)

Homework 1: Building the standard deviation file for user model configuration.

Day 2 "Dual 4D-Var and Observing System Simulation Experiments" - Tuesday, 30 July:

9:00-10:30am:

Lecture 3 (Moore, 90 mins)

- 4D-Var recap
- dual 4D-Var (4D-PSAS)
- the basic 4D-PSAS algorithm
- weak constraint 4D-Var
- the importance of preconditioning

10:30-11:00am: Break

11:00-12:30pm:

Lecture 4 (Moore, 90 mins)

- observing system experiments

- error models
- innovation statistics

12:30 -1:30pm: Lunch

1:30-4:30pm: 4D-PSAS exercises and tutorials

Tutorial 5: Explanation of cpp options, ocean.in, s4dvar.in (Arango, 30 mins)

Run **Exercise 3** - 4D-PSAS for a single outer-loop (30 mins)

- running CCS 4D-PSAS
- exploring preconditioning

Tutorial 6: Semi-variograms (Wilkin, 30 mins)

A practical method for estimating de-correlation length scales.

Run **Exercise 4** - 4D-PSAS subject to the weak constraint

- same as exercise 3 but subject to weak constraint.

Tutorial 7: ERDDAP data server and management tools (Wilkin, 30 mins)

Tutorial 8: Discussion of exercises 3 & 4 (Moore, 30 mins)

- 4D-Var output, comparison of circulation estimates with I4D-Var from Exercise 1.

Tutorial 9: Computing normalization coefficients for covariance models (Arango & Moore & 7 30 mins)

Homework 2: Building the file of normalization coefficients for the prior error covariance matrix for user model configuration.

Day 3 "Observation Impacts and Sensitivity" - Wednesday, 31 July:

9:00-10:30am

Tutorial 10: Building your observation files (including discussion of provenances). (Arango & Wilkin, 90 mins)

Homework 3: Build observation file for user model configuration.

10:30-11:00am: Break

11:00-12:30pm:

Lecture 5 (Moore, 90 mins)

- observation impacts
- adjoint 4D-Var
- observation sensitivity

12:30-1:30pm Lunch

1:30-2:15pm:

Lecture 6: The MARACOOS analysis-forecast system (Wilkin, 45mins)

2:15-4:30pm: Observation impact and observation sensitivity exercises and tutorials

Run **Exercise 5** - Observation impact calculations (4D-PSAS)

- computation of the impact of the observations on the 4D-Var increments in CCS transport.

Tutorial 11: Setting up the impact/sensitivity functional, build script, cpp options and s4dvar.in (Moore, 45 mins)

Tutorial 12: Discussion of exercise 5. (Moore, 30 mins)

Tutorial 13: Using ERDDAP to view observation impact information (Wilkin, 30 mins)

Day 4 "More on Observation Sensitivity and Array Modes" - Thursday, 1 August:

9:00-10:30pm:

Lecture 7 (Moore, 90 mins)

- array modes
- clipping
- degrees of freedom

10:30-11:00am: Break

11:00-12:30pm: Exercises and observations

Run **Exercise 6** - Observation sensitivity calculation (4D-PSAS)

- computation of the sensitivity of the 4D-Var increments in CCS transport to changes in the observations or observation array.

Run **Exercise 7** - Array modes

- computation of array modes using the output from 4D-PSAS.

Tutorial 14: Discussion of exercise 6 & 7. (Moore, 30 mins)

12:30-1:30pm: Lunch

1:30-2:15pm:

Lecture 8: The West Coast Ocean Forecasting System (WCOFS) (Xu, 45mins)

2:30-4:30pm:

Run **Exercise 8** - Forecast observation impact calculations (4D-PSAS) - optional

- computation of the impact of observations on the forecast skill.

Run **Exercise 9** - Forecast observation sensitivity calculations (4D-PSAS) - optional

- computation of the sensitivity of forecast skill to changes in the observations or observation array .

Tutorial 15: Putting it all together (Moore, 30 mins)

Tutorial 16: Configuring ROMS 4D-Var for your model (Various, 60 mins)
(ini file, don't use restart files, etc)

Tutorial 17: Running your own 4D-Var PSAS-RPCG application (Various, 90 mins)

Day 5 "Running Your Own Application" - Friday, 2 August:

9:00-9:45am:

Lecture 9: The CeNCOOS and PacIOOS analysis-forecast systems (Moore, 45 mins)

10:30-11am: Break

11:00-12:30pm:

- Tutorials and discussion of results (Arango, Moore, Wilkin, 45 mins)
- **Lecture 10: What's Next? (Moore, 45mins)**
- Workshop Adjourns

12:30-2:00pm: Lunch