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Assimilation of Norwegian Radar Reflectivity in Harmonie: Quality Control Strategies

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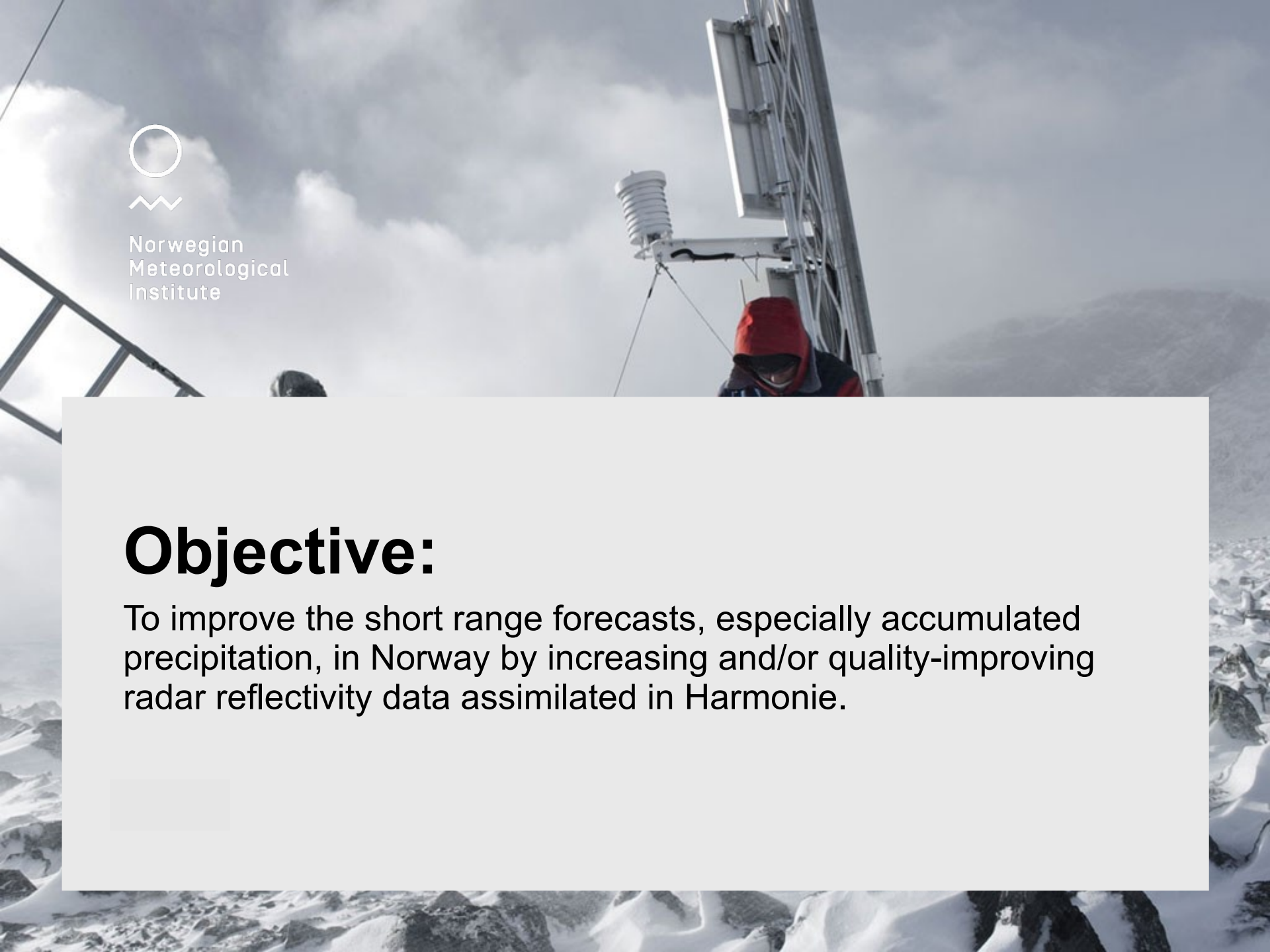
Roger Randriamampianina and Christoffer Elo

04.04.16



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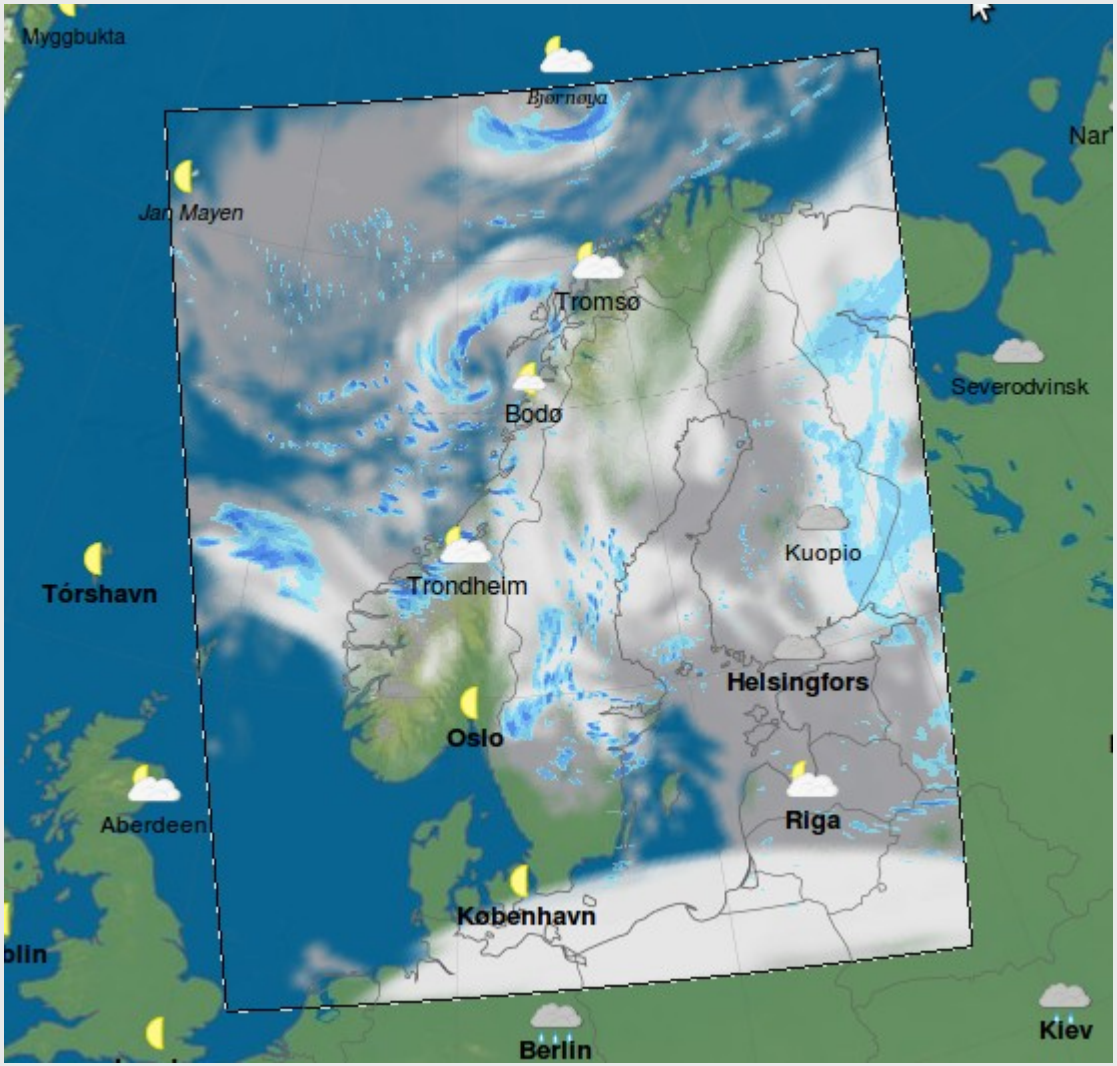
Objective:

To improve the short range forecasts, especially accumulated precipitation, in Norway by increasing and/or quality-improving radar reflectivity data assimilated in Harmonie.

AROME-MetCoOP: domain



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AROME-MetCoOP

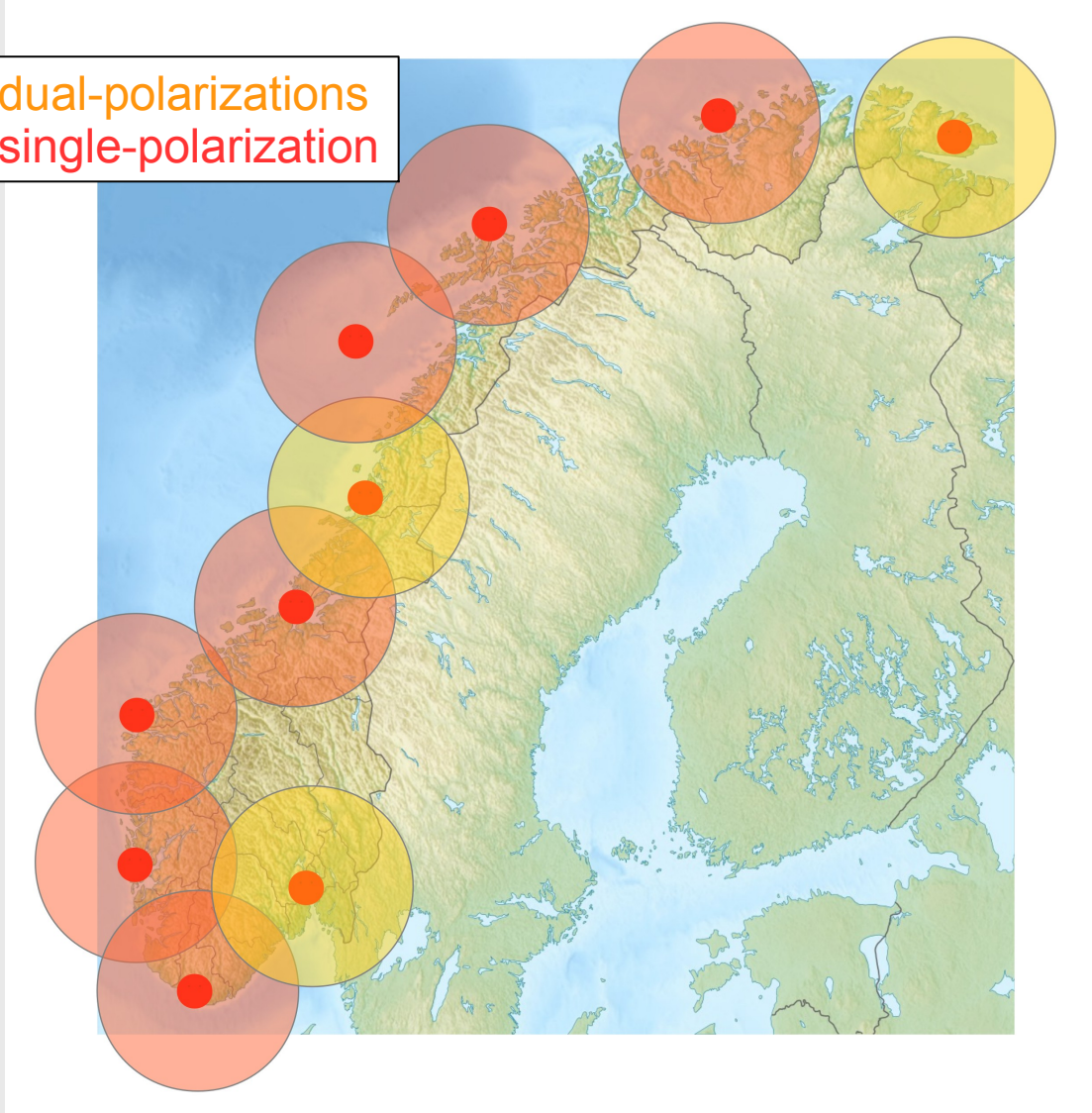
- operational cooperation between SMHI and MET
- using Norwegian and Swedish facilities
- base for official forecasts on yr.no

- harmonie cycle 38h12
- AROME physical parametrization
- domain with 750×960 grid-points, 2.5 km, 65 levels, 10hPa top
- hourly boundaries from ECMWF
- forecast length 66 hours
- SURFEX for surface modeling

- 3DVAR (conventional, ATOVS, GNSS, radar reflectivity)
- 3-hourly cycling and LSMIX

Norwegian radars

3 radars with dual-polarizations
7 radars with single-polarization



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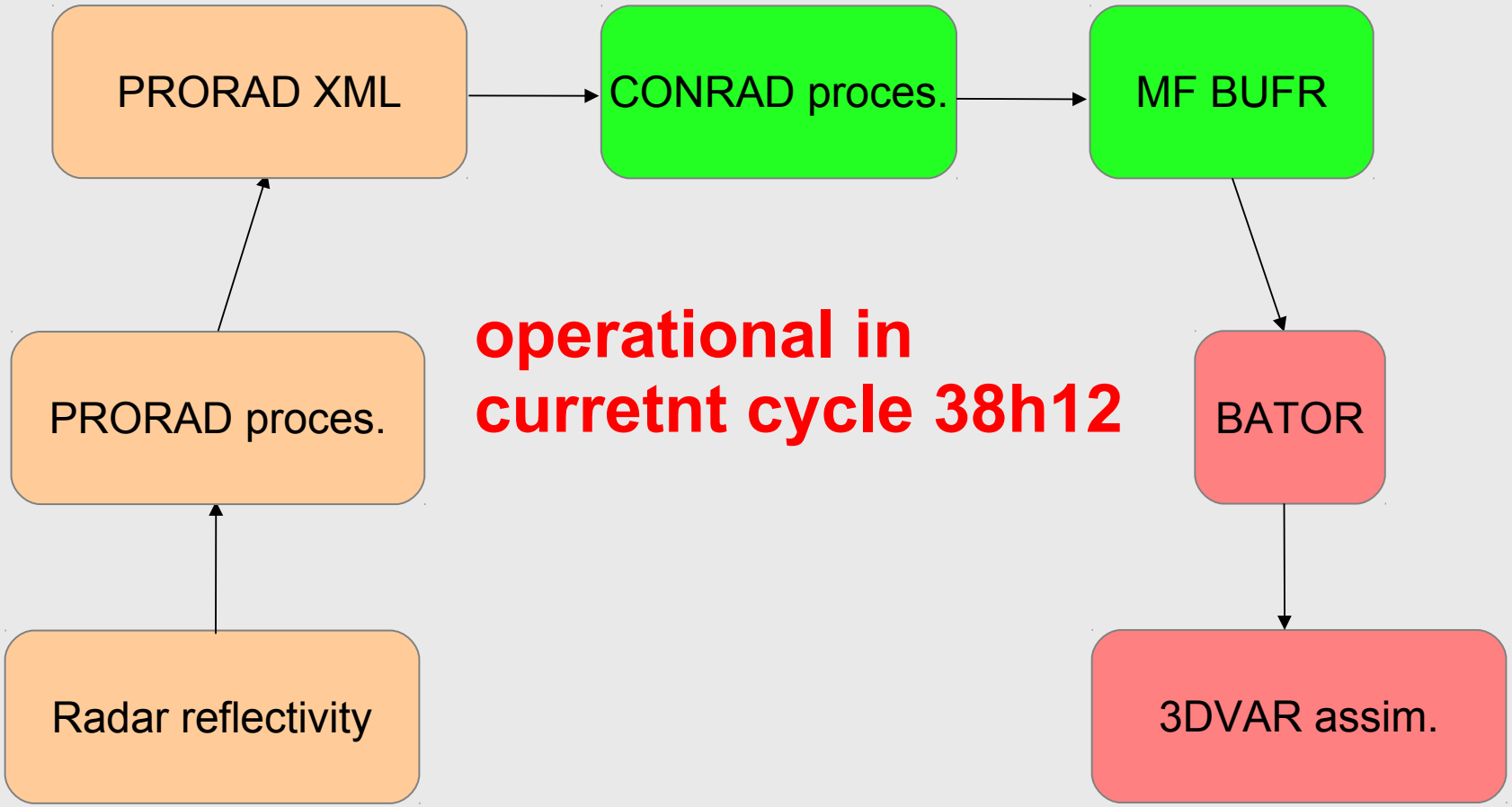
Norwegian Radar DA in AROME-MetCoOp



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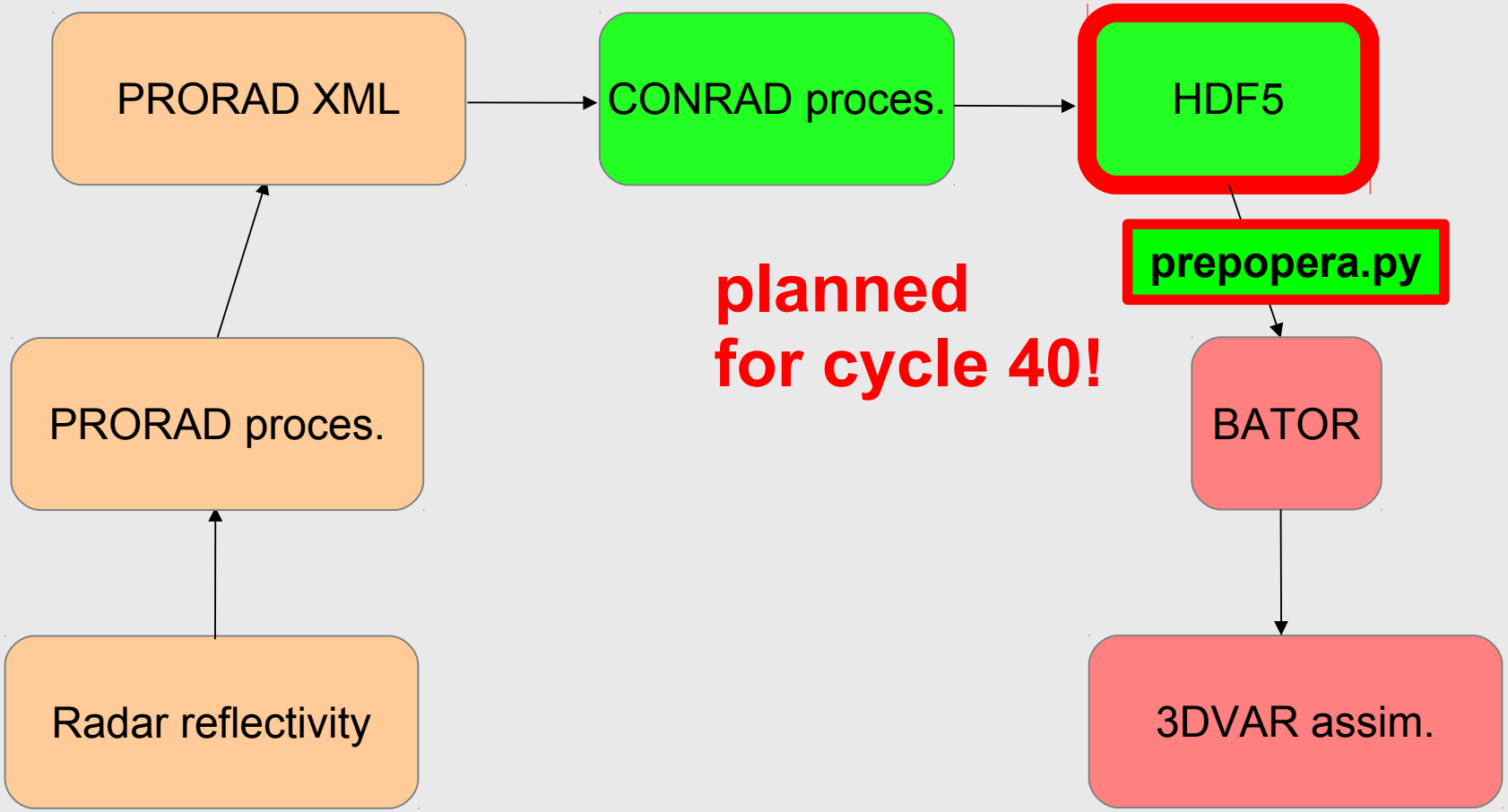

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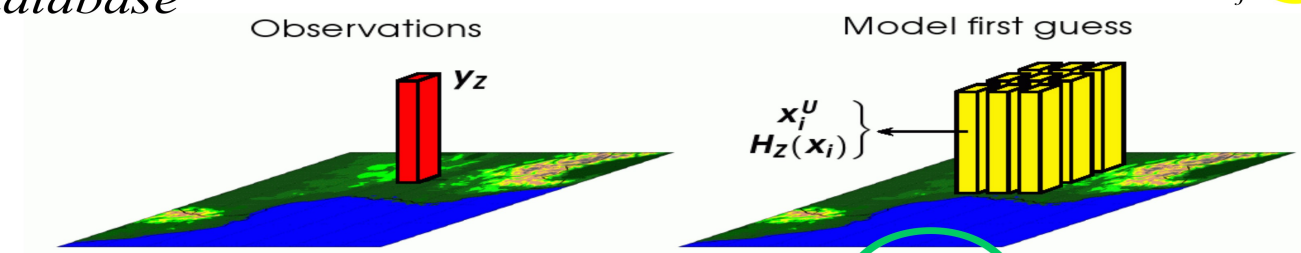
Radar DA in AROME-MetCoOp

- 1D+3DAVR method
- using columns of observations in the model
- if only one pixel is rainy either in the model or in the radar
- altitudes of the pixels considering a constant refractivity index
- computing of a humdity retrieval

Caumont, 2006: Use of model profiles in the vicinity of the observation as « representative » database

$$E(x) = \sum_j x_j \frac{\exp \frac{-1}{2} \cdot \| y_0 - y_s(x_j) \|^2}{\sum_j \exp \frac{-1}{2} \cdot \| y_0 - y_s(x_j) \|^2}$$



$$y_{po}^U = \sum_{\substack{i \in \\ \text{neighbours}}} x_i^U \frac{\exp\left(-\frac{1}{2} \| y_Z - H_Z(x_i) \|^2\right)}{\sum_{\substack{j \in \\ \text{neighbours}}} \exp\left(-\frac{1}{2} \| y_Z - H_Z(x_j) \|^2\right)}$$

Observation operator of reflectivity

y_{po}^U: column of pseudo-observed relative humidity,
y_Z: column of observed reflectivities,
x_i^U: column of relative humidity,
$H_Z(x_i)$: column of simulated reflectivities.

Quality Control Experiments

1. **CLEAR ECHO**: investigate the quality of clear sky data

2. **BLOCKING**: correct the reflectivity estimation

3. **RANGE**: optimal range to assimilate reflectivity

Quality Control Experiments

- **two periods in 2015:**
  - Winter case from 15 Jan to 15 Feb
  - Summer case from 25 May to 25 Jun
- **Mimicing operational seting and cutoff for observations**
  - SYNOP => ~10000 data count
  - AIRCRAFT => ~1500 data count
  - DRIBU => ~ 30 data count
  - TEMP => ~ 5000 data count
  - ATOVS:
  - amsua => ~10000 data count
  - amsub => ~15000 data count

- 24h or 48h forecast at {00} and {12}.

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1. CLEAR ECHO

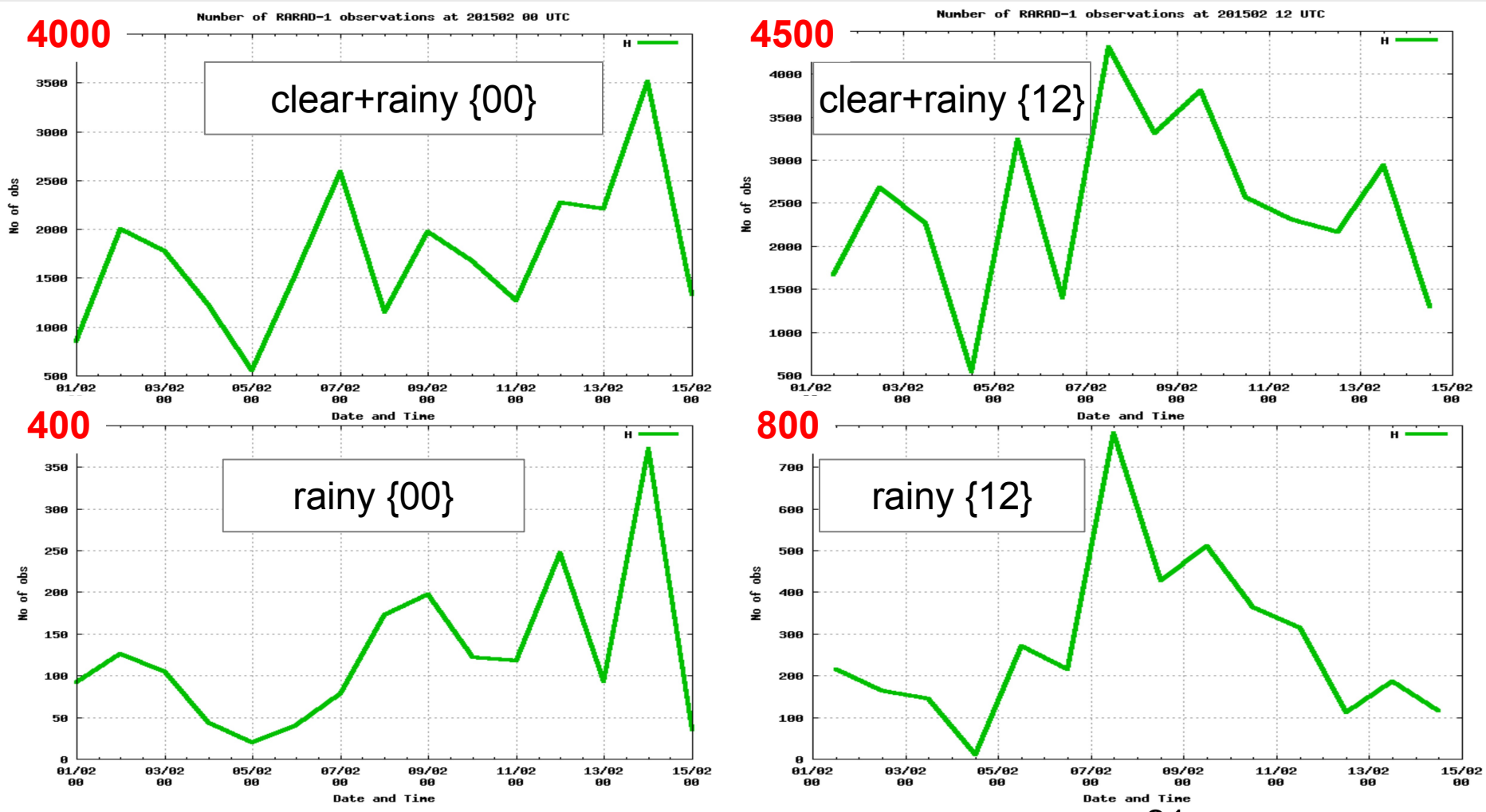
- Radar reflectivity data are flagged:

RABSI = **no data**
0 = **no rain**
6 = **rain**

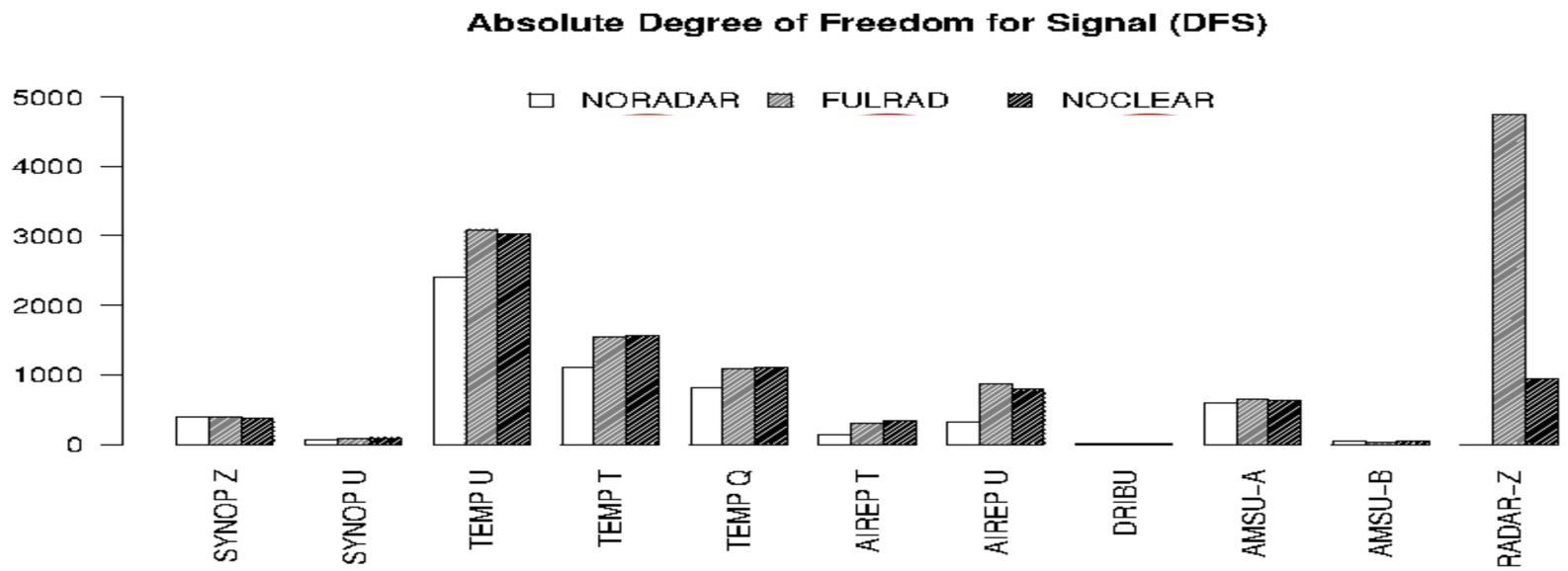
- the usage can be controlled in BATOR before filling up ODB.
- we modified BATOR so that the flag 6 was only used.
- only assimilation for humidity profiles with rainy pixels.

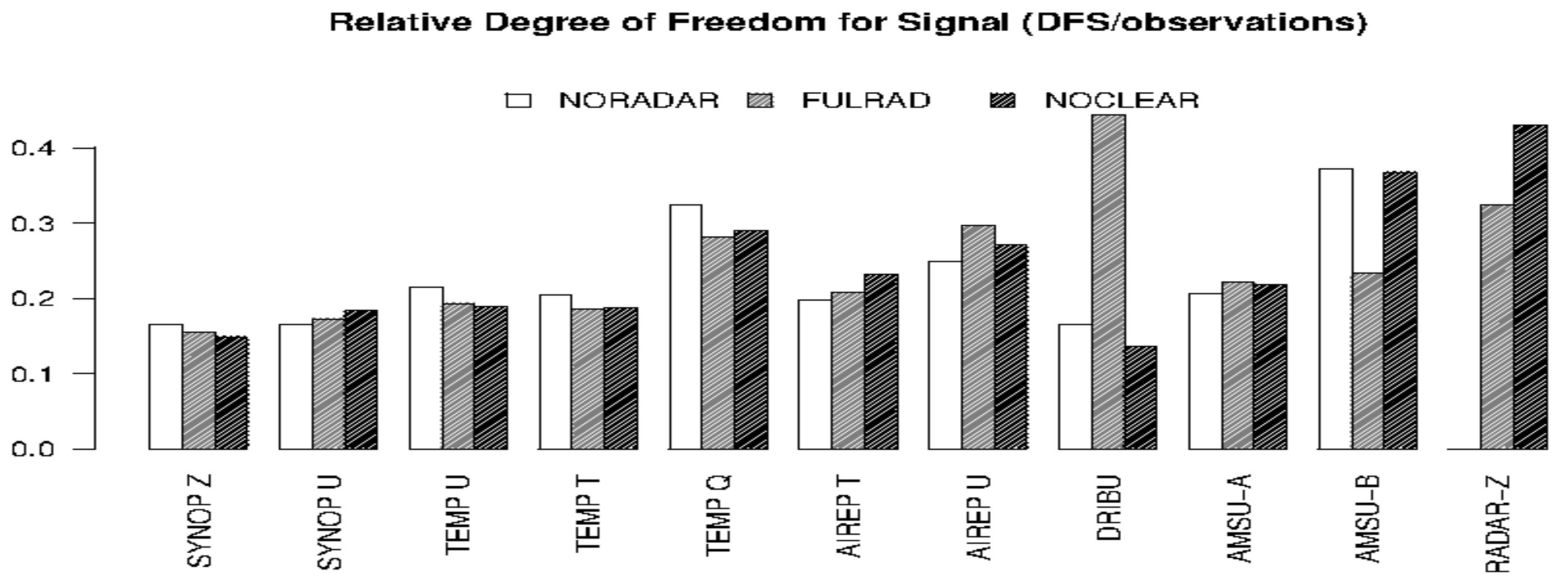
1. CLEAR ECHO

- Radar observation usage: ~%10 rainy data



1. CLEAR ECHO: DFS





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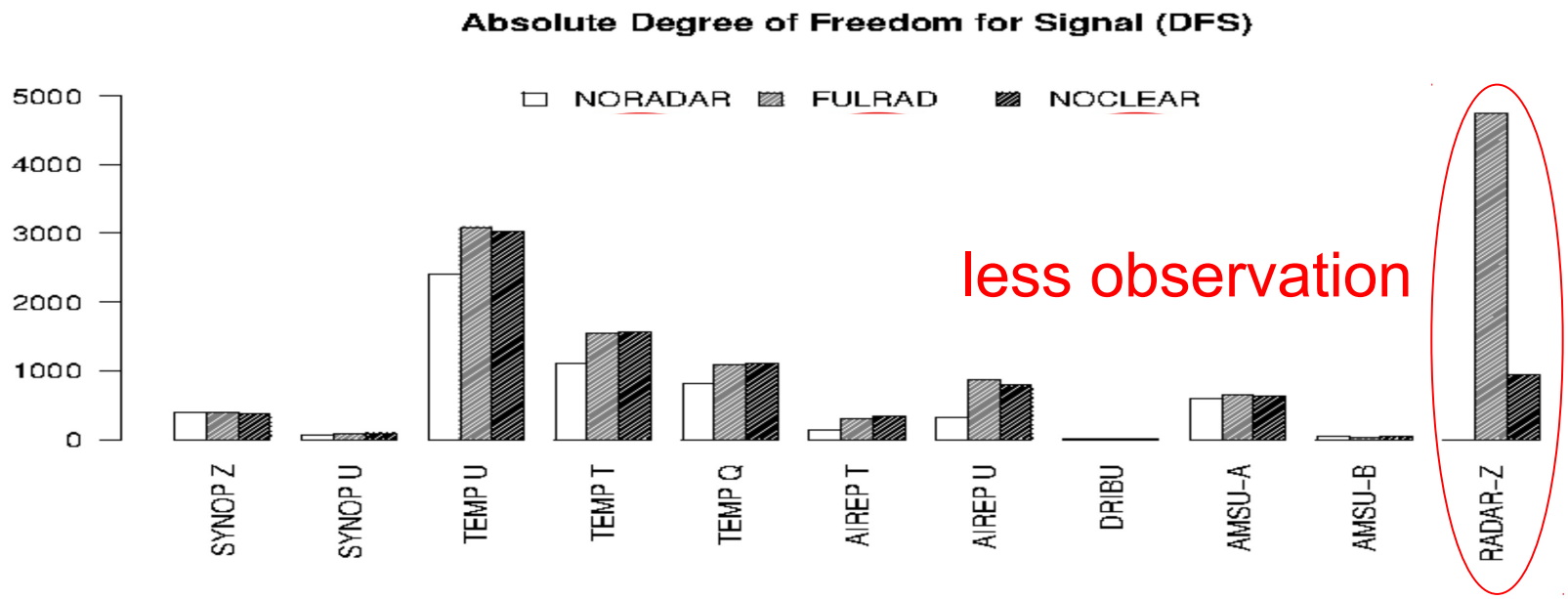

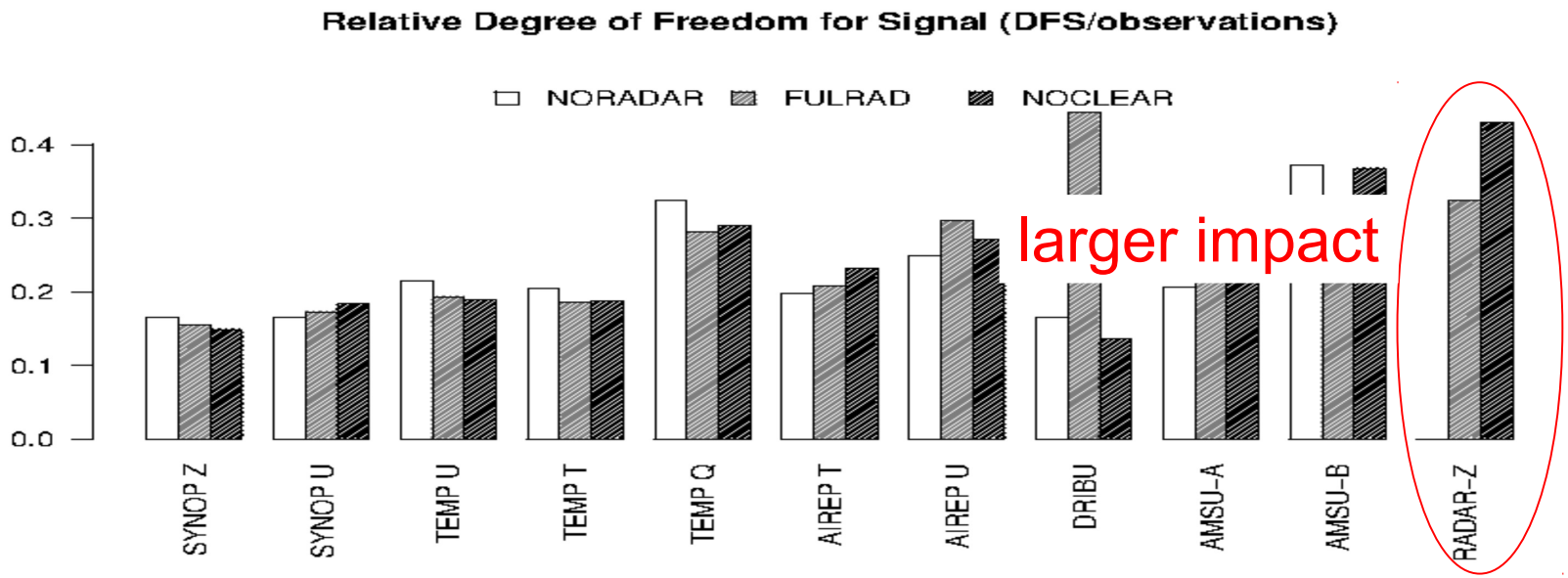

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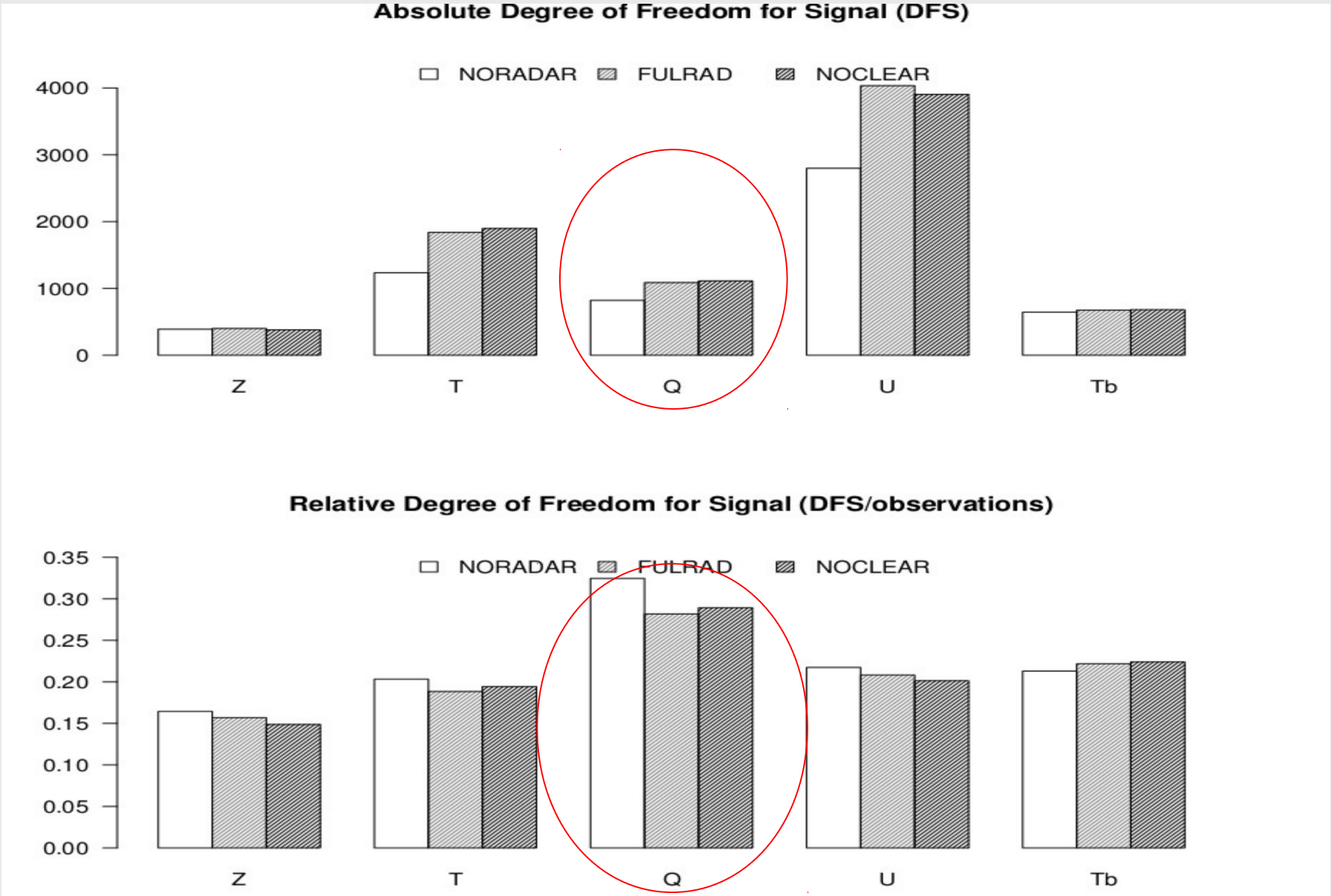
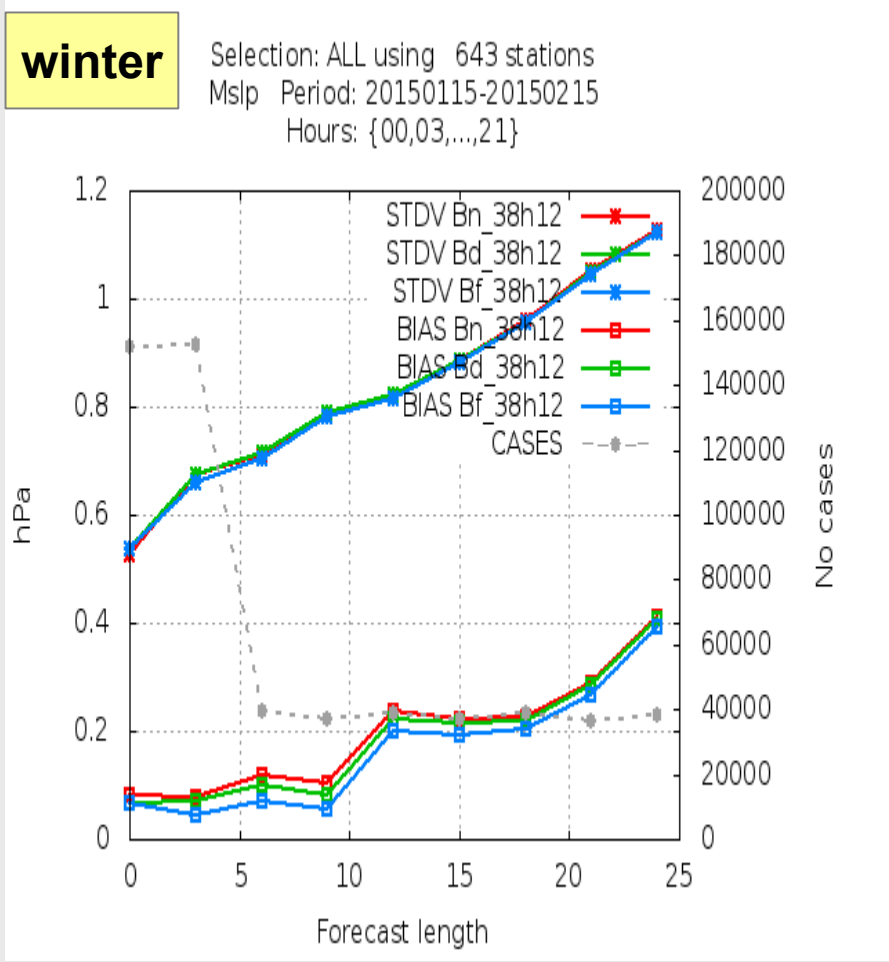
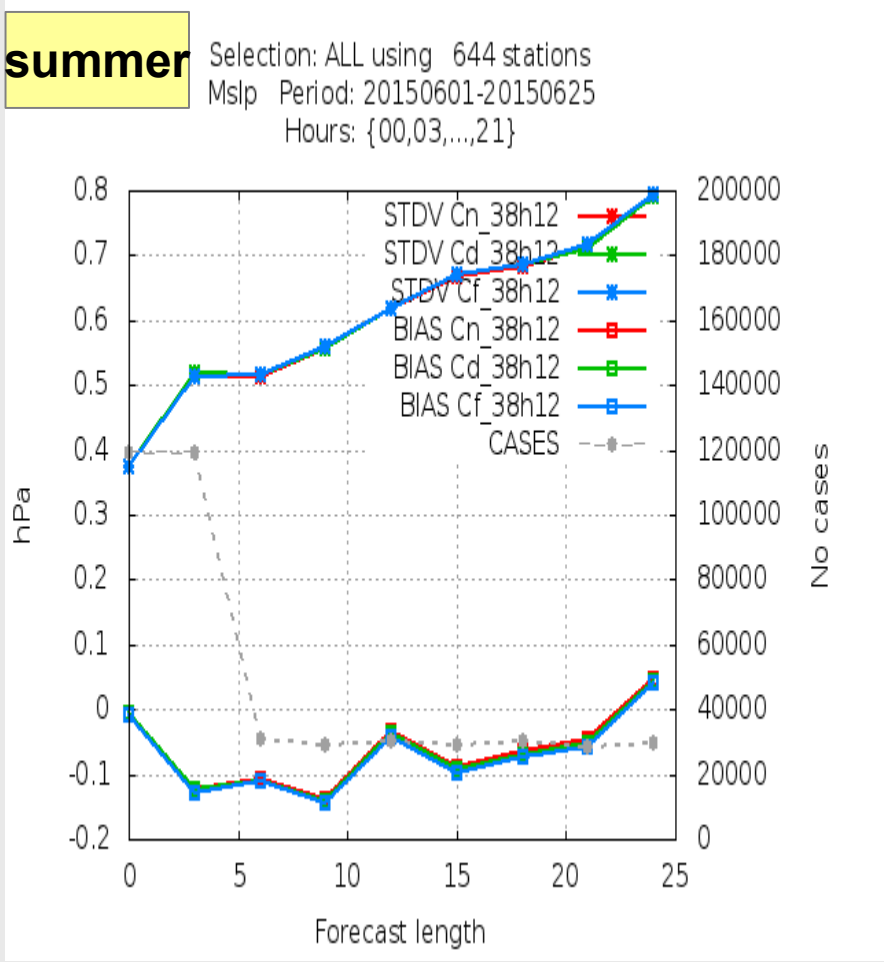


1. CLEAR ECHO: surface verification-MSLP





noradar, radar-all, radar-rainy

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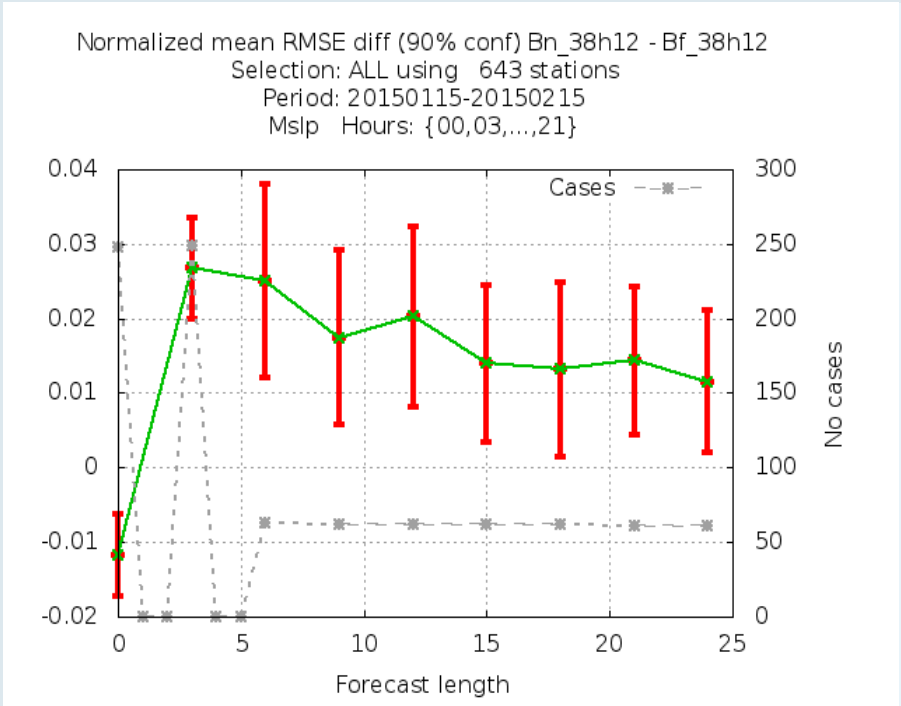
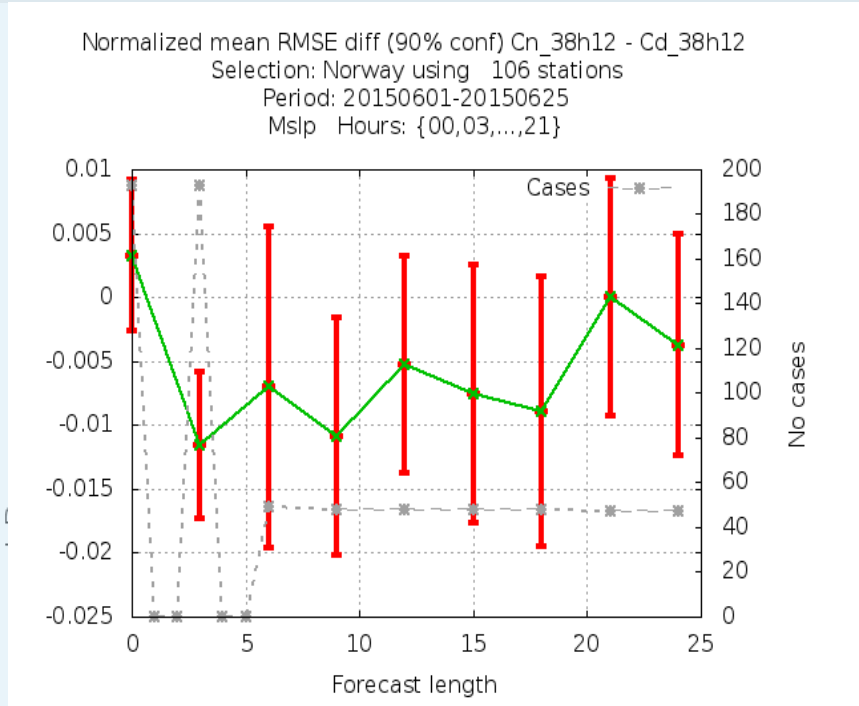
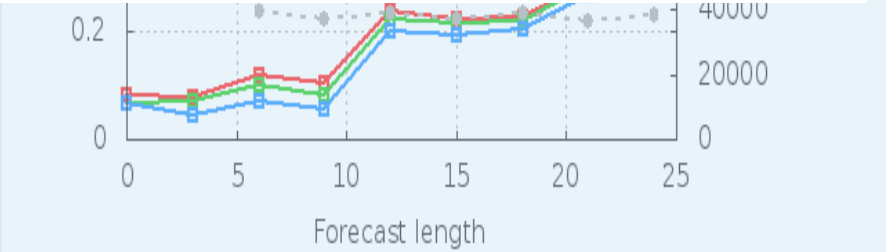
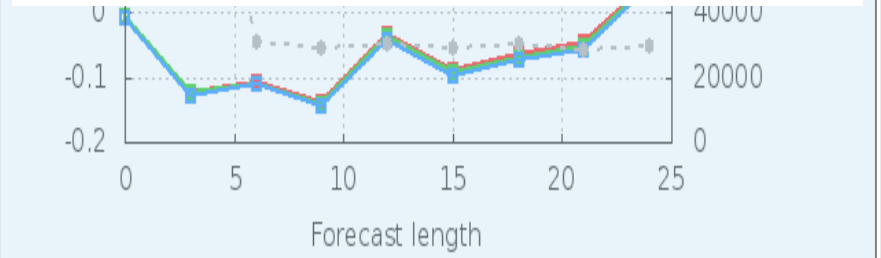
1. CLEAR ECHO: surface verification









noradar, radar-all, radar-rainy

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1. CLEAR ECHO: surface verification

smallest bias winter

Mslp	**radar-rain**
T2m	**radar-rain**
Td2m	**radar-rain**
RH2m	**radar-full**
U10m	-
U10m dir.	-

smallest bias summer

Mslp	-
T2m	**radar-full**
Td2m	**radar-full**
RH2m	**radar-full**
U10m	-
U10m dir.	-

noradar, **radar-all**, **radar-rainy**

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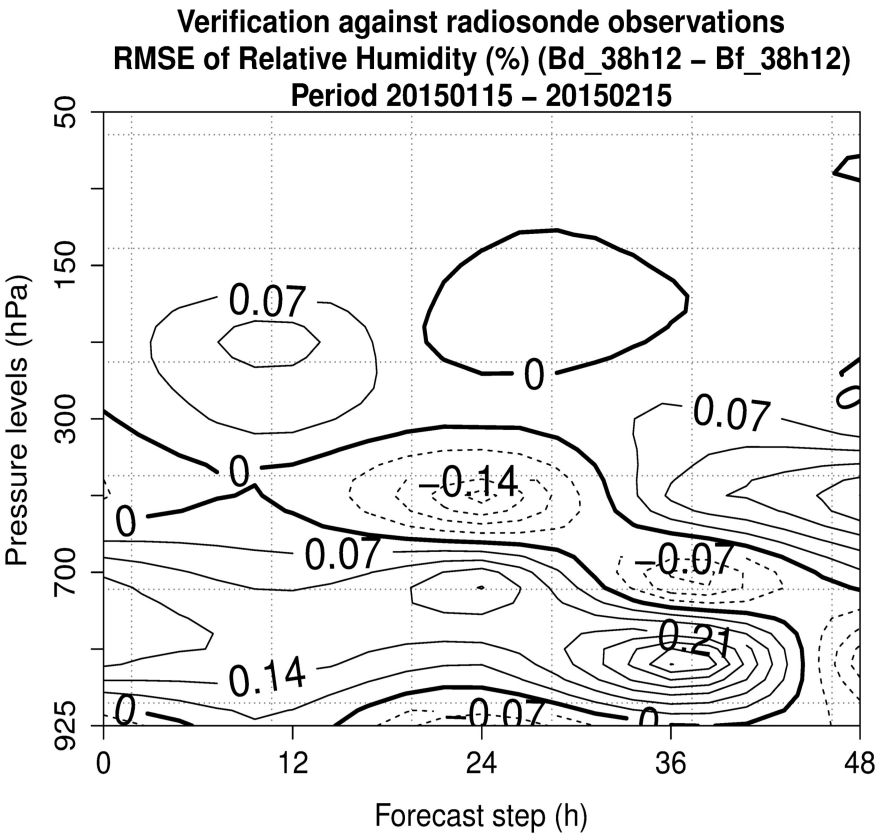
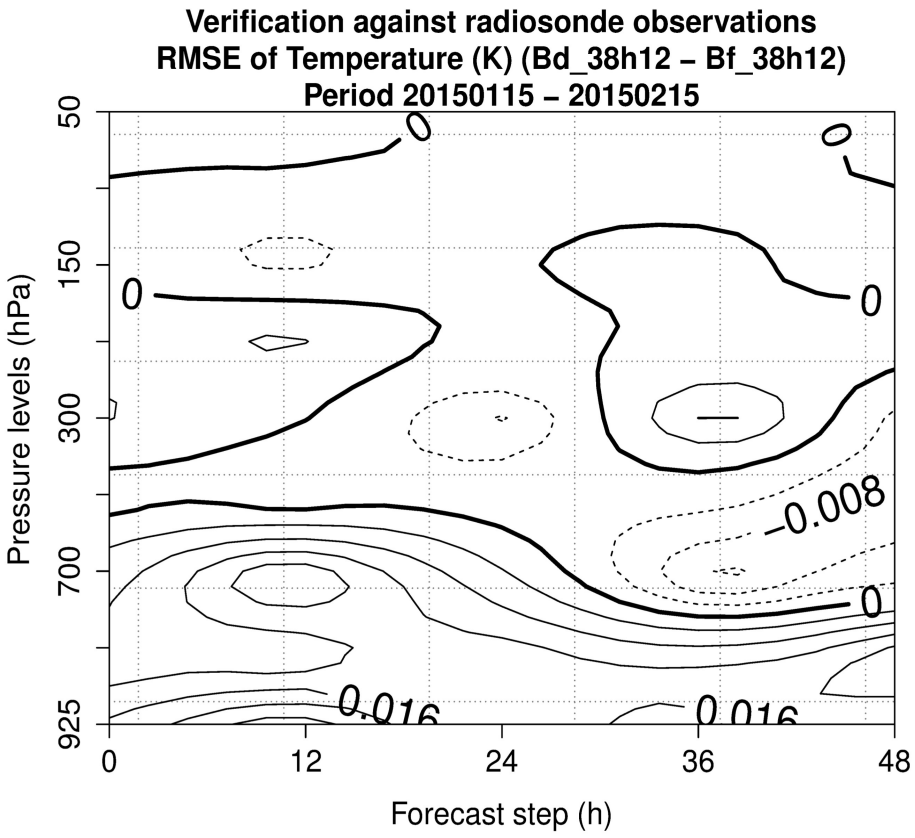
1. CLEAR ECHO: vertical profile-RH2m&T2m





Better forecast skill of temperature and humidity at lower levels in radar-rainy than radar-full at {00}.

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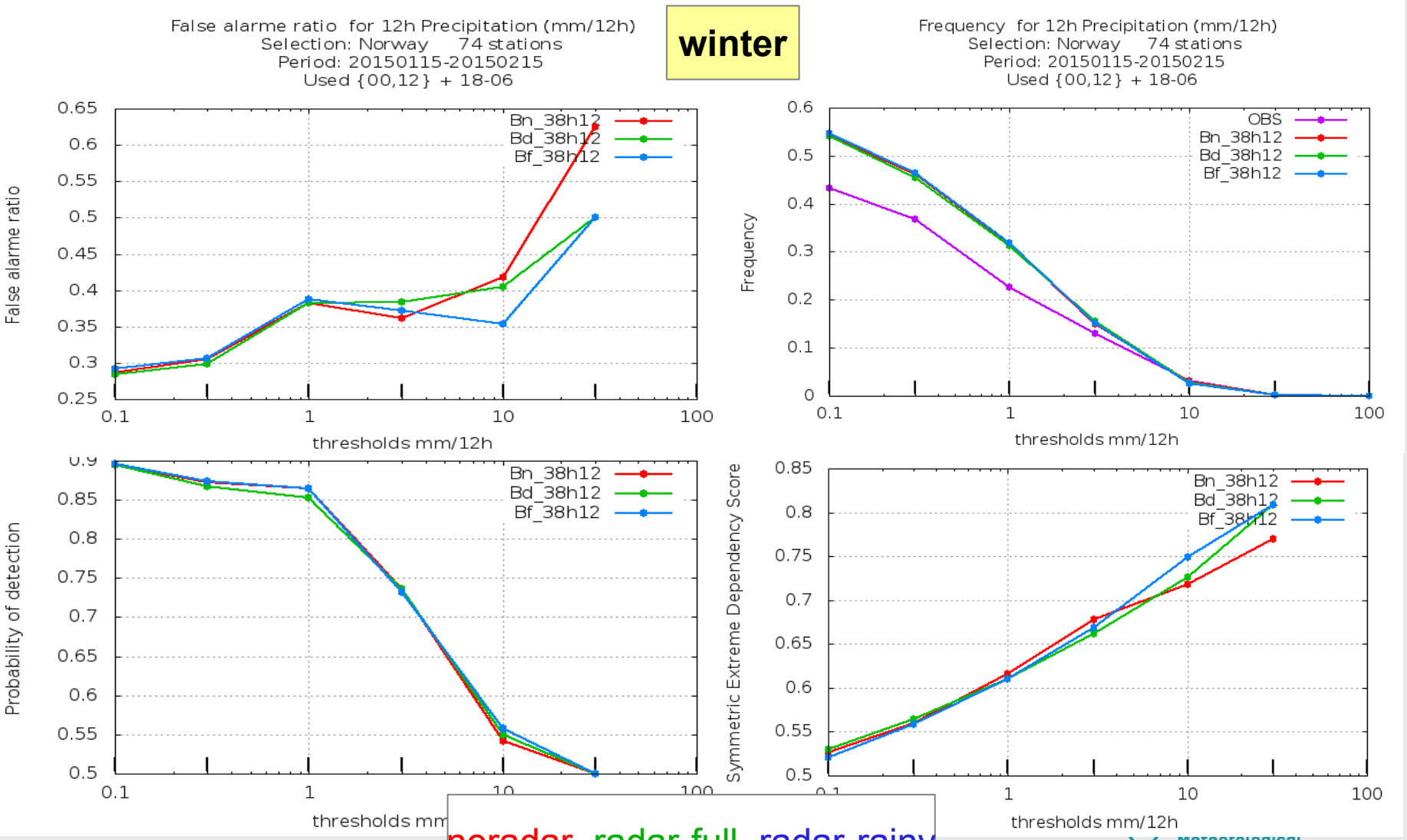
1. CLEAR ECHO: surface skill-12h prec.

winter



noradar, radar-full, radar-rainy

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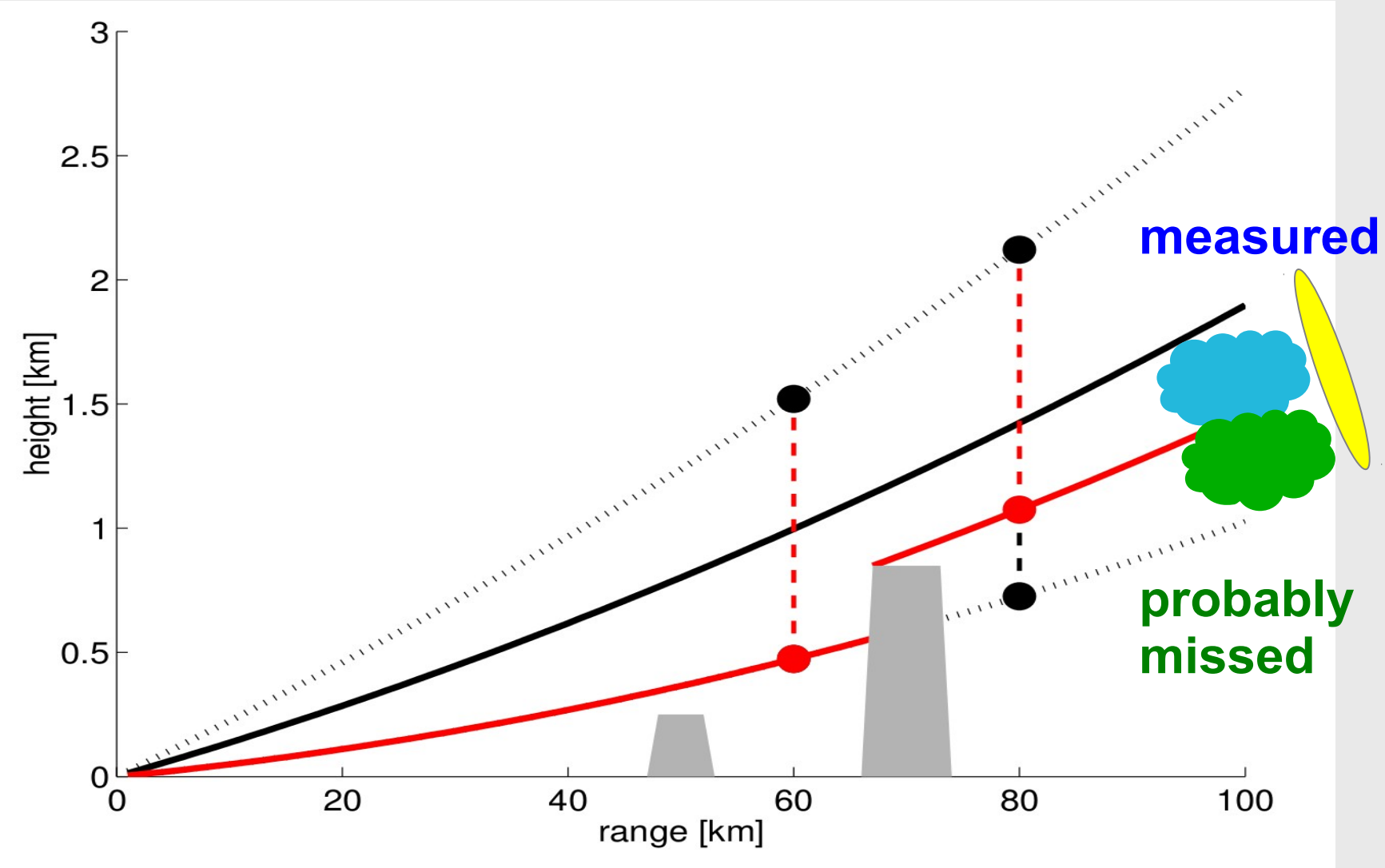
2. BLOCKING: background

- Norwegian radars located mostly in mountainous coastal regions
- radar beams partly blocked in lower scans by the terrains
- reflected echo from hydrometers under-represents the actual power

- to account for blockage percent and estimate actual beam power
- use a new function in CONRAD

- to assimilate corrected blocked radar reflectivity

2. BLOCKING: preprocessing- why 50%



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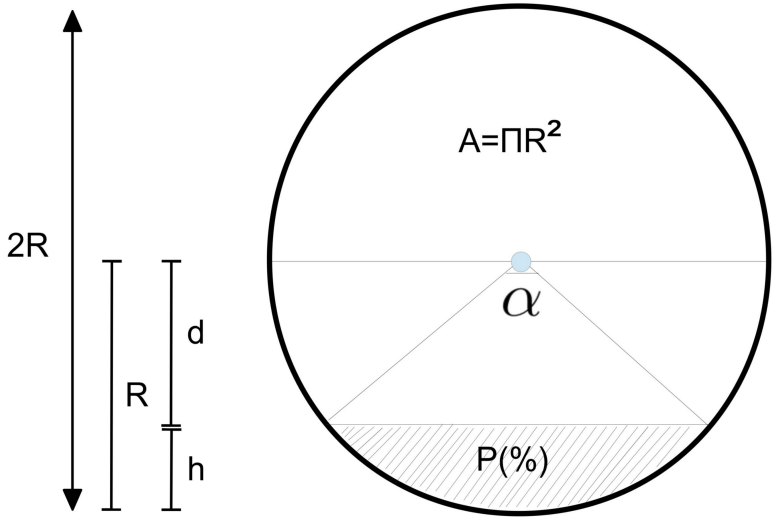
2. BLOCKING: preprocessing

$$R_{new2} = R_{old} + R_{old} * B * f(\alpha)$$

blockage percent ($0 \leq B \leq 0.5$)

$$f(\alpha) = exp\left[-ln2(cos\frac{\alpha}{2})^2\right]$$



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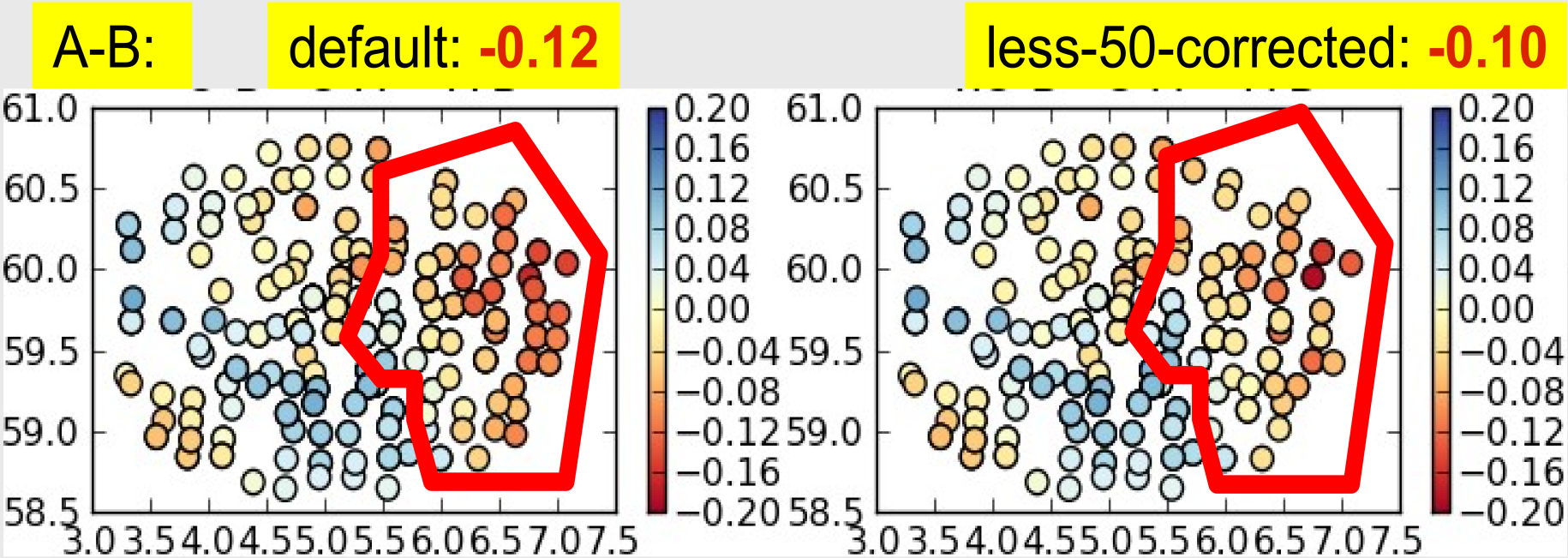

In radar Bomlø for observations in 850-500 mb, the correction moistens the humidity profiles inside the blocked region.

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1. BLOCKING: surface verification

smallest bias winter

Mslp	**block-corr**
T2m	**block-corr**
Td2m	**block-corr**
RH2m	-
U10m	**block-corr**
U10m dir.	-

smallest bias summer

Mslp	**radar-full**
T2m	**block-corr**
Td2m	**radar-full**
RH2m	**radar-full**
U10m	-
U10m dir.	-

noradar, **radar-full**, **block-corr**

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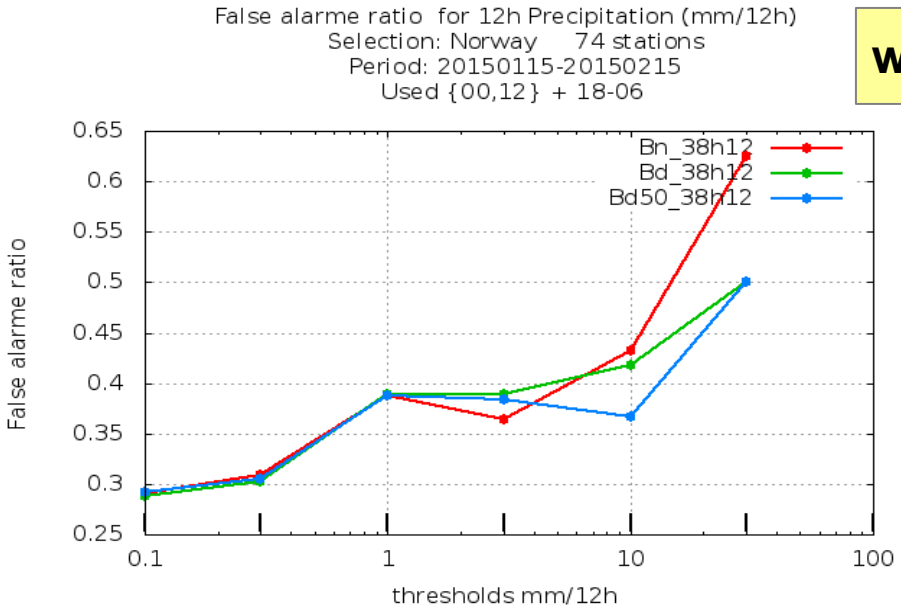
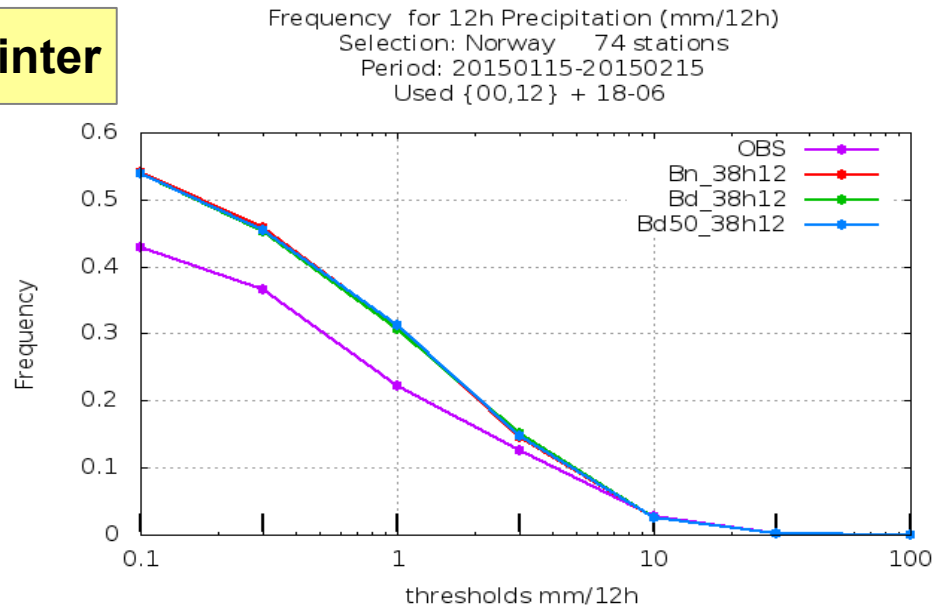
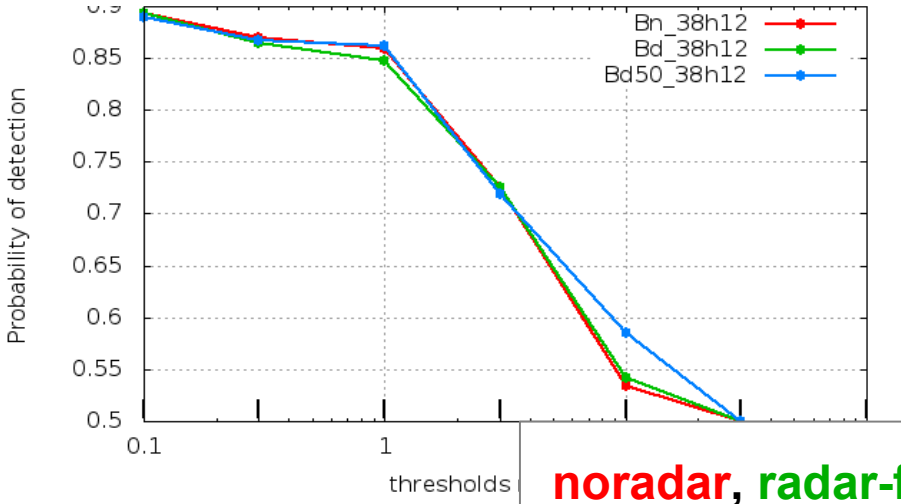
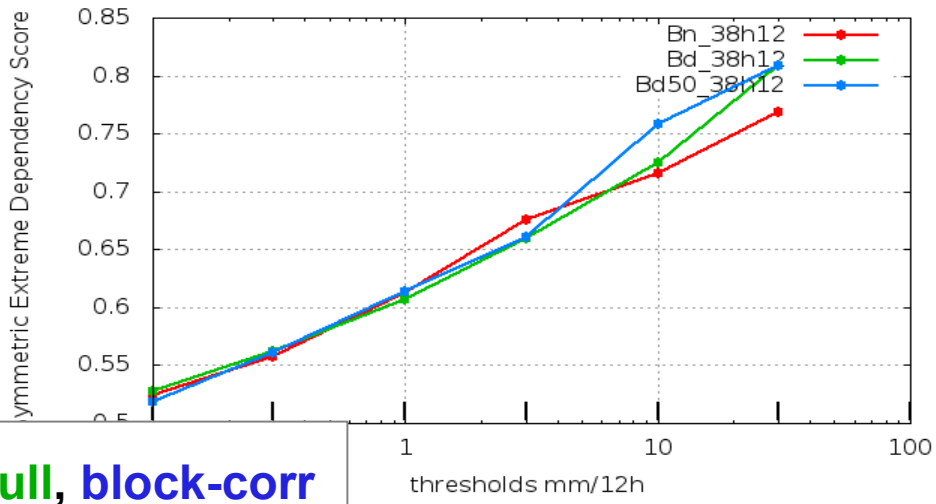
2. BLOCKING: surface skill-12h prec.

winter









noradar, radar-full, block-corr

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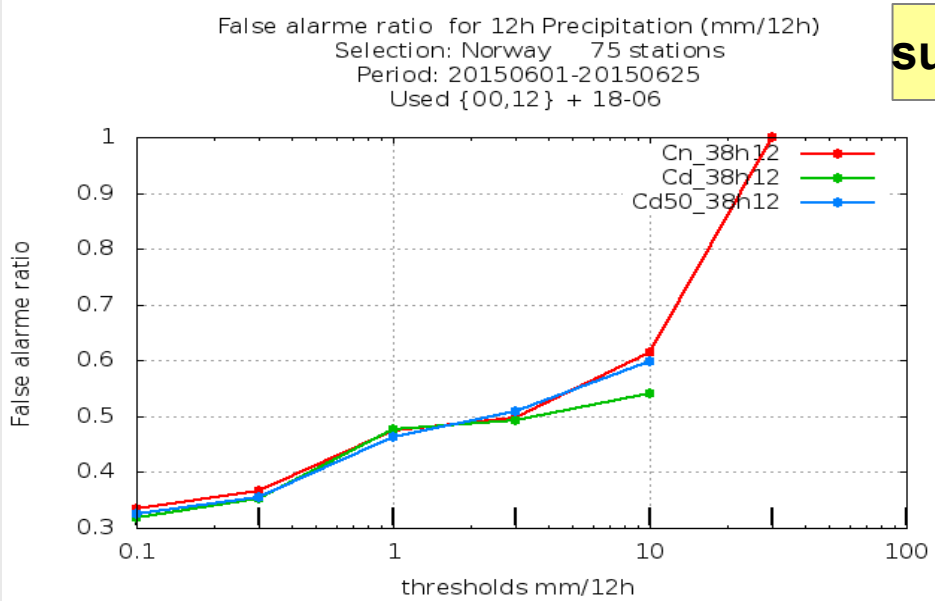
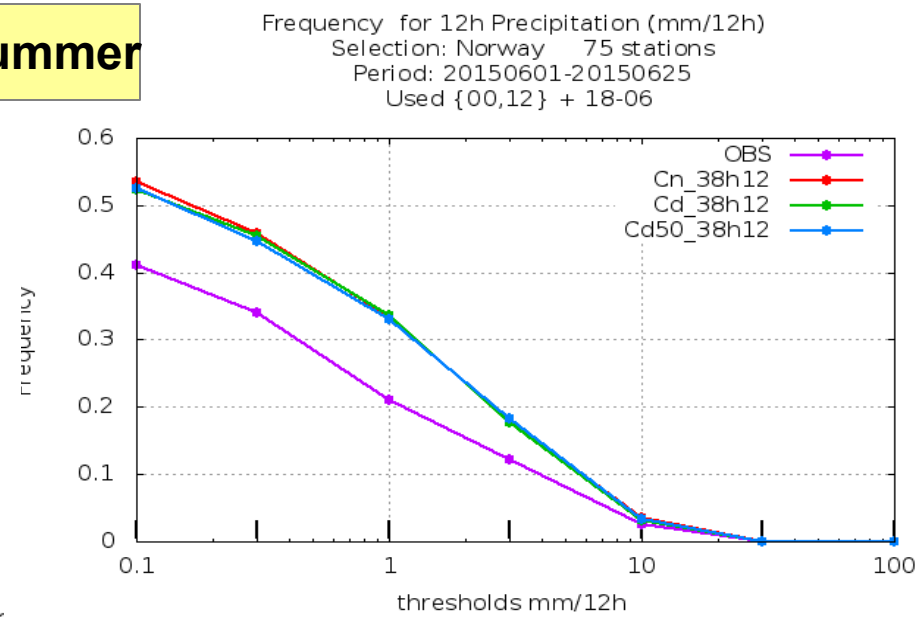
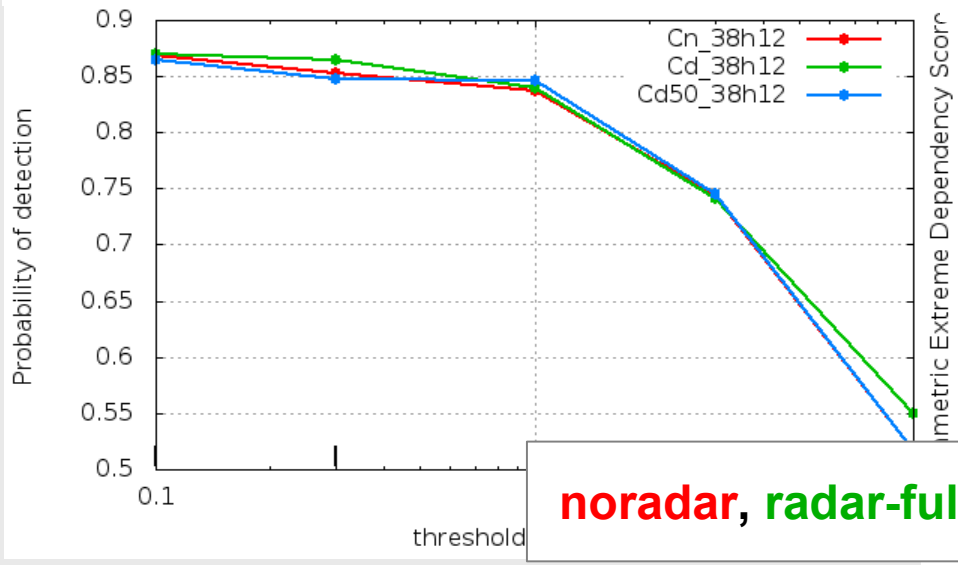
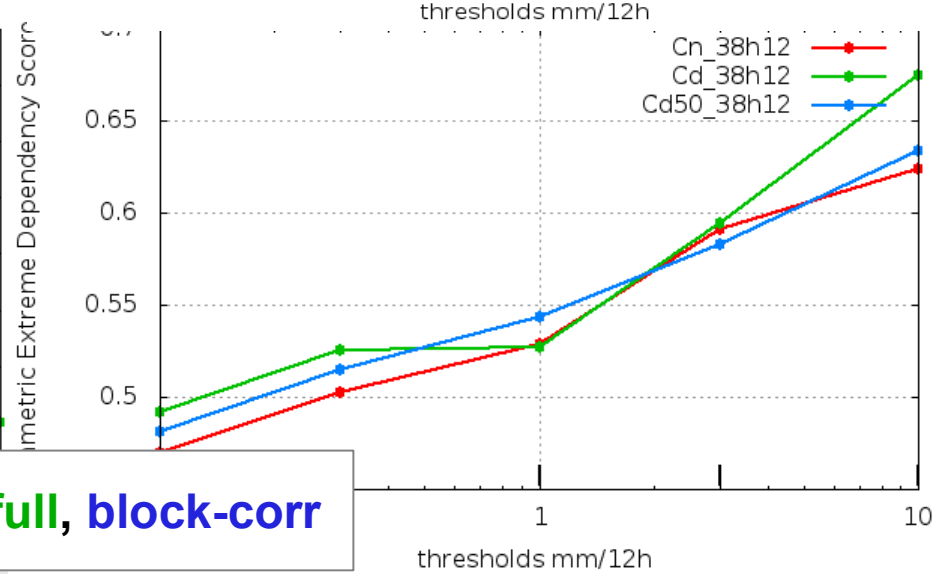
2. BLOCKING: surface skill-12h prec.

summer









noradar, radar-full, block-corr

3. RANGE: the optimal range

- the echoes observed furthest out are at high levels.
- rainfall which reaches down to the ground may not be measured.
- signal width increases with distance so the resolution is coarser.

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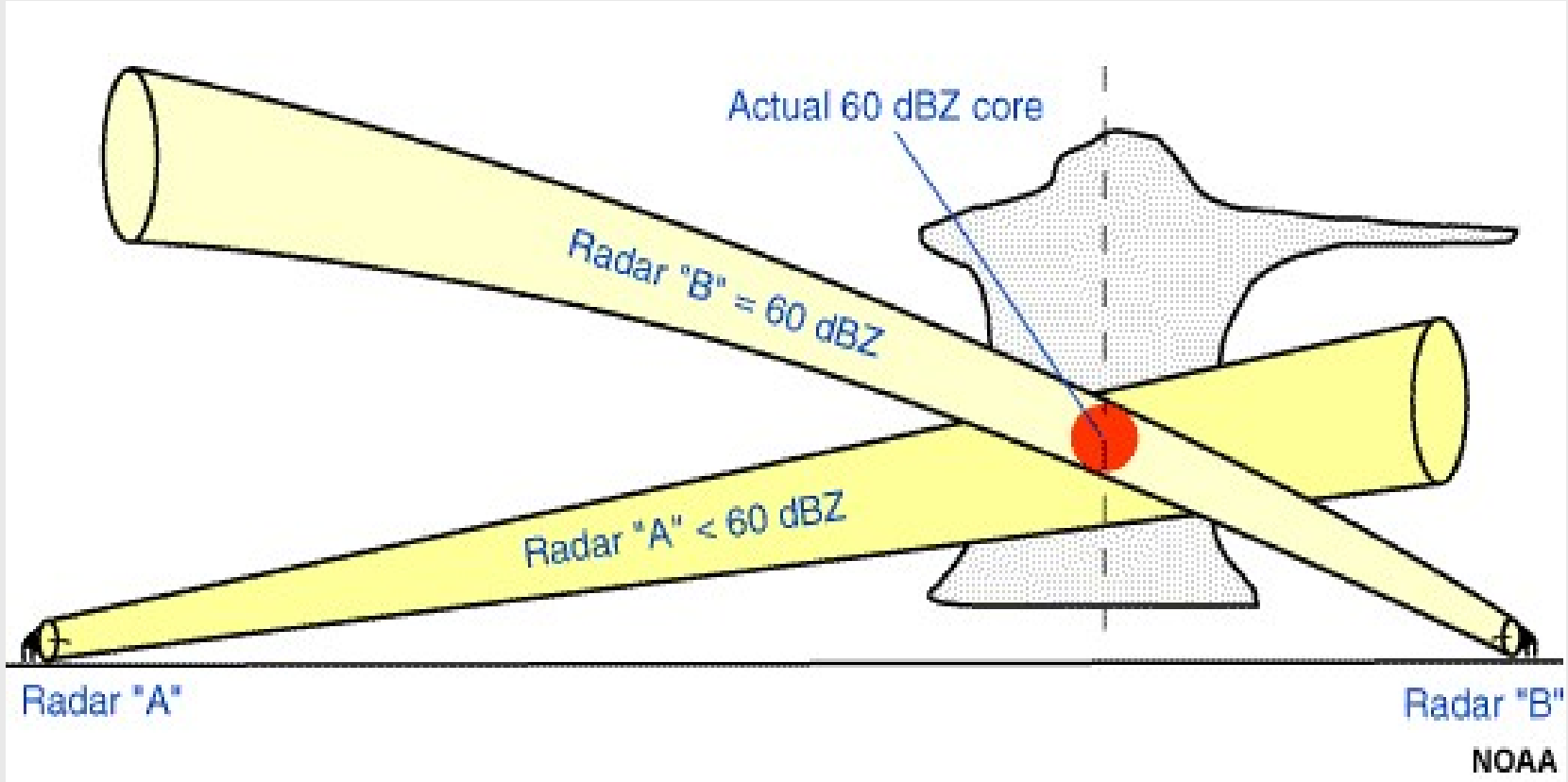
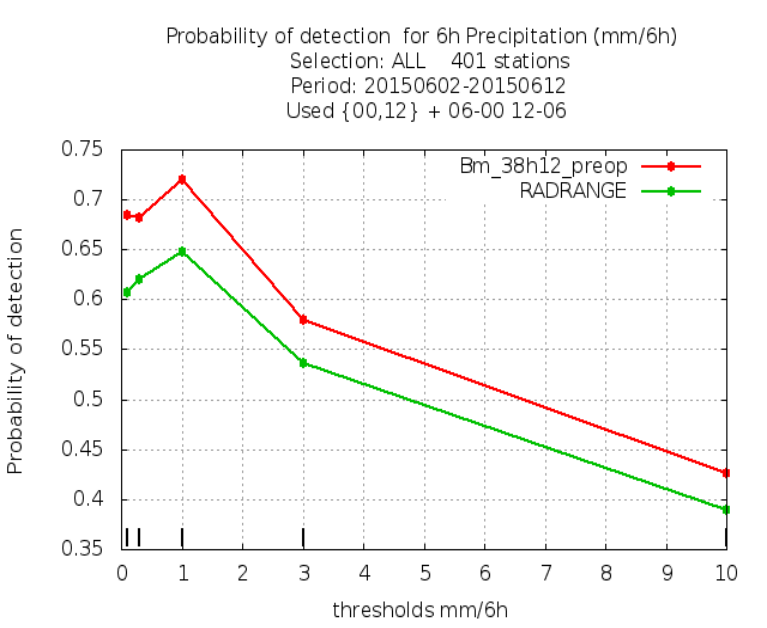
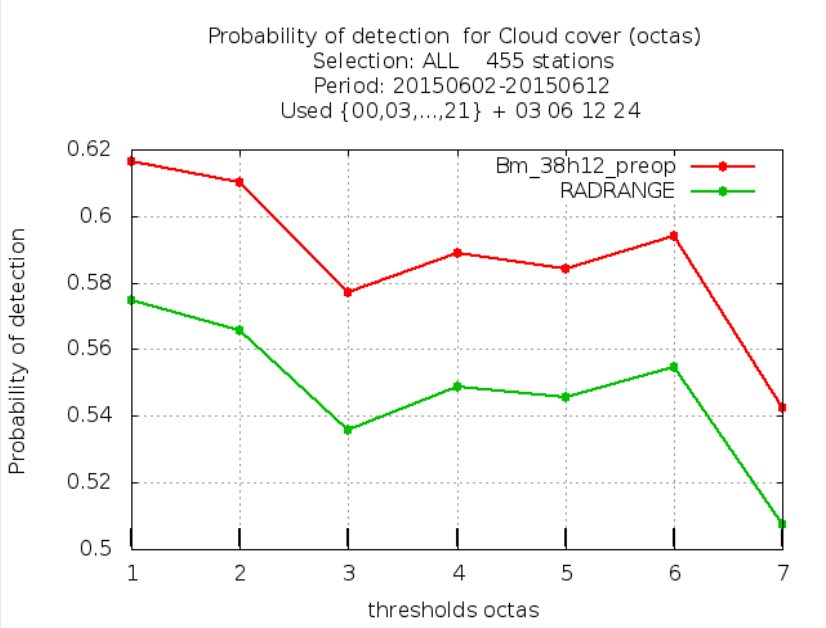


3. RANGE: significant degradation for 240km





radar_120km, radar_240km

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Concluding Remarks

- Only assimilating rainy pixels improves the forecast skill for the winter period.

- Correcting the reflectivity from blocked beams increases the skill , also for the accumulated precipitation, for both winter and summer period.

- The optimal range for radar data should be chosen to be less than the maximum range. But currently 120 km range should be revised.

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