# Discussion on data/solution updates

**ECCO Meeting, California Institute of Technology, Pasadena**

**November 6-8, 2017**

- ❑ **What vital data sets have we been using?**
- ❑ **How to make sure we keep up with data sets for future estimates?**
- ❑ **How to share data processing responsibilities?**
- ❑ **Define plans for maintaining ”central” estimates up-to-date**

# Data sets used in v4r3

| Variable | Observations |
|---|---|
| Sea level | TOPEX/Poseidon (1993-2005), Jason-1 (2002-2008), Jason-2 (2008-2015), Geosat-Follow-On (2001-2007), CryoSat-2 (2011-2015), ERS-1/2 (1992-2001), ENVISAT (2002-2012), SARAL/AltiKa (2013-2015) |
| Global mean sea level | Average of mean sea level curves from AVISO, CSIRO, NOAA |
| Temperature profiles | Argo floats (1995-2015), XBTs (1992-2008), CTDs (1992-2011), Southern Elephant seals as Oceanographic Samplers (SEaOS; 2004-2010), Ice-Tethered Profilers (ITP, 2004-2011) |
| Temperature (moorings) | Beaufort Gyre, Bering/Davis/Fram Straits (coverage?) |
| Salinity profiles | Argo floats (1997-2015), CTDs (1992-2011), SEaOS (2004-2010) |
| Salinity (moorings) | Beaufort Gyre, Bering/Davis/Fram Straits (coverage?) |
| Sea surface temperature | AVHRR (1992-2013) |
| Sea surface salinity | Aquarius (2011-2013) |
| Sea-ice concentration | SSM/I DMSP-F11 (1992-2000) and -F13 (1995-2009) and SSMIS DMSP-F17 (2006-2015) |
| Ocean bottom pressure | GRACE (2002-2014), including global mean ocean mass |
| TS climatology | World Ocean Atlas 2009 |
| Mean dynamic topography | DTU13 (1992-2012) |

# Data sets used in v4r3

| Data | Filename | Version | Souce | Post-processed by |
|---|---|---|---|---|
| GRACE OBP | GRACE_jpl_rl05m_withland_YYYY | One | JPL (http://grace.jpl.nasa.gov/data/get-data/jpl_global_mascons/) | Katherine Quinn (1/7/2016) |
| Global mean OBP | GRACE_jpl_rl05m_SpatialMean.asc | One | JPL (http://grace.jpl.nasa.gov/data/get-data/jpl_global_mascons/) | Katherine Quinn (1/7/2016) |
| RADS TP/J1/J2 SSH | RADS_TJ_mar2016_YYYY | | RADS | |
| RADS GFO/C2 SSH | RADS_GFO_C2_mar2016_YYYY | | RADS | |
| RADS ERS/ENVISAT/SARAL/AltiKa SSH | RADS_ERS_ENV_SA_mar2016_YYYY | | RADS | |
| MDT | mdt_dtu13.bin | DTU13 | DTU | Katherine Quinn (12/10/2014) |
| Global mean SSH | ensemble_avg_gmsl.asc | | AVISO, CSIRO, NOAA | Christopher Piecuch (03/07/2016) |
| NOAA NSIDC Sea-ice concentration | AA_NSIDC_DAILY_MAPPED_TO_LLC90_YYYY.bin | | NOAA/NSIDC | Ian Fenty |
| Aquarius SSS | monthlyAQ_v3_092011-122013_YYYY | | Aquarius | Nadya vinogradova (06/13/2014) |
| Reynolds SST | reynolds_oiv2_r1_YYYY | | NOAA/NCDC | |
| WOA09 Climatology T | T_monthly_woa09 | WOA09 | NOAA/NODC | |
| WOA09 Climatology S | S_monthly_woa09 | WOA09 | NOAA/NODC | |
| | | | | |
| Profile data | | | | |
| Argo TS | go_YYYY_feb2016_llc90_step_09_20160308.nc | | Argo | Ian Fenty |
| CTD TS | td_Arctic_NordicSeas_GAMMA_20150915.nc | | CTD | Ian Fenty |
| CTD TS | ctdhilat_nodupices_GAMMA_20150915.nc | | CTD | Ian Fenty |
| CTD TS | ctdlowlat_GAMMA_20150915.nc | | CTD | Ian Fenty |
| XBT T | xbt_GAMMA_20150915.nc | | XBT | Ian Fenty |
| CLIMODE TS | climode_GAMMA_20150915.nc | | CLIMODE | Ian Fenty |
| ICES TS | s19922012hi_pot_theta_GAMMA_20150915.nc | | ICES | Ian Fenty |
| ICES TS | s19922012lo_pot_theta_GAMMA_20150915.nc | | ICES | Ian Fenty |
| ITP TS | itp_GAMMA_20150915.nc | | ITP | Ian Fenty |
| SEaOS TS | seals_GAMMA_20150915.nc | | SEaOS | Ian Fenty |
| Beaufort Gyre mooring TS | beaufortgyremooring_GAMMA_20150915.nc | | | Ian Fenty |
| Bering Strait mooring TS | beringstraitmooring_GAMMA_20150915.nc | | | Ian Fenty |
| Davis Strait mooring TS | davisstraitmooring_GAMMA_20150915.nc | | | Ian Fenty |
| Fram Strait mooring TS | framstraitmooring_GAMMA_20150915.nc | | | Ian Fenty |

# Data updating (I)

- ❑ Sea level (JPL/MIT)
- ❑ Global mean sea level (AER/JPL)
- ❑ Ocean bottom pressure (AER/JPL)
  - ❑ Grids
  - ❑ Global mean
- ❑ Mean dynamic topography…upcoming DTU17 (AER/UTA)

# Data updating (II)

- SST (JPL/MIT)

- SSS…update Aquarius through end of mission, upcoming v5…(AER/JPL)

- Sea-ice concentration…An using OSISAF/daily/until April 2015 (UTA/JPL)

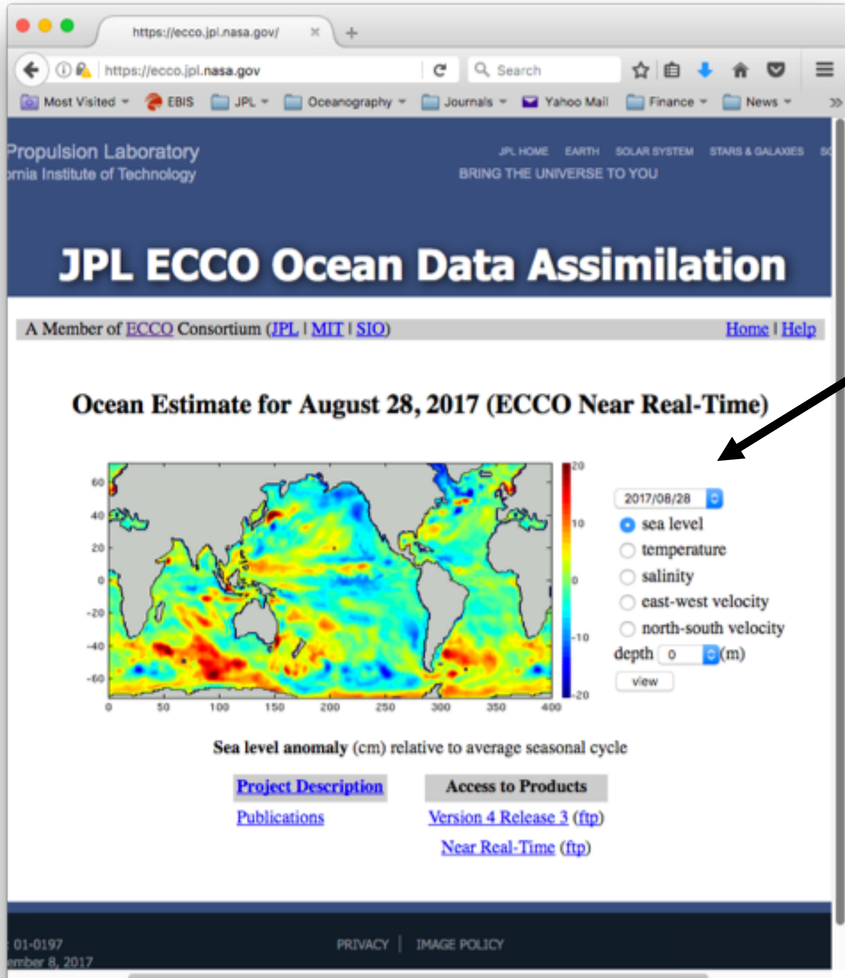
# Data updating (III)

- Temperature profiles
  - Argo (MIT/JPL)
  - XBT (JPL/MIT)
  - CTD (JPL/MIT)
  - SEaOS (??)
  - ICES (JPL)
  - ITP…updates through 2015 by An, used in ASTE, from J. Toole and R. Krischfield (UTA/JPL)
- Salinity profiles (as for T profiles)
- Temperature/salinity (moorings)…updates for western Arctic/Fram Strait by An, used in ASTE (UTA/JPL)

# Updating ECCO Central Product

- Update the adjoint Central Estimate on an annual basis;
  - Redo the 25+ year optimization starting from existing solution,
  - Just redo the last ~5-years annually (re-)adjusting time-variable controls.
- Extend the adjoint Central Estimate in “near real-time” with Kalman filter/RTS smoother

# ECCO Near Real-Time Analysis




- Updated quarterly
- Presently available for 01/1993-08/2017
- Kalman filter & RTS smoother
- Highlights @ http://ecco.jpl.nasa.gov/
- data: SSH, temperature profiles
- controls: winds

Pros:

- Computationally inexpensive,
- Stable & robust,
- Formal uncertainty estimates,

Cons:

- Less comprehensive an estimate than the adjoint,

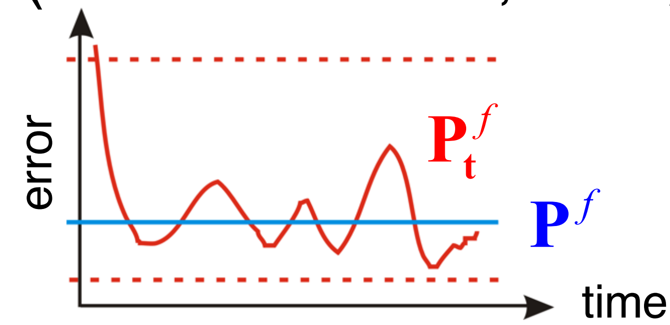
I.Fukumori/JPL

JPL

# ECCO Approximate KFS

1) Time-asymptotic approximation (Fukumori et al., *JPO, 1993*);

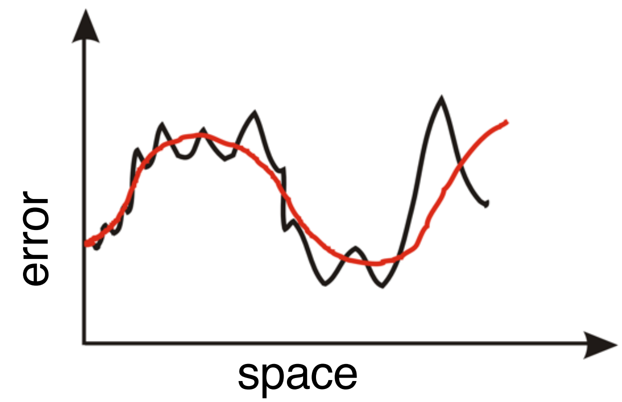
$$\mathbf{P}_{\mathbf{t}}^{f} \approx \mathbf{P}^{f}$$




2) State reduction (Fukumori and Rizzoli, *JGR, 1995*).

$$\delta\mathbf{x} \approx \mathbf{B}\delta\mathbf{x}', \quad \dim(\delta\mathbf{x}) \qquad \dim(\delta\mathbf{x}')$$

$$\mathbf{P} \equiv \left\langle \delta\mathbf{x}\delta\mathbf{x}^{T} \right\rangle \approx \mathbf{B}\left\langle \delta\mathbf{x}'\delta\mathbf{x}'^{T} \right\rangle\mathbf{B}^{T} \approx \mathbf{B}\mathbf{P}'\mathbf{B}^{T}$$

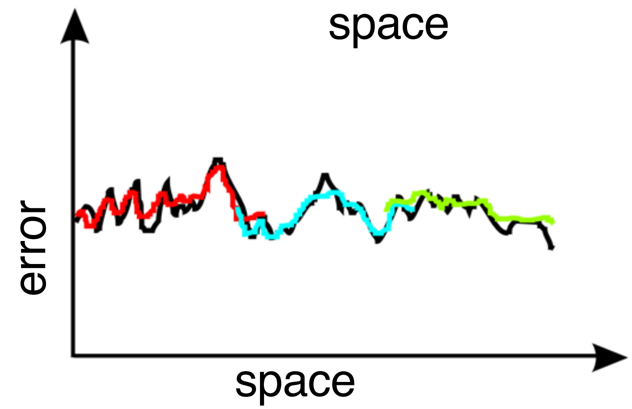



3) Partitioning (Fukumori, *MWR, 2002*).

$$\delta\mathbf{x} \approx \mathbf{B}_1\delta\mathbf{x}_1' + \quad + \mathbf{B}_L\delta\mathbf{x}_L' \approx \sum_{i}^{L}\mathbf{B}_i\delta\mathbf{x}_i'$$

$$\dim(\delta\mathbf{x}) \qquad \dim(\delta\mathbf{x}_i')$$

$$\mathbf{P} \approx \sum_{i}^{L}\mathbf{B}_i\mathbf{P}_i'\mathbf{B}_i^{T}, \qquad \mathbf{P}_i' \equiv \left\langle \delta\mathbf{x}_i'\delta\mathbf{x}_i'^{T} \right\rangle$$

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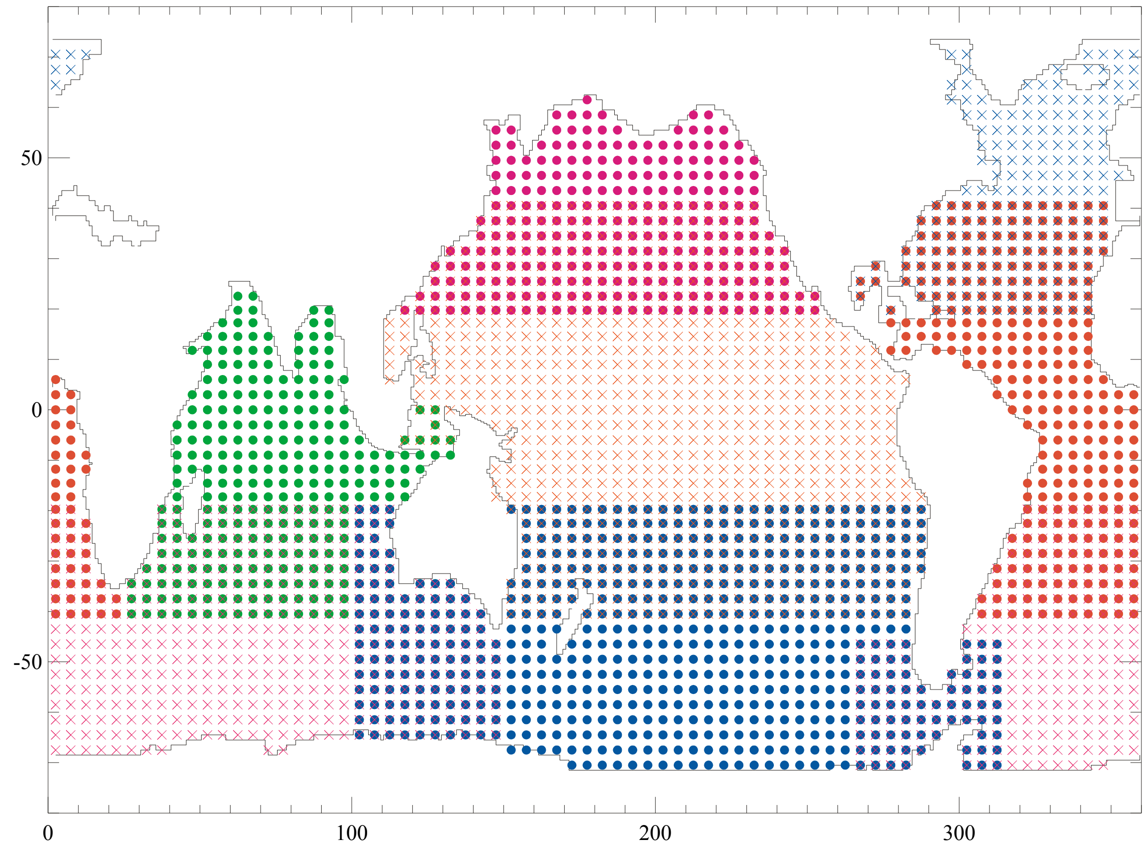
# ECCO Approximate KFS

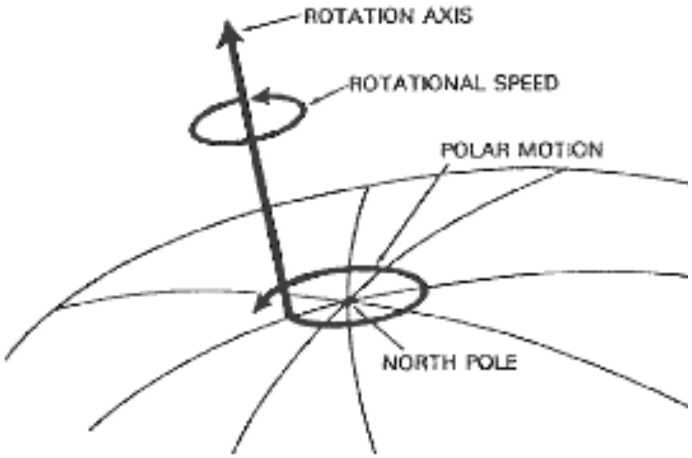



- Global barotropic cell: global 6°× 6° grid, barotropic UVH
- 7 regional baroclinic cells: regional 5°× 3° grid, baroclinic UVD (5 gravest modes)

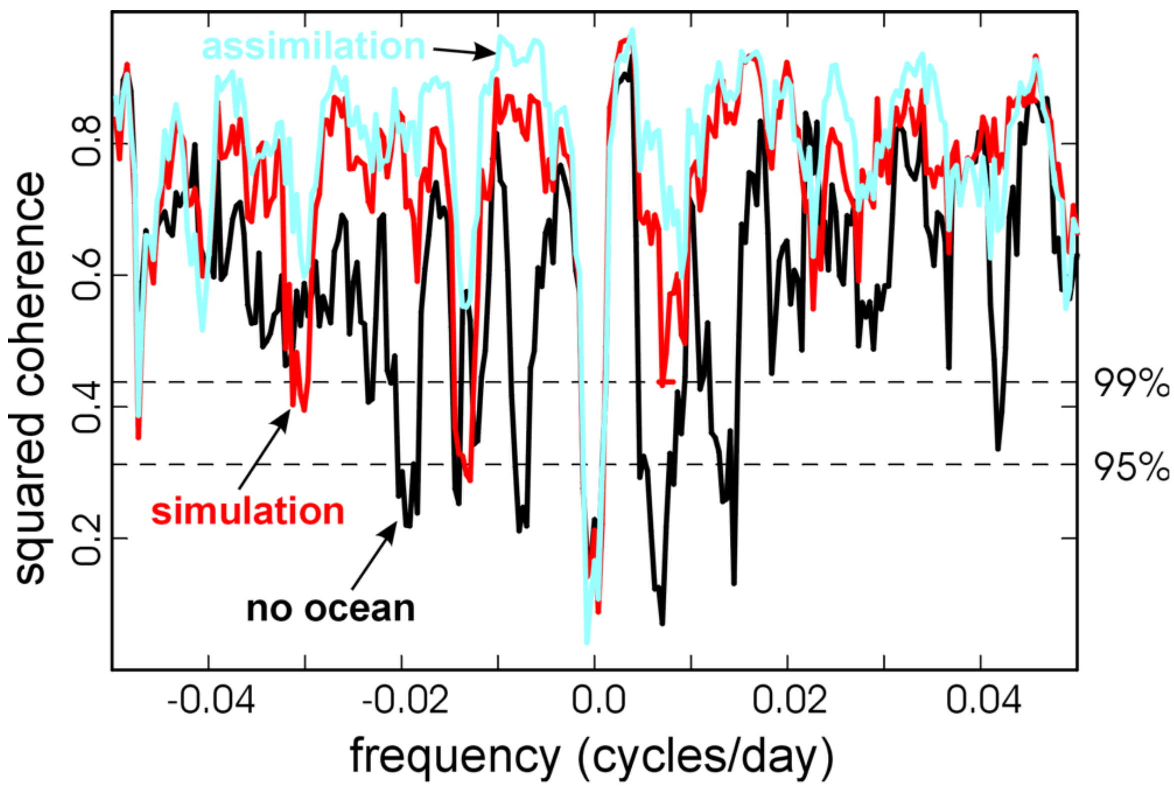
I.Fukumori/JPL

# Skill (Geodetic Applications)

Comparison to independent data: ECCO assimilation explains observed polar motion better than ocean simulation does.




**Coherence of observed & modeled excitation**




*(Gross et al., 2003, JGR)*

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# Error Estimate

Model-data residuals should be comparable to expectation

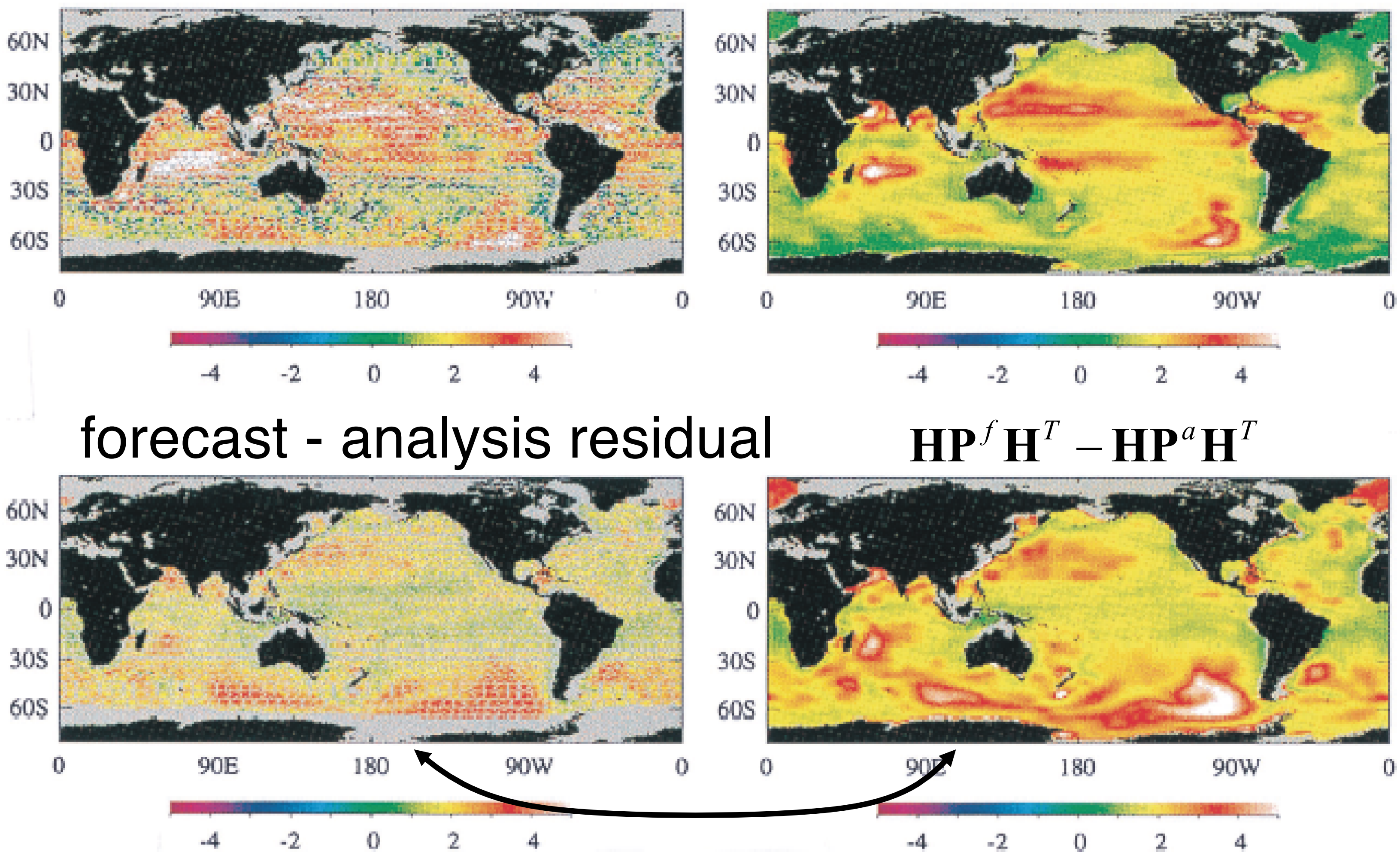
1st order consistency

simulation - forecast residual

$$\mathbf{HP}_{sim}\mathbf{H}^T - \mathbf{HP}^f\mathbf{H}^T$$

forecast - analysis residual

$$\mathbf{HP}^f\mathbf{H}^T - \mathbf{HP}^a\mathbf{H}^T$$

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