



# Some notions on the increasing role of Artificial Intelligence in the Atmospheric Sciences within Europe

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*Thanks to Monique Kuglitsch*

**Third ITU/WMO/UNEP workshop  
on AI for natural disaster  
management**

August 30, 2021

## *Contents talk*

Some background

How does Artificial Intelligence (AI) / Machine Learning (ML) play a role in the Atmospheric Sciences?

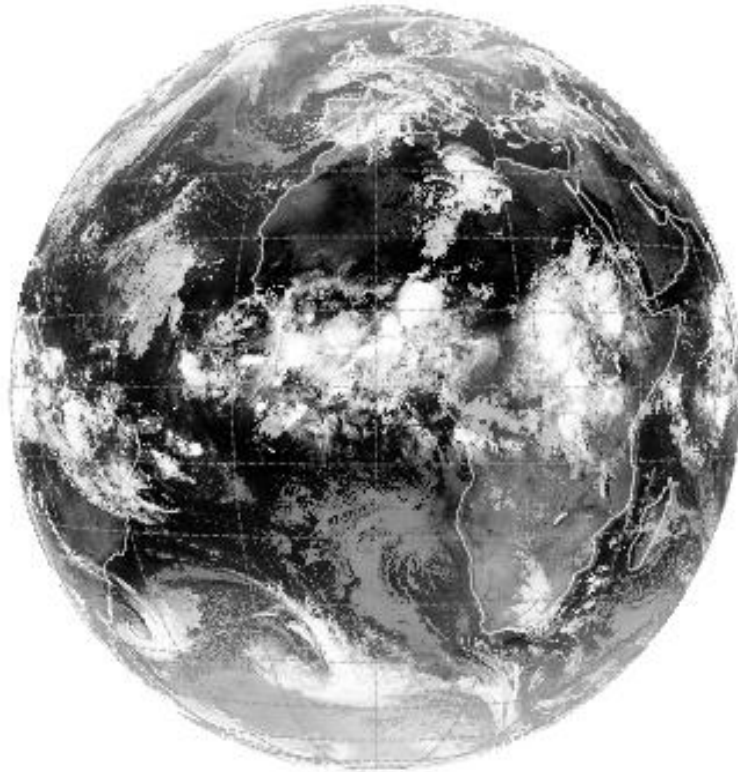
How is AI/ML being used within the EMS community?

# Silent Revolution in Meteorology

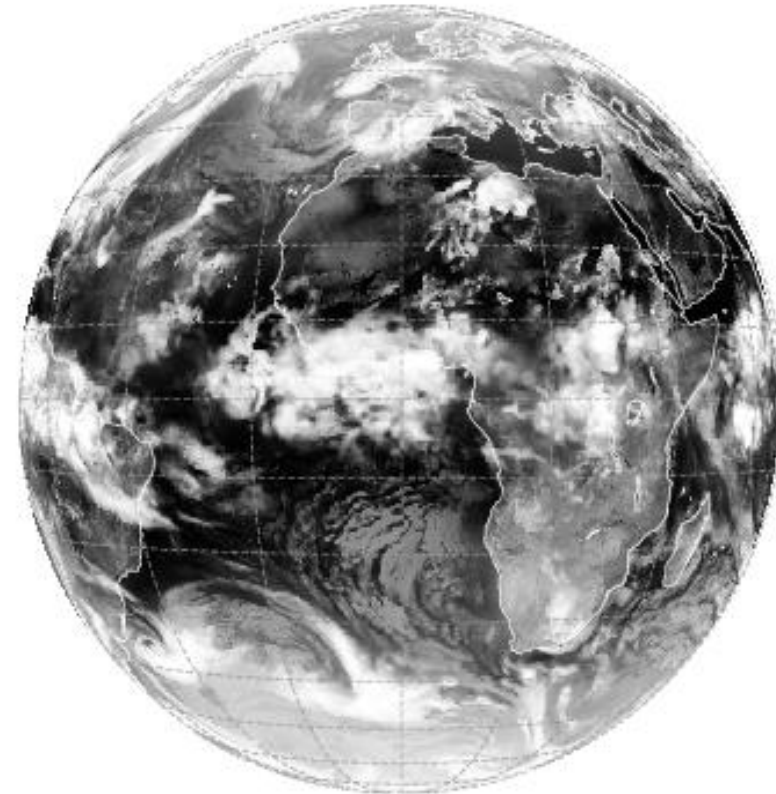
## The benefits of working together

### MeteoSat observations versus ECMWF predictions

**Meteosat 9 IR10.8 20080525 0 UTC**

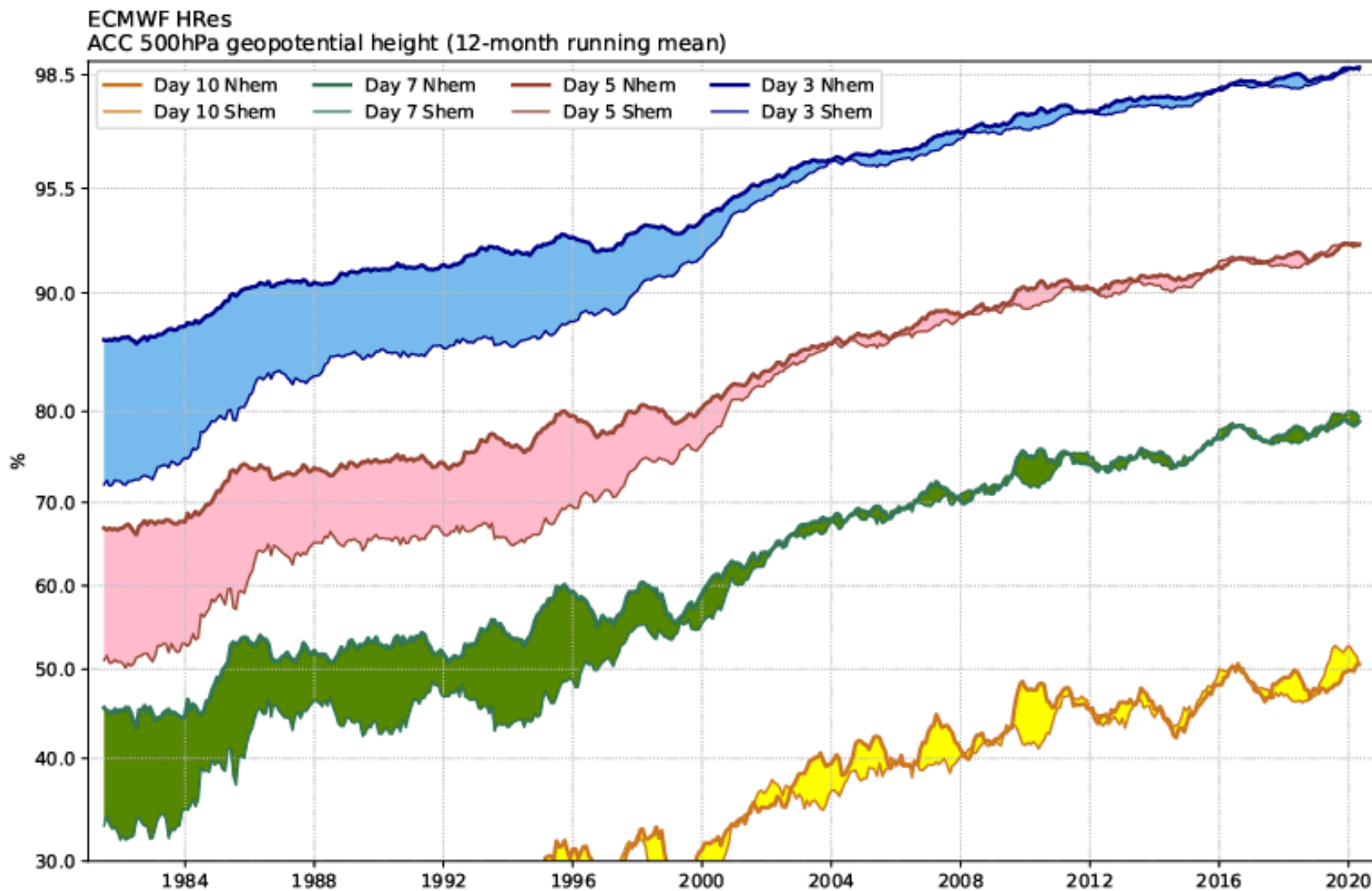


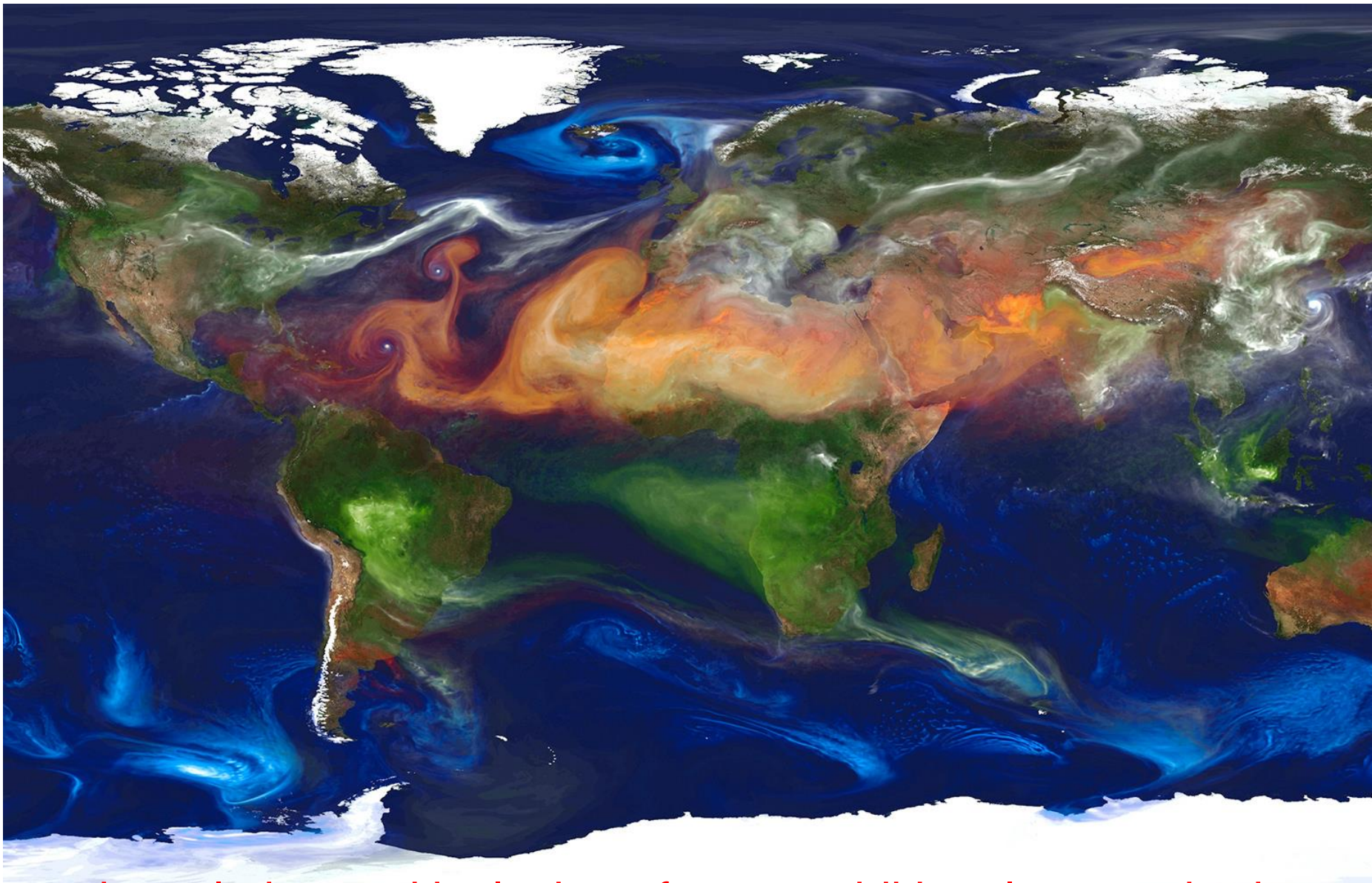
**ECMWF Fc 20080525 00 UTC+0h:**



(See also Bauer et al., 2015)

# Increase in numerical weather forecasting (NWP) performance on hemispheric scales during the years

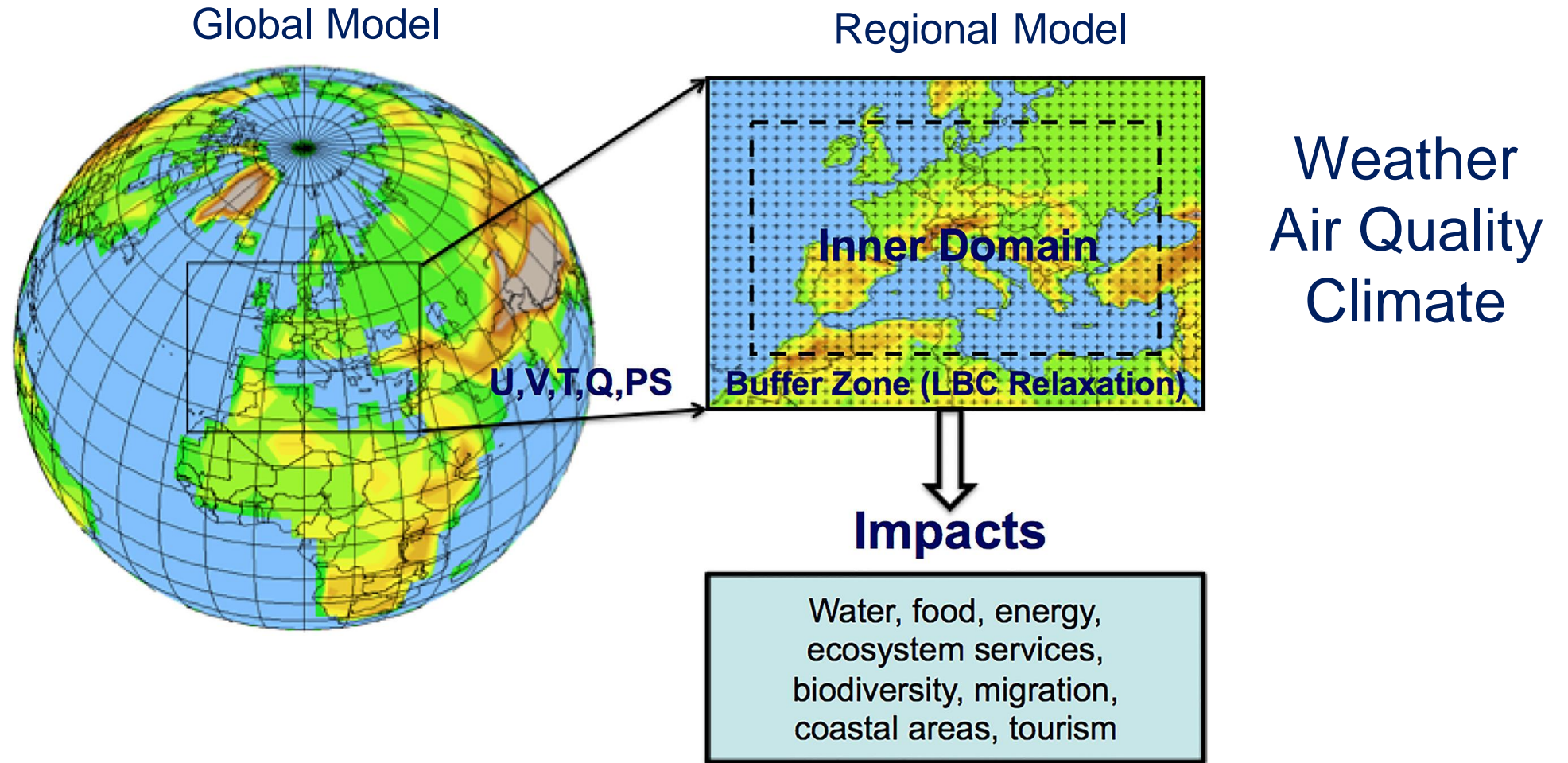




**Enhanced resolution and inclusion of many additional atmospheric processes**  
e.g. view of aerosol movement created by a coupled model

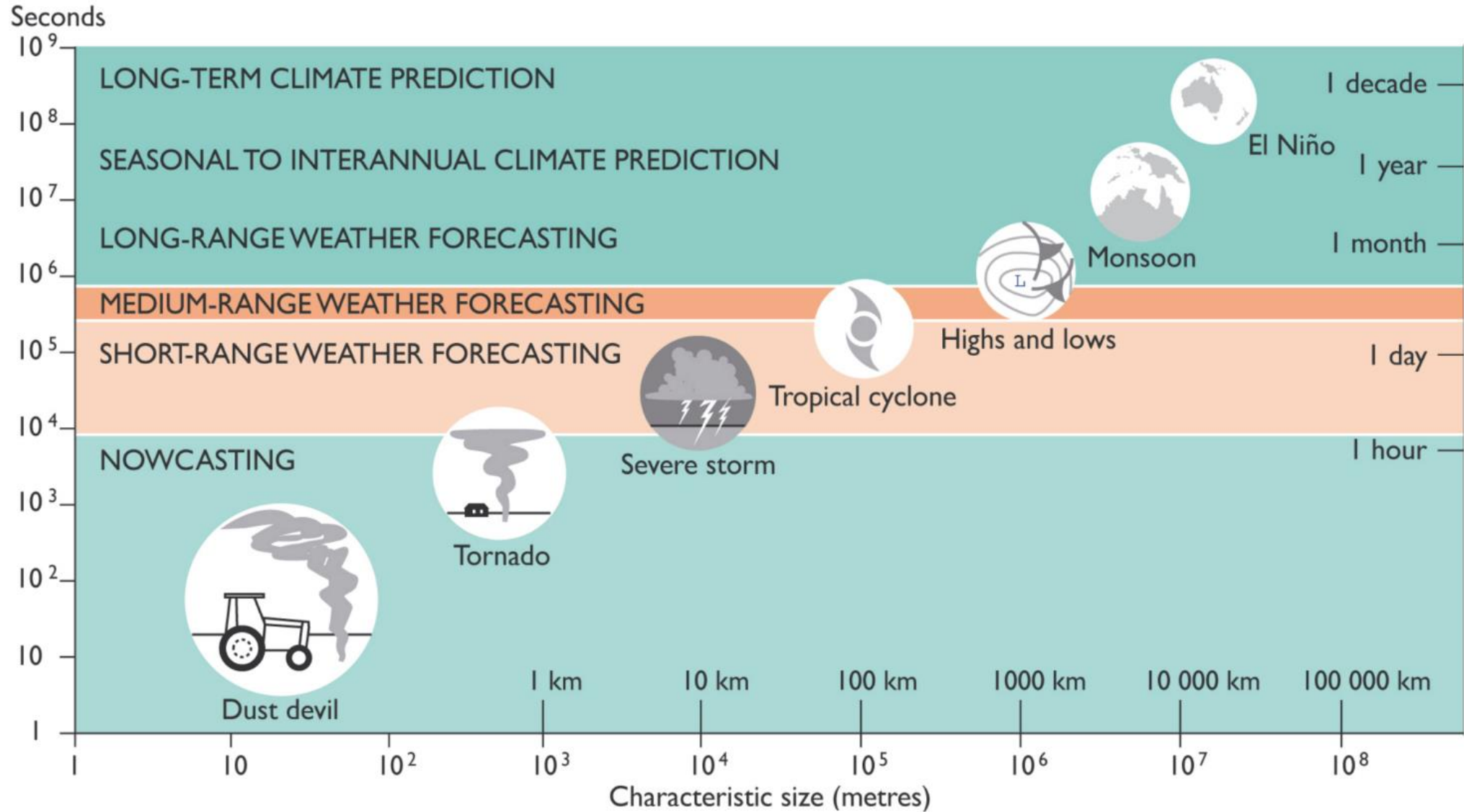
Credit: NASA/Goddard Space Flight Center

# Atmospheric modelling and downscaling (bridging to many applications)

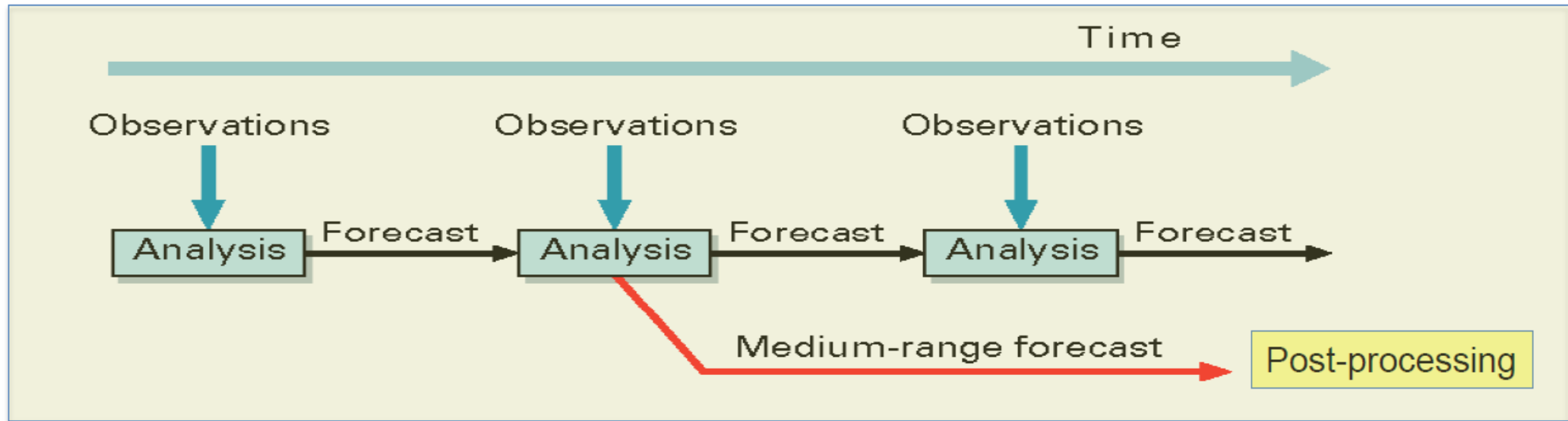


After Giorgi, F., JGR-A 2019, Thirty Years of Regional Climate Modeling:  
Where are we and where are we going next?

# Great Progress of Observations, Understanding and Prediction of Atmospheric Processes on many scales



Adapted from: Zillman, WMO Bulletin 48 (2), April 1999



All components of the NWP workflow can potentially be improved by ML technologies:

- a) **Observations**: Quality Control decisions, Bias correction, Observation operator
- b) **Forecast**: Model error correction, Model identification, model development
- c) **Analysis**: Model error estimation and correction, Model parameter estimation, linearised/adjoint models
- d) **Post-processing**: Ensemble/Determ. post-processing, Sig. Weather ident.,

(adapted from slides by Massimo Bonavita, ECMWF-ESA Workshop, Oct. 2020)



# Increasing role of Artificial Intelligence /Machine Learning applications

Enhancing Satellite Observation with Machine Learning

Hybrid Data Assimilation - Machine Learning Approaches

Enhancing the representation of small-scale processes

Forecasting with Machine Learning and Hybrid Models

Machine Learning for Post-Processing and Dissemination

Much of this is related to pattern recognition and downscaling

(See also ECMWF-ESA Workshops on Machine Learning for Earth System Observation and Prediction, held online 5-8 October 2020 and upcoming 15-18 November, 2021)

# Weather and Climate Challenges: Understanding and Representation of Fine-Scale Atmospheric Processes

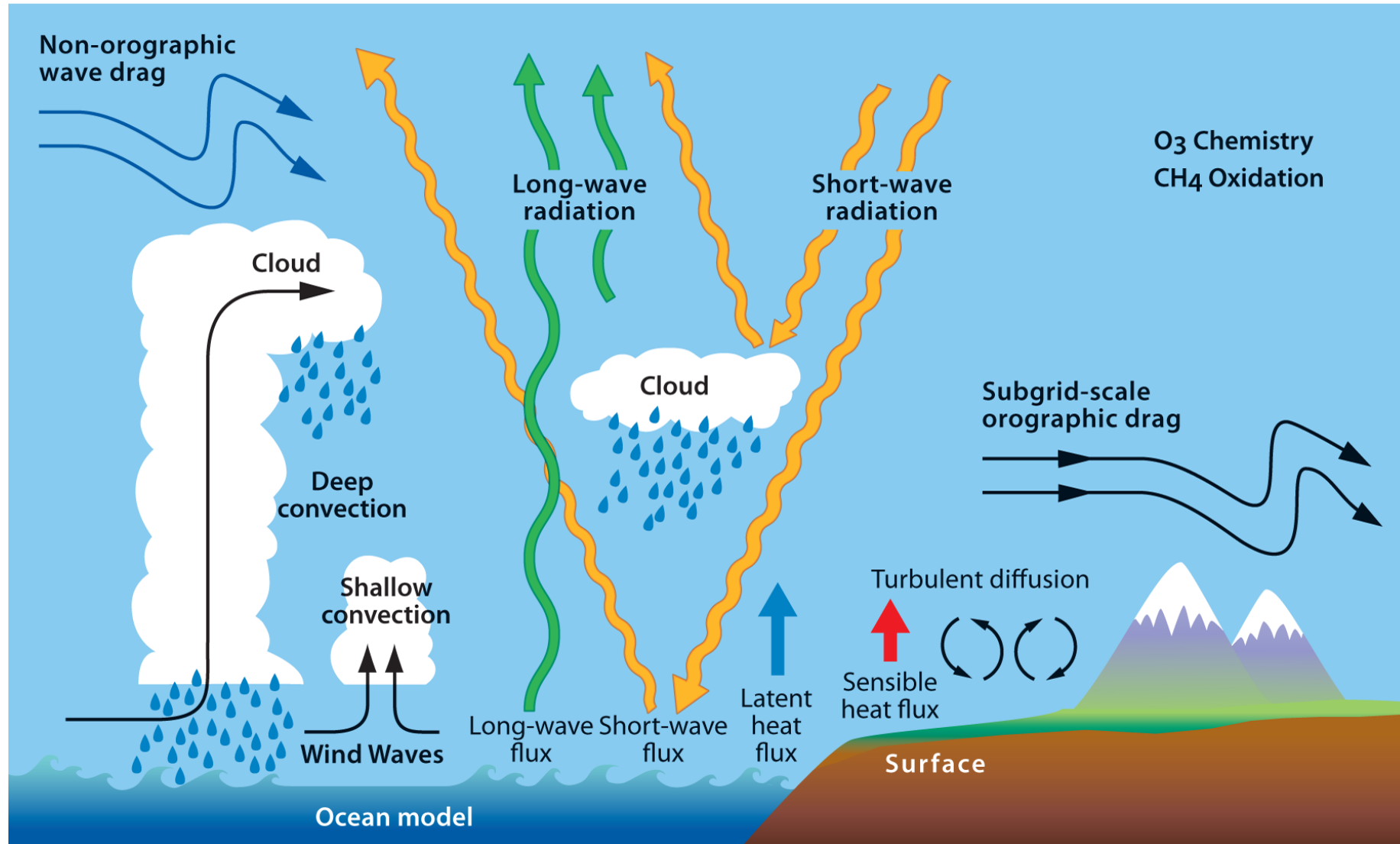


Figure Courtesy ECMWF

How can AI/ML help in making real progress for representing these processes?

# Ongoing questions in Meteorology where AI/ML can be of great help

How well can we predict severe weather on time to benefit users?

How does climate change impact on severe weather events?

How to support public understanding of weather and climate issues?



## Three killed as severe storm lashes Netherlands

*Air traffic, trains and buses halted nationwide after Code Red weather alert is issued for large parts of the country.*

18 Jan 2018



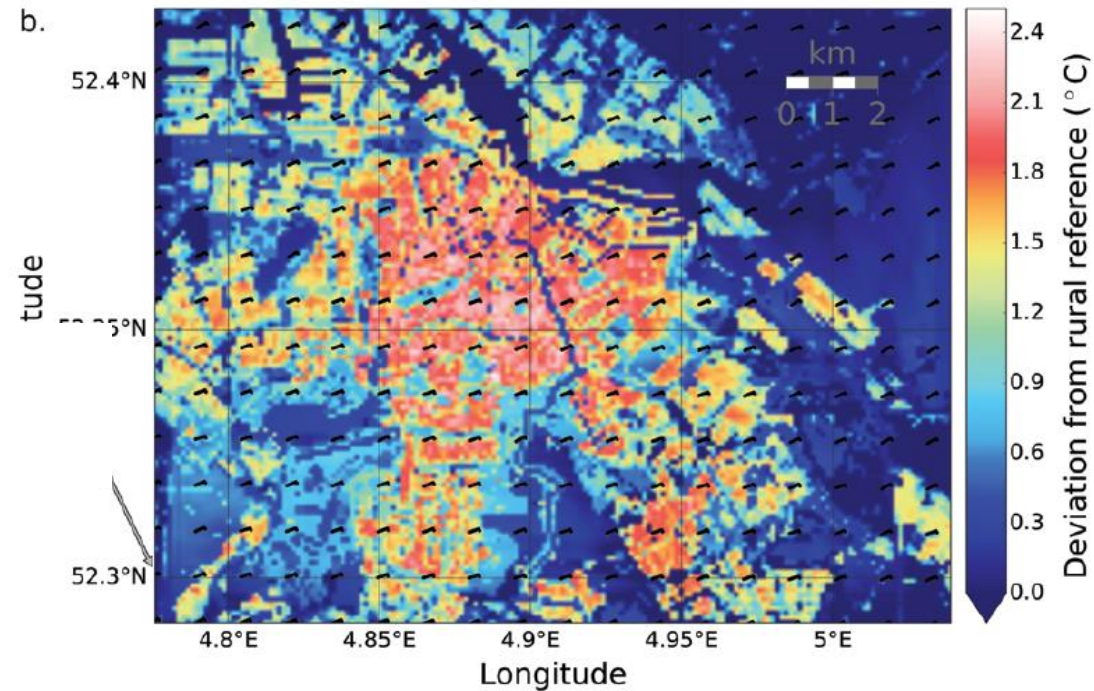
The Dutch meteorological institute KNMI issued a Code Red for the storm, bringing wind speeds up to 140 kp/h [EPA]

## 'Summer in the city'

Development of an urban weather forecasting system for Amsterdam and the application of citizens data



Typical weather forecast for rural areas



Forecasts on urban street level (~100 m) reveals weather conditions with unprecedented detail (Ronda et al., BAMS, 2017)

How can AI/ML help improving this further?

# Sustainable Energy Resources also request very fine scale weather forecasting and help of AI/ML



<https://www.impa.com/solar>



[https://greenliving.lovetoknow.com/Pros\\_and\\_Cons\\_of\\_Wind\\_Energy](https://greenliving.lovetoknow.com/Pros_and_Cons_of_Wind_Energy)

Impact of solar and wind energy farms can also be significant on local and regional weather and climate

*A special session on AI/ML at upcoming EMS conference, “Machine Learning and Computer Vision in Weather and Climate” (OSA1.8), September 3-10, 2021 for the first time*

5 talks on Machine Learning in NWP Postprocessing

3 talks on Machine Learning in Nowcasting

3 talks on Other Aspects of Machine Learning

(including understanding the relationship between clouds and surface downward radiation forecast errors)

In addition, several other talks on *AI/ML in 10 other sessions*

## *Take home points:*

Artificial Intelligence (AI) / Machine Learning (ML) plays an increasing role in the atmospheric sciences within Europe

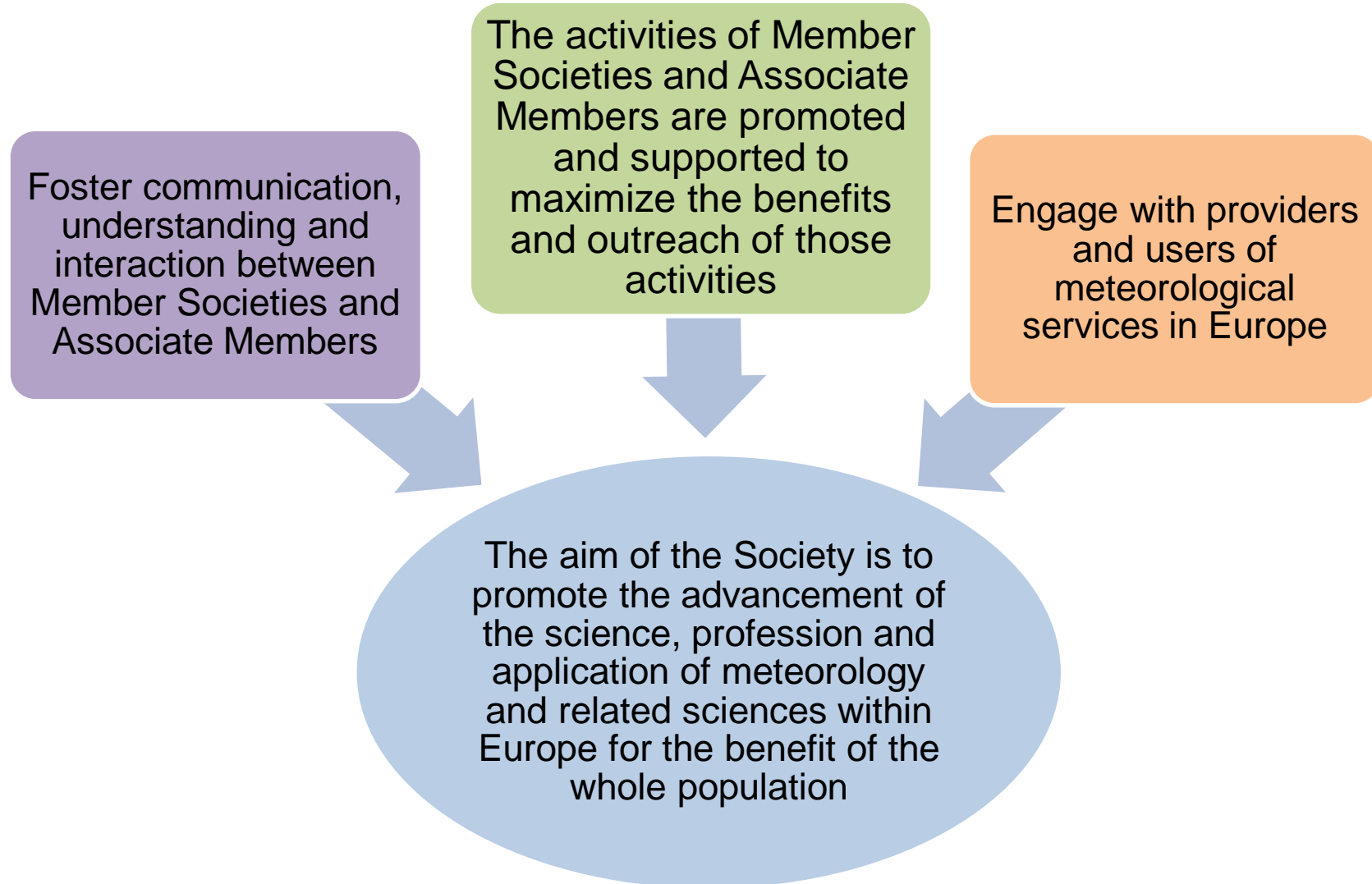
Working together in Meteorology has been very successful in progressing observations, understanding and forecasting

Use of AI/ML is expected to further enhance progress in Meteorology  
(but see the raised questions in this talk)

EMS strongly supports the works and outreach of AI/ML!

# *EMS: A society of societies in Europe*

## **Mission and Objectives**



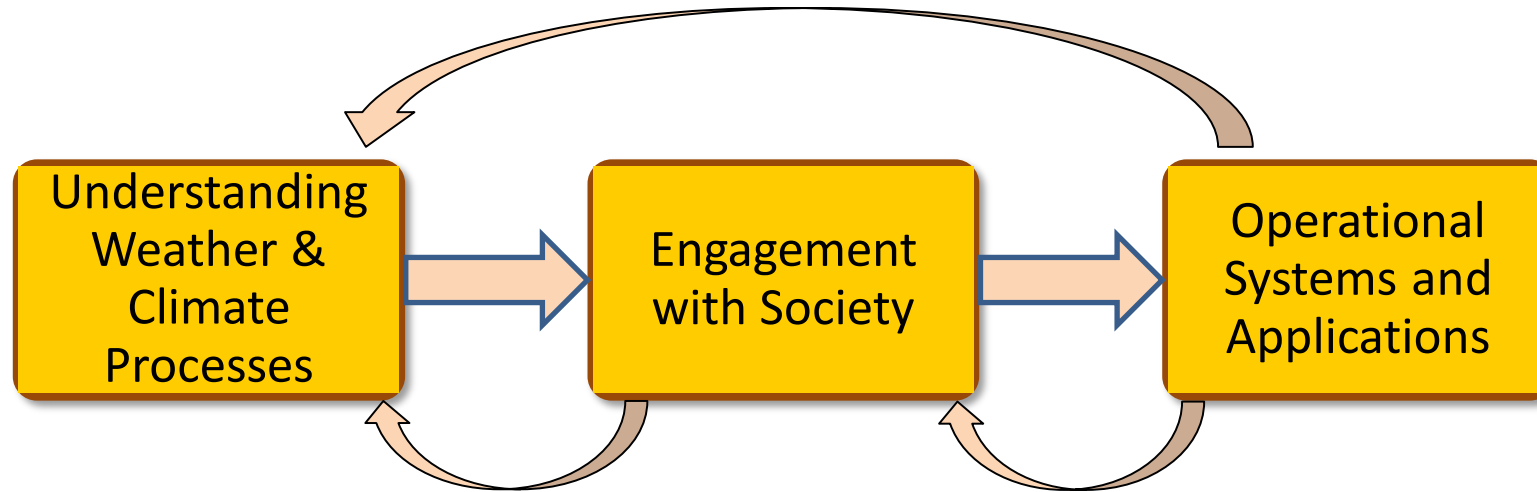


# The Membership of the EMS

(founding process was completed in 1999)

- National and regional Meteorological societies in Europe (WMO RA VI): currently 38 Member Societies
- Strongly supported by Associate Members, currently 31; organisations with an interest in the aims of the EMS:
  - national meteorological and hydrological services
  - companies with interest in meteorology, related sciences and their applications
  - research and education institutes and departments
  - European-wide bodies with similar interests
  - non-European meteorological societies

# EMS Annual Meeting Programme Structure



## And horizontal grand items

