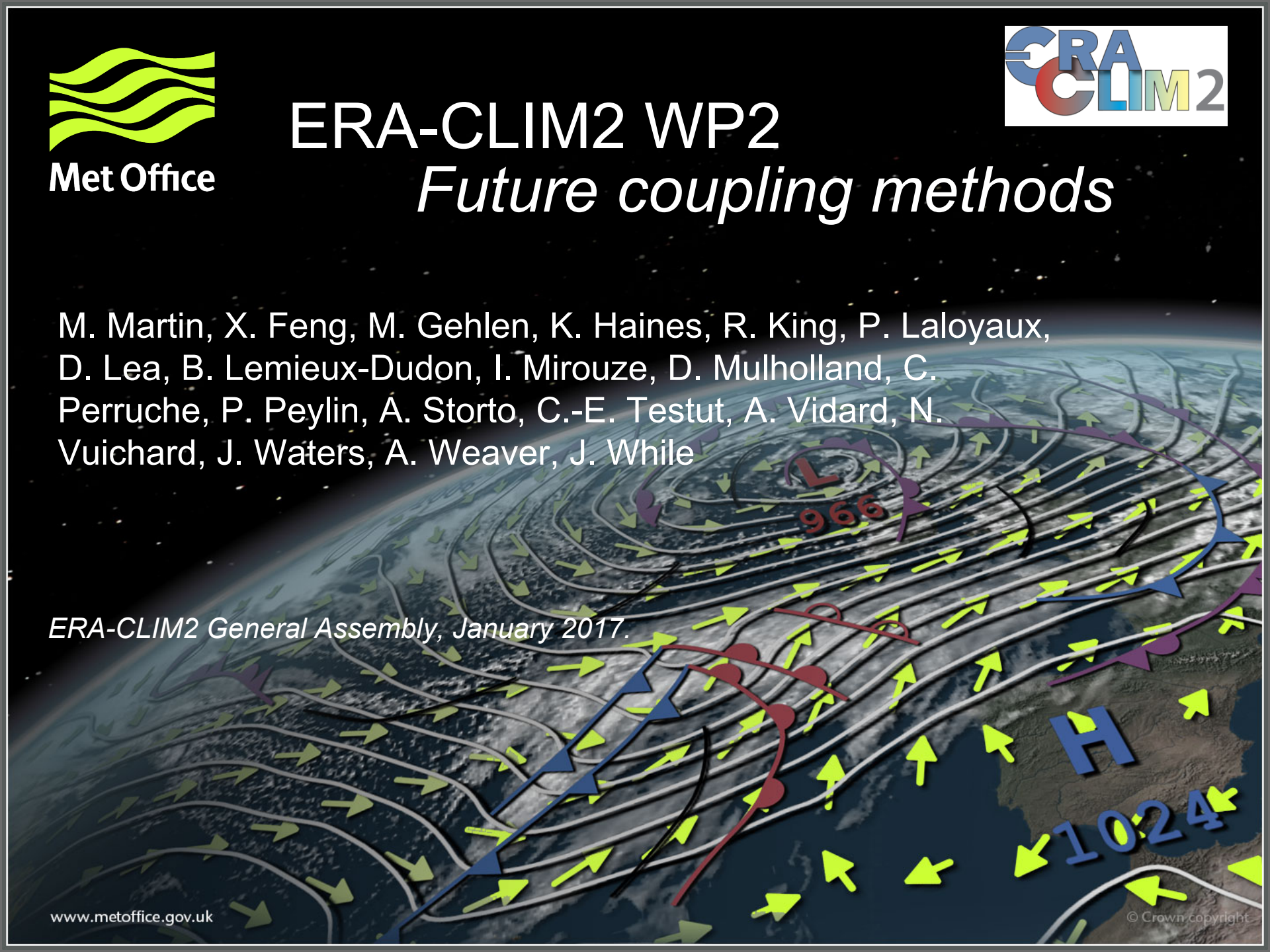
ERA-CLIM2 WP2
Future coupling methods

M. Martin, X. Feng, M. Gehlen, K. Haines, R. King, P. Laloyaux, D. Lea, B. Lemieux-Dudon, I. Mirouze, D. Mulholland, C. Perruche, P. Peylin, A. Storto, C.-E. Testut, A. Vidard, N. Vuichard, J. Waters, A. Weaver, J. While

ERA-CLIM2 General Assembly, January 2017.



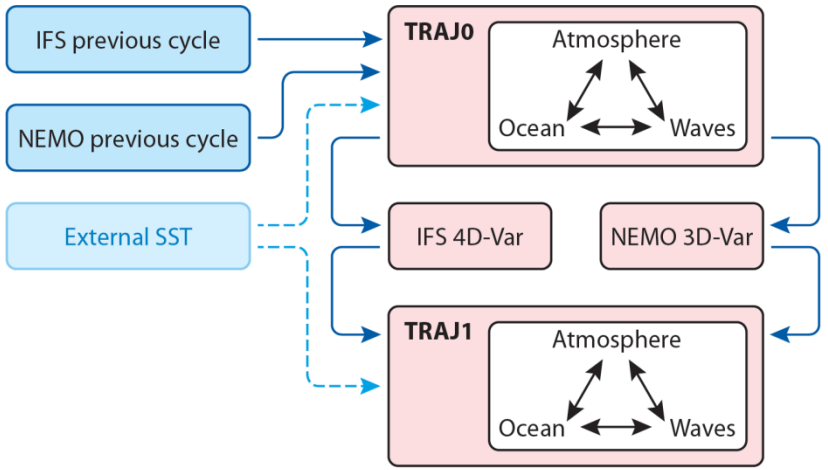
Contents

- Objectives of WP2
- Deliverables' status
- Outreach
- Plans

WP2 objectives
Future coupling methods

- Research and development in coupled data assimilation for climate reanalysis, and work on development of the carbon component.
- Developments will be available for implementation in the CERA (Coupled ECMWF Reanalysis) framework developed at ECMWF.
- The work package will address the special requirements for the pre-satellite data-sparse era and the requirement to maintain a consistent climate signal throughout the entire reanalysis period.

- T2.1: Coordination and management
- T2.2: To include SST and sea-ice assimilation in NEMOVAR
- T2.3: To improve the ocean analysis component including use of ensembles and 4D-VAR
- T2.4: Development of the carbon component of coupled earth system reanalysis
- T2.5: Towards development of fully coupled data assimilation



WP2 status of deliverables

Deliverable number	Deliverable title	Delivery date	Type
D2.1	Assimilation of sea-surface temperature observations [METO]	27 => 39	Code + documented results
D2.2	Assimilation of sea-ice observations [MERCO]	27 => 39	Code + documented results
D2.3	Ensemble-based covariance estimates [CERFACS]	34 => 46	Code + documented results
D2.4	Ensemble-based covariances in coupled data assimilation [CMCC]	24 => 36	Report
D2.5	4D-Var in NEMOVAR [INRIA]	27 => 39	Report
D2.6	Optimised model parameters for the carbon cycle [UVSQ]	34 => 46	Report
D2.7	Alternatives for coupling ocean biogeochemistry [MERCO]	34 => 46	Report
D2.8	Weakly coupled assimilation methods [UREAD]	18	Report
D2.9	Covariances from weakly coupled data assimilation [METO]	18	Report
D2.10	Coupled-model drift [UREAD]	34 => 46	Report
D2.11	Fully coupled data assimilation [INRIA]	34 => 46	Report
D2.12	Status report WP2 [METO]	8	Report

- 4 deliverables complete. The latest is the D2.4 report from CMCC.
- 3 deliverables are due soon (month 39). They are expected to be delivered on time.
- 5 deliverables are due at month 46.

WP2 outreach (1)

Published papers related to ERA-CLIM2 WP2 work:

- Mulholland, D. P., P. Laloyaux, K. Haines and M.-A. Balmaseda. Origin and impact of initialisation shocks in coupled atmosphere-ocean forecasts. Mon. Wea. Review, http://dx.doi.org/10.1175/MWR-D-15-0076.1.
- Mulholland, D. P., Haines, K. and Balmaseda, M. A. (2016), Improving seasonal forecasting through tropical ocean bias corrections. Q.J.R. Meteorol. Soc., 142: 2797–2807. doi: 10.1002/qj.2869
- Weaver AT, Tshimanga J, Piacentini A, 2016. Correlation operators based on an implicitly formulated diffusion equation solved with the Chebyshev iteration. *Q. J. Roy. Meteorol. Soc.,* **142**: 455-471.
- Lea, D. J., I. Mirouze, M. J. Martin, R. R. King, A. Hines, D. Walters, and M. Thurlow, 2015: Assessing a New Coupled Data Assimilation System Based on the Met Office Coupled Atmosphere–Land–Ocean–Sea Ice Model. Monthly Weather Review, 143, 4678–4694, doi: 10.1175/MWR-D-15-0174.1.
- Peylin, P., Bacour, C., MacBean, N., Leonard, S., Rayner, P. J., Kuppel, S., Koffi, E. N., Kane, A., Maignan, F., Chevallier, F., Ciais, P., and Prunet, P.: A new stepwise carbon cycle data assimilation system using multiple data streams to constrain the simulated land surface carbon cycle, Geosci. Model Dev., 9, 3321-3346, doi: 10.5194/gmd-9-3321-2016
- Conference paper: Toward variational data assimilation for coupled models: first experiments on a diffusion problem. Rémi Pellerej, Arthur Vidard, Florian Lemarié. CARI 2016, Oct 2016, Tunis, Tunisia. 2016

WP2 outreach (2)

WP2 participants involved in the GODAE OceanView Data Assimilation Task Team meeting in Santa Cruz, USA, July 2016:

- ERA-CLIM2 presentation from P. Laloyaux; ensemble ocean DA from A. Weaver; EOF-based error covariances from D. Lea; sea-ice assimilation work from C.-E. Testut; ocean biogeochemistry from C. Perruche.

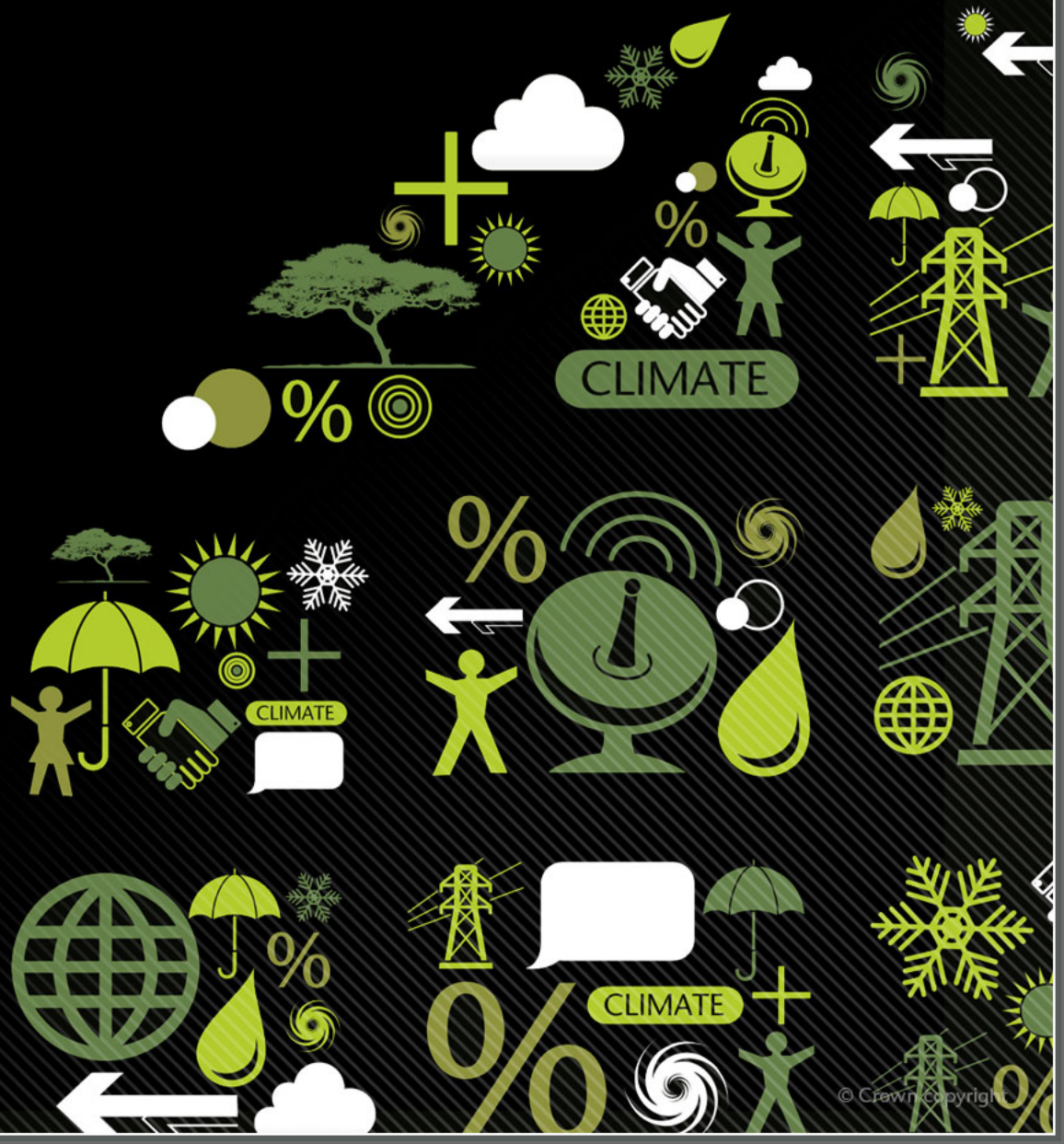
Many contributions from WP2 participants to the Coupled Data Assimilation Workshop organised by WMO (and sponsored by ERA-CLIM2) in Toulouse, October 2016:

- 6 presentations from WP2 partners;
- Organised a breakout discussion on the challenges and future direction of coupled reanalysis. Many WP2 partners and included other workshop participants from around the world.
- Main areas of challenges/priorities:
  - Coupled model biases
  - Coupled DA methodology
  - Spin-up and initialization of multiple streams
  - Changes in the observing system over time; use of novel observing systems.
  - Assessment of coupled system.

WP2 plans for the rest of the project

- Continue to make progress against deliverables. Next WP2 deliverables are due in Mar 2017 [METO, MERCO, INRIA], then Oct 2017 [CERFACS, MERCO, UVSQ, UREAD, INRIA].
- Coordination of code deliverables from METO, CERFACS and INRIA is on-going through the NEMOVAR steering group.
- METO/INRIA/CERFACS are now using directly the central NEMOVAR git repository hosted by ECMWF so ERA-CLIM2 NEMOVAR code developments will therefore be directly accessible by ECMWF.
- Code developments by MERCO will be provided as a library which could be used with NEMO/NEMOVAR.
- Plan between METO and ECMWF to implement and test SST data assimilation capability in CERA.

Met Office



www.metoffice.gov.uk

CDAW breakout
Challenges/priorities for coupled DA

- **Coupled model biases**
  - Fewer data to constrain the system in the early period.
  - Drift and "jumps" in stratosphere, deep ocean, sea ice.
  - Challenge for strongly coupled DA (transfer of biases or positive impact?).
  - More research needed on coupled model improvement and bias correction.
  - Less flexibility in coupled system to compensate for biases in individual components.
  - Encourage inter-comparison of biases and drifts in different coupled reanalyses.

CDAW breakout
Challenges/priorities for coupled DA

- **Coupled DA methodology**
  - Smoothness between cycles.
  - Longer assimilation windows (?)
  - Flexibility in the representation of (multiple) spatial scales in the background error covariances.
  - Better assimilation at the air-sea interface (bias reduction vs. coupled interactions).
  - Use of coupled reanalysis ensembles for flow-dependent covariance estimation as well as uncertainty estimation.
  - Consistent DA methodology between components.

CDAW breakout
Challenges/priorities for coupled DA

- **Spin up and initialization of multiple streams**
  - Computational cost.
  - Ocean and sea-ice initialization at start of century.
  - Determining uncertainty in initial conditions.

- **Changes in the observing system over time**
  - Spurious climate signals/trends exacerbated by model and observation bias.
  - Model and observation bias correction is needed.
  - Assimilate only surface pressure and SST (current approach for climate reanalysis).
  - Quality control (esp. newly observed area).

CDAW breakout
Challenges/priorities for coupled DA

- **Assessment**
  - Difficult because of multiple components.
  - Visualization and diagnostics.
  - Provide feedback on coupled model biases (analysis increments).
- **Novel observation types**
  - Tracer observations
  - Bottom pressure
  - Tide gauges
  - Tree rings, coral isotopes