Spatial Verification in harp

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ACCORD ASW - SMHI
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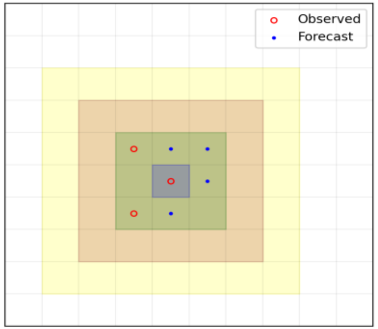
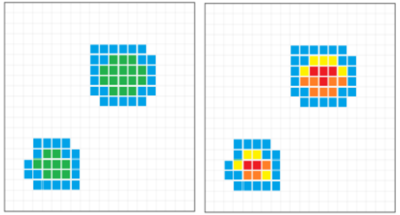
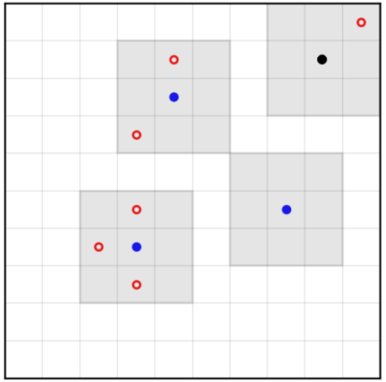
Spatial Prespectives

- Point Obs –Point Fcst
- Field Obs – Field Fcst
  - **Fuzzy**: Neighbourhood (Theis et al. 2006)
  - Features(Object)-based (Ebert and McBride 2000) – **SAL**
  - Scale-separation (Briggs and Levine 1997)
  - Field deformation (Hoffman et al. 1995)
- **Point Obs –Field Fcst (Fuzzy)**
  - Multi-event contingency table (Atger 2001)
  - Pragmatic (Theis et al. 2005)
  - conditional square root of RPS (Germann and Zawadzki 2004)
  - Practically perfect hindcast (Brooks et al. 1998)







Scores- FSS, SAL

Fractions Skill Score (FSS)

$$b_i = \begin{cases} 1 & \text{if } a_i \geq q \\ 0 & \text{if } a_i < q \end{cases}$$

$$\text{FSS} = 1 - \frac{\sum_{i=1}^{n} (o_i - f_i)^2}{\sum_{i=1}^{n} (o_i^2 + f_i^2)}$$

$$p_i = \frac{1}{n_s} \sum_{k \in S_i} b_k$$

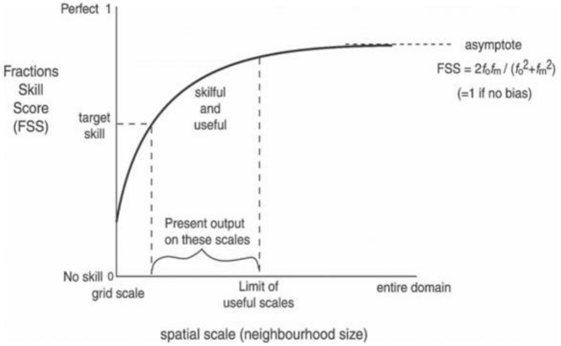
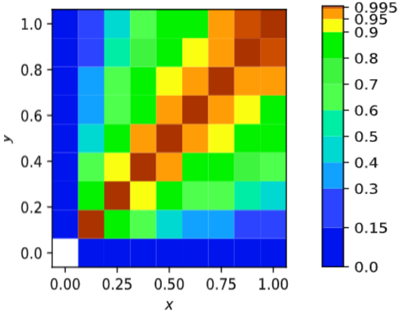


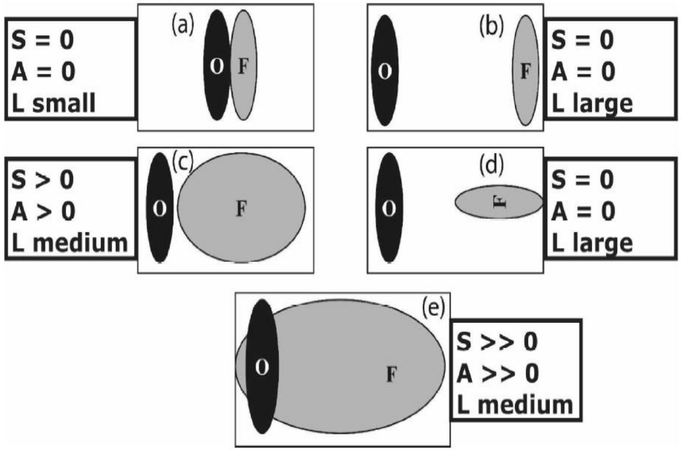
FIG. 3. Schematic graph of skill against spatial scale (see text).

$$1 - \frac{(o - f)^2}{o^2 + f^2}$$



From Roberts and Lean (2008)

SAL: Structure-Amplitude-Location



Object Identification

- Define a threshold (max precipitation)/15
- All connected grid cells exceed the threshold define an object
- Compute total value, center of mass, ...

Contingency tables

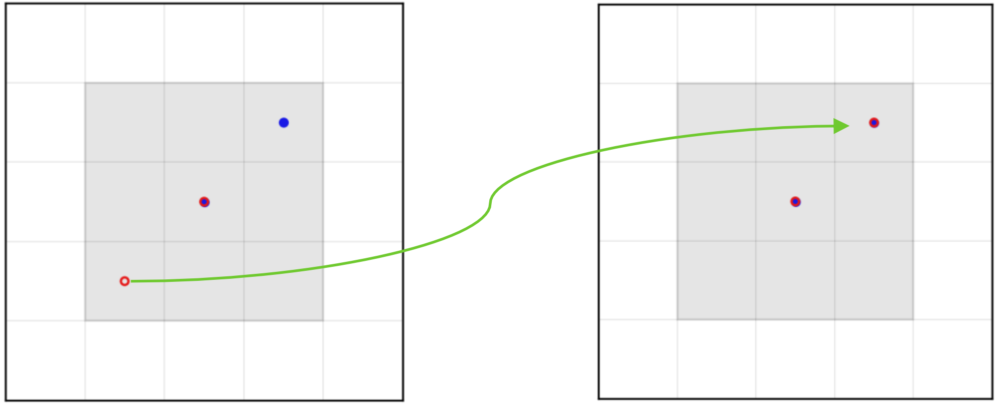
Forecast\Obs	T	F
T	Hits (a)	False Alarms (b)
F	Misses (c)	Correct Rejections (d)

TABLE 3. Criteria for filling the contingency tables for the ith grid point using the three methods described by Schwartz (2017).

Method	a	b	c	d
C10	$f_i = 1$ and $O_i = 1$ or $F_i = 1$ and $o_i = 1$	$f_i = 1$ and $O_i = 0$	$F_i = 0$ and $o_i = 1$	$f_i = 0$ and $o_i = 0$
MS15	$f_i = 1$ and $O_i = 1$	$f_i = 1$ and $O_i = 0$	$f_i = 0$ and $O_i = 1$	$f_i = 0$ and $O_i = 0$
NM	$F_i = 1$ and $O_i = 1$	$F_i = 1$ and $O_i = 0$	$F_i = 0$ and $O_i = 1$	$F_i = 0$ and $O_i = 0$

But Stein and Stoop (2019) is implemented in harp.

$$t_n = \begin{bmatrix} a + \min(b,c) & b - \min(b,c) \\ c - \min(b,c) & d + \min(b,c) \end{bmatrix}.$$



Before compensation
a=1, b=1, c=1, d=6

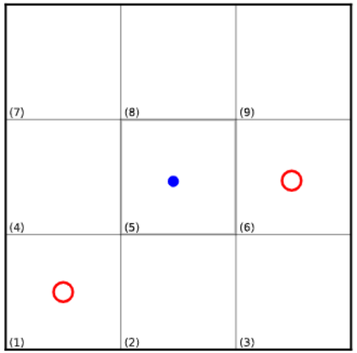
After compensation
a=2, b=0, c=0, d=7

C10: Clark et al. (2010), MS15: McMillen and Steenburgh (2015) , NM: Sobash et al (2011).

High Resolution Assessment (HiRA)

Single point vs forecast neighbourhood

- Multi-event contingency table (Atger 2001)
- Pragmatic (Theis et al. 2005)
- Practically perfect hindcast (Brooks et al. 1998)
- Conditional square root of RPS (Germann and Zawadzki 2004)

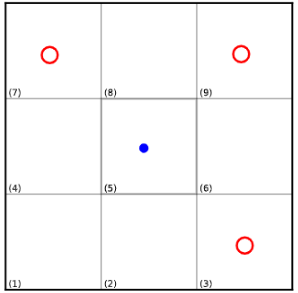


High Resolution Assessment (HiRA)

Fuzzy method	Matching strategy[a]	Decision model	Quantities compared	Decision rule for event $\langle I \rangle_s$
Multi-event contingency table (Atger, 2001)	SO-NF	Useful forecast predicts at least one event close to an observed event	$I_x, \langle I_y \rangle_s$	$\langle I \rangle_s = \begin{cases} 0 & \langle P \rangle_s < P_e \\ 1 & \langle P \rangle_s \geq P_e \end{cases}$
Pragmatic (Theis *et al.*, 2005)	SO-NF	Useful forecast has a high probability of detecting events and non-events	$I_x, \langle P_y \rangle_s$	
Conditional square root of RPS (Germann and Zawadzki, 2004)	SO-NF	Useful forecast has a high probability of matching the observed value	$I_x, \langle P_y \rangle_s$	

$$P_e = \frac{1}{N_s}$$

BS, BSS



$$\text{ME:} \quad I_x = 1, \quad \langle I_y \rangle_s = 1$$

$$\text{CSRR} = \frac{\sqrt{\text{RPS}}}{P_{x>0}}$$

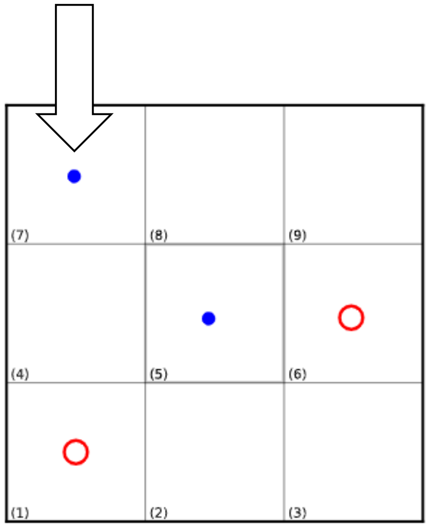
$$\text{PRAG, CSRR} \quad I_x = 1, \quad \langle P_y \rangle_s = \frac{3}{9}$$

$$\text{RPS} = \frac{1}{M-1} \sum_{m=1}^{M} (\text{CDF}_{y,m} - o_m)^2$$

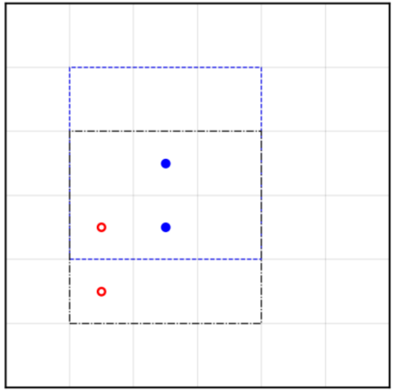
High Resolution Assessment (HiRA)

Make use of other observations in the neighbourhood

- Hit: $\langle P_y \rangle_s \geq \langle P_x \rangle_s$ and $\langle P_x \rangle_s > 0$
- Miss: $\langle P_y \rangle_s < \langle P_x \rangle_s$ and $\langle P_x \rangle_s > 0$
- False Alarm: $\langle P_y \rangle_s > 0$ and $\langle P_x \rangle_s = 0$
- Correct Rejection (otherwise): $\langle P_y \rangle_s = 0$ and $\langle P_x \rangle_s = 0$



Model A



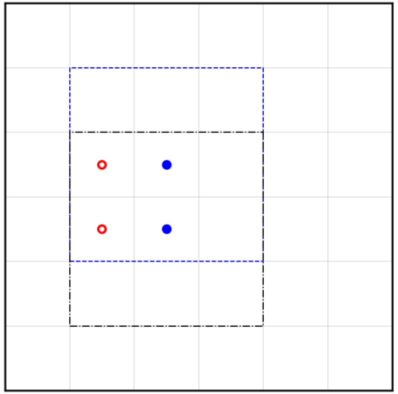
Multi-Event Method
a=2, b=0, c=0, d=0
POD = a/(a+c) = 1
TS = a/(a+c+b) = 1

The proposed method
a=1, b=0, c=1, d=0
POD = a/(a+c) = 0.5
TS = a/(a+c+b) = 0.5

Subjectively, model B performs better than model A

a: Hit
b: False Alarm
c: Miss
d: Correct Rejection

Model B



Multi-Event Method
a=2, b=0, c=0, d=0
POD = a/(a+c) = 1
TS = a/(a+c+b) =1

The proposed method
a=2, b=0, c=0, d=0
POD = a/(a+c) = 1
TS = a/(a+c+b) =1

Sqlite Tables – Bias mse and mae

SMHI

	model	prm	fcdate	leadtime	bias
	Search column...	Search column...	Search column...	Search column...	Search column...
1	ar13	AccPcp1h	1661990400	10800	-0.00010606770874...
2	ar13	AccPcp1h	1661990400	21600	0.000002580020733...
3	ar13	AccPcp1h	1661990400	32400	0
4	ar13	AccPcp1h	1661990400	43200	0.000034378446737...

	model	prm	fcdate	leadtime	mse
	Search column...	Search column...	Search column...	Search column...	Search column...
1	ar13	AccPcp1h	1661990400	10800	0.000028236815423...
2	ar13	AccPcp1h	1661990400	21600	1.225987613389530...
3	ar13	AccPcp1h	1661990400	32400	0
4	ar13	AccPcp1h	1661990400	43200	0.000001873221739...

	model	prm	fcdate	leadtime	mae
	Search column...	Search column...	Search column...	Search column...	Search column...
1	ar13	AccPcp1h	1661990400	10800	0.000107624267216...
2	ar13	AccPcp1h	1661990400	21600	0.000002826862927...
3	ar13	AccPcp1h	1661990400	32400	0
4	ar13	AccPcp1h	1661990400	43200	0.000040896404566...

Sqlite Tables – SAL and NACT, FSS

	model	prm	fcdate	leadtime	S	A	L
	Search column...	Search column...	Search column...	Search column...	Search column...	Search column...	Search column...
1	ar13	AccPcp1h	1662076800	43200	-0.92504585442140...	-1.66296842750960...	0.9859785831485544
2	ar13	AccPcp1h	1662120000	32400	0.196597004563649...	-0.55303378598077...	0.7041999130457535
3	ar13	AccPcp1h	1662120000	43200	-0.17165987480419...	-1.06080867761500...	0.5645631183935949
4	ar13	AccPcp1h	1662120000	10800	-1.20714109830336...	-1.55339059896900...	0.5467558421484725

	model	prm	fcdate	leadtime	threshold	scale	hit	fa	miss	cr
	Search column...	Search column...	Search column...	Search column...	Search column...	Search column...	Search column...	Search column...	Search column...	Search column...
1	ar13	AccPcp1h	1661990400	10800	0.1	1	0	0	0.000412890033621...	0.999587109966379
2	ar13	AccPcp1h	1661990400	10800	0.1	3	0	0	0.000412890033621...	0.999587109966379
3	ar13	AccPcp1h	1661990400	10800	0.1	5	0	0	0.000412890033621...	0.999587109966379
4	ar13	AccPcp1h	1661990400	10800	0.1	11	0	0	0.000408615809670...	0.9995913841903294
5	ar13	AccPcp1h	1661990400	10800	0.1	21	0	0	0.000358935411287...	0.9996410645887126

	model	prm	fcdate	leadtime	threshold	scale	fss
	Search column...	Search column...	Search column...	Search column...	Search column...	Search column...	Search column...
1	ar13	AccPcp1h	1662033600	21600	0.1	21	0.047486511946553...
2	ar13	AccPcp1h	1662120000	43200	0.1	21	0.007774466883065...
3	ar13	AccPcp1h	1662120000	43200	0.1	1	0.002975550454890...
4	ar13	AccPcp1h	1662120000	43200	0.1	11	0.002875977104774...

Sqlite Tables – HiRA: ME, PRAGM, CSRR

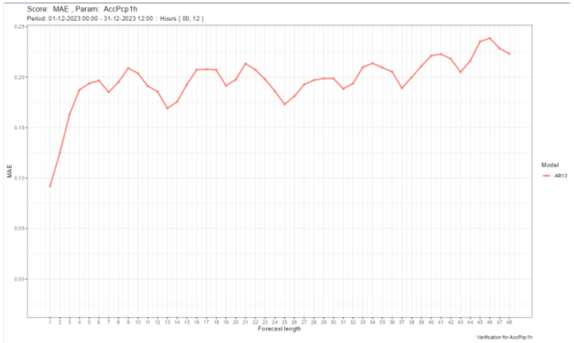
	model	prm	fcdate	leadtime	threshold	scale	count	hit	fa	miss	cr
	Search column...	Search column...	Search column...	Search column...	Search column...	Search column...	Search column...	Search column...	Search column...	Search column...	Search column...
1	meps	AccPcp3h	1704153600	10800	0.1	0	26	9	0	1	16
2	meps	AccPcp3h	1704153600	10800	0.1	1	26	9	0	1	16
3	meps	AccPcp3h	1704153600	10800	0.1	2	26	9	0	1	16
4	meps	AccPcp3h	1704153600	10800	0.1	4	26	10	0	0	16

	model	prm	fcdate	leadtime	threshold	scale	count	bss	bs
	Search column...	Search column...	Search column...	Search column...	Search column...	Search column...	Search column...	Search column...	Search column...
1	meps	AccPcp3h	1704153600	10800	0.1	0	26	0.8375000357627869	0.038461539894342...
2	meps	AccPcp3h	1704153600	10800	0.1	1	26	0.8375000357627869	0.038461539894342...
3	meps	AccPcp3h	1704153600	10800	0.1	2	26	0.8375000357627869	0.038461539894342...
4	meps	AccPcp3h	1704153600	10800	0.1	4	26	0.8569425940513611	0.033859752118587...

	model	prm	fcdate	leadtime	scale	count	rps	csrr
	Search column...	Search column...	Search column...	Search column...	Search column...	Search column...	Search column...	Search column...
1	meps	AccPcp3h	1704153600	10800	0	26	0.7637363076210022	1.409153699874878
2	meps	AccPcp3h	1704153600	10800	1	26	0.7893094420433044	1.4325517416000366
3	meps	AccPcp3h	1704153600	10800	2	26	0.7724751830101013	1.417192816734314
4	meps	AccPcp3h	1704153600	10800	4	26	0.736739456653595	1.3840240240097046

harpVis and Shiny interface

```
> plot_spatial_verif(verif_data, 'SAL')
> plot_spatial_verif(verif_data, 'FSS', filter_by =
vars(threshold %in% c(0.1,1.0), scale %in% c(15,20)))
> plot_spatial_verif(verif_data, 'NACT', plot_opts =
list(nact_scores = list("pod", "far"), colour_by =
"scale"))
```



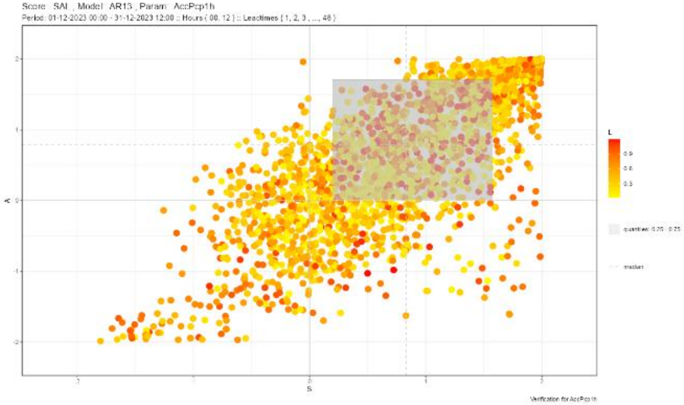
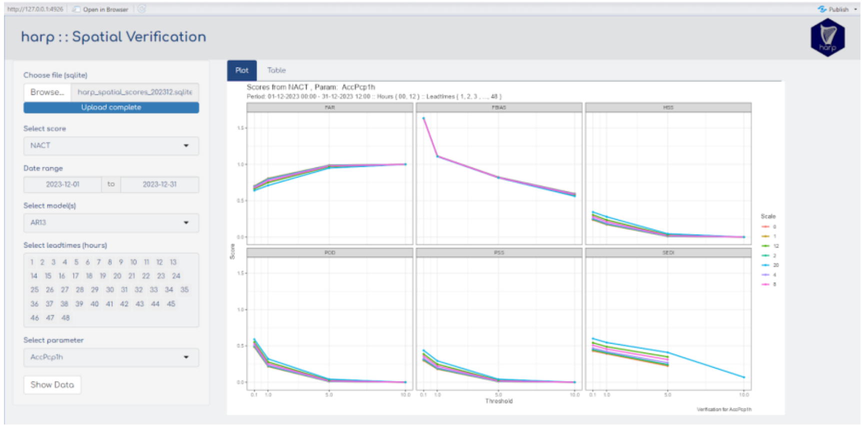


Figure 4.1: SAL plot produced by the plotting functions from harpVis over a December period 2023.



Thanks for your Attention