



ILMATIETEEN LAITOS
METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE

Verification of high-resolution precipitation forecasts by using the SAL method

Sami Niemelä
FMI

NetFAM moist physics workshop 2009
SMHI, Norrköping, Sweden,
15. - 17.6.2009.



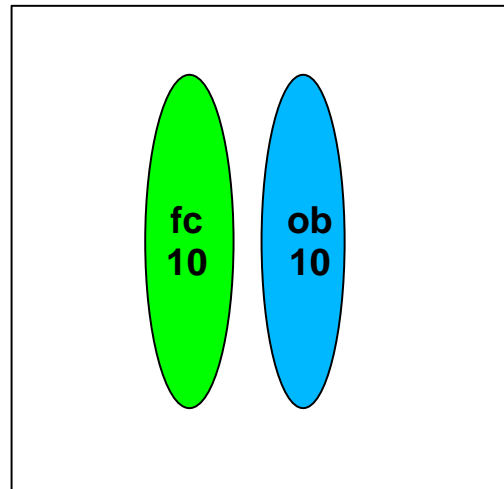
Outline

- A brief introduction to SAL.
- FMI's real-time SAL verification setup.
- What can we see from SAL?
- Diagnosing the NWP model by using SAL verification method.

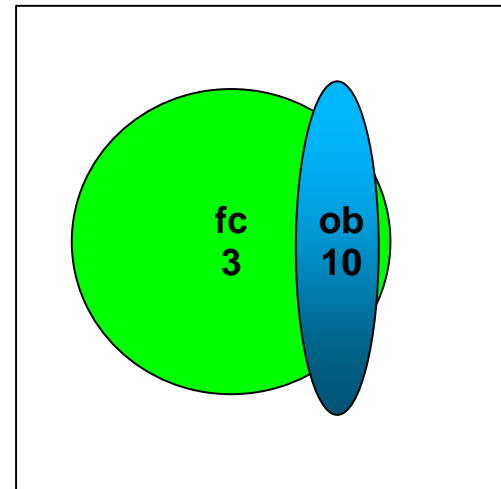


Verification of precipitation

- Traditional verification methods penalize higher-resolution models.



High resolution forecast
RMS ~ 4.7
POD = 0, FAR = 1, TS = 0

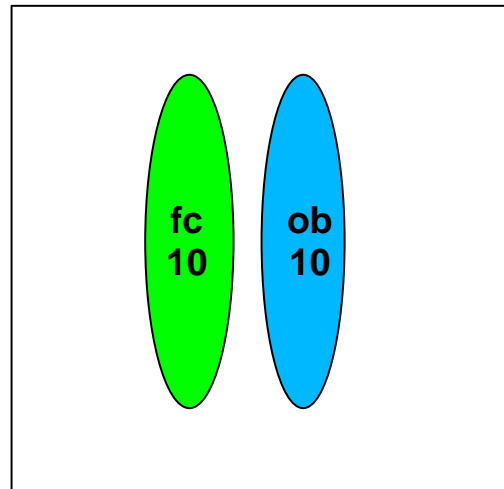


Low resolution forecast
RMS ~ 2.7
POD ~1, FAR ~0.7, TS ~0.3

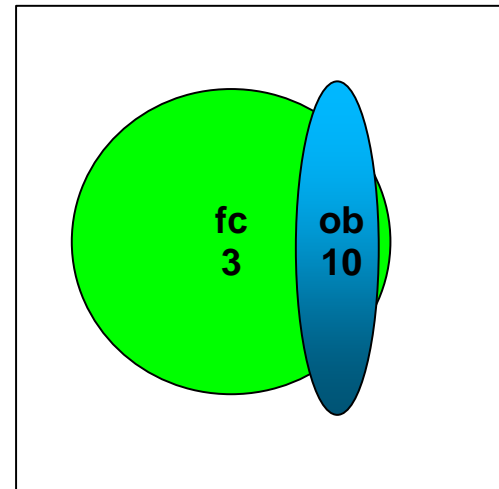


Verification of precipitation

- Traditional verification methods penalize higher-resolution models.



High resolution forecast
RMS ~ 4.7
POD = 0, FAR = 1, TS = 0



Low resolution forecast
RMS ~ 2.7
POD ~1, FAR ~0.7, TS ~0.3

→ Other methods (e.g. object based), which can capture the signal of possible additional value, are needed!



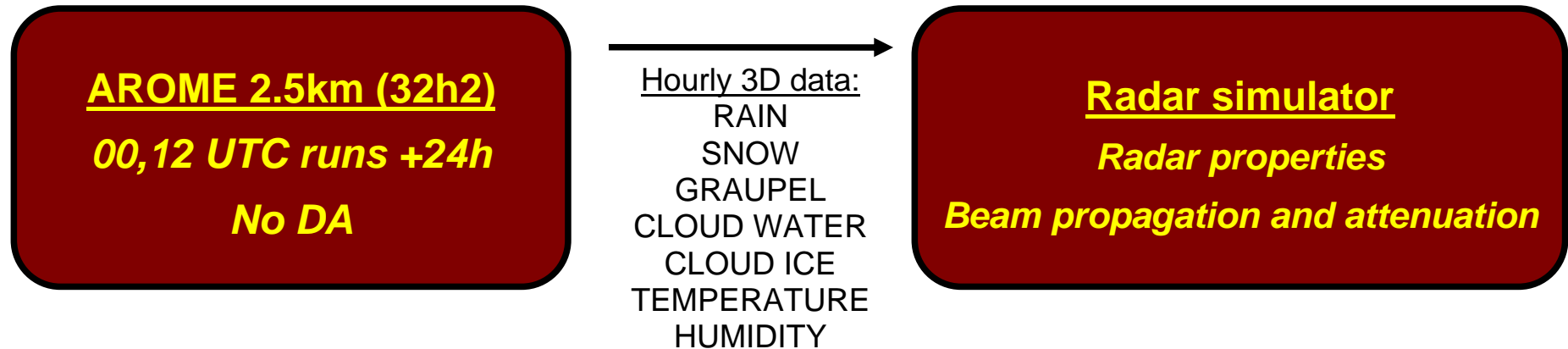
Structure Amplitude Location (SAL)

- **SAL** is object-based quality measure for the verification of QPFs.
- **SAL** contains three distinct components that focus on **Structure**, **Amplitude** and **Location** of the precipitation field in a specified domain.
- **S**: Model precipitation areas too large/flat or small/peaked. [-2...2]
- **A**: Difference of domain averaged precipitation. [-2...2]
- **L**: Location component = difference of mass centers of precipitation fields + averaged distance between the total mass center and individual precipitation objects. [0...2]

Wernli et al. (2008) SAL – a novel quality measure for the verification of quantitative precipitation forecasts. MWR, 136, 4470-4487.



FMI's real-time SAL verification setup





FMI's real-time SAL verification setup

AROME 2.5km (32h2)

00,12 UTC runs +24h

No DA

Hourly 3D data:

RAIN
SNOW
GRAUPEL
CLOUD WATER
CLOUD ICE
TEMPERATURE
HUMIDITY

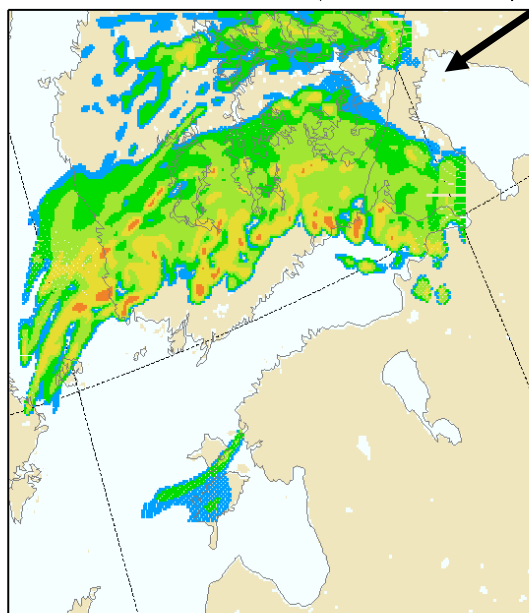
Radar simulator

Radar properties

Beam propagation and attenuation

AROME dBZ

AROME 08AUG2008 00 UTC Forecast. Radar reflectivity [dBZ]
08AUG2008 10:00 UTC (aro32h2,2.5km).

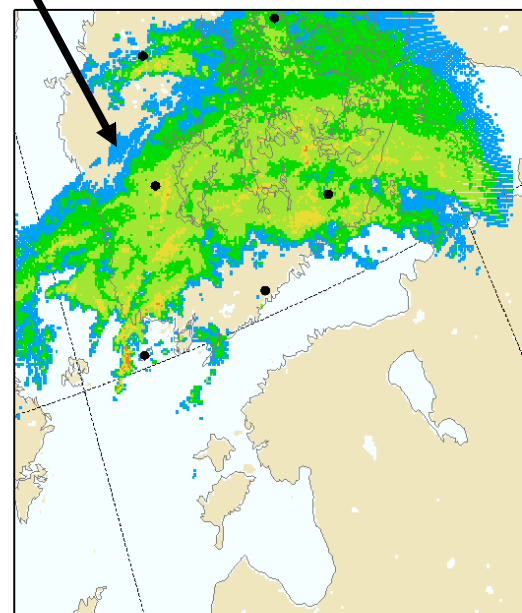


Radars:VAN,IKA,ANJ,KUO,KOR,VIM

Max:
45.1562

Observed dBZ in model grid

Observed radar reflectivity [dBZ].
08AUG2008 10:00 UTC.



Radars:VAN,IKA,ANJ,KUO,KOR,VIM

Max:
47.0547



FMI's real-time SAL verification setup

AROME

00,12 UTC

SAL verification

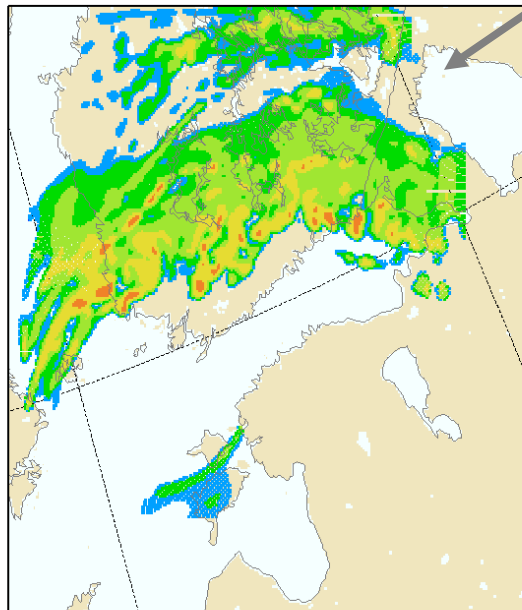
Fixed threshold for object detection = 16dBZ

Forecast lengths 1-24h are processed, every hour.

Each SAL point is ready ~20min after obs. is available

Attenuation

AROME 08AUG2008 00 UTC Forecast. Radar reflectivity [dBZ]
08AUG2008 10:00 UTC (aro32h2,2.5km).



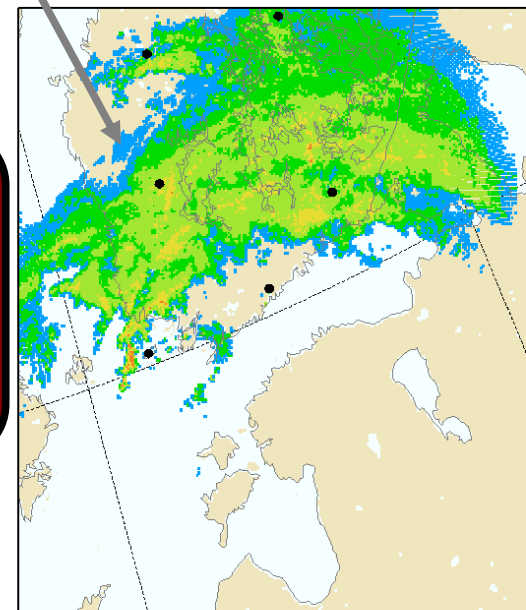
Max:
45.1562

S = - 0.34

A = - 0.12

L = 0.07

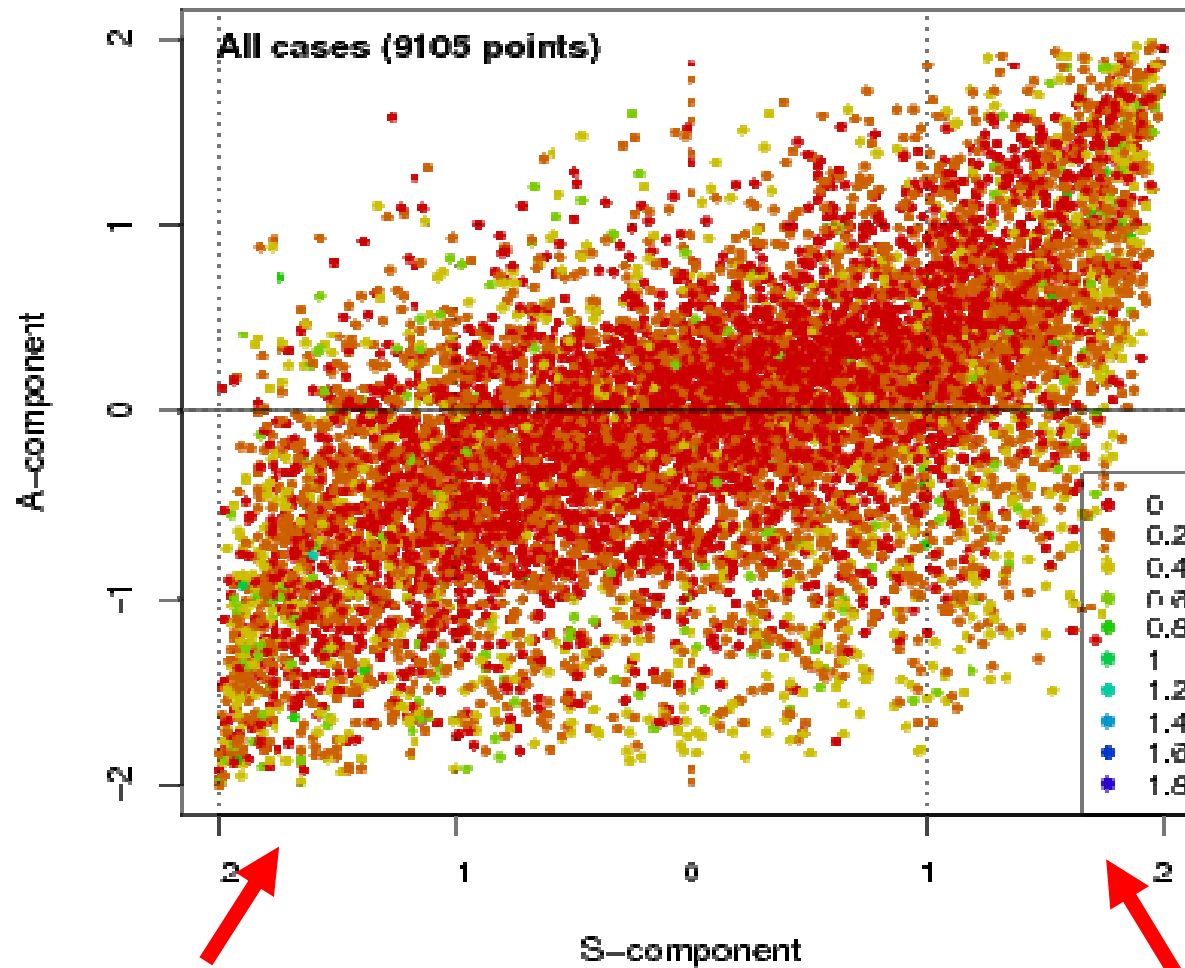
Observed radar reflectivity [dBZ].
08AUG2008 10:00 UTC.



Max:
47.0547



What can we see from SAL?

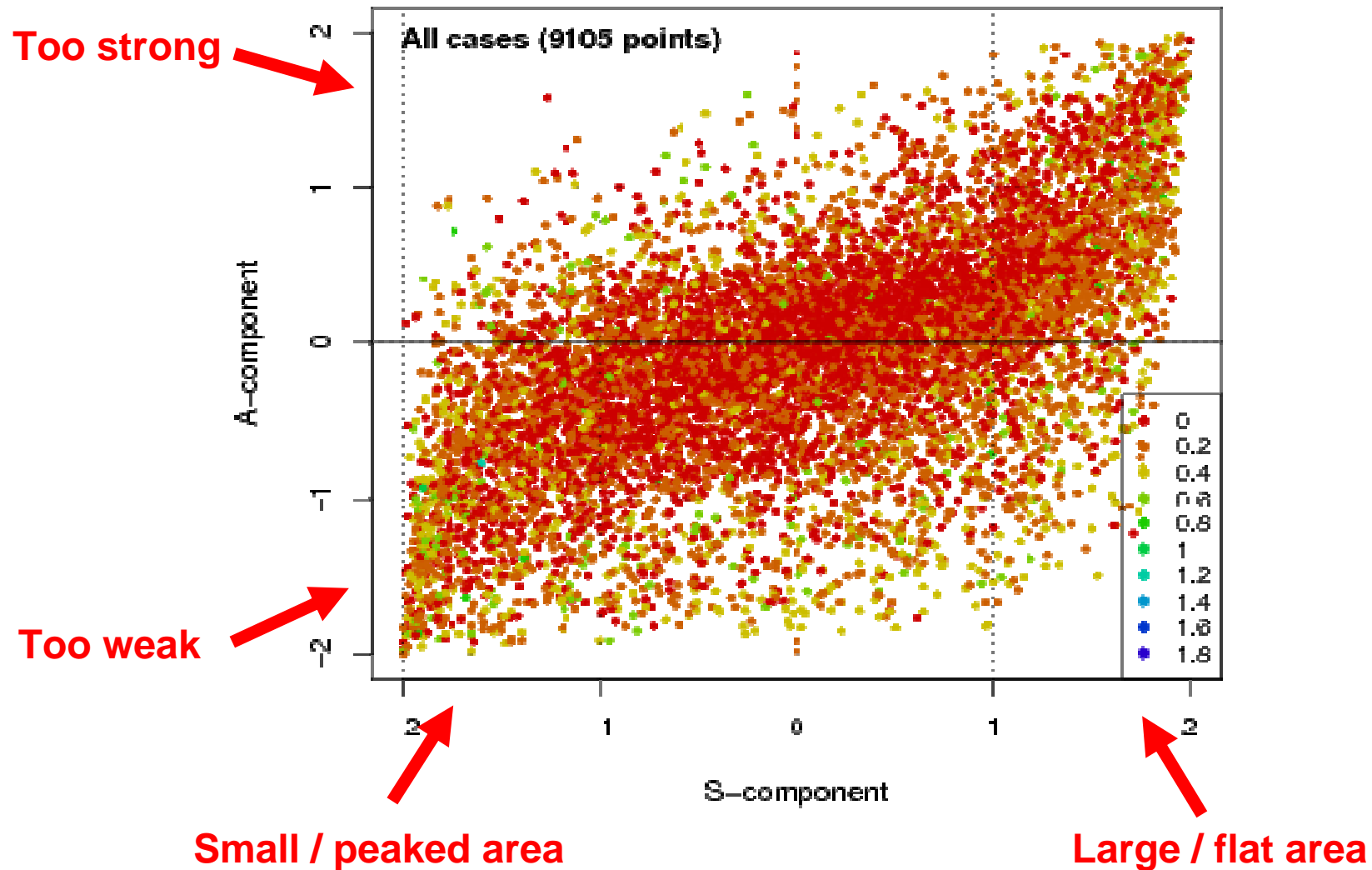


Small / peaked area

Large / flat area

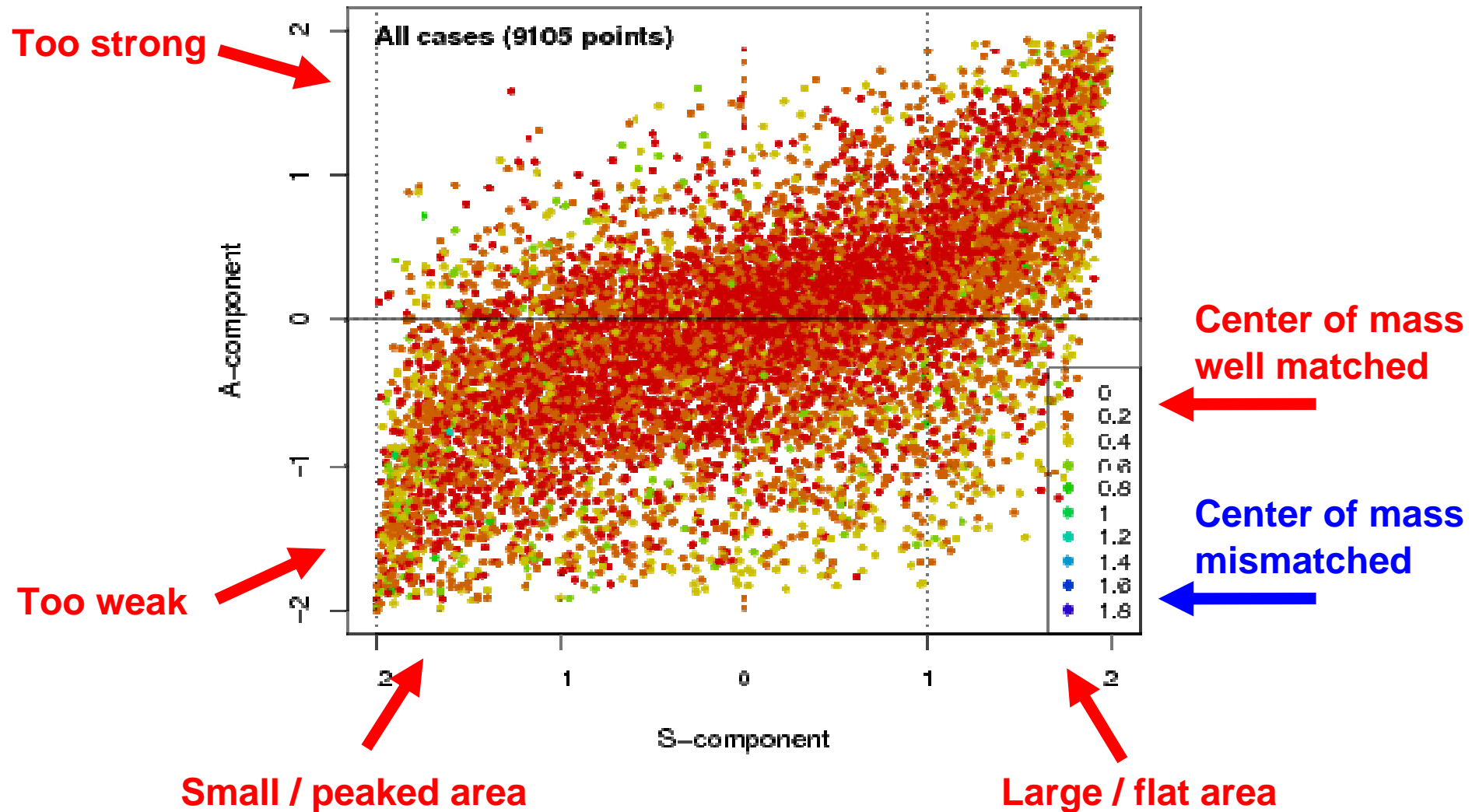


What can we see from SAL?



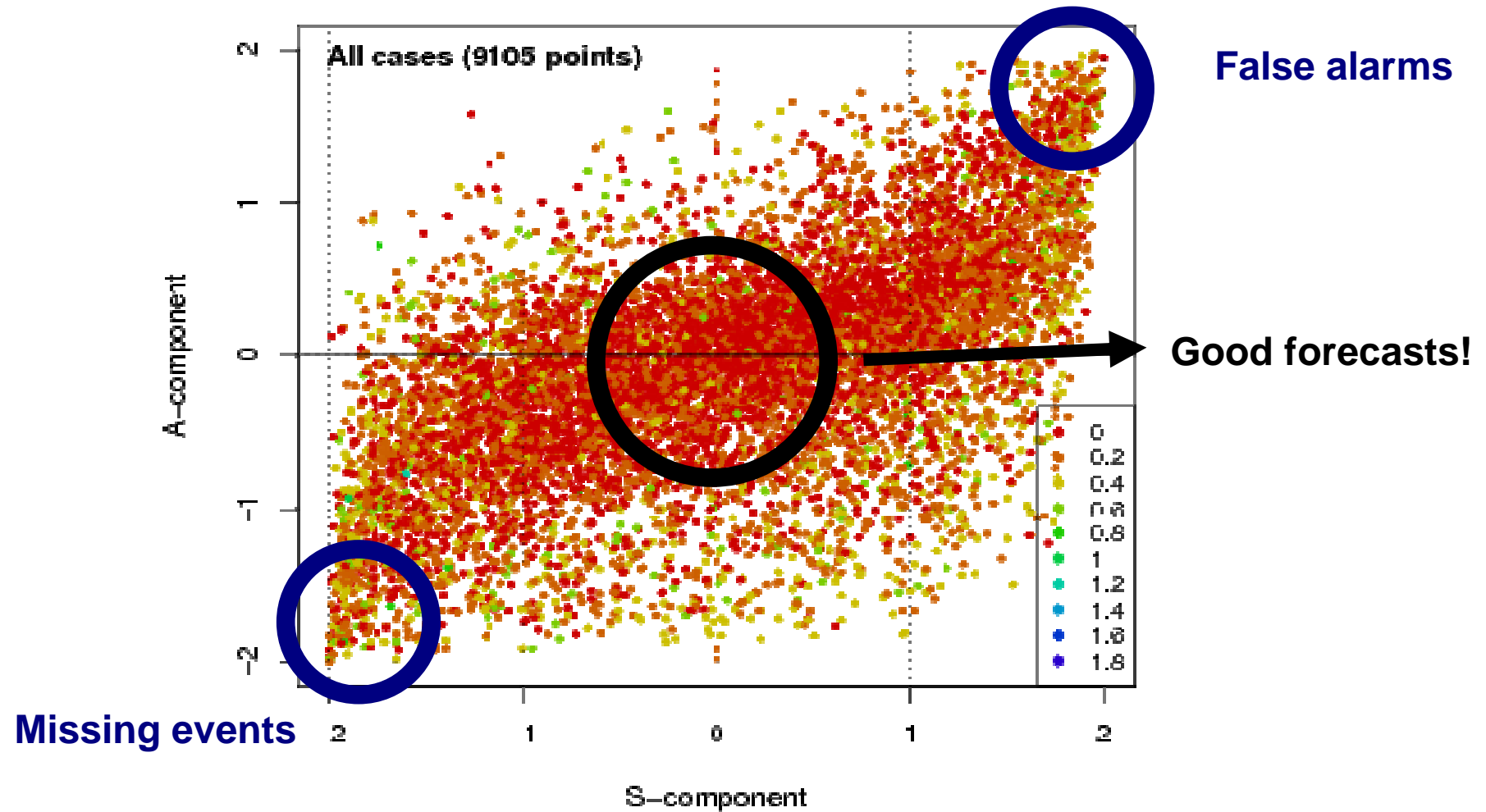


What can we see from SAL?



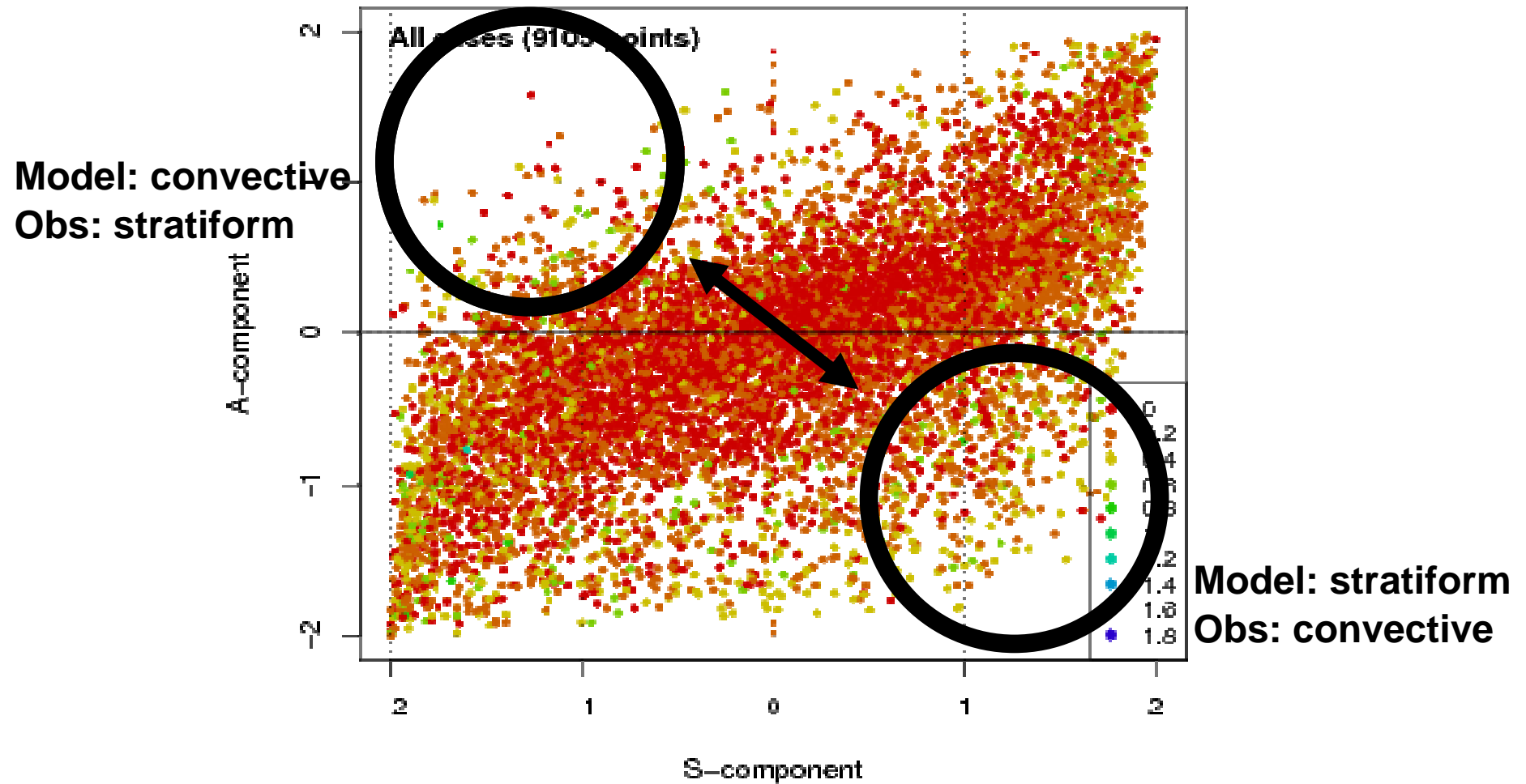


What can we see from SAL?





What can we see from SAL?





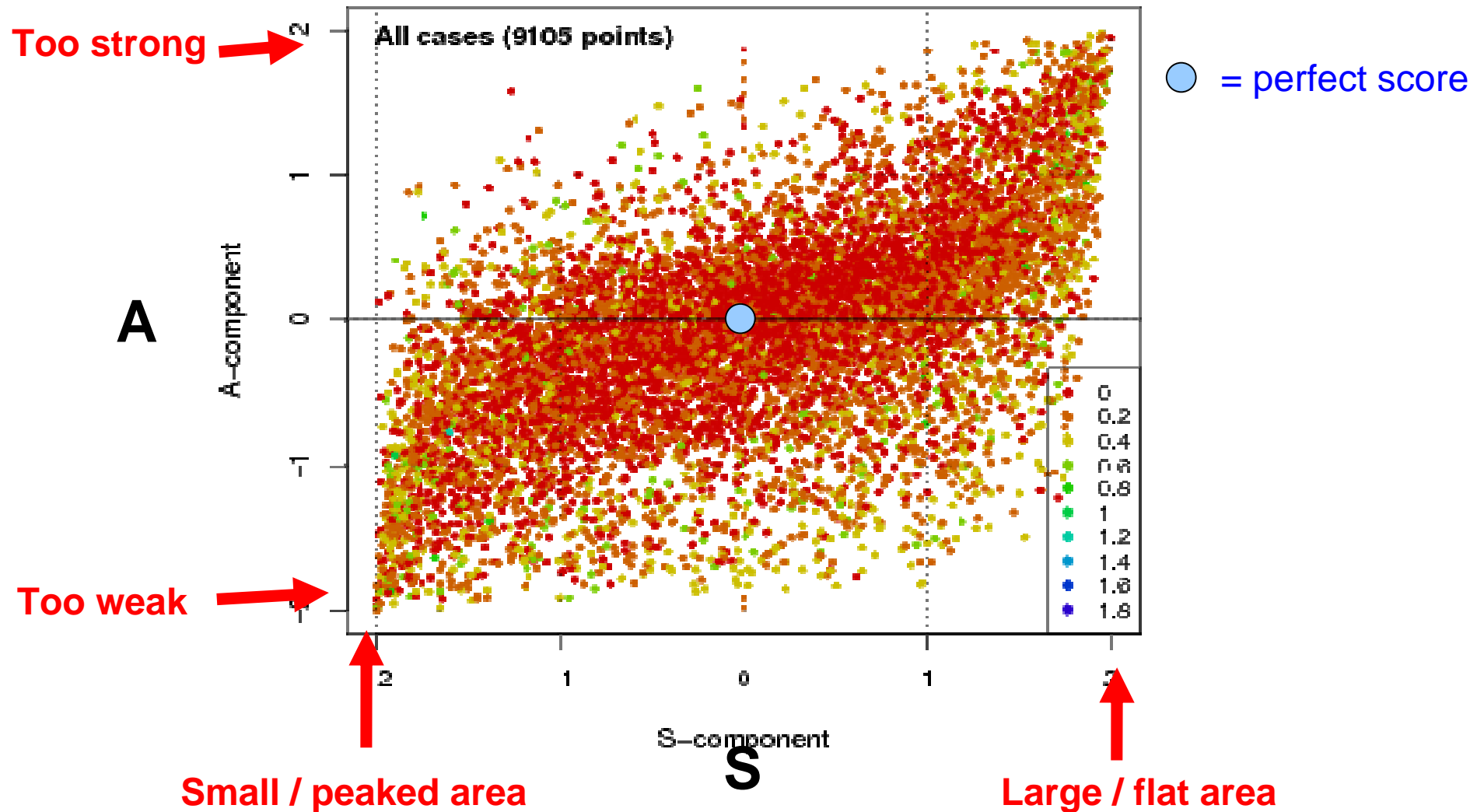
Diagnosing the NWP model by using SAL
verification method.

or

What SAL is able to tell us about the
precipitation forecasts of AROME model?



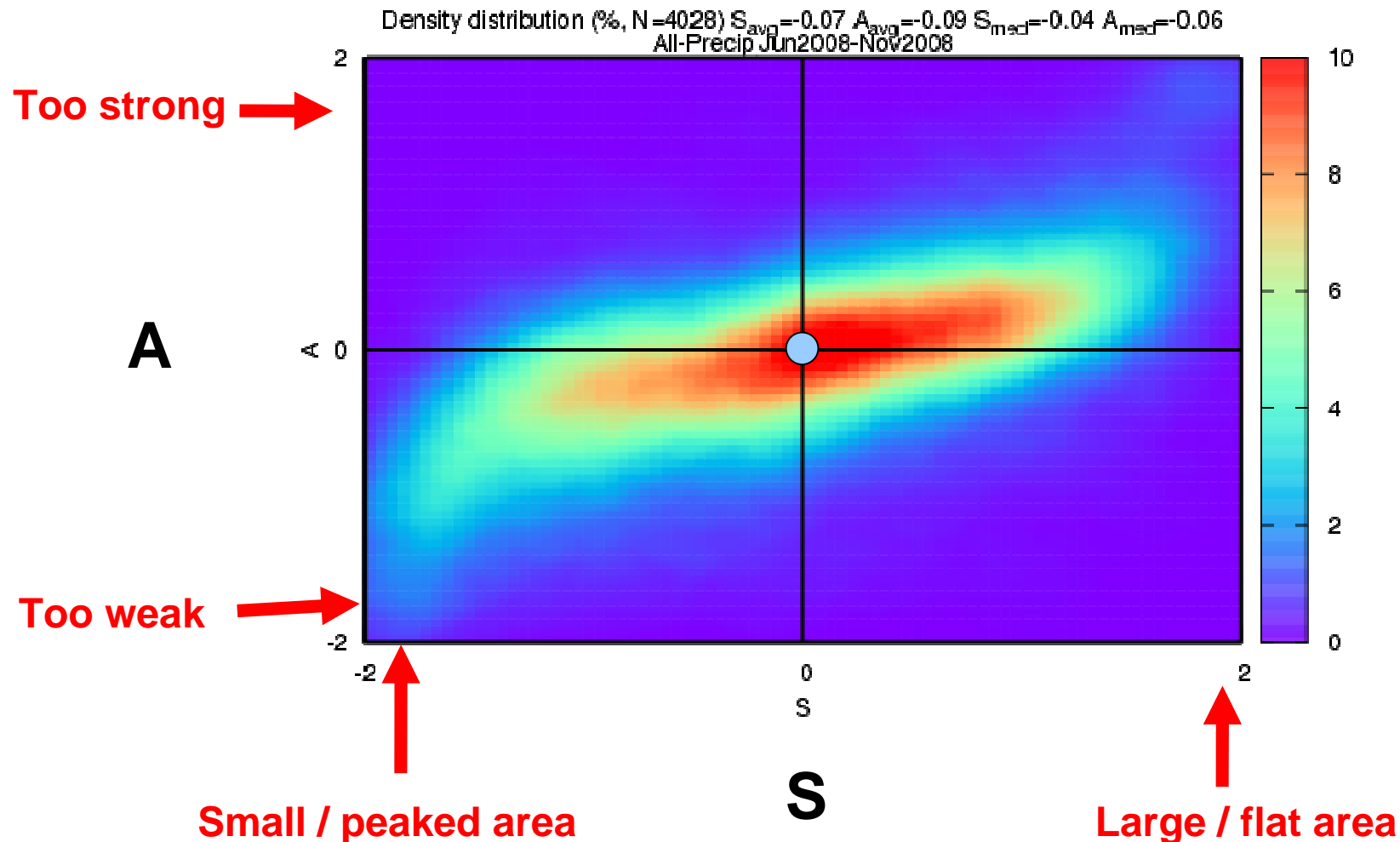
All cases Jun 2008 – Mar 2009





S vs. A - Precipitation cases Jun 2008 – Nov 2008

● = perfect score

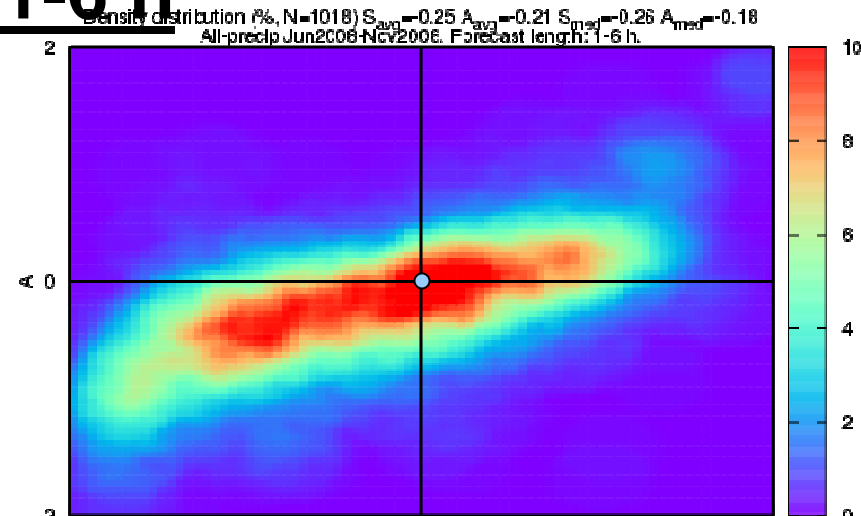




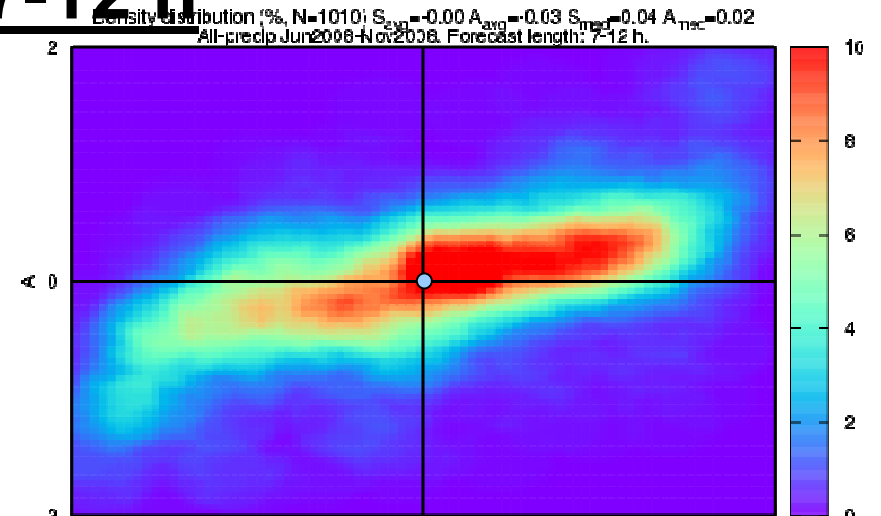
S vs. A - Time dependency

● = perfect score

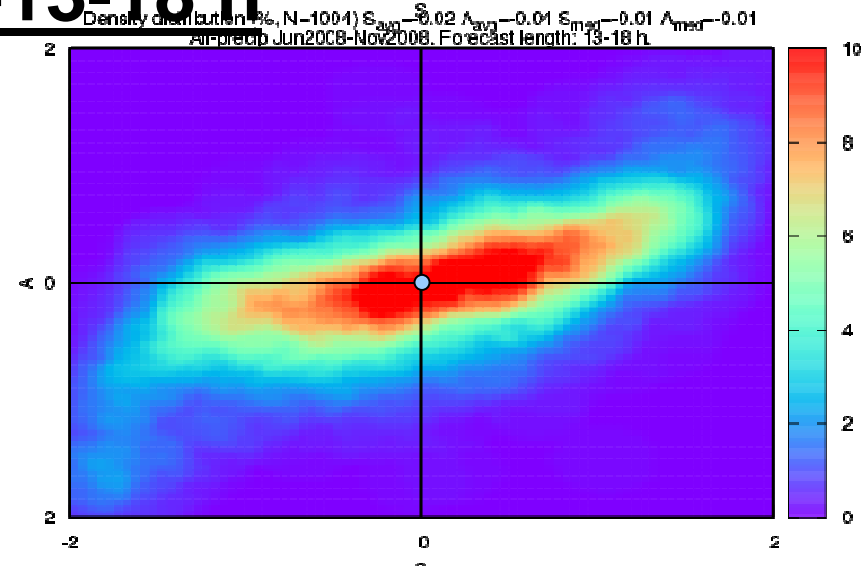
+1-6 h



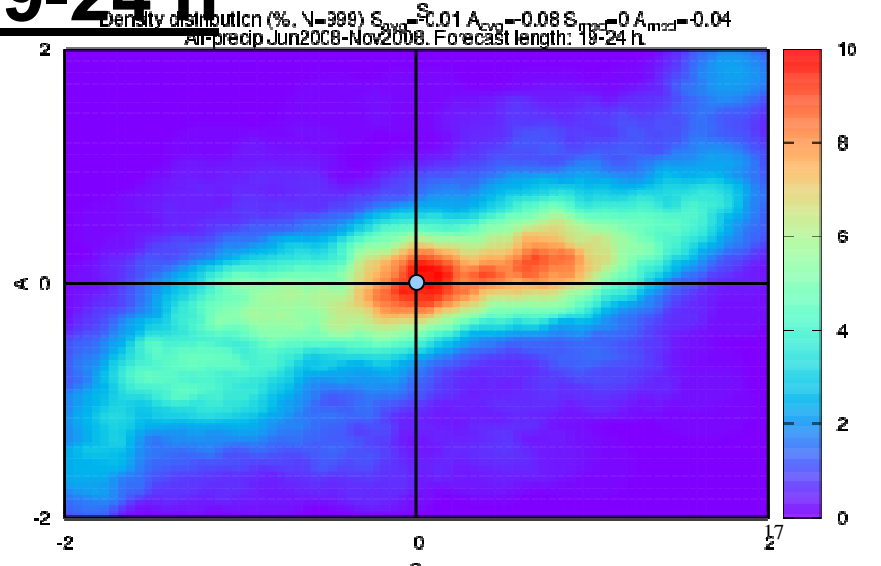
+7-12 h



+13-18 h



+19-24 h



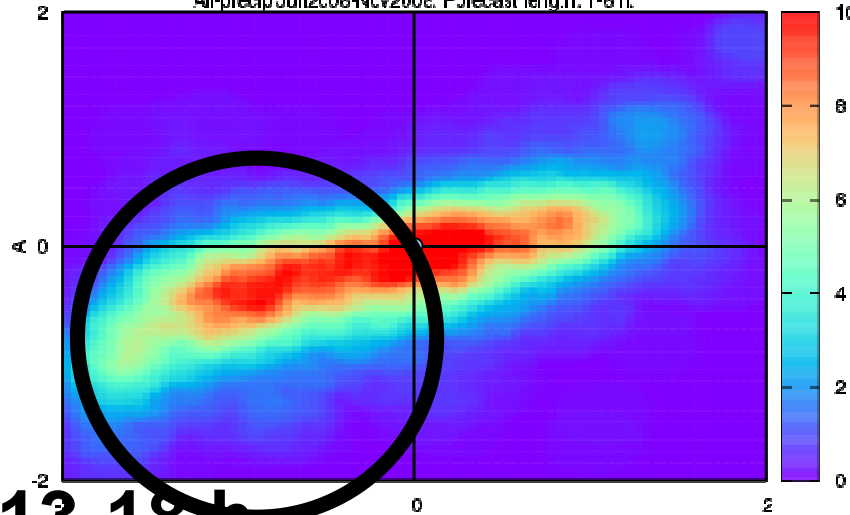


S vs. A - Time dependency

● = perfect score

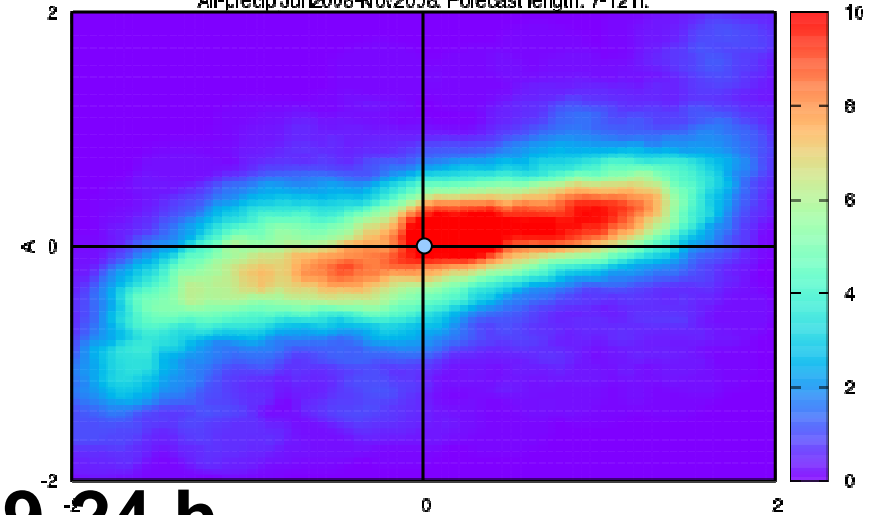
+1-6 h

Density distribution (%; N=1018) $S_{avg} = -0.25$ $A_{avg} = -0.21$ $S_{med} = -0.26$ $A_{med} = -0.18$
All-precip Jun2008-Nov2008. Forecast length: 1-6 h.



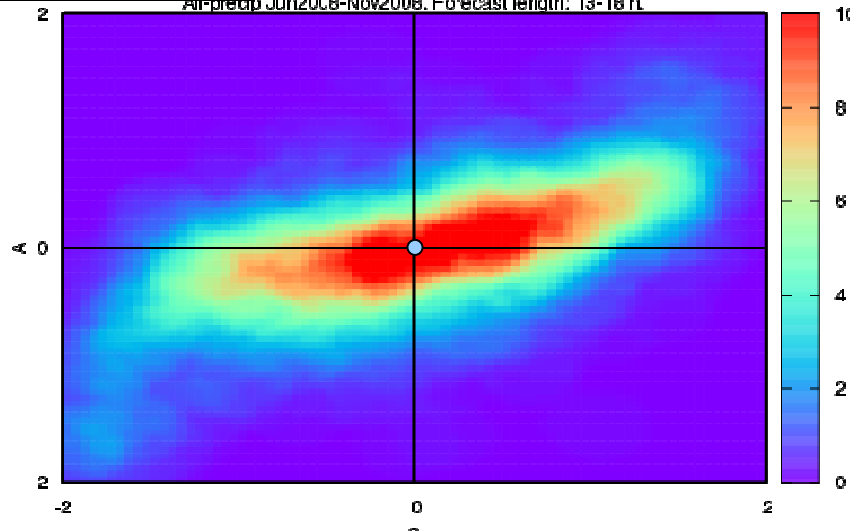
+7-12 h

Density distribution (%; N=1010) $S_{avg} = -0.00$ $A_{avg} = -0.03$ $S_{med} = 0.04$ $A_{med} = 0.02$
All-precip Jun2008-Nov2008. Forecast length: 7-12 h.



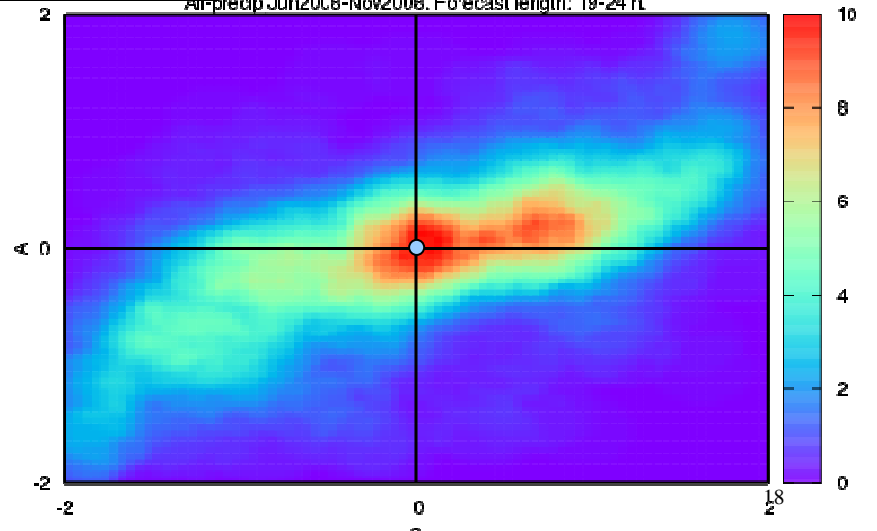
+13-18 h

Density distribution (%; N=1004) $S_{avg} = -0.02$ $A_{avg} = -0.01$ $S_{med} = -0.01$ $A_{med} = -0.01$
All-precip Jun2008-Nov2008. Forecast length: 13-18 h.



+19-24 h

Density distribution (%; N=999) $S_{avg} = -0.01$ $A_{avg} = -0.08$ $S_{med} = 0$ $A_{med} = -0.04$
All-precip Jun2008-Nov2008. Forecast length: 19-24 h.

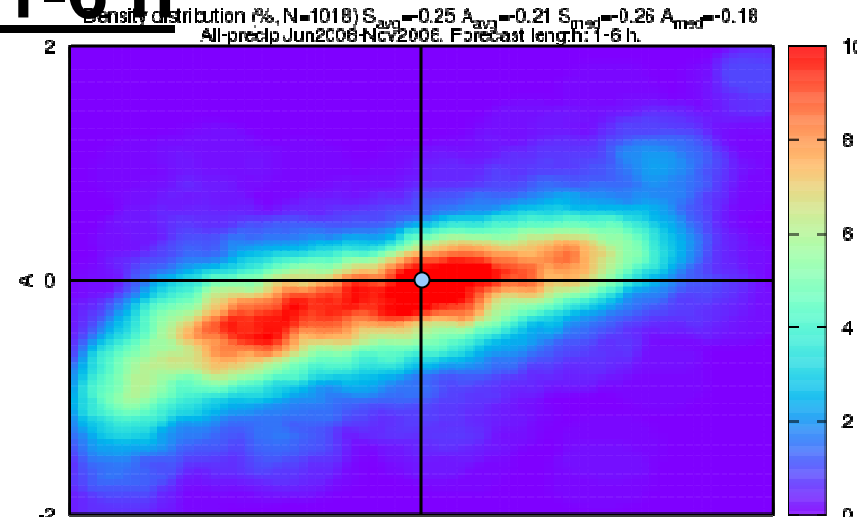




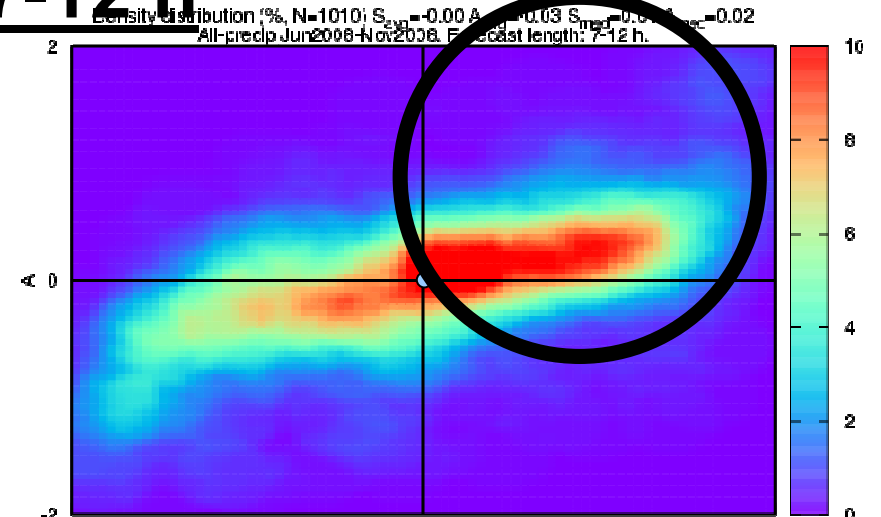
S vs. A - Time dependency

● = perfect score

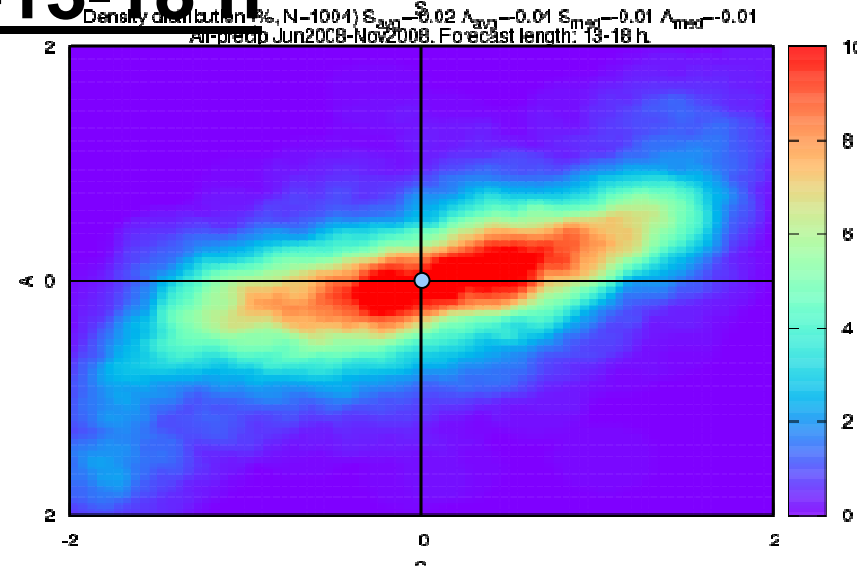
+1-6 h



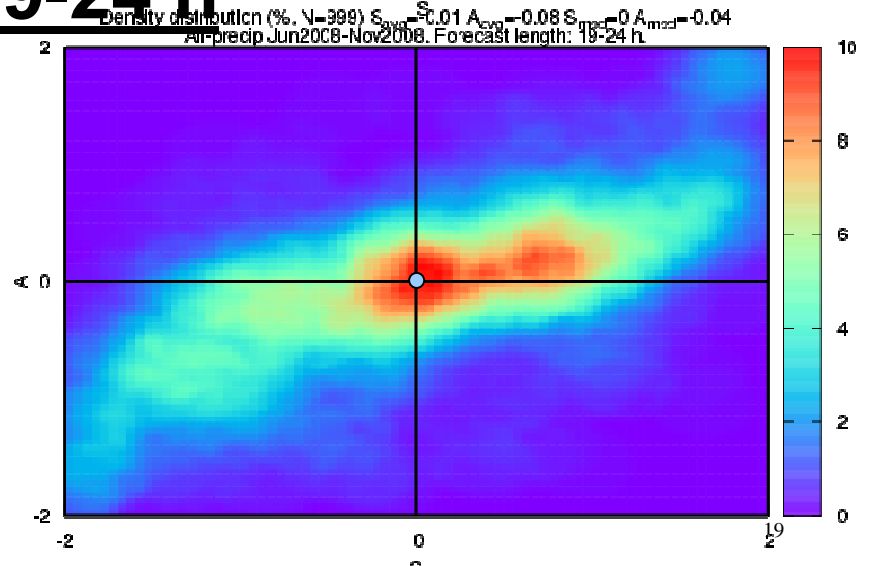
+7-12 h



+13-18 h



+19-24 h

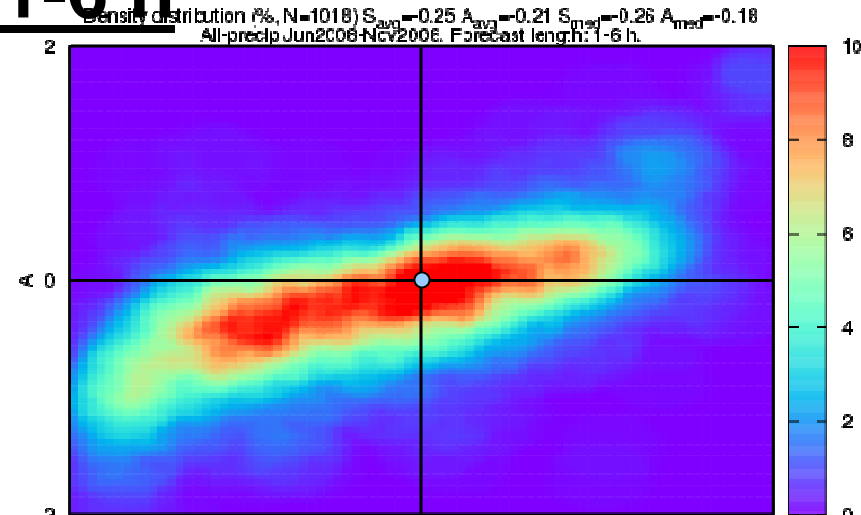




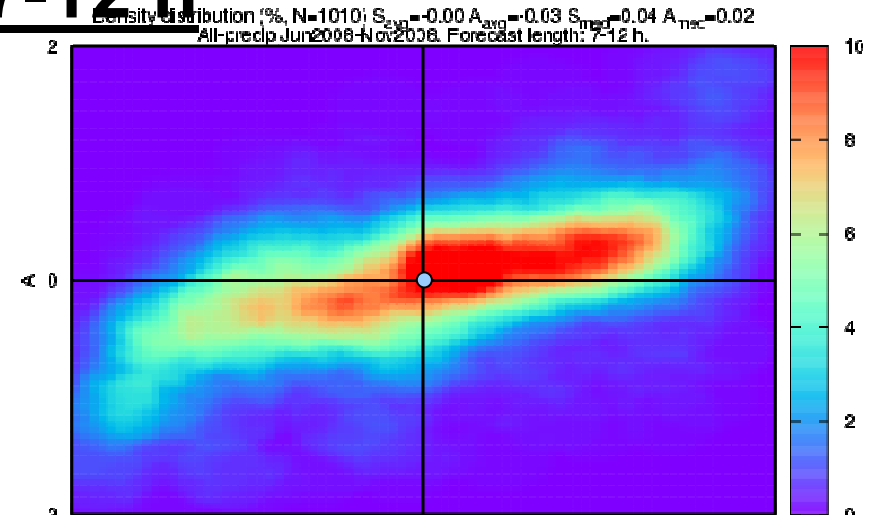
S vs. A - Time dependency

● = perfect score

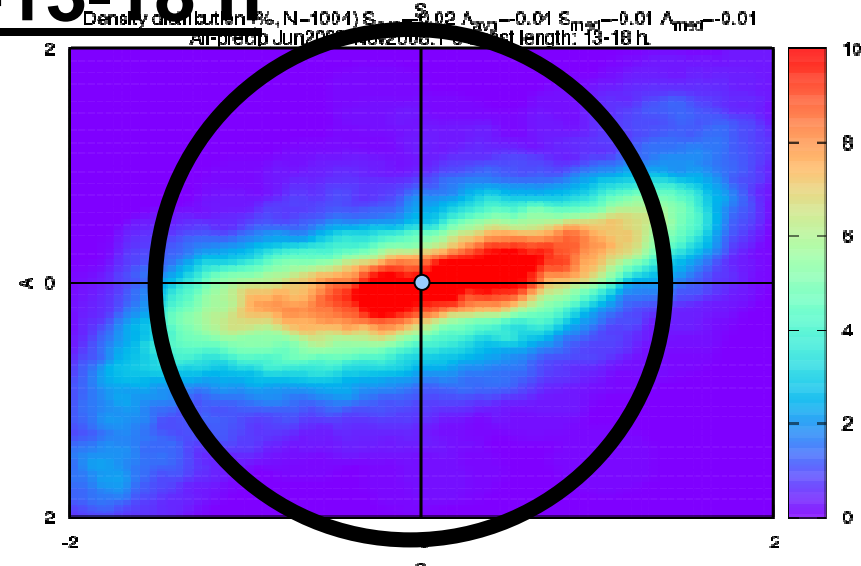
+1-6 h



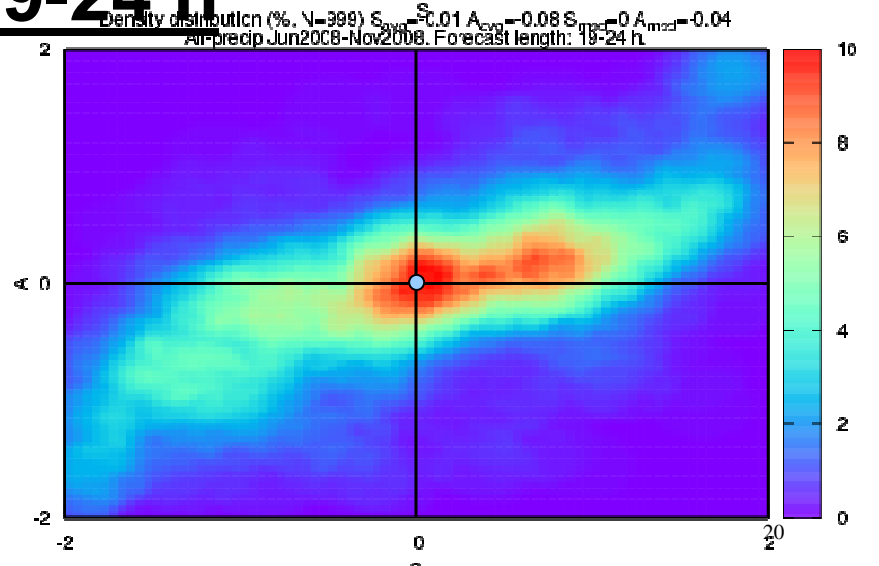
+7-12 h



+13-18 h



+19-24 h

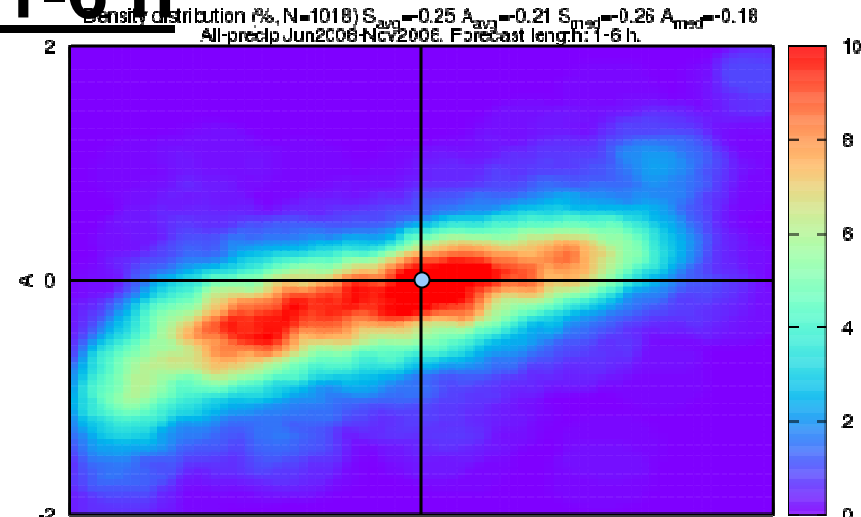




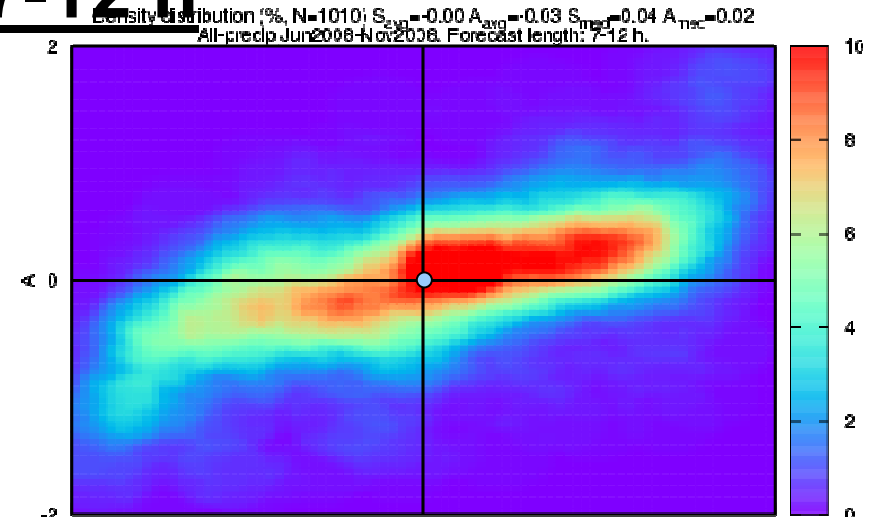
S vs. A - Time dependency

● = perfect score

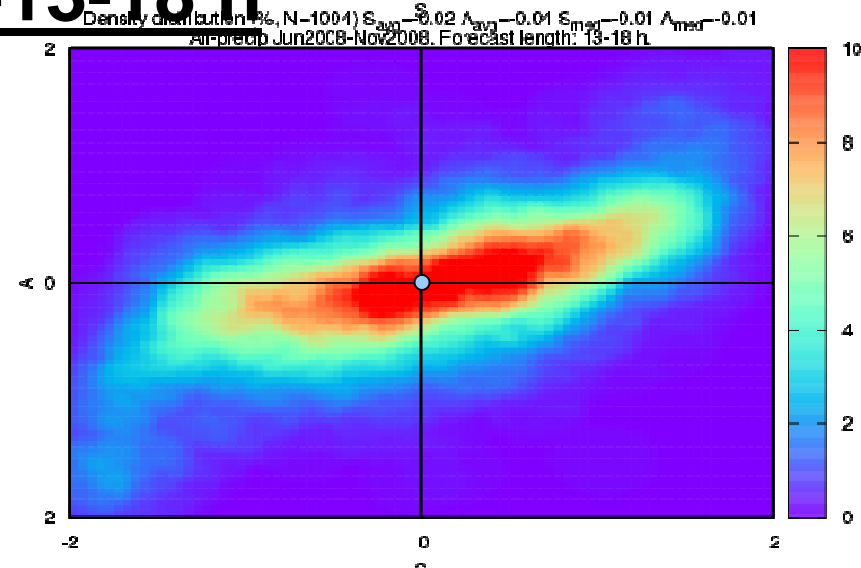
+1-6 h



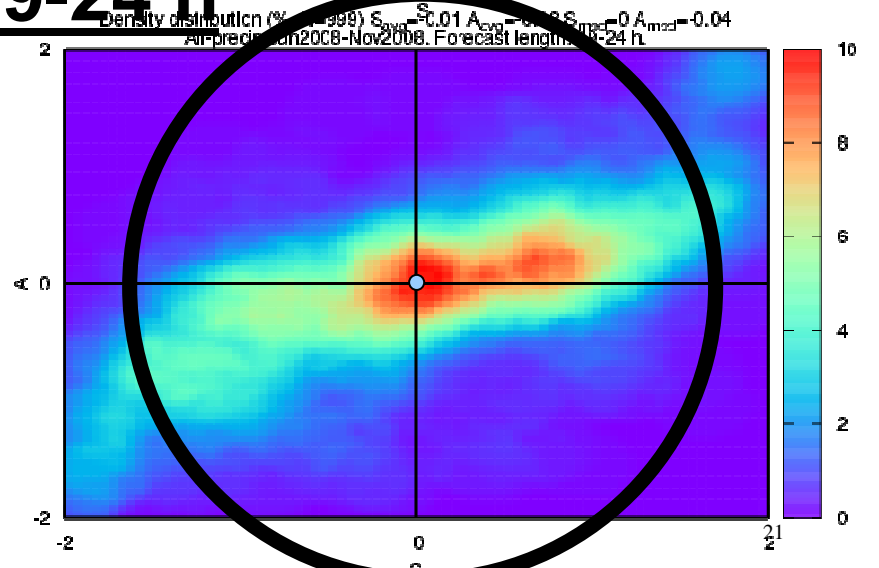
+7-12 h



+13-18 h



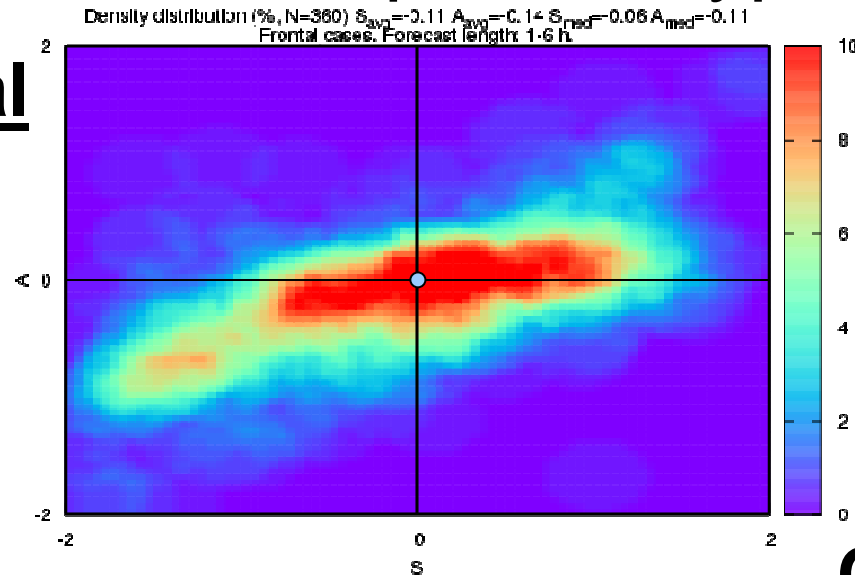
+19-24 h





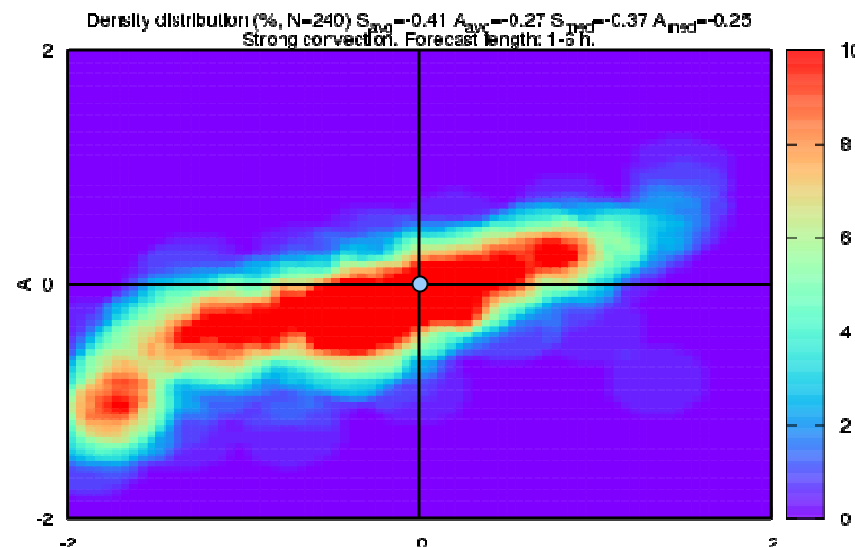
S vs. A – Precipitation type +1-6h

Frontal

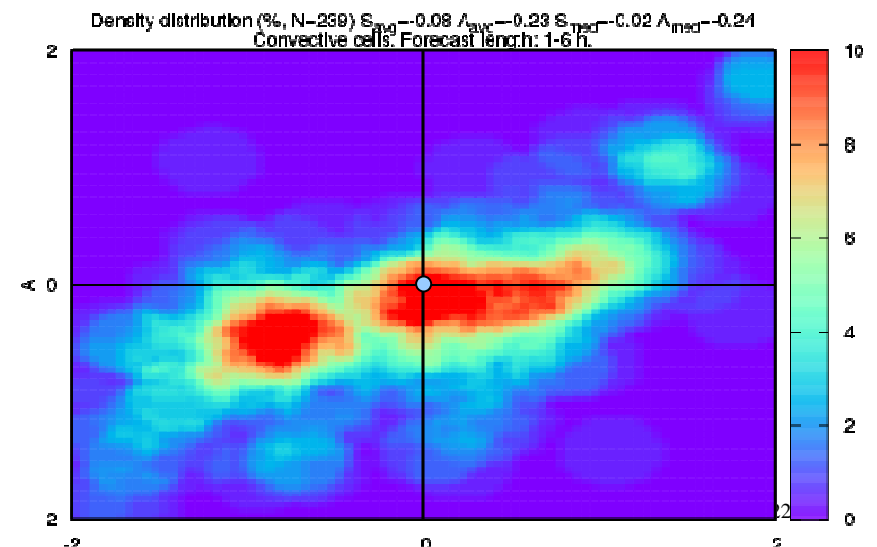


○ = perfect score

Strong conv.



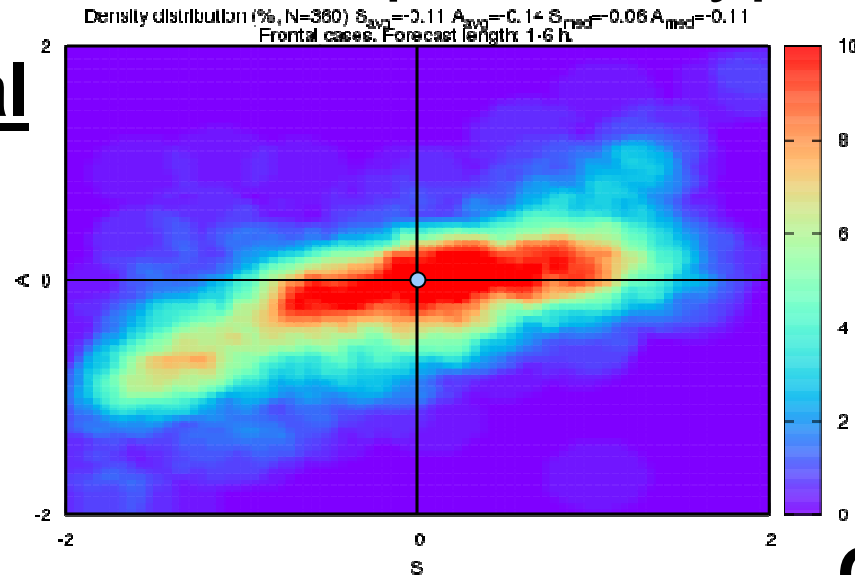
Open cell conv.





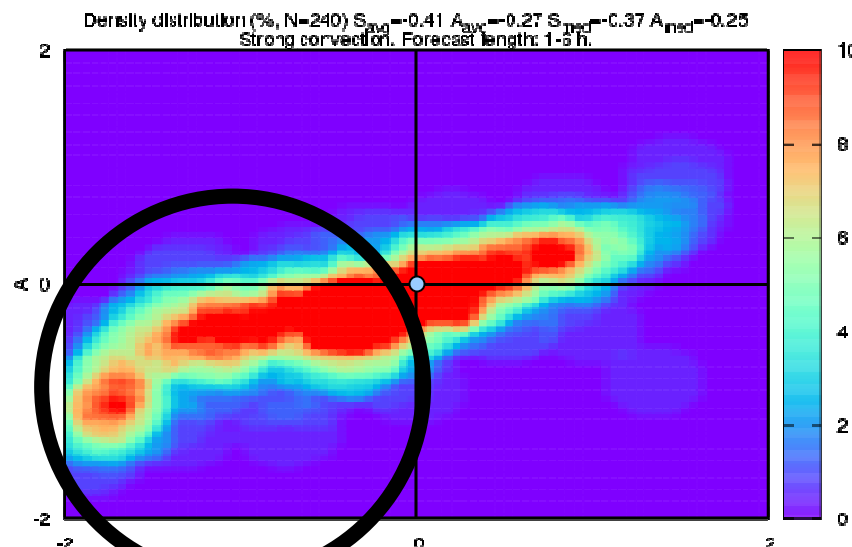
S vs. A – Precipitation type +1-6h

Frontal

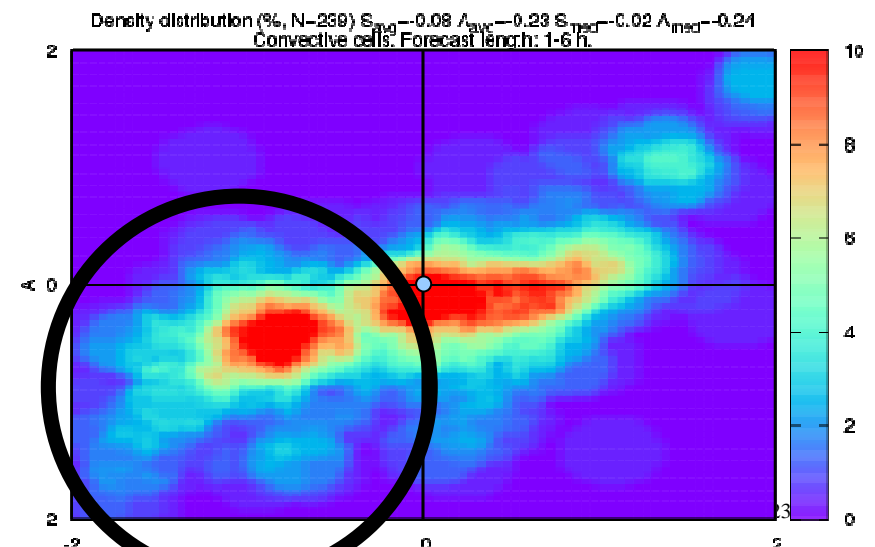


○ = perfect score

Strong conv.



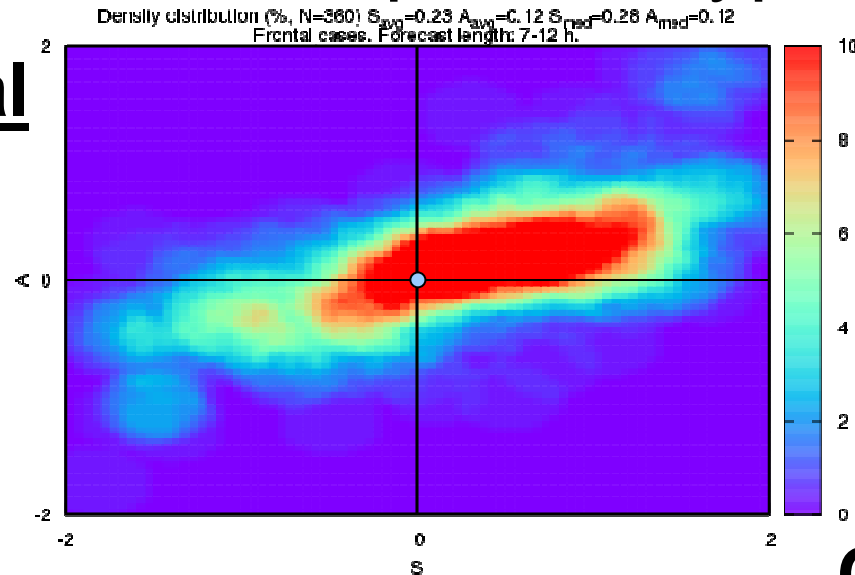
Open cell conv.





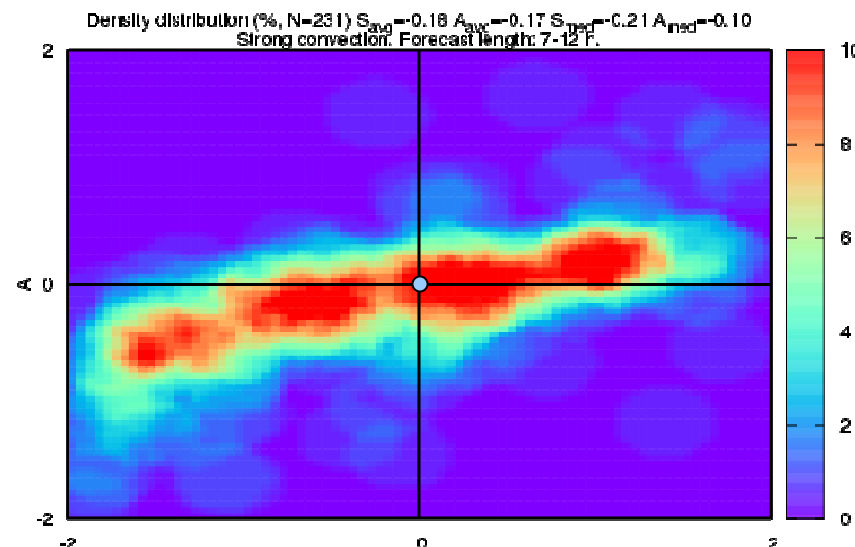
S vs. A – Precipitation type +7-12h

Frontal

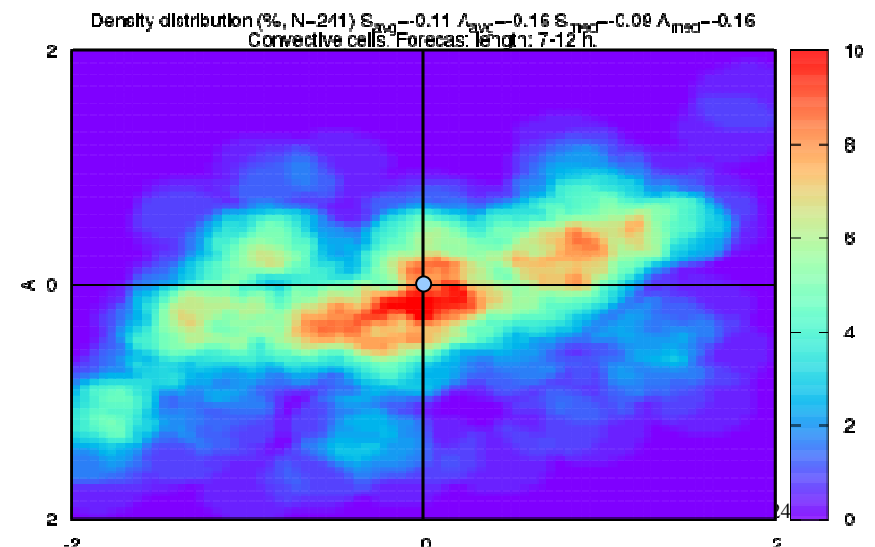


○ = perfect score

Strong conv.



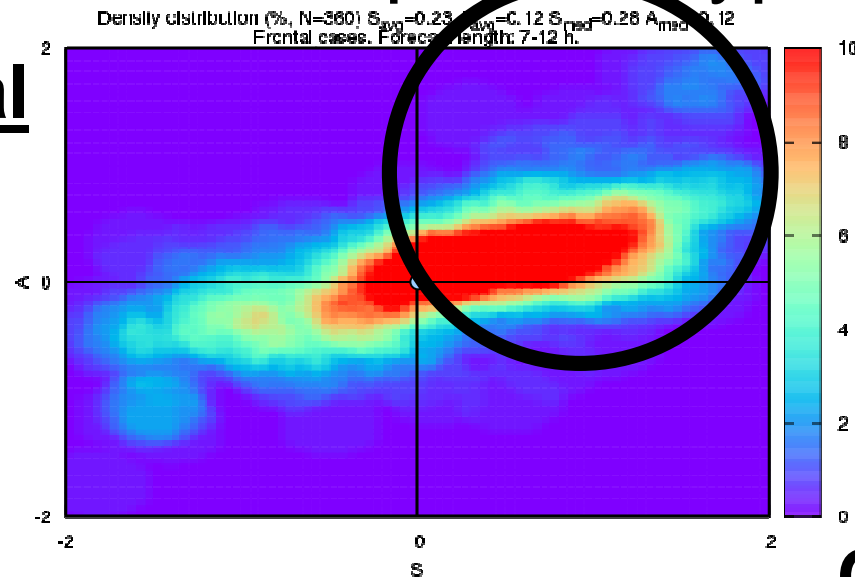
Open cell conv.





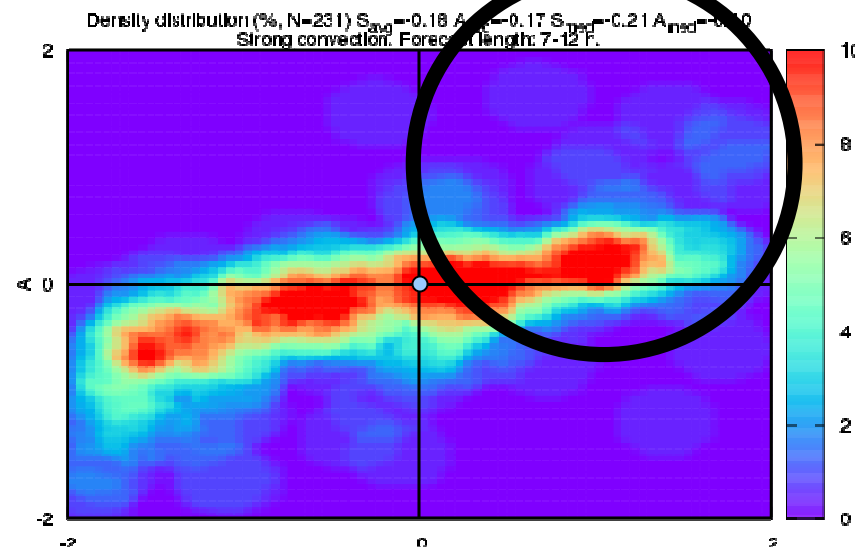
S vs. A – Precipitation type +7-12h

Frontal

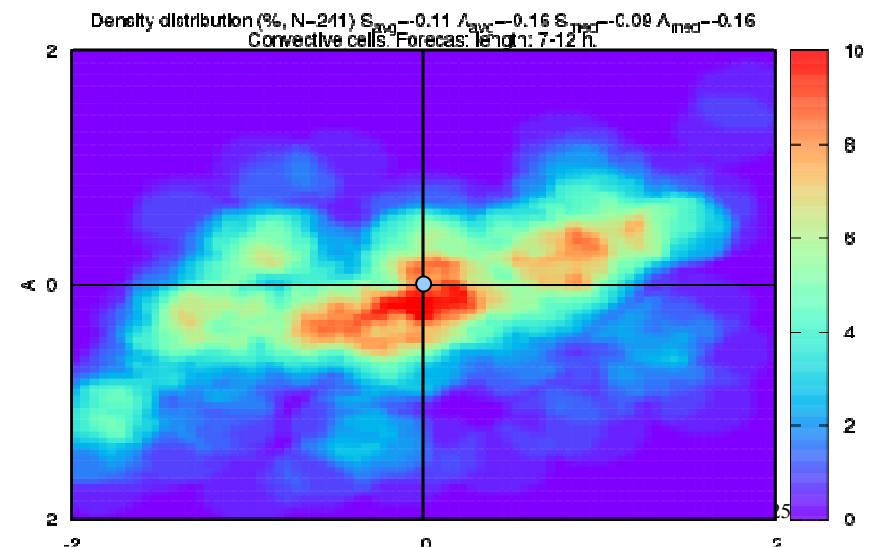


○ = perfect score

Strong conv.



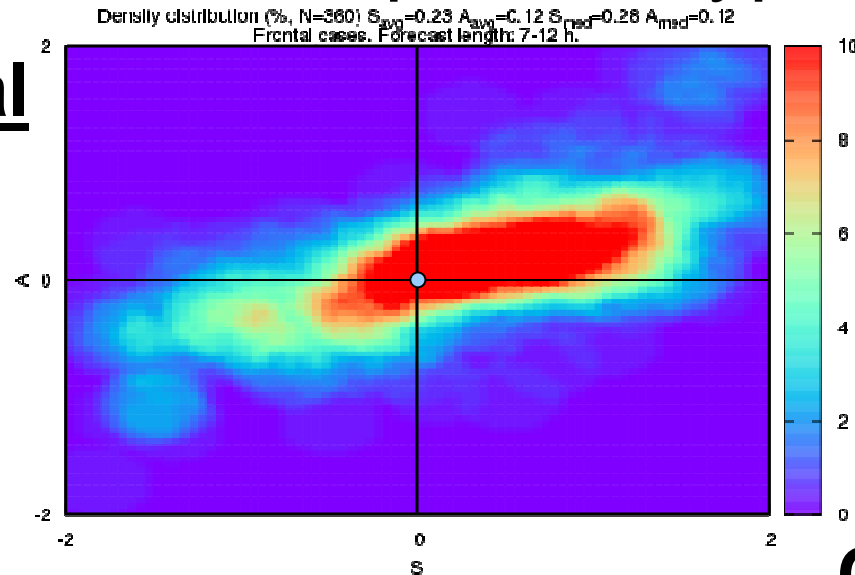
Open cell conv.





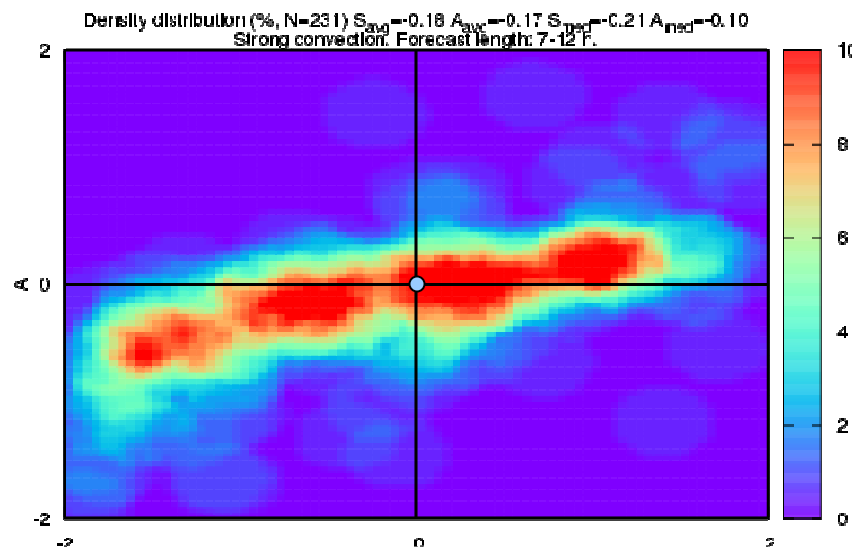
S vs. A – Precipitation type +7-12h

Frontal

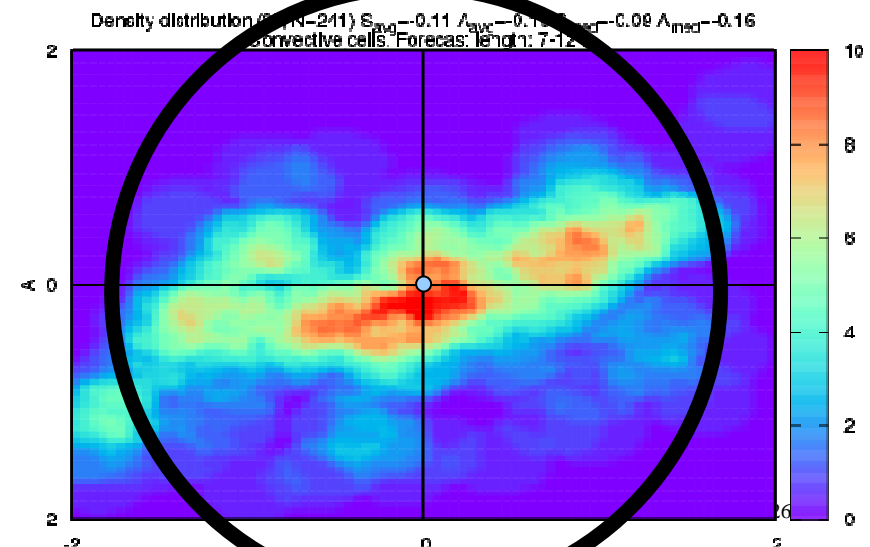


○ = perfect score

Strong conv.



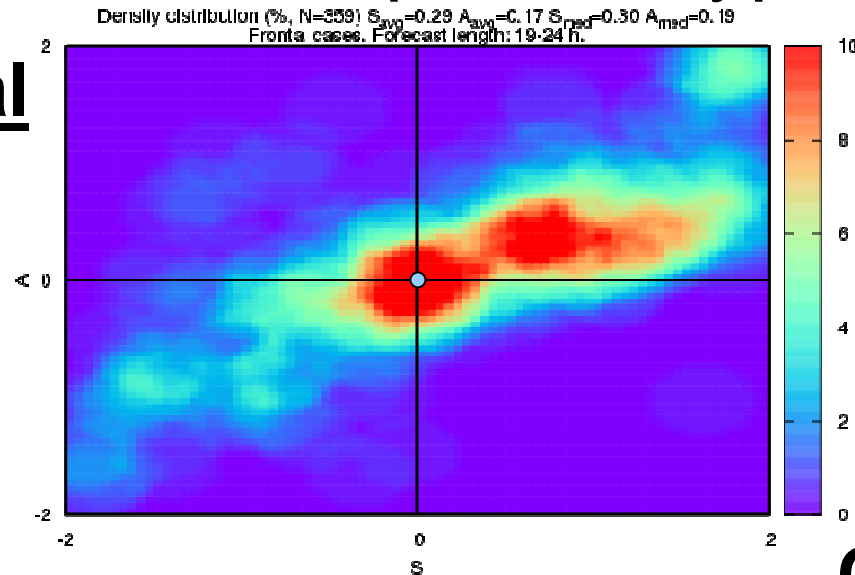
Open cell conv.





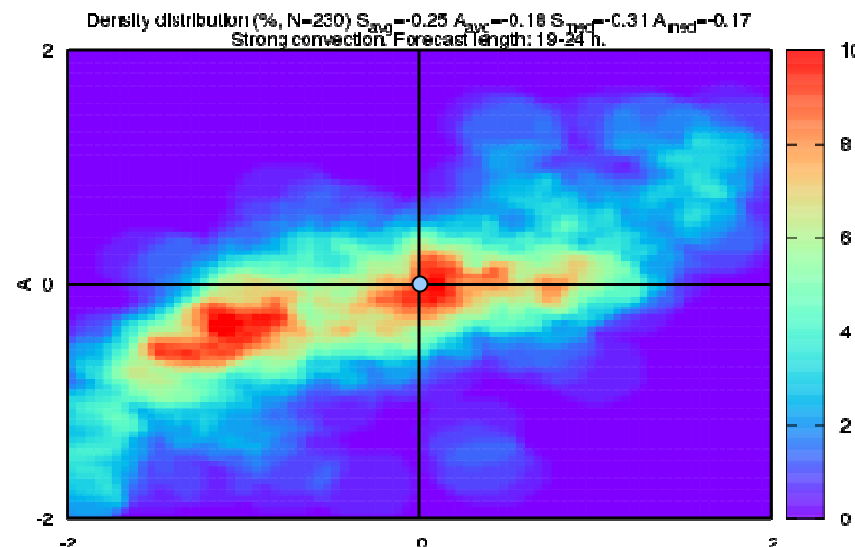
S vs. A – Precipitation type +19-24h

Frontal

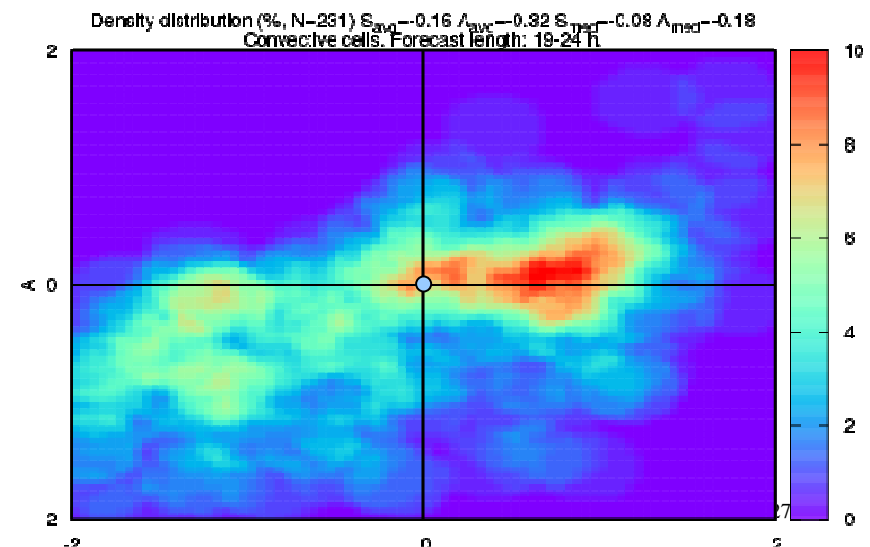


○ = perfect score

Strong conv.



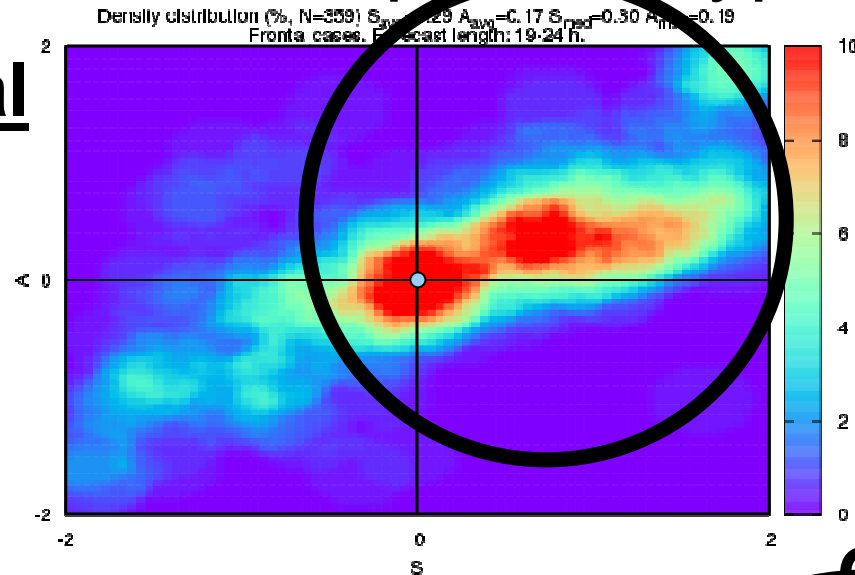
Open cell conv.





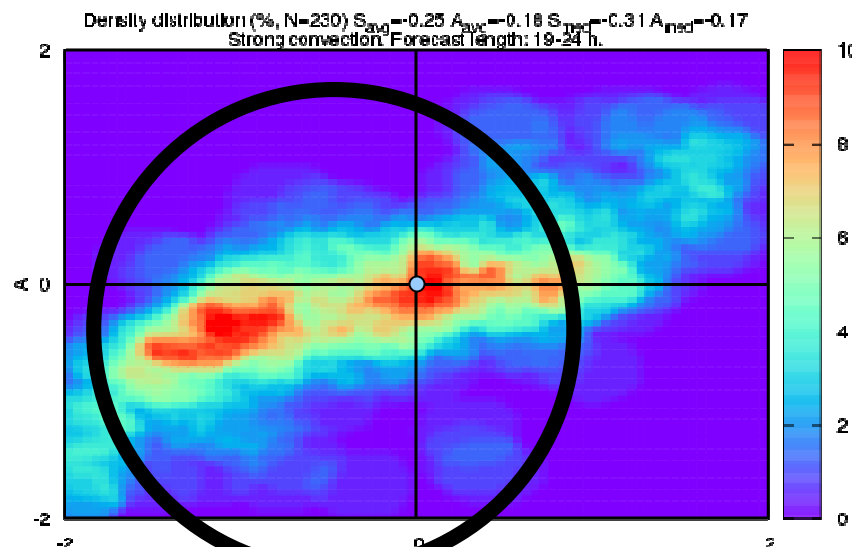
S vs. A – Precipitation type +19-24h

Frontal

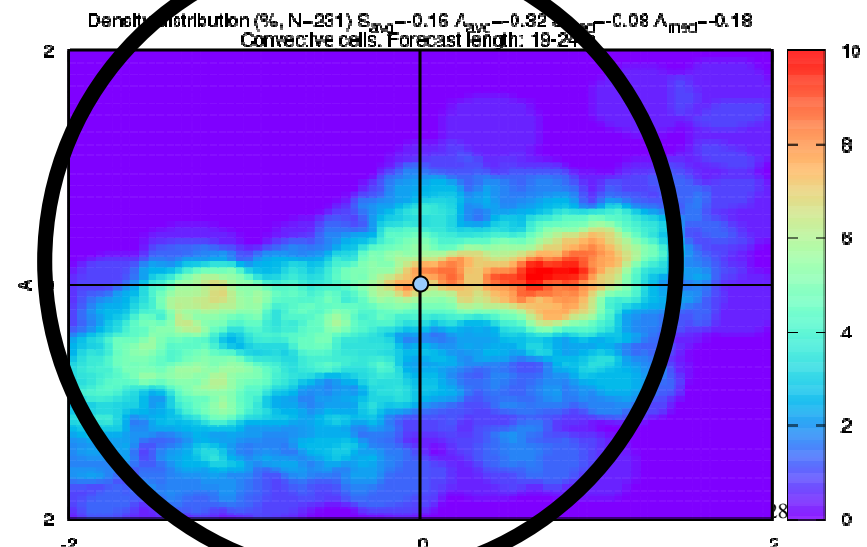


○ = perfect score

Strong conv.



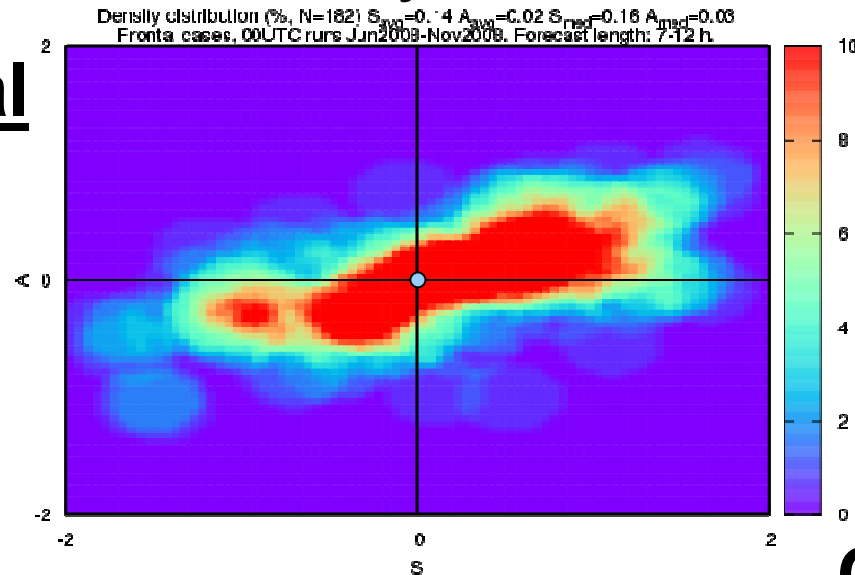
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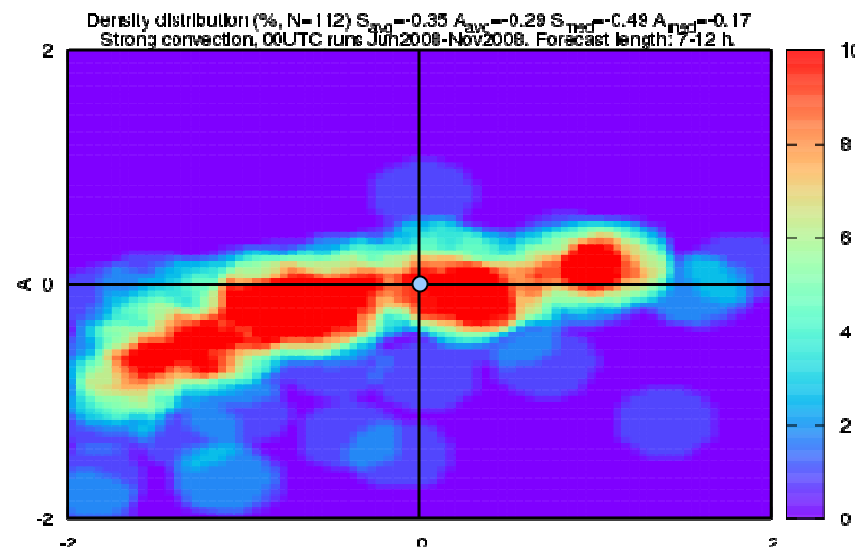
S vs. A – diurnal cycle 00 UTC +7-12h

Frontal

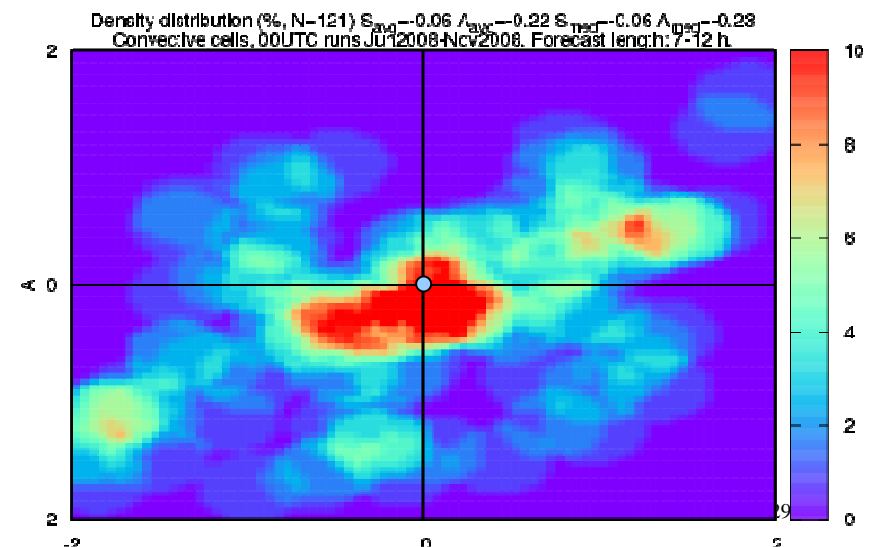


○ = perfect score

Strong conv.



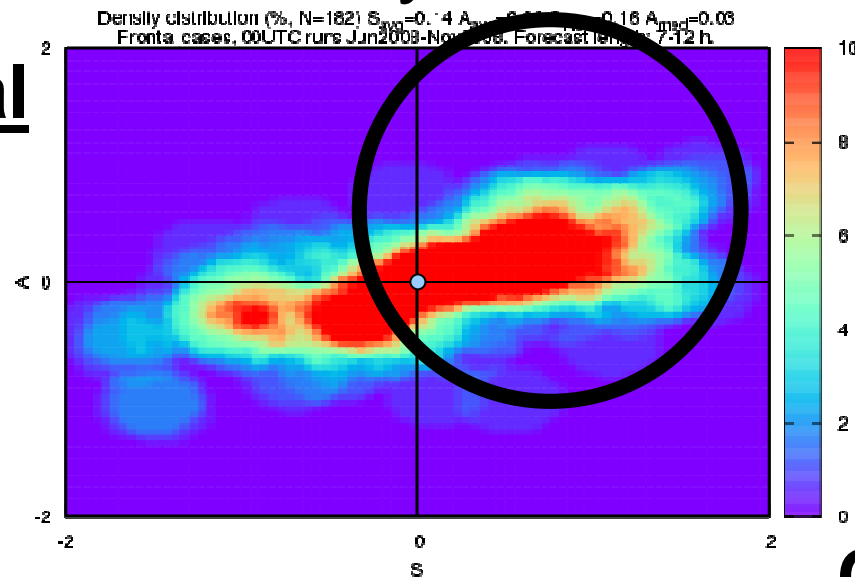
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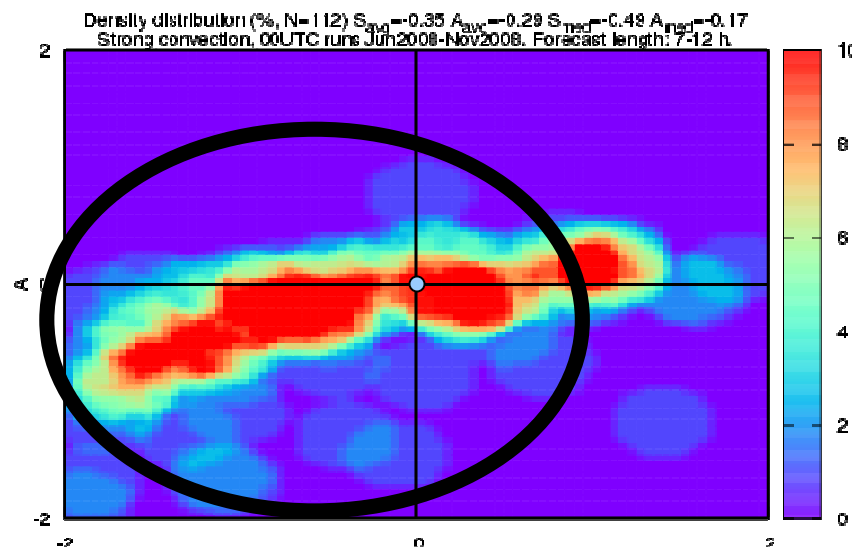
S vs. A – diurnal cycle 00 UTC +7-12h

Frontal

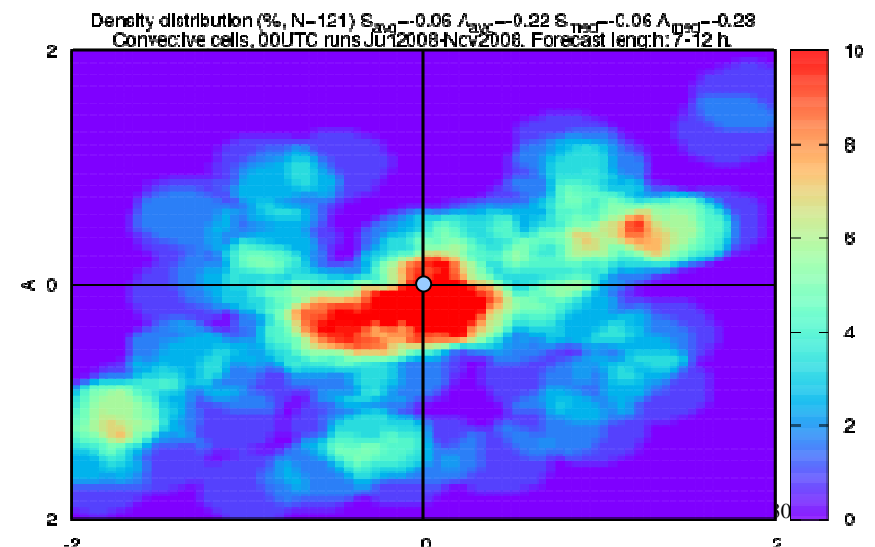


○ = perfect score

Strong conv.



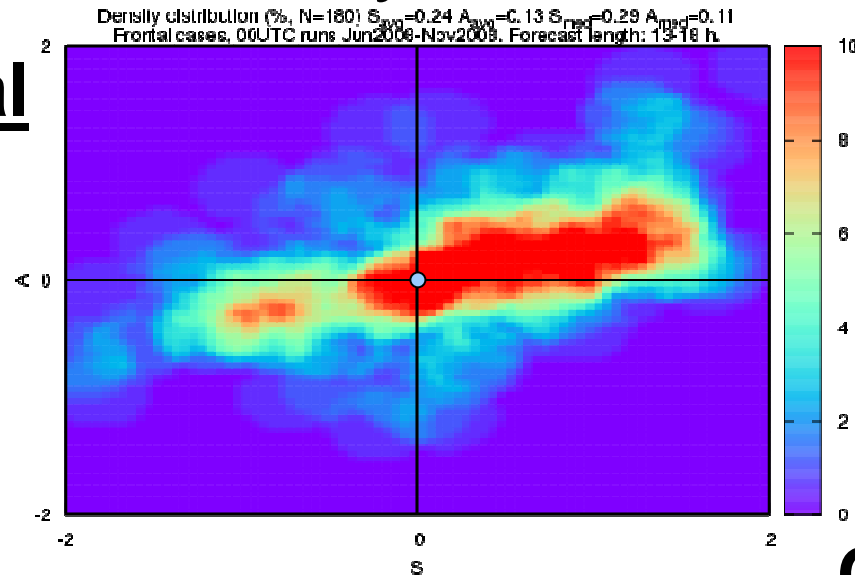
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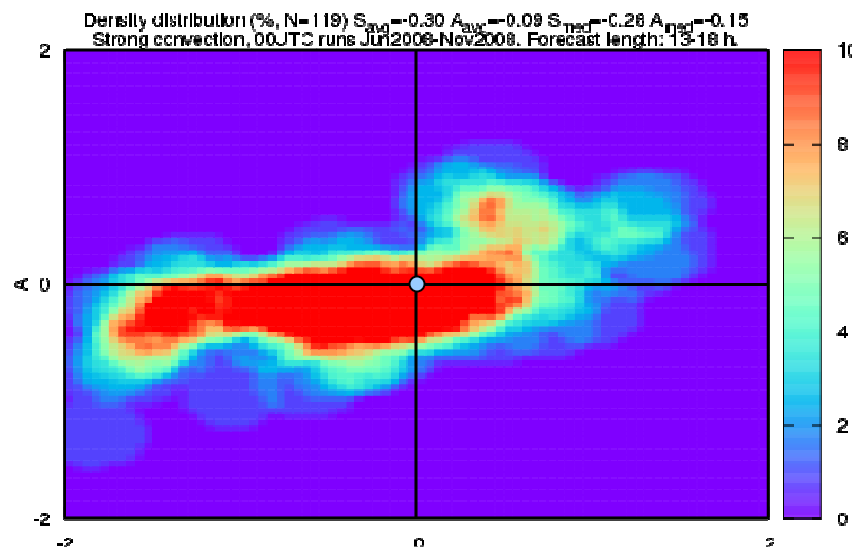
S vs. A – diurnal cycle 00 UTC +13-18h

Frontal

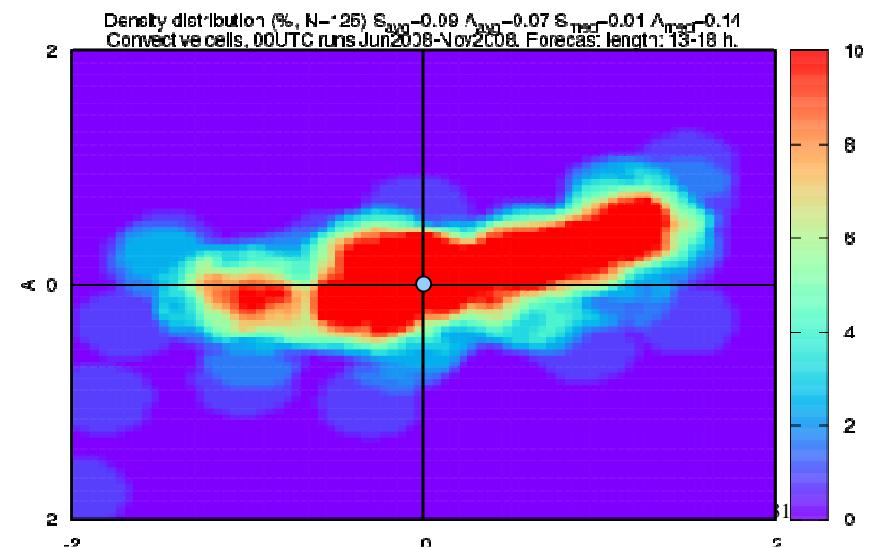


○ = perfect score

Strong conv.



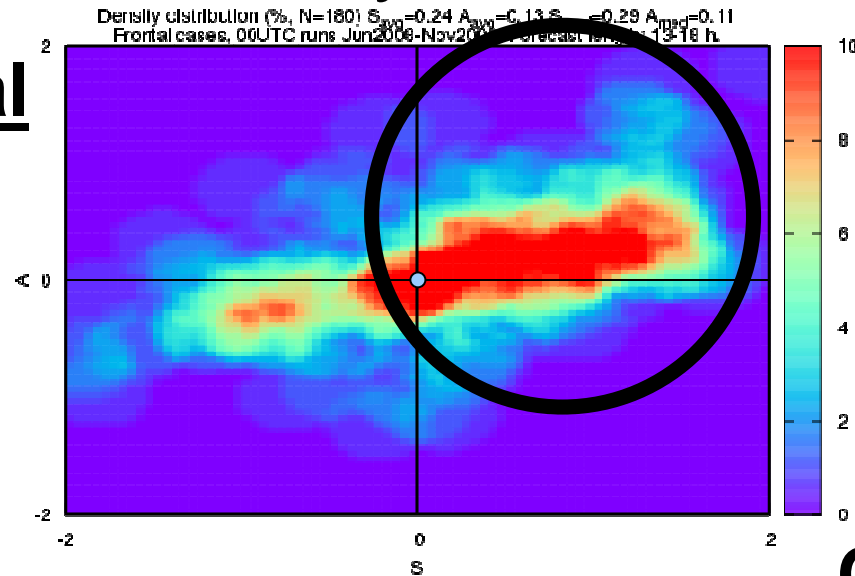
Open cell conv.





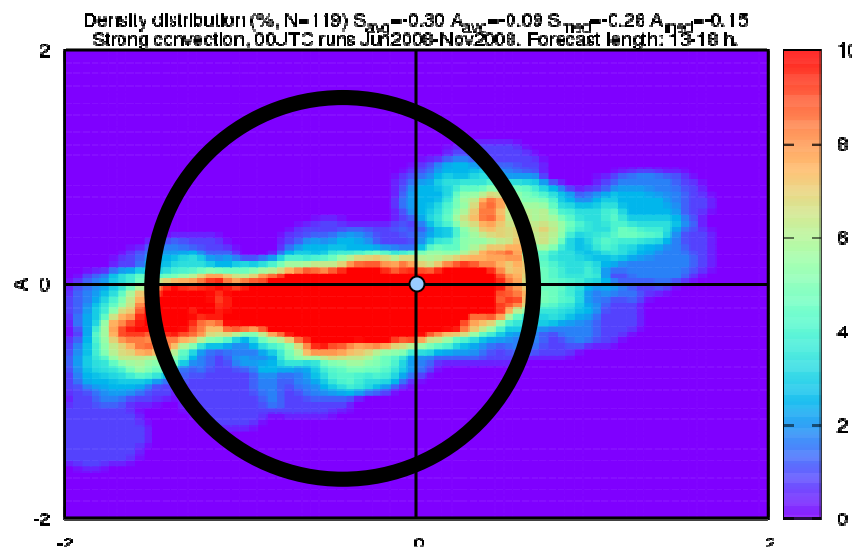
S vs. A – diurnal cycle 00 UTC +13-18h

Frontal

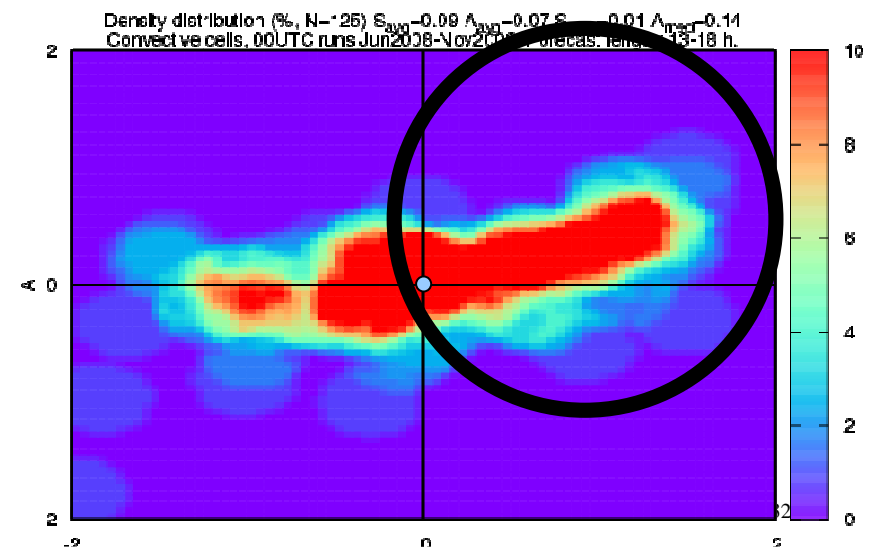


○ = perfect score

Strong conv.



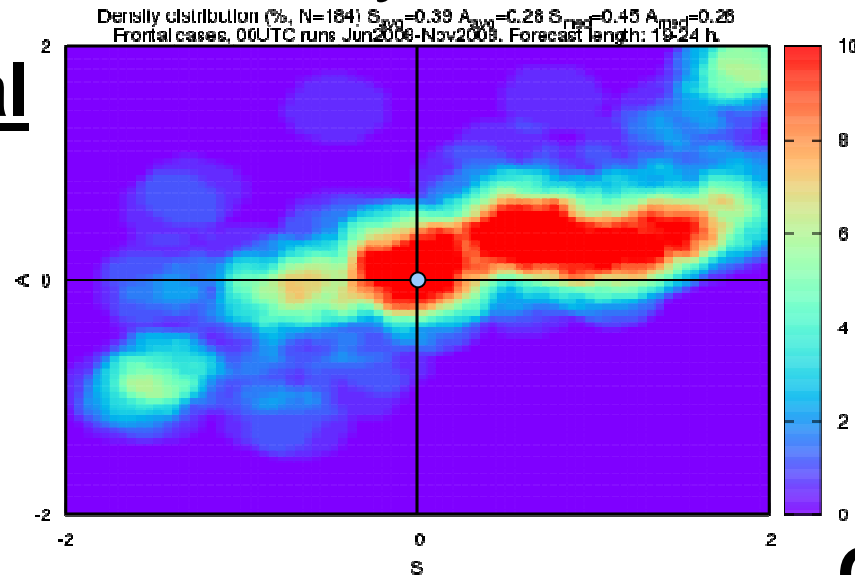
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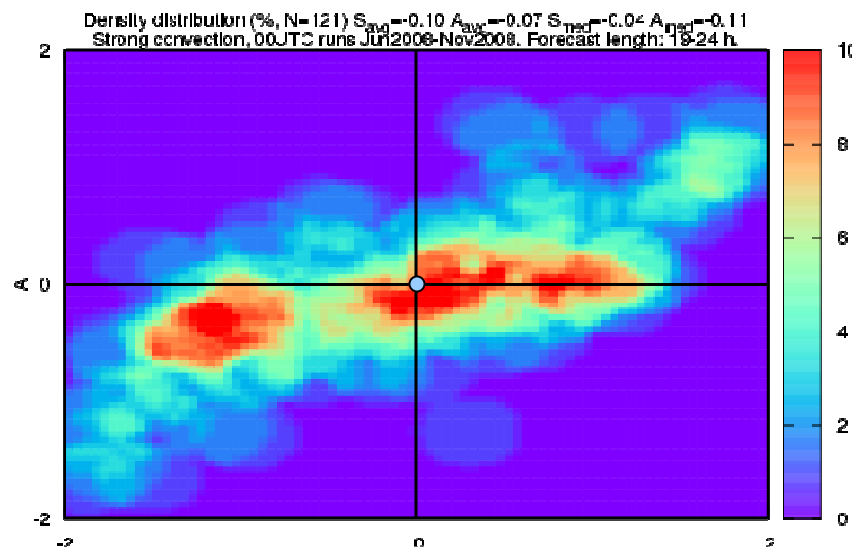
S vs. A – diurnal cycle 00 UTC +19-24h

Frontal

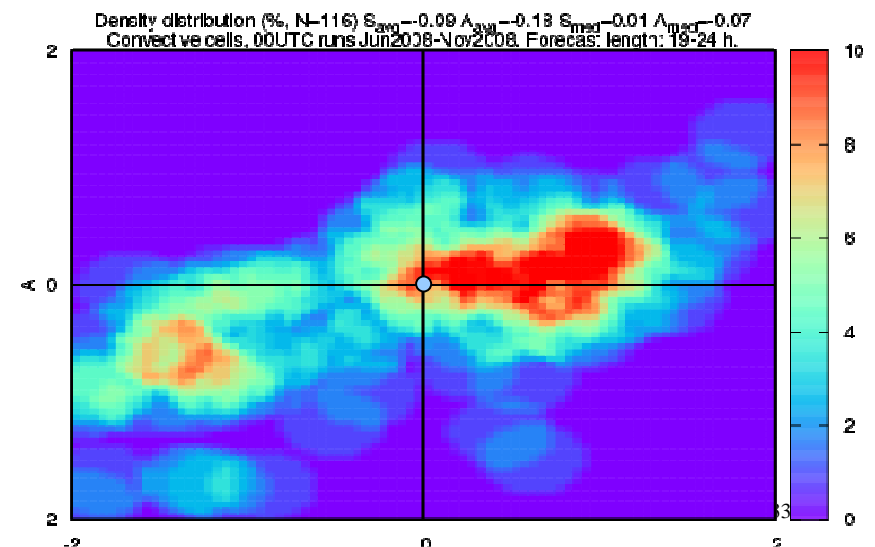


○ = perfect score

Strong conv.



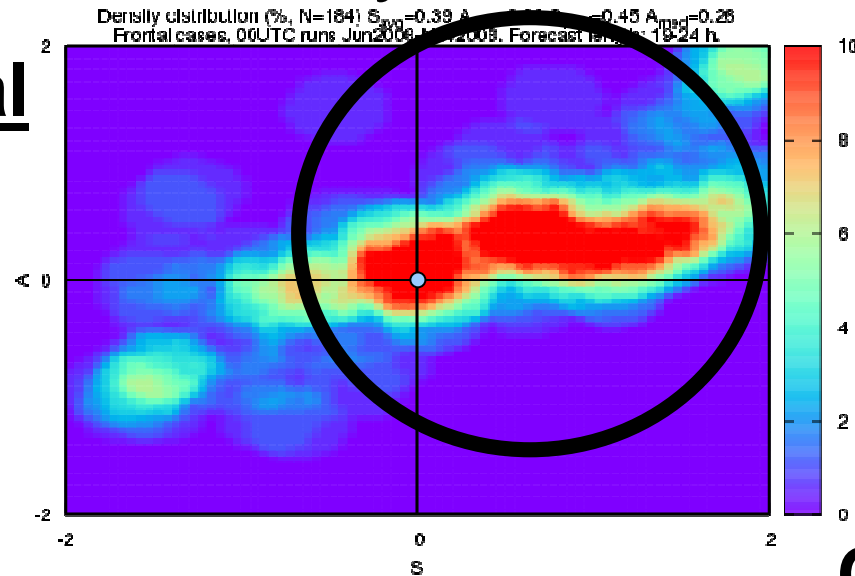
Open cell conv.





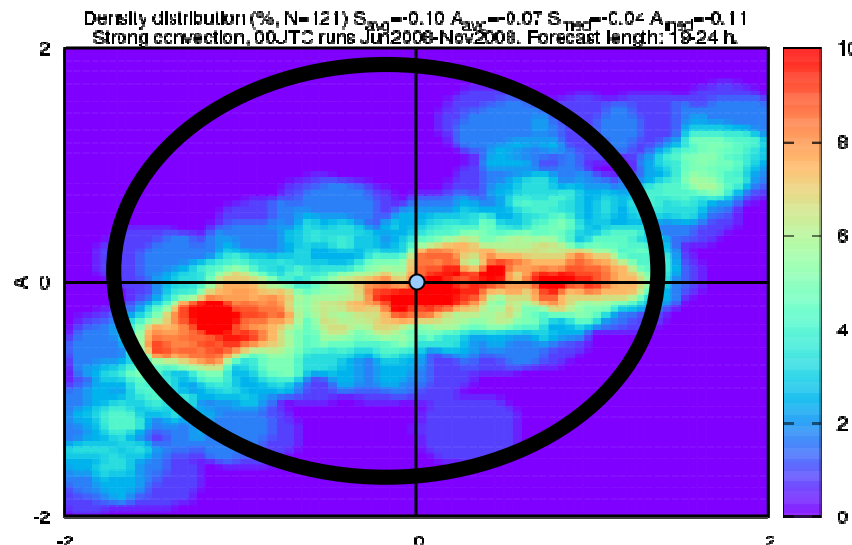
S vs. A – diurnal cycle 00 UTC +19-24h

Frontal

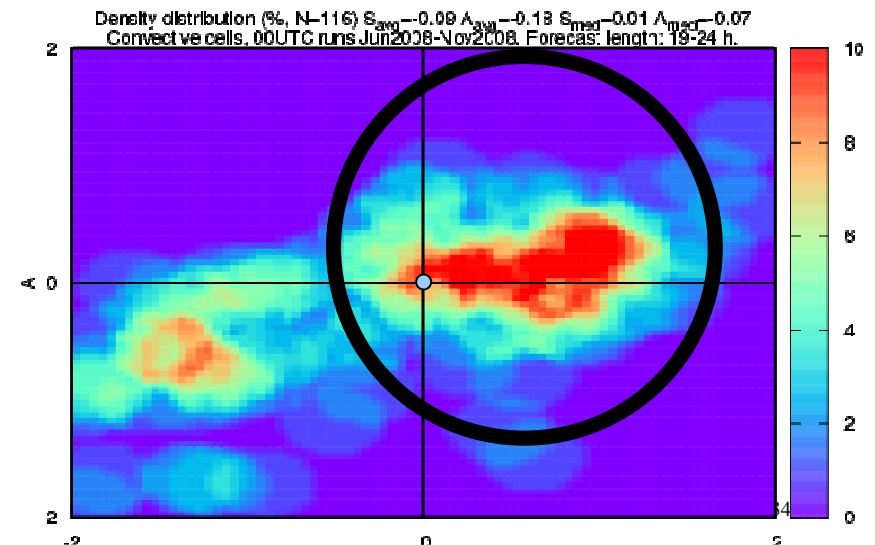


● = perfect score

Strong conv.



Open cell conv.





Summary

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- SAL is a **fair method** in comparison of different resolution models! It won't penalize the higher resolution model.
- However, SAL can give information about the behaviour of high-resolution precipitation forecasts alone.
- On the average, the SAL scores of AROME are very good.
- Convective cases underestimate from too small system during the first hours of the forecast.
- In the middle of the forecast frontal (and strong convective) cases tend to overestimate from too large system.
- In open cell cases, precipitation structures are too large in the afternoon. The distribution of SAL scores spreads as forecast length increases.



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THANK YOU!