
ECCOc: The ECCO-GODAE Ocean State Estimation Effort at MIT/AER

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Other groups closely involved:

- ▶ **MITgcm**
- ▶ **ECCO2**
- ▶ **GECCO**

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<http://ecco.mit.edu>

Very brief history: from ECCO to “ECCOc”

▶ Version 0:

The original 2° config. covering 1992 to 1997, started at MIT
Stammer et al., 2002, 2003, 2004

▶ Version 1:

69 iterations covering 1992 to 2002 at 1°, performed at SIO (Drs. Köhl,
Stammer), producing what is now **ECCOa = ECCO-SIO-v1.69**

▶ Version 2:

- departure of version 1 team from SIO, and end of ECCO funding period lead to transfer of OSE system back to MIT & AER
- follow-on project ECCO-GODAE got underway to sustain up-to-date OSE production
- various updates and iterations done (to be discussed), covering 1992 to 2004 resulting in **ECCOc = ECCO-GODAE-v2.199**

▶ Version 3:

- This system implements first set of changes towards a new generation global coupled ocean/sea-ice estimation system;
- first experimental solution covering 1992 to 2005 to be released soon

Forward model: MITgcm, <http://mitgcm.org>

- ▶ Integration period: 1992 to 2004, at hourly time step
- ▶ model: MITgcm, essentially in its latest available revision (checkpoint58) (finite-volume, z-level, C-grid, Boussinesq, implicit free surface)
- ▶ same as ECCOa: 1° horiz., between 80° N/S; 23 vertical levels;
- ▶ current domain decomposition on 60 processors (virtually platform-independent)
- ▶ some numerics:
 - Adams-Bashforth time stepping, 3rd order upwind tracer advection
 - equation of state by Jackett and McDougall (1995) and virtual salt flux BC
- ▶ sub-grid scale parameterizations
 - GM/Redi isopycnal diffusion and bolus advection of eddies
 - non-local K-profile parameterization (KPP) of vertical diffusion
- ▶ forcing:
 - 6-hourly NCEP/NCAR buoyancy and momentum fluxes
 - time-varying control adjustments every 2 days

The adjoint-based ECCO ocean state estimation system

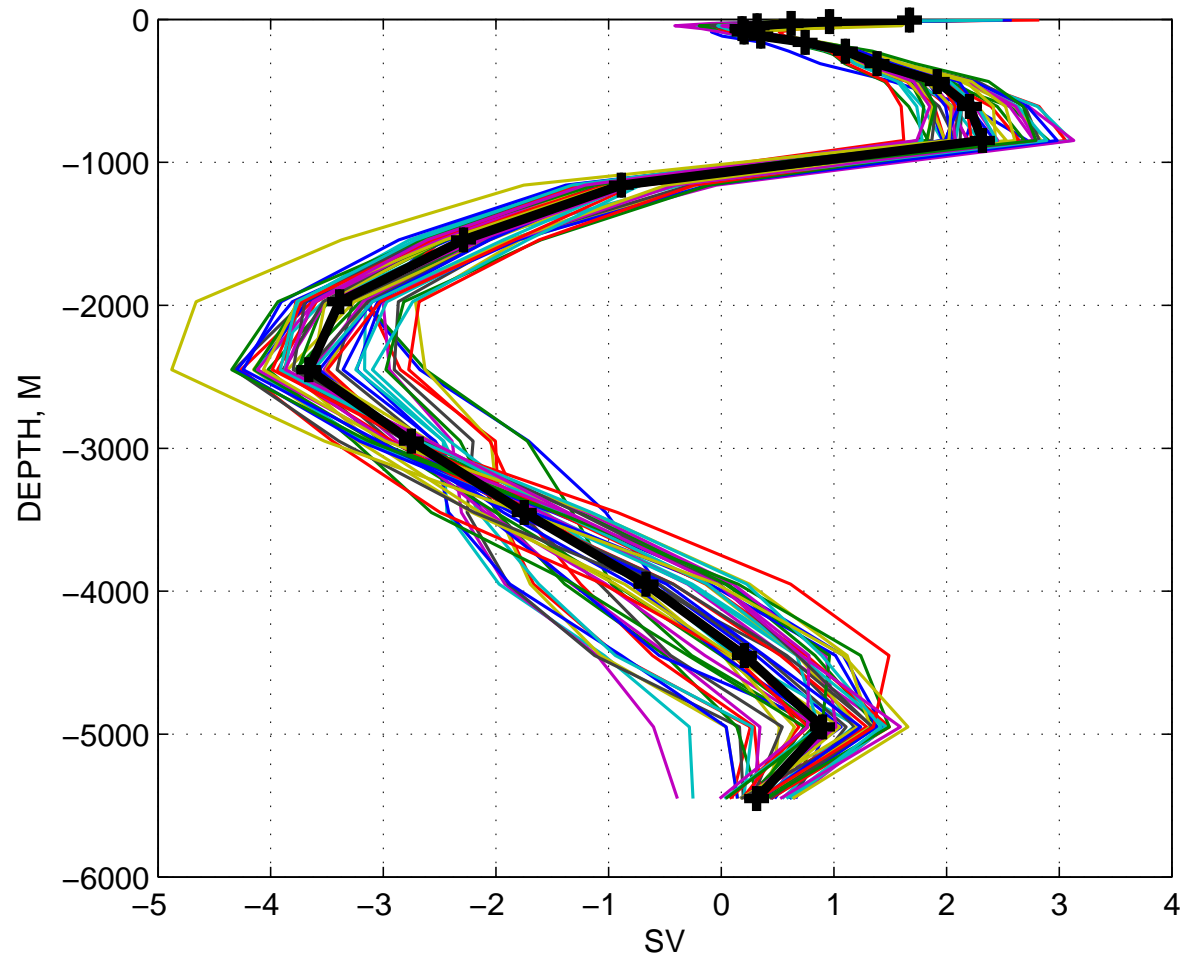
- ▶ adjoint of MITgcm derived automatically using AD tool TAF
(Giering and Kaminski, TOMS, 1998; Marotzke et al., JGR, 1999)
- ▶ MITgcm adjoint again based on latest model revision (checkpoint58)
(Heimbach et al., FGCS, 2005)
- ▶ KPP and GM/Redi not currently used in reverse mode
- ▶ 60-processor domain decomposition inherited from forward model
- ▶ control space consists of (as in ECCOa)
 - 3-dim. initial conditions for T , S
 - time-varying boundary conditions for heat and freshwater fluxes,
and zonal/meridional wind stresses; updates ever 2 days
- ▶ some aspects described in
Wunsch and Heimbach, JPO, 2006 (in press);
Wunsch and Heimbach, Physica D, 2006 (in press);
Heimbach et al., 2006 (ESA Proceedings)

Observational constraints and uncertainties/weights

- ▶ GRACE-based mean dynamic topography (MDT) from CLS (Rio, 2005)
- ▶ sea-level anomalies (SLA) from three series:
TOPEX/POSEIDON & Jason-1; ERS-1/2 & ENVISAT; GFO
- ▶ SST data of Reynolds & Smith, and TRMM/TMI satellite
- ▶ In-situ measurements, mainly 3 components:
Argo floats (T , S); XBT; CTD
- ▶ climatological T , S : (blended Conkright et al. (2002) WOA01, and Gouretski & Koltermann (2004) WOCE Atlas)
- ▶ penalty terms for all control variables
- ▶ weak drift constraints between last year and first year
- ▶ spatially varying weights for climatologies and in-situ data based on Forget and Wunsch, JPO, 2006, in press.
- ▶ Altimetric weights based on Ponte et al., JAOT, 2006, submitted.

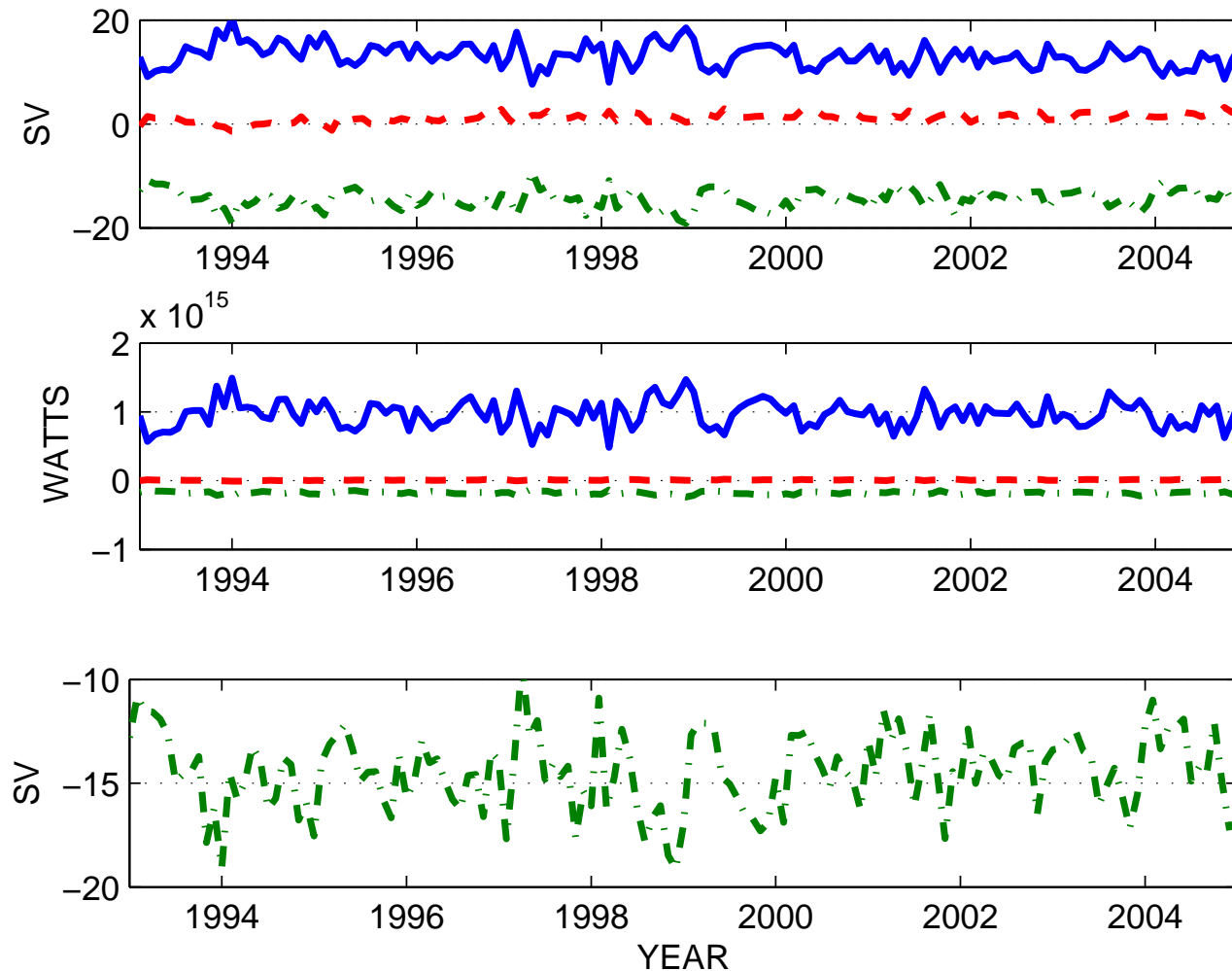
Sample results: Decadal Atlantic volume and heat transport at 26N

Month-to-month zonal mean volume transport vs. depth



Sample results: Decadal Atlantic volume and heat transport at 26N

0 to 1100m, 1100 to 4450m, 4450m to bottom



Some ECCOc-related References

<http://ecco.mit.edu>

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Ponte, R. M., C. Wunsch and D. Stammer, 2005: Spatial mapping of time-variable errors in Jason-1 and TOPEX/POSEIDON sea surface height measurements. JAOT, in press.

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