

# **GODAE OceanView**



## **1<sup>st</sup> GOV-DA-TT Workshop**

*Met Office, Exeter, UK*

*20-22 May 2015*

## **Minutes**

*Prepared by*

*Matthew Martin (Met Office), Andy M Moore (UCSC)*

*and Kirsten Wilmer-Becker (Met Office)*



DA-TT workshop participants<sup>1</sup>, Met Office, Exeter, UK

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<sup>1</sup> Back from left: Andrea Storto, Changxiang Yan, Davi Mignac, Tomislava Vukicevic, David Mulholland, Patrick Laloyaux, Maria Valdivieso, Chris Hughes (back), Arthur Vidard, David Ford, Chris Harris, Pavel Sakov, Dan Lea, Richard Matear, Hernan G Arango, Young Ho Kim, Kai Christensen (back), Charles-Emmanuel Testut, Keith Haines, Ann Kristin Sperrevik, Andy Moore, Jenny Pistoia, Anthony Weaver, Magdalena Alonso Balmaseda, Isabelle Mirouze, Mike Bell, Robert King and Norihisa Usui  
Front from left: Kirsten Wilmer-Becker, Paolo Oddo, James While, Benedicte Lemieux-Dudon, Elisabeth Remy and Matt Martin



Many thanks to Met Office staff and catering for supporting the workshop

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Presentations referred to in this report are available from the GODAE OceanView website at <https://www.godae-oceanview.org/outreach/meetings-workshops/task-team-meetings/coss-tt-workshop-2014/presentations/>

## Table of contents

<b>1 Workshop introduction</b> .....	5
1.1 Workshop objectives .....	5
1.2 Host, attendance and abstracts.....	6
<b>2 Science sessions presentations</b> .....	7
2.1 Global Ocean Data Assimilation Systems.....	7
2.2 Data Assimilation in Coupled Models.....	7
2.3 Regional Ocean Data Assimilation Systems.....	8
2.4 Error Covariance Modelling .....	9
2.5 Model Error and Bias .....	10
2.6 Hybrid Data Assimilation Approaches .....	10
2.7 Observation Impact and Sensitivity.....	11
<b>3 Discussions</b> .....	12
3.1 Work plan on model error assessment .....	12
3.2 Work plan on Hybrid DA.....	14
3.3 Work plan on single-observation experiments .....	14
3.4 General .....	16
<b>Appendices</b> .....	17
Appendix A: Agenda.....	17
Appendix B: Participants list .....	21
Appendix C: Action list .....	23

# 1. Workshop introduction

## 1.1 Workshop objectives

The [Data Assimilation Task Team](#) was set up following the endorsement of the GOV Science Team at the last GODAE OceanView Science Team meeting (GOVST-V), Oct 2014 in Beijing, China. The DA-TT was created to foster the development and evaluation of data assimilation systems relevant to GOV to support the coordination of the fundamental and challenging issues in the ocean forecasting process, of which data assimilation is a significant part.

The 1<sup>st</sup> DA-TT workshop was organised to review the current status of ocean data assimilation in operational and near-real time systems and to discuss and agree the way forward on each of the DA-TT work plan items:

1. Improving understanding of error covariances in existing DA systems via a common set of coordinated single observation experiments
2. Identifying and quantifying model and forcing bias that are common to global data assimilation systems via coordinated experiments
3. Promoting the development of hybrid data assimilation methods in the ocean (eg. ensemble variational methods)
4. Organise a meeting of the TT to foster the development of data assimilation, establish linkages, forge collaborations, and encourage joint publications

Furthermore the workshop provided a forum for discussion of latest developments in ocean and coupled data assimilation.

The workshop was organised as a mix of oral presentations, open discussion, and poster presentations following a structure of dedicated science sessions.

No	Workshop sessions
1	Global Ocean Data Assimilation Systems
2	Data Assimilation in Coupled Models
3	Regional Ocean Data Assimilation Systems
4	Error Covariance Modelling
5	Model Error and Bias
6	Hybrid Data Assimilation Approaches
7	Observation Impact and Sensitivity

**Table 1:** Abstracts (oral/poster) were invited to cover the above categories

Sessions 1-3 provided an overview of some of the existing global and regional ocean and coupled DA systems, while session 4 focussed on the developments in error covariance representation.

Sessions 5-7 provided an overview and in-depth discussions on the work plan items:

- Model error and bias
- Hybrid data assimilation – including a talk on the experience from NWP systems
- Observation impact and sensitivity

Final discussion sessions offered an opportunity to discuss the agreement on how to move forward with the work plan. The running of the workshop was kindly supported by session chairs coordinating the timing of presentations and the subsequent questions and answer slots. The workshop was set up as a video conference with some external participation.

Attendees to the workshop included [DA-TT members](#) (or substitutes), representatives from the GODAE OceanView Science Team and the GOV Patrons' Group and Ocean DA experts not directly involved in GOV.

## 1.2 Host, attendance and abstracts

The workshop was held at the Met Office in Exeter on the 20-22 May 2015 over 2.5 days. It was followed by a short DA-TT member meeting on 22 May in the afternoon. The Met



Office is the UK's official weather & climate service (including ocean forecasting) and provided all facilities for the DA-TT workshop.



The workshop was well attended with about 40 people registering including a number of local participants. The workshop audience was broad representing many countries, organisations and projects involved in global and regional data assimilation systems. [25 abstract](#) were submitted of which most were presented orally.

## 2 Science sessions presentations

The workshop was arranged in 7 science sessions (see table 1) and offered a broad spectrum of presentations (oral and poster).

### 2.1 Global Ocean Data Assimilation Systems

**Title:** [2.1 An overview of data assimilation activities at CMCC](#)

**Presenter:** Andrea Storto, CMCC

**Summary:** The talk focussed on the DA at CMCC which is mainly performed in the context of ocean physical reanalyses (C-GLORS) using 3DVAR/FGAT (OceanVar). New reanalysis (C-GLORS5) is planned (1979-2014) and contains a few improvements (ICs, sea-ice thickness constraint, BEC re-tuned through C-GLORS4, tuning of atmospheric forcing correction and large-scale bias correction, higher temporal frequency of outputs). Ongoing developments covering horizontal correlation model improvements and multi-scale analysis were presented.

**Title:** [2.2 Global 1° 4D-var ocean reanalysis, is it worth the pain?](#)

**Presenter:** Arthur Vidard, Inria

**Summary:** This talk compared results of 3Dvar and 4Dvar DA and concluded that 4Dvar is producing the better fit to the data with smaller increment than 3Dvar, but that it is not yet performing satisfactorily, in particular for vertical velocities below 1000m.

**Title:** [2.3 Seamless data assimilation: one size can fit all](#)

**Presenter:** Richard Matear, CSIRO

**Summary:** The talk provides an overview and motivation of the DA development under BlueLink, gives examples of its performance and future plans (to include sea-ice and bgc), as well as suggests new DA methodologies that could be adopted.

**Title:** [2.4 Recent developments to the FOAM global data assimilation system](#)

**Presenter:** Matt Martin, Met Office

**Summary:** This talk focused on DA in FOAM using NEMOVAR. It described the method used to improve the sub-surface profile statistics (for T&S) by implementing a multiple length-scale correlation operator and an instantaneous pressure correction scheme to balance T/S and SSH increments at the equator to reduce spurious circulations generated by DA.

### 2.2 Data Assimilation in Coupled Models

**Title:** [3.1 The ECMWF coupled ocean-atmosphere assimilation system](#)

**Presenter:** Patrick Laloyaux, ECMWF

**Summary:** This talk provided an overview of the prototype ocean-atmosphere coupled assimilation system (CERA) developed at ECMWF, showing comparison with an uncoupled system using case studies.

**Title:** [3.3 The Met Office Coupled Atmosphere/Land/Ocean/Sea-Ice Data Assimilation System](#)

**Presenter:** Dan Lea, Met Office

**Summary:** This talk provided an overview of the coupled modelling effort at the Met Office, and demonstrated the performance of the current used weakly coupled system through comparison with the uncoupled system.

**Title:** [3.4 An assessment of ocean climate reanalysis by the Data Assimilation System of KIOST applying Ensemble Optimal Interpolation](#)

**Presenter:** Young Ho Kim, KIOST

**Summary:** The talk described the current KIOST DA system based on EnOI, and evaluated the results from the KIOST climate reanalysis through comparisons with observations and independent reanalyses. It also provided an overview of the KIOST climate prediction system.

## 2.3 Regional Ocean Data Assimilation Systems

**Title:** [4.1 Regional ocean data assimilation system in the Indian-Pacific Oceans](#)

**Presenter:** Changxiang Yan, IAP-CAS

**Summary:** This talk provided an overview of the regional DA system (Indian and Pacific Ocean) at IAP using HYCOM (EnOI), focussing on new assimilation schemes for T&S and SLA. It included details about the regional assimilation system evaluation which shows good results.

**Title:** [4.2 Ensemble data assimilation with a high resolution regional model for the Italian seas](#)

**Presenter:** TomislavaVukicevic, CMCC

**Summary:** The talk described the new Ensemble DA system for a high-res regional model (Adriatic Ionian Forecast System – AIFS) to improve high-res model initialisation. Initial DA experiments (using Argo) show that further improvement of the ensemble representations of background errors in the initial ensemble is required.

**Title:** [4.3 Development of a four-dimensional variational assimilation system in the western North Pacific](#)

**Presenter:** Norihisa Usui, MRI-JMA

**Summary:** This talk provided an overview of the development of a new 4DVAR version of the MOVE system at MRI-JAM in the western North Pacific, and described results from the MOVE-4DVAR long-term reanalysis experiment.

**Title:** [4.4 Constraining the mesoscale: how well are we doing?](#)

**Presenter:** Pavel Sakov, BoM

**Summary:** This talk described the latest DA developments at BoM introducing a new EnKF-C code. Application of the different DA methods (EnKF and EnOI) in the current global and regional ocean forecasting systems and comparison with innovations stats or independent observations show improvements when using EnKF.

**Title:** [4.5 E-Reef Modelling: Assimilation of remotely-sensed surface reflectance into a coupled hydrodynamic-BGC](#)

**Presenter:** Richard Matear, CSIRO

**Summary:** This talk described the biogeochemical DA system based on EnKF and ensemble OI used at CSIRO (eReefs project) assimilating surface reflectance (among other obs). The performance of the system was discussed and issues relating to ensemble size.

**Title:** [4.6 A Reanalysis and Near Real-Time Forecasting System in Support of the Central and Northern California Ocean Observing System \(CeNCOOS\)](#)

**Presenter:** Andy Moore, UC Santa Cruz

**Summary:** CeNCOOS is part of the U.S. IOOS located of the central and north Californian coast. Using the Regional Ocean Modeling System (ROMS) a 31 year sequence of historical analyses computed for the entire U.S. west coast circulation was described. This talk reviewed the current status of the ROMS 4D-Var system, the historical analyses, and the NRT system.

## 2.4 Error Covariance Modelling

**Title:** [5.1 Representing correlation operators using an implicitly formulated diffusion equation solved with the Chebyshev iteration](#)

**Presenter:** Anthony Weaver, CERFACS

**Summary:** This presentation described new approaches for defining correlation operators based on diffusion operators. The methods were evaluated in a global ocean variational data assimilation system. An iterative algorithm based on the Chebyshev iteration was shown to be particularly promising. Techniques for further improving the parallel aspects of the algorithm were discussed.

**Title:** [5.2 An improved data assimilation scheme for the Mediterranean Forecasting system](#)

**Presenter:** Jenny Pistoia, INGV

**Summary:** This talk described a new estimate of the background error covariance matrix used in the MFS 3D-VAR DA scheme which now uses vertical Empirical Orthogonal Functions (EOFs) defined at each grid point of the model domain in order to better account for the error covariance between temperature and salinity in the shelf and open ocean areas.

**Title:** [5.3 Towards an error covariance modeling using ensemble statistics for the Mercator-Ocean reanalysis and forecasting system: application to a regional configuration](#)

**Presenter:** Charles-Emmanuel Testut

**Summary:** This presentation described a twin-experiment using ensemble statistics to assess error uncertainties in a high-resolution Bay of Biscay model configuration. First results indicate that the ensemble method generally outperforms the current operational methods using static covariances.

**Title:** [5.4 Wavelet based representation of observation error covariance](#)

**Presenter:** Arthur Vidard, Inria

**Summary:** This talk described an approach to improve observation error covariance through a wavelet based representation. The benefit of this approach was demonstrated through twin experiments involving a 2D-shallow water model and synthetic observations.

## 2.5 Model Error and Bias

**Title:** [6.1 The bias correction scheme at ECMWF: the good and the not-so-good](#)

**Presenter:** Magdalena Alonso Blamaseda, ECMWF

**Summary:** This talk provided an overview of the current bias correction scheme used within the ECMWF ocean reanalysis system, showing mostly improved results but also highlighting the shortcomings, e.g. it can degrade the AMOC.

## 2.6 Hybrid Data Assimilation Approaches

**Title:** Invited talk: [7.1 Hybrid-DA in NWP – Experience at the Met Office and Elsewhere](#)

**Presenter:** Andrew Lorenc, Met Office

**Summary:** This talk provided a short overview of the recent history of DA in NWP, comparing 4D-VAR, 4DEn-VAR and hybrid methods, and provided the context for the following discussion on the development of hybrid methods in oceanography.

**Title:** [7.2 A general hybrid formulation of the background-error covariance matrix for ensemble variational ocean data assimilation](#)

**Presenter:** Anthony Weaver, CERFACS

**Summary:** This presentation described recent extensions to the NEMOVAR DA system to exploit ensemble perturbations for specifying a flow-dependent background error covariance, **B**. A distinguishing feature of the formulation is the use of implicitly formulated diffusion operators for the correlation model, spatial localization operator, and parameter filtering.

## 2.7 Observation Impact and Sensitivity

**Title:** [8.1 Variational data assimilation of open sea and coastal chlorophyll in the Mediterranean Sea operational forecast system](#)

**Presenter:** Anna Teruzzi, OGS

**Summary:** This presentation provided an overview of the impact of improved surface chlorophyll concentration assimilation in the MFS BGC system using a new variational scheme (using both open ocean and coastal observations).

**Title:** [8.2 Observing system experiments over the Atlantic with the REMO ocean data assimilation system into HYCOM](#)

**Presenter:** Davi Mignac, REMO-UFBA

**Summary:** This talk described observing system experiments conducted at REMO using their Ocean Data Assimilation System (RODAS) into HYCOM, systematically withholding observations during a 3-year assimilation runs over the Atlantic Ocean. It was shown that the system is able to improve the SST, T/S subsurface structure and circulation, and that all observations are relevant to constrain the model.

**Title:** [8.3 A High resolution assimilation experiment with dense observations in the coastal ocean west of Sardinia Island \(Mediterranean Sea\): Sensitivity analysis to error background, assimilated data and external forcing](#)

**Presenter:** Paolo Oddo, CMRE

**Summary:** This talk described a dense observation experiment (1km resolution) in the Mediterranean Sea for model and DA validation purposes, employing a 3D-Var assimilation scheme. Results are encouraging and further work is planned.

**Title:** [8.4 An Analysis of the Impact of the California Current Observing System on 4D-Var Circulation Estimates spanning three Decades](#)

**Presenter:** Andy Moore, UCSC

**Summary:** The final talk of the workshop focused on a 31 year analysis of the California Current system using ROMS 4D-VAR (1980-2010). This work allows assessment of how the relative impact of each observing platform has changed over a period spanning three decades, from only in-situ hydrographic observation in the 1980s to Argo profiling float network and multiple satellite observation platforms.

### 3 Discussions

The DA-TT will foster the development and evaluation of data assimilation (DA) systems relevant to GOV. This requires the coordination of fundamental and challenging issues in the ocean forecasting process of which DA is a significant part. The DA-TT is working towards a work plan which identifies the relevant actions supporting this aim. The task team plans follow an annual schedule. The outcome from the discussion at this workshop is intended to support defining and specifying the joint activities of the contributing groups. Discussion outcomes are summarised below:

#### 3.1 Work plan on model error assessment

*Chaired by Matt Martin and Magdalena Balmaseda*

The DA-TT work plan describes coordinated experiments to identify and quantify model and forcing biases that are common to global data assimilation systems. It was proposed to utilise DA increments to identify systematic errors in the assimilation-forecast system. Each system could provide increments on a common grid for a particular period, providing monthly means and standard deviation of the increments which can be compared in the different systems.

*How long should this period be and what information should be exchanged?*

- Near surface assessment does not require a long time
- If done for a longer period it could include looking at interannual variability/ or different phases of interannual variability
- A longer period would be advantageous for identification of observation errors
- Suggestion to provide average increments for 1-2 years
- Provide increments for multiple years to keep seasonality (is this feasible?)
- Consider to intercomparisons for the identification of error sources
- Could include global average increments
- Consider Vertical structures
- Surface fluxes

*Discussion about which groups could get involved:*

- Should include groups who develop reanalysis, but not exclusively
- Not all GOV groups have reanalyses

*Grids and background fields:*

It was suggested to agree on a common grid, although re-gridding later was also considered. Monthly mean STD (normalised) could be shared. It was suggested to start

with 1° fields, monthly means and then zoom in, and/or look at specific regions or zoom in from the global model. This could also include ensemble systems with focus on increment variability.

**Action DA-TT-1:** DA-TT co-chairs to contact someone from NERSC (e.g. Laurent Bertino) to get involved in using DA increments to identify systematic errors in the assimilation-forecast ensemble system.

Background fields are needed by anyone doing the assessment. What is used and how it's done (methodologies) need to be shared and results should be made available. To know how the partners assess systematic errors in the assimilation-forecast systems provides interesting information and can help others to learn more about their own system. The real interest lies in finding out about mean errors, e.g. of surface fluxes.

#### *Consideration of variables:*

T&S are important at the surface, also sea-ice. However sea-ice assimilation is not done by many of the GOV groups.

SSH should also be considered.

It could also be interesting to look at innovations, but some groups might not be able to contribute to this.

An OSE could help to check the different increments coming from the different systems for SSH (also includes information about velocities). Time period could be restricted to the Argo period (e.g. from 2005 onwards). Focus could be on balancing vertical velocities or the mixed layer, e.g. identifying consistent errors in that. The person doing the analysis could be put in charge of defining the criteria for comparison.

#### *Documentation and communication*

To move forward with the experiments all details need to be documented (variables, grid, etc.) One issue is that the systems have different periods, which might only allow qualitative comparisons.

Outcomes from the coordinated experiments within the DA-TT should be considered for feedback to the modelling groups. For example assessing the outcome of results in the equatorial or Arctic region could be of interest to international groups, e.g. TPOS2020, YOPP, etc.

An important aspect of the joint activities is to agree on how to communicate. It was proposed to use the GOV twiki page to exchange information and define experiments.

**Action DA-TT-2:** Matt Martin and Magdalena Balmaseda to summarise the approach of how to do the coordinated experiment and circulate to all for agreement and confirmation of participation.

## 3.2 Work plan on Hybrid DA

*Chaired by Anthony Weaver and Andy Moore*

Using a combination of ensemble and variational assimilation methods to improve DA is desirable (e.g. provides better large-scale localisation) as already demonstrated extensively in NWP. It will be beneficial to exchange information between groups already developing this method and those willing to engage in it, to learn more about the associated difficulties and solutions. Current groups developing Hybrid DA methods were named as e.g. HYCOM (Jim Cummings), ROMS (Alex Kurapov), and NEMO (CERFACS). It would be helpful to find out which groups would consider adopting Hybrid DA methods as well as what advantages can be expected over non-hybrid methods.

Hybrid DA could include looking at the perturbation methods for generating forecasts ensembles. It was proposed to explore the techniques for generating ensembles (e.g. starting from stochastic physics or forcing perturbations). Large ensembles can only be run by some of the groups and are likely to be at low resolution. A question was whether  $\frac{1}{4}$  deg would be a sensible approach for representing errors in higher resolution (eddy resolving models).

It was also suggested to clarify terminology to avoid misunderstandings about the methods e.g. hybrid DA, ensemble VAR or Hybrid VAR. Different methods have been proposed to generate an analysis ensemble and their respective advantages and disadvantages need to be better understood.<sup>2</sup>

## 3.3 Work plan on single-observation experiments

*Chaired by Matt Martin*

To improve the understanding of error covariances in existing DA systems it was proposed to collaborate by setting up a common set of coordinated single observation experiments. This will also help to understand the impact of observations from an OSEval-TT perspective.

To be sure that different observations do not interact  $30^\circ$  was agreed to be the safest distance between observations. It was proposed to send out a preliminary set of locations and check whether observations are available at the site, e.g. Med or tropical Pacific (might work better with tropical moorings on equator).

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<sup>2</sup> Different ensemble DA methods which have been developed over the past years:

EDA – Ensemble data assimilation

EnKF – Ensemble Kalman Filter

LETKF – Local ensemble transform Kalman filter

EnSRF – Ensemble square root filter

EAKF – Ensemble adjustment Kalman filter

EVIL – Ensemble-Variational Integrated Localized algorithm

*How long does the forecast need to be to see the full impact and some propagation? 10 days?*

10-days was agreed to be a reasonable forecast length as it will allow getting a few days of genuine forecast. Several groups agreed to participate. There was also a suggestion to look at innovations and spread.

*Full depth profiles of T&S or single level?*

It was stated that this will depend on what type of innovation will be used. As there could be issues assimilating full profiles it was suggested to start with a single level.

*Include altimeter tracks rather than single obs?*

To keep it simple for now it was suggested not to include altimeter tracks.

*Does it matter which day we choose?*

The experiment can be done for a single day or several days. There could be different time windows for different systems. It was suggested to also try to keep this as simple as possible.

The background state of each model needs to be known or the same background field could be shared among the groups. This needs to be decided before the experiment(s) can go ahead. There are advantages with both approaches.

Another approach could be to run the same case study (as well as single obs experiments) at different systems e.g. looking at AMOC (what happens with coastal obs) or profiles of Med outflow.

*The suggested method includes:*

- Define common set of innovations and a common date:
  - T/S, SSH, SST observations separately
- Grid of observations, very far apart. 30° was seen as the best solution

Each participating centre runs their data assimilation system with those innovations and using background information for that date.

Resulting increment fields for all variables are interpolated to a common grid, and sent to DA-TT and OSEval-TT co-chairs who will collate and plot the results in a common way to understand the way in which the existing schemes spread information in the horizontal, vertical and between variables.

Add the resulting increments into a model forecast to see how well they are retained by the model over some days? Test of initialisation.

**Organisation of future activity:**

- Partners confirming interest to get involved include: Anthony Weaver (CERFACS), Mercator Ocean, Arthur Vidard (INRIA), Andrew Moore (UCSC), Magdalena Balmaseda (ECMWF), Matt Martin (Met Office), REMO Brazil
- It was proposed to include coupled systems for which a full profile (atmosphere/ocean) could be defined to check how the system reacts. A forecast experiment should allow us to see what impact the ocean has on the atmosphere
- Next step will need to provide a sample set of observations & innovations (same time)
- It will also be important to check sensitivities and initialisations
- Variables used are T, S, u, v and SSH. Velocity data (or SSS) are currently not being assimilated
- No decision was taken with regard to global or regional grids (suggestions were to use  $\frac{1}{4}^\circ$  (global) and  $1/10^\circ$  (regional))
- The timescale for this work is expected to be  $\sim 1$  year, with details being agreed/defined within the next 2-3 months
- If this is set up soon first results could be available for the GOVST-VI meeting

### 3.4 General

*Chaired by Matt Martin and Andy Moore*

It was agreed to make the DA-TT workshops an annual event and that “in-person” workshops are preferred to remote meetings. It was also understood that the workshops are part of a larger collaborations between the groups contributing to tangible outcomes through agreed experiments. It was stated that other partners should get involved in the activities and that this group must reach out to engage with them.

The next meeting is planned for June 2016, and is likely to be hosted by the University of California at Santa Cruz (tbc). Ideally the workshops should be co-located with other GOV groups (e.g. OSEval-TT or MEAP-TT) or larger events (e.g. AGU, Liege Colloquium, etc.) to reduce travel time/costs.

Participants were generally happy with the meeting format but it was suggested to keep the agenda more open and increase discussion time. It was also suggested to keep the audience relatively small and allow for more time for posters.

**Action DA-TT-3:** DA-TT co-chairs to invite Arthur Vidard and Young Ho Kim as new members of the DA-TT.

Collaborations with the other TTs should be intensified.

## Appendices

### Appendix A: Agenda

#### **Wednesday 20 May**

**09:00 – 09:45 Registration and fee payments (teas & coffees)**

**09:45 – 10:00** Welcome and logistics - *Matt and Kirsten*

**10:00 – 10:15** An overview of the mission of DA-TT - *Matt Martin*

#### **Global Ocean Data Assimilation Systems – chair: Cummings**

**10:15 – 10:40** An overview of data assimilation activities at CMCC - *Andrea Storto*

**10:40 – 11:05** Global 1° 4D-var ocean reanalysis, is it worth the pain? - *Arthur Vidard*

**11:05 – 11:35** Break

#### **Global Ocean Data Assimilation Systems (continued)**

**11:35 – 12:00** Review of the Australian Global Data assimilation system - *Richard Matear*

**12:00 – 12:25** Recent developments to the FOAM global data assimilation system - *Matt Martin*

**12:25 – 13:30** Lunch

#### **Data Assimilation in Coupled Models chair: Magdalena Balmaseda**

**13:30 – 13:55** The ECMWF coupled ocean-atmosphere assimilation system - *Patrick Laloyaux*

**13:55 – 14:20** Overview of Ocean Data Assimilation Activities in support of the Earth System Prediction Capability at the Naval Research Laboratory - *Jim Cummings*

**14:20 – 14:45** The Met Office Coupled Atmosphere/Land/Ocean/Sea-Ice Data Assimilation System - *Dan Lea*

**14:45 – 15:10** An assessment of ocean climate reanalysis by the Data Assimilation System of KIOST applying Ensemble Optimal Interpolation - *Young Ho Kim*

**15:10 – 15:40** Break

#### **Regional Ocean Data Assimilation Systems – chair: Storto**

**15:40 – 16:05** Regional ocean data assimilation system in the Indian-Pacific oceans - *Changxiang Yan*

**16:05 – 16:30** Ensemble data assimilation with a high resolution regional model for the Italian seas - *Tomislava Vukicevic*

16:30 – 16:55 Development of a four-dimensional variational assimilation system in the western North Pacific - *Norihisa Usui*

16:55 – 17:20 Constraining the mesoscale - how well are we doing? - *Pavel Sakov*

17:20 finish

### **Thursday 21 May**

09:00 start

#### **Regional Ocean Data Assimilation Systems (continued)**

09:00 – 09:25 E-Reef biogeochemical data assimilation system update - *Richard Matear*

09:25 – 09:50 A Reanalysis and Near Real-Time Forecasting System in Support of the Central and Northern California Ocean Observing System (CeNCOOS) - *Andy Moore*

#### **Error Covariance Modeling – chair: Matear**

09:50 – 10:15 Representing correlation operators using an implicitly formulated diffusion equation solved with the Chebyshev iteration - *Anthony Weaver*

10:15 – 10:40 An improved data assimilation scheme for the Mediterranean Forecasting system - *Jenny Pistoia*

10:40 – 11:10 Break

#### **Error Covariance Modeling (continued)**

11:10 – 11:35 Towards an error covariance modeling using ensemble statistics for the Mercator-Ocean reanalysis and forecasting system: application to a regional configuration - *Charles Emmanuel Testut*

11:35- 12:00 Wavelet based representation of observation error covariance - *Arthur Vidard*

#### **Model Error and Bias – chair: Martin**

12:00 – 12:25 The bias correction scheme at ECMWF: the good and the no-so-good – *Magdalena Balmaseda*

12:25 – 12:40 Group photograph

12:40 – 14:00 Lunch

14:00 – 15:00 **1 hour discussion of work plan on model error assessment (Martin, Balmaseda)**

15:00 – 15:30 Break

**Hybrid Data Assimilation Approaches – chair: Moore**

15:30 – 16:00 Invited talk: Hybrid-DA in NWP – Experience at the Met Office and Elsewhere - *Andrew Lorenc*

16:00 – 16:25 A general hybrid formulation of the background-error covariance matrix for ensemble variational ocean data assimilation - *Anthony Weaver*

16:25 – 17:25 **1.0 hour discussion of work plan on Hybrid DA (Moore, Weaver)**

17:25 finish

19:30 Dinner

**Friday 22 May**

09:00 start

**Observation Impact and Sensitivity – chair: Weaver**

09:00 – 09:25 Variational data assimilation of open sea and coastal chlorophyll in the Mediterranean Sea operational forecast system - *Anna Teruzzi*

09:25 – 09:50 Observing system experiments over the Atlantic with the REMO ocean data assimilation system into HYCOM - *Davi Mignac*

09:50 – 10:15 A High resolution assimilation experiment with dense observations in the coastal ocean west of Sardinia Island (Mediterranean Sea): Sensitivity analysis to error background, assimilated data and external forcing. - *Paolo Oddo*

10:15 – 10:40 An Analysis of the Impact of the California Current Observing System on 4D-Var Circulation Estimates Spanning three Decades - *Andy Moore*

10:40 – 11:10 Break

**Observation Impact and Sensitivity (continued)**

11.10 – 12:10 **+1 hour discussion of work plan on single-observation experiments (Martin, Oke)**

**Open discussion on all topics**

**12:10 – 13:00 50 minute discussion on all topics**

**13:00 finish**

**From 13:00 DA-TT members' discussion over lunch**

## Appendix B: Participants list

No	First name	Surname	Affiliation	Country
1	Magdalena	Alonso Balmaseda	ECMWF	UK
2	Hernan G	Arango	Rutgers University	USA
3	Kai	Christensen	Norwegian Meteorological Institute	Norway
4	James	Cummings	Naval Research Laboratory	USA
5	Xiangbo	Feng	University of Reading	UK
6	David	Ford	Met Office	UK
7	Keith	Haines	University of Reading	UK
8	Chris	Harris	Met Office	UK
9	Chris	Hughes	Met Office	UK
10	Young Ho	Kim	Korea Institute of Ocean Science & Technology	South Korea
11	Robert	King	Met Office	UK
12	Patrick	Laloyaux	ECMWF	UK
13	Daniel	Lea	Met Office	UK
14	Bénédicte	Lemieux- Dudon	Laboratoire d'aérodologie de Toulouse	France
15	Matt	Martin	Met Office	UK
16	Richard	Matear	CSIRO	Australia
17	Davi	Mignac	REMO-UFBA	Brazil
18	Isabelle	Mirouze	CMCC	French
19	Andy	Moore	University of California Santa Cruz	USA
20	David	Mulholland	University of Reading	UK
21	Paolo	Oddo	CMRE	Italy
22	Drew	Peterson	Met Office	UK
23	Jenny	Pistoia	Istituto Nazionale Geofisica e Vulcanologia	Italy
24	Elisabeth	Remy	Mercator Ocean	France

25	Pavel	Sakov	BoM	Australia
26	Ann Kristin	Sperrevik	Norwegian Meteorological Institute	Norway
27	Andrea	Storto	CMCC	Italy
28	Anna	Teruzzi	OGS	Italy
29	Charles-Emmanuel	Testut	Mercator Ocean	France
30	Norihisa	Usui	Meteorological Research Institute / JMA	Japan
31	Maria	Valdivieso	Department of Meteorology, University of Reading	UK
32	Arthur	Vidard	Inria	France
33	Tomislava	Vukicevic	CMCC	Italy
34	Anthony	Weaver	CERFACS	France
35	James	While	Met Office	UK
36	Kirsten	Wilmer-Becker	Met Office	UK
37	Changxiang	Yan	Institute of Atmospheric Physics, Chinese Academy of Sciences	China

## Appendix C: Action list

- Action DA-TT-1:** DA-TT co-chairs to contact someone from NERSC (e.g. Laurent Bertino) to get involved in using DA increments to identify systematic model errors in an ensemble system.
- Action DA-TT-2:** Matt Martin and Magdalena Balmaseda to summarise the approach of how to do the coordinated experiment and circulate to all for agreement and confirmation of participation.
- Action DA-TT-3:** DA-TT co-chairs to invite Arthur Vidard and Young Ho Kim as new members of the DA-TT.