

Report on the COST/CLIVA Workshop on Ocean Reanalysis and Intercomparison

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A. Storto, K. Haines, N. Caltabiano with contributions from all Workshop participants

Summary and recommendations

The COST/CLIVAR Workshop on Ocean Reanalyses and Intercomparison took place in Toulouse on the 29th and 30th June 2017. Fifty two participants from 11 countries attended the workshop and discussed the status and plans for reanalysis production and intercomparison. The 2-day workshop format included talks presenting current intercomparison studies and individual reanalysis production, followed by round tables aimed at designing the next ORA-IP exercise.

Following the previous efforts of ORA-IPv1 that led to a Special Issue in Climate Dynamics (published online in 2015 and issued in August 2017), it has been agreed to perform a new coordinated intercomparison exercise, which will be called ORA-IPv2. Main objectives of ORA-IPv2 will be i) to assess the advances of the ocean reanalysis products by comparing the performances of the reanalyses in ORA-IPv2 with respect to those in ORA-IPv1, and ii) to perform comparisons of new metrics that were not considered in ORA-IPv1. For the latter, there has been consensus during the workshop to have more specific focus on (a) assimilation diagnostics and statistics; (b) regional (basin level) studies; (c) comparisons investigating the representation of water masses in reanalyses; and, (d) specific assessment of currents and mesoscale activity.

The need of directly involving in ORA-IPv2 both observational and modelling community (e.g. linking with in-situ data managers, and the CLIVAR Ocean Model Development Panel - OMDP, respectively) has been strongly encouraged during the workshop, although keeping the producers involved in all comparisons. A general protocol has also been agreed, according to which the comparison period should span the altimetry era (1993-onward) and monthly means should be adopted, except for studies aiming at high-frequency variability comparisons, e.g. for upper ocean parameters (e.g. SST, MLD). The proliferation of centennial scale reanalyses may also lead to selected comparisons on decadal variability. A common grid at 1deg horizontal resolution seems also enough for ORA-IPv2, given that most diagnostics require computations on the native grid, later mapped onto the coarser reference 1deg grid. The workshop also recommended that reanalysis producers should provide a control simulation in addition to the reanalysis (possibly without any surface relaxation), in order to evaluate the impact of boundary conditions (e.g. atmospheric forcing), and model configuration without the data assimilation corrections. This represents a novelty with respect to ORA-IPv1. No repository has been yet identified to host entire reanalysis dataset, while current ones (e.g. University of Hamburg) might host the post-processed diagnostics.

Finally, a tentative schedule towards ORA-IPv2 has been setup: a “call for expression of interest” for processors should be opened from September to December 2017, and disseminated across regional experts, observation and modelling communities, and further to reanalysis experts. The forthcoming ICR5 conference (November 2017) represents an opportunity for further update on the status of the call. The workshop also recommends in the future to document, perhaps through a publication, all

reanalyses that will participate in the ORA-IPv2, along with the agreed protocol, and good practice in reanalysis production and outputs.

Workshop Day 1

Session

The first session included 16 presentations that summarized previous, on-going and future intercomparison efforts, in the framework of ORA-IPv1, the EOS COST Action (PORA-IP, regional inter-comparisons), the Copernicus Marine Service (the assessment of the 4-member GREP reanalysis ensemble and the analyses performed for the Ocean State Report), MULTI-ORA comparisons of real-time reanalysis (temperature and salinity) included in TPOS2020, analogous activities of comparisons performed in the frame of CLIVAR OMDP (OMIPs), future comparison activities within APPLICATE and YOPP, plus a number of comparison studies conceived for validation purposes.

Discussion

During the day 1 round table, issues about the comparison protocol for the next ORAIP (say v2) exercise have been discussed. What emerged from the discussion is summarized in the following points:

- It appears clear that most comparisons within the next ORAIP will focus on the latest decades (i.e. repeating the comparisons over the target altimetry period 1993-onwards, also for consistency with Copernicus reanalyses). However, the recent production of 20th century reanalyses (ECMWF with ORA-20C and CERA-20C, SODA, CMCC CHOR, MIROC) may allow specific comparisons focussing on i) early periods, and ii) representation of decadal variability;
- The 1x1 degree regular grid emerged as target resolution for the comparisons with gridded data (as in ORAIPv1), in spite of the increased resolution of many products. However, most of diagnostics (including specific ones affected by resolution, such as eventually eddy energy) must be calculated over the native grid and later coarsened to 1 degree resolution. Care should be taken in order to identify diagnostics that are affected by the mapping procedure (e.g. all transports and related diagnostics to be calculated from the native grid data);
- Keeping the protocol as close as possible to the previous one may speed up the process as most producers already know it, and processors have already developed comparison tools;
- Using a common land-sea mask (3D and 2D) on the target 1x1 degree grid is important to avoid mismatches, especially in ice-covered areas;
- Temporal resolution is kept in principle at monthly scales. High temporal resolution comparisons for selected 2D parameters (e.g. SST and MLD variability) may be envisaged as well, depending upon data availability (likely only a subset of the reanalyses has such data available). Studying daily maxima or diurnal amplitude in order to analyse the representation of the diurnal cycle for selected parameters (e.g. SST and MLD) is also attractive, but this is likely to be achieved only for future reanalyses;
- Next ORA-IP exercise should also aim at evaluating progresses and advances of the reanalyses community with time, namely assessing the improvements with respect to ORA-IPv1. To this end, previous processors (e.g. ocean heat content at MetOffice, salinity at BoM, steric sea level at CMCC) are encouraged to perform a follow-up comparison;
- Still not clear whether repositories will be available for next ORA-IP: the repository at University of Hamburg may host post-processed diagnostics but not entire datasets. CREATE-IP project (NASA) might host entire reanalysis datasets. Stronger link with CMIP

- (through ESGF) might also be considered, although technically demanding. Data repository managers will be contacted soon to understand the feasibility of accessing such repositories;
- In order to stimulate active participation of reanalysis producers and their potential support in data analysis, it is important to involve them at all stages of comparison, and acknowledge their participation in the comparison through co-authorship in published works;
 - A publication documenting and summarizing all the systems participating to next ORA-IP will ease the data usage and the citation of the reanalysis data with proper tables (CLIVAR could support this effort). Focus in particular should be given to the different assimilation schemes implemented in the ORA-IP reanalyses. The protocol might also be part of such publication, although it might be much too technical;
 - A specific comparison may also be performed in order to study the climatological (or ensemble) error covariance and observational errors, to have a flavour of how much weight is given to observations in the ORA-IP reanalyses; another (or the same) comparison should aim also at comparing assimilation statistics, such as: i) analysis increments, and ii) observation misfits (in observation space) as done for GODAE Class 4 diagnostics. For the latter, monthly mean data might be fine, provided that specific reanalyses may help estimating the error introduced by downgrading the temporal resolution. Within GODAE DA-TT, similar comparisons are being performed e.g. to compare background-error covariances from different systems and the link can be created;
 - Next ORAIPv2 might aim at high-level publication (e.g. BAMS). Main outcomes from ORA-IPv1 might also be summarized soon in such high level journals to give maximum visibility to the ORA-IP efforts, depending on time, availability, etc.;
 - Comparisons included in MULTI-ORA (real-time monitoring and comparisons) might now include more systems than those included at present, owing to more centres performing seasonal predictions. Real-time reanalyses producers are encouraged to contact NCEP and BoM for temperature and salinity comparisons, respectively;
 - A new important requirement emerged for next ORA-IP: producers should also provide, whenever possible, the control experiment differing from the reanalysis only for the data assimilation switched off (without any surface relaxation either, when possible). This clearly represents also a good practice for future reanalysis productions. For the comparisons, even a subset of products might be used. This will allow disentangling the impact of different input datasets (e.g. atmospheric forcing) from the differences induced by data assimilation system, filling the gap between the protocol-free nature of the production in ORA-IP and the stricter protocol used in the production of simulations participating AMIP (CORE-II).

Workshop Day 2

Session

During the morning Session of Day 2, 13 presentations summarized activities from individual groups producing ocean reanalyses, presenting in particular the production status and plans and in most cases, selected validation procedures and results. In particular, a number of routinely produced reanalyses was presented (from BoM, UKMO, NASA, CMCC, ECMWF, Mercator, JMA, JAMSTEC, NCEP, MERRA, NERSC, NRL), whose developments and production is primarily (but not only) fostered by the need of initializing long-range (seasonal, decadal) prediction systems. Another set of reanalyses (from CMCC, ECMWF, JMA, NCEP) spans a longer period, are not updated in near real time and were genuinely conceived for ocean climate monitoring. Finally, a physical-statistical observation product (from CLS) was also presented.

Discussion

During the round table held during day 2, specific diagnostics and regional studies of interest for next ORA-IP exercise have been discussed. Some people expressed interest in leading a number of comparisons, somehow already in place. Furthermore, a tentative roadmap has been set up. What emerged from the discussion is summarized in the following points:

- The need of a few more studies missing in ORA-IPv1 emerged from the discussion (see also Day 1 outcomes, in particular for assimilation output inter-comparisons). Comparing water mass characteristics (e.g. T/S diagrams, etc.), at monthly to climatological scale and selected regions (Atlantic, North Pacific), eventually in observation space, might provide an interesting global perspective on the representation of water masses in reanalyses. Expertise from observational communities should be pursued for this kind of studies. M. Valdivieso (North Atlantic) and T. Toyoda (North Pacific) expressed interest in this kind of comparisons. M. Valdivieso could thus get involved in the North Atlantic comparison led by L. Jackson at MetOffice;
- It seems desirable a closer link with the TPOS community, in particular to compare high frequency variability in the tropical Pacific Ocean, and make the two groups benefit from each other's assessments;
- L. Jackson and L. Allison (MetOffice) expressed interest in expanding the North Atlantic intercomparison (initiated in the frame of Copernicus) in order to include a larger number of products. They presented initial results and proposed to continue the efforts. A dedicated workshop, supported by COST, will be held at University of Reading end of September;
- Comparison investigating mesoscale activity in reanalyses (possibly evaluating surface currents and/or statistics from eddy tracking), missing in ORA-IPv1, is also encouraged, especially in light of the increase of horizontal resolution in many systems;
- Comparisons of 20°C isotherm depth, possibly along with 26°C and 28°C isotherm depths (eventually also 15°C or 14°C), and warm water volume should be encouraged, along with barrier layer representation among the products (J. Richman expressed interest);
- M. Balmaseda plans to ask U. Send (OceanSites) the status of the OceanSites data dissemination for possible use within comparison studies
- The possibility to involve coupled data assimilation experts, in light of current and forthcoming coupled reanalyses, seems appealing. In particular, comparison of air-sea exchanges is of crucial interest for both communities, and there is already a good overlap between the two communities;
- Tools for online calculation of observation misfits (generally used in most data assimilation schemes) should also be made available for model simulation producers, in order to foster comparisons in observation space that include also control simulations (e.g. mooring innovations,);
- The CLIVAR/IOC-GOOS Indian Ocean Region Panel (IORP) could be involved in order to provide regional comparison in the Indian Ocean (NCOIS group collaborates with Y. Xue; M. Balmaseda in contact with IORP). More in general, CLIVAR regional panels should be involved closely in the comparisons, as well as the OMDP Panel;
- Global transports studies, picturing the global ocean circulation and transports at selected (e.g. GO-SHIP) sections were also missing in ORA-IPv1, and it seems important to have them in ORA-IPv2. This study may not limit to GO-SHIP sections, but also consider, when possible, availability of observational data (e.g. in the Indonesian Throughflow). K. von Schuckmann and A. Karspeck support the transect comparisons and may have more precise proposal in the future;

- As a general roadmap, a call for expression of interest in leading inter-comparison may be opened in September and tentatively closed around November/December; a further update may be done during the ICR5 conference on reanalyses (next November in Rome). During the ICR5 conference, a possible link with the WMO TIRA initiative (comparison of atmospheric reanalyses) should be pursued as well. A webpage containing basic information (possibly endorsed and hosted by CLIVAR) might be created in September.

List of participants

Attached

Name	Affiliation	Country	Email	COST participant
Aida Alvera Azcarate	Univeristy Liege	Belgium	a.alvera@ulg.ac.be	X
Lesley Allison	MetOffice	UK	lesley.allison@metoffice.gov.uk	X
Magdalena Balmaseda	ECMWF	UK	magdalena.balmaseda@ecmwf.int	X
Remigijus Dailide	University Klaipeda	Lithuania	remigijus.dailide@gmail.com	X
Inga Dailidiene	University Klaipeda	Lithuania	inga.dailidiene@ku.lt	X
Marie Drevillon	Mercator Ocean	France	marie.drevillon@mercator-ocean.fr	X
Keith Haines	University Reading	UK	k.haines@reading.ac.uk	X
Fabric Hernandez	Mercator Ocean	France	fabrice.hernandez@mercator-ocean.fr	X
Deniz Caraca	COST	Belgium	deniz.karaca@cost.eu	X
Alicia Karspeck	UCAR	USA	aliciak@ucar.edu	X
Margarida Liberato	UTAD	Portugal	mlr@utad.pt	X
Simona Masina	CMCC	Italy	simona.masina@ingv.it	X
Toma Mingelaite	University Klaipeda	Lithuania	toma.mingelaite@gmail.com	X
Drew Peterson	MetOffice	UK	kandrewpeterson@yahoo.ca	X
Viktorija Rukseniene	University Klaipeda	Lithuania	viktorija.rukseniene@gmail.com	X
Andrea Storto	CMCC	Italy	andrea.storto@cmcc.it	X
Ana Trindade	ICM	Spain	atrindade@icm.csic.es	X
Maria Valdivieso	University Reading	UK	m.valdiviesodacosta@reading.ac.uk	X
Karina von Schuckmann	Mercator Ocean	France	karina.von.schuckmann@mercator-ocean.fr	X
Hao Zuo	ECMWF	UK	hao.zuo@ecmwf.int	X
Steve Penny	NOAA	USA	Steve.Penny@noaa.gov	X
Tony Rosati	NOAA	USA	tony.rosati@noaa.gov	X
Eric de Boisseson	ECMWF	UK	Eric.Boisseson@ecmwf.int	X
Chris Harris	MetOffice	UK	christopher.harris@metoffice.gov.uk	X
James Richman	NRL	USA	james.richman.ctr@nrlssc.navy.mil	X
Stephanie Guinehut	CLS	France	sguinehut@cls.fr	X
Yann Drillet	Mercator Ocean	France	ydrillet@mercator-ocean.fr	X
Elisabeth Remy	Mercator Ocean	France	eremy@mercator-ocean.fr	X
Romaine Bourdalle-Badie	Mercator Ocean	France	rbourdald@mercator-ocean.fr	X
Isabelle Mirouze	CMCC	Italy	isabelle.mirouze@cmcc.it	X
Arun Kumar	NOAA	USA	arun.kumar@noaa.gov	X
Antonio Bonaduce	Mercator Ocean	France	antonio.bonaduce@mercator-ocean.fr	X
Matthieu Chevallier	Météo-France	France	matthieu.chevallier@meteo.fr	X
Robin Wedd	BOM	Australia	r.wedd@bom.gov.au	X
Tanguy Szekely	Ifremer	France	tanguy.szekely@ifremer.fr	X
Yiguo Wang	NERSC	Norway	yiguo.wang@nersc.no	X
Clement Bricaud	Mercator Ocean	France	cbricaud@mercator-ocean.fr	X
Jay Shriver	NRL	USA	jay.shriver@nrlssc.navy.mil	X
Anna Borovikov	NASA	USA	anna.borovikov@nasa.gov	X
Marie Helene Rio	CLS	France	mrrio@cls.fr	X
Clotilde Dubois	Météo-France	France	clotilde.dubois@meteo.fr	X
Sandrine Mulet	CLS	France	smulet@cls.fr	X
Jean-Michel Lellouche	Mercator Ocean	France	jlellouche@mercator-ocean.fr	X
Takahiro Toyoda	JMA	Japan	ttoyoda@mri-jma.go.jp	X
Eric Hackert	NASA	USA	eric.c.hackert@nasa.gov	X
Laura Jackson	MetOffice	UK	laura.jackson@metoffice.gov.uk	X
Nathalie Verbrugge	CLS	France	nverbrugge@cls.fr	X
Gilles Garric	Mercator Ocean	France	gilles.garric@mercator-ocean.fr	X
Anthony Weaver	CERFACS	France	weaver@cerfacs.fr	X
Eric Greiner	CLS	France	eric.greiner@cls.fr	X