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WORK PACKAGE 6

Evaluation and exploitation of demonstrator results for future C3S implementations

Jeff Knight[1] and Frederic Vitart[2]
1.Met Office
2.ECMWF

WP6 top level objective

Evaluate the benefits of LS improvements in the reanalysis prototypes and seasonal prediction demonstrators created in CERISE, and provide recommendations for the future of the C3S service

WP6 Specific Objectives

- Develop innovative diagnostic methods to assess quality in reanalyses and seasonal forecasts
- Provide feedbacks to WP1-3 on pre-prototype and pre-demonstrator developments
- Evaluate improved quality of reanalysis and seasonal forecast demonstrators using new methods and identify remaining gaps
- Provide recommendations for future system developments

WP6 Team

WP6 lead: Frederic Vitart (ECMWF) and Jeff Knight (Met Office)

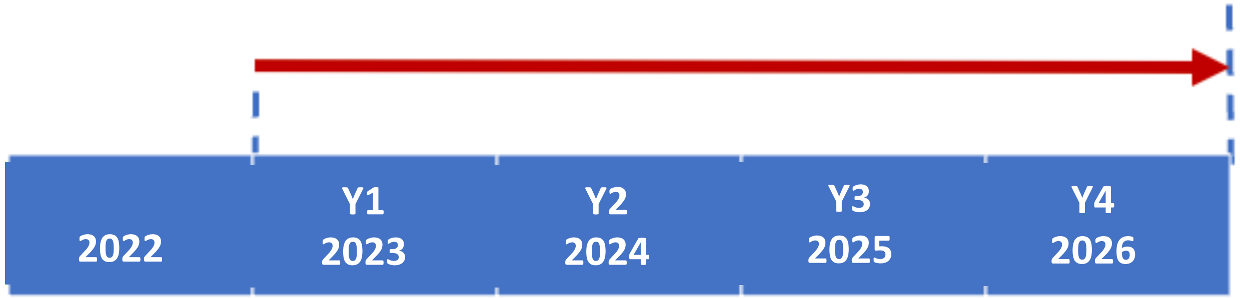
WP6 partners:

Participant number	1	2	3	4	5	6	7	8	9	10	11	12	
Short name of participant	ECMWF	MET Norway	SMHI	MF	DWD	CMCC	BSC	MetO	DMI	ESTELLUS	IPMA	NILU	Total
PMs per participant	36	0	0	43.3	0	18	52	24	8	0	14	22	217.3

Lead partner: ECMWF

Resource: about 4.6 FTE for 48 months

WP6 Timeline



Task 1: Develop techniques and methodologies (M1-30)

Task 2: Assess impacts of pre-prototype reanalyses (M12-46)

Task 3: Evaluation of full prototypes and seasonal demonstrators (M30-45)

Task 4: Report on recommendations and legacy (M36-48)

WP6 Tasks

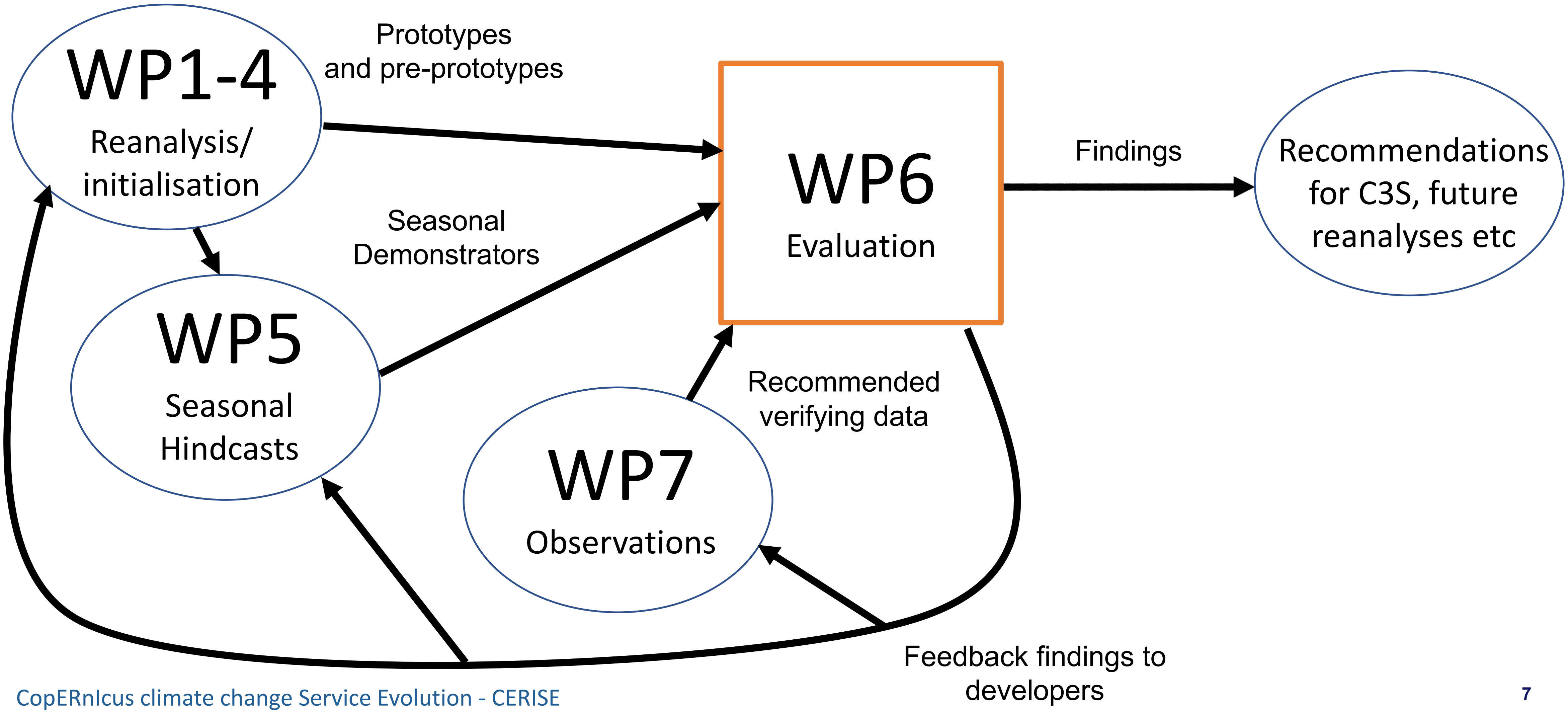
Task 6.1: Develop techniques and methodologies for evaluating the increased fidelity of land surface processes in the prototypes and demonstrators, establishing a framework for assessing improvement and identifying verifying datasets (M1-30, Lead partner: BSC, contributing ECMWF, BSC, CMCC, MF, DMI, Met Office, NILU and IPMA)

Task 6.2: Assess the impacts of developments in reanalysis methods (performing additional experiments where necessary) and provide feedback on their benefits to WPs 1-3 (M12-32, Lead partner: ECMWF, contributing: ECMWF, BSC, CMCC, MF, DMI, UKMO, NILU and IPMA)

Task 6.3: Evaluate reanalysis prototypes and seasonal forecast demonstrators (M30-45, Lead partner: MF, contributing: ECMWF, BSC, CMCC, DMI, MF, UKMO, IPMA and NILU)

Task 6.4: Legacy and recommendations based on the project's findings (M36-48, Lead partner: Met O, contributing: all WP6 partners)

Connectivity with the project



WP6 Deliverables

Year 3

- D6.1 Report providing a protocol for assessing the improvement in the quality in the demonstrators (BSC, R, PU, M30)
- D6.2 Report providing feedback on the impact of time varying vegetation in reanalysis on seasonal forecasts (ECMWF, R, PU, M36)
- D6.3 Report providing feedback on the impact of land assimilation in reanalysis on seasonal forecasts (ECMWF, R, PU, M36)

Year 4

- D6.4 Recommendations report on next C3S system developments and future reanalysis and seasonal forecast assessment (UKMO, R, PU, M48)
- D6.5 Recommendations report of new land products for C3S (ECMWF, R, PU, M48).

WP6 Milestones

Year 2

- M6.1 Deliver preliminary methodologies and corresponding assessments of the current C3S seasonal forecast demonstrator initial conditions to WP3 (M18)

Year 3

- M6.2 Complete assessment of current C3S re-analyses and seasonal forecasts (M30)
- M6.3 Analysis of sensitivity experiments to assess the impact of time-varying vegetation and land assimilation (M32)
- M6.4 Complete assessment of re-analysis and seasonal forecast demonstrators (M45)

Task 6.1: Develop techniques and methodologies for evaluating the increased fidelity of land surface processes in the demonstrators, establishing a framework for assessing improvement and identifying verifying datasets (M1-30)

- Use existing reanalyses and seasonal reforecasts to design methods to efficiently detect the changes in quality between baseline and improved versions of products and systems (M1-30)
- Identify a set of time intervals in which sensitivity to land surface conditions may be increased (‘windows of opportunity’), allowing greater detectability of changes in product quality, for later use in assessing the demonstrators (M1-30)
- Assess the level of consistency between earth system components in currently available global and regional reanalyses and between real-time forecast and re-forecasts (M1-30)
- Produce a protocol for assessing the improvement in quality in the demonstrator using the techniques and datasets identified (M1-30)

Lead partner: BSC, contributing ECMWF, BSC, CMCC, MF, DMI, Met Office, NILU and IPMA)

Task 6.2: Assess the impacts of developments in reanalysis methods (performing additional experiments where necessary) and provide feedback on their benefits to WPs 1-3 (M12-42):

- Assess the fidelity of low frequency variability and identify potential jumps and trends, validate the new regional and global re-analysis pre-prototype land surface variables against independent observed datasets provided by WP7, investigate errors. (M12-36)
- Assess the benefit of land surface assimilation on land reanalysis (M12-36)
- Assess impact changes in land surface properties on global and regional re-analyses and seasonal forecasts, including sensitivity forecast experiments (M18-42)
- Assess impact of land surface coupled data assimilation on global and regional re-analyses and seasonal forecasts, including sensitivity forecast experiments (M18-42)

Lead partner: ECMWF, contributing: ECMWF, BSC, CMCC, MF, DMI, UKMO, NILU and IPMA

Task 6.4: Legacy and recommendations based on the project's findings (M36-48)

- Provide new land surface products based on evaluation performed in WP 5 and 6
- Provide recommendations for the development of the next C3S systems and products
- Suggest how systems may be developed further in time
- Recommend techniques for future assessment of quality/skill in reanalyses and seasonal predictions, in light of the experience of assessment of the demonstrators in task 3

Lead partner: UKMO, contribution: all the partners contributing to WP6

Partner	Tasks	Task 1/3 Focus	Demonstrators	Task 2 Focus
BSC	1,2,3,4	Hot/dry extremes	Reanalysis Seasonal	Heat extremes/drought
CNRM	1,2,3,4	River discharge	Regional reanalysis Seasonal forecasts	Sensitivity experiment soil re-analysis
CMCC	1,2,3,4	Vegetation	Seasonal forecasts	Vegetation
DMI	1,2,3,4	Snow cover	Regional Reanalysis Greenland area	Pan Arctic CARRA LDAS
ECMWF	1,2,3,4	Temporal consistency and trends	Reanalysis Seasonal	Sensitivity experiments reanalysis and seasonal
Met Office	1,2,3,4	Fidelity	Seasonal	-
NILU	1,2,3,4	Snow cover	Seasonal	Snow
IMPA	1,2	LST/fluxes	Reanalyses and seasonal forecasts	LST/Fluxes

ECMWF Contribution to WP6

Task 6.1:

- Develop methodology to diagnose **time consistency and trends** of land surface variables in re-analysis and seasonal forecasts and apply to it to current systems. *Create techniques to compare land initial conditions in seasonal forecast systems (WP3)*

Task 6.2:

- In-depth validation of and comparison between ERA5 and ERA5-Land for all its surface parameters. Assess impact of data assimilation on ECMWF land re-analysis
- Assess re-analysis ECMWF pre-demonstrators: 1) fidelity of low-frequency variability (looking for jumps, trends), *2)* validation with independent datasets, 3) investigate damages from incomplete QC, 4) validation of hourly data. Provide feedbacks to WP1, 2 and 4. Detect potential systematic model biases, issues with QC, issues with the hourly products.
- Design and analyse sensitivity seasonal forecast experiments initialized from re-analyses with and without time varying vegetation (e.g. 40-year seasonal forecasts initialized from ERA5 + offline soil re-analysis with and without time varying vegetation, possibly at low-resolution to complement CONFESS runs).
- Design and analyse sensitivity seasonal forecast experiments initialized from re-analyses with and without coupled land-atmosphere (e.g. 40-year seasonal re-forecasts, possibly at low resolution)

Task 6.3: Apply methodology developed in Task 6.1 to assess trends in re-analysis and seasonal forecast demonstrators.

Task 6.4: Based on WP5 and 6 results, propose new seasonal products and provide recommendations.

ECMWF Contribution to WP6 in Year 1

1 person recruited: Jonny Day who will work for WP3 and WP6.

In 2022, ECMWF will contribute to the following activities:

1. *Create techniques to compare land initial conditions in seasonal forecast systems (WP3)*

2. Develop methodology to diagnose **time consistency and trends** of land surface variables in re-analysis and seasonal forecasts and apply to it to current systems. (Task 6.1)

3. In-depth validation of and comparison between ERA5 and ERA5-Land for all its surface parameters. Assess impact of data assimilation on ECMWF land re-analysis (Task 6.2)

Met Office contribution to WP6

Task 6.1: Develop techniques and methodologies

- Assess the consistency of initial hindcast and forecast conditions in existing C3S systems
- Develop methods using observable atmosphere-land surface physical relationships as tests of improvements in fidelity
- Identify case study seasons in which land surface conditions play a role

Task 6.2: Assess the impacts of developments in reanalysis methods

- Analyse GloSea6 hindcast ensembles with and without land data assimilation

Task 6.3: Evaluate reanalysis prototypes and seasonal forecast demonstrators

- Assess the consistency of initial hindcast and forecast conditions in seasonal forecast demonstrator
- Evaluate improved fidelity of seasonal forecast demonstrators in terms of atmosphere-land surface physical relationships
- Assess improvements in the representation of specific case study seasons in which land surface conditions play a role

Task 6.4: Legacy and recommendations based on the project's findings

- Lead report on legacy and recommendations for C3S services and methods of reanalysis and seasonal hindcast assessment

Met Office Year 1 activity

David Fereday will work on WP6, with input from Jeff Knight and Adam Scaife

Work will start later in the year on the consistency analysis and development of new analysis methods (6.1)

BSC contributions to CERISE WP6

Task 6.1:

- develop techniques for assessing the fidelity of land surface variability and processes, and assess physical consistency between land/atmosphere components; focus on
    - soil moisture variability
    - land-atmosphere interactions driving heatwaves and droughts
    - identify ‘windows of opportunity’ for increased predictability conditional on land surface state

Task 6.2:

- apply these tools/diagnostics developed in T6.1 to reanalysis pre-prototypes
- test how the improved land-surface representation effects the representation of long-term changes in historical heatwaves and droughts

Task 6.3:

- apply these tools/diagnostics to reanalysis prototypes and seasonal forecast demonstrators

Task 6.4:

- Contribute to recommendations for the improvement of operational land products in C3S

Activities planned during year 1

Task 6.1:

- start developing the diagnostics to evaluate soil moisture variability and land-atmosphere interactions in relation to heatwaves and droughts, and
- test these on existing reanalysis (ERA5) and seasonal prediction systems (C3S)

CMCC contribution to WP6

Role of CMCC: Develop approaches to identify and assess the effects of systematic errors, their growth and impacts on forecasts, analysing coupling between vegetation and atmosphere.

Task 6.1 (**M1-30**) CMCC will develop methods to assess **land-atmosphere fluxes and biases in seasonal predictions**, and **evaluate the effects of improved land-surface representation on seasonal forecast errors**.

Task 6.2 (**M12-46**) CMCC will **analyse forecast experiments (WP5), initialised with the weakly coupled data assimilation analysis**, and **alternatively prescribing LAI, snow cover and soil moisture**, in order to identify the contribution of surface variables to the prediction error and its growth.

Task 6.3 (**M30-45**) CMCC will **assess the effects of improved land-surface representation** on seasonal forecast errors, and in addition will provide an **assessment focused on instances of large surface fluxes and biases in the seasonal forecast demonstrators**.

Task 6.4 (**M36-48**) CMCC will contribute to recommendations for the improvement of operational land products in C3S.

CMCC contribution to WP6

Activities during the first 12 project months

CMCC will contribute to Task 6.1:

- definition of methodologies and techniques to evaluate the impacts of improved land–surface IC on the forecasts;
- identify where and when the land surface has the largest impact on land-atmosphere fluxes of moisture and energy, and where there are the largest biases and errors in the seasonal forecast demonstrators.
- start the design of the sensitivity experiments aimed at analysing the contribution of the errors in surface variable ICs to the prediction error and its growth.

People involved: Silvio Gualdi, Daniele Peano, Giovanni Conti, Louis-Gustavo Goncalves

MF’s contribution to WP6 will focus on river discharge

Task6.1

Design a framework to calculate river discharge from SF prototypes and reanalysis demonstrators. Use of ISBA-CTRIP routing model for the evaluation requires (i) modeled surface runoff and soil infiltration, and (ii) verifying datasets.

Task6.2

Evaluate CERRA-Land European reanalysis with and without LULC change.

Task6.3 (lead MF)

Deployment of the method set up in Task6.1 for river discharge. Follow-up of the deployment of the methods implemented by the partners (ECMWF, BSC, CMCC, DMI, MF, MetO, IPMA and NILU) in Task6.1.

Task6.4

Contribute to propose recommandations to improve land product in C3S.

MF’s contribution to WP6 M1-12

Task 6.1: Design a framework to calculate river discharge from SF prototypes and reanalysis demonstrators.

- Set up the framework based on MF’s production for both SF prototype and reanalysis (for further contribution to Task6.3).
- Select sensitive basins (‘windows of opportunity’) for the hydrological evaluation.
- Compute statistical scores to assess river discharges.

WP 6 Evaluation and exploitation of demonstrator results for future C3S implementations

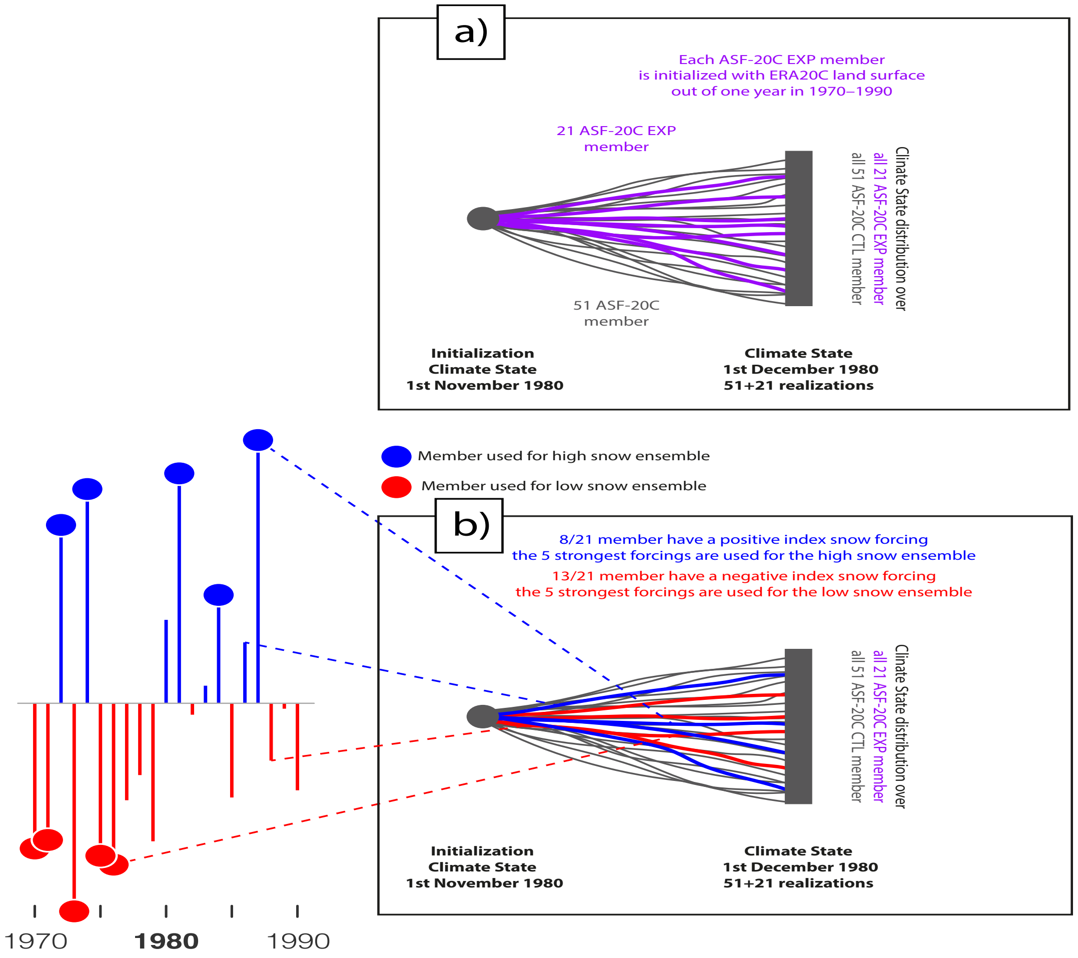
Partner NILU Role: Develop and apply diagnostics of snow in global and land-reanalyses and seasonal forecasts and analyse snow-atmosphere coupling processes

Task running through Year 1:

(Task 6.1: Develop techniques and methodologies for evaluating the increased fidelity of land surface processes in the demonstrators, establishing a framework for assessing improvement and identifying verifying datasets

- develop a conditional approach to assess snow variables in seasonal forecasts.
- develop techniques for assessing the accuracy and reliability of snow variables in seasonal forecasts.

Example of the use of the conditional (subsampling) approach



We compared twin ensemble experiments

(ASF-20C and a perturbed twin)

We changed land initial conditions in the perturbed experiment

We sub-select 5 members with **High** or **Low snow index** initial conditions

We can follow the impact of the **High or Low snow initial conditions** on the atmosphere evolution by examining **High - Low**

There exists different methods to generate the intial land conditions in perturbed experiment [scrambling/shift across years, or season, or clim+ perturb]

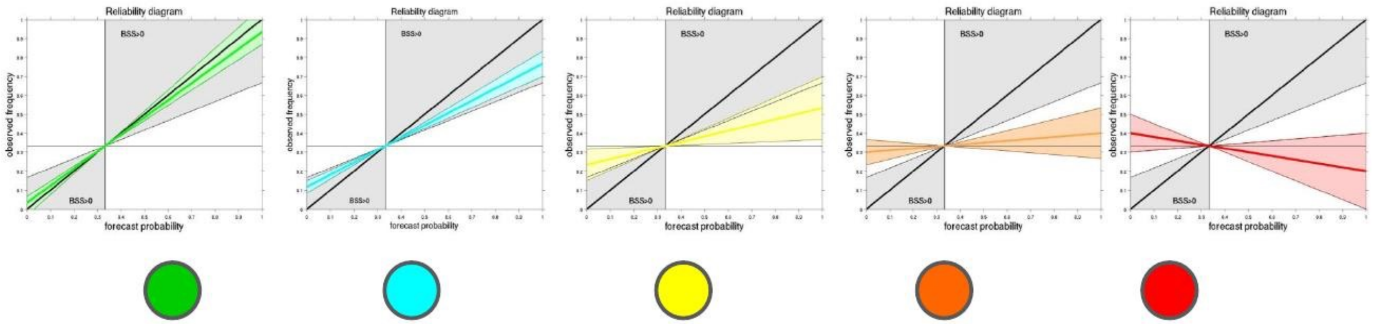
We won't have the luxury of a twin experiment: ->adapt this method

Impact of Eurasian autumn snow on the winter North Atlantic Oscillation in seasonal forecasts of the 20th Century, M. Wegmann, Y. Orsolini, A. Weisheimer, B. van den Hurk, and G. Lohmann, Weather Clim. Dynam., 2, 1245–1261, 2021

Reliability Diagrams / Categories of Reliability for snow depth in seasonal forecasts over NH

5 proposed reliability categories:

Based on Weisheimer and Palmer (2014)

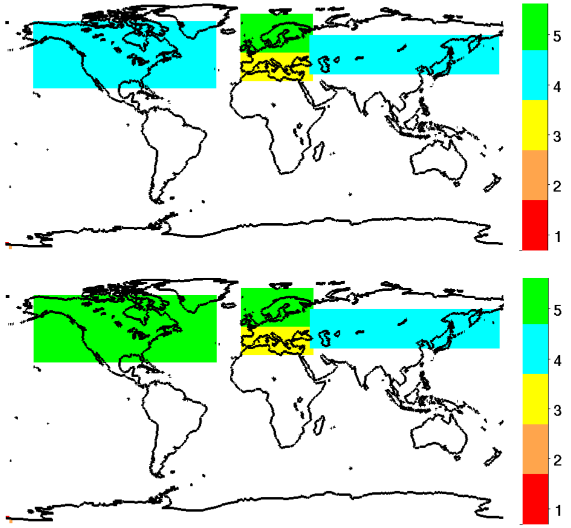


perfect | still useful | marginally useful | not useful | dangerous

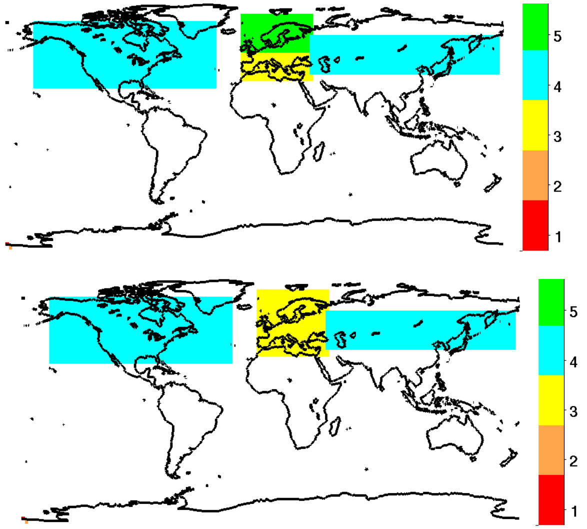
- Finer grid
- Time evolution

Lower Tercile of snow depth

Upper Tercile of snow depth



Realistic initialisation



Climatology initialisation

1-month lead

Figs : D. Decremer (ECMWF)
From SPECS FP-7 EU project final report; Orsolini Y., lead author

Improved snow analyses over High Mountain Asia : with /without satellite (IMS) snow cover data assimilation

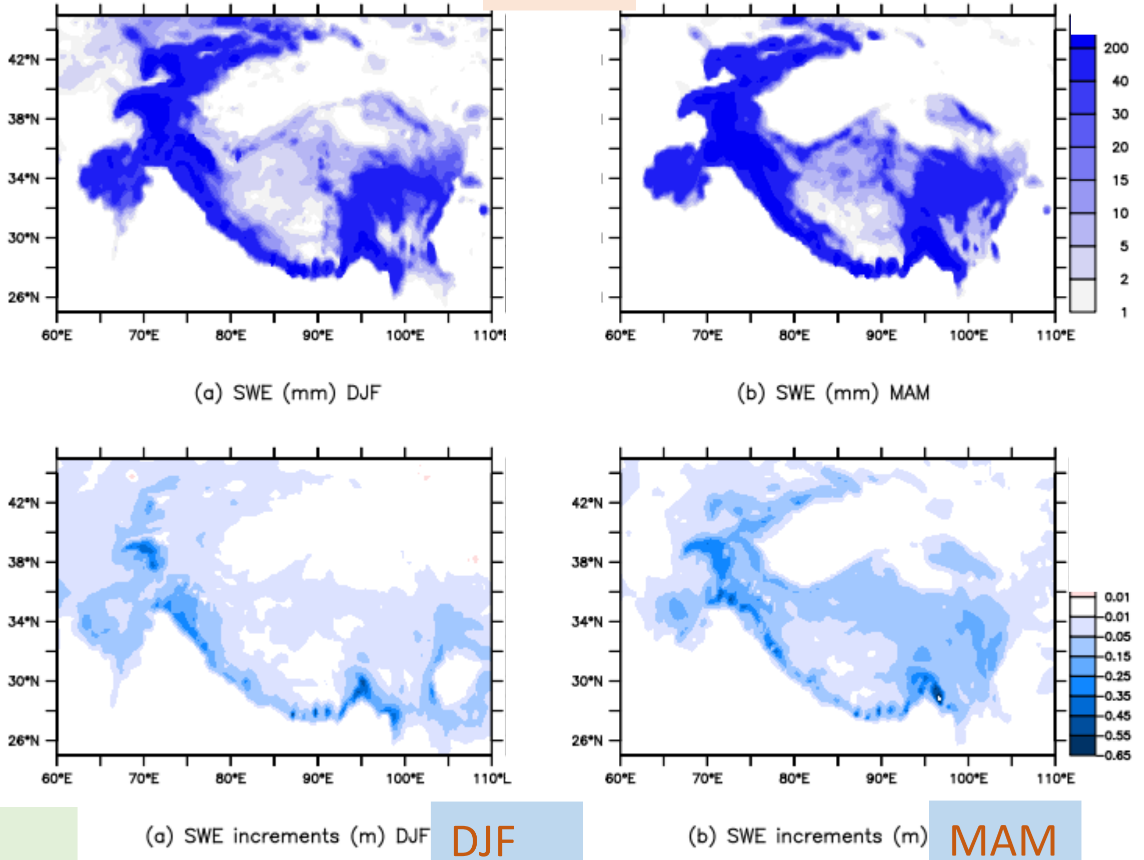
These two snow analyses used as initial conditions for ECMWF model (SEA5-like)

Analyse the Impact on springtime seasonal fc (test year 2018)

Relevant Task 6.2

- Extensive periods (e.g.,2000-2020)
- Different satellite data (e.g.ESA CCI)
- Snow cover / depth
- Verification datasets

SWE



DJF

MAM

(CTRL)
"ECMWF operational": IMS assimilation turned off above 1500m

With IMS DA
Improved snow compared to in-situ data

Decrements (m)
Negative! (excess of snow removed by DA)

Impacts of snow assimilation on seasonal snow and meteorological forecasts for the Tibetan Plateau

Wei Li, Jie Chen, Lu Li, Yvan J. Orsolini, Yiheng Xiang, Retish Senan, and Patricia de Rosnay

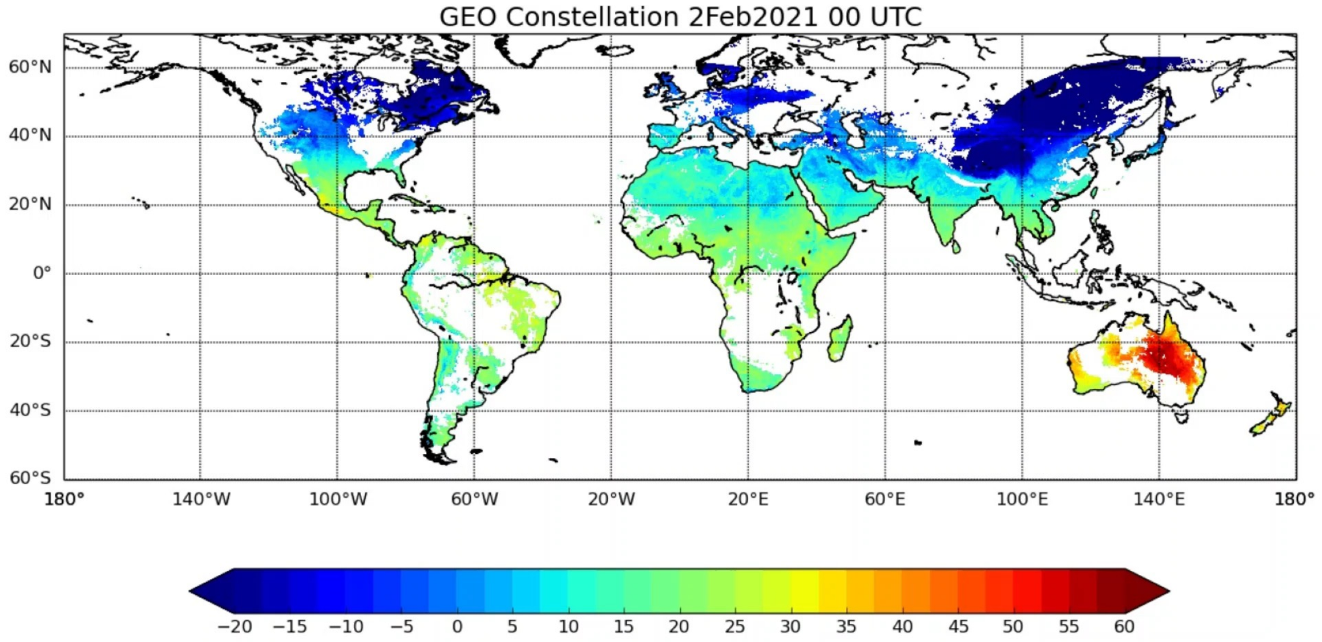
The Cryosphere, 16, 4985–5000, 2022

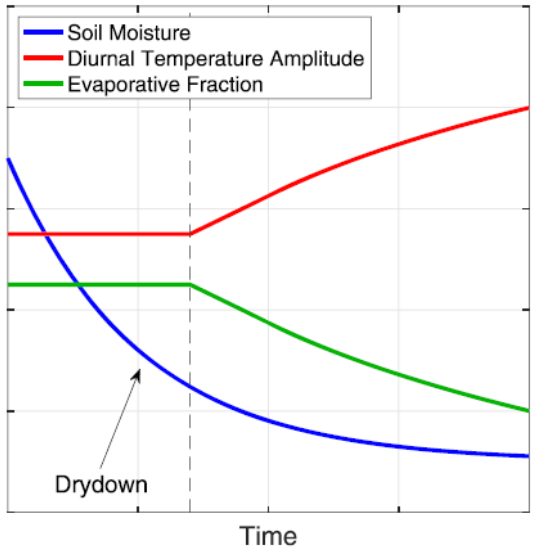
WP6 – Exploring LST for Model Assessment

Evaluate the impact of new land surface properties on skin temperature:

✓ Land Surface Temperature closely linked to heat and water flu

Contains information on evaporative regimes



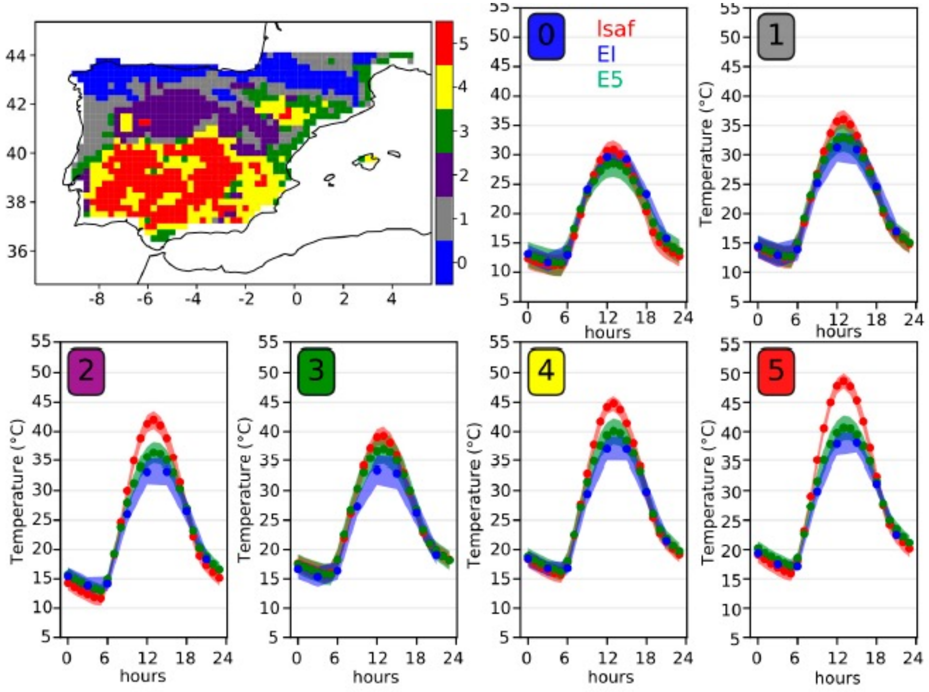


WP6 – Exploring LST for Model Assessment

Year 1:

Prepare LST vs Skin Temperature comparisons: clear sky conditions;
Selection of cases: summer/extreme conditions; look at LST daily Max

Summer LST in Iberia:
ERA-Int, ERA-5, SEVIRI/MSG LST

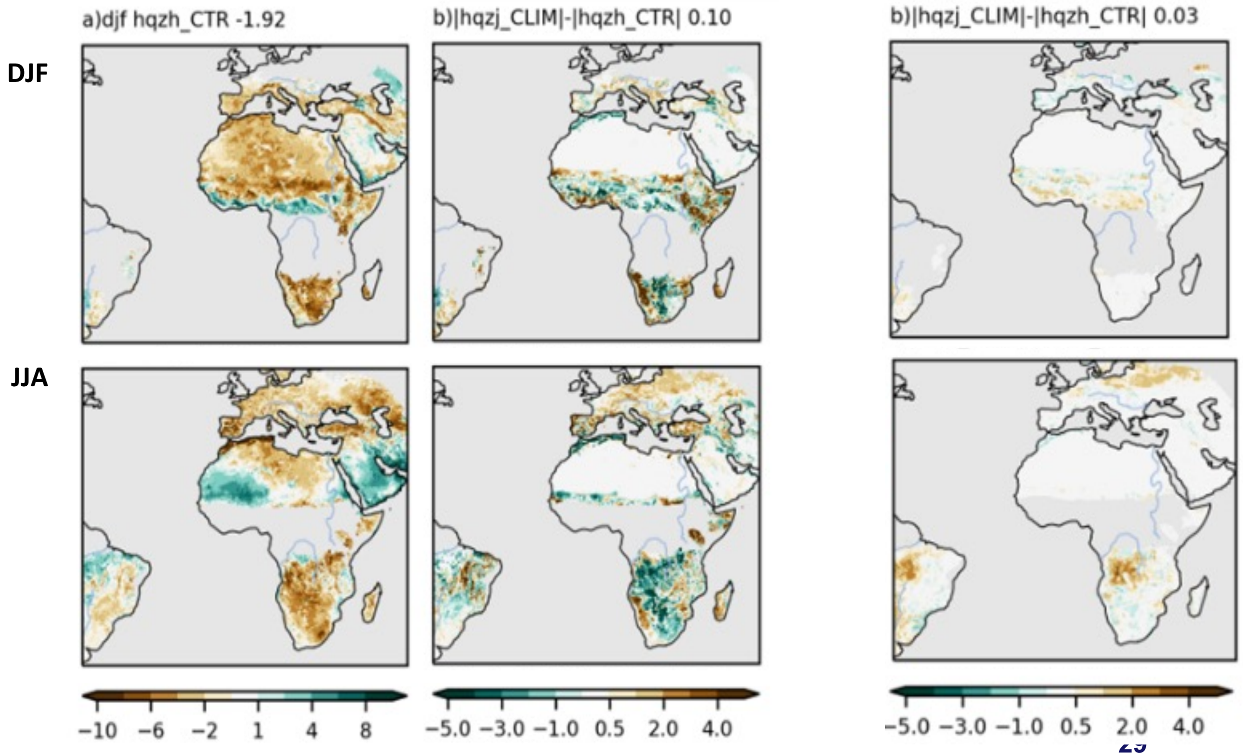


Johannsen et al, 2019 doi:10.3390/rs11212570

CoCO2

Daily maximum **Daily minimum**

Bias CTRL (ECLand) Impact (revised low&high veg + LAI)



DMI contribution to CERISE/WP6

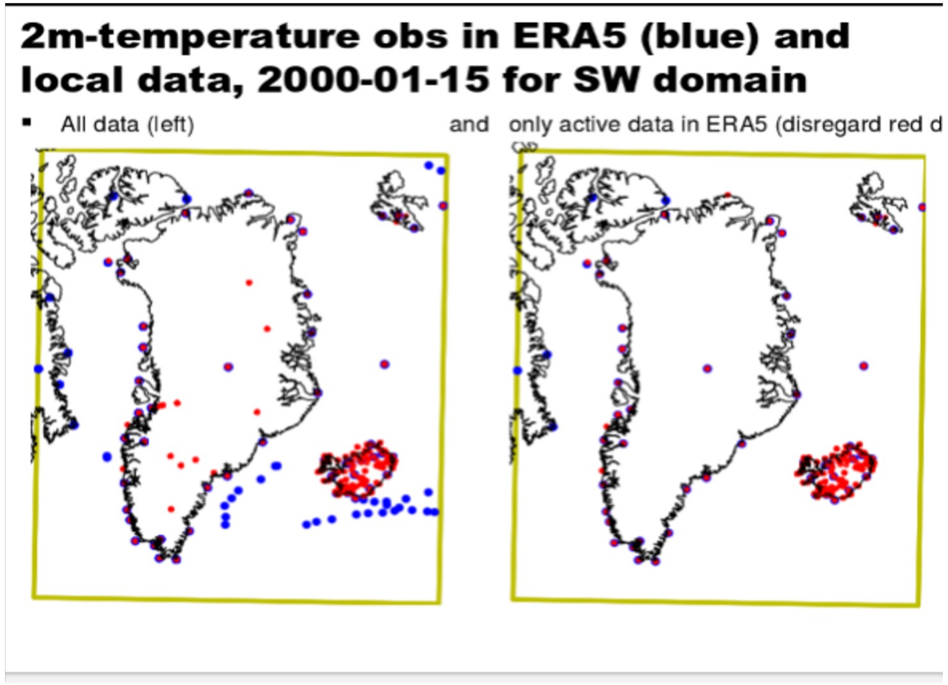
Contributing Staffs

Carlos Peralta, Bjarne Amstrup, Fabrizio Baordo, NN, Xiaohua Yang (a total of 9 PM?)

Committed DMI activities on WP6

With focus on validation of re-analyses over permafrost regions/Ice sheet

1) Participate in discussion about general methodology on verification
2) App relevant verification/methodology to data sets from CARRA & demonstrators in WP4 to assess trgional LDAS in reference to regular reanalysis
3) Contribution to collection of shared validation dataset/intercomparisons.



Main Contacts for WP6

ECMWF Frederic Vitart/Jonny Day

UKMO: Jeff Knight/David Fereday

BSC: Markus Donat

Meteo-France: Patrick le Moigne

CMCC: Silvio Gualdi

IPMA: Isabel Trigo

DMI: Xiaohua Yang

NILU: Yvan Orsolini

Discussions

- Possible overlaps between partners
- Opportunities for collaborations
- Data needed for WP6 diagnostics (variables, temporal and spatial resolution, re-forecast length….)
- Interactions with WP4 (e.g. timeline) and WP7 (e.g. data for verification).

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Thank you

ECMWF, MetNorway, SMHI, Météo-France, DWD, CMCC, BSC, MetOffice, DMI, ESTELLUS, IPMA, NILU

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