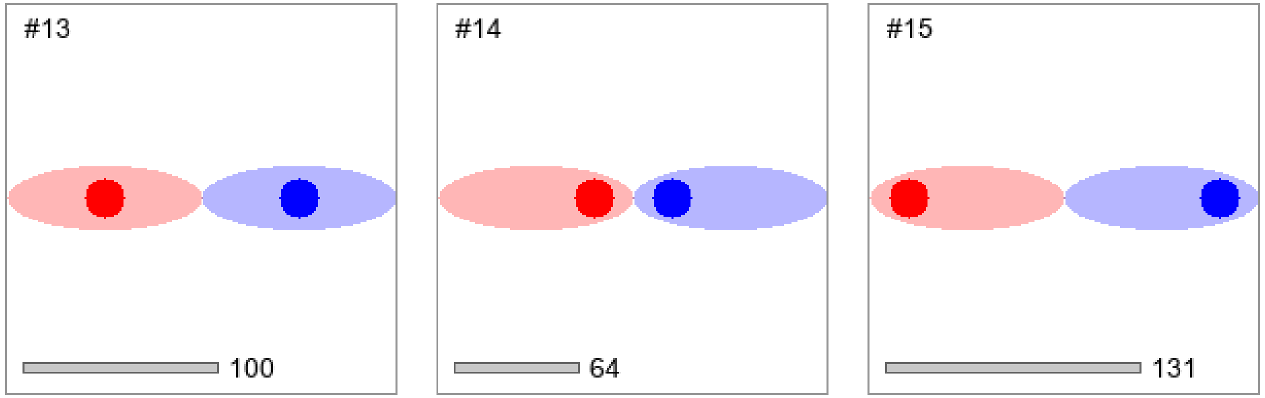
A new spatial displacement measure for continuous fields



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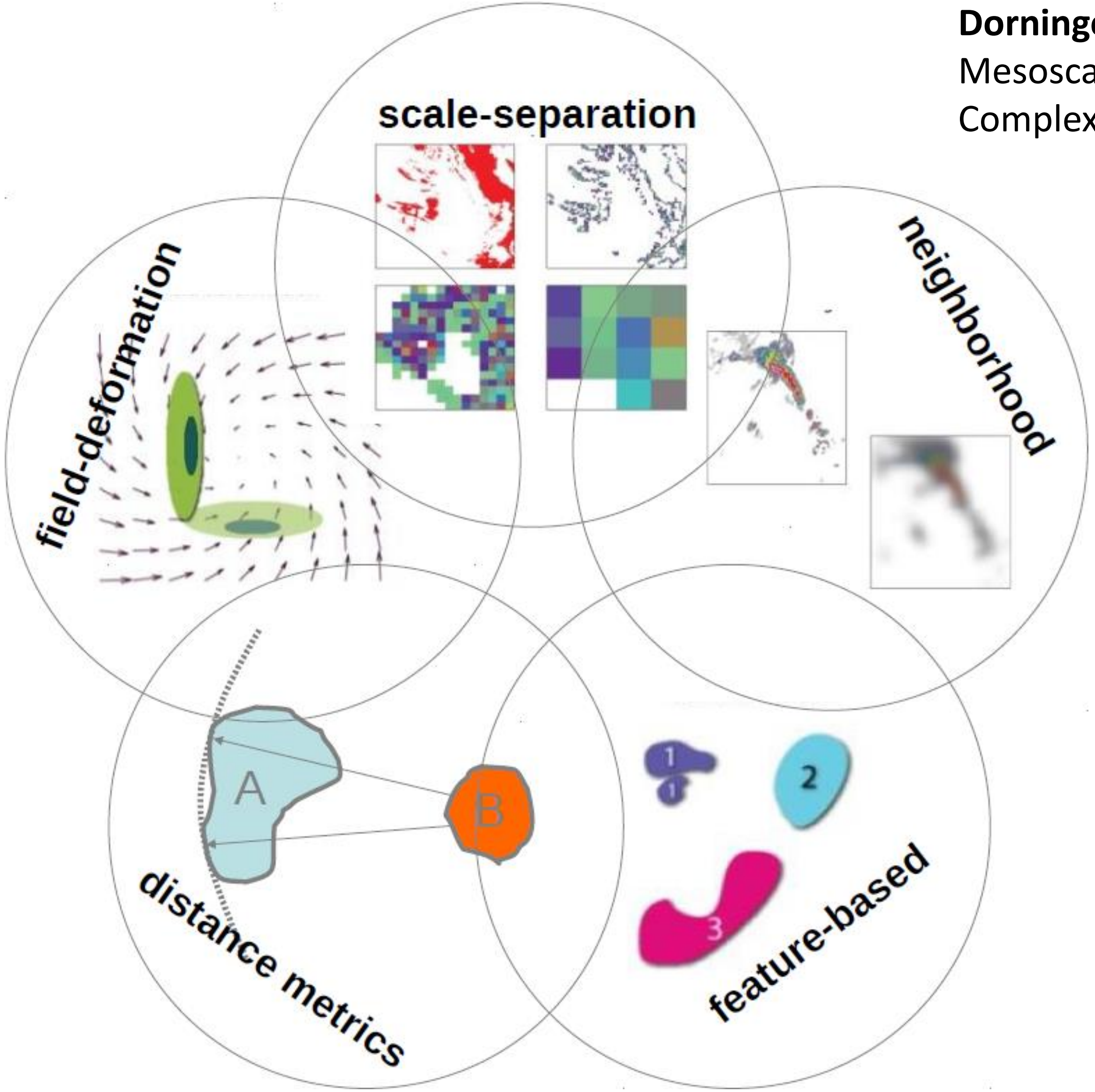
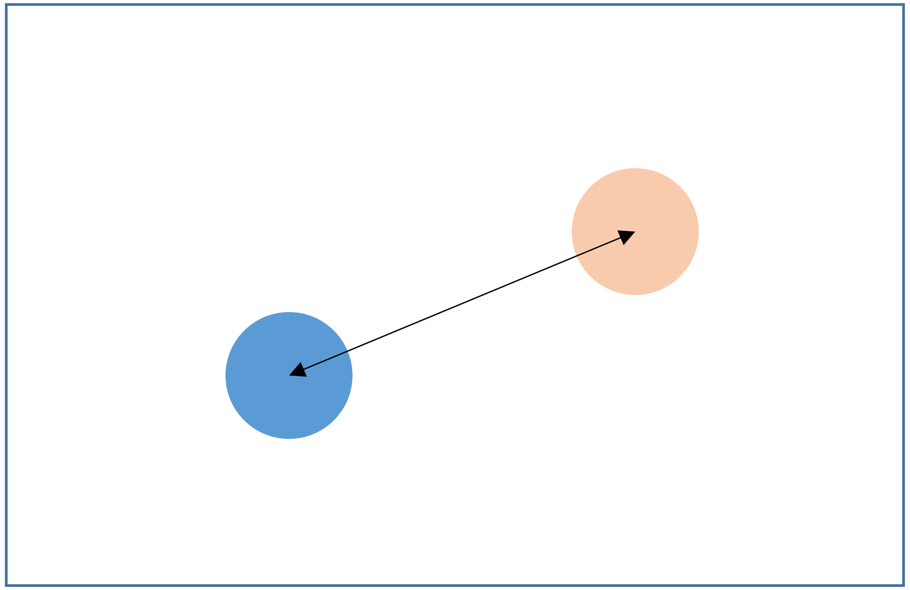
Classes of spatial verification methods



Dorninger et. al, 2018: The set-up of the Mesoscale Verification Inter-Comparison over Complex Terrain (MesoVICT) Project. BAMS.

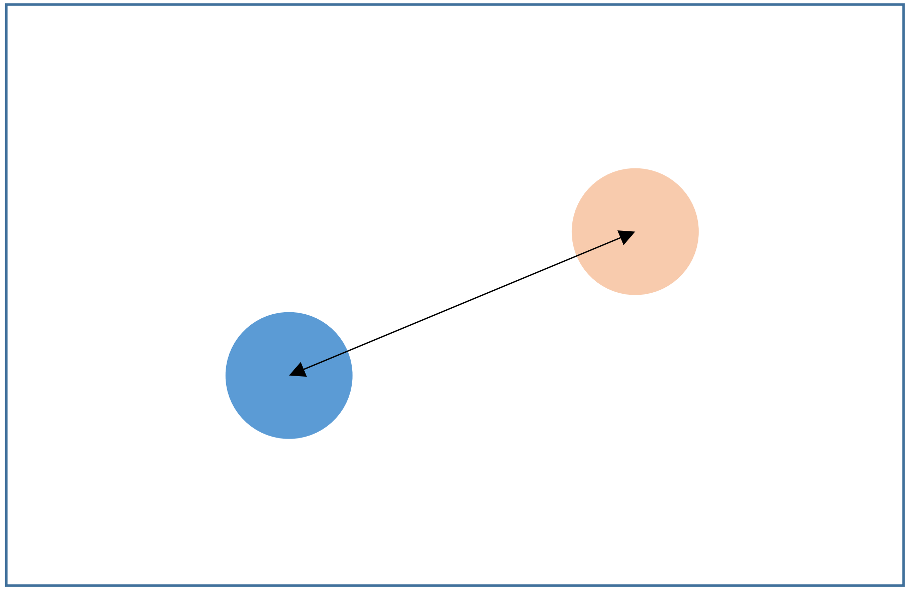
Distance measures

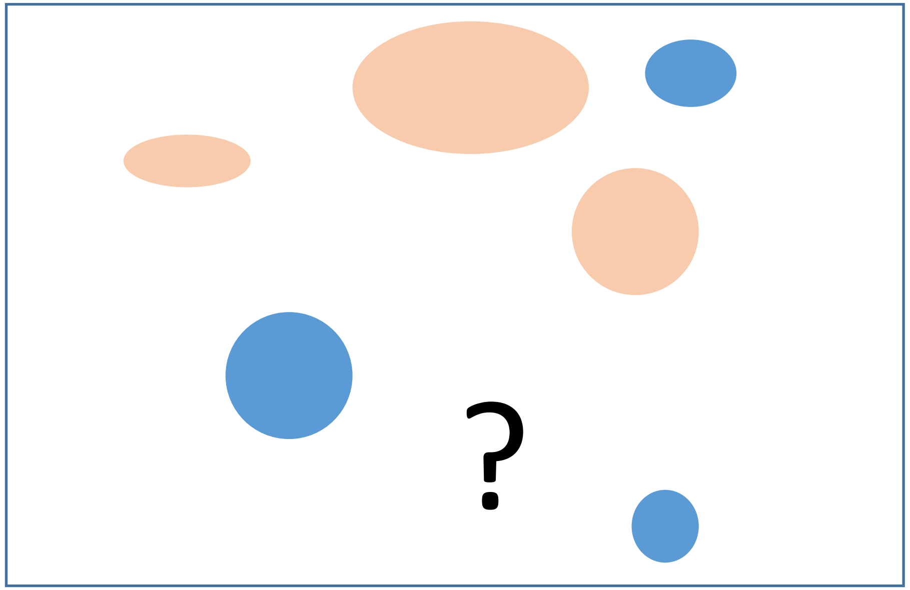
- The result is provided in terms of spatial distance
- Some methods try to provide an estimate of spatial displacement - **appealing for forecast interpretation**



Distance measures

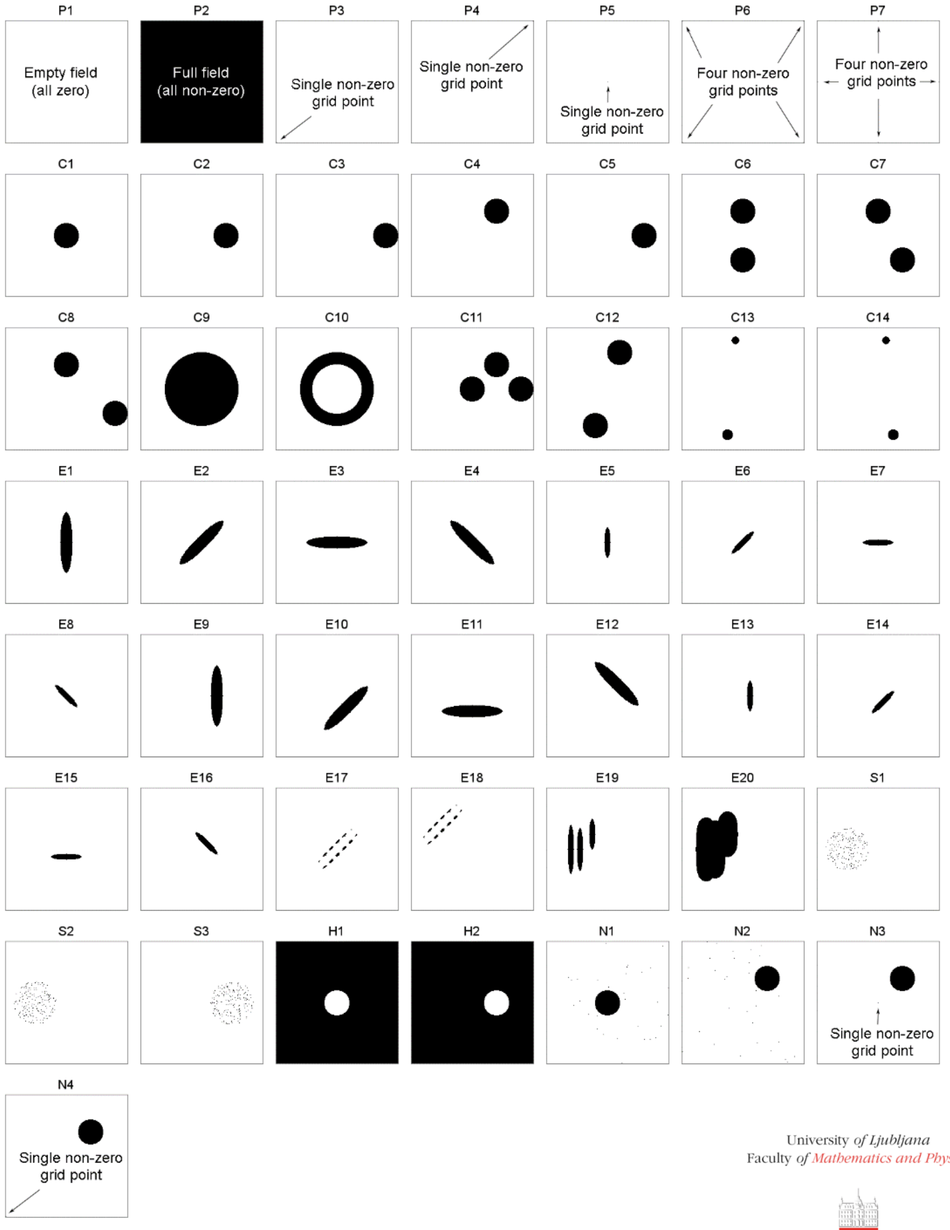
- The result is provided in terms of spatial distance
- Some methods try to provide an estimate of spatial displacement - **appealing for forecast interpretation**
- It is not always clear what the correct spatial displacement should be
- It is important to evaluate and compare results of different measures





Gilleland et al., 2020, MWR paper

- Intercomparison of 6 distance measures
- A set of **50 idealized binary fields**
- Gain basic understanding of how the measures behave



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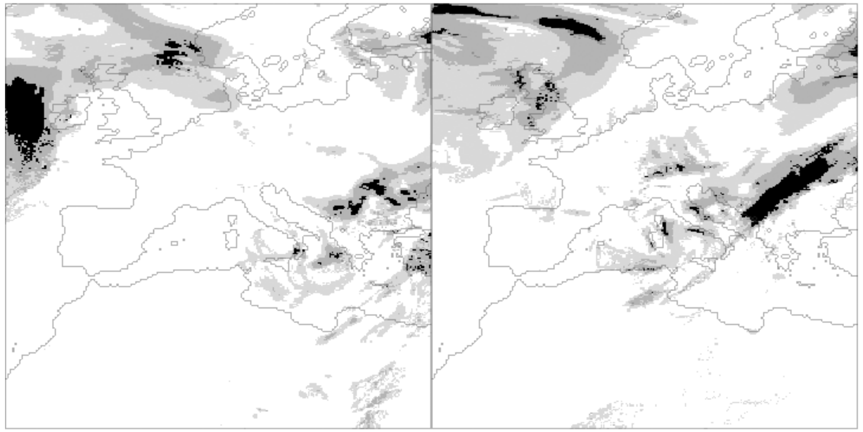
Motivation

- All the distance measures tested by Gilleland et al., 2020, require binary fields as input.
- These are usually obtained via thresholding:
  - thresholding **removes** some **information**
  - the results are **sensitive** on the choice of threshold
  - the problem of **too low** or **too high** thresholds
  - all values above the threshold are **treated equally**



Goal

- To design a score that uses similar concepts as the Fraction Skill Score distance (**dFSS**),
- but would be able to **analyse continuous fields**, and thus avoid problems related to thresholding.

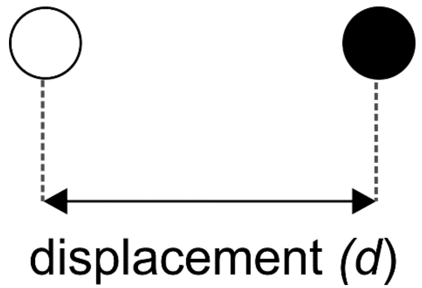
The dNSS measure

- Input fields are smoothed using a square neighbourhood (n)
- A new score: Neighbourhood Skill Score (NSS)

$$NSS(n) = 1 - \frac{\sum_{i,j} |f_A(n)(i,j) - f_B(n)(i,j)|}{\sum_{i,j} f_A(n)(i,j) + \sum_{i,j} f_B(n)(i,j)}$$

values between 0 (worst) and 1 (best)

- A simple idealized setup with a single displaced event
- The displacement can be estimated as



Neighbourhood Skill Score displacement

neighbourhood size where NSS=0.5

$$dNSS = \frac{n'}{2}$$

The dNSS measure

- Although this result is based on a very simple idealized setup it works quite well also in other situations
- The fields need to be unbiased prior to analysis. A special adjustment needs to be made if events are overlapping.

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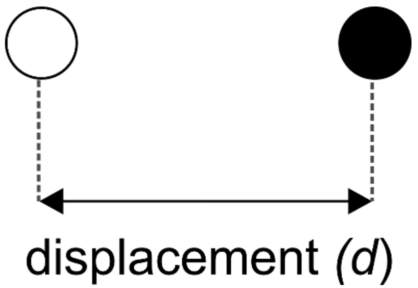
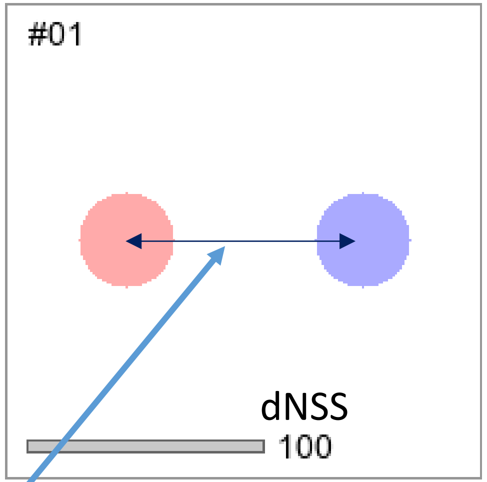
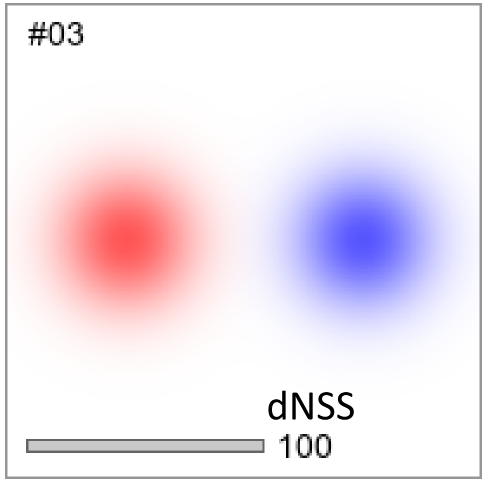


neighbourhood size where NSS=0.5

$$dNSS = \frac{n'}{2}$$

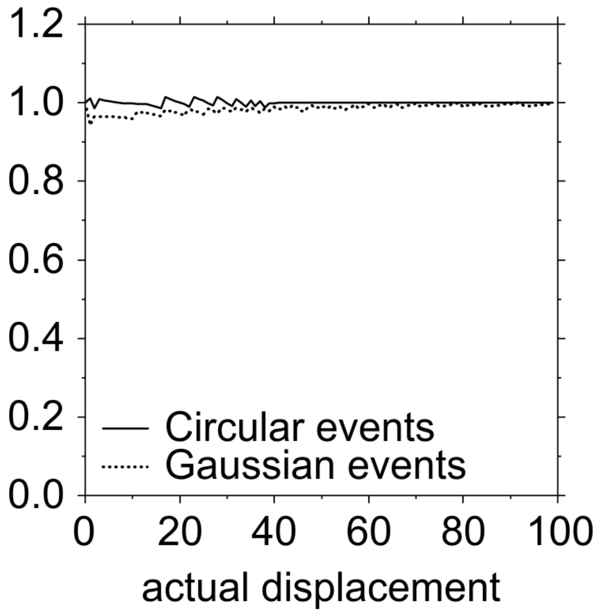
Binary vs. continuous events





Actual displacement
is 100 points

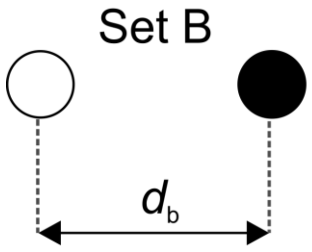
ratio dNSS/(actual displacement)



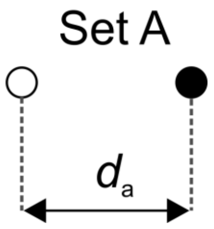
Effect of magnitude of events

- Magnitude: the **sum of values** inside an event
- two sets of events with different magnitude

$$dNSS = \frac{d_\mathrm{a} + x \cdot d_\mathrm{b}}{1 + x}$$

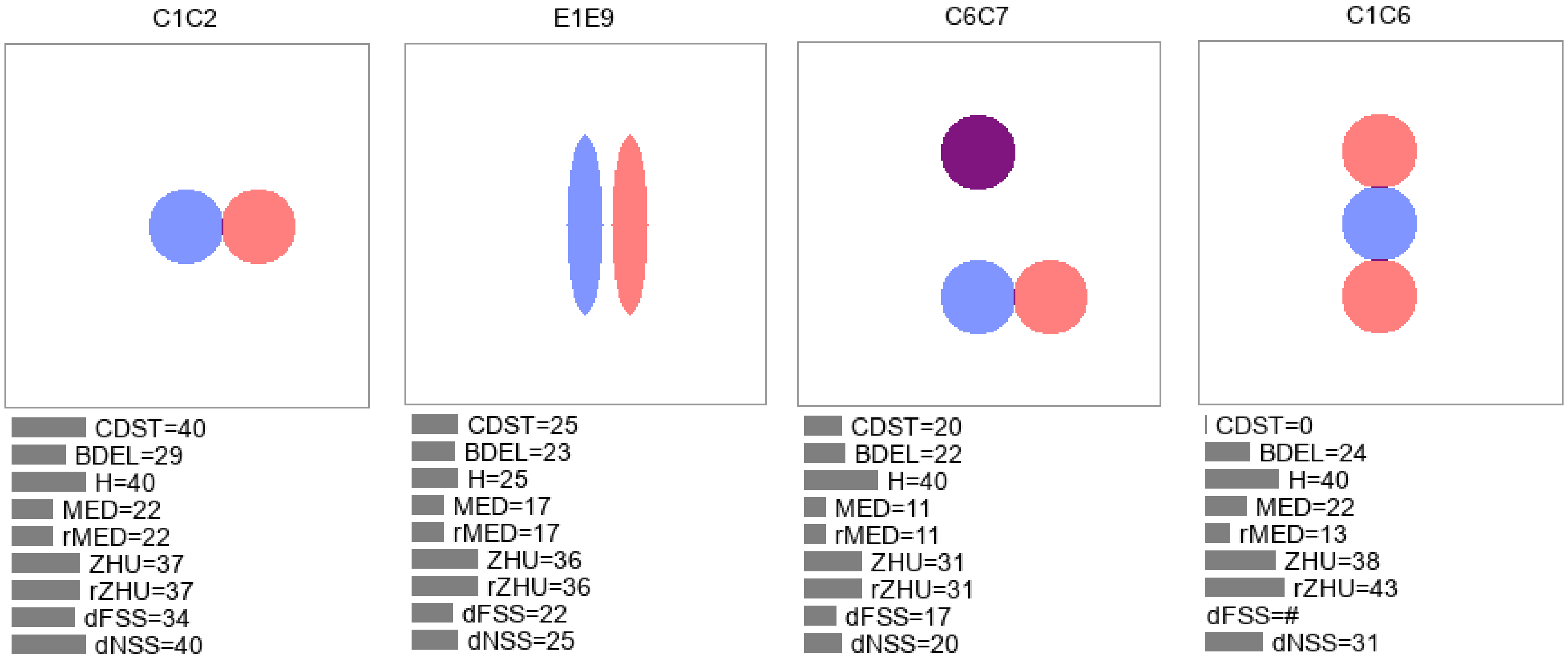


- x = ratio between magnitudes of both sets
- weighted average of both displacements
- the dependence on magnitude **is linear**



Idealized examples

Geometric cases from Gilleland et al., 2020, MWR



Idealized examples

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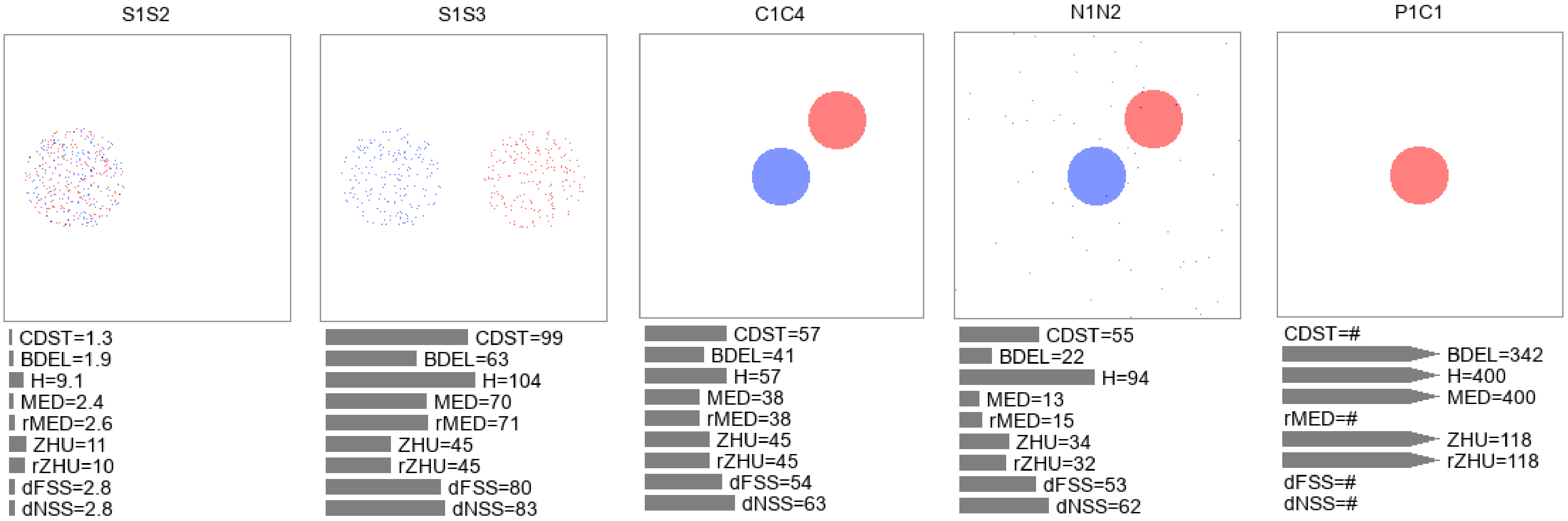

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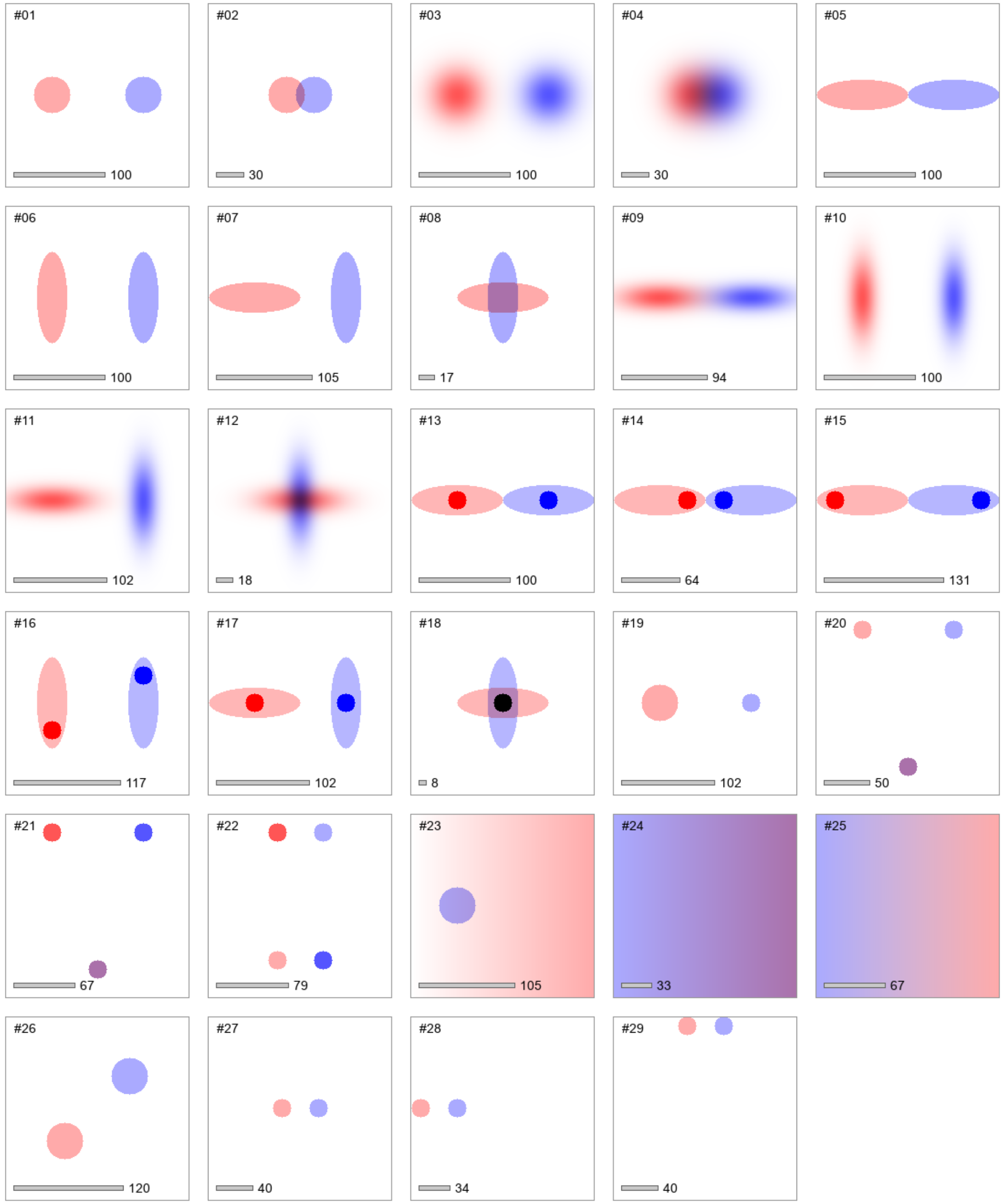
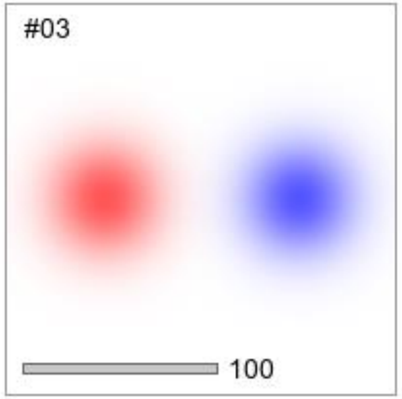
Idealized examples

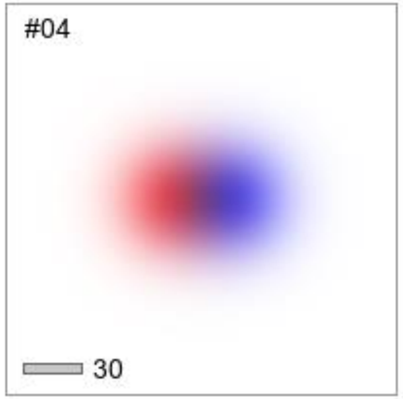
New geometric cases



Idealized examples

New idealized cases





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Idealized examples

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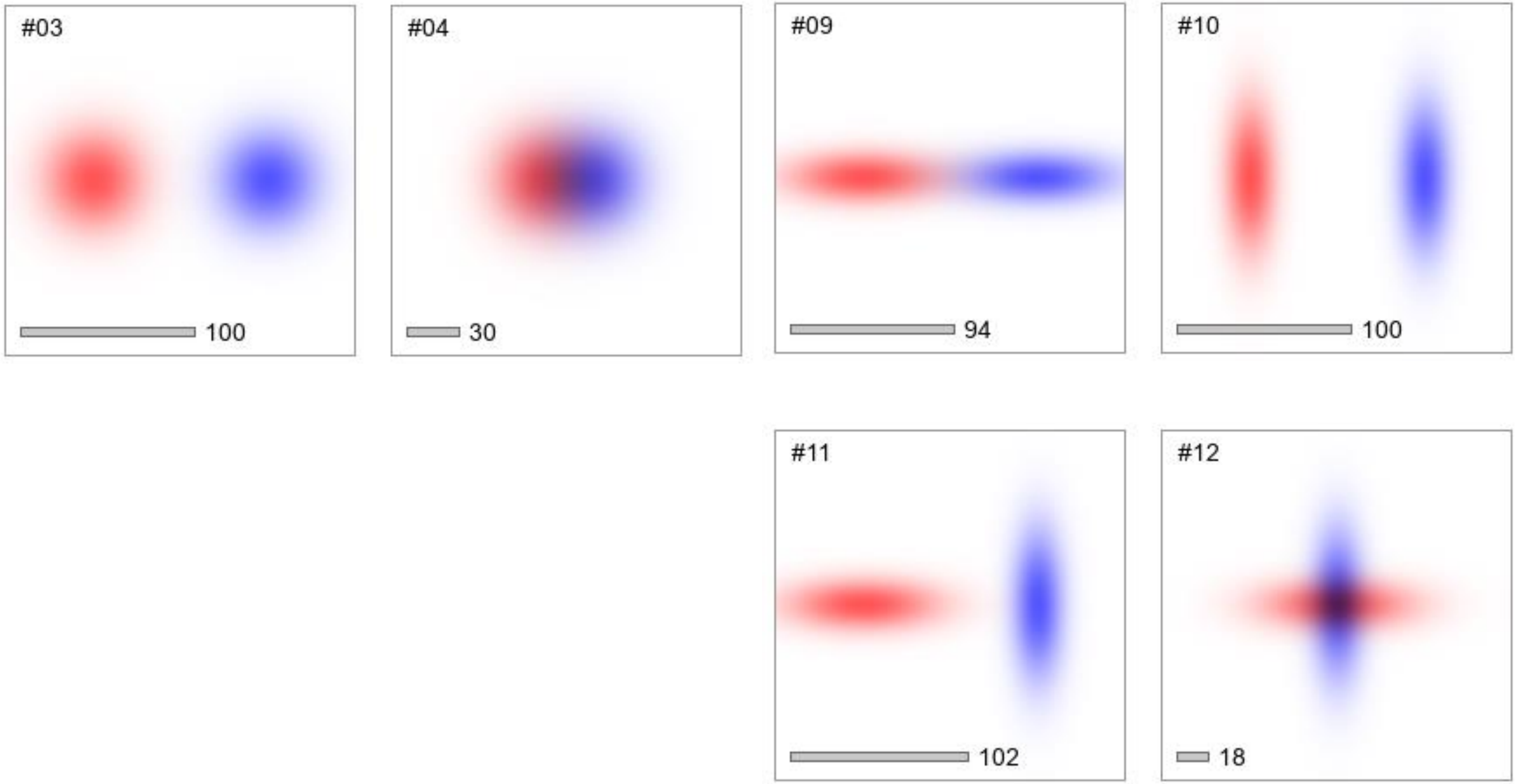

Idealized examples

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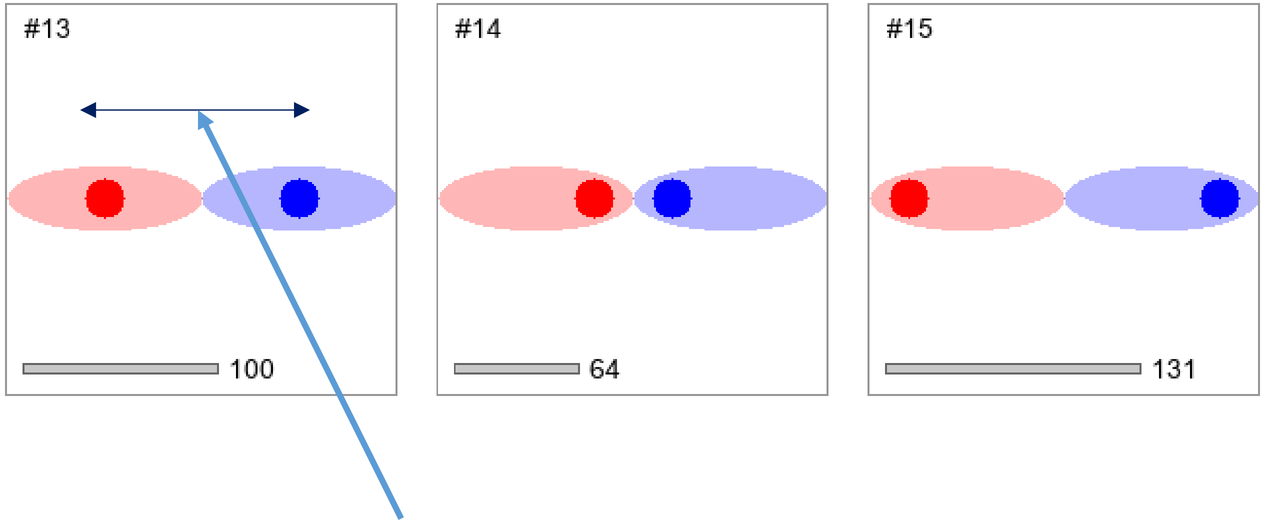

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Idealized examples

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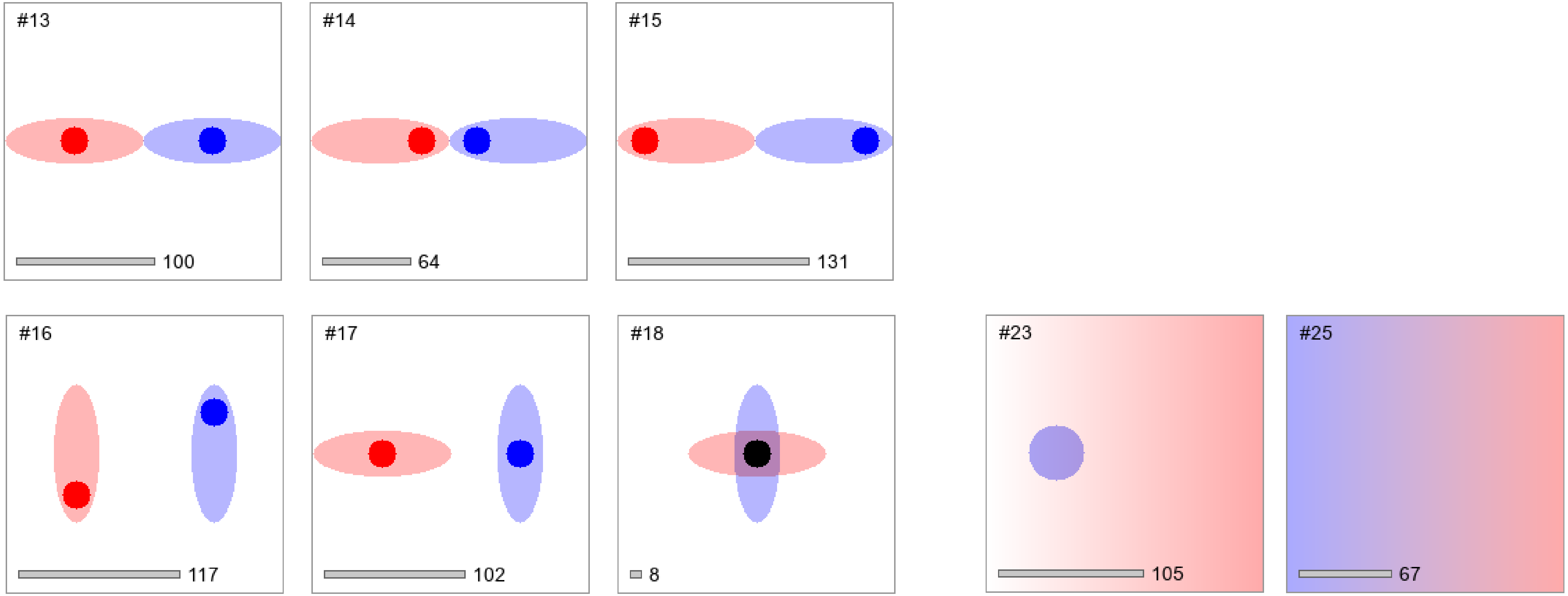
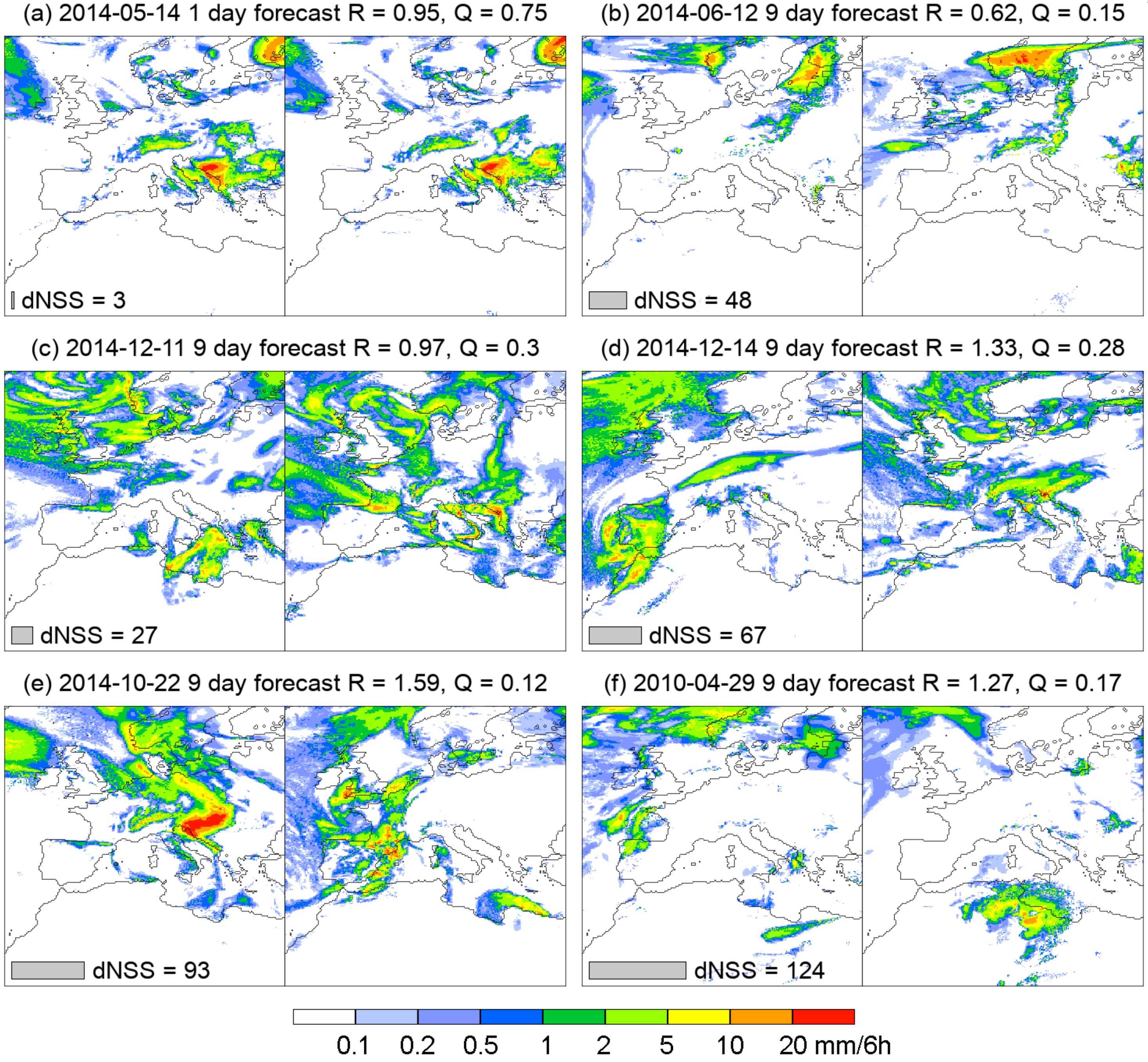


Real examples

ECMWF forecast

6-hourly precipitation

0.125° resolution



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Real examples

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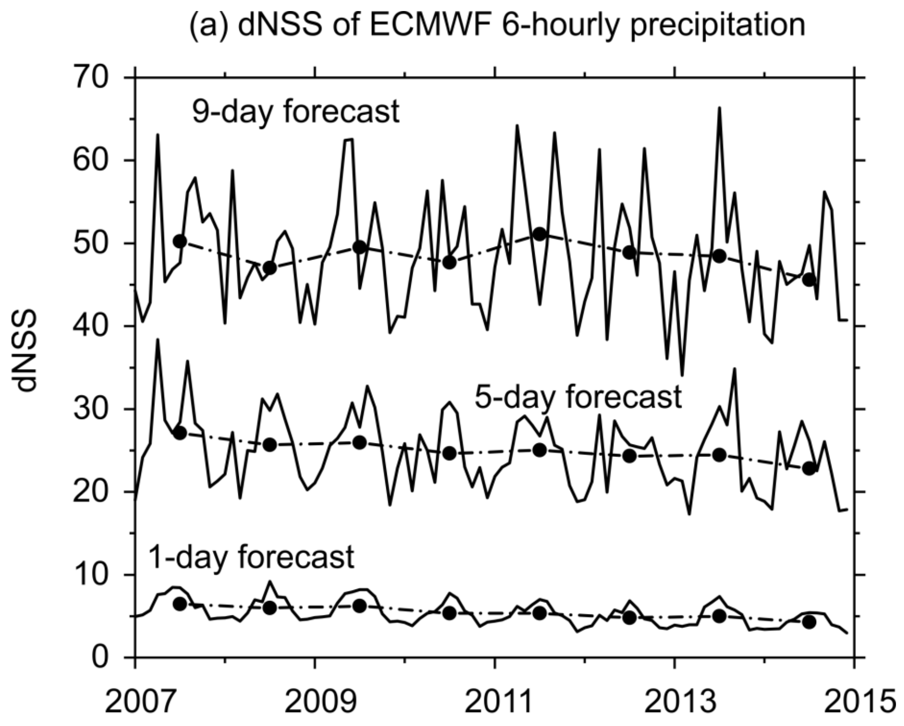

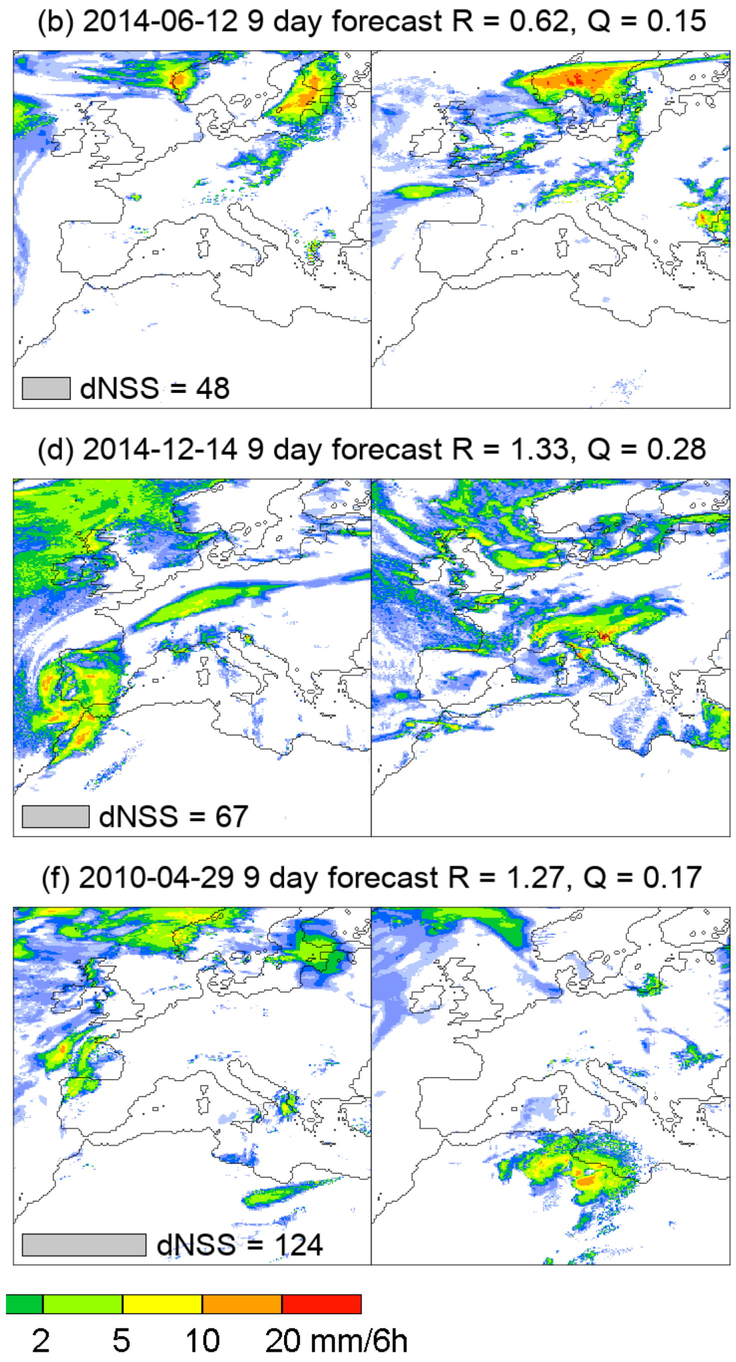

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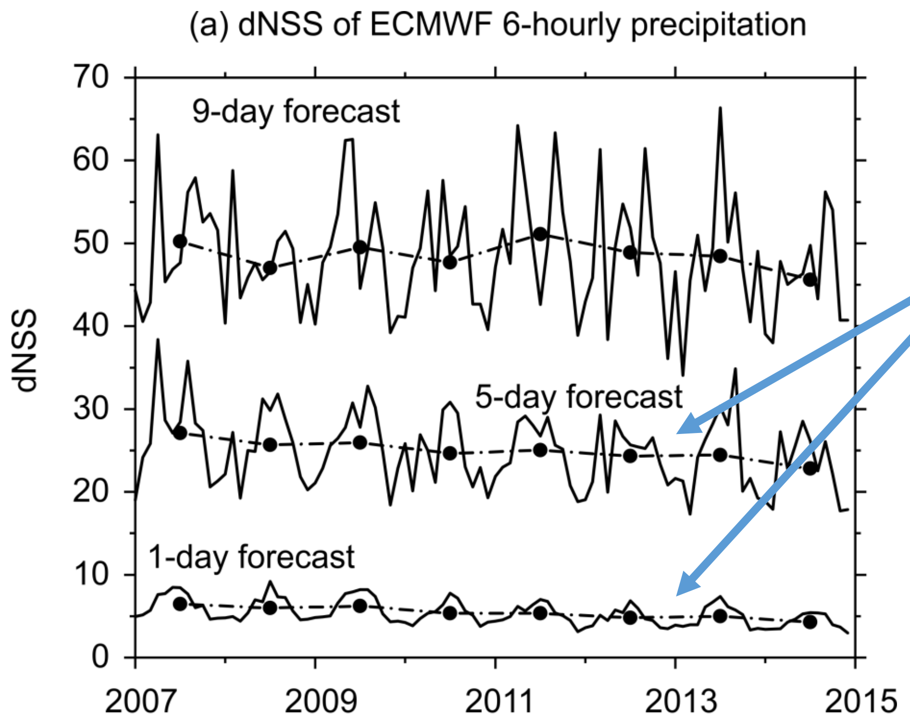
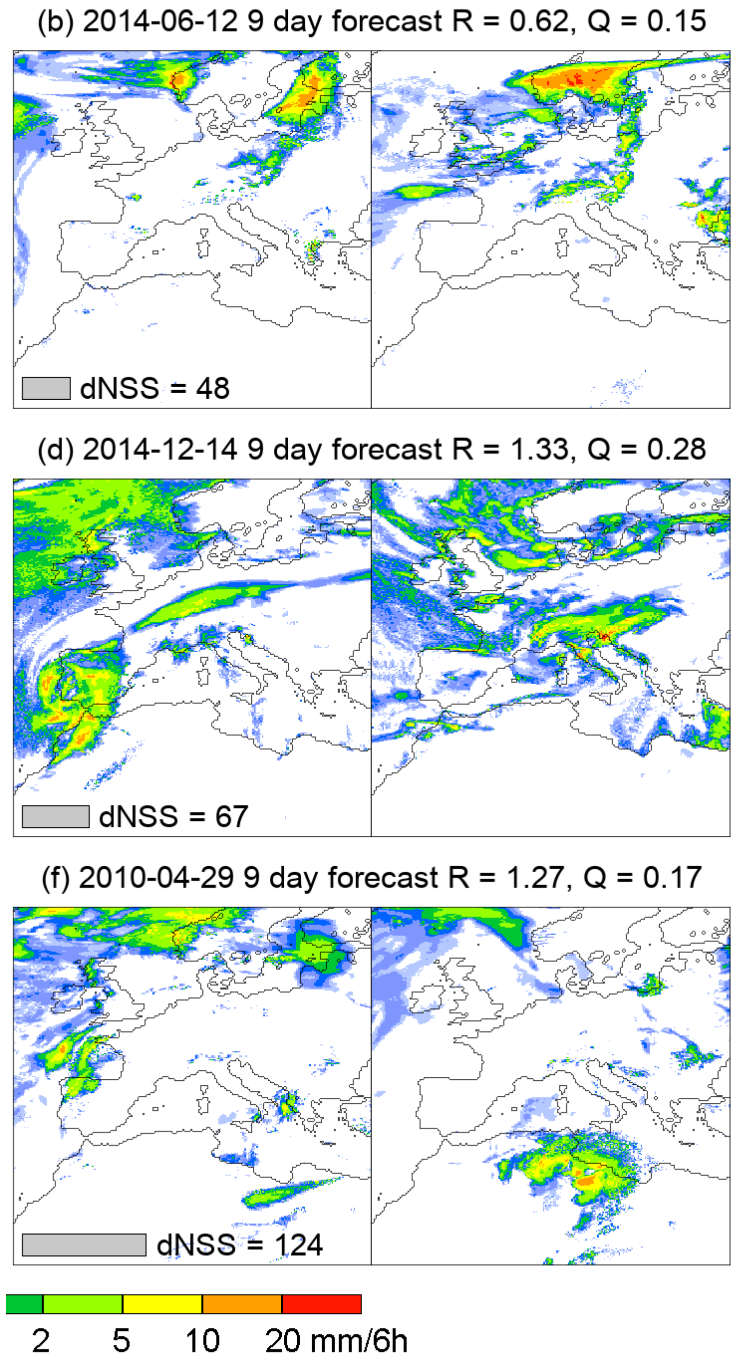


Statistically significant **decreasing trends** of dNSS:

-0.49 grd.points/year, p > 0.0026

-0.29 grd.points/year, p > 0.016



Conclusions 1/2

- A new score was devised to avoid the problems associated with thresholding
- It behaves similarly to dFSS
  - can be used to determine spatial displacement in a meaningful way
  - is not sensitive to noise
  - results are directly related to the actual displacements of events
  - events with higher magnitude have a larger influence on the resulting value
  - cannot be used in case of empty fields, is somewhat sensitive to orientation and closeness of the events to the border.

Conclusions 2/2

- dNSS has some important **advantages** compared to dFSS
  - it is not limited by bias
  - a more proportional response to the magnitude of events
  - can be used for direct analysis of continuous or multi-level fields
  - avoids the potential problems associated with thresholding
- Submitted to MWR
- The code will be made available in SpatialVx R-package

Thank you !

The dNSS measure

- Smooth the whole field using a square neighbourhood (n)
- **Define** a new score: neighbourhood skill score (NSS)

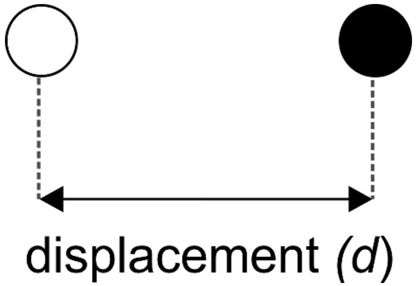
$$NSS(n) = 1 - \frac{\sum_{i,j} |f_A(n)(i,j) - f_B(n)(i,j)|}{\sum_{i,j} f_A(n)(i,j) + \sum_{i,j} f_B(n)(i,j)}$$

values between 0 (worst) and 1 (best)

- A simple idealized setup with a **single displaced event**

$$NSS = 1 - d/n$$

$$d = (1 - NSS) \cdot n$$



The dNSS measure

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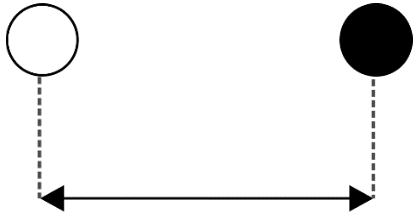

- Determine the neighbourhood size where NSS=0.5 (n‘)
- The displacement can then be estimated as

$$dNSS = \frac{n'}{2}$$

- Although this result is based on a very simple idealized setup it works quite well also in other situations
- A special adjustment needs to be made if events are overlapping. The fields need to be unbiased prior to analysis.

Idealized examples

New idealized cases