Precipitation verification

Contributions from: CMC, CPTEC, DWD, ECMWF, JMA, MF, NCEP, NRL, RHMC, UKMO

WGNE - 31
Council for Scientific and Industrial Research
South Africa
26 - 29 April 2016

WCRP World Climate Research Programme

World Meteorological Organization
Weather • Climate • Water

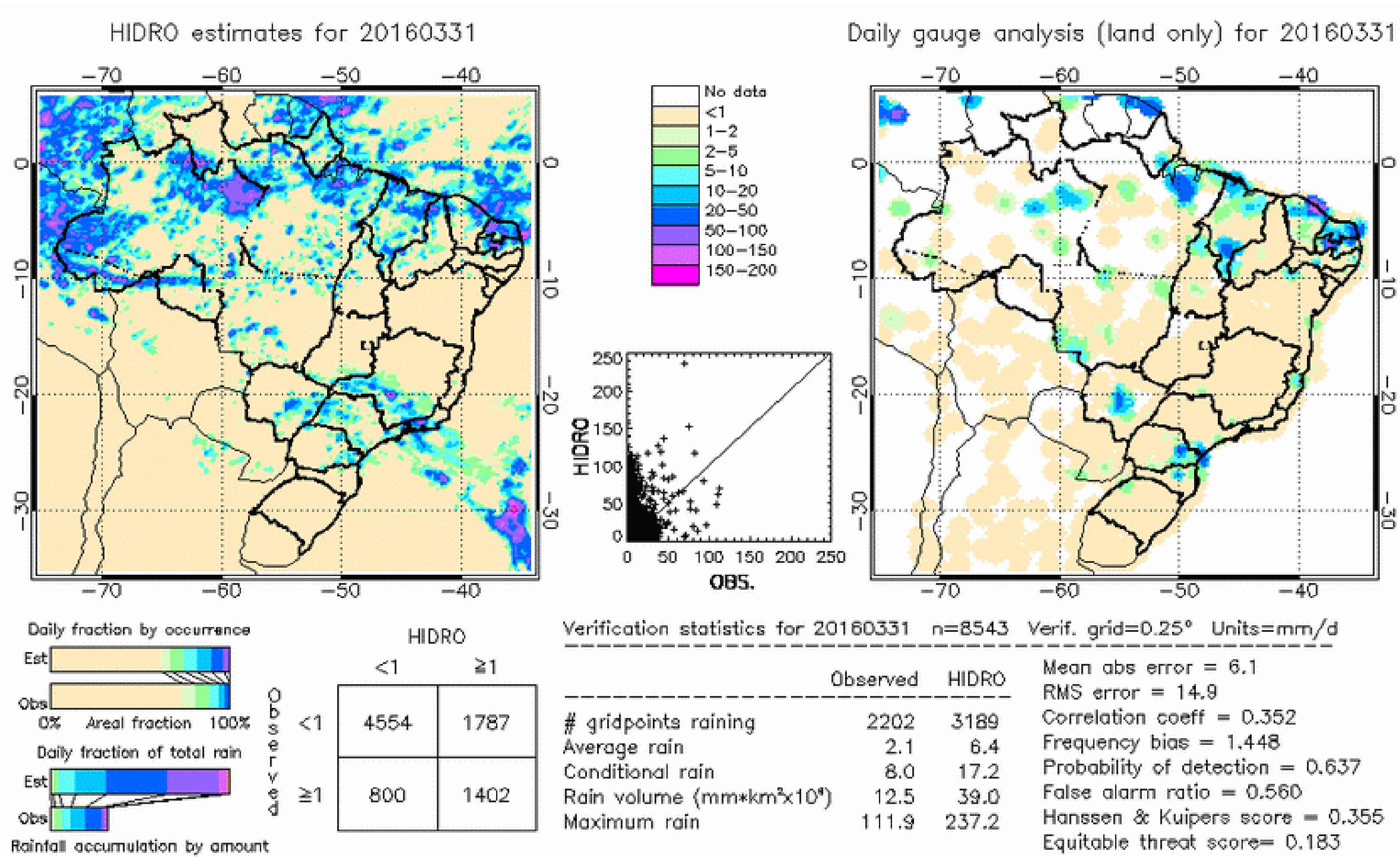
CSIR our future through science

Operational verification of quantitative precipitation forecast at INPE/CPTEC

April, 2016

Thanks for José R. Rozante and Daniel A. Vila,

Satellite precipitation validation

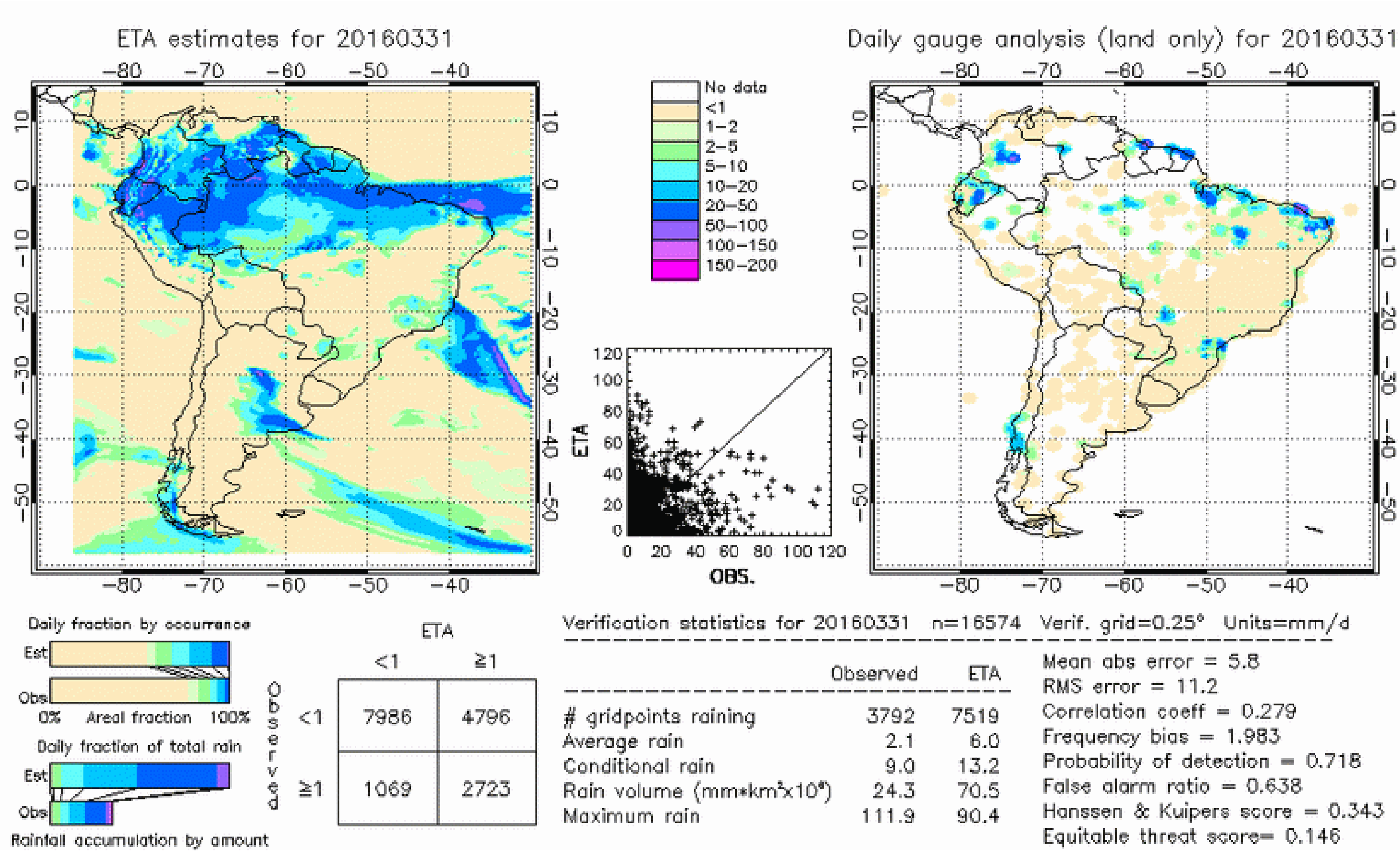


Rain gauges in South America
White areas: no rain gauges stations

Statistical scores

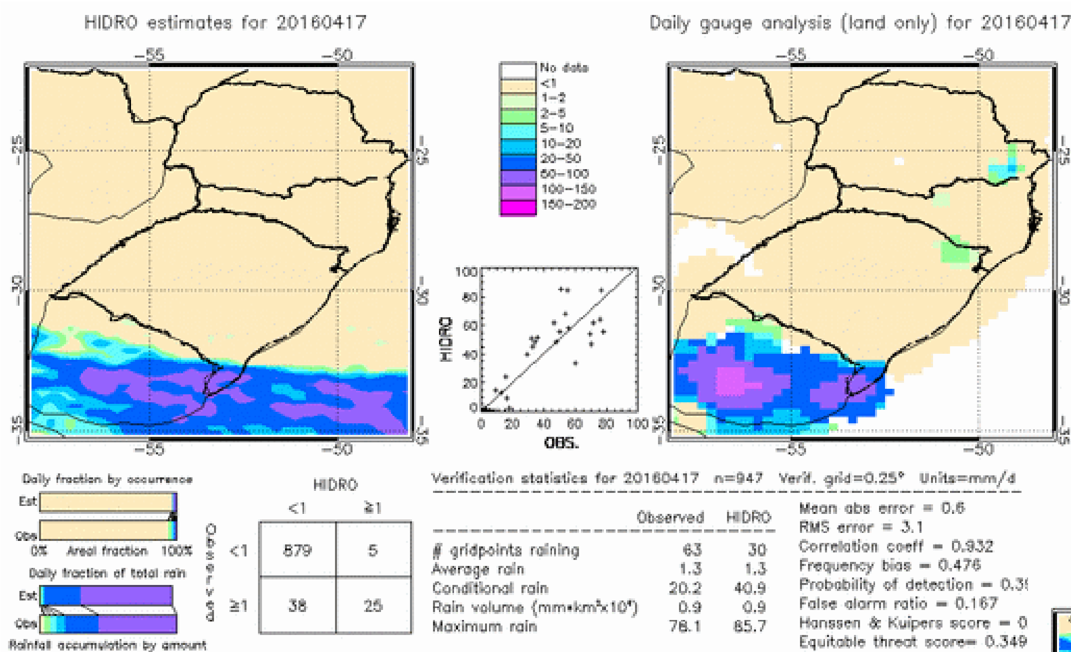
Hydroestimator – comparison with rain gauges

Model precipitation validation

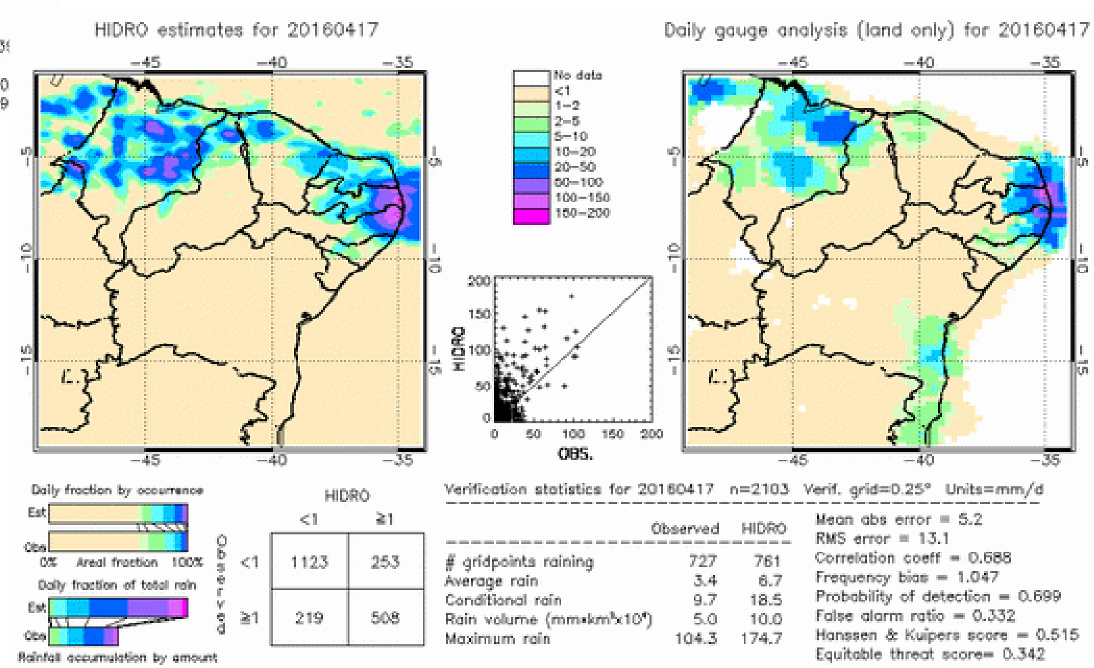


Regional model ETA

The same for different areas



Southern Brazil



Northeast Brazil

Model verification

http://avaliacaodemodelos.cptec.inpe.br/

Monthly categorical verification

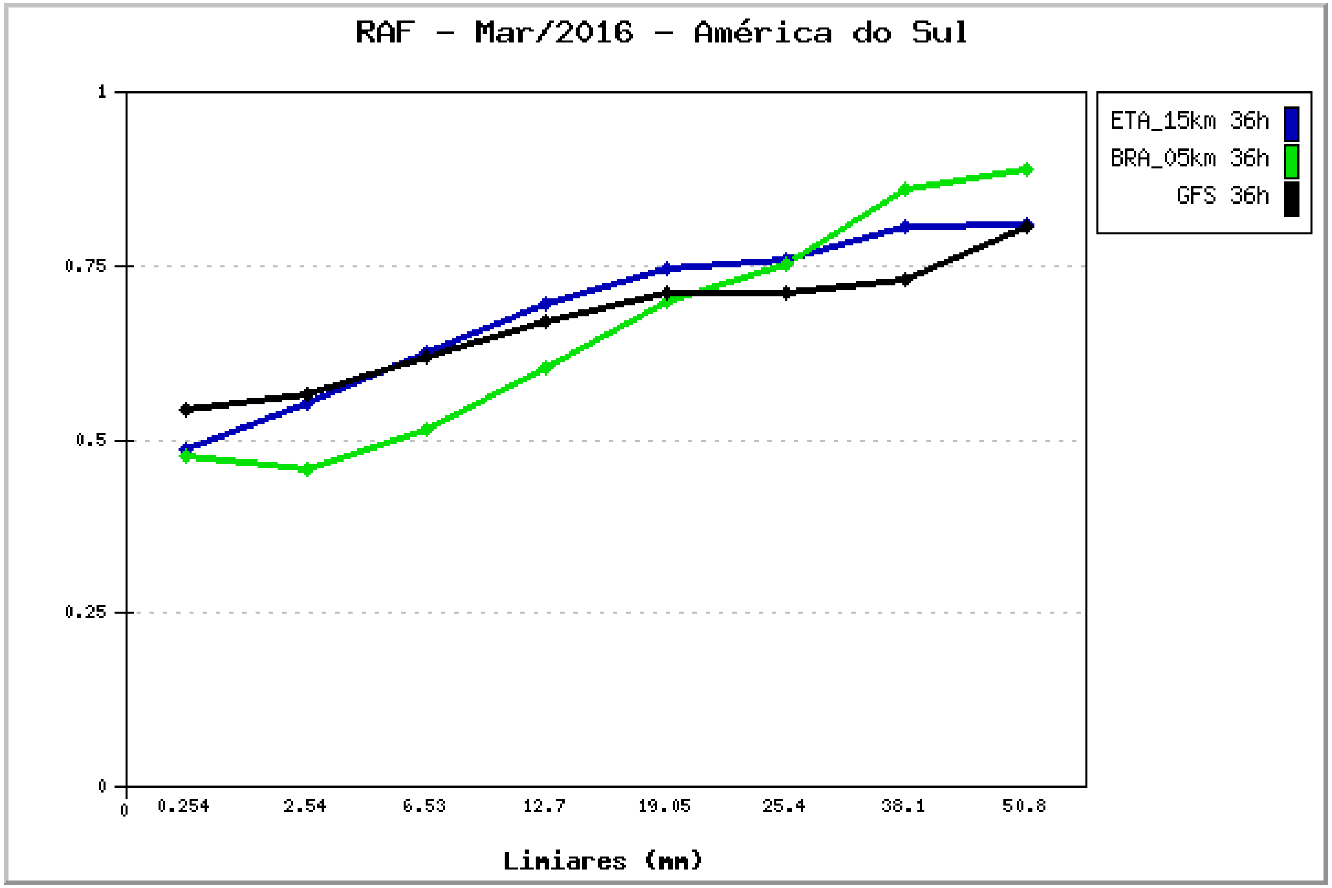
FAR for South America

Models evaluated:

BRAMS

ETA

GFS



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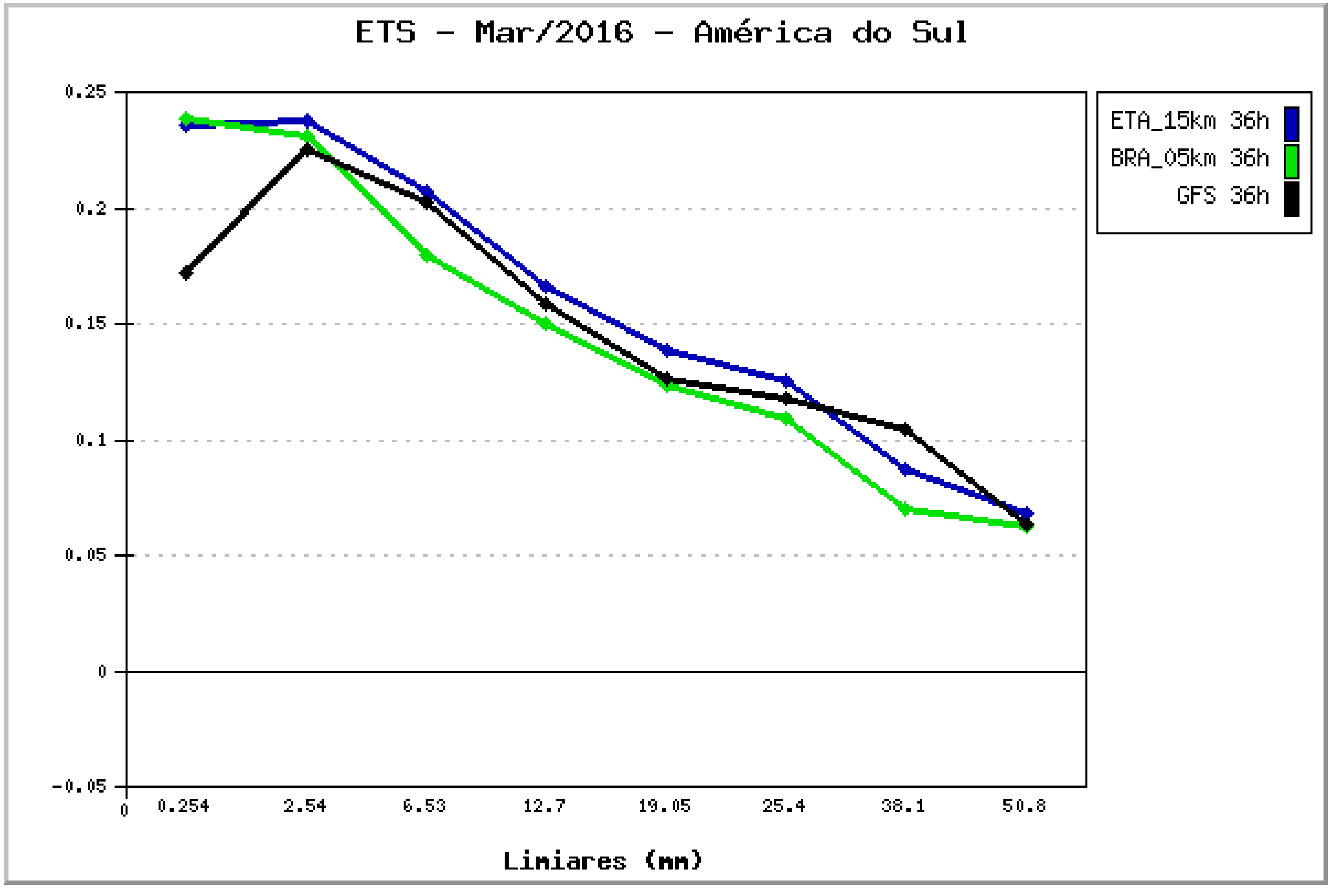


DWD

22 April 2016

Felix Fundel, Ulrich Pflüger (DWD)

Verification Settings

Participating

- Germany: DWD GME (until Dec. 2014) and ICON (from Jan. 2015)
- ECMWF: IFS
- France: Meteo-France Arpege
- Canada: CMC GDPS
- U.K.: UKMO Unified Model (no data for DJF 2014)
- ~~USA: NCEP GFS (data problems)~~

Observations

- Calibrated radar composite over Germany
- 24h sums (06-06 UTC)

Preprocessing

- Re-gridding to 0.025°x0.025° (both models and observations)

Verification

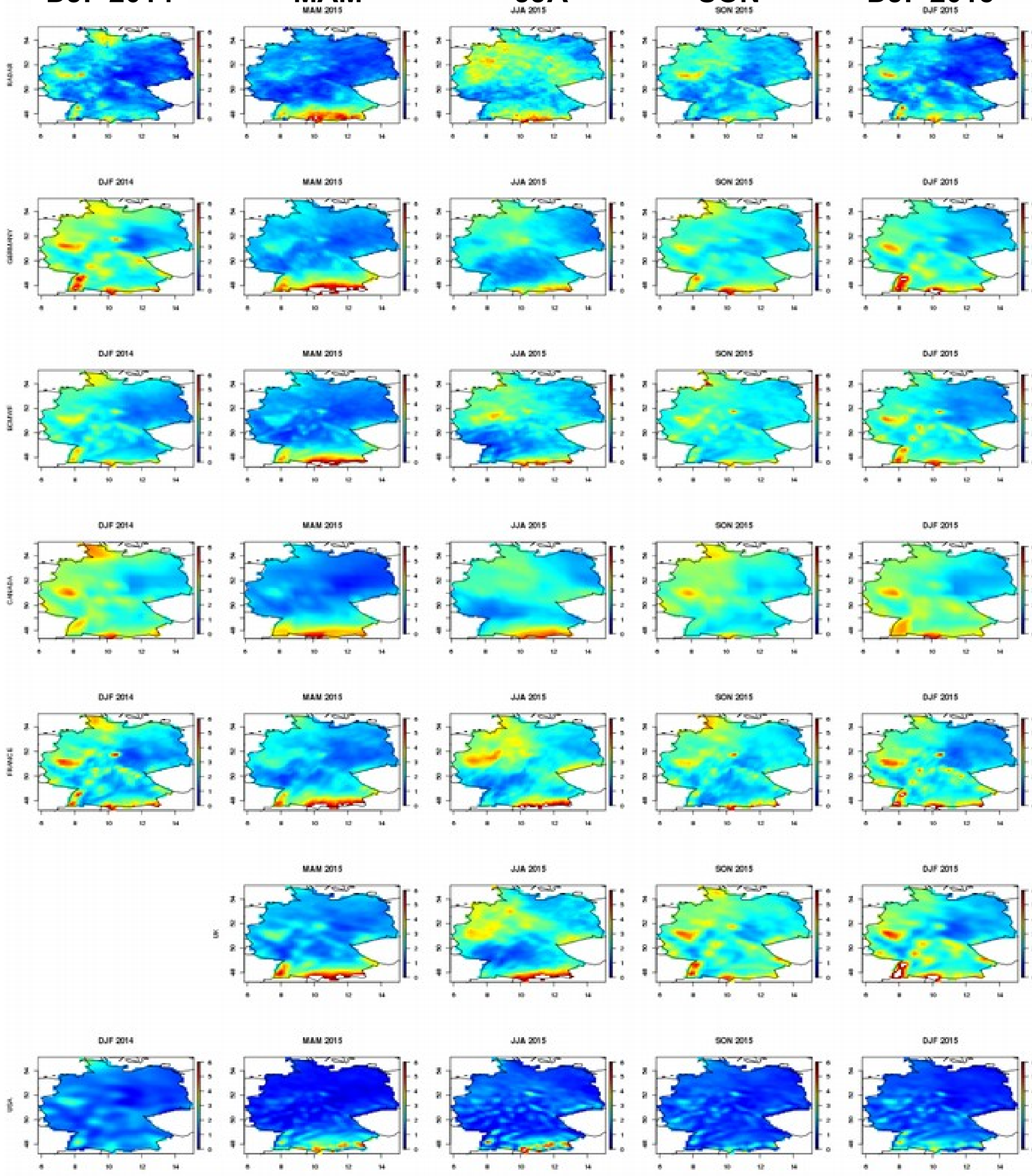
- Scales 1x1, 3x3, 5x5, 9x9 grid points
- Thresholds 0.1, 1, 2, 5, 10, 20, 50 mm/24h
- Lead-Times: 30, 54 and 78h of 00 UTC runs
- Seasonal verification DFJ 2014 – DFJ 2015

Seasonal avg. of daily precipitation

LT 06-30h

!DATA PROBLEMS!

	DJF 2014	MAM	JJA	SON	DJF 2015
RADAR					
GERMANY					
ECMWF					
CANADA					
FRANCE					
UK					
USA					



Fractions Skill Score

JJA 2015

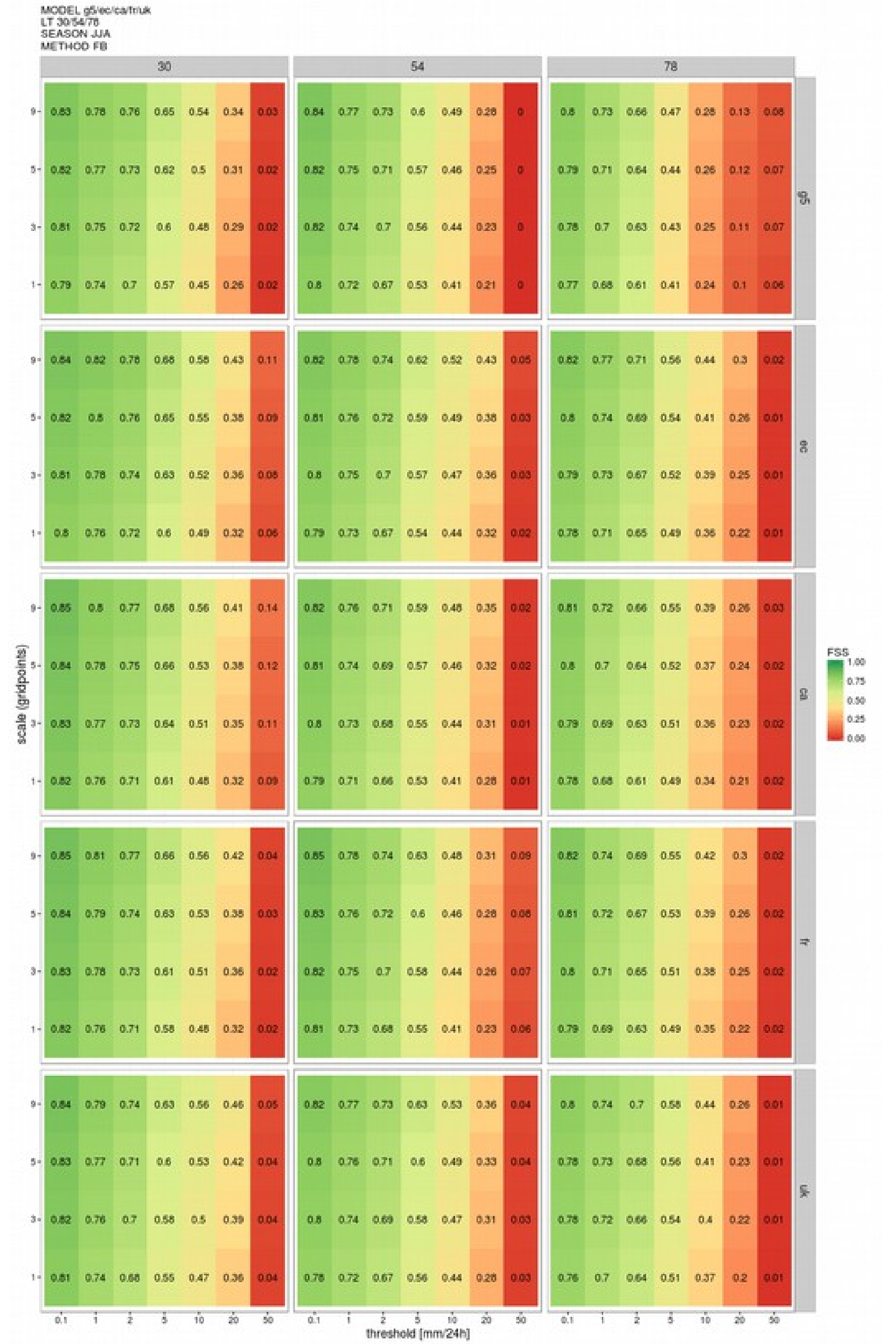
GERMANY

ECMWF

CANADA

FRANCE

U.K.



Fractions Skill Score

DJF 2015

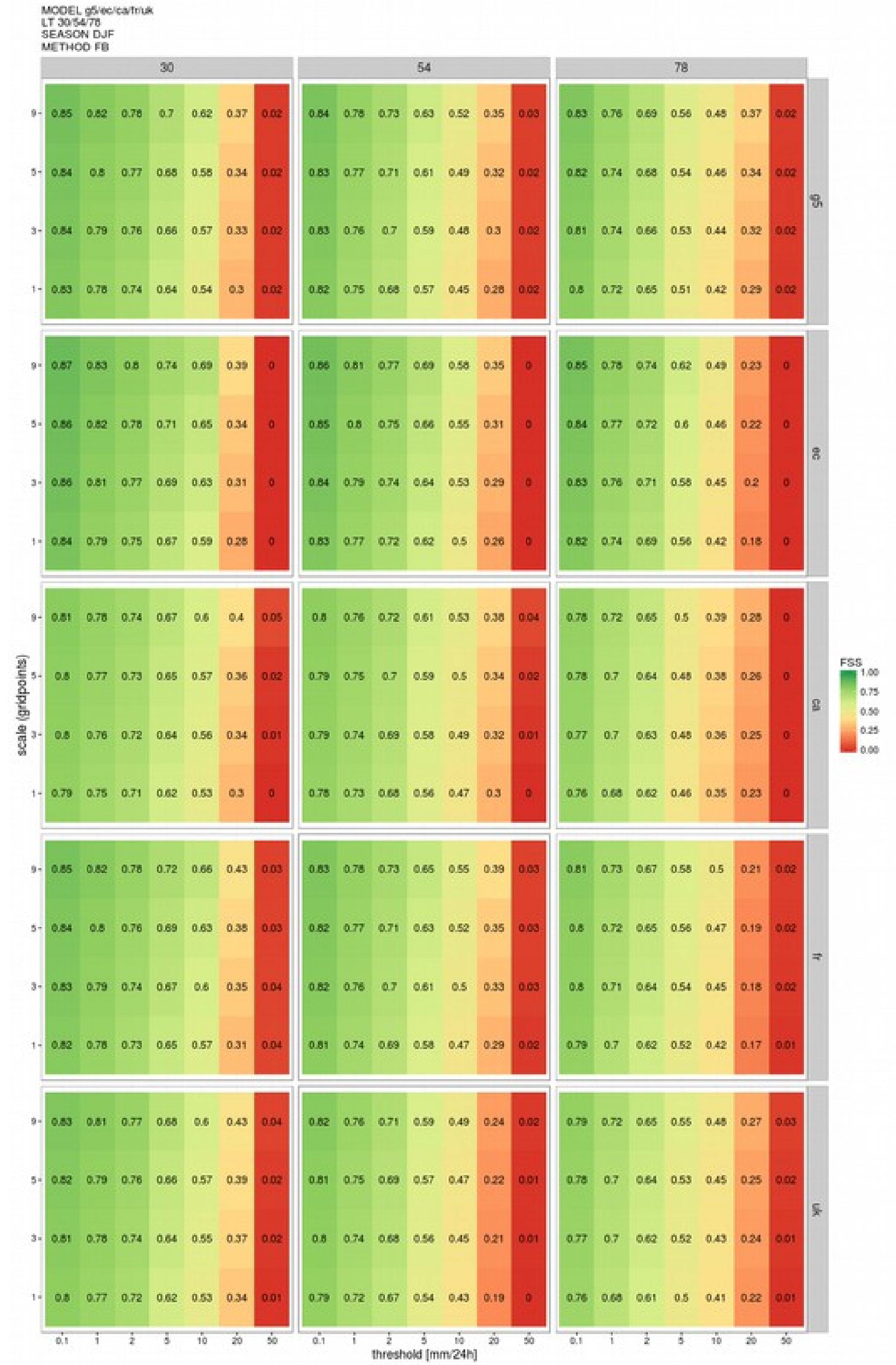
GERMANY

ECMWF

CANADA

FRANCE

U.K.



Brier Skill Score (pragmatic)

JJA 2015

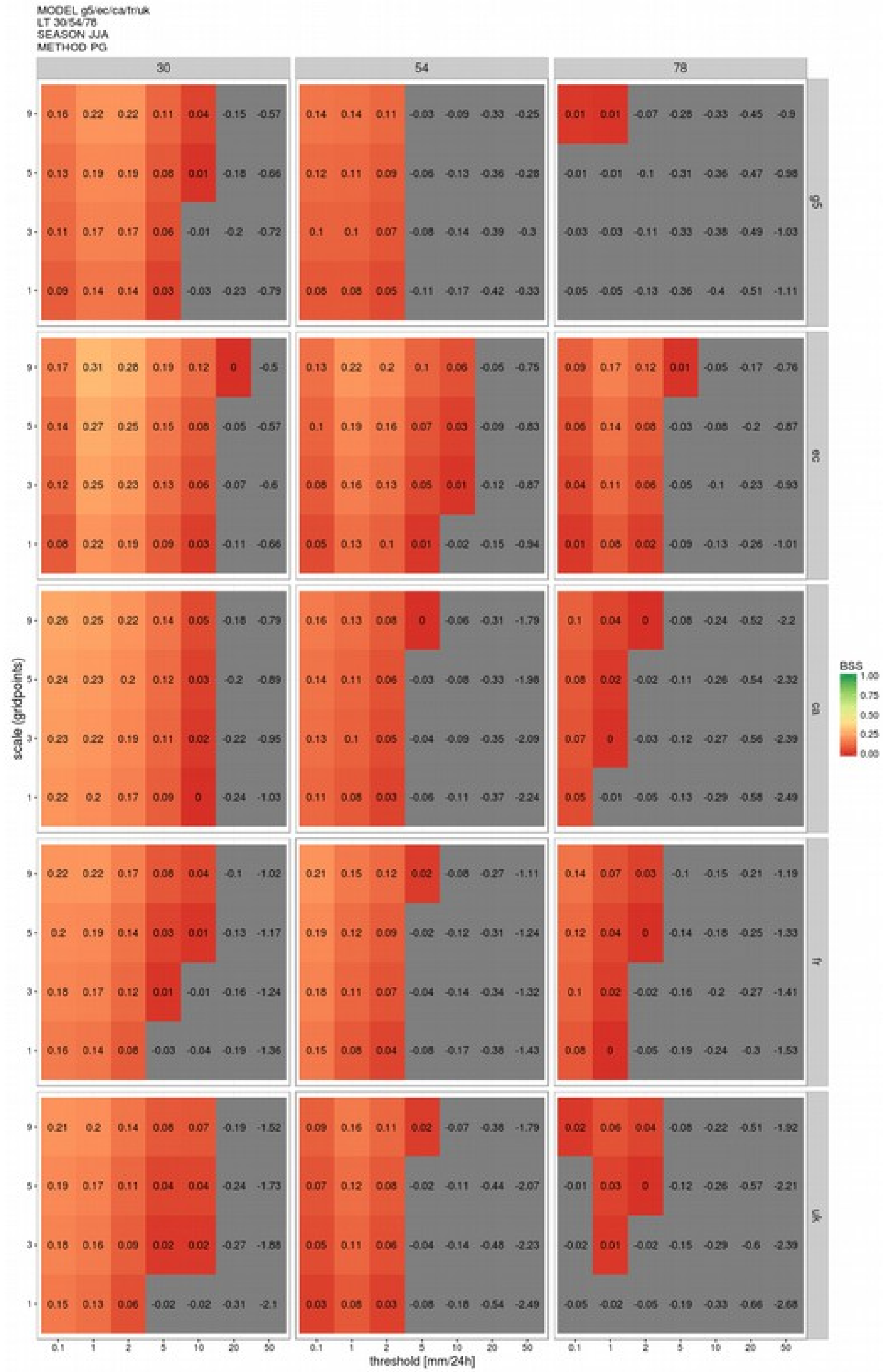
GERMANY

ECMWF

CANADA

FRANCE

U.K.



Brier Skill Score (pragmatic)

DJF 2015

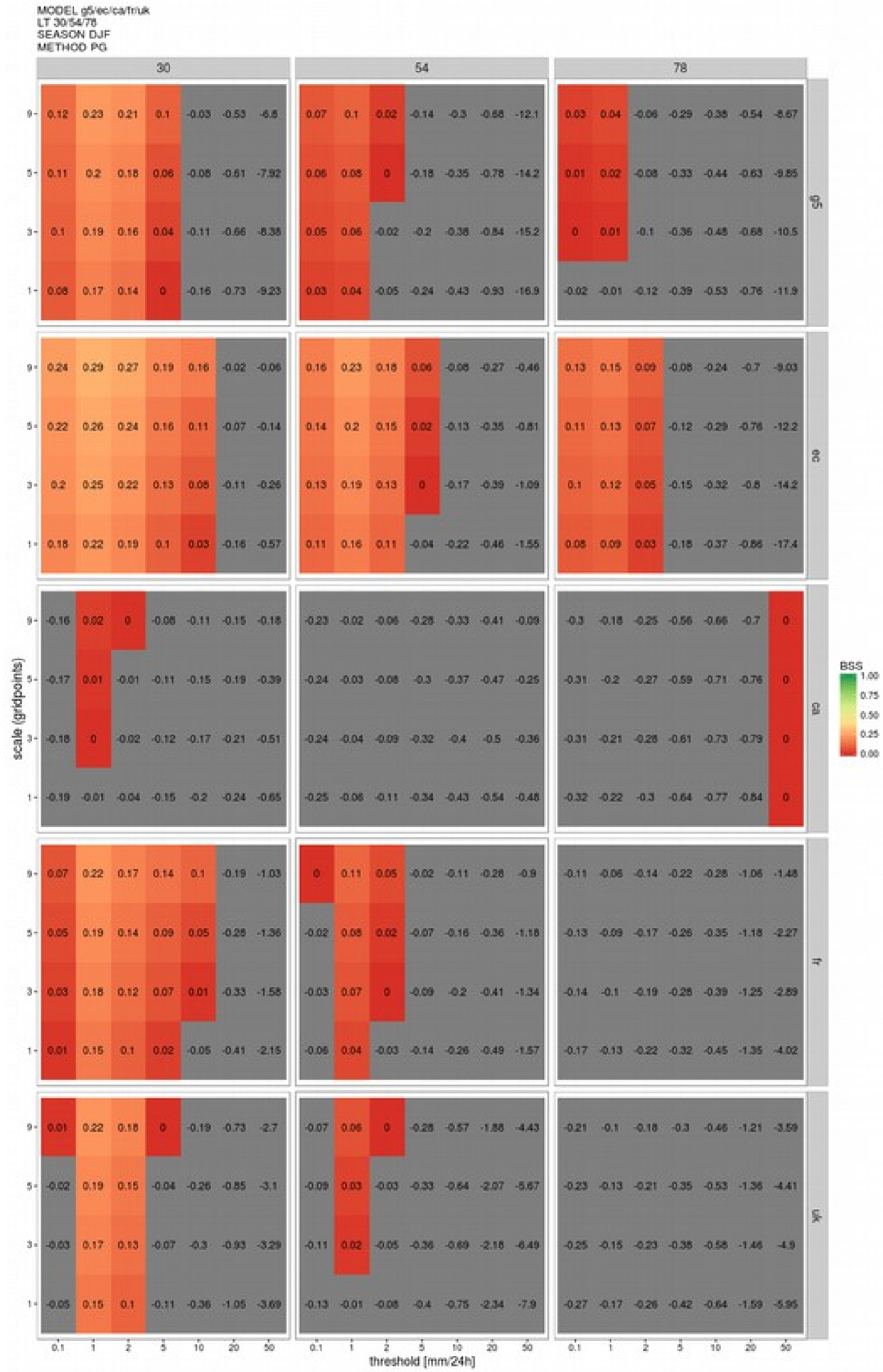
GERMANY

ECMWF

CANADA

FRANCE

U.K.

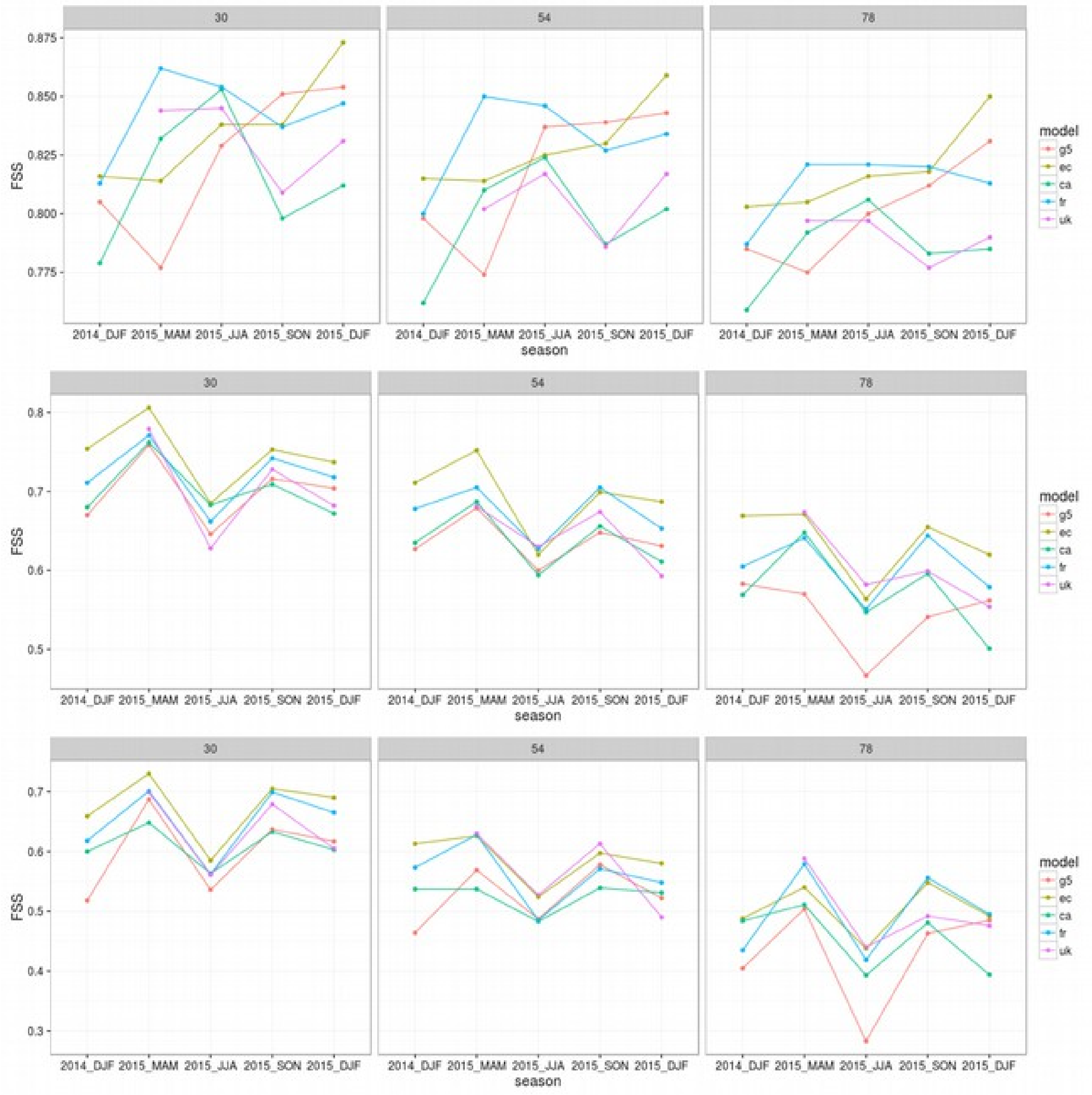


Fractions Skill Score
Scale: 9x9 GP

0.1 mm/24h

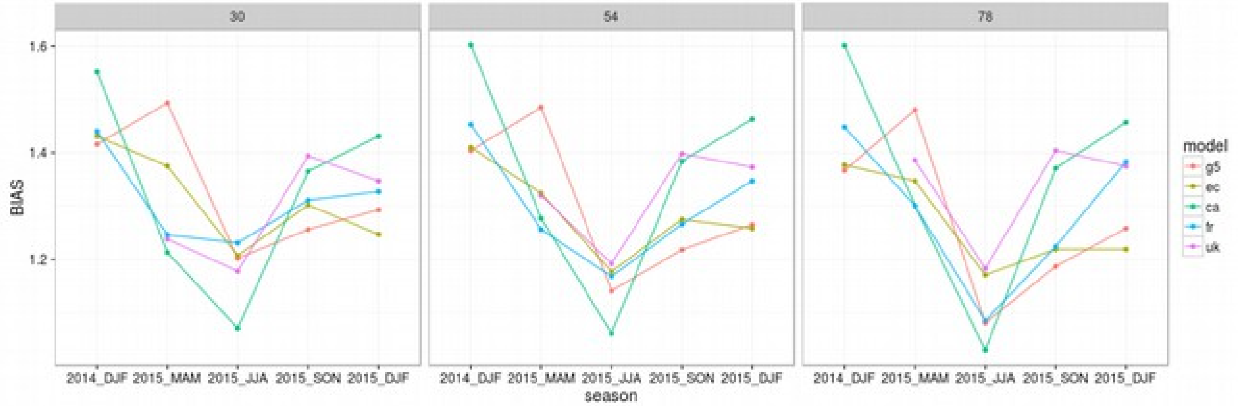
5 mm/24h

10 mm/24h



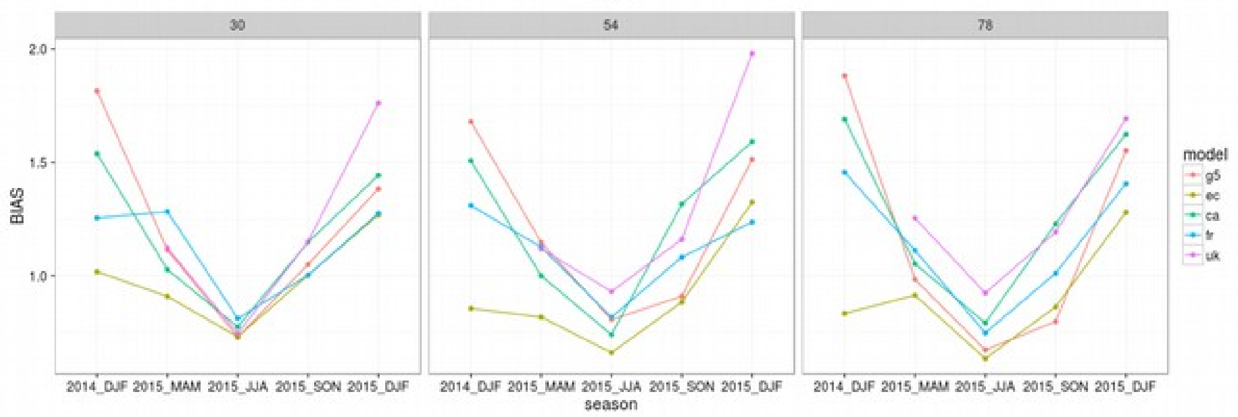
Freq. Bias (upscaling)
Scale: 9x9 GP

0.1 mm/24h



5 mm/24h

10 mm/24h



ECMWF

Tomas Haiden

Verification using SYNOP

Characteristics

- 24-h precipitation
  - Forecast days 1 to 10
  - Aggregation over large domains (extra-tropics, tropics, Europe)

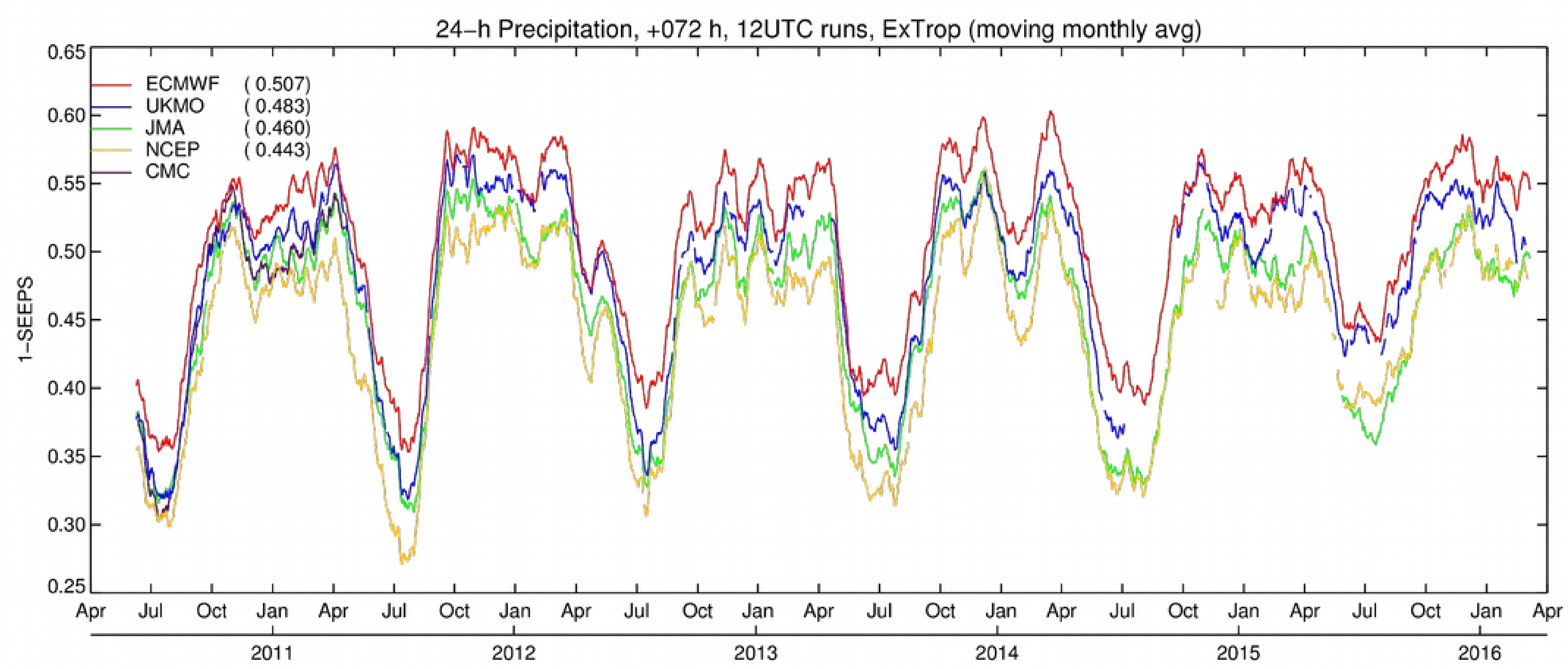
Verification of Deterministic Forecasts

- Symmetric Equitable Error in Probability Space (SEEPS)
- Equitable Threat Score (ETS)
- Frequency bias (FB)
- Symmetric Extremal Dependence Index (SEDI)

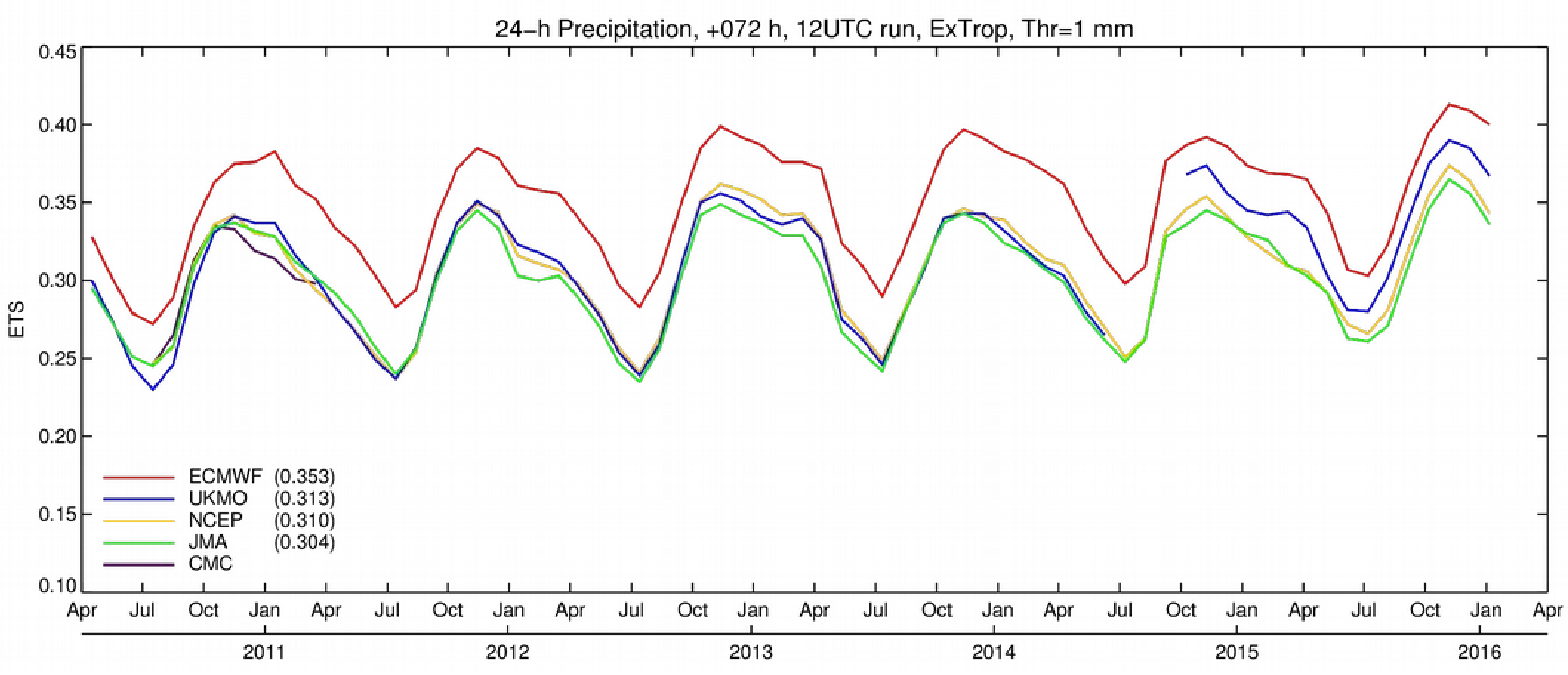
Verification of Ensemble Forecasts

- Continuous Rank Probability Skill Score (CRPSS)
  - Brier Skill Score (BSS)

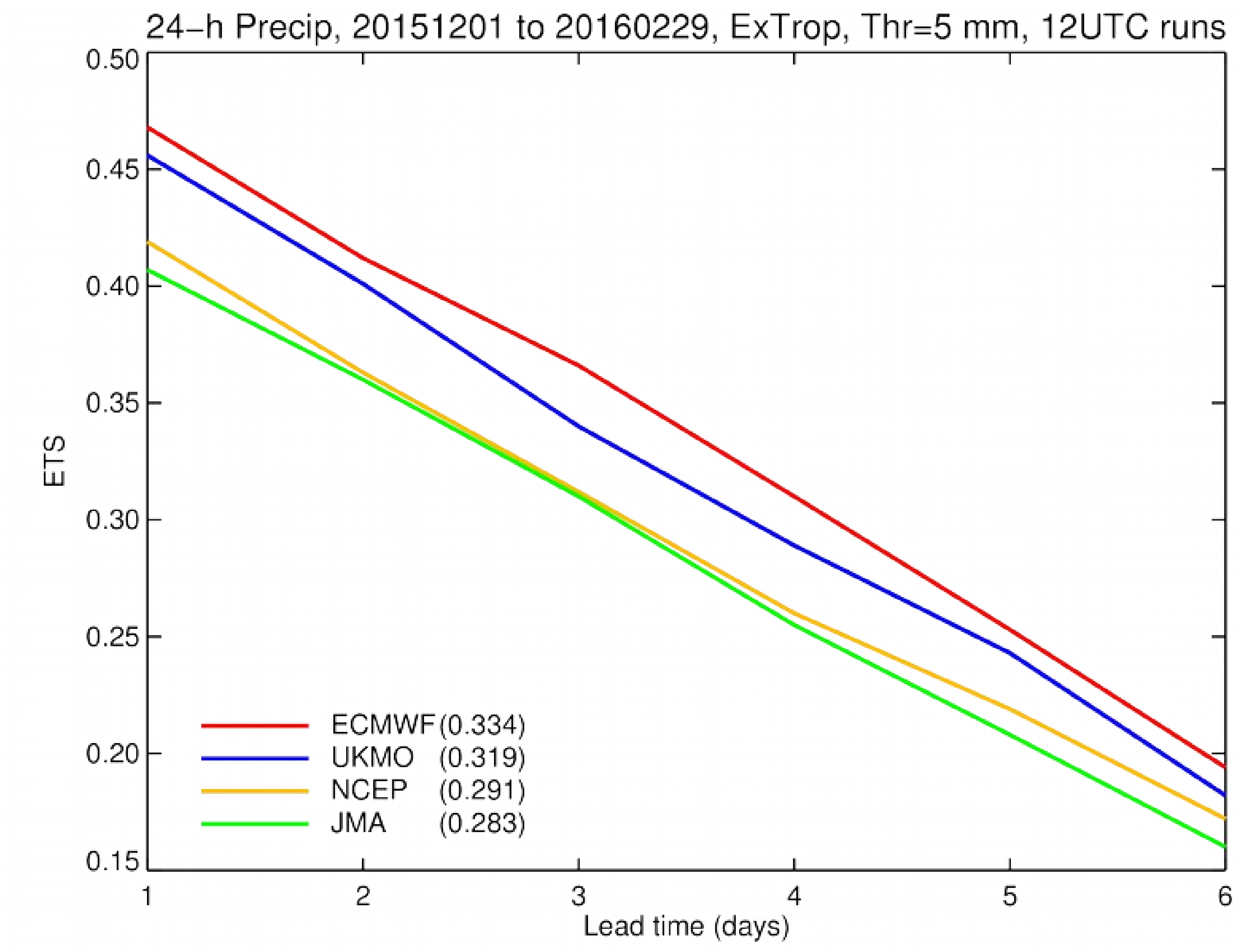
Model intercomparison – deterministic forecast



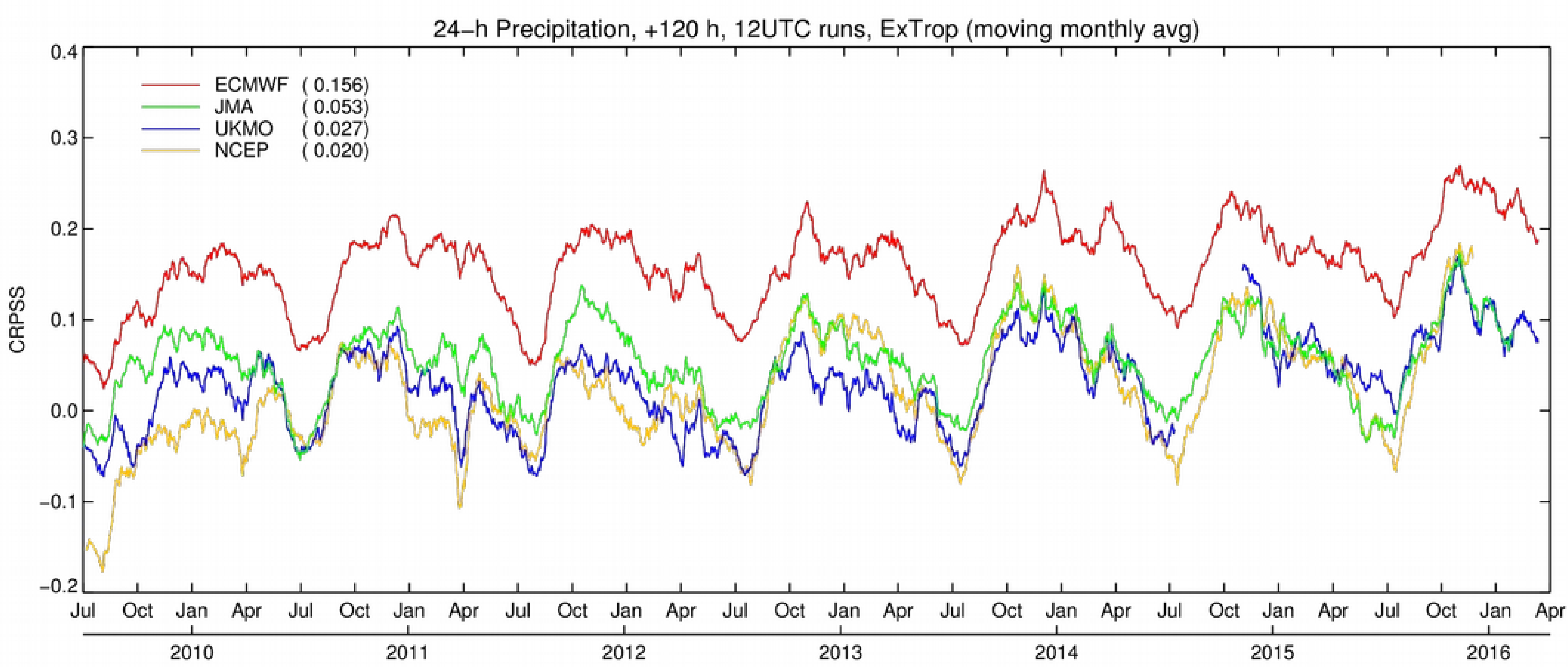
Model intercomparison – deterministic forecast



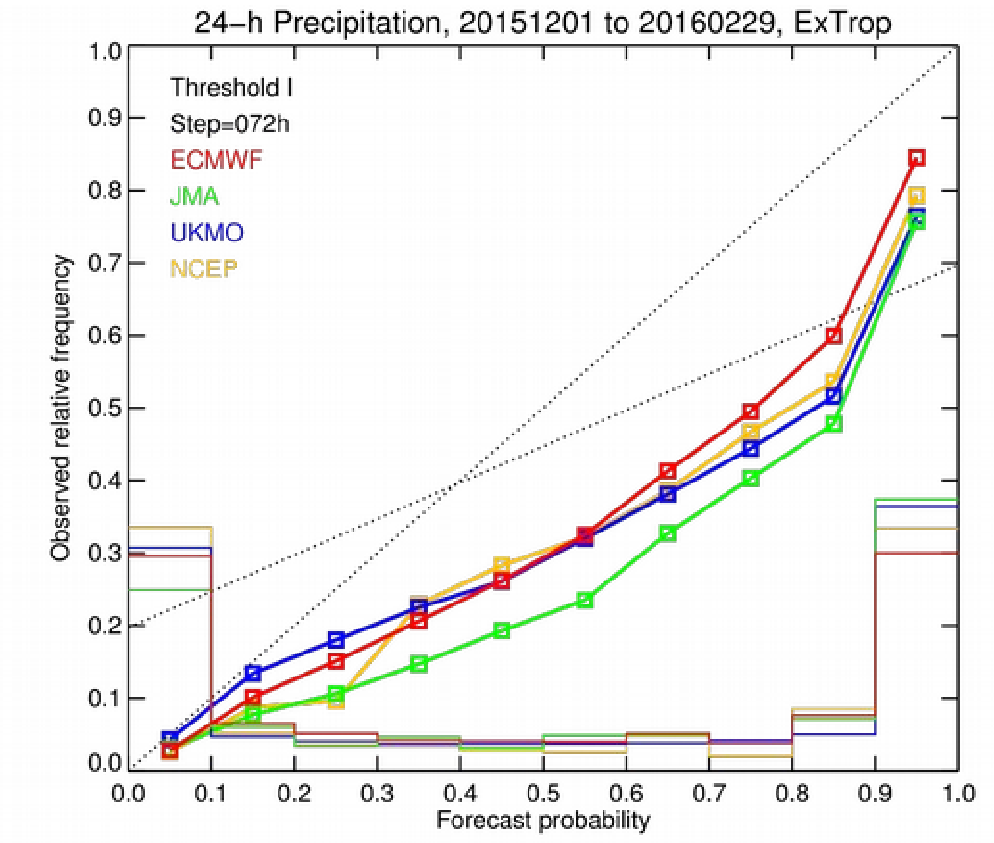
Model intercomparison – deterministic forecast



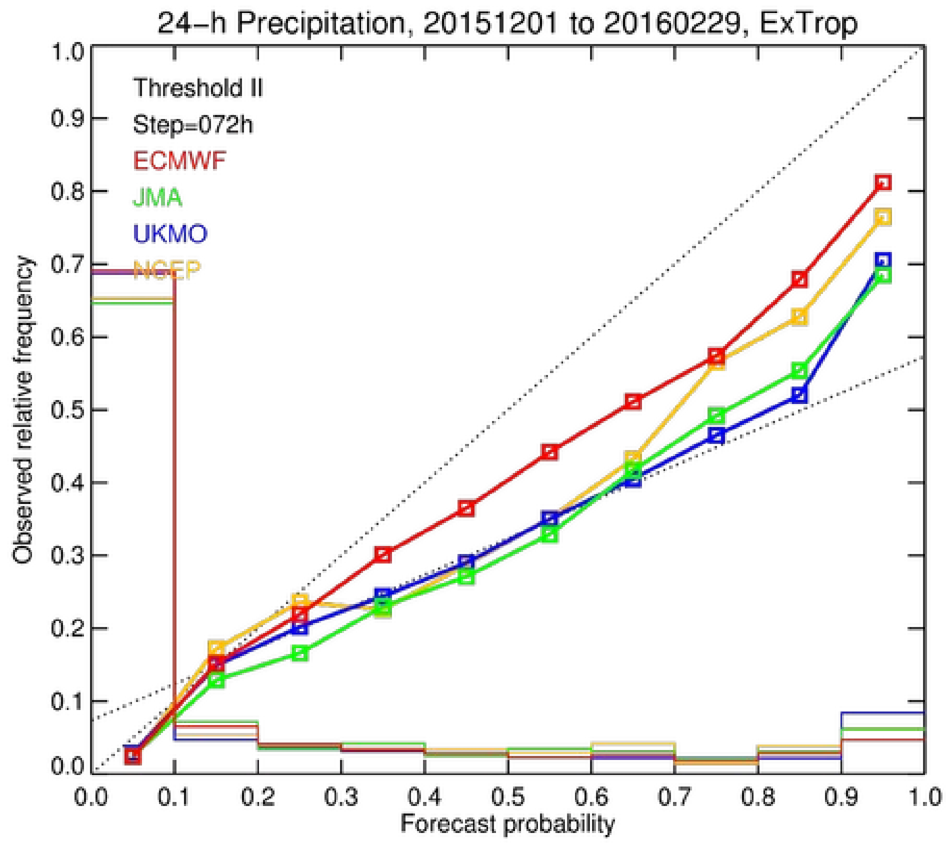
Model intercomparison – ensemble forecast



Model intercomparison – ensemble forecast



Light precipitation



Moderate-to-heavy precipitation

Verification using additional datasets

High Density observations (HDOBS)

- precipitation data from 15 ECMWF Member States
  - mix of hourly, 6-hourly, and daily reports
  - up to 16 months of data
  - HDOBS/SYNOP ratio of station numbers on average 3/1

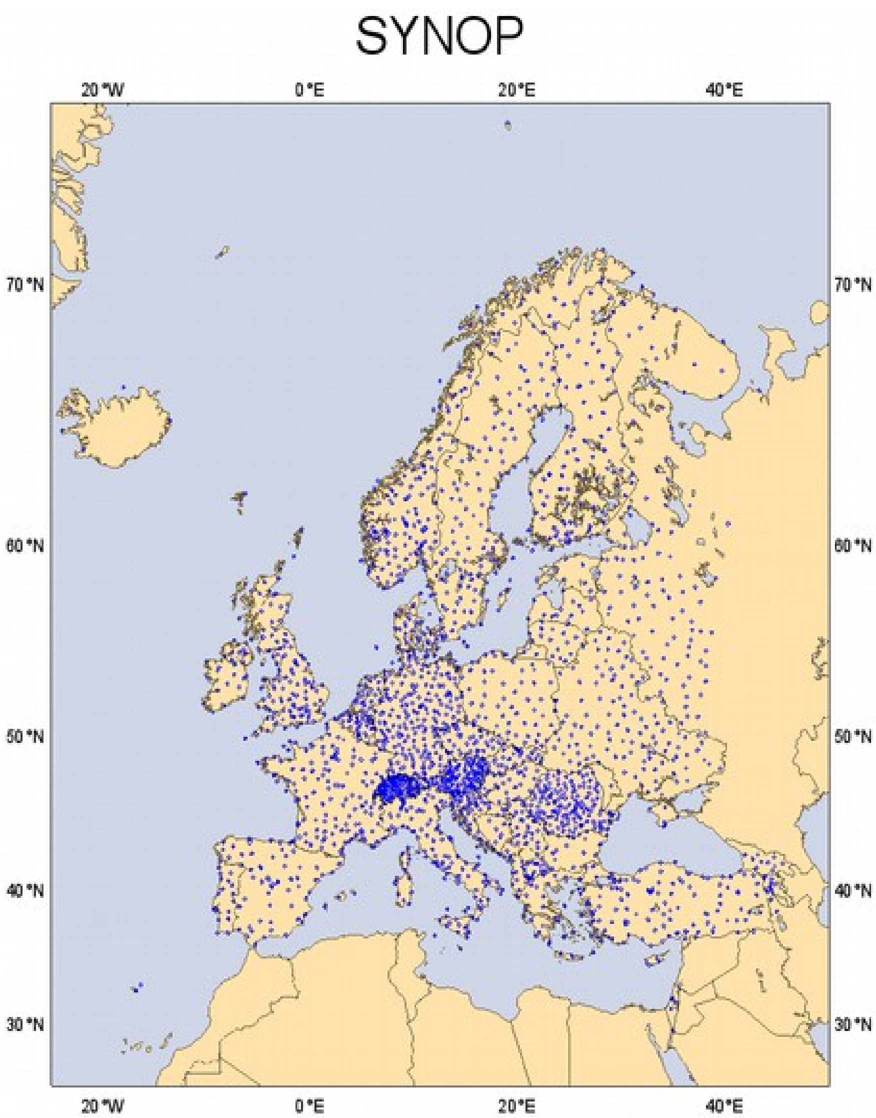
Verification of Deterministic Forecasts

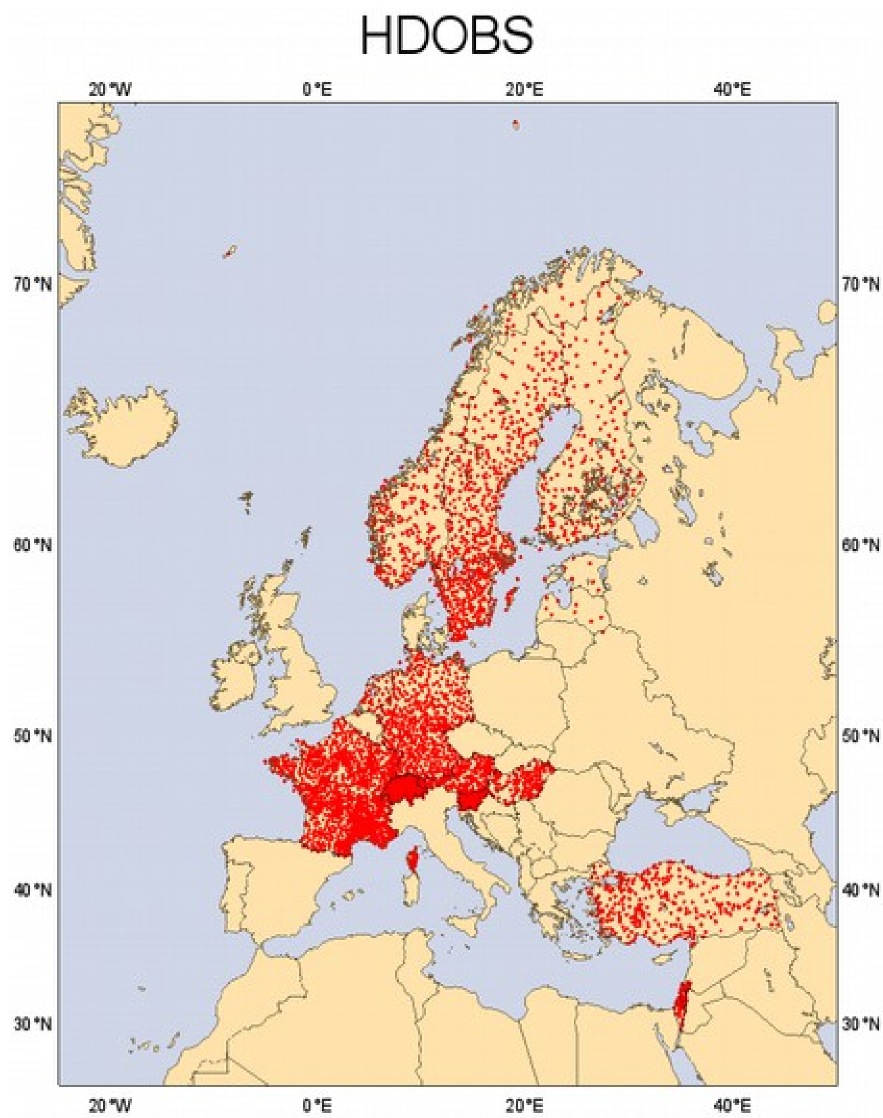
- Equitable Threat Score (ETS)
- Symmetric Extremal Dependence Index (SEDI)

Verification of Ensemble Forecasts

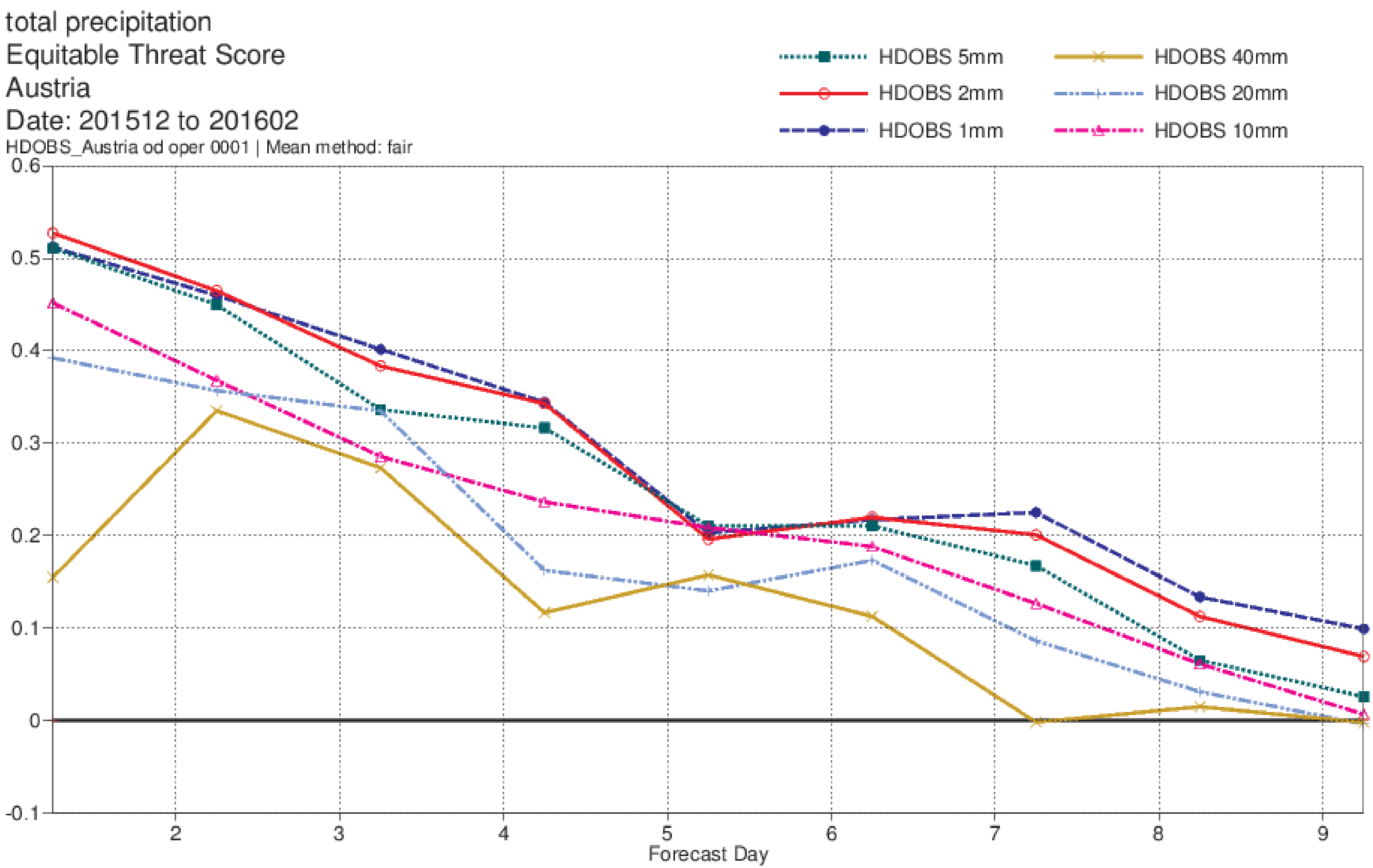
- Continuous Rank Probability Score (CRPS)
  - Brier Score (BS)

Surface Observations – Daily Precip to 06Z

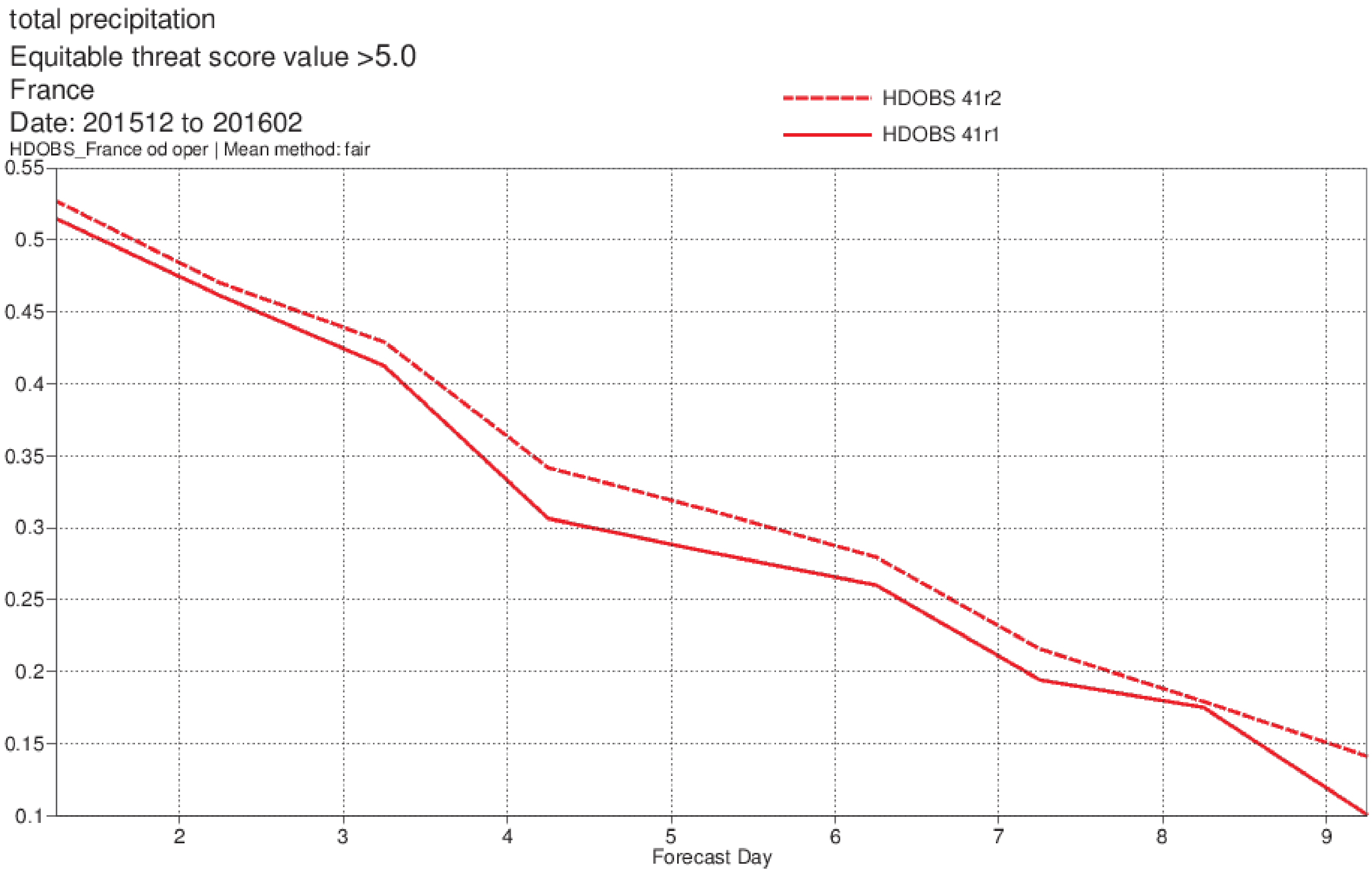




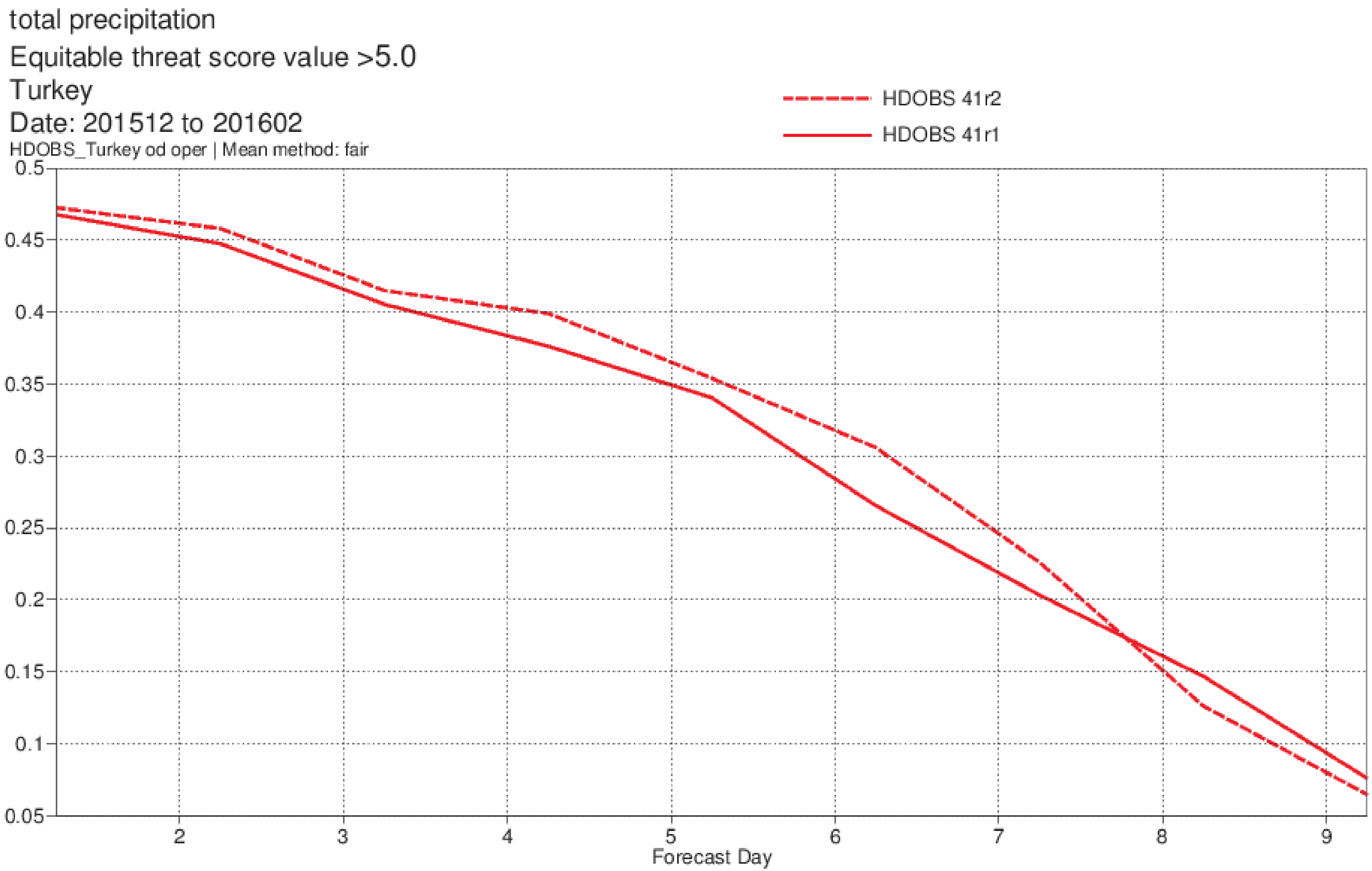
HDOBS ETS for Austria in DJF 2015/16



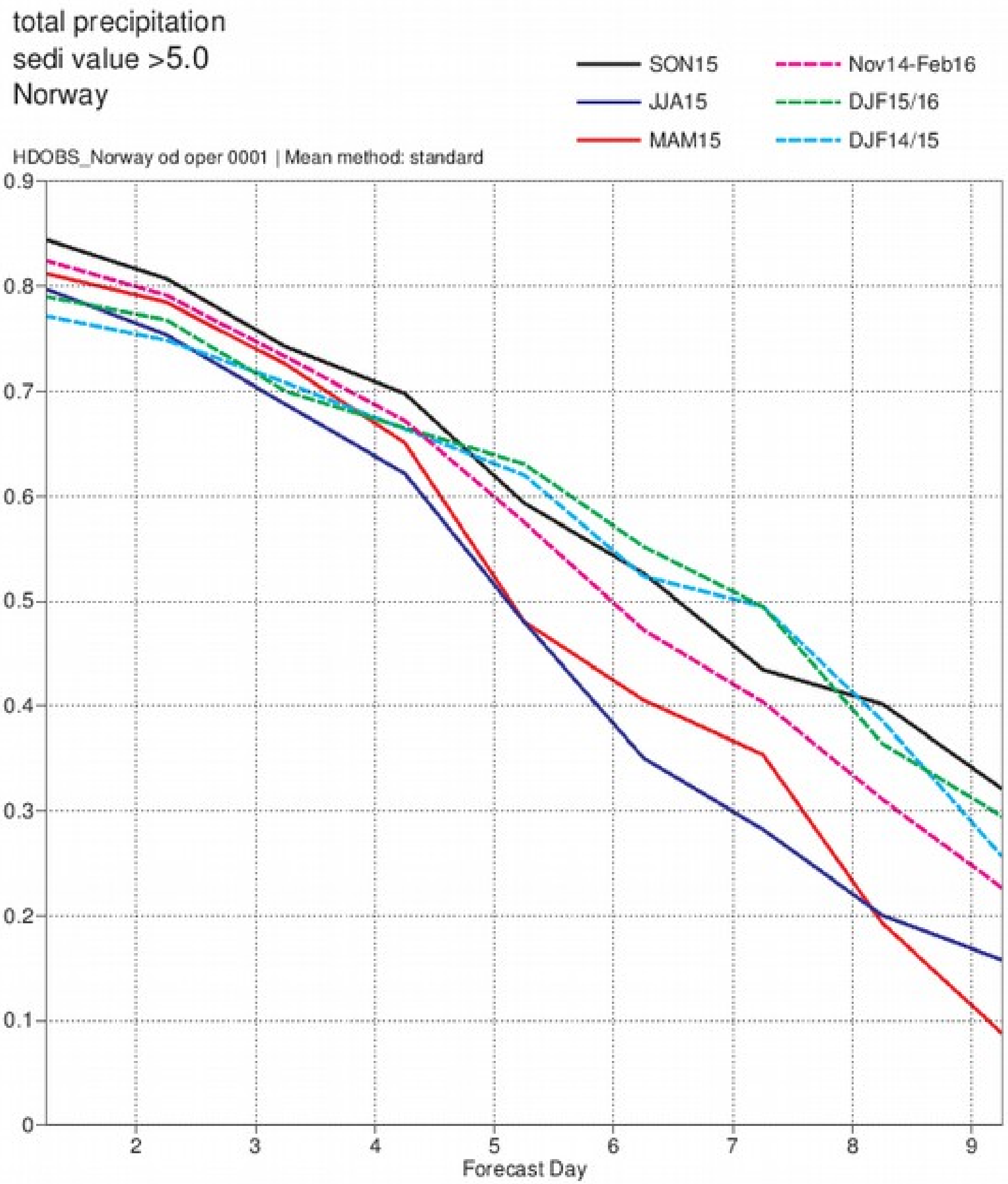
HDOBS 41r1-v-41r2 for France, DJF 2015/16

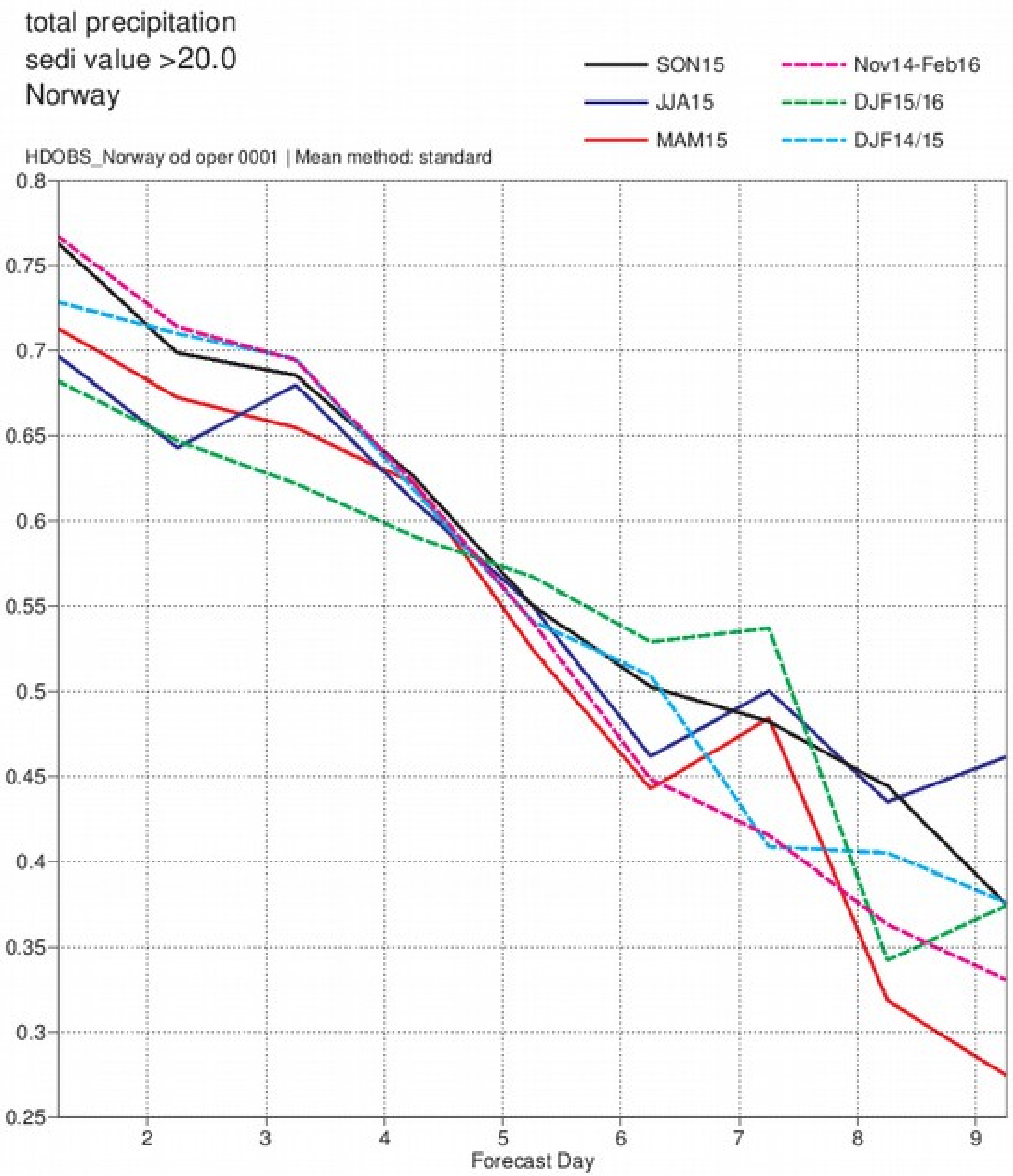


HDOBS 41r1-v-41r2 for Turkey, DJF 2015/16



HDOBS – Seasonality for Norway





WGNE QPF Verifications over Japan Dec 2014–Nov 2015

JMA

WGNE-31

Data and Verification Method

Verification grid

80 km×80 km

Converting method

Simple average or interpolation

Reference data (Observations)

Amount of precipitation observed by rain gauges

Verified data (QPFs data)

See next slide

Error bars

Estimated by bootstrap method
with 95% confidence intervals

Verification method

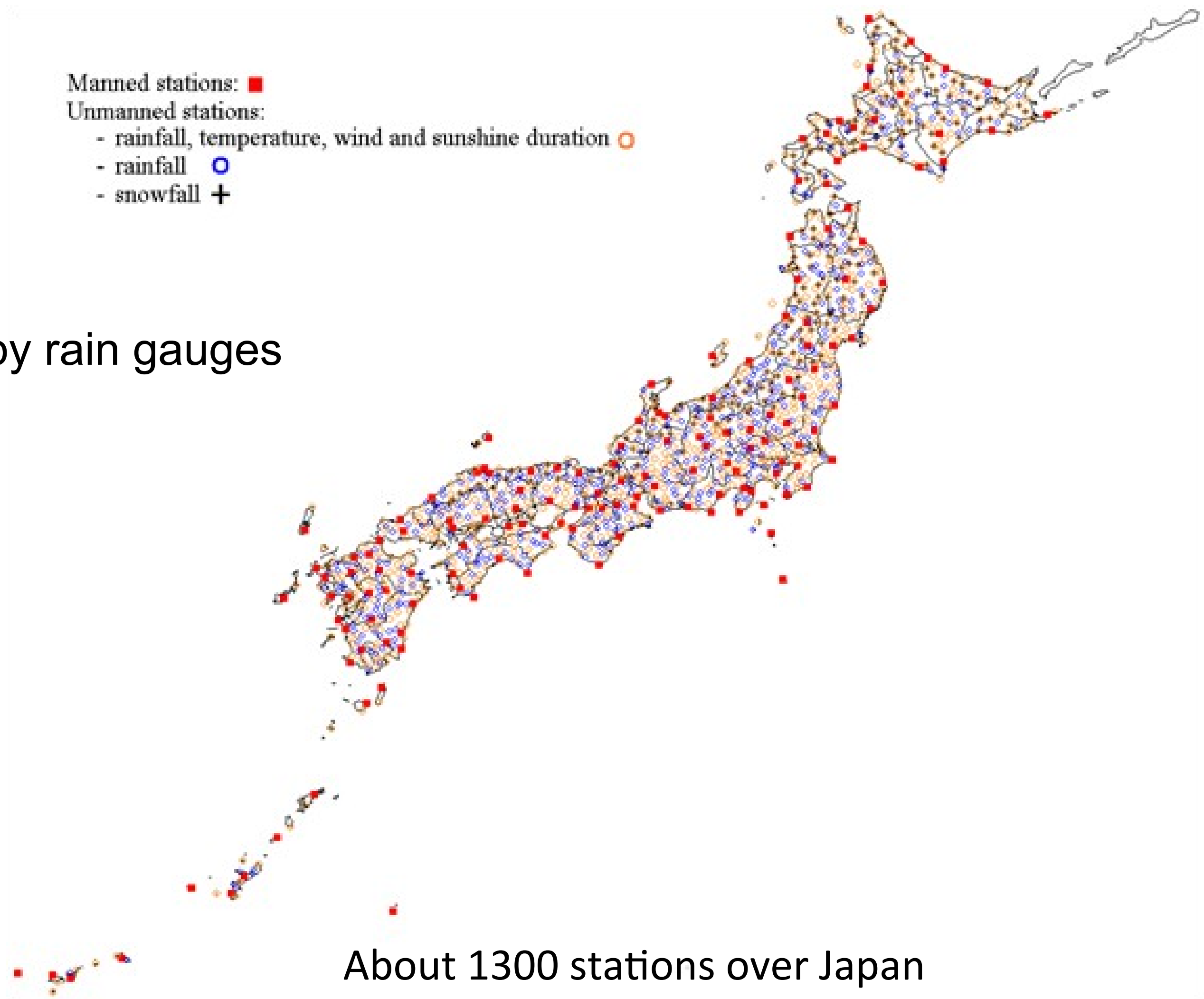
Equitable Thread Score (ETS)

Extremal Dependency Index (EDI)

Bias Score (BI, Optional)

Hit Rate (HR, Optional)

False Alarm Rate (FAR, Optional)



About 1300 stations over Japan

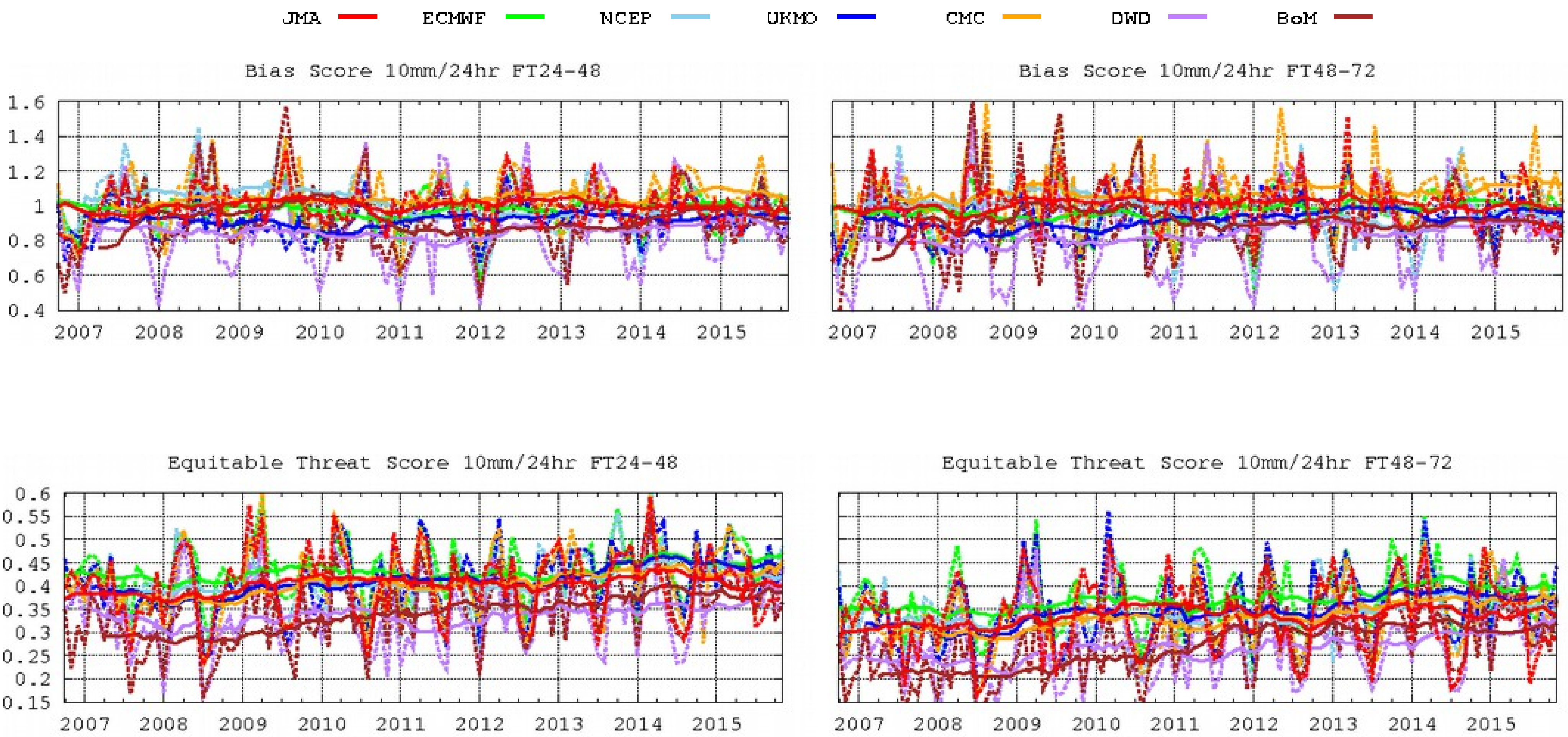
Average distance (among stations): ~17 km

Verification with 80 km×80 km grid

NWP Center	horizontal resolution of verified data (degree)	forecast time (hour)	converting method in 80 km verification
BoM	0.5625 × 0.375	6, 12, ..., 144	average
CMC	1.00×1.00	6, 12, ..., 120	interpolation
DWD	0.25×0.25	6, 12, ..., 174	average
ECMWF	0.50×0.50	6, 12, ..., 72	average
NCEP	1.00×1.00 (*1) 0.50×0.50	6, 12, ..., 84	interpolation average
UKMO	0.234×0.156	6, 12, ..., 96	average
JMA	0.25×0.25 (GSM[*2]) 5 km×5 km (MSM[*3])	6, 12, ..., 84 3, 6, ..., 39	average average
Observation	Corresponding to 17 km×17 km	–	average

(*1) before 2015/01/14
(*2) global model
(*3) regional model

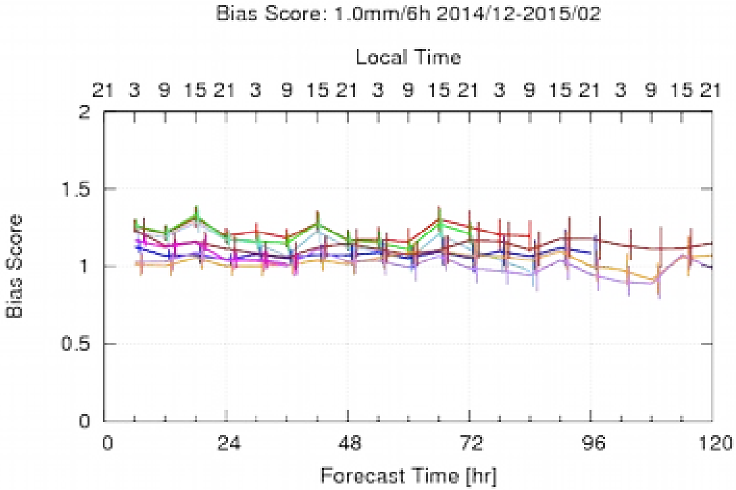
Time series from late 2006

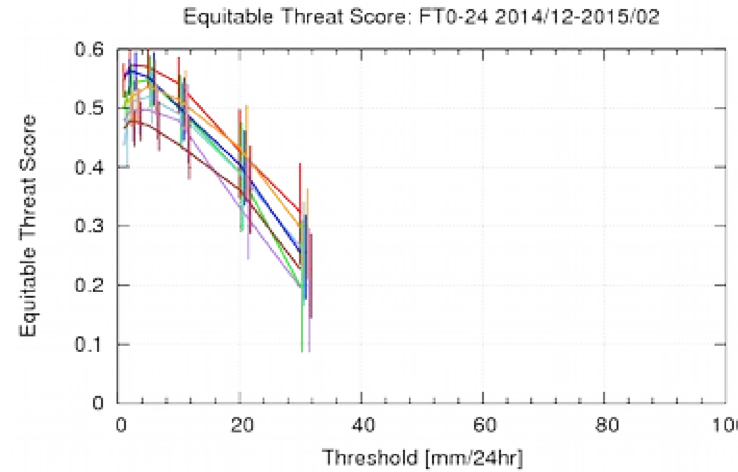


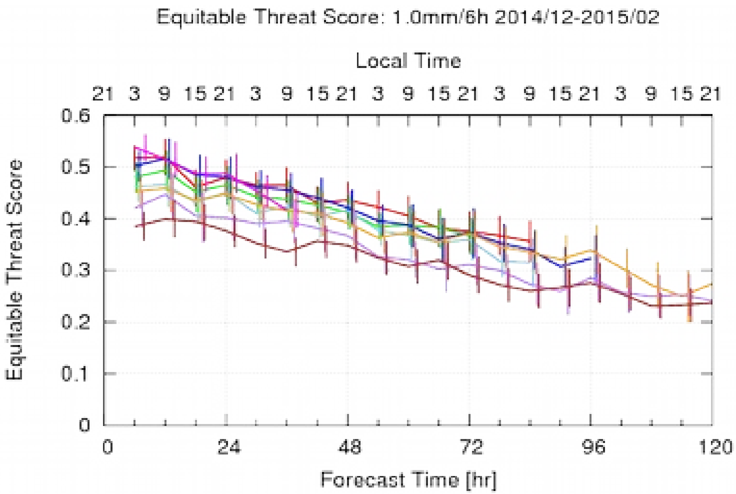
○ETS of DWD increases in 2015.

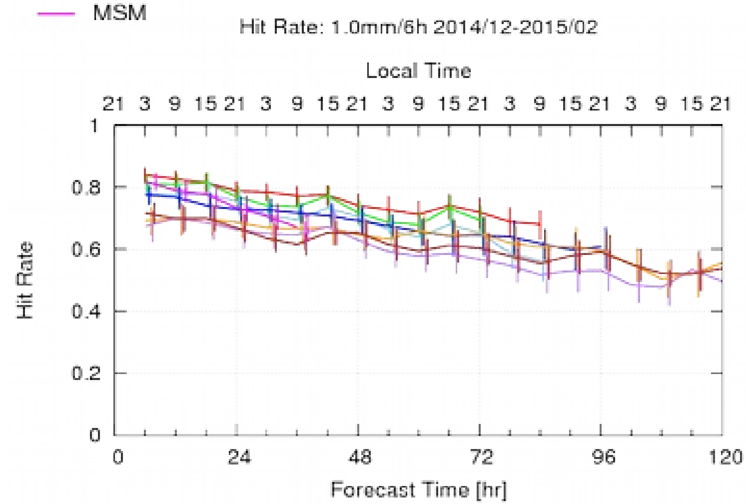
NOTE: Solid lines represent moving-average (12 months).

2014DJF

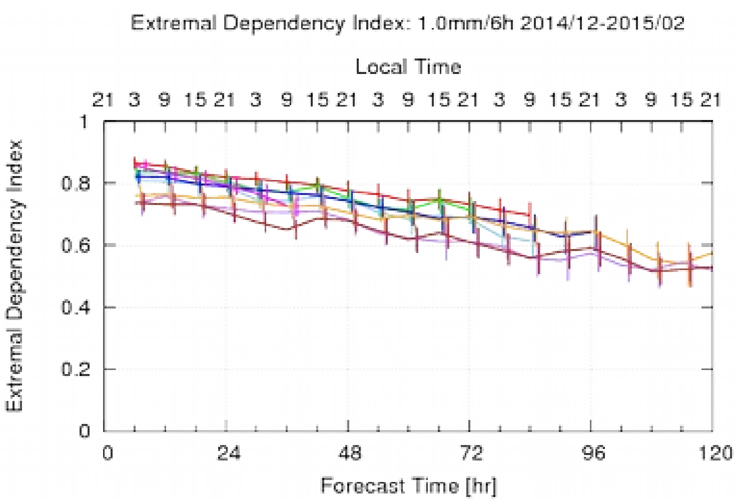


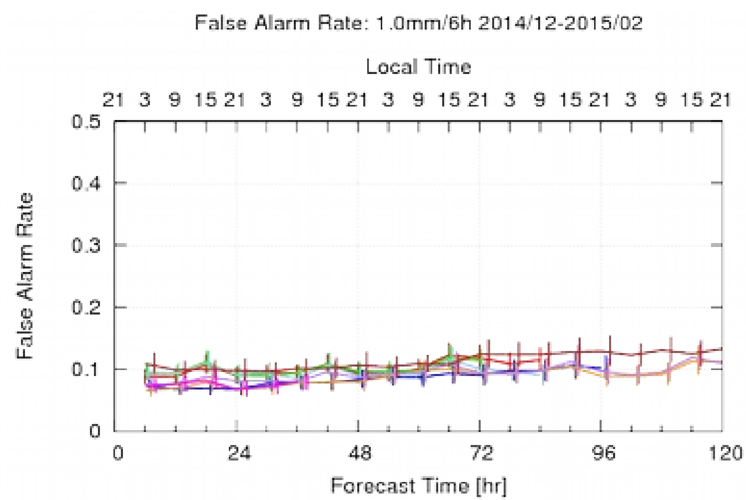




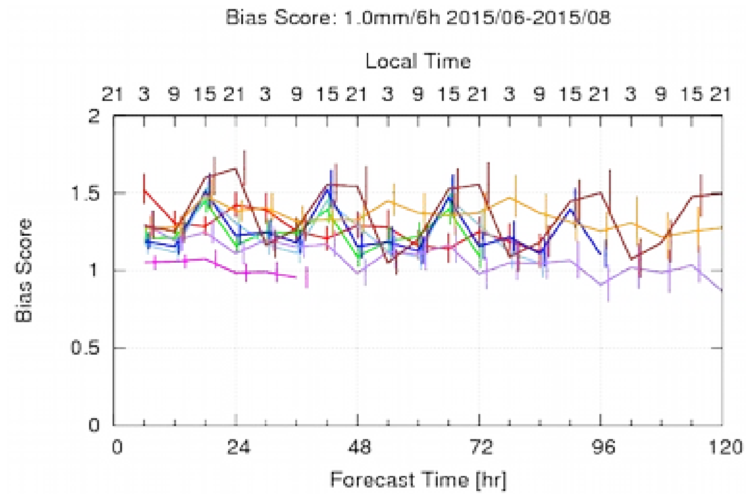


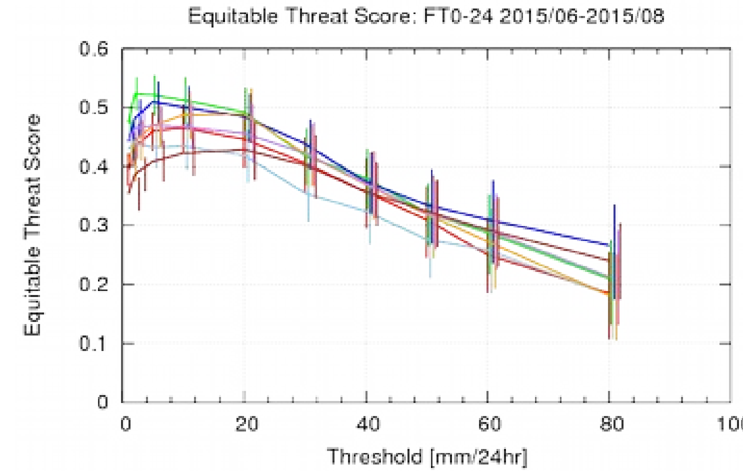
- ○At 1mm/6hr threshold, JMA performs better in ETS, EDI, and HR, but has large BI and FAR.
- ○ECMWF performs better in ETS at low thresholds.
- ○CMC performs better in ETS at high threshold.



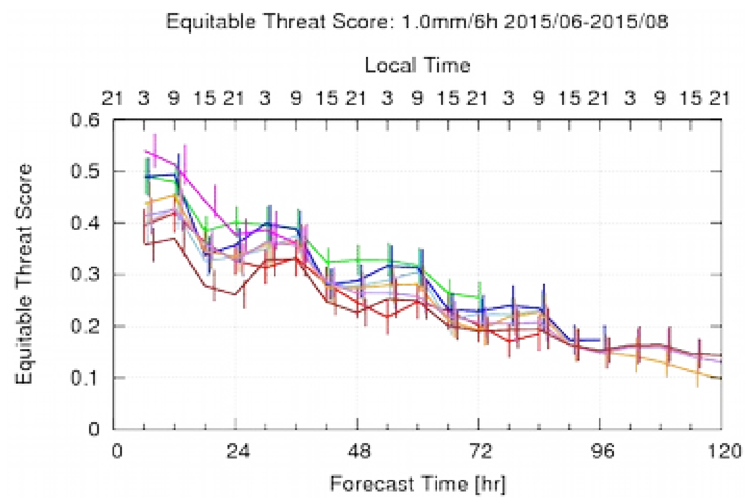


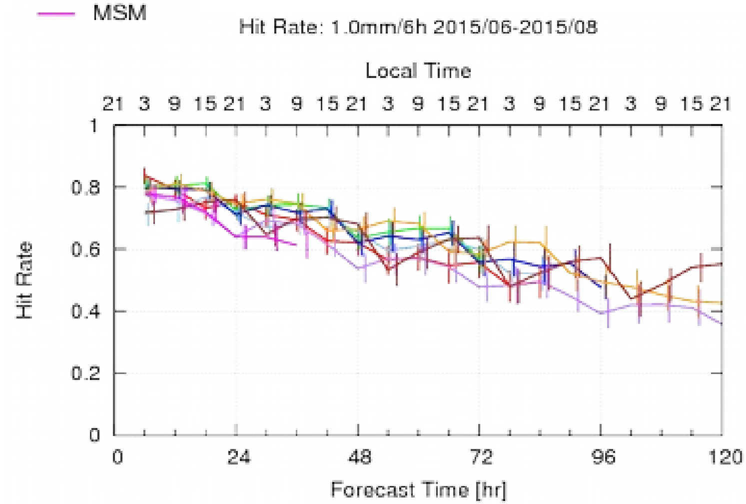
2015JJA

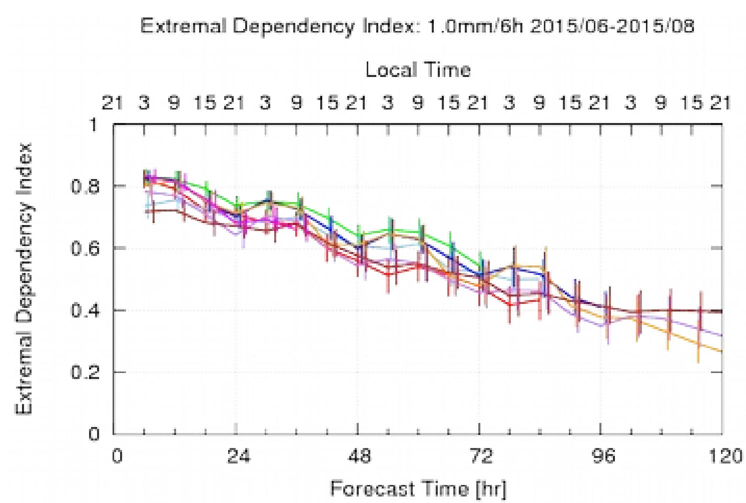


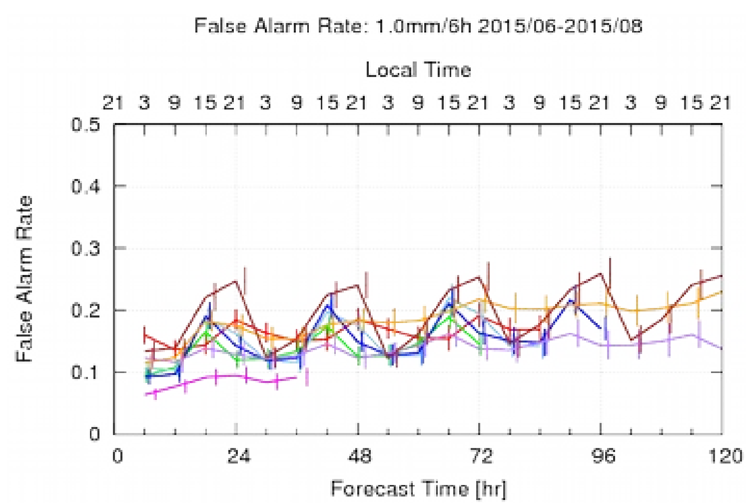


- JMA
- ECMWF
- NCEP
- UKMO
- CMC
- DWD
- BoM
- MSM









- ○In BI, diurnal cycle is seen in many centers (large BI at 15 local time).
- ○At 1 mm/6hr threshold, MSM performs quite better in BI.
- ○ECMWF performs better in ETS at thresholds below 50 mm/24hr.
- ○UKMO performs better in ETS at any thresholds.

Backup Slides

Data and Verification Method

Verification grid

80 km×80 km

Converting method

Simple average or interpolation

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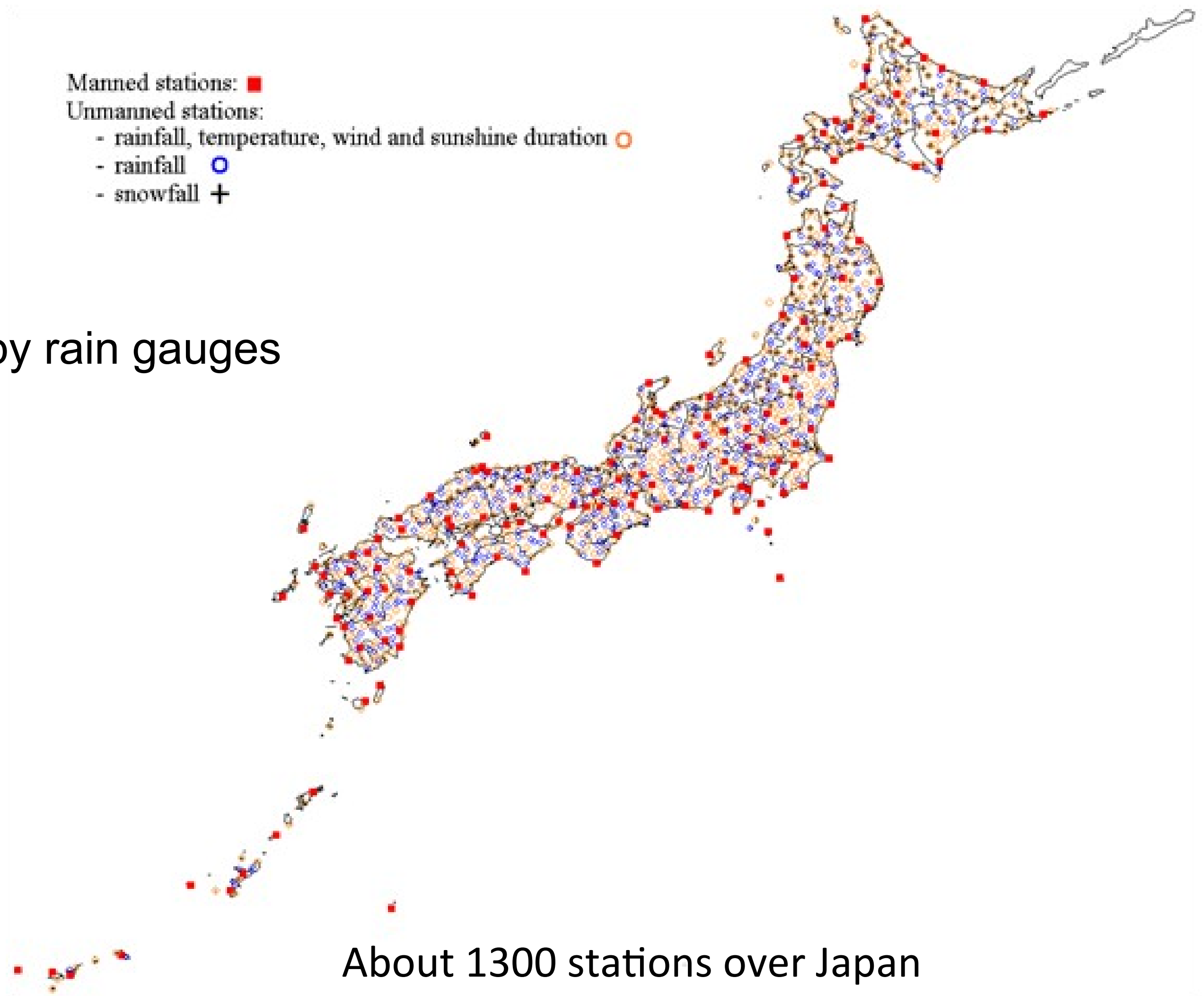
Bias Score (BI, Optional)
Hit Rate (HR, Optional)
False Alarm Rate (FAR, Optional)



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(*1) before 2015/01/14
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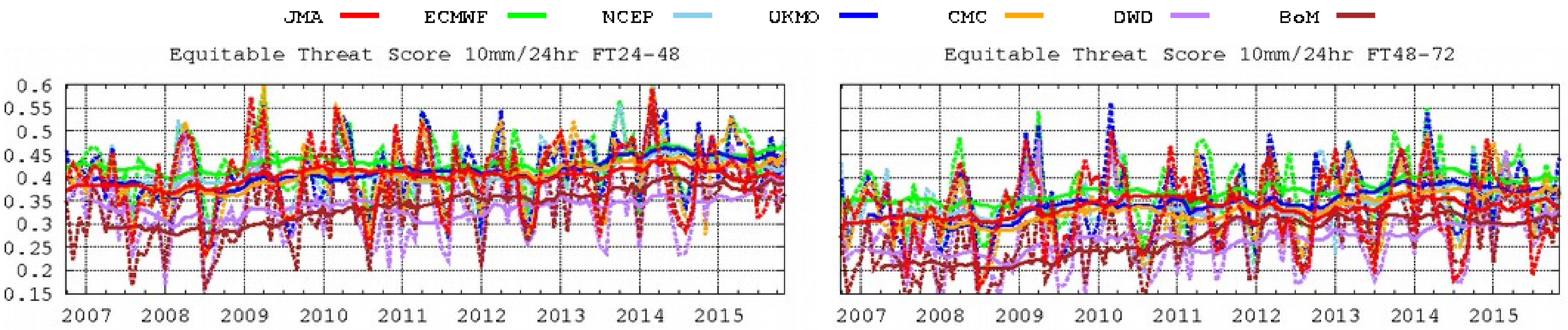
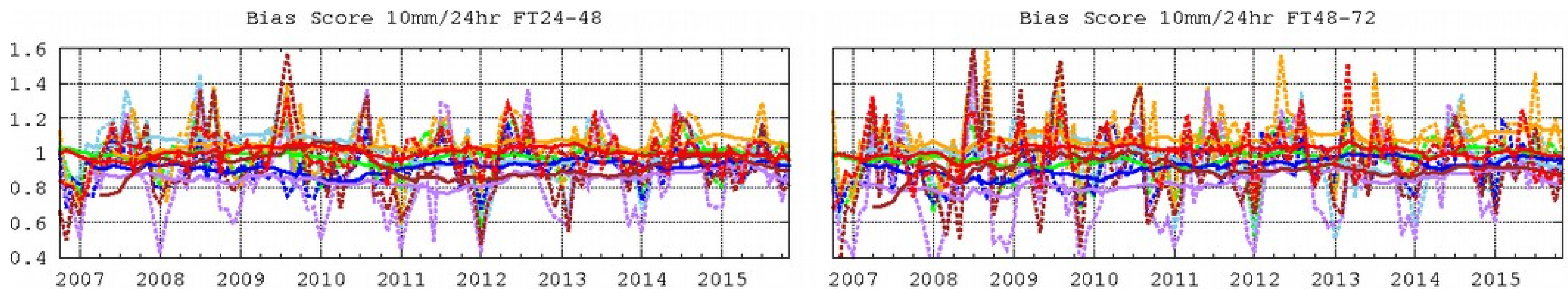
(*3) regional model



○ETS of DWD increases in 2015.
○ETS of JMA in 2015 is worse than that in 2014.



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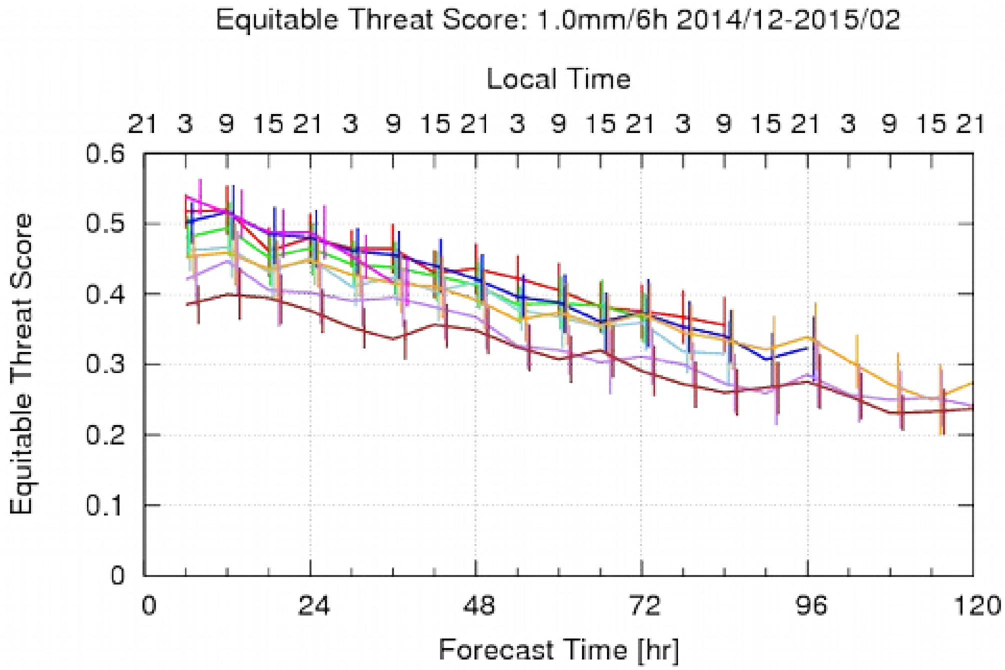
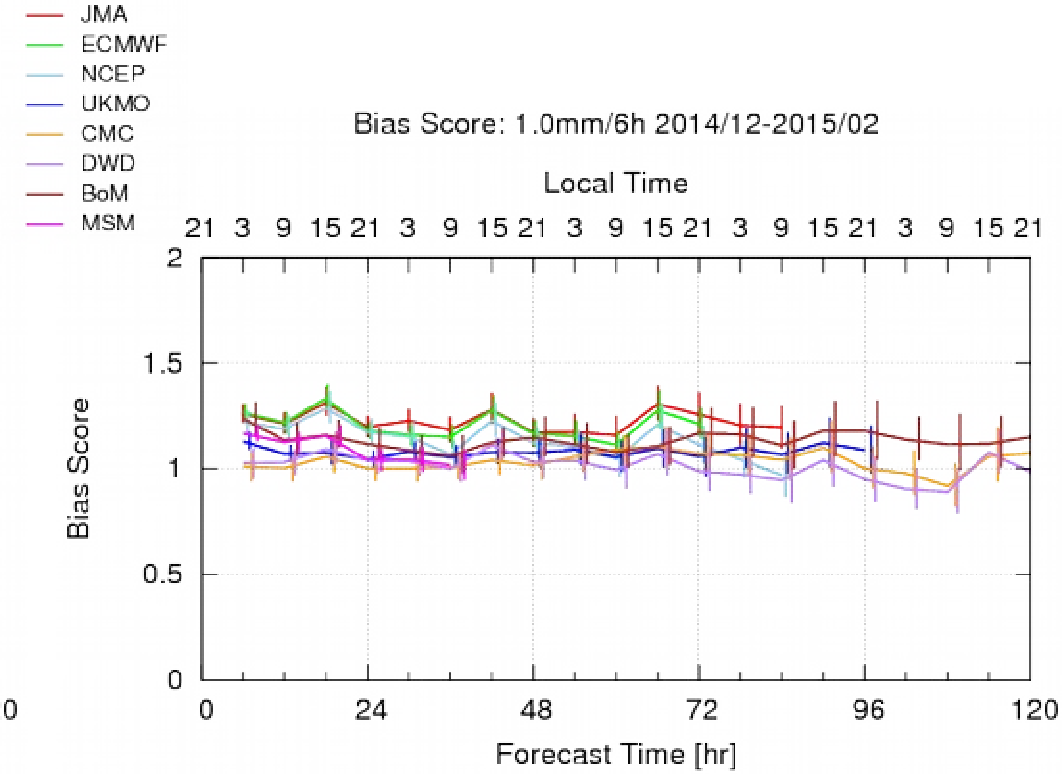
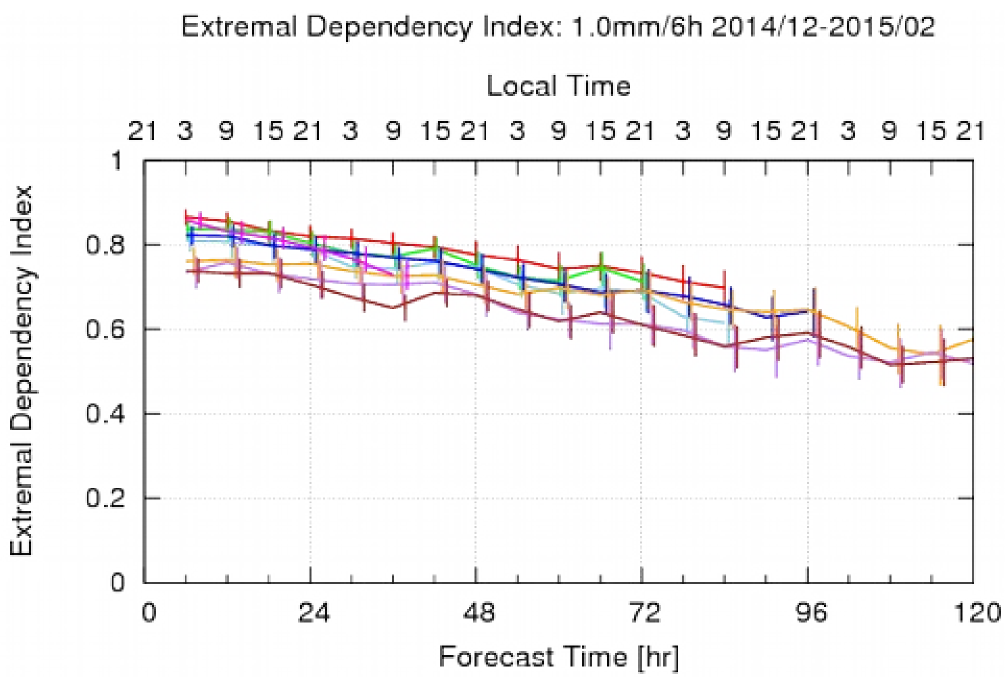
2014DJF

2014DJF: 1 mm/6hr

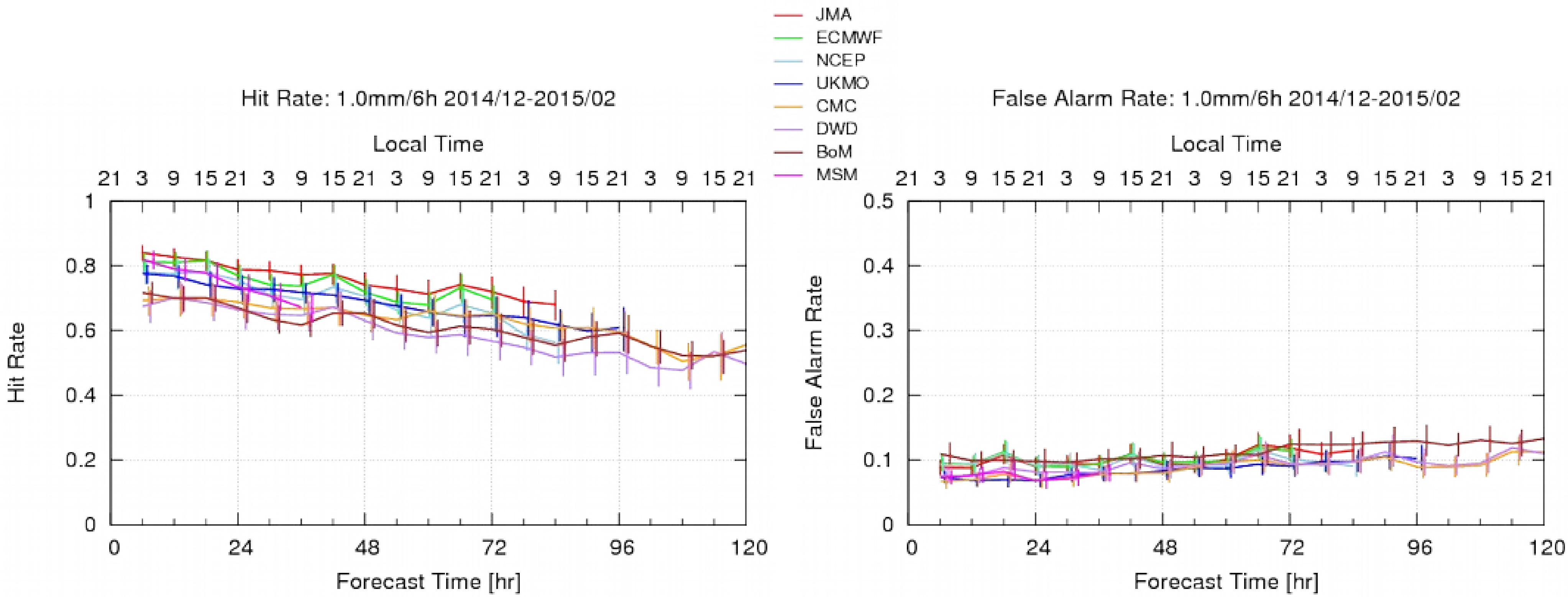






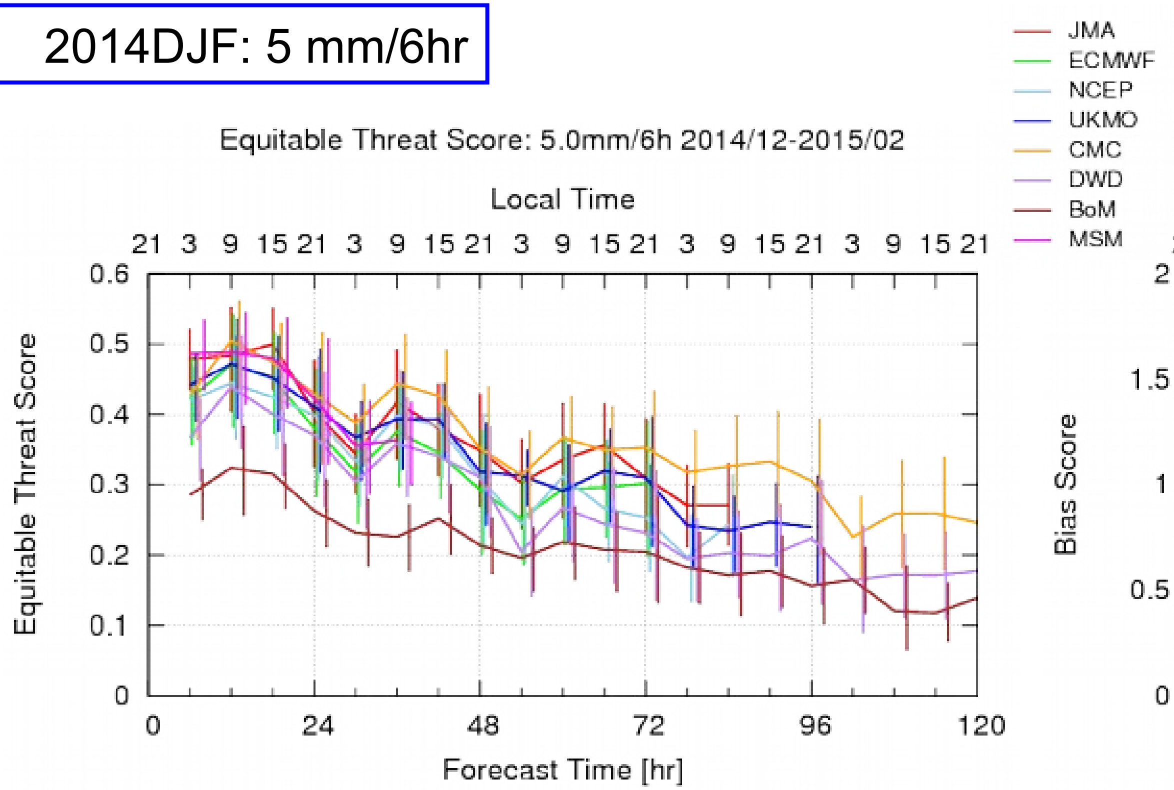
○JMA performs better in ETS and EDI,
but has large BI.

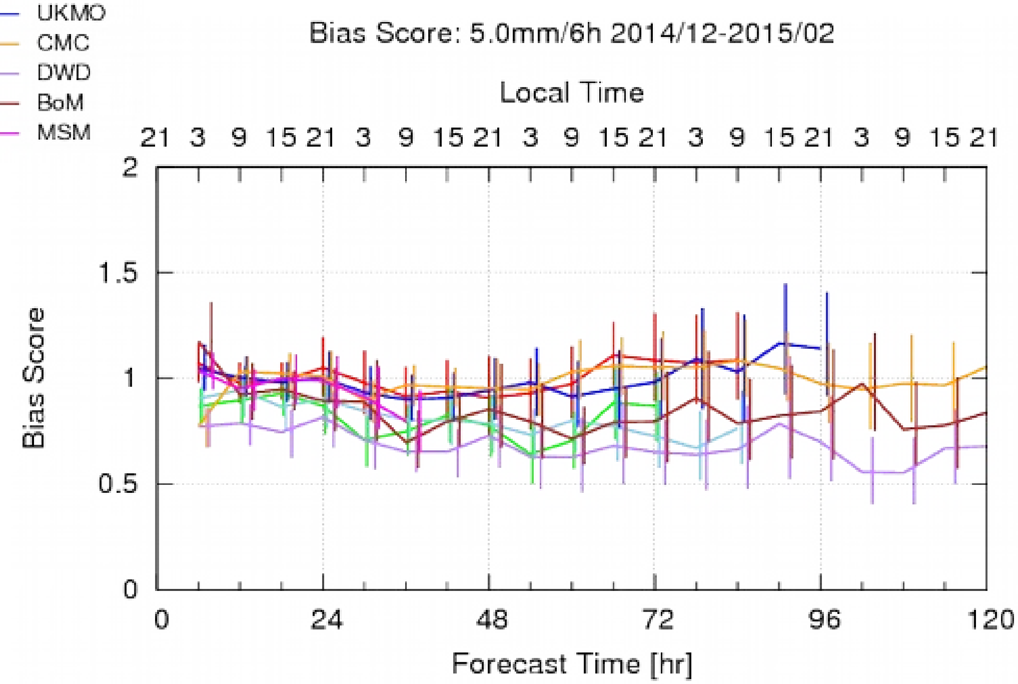
NOTE: Error bars are shifted slightly for clarification.

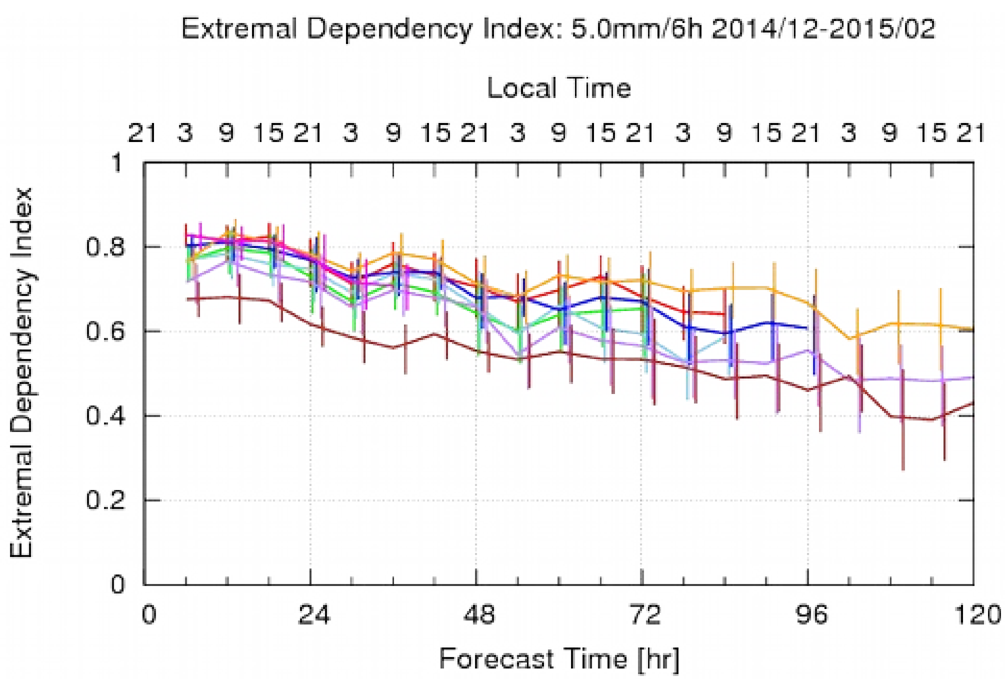


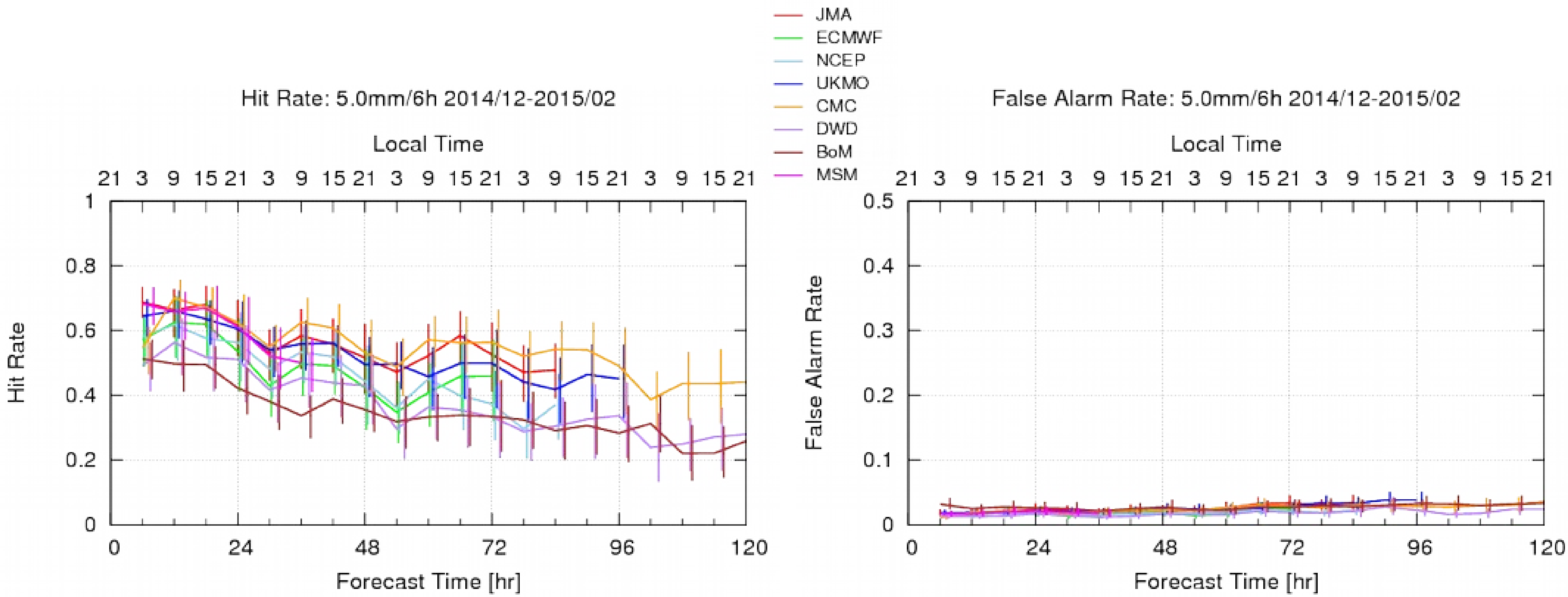
○JMA performs better in HR, but has rather large FAR.

2014DJF: 5 mm/6hr

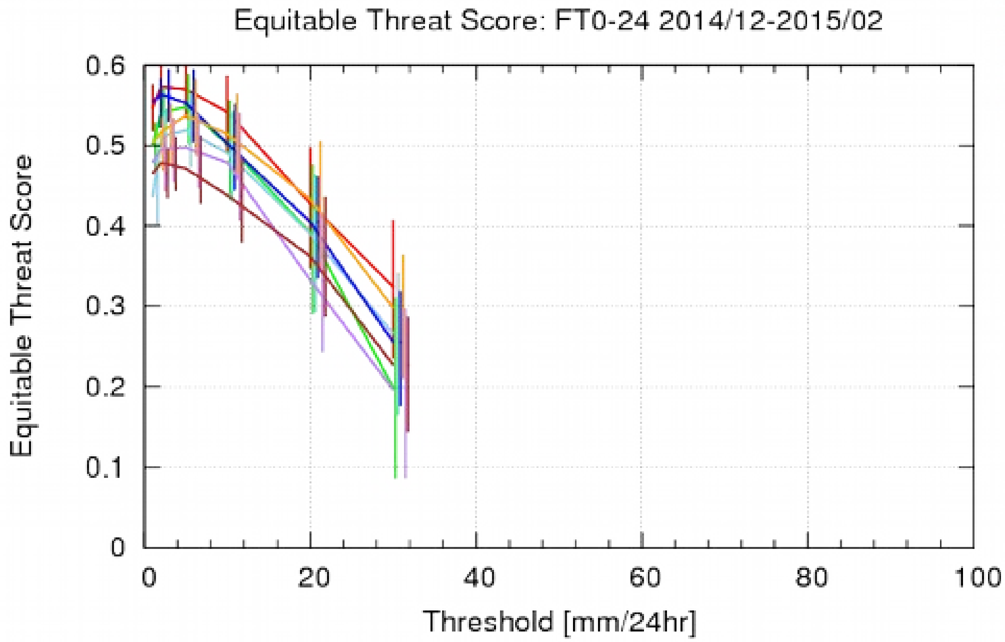


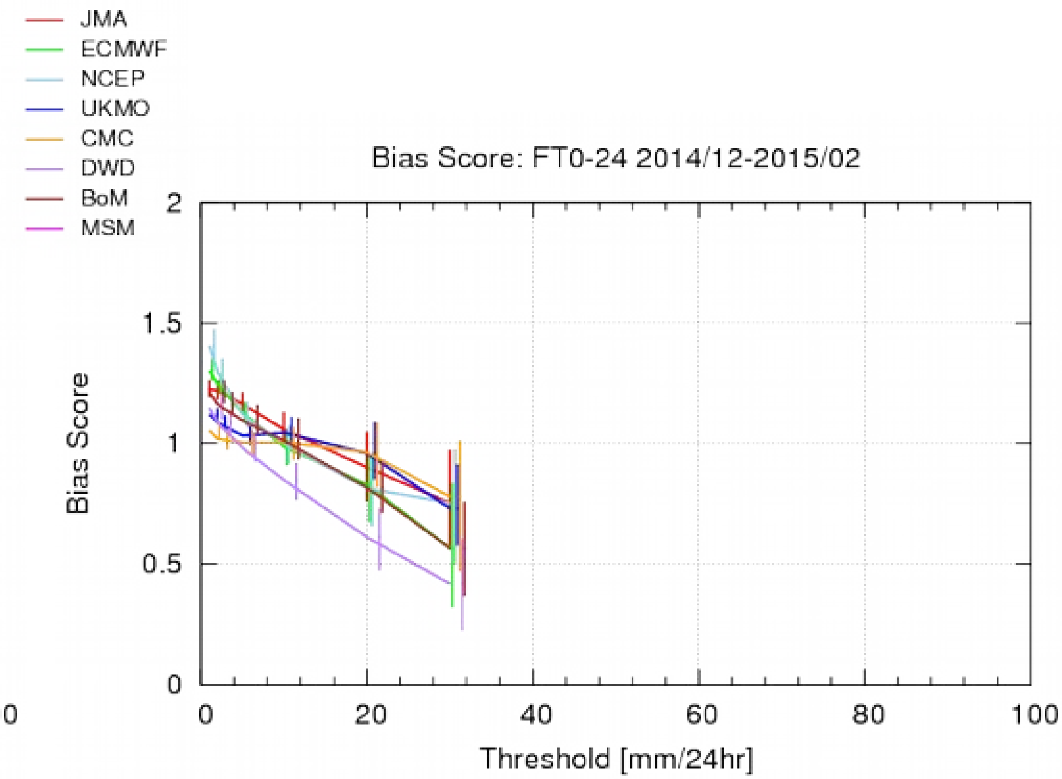


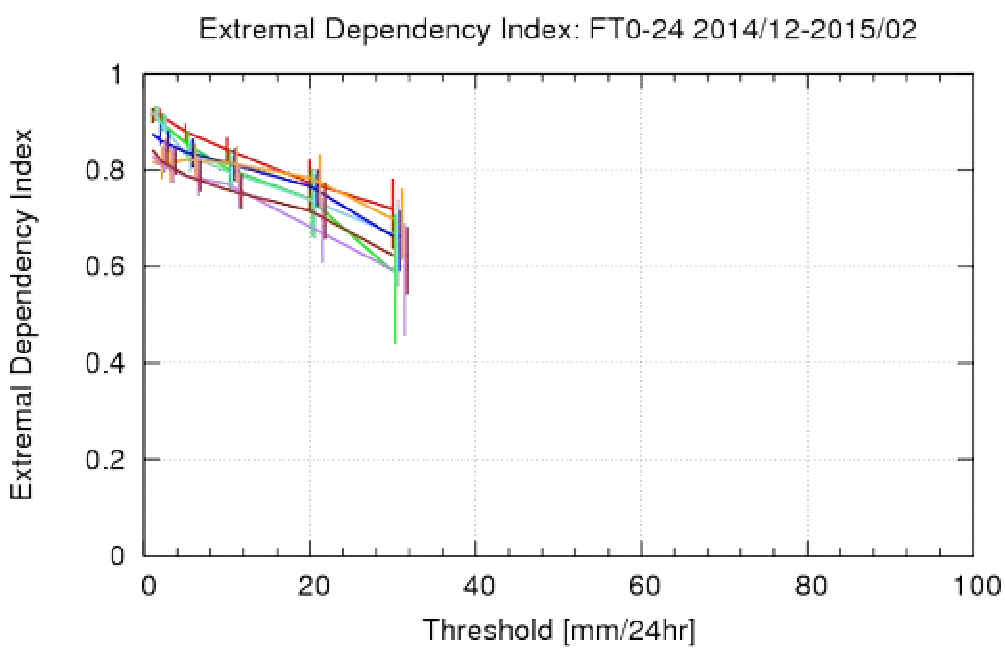



JMA
ECMWF
NCEP
UKMO
CMC
DWD
BoM
MSM
Hit Rate: 5.0mm/6h 2014/12-2015/02
Local Time
21 3 9 15 21 3 9 15 21 3 9 15 21 3 9 15 21 3 9 15 21
Hit Rate
0 0.2 0.4 0.6 0.8 1
0 24 48 72 96 120
Forecast Time [hr]
False Alarm Rate: 5.0mm/6h 2014/12-2015/02
Local Time
21 3 9 15 21 3 9 15 21 3 9 15 21 3 9 15 21 3 9 15 21
False Alarm Rate
0 0.1 0.2 0.3 0.4 0.5
0 24 48 72 96 120
Forecast Time [hr]

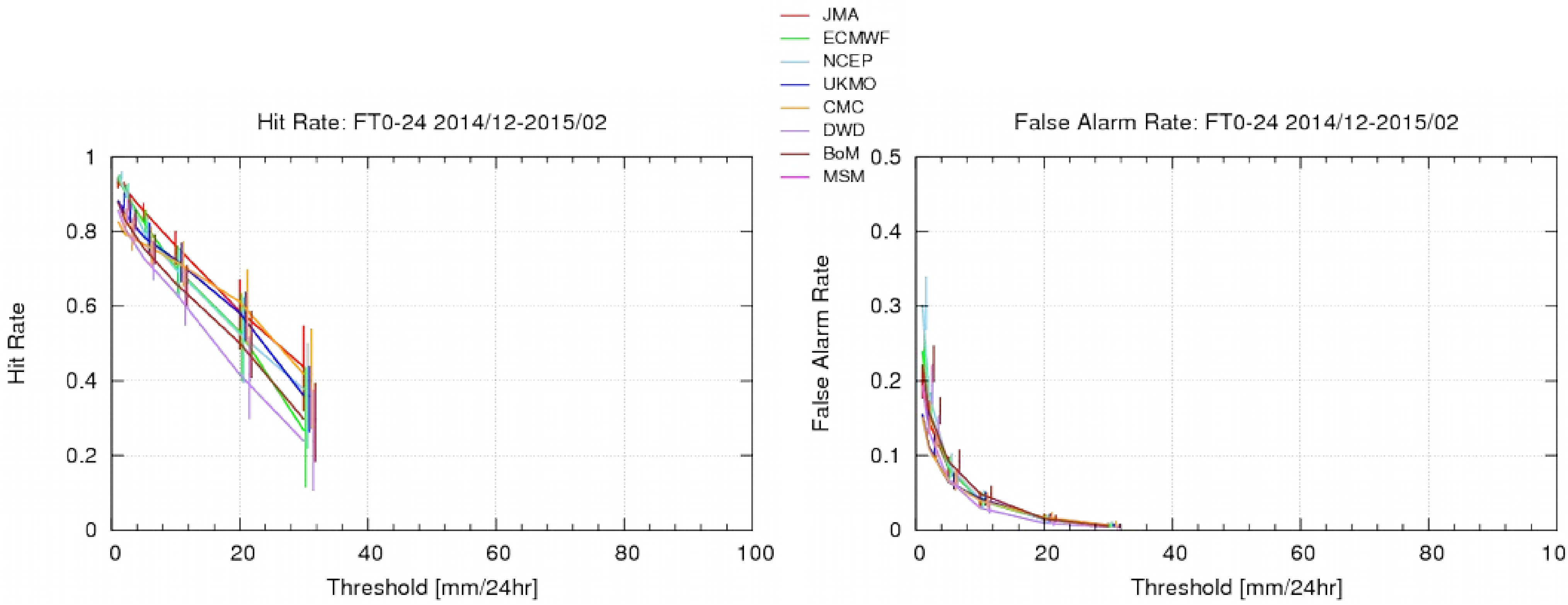
2014DJF: FT=0-24





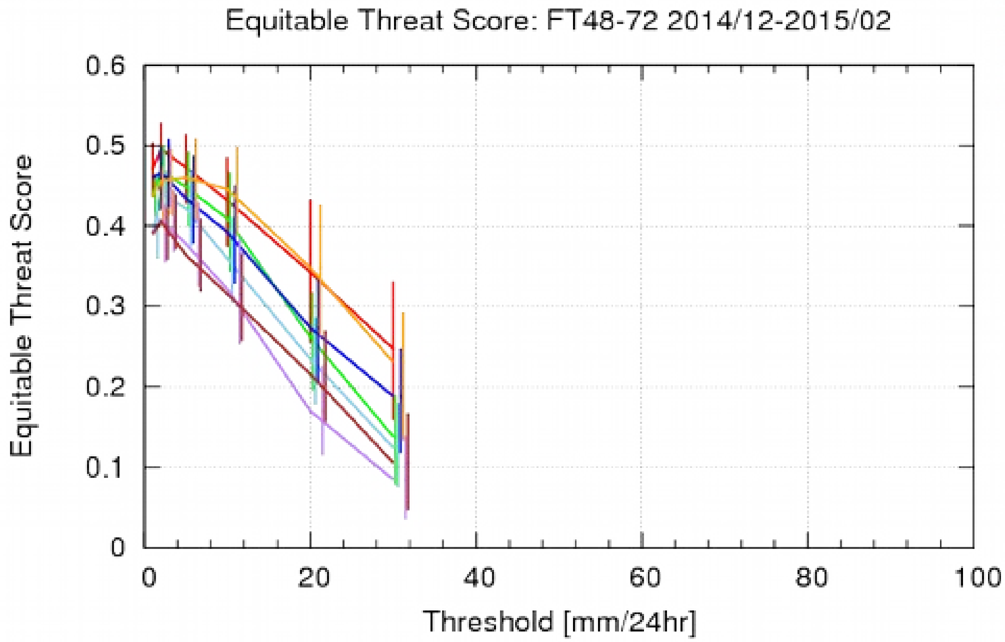


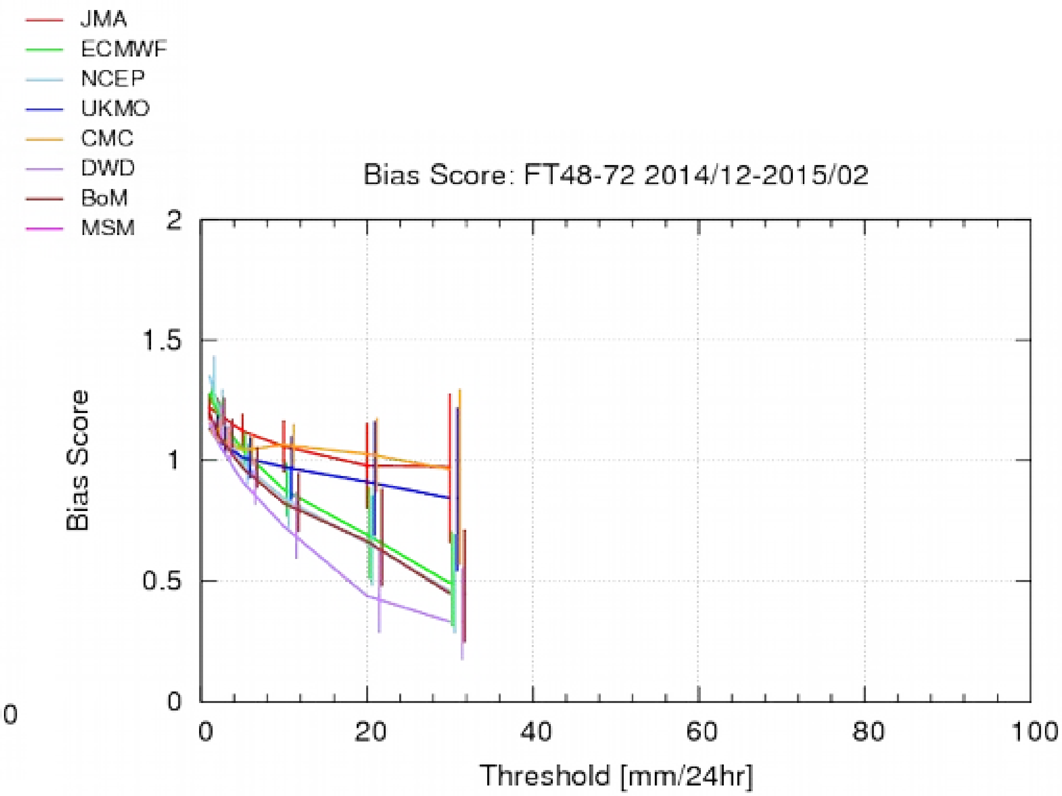
- ○CMC performs better in BI.
- ○JMA performs better in ETS and EDI.
- ○ECMWF performs better in ETS and EDI at the low threshold.
- ○CMC performs better in ETS and EDI at the high threshold.

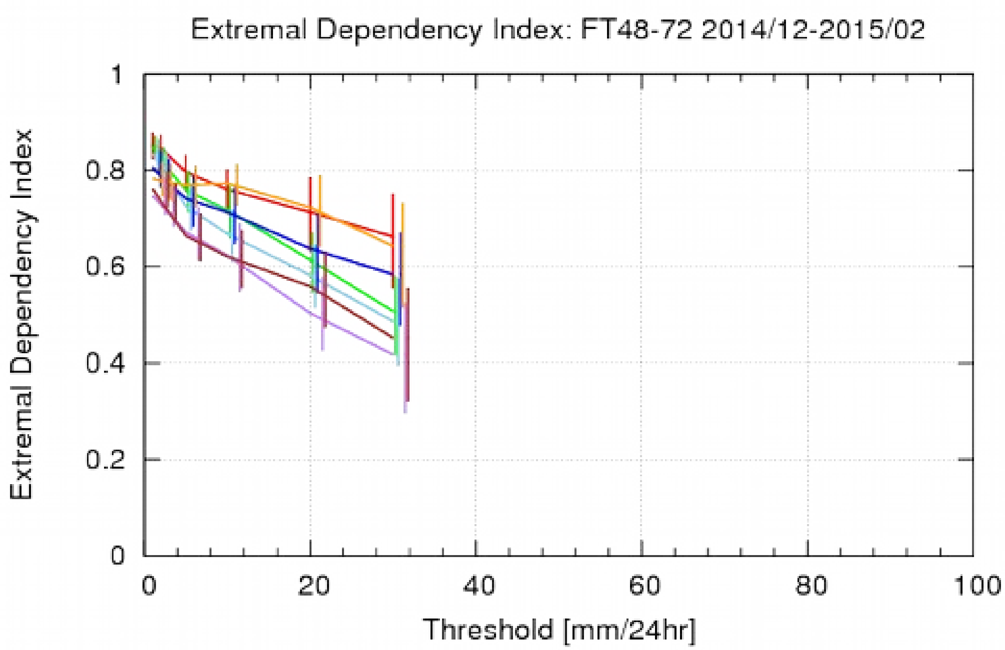


○JMA performs better in HR.

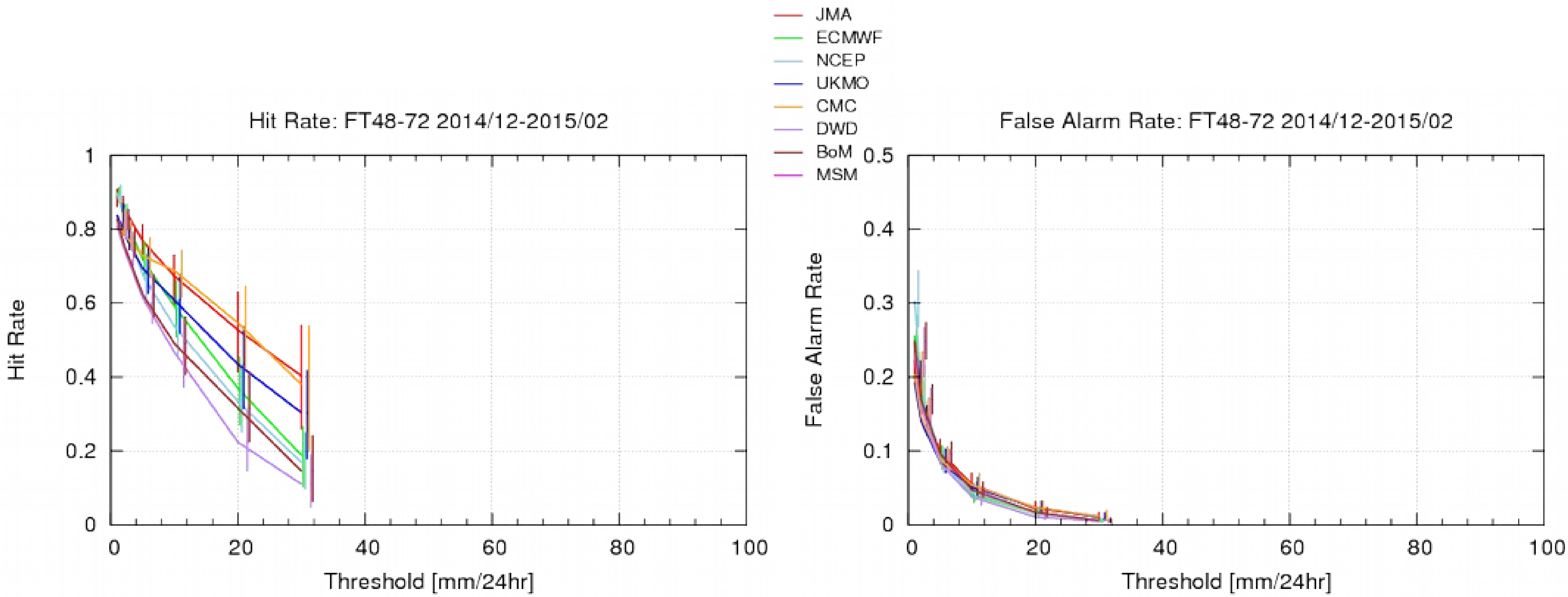
2014DJF: FT=48-72







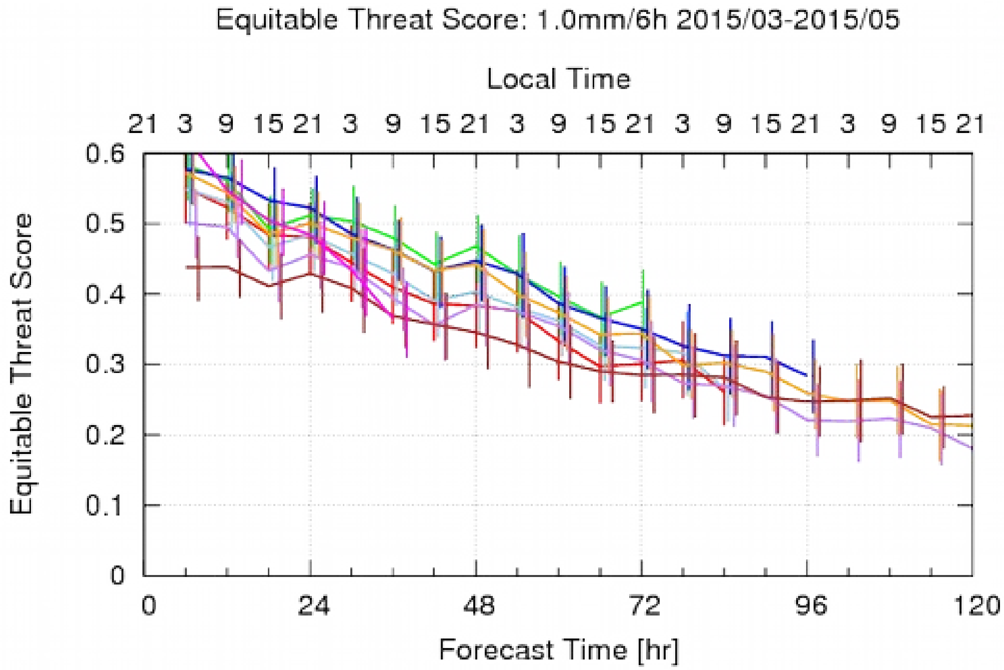
○JMA performs better in ETS and EDI.
○CMC performs better in ETS and EDI at the high threshold.

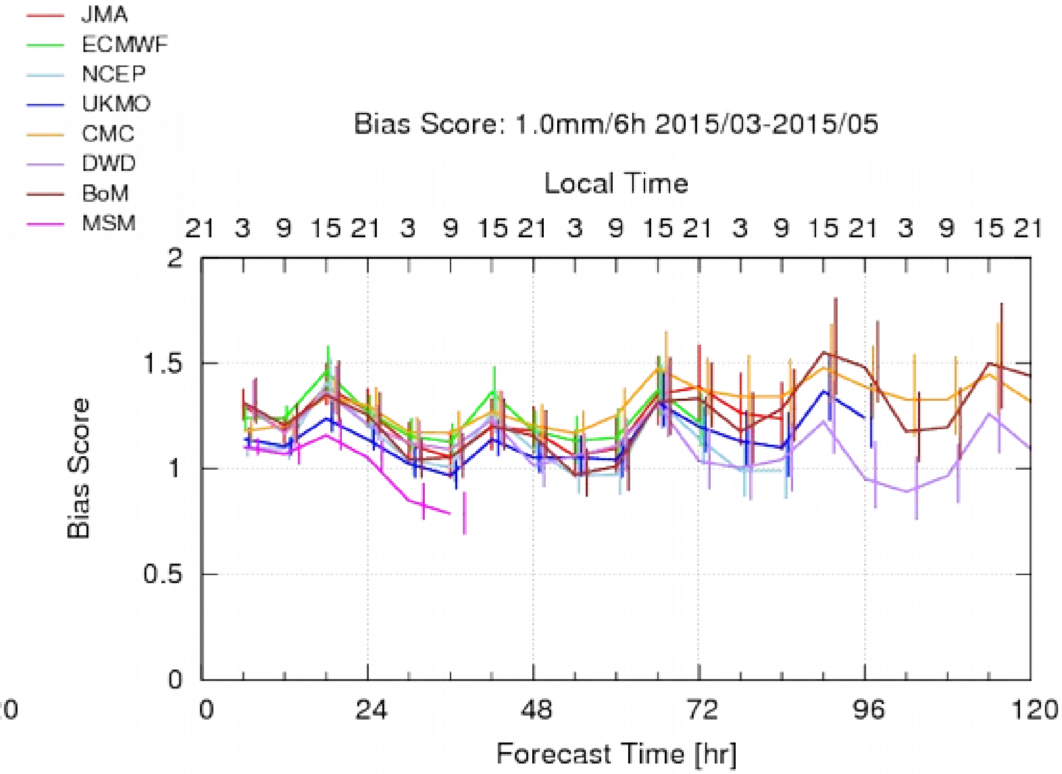


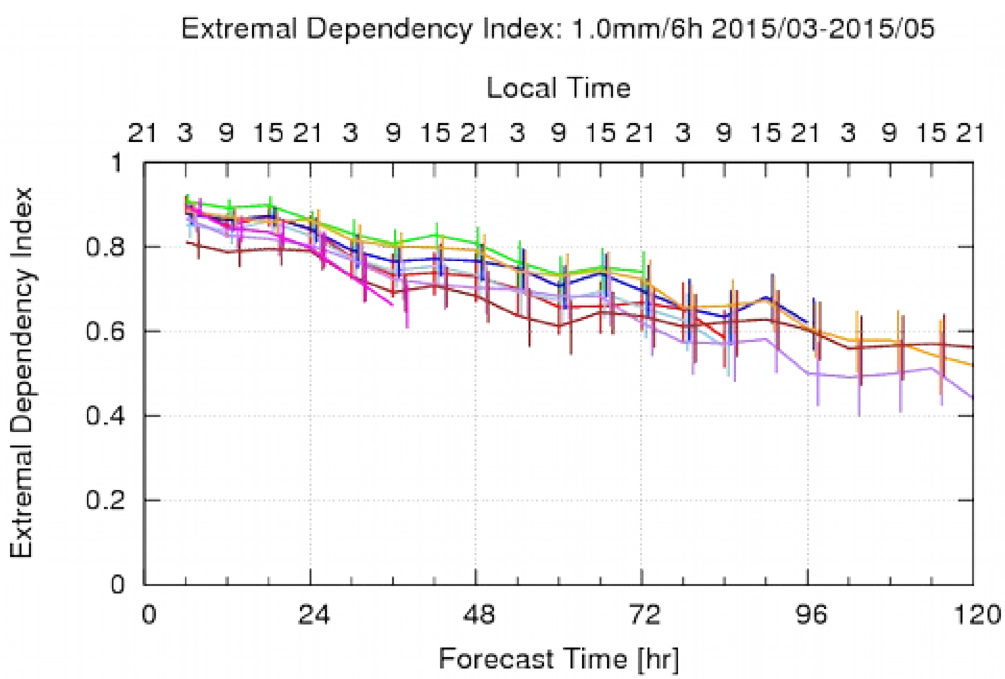
○JMA performs better in HR.

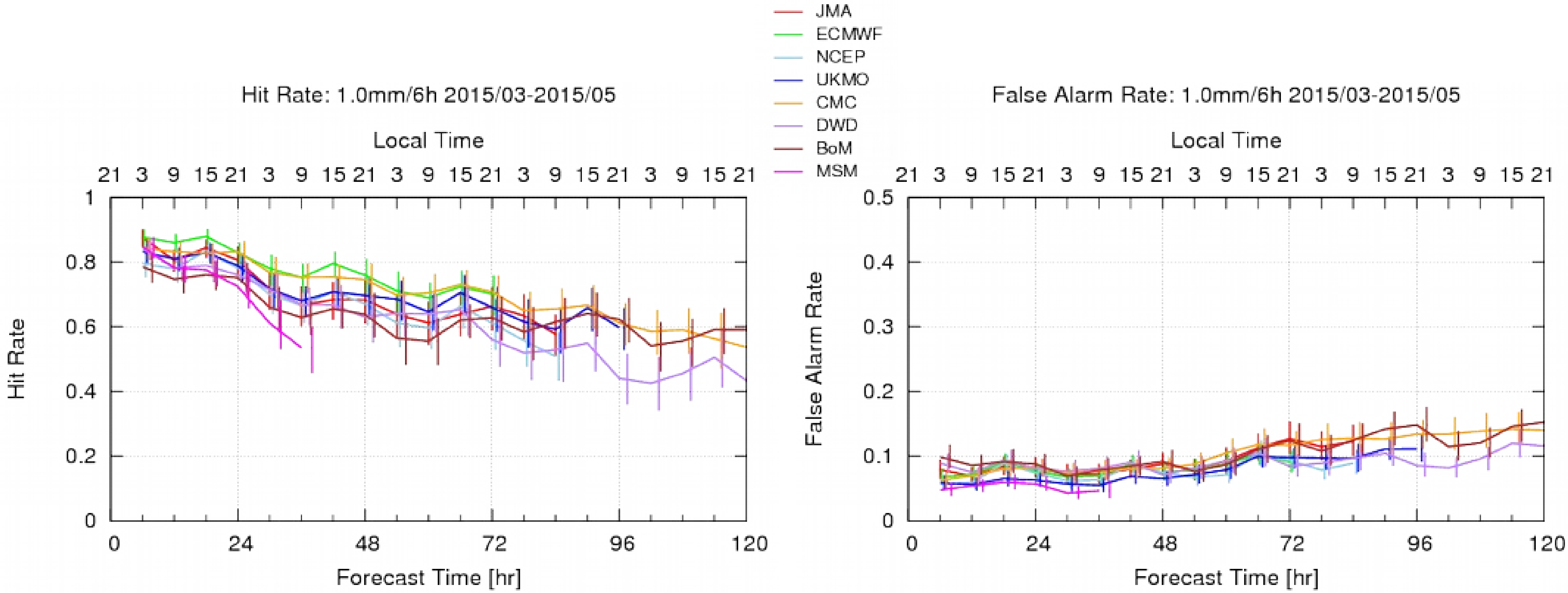
2015MAM

2015MAM: 1 mm/6hr

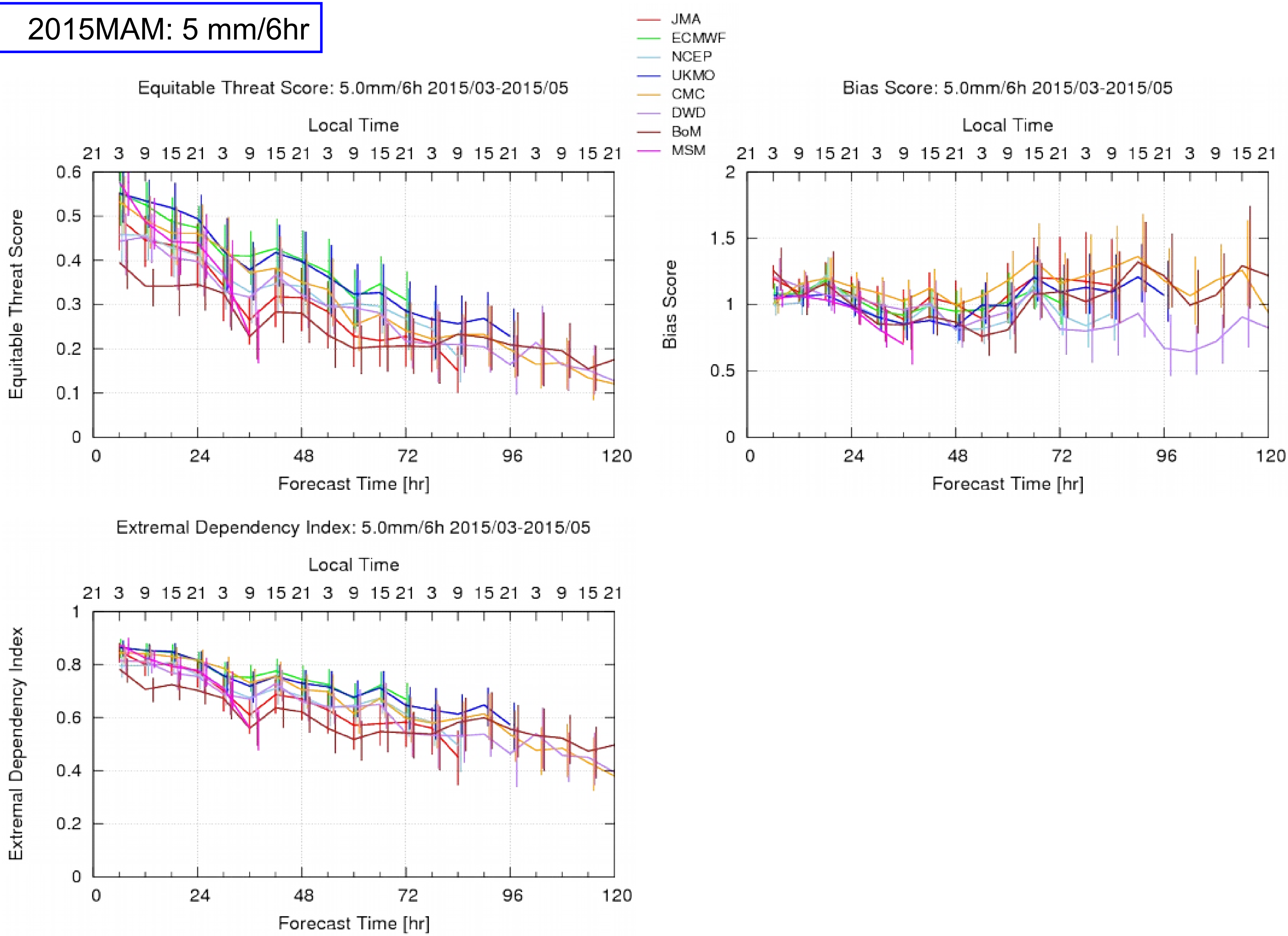


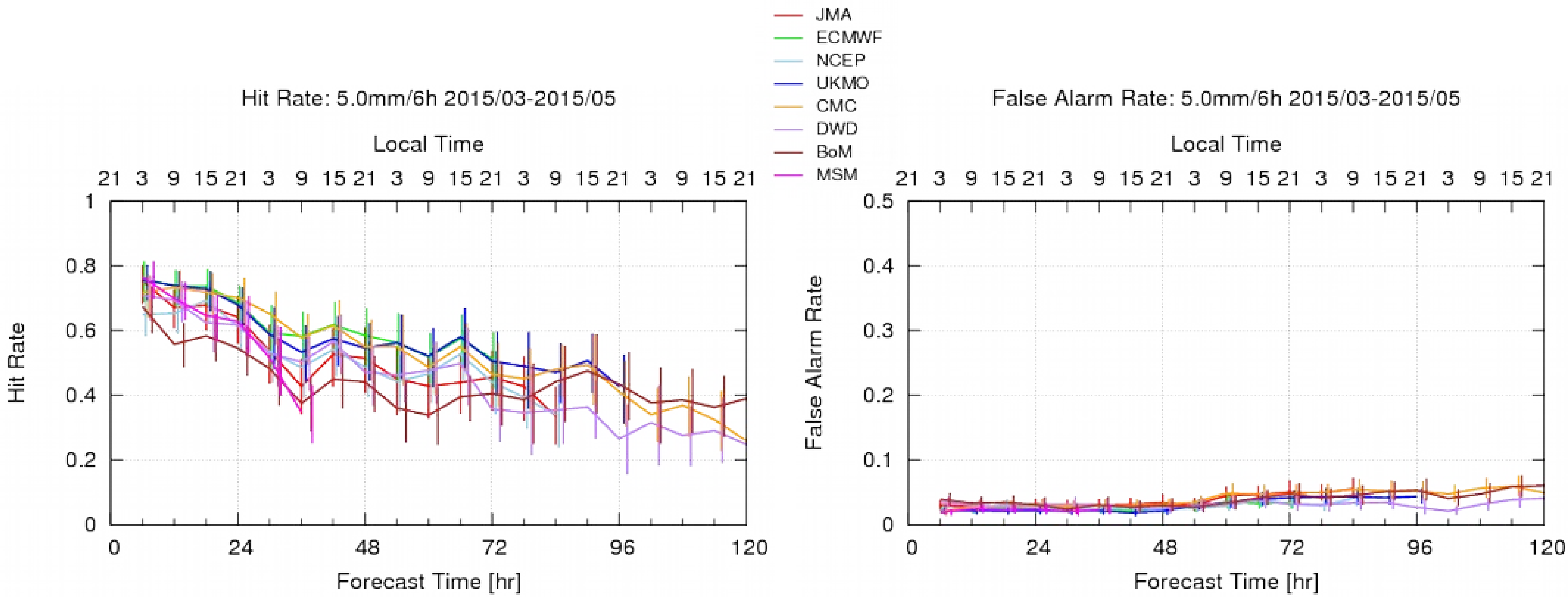




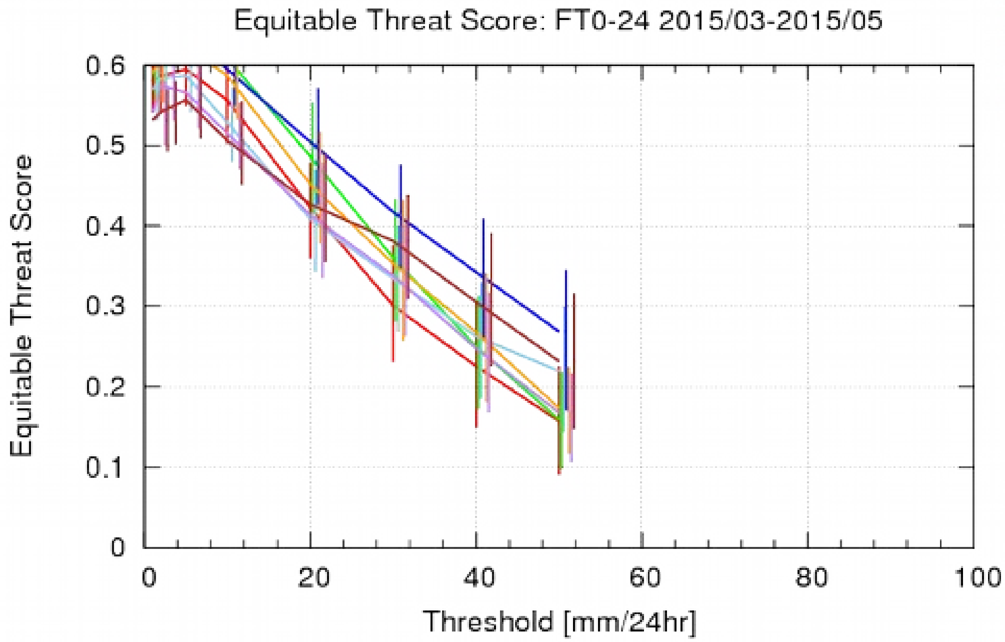

JMA
ECMWF
NCEP
UKMO
CMC
DWD
BoM
MSM
Hit Rate: 1.0mm/6h 2015/03-2015/05
Local Time
21 3 9 15 21 3 9 15 21 3 9 15 21 3 9 15 21 3 9 15 21
Hit Rate
1
0.8
0.6
0.4
0.2
0
0 24 48 72 96 120
Forecast Time [hr]
False Alarm Rate: 1.0mm/6h 2015/03-2015/05
Local Time
21 3 9 15 21 3 9 15 21 3 9 15 21 3 9 15 21 3 9 15 21
False Alarm Rate
0.5
0.4
0.3
0.2
0.1
0
0 24 48 72 96 120
Forecast Time [hr]

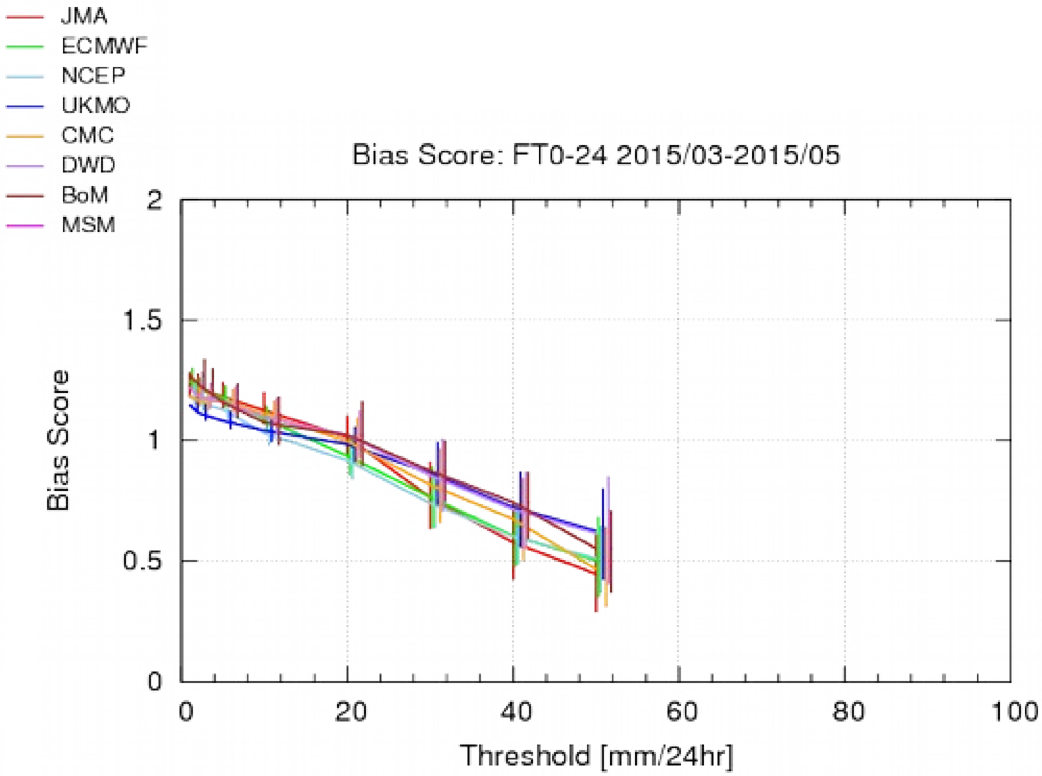
2015MAM: 5 mm/6hr

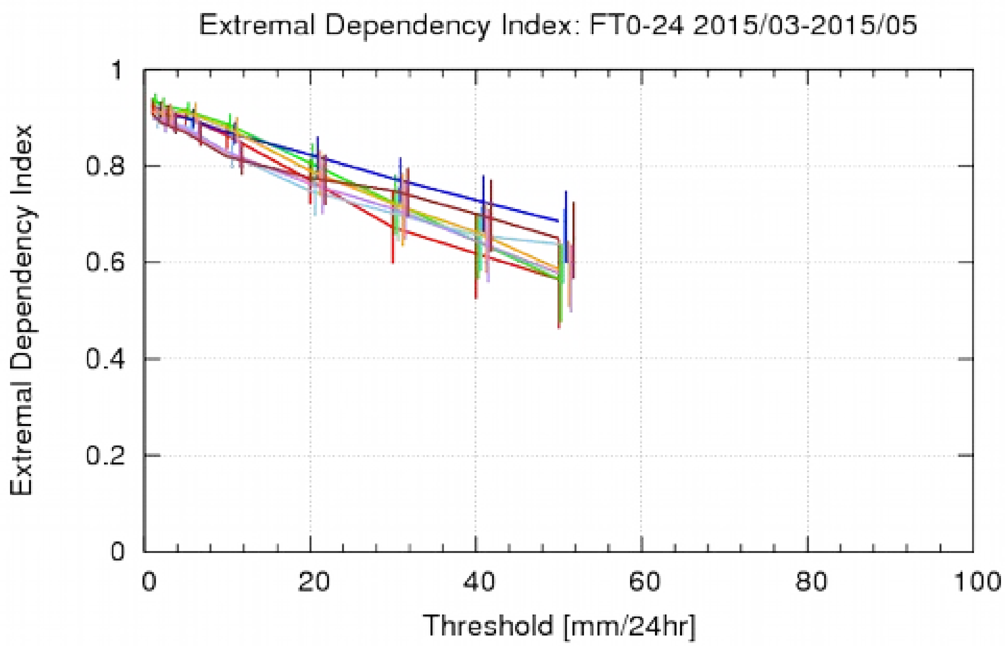


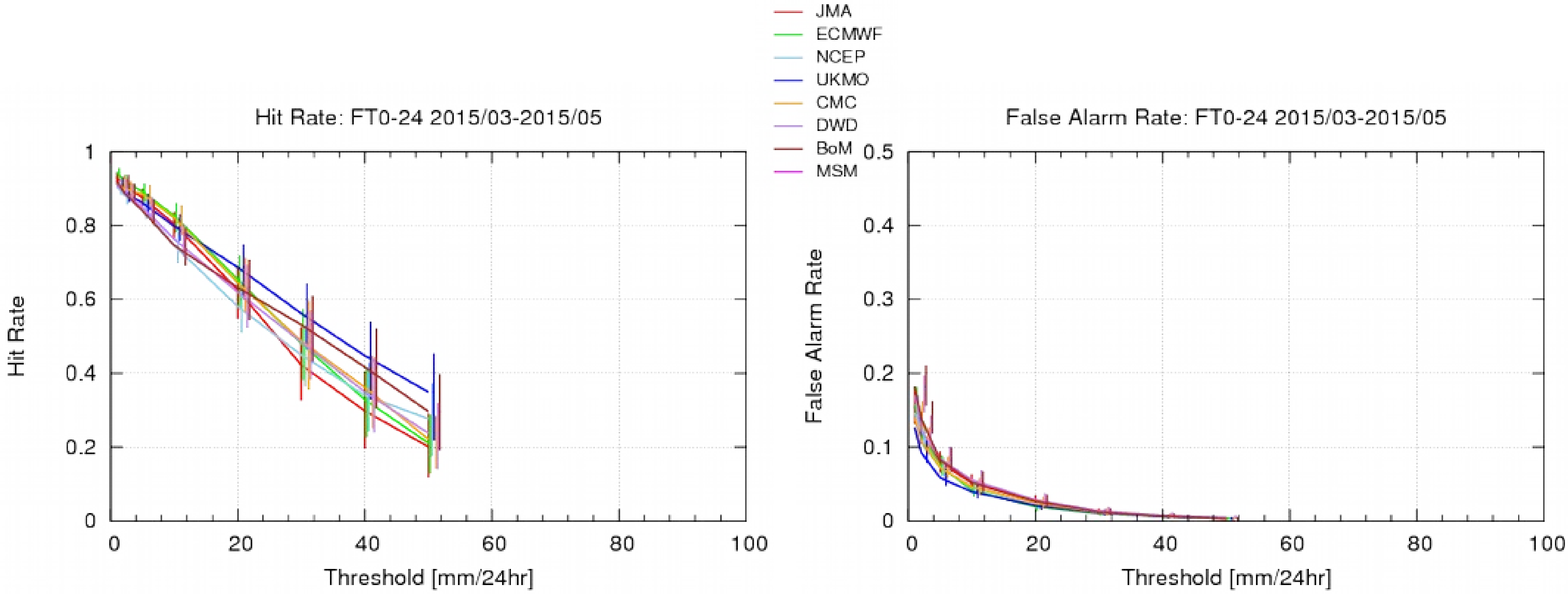

JMA
ECMWF
NCEP
UKMO
CMC
DWD
BoM
MSM
Hit Rate: 5.0mm/6h 2015/03-2015/05
Local Time
Hit Rate
Forecast Time [hr]
False Alarm Rate: 5.0mm/6h 2015/03-2015/05
Local Time
False Alarm Rate
Forecast Time [hr]

2015MAM: FT=0-24



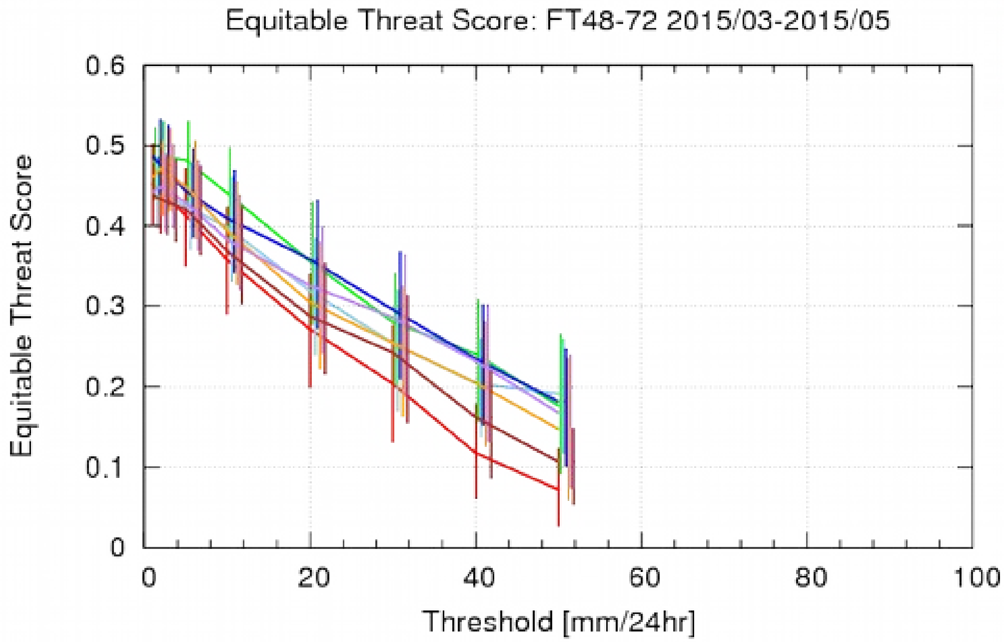


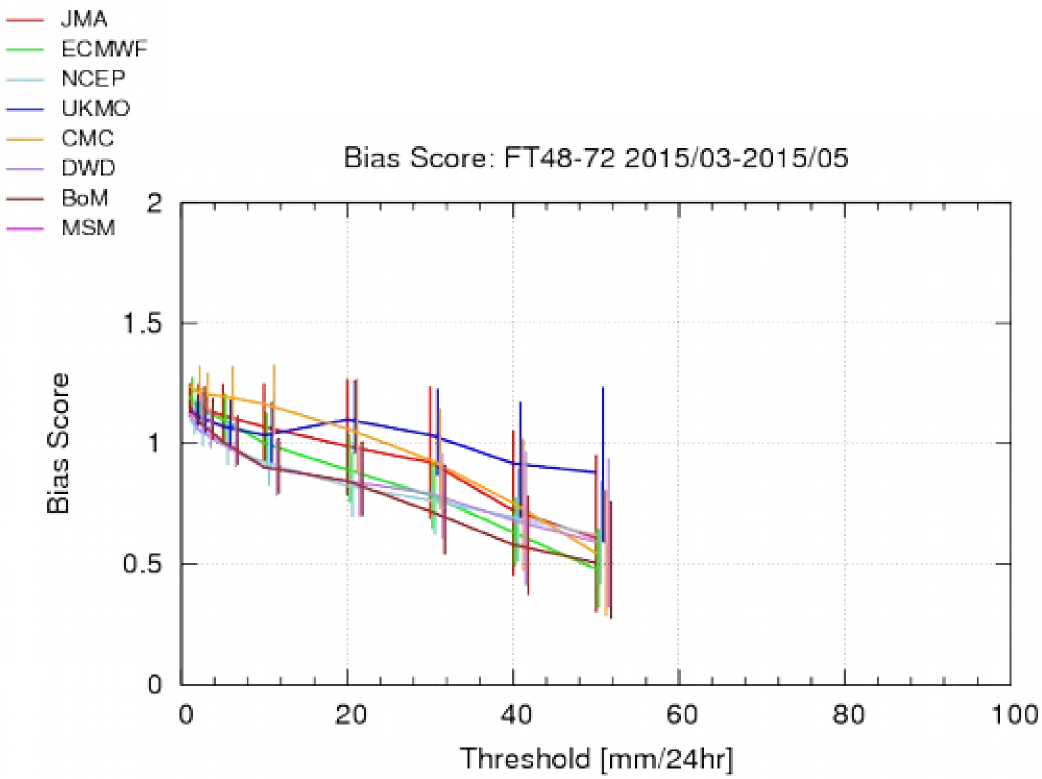


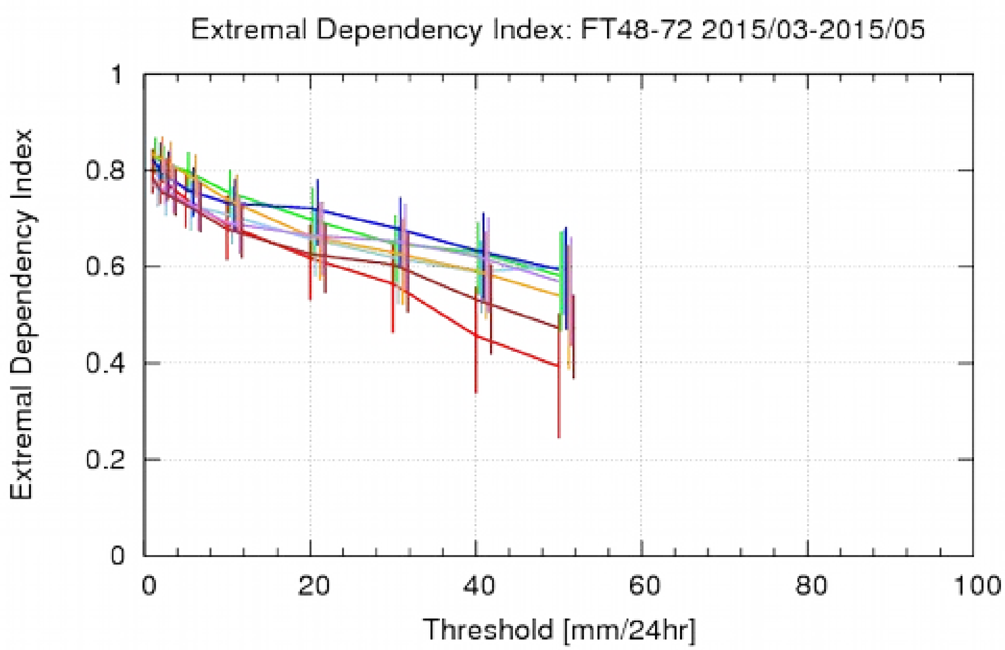


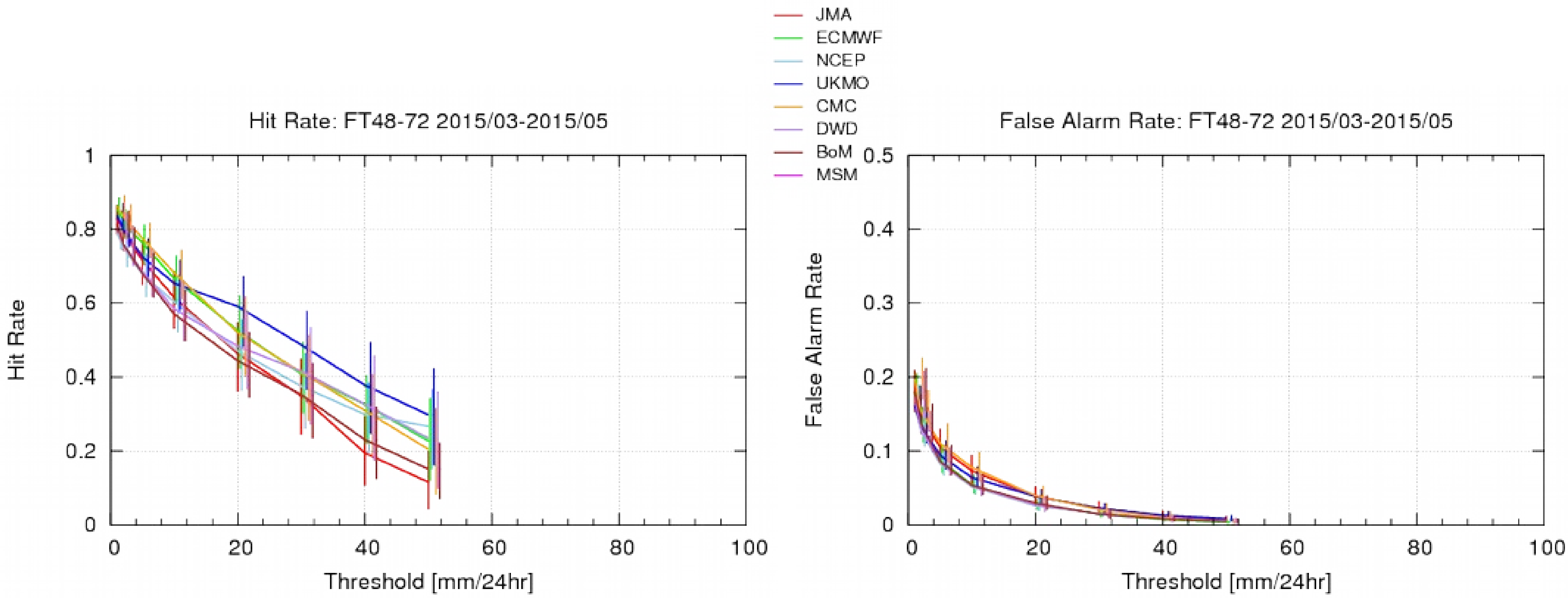
JMA
ECMWF
NCEP
UKMO
CMC
DWD
BoM
MSM
Hit Rate: FT0-24 2015/03-2015/05
Hit Rate
Threshold [mm/24hr]
False Alarm Rate: FT0-24 2015/03-2015/05
False Alarm Rate
Threshold [mm/24hr]

2015MAM: FT=48-72



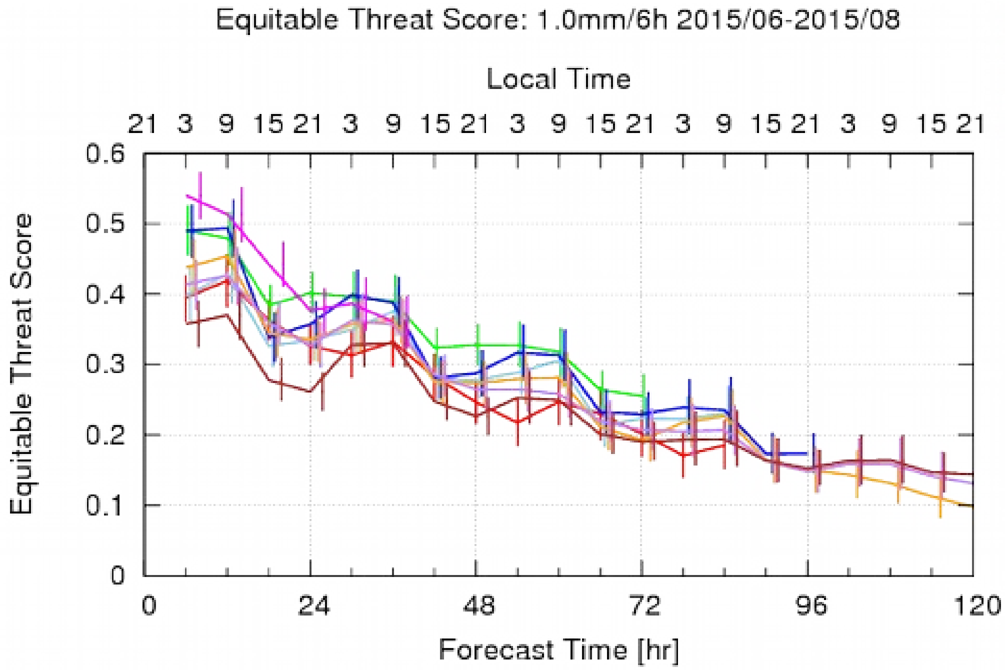


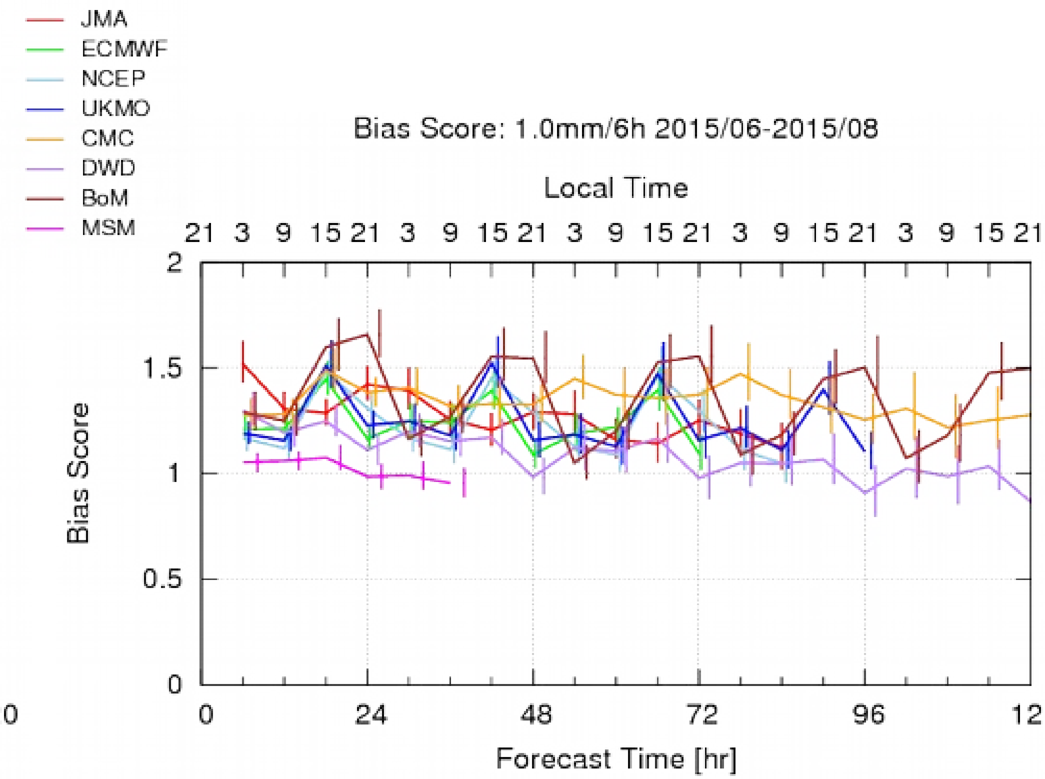


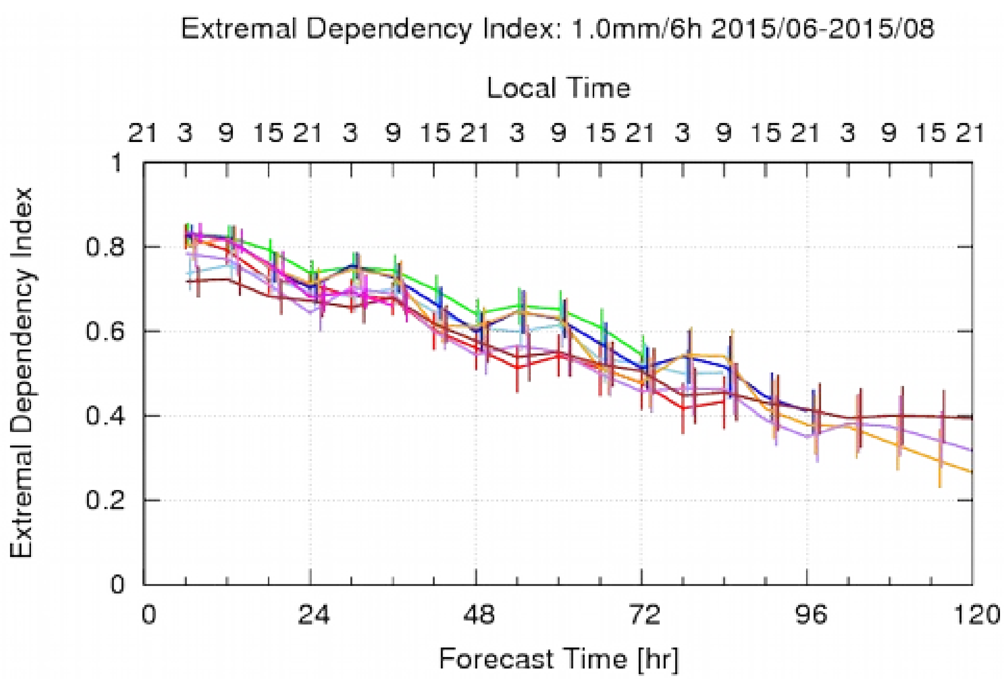

JMA
ECMWF
NCEP
UKMO
CMC
DWD
BoM
MSM
Hit Rate: FT48-72 2015/03-2015/05
Hit Rate
Threshold [mm/24hr]
False Alarm Rate: FT48-72 2015/03-2015/05
False Alarm Rate
Threshold [mm/24hr]

2015JJA

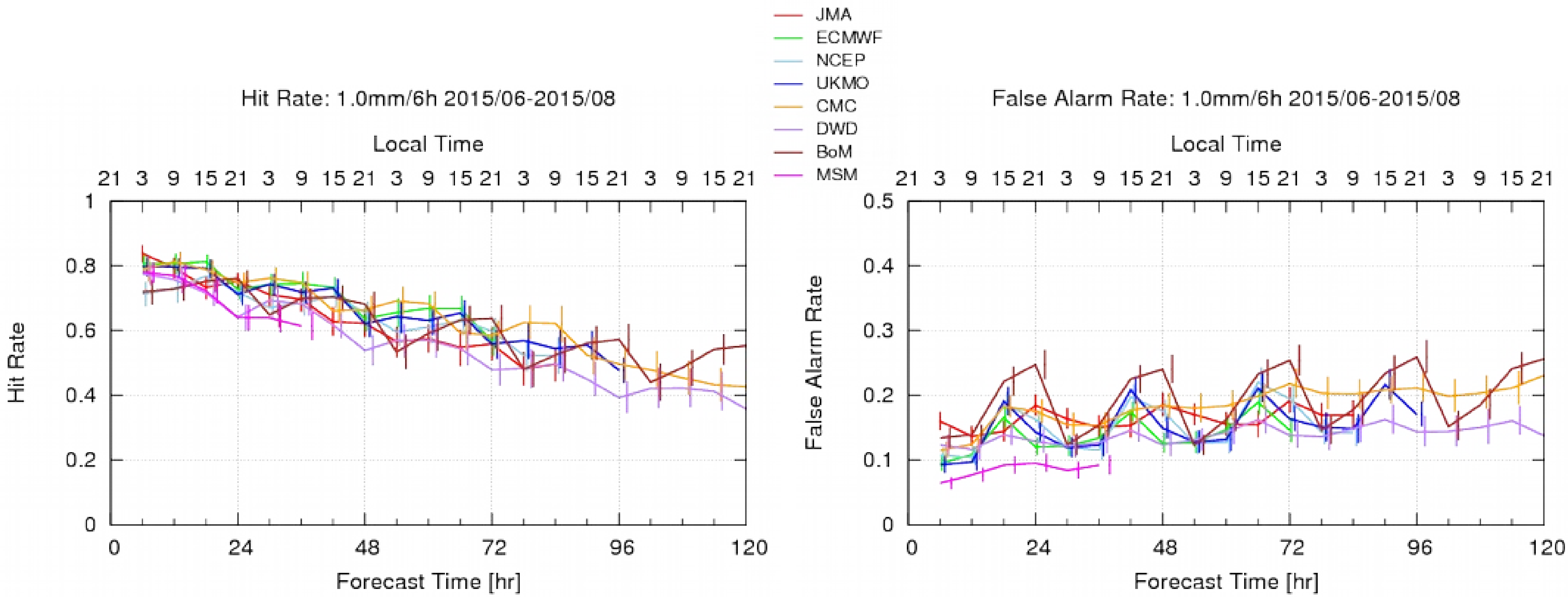
2015JJA: 1 mm/6hr





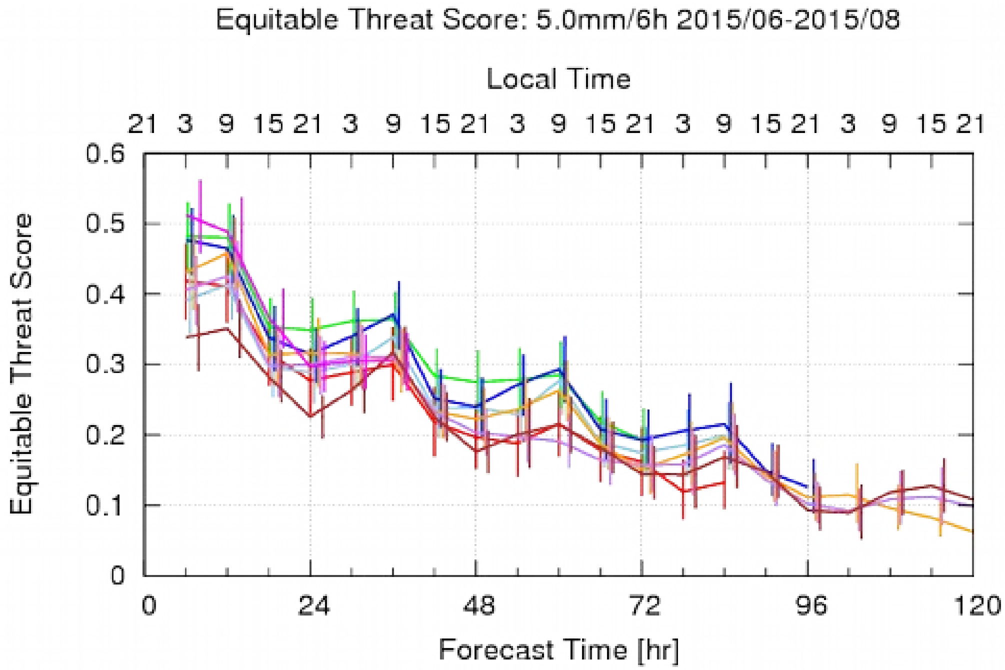


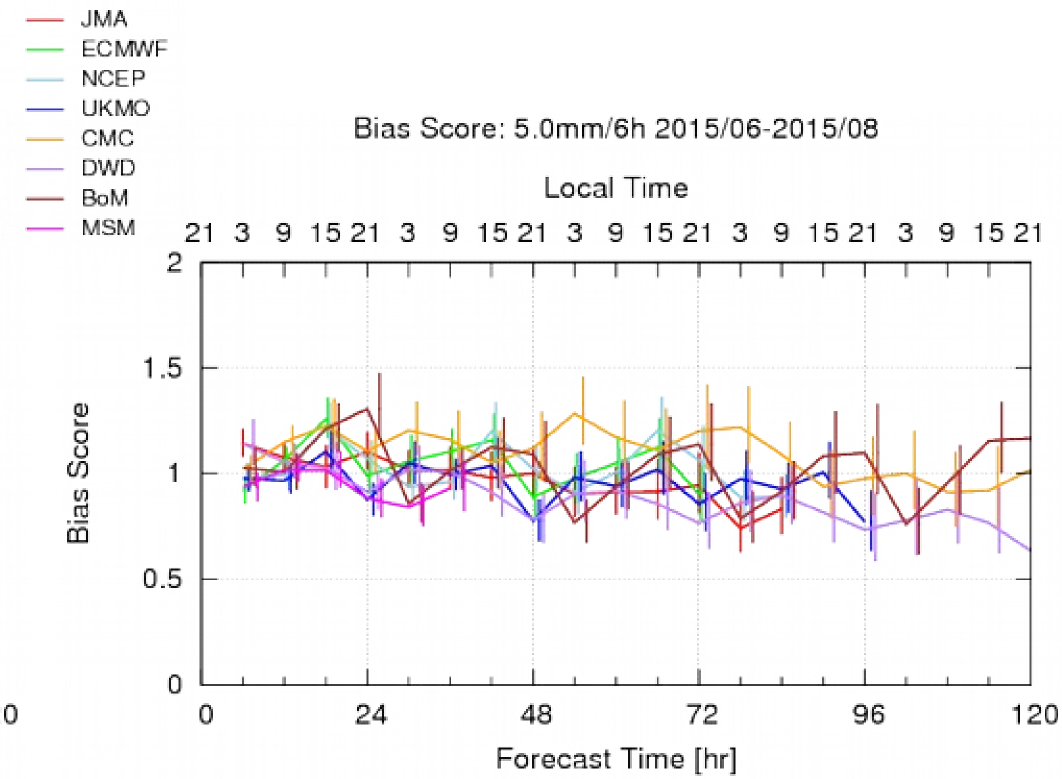
- ○MSM performs quite better in BI.
- ○In BI, diurnal cycle is seen in many centers (large BI at 15 local time).
- ○MSM performs better in ETS on FT<24.
- ○ECMWF performs better in ETS and EDI.

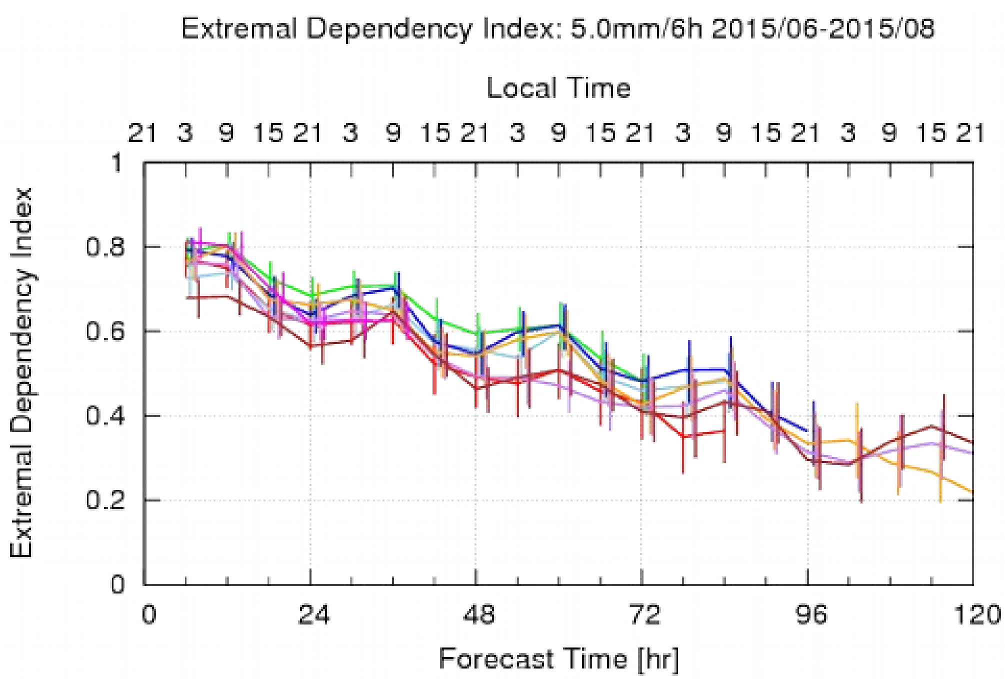


○MSM performs better in HR and FAR on FT<24. HR of MSM decreases on FT>=24, which may cause descent of ETS and EDI. JMA, which provides the boundary condition of MSM, does not how such a behavior.

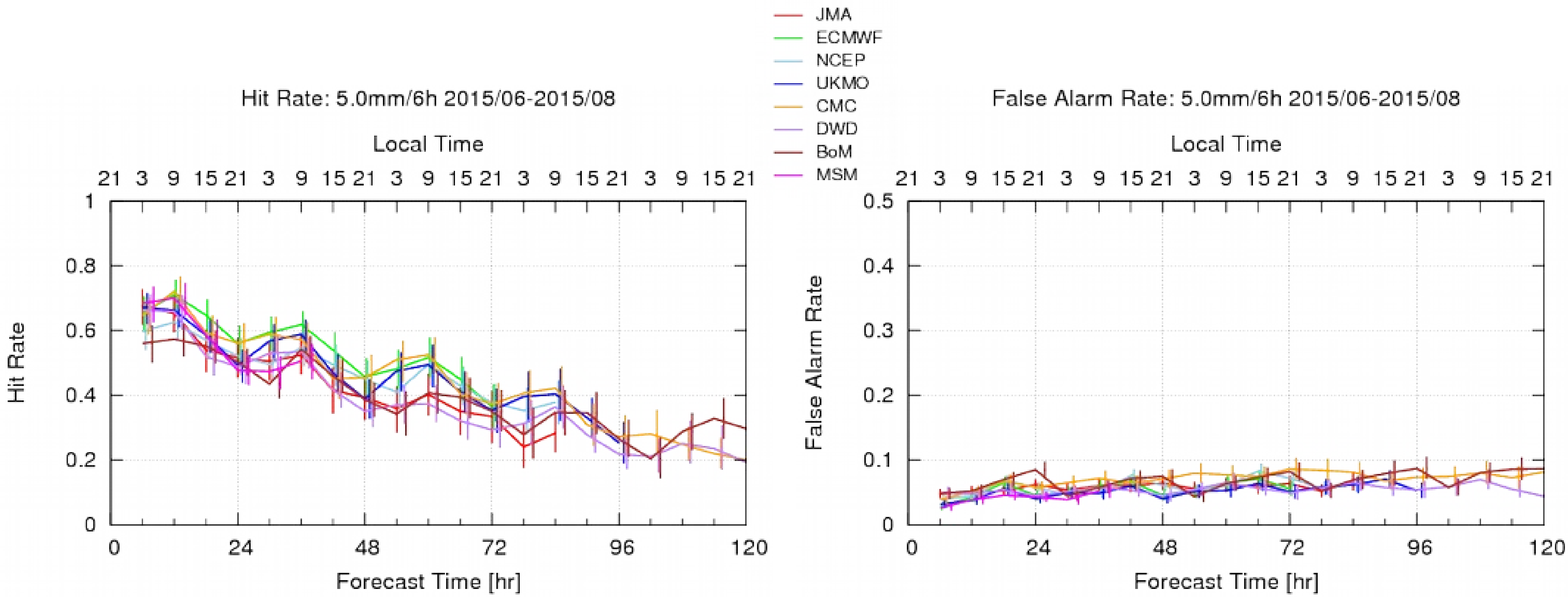
2015JJA: 5 mm/6hr



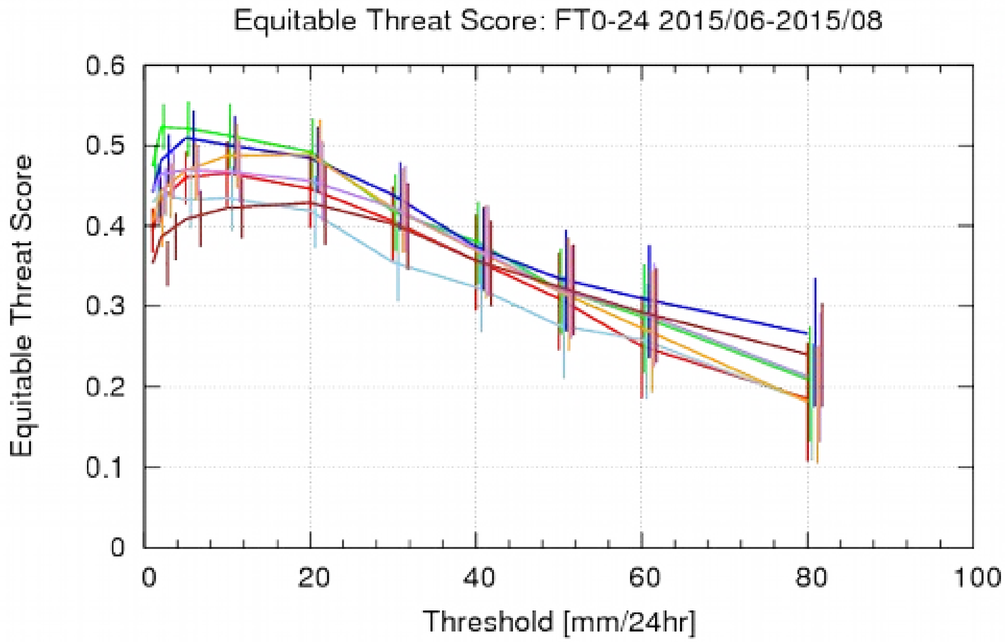


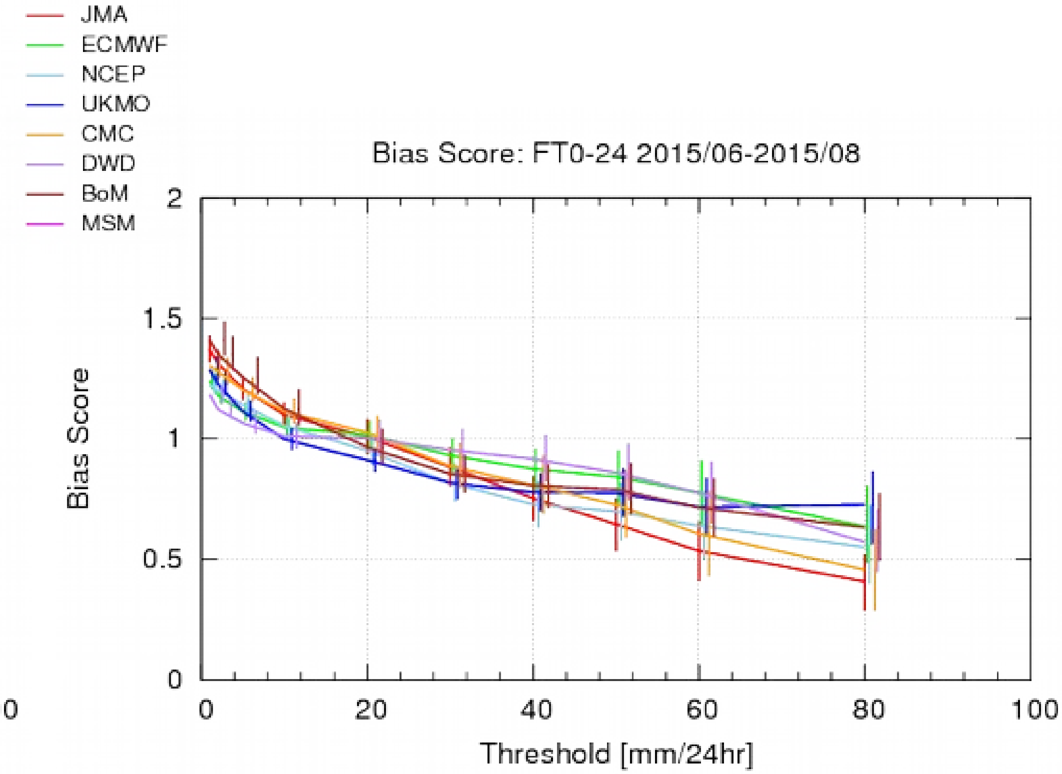


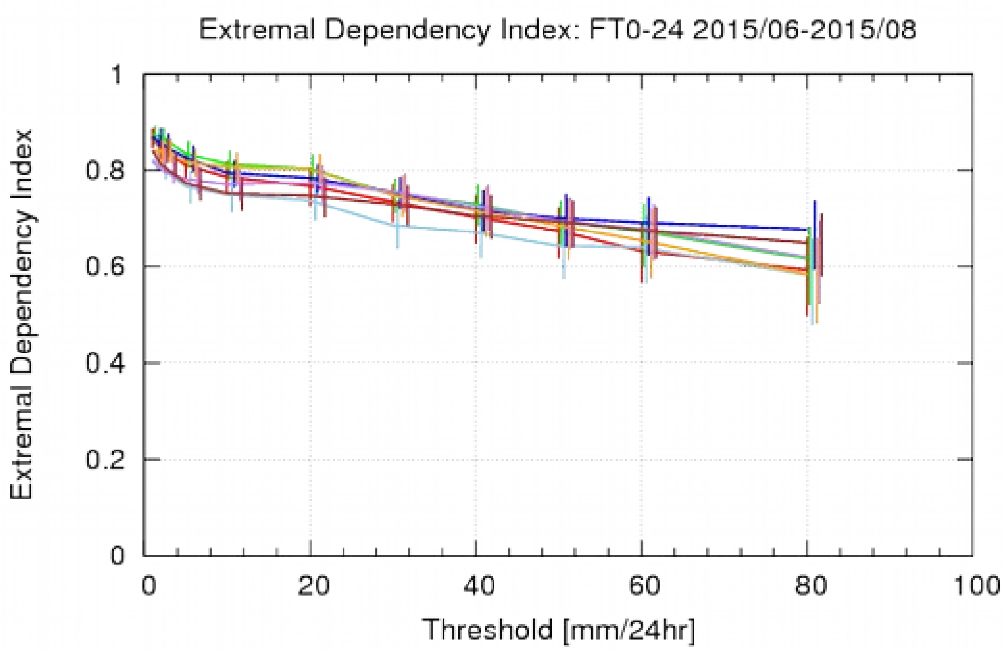
○ECMWF performs better in ETS and EDI.


JMA
ECMWF
NCEP
UKMO
CMC
DWD
BoM
MSM
Hit Rate: 5.0mm/6h 2015/06-2015/08
Local Time
Hit Rate
Forecast Time [hr]
False Alarm Rate: 5.0mm/6h 2015/06-2015/08
Local Time
False Alarm Rate
Forecast Time [hr]

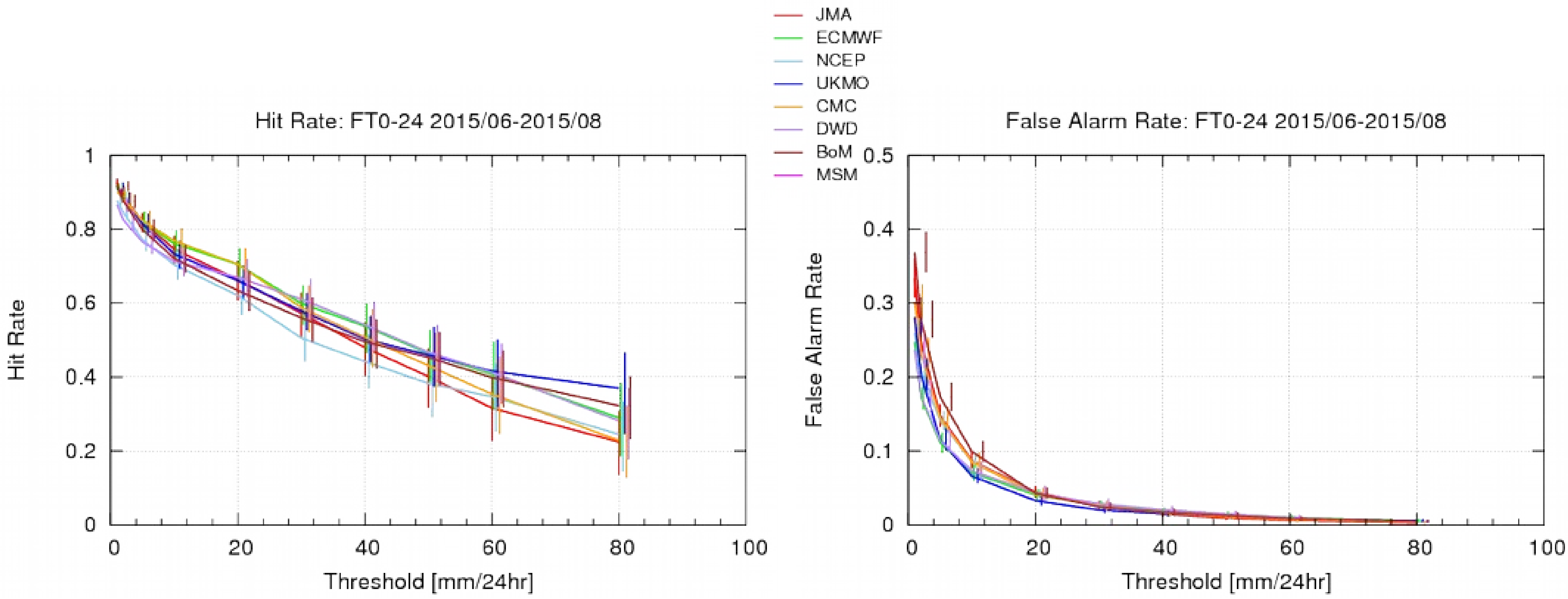
2015JJA: FT=0-24



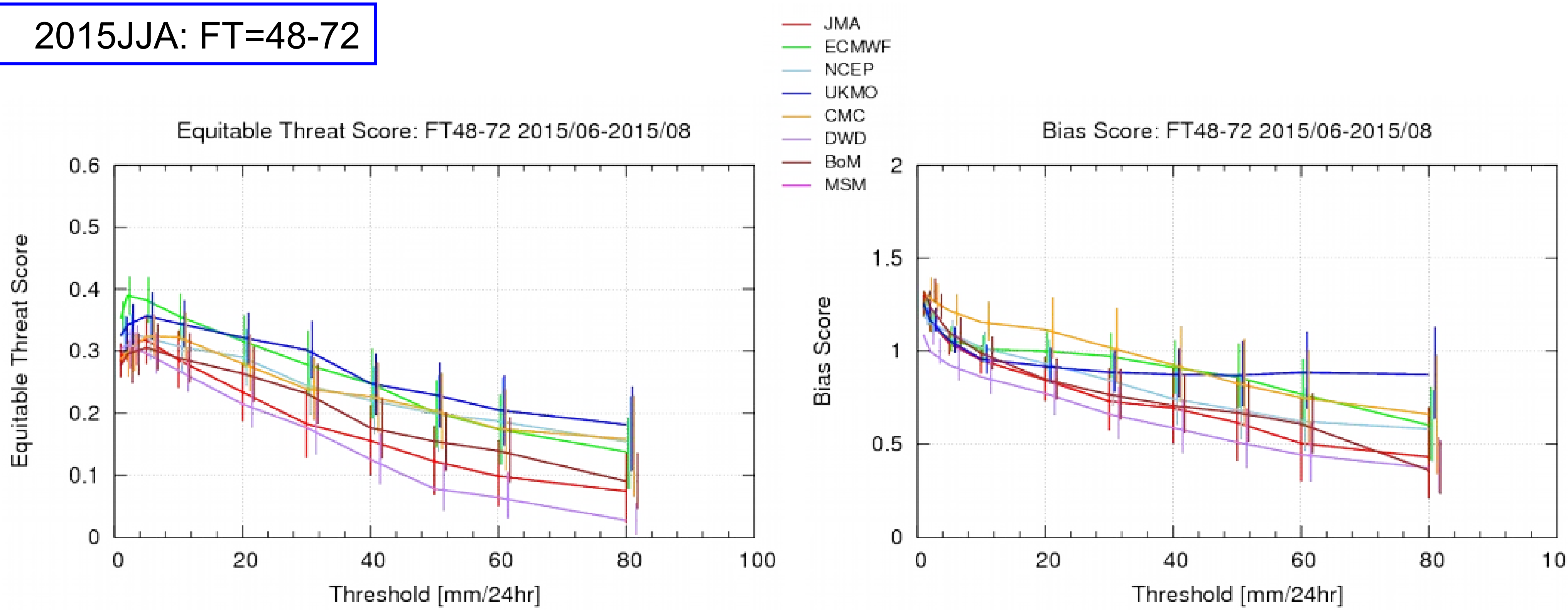


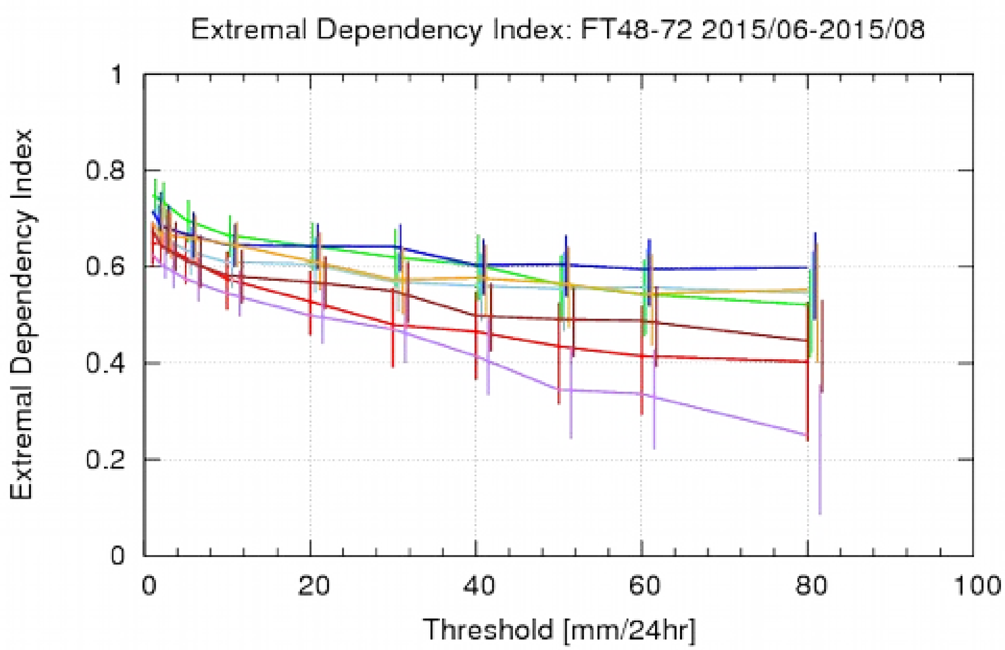


- ○ECMWF performs better in ETS and EDI on <= 50 mm/24hr.
- ○UKMO performs better in ETS and EDI.

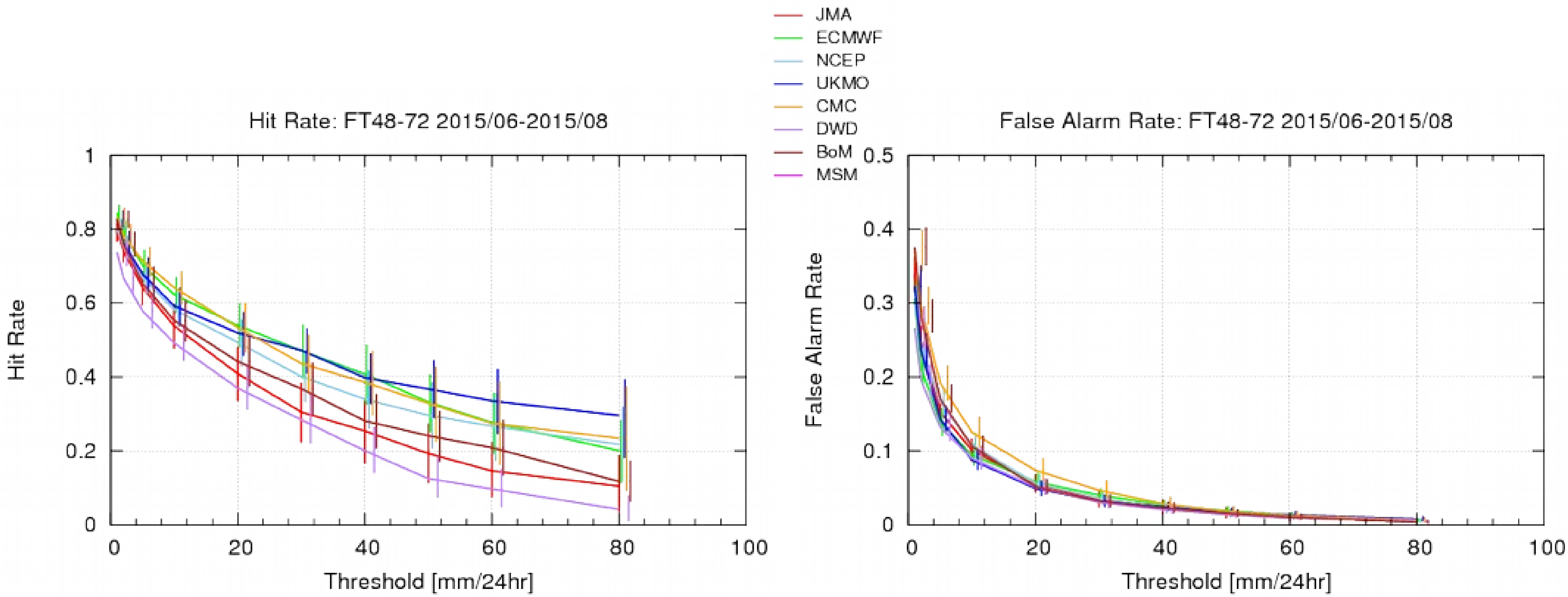

JMA
ECMWF
NCEP
UKMO
CMC
DWD
BoM
MSM
Hit Rate: FT0-24 2015/06-2015/08
Hit Rate
Threshold [mm/24hr]
0
0.2
0.4
0.6
0.8
1
0
20
40
60
80
100
False Alarm Rate: FT0-24 2015/06-2015/08
False Alarm Rate
Threshold [mm/24hr]
0
0.1
0.2
0.3
0.4
0.5
0
20
40
60
80
100

2015JJA: FT=48-72



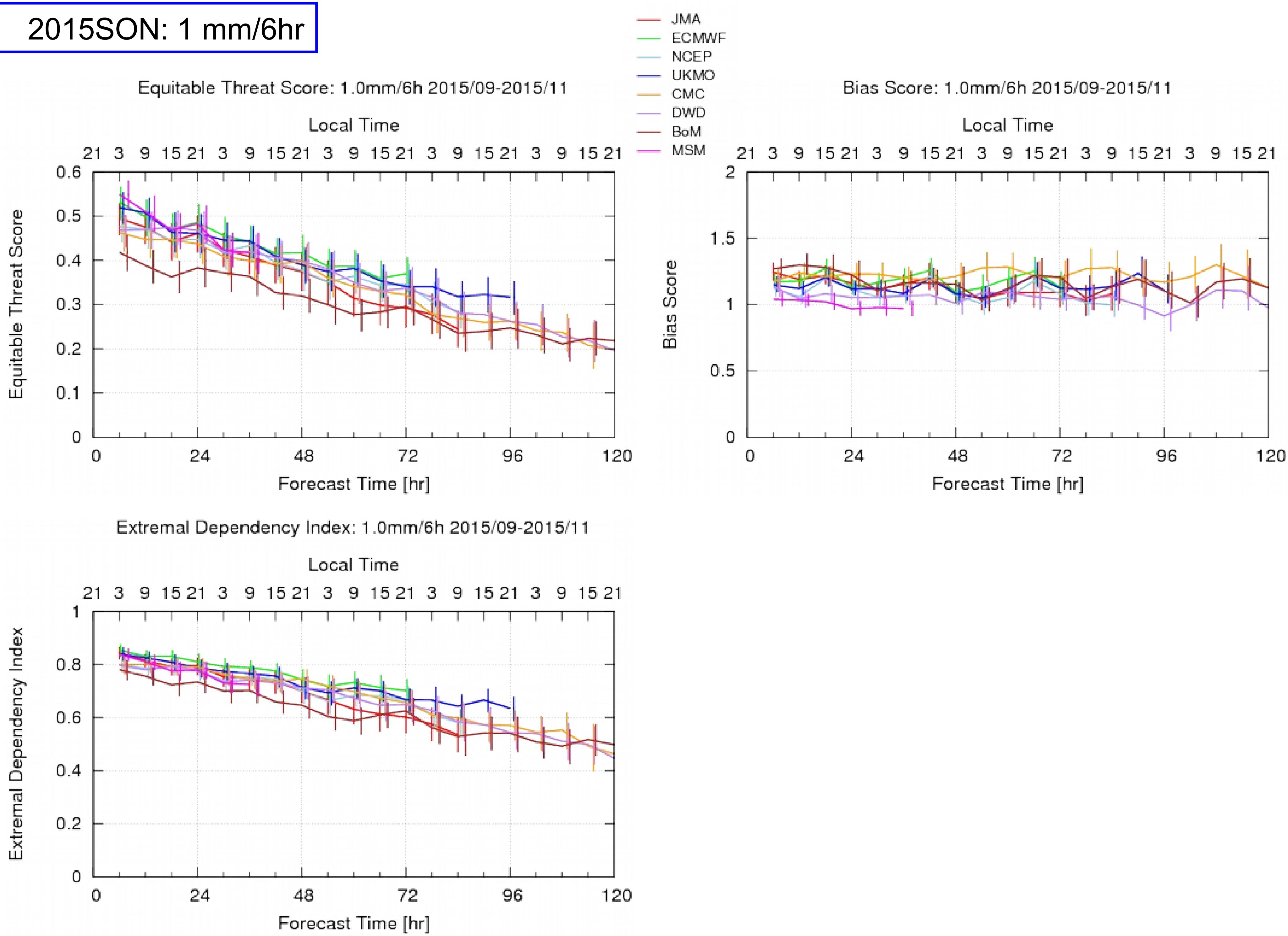


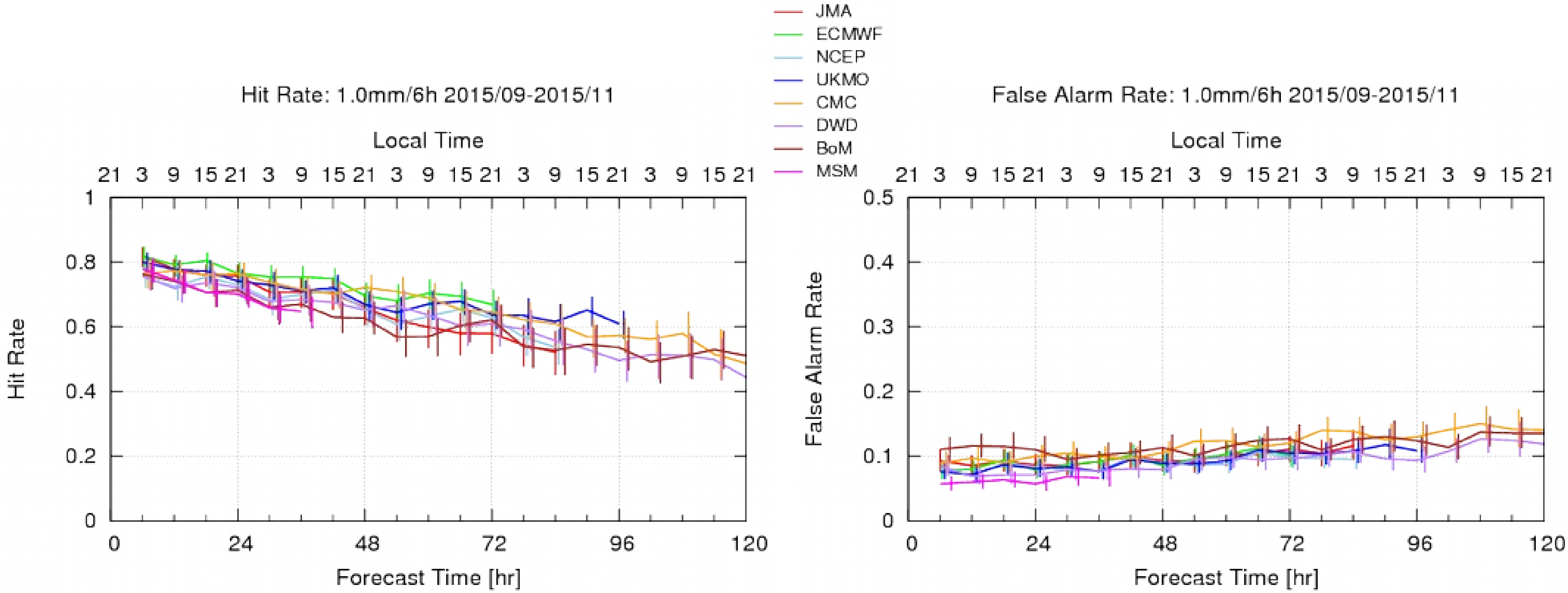
- ○ECMWF performs better in ETS and EDI on <= 50 mm/24hr.
- ○UKMO performs better in ETS and EDI.


JMA
ECMWF
NCEP
UKMO
CMC
DWD
BoM
MSM
Hit Rate: FT48-72 2015/06-2015/08
Hit Rate
Threshold [mm/24hr]
False Alarm Rate: FT48-72 2015/06-2015/08
False Alarm Rate
Threshold [mm/24hr]

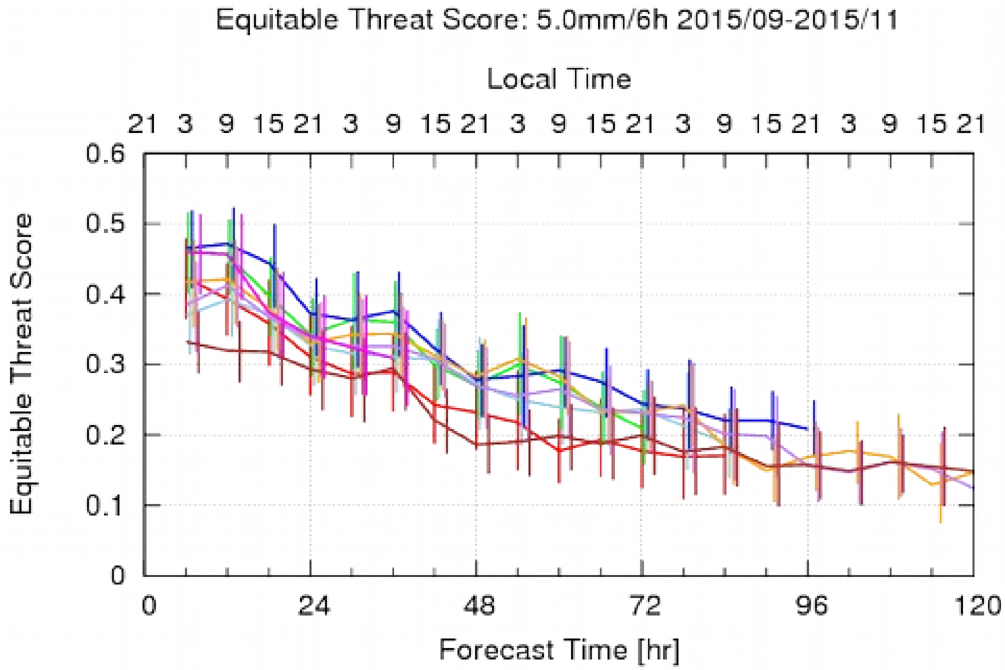
2015SON

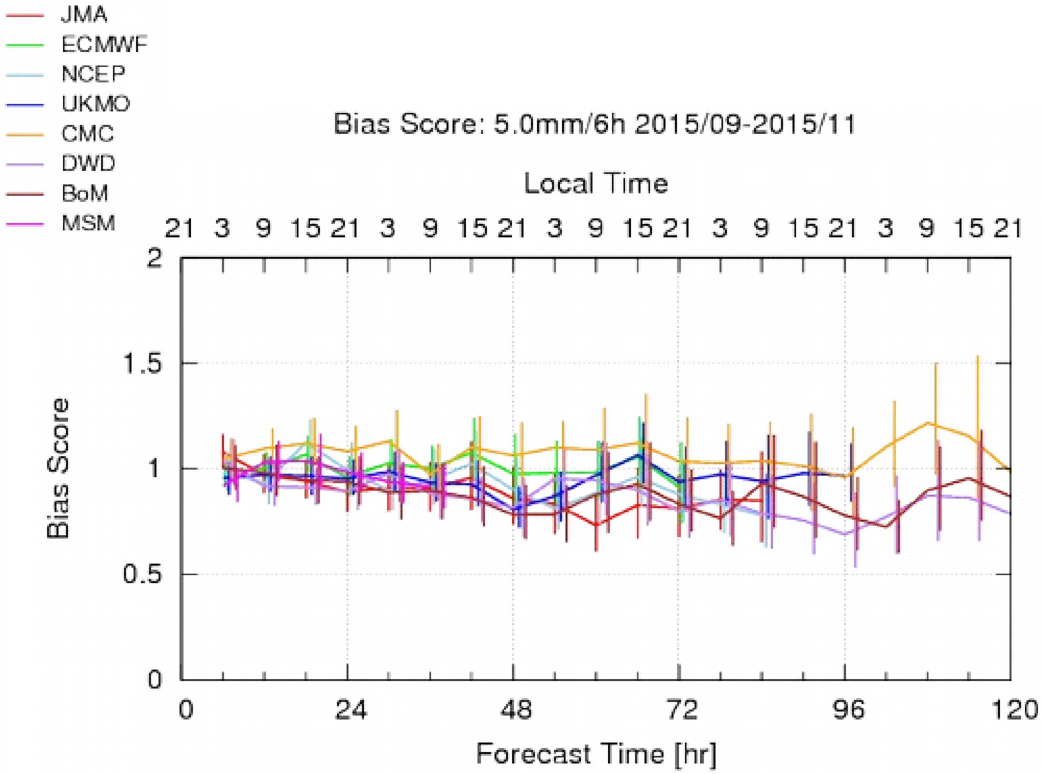
2015SON: 1 mm/6hr

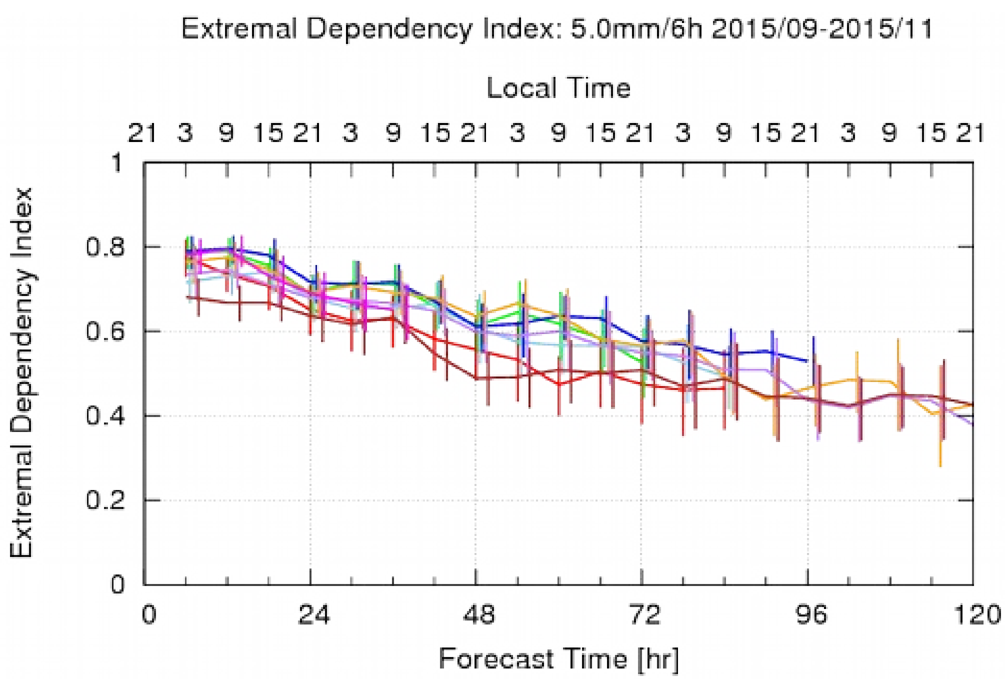


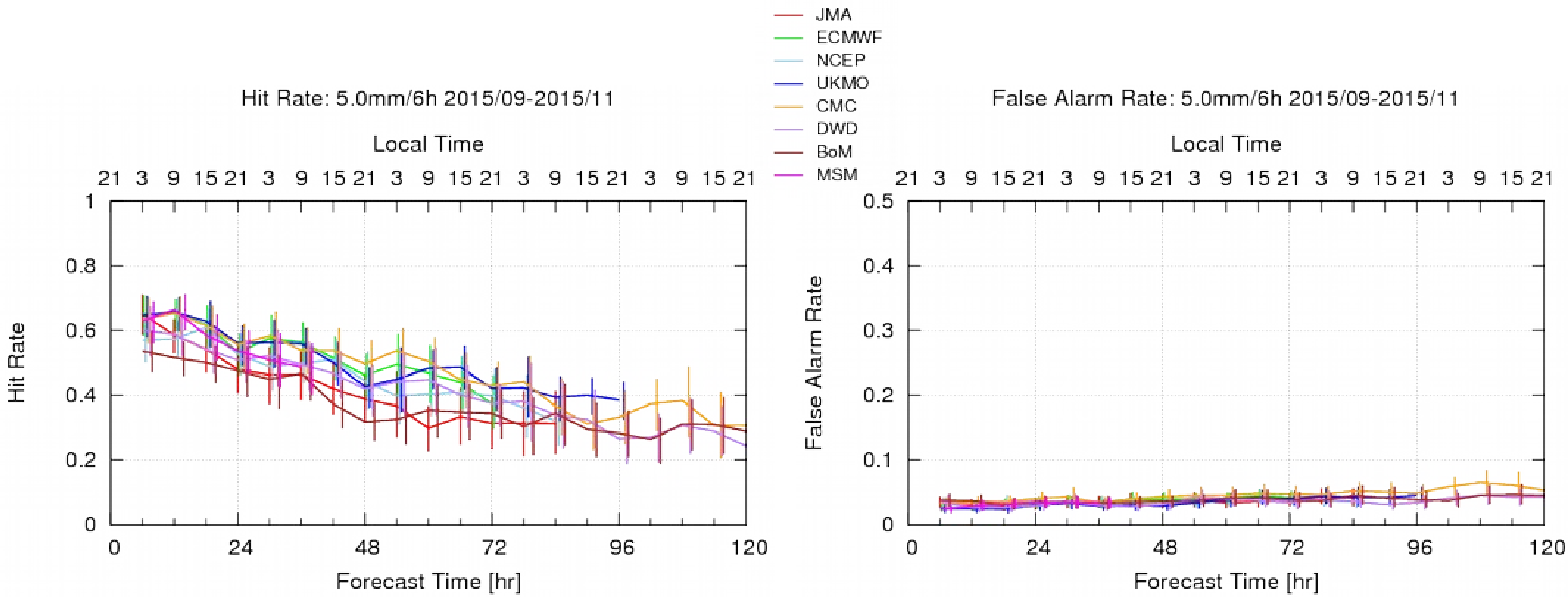

JMA
ECMWF
NCEP
UKMO
CMC
DWD
BoM
MSM
Hit Rate: 1.0mm/6h 2015/09-2015/11
Local Time
21 3 9 15 21 3 9 15 21 3 9 15 21 3 9 15 21 3 9 15 21
Hit Rate
1
0.8
0.6
0.4
0.2
0
0 24 48 72 96 120
Forecast Time [hr]
False Alarm Rate: 1.0mm/6h 2015/09-2015/11
Local Time
21 3 9 15 21 3 9 15 21 3 9 15 21 3 9 15 21 3 9 15 21
False Alarm Rate
0.5
0.4
0.3
0.2
0.1
0
0 24 48 72 96 120
Forecast Time [hr]

2015SON: 5 mm/6hr

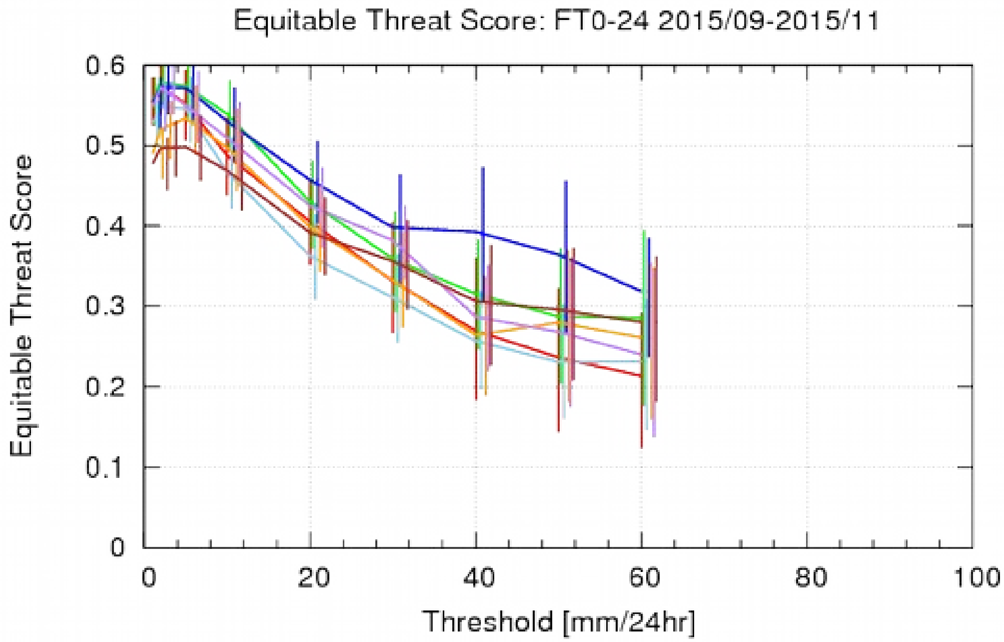


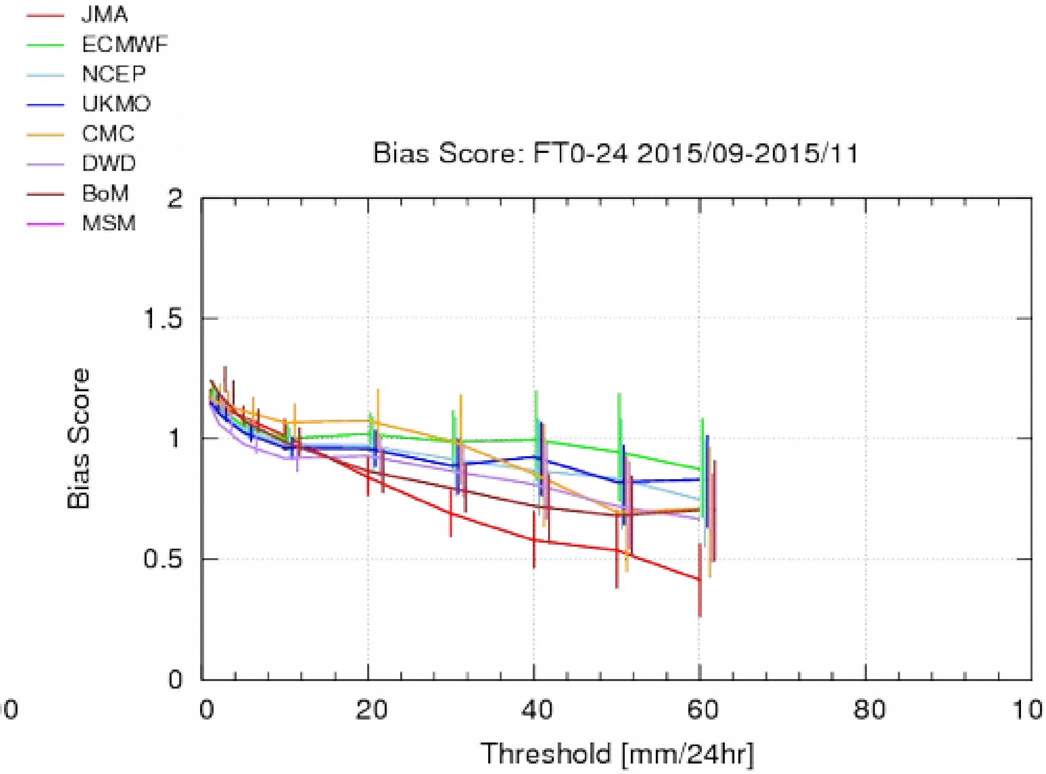


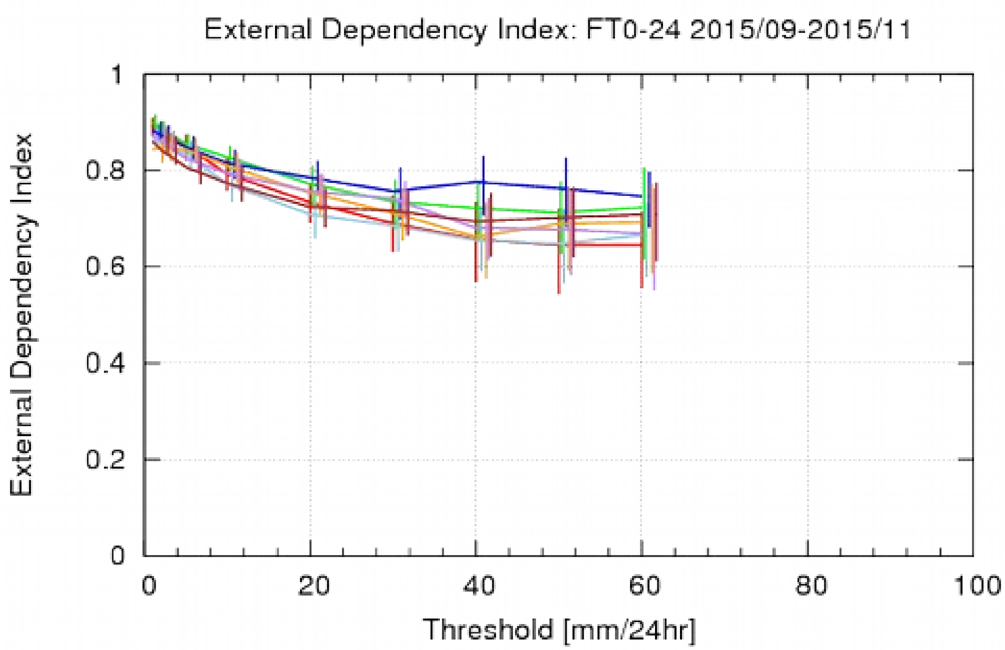


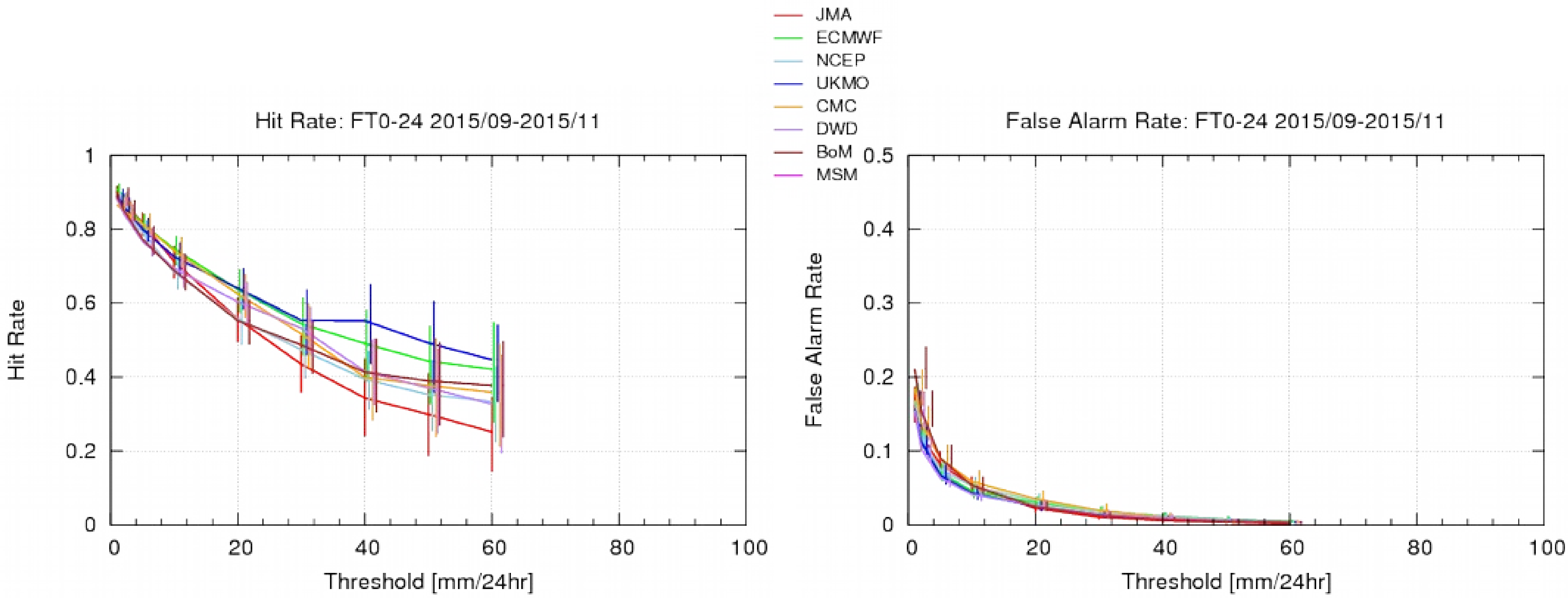

JMA
ECMWF
NCEP
UKMO
CMC
DWD
BoM
MSM
Hit Rate: 5.0mm/6h 2015/09-2015/11
Local Time
21 3 9 15 21 3 9 15 21 3 9 15 21 3 9 15 21 3 9 15 21
Hit Rate
1
0.8
0.6
0.4
0.2
0
0 24 48 72 96 120
Forecast Time [hr]
False Alarm Rate: 5.0mm/6h 2015/09-2015/11
Local Time
21 3 9 15 21 3 9 15 21 3 9 15 21 3 9 15 21 3 9 15 21
False Alarm Rate
0.5
0.4
0.3
0.2
0.1
0
0 24 48 72 96 120
Forecast Time [hr]

2015SON: FT=0-24

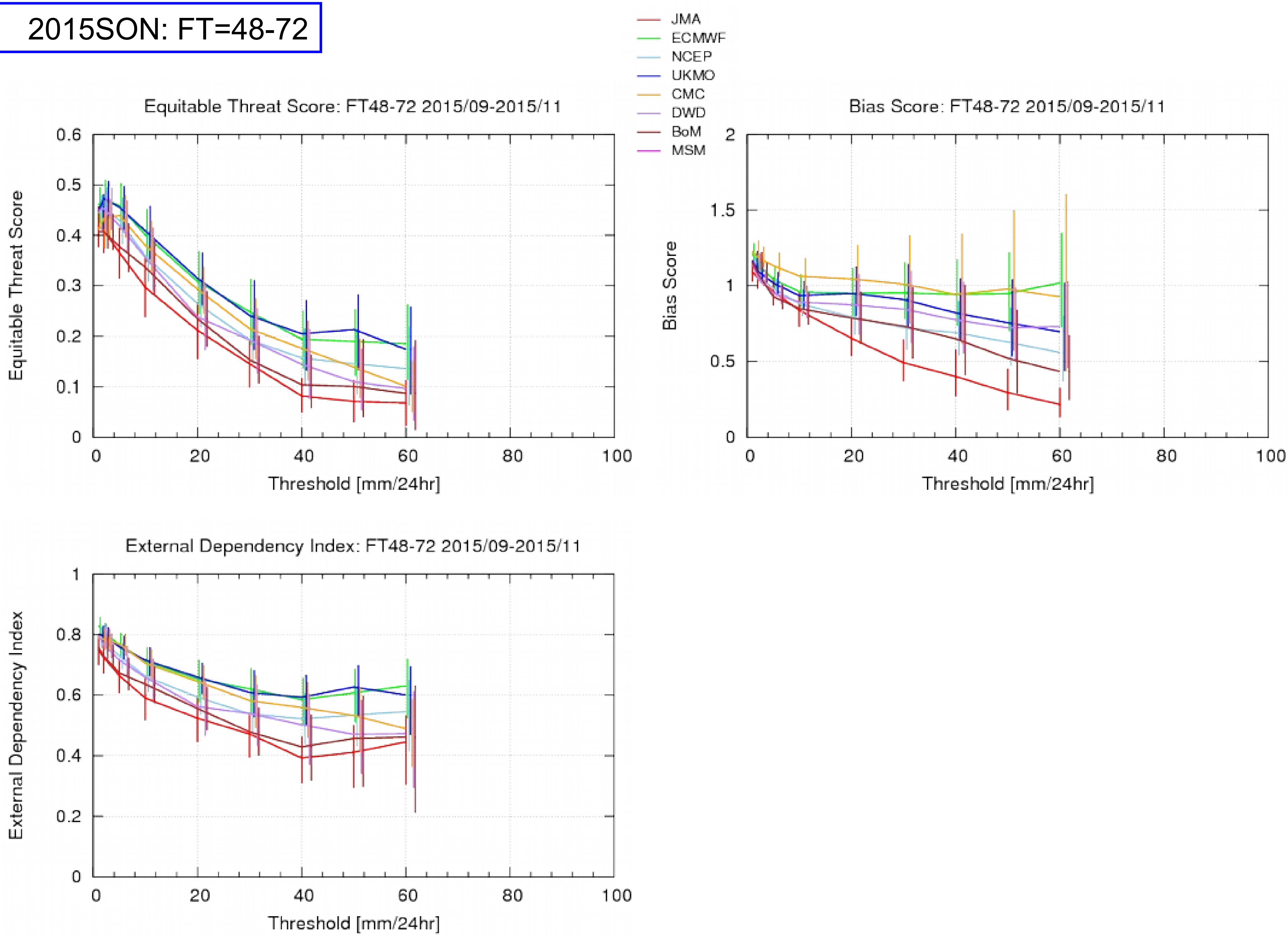


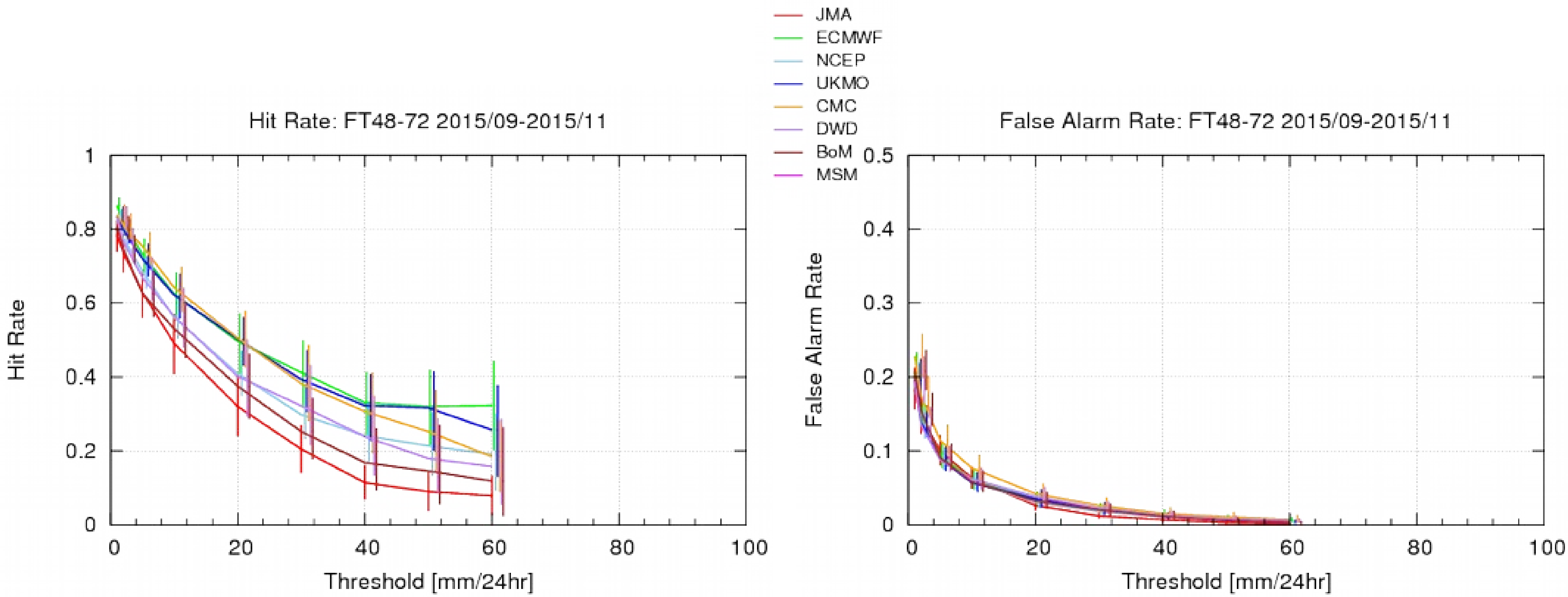





JMA
ECMWF
NCEP
UKMO
CMC
DWD
BoM
MSM
Hit Rate: FT0-24 2015/09-2015/11
Hit Rate
Threshold [mm/24hr]
False Alarm Rate: FT0-24 2015/09-2015/11
False Alarm Rate
Threshold [mm/24hr]

2015SON: FT=48-72




JMA
ECMWF
NCEP
UKMO
CMC
DWD
BoM
MSM
Hit Rate: FT48-72 2015/09-2015/11
Hit Rate
Threshold [mm/24hr]
False Alarm Rate: FT48-72 2015/09-2015/11
False Alarm Rate
Threshold [mm/24hr]

Memorandum

Major upgrades in 2014/12–2015/11

2014/11/18

CMC: Introduction of 4D-EnVar (previously 4D-Var). Improved data assimilation. Introduction of new sea-ice concentration analysis.

2015/01/14

NCEP: Improved horizontal resolution of forecast from Eulerian T574 (~27 km) to Semi-Lagrangian T1534 (~13 km). Improved horizontal resolution of analysis from Eulerian T192 (~84 km) to Semi-Lagrangian TL574 (~35 km). Improved physics.

2015/01/20

DWD: Introduction of ICON with horizontal resolution of 13 km (previously GME with 20 km).

2015/05/12

ECMWF: Introduction of Cycle 41r1 (including physics, data assimilation, etc.).

Major upgrades before 2014/12

BoM

2012/03/28: improved vertical and horizontal resolution to 40kmL70 to 80kmL50.

CMC

2013/02/13: Improved horizontal resolution to 25 km from 33 km. Changed vertical coordinate to sigma-p hybrid coordinate from sigma coordinate. Improved 4D-Var data assimilation and model physics.

2013/12/04: Changed the treatment of SST.

DWD

ECMWF

2013/06/25: improved vertical resolution to L137 from L91.

2013/11/19: Introduction of Cycle 40r1.

NCEP

UKMO

2014/07/15: Improved horizontal resolution to 17 km from 25 km. Introduction of new dynamical core (ENDGame).

JMA

2007/11/xx: improved horizontal and vertical resolution (20 km, 60 levels, model top 0.1 hPa).

2008/01/xx: Improved deep convection scheme.

2008/08/xx: Improved dynamics. Introduction of adaptive Gauss mesh.

2012/12/xx: Improve Sc scheme.

2013/04/xx: Improved radiation processes.

2014/03/18: Improved the vertical resolution to TL959L100 (top 0.01 hPa) from TL959L60 (0.1 hPa). Improved physics.

MSM

Major upgrades after 2015/11

CMC

2015/12/15: GDPS version 5.0.0

JMA

2016/03/24?: Improved physics.

Intercomparison over France of QPF from WGNE members models

Observations : Rain gauges

RR24: 24 hours accumulated rainfall

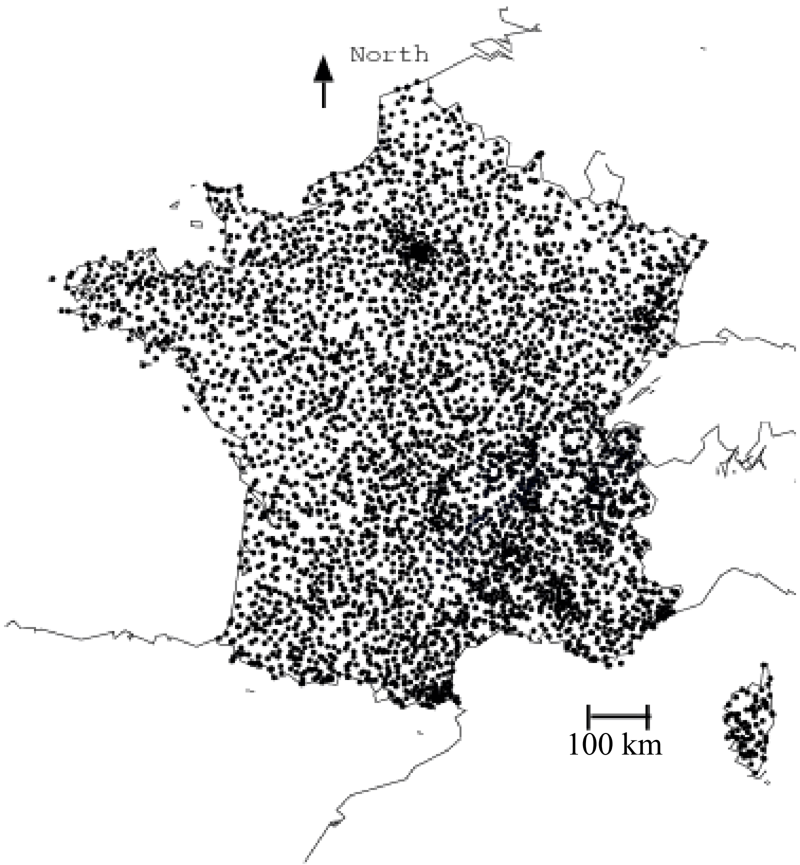
J+1

Bias, FAR, POD and HSS

Thresholds 1mm and 10 mm

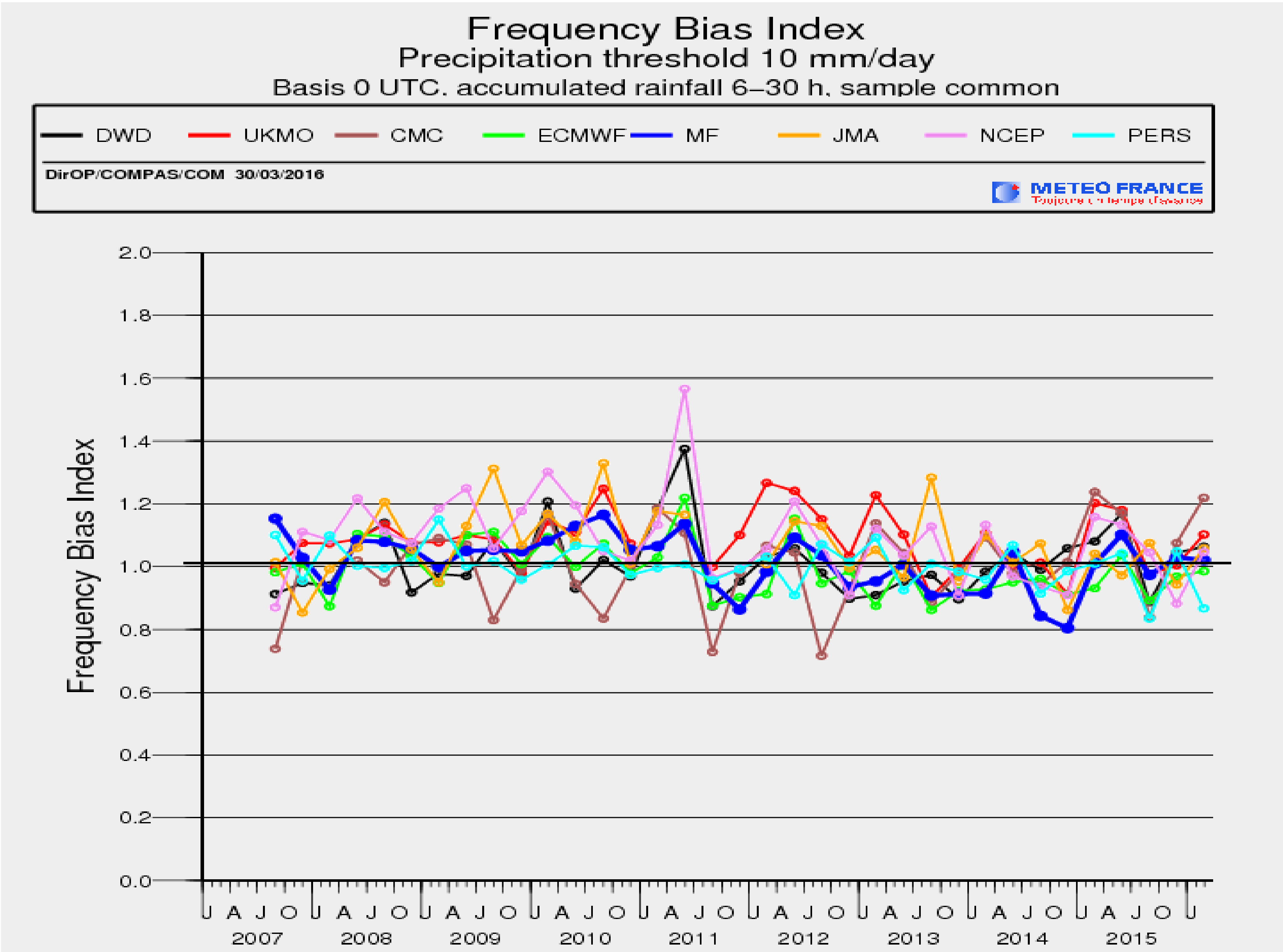
QPF verification

- Average the data and the models QPF at 0.5°x0.5°

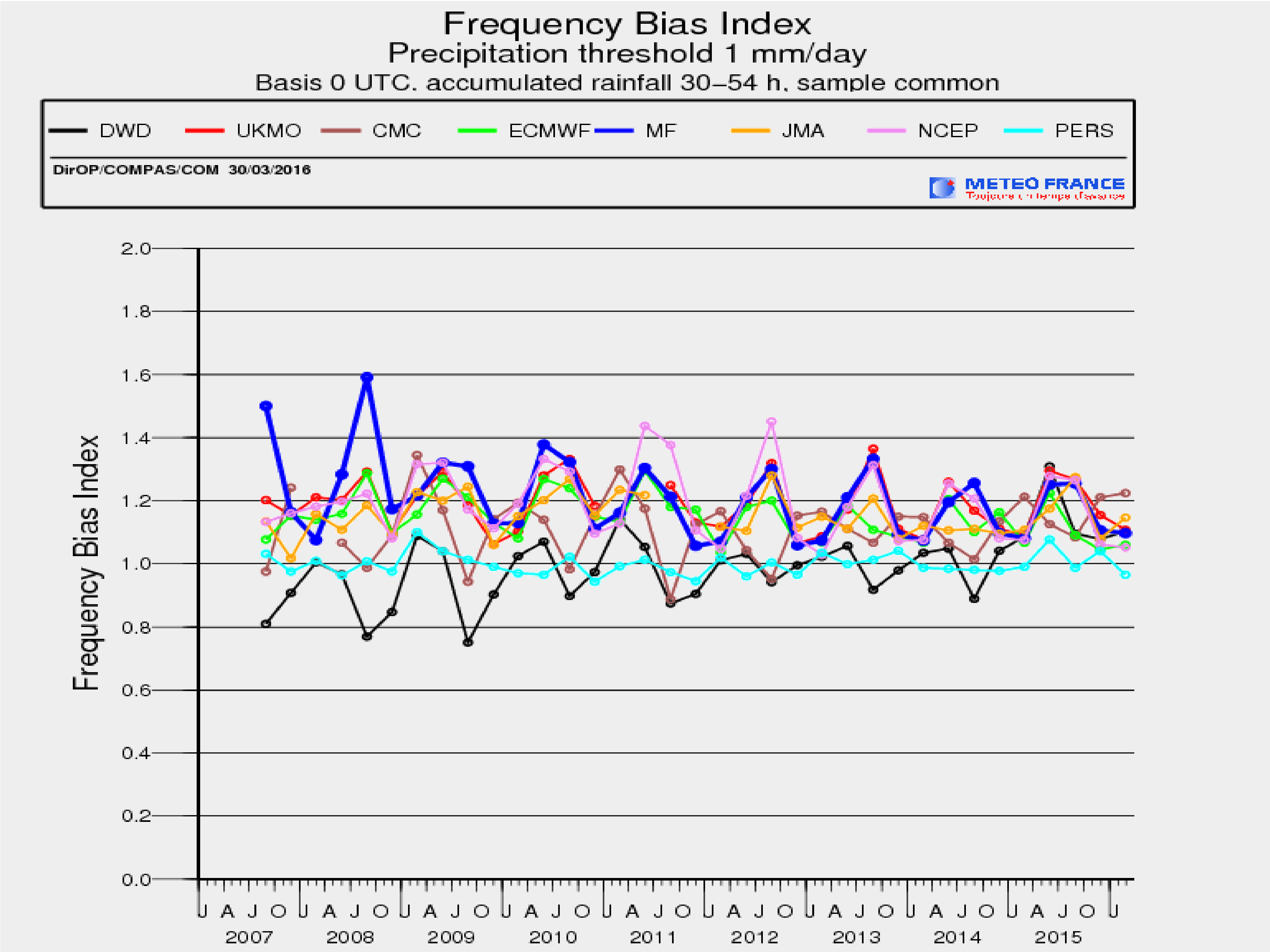


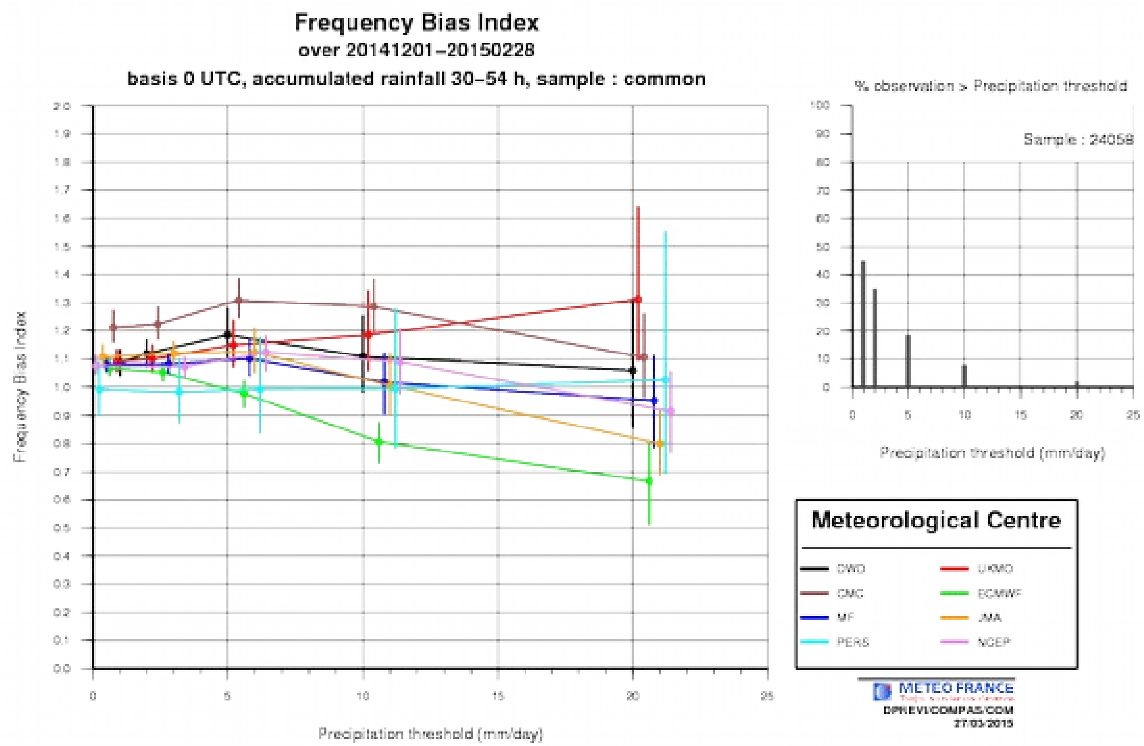
Climatological state network

~4000 raingauges giving 24 hours accumulated rain every day



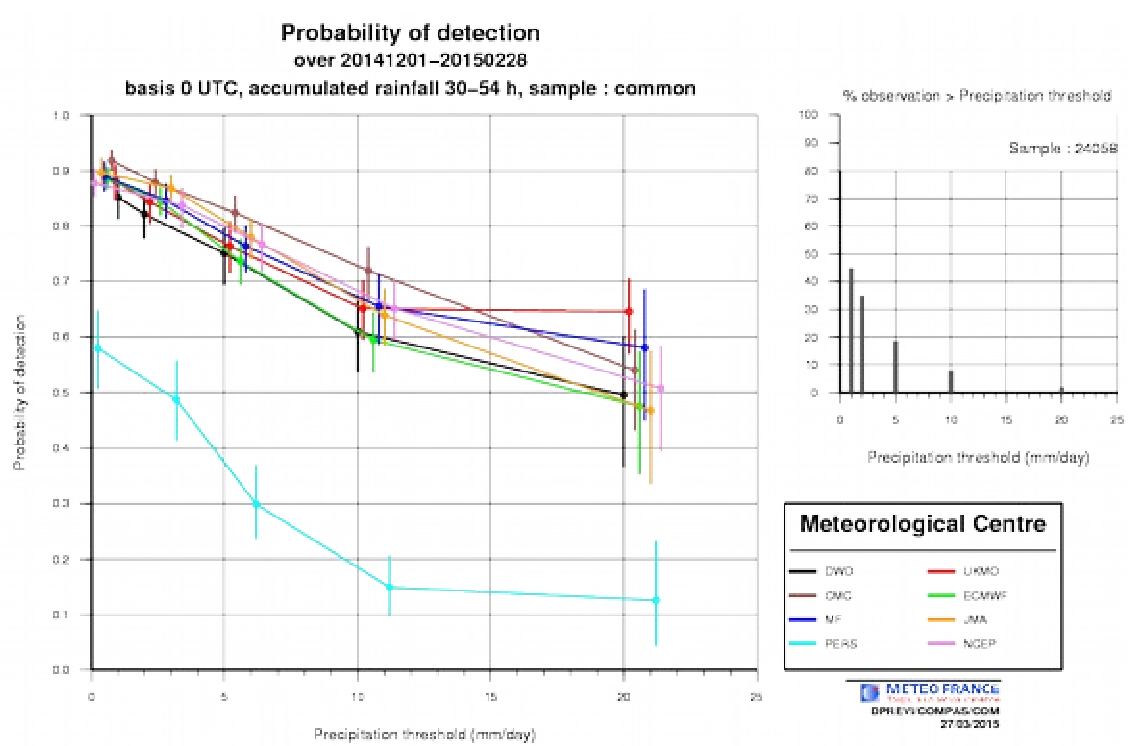
Frequency Bias Index
Precipitation threshold 10 mm/day
Basis 0 UTC. accumulated rainfall 6–30 h, sample common
DWD
UKMO
CMC
ECMWF
MF
JMA
NCEP
PERS
DirOP/COMPAS/COM 30/03/2016
METEO FRANCE
Frequency Bias Index
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
J A J O J A J O J A J O J A J O J A J O J A J O J A J O J A J O J A J O J
2007
2008
2009
2010
2011
2012
2013
2014
2015

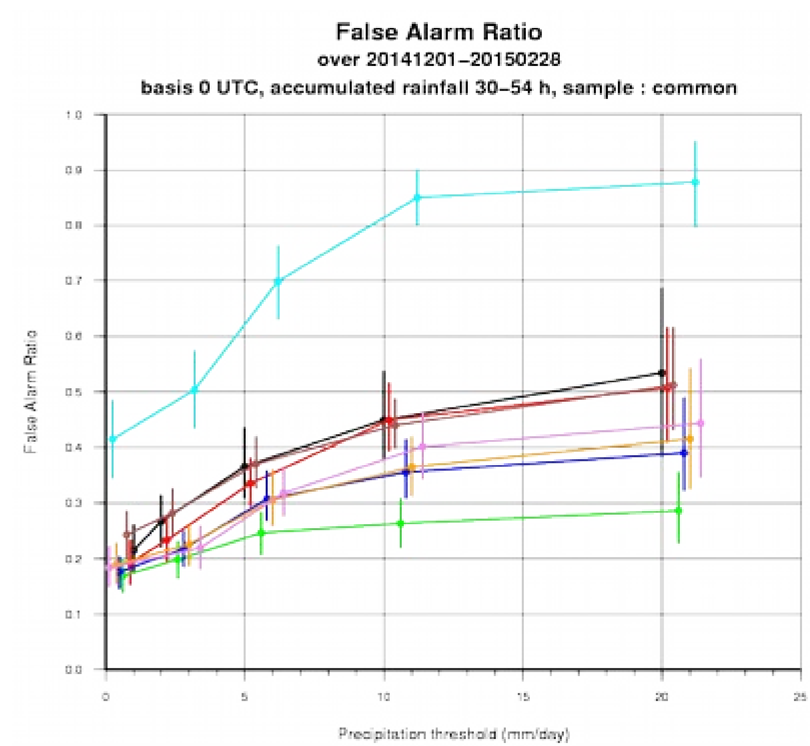

Frequency Bias Index
Precipitation threshold 1 mm/day
Basis 0 UTC. accumulated rainfall 30–54 h. sample common
DWD
UKMO
CMC
ECMWF
MF
JMA
NCEP
PERS
DirOP/COMPAS/COM 30/03/2016
METEO FRANCE
Frequency Bias Index
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
2007
2008
2009
2010
2011
2012
2013
2014
2015



WINTER 2014-2015

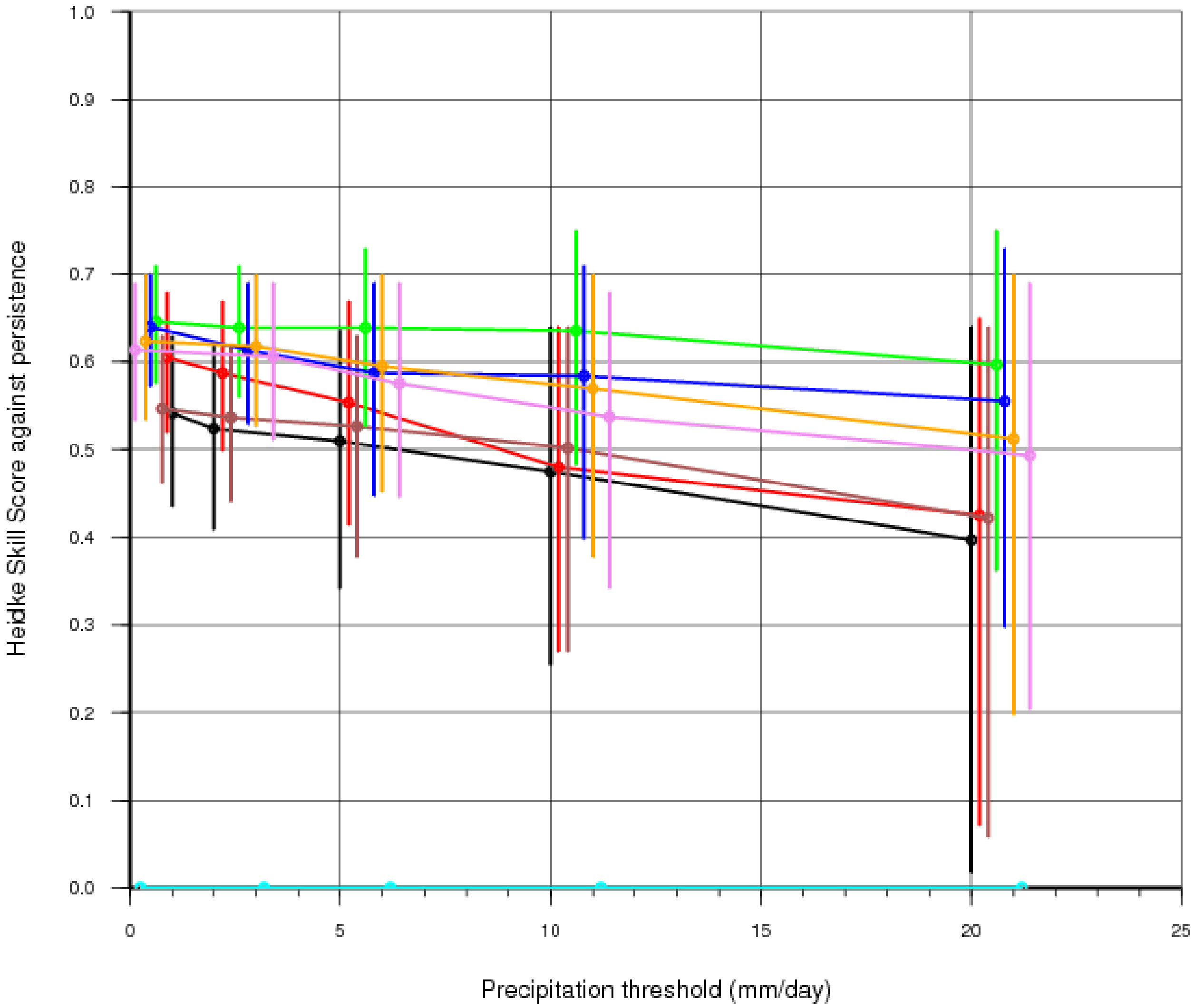
Lead time 54 UTC

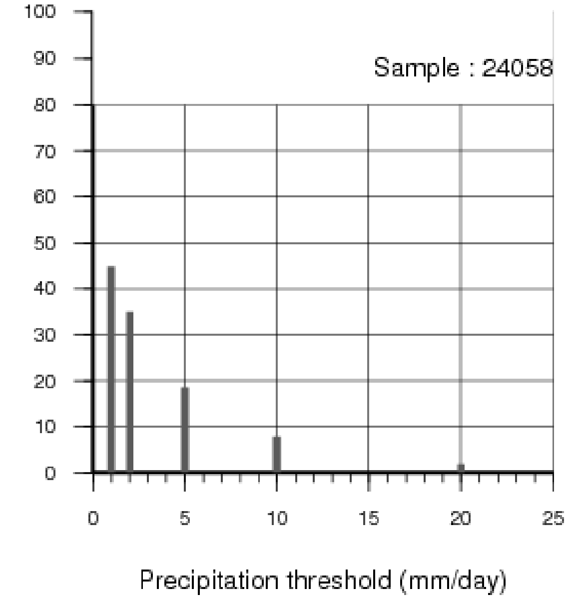




WINTER 2014-2015

Lead time 54 UTC





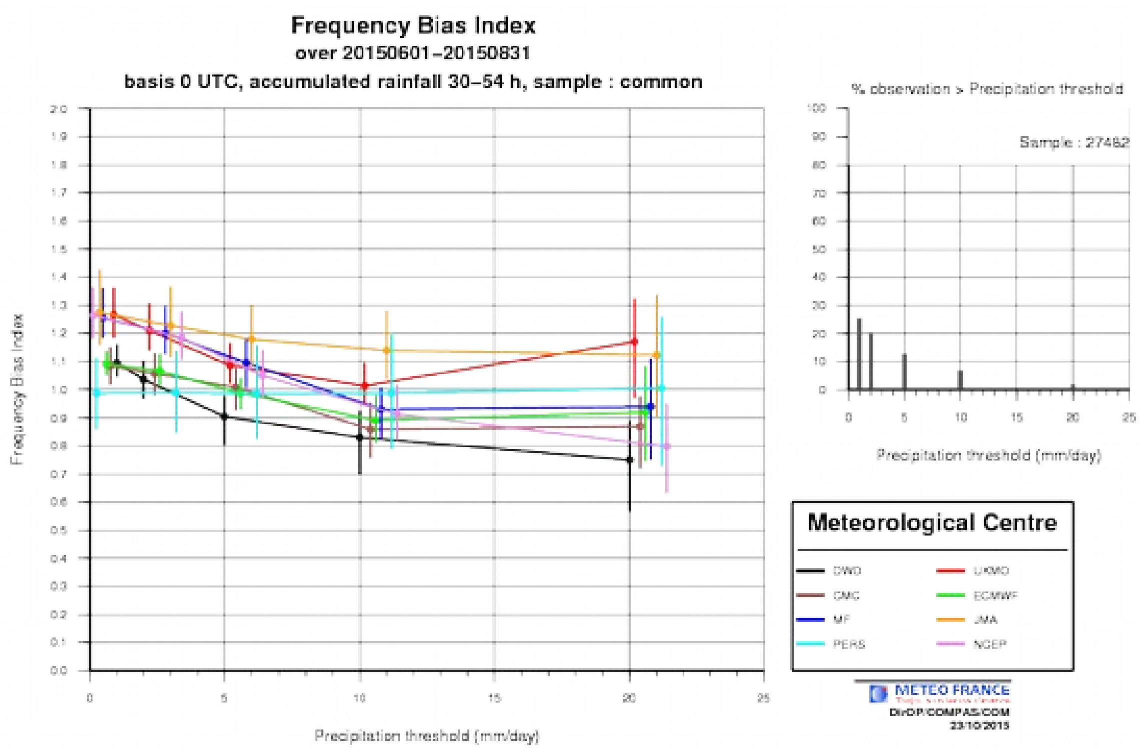
Meteorological Centre

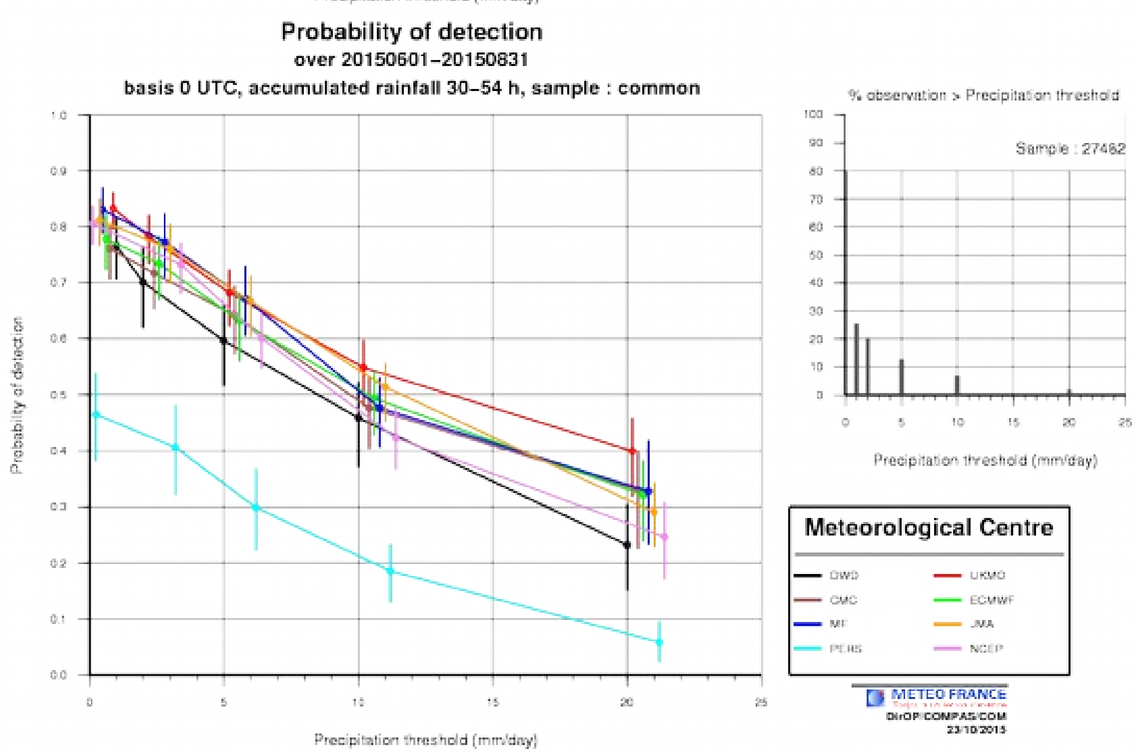
DWD	UKMO
CMC	ECMWF
MF	JMA
PERS	NCEP

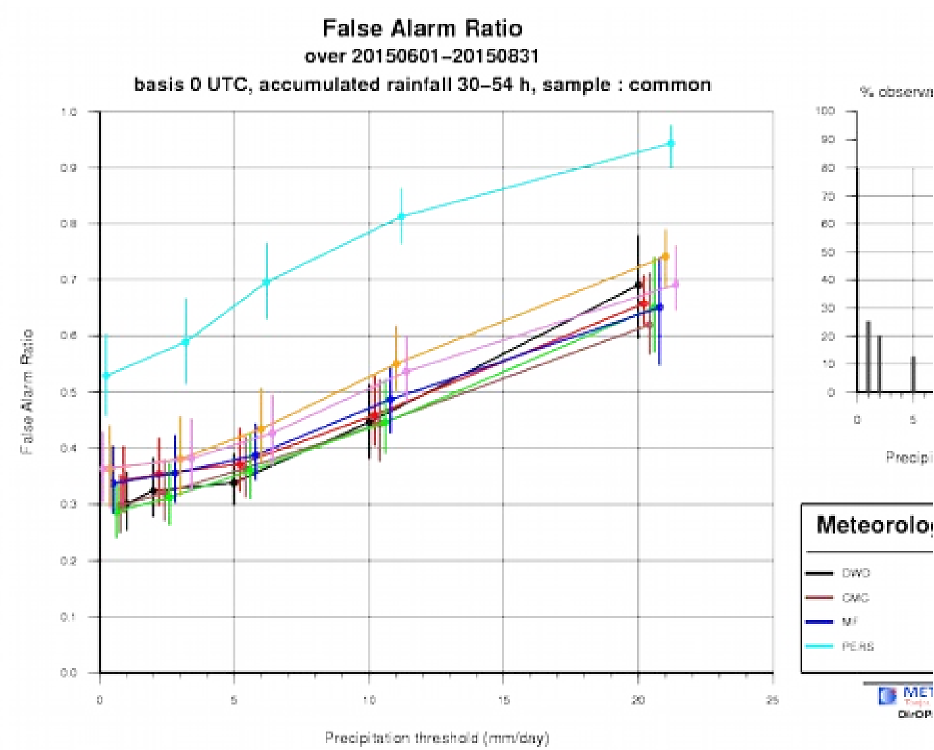
METEO FRANCE
DPREVI/COMPAS/COM
27/03/2015

Summer 2015

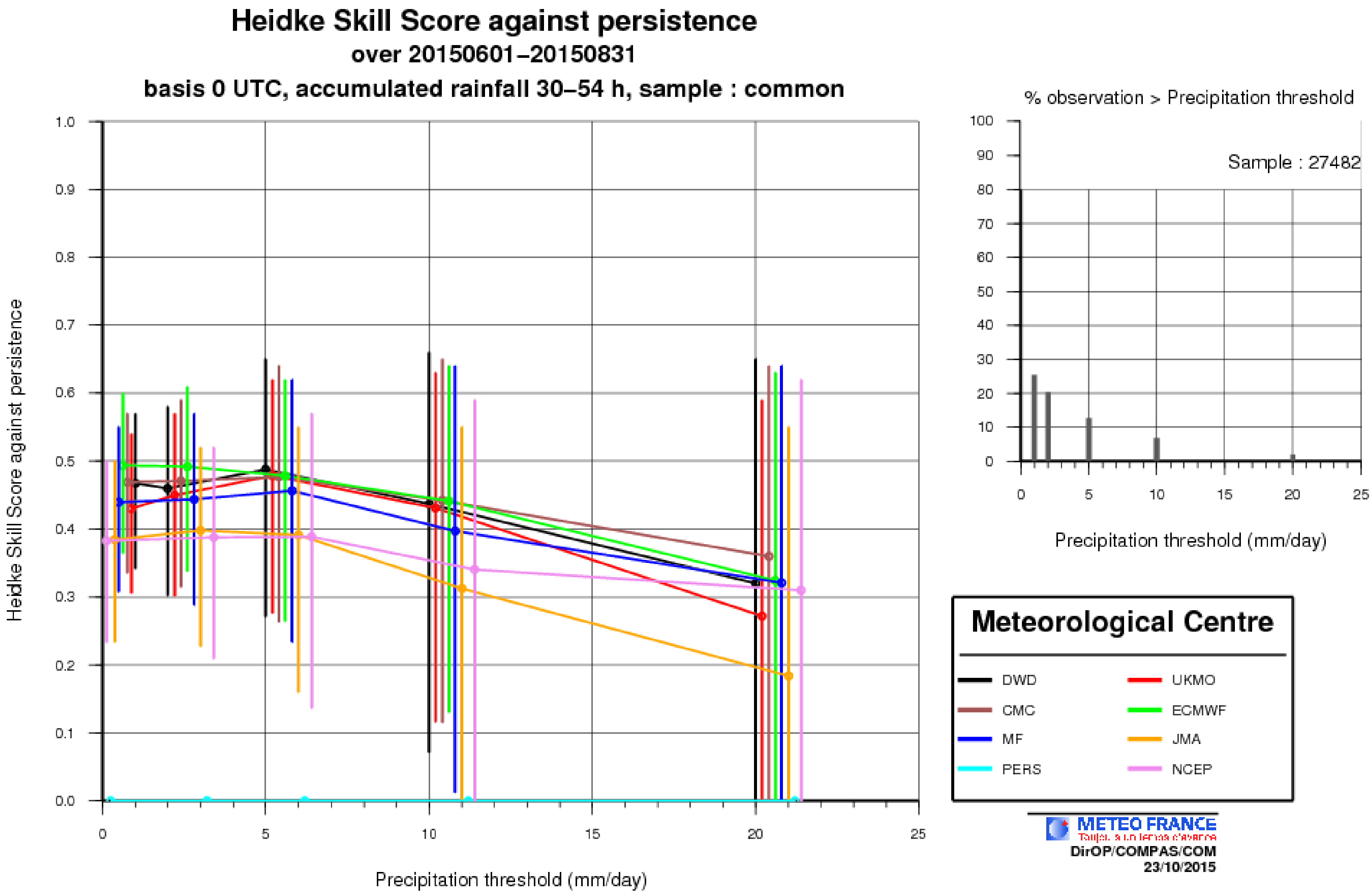
Lead time 54 UTC







Summer 2015 Lead time 54 UTC

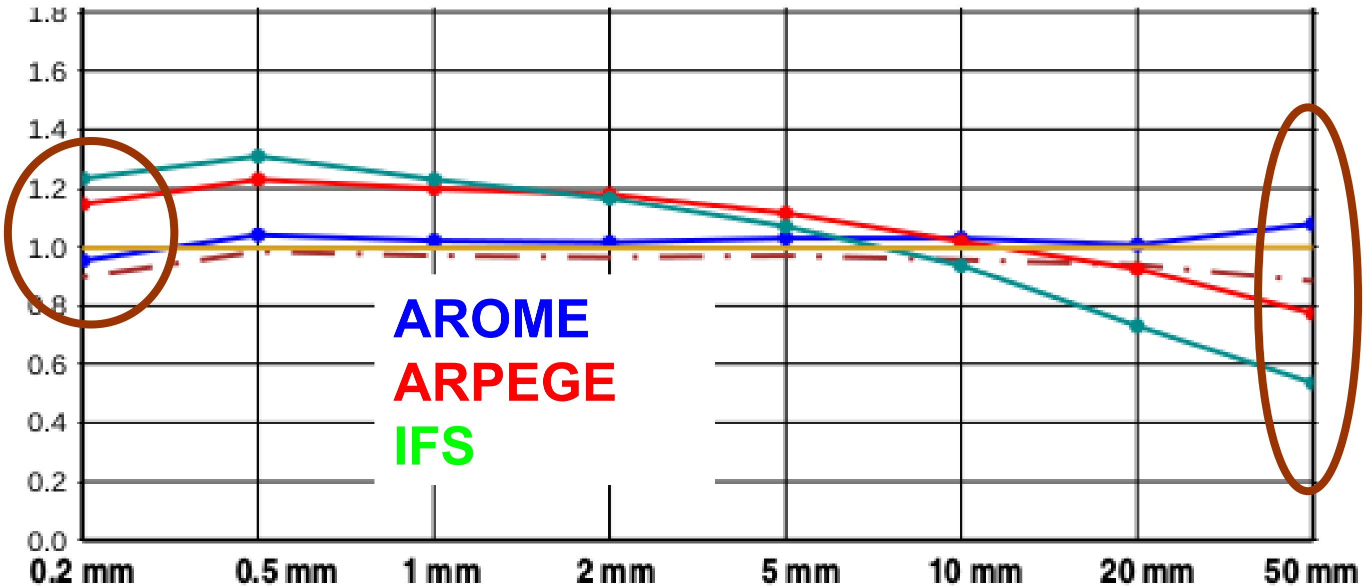


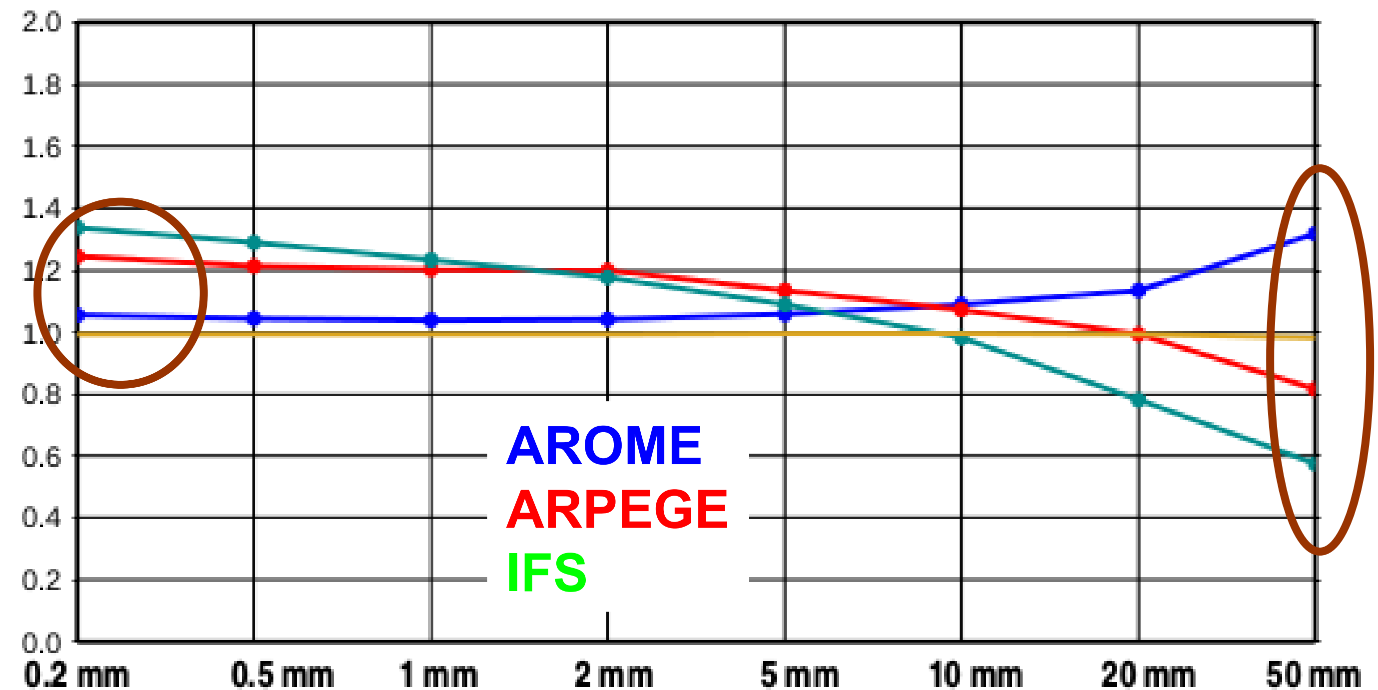
METEO FRANCE
DirOP/COMPAS/COM
23/10/2015

QPF verification over France from operational models against hight resolution observations

- **Gridded observations : combined radar-gauge analyses (ANTILOPE)**
- **RR24**
- Verification grid 0.025°
- Year 2014
- Bias, BSS_NO
- Thresholds 0.2, 0.5, 1, 2, 10, 20 and 50 mm

RR24 Year 2015 Frequency Bias





Against Rain gauges Stations ⌈ 4000 pts

ANTILOPE BIAS :

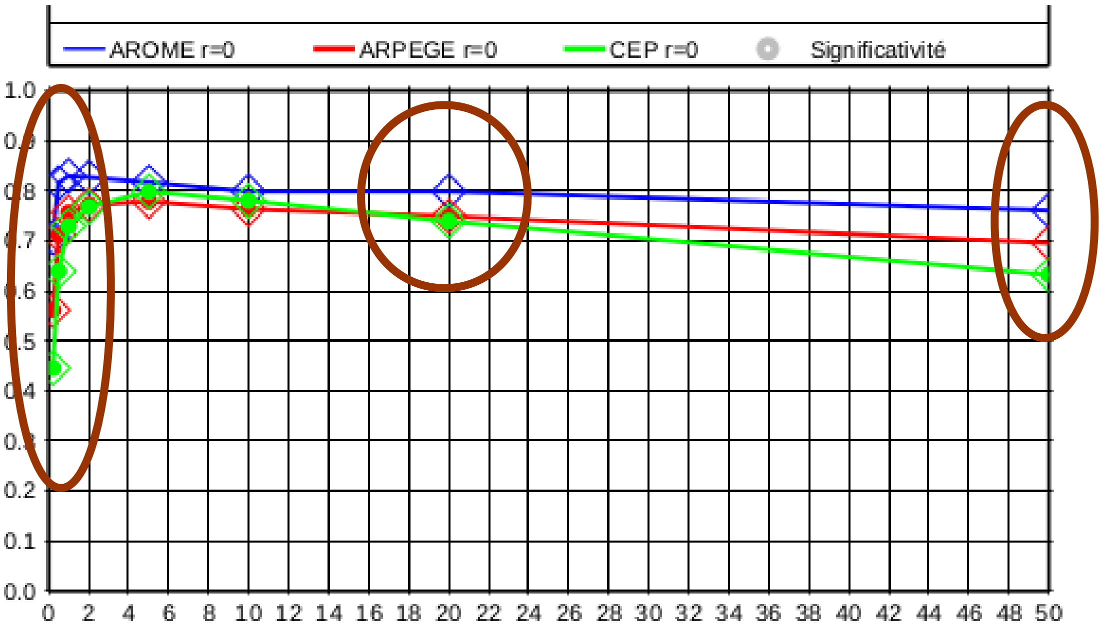
Sligth underestimation for weak rains

10% underestimation rr24 >= 50mm/24H

Against ANTILOPE ⌈ 125000 pts

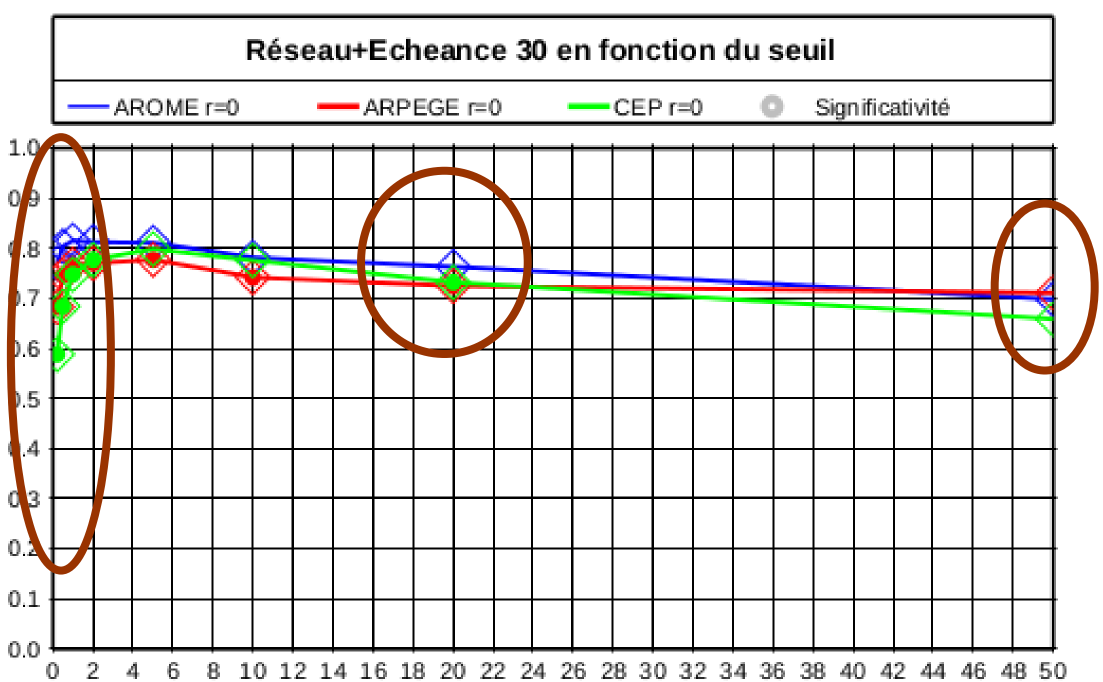
AROME bias for heavy rains increases when ANTILOPE underestimates phenomena

RR24 Year 2015 BSS_NO 50 km



Against
Rain gauges
stations

AROME
ARPEGE
IFS



Against ANTILOPE :

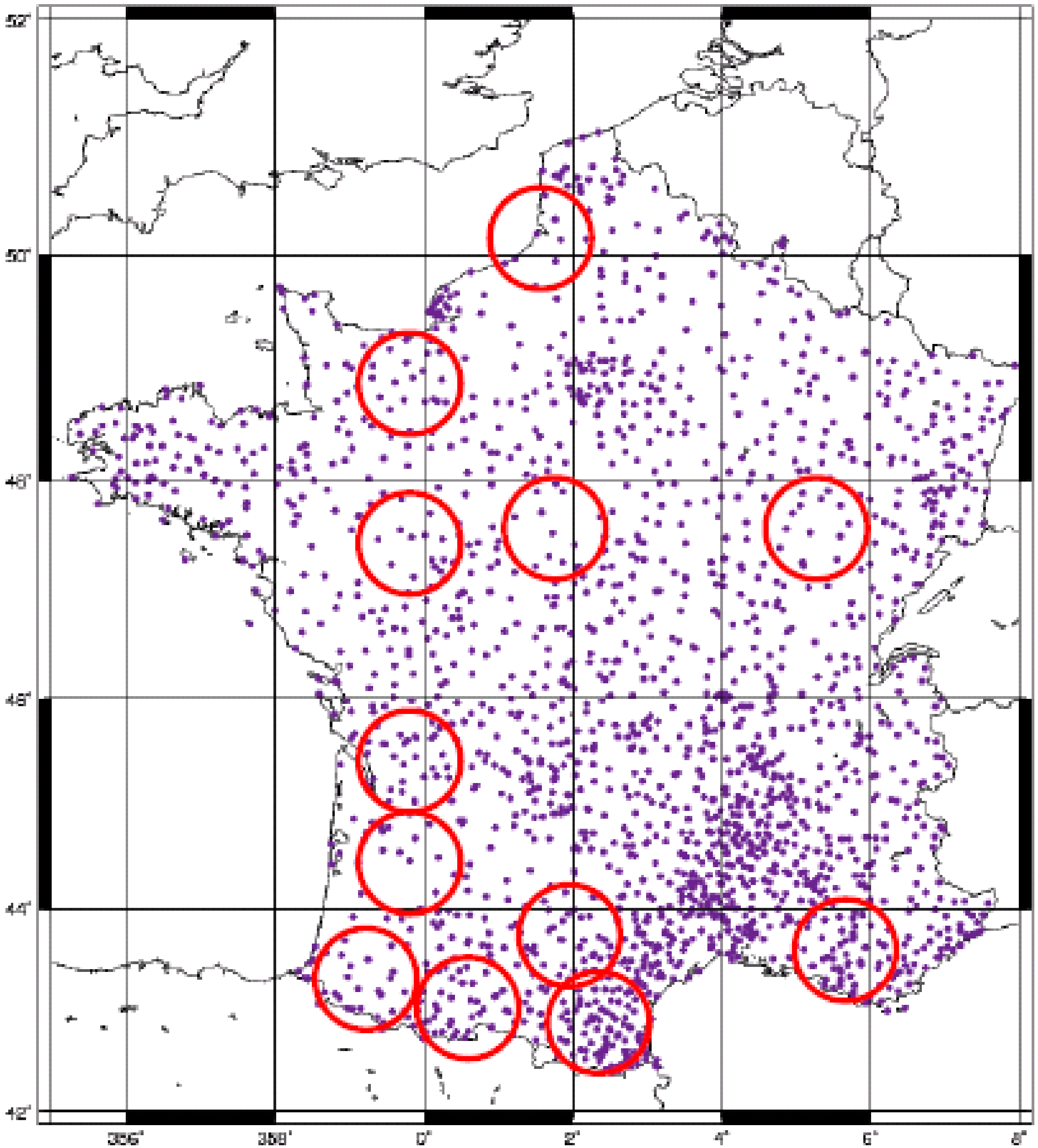
Better estimation of rain/no rain threshold

similar results with both references except for 50mm threshold

QPF verification over France from the operational HR model AROME using neighbourhood method

- **RR6: 6 hours accumulated rainfall**
- recommandation : FSS
- Météo-France choice : BSS

6 hours accumulated rainfall



data and models QPF are averaged on 0.0025°squares

Climatological state network

~1800 raingauges giving hourly accumulated rain

Red circles of radius 50 km give exemples of neighbourhood

FSS versus BSS_NO

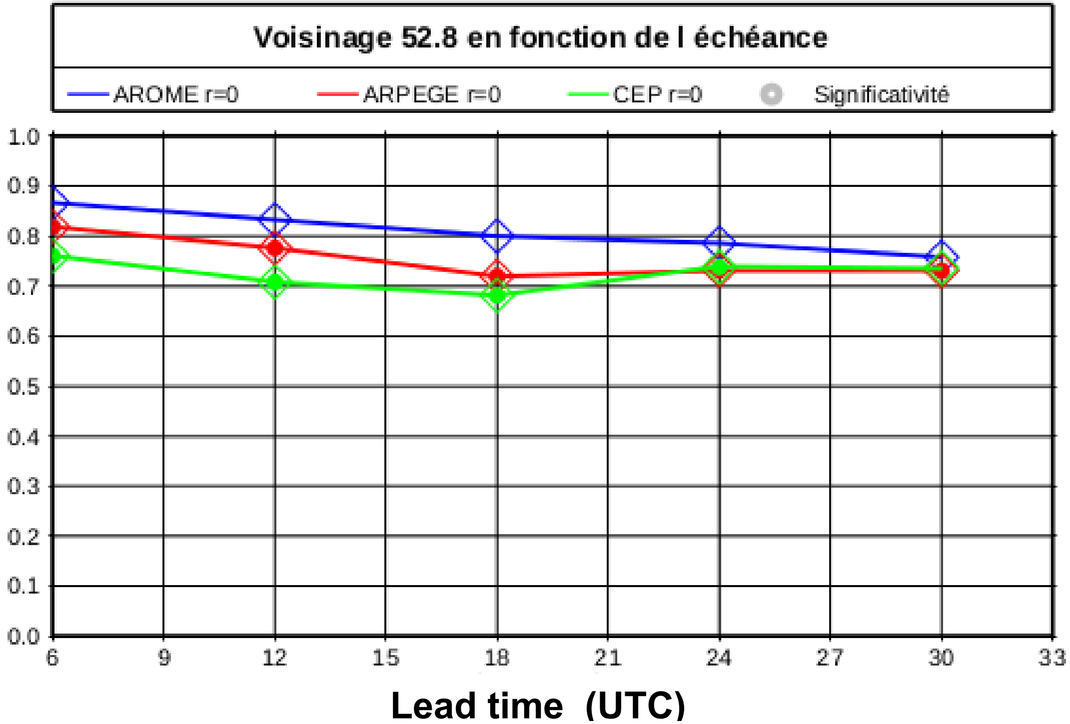
$$\textbf{BS or FBS} = \frac{1}{N_{days}} \sum_{j=1}^{N_{days}} \frac{1}{N_{obs}} \sum_{o=1}^{N_{obs}} \left(v_{forecast}(o,j) - v_{obs}(o,j) \right)^2$$

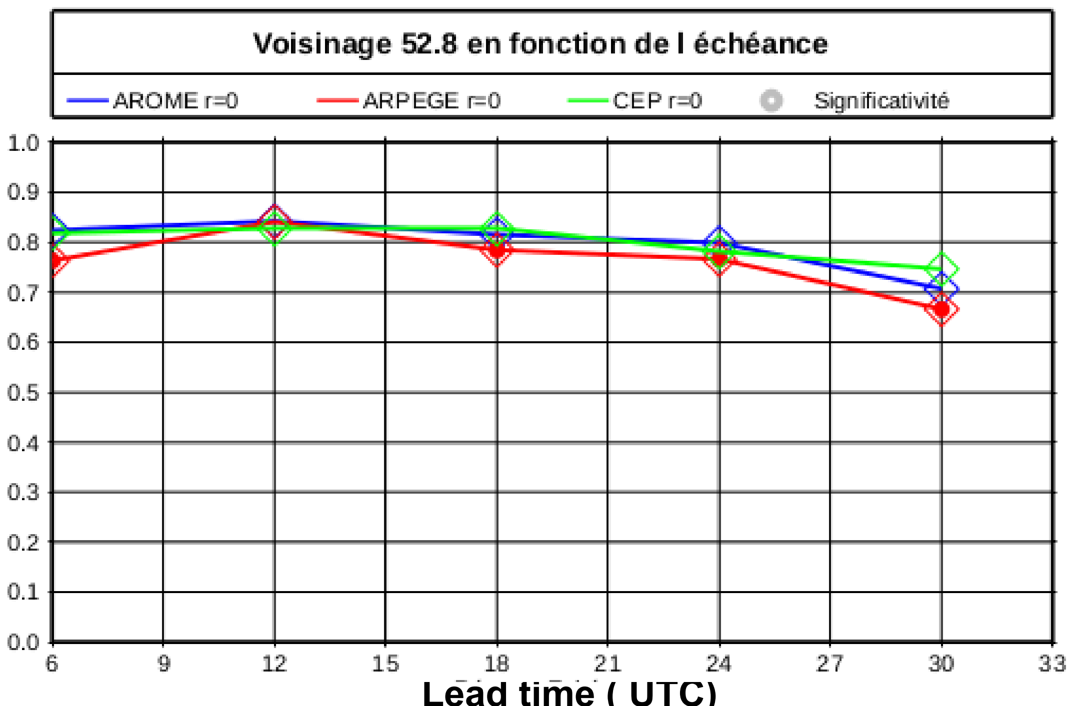
$$\textbf{FSS} = 1 - \frac{\textbf{FBS}}{\textbf{FBS}_{reference}}$$

$$\textbf{BSS\_NO} = 1 - \frac{\textbf{FBS}}{\textbf{FBS}_{persistence}}$$

$$\textbf{FBS}_{reference} = \frac{1}{N_{days}} \sum_{j=1}^{N_{days}} \frac{1}{N_{obs}} \left[\sum_{o=1}^{N_{obs}} v_{forecast}(o,j)^2 + \sum_{o=1}^{N_{obs}} v_{obs}(o,j)^2 \right]$$

6 hours accumulated rainfall BSS_NO





Neighbourhood **50 km**

Winter 2014-2015

Threshold **0.5 mm**

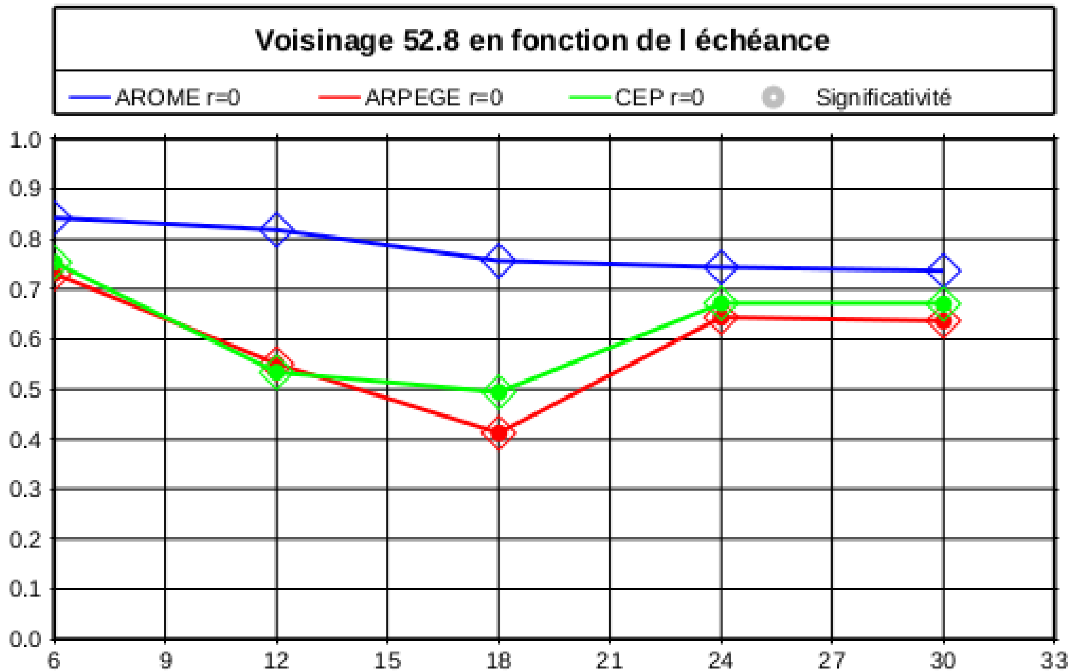
AROME
ARPEGE
IFS

Threshold **5 mm**

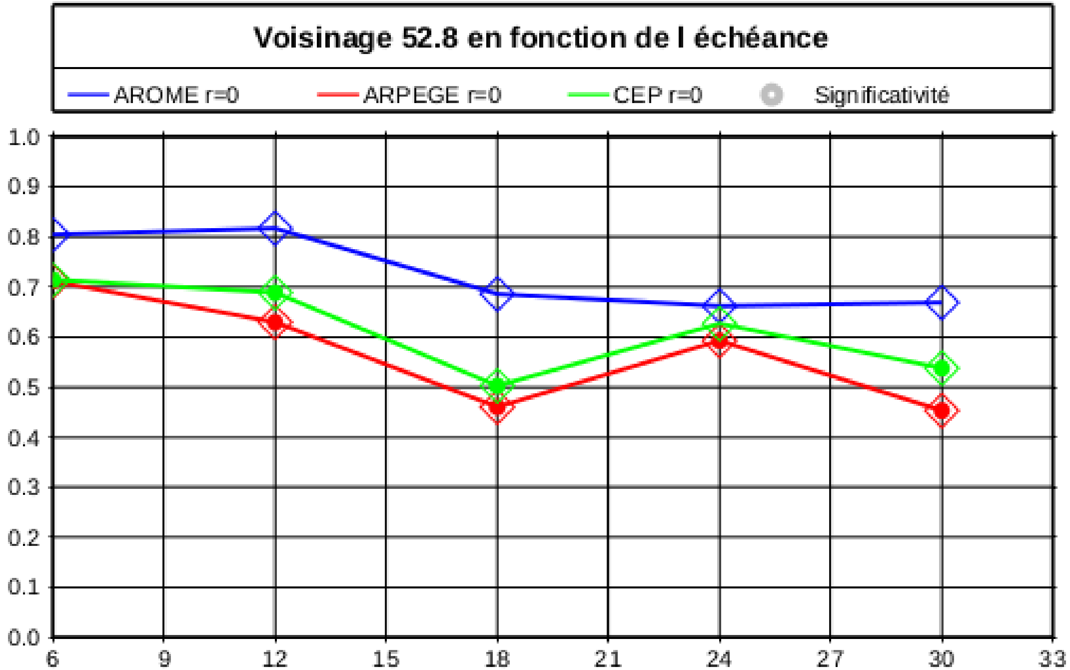
6 hours accumulated rainfall BSS_NO

Neighbourhood 50 km

Summer 2015



Threshold 0.5 mm



Threshold 5 mm

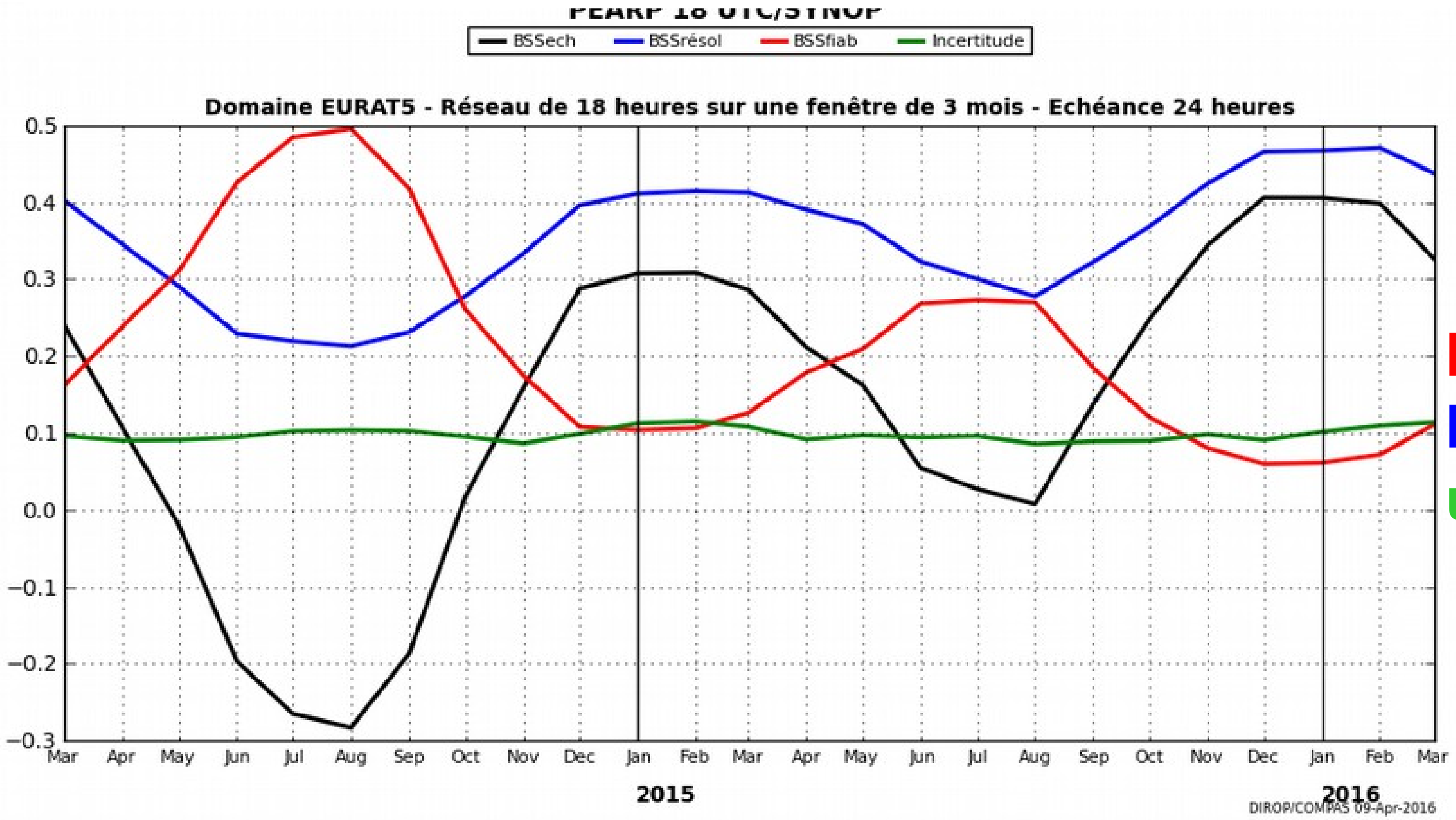
Probabilistic forecasts from ensembles

- RR6 verification of PEARP
  - ✓ for thresholds 0.2 1 2 et 4mm/6h // raingauges ;
  - ✓ 0.5° grid
  - ✓ Verification using the nearest grid point of the observation
- RR24 verification for thresholds 1 5 10 20mm /24h
- Scores :
  - ✓ BSS and components
  - ✓ Reliability diagram
  - ✓ Roc diagram and roc area

BSS and components

PEARP 18 UTC/SYNOP Domain EURAT5

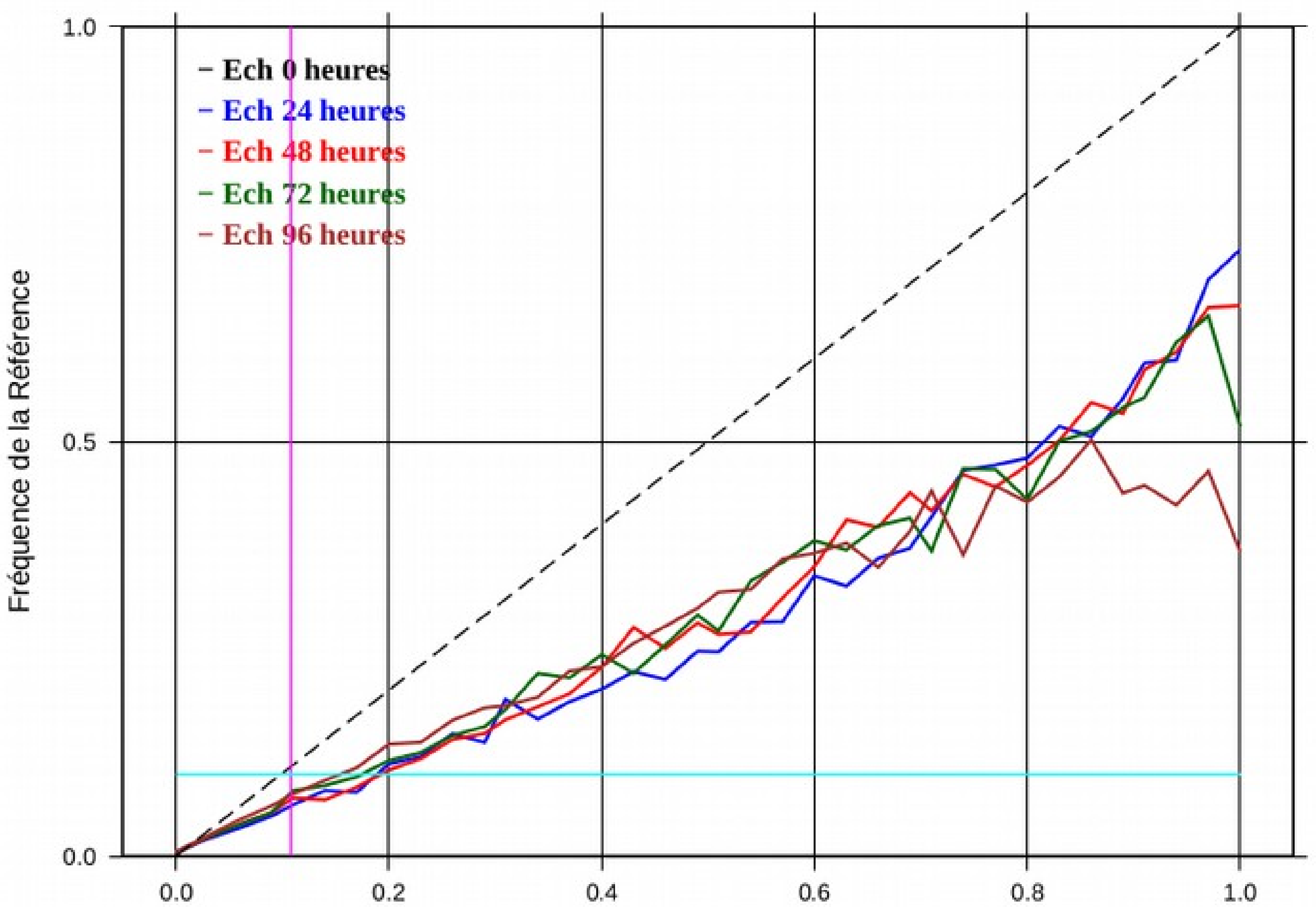
6 hours accumulated rainfall for threshold 1 mm



BSS_clim
BS_reliability
BS_resolution
uncertainty

Reliability diagram

PEARP/SYNOP Domain EURAT5



SUMMER 2015

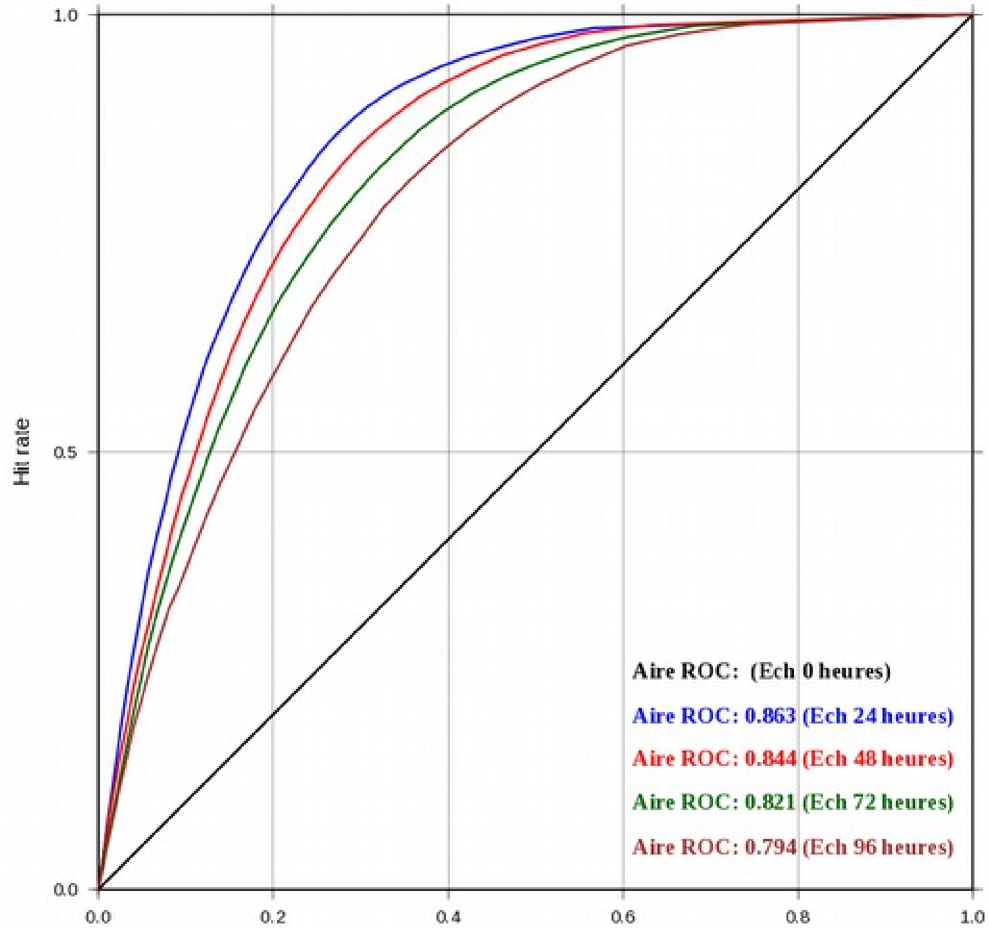
6 hours accumulated rainfall
threshold 1 mm
Issu 18UTC
validity 18 UTC

Roc diagram and roc area

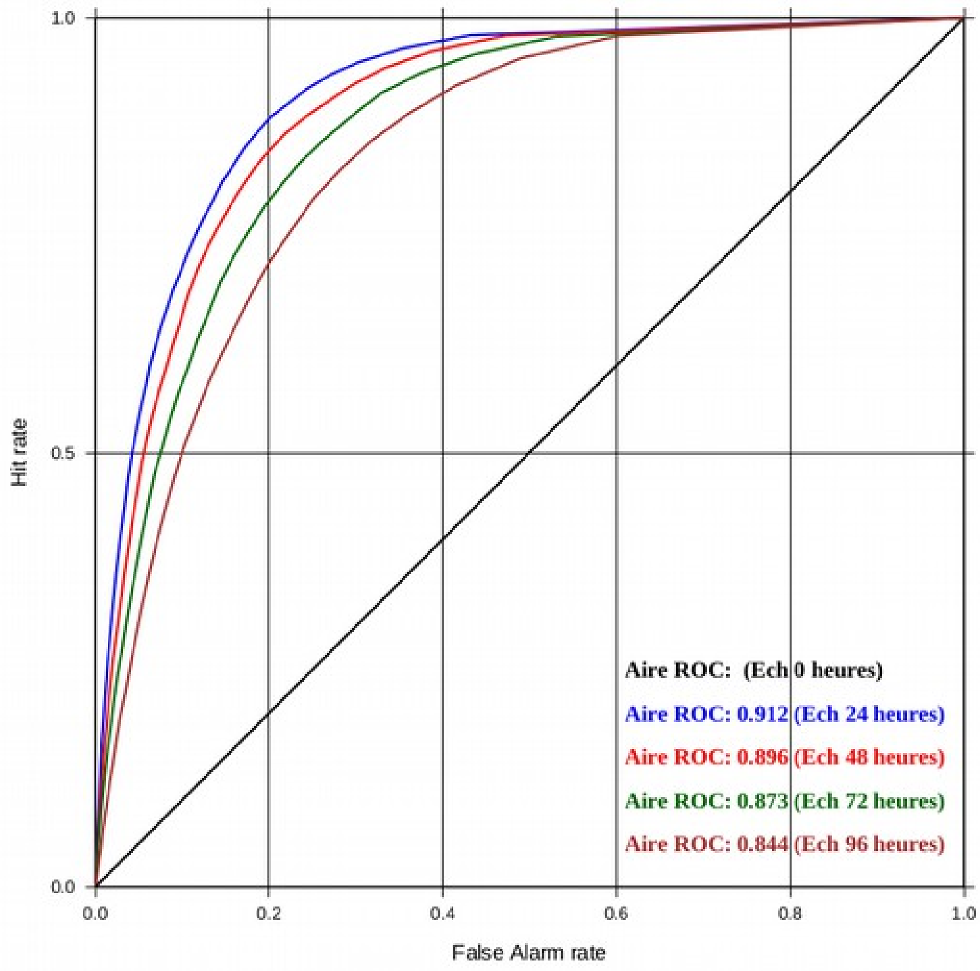
PEARP/SYNOP   Domain EURAT5   6 hours accumulated rainfall

threshold 1 mm / issu 18 UTC / validity 18 UTC

Summer 2014



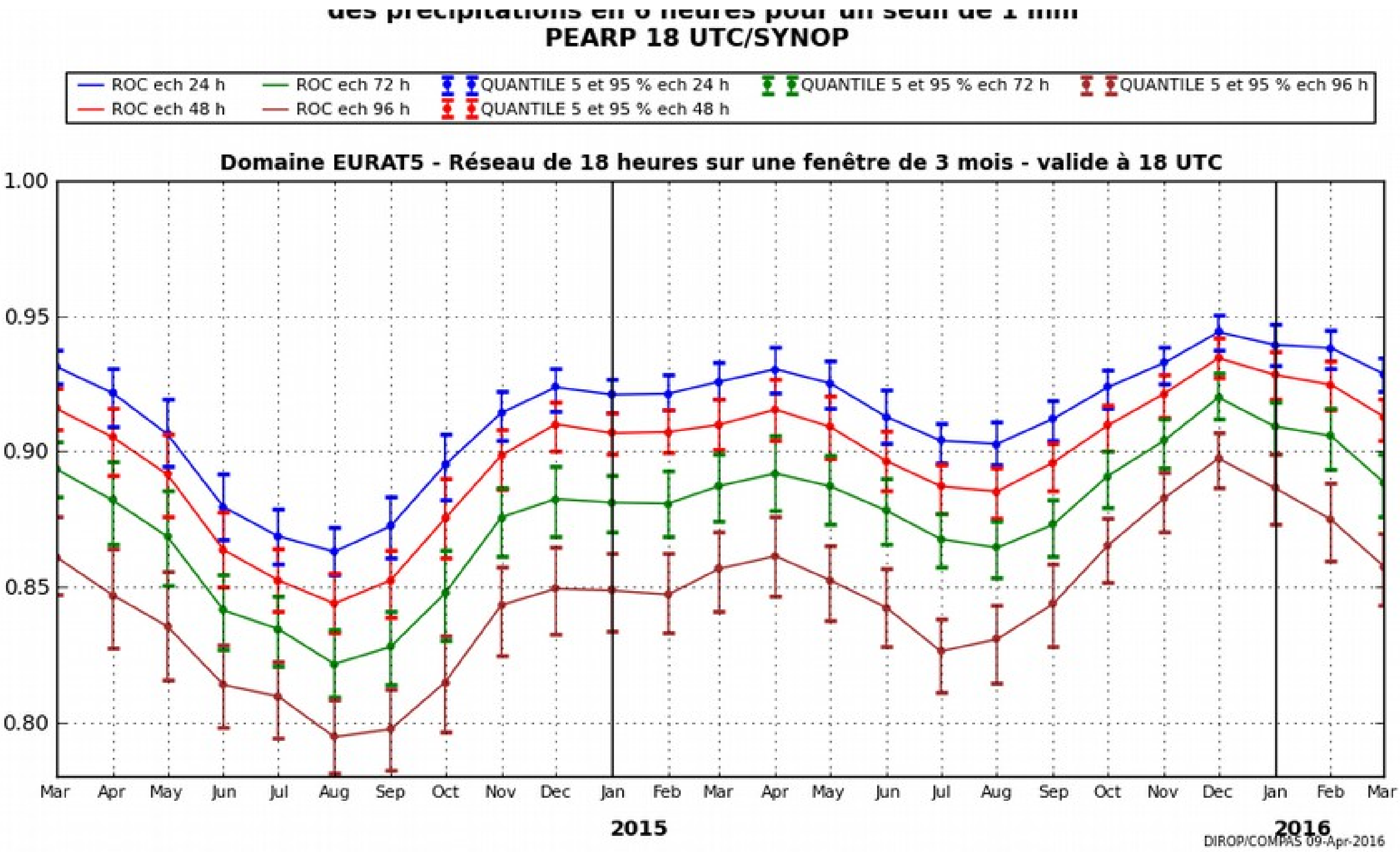
SUMMER 2015



Roc area : 3 month mean evolution

PEARP 18 UTC/SYNOP Domain EURAT5

6 hours accumulated rainfall for threshold 1 mm



24 h range

48 h range

72 h range

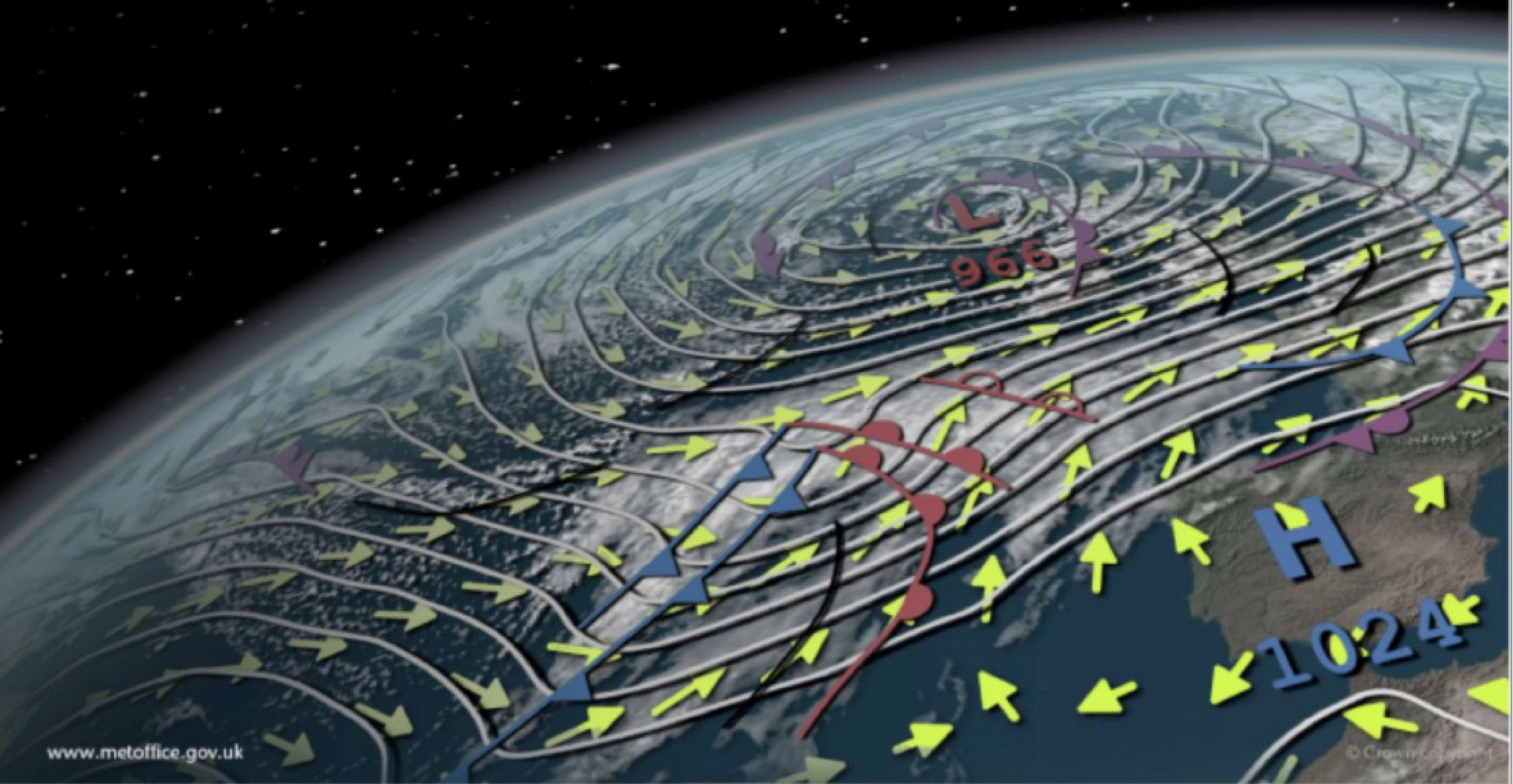
96 h range

&quantiles 5 95%

UKMO

Met Office

Global model precipitation verification

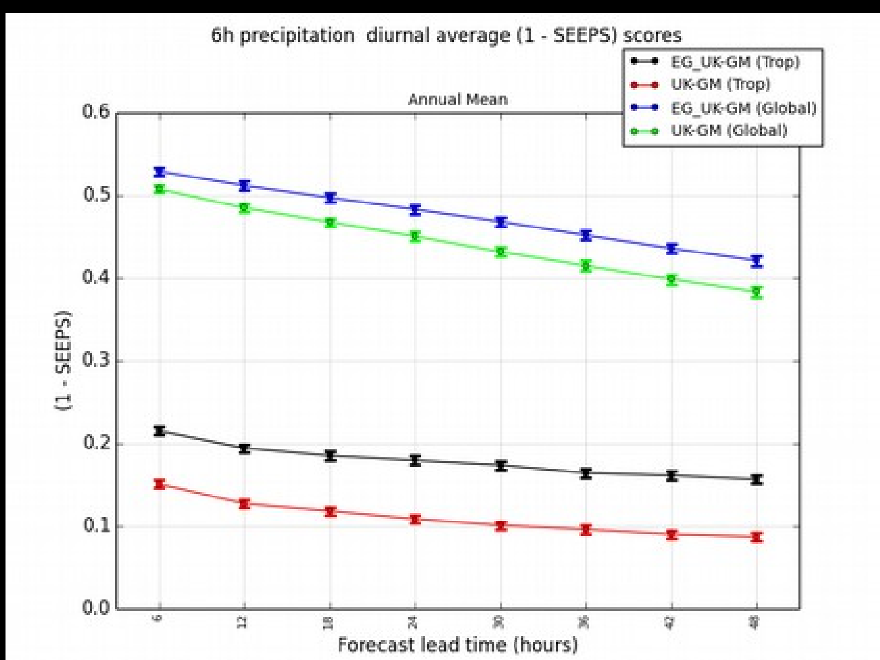


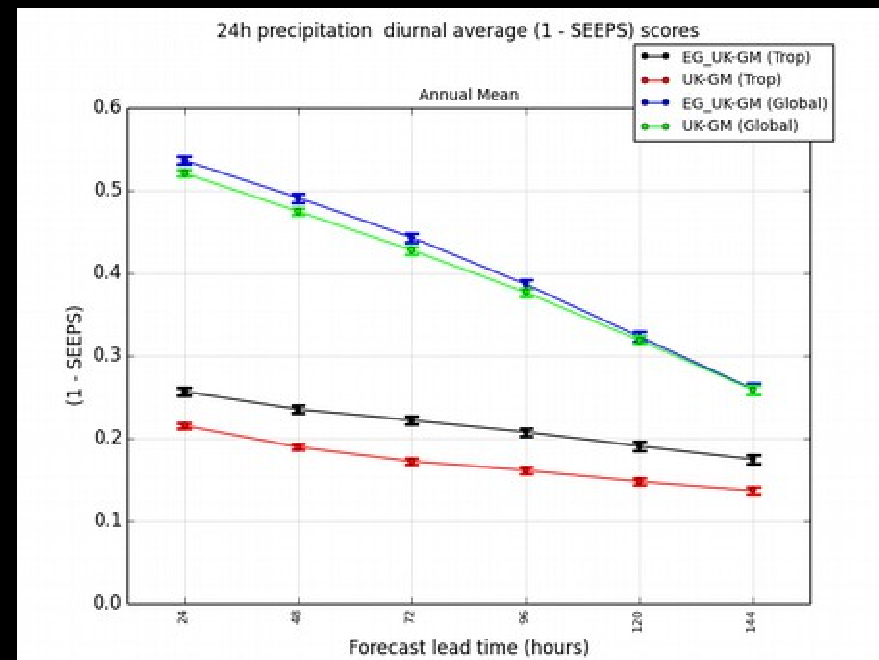
Verification of QPF using SEEPS

Score with forecast lead time, April 2012 to February 2016

SEEPS skill score from UM Global
6-hour accumulations
(6h to 48h)

Diurnal averages
Tropics: red & black
Global: blue & green





SEEPS skill score from UM Global
24-hour precipitation accumulations (day 1 to 6)

www.metoffice.gov.uk

Verification of QPF using SEEPS

Score with forecast lead time, April 2012 to February 2015

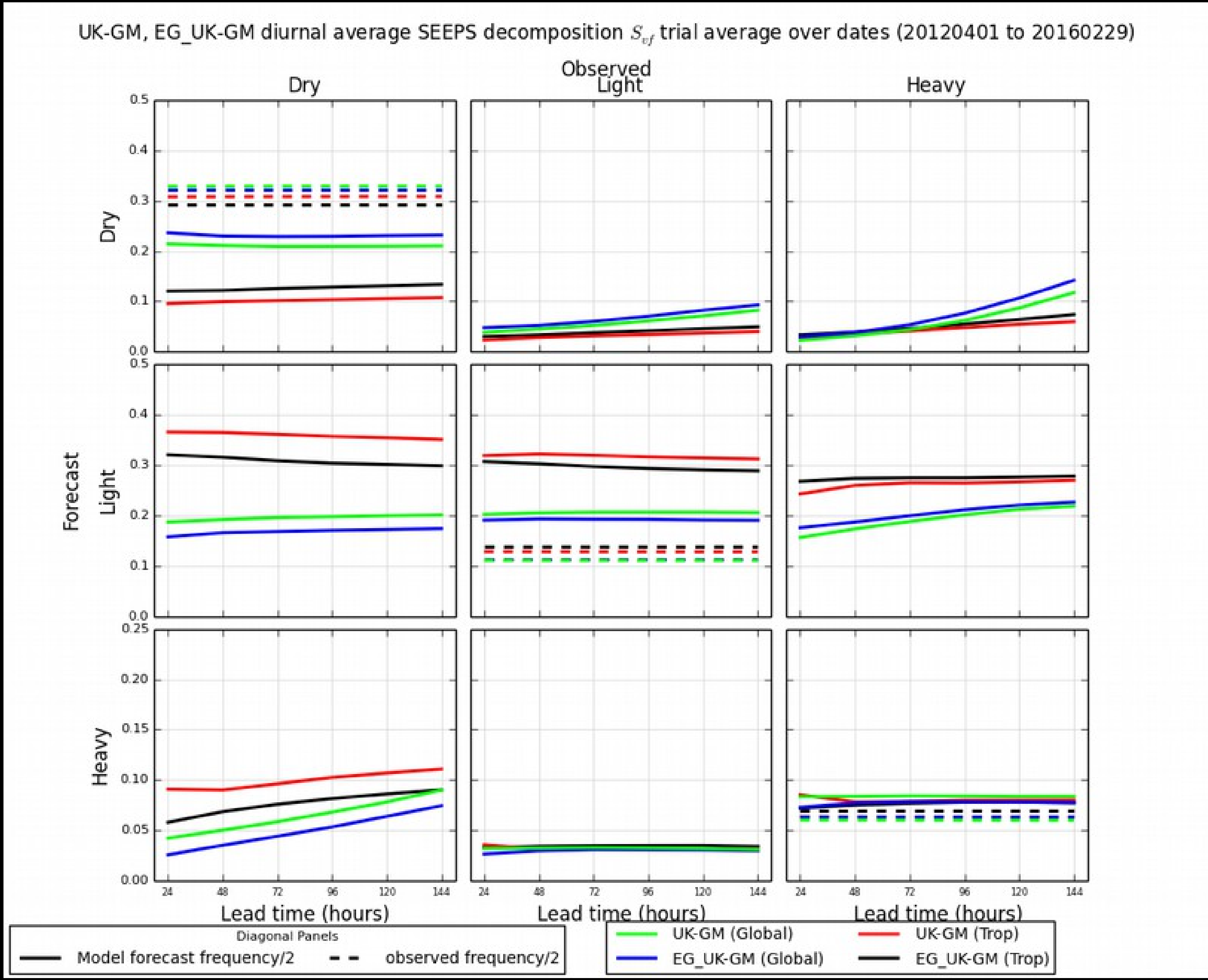
- Globally, model has useful skill.
- SEEPS shows model has almost 3x skill globally than in the Tropics.
- Latest UM upgrades (labelled “EG_” in previous slide) confirm signs of improvement over the Tropics.
- Tropics errors are almost constant with forecast lead time.

Verification of QPF using SEEPS

Decomposition into constituent error sources

Diurnal Average 2012-2016

24-hour totals

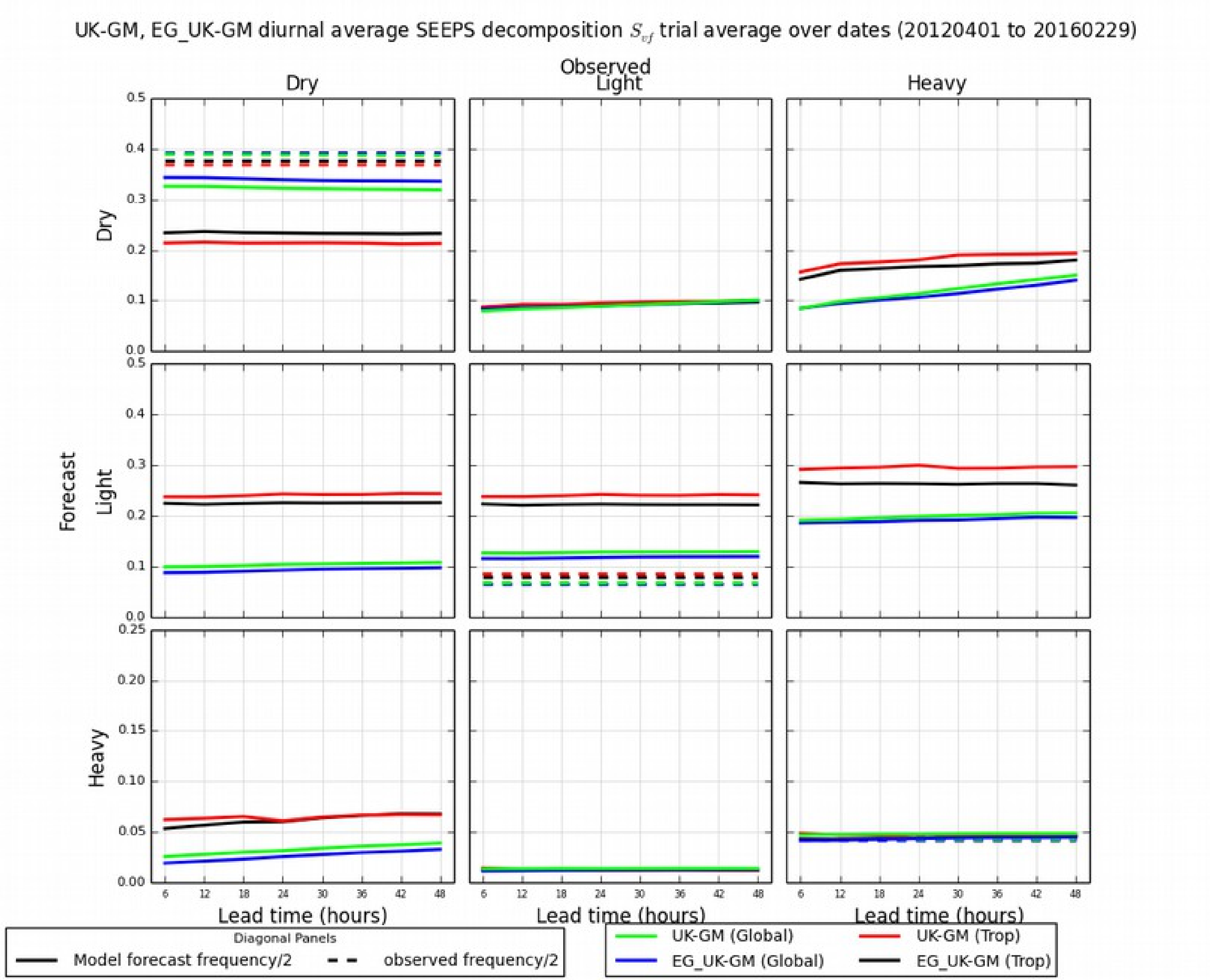


Verification of QPF using SEEPS

Decomposition into constituent error sources

Diurnal Average 2012-2016

6-hour totals



Verification of QPF using SEEPS

Decomposition into constituent error sources

- Sources contributing most to SEEPS score from 24-h accumulations are the observed dry/forecast light (especially in the Tropics) and the observed heavy/forecast light error categories. Both categories contribute similar proportions to the total score.
- Largest fraction of SEEPS score for 6-h accumulations is contributed by observed heavy/forecast light.
- Drop in skill in 24-h scores over Tropics is from observed dry/forecast light and heavy and the observed heavy/forecast light categories.
- Similar story for the 6-h scores over Tropics, but with the addition of the contribution from the observed heavy/forecast dry.
- Under-prediction of the number of dry events for both 6-h and 24-h accumulations.
- Over-prediction of the number of light precipitation events for both 6-h and 24-h totals.

Verification of QPF using SEEPS

Decomposition into constituent error sources

- UM GA6 still indicating improved frequency bias in number of dry events for both 6-hour and daily totals.

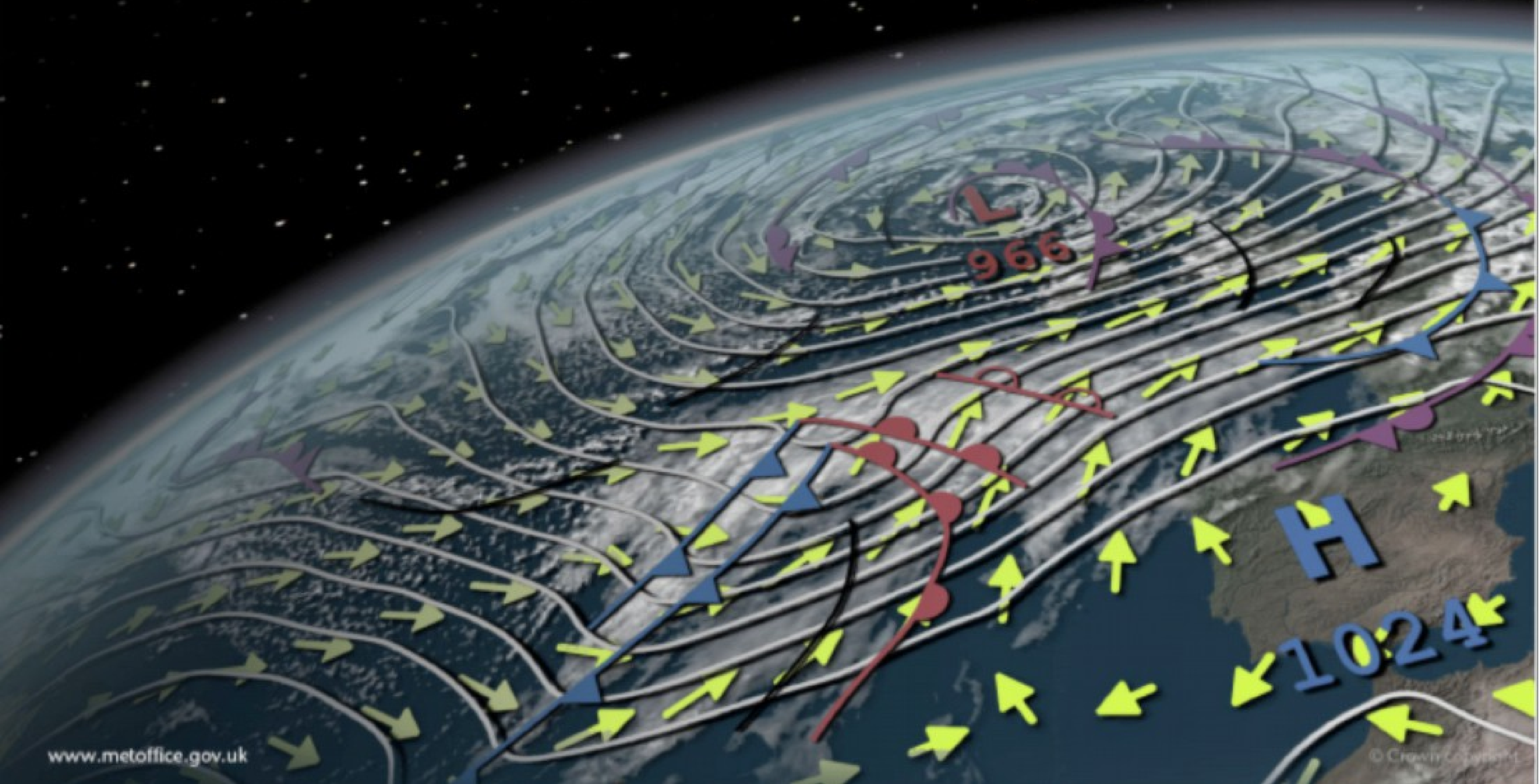
- Dips in skill seen in Northern Hemisphere summer (associated with convection and due to domination of Northern Hemisphere sites to the aggregated total score).

- Missed heavy events are penalised more at longer lead times, and a large source to error score.

Met Office

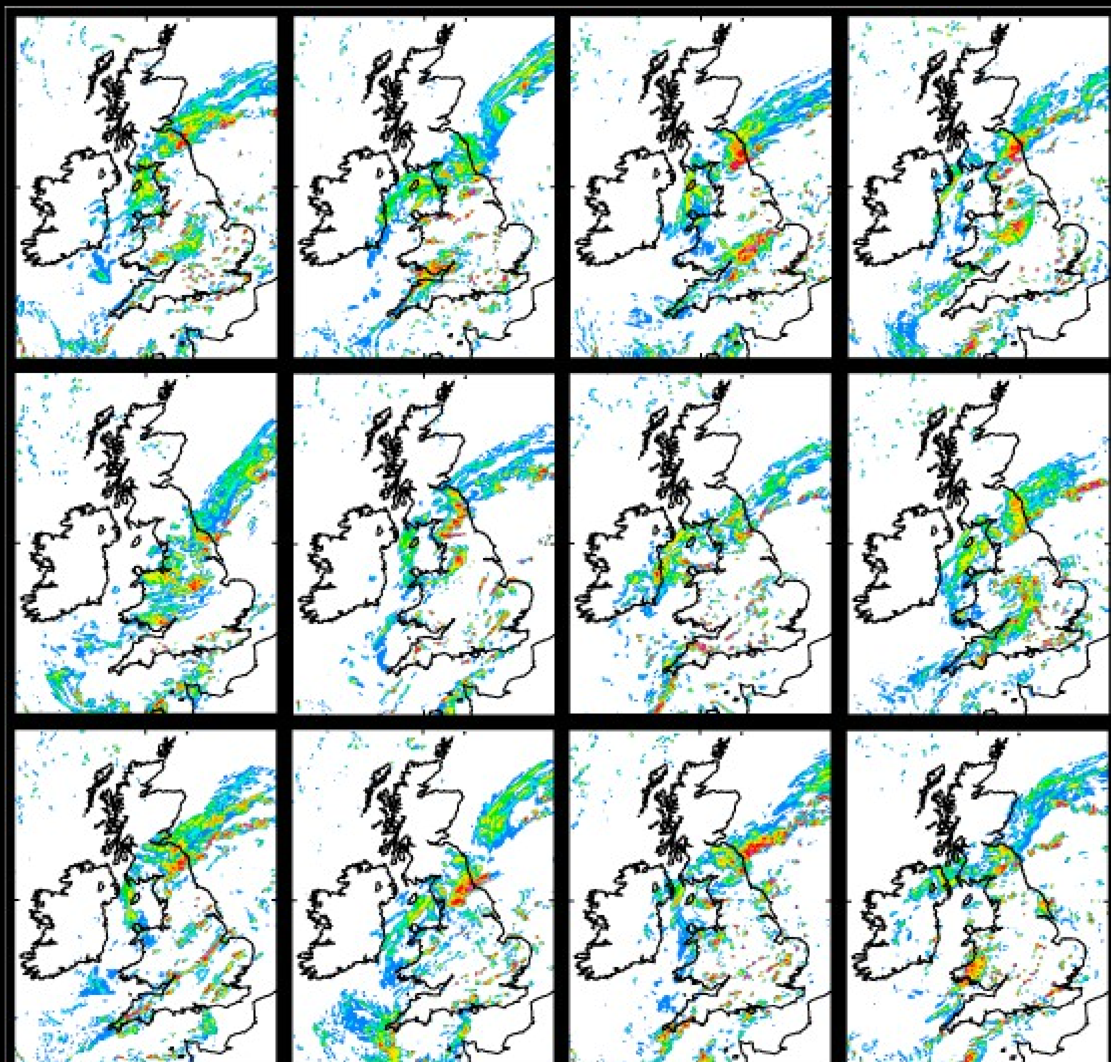
Regional model precipitation verification

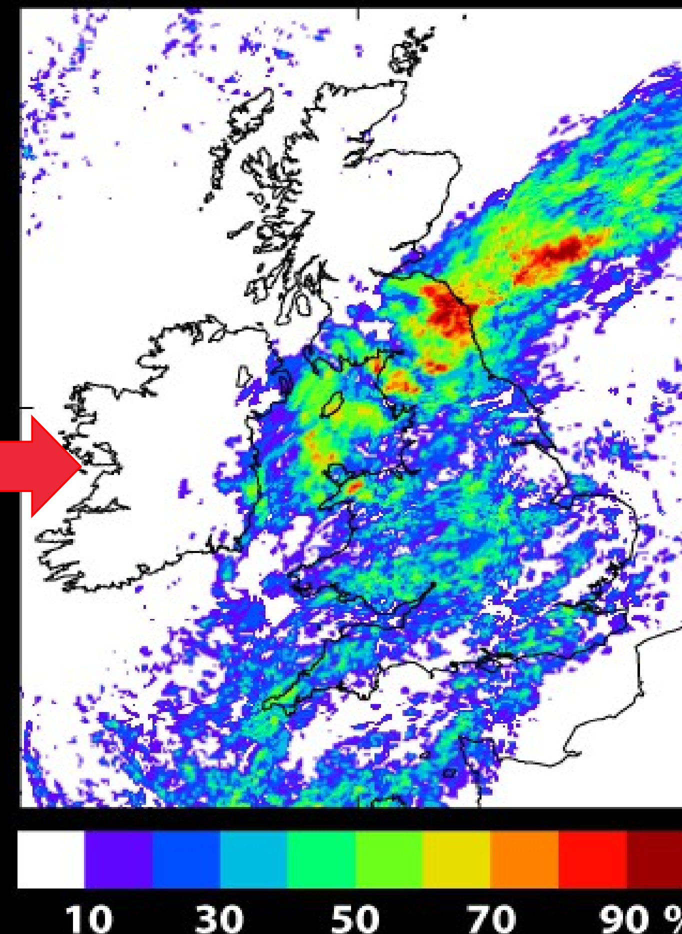
Researching use of neighbourhood processing for probabilistic prediction



MOGREPS-UK

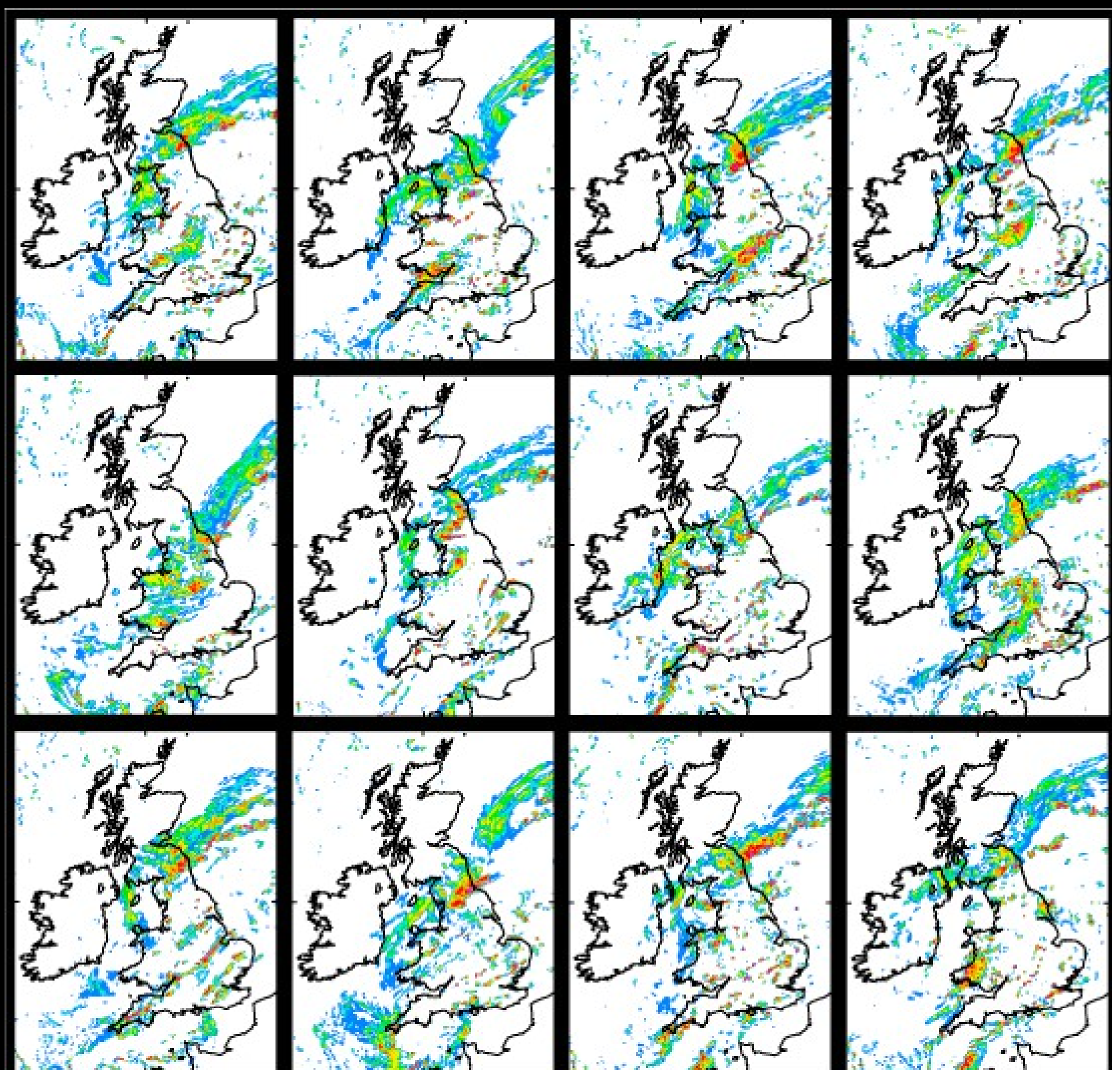
2.2km ensemble

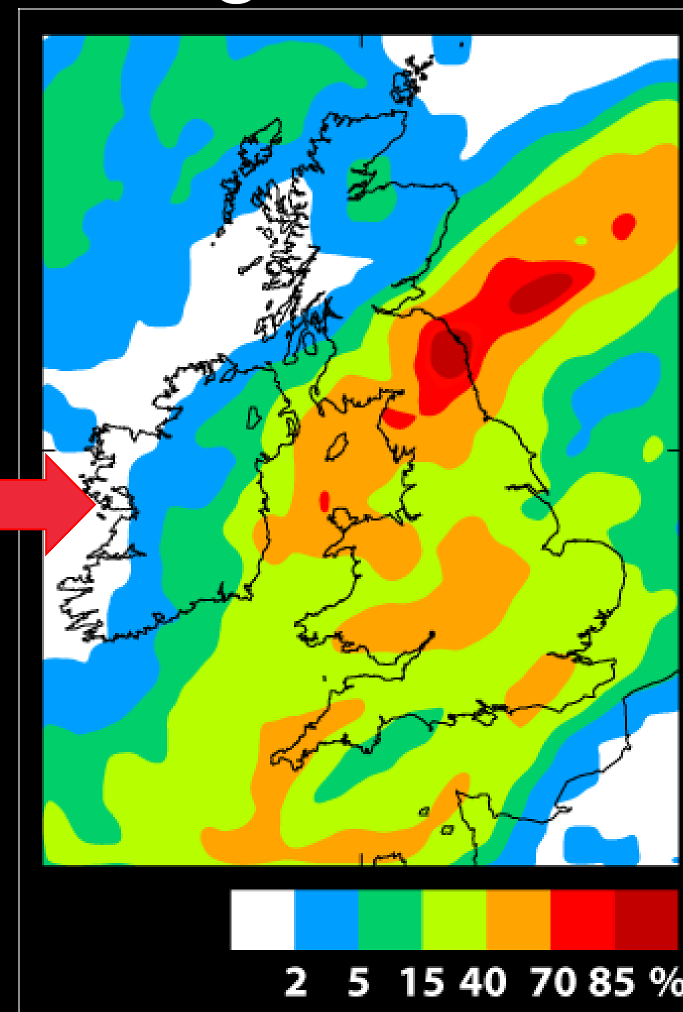




Undersampling leaves “holes” of zero-probability where showers could still occur

MOGREPS-UK … with Neighbourhood processing





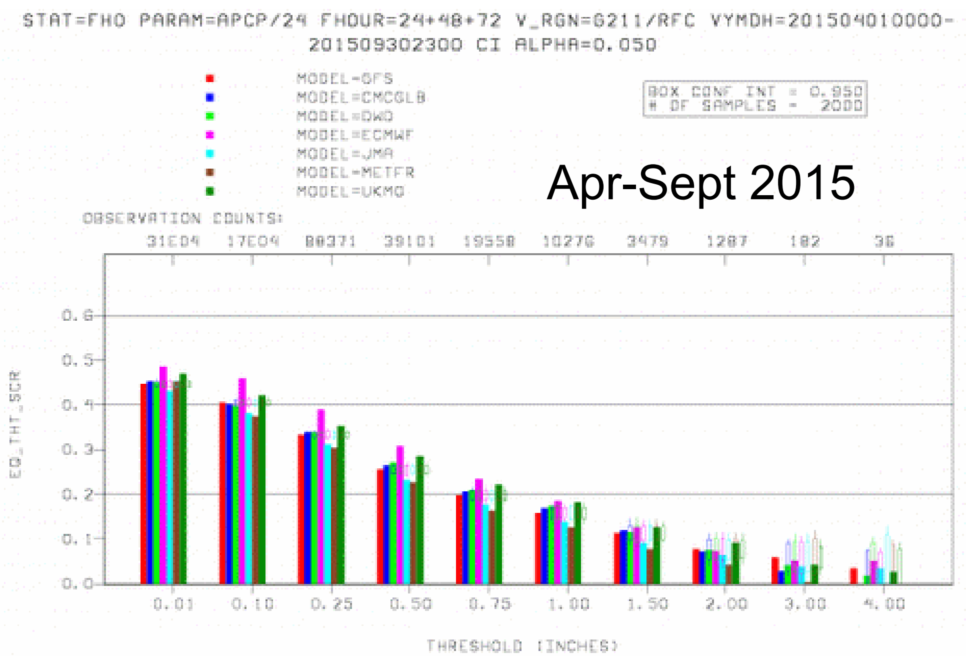
Holes filled in

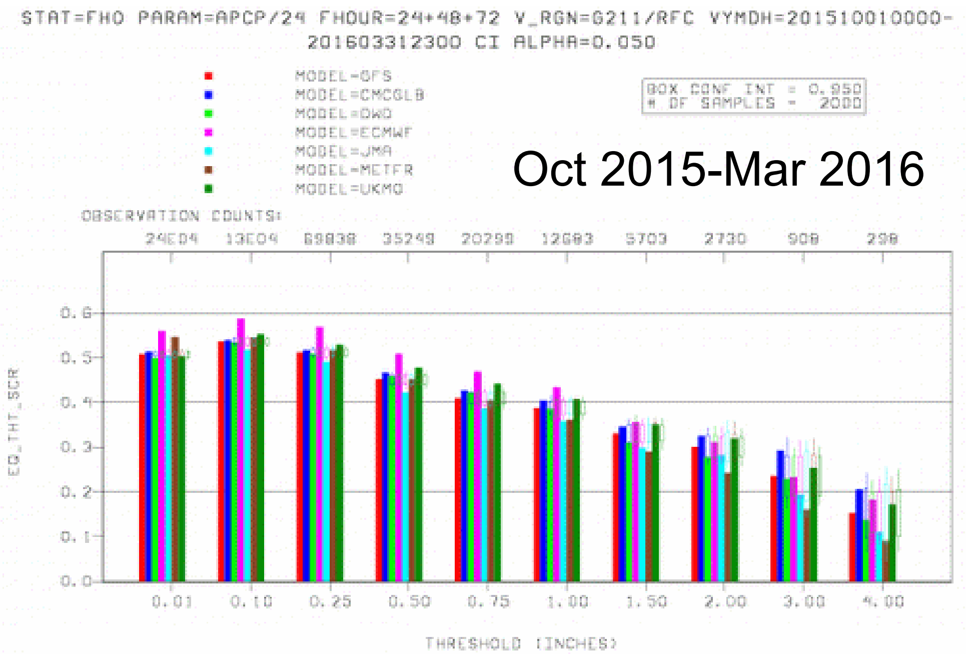
NCEP

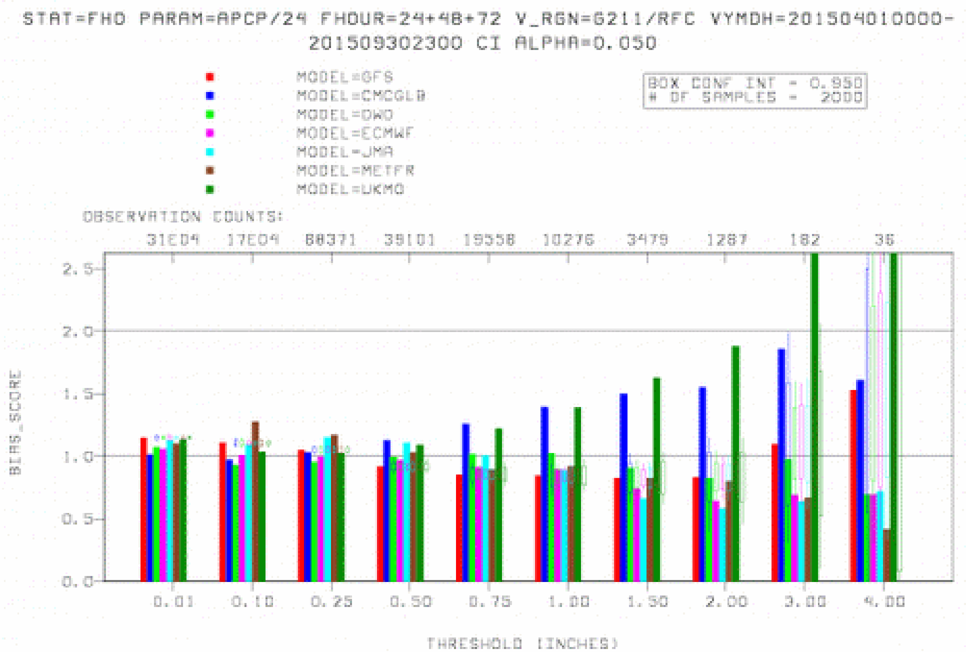
QPF Verification at NCEP for Deterministic NCEP and International Models

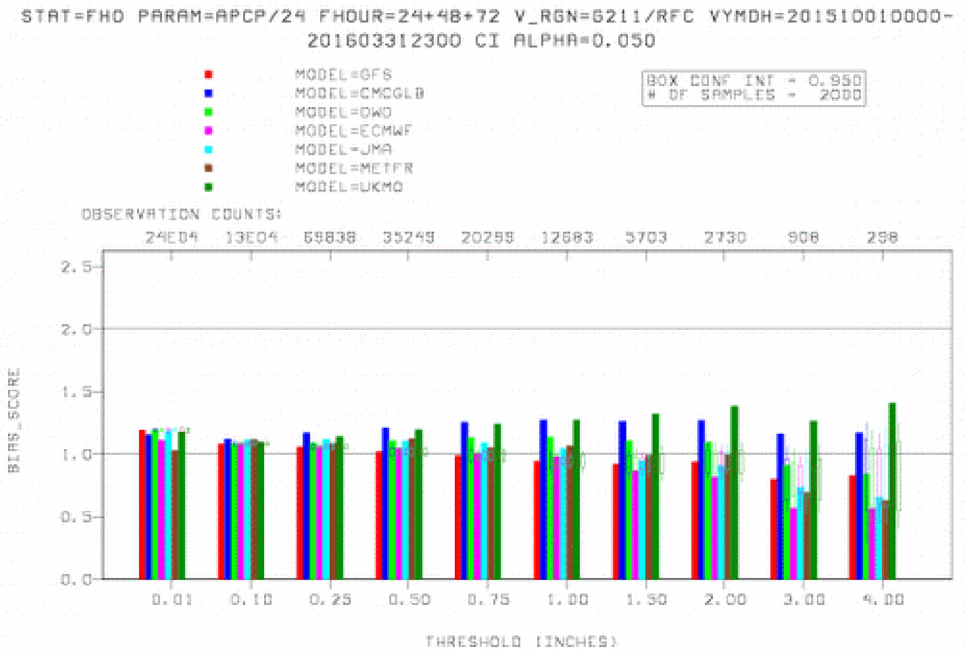
- 24h (12Z-12Z) contingency table-based verifications for all models
- 24h (12Z-12Z) contingency table-based verification for Alaska, Hawaii, Puerto Rico for select NCEP opnl and para models (observation/analysis quality not as high as over ConUS)
- 3-hourly contingency table-based verifications for NCEP operational and parallel models
- Contingency table-based scores include FB, POD, FAR, POFD, TS, ETS, HK, HSS, OR, EDI, SEDS, SEDI and many others
- 24h FSS computation for NCEP operational and parallel models
- 6-hourly FSS for select NCEP operational and parallel models, beginning Aug 2015
- International models verified over ConUS: CMC (global and regional), DWD, ECMWF, JMA, METFR, UKMO (24h only)

ETS/Bias over ConUS, 1/2/3-day fcsts of Global Models

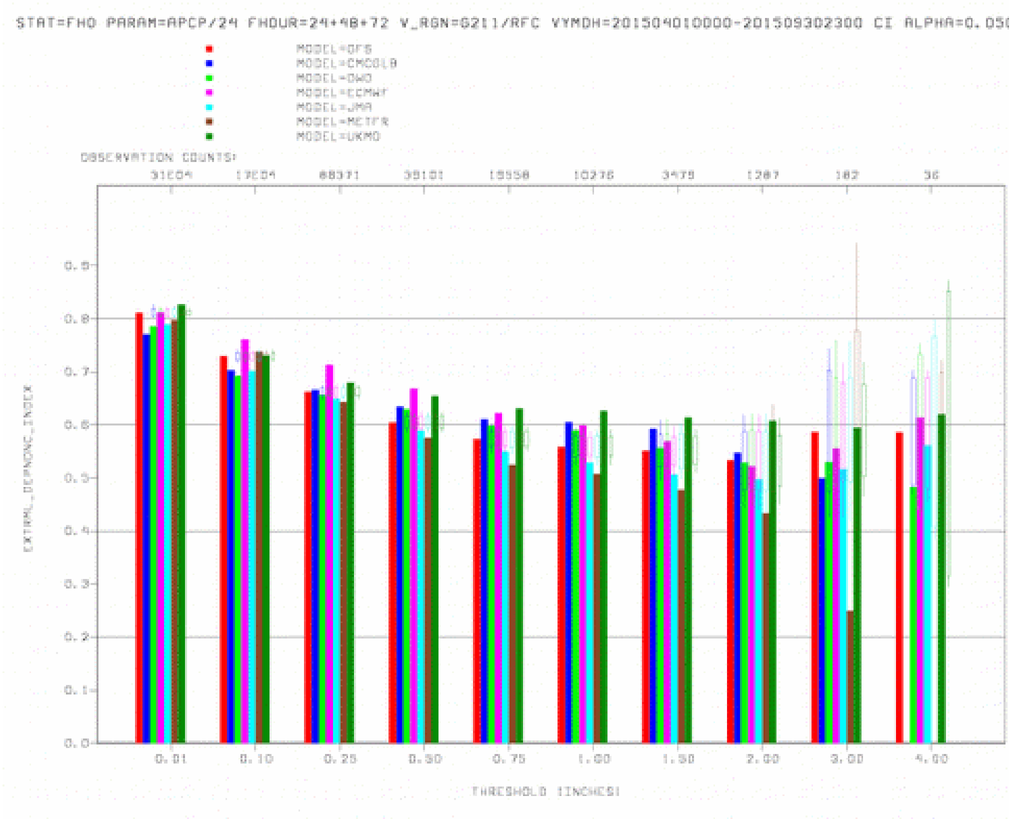




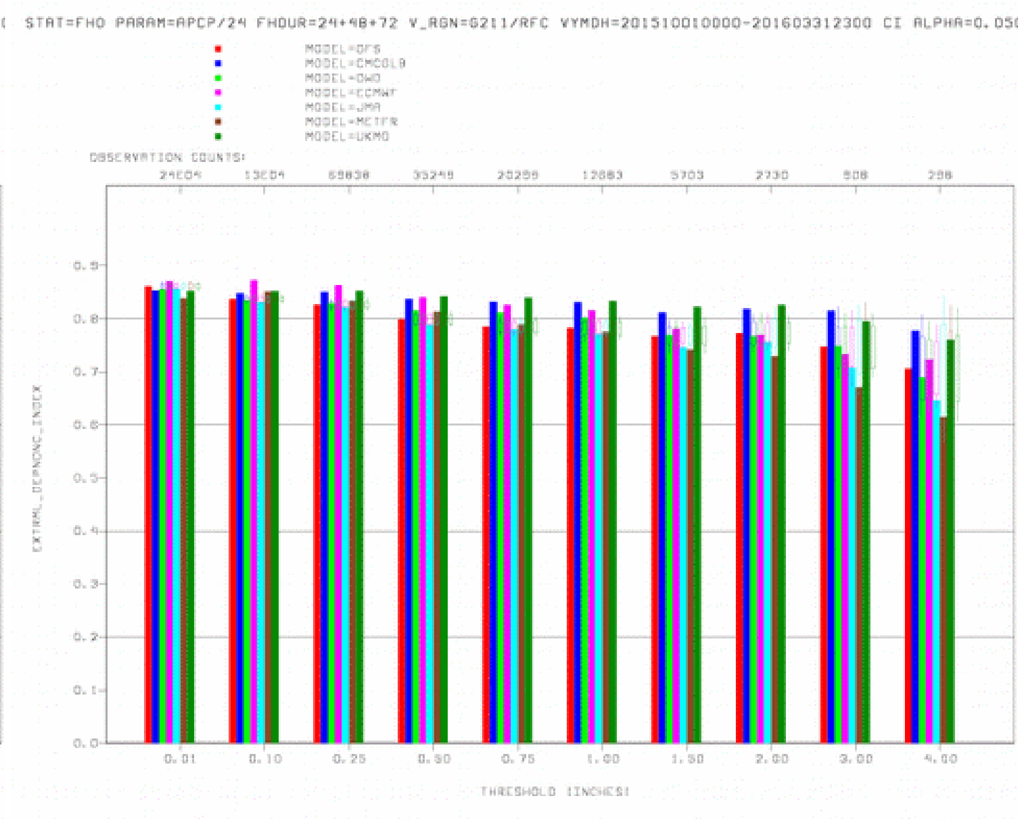




Extremal dependence index over ConUS
1/2/3-day fcsts of Global Models

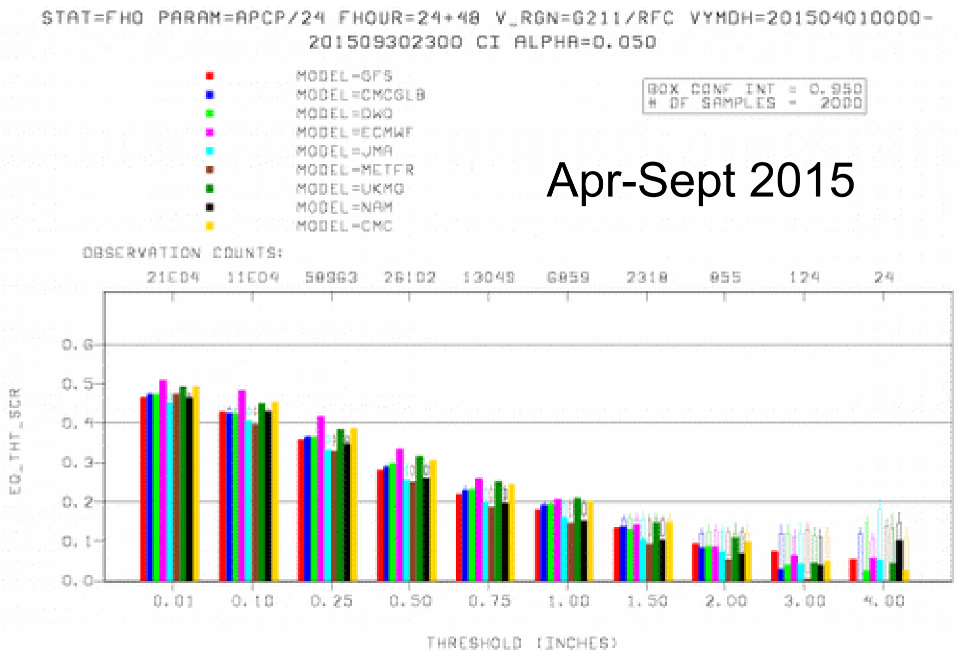


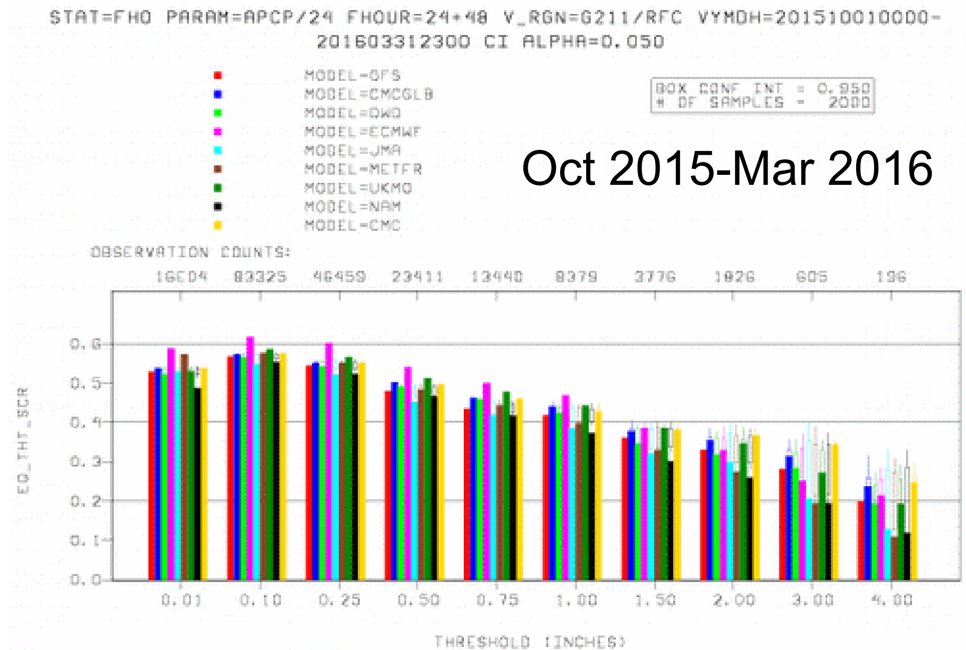
Apr-Sept 2015

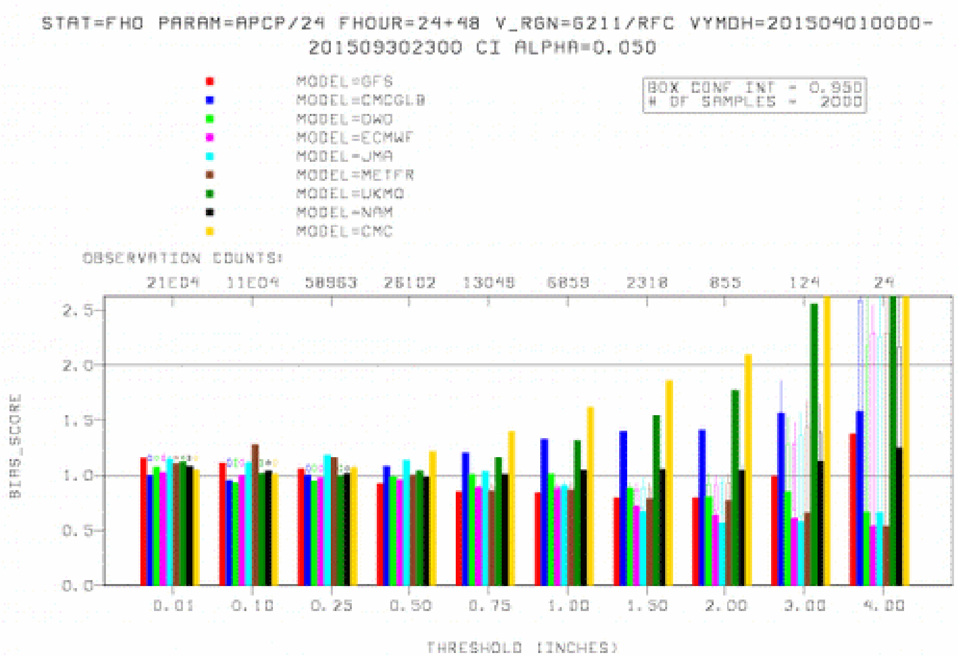


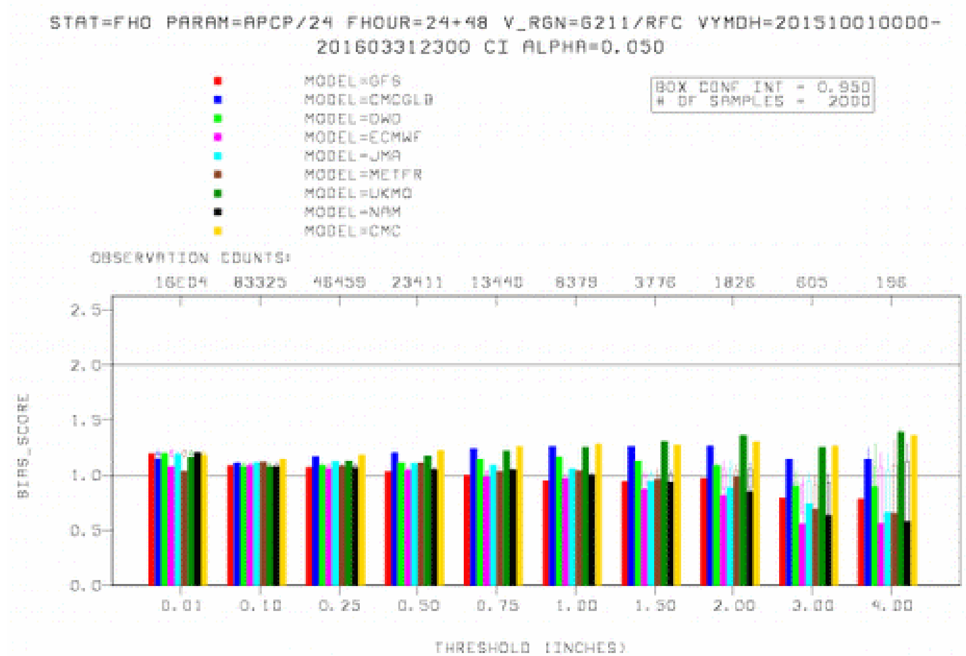
Oct 2015-Mar 2016

ETS/Bias over ConUS, 1/2-day fcsts of Global Models and NAM/CMC (CMC fcst to 48h)

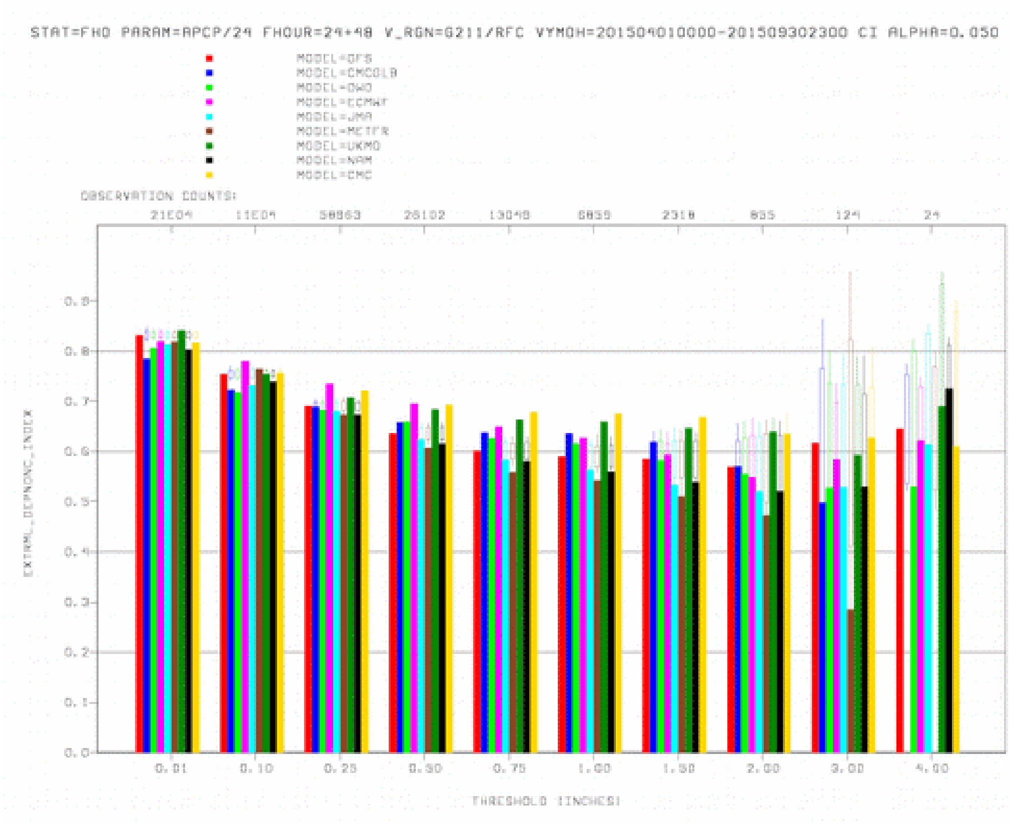




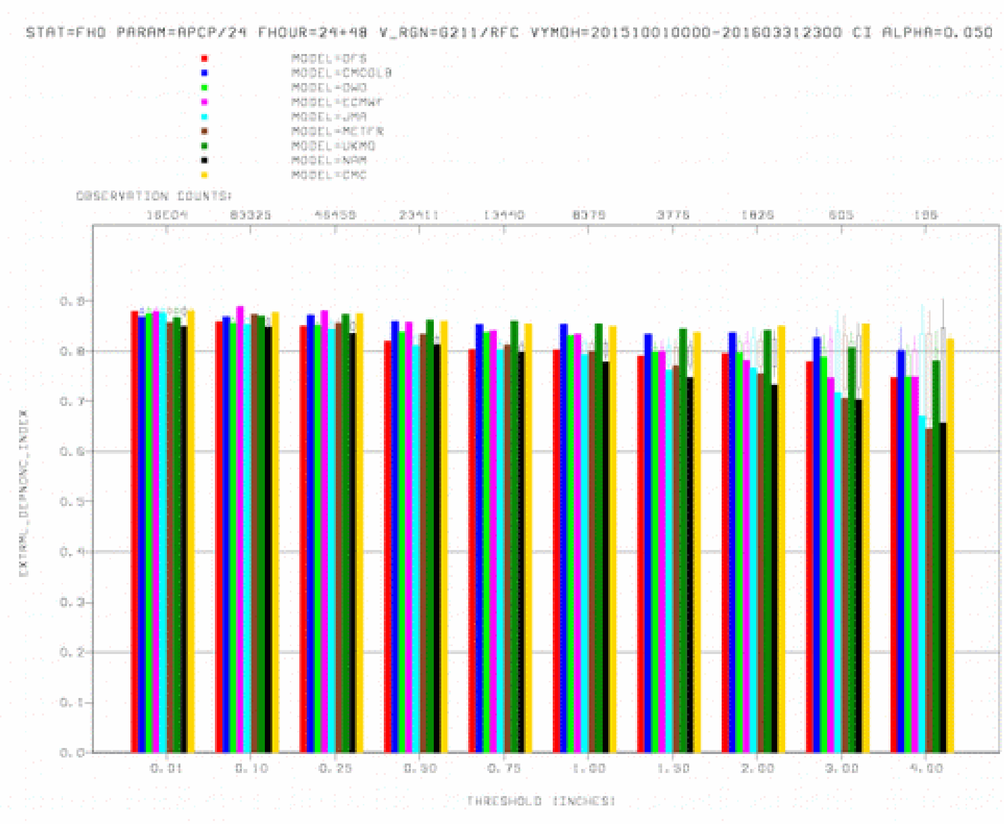




Extremal Dependence index over ConUS, 1/2-day fcsts of Global Models and NAM/CMC (CMC fcst to 48h)

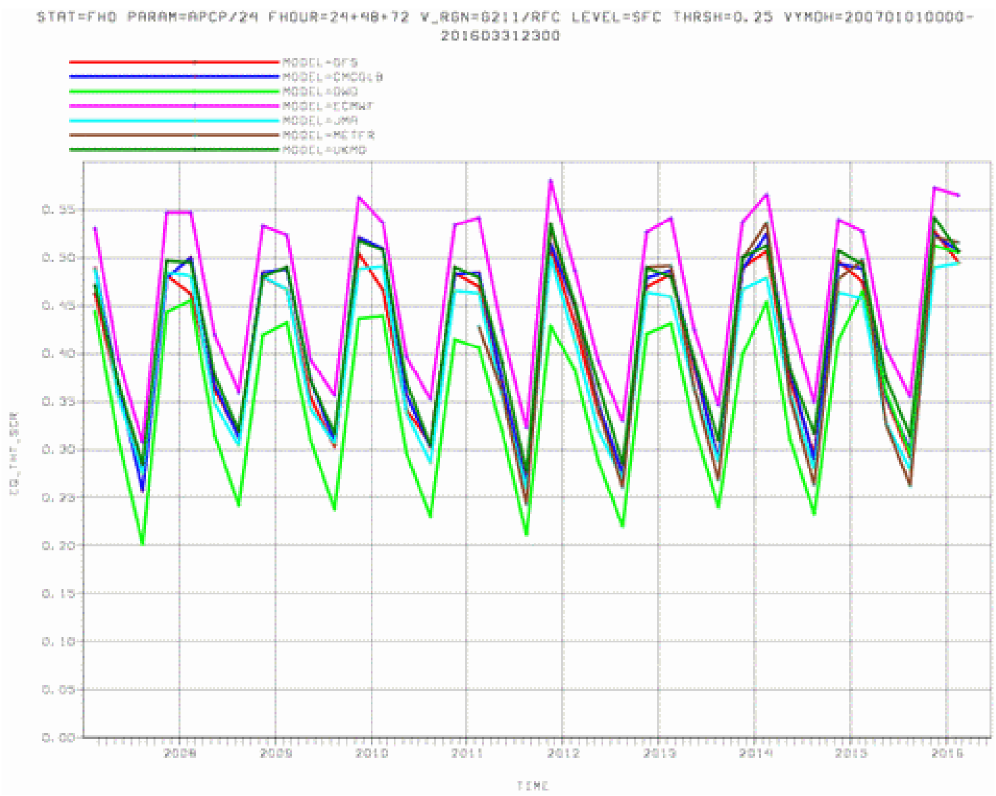


Apr-Sept 2015

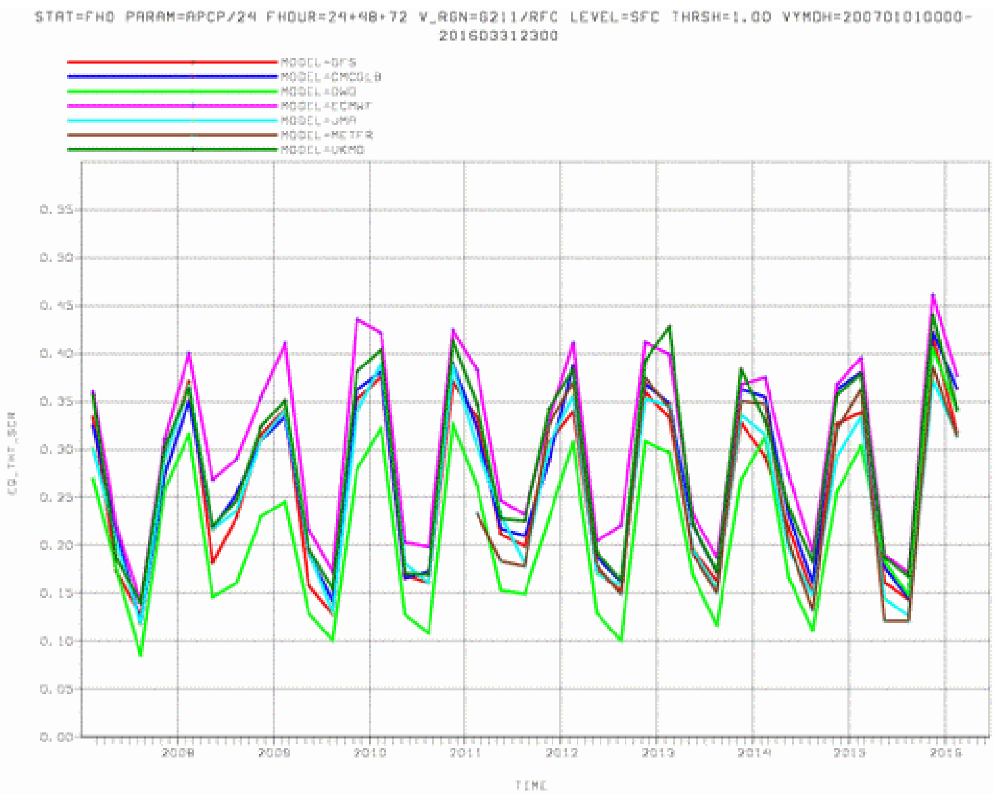


Oct 2015-Mar 2016

Quarterly time series of ETS, all global models



6.35mm/day threshold

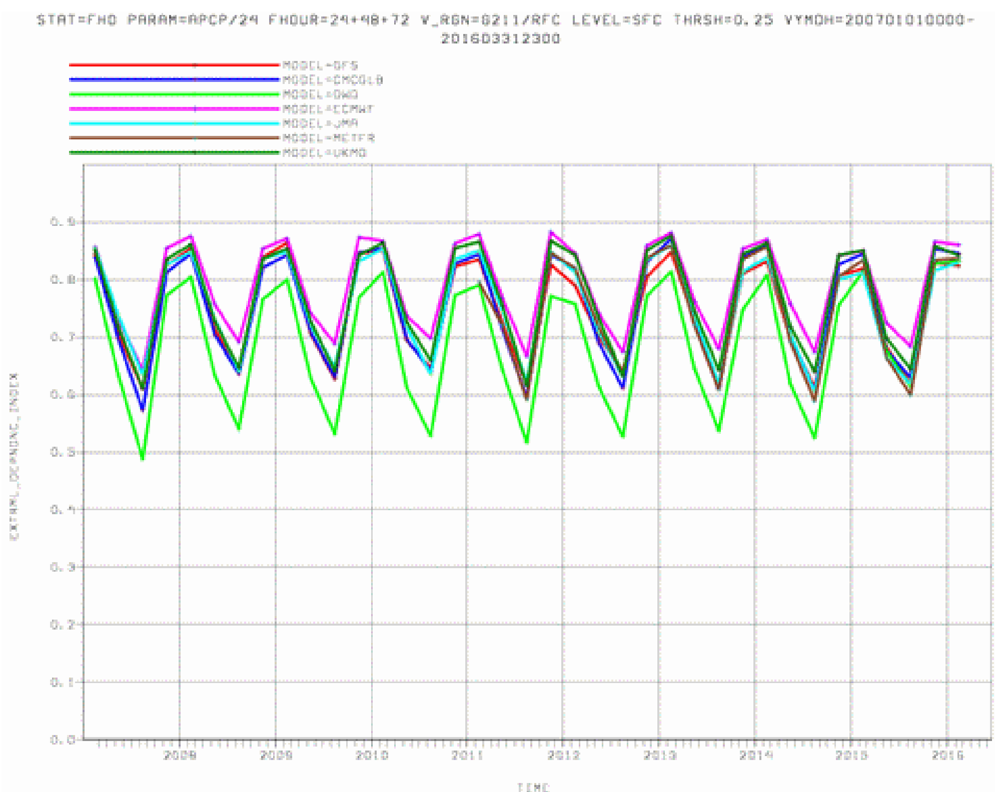


25.4mm/day threshold

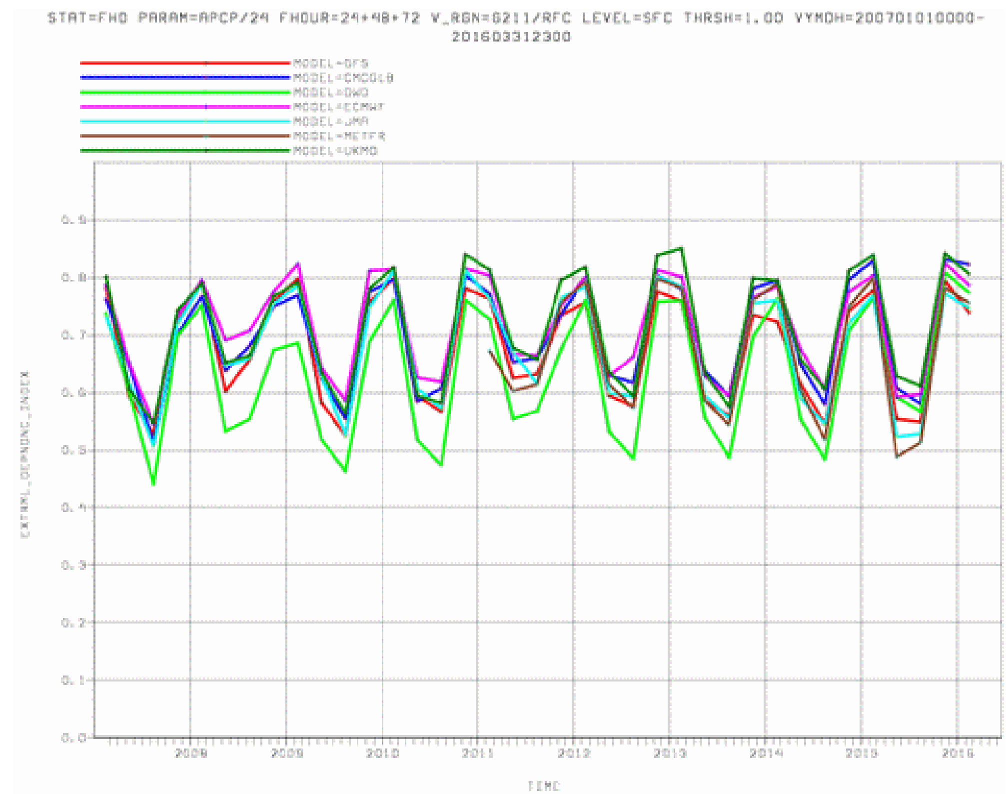
(verification for Metéo-France began in Mar 2011)

Quarterly time series of Extremal Dependence Index

all global models



6.35mm/day threshold



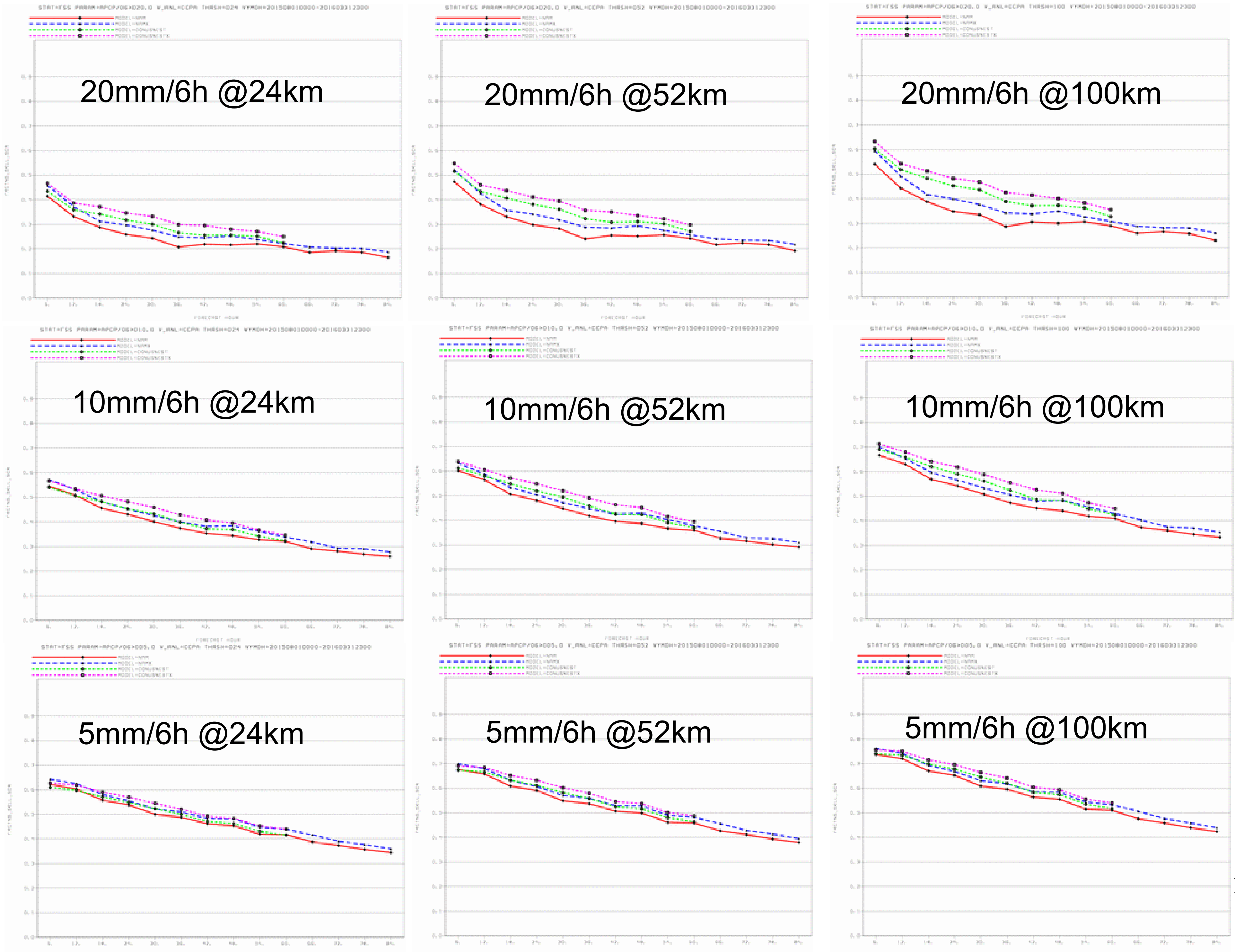
25.4mm/day threshold

(verification for Metéo-France began in Mar 2011)

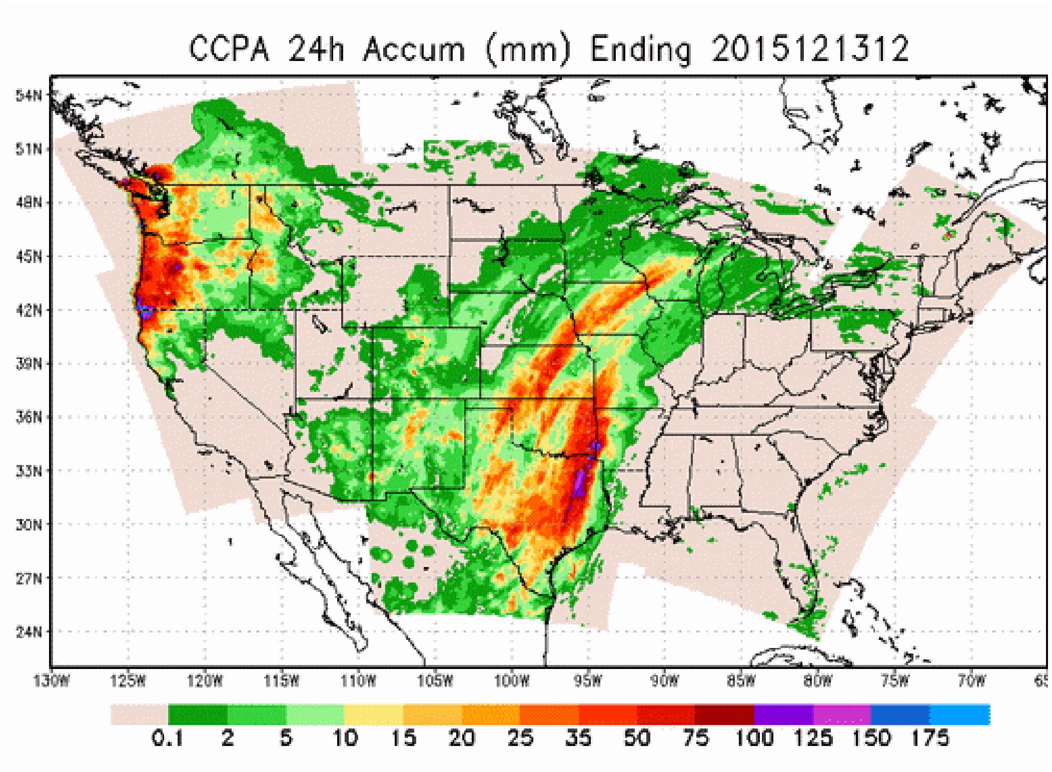
Moving toward adopting more of the JWGFVR recommendations

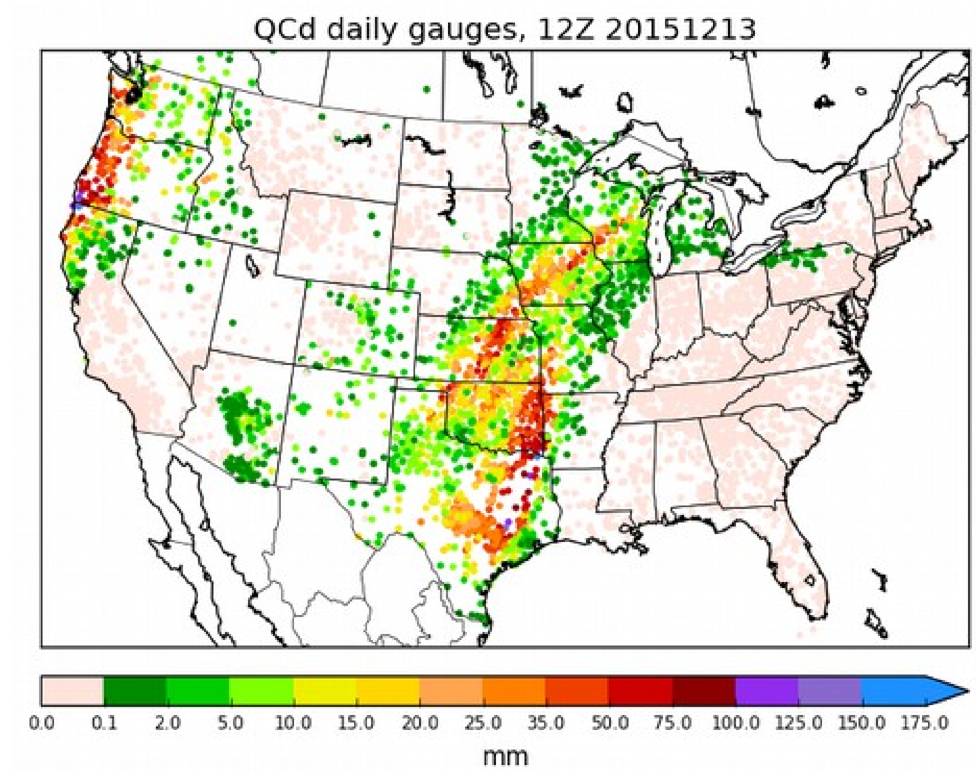
- Began routine 6-hourly FSS calculations for NCEP models (using recommended thresholds in SI units). Examples show on P9. Would like more international model 6-hourly forecast files made available.
- Began verification on nearest gauge locations (using recommended thresholds in SI units)

NAM/NAMX/CONUSNEST/CONUSNESTX Aug 2015 – Mar 2016, 6h FSS



Verifying analysis/gauges





CCPA: NCEP Stage IV (radar+gauges) analysis with climate calibration. Used for 24h/6h/3h gridded verifications.

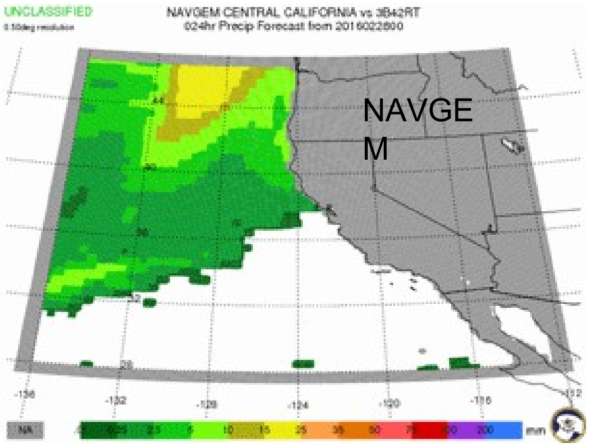
~8,000 QC'd daily gauge reports.

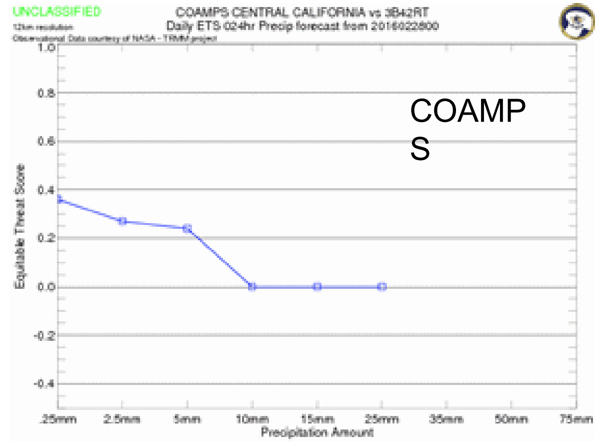
Additional Information

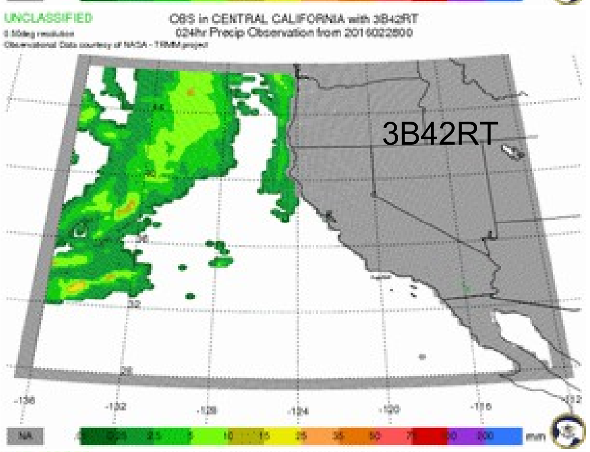
- GFS data made available to NCEP's international partners: http://nomads.ncep.noaa.gov/pub/data1/nccf/com/verf/prod/precip.yyyymmdd/
- Monthly precipitation scores of operational models: http://www.emc.ncep.noaa.gov/mmb/ylin/pcpverif/scores/
- Monthly precipitation scores of regional experimental model runs: http://www.emc.ncep.noaa.gov/mmb/ylin/pcpverif/scores.paramodels/
- Global experimental verification scores: http://www.emc.ncep.noaa.gov/gmb/STATS_vsdb/
- Daily side-by-side precipitation verification comparisons: http://www.emc.ncep.noaa.gov/mmb/ylin/pcpverif/daily/

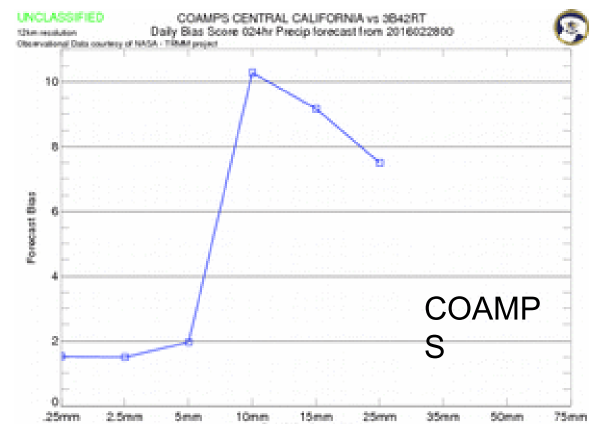
NRL

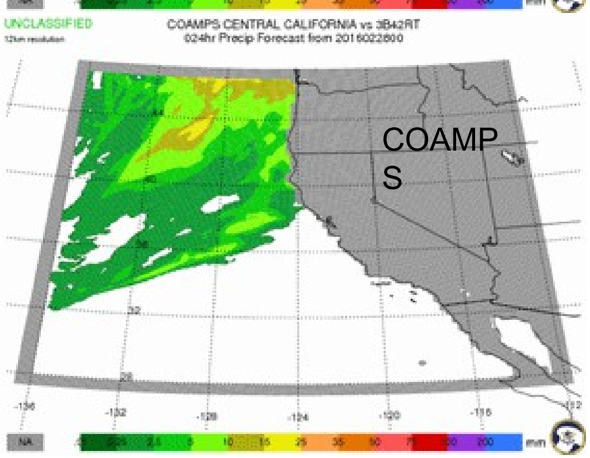
US Navy FNMOC QPF Verification

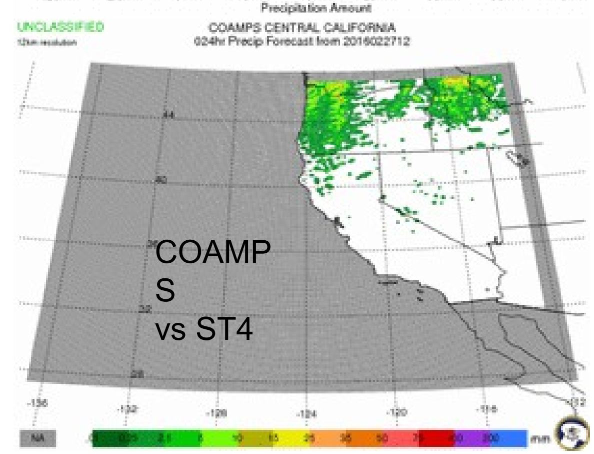












- Global and ~25 regionally relocatable regions verified operationally.
- Over-Water verification against TRMM 3B42RT (soon IMERG 3BHHRL)
- Over-Land verification against US NCEP ST4 and Aust. BoM radar/rain gauge sets
- Bias, ETS, and HK at 9 thresholds (Trace to 75mm)
- POD, POFD, FSS and other scores capable (not operationally done)
- Monthly verification can be performed (not done operationally)

- Code is NRLMRY and FNMOC collaboration
- Global verification results publicly available online at FNMOC public verification page: **https://www.fnmoc.navy.mil/verify_cgi/**

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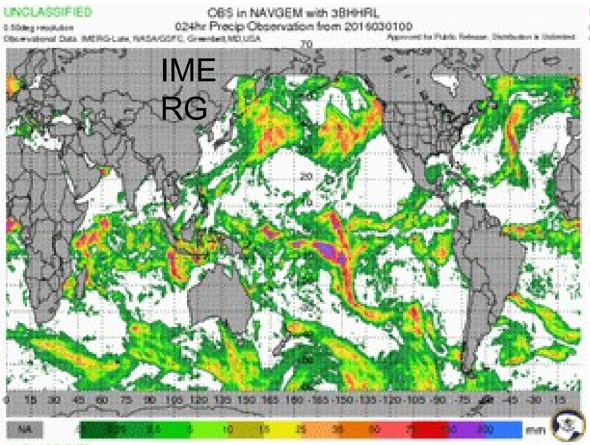
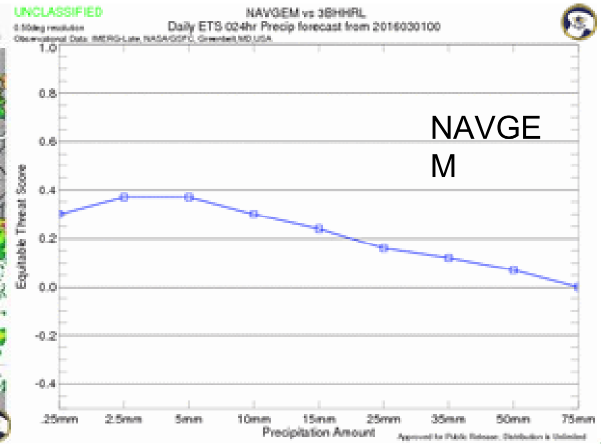
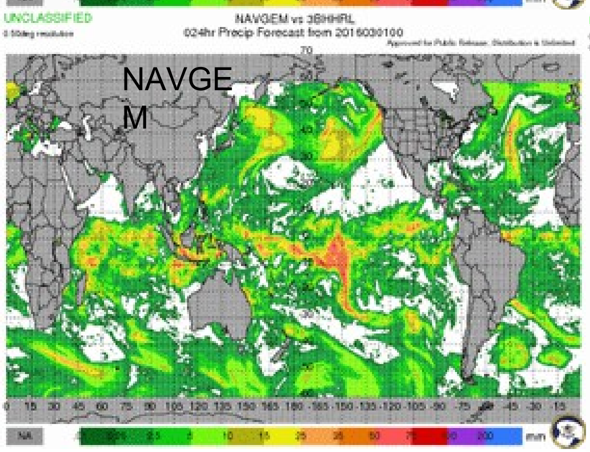
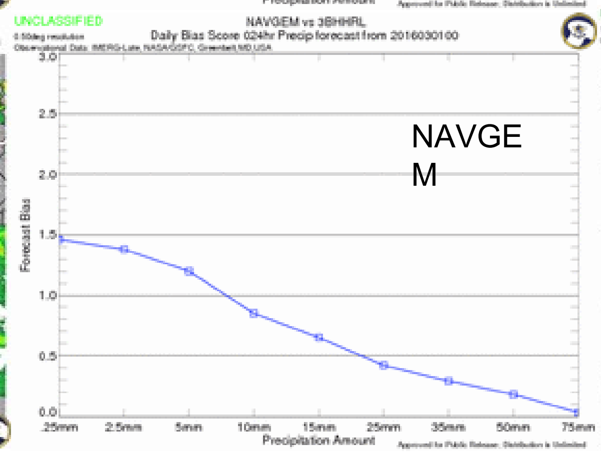
QPF Verification Against NASA GSFC GPM/IMERG

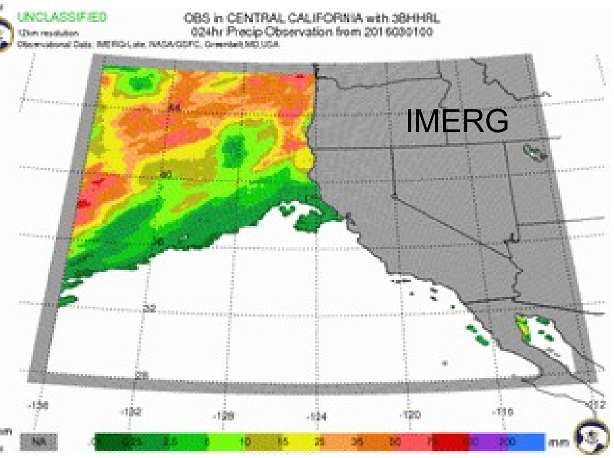


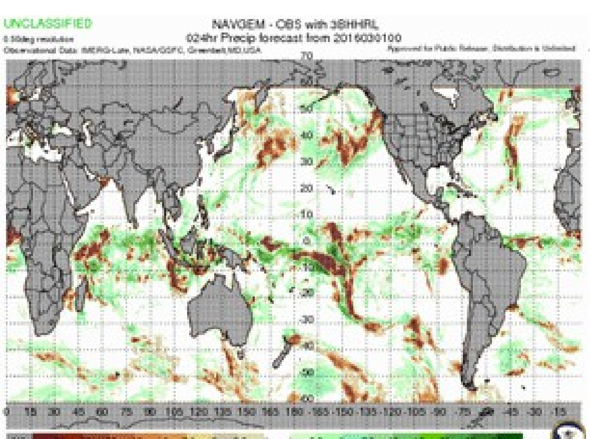


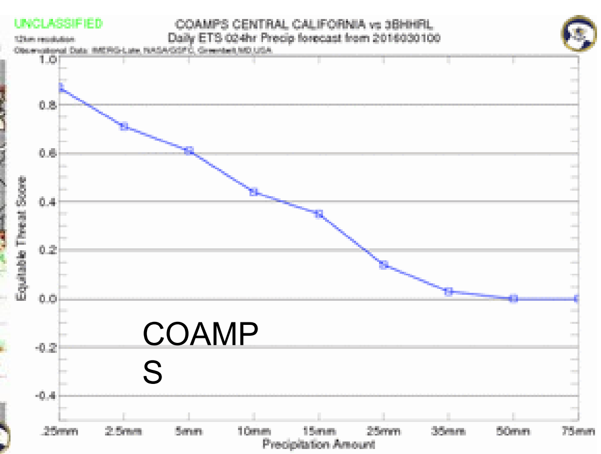
Observational data from:
G. Huffman, D. Bolvin, D. Braithwaite, K. Hsu, R. Joyce, P. Xie, 2014: Integrated Multi-satellitE Retrievals for GPM (IMERG), version V03E. NASA's Precipitation Processing Center, accessed 2016, ftp://jsimpson.pps.eosdis.nasa.gov

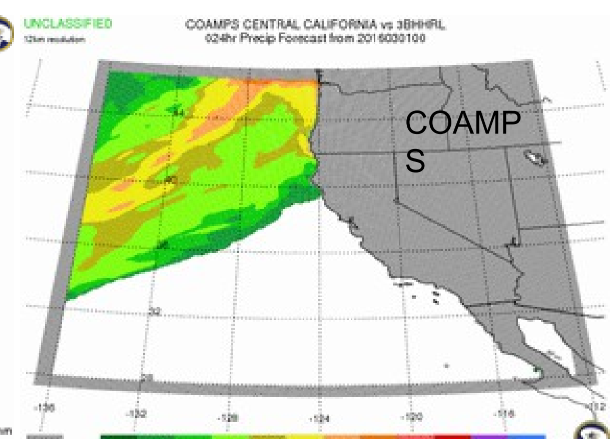












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RHMC

Russian experiments on QPF assessment using high-resolution models

Introduction

With gridded precipitation data from radar measurements and denser AMS networks becoming available, a number of recently developed verification methods and scores were introduced into practice at the Hydrometcentre of Russia of Roshydromet, however they are not yet operational:

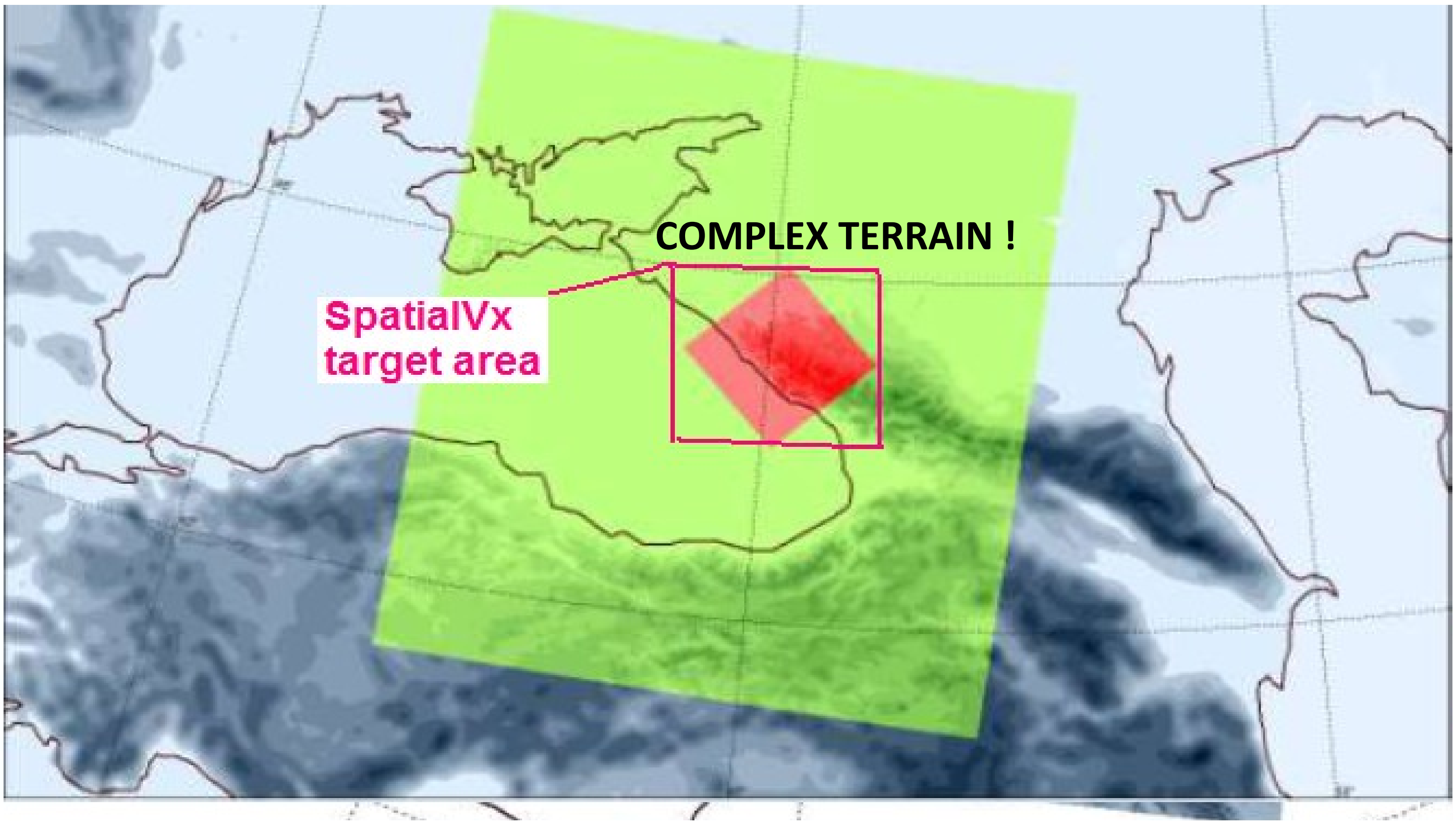
scores for rare events, such as EDI

spatial verification methods

Many of these methods were tested in the Sochi area, as an extensive dataset was accumulated there during the Sochi-2014 Winter Olympic and Paralympic Games

Area of the study

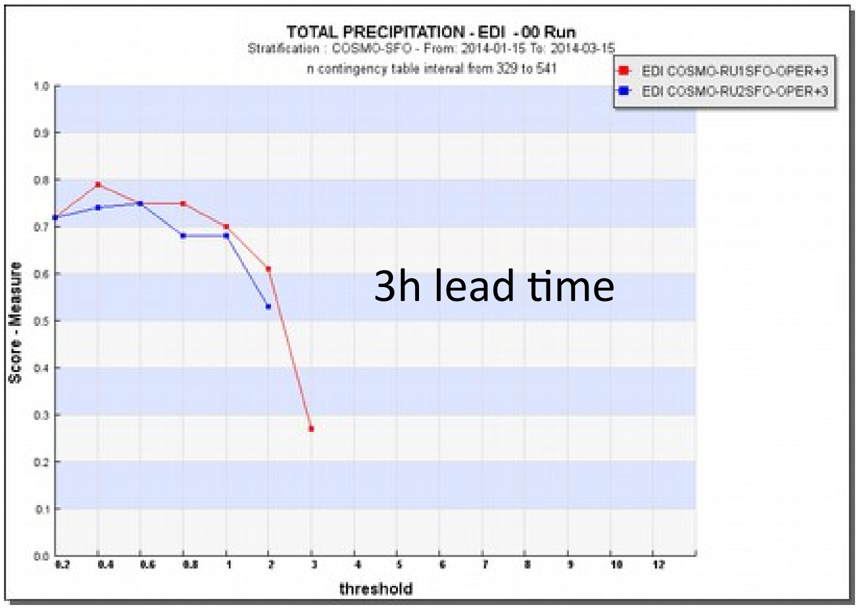
349 lon points * 481 lat points with **0.00833** lat-lon increments.
1 grid size by **longitude** = 111*0.00833 = **930 m**,
1 grid size by **latitude** = cos(43°35’)*930 m = 0.72*930 = **~ 670 m**

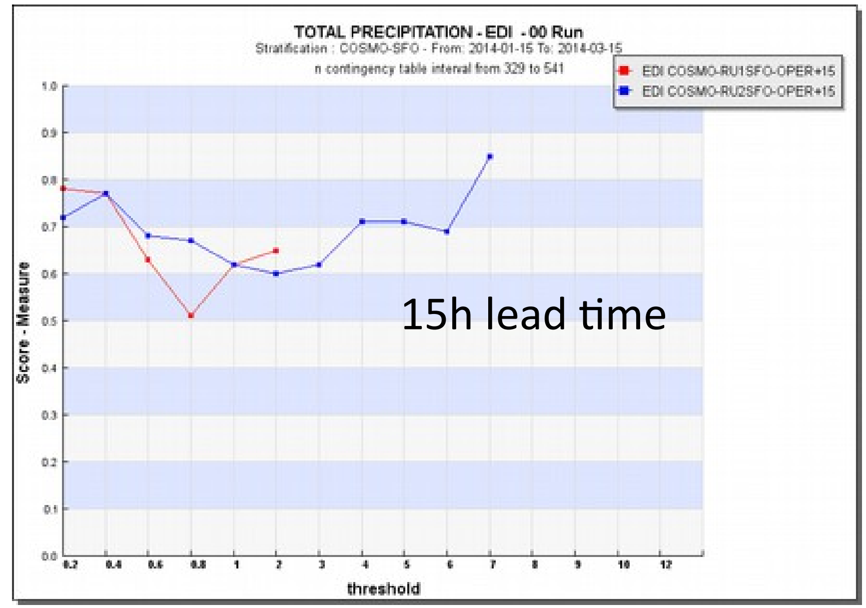


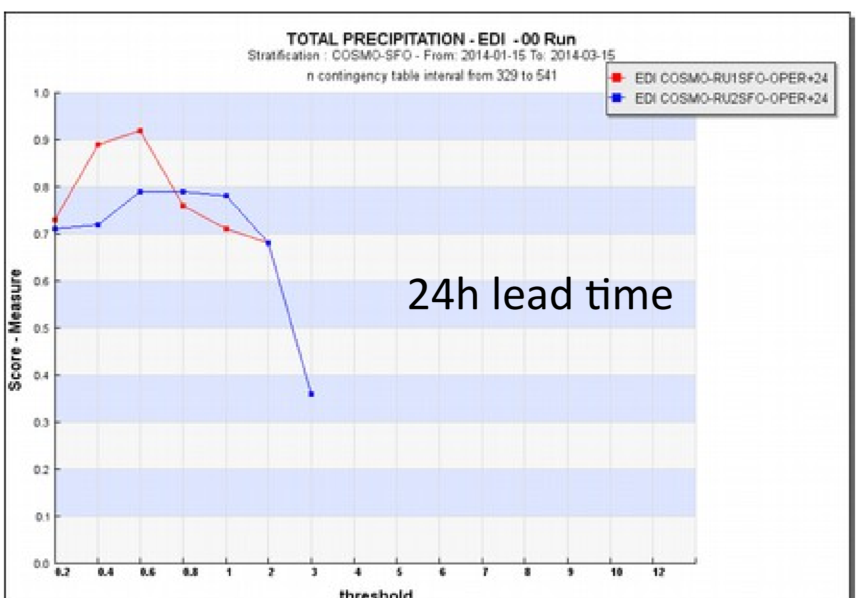
COSMO-Ru2 domain (2.2-km resolution)

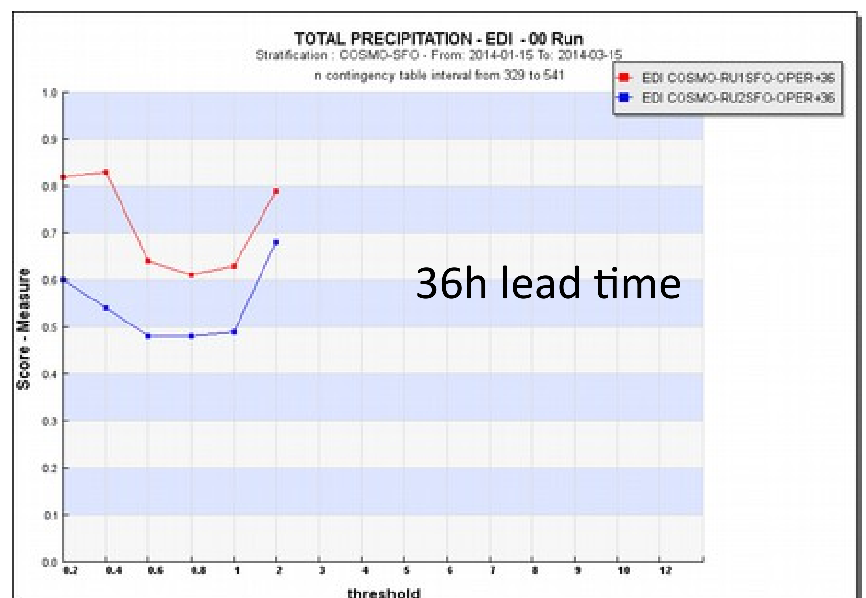
COSMO-Ru1 domain (1.1-km resolution)

EDI of 1h precipitation, Sochi region, Comparison with the station data (~23 stations) as a function of threshold, COSMO-Ru1 and COSMO-Ru2

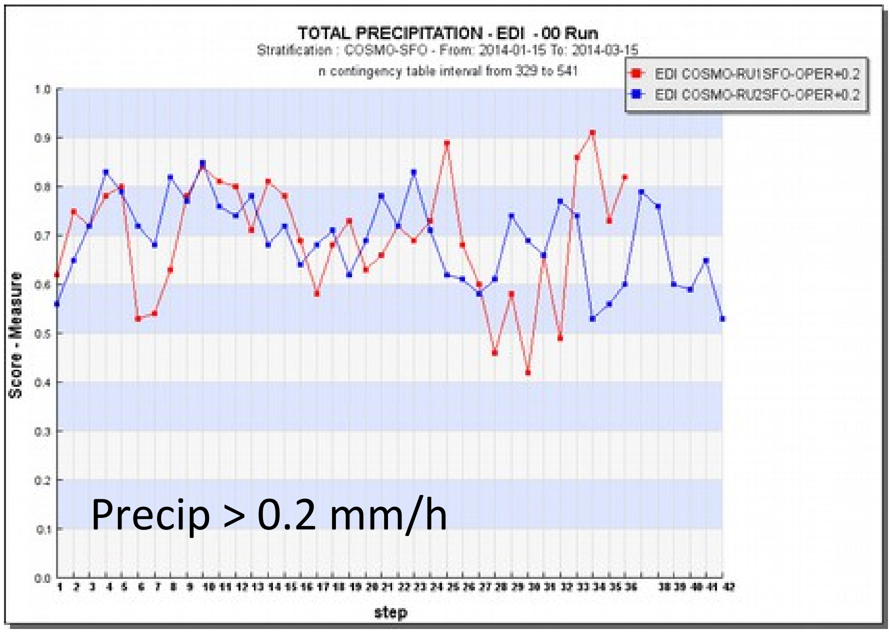


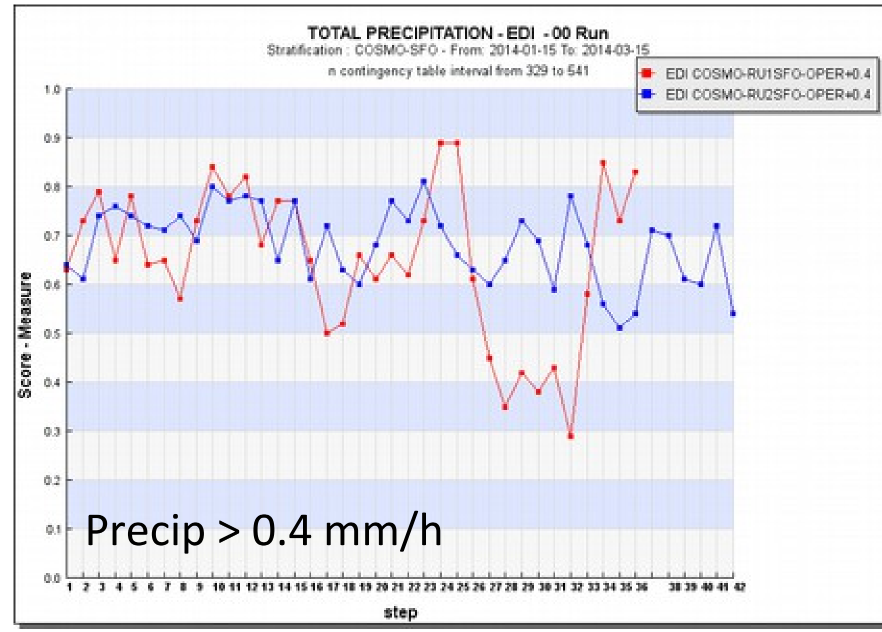


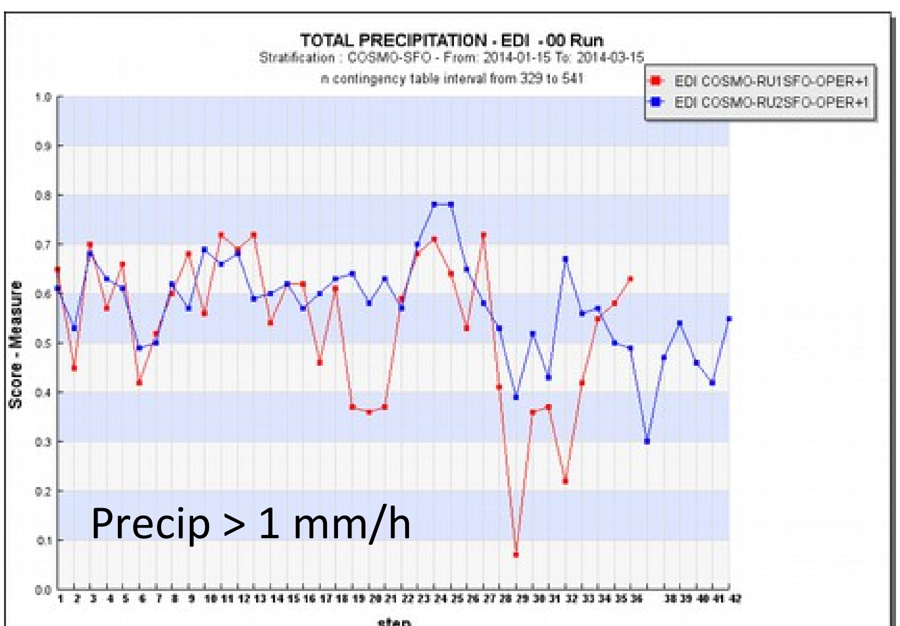


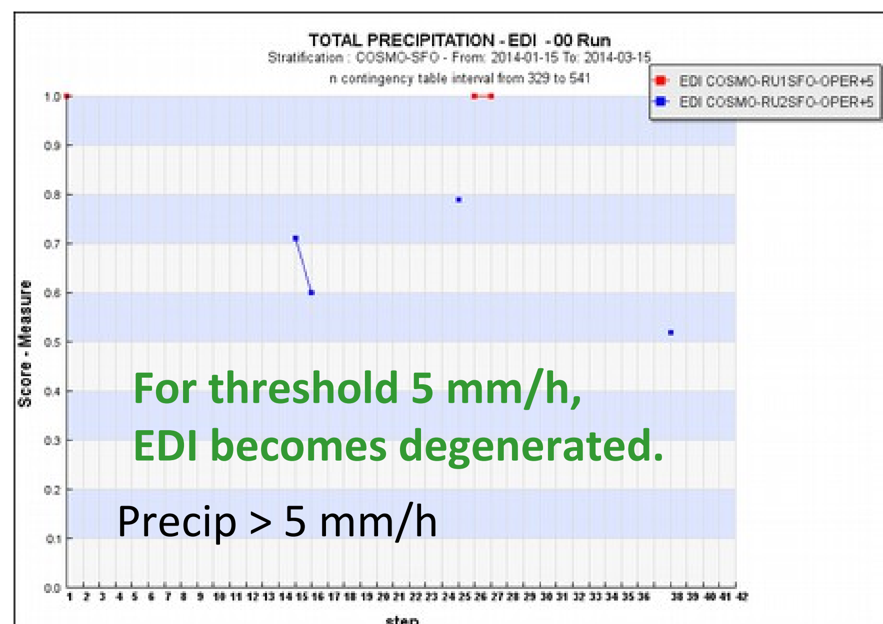


EDI of 1h precipitation, Sochi region, Comparison with the station data (~23 stations) As a function of lead time, COSMO-Ru1 and COSMO-Ru2









Experiments on matching precipitation objects, Sochi region

Setup of experiments

- Motivation: To apply CRA (Contiguous Rain Area, Ebert and McBride 2000) method (one of the object-based spatial verification methods) in order to avoid double-penalty problem of point-wise verification
- 1h precipitation fields from COSMO-Ru2 and COSMO-Ru1 compared to Sochi radar data
- 35 cases with intense precipitation over the period from 15 Jan to 15 Mar 2014 were considered
- Precipitation threshold for object identification: 1 mm/h, convolution smoother
- R SpatialVx package (developed by Eric Gilleland) for object identification and matching
- Problem: radar data cut-off areas

Object-based methods

- In each approach, it is necessary to determine the distance between two objects, which is not always straightforward because of widely varying shapes and sizes of objects
- Once objects have been identified, it is often necessary to subsequently merge some objects together (that are part of the same weather system) (Gilleland et al. 2008)

Functions for matching objects in R SpatialVx

- ***Minboundmatch*** (in single matches mode): each object is paired to only one object according to the smallest minimum boundary separation
- ***Deltamm*** – merges and/or matches using Baddeley's Delta Image Metric (Gilleland 2008), which yields a type of average pixel distance between sets (objects) *A* and *B* under certain assumptions (chosen in this case)
- ***Centmatch*** is similar to *deltamm*. It is based on the method proposed by Davis et al. (2006a). It is possible for more than one object to be matched to the same object in another field.

  Objects are matched, if the centroid distance D is less than

  1) the sum of the sizes of the two objects in question (size is the square root of the area of the object) (D=1)

  2) the average size of the two objects in question (D=2)

  3) a given constant (D=3)

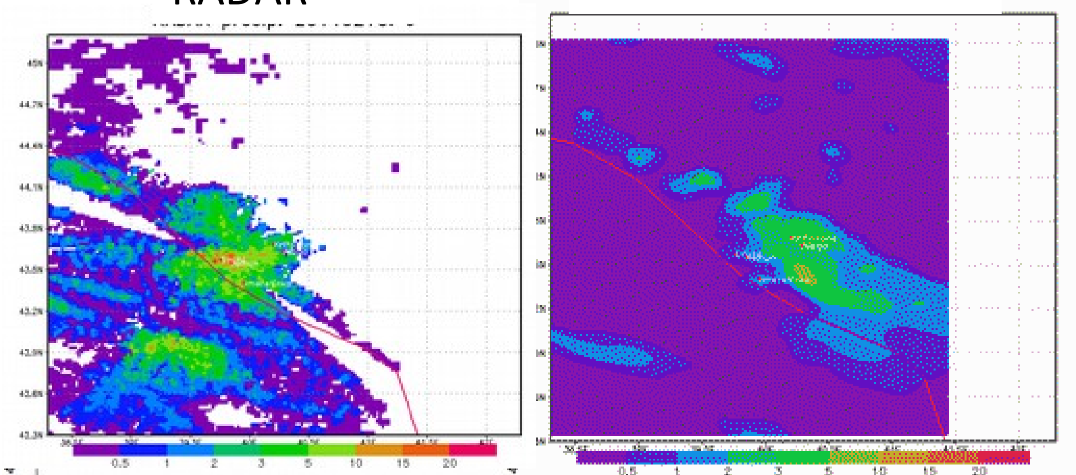
  D=1 and D=2 were used.

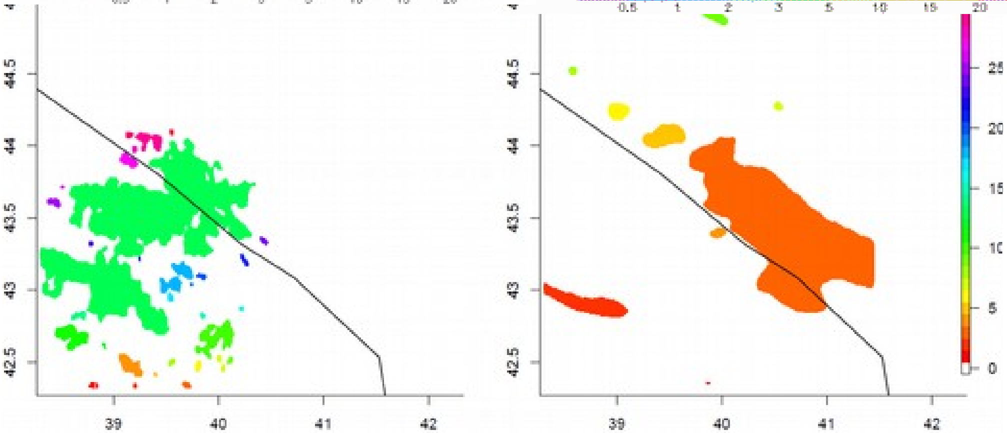
  Centmatch doesn't merge objects explicitly, but determines possible merges applied if ***MergeForce*** function is run after *centmatch* (**used in this case**)

Example: 2014021809, Identification of objects

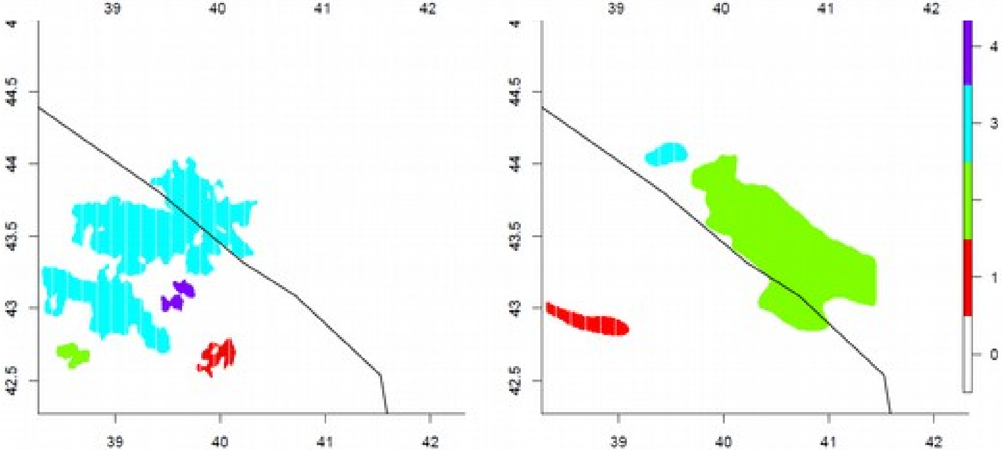
RADAR

COSMO-Ru2





NO cutting off

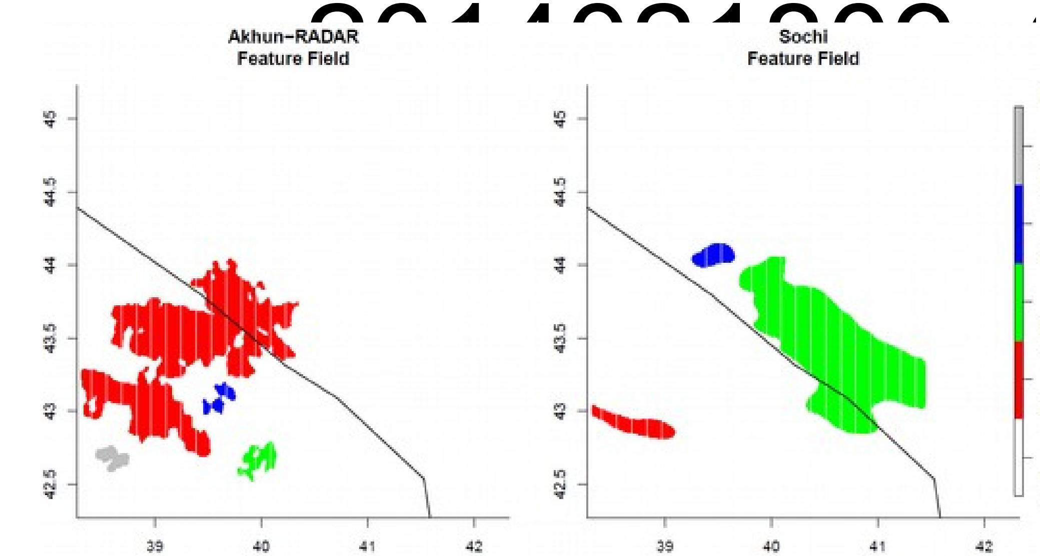


WITH cutting off

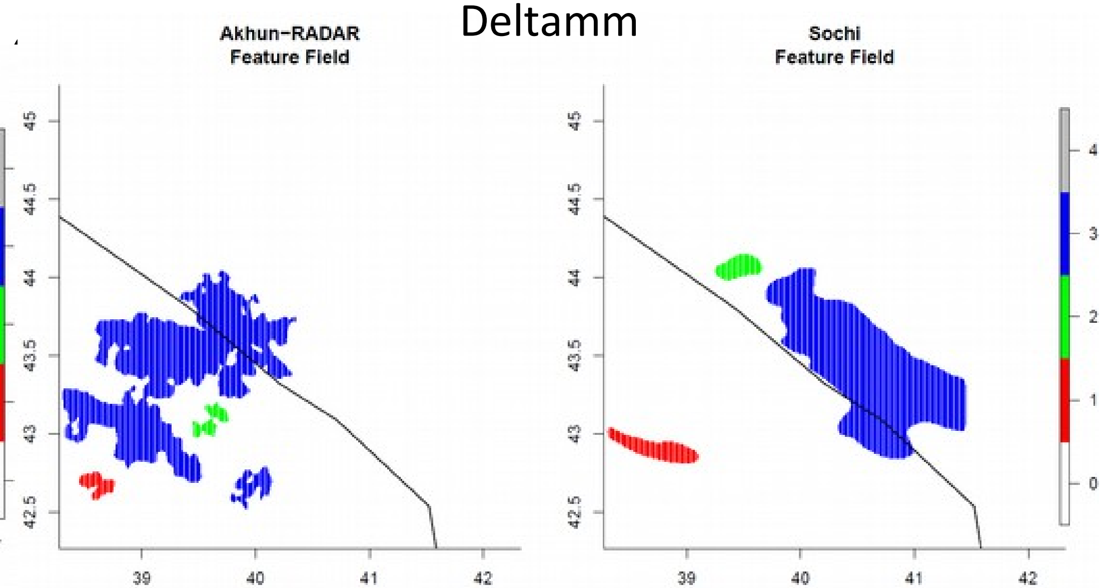
New R SpatialVx option allowing cutting off too small objects proved very useful

Example: Object merging and matching

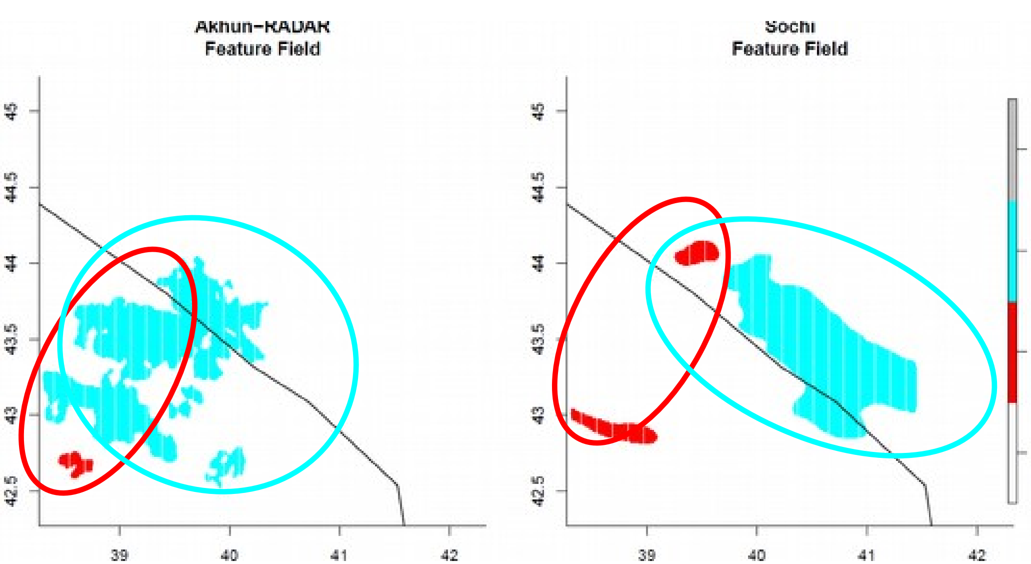
Minboundmatch



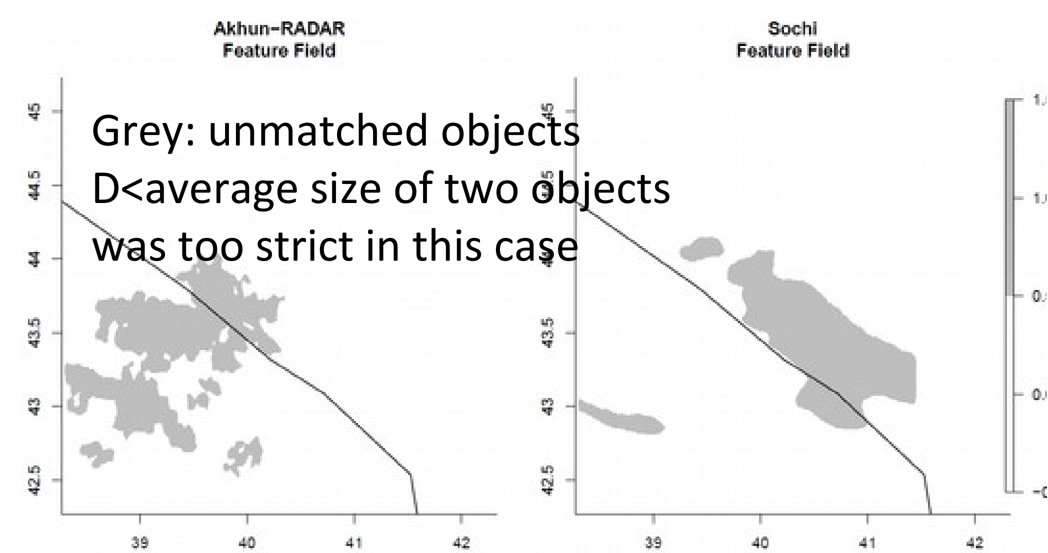
Deltamm



Centmatch, D=1



Centmatch, D=2



Grey: unmatched objects
D<average size of two objects
was too strict in this case

Discussion

- It is difficult as yet to choose a best universal object matching method in the complex terrain
- Minboundmatch tends to find the first good match, the others can be less obvious. Sometimes, big objects are matched to small ones
- Matching based on centroid distance less than the sum of the sizes of two objects provides two much matches overall,
- Matching based on centroid distance less than the average size of two objects gives better results, however, leaving many unmatched objects