Ensemble based seven day high impact weather outlook

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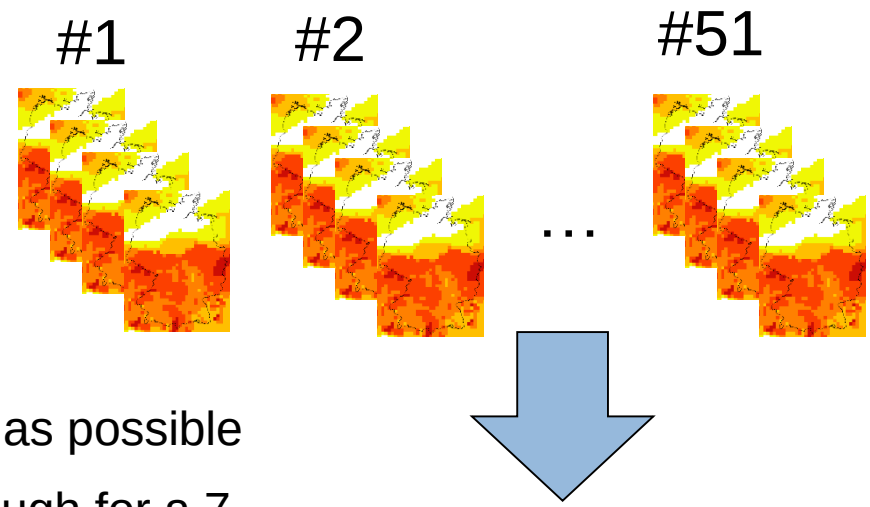
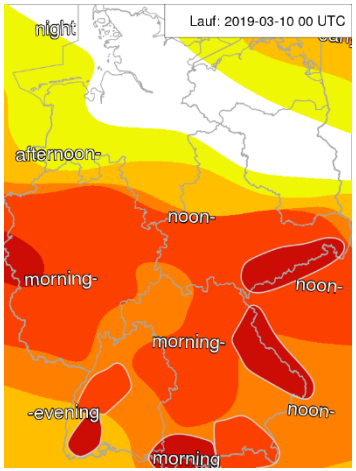
Motivation

- Currently at DWD: Forecasters produce text product for Germany
- In testing: Forecasters produce a graphical product for Germany
- In development: An automated ensemble based product (Daily Model Guidance - DMG)
  - as support for forecasters
  - as potential product for the public

Challenges & goals

- Challenges: Combine ensemble and temporal information for one day and one warning event in one graph that is …
  - "pretty"
  - meteorologically meaningful
  - without clutter
  - easy to understand
  - with as much information reduction as possible
- Prerequisite : model forecast good enough for a 7 days high impact weather outlook
- Product that allows for quick comparison
  - of different models
  - of different model runs
  - with observations (in retroperspective)
  - with forecasters' warnings (in retroperspective)

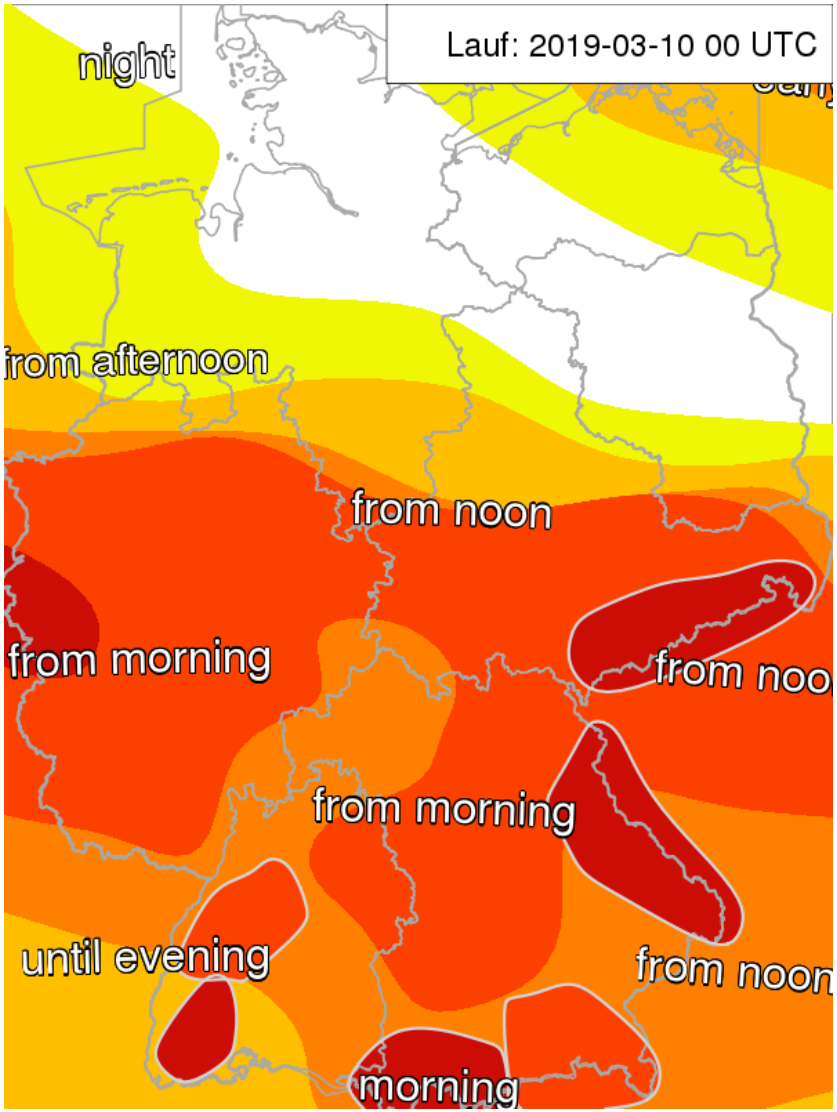




Overview – DMG (Daily Model Guidance)

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

- Generated from Ensemble data
- For IFS-EPS, ICON-EU-EPS, COSMO-D2-EPS (only 2 days)
- For gusts, persistent rain, snowfall and thunderstorms
- Model data converted to warning categories based on 90th%ile (via optimization of Heidke Skill Score)



- -
- >14m/s
- >18m/s
- >25m/s
- >29m/s
- >33m/s
- >39m/s

Overview – DMG (Daily Model Guidance) Uncertainty

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

- r=(Q90-Q10)/Q50
- Labelling:

  0.5<r uncertain

  0.3<r<0.5 less certain

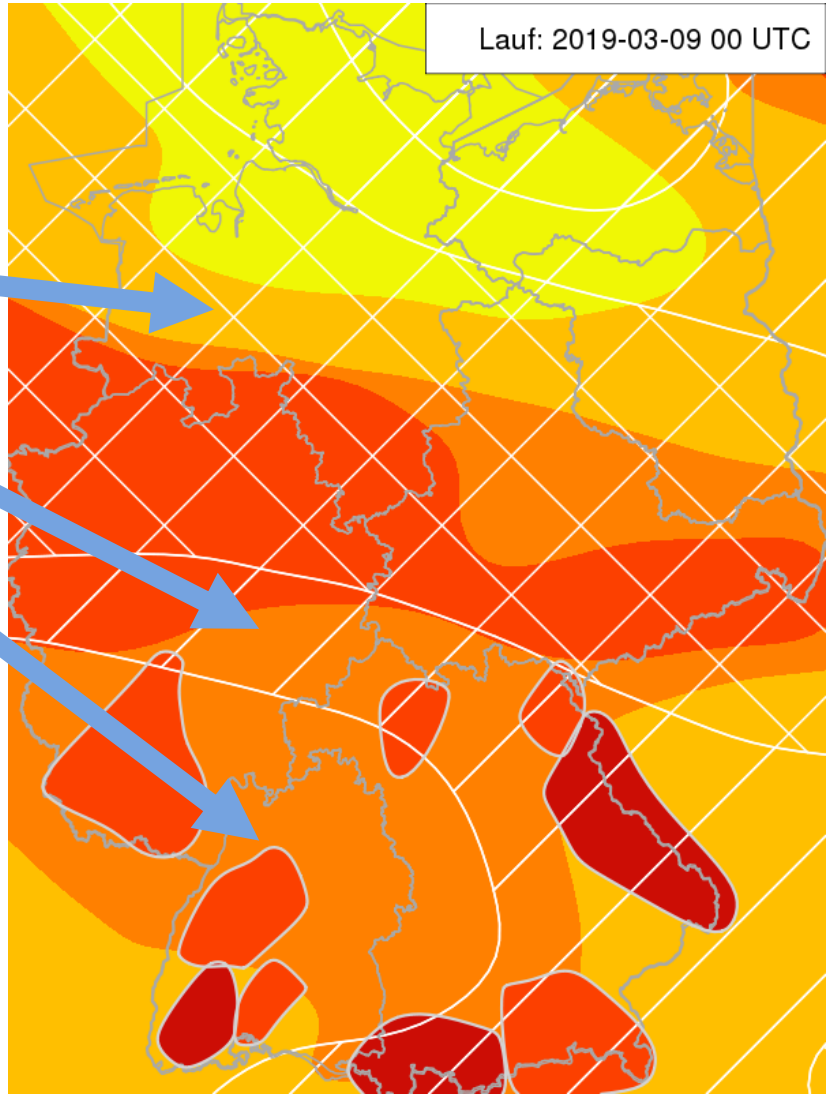
  r<0.3 more certain

- Rain and snow: (Q90-Q10)

  >=2 warning categories – uncertain

  1-2 warning categories – less certain

  <1 warning category – more certain



Overview – DMG (Daily Model Guidance) Uncertainty

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

- r=(Q90-Q10)/Q50 (for wind)
- Labelling:

  0.5<r uncertain

  0.3<r<0.5 less certain

  r<0.3 more certain

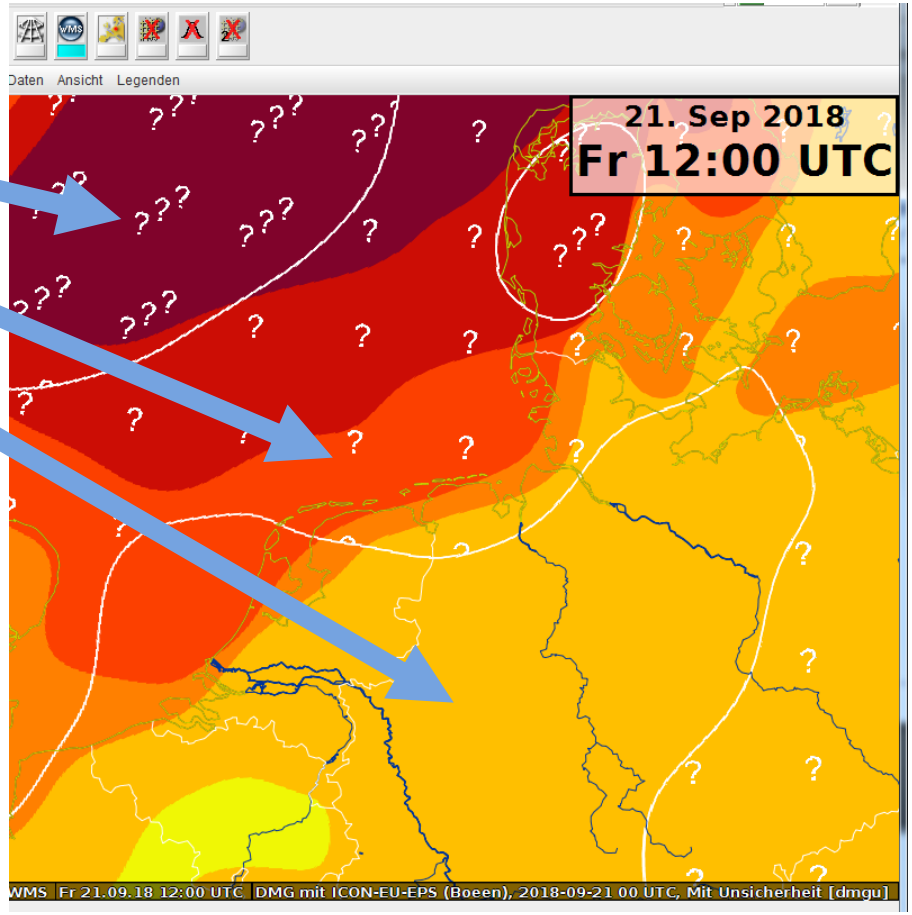
- Rain and snow: (Q90-Q10)

  >=2 warning categories – uncertain

  1-2 warning categories – less certain

  <1 warning category – more certain

In meteorological workstation NinJo

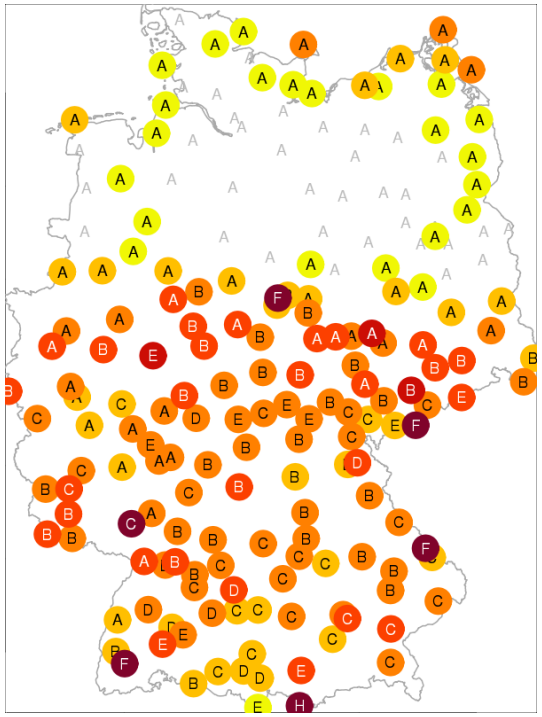


Input data – Correlation with station data
Verification period Dec ‘18 – March ‘19

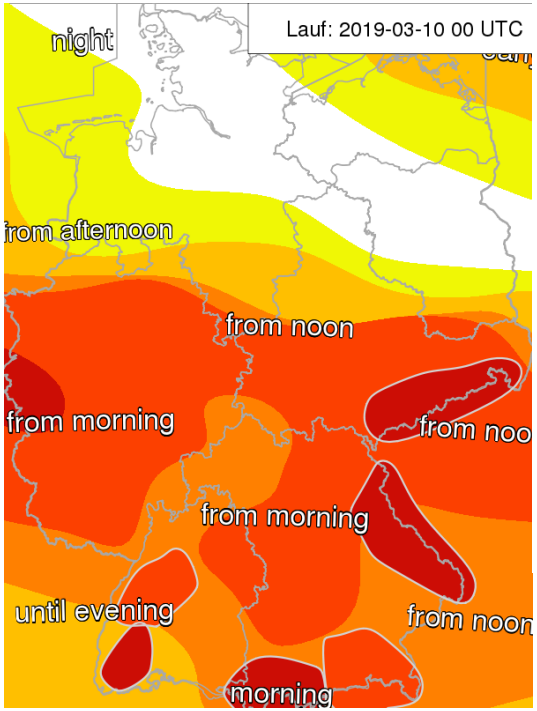
Deutscher Wetterdienst
Wetter und Klima aus einer Hand

- Verification with station observations
- Station data and model data is coarsened to 150km radius and 24h maximum to avoid location/time mismatch

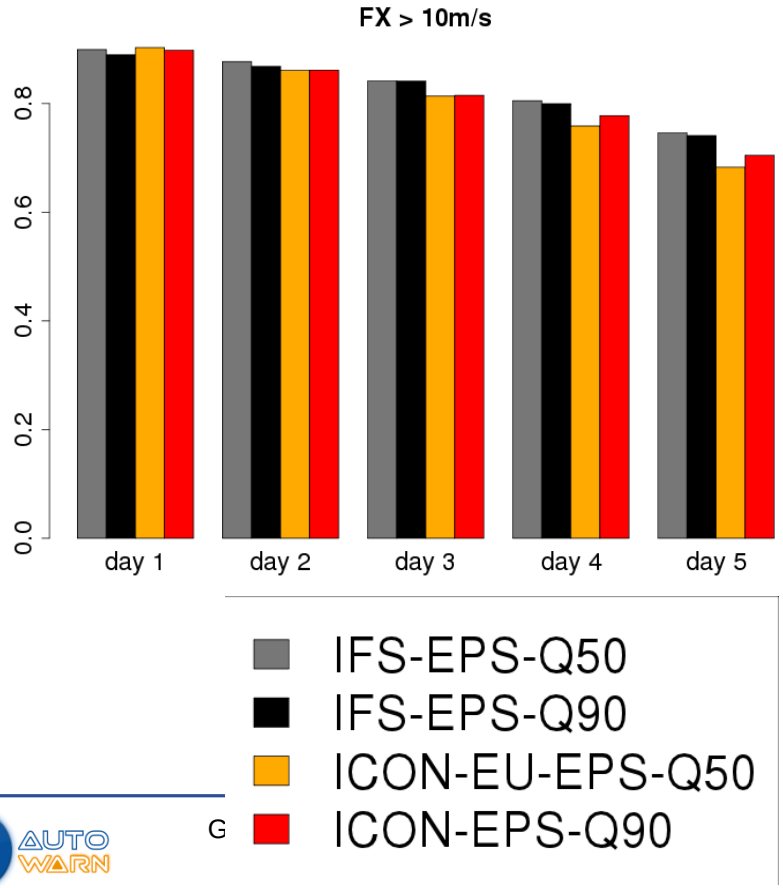
Gusts: ~220 stations



Example



Gust correlation

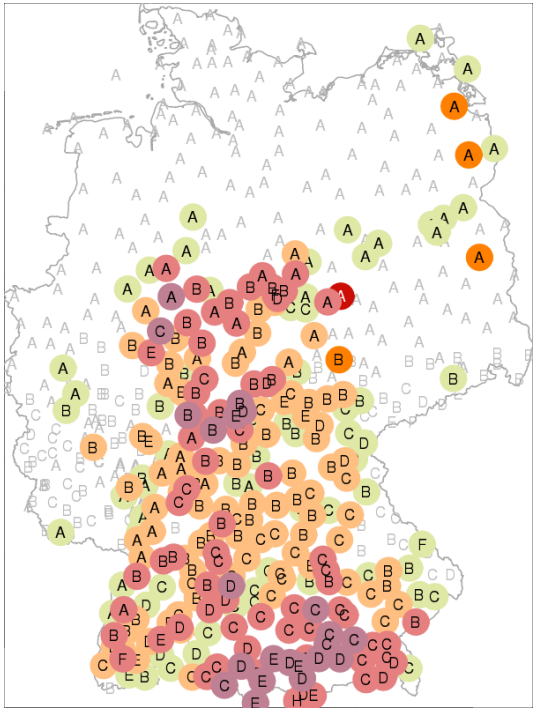


Input data – Correlation with station data
Verification period Dec ‘18 – March ‘19

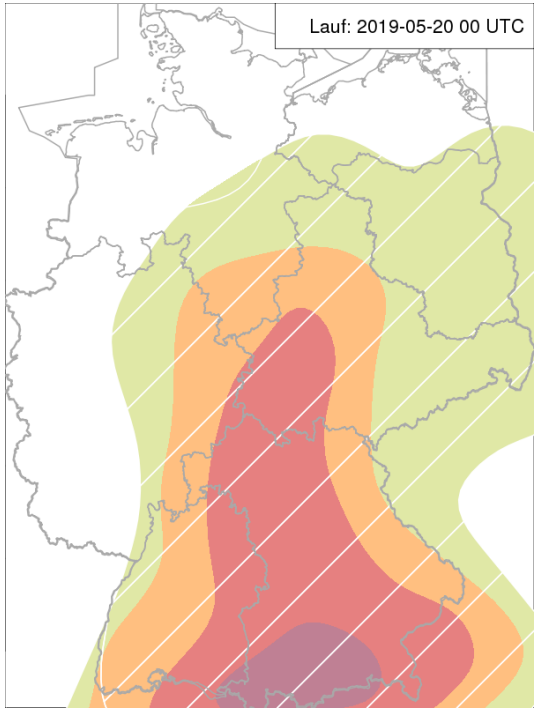
Deutscher Wetterdienst
Wetter und Klima aus einer Hand

- Verification with station observations
- Station data and model data is coarsened to 150km radius and 24h sum to avoid location/time mismatch

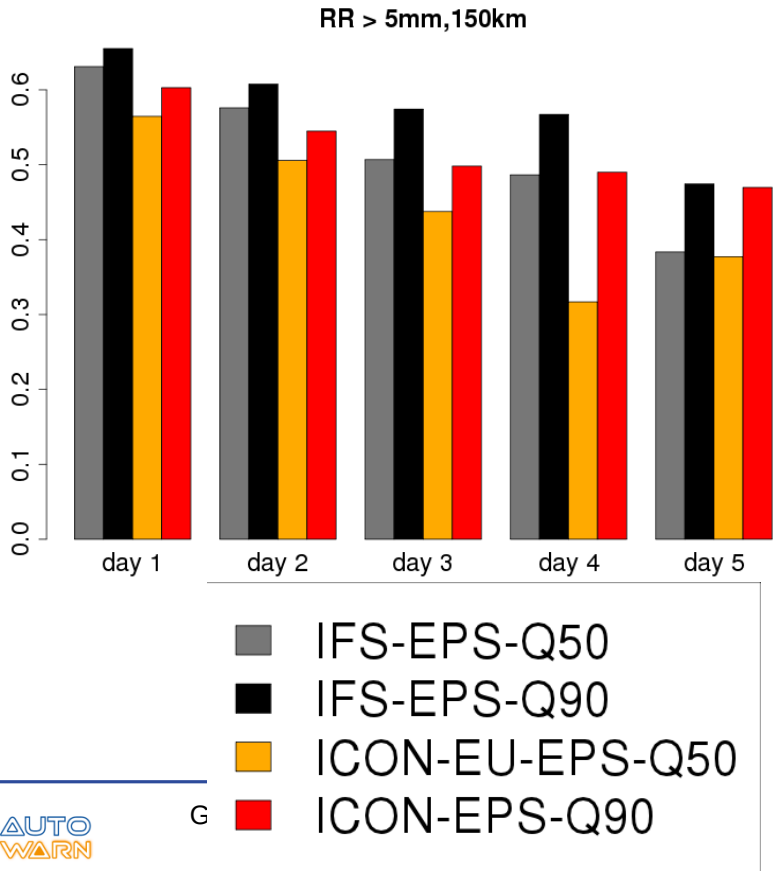
Rain: ~530 stations



Example



Rain correlation

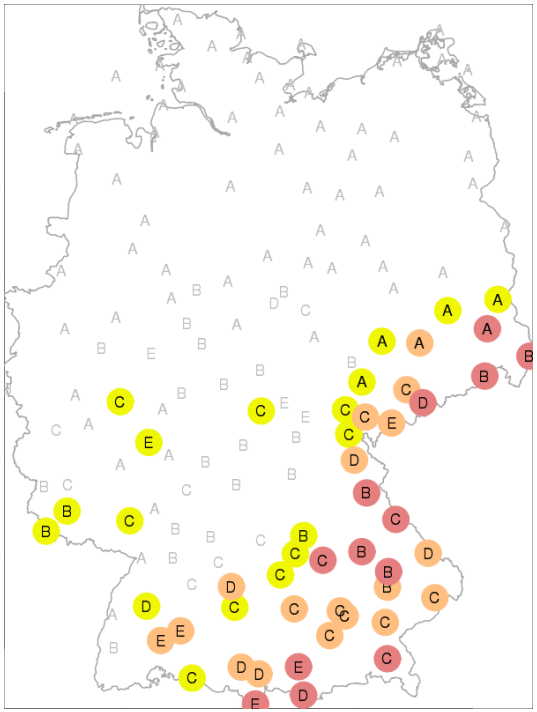


Input data – Correlation with station data
Verification period Dec ‘18 – March ‘19

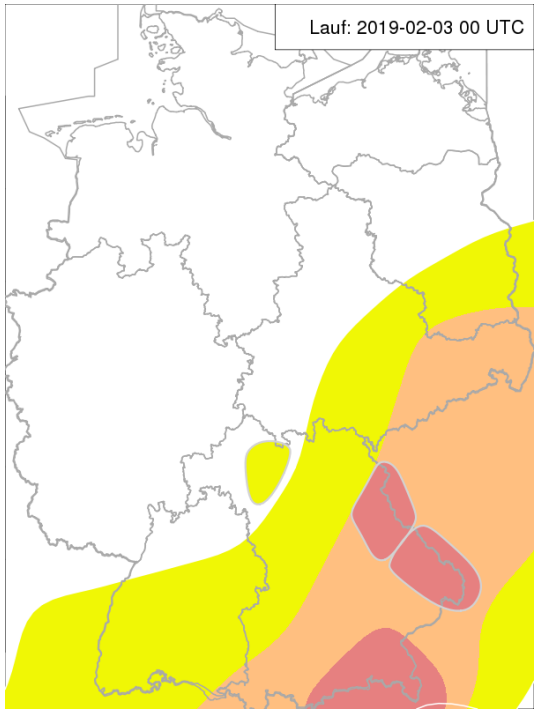
Deutscher Wetterdienst
Wetter und Klima aus einer Hand

- Verification with station observations
- Station data and model data is coarsened to 150km radius and 24h maximum to avoid location/time mismatch

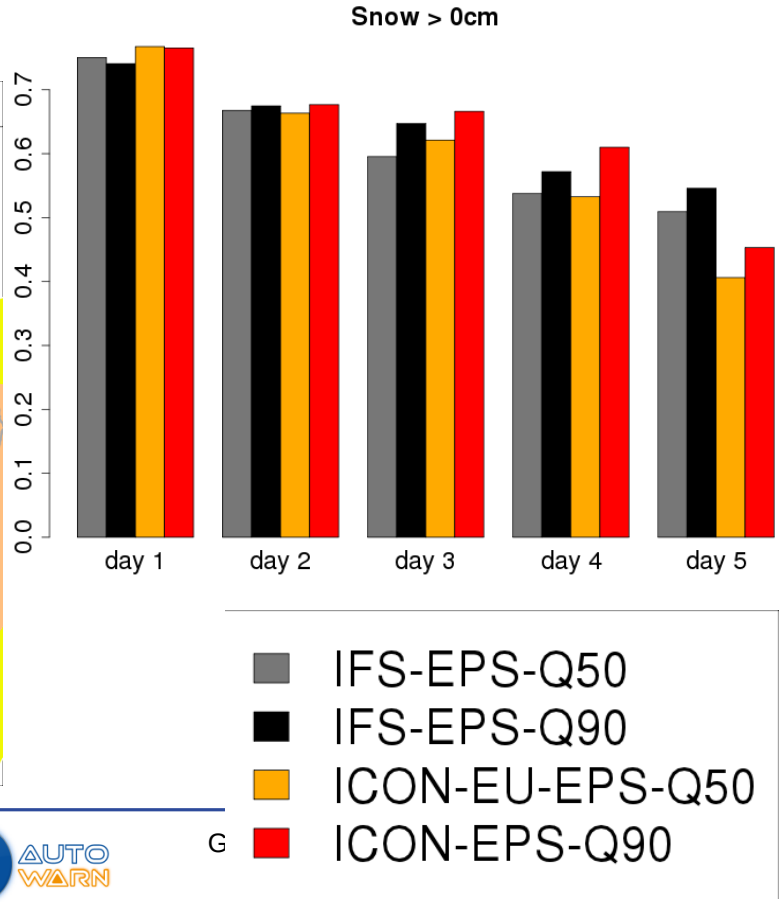
Snow depth: ~150 stations



Example



Snowfall Correlation

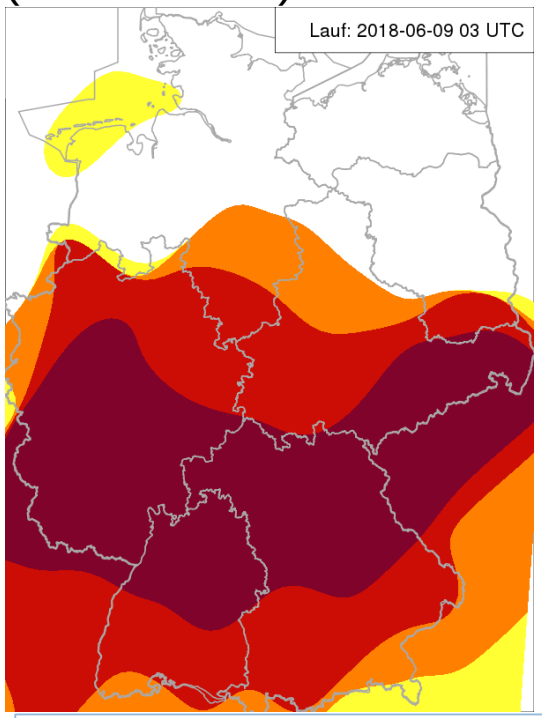


Input data – Correlation with NowCastMIX Analysis
Verification period 06 June - 31 July 2018

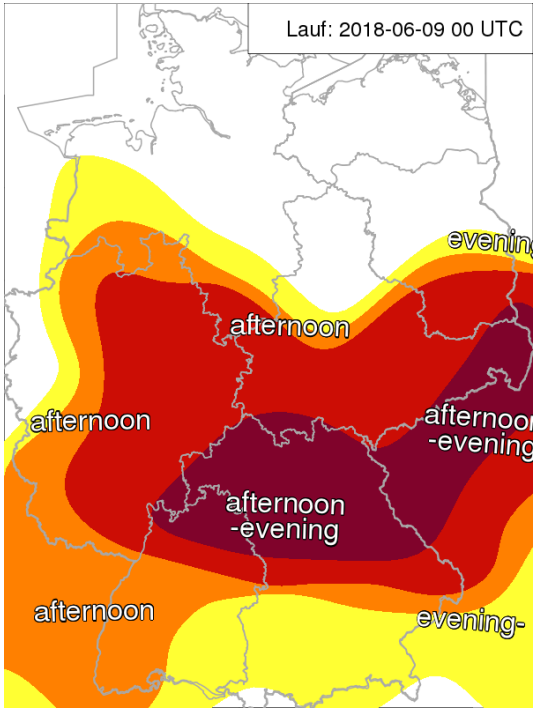
Deutscher Wetterdienst
Wetter und Klima aus einer Hand

- ➔ Analysis data and model data is coarsened to 150km radius and 24h maximum to avoid location/time mismatch
- ➔ Litghenintg flash density from IFS (not available for ICON)

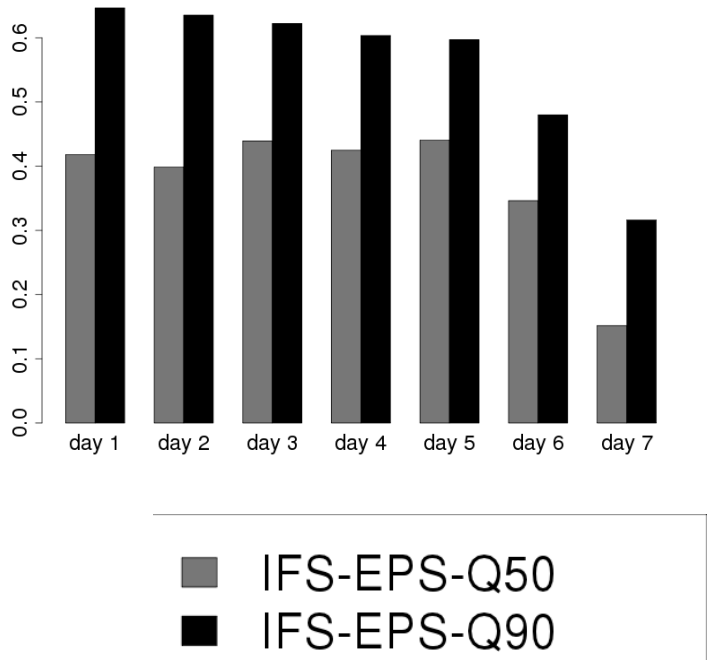
NowCastMIX Analysis (James et al.)



Example



Thunderstorm correlation



*James, P.M. et al. 2018: NowCastMIX: Automatic Integrated Warnings for Severe Convection on Nowcasting Time Scales at the German Weather Service. Wea. Forecasting 33. 1413-1433.

Why smoothing?

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

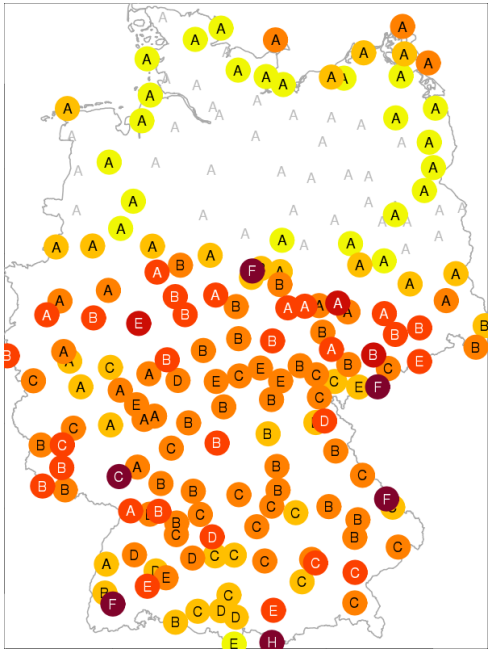
- DMG is a coarse product
- Certain features not significant especially several days ahead
- Noisy data more difficult to interprete for laymen

Station height levels:

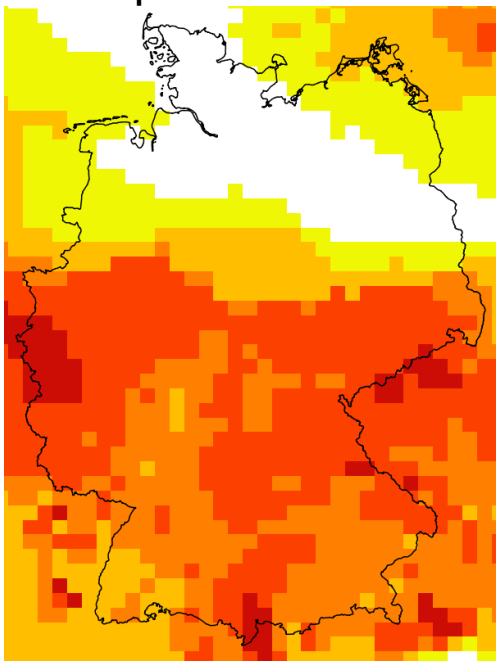
A - > 0m
B - > 200m
C - > 400m
D - > 600m
E - > 800m
F - > 1000m
G - > 1500m
H - > 2000m

-	-
Bft 7	>14m/s
Bft 8,9	>18m/s
Bft 10	>25m/s
Bft 11	>29m/s
Bft 12	>33m/s
> Bft 12	>39m/s

Gust observations
10 March 2019



Same day IFS forecast
90th percentile

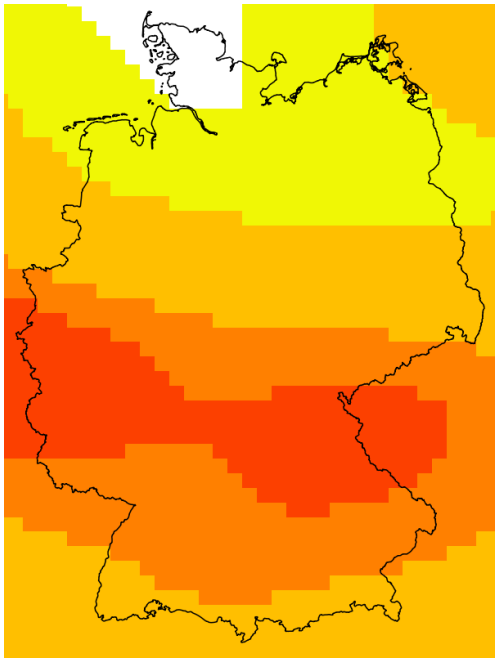


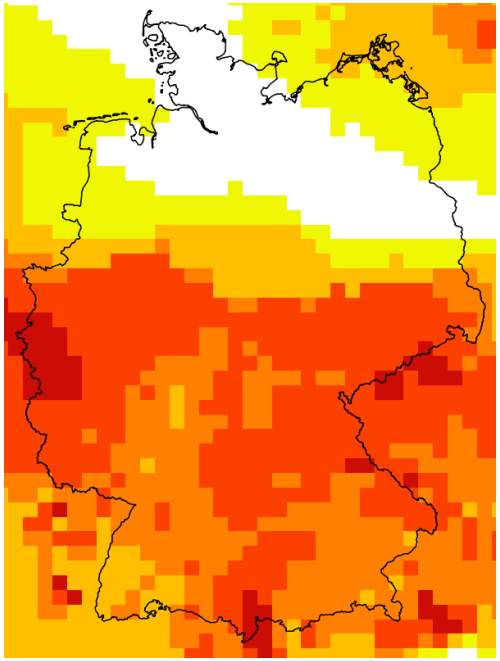
Why not simple smoothing?

- Example – basic 3 point filter $u'_i = 0.25u_{i-1} + 0.5u_i + 0.25u_{i+1}$
- Extrema damped (underwarning)
- Overwarning in other areas
- Some significant features removed

Same day IFS forecast (smoothed 50 times with 3p-Filter)

Same day IFS forecast



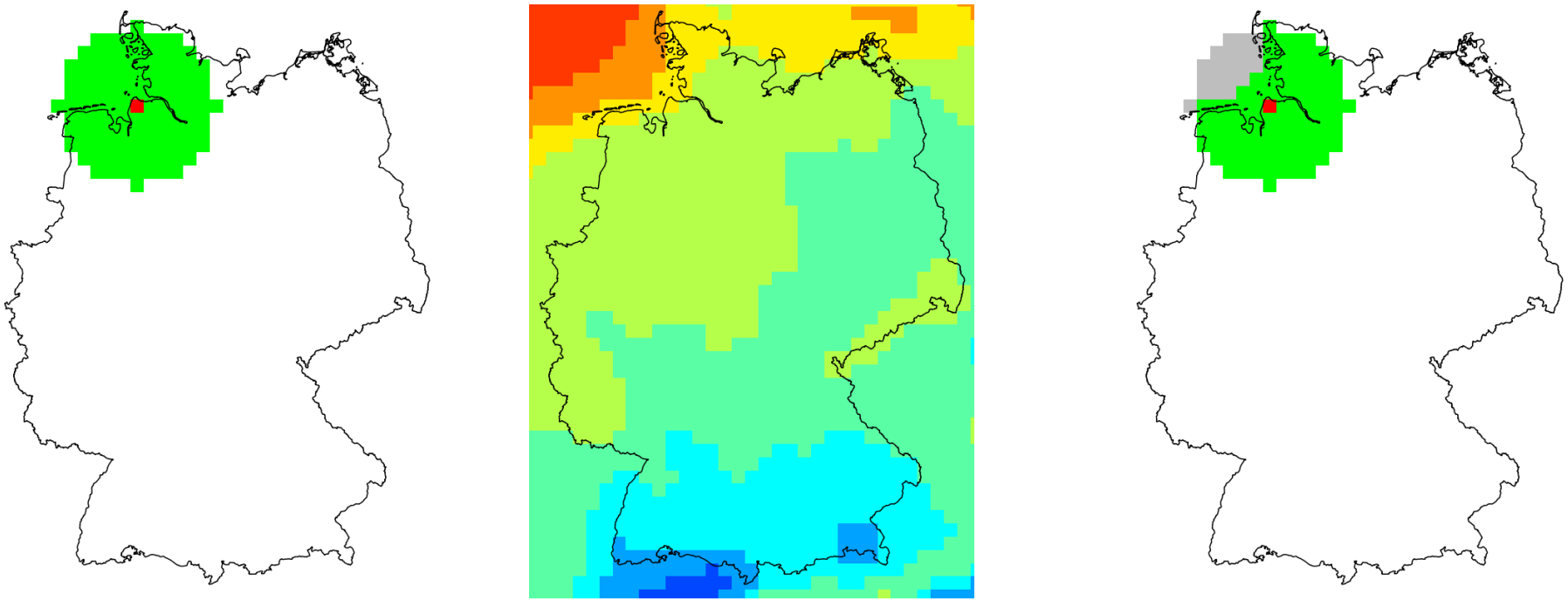


-		-
Bft 7		>14m/s
Bft 8,9		>18m/s
Bft 10		>25m/s
Bft 11		>29m/s
Bft 12		>33m/s
> Bft 12		>39m/s

Smoothing algorithm for DMG

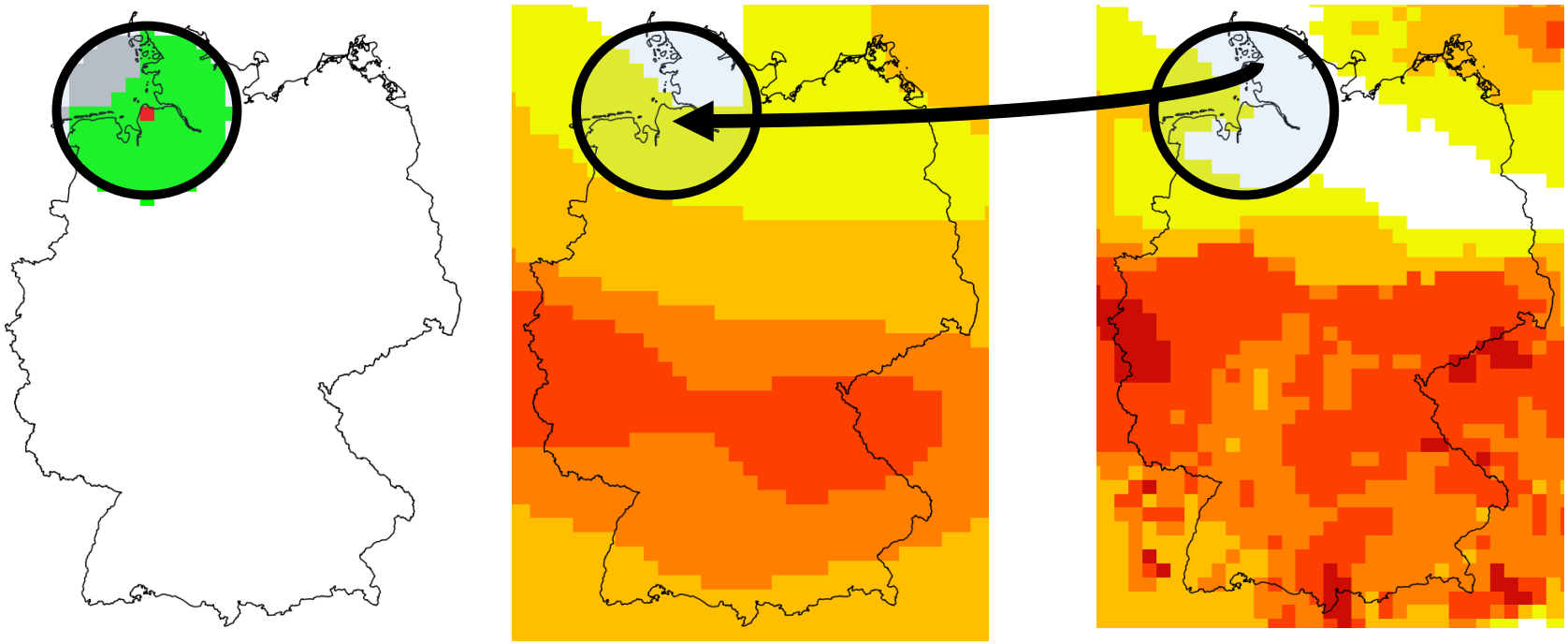
- Define radius r
- Smoothed value of each grid point is constructed from grid points within circle
- Only grid points considered with similar climatology (defined by threshold th)

IFS Climate (50%ile – winter – 1m/s contour)



Smoothing algorithm for DMG

- Start from simple smoothing
- For target grid point compute rank within (green area of) circle based on smoothed field
- From the non smoothed field retrieve the value with the same rank
- This becomes the value of the target grid point



Smoothing algorithm for DMG
Examples for different configurations

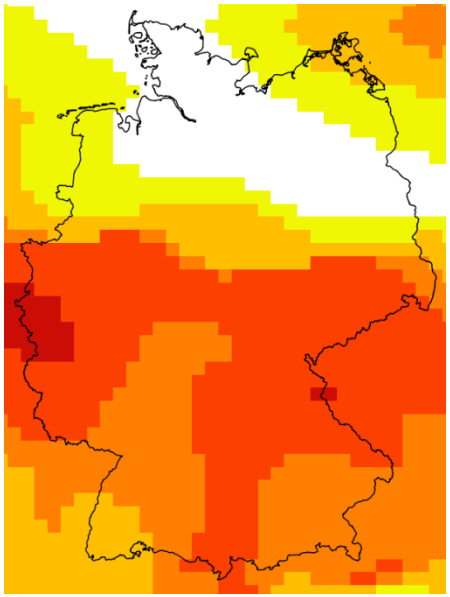
Deutscher Wetterdienst
Wetter und Klima aus einer Hand

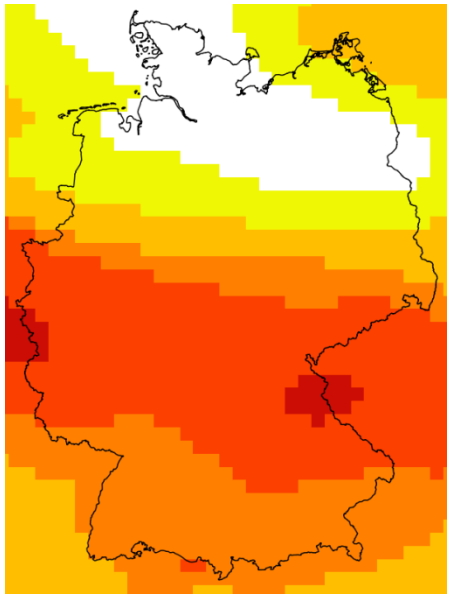
$3p - Filter: 50\ times$
$r = 60km$
$th = 1m/s$

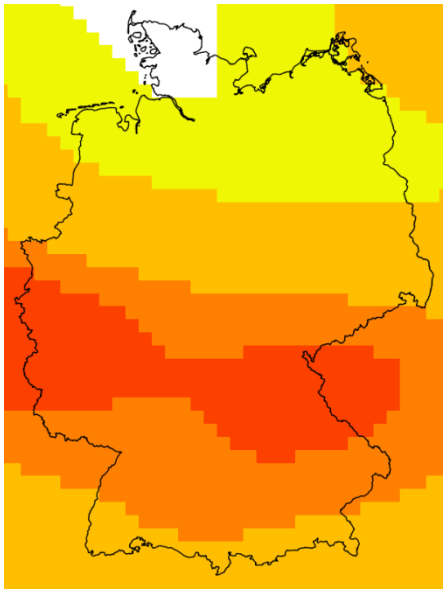
$3p - Filter: 50\ times$
$r = 240km$
$th = 1m/s$

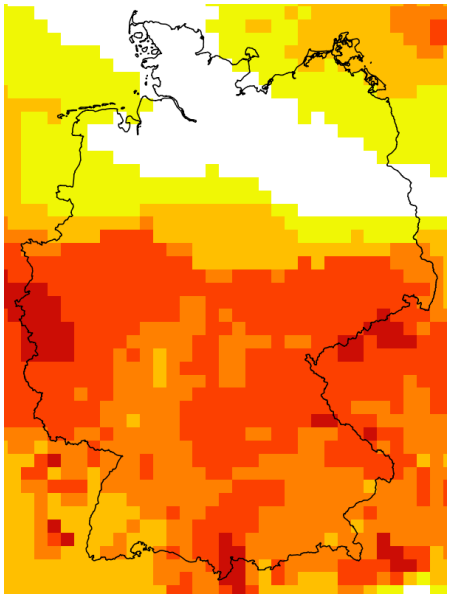
$3p - Filter: 50\ times$

raw IFS forecast





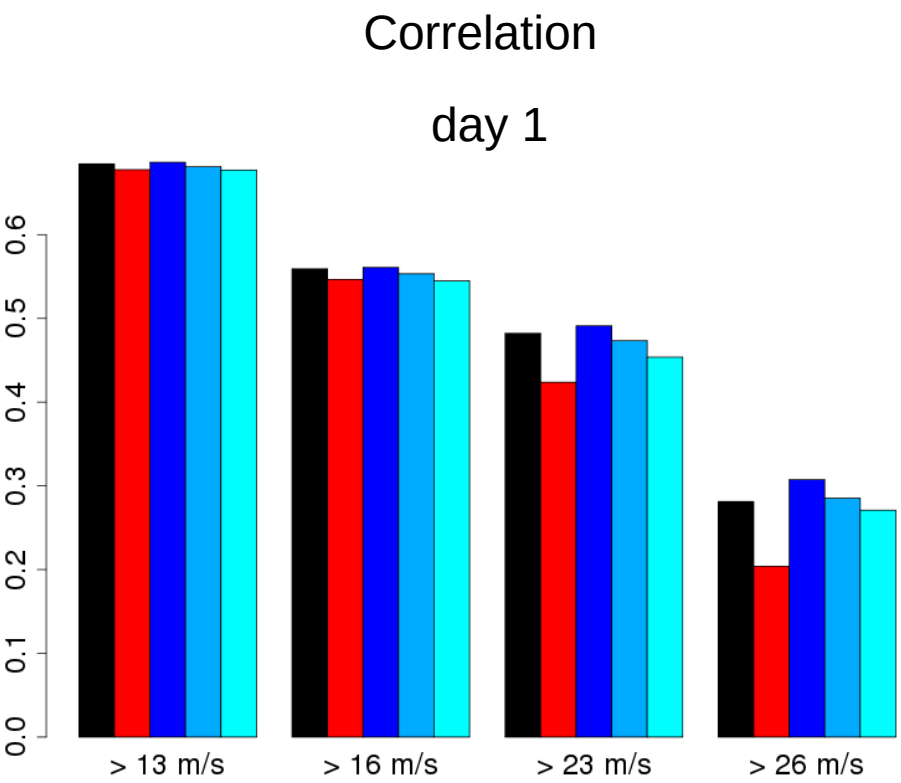


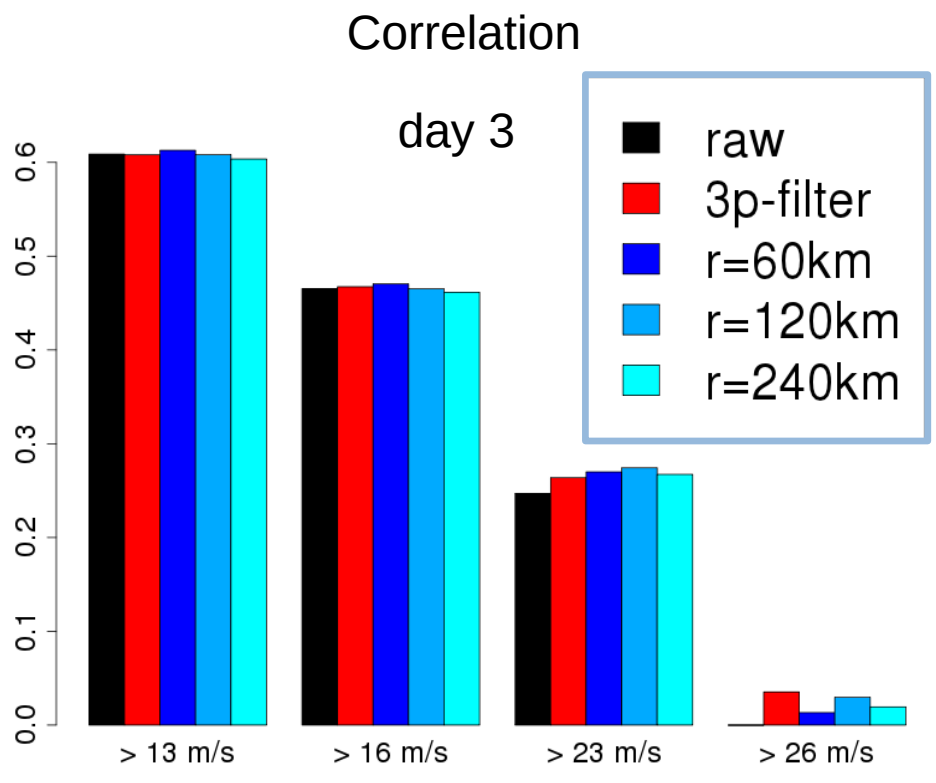


Correlation depending on configuration

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

- Verification for gusts for Dec 2018-March 2019
- Correlation computed for subset of data (FX >13, 16, 23, 26m/s)
- Good result for leadtime





Smoothing algorithm for DMG
Examples for different configurations

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Day 1-2

$3p - Filter: 50\ times$

$r = 60km$

$th = 1m/s$

Day 3-5

$3p - Filter: 50\ times$

$r = 120km$

$th = 1m/s$

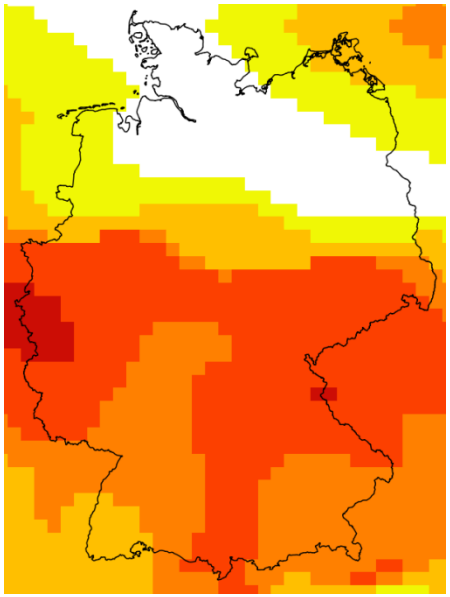
Day 6-7

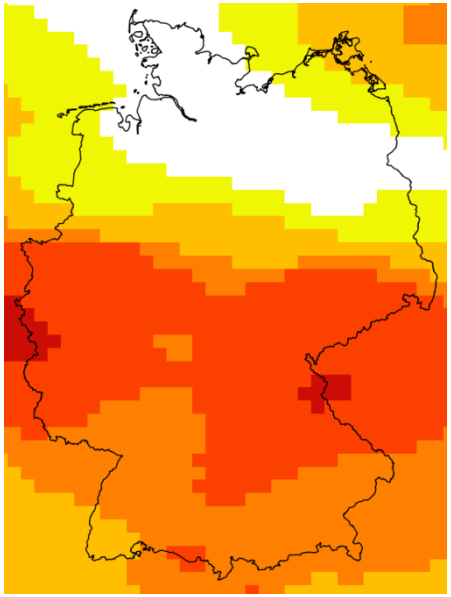
$3p - Filter: 50\ times$

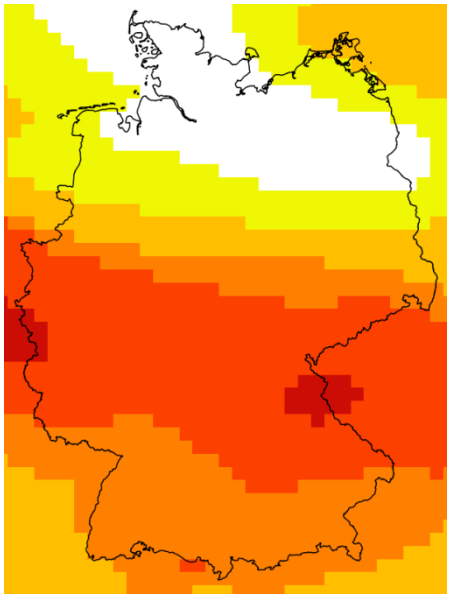
$r = 240km$

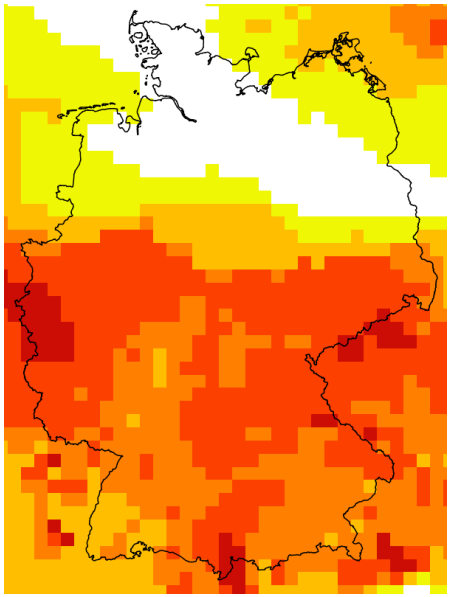
$th = 1m/s$

raw IFS forecast







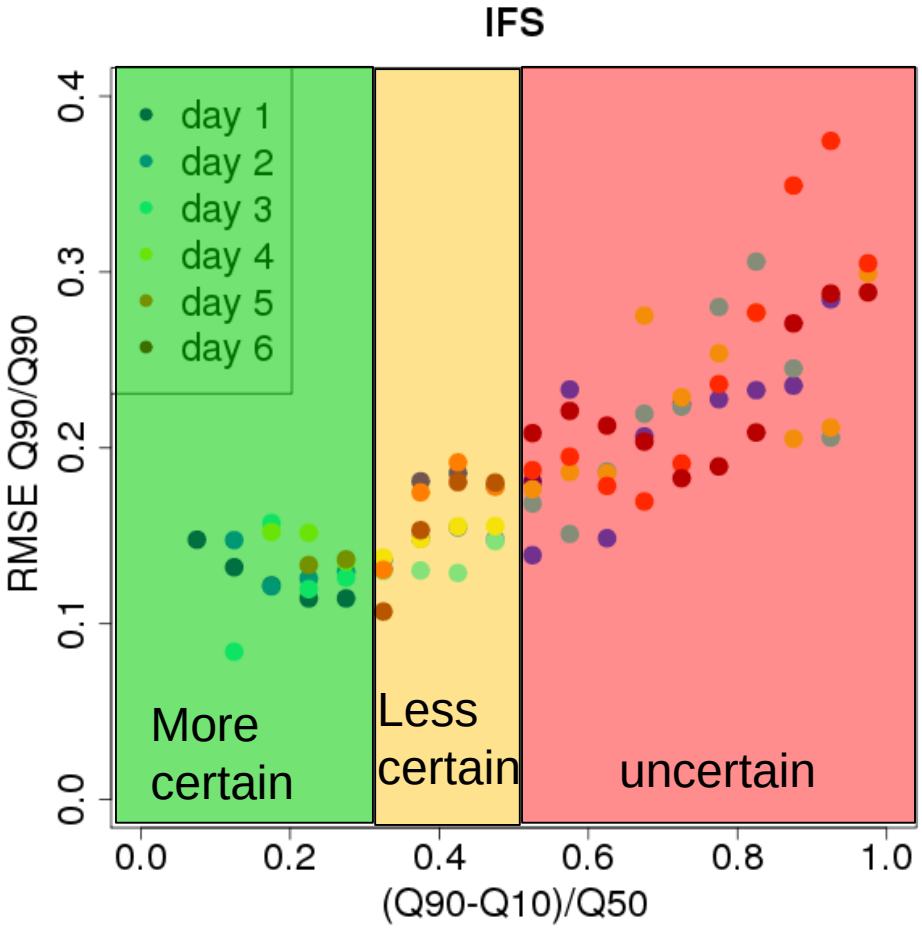


Uncertainty of forecast
Which uncertainty measure is used?

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

- Dec 2018-Mar 2019
- Daily FX max
- Model FX Q50 > 14m/s
- 10,000-15,000 data points

Normalized difference of 90%ile-10%ile



Components
Uncertainty of forecast

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

- r=(Q90-Q10)/Q50
- Labelling:

  0.5<r uncertain

  0.3<r<0.5 less certain

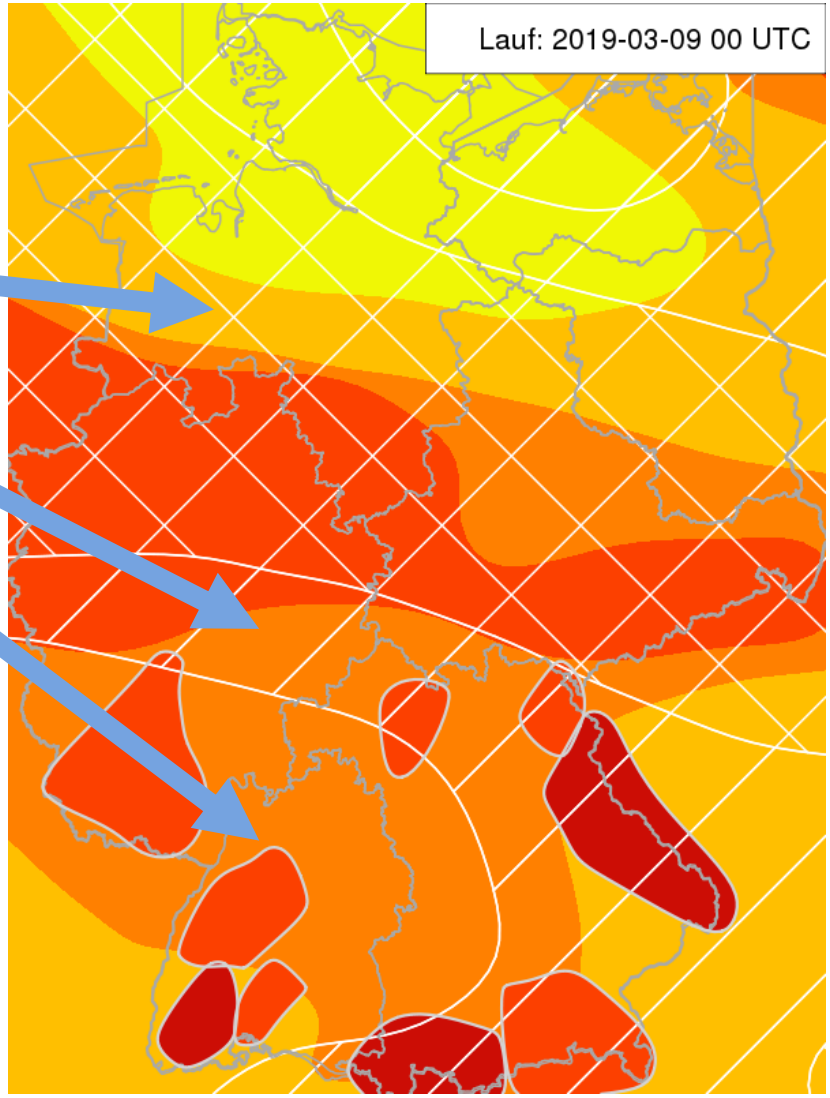
  r<0.3 more certain

- Rain and snow: (Q90-Q10)

  >=2 warning categories – uncertain

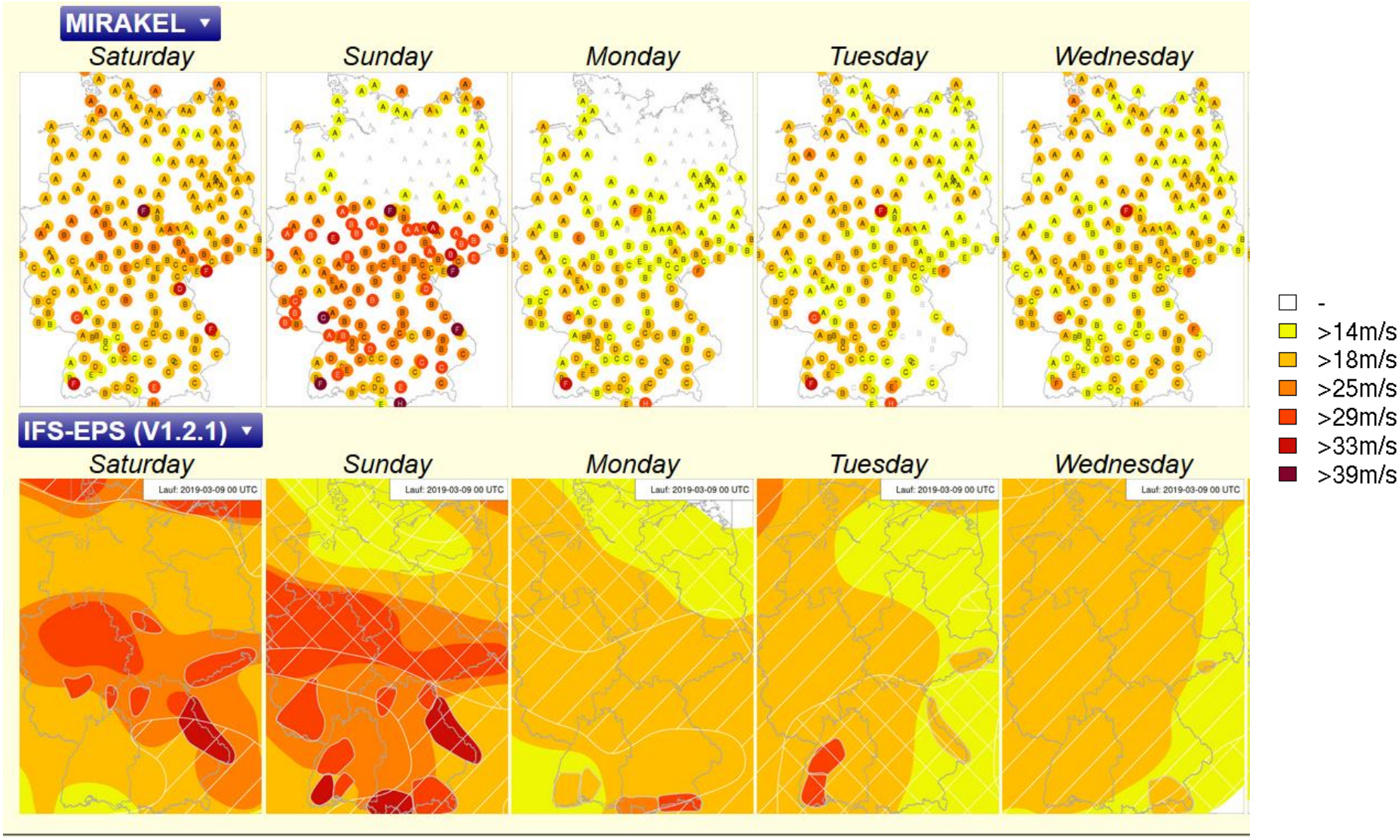
  1-2 warning categories – less certain

  <1 warning category – more certain



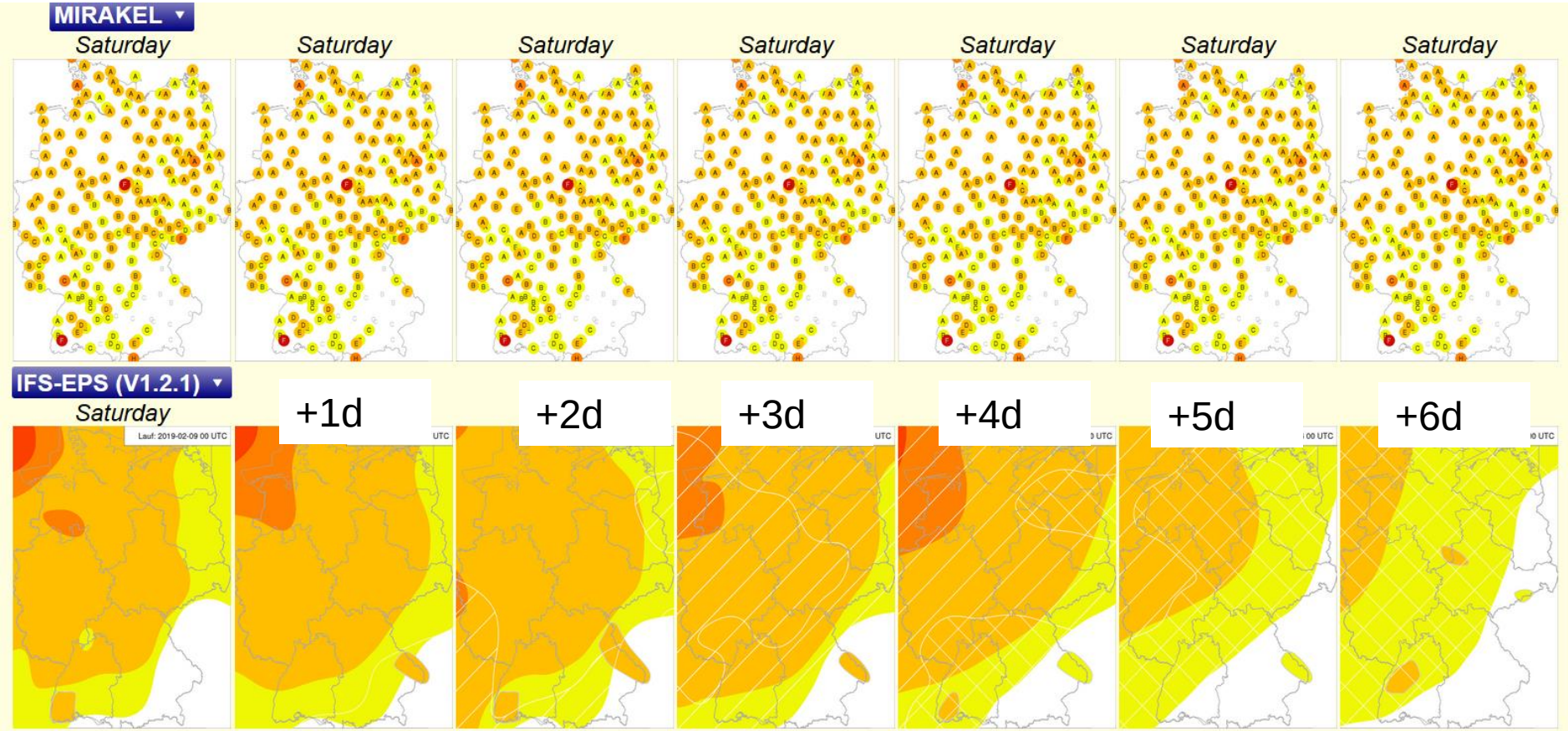
Wind gusts
IFS 09 March 2019 00 UTC

Deutscher Wetterdienst
Wetter und Klima aus einer Hand



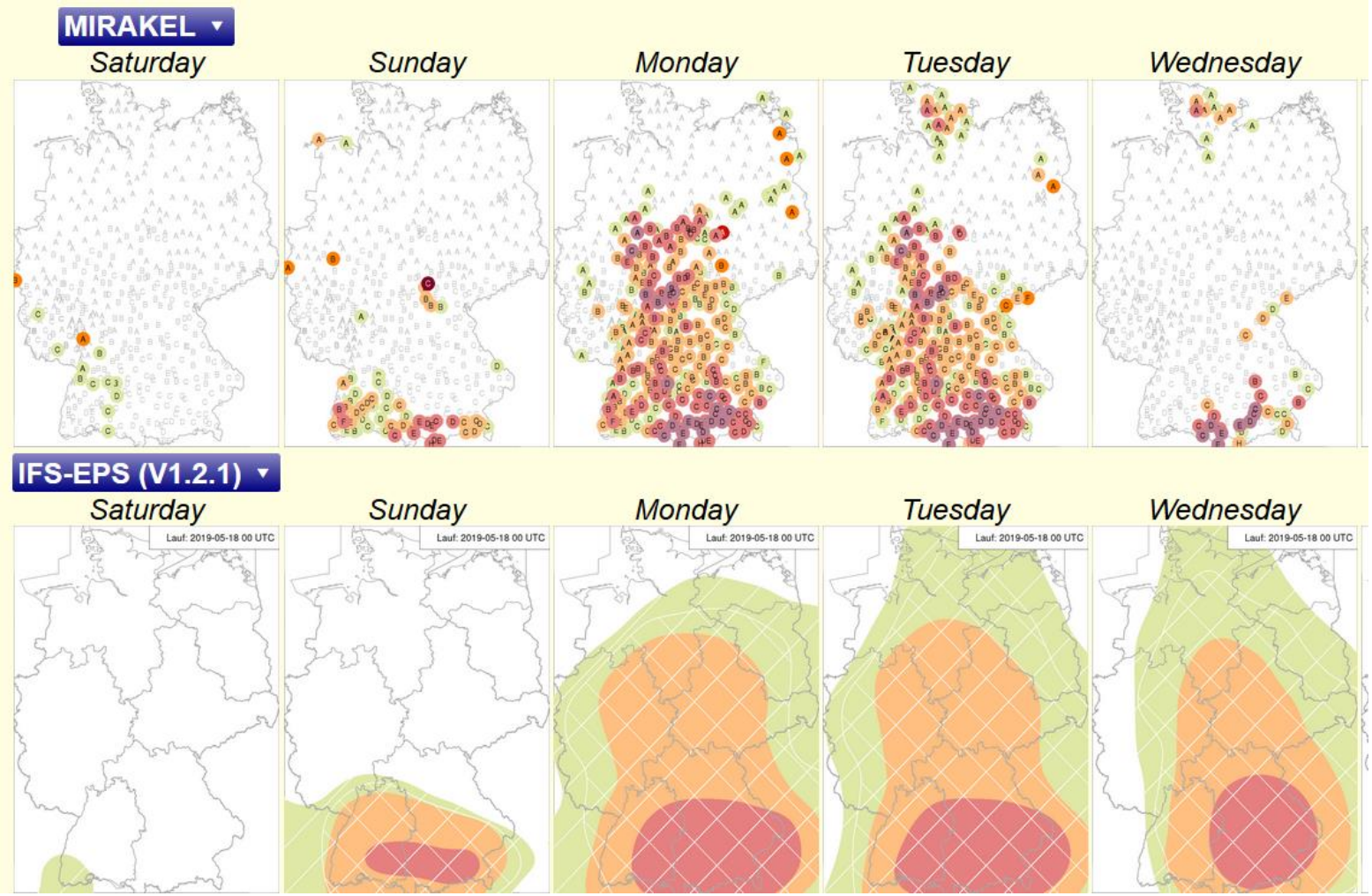
Wind gusts
09 Feb 2019

Deutscher Wetterdienst
Wetter und Klima aus einer Hand



Persistent rain
IFS 18 May 2019 00 UTC

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

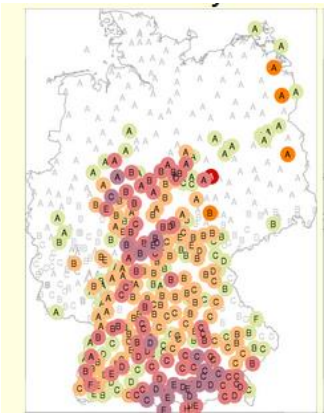


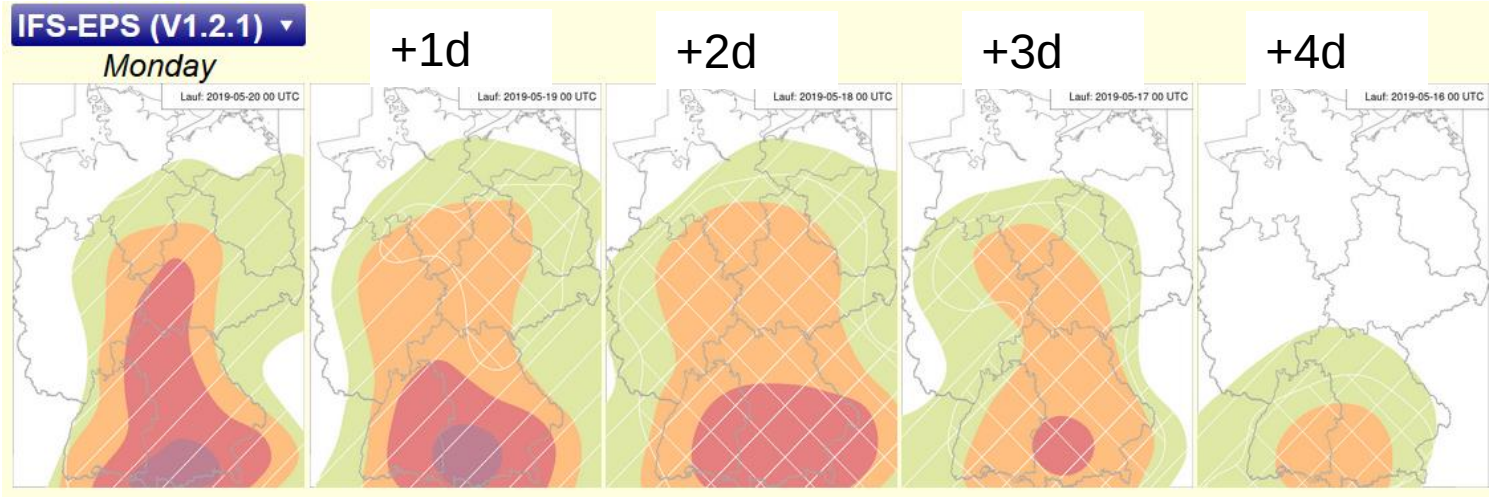
- >30mm/24h
- >50mm/24h
- >80mm/24h

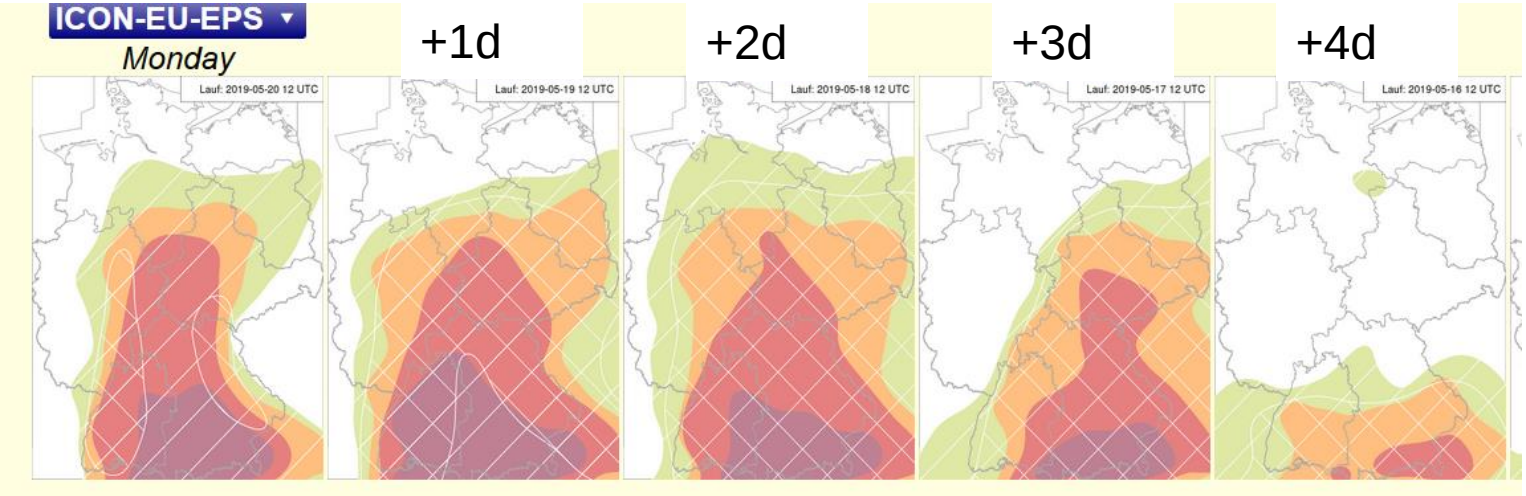
Persistent rain
20 May 2019

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Gauge data



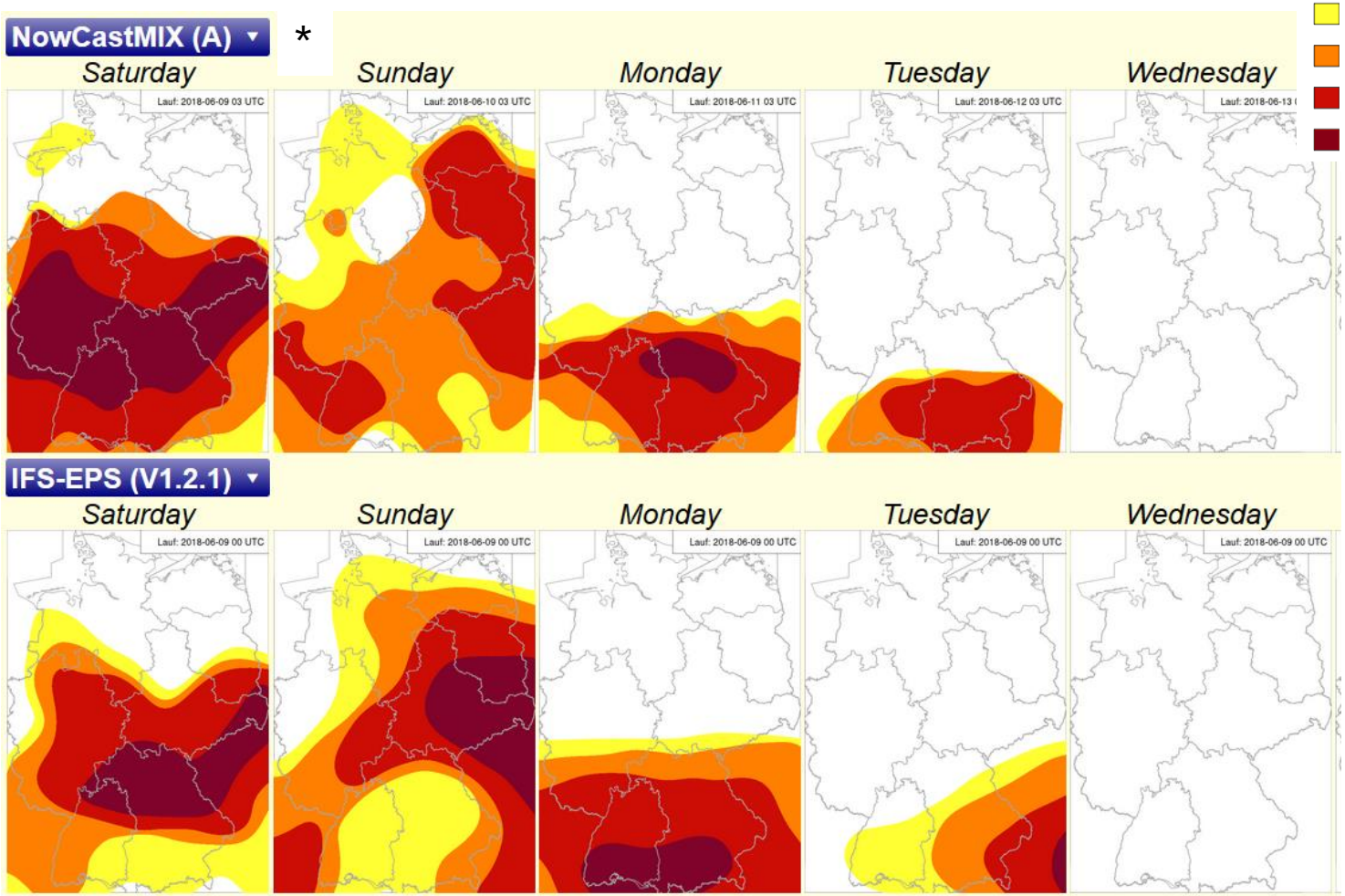




- >30mm/24h
- >50mm/24h
- >80mm/24h

Thunderstorms
Week from 9 June 2018

Deutscher Wetterdienst
Wetter und Klima aus einer Hand



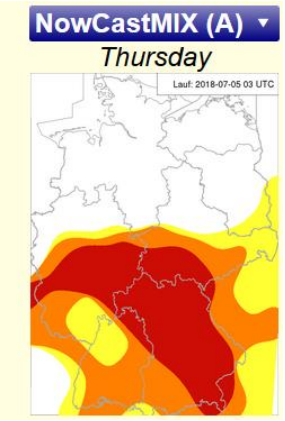
- Thunderstorms
- Heavy thunderstroms
- Severe thunderstorms
- Extreme thunderstorms

Graphs for thunderstorms without uncertainty information

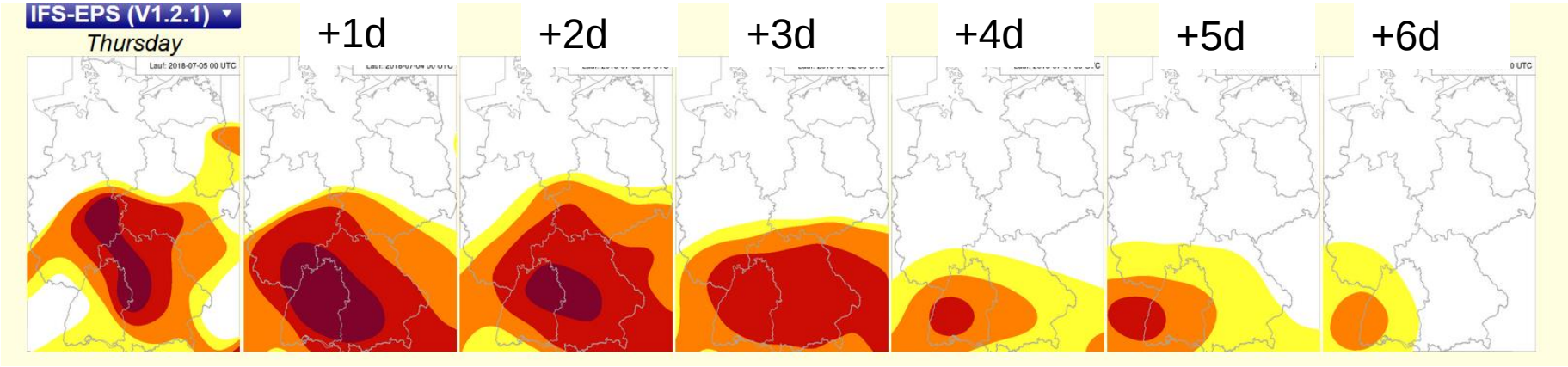
*James, P.M. et al. 2018: NowCastMIX: Automatic Integrated Warnings for Severe Convection on Nowcasting Time Scales at the German Weather Service. Wea. Forecasting 33. 1413-1433.

Thunderstorms
05 July 2018

Deutscher Wetterdienst
Wetter und Klima aus einer Hand



- Thunderstorms
- Heavy thunderstroms
- Severe thunderstorms
- Extreme thunderstorms



Summary and further steps

- DMG (Daily Model Guidance) provides one graph each for gusts, persistant rain, snowfall and thunderstorms
- Includes uncertainy and timing
- One graph per model and day
- Smoothing configuration depending on uncertainty (fixed via lead time)

Further steps

- Combination of several models
- Uncertainty measure should include multiple models and maximum forecast
- Uncertainty and smoothing adjustment for rain, snow and thunderstorms
- Coarser warning categories to account for predictability

Thanks!

Appendix

quantile score - Google-Suche | ECMWF Forecasts | Inbox (2,463) - u232020@gmail | Webseite von G.Schroeder auf HPC | RMV.DE - Mit der richtigen Verb

wsfe22/dmg/flex_eng.html?peril=Regen&config=MultiModelrun&data1=DMGV1.1.0_MIRAKEL&data2=DMGV1.2.1_IFS-EPS&time=2019052003UTC#

Erste Schritte | ASG | AutoWARN | DWD | FEZE-Verfahren | NinJo | Geoserver | Wetterinfos | NinJo

AUTO WARN

Monday

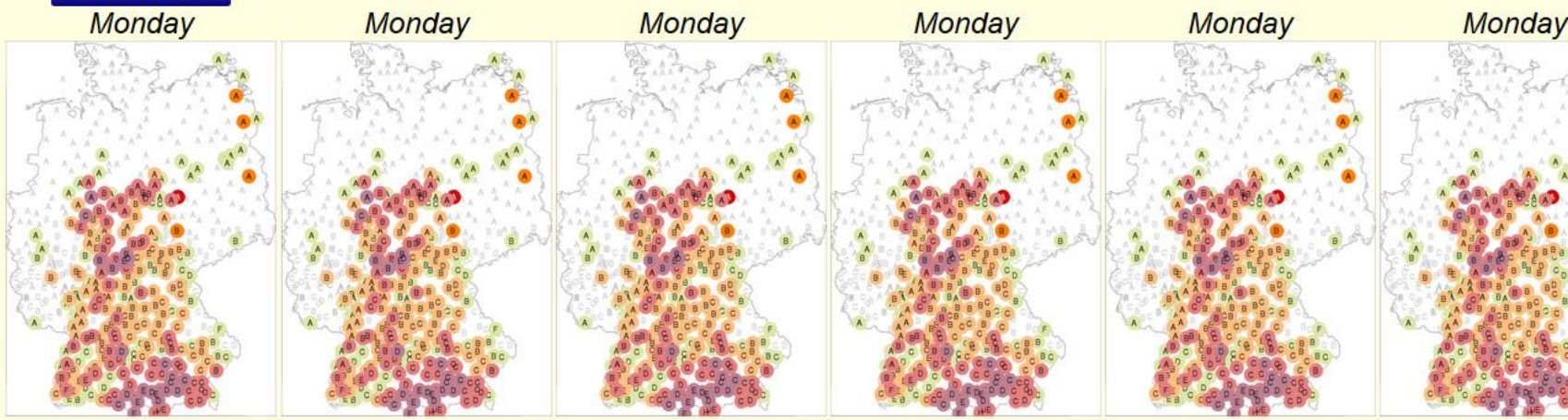
20.05.2019 03:00 UTC

live

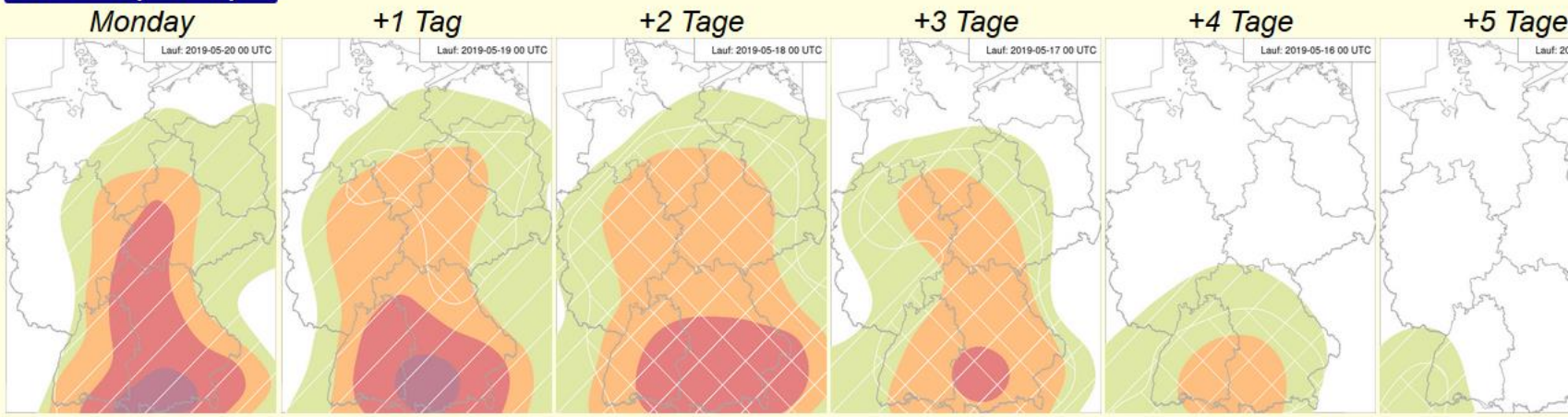
Neu: Anleitung DMG in NinJo

Was ist DMG | Regen | Historie | Config | Zeit einblenden

MIRAKEL



IFS-EPS (V1.2.1)



quantile score - Google-Suche | ECMWF Forecasts | Inbox (2,463) - u232020@gmail | Webseite von G.Schroeder auf HPC | RMV.DE - Mit der richtigen Verb

wsfe22/dmg/flex_eng.html?peril=Boeen&config=MultiModelrun&data1=DMGV1.1.0_MIRAKEL&data2=DMGV1.2.1_IFS-EPS&time=2019031012UTC

Erste Schritte | ASG | AutoWARN | DWD | FEZE-Verfahren | NinJo | Geoserver | Wetterinfos | NinJo

AUTO WARN

Sunday

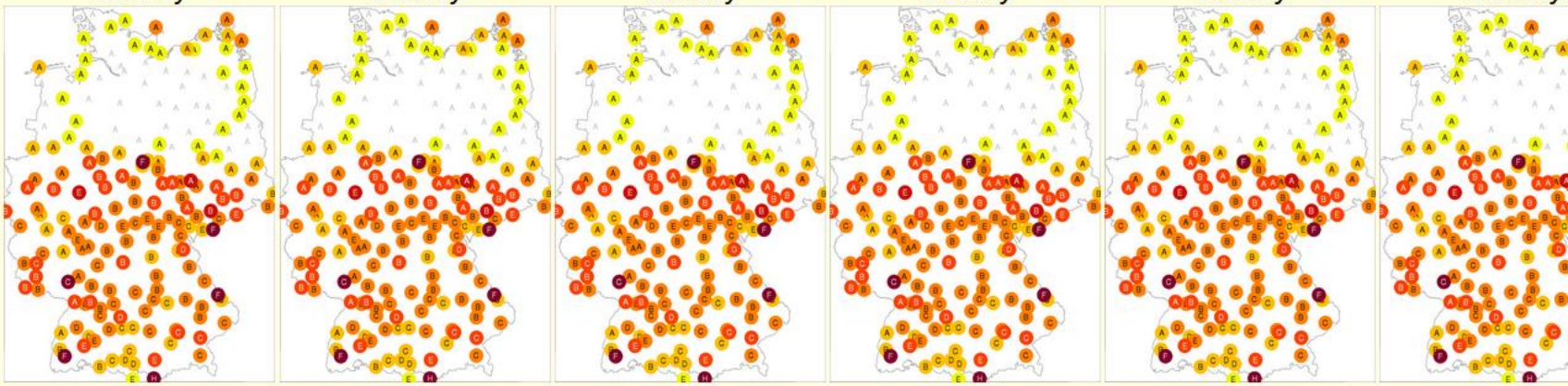
10.03.2019 12:00 UTC

live

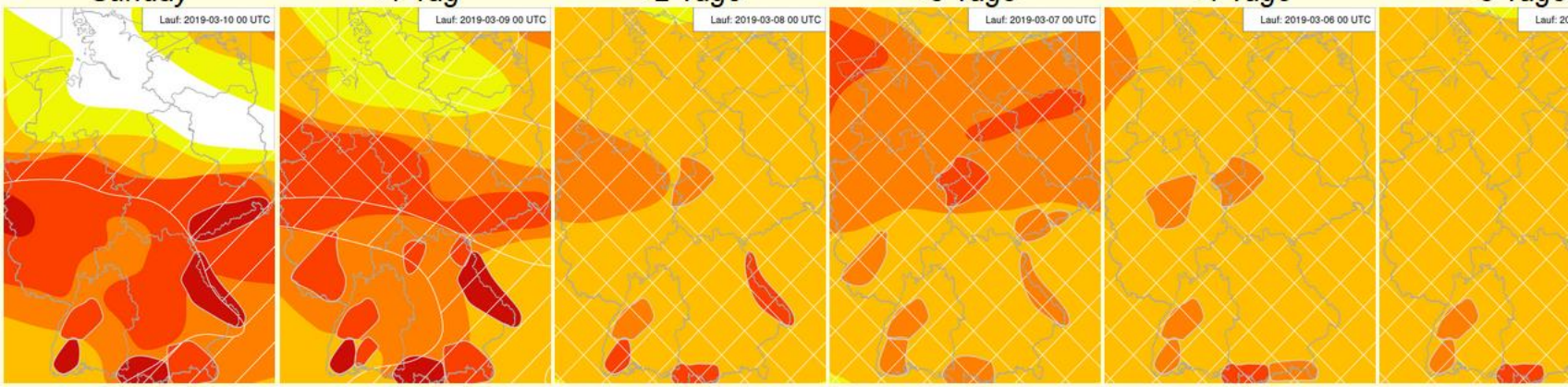
Neu: Anleitung DMG in NinJo

Was ist DMG | Böen | Historie | Config | Zeit einblenden

MIRAKEL



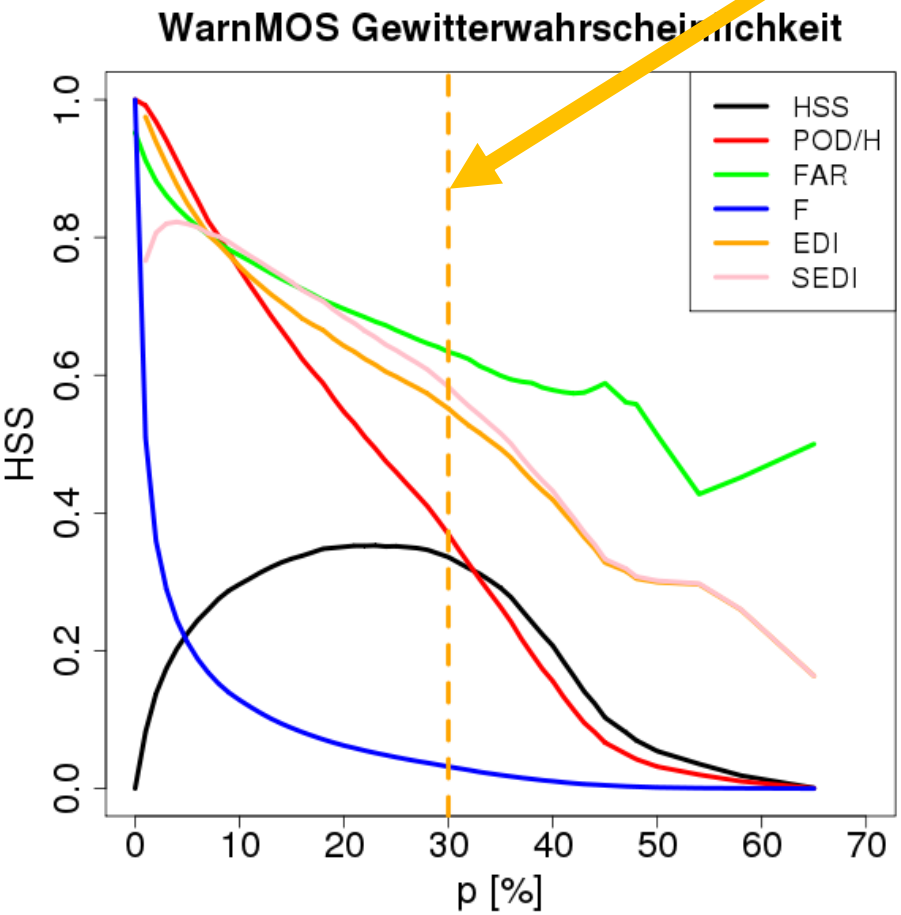
IFS-EPS (V1.2.1)

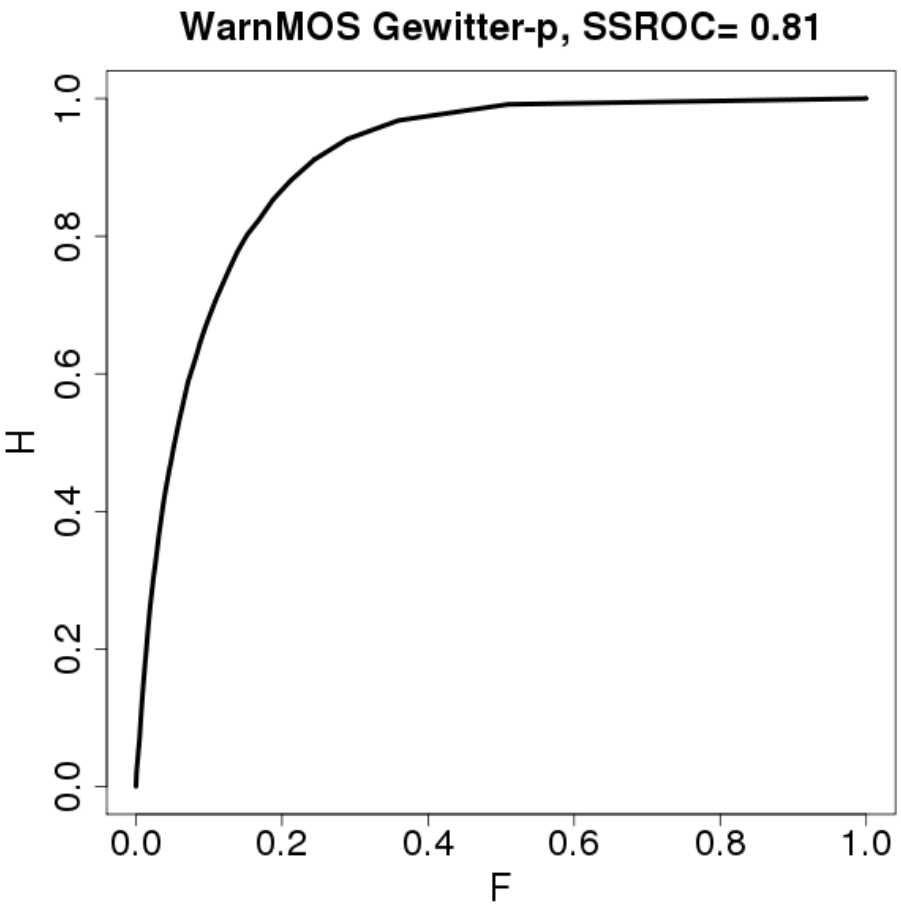


Scores

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

EDI needd Calibration:
no BIAS!



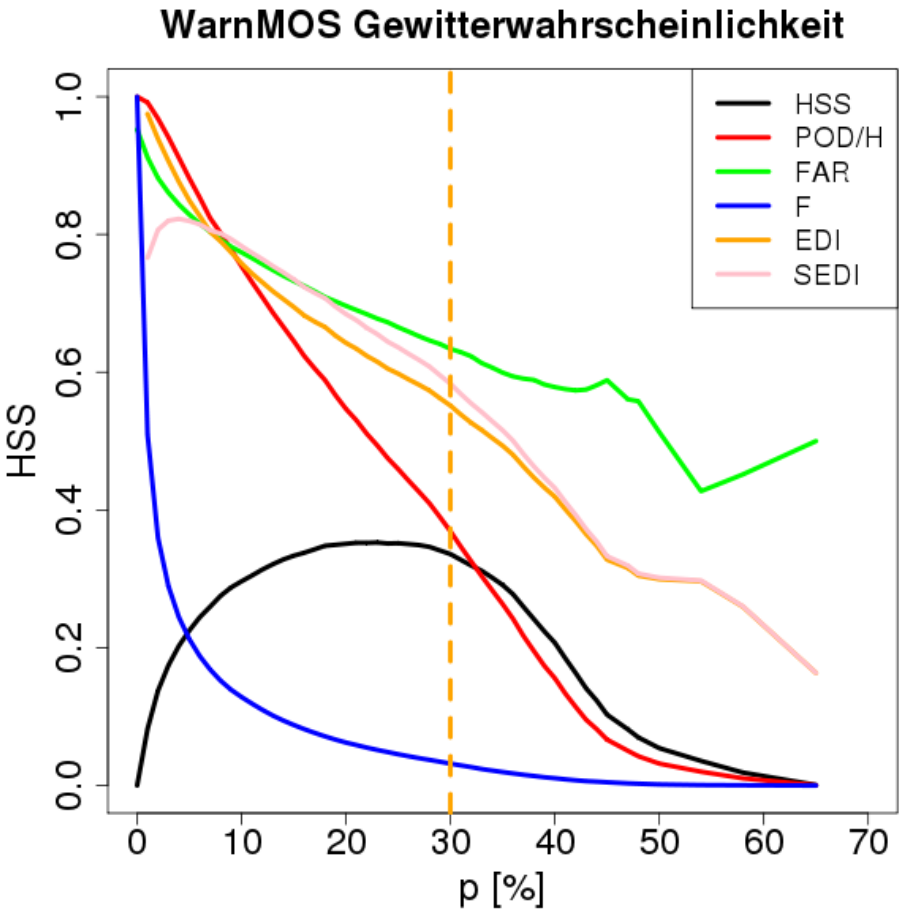


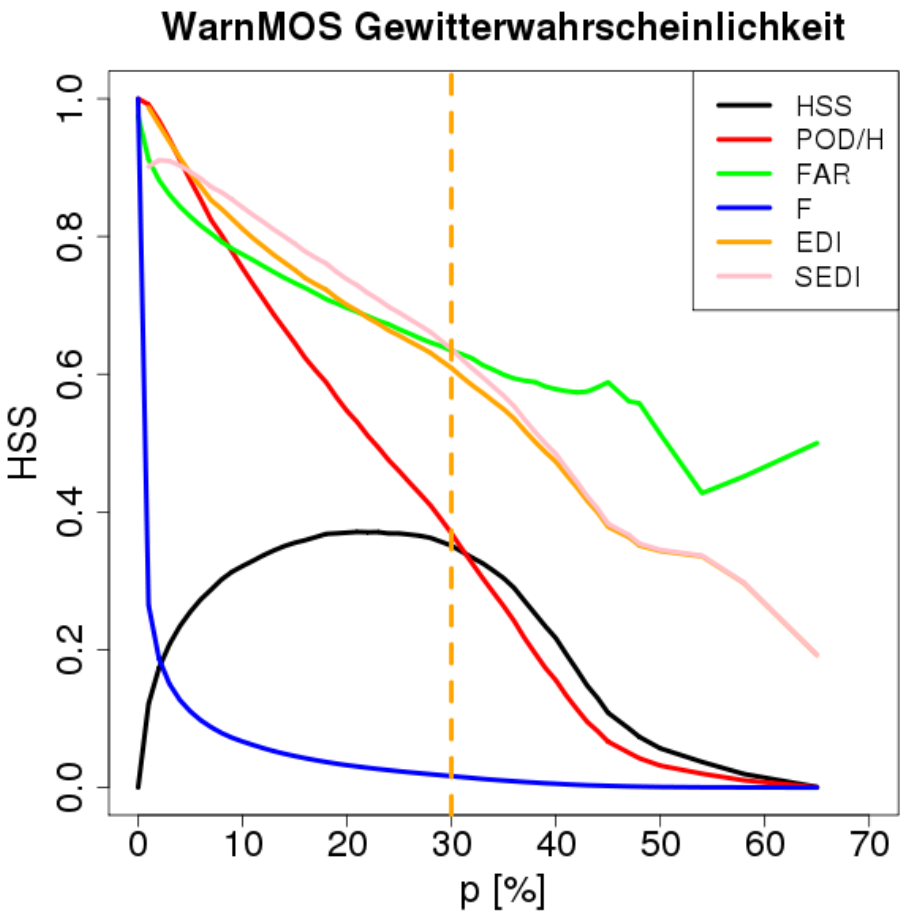
Scores when added non-events

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

POD, FAR stay the same
HSS in increases slightly
SEDI changes location of maximum

Test: 1 month of correctly forecast non-events added





HSS-max 0.35 at 21%
SEDI-max 0.82 at 4%

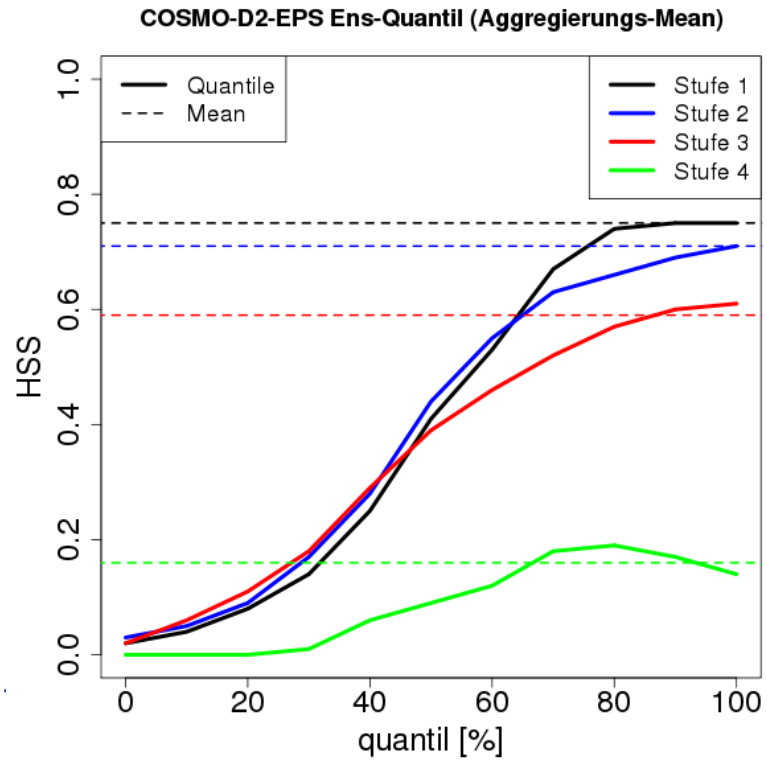
HSS-max 0.37 at 21%
SEDI-max 0.91 at 2%

Gewitterkalibrierung- Welches Quantil für COSMO-D2-EPS?

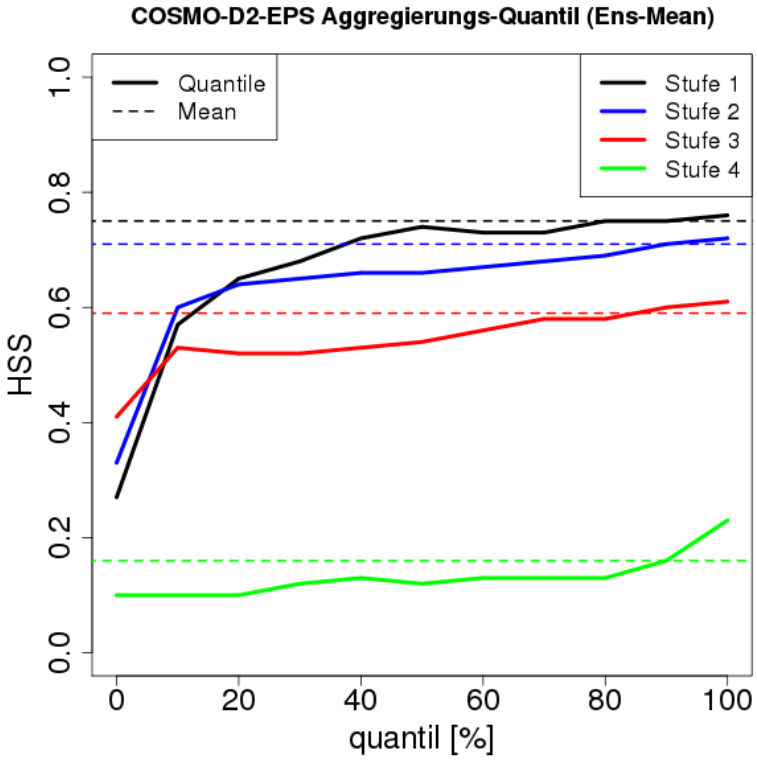
Deutscher Wetterdienst
Wetter und Klima aus einer Hand

- 2 Quantile relevant für COSMO-D2-EPS:
  - Aggregierung von 2.2 km auf 20km – hier wird ein Quantil gebildet
  - Vom Ensemble wird ein Quantil gebildet

Ensemblequantil wird variiert bei festem Aggregierungs-Mean



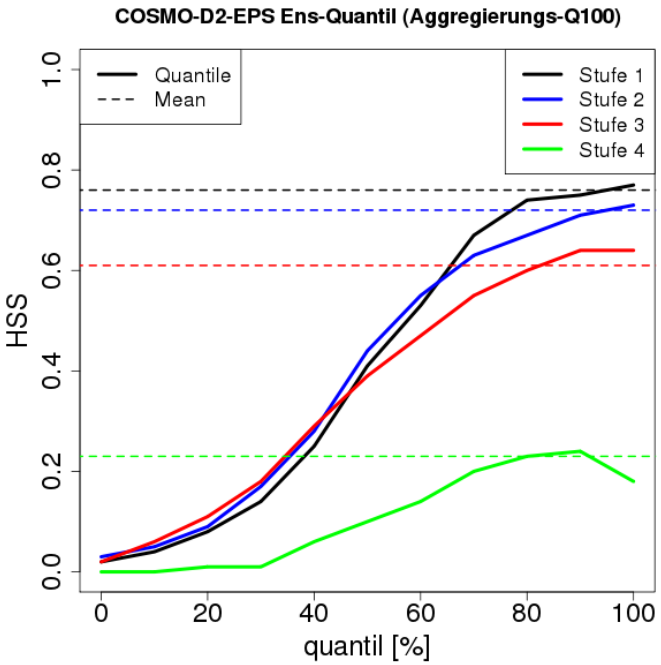
Aggregierungsquantil Quantil wird variiert bei festem Ensemble-Mean



Gewitterkalibrierung- Welches Quantil für COSMO-D2-EPS?

- 2 Quantile relevant für COSMO-D2-EPS:
  - Aggregierung von 2.2 km auf 20km – hier wird ein Quantil gebildet
  - Vom Ensemble wird ein Quantil gebildet

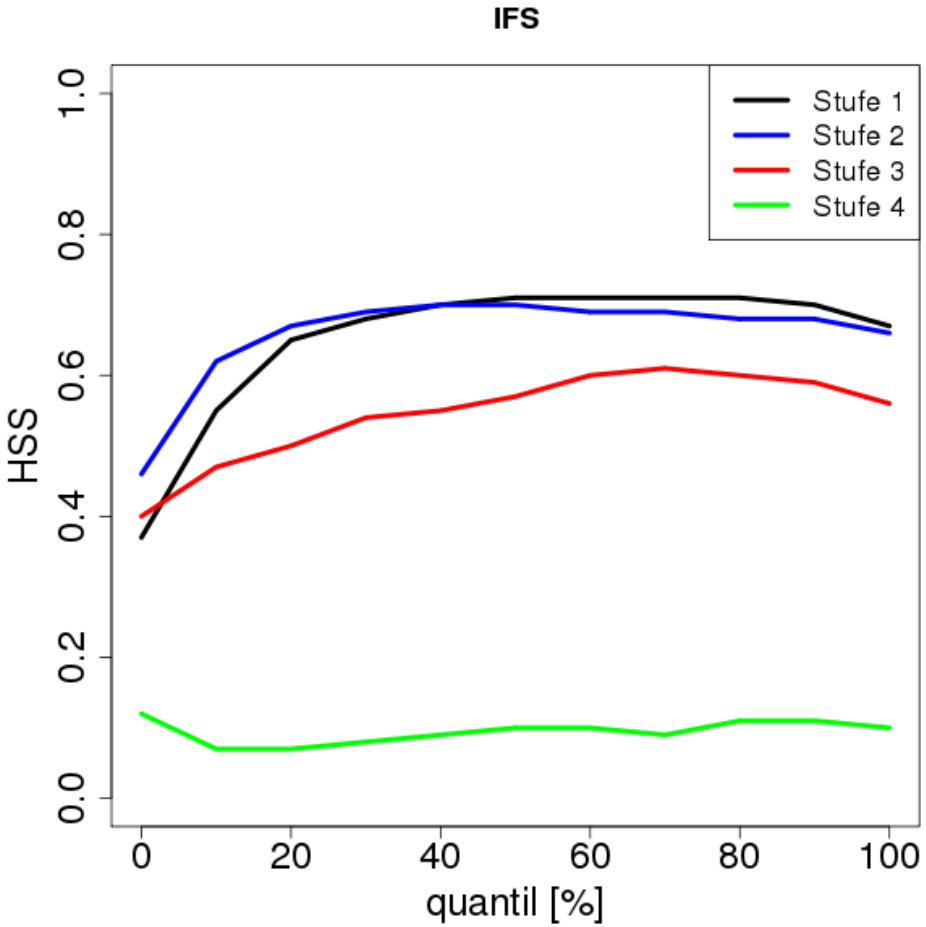
Ensemblequantil wird variiert bei festem Aggregierungsquantil 100



- Am besten man nimmt das Maximum bei der Aggregierung und auch vom Ensemble

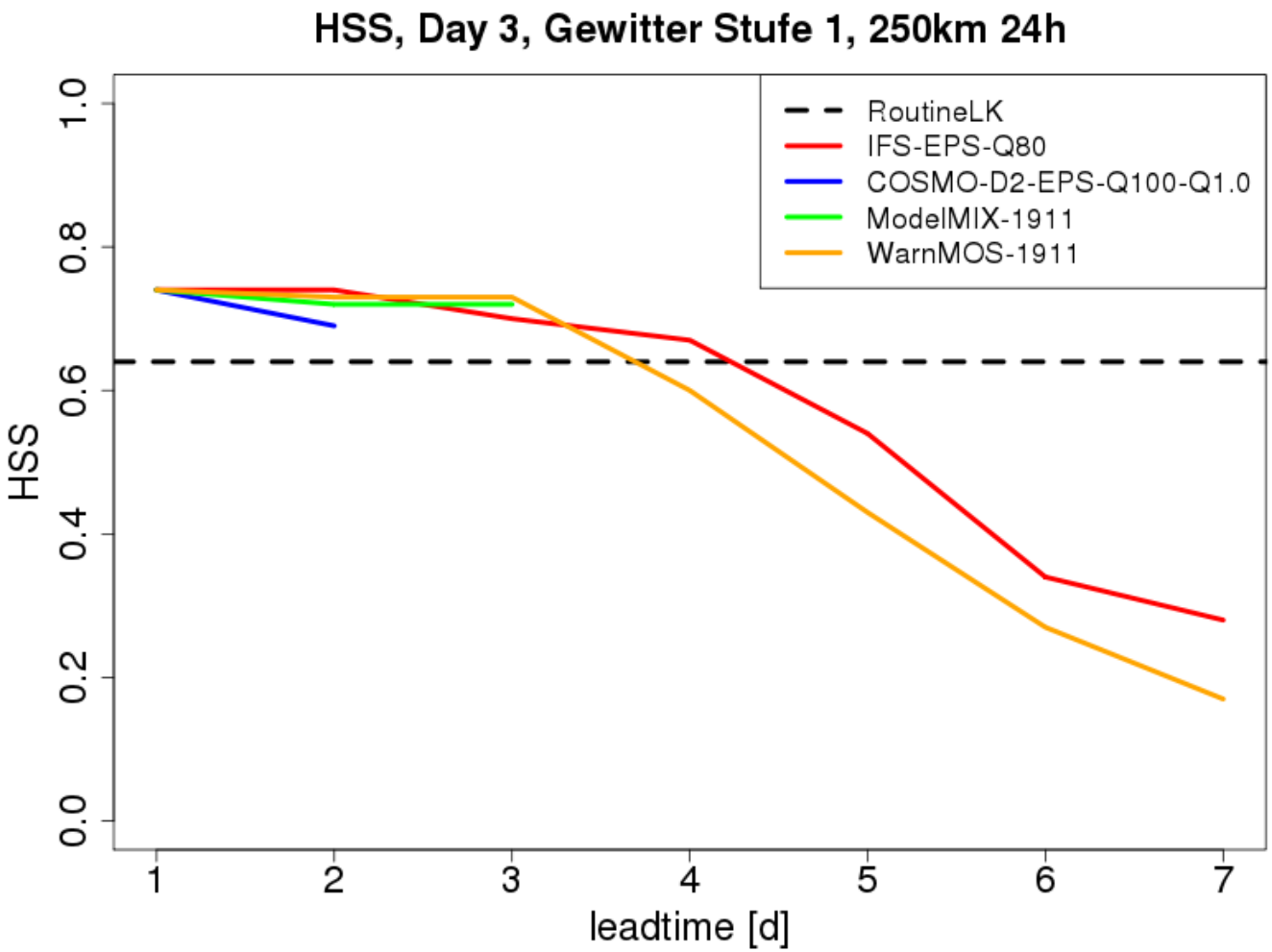
Gewitterkalibrierung- Welches Quantil für IFS?

- ➔ Nur Ensemble-Quantile relevant für IFS-EPS
- ➔ Das 80. Perzentil scheint optimal zu sein



Auswertung für 50km Unschärfe-Radius und 12h-Zeitintervall

Thunderstorm calibration for 06/06/2018-31/07/2019

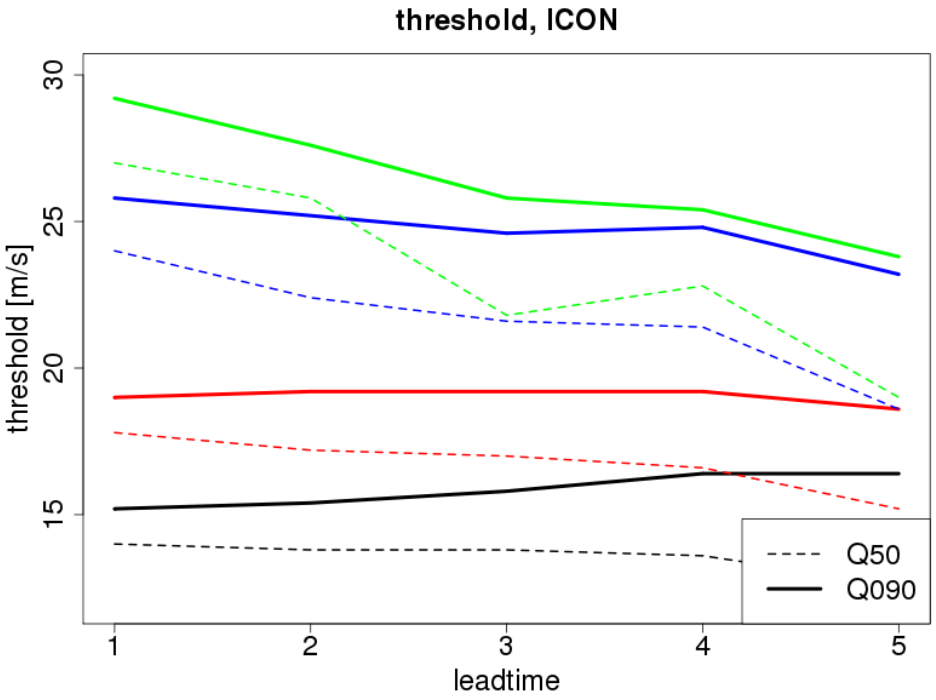


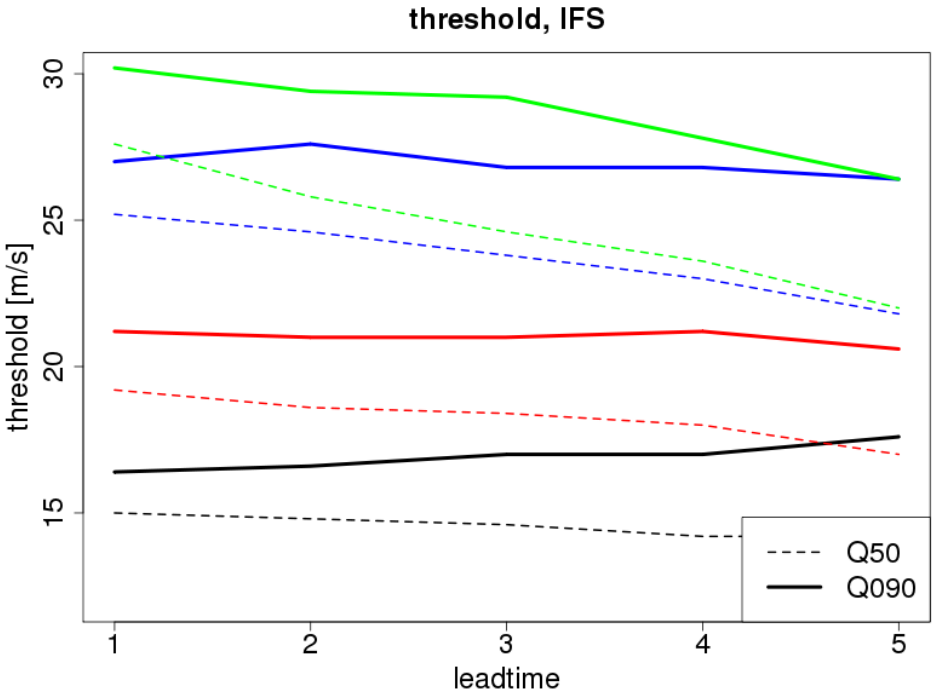
➔ After day 6 skill drops

Gust calibration for 12/2018-03/2019
Which quantile?

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

- For Q50 strong dependency of threshold from lead time
- For Q90 weaker dependency
- => 90th percentile more recommendable





Gust calibration12/2018-03/2019
Maxmum Heidke Skill Score

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

➔ IFS better for larger lead times