Project 6: Evaluation of sub-seasonal 5 day average precipitation forecasts for India

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Outline

Part-1
- Data Description (Study Site, Model and Observation)

Part-2
- Methodology/Verification Scores

Part-3
- Some results and Interpretation

Part-4
- Conclusions

Description of models and forecast strategy

Models:

1. **CFSv2_T382 (NCEP Climate Forecasting System; resolution ~ 38 Km)**
2. **CFSv2_T126 (NCEP Climate Forecasting System; resolution ~ 110 Km)**
3. **GFSv2_T382 (Stand alone GFS, forced with bias corrected SST, obtained from CFSv2_T382)**
4. **GFSv2_T126 (Stand alone GFS, forced with bias corrected SST, obtained from CFSv2_T126)**

Forecast starting dates:

The models were run for 5 day intervals e.g. 16th May, 21st May, 26th May, 31st May, 5th June, ... , 23rd Sept and 28th Sept.

Number of ensembles:

10 perturbed and one control atmospheric initial conditions (total 11) were prepared using the technique described in Abhilash et al., 2014 (*Int. J. Climatol.***, 2014, 34, 98–113).**

Pentad leads

Initial Condition (IC: mmdd)	P-1 lead (day 1 to day 5)	P-2 lead (day 6 to day 10)	P-3 lead (day 11 to day 15)	P-4 lead (day 16 to day 20)
0516	17May - 21May	22May - 26May	27May - 31May	01Jun – 05Jun
0521	22May - 26May	27May - 31May	01Jun – 05Jun	06Jun – 10Jun
0526	27May - 31May	01Jun – 05Jun	06Jun – 10Jun	11Jun – 15Jun
0531	01Jun – 05Jun	06Jun – 10Jun	11Jun – 15Jun	16Jun – 20Jun
0605	06Jun – 10Jun	11Jun – 15Jun	16Jun – 20Jun	21Jun – 25Jun
…….. …….. ……..	…….. …….. ……..	…….. …….. ……..	…….. …….. ……..	…….. …….. ……..
0908	09Sep – 13Sep	14Sep – 18Sep	19Sep – 23Sep	24Sep – 28Sep
0913	14Sep – 18Sep	19Sep – 23Sep	24Sep – 28Sep	29Sep – 03Oct
0918	19Sep – 23Sep	24Sep – 28Sep	29Sep – 03Oct	04Oct – 08Oct
0923	24Sep – 28Sep	29Sep – 03Oct	04Oct – 08Oct	09Oct – 13Oct
0928	29Sep – 03Oct	04Oct – 08Oct	09Oct – 13Oct	14Oct – 18Oct

For the period JJAS (1st June to 28th September), 120 days. But it is a 5 day averaged data (e.g. 1-5Jun, 6-10Jun, 11-15Jun, ….., 18-23Sept and 24-28Sept) of time steps 24.

P-1 lead

Duration	Corresponding ICs
1st June - 5th June	0531
6th June - 10th June	0605
11th June – 15th June	0610
…….	…….
19th Sept - 23rd Sept	0918
24rd Sept – 28th Sept	0923

P-2 lead

Duration	Corresponding ICs
1st June - 5th June	0526
6th June - 10th June	0531
11th June – 15th June	0605
…….	…….
19th Sept - 23rd Sept	0913
24rd Sept – 28th Sept	0918

P-3 lead

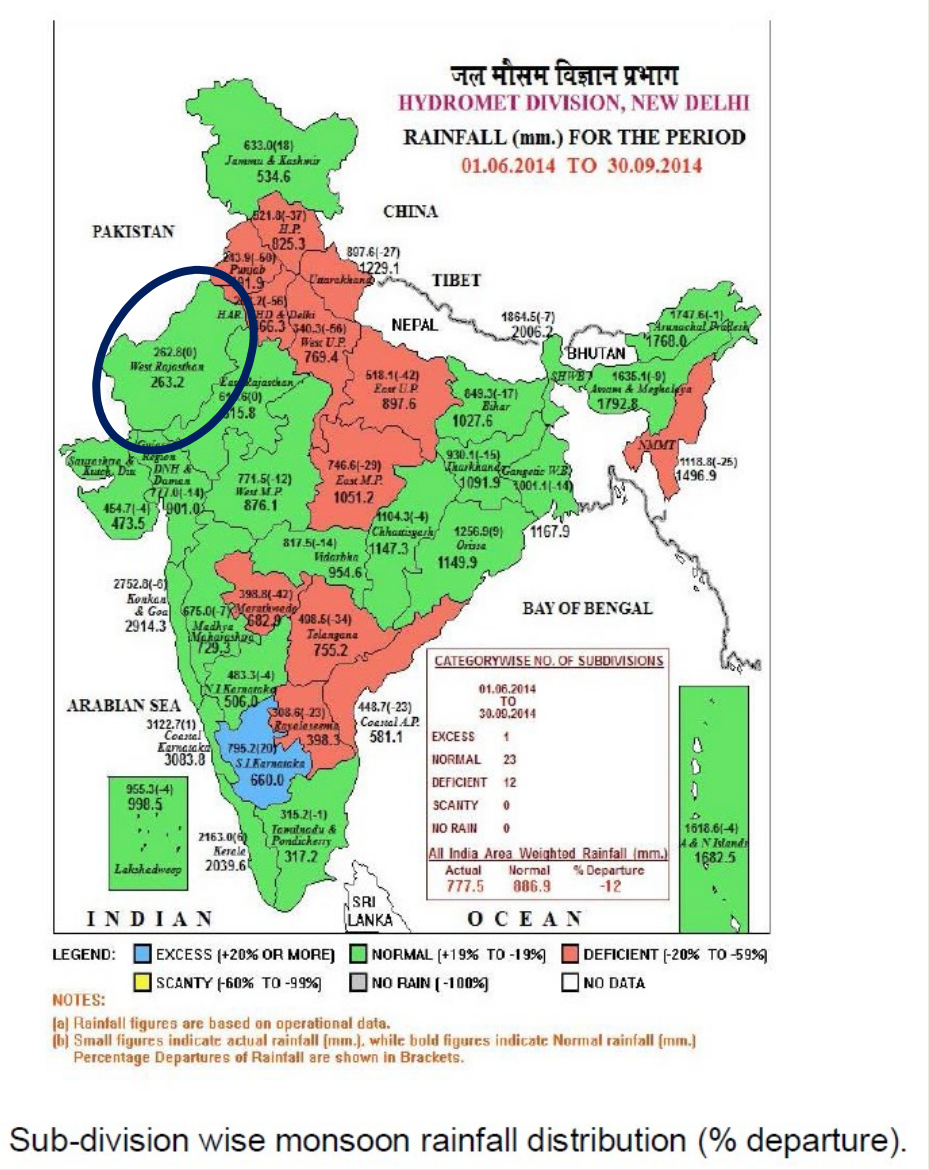
Duration	Corresponding ICs
1st June - 5th June	0521
6th June - 10th June	0526
11th June – 15th June	0531
…….	…….
19th Sept - 23rd Sept	0908
24rd Sept – 28th Sept	0913

P-4 lead

Duration	Corresponding ICs
1st June - 5th June	0516
6th June - 10th June	0521
11th June – 15th June	0526
…….	…….
19th Sept - 23rd Sept	0903
24rd Sept – 28th Sept	0908

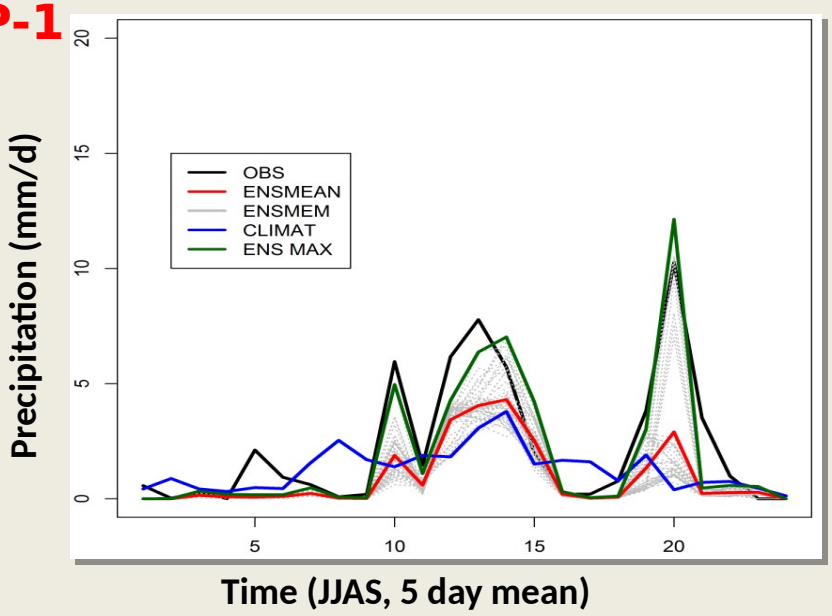
Data used in this present study

Precipitation data for a particular sub-division (West Rajasthan, India) during JJAS 2014 for model and observation (IMD, India)

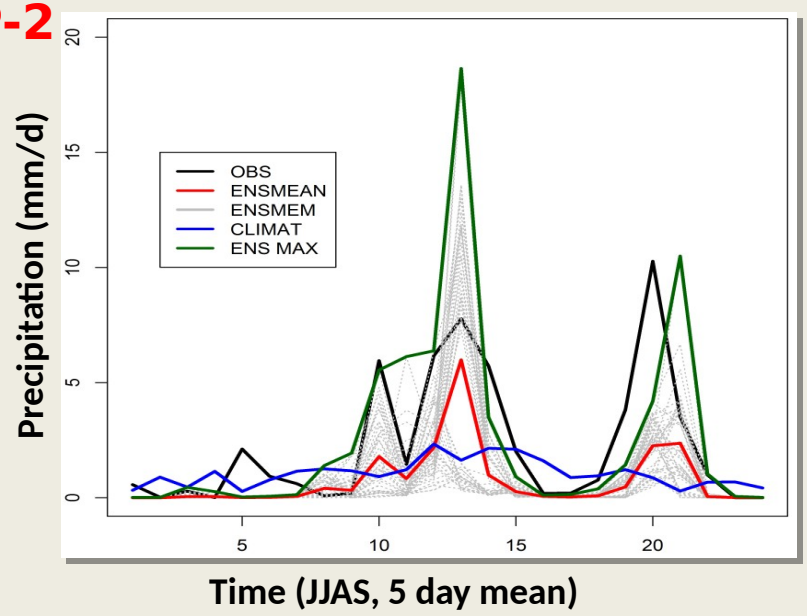


Sub-division wise monsoon rainfall distribution (% departure).

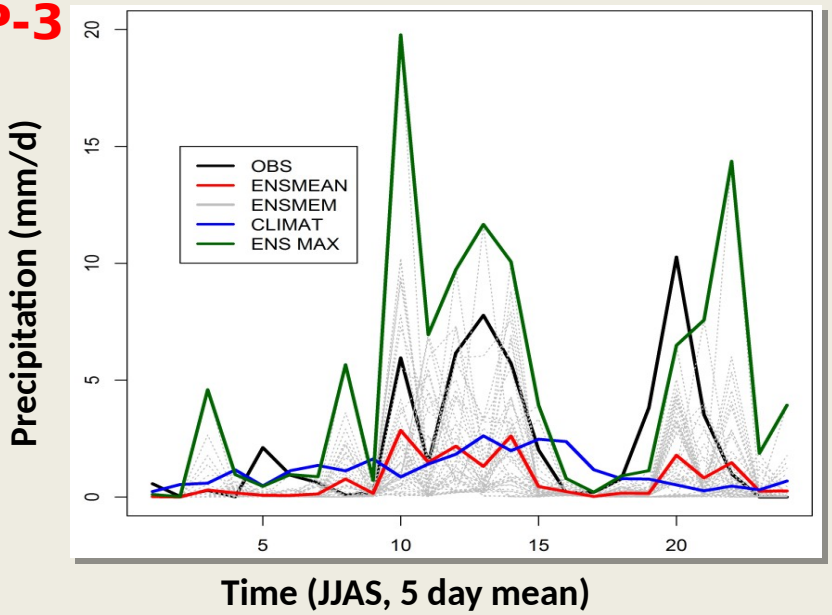
P-1


OBS
ENSMEAN
ENSMEM
CLIMAT
ENS MAX
Precipitation (mm/d)
Time (JJAS, 5 day mean)

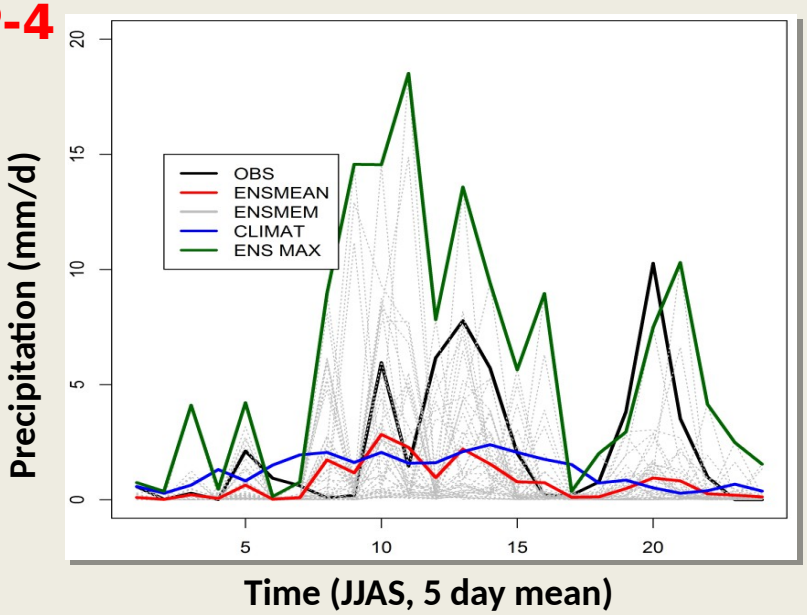
P-2


OBS
ENSMEAN
ENSMEM
CLIMAT
ENS MAX
Precipitation (mm/d)
Time (JJAS, 5 day mean)

P-3


OBS
ENSMEAN
ENSMEM
CLIMAT
ENS MAX
Precipitation (mm/d)
Time (JJAS, 5 day mean)

P-4


OBS
ENSMEAN
ENSMEM
CLIMAT
ENS MAX
Precipitation (mm/d)
Time (JJAS, 5 day mean)

Verification

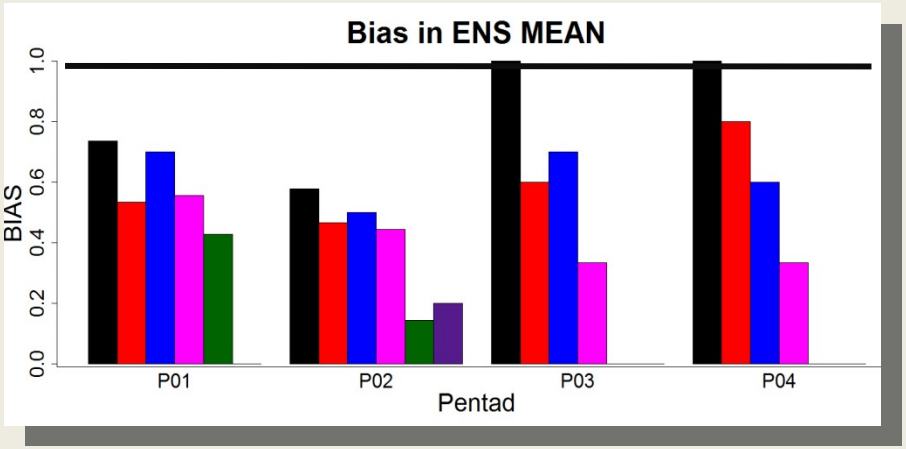
- Deterministic Verification
  - Ensemble Mean
  - Ensemble Maximum
- Probabilistic Verification
- Rainfall Thresholds:
  - 0.1, 0.5, 1, 2, 3 and 5 mm/day

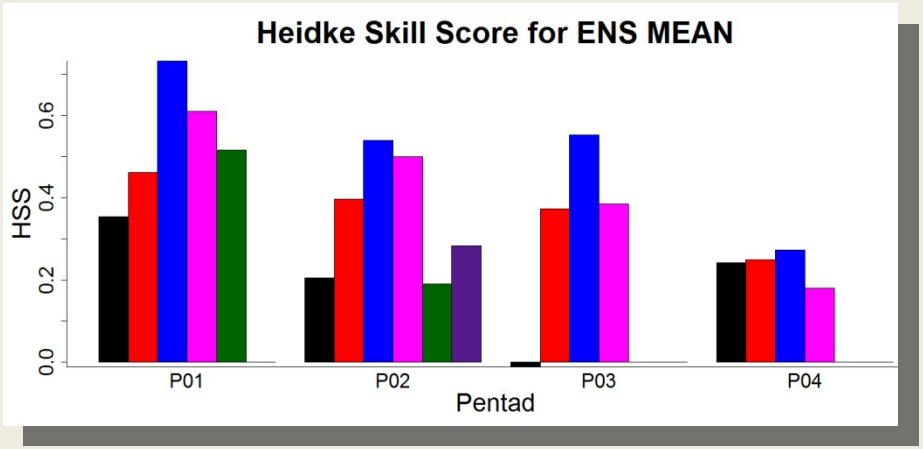
Deterministic Verification

Based on contingency tables constructed for each of the events described by Rainfall exceeding the thresholds

- Frequency Bias
- Heidke Skill Score (HSS)
- False Alarm Ratio (FAR)
- Probability of Detection (PoD)
- Threat Score/Critical Success Index (CSI)
- Equitable Threat Score (ETS)

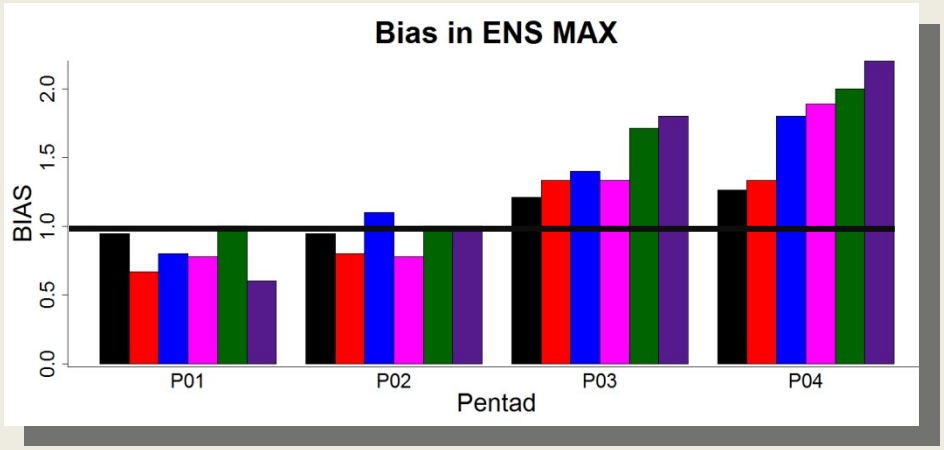
Ensemble Mean

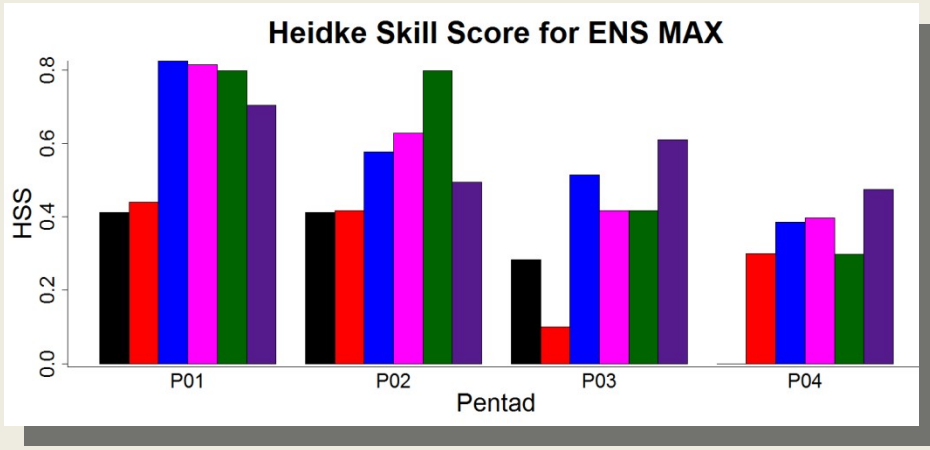




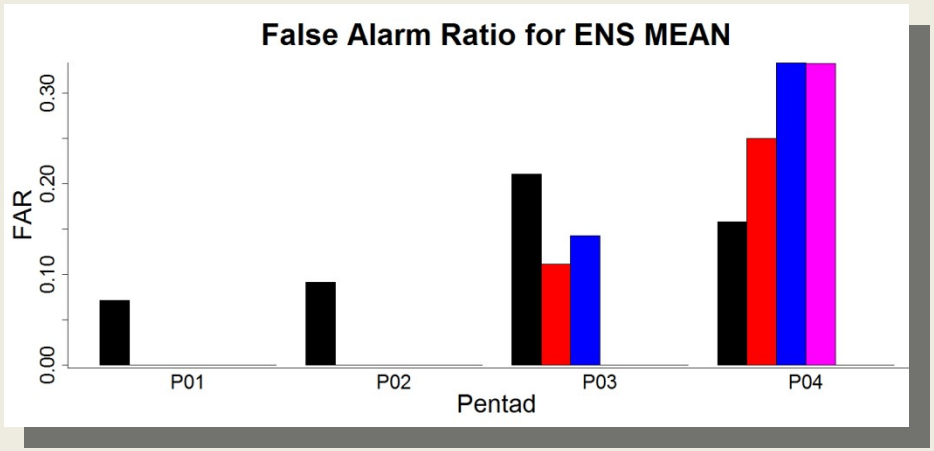
th=0.1 mm/day
th=0.5 mm/day
th=1 mm/day
th=2 mm/day
th=3 mm/day
th=5 mm/day

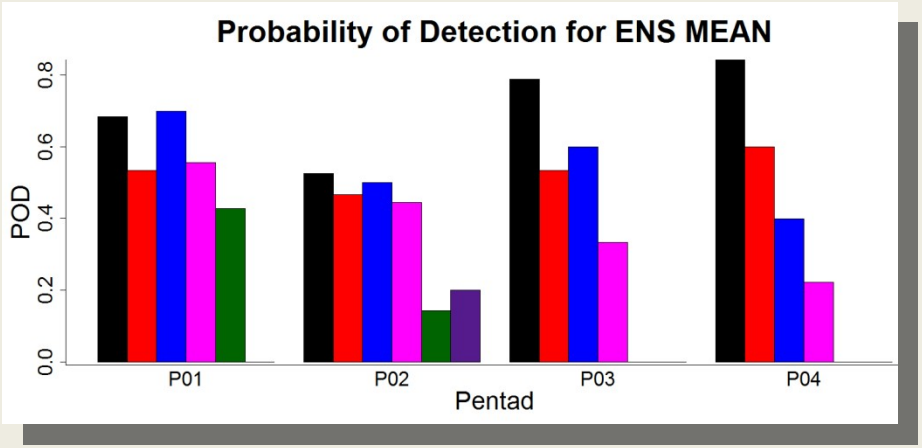
Ensemble Max

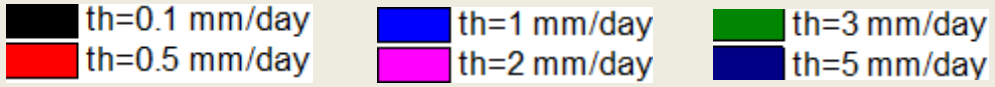




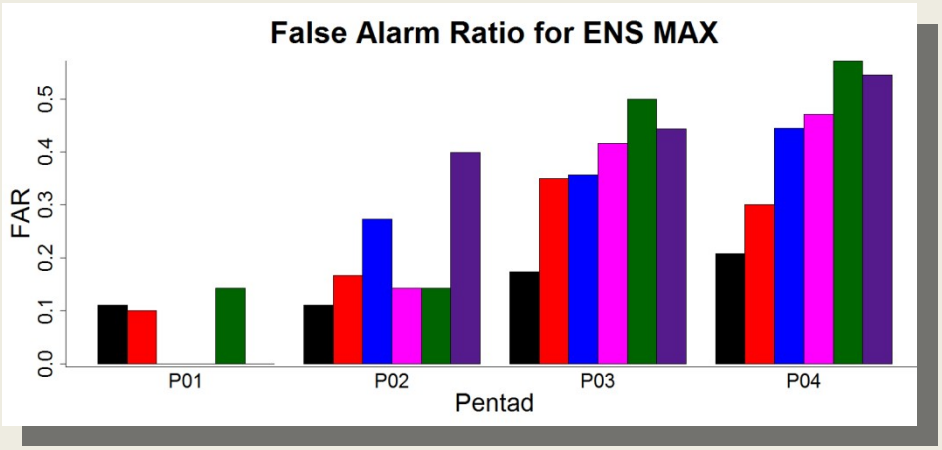
Ensemble Mean

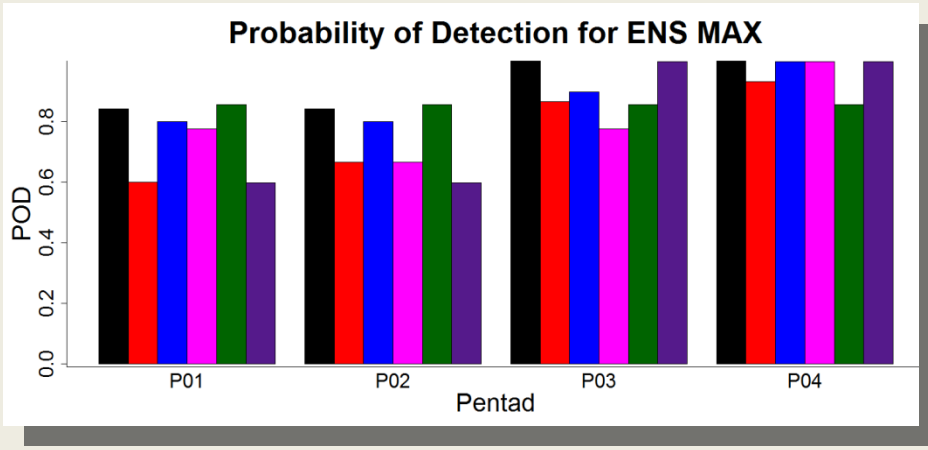




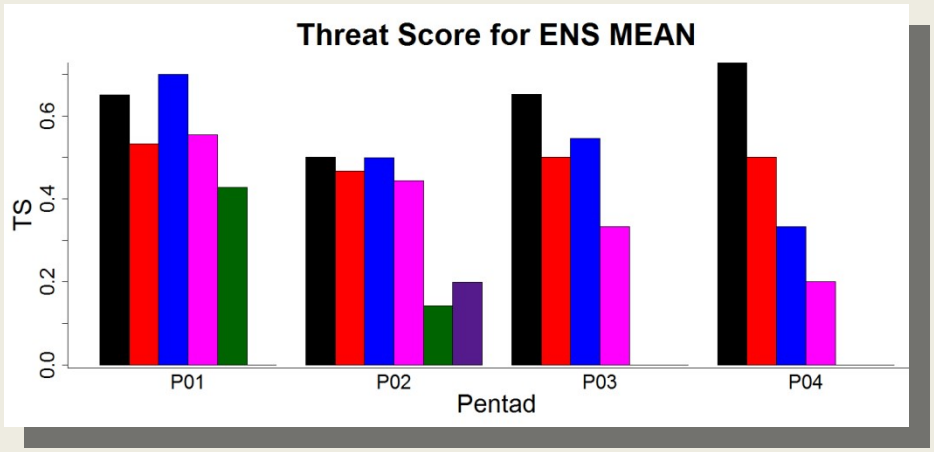


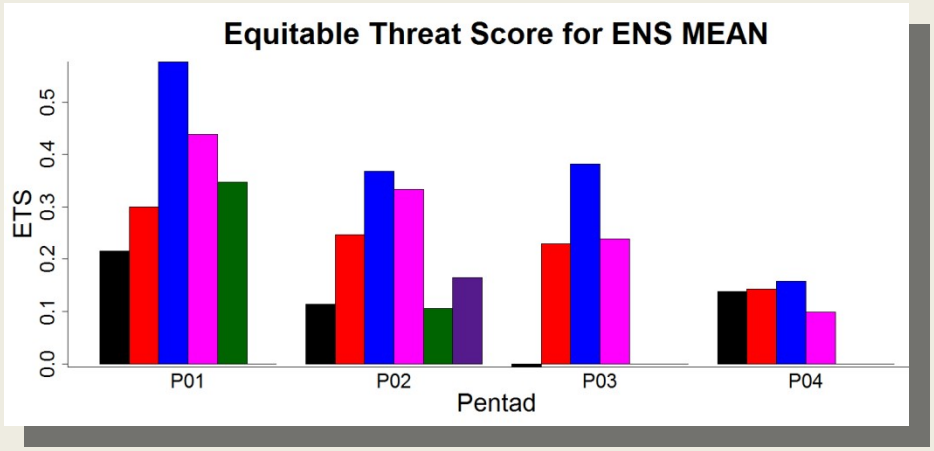
Ensemble Max

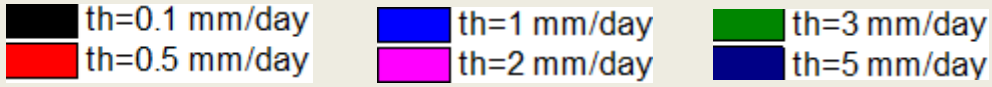




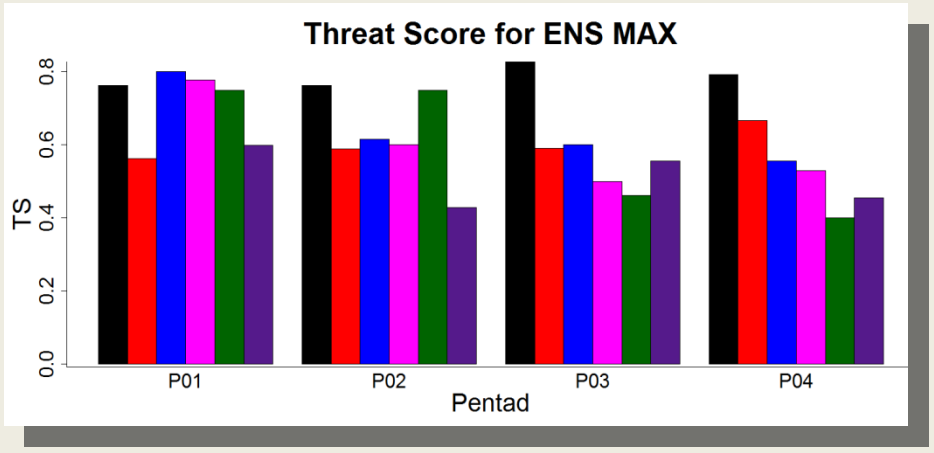
Ensemble Mean

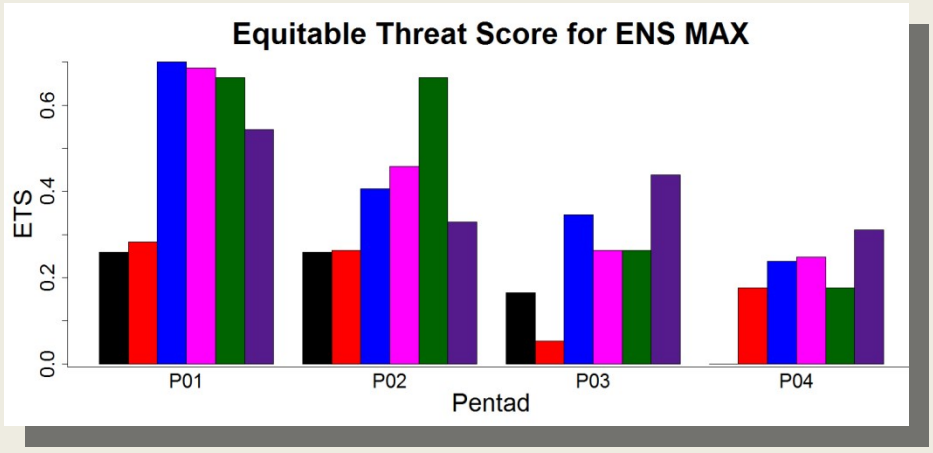




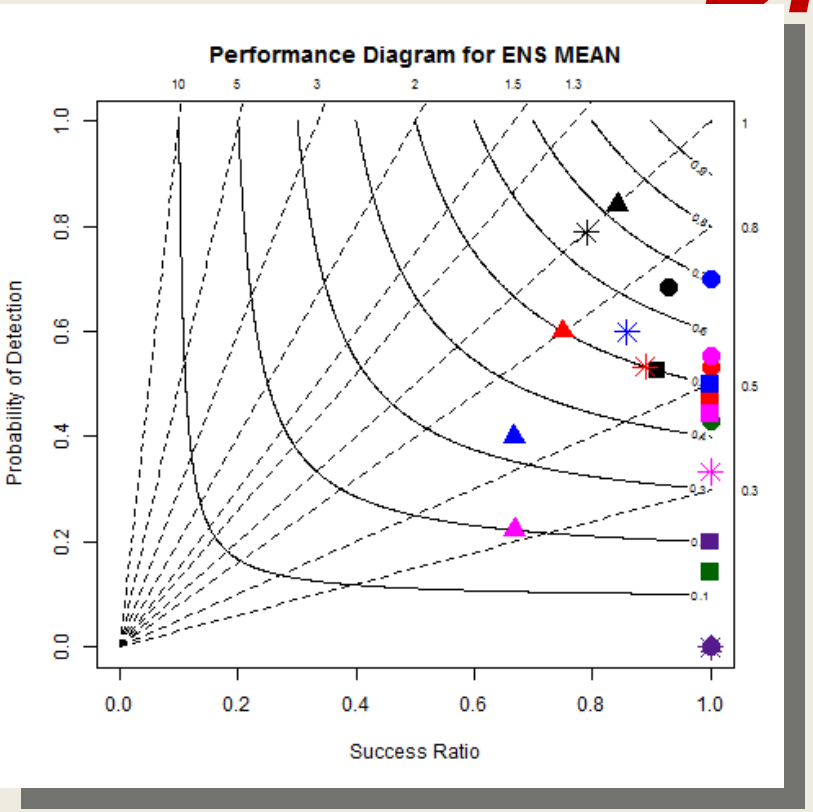


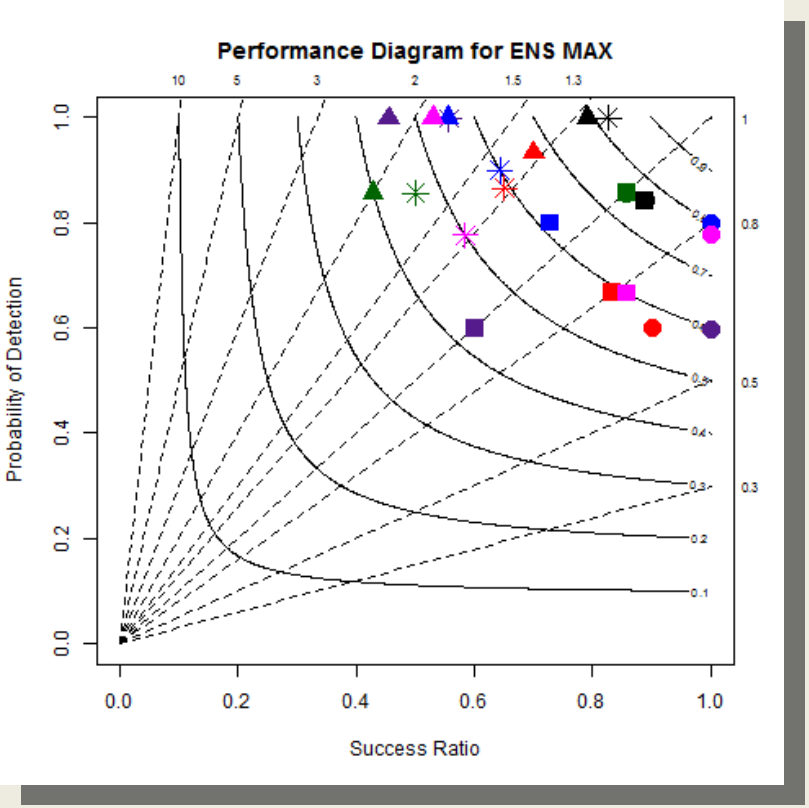
Ensemble Max





Performance Diagram





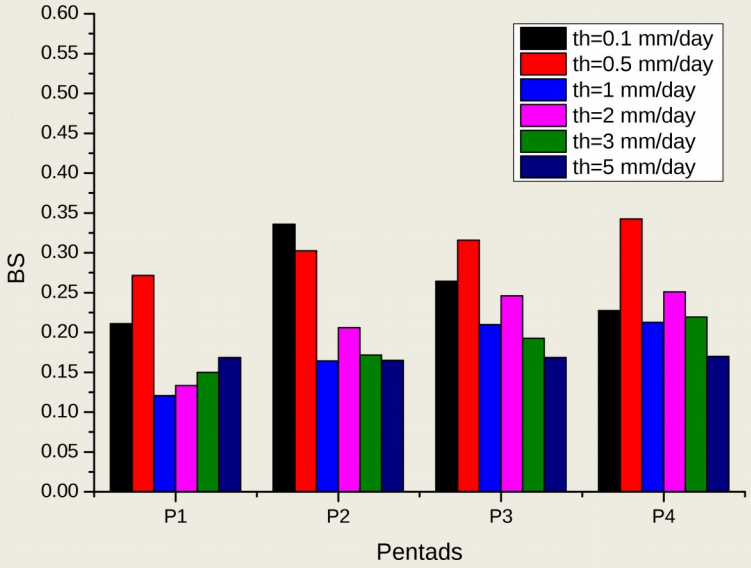
th=0.1 mm/day
th=0.5 mm/day
th=1 mm/day
th=2 mm/day
th=3 mm/day
th=5 mm/day

■ Pentad 1
● Pentad 2
∗ Pentad 3
▲ Pentad 4

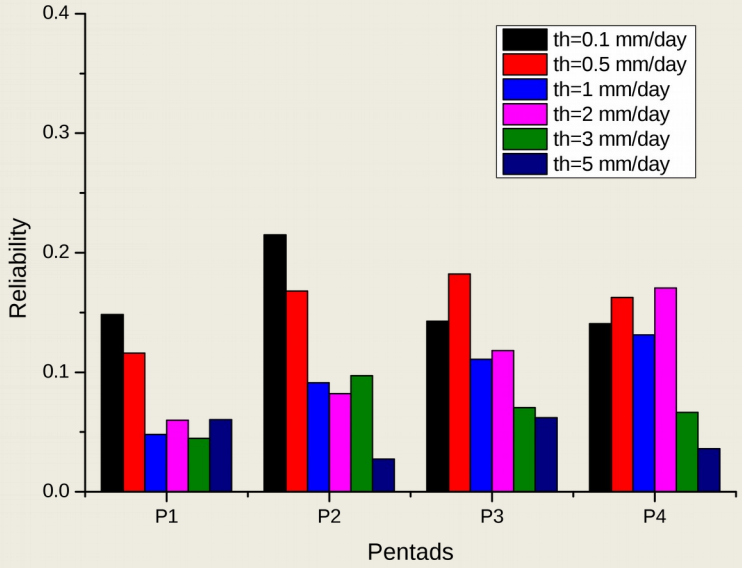
Probabilistic Verification

- Brier Score
  - Decomposition of Brier Score: Reliability, Resolution and Uncertainty
- ROC as a measure of Resolution (Bootstrap)
  - Area under ROC curve
- Continuous Ranked Probability Score (CRPS)
  - Decomposition of CRPS
- Talagrand Diagram (Rank Histogram)

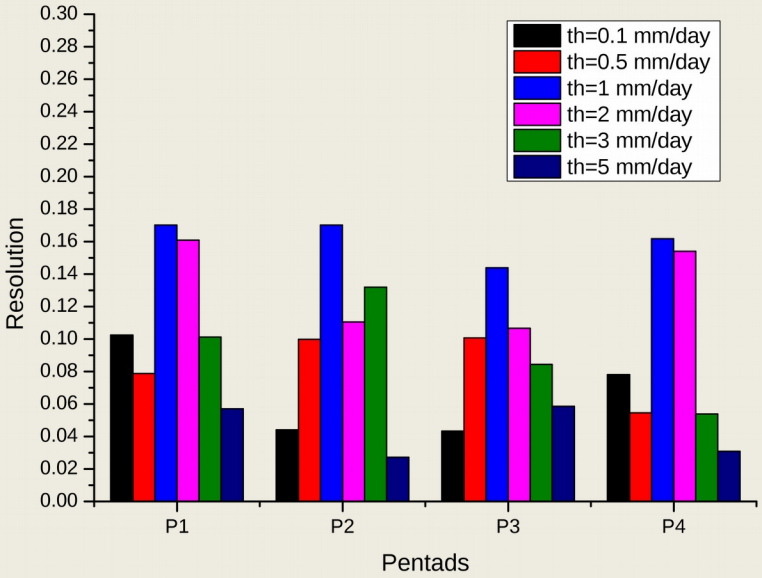
Brier Score



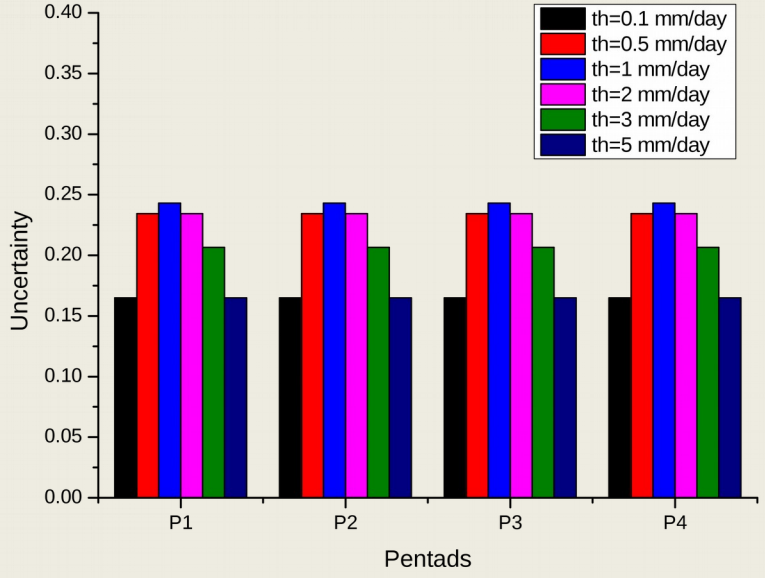
Reliability



Resolution



Uncertainty



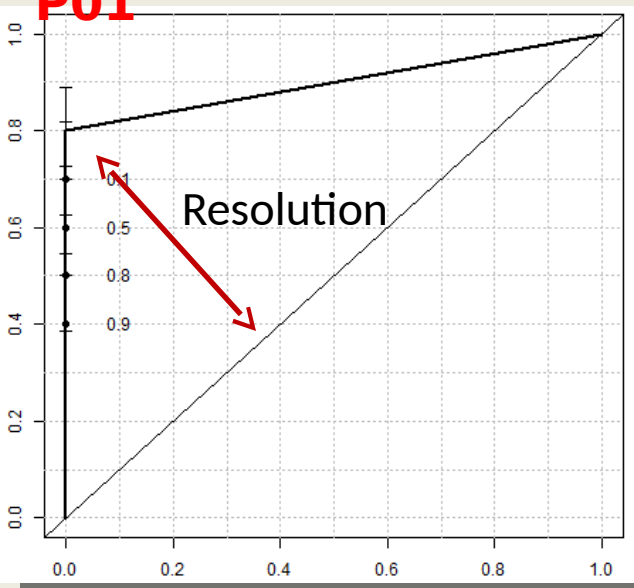
ROC

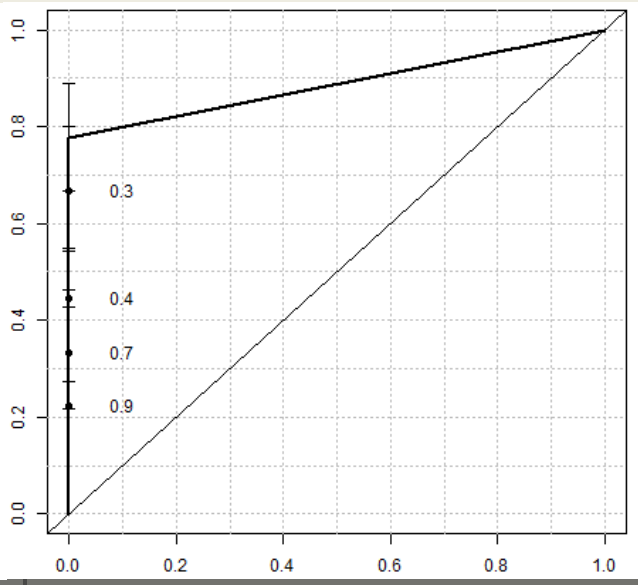
1 mm/d

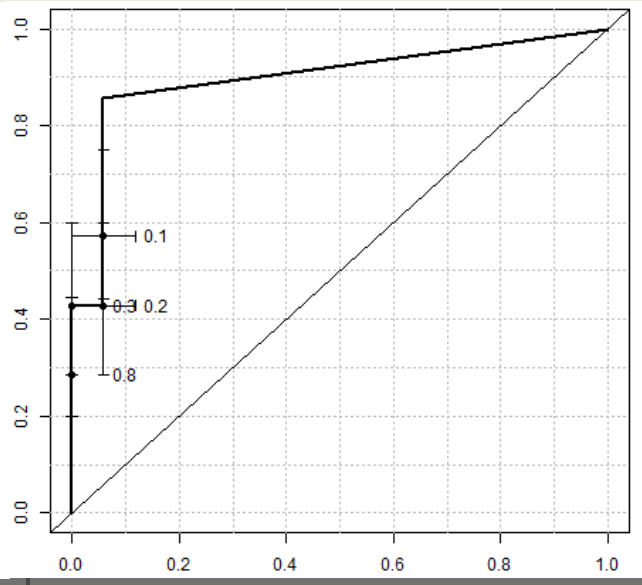
2 mm/d

3 mm/d

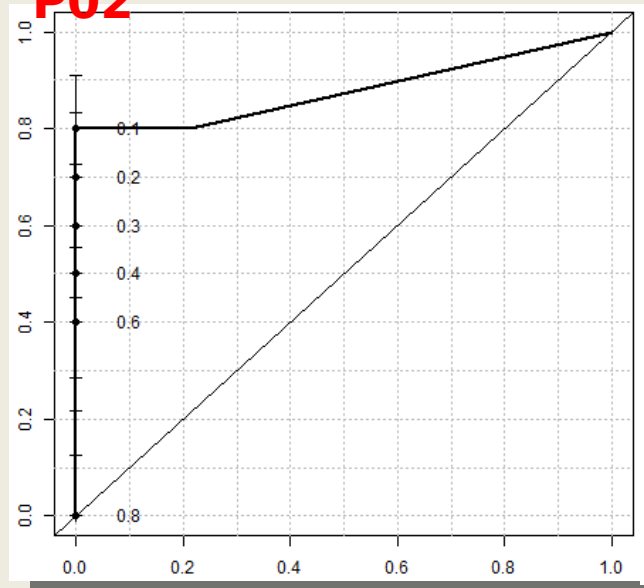
P01

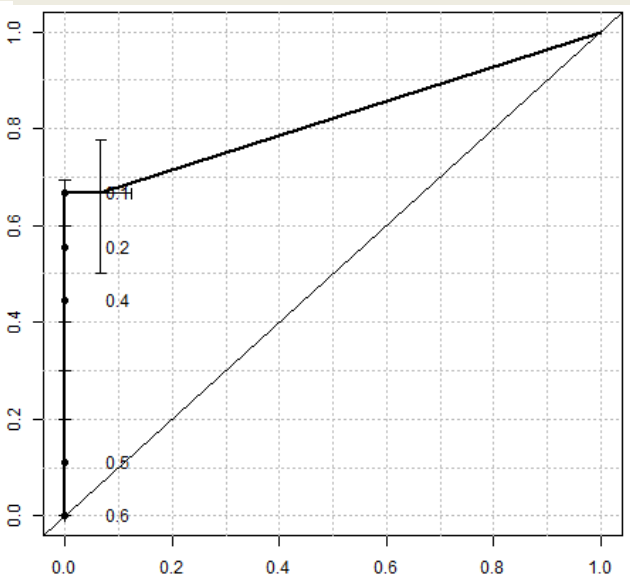


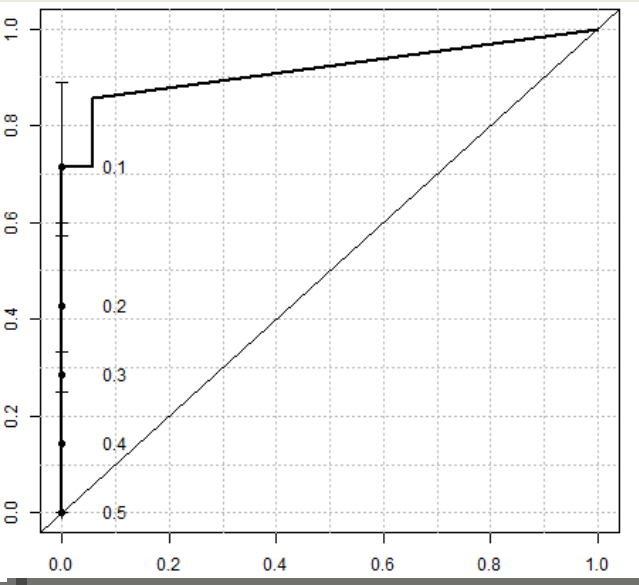




P02

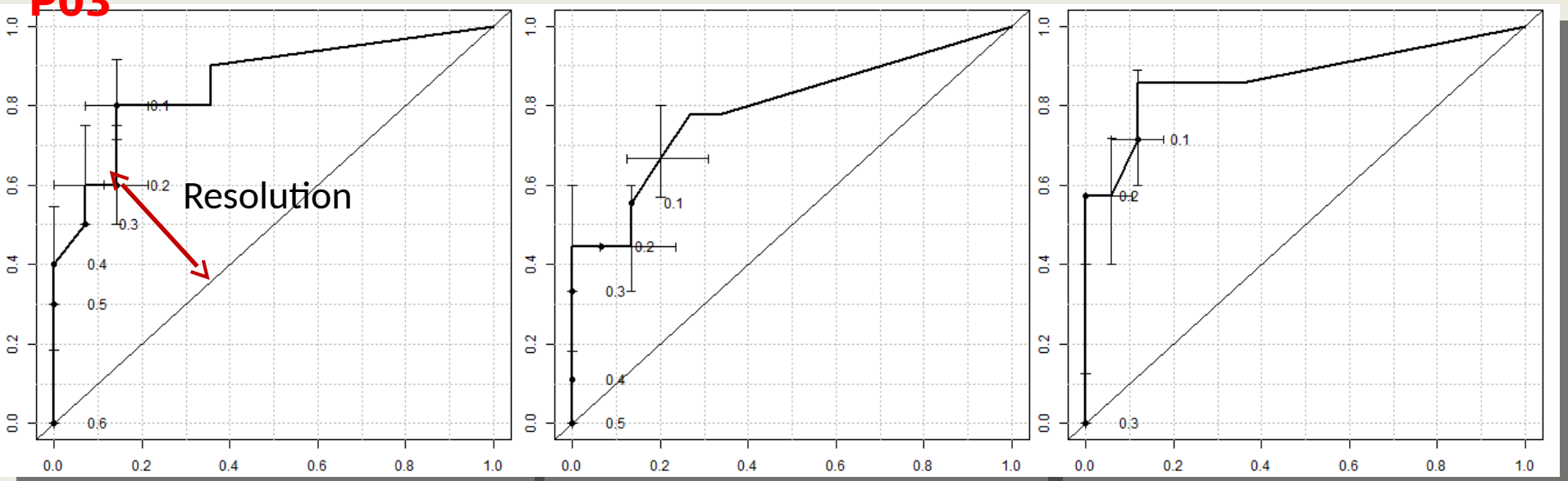




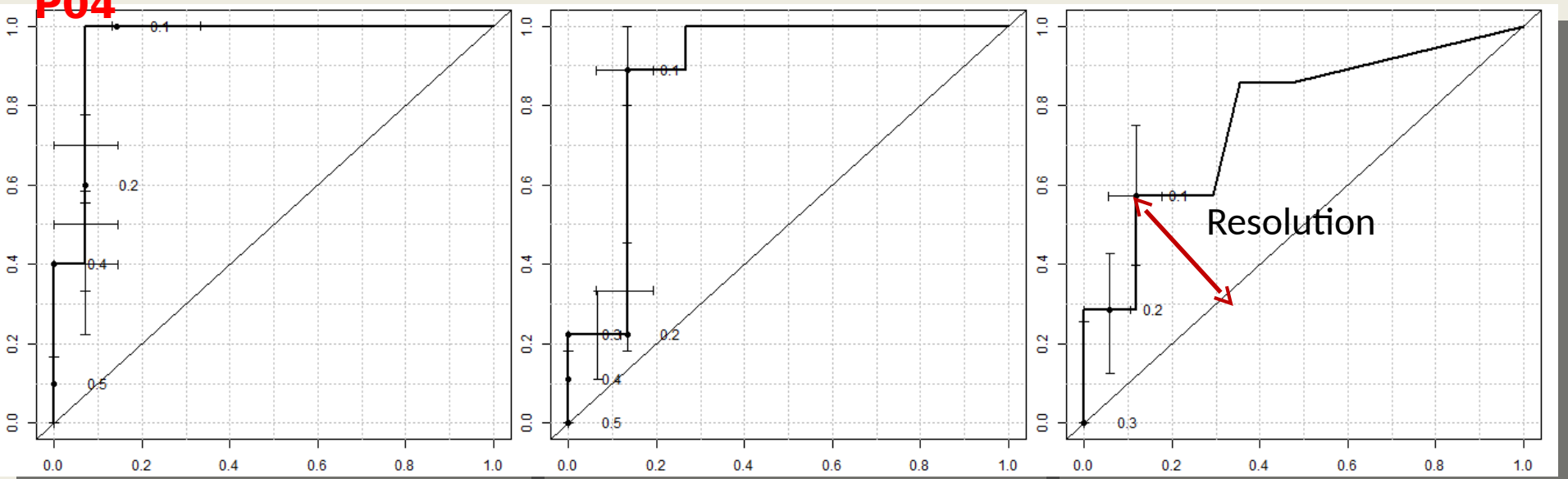


1 mm/d 2 mm/d 3 mm/d

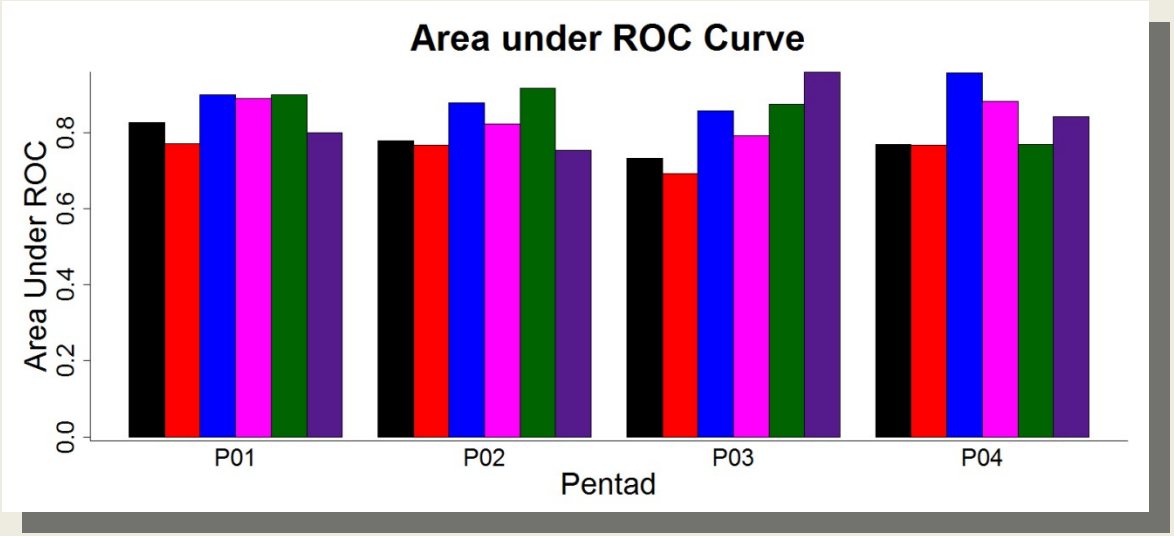
P03



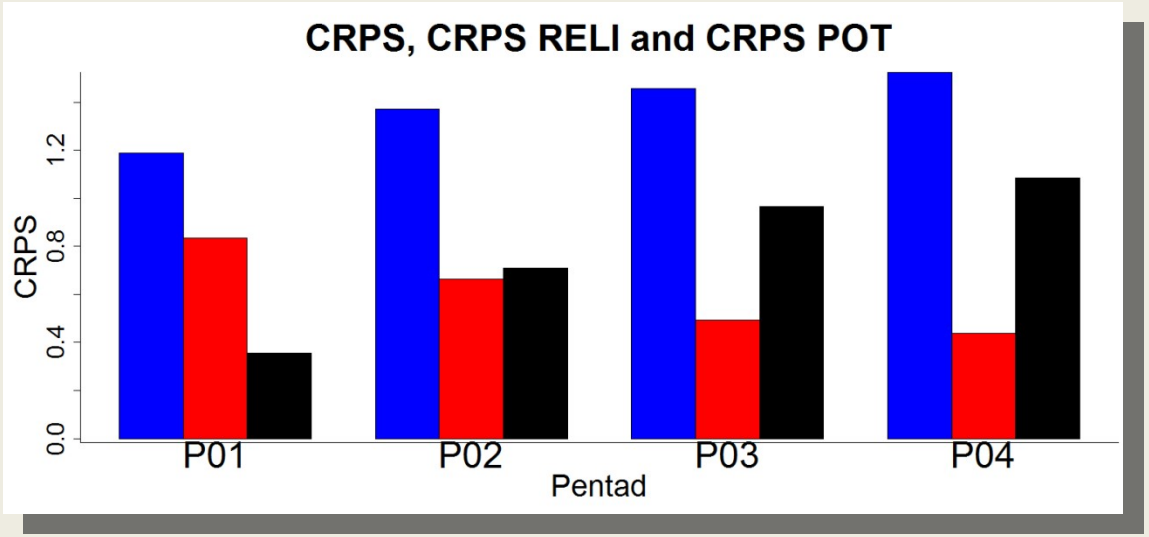
P04



Area Under ROC

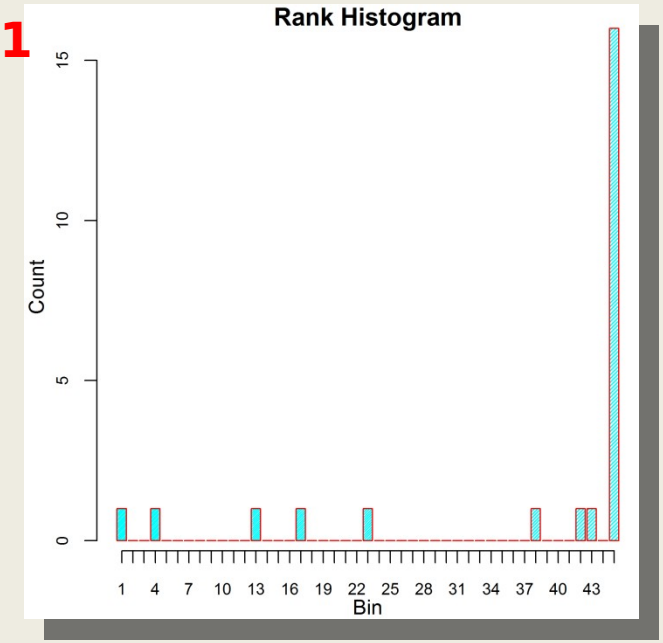


CRPS

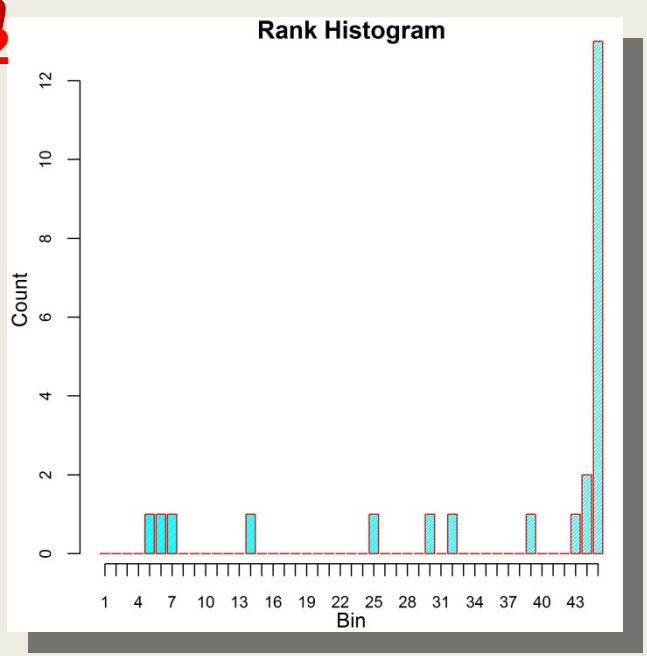


Rank Histogram/Talagrand Diagram

P01



P02



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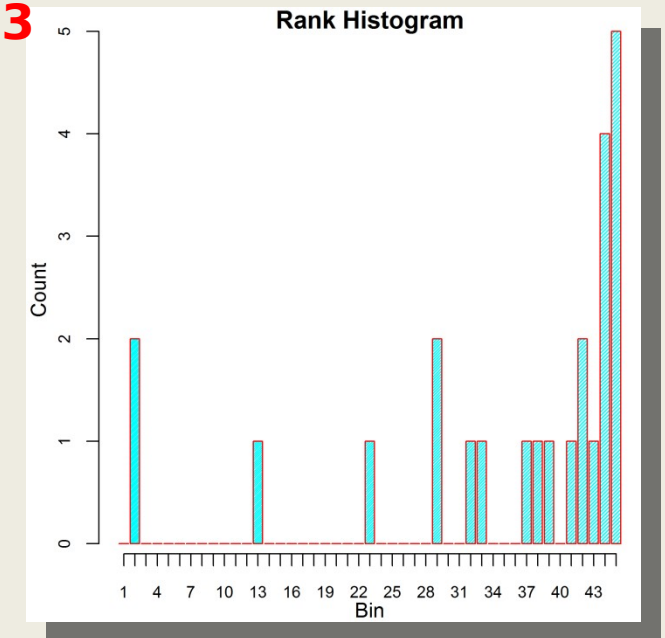
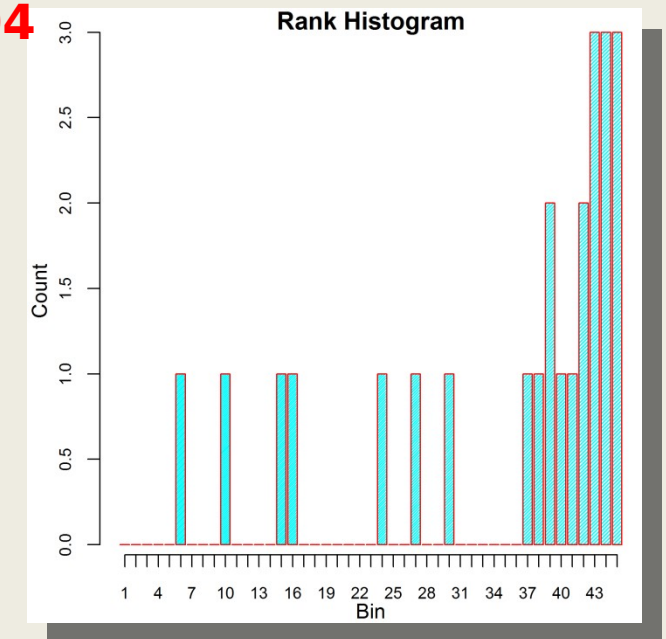


P04



Conclusions

- Verification of ensemble mean and maximum shows that latter compares better with observations in terms of having higher POD, SR, CSI, ETS and Bias.
- This is indicative of under-prediction by the model (bias <1 for Ensemble Mean)
- The bias in the model also results in a poorer Reliability (>0).
- Forecast Bias is also indicated by Talagrand diagram (skewed to right).
- ROC curve shows that the model has a capability of discriminating between hits and false alarms. AROC > 0.5 for all thresholds and lead times indicating good discrimination ability.
- Finally, the model shows good resolution but poor reliability which can be corrected by using statistical post processing.
- Further work is required by using a more comprehensive data set (more seasons and more grid points).

Acknowledgement

- **WMO**
- **Director, IITM; Head, NCMRWF; Head, CDP, TU**
- **NCEP/NOAA**
- **IMD, India**
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Raju