eReefs biogeochemical data assimilation

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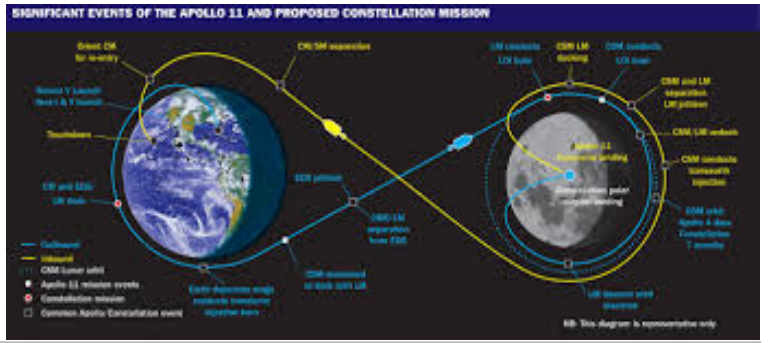
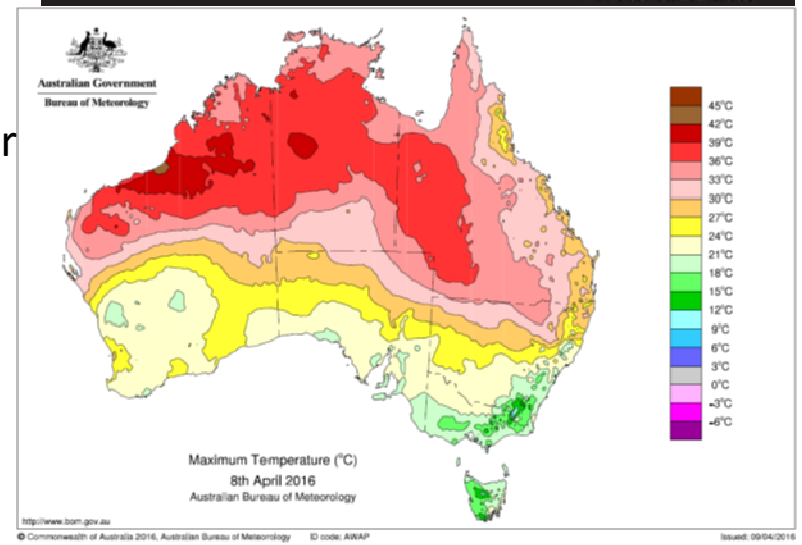
Why data assimilation (DA)?

- The modelling system (equations, parameter values, resolution and forcing functions) contains approximations and / or errors.
- Observations contain errors.
- Data assimilation provides a means to correct for both observation and model errors, and to interpolate between observation points in a manner that is consistent with the proposed model.
- DA has been applied in many fields, such as spacecraft trajectories, weather forecasting etc.
- The particular DA system we apply, Kalman Filters are the backbone of GPS systems and weather forecasts. The BOM's analysis of today is from DA.





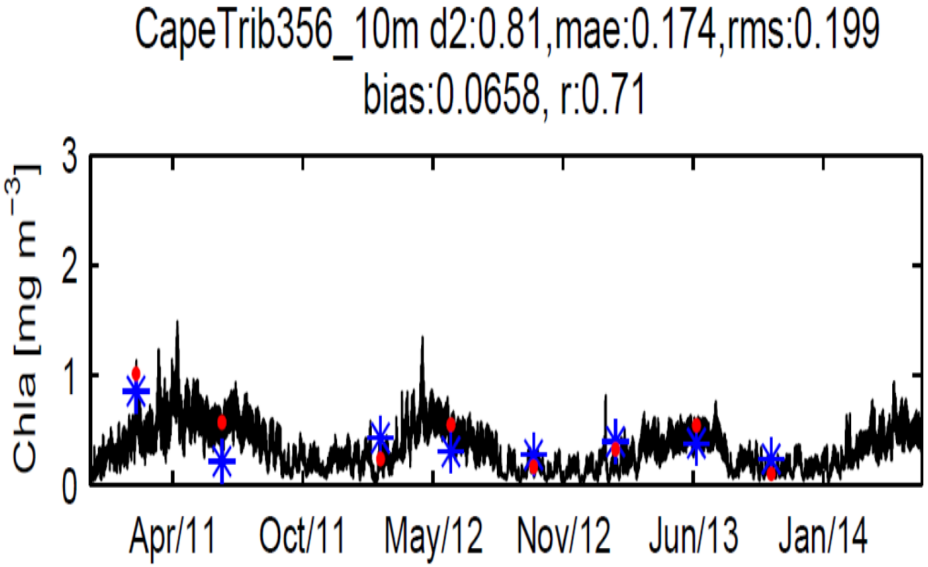
Ultimately the best estimate of the biogeochemical state (Chl concentration etc.) of the GBR will be determined by assimilating high quality observations into a skilful model.

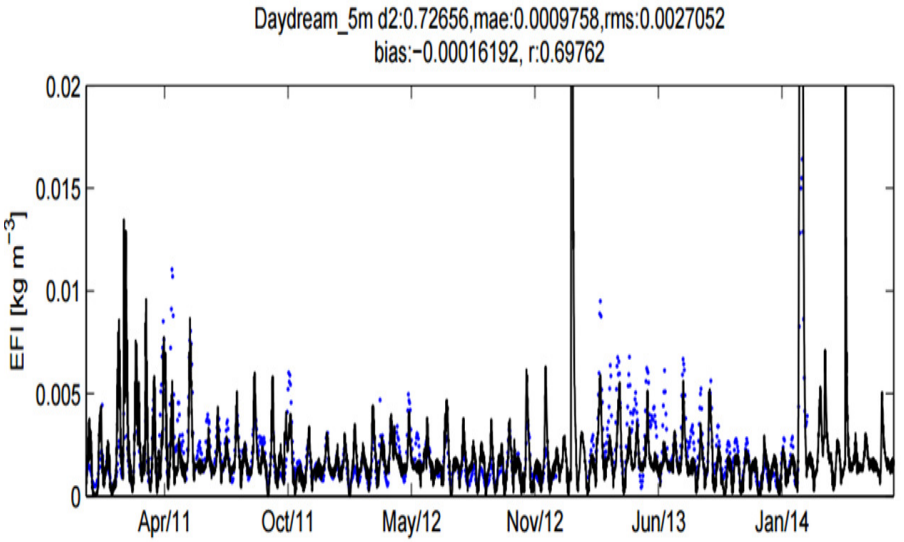
eReefs BGC Data Assimilation System

- Deterministic EnKF
  - 36 Members
  - Perturbed Initial Conditions
  - Perturbed loads in all rivers
  - Localization: Isotropic 50 km (Gaspari and Cohn, 1999)
  - Ensemble Inflation factor: 1.07
  - Forecast length: 5 days
  - Assimilation Window: +- 3hrs of 1200 local time
  - Assimilated Observations: MODIS OC3 Chl-a
  - Case Study Period: 20/5/13 – 20/8/13

The model is already pretty good, but we have prototype a DA simulation …

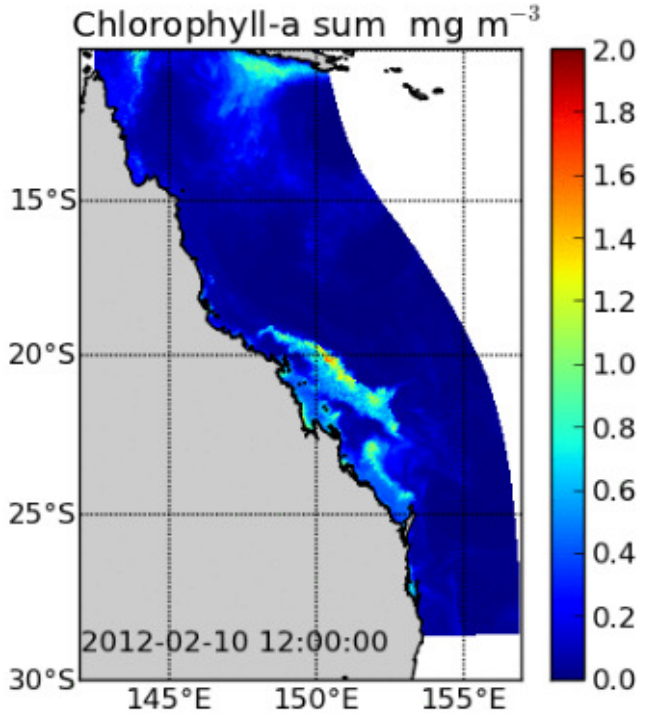
Surface chlorophyll concentrations were compared to 4-monthly water samples and had **a bias of -0.07 and a rms error of 0.33 mg m^{-3}** (example below left). **Total suspended solids** was compared to NTU on a mooring, with **a bias of -0.5 and a rms error of 1.0 g m^{-3}** (example below right)



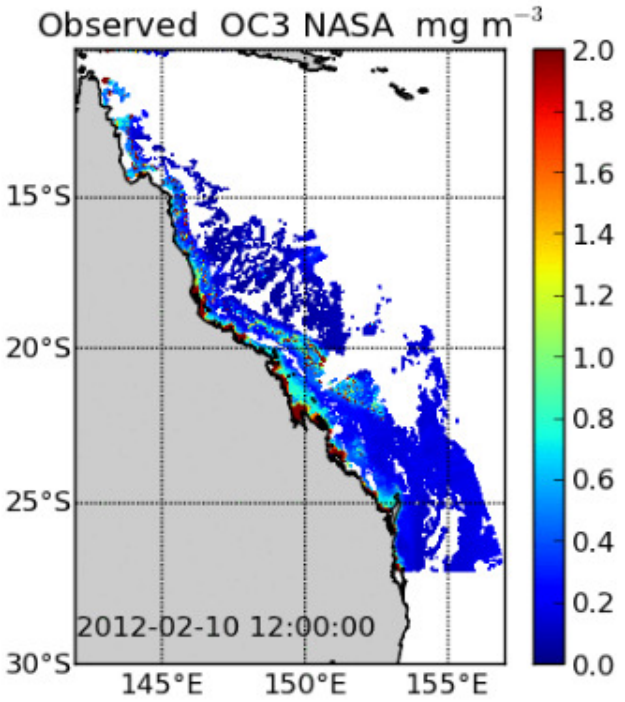


All other BGC data assimilation systems use the mis-match between satellite estimated chlorophyll and model chlorophyll – this introduces the errors of the chlorophyll algorithm, which we know can be large in coastal waters.

Error =

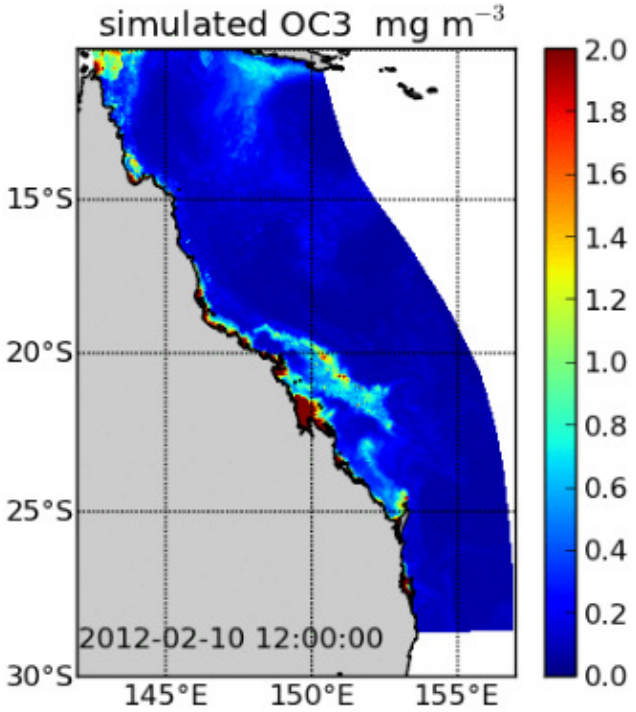


minus



Instead we use the mis-match between satellite estimated chlorophyll and chlorophyll calculated using the model simulated remote-sensing reflectance – the International Ocean-Colour Coordinating Group (IOCCG) acknowledged this.

Error =



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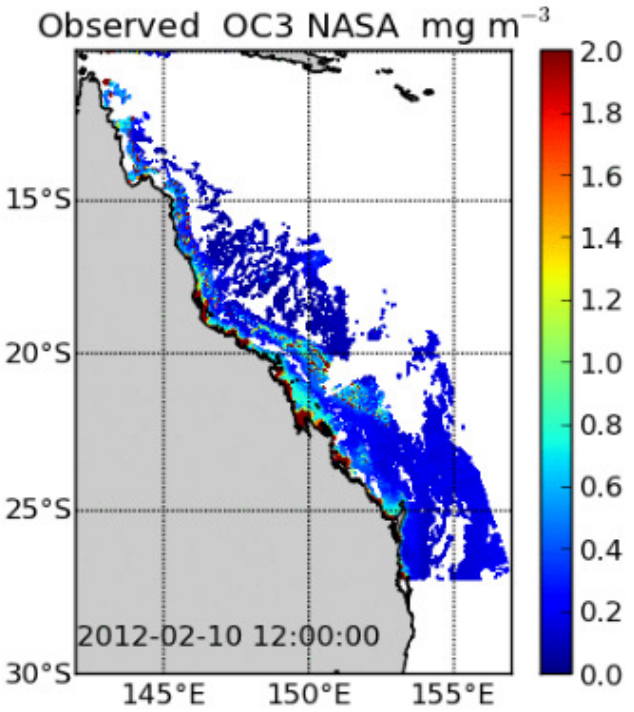
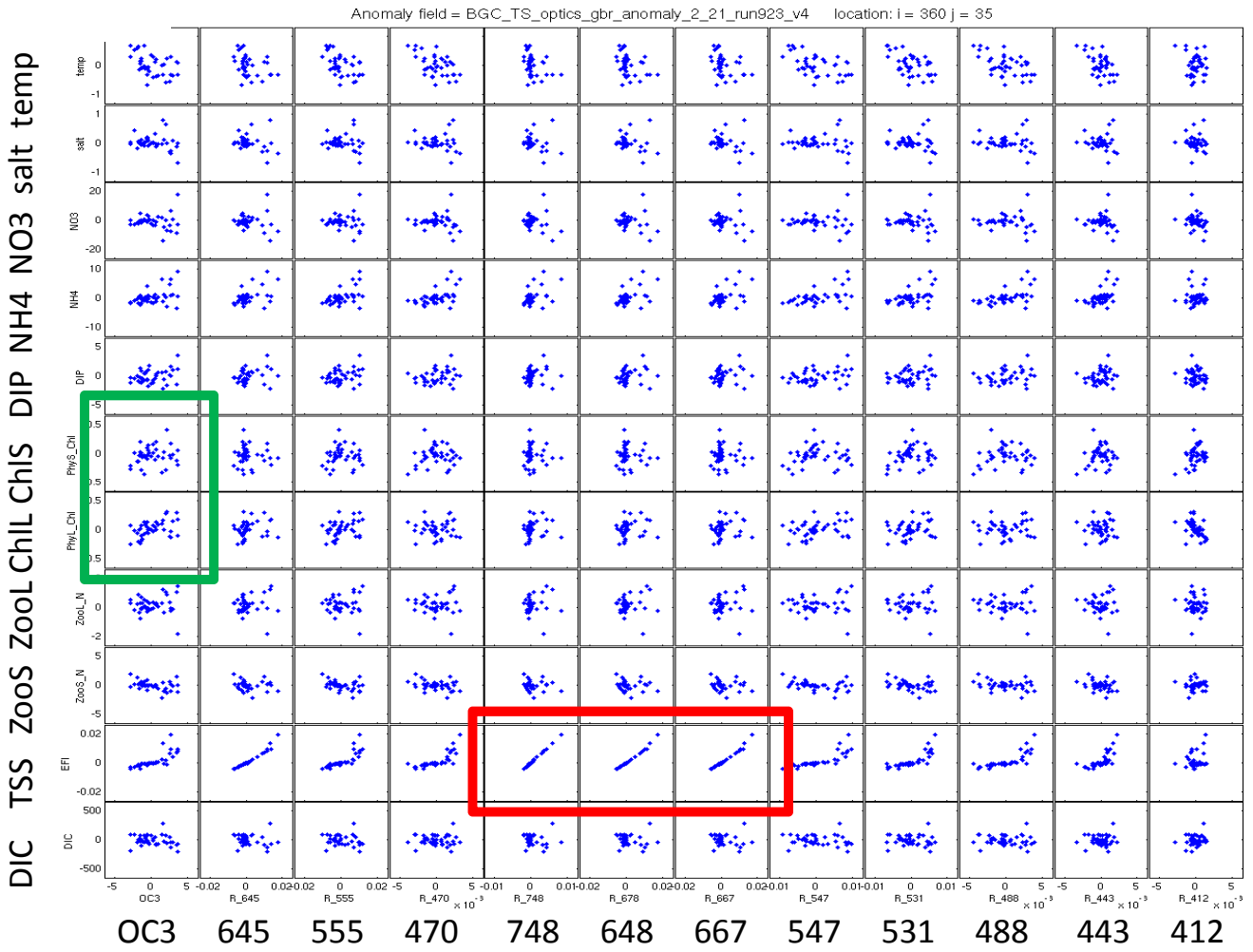
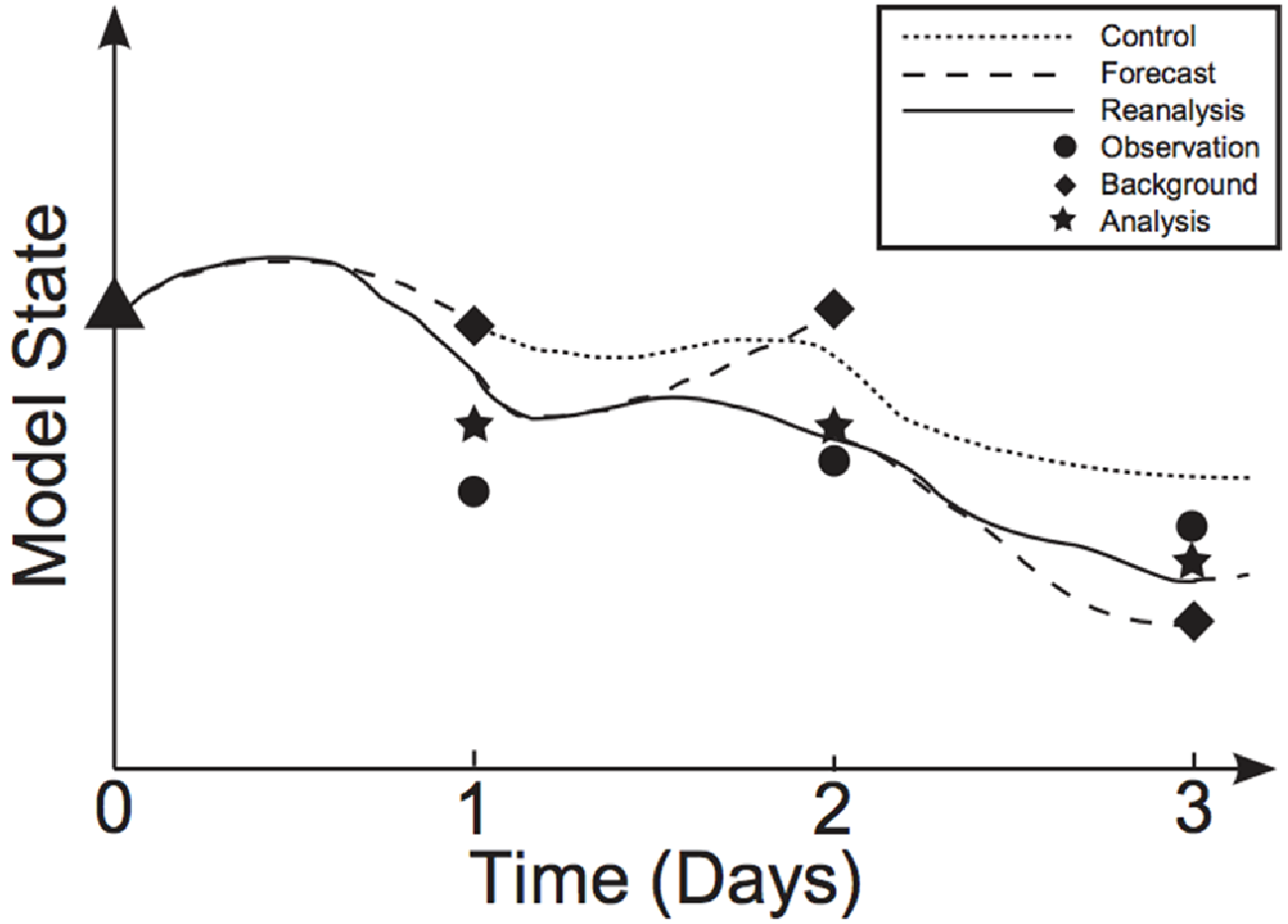


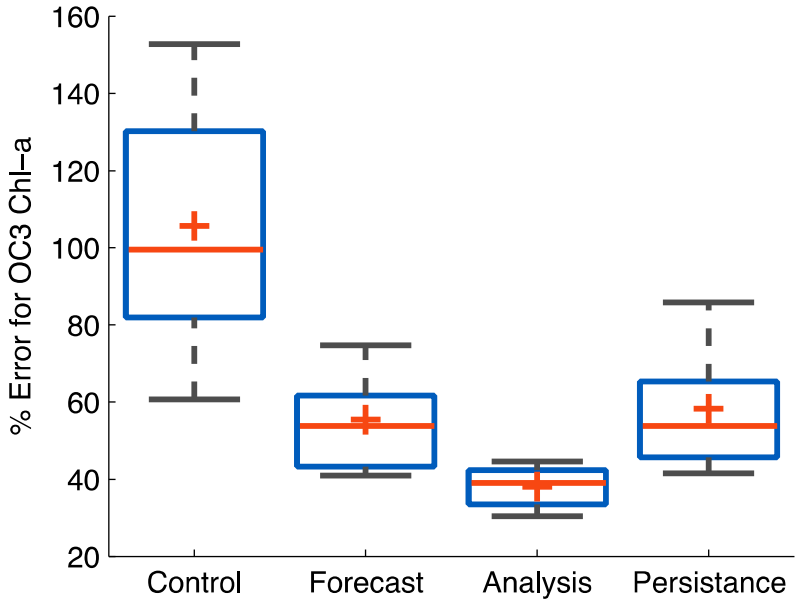
Does the remote-sensing reflectance correlate with the in water properties?

TSS vs red bands extremely well correlated.

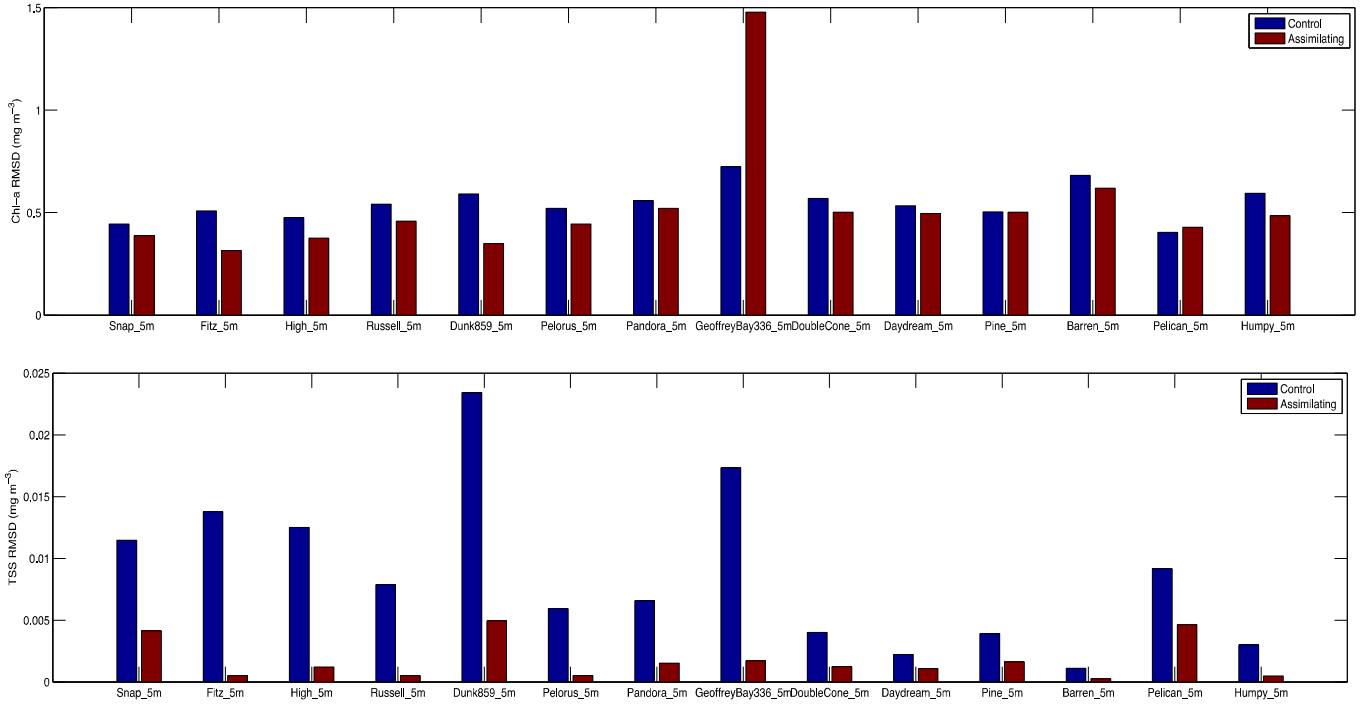
In situ chl and OC3 less so, but good enough for assimilation systems




Control
Forecast
Reanalysis
Observation
Background
Analysis
Model State
0
1
2
3
Time (Days)


% Error for OC3 Chl–a
160
140
120
100
80
60
40
20
Control
Forecast
Analysis
Persistance

How much do we improve in-situ observations? RMS error of control (blue) and assimilation (red) for in-situ obs: Chl-a (top) and TSS (bottom)

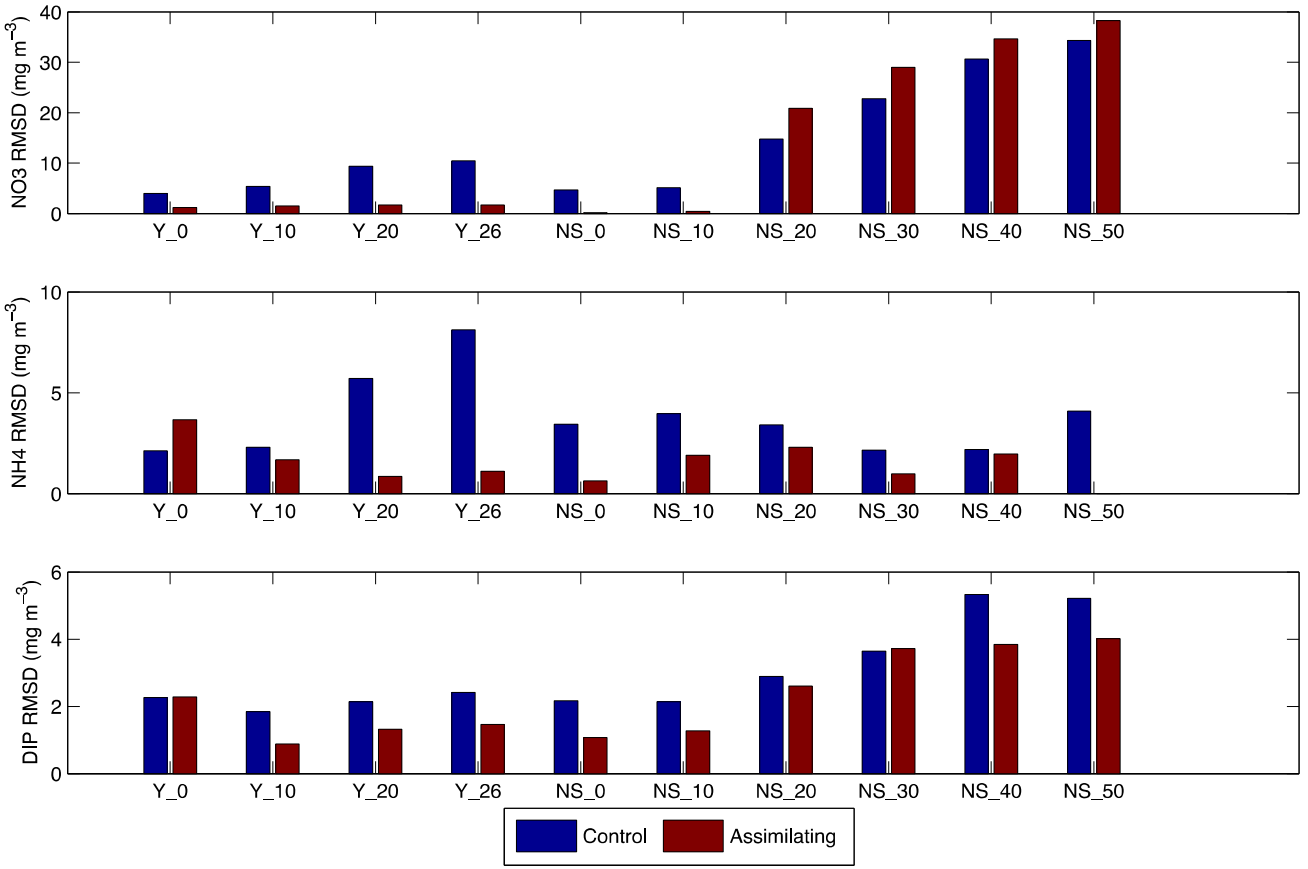


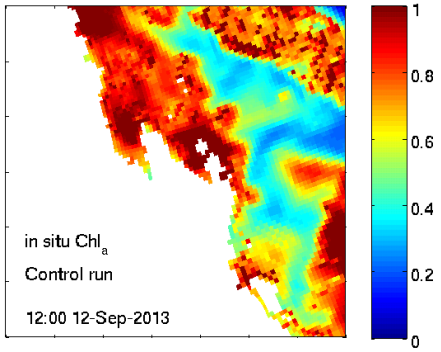
Slight improvement in Chla (which was already pretty good)

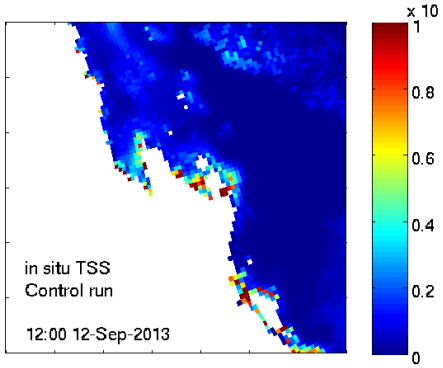
Large improvement in TSS

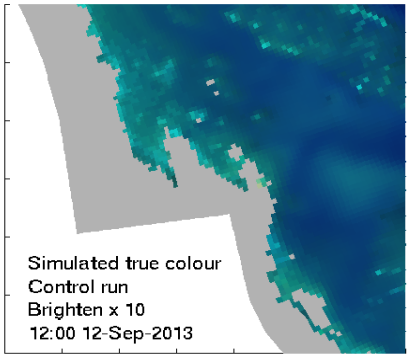
Geoffrey Bay site is too close to land for our 4 km model.

How much do we improve in-situ observations? RMS errors in dissolved nutrients: NO3 (top), NH4 (middle) and DIP (bottom)

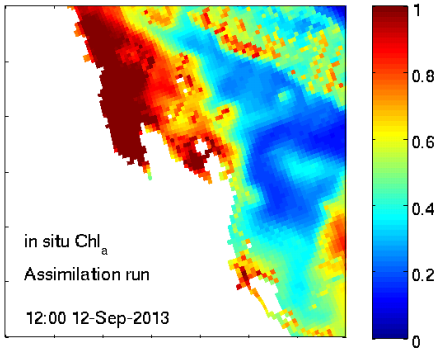


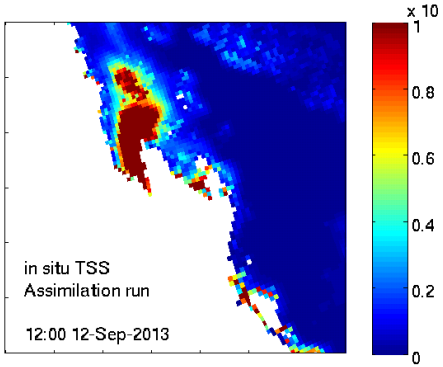


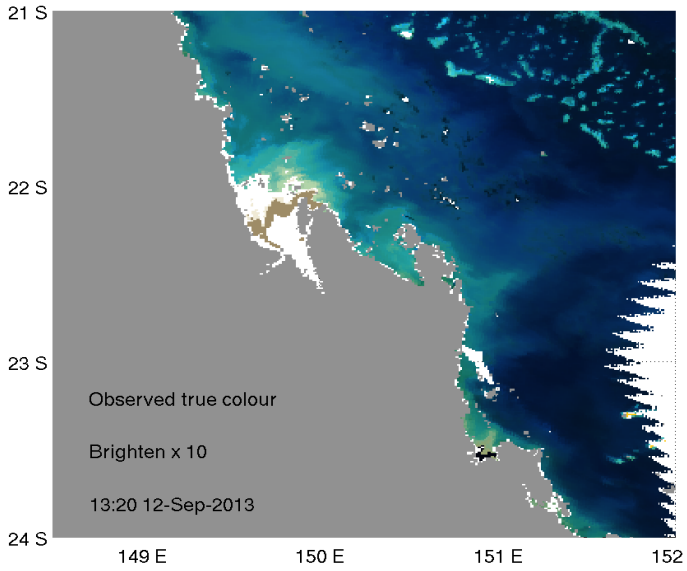




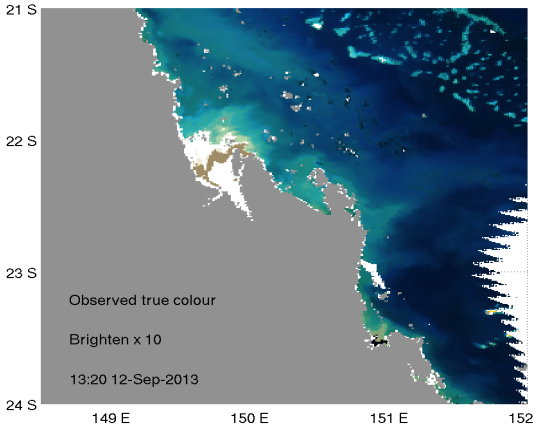
Mis-match in observed and control run remote-sensing reflectance – though correlation, assimilation run updates TSS and Chl.

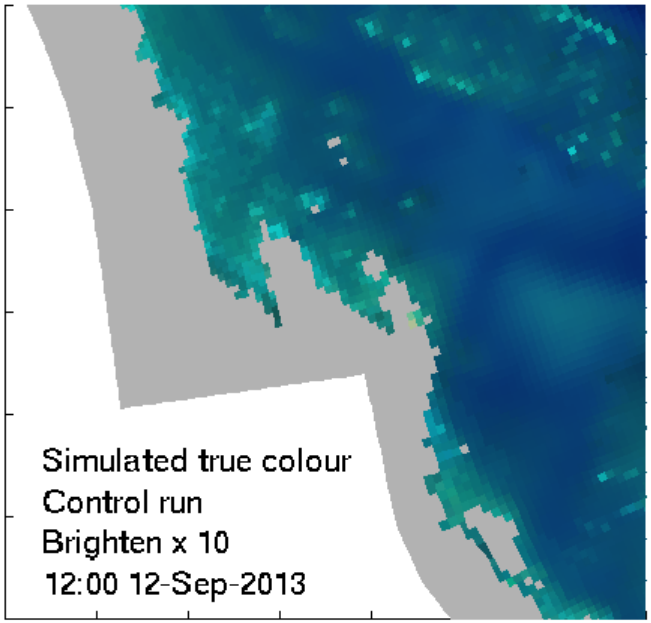


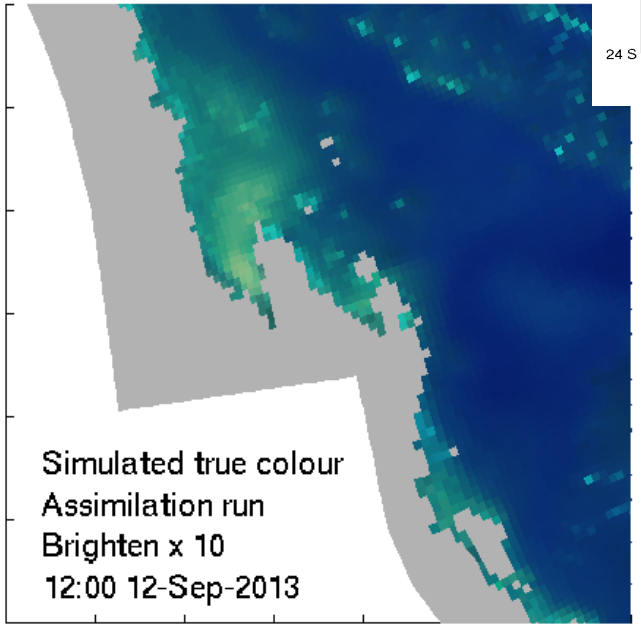




Updated simulated true colour shows improved model solution.







Analysis / re-analysis.

- We are all familiar with using analysis products generated by BOM.
- Better than either observations or models alone.
- An interpolation between observations using the dynamical structure found in the model.
- Relies on good quality, timely data streams (i.e. atmospherically-corrected RS, AIMS sites.)