On the spatial verification of FROST-2014 precipitation forecast fields

Anatoly Muraviev (1), Anastasia Bundel (1), Dmitry Kiktev (1),

Nikolay Bocharnikov (2), and Tatiana Bazlova (2)

(1) Hydrometcentre of Russia/Roshydromet, Moscow,

(2) Institute of Radar Meteorology, Saint-Petersburg, Russia

COSMO GM, 07 September 2015, Wrocław, Poland

Outline

1. **Radar and model data used**
2. **Neighborhood method: R SpatialVx** *hoods2d* **function**
3. **Contiguous Rain Area: R SpatialVx** *craer* **function**
4. **Conclusions on application of spatial methods for precipitation during the Sochi-2014 Games**

One-hour radar precipitation analysis was prepared by IRAM

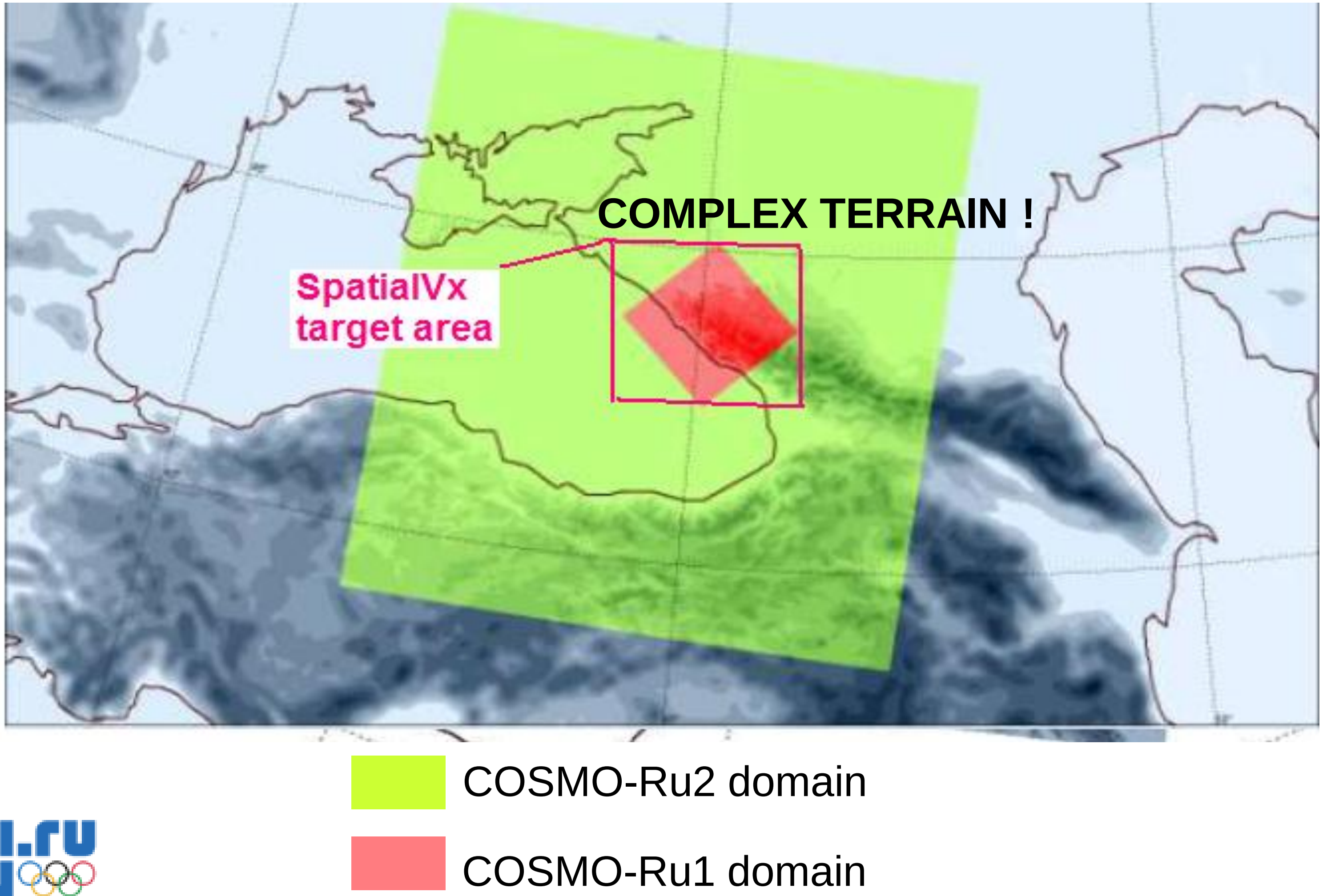
Akhun (Sochi) Radar

- Location: 43.5482, -320.149
- Ground Height: 650 m
- Horn Height: 33 m
- Wavelength: 5 cm; C-Band
- Beam Width: 0.95 deg
- Vaisala WRM200, RVP900, IRIS 8.13
- This work used the HIGH_PRF scan
  - Dual-polarized volume scan
  - PRF 1000/750 Hz
  - Pulse width 0.50 μs
  - 9 elevation angles
  - 0.25 km range bins out to 125 km
  - 1 deg azimuth resolution
  - Scan every 10 minutes

From Reid et. al
4th FROST meeting

Area of the study

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

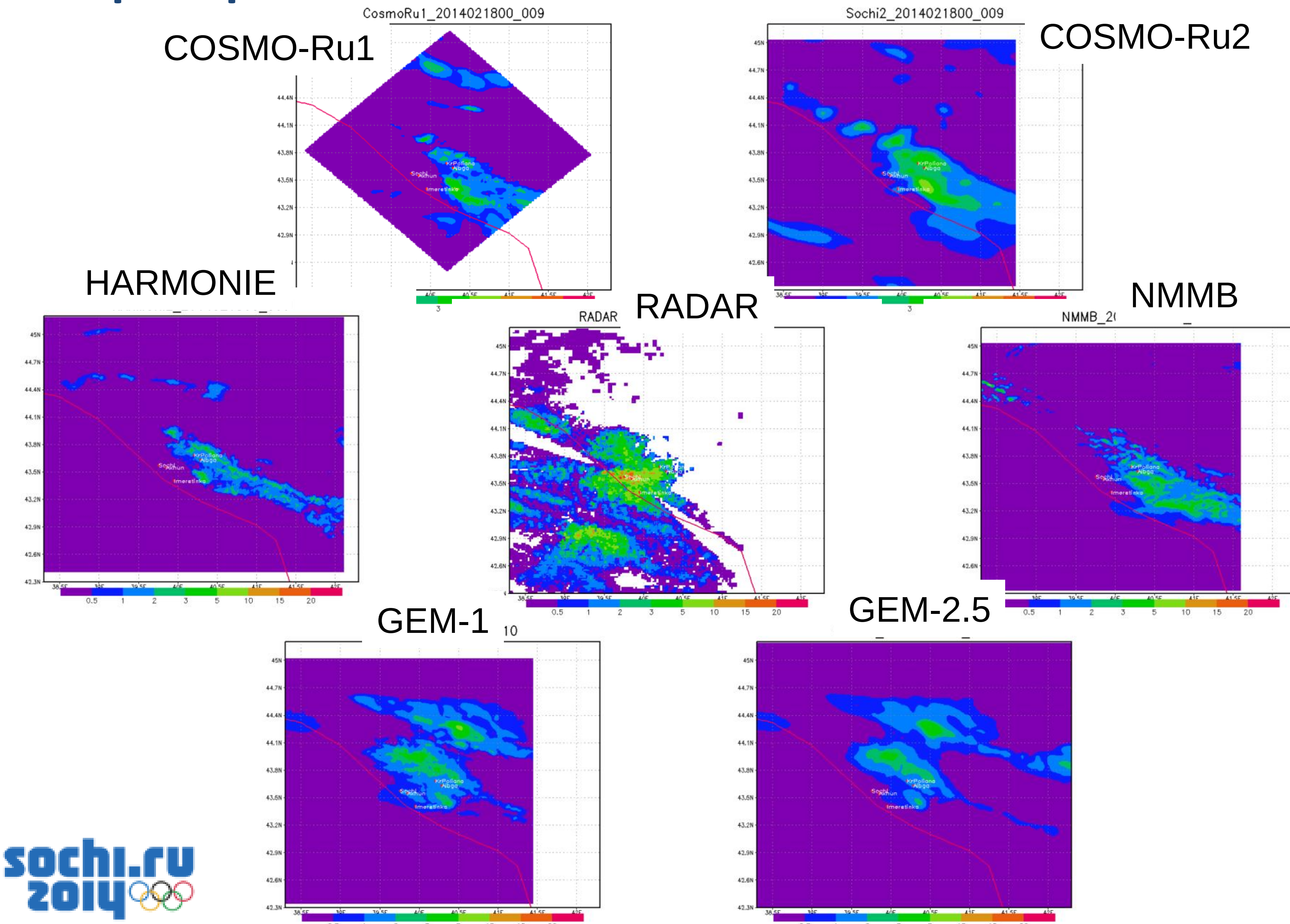


All the models were interpolated into the radar grid using GRADS (function *lterp*)

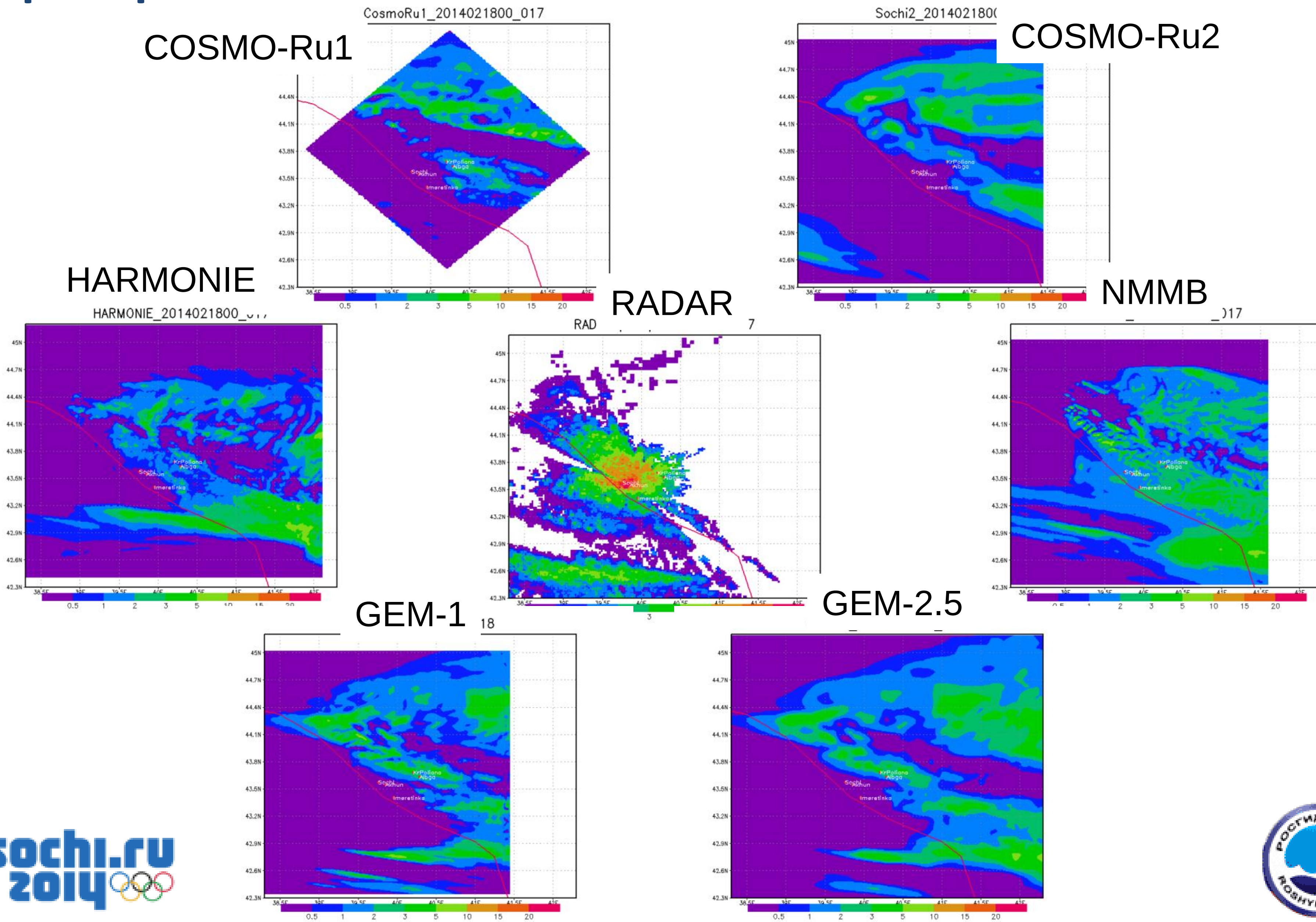
- COSMO-Ru1 (1 km)
- COSMO-Ru2 (2 km)
- NMMB (1 km)
- HARMONIE (1 km)
- GEM-1 (1 km)
- GEM-2.5 (2.5 km)

GEM-0.25: too small domain!

18 Feb 2014, 09 UTC, cold front: All models underestimated max precip and didn’t give precip over the sea.

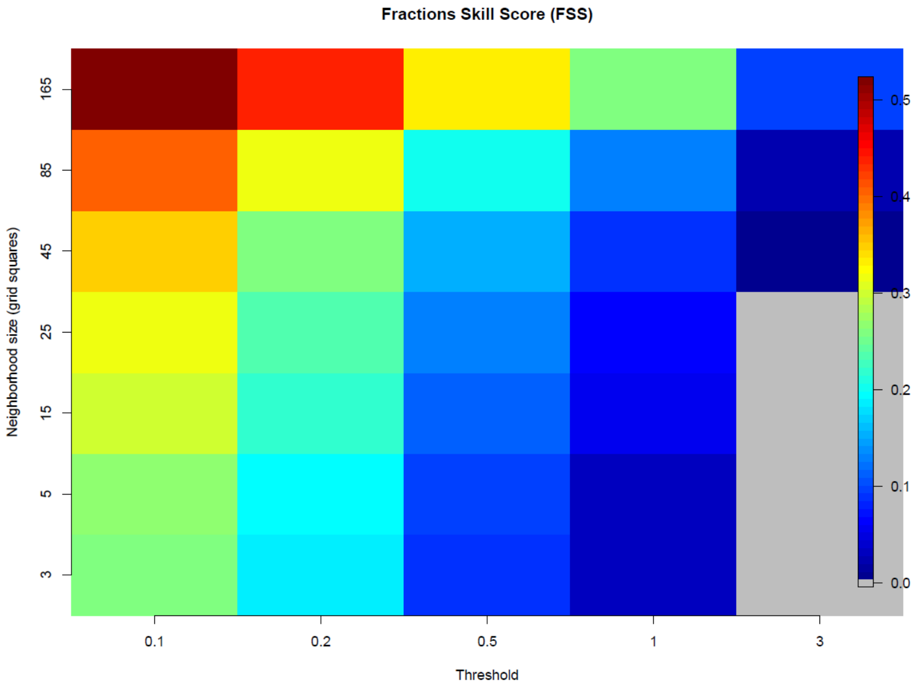


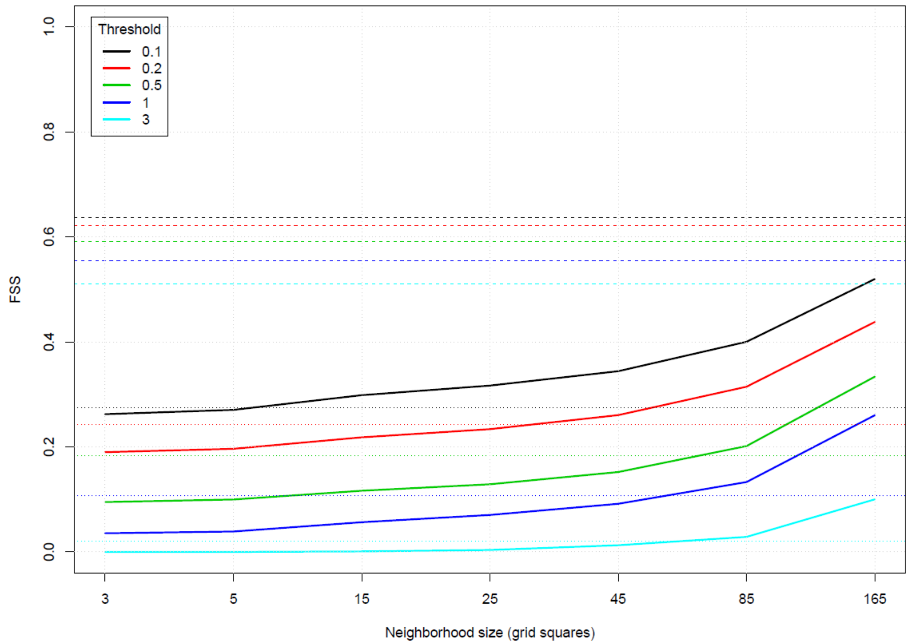
18 Feb 2014, 17 UTC, all models predicted expanding precipitation area, but not the max value



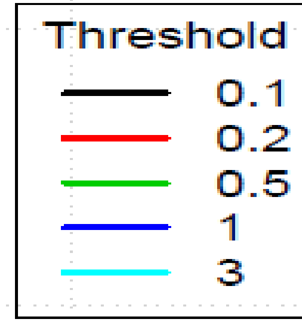
hoods2d

- Different scores were calculated, but the FSS (Roberts and Lean 2008) is presented as one of most useful neighborhood statistics (see, e.g., COSMO INTERP project)



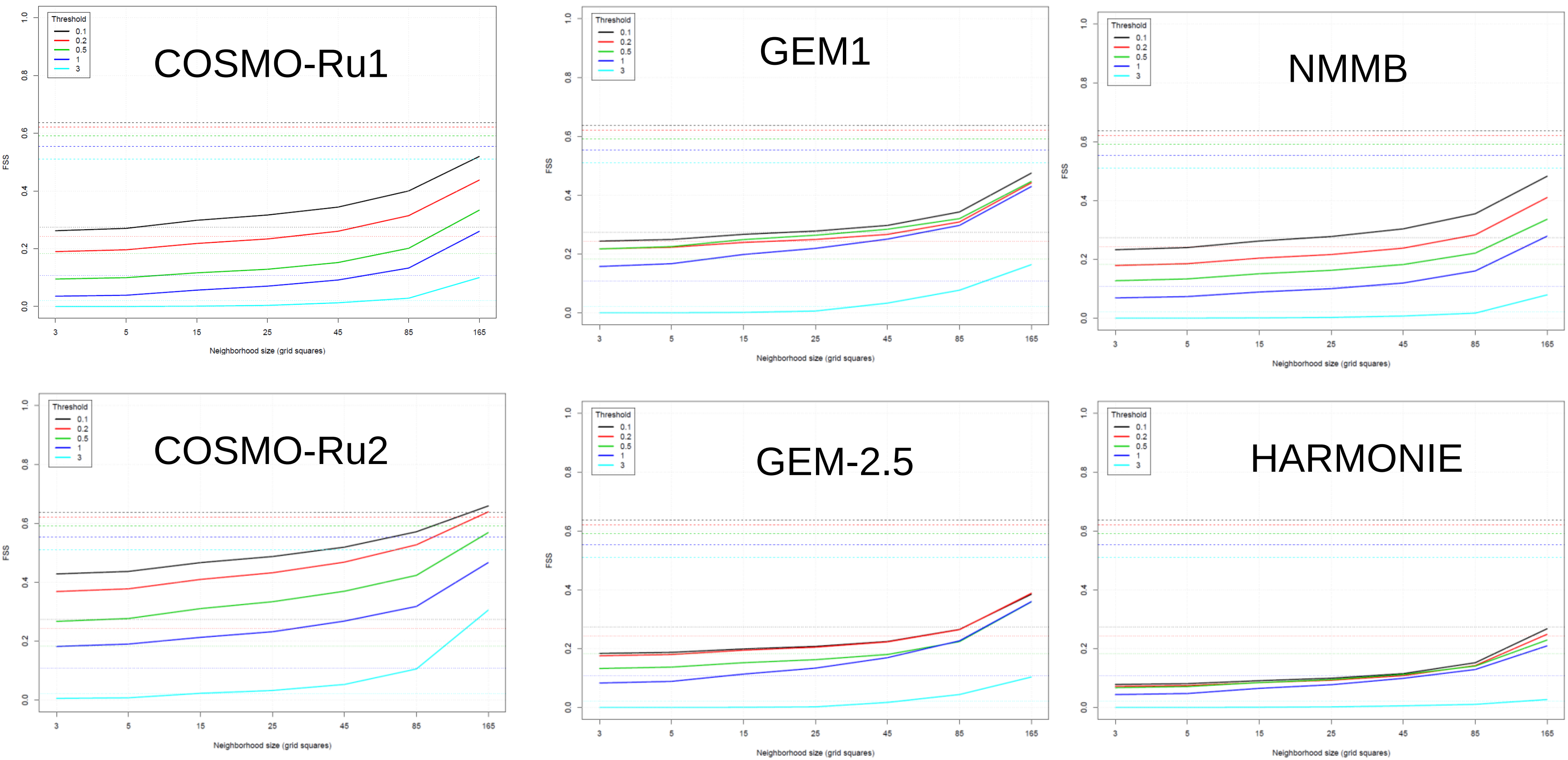


FSS, 18 Feb 2014, 09 UTC



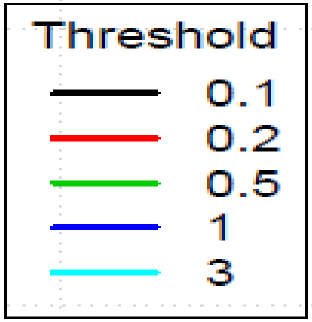
Note: 2-2.5-km models are interpolated onto ~1km grid!

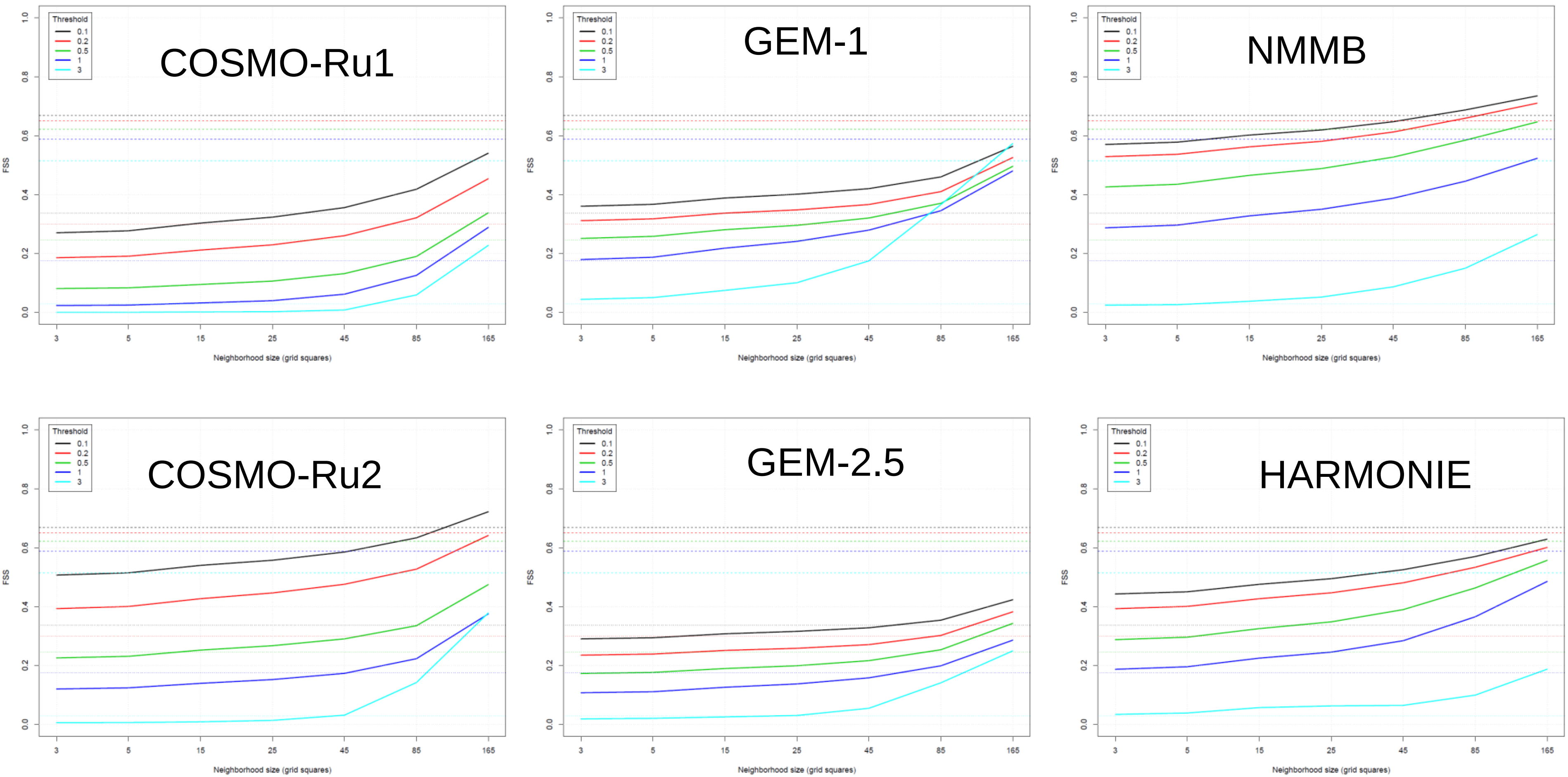
COSMO-Ru2 is best here, its FSS is useful at all scales except for the highest threshold (precip ≥ 3mm/h)
GEM-1 is good for middle thresholds (0.5 and 1 mm/h)



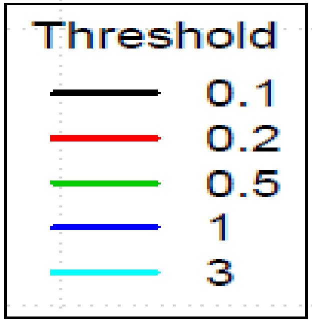
FSS, 18 Feb 2014, 17 UTC

NMMB and HARMONIE have comparable high skill.
COSMO-Ru2 looses its skill for higher thresholds





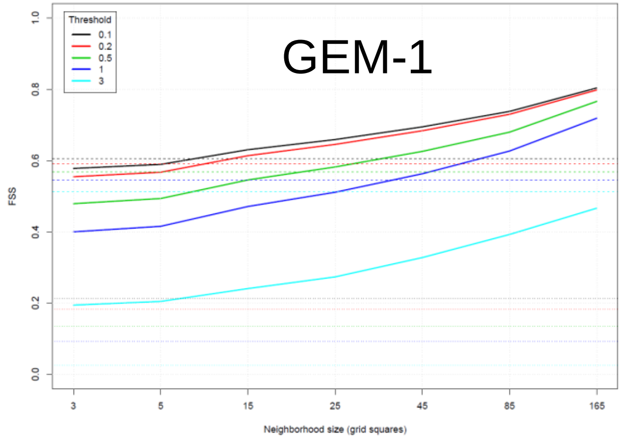
22 Jan 2014, 23 UTC, intense precipitation

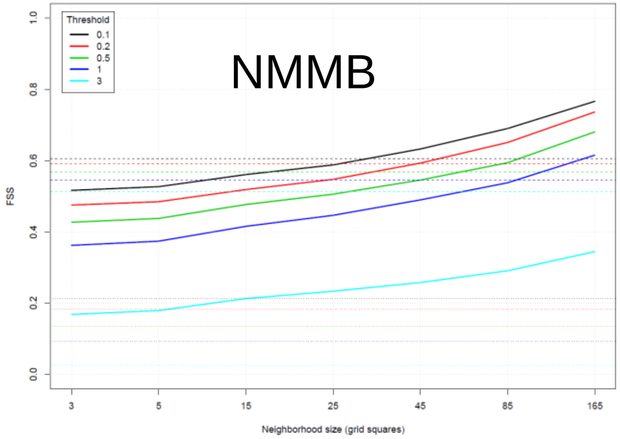


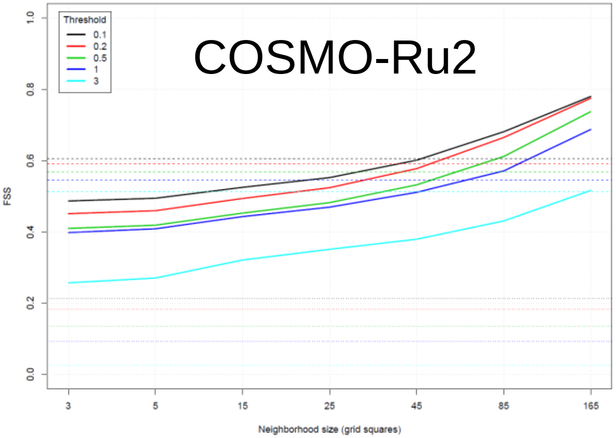
Good forecast by all models.
COSMO-Ru2 and GEM-1 are the leaders

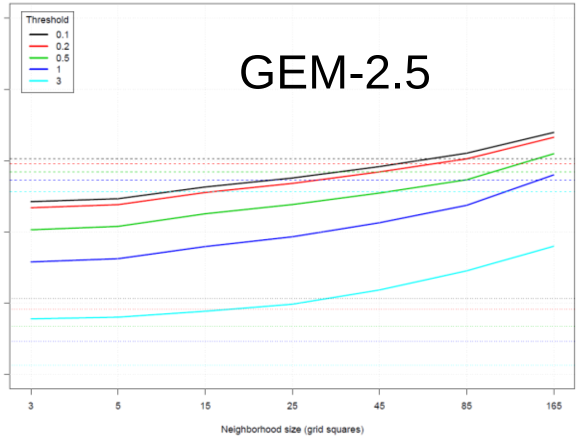
COSMO-Ru1

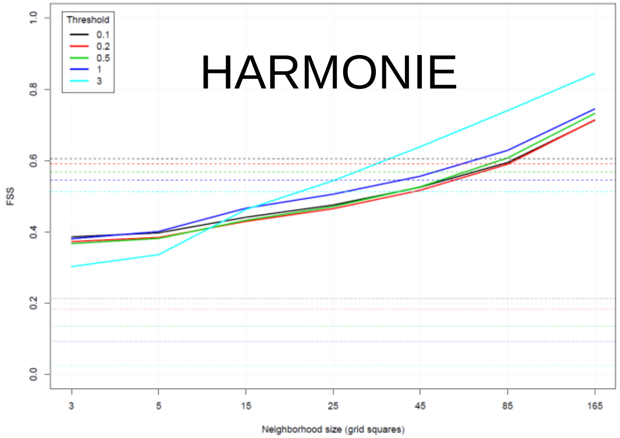
Not avail. until 29 Jan



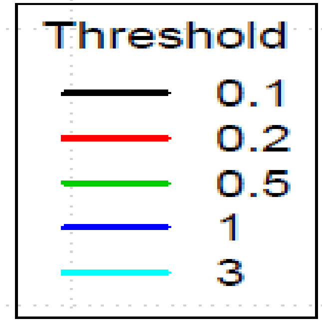




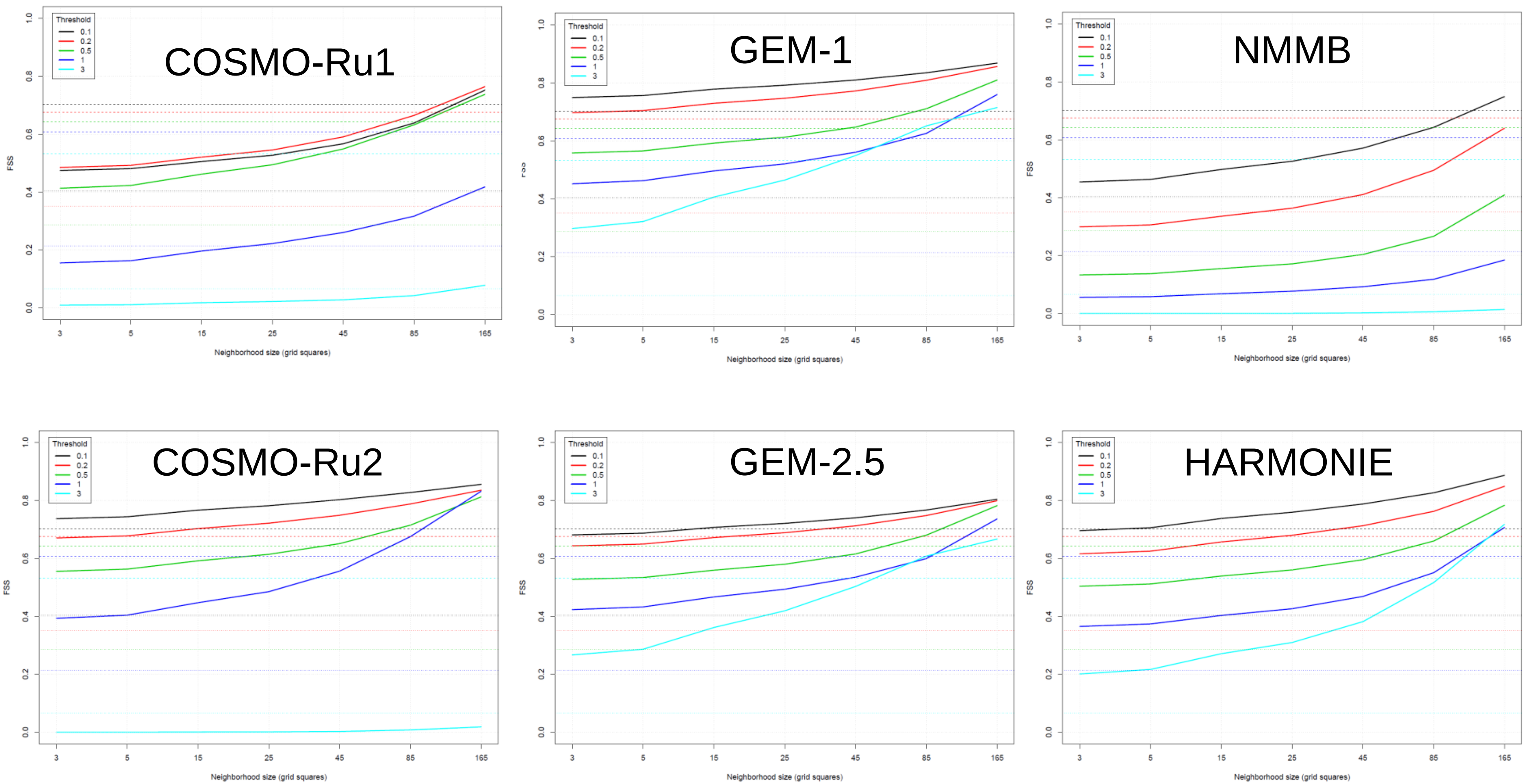




29 Jan 2014 21h

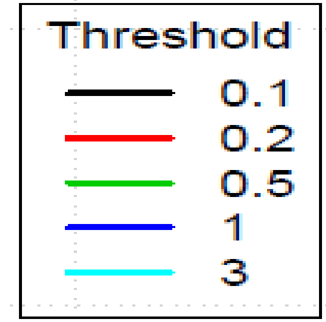


GEM-1, HARMONIE and COSMO-Ru2 are good,
but very bad forecast of precip>=3 mm/h by COSMO-Ru2
NMMB is worst here



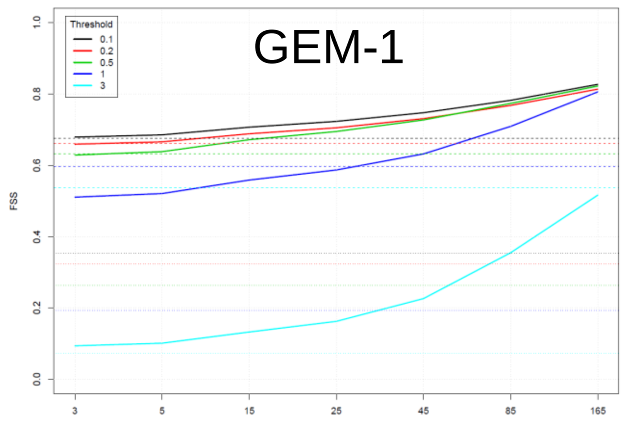
11 March 2014, 09UTC

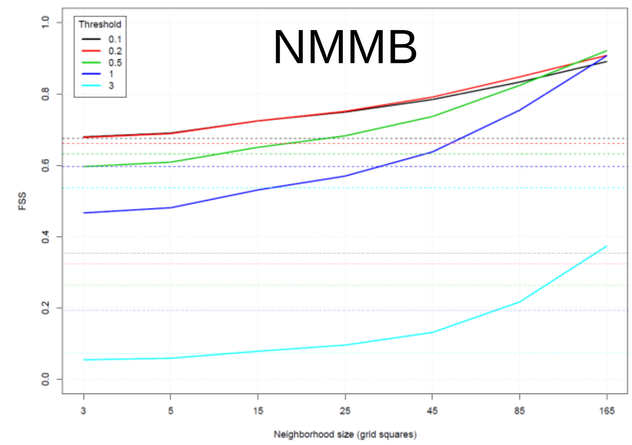
All: Bad forecast of precip>=3 mm/h

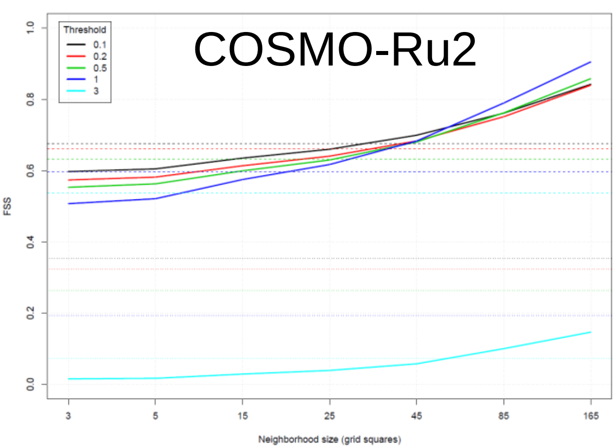


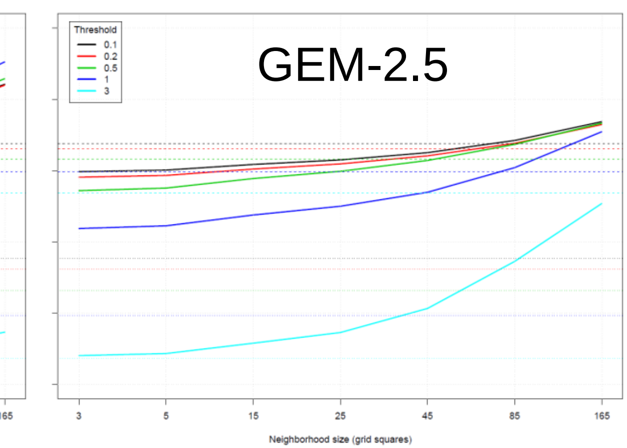
COSMO-Ru1

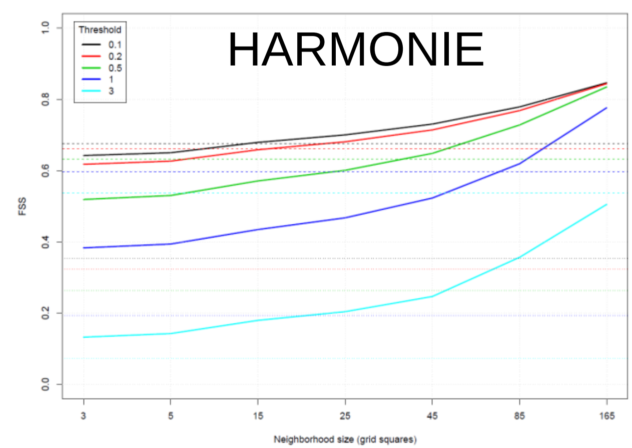
Not enough cases
to run hoods2d!











Neighborhood: conclusions

- All the models underestimated the maximum precipitation
- According to the FSS, COSMO-Ru2 tends to be better then COSMO-Ru1, GEM-1 is better than GEM-2
- Bad forecast of higher thresholds

We need to:

- aggregate neighborhood scores over all cases to estimate the systematic models' behavior
- include the cases where precipitation was predicted, but not observed
- analyze timing errors

CRA – Contiguous Rain Area (E.E. Ebert, J.L. McBride 2000)

http://www.cawcr.gov.au/projects/verification/CRA/CRA_verification.html

MSEtotal = MSEdisplacement + MSEvolume + MSEpattern

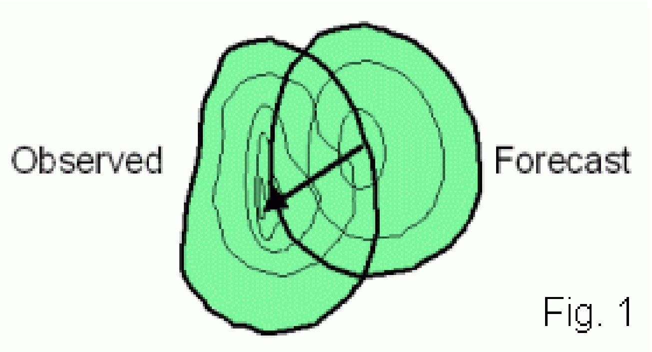


Fig. 1

MSEdisplacement = MSEtotal – MSEshifted

MSEvolume = (***F*** - ***X***)2

where ***F*** and ***X*** are the CRA mean forecast and observed values after the shift.

MSEpattern = MSEshift – MSEvolume

The CRA concept is easy to understand, but there are many important issues and nuances in application of the CRA

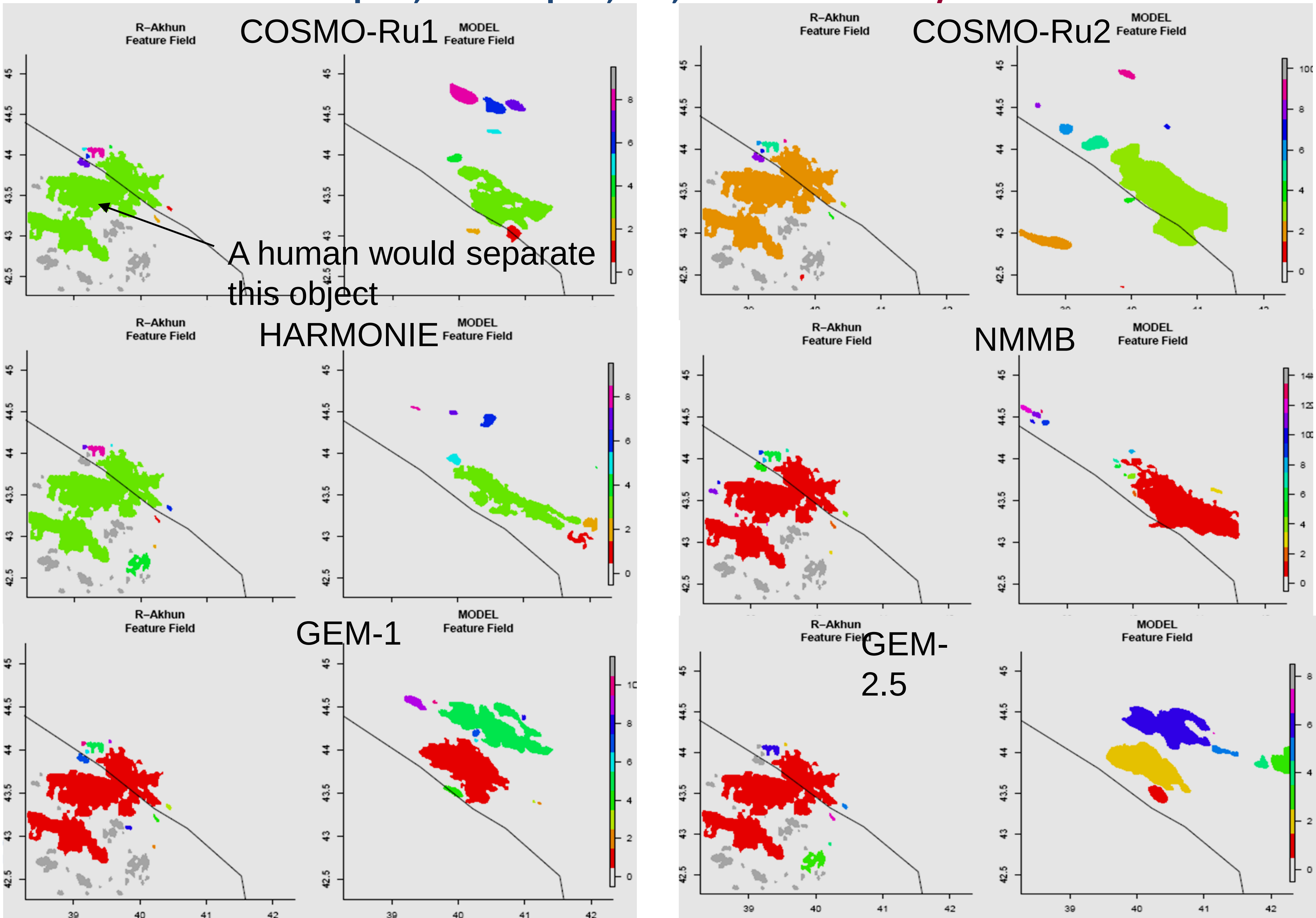
R SpatialVx *craer* function

- **Convolution threshold technique.** First, the field is smoothed using a convolution smoother, and then it is set to a binary image where everything above a given threshold is set to one (Davis et al, 2006)
- *Minboundmatch* function– **each object is pared to only one object according to the smallest minimum boundary separation**

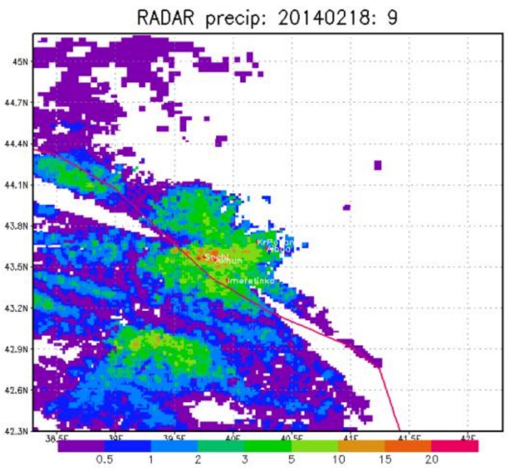
```
hold <- make.SpatialVx(xx, yy, map=TRUE, loc=zz,
field.type="Precipitation", units="mm/h",
data.name=c("Sochi_frcsts", "R-Akhun", "GEM25"))

look <- convthresh(hold, smoothpar=3, thresh=1)

look2 <- minboundmatch( look )

craer( look2, type = "fast", verbose = TRUE)
```

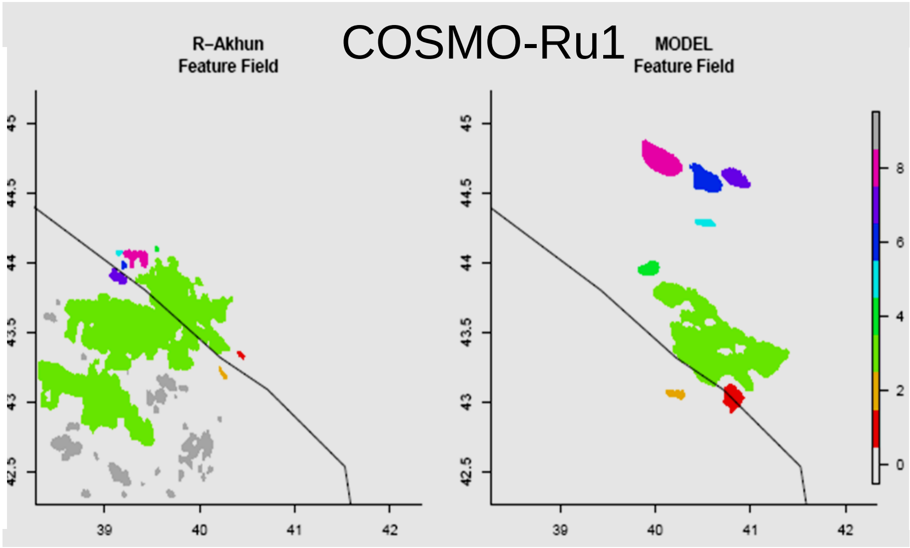
Pairs of matched objects from *craer*, 18 Feb 2014, 09 UTC

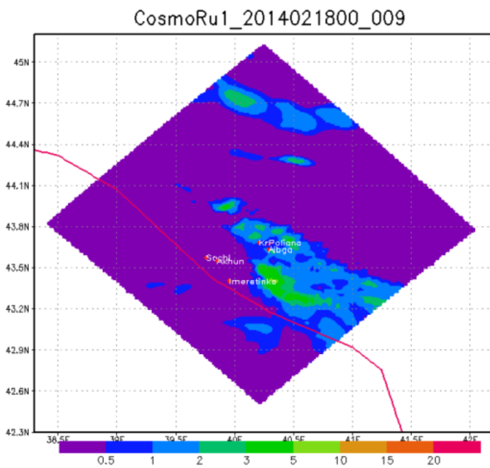
Colors indicate the 1st pair, the 2^{nd} pair, etc, threshold: 1mm/h



COSMO-Ru1



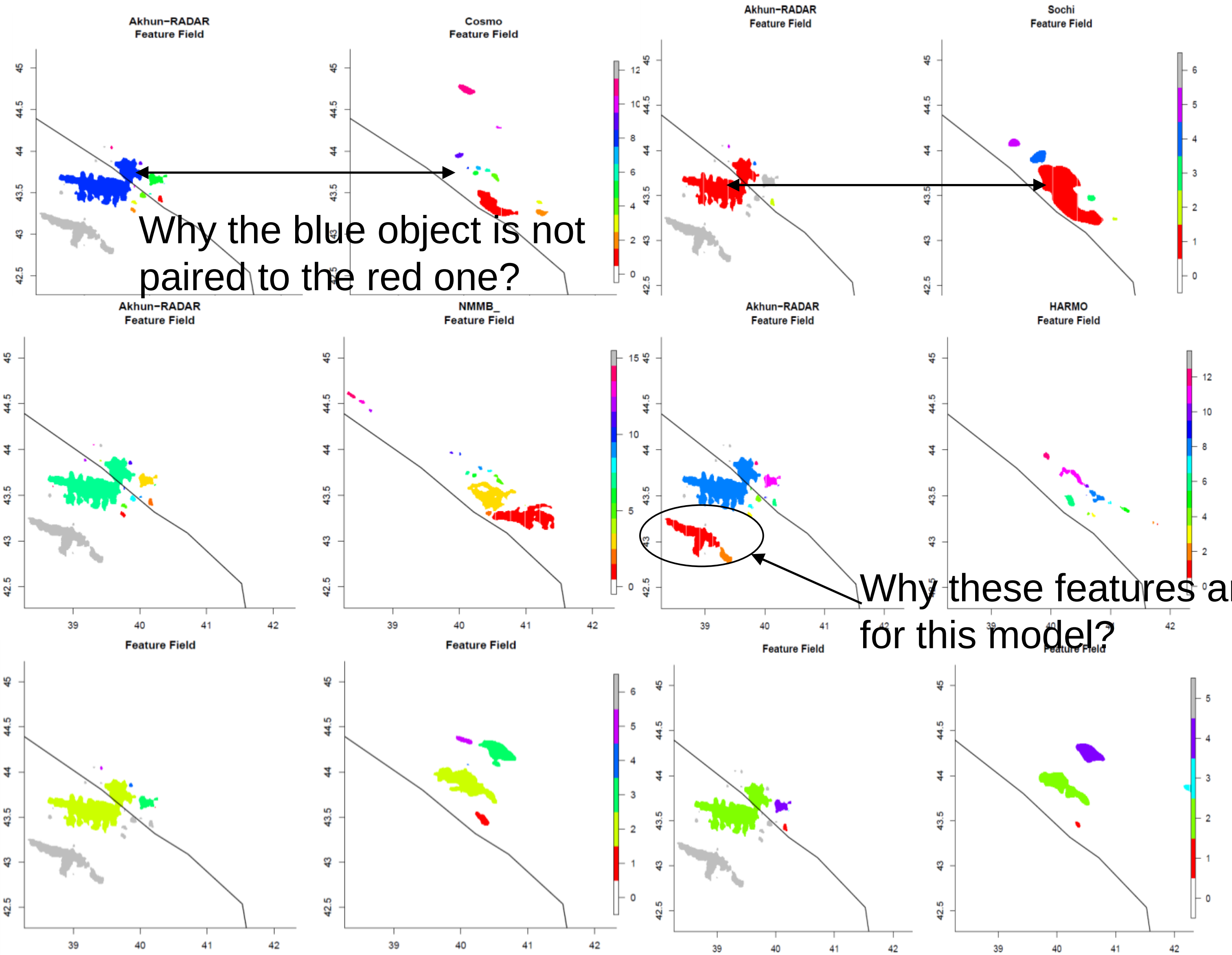




ir	x	y	MSE.total	MSE.shift	MSE.displace	MSE.volume	MSE.pattern
1	45.4021	-36.5179	0.0028	0.0023	0.0005	0.0000	0.0022
2	-2.7630	-17.8333	0.0011	0.0007	0.0004	0.0000	0.0007
3	159.7069	2.3035	0.1246	0.0820	0.0426	0.0027	0.0793
4	45.9893	-16.9170	0.0014	0.0012	0.0002	0.0000	0.0012
5	164.7442	25.5963	0.0011	0.0006	0.0005	0.0000	0.0006
6	159.3112	74.1525	0.0037	0.0033	0.0004	0.0000	0.0033
7	204.6084	85.0732	0.0032	0.0013	0.0019	0.0000	0.0013
8	85.7776	83.9482	0.0068	0.0036	0.0031	0.0000	0.0036

According to these scores, most of the total MSE error comes from the small-scale pattern errors for most object pairs

CRA threshold: 2 mm/h
(3mm/h gives too many little objects!)



Why the blue object is not paired to the red one?

Why these features are paired for this model?

Questions:

- There are many little objects. Can we set up a limitation on the maximum number of objects?
- Two apparently similar GEM fields: Different model objects are paired with the same radar object.
- Should there be a condition on the area size when pairing the objects? (the largest is paired to the largest)
- Try another pairing methods (*deltamm, e.g.*) with merging objects?

This study shows that we are not yet able to give general CRA statistics about the location, volume, and fine-scale structure neither can we yet range the models according to these statistics

Thank you for your attention!