Data Assimilation Research Centre

University of Reading

Data assimilation for an idealised coupled atmosphere-ocean model

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Motivation

What can experiments with idealised models tell us?

- Allows for more sophisticated experiments than in the operational setting, e.g.
  - Implementation of strongly coupled 4DVar.
  - Weak constraint formulation.
  - Estimation of coupled parameters
- Easier interpretation of results which can then inform the design of operational systems.

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Need to ensure our model, although simple, can replicate the same problems seen in the operational context.

The idealised model

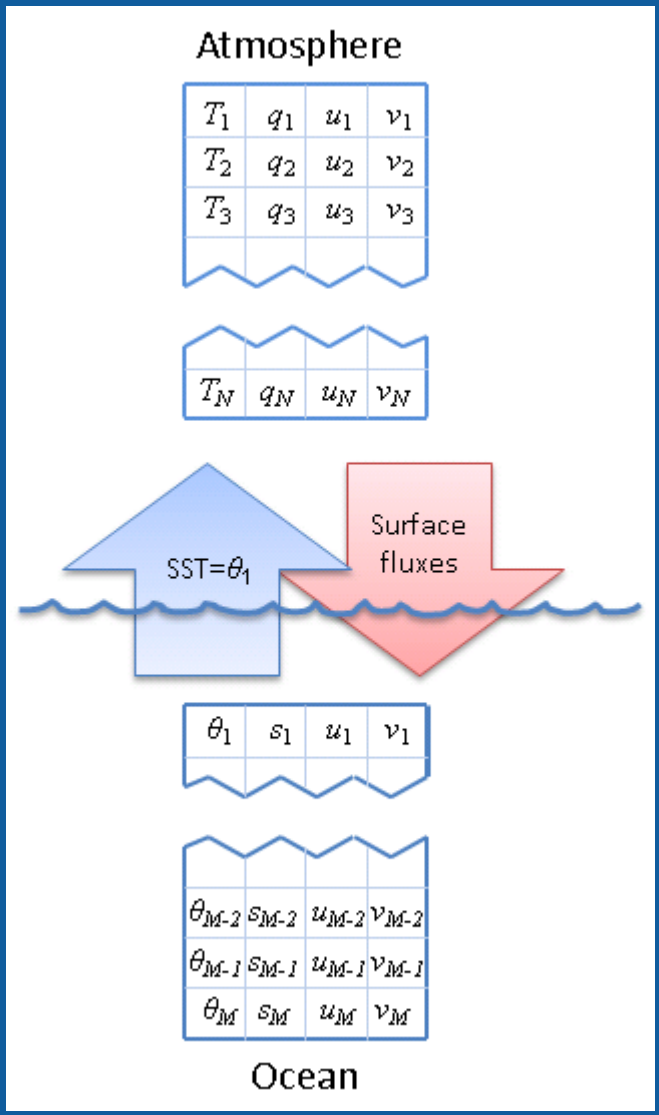
Atmosphere: based on the ECMWF's single column model:

- 4 state variables on 60 model levels (eta-coordinate system).
- Forced by large scale horizontal advection.

Ocean: based on the Large et al. KPP model:

- 4 state variables on 35 model levels (increased resolution close to the surface)

Coupled via SST's and surface fluxes of heat, moisture and momentum.



The idealised model

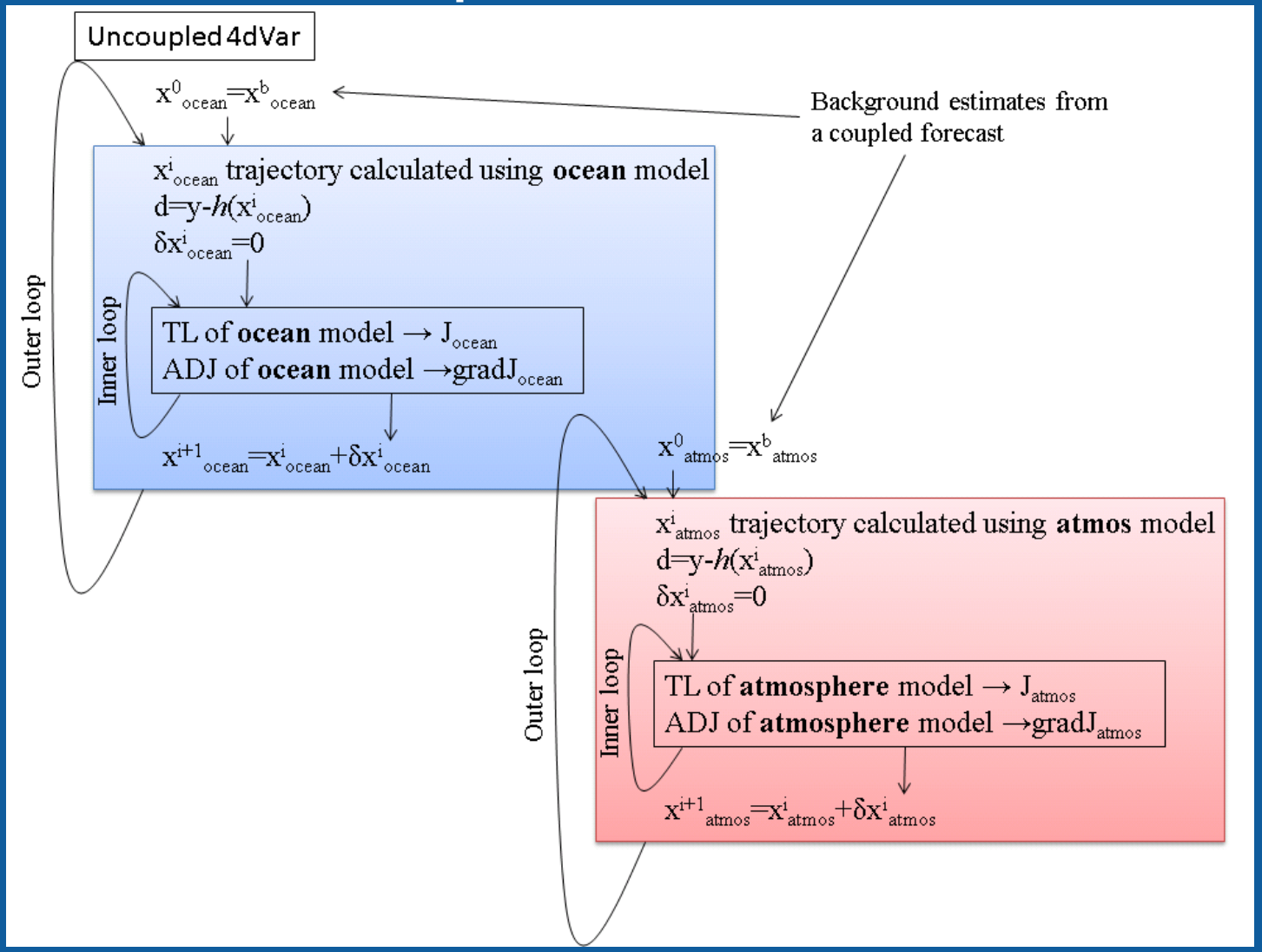
Simplifications for 4DVar:

- Have reduced the atmospheric model to the adiabatic scheme with parameterisation schemes for the vertical diffusion and the moisture, LH, SH and momentum surface fluxes.
  - Forced by read in SW and LW surface radiative fluxes.
- The non-local turbulent mixing term in the KPP-model has been switched off.

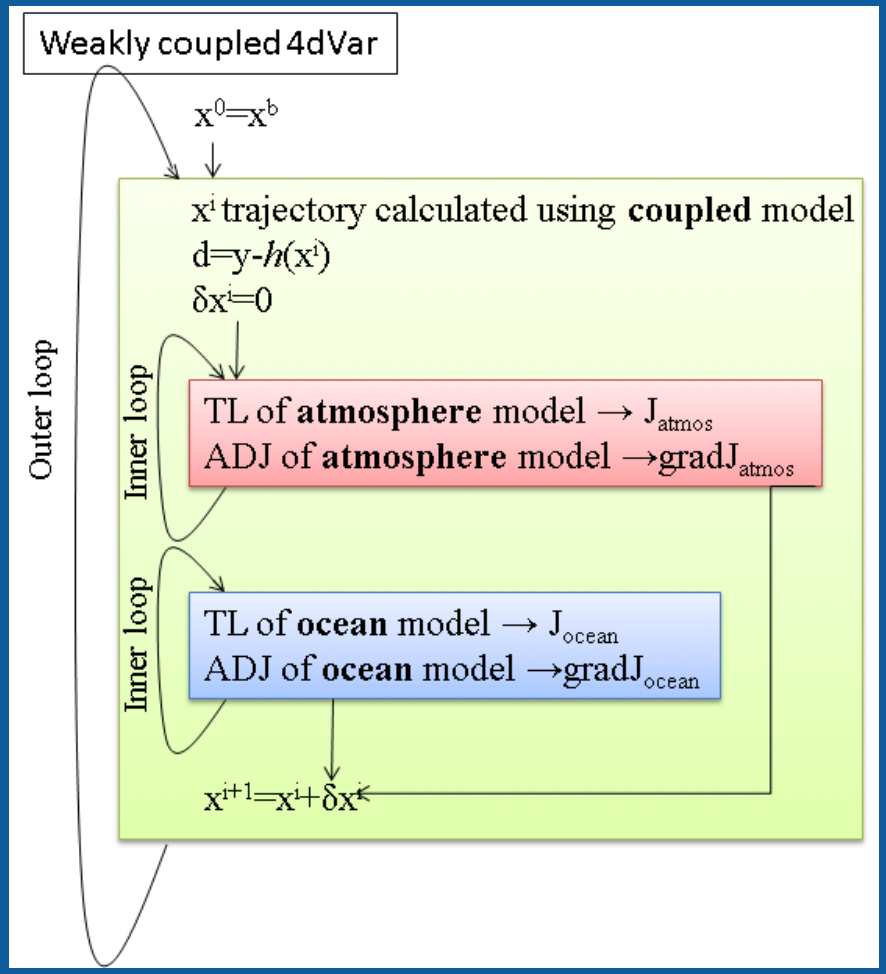
4DVar development

- Have developed the TL and adjoint of the simplified model.
- Developed an incremental 4Dvar scheme.
- Can be run in strongly or weakly coupled mode or uncoupled.

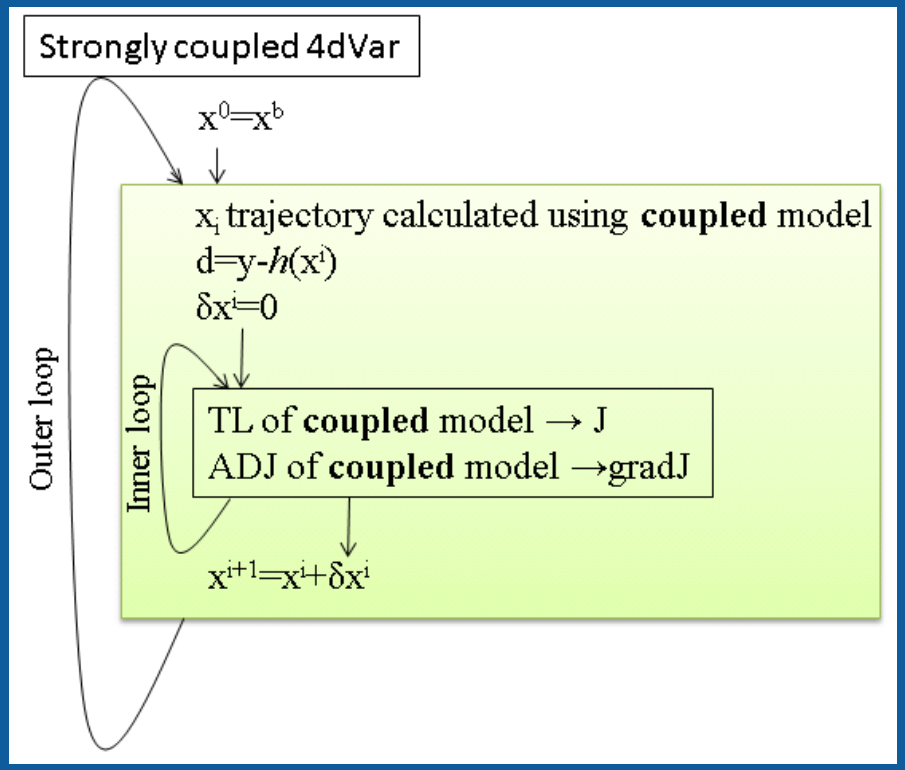
4DVar development

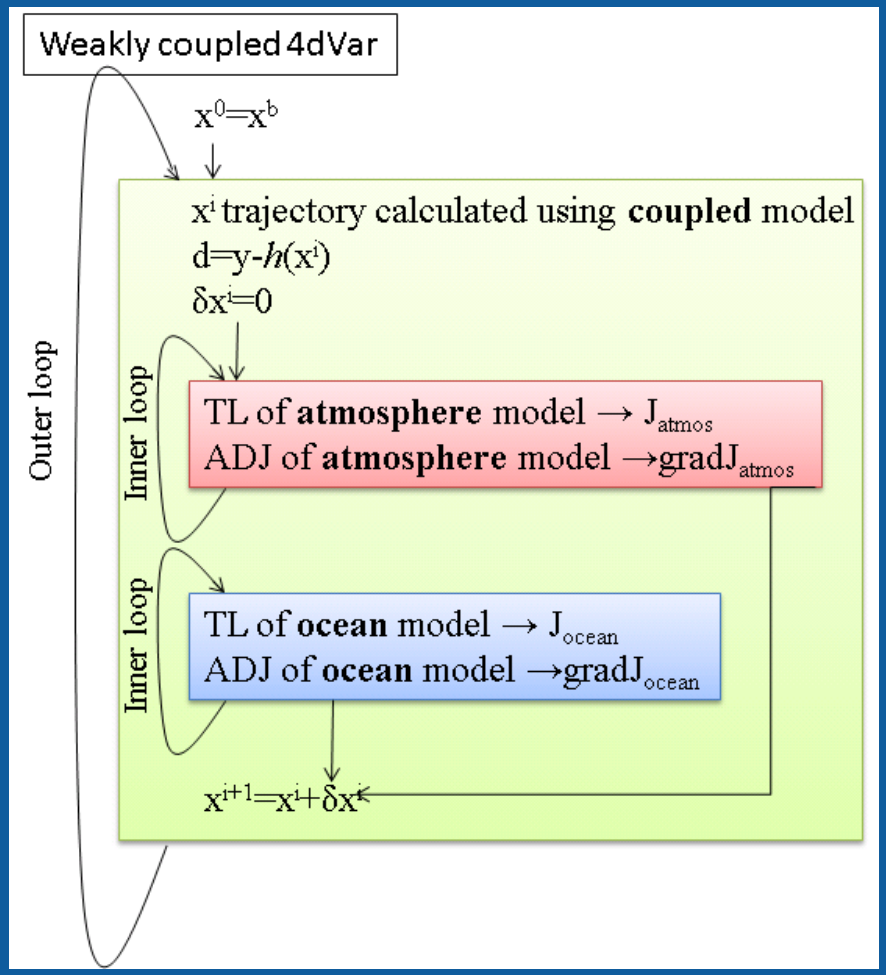


4DVar development

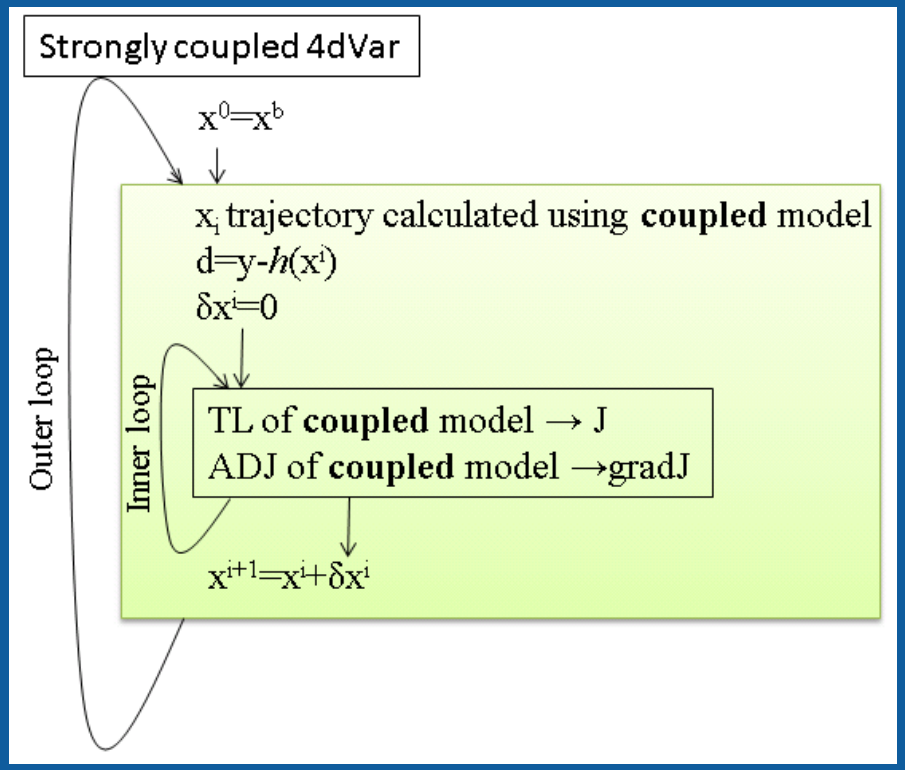


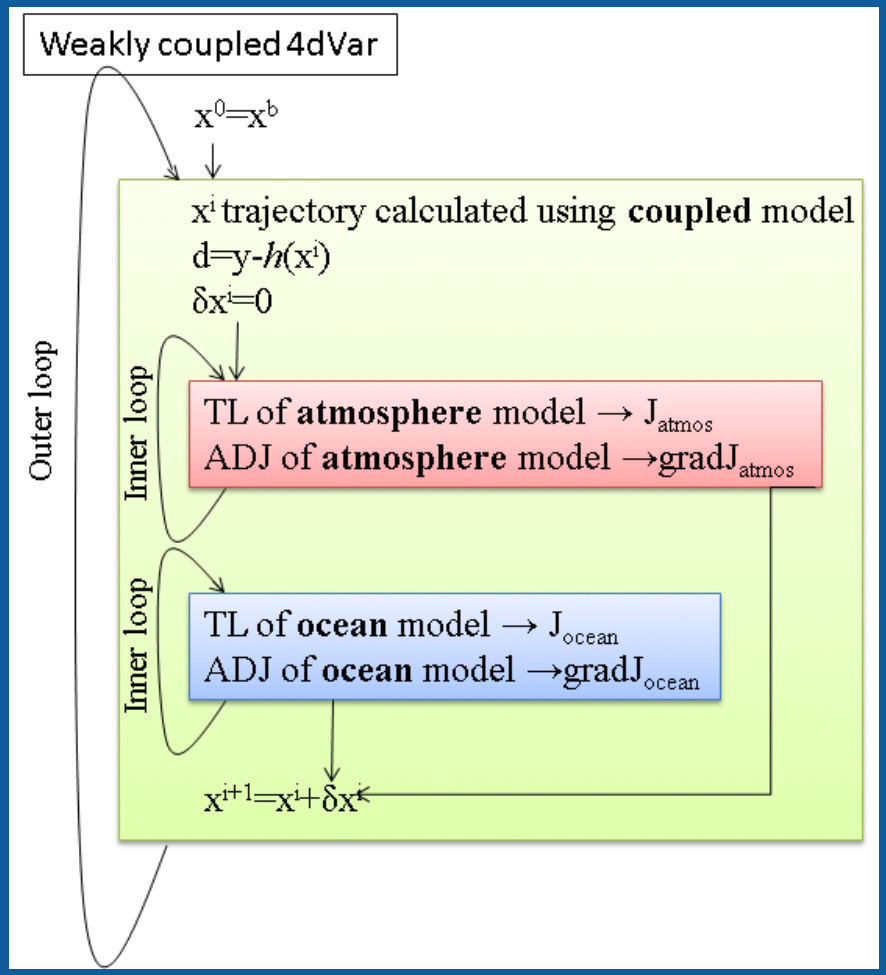
4DVar development





4DVar development





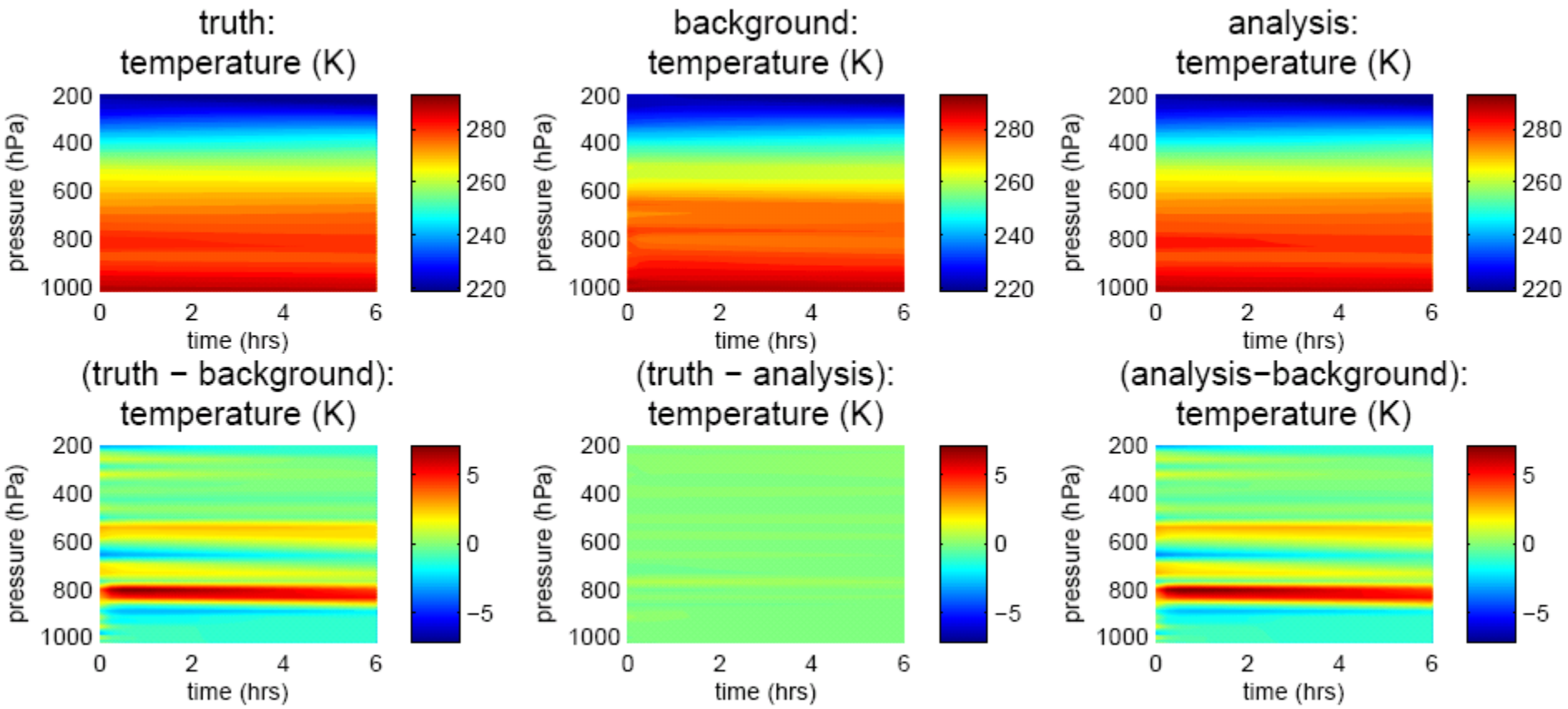
- Need to use the same window lengths for both the atmosphere and ocean but the resulting analysis should be nearly balanced.
- Can include cross-correlations between the atmosphere and ocean.

Strongly coupled twin DA experiments-preliminary results

- strongly coupled, 10 outer loops, 6hr window.
- '*true*' solution is non-linear model run with initial atmosphere state from ERA Interim and initial ocean state from Mercator Ocean
- data for January 2013, 235.5^{o}E, 24.5^{o}N
- Observations are of every variable, at every timestep and every model level.
- $\mathbf{B}=\sigma_b\mathbf{I}$ and $\mathbf{R}=\sigma_o\mathbf{I}$, $\sigma_o/\sigma_b = 0.1$

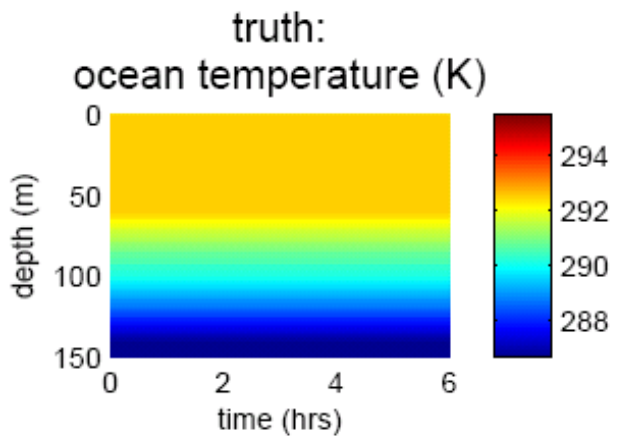
Atmospheric temperature- strongly coupled DA

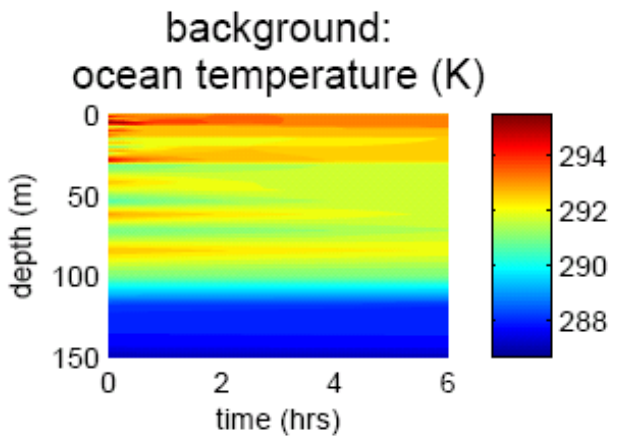
6hr forecast fields

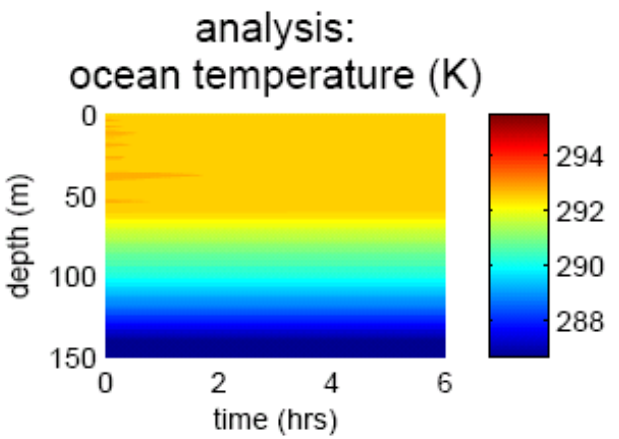


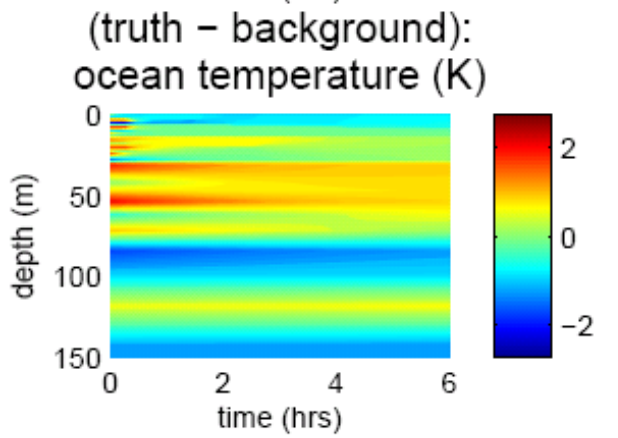
Oceanic temperature- strongly coupled DA

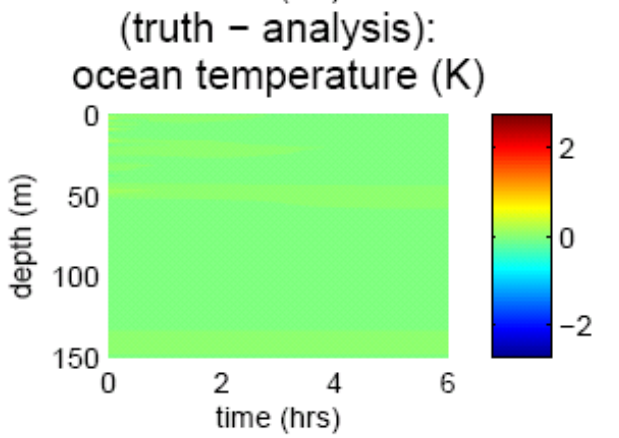
6hr forecast fields

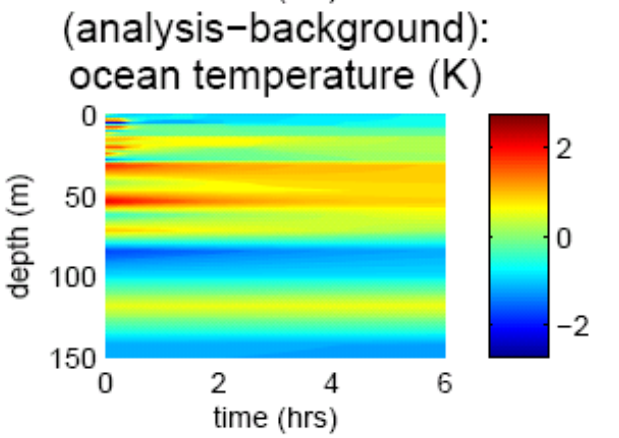




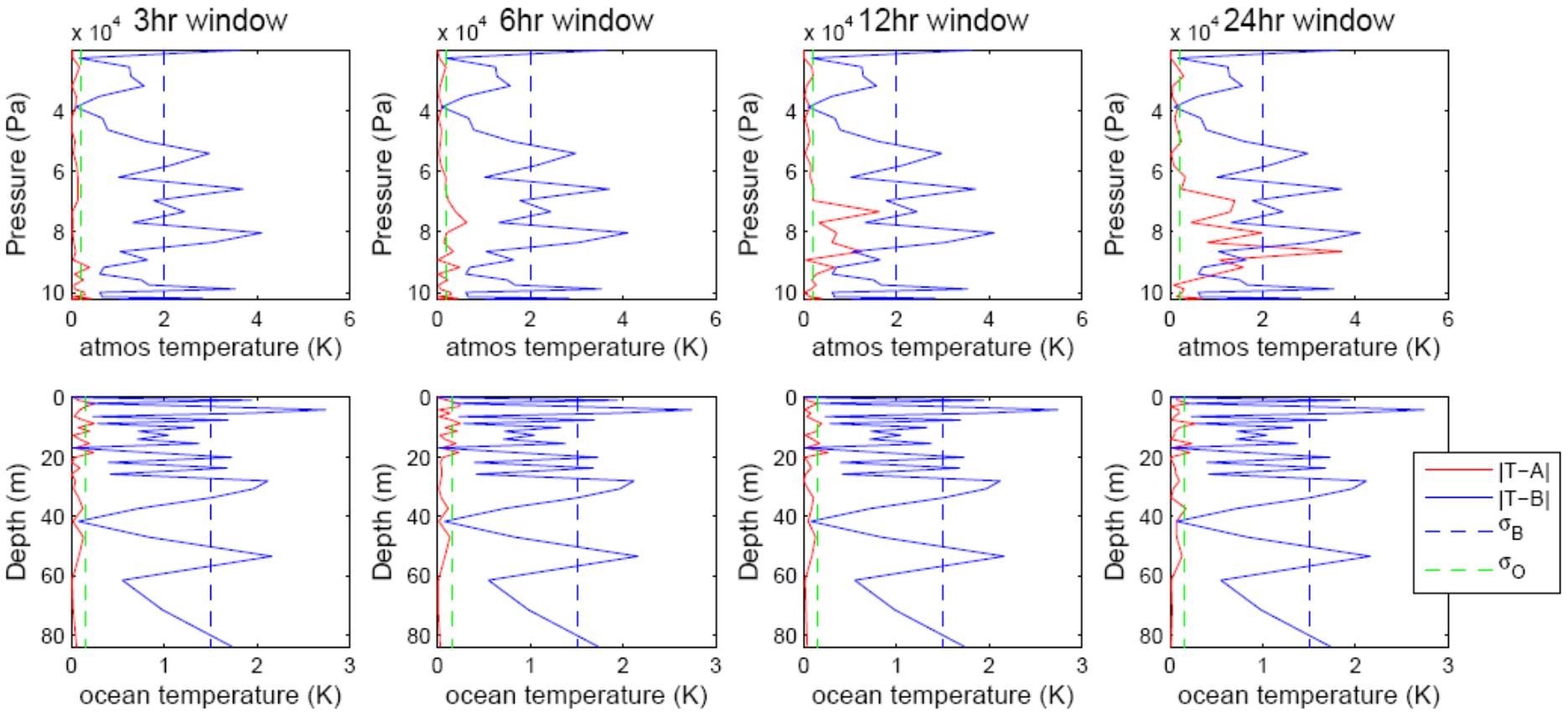








Error's dependence on window length



Research Questions

ESA project (Polly Smith)

- Study difference between different coupling strategies being developed at ECMWF.
  - Can we recreate initialisation shocks when using uncoupled 4Dvar?
  - How do the different strategies treat information from near surface observations?
  - What constraints do the different coupling strategies impose on window lengths?

Research Questions

NERC project (Alison Fowler, Polly Smith (6 months))

- Weak constraint 4DVar
  - Simulate model error as the difference between the full physics model (the 'truth') and the simplified physics model (used within the assimilation).
  - What statistical characteristics does the model error have?
  - Can model error estimation enable the truth to be recovered?
    - Does this allow us to increase the window length and does this improve the analysis?

Related work

- Part of NERC project- PhD student, Kat Howes, working on project entitled:

'Four-dimensional variational data assimilation in coupled systems: model error'

  - Analytical study with results illustrated by the Lorenz 63 model coupled to a 2D linear model.
  - Can parameter estimation compensate for model bias?
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  - Methods for estimating the **Q**-matrix in weak constraint 4DVar.

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Thank you for listening, any questions?