7IVMW Project 2:

The Great Africas Cup: Verification of ECMWF and MOGREPS ensemble forecasts for East Africa

Luxi Jin, *Humbolt Univeristy of Berlin, Germany*
Ana Mihalovic, *RHMSS of Serbia*
Dr. Jianhua Dai, *Shanghai Meteorological Service of China*
Dr. Nsadisa Faka, *Southern African Development Community Climate Service Centre, Botswana*

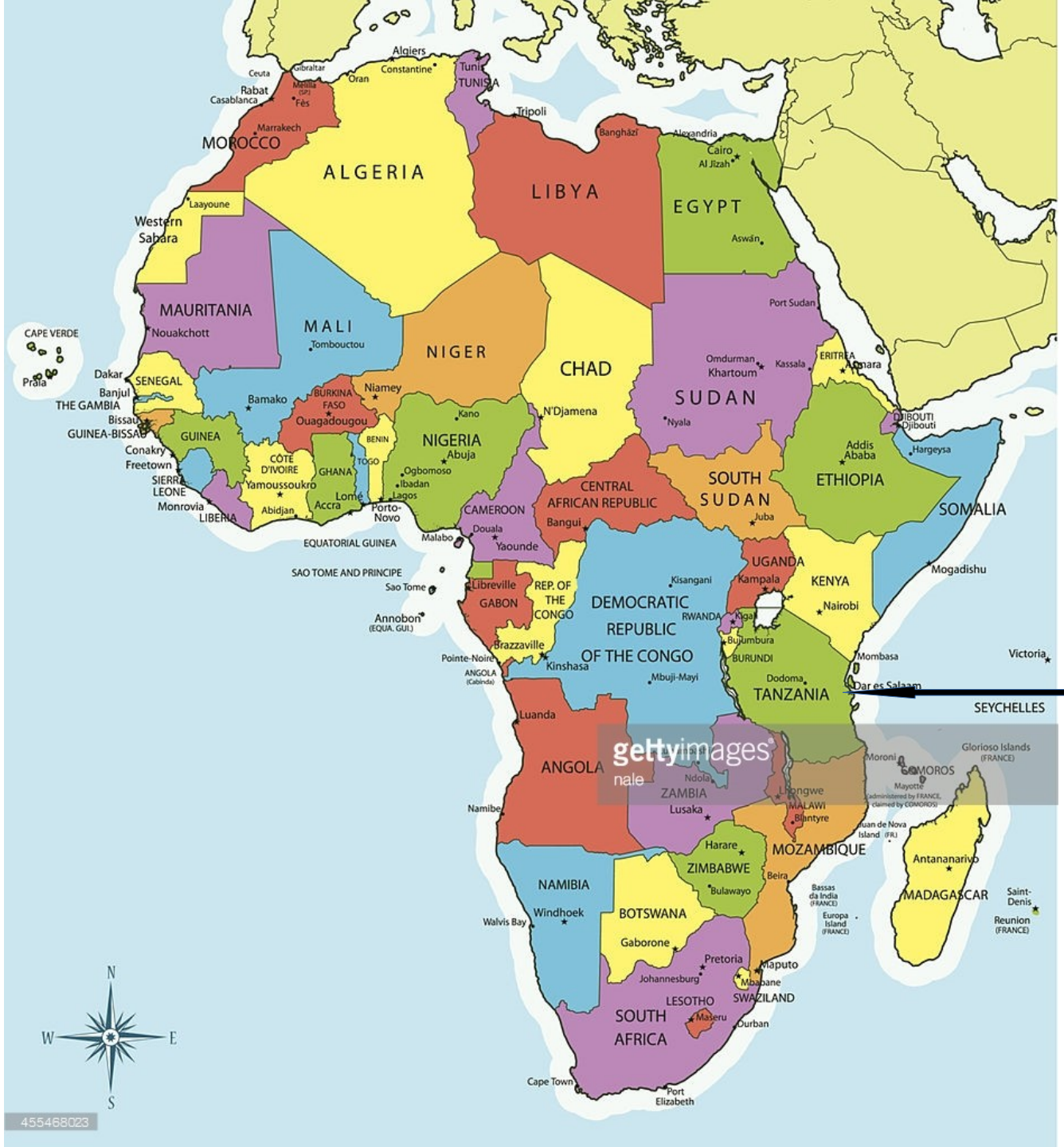
2017.05.10

Introduction

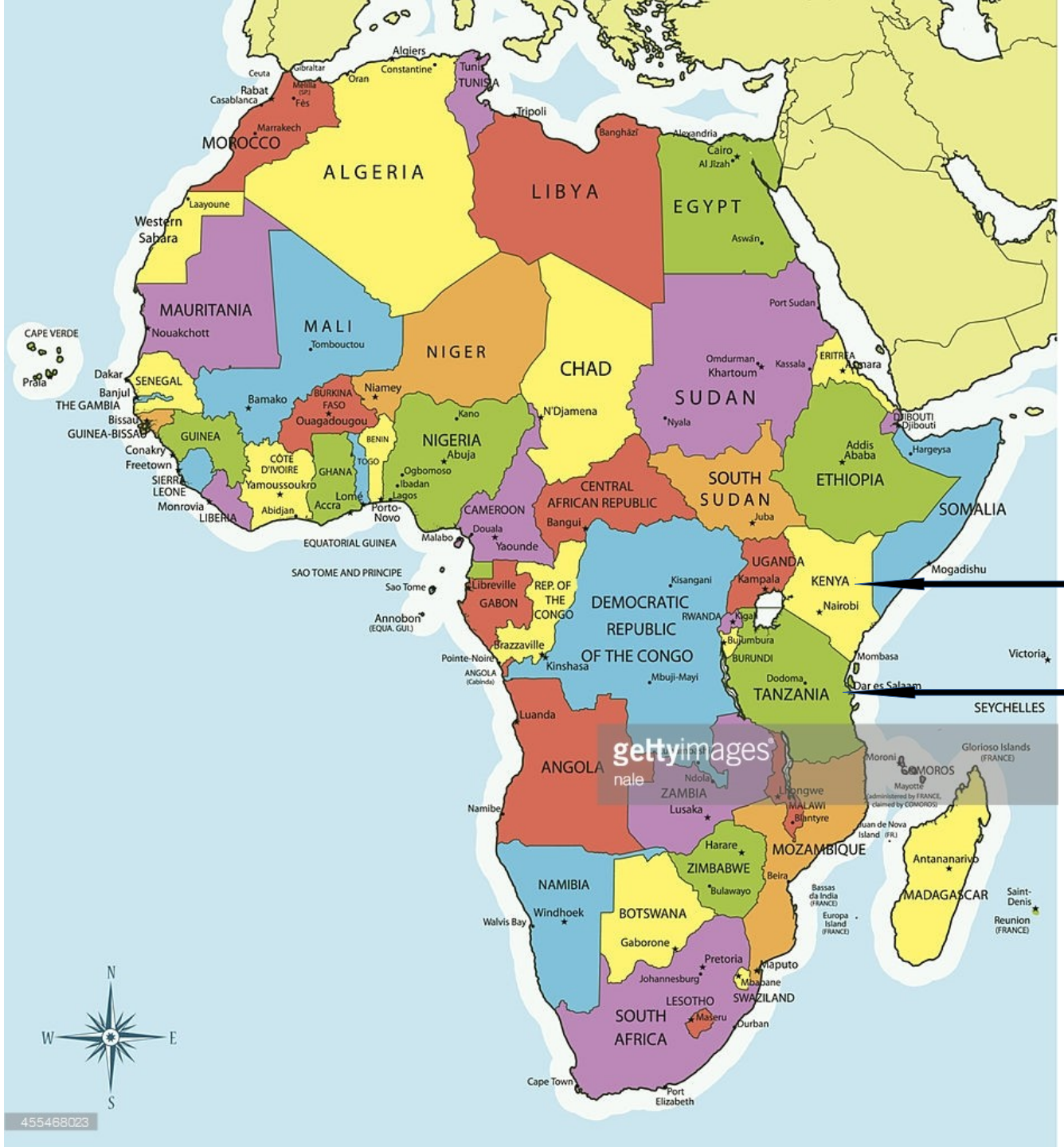
- Parameter: precipitation
- Period: one rain season (8 months) in 2010/11
- Location: Eastern Africa
- Datasets: ECMWF (50 member EPS)

  MOGREPS (UK 24 member EPS)

  OBS (50 Stations, mostly in Tanzania, Kenya and Uganda, not homogeneous)

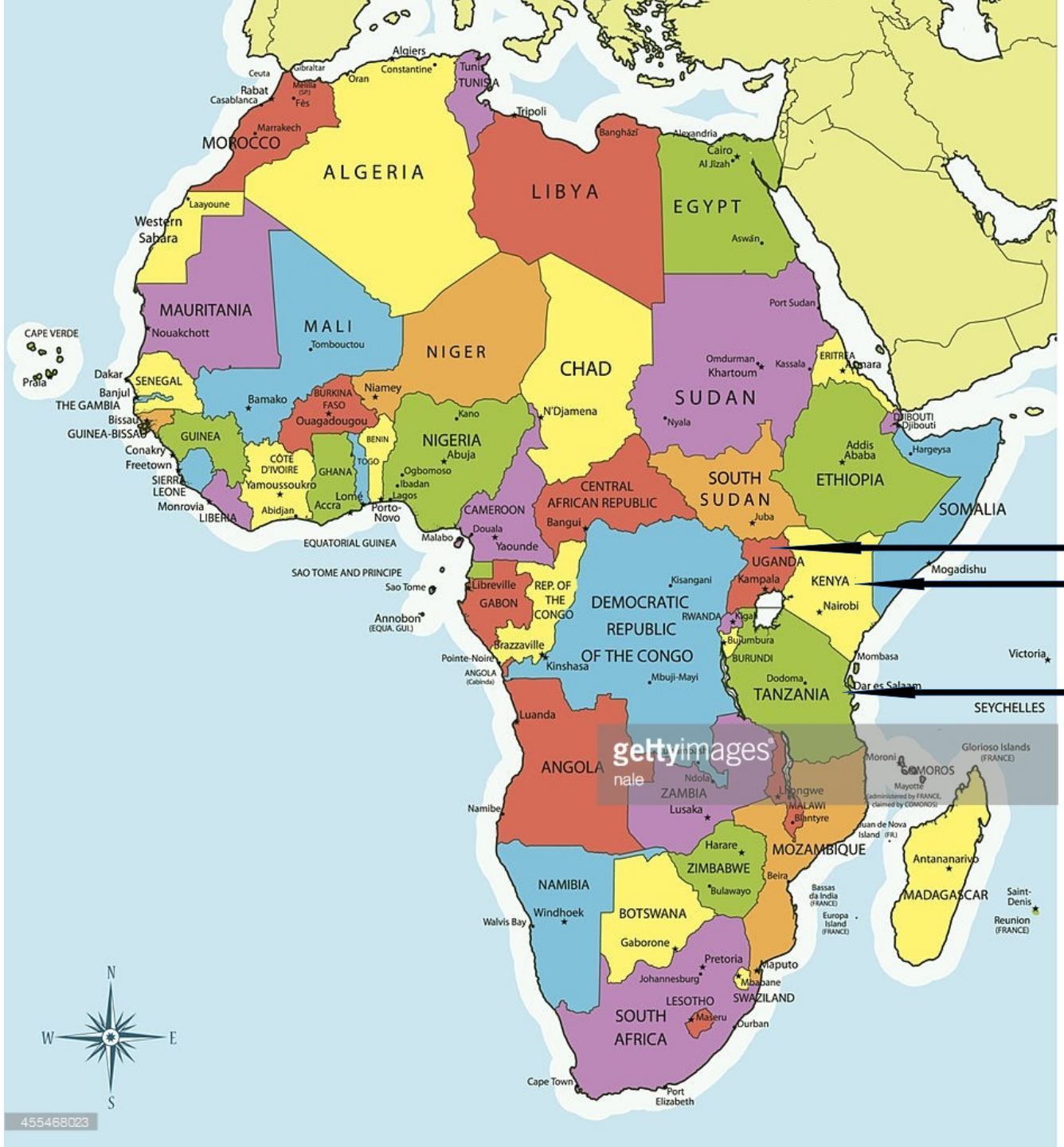

Algiers
Constantine
Oran
Ceuta
Gibraltar
Rabat
Casablanca
Fès
Marrakech
MOROCCO
ALGERIA
TUNISIA
Tripoli
Banghāzī
LIBYA
Alexandria
Cairo
Al Jizah
EGYPT
Aswān
Laayoune
Western Sahara
MAURITANIA
Nouakchott
MALI
Tombouctou
NIGER
CHAD
Port Sudan
Omdurman
Khartoum
Kassala
ERITREA
Asmara
SUDAN
Nyala
CAPE VERDE
Praia
Dakar
SENEGAL
Banjul
THE GAMBIA
Bissau
GUINEA-BISSAU
Bamako
BURKINA FASO
Ouagadougou
Niamey
Kano
N'Djamena
GUINEA
Conakry
Freetown
SIERRA LEONE
Monrovia
LIBERIA
CÔTE D'IVOIRE
Yamoussoukro
Abidjan
GHANA
Accra
Lomé
TOGO
BENIN
Porto-Novo
NIGERIA
Abuja
Ogbomoso
Ibadan
Lagos
CAMEROON
Douala
Malabo
EQUATORIAL GUINEA
Yaounde
CENTRAL AFRICAN REPUBLIC
Bangui
SOUTH SUDAN
Juba
DJIBOUTI
Djibouti
Addis Ababa
ETHIOPIA
Hargeysa
SOMALIA
Mogadishu
SAO TOME AND PRINCIPE
Sao Tome
Libreville
GABON
REP. OF THE CONGO
Brazzaville
Pointe-Noire
ANGOLA
(Cabinda)
Annobon
(EQUA. GUI.)
DEMOCRATIC REPUBLIC OF THE CONGO
Kisangani
Kinshasa
Mbuji-Mayi
RWANDA
Kigali
BURUNDI
Bujumbura
UGANDA
Kampala
KENYA
Nairobi
Mombasa
Victoria
Dodoma
Dar es Salaam
TANZANIA
SEYCHELLES
Luanda
ANGOLA
Namibe
Ndola
ZAMBIA
Lusaka
Livingstone
MALAWI
Blantyre
Moroni
COMOROS
Mayotte
(administered by FRANCE, claimed by COMOROS)
Glorioso Islands
(FRANCE)
Juan de Nova Island (FR.)
MOZAMBIQUE
Harare
ZIMBABWE
Beira
Bulawayo
Bassas da India (FRANCE)
Europa Island (FRANCE)
Antananarivo
MADAGASCAR
Saint-Denis
Reunion
(FRANCE)
NAMIBIA
Windhoek
Walvis Bay
BOTSWANA
Gaborone
Pretoria
Johannesburg
Maputo
Mbabane
SWAZILAND
LESOTHO
Maseru
SOUTH AFRICA
Durban
Cape Town
Port Elizabeth
N
W
E
S
gettyimages
nale
455468023

Tanzania



Kenya

Tanzania



Uganda

Kenya

Tanzania

Introduction

- Parameter: precipitation
- Period: one rain season (8 months) in 2010/11
- Location: Eastern Africa
- Datasets: ECMWF (50 member EPS)

  MOGREPS (UK 24 member EPS)

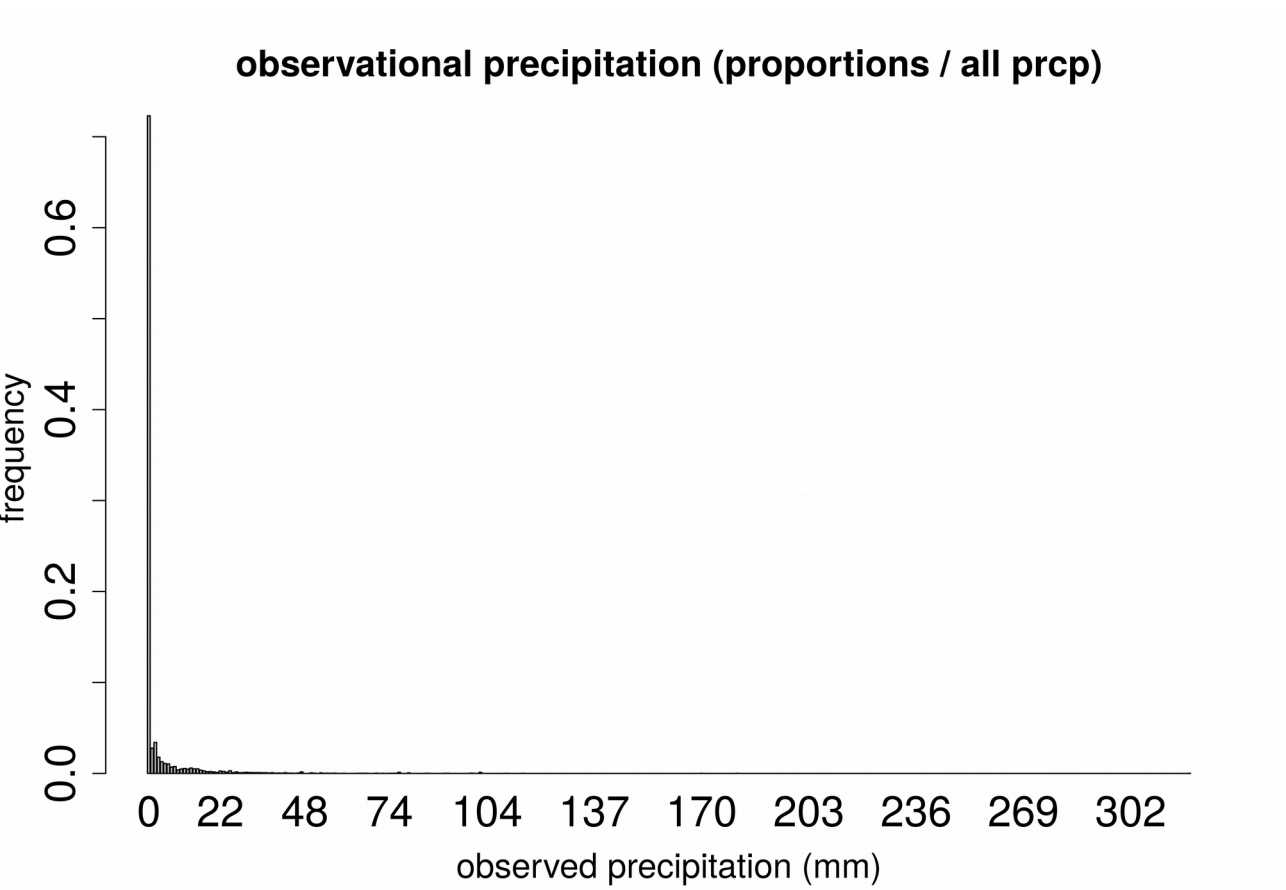
  OBS (50 Stations, mostly in Tanzania, Kenya and Uganda not homogenious)

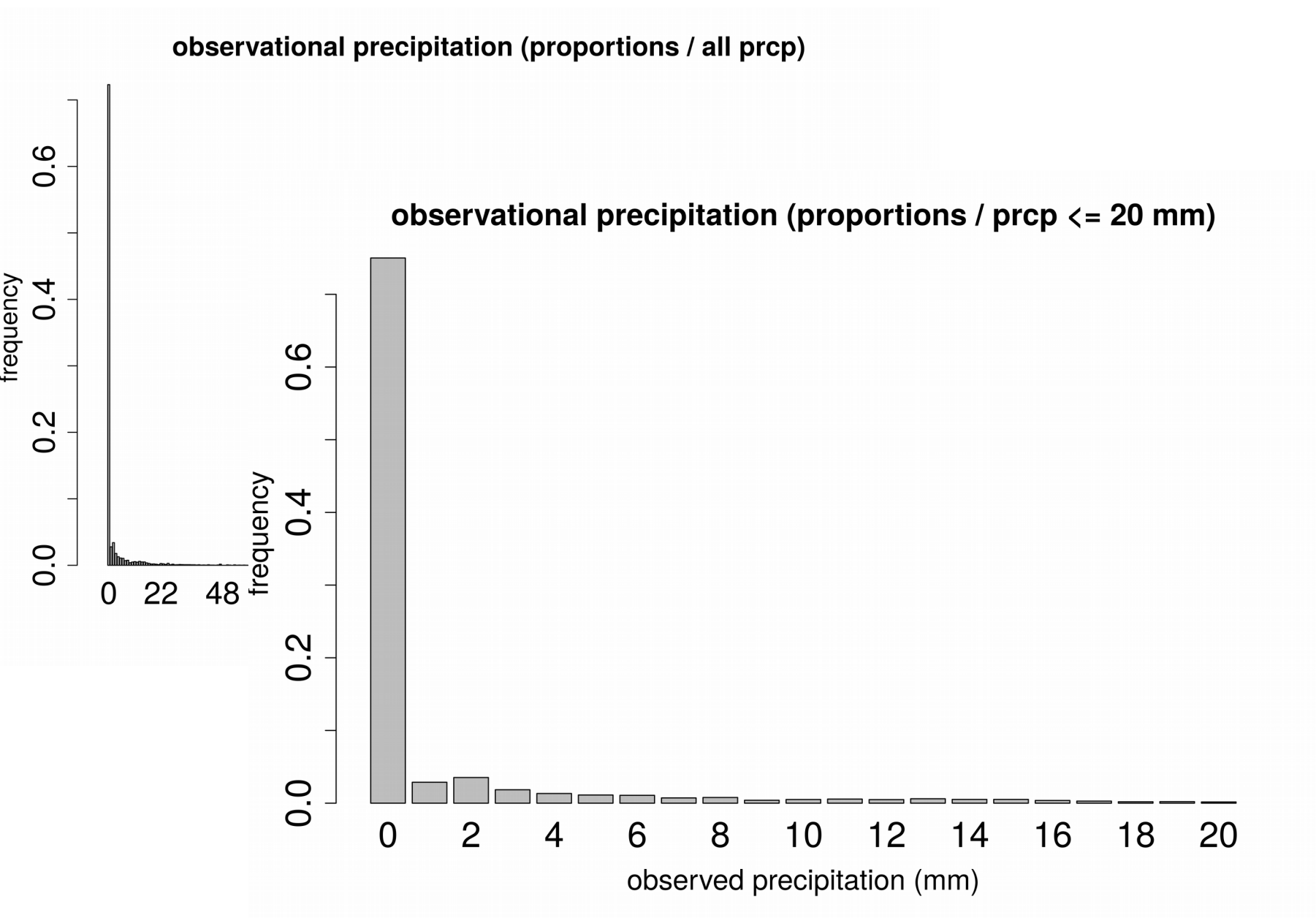
ECMWF vs MOGREPS

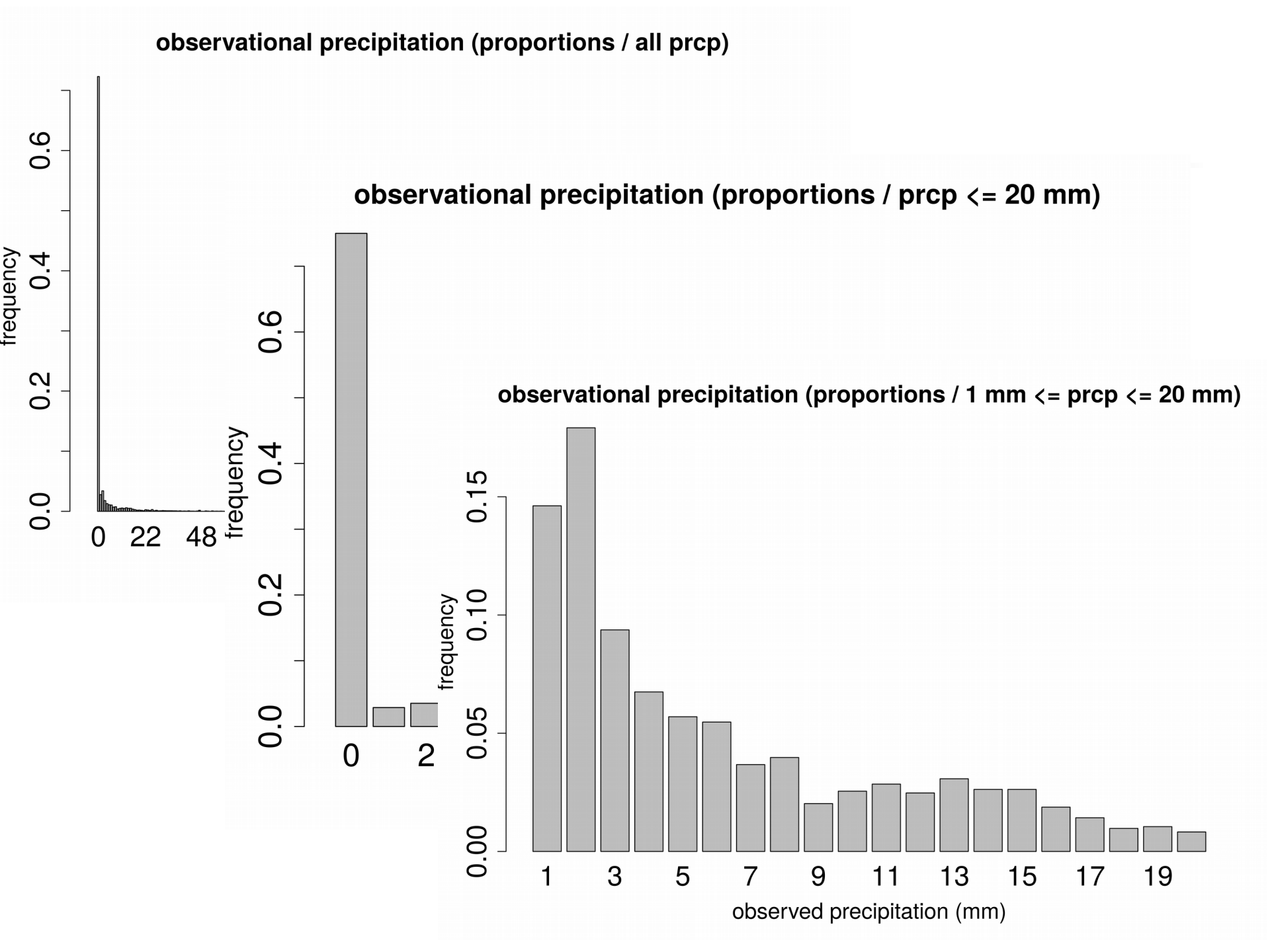
Which one is „better“ ?

Outlines

- How do our observations look like?
- Thresholds: $>$ 1mm/5 mm/10 mm/15 mm/20mm
- Verification methods:
  - Reliability diagram
  - Brier scores (benefits & obstacles)
  - ROC curve
- Conclusion


observational precipitation (proportions / all prcp)
frequency
0.0
0.2
0.4
0.6
0
22
48
74
104
137
170
203
236
269
302
observed precipitation (mm)


observational precipitation (proportions / all prcp)
frequency
0.0
0.2
0.4
0.6
0
22
48
observational precipitation (proportions / prcp <= 20 mm)
frequency
0.0
0.2
0.4
0.6
0
2
4
6
8
10
12
14
16
18
20
observed precipitation (mm)

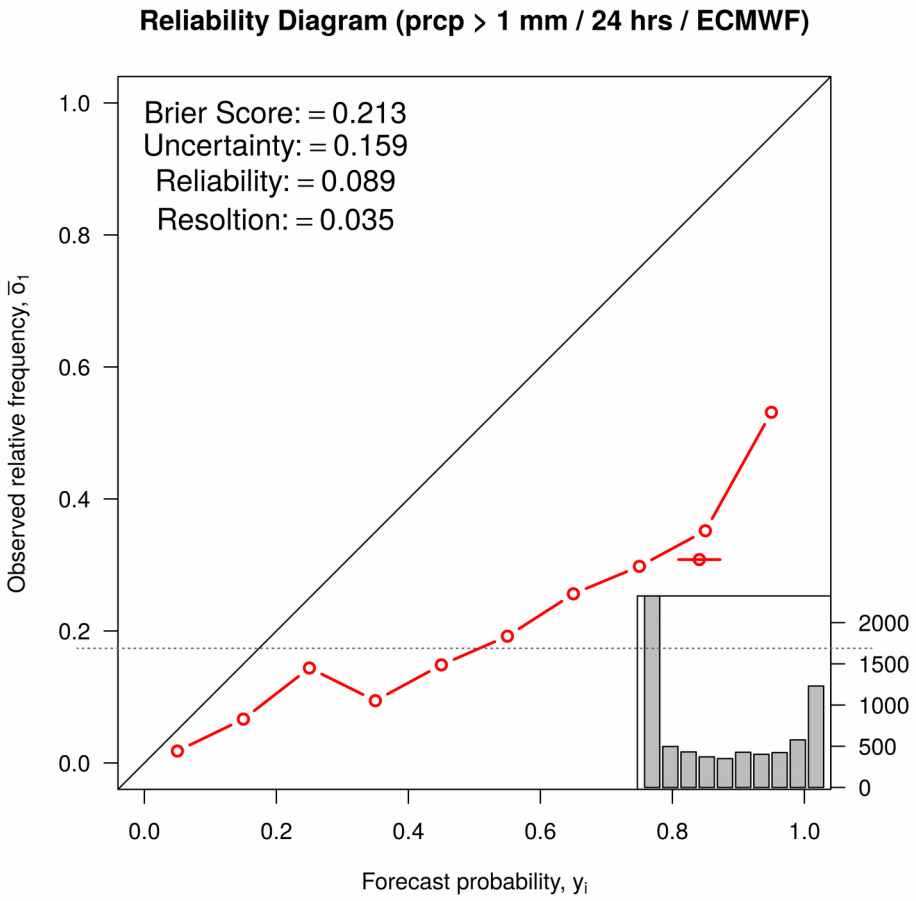

observational precipitation (proportions / all prcp)
frequency
0.0
0.2
0.4
0.6
0
22
48
observational precipitation (proportions / prcp <= 20 mm)
frequency
0.0
0.2
0.4
0.6
0
2
observational precipitation (proportions / 1 mm <= prcp <= 20 mm)
frequency
0.00
0.05
0.10
0.15
1
3
5
7
9
11
13
15
17
19
observed precipitation (mm)

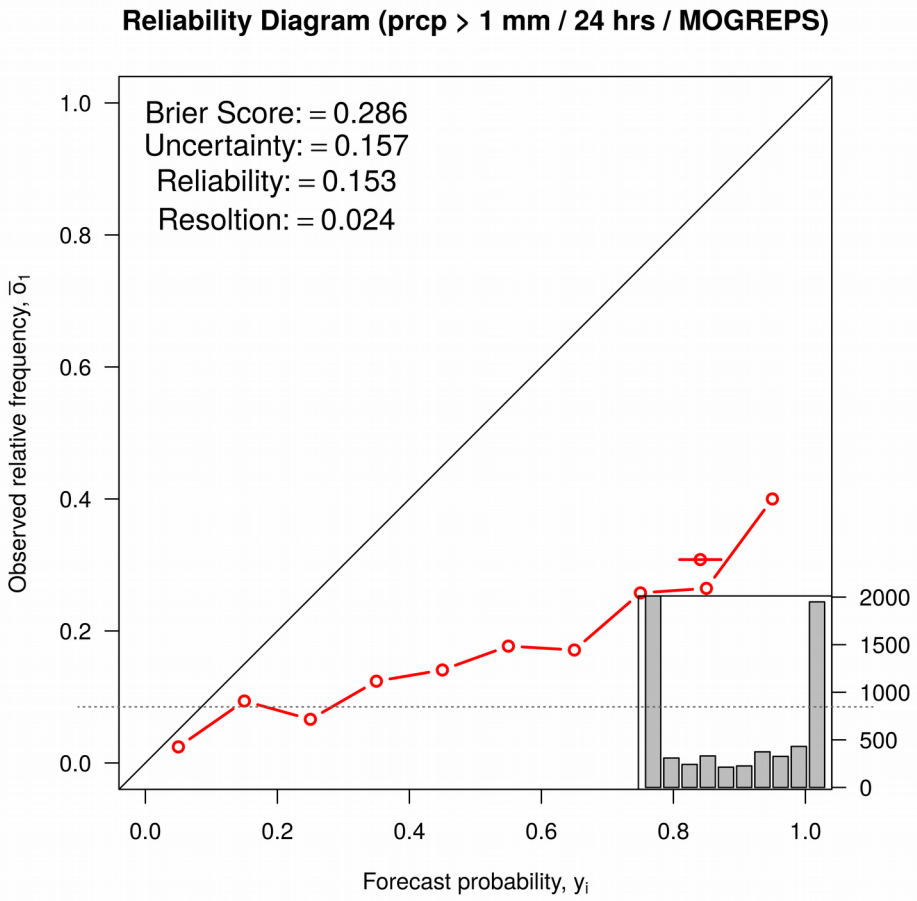
Outlines

- How do our observations look like?
- Thresholds: $>$ 1mm/2mm/.../20mm
- Verification methods:
  - Reliability diagram
  - Brier scores (benefits & obstacles)
  - ROC curve
- Conclusion

Outlines

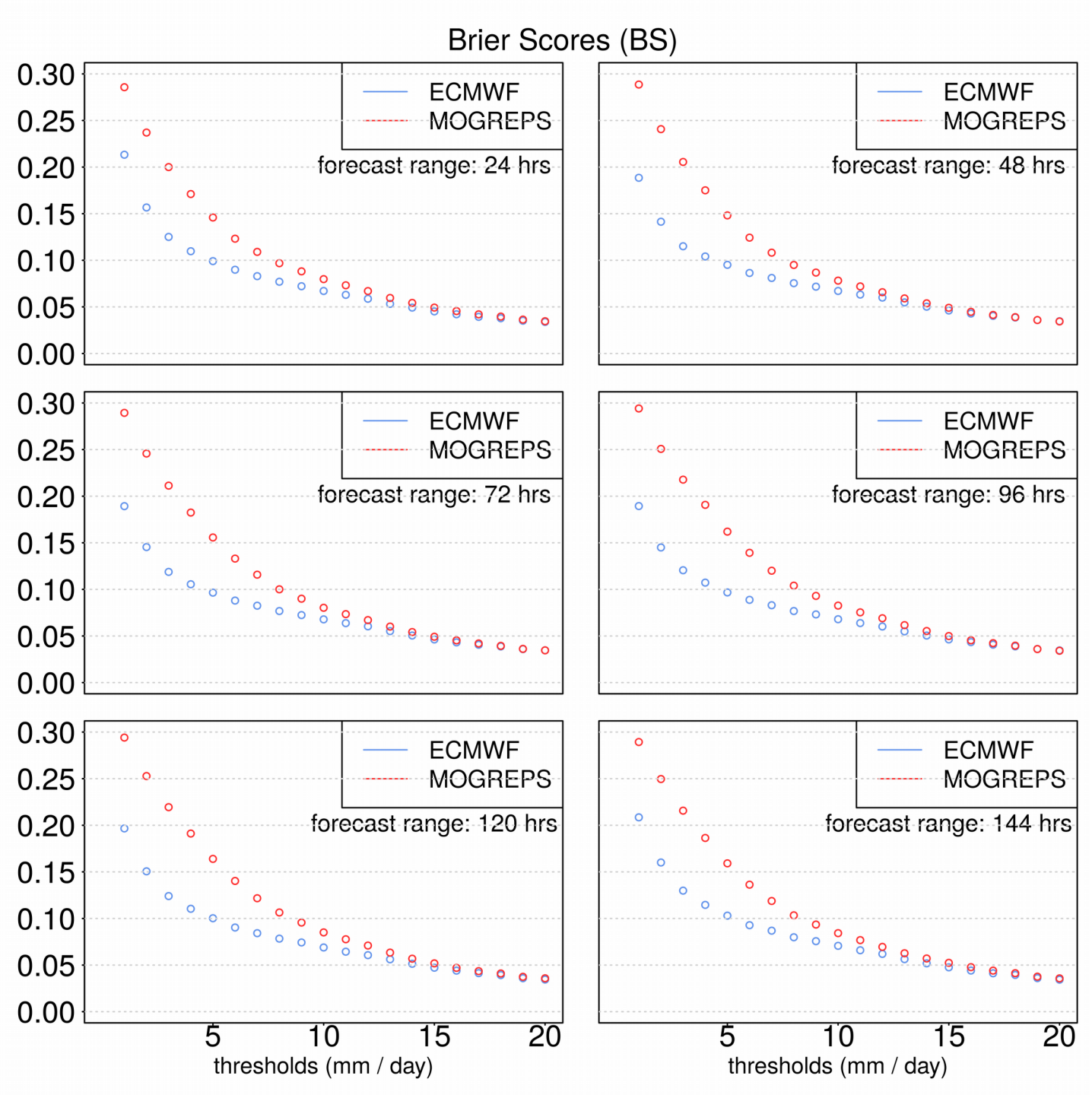
- How do our observations look like?
- Thresholds: $>$ 1mm/2mm/.../20mm
- Verification methods:
  - Reliability diagram
  - Brier scores (benefits & obstacles)
  - ROC curve
- Conclusion

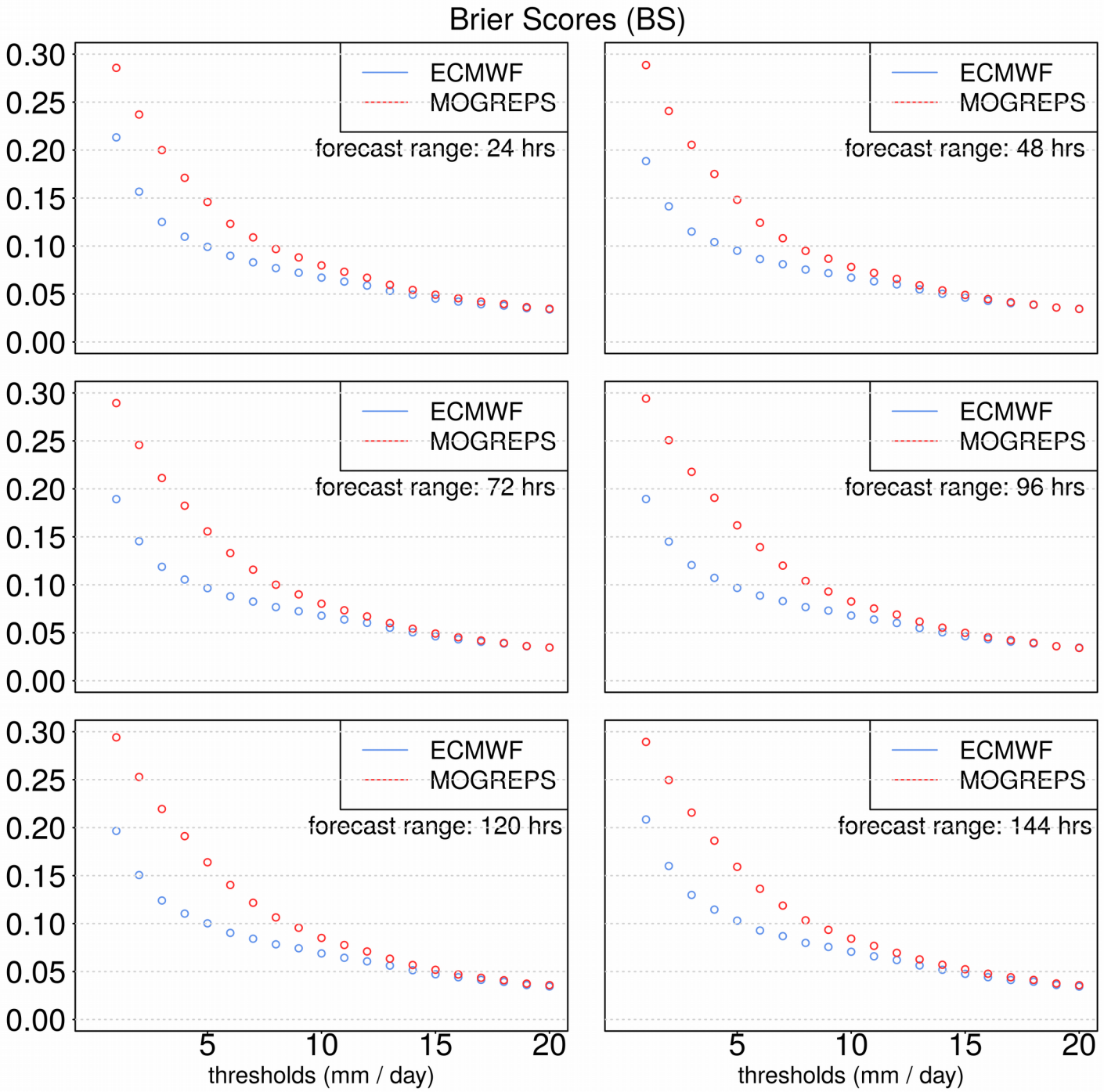

Reliability Diagram (prcp > 1 mm / 24 hrs / ECMWF)
Brier Score: = 0.213
Uncertainty: = 0.159
Reliability: = 0.089
Resoltion: = 0.035
Observed relative frequency, $\bar{o}_1$
Forecast probability, y_i
0.0
0.2
0.4
0.6
0.8
1.0
0
500
1000
1500
2000


Reliability Diagram (prcp > 1 mm / 24 hrs / MOGREPS)
Brier Score: = 0.286
Uncertainty: = 0.157
Reliability: = 0.153
Resoltion: = 0.024
Observed relative frequency, $\bar{o}_1$
Forecast probability, y_i
0.0
0.2
0.4
0.6
0.8
1.0
0
500
1000
1500
2000

Outlines

- How do our observations look like?
- Thresholds: $>$ 1mm/5 mm/10 mm/15 mm/20mm
- Verification methods:
  - Reliability diagram
  - Brier scores (benefits & obstacles)
  - ROC curve
- Conclusion


Brier Scores (BS)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
ECMWF
MOGREPS
forecast range: 24 hrs
forecast range: 48 hrs
forecast range: 72 hrs
forecast range: 96 hrs
forecast range: 120 hrs
forecast range: 144 hrs
5
10
15
20
thresholds (mm / day)

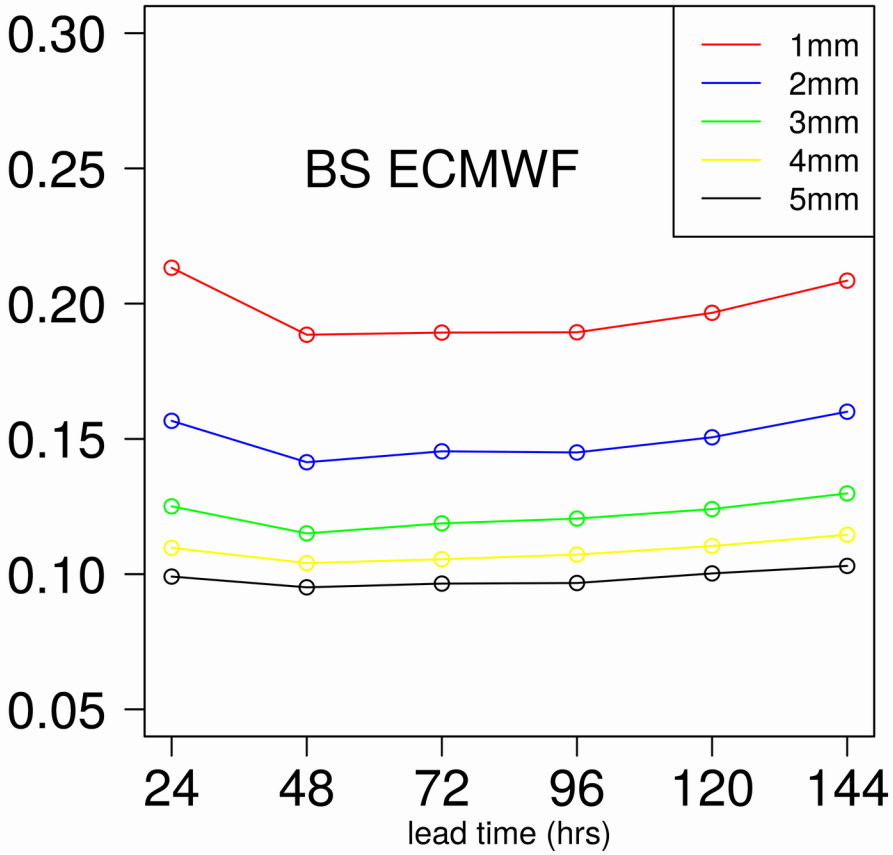


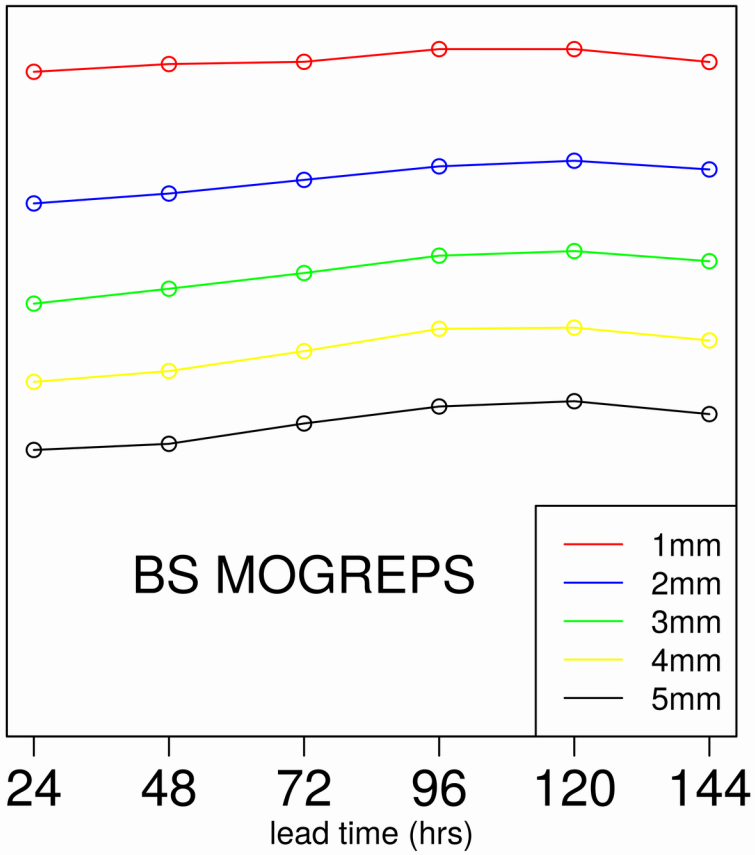
Good news:

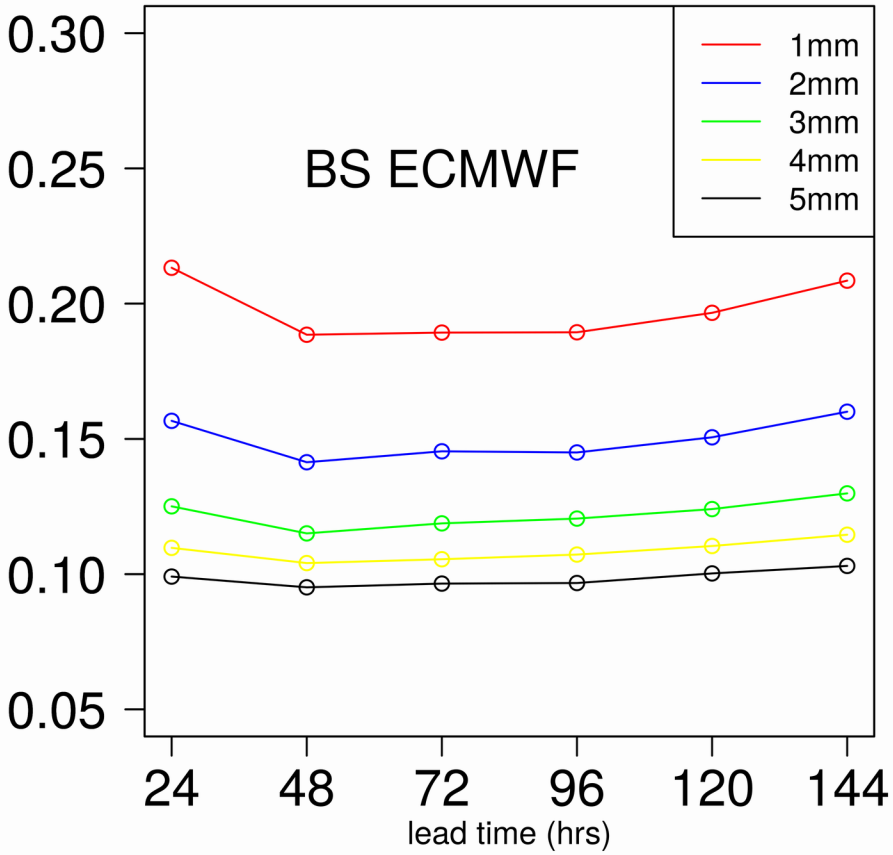
- distinguished model performance

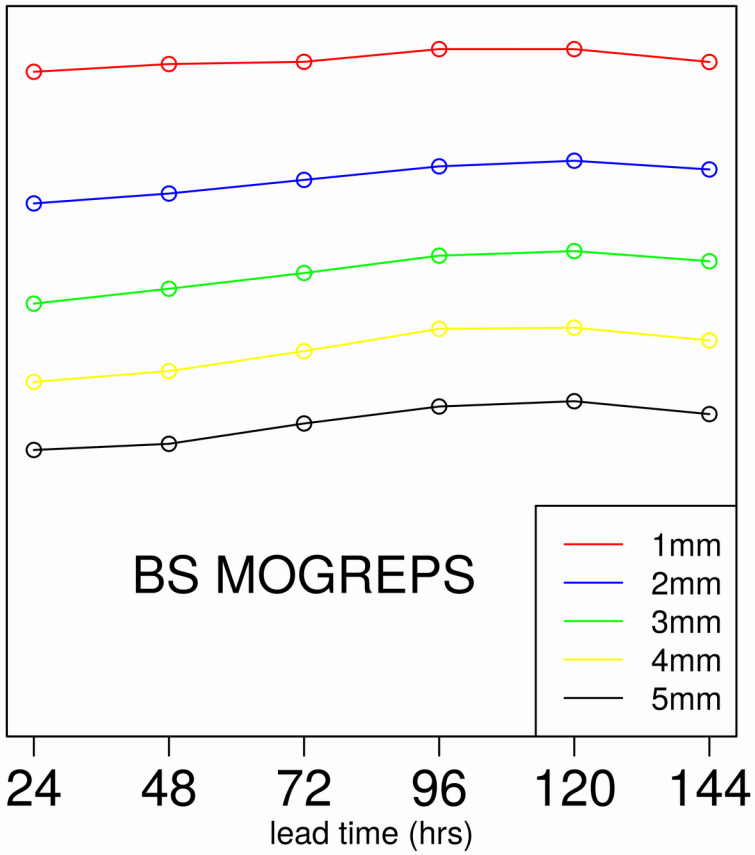
Bad news:

- diffrence in fc ranges not clear


BS ECMWF
1mm
2mm
3mm
4mm
5mm
0.30
0.25
0.20
0.15
0.10
0.05
24
48
72
96
120
144
lead time (hrs)


BS MOGREPS
1mm
2mm
3mm
4mm
5mm
24
48
72
96
120
144
lead time (hrs)





Possible explainations:

1) inhomogeneous OBS in space and time

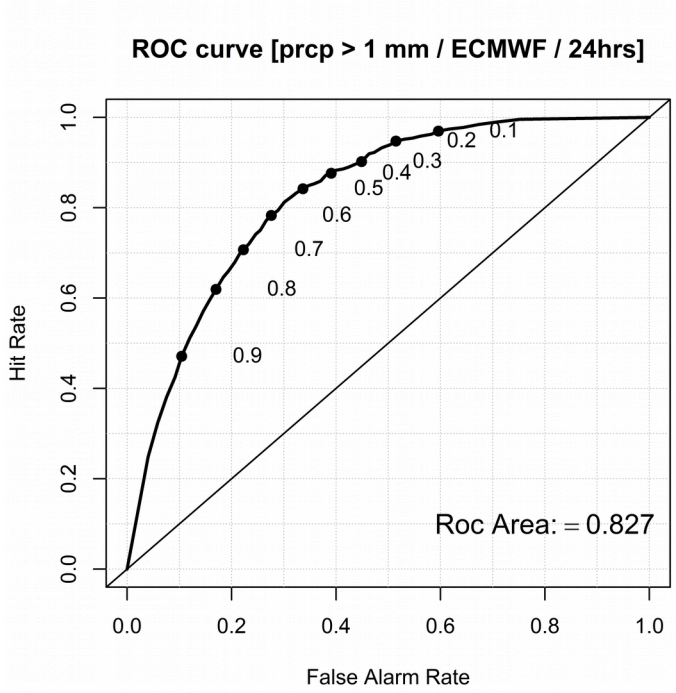
2) sample size (one rain season) not representative

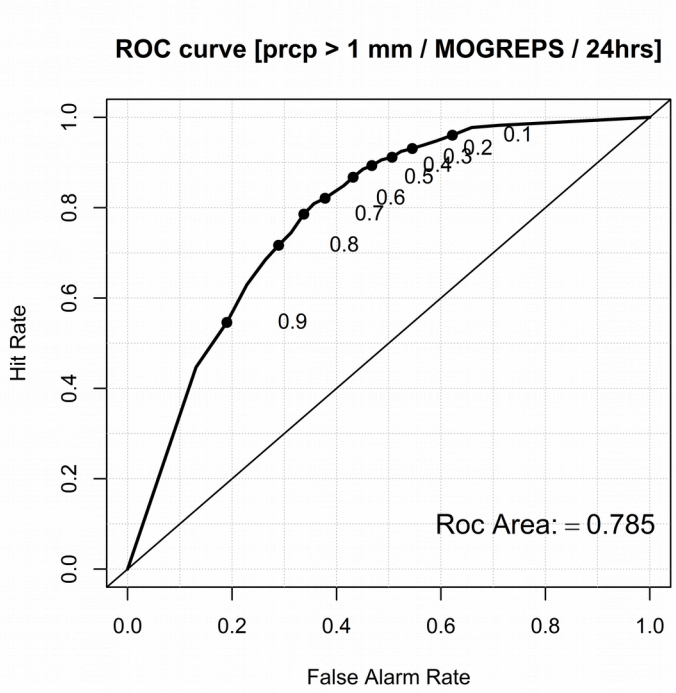
3) many non-precipiation cases (over 70%)

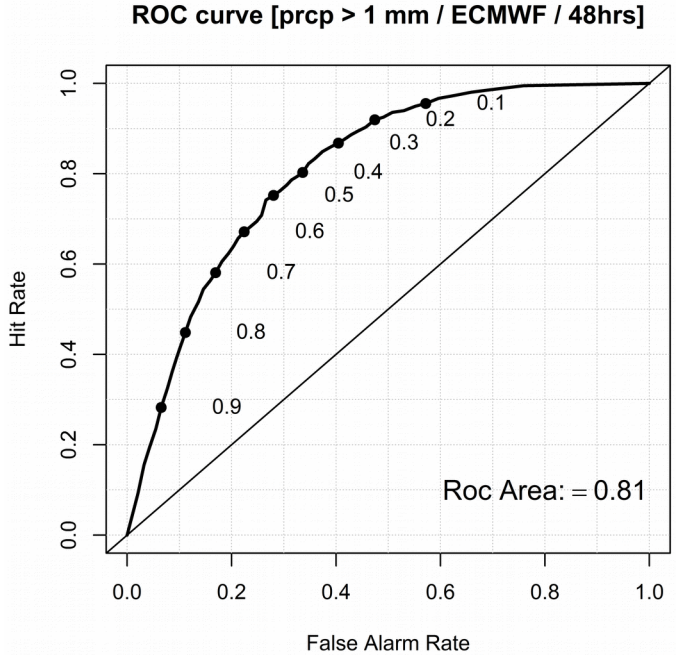
$$BS = \frac{1}{N}\sum_{t=1}^{N}(f_t - o_t)^2$$

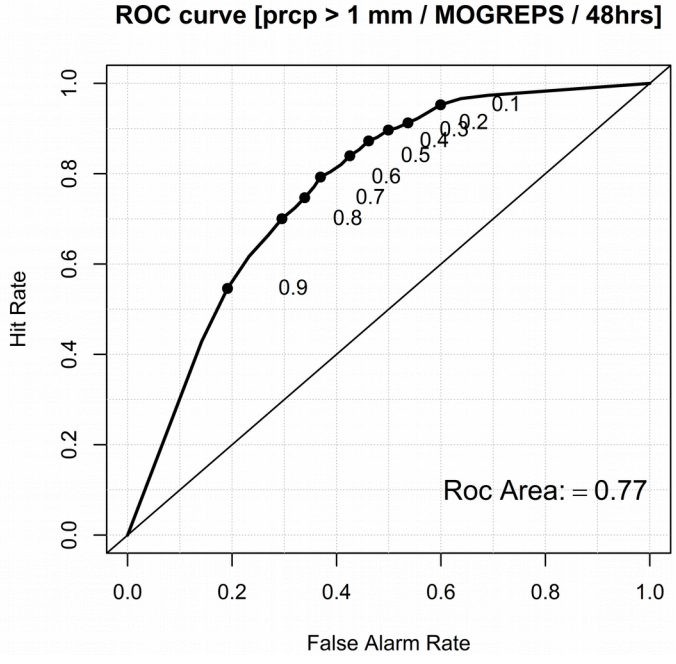
Outlines

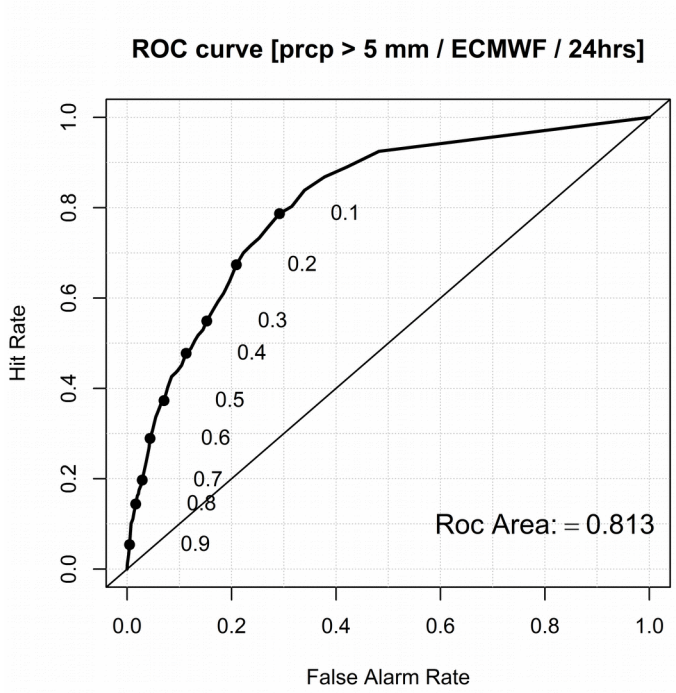
- How do our observations look like?
- Thresholds: $>$ 1mm/5 mm/10 mm/15 mm/20mm
- Verification methods:
  - Reliability diagram
  - Brier scores (benefits & obstacles)
  - ROC curve
- Conclusion

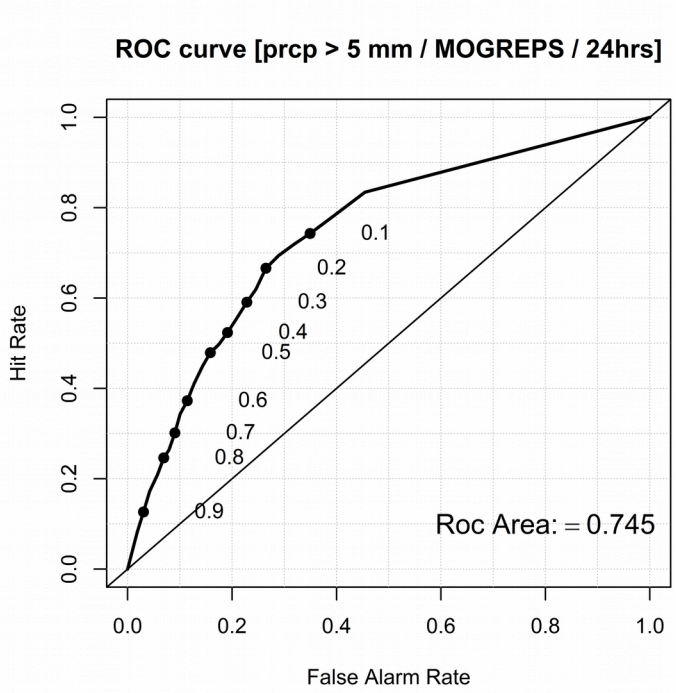

ROC curve [prcp > 1 mm / ECMWF / 24hrs]
Hit Rate
False Alarm Rate
0.0
0.2
0.4
0.6
0.8
1.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Roc Area: = 0.827

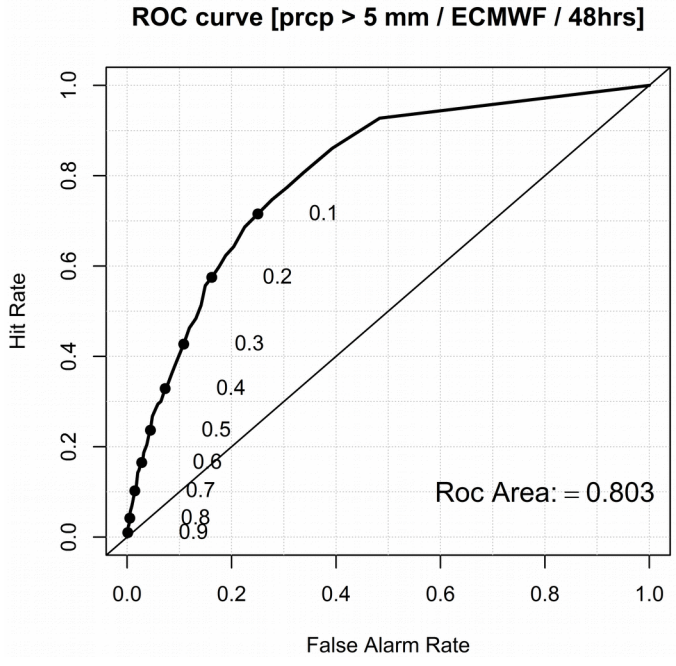

ROC curve [prcp > 1 mm / MOGREPS / 24hrs]
Hit Rate
False Alarm Rate
0.0
0.2
0.4
0.6
0.8
1.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Roc Area: = 0.785

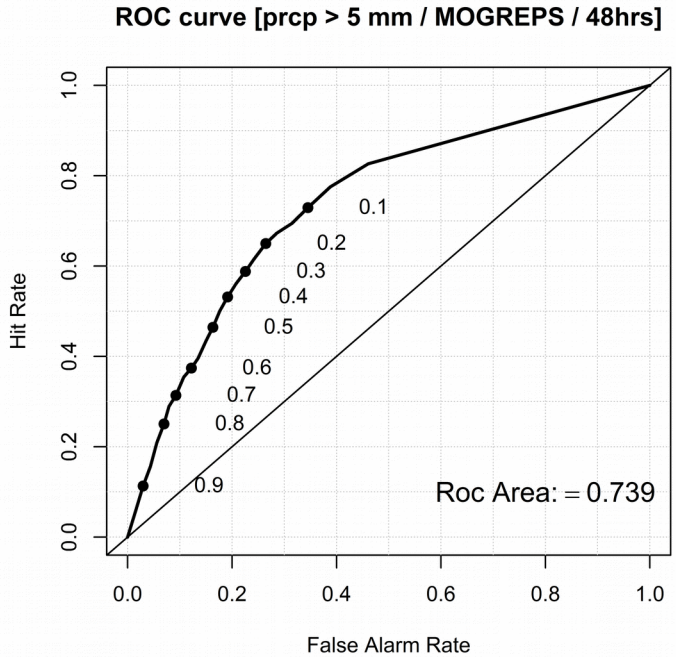

ROC curve [prcp > 1 mm / ECMWF / 48hrs]
Hit Rate
False Alarm Rate
0.0
0.2
0.4
0.6
0.8
1.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Roc Area: = 0.81


ROC curve [prcp > 1 mm / MOGREPS / 48hrs]
Hit Rate
False Alarm Rate
0.0
0.2
0.4
0.6
0.8
1.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Roc Area: = 0.77

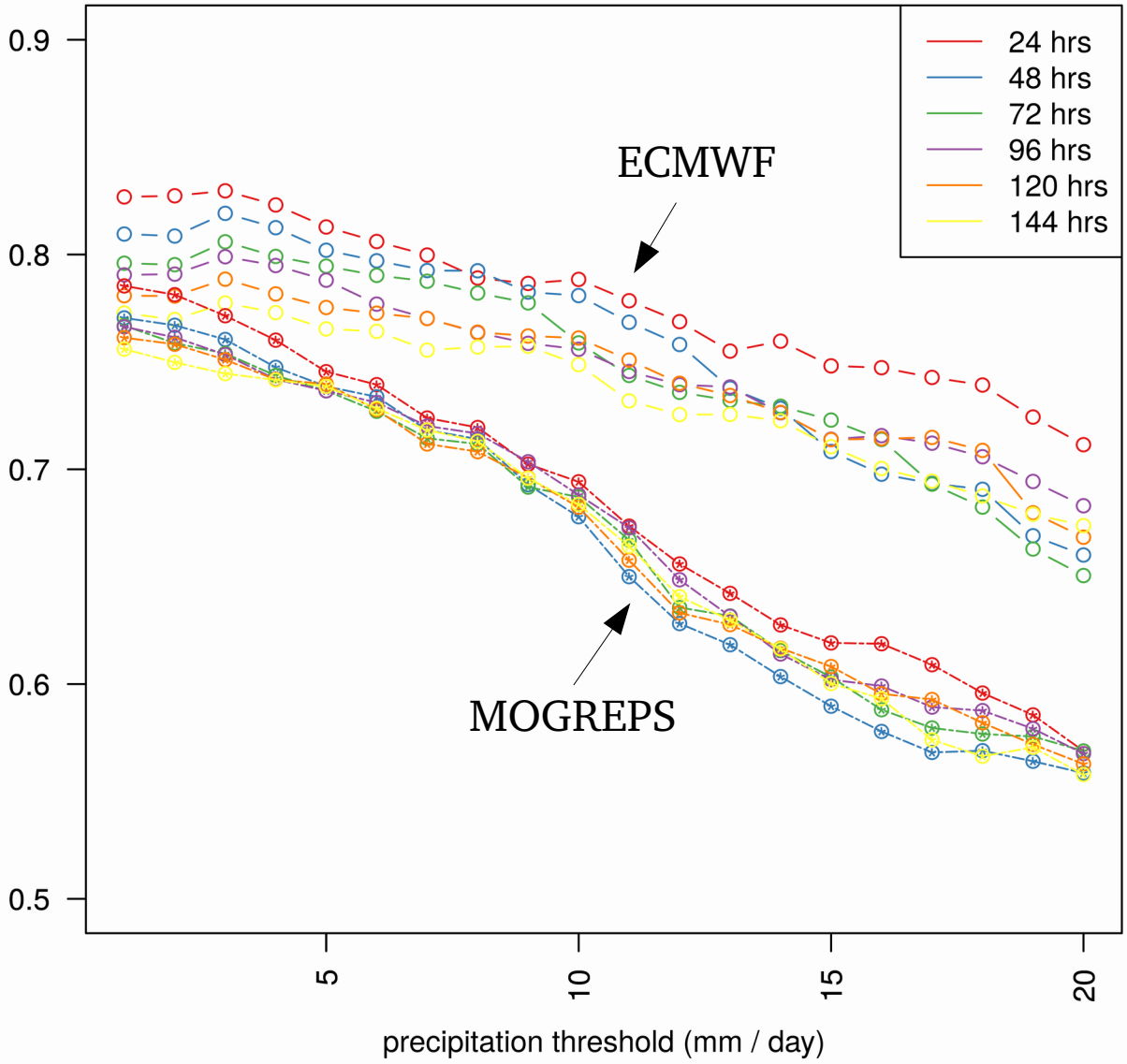

ROC curve [prcp > 5 mm / ECMWF / 24hrs]
Hit Rate
False Alarm Rate
0.0
0.2
0.4
0.6
0.8
1.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Roc Area: = 0.813


ROC curve [prcp > 5 mm / MOGREPS / 24hrs]
Hit Rate
False Alarm Rate
0.0
0.2
0.4
0.6
0.8
1.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Roc Area: = 0.745

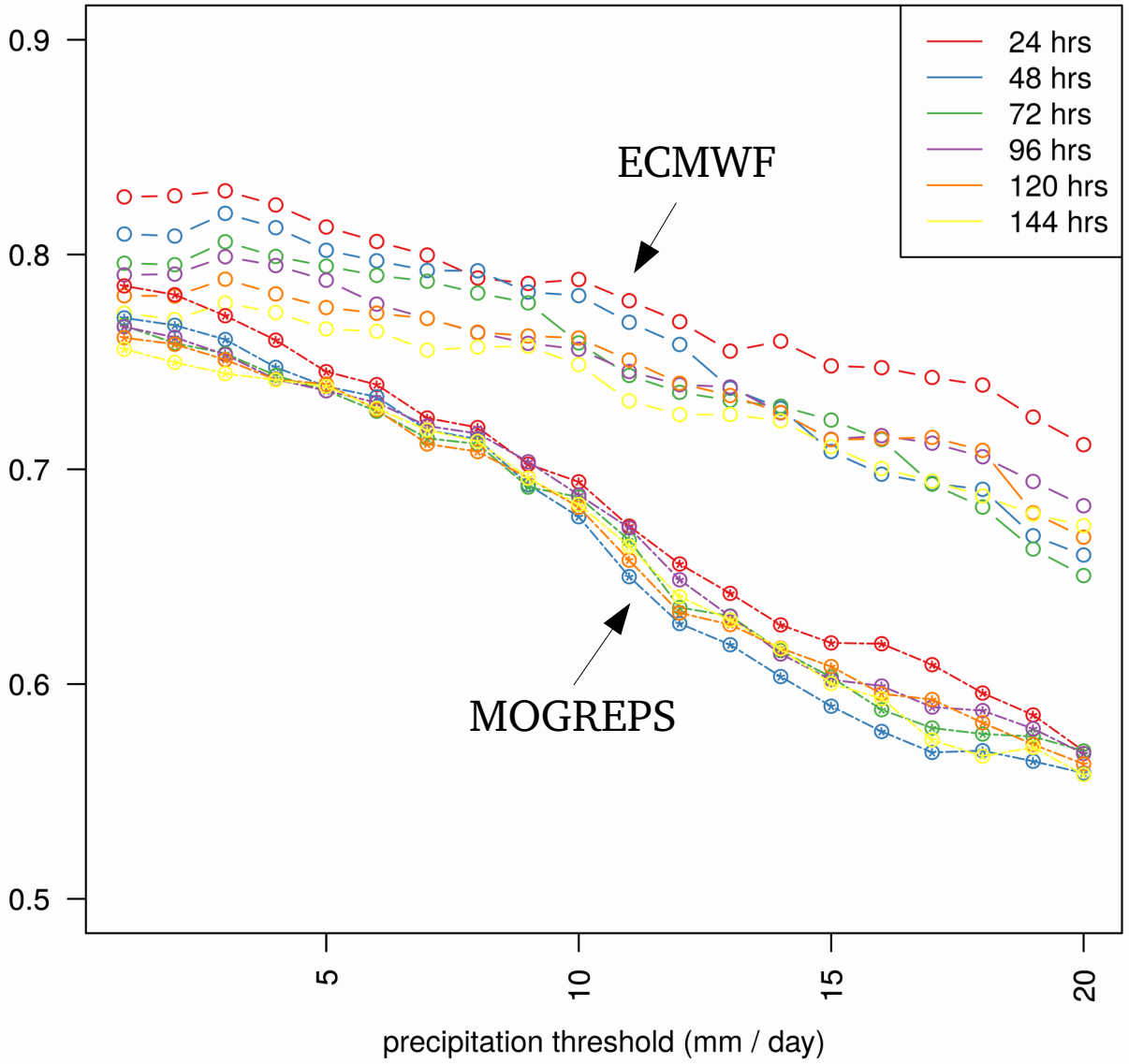

ROC curve [prcp > 5 mm / ECMWF / 48hrs]
Hit Rate
False Alarm Rate
0.0
0.2
0.4
0.6
0.8
1.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Roc Area: = 0.803


ROC curve [prcp > 5 mm / MOGREPS / 48hrs]
Hit Rate
False Alarm Rate
0.0
0.2
0.4
0.6
0.8
1.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Roc Area: = 0.739

ROC Area


0.9
0.8
0.7
0.6
0.5
5
10
15
20
precipitation threshold (mm / day)
24 hrs
48 hrs
72 hrs
96 hrs
120 hrs
144 hrs
ECMWF
MOGREPS

ROC Area



- ROC area decreases with lead time and threshold
- ROC area of MOGREPS differs more
- ECMWF has bigger ROC area in all cases

Outlines

- How do our observations look like?
- Thresholds: $>$ 1mm/5 mm/10 mm/15 mm/20mm
- Verification methods:
  - Reliability diagram
  - Brier scores (benefits & obstacles)
  - ROC curve
- Conclusion

  In this case, ECMWF shows better performance than MOGREPS

Outlines

- How do our observations look like?
- Thresholds: > 1mm/5 mm/10 mm/15 mm/20mm
- Verification methods:
  - Reliability diagram
  - Brier scores (benefits & obstacles)
  - ROC curve
- Conclusion

  In this case, ECMWF shows better performance than MOGREPS
- Outlook (not enough!)
  - More verification methods
  - More observations should be considered
- - Quality control for observations

Group members and Instructors

- Special thanks to

  Chiara Marsigli, Stephanie Landman, Laurie Wilson


Zur Bratpfanne
BLITZ

Discussion

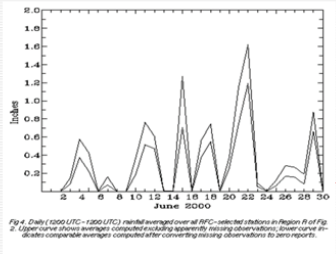
$$BS = \frac{1}{N}\sum_{t=1}^{N}(f_t - o_t)^2$$

In which, f_t is the probability that was forecast, o_t the actual outcome of the event at instance t (0 if it does not happen and 1 if it does happen) and N is the number of forecasting instances. In effect, it is the mean squared error of the forecast. This formulation is mostly used for binary events (for example
"rain" or "no rain"). The above equation is a proper scoring rule only for binary events; if a multi-category forecast is to be evaluated, then the original definition given by Brier below should be used.

- ot is the true observation of probability?

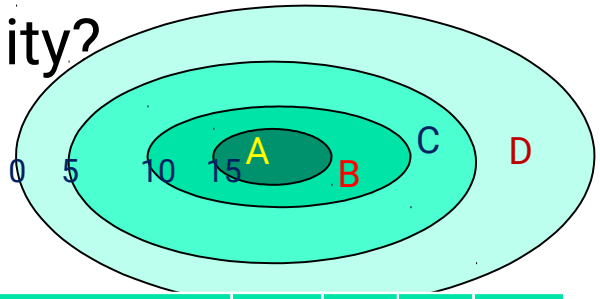
Sources of error and uncertainty associated with observations

- Biases in frequency or value
- Instrument error
- Random error or noise
- Reporting errors
- Representativeness error
- Precision error
- Conversion error
- Analysis error/uncertainty
- Other?

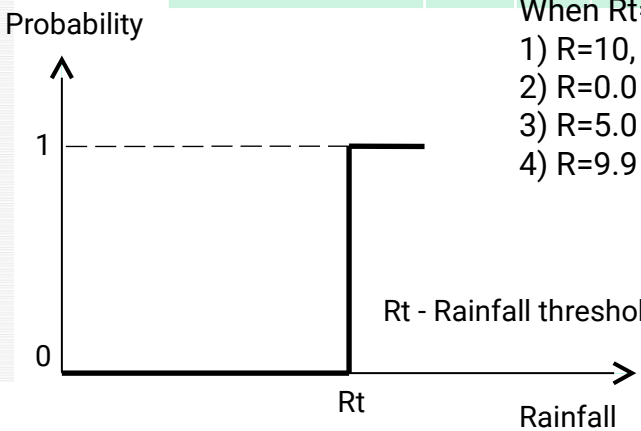


Example: Missing observations interpreted as "0's"

Barbara Brown



Station	A	B	C	D
Rainfall (mm/d)	18	13	7	3



When Rt=10
1) R=10, Prob =1.0
2) R=0.0 Prob = 0.0
3) R=5.0 Prob = 0.0
4) R=9.9 Prob = 0.0?

Discussion

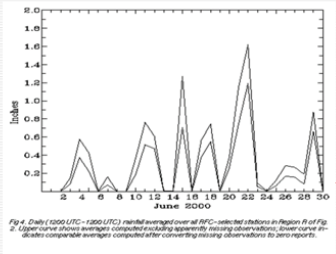
$$BS = \frac{1}{N}\sum_{t=1}^{N}(f_t - o_t)^2$$

In which, f_t is the probability that was forecast, o_t the actual outcome of the event at instance t (0 if it does not happen and 1 if it does happen) and N is the number of forecasting instances. In effect, it is the mean squared error of the forecast. This formulation is mostly used for binary events (for example
"rain" or "no rain"). The above equation is a proper scoring rule only for binary events; if a multi-category forecast is to be evaluated, then the original definition given by Brier below should be used.

- ot is the true observation of probability?

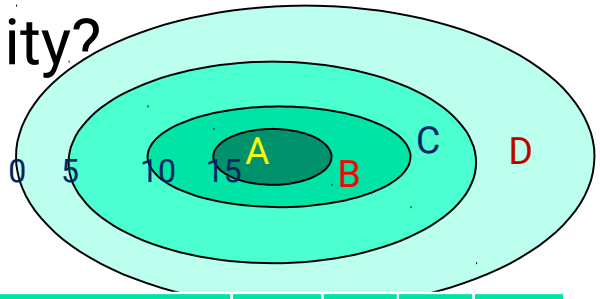
Sources of error and uncertainty associated with observations

- Biases in frequency or value
- Instrument error
- Random error or noise
- Reporting errors
- Representativeness error
- Precision error
- Conversion error
- Analysis error/uncertainty
- Other?

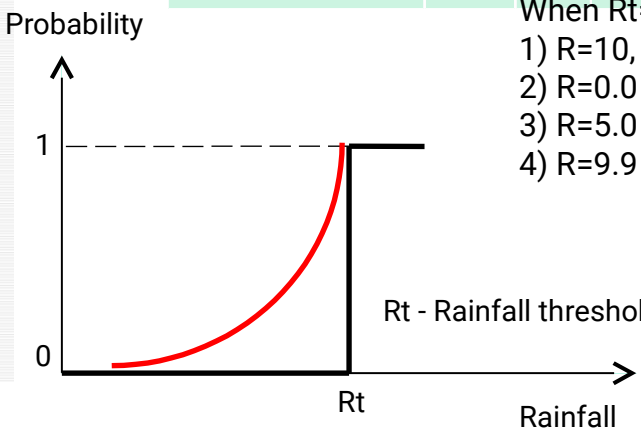


Example: Missing observations interpreted as "0's"

Barbara Brown



Station	A	B	C	D
Rainfall (mm/d)	18	13	7	3



When Rt=10
1) R=10, Prob =1.0
2) R=0.0 Prob = 0.0
3) R=5.0 Prob = 0.0
4) R=9.9 Prob = 0.0?

Thank

You