HELLENIC NATIONAL METEOROLOGICAL SERVICE

SAL Applications Overview

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SAL:
Object based
verification measure
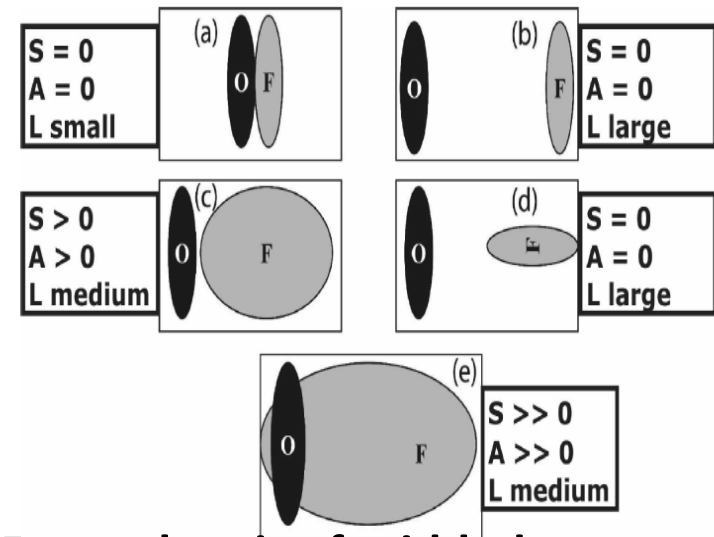
SAL Method (Wernli et al. 2008, 2009) For each pair of gridded observations/forecast field 3 indexes are calculated.

S: Structure Component (Compares Total Volume of Normalized - Objects of obs/fcst . Captures size and shape of objects) (Values from -2 to 2) S=0 perfect, S >> 0 forecast predicts more widespread pcp , S<< 0 forecast predicts more peaked objects

A: Amplitude Component (Normalized difference of domain-averaged values of forecast and obs field) (Values from-2 to 2) A=0 perfect, A >> 0 forecast overpredicts pcp A<< 0 forecast underpredicts

L: Location Component (Consists of L1+L2) (L Values from 0 to 2) (0 perfect)
L1 : normalized distance between centers of mass of the obs/fcst fields
L2: difference of normalized distance between center of mass and individual objects over observed and forecast field. **Difference of Scattering of objects**

Method of SAL Computation :

- Identifications of objects, necessary for S and L (specifically **L2**) is performed by setting a **constant** or **statistically specified threshold R** :

- An object is identified as a set or grid points that exceed the threshold R:

- It is performed by Function **FeatureFinder (SpatialVx)** with possibility of smoothing, omitting small objects and then use of **saller** function to calculate SAL components.

- **Note: A and L1 are independent of objects identification**

 The mostly used statistical specification of threshold is :

   R is the product of R95 (the 95th percentile of values >=0.1) (**exclude extreme values**) and factor which is usually set to 1/15.

   ❖ Note : Small threshold variations can lead to significant changes of S and L2 .

Example : CMH and COSMO2 versus Obs. for 12 h. Precipitation of 18h for 19/7/2007

Observations   CMH   COSMO2
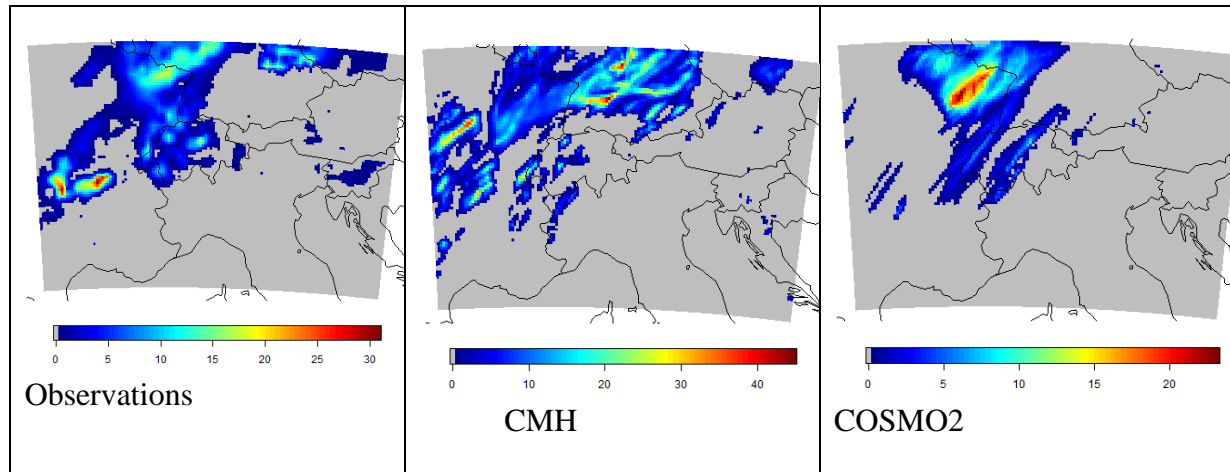
| Model	S	A	L	TaSaL
CMH	0.22	0.48	0.18	0.88
COSMO2	-0.12	-0.55	0.25	0.92

In this case , CMH slightly overpredicts domain values (A>0) while COSMO2 underpredicts. COSMO2 S negative values indicate slightly small or localized objects. Slightly higher S for COSMO2

-**Finally which forecast was better ? TaSAL index (Lawson et Gallus, 2016)**

Sal Total (TaSaL) (|S| +|A|+|L|) -> TaSal lower for CMH

SAL PLOTS:

- 12h pcp 06-18h from 5 MESOVICT cases COSMO2 and CMH with statistical threshold.

- Red lines represent median values of S and A. Grey area represents the 25%-75% percentiles.

- The figures show that median values are close to zero and COSMO2 S values have a negative tendency (predicts too peaked objects). CMH values show more spread.

- Points are in area 1 produce too much rain with too large or too flat objects. In area 3 rain is underestimated and objects are too peaked.

- ❖ Statistically specified thresholds are mostly used, especially when dealing with many cases with different pcp. amounts. If cases with similar conditions and when a certain threshold is tested then it can be constant.

SAL PLOT CO2

SAL PLOT CMH
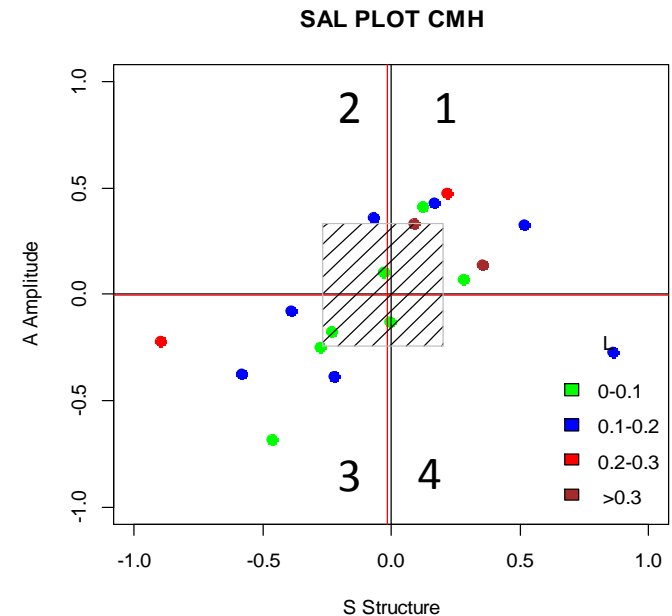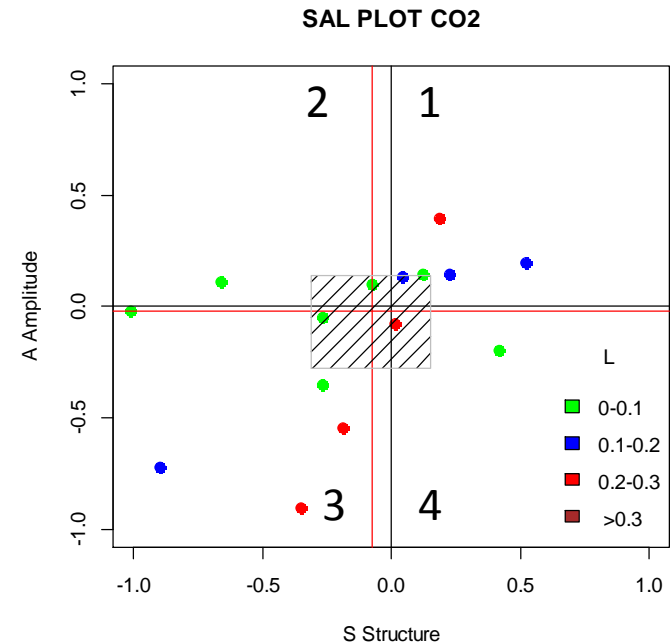
FeatureFinder Options for objects identification

1. Smoothing

- Smoothing option (**do.smooth= TRUE**) smooths **borders of objects** and filters out **small scale noise.**
- Depends on "smoothpar" which determines the number of grid points that will be averaged.
- The S and L2 are affected and values are **not stable** on smoothpar variations
- A small change on smoothpar can lead to unification/separation of objects in one of the two fields, therefore significant and unpredictable changes on these parameters.

Smoothpar=3

S=0.23

L2=0.15

Smoothpar=4

S=-0.07

L2=0.14
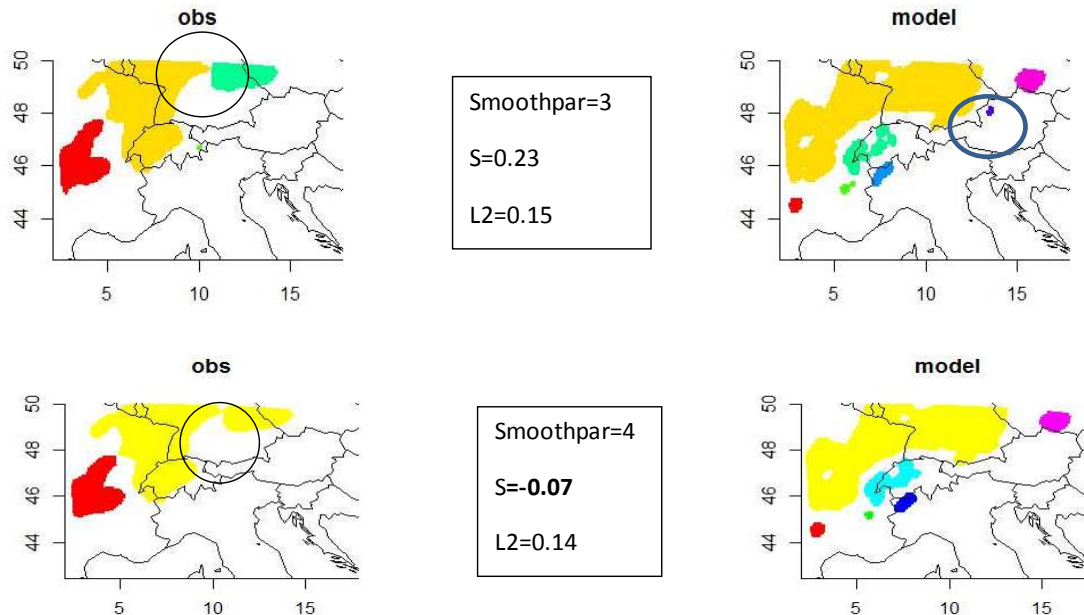
❖ !!Option should be used in caution in a SAL plot with different cases!!

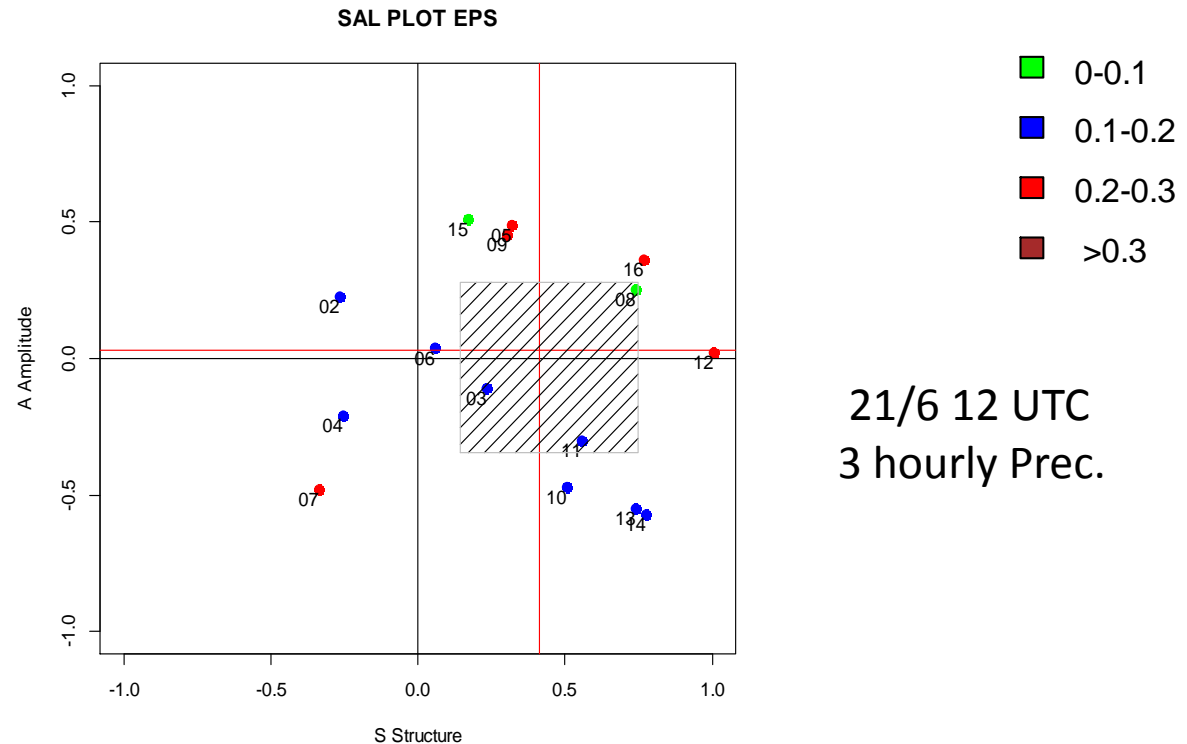# FeatureFinder Options for objects identification

2. Omission of small objects

- **Min.size (n.min)** option of featurefinder excludes objects with less that **n.min** defined by the user for observed and forecast fields. This option does not unify or separate objects. It affects S and L2 parameters in a more stable way. **Useful for omitting erroneous noise of any intensity.**


Min.size=50

S=0.24

L2=0.17

Min.size=100

S=0.28

L2=0.18
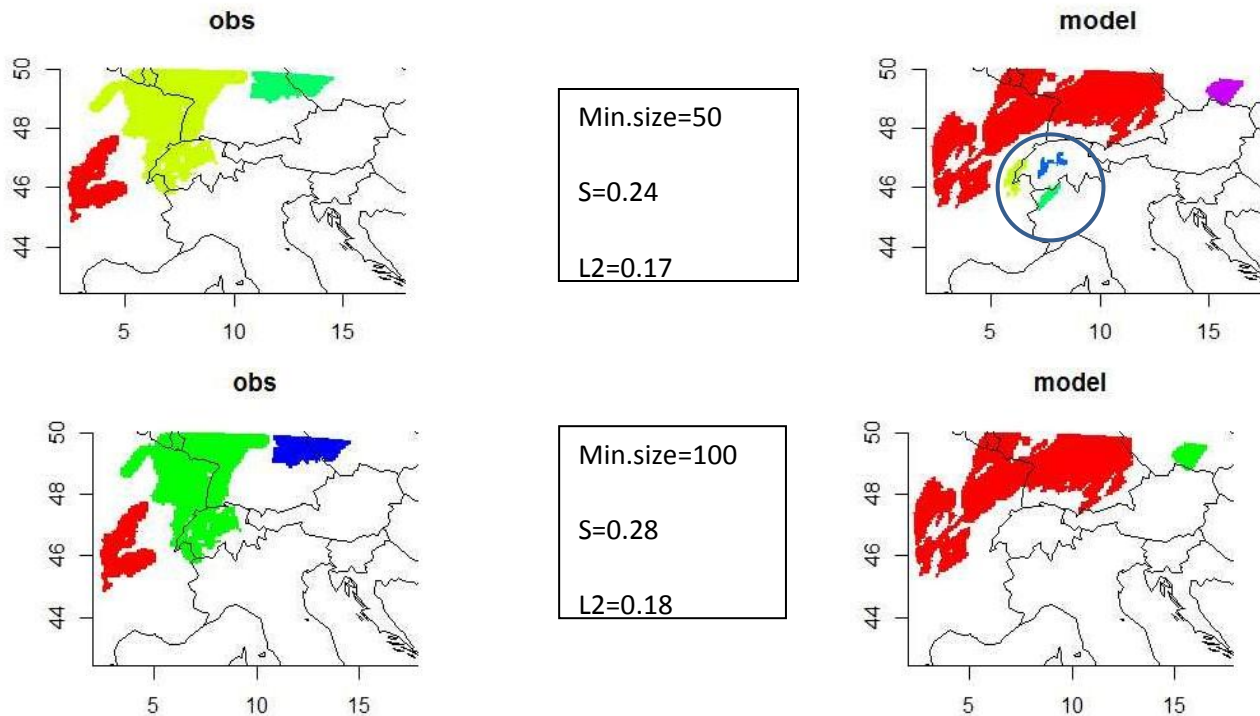
Methods of calculating SAL with Ensemble Forecasts

1) For one specific time:

SAL PLOT EPS

Legend:
- 0-0.1 (green)
- 0.1-0.2 (blue)
- 0.2-0.3 (red)
- >0.3 (brown)

21/6 12 UTC
3 hourly Prec.

SAL Plot method can be applied in order to estimate the performance of an Ensemble forecast for a specific time. Each point of the SAL plot represents one member, and an ensemble performance is estimated.
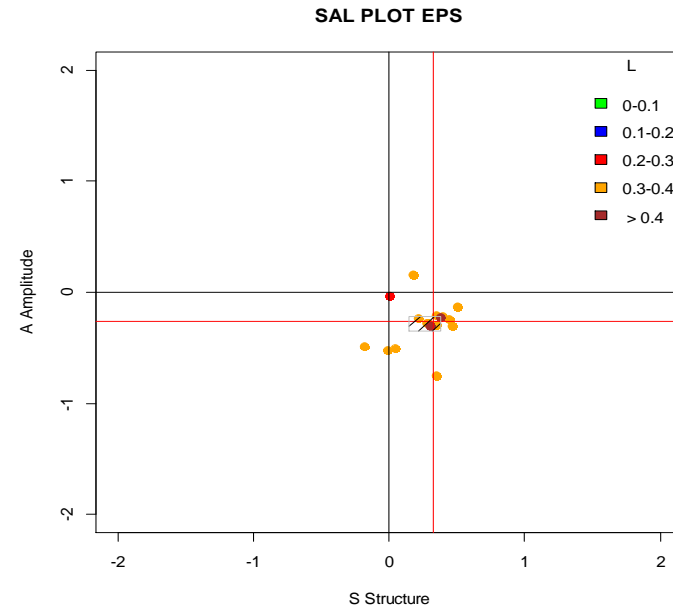
2) For a series of time leads in one plot boxplots can be used

S EPS PLOT

S Structure

A EPS PLOT

A Amplitude

L EPS PLOT

L location

Run of 19/12
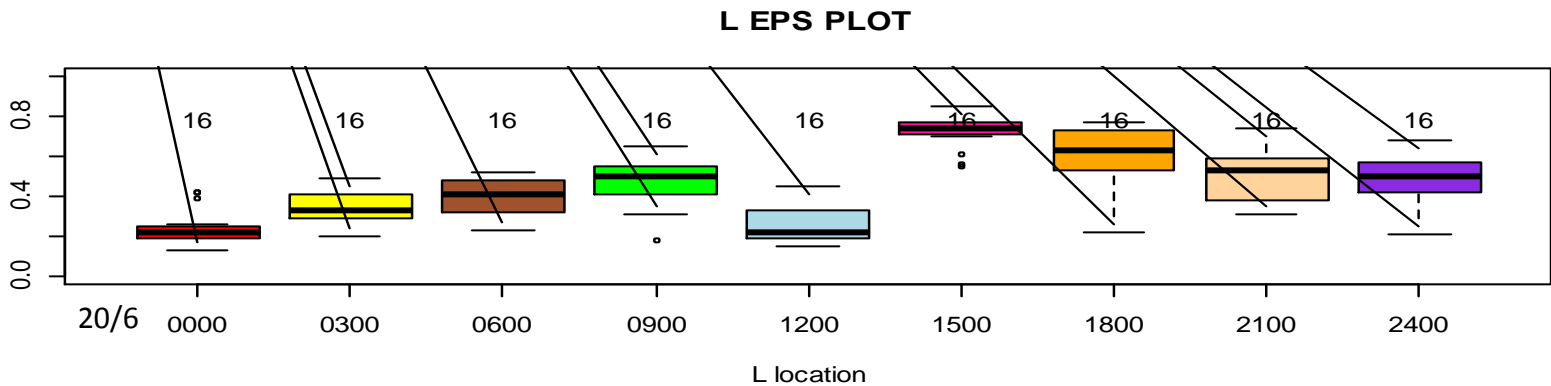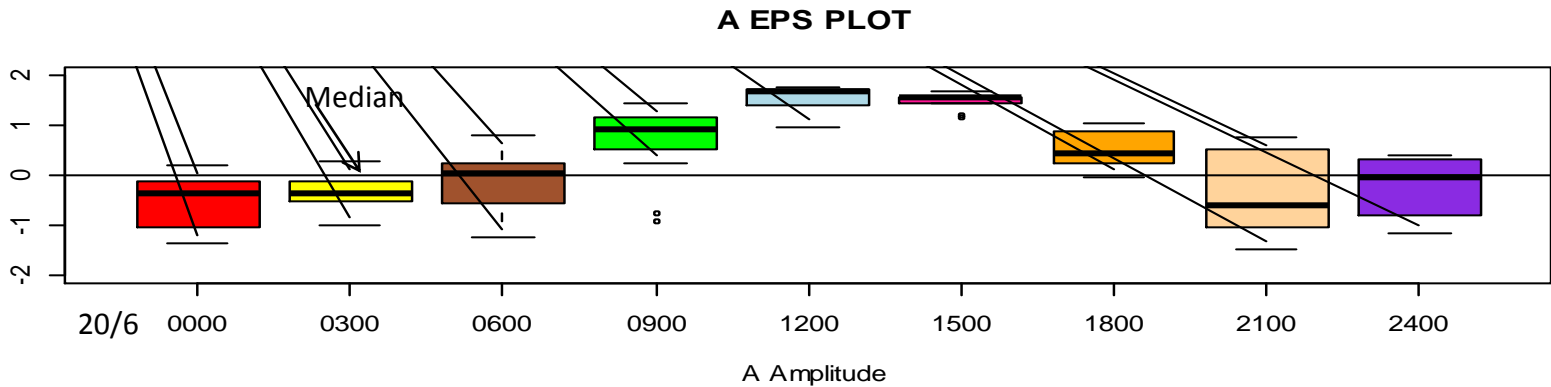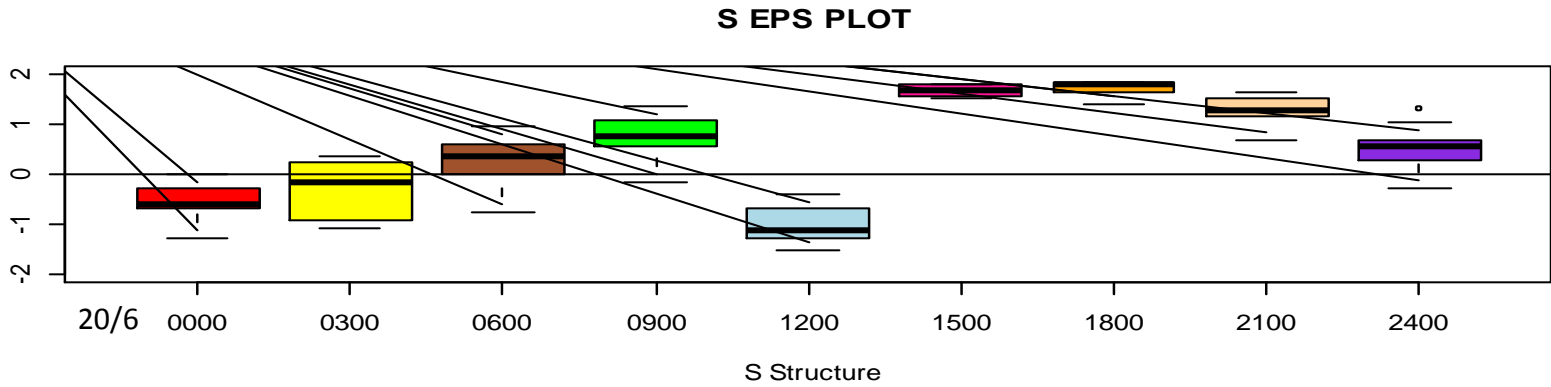
Forecast period of 20-21-22/6
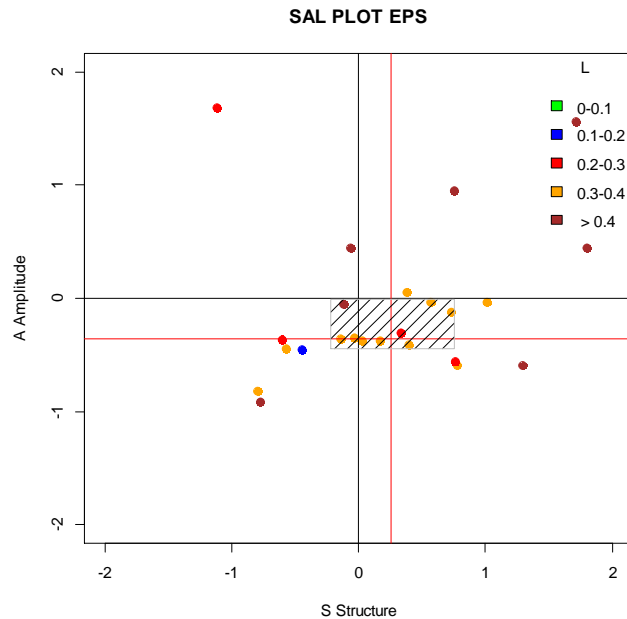
SAL plots with **Medians** of S, A and L parameters of all time leads for a specific period can be created where each point represents one time step.
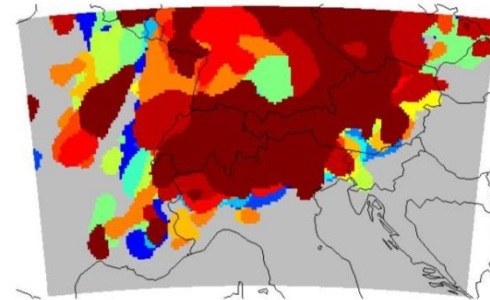
Another possible representation of SAL plots with Medians of S, A and L parameters of each member over all time leads can be created, where each point represents one member.

A new approach into investigation : EPS Probability Objects

- Without observation uncertainty
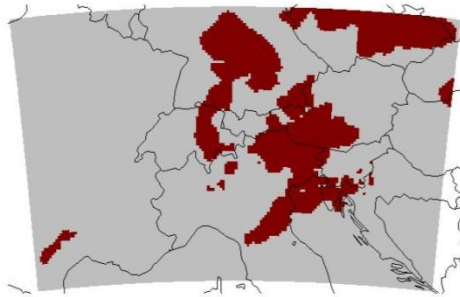
Observations

LEPS

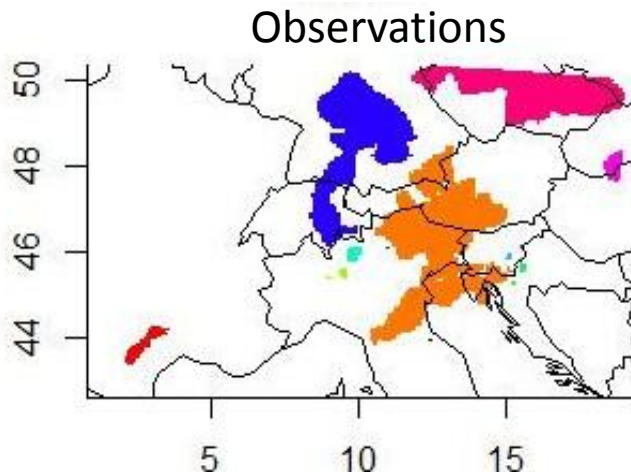Probability   3 h Prec. 21/6 12 UTC   Probability
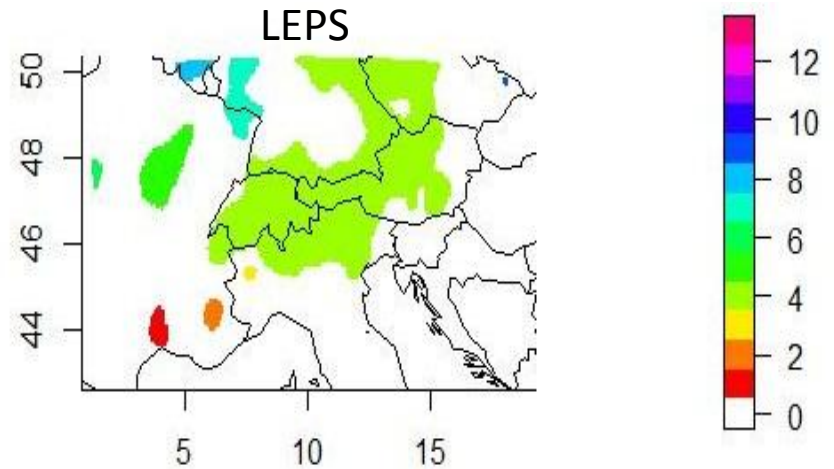
Constant threshold : Probability that precipitation >= 2mm

- What is the fraction of model members that predicts precipitation >=2 mm ?
- Observation certainty (P=1) compared with probability objects of 16 members exceeding the threshold (the brown objects)

Objects comparison for probability of precipitation (Featurefinder) >= 2mm

Probability threshold =1

Observations   LEPS
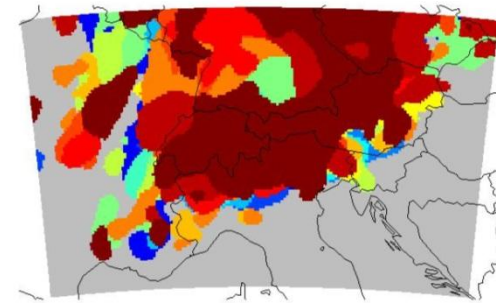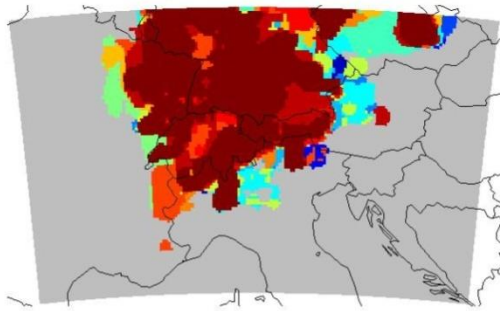

Preci >= 2 mm   Preci >= 2 mm for all 16 members

3 h Precipitation 21/6 12 UTC

S=1, A=0.38, L=0.3

EPS Probability Objects
Taking into account observations uncertainty (VERA Ensemble dataset)
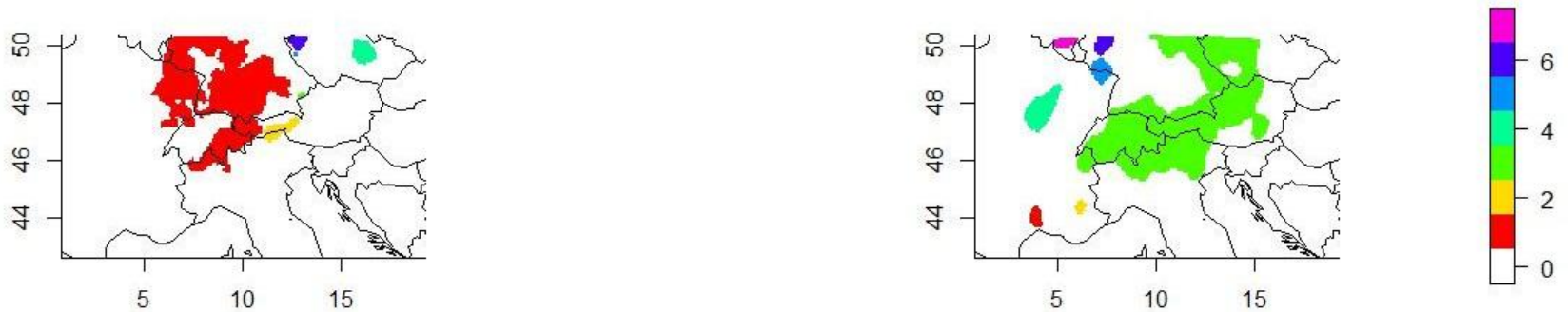

### 3 h Precipitation 21/6 12 UTC

Probability

Taking into account observations uncertainty (16 out of 50 members) . What is the fraction of obs and model members that predicts precipitation > 2 mm ?
Possibility of calculation of objects with probabilities **boundaries** less than 1

Objects comparison for probability of precipitation >= 2mm

Prob (Preci >=2mm)= 1 (All models and all VERA ens predict >=0.2)
S=0.37, A=0.6, L=0.1
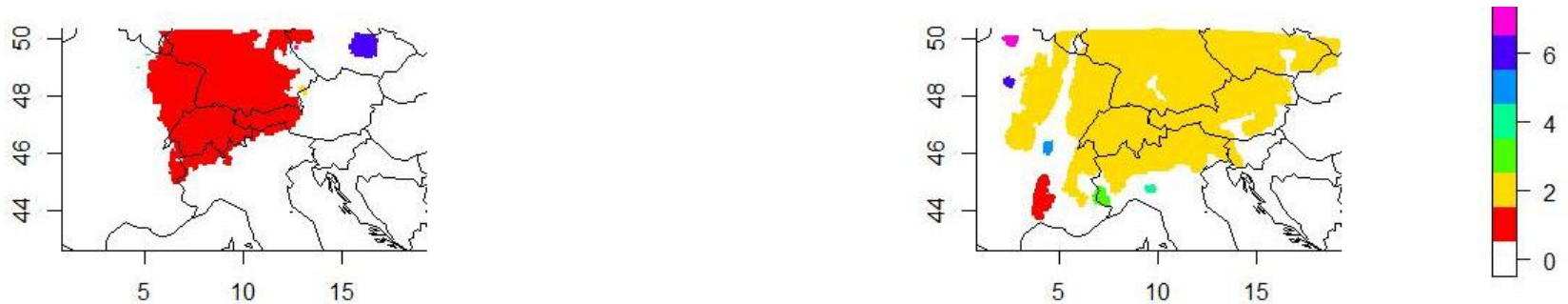
Prob (Preci >=2mm)>=0.5 (At least half of the members)
S=0.65, A=0.6, L=0.05

(Radanovic S., 2017) intoduced a new SAL index for EPS (Ensemble SAL) with average means over the members of the equations parameters (modified SpatialVx Code)
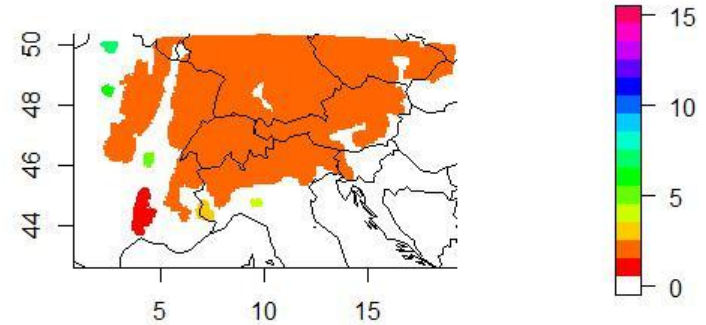
$$A = \frac{\langle \overline{rr_{mod}} \rangle - \langle \overline{rr_{obs}} \rangle}{0.5[\langle \overline{rr_{mod}} \rangle + \langle \overline{rr_{obs}} \rangle]}$$

$$L_1 = \frac{|\langle \mathbf{x}(rr_{mod}) \rangle - \langle \mathbf{x}(rr_{obs}) \rangle|}{d}$$

$$L_2 = 2 \times CRPS\left(P\left(\frac{\mathbf{r}(mod)}{d}\right), P\left(\frac{\mathbf{r}(obs)}{d}\right)\right)$$

$$S = \frac{\langle V(mod) \rangle - \langle V(obs) \rangle}{0.5[\langle V(mod) \rangle + \langle V(obs) \rangle]}$$

The formulas can be tested in a further research

Observations uncertainty NOT INCLUDED
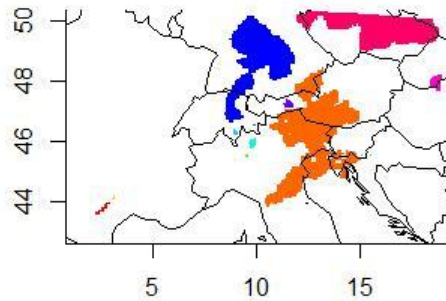
OBS preci Threshold >=2mm   Probability (Mod preci Threshold >=2mm) >=0.5

Featurefinder routine creates objects by setting a **minimum threshold** (so the object includes also higher probabilities), therefore if the probability threshold of the model is set to 0.5, (AT LEAST half members predict Preci >=2mm), the model object is bigger because it includes 0.5 and all higher probabilities. So maybe it is not so certain if we can compare these probability objects with the observations for SAL if there is no uncertainty on them .