ECCO Modeling Utilities (EMU)

"Point-and-Click" tools to <mark>analyze the ECCO model</mark>
with *no need of modeling expertise.*

	Tool	Description
1	Sampling	Extracts time-series of <u>user-specified quantity.</u>
2	Perturbation	Computes model's response to a change in <u>user-specified forcing</u> (forward gradient).
3	Adjoint	Computes sensitivity of a <u>user-specified quantity</u> to different forcing (adjoint gradient).
4	Convolution	Computes convolution of <u>user-specified</u> adjoint gradients with forcing (adjoint gradient decomposition).
5	Tracer	Computes evolution of a <u>user-defined passive tracer</u> and <u>its adjoint.</u>
6	Budget	Extracts variables and fluxes underlying the budget of a <u>user-specified quantity</u>

Where are the Tools? How do you run them?

1) NAS Pleiades:/nobackup/ifukumor/ECCO_tools/emu

2) http://ecco.smce.nasa.gov/

3) https://github.com/ECCO-GROUP/ECCO-EIS.git

```
pfe25>source emu_adj.csh
**********************************
    EMU Adjoint Tool
**********************************
See /nobackup/ifukumor/ECCO_tools/emu/README_adj

Define objective function (OBJF; J^bar in Eq 5 of Guide) ...

First define OBJF time-period (t_start and t_g in Eq 6 of Guide) ...
    Enter FIRST month of OBJF period (t_start in Eq 6 of Guide) ... (1-312)?
24
    Enter LAST month of OBJF period (t_g in Eq 6 of Guide) ... (1-312)?
24
------------------
    Choose OBFJ variable (v in Eq 1 of Guide) # 1 ... (1-5)?
    (Enter 0 to end variable selection)
1
    OBJF variable  1 is SSH
    Choose either VARIABLE at a point (1) or VARIABLE weighted in space (2) ... (1/2)?
2

    Enter MASK filename (T in Eq 1 of Guide) ... ?
../mask.beaufort

    Enter scaling factor (alpha in Eq 1 of Guide)... ?
1
------------------
    Choose OBFJ variable (v in Eq 1 of Guide) # 2 ... (1-5)?
    (Enter 0 to end variable selection)
0

Running do_adj.csh
Estimated wallclock time: #PBS -l walltime=9:00:00

**********************************
    Results will be in emu_adj_24_24_1_mask.beaufort_1/output.
**********************************
```

ECCO Perturbation Tool

The interface is under development and may therefore contain defects. A primary purpose of this product to obtain feedback on model performace and the identification of defects.

This webpage has a corresponding Jupyter notebook with the same functionality. The notebook can be found here: https://git.mysmce.com/jli30/ecco-interface-test

The Perturbation Tool computes the gradient as differences of the state between model integrations with and without the forcing perturbation. This interface allows user to select a particular forcing (i.e. 'control') at a specific location and time. The Perturbation Tool computes gradients for all standard state variables (salinity, temperature, etc.) at different locations and time of the model.

Job Query

Select Control ... (1-8)

7 tauu (westward wind stress)

Chosse location for perturbation
● lat/lon
○ native grid

Enter location to perturb longitude ... (-180.0 - 180.0)

-145

Enter location to perturb latitude ... (-90.0 - 90.0)

0

Water depth = 4352.231

Get Default Perturbation Magnitude

Keep default perturbation
● Yes
○ No

Enter # of week when perturbation starts ... (1-1358)

6

Enter user specified run id ...

IF001   5/6

Check Input Parameters

Submit a Job

Post Process

Run id

v

Select a case to view

v3_run_pert_7_15_743_3_-1.00e-01

Download Output Data

Plot Example

Daily mean output of sea level (SSH, unit: m); Normalized as model's response to unit perturbation

Download image

Daily mean output of sea level (SSH, unit: m) w/o perturbation

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1

What can you do with the Tools? 1/2

Command Line Interface (on NAS Pleiades)

Define EMU user directory

pfe25>set emu=/nobackup/ifukumor/ECCO_tools/emu

1) Sampling Tool

pfe25>source ${emu}/**emu_samp.csh**

2) Perturbation Tool

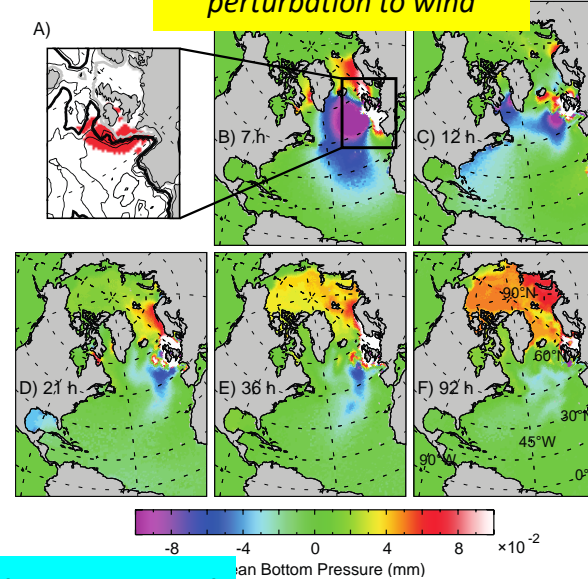pfe25>source ${emu}/**emu_pert.csh**

3) Adjoint Tool

pfe25>source ${emu}/**emu_adj.csh**

Sampling Tool
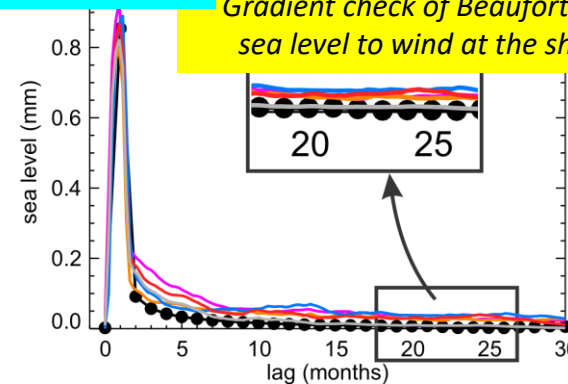
Beaufort Sea Sea Level

Perturbation Tool

OBP variation by perturbation to wind

Adjoint gradient of Arctic mean OBP to along-bathymetry wind

Adjoint Tool

Perturbation Tool

Gradient check of Beaufort Sea mean sea level to wind at the shelf break
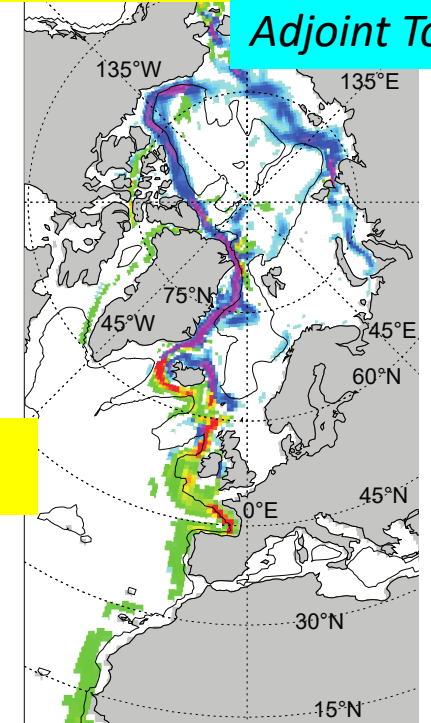
What can you do with the Tools? 2/2

Command Line Interface (on NAS Pleiades)

Define EMU user directory

    pfe25>set emu=/nobackup/ifukumor/ECCO_tools/emu

4) Convolution Tool
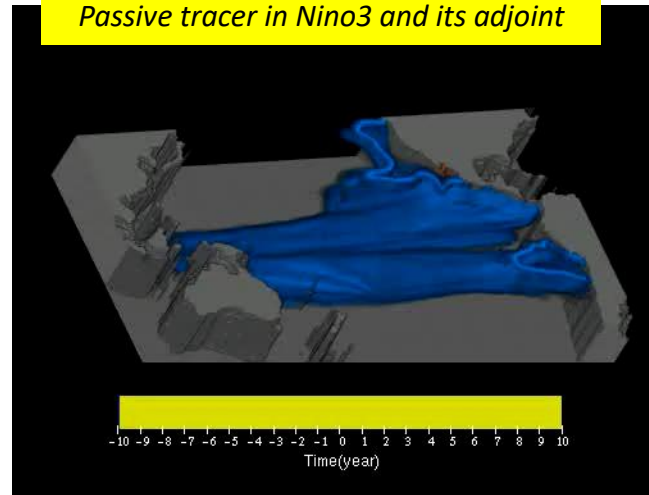
    pfe25>source ${emu}/**emu_conv**.csh

5) Tracer Tool

    pfe25>source ${emu}/**emu_trc**.csh

6) Budget Tool

    pfe25>source ${emu}/**emu_bud**.csh

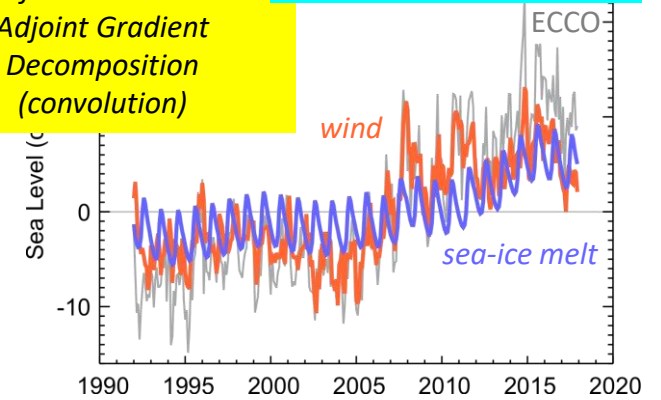**Convolution Tool**

Beaufort Sea Sea Level Adjoint Gradient Decomposition (convolution)

Tracer Tool

Passive tracer in Nino3 and its adjoint

Budget Tool

Beaufort Sea heat budget
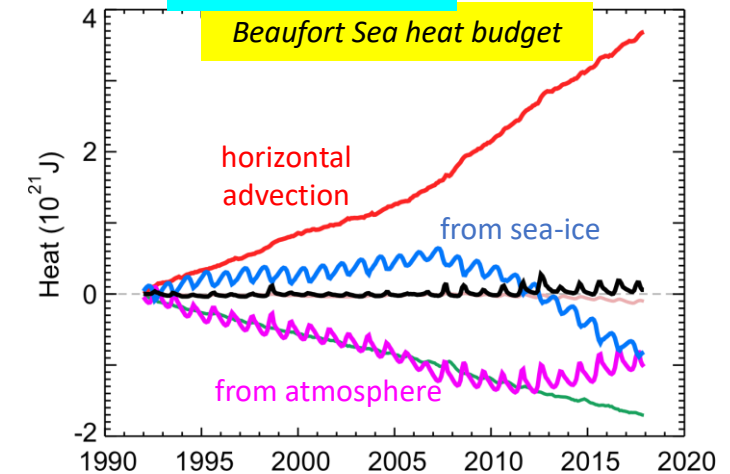
What's Next?

1) Implementation in the cloud,

2) Budget Tool (ocean & sea-ice),

3) Start models from arbitrary year (perturbation & adjoint),

4) Finite regional and temporal forcing perturbation,

5) Surface tracer boundary condition,

6) Tool to generate masks (T) for EMU, $$J(t) = \sum_i \alpha_i \sum_{\mathbf{x}} \mathbf{T}_i(\mathbf{x}) v_i(\mathbf{x}, t)$$

7) Tool to read and rewrite (map) EMU output,

8) Sea-ice tracer.

EMU is available at ...

1)   NAS Pleiades:/nobackup/ifukumor/ECCO_tools/emu
2)   *http://ecco.smce.nasa.gov/*
3)   *https://github.com/ECCO-GROUP/ECCO-EIS.git*