ECCO: Understanding Sea Level, Ice, and Earth's Climate

I.Fukumori, D.Menemenlis, I.Fenty, O.Wang (JPL/Caltech)

H.Zhang, M.Schodlok (UCLA)

P.Heimbach (UT Austin)

C.Hill, C.Wunsch, J.-M. Campin (MIT)

R.Ponte, C.Piecuch (AER)

Over the next 4 years we aim to establish ECCO as a "community facility" for studying the ocean & climate

1. Sustained production of ECCO Central State Estimate,

2. Advance fidelity & capability of the ECCO analysis with a focus on improving understanding of sea level change,

   - include ocean-ice interaction (sea-ice, ice sheet/ice shelf)
   - eddy-permitting resolution
   - tides, SAL, surface pressure

3. Support and foster community utilization of ECCO products.

1. Sustained Production (Fukumori)

- Update the adjoint Central Estimate on an annual basis

- Extend in near-real-time with Kalman filter/RTS smoother (FY18)

- Expanded Controls;
    - cross-covariance among atmospheric controls (FY18),
    - seasonal varying data and control errors (FY18),
    - time-varying mixing coefficients (FY19),
    - additional controls (bottom mixing, geothermal flux) (FY19),

- Integrate model advancements;
    - Incorporate ocean-ice interaction (sea-ice, ice-sheet) (FY18 & 19),
    - Transition to eddy-permitting estimate (FY19, 21),
    - Incorporate tides, SAL, atmospheric pressure forcing (FY20).

2a. Sea Ice Estimation (Fenty)

- Integrate & adapt an adjointable thermodynamic sea ice model (FY18)

  - Conform subroutines with main MITgcm code,

  - Implement new parameterizations for ice area and ice thickness,

  - Additional parameterization for high-brine plume.

- Adding sea ice and snow data into cost (FY18)

  - Acquire and QC concentration & thickness data

  - Formulate error estimates

- Explore additional sea ice data (FY19)

  - Ice and/or snow temperature

  - Snow thickness

  - Sea ice vertical temperature profile

  - Lead fraction

2b. Ice Shelf & Ice Sheet (Menemenlis, Heimback)

- Parameterize melt rate and implied freshwater input around Greenland & Antarctica based on observations and high-resolution simulations (FY18),

- Regional ocean, sea ice, and ice shelf cavity adjoint optimization of Amundsen-Bellingshausen Sea cut from LLC270 (FY19),

- Incorporate ice shelf cavity optimization in global models (LLC270 in FY20, LLC540 in FY21),

- Experiment with higher-resolution (LLC540~4320) simulations with sea ice and ice shelf cavity that include tides (FY19).

2c. Eddy-Permitting Estimation (Heimbach, Menemenlis)

- LLC270 (nominally 1/3-deg) as ECCO Version 5 in FY19.

- LLC540 (nominally 1/6-deg) as ECCO Version 6 in FY21.

- Experiment coupling high-resolution forward model (e.g., LLC1080) with low-resolution adjoint.

- Regional high-resolution model nested with global estimate.

2d. Data & Uncertainty Estimates (Ponte)

- Evaluation of data versions and inclusion of updates,

- Preparation of new data types; drifters, Argo displacement, SMAP, high-latitude data (e.g., IceSat-1, CryoSat-2, OMG) (FY18),

- Data to constrain atmospheric controls (e.g., GPM) (FY19),

- Derivation and re-evaluation of data weights (esp. w/ model change),

- Implementation and assessment of time-dependent weights,

- Implementation of model improvements for high-frequency variations,
  - Surface pressure forcing (FY18),
  - Long- & short-period tides (FY19),
  - Self-attraction and loading (FY18),
  - Gravitational effects from land hydrology & ice.

2e. MITgcm Infrastructure (Hill, Campin)

- Targeted configuration enhancements;

  - Wetting & drying algorithms for ice-sea boundary change,

  - Ice-shelf/ice-sheet/glacial mass flux parameterization,

  - Non-Boussinesq formulation for more precise mass budgets,

  - Regridding/interpolation to more readily accessible grids,

  - Online diagnostic computations with asynchronous processing

3. Community Engagement

- Overhaul ECCO website & data server (Heimbach)
  - Distributed content update,
  - Live access and data manipulation.

- OpenAD based ECCO infrastructure (Heimbach),

- Implement tools and web-based interface;
  - tracer tool (Fukumori, FY18),
  - comprehensive budget analysis (Ponte, FY19),
  - adjoint gradient applications (Heimbach, FY20).

- Cloud hosted system configuration (Hill, Forget)

- Summer school and workshops;
  - ECCO Summer School (Heimbach, FY19),
  - ECCO Workshop @ AGU Ocean Sciences Mtg (Fenty, FY18).