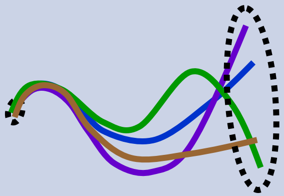
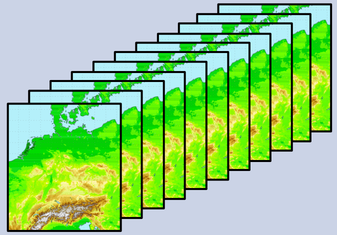




Limited-area ensembles:

finer grids & shorter lead times

Susanne Theis

COSMO-DE-EPS project leader

Deutscher Wetterdienst

Thank You

Neill Bowler et al. (UK Met Office)

Andras Horányi et al. (Hungarian Meteorological Service)

Trond Iversen and Jørn Kristiansen (Norwegian Meteorological Institute)

Chiara Marsigli and Tiziana Paccagnella (ARPA SIMC)

Olivier Nuissier et al. (Meteo France)

Axel Seifert (Deutscher Wetterdienst)

Presentation Overview

- ➔ introduction to limited-area ensembles
- ➔ finer grids – what do they promise?
- ➔ predictability issues
- ➔ constructing limited-area ensembles
- ➔ probability maps – aim at finest grid?

Introduction to

Limited-Area Ensembles

Limited-area ensembles

➔ computing resources are limited

➔ compromise between
grid size / number of members / model complexity
etc

Limited-area ensembles

- ➔ computing resources are limited

- ➔ compromise between
  grid size / number of members / model complexity
  etc

Limited area allows for finer grid

Limited-area ensembles

➔ driven by members of **global ensemble**

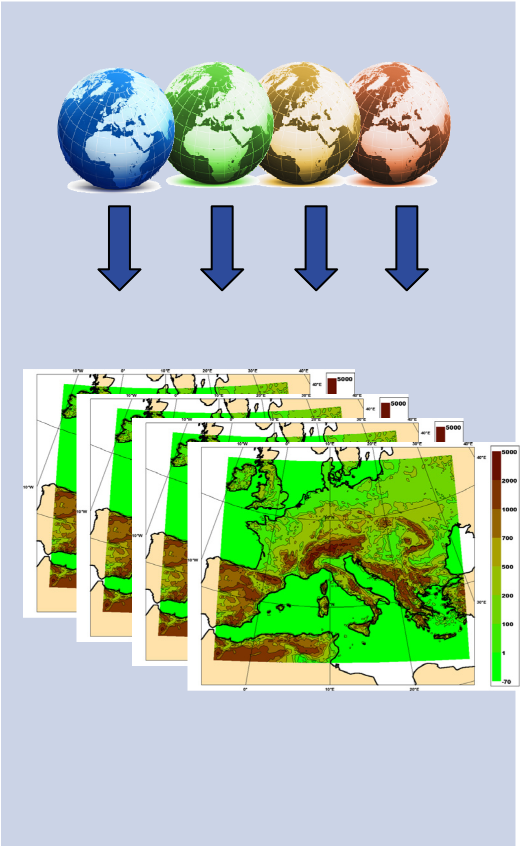
➔ **„dynamical downscaling ensemble"**

➔ plus other perturbations

➔ **today in Europe:**

more than 10 different ensemble systems

(Marsigli et al. 2005, Frogner et al. 2006, Bowler et al. 2008, etc)



Limited-area ensembles in Europe („large“ domains)

system	grid size	lead time	father EPS (global)
MOGREPS-R	18 km	2.25 days	MOGREPS-G
COSMO-LEPS *	7 km	5.5 days	ECMWF EPS selection
GLAMEPS	13 km	1.75 days	ECMWF EPS (v0: EuroTEPS)
LAMEPS #	12 km	2.5 days	ECMWF / EuroTEPS
ALADIN-HUNEPS *	12 km	2.5 days	PEARP
ALADIN-LAEF	18 km	2.5 days	ECMWF EPS selection
COSMO-SREPS *	7 km	2 days	multi-model
AEMET-SREPS	0.25°	3 days	multi-model

* central / southern
\# northern

+ *SRNWP-PEPS*

Limited-area ensembles in Europe („small“ domains)

system	grid size	convection-permitting	lead time	status
MOGREPS-UK	2.2 km	yes	1.5 days	development
AROME-EPS	2.5 km	yes	1.5 days	development
COSMO-DE-EPS	2.8 km	yes	21 hours	running
DMI-EPS	0.05°	no	1.5 days	running
UMEPS	4km	no		research
…	…	…	…	…

Limited-area ensembles in Europe („small“ domains)

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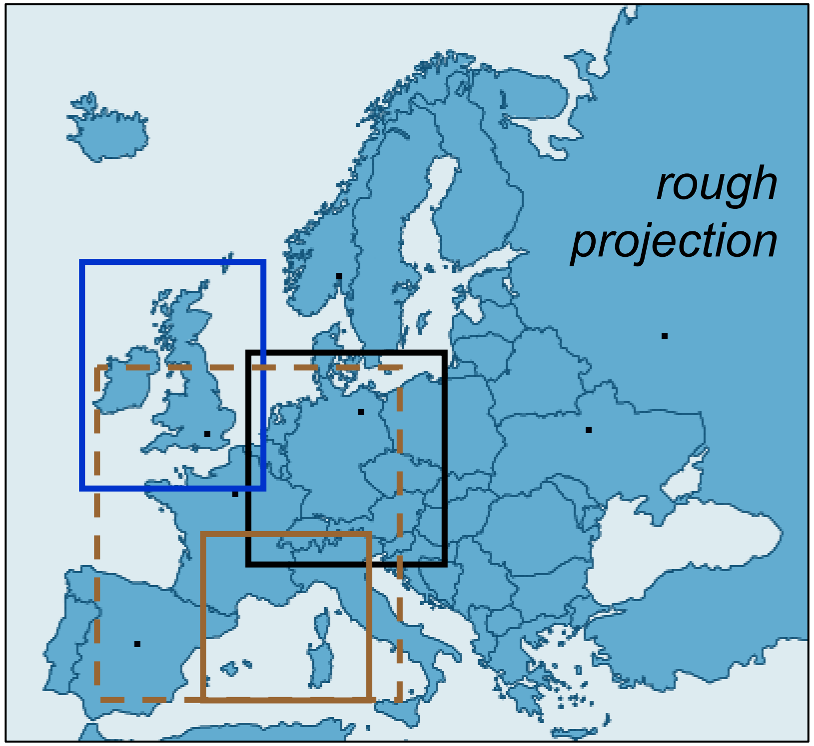


MOGREPS-UK

COSMO-DE-EPS

AROME-EPS
- HyMeX campaign
- future operational

Finer Grids

- what do they promise?

Finer Grids

- what do they promise?

Examples from ALADIN-HUNEPS, COSMO-LEPS, UMEPS

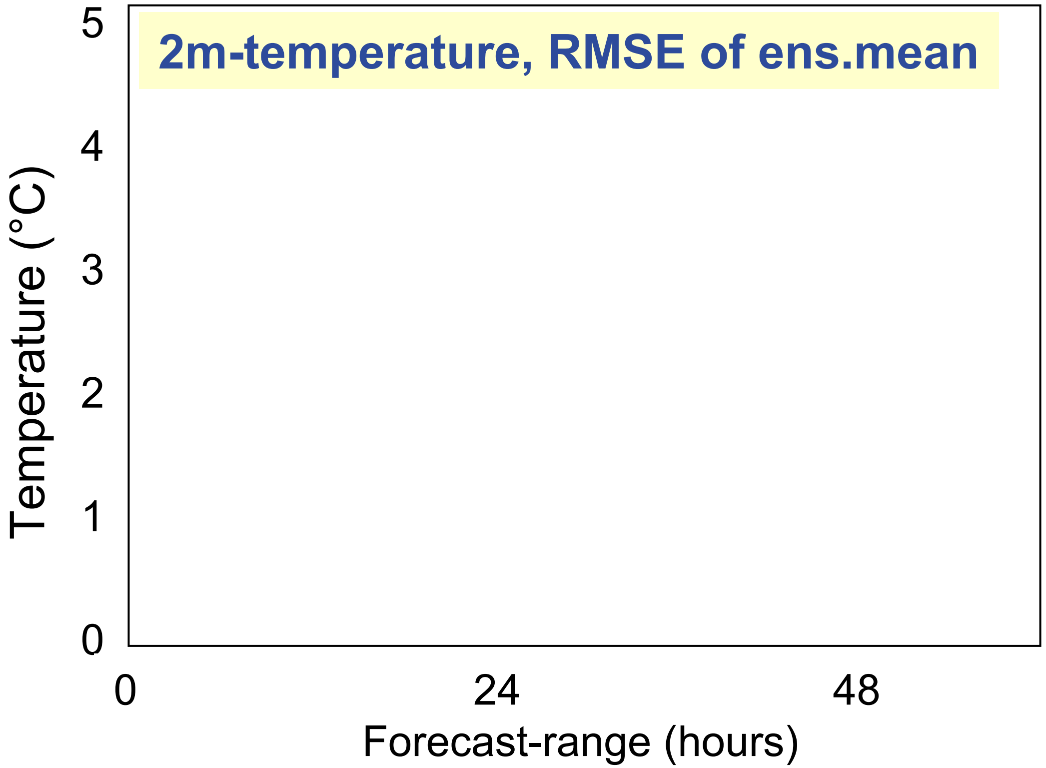
Benefit shown by verification (ALADIN-HUNEPS)

Horányi et al. (2011),
Tellus 63A: 642-651.
DOI: 10.1111/j.1600-0870.2011.00518.x
Figure 5 (right)

Latest developments around the ALADIN operational short-range ensemble prediction system im Hungary

grid size: **12 km**

Benefit shown by verification (ALADIN-HUNEPS)



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schematic reproduction of some features in original figure

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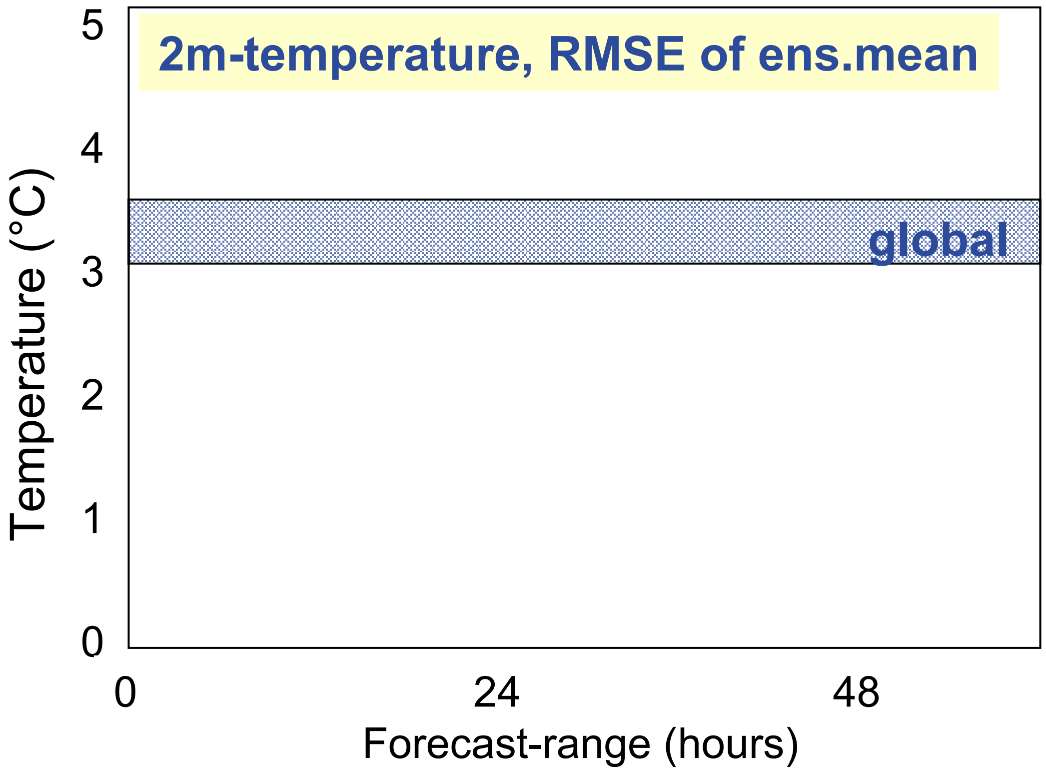

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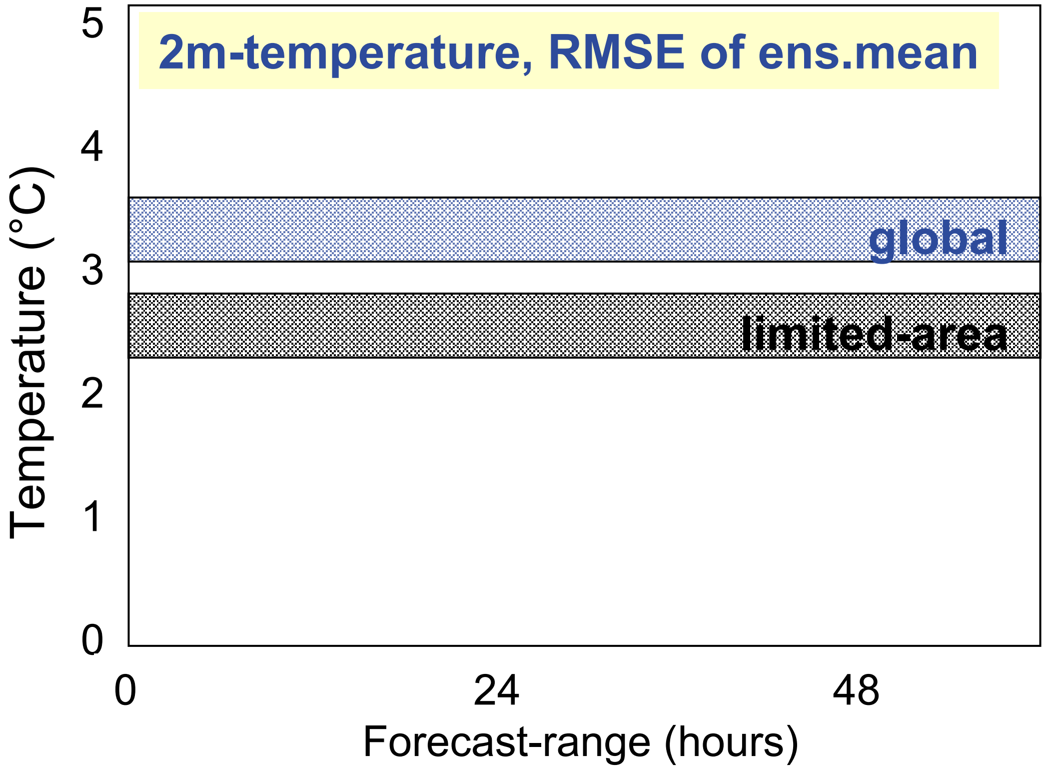

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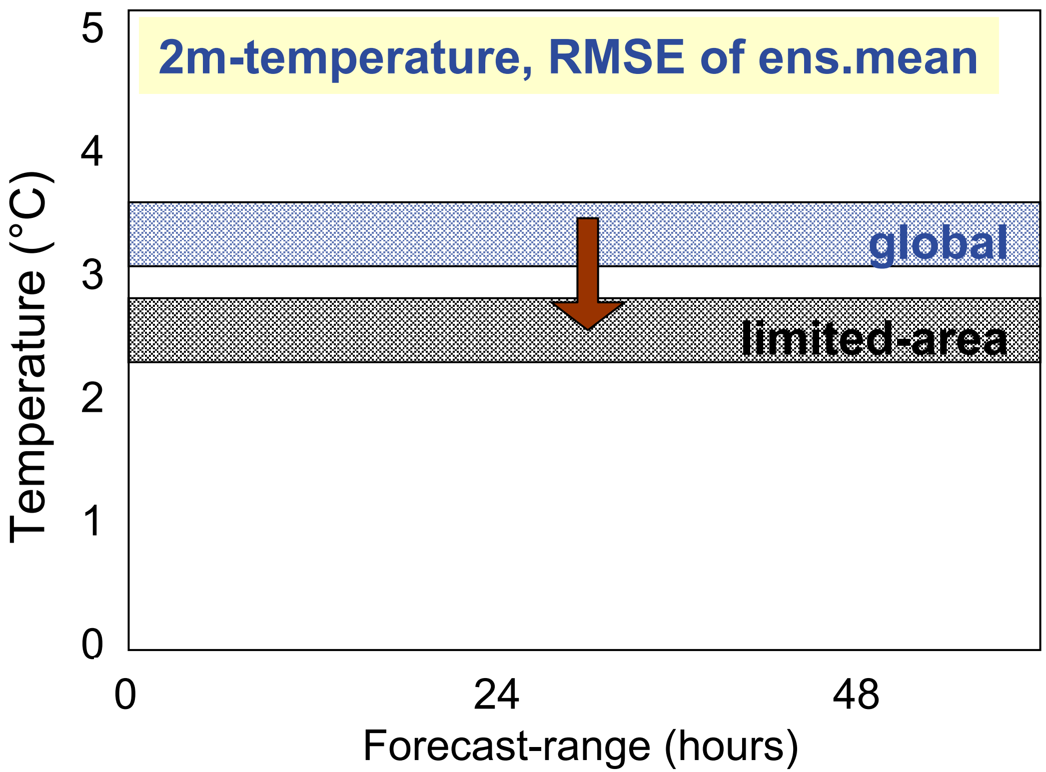

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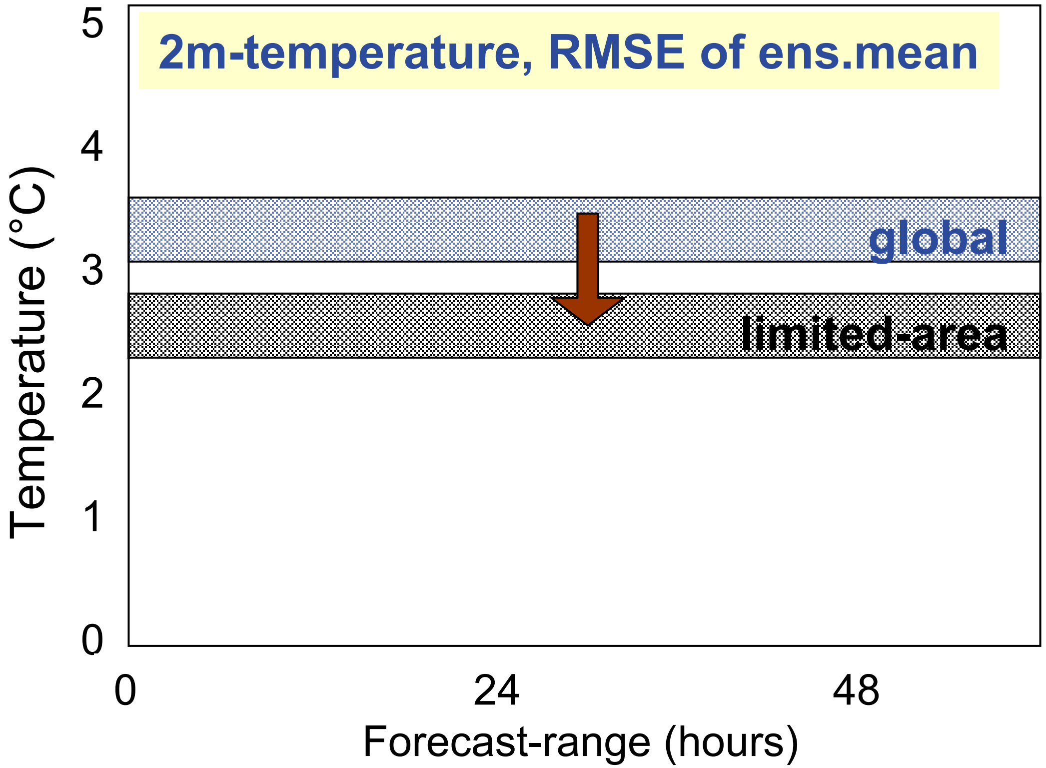

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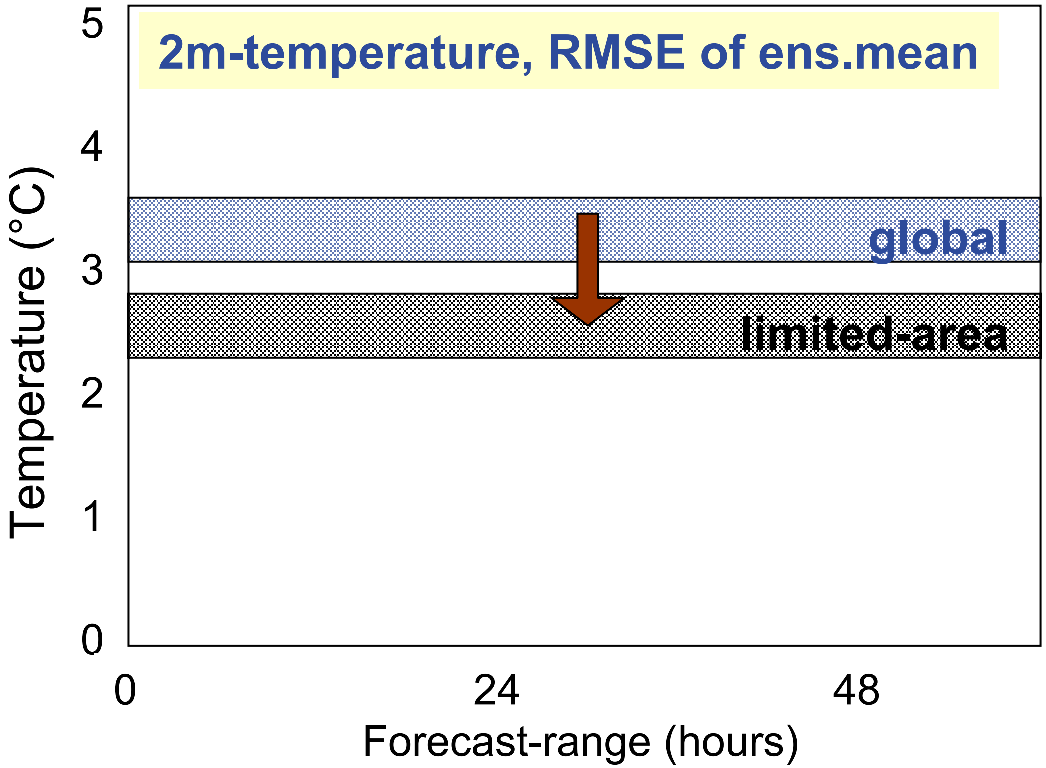
„**At 2m** (…) ALADIN HUNEPS **limited area ensemble significantly improves in quality** with decreasing values of RMSE (this being due to the higher resolution limited area model and with a better description of the corresponding surface).“

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Benefit shown by verification (ALADIN-HUNEPS)



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Benefit:
near-surface variables

Benefit shown by verification (COSMO-LEPS)

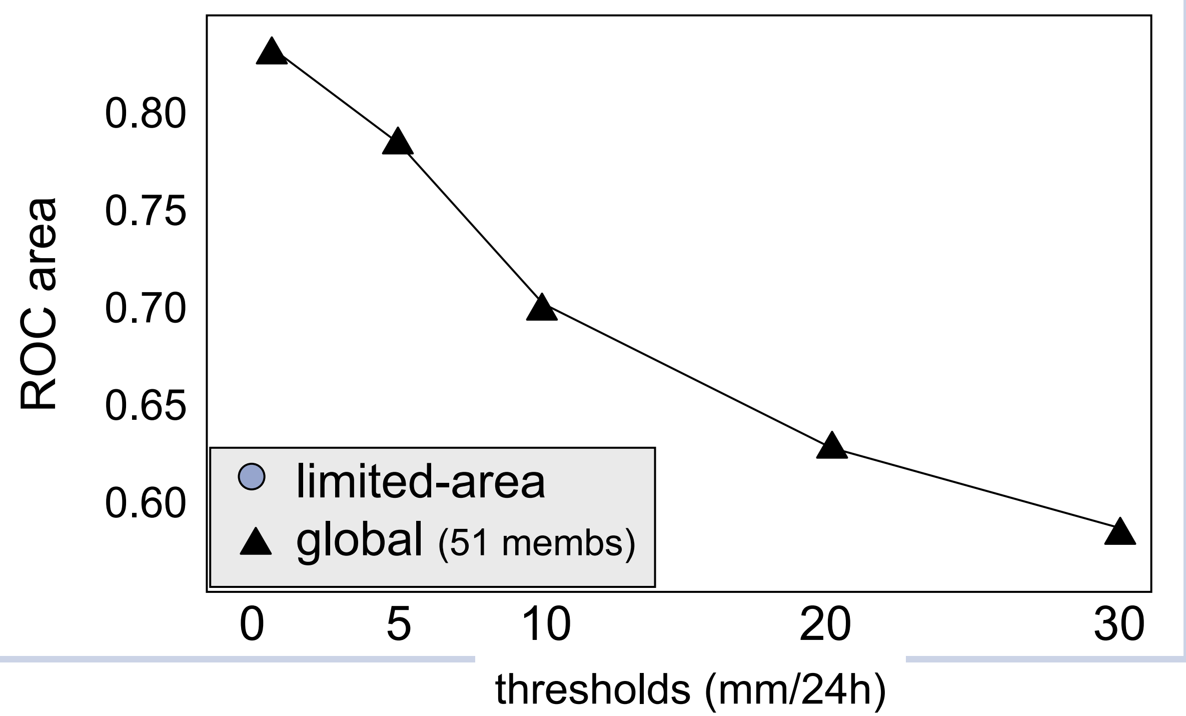
Marsigli et al. (2008), Meteorol. Appl. 15: 125-143.
DOI: 10.1002/met.65
Figure 7(e)

A spatial verification method applied to the evaluation of high-resolution ensemble forecasts

grid size: **10 km**

Benefit shown by verification (COSMO-LEPS)

verification of **precipitation**



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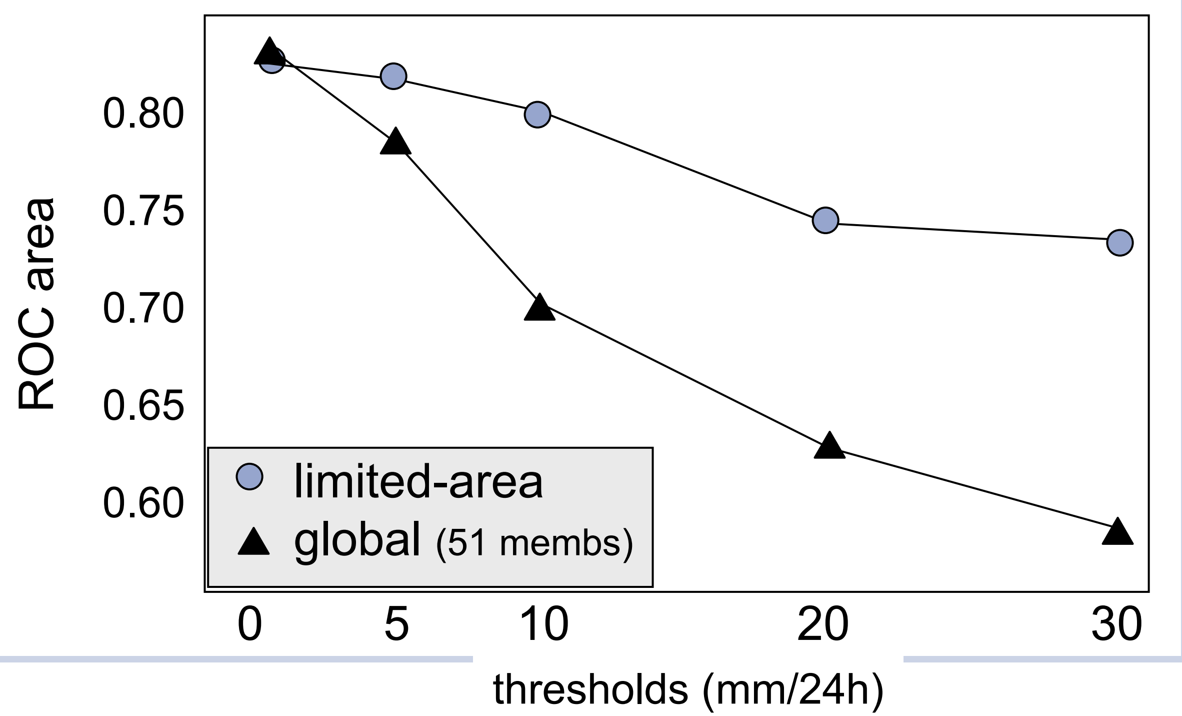

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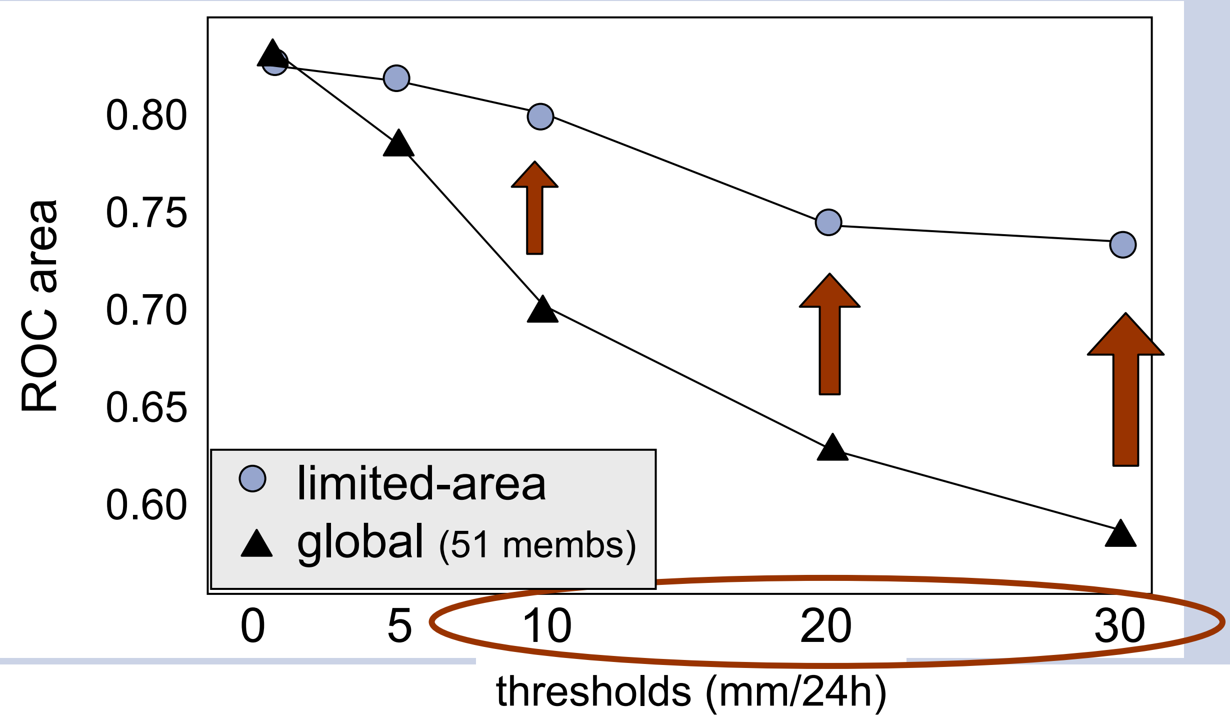

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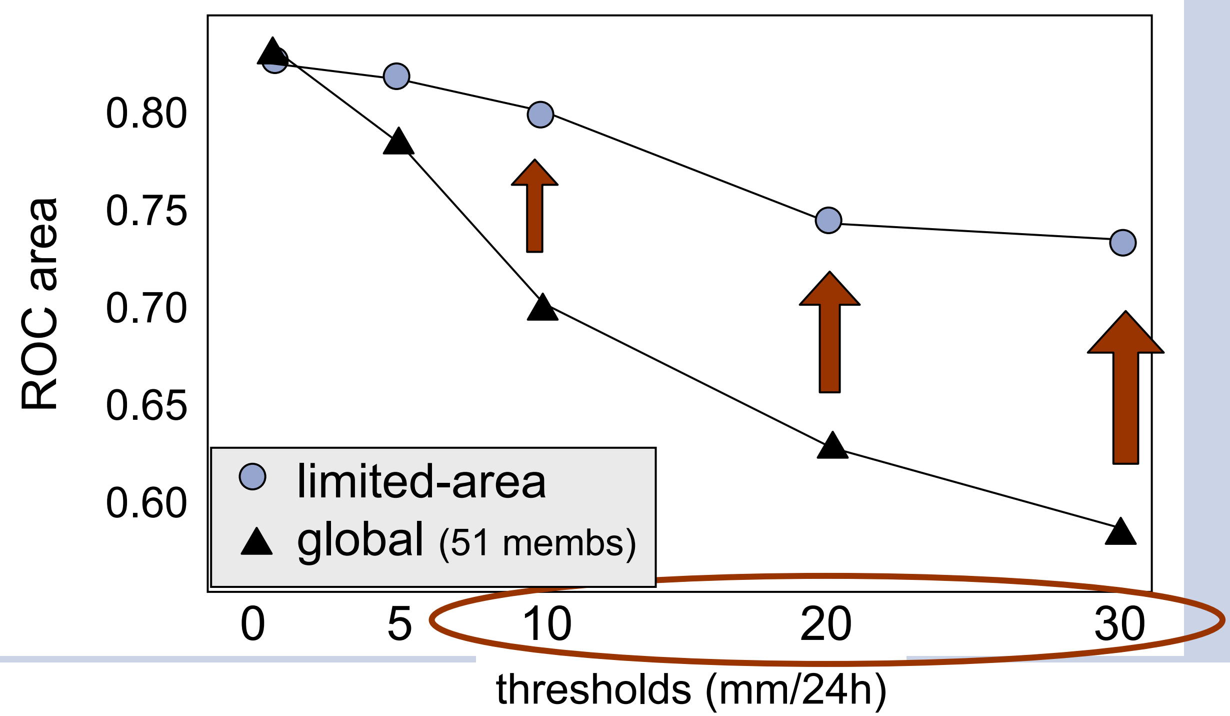

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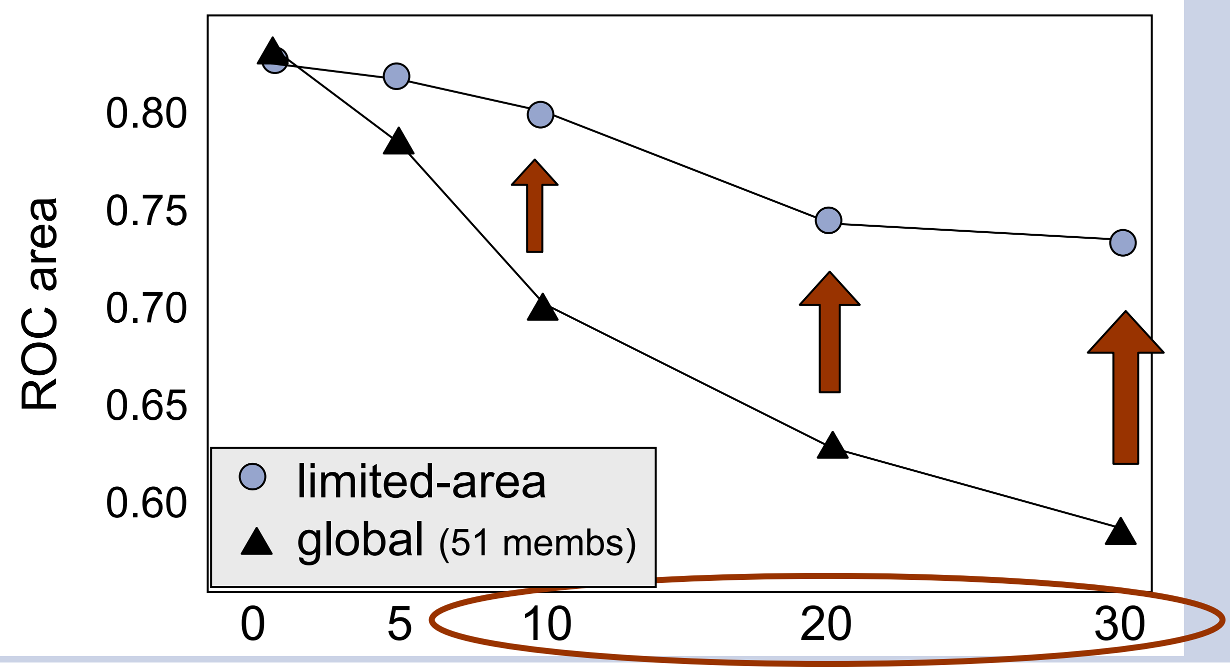
A spatial verification method applied to the evaluation of high-resolution ensemble forecasts

grid size: **10 km**

„COSMO-LEPS has the skill in forecasting the **occurrence of precipitation peaks** over an area, irrespective of the exact location.“

Benefit shown by verification (COSMO-LEPS)

verification of **precipitation**



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Benefit:
precipitation peaks

The „Polar Low Example“ (UMEPS)

Kristiansen et al. (2011),
Tellus 63A: 585-604.
DOI: 10.1111/j.1600-0870.2010.00498.x
Figure 7 (c) (d)

High-resolution ensemble prediction of a polar low development

grid size: **4 km**

The „Polar Low Example“ (UMEPS)

About polar lows:

➔ frequently accompanied by **severe weather**

➔ **moist convective processes** are important

➔ prediction of polar lows often fails

➔ example indicates
added value of a high-resolution ensemble

Kristiansen et al. (2011),
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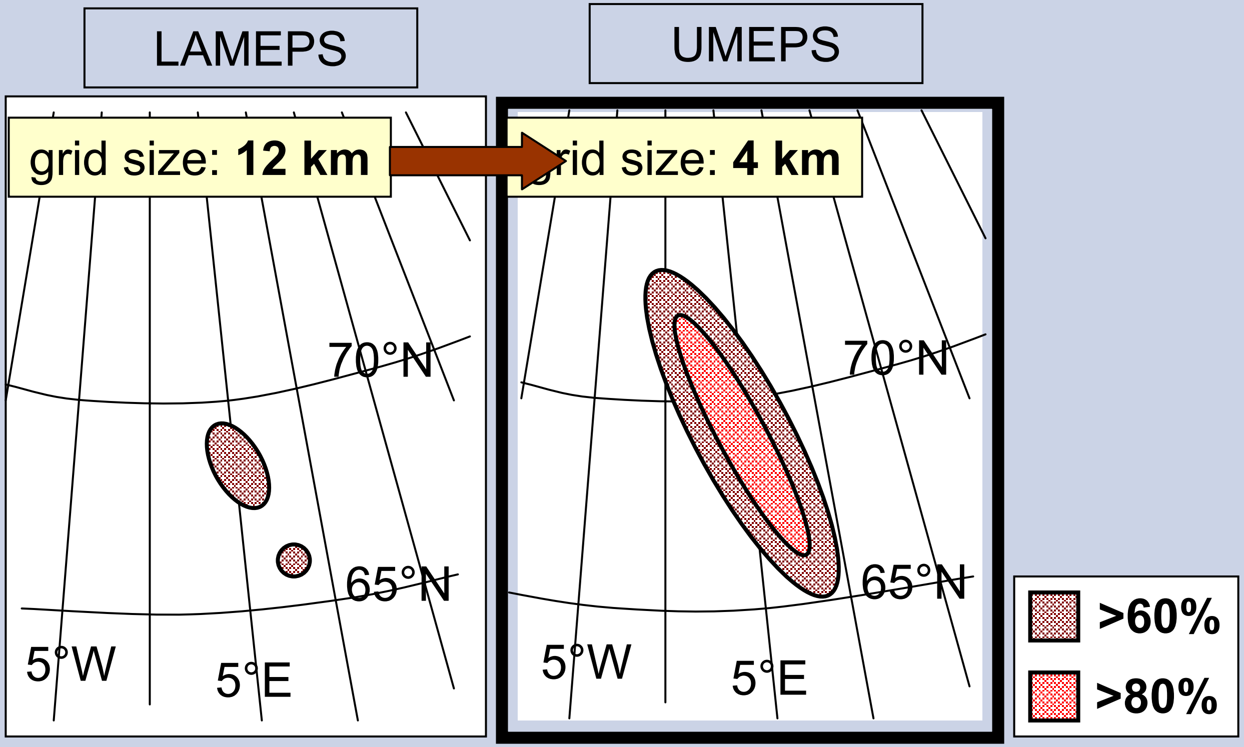
Probability [%] of wind speed > 25 m/s



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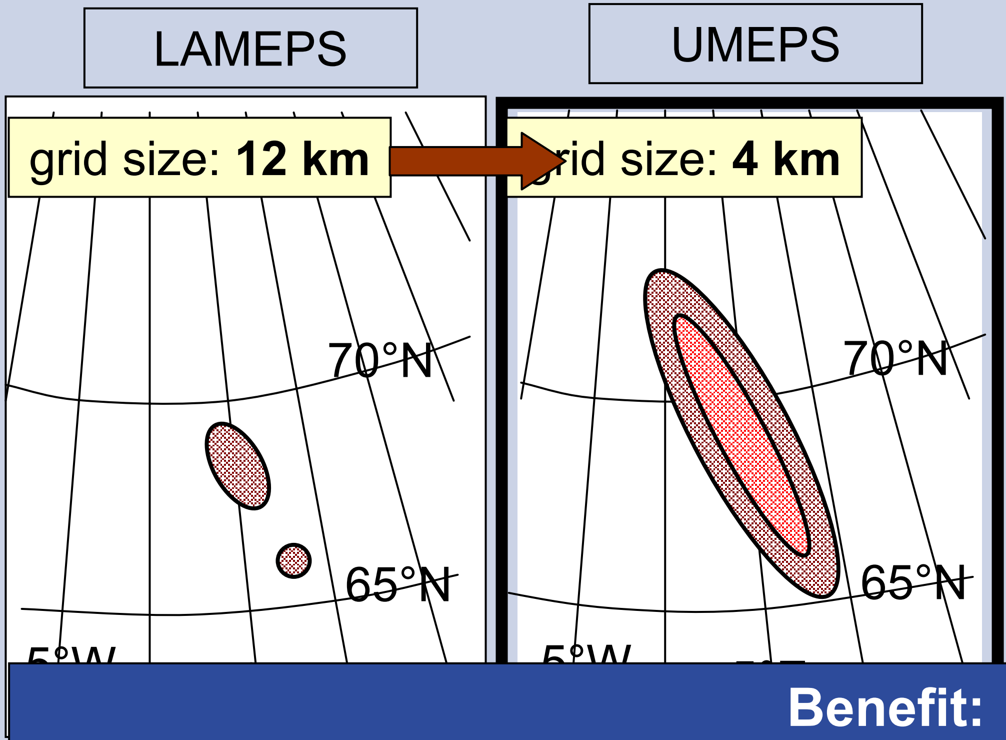

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High-resolution ensemble prediction of a polar low development

Benefit:
improved representation of processes leading to severe weather

Benefit of ensembles with finer grids

➔ improved representation of **atmospheric processes**:
subsynoptic, mesoscale, convective

➔ improved forecasts of **near-surface variables**:
precipitation, 2m-temperature, wind gusts

➔ improved forecasts of **severe weather**

(Horanyi et al. 2011) (Iversen et al. 2011) (Marsigli et al. 2008) (Bowler et al. 2008) etc

Entering Key Applications

➔ probabilistic forecasts of **severe weather, near-surface variables,** for **short lead times:**

- ➔ **weather warnings**
- ➔ **flood warnings**
- ➔ **aviation**
- ➔ **wind energy**
- ➔ **etc**

Predictability Issues

Predictability Issues

General Remarks

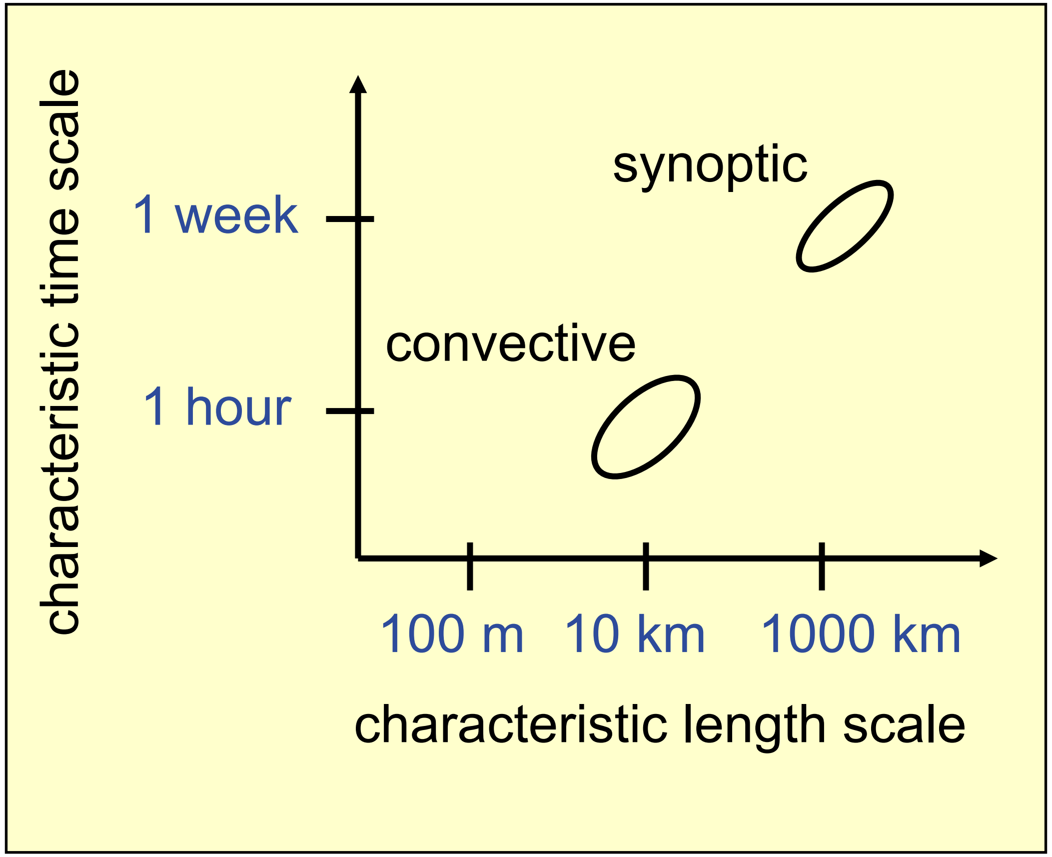
„Supercell Example“ by COSMO-DE-EPS

Finer Grids – gain in predictability?

Finer Grids – gain in predictability?

➔ **not necessarily !**

scale diagram



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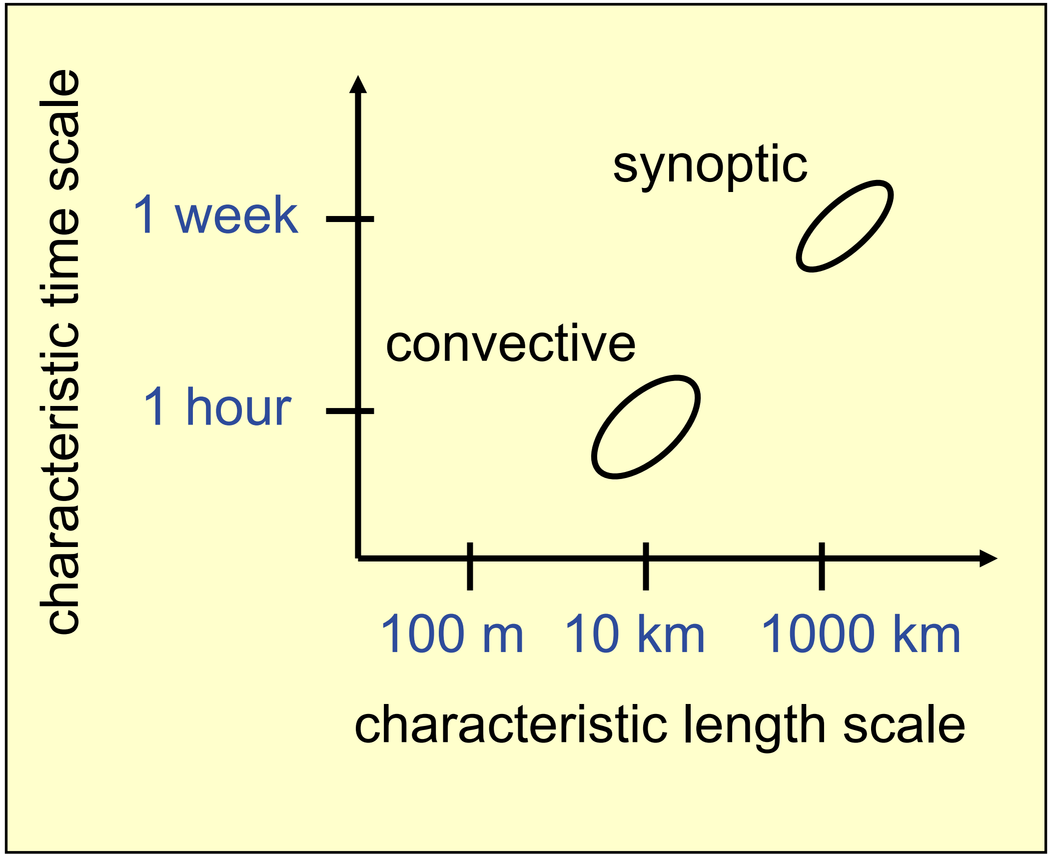
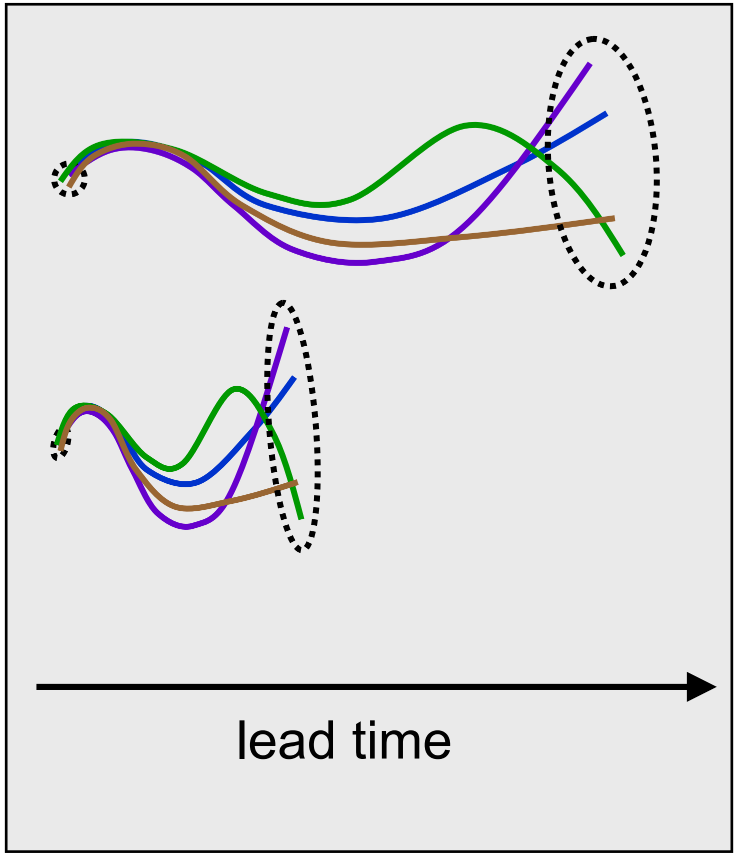


predictability



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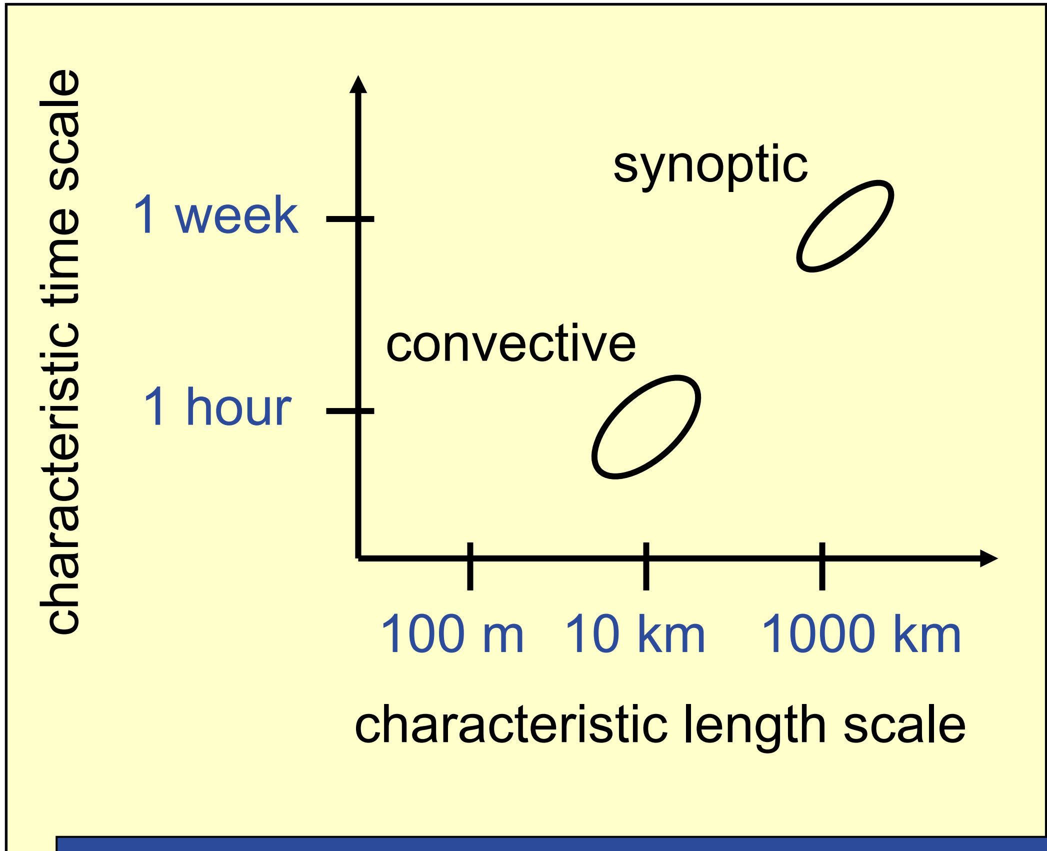

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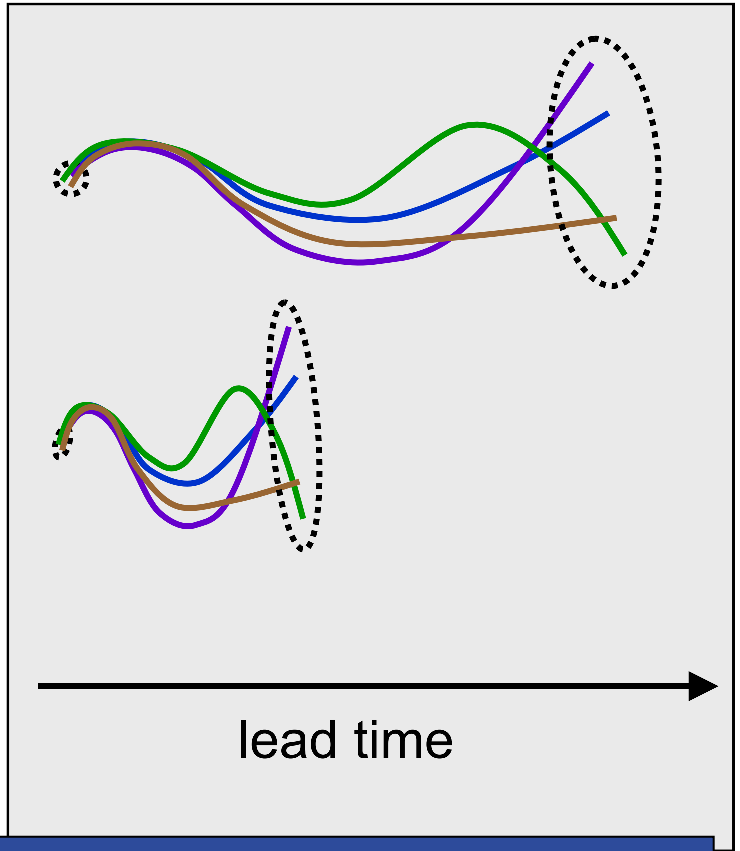

Uncertainties in small scales grow faster *(Lorenz 1969)*

Finer Grids – gain in predictability?

➔ **smaller scales** usually possess
shorter life cycles, **faster error growth, shorter predictability limits**

➔ high-resolution model simulations are expected
to contain a **larger degree of randomness**

➔ this **can offset the benefits** due to a smaller model grid box size
if forecast uncertainties are not addressed explicitly *(e.g. Mass et al. 2002)*

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Forecasts must be addressed in a probabilistic framework

The „Supercell Example“ (COSMO-DE-EPS)

by
Axel Seifert

with Thomas Hanisch,
Christoph Gebhardt,
Zied Ben Bouallègue,
Michael Buchhold

Deutscher Wetterdienst

The „Supercell Example“ (COSMO-DE-EPS)

➔ COSMO-DE: convection-permitting model (2.8 km)

➔ can **explicitly simulate severe storms,**
but **deterministic forecasts** of individual cells
are not possible with 12 h lead time

➔ i.e. the **model provides a possible scenario**
for the development of individual convective cells

➔ in this example: visualized by
- simulated radar reflectivity
- the **supercell detection index (SDI)**
Wicker et al. (2005)

by
Axel Seifert

with Thomas Hanisch,
Christoph Gebhardt,
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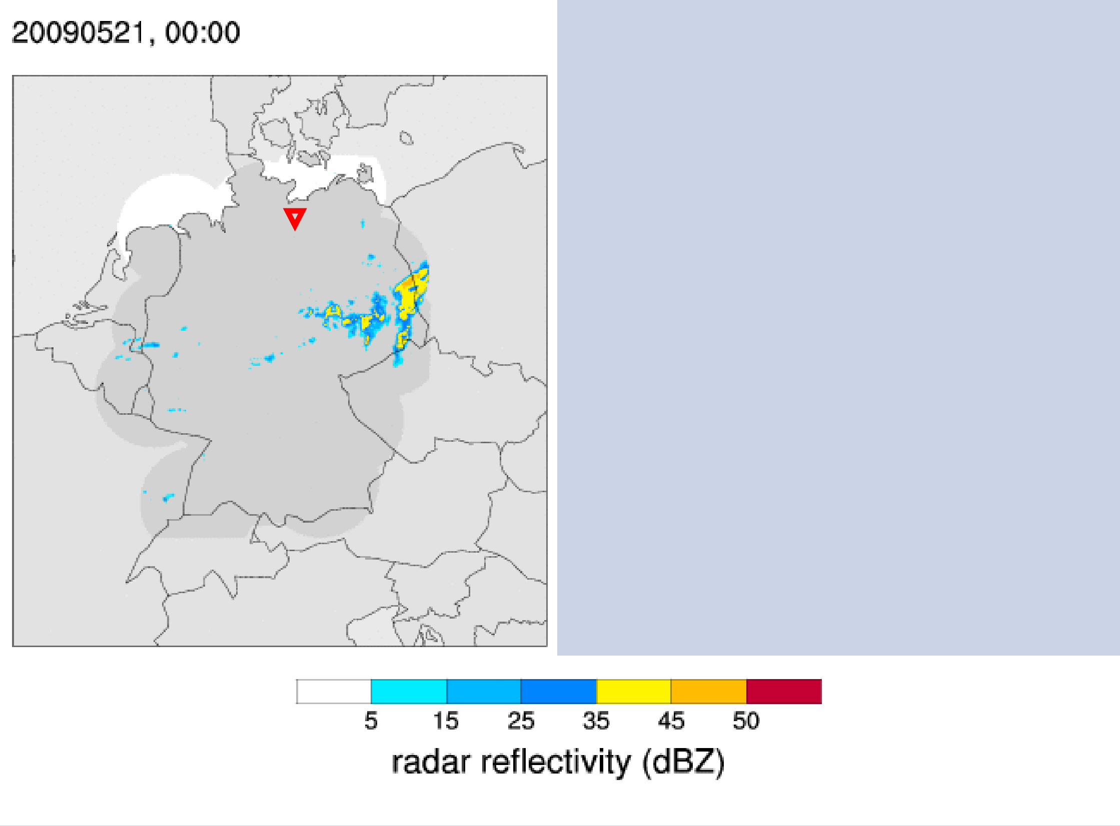
Michael Buchhold

Deutscher Wetterdienst

The „Supercell Example“ (COSMO-DE-EPS)

observed by radar



→ F2 tornado ▽

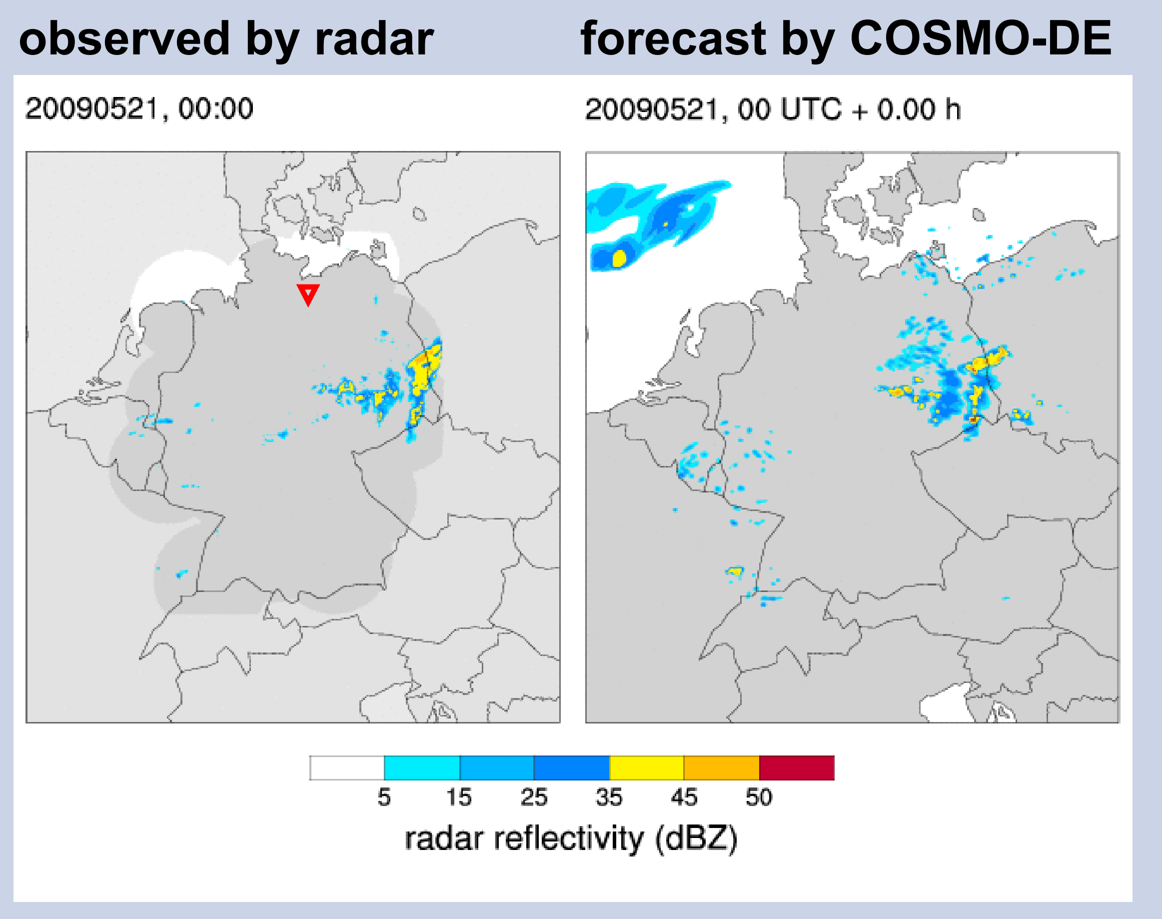
near “Plate” close to the Baltic coast

16:20 UTC

by
Axel Seifert

Deutscher Wetterdienst

The „Supercell Example“ (COSMO-DE-EPS)



- ➔ F2 tornado

  near “Plate” close to the Baltic coast

  16:20 UTC

- ➔ the forecast shows many ‘SDI events’ in that region

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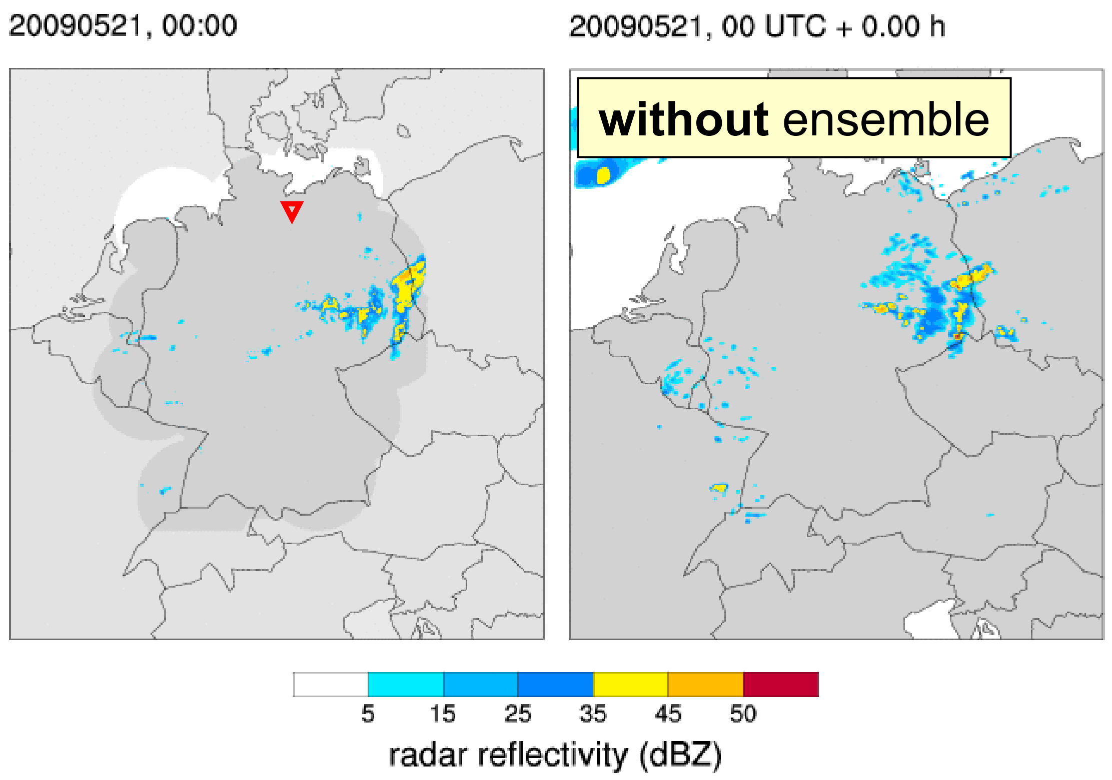
The „Supercell Example“ (COSMO-DE-EPS)

observed by radar **forecast by COSMO-DE**



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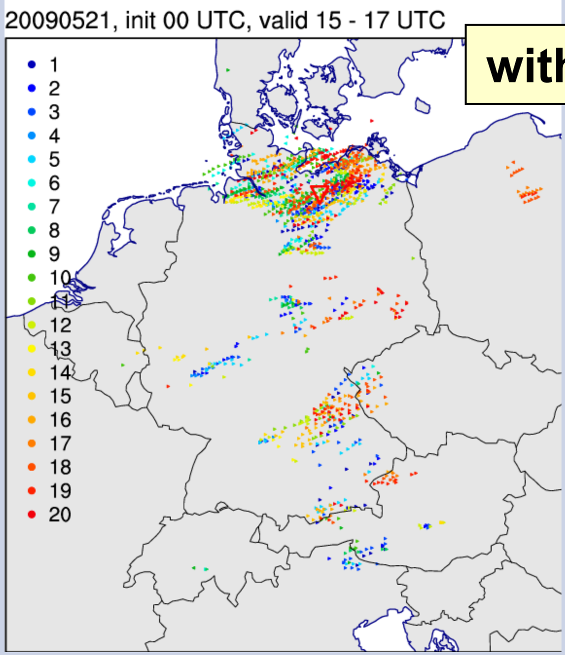
The „Supercell Example“ (COSMO-DE-EPS)

forecast by COSMO-DE-EPS *(Gebhardt et al., 2011)*

20 scenarios of ‘SDI events’



with ensemble (2.8 km)

➔ ensemble provides 20 scenarios

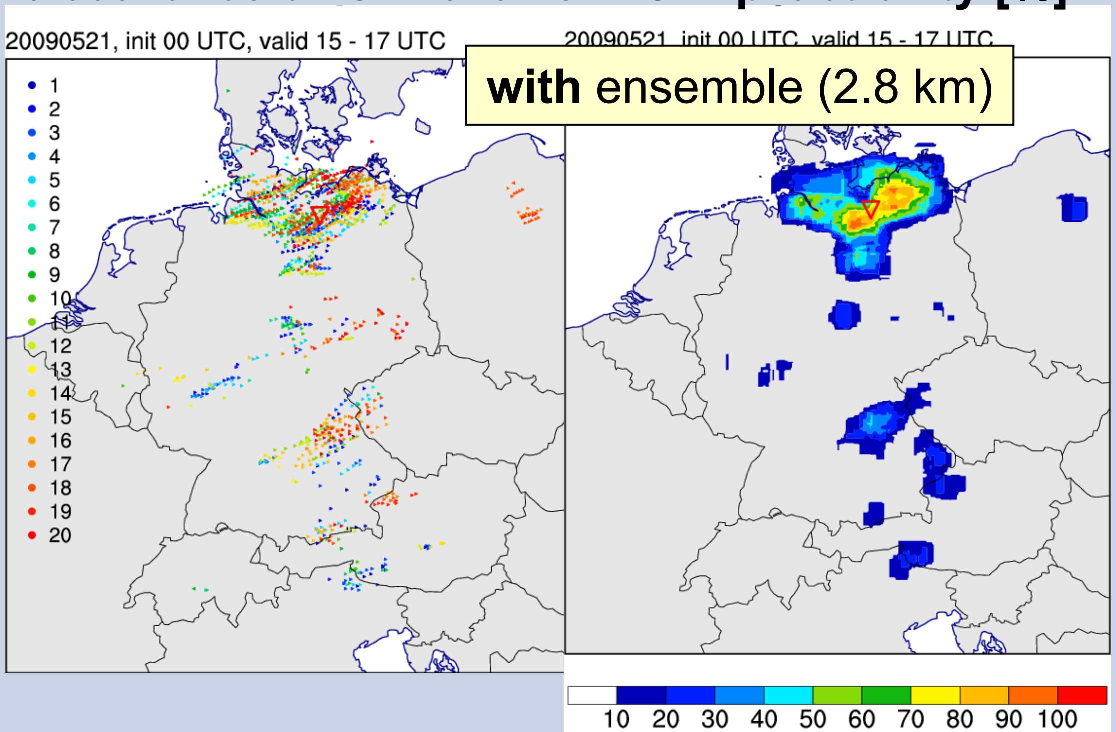
by
Axel Seifert

Deutscher Wetterdienst

The „Supercell Example“ (COSMO-DE-EPS)

forecast by COSMO-DE-EPS *(Gebhardt et al., 2011)*

20 scenarios of ‘SDI events’ **SDI probability [%]**



- ➔ ensemble provides 20 scenarios
- ➔ **combined in a probability product**
- ➔ **useful guidance**

by
Axel Seifert

Deutscher Wetterdienst

The „Supercell Example“ (COSMO-DE-EPS)

forecast by COSMO-DE-EPS *(Gebhardt et al., 2011)*

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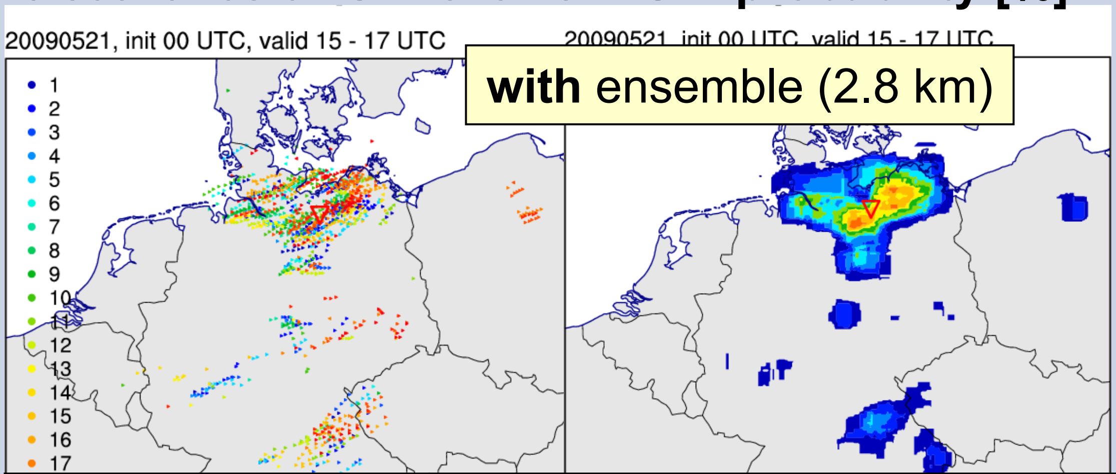

- ensemble provides 20 scenarios
- **combined in a probability product**
- **useful guidance**

Convection-permitting model can simulate process.

Ensemble accounts for limited predictability and derives useful guidance.

Constructing limited-area ensembles

- same as global?

Finer grids: revision of ensemble techniques

- ➔ focus on **short lead times**
- ➔ account for **uncertainties coming from the driving model**
- ➔ introduce **uncertainties in the relevant scales and processes**
- ➔ some techniques are **not applicable anymore**
- ➔ high demand of computing resources

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new scientific challenges

Probability maps:

aim at finest grid?

Probability maps: aim at finest grid?

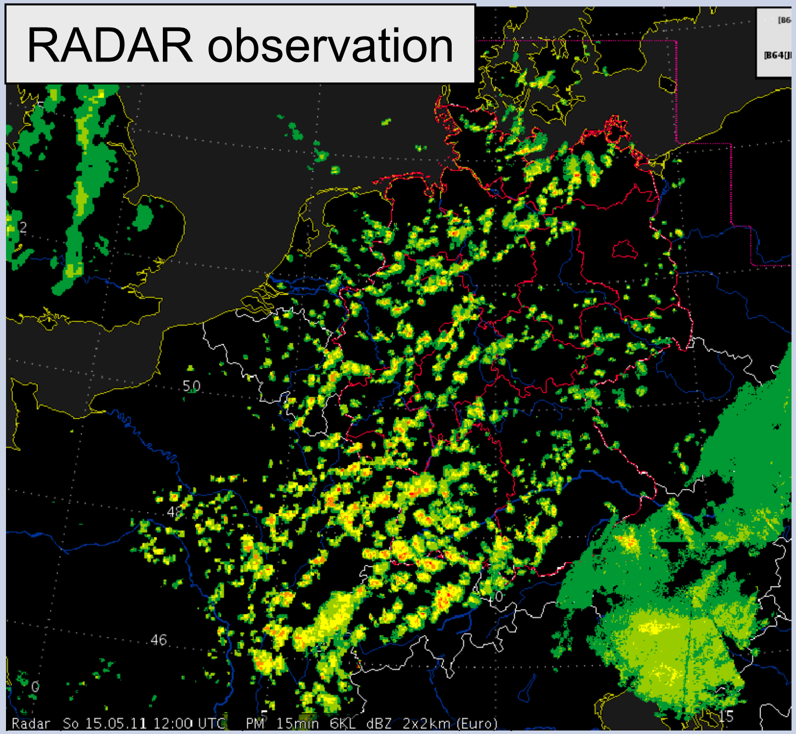
Probability maps: aim at finest grid?

➔ convection-permitting ensembles have a grid size of 1-3 km

➔ we can produce probability maps for this grid size

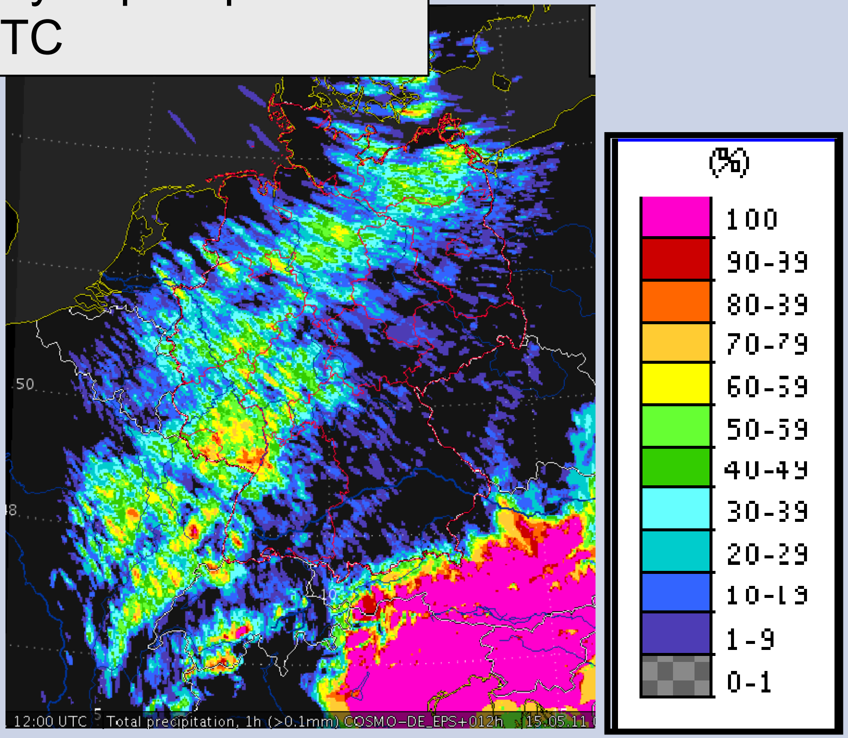
Probability maps: aim at finest grid?

Example: 15 May 2011 12 UTC



Probability maps: aim at finest grid?

Forecast:
Probability of precipitation
11-12 UTC

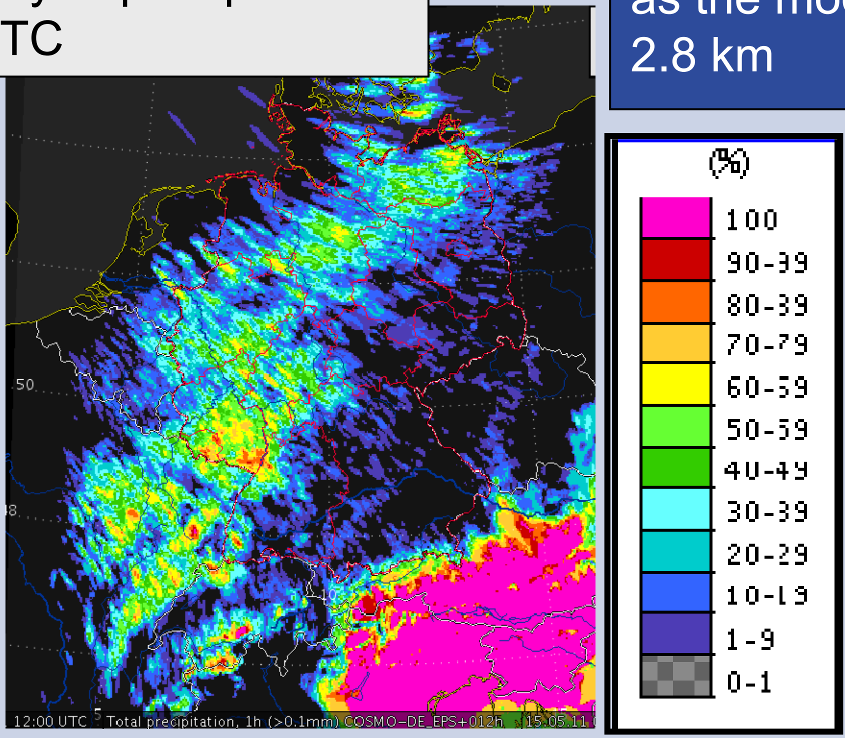


derived from
COSMO-DE-EPS 2.8 km

Probability maps: aim at finest grid?

Forecast:
Probability of precipitation
11-12 UTC

on the same grid
as the model:
2.8 km



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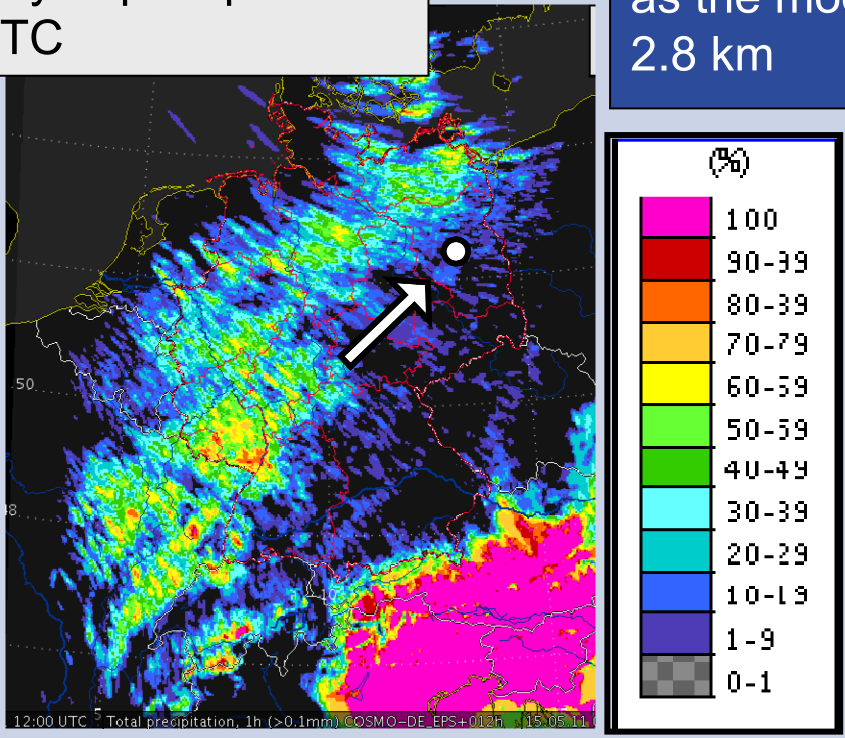

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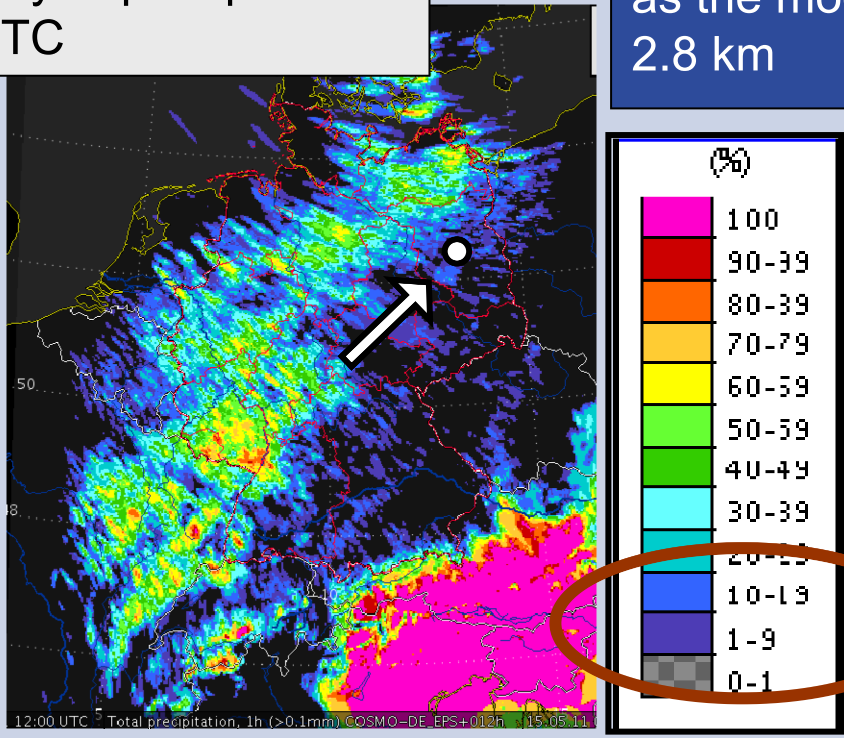
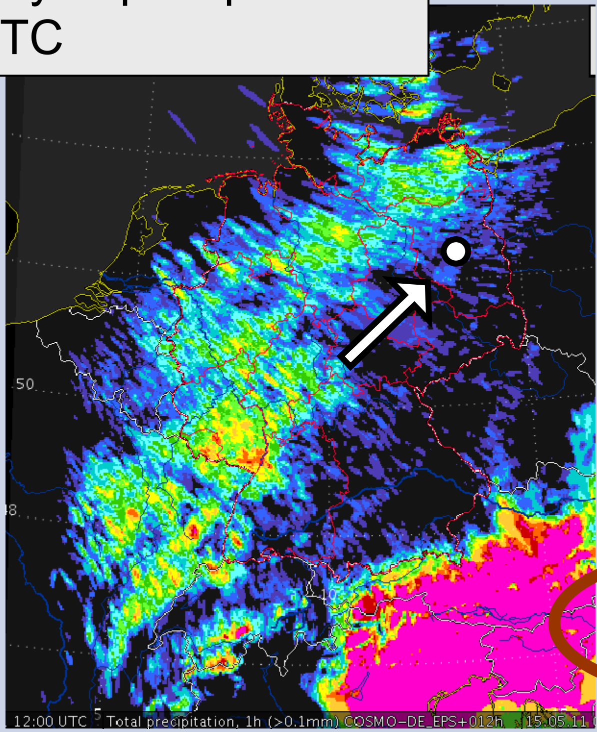


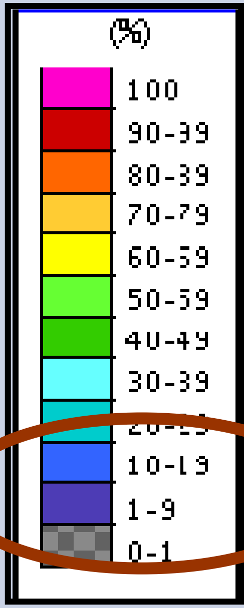
derived from
COSMO-DE-EPS 2.8 km

Probability maps: aim at finest grid?

Forecast:
Probability of precipitation
11-12 UTC



on the same grid
as the model:
2.8 km



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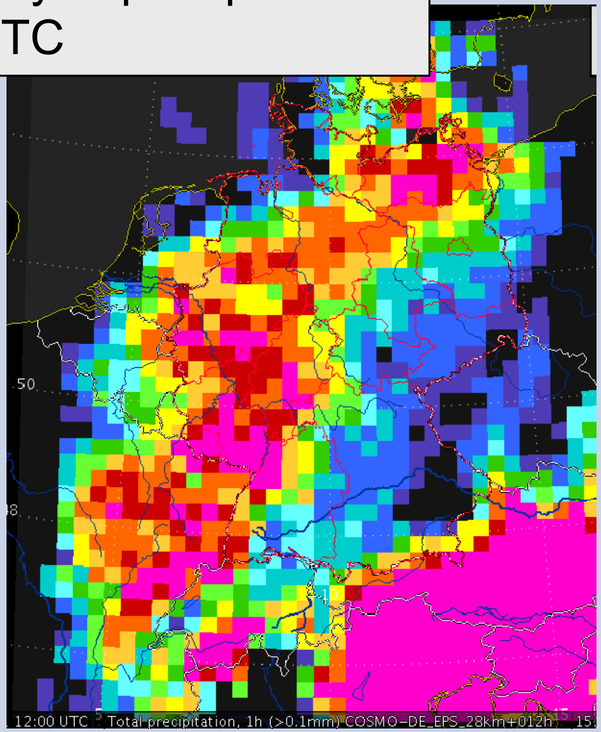
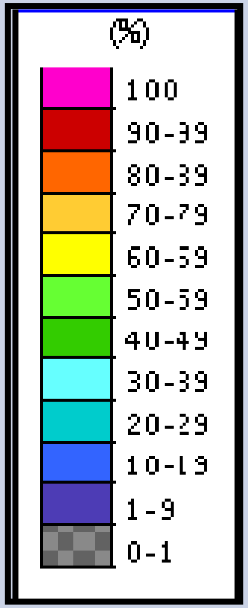


on a larger grid than the model: **28 km**



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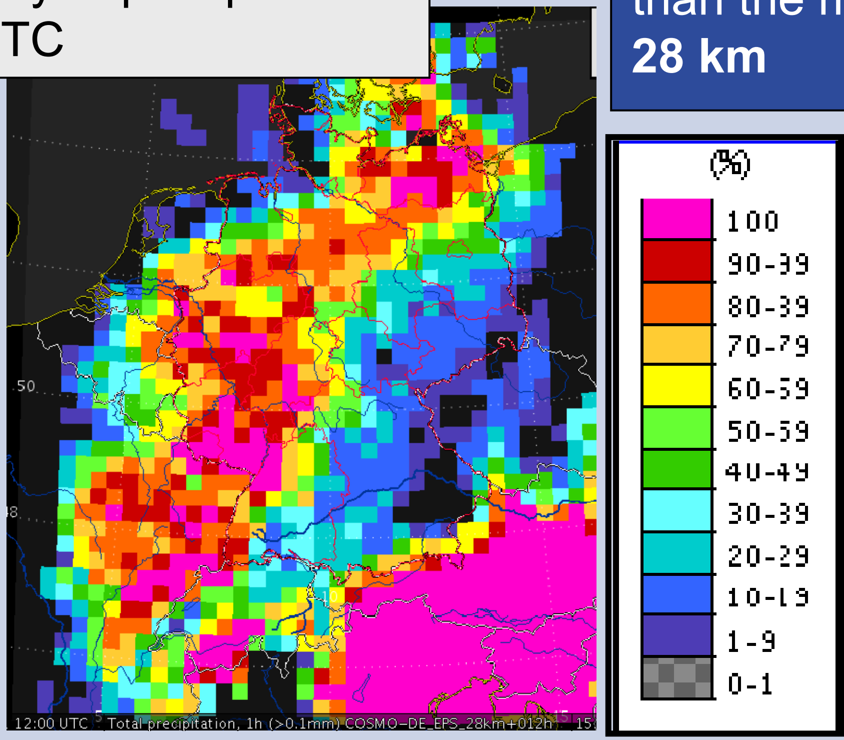

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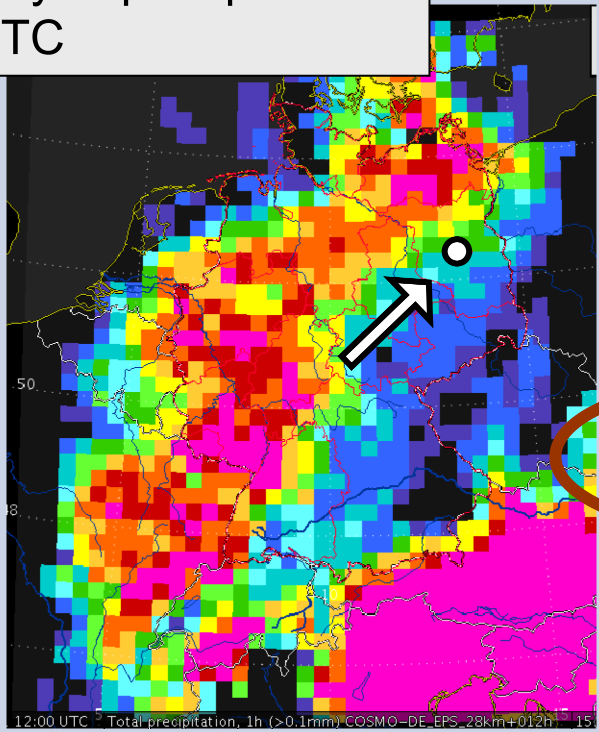

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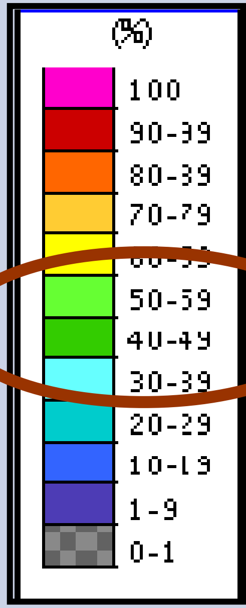

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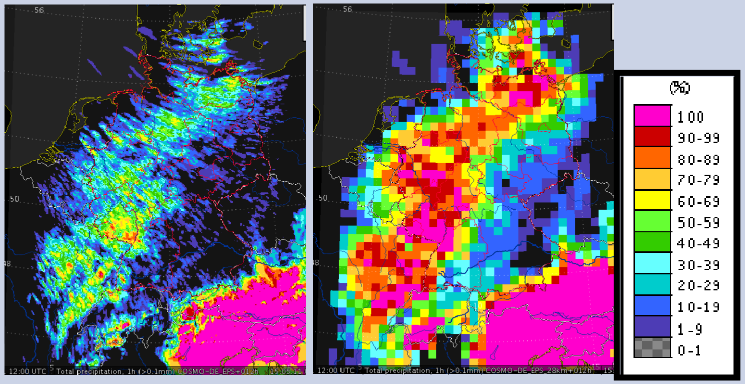

COSMO-DE-EPS example by DWD
S.Theis, C.Gebhardt, Z. Ben Bouallègue, M.Buchhold

➔ think about scale of interest

➔ “alert areas”

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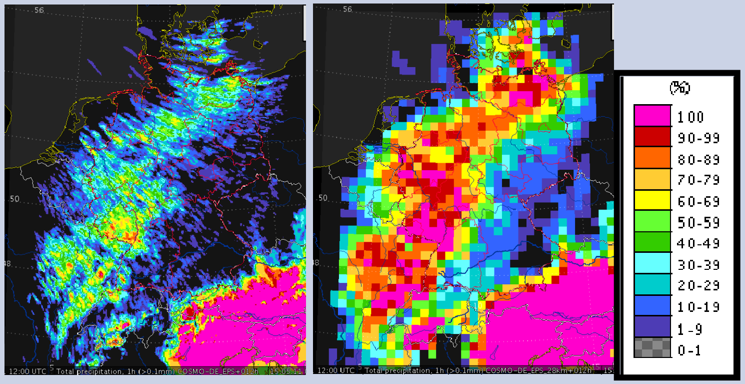

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e.g. UK Met Office: MOGREPS-W

derives area warnings from MOGREPS-R (18 km)

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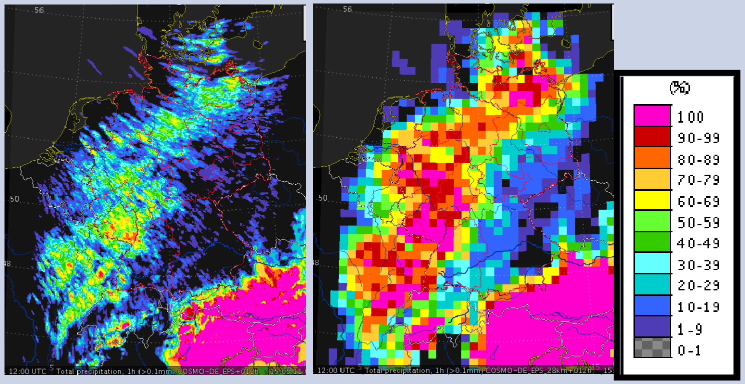

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End product not necessarily on finest grid

Beneficial if underlying ensemble is on finest grid

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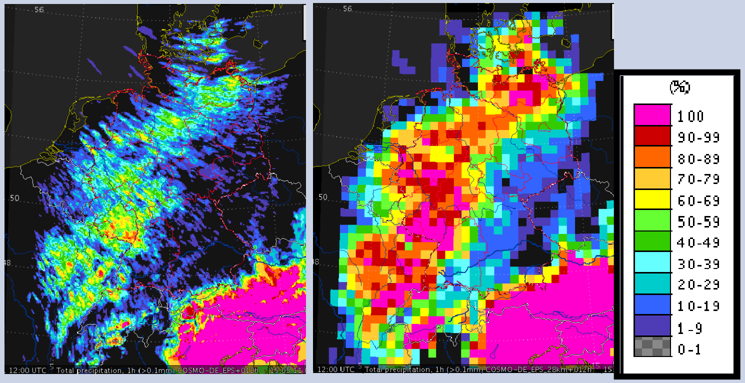

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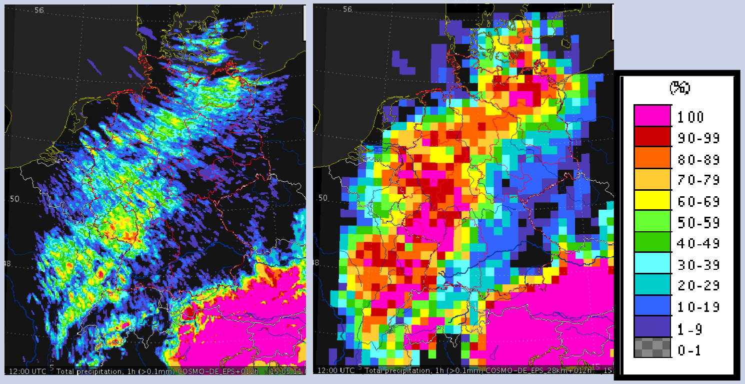
➔ users must know and understand the reference area of probabilities

Probability maps: aim at finest grid?



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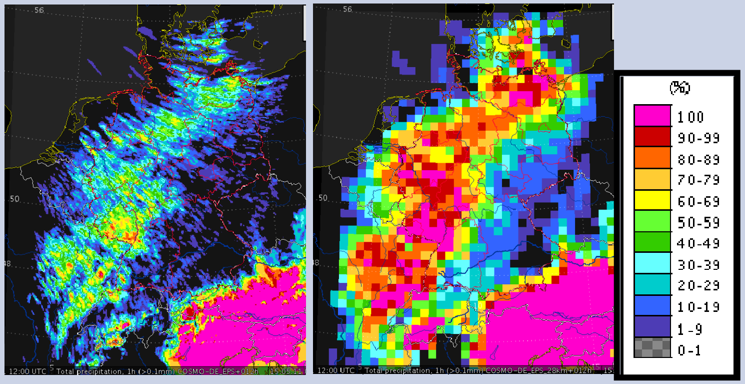
(Epstein, 1966)
(Murphy, 1980)
and (Gigerenzer et al., 2005)
…"reference class"

Probability maps: aim at finest grid?



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…“reference class”

Users (and providers) must achieve “risk literacy”

Summary

- ➔ **ensembles are going to finer grids**
  - ➔ improved representation of atmospheric processes,
    improved forecasts of near-surface weather, severe weather
  - ➔ even less deterministic predictability → increased need for ensembles
  - ➔ new challenges for ensemble techniques

- ➔ **implication for ensemble applications**
  - ➔ entering key applications
  - ➔ end products on scale of interest, not necessarily on finest grid
  - ➔ „risk literacy“ is essential