Application of convection-permitting EPS C-LAEF at ZAMG

Clemens Wastl, Yong Wang, Christoph Wittmann

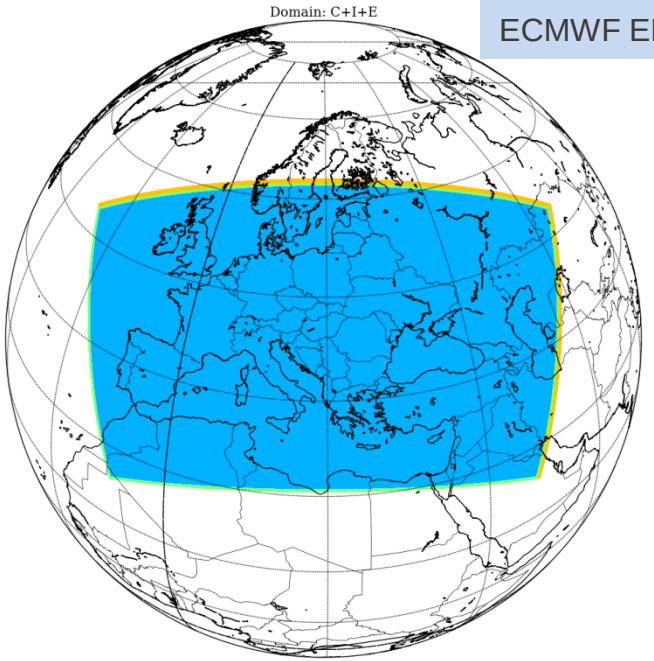
ZAMG
Zentralanstalt für
Meteorologie und
Geodynamik

Overview

- EPS at ZAMG
- C-LAEF: System introduction
- Uncertainty representation in C-LAEF
- Application of C-LAEF: Forecasters‘ perspective
- Verification
- Conclusions & Outlook

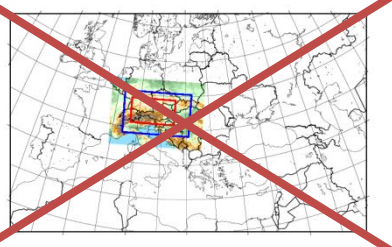
ZAMG
Zentralanstalt für Meteorologie und Geodynamik

Ensemble prediction systems at ZAMG

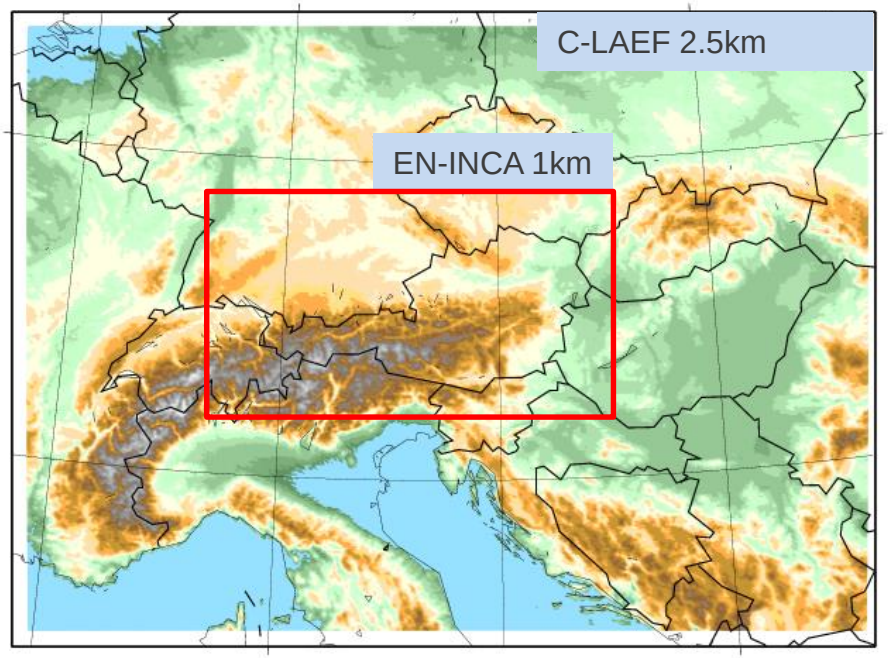


ECMWF ENS 18km

ALADIN-LAEF 11km



C-LAEF and EN-INCA



Part of a seamless system

ZAMG
Zentralanstalt für Meteorologie und Geodynamik

C-LAEF – Fact sheet

C-LAEF: Convection permitting - Limited Area Ensemble Forecasting	
model code based on AROME (cy40t1), upgrade planned in autumn 2020 to cy43 operational since November 2019, running on ECMWF HPC - time critical option TC-2	
Ensemble size	16 + 1 (control)
Δx / vertical levels	2.5 km / 90
Coupling	ECMWF-ENS (3-hourly coupling), IFS-HRES (control member, 3-hourly coupling)
Runs per day	00 UTC (+60h), 12 UTC (+48h), 06 and 18 UTC (+6h)
Assimilation cycle	6h
Assimilation	Atmosphere (3D-VAR), surface (OI)
Output	Hourly (optional 15min for precipitation)
Perturbations	Observations (surface, atmosphere), LBC, model (stoch. physics)
Archive	Archiving of grb Files of 00 und 12 UTC at MARS archive of ECMWF
Backup	ECMWF-ENS downscaling
Availability	4h after initialisation

ZAMG
Zentralanstalt für Meteorologie und Geodynamik

C-LAEF – Uncertainty representation

Initial conditions error

- Ensemble-data-assimilation (EDA)
- Ensemble-data-assimilation at surface (sEDA)
- Ensemble-Jk

Keresturi et al., 2019: Improving initial condition perturbations in a convection-permitting ensemble prediction system , *Q J R Meteorol Soc*. 145, 993-1012.

Lateral boundary conditions error

- Coupling with ECMWF-ENS
- Ensemble-Jk

Model error

- Stochastic physics: Hybrid system HSPP; Combination of tendency and parameter perturbations

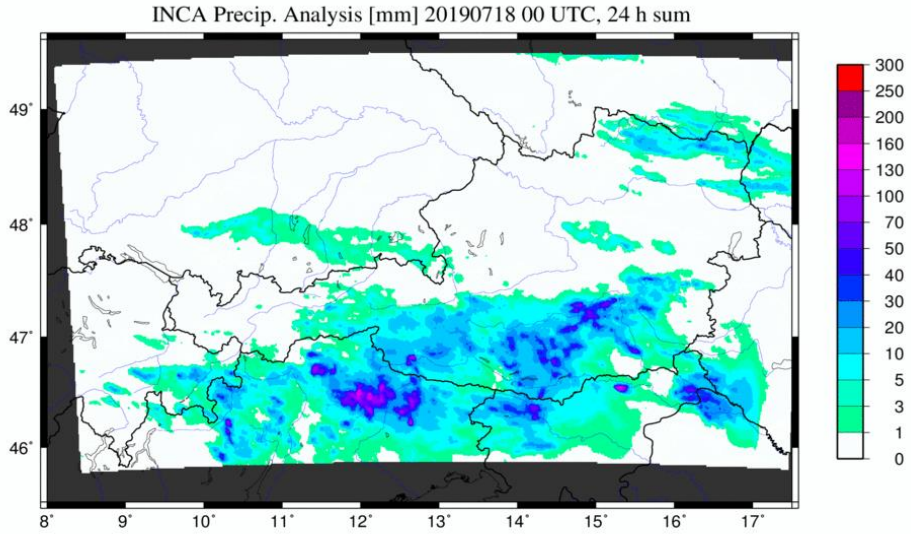
Wastl et al., 2019a: Independent perturbations for physics parametrization tendencies in a convection-permitting ensemble (pSPPT), *Geosci. Model Dev.,* 12, 261-273.

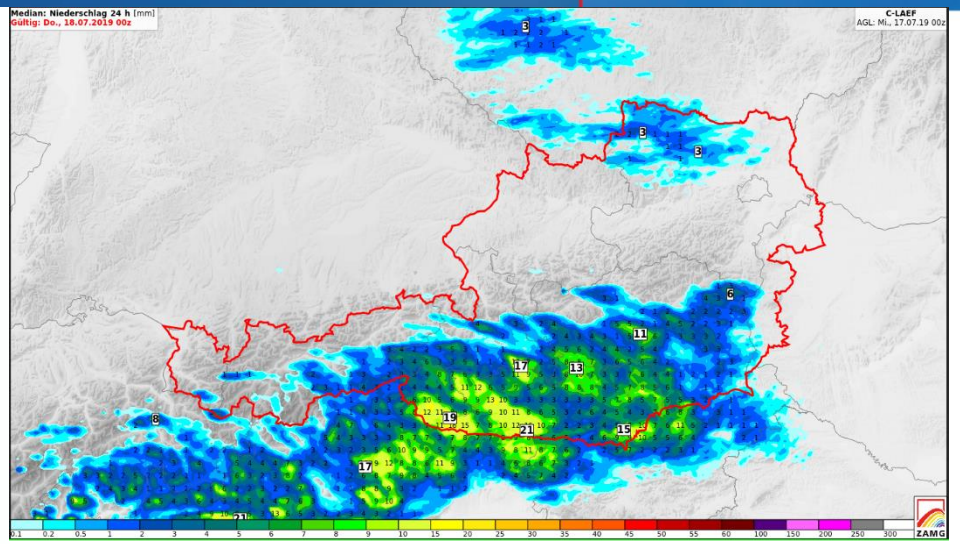
Wastl et al., 2019b: A hybrid stochastically perturbed parametrization scheme in a convection-permitting ensemble, Mon. Wea. Rev. 147, 2217-2230.

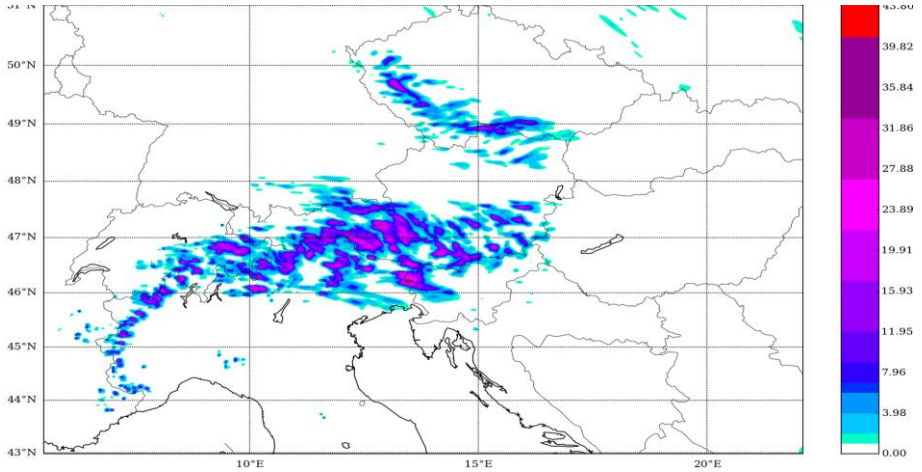
Wastl et al., 2019c: A comparison of different versions of the Stochastically Perturbed Parametrization Tendency (SPPT) scheme, Met. Z., online pre-published.

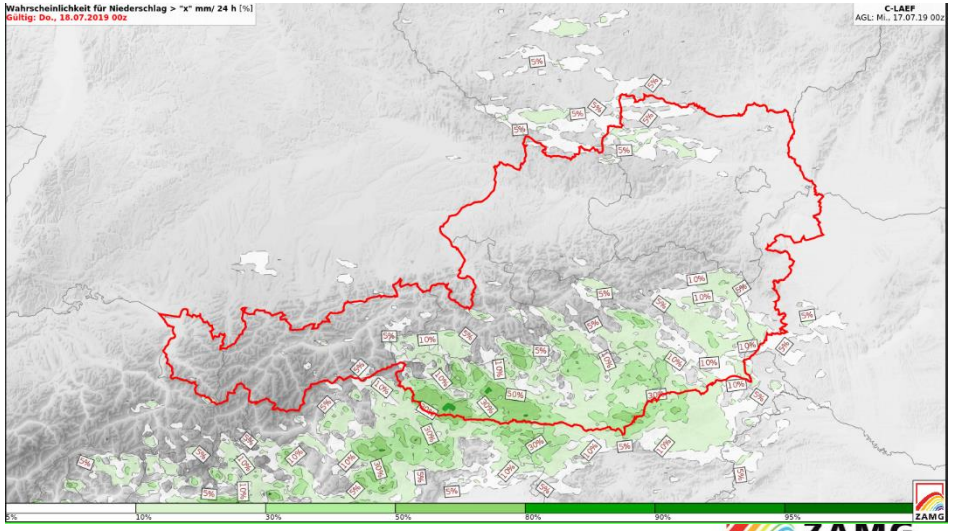
ZAMG
Zentralanstalt für Meteorologie und Geodynamik

Application of C-LAEF: Convective event



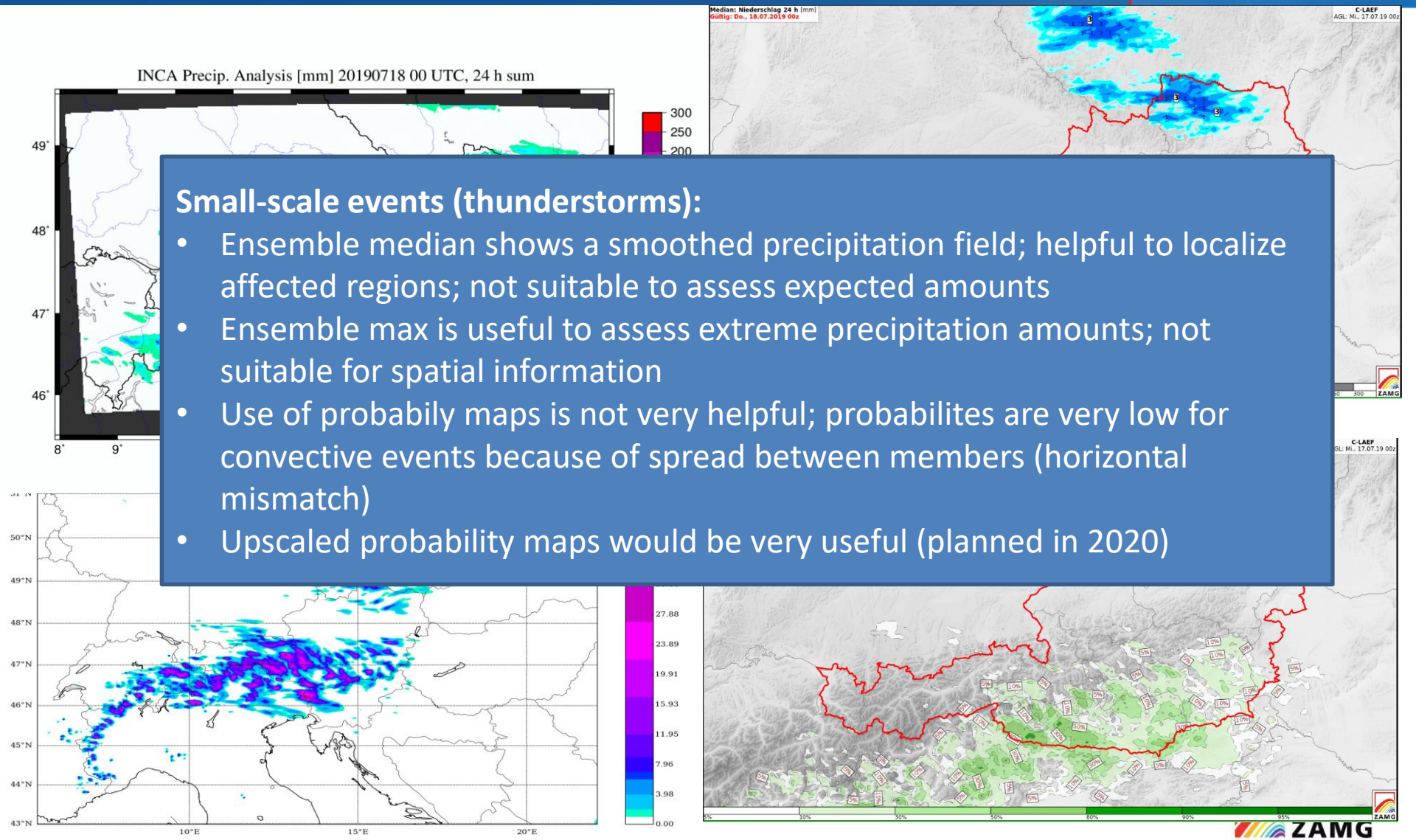






ZAMG
Zentralanstalt für Meteorologie und Geodynamik

Application of C-LAEF: Convective event

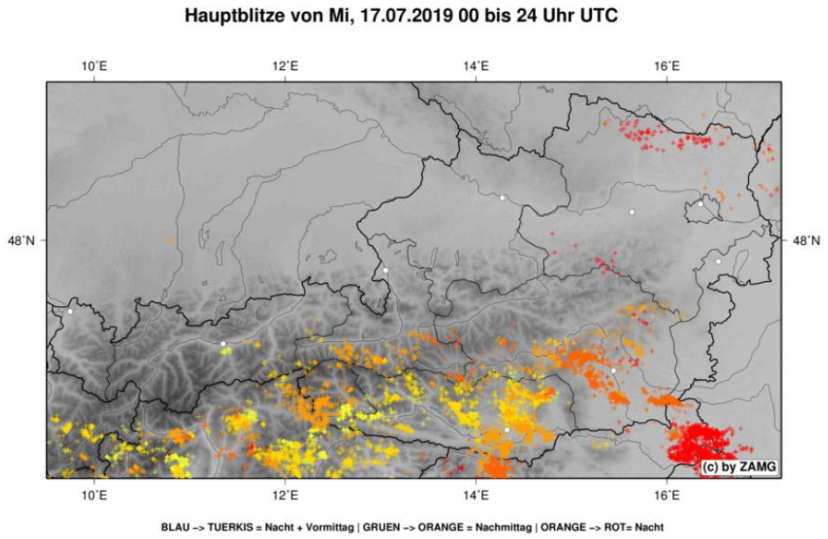


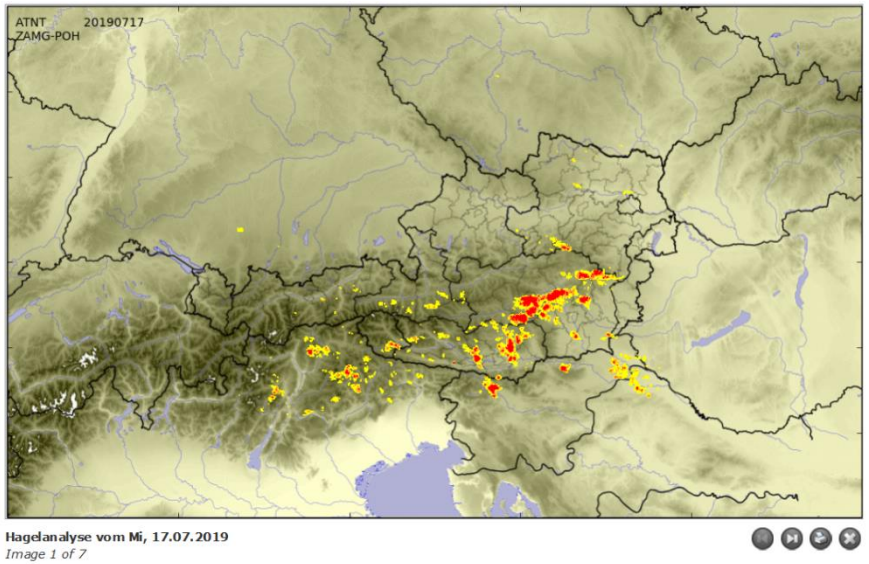
Small-scale events (thunderstorms):

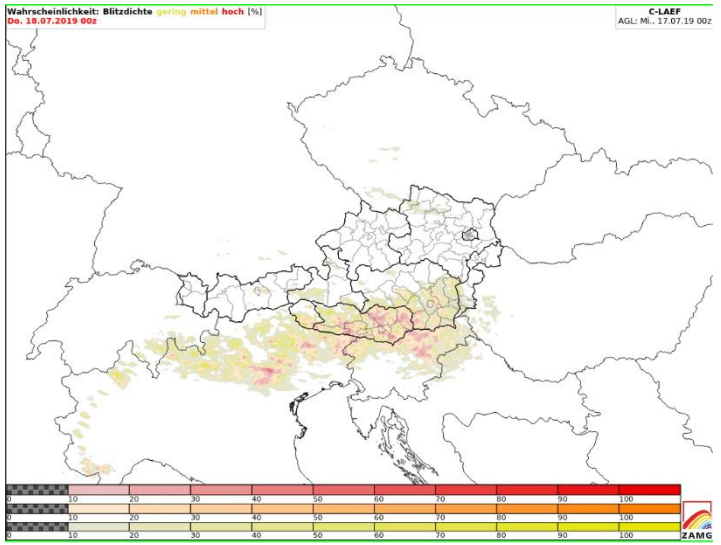
- Ensemble median shows a smoothed precipitation field; helpful to localize affected regions; not suitable to assess expected amounts
- Ensemble max is useful to assess extreme precipitation amounts; not suitable for spatial information
- Use of probabily maps is not very helpful; probabilites are very low for convective events because of spread between members (horizontal mismatch)
- Upscaled probability maps would be very useful (planned in 2020)

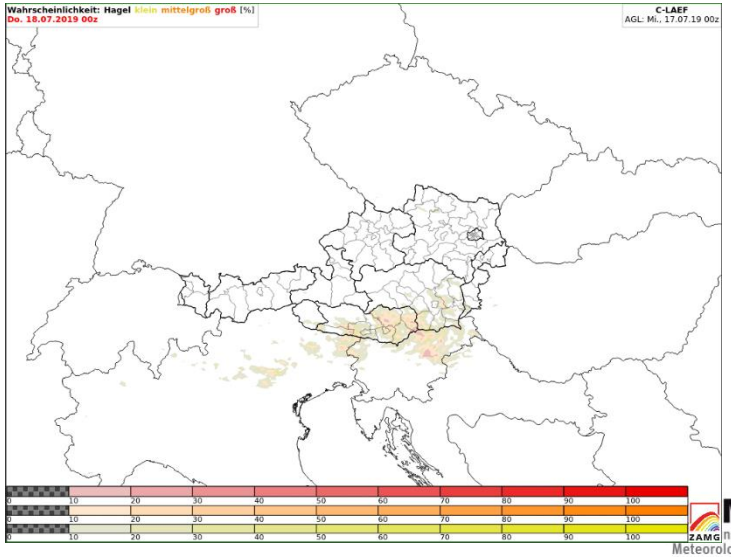
ZAMG
Zentralanstalt für Meteorologie und Geodynamik

Application of C-LAEF: Convective event



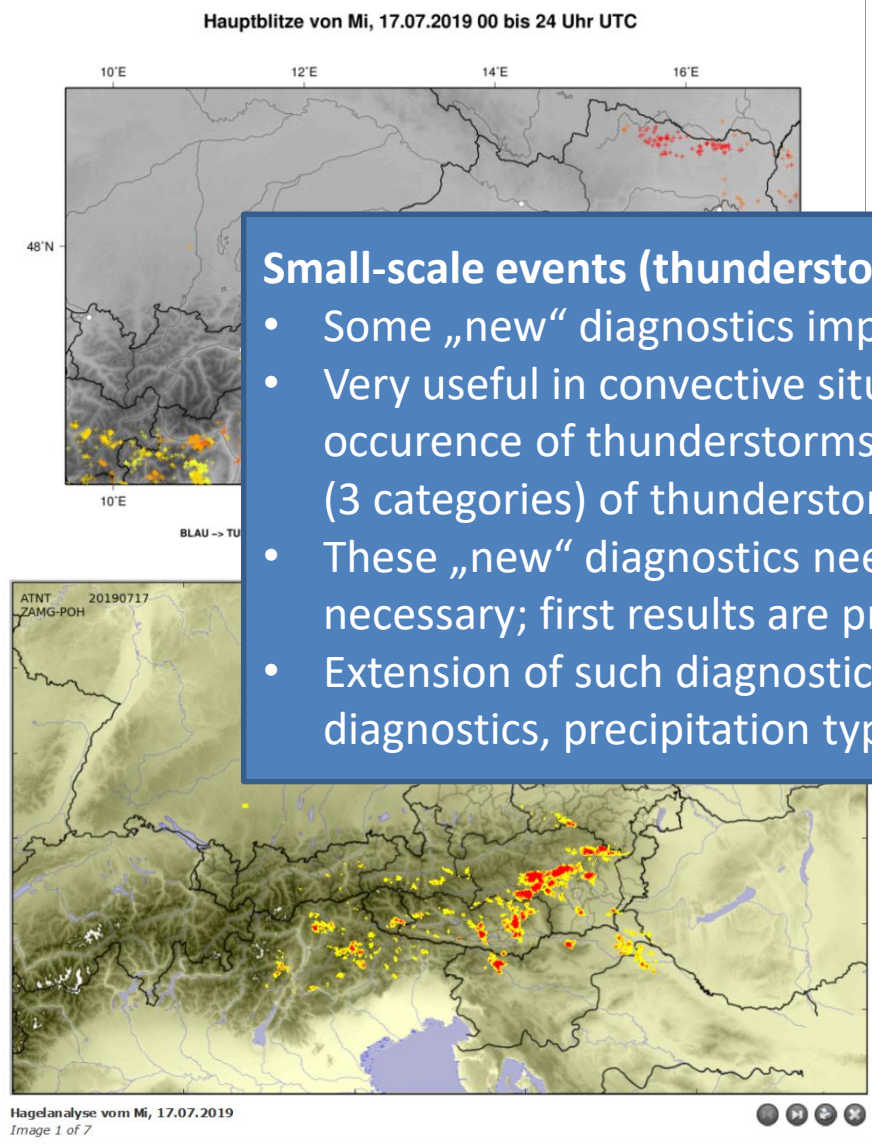






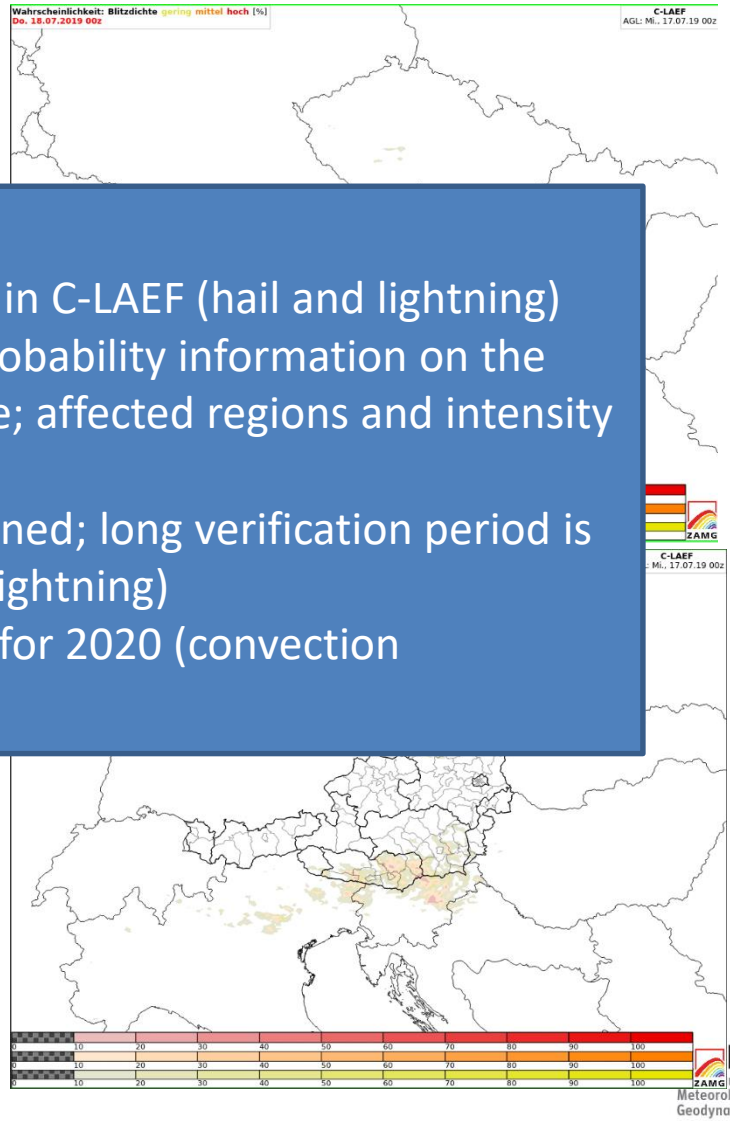
ZAMG
Zentralanstalt für Meteorologie und Geodynamik

Application of C-LAEF: Convective event

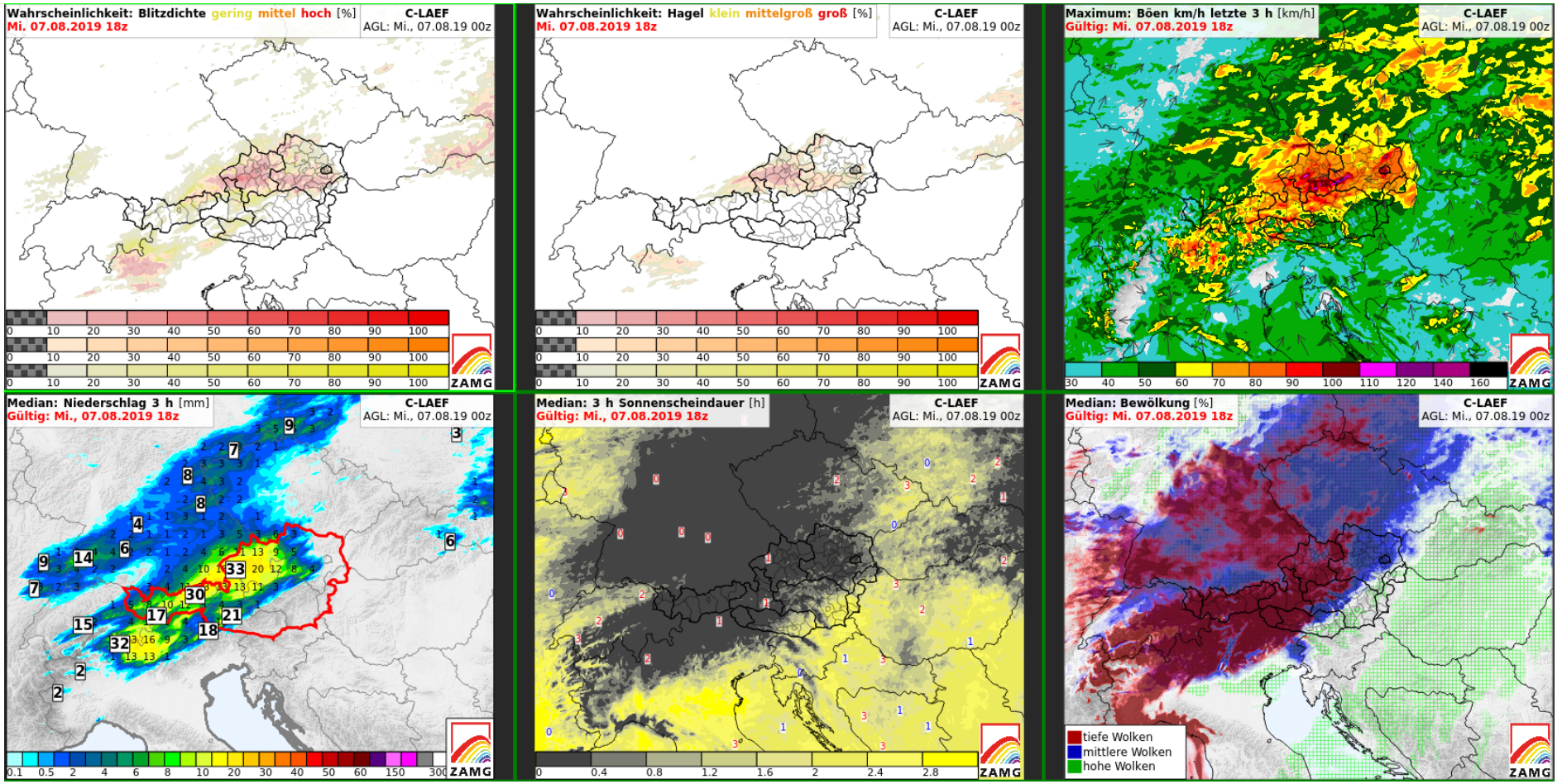


Small-scale events (thunderstorms):

- Some „new“ diagnostics implemented in C-LAEF (hail and lightning)
- Very useful in convective situations; probability information on the occurence of thunderstorms is possible; affected regions and intensity (3 categories) of thunderstorms
- These „new“ diagnostics need to be tuned; long verification period is necessary; first results are promising (lightning)
- Extension of such diagnostics planned for 2020 (convection diagnostics, precipitation types, etc.)

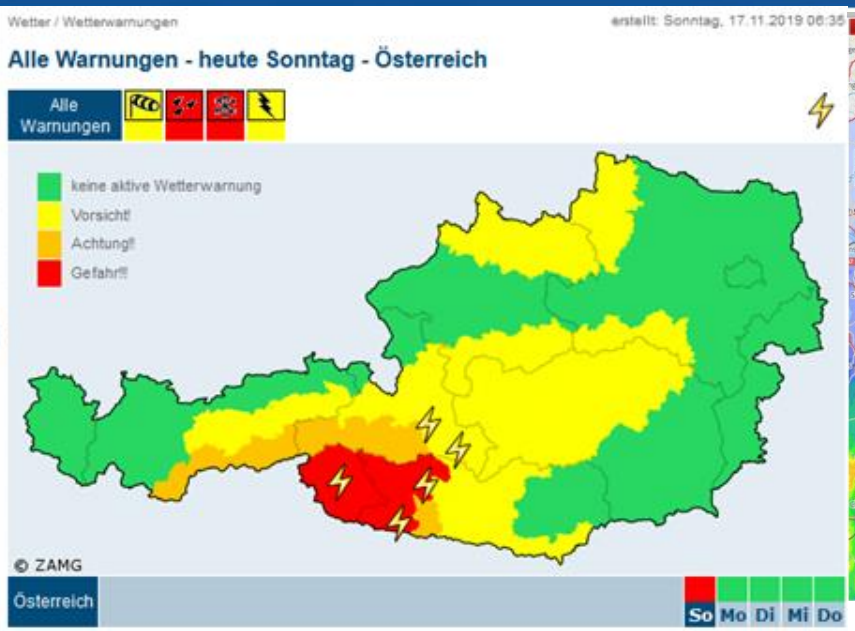


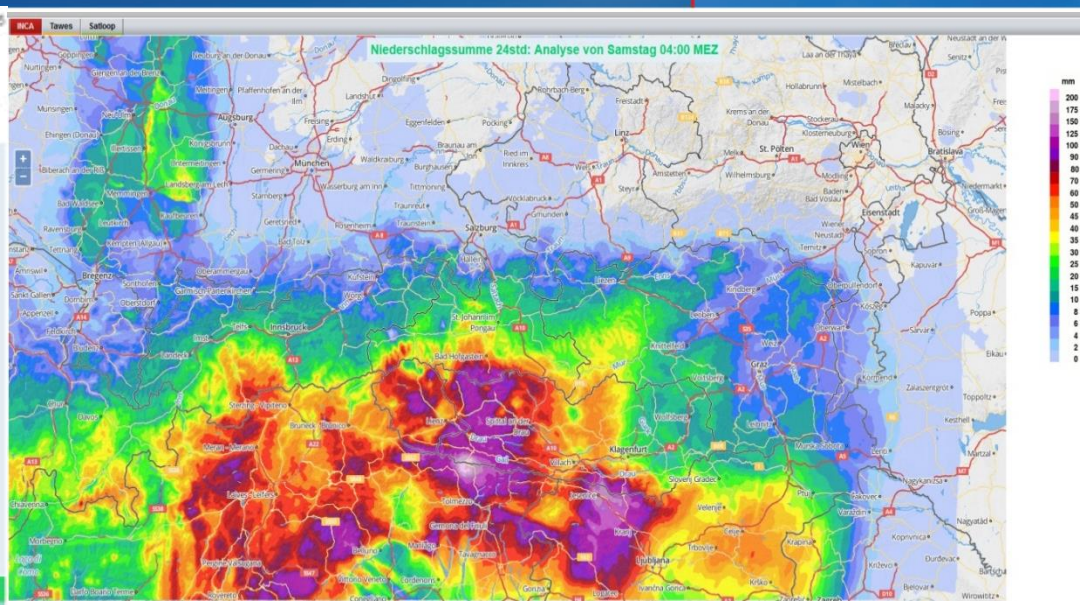
Application of C-LAEF: Summer panel

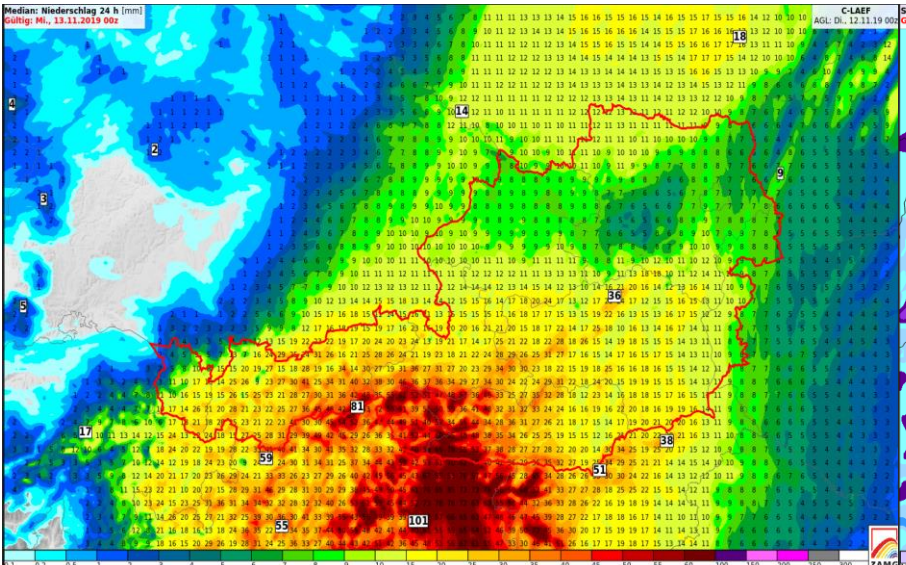


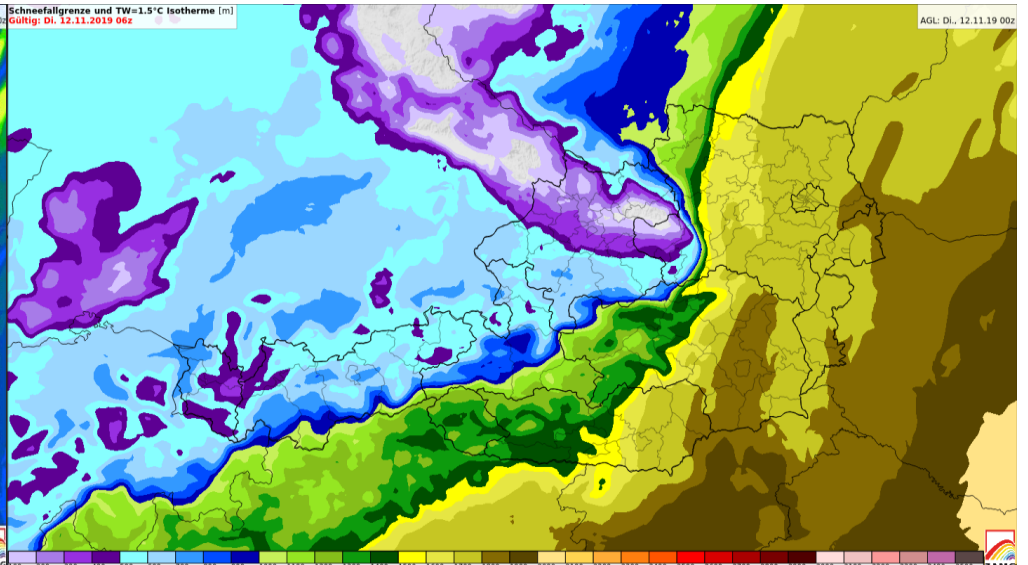
ZAMG
Zentralanstalt für Meteorologie und Geodynamik

Application of C-LAEF: Flood event

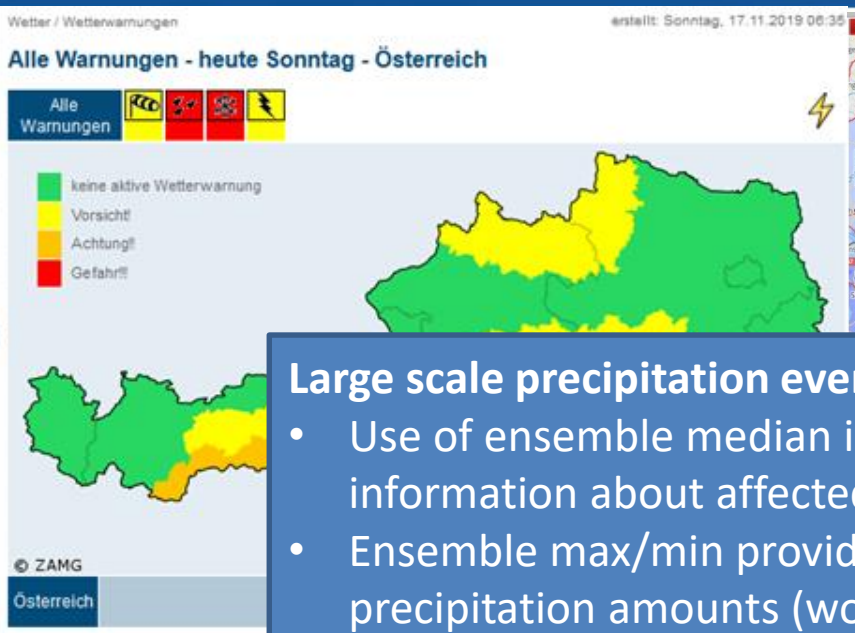






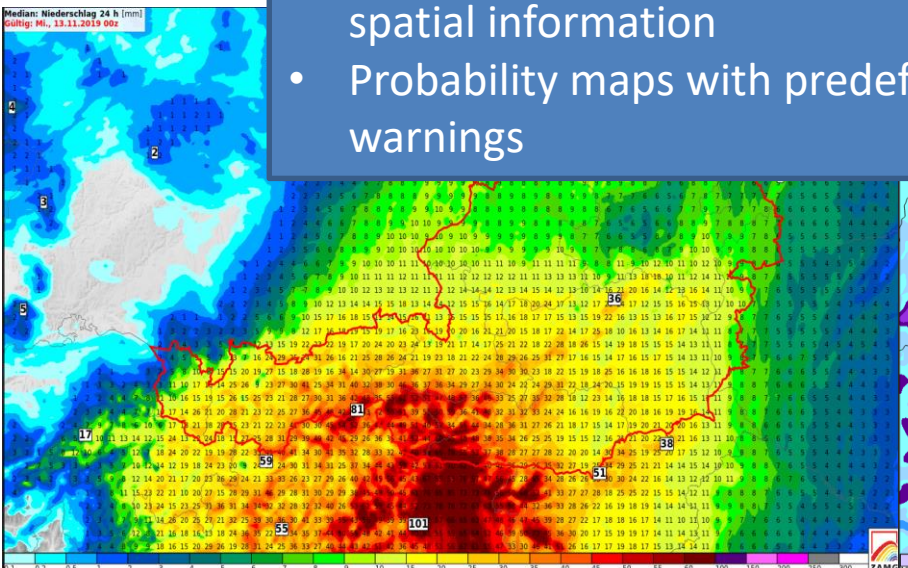


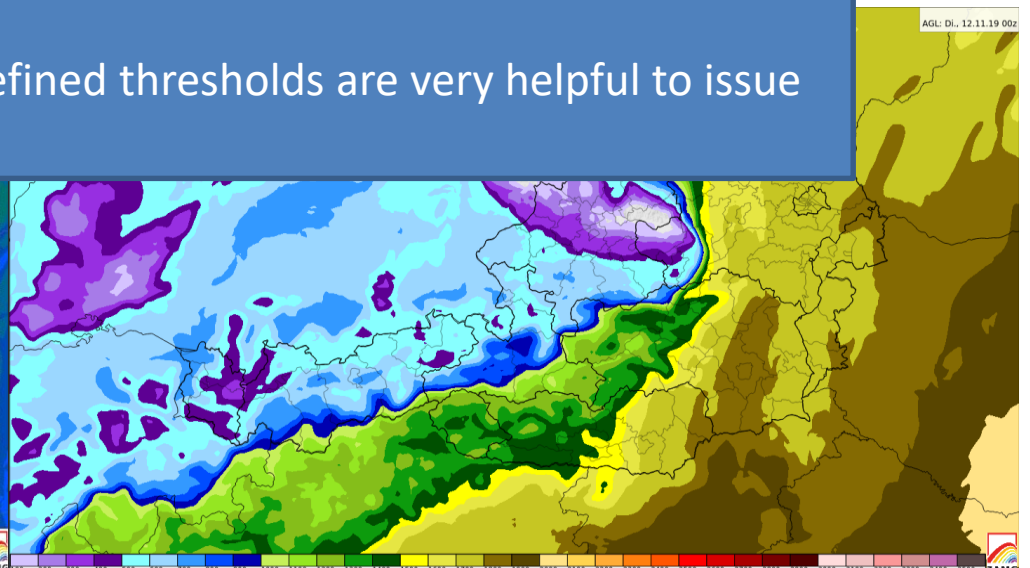
Application of C-LAEF: Flood event



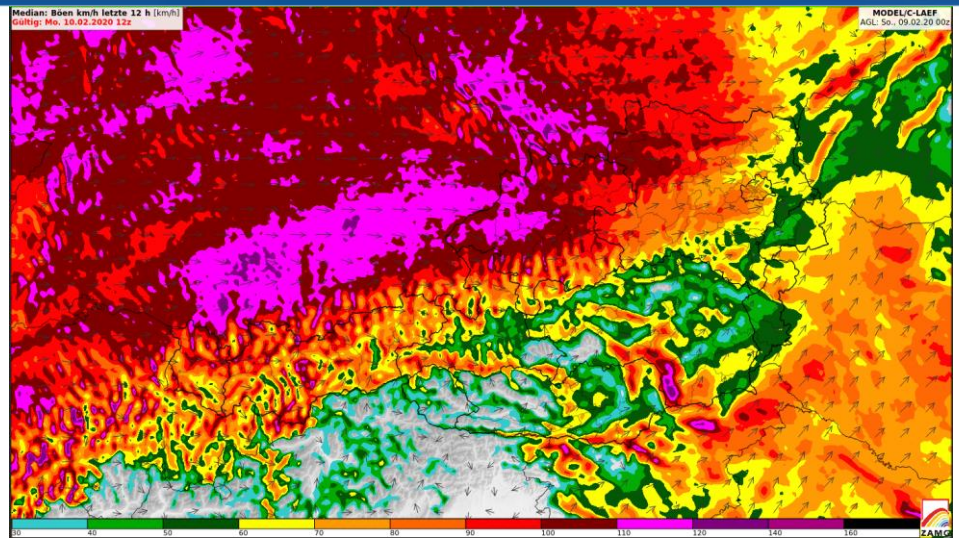
Large scale precipitation events (floods):

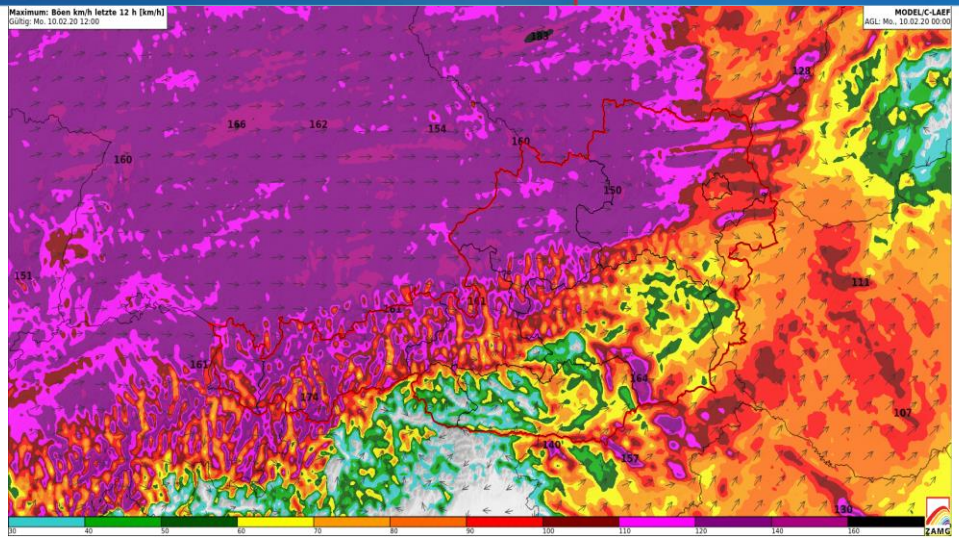
- Use of ensemble median is very helpful; more consistent and reliable information about affected area; deterministic runs are more jumpy
- Ensemble max/min provides important information on possible precipitation amounts (worst/best-case scenario); not suitable for spatial information
- Probability maps with predefined thresholds are very helpful to issue warnings

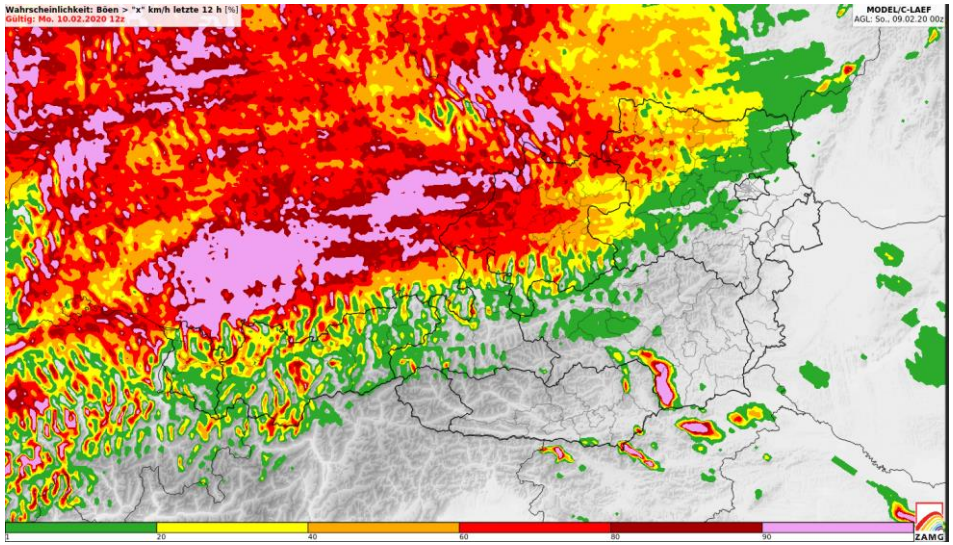


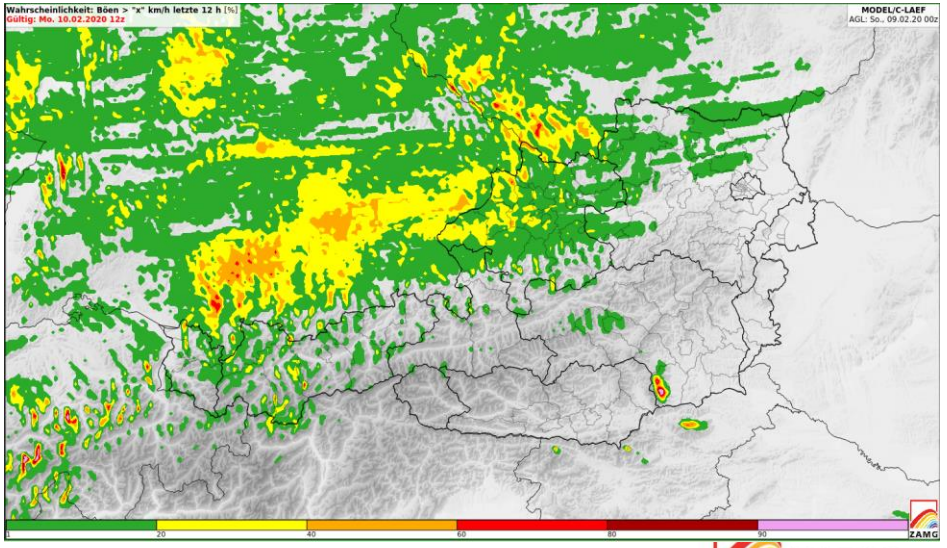


Application of C-LAEF: Storm event



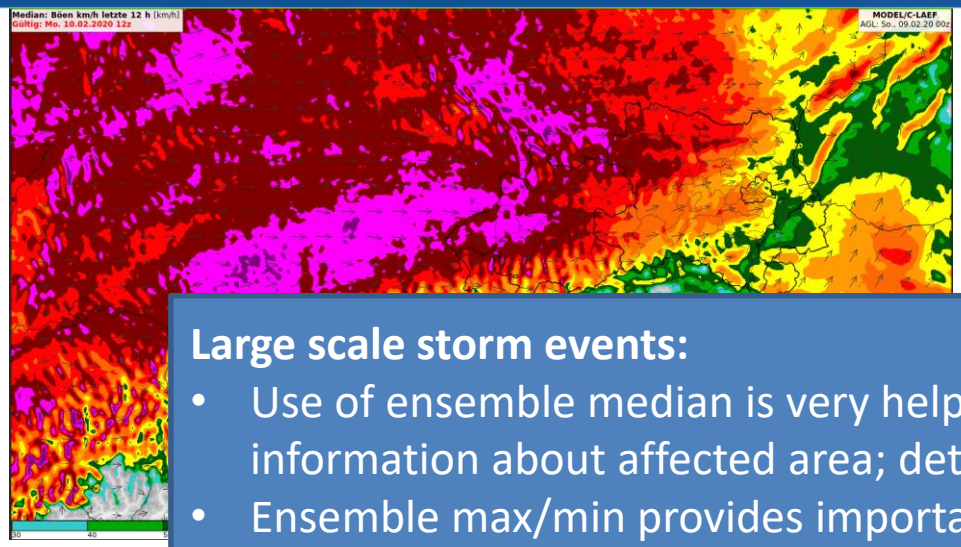


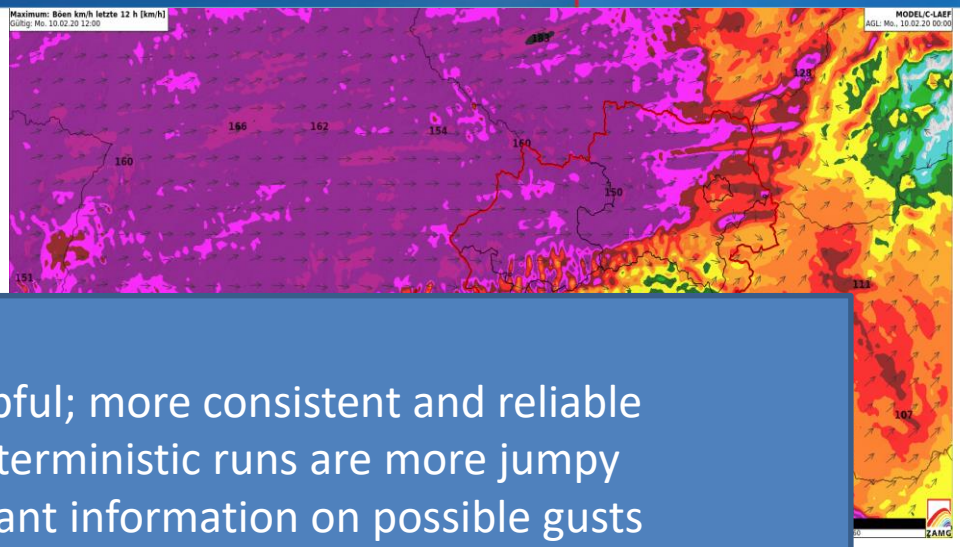




ZAMG
Zentralanstalt für Meteorologie und Geodynamik

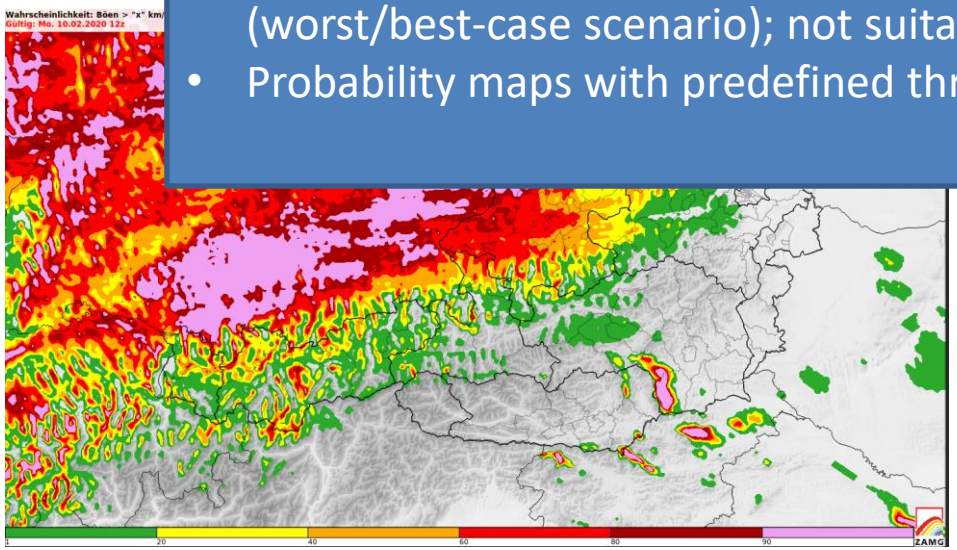
Application of C-LAEF: Storm event





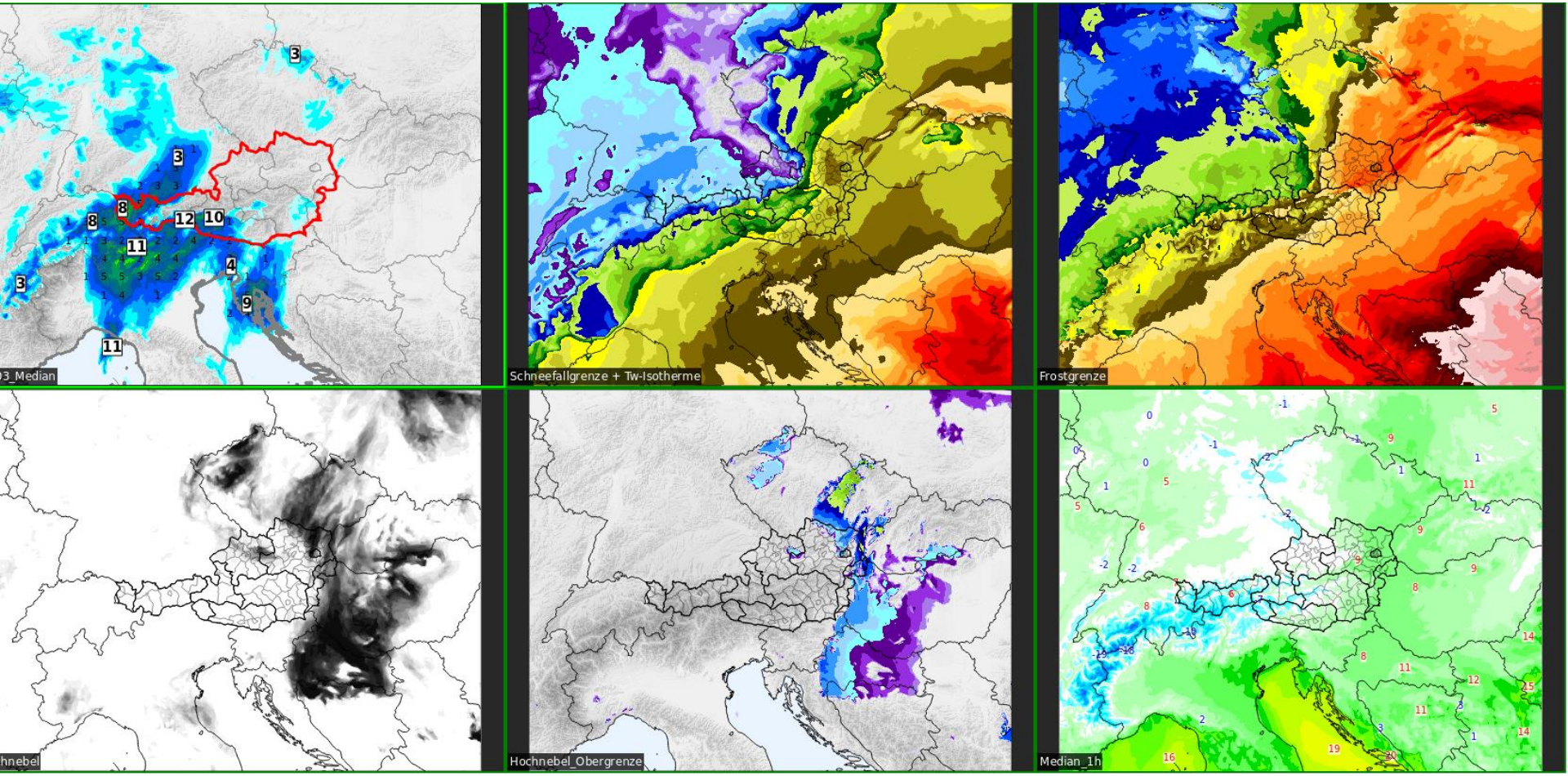
Large scale storm events:

- Use of ensemble median is very helpful; more consistent and reliable information about affected area; deterministic runs are more jumpy
- Ensemble max/min provides important information on possible gusts (worst/best-case scenario); not suitable for spatial information
- Probability maps with predefined thresholds are very helpful to issue warnings



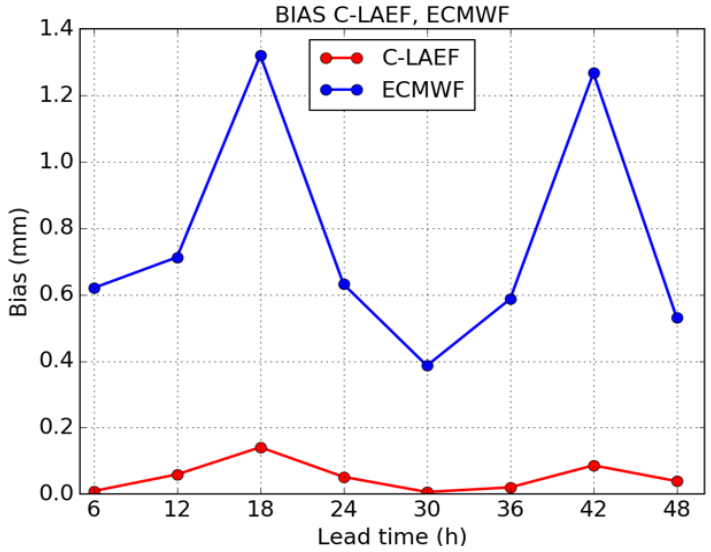
ZAMG
Zentralanstalt für Meteorologie und Geodynamik

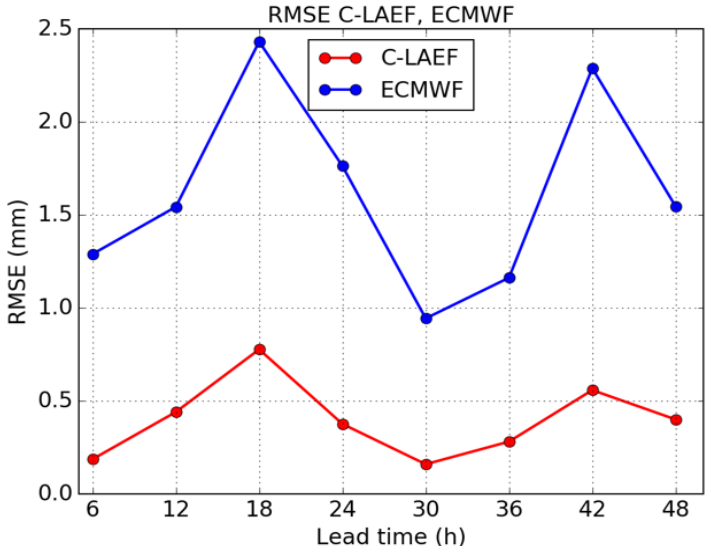
Application of C-LAEF: Winter panel



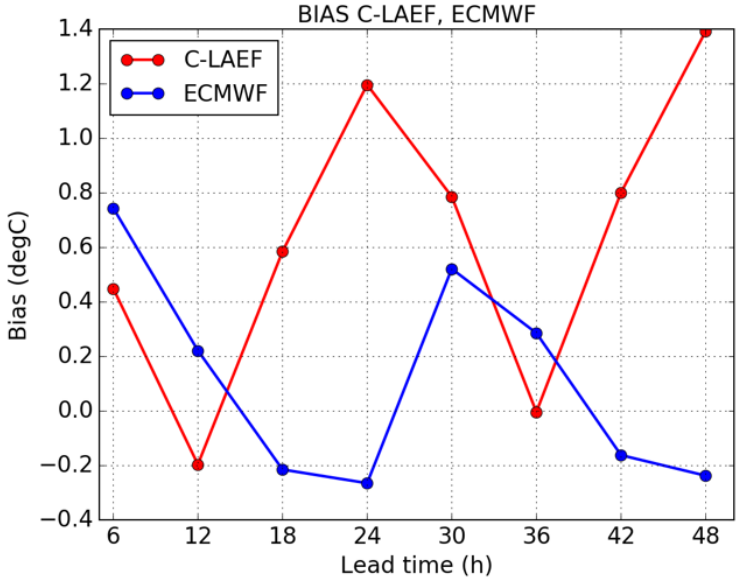
ZAMG
Zentralanstalt für Meteorologie und Geodynamik

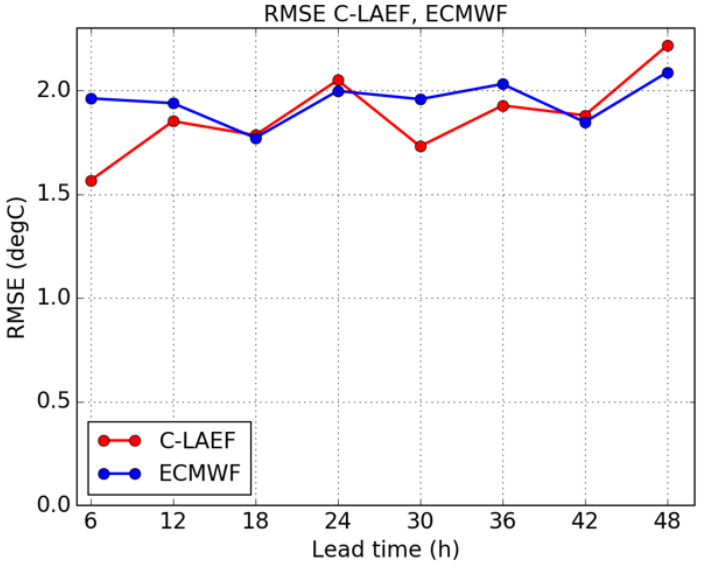
Verification: August 2019





RRR



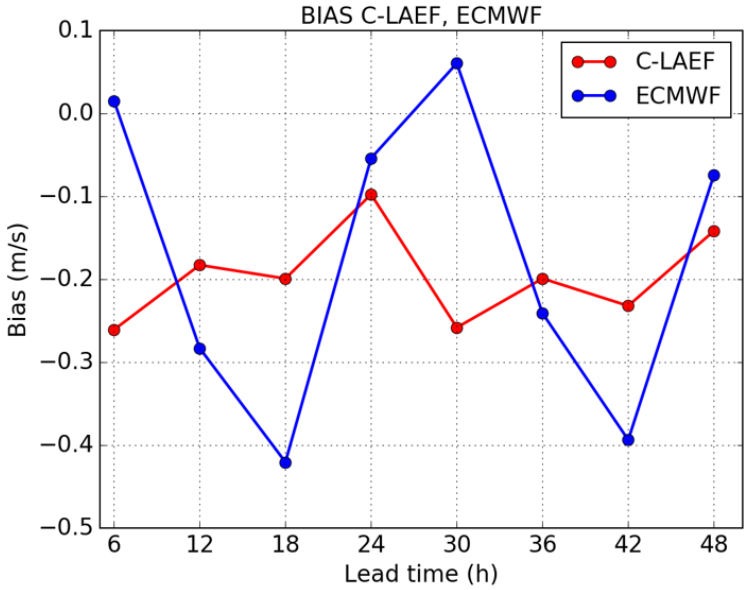


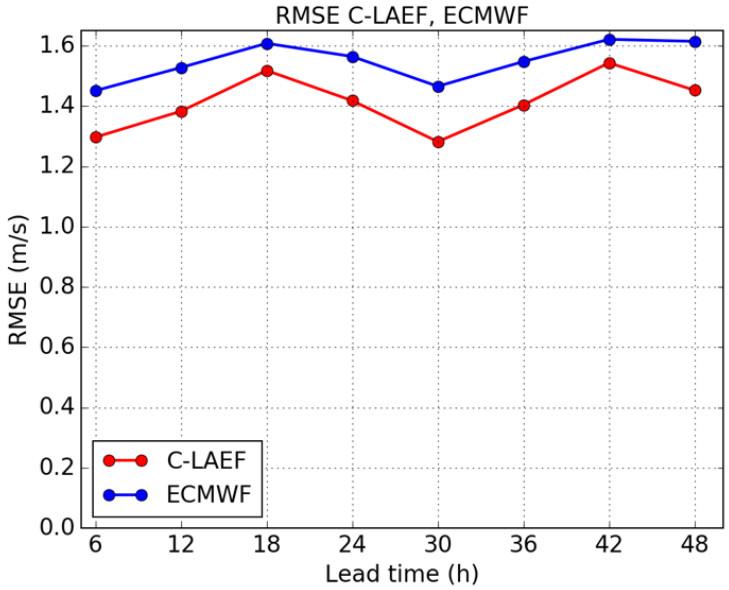
T2m

ZAMG
Zentralanstalt für Meteorologie und Geodynamik

Verification: August 2019

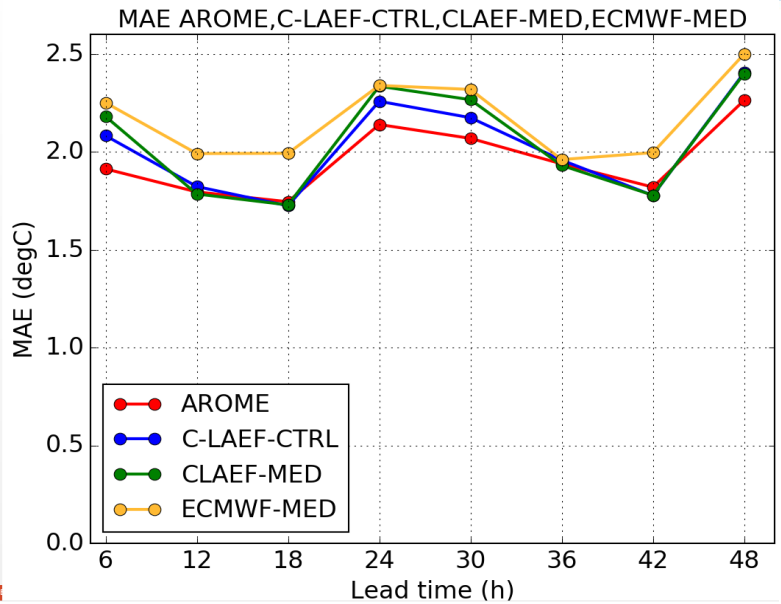
FF10m



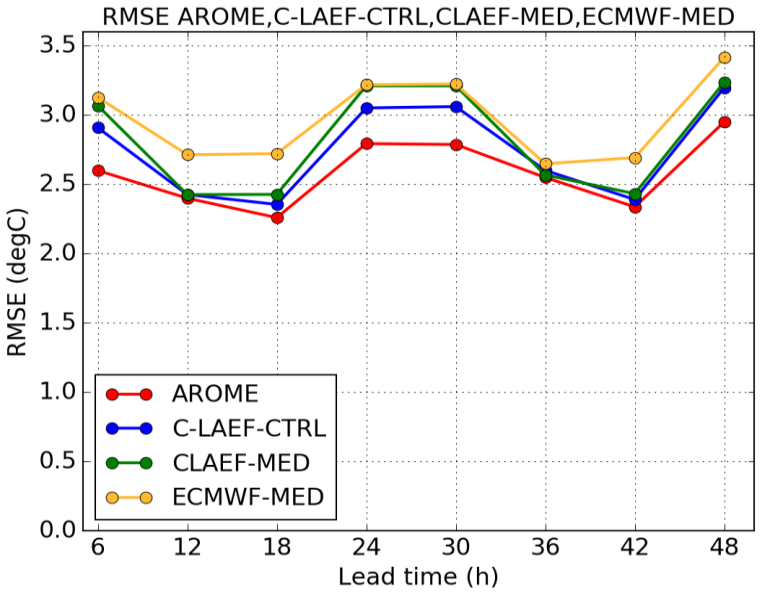


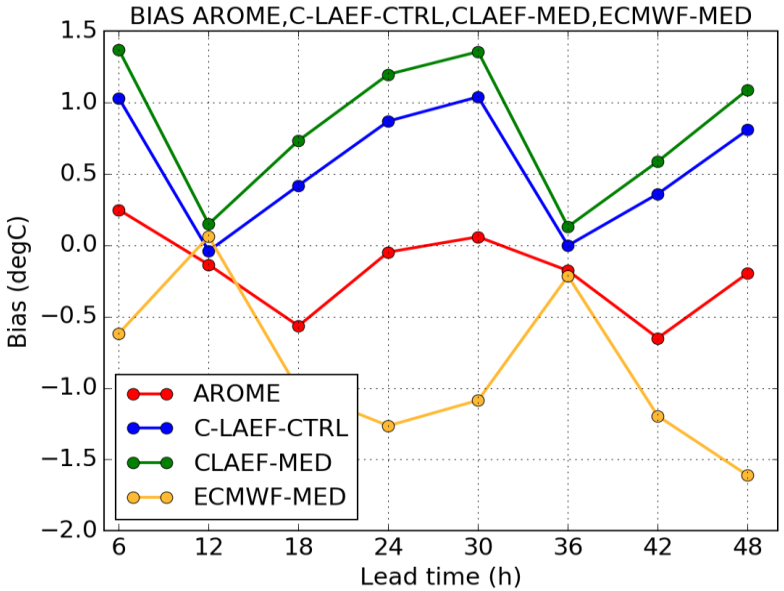
ZAMG
Zentralanstalt für Meteorologie und Geodynamik

Verification: February 2020



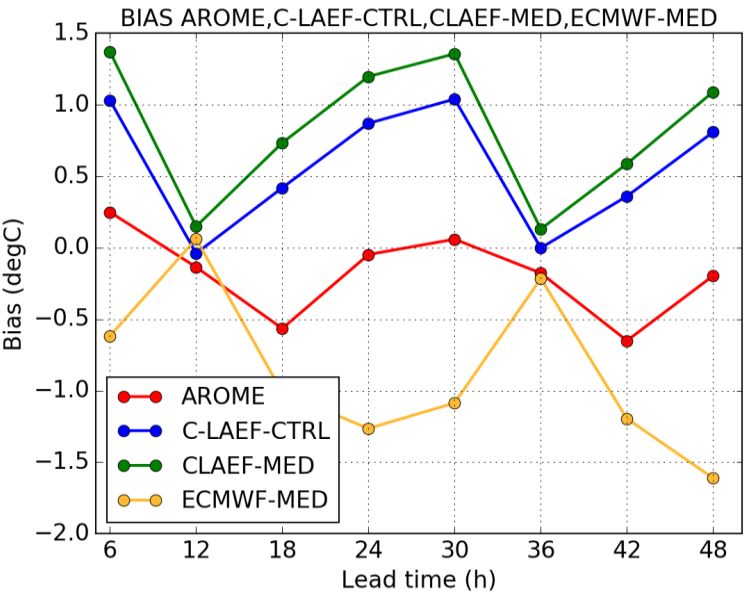
T2m
All stations



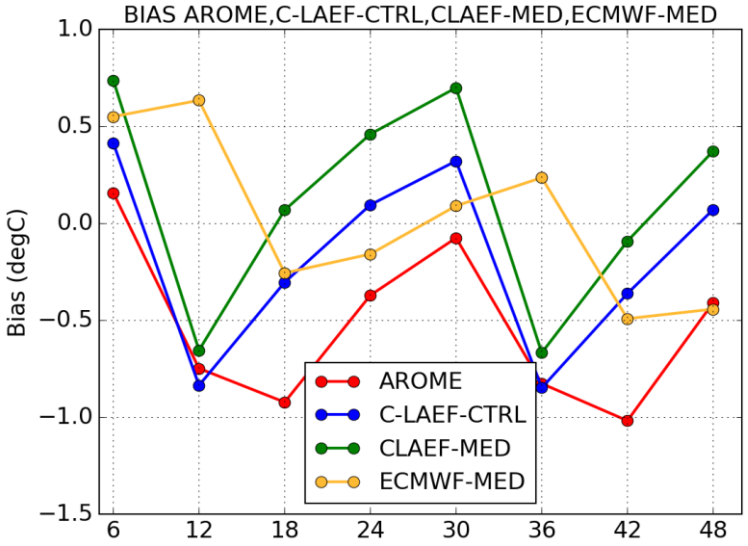


ZAMG
Zentralanstalt für Meteorologie und Geodynamik

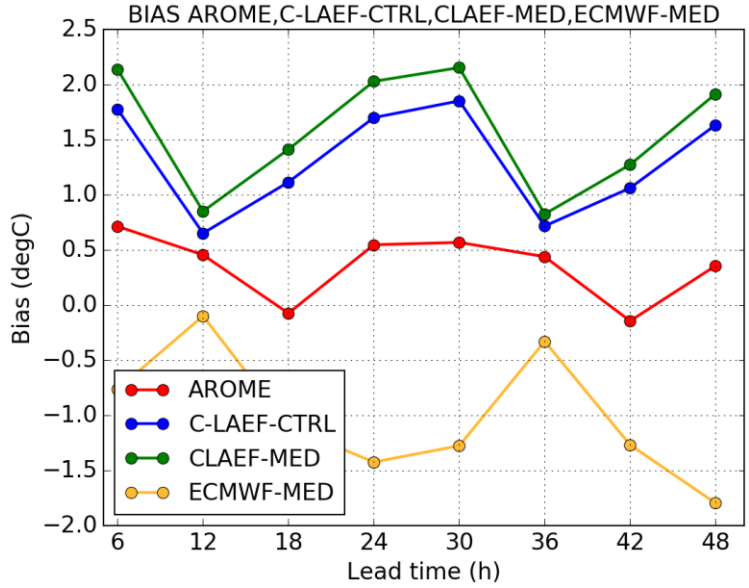
Verification: February 2020



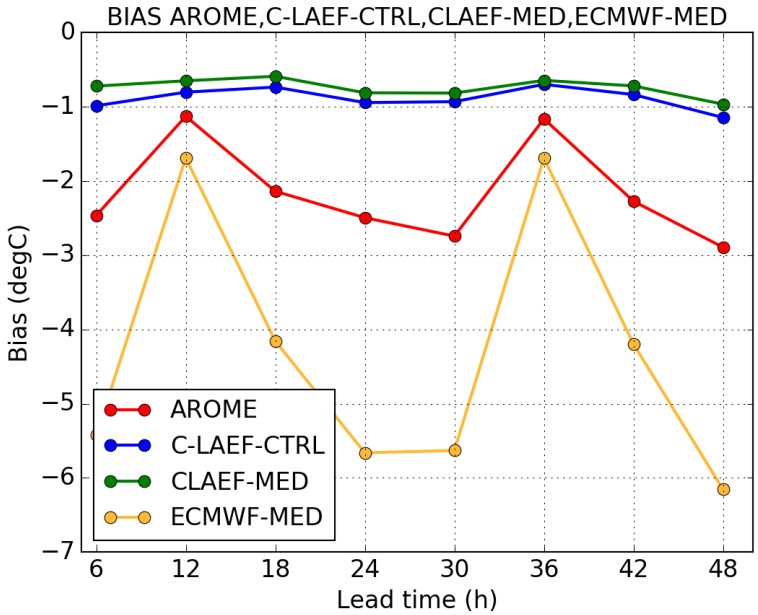
T2m
All stations



T2m
0-500m



T2m
500-1500m

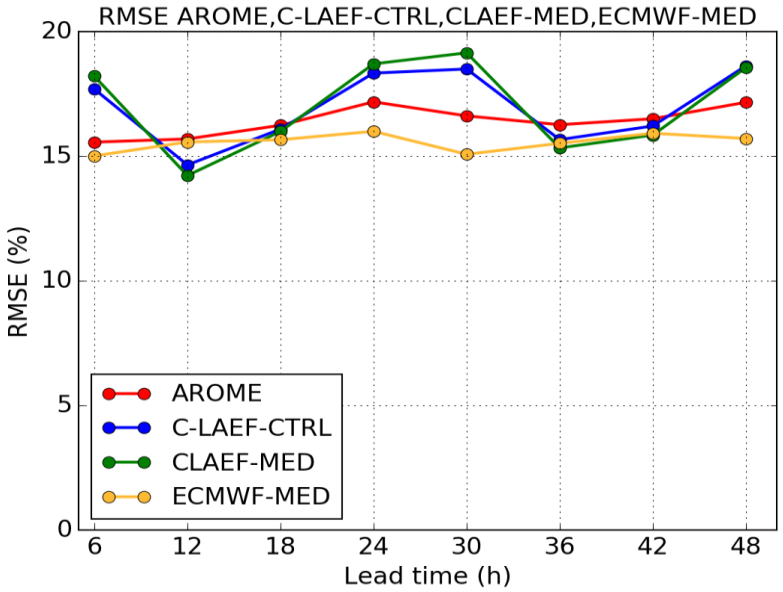


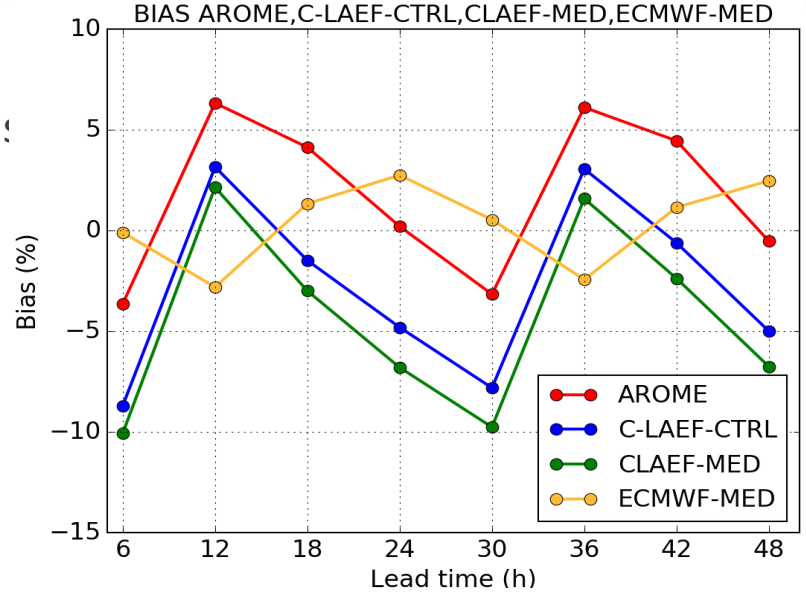
T2m
1500-
3500m

ZAMG
Zentralanstalt für Meteorologie und Geodynamik

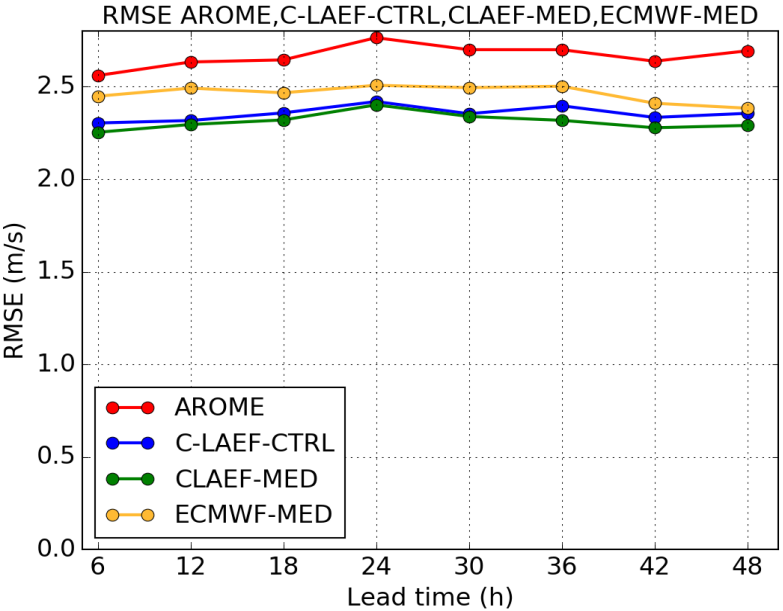
Verification: February 2020

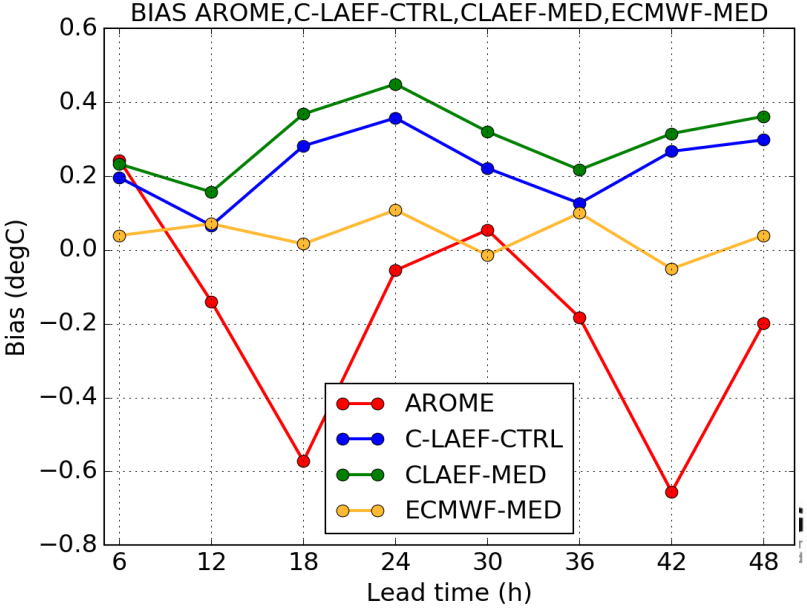
RH2m
All stations



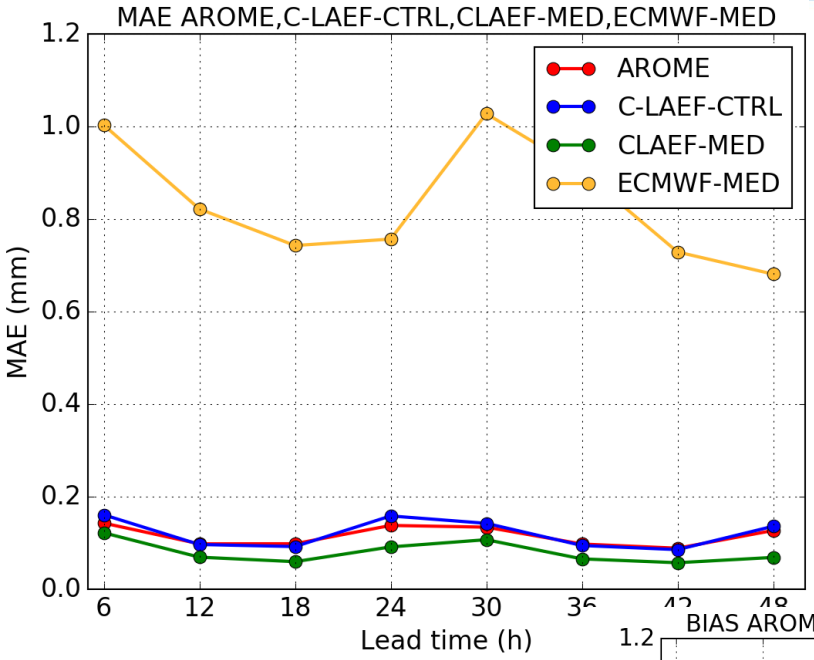


FF10m
All stations

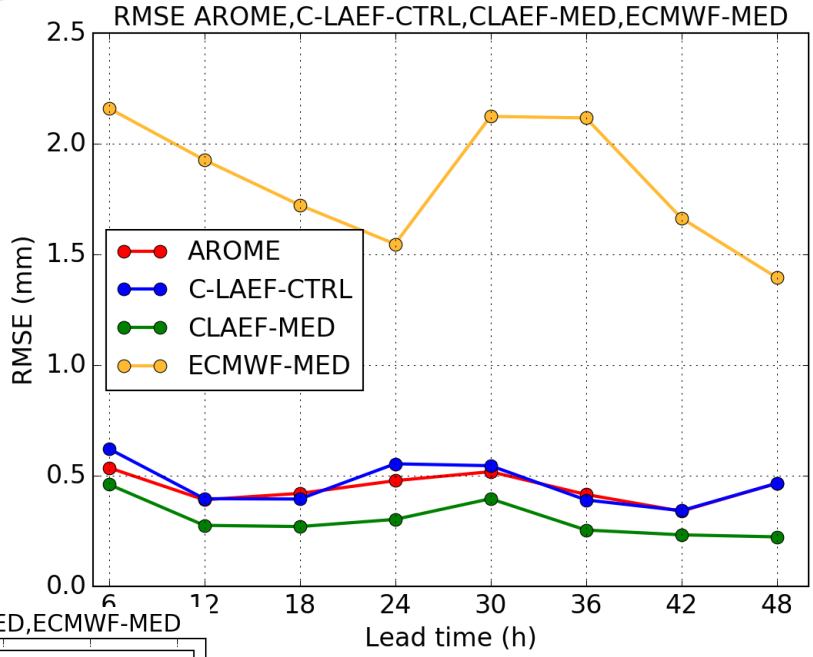


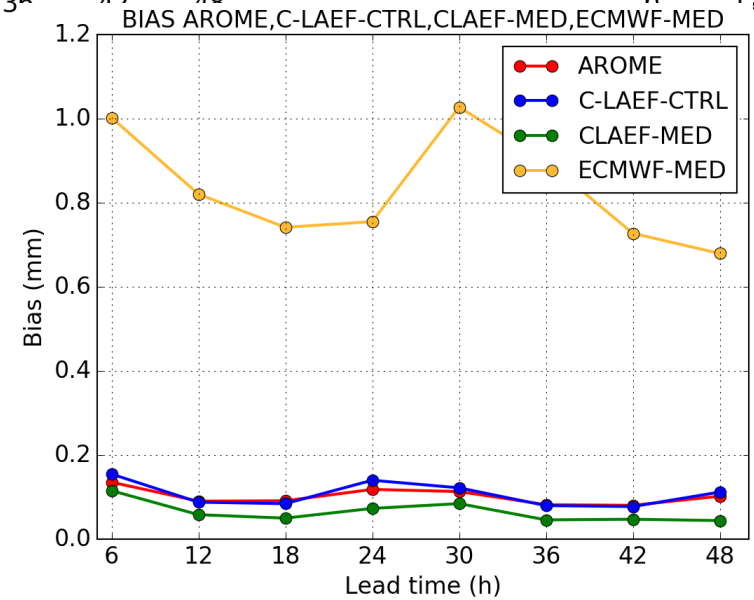


Verification: February 2020



RRR
All stations





ZAMG
Zentralanstalt für Meteorologie und Geodynamik

C-LAEF: Conclusions & Outlook

- C-LAEF is running on the ECMWF HPC; Pre-operational mode started in July 2019; fully operational (with backup, archiving, verification, etc.) since November 2019
- C-LAEF has become an important forecasting tool at ZAMG in the 3 months since its operational implementation
- Operational forecasters are using it regularly (among the 3 most used models at ZAMG)
- Especially used in case of severe weather events (floods, storm events, thunderstorms)
- Some problems identified (2m diagnostics, underdispersive, problems with orographic precipitation , etc.)
- Not yet provided to customers, but many products are in preparation
- Upgrade to cy43 in autumn 2020
- 2 internal projects are dealing with C-LAEF (improvement of system, extension of probablistic products)

ZAMG
Zentralanstalt für Meteorologie und Geodynamik