VAST improvements and Case Studies

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VAST 2.0 beta improvements

This version contains the following updates:

- Possibility to verify precipitation, total cloud cover and wind speed starting from TXT files. (Only precipitation with LIBSIM preprocessing at the moment)
- Possibility to verify boxes containing more than one timestep (3D boxes versus previous 2D boxes)
- Possibility to specify if the R version is older than 3.0 or not (from this version on some functions have changed so I had to rearrange the code)
- Updated user manual

New variables can be verified

- From version 2.0.beta it is possible to verify three different variables with VAST (NOT starting from LIBSIM): precipitation (mm), total cloud cover (%, values larger than 100 will be put to “no data”), wind speed (m/s).
- The variable must be selected in the “input_fuzzy.nml” namelist:

```
!Indicate the variable the user wants to verify:
!'pre' for precipitation (mm)
!'tcc' for total cloud cover (%)
!'win' for wind (m/s)
variable='pre'
```

Using more than one timestep

- From version 2.0.beta it is possible to verify 3D boxes of observation and forecast by introducing the time dimension.
- The user should set the variable “n dimension”=1 in “input_fuzzy.nml” if a standard 2D verification is required. The user should use a variable greater than 1 to elaborate 3D boxes.

```
!NEW! Number of different timesteps for 3D box
!Example: n_timesteps=3 => previous one, current, following one
!Example: n_timesteps=5 => previous two, current, following two
!ATTENTION: the higher the number, the slower the process
n_timesteps=3,
```

R version

- Due to some changes in the newer R packages, the user must specify wether he/she is using an R version older then 3.0

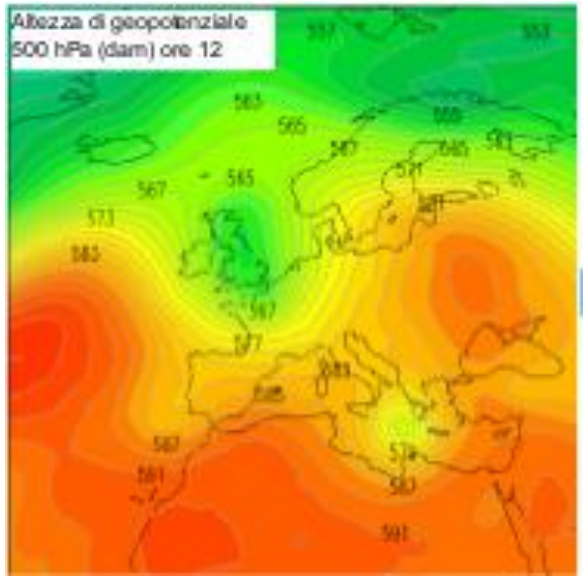
```
!Is your R version >=3.0? (y/n)
r_version='n'
```

Case Studies (1)

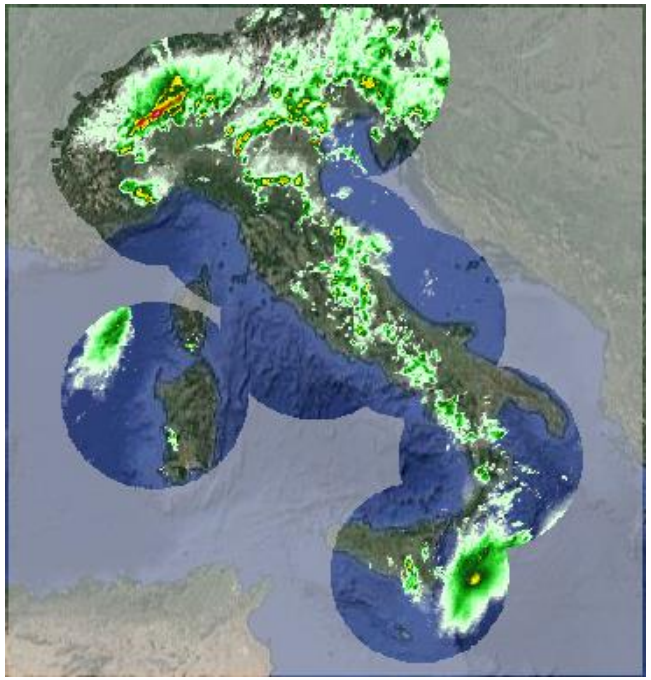
Episodes of forecasted heavy rain occurred in Italy during the summer of 2016 (June - September)

RUN 00, first forecast day, 3h accumulated, over Italy

2016/06/25



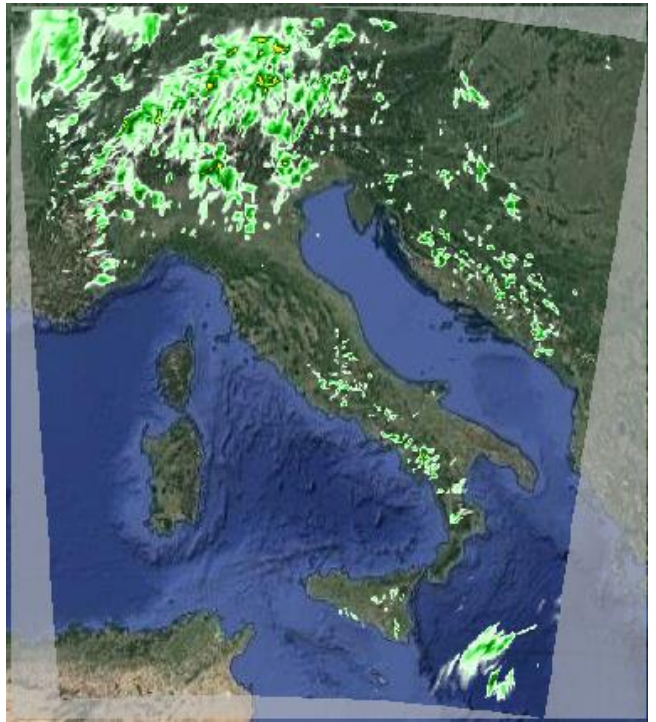
ANALYSIS



WEATHER RADAR

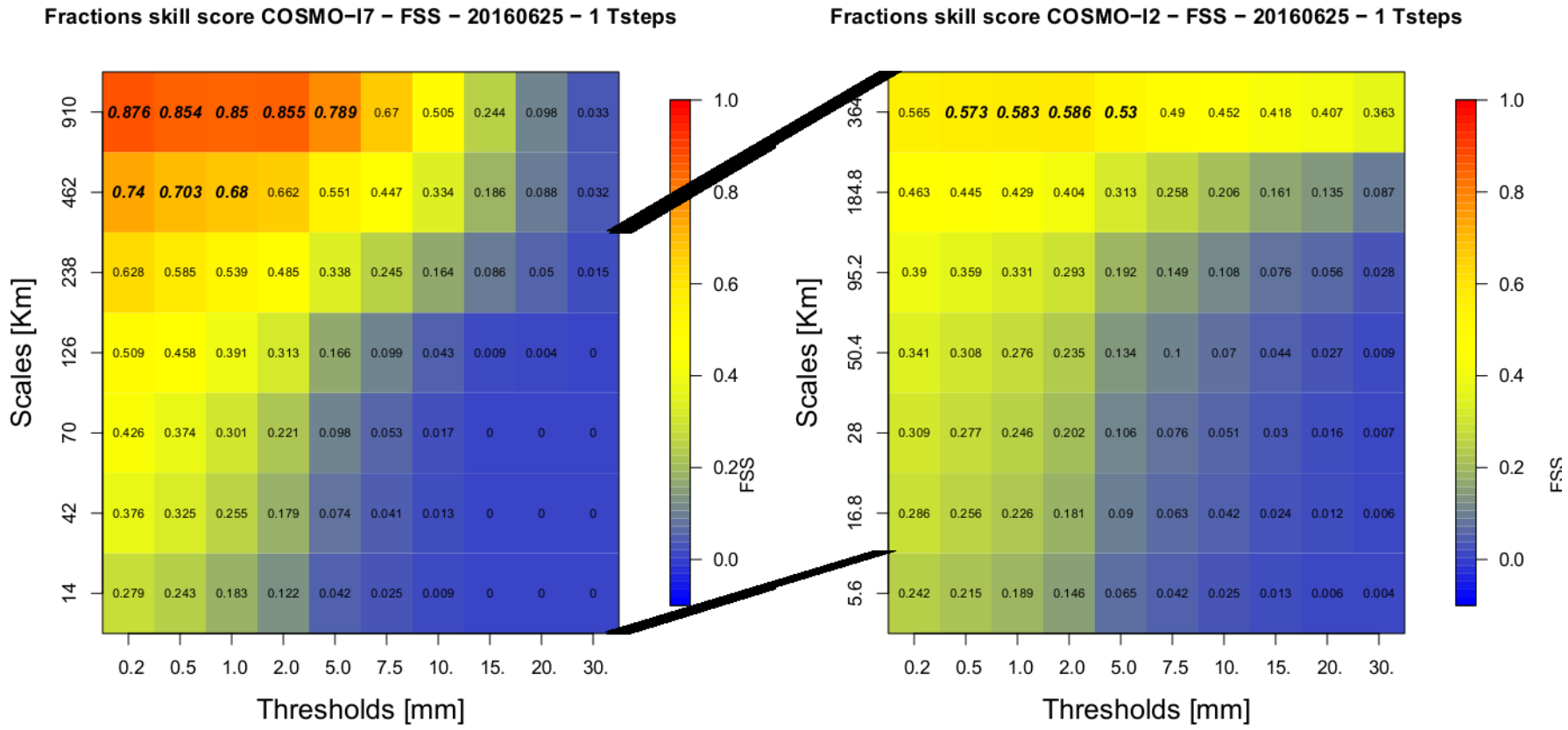
- Trough on the British Islands and secondary low pressure area in the Ionian Sea
- Precipitation spread over the whole peninsula
- COSMO – I7 overestimates in the north and underestimates the rest
- COSMO – I2 largely underestimates along the peninsula

COSMO – I7



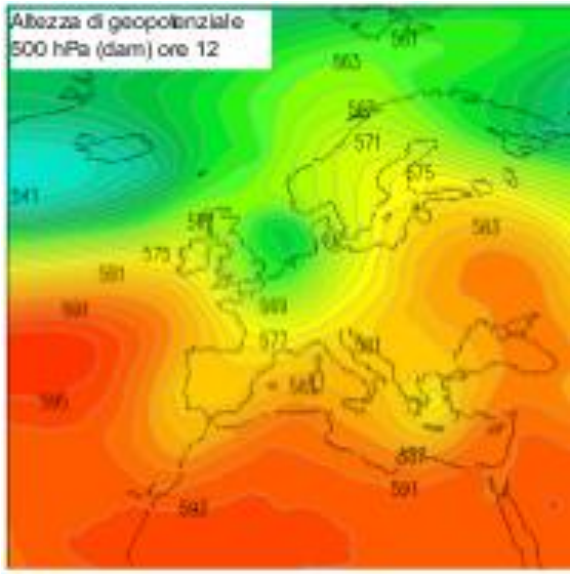
COSMO – I2

2016/06/25 - FSS

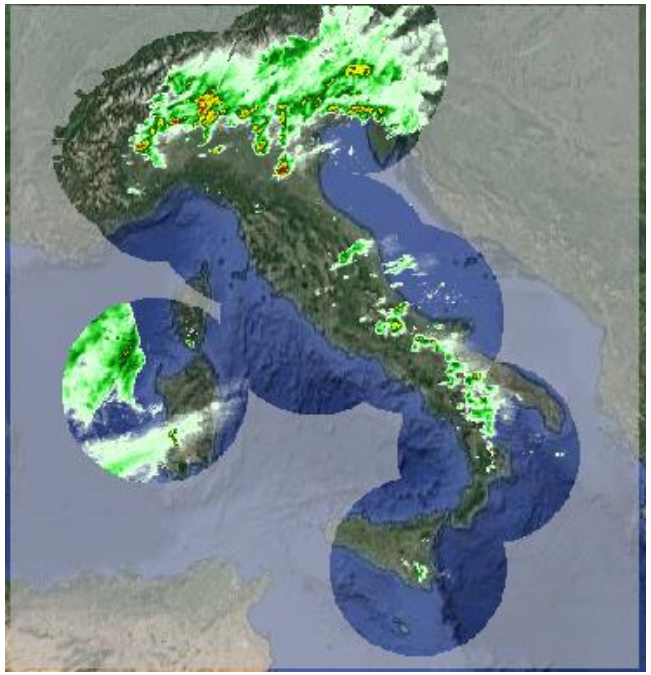


Both COSMO – I7 and COSMO – I2 have good FSS results only for the largest areas and low – medium thresholds

2016/06/26



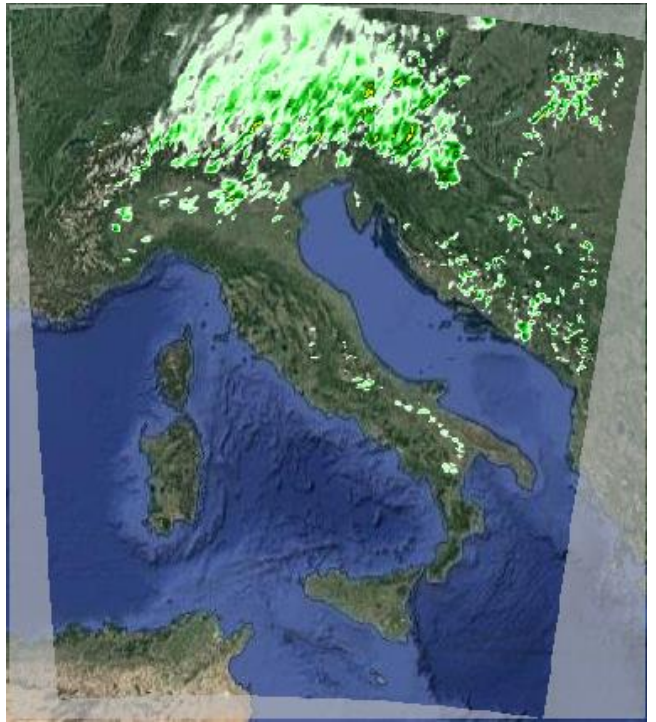
ANALYSIS



WEATHER RADAR

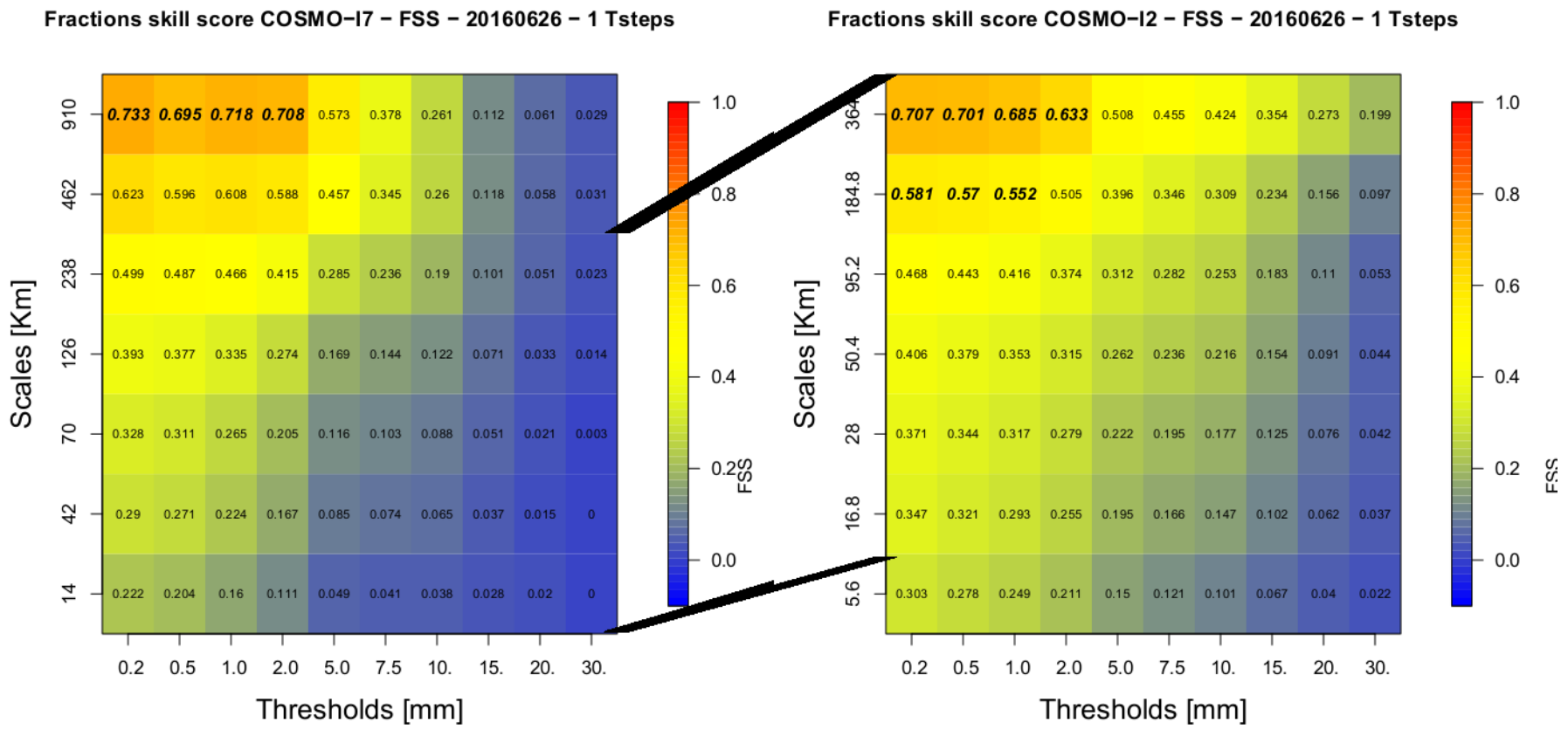
- Low pressure area on the British Islands and weaker trough over Spain and Italy
- Haviest precipitation on the north – east of Italy and less intense on the southern part of the peninsula
- COSMO – I7 correctly forecasts the precipitatoin in the north of Italy, misses the rest
- COSMO – I2 largely underestimates all the precipitation

COSMO – I7



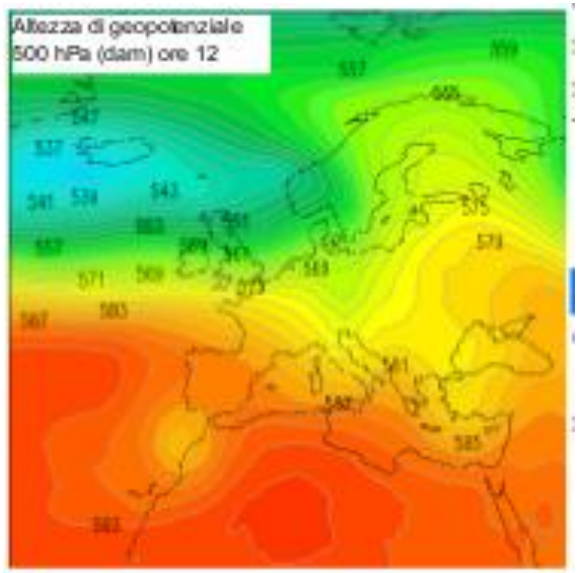
COSMO – I2

2016/06/26 - FSS

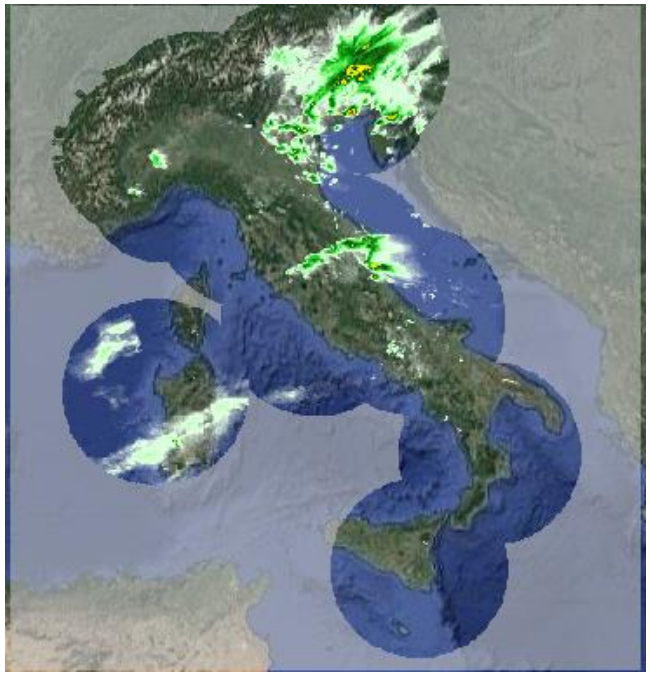


Both COSMO – I7 and COSMO – I2 have good FSS results only for the largest areas and low thresholds

2016/06/27



ANALYSIS



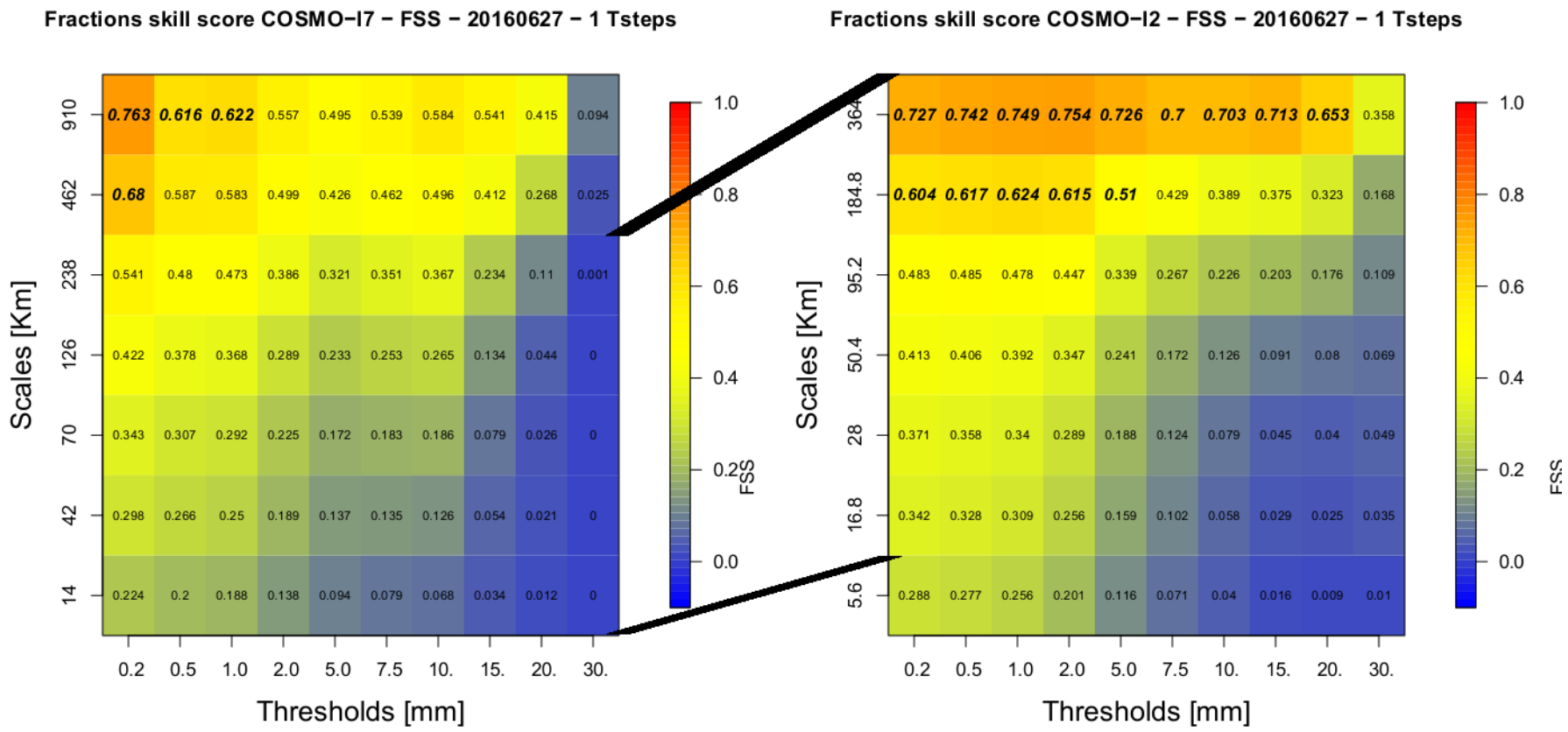
WEATHER RADAR

- Trough on the British Islands (east – west axes) and low pressure over the Balkan area
- Residual precipitation over the north – east of Italy and some isolated shower over the Apennines
- COSMO – I7 correctly forecasts the precipitation over the north – east of Italy, overestimates over the peninsula
- COSMO – I2 underestimates along the peninsula and overestimates over the Liguria and Piedmont region

COSMO – I7

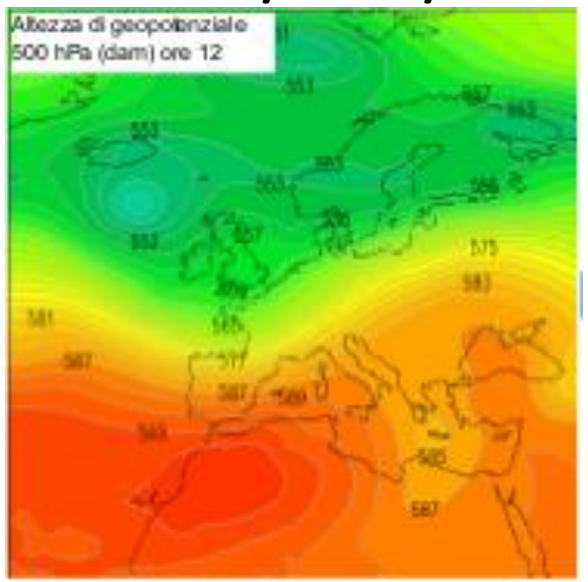
COSMO – I2

2016/06/27 - FSS



COSMO – I7 has good FSS results only for the largest areas and low thresholds. COSMO – I2 behaves a little better up to the higher thresholds but only for large areas

2016/07/12

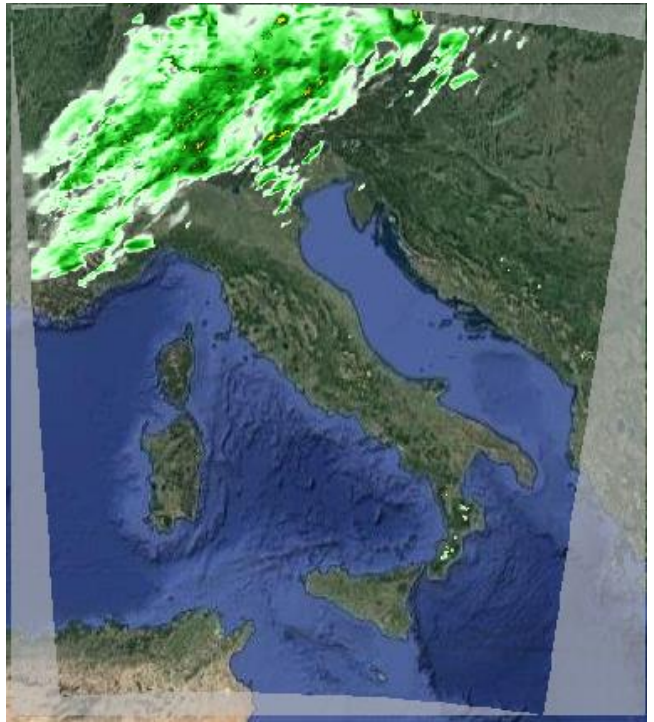


ANALYSIS

WEATHER RADAR

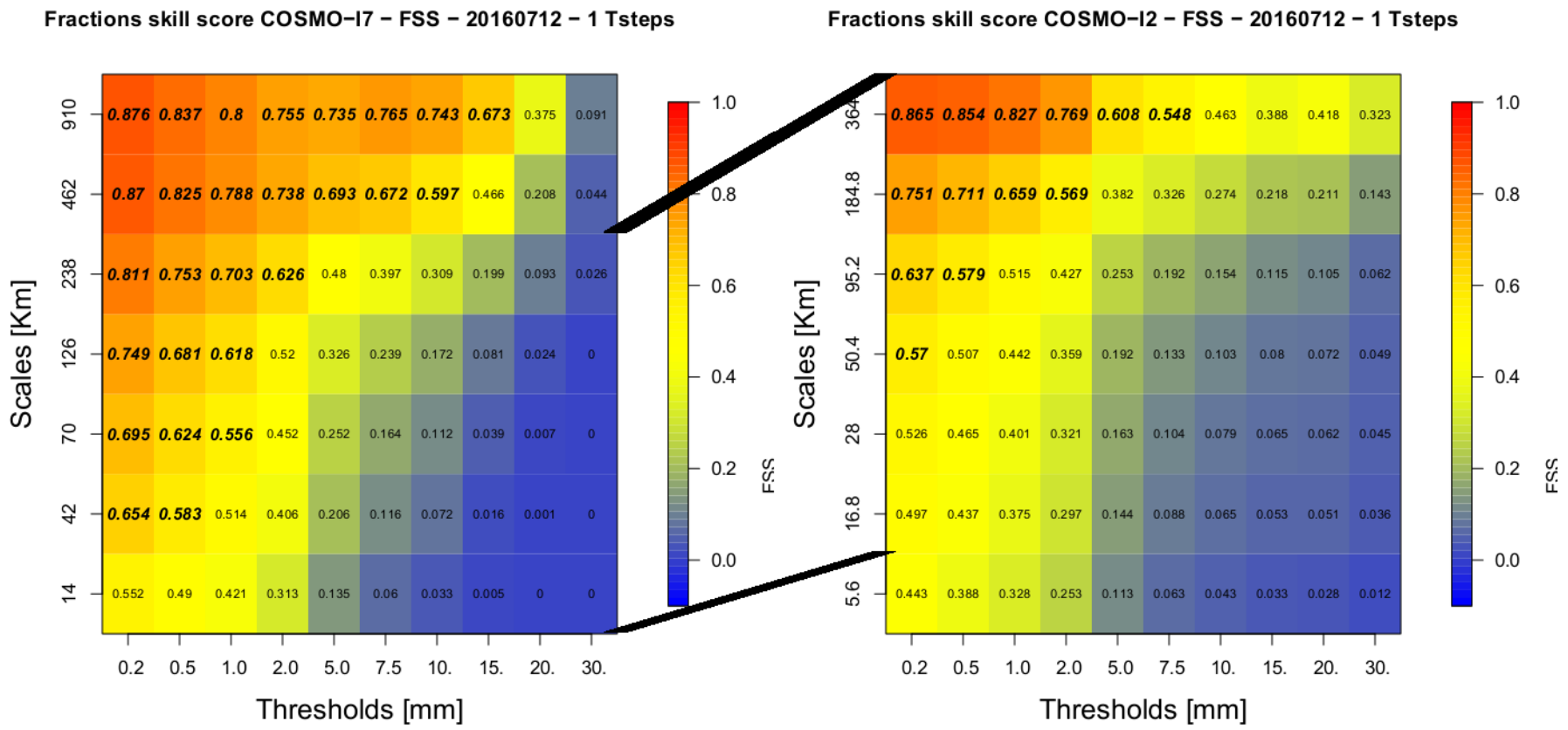
- Deep low pressure over the British Islands and trough close to the Alpine region
- Precipitation only in the north of Italy
- COSMO – I7 forecasts the precipitation very well with a little overestimation along the Po Valley
- COSMO – I2 forecasts the precipitation very well with some underestimation on the north – east of Italy

COSMO – I7



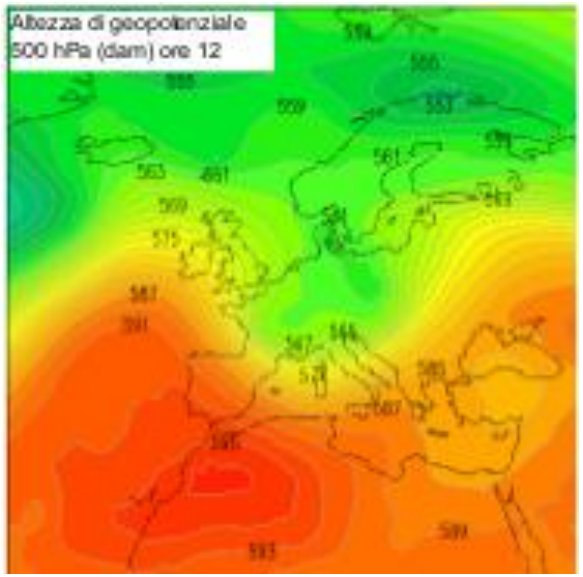
COSMO – I2

2016/07/12 - FSS

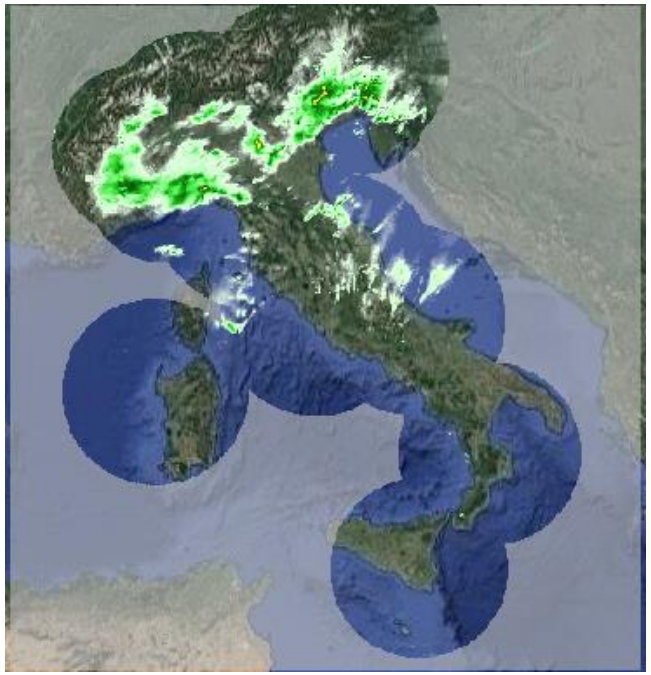


COSMO – I7 better than COSMO – I2 extends the good performance to smaller areas and higher thresholds

2016/07/14

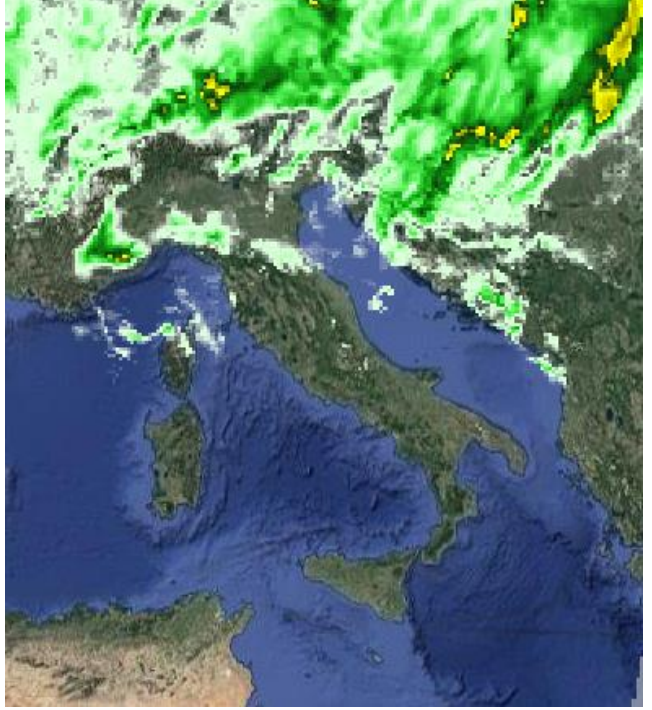


ANALYSIS

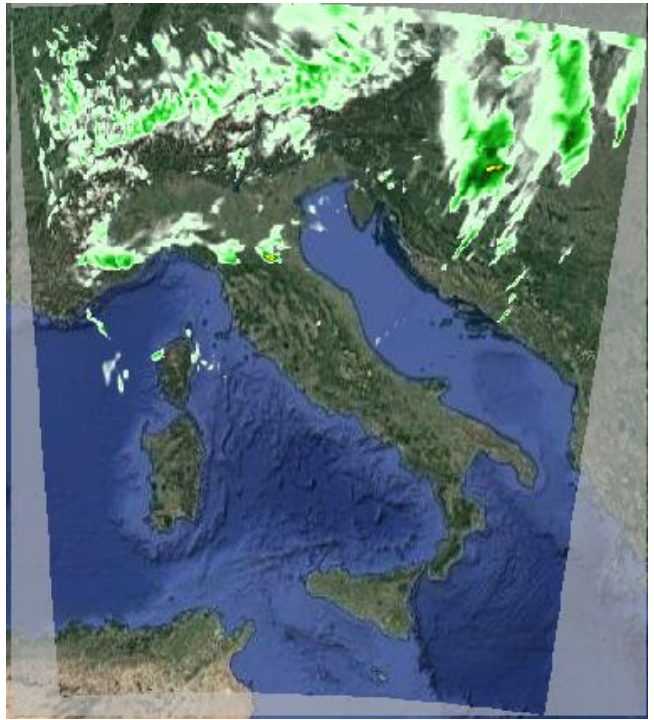


WEATHER RADAR

- Trough descending from the British Islands to the Italian peninsula
- Precipitation limited to the north of Italy with isolated showers along the peninsula
- COSMO – I7 overestimates the prec. north of the Alps
- COSMO – I2 underestimates the prec. in the Po Valley

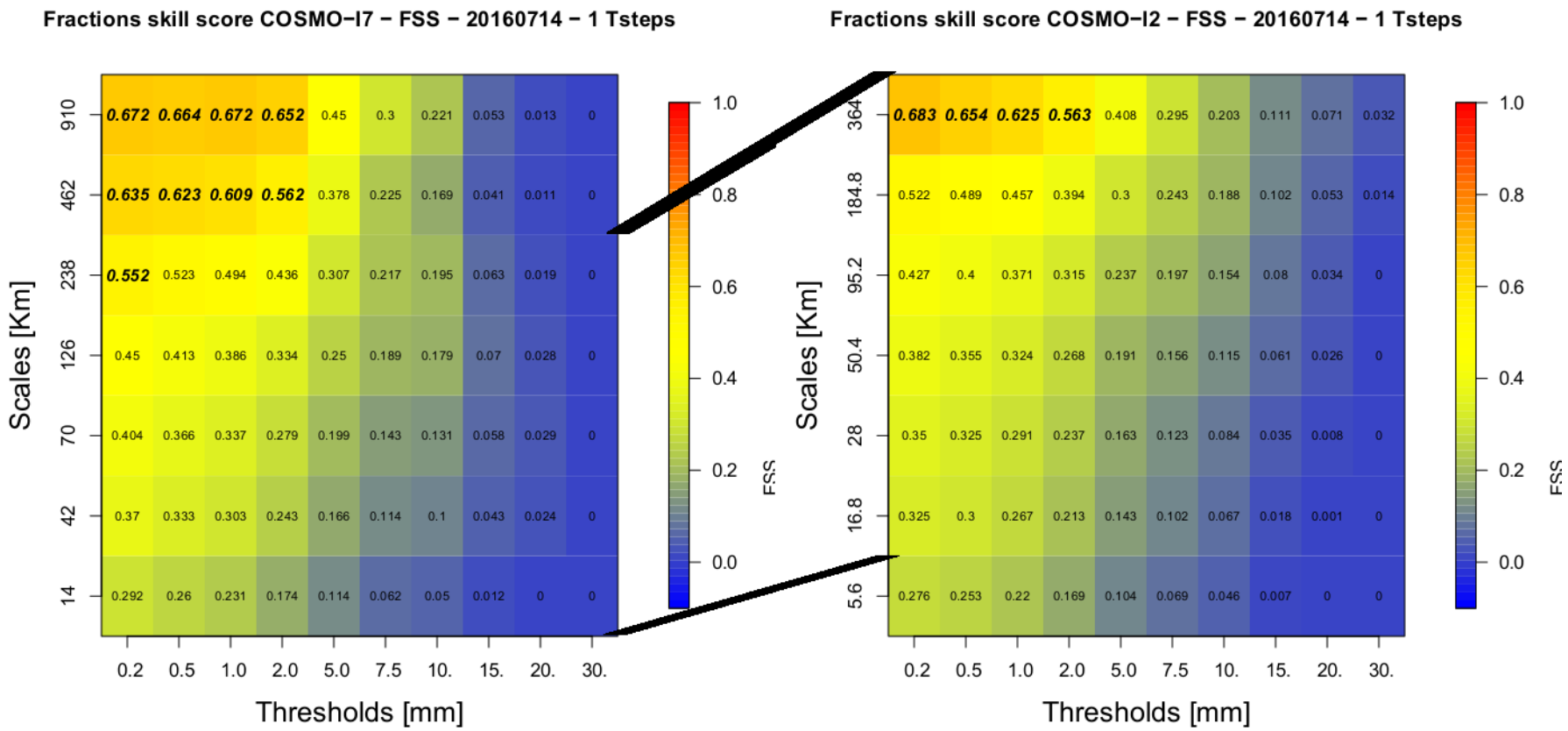


COSMO – I7



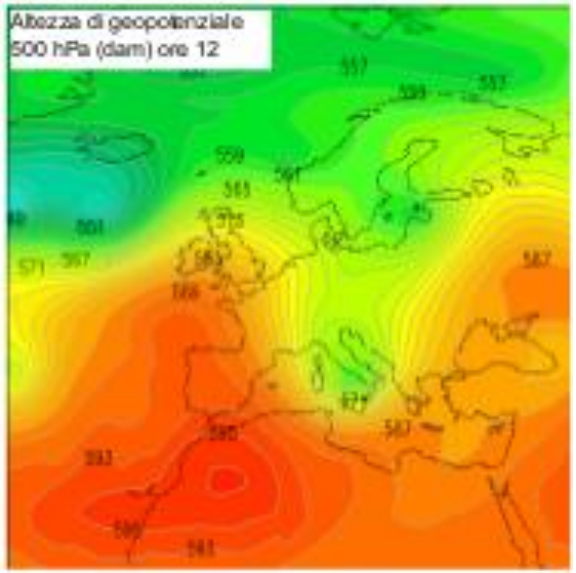
COSMO – I2

2016/07/14 - FSS

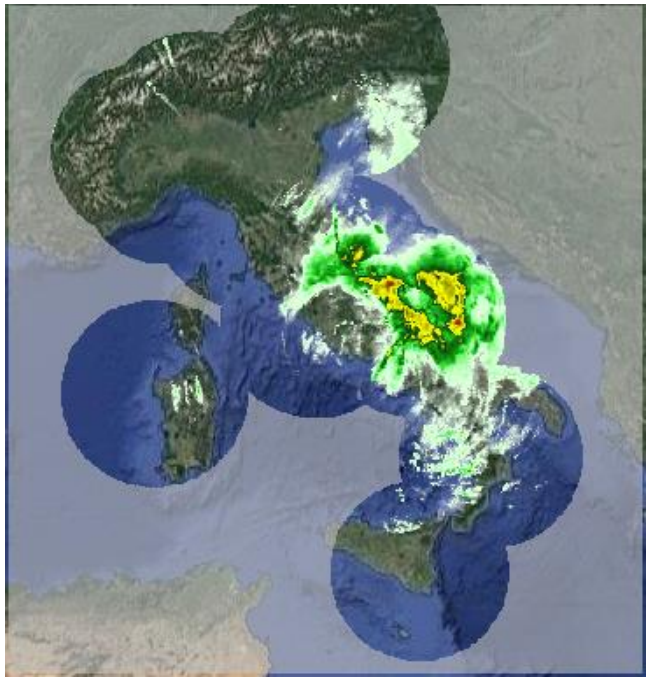


Both COSMO – I7 and COSMO – I2 have good FSS results only for the largest areas and low – medium thresholds.
COSMO – I7 better than COSMO – I2

2016/07/15

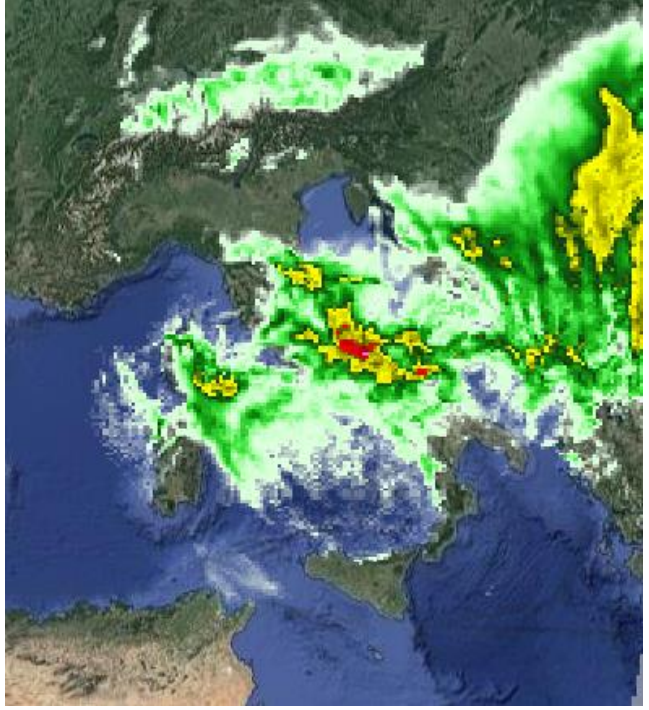


ANALYSIS

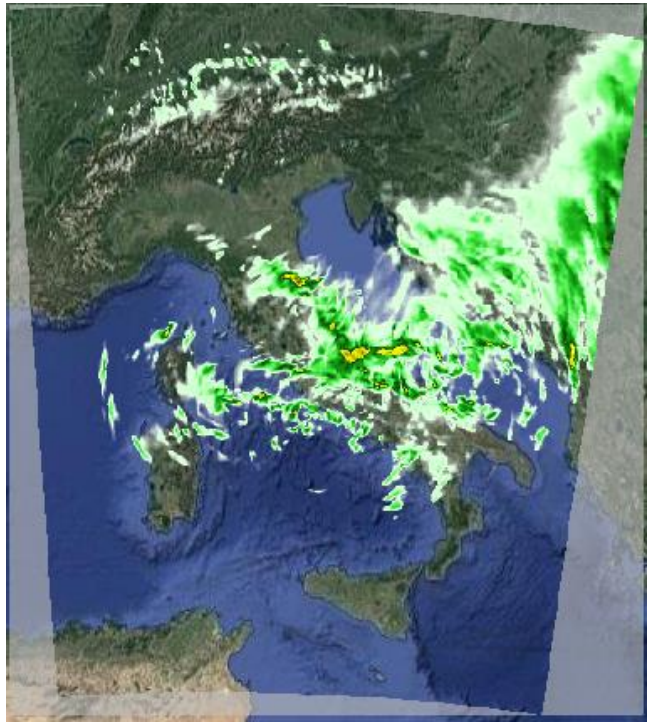


WEATHER RADAR

- Trough descending from the Brithsh Islands creating a cut off over the Italian peninsula
- Precipitation limited to the central part of Italy
- COSMO – I7 and COSMO – I2 forecast the precipitation very well (little overestimation for COSMO – I7)

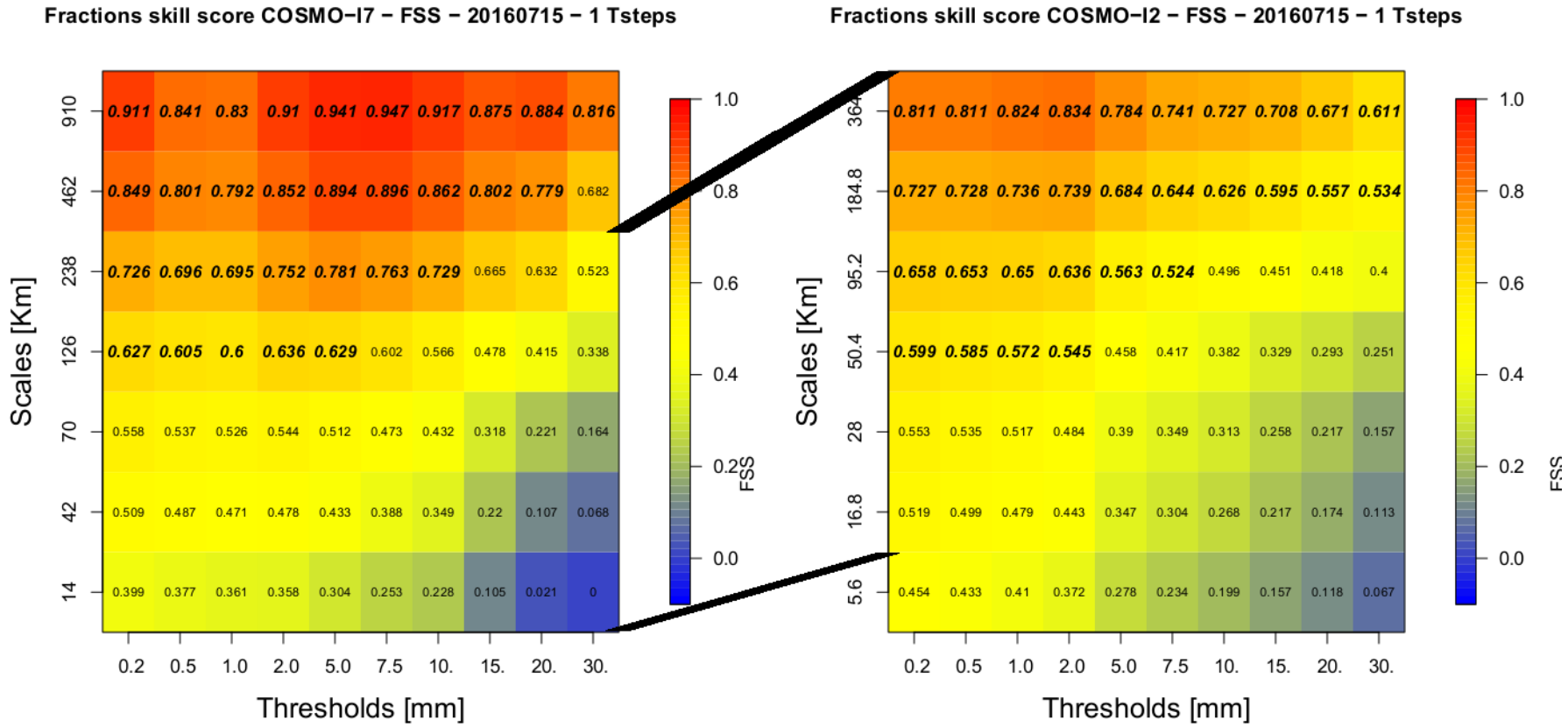


COSMO – I7



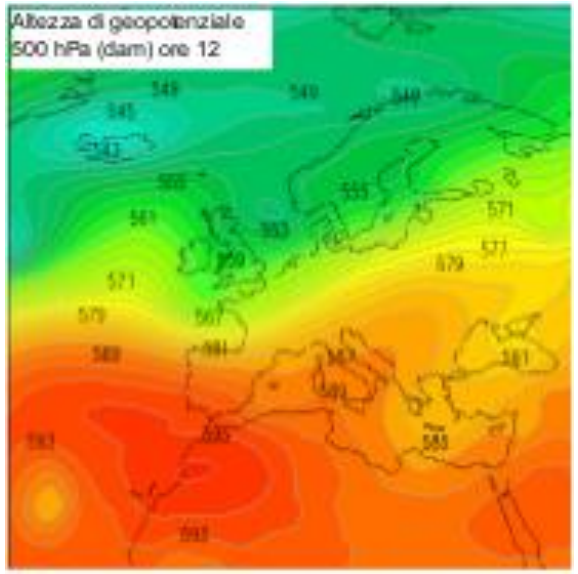
COSMO – I2

2016/07/15 - FSS

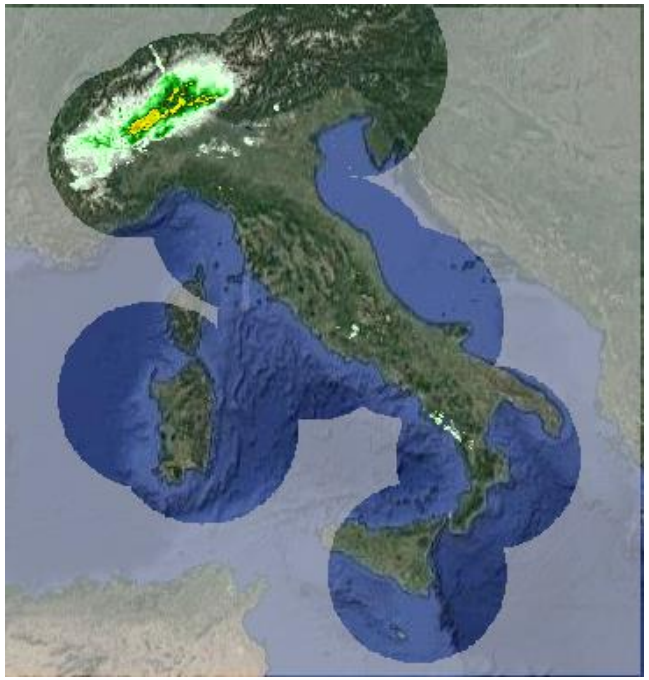


Both COSMO – I7 and COSMO – I2 have good FSS results for all thresholds at larger scales. Good performances for low – medium thresholds at medium scales. COSMO – I2 better than COSMO – I7

2016/08/04



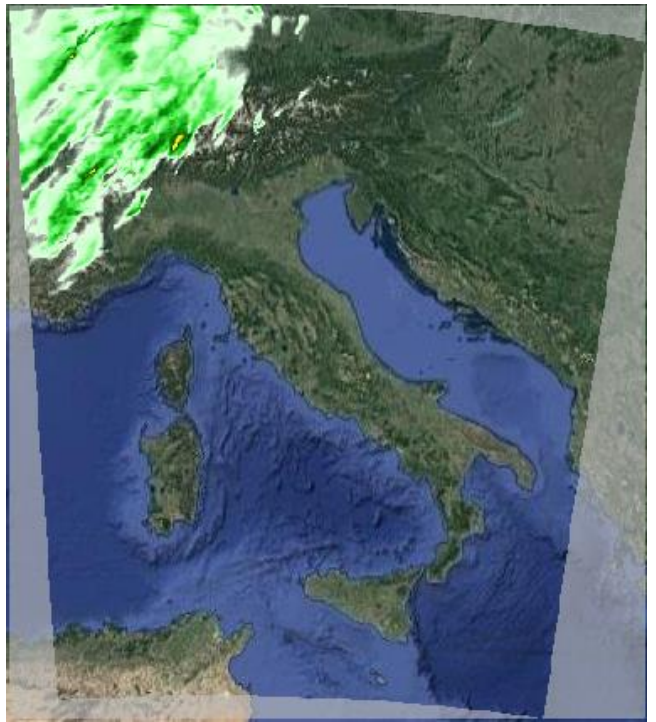
ANALYSIS



WEATHER RADAR

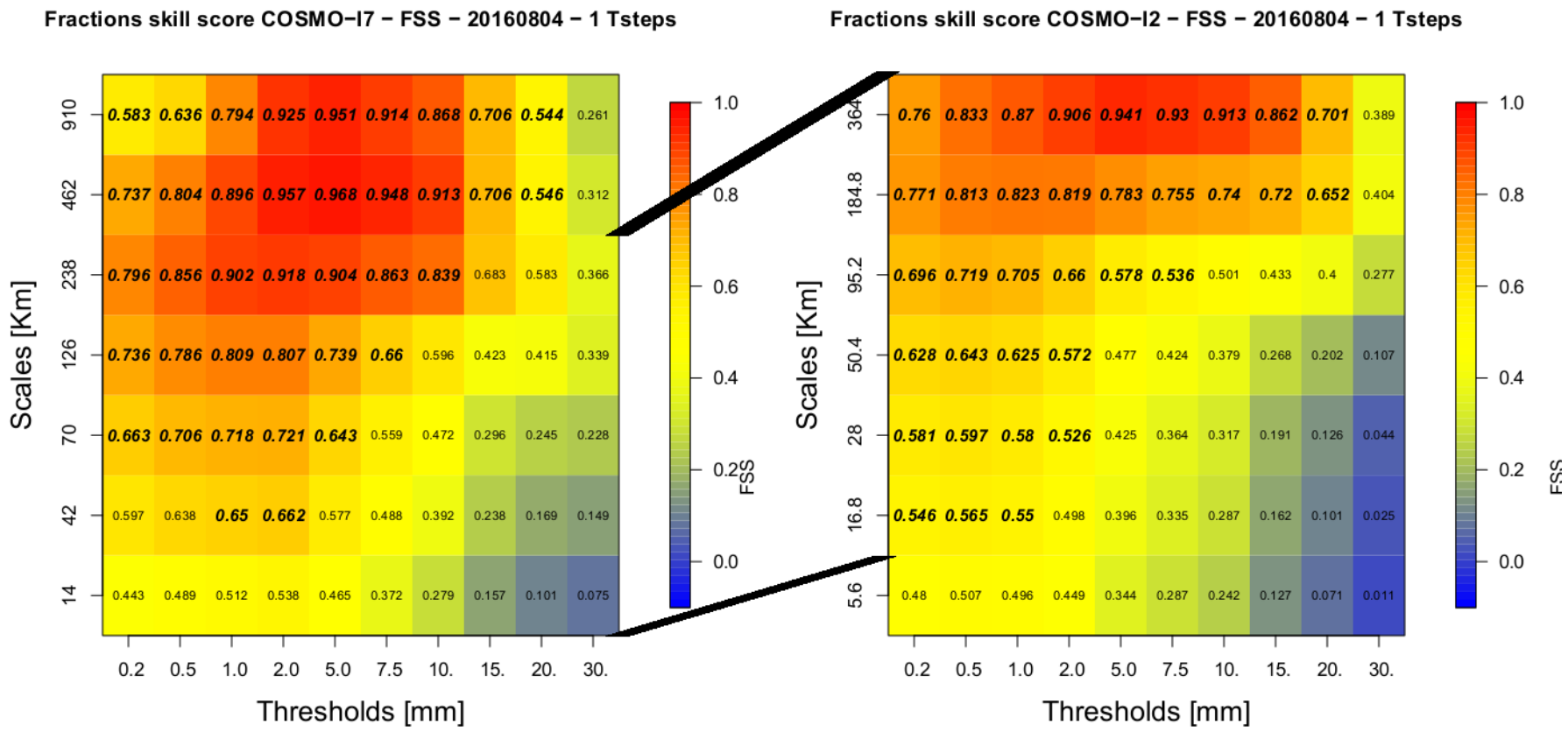
- Trough descending from the British Islands to the north of the Alps
- Precipitation limited to the north western part of Italy
- COSMO – I7 forecasts the precipitation very well (little overestimation)
- COSMO – I2 forecasts the precipitation very well (little undererestimation)

COSMO – I7



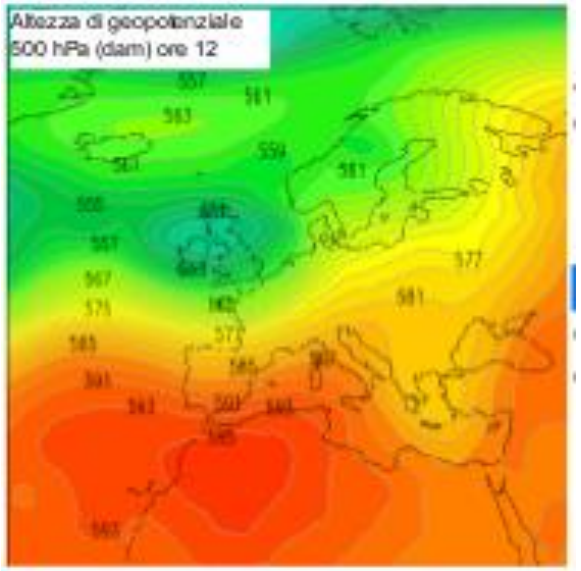
COSMO – I2

2016/08/04 - FSS

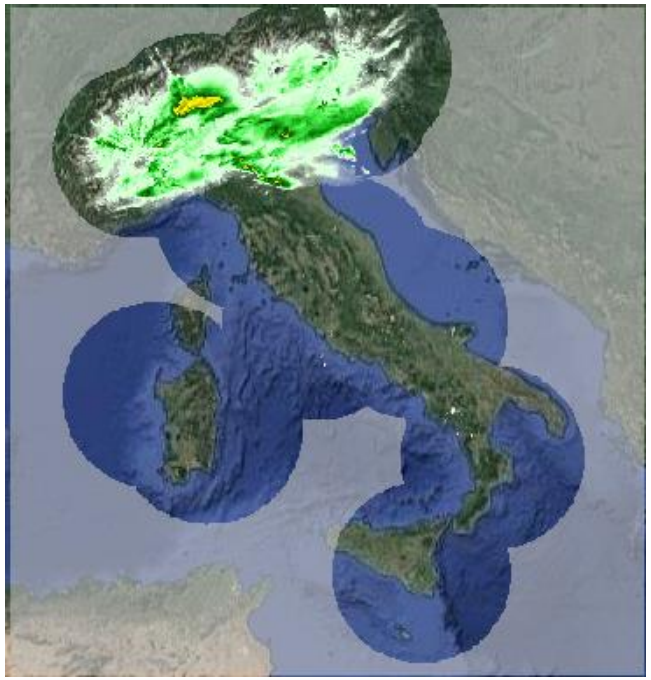


Both COSMO – I7 and COSMO – I2 have good FSS results for all thresholds at larger scales. Good performances for low – medium thresholds at medium scales. COSMO – I2 slightly better than COSMO – I7

2016/08/20



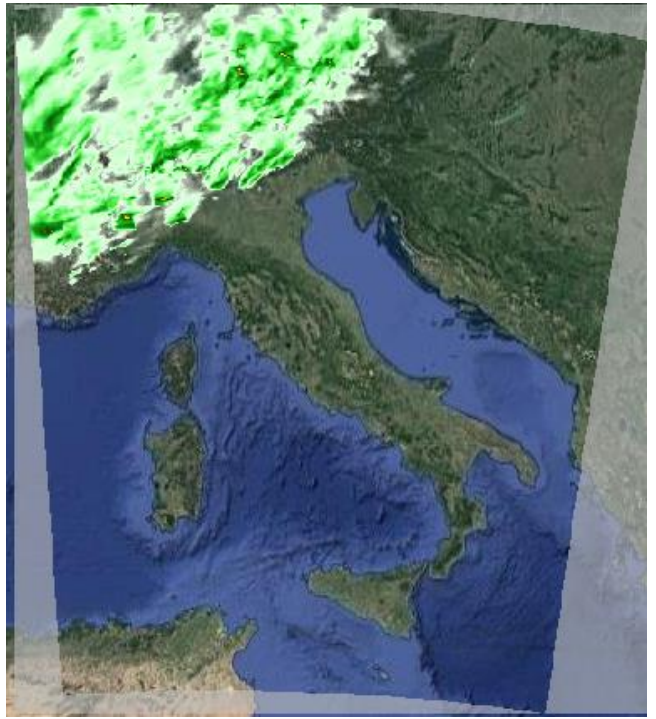
ANALYSIS



WEATHER RADAR

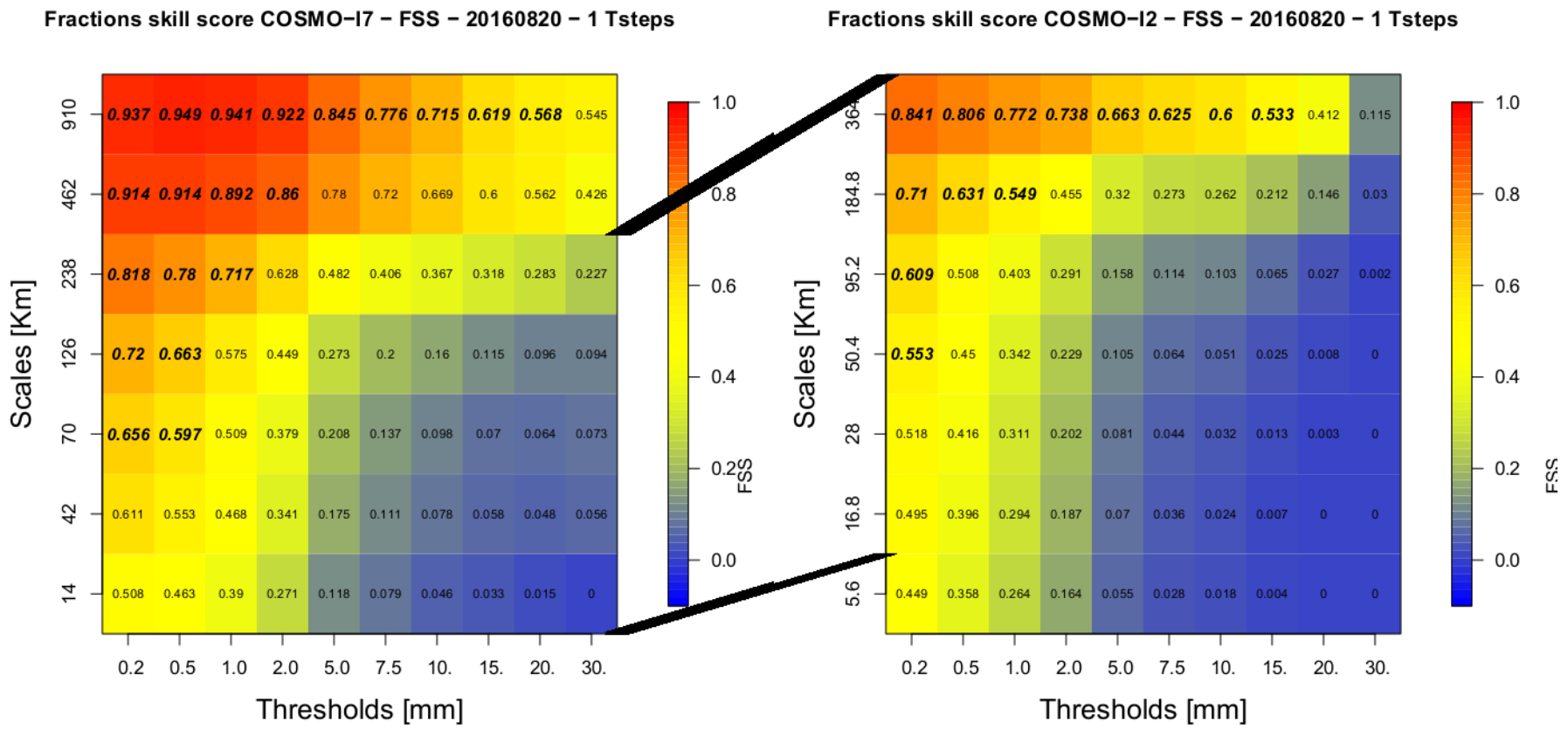
- Trough descending from the British Islands to the north of the Alps and a secondary low pressure area on the Balkans
- Precipitation limited to the northern part of Italy
- COSMO – I7 and COSMO – I2 forecast the precipitation very well (little overestimation for COSMO – I7 and little underestimation in the Po Valley for COSMO – I2)

COSMO – I7



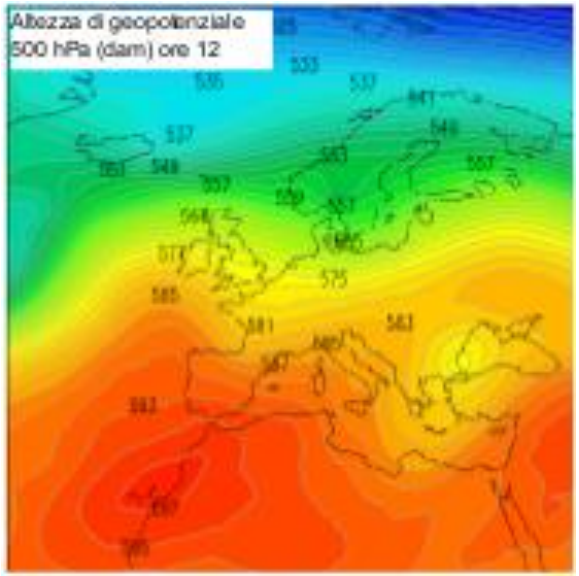
COSMO – I2

2016/08/20 - FSS

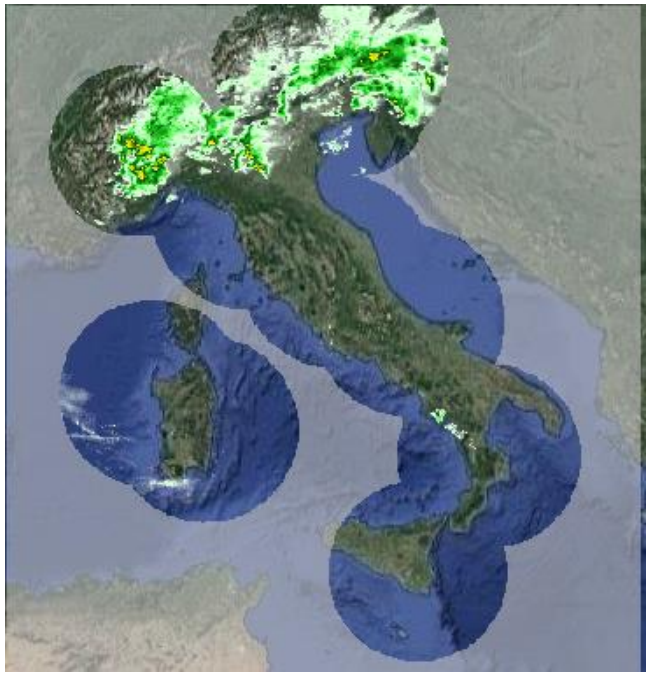


Both COSMO – I7 and COSMO – I2 have good FSS results for low - medium thresholds at larger scales. Good performances for low thresholds at medium scales. COSMO – I2 better for higher thresholds at larger scales, COSMO – I7 better for low thresholds for medium scales

2016/08/29



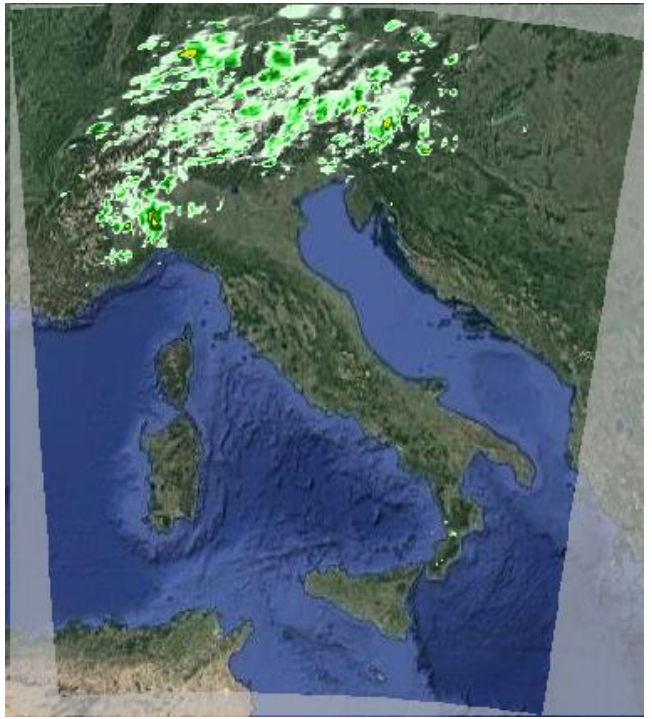
ANALYSIS



WEATHER RADAR

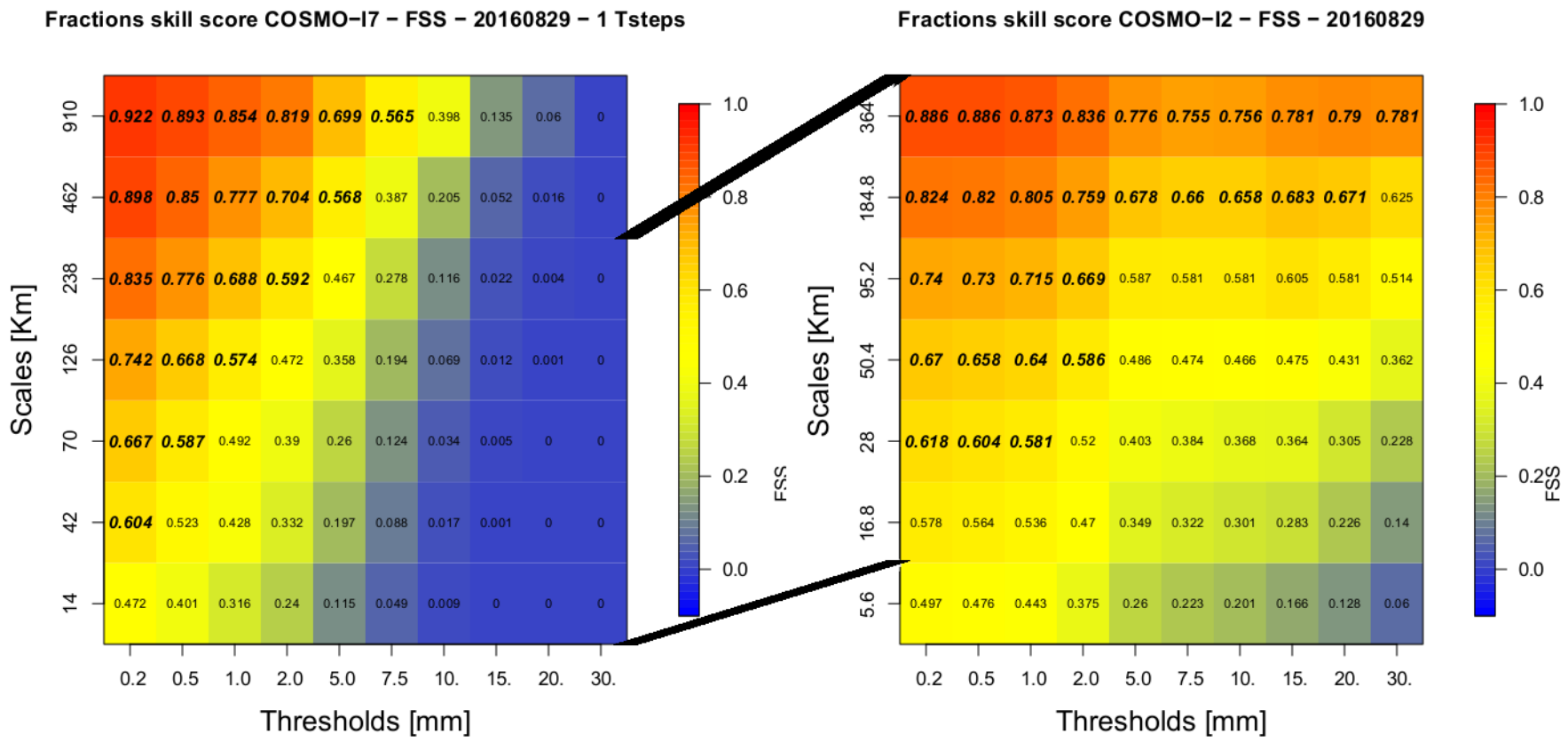
- Trough descending from the Scandinavia peninsula to the north of the Alps
- Precipitation limited to the northern part of Italy
- COSMO – I7 and COSMO – I2 forecast the precipitation very well (little underestimation for COSMO – I2)

COSMO – I7



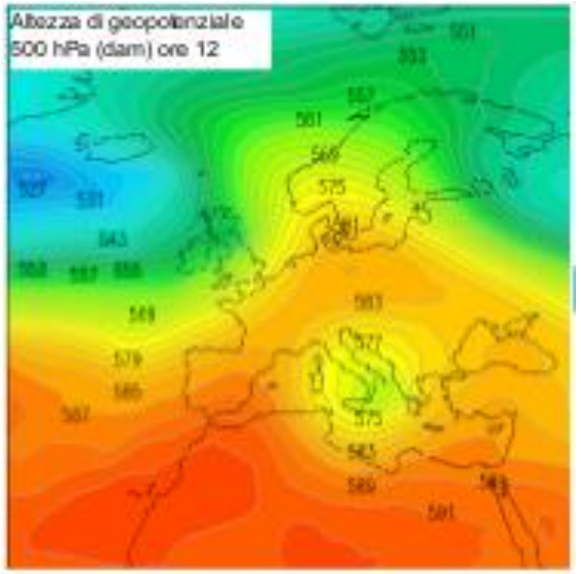
COSMO – I2

2016/08/29 - FSS

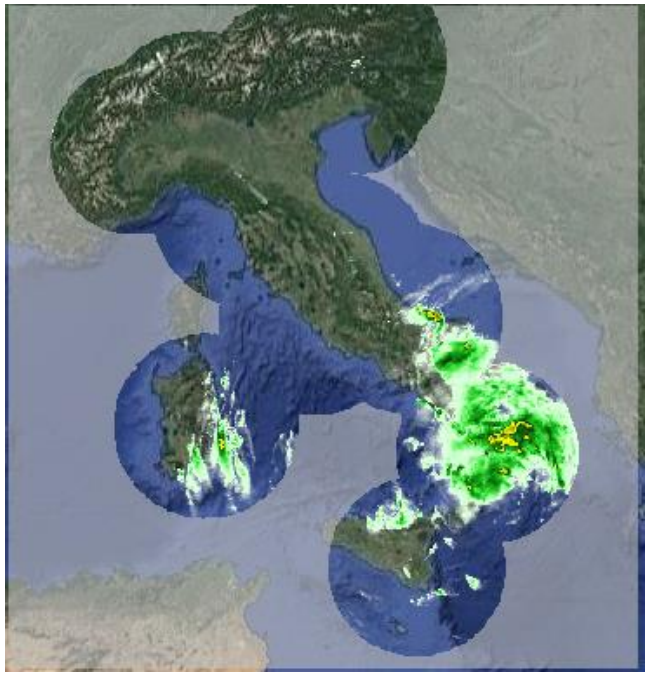


Both COSMO – I7 and COSMO – I2 have good FSS results for low - medium thresholds at larger scales. Very good performances for high thresholds at larger scales for COSMO – I2. Good performance for low - medium thresholds at medium scales. COSMO – I2 better for higher thresholds at all scales

2016/09/08



ANALYSIS



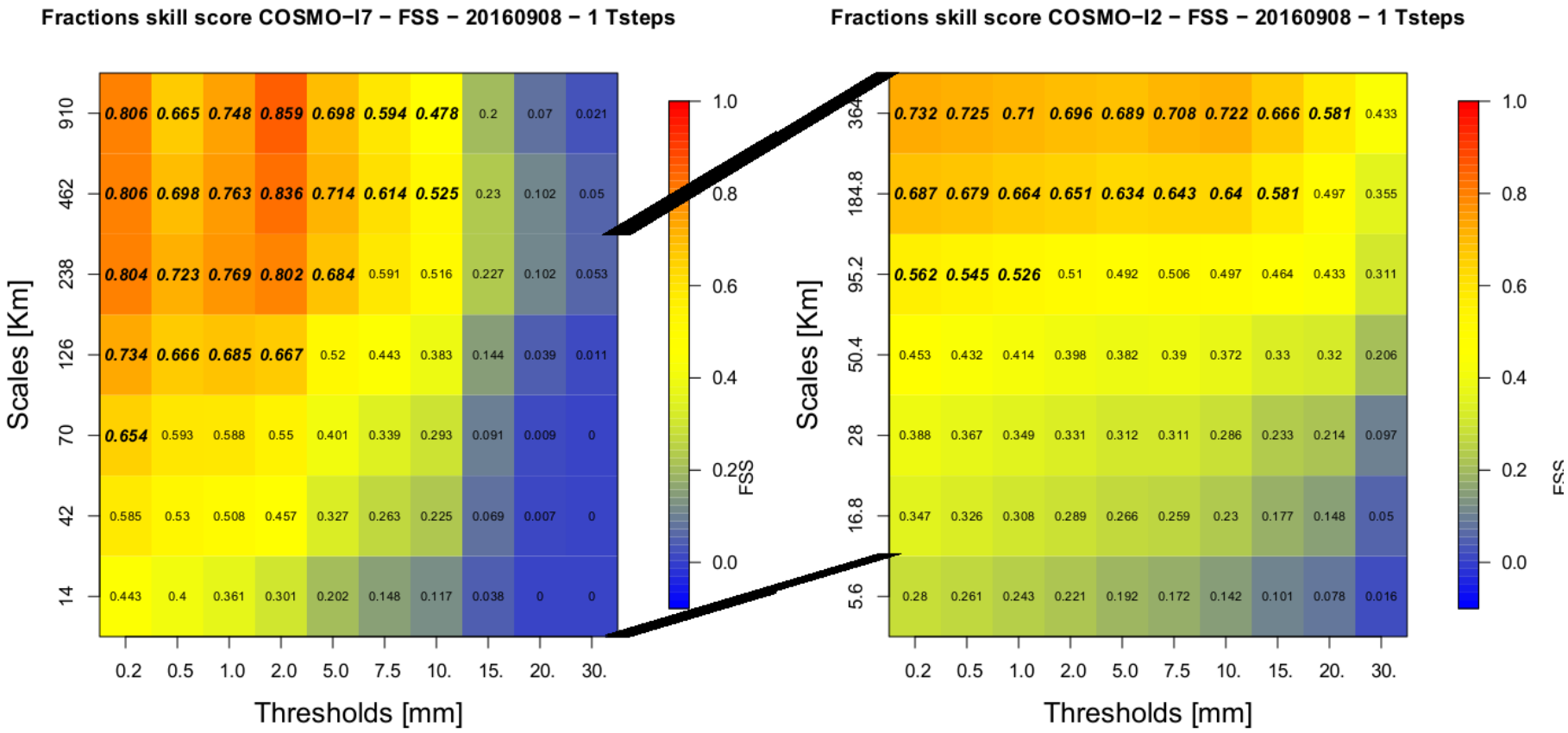
WEATHER RADAR

- Cut off over the southern part of Italy
- Precipitation limited to the southern part of Italy
- COSMO – I7 overestimates the precipitation in the central part of Italy
- COSMO – I2 underestimates the precipitation

COSMO – I7

COSMO – I2

2016/09/08 - FSS



Both COSMO – I7 and COSMO – I2 have good FSS results for low - medium thresholds at larger scales. Good performance for high thresholds at larger scales for COSMO – I2. Good performance for low - medium thresholds at medium scales. COSMO – I2 better for higher thresholds at all scales, COSMO – I7 better for low – medium thresholds at medium scales.

Conclusions

- The behavior of the models does not seem to be linked to the type of synoptic situation or to the displacement of the precipitation
- COSMO – I7 seems to overestimate the low and medium thresholds while it almost always underestimates the high thresholds
- COSMO – I2 does not overestimate the low thresholds, often reproduces the peaks of precipitation but sometimes it does not place them in the correct location (misplacement error)
- When COSMO – I2 misplaces the precipitation peaks COSMO – I7 may have better performances

Case Studies (2)

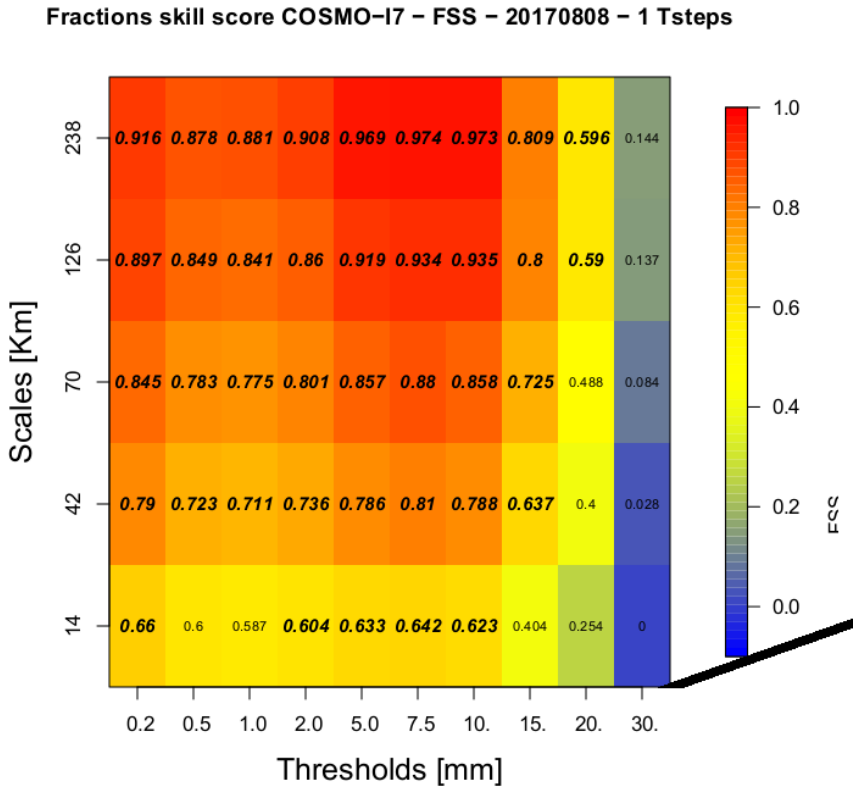
Forecasted heavy rain over Piedmont 2017/08/08

Confrontation of COSMO 7km, 5km and 2.8km

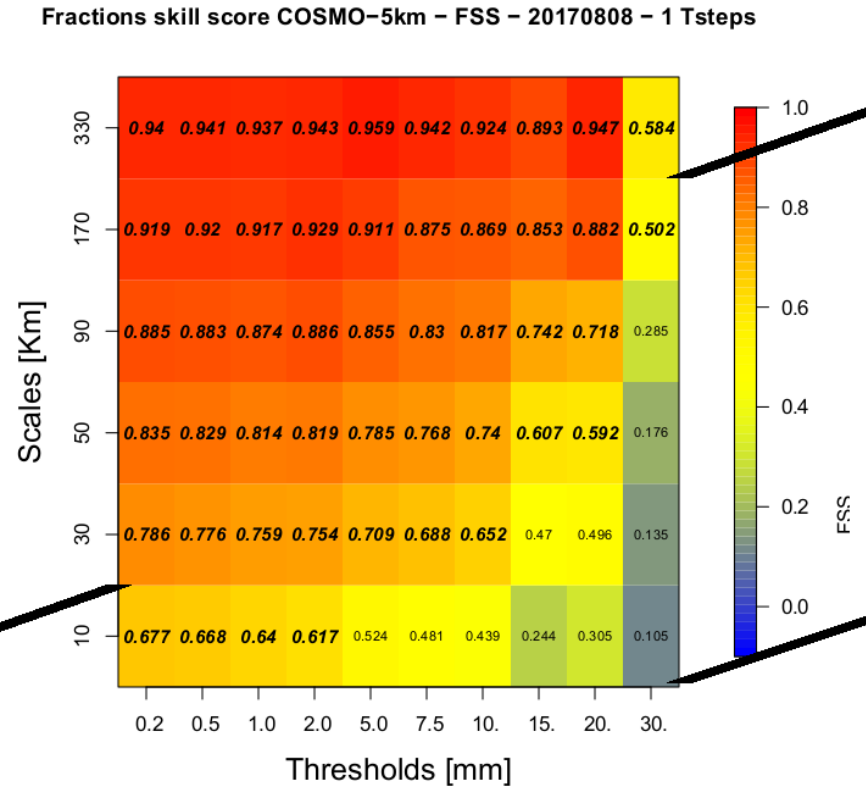
RUN 00, first forecast day, 6h cumulated, over Piedmont

2017/08/08

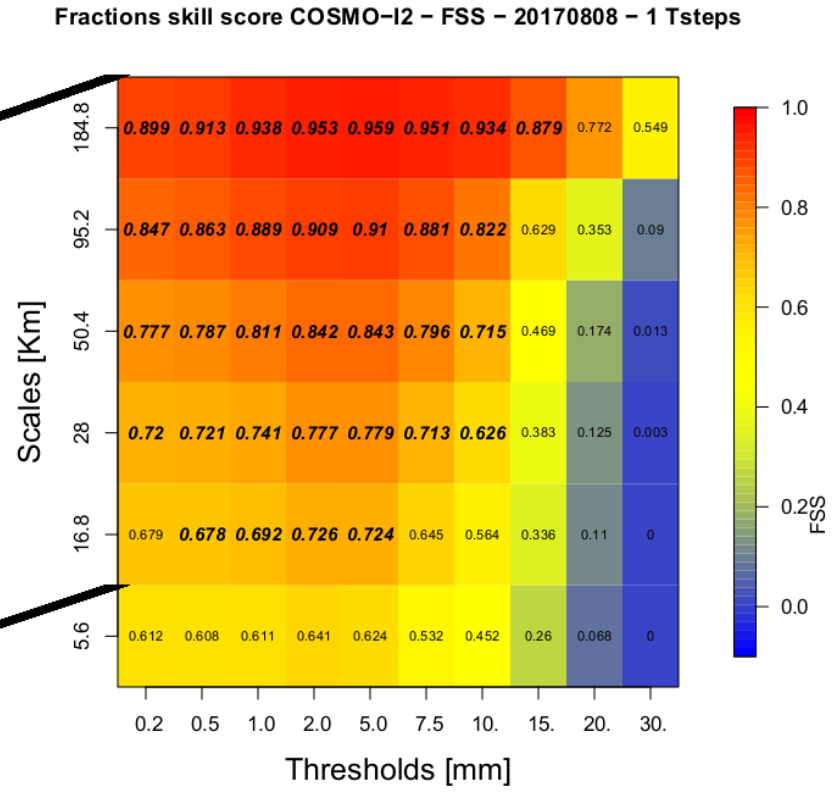
COSMO 7km



COSMO 5km



COSMO 2.8km



For the selected case study COSMO 5km has better performances than COSMO 7km for all scales and all thresholds. It also has better performances than COSMO 2.8km for high thresholds.

Future developments

- I’ll be back to work in december, so no developments before that date
- In December I will fix some minor bugs of the VAST version 2.0 beta (so it will became official)
- Further major developments will be planned in 2018

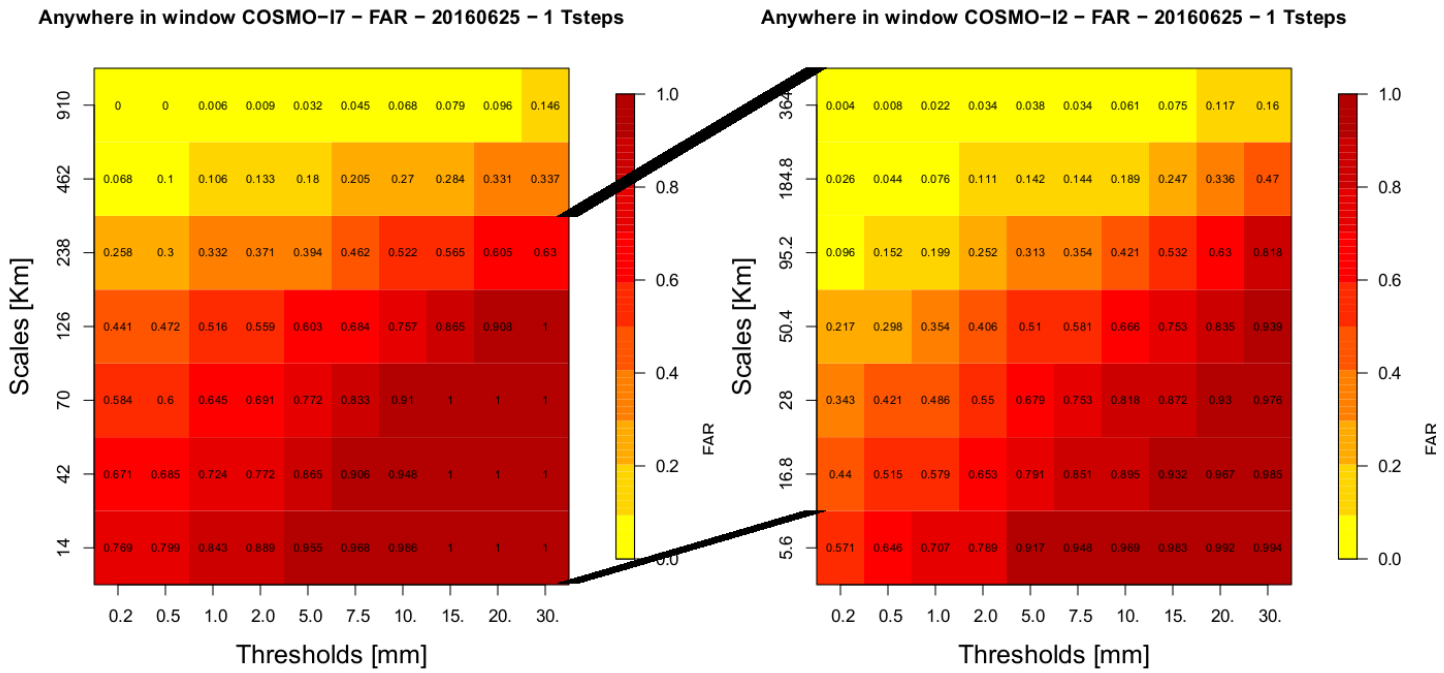
For any question:

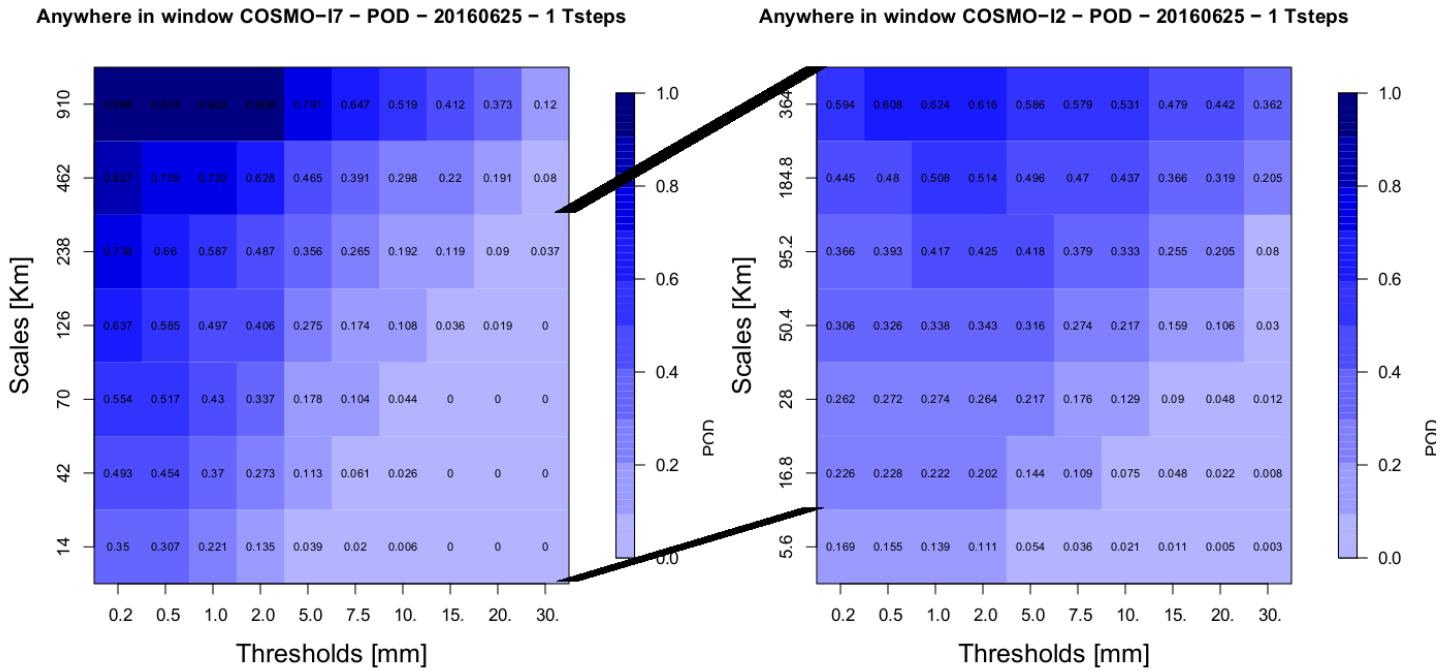
naima.vela@arpa.piemonte.it

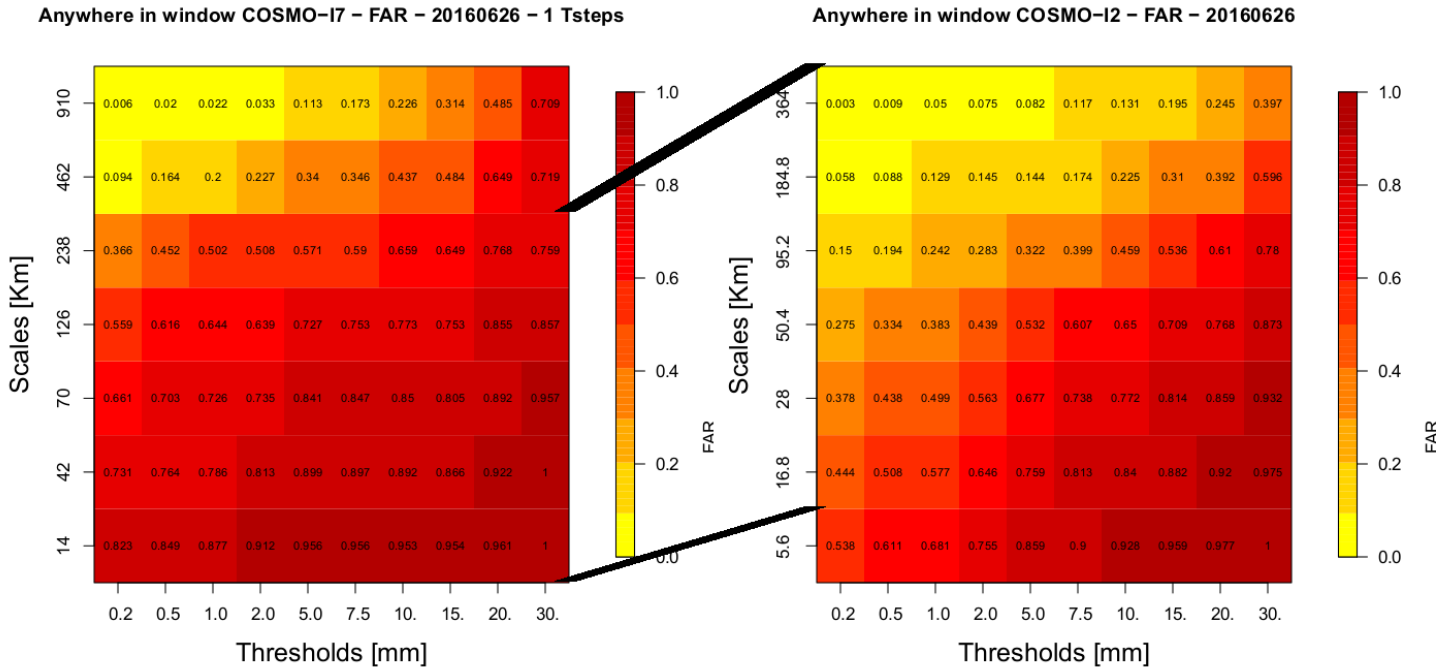

THANK YOU
FOR YOUR
ATTENTION!

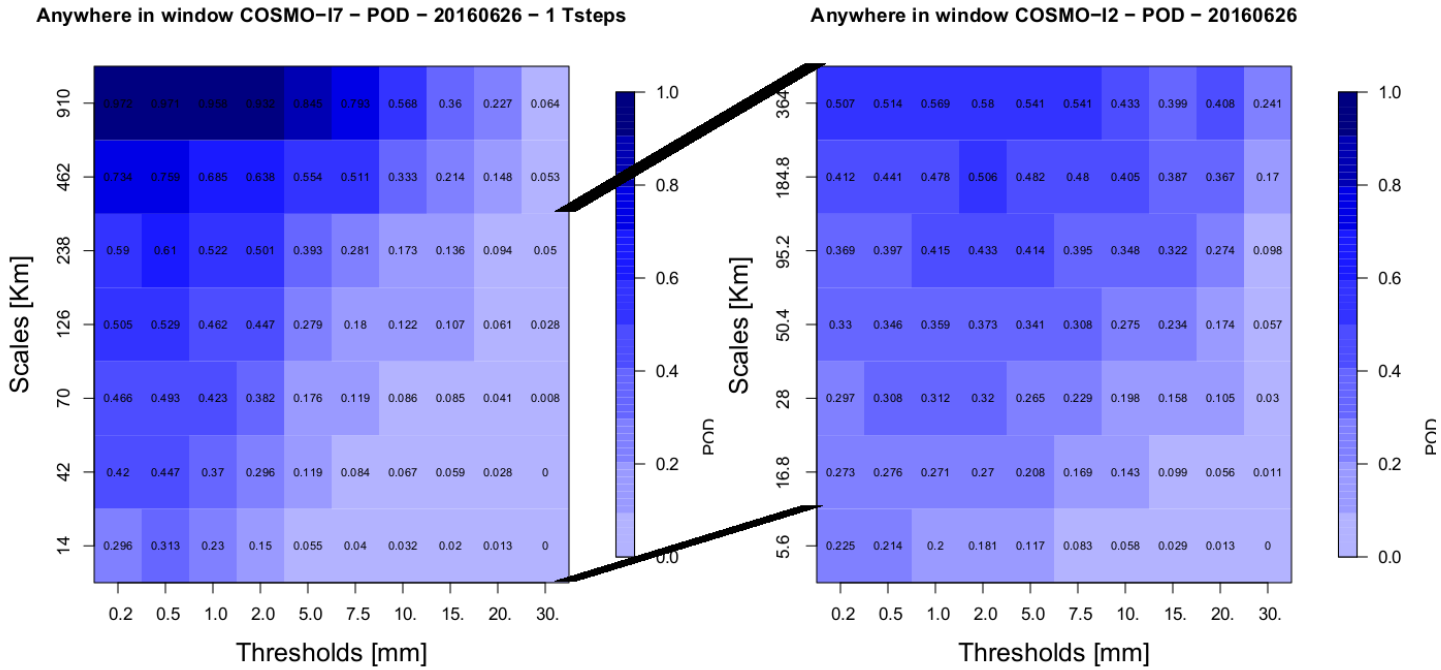
Further images from the case studies

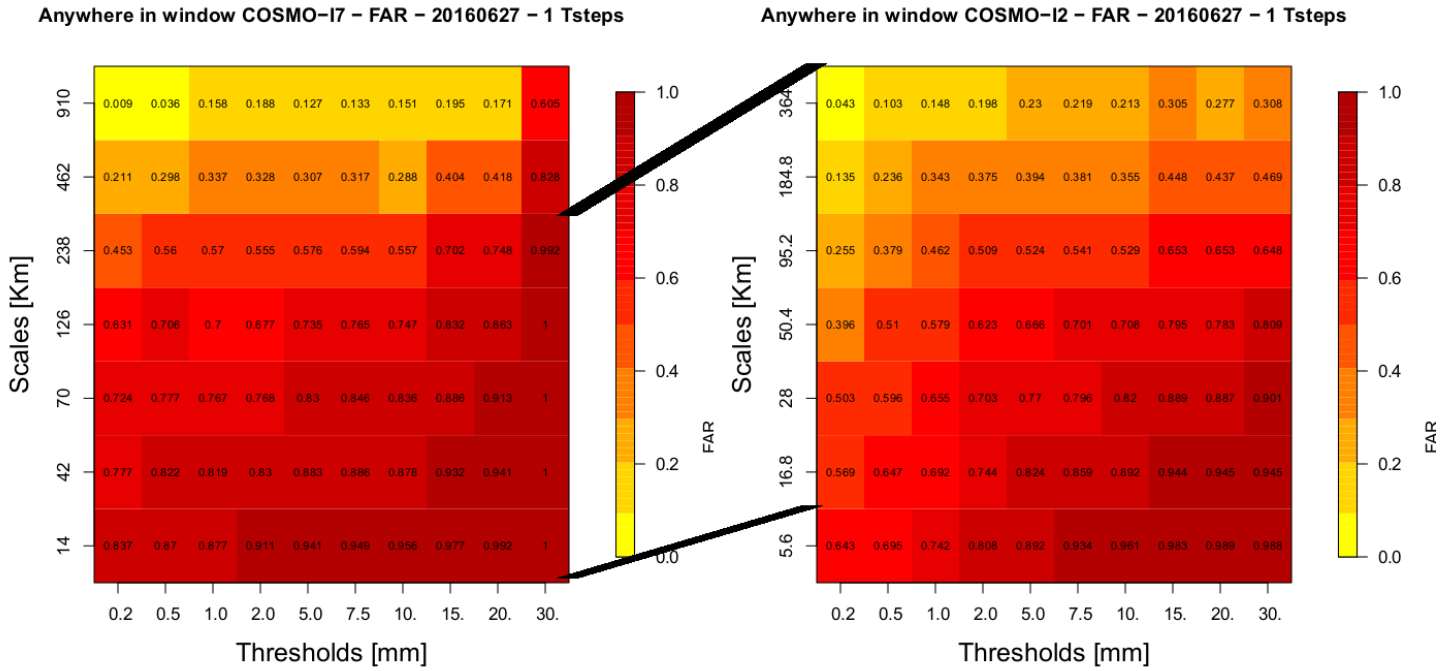
(not commented)

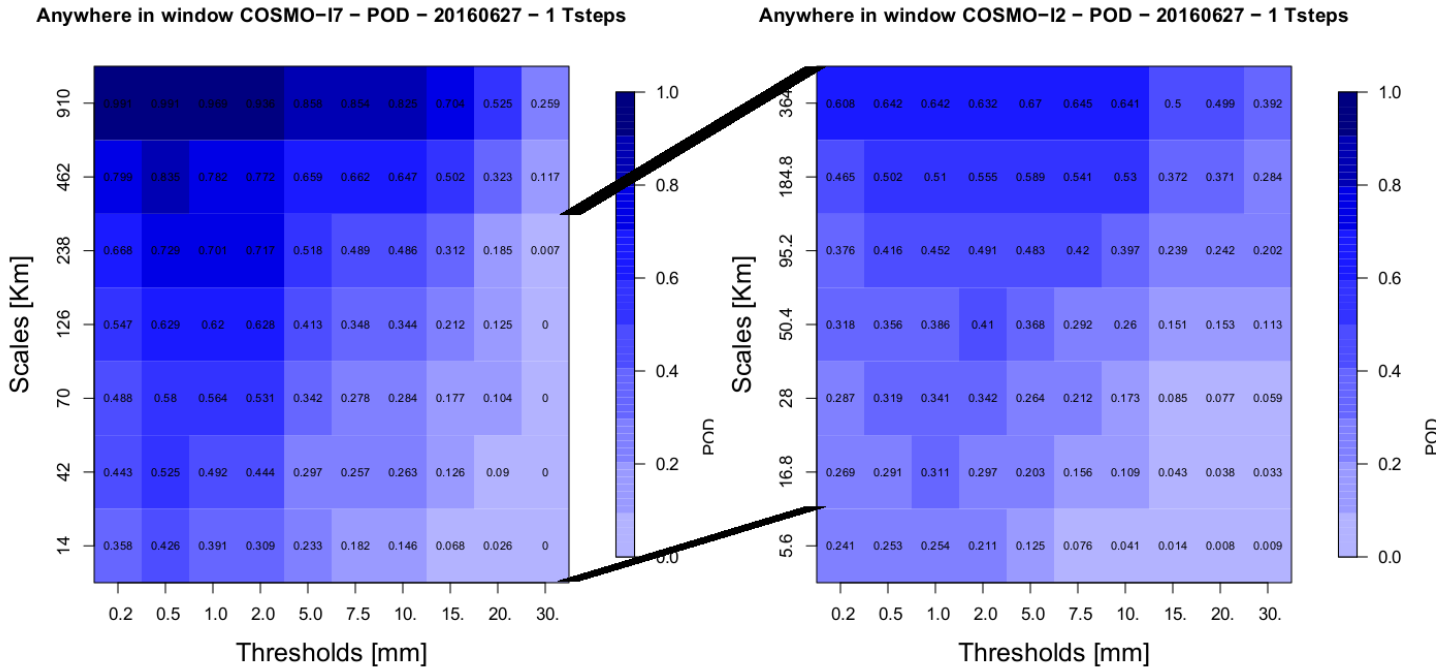

Anywhere in window COSMO−I7 − FAR − 20160625 − 1 Tsteps
Anywhere in window COSMO−I2 − FAR − 20160625 − 1 Tsteps
Scales [Km]
910 462 238 126 70 42 14
0 0 0.006 0.009 0.032 0.045 0.068 0.079 0.096 0.146
0.068 0.1 0.106 0.133 0.18 0.205 0.27 0.284 0.331 0.337
0.258 0.3 0.332 0.371 0.394 0.462 0.522 0.565 0.605 0.63
0.441 0.472 0.516 0.559 0.603 0.684 0.757 0.865 0.908 1
0.584 0.6 0.645 0.691 0.772 0.833 0.91 1 1 1
0.671 0.685 0.724 0.772 0.865 0.906 0.948 1 1 1
0.769 0.799 0.843 0.889 0.955 0.968 0.986 1 1 1
0.2 0.5 1.0 2.0 5.0 7.5 10. 15. 20. 30.
Thresholds [mm]
FAR
1.0 0.8 0.6 0.4 0.2 0.0
364 184.8 95.2 50.4 28 16.8 5.6
0.004 0.008 0.022 0.034 0.038 0.034 0.061 0.075 0.117 0.16
0.026 0.044 0.076 0.111 0.142 0.144 0.189 0.247 0.336 0.47
0.096 0.152 0.199 0.252 0.313 0.354 0.421 0.532 0.63 0.818
0.217 0.298 0.354 0.406 0.51 0.581 0.666 0.753 0.835 0.939
0.343 0.421 0.486 0.55 0.679 0.753 0.818 0.872 0.93 0.976
0.44 0.515 0.579 0.653 0.791 0.851 0.895 0.932 0.967 0.985
0.571 0.646 0.707 0.789 0.917 0.948 0.969 0.983 0.992 0.994

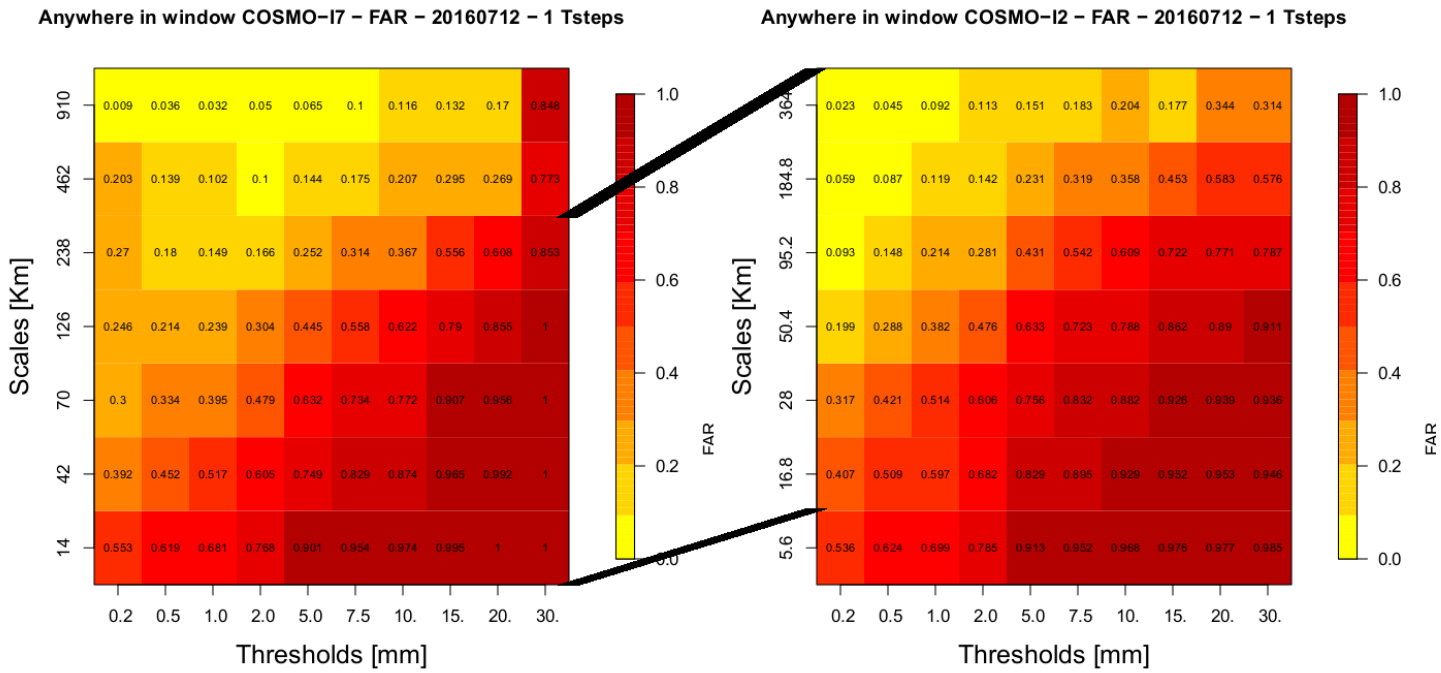

Anywhere in window COSMO−I7 − POD − 20160625 − 1 Tsteps
Anywhere in window COSMO−I2 − POD − 20160625 − 1 Tsteps
Scales [Km]
910 462 238 126 70 42 14
0.988 0.974 0.962 0.908 0.791 0.647 0.519 0.412 0.373 0.12
0.827 0.759 0.732 0.628 0.465 0.391 0.298 0.22 0.191 0.08
0.738 0.66 0.587 0.487 0.356 0.265 0.192 0.119 0.09 0.037
0.637 0.585 0.497 0.406 0.275 0.174 0.108 0.036 0.019 0
0.554 0.517 0.43 0.337 0.178 0.104 0.044 0 0 0
0.493 0.454 0.37 0.273 0.113 0.061 0.026 0 0 0
0.35 0.307 0.221 0.135 0.039 0.02 0.006 0 0 0
0.2 0.5 1.0 2.0 5.0 7.5 10. 15. 20. 30.
Thresholds [mm]
POD
1.0 0.8 0.6 0.4 0.2 0.0
364 184.8 95.2 50.4 28 16.8 5.6
0.594 0.608 0.624 0.616 0.586 0.579 0.531 0.479 0.442 0.362
0.445 0.48 0.508 0.514 0.496 0.47 0.437 0.366 0.319 0.205
0.366 0.393 0.417 0.425 0.418 0.379 0.333 0.255 0.205 0.08
0.306 0.326 0.338 0.343 0.316 0.274 0.217 0.159 0.106 0.03
0.262 0.272 0.274 0.264 0.217 0.176 0.129 0.09 0.048 0.012
0.226 0.228 0.222 0.202 0.144 0.109 0.075 0.048 0.022 0.008
0.169 0.155 0.139 0.111 0.054 0.036 0.021 0.011 0.005 0.003

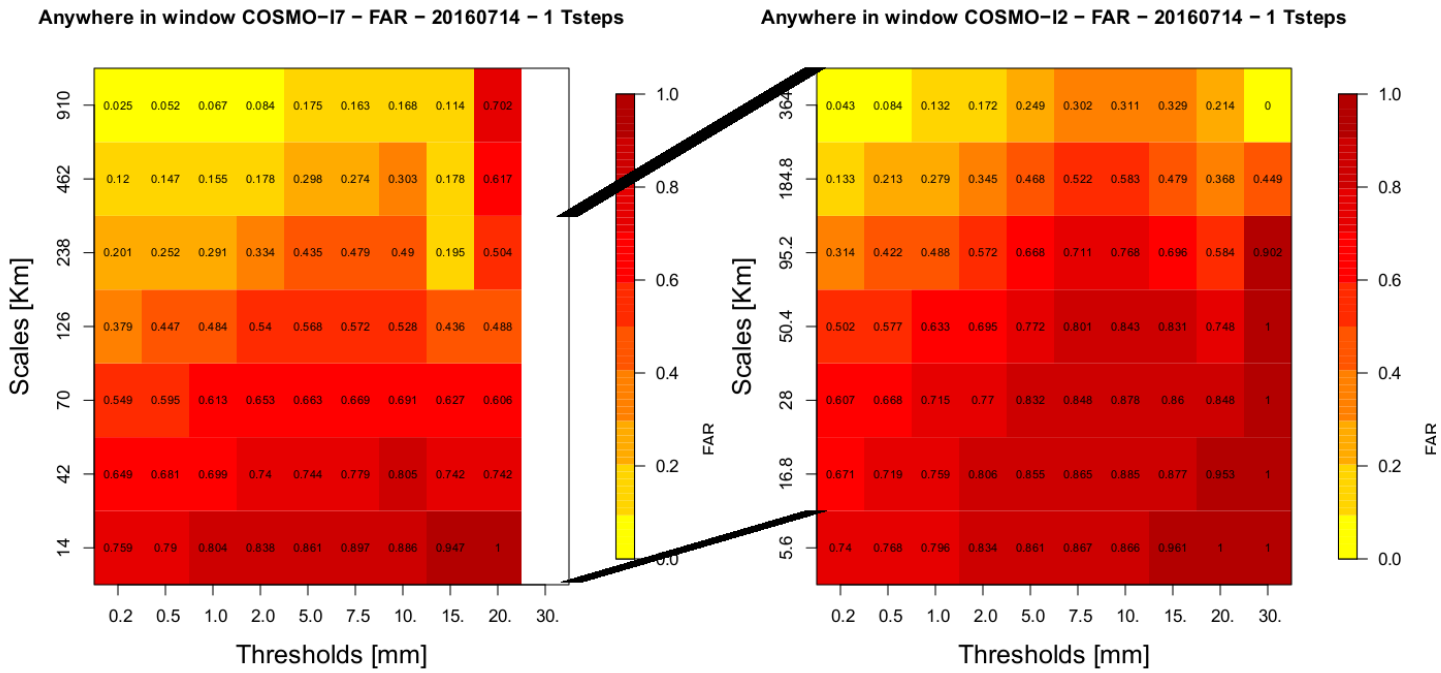

Anywhere in window COSMO−I7 − FAR − 20160626 − 1 Tsteps
Anywhere in window COSMO−I2 − FAR − 20160626
Scales [Km]
910 462 238 126 70 42 14
0.006 0.02 0.022 0.033 0.113 0.173 0.226 0.314 0.485 0.709
0.094 0.164 0.2 0.227 0.34 0.346 0.437 0.484 0.649 0.719
0.366 0.452 0.502 0.508 0.571 0.59 0.659 0.649 0.768 0.759
0.559 0.616 0.644 0.639 0.727 0.753 0.773 0.753 0.855 0.857
0.661 0.703 0.726 0.735 0.841 0.847 0.85 0.805 0.892 0.957
0.731 0.764 0.786 0.813 0.899 0.897 0.892 0.866 0.922 1
0.823 0.849 0.877 0.912 0.956 0.956 0.953 0.954 0.961 1
0.2 0.5 1.0 2.0 5.0 7.5 10. 15. 20. 30.
Thresholds [mm]
FAR
1.0 0.8 0.6 0.4 0.2 0.0
364 184.8 95.2 50.4 28 16.8 5.6
0.003 0.009 0.05 0.075 0.082 0.117 0.131 0.195 0.245 0.397
0.058 0.088 0.129 0.145 0.144 0.174 0.225 0.31 0.392 0.596
0.15 0.194 0.242 0.283 0.322 0.399 0.459 0.536 0.61 0.78
0.275 0.334 0.383 0.439 0.532 0.607 0.65 0.709 0.768 0.873
0.378 0.438 0.499 0.563 0.677 0.738 0.772 0.814 0.859 0.932
0.444 0.508 0.577 0.646 0.759 0.813 0.84 0.882 0.92 0.975
0.538 0.611 0.681 0.755 0.859 0.9 0.928 0.959 0.977 1

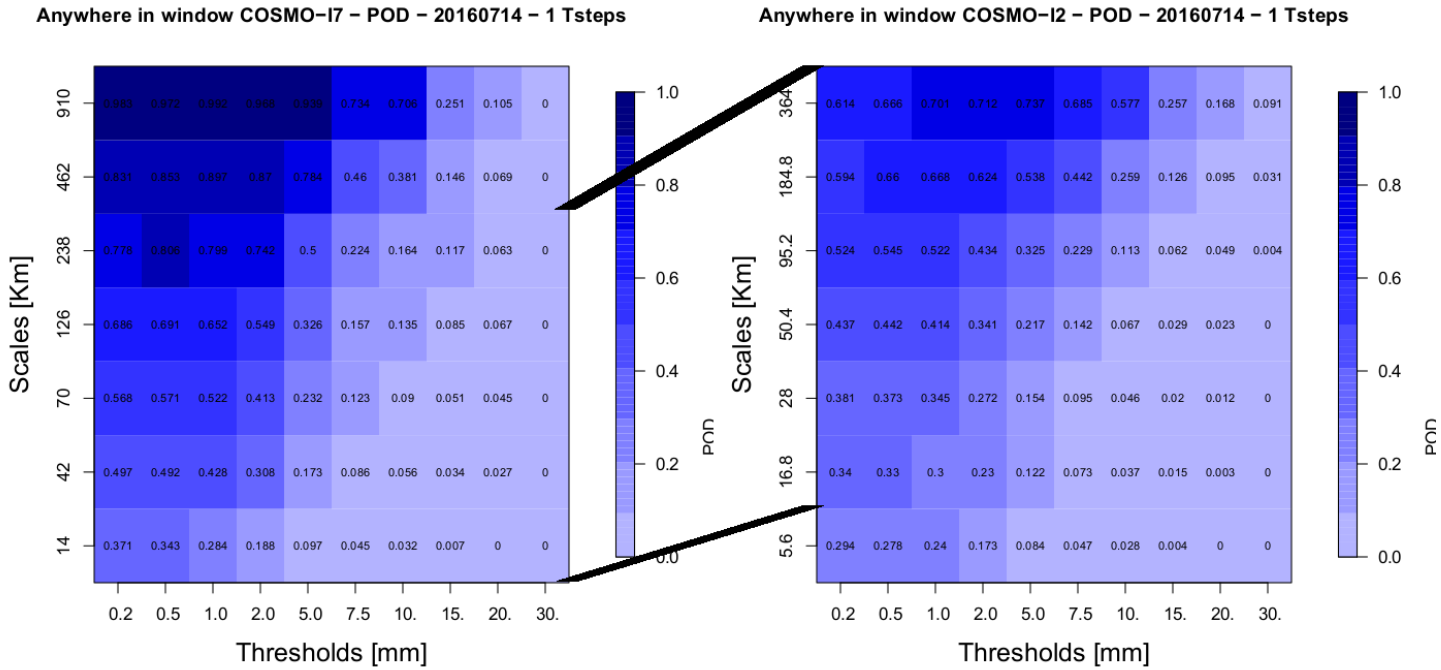

Anywhere in window COSMO−I7 − POD − 20160626 − 1 Tsteps
Anywhere in window COSMO−I2 − POD − 20160626
Scales [Km]
910 462 238 126 70 42 14
0.972 0.971 0.958 0.932 0.845 0.793 0.568 0.36 0.227 0.064
0.734 0.759 0.685 0.638 0.554 0.511 0.333 0.214 0.148 0.053
0.59 0.61 0.522 0.501 0.393 0.281 0.173 0.136 0.094 0.05
0.505 0.529 0.462 0.447 0.279 0.18 0.122 0.107 0.061 0.028
0.466 0.493 0.423 0.382 0.176 0.119 0.086 0.085 0.041 0.008
0.42 0.447 0.37 0.296 0.119 0.084 0.067 0.059 0.028 0
0.296 0.313 0.23 0.15 0.055 0.04 0.032 0.02 0.013 0
0.2 0.5 1.0 2.0 5.0 7.5 10. 15. 20. 30.
Thresholds [mm]
POD
1.0 0.8 0.6 0.4 0.2 0.0
364 184.8 95.2 50.4 28 16.8 5.6
0.507 0.514 0.569 0.58 0.541 0.541 0.433 0.399 0.408 0.241
0.412 0.441 0.478 0.506 0.482 0.48 0.405 0.387 0.367 0.17
0.369 0.397 0.415 0.433 0.414 0.395 0.348 0.322 0.274 0.098
0.33 0.346 0.359 0.373 0.341 0.308 0.275 0.234 0.174 0.057
0.297 0.308 0.312 0.32 0.265 0.229 0.198 0.158 0.105 0.03
0.273 0.276 0.271 0.27 0.208 0.169 0.143 0.099 0.056 0.011
0.225 0.214 0.2 0.181 0.117 0.083 0.058 0.029 0.013 0

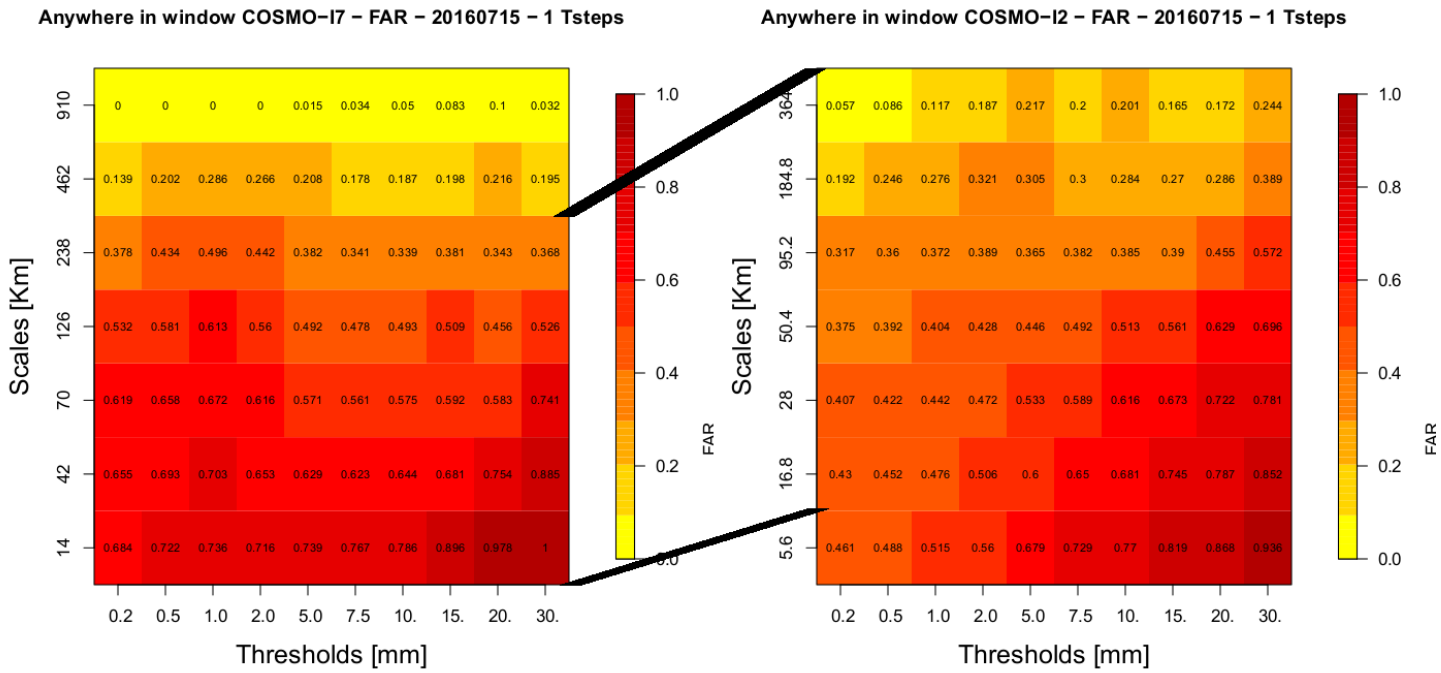

Anywhere in window COSMO−I7 − FAR − 20160627 − 1 Tsteps
Scales [Km]
910 462 238 126 70 42 14
0.009 0.036 0.158 0.188 0.127 0.133 0.151 0.195 0.171 0.605
0.211 0.298 0.337 0.328 0.307 0.317 0.288 0.404 0.418 0.828
0.453 0.56 0.57 0.555 0.576 0.594 0.557 0.702 0.748 0.992
0.631 0.706 0.7 0.677 0.735 0.765 0.747 0.832 0.863 1
0.724 0.777 0.767 0.768 0.83 0.846 0.836 0.886 0.913 1
0.777 0.822 0.819 0.83 0.883 0.886 0.878 0.932 0.941 1
0.837 0.87 0.877 0.911 0.941 0.949 0.956 0.977 0.992 1
0.2 0.5 1.0 2.0 5.0 7.5 10. 15. 20. 30.
Thresholds [mm]
FAR
1.0 0.8 0.6 0.4 0.2 0.0
Anywhere in window COSMO−I2 − FAR − 20160627 − 1 Tsteps
Scales [Km]
364 184.8 95.2 50.4 28 16.8 5.6
0.043 0.103 0.148 0.198 0.23 0.219 0.213 0.305 0.277 0.308
0.135 0.236 0.343 0.375 0.394 0.381 0.355 0.448 0.437 0.469
0.255 0.379 0.462 0.509 0.524 0.541 0.529 0.653 0.653 0.648
0.396 0.51 0.579 0.623 0.666 0.701 0.708 0.795 0.783 0.809
0.503 0.596 0.655 0.703 0.77 0.796 0.82 0.889 0.887 0.901
0.569 0.647 0.692 0.744 0.824 0.859 0.892 0.944 0.945 0.945
0.643 0.695 0.742 0.808 0.892 0.934 0.961 0.983 0.989 0.988
0.2 0.5 1.0 2.0 5.0 7.5 10. 15. 20. 30.
Thresholds [mm]
FAR
1.0 0.8 0.6 0.4 0.2 0.0

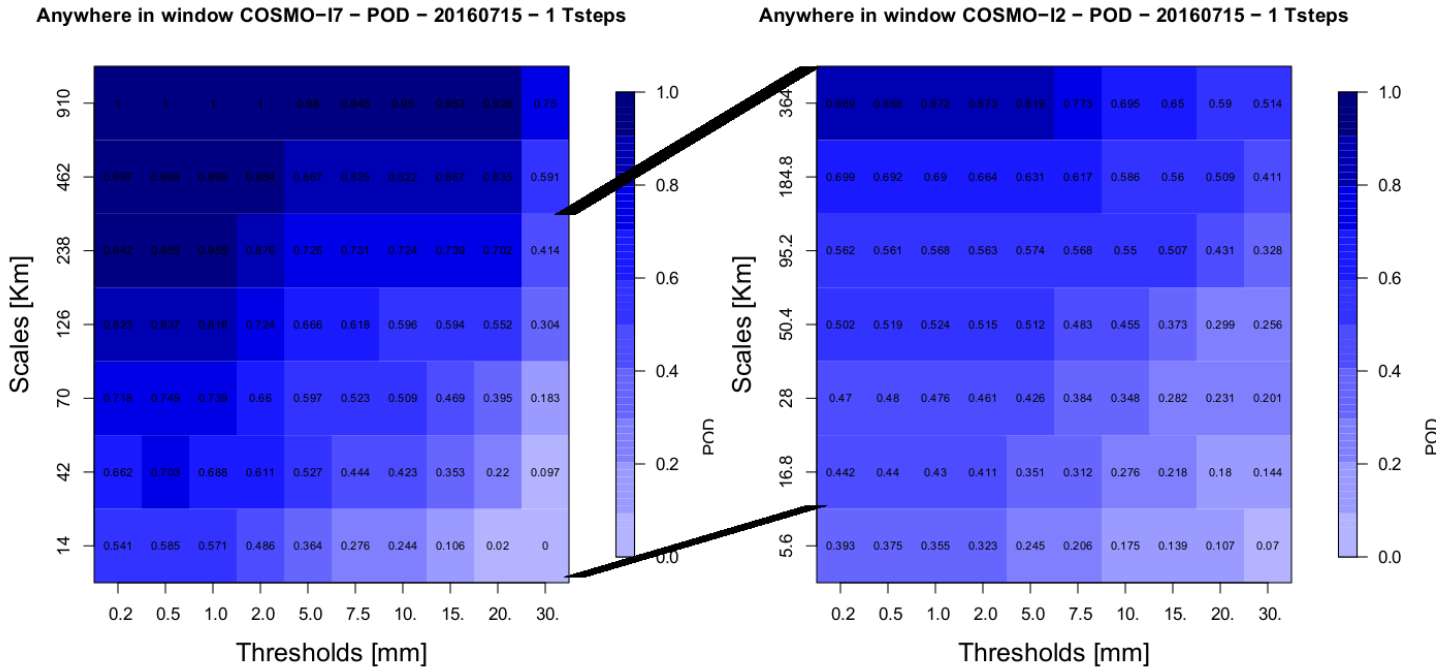

Anywhere in window COSMO−I7 − POD − 20160627 − 1 Tsteps
Scales [Km]
910 462 238 126 70 42 14
0.991 0.991 0.989 0.986 0.858 0.854 0.825 0.704 0.525 0.259
0.799 0.835 0.782 0.772 0.659 0.662 0.647 0.502 0.323 0.117
0.668 0.729 0.701 0.717 0.518 0.489 0.486 0.312 0.185 0.007
0.547 0.629 0.62 0.628 0.413 0.348 0.344 0.212 0.125 0
0.488 0.58 0.564 0.531 0.342 0.278 0.284 0.177 0.104 0
0.443 0.525 0.492 0.444 0.297 0.257 0.263 0.126 0.09 0
0.358 0.426 0.391 0.309 0.233 0.182 0.146 0.068 0.026 0
0.2 0.5 1.0 2.0 5.0 7.5 10. 15. 20. 30.
Thresholds [mm]
POD
1.0 0.8 0.6 0.4 0.2 0.0
Anywhere in window COSMO−I2 − POD − 20160627 − 1 Tsteps
Scales [Km]
364 184.8 95.2 50.4 28 16.8 5.6
0.608 0.642 0.642 0.632 0.67 0.645 0.641 0.5 0.499 0.392
0.465 0.502 0.51 0.555 0.589 0.541 0.53 0.372 0.371 0.284
0.376 0.416 0.452 0.491 0.483 0.42 0.397 0.239 0.242 0.202
0.318 0.356 0.386 0.41 0.368 0.292 0.26 0.151 0.153 0.113
0.287 0.319 0.341 0.342 0.264 0.212 0.173 0.085 0.077 0.059
0.269 0.291 0.311 0.297 0.203 0.156 0.109 0.043 0.038 0.033
0.241 0.253 0.254 0.211 0.125 0.076 0.041 0.014 0.008 0.009
0.2 0.5 1.0 2.0 5.0 7.5 10. 15. 20. 30.
Thresholds [mm]
POD
1.0 0.8 0.6 0.4 0.2 0.0

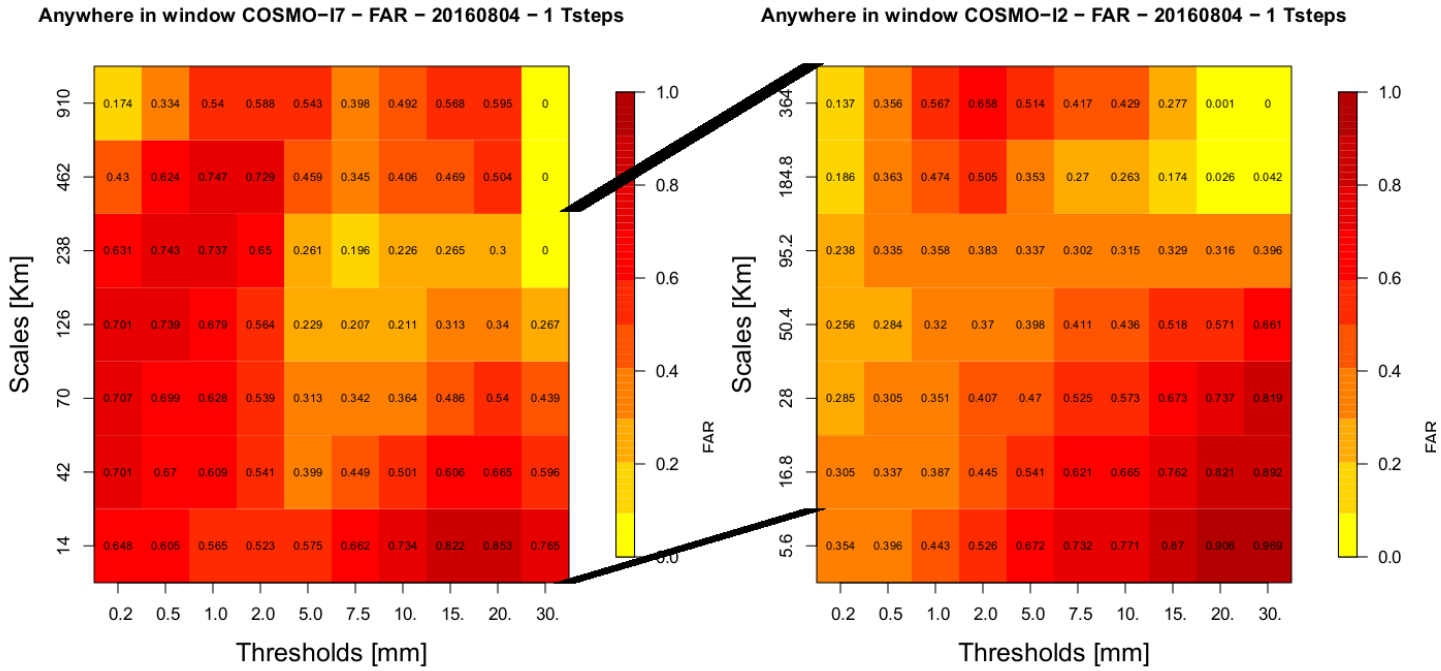

Anywhere in window COSMO−I7 − FAR − 20160712 − 1 Tsteps
Scales [Km]
910 462 238 126 70 42 14
0.009 0.036 0.032 0.05 0.065 0.1 0.116 0.132 0.17 0.848
0.203 0.139 0.102 0.1 0.144 0.175 0.207 0.295 0.269 0.773
0.27 0.18 0.149 0.166 0.252 0.314 0.367 0.556 0.608 0.853
0.246 0.214 0.239 0.304 0.445 0.558 0.622 0.79 0.855 1
0.3 0.334 0.395 0.479 0.632 0.734 0.772 0.907 0.956 1
0.392 0.452 0.517 0.605 0.749 0.829 0.874 0.965 0.992 1
0.553 0.619 0.681 0.768 0.901 0.954 0.974 0.995 1 1
0.2 0.5 1.0 2.0 5.0 7.5 10. 15. 20. 30.
Thresholds [mm]
FAR
1.0 0.8 0.6 0.4 0.2 0.0
Anywhere in window COSMO−I2 − FAR − 20160712 − 1 Tsteps
Scales [Km]
364 184.8 95.2 50.4 28 16.8 5.6
0.023 0.045 0.092 0.113 0.151 0.183 0.204 0.177 0.344 0.314
0.059 0.087 0.119 0.142 0.231 0.319 0.358 0.453 0.583 0.576
0.093 0.148 0.214 0.281 0.431 0.542 0.609 0.722 0.771 0.787
0.199 0.288 0.382 0.476 0.633 0.723 0.788 0.862 0.89 0.911
0.317 0.421 0.514 0.606 0.756 0.832 0.882 0.926 0.939 0.936
0.407 0.509 0.597 0.682 0.829 0.895 0.929 0.952 0.953 0.946
0.536 0.624 0.699 0.785 0.913 0.952 0.968 0.976 0.977 0.985
0.2 0.5 1.0 2.0 5.0 7.5 10. 15. 20. 30.
Thresholds [mm]
FAR
1.0 0.8 0.6 0.4 0.2 0.0
Anywhere in window COSMO−I7 − POD − 20160712 − 1 Tsteps
Scales [Km]
910 462 238 126 70 42 14
0.977 0.96 0.948 0.945 0.924 0.942 0.95 0.918 0.733 0.058
0.83 0.842 0.808 0.857 0.832 0.863 0.886 0.711 0.46 0.072
0.793 0.826 0.819 0.868 0.817 0.784 0.761 0.465 0.246 0.055
0.797 0.834 0.829 0.837 0.758 0.629 0.535 0.243 0.096 0
0.807 0.823 0.8 0.776 0.631 0.448 0.338 0.112 0.03 0
0.797 0.79 0.761 0.701 0.487 0.304 0.188 0.041 0.005 0
0.721 0.687 0.618 0.481 0.213 0.089 0.044 0.006 0 0
0.2 0.5 1.0 2.0 5.0 7.5 10. 15. 20. 30.
Thresholds [mm]
POD
1.0 0.8 0.6 0.4 0.2 0.0
Anywhere in window COSMO−I2 − POD − 20160712 − 1 Tsteps
Scales [Km]
364 184.8 95.2 50.4 28 16.8 5.6
0.585 0.646 0.694 0.733 0.805 0.728 0.72 0.726 0.578 0.471
0.526 0.571 0.649 0.682 0.692 0.631 0.613 0.516 0.4 0.308
0.503 0.558 0.603 0.612 0.58 0.501 0.44 0.315 0.246 0.164
0.498 0.537 0.547 0.526 0.45 0.367 0.291 0.181 0.132 0.067
0.482 0.497 0.486 0.45 0.344 0.251 0.18 0.108 0.08 0.047
0.462 0.463 0.435 0.394 0.268 0.171 0.117 0.079 0.066 0.039
0.424 0.401 0.361 0.309 0.162 0.093 0.066 0.05 0.037 0.01
0.2 0.5 1.0 2.0 5.0 7.5 10. 15. 20. 30.
Thresholds [mm]
POD
1.0 0.8 0.6 0.4 0.2 0.0

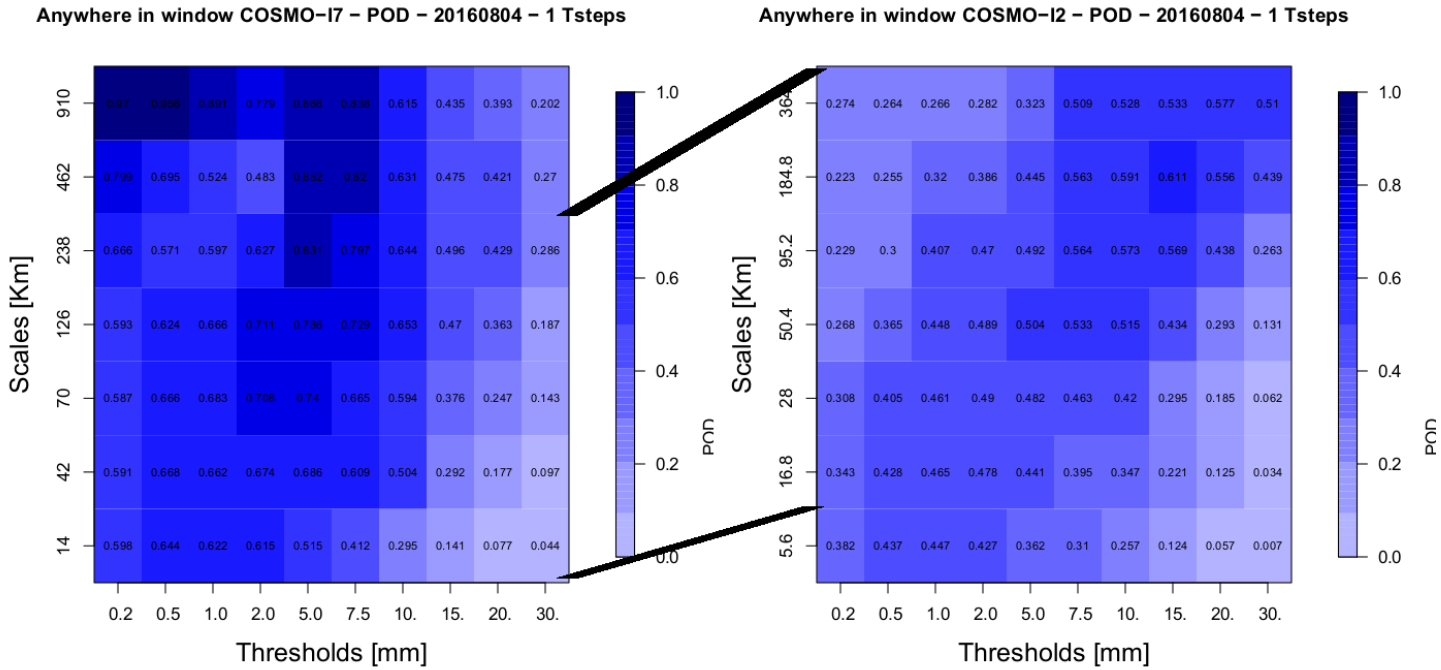

Anywhere in window COSMO−I7 − FAR − 20160714 − 1 Tsteps
Scales [Km]
910 462 238 126 70 42 14
0.025 0.052 0.067 0.084 0.175 0.163 0.168 0.114 0.702
0.12 0.147 0.155 0.178 0.298 0.274 0.303 0.178 0.617
0.201 0.252 0.291 0.334 0.435 0.479 0.49 0.195 0.504
0.379 0.447 0.484 0.54 0.568 0.572 0.528 0.436 0.488
0.549 0.595 0.613 0.653 0.663 0.669 0.691 0.627 0.606
0.649 0.681 0.699 0.74 0.744 0.779 0.805 0.742 0.742
0.759 0.79 0.804 0.838 0.861 0.897 0.886 0.947 1
0.2 0.5 1.0 2.0 5.0 7.5 10. 15. 20. 30.
Thresholds [mm]
FAR
1.0 0.8 0.6 0.4 0.2 0.0
Anywhere in window COSMO−I2 − FAR − 20160714 − 1 Tsteps
Scales [Km]
364 184.8 95.2 50.4 28 16.8 5.6
0.043 0.084 0.132 0.172 0.249 0.302 0.311 0.329 0.214 0
0.133 0.213 0.279 0.345 0.468 0.522 0.583 0.479 0.368 0.449
0.314 0.422 0.488 0.572 0.668 0.711 0.768 0.696 0.584 0.902
0.502 0.577 0.633 0.695 0.772 0.801 0.843 0.831 0.748 1
0.607 0.668 0.715 0.77 0.832 0.848 0.878 0.86 0.848 1
0.671 0.719 0.759 0.806 0.855 0.865 0.885 0.877 0.953 1
0.74 0.768 0.796 0.834 0.861 0.867 0.866 0.961 1 1
0.2 0.5 1.0 2.0 5.0 7.5 10. 15. 20. 30.
Thresholds [mm]
FAR
1.0 0.8 0.6 0.4 0.2 0.0

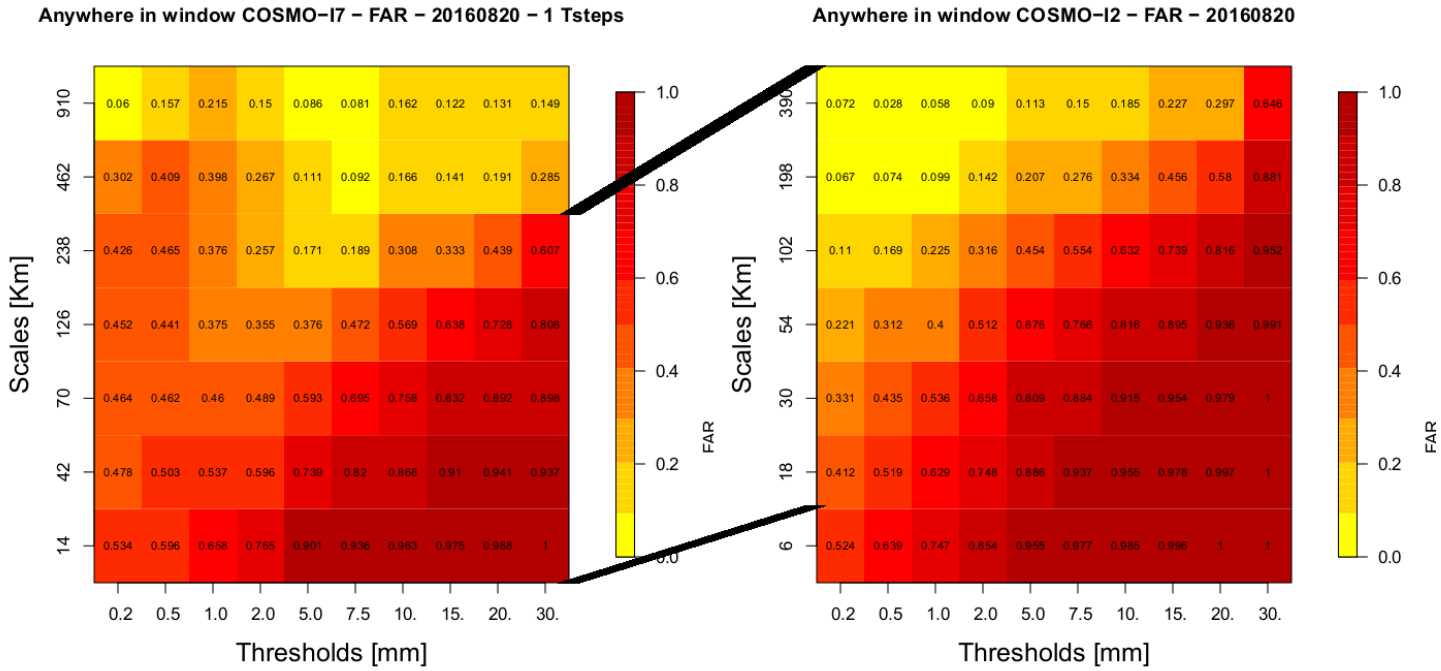

Anywhere in window COSMO−I7 − POD − 20160714 − 1 Tsteps
Scales [Km]
910 462 238 126 70 42 14
0.983 0.972 0.932 0.968 0.939 0.734 0.706 0.251 0.105 0
0.831 0.853 0.897 0.87 0.784 0.46 0.381 0.146 0.069 0
0.778 0.806 0.799 0.742 0.5 0.224 0.164 0.117 0.063 0
0.686 0.691 0.652 0.549 0.326 0.157 0.135 0.085 0.067 0
0.568 0.571 0.522 0.413 0.232 0.123 0.09 0.051 0.045 0
0.497 0.492 0.428 0.308 0.173 0.086 0.056 0.034 0.027 0
0.371 0.343 0.284 0.188 0.097 0.045 0.032 0.007 0 0
0.2 0.5 1.0 2.0 5.0 7.5 10. 15. 20. 30.
Thresholds [mm]
POD
1.0 0.8 0.6 0.4 0.2 0.0
Anywhere in window COSMO−I2 − POD − 20160714 − 1 Tsteps
Scales [Km]
364 184.8 95.2 50.4 28 16.8 5.6
0.614 0.666 0.701 0.712 0.737 0.685 0.577 0.257 0.168 0.091
0.594 0.66 0.668 0.624 0.538 0.442 0.259 0.126 0.095 0.031
0.524 0.545 0.522 0.434 0.325 0.229 0.113 0.062 0.049 0.004
0.437 0.442 0.414 0.341 0.217 0.142 0.067 0.029 0.023 0
0.381 0.373 0.345 0.272 0.154 0.095 0.046 0.02 0.012 0
0.34 0.33 0.3 0.23 0.122 0.073 0.037 0.015 0.003 0
0.294 0.278 0.24 0.173 0.084 0.047 0.028 0.004 0 0
0.2 0.5 1.0 2.0 5.0 7.5 10. 15. 20. 30.
Thresholds [mm]
POD
1.0 0.8 0.6 0.4 0.2 0.0

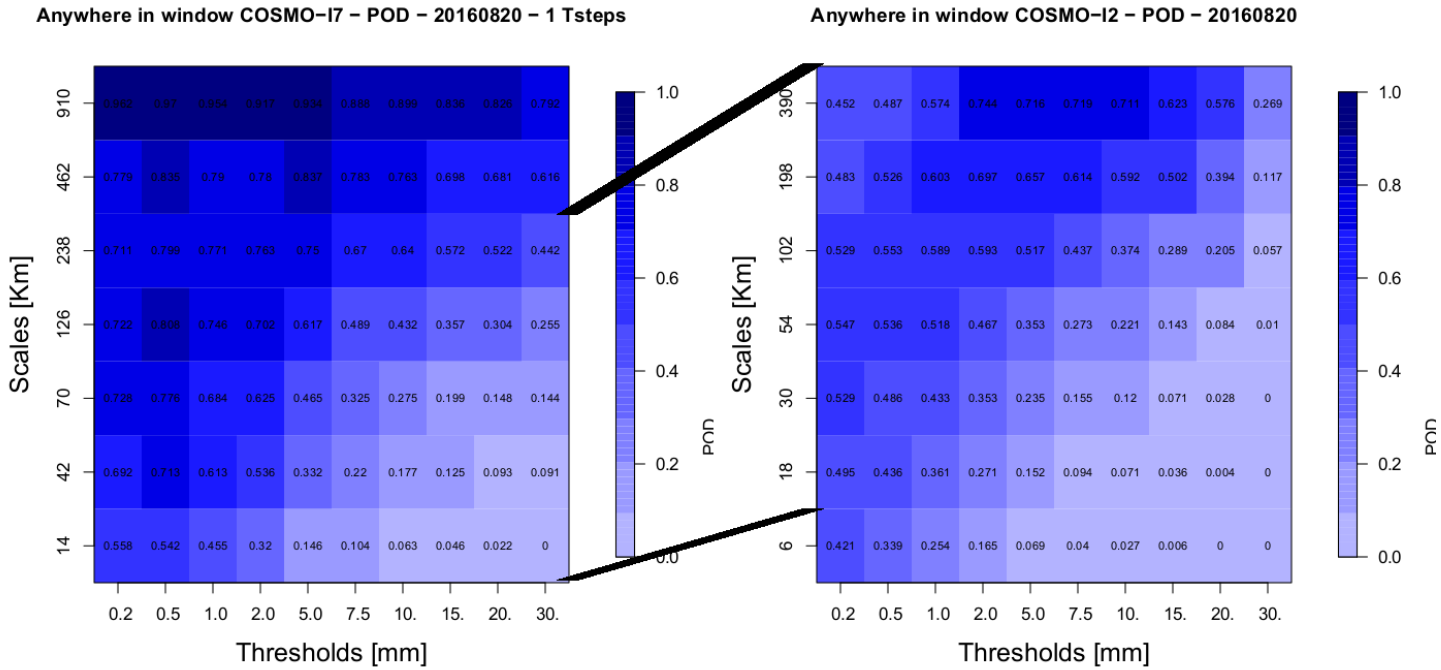

Anywhere in window COSMO−I7 − FAR − 20160715 − 1 Tsteps
Anywhere in window COSMO−I2 − FAR − 20160715 − 1 Tsteps
Scales [Km]
910
462
238
126
70
42
14
0 0 0 0 0.015 0.034 0.05 0.083 0.1 0.032
0.139 0.202 0.286 0.266 0.208 0.178 0.187 0.198 0.216 0.195
0.378 0.434 0.496 0.442 0.382 0.341 0.339 0.381 0.343 0.368
0.532 0.581 0.613 0.56 0.492 0.478 0.493 0.509 0.456 0.526
0.619 0.658 0.672 0.616 0.571 0.561 0.575 0.592 0.583 0.741
0.655 0.693 0.703 0.653 0.629 0.623 0.644 0.681 0.754 0.885
0.684 0.722 0.736 0.716 0.739 0.767 0.786 0.896 0.978 1
0.2 0.5 1.0 2.0 5.0 7.5 10. 15. 20. 30.
Thresholds [mm]
FAR
1.0 0.8 0.6 0.4 0.2 0.0
Scales [Km]
364
184.8
95.2
50.4
28
16.8
5.6
0.057 0.086 0.117 0.187 0.217 0.2 0.201 0.165 0.172 0.244
0.192 0.246 0.276 0.321 0.305 0.3 0.284 0.27 0.286 0.389
0.317 0.36 0.372 0.389 0.365 0.382 0.385 0.39 0.455 0.572
0.375 0.392 0.404 0.428 0.446 0.492 0.513 0.561 0.629 0.696
0.407 0.422 0.442 0.472 0.533 0.589 0.616 0.673 0.722 0.781
0.43 0.452 0.476 0.506 0.6 0.65 0.681 0.745 0.787 0.852
0.461 0.488 0.515 0.56 0.679 0.729 0.77 0.819 0.868 0.936
0.2 0.5 1.0 2.0 5.0 7.5 10. 15. 20. 30.
Thresholds [mm]
FAR
1.0 0.8 0.6 0.4 0.2 0.0

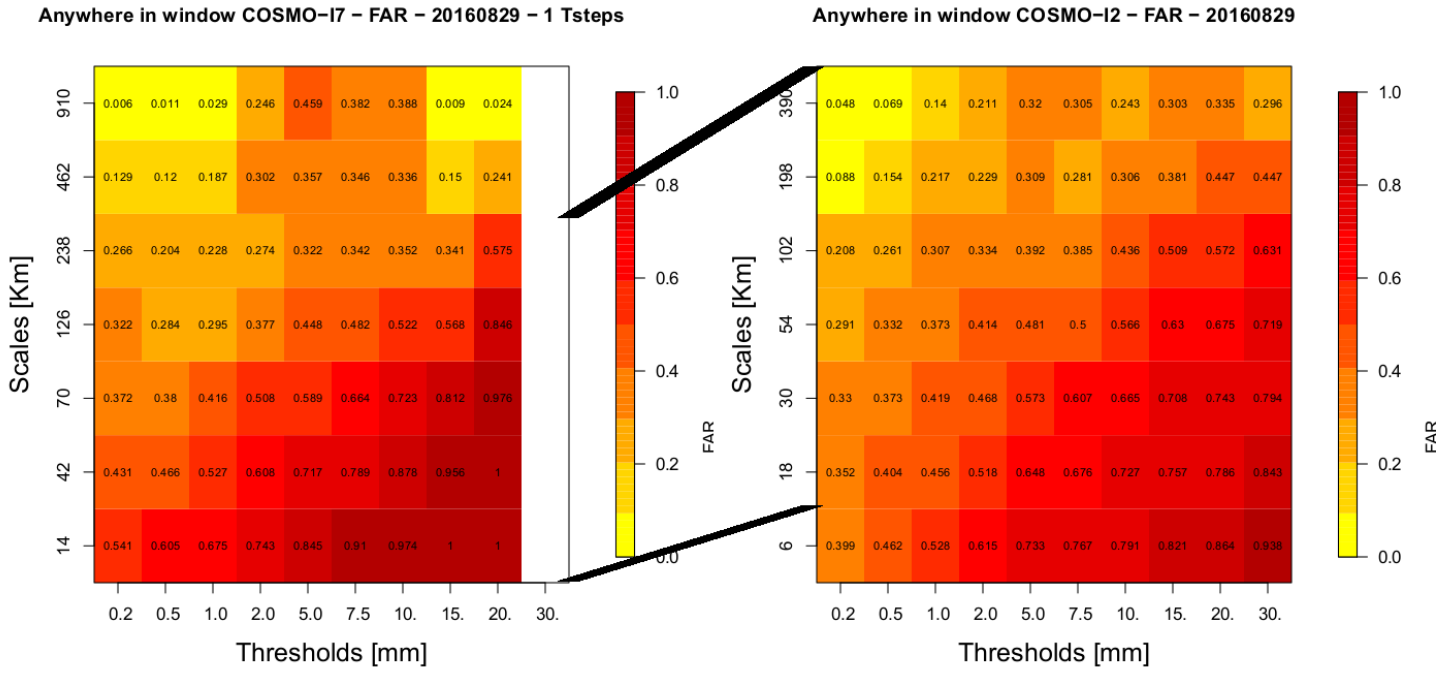

Anywhere in window COSMO−I7 − POD − 20160715 − 1 Tsteps
Anywhere in window COSMO−I2 − POD − 20160715 − 1 Tsteps
Scales [Km]
910
462
238
126
70
42
14
1 1 1 1 0.98 0.945 0.95 0.953 0.926 0.75
0.997 0.998 0.999 0.984 0.867 0.825 0.822 0.887 0.835 0.591
0.942 0.955 0.955 0.876 0.726 0.731 0.724 0.739 0.702 0.414
0.823 0.837 0.818 0.724 0.666 0.618 0.596 0.594 0.552 0.304
0.718 0.749 0.739 0.66 0.597 0.523 0.509 0.469 0.395 0.183
0.662 0.703 0.688 0.611 0.527 0.444 0.423 0.353 0.22 0.097
0.541 0.585 0.571 0.486 0.364 0.276 0.244 0.106 0.02 0
0.2 0.5 1.0 2.0 5.0 7.5 10. 15. 20. 30.
Thresholds [mm]
POD
1.0 0.8 0.6 0.4 0.2 0.0
Scales [Km]
364
184.8
95.2
50.4
28
16.8
5.6
0.869 0.868 0.872 0.873 0.819 0.773 0.695 0.65 0.59 0.514
0.699 0.692 0.69 0.664 0.631 0.617 0.586 0.56 0.509 0.411
0.562 0.561 0.568 0.563 0.574 0.568 0.55 0.507 0.431 0.328
0.502 0.519 0.524 0.515 0.512 0.483 0.455 0.373 0.299 0.256
0.47 0.48 0.476 0.461 0.426 0.384 0.348 0.282 0.231 0.201
0.442 0.44 0.43 0.411 0.351 0.312 0.276 0.218 0.18 0.144
0.393 0.375 0.355 0.323 0.245 0.206 0.175 0.139 0.107 0.07
0.2 0.5 1.0 2.0 5.0 7.5 10. 15. 20. 30.
Thresholds [mm]
POD
1.0 0.8 0.6 0.4 0.2 0.0

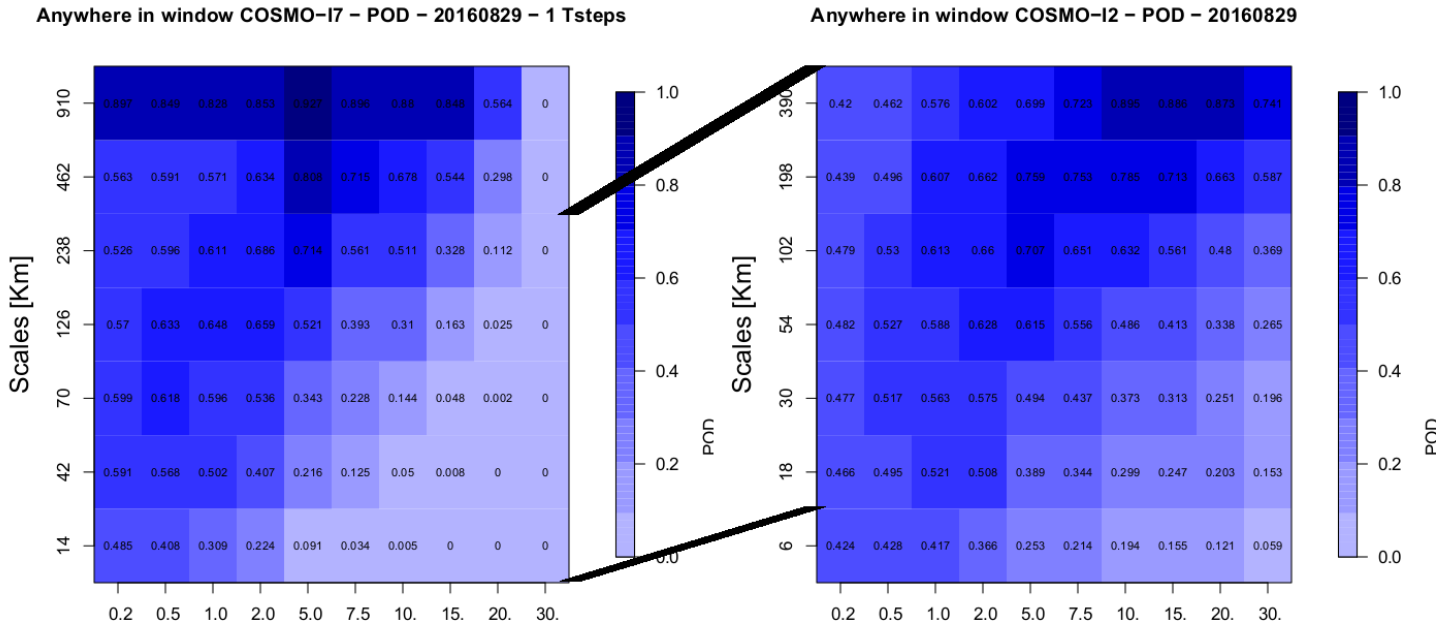

Anywhere in window COSMO−I7 − FAR − 20160804 − 1 Tsteps
Scales [Km]
910 462 238 126 70 42 14
0.174 0.334 0.54 0.588 0.543 0.398 0.492 0.568 0.595 0
0.43 0.624 0.747 0.729 0.459 0.345 0.406 0.469 0.504 0
0.631 0.743 0.737 0.65 0.261 0.196 0.226 0.265 0.3 0
0.701 0.739 0.679 0.564 0.229 0.207 0.211 0.313 0.34 0.267
0.707 0.699 0.628 0.539 0.313 0.342 0.364 0.486 0.54 0.439
0.701 0.67 0.609 0.541 0.399 0.449 0.501 0.606 0.665 0.596
0.648 0.605 0.565 0.523 0.575 0.662 0.734 0.822 0.853 0.765
0.2 0.5 1.0 2.0 5.0 7.5 10. 15. 20. 30.
Thresholds [mm]
FAR
1.0 0.8 0.6 0.4 0.2 0.0
Anywhere in window COSMO−I2 − FAR − 20160804 − 1 Tsteps
Scales [Km]
364 184.8 95.2 50.4 28 16.8 5.6
0.137 0.356 0.567 0.658 0.514 0.417 0.429 0.277 0.001 0
0.186 0.363 0.474 0.505 0.353 0.27 0.263 0.174 0.026 0.042
0.238 0.335 0.358 0.383 0.337 0.302 0.315 0.329 0.316 0.396
0.256 0.284 0.32 0.37 0.398 0.411 0.436 0.518 0.571 0.661
0.285 0.305 0.351 0.407 0.47 0.525 0.573 0.673 0.737 0.819
0.305 0.337 0.387 0.445 0.541 0.621 0.665 0.762 0.821 0.892
0.354 0.396 0.443 0.526 0.672 0.732 0.771 0.87 0.906 0.969
0.2 0.5 1.0 2.0 5.0 7.5 10. 15. 20. 30.
Thresholds [mm]
FAR
1.0 0.8 0.6 0.4 0.2 0.0

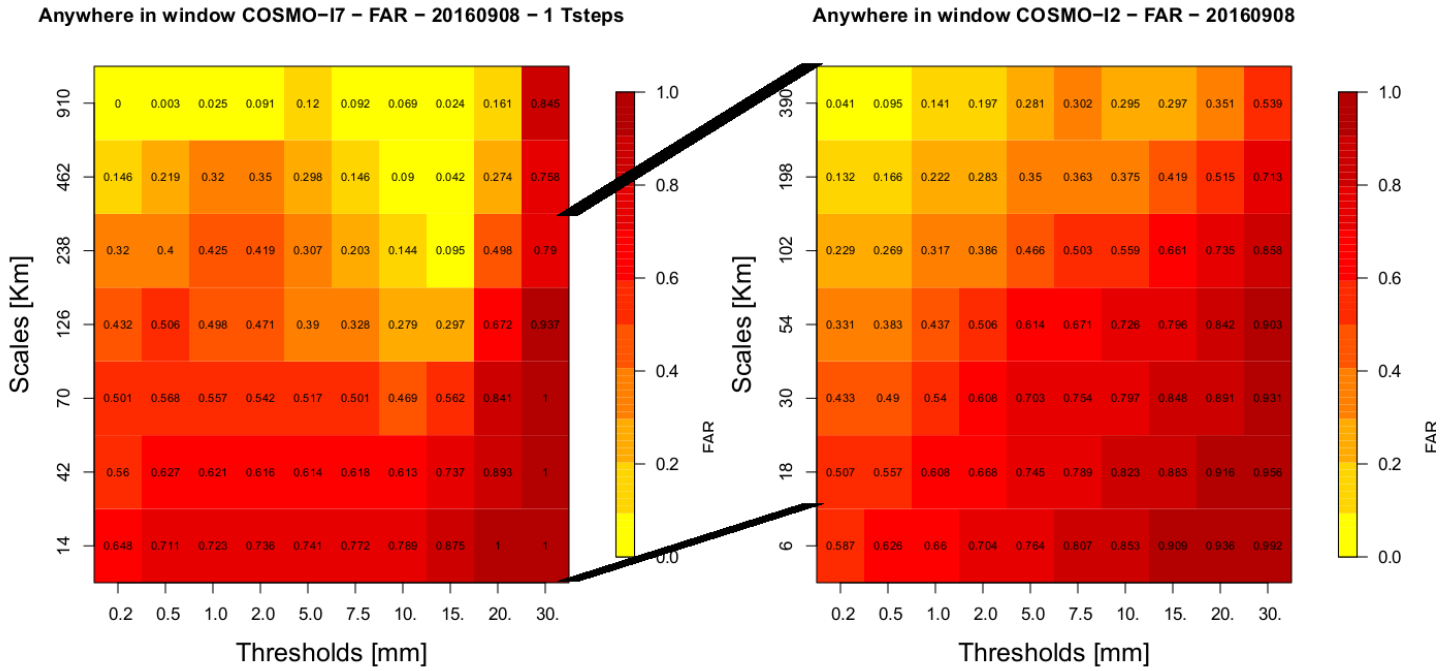

Anywhere in window COSMO−I7 − POD − 20160804 − 1 Tsteps
Scales [Km]
910 462 238 126 70 42 14
0.97 0.956 0.891 0.779 0.866 0.838 0.615 0.435 0.393 0.202
0.799 0.695 0.524 0.483 0.852 0.82 0.631 0.475 0.421 0.27
0.666 0.571 0.597 0.627 0.831 0.797 0.644 0.496 0.429 0.286
0.593 0.624 0.666 0.711 0.786 0.729 0.653 0.47 0.363 0.187
0.587 0.666 0.683 0.708 0.74 0.665 0.594 0.376 0.247 0.143
0.591 0.668 0.662 0.674 0.686 0.609 0.504 0.292 0.177 0.097
0.598 0.644 0.622 0.615 0.515 0.412 0.295 0.141 0.077 0.044
0.2 0.5 1.0 2.0 5.0 7.5 10. 15. 20. 30.
Thresholds [mm]
POD
1.0 0.8 0.6 0.4 0.2 0.0
Anywhere in window COSMO−I2 − POD − 20160804 − 1 Tsteps
Scales [Km]
364 184.8 95.2 50.4 28 16.8 5.6
0.274 0.264 0.266 0.282 0.323 0.509 0.528 0.533 0.577 0.51
0.223 0.255 0.32 0.386 0.445 0.563 0.591 0.611 0.556 0.439
0.229 0.3 0.407 0.47 0.492 0.564 0.573 0.569 0.438 0.263
0.268 0.365 0.448 0.489 0.504 0.533 0.515 0.434 0.293 0.131
0.308 0.405 0.461 0.49 0.482 0.463 0.42 0.295 0.185 0.062
0.343 0.428 0.465 0.478 0.441 0.395 0.347 0.221 0.125 0.034
0.382 0.437 0.447 0.427 0.362 0.31 0.257 0.124 0.057 0.007
0.2 0.5 1.0 2.0 5.0 7.5 10. 15. 20. 30.
Thresholds [mm]
POD
1.0 0.8 0.6 0.4 0.2 0.0

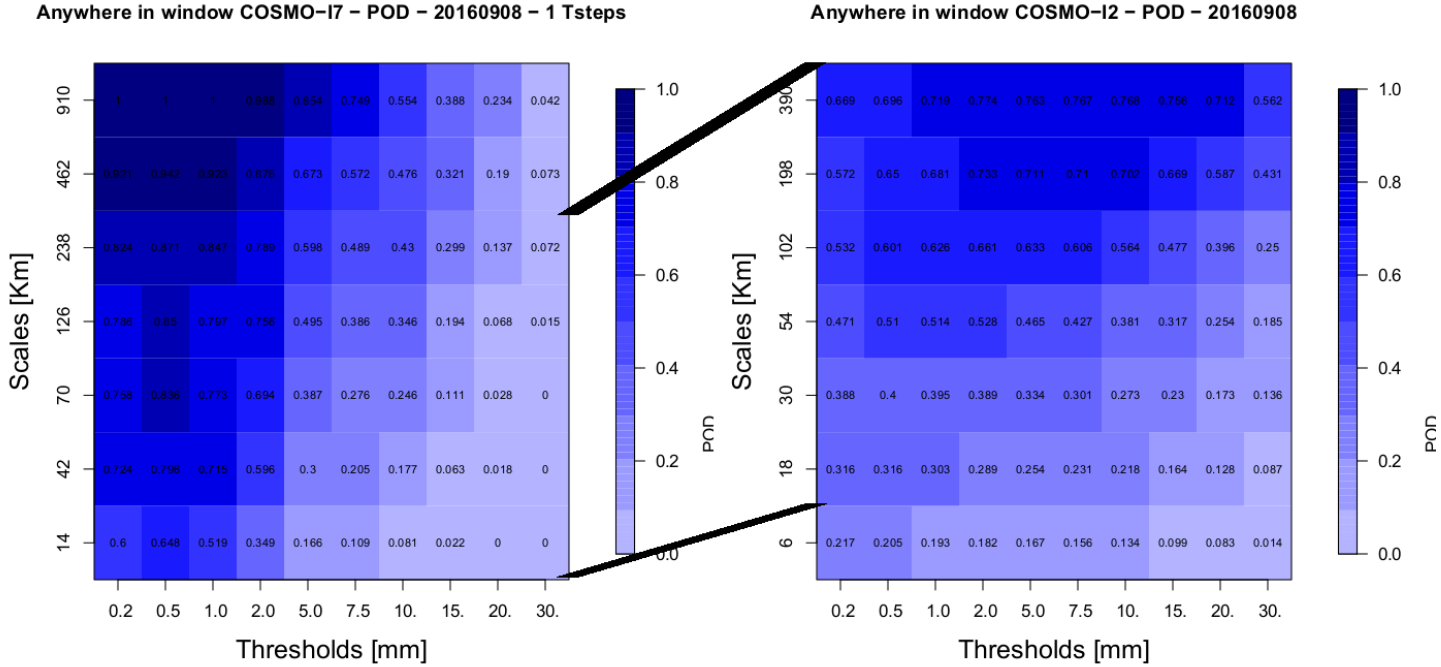

Anywhere in window COSMO−I7 − FAR − 20160820 − 1 Tsteps
Scales [Km]
910 462 238 126 70 42 14
0.06 0.157 0.215 0.15 0.086 0.081 0.162 0.122 0.131 0.149
0.302 0.409 0.398 0.267 0.111 0.092 0.166 0.141 0.191 0.285
0.426 0.465 0.376 0.257 0.171 0.189 0.308 0.333 0.439 0.607
0.452 0.441 0.375 0.355 0.376 0.472 0.569 0.638 0.728 0.806
0.464 0.462 0.46 0.489 0.593 0.695 0.758 0.832 0.892 0.898
0.478 0.503 0.537 0.596 0.739 0.82 0.868 0.91 0.941 0.937
0.534 0.596 0.658 0.765 0.901 0.936 0.963 0.975 0.988 1
0.2 0.5 1.0 2.0 5.0 7.5 10. 15. 20. 30.
Thresholds [mm]
1.0 0.8 0.6 0.4 0.2 0.0
FAR
Anywhere in window COSMO−I2 − FAR − 20160820
Scales [Km]
390 198 102 54 30 18 6
0.072 0.028 0.058 0.09 0.113 0.15 0.185 0.227 0.297 0.646
0.067 0.074 0.099 0.142 0.207 0.276 0.334 0.456 0.58 0.881
0.11 0.169 0.225 0.316 0.454 0.554 0.632 0.739 0.816 0.952
0.221 0.312 0.4 0.512 0.676 0.766 0.816 0.895 0.936 0.991
0.331 0.435 0.536 0.658 0.809 0.884 0.915 0.954 0.979 1
0.412 0.519 0.629 0.748 0.886 0.937 0.955 0.978 0.997 1
0.524 0.639 0.747 0.854 0.955 0.977 0.985 0.996 1 1
0.2 0.5 1.0 2.0 5.0 7.5 10. 15. 20. 30.
Thresholds [mm]
1.0 0.8 0.6 0.4 0.2 0.0
FAR


Anywhere in window COSMO−I7 − POD − 20160820 − 1 Tsteps
Scales [Km]
910 462 238 126 70 42 14
0.962 0.97 0.954 0.917 0.934 0.888 0.899 0.836 0.826 0.792
0.779 0.835 0.79 0.78 0.837 0.783 0.763 0.698 0.681 0.616
0.711 0.799 0.771 0.763 0.75 0.67 0.64 0.572 0.522 0.442
0.722 0.808 0.746 0.702 0.617 0.489 0.432 0.357 0.304 0.255
0.728 0.776 0.684 0.625 0.465 0.325 0.275 0.199 0.148 0.144
0.692 0.713 0.613 0.536 0.332 0.22 0.177 0.125 0.093 0.091
0.558 0.542 0.455 0.32 0.146 0.104 0.063 0.046 0.022 0
0.2 0.5 1.0 2.0 5.0 7.5 10. 15. 20. 30.
Thresholds [mm]
1.0 0.8 0.6 0.4 0.2 0.0
POD
Anywhere in window COSMO−I2 − POD − 20160820
Scales [Km]
390 198 102 54 30 18 6
0.452 0.487 0.574 0.744 0.716 0.719 0.711 0.623 0.576 0.269
0.483 0.526 0.603 0.697 0.657 0.614 0.592 0.502 0.394 0.117
0.529 0.553 0.589 0.593 0.517 0.437 0.374 0.289 0.205 0.057
0.547 0.536 0.518 0.467 0.353 0.273 0.221 0.143 0.084 0.01
0.529 0.486 0.433 0.353 0.235 0.155 0.12 0.071 0.028 0
0.495 0.436 0.361 0.271 0.152 0.094 0.071 0.036 0.004 0
0.421 0.339 0.254 0.165 0.069 0.04 0.027 0.006 0 0
0.2 0.5 1.0 2.0 5.0 7.5 10. 15. 20. 30.
Thresholds [mm]
1.0 0.8 0.6 0.4 0.2 0.0
POD


Anywhere in window COSMO−I7 − FAR − 20160829 − 1 Tsteps
Anywhere in window COSMO−I2 − FAR − 20160829
Scales [Km]
Thresholds [mm]
FAR
0.2 0.5 1.0 2.0 5.0 7.5 10. 15. 20. 30.
910 462 238 126 70 42 14
390 198 102 54 30 18 6
0.006 0.011 0.029 0.246 0.459 0.382 0.388 0.009 0.024
0.129 0.12 0.187 0.302 0.357 0.346 0.336 0.15 0.241
0.266 0.204 0.228 0.274 0.322 0.342 0.352 0.341 0.575
0.322 0.284 0.295 0.377 0.448 0.482 0.522 0.568 0.846
0.372 0.38 0.416 0.508 0.589 0.664 0.723 0.812 0.976
0.431 0.466 0.527 0.608 0.717 0.789 0.878 0.956 1
0.541 0.605 0.675 0.743 0.845 0.91 0.974 1 1
0.048 0.069 0.14 0.211 0.32 0.305 0.243 0.303 0.335 0.296
0.088 0.154 0.217 0.229 0.309 0.281 0.306 0.381 0.447 0.447
0.208 0.261 0.307 0.334 0.392 0.385 0.436 0.509 0.572 0.631
0.291 0.332 0.373 0.414 0.481 0.5 0.566 0.63 0.675 0.719
0.33 0.373 0.419 0.468 0.573 0.607 0.665 0.708 0.743 0.794
0.352 0.404 0.456 0.518 0.648 0.676 0.727 0.757 0.786 0.843
0.399 0.462 0.528 0.615 0.733 0.767 0.791 0.821 0.864 0.938
0.0 0.2 0.4 0.6 0.8 1.0


Anywhere in window COSMO−I7 − POD − 20160829 − 1 Tsteps
Anywhere in window COSMO−I2 − POD − 20160829
Scales [Km]
Thresholds [mm]
POD
0.2 0.5 1.0 2.0 5.0 7.5 10. 15. 20. 30.
910 462 238 126 70 42 14
390 198 102 54 30 18 6
0.897 0.849 0.828 0.853 0.927 0.896 0.88 0.848 0.564 0
0.563 0.591 0.571 0.634 0.808 0.715 0.678 0.544 0.298 0
0.526 0.596 0.611 0.686 0.714 0.561 0.511 0.328 0.112 0
0.57 0.633 0.648 0.659 0.521 0.393 0.31 0.163 0.025 0
0.599 0.618 0.596 0.536 0.343 0.228 0.144 0.048 0.002 0
0.591 0.568 0.502 0.407 0.216 0.125 0.05 0.008 0 0
0.485 0.408 0.309 0.224 0.091 0.034 0.005 0 0 0
0.42 0.462 0.576 0.602 0.699 0.723 0.895 0.886 0.873 0.741
0.439 0.496 0.607 0.662 0.759 0.753 0.785 0.713 0.663 0.587
0.479 0.53 0.613 0.66 0.707 0.651 0.632 0.561 0.48 0.369
0.482 0.527 0.588 0.628 0.615 0.556 0.486 0.413 0.338 0.265
0.477 0.517 0.563 0.575 0.494 0.437 0.373 0.313 0.251 0.196
0.466 0.495 0.521 0.508 0.389 0.344 0.299 0.247 0.203 0.153
0.424 0.428 0.417 0.366 0.253 0.214 0.194 0.155 0.121 0.059
0.0 0.2 0.4 0.6 0.8 1.0


Anywhere in window COSMO−I7 − FAR − 20160908 − 1 Tsteps
Anywhere in window COSMO−I2 − FAR − 20160908
Scales [Km]
Thresholds [mm]
FAR
910 462 238 126 70 42 14
390 198 102 54 30 18 6
0.2 0.5 1.0 2.0 5.0 7.5 10. 15. 20. 30.
0.0 0.2 0.4 0.6 0.8 1.0


Anywhere in window COSMO−I7 − POD − 20160908 − 1 Tsteps
Anywhere in window COSMO−I2 − POD − 20160908
Scales [Km]
Thresholds [mm]
POD
910 462 238 126 70 42 14
390 198 102 54 30 18 6
0.2 0.5 1.0 2.0 5.0 7.5 10. 15. 20. 30.
0.0 0.2 0.4 0.6 0.8 1.0