**Advanced models and weather prediction in the Arctic: Enhanced capacity from observations and polar process representations (ALERTNESS) (Forskerprosjekt - POLARPROG)**

**Application Number: ES600375 Project Number: -1**

---

# Applicant

## Project Owner

| | |
|---|---|
| Institution / company (Norwegian name) | METEOROLOGISK INSTITUTT |
| Faculty | |
| Institute | |
| Department | |
| Address | Postboks 43 BLINDERN |
| Postal code | 0313 |
| City | OSLO |
| Country | Norway |
| E-mail | post@met.no |
| Website | met.no/ |
| Enterprise number | 971274042 |

| | |
|---|---|
| eAdministration | |

## Project administrator

| | |
|---|---|
| First name | Jørn |
| Last name | Kristiansen |
| Date of birth | 031271 |
| Personal number | ********** |
| Gender | Male |
| Position/title | Direktør |
| Phone | +47 46420054 |
| E-mail | jornk@met.no |
| Confirmation | ✔ The application has been approved by the |

**Advanced models and weather prediction in the Arctic: Enhanced capacity from observations and polar process representations (ALERTNESS) (Forskerprosjekt - POLARPROG)**

**Application Number: ES600375 Project Number: -1**

| | |
|---|---|
| | Project Owner |

## Project manager

| | |
|---|---|
| First name | Jørn |
| Last name | Kristiansen |
| Date of birth | 031271 |
| Personal number | ********** |
| Gender | Male |
| Institution / company (Norwegian name) | METEOROLOGISK INSTITUTT |
| Faculty | |
| Institute | |
| Department | Senter for utvikling av varslingstjenesten |
| Address | Postboks 43 BLINDERN |
| Postal code | 0313 |
| City | OSLO |
| Country | Norway |
| Position/title | Direktør |
| Academic degree | Ph.D |
| Preferred language | Bokmål |
| Phone | +47 46420054 |
| E-mail | jornk@met.no |

## Project info

## Project title

| | |
|---|---|
| Project title | Advanced models and weather prediction in the Arctic: Enhanced capacity from observations and polar process representations (ALERTNESS) |

## Primary and secondary objectives of the project

**Advanced models and weather prediction in the Arctic: Enhanced capacity from observations and polar process representations (ALERTNESS) (Forskerprosjekt - POLARPROG)**

**Application Number: ES600375 Project Number: -1**

| | |
|---|---|
| Primary and secondary objectives | The ambition and primary objective of ALERTNESS is to develop world leading capacity for the delivery of reliable and accurate Arctic weather forecasts and warnings for the benefit of maritime operations, business and society.<br><br>Secondary objectives<br>1. Develop and apply verification metrics and diagnostics for Numerical Weather Prediction (NWP) in the Arctic<br>2. Improve use and assimilation of Arctic observations for NWP<br>3. Enhance and improve NWP model capabilities and diagnostics for high latitudes<br>4. Develop an Ensemble Prediction System optimized for Arctic conditions<br>5. Improve polar prediction through the ALERTNESS value chain |

## Project summary

| | |
|---|---|
| Project summary | High-impact weather conditions, rapid climate change and limited predictability make the Arctic a challenging operating environment leading to substantial business, societal and environmental risks. ALERTNESS will meet this growing need for reliable and accurate weather predictions by addressing forecast challenges unique to the Arctic: availability and quality of observations, exploitation of satellite observations over snow and ice, model uncertainty due to physics parameterisations, and specific high-impact weather situations. A new set of verification measures appropriate for Arctic will be developed and employed throughout the project to efficiently monitor progress and user needs. ALERTNESS will take advantage of several unique opportunities arising during the Year of Polar Prediction (YOPP) to tackle long-standing issues in atmospheric models in polar environments: advance atmospheric and sea ice analysis in the Arctic using more and new observation types, optimize observation usage and implement state-of-the-art analysis techniques; enhance the representation of Arctic processes including a revised approach to heat flux parameterisation; and improve understanding of error compensation between different processes. Furthermore, ALERTNESS will explore new ways to diagnose uncertainties evolving from representations of small-scale processes, and is set to generate substantial advances in probabilistic forecasting for the Arctic. ALERTNESS builds directly on existing user and stakeholder mechanisms and will enable stakeholders to, for instance, use the advances of probabilistic forecasting for the benefit of safer and more efficient operations in the Arctic. Our tight collaboration between academia and the operational environment at MET Norway will efficiently transfer the results from research to operations, creating a lasting legacy in Arctic weather prediction capacity. |

## Funding scheme

**Advanced models and weather prediction in the Arctic: Enhanced capacity from observations and polar process representations (ALERTNESS) (Forskerprosjekt - POLARPROG)**

**Application Number: ES600375 Project Number: -1**

## Supplementary info from applicant

| | |
|---|---|
| Programme / activity | POLARPROG |
| Application type | Forskerprosjekt |
| Topics | |
| Other relevant programmes/ activities/projects | |
| Discipline(s) | Meteorology |
| If applying for additional funding, specify project number | |
| Have any related applications been submitted to the Research Council and/or any other public funding scheme | No |
| If yes, please provide further information | |

## Progress plan

## Project period

| | |
|---|---|
| From date | 20180101 |
| To date | 20211231 |

## Main activities and milestones in the project period (year and quarter)

| Milestones throughout the project | From | | To | |
|---|---|---|---|---|
| WP1: Verification and diagnostics | 2018 | 1 | 2021 | 4 |
| WP2: Improve use of Arctic observations | 2018 | 2 | 2021 | 4 |
| WP3: Enhance NWP capabilities in the Arctic | 2018 | 1 | 2021 | 4 |
| WP4: Develop EPS for Arctic conditions | 2018 | 1 | 2021 | 4 |
| WP5: Utilize ALERTNESS value chain | 2018 | 1 | 2021 | 4 |
| D1.1 Public database and report | 2018 | 4 | 2020 | 4 |
| D1.2 Report: Evaluation metrics | 2019 | 3 | 2019 | 3 |

| | | | | |
|---|---|---|---|---|
| D1.3 Publication: NWP model evaluations | 2020 | 1 | 2020 | 1 |
| D1.4 Report: Strategies for model improvement | 2021 | 4 | 2021 | 4 |
| D2.1 Report: New satellite obs. operator | 2020 | 2 | 2020 | 2 |
| D2.2 Publication:Sea ice temp. and rad. assim | 2020 | 2 | 2020 | 2 |
| D2.3 Prototype ready: 4D-Var | 2021 | 3 | 2021 | 3 |
| D2.4 Prototype ready: EDA | 2021 | 3 | 2021 | 3 |
| D2.5 Report: All-Sky assimilation | 2021 | 3 | 2021 | 3 |
| D2.6 YOPP recommendation; future obs. system | 2021 | 4 | 2021 | 4 |
| D3.1 Tendency/tracer diagnostic implemented | 2018 | 3 | 2018 | 3 |
| D3.2 New heat flux parameteris. implemented | 2019 | 1 | 2019 | 1 |
| D3.3 Stochastic parameterisations implemented | 2020 | 2 | 2020 | 2 |
| D3.4 Publication: Lessons learned | 2021 | 4 | 2021 | 4 |
| D4.1 Data and Report: Adapting EPS to Arctic | 2019 | 1 | 2019 | 2 |
| D4.2 Publication: SST/sea ice perturbations | 2020 | 3 | 2020 | 3 |
| D4.3 Report: HIW predictability in the Arctic | 2021 | 3 | 2021 | 3 |
| D4.4 Prototype: Arctic optimised EPS | 2021 | 4 | 2021 | 4 |
| D5.1 Establish data management plan | 2018 | 1 | 2018 | 1 |
| D5.2 Establish communication plan and website | 2018 | 2 | 2018 | 2 |
| D5.3 ALERTNESS Progress report | 2019 | 4 | 2019 | 4 |
| D5.4 Publication: ALERTNESS NWP value chain | 2020 | 4 | 2020 | 4 |
| D5.5 ALERTNESS Final report | 2021 | 4 | 2021 | 4 |

## Dissemination of project results

| | |
|---|---|
| Dissemination plan | Mature research results in ALERTNESS will be disseminated through the main communication channel of MET Norway: In the operational weather forecasts published on Yr.no. Improvements and forecast issues of significance will be picked up by the science journalists in Yr.no (NRK) and social media via MET's newsdesk Redaksjonen.<br><br>Given the large number of different end-users and stakeholders, we will use existing mechanisms (see Fig. 3 in application text) to target the different preferences and needs for weather information. We will inform forecast users on results of significance for their work and how ALERTNESS tackles the |

unique Arctic forecasting challenges to improve the weather forecasting capacity, e.g. BarentsWatch, SIOS, the YOPP Community, WMO-PRCC and other regular "downstream" providers of polar environmental information. An important aim is to transfer the accurate and reliable weather predictions into better informed decision making and special focus will be given to enable stakeholders to use the advances of probabilistic forecasting.

Dissemination to decision-makers will also take place in Arctic stakeholder conferences (e.g. Arctic Frontiers) and policy panels (e.g. Arendalsuka). Results can also be of political interest for the Arctic Council where the current Finnish chairmanship focuses on meteorology and environmental change in the Arctic, and for the assessment work in AMAP, in particular when results can be seen to improve the capacity to manage the risks of shipping, fisheries, tourism, oil and gas exploration, research and living in the polar region.

Scientific results from the project will be published in major peer-review journals (following EU rules for open access) and presented at international conferences. The results will also be presented in national popular science journals (e.g. forskning.no and KLIMA), in mass media, social media and on the project partners' web pages. During the IGP flight campaign, Erik Kolstad will update his popular blog polarlows.wordpress.com.

To reach a wider audience including children, one or two GPS-marked paths along the coast in northern Norway will be developed in collaboration with the Turspor project at the Bjerknes Centre for Climate Research. Turspor is used to disseminate location-specific information about geography, weather and climate. We will use markers of past weather disasters (e.g. graveyards with many victims of the same historical storm) to illustrate the need for accurate and reliable weather forecasts.

The project will prepare and update a central project website with the ALERTNESS logo, and data will be shared (in real-time) at the YOPP data portal hosted by MET. The scientific results will also be shared through the HIRLAM consortium, including a workshop in Tromsø during the project period. A wide range of academic users will be encouraged to actively use the high-resolution weather forecast methods, tools, models, data and products developed in ALERTNESS.

## Budget

## Cost plan (in NOK 1000)

**Advanced models and weather prediction in the Arctic: Enhanced capacity from observations and polar process representations (ALERTNESS) (Forskerprosjekt - POLARPROG)**

**Application Number: ES600375 Project Number: -1**

| | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | Sum |
|---|---|---|---|---|---|---|---|---|---|
| Payroll and indirect expenses | 5545 | 9805 | 7398 | 4619 | | | | | 27367 |
| Procurement of R&D services | 158 | 210 | 50 | 50 | | | | | 468 |
| Equipment | 512 | 113 | 112 | 113 | | | | | 850 |
| Other operating expenses | 225 | 225 | 225 | 225 | | | | | 900 |
| *Totals* | 6440 | 10353 | 7785 | 5007 | 0 | 0 | 0 | 0 | 29585 |

| | |
|---|---|
| Specification | Payroll:<br>See attached sheet "resource_allocation_alertness.pdf" with man month pr work package, and associated cost pr person.<br><br>Procurement of R&D services:<br>Hourly based research assistance of master/PhD students at UiT and UNIS: 50KNOK pr year<br>Visiting research grants; 108KNOK in 2018, 54KNOK in 2019<br>Overseas research grant; 96KNOK in 2019<br>6 month in-kind office hosting at KNMI; 10KNOK<br><br>Equipment:<br>Archive model data (10TB) 10 years at MET or NORSTORE: 100KNOK<br>CPUcost: 3,2 million CPUhours at 0.11NOK/CPUhour; 350KNOK. 100KNOK in-kind to cover cost over 0.07NOK/CPUhour<br>One buoy, 400KNOK in 2018, rented from UiB.<br><br>Other operating expenses:<br>Publication fees: 150KNOK<br>Travel/meetings: 750KNOK |

## Cost code (in NOK 1000)

| | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | Sum |
|---|---|---|---|---|---|---|---|---|---|
| Trade and industry | | | | | | | | | 0 |
| Independent research institutes | 5651 | 8174 | 6236 | 4136 | | | | | 24197 |
| Universities and university colleges | 789 | 1613 | 1549 | 871 | | | | | 4822 |

**Advanced models and weather prediction in the Arctic: Enhanced capacity from observations and polar process representations (ALERTNESS) (Forskerprosjekt - POLARPROG)**

**Application Number: ES600375 Project Number: -1**

| | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | Sum |
|---|---|---|---|---|---|---|---|---|---|
| Other sectors | | | | | | | | | 0 |
| Abroad | | 566 | | | | | | | 566 |
| *Totals* | 6440 | 10353 | 7785 | 5007 | 0 | 0 | 0 | 0 | 29585 |

## Funding plan (in NOK 1000)

| | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | Sum |
|---|---|---|---|---|---|---|---|---|---|
| Own financing | 760 | 1117 | 1231 | 1056 | | | | | 4164 |
| International funding | | | | | | | | | 0 |
| Public funding | | | | | | | | | 0 |
| Private funding | | | | | | | | | 0 |
| The Research Council | 5680 | 9236 | 6554 | 3951 | | | | | 25421 |
| *Totals* | 6440 | 10353 | 7785 | 5007 | 0 | 0 | 0 | 0 | 29585 |

| | |
|---|---|
| Specification | Prof. Harald Sodemann and Prof. Rune Graversen are 100 %in-kind.<br>Employees from MET, UNIS and UiT are partially in-kind.<br>KNMI staff provide assistance and office 100% in-kind in WP2<br>100KNOK of CPU-cost is in-kind. |

## Person for whom a fellowship/position is being sought

### Basis for calculation of position

| Type of fellowship | From date (yyyymmdd) | To date (yyyymmdd) |
|---|---|---|
| Doctoral research fellowship | 20180701 | 20210630 |

### Person for whom a fellowship/position is being sought

| First name | Last name | National identity number |
|---|---|---|

**Advanced models and weather prediction in the Arctic: Enhanced capacity from observations and polar process representations (ALERTNESS) (Forskerprosjekt - POLARPROG)**

**Application Number: ES600375 Project Number: -1**

N.N

## Percentage of full time position

| | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|---|
| Percentage of full time position | 50 | 100 | 100 | 50 | | | | |

## Basis for calculation of position

| Type of fellowship | From date (yyyymmdd) | To date (yyyymmdd) |
|---|---|---|
| Post-doctoral research fellowship | 20180701 | 20200630 |

## Person for whom a fellowship/position is being sought

| First name | Last name | National identity number |
|---|---|---|
| N.N | | |

## Percentage of full time position

| | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|---|
| Percentage of full time position | 50 | 100 | 50 | | | | | |

## Basis for calculation of position

| Type of fellowship | From date (yyyymmdd) | To date (yyyymmdd) |
|---|---|---|
| Doctoral research fellowship | 20180701 | 20210630 |

## Person for whom a fellowship/position is being sought

| First name | Last name | National identity number |
|---|---|---|
| N.N | | |

**Advanced models and weather prediction in the Arctic: Enhanced capacity from observations and polar process representations (ALERTNESS) (Forskerprosjekt - POLARPROG)**

**Application Number: ES600375 Project Number: -1**

## Percentage of full time position

| | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|---|
| Percentage of full time position | 50 | 100 | 100 | 50 | | | | |

## Basis for calculation of position

| Type of fellowship | From date (yyyymmdd) | To date (yyyymmdd) |
|---|---|---|
| Post-doctoral research fellowship | 20181001 | 20200930 |

## Person for whom a fellowship/position is being sought

| First name | Last name | National identity number |
|---|---|---|
| N.N | | |

## Percentage of full time position

| | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|---|
| Percentage of full time position | 25 | 100 | 75 | | | | | |

## Basis for calculation of position

| Type of fellowship | From date (yyyymmdd) | To date (yyyymmdd) |
|---|---|---|
| Visiting researcher grants | 20181001 | 20181031 |

## Person for whom a fellowship/position is being sought

| First name | Last name | National identity number |
|---|---|---|
| Patrick | Samuelsson | |

**Advanced models and weather prediction in the Arctic: Enhanced capacity from observations and polar process representations (ALERTNESS) (Forskerprosjekt - POLARPROG)**

**Application Number: ES600375 Project Number: -1**

## Percentage of full time position

| | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|---|
| Percentage of full time position | | | | | | | | |

## Documentation for calculation of overseas research grant and visiting researcher grant

| | | | |
|---|---|---|---|
| Institution / company | SMHI | Travelling with family | Travel expenses |
| Location | Norrköping | No | |
| Country | Sweden | | **Period** |
| | | | From date (yyyymmdd) |
| | | | 20181001 |
| | | | To date (yyyymmdd) |
| | | | 20181031 |

## Basis for calculation of position

| Type of fellowship | From date (yyyymmdd) | To date (yyyymmdd) |
|---|---|---|
| Visiting researcher grants | 20190301 | 20190331 |

## Person for whom a fellowship/position is being sought

| First name | Last name | National identity number |
|---|---|---|
| Carl | Fortelius | |

## Percentage of full time position

| | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|---|
| Percentage of full time position | | | | | | | | |

## Documentation for calculation of overseas research grant and visiting researcher grant

| | | | |
|---|---|---|---|
| Institution / company | FMI | Travelling with family | Travel expenses |

**Advanced models and weather prediction in the Arctic: Enhanced capacity from observations and polar process representations (ALERTNESS) (Forskerprosjekt - POLARPROG)**

**Application Number: ES600375 Project Number: -1**

| | | | |
|---|---|---|---|
| Location | Helsinki | No | |
| Country | Finland | | **Period** |
| | | | From date (yyyymmdd) |
| | | | 20190301 |
| | | | To date (yyyymmdd) |
| | | | 20190331 |

## Basis for calculation of position

| Type of fellowship | From date (yyyymmdd) | To date (yyyymmdd) |
|---|---|---|
| Overseas Research Grants | 20190101 | 20190630 |

## Person for whom a fellowship/position is being sought

| First name | Last name | National identity number |
|---|---|---|
| N.N | | |

## Percentage of full time position

| | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|---|
| Percentage of full time position | | | | | | | | |

## Documentation for calculation of overseas research grant and visiting researcher grant

| | | | |
|---|---|---|---|
| Institution / company | KNMI | Travelling with family | Travel expenses |
| Location | De Bilt | No | |
| Country | Netherlands | | **Period** |
| | | | From date (yyyymmdd) |
| | | | 20190101 |
| | | | To date (yyyymmdd) |
| | | | 20190630 |

**Advanced models and weather prediction in the Arctic: Enhanced capacity from observations and polar process representations (ALERTNESS) (Forskerprosjekt - POLARPROG)**

**Application Number: ES600375 Project Number: -1**

## Basis for calculation of position

| Type of fellowship | From date (yyyymmdd) | To date (yyyymmdd) |
|---|---|---|
| Visiting researcher grants | 20181001 | 20181031 |

## Person for whom a fellowship/position is being sought

| First name | Last name | National identity number |
|---|---|---|
| Danijel | Belusic | |

## Percentage of full time position

| | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|---|
| Percentage of full time position | | | | | | | | |

## Documentation for calculation of overseas research grant and visiting researcher grant

| | | | |
|---|---|---|---|
| Institution / company | SMHI | Travelling with family | Travel expenses |
| Location | Norrköping | No | |
| Country | Sweden | | **Period** |
| | | | From date (yyyymmdd) |
| | | | 20181001 |
| | | | To date (yyyymmdd) |
| | | | 20181031 |

# Allocations sought from the Research Council (in 1000 NOK)

| | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | Sum |
|---|---|---|---|---|---|---|---|---|---|
| Student fellowships | | | | | | | | | 0 |
| Doctoral fellowships | 1075 | 2226 | 2292 | 1180 | | | | | 6773 |
| Post-doctoral fellowships | 806 | 2226 | 1433 | | | | | | 4465 |

**Advanced models and weather prediction in the Arctic: Enhanced capacity from observations and polar process representations (ALERTNESS) (Forskerprosjekt - POLARPROG)**

**Application Number: ES600375 Project Number: -1**

| | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | Sum |
|---|---|---|---|---|---|---|---|---|---|
| Grants for visiting researchers | 108 | 54 | | | | | | | 162 |
| Grants for overseas researchers | | 96 | | | | | | | 96 |
| Researcher positions | 2821 | 4121 | 2467 | 2408 | | | | | 11817 |
| Hourly-based salary including indirect costs | | | | | | | | | 0 |
| Procurement of R&D services | 158 | 200 | 50 | 50 | | | | | 458 |
| Equipment | 487 | 88 | 87 | 88 | | | | | 750 |
| Other operating expenses | 225 | 225 | 225 | 225 | | | | | 900 |
| *From Research Council* | 5680 | 9236 | 6554 | 3951 | 0 | 0 | 0 | 0 | 25421 |

## Partners

## Partners under obligation to provide professional or financial resources for the implementation of the project

1

| | |
|---|---|
| Institution/ company | UNIVERSITETSSENTERET PÅ SVALBARD AS |
| Department/ section | |
| Address | Postboks 156 |
| Postal code | 9171 |
| City | LONGYEARBYEN |
| Country | Norway |
| Enterprise number | 985204454 |
| Contact person | Marius O. Jonassen |
| Contact tel. | +47 79023339 |
| Contact e-mail | marius.jonassen@unis.no |
| Partner's role | Financing and Research activity |

**Advanced models and weather prediction in the Arctic: Enhanced capacity from observations and polar process representations (ALERTNESS) (Forskerprosjekt - POLARPROG)**

**Application Number: ES600375 Project Number: -1**

2

| | |
|---|---|
| Institution/ company | Universitetet i Bergen |
| Department/ section | Geofysisk institutt |
| Address | Allégaten 70 |
| Postal code | 5007 |
| City | BERGEN |
| Country | Norway |
| Enterprise number | 874789542 |
| Contact person | Harald Sodemann |
| Contact tel. | +47 55582974 |
| Contact e-mail | Harald.Sodemann@uib.no |
| Partner's role | Financing and Research activity |

3

| | |
|---|---|
| Institution/ company | Uni Research |
| Department/ section | Climate |
| Address | Jahnebakken 5 |
| Postal code | 5007 |
| City | BERGEN |
| Country | Norway |
| Enterprise number | 985827117 |
| Contact person | Erik W. Kolstad |
| Contact tel. | +47 55582432 |
| Contact e-mail | erik.kolstad@uni.no |
| Partner's role | Research activity |

4

| | |
|---|---|
| Institution/ company | Nansen Environmental and Remote Sensing Center |
| Department/ section | |
| Address | Thormøhlensgate 47 |
| Postal code | 5006 |

**Advanced models and weather prediction in the Arctic: Enhanced capacity from observations and polar process representations (ALERTNESS) (Forskerprosjekt - POLARPROG)**

**Application Number: ES600375 Project Number: -1**

| | |
|---|---|
| City | BERGEN |
| Country | Norway |
| Enterprise number | 943432449 |
| Contact person | Igor Esau |
| Contact tel. | +47 47399690 |
| Contact e-mail | igor.ezau@nersc.no |
| Partner's role | Research activity |

5

| | |
|---|---|
| Institution/ company | Universitetet i Tromsø |
| Department/ section | Institutt for fysikk og teknologi |
| Address | Postboks 6050 Langnes |
| Postal code | 9037 |
| City | TROMSØ |
| Country | Norway |
| Enterprise number | 970422528 |
| Contact person | Rune Graversen |
| Contact tel. | +47 77625242 |
| Contact e-mail | rune.graversen@uit.no |
| Partner's role | Financing and Research activity |

6

| | |
|---|---|
| Institution/ company | Finnish Meteorlogical Institute |
| Department/ section | |
| Address | P.O. Box 503 |
| Postal code | 00101 |
| City | Helsinki |
| Country | Finland |
| Enterprise number | |
| Contact person | Carl Fortelius |
| Contact tel. | +358 295251394 |

**Advanced models and weather prediction in the Arctic: Enhanced capacity from observations and polar process representations (ALERTNESS) (Forskerprosjekt - POLARPROG)**

**Application Number: ES600375 Project Number: -1**

| | |
|---|---|
| Contact e-mail | carl.fortelius@fmi.fi |
| Partner's role | Financing and Research activity |

7

| | |
|---|---|
| Institution/ company | Swedish Meteorological and Hydrological Institute |
| Department/ section | |
| Address | Folkborgsvägen 17 |
| Postal code | 60176 |
| City | Norrköping |
| Country | Sweden |
| Enterprise number | |
| Contact person | Patrick Samuelsson |
| Contact tel. | +46 114958614 |
| Contact e-mail | Patrick.Samuelsson@smhi.se |
| Partner's role | Financing and Research activity |

8

| | |
|---|---|
| Institution/ company | The Royal Netherlands Meteorological Institute |
| Department/ section | |
| Address | PO Box 201 |
| Postal code | 3730 |
| City | AE De Bilt |
| Country | Netherlands |
| Enterprise number | |
| Contact person | Wim de Rooy |
| Contact tel. | |
| Contact e-mail | wim.de.rooy@knmi.nl |
| Partner's role | Financing and Research activity |

9

| | |
|---|---|
| Institution/ company | METEOROLOGISK INSTITUTT |
| Department/ section | |

**Advanced models and weather prediction in the Arctic: Enhanced capacity from observations and polar process representations (ALERTNESS) (Forskerprosjekt - POLARPROG)**

**Application Number: ES600375 Project Number: -1**

| | |
|---|---|
| Address | Postboks 43 BLINDERN |
| Postal code | 0313 |
| City | OSLO |
| Country | Norway |
| Enterprise number | 971274042 |
| Contact person | Jørn Kristiansen |
| Contact tel. | |
| Contact e-mail | jornk@met.no |
| Partner's role | Financing and Research activity |

## Attachments

## Project description

| | |
|---|---|
| Filename | ALERTNESS-POLARPROGmaster.pdf |
| Reference | ES600375_001_1_Prosjektbeskrivelse_20170906 |

## Curriculum vitae (CV) with list of publications

| | |
|---|---|
| Filename | jornk_cv.pdf |
| Reference | ES600375_002_1_CV_20170905 |

| | |
|---|---|
| Filename | CV_MOJ_4pages_ALERTNESS.pdf |
| Reference | ES600375_002_2_CV_20170905 |

| | |
|---|---|
| Filename | cv-erik_alertness.pdf |
| Reference | ES600375_002_3_CV_20170905 |

| | |
|---|---|
| Filename | CV_RRoger_2017.pdf |

**Advanced models and weather prediction in the Arctic: Enhanced capacity from observations and polar process representations (ALERTNESS) (Forskerprosjekt - POLARPROG)**

**Application Number: ES600375 Project Number: -1**

| | |
|---|---|
| Reference | ES600375_002_4_CV_20170905 |

| | |
|---|---|
| Filename | CV_HS_2017.pdf |
| Reference | ES600375_002_5_CV_20170905 |

| | |
|---|---|
| Filename | cv_valkonen.pdf |
| Reference | ES600375_002_6_CV_20170905 |

| | |
|---|---|
| Filename | FrognerCV.pdf |
| Reference | ES600375_002_7_CV_20170905 |

| | |
|---|---|
| Filename | SingletonCV_ALERTNESS.pdf |
| Reference | ES600375_002_8_CV_20170905 |

| | |
|---|---|
| Filename | CV Igor Esau partner.pdf |
| Reference | ES600375_002_9_CV_20170905 |

## Grade transcripts (Doctoral and student fellowships)

| | |
|---|---|
| Filename | |
| Reference | |

## Referees

| | |
|---|---|
| Filename | Referees_ALERTNESS.pdf |
| Reference | ES600375_005_1_Fageksperter_20170830 |

## Recommendation and invitation

| | |
|---|---|
| Filename | recommandation_overseas_MET.pdf |
| Reference | ES600375_006_1_AnbefalingInvitasjon_20170905 |

| | |
|---|---|
| Filename | invitation_KNMI_signed.pdf |
| Reference | ES600375_006_2_AnbefalingInvitasjon_20170905 |

## Confirmation from partner(s)

| | |
|---|---|
| Filename | LettersOfConfirmation.pdf |
| Reference | ES600375_008_1_AktiveSamarbeidspartnere_20170905 |

## Other items

| | |
|---|---|
| Filename | YOPP_Endorsement_Response_ALERTNESS.pdf |
| Reference | ES600375_010_1_Annet_20170905 |

| | |
|---|---|
| Filename | YOPP_Endorsement_Response_METNorway.pdf |
| Reference | ES600375_010_2_Annet_20170905 |

| | |
|---|---|
| Filename | Resource_allocation_alertness_v2.pdf |
| Reference | ES600375_010_4_Annet_20170905 |

# ALERTNESS (Advanced models and weather prediction in the Arctic: Enhanced capacity from observations and polar process representations)

Project lead: Jørn Kristiansen (MET Norway), Project co-lead: Marius O. Jonassen (UNIS)
Partner institutions: The Norwegian Meteorological Institute (MET Norway), University of Bergen (UiB), Uni Research (UNI), University of Tromsø (UiT), The Royal Netherlands Meteorological Institute (KNMI), Nansen Environmental and Remote Sensing Center (NERSC), The University Centre in Svalbard (UNIS)

## 1. Relevance relative to the call for proposals

ALERTNESS takes an innovative and comprehensive approach to address the growing need for accurate and reliable weather predictions in the Arctic, especially in relation to high-impact weather. Rapid climatic and environmental changes, and an increasing human presence in the region, have all triggered an immediate need for both applied and basic research advances to improve Arctic weather **prediction**. Marine icing, fog, polar lows, strong winds and high waves are major hazards to marine operations and industrial development.

We will take advantage of several unique opportunities arising during the Year of Polar Prediction (YOPP). Our approach is to develop new methods to tackle long-standing issues in atmospheric models in polar environments, and to continually evaluate these methods against data from YOPP observations. We will also enable more comprehensive use of valuable observations from past field campaigns. ALERTNESS will explore new ways to diagnose uncertainties evolving from representations of small-scale processes, and generate substantial gains in probabilistic forecasting for the Arctic.

An important aspect of ALERTNESS is that academic researchers collaborate directly with operational forecasting centres. Our advances will provide guidance for long-term model improvement by the larger Numerical Weather Prediction (NWP) community, and ensure sustained benefits for the scientific and wider communities. All of our research data and publications will be made available for open access. ALERTNESS will work towards enabling stakeholders in the region to make better informed risk-based decisions. Our work will be guided by recommendations from international strategy documents, invoke the expertise of international partners, and be closely coordinated with several related national and international projects.

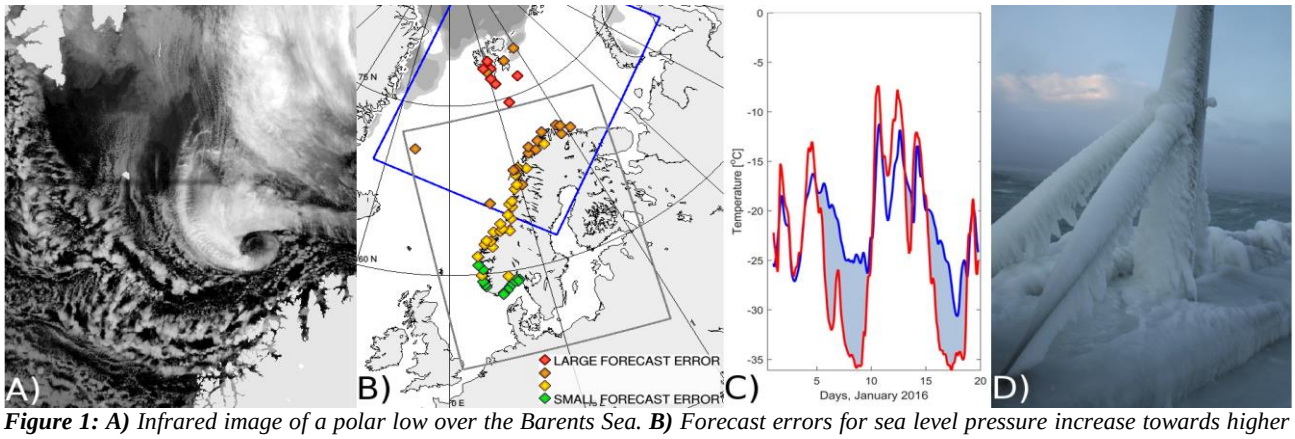



***Figure 1: A)*** *Infrared image of a polar low over the Barents Sea.* ***B)*** *Forecast errors for sea level pressure increase towards higher latitudes and the sea-ice edge (grey shading) in comparison to coastal SYNOP stations. The boxes indicate the domains of AROME Arctic (blue) and MetCoOp (*Müller et al. 2017b; *grey).* ***C)*** *A 1km model overpredicts 2m temperature during cold events in the Arctic (blue shading). Blue: Model time series (data by M. Varentsov) for the Kola Peninsula; Red: station data.* ***D)*** *Icing on an installation in northern Norway during the extreme weather event Ask in 2010 (photo: Karl-Idar Berg).*

## 2. Aspects relating to the research project

### 2.1 Background and status of knowledge

There is a growing interest in Arctic operations due to socio-economic opportunities. Fuelled by increased accessibility due to recent sea ice retreat, activities related to exploration, tourism, transportation and scientific research are expected to attract economic investments exceeding $100bn (Lloyd's 2012) over the coming decade. However, Arctic weather can be a hazard to high-latitude activities and infrastructure, such as shipping, fishery, gas and oil exploration and exploitation, land transport and aviation. There is **an urgent need for research towards reliable and accurate polar weather prediction capabilities**.

NWP models generally show lower forecast capability at high latitudes compared to other regions (Jung et al. 2016). This is partly because Arctic weather systems pose challenges different to those at mid-latitudes for which most of these models are developed, and partly due to the scarcity of in-situ observations. Forecasting high-impact weather (HIW) events in the Arctic has proven to be especially challenging. Repeated severe forecast misses, aggravated by fast climatic change inducing unusual weather, have had dramatic consequences for local communities. Such HIW events include intense and rapidly developing mesoscale cyclones known

as polar lows (PLs, Fig. 1a) embedded in large cold-air outbreaks (CAOs) characterised by convective processes (Kolstad 2017), icing conditions (Fig. 1d) from sea spray during winter (Samuelsen et al. 2017), episodes of persistent fog during summer and aviation icing (Gultepe et al. 2015), and avalanche and landslide risks after heavy precipitation. In the Arctic, the **societal value of fundamental weather research** is strongly conditioned upon the ability to provide forecasts and warnings that user groups can incorporate in their decision-making processes.

In response to the urgent need for Arctic weather prediction, a convection-permitting mesoscale model for the Arctic has recently been introduced into service by MET Norway (Müller et al. 2017a). AROME Arctic, **an operational short-range, convection-permitting prediction system dedicated to the European Arctic**, issues forecasts four times per day with a lead time of 66 hours, at a horizontal grid spacing of 2.5 km (Fig. 1b). The important processes of sea ice and interactions across the air–ice–ocean interface are represented by a one-dimensional sea ice model (SICE). One major challenge in the Arctic is that small-scale processes and variability are particularly relevant for the accuracy of a forecast (WMO-PPP 2013). While large-scale circulation patterns may be reasonably predictable several days in advance, mesoscale weather (e.g. PLs) is **strongly influenced by parameterized, sub-grid scale processes, such as surface fluxes, radiation, convection and cloud microphysics, and their interaction,** which in many cases are highly uncertain in polar regions (Vihma et al. 2014) and not always well represented in NWP models.

The Arctic is a territory of extremes for cloud micro-physics and small-scale turbulent mixing dynamics, with clear implications for NWP. Persistent temperature inversions in the lower atmosphere control the shallow stably stratified boundary layer where even at high spatial resolution, NWP models continue to exhibit a warm surface bias (Fig. 1c). This **remains a long-standing and hitherto unresolved issue in high-latitude NWP** (Holtslag et al. 2013). The impact of turbulent fluxes on the surface heat balance and the moisture balance of the cloud layers could be a key to achieve more accurate predictions (Tjernström et al. 2005). Although observational and process studies have improved our understanding of the relevant polar weather physics, incorporation into the model parameterisations lags significantly (Vihma et al. 2014). The parameterisations of heat fluxes used in current NWP and climate models are typically constrained by surface temperature. However, surface temperature is itself dependent on the height of the stable boundary-layer (Davy and Esau 2014). With momentum and heat fluxes parameterised in essentially the same way, an ill-posed optimisation problem arises. Pilot studies indicate that a novel energy-flux-balance (EFB) approach by Zilitinkevich et al. (2013) could eliminate the problem (Pithan et al. 2015).

Model performance is commonly optimized by tuning the parameterisation schemes. The predominance of different parameterised processes, in addition to their individual uncertainties, leads to error compensation from several poorly constrained processes. Excessive evaporation may be compensated by too efficient precipitation. Model tuning makes inherent use of error compensation which may work for a given case, but without sustained progress in model improvement. **New approaches are therefore needed to identify error compensation in NWP models**, and to trace parameterisation tendencies in the forecasting domain.

The importance of kilometre-scale grid spacing for the forecast quality of PLs has repeatedly been highlighted (e.g. Kristiansen et al. 2011), and is explored in several research projects (e.g. EU-project APPLICATE). Yet even at 2.5 km grid spacing, moist convection, critical for representing PLs (Kolstad et al. 2016), is only partly resolved. Gradual increase of the open water exposure to CAOs leads to more frequent extreme convective events with the heat fluxes exceeding 500 W $m^{-2}$ (Smedsrud et al. 2013). The large fluxes drive strong self-organized cellular convection, responsible for hail, snow and gale force wind gusts – dangerous, but potentially predictable phenomena, given appropriate parameterisations (Feingold et al. 2010). Current NWP models act on a per-column basis, so the sensitivity of Arctic weather forecasts to organising convection is as yet unknown. The presence of sea ice is a further complicating factor, which introduces a long-memory component that causes substantial variability of surface conditions (Valkonen et al. 2008). Moreover, the fine-scale structure of leads and polynyas mean that sea ice is difficult to accurately observe and therefore represent in an NWP model.

The difficulties for NWP in the Arctic are **exacerbated by a sparse conventional observation network, especially over the ocean and sea-ice,** which is both error-prone and of limited representativeness (Casati et al. 2017). Observations play a cross-cutting role in the context of NWP in that they are used for understanding and parameterising physical processes, for model verification, and for model initialisation. For verification and process study purposes over the Arctic, past campaigns (e.g. IPY-THORPEX; Kristjansson et al. 2011) have not yet been fully utilized, and several YOPP campaigns are planned. To this end, both development and comprehensive testing of new tailored verification techniques are needed, constituting a key challenge in polar verification (WMO-PPP 2013).

Initial conditions (ICs) for forecasts are generated through a process known as data assimilation (DA),

where a statistically optimal blend between a previous forecast or model state, and the currently available observations is obtained. In addition to the radiosonde network, satellite observations are a crucial data source in the Arctic. Retrieval methods are, however, **challenged by the prevalence of snow and ice-covered surfaces and clouds** resulting in sub-optimal observational data usage and rejection of large data volumes. Traditional 3D-Var DA is designed to use observations around the assimilation time, meaning that only a small fraction of the available satellite data is ingested (Randriamampianina et al. 2016; Valkonen et al. 2017). State-of-the-art 4D-Var DA, however, allows the assimilation of data at all observation times within an assimilation window, and so introduces flow dependence, which has been shown to lead to tremendous improvements in forecast performance in global models (Bauer et al. 2015).

Although 4D-Var can be expected to improve model ICs, there will still be errors due to gaps in the observation network, errors in the observations themselves and errors in the representativeness of the observations. Uncertainties in the model parameterisations will further limit the extent to which small scale processes can be estimated. The observation and model errors, even if small, may amplify with time through highly non-linear atmospheric processes leading to finite and weather dependant predictability. Ensemble Prediction Systems (EPSs) have been developed to include estimations of forecast uncertainties. EPS forecasts are produced from many instances of the same NWP model that differ slightly in their initial conditions, forcing and parameterisations. Uncertainty is also a key element in DA, allowing the model to acquire observational data where the model is uncertain. Thus, **optimizing the capability of DA to exploit the observations to the fullest possible extent and EPS development are closely related key challenges**.

Convective scale EPSs are typically developed for mid-latitudes and use a number of methods to estimate uncertainty. IC and boundary uncertainties are estimated from, amongst others, downscaled global ensembles, EDA and perturbations to physiographic fields (e.g. Bouttier et al. 2016). Model uncertainty can be accounted for by, amongst others, applying stochastic perturbations to the parameterisation tendencies (SPPT; Buizza et al. 1999), or by stochastically perturbing parameters inside the parameterisation schemes (SPP; Ollinaho et al. 2017). Such EPS generation techniques may be applied to the Arctic, but **in the Arctic region, uncertainty is even more prevalent for both model and observations.** For example, modelling of the atmospheric boundary layer is especially sensitive to uncertainties in sea ice concentration estimates, and sea surface temperature (SST) products from satellites have been shown to be particularly uncertain in the Arctic. In HIW situations where parameterised processes have a strong influence and the observations might be less reliable, more research is needed to understand how these uncertainties affect the forecast uncertainty. Indeed, one of the most prominent research issues for short-range predictability in polar areas is to understand complete forecast misses of PLs (WMO-PPP 2013), as well as other major forecast misses.

## 2.2 Approaches, hypotheses and choice of method

As outlined above, the Arctic has unique forecasting challenges; limited availability and quality of observations, model uncertainty due to physics parameterisations and specific high-impact weather situations. Within ALERTNESS we will adopt a bold and innovative approach to key specifically Arctic challenges, while exploiting the opportunities of YOPP in terms of field campaigns, observations and modelling efforts to achieve a major step forward in polar prediction capacity.

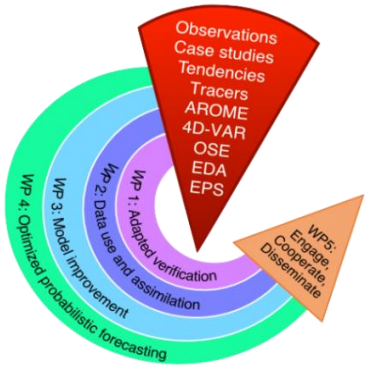



Figure 2: ALERTNESS ambition and approach depicting the proposed data and methods (red wedge) and the implementation of the value chain (orange arrow).

***The ambition and primary objective of ALERTNESS*** *is to develop world leading capacity for the delivery of reliable and accurate Arctic weather forecasts and warnings for the benefit of maritime operations, business and society.*

We are **guided by the scientific hypotheses** that (i) improved observations and improved use of observations enable advances in Arctic forecasting, (ii) new ways to identify error compensation will create a pathway to sustained model improvement, and (iii) embracing forecast uncertainty will result in more robust forecasts of Arctic weather. The overall aim (primary objective) is addressed by four scientific objectives. In the following, the ways in which each objective translates into a scientific work package (WP1 to WP4), and which methods are applied throughout the project are outlined.

**The methodological basis** of our work is formed by the operational forecast systems AROME Arctic (Müller et al. 2017a) and MetCoOp (Müller et al. 2017b), and established methods for DA (Valkonen et al. 2017) and EPS (Frogner et al. 2016). The model systems are configurations of HARMONIE-AROME developed jointly by the Aladin and HIRLAM consortia (Bengtsson et al. 2017). Recently, an AROME based

EPS (MEPS; Andrae et al. 2017) became operational in the Norway-Sweden-Finland meteorological collaboration on NWP (MetCoOp).

Throughout ALERTNESS, developments will be made to AROME Arctic related to DA, sub-grid scale parameterisations and generating ensembles in order to test our hypotheses against a comprehensive set of well observed case studies, including HIW events, for the Arctic. Equally important for the success of the project, is that ALERTNESS will be embedded in an existing **value chain** structure, illustrated in Fig. 3, which to a large extent is in place and operational at MET Norway. It is mainly driven by the science for service work required for MET Norway to fulfil its mandate, supplemented by well-established international and national links with academia and research institutions, including scientists in the ALERTNESS partner institutions. We thereby tie academic excellence into the end-user experience and knowledge that is derived from continuous service delivery at MET Norway. Another element of the value chain is the direct coupling to important international research activities, and applications of research, e.g. Copernicus and Horizon2020. A schematic structure such as Fig. 3 is helpful in efficiently identifying crucial strengths, weaknesses, deficiencies and needs in the polar weather prediction capacity. A separate work package, WP5, is therefore warranted in order to cover the ALERTNESS value chain and project management as well as communication and data management.

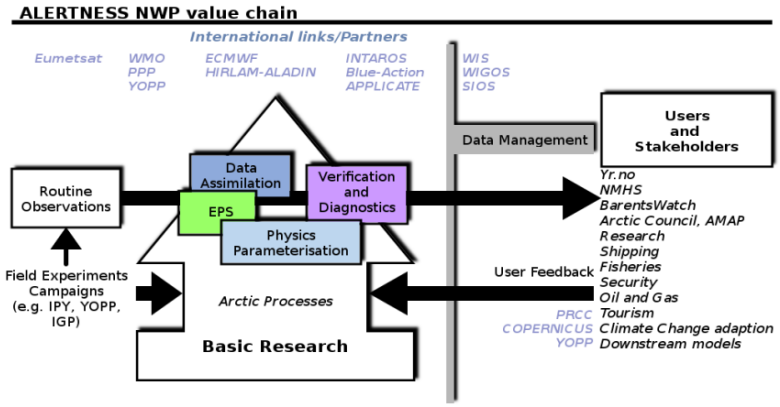



***Figure 3:*** *The ALERTNESS value chain for NWP shows how ALERTNESS adds to the existing, tested and operational value chain for joining mature research results, operational forecasts and user and stakeholder interests. APPLICATE, INTAROS and Blue-Action are H2020 projects. Abbreviations used but not defined elsewhere in the text. HIRLAM-ALADIN-High Resolution Limited Area Model-Aire Limitée Adaptation Dynamique Développement International, ECMWF-European Centre for Medium-Range Weather Forecasts, WIS-WMO Information System, WIGOS-WMO Integrated Global Observing System, SIOS-Svalbard Integrated Arctic Earth Observing System, IPY-International Polar Year, PRCC-Polar Regional Climate Centre, AMAP-Arctic Monitoring and Assessment Programme, C3S-Copernicus Climate Change Service, NMHS-National Meteorological and Hydrological Service.*

**Objective 1: Develop and apply verification metrics and diagnostics for NWP in the Arctic (WP1)**

ALERTNESS will tackle the Arctic verification problem by using as many (routine and campaign) observation and model data sets as possible for in-depth evaluation of AROME Arctic, including comparison with other YOPP core models. To this end, a reference database of well-observed HIW events will provide a baseline for model developments in WPs 2-4 (see Fig. 2). The database will include episodes from the YOPP special observing periods (SOPs), the YOPP-endorsed Iceland Greenland Seas Project (IGP) aircraft campaign in March 2018, and other historical campaigns (e.g. IPY-THORPEX). In IGP the project will fund a much needed met buoy co-located with an existing subsurface mooring, set up and run dedicated model simulations and perform model analyses. WP1 will design, develop, use and distribute deterministic and probabilistic verification methods (WPs 2-4), metrics (such as the MET-Norway PL tracking tool; Kristiansen et al. 2011), and diagnostics towards the specific requirements of the polar environment. For mutual benefit between model developers, operational forecasters, related projects (EU projects Blue-Action and APPLICATE) and end-users, WP1 will, in collaboration with WP5, the existing user and stakeholder mechanisms for exchange of requirements, opportunities and experience (see Fig. 3). Special attention will be given to aviation, persistent summertime fog, and maritime icing due to high wind and sea spray. This new set of verification measures appropriate for Arctic weather forecasts will be used throughout the project in tandem with standard measures to monitor progress, including user-relevant parameters.

We will follow key research foci in polar verification discussed by Casati et al. (2017): account for observational uncertainty (e.g. Mittermaier 2014; Wolff et al. 2015), enhance synergies between verification and data assimilation by exploring the use of model analyses for verification (e.g. Randriamampianina et al. 2011; Lemieux et al. 2016), and include spatial and probabilistic verification methods available in the HIRLAM-Aladin R Package (HARP). Events with large forecast misses will be identified and investigated in qualitative case studies to better understand the origins of the forecast errors. Typically, this will happen during YOPP were MET Norway will be one of the centres providing operational support. To enable robust conclusions, these events will be compared with a wider set of (historical) cases.

**Objective 2: Improve use and assimilation of Arctic observations for NWP (WP2)**

ALERTNESS will advance atmospheric mesoscale and sea ice DA in the Arctic using more and new types of

observation types, optimize observation usage and implement state-of-the-art analysis techniques for the benefit of weather prediction. To decrease observation representativeness errors and to better utilize observations in weather prediction, we will develop observation operators for satellite observations to account for the scale difference between the model resolution and the footprint of satellite observations (supermoding). We will improve surface temperatures in AROME Arctic by assimilation of satellite observations of sea ice-surface temperatures (Key and Haefliger 1992). This will again benefit the representation of emissivity for radiance assimilation (especially) of low peaking channels over sea ice (Karbou et al. 2014), as well as model developments (WP3). To improve forecast ICs and initial perturbations (WP4), flow-dependent DA will be developed to better use observations relative to the daily uncertainty in the model forecast (Brousseau et al. 2012). To this end, 4D-Var and ensemble of data assimilations (EDA; Bonavita et al. 2012) are available in HARMONIE-AROME.

The assimilation of all-sky radiances (Bauer et al. 2010) will be technically ready for use in Harmonie-AROME early in the lifetime of ALERTNESS, and the main step for their implementing will be to build an interface and tune all-sky observations for mesoscale DA. An obvious choice for improving prediction capacity is to increase observation density. MET Norway will contribute to YOPP with additional radiosonde launches at Jan Mayen and Bear Island up to every three and six hours, respectively, in SOP1 and SOP2. The SOPs will therefore offer a unique opportunity to conduct Observation System Experiments (OSEs) from a temporal increase of the observation network during both summer and winter (YOPP 2016). WP2 will carefully evaluate the benefit of such additional observations in OSEs.

**Objective 3: Enhance and improve NWP model capabilities and diagnostics for high latitudes (WP3)**

WP3 includes a revised approach to heat flux parameterisation, developing novel ways to trace the impact of model uncertainty from individual components, and to identify how interactions between parameterised polar processes lead to error compensation. We focus on improvements relevant to hazardous Arctic weather situations with poor predictability, such as PLs/CAOs and fog conditions, where parameterised processes act together to deviate from the large-scale situation. We will consider individual aspects in an Arctic forecasting system in combination, including all represented processes and their interaction. We will utilize the recently developed total turbulence energy theory (Zilitinkevich et al. 2008) and a corresponding hierarchy of energy flux balance closures (Zilitinkevich et al. 2013) in an attempt to resolve the current deadlock with respect to simulating surface temperature. Based on first implementation tests we expect that both systematic wind and temperature biases could be reduced (Pithain et al. 2015). We will implement and test this new parameterisation approach in both 1D (MUSC; Gleeson et al. 2016) and 3D versions of AROME Arctic.

Model uncertainty will be made accessible to DA (WP2) and the EPS (WP4) by implementing situation-dependent stochastically perturbed parameterisations (SPP). This will include mixed-phase cloud microphysical parameters, which potentially have a large impact on predictability during hazardous long-lasting fog episodes and icing conditions (WP1). Taking a new approach to the required retuning of the model after compensating errors are removed, we will make use of the output of physical parameterisation tendencies during forecast time to evaluate the impact of parameterisation schemes on the grid-scale variables (Joos and Wernli 2012). We will employ artificial tracers in an NWP framework (Sodemann and Stohl 2013) in combination with the physics tendencies to enable tracking of the accumulated parameterisations impact during forecast time. An assessment of the potential of the newly developed methods and selected salient parameterisation aspects pertaining to the next generation of high-resolution NWP models, such as lateral fluxes during convective conditions, will be conducted.

**Objective 4: Develop an Ensemble Prediction System optimized for Arctic conditions (WP4)**

ALERTNESS will address uncertainties due to both the sparsity of, and errors in, the observations, and the errors in the model parameterisations. In the EPS formulation of HARMONIE-AROME, initial conditions uncertainties can be taken account of by perturbing observations within their known error statistics (EDA), downscaling global ensembles and perturbing physiographic parameters. Model uncertainties can be accounted for by SPPT. In ALERTNESS, these perturbation methods will be adapted for use in the Arctic. Furthermore, polar ocean conditions, snow covered land surfaces and the presence of sea ice are additional sources of uncertainty due to poor observations. ALERTNESS will therefore pay particular attention to these parameters. Model uncertainty will further be taken account of by introducing stochasticity into uncertain parameterisations (SPP). In collaboration with WP3, uncertain parameters that the Arctic atmosphere is sensitive to will be identified and probability density functions derived from which to perturb values of these parameters (SPP). This will include parameters critical to the modelling of sea ice in AROME Arctic. Correlation length scales for SPP, in both time and space, which give the optimum ensemble spread and skill, will be found following Ollinaho et al. (2017).

It is expected that some EPS methods will be computationally expensive and their efficacy compared with,

and in combination with, other methodologies needs to be thoroughly assessed. Throughout WP4, verification will be done against all available observations using standard EPS verification techniques as well as new metrics and diagnostics developed in WP1. Furthermore, the outputs from each development of the EPS will be used to drive an icing model (Samuelsen et al. 2017) in order to derive probabilities of icing, which will be verified to measure the impact of EPS developments.

**Objective 5: Improve polar prediction through the ALERTNESS value chain (WP5)**

The experience and expertise of the project lead will ensure project progress, collaboration, cooperation and quality according to the project plan and within the assigned budget. The dissemination and communication plan, provided in the grant application form (some of the elements are shown in Fig. 3), will be discussed during the kick-off meeting and updated during the project lifetime. The project lead will manage and facilitate engagement and collaboration with external institutions, campaigns, projects and initiatives, as illustrated in Fig. 3, to ensure learning from and contribution to other relevant activities, most notably YOPP. Fully coupled dynamic modelling and coupled data assimilation are major medium-term challenges in Arctic weather prediction (Jung et al. 2016). With its atmospheric focus, ALERTNESS will be an important contribution to the concerted effort that is required to reach this goal. Alignment with the proposed Nansen Legacy project, where the challenges of a coupled system will be explored, will be an important success factor on the long run.

In concert with a rapidly changing Arctic climate, the interest, presence and activity in the Arctic has never been greater. The breadth of ALERTNESS thus encompasses a large number of different end-users and stakeholders, Fig. 3. Polar weather prediction will be improved when the project results are transformed into better informed decision making for users: Knowledge and data, products and services will be disseminated and co-produced for the benefit of safer and more efficient operations in the Arctic. Through our value chain structure we build directly on the existing user and stakeholder mechanisms that are evolving between the service provider and the user community, they will serve also in the exchange of requirements, opportunities and experience in this project. For instance, WP1 will select and analyse HIW events and weather prediction verification measures for relevant activities and decision making, the recent YOPP Polar Prediction Matters platform will be included in our user engagement and we will enable stakeholders to use the advances of probabilistic forecasting. Our value chain also serves the interests of downstream (operational) models. For instance, improved polar NWP capacity will lead to improved results in high-resolution regional sea ice models (Rampal et al. 2016), creating dialogue which again will guide NWP research and development in ways that are meaningful to the users and stakeholders.

*In summary, ALERTNESS will employ a combination of methodological approaches (red cone in Fig. 2) to an extent not attempted before for Arctic conditions. Individual WPs will share methods and thus naturally collaborate towards the scientific aim. WPs are tightly aligned and share common tasks to enable continuous cross-fertilisation and information exchange. Given the tight collaboration between academia and the operational environment at MET Norway (value chain in Fig. 3) our results will be efficiently transferred from research to operations, creating a lasting legacy in Arctic weather prediction capacity.*

## 3. The project plan, project management, organisation and cooperation

This 4-year project consists of a consortium of leading scientists in the fields of atmospheric modelling, polar processes and weather forecasting, and people familiar with the technical aspects, models and tools. In the following, the details of the work plan as tasks and coordination between WPs is detailed, and the WP leads and partners are presented. Important milestones and deliverables will be achieved according to the time plan outlined in Table 1 and the online form. The project management and cooperation are covered through WP5.

WP1: Develop and apply verification metrics and diagnostics for NWP in the Arctic (55.5 pm)

Lead: Erik W. Kolstad (UNI) Partners: Morten Køltzow (MET), Marius O. Jonassen (UNIS), PhD (UNI), Rune Graversen (UiT)

**Task 1.1** will create and update a reference database of representative HIW cases with good observational data (including satellite data). Model simulations of these cases will be included for the benefit of all WPs.

**Task 1.2** will develop new verification metrics and diagnostics for convection-permitting models in the Arctic, including icing for aviation and maritime operations.

**Task 1.3** will apply new and existing verification metrics and diagnostics to evaluate AROME Arctic's performance for the reference cases.

**Task 1.4** will (midway and at end of project) perform simulations with AROME Arctic configurations resulting from developments in WPs 2-4. These will be compared to the reference simulations to evaluate whether improvements in forecast quality have been achieved.

**Task 1.5** will participate in and make use of observations from the IGP flight campaign.

WP2: Improve use and assimilation of Arctic observations for NWP (54 pm)

Lead: Roger Randriamampianina (MET) Partners: Yurii Batrak (MET), Roohollah Azad (MET), Postdoc (MET/KNMI), staff at KNMI.

**Task 2.1** will develop a "model-state-aggregation" technique (supermoding) to better fit satellite observations to the model state.

**Task 2.2** will develop and implement sea ice-surface temperature assimilation in SICE using near real-time satellite observations. With improved representation of sea ice emissivity, we will employ and, if necessary, further develop two methods for radiance assimilation, Thyness et al. (2005) and Karbou et al. (2014).

**Task 2.3** will introduce flow-dependency in AROME Arctic DA by 1) implementing 4D-Var and 2) setting up EDA with 4D-Var for combining accuracy in forecast ICs and generation of EPS initial perturbations (Task 4.3).

**Task 2.4** will improve assimilation of microwave radiances to use observations in cloudy and precipitating regions (all-sky). The work will benefit from better representation of precipitation and clouds in Task 3.3.

**Task 2.5** will use OSEs to assess the benefit of additional SOP radiosonde and buoy observations.

WP3: Enhance and improve NWP model capabilities and diagnostics for high latitudes (76 pm)

Lead: Harald Sodemann (UiB) Co-lead: Teresa Valkonen (MET) Partners: Igor Esau (NERSC), Stephen Outten (NERSC), PhD (UiB), Wim de Rooij (KNMI)

**Task 3.1** will implement the Zilitinkevic et al. (2010) parameterisation for heat fluxes in MUSC (1D), evaluate the scheme for case studies over sea ice and land surface with very stable boundary layer, and perform and analyse sensitivity simulations with AROME Arctic (Task 2.2)

**Task 3.2** will identify how interactions between parameterised processes lead to error compensation in AROME Arctic. The output of physical tendencies from parameterised processes will be implemented, as well as a passive tracer variable. Tendency accumulation will be explored as a measure of model uncertainty in simulations with the new and previous heat flux parameterisation (Task 3.1).

**Task 3.3** will implement and test stochastic parameterisations of key influential processes. The perturbation range of target variables for stochastic parameterisations will be identified (Task 3.2) and tested on turbulent fluxes. The impact of new parameterisation on the old and new DA schemes will be tested (coordination with Task 2.3), as well as the growth of uncertainty with stochastic parameterisations in an EPS (coordination with Task 4.4).

**Task 3.4** will analyse the sensitivity of fog/icing forecasts (Task 1.1) to model cloud microphysics by implementing stochastic microphysics parameterisations, targeting mixed-phase cloud processes. Tests will be performed in MUSC, as well as AROME Arctic with tendency output.

**Task 3.5** will analyse important aspects for the future development of high-resolution forecasting models in the Arctic, such as the impact of representation of lateral fluxes between grid cells, the ability of the methods in Task 3.2 to identify error compensation between parameterisations, and evaluate the overall impact of the new heat flux and stochastic parameterisation (Task 3.1).

WP 4: Develop an Ensemble Prediction System optimized for Arctic conditions (42 pm)

Lead: Inger-Lise Frogner (MET) Co-lead: Andrew Singleton (MET) Partners: Postdoc (MET), NN (MET)

**Task 4.1** will first produce a set of EPS simulations for the weather reference cases defined in Task 1.1, and then adapt the existing EPS perturbations for the Arctic.

**Task 4.2** will in collaboration with APPLICATE assess the sensitivity to changes in sea ice and SST and develop novel methods to perturb these fields. The perturbations will be targeted to areas where the uncertainty is greatest.

**Task 4.3** will in collaboration with Task 2.3, implement and tune EDA in the EPS setup and the impact assessed against the output of Task 4.2.

**Task 4.4** will build on Task 3.3 by determining appropriate spatial and temporal correlations for the physics parameter perturbations. The impact will be compared with a more straightforward SPPT approach. Additionally, a combination of the two approaches will be tested. The spatial and temporal scales of predictability of Arctic weather phenomena will be assessed.

**Task 4.5** will recommend the optimum EPS setup that balances the need for sharp and reliable probabilistic forecasts with efficient computation.

WP5: Improve polar prediction through the ALERTNESS value chain (10 pm)

Lead: Jørn Kristiansen (MET) Co-lead: Marius O. Jonassen (UNIS) Partners: Eivind Støylen (MET), Erik W. Kolstad (UNI), Magne Velle (MET)

**Task 5.1** will arrange the kick-off meeting, set up the management structure, the periodic meetings and the data management plan (Sec. 6).

**Task 5.2** will manage the project, (progress and final) reporting and response to requests, as well as its cooperation and dependencies.
**Task 5.3** will establish and update the dissemination and communication plan. Swift and wide distribution of information on the results will be provided by participation in conferences, networks and seminars.
**Task 5.4** will use the ALERTNESS value chain to engage a wide range of stakeholders and user groups to connect weather information and sectoral interests for mutual benefit.

| **Table 1: Time schedule for milestone activities.** Deliverables: R-Report/peer-review publication; P-Prototype; D-Data | 2018 | | | | 2019 | | | | 2020 | | | | 2021 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| WP1: Develop and apply verification metrics and diagnostics for NWP in the Arctic | | | | | | | | | | | | | | | | |
| Establish a reference database of well-observed high-impact weather events (T1.1) | | | | D | | | | | | | | D | | | | |
| Develop metrics and diagnostics appropriate for the (maritime) Arctic (T1.2) | | | | | | | R | | | | | | | | | |
| Evaluate the model performance during high-impact weather events (T1.3) | | | | | | | | | R | | | | | | | |
| Analyse the forecast skill of existing and enhanced AROME Arctic (T1.4) | | | | | | | | | | | | | | | | R |
| Participate in IGP flight campaign (T1.1 and T1.5) | | | | | | | | | | | | | | | | |
| WP2: Improve the use of Arctic observations for accurate mesoscale forecasts | | | | | | | | | | | | | | | | |
| Optimized assimilation of satellite observations (T2.1) | | | | | | | | | | R | | | | | | |
| Implement assimilation of satellite observations over sea ice (T2.2) | | | | | | | | | | R | | | | | | |
| Implement flow-dependent DA (T2.3) | | | | | | | | | | | | | | | P | |
| Change clear-sky to all-sky radiance assimilation (T2.4) | | | | | | | | | | | | | | | R | |
| OSEs to evaluate the benefit of enhancements to the Arctic observing network (T2.5) | | | | | | | | | | | | | | | | R |
| WP3: Enhance and improve NWP model capabilities and diagnostics for high latitudes | | | | | | | | | | | | | | | | |
| Test a new approach to parameterise heat fluxes in stable boundary layers (T3.1) | | | | | P | | | | | | | | | | | |
| Identify how interaction between parameterisations causes error compensation (T3.2) | | | P | | | | | | | | | | | | | |
| Implement and test stochastic parameterisations of key processes (T3.3) | | | | | | | | | | P | | | | | | |
| Analyse the sensitivity of fog/icing weather forecasts to cloud microphysics (T3.4) | | | | | | | | | | | | | | | | |
| Analyse the importance of key aspects for the future model development (T3.5) | | | | | | | | | | | | | | | | R |
| WP4: Develop an Ensemble Prediction System optimized for Arctic conditions | | | | | | | | | | | | | | | | |
| Run reference experiments and tune for the Arctic (T4.1) | | | | | D | R | | | | | | | | | | |
| Develop methods for perturbing sea ice and sea surface temperature (T4.2) | | | | | | | | | | | R | | | | | |
| Implement and tune EDA in EPS (T4.3) | | | | | | | | | | | | | | | | |
| Implement stochastic physics in EPS and tune spatial and temporal correlations (T4.4) | | | | | | | | | | | | | | | R | |
| Select optimum EPS setup for the Arctic (T4.5) | | | | | | | | | | | | | | | | P |
| WP5: Improve polar prediction through the ALERTNESS value chain | | | | | | | | | | | | | | | | |
| Project initiation (T5.1) | R | | | | | | | | | | | | | | | |
| Management and coordination (T5.2) | | | | | | | | R | | | | | | | | R |
| Communication and dissemination (T5.3) | | R | | | | | | | | | | | | | | |
| Connect weather information and sectoral interests (T5.4) | | | | | | | | | | | | R | | | | |

**Project team and cooperation**

The project leader, Dr. Jørn Kristiansen, is Director of the Development Centre for Weather Forecasting at MET Norway, where he has responsibility for NWP research and operations, including Yr. Dr. Kristiansen, a member of the WMO Polar Prediction Project SG, have long experience in research and management. The project co-leader, Assoc. Prof. Marius O. Jonassen, UNIS and UiB, has considerable experience from polar weather research, both in terms of meso-scale modelling of high-impact weather and field campaigns. Dr. Erik W. Kolstad was a WP leader in the Norwegian IPY-THORPEX project (2007–2011) and is now a Research Professor at Uni Research Climate with more than 10 years of experience in Arctic extreme weather research, specializing in PLs. Dr. Roger Randriamampianina is project leader for data assimilation in the HIRLAM-C programme, and has experience with assimilation of both conventional and satellite observations and in its operational implementation in limited area models, including over the Arctic. Prof. Harald Sodemann is an expert in diagnostic tracer methods for numerical models and the representation of parameterised processes in NWP models; an ERC consolidator grant will, if funded, supplement ALERTNESS with a novel approach to validate the water cycle in Arctic high-resolution models. Dr. Inger-Lise Frogner has been project leader for EPS and predictability in the HIRLAM program since 2012. She has wide experience in developing EPS, most recently the joint operational EPS (Norway-Sweden-Finland), and a member of the ECMWF Scientific Advisory Committee. Igor Esau is a renowned and innovative expert in stable boundary layer research.

The ALERTNESS project team will collaborate with leading international experts. We will collaborate with ECMWF, Linus Magnusson and a MET Norway meteorologist Matilda Hallerstig working as graduate trainee, on PL analysis. Ad Stoffelen, Gert-Jan Marseille and Jan Barkmeijer are senior researchers with

outstanding and longstanding expertise in NWP, satellite observation processing and (variational) data assimilation. We maintain contact with S. Zilitinkevich at the Finnish Meteorological Institute (FMI). The PhD in WP1 will be supervised by Kolstad and based at the Bjerknes Centre for Climate Research (BCCR), focussing on Tasks 1.1–1.3. Sodemann and Jonassen will act as co-supervisors. Extended visits to MET Norway in Oslo (Køltzow) and to Jonassen at UNIS are expected. The PhD project in WP3 will mainly be related to Tasks 3.2-3.4 and include an extended stay at KNMI where valuable expertise in stable boundary layer modelling with MUSC is located (Wim de Rooy). Visiting research grants for Danijel Belusic and Patrick Samuelsson (SMHI) and Carl Fortelius (FMI) to Norway ensure the PhD support from the larger Nordic NWP community. The Postdoc in WP4 will be a joint position with APPLICATE. At UNIS and UiT new knowledge from ALERTNESS will be incorporated in graduate level courses. We will integrate master students in the project and expose them to our research and contribute to their education. Our participation in the IGP campaign will foster international collaboration with colleagues in the polar prediction community.

**Budget ->** Please see grant application form.

## 4. Key perspectives and compliance with strategic documents

### Compliance with strategic documents

Guided by the recommendations from strategy documents (e.g. WMO/WWRP/PPP, Arctic Council, White House Arctic Science Ministerial), ALERTNESS will meet strategic objectives to improve weather forecasts and warnings for authorities and individuals in the Arctic. ALERTNESS, as well as MET Norway and UiB, are endorsed by YOPP. We will strengthen preparedness and safety, thus contributing to the accomplishment of the Norwegian polar research policy goals and Norway's role as a leading polar nation. AROME Arctic covers METAREA XIX where MET Norway provides meteorological and navigation warnings including ice conditions as mandated by the International Maritime Organization.

### Relevance and benefit to society

Relevance and benefit to society have high priority, as reflected in our aim, and WP5 is dedicated to improve polar prediction through the ALERTNESS value chain. Benefits accrue from improved knowledge of high impact weather, increased predictive capacity and better estimates of (weather dependent) uncertainties in operational weather prediction in the Arctic, including Yr.no. In particular, enhanced weather forecasts for HIW imply more timely warnings that can save lives and property, make search and rescue operations more efficient, provide socioeconomic benefits, and improve decision making for public and private sectors.

### Environmental impact

The largest environmental impacts caused by this project will be via air travel to meetings and conferences. Where air travel is unavoidable, ALERTNESS will purchase carbon offsets. Project meetings will preferably be held close to the railroad between Oslo and Bergen and on video. We will mostly use The National Supercomputer Centre in Sweden (NSC) for high performance computing which uses district cooling to minimize energy consumption. UiB and UNI are members of Miljøfyrtårn. The partners have environmental protection efforts as central points in their strategies.

**Ethical perspectives - >** There are no ethical issues of importance foreseen in this project.

### Gender issues (Recruitment of women, gender balance and gender perspectives)

ALERTNESS supports equal opportunity for women and men to be active in all areas and all levels in science. The project involves two female scientists from MET Norway, one of them being WP co-lead and the other lead. The WP4, Postdoc and PhD positions are opportunities for recruitment of female candidates a field with relatively large bias towards male scientists. The work environment, meetings and reporting will be organised in a flexible and predictable manner to support researchers with children or other dependants.

## 5. Dissemination and communication of results - > Please see grant application form and WP5.

## 6. Additional information specifically requested in the call for proposals

### 6.1 Data management and dissemination

ALERTNESS will employ the data management structure that is emerging as the generic, global way of managing research and operational data. This is also a strong element in organizing ALERTNESS along a value chain, since this gives a high dividend to the application community, as listed on the right in the "users and stakeholder community"-panel in Fig. 3. A data management and dissemination plan will be developed in WP5 following the YOPP data protocol. The plan will include documentation of experiments, data formats, dissemination technology, data curation and guidance for complying with existing standards. We will run a large number of model simulations, as well as provide real-time YOPP core and tendency data. We have an open data policy and access to observation and model data will be ensured through web-portals hosted by MET, e.g. YOPP. Meta-data and new data sets will be registered at the SIOS Knowledge Centre in Longyearbyen. Data will be archived, backed up and maintained for at least 10 yrs on national infrastructure.

## 6.2 References


Andrae, U., and co-authors, 2017: The MetCoOp ensemble MEPS, ALADIN-HIRLAM Newsletter. 8, 98-104.

Bauer, P., and co-authors, 2010: Direct 4D-Var assimilation of all-sky radiances. Part I: Implementation. Q. J. Roy. Meteor. Soc., 136, 1868–1885.

Bauer, P., A. Thorpe, and G. Brunet, 2015: The quiet revolution of numerical weather prediction, Nature, 525, 47–55.

Bengtsson, L. and co-Authors, 2017: The HARMONIE-AROME model configuration in the ALADIN-HIRLAM NWP system, Mon. Wea. Rev., 145. 1919-1935.

Bonavita, M., L. Isaksen and E. Holm, 2012: On the use of EDA background error variances in the ECMWF 4D-Var, ECMWF Tech. Memo. 664.

Brousseau, P., and co-authors, 2012: Flow-dependent background-error covariances for a convective-scale data assimilation system. Q. J. Roy. Meteor. Soc., 138, 310-322.

Bouttier, F., and co-authors, 2016: Sensitivity of the AROME ensemble to initial and surface perturbations during HyMeX. Q.J.Roy. Meteor. Soc., 142, 390–403.

Buizza, R., M. Miller and T.N. Palmer, 1999: Stochastic representation of model uncertainties in the ECMWF ensemble prediction system. Q. J. Roy. Meteor. Soc., 125, 2887-2908.

Casati, B., and co-authors, 2017: Verification of Environmental Prediction in Polar Regions: Recommendations for the Year of Polar Prediction, WWRP 2017 – 1.

Davy R. and I. Esau, 2014: Global climate models' bias in surface temperature trends and variability, Environ.Res.Lett,9.

Feingold, G., and co-authors, 2010: Precipitation-generated oscillations in open cellular cloud fields. Nature, 849–852.

Frogner, I.-L., and co-authors, 2016: Ensemble Prediction with Different Spatial Resolutions for the 2014 Sochi Winter Olympic Games: The Effects of Calibration and Multimodel Approaches., Wea. Forecasting, 31, 1833–1851.

Gleeson, E., and co-authors, 2016: Effects of aerosols on clear-sky solar radiation in the ALADIN-HIRLAM NWP system, Atmos. Chem. Phys., 16, 5933-5948.

Gultepe, I. and co-authors, 2015: A review on ice fog measurements and modeling, Atmos. Res., 151, 2-19.

Holtslag, A. A. M., and co-authors, 2013: Stable Atmospheric Boundary Layers and Diurnal Cycles Challenges for Weather and Climate Models, Bull. Am. Met. Soc, 11, 1691-1706

Joos, H. and H. Wernli, 2012: Influence of microphysical processes on the potential vorticity development in a warm conveyor belt: a case-study with the limited-area model COSMO. Q. J. Roy. Meteor. Soc., 138, 407-418.

Jung, T., and co-authors, 2016: Advancing polar prediction capabilities on daily to seasonal time scales. Bull. Am. Met. Soc., 97, 1631-1647.

Karbou, F., F. Rabier and C. Prigent, 2014: The Assimilation of Observations from the Advanced Microwave Sounding Unit over Sea Ice in the French Global Numerical Weather Prediction System, Mon. Wea. Rev., 142, 125–142.

Key, J. and M. Haefliger, 1992: Arctic ice surface temperature retrieval from AVHRR thermal channels, J. Geophys. Res., 97, 5885-5893.

Kolstad, E. W., T. J. Bracegirdle and M. Zahn, 2016: Re-examining the roles of surface heat flux and latent heat release in a “hurricane-like” polar low over the Barents Sea. J. Geophys. Res., 121, 7853–7867

Kolstad, E. W. 2017. Higher ocean wind speeds during marine cold air outbreaks. Q. J. Roy. Meteor. Soc., 143, 2084–2092.

Kristiansen J., S.L. Sørland, T. Iversen, D. Bjørge, M.Ø. Køltzow, 2011: High-resolution ensemble prediction of a polar low development. Tellus 63A, 585–604.

Kristjánsson, J.E., and co-authors, 2011: The Norwegian IPY–THORPEX: Polar lows and Arctic fronts during the 2008 Andøya campaign. Bull. Am. Met. Soc., 92, 1443-1466.

Lemieux, J.F. and co-authors, 2016: The Regional Ice Prediction system (RIPS): verification of forecast sea ice concentration, Q. J. Roy. Meteor. Soc., 142, 632-643.

Lloyd’s, 2012: Arctic Opening: Opportunity and Risk in the High North, Chatham House-Lloyd's Risk Insight Report www.chathamhouse.org/publications/papers/view/182839

Mittermaier, M.P., 2014: How temporally representative are synoptic observations? WWOSC, Montreal, Canada.

Müller, M. and co-authors, 2017a: Characteristics of a convective-scale weather forecasting system in the Arctic. Mon. Wea. Rev. Accepted with minor rev.

Müller, M. and co-authors, 2017b: AROME-MetCoOp: A Nordic Convective-Scale Operational Weather Prediction. Wea. Forecasting, 32, 609–627.

Ollinaho, P., and co-authors, 2017: Towards process-level representation of model uncertainties: stochastically perturbed parametrizations in the ECMWF ensemble. Q.J.R. Meteor. Soc., 143, 408–422.

Pithan, F., W. Angevine and T. Mauritsen, 2015: Improving a global model from the boundary layer: Total turbulent energy and the neutral limit Prandtl number. J. Adv. Model. Earth. Syst., 7, 791-805

Rampal, P., and co-authors, 2016: neXtSIM: a new Lagrangian sea ice model. The Cryosphere, 10, 1055–1073.

Randriamampianina, R.,T. Iversen and A. Storto, 2011: Exploring the assimilation of IASI radiances in forecasting polar lows. Q.J.R. Meteor. Soc., 137. 1700–1715.

Randriamampianina R., and co-authors, 2016: Observing system experiments and observing system simulation experiments using mesoscale model in Arctic, WMO Workshop. Shanghai.

Samuelsen, E. M., K. Edvardsen and R. Graversen, 2017: Modelled and observed sea-spray icing in Arctic-Norwegian waters. Cold Regions Science and Technology. 134, 54-81.

Smedsrud, L.H., and co-authors, 2013. The role of the Barents Sea in the Arctic climate system. Rev. Geophys., 51, 415-449.

Sodemann, H. and A. Stohl, 2013: Moisture origin and meridional transport in atmospheric rivers and their association with multiple cyclones. Mon. Wea. Rev., 141, 2850-2868.

Thyness, V., and co-authors, 2005: Assimilating AMSUA over sea ice in HIRLAM 3D-Var, ITSC XIV. Proceedings, Beijing.

Tjernström, M., and co-authors, 2005: Modelling the Arctic boundary layer: an evaluation of six ARCMIP regional-scale models using data from the SHEBA project. Bound.-Layer Meteorol., 117, 337-381.

Valkonen, T., T. Vihma and M. Doble, 2008: Mesoscale modelling of the atmospheric boundary layer over the Antarctic sea ice: a late autumn case study. Mon. Wea. Rev., 136, 1457–1474.

Valkonen, T., H. Schyberg and J. Figa-Saldaña, 2017: Assimilating advanced scatterometer winds in a high-resolution limited area model over Northern Europe. IEEE JSTARS. 10, 2394-2405.

Vihma, T., and co-authors, 2014: Advances in understanding and parameterization of small-scale physical processes in the marine Arctic climate system: a review. Atmos. Chem. Phys., 14, 9403-9450.

WMO-PPP, 2013: Science Plan, polarprediction.net/documents/

Wolff, M. A., and co-authors, 2015: Derivation of a new continuous adjustment function for correcting wind-induced loss of solid precipitation: results of a Norwegian field study, Hydrol. Earth Syst. Sci., 19, 951-967.

YOPP 2016:Implementation Plan,polarprediction.net/documents

Zilitinkevich, S.S., and co-authors, 2008: Turbulence energetics in stably stratified geophysical flows: Strong and weak mixing regimes. Q. J. Roy. Meteor. Soc., 134, 793-799.

Zilitinkevich, S.S., and co-authors, 2013: A hierarchy of energy- and flux-budget (EFB) turbulence closure models for stably stratified geophysical flows, Bound.-Layer Meteorol.341-373.

# Curriculum Vitae

Name: Jørn Kristiansen  Born: 031271 in Norway
Staus: Married, 2 children  Nationality: Norwegian
Address: Storåsveien 9F, 1169, Oslo, Norway
Phone: +4746420054 E-mail: jornk@met.no

## Experience

- Director Development Centre for Weather Forecasting at the Norwegian Meteorological Institute (MET). The department holds 42 employees. The Centre performs research and development on Numerical Weather Prediction (NWP); is responsible for the NWP production chain (from observations to users); develop internal services; contribute to the development of MET's various production chains and its open data and software policy; responsible for the development of MET's external Application Programming Interface (api.met.no); is responsible for the development of the world-leading weather service Yr.no; and develop and provide data, products and services (including frontend and human to human) in co-production with and for other public sector bodies. The Centre is responsible for MET Norway's novel value chain for NWP.
- Member of WMO WWRP Polar Prediction Project (PPP) Steering Group.
- Since 2010 head of Yr, and responsible for both the maintenance and development of the technical infrastructure, scientific content and quality as well as the day-to-day running of the system, and how the forecasts are presented. Leader of Yr's Steering Group (NRK and MET).
- In 2012 and 2013 Nordic, Ireland and Iceland appointed representative to the ECMWF Finance Committee. Represented Norway in ECMWF Policy Advisory Committee Spring 2012 and part of the Norwegian delegation to ECMWF Council since Autumn 2012.
- Member of the HIRLAM Advisory Committee (HAC; 2011-2017), vice-chair since 2016, and Steering Group for the operational NWP collaboration between the Swedish Hydrological and Meteorological Institute (SMHI) and The Norwegian Meteorological Institute. Leader of steering group of the future Nordic (and Baltic) cooperation on operational NWP (2017-).
- Lecturer at UiO on several occasions and reviewer for several journals
- Experience form a number of different research projects, incl steering group member and lead.
- Broad research experience ranging from climate studies to high-resolution EPS. Main research interest are high-resolution NWP with special focus on EPS, and land surface – atmosphere interactions including surface modeling.

## Education

- 24-28 April, 2006: Predictability, Diagnostics, and Seasonal Forecasting, ECMWF Meteorological training course.
- 1999 – 2004: Ph.D. in meteorology, Department of geosciences, University of Oslo (UiO). Thesis: On solar activity and cloudiness. Supervisors: Jon Egill Kristjansson (Department of geosciences, UiO), Hans Gleisner and Peter Thejll (Denmark Meteorological Institute).
- Spring 2002: PSYKRI–Organisjonspsykologi:Ledelse og samarbeid; MØ100–Innføring i økonomi, UiO.
- 1996 − 1998: Cand. scient. in meteorology, Department of geosciences, UiO: Beregninger av strålingsføring for marine stratocumulusskyer. Supervisor: Jon Egill Kristjansson.
- 1992 − 1997: Cand. mag. in meteorology, Department of geosciences, UiO.

## Employment

- 2016 - : Director Development Centre for Weather Forecasting.
- 2011 – 2015: Division Head Numerical Weather Prediction, Research and Development Department (FoU), Norwegian Meteorological Institute (MET Norway).
- Spring 2014 and 2017: Lecturer GEF2200 – Atmosfærefysikk (UiO). Course responsible: Frode Stordal.
- 2005 – 2011: Research scientist, Section for meteorology, FoU, MET Norway.
- 2001-2010: Lecturer/assistant at UiO on various courses.
- February1999 − July 1999: Research scientist, Section for meteorology, FoU, MET Norway.

- November 1998 − January 1999: Research assistant NOrdic CLImate Modelling Project (NOCLIMP), Department of geosciences, UiO.
- May 1998 − July 1998: NOCLIMP, Department of geosciences, UiO.

## Publications

- Nordhagen, R., T. Spengler, J. Reuder and J. Kristiansen, 2017. Wintertime Temperature Problems in a Norwegian Valley: A Case Study with a low-cost Mesoscale-Network. *Tellus, in preparation,*
- Müller, M., Y. Batrak, J. Kristiansen, M. Ø. Køltzow, G. Noer and A. Korslv, 2017. Characteristics of a convective-scale weather forecasting system in the Arctic. Mon. Wea. Rev. *Accepted with minor rev.*
- Rasheed, A., T. Mandar, J.K. Süld, J. Kristiansen, and T. Kvamsdal, 2017. Demonstrating the improved performance of an Ocean-Met model using bi-directional coupling. *To appear in Energy Procedia*.
- Müller, M., M. Homleid. K.-I. Ivarsson, M. A. Ø. Køltzow, M. Lindskog, U. Andrae, T. Aspelien, L. Berggren, D. Bjørge, P. Dahlgren, J. Kristiansen, R. Randriamampianina, M. Ridal and O. Vignes, 2017. AROME - MetCoOp : A Nordic convective scale operational weather prediction model. *Wea. Forecasting*, 32, 609-627. https://doi.org/10.1175/WAF-D-16-0099.1
- Erlandsen, H.B., I. Haddeland, L.M. Tallaksen, and J. Kristiansen, 2017. The Sensitivity of the Terrestrial Surface Energy and Water Balance Estimates in the WRF Model to Lower Surface Boundary Representations: A South Norway Case Study. *J. Hydrometeor.,* 18, 265–284, https://doi.org/10.1175/JHM-D-15-0146.1
- Süld, J.K, A. Rasheed, J. Kristiansen, Ø. Sætra, A. Carrasco and T. Kvamsdal, 2015. Mesoscale numerical modeling of ocean-atmospheric interactions. *Energy Procedia*, 80, 433-441.
- Sivle, A.D., S.D. Kolstø, P.J.K. Hansen, and J. Kristiansen, 2014. How Do Laypeople Evaluate the Degree of Certainty in a Weather Report? A Case Study of the Use of the Web Service yr.no. *Wea. Climate Soc.*, 6, 399–412. doi:http://dx.doi.org/10.1175/WCAS-D-12-00054.1
- Kristiansen, J., D. Bjørge, J. M. Edwards and G. Rooney: Soil-field model-interoperability, 2012. Challenges and impact on screen temperature forecast skill during the Nordic winter. J. Hydrometeor., 13, 1215–1232. doi:http://dx.doi.org/10.1175/JHM-D-11-095.1
- Mc Innes, H., J. Kristiansen, J.E. Kristjansson and H. Schyberg, 2011. The role of horizontal resolution for polar low simulations. Quart. J. Roy. Meteor. Soc., 137:1674–1687. doi:10.1002/qj.849.
- Kristiansen, J., S.L. Sørland, T. Iversen, D. Bjørge and M.Ø. Køltzow, 2011. High-resolution ensemble prediction of a polar low development. Tellus 63A, doi: 10.1111/j.1600-0870.2010.00498.x.

## Selected presentations

- Kristiansen, J., 2017. Yr and the Benefits of Open and Collaborative Numerical Weather Prediction (keynote) #NeIC 2017, Umeå, Sweden. http://neic2017.nordforsk.org/talks/6c/
- Kristiansen, J., 2017. Under the hood of Yr (keynote). 12th international conference on computational fluid dynamics in the oil & ga, metallurgical and process industries, Trondheim, Norway. https://www.sintef.no/projectweb/cfd-2017/
- Kristiansen, J., Å. Bakketun and A. Ommundsen, 2015: Modelling the vehicle bearing capacity for winter operations over frozen soil. The 3rd Conference on Modelling Hydrology, Climate and Land Surface Processes, Lillehammer, 7-9 September.
- Kristiansen, J., 2015. Under panseret på Yr finnes Big Data. Digitalkornferansen 2015, Kristiansand, http://www.digin.no/news/her-er-foredragene-fra-digitalkonferansen-2015.
- Kristiansen, J. and R. Randriamampianina, 2015. Short-range NWP in the polar regions: Status and developments at Met Norway. High Latitude Dynamics Workshop 23-27 March, Rosendal, Norway. (Invited speaker). http://highlatdynamics.b.uib.no/workshop-details/
- Kristiansen, J., and B. Hackett, 2015. Meteorologisk institutts tjenester for søk og redning, SARiNOR - Nye løsninger for alarmering og varsling, Bodø, Norway.
- Kristiansen, J. and K. Lyng, 2014. Weather Information as a Public Common Good for the global community. Knowledge partnership day, GFDRR, World Bank, Washington DC, 28 October.
- Kristiansen, J., I. Støver Jensen, M. Køltzow, B.K. Larsen, J.I. Pladsen and J. Smits, 2014. How to communicate weather forecasts on web services: Yr, a Norwegain example. 19 August at WWOSC (http://wwosc2014.org/), Montreal, Canada, Oral.
- Midtbø, K.H., J. Süld, K. Sørli and J. Kristiansen, 2014: An operational system for forecasting of turbulence in the vicinity of airports in Norway, 18 August at WWOSC (http://wwosc2014.org/), Montreal, Canada, Oral.
- Kristiansen, J., D. Bjørge, J.M. Edwards and G.G. Rooney, 2013. Soil Field Model Interoperability: Challenges and Impact on Screen Temperature Forecast Skill during the Nordic Winter, EGU, oral.
- Kristiansen, J., T. Iversen, T. Jung and J. Barkmeijer, 2013. Optimal forcing perturbations for regional flow patterns conditioning polar low development, EGU, poster.
- Vikhamar-Schuler, D., J.M. Edwards, G.G. Rooney and J. Kristiansen, 2012. Evaluation of JULES multi-layer snow scheme for Norwegian snow conditions. EGU, poster.

# Curriculum vitae

## PERSONAL INFORMATION

*Family name, First name: Jonassen, Marius Opsanger
*Date of birth: *23.07.1983*
*Sex: Male
*Nationality: Norwegian

## EDUCATION

**Bachelor in meteorology and oceanography**
University of Bergen (UoB), Geophysical Institute
08/2003- 06/2006
**Master in geophysics, meteorology**
University of Bergen, Geophysical Institute
08/2006- 06/2008
Thesis:
*"The Small Unmanned Meteorological Observer (SUMO), - Characterization and test of a new measurement system for boundary layer research"*
Advisor:
Dr. Joachim Reuder, University of Bergen.
**PhD in meteorology**
University of Bergen, Geophysical Institute
08/2008- 11/2012
Thesis:
*"Local- and mesoscale variability of winds in the complex topography of southwestern Norway and Iceland"*
Advisors:
Dr. Haraldur Ólafsson, University of Bergen and University of Iceland
Dr. Joachim Reuder, University of Bergen.

## CURRENT AND PREVIOUS POSITIONS

08/2008- 08/2012 PhD candidate in meteorology at Geophysical Institute, University of Bergen
09/2012- 11/2012 Assistant professor at Geophysical Institute, University of Bergen
01/2013- 06/2013 Associate professor at Geophysical Institute, University of Bergen
06/2013- 08/2013 Researcher at the Finnish Meteorological Institute (for a scientific cruise in the Weddell Sea)
09/2013- present Adjunct Associate professor at Geophysical Institute, University of Bergen
09/2013- present Associate professor at the University Centre in Svalbard, UNIS
02/2016- 10/2016 Acting head of department, Department of Arctic Geophysics, UNIS

## MOBILITY

**Reykjavík, Iceland**
01/2010 – 08/2010,
04/2011 – 06/2011 and
05 *and* 07 *and* 11/2012
Host: Icelandic Institute for Meteorological Research (IMR), Belgingur.
Main contact persons: Haraldur Ólafsson and Ólafur Rögnvaldsson.

**Palma de Mallorca, Spain**
10/2010 – 12/2010 and
04/2011 – 06/2011:

Host: University of the Balearic Islands.
Main contact person: Joan Cuxart, professor in meteorology.

## SUPERVISION OF GRADUATE STUDENTS AND RESEARCH FELLOWS

*Master students:*
Birthe Steensen, 2010:
*"Extreme precipitation in Central Norway. A case and climate study" Mark: B*
Gunnar Livik, 2011:
*"An observational and numerical study of local winds in Kongsfjorden, Spitsbergen" Mark: B*
Aslaug Valved, 2012:
*"Local flow conditions in the Bergen valley based on observations and numerical simulations" Mark: B*
Aurora Stenmark, 2013:
*"The influence of nunataks on the atmospheric boundary layer during summer in Dronning Maud Land, Antarctica" Mark: B*
Line Båserud, 2013:
*"Investigating the potential of turbulence measurements with the RPAS SUMO" Mark: B*
Friedrich Richter, autumn 2014:
*"The atmospheric response to sea ice changes investigated with the Planet Simulator"*
Guest master student for 3 months at UNIS.
Philipp Franzen, 2016
Master student at the University of Mainz and the University Centre in Svalbard. Mark: B
Mathias Tollinger, 2017 (ongoing)
Master student at the University of Innsbruck and the University Centre in Svalbard
Marvin Kähnert, 2017 (ongoing)
Master student at the University of Hamburg and the University Centre in Svalbard
*PhD students*
Stephan Kral, due to finish in 3-4 years
PhD student at the University of Bergen under my co-supervision
Line Båserud, due to finish in 3-4 years
PhD student at the University of Bergen under my co-supervision
Siiri Wickström, due to finish in 2020
PhD student at the University of Bergen and the University Centre in Svalbard

## TEACHING ACTIVITIES

2009, spring:
Teaching assistant at UoB in GEOF-322: "Field course in meteorology". 5 ECTS
2009, spring:
Teaching assistant at UoB in GEOF-110: "Introduction to atmosphere-ocean dynamics". 10 ECTS
2009, autumn:
Teaching assistant at UoB in GEOF-320: "Dynamics of the atmosphere I". 15 ECTS
2009/10/11/12, spring:
Teaching assistant at UoB in GEOF-301: "An introduction to master's studies". 5 ECTS
2011, spring:
Teaching assistant at UoB in observation course in GEOF-120: "Meteorology". 10 ECTS
2011, autumn:
Lecturer during the Earth Observation Summer camp at Andøya Rocket Range. 5 ECTS
2012/13, spring:
Co-lecturer and lecturer at UoB in GEOF-120: "Meteorology". 10 ECTS
2013/14/15, autumn:
Lecturer at UNIS in AGF-213: "Polar Meteorology and Climate". 15 ECTS
2014/16, spring:
Lecturer at UNIS in AGF-350/850: "The Arctic Atmospheric Boundary Layer and Local Climate Processes". 10 ECTS
2014/16 autumn:
Lecturer at UNIS in AGF-311/811: "Air-Ice-Sea Interaction II". 10 ECTS

## Grants

*Arktisstipendet, 2008.* 50 000 NOK. Provided by Norwegian Polar Institute to perform fieldwork on Svalbard.
*Young Scientist Travel Award (YSTA)* 500 EUR for Nordisk meteorologmøte (Nordic Meteorology Meeting), Helsinki June 2010. Provided by European Meteorological Society.
*Arctic Studies Exchange Scholarship, 2012,* from Office of International Education, Iceland.
(EUR 1200 for travel and a monthly subsistence grant at a rate of EUR 520)

**Field work**
08/2008, 3 weeks The FLUXPAT III field campaign in Jülich, Germany. Study of exchange processes between the soil, vegetation and the adjacent atmospheric boundary layer. Leader of operations of a UAV system.
02/2008 – 03/2008, 3 weeks IPY- THORPEX related scientific cruise with KV Svalbard and field campaign on Svalbard. "Testing of a new meteorological measurement system in Arctic conditions". Partly funded by a personal "Arktis stipend" from the Norwegian Polar Institute.
03/2009 – 04/2009, 4 weeks Field campaign on Svalbard. Study of the Arctic stable atmospheric boundary layer using in-situ observations and numerical modelling.
07/2009, 4 weeks Moso field campaign in southwest Iceland. Study of orographically modified and thermally driven flow using in-situ meteorological observations and numerical modelling.
09/2009, 1 week Scientific cruise with KV Harstad in the Lofoten area, Norway.
Leader of UAV operations from a ship.
05/2011, 1 week Field campaign in Denmark, Lolland. UAV measurements of atmospheric turbulence in a wind turbine park.
06-07/2011, 5 weeks Boundary-Layer Late Afternoon and Sunset Turbulence (BLLAST), Southern France. Responsible for meteorological measurements and weather forecasting
06-08/2013, 10 weeks Cruise with R/V Polarstern in the Weddell Sea, Antarctica. ANT-XXIX/6 (AWECS). Responsible for meteorological measurements over sea ice.
Autumn term 2013->2016 and spring term 2014->2016. Approximately 10 weeks of fieldwork. Organisation and leading fieldwork in the UNIS undergraduate and graduate courses AGF-211, AGF-213, AGF-350/850 and AGF-311/811

## Early achievements track record

1. I have authored and co-authored a total of 20 scientific articles
2. Five main publications:

Improving High-Resolution Numerical Weather Simulations by Assimilating Data from an Unmanned Aerial System
Jonassen, M. O., Ólafsson, H., Ágústsson, H. Rögnvaldsson, Ó. and Reuder, J. (2012)
Monthly Weather Review, 140, pp. 3734-3756

Impact of surface characteristics on flow over a mesoscale mountain
Jonassen, M. O., Ágústsson, H. and Ólafsson, H. (2014)
Quarterly Journal of the Royal Meteorological Society, DOI: 10.1002/qj.2302

Application of remotely piloted aircraft systems in observing the atmospheric boundary layer over Antarctic sea ice in winter.
Jonassen, M.O., Tisler,P., Altstädter, B., Scholtz, A., Vihma, T., Lampert, A.and Lüpkes, C. (2015) Polar Research

Atmospheric profiling with the UAS SUMO: a new perspective for the evaluation of fine-scale atmospheric models
Mayer, S., Sandvik, A., Jonassen, M. O. and Reuder, J. (2012)
Meteorology and Atmospheric Physics, DOI: 10.1007/s00703−010−0063-2

Multi-scale variability of winds in the complex topography of southwestern Norway
Jonassen, M. O., Ólafsson, H., Reuder, J. and Olseth, J. A. (2012)
Tellus 64A, pp. 1−17

## CV WITH TRACK RECORD

### Personal information

Family name, First name: Kolstad, Erik W.
Date of birth: 18.03.1974
Sex: Male
Nationality: Norwegian

### Researcher unique identifiers

ORCID: 0000-0001-5394-9541
ResearcherID: A-2311-2015

### Web pages

URL for personal web site: ewk.no

## ROLE IN PROJECT

Project manager ☐ Collaborator ☒

## SUMMARY OF RELEVANT EXPERIENCE

I obtained my PhD in meteorology at the Geophysical institute at the University of Bergen in 2007, focusing mainly on polar lows and marine cold air outbreaks. After that I was lucky enough to be part of a substantial Norwegian IPY research project entitled *IPY-THORPEX*, led by the late Jón Egill Kristjánsson. From 2011 to 2014, I worked for the commercial weather company StormGeo in Bergen, before I came back "home" to Uni Research Climate and the Bjerknes Centre for climate research. Apart from polar meteorology, one of my main research interests is seasonal forecasting. This started when I met Adam Scaife and we started discussing whether stratospheric sudden warmings (SSWs) could potentially influence cold air outbreaks over the Northeast Atlantic, which would then mean that they influenced the probability of polar lows. We wrote a paper about that in QJRMS in 2010. In the recently started European Commission project *Blue-Action*, I will pick this idea back up and study the predictability of cold air outbreaks (and indirectly of polar lows) on the seasonal time scale. In 2015, I also published the first paper in a series on month-to-month persistence and its physical pathways. Persistence is perhaps the most readily available source of predictability in the climate system, and is therefore a key predictor in empirical forecast models.

I have long experience in leadership, co-production and outreach. In 2010, I was recruited as the head of the research groups for regional climate modelling and climate services at Uni Research and the Bjerknes Centre. When at StormGeo, I had the responsibility for all operational forecasts and hindcasts. Currently, I co-lead the same research group at Uni Research Climate, where one of my main tasks is the nurture and establish new collaborations with researchers at other institutions, including from other disciplines. In this capacity, I will lead one of three focus areas (the one for transformation outcomes) in the newly established *Centre for Climate and Energy Transformation* at the University of Bergen. Inter-disciplinary research and climate service is my other main research interest. I lead the Research Council of Norway (RCN) funded *HordaKlim* project. This is a collaboration with Hordaland county, and the aim is to make future climate projections usable and relevant for users in municipalities and businesses in western Norway. User engagement, two-way communication and co-production are key words that describe this work. I'm also a work package leader in two other climate service projects, and I currently supervise one PhD student. In terms of outreach, I have written or contributed to four popular science books, and I frequently write opinion articles in Norwegian newspapers. I am also often interviewed for newspaper articles, or for radio and TV, and I have several active web pages and blogs about weather and climate.

## EDUCATION

| | |
|---|---|
| *2007* | Doctor of Philosphy (PhD): March 2007<br>Geophysical Institute, University of Bergen, Norway (GFI) |
| *1997* | Master of Science (MSc): March 1997<br>Dept. of Mathematics, University of Bergen, Norway |

## ACADEMIC CAREER

| | |
|---|---|
| *2015–* | Research Professor (*Forsker 1*) at Uni Research Climate, Bergen, Norway (UNI). Affiliated with the Bjerknes Centre for Climate Research (BCCR) |
| *2016–* | Co-leader of the research group for Regional Climate and Climate Services at UNI |
| *2014–2015* | Senior Researcher (*Forsker 2*), UNI & BCCR |
| *2011-2014* | Senior Research Scientist<br>StormGeo AS, Bergen, Norway |
| *2010* | Senior Researcher (*Forsker 2*) and leader of the research group for Global and Regional Climate Projections, UNI & BCCR |
| *2007–2010* | Postdoctoral Fellow, UNI & BCCR |
| *2003–2007* | PhD Fellow, GFI & BCCR |

## SUPERVISION

| | |
|---|---|
| *2015–* | PhD student Marie Pontoppidan (main supervisor), UNI & BCCR |
| *2007–2008* | MSc student Mathew Reeve (co-supervisor), GFI |
| *2008–2009* | MSc student Beathe Tveita (co-supervisor), GFI |
| *2008–2009* | MSc student Berit Hagen (co-supervisor), GFI |

## TEACHING

| | |
|---|---|
| *2016* | Lecture and practical on polar lows at the 2016 Polar Prediction School in Abisko, Sweden, organized by WWRP, WCRP, and the Bolin Center. I will also teach at the 2018 winter school |
| *2008* | Teaching position – GEOF120, *Introduction to Meteorology*, Geophysical Institute, University of Bergen |

## COMMISSIONS OF TRUST

| | |
|---|---|
| *2007–* | Article Reviewer for Journal of the Atmospheric Sciences, Quarterly Journal of the Royal Meteorological Society, Journal of Climate, Journal of Geophysical Research–Atmospheres, Monthly Weather Review, Climate Dynamics, Geophysical Research Letters, Tellus A, Atmospheric Science Letters, and Bulletin of the American Meteorological Society |
| *2010–* | Grant Reviewer, the US National Science Foundation |
| *2014–* | Associate Editor, the Quarterly Journal of the Royal Meteorological Society |
| *2015–2016* | Board member of the Norwegian Geophysical Union |
| *2017–* | Member of the steering committee of of SNAP - the Stratospheric Network for the Assessment of Predictability. SNAP is a SPARC (Stratosphere-troposphere Processes And their Role in Climate) network, and SPARC is a core project of the World Climate Research Programme (WCRP). |

## COLLABORATIONS

Thomas J. Bracegirdle, British Antarctic Survey, Cambridge, UK
Jón Egill Kristjánsson (deceased), Dept. of Geosciences, University of Oslo, Norway
Stefan P. Sobolowski, Uni Research Climate, Bergen, Norway
Adam A. Scaife, Met Office Hadley Centre, Exeter, UK

## CAREER BREAK

*2011–2014* I was working as a senior research scientist and developer at StormGeo, Bergen, Norway, where I was responsible for all operational weather forecasts and hindcasts.

## TRACK RECORD

Total number of peer-reviewed journal publications since 2006: **23**
Number of first author publications: **15**
Citation index: h-index **10** (Scopus), **11** (Google Scholar)
Number of citations: **341** (Scopus), **519** (Google Scholar)

### Ten most relevant publications from the last ten years

1. Kolstad, E. W. (2008): A QuikSCAT climatology of ocean surface winds in the Nordic Seas: identification of features and comparison with NCEP/NCAR reanalysis. *J. Geophys. Res. Atm.*, **113**, D11106
2. Kolstad, E. W. and T. J. Bracegirdle (2008): Marine cold-air outbreaks in the future: an assessment of IPCC AR4 model results for the Northern Hemisphere. *Clim. Dynam.*, **30**, 871–885
3. Føre, I., J. E. Kristjánsson, E. W. Kolstad, T. J. Bracegirdle, Ø. Sætra and B. Røsting (2011): A "hurricane-like" polar low fueled by sensible heat flux: high-resolution numerical simulations. *Quart. J. Roy. Meteorol. Soc.*, **138**, 1308–1324
4. Kristjánsson, J. E., I. Barstad, T. Aspelien, I. Føre, Ø. Godøy, Ø. Hov, E. Irvine, T. Iversen, E. W. Kolstad, T.E. Nordeng, H. McInnes, R. Randriamampianina, J. Reuder, Ø. Sætra, M. Shapiro, T. Spengler and H. Olafsson (2011): The Norwegian IPY-THORPEX: Polar Lows and Arctic Fronts during the 2008 Andøya campaign. *Bull. Am. Meteorol. Soc.*, **92**, 1443–1466
5. Kolstad, E. W. (2011): A global climatology of favourable conditions for polar lows. *Quart. J. Roy. Meteorol. Soc.*, **137**, 1749–1761
6. Kolstad, E. W. (2015): Extreme small-scale wind episodes over the Barents Sea — when, where and why? *Clim. Dynam.*, **45**, 2137–2150
7. Kolstad, E. W., T. J. Bracegirdle and M. Zahn (2016): Re-examining the roles of surface heat flux and latent heat release in a "hurricane-like" polar low over the Barents Sea, *J. Geophys. Res.*, **121**, 7853–7867
8. Pontoppidan, M., J. Reuder, S. Mayer and E. W. Kolstad (2017): Downscaling an intense precipitation event in complex terrain: The importance of high grid resolution. Tellus A, **69**
9. Kolstad, E. W. and T. J. Bracegirdle: Sensitivity of an Apparently Hurricane-like Polar Low to Sea Surface Temperature. *Quart. J. Roy. Meteorol. Soc.*, **143**, 966–973
10. Kolstad, E. W.: Higher ocean surface wind speeds during marine cold air outbreaks (2017). *Quart. J. Roy. Meteorol. Soc.*, **143**, 2084–2092

### Presentations

I usually give 20–30 presentations per year to a wide range of audiences, from scientific conferences to more popular science presentations at inter-disciplinary conferences. Here's a selection of ten presentations from the past ten years:

- *Polar lows and Arctic fronts: mesoscale weather systems at high latitudes*. EGU general assembly, Vienna, 2007 (invited)
- *Climate change: Impacts and adaptation. Strategies for developing a knowledge base from climate system studies*. SANORD meeting, Cape Town, 2007 (invited)
- *Results from the IPY-THORPEX field campaign in 2008*. SCAR/IPY open science conference in St Petersburg, 2008 (invited)
- *Extreme small-scale wind episodes over the Barents Sea — when, where and why?* EGU general assembly, Vienna, 2015
- *Stratospheric Pathways to Enhanced Persistence of European Surface Temperatures.* EGU general assembly, Vienna, 2015
- *Polar lows: Arctic hurricanes?* Abisko polar prediction winter school, 2016 (invited)

- *What do climate service users need? And what can they get?* Fourth Nordic Conference on Climate Change Adaptation, Bergen, Norway, 2016 (invited)
- *Climate change and consequences for water management.* VA-dagene på Innlandet, Hamar, Norway, 2016 (invited)
- *Floods in western Norway in the past, present and future.* Seminar organized by the *Norwegian Society for the Conservation of Nature*, Voss, Norway, 2017 (invited)

Public outreach (selected)

Author of 2 popular science books on weather and climate: *Uvær* (2009) & *Hva er klima* (2011, w/Øyvind Paasche) • Currently contributing two chapters to forthcoming textbook on geography, aimed at geography teachers from elementary to high school • Author of about 20 popular science op-ed pieces in Norwegian newspapers • Interviewed in about 60 newspaper articles in Norway • In the period from 2004 to 2008, I wrote blog posts about weather and climate for the newspaper Bergens Tidende and the public Norwegian broadcasting company (NRK) • Many appearences as climate and weather expert in Norwegian newspapers, radio (Verdt å vite, Kveldsåpent, Naturens Verden) and TV (Sveip, Newton, Schrödingers katt) • In 2009, I was asked to give a 30-minute lecture on the NRK radio programme P2-akademiet (published in print in 2010) • In 2009, highlighted on the front page of the International Polar Year (IPY) web site, leading to publication on Reuters and many web sites worldwide (Scientific American, USA Today etc.) • Author of a 2012 article about clouds in "Fjell og Vidde", the magazine of the Norwegian Trekking Organization (Den Norske Turistforening) • Reviewer for two popular science books: *Regnværsboka* by Dagny Holm and *Newton klimabok* by Unni Eikeseth • http://polarlows.wordpress.com/ (Blog about polar lows with Tom Bracegirdle) • https://facebook.com/bergensveret (Blog about the Bergen weather with Paul Skeie and Roar Inge Hansen) • Administrator of the Bjerknes Centre Facebook page (https://www.facebook.com/Bjerknessenteret)

Successful grant proposals

| | |
|---|---|
| *2007–2011* | *IPY-THORPEX*, 4-year postdoctoral scholarship and WP leader, project led by Jón Egill Kristjánsson, ~40 MNOK, Research Council of Norway (RCN) |
| *2015–2017* | *HordaKlim*, Principal Investigator, 6 MNOK, Regional Research Fund for Western Norway (RFF) grant 245403 |
| *2015–2018* | *R3 (Relevant, reliable and robust local-scale climate projections for Norway)*, WP leader, project led by Stefan Sobolowski, 10 MNOK, RCN grant 255397 |
| *2015–2017* | *SNOWGLACE*, Co-investigator, project led by Yvan Orsolini, 6 MNOK, RCN |
| *2016–2019* | *Blue-Action*, Co-investigator, project led by Steffen Olson, €8M, European Commission, grant 727852 |
| *2017–2020* | *HordaFlom*, Co-investigator, project led by Øyvind Paasche, 7 MNOK, RFF |
| *2017–2017* | *Seasonal Forecast Engine (SFE)*, Principal Investigator, 500 kNOK in Phase 1, 16 MNOK total (2017–2020) if approved for Phase 2, RCN, grant 270733 |
| *2018–2020* | *Climate hazards*, Principal Investigator, 8 MNOK. One of five Bjerknes Centre cross-cutting internal projects, funded by the Government of Norway |

Business experience

| | |
|---|---|
| *1999–2000* | Software Developer at CSC (then PMSC) |
| *2000–2003* | Software Developer at IceSoft |
| *2011–2014* | Senior Research Scientist and Developer at StormGeo |
| *2011–2014* | Multiple contract and tender awards at StormGeo, including hindcasts for wind energy potential assessments for Statoil, ScottishPower and Vattenfall, and operational wind and weather forecasts in Norway, China, Russia and the USA |
| *2013–* | Co-founder of Suncurves (http://www.suncurves.com/) |

# Curriculum Vitae

**Personal**

| | |
|---|---|
| Name: | Roger Randriamampianina |
| Date and place of birth: | 18 January, 1963, Ambatondrazaka, Madagascar |

**Research interests**

- Development of mesoscale numerical weather prediction models with special focus on data assimilation systems and use of different type of observations
- Observing system simulation experiments

**Present position**

| | |
|---|---|
| Since January, 2016: | *Project leader* for atmospheric data assimilation in HIRLAM consortium; |
| Since March, 2013: | *Researcher,* Numerical Weather Prediction Division, Research and Development, Norwegian Meteorological Institute; |

**Affiliation**

| | |
|---|---|
| Jan. 2011 – Mar. 2013: | *Division leader*, Hungarian Meteorological Service, Informatics and Methodology Department, Methodology Development Division; |
| Feb. 2011 – Mar. 2013: | Researcher, Numerical Weather Prediction Division, Research and Development, Norwegian Meteorological Institute (distant work, 20%); |
| April 2007 - Dec. 2010: | Senior researcher, Remote Sensing Section, Research and Development, Norwegian Meteorological Institute |
| June 2005 - April 2007: | Senior Researcher, Numerical Modelling and Climate-dynamic Division, Department for Weather Forecast and Climate, Hungarian Meteorological Service (OMSZ); |
| Jan. 2000 - June 2005: | Senior Researcher, Numerical Weather Prediction Division, Department for Research and Development, OMSZ; |
| Feb. 1994 - Dec. 1999: | Researcher, Satellite Research Laboratory, Department for Research and Development, OMSZ. |

**Education**

1995: *Ph.D. in Mathematics and Physics*, Russian State Hydrometeorological University, St. Petersburg, Russia (former Leningrad Hydrometeorological Institute); (naturalised by the Hungarian Academy of Sciences in 1997)

1991: *MSc in Meteorology*, Leningrad Hydrometeorological Institute, Leningrad, S.U.

1983-85: Student of the Faculty of Chemistry and Physics, Madagascar University of Sciences, Antananarivo

1982: High school graduation, Lycée of Maroantsetra, Madagascar

**Knowledge of languages:** Malagasy (native); French (Excellent); Russian (Excellent); Hungarian (Excellent); English (Good); Norwegian (Basic).

**Grants**

2004-2007: János Bolyai Individual Postdoctoral Research Grant of the Hungarian Academy of Sciences on "Assimilation of data measured by advanced satellite sensors in a limited area model", including research on assimilation of raw radiances in high resolution (1x1 FOV) and investigation of appropriate bias correction techniques for a limited area model.

**Trainings**

2002: International Post-Graduate Summer School on Data Assimilation, NATO ASI –Data assimilation for the Earth System. Sapri, Italy

2001: International Post-Graduate School on Cloud-Aerosol-Radiation Interactions. Toulon, France
2000: EUMETSAT-HMS Training Course on MSG, Budapest, Hungary
1994: International Post-Graduate School on Meteorology: 'Eta co-ordinate Regional Model with Step-like Mountain Representation and its Application in Weather Forecasting and Environmental Studies'. Backa Topola, Yugoslavia.

**Membership, scientific group**

Since 2006 – Member of the EUMETNET observation science expert team;
Since 2014 – Member of EUMETSAT's science advisory group for 2nd generation of satellite microwave sounders;

**Professional experience and selected research projects**

**2017:** CARRA – Copernicus Arctic Regional Reanalysis. *Role: Task leader for several of the satellite data assimilation tasks*

**2017:** PRECISE – Production of a regional Reanalysis for Europe within the Copernicus ClImate change Services. *Role: Participant*

**2017:** RadPrO – Radar for Improving Precipitation Estimates and Optimization of Hydropower Energy Production. *Role: manager*

**2015:** Internal project on operational implementation of the AROME-Arctic mesoscale model at MET Norway. *Role: manager*

**2015-2016:** Satellite Winds for Rapid-refresh weather prediction (SAWIRA) project financed by Norwegian Space Centre. *Role: manager*

**2013-2014:** PROMO project at MET, coordinating the operational implementation of the numerical (atmospheric and ocean) models at MET Norway. *Role: manager*

**From 2012: T**he EU-funded ACCESS project. *Role: participant*

1. Set up and access the forecasting capability of a mesoscale regional model over the Arctic region.
2. Identify key factors limiting the monitoring and forecasting capabilities, and give recommendations for key areas to improve the capabilities (ongoing work).

**2011- March 2013:** ALADIN Coordinator for Networking Activities (ACNA) in the ALADIN consortia

**From 2010:** Different projects (in Hungary and Norway) dealing with assimilation of radar data in mesoscale data assimilation systems. *Roles: manager/participant*

**2007-2010:** Participation in the Norwegian IPY-THORPEX. *Role: participant*

1. Implementation of the HARMONIE/Norway assimilation and forecast system.
2. Assimilation of IASI radiances in the HARMONIE model.

   *Outcomes:* Our script system served as basic for the HARMONIE mSMS system. We worked out a new concept for the ALADIN/HARMONIE observation pre-processing. We are delivering also monitoring and diagnostic (e.g. different ways of background errors estimation and LAM assimilation/forecast system sensitivity estimate – Storto and Randriamampianina, 2010a and 2010b, respectively) tools for the community.

**2005-2008:** Hungarian National Scientific Research Foundation (NSFR) project on "Utilisation of aircraft and remotely sensed observations in a mesoscale model". *Role: manager*

**2004-2006**: EUCOS project on "Space/ terrestrial link": Evaluating the impact of different terrestrial (conventional) observations on a mesoscale model. *Role: participant*

**2000-2006**: Participation in the international project ALADIN

1. Parameterisation of the radiation scheme in the ARPEGE/ALADIN model (including a 3-month work in Toulouse, GMAP, Météo France).
2. Implementation and assimilation of various observations (AMSU-A, Wind Profiler, AMDAR, Atmospheric Motion Vector and AMSU-B data) in the limited area model ALADIN.

   Main objectives: using all the available observations in as fine resolution as possible; special attention was paid on particularities of the limited area model.

*Outcomes:* The AMSU-A, AMSU-B/MHS, AMDAR, AMV, and Wind Profiler data are used

operationally at the Hungarian Meteorological Service (OMSZ).

**2000-2003**: NSFR project on "Determination of cloud base and cloud top heights using radar and satellite observation and their use in nowcasting of dangerous meteorological phenomena". *Role: manager*
*Outcomes*: The methods and routines, developed in the project are used operationally in the nowcasting system of OMSZ.

**2000-2003**: NSFR project on "Investigation of TOVS and ATOVS data for their operational utilization". *Role: participant*

**2001**: Regional use of locally received ATOVS radiances in NWP. (EUMETSAT SAF NWP visiting scientist, Météo France, Toulouse, 4 months): Comparison and quality control of the satellite radiances, produced by NESDIS and those pre-processed in Lannion. *Outcome:* A bit later, Météo France started to use also the locally pre-processed radiances from Lannion.

**1997-2000:** Participation in the international project ALADIN.
Tasks: Implementation of the 3D-VAR data assimilation system in the limited area model ALADIN (Including a 2 month stay in Toulouse, GMAP, Météo France in 1997).

## List of selected publications

**Refereed publications**

1. M Müller, M Homleid, K-I Ivarsson, M A Ø Køltzow, M Lindskog, K H Midtbø, U Andrae, T Aspelien, L Berggren, D Bjørge, P Dahlgren, J Kristiansen, ***R Randriamampianina***, M Ridal, AND O Vignes, 2017. AROME-MetCoOp: A Nordic Convective-Scale Operational Weather Prediction Model. Mon. Wea. Rev., **32**, 609–627. DOI: 10.1175/WAF-D-16-0099.1.
2. Szintai B, M Szűcs, ***R Randriamampianina,*** L Kullmann, 2015. Application of the AROME non-hydrostatic model at the Hungarian Meteorological Service: physical parameterizations and ensemble forecasting, *Időjárás, 119(2):241-265.*
3. Mile M, G Bölöni, ***R Randriamampianina***, L Kullmann, Roland Steib, I Sebők, E Kucukkaraca, 2015. Overview of mesoscale data assimilation developments at the Hungarian Meteorological Service, *Időjárás, 119(2):215-239.*

**Reports**

1. ***Randriamampianina, R***, T Aspenes, M Mile and H Schyberg, 2017: Impact of Atmospheric Motion Vectors (AMV) on rapid update cycling (RUC) and rapid-refresh (RR) systems. MET report N 04/2017, available on www.met.no.
2. ***Randriamampianina, R***, T Aspenes, M Mile and H Schyberg, 2016: Assessment and implementation of Atmospheric Motion Vectors (AMV) into the LAM models (AROME-MetCoOp and AROME-Arctic) at MET Norway. MET report N 02/2016, available on www.met.no.
3. Schyberg Harald, Thomas Nipen, Yurii Batrak, Mariken Homleid, and ***Roger Randriamampianina***, 2014, Monitoring and forecasting for a short time range in the Arctic, ACCESS project, WP1 task 1.8 report, 2-4 June 2014, Villefranche, France.
4. ***Randriamampianina R***, **M Mile and H Schyberg,** 2013, Assimilation and impact of IASI moisture channels, MET report N 20/2013, available on www.met.no.

**Conference proceedings**

1. ***Randriamampianina Roger,*** Harald Schyberg and Máté Mile, 2016. Towards operational use of satellite radiances in an Arctic mesoscale model. The 20th International TOVS Study Conference (ITSC-20), *Lake Geneva, Wisconsin, USA.Available from: https://cimss.ssec.wisc.edu/itwg/itsc/itsc20/program/PDFs/2Nov/session11b/11p_06_roger.pdf*
2. ***Randriamampianina Roger***, 2014, Non-conventional observations: Radiance assimilation, HARMONIE System Working Week (https://hirlam.org/trac/wiki/HarmonieSystemTraining2014), 24th - 28th of November 2014, SMHI, Norrköping, Sweden.
3. ***Randriamampianina Roger***, Patrik Benacek, Máté Mile, Magnus Lindskog, Sigurdur Thorsteinsson, 2014, Radiance data assimilation in HIRLAM and ALADIN consortia - Recent developments, ITSC-XIX (http://cimss.ssec.wisc.edu/twig/itsc/itsc19/), 26 March-1 April 2014, Jeju Island, South Korea.
4. ***Randriamampianina Roger***, Malte Müller, Máté Mile and Harald Schyberg, 2014, Progress in data assimilation and implementation of the AROME-Arctic, Joint 24th HIRLAM-ALADIN All Staff Meeting, 7-11 April 2014, Bucharest, Romania.

# Curriculum vitae with track record
# (for established researchers)

## ROLE IN PROJECT

Project manager ☐ Collaborator ☒

## PERSONAL INFORMATION

Family name, First name: Sodemann, Harald

Date of birth: *16.12.1975*

Sex: male

Nationality: German

Researcher unique identifier: ORCID 0000-0002-8167-0860
URL for personal web site: http://www.uib.no/persons/Harald.Sodemann

## EDUCATION

*2003-2006* PhD, Disputation date: *10.05.2006*
Institute for Atmosphere and Climate Science, ETH Zürich, Switzerland, supervised by Prof. Huw C. Davies and Prof. H. Wernli

*1996-2002* Diplom (Master) in Geoecology
Faculty for Geosciences, University of Bayreuth, Germany

*2000* BSc Honors in Atmospheric Sciences
University of Cape Town, South Africa

## CURRENT AND PREVIOUS POSITIONS

*since 2016* Professor in Meteorology, Geophysical Insitute, University of Bergen, Norway

*2014-2016* Førsteamanuensis (Associate Professor) in Meteorology
Geophysical Institute, University of Bergen, Norway

*2010-2014* Oberassistent (Senior Scientist) and Lecturer
Institute for Atmospheric and Climate Science, ETH Zürich, Switzerland

2007-2010 Postdoctoral researcher
Department for Atmospheric and Climate Research, NILU, Norway

2008-2009 1-year visiting postdoctoral fellow
Division of Geological and Planetary Sciences, CalTech, USA

2006-2007 Postdoctoral researcher
Institute for Atmospheric and Climate Science, ETH Zürich, Switzerland

2003-2006 Research assistent
Institute for Atmospheric and Climate Science, ETH Zürich, Switzerland

## PRIZES AND AWARDS

*2009* NASA Group Achievement Award for outstanding accomplishments in ARCTAS

*2007* Medal of the ETH Zürich for PhD Thesis, 2 kEUR

*2000* 1-year stipend from German Academic Exchange Service to study in Cape Town, SA

## RESEARCH GRANTS

*2017-2021* NRF grant "SNOWPACE (Sources of the Norwegian Winter season snow pack constrained by stable water isotopes)", PI, 1M EUR

*2017-2022* EU-Project Integrated Arctic Observation System (INTAROS), co-I, 15.5M EUR (UiB 1.2M EUR)

*2017-2021* Differential Absorption lidar for monitoring water vapor and isotope HDO in the lower troposphere: the Water Vapor and Isotope Lidar (WaVIL), Agence Nationale de la Recherce project, International partner.

*2016-2017* Antartic Circumnavigation Expedition proposal „Investigation of air-sea interaction in the Southern Ocean from stable water isotope measurements“, co-PI, 100 kEUR

*2015-2018* Norwegian Research Foundation National Infrastructure establishment grant “FARLAB (Facility for advanced isotopic research and monitoring of weather, climate, and biogeochemical cycling)“, co-Manager, 2M EUR

*2015-2019* Atmospheric circulation and Arctic hydrological cycle changes, Agence Nationale de la Recherce project, International partner.

*2013-2016* Swiss National Science Foundation Research Grant "Waterscales", PI, 132 kEUR

*2011* EUFAR Transnational Access project "LADUNEX", PI, 100 kEUR

**SUPERVISION OF GRADUATE STUDENTS AND RESEARCH FELLOWS**

*since 2014* Supervision and Co-Supervision of 3 PhD and 1 Master students
Geophysical Institute, University of Bergen, Norway

*2010-2016* Supervision and Co-Supervision of 7 PhD and 3 Master students
Institute for Atmospheric and Climate Science, ETH Zurich, Switzerland

*2007-2010* Co-Supervision of 1 PhD student
Institute for Atmospheric and Climate Science, ETH Zurich, Switzerland

**TEACHING ACTIVITIES**

*since 2014* Lecture courses “Atmosphere and Ocean Physics”, “Numerical Weather Prediction”, “Practical Meteorology and Oceanography”, "Seminar in Atmospheric Sciencies", University of Bergen, Norway

*2012-2014* Lecture courses “Mesoscale Atmospheric Systems” and “Practical Field Work”, ETH Zurich, Switzerland

**ORGANISATION OF SCIENTIFIC MEETINGS**

*2018* Convener for session “Atmospheric water cycle”, EGU Conference, Austria

*2016* Member of Organizing Committee, Leonardo conference, Ourense, Spain

*2016* Session convener at the Atmospheric Rivers conference, La Jolla, USA

*since 2013* Co-Convener for session “Atmospheric Transport”, EGU Conference, Austria

**INSTITUTIONAL RESPONSIBILITIES**

*since 2017* Member of the institute board, Geophysical Institute, University of Bergen

*since 2015* Member of study program committee, Geophysical Institute, University of Bergen, Norway

**COMMISSIONS OF TRUST**

*since 2015* Internal examiner for 3 PhD and 4 Masters examinations at UiB

*2016* External examiner in the PhD jury of C Woods, Stockholm University, Sweden

*2015* External examiner in the PhD jury of J.-L. Bonne, University of Versailles, France

*since 2004* Reviewer for in total 73 manuscripts submitted to Science, Geophysical Research Letters, Journal of Geophysical Research, Quarterly Journal of the Royal

Meteorological Society, Atmospheric Chemistry and Physics, Tellus A, Tellus B, Journal of Hydrometeorology, EOS, Atmospheric Environment, Climate of the Past, Climate Dynamics, Journal of Glaciology, Advances in Science and Research, Atmospheric Research, Geochimica et Cosmochimica Acta, Atmospheric Measurement Techniques, Hydrological Sciences Journal, Acta Meteorologica Sinica;, Quarternary Science Reviews, Journal of Atmospheric Sciences;

*since 2004* Reviewer for in total 13 research grant proposals submitted to NERC (UK), NSF (USA), CFCAS (Canada), IPEV (France), NWO (The Netherlands), Rannis (Iceland), ETH Grants (Switzerland), Belmont Forum (USA), Cineca (Italy), DLR/ BMBF (Germany), DFG (Germany).

**MEMBERSHIPS OF SCIENTIFIC SOCIETIES**

*since 2015* Member of the Research Network "Stable isotope observations in the Arctic"
*since 2007* Member of the FLEXPART model developer team
*since 2005* Member of the Deutsche Meteorologische Gesellschaft
*since 2002* Member of the European Geophysical Union

**MAJOR COLLABORATIONS**

Valerie Masson-Delmotte, LSCE, France: Stable water isotope measurements in Svalbard.
Andreas Stohl, NILU, Norway: Moisture sources of atmospheric rivers, FLEXPART Lagrangian transport model development.
Heini Wernli and Stephan Pfahl, ETH Zürich, Switzerland: Below-cloud stable water isotope. processes, deuterium excess and high-resolution precipitation sampling.
Jean-Louis Bonne and Martin Werner, AWI Bremerhaven, Germany: Stable water isotope measurements on R/V Polarstern and stations in Russia.
Richard Moore, Meteorological Institute, Norway: Moisture transport during atmospheric rivers.
Jana Sillmann, CICERO, Norway: Objective analysis of atmospheric rivers.
Hans Schlager, DLR Oberpfaffenhofen, Germany: Tracer release experiments from aircraft

**Track record**

**PUBLICATIONS IN PEER-REVIEWED JOURNALS**

I have published 51 papers in international peer-reviewed journals. My publications have been cited 1628 times (without self-citations, according to Web of Science, Thompson Reuters as of Sep 2017), and my h-index is 25. I list my 10 most important scientific publications chronologically:

1) Sodemann, H., et al., 2017: The stable isotopic composition of water vapour above Corsica during the HyMeX SOP1 campaign: insight into vertical mixing processes from lower-tropospheric survey flights, *Atmos. Chem. Phys.*, 17: 6125-6151. ***Citations: 0***
2) Läderach, A. and Sodemann, H., 2016: A revised picture of the atmospheric moisture residence time, Geophys. Res. Lett., 43. ***Citations: 5***
3) Luetscher, M., Boch, R., Sodemann, H., Spoetl, C., Cheng, H., Edwards, R. L., Frisia, S., Hof, F., Mueller, W., 2015: North Atlantic storm track changes during the Last Glacial Maximum recorded by Alpine speleothems, Nature Comm. 6: 6344. ***Citations: 20***
4) Pfahl, S. and H. Sodemann, 2014. What controls deuterium excess in global precipitation? *Clim. Past* 10**,** 771-781. ***Citations: 45***

5) Kennett, D. J., Breitenbach, S. F. M., Aquino, V. V., Asmerom, Y., Awe, J., Baldini, J. U. L., Bartlein, P., Culleton, B. J., Ebert, C., Jazwa, C., Macri, M. J., Marwan, N., Polyak, V., Prufer, K. M., Ridley, H. E., Sodemann, H., Winterhalder, B. and Haug, G. H., 2012: Development and Disintegration of Maya Political Systems in Response to Climate Change. Science, 338: 788-791. ***Citations: 141***
6) Sodemann, H. and Stohl, A., 2013: Moisture origin and meridional transport in atmospheric rivers, and their association with multiple cyclones. Mon. Wea. Rev., 141: 2850-2868. ***Citations: 42***
7) Meckler, A. N., Clarkson, M. O., Cobb, K. M., Sodemann, H., and Adkins, J. F., 2012: Interglacial hydroclimate in the Tropical West Pacific through the Late Pleistocene. Science, 336: 1301-1304. ***Citations: 30***
8) Sodemann, H. and Zubler, E., 2010: Seasonality and inter-annual variability of the moisture sources for Alpine precipitation during 1995-2002, Int. J. Climatol., 30: 947-961. ***Citations: 52***
9) Sodemann, H., and Stohl, A., 2009: Asymmetries in the moisture origin of Antarctic precipitation, Geophys. Res. Lett., 36, L22803. ***Citations: 51***
10) Sodemann, H., Schwierz, C., and Wernli, H., 2008: Inter-annual variability of Greenland winter precipitation sources. Lagrangian moisture diagnostic and North Atlantic Oscillation influence, J. Geophys. Res., 113, D03107. ***Citations: 104***

**RESEARCH MONOGRAPHS AND ANY TRANSLATIONS THEREOF**

1) Sodemann, H., 2006: *Tropospheric transport of water vapour: Lagrangian and Eulerian perspectives*, PhD Thesis, Diss. No. 16623, ETH Zürich. Logos Verlag, Berlin, ISBN 3-8325-1384-1, 230 pp.

I currently work on a book project on "Atmospheric Rivers", edited by Mary Ralph and Michael Dettinger, UCSD, USA as section editor and chapter lead author. Publication expected 2017.

**INVITED PRESENTATIONS TO PEER-REVIEWED, INTERNATIONALLY ESTABLISHED CONFERENCES**

*2014* Invited speaker to AGU Fall Meeting, San Francisco, USA (declined)
*2011* AGU Chapman Conference on Lagrangian Modeling, Grindelwald, Switzerland

I have in addition given 10 invited seminar presentations at various institutes in Europe and the United States, and numerous regular conference and workshop presentations since 2003.

**RESEARCH EXPEDITIONS THAT THE APPLICANT PI HAS LED**

*2016* co-PI of the EUFAR TA project "NEAREX" as part of the international NAWDEX-EPATAN field campaing in Iceland, ca. 100kEUR.
*2012* co-PI of the ETH HyMeX airborne stable isotope measurement campaign in Solenzara, Corsica, France, as part of the KIT HyMeX deployment
*2012* co-PI of the ETH and DLR airborne tracer release and sampling experiment campagin in Oberpfaffenhofen, Germany
*2011* EUFAR Transnational Access project "LADUNEX" as part of the international Fennec field campaign in the Western Sahara region, PI, 100 kEUR

**ORGANISATION OF INTERNATIONAL CONFERENCES IN THE FIELD OF THE APPLICANT (MEMBERSHIP IN THE STEERING/ORGANISING COMMITTEE)**

*2016* Member of Organizing Committee, Leonardo conference, Ourense, Spain
*2016* Session convener at the Atmospheric Rivers conference, La Jolla, USA

Teresa Maaria Valkonen
Kokkerudåsen 14
1363 Høvik NORWAY

04 September 2017

**PERSONAL DETAILS**

| | |
|---|---|
| Date of birth | 1980-08-18 |
| Gender | Woman |
| Citizenship | Finland |
| E-mail | teresav@met.no |
| Phone work | +47 948 61 869 |
| Phone private | +47 984 36 207 |

**EDUCATION**

*2006-08 - 2013-09* University of Helsinki, Finland - Doctor of Philosophy (Science)

A doctoral dissertation in Meteorology: *Surface Influence on the Marine and Coastal Antarctic Atmosphere*. Supervisors Prof. Timo Vihma and Prof. Hannu Savijärvi

*2000-08 - 2006-06* University of Helsinki, Finland - Master of Science Meteorology

Major subject: Meteorology, Minor subject: Geophysics, Physics and Theoretical physics. A master's thesis in Meteorology: *Atmospheric boundary layer over fractured sea ice on the Weddell Sea*.

**WORK EXPERIENCE**

*2017-02 - present* Norwegian Meteorological Institute, Development Centre for Weather Forecasting, Oslo (Norway) - Scientist

*2013-05 - 2017-01* Norwegian Meteorological Institute, Development Centre for Weather Forecasting, Oslo (Norway) - Scientist (EUMETSAT fellow) (80%)

EUMETSAT funded fellowship for application of scatterometer wind data in forecasting of rapidly developing storms

*2013-01 - 2013-04* Finnish Meteorological Institute, Numerical Weather Prediction, Helsinki (Finland) - Scientist

Research in two Finnish Academy projects: *Changing Arctic Climate System: Interaction of Stratosphere, Troposphere, and Sea Ice (CACSI)*, and *Antarctic Meteorology and its Interactions with the Cryosphere and the Ocean (AMICO)*.

**LANGUAGES**

| | |
|---|---|
| *Finnish* | Verbal skills: Native language, Written skills: Native language |
| *English* | Verbal skills: Fluent, Written skills: Fluent |
| *Norwegian* | Verbal skills: Good knowledge, Written skills: Good knowledge |

## PUBLICATIONS

### Peer reviewed scientific articles

Valkonen, T., Schyberg, H., and Figa-Saldana, J. (2017) Assimilating Advanced Scatterometer winds in a high-resolution limited area model over Northern Europe. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, vol. 10, no. 5, pp. 2394-2405, May 2017. doi: 10.1109/JSTARS.2016.2602889

Valkonen, T., Vihma, T., Johansson, M. M. and Launiainen, J. (2014) Atmosphere–sea ice interaction in early summer in the Antarctic: evaluation and challenges of a regional atmospheric model. Q.J.R. Meteorol. Soc., 140:1536–1551. doi:10.1002/qj.2237

Nygård, T., Valkonen, T., and Vihma, T. (2014) Characteristics of Arctic low-tropospheric humidity inversions based on radio soundings, Atmos. Chem. Phys., 14, 1959-1971, doi:10.5194/acp-14-1959-2014.

Nygård, T., Valkonen, T., and Vihma, T. (2013) Antarctic Low-Tropospheric Humidity Inversions: 10-year Climatology. J. Climate, 26, 5205–5219. doi:http://dx.doi.org/10.1175/JCLI-D-12-00446.1

Valkonen, T., Vihma, T., Kirkwood, S., and Johansson, M. M. (2010) Fine-scale model simulation of gravity waves generated by Basen nunatak in Antarctica. Tellus, 62A, 319–332.

Valkonen, T., Vihma, T., and Doble, M. (2008) Mesoscale modelling of the atmospheric boundary layer over the Antarctic sea ice: a late autumn case study. Mon. Wea. Rev., 136, 1457–1474.

### Non-refereed scientific articles

Valkonen, T., and Schyberg, H. (2017) ASCAT winds in the Arctic weather prediction system at MET Norway. EUMETSAT Fellowship Programme: Third year report. Norwegian Meteorological Institute

Valkonen, T., and Schyberg, H. (2015) The impact of ASCAT winds in storm cases using the HARMONIE model system. EUMETSAT Fellowship Programme: First year report. MET report 2/2015, ISSN 2387-4201, Norwegian Meteorological Institute

Valkonen, T. (2014) Impact studies of ASCAT wind assimilation in storm cases using the HARMONIE NWP system. Proceedings of the IWW12 Twelfth International Winds Workshop, 16-20 June 2014, Copenhagen, Denmark

Valkonen, T. (2014) Experiences with scatterometer assimilation in HARMONIE in a severe storm case. ALADIN-HIRLAM Newsletter no. 3, 2014. Presented at the 24th ALADIN workshop & HIRLAM All Staff Meeting, 7-11 April 2014, Bucharest, Romania

# INGER-LISE FROGNER

Date of revision 17.08.2017


## Name: Inger-Lise Frogner

**Born**: 01.01.1971
**Nationality:** Norwegian
**E-mail**: i.l.frogner@met.no
**Present position:** *** HIRLAM-C Project leader for probabilistic forecasting**
*** Senior Scientist, Norwegian Meteorological Institute**


## Academic degrees:

2001 **PhD** in Dynamic Meteorology, University of Oslo, Norway

1995 **M.Sc.,** same field and place

## Work experience:

2016 – **HIRLAM-C Project leader for probabilistic forecasting**
- Leading the development of probabilistic forecasting and EPS systems in HIRLAM-C program, a cooperation consisting of 10 European countries

2012 – 2015 **HIRLAM-B Project leader for probabilistic forecasting**
- Leading the development of probabilistic forecasting and EPS systems in HIRLAM-B program

2001 – **Researcher, Norwegian Meteorological Institute**
- High-resolution EPS with the Harmonie system (HarmonEPS, MEPS)
- Development of EuroTEPS – Targeted ensemble prediction system for Europe, part of the GLAMEPS-project
- Predictability and ensemble forecasting with the HIRLAM model, focusing on extreme weather events. LAMEPS.
- Developed MET Norway's EPS system NORLAMEPS
- Estimating optimal forcing perturbations as a mean to interpret non-linear climate scenarios.

1997 – 1998 **Consultant, ECMWF**, Reading, UK. (6 months stay, part of PhD)
- Targeted ensembles of the ECMWF model. TEPS.

1996 – 2001 **Research Fellow, Dep. of Geophysics, University of Oslo**.
- Studying atmospheric weather predictability for a sub-domain of the Northern Hemisphere using lagged averaged forecasts (LAF), targeted ensembles of a global model and by running ensembles with a limited area model (HIRLAM).

1995 – 1996 **Weather Forecaster**, **Norwegian Meteorological Inst.**,
Allied Command PSC North, Stavanger, Norway.
- Weather forecasting, including special training in weather forecasting for civil and military purposes.

# Fields of interest:

- Probabilistic forecasting and systems
- Atmospheric predictability and sensitivity
- Developing systems for predicting extreme/rare weather events.
- Probabilistic verification.

# Supervisory activities:

- Torge Lorenz, University of Bergen, PhD 5 May 2017. Dynamical downscaling of North sea winds: Reanalysis and ensemble predictions

# Professional Activities and Responsibilities

- Member of ECMWF Scientific Advisory Committee (SAC)
- Member of SRNWP Expert Team for Predictability and EPS
- Hirlam's project leader in the FROST project (Sochi winter Olympic Games 2014)
- Norwegian HIRLAM core-person (2007 - 2011)
- Member of TIGGE-LAM, European panel (2010-)
- Member of Norwegian Geophysical Society (NGF).
- Member of European Geosciences Union (EGU)
- Employee representative (union for researchers, 2003-2006)

# List of Publications

## Peer-Reviewed Publications


Kiktev, D., Joe, P., Isaac, G.A., Montani, A., Frogner, I.-L., Nurmi, P., Bica, B., Milbrandt, J., Tsyrulnikov, M., Astakhova, E., Bundel, A., Bélair, S., Pyle, M., Muravyev, A., Rivin, G., Rozinkina, I., Paccagnella, T., Wang, Y., Reid, J., Nipen, T., Ahn, K.-D. 2016. FROST-2014: the Sochi Winter Olympics International Project, *BAMS*, Early Online Release, DOI:10.1175/BAMS-D-15-00307.1

Frogner, I.-L., Nipen, T., Singleton, A., Bremnes J.B. And Vignes, O., 2016, Ensemble Prediction with Different Spatial Resolutions for the 2014 Sochi Winter Olympic Games: The Effects of Calibration and Multimodel Approaches. *Weather and Forecasting, **31**, 1833–1851, DOI:* 10.1175/WAF-D-16-0048.1

Frogner, I.-L. and Iversen, T., 2011, EuroTEPS - A targeted version of ECMWF EPS for the European area. *Tellus* **63A**, 415-428, DOI: 10.1111/j.1600-0870.2010.00504.x

Aspelien, T., Iversen, T., Bremnes, J. B. and Frogner, I.-L., 2011, Short-range probabilistic forecasts from the Norwegian limited-area EPS: long-term validation and a polar low study. *Tellus*, **63A**: 564–584. doi: 10.1111/j.1600-0870.2010.00502.x

Iversen, T., Deckmyn, A., Santos, C, Sattler, K., Bremnes, J. B., Feddersen, H and Frogner, I.-L. 2011 Evaluation of "GLAMEPS" - a proposed multi-model EPS for short range forecasting *Tellus* **63A**: 513-530. DOI: 10.1111/j.1600-0870.2010.00507.x

Frogner, I.-L, H. Haakenstad, and T. Iversen, 2006: Limited-area ensemble predictions at the Norwegian Meteorological Institute. *Q.J.R. Meteorol.Soc.*, **132**, 2785-2808. doi:10.1256/qj.04.178

Frogner, I.-L. and Iversen, T. 2002, High resolution limited area ensemble prediction based on low resolution targeted singular vectors, *Q.J. Roy. Meteor. Soc*, **128**, 1321-1341.

Frogner, I.-L. and Iversen, T. 2001, Targeted ensemble prediction for Northern Europe and parts of the North Atlantic Ocean, *Tellus*, **53A**, 35-55.

## Dissertations

Numerical ensemble prediction systems for northern Europe and parts of the north Atlantic Ocean (2001), Thesis for the doctorate, Faculty of Mathematics and Natural Sciences, University of Oslo, No. 130.

**Andrew Singleton**
Norwegian Meteorological Institute
Numerical Weather Prediction Division
Postboks 43 Blindern
0313 OSLO
Norway
andrewts@met.no

## EDUCATION

| | | |
|---|---|---|
| PhD Meteorology | *University of Cape Town, South Africa* | Awarded: Jun 2005 |
| MSc Atmospheric Sciences | *University of East Anglia, UK* | Awarded: Aug 1999 |
| BEng(Hons) Automotive Engineering | *Loughborough University, UK* | Awarded: Jul 1997 |

## RESEARCH EXPERIENCE

### Norwegian Meteorological Institute, Oslo, Norway — Mar 2013 - present

*EPS Scientist, Numerical Weather Prediction Division*

- Research into perturbing land surface to model uncertainty in the Harmonie EPS.
- Development of HARP – software for computation and visualisation of EPS verification.
- Research into neighbourhood methods for probabilistic precipitation forecasts.

### European Commission Joint Research Centre, Ispra, Italy — June 2010 – Feb 2013

*Post-Doctorate Grantholder, DESERT Action*

- Research into predicting meteorological drought using ECMWF ensemble forecasts.
- Software development for operational monitoring of meteorological drought.
- Research into statistical properties of rainfall.

### Imperial College London, United Kingdom — Jan 2008 – June 2010

*Post-Doctoral Research Assistant, Department of Physics*

- Development of a coupled atmosphere-ocean model for the Caspian Sea.
- Modelling of temperature dependence of rainfall extremes.
- User support for WRF atmospheric model.
- Dynamical downscaling of winds for meteorite trajectory modelling.

### Met Office, Wallingford, United Kingdom — Jan 2005 – Jan 2008

*Scientific Officer, Joint Centre for Hydro-Meteorological Research*

- Development of probabilistic forecast products for application in flood forecasting and warning.
- Verification of very short range probabilistic rainfall forecasts.
- Development of algorithm to model convective uncertainty in a stochastic nowcast model.

**University of Cape Town, South Africa** **Dec 2000 – Dec 2004**

*PhD, Department of Environmental and Geographical Science / Department of Oceanography*
**Thesis Title:** Cut-off low pressure systems and extreme rainfall in South Africa.

- Numerical modelling of extreme rainfall events related to cut-off low pressure systems.
- Numerical modelling of the sensitivity of extreme rainfall to sea surface temperature and topography.
- Research into the characteristics of cut-off low pressure systems using reanalysis data.

## IT AND PROGRAMMING SKILLS

- *Operating systems*: UNIX/LINUX, Windows, Mac OSX.
- *Programming*: FORTRAN, R, IDL, Matlab, Shell script, basic HTML, basic C++.
- *Meteorological models*: HARMONIE-AROME, WRF, MM5.
- *Ocean models*: ROMS.
- *Graphics packages*: NCL, IDV, GrADS.
- *Data Formats*: NetCDF, GRIB, BUFR, Met Office PP.
- *Others*: Microsoft Office (Word, Excel, PowerPoint), SQL.

## COMPLETED PROFESSIONAL TRAINING COURSES

- Harmonie System Training, *SMHI, Norrköping, Sweden.* 2014
- Nordic Surfex Course, *SMHI, Norrköping, Sweden*. 2013
- Data Assimilation Course, *ECMWF, Reading, UK.* 2013
- ECMWF Computing Resources. *ECMWF, Reading, UK.* 2011
- WRF, WRF-Data Assimilation, Model Evaluation Toolkit. *NCAR, Boulder, CO, USA.* 2009
- PRINCE2 Project Management. *Met Office, Exeter, UK.* 2006
- Intermediate FORTRAN. *Met Office, Exeter, UK.* 2005

## PUBLICATIONS (present – 2012)

### *Peer Reviewed*

Russo, S., A. Dosio, R. G. Graversen, J. Sillmann, H. Carrao, M. B. Dunbar, A. Singleton, P. Montagna, P. Barbosa, and J. V. Vogt, 2014: Magnitude of extreme heat waves in present climate and their projection in a warming world. *Journal of Geophysical Research: Atmospheres*, **119**, doi: 10.1002/2014jd022098

Carrão, H., A. Singleton, G. Naumann, P. Barbosa, and J. V. Vogt, 2014: An Optimized System for the Classification of Meteorological Drought Intensity with Applications in Drought Frequency Analysis. *Journal of Applied Meteorology and Climatology*, **53**, 1943–1960, doi:10.1175/jamc-d-13-0167.1.

Singleton, A., and R. Toumi, 2012: Super-Clausius-Clapeyron scaling of rainfall in a model squall line. *Quarterly Journal of the Royal Meteorological Society*, **139**, 334–339, doi:10.1002/qj.1919.

Naumann, G., P. Barbosa, H. Carrao, A. Singleton, and J. Vogt, 2012: Monitoring Drought Conditions and Their Uncertainties in Africa Using TRMM Data. *Journal of Applied Meteorology and Climatology*, **51**, 1867–1874, doi:10.1175/jamc-d-12-0113.1.

Sepulcre-Canto, G., S. Horion, A. Singleton, H. Carrao, and J. Vogt, 2012: Development of a Combined Drought Indicator to detect agricultural drought in Europe. *Natural Hazards and Earth System Science*, **12**, 3519–3531, doi:10.5194/nhess-12-3519-2012.

### *Technical Reports*

Singleton, A., 2012: Forecasting Drought in Europe with the Standardized Precipitation Index. An assessment of the performance of the European Centre for Medium Range Weather Forecasts Variable Resolution Ensemble Prediction System. EUR 25254 EN. Luxembourg (Luxembourg): Publications Office of the European Union, JRC688839, doi: 10.2788/16459.

Horion, S., H. Carrão, A. Singleton, P. Barbosa, and J. Vogt , 2012: JRC experience on the development of Drought Information Systems. Europe, Africa and Latin America. EUR 25235 EN. Luxembourg (Luxembourg): Publications Office of the European Union, JRC68769, doi: 10.2788/15761.

### *Relevant International conference presentations*

Singleton, A., I.L. Frogner, O. Vignes, 2014: Surface perturbations in HarmonEPS. *World Weather Open Science Conference, Montreal, Canada,* 16-21 August 2014. Poster presentation.

Singleton, A.T., C.E. Pierce, D. Whitfield, 2007: Use of probabilistic rainfall forecasts for fluvial flood forecasting and warning. *7th EMS Annual Meeting / 8th European Conference on Applications of Meteorology,* San Lorenzo de El Escorial, Spain. 1-5 October 2007. Poster presentation.

Singleton, A.T., 2006: Modelling convective precipitation unresolved by NWP using an ensemble based approach within STEPS. *2nd International Symposium on Quantitative Precipitation Forecasting and Hydrology,* Boulder, USA. 4-8 June 2006. Poster presentation.

## Curriculum vitae with track record

**ROLE IN PROJECT**
Project manager ☐ Collaborator ☒

**PERSONAL INFORMATION**

*Family name, First name: **Esau, Igor**

*Date of birth: **15.10.1969**

*Sex: **M**

*Nationality: **Russian**

Researcher unique identifier(s): 0000-0003-4122-6340 (ORCID); C-6298-2008 (ResearcherID)

URL for personal web site: https://www.nersc.no/staff/igor-ezau , https://www.researchgate.net/profile/Igor_Esau , https://scholar.google.no/citations?user=HAue2YoAAAAJ&hl=en

***EDUCATION**

| | |
|---|---|
| *2003* | PhD: **Disputation date:** *27.03.2003.* Department of Geosciences, Uppsala University, Sweden |
| *1996* | PhD: **Disputation date:** *29.12.1996.* Institute for Numerical Mathematics, Russian Academy of Science, Russia |
| *1992* | Diploma with honour degree; Chair of Meteorology and Climatology, Tomsk State University, Russia |

***CURRENT AND PREVIOUS POSITIONS**

| | |
|---|---|
| *Since 2016* | Adjunct Professor at Geophysical Institute of University in Bergen, Norway |
| *Since 2009* | Research Director at Nansen Environmental and Remote Sensing Centre, Norway |
| *2003-2009* | Researcher at Nansen Environmental and Remote Sensing Centre, Norway |
| *1997-1999* | Post-doctoral Researcher at Institute for Numerical Mathematics, Russian Academy of Science, Moscow, Russia |
| *1992-1993* | Engineer at Regional Agency for Environmental Monitoring, Omsk, Russia |

**MOBILITY** (*research stays abroad lasting more than three months*) **(if applicable)**

| | |
|---|---|
| *2015* | (6 months) Internship at the Norwegian Research Council Office with European Commission, Brussels, Belgium |
| *2002* | (4 months) Scholarship in the European training programme for high-performance computing infrastructure (TRACS), University of Edinburgh, Scotland |
| *2000* | (4 months) Scholarship in the Burgers centrum, Delft Tech. University, the Netherlands |

**SUPERVISION OF GRADUATE STUDENTS AND RESEARCH FELLOWS (if applicable)**

| | |
|---|---|
| *2004-2015* | Postdocs (3): Richard Davy (received outstanding young scientist award of EGU in 2015); Stephen Outten; Yiwen Xu<br>PhD students (5): Tobias Wolf-Grosse (defended the thesis in 2016, UiB); Svetlana Sorokina (defended the thesis in 2015, UiB); Mikhail Varentsov (defended the thesis in 2017, Moscow State Univ.); Omar El Guernaoui (UiB); Marwan Khalil (EU Marie Curie Studentship). |

**TEACHING ACTIVITIES**

| | |
|---|---|
| *Since 2016* | Lecturer in Energy Meteorology, Geophysical Institute, University in Bergen |

**ORGANISATION OF SCIENTIFIC MEETINGS (if applicable)**

*2016* 2nd Pan-Eurasian Experiment Conference, Member of organising committee, China
*2015* Workshop "Climatology of High Latitudes", Organizer, Norway
*2014* Conference "Atmosphere-hydrosphere interaction in the Baltic Basin and Arctic Seas", Member of organising committee, Russia
*2013* Workshop "Studies of nature and climate of Spitzbergen", Member of organising committee, Russia
*2012-2014* Responsible guest editor of the special issues in *Advances in Meteorology* and *Nonlinear Processes in Geophysics*.

**INSTITUTIONAL RESPONSIBILITIES (if applicable)**

*Since 2009* Research Director at Nansen Environmental and Remote Sensing Centre, Norway
*Since 2012* Representative (Fagutvalg) in the Bjerknes Centre for Climate Research, Norway
*Since 2009* Representative in the Norwegian School for Climate Dynamics, Norway

**COMMISSIONS OF TRUST (if applicable)**

*2015* Referee for the Finnish Academy of Science
*2014* Referee for the European Science Foundation (AXA scheme)
*2014* Referee for the NWO division Earth and Life Sciences (the Netherlands)
*2013-on* Referee for the European Research Council
*2013-2015* Referee for the Croatian Ministry of Science, Education & Sports (NEWFELPRO)
*2005-2013* Referee for the Estonian National Research Agency
*2012-2013* Referee for the KAUST agency (Saudi Arabia)
*2015-on* Referee for the National Science Funding Agency (Russia)
*2017-on* Referee for the EU Joint Programming Initiative – Climate
*Since 2015* Member of the editorial board in "*Advances in Meteorology*" journal
*Since 2003* Regular reviewer for a number of disciplinary journals (5-10 papers per year), including QJRMS, JGR (Atmosphere), Boundary Layer Meteorology, JAS etc.

**MEMBERSHIPS OF SCIENTIFIC SOCIETIES (if applicable)**

*Since 2000* Member of the European Geophysical Union
*Since 2000* Member of the American Geophysical Union
*Since 2012* Valid Member of the International Eurasian Academy of Science

**MAJOR COLLABORATIONS (if applicable)**

The Pan-Eurasian Experiment (PEEX; https://www.atm.helsinki.fi/peex/), Climate and environment of the high latitudes, International
Prof. Siegfried Raasch, Large-eddy simulations, Leibniz University in Hannover, Germany
Prof. Sergej Zilitinkevich, Boundary layer and turbulence theory, University of Helsinki, Finland
Prof. Peter Thorne, Environmental data analysis, Maynooth University, Ireland
Prof. Vladimir Alexeev, Polar climate & environment, Int. Arctic Research Centre, Alaska, USA

**CAREER BREAKS (not applicable)**

**Track record**

**The total number of peer-review publications up till May 2017 is 82.**
**Total number of citations** (ISI Web of knowledge/Google Scholar/ResearchGate) is **(965/2150/1810); h-factor is (17/23/23)**

**List of ten the most recent significant publications:**


[1] Davy R. and Esau I., 2016: Differences in the efficacy of climate forcings explained by variations in atmospheric boundary layer depth, *Nature Communications*, 7:11690, doi: 10.1038/ncomms11690

[2] Esau I., Miles V., Miles M., Davy R., Kurchatova A., 2016: Trends in the normalized difference vegetation index (NDVI) associated with urban development of Northern West Siberia, *Atmospheric Chemistry and Physics*, doi:10.5194/acp-2016-51

[3] Davy R., Esau I., Outten S., Chernokulsky A. and Zilitinkevich S., 2016: Diurnal asymmetry to the observed global warming, *International Journal of Climatology*, doi: 10.1002/joc.4688

[4] Davy R. and I. Esau, 2014: Global climate models' bias in surface temperature trends and variability, *Environmental Res. Letters*, 9, 114024, doi:10.1088/1748-9326/9/11/114024

[5] Outten, S., and Esau, I., 2016: Bjerknes Compensation in the Bergen Climate Model, *Climate Dynamics*, doi: 10.1007/s00382-016-3447-2

[6] Esau I., 2014: Indirect air-sea interactions simulated with a coupled turbulence-resolving model, *Ocean Dynamics*, 64(5), 689-705, doi 10.1007/s10236-014-0712-y

[7] Esau I., R. Davy, S. Outten, S. Tyuryakov, S. Zilitinkevich, 2013: Structuring of turbulence and its impact on basic features of Ekman boundary layers, *Nonlin. Proc. Geophys.*, 20, 589-604

[8] Zilitinkevich S., Elperin T., Kleeorin N., Rogachevskii I. and I. Esau, 2012: A hierarchy of energy- and flux-budget (EFB) turbulence closure models for stably stratified geophysical flows, *Boundary-Layer Meteorology*, 146(3), 341-373, DOI: 10.1007/s10546-012-9768-8

[9] Canuto, V.M., Cheng, Y., Howard, A.M., and Esau, I., 2008: Stably stratified flows: A model with no Ri(cr), *J. Atmos. Sci.*, **65**, 2437-2447

[10] Esau, I., 2007: Amplification of turbulent exchange over wide Arctic leads: Large-eddy simulation study, *J. Geophysical Research*, **112**(D), D08109, doi:10.1029/2006JD007225


**Research monographs and any translations thereof (if applicable):**


[1] Esau I. and O. Byrkjedal, 2012: in *Atmospheric boundary layers. Nature, theory and applications to modeling and environmental safety*, Ed. A. Baklanov, "*GEOS*", Moscow, 260 pp., ISBN 978-5-89118-595-1

[2] Esau I., 2011: in *Sustainable Environmental Design in Architecture: Impacts on Health*, Eds. S. Rassia and P. Pardalos, Springer, book nr. **56**, DOI 10.1007/978-1-4419-0745-5

[3] Esau I. and S. Sorokina, 2010: in *Atmospheric Turbulence, Meteorological Modeling and Aerodynamics*, Eds. P. Lang and F. Lombargo, Nova Science Publishers Inc., pp. 3-58


**Major contributions to the early careers of excellent researchers:** PostDoc R. Davy received the Outstanding Young Scientist Award of the Atmospheric science Section of the European Geophysical Society in 2015.

These are the proposed referees to the ALERTNESS project proposal.

1. Prof. Dr. Thomas Jung
Thomas.Jung@awi.de
Alfred Wegener Institute
Bussestraße 24
27570 Bremerhaven
Germany

2. Eric Bazile
eric.bazile@meteo.fr
Meteo-France
CNRM/GMAP
42 av G. Coriolis
31057 TOULOUSE CEDEX
France

3. Prof. Erland Källen
erland.kallen@misu.su.se
Meteorologiska institutionen (MISU)
106 91 Stockholm
Sweden

Meteorologisk institutt,
Postboks 43 Blindern,
0313 OSLO

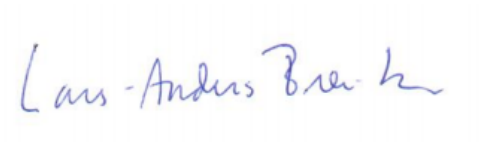
Norwegian Meteorological Institute

**Date**
01.09.2017

## Recommendation regarding overseas research grant

The Norwegian Meteorological Institute hereby recommends that a post-doc travels to the Royal Netherlands Meteorological Institute (KNMI), and stays there for 6 months, working on work package 2 in the ALERTNESS project proposed to the Research Council of Norway.

Yours sincerely



Lars-Anders Breivik
Director of Research

Royal Netherlands
Meteorological Institute
*Ministry of Transport,*
*Public Works and Water Management*

> Return address PO Box 201 3730 AE De Bilt

**KNMI**

Visiting address
Utrechtseweg 297
3731 GA De Bilt
The Netherlands
PO Box 201
3730 AE De Bilt
The Netherlands

**Contact**
Dr. Ir. G.J. Marseille
T +31 30 2206 820
Gert-Jan.Marseille@knmi.nl

Date 01-09-2017
Subject Invitation regarding overseas research grant

This is to confirm that The Royal Netherlands Meteorological Institute (KNMI) formally invites a post-doc to stay at our institution for a period of 6 months, working on work package 2 in the ALERTNESS project.

We look forward to collaborating with the ALERTNESS partners and hope for a successful proposal.

Yours Sincerely,

Dr. Ir. G.J. Marseille
Senior scientist in the R&D Satellite Observations section, KNMI

(on behalf of Dr. Ir. Ad Stoffelen, Dr. J. Barkmeijer, Drs. W. de Rooy, all KNMI staff)

Norwegian Meteorological Institute

Norwegian Meteorological Institute,
Postboks 43 Blindern,
0313 OSLO

**Date**
09/01/17

# Letter of Confirmation: ALERTNESS

This is to confirm that the Norwegian Meteorological Institute (MET) will lead the project ALERTNESS proposed to the Research Council of Norway. MET will have active involvement in all work packages, will host two post-docs, and provide data management infrastructure for the project.

ALERTNESS address key challenges in weather forecasting in the Arctic, a topic of increasing importance and relevance for the activities and responsibilities of MET at high latitudes. The project results will be readily applicable to the operational forecast systems at MET.

ALERTNESS will actively collaborate with research institutes, universities and operational forecasting institutes, nationally and abroad, which will enhance the knowledge transfer and competence of all parties.

Yours sincerely

Lars-Anders Breivik

Director of Research

UNIS
The University Centre in Svalbard

Research Council of Norway
P.O. Box 564
NO-1327 Lysaker

**Letter of Confirmation: ALERTNESS**

This is to confirm that The University Centre in Svalbard (UNIS) will actively contribute with our personnel Marius O. Jonassen (MOJ) in the project ALERTNESS proposed to the Research Council of Norway.

MOJ will be the co-leader of the project. As co-leader, he will assist the leader in his tasks, which include amongst others ensuring project progress and quality according to the project plan, deliverance of contractual progress and final reports, respond to requests and report on the dissemination and exploitation of results. These tasks are all located within Work package 5 of the proposed project.

In addition, MOJ will contribute to Work package 1, which focuses on model verification. MOJ will also incorporate new knowledge gained in the project in the curriculum at UNIS and contribute with supervision of graduate students connected to the project.

Yours sincerely,

Harald Ellingsen
Director

Address: P.O.Box. 156, N-9171 Longyearbyen | Phone: (47) 79 02 33 00 | Fax: (47) 79 02 33 01
E-mail: post@unis.no | Web: www.unis.no | Organisation number: 985 204 454

uni Research

**Uni Research Climate**
**Visiting address** Jahnebakken 5, 5007 Bergen
**Mailing address** Postboks 7810, N-5020 Bergen
**Tel** +47 55 58 98 70 **fax** +47 55 58 43 30
**Web** http://uni.no/klima/ **e-mail** klima@uni.no
**Organisation number** 985 827 117 mva

To whom it may concern

Bergen 23.8.2017

**Letter of Confirmation: ALERTNESS**

I am writing this to confirm that Uni Research Climate are enthusiastic partners in the ALERTNESS proposal to the Research Council of Norway. From our side, Erik Kolstad will lead Work Package 1, and we will also host a PhD student associated with this work package.
We see the proposed work in ALERTNESS as an excellent opportunity to promote national collaboration in the highly important field of polar meteorology. All the research environments in the proposal will be strengthened by this work, and Norway's reputation as a major actor in the Arctic will be bolstered. The proposed work is fully in line with the long term strategy of Uni Research Climate, as well as the Bjerknes Centre for Climate Research (where Uni Research Climate is one of the four partners).

Yours sincerely,

Trond Dokken
Research Director, Uni Research Climate

UNIVERSITY OF BERGEN
GEOPHYSICAL INSTITUTE

To: Research Council of Norway

Bergen, 24.08.2017

**Letter of Confirmation: ALERTNESS**

This is to confirm that the Geophysical Institute at University of Bergen will actively contribute with our personell Professor Harald Sodemann in the project ALERTNESS led by Jørn Kristiansen, Met.no and proposed to the Research Council of Norway.

ALERTNESS offers the opportunity to build a strong link between academia and the Meteorological Institute on a key topic for the University of Bergen. Harald Sodemann will lead the activities in Work Package 3 aiming to enhance and improve NWP model capabilities for high latitudes as detailed in the project proposal, and act as the main supervisor for a PhD student funded through the project. The PhD will be hosted by the Geophysical Institute.

We are looking forward to a productive collaboration and hope the proposal will be successful.

Nils Gunnar Kvamstø

Prof. Nils Gunnar Kvamstø
Head of Department

| Address: | E-mail: | Phone: | Fax: |
|---|---|---|---|
| Allégaten 70<br>N-5007 Bergen | Nils.Kvamsto@gfi.uib.no | +4755582898 | +4755589883 |

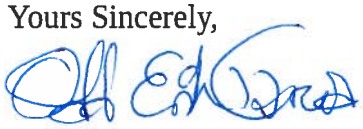
Department of Physics and Technology
University of Tromsø
Postboks 6050 Langnes
9037 Tromsø

**Letter of Confirmation: ALERTNESS**

This is to confirm that Department of Physics and Technology will actively contribute with our personnel Professor Rune Grand Graversen in the project ALERTNESS proposed to the Research Council of Norway.

The institute has developed expertise on data assimilation in sea-ice models, and interpretation of Synthetic Aperture Radar data for sea-ice information. This is relevant for work package 2 in ALERTNESS. It also has expertise on extreme weather in the Arctic such polar lows and icing conditions, which is relevant for work packages 1 and 3.

Yours Sincerely,



Odd Erik Garcia
Professor
Head of Department

From the Administration

**NERSC**

NANSEN ENVIRONMENTAL AND
REMOTE SENSING CENTER
Thormøhlensgate 47
N-5006 Bergen
Norway
Phone: +47 55 20 58 00
Fax: +47 55 20 58 01
E-mail: admin@nersc.no
Web-site: www.nersc.no

Enterprise no: NO 943 432 449

Your ref.: Our ref.: Bergen: 22. August 2017

## Letter of Confirmation
## Advanced models and weather prediction in the Arctic: New understandings of observations and key polar processes (ALERTNESS)

With this letter the Nansen Environmental and Remote Sensing Centre (NERSC) confirms participation in and active contribution to the project ALERTNESS of the Research Council of Norway. If funded, the project work will be conducted by Igor Esau (principal investigator) and Stephen Outten (researcher) in 2018-2019 with the subsequent joint work towards the achievement of the project goals. The NERSC team will work with further studies of the turbulence dynamics and micro-physical processes in the 1D MUSC and 3D AROME models. A novel energy-flux balance approach to parameterize the turbulence dynamics will be implemented and tested in the project.

Yours sincerely,

Sebastian Mernild,

Director

NANSEN ENVIRONMENTAL
RESEARCH CENTER (INDIA)
Pria Square, Karshaka rd.,
Kochi 682016, Kerala
INDIA
Phone: +91 484 2322 351
Fax: +91 484 2323 694
E-mail: nerci@ipath.net.in

NANSEN-ZHU INTERNATIONAL
RESEARCH CENTRE
c/o Institute of Atmospheric Physics
Chinese Academy of Sciences
PO Box 9804
Beijing 100029
CHINA
Phone: +86-10-62063256
E-mail: nzc@mail.iap.ac.cn

NANSEN INTERNATIONAL ENVIRONMENTAL
AND REMOTE SENSING CENTER
7A, 14th Line Street, office 49
Vasilievsky Island
199034 St. Petersburg
RUSSIA
Phone: +7 (812) 324 51 03
Fax: +7 (812) 324 51 02
E-mail: adm@niersc.spb.ru

Royal Netherlands
Meteorological Institute
*Ministry of Transport,*
*Public Works and Water Management*

> Return address PO Box 201 3730 AE De Bilt

**KNMI**

Visiting address
Utrechtseweg 297
3731 GA De Bilt
The Netherlands
PO Box 201
3730 AE De Bilt
The Netherlands

**Contact**
Dr. Ir. G.J. Marseille
T +31 30 2206 820
Gert-Jan.Marseille@knmi.nl

Date 01-09-2017
Subject Letter of confirmation: ALERTNESS

This is to confirm that The Royal Netherlands Meteorological Institute (KNMI) will actively contribute with our personell Wim de Rooy, Ad Stoffelen, Gert-Jan Marseille and Jan Barkmeijer in the project ALERTNESS proposed to the Research Council of Norway.

In work package 2, KNMI will host a post-doc for 6 months, and will provide office facilities and other office overheads at KNMI, scientific and technical support (in-kind) for the post-doc, and 4D-Var task contributions as in-kind also.

In work package 3, the budgeted 500KNOK in the ALERTNESS proposal will be used to contribute in tasks related to boundary layer modelling by Wim de Rooy, and provide support for the PhD who will be staying for up to 2 months.

We look forward to collaborating with the ALERTNESS partners and hope for a successful proposal.

Yours Sincerely,

Dr. Ir. G.J. Marseille
Senior scientist in the R&D Satellite Observations section, KNMI

(on behalf of Dr. Ir. Ad Stoffelen, Dr. J. Barkmeijer, Drs. W. de Rooy, all KNMI staff)

SMHI

## MET Norway

**Letter of confirmation SMHI-ALERTNESS**

August 30th 2017

This is to confirm that the Swedish Meteorological and Hydrological Institute will contribute with our personnel Dr. Patrick Samuelsson and Dr. Danijel Belusic in the project ALERTNESS proposed to the Research Council of Norway.

Collaborating on tasks in the ALERTNESS work package 3, they will act as linkages towards the HIRLAM and MetCoOp NWP communities focusing on parameterizations. Beside consulting activities, sharing expertise knowledge, a visiting research grant for up to four weeks stay in Oslo or Bergen will enable them to focus on the scientific issues together with the ALERTNESS project team in an efficient manner.

We look forward to collaborating with the ALERTNESS partners and hope the proposal is successful.

Sincerely your,

Erik Kjellström

SMHI Research and Development leader representative

**SMHI – Swedish Meteorological and Hydrological Institute,** SE-601 76 Norrköping, Sweden Visit Folkborgsvägen 17 Phone +46 11 495 80 00 Fax +46 11 495 80 01

FINNISH METEOROLOGICAL INSTITUTE

Finnish Meteorological Institute
P.O. Box 503
FI-00101 Helsinki,Finland

28 August, 2017

**Letter of Confirmation: ALERTNESS**

This is to confirm that Finnish Meteorological Institute will actively contribute through our employee Dr Carl Fortelius in the project ALERTNESS proposed to the Research Council of Norway.

During a stay at the premises of Met Norway of up to 4 weeks duration, Fortelius will be assisting the project team, and especially the PhD student chosen to work within the project, in assessing how interaction between parameterised processes leads to error compensation in AROME Arctic (task 3.2) and with implementation and testing stochastic parameterisations of key influential processes (task 3.3).

Yours sincerely

Dr Sami Niemelä
Head of Meteorological Research

Prof Ian Renfrew,
School of Environmental Sciences
University of East Anglia,
Norwich, NR4 7PW, UK
21st August 2017

**Letter of confirmation: ALERTNESS**

This is to confirm that the project ALERTNESS will participate in the YOPP-endorsed **Iceland Greenland Seas Project (IGP)** by contributing the funding for a meteorological buoy. The IGP observational campaign is comprehensive, including 60-hours flying on a research aircraft, and meteorological and oceanographic observations from two winter-time research vessel cruises. However a meteorological buoy is currently missing from our observational plans. Consequently this contribution from the ALERTNESS project will be an important addition to our observing system, in some ways the final piece of our observational jigsaw.

The IGP field campaign will be focused on February and March 2018, during YOPP SOP1 (Special Observing Period 1). All observations from the IGP will be made available to the ALERTNESS team as soon as is practical, so these can form part of the AROME verification and assessment workpackage 1 of your project. Thus the IGP will be providing comprehensive and relatively rare winter-time observations at no cost to ALERTNESS. The broader scientific outcomes of the IGP will also be of significance to that proposed in ALERTNESS, so this link between the two YOPP projects will be of benefit to both teams.

To give a little more background to the IGP: an internationally-funded team (from the UJ, USA & Norway amongst others) will examine wintertime atmosphere-ocean processes in the Iceland and Greenland Seas by characterising the atmospheric forcing and the ocean response. We will observe the spatial structure and variability of surface flux fields in the region and the weather systems that dictate these fluxes, through the first meteorological field campaign in the Iceland Sea. This will be done as part of a *coupled* atmosphere-ocean field campaign in winter 2018 involving a rare wintertime research cruise and a host of ocean observing systems. We will make in situ observations of air-sea interaction processes from several platforms (e.g. research aircraft and research vessels) and use these to evaluate meteorological analyses, reanalyses and climate models. We will also carry out numerical modelling experiments to investigate the dynamics of selected weather systems which strongly influence the region, but appear not to be well represented in many models; for example, the cold-air outbreaks that stream south over the marginal-ice-zone and the orographic jets and wakes that occur downstream of Iceland. In short the IGP has many synergies with the science of ALERTNESS and this link will enhance both projects. In summary, I offer my fullest possible support to your proposal.

Yours sincerely

Ian A. Renfrew

Professor Ian Renfrew

ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG

Alfred-Wegener-Institut, Postfach 12 01 61, 27515 Bremerhaven

Dr Jørn Kristiansen
The Norwegian Meteorological Institute
Postboks 43 Blindern
0313 Oslo
Norway

Via E-Mail: jornk@met.no

World Meteorological Organization
Weather · Climate · Water

WWRP WORLD WEATHER RESEARCH PROGRAMME

04.09.17

Prof. Dr. Thomas Jung
International Coordination Office for Polar Prediction
Bussestraße 24
D-27570 Bremerhaven
T +49 471 4831 1761
F +49 471 4831 1797
thomas.jung@awi.de

YOPP Endorsement for ***Advanced models and weather prediction in the Arctic: Enhanced capacity from observations and polar process representations - ALERTNESS***

Dear Dr Kristiansen,

Following your application for YOPP endorsement, the PPP steering group has reviewed your request taking into account the following criteria:

- The project addresses or contributes to the general YOPP objectives as outlined in the YOPP Implementation Plan.
- The project acknowledges the importance of close coordination of all planned YOPP activities.
- There is agreement that a summary of the planned activities of the endorsed projects/programmes/initiatives (including their logos, if applicable) will be made public through the website of the International Coordination Office (ICO) and other appropriate means.
- Open data sharing is an important element of the project and the project data relevant to YOPP will be made available in alignment with the YOPP data strategy as outlined in the YOPP Summit report (see http://www.polarprediction.net/yopp/yopp-summit/).
- The project researchers agree to support the work of the PPP Societal and Economic Research Applications (SERA) subcommittee, e.g., by interviews, discussions, surveys or other means of communication should they be contacted by PPP-SERA.
- There is agreement that points of contact have the obligation to inform the ICO about possible changes to the project.

It is my pleasure to let you know that the PPP steering group unanimously agreed to endorse *ALERTNESS*. The activities make substantial contributions to YOPP.

Please note that the endorsement will be made public through the website of the International Coordination Office (http://www.polarpredicton.net).

Yours sincerely,

(Thomas Jung, Chair of the Polar Prediction Project)

**Alfred-Wegener-Institut**
Helmholtz-Zentrum für
Polar- und Meeresforschung

**BREMERHAVEN**

Am Handelshafen 12
27570 Bremerhaven
Telefon 0471 4831-0
Telefax 0471 4831-1149
www.awi.de

Stiftung des öffentlichen Rechts

Sitz der Stiftung:
Am Handelshafen 12
27570 Bremerhaven
Telefon 0471 4831-0
Telefax 0471 4831-1149
www.awi.de

Vorsitzender des Kuratoriums:
MinDir Dr. Karl Eugen Huthmacher
Direktorium:
Prof. Dr. Dr. h.c. Karin Lochte
(Direktorin)
Dr. Karsten Wurr
(Verwaltungsdirektor)
Dr. Uwe Nixdorf
(Stellvertretender Direktor)
Prof. Dr. Karen H. Wiltshire
(Stellvertretende Direktorin)

Bankverbindung:
Commerzbank AG,
Bremerhaven
BIC/Swift COBADEFF292
IBAN DE12292400240349192500
UST-Id-Nr. DE 114707273

HELMHOLTZ GEMEINSCHAFT

ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG

Alfred-Wegener-Institut, Postfach 12 01 61, 27515 Bremerhaven

Dr Jørn Kristiansen
The Norwegian Meteorological Institute
Postboks 43 Blindern
0313 Oslo
Norway

Via E-Mail: jornk@met.no

World Meteorological Organization
Weather · Climate · Water

WWRP WORLD WEATHER RESEARCH PROGRAMME

Prof. Dr. Thomas Jung
International Coordination Office for Polar Prediction
Bussestraße 24
D-27570 Bremerhaven
T +49 471 4831 1761
F +49 471 4831 1797
thomas.jung@awi.de

Alfred-Wegener-Institut
Helmholtz-Zentrum für Polar- und Meeresforschung
BREMERHAVEN

Am Handelshafen 12
27570 Bremerhaven
Telefon 0471 4831-0
Telefax 0471 4831-1149
www.awi.de

Stiftung des öffentlichen Rechts

Sitz der Stiftung:
Am Handelshafen 12
27570 Bremerhaven
Telefon 0471 4831-0
Telefax 0471 4831-1149
www.awi.de

Vorsitzender des Kuratoriums:
MinDir Dr. Karl Eugen Huthmacher
Direktorium:
Prof. Dr. Dr. h.c. Karin Lochte (Direktorin)
Dr. Karsten Wurr (Verwaltungsdirektor)
Dr. Uwe Nixdorf (Stellvertretender Direktor)
Prof. Dr. Karen H. Wiltshire (Stellvertretende Direktorin)

Bankverbindung:
Commerzbank AG,
Bremerhaven
BIC/Swift COBADEFF292
IBAN DE12292400240349192500
UST-Id-Nr. DE 114707273

HELMHOLTZ GEMEINSCHAFT

04.09.17

YOPP Endorsement for ***The Norwegian Meteorological Institute – MET Norway***

Dear Dr Kristiansen,

Following your application for YOPP institutional endorsement, the PPP steering group has reviewed your request taking into account the following criteria:

- Your institution addresses or contributes to the general YOPP objectives as outlined in the YOPP Implementation Plan.
- Your institution acknowledges the importance of close coordination of all planned YOPP activities.
- There is agreement that a summary of the planned activities of the endorsed institutes (including their logos, if applicable) will be made publicly available through the website of the International Coordination Office (ICO) and other appropriate means.
- Open data sharing is an important element of YOPP and the data relevant to YOPP will be made available in alignment with the YOPP data strategy as outlined in the YOPP Summit report (see http://www.polarprediction.net/yopp/yopp-summit/).
- The involved researchers of the endorsed institutes agree to support the work of the PPP Societal and Economic Research Applications (SERA) subcommittee, e.g., by interviews, discussions, surveys or other means of communication should they be contacted by PPP-SERA.
- There is agreement that points of contact have the obligation to inform the ICO about possible changes to the planned activities.

It is my pleasure to let you know that the PPP steering group unanimously agreed to endorse *MET Norway*. The proposed activities will make substantial contributions to YOPP!

Please note that the endorsement will be made public through the website of the International Coordination Office (http://www.polarpredicton.net).

Yours sincerely,

(Thomas Jung, Chair of the Polar Prediction Project)

| Work package contributions (in person months) | | | | | | | | | | | | | | | | | | | | Rate NOK (120 hours pr PM) | | | | Fraction | Applied NFR (KNOK) | | | | Sum | Total cost (KNOK) | | | | Sum |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2018 | 2018 | 2018 | 2018 | 2019 | 2019 | 2019 | 2019 | 2020 | 2020 | 2020 | 2020 | 2021 | 2021 | 2021 | 2021 | Sum | | 2018 | 2019 | 2020 | 2021 | in-kind | 2018 | 2019 | 2020 | 2021 | applied | 2018 | 2019 | 2020 | 2021 | total |
| | | 1,0 | 2,0 | 3,0 | 4,0 | 1,0 | 2,0 | 3,0 | 4,0 | 1,0 | 2,0 | 3,0 | 4,0 | 1,0 | 2,0 | 3,0 | 4,0 | | | | | | | | | | | | | | | | | |
| **WP1, sum->** | | | | | | | | | | | | | | | | | | 55,5 | | | | | | | | | | | 5482,3 | | | | | 6116,6 |
| *Erik Kolstad* | UNI | 0,5 | 0,7 | 0,7 | 0,5 | 0,5 | 0,5 | 0,5 | 0,5 | 0,2 | 0,2 | 0,2 | 0,5 | 0,5 | 0,5 | 0,5 | 0,5 | 7,5 | | 1305,0 | 1305,0 | 1305,0 | 1305,0 | 0,0 | 375,8 | 313,2 | 172,3 | 313,2 | 1174,5 | 375,8 | 313,2 | 172,3 | 313,2 | 1174,5 |
| PhD (N.N) | UNI | 0,0 | 0,0 | 3,0 | 3,0 | 3,0 | 3,0 | 3,0 | 3,0 | 3,0 | 3,0 | 3,0 | 3,0 | 3,0 | 3,0 | 0,0 | 0,0 | 36,0 | | 746,5 | 773,0 | 796,0 | 819,0 | 0,0 | 537,5 | 1113,1 | 1146,2 | 589,7 | 3386,5 | 537,5 | 1113,1 | 1146,2 | 589,7 | 3386,5 |
| Morten K | MET | 0,5 | 0,5 | 0,5 | 0,5 | 0,5 | 0,5 | 0,5 | 0,5 | 0,5 | 0,5 | 0,5 | 0,5 | 0,5 | 0,5 | 0,5 | 0,5 | 8,0 | | 1140,0 | 1170,0 | 1210,0 | 1250,0 | 0,3 | 191,5 | 196,6 | 203,3 | 210,0 | 801,4 | 273,6 | 280,8 | 290,4 | 300,0 | 1144,8 |
| Rune G | UiT | 0,0 | 0,0 | 0,1 | 0,1 | 0,2 | 0,2 | 0,2 | 0,2 | 0,2 | 0,2 | 0,1 | 0,1 | 0,1 | 0,1 | 0,1 | 0,1 | 2,0 | | 844,5 | 865,5 | 887,0 | 909,0 | 1,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 20,3 | 83,1 | 63,9 | 43,6 | 210,9 |
| Marius J | UNIS | 0,1 | 0,1 | 0,1 | 0,1 | 0,2 | 0,2 | 0,2 | 0,2 | 0,2 | 0,2 | 0,1 | 0,1 | 0,1 | 0,1 | 0,0 | 0,0 | 2,0 | | 833,0 | 833,0 | 833,0 | 833,0 | 0,4 | 24,0 | 48,0 | 36,0 | 12,0 | 120,0 | 40,0 | 80,0 | 60,0 | 20,0 | 199,9 |
| **WP2, sum->** | | | | | | | | | | | | | | | | | | 54,4 | | | | | | | | | | | 5200,8 | | | | | 6476,8 |
| *Roger R* | MET | 0,5 | 0,5 | 0,5 | 0,5 | 0,5 | 0,5 | 0,5 | 0,5 | 0,5 | 0,5 | 0,5 | 0,5 | 1,0 | 1,0 | 1,0 | 1,0 | 10,0 | | 1140,0 | 1170,0 | 1210,0 | 1250,0 | 0,3 | 191,5 | 196,6 | 203,3 | 420,0 | 1011,4 | 273,6 | 280,8 | 290,4 | 600,0 | 1444,8 |
| PostDoc (N.N.) | MET | 0,0 | 0,0 | 3,0 | 3,0 | 3,0 | 3,0 | 3,0 | 3,0 | 3,0 | 3,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 24,0 | | 746,5 | 773,0 | 796,0 | 819,0 | 0,0 | 537,5 | 1113,1 | 573,1 | 0,0 | 2223,7 | 537,5 | 1113,1 | 573,1 | 0,0 | 2223,7 |
| Roohallah A. | MET | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 1,0 | 1,0 | 1,4 | 1,4 | 1,4 | 1,4 | 1,4 | 1,0 | 10,0 | | 1140,0 | 1170,0 | 1210,0 | 1250,0 | 0,3 | 0,0 | 0,0 | 487,9 | 546,0 | 1033,9 | 0,0 | 0,0 | 697,0 | 780,0 | 1477,0 |
| Yurii B. | MET | 0,0 | 0,5 | 1,0 | 1,2 | 1,2 | 1,2 | 1,4 | 1,0 | 1,0 | 0,5 | 0,5 | 0,5 | 0,0 | 0,0 | 0,0 | 0,0 | 10,0 | | 1080,0 | 1110,0 | 1140,0 | 1170,0 | 0,3 | 244,9 | 447,6 | 239,4 | 0,0 | 931,9 | 349,9 | 639,4 | 342,0 | 0,0 | 1331,3 |
| KNMI staff | KNMI | 0,0 | 0,0 | 0,0 | 0,0 | 0,2 | 0,2 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,4 | | 1140,0 | 1170,0 | 1210,0 | 1250,0 | 1,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 56,2 | 0,0 | 0,0 | 56,2 |
| **WP3, sum->** | | | | | | | | | | | | | | | | | | 75,7 | | | | | | | | | | | 7380,5 | | | | | 8546,0 |
| *Harald Sodemann* | UiB | 0,2 | 0,2 | 0,2 | 0,2 | 0,5 | 0,5 | 0,5 | 0,5 | 0,5 | 0,5 | 0,2 | 0,2 | 0,2 | 0,2 | 0,2 | 0,2 | 5,0 | | 844,5 | 865,5 | 887,0 | 909,0 | 1,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 81,1 | 207,7 | 149,0 | 87,3 | 525,1 |
| Teresa V. | MET | 0,8 | 0,8 | 0,8 | 0,8 | 1,3 | 1,3 | 1,4 | 1,4 | 1,0 | 1,2 | 1,2 | 1,0 | 0,5 | 0,5 | 0,5 | 0,5 | 15,0 | | 1140,0 | 1170,0 | 1210,0 | 1250,0 | 0,3 | 306,4 | 530,7 | 447,2 | 210,0 | 1494,4 | 437,8 | 758,2 | 638,9 | 300,0 | 2134,8 |
| PhD (N.N) | UiB | 0,0 | 0,0 | 3,0 | 3,0 | 3,0 | 3,0 | 3,0 | 3,0 | 3,0 | 3,0 | 3,0 | 3,0 | 3,0 | 3,0 | 0,0 | 0,0 | 36,0 | | 746,5 | 773,0 | 796,0 | 819,0 | 0,0 | 537,5 | 1113,1 | 1146,2 | 589,7 | 3386,5 | 537,5 | 1113,1 | 1146,2 | 589,7 | 3386,5 |
| Igor Esau | NERSC | 0,0 | 0,0 | 1,0 | 2,0 | 1,8 | 1,5 | 1,0 | 0,5 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 7,8 | | 1120,0 | 1210,0 | 0,0 | 0,0 | 0,0 | 403,2 | 697,0 | 0,0 | 0,0 | 1100,2 | 403,2 | 697,0 | 0,0 | 0,0 | 1100,2 |
| Stephen O. | NERSC | 0,0 | 0,0 | 1,0 | 2,0 | 1,9 | 1,5 | 1,0 | 0,5 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 7,9 | | 900,0 | 980,0 | 0,0 | 0,0 | 0,0 | 324,0 | 576,2 | 0,0 | 0,0 | 900,2 | 324,0 | 576,2 | 0,0 | 0,0 | 900,2 |
| Wim De Rooy | KNMI | 0,0 | 0,0 | 0,0 | 0,0 | 1,0 | 1,0 | 1,0 | 1,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 4,0 | | 1040,0 | 1040,0 | 1040,0 | 1040,0 | 0,0 | 0,0 | 499,2 | 0,0 | 0,0 | 499,2 | 0,0 | 499,2 | 0,0 | 0,0 | 499,2 |
| **WP4, sum->** | | | | | | | | | | | | | | | | | | 42,0 | | | | | | | | | | | 4040,8 | | | | | 4811,9 |
| *Inger-Lise F.* | MET | 0,2 | 0,1 | 0,1 | 0,1 | 0,1 | 0,1 | 0,1 | 0,3 | 0,3 | 0,2 | 0,1 | 0,1 | 0,3 | 0,3 | 0,4 | 0,2 | 3,0 | | 1140,0 | 1170,0 | 1210,0 | 1250,0 | 0,3 | 47,9 | 59,0 | 71,1 | 126,0 | 304,0 | 68,4 | 84,2 | 101,6 | 180,0 | 434,3 |
| Andrew S. | MET | 0,5 | 1,0 | 0,5 | 0,5 | 0,5 | 0,5 | 1,0 | 0,5 | 0,5 | 0,5 | 0,5 | 1,0 | 0,3 | 0,3 | 0,4 | 0,5 | 9,0 | | 1140,0 | 1170,0 | 1210,0 | 1250,0 | 0,3 | 239,4 | 245,7 | 254,1 | 157,5 | 896,7 | 342,0 | 351,0 | 363,0 | 225,0 | 1281,0 |
| PostDoc (N.N.) | MET | 0,0 | 0,0 | 0,0 | 3,0 | 3,0 | 3,0 | 3,0 | 3,0 | 3,0 | 3,0 | 3,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 24,0 | | 746,5 | 773,0 | 796,0 | 819,0 | 0,0 | 268,7 | 1113,1 | 859,7 | 0,0 | 2241,5 | 268,7 | 1113,1 | 859,7 | 0,0 | 2241,5 |
| Rafael G. | MET | 0,5 | 1,0 | 0,5 | 0,2 | 0,2 | 0,2 | 0,5 | 0,2 | 0,2 | 0,2 | 0,2 | 0,5 | 0,5 | 0,2 | 0,4 | 0,5 | 6,0 | | 1140,0 | 1170,0 | 1210,0 | 1250,0 | 0,3 | 210,7 | 108,1 | 111,8 | 168,0 | 598,6 | 301,0 | 154,4 | 159,7 | 240,0 | 855,1 |
| **WP5, sum->** | | | | | | | | | | | | | | | | | | 10,0 | | | | | | | | | | | 951,8 | | | | | 1359,7 |
| *Jørn Kristiansen* | MET | 0,3 | 0,2 | 0,2 | 0,2 | 0,2 | 0,2 | 0,2 | 0,2 | 0,3 | 0,3 | 0,3 | 0,3 | 0,2 | 0,2 | 0,2 | 0,5 | 4,0 | | 1260,0 | 1300,0 | 1340,0 | 1380,0 | 0,3 | 95,3 | 87,4 | 135,1 | 127,5 | 445,2 | 136,1 | 124,8 | 193,0 | 182,2 | 636,0 |
| Marius J | UNIS | 0,2 | 0,2 | 0,1 | 0,1 | 0,2 | 0,2 | 0,2 | 0,2 | 0,2 | 0,2 | 0,2 | 0,2 | 0,2 | 0,2 | 0,2 | 0,2 | 3,0 | | 833,0 | 833,0 | 833,0 | 833,0 | 0,3 | 42,0 | 56,0 | 56,0 | 56,0 | 209,9 | 60,0 | 80,0 | 80,0 | 80,0 | 299,9 |
| Erik Kolstad | UNI | 0,1 | 0,0 | 0,0 | 0,0 | 0,1 | 0,1 | 0,0 | 0,0 | 0,1 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,1 | 0,5 | | 1305,0 | 1305,0 | 1305,0 | 1305,0 | 0,3 | 11,0 | 21,9 | 11,0 | 11,0 | 54,8 | 15,7 | 31,3 | 15,7 | 15,7 | 78,3 |
| Eivind S | MET | 0,5 | 0,1 | 0,1 | 0,1 | 0,1 | 0,1 | 0,0 | 0,0 | 0,1 | 0,1 | 0,0 | 0,0 | 0,1 | 0,1 | 0,0 | 0,1 | 1,5 | | 1140,0 | 1170,0 | 1210,0 | 1250,0 | 0,3 | 76,6 | 19,7 | 20,3 | 31,5 | 148,1 | 109,4 | 28,1 | 29,0 | 45,0 | 211,6 |
| Magne V | MET | 0,1 | 0,2 | 0,1 | 0,0 | 0,1 | 0,0 | 0,1 | 0,0 | 0,1 | 0,0 | 0,1 | 0,0 | 0,1 | 0,0 | 0,0 | 0,1 | 1,0 | | 1080,0 | 1110,0 | 1140,0 | 1170,0 | 0,3 | 36,3 | 18,6 | 19,2 | 19,7 | 93,7 | 51,8 | 26,6 | 27,4 | 28,1 | 133,9 |
| **SUM** | | | | | | | | | | | | | | | | | | | | | | | | | **4701,7** | **8573,8** | **6193,1** | **3587,7** | **23056,2** | **5544,8** | **9804,6** | **7398,4** | **4619,3** | **27367,1** |