# HARMONIE-AROME Physics

**Emily Gleeson**
**on behalf of the HIRLAM Physics Team**

# ACCORD

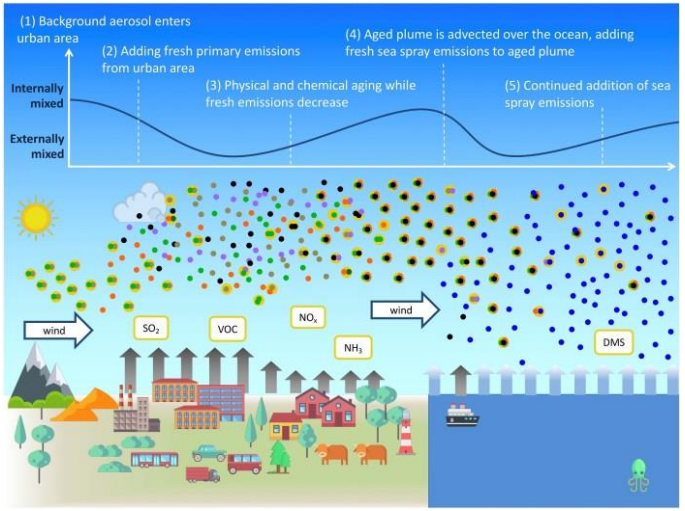
A Consortium for COnvection-scale modelling Research and Development


**HIRLAM countries – HARMONIE-AROME**

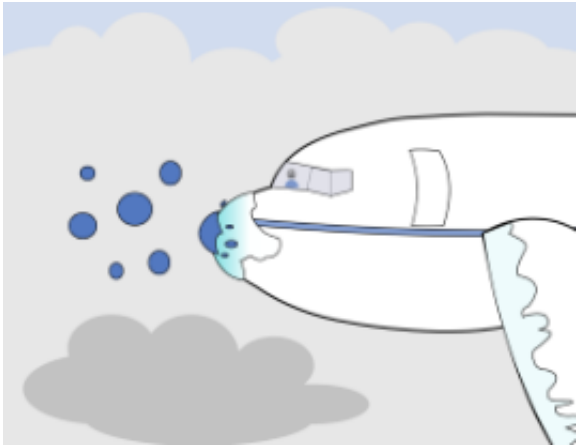
High Resolution Limited Area Model

# Overview

- HARMONIE-AROME developments
- Work on fog
- Other topics
- Physics working week



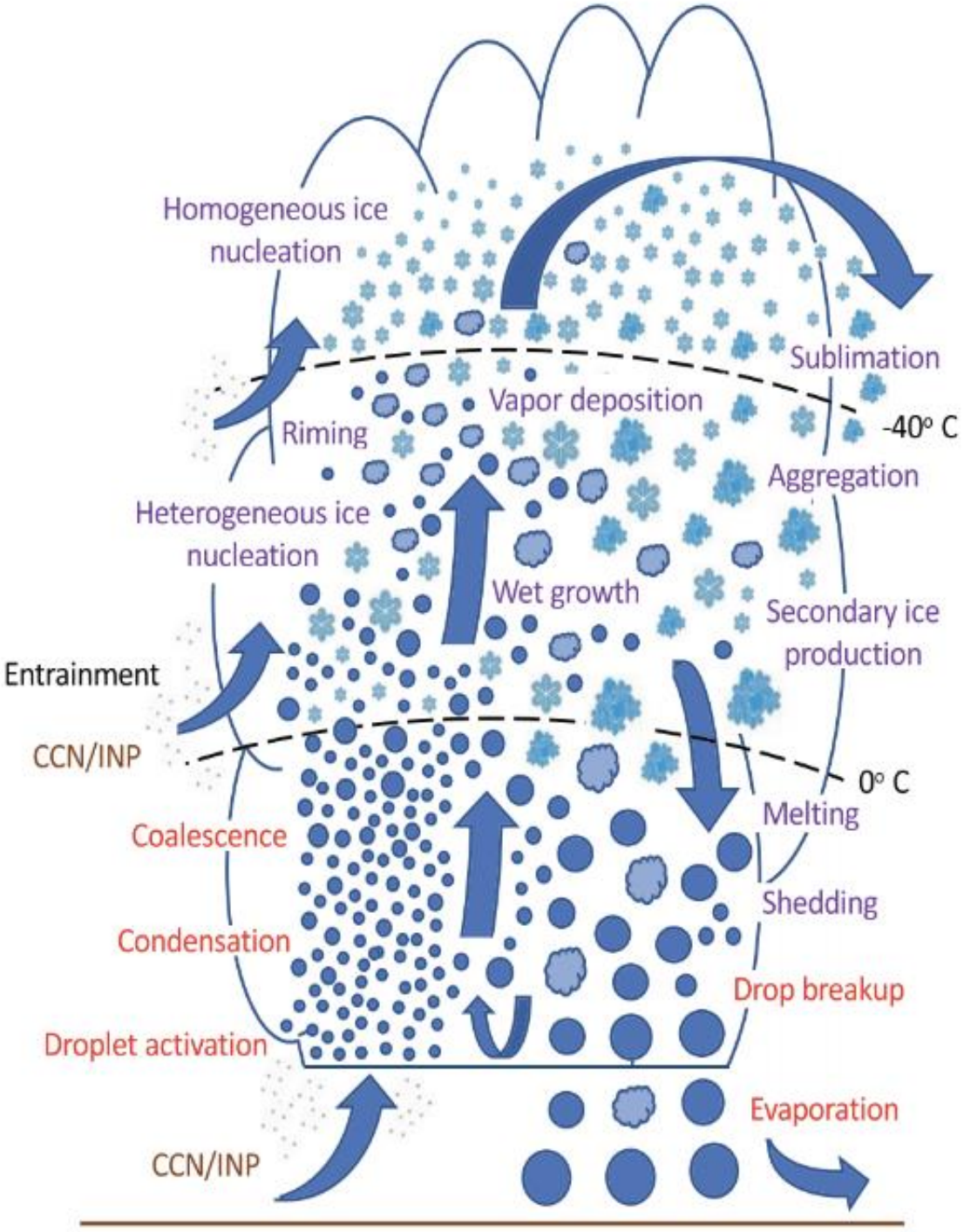

# 1. Supercooled Liquid Clouds & ICE-T



Meteorologisk institutt

Bjørg Jenny Engdahl

# ICE3



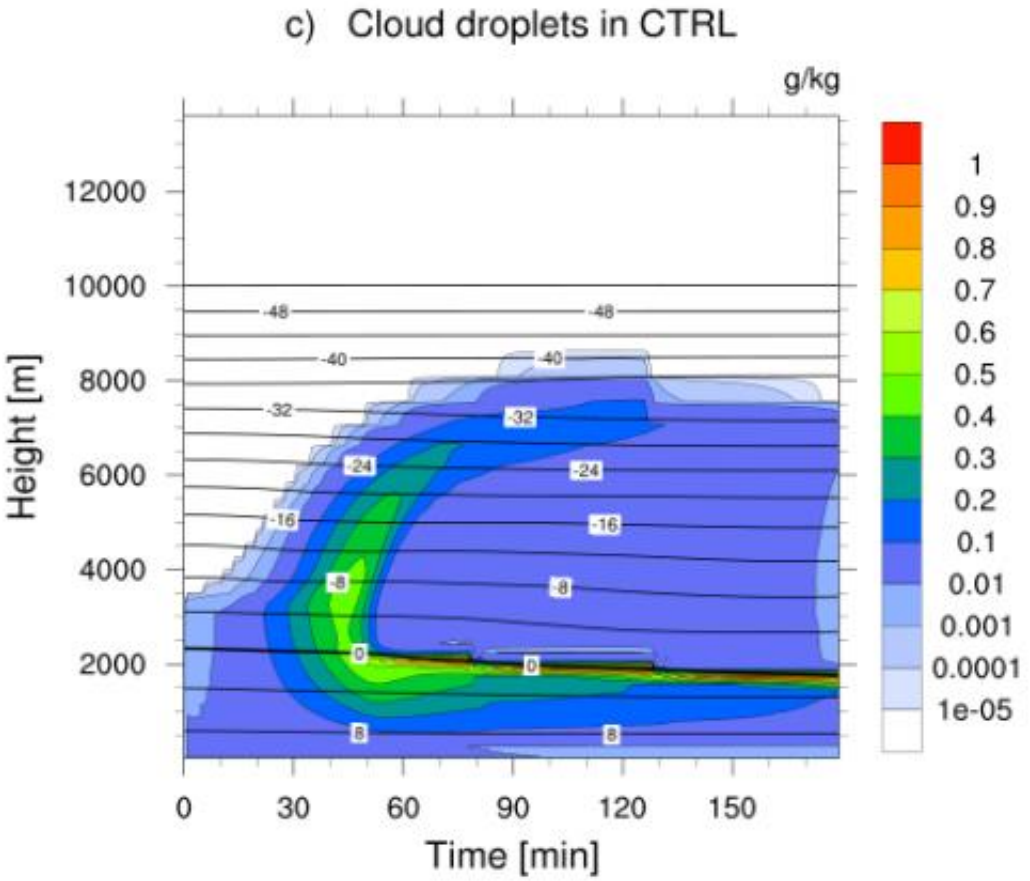

# Important Cloud Processes

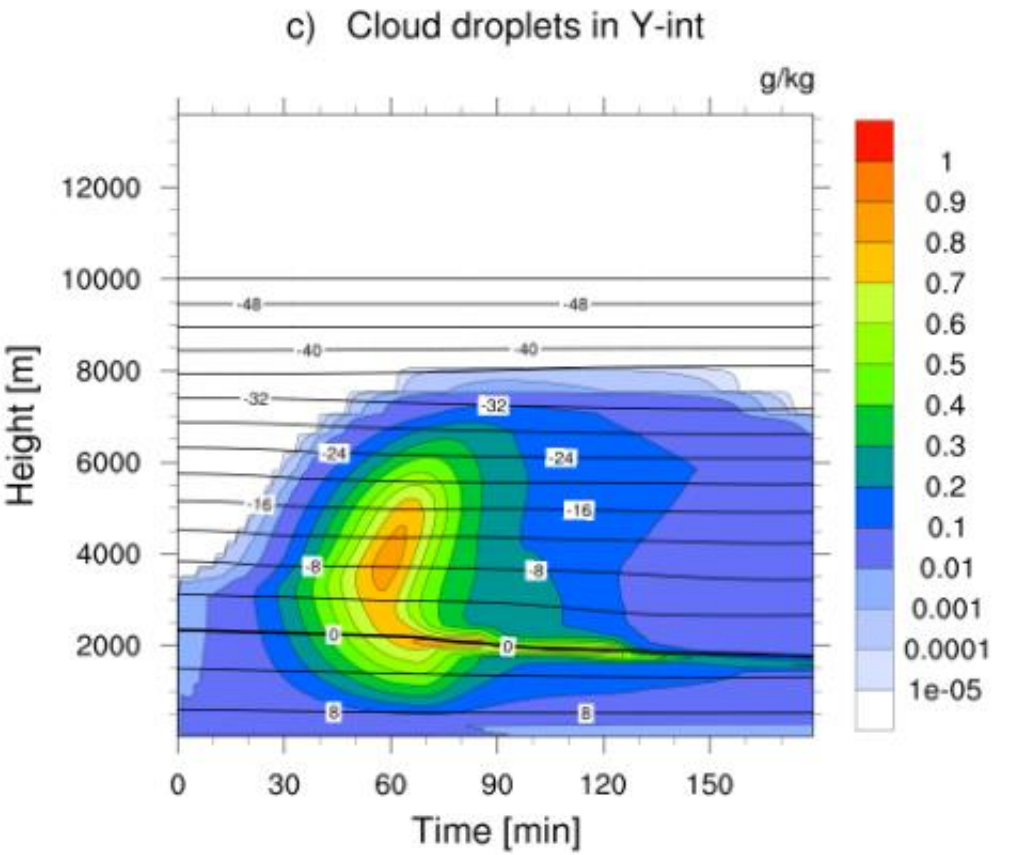
- Ice initiation: Stricter criteria for heterogeneous ice nucleation

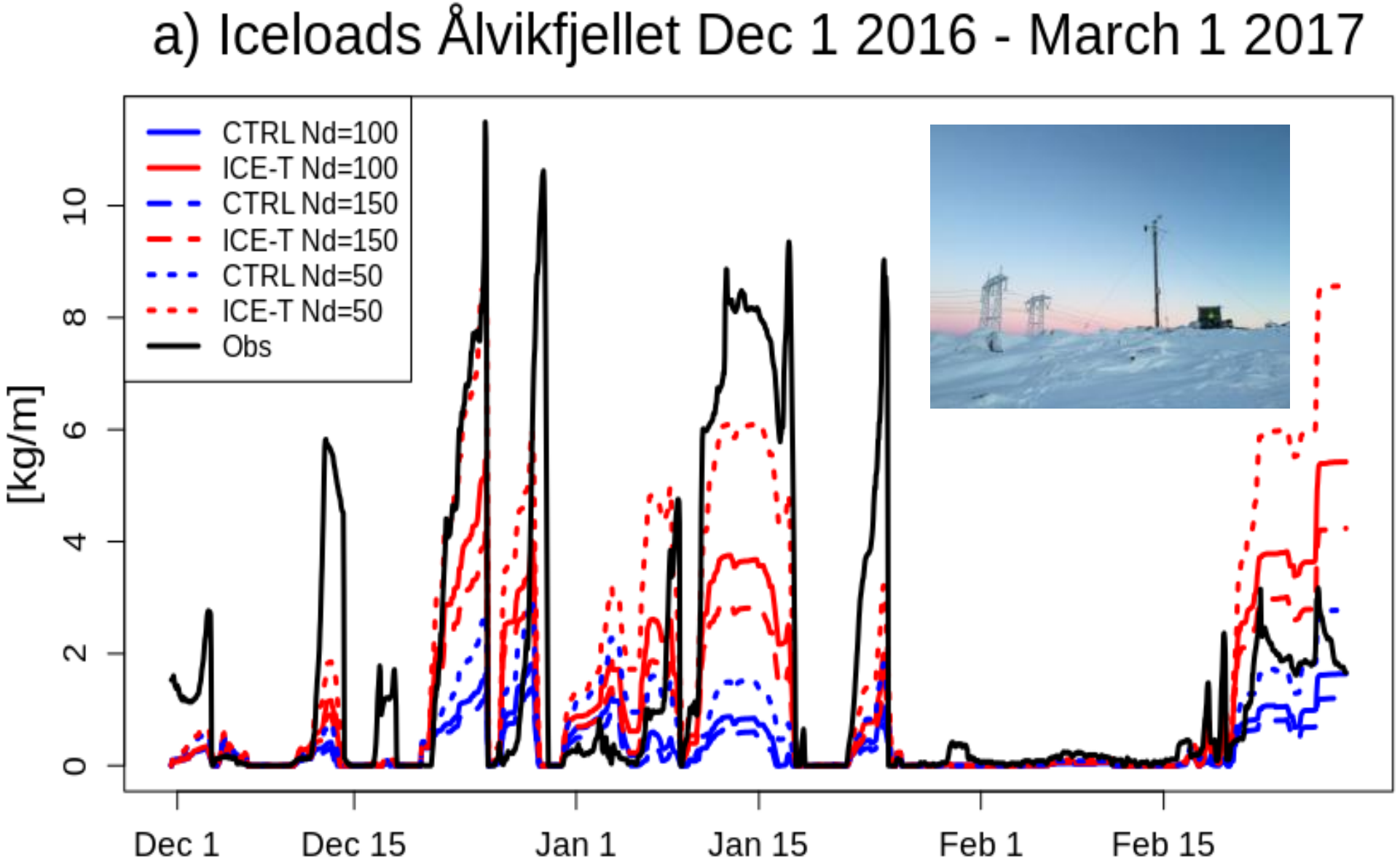
- Accretion of liquid water (cloud water/rain) by solid species (snow/graupel): less efficient accretion

- Rain size distribution

# Change in Supercooled Liquid Water



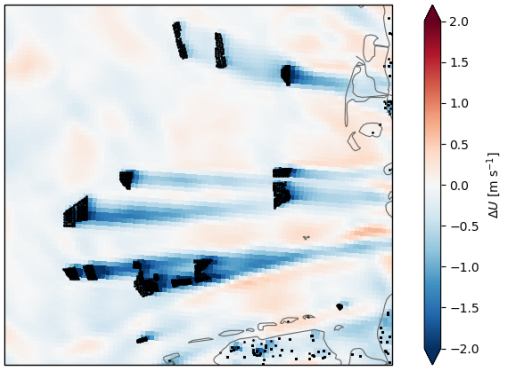



**Jenny's talk at ECMWF Annual Seminar:**
**https://vimeo.com/749495421/fcb7a553b1**

# 2. Wind Farm Parametrization

- Fitch et al. wind farm param (WFP) implemented and tested in the DOWA & WIN550 projects
- Running stably at KNMI since Dec 2021 (CY43h2.2)
- Input files – location/properties
- Documentation and tools for creating the input files
- Plans to implement in UWC-West domain
- Testing DTU WFP (EWP-Volker et al., 2015)

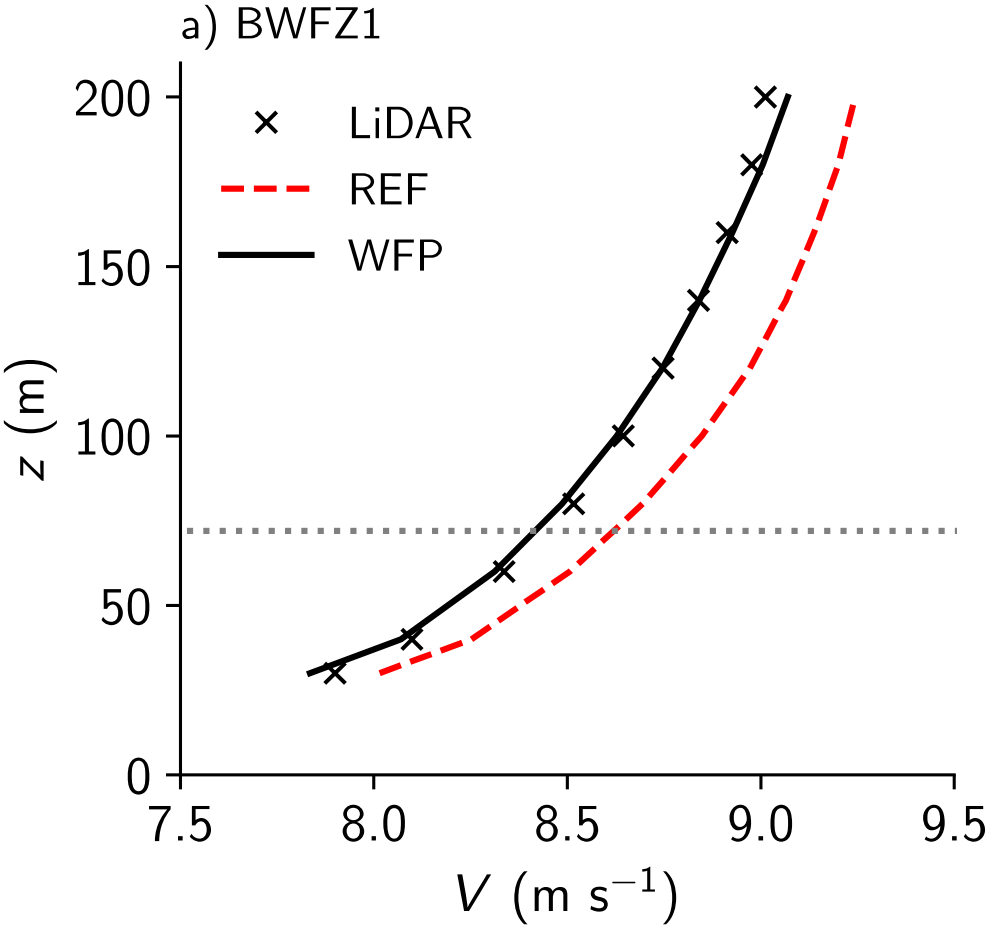
Natalie Theeuwes

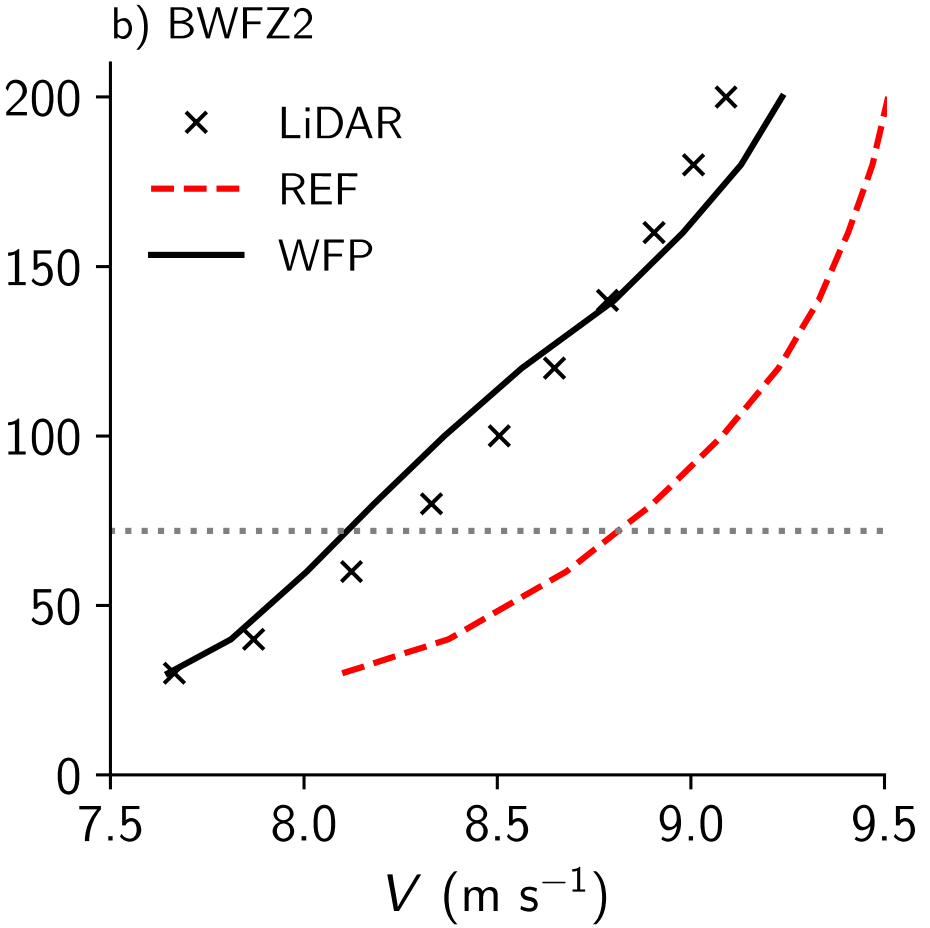



Royal Netherlands Meteorological Institute
*Ministry of Infrastructure and the Environment*

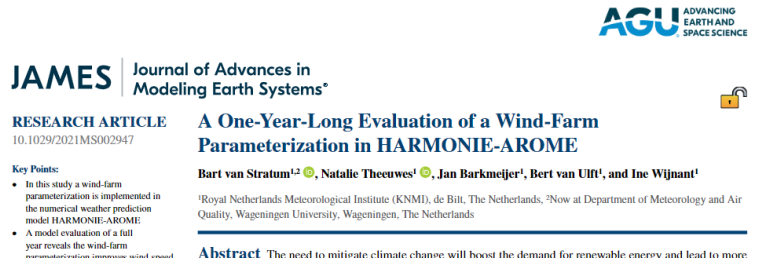
High Resolution Hirlam Limited Area Model

# Evaluating Wind Profiles




Van Stratum et al. (2022, JAMES)


JAMES | Journal of Advances in Modeling Earth Systems

RESEARCH ARTICLE
10.1029/2021MS002947

A One-Year-Long Evaluation of a Wind-Farm Parameterization in HARMONIE-AROME

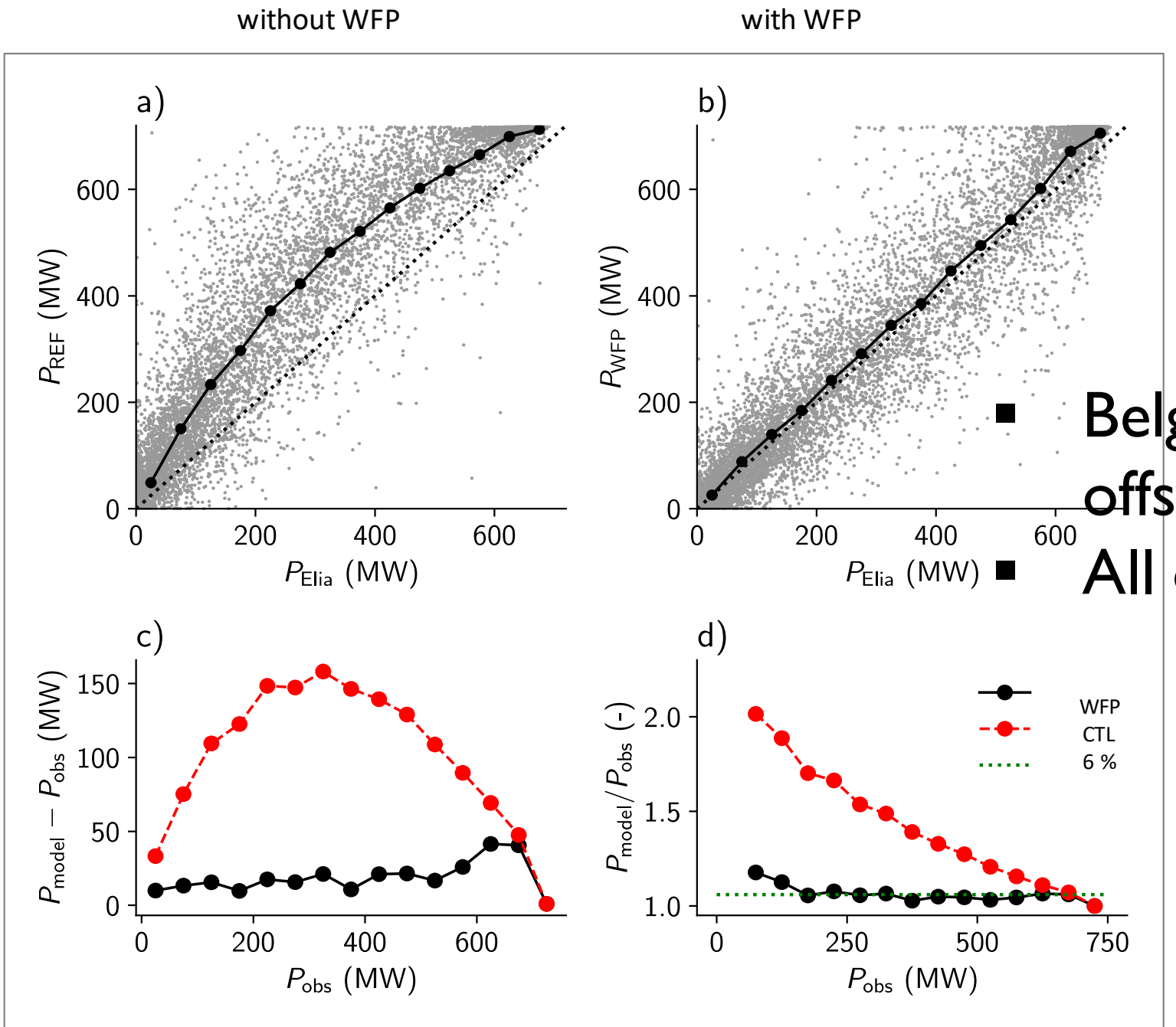
Bart van Stratum[1,2], Natalie Theeuwes[1], Jan Barkmeijer[1], Bert van Ulft[1], and Ine Wijnant[1]

[1]Royal Netherlands Meteorological Institute (KNMI), de Bilt, The Netherlands, [2]Now at Department of Meteorology and Air Quality, Wageningen University, Wageningen, The Netherlands

Key Points:
- In this study a wind-farm parameterization is implemented in the numerical weather prediction model HARMONIE-AROME
- A model evaluation of a full year reveals the wind-farm

Abstract The need to mitigate climate change will boost the demand for renewable energy and lead to more

# Wind Power

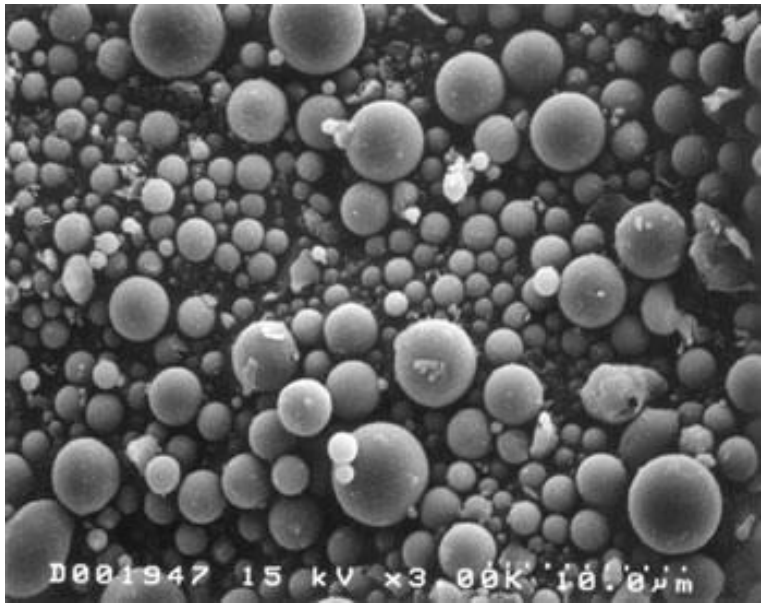



Belgium offshore

All of 2016

# 3. CAMS aerosols

- CY46h branch contains the routines for CAMS aerosols.
- Microphysics (ICE3) and radiation (old IFS scheme)
- Cloud droplets for microphysics (autoconversion, sedimentation and collision of cloud droplets) and the radiation schemes (effective radius). MMR in the radiation scheme (extinction).
- Dust emission and Sea Salt emission ($gm^{-2}s^{-1}$) have been implemented (not yet in 46h1).

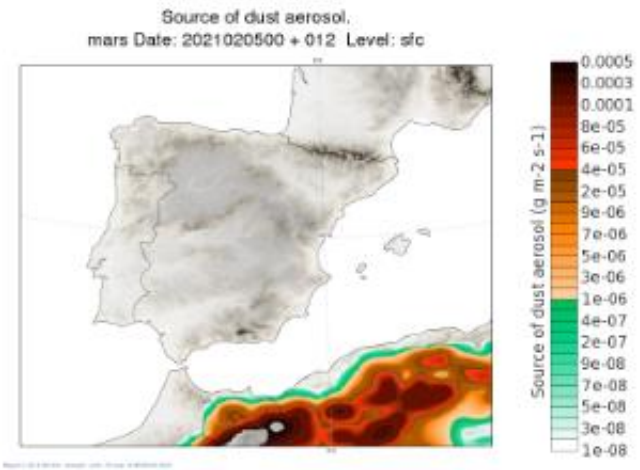
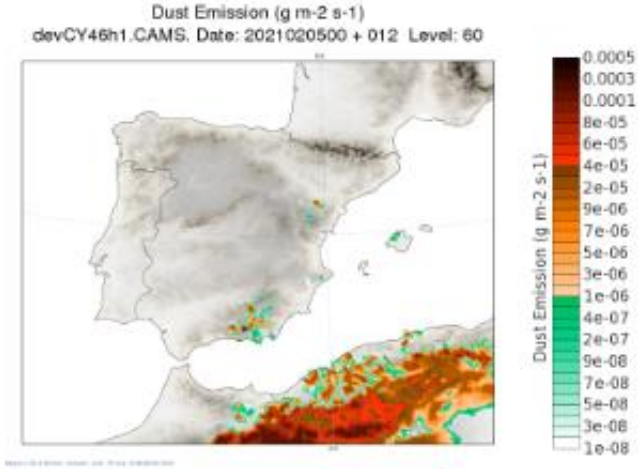
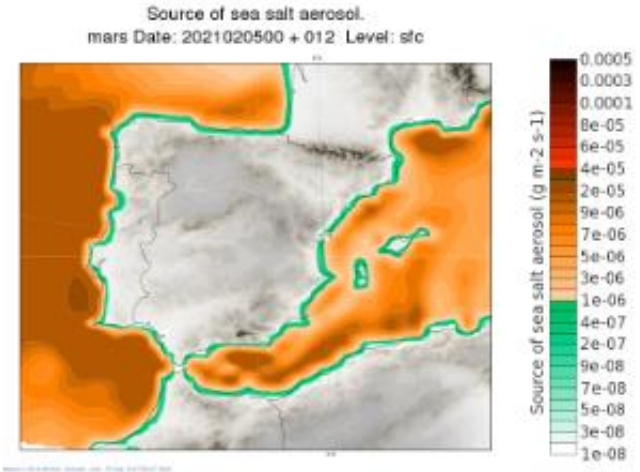
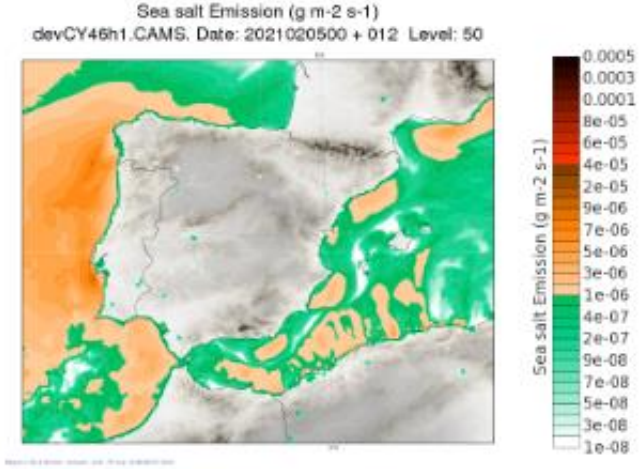



Daniel Martín Pérez

AEMet Agencia Estatal de Meteorología

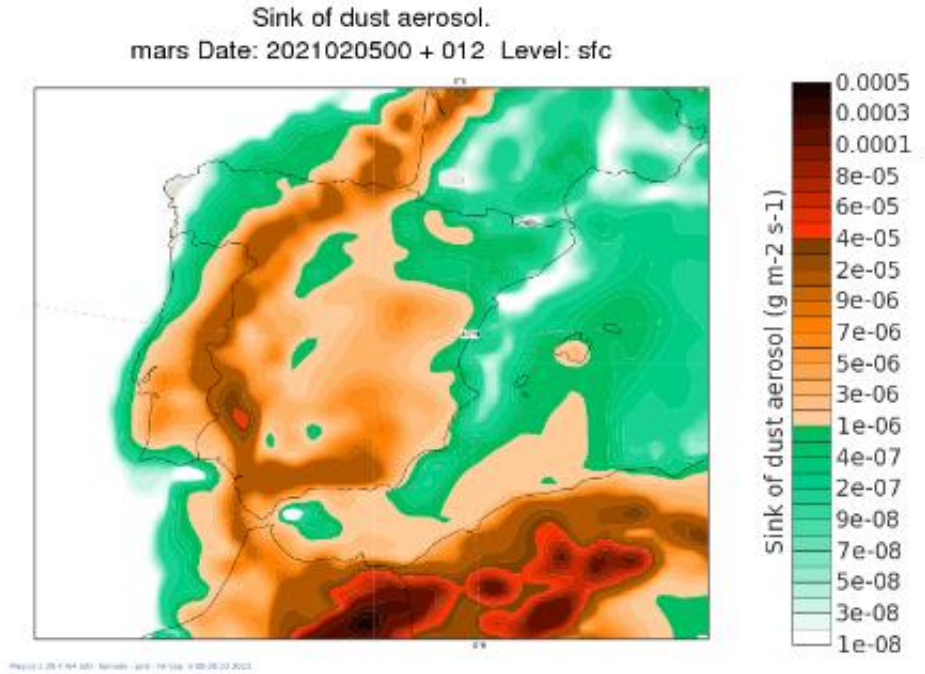
HIRLAM High Resolution Limited Area Model

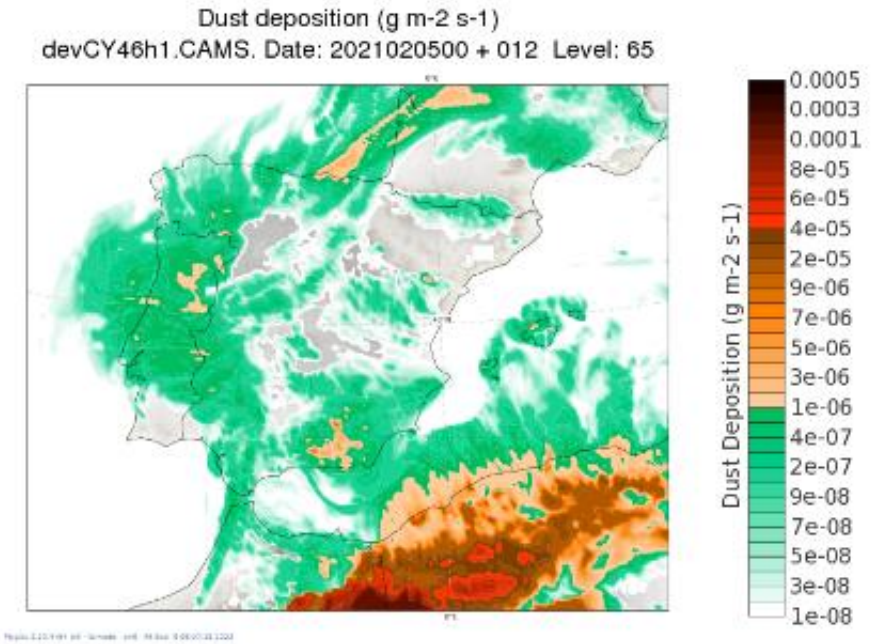
- **Dust emissions** are important for domains with desert zones. Similar to CAMS emission
- **Sea salt emissions** are needed as the removal parametrization reduces the sea salt concentration strongly.

| | CAMS (source) | HARMONIE-AROME (emission) |
|---|---|---|
| Dust |  |  |
| Sea salt |  |  |

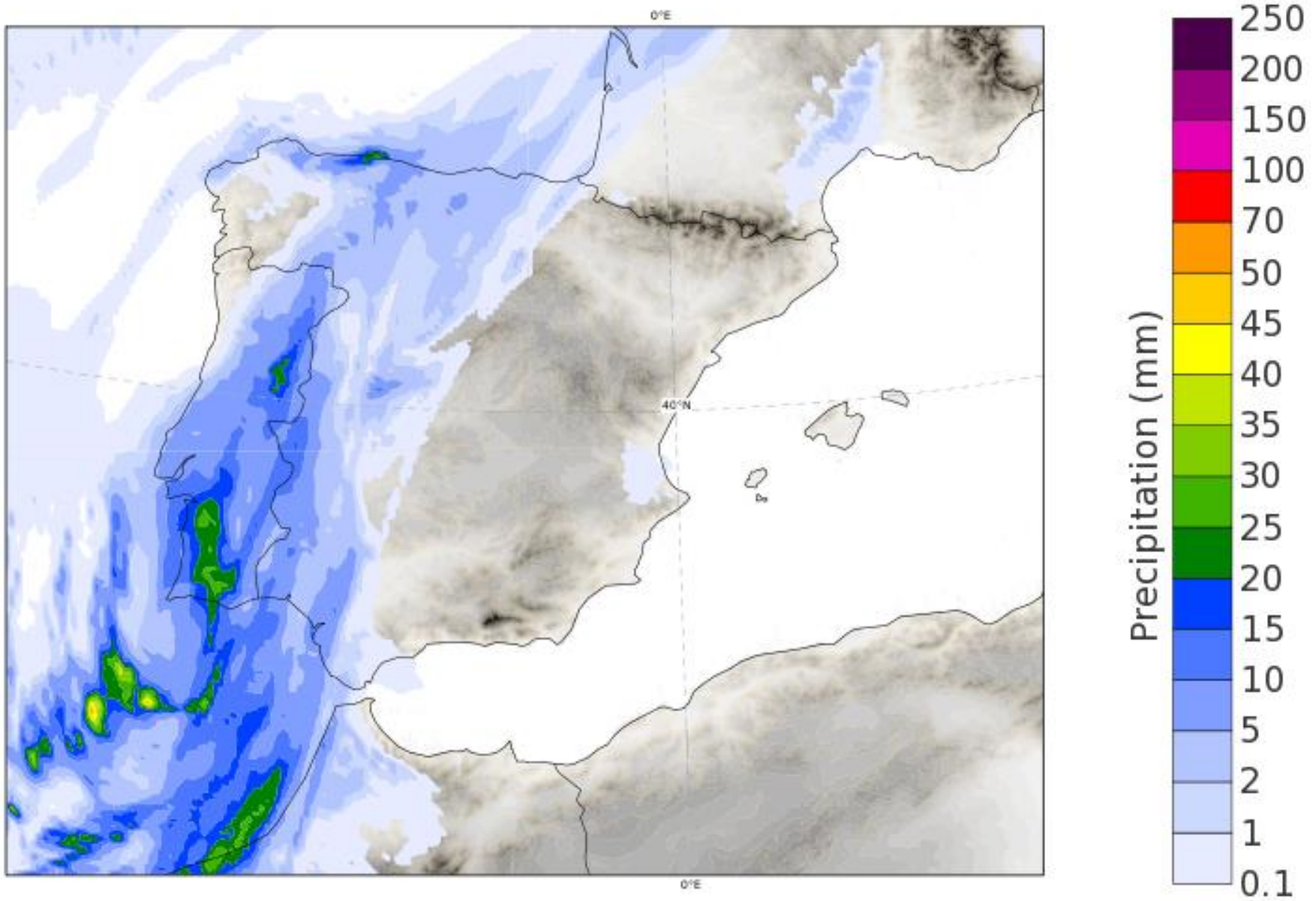
CAMS (sink)

HARMONIE-AROME (deposition)




- Calculation of DUST SINK implemented (with Laura Rontu; unit: $gm^{-2}s^{-1}$).
- Comparison with CAMS: sum of all the contributions and all dust bins.
- Dry deposition gives similar values (African area)
- Wet deposition is higher in the case of CAMS (Iberian Peninsula area).




Peninsula area).

# Overview

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- Other topics
- Physics working week

# Fog Sensitivity Tests

MDPI

*Article*

## Impact of the Microphysics in HARMONIE-AROME on Fog

Sebastián Contreras Osorio [1,*], Daniel Martin Perez [2], Karl-Ivar Ivarsson [3], Kristian Pagh Nielsen [4], Wim C. de Rooy [1], Emily Gleeson [5], Ewa McAufield [5]

[1] Research & Development Weather and Climate models, Royal Netherlands Meteorological Institute (KNMI), P.O. Box 201, 3730AE, De Bilt, Utrecht, the Netherlands
[2] Agencia Estatal de Meteorología (AEMET), Madrid, Spain
[3] Swedish Meteorological and Hydrological Institute (SMHI), Norrköping, Sweden
[4] Danish Meteorological Institute (DMI), Copenhagen, Denmark
[5] Irish Meteorological Service (Met Éireann), 67 Glasnevin Hill, Glasnevin, Dublin 9, D09 Y921, Ireland
* Correspondence: sebastian.contrerasosorio@knmi.nl

**Abstract:** The present study concerns the impact of microphysics on the numerical weather prediction model HARMONIE-AROME. Particularly, the representation of cloud droplets in the single-moment bulk microphysics scheme of the model is examined in relation to fog forecasting. We focus on the parameters of the cloud droplet size distribution and recent changes to the representation of the

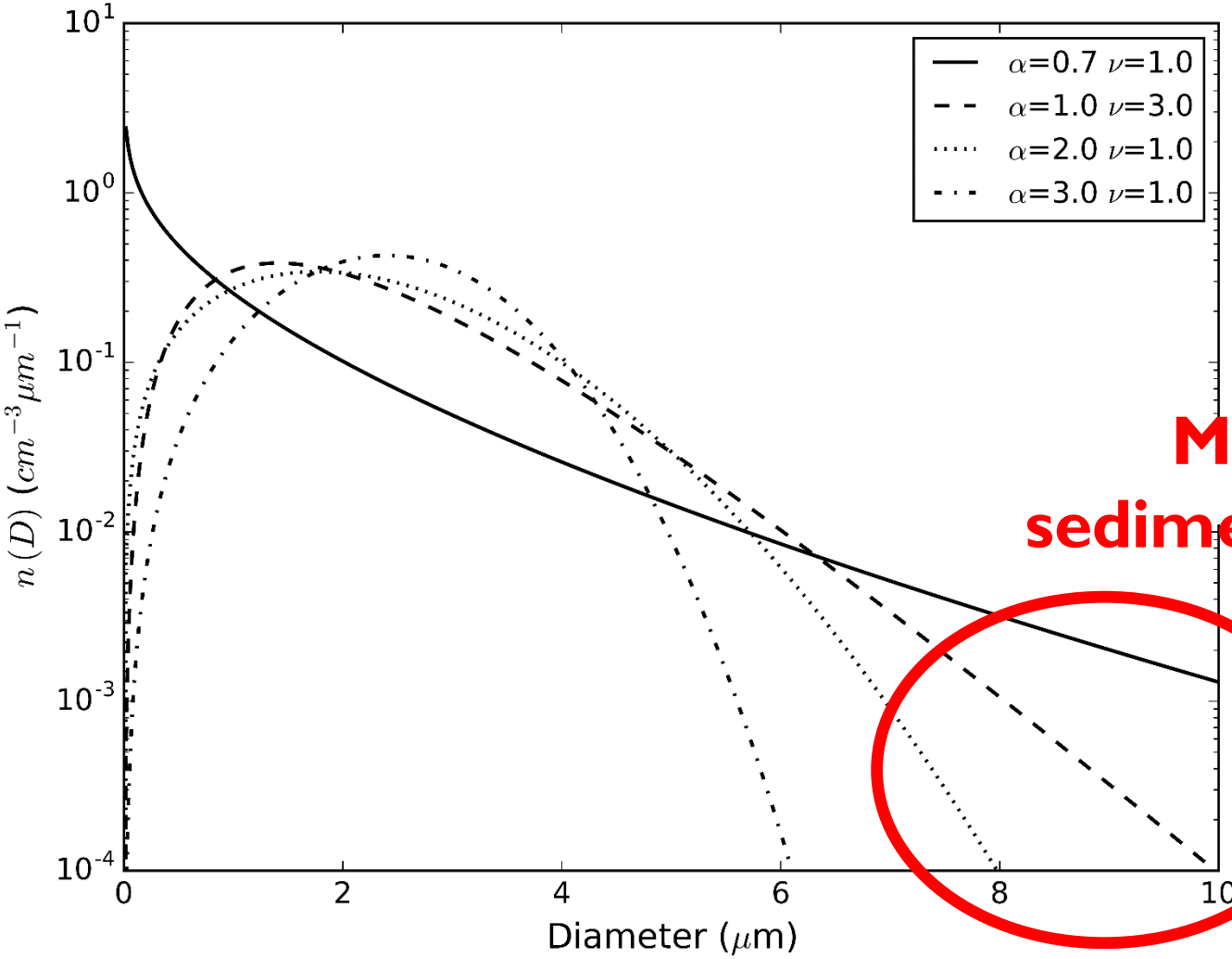
- One-moment ICE3 scheme
- Cloud droplet size distribution (shape parameters)
- Cloud droplet number concentration (CDNC)
- Iberian peninsula and the North Sea
- Focus on sedimentation

Sebastián Contreras Osorio et al.

High Resolution Limited Area Model HIRLAM

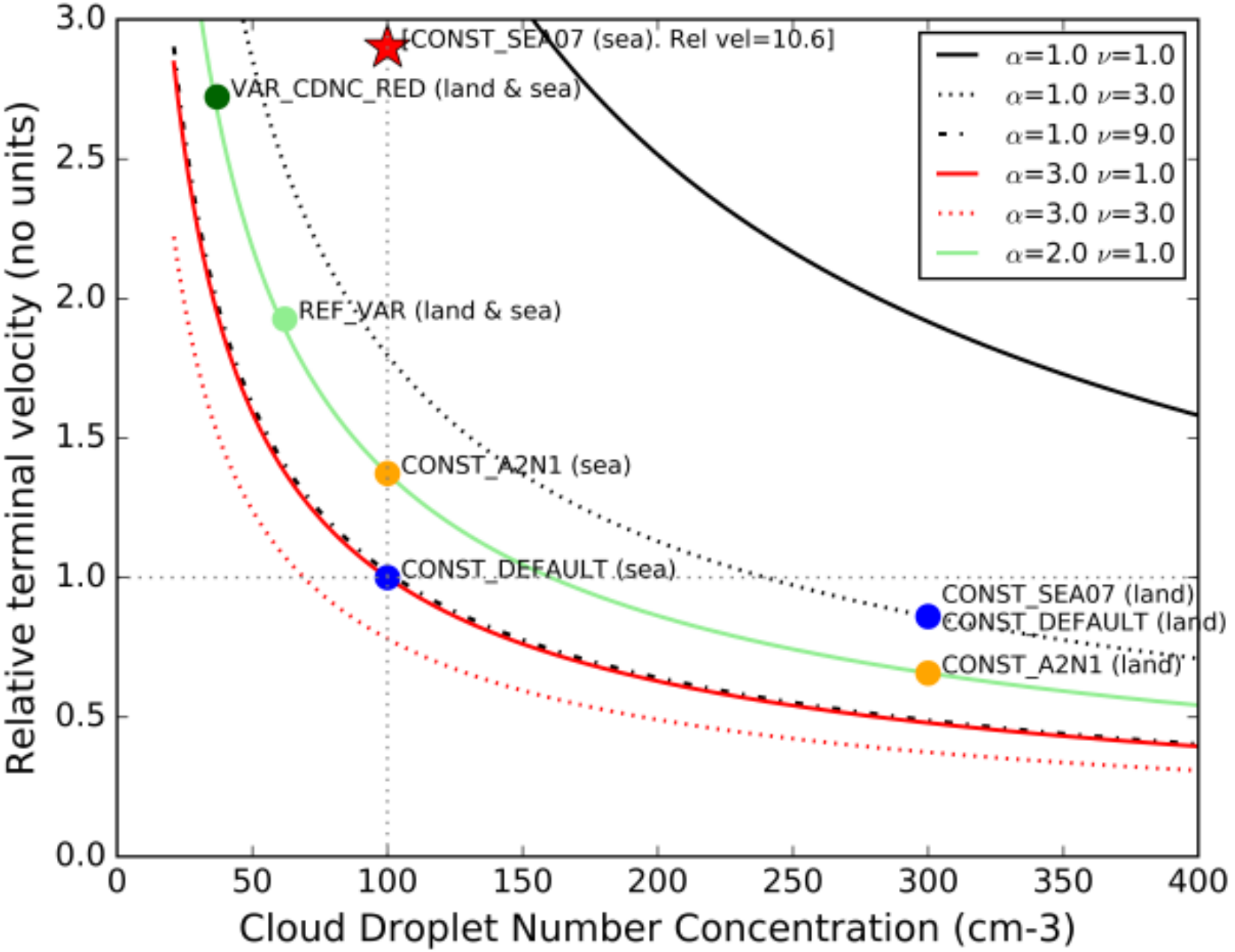
# Cloud Droplet Size Spectrum

$$n(D) = N \frac{\alpha}{\Gamma(\nu)} \lambda^{\alpha\nu} D^{\alpha\nu-1} \exp^{-(\lambda D)^{\alpha}}$$




**More sedimentation**

# Terminal Velocity - Sedimentation



# Sample Results

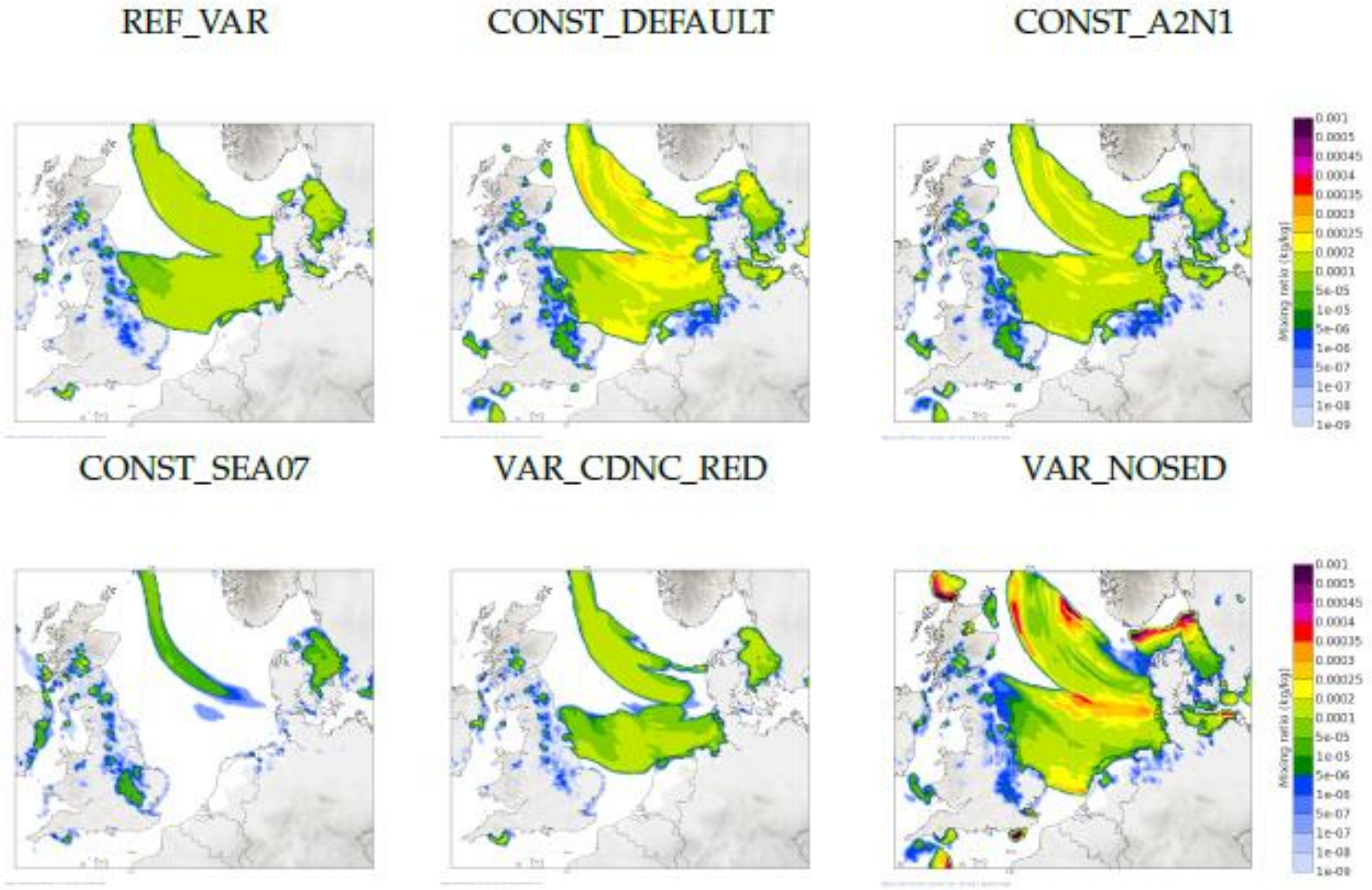



**Figure 9.** North Sea. Liquid-water mixing ratio at the lowest model level +023 (23/03/2012 at 11 UTC).

# Machine Learning for Fog

## Delays at Dublin Airport over dense fog

Anybody using the airport is being advised to check with their airline before travelling.

Apr 3rd 2018, 10:03 AM · 33,729 Views · 12 Comments · Share 28 · Tweet · Email 3

PEOPLE ARE BEING advised to check with their airline before travelling as some flights have been cancelled at Dublin Airport this morning.

In a tweet, Dublin Airport says the delays are due to dense fog on the airfield.

*Image: Sam Boal via RollingNews.ie*

- Dublin Airport
- Data driven approaches – ML
- Observations
- Imbalanced dataset
- Looking one hour ahead
- Focus on transitions

David McMahon et al.

MDPI

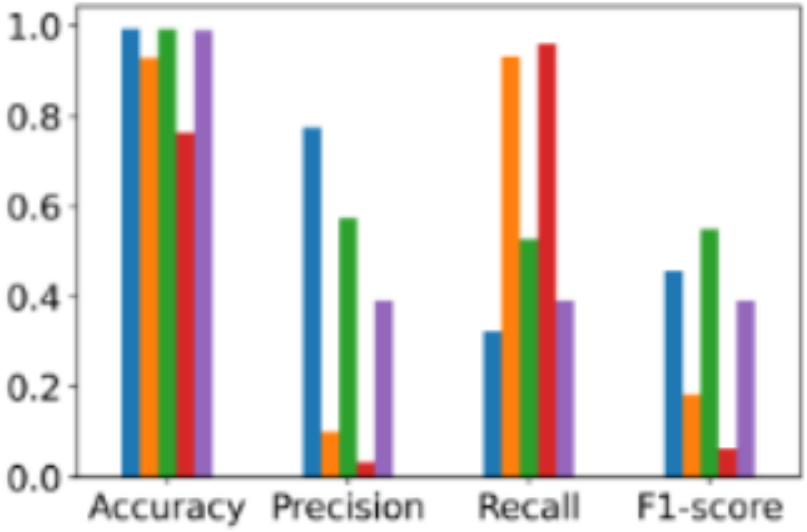
*Article*

### Part 1: Developments in Machine Learning for Forecasting Fog Conditions at Dublin Airport

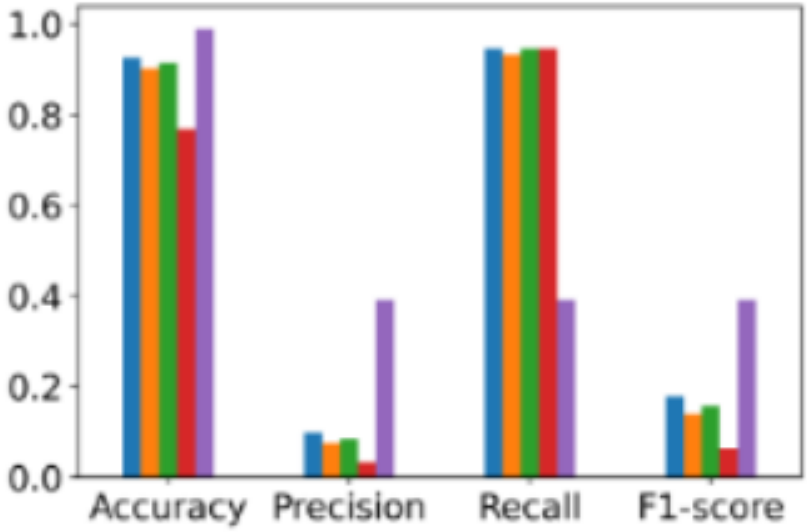
David J. McMahon [1,2], Kevin M. Devine [2,*], Ewa McAufield [2], Emily Gleeson [2], Tomás Ward [3,4], Kristian Pagh Nielsen [5]

1 SFI Centre for Research Training in Foundations of Data Science, Department of Mathematics and Statistics, University of Limerick, Limerick, V94 T9PX, Ireland
2 Met Éireann, 67 Glasnevin Hill, Glasnevin, Dublin 9, D09 Y921, Ireland
3 School of Computing, Dublin City University, Dublin 9, D09 Y074 Ireland
4 Insight SFI Research Centre for Data Analytics, Dublin City University, Dublin 9, D09 Y074 Ireland
5 Danish Meteorological Institute, Copenhagen, Denmark
* Correspondence: kevin.devine@met.ie

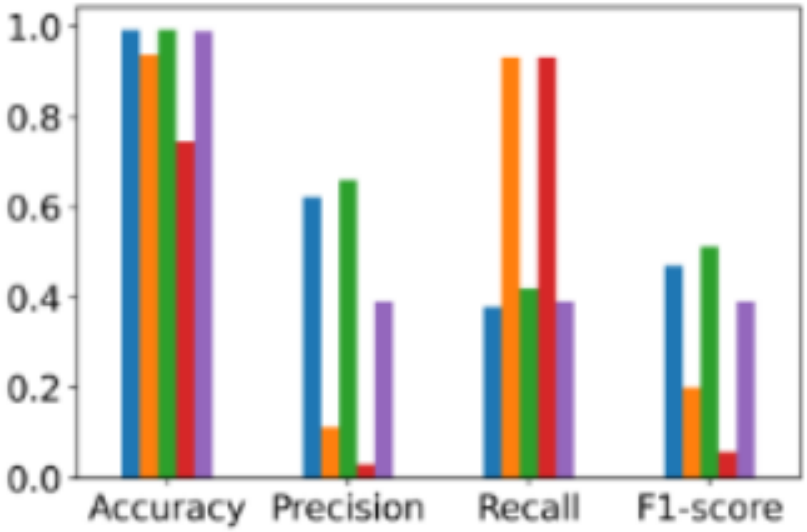
**Abstract:** This paper is part of a two part series on the work done on improving fog prediction within the HIRLAM Numerical Weather Prediction countries. Here the focus is on data-driven approaches based on machine learning techniques. The second paper in the series focusses on model-driven approaches. Using machine learning methods, we considered a novel approach to predicting low-visibility events. We considered the case of fog occurring in the next hour at Dublin Airport as a binary classification problem, using current and recent weather conditions as predictors.



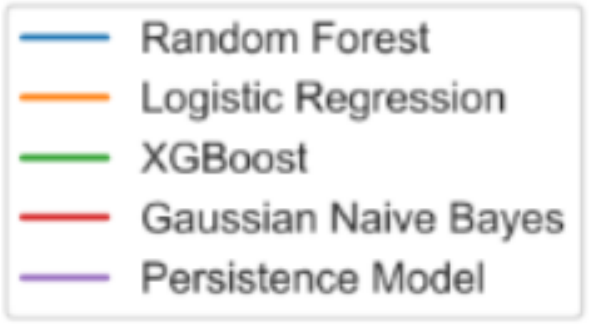

(a) Oversampling




(b) Undersampling




(c) SMOTE




Talk on this as part of the Met Éireann data science seminar on October 5th

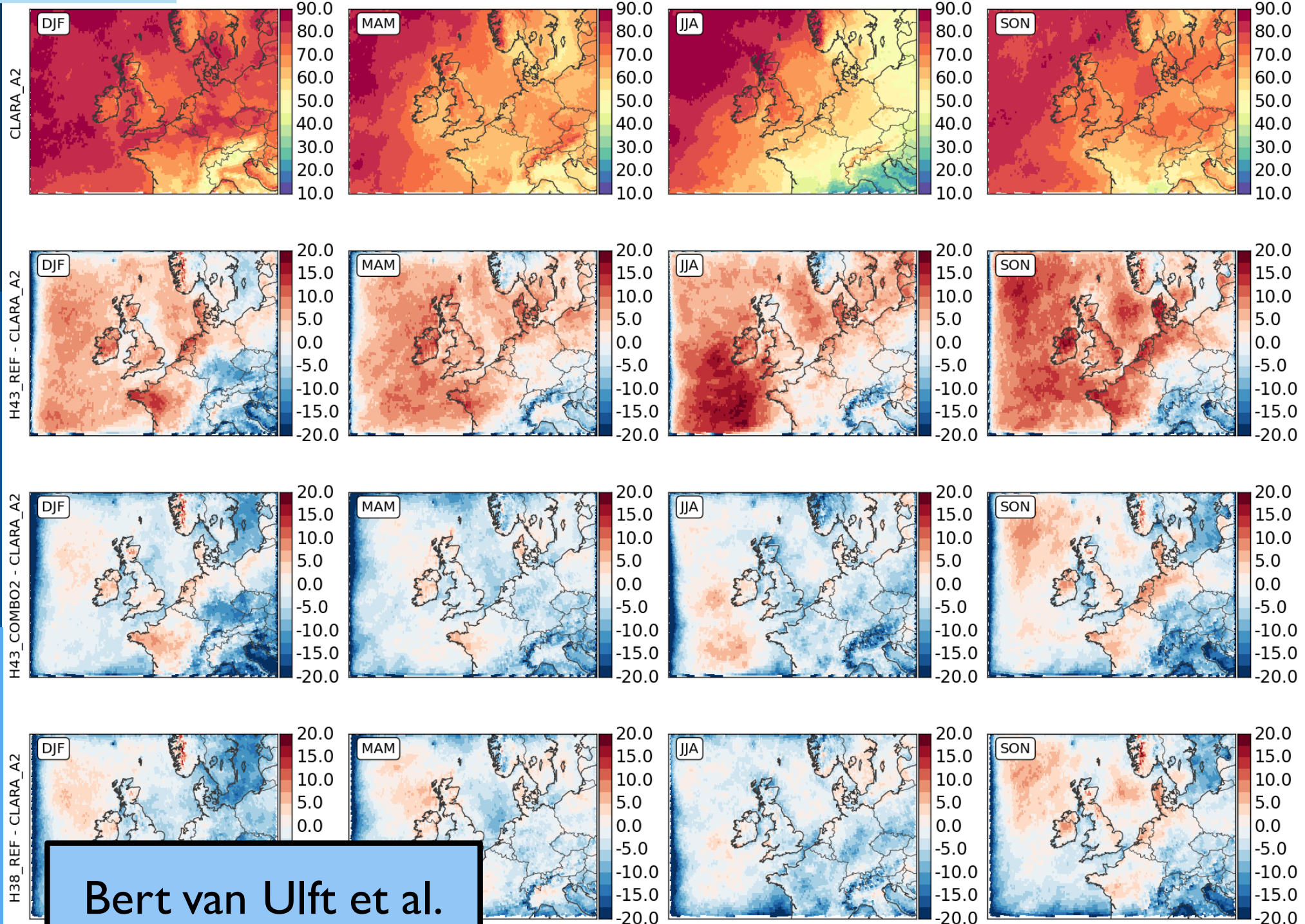
# Overview

- HARMONIE-AROME developments
- Work on fog
- Other topics
- Physics working week

# Model Testing

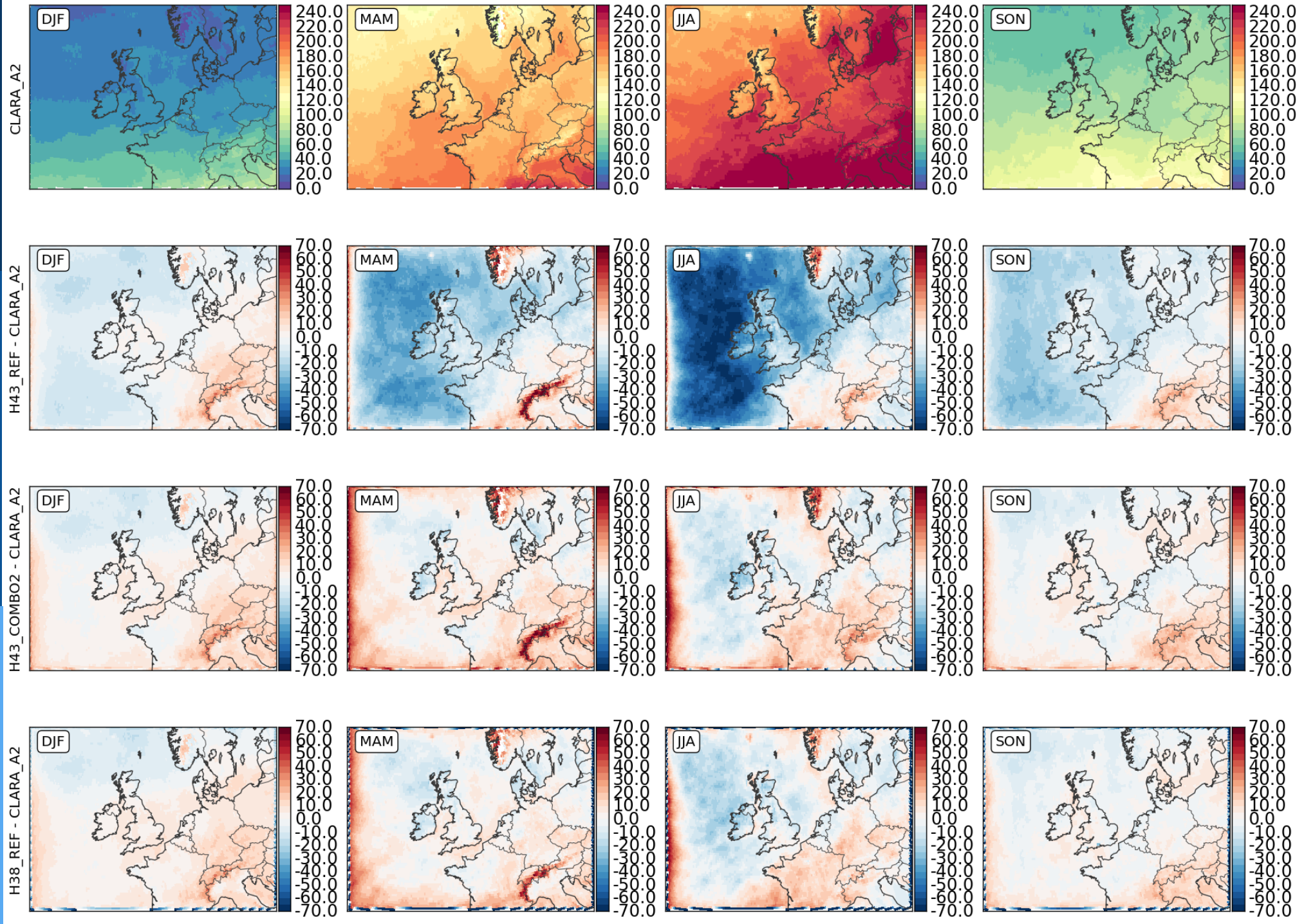
- HCLIM – climate mode
- Year long at 12 km in a day
- Test many settings quickly

# Cloud cover

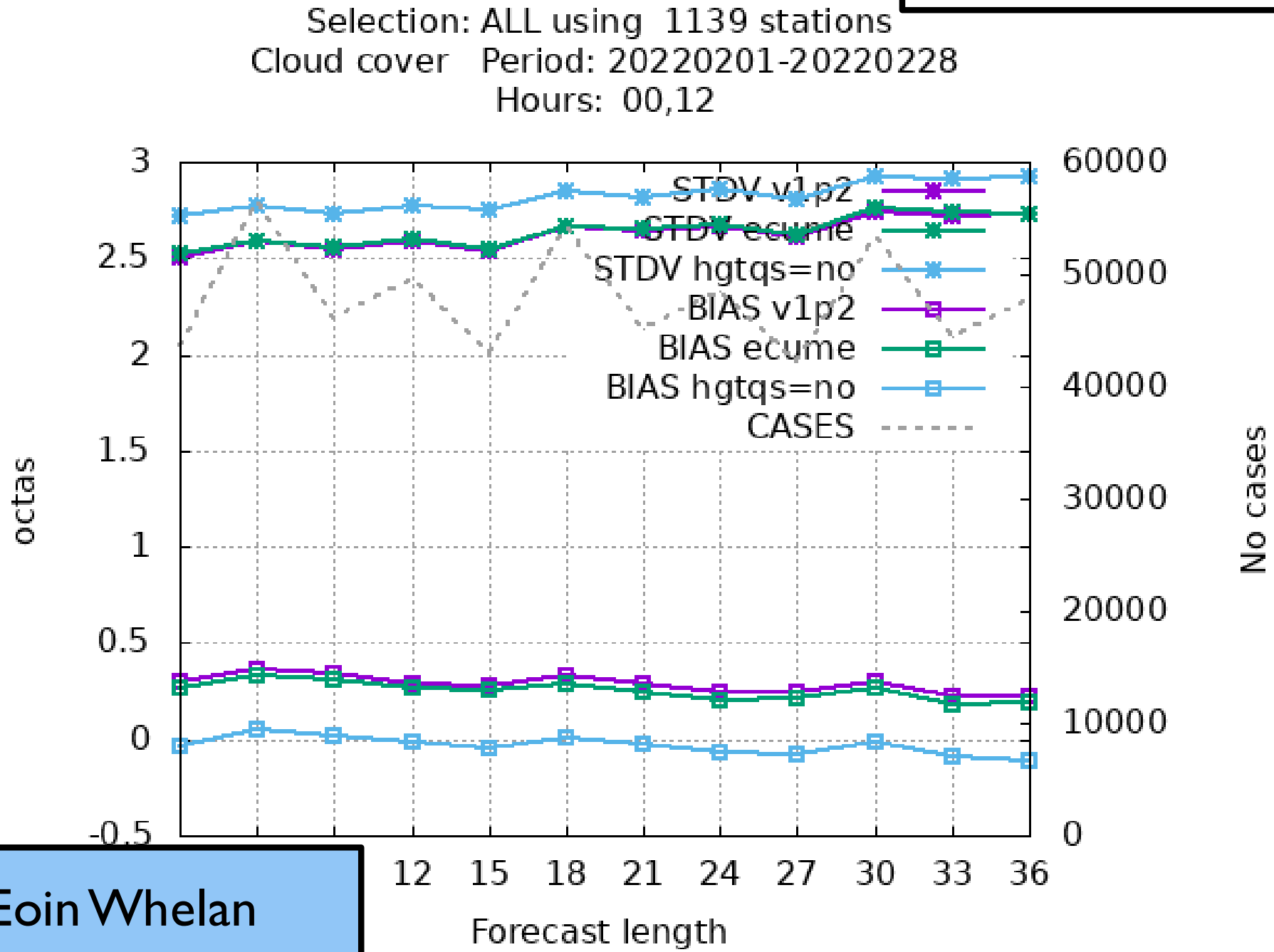



Bert van Ulft et al.

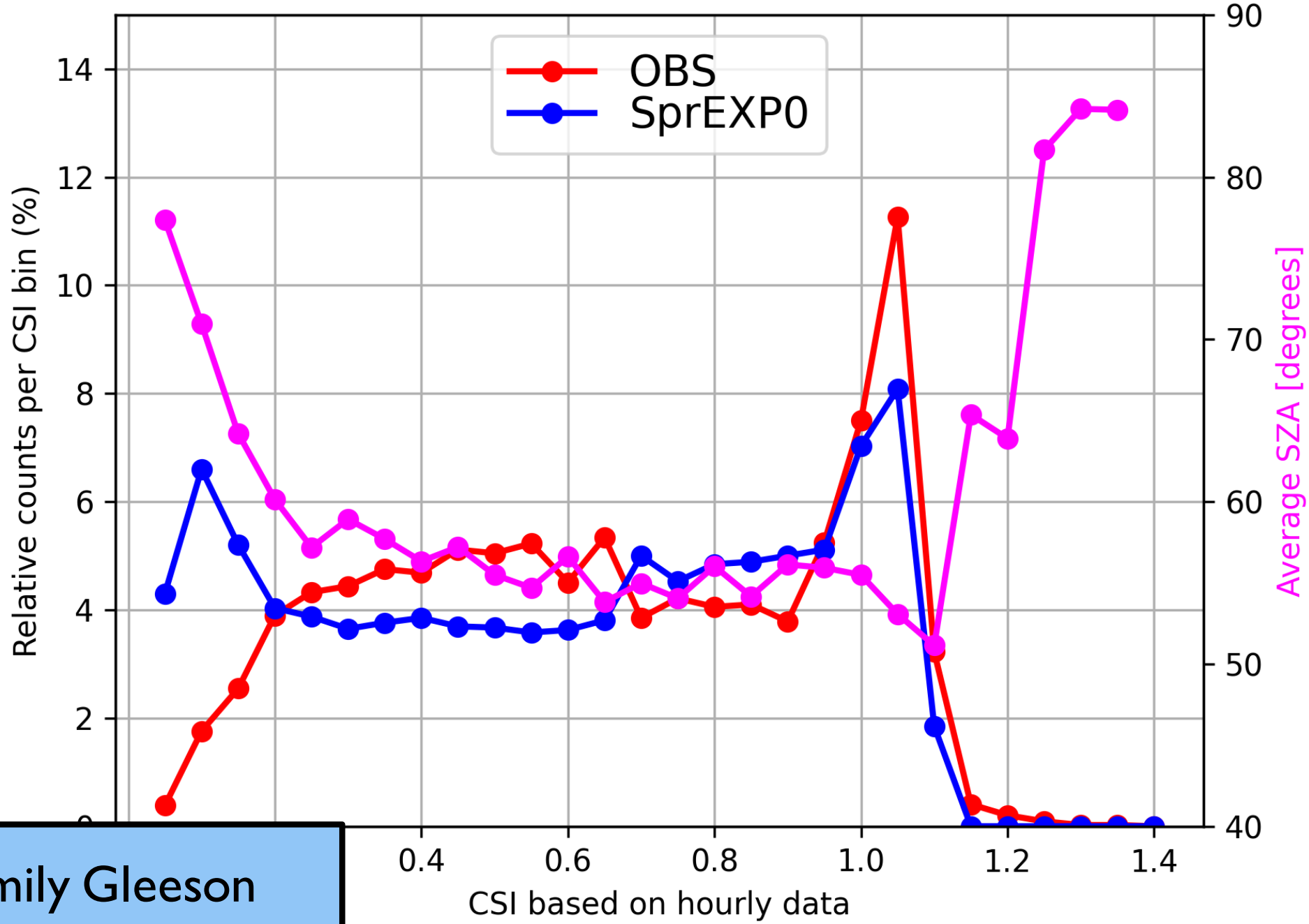
# SWD


CLARA_A2
H43_REF - CLARA_A2
H43_COMBO2 - CLARA_A2
H38_REF - CLARA_A2
DJF
MAM
JJA
SON
240.0 220.0 200.0 180.0 160.0 140.0 120.0 100.0 80.0 60.0 40.0 20.0 0.0
70.0 60.0 50.0 40.0 30.0 20.0 10.0 0.0 -10.0 -20.0 -30.0 -40.0 -50.0 -60.0 -70.0

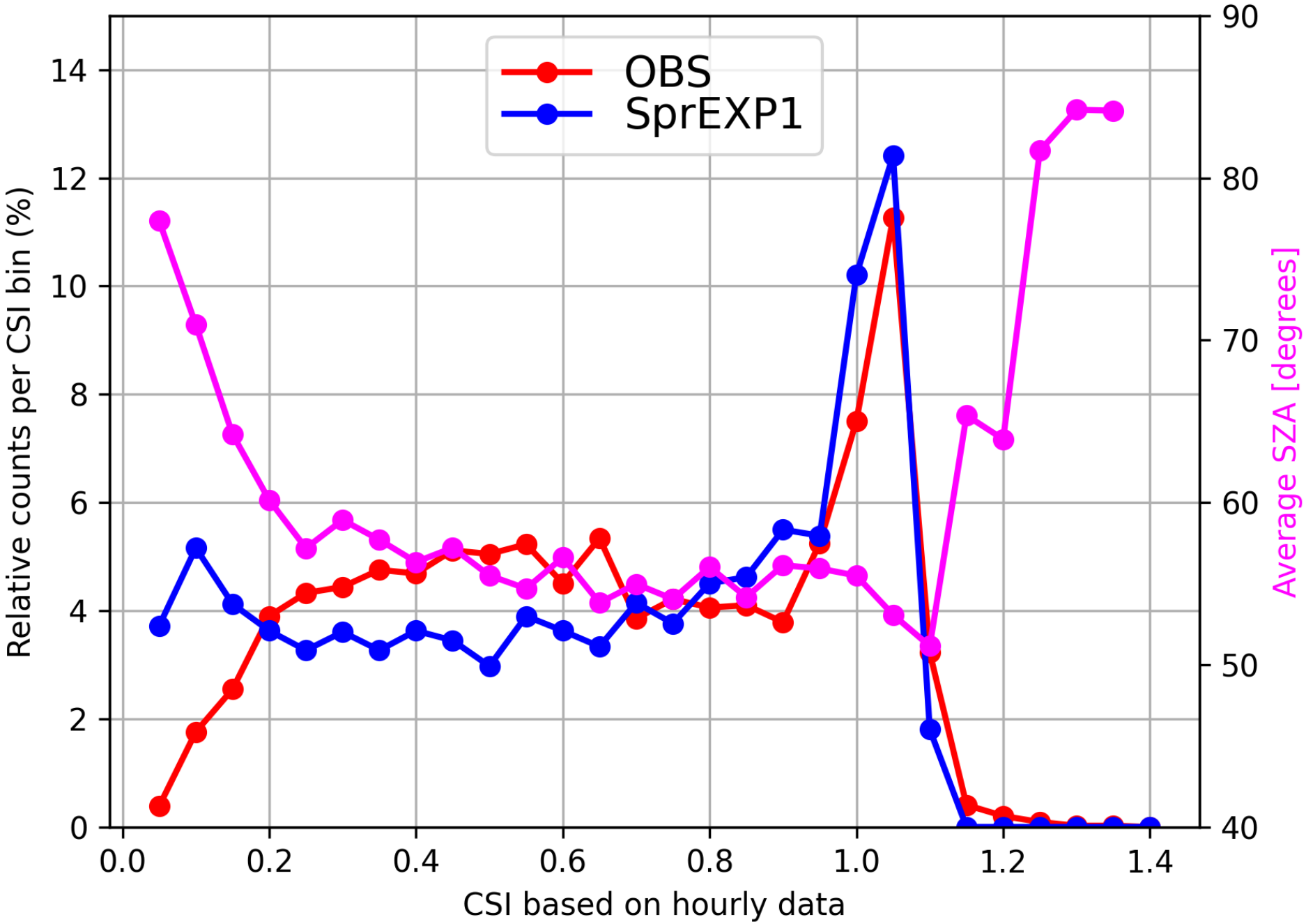
# DINI: Cloud Cover



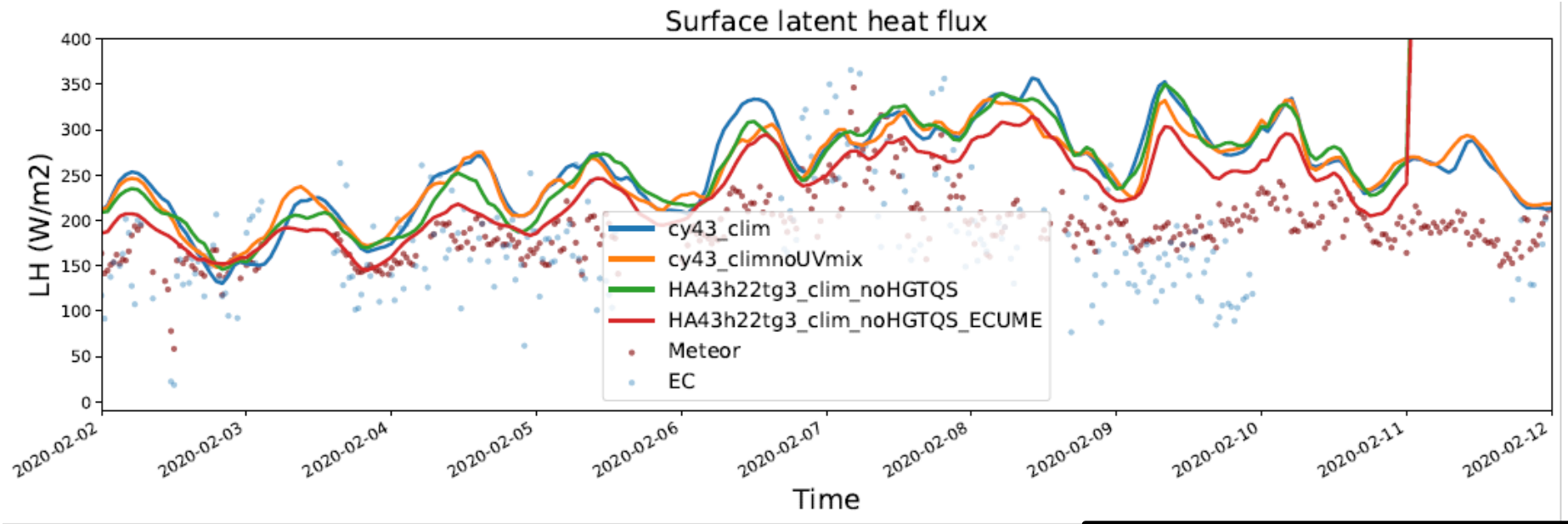

Eoin Whelan

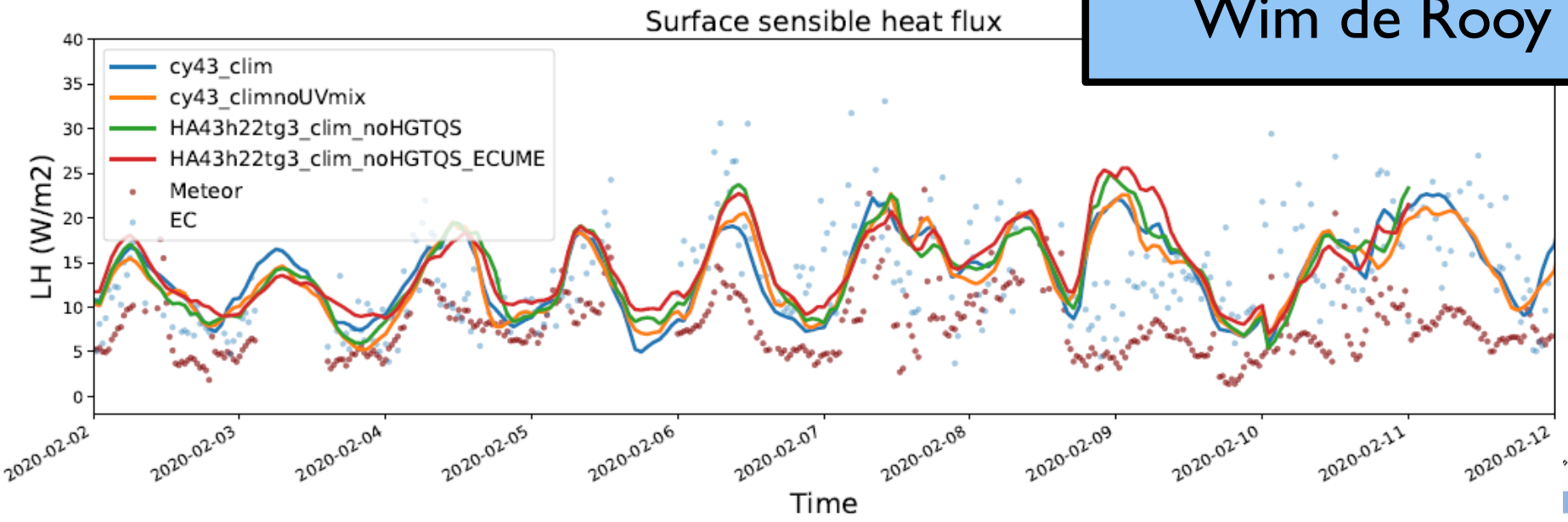



Emily Gleeson


OBS
SprEXP1
Relative counts per CSI bin (%)
Average SZA [degrees]
CSI based on hourly data
0
2
4
6
8
10
12
14
40
50
60
70
80
90
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4

# EUREC⁴A - Barbedos

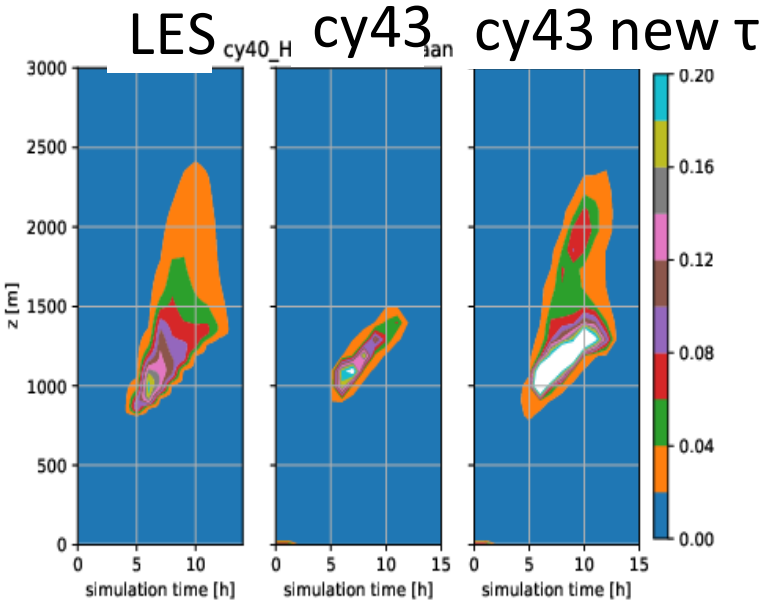



Wim de Rooy

# Some Other Topics

- EUREC$^4$A cloud validation HARMONIE-AROME (different options, including work on convection time scale, cloud organisation)
- EUREC$^4$A surface fluxes (deMott method and adding extra observation sets)
- Making turbulence and convection schemes scale adaptive for the grey zone.
- Code refactoring
- ML and radiation (optimized ecRad, Tripleclouds and SPARTACUS)
- Stochastic – intermittent turbulence
  - SBL




Wim de Rooy, Peter Ukkonen, Meto Shapkalijevski

# Overview

- HARMONIE-AROME developments
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# Physics Working Week

Oct 24-28th 2022

## Physical Parametrizations / Forecast Model Working Week

- When: October 24th to 28th 2022
- Where: Pembroke Hotel, Kilkenny, Ireland (ttps://www.pembrokekilkenny.com; https://kilkenny.com/). They offer a rate of 149 Euro per night (quote Met Éireann to get this rate).
- Meeting Rooms: Berkeley and Hoban suites
- Parking: They offer parking complimentary, some is available on site with additional parking in Jacob street which is a short 2-3 minute walk from the hotel.

## How to get there

- https://visitkilkenny.ie/getting-here/
- Taking a bus from Dublin Airport is probably the handiest option (www.jjkavanagh.ie or www.dublincoach.ie)

## Participants

| Name | Institute | In person or online | Accomodation |
|---|---|---|---|
| Emily Gleeson | Met Éireann | in person | |
| Bjørg Jenny Engdahl | MET-Norway | in person | hotel |
| Kristian Pagh Nielsen | DMI | in person | The Club House Hotel, October 23rd-28th |
| Oskar Landgren | MET Norway | in person | hotel |
| Wim de Rooy | KNMI | in person | hotel |
| Colm Clancy | Met Éireann | in person | |
| Eoin Whelan | Met Éireann | in person | will cherry-pick days to attend |
| Meto Shapkalijevski | SMHI | in person (aiming to) | hotel |
| James Fannon | Met Éireann | in person | |
| Ewa McAufield | Met Éireann | in person | |
| Bert van Ulft | KNMI | in person | hotel |
| Daniel Martin Perez | AEMET | in person | hotel |
| Rolf Heilemann Myhre | Met Norway | in person | |
| Panu Maalampi | FMI | awaiting confirmation | |
| Sebastián Contreras Osorio | kNMI | awaiting confirmation | |
| Natalie Theeuwes | KNMI | awaiting confirmation | |
| Yogesh V Kumkar | MET Norway | in person | |
| Geoffrey Bessardon | Met Éireann | in person | |
| Thomas Bieutord | Met Éireann | in person | |

# PhD Theses

**Improved predictions of supercooled liquid water and atmospheric icing in the HARMONIE-AROME weather prediction model**

**Bjørg Jenny Kokkvoll Engdahl**

Dissertation for the degree of Philosophiae Doctor (PhD)

Section for Meteorology and Oceanography

Department of Geosciences

University of Oslo

March 2021

**Advancing the capabilities of numerical weather prediction - On the utility of individual tendency output**

Marvin Kähnert

Dissertation for the degree of Philosophiae Doctor (PhD)
at the University of Bergen

2022

UNIVERSITY OF COPENHAGEN
FACULTY OF SCIENCE

ESCAPE 2

Horizon 2020 European Union funding for Research & Innovation

Danmarks Meteorologiske Institut

Ph.D. thesis

**Improving the trade-off between accuracy and efficiency of atmospheric radiative transfer computations by using machine learning and code optimization**

**Peter Ukkonen**

Supervisors:
Professor Eigil Kaas (NBI)
PhD Kristian Pagh Nielsen (DMI)

Submitted on: March 31, 2022

This thesis has been submitted to the PhD School of The Faculty of Science, University of Copenhagen

HIRLAM Limited Area Model