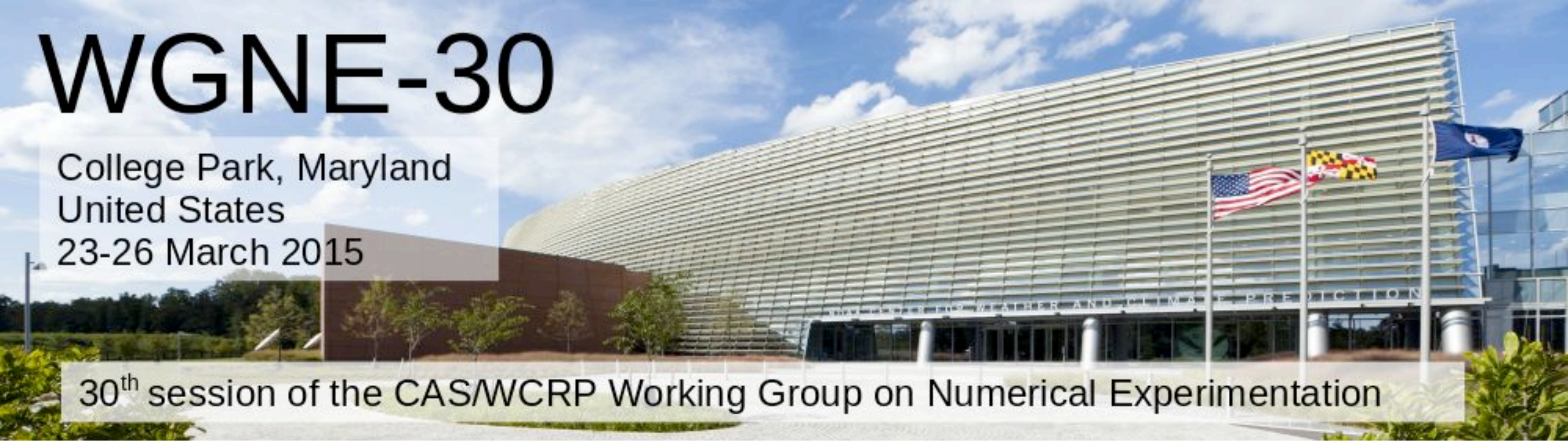


Precipitation verification

Contributions from: CMA, DWD, ECMWF, JMA, MF, NCEP, RHMC, UKMO

QPF recommandations

Reference note: Suggested methods for the verification of precipitation forecasts against high resolution limited area observations (JWGFVR, Nov 2013)

Primary temporal resolution (6h)
Thresholds (1, 2, 5, 10, 20, 50 mm per 6h)
Stratification (lead time, season, region, observed intensity threshold, …)
Comparison against station observation or gridded observations
Aggregate verification scores should be accompanied by 95% confidence intervals

For deterministic model forecasts:

- Equitable threat score (ETS)
- Extremal dependency index (EDI)
- Fractions skill score (FSS) (where gridded observations are available)
- (Additional diagnostics: HR, FAR, FBI)

For probabilistic forecasts interpreted from ensembles, or by statistical post-processing

- Brier skill score BSS (and components)
- ROC area
- Continuous ranked probability skill score (CRPSS)

Verification country	Models	Region	Sample size	Data processing	Accumulation period	Scores	Cinfidence intervals
CMA	Global deterministic	China	National network		24	ETS, FBI Also maps	
DWD	Global deterministic	Germany	National network (1000 stations)	Gridded	24	ETS, FBI	
ECMWF	Global deterministic and ensemble	Tropics, Extra-tropics, USA	GTS obs, NEXRAD		24	CRPSS, SEEPS, ETS, FBI FSS	
JMA	Global deterministic and 5km MSM	Japan	National network (1300 stations)	Gridded Station obs	6h	ETS, EDI, FBI	Yes
NCEP	Global deterministic GFS, NAM, CONUSNEST	USA			24h, 3h	ETS, FBI, EDI,	
Russia	HR models deterministic and ensemble	Sochi region	13 stations	Station obs	3h	EDI, PSS, Base rate BSS, ROCA	
UKMO	UM global (oper & e-suite)	Tropics, Global	GTS obs		6h, 24h	SEEPS	
Meteo-France	Global deterministic MF models (deterministic and ensemble)	France	National network (4000 stations)	Gridded Combined radar-gauge analysis	24h, 6h	FBI, POD, FAR, BSS, FSS	Yes

QPF Skill Scores over China

NWPC/CMA

2015.03.20

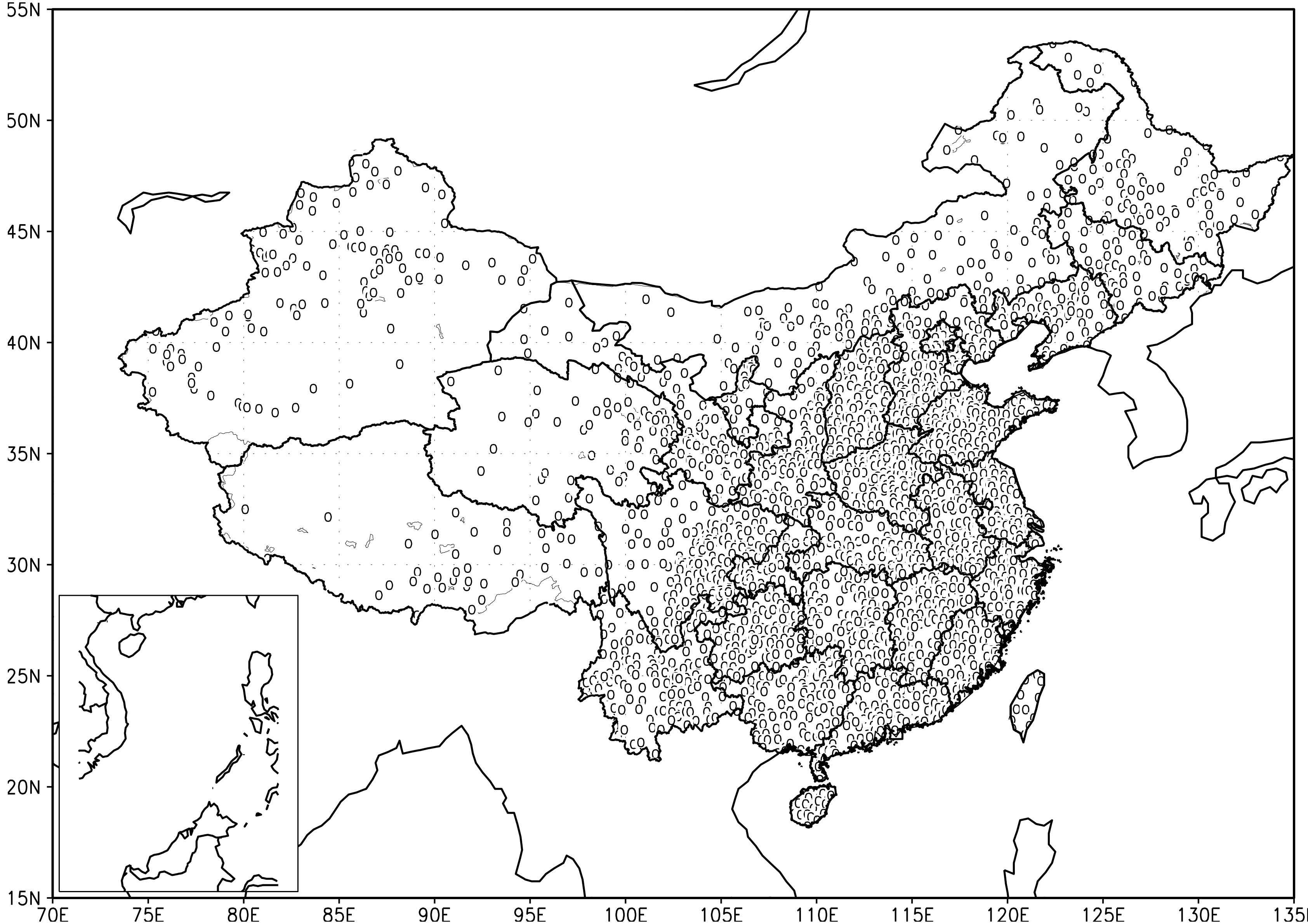
QPF Skill Scores over China

May 2014 – Sept 2014(warm season)

Models included in analysis:

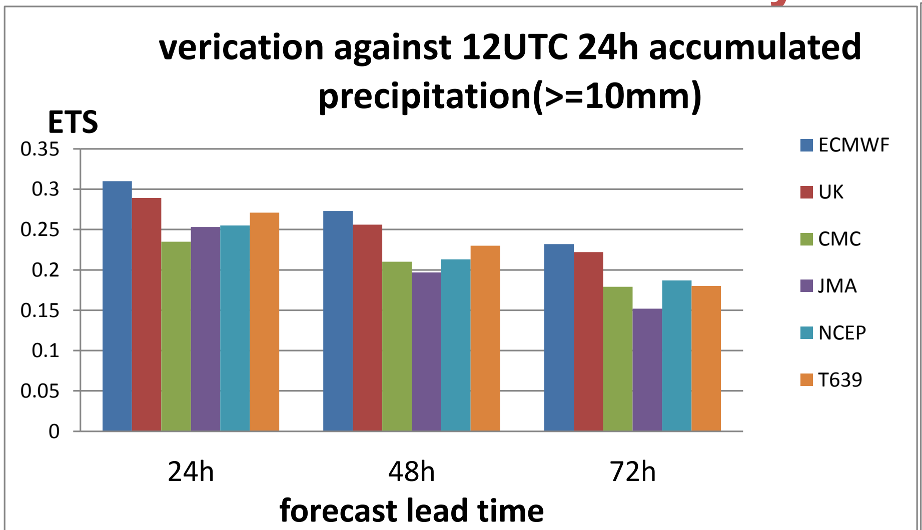
- NCEP GFS
- CMC Global
- ECMWF
- JMA
- UK
- CMA Global

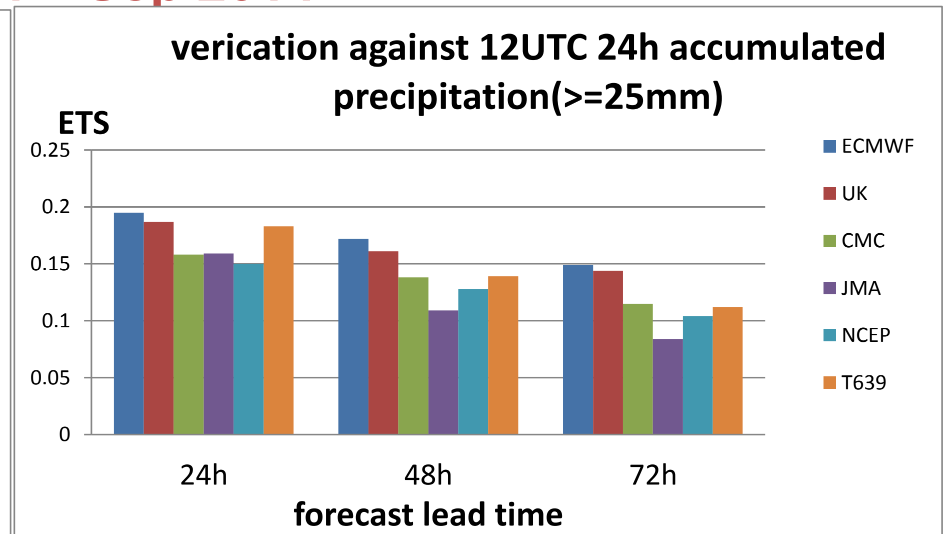
Observation station distribution

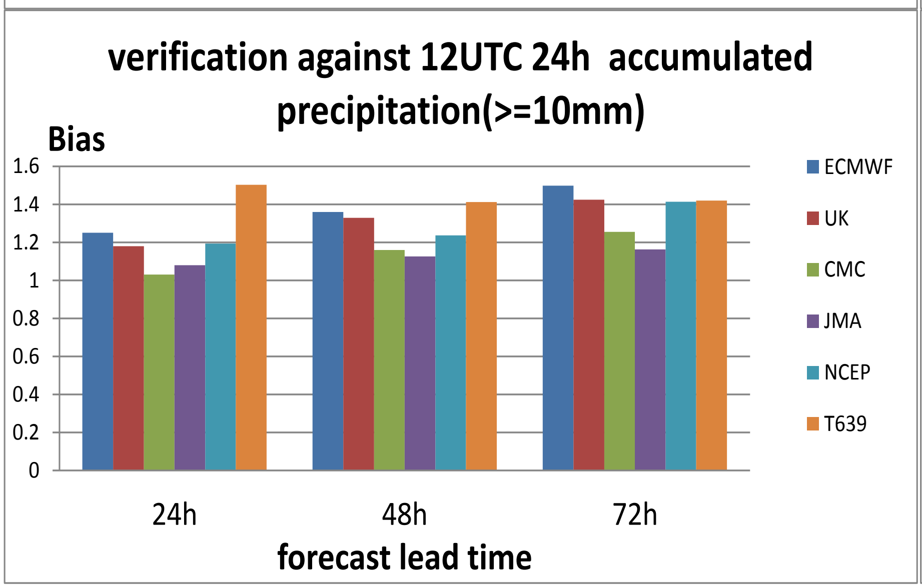


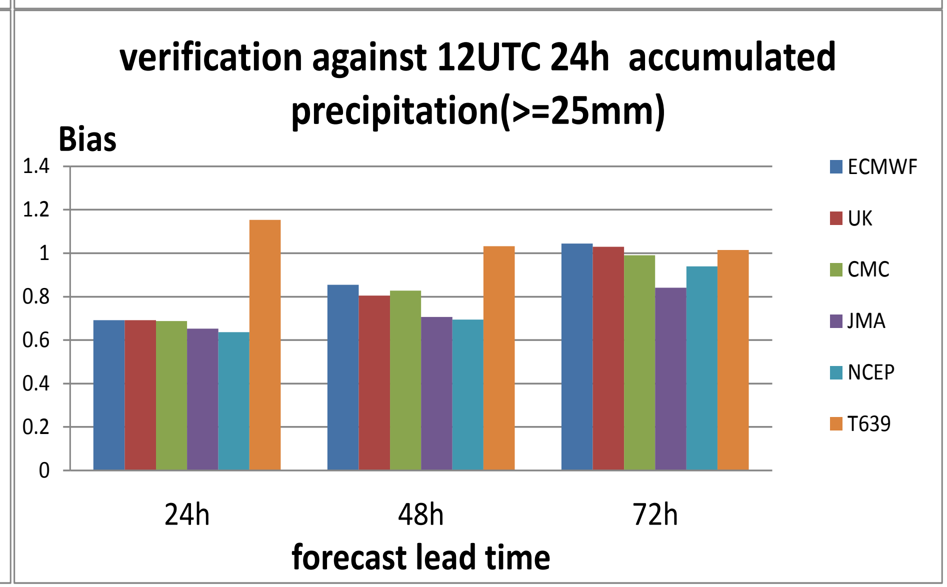
Mean QPF Skill Scores over China

May 2014 – Sep 2014



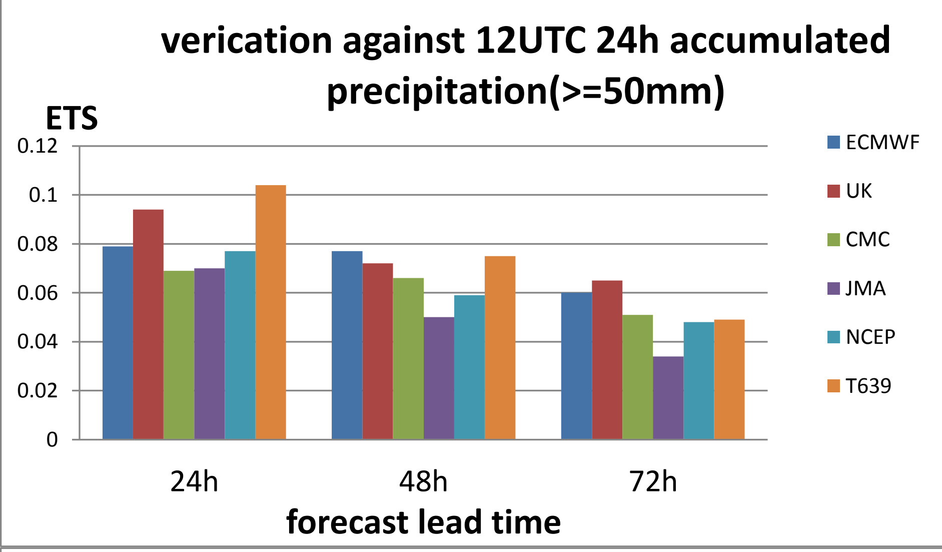


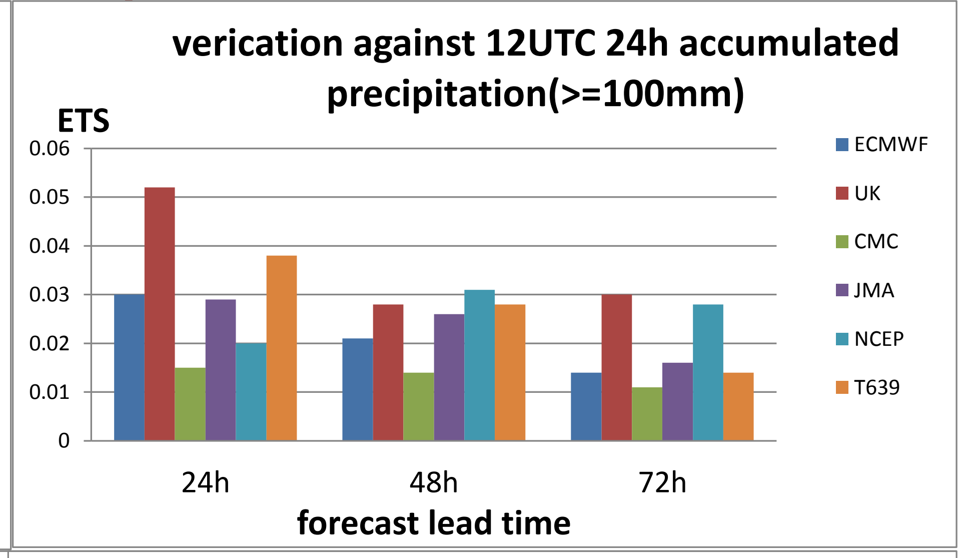


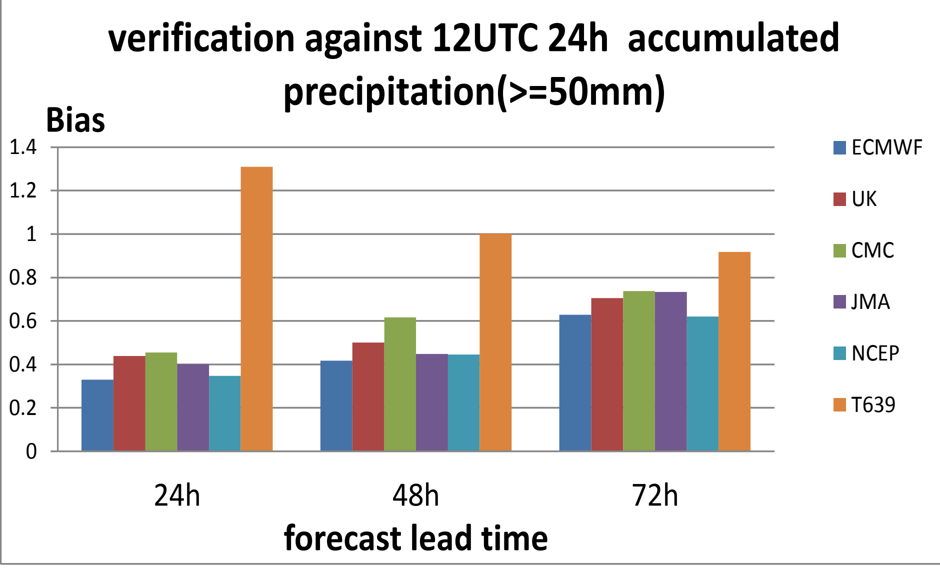


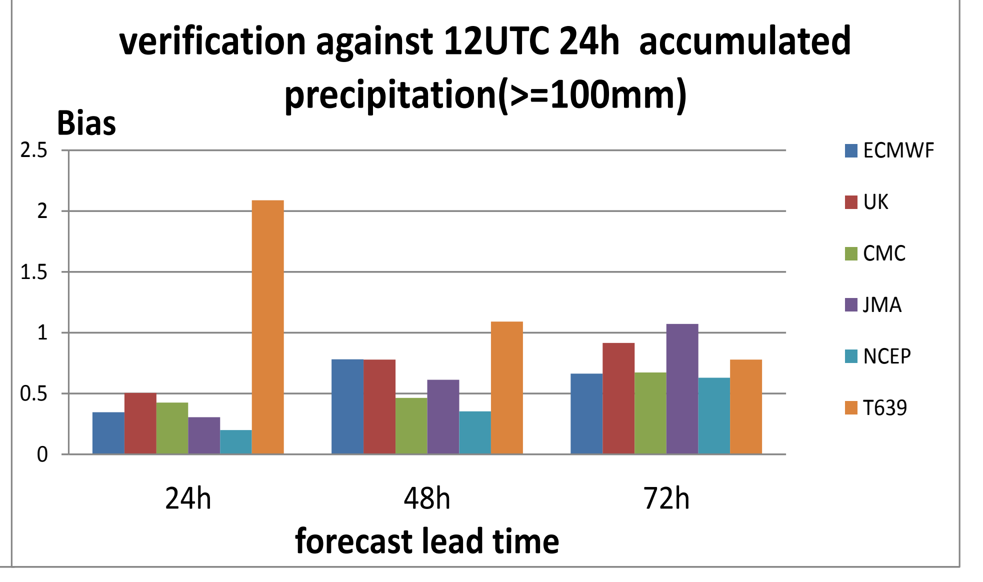
Mean QPF Skill Scores over China

May 2014 – Sep 2014



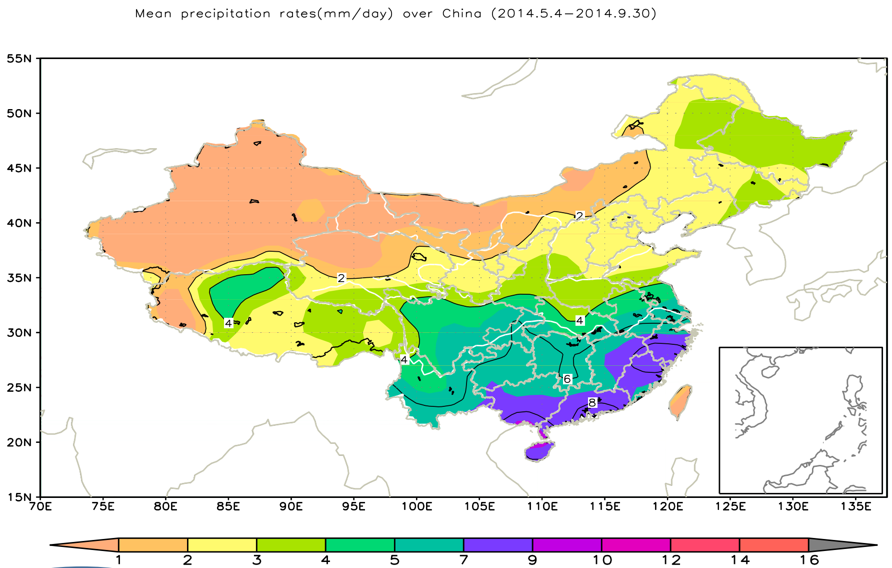




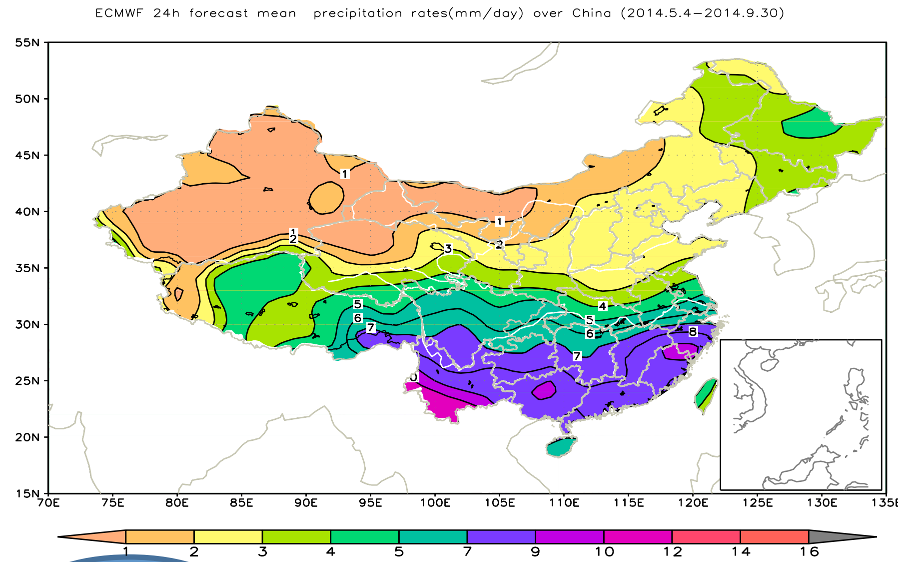


Distribution of mean precipitation rates(mm/day) over China

(2014.5.04-2014.9.30)

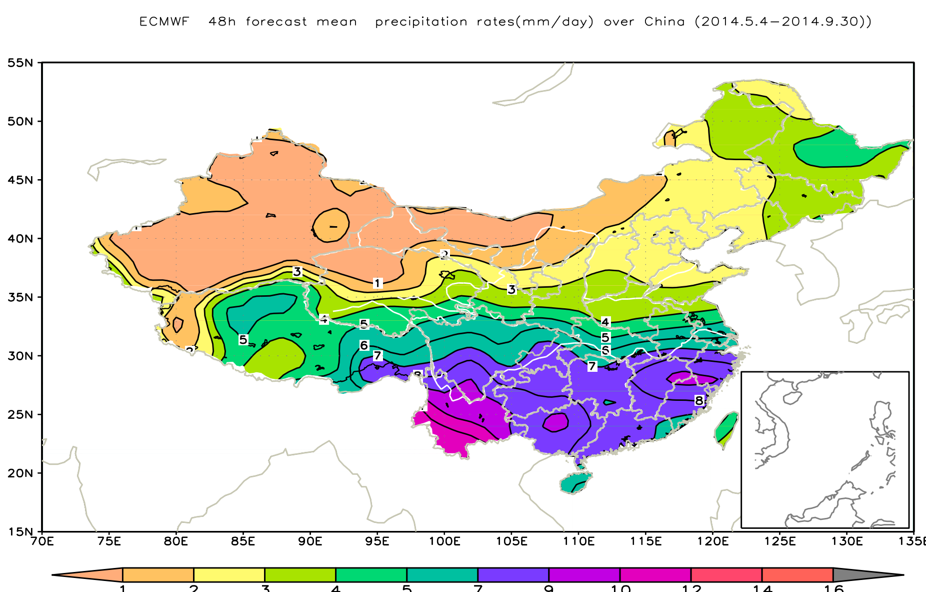


OBS

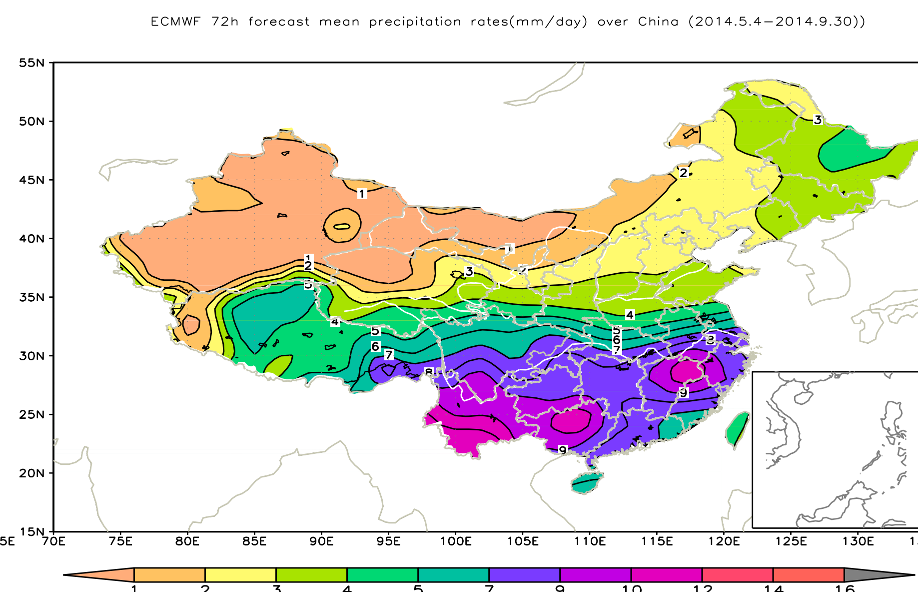


24H

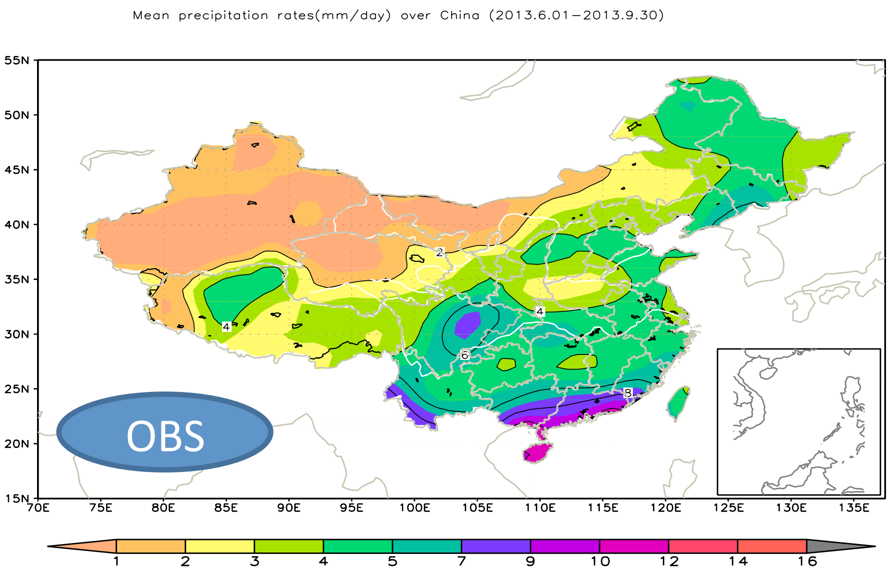
ECMWF 1/2/3day forecast mean precipitation rate distibution

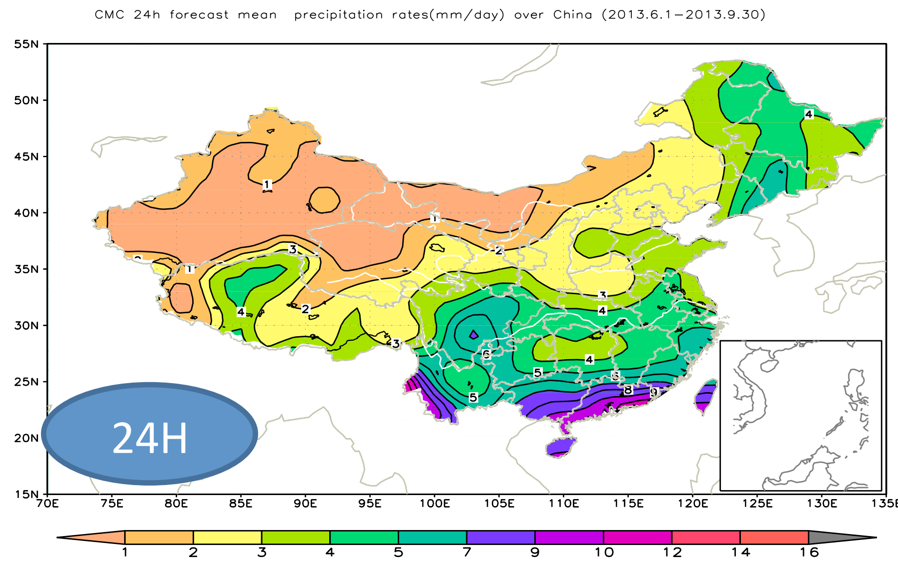


48H

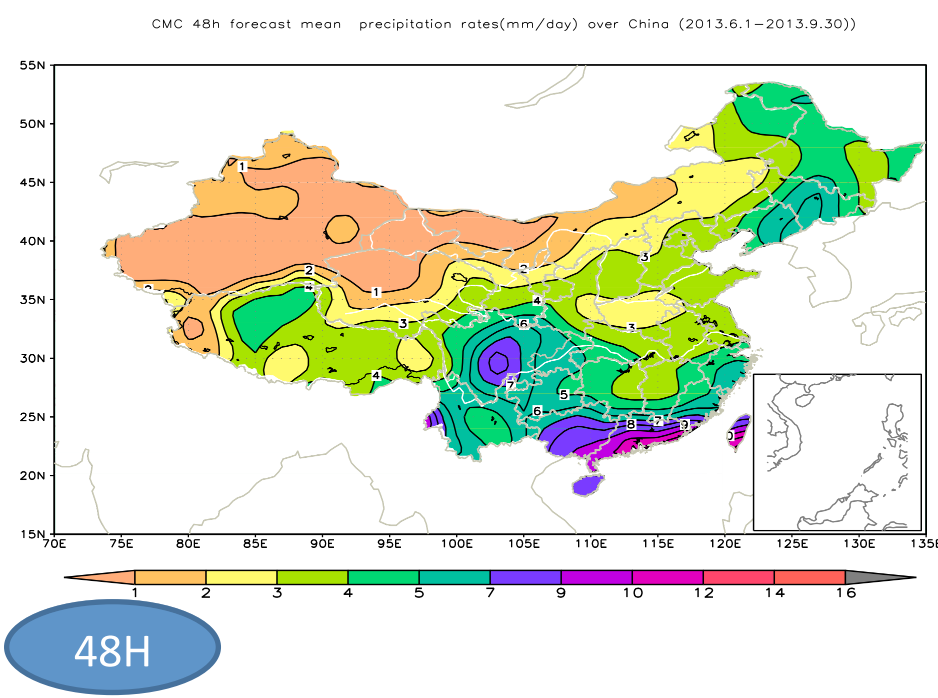


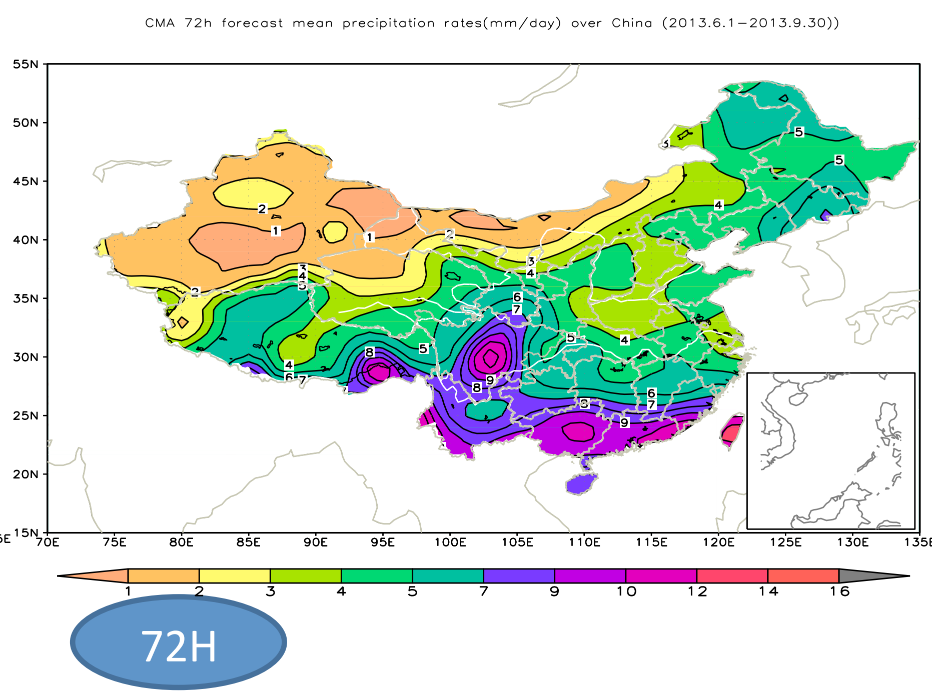
72H

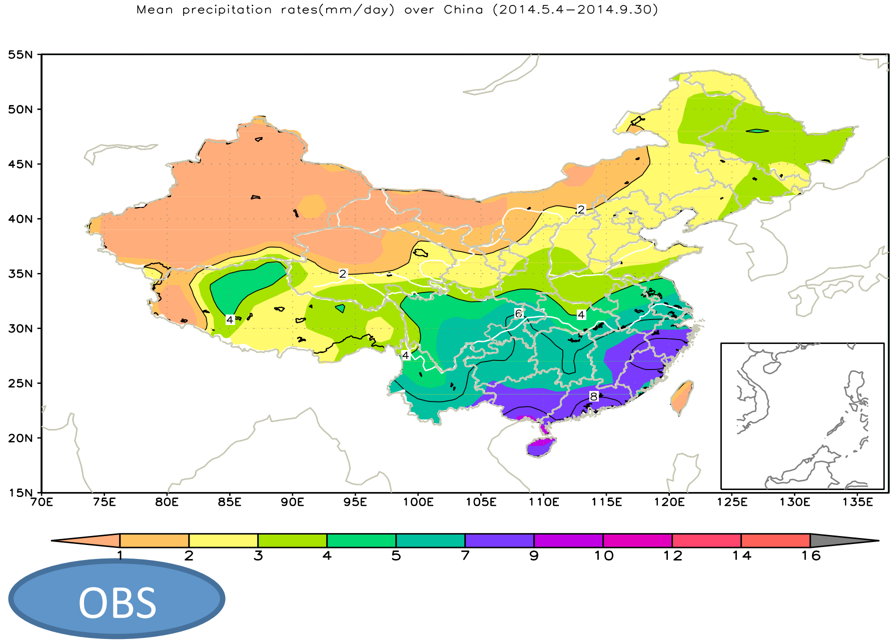


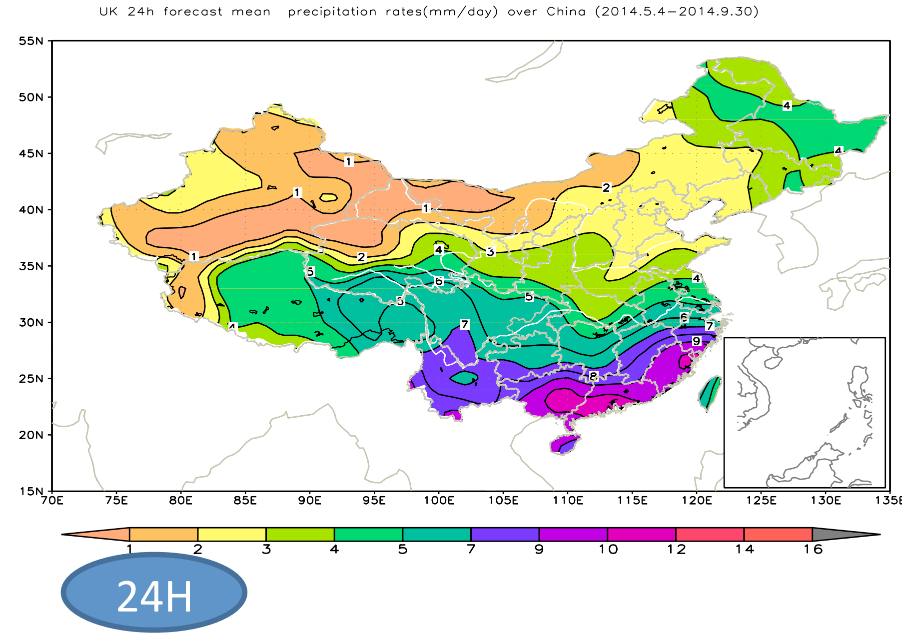


CMC 1/2/3day forecast mean precipitation rate distibution

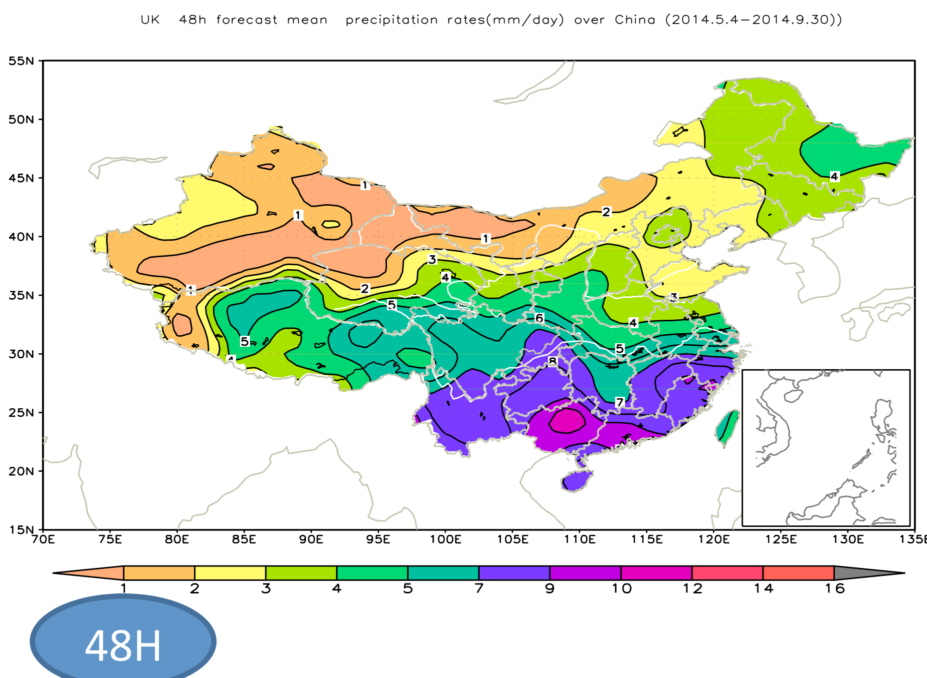


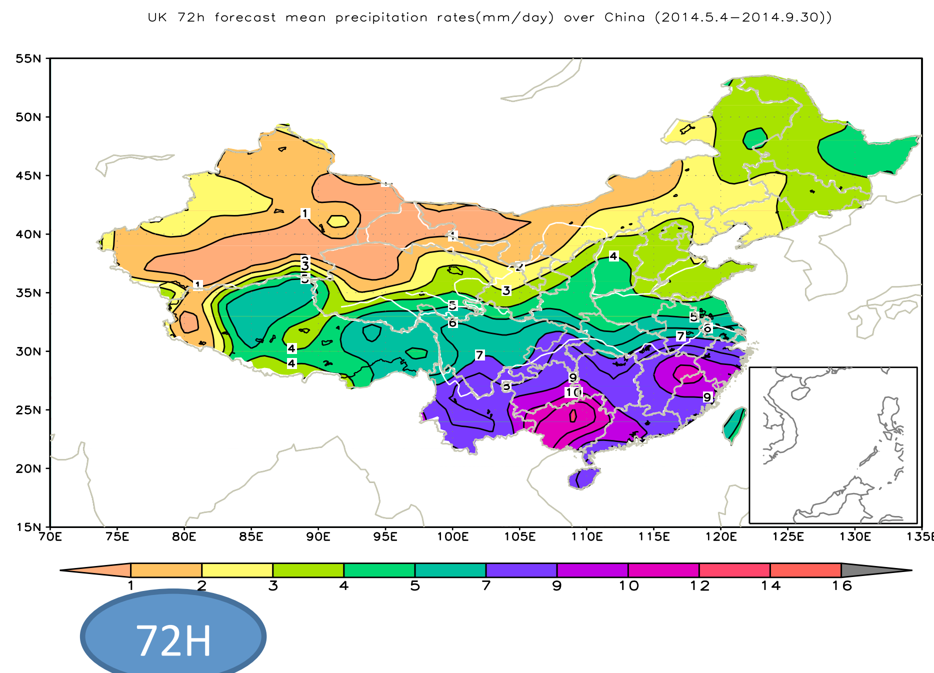


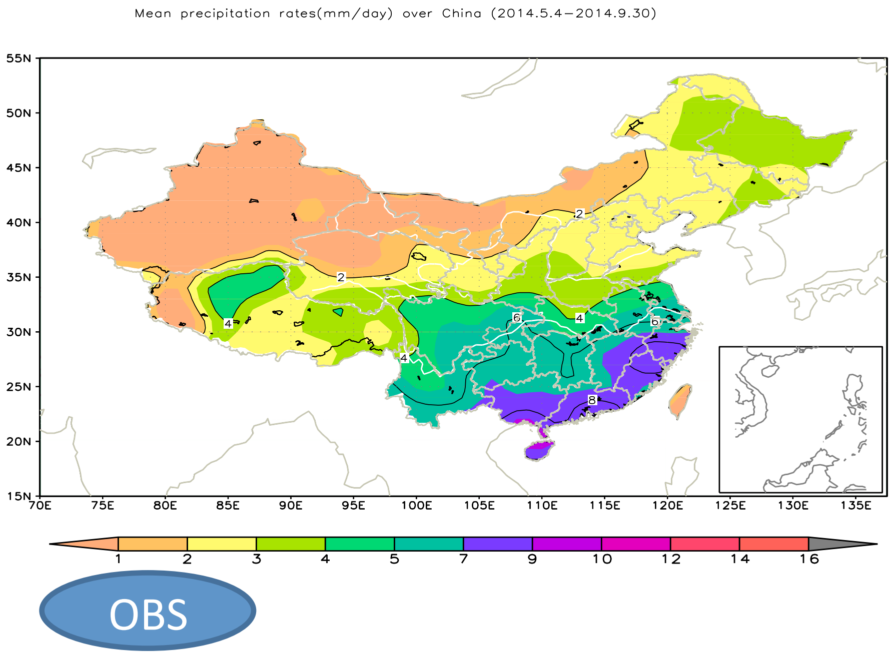


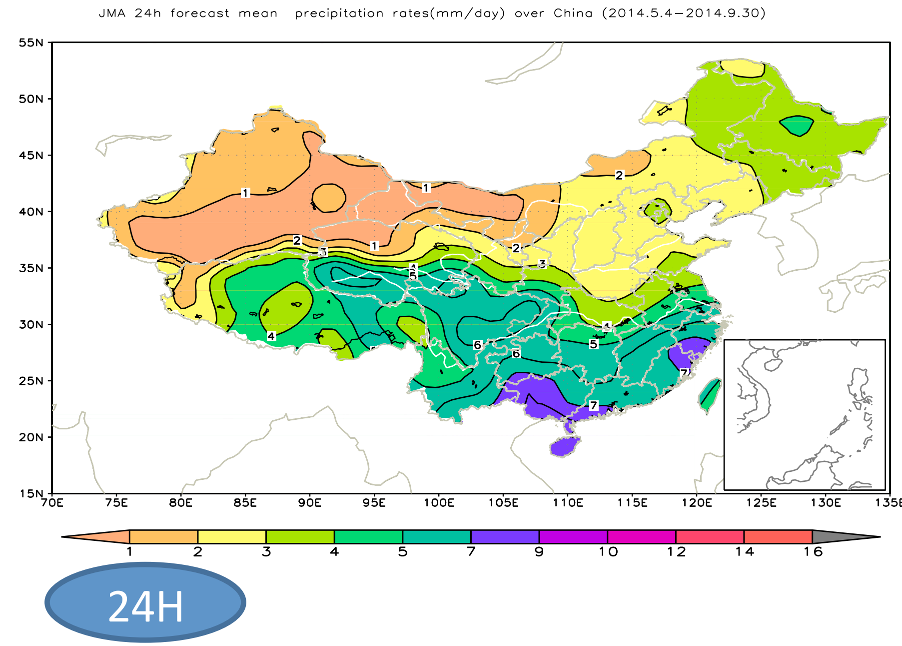


UK 1/2/3day forecast mean precipitation rate distibution

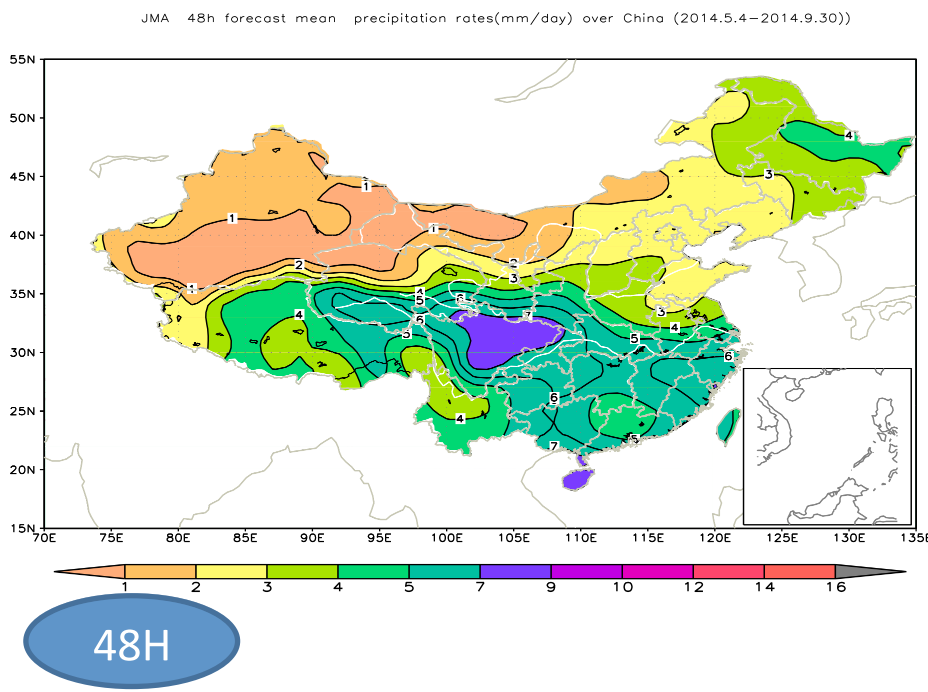


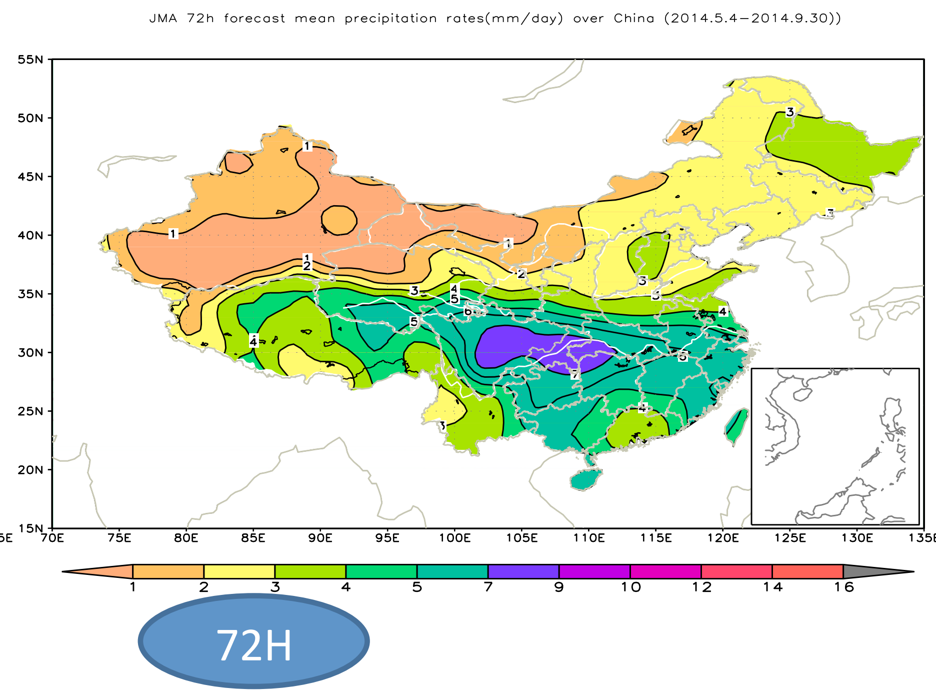


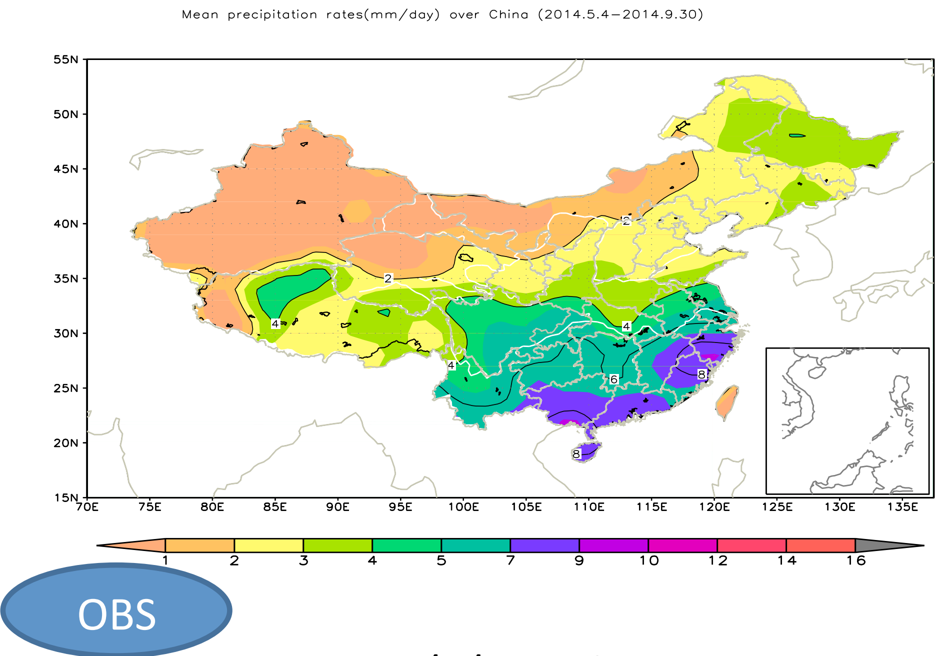


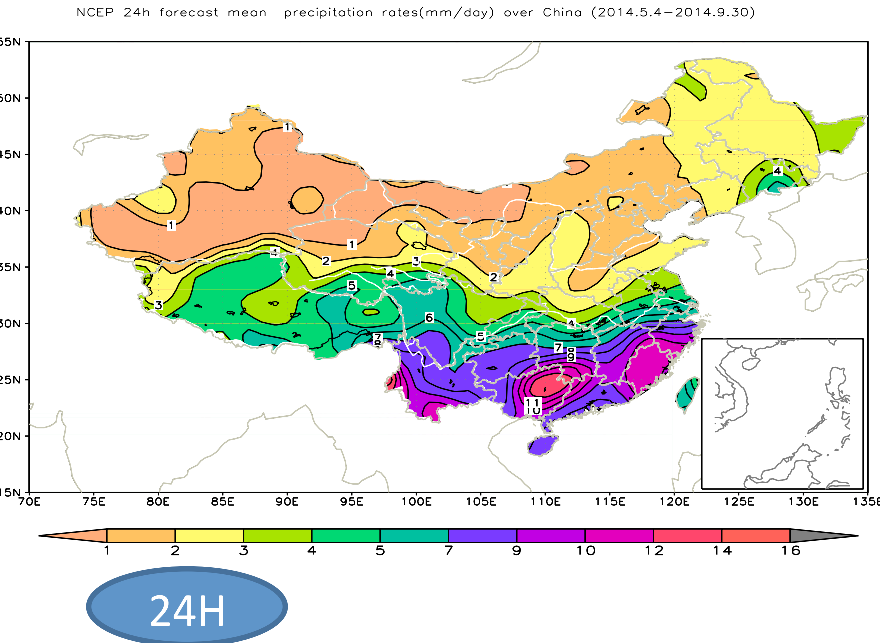


JMA 1/2/3day forecast mean precipitation rate distibution

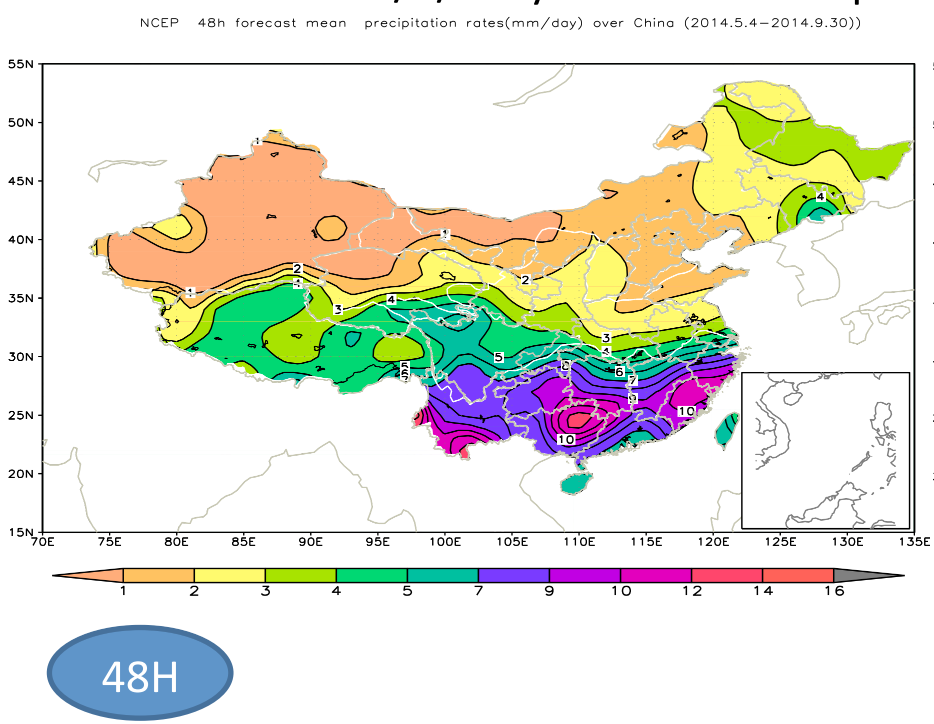


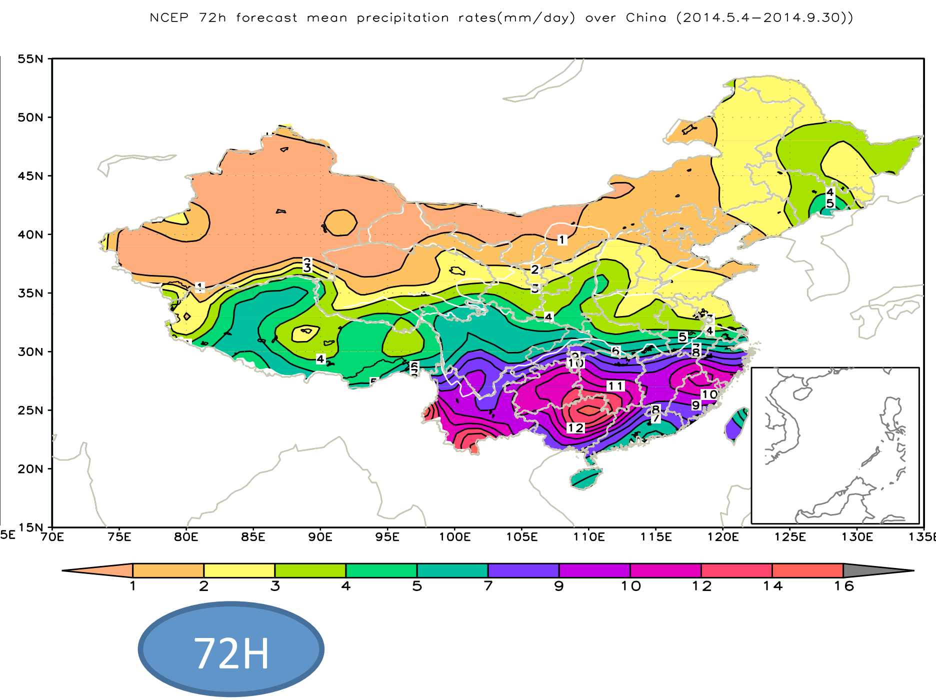


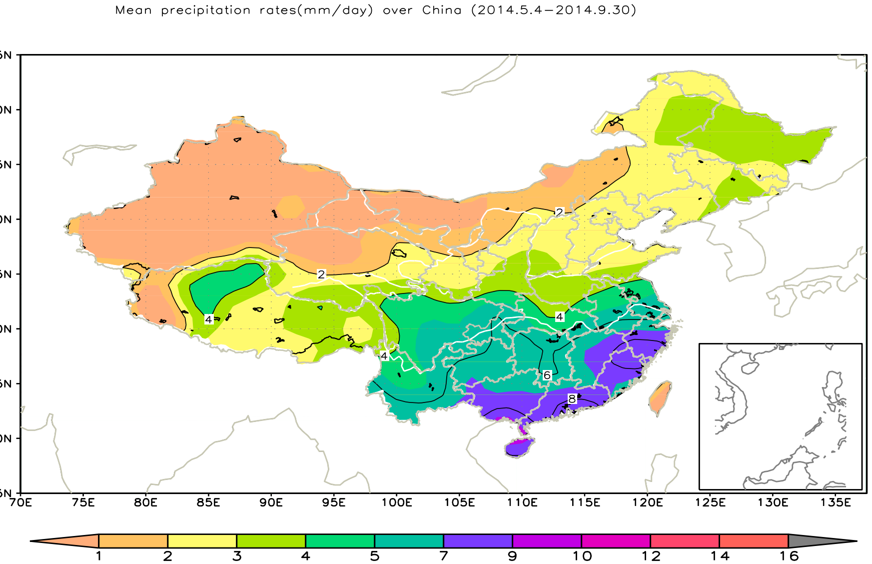




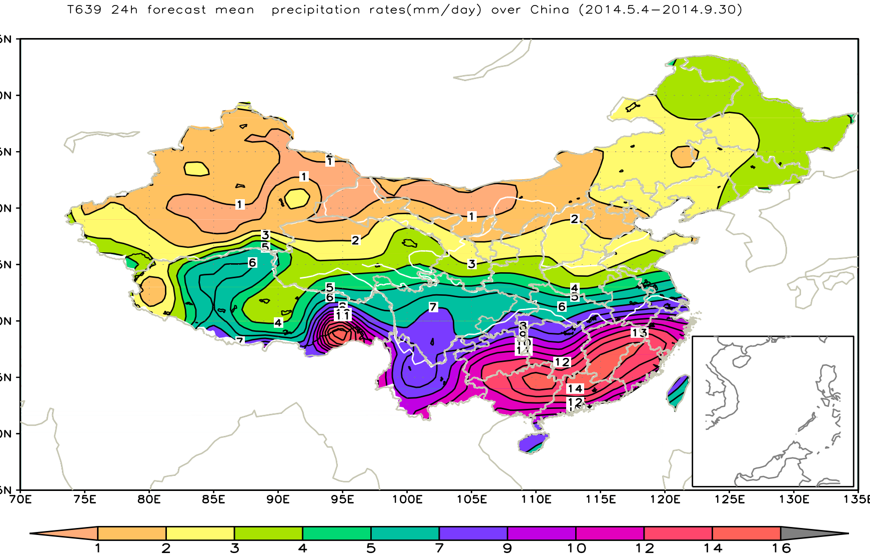
NCEP 1/2/3day forecast mean precipitation rate distibution





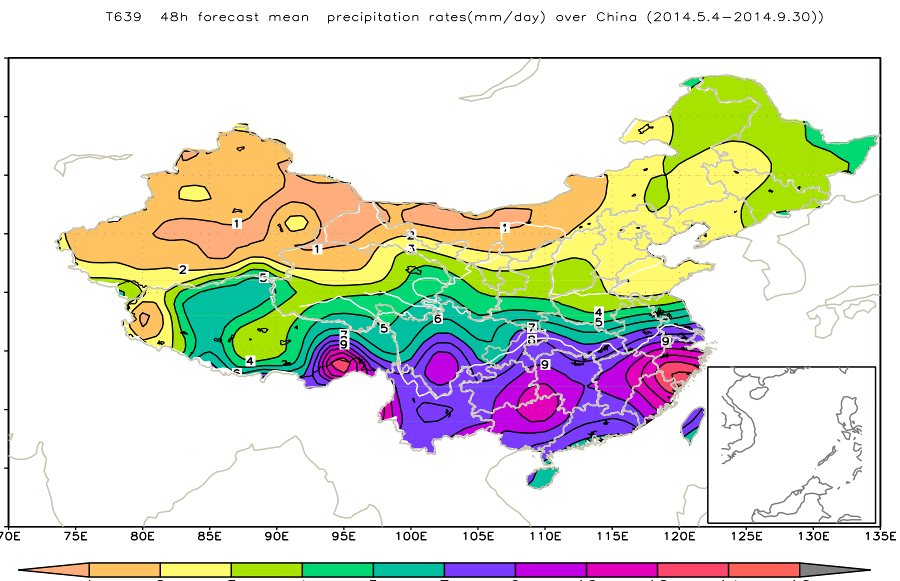


OBS

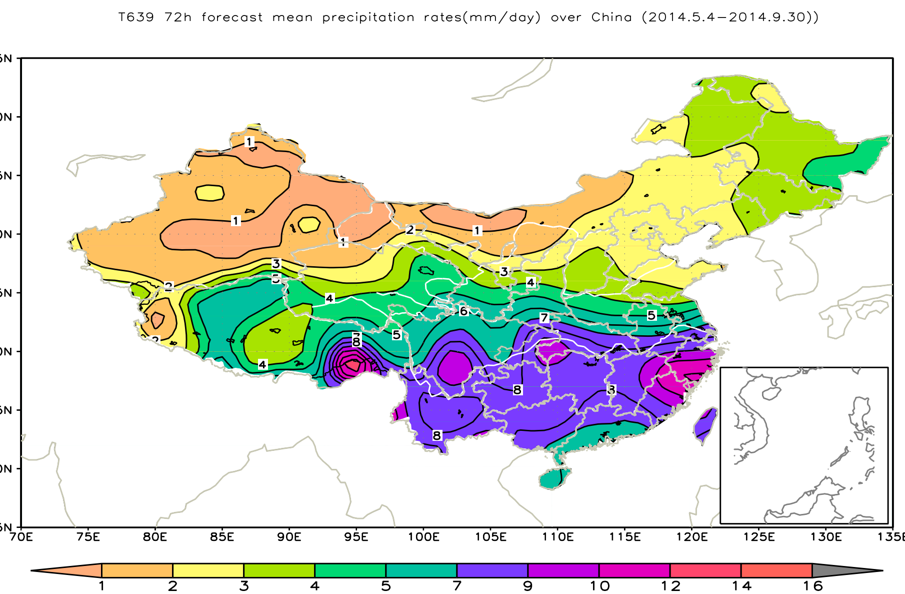


24H

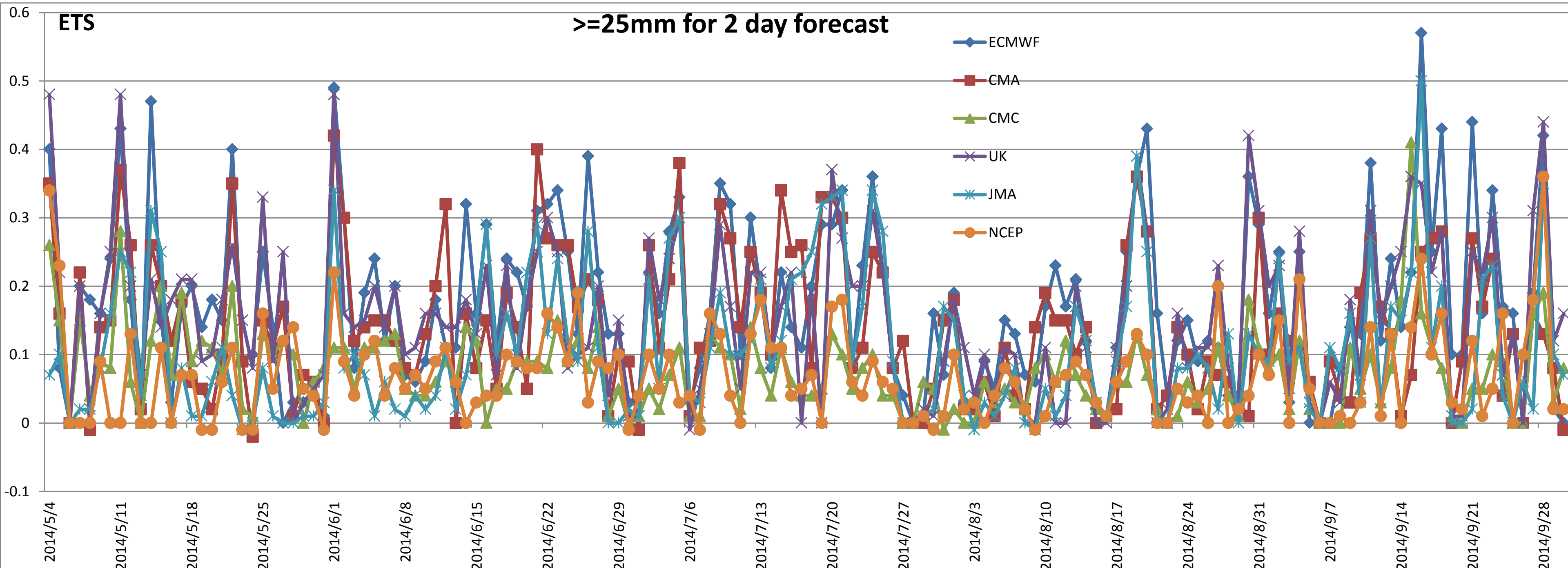
CMA 1/2/3day forecast mean precipitation rate distibution



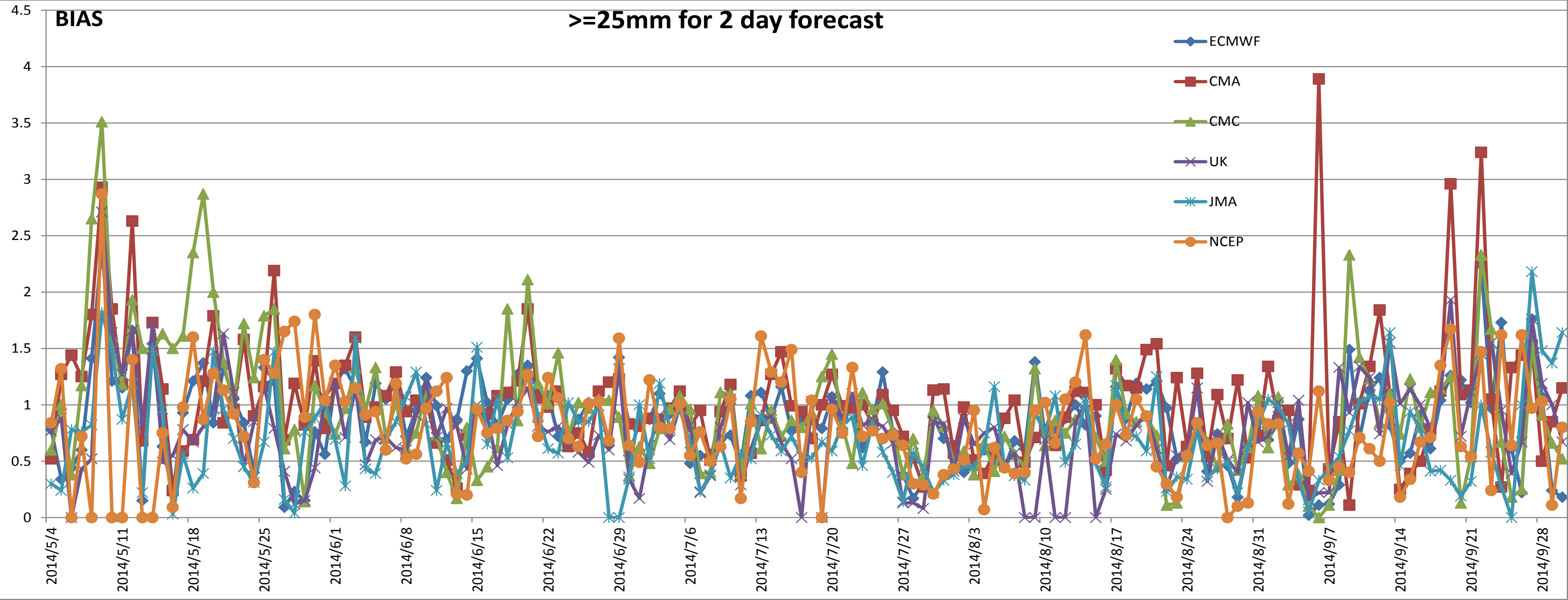
48H



72H



ETS
>=25mm for 2 day forecast
ECMWF
CMA
CMC
UK
JMA
NCEP
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
2014/5/4
2014/5/11
2014/5/18
2014/5/25
2014/6/1
2014/6/8
2014/6/15
2014/6/22
2014/6/29
2014/7/6
2014/7/13
2014/7/20
2014/7/27
2014/8/3
2014/8/10
2014/8/17
2014/8/24
2014/8/31
2014/9/7
2014/9/14
2014/9/21
2014/9/28

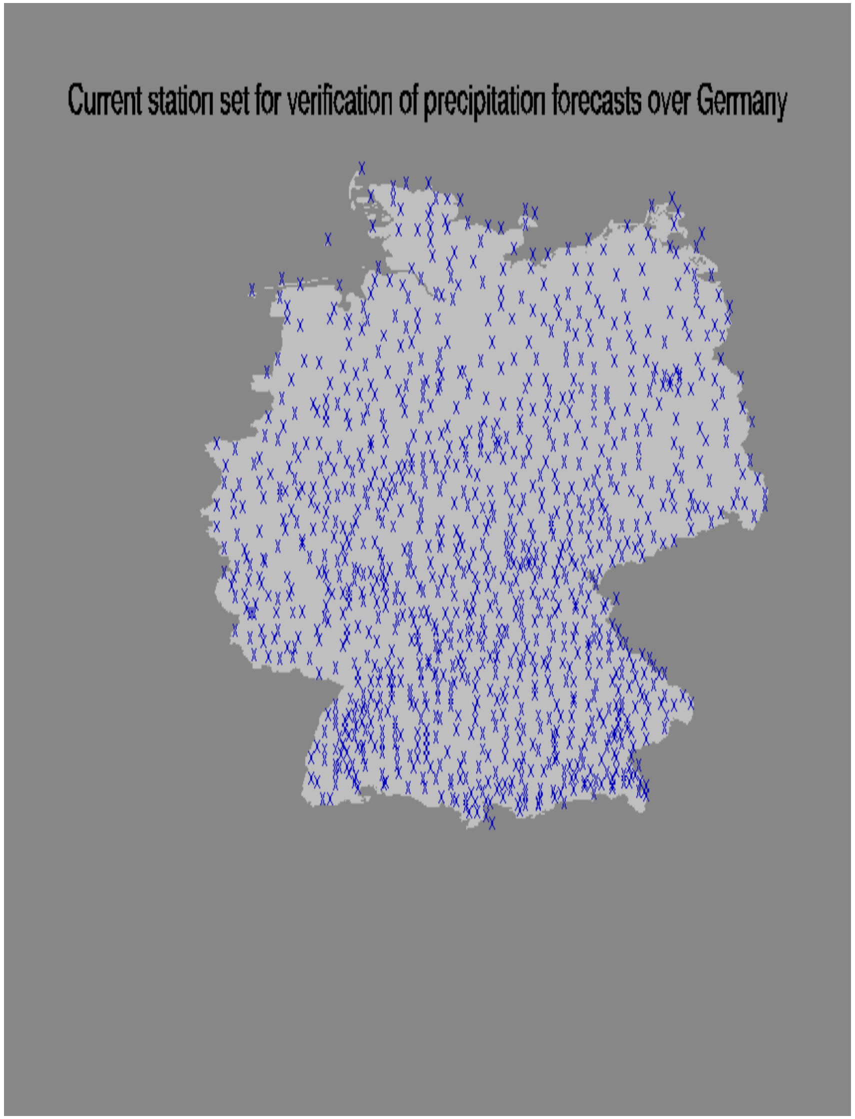


BIAS
>=25mm for 2 day forecast
ECMWF
CMA
CMC
UK
JMA
NCEP
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
2014/5/4
2014/5/11
2014/5/18
2014/5/25
2014/6/1
2014/6/8
2014/6/15
2014/6/22
2014/6/29
2014/7/6
2014/7/13
2014/7/20
2014/7/27
2014/8/3
2014/8/10
2014/8/17
2014/8/24
2014/8/31
2014/9/7
2014/9/14
2014/9/21
2014/9/28

Precipitation verification at DWD

30th WGNE meeting,
23-26 March 2015, NCEP, Washington

U. Damrath (DWD)



1000 stations; controlled data are available around 10 days after measurement.

Verification method:

Aggregation to a 1° x 1° grid: forecasts in the model grid, observations as so called *superobservations* in each model grid.

18

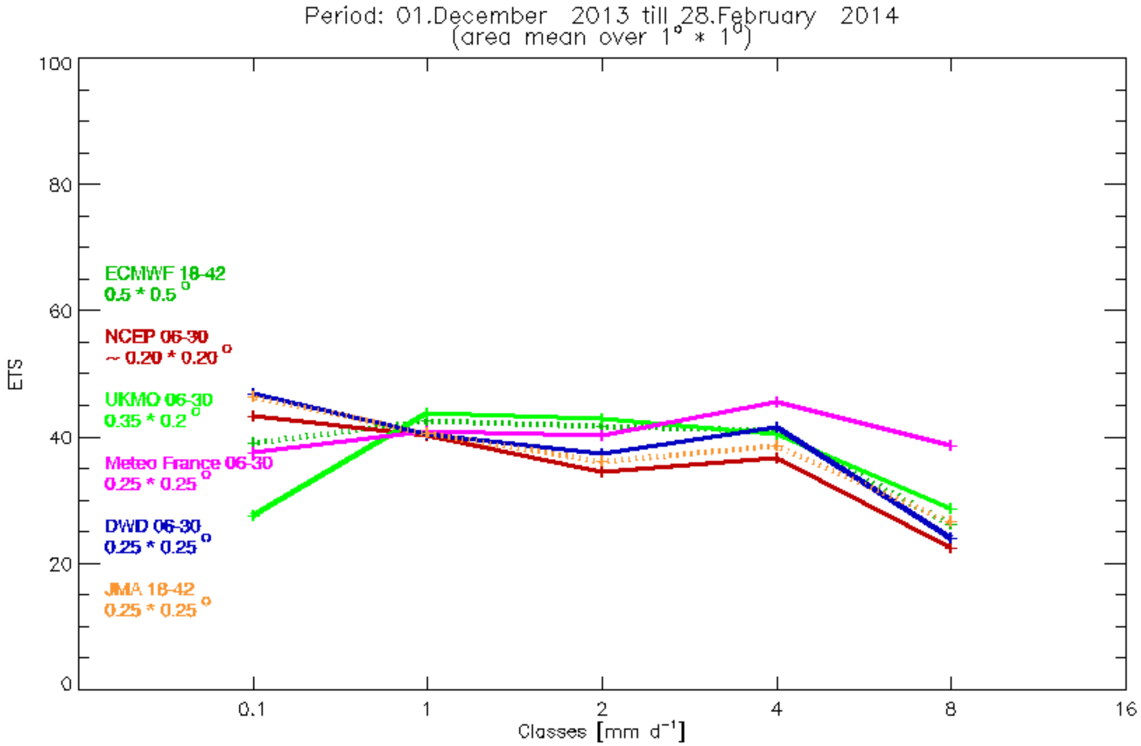
We are (again) sorry for (still) not entirly considering Laurie Wilson ‘s Verification proposal, due to several migrations of the verification system during the last year:

•libdwd → GRIB-API (ECMWF)

•GRIB1 → GRIB2

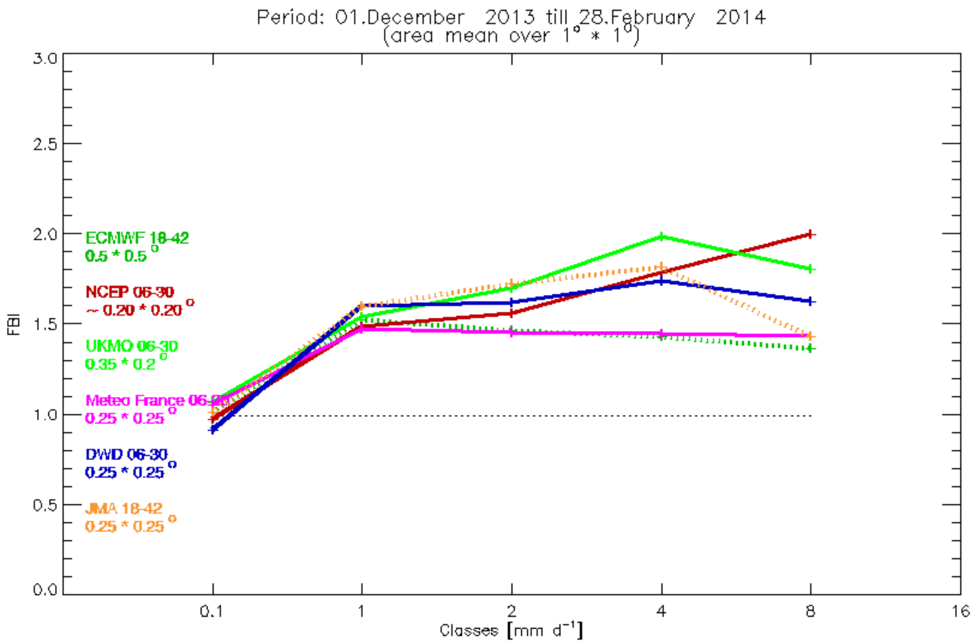
•database requesting layer (csobank → sky)

•Cray XC30 → Cray XC30/40
→ this unfortunately caused a loss of data for summer and autumn 2014

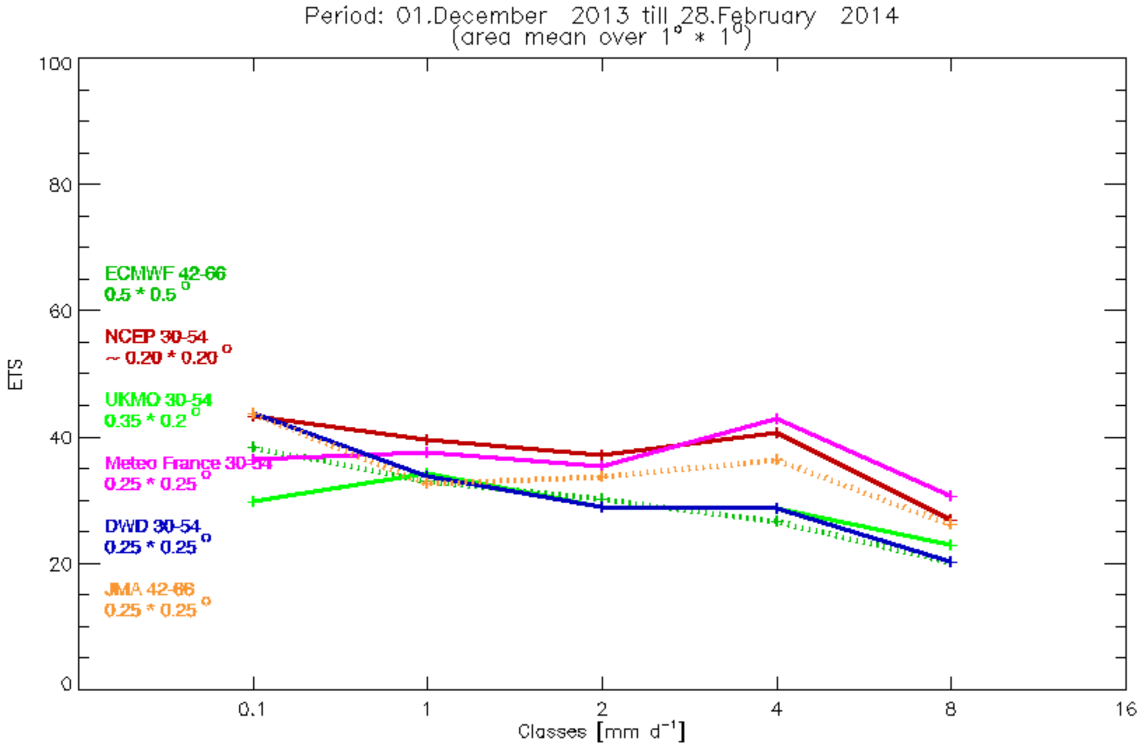


Winter 2013/14

Forecast day 1

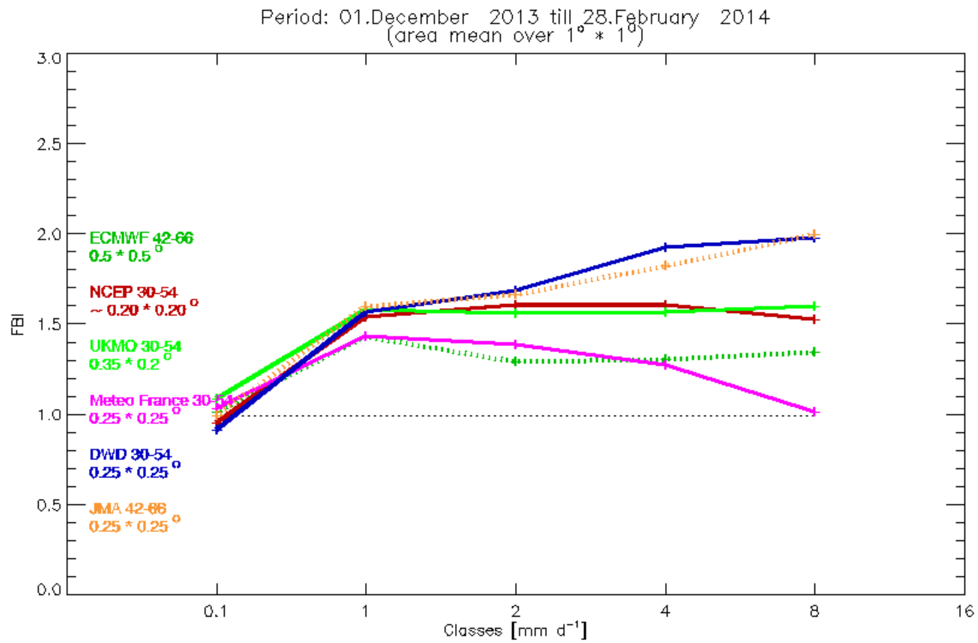


M. Baldauf (DWD)

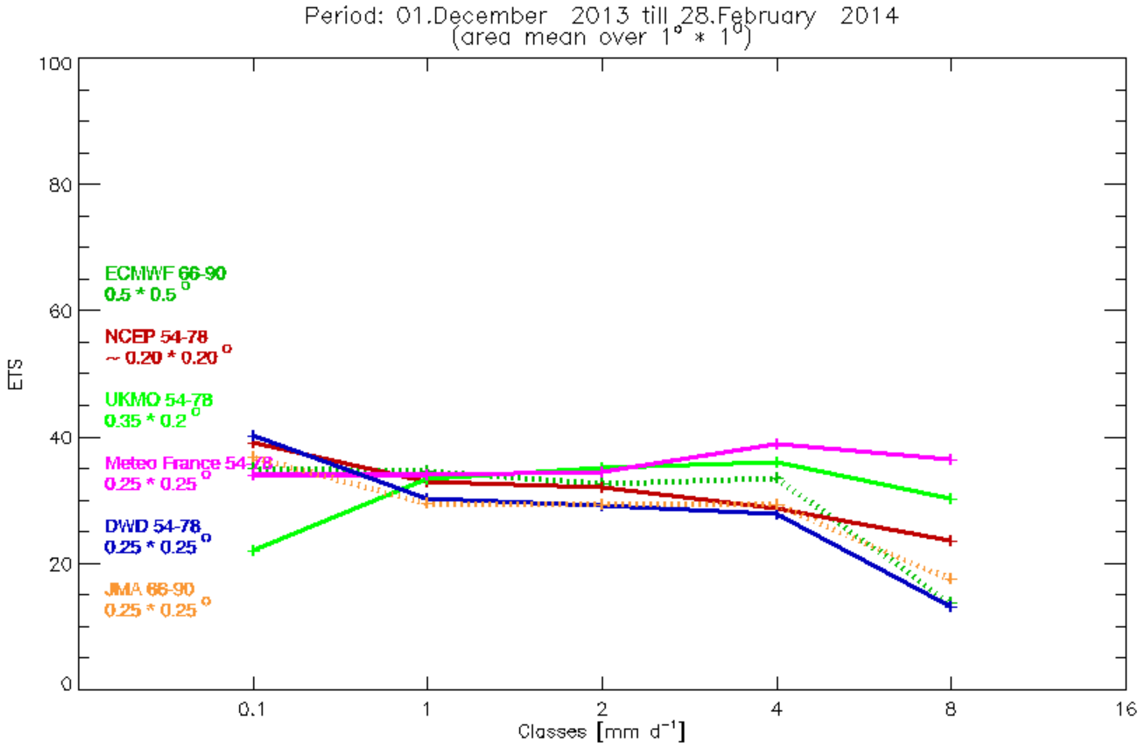


Winter 2013/14

Forecast day 2

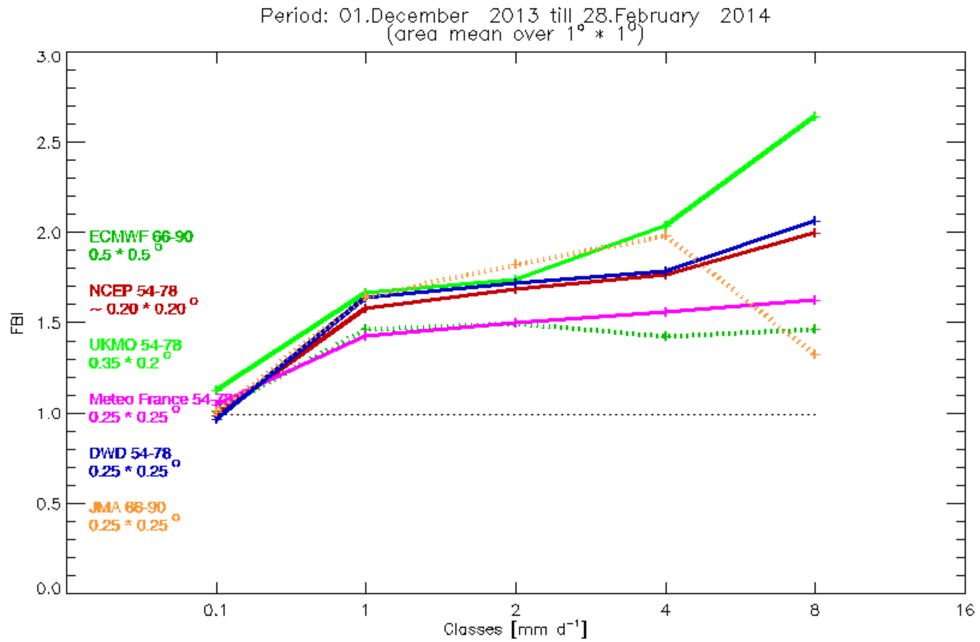


M. Baldauf (DWD)

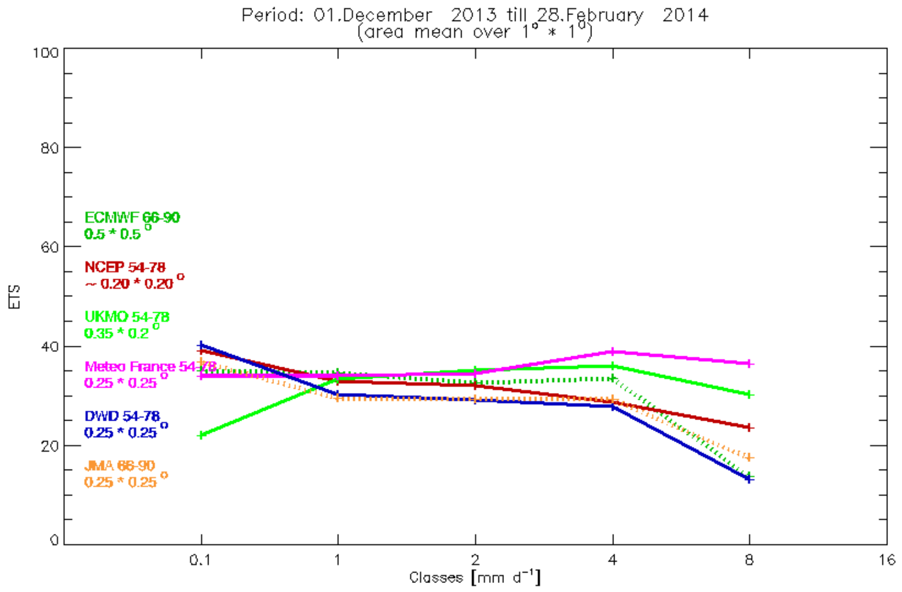


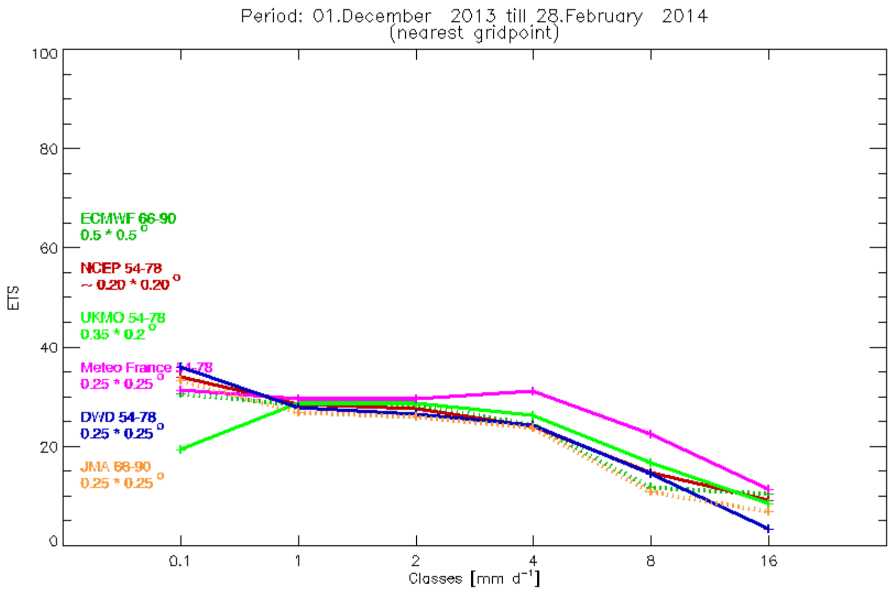
Winter 2013/14

Forecast day 3

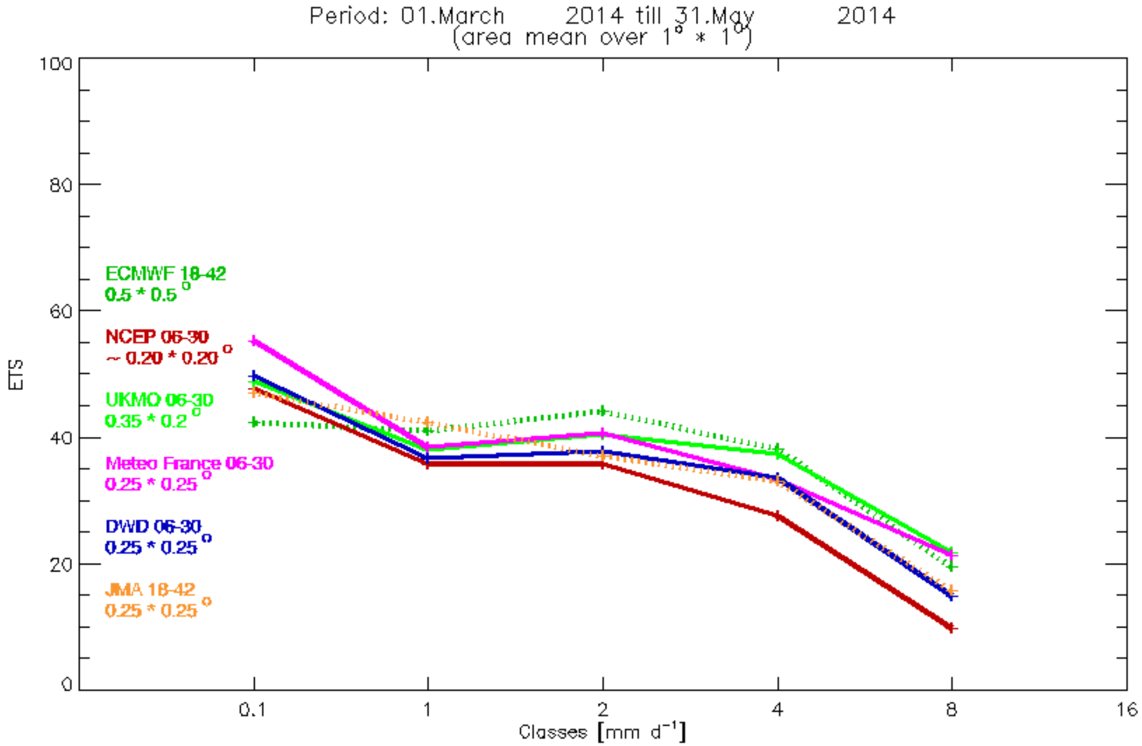


M. Baldauf (DWD)



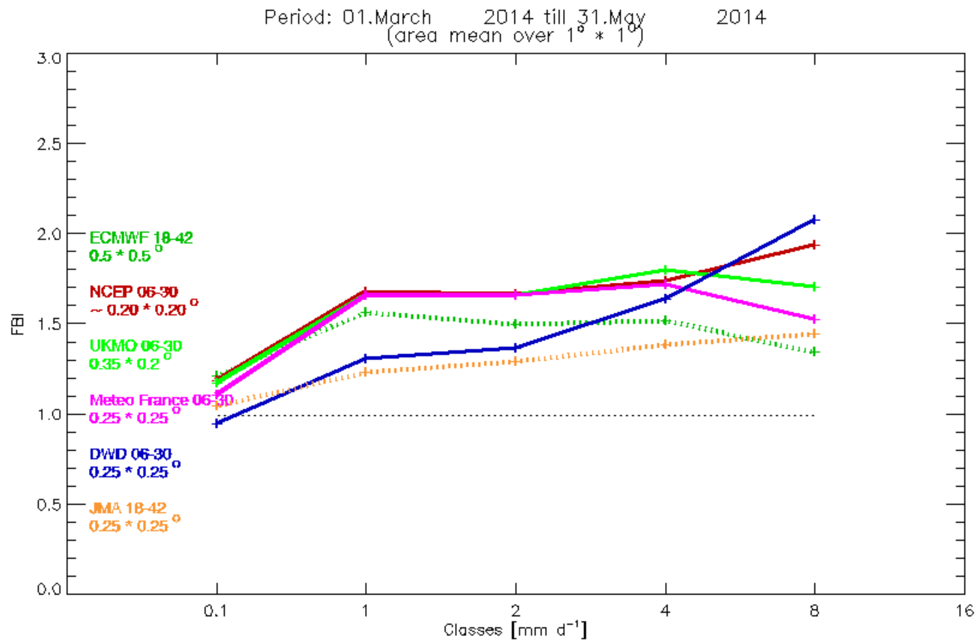


Comparison between two verification methods:
area mean and nearest neighbour

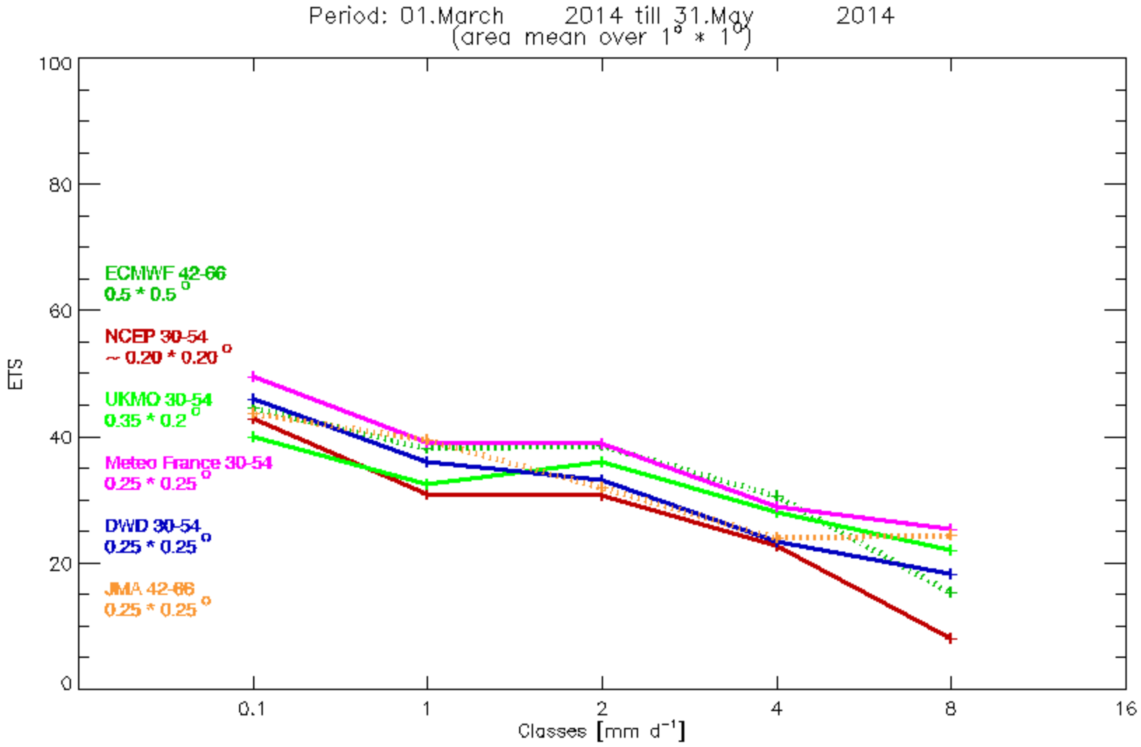


Spring 2014

Forecast day 1

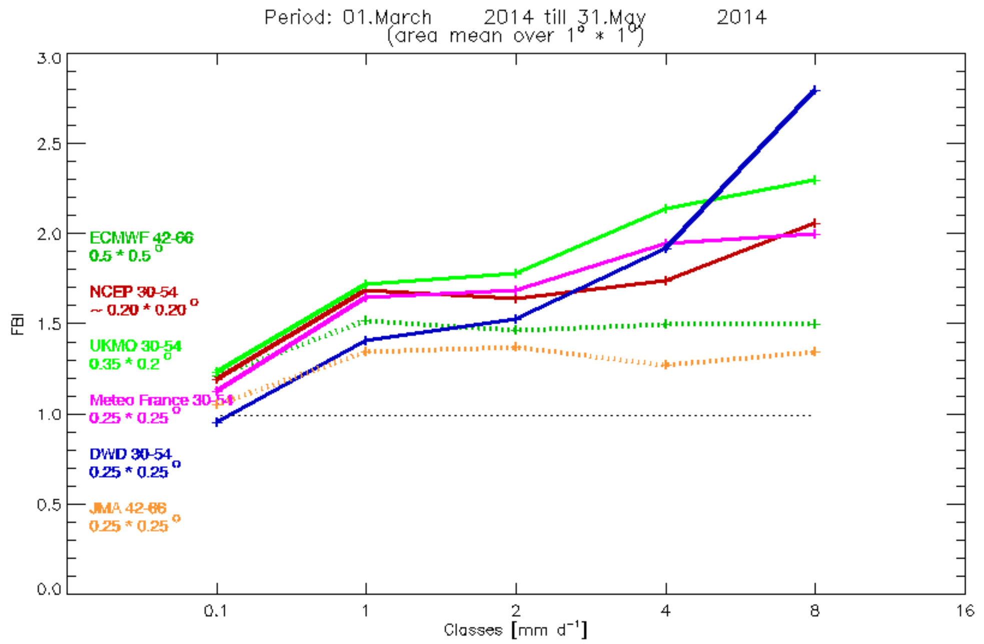


M. Baldauf (DWD)

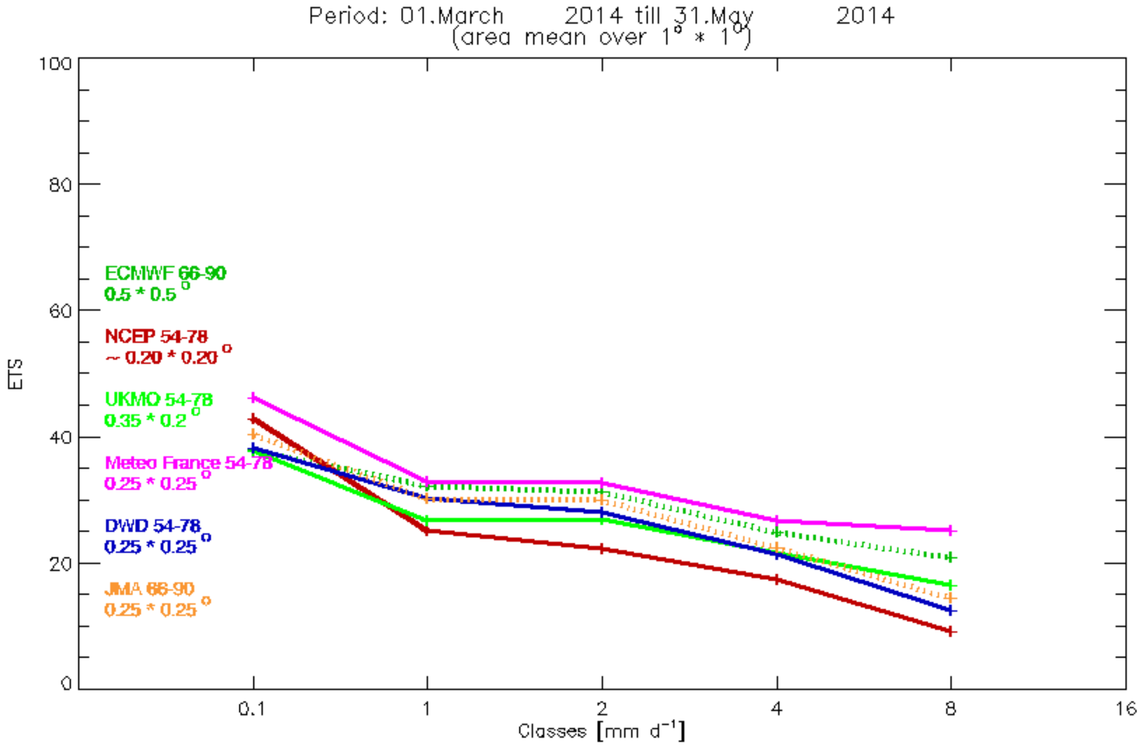


Spring 2014

Forecast day 2

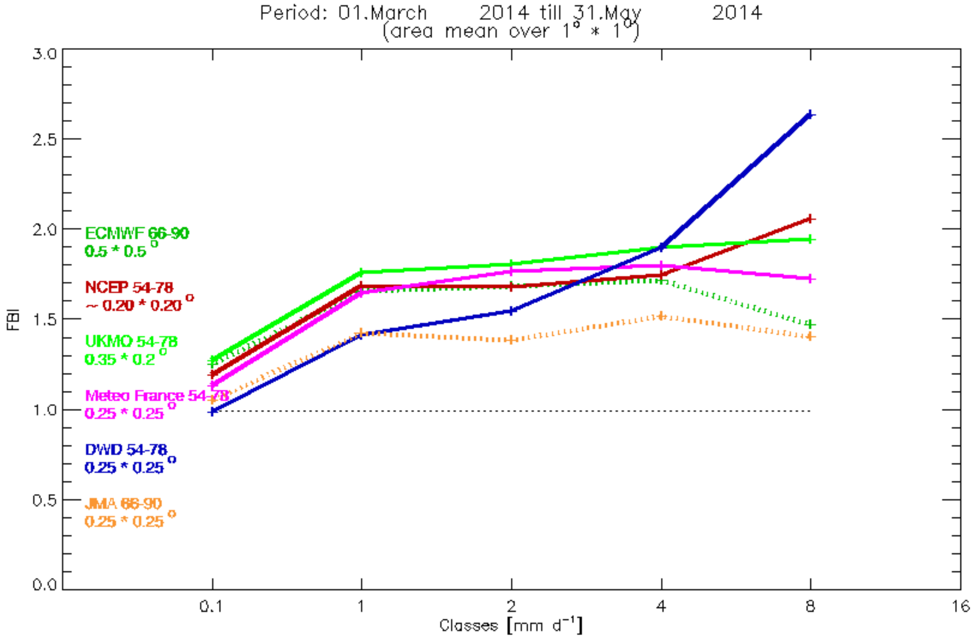


M. Baldauf (DWD)

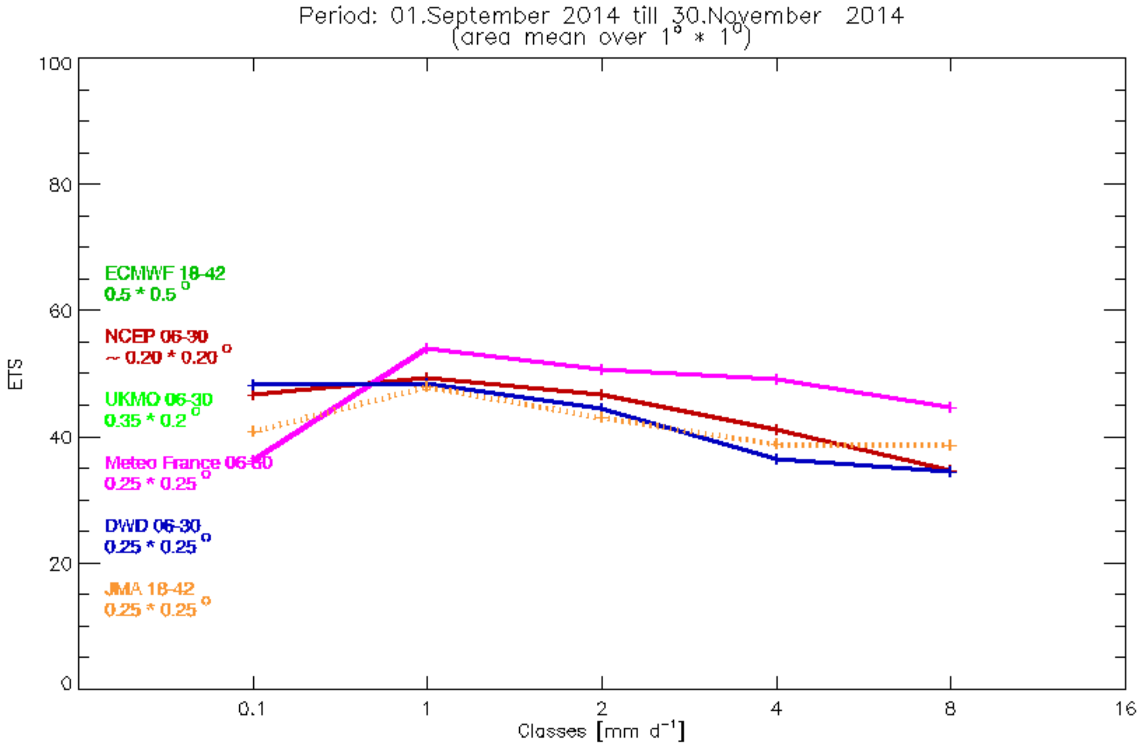


Spring 2014

Forecast day 3



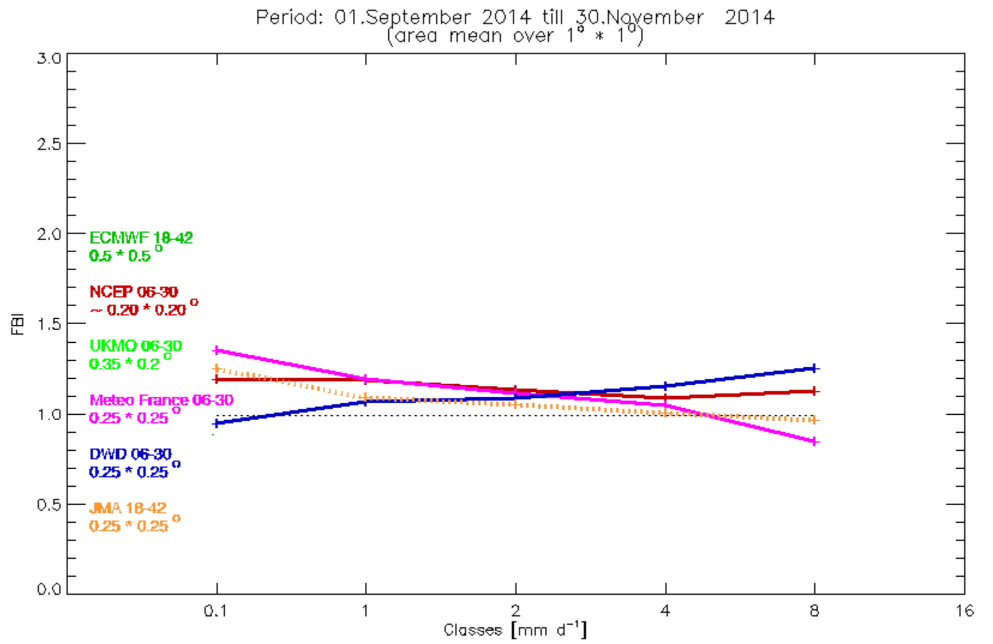
M. Baldauf (DWD)



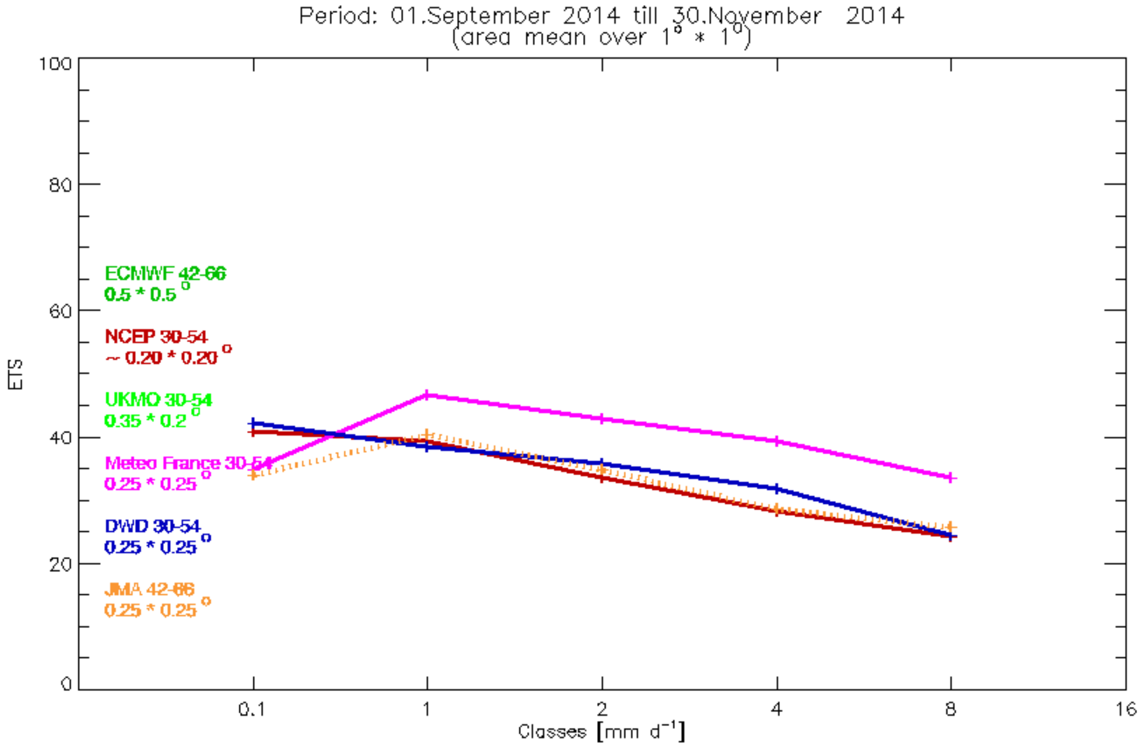
Autumn 2014

Forecast day 1

No/Incorrect scores
for ECMWF and UKMO
due to DWD-internal data loss!



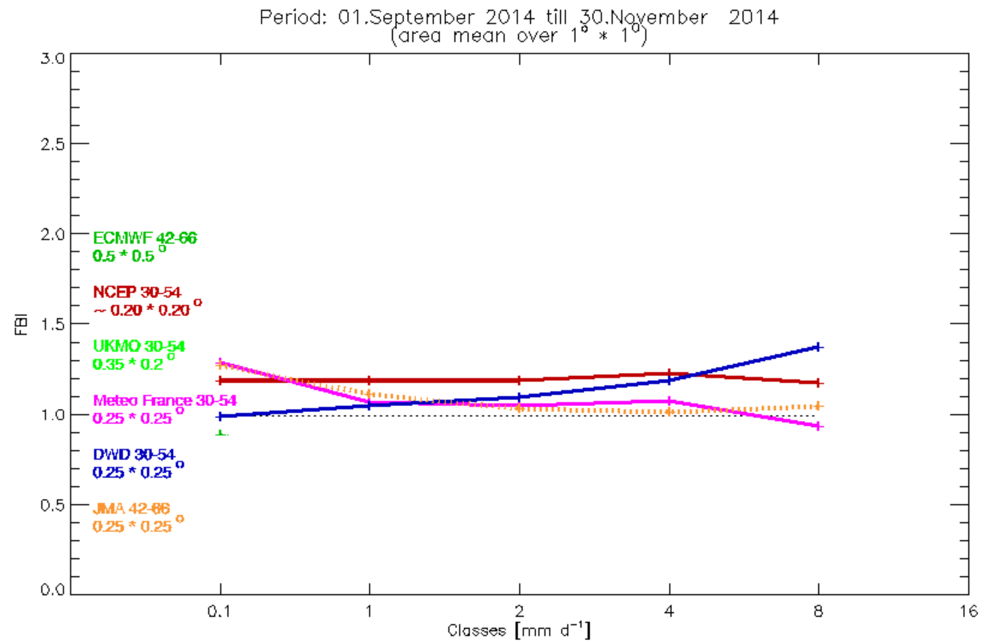
M. Baldauf (DWD)



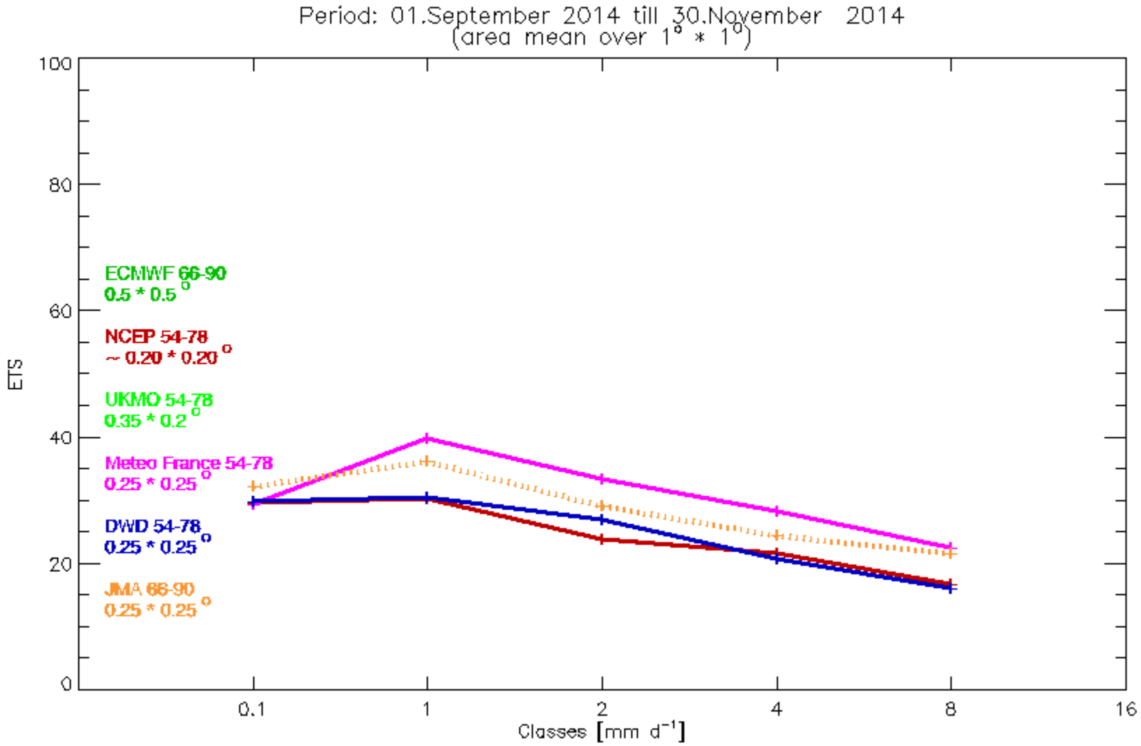
Autumn 2014

Forecast day 2

No/Incorrect scores
for ECMWF and UKMO
due to DWD-internal data loss!

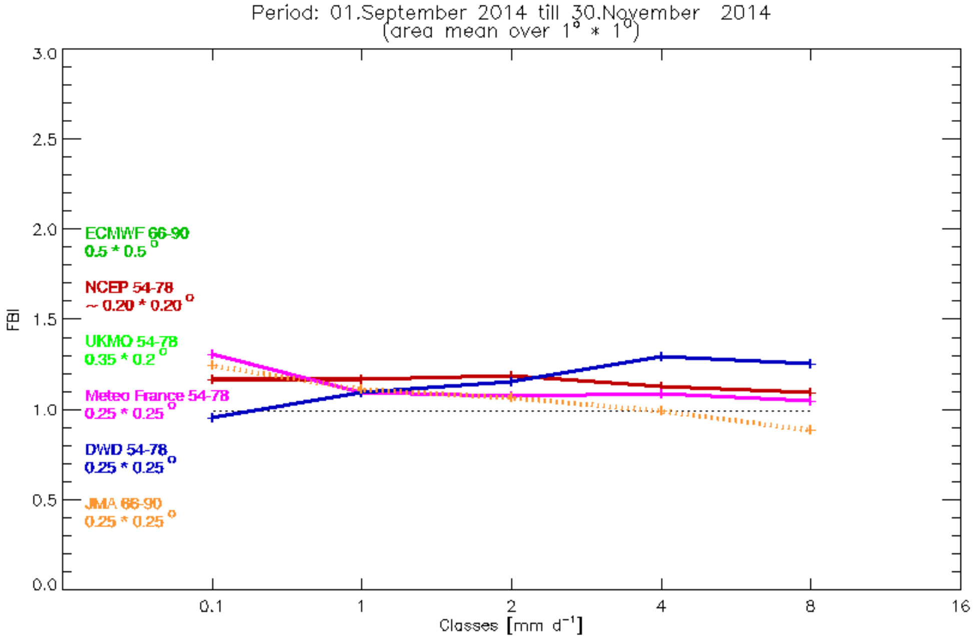


M. Baldauf (DWD)



Autumn 2014

Forecast day 3

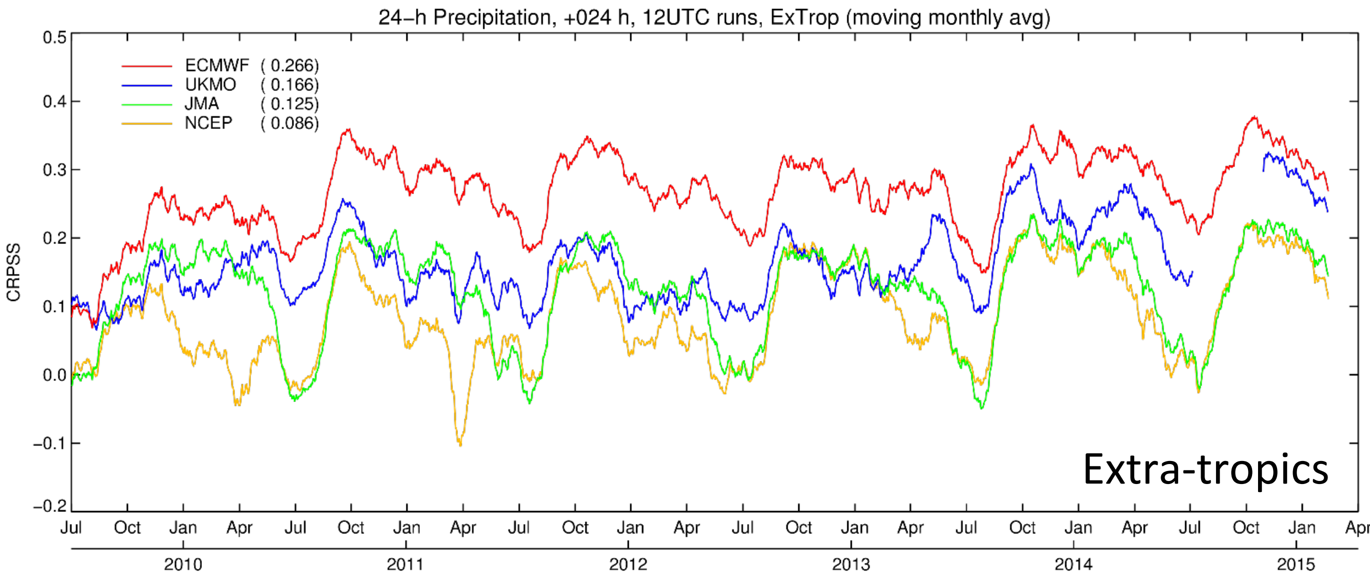


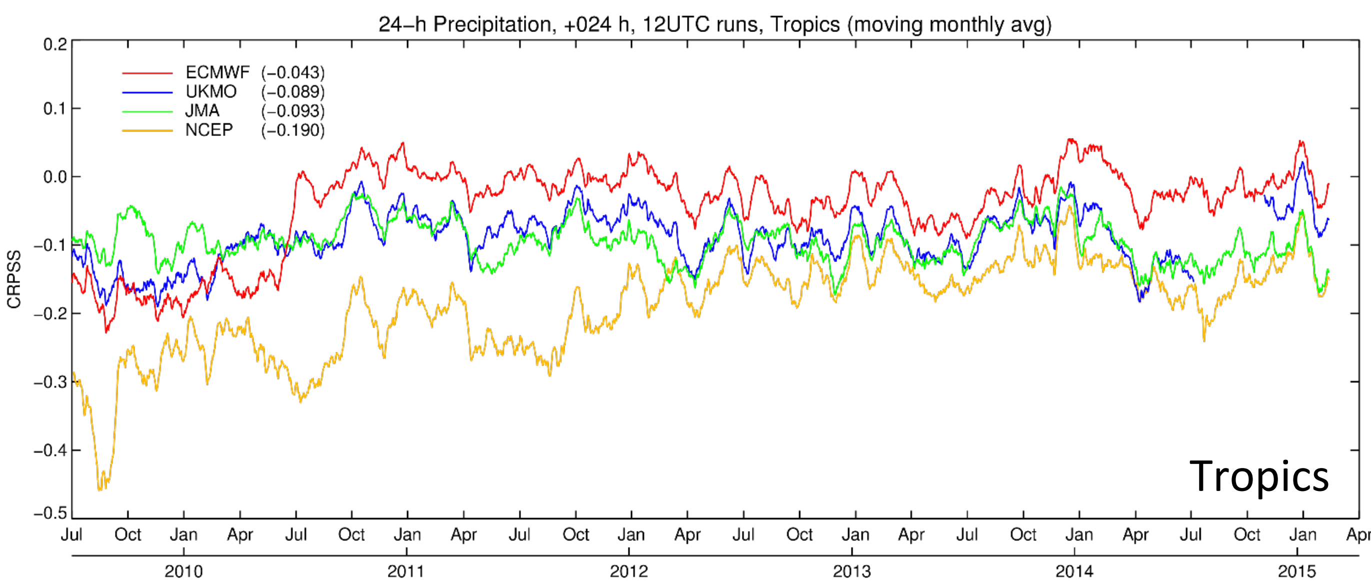
No/Incorrect scores
for ECMWF and UKMO
due to DWD-internal data loss!

M. Baldauf (DWD)

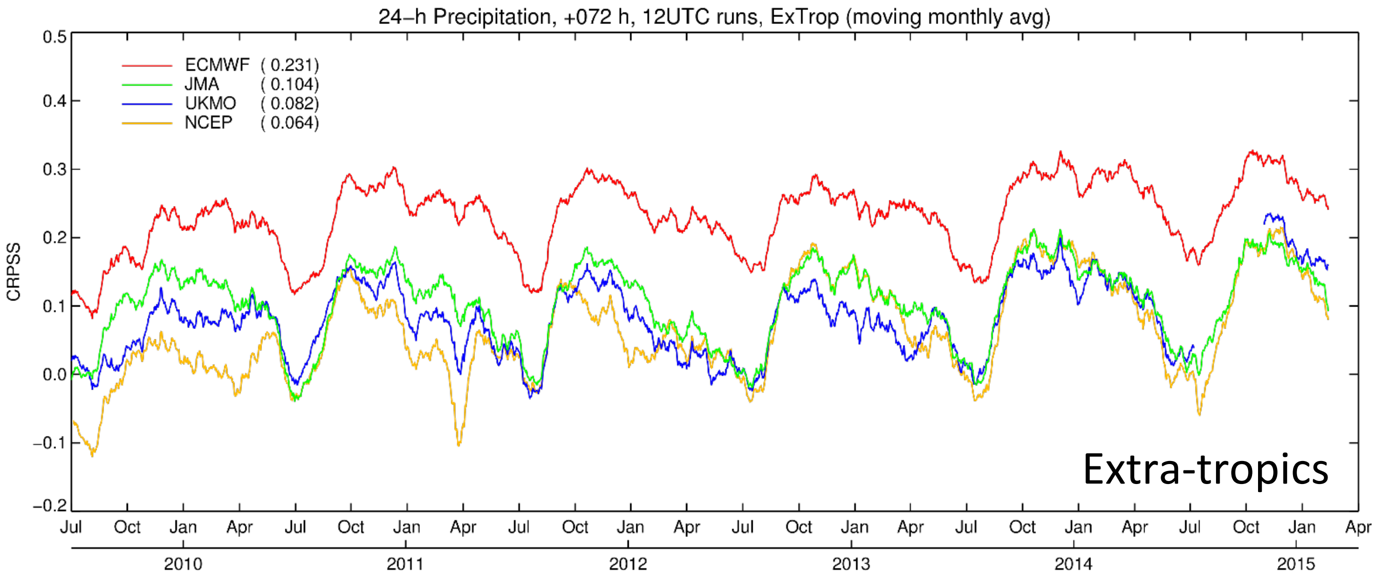
ECMWF

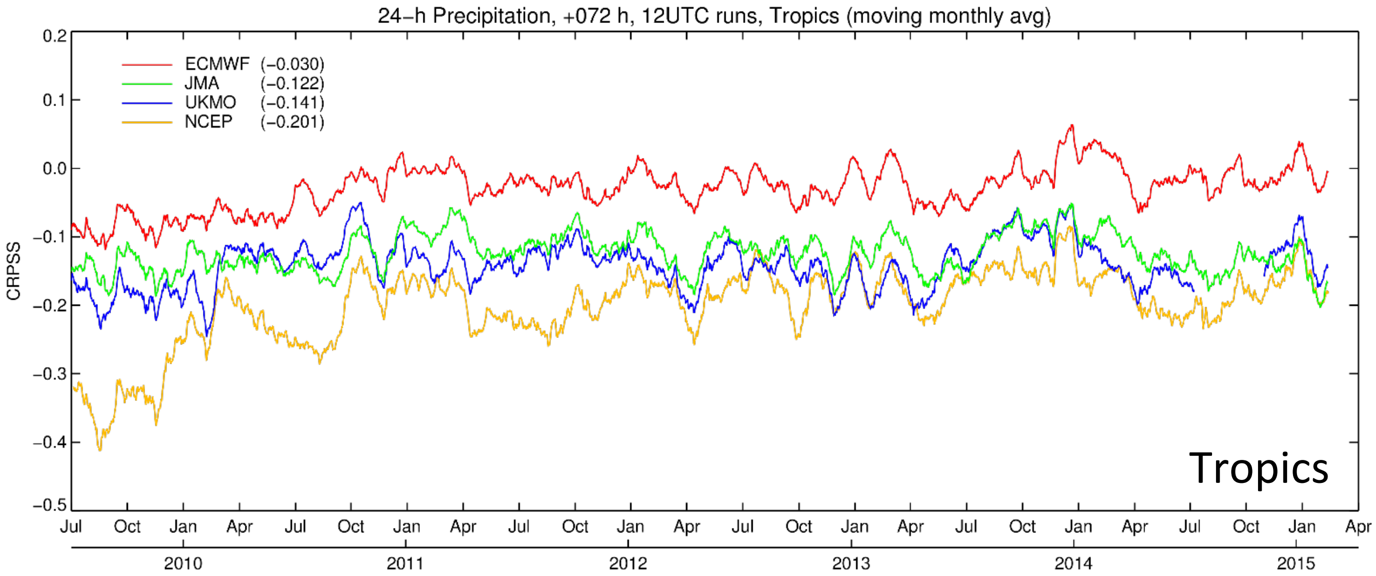
CRPSS for 24-h precipitation - day 1



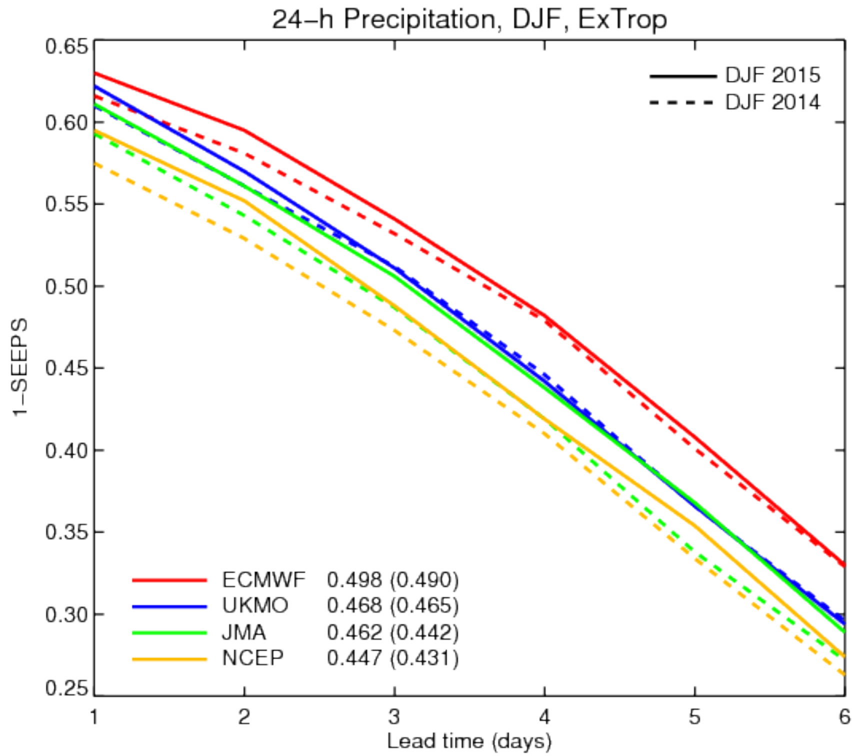


CRPSS for 24-h precipitation - day 3

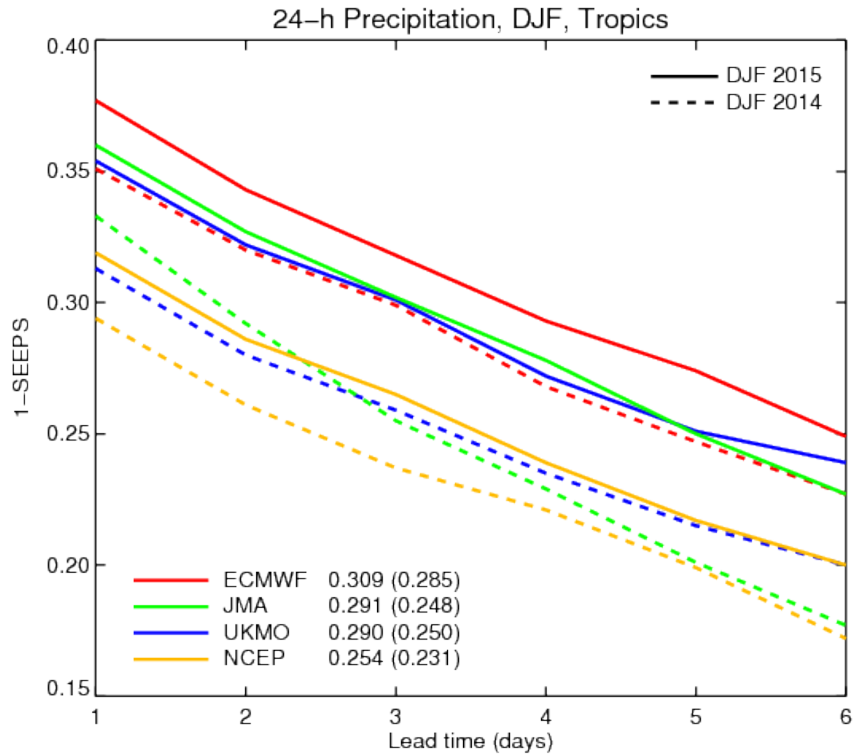




SEEPS – other centres

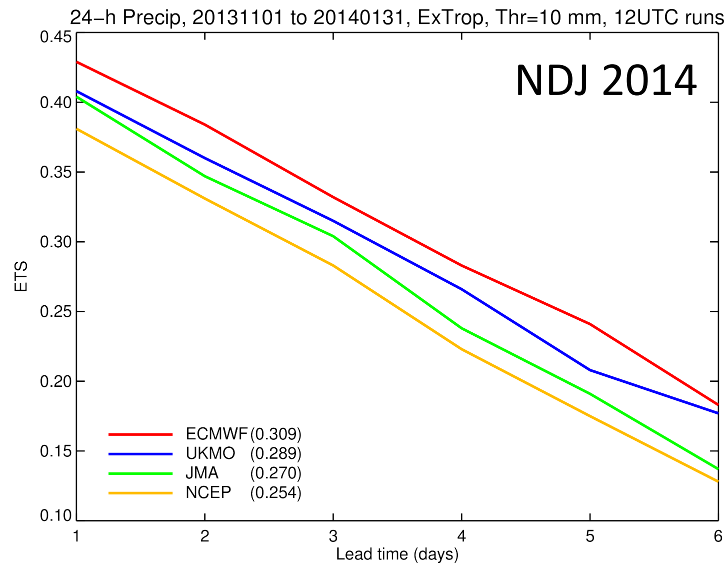


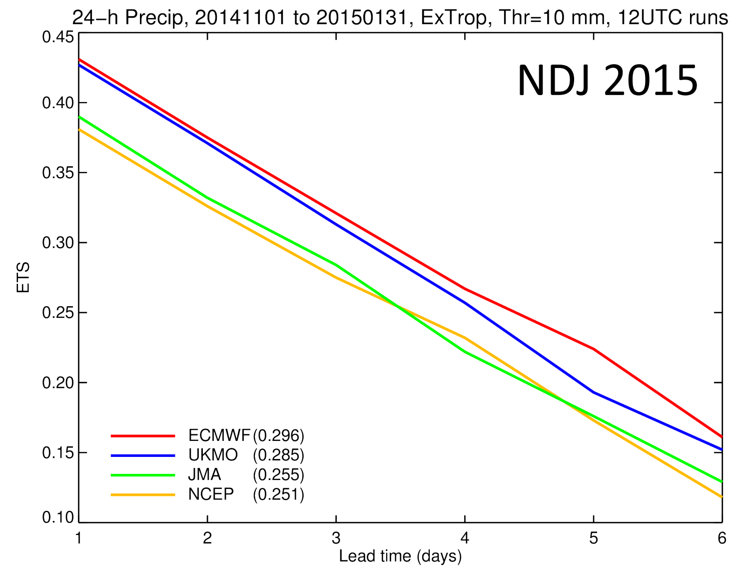
Extra-tropics



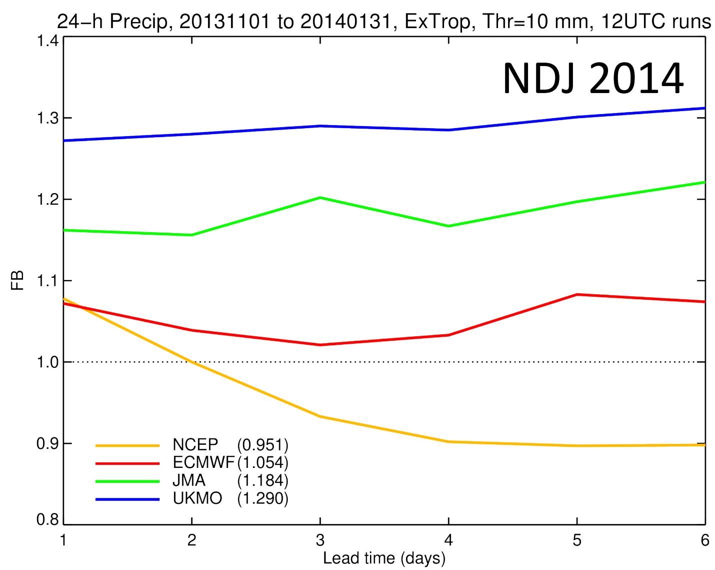
Tropics

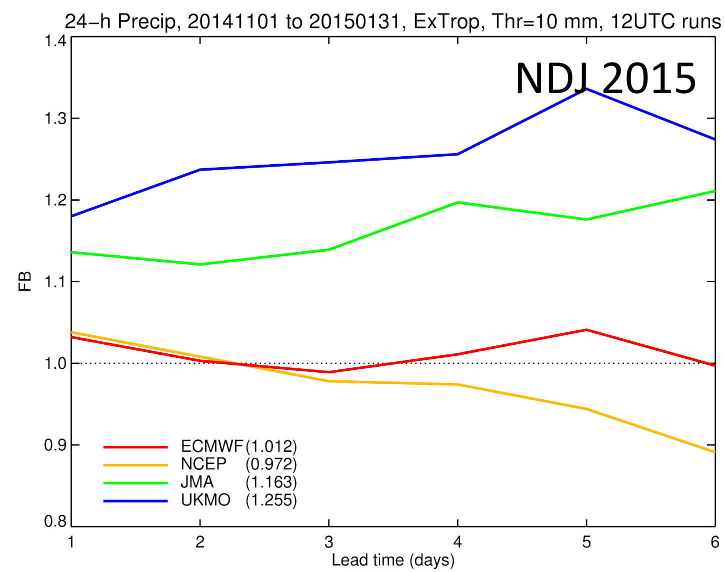
ETS and frequency bias, extra-tropics





ETS

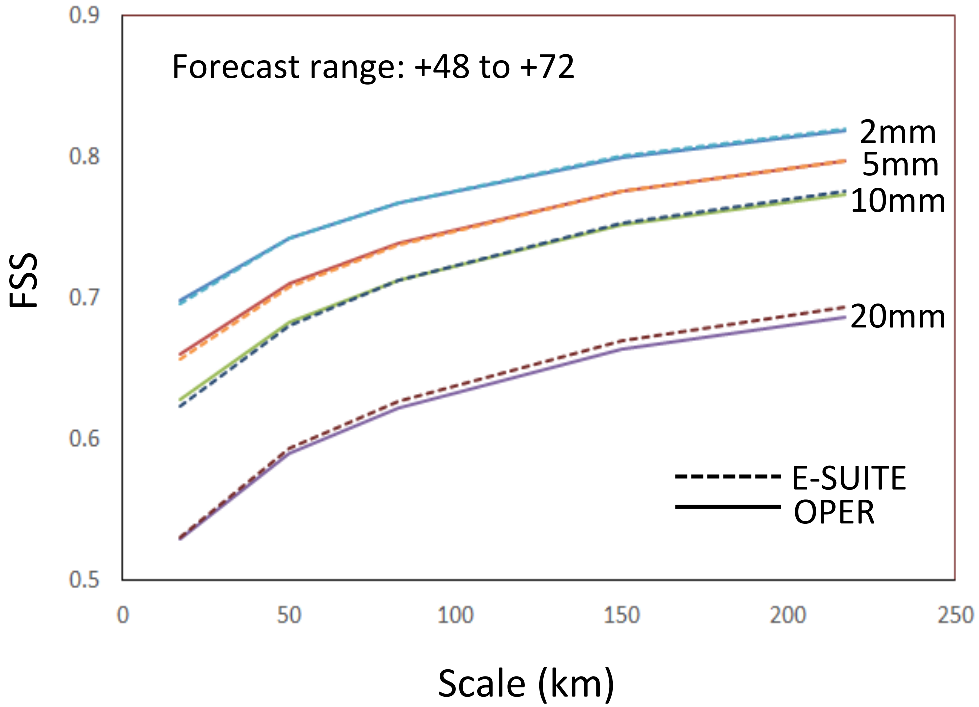


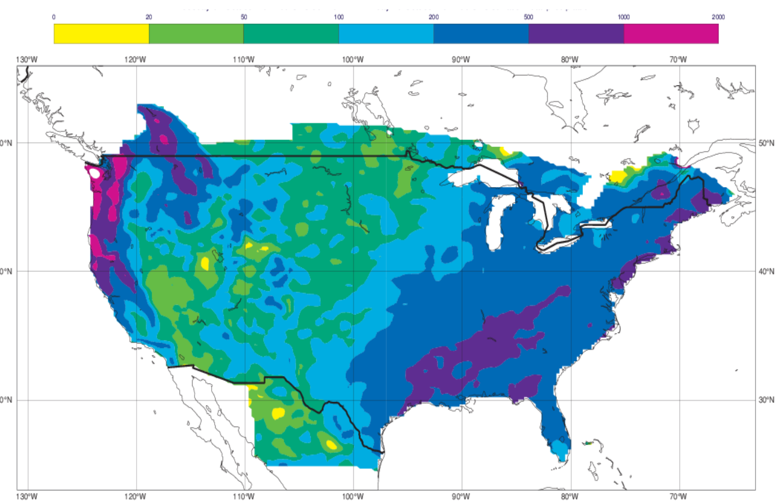


FB

Fractions Skill Score (NEXRAD data)

24-h precip, US, 7 Oct 2014 – 28 Feb 2015





NEXRAD precipitation
7 Oct 2014 – 28 Feb 2015

WGNE QPF VERIFICATION over Japan Dec2013 – Nov2014

JMA

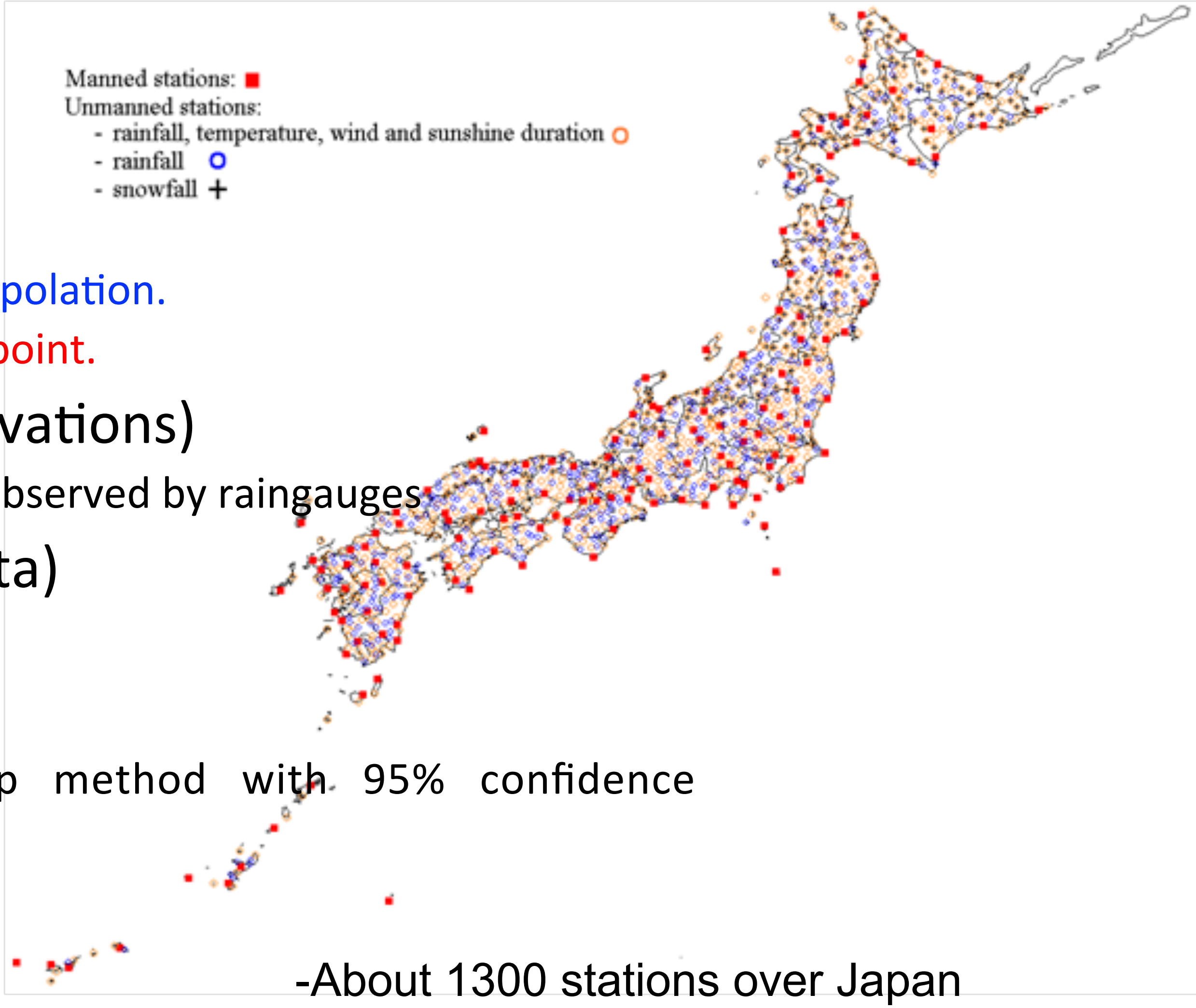
WGNE-30

Recommendations

- Include high resolution models and ensemble.
  - High resolution => included JMA MSM (5km)
  - Ensemble => not yet.
- 6-hour precipitation accumulation (Observed precipitation thresholds 1, 2, 5, 10, 20, 50mm)
- Verified with station observations.
  - Verified with all stations and averaged over the whole of Japan.
- With 95% confidence intervals.
  - Estimated by bootstrap method.

Data and Verification Method

- Verification grid
  - 1) 80km x 80km
  - 2) All stations over Japan.
- Converting method
  - 1) Simple average or interpolation.
  - 2) Using the nearest grid point.
- Reference data (Observations)
  - Amount of precipitation observed by raingauges
- Verified data (QPFs data)
  - Please see next page.
- Error bars
  - Estimated by bootstrap method with 95% confidence intervals.
- Verification method
  - Equitable Threat Score
  - Extremal Dependency Index
  - Bias Score (optional)



-About 1300 stations over Japan

-average distance (among stations): 17km

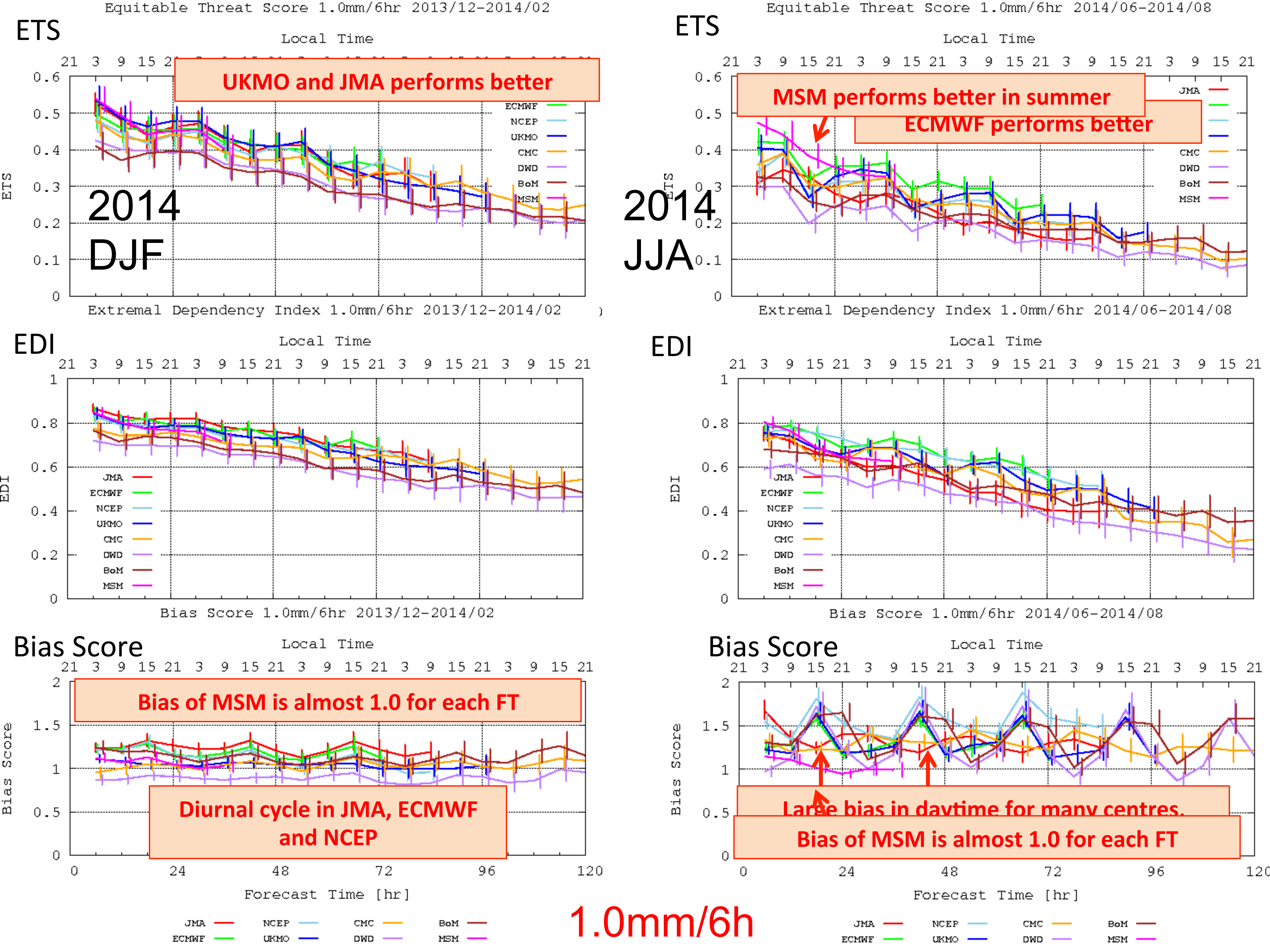
Data Specifications (~ Nov. 2014)

NWP center	horizontal resolution of verified data (degree)	forecast time (hour)	Deep convection scheme	Large scale cloud scheme	converting method in 80km verif.
BoM	0.5625 X 0.375	6,12,18,...,144	Gregory and Rowntree (1990)	Wilson and Ballard (1999)	Average
CMC	1.00 X 1.00	6,12,18 ,…,120	Kain and Fritsch (1990), (1993)	Sundqvist et al. (1989), Pudykiewicz et al. (1992)	Interpolate
DWD	0.25 X 0.25	6,12,18,...,174	Tiedtke (1989)	Kessler-type	Average
ECMWF	0.50 X 0.50	6,12,18,...,72	Tiedtke (1989)	Tiedtke (1993)	Average
NCEP	1.00 X 1.00	6,12,18,...,84	Pan and Wu (1994)	Zhao and Carr (1997)	Interpolate
UKMO	0.35 X 0.23 0.23 X 0.16	6,12,18,...,96	Gregory and Rowntree (1990)	PC2: Wilson et al. (2008) Wilson and Ballard (1999)	Average
JMA	0.25 X 0.25(GSM)	6,12,18,...,84	Arakawa and Schubert (1974)	Smith (1990)	Average
	5km(MSM)	6,12,18,…,36	Kain and Fritsch (1990), Kain (2004)	Cloud microphysics (Ikawa and Saito 1991)	Average
observation	Corresponding to 17km X 17km	-	-	-	Average

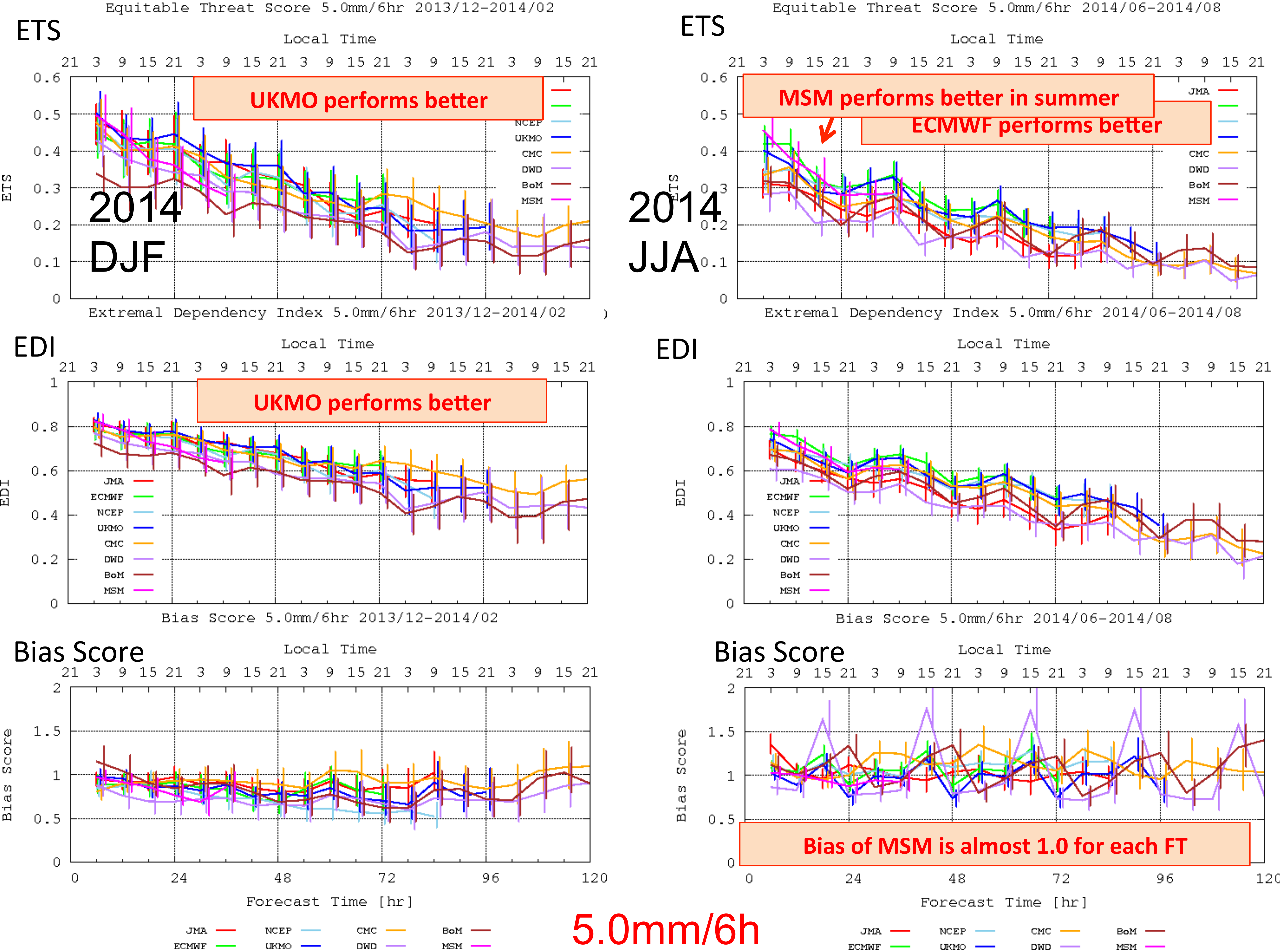
Verification with 80x80km grid.

- Verified with 80x80km grid by simple average or interpolation (see below).

NWP center	horizontal resolution of verified data (degree)	converting method in 80km verif.
BoM	0.5625 X 0.375	Average
CMC	1.00 X 1.00	Interpolate
DWD	0.25 X 0.25	Average
ECMWF	0.50 X 0.50	Average
NCEP	1.00 X 1.00	Interpolate
UKMO	0.35 X 0.23 0.23 X 0.16	Average
JMA	0.25 X 0.25(GSM)	Average
	5km(MSM)	Average
observation	Corresponding to 17km X 17km	Average



ETS
Equitable Threat Score 1.0mm/6hr 2013/12-2014/02
Local Time
UKMO and JMA performs better
2014
DJF
ETS
Equitable Threat Score 1.0mm/6hr 2014/06-2014/08
Local Time
MSM performs better in summer
ECMWF performs better
2014
JJA
EDI
Extremal Dependency Index 1.0mm/6hr 2013/12-2014/02
Local Time
EDI
Extremal Dependency Index 1.0mm/6hr 2014/06-2014/08
Local Time
Bias Score
Bias Score 1.0mm/6hr 2013/12-2014/02
Local Time
Bias of MSM is almost 1.0 for each FT
Diurnal cycle in JMA, ECMWF and NCEP
Bias Score
Bias Score 1.0mm/6hr 2014/06-2014/08
Local Time
Large bias in daytime for many centres.
Bias of MSM is almost 1.0 for each FT
Forecast Time [hr]
JMA
ECMWF
NCEP
UKMO
CMC
DWD
BoM
MSM
1.0mm/6h

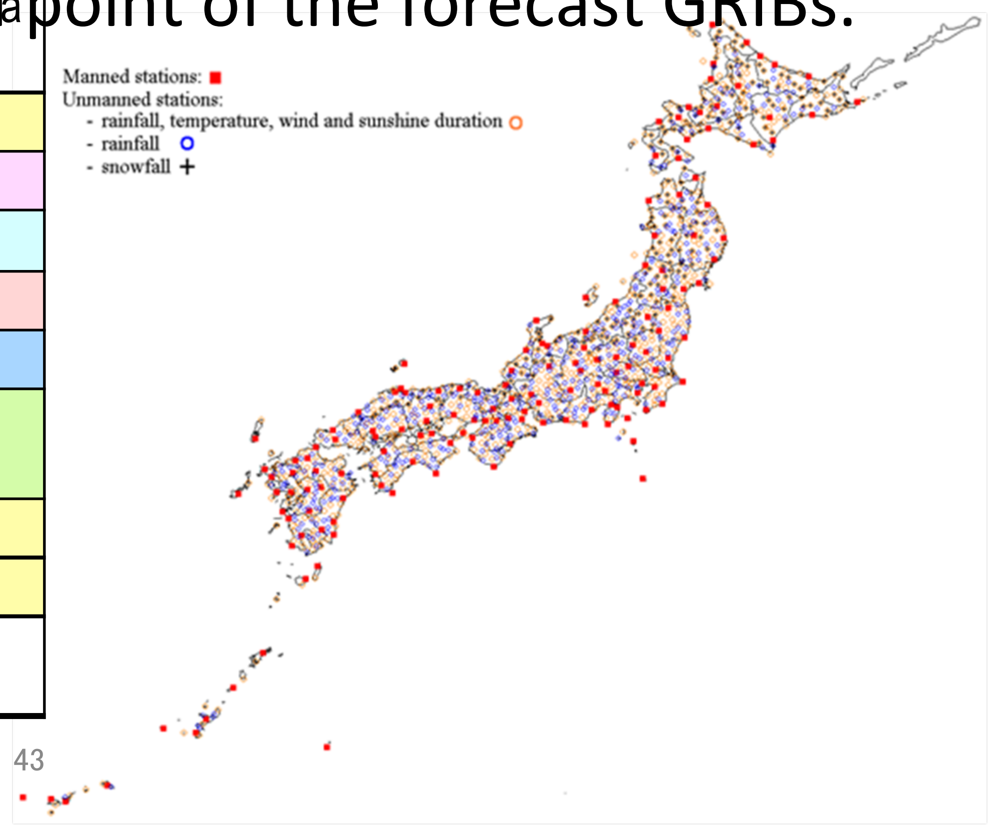


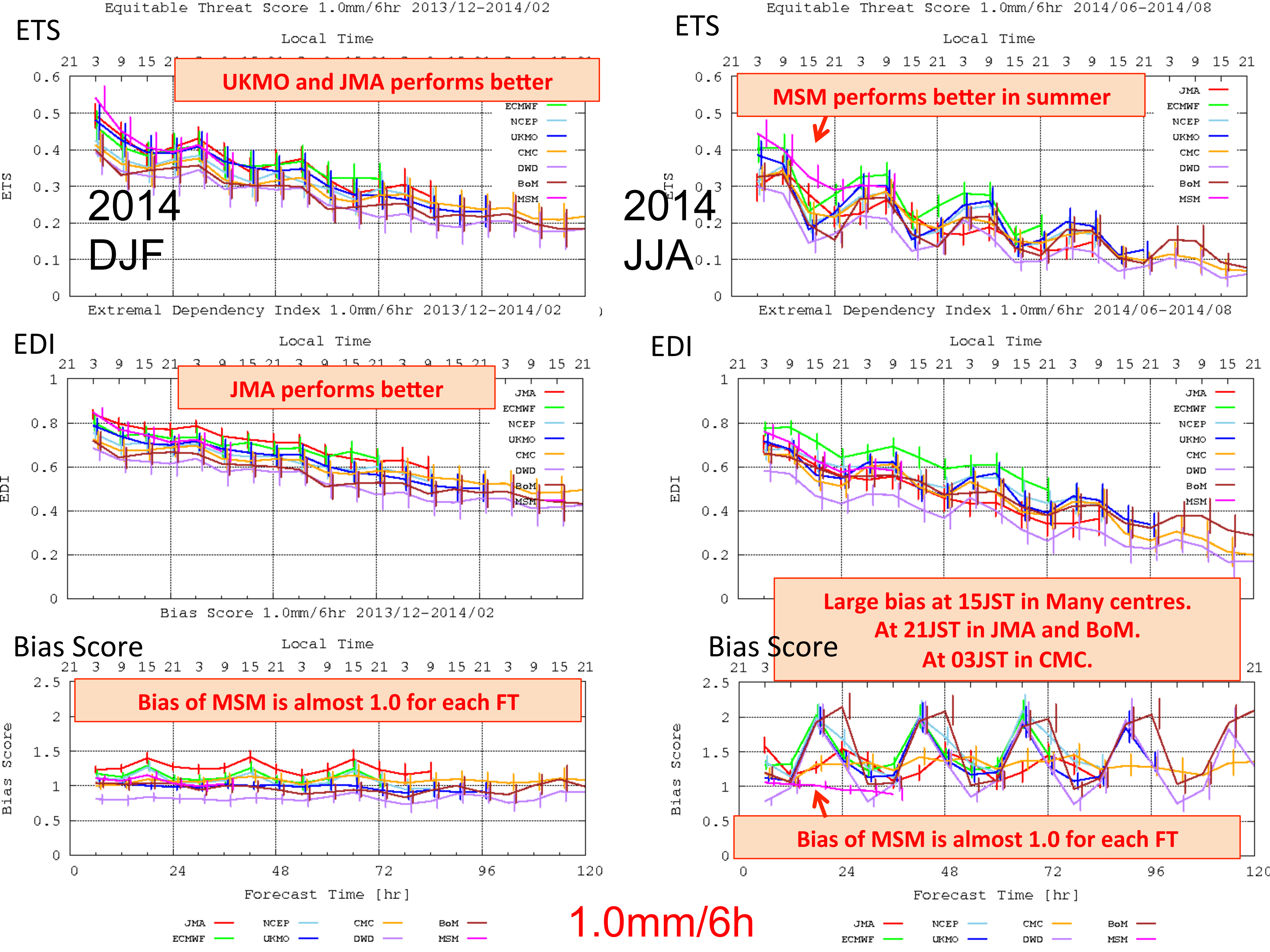
ETS
Equitable Threat Score 5.0mm/6hr 2013/12-2014/02
UKMO performs better
2014
DJF
ETS
Equitable Threat Score 5.0mm/6hr 2014/06-2014/08
MSM performs better in summer
ECMWF performs better
2014
JJA
EDI
Extremal Dependency Index 5.0mm/6hr 2013/12-2014/02
UKMO performs better
EDI
Extremal Dependency Index 5.0mm/6hr 2014/06-2014/08
Bias Score
Bias Score 5.0mm/6hr 2013/12-2014/02
Bias Score
Bias Score 5.0mm/6hr 2014/06-2014/08
Bias of MSM is almost 1.0 for each FT
Local Time
Forecast Time [hr]
JMA
ECMWF
NCEP
UKMO
CMC
DWD
BoM
MSM
5.0mm/6h

Verification with station observations.

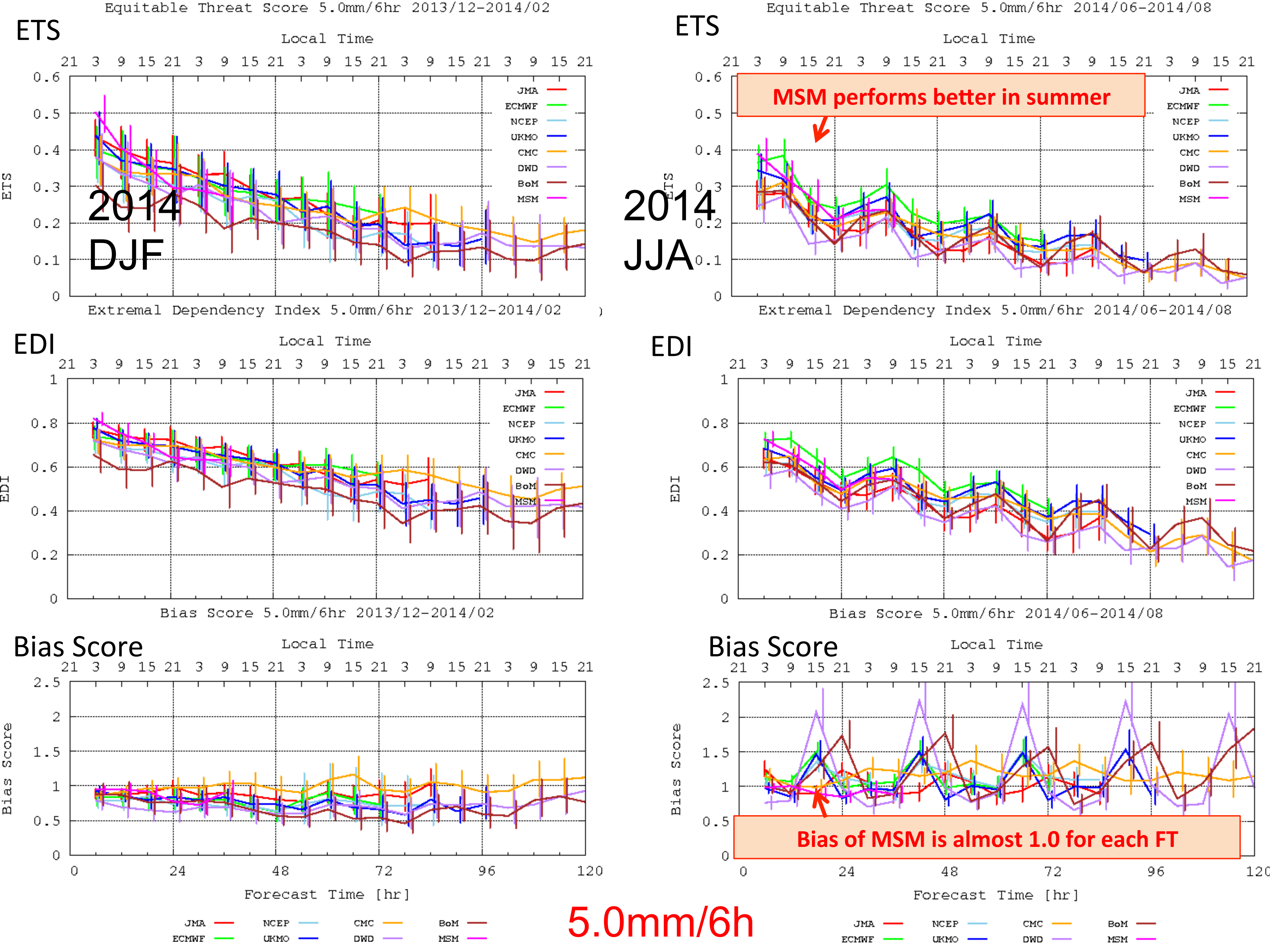
- Verified with all stations and averaged over the whole of Japan
  - Using the nearest grid point of the forecast GRIBs.

NWP center	horizontal resolution of verified data (degree)
BoM	0.5625 X 0.375
CMC	1.00 X 1.00
DWD	0.25 X 0.25
ECMWF	0.50 X 0.50
NCEP	1.00 X 1.00
UKMO	0.35 X 0.23 0.23 X 0.16
JMA	0.25 X 0.25(GSM)
	5km(MSM)
observation	Corresponding to 17km X 17km





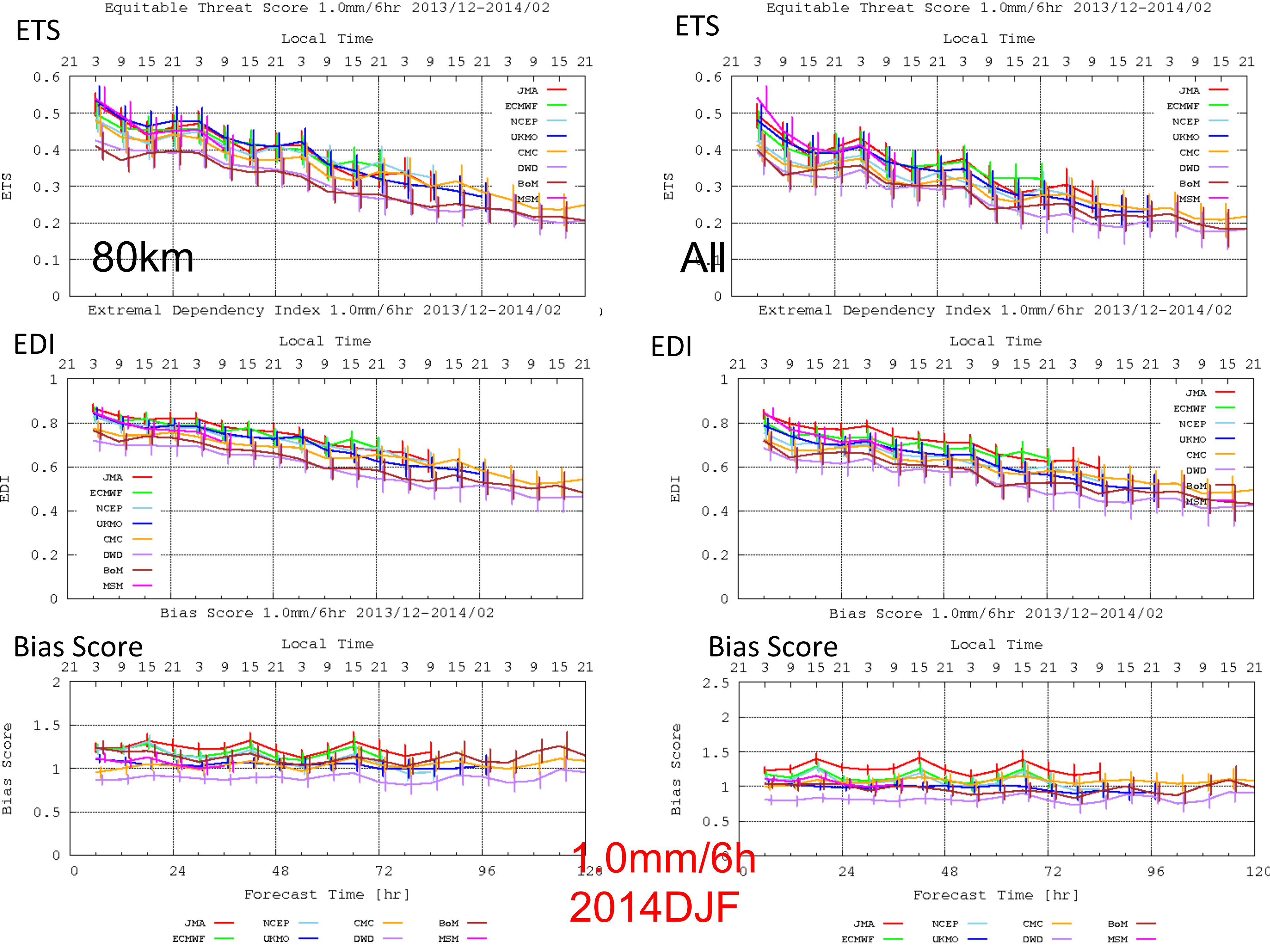
ETS
Equitable Threat Score 1.0mm/6hr 2013/12-2014/02
Local Time
UKMO and JMA performs better
2014
DJF
ETS
Equitable Threat Score 1.0mm/6hr 2014/06-2014/08
Local Time
MSM performs better in summer
2014
JJA
EDI
Extremal Dependency Index 1.0mm/6hr 2013/12-2014/02
Local Time
JMA performs better
EDI
Extremal Dependency Index 1.0mm/6hr 2014/06-2014/08
Local Time
Large bias at 15JST in Many centres.
At 21JST in JMA and BoM.
At 03JST in CMC.
Bias Score
Bias Score 1.0mm/6hr 2013/12-2014/02
Local Time
Bias of MSM is almost 1.0 for each FT
Forecast Time [hr]
Bias Score
Bias of MSM is almost 1.0 for each FT
Forecast Time [hr]
JMA
ECMWF
NCEP
UKMO
CMC
DWD
BoM
MSM
1.0mm/6h

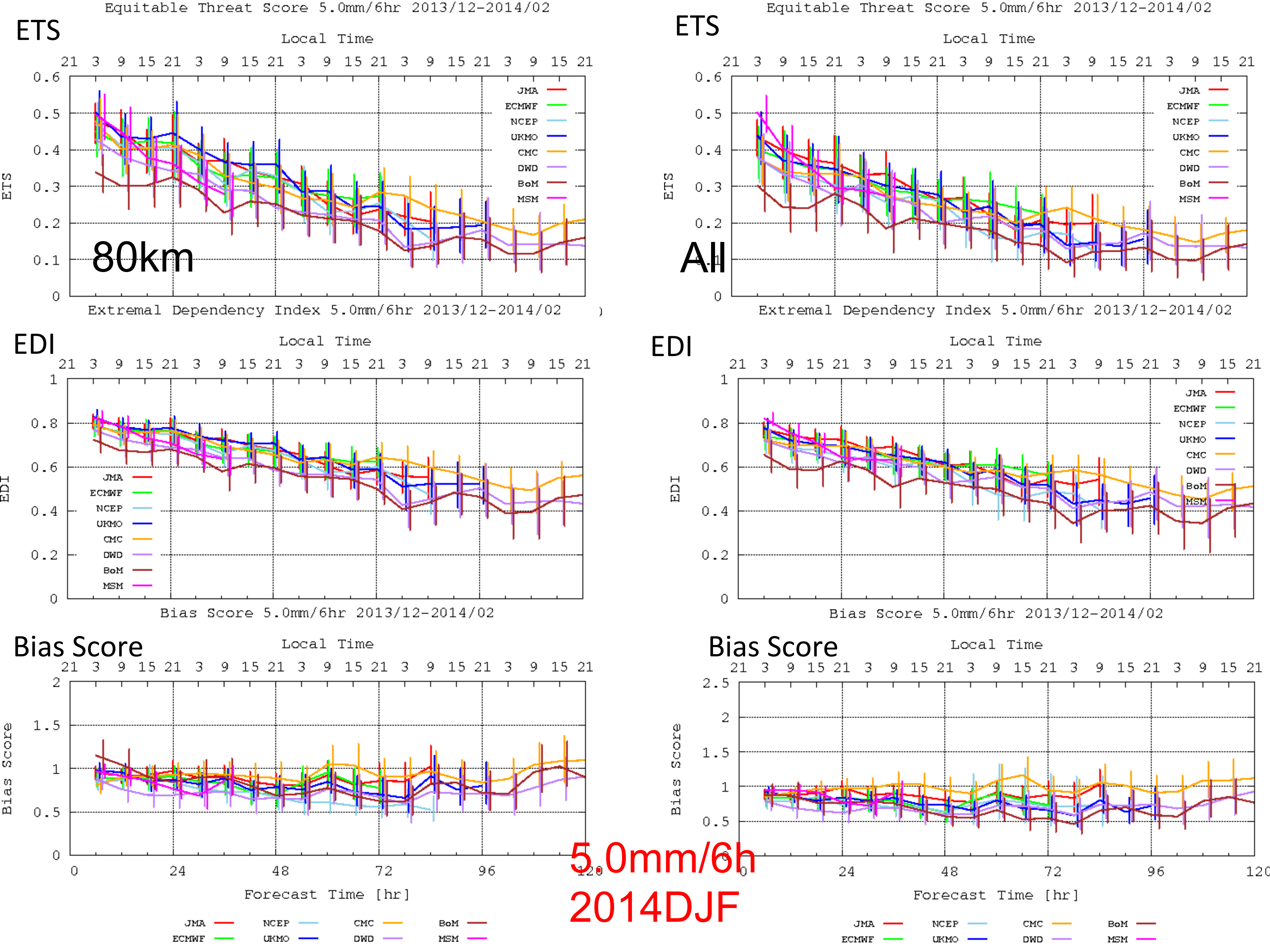


Equitable Threat Score 5.0mm/6hr 2013/12-2014/02
ETS
2014
DJF
Equitable Threat Score 5.0mm/6hr 2014/06-2014/08
ETS
2014
JJA
MSM performs better in summer
Extremal Dependency Index 5.0mm/6hr 2013/12-2014/02
EDI
Extremal Dependency Index 5.0mm/6hr 2014/06-2014/08
EDI
Bias Score 5.0mm/6hr 2013/12-2014/02
Bias Score
Bias Score 5.0mm/6hr 2014/06-2014/08
Bias Score
Bias of MSM is almost 1.0 for each FT
Local Time
Forecast Time [hr]
JMA
ECMWF
NCEP
UKMO
CMC
DWD
BoM
MSM
5.0mm/6h

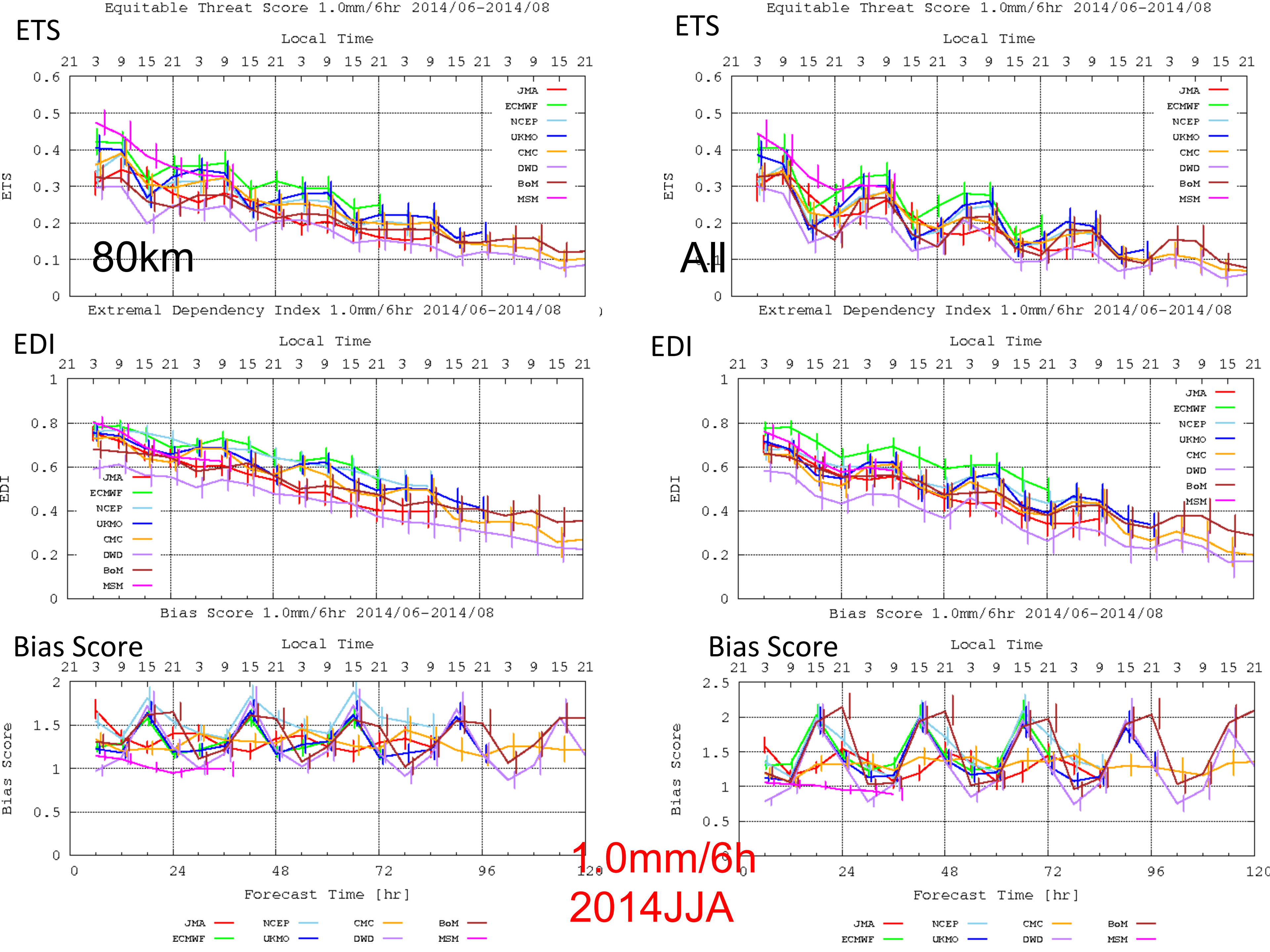
Verification with all stations

- Winter
  - High resolution model (5km MSM) performs better.
  - UKMO and JMA perform better.
- Summer
  - High resolution model (5km MSM) performs better.
  - ECMWF performs better.
  - BI of 5mm/6h averaged for all stations are larger than that for 80km ave.
  - Large bias are predicted at 15JST in DWD,ECMWF and UKMO. At 21JST in BoM and JMA, and at 03JST in CMC.

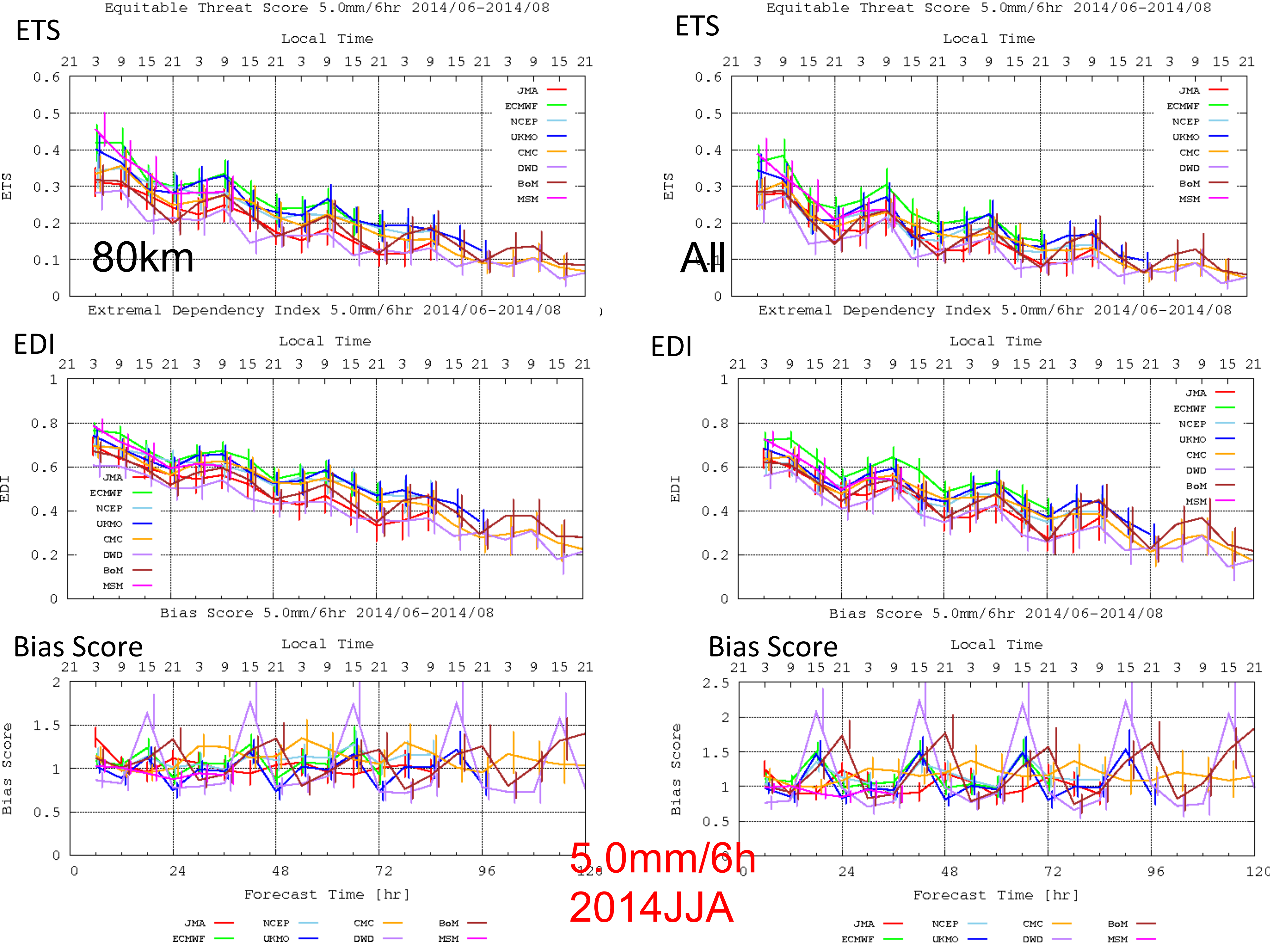

ETS
Equitable Threat Score 1.0mm/6hr 2013/12-2014/02
Local Time
ETS
80km
All
EDI
Extremal Dependency Index 1.0mm/6hr 2013/12-2014/02
Local Time
EDI
Bias Score
Bias Score 1.0mm/6hr 2013/12-2014/02
Local Time
Bias Score
Forecast Time [hr]
JMA
ECMWF
NCEP
UKMO
CMC
DWD
BoM
MSM
1.0mm/6h
2014DJF



ETS
Equitable Threat Score 5.0mm/6hr 2013/12-2014/02
Local Time
80km
EDI
Extremal Dependency Index 5.0mm/6hr 2013/12-2014/02
Bias Score
Bias Score 5.0mm/6hr 2013/12-2014/02
Forecast Time [hr]
JMA
ECMWF
NCEP
UKMO
CMC
DWD
BoM
MSM
All
5.0mm/6h
2014DJF



ETS
Equitable Threat Score 1.0mm/6hr 2014/06-2014/08
Local Time
80km
All
EDI
Extremal Dependency Index 1.0mm/6hr 2014/06-2014/08
Bias Score
Bias Score 1.0mm/6hr 2014/06-2014/08
Forecast Time [hr]
JMA
ECMWF
NCEP
UKMO
CMC
DWD
BoM
MSM
1.0mm/6h
2014JJA

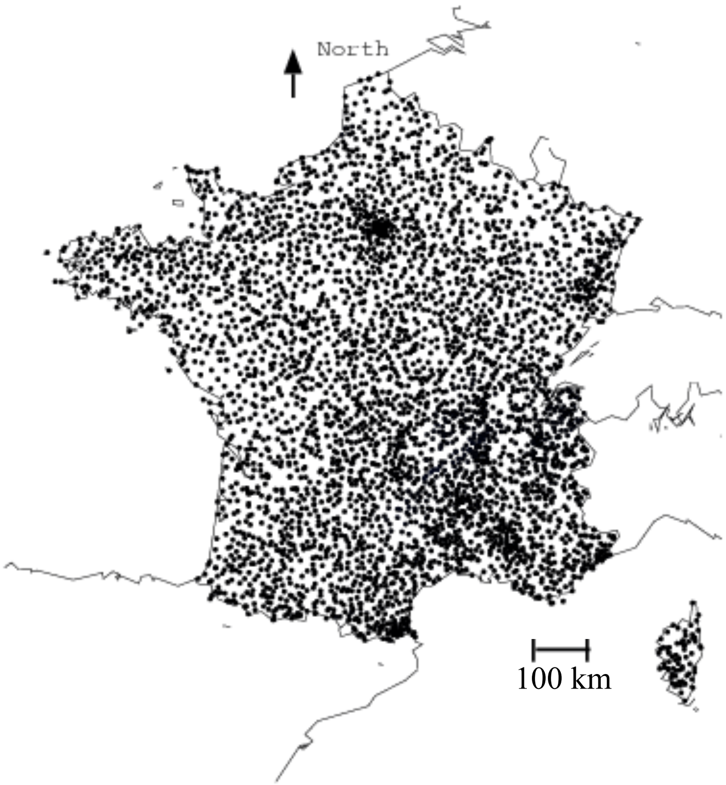

Equitable Threat Score 5.0mm/6hr 2014/06-2014/08
ETS
Local Time
80km
Extremal Dependency Index 5.0mm/6hr 2014/06-2014/08
EDI
Bias Score 5.0mm/6hr 2014/06-2014/08
Bias Score
Forecast Time [hr]
JMA
ECMWF
NCEP
UKMO
CMC
DWD
BoM
MSM
Equitable Threat Score 5.0mm/6hr 2014/06-2014/08
ETS
Local Time
All
Extremal Dependency Index 5.0mm/6hr 2014/06-2014/08
EDI
Bias Score 5.0mm/6hr 2014/06-2014/08
Bias Score
Forecast Time [hr]
5.0mm/6h
2014JJA

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

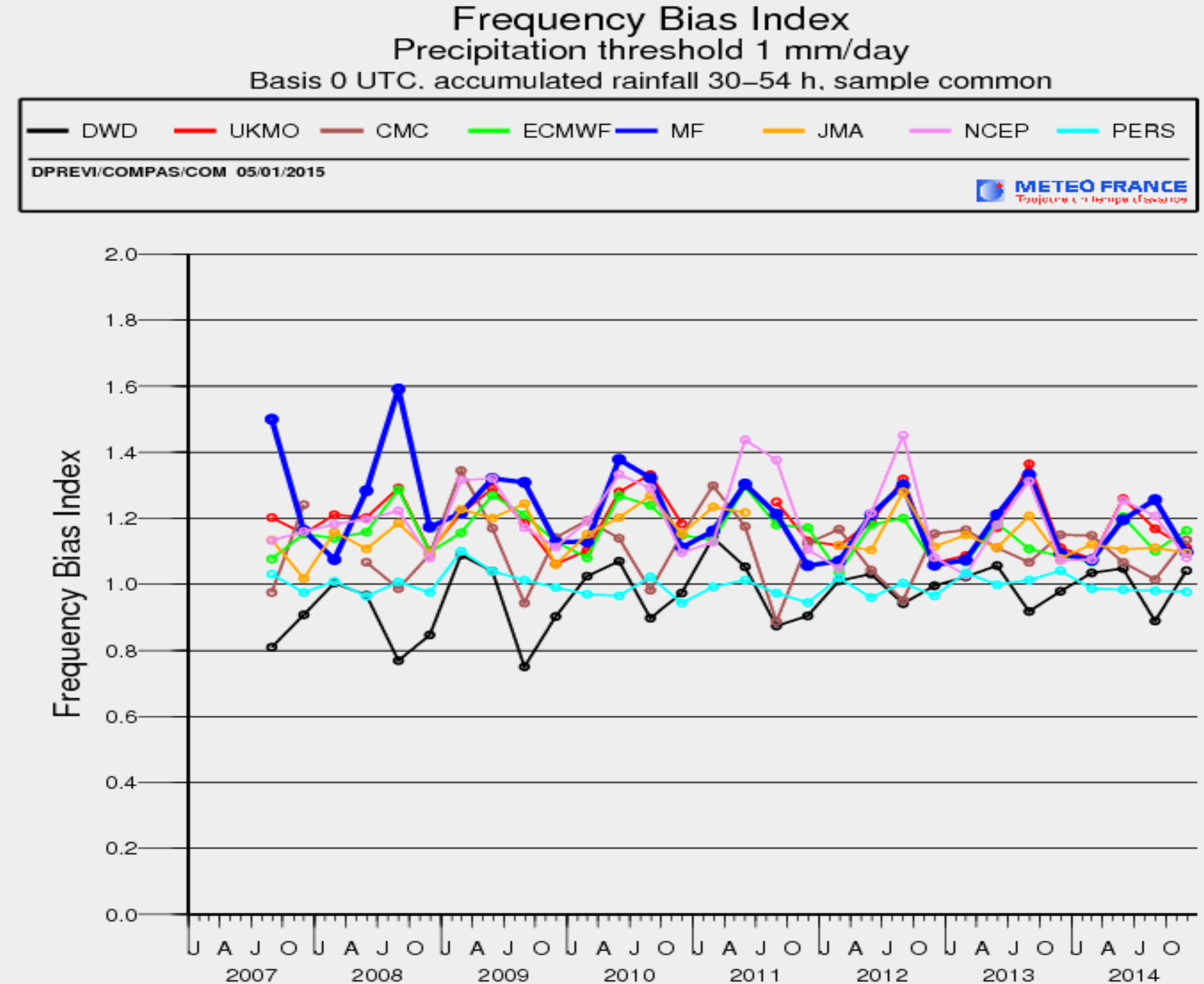
QPF verification

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

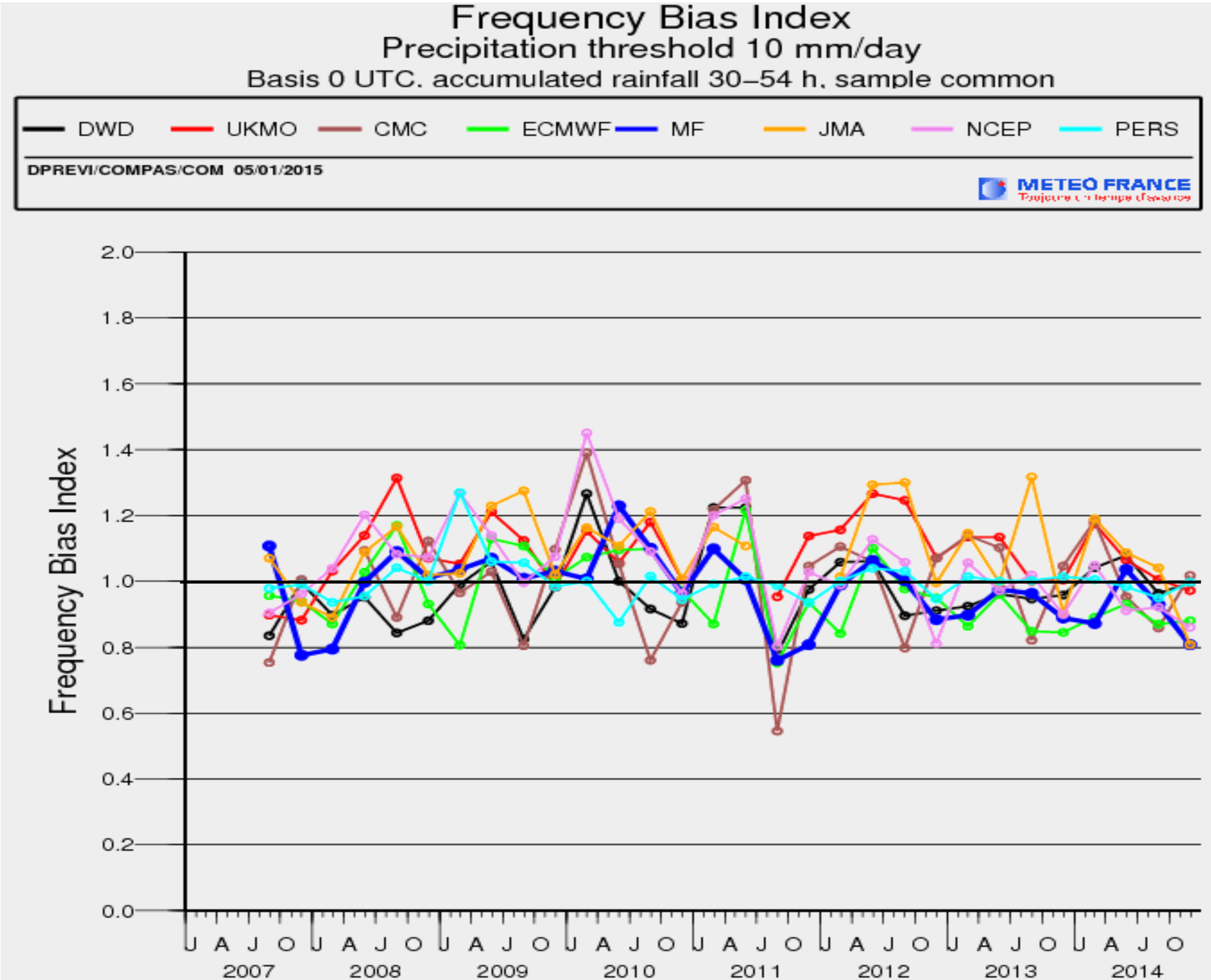


Climatological state network

~4000 raingauges giving 24 hours accumulated rain every day

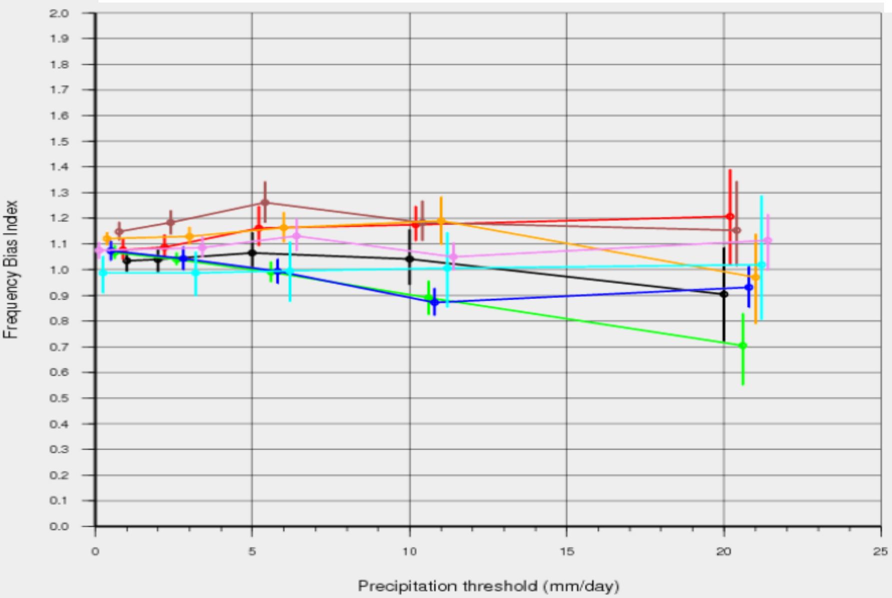


Frequency Bias Index
Precipitation threshold 1 mm/day
Basis 0 UTC. accumulated rainfall 30–54 h, sample common
DWD
UKMO
CMC
ECMWF
MF
JMA
NCEP
PERS
DPREVI/COMPAS/COM 05/01/2015
METEO FRANCE
Frequency Bias Index
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
J A J O
2007
2008
2009
2010
2011
2012
2013
2014

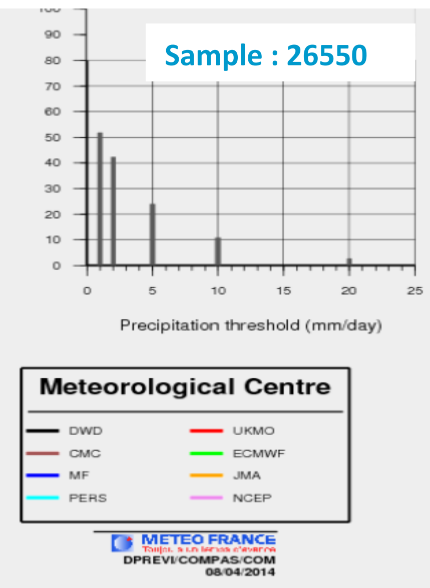


Frequency Bias Index
Precipitation threshold 10 mm/day
Basis 0 UTC. accumulated rainfall 30–54 h. sample common
DWD
UKMO
CMC
ECMWF
MF
JMA
NCEP
PERS
DPREVI/COMPAS/COM 05/01/2015
METEO FRANCE
Frequency Bias Index
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
J A J O J A J O J A J O J A J O J A J O J A J O J A J O J A J O
2007
2008
2009
2010
2011
2012
2013
2014

Frequency Bias



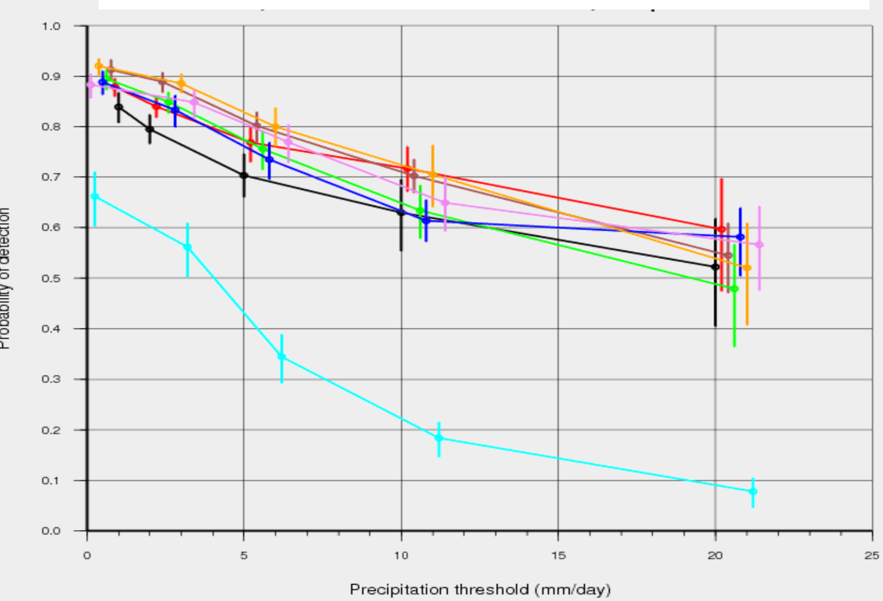
% Observation



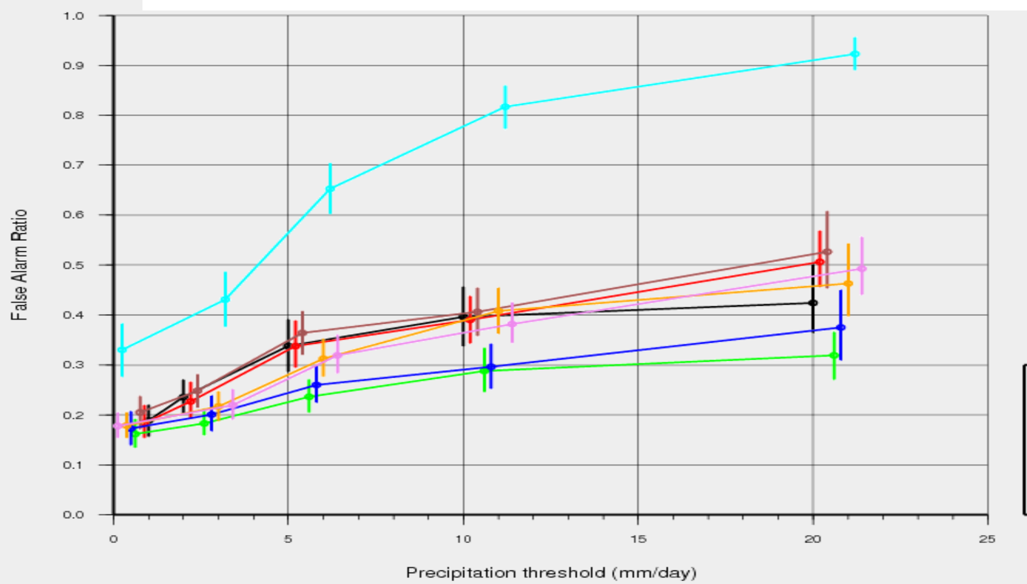
WINTER 2014

Lead time 54 UTC

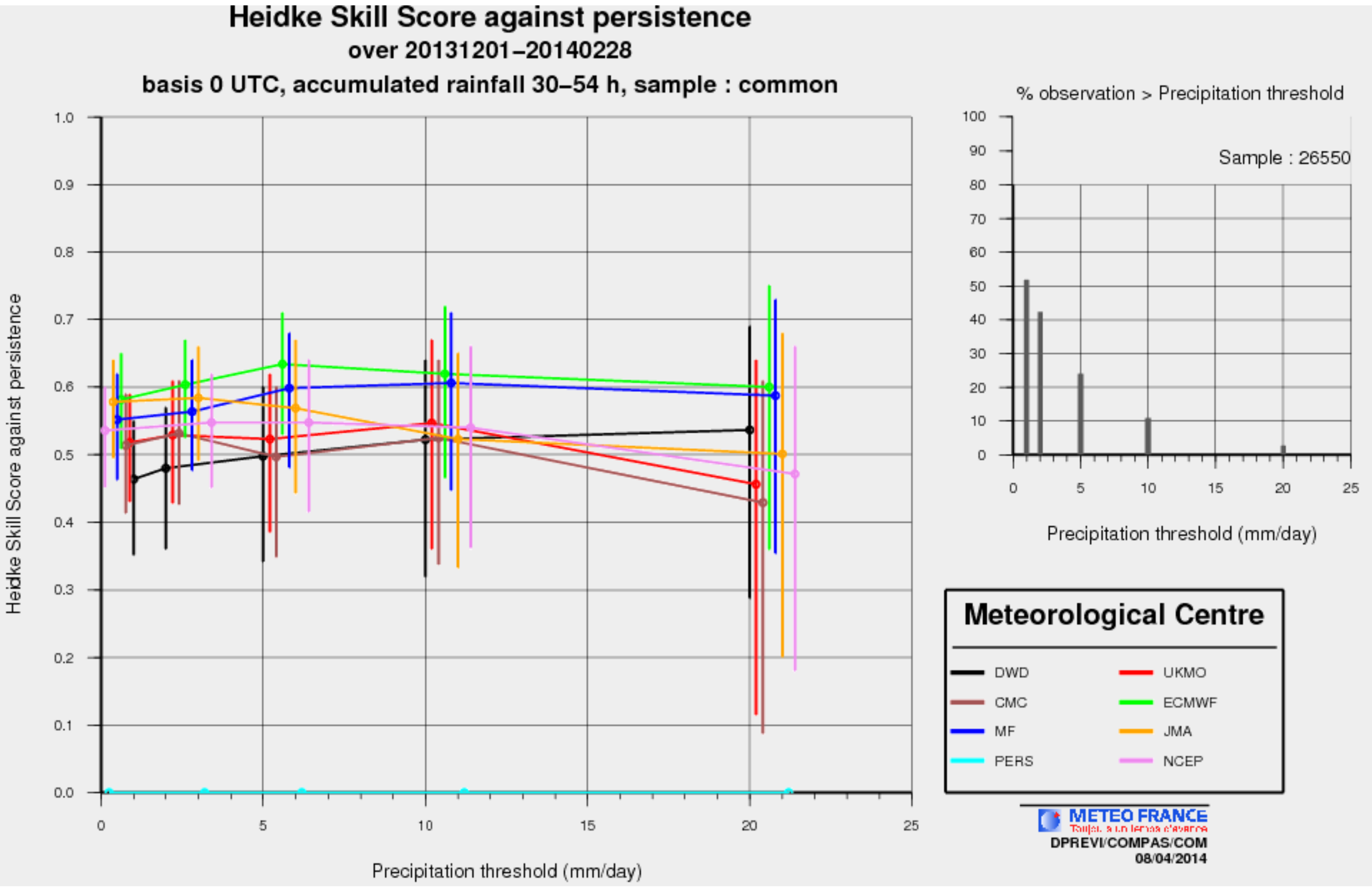
Probability of Detection



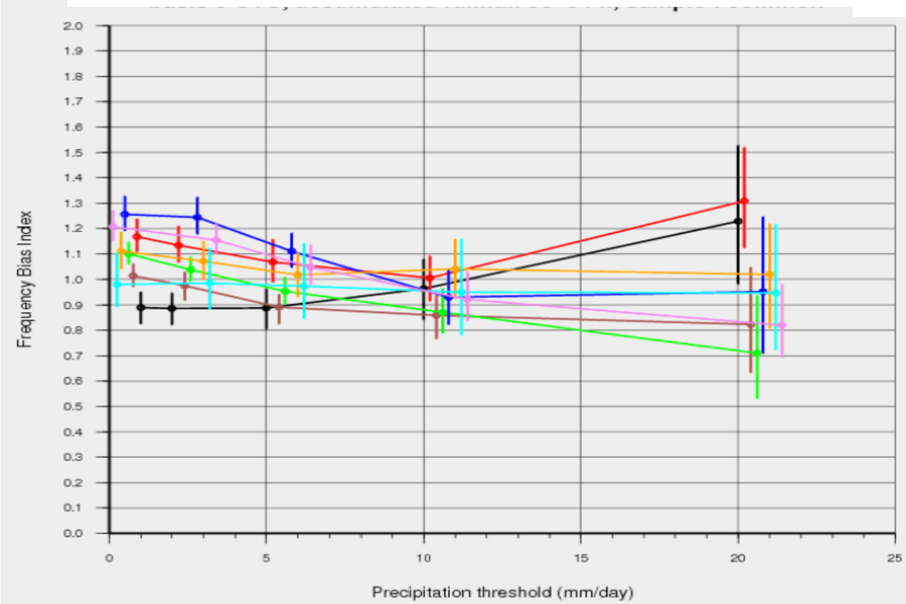
False Alarm Ratio



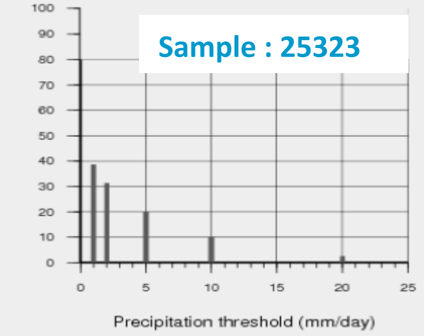
WINTER 2014 Lead time 54 UTC

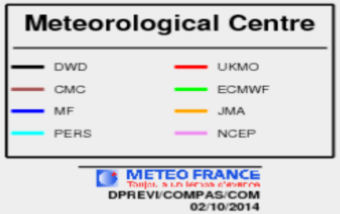


Frequential Bias



% Observation

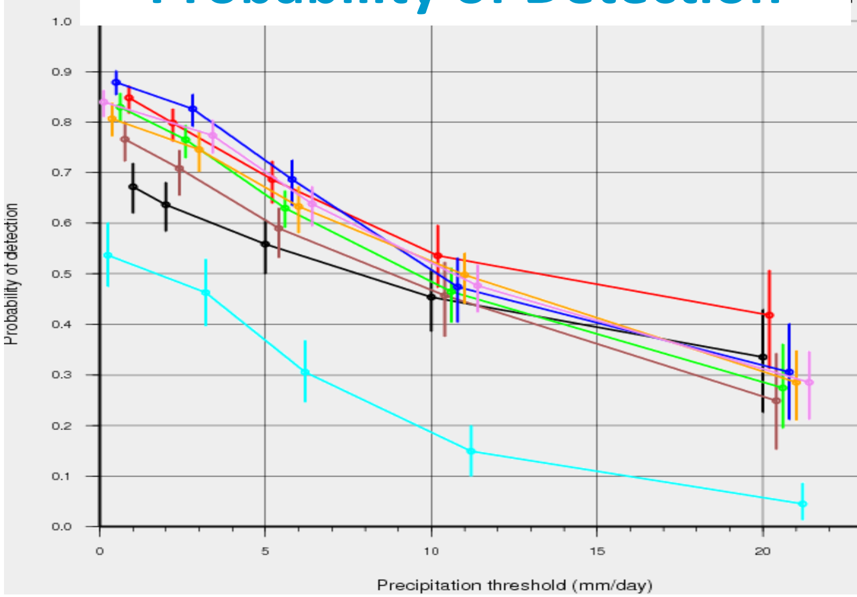




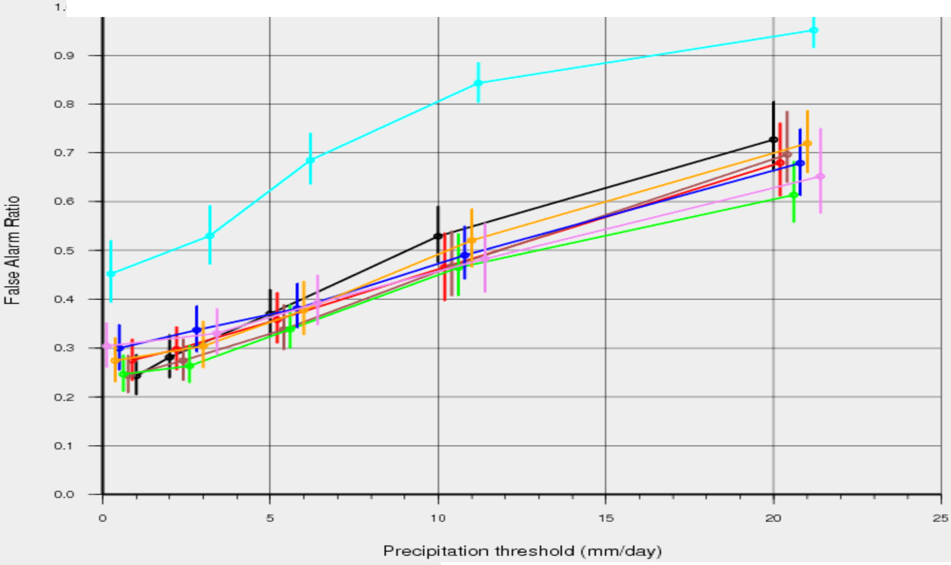
Summer 2014

Lead time 54 UTC

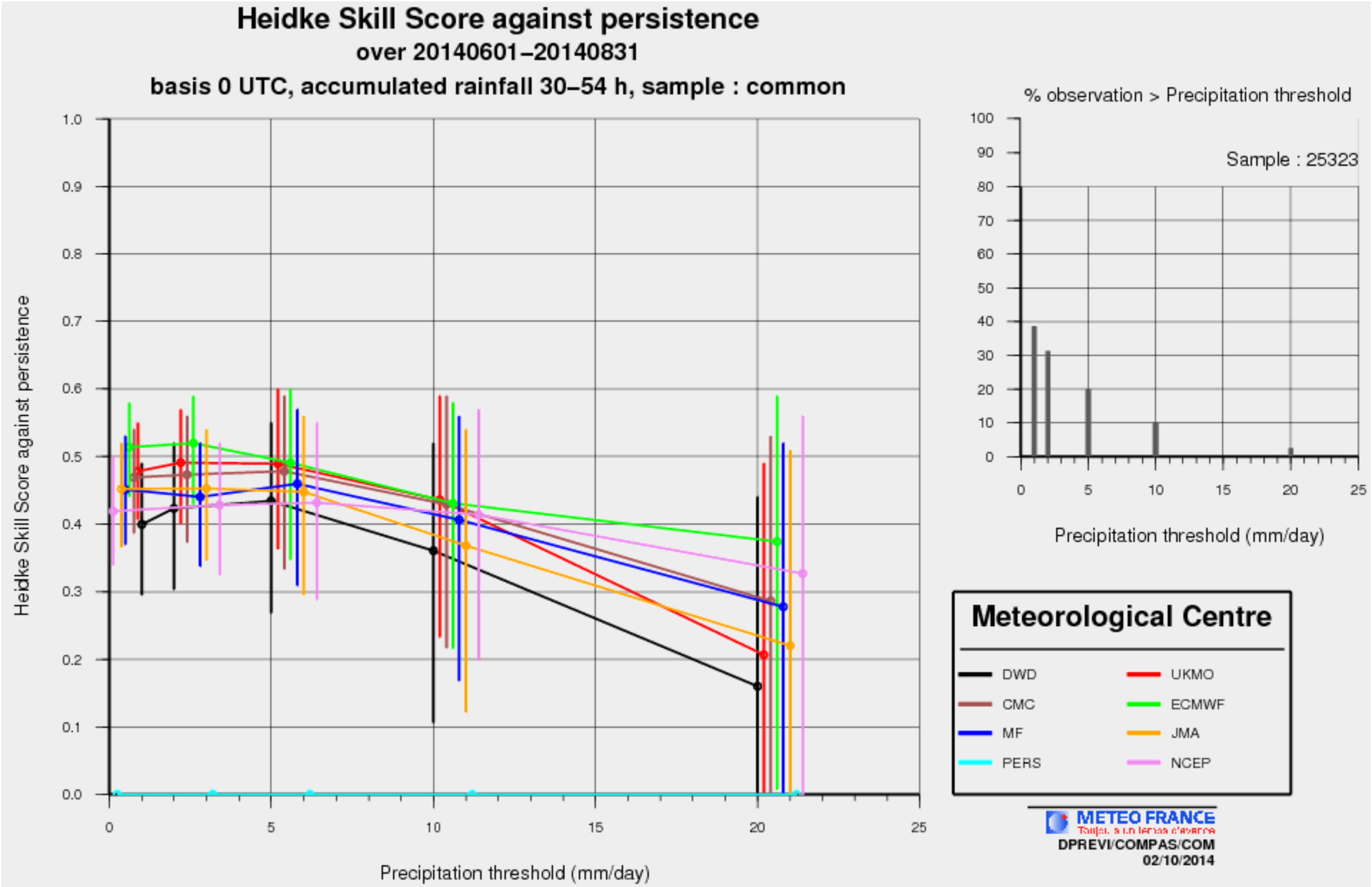
Probability of Detection



False Alarm Ratio



Summer 2014 Lead time 54 UTC

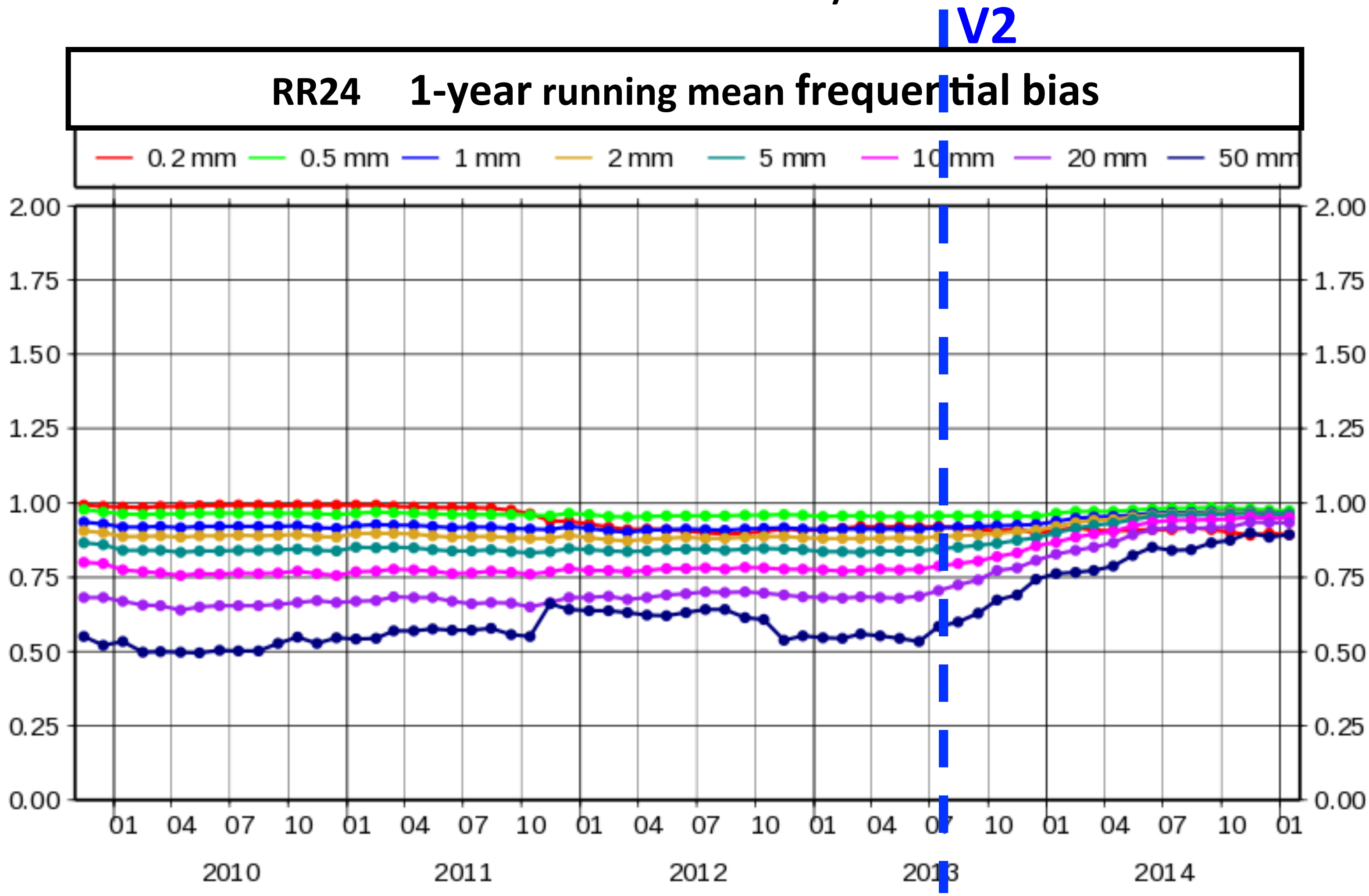


QPF verification over France from operational models against hight resolution observations

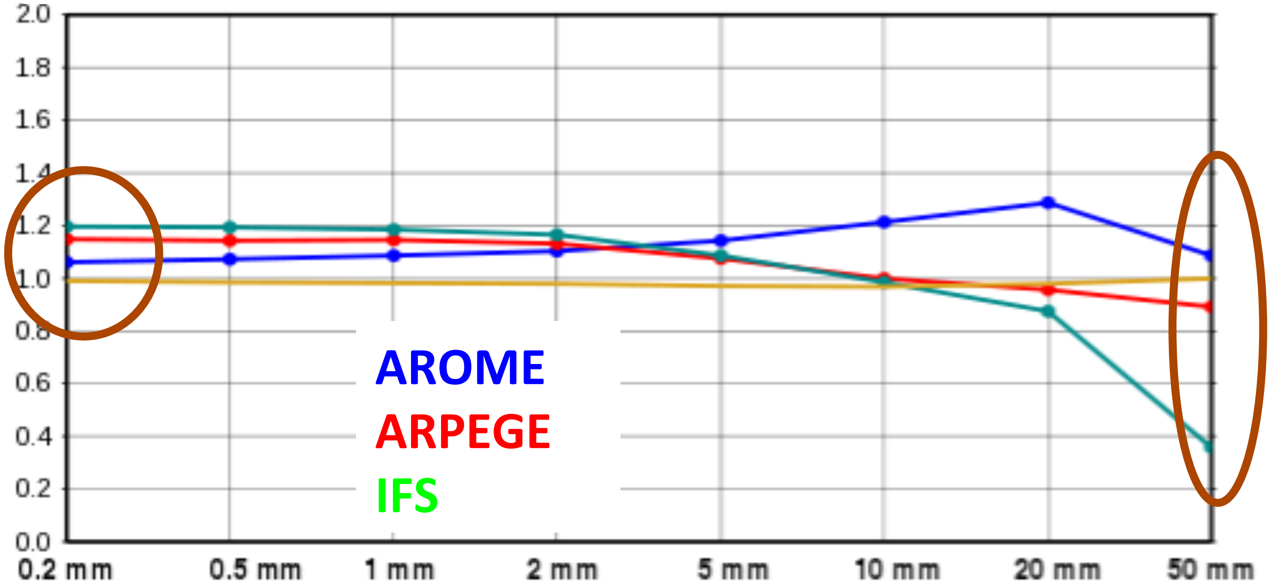
- **Gridded observations : combined radar-gauge analyses (ANTILOPE)**
- **RR24**
- Verification grid 0.025°
- Year 2014
- Bias, BSS_NO
- Thresholds 0.2, 0.5, 1, 2, 10, 20 and 50 mm

Combined radar-gauge analyses ANTILOPE against rain gauges stations

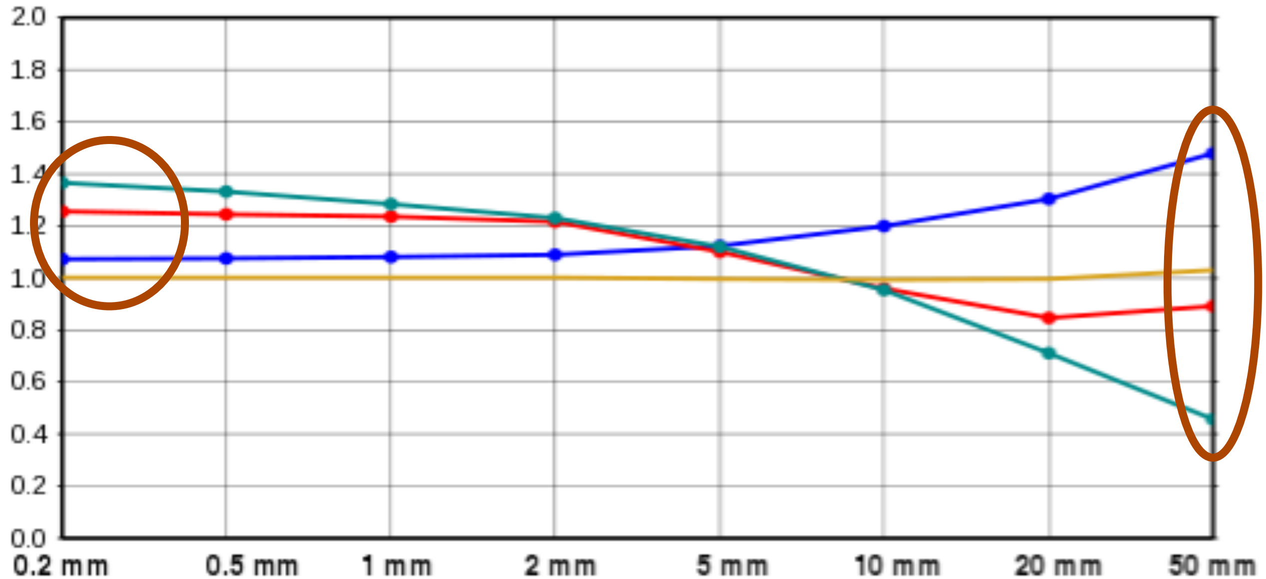
- A new version V2 available since July 2013



RR24 Year 2014 Frequency Bias

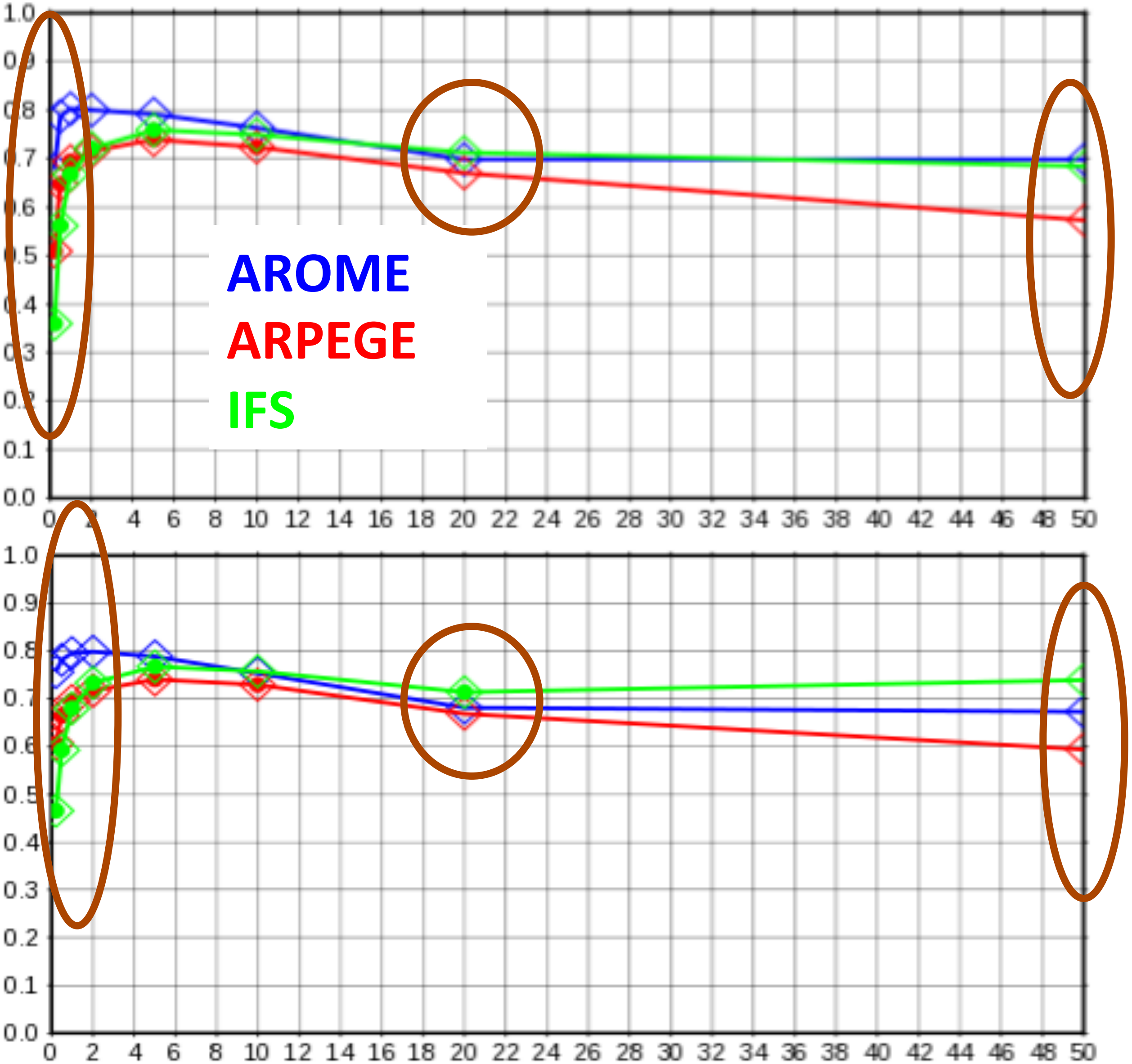


Against
Rain gauges
Stations
≅ 4000 pts



Against
ANTILOPE
≅125000 pts

RR24 Year 2014 BSS_NO 50 km



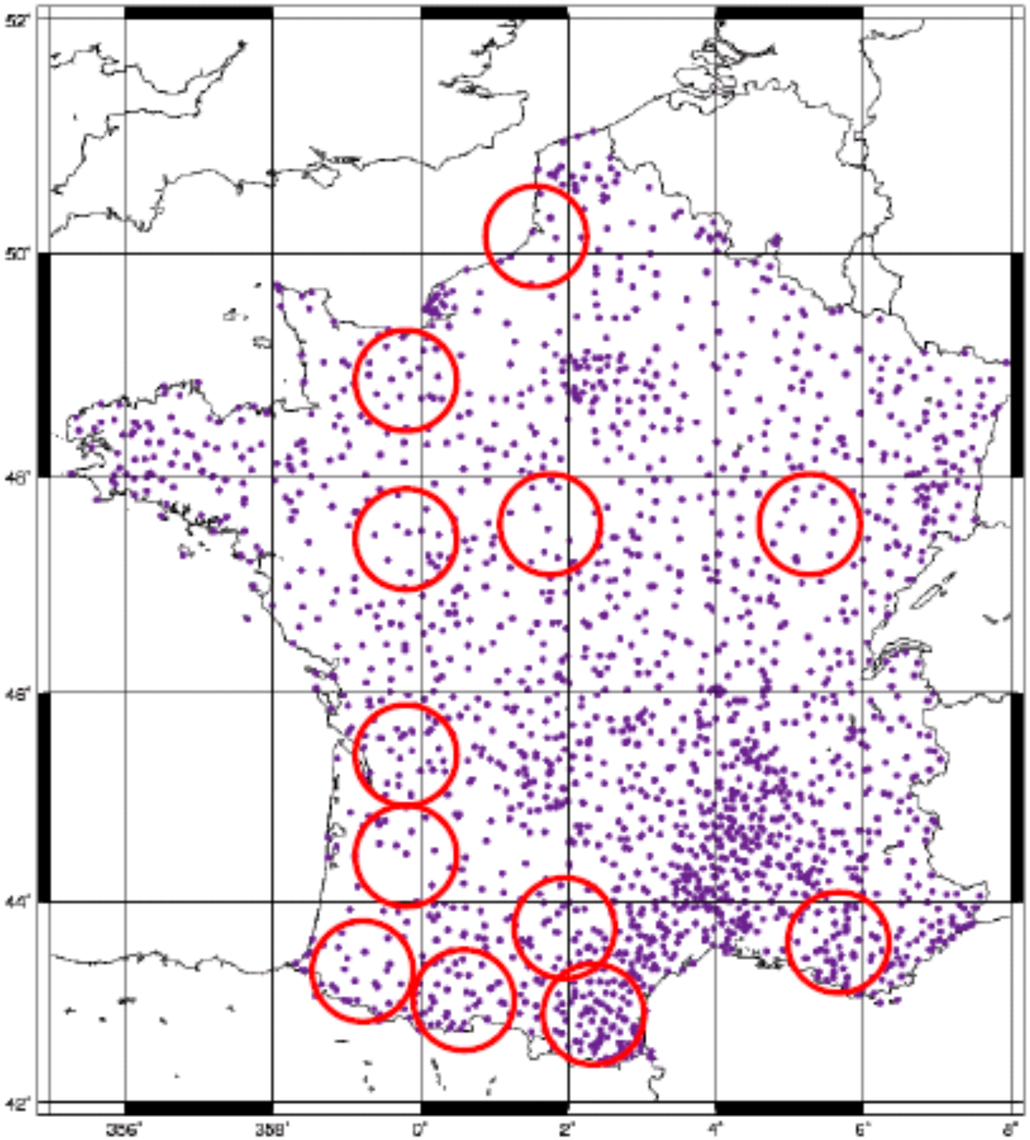
Against
Rain gauges
stations

Against
ANTILOPE

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

BS** or **FBS

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

FSS

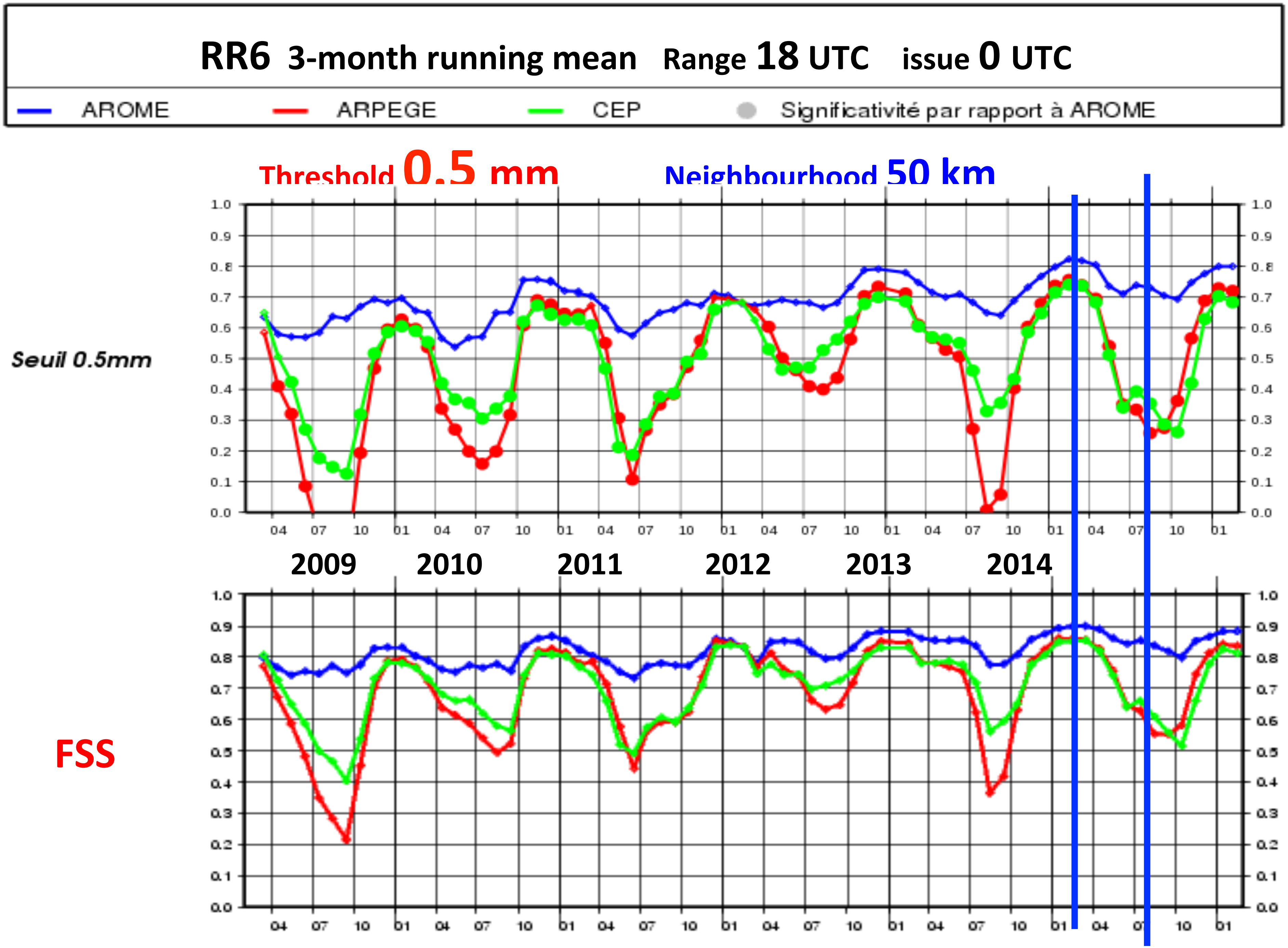
$$= 1 - \frac{FBS}{FBS_{reference}}$$

BSS_NO

$$= 1 - \frac{FBS}{FBS_{persistence}}$$

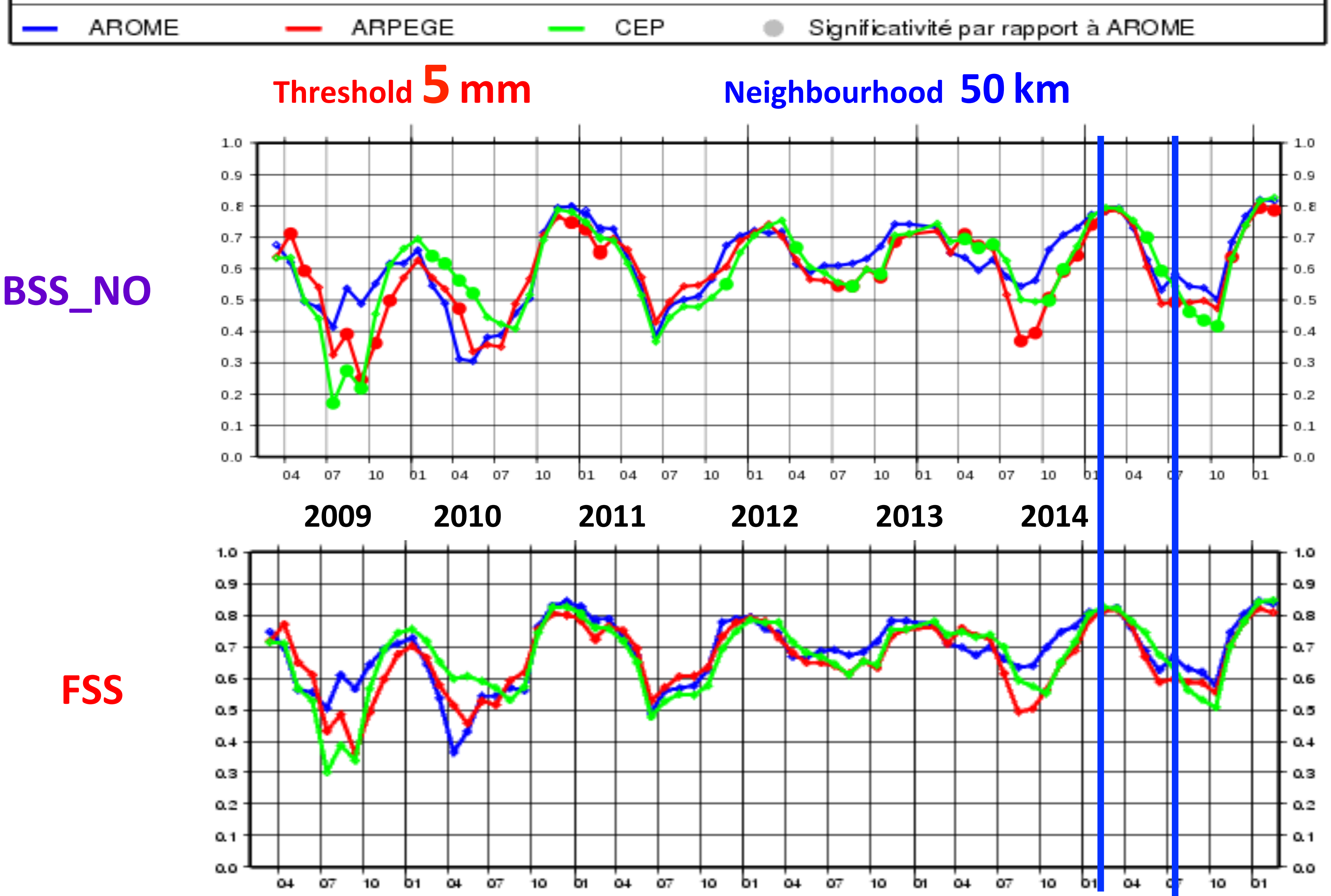
***FBS** reference*

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



RR6 3-month running mean Range 18 UTC issue 0 UTC
AROME
ARPEGE
CEP
Significativité par rapport à AROME
Threshold 0.5 mm
Neighbourhood 50 km
Seuil 0.5mm
2009
2010
2011
2012
2013
2014
FSS

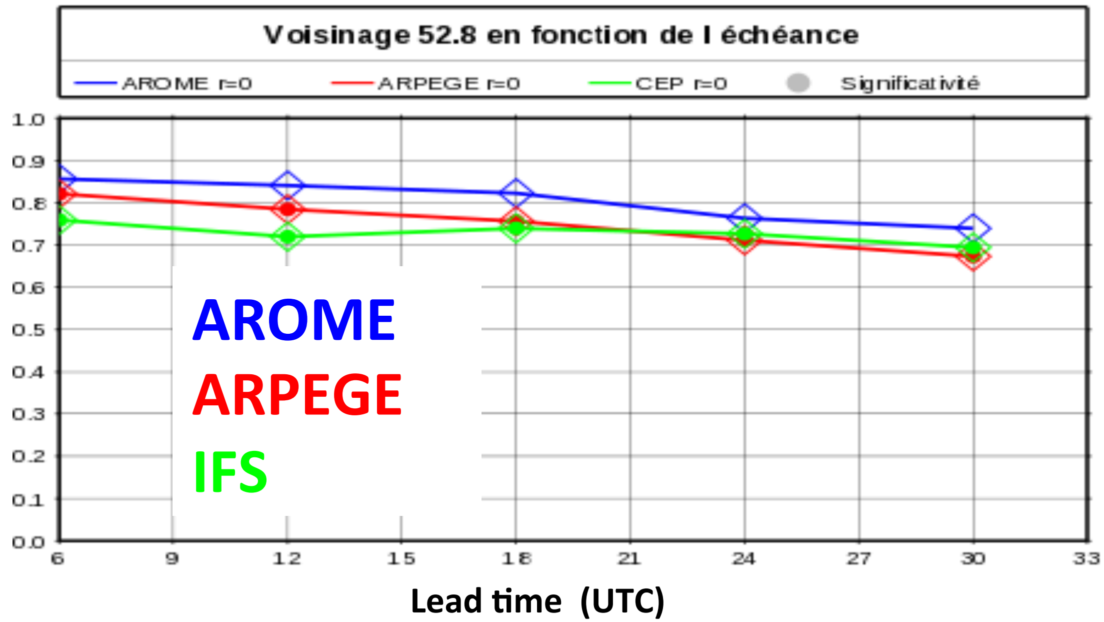
RR6 3-month running mean Range 18 UTC issue 0 UTC



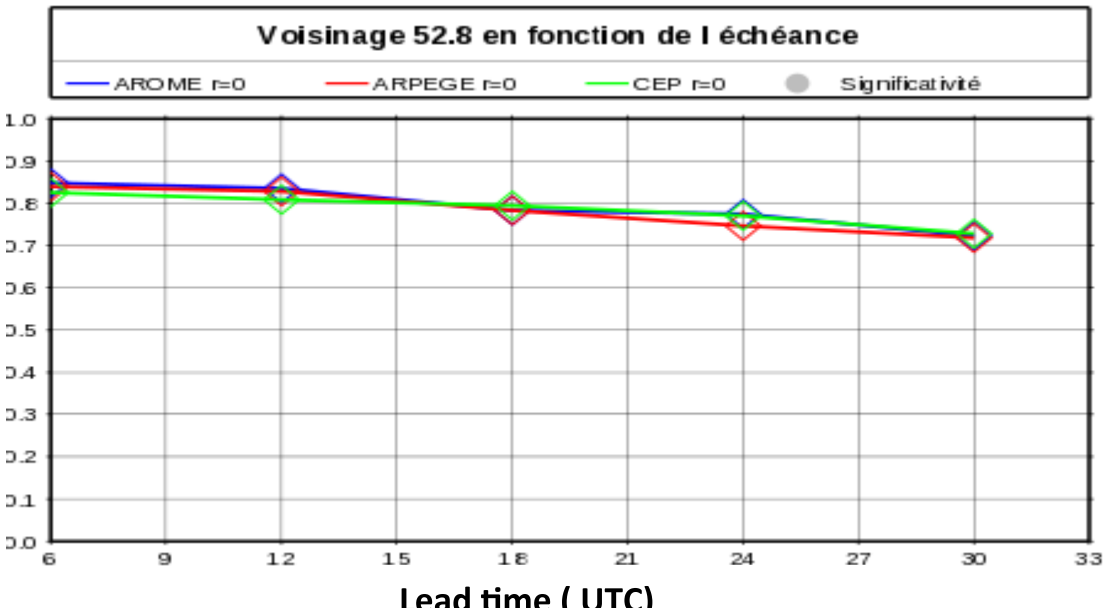
6 hours accumulated rainfall BSS_NO

Neighbourhood **50 km**

WINTER 2014



Threshold **0.5 mm**

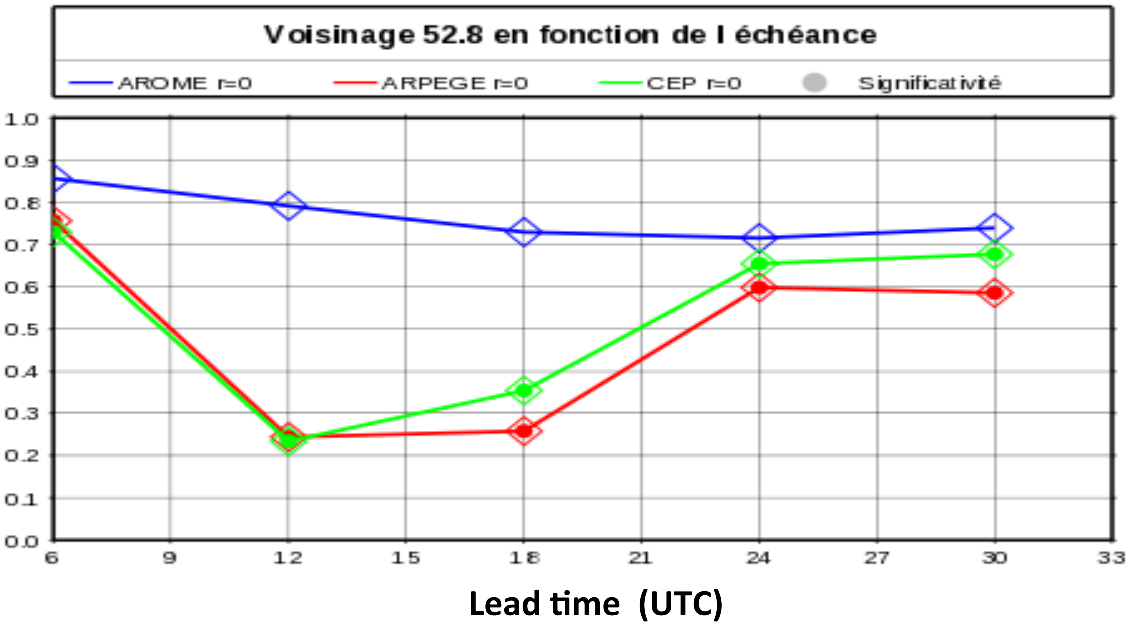


Threshold **5 mm**

6 hours accumulated rainfall BSS_NO

Neighbourhood 50 km

SUMMER 2014

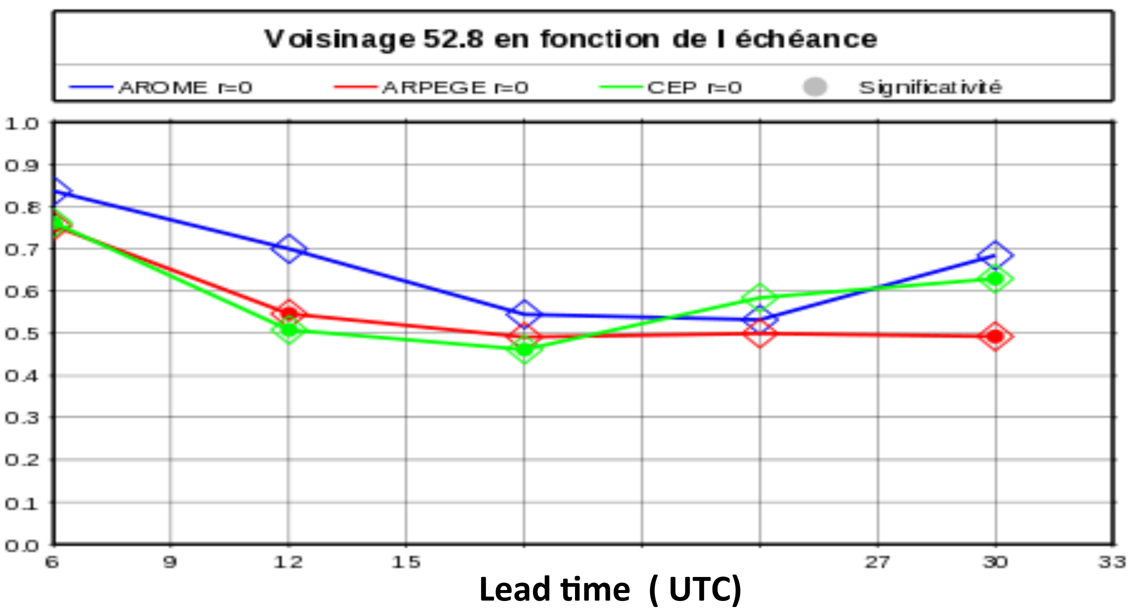


Threshold 0.5 mm

AROME

ARPEGE

IFS



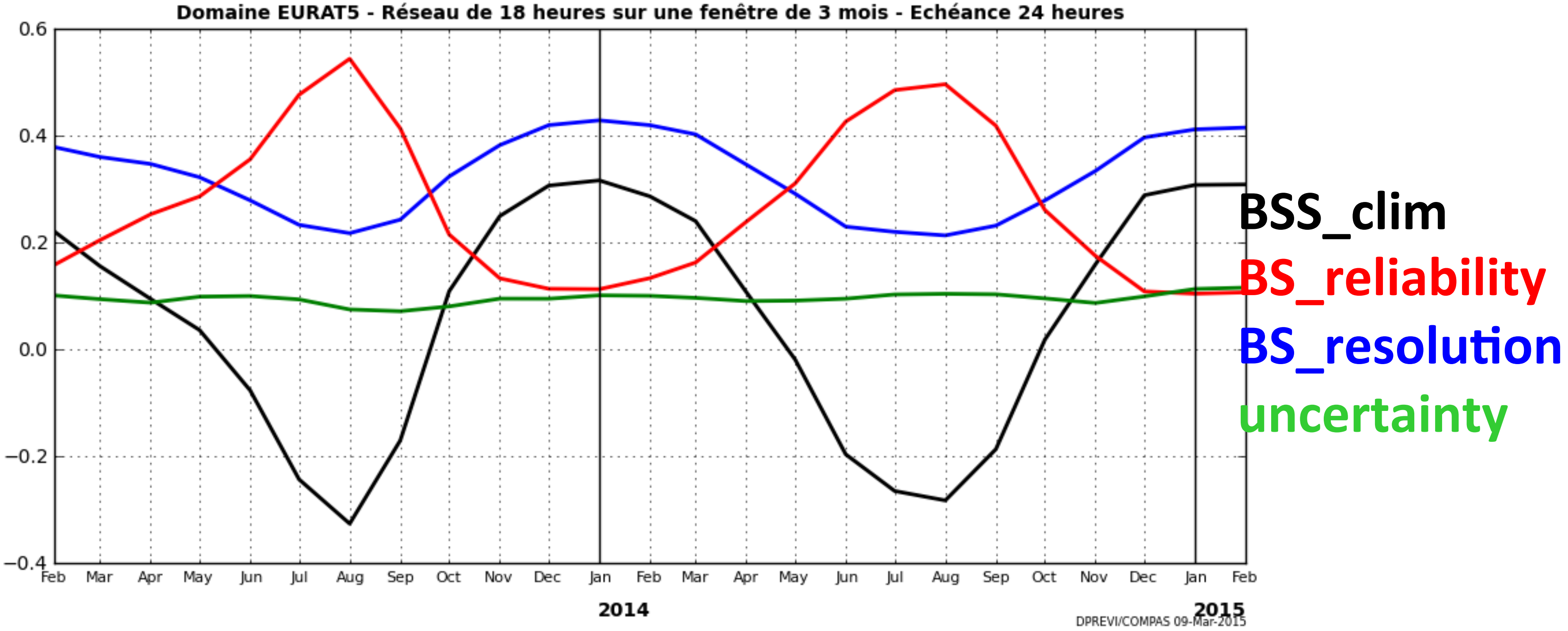
Threshold 5 mm

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

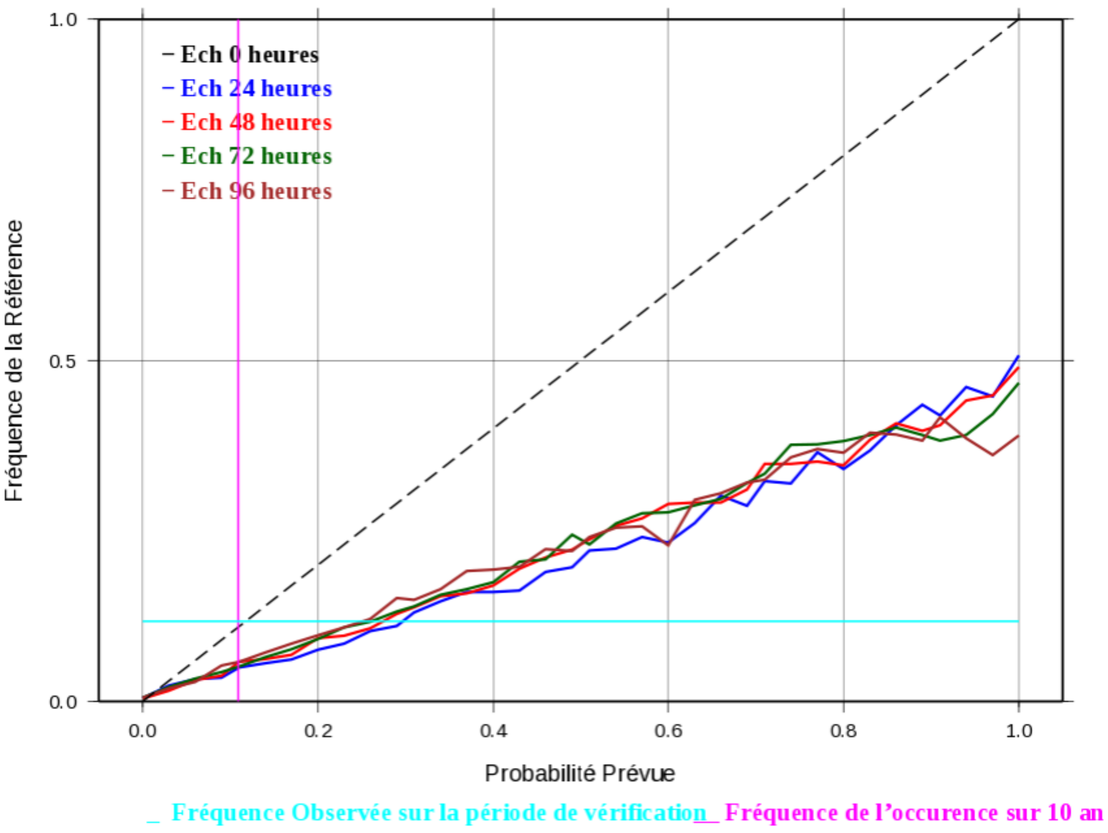
BSS and components

PEARP 18 UTC/SYNOP   Domain EURAT5
6 hours accumulated rainfall for threshold 1 mm



Reliability diagram

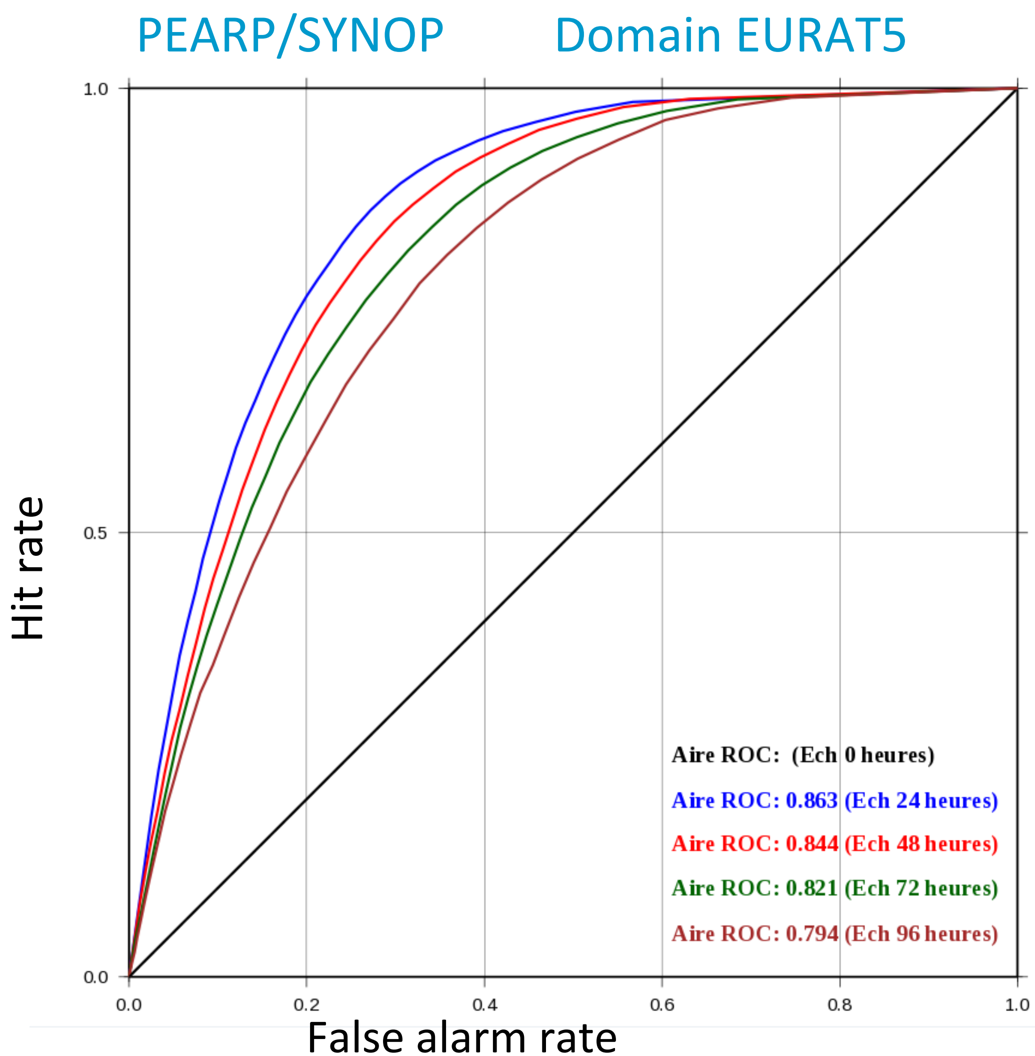
PEARP/SYNOP Domain EURAT5



SUMMER 2014

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

Roc diagram and roc area



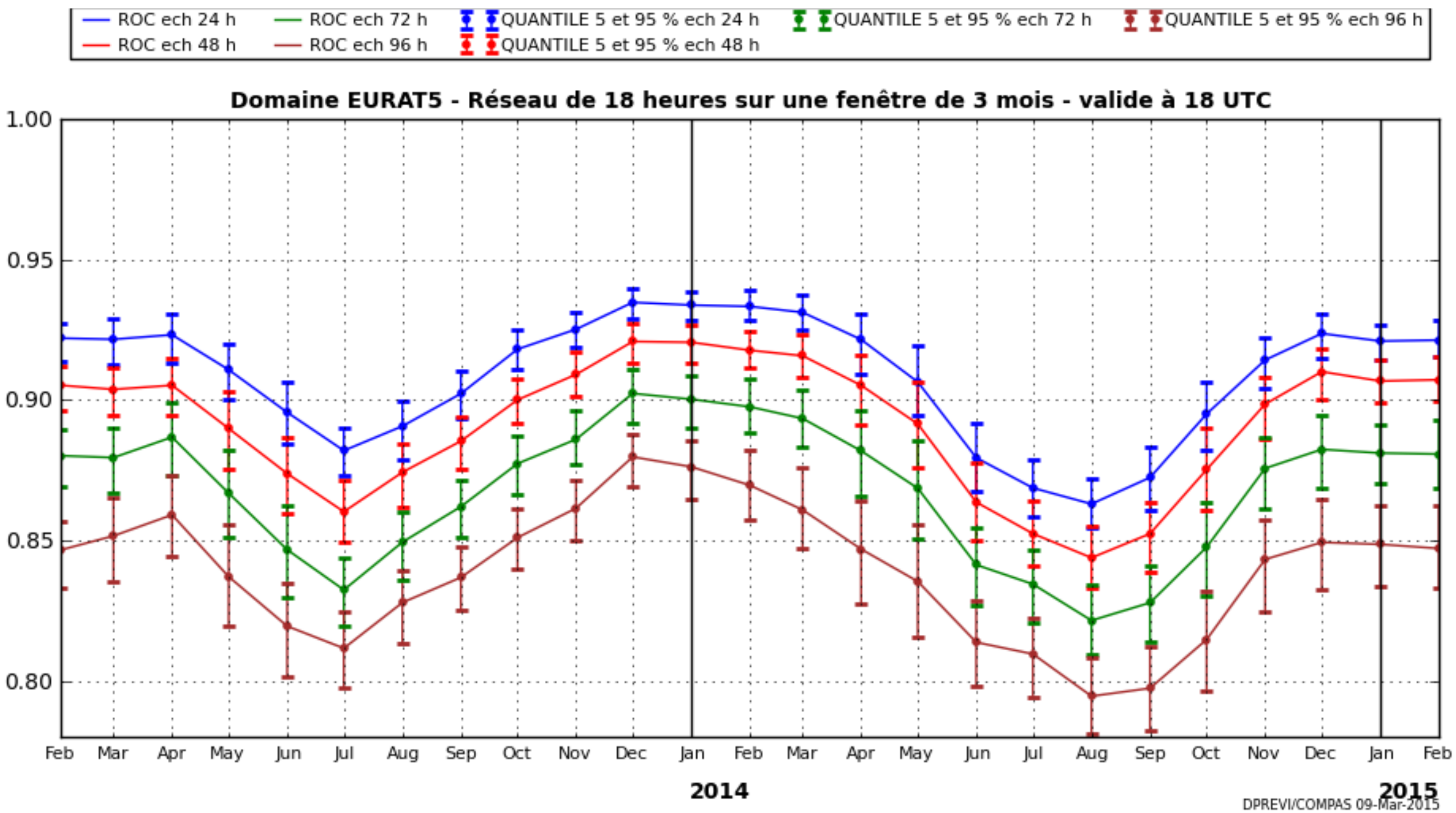
SUMMER 2014

- 6 hours accumulated rainfall
- threshold 1 mm
- issu 18 UTC
- validity 18 UTC

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

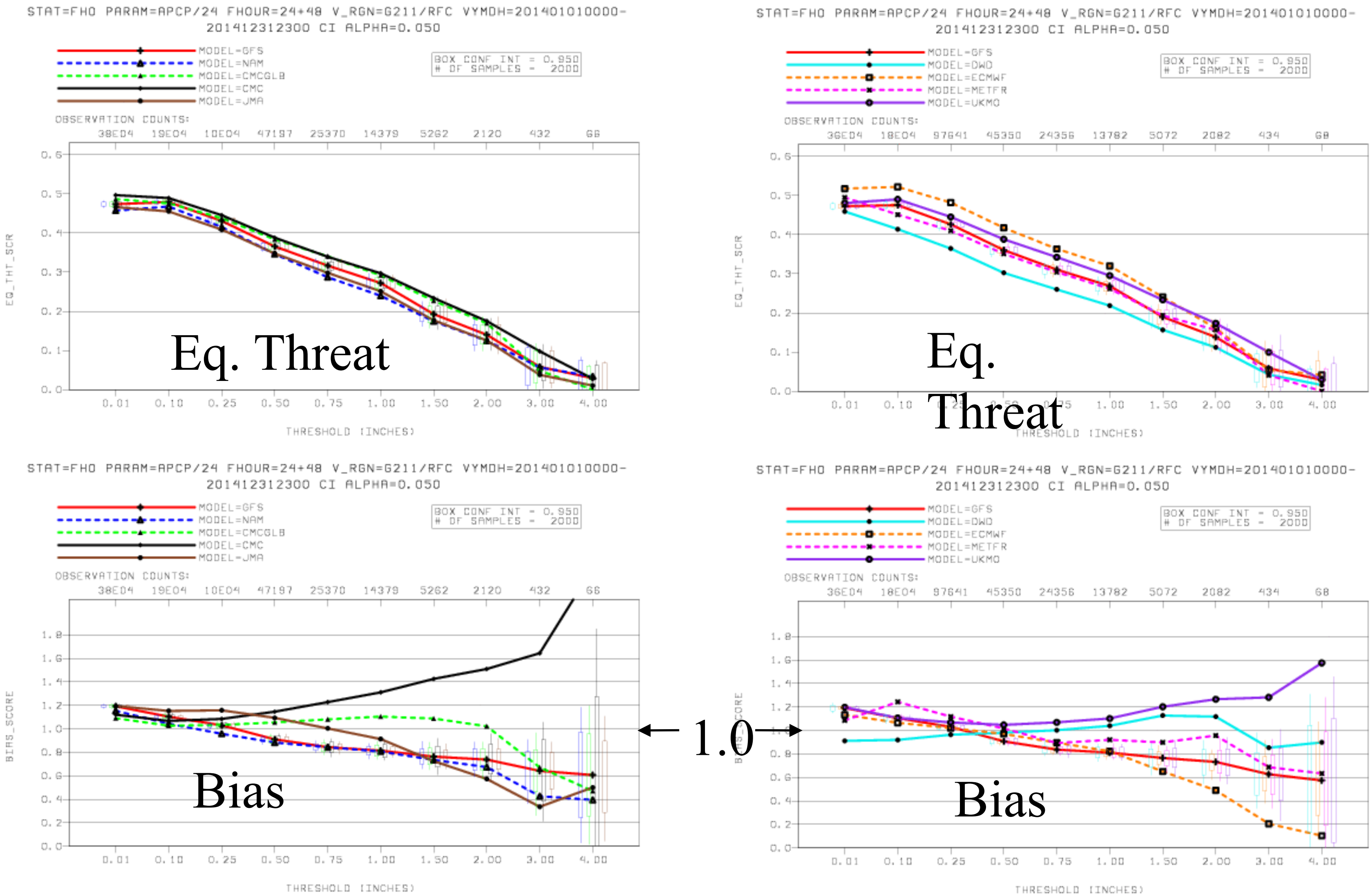
96 h range

&quantiles 5 95%

QPF Verification at NCEP for Deterministic NCEP and International Models

- 24h (12Z-12Z) contingency table-based verifications for all models
- 3-hourly contingency table-based verifications for NCEP operational and parallel models
- 24h fractions skill scores computation for NCEP operational and parallel models. Retrospective FSS for GFS and NAM from 2002.

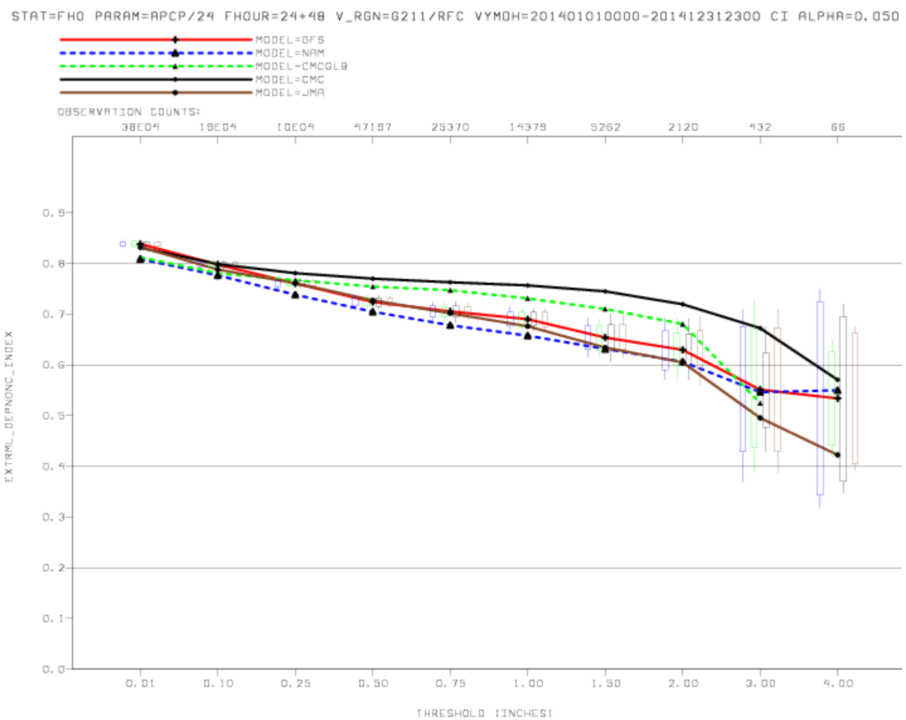
ETS/Bias over ConUS, Jan – Dec 2014, 1 &2 day fcsts

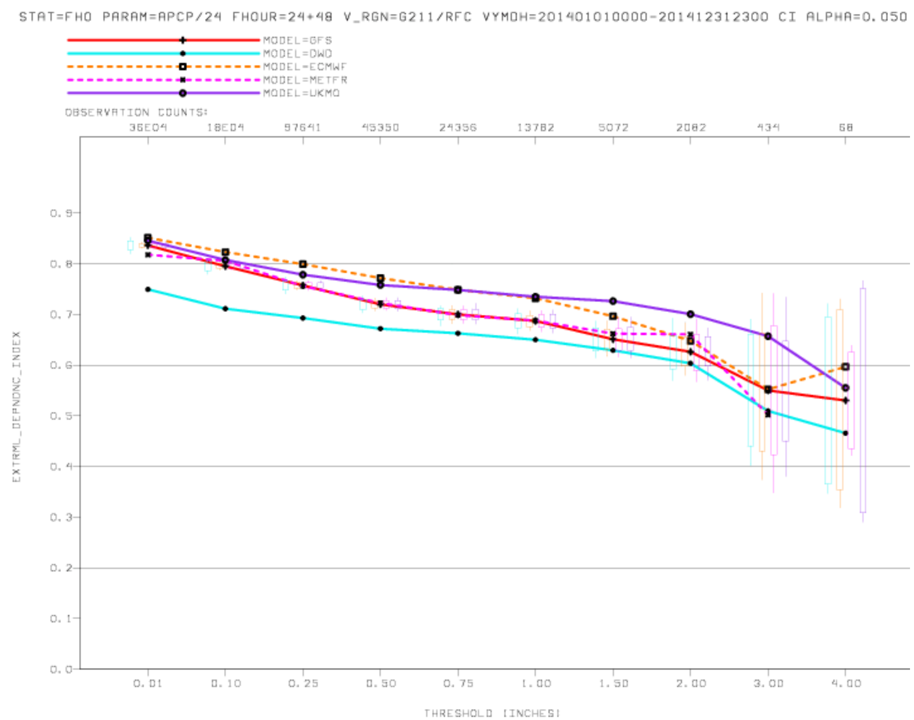


GFS,NAM,CMCGLB,CMC,JMA

GFS,DWD,ECMWF,METFR,UKMO

Extremal Dependence Index over ConUS
Jan – Dec 2014, 1 &2 day fcsts

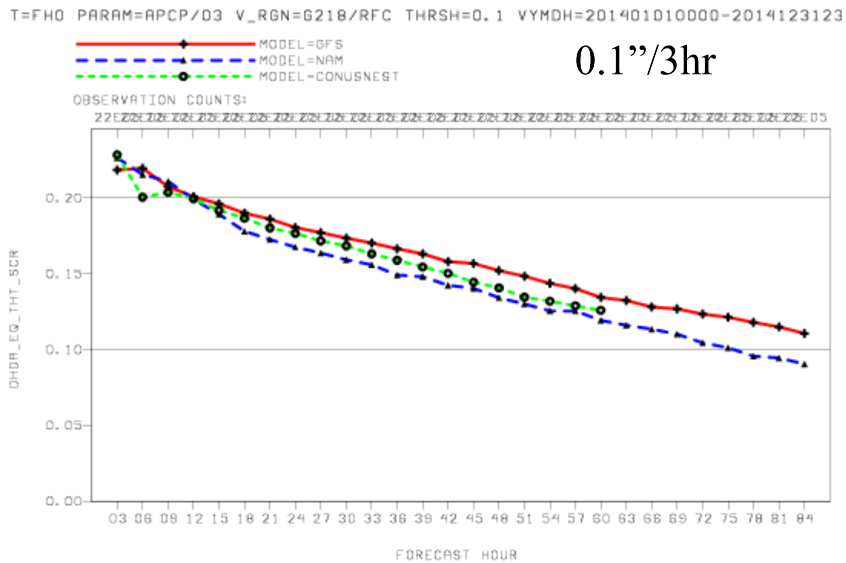


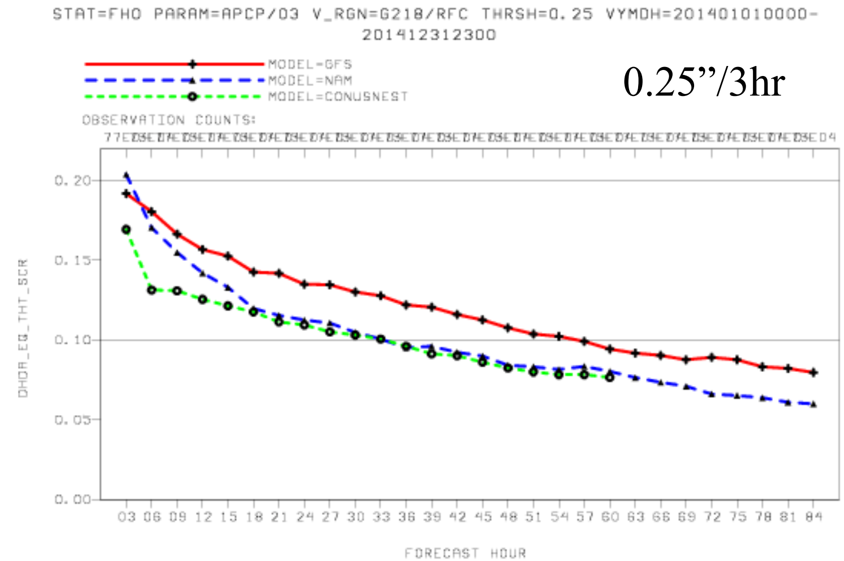


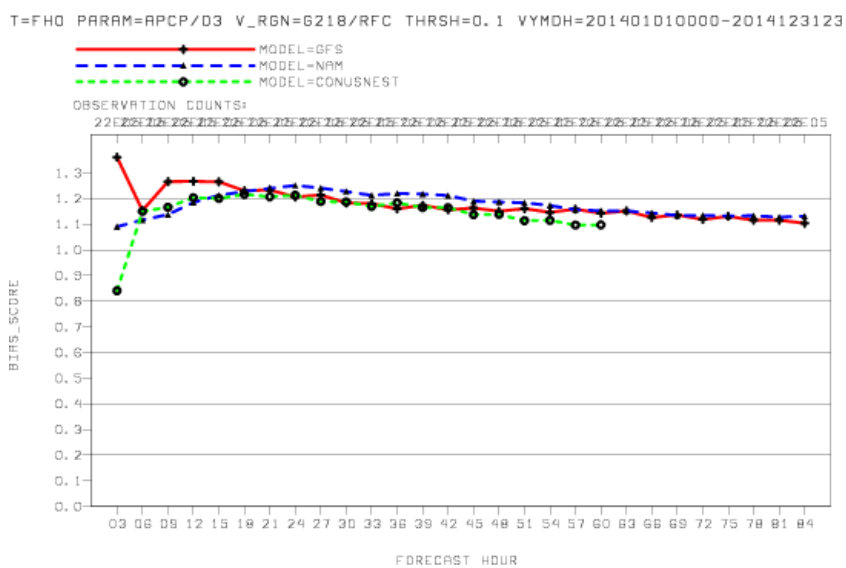
GFS,NAM,CMCGLB,CMC,JMA

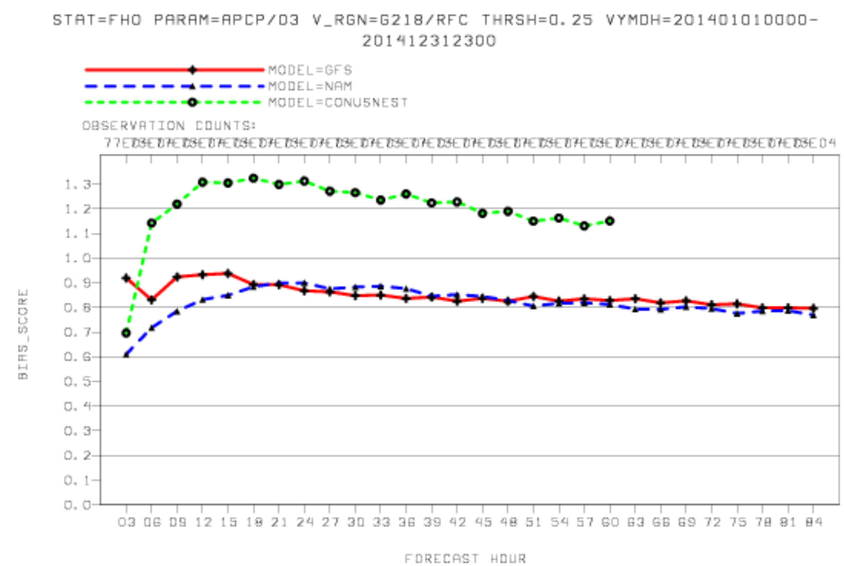
GFS,DWD,ECMWF,METFR,UKMO

ConUS-averaged 3-hourly precip, Jan-Dec 2014
GFS/NAM/CONUSNEST

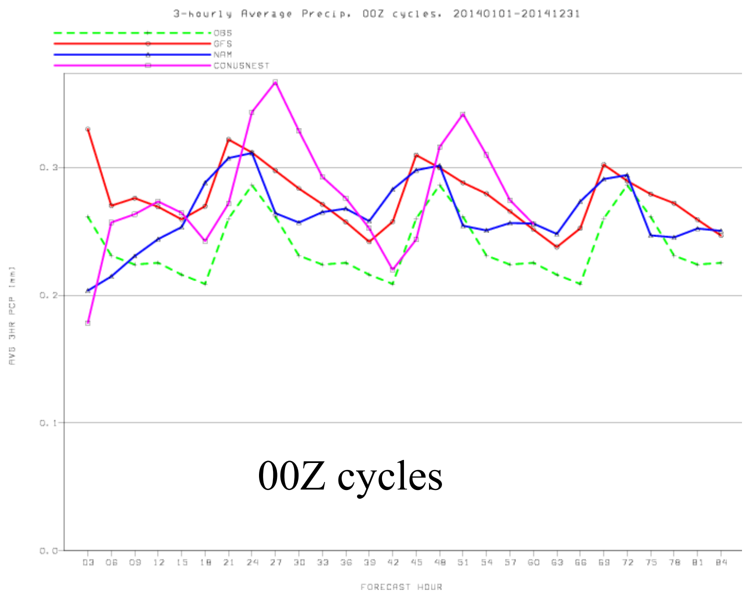


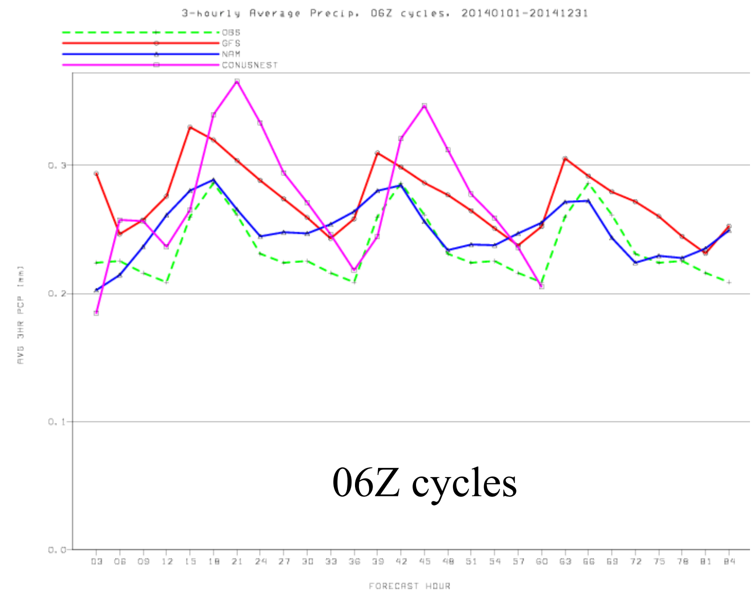


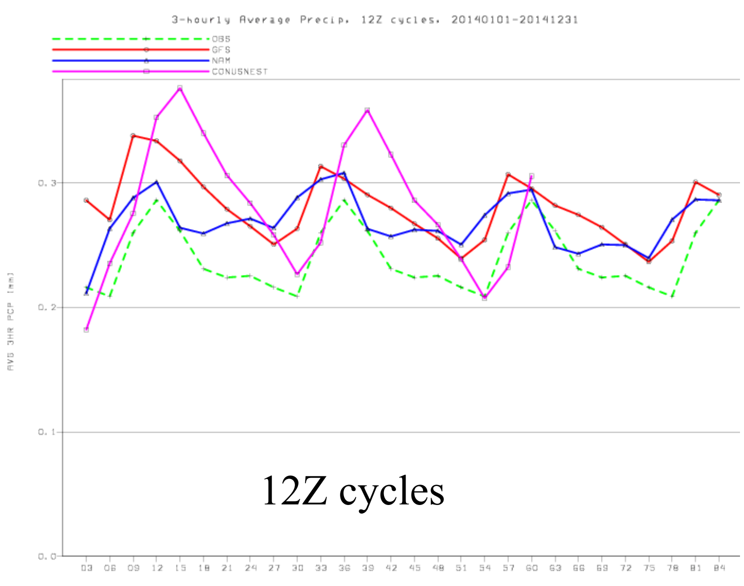


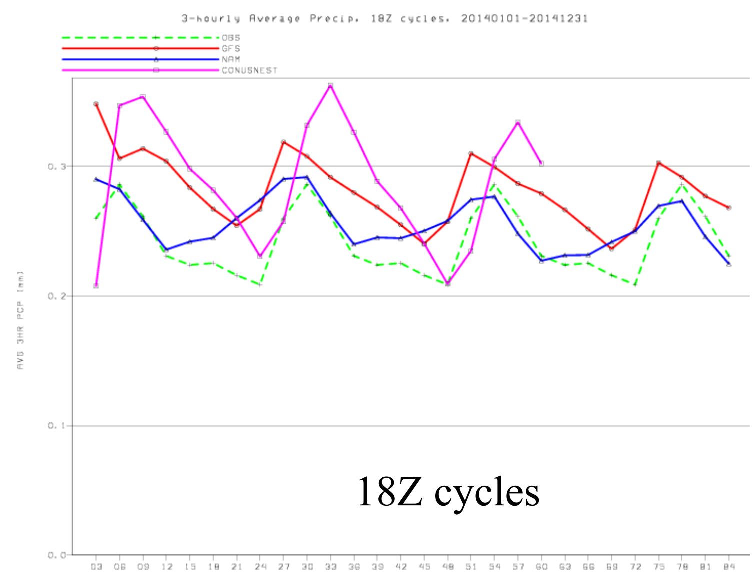


ConUS-averaged 3-hourly precip, Jan-Dec 2014
GFS/NAM/CONUSNEST *vs.* analysis

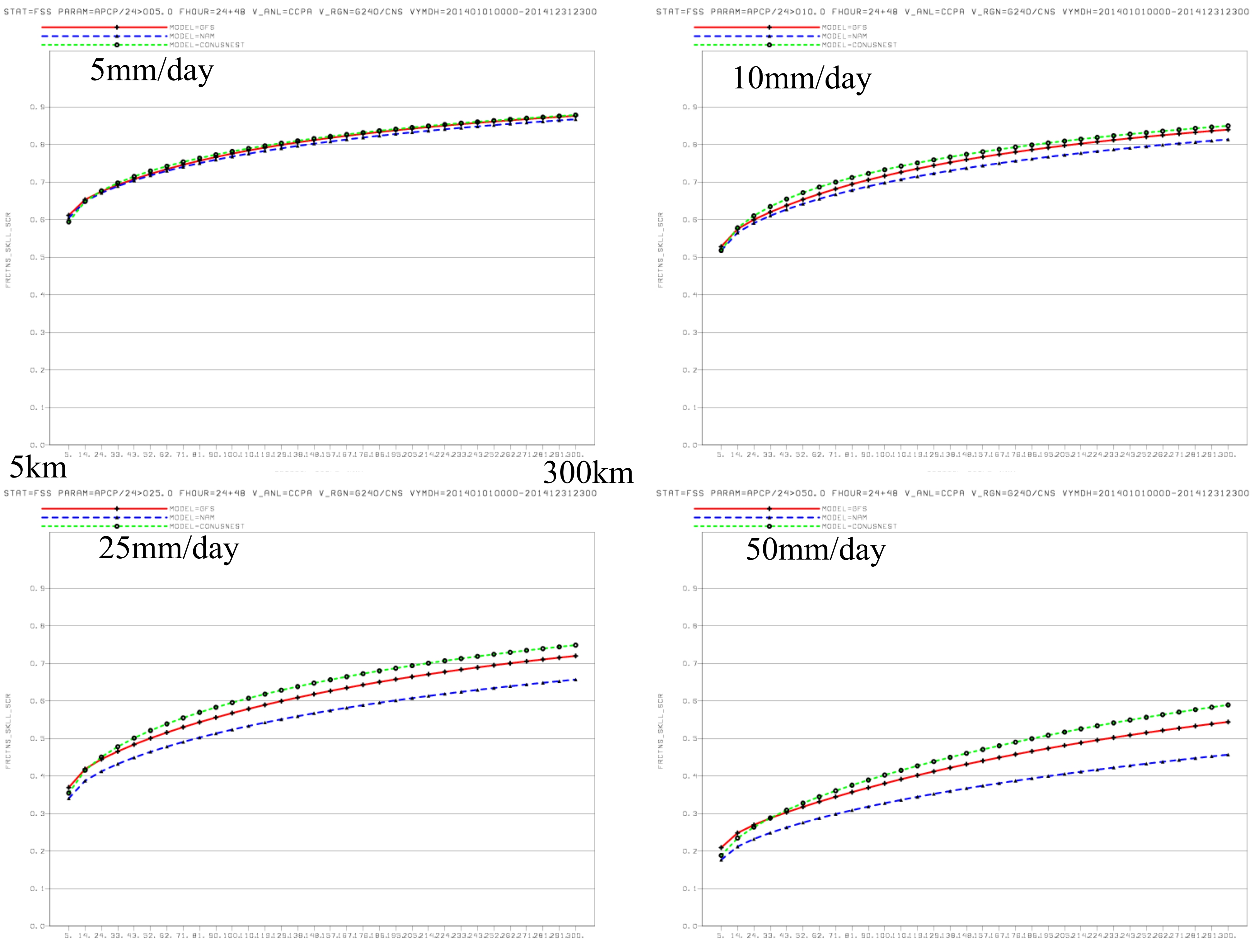








GFS, NAM, CONUSNEST 24+48 FSS, Jan-Dec 2014



EDI, ETS, and PSS were applied for HIW forecast verification during trial competitions (2013) and Olympic Games (2014) in Sochi

Eight deterministic forecast systems and six EPS were involved in the WWRP FDP/RDP FROST-2014. Interrelations of various performance measures have been studied for FROST-2014 forecasts with special attention to the distribution tails.

Analyzed systems and periods presented below:

- Two deterministic systems,COSMO-Ru2 (2.2 km) and NMMB (1 km), for 2013: *EDI as a tool to estimate the skill of HIW prediction*
- Six EPSs, COSMO-S14-EPS,GLAMEPS,ALADIN-LAEF,NMMB-EPS,HarmonEPS,and COSMO-Ru2-EPS, for Olympic Games 2014): *ROCA for all EPSs*

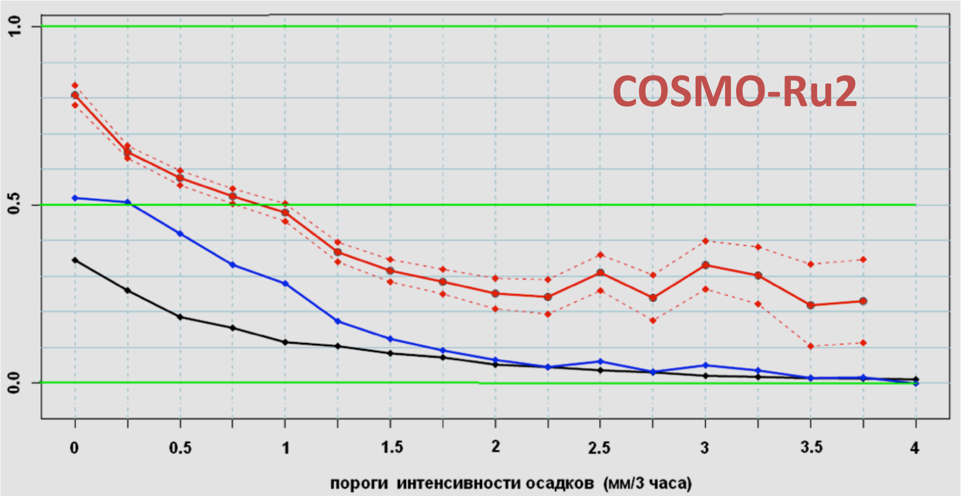
Tool: The R Project for Statistical Computing

Contact person: Anatoly Muravev muravev2003@mail.ru

Deterministic models: PSS, EDI and Base Rate as functions of threshold

3 hr forecasts, COSMO-Ru2 (top) & NMMB (bottom)

Trial period: Jan-Mar 2013
Mountain Cluster of the Sochi 2014 Olympics: 10 stations
Thresholds: 0 - 4 mm/h, step 0.25
Initial time: all starts, 00,06,12,18 UTC

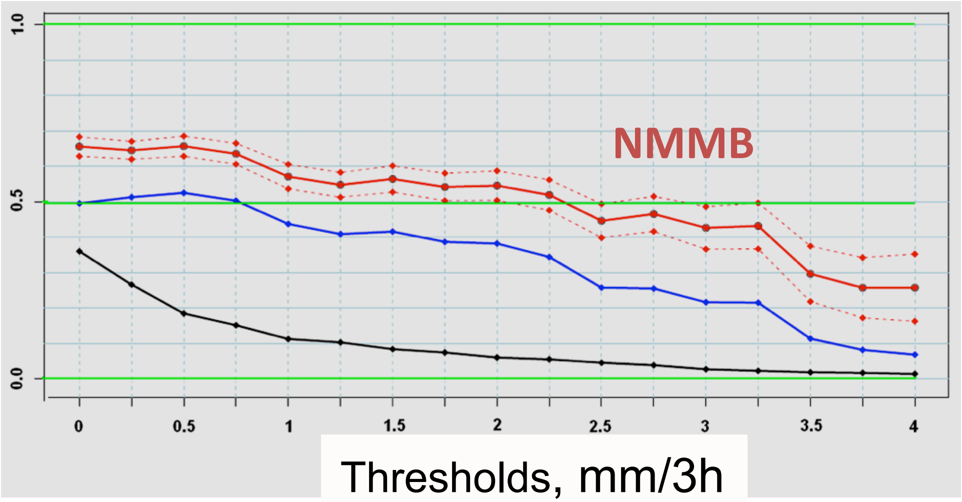


EDI – red, PSS – blue,
Base Rate (p) - black

#The 0 mm EDI (precip event) is higher for COSMO-Ru2

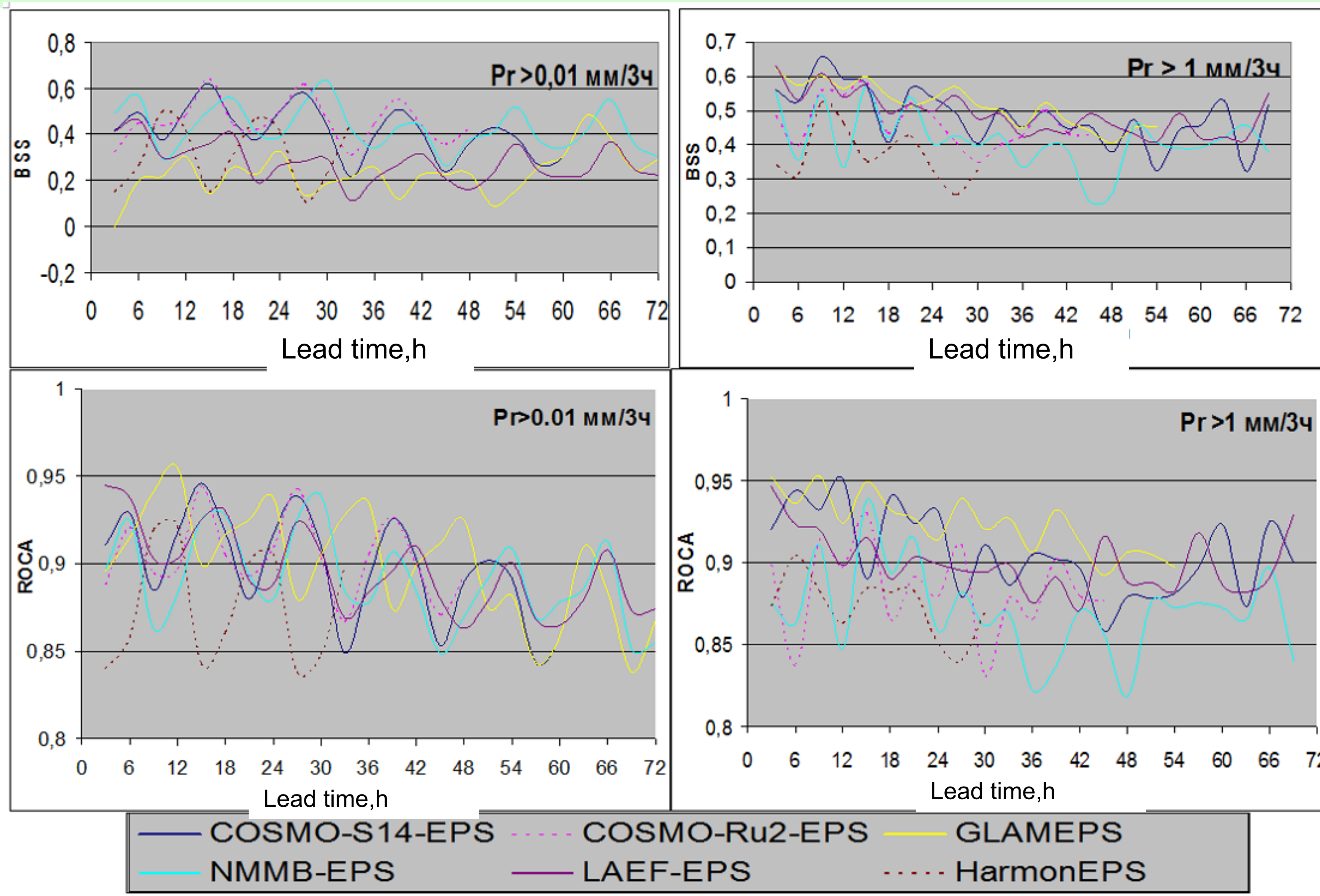
#The nonzero precip EDI is significantly higher for NMMB

#With EDI we can reasonably estimate the skill of rare event forecasts

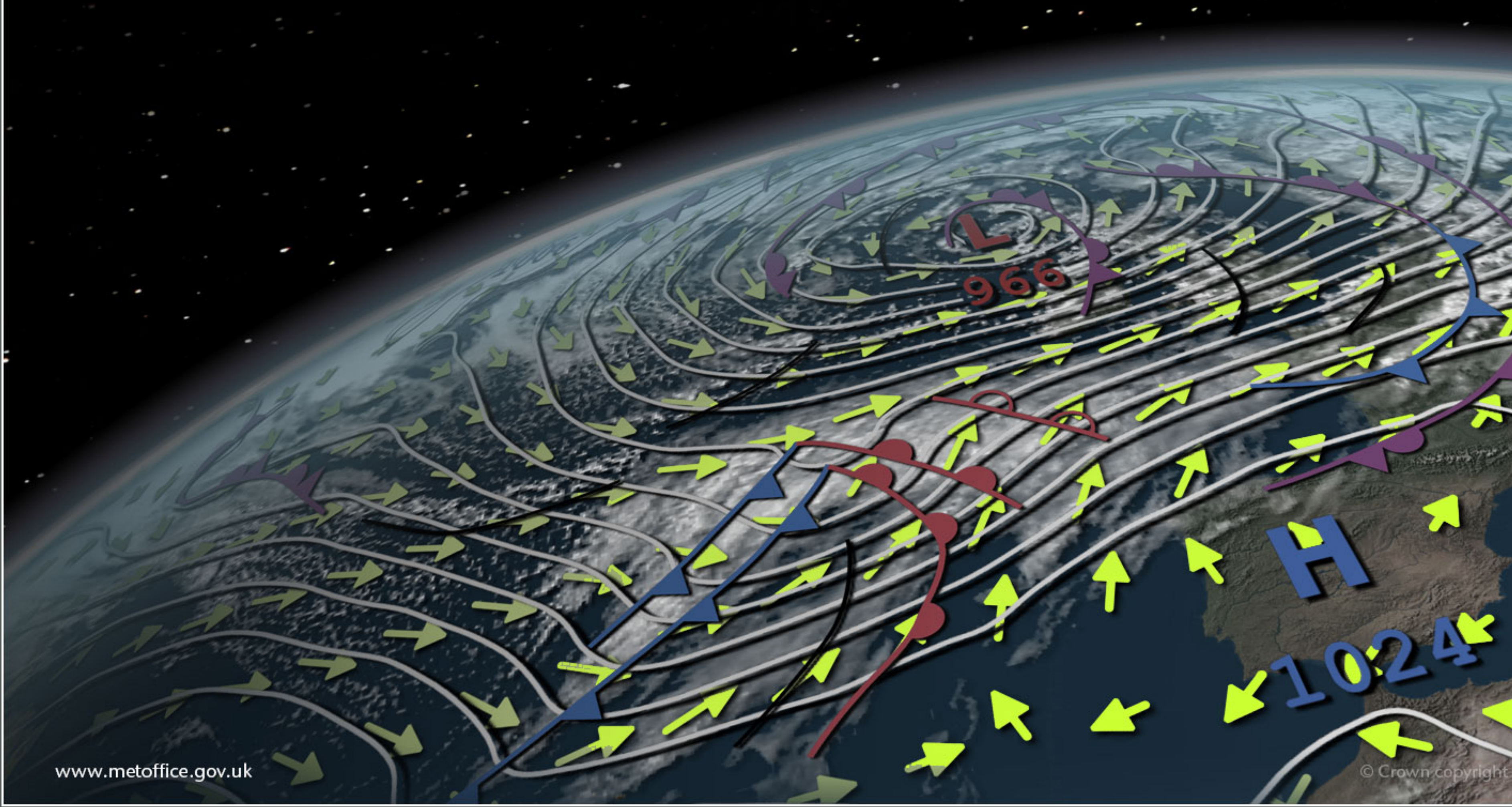


Totally, COSMO-Ru2 is more skillful in predicting the event of precipitation, while NMMB performs better for heavier precipitation and HIW

EPS: BSS and ROCA for January 15- March 15, 2014.
13 stations in Sochi2014 mountain cluster, nearest point approach



Global model precipitation verification

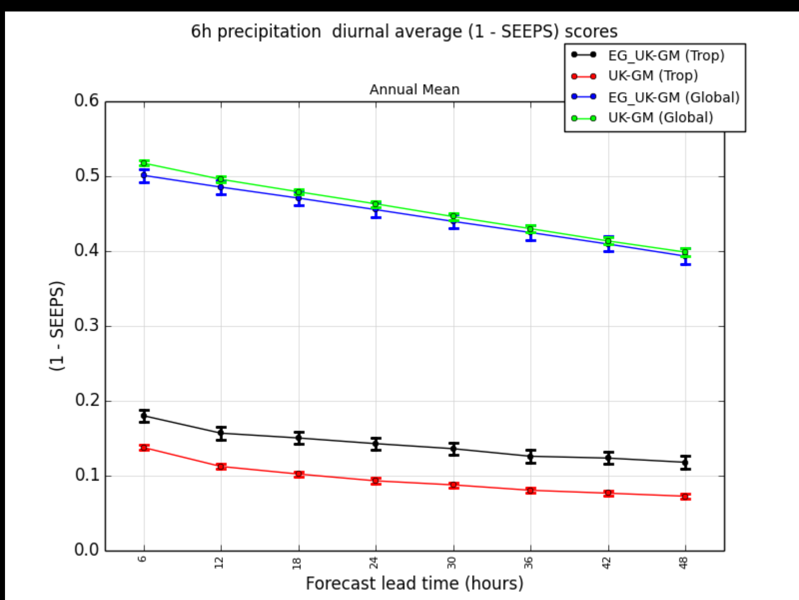


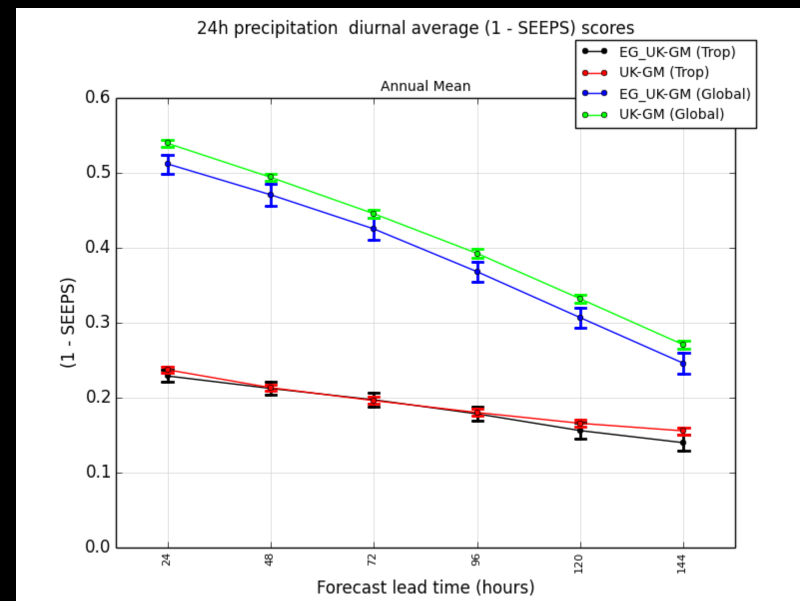
Verification of QPF using SEEPS

Score with forecast lead time, April 2012 to February 2015

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)

Verification of QPF using SEEPS

Score with forecast lead time, April 2012 to February 2015

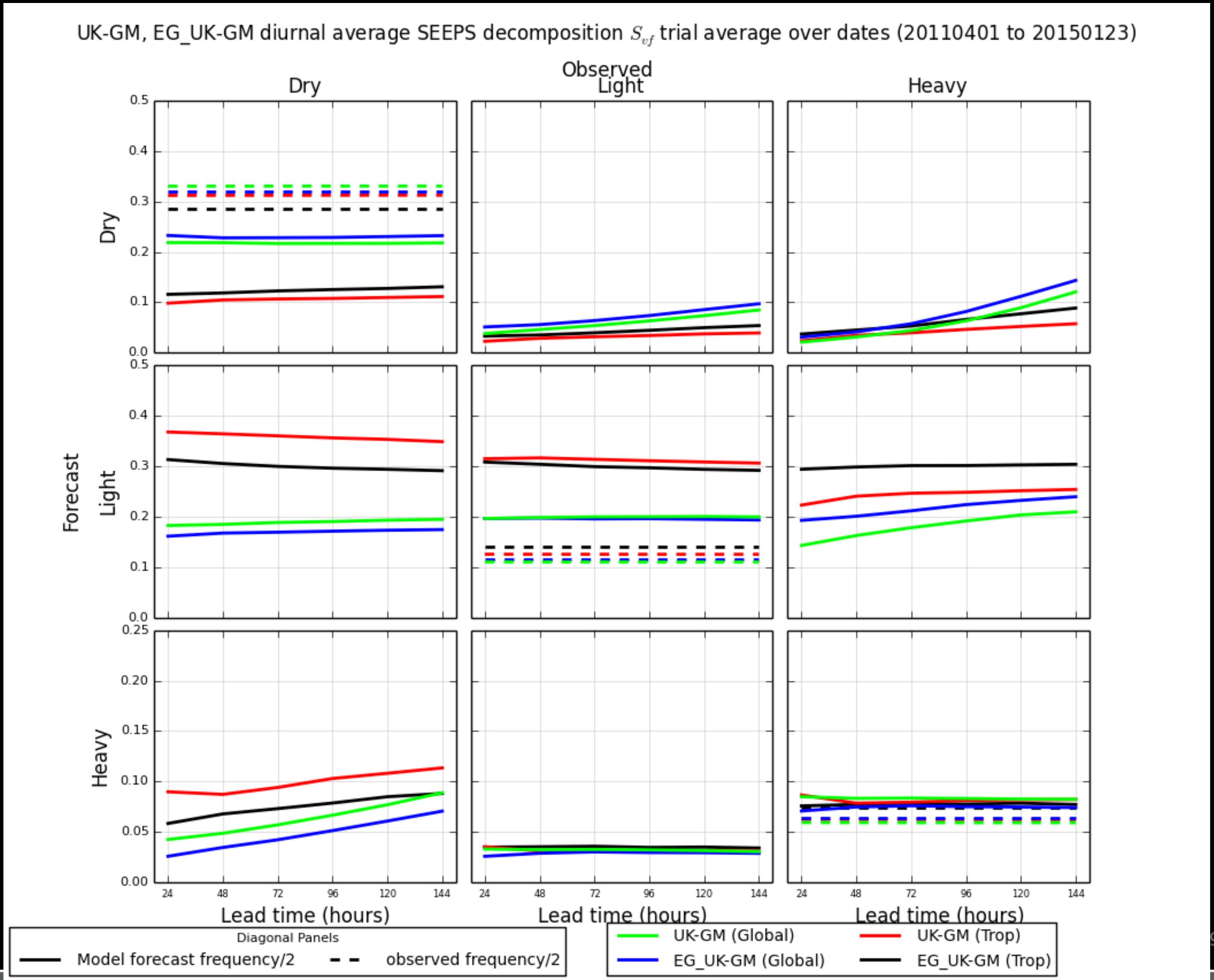
- Globally, model has useful skill
- SEEPS shows model has almost 3x skill globally than in the Tropics.
- Latest UM upgrades initial signs of improvement over the Tropics
- Tropics errors are almost constant with forecast lead time

Verification of QPF using SEEPS

Decomposition into constituent error sources

Diurnal Average 2011-2015

24-hour totals

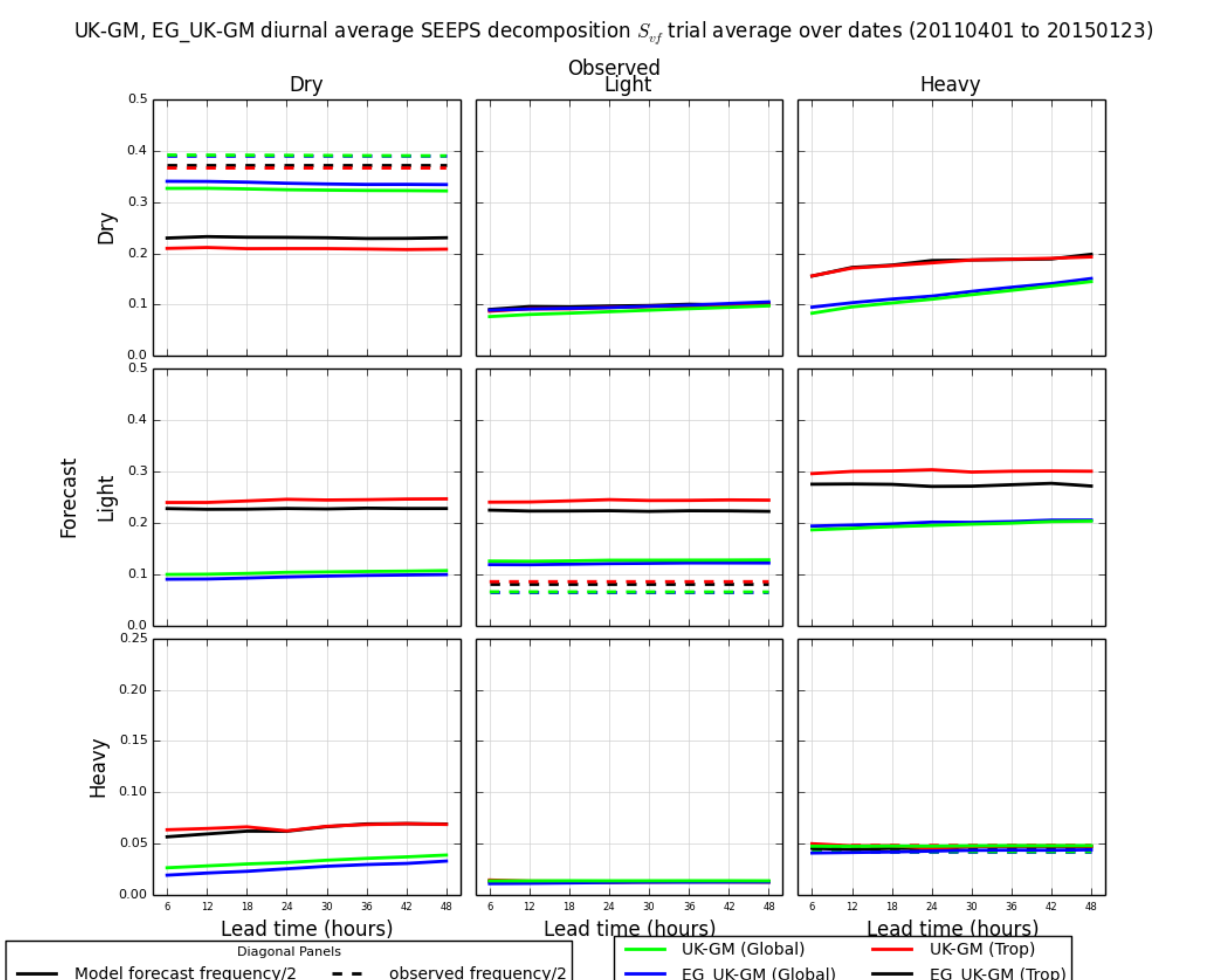


Verification of QPF using SEEPS

Decomposition into constituent error sources

Diurnal
Average
2011-2015

6-hour
totals



Verification of QPF using SEEPS

Decomposition into constituent error sources

- Source contributing most to SEEPS score from 24-h accumulations is the observed dry/forecast light error category.
- 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

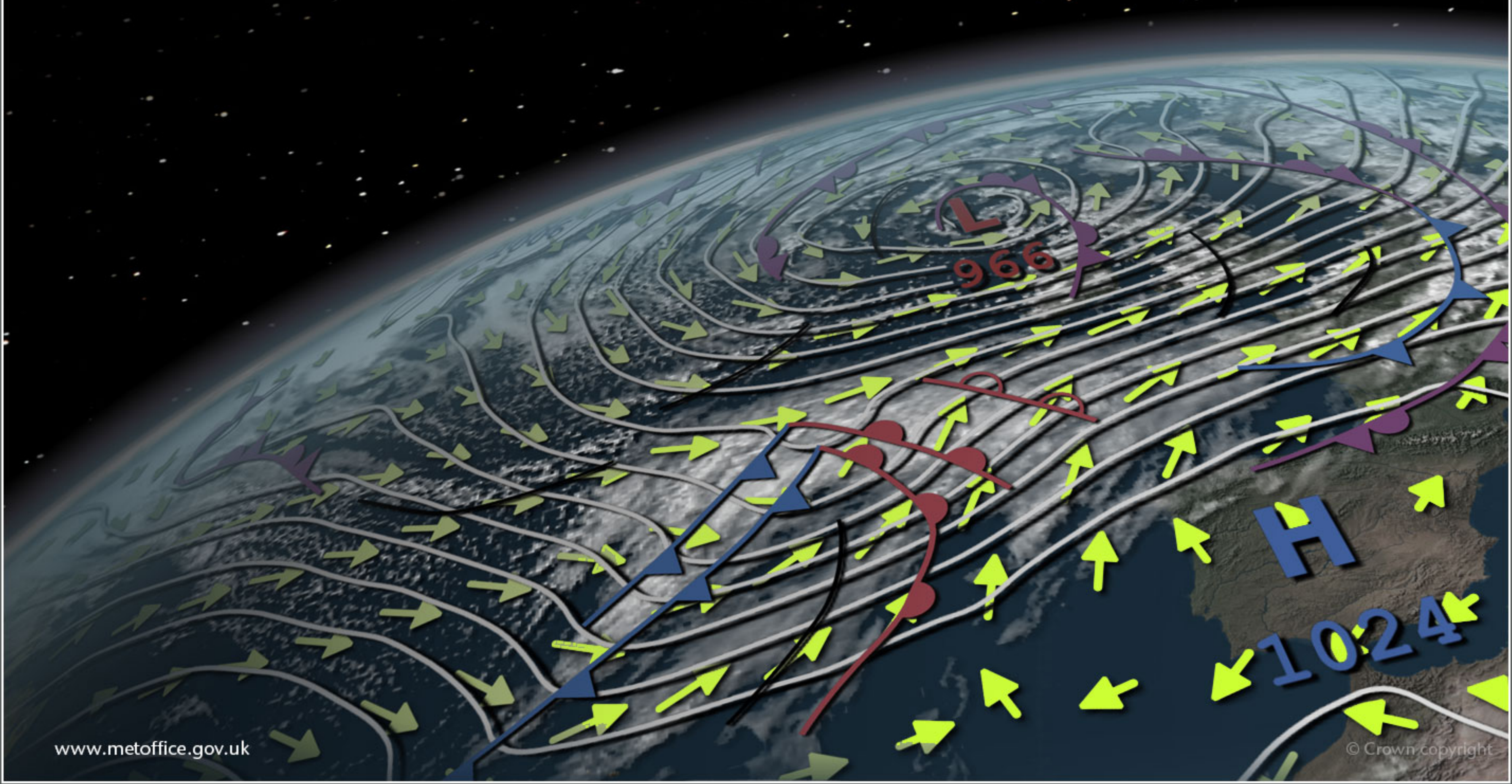
Decomposition into constituent error sources

- UM GA6 currently 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.

Regional model precipitation verification

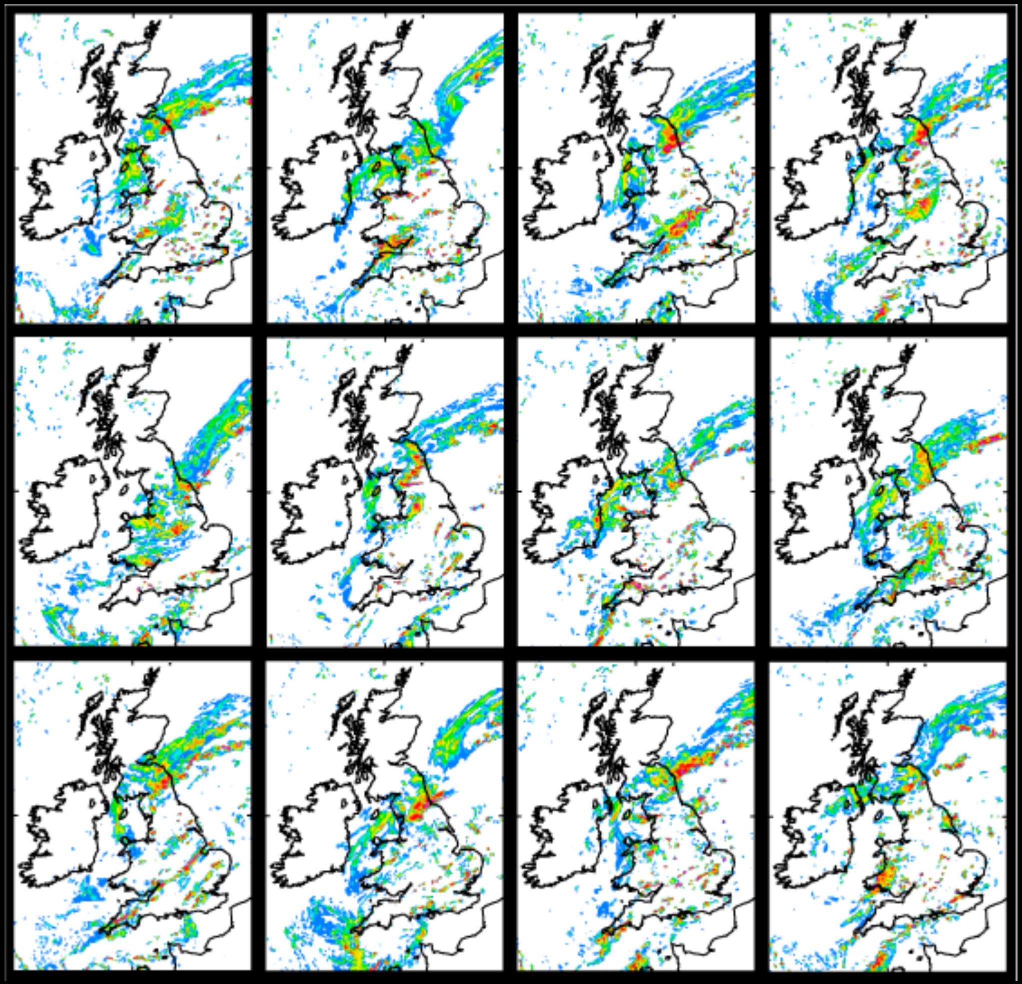


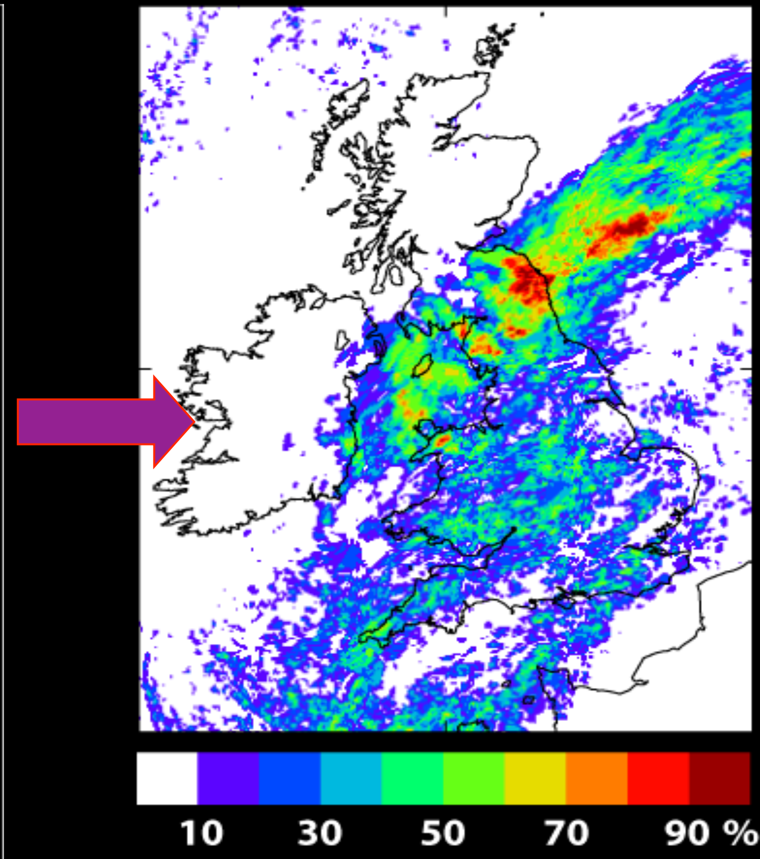
Regional model precipitation verification

Area of active research

Exploring use of neighbourhood processing for probabilistic prediction

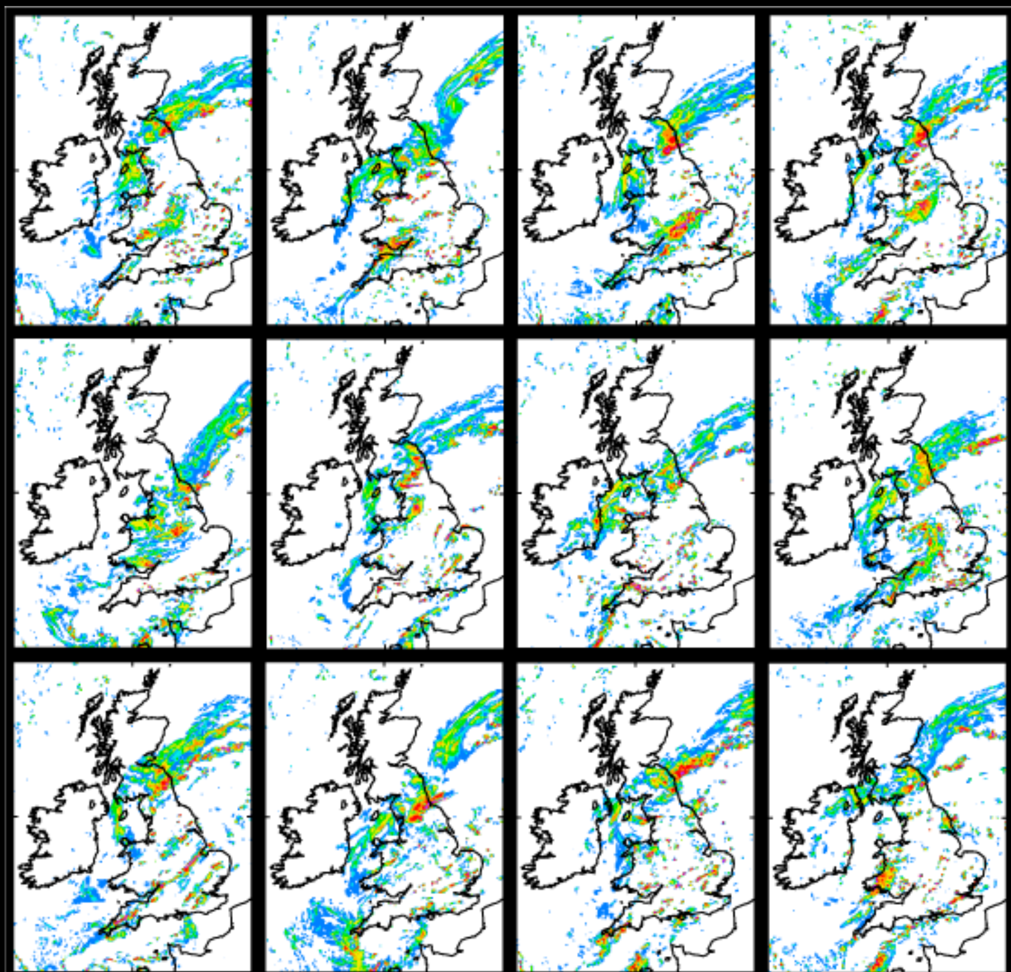
MOGREPS-UK
2.2km ensemble

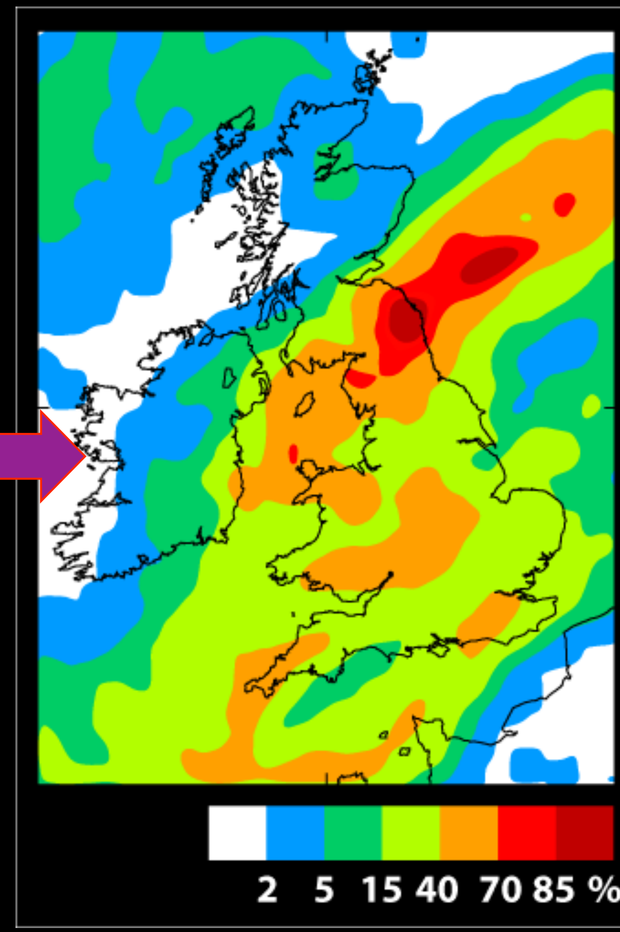




Undersampling leaves "holes" of zero-probability where showers could still occur

MOGREPS-UK … with Neighbourhood processing





Holes filled in

Conclusions and Perspectives

More contributions from centres compared with WGNE29

QPF verification of global models with high resolution national observation network is extremely useful:

- results should be ideally available on Web site (password if necessary)
- extend comparison to more models, when possible
- increase forecast data resolution in time (at least 6h) and space

Progressive adoption of suggested methods for the verification of precipitation forecasts against high resolution limited area observations (JWGFVR, Nov 2013):

- should be pursued in each centres,
- generalize the use of confidence intervals on aggregate verification
- still a lot to do for EPS verification