ECCO Version 4:
The Matrix

Gaël Forget

acknowledgments: Campin, Heimbach, Hill, Ponte, Wunsch, Wang, Fukumori, Fenty, Menemenlis, Nguyen, King, Spiegel, Malinowski, Ayers + many collaborators and users

ECCO Meeting MIT 2016/05/16

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Global MITgcm Grids, And Matlab Software

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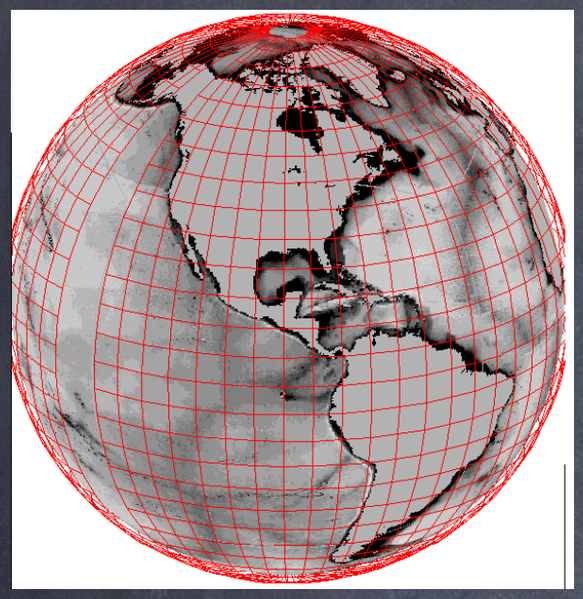

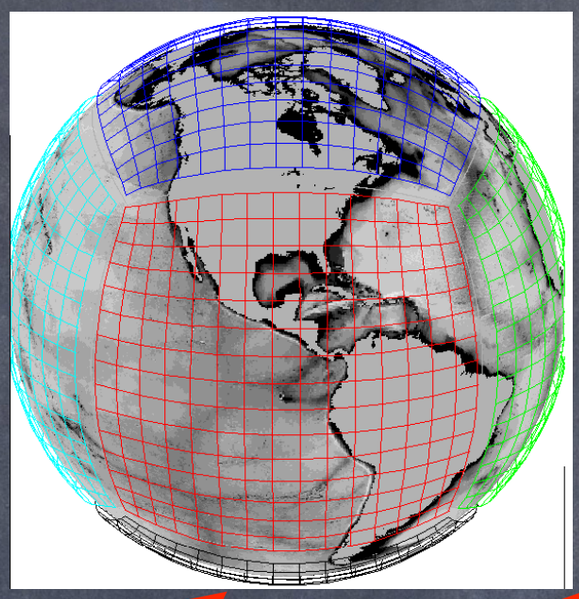

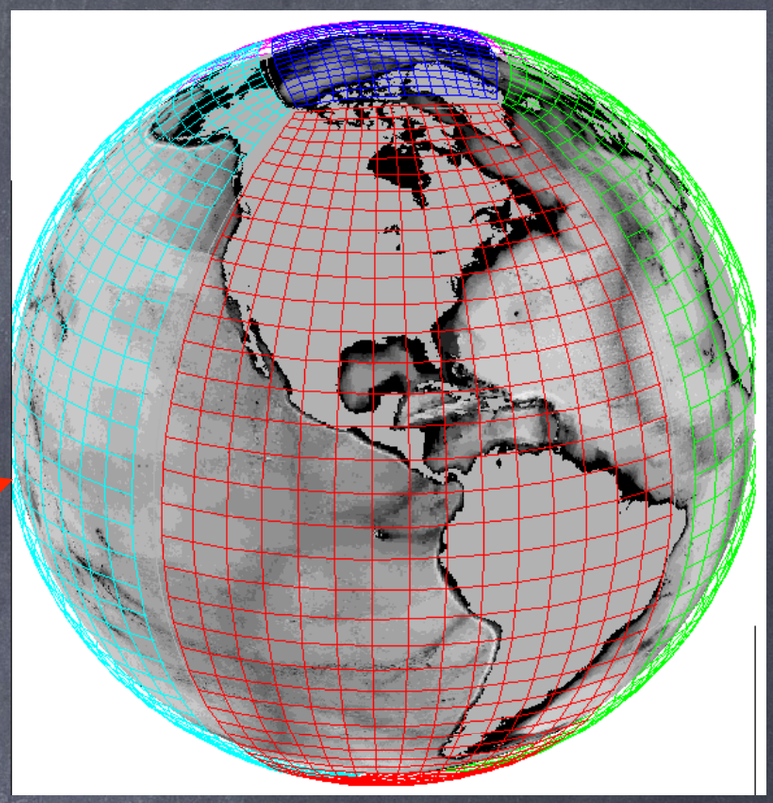

- **Access GRIDS:** ftp://mit.ecco-group.org/ecco_for_las/version_4/grids/grids_input/
- **Matlab Software:** http://mitgcm.org/viewvc/*checkout*/MITgcm/MITgcm_contrib/gael/matlab_class/gcmfaces.pdf
- **Reference:** Forget, et al., 2015 (GMD)

```
fld =
        nFaces:    5
           f1:    [90x270 double]
           f2:    [90x270 double]
           f3:    [90x90 double]
           f4:    [270x90 double]
           f5:    [270x90 double]
```

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ECCO Version 4 Release 2

2016 ECCO meeting

```
doc
profiles
interp_monthly
interp_climatology
nctiles_grid
nctiles_monthly
nctiles_climatology
nctiles_tendencies
nctiles_remotesensing
input_forcing
input_ecco
```

- Each subdirectory contains its own README

Citeable Indentifier: http://hdl.handle.net/1721.1/102062

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2016 ECCO meeting

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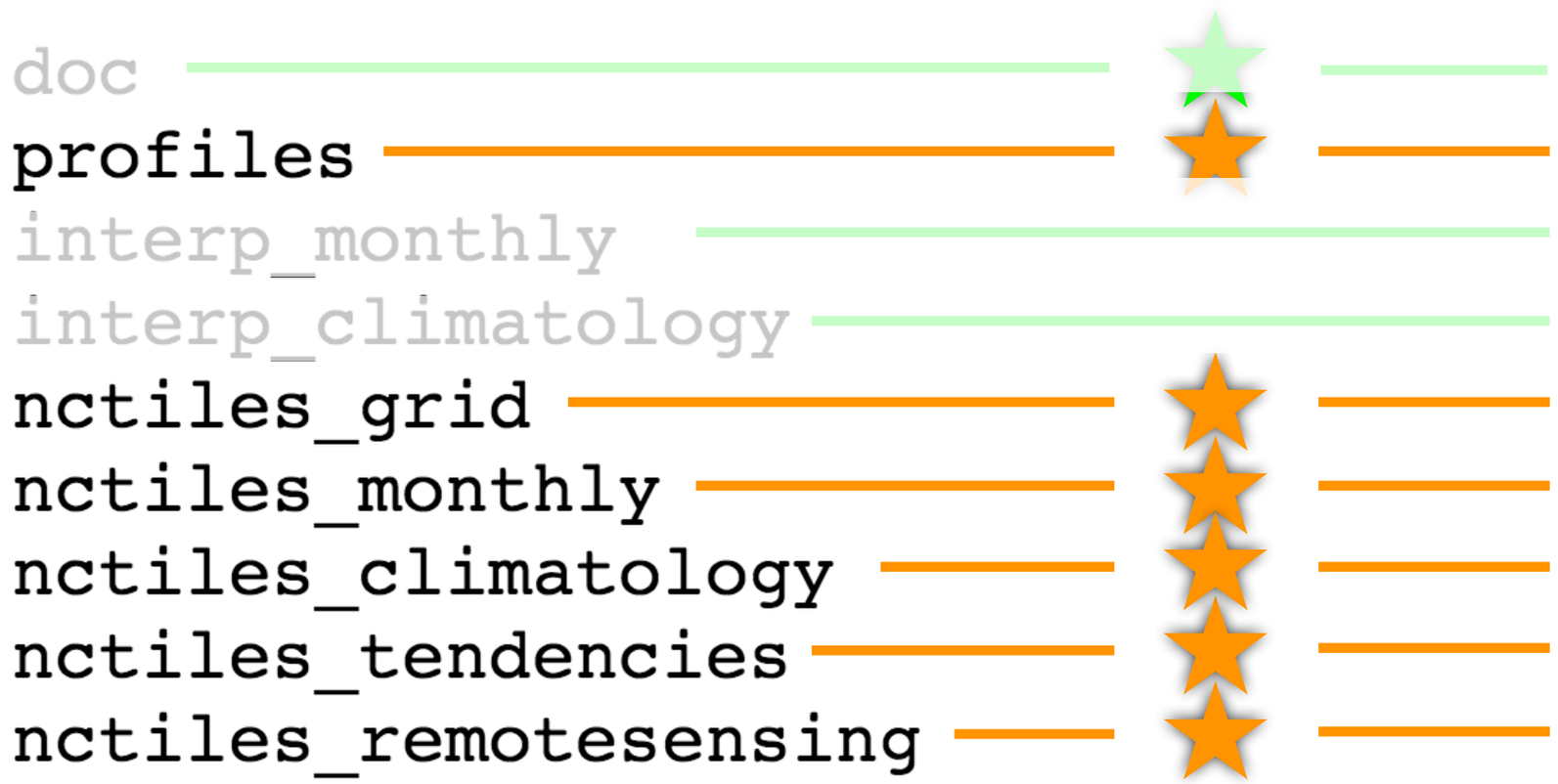

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Inside release2/doc/

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Solution History: the 1992-2011 solution documented here (ECCO v4-r2) is a minor update to the original ECCO v4 solution documented by Forget et al 2015 (ECCO v4-r1). As compared with ECCO v4-r1 (see Forget et al 2015 for details and notations) ECCO v4-r2 benefits from a few additional corrections in the model settings:

1. Inclusion of geothermal heating at the sea floor in MITgcm and ECCO v4 settings.
2. Inclusion of $\mathcal{K}_{gm}$ and $\mathcal{K}_{\sigma}$ interpolation to C-grid velocity points in MITgcm and ECCO v4 settings.
3. Re-inclusion of targeted bottom viscosity in ECCO v4 settings.
4. Re-inclusion of estimated wind stress adjustments over 2000-2011 in ECCO v4 settings.
5. Re-adjustment of ECCO v4 global mean precipitation (homogeneously) to match the AVISO global mean sea level time series (`http://www.aviso.altimetry.fr/`).

Contents Included Below: the gcmfaces 'standard analysis' (introduced in Forget et al. 2015) appended below for ECCO v4-r2 depicts routinely monitored characteristics of ECCO solutions. It allows for direct comparison with the published ECCO v4-r1 standard analysis (doi:10.5194/gmd-8-3071-2015-supplement).

- **Location ECCO v4-r2:** ftp://mit.ecco-group.org/ecco_for_las/version_4/release2/
- **Contents of release2/doc/:** README, standardAnalysis.pdf (http://hdl.handle.net/1721.1/102062), diffusivities, nctiles90x90.jpg, ...

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Inside release2/doc/

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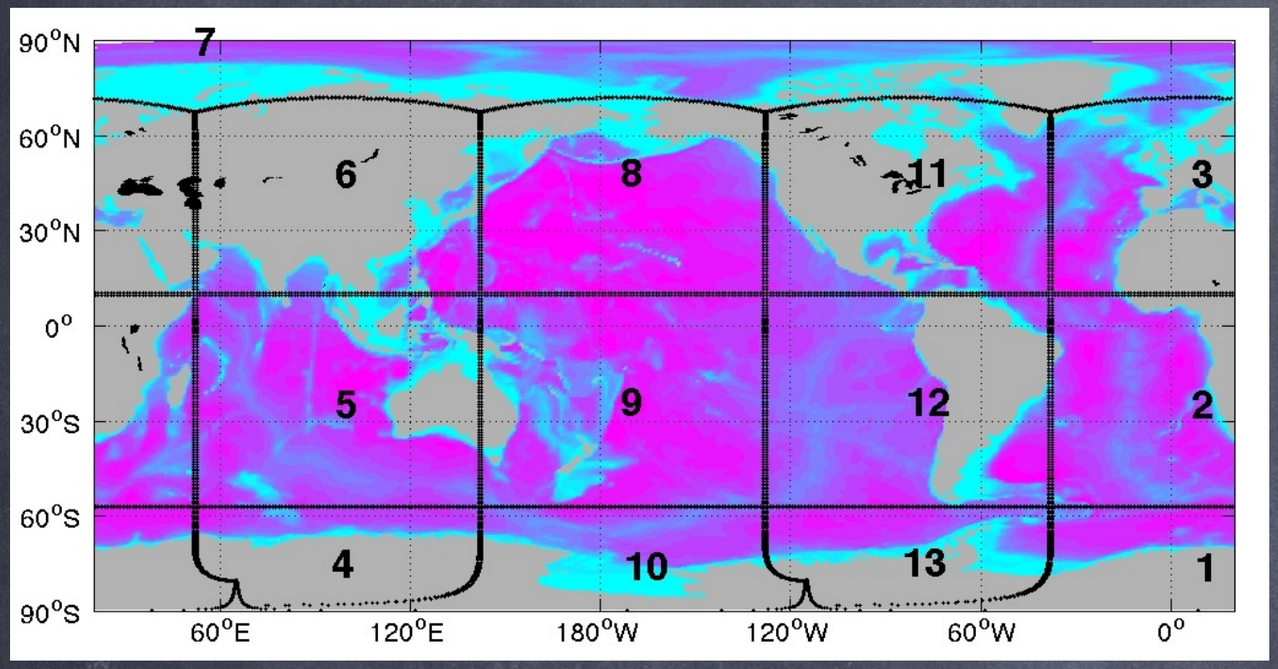

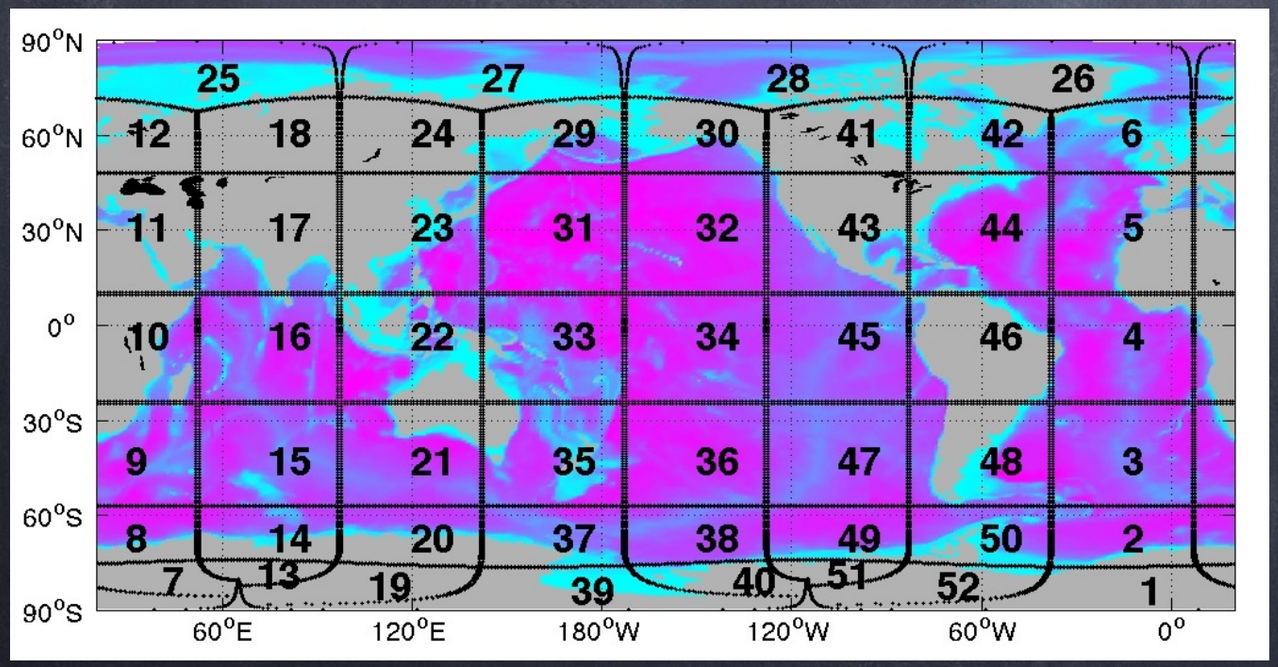

- Individual netcdf files can be read directly in any netcdf enabled software (e.g. NASA's panoply).

- In Matlab 'nctiles' files groups can also be read collectively using the 'gcmfaces' toolbox.

- alternative to nctiles: interpolated fields (0.5x0.5 grid) are provided in release2/interp_*/

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Using release2/nctiles_climatology/

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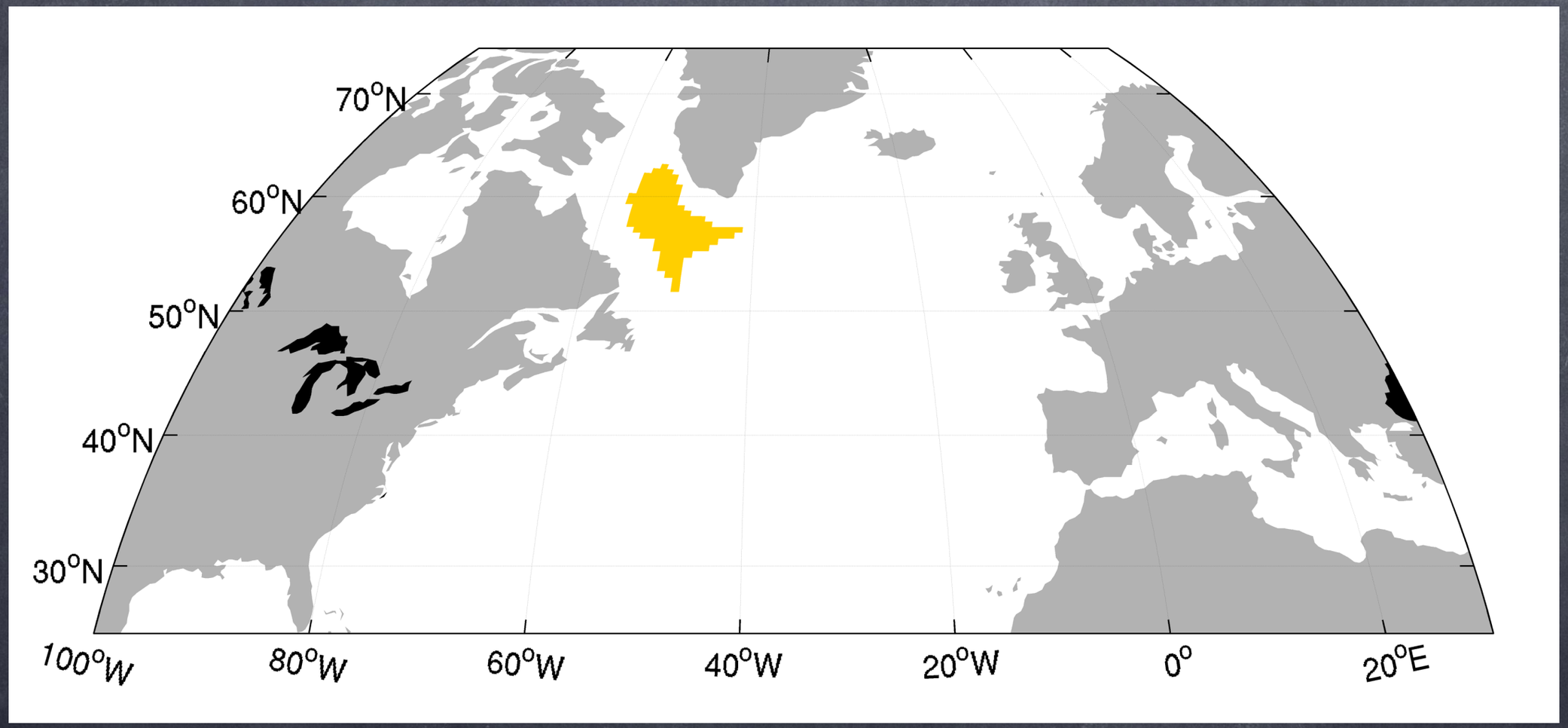

Averaging region (following slides) defined using ECCO climatological March MXLDEPTH.

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Using release2/nctiles_monthly/

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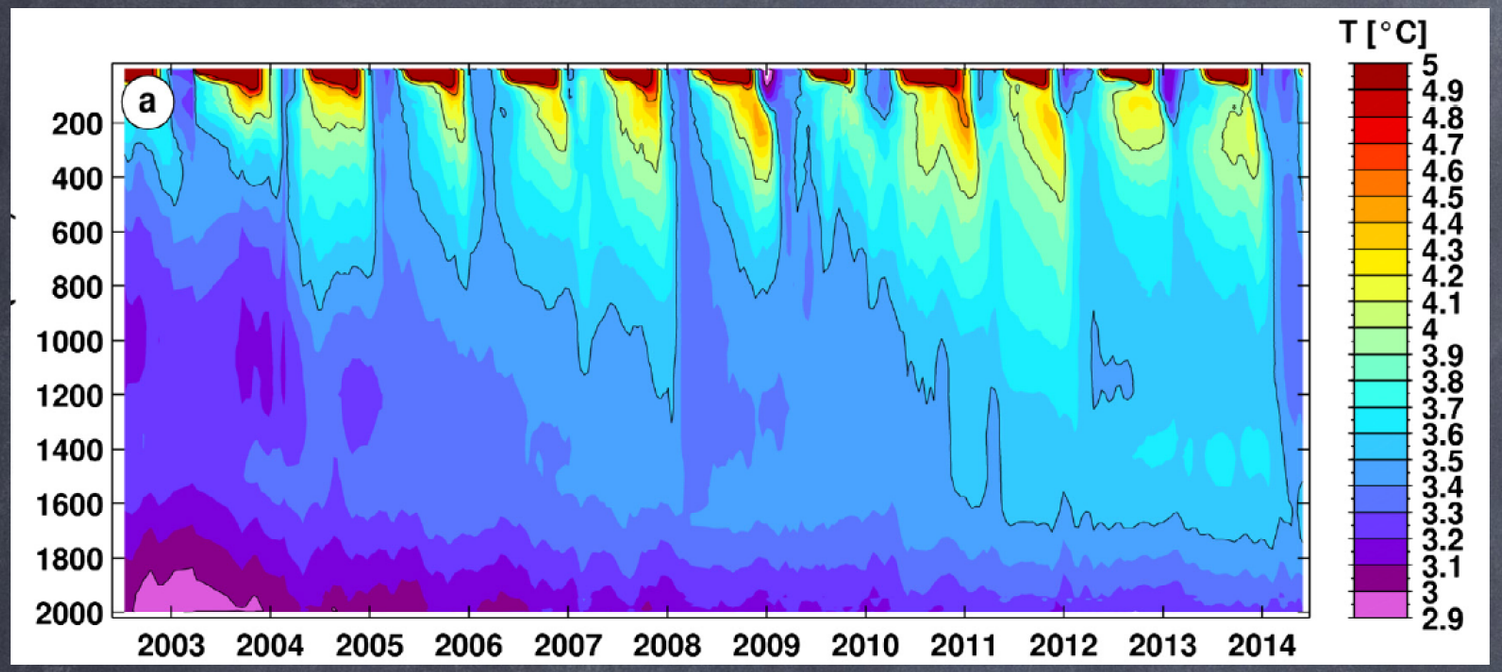
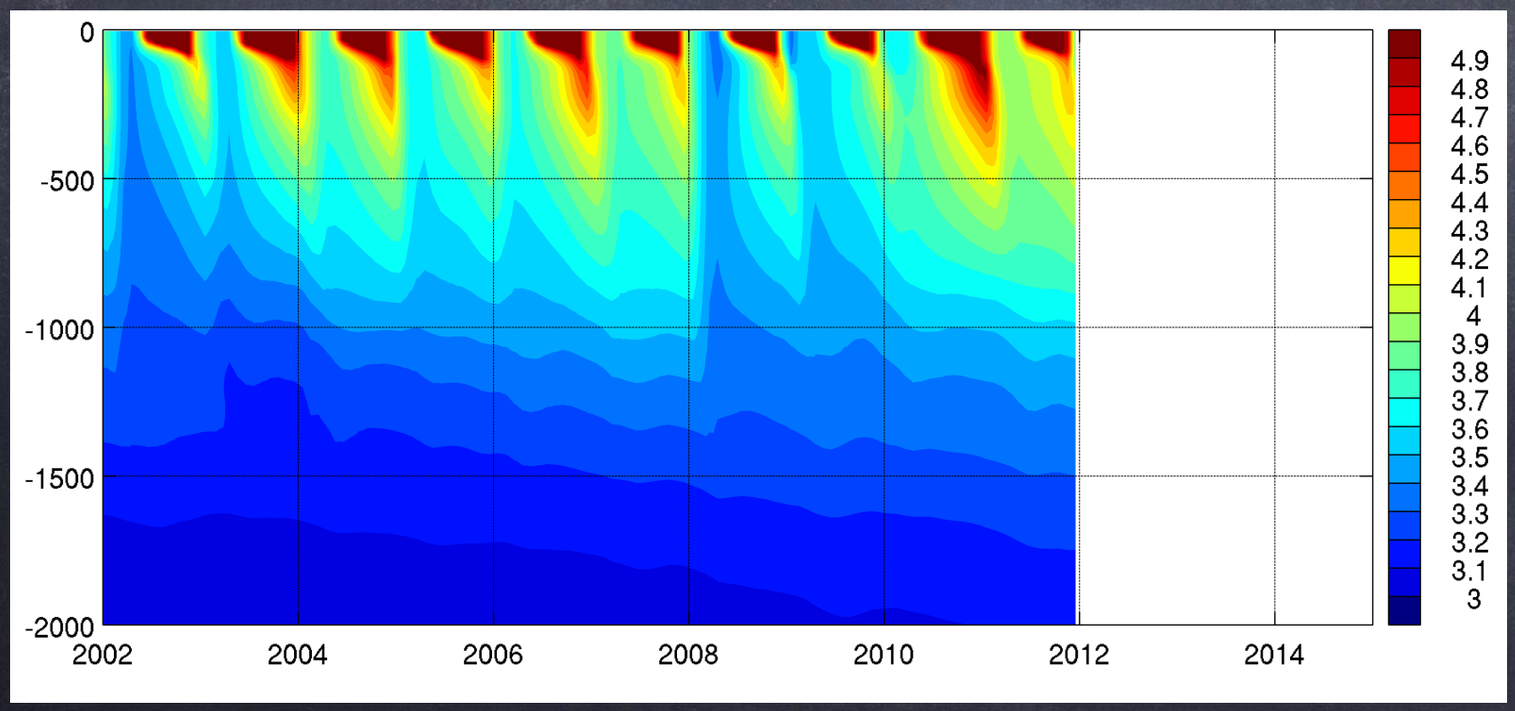


Argo Temperature
(Kierke & Yashayaev 2015)



ECCO v4-r2
Temperature

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Using release2/nctiles_tendencies/

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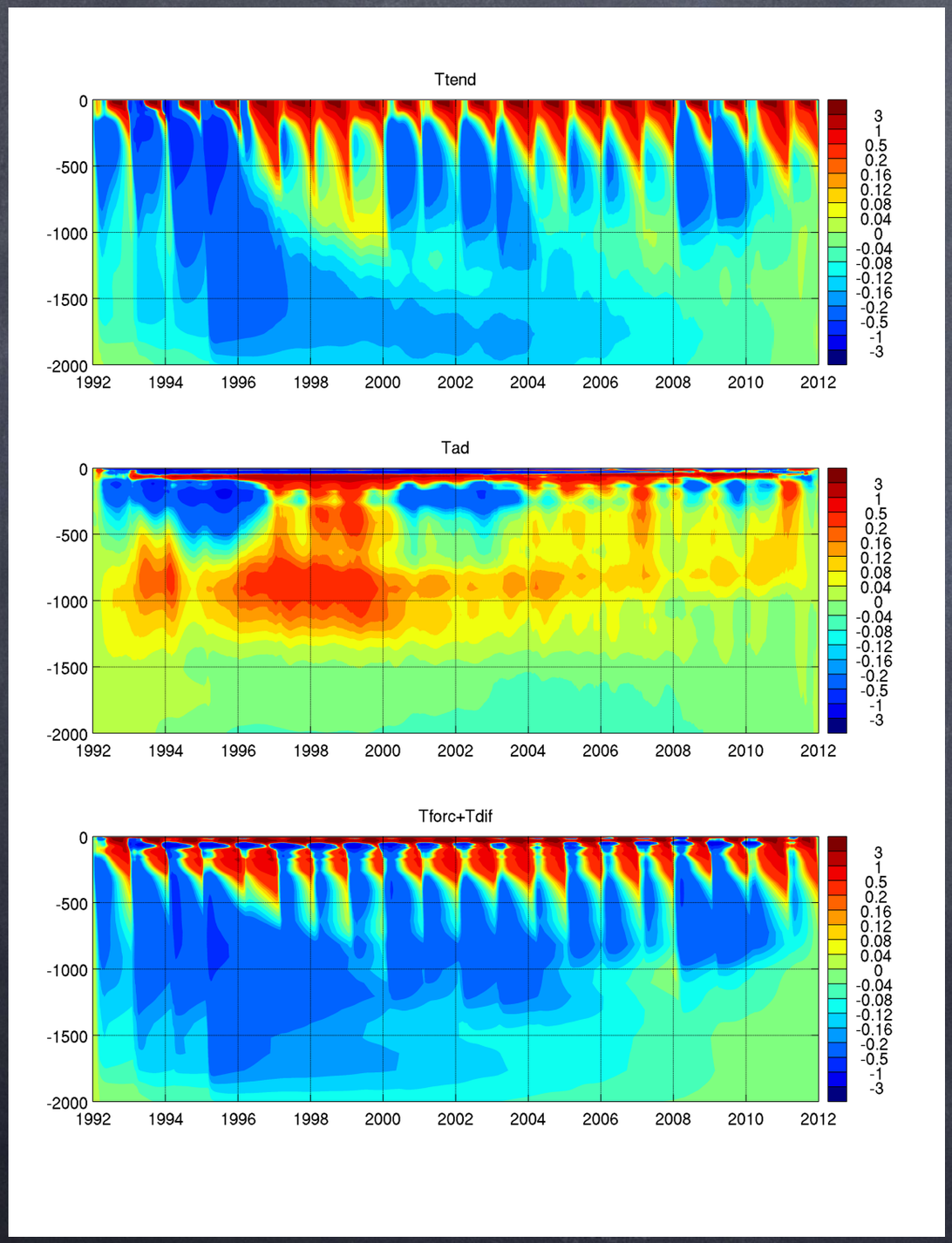

Temperature Anomaly
(detrended integrated ‘Ttend’)

Advection
(… ‘Tad’)

Diabatic Terms
(… ‘Tdi+Tforc’)

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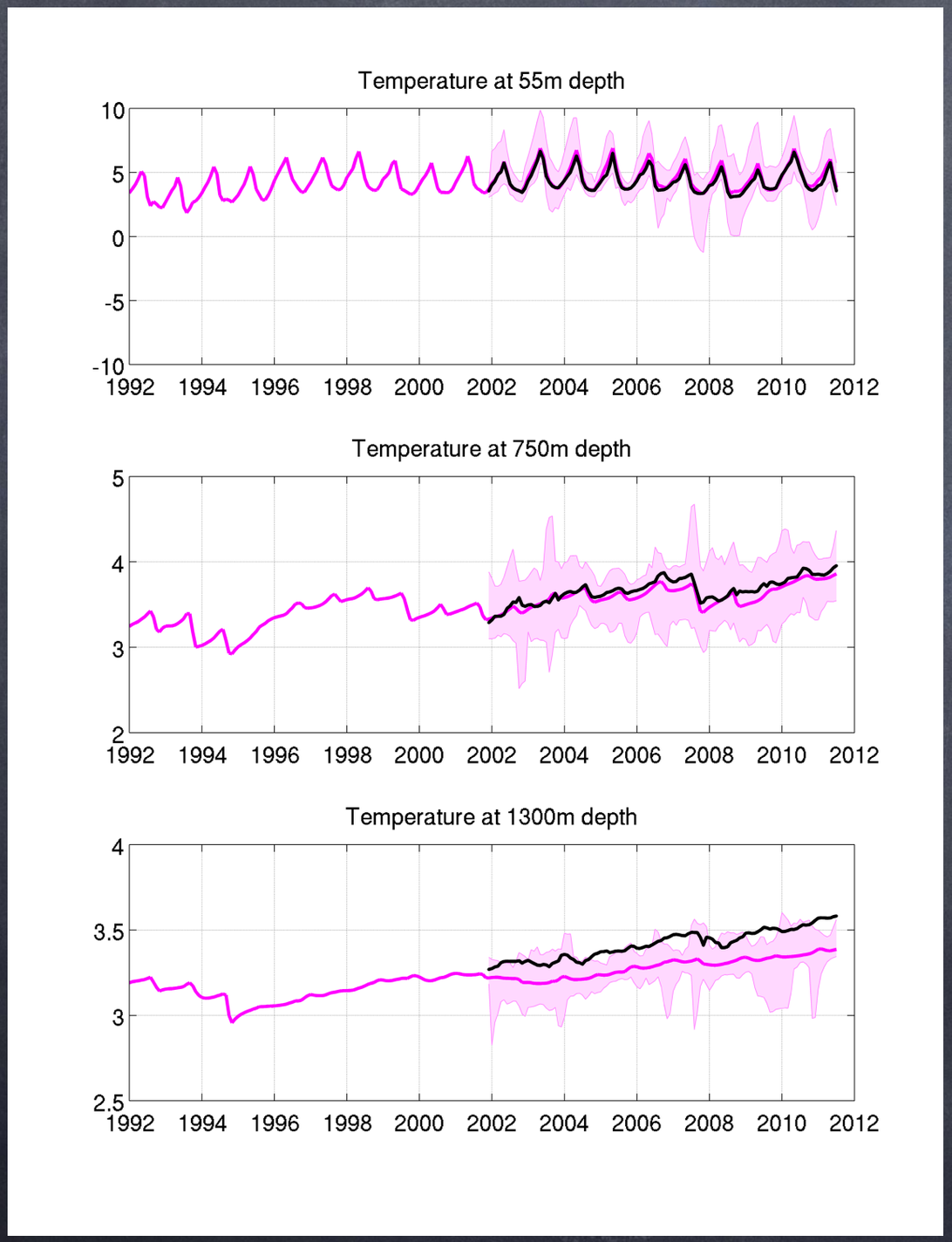
Using release2/profiles/

2016 ECCO meeting



ECCO v4-r2 Temperature (pink) w. 95% misfit interval (shading) & Argo Temperature (black)

55m depth (top)
750 m depth (middle)
1300m depth (bottom)

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Using release2/ nctiles_remotesensing/

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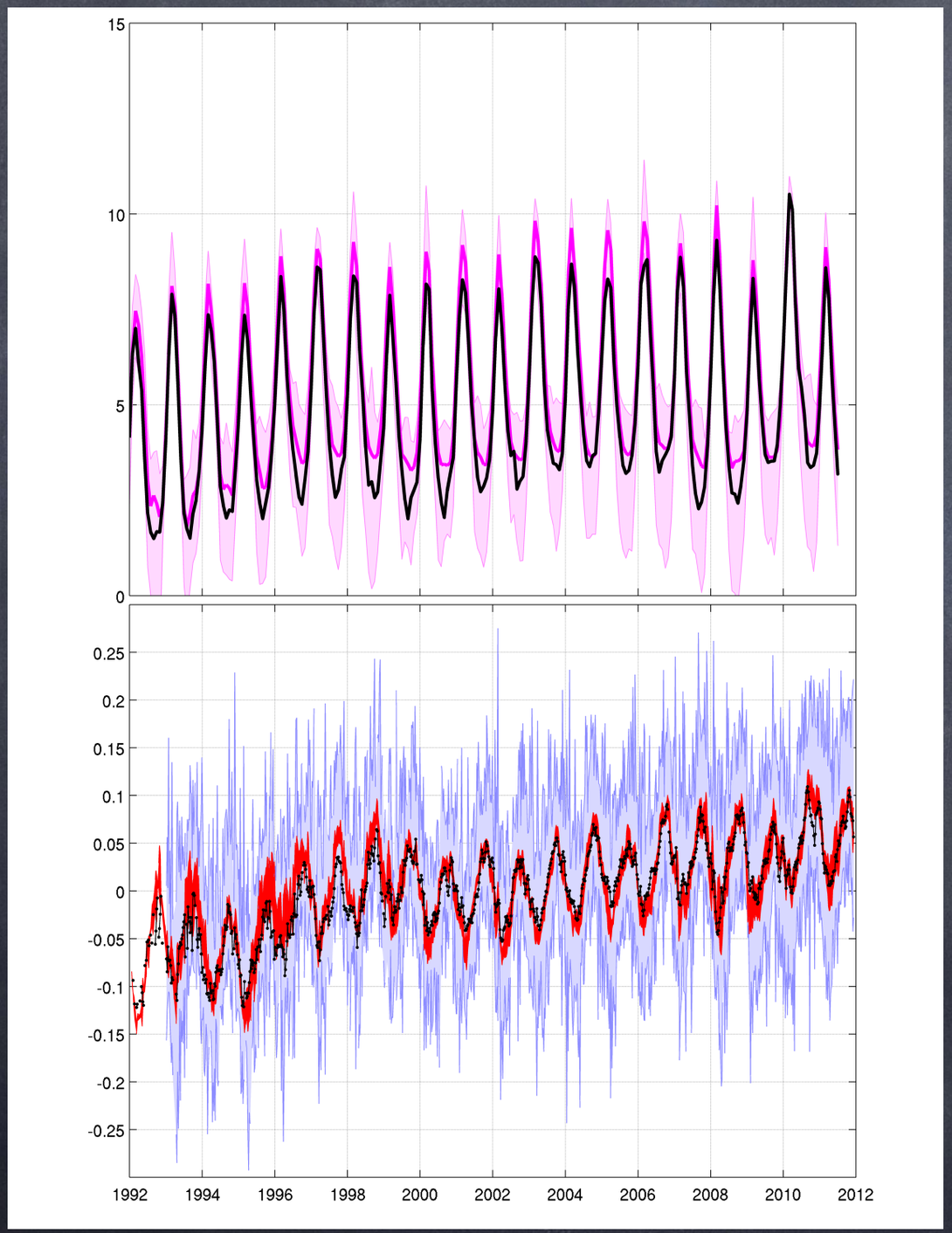

ECCO v4-r2 SST (pink)
w. 95% misfit interval (shading)
& Reynolds oi-v2 SST (black)

ECCO v4-r2 SLA (red)
w. 95% misfit interval (shading)
& altim. large scale SLA (black)

SLA in ECCO differs from 'ETAN' by ice load and global thermosteric correction

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Re-Running ECCO v4-r2

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```
#1) compile the model
cd MITgcm/verification/global_oce_llc90/build
../../../tools/genmake2 -mods=../code -optfile \
     ../../../tools/build_options/linux_amd64_gfortran -mpi
make depend
make -j 4

#2) link files into run directory
cd ../run
ln -s ../build/mitgcmuv .
ln -s ../input.ecco_v4/* .
ln -s ../input_fields/* .
ln -s ../../inputs_baseline2/input*/* .
ln -s ../../forcing_baseline2 .

#3) run model
mpiexec -np 96 ./mitgcmuv
```

- **Purpose:** additional output, investigative experiments, ...
- **Daily Tests:** http://mitgcm.org/public/testing.html
- **Location:** http://mitgcm.org/viewvc/MITgcm/MITgcm_contrib/gael/verification/ (contains eccov4.pdf user guide that provides download directions etc.)
- **Documentation:** Forget, et al., 2015 (GMD).

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Forward Experiments

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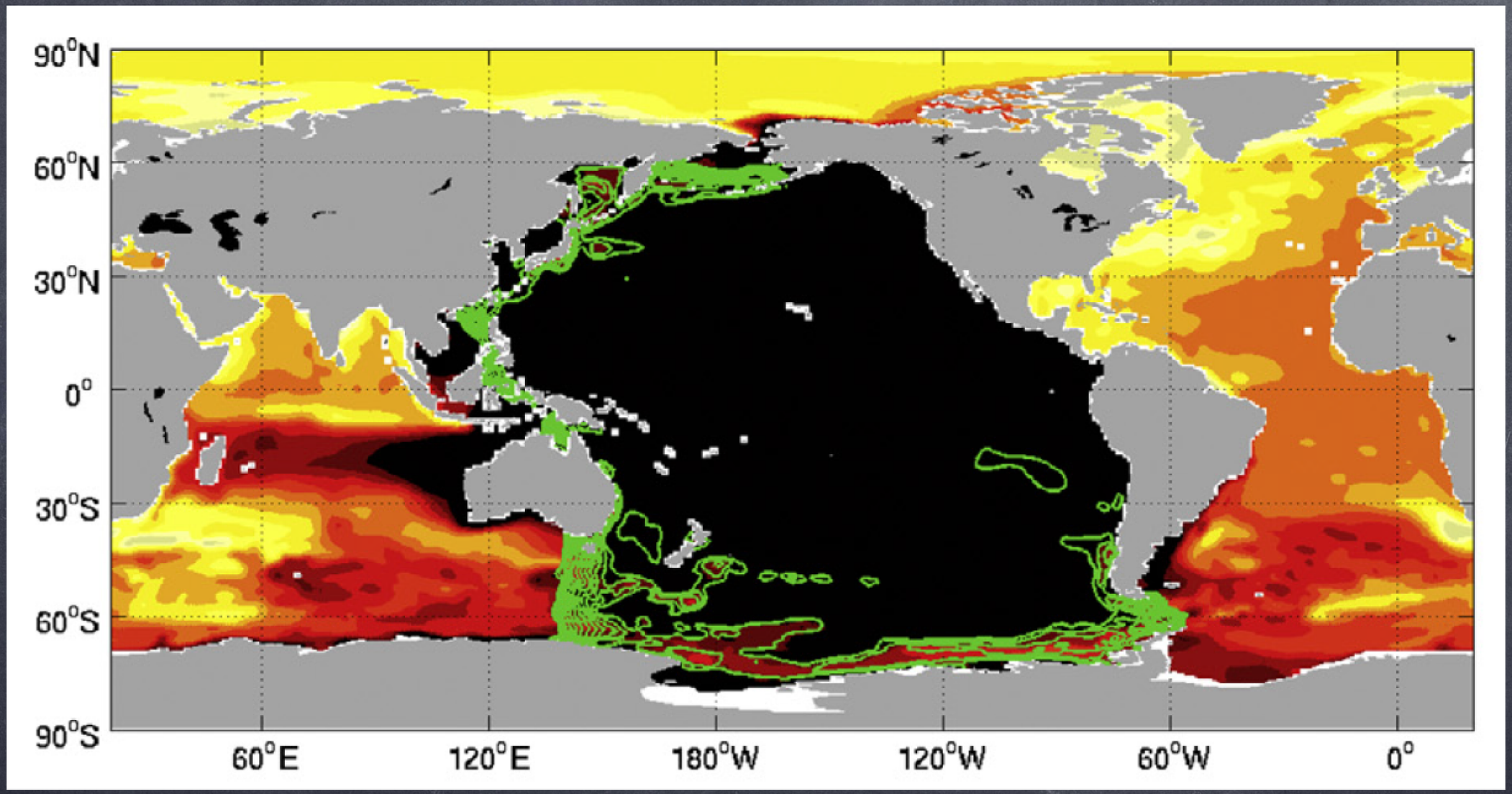

Forget and Ponte, 2015 (PO)

Other examples: Forget et al 2015 (GMD), Forget et al 2015 (OS) and wednesday presentation

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Adjoint Experiments

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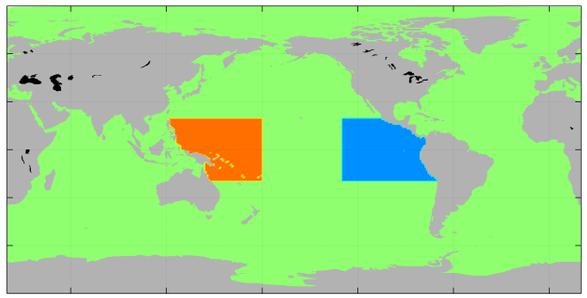

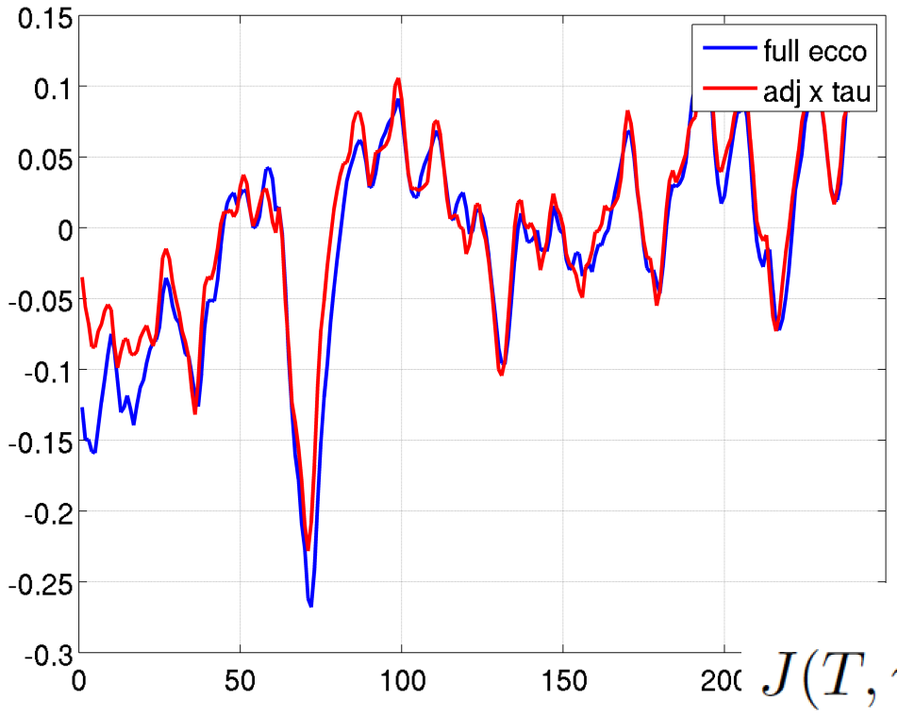

Tropical Parcific Sea Level Differential (blue curve) and its reconstruction using the adjoint (blue curve)

The reconstruction is achieved by convolving adjoint sensitivities with wind stress anomalies (Equations below). For published examples: see Fukumori et al 2015 and reference therein.

$$J(T,\tau) = \int_{wtp} H(x,y,T,\tau)\ dxdy - \int_{etp} H(x,y,T,\tau)\ dxdy$$

$$\mathcal{G}(x,y,t-T) = \frac{\partial J}{\partial \tau}(t-T) \text{ from the adjoint model}$$

$$K(T,\tau) = \int_{-\infty}^{T} \int_{glo} \mathcal{G}(x,y,t-T) \cdot \tau'(x,y,t)\ dxdy\ dt$$

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Entry Points

2016 ECCO meeting

- **ECCO v4, OVERVIEW:** Forget, G., J.-M. Campin, P. Heimbach, C. N. Hill, R. M. Ponte, and C. Wunsch, 2015 (GMD, http://dx.doi.org/10.5194/gmd-8-3071-2015)
- **ECCO v4, RELEASE 2:** ftp://mit.ecco-group.org/ecco_for_las/version_4/release2/ (READMEs, http://hdl.handle.net/1721.1/102062)
- **ECCO v4, MATLAB FRAMEWORK:** http://mitgcm.org/viewvc/MITgcm/MITgcm_contrib/gael/matlab_class/ (gcmfaces.pdf)
- **ECCO v4, MODEL SETUP AND USER GUIDE:** http://mitgcm.org/viewvc/MITgcm/MITgcm_contrib/gael/verification/ (eccov4.pdf)
- **ECCO v4, GRID FAMILY:** ftp://mit.ecco-group.org/ecco_for_las/version_4/grids/grids_input/ (README)
- **FOR MORE:** http://ecco-group.org/products.htm, http://ecco-group.org/model.htm, http://mailman.mit.edu/mailman/listinfo/ecco-support, http://mitgcm.org/mailman/listinfo/mitgcm-support, http://mitgcm.org/, http://www.autodiff.org/
- **WORK IN PROGRESS:** Archiving via DataVerse, documentation via DSpace