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 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

- 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