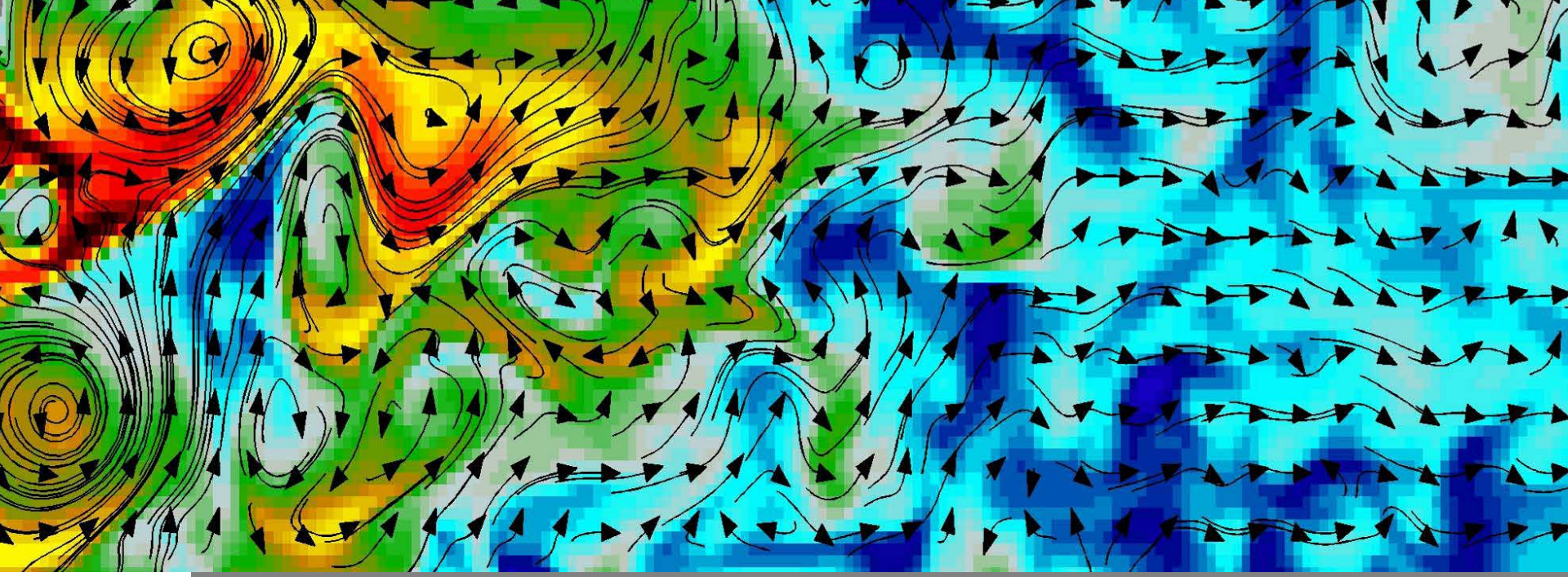

Error estimates for a data assimilation system: what modellers really need

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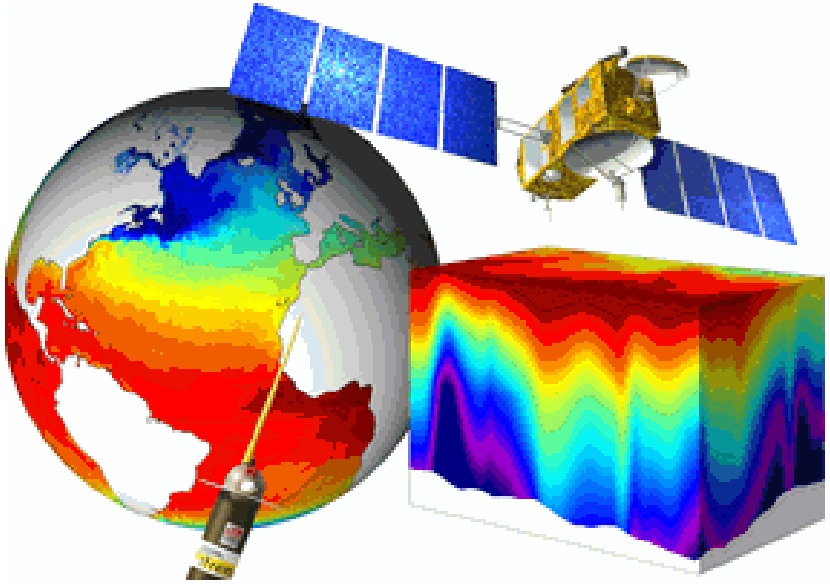
"The most exciting phrase to hear in science, the one that heralds the most discoveries, is not 'Eureka!', but 'That's funny…' ", Isaac Asimov (1920-1992)

www.cmar.csiro.au/staff/oke/

Outline

- GODAE data assimilation systems
- Error estimates for data assimilation
  - Instrument Error
  - Representation Error
  - Age Error
- What might we have missed?
- Conclusions

GODAE OceanView



GODAE data assimilation systems

All systems require explicit estimates of observation errors, like …

$$(\text{OBS ERR})^2 = (\text{INS ERR})^2 + (\text{REP ERR})^2 + (\text{AGE ERR})^2$$

Table 1. Data assimilation methods used by GODAE systems

System Name	Country	Data Assimilation Method	Reference
BODAS	Australia	Ensemble Optimal Interpolation	Oke et al., 2008
ECCO-JPL	USA	Kalman filter and smoother	Fukumori, 2002
FOAM	UK	Analysis Correction	Martin et al., 2007
Mercator	France	Static SEEK filter	Brasseur et al., 2005
MOVE/MRI.COM	Japan	Multivariate 3DVAR	Fujii and Kamachi, 2003
NCODA	USA	Multivariate Optimal Interpolation	
NEMOVAR	European Union	Multivariate Incremental 3DVAR	
TOPAZ	Norway	Ensemble Kalman filter	

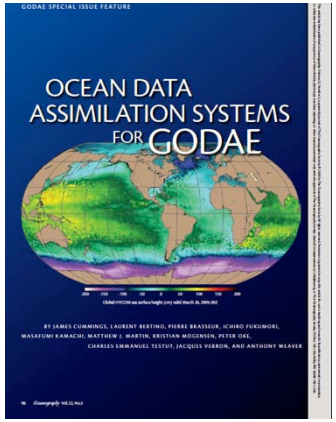


Table 2: Observing systems assimilated by each of the GODAE systems

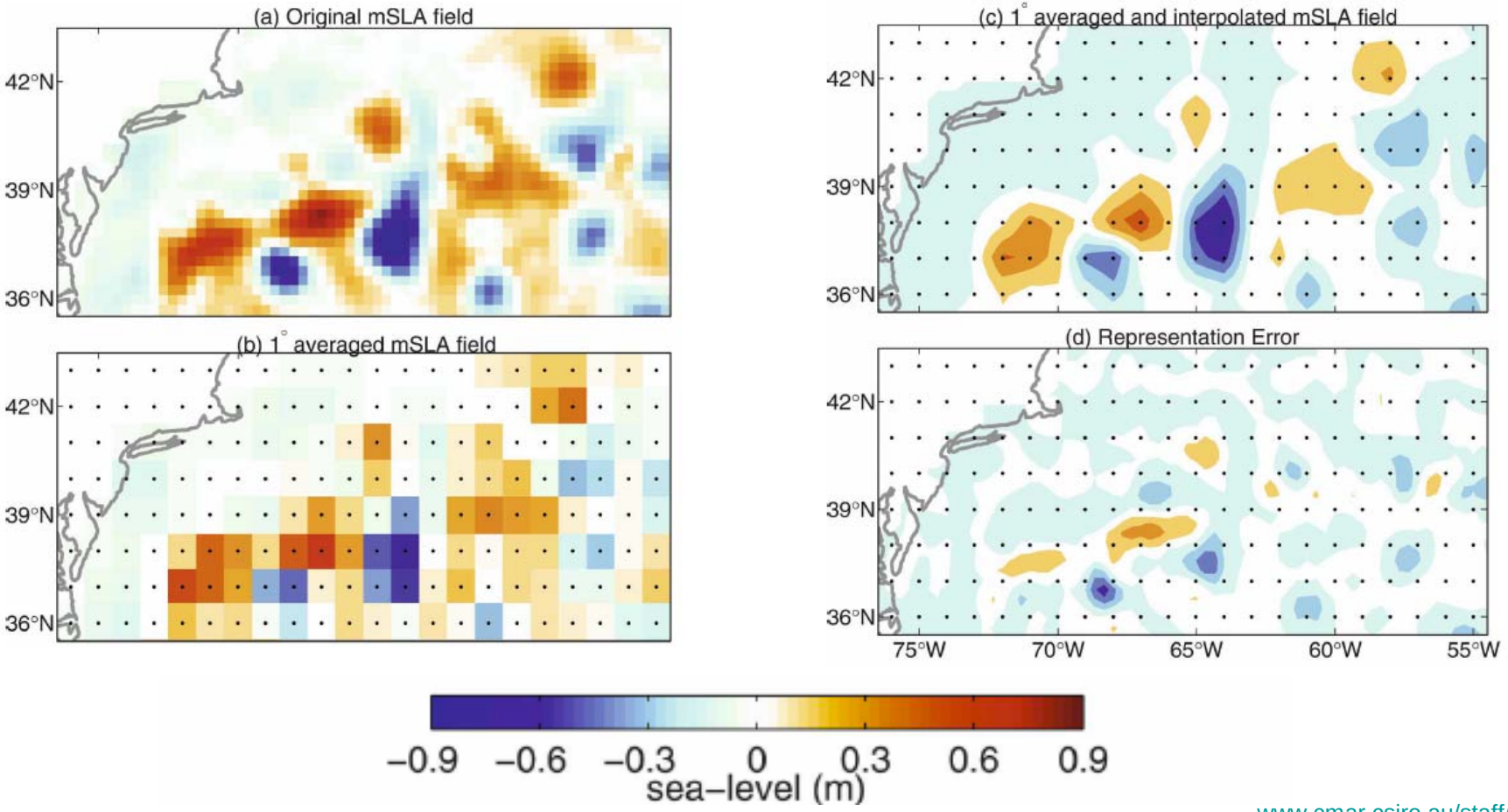
System	Sea Level	Subsurface Temperature and Salinity	Surface Temperature	Sea Ice
BODAS	Along-track data from satellite altimeters, coastal tide gauges	Argo, CTD, XBT, and moorings	Satellite data	
ECCO-JPL	Along-track data from TOPEX/ Poseidon and Jason-1	Argo, CTD, XBT, and moorings	Reynolds SST analysis	
FOAM	Along-track data from satellite altimeters	Argo, CTD, XBT, and moorings	In situ and satellite data	OSI-SAF sea ice analysis
Mercator	Along-track data from satellite altimeters	Argo, CTD, XBT, and moorings	NOAA RTG SST analysis	
MOVE/MRI.COM	Along-track data from all satellite altimeters	Argo, CTD, XBT, and moorings	MGDSST SST analysis	MGDSST sea ice analysis
NCODA	Along-track data from satellite altimeters	Argo, CTD, XBT, moorings, drifting buoys, and gliders	In situ and satellite data	SSM/I and SSMIS sea ice concentration
NEMOVAR	Along-track data from satellite altimeters	Argo, CTD, XBT, and moorings	In situ and satellite data	
TOPAZ	Gridded sea level anomaly maps	Argo	Reynolds SST analysis	AMSR sea ice concentration and sea ice drift products

Instrument Error

- Instrument dependent guestimate:
  - Jason 1, 2, T/P = 3 cm
  - Envisat, ERS-1, ERS-2, GFO = 5 cm

Representation Error

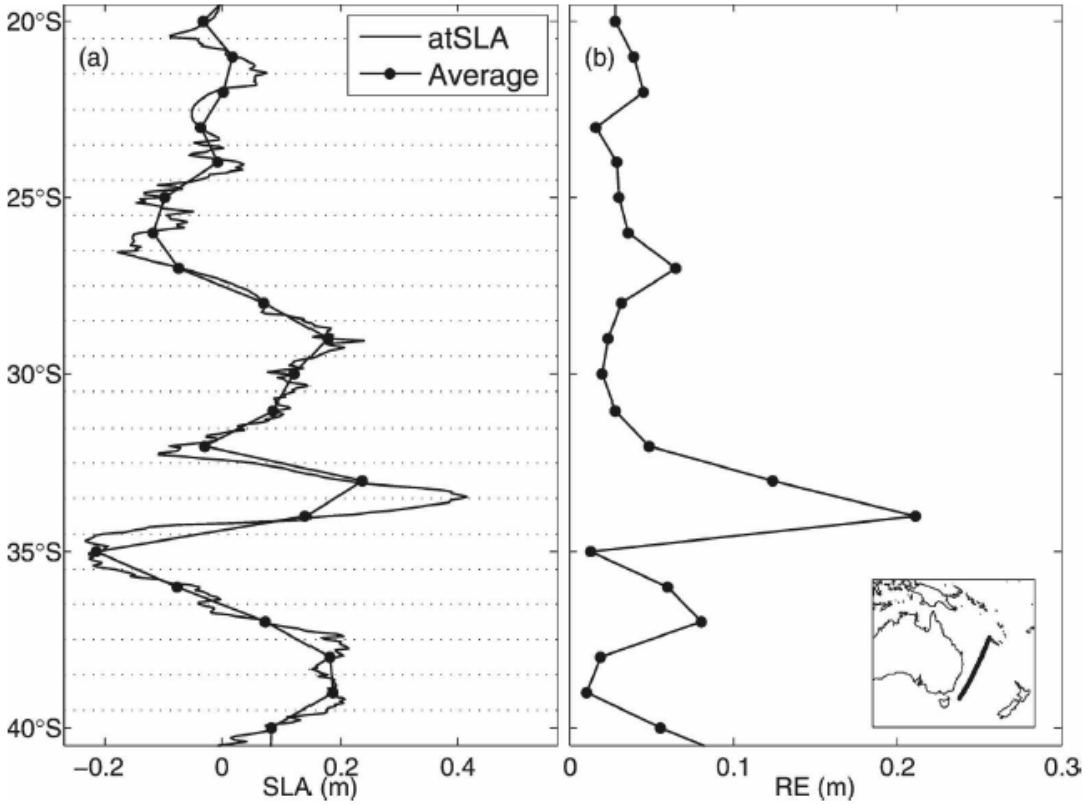
- Observations don't usually measure what the model wants
- The difference is treated as error by a DA system



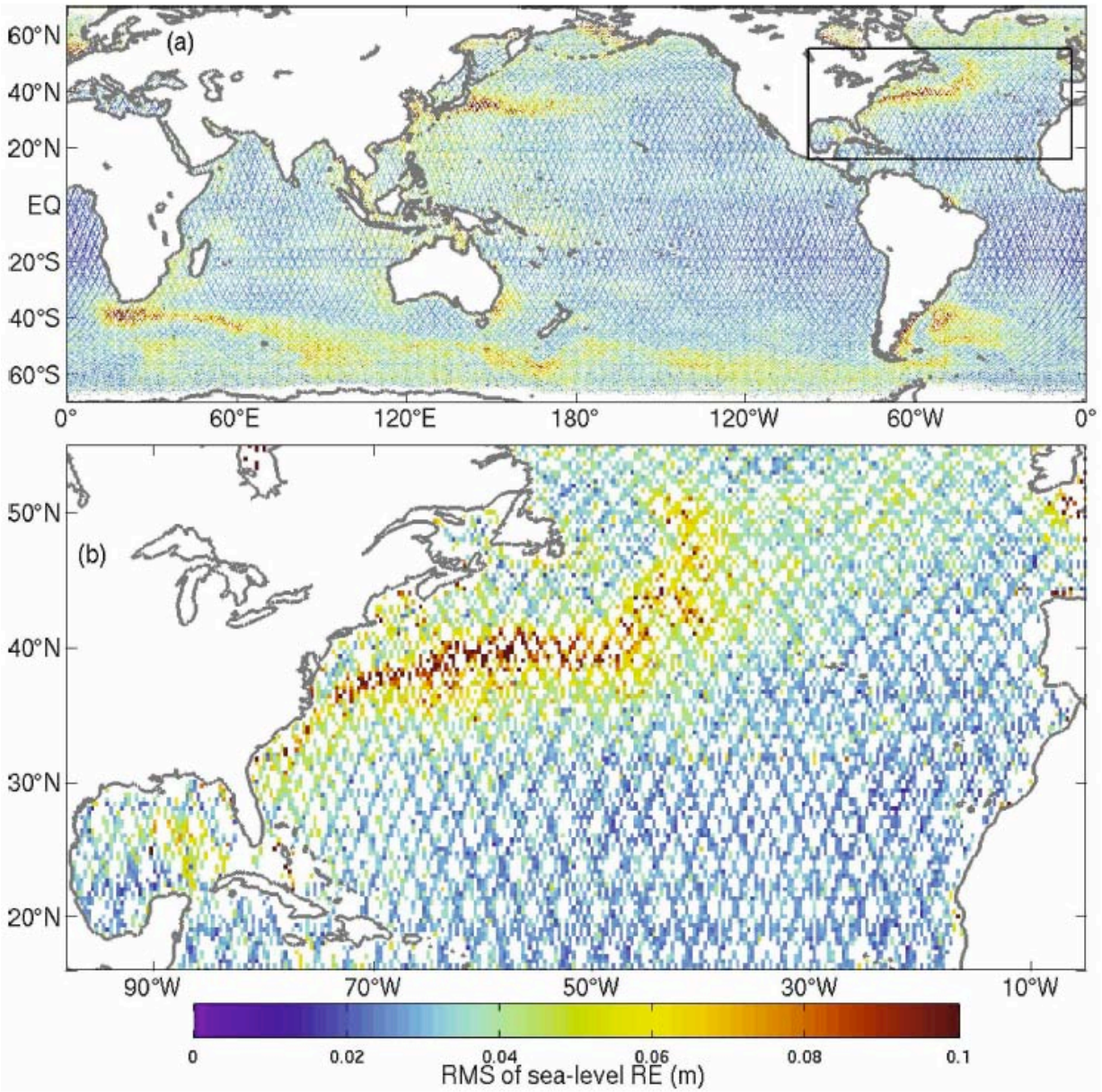
Representation Error

- Representation error is the sub-grid scale variability
- Can be estimated for coarse resolution applications from observations

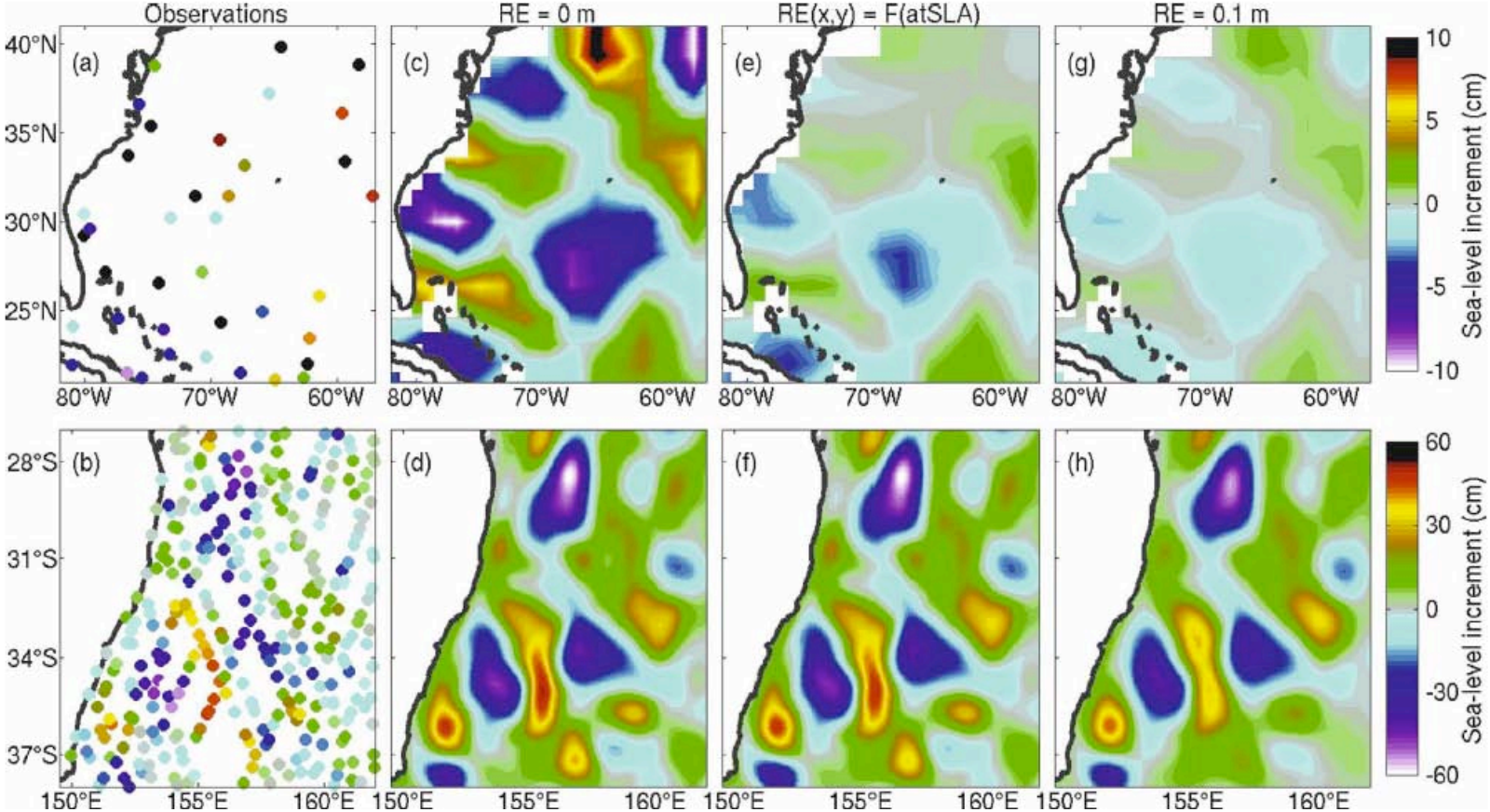
… obs-based estimate always under-estimate



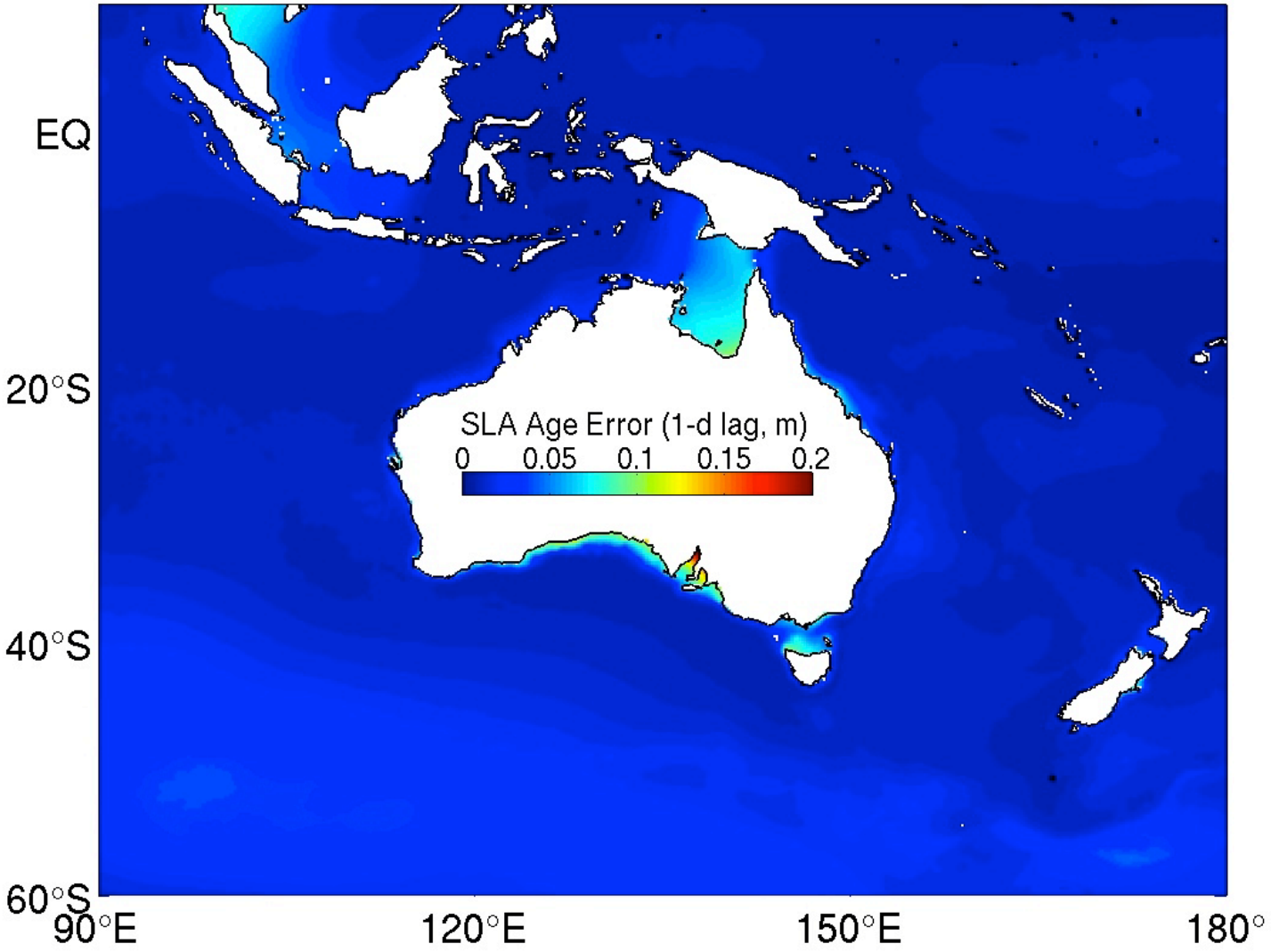
Representation Error Estimates for a 1/3 degree model



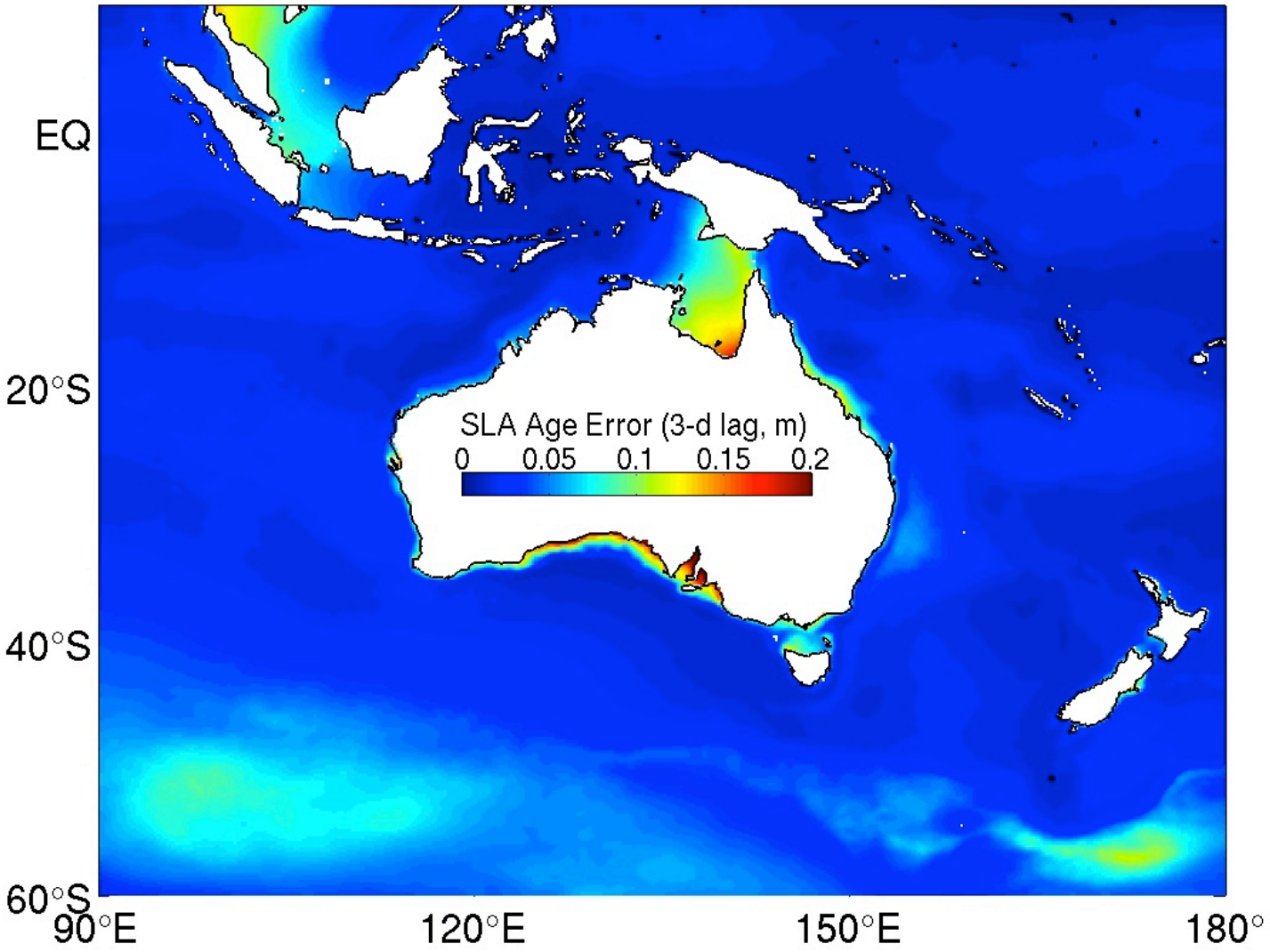
Impact of error estimates on analyses



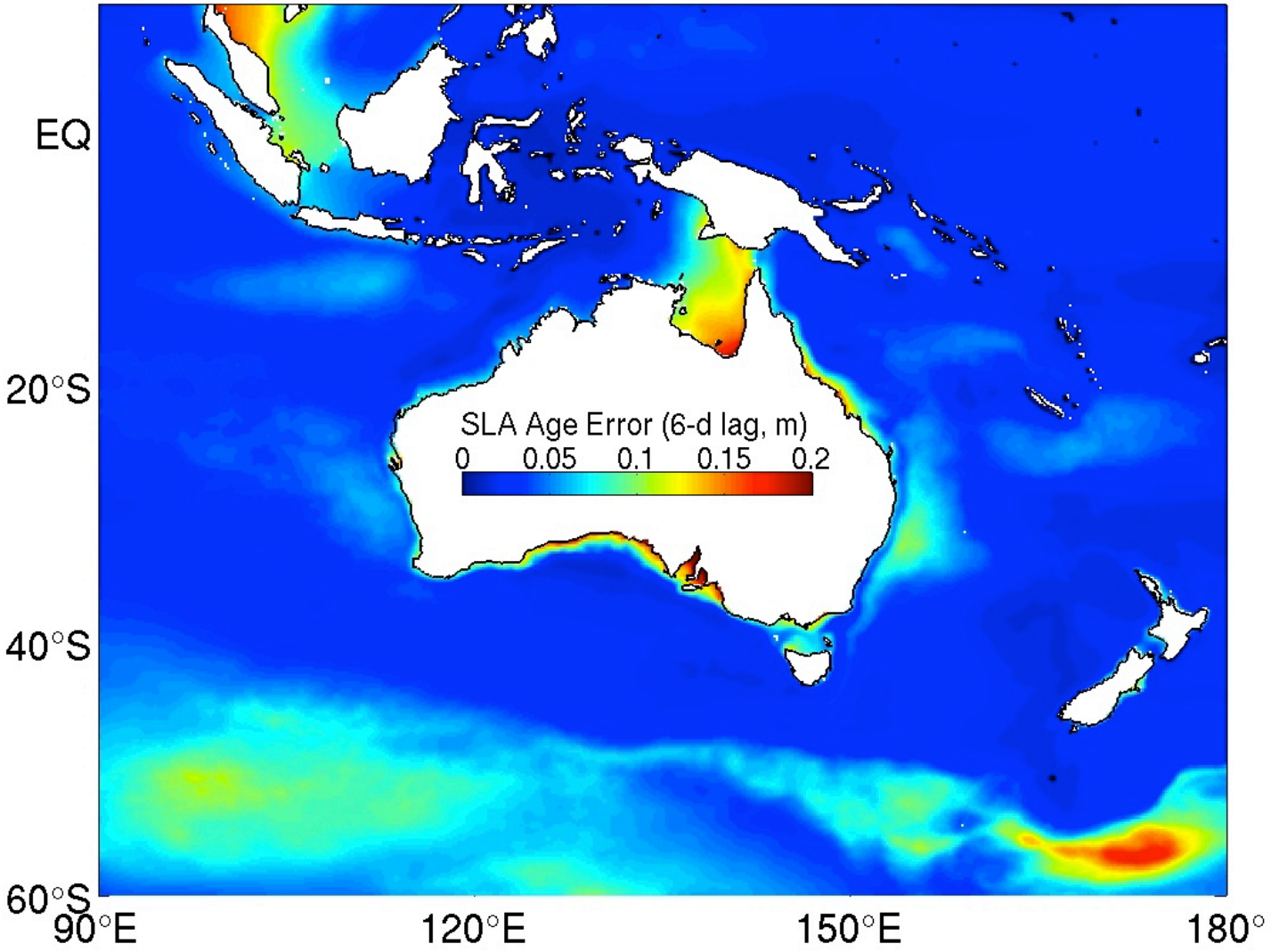
Age error (1-day)



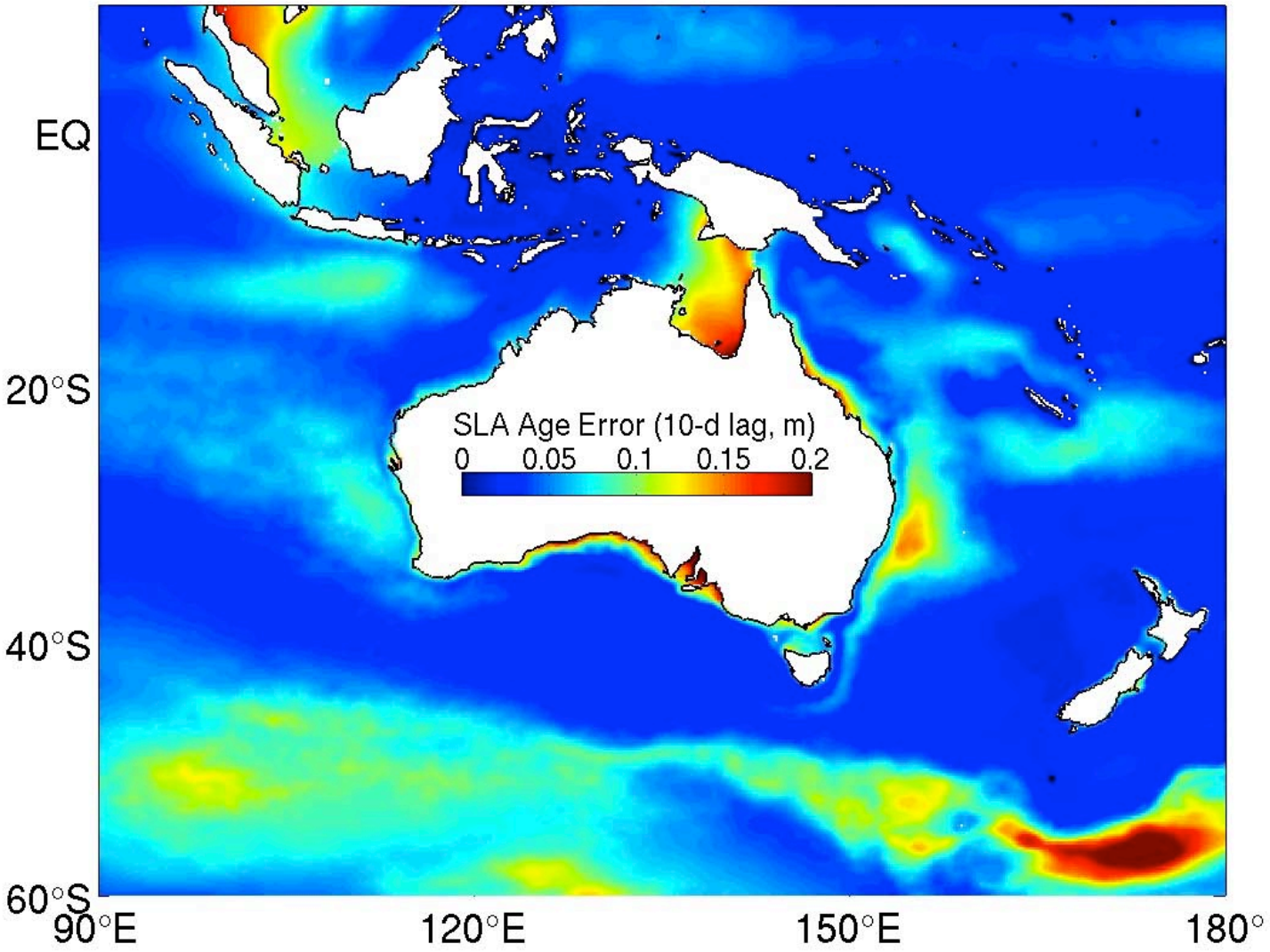
Age error (3-day)



Age error (6-day)



Age error (10-day)



GODAE data assimilation systems: error estimates

$$(\text{OBS ERR})^2 = (\text{INS ERR})^2 + (\text{REP ERR})^2 + (\text{AGE ERR})^2$$

… are our guestimates rigorous enough?

… can you help?

Table 2: Observing systems assimilated by each of the GODAE systems

System	Sea Level	Subsurface Temperature and Salinity	Surface Temperature	Sea Ice
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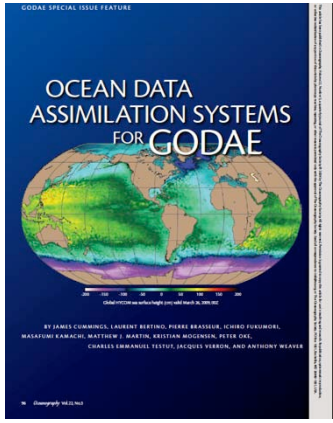
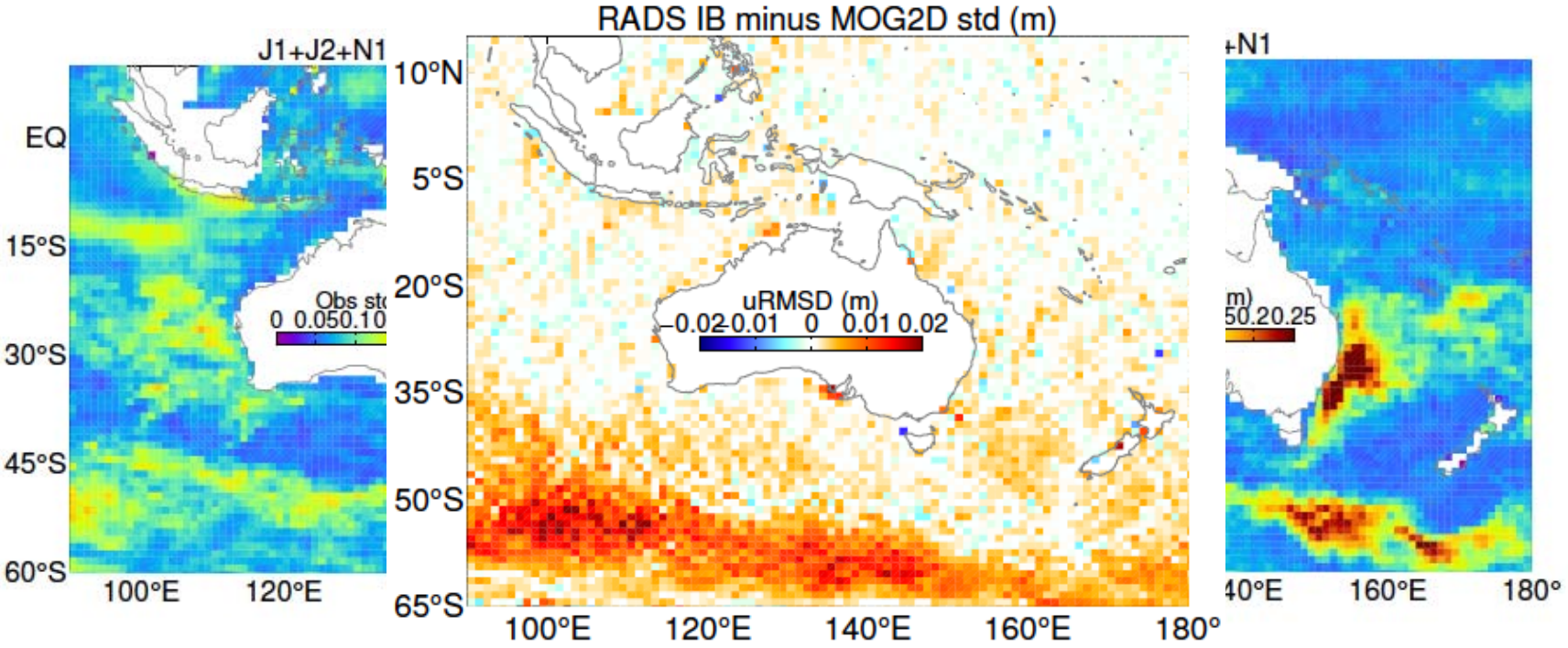


What might we have missed?

What corrections should be applied?

- IB-correction? Yes … if atm pressure is not used
- Tidal correction? Yes … if model doesn't resolve tides or if we're not trying to correct the tide
- MOG2D? … excludes the ocean's barotropic response to winds (pers. comm. A. Taylor, BoM)



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- What else have we missed?

Most systems assimilate along-track data … we need to be careful about what corrections are applied?

Our model's are volume conserving … so should we process altimeter data so that it is also volume conserving?

What might we have missed?

What can model's reproduce?

- Greatbatch (1994; JGR, vol 99) made the point that most OGCMs make a Boussinesq approximation and conserve volume, rather than mass … so they don't represent thermal expansion … but sea-level from altimeter data does …

  so …

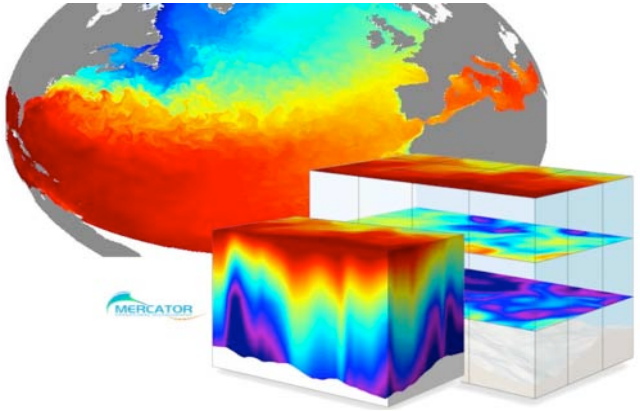
Conclusions

- Ocean data assimilation systems developed under GODAE and GODAE OceanView are maturing
- All DA systems require explicit error estimates for observations

… please help

- Many decisions are made when we specify observation errors
  - Are we being rigorous enough?
- What else are we missing?
- Guidance/feedback/review from observational community is essential

GODAE OceanView



Abstract

Several ocean forecast systems have been developed under the Global Ocean Data Assimilation Experiment (GODAE) and its successor, GODAE OceanView. Each system uses data assimilation to combine model fields with a range of observations, including satellite altimetry, Argo, and satellite SST. Error estimates for all observations are important, and control the impact of each observation on the analysis and forecast system. Modellers prefer to over-estimate, rather than under-estimate, observation errors, for fear of over-fitting. Over-fitting an observation, particularly a bad observation, can degrade the quality of an entire forecast and compromise future forecasts for multiple subsequent forecasts. There are typically two components of error considered for each observation - an instrument error, and a "representation" error. The representation error is typically the dominant component and depends on the application. Representation error of an observation for a coarse-resolution model is much greater than the representation error of the same observation for a high-resolution model. This is because for a coarse-resolution application, the observation "represents" different processes and dynamics than the observation. If the observation represents eddies, for example, but the model doesn't, then the signal of the unrepresented eddy should be treated as an observation error. Even a perfect observation that faithfully measures reality should be assigned a representation error for a data-assimilating model. A description of how representation error is typically estimated for GODAE systems will be outlined, along with a series of examples demonstrating the impact of different estimates.