SEEDS - Sentinel EO-based Emission and Deposition Service

NILU

Koninklijk Nederlands
Meteorologisch Instituut
Ministerie van Infrastructuur en Waters

BIRA-IASB

CERFACS
CENTRE EUROPÉEN DE RECHERCHE ET DE FORMATION AVANCÉE EN CALCUL SCIENTIFIQUE

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2nd SEEDS General Assembly and Stakeholder Engagement Meeting
-
Added value of deposition products to the CAMS operational system

Joaquim Arteta, Nicolas Frébourg and Virginie Marécal
CNRM - Météo-France

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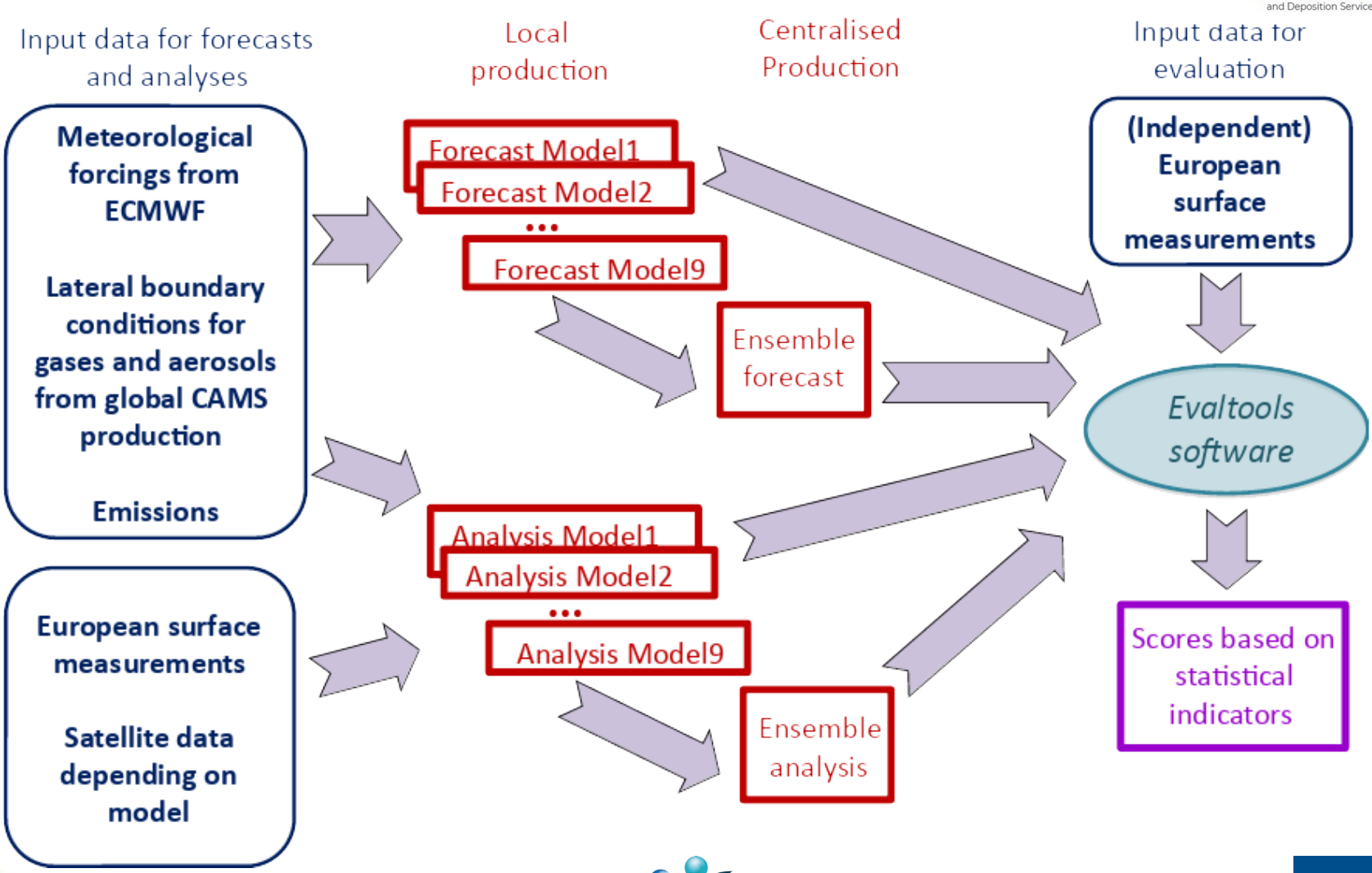
WP5: general objective

Assessment of the impact of the SEEDS products (WP1, WP2, WP3 and WP4) on the Copernicus Atmosphere Monitoring Service (CAMS) operational regional analyses and forecasts

General design of the CAMS regional production



Testing methods

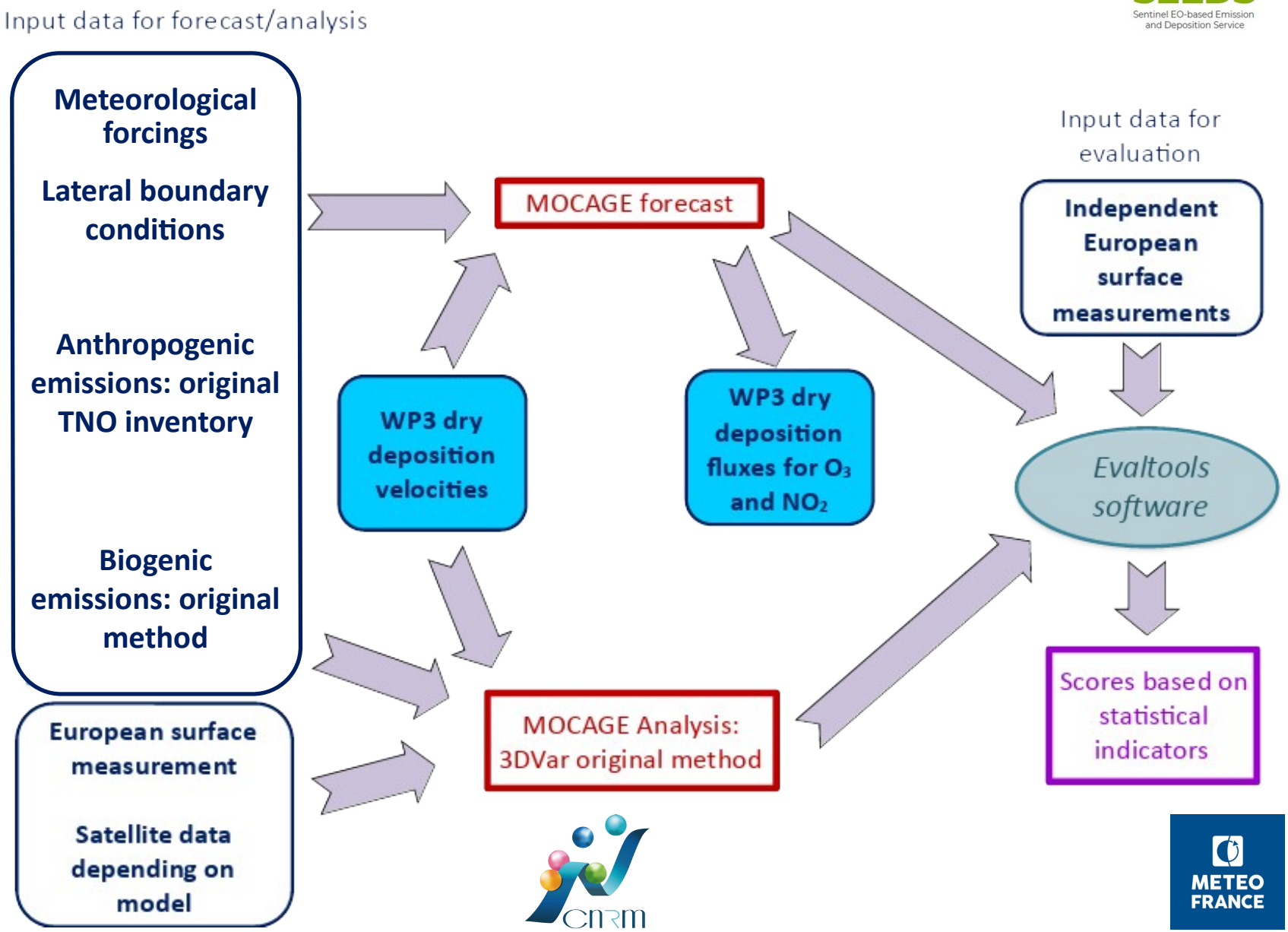
To test the added value of the SEEDS deposition products:

- Use of the CAMS2-40 production framework:
  - Input data for model and data assimilation system, except those provided in SEEDS
  - Evaltools free software developed by CNRM/Meteo-France for the evaluation of the forecast and analysis performances using the operational selection of measurements

Focus on the 4 main air quality pollutants, ozone, NO_2, PM10 and PM2.5 that are also affected directly or indirectly by dry deposition of ozone and nitrogen compounds.

- Use **MOCAGE** model that is the model developed by CNRM/Météo-France together with CERFACS for its data assimilation system
  - MOCAGE is one of the models of the CAMS regional operational ensemble produced by Meteo-France in CAMS2-40
  - MOCAGE performances are representative of the mean performances of the 9 models of the ensemble

General design of the testing method



Configuration used to test products

Current MOCAGE setup for CAMS2-40 (U7)

- Forecasts/analyses from ECMWF + forecasts/analyses chemical BC
- MOCAGE forecast initialized from an assimilation cycle (satellite obs)
- MOCAGE cycle mo11 used
- Regional Emissions from CAMS-REG-APv5.1 (2018)
- Global domain : Arpege 1x1° + CAMS-GLOB-ANT/CAMS-GLOB-BIO/CAMS-GLOB-OCE (2020)

Selected MOCAGE setup for SEEDS (U0)

- Forecasts/analyses from ECMWF + forecasts/analyses chemical BC
- MOCAGE forecast initialized from previous forecast
- MOCAGE cycle mo11 used (cycle mo07 in 2019)
- Regional Emissions from CAMS-REG-APv2.2 (2015)
- Global domain : Arpege 1x1° + MACCity (2016)/RCP60 (2016)/MEGAN-MACC (2010)
    - **MOCAGE o-suite in 2019** (except for source code)

Deposition velocities
(cf. P.Hamer's presentation)

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Analysis runs, meteorologically driven by IFS analyses

- MOCAGE with SUMO-Wesely
- MOCAGE with SURFEX-Wesely Open-loop
- MOCAGE with SURFEX-Wesely EKF
- MOCAGE with SURFEX-EMEP Open-loop
- MOCAGE with SURFEX-EMEP EKF

Forecast runs, meteorologically driven by IFS forecasts

- MOCAGE with SUMO-Wesely
- MOCAGE with SURFEX-EMEP Open-loop
- MOCAGE with SURFEX-EMEP EKF

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Deposition velocities (analyses)
(cf. P.Hamer's presentation)

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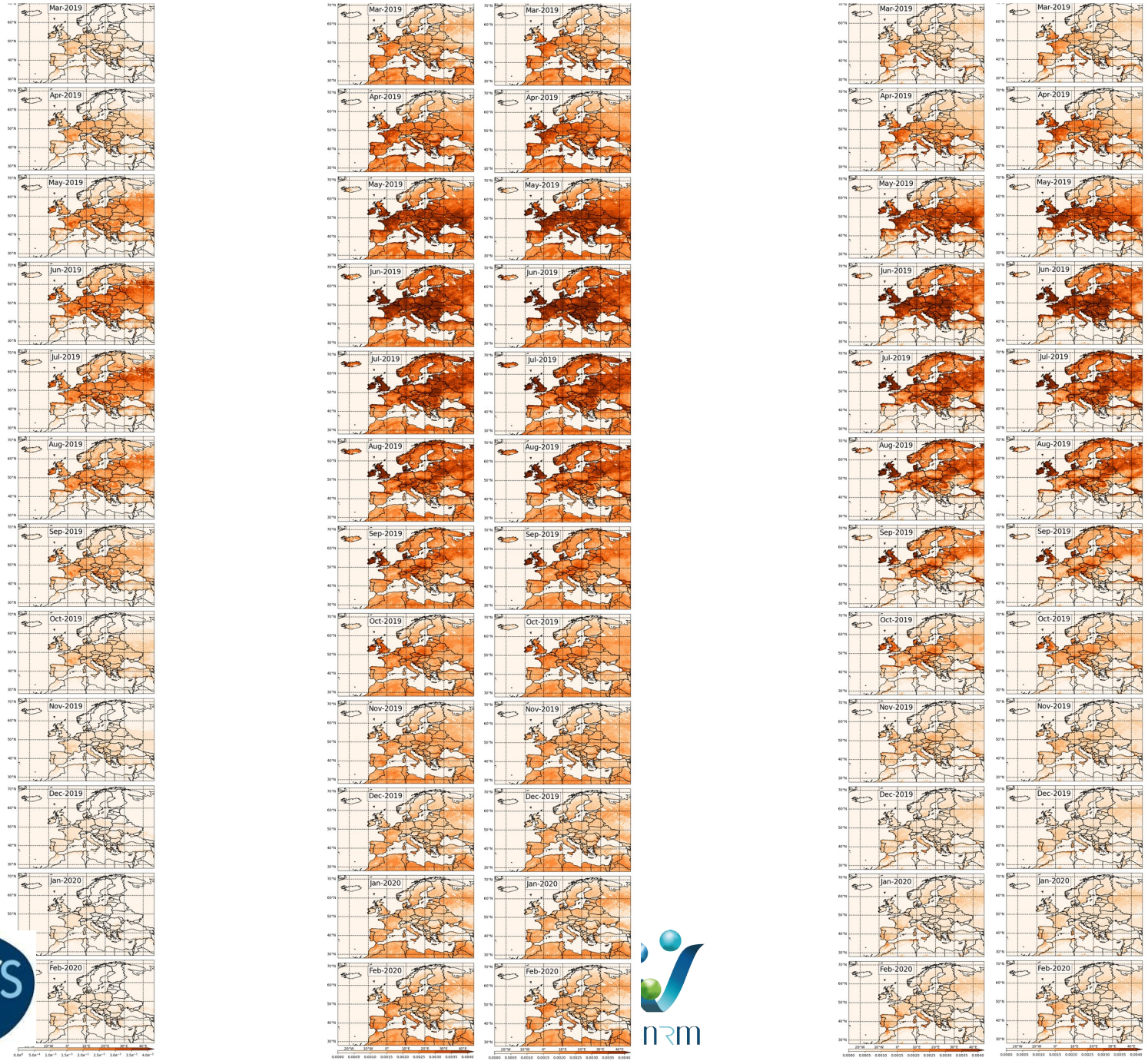
Reference

Wesely OL/EKF

EMEP OL/EKF



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NO_2

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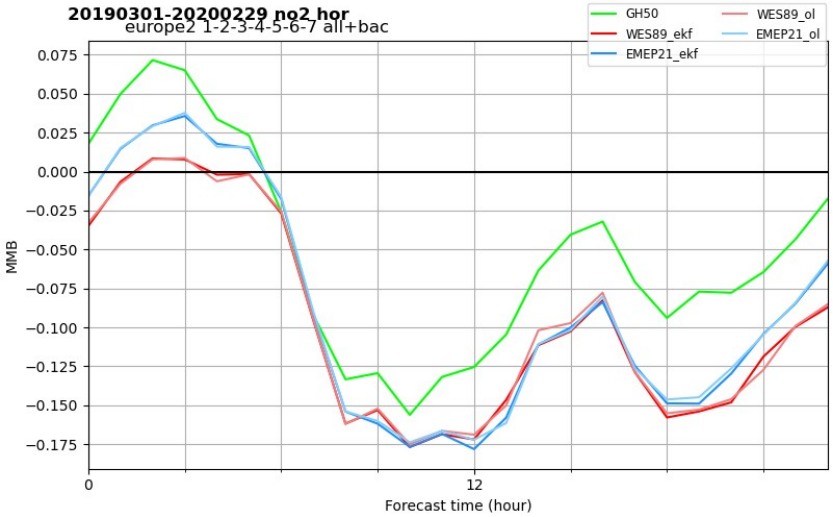
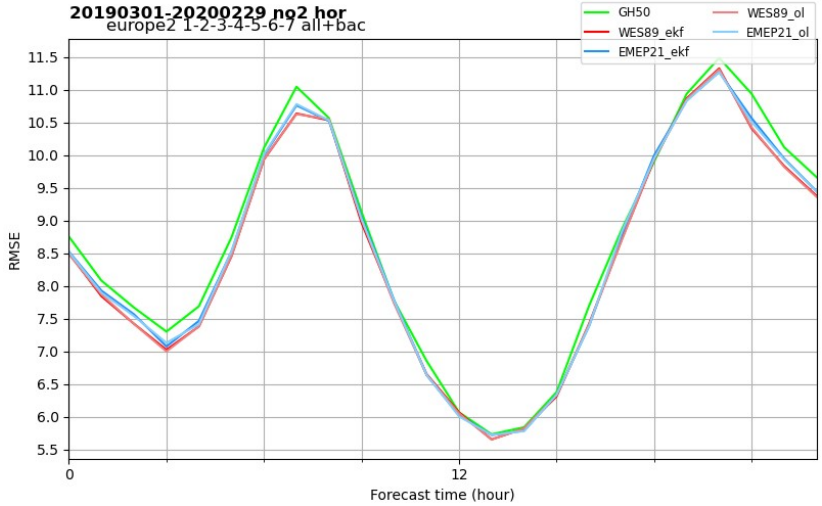
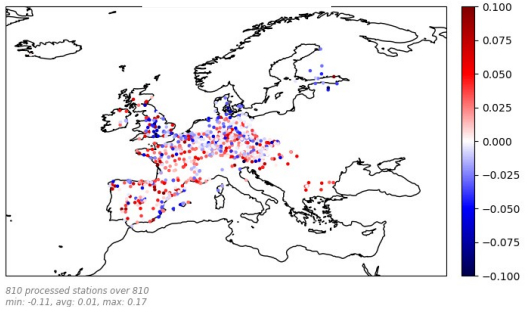
Results in Analysis chain - NO_2





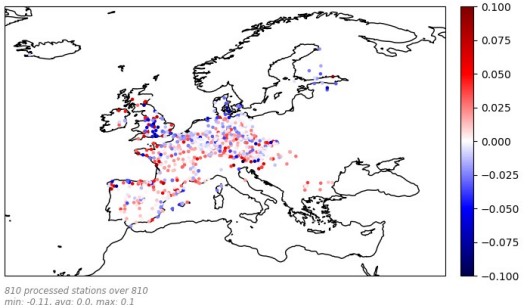
Results in Analysis chain - NO_2

MMB



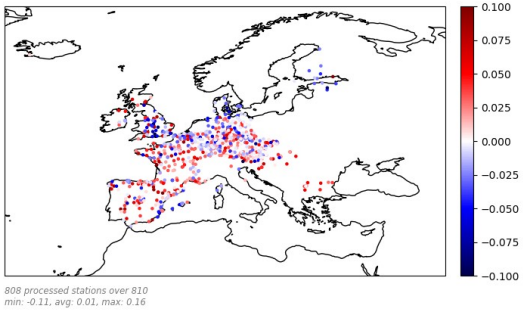
810 processed stations over 810
min: -0.11, avg: 0.01, max: 0.17

Wesely-OL - Ref



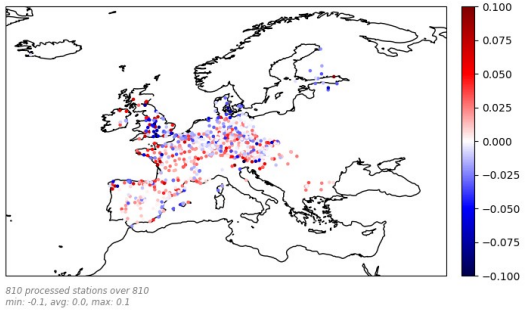
810 processed stations over 810
min: -0.11, ava: 0.0, max: 0.1

EMEP-OL - Ref



808 processed stations over 810
min: -0.11, avg: 0.01, max: 0.16

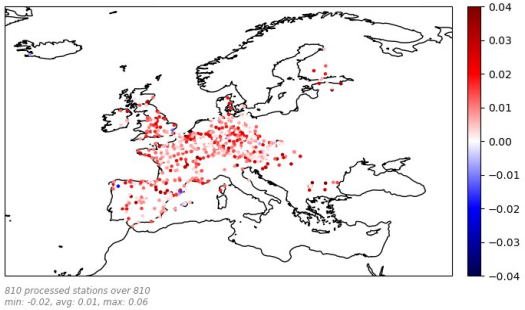
Wesely-EKF - Ref



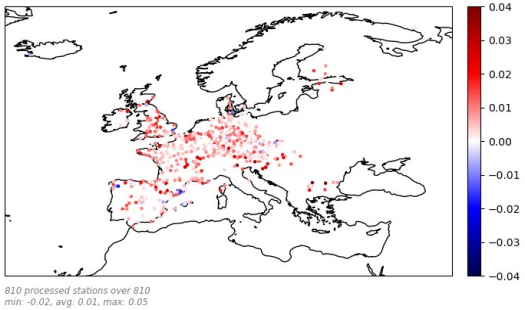
810 processed stations over 810
min: -0.1, avg: 0.0, max: 0.1

EMEP-EKF - Ref

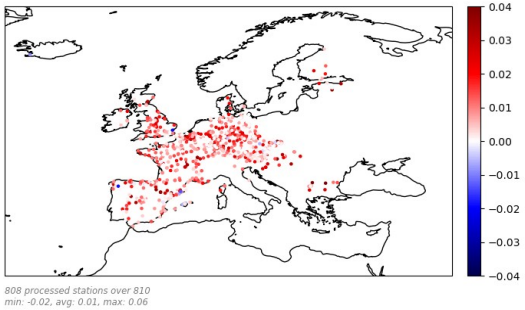
Correlation



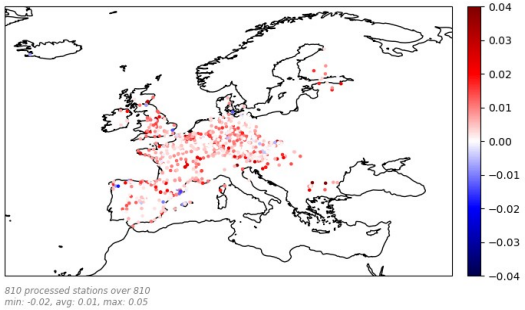
810 processed stations over 810
min: -0.02, avg: 0.01, max: 0.06



810 processed stations over 810
min: -0.02, avg: 0.01, max: 0.05



808 processed stations over 810
min: -0.02, avg: 0.01, max: 0.06



810 processed stations over 810
min: -0.02, avg: 0.01, max: 0.05

Results in Analysis chain - NO_2

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Success ratio : Wesely > EMEP > Reference (Target of 1)
False alarm ratio : Wesely < EMEP < Reference (Target of 0)
Bias score : Reference > EMEP > Wesely (Target of 1)

threshold = 50.0					
	accuracy	bias_score	success_ratio	hit_rate	false_alarm_ratio
GH50	0.86	0.6	0.5	0.3	0.5
WES89_ekf	0.87	0.53	0.52	0.28	0.48
EMEP21_ekf	0.86	0.55	0.51	0.28	0.49
WES89_ol	0.87	0.53	0.52	0.28	0.48
EMEP21_ol	0.86	0.56	0.51	0.28	0.49
threshold = 30.0					
	accuracy	bias_score	success_ratio	hit_rate	false_alarm_ratio
GH50	0.72	0.61	0.77	0.47	0.23
WES89_ekf	0.72	0.57	0.79	0.45	0.21
EMEP21_ekf	0.72	0.58	0.79	0.46	0.21
WES89_ol	0.72	0.57	0.79	0.45	0.21
EMEP21_ol	0.72	0.58	0.79	0.46	0.21

=> SEEDS products:
- improve the detection of NO_2 events in analyses
- degrade NO_2 bias

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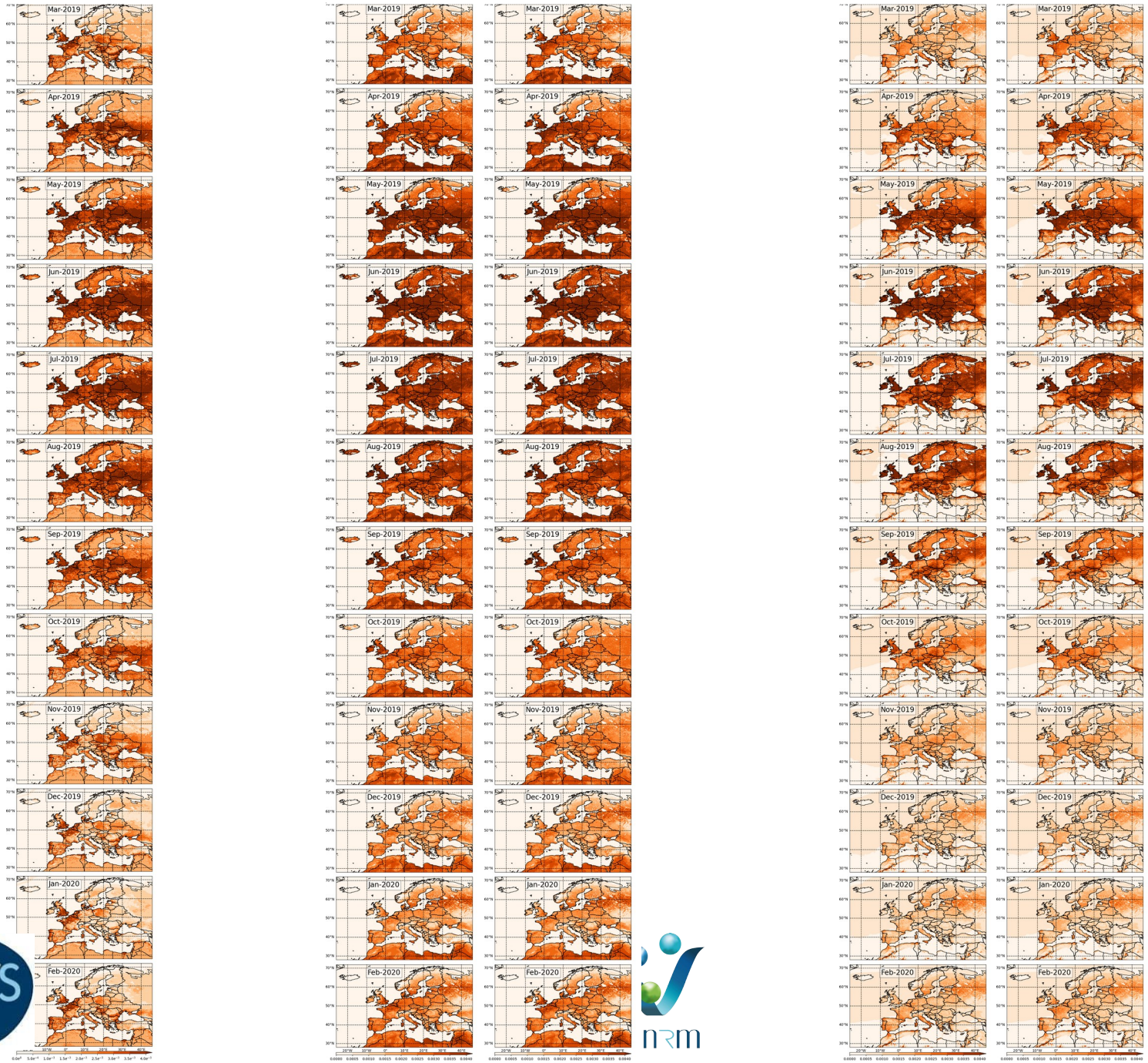
Reference

Wesely OL/EKF

EMEP OL/EKF



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OZONE

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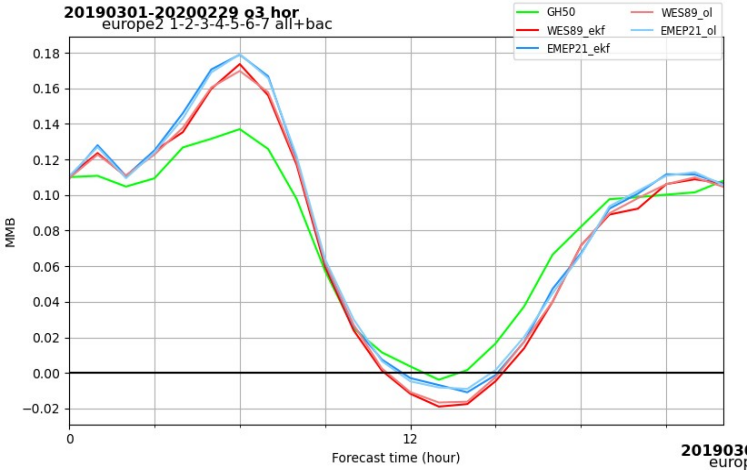
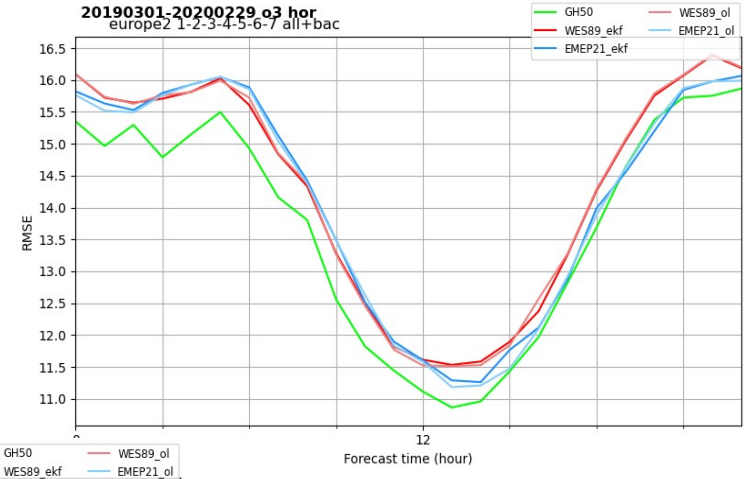
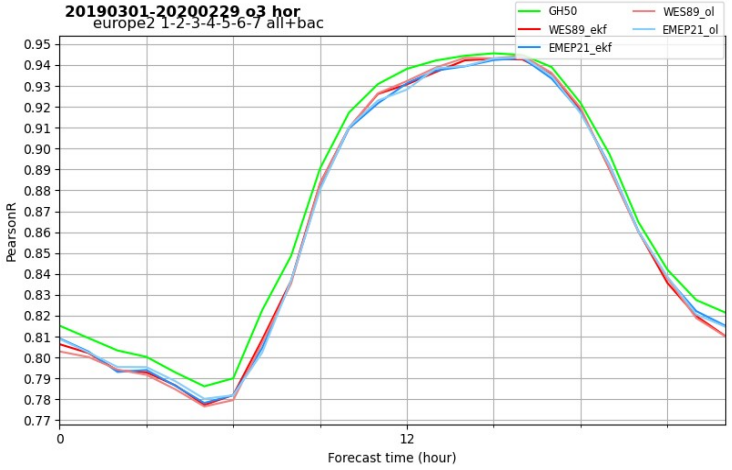
Results in Analysis chain - O_3

Median station score of all stations over a 24h forecast

- Reference have better score (RMSE and Correlation mainly)
  - smoother deposition for reference = better mean scores (lots of background stations)
  - EKF and OL have low impact. (nearly overlapping curves)

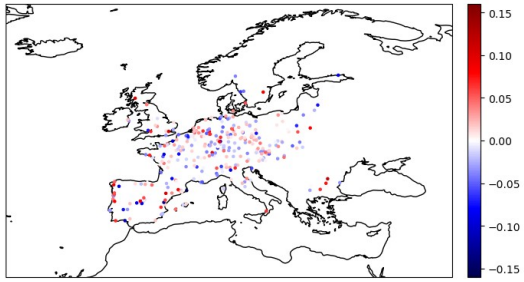






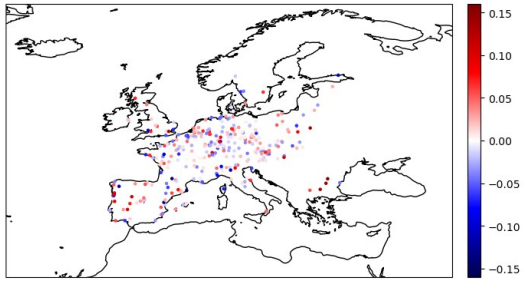
Results in Analysis chain - O_3

MMB



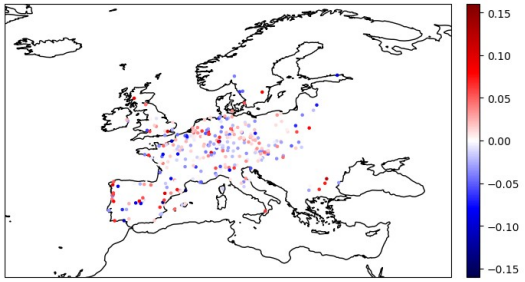
327 processed stations over 327
min: -0.18, avg: -0.0, max: 0.11

Wesely-OL - Ref



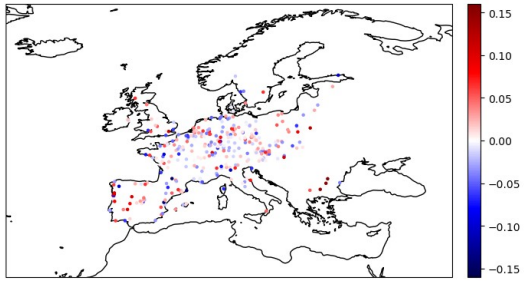
327 processed stations over 327
min: -0.16, avg: 0.0, max: 0.21

EMEP-OL - Ref



327 processed stations over 327
min: -0.17, avg: -0.0, max: 0.12

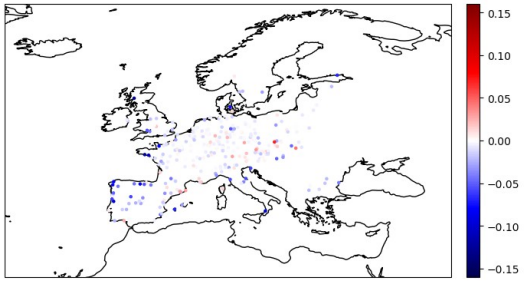
Wesely-EKF - Ref



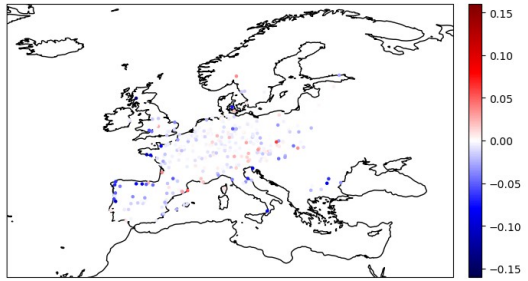
327 processed stations over 327
min: -0.15, avg: 0.0, max: 0.22

EMEP-EKF - Ref

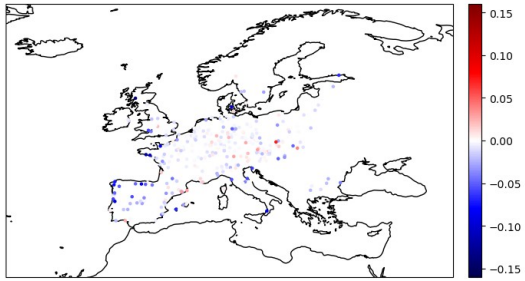
Correlation



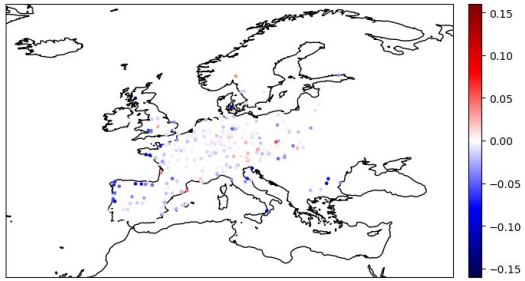
327 processed stations over 327
min: -0.13, avg: -0.01, max: 0.07



327 processed stations over 327
min: -0.14, avg: -0.01, max: 0.06



327 processed stations over 327
min: -0.14, avg: -0.01, max: 0.07



327 processed stations over 327
min: -0.15, avg: -0.01, max: 0.06

Results in Analysis chain

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Success ratio :	EMEP > Wesely > Reference	(Target of 1)
False alarm ratio :	EMEP < Wesely < Reference	(Target of 0)
Bias score :	Reference > EMEP > Wesely	(Target of 1)

threshold = 180.0					
	accuracy	bias_score	success_ratio	hit_rate	false_alarm_ratio
GH50	0.99	0.71	0.6	0.43	0.4
WES89_ekf	0.99	0.59	0.67	0.39	0.33
EMEP21_ekf	0.99	0.55	0.7	0.39	0.3
WES89_ol	0.99	0.58	0.69	0.39	0.31
EMEP21_ol	0.99	0.54	0.7	0.37	0.3
threshold = 150.0					
	accuracy	bias_score	success_ratio	hit_rate	false_alarm_ratio
GH50	0.96	0.7	0.73	0.51	0.27
WES89_ekf	0.96	0.62	0.76	0.47	0.24
EMEP21_ekf	0.96	0.61	0.77	0.47	0.23
WES89_ol	0.96	0.62	0.76	0.47	0.24
EMEP21_ol	0.96	0.6	0.78	0.47	0.22

=> SEEDS products:
- improve the quality of representation of more extreme ozone events
- degrade O_3 bias

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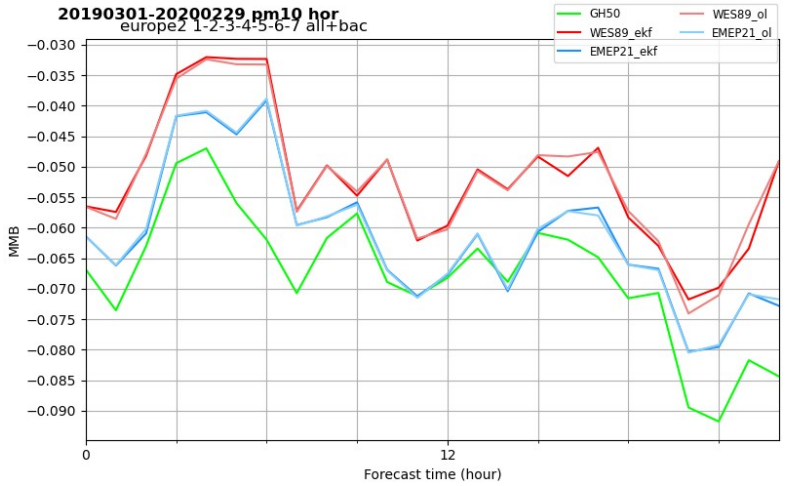
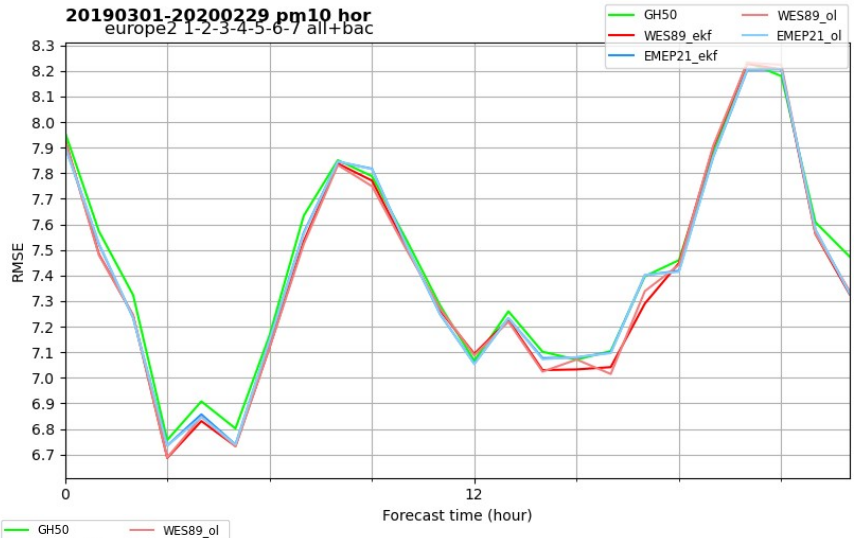
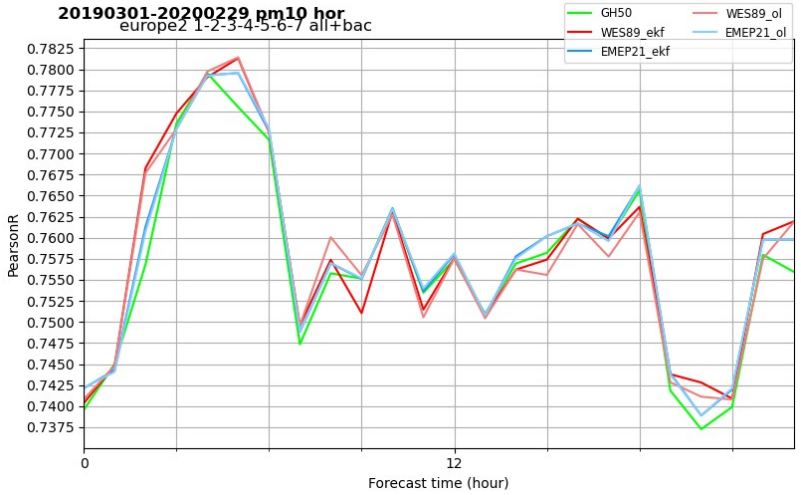
Results in Analysis chain - PM10



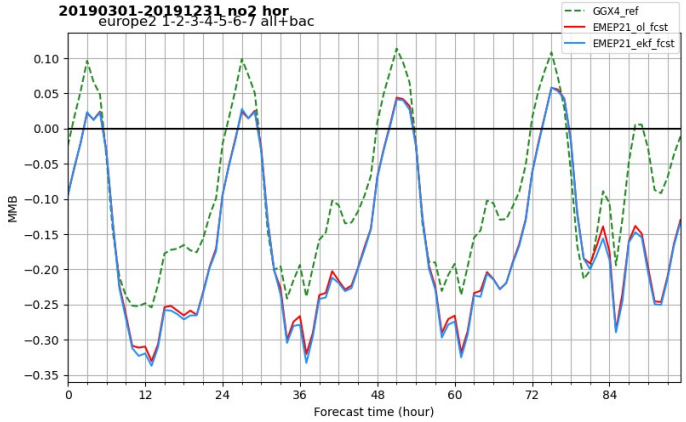


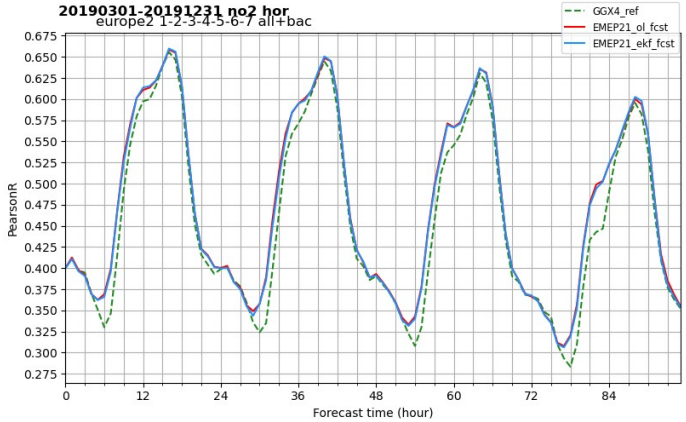


=> Impact due to SIA

Improved biais

Results in Forecast chain - NO_2





threshold = 50.0	accuracy	bias_score	success_ratio	hit_rate	false_alarm_ratio
GGX4_ref	0.85	0.66	0.36	0.24	0.64
EMEP21_ol_fcst	0.86	0.59	0.38	0.22	0.62
EMEP21_ekf_fcst	0.86	0.59	0.38	0.22	0.62
threshold = 30.0	accuracy	bias_score	success_ratio	hit_rate	false_alarm_ratio
GGX4_ref	0.7	0.55	0.69	0.38	0.31
EMEP21_ol_fcst	0.7	0.51	0.7	0.36	0.3
EMEP21_ekf_fcst	0.7	0.51	0.7	0.36	0.3

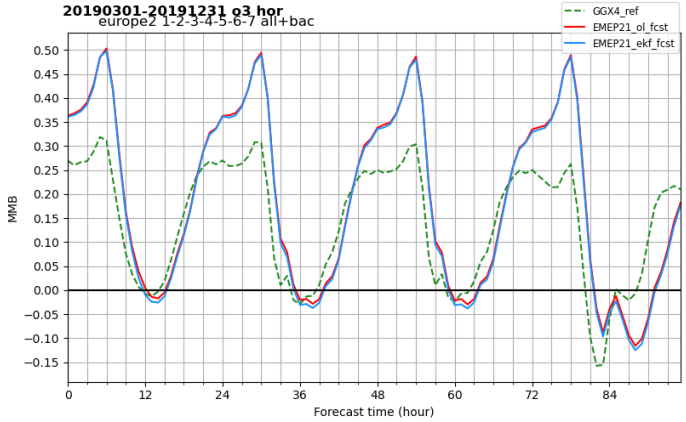
D0

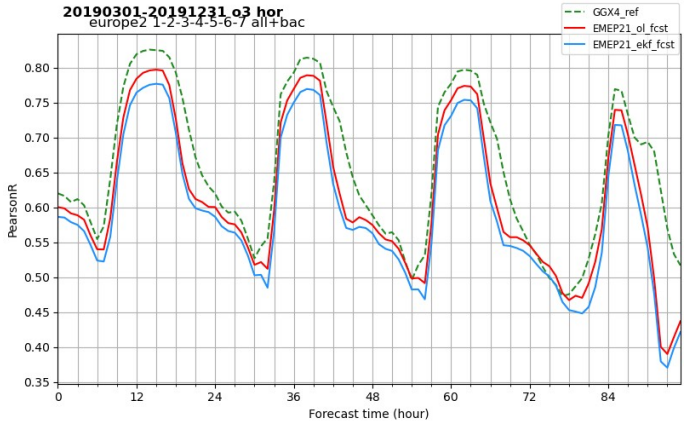
D3

threshold = 50.0	accuracy	bias_score	success_ratio	hit_rate	false_alarm_ratio
GGX4_ref	0.85	0.76	0.35	0.26	0.65
EMEP21_ol_fcst	0.86	0.62	0.37	0.23	0.63
EMEP21_ekf_fcst	0.86	0.62	0.37	0.23	0.63
threshold = 30.0	accuracy	bias_score	success_ratio	hit_rate	false_alarm_ratio
GGX4_ref	0.7	0.59	0.67	0.4	0.33
EMEP21_ol_fcst	0.69	0.52	0.69	0.36	0.31
EMEP21_ekf_fcst	0.69	0.52	0.69	0.36	0.31

=> SEEDS products:
- slightly improve the quality of NO_2 predictions, during the 4 days of forecasting
- degrade bias

Results in Forecast chain - O_3





threshold = 240.0

	accuracy	bias_score	success_ratio	hit_rate	false_alarm_ratio
GGX4_ref	1	0.33	0.13	0.045	0.87
EMEP21_ol_fcst	1	0.3	0.13	0.04	0.87
EMEP21_ekf_fcst	1	0.33	0.12	0.04	0.88

threshold = 180.0

	accuracy	bias_score	success_ratio	hit_rate	false_alarm_ratio
GGX4_ref	0.99	0.76	0.38	0.29	0.62
EMEP21_ol_fcst	0.99	0.57	0.39	0.22	0.61
EMEP21_ekf_fcst	0.99	0.61	0.38	0.24	0.62

D0

D3

threshold = 240.0

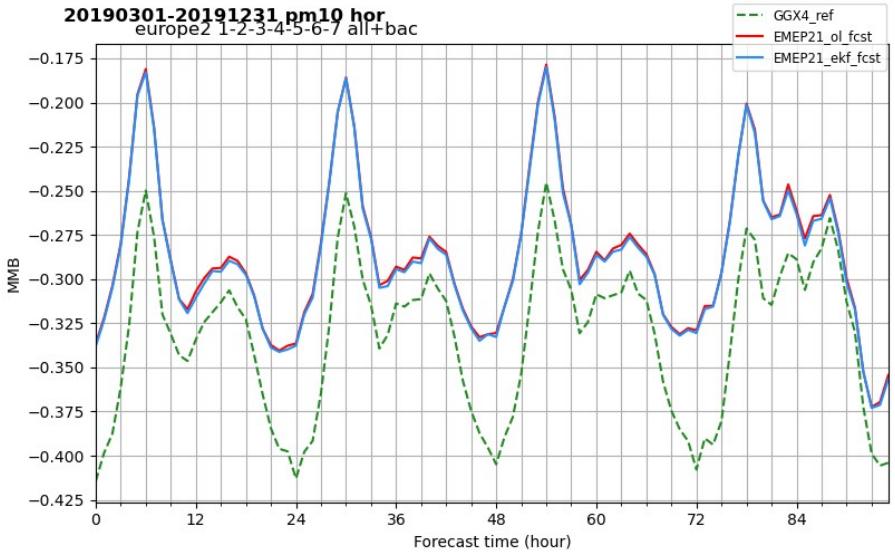
	accuracy	bias_score	success_ratio	hit_rate	false_alarm_ratio
GGX4_ref	1	0.95	0.048	0.045	0.95
EMEP21_ol_fcst	1	0.63	0.057	0.036	0.94
EMEP21_ekf_fcst	1	0.67	0.054	0.036	0.95

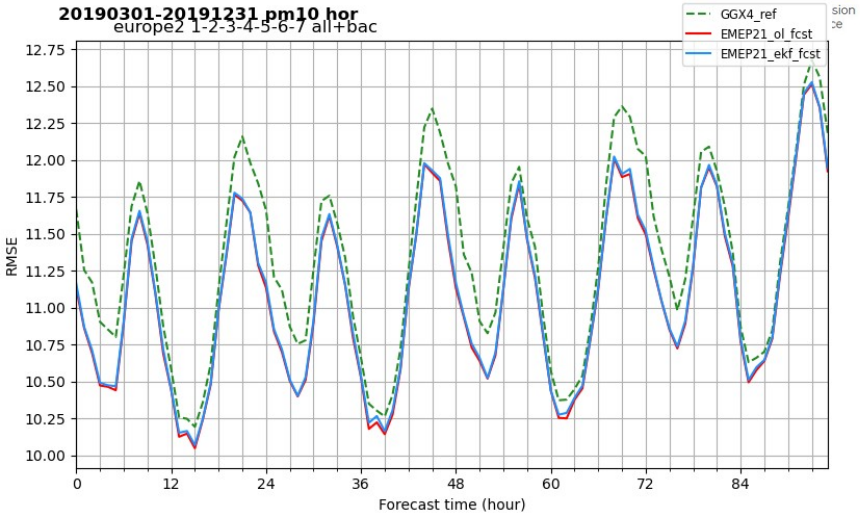
threshold = 180.0

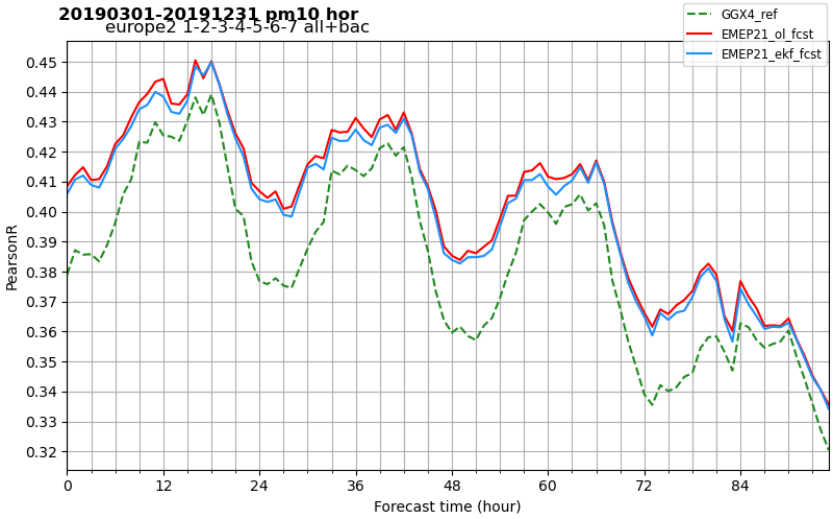
	accuracy	bias_score	success_ratio	hit_rate	false_alarm_ratio
GGX4_ref	0.99	1.8	0.22	0.38	0.78
EMEP21_ol_fcst	0.99	1.3	0.18	0.24	0.82
EMEP21_ekf_fcst	0.99	1.4	0.18	0.26	0.82

=> SEEDS products:
- degrade events detection
- degrade overall quality of the forecast
- degrade bias

Results in Forecast chain





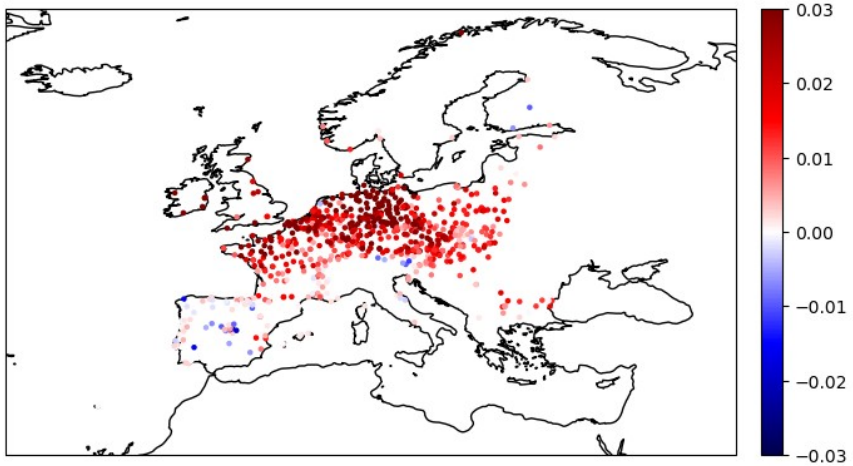


=> Nice improvement of PM10 forecasts !

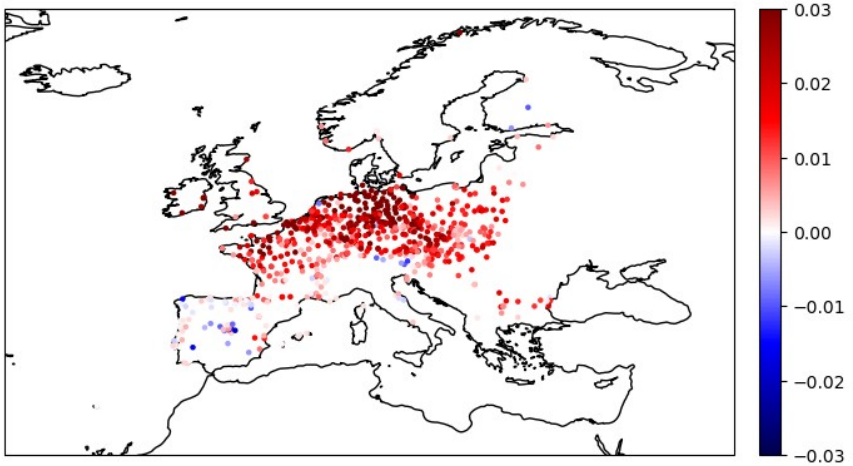
Results in Forecast chain - PM10

SEEDS
Sentinel EO-based Emission and Deposition Service

Correlation



EMEP-OL - Ref



EMEP-EKF - Ref

=> Strange zonal variation...

cnrs

CNRM

METEO FRANCE

Conclusion

Analyses

- No big improvement, but
  - interesting impact on ozone events
  - Reduction of PM10 bias
  - Difficulties to improve result in analyses

Forecasts

- Degradation of ozone scores :-(
  - But variable depending season
- Improvement of PM10 scores :-)

General

- Lots of work to analyze in depth all the simulations
- Same behaviour between OL/EKF
- Impact visible on secondary pollutant
- All deposition velocities are changing
  - Not easy to determine the ways of the improvements/degradation
  - Lack of deposition velocities measurements to validate deposition schemes
    - Potential link with CAMS2_40 Task 4041 on deposition
  - Lack of concentration measurements
    - NH3, NMVOC, SIA, etc…
- Are these conclusions the same in other models? Need intercomparison

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