

# Model-data fusion Workshop: Revised Ocean Data Assimilation Summary

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# Talk Outline

- Current capabilities in Australia
- Aspirations for the Australian community
- Stakeholder needs and requirements
- Gaps in capability and/or capacity and potential avenues for addressing gaps
  
- Discussion included:
  - Ocean physics and marine BGC
  - Coastal, open ocean, seasonal applications, and uncertainty

# Current capabilities in Australia

## ➤ *Ocean data assimilation*

- Bluelink: Andreu-Burillo, Brassington, Oke, ...

Status: The Bluelink Ocean Data Assimilation System (BODAS) has been used for several applications; further developments planned (extension to 4d, additional observation types, ...).

- Coastal (e.g., INFORMD): Jones, Nugzar, Parslow, ...

Status: developing an EnOI for a coastal model; main challenges are the lack of observations and dealing with tides.

- ROAM: Oke, Sun, ...

Status: Preliminary system developed based on Bluelink system.

# Current capabilities in Australia

## ➤ *Coupled ocean / atmosphere*

- Regional: Andreu-Burillo, Brassington, Sandery, ...

Status: Preliminary system using MOM4 ocean, TC-LAPS atmosphere, BODAS, and OASIS-3 coupler. Next step to use UM. No coupled DA yet.

- Seasonal: Alves, Hudson, O'Kane, Oke, Okely, Wedd, Yin, ...

Status: Operational system running, and a new PEODAS system being transferred to operations. Started work on coupled DA. 50-year reanalysis completed.

# Current capabilities in Australia

## ➤ *Biogeochemical data assimilation*

- *Coastal: Jones, Parslow, ...*

*Status:* Tested various techniques for BGC for toy models.  
Developed a “good framework” for 4d application.

- *Open Ocean: Lenton, Matear, ...*

*Status:* Practical plan for BGC DA under Bluelink-3.

## ➤ *Sea-ice data assimilation: Heil, Reid*

- Plans have been discussed and preliminary steps taken towards the development of a sea-ice DA capability.

# Current capabilities in Australia

## ➤ *Uncertainty*

- Estimating forecast error: O’Kane, Oke

Applications: Quantifying uncertainty, adaptive sampling, ...

Status: Breeding system developed for MOM4; application to WBC complete.

# Aspirations for the Australian community

- For all disciplines and all applications:
  - Use data assimilation to understand model error (Alves)
  - Pursue rigorous treatment of (model or obs) bias (Andreu-Burillo):
    - apply systematic sub-grid-scale parameterisation theory to realistic applications (O'Kane)

# Aspirations for the Australian community

## ➤ *Ocean data assimilation*

- Development of advanced methods (Oke, O’Kane, Sun). Plans to develop an ensemble-Var ocean DA system – funding pending from ONR. Initial applications will be to coastal ocean applications.
- **Developments of methods to optimise BCs, surface forcing, parameters (Jones, O’Kane, Oke, Parslow, Sun, ...) for coastal ocean applications and climate applications (Hirst, Lenton, ...)**
- Ocean state estimation capability; particularly for decadal prediction (Hirst, Lenton, ...)
- **Optimisation of model configuration using DA tools (Parslow)**
- Implementation of ROMS 4d-Var to UNSW ROMA configuration (MacDonald)
- **Dimension reduction and emulation of computationally intensive models (Nugzar) ... explore different options to with uncertainty ... other than really crass estimates (Parslow, referring to Bluelink)**



# Aspirations for the Australian community

## ➤ *Coupled ocean/atmosphere*

- We should aspire to be world leaders in coupled DA – ocean/ atmosphere (Brassington, ...)
- Develop a global high-resolution coupled ocean / NWP forecast system (Brassington, ... NWP DA team)
- Seasonal:
  - Assimilate all ocean observations into operational seasonal forecast system (Alves, O’Kane, Oke, Yin, ...)
  - Develop coupled DA capability (Alves, Hudson, Okely, Wedd, ...)
  - Refine ensemble generation strategy to quantify uncertainty and for adaptive sampling (O’Kane, ...)
  - Consider developing a capacity for coupled ocean / atmosphere / waves (Brassington)
  - Extend skill of POAMA to multi-week forecasting to match NWP-ocean forecast systems (Alves, Hudson, ...)
  - Dynamical downscaling of climate/seasonal forecasts to meet needs of e.g., aquaculture (Parslow, Sun, ...)

# Aspirations for the Australian community

## ➤ *Biogeochemical data assimilation*

- Capability to run scenarios and understand uncertainty of those scenarios (Parslow)
- Short-term BGC forecasts from 100m – 10 km scales to predict e.g., harmful algal blooms)
- Use BGC DA to constrain BGC and physics – involves algorithm development (Jones, Parslow) ... key innovation is BGC observations (e.g., ocean colour) → physics
- Quantify error propagation from uncertainty in physics to BGC (Nugzar); how do errors in physics propagate through to errors in BGC ...

# Aspirations for the Australian community

- *Sea-ice data data assimilation: Heil, Ried, ...*
  - Develop coupled ocean/atmosphere/sea-ice/... DA system for application to NWP
  - Development of an operation sea-ice forecast system that's underpinned by a sea-ice data assimilation system

# Stakeholder needs and requirements

- Stakeholder needs and requirements
  - Stakeholders want to better understand uncertainty of climate forecasts due to parameter choices (Hirst)

# Gaps in capability and/or capacity and avenues for addressing gaps

## ➤ Forcing data sets

- Systems are configured and tuned for certain NWP product that is not always available (e.g., develop, tune, and evaluate a coastal model forced by MesoLAPS; but MesoLAPS is not available for all time so scenarios cannot be considered)

# Gaps in capability and/or capacity and avenues for addressing gaps

## ➤ Community tool box:

- Code for toy models and toy DA systems available for learning
- Web site with links to international DA tools
- Links to data sets (international sources, eMII, AODN, ...)
- List of papers published and data used

# Gaps in capability and/or capacity and avenues for addressing gaps

## ➤ Outreach:

- Annual DA summer school (Jeff Walker to organise @ Monash)
  - Lecturer from ocean, atmosphere, BGC, terrestrial, ...
  - CSIRO and maybe Australian mathematics society to fund
  - E.g., Day 1-3 focus on methods (theory and exercises using above-mentioned toolbox); day 4-5 focus on applications
  - Other countries have run successfully (e.g., Oxford Uni; MSRI Berkley)

# Summary

## ➤ Current capability:

- Well-established capability in open ocean DA (Bluelink) and seasonal prediction (POAMA)
- Developing capabilities in coastal ocean DA
- Developing capability in BGC DA

## ➤ Aspirations:

- Address known limitations of DA systems
- Extend DA capabilities to coupled systems (ocean forecasting-NWP)
- Develop rigorous methods to quantify uncertainty (forecasting and scenarios)
- Establish community resource web page

## ➤ Capability/capacity gaps

- Limitation of observing systems (eg BGC)
- Difficulty recruiting; possibly address through annual summer school