Conditional and Weather-Defined Verification:

Tools to analyze COSMO model performance

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with members of COSMO

WG on Verification and Case Studies

34th EWGLAM and 19th SRNWP Meeting, Helsinki, 8-11 October 2012

Outline

- Goal of Common Verification activities
- Conditional Verification (CV)
- Weather Dependant Verification (WDV)

Both tools are included in VERSUS Official verification software in COSMO consortium

Goal of Verification activities

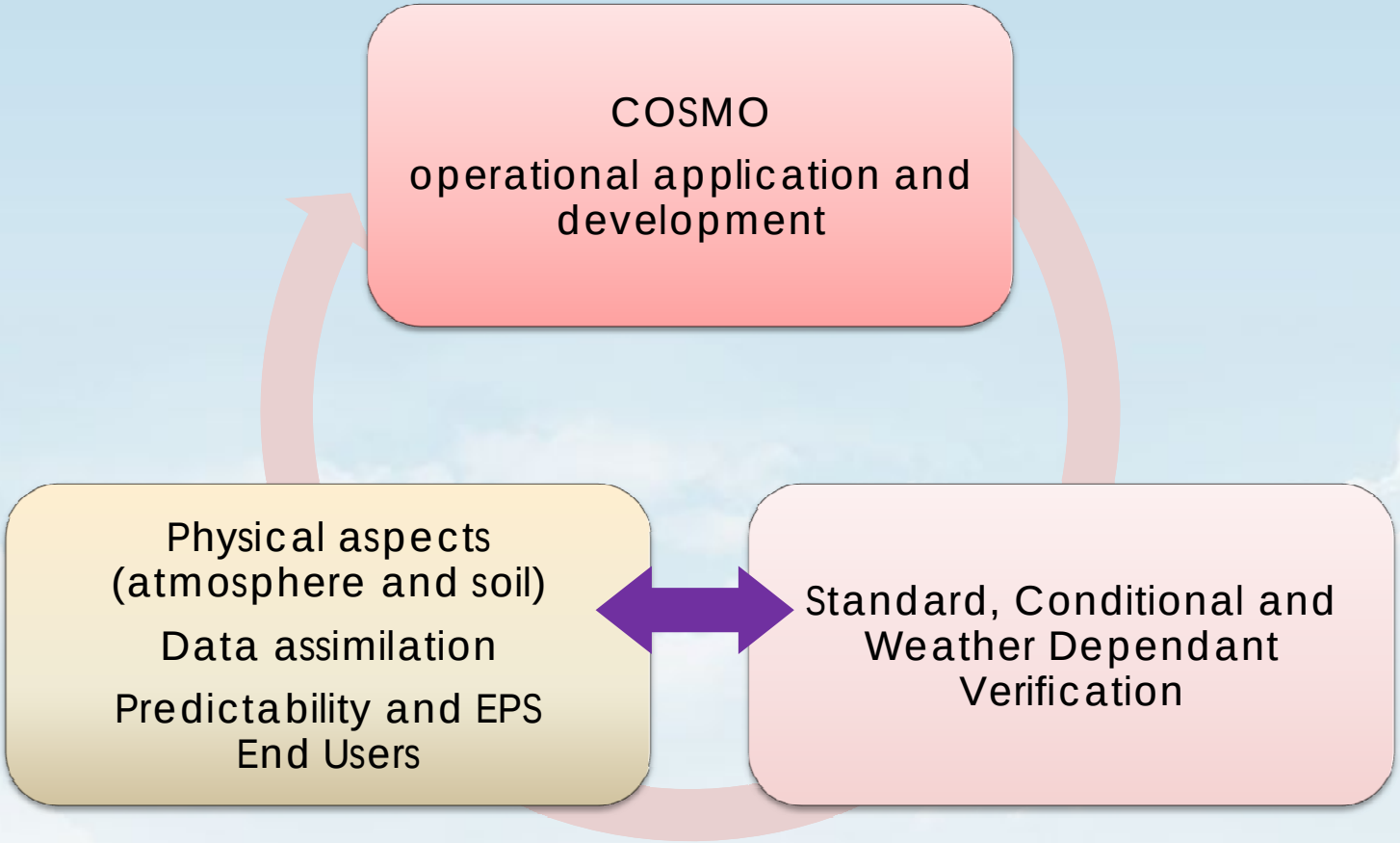
- to generally assess COSMO model performance and trends
- give feedback to modelers:
  - ✓Contribute to COSMO model development
  - ✓Improve the understanding of forecast errors
  - ✓Identify possible sources of errors in COSMO
- give hints for a better understanding of COSMO model to the users (e.g. Forecasters in the daily operational activity) and contribute to guidelines on how to use COSMO forecasts

AND

to receive requirements by modelers and users for specialized verification needs and keep

the following loop alive

Feedback loop within COSMO



Conditional Verification

- **Working package for all COSMO countries**
- **Setup of common CV tests, e.g. conditions on 2mT verification mandatory for all countries**
- **Discussion on the results during Verification workshops and annual General Meeting**
- **Quarterly report on COSMO Website with common standard and CV scores by all countries**

http://www.cosmo-model.org/content/tasks/verification.priv/common/default.htm

CONSORTIUM FOR SMALL SCALE MODELING

COSMO

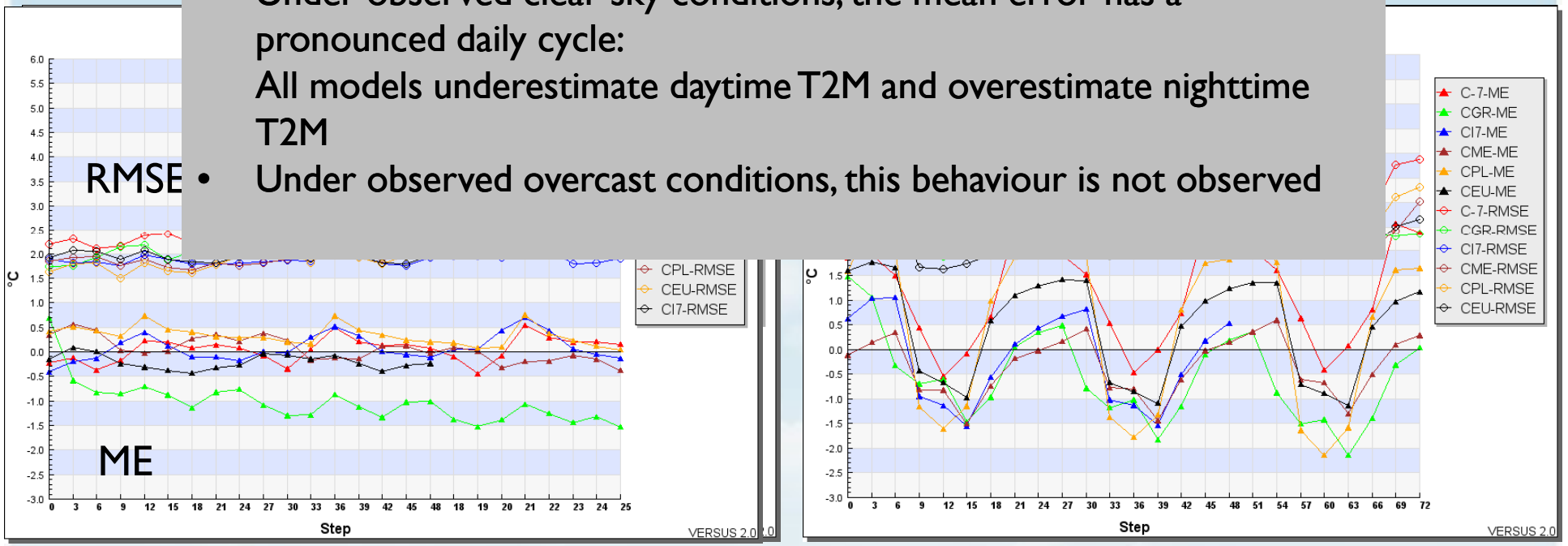
List of Conditional Verification tests as was proposed by Model Developers

Conditions imposed both in fcst and obs space

2m Temperature	
1st condition: 2nd condition:	Total cloud cover >= 75% (overcast condition) a. THICK using TQC (Total column cloud water) b. THIN using TQC - Reference value TQC<5 g/m2
1st condition: 2nd condition:	Total cloud cover <= 25% (clear sky condition) a. THICK using TQC - Reference value TQC>5 g/m2 b. THIN using TQC - Reference value TQC<5 g/m2
1st condition:	2m Temp for various thresholds 2mT with wind in selected stations 2mT with snow cover 2mT/Td with soil moisture
1st condition: 2nd condition:	Total cloud cover <= 25% (overcast condition) Wind speed <= 2,5 m/s
Precipitation	
1st condition:	Convective precipitation (unstable atmosphere) Reference value of CAPE 50 J/Kg Precipitation for various weather classes Check pressure tendency availability
1st condition:	Large scale precipitation (LSP) using non convective CAPE values
Cloud cover with stability index	
Wind Speed	
WS with roughness length	
Wind gust	
1st condition:	Convective (unstable atmosphere) Wind gust for convective precipitation cases
1st condition:	non convective atmosphere, using non convective CAPE

Common conditional verification results

- Cloud cover clearly stratifies the COSMO forecast error of T2M (no matter which diagnostic)
- Under observed clear sky conditions, the mean error has a pronounced daily cycle:
  All models underestimate daytime T2M and overestimate nighttime T2M
- Under observed overcast conditions, this behaviour is not observed



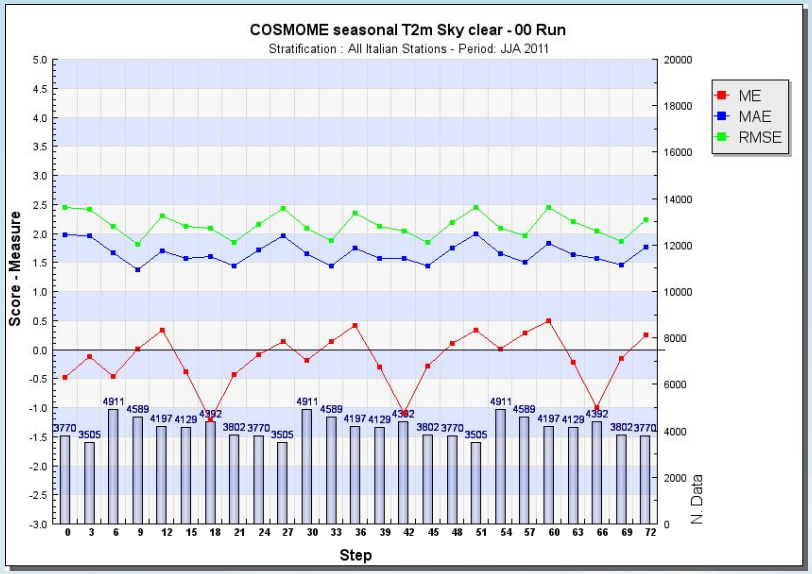
Autumn 2011, ME and RMSE for many COSMO model configurations

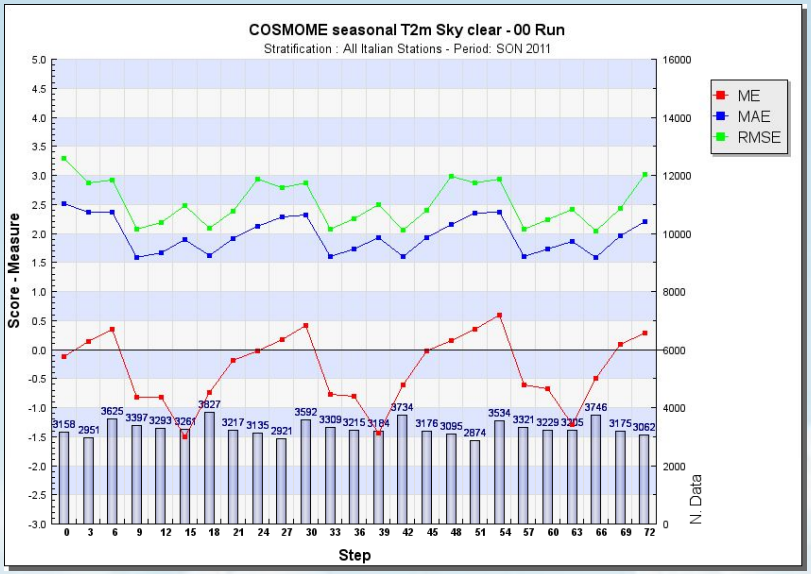
Searching for clues…

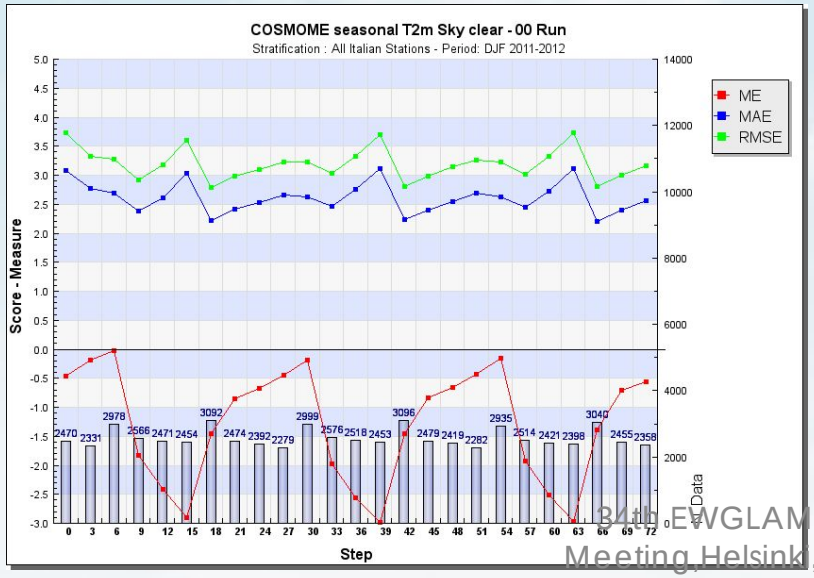
- Additional stratification to look at cases with stable boundary layer → distinguish between dynamical and radiation dominated processes

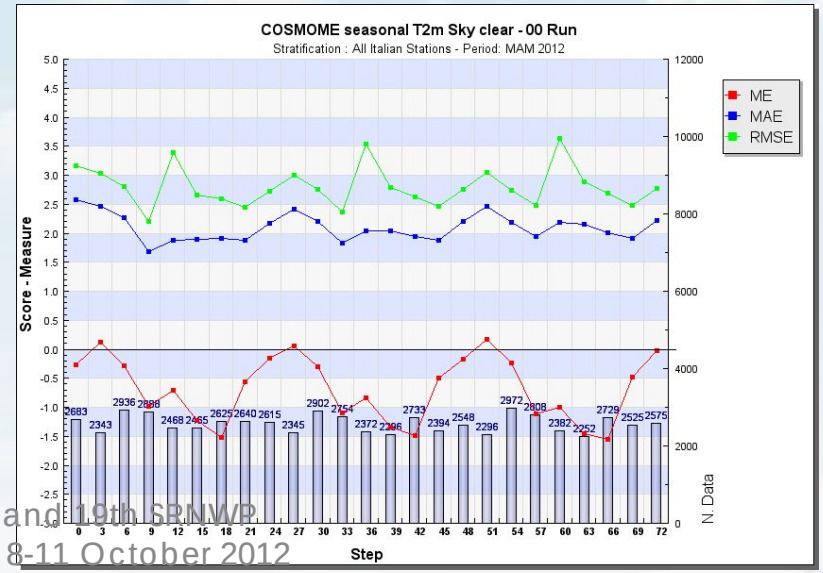
COSMO-ME Conditional Verification

T2m when observed TCC ≤ 25%



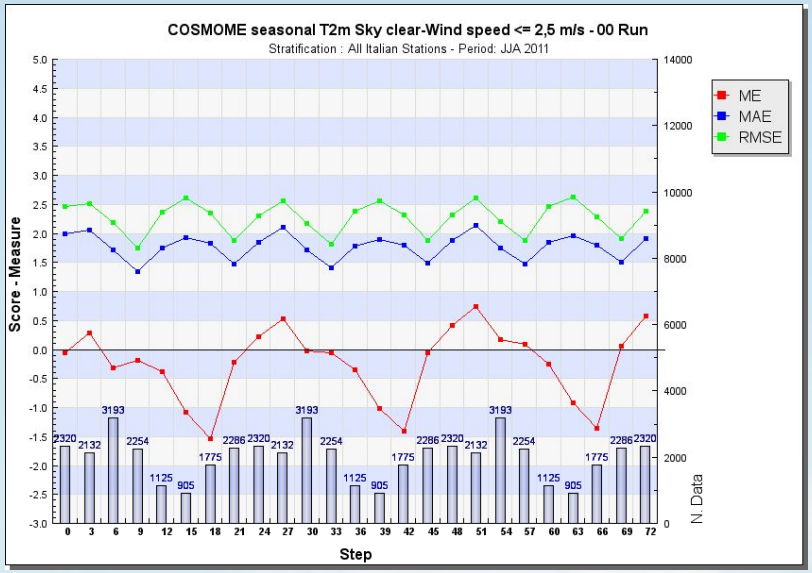


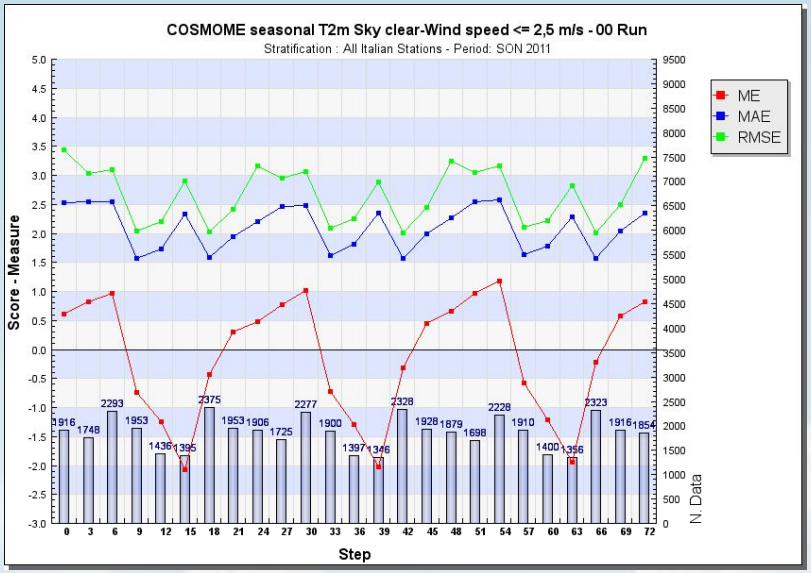


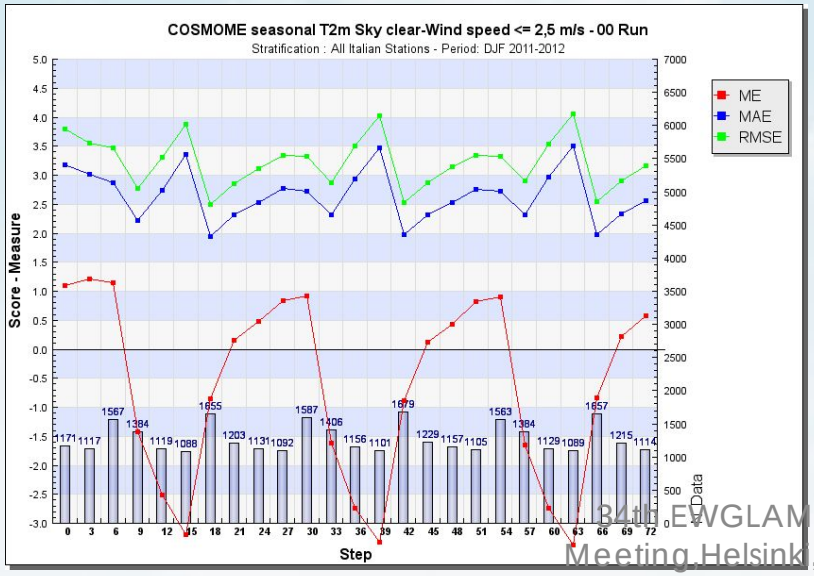


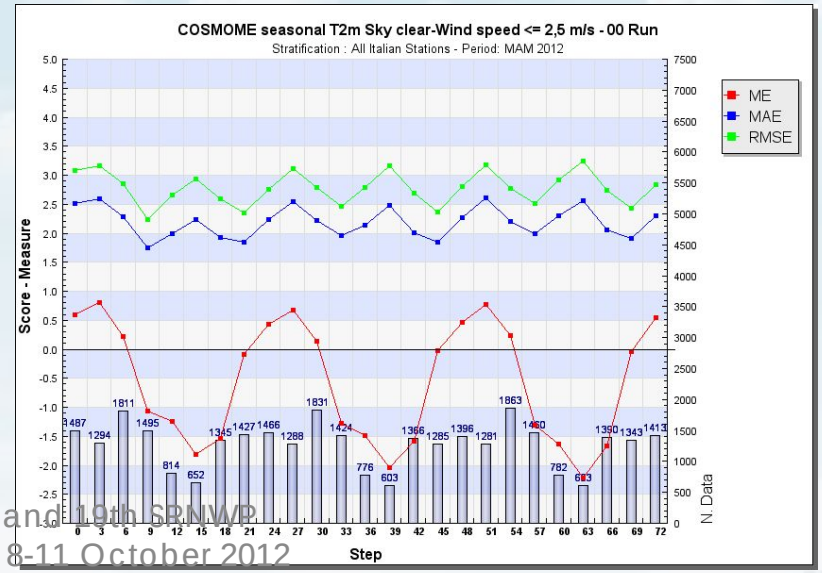
COSMO-ME Conditional Verification

T2m when observed TCC ≤ 25% & wind speed ≤ 2 m/s



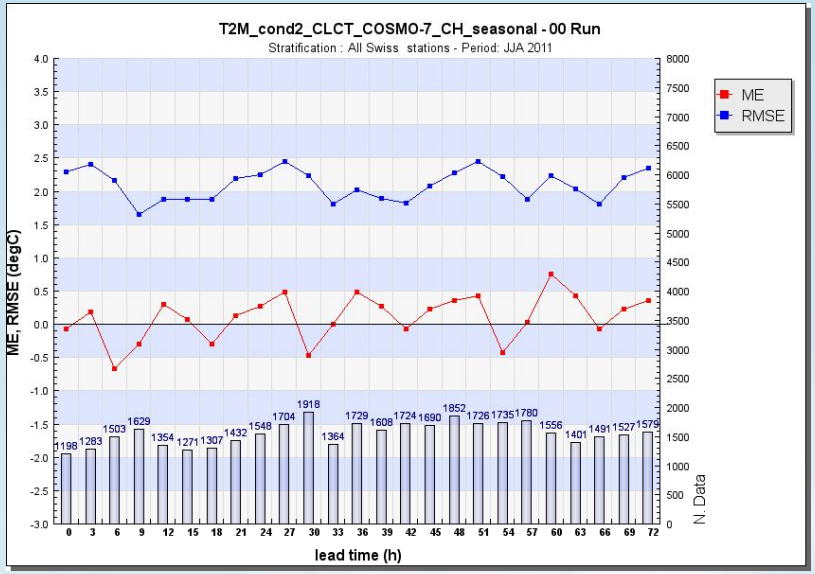


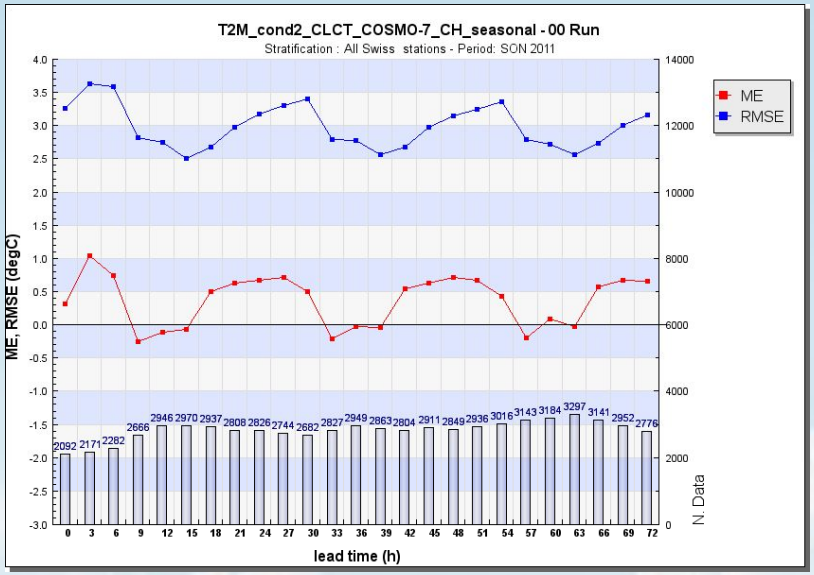


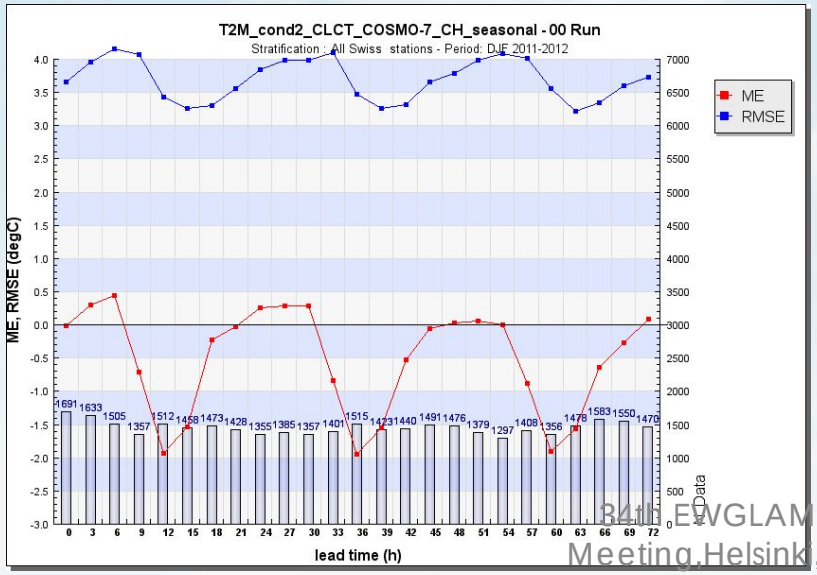


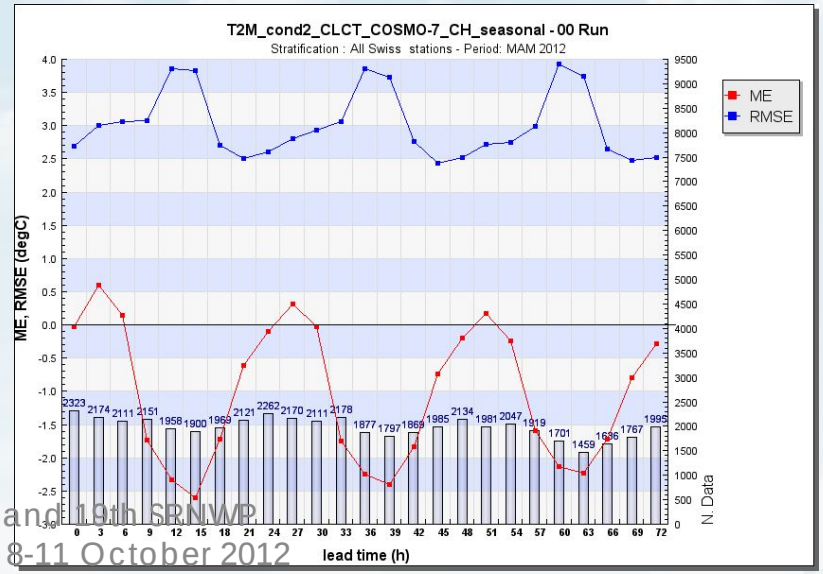
COSMO-7 Conditional Verification

T2m when forecast TCC ≤ 25%



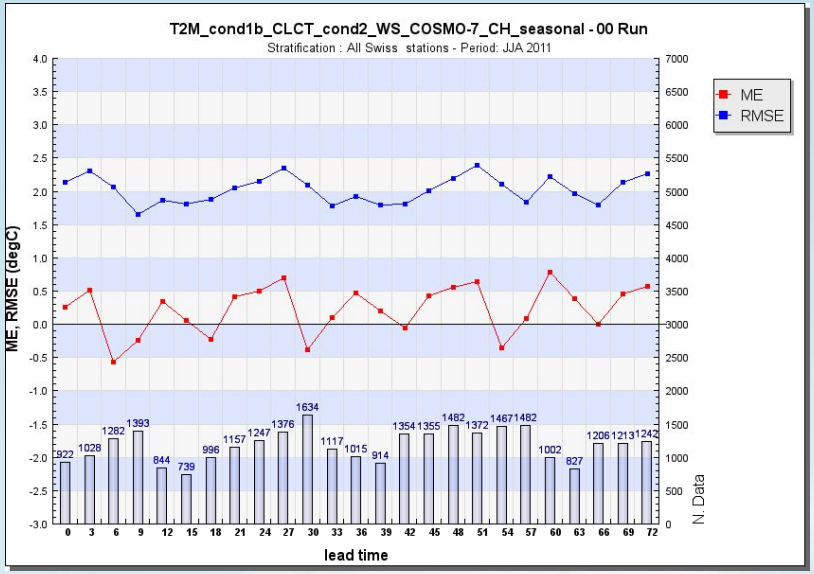


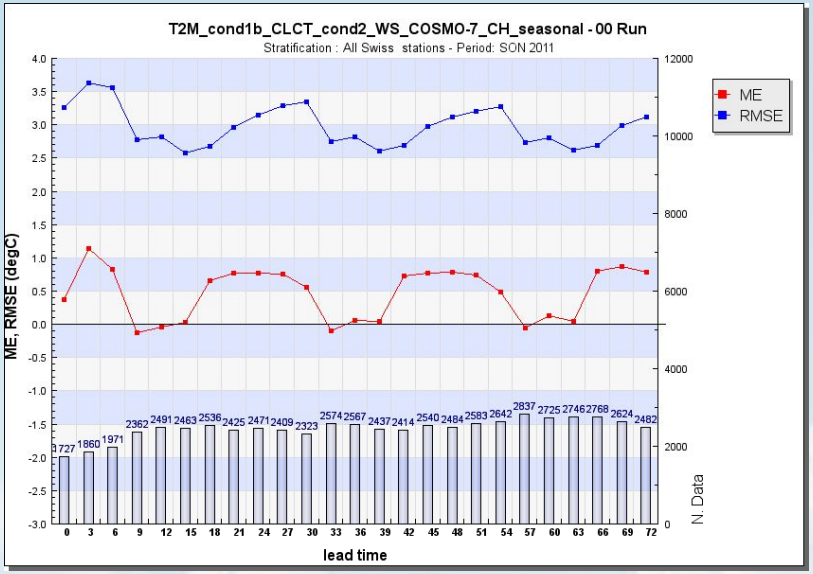


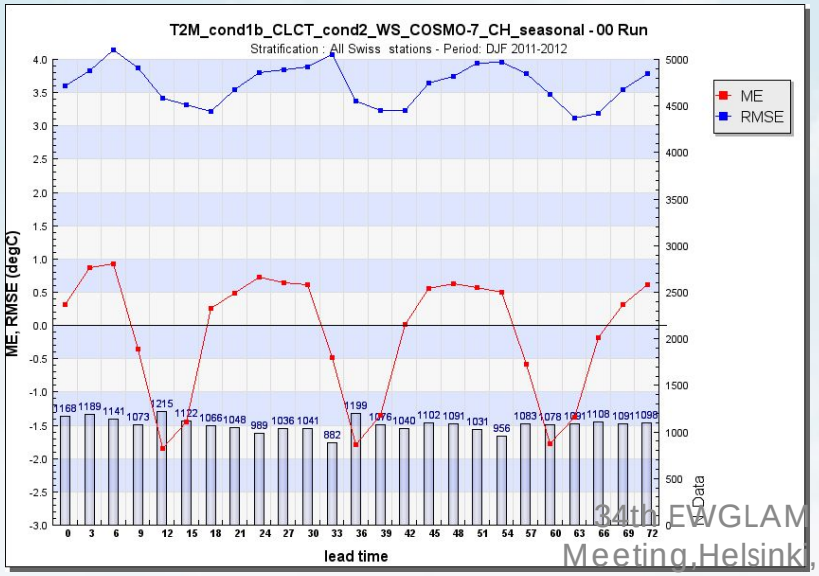


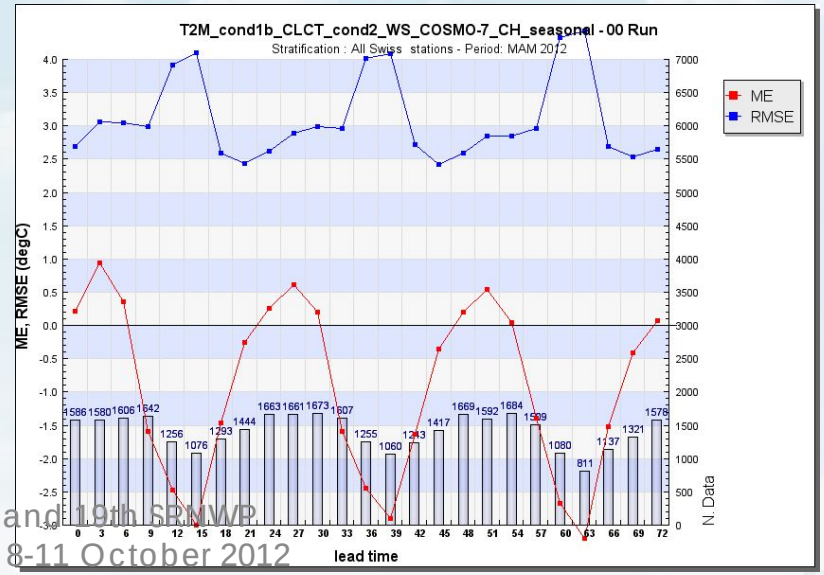
COSMO-7 Conditional Verification

T2m when <u>forecast</u> TCC ≤ 25% & wind speed ≤ 2.5 m/s

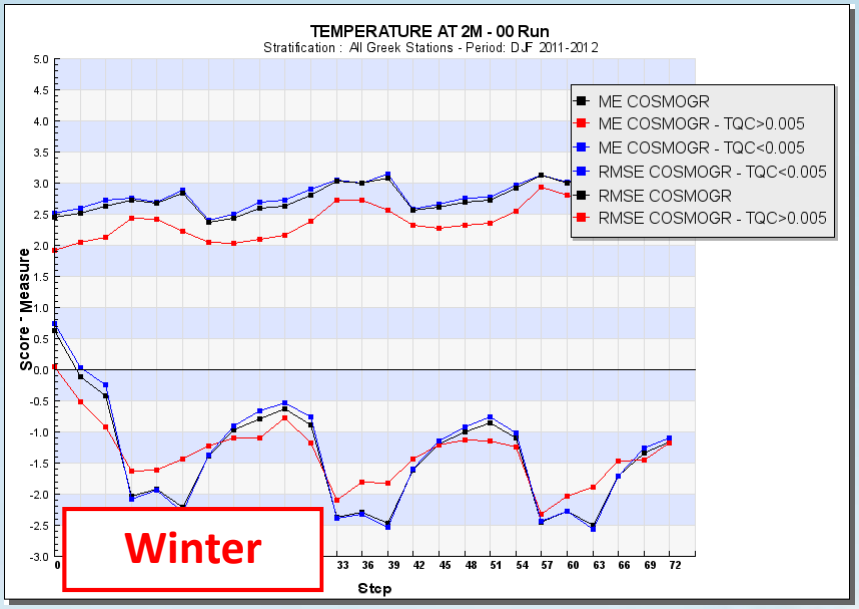




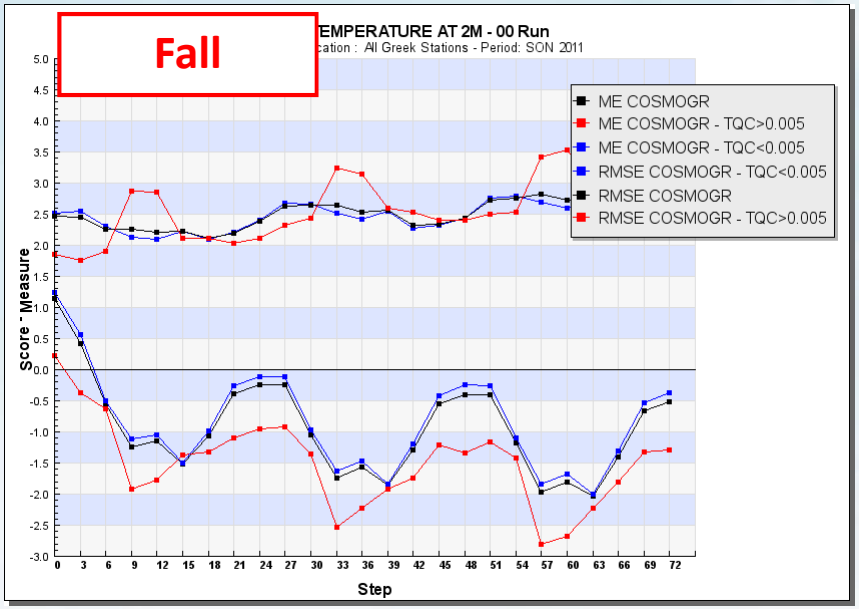


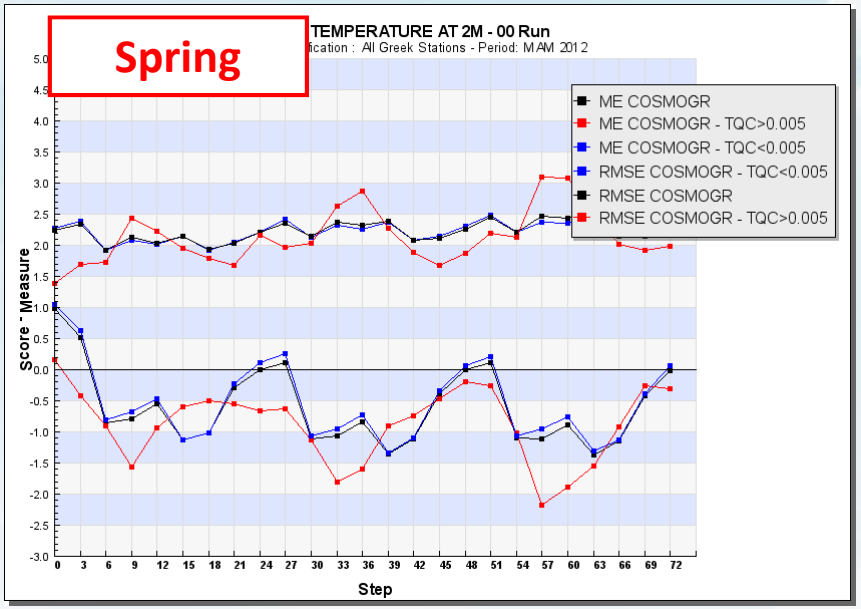


2mT vs 2mT under variable TQC (cond on fct space)



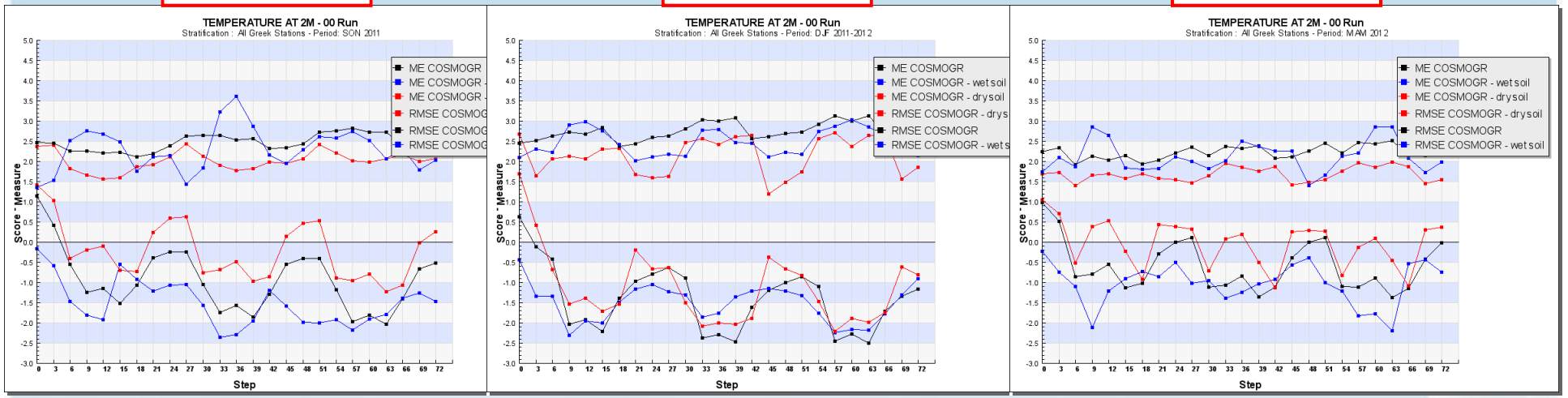
Similar effect with cloudiness, higher TQC values match with better performance in 2mT predictions



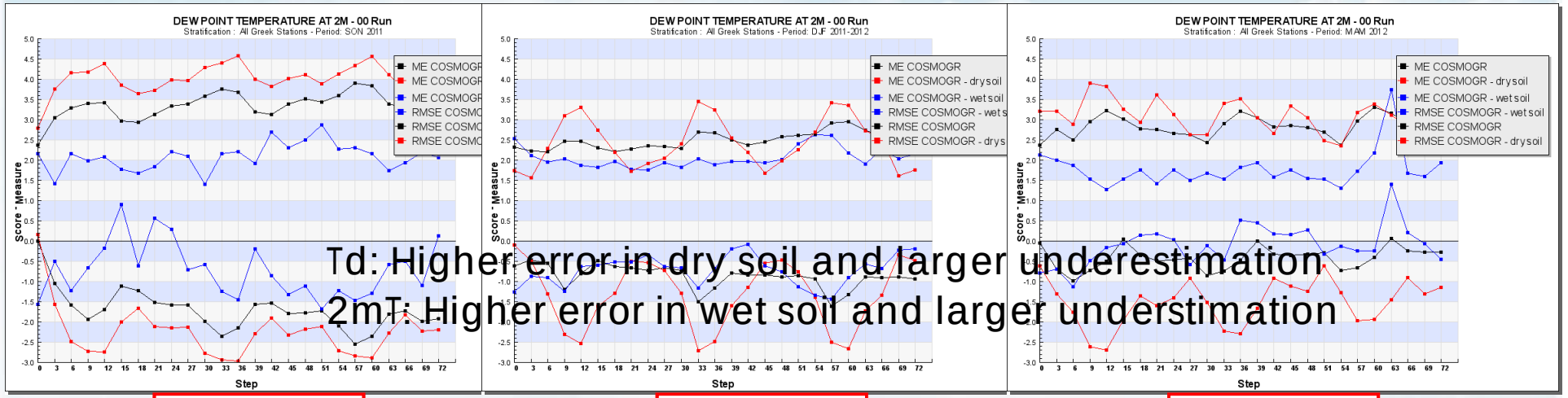


DewP T, 2mT with dry or wet soil conditions

Fall | **Winter** | **Spring**



W_SO Water content of first soil layer(kg/m2) **1cm.**



Td: Higher error in dry soil and larger underestimation

2mT: Higher error in wet soil and larger understimation

Fall | **Winter** | **Spring**

Searching for clues…

- Additional stratification to look at cases with stable boundary layer → distinguish between dynamical and radiation dominated processes

  → in Clear Sky calm wind conditions, the **underestimation of the daily temperature amplitude** is even more pronounced→ overestimated thermal mixing (minimal diffusion coefficient?)

  Nighttime overestimation from insufficient radiative cooling? Thermal conductivity of the soil?

  Daytime underestimation from underestimated sensible heat flux? Impact of soil moisture?

Weather type Dependent Verification

- Working package for all COSMO countries
- Subjective or objective classification can be used
- Aimed to give indication whether the Model has a "favourite" weather type through the exploitation of statistical scores
- Usefulness as guidelines to forecasters

Examples from Italian subjective classification and verification results

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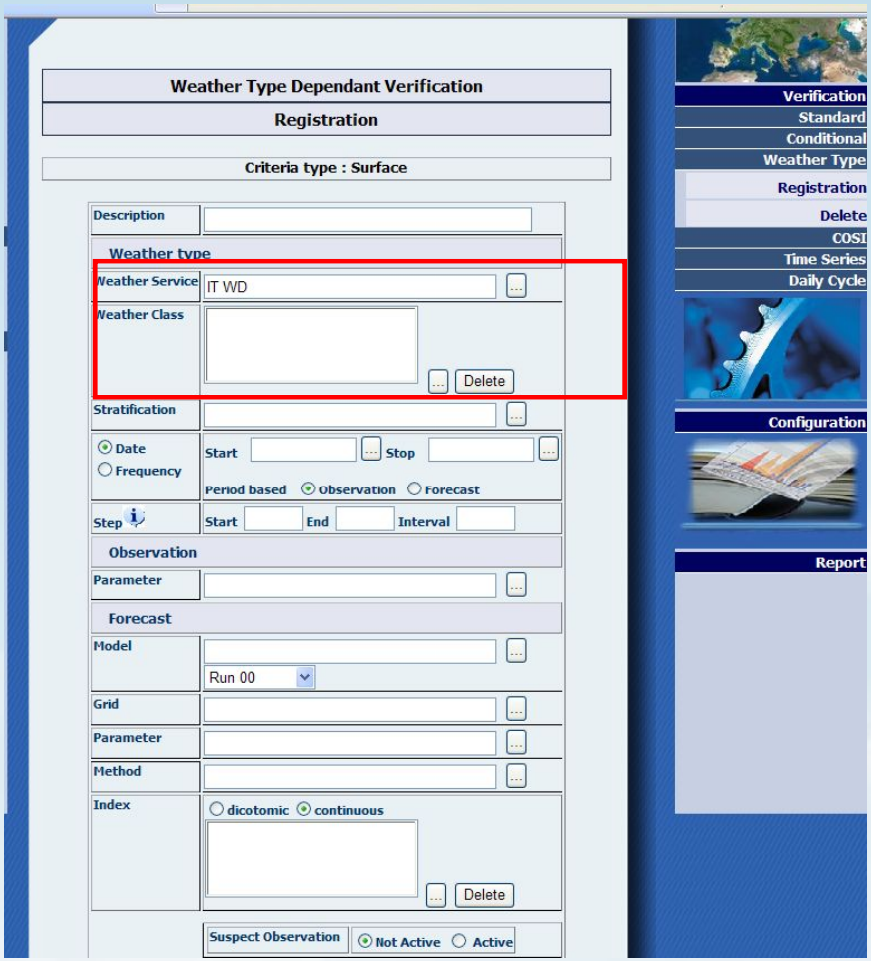
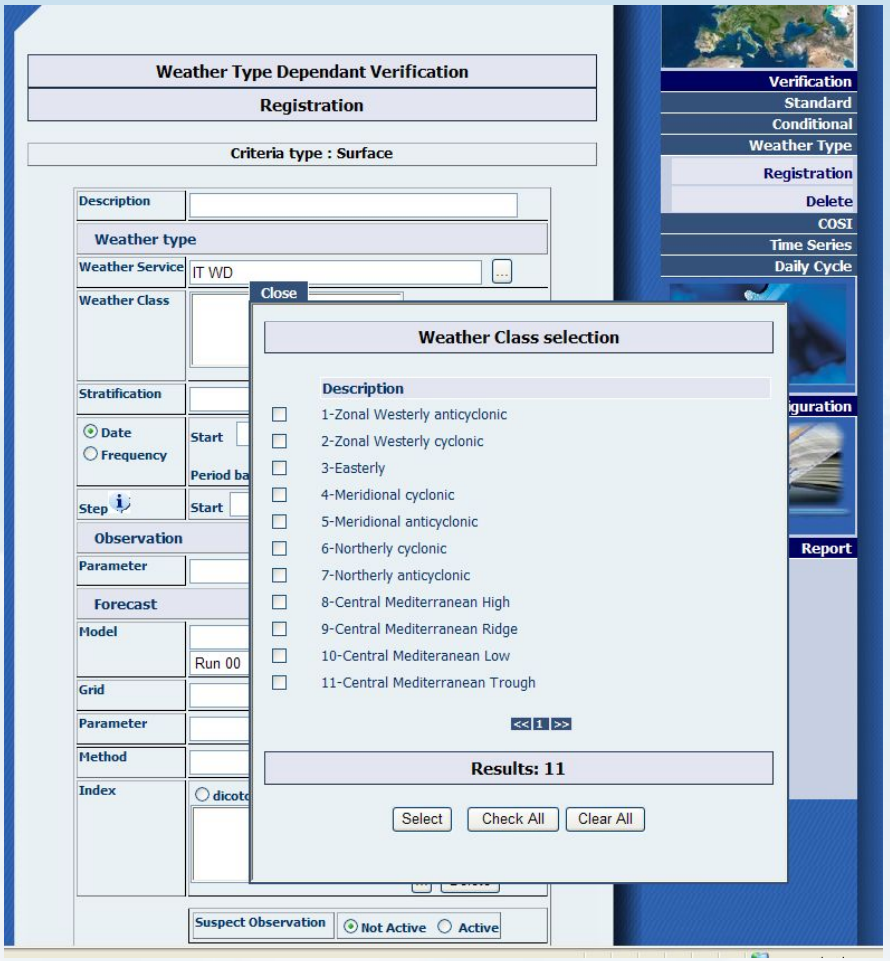
WDV – Registration





Subjective Classification at CNMCA

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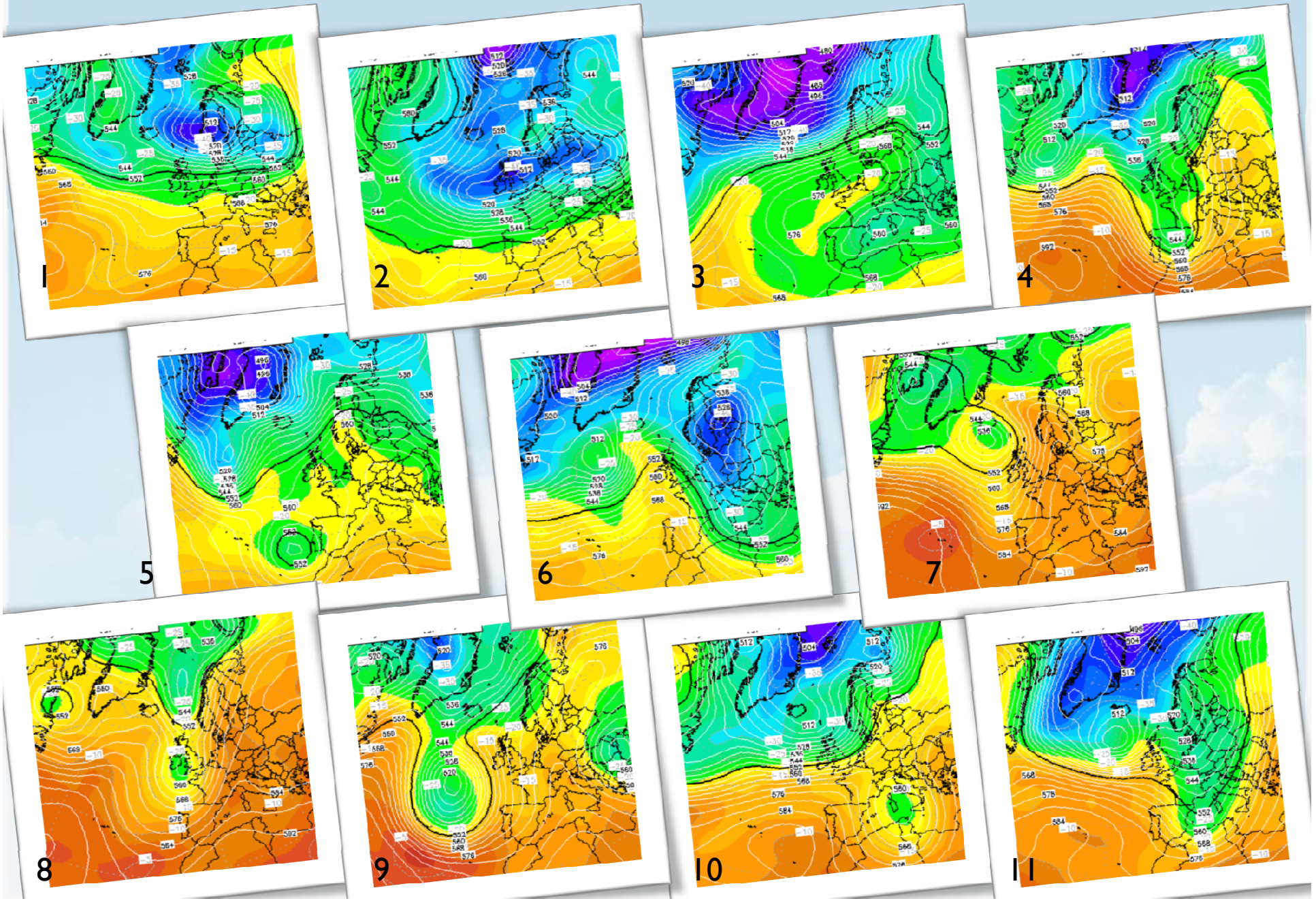
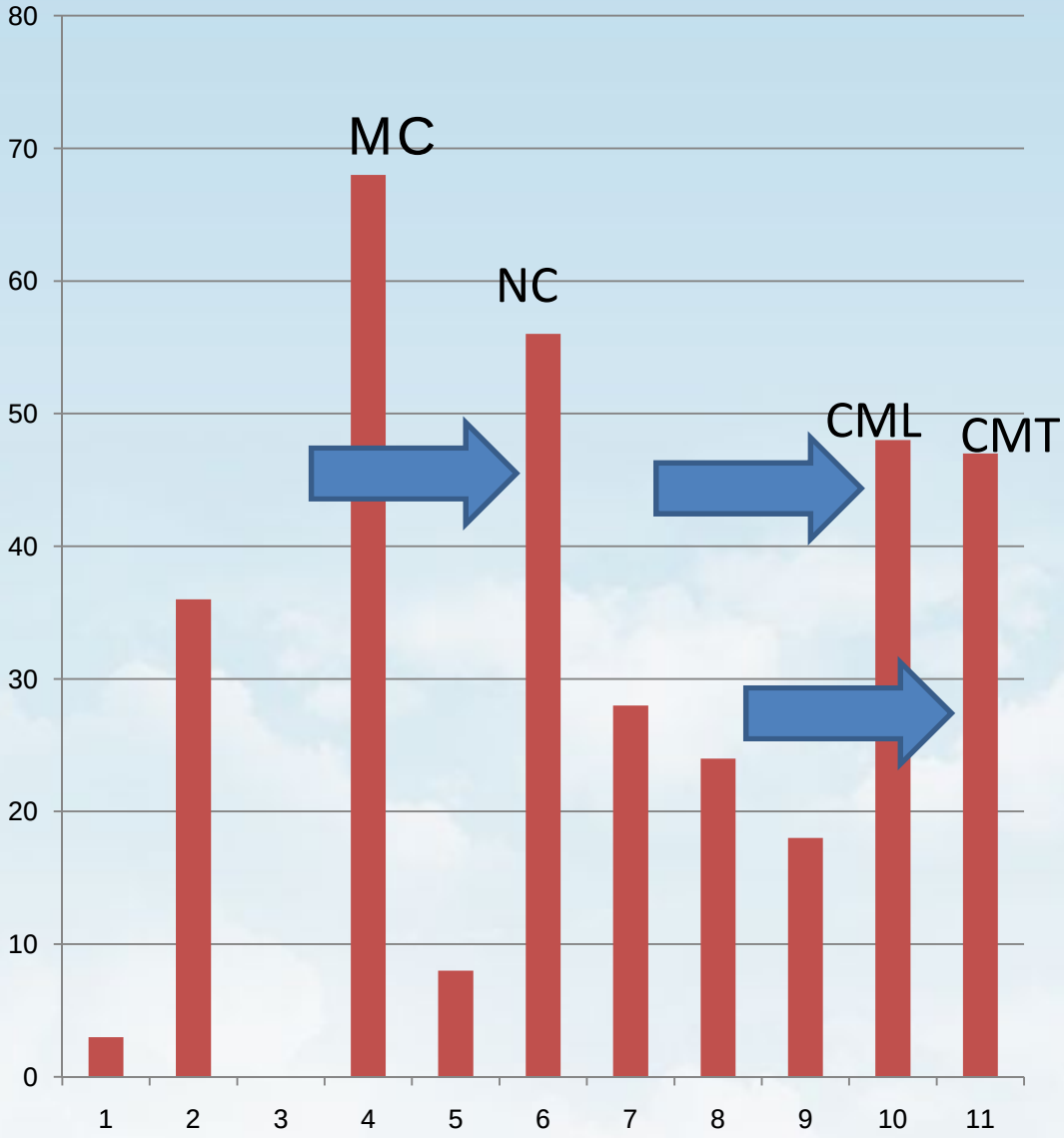


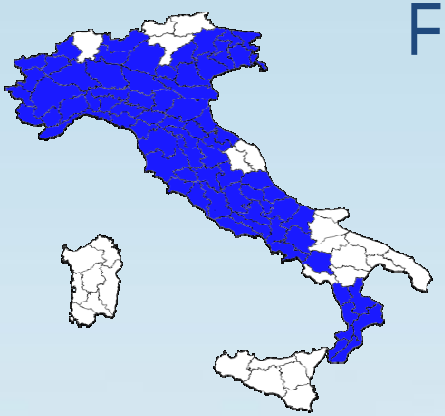
Subjective Classification at CNMCA



1 Zonal Westerly anticyclonic
2 Zonal Westerly cyclonic
3 Easterly
4 Meridional cyclonic
5 Meridional anticyclonic
6 Northerly cyclonic
7 Northerly anticyclonic
8 Central Mediterranean High
9 Central Mediterrananean
10 Central Mediterranean Low
11 Central

From 1st March 2010
To 28th February 2011

COSMO-MED,COSMO-I7,COSMO-I2,ECMWF against high resolution raingauges - Total Precipitation (24h)



For each weather type category:

	Day 1	Day 2	...	Day n
Area 1				
Area 2				
...				
Area 96				

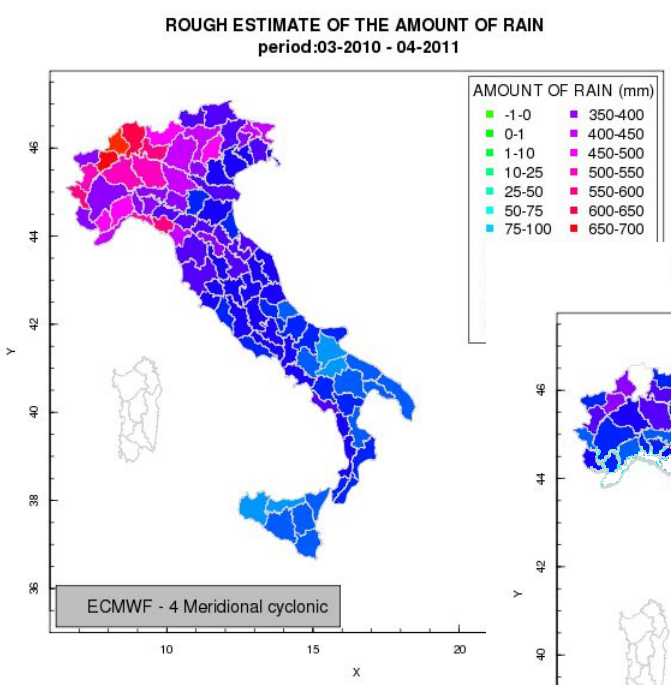
Σ

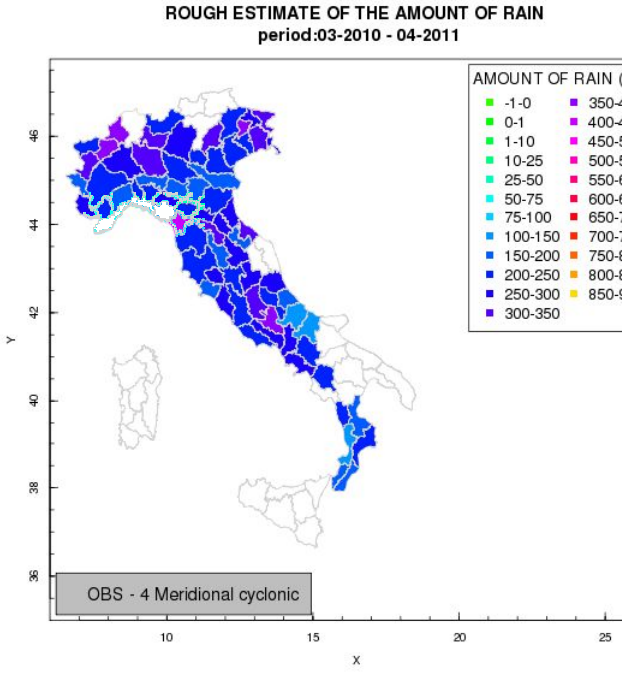
Daily scores

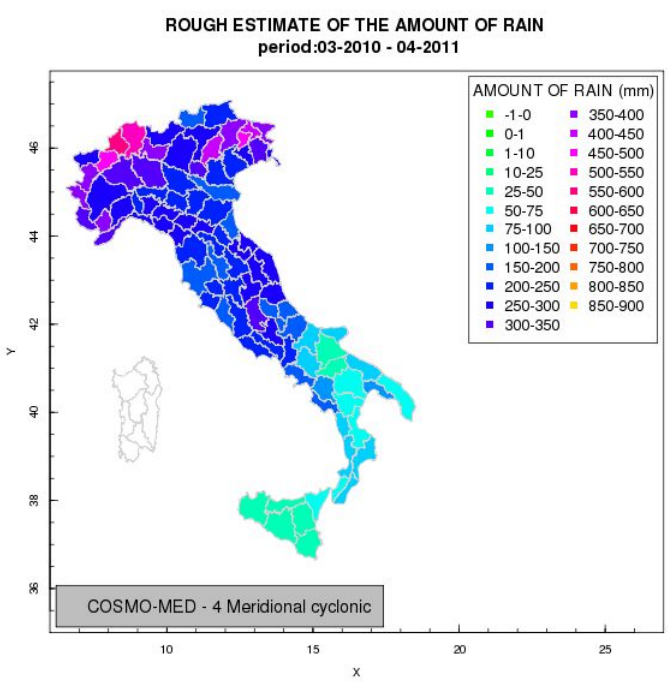
Scores for the selected category

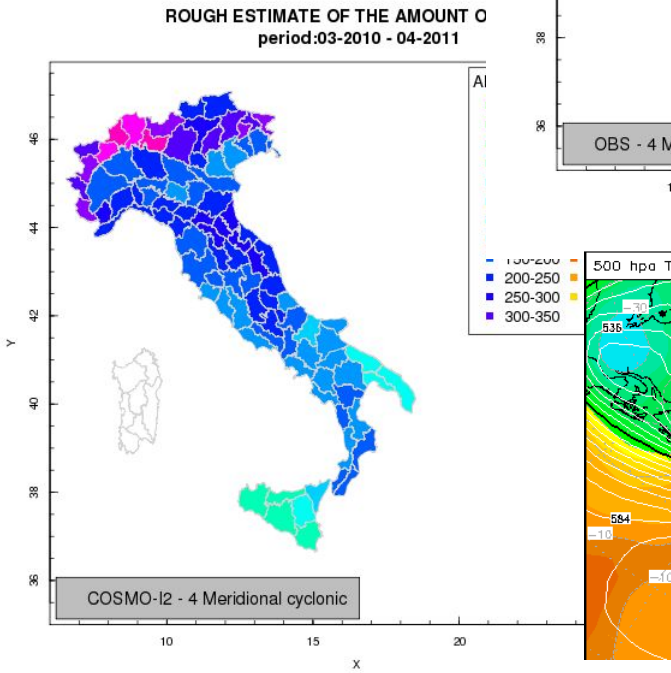
Mean / Median value of precipitation

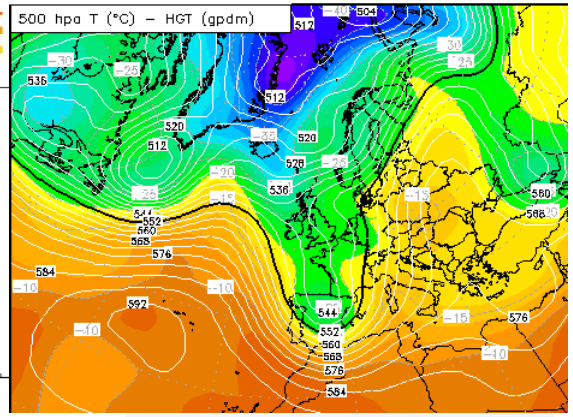
4-Meridional cyclonic

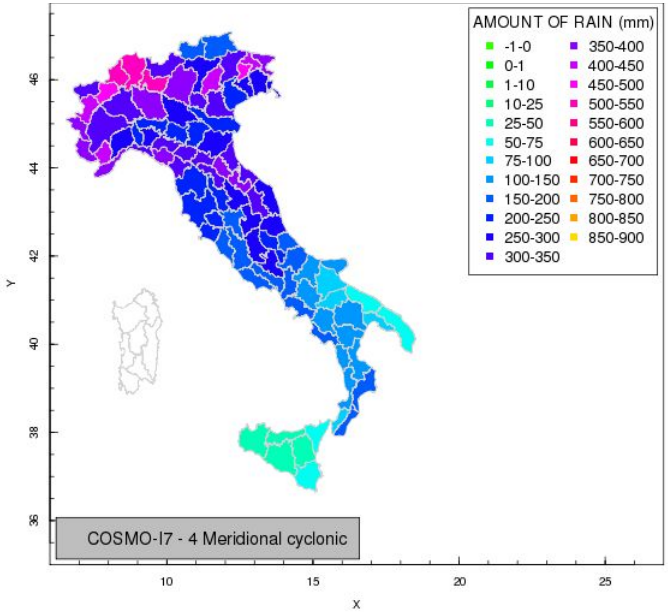




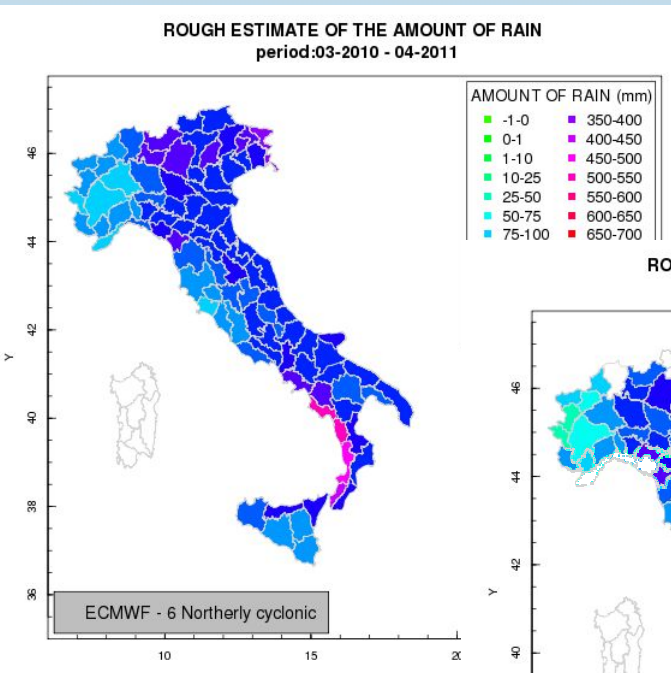


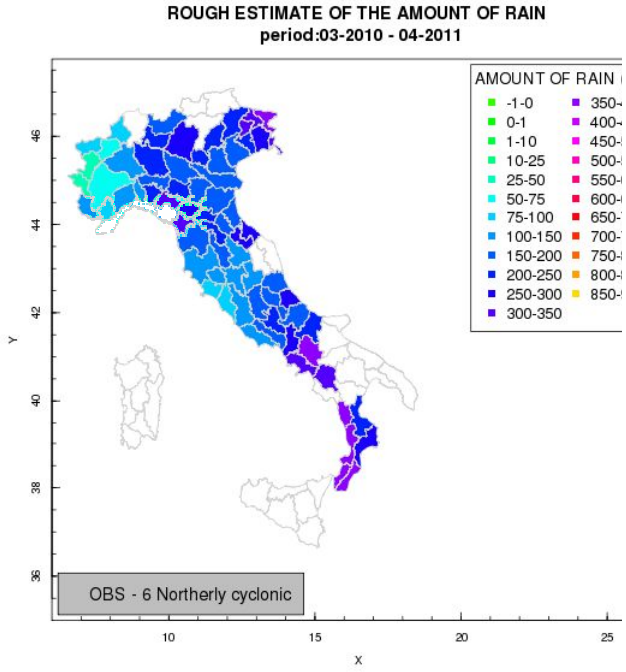


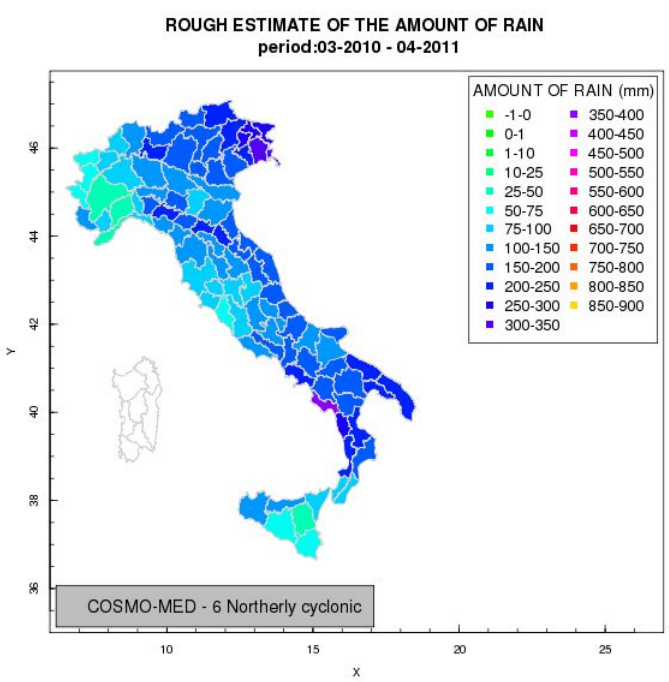


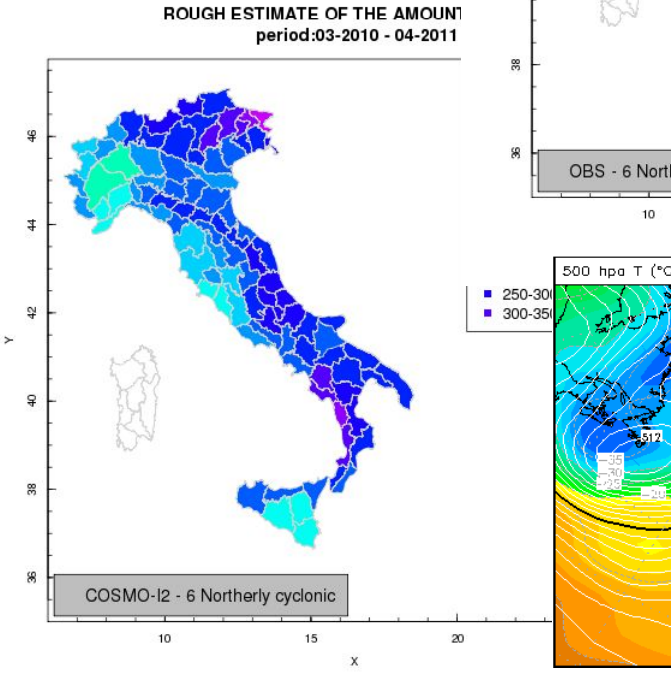


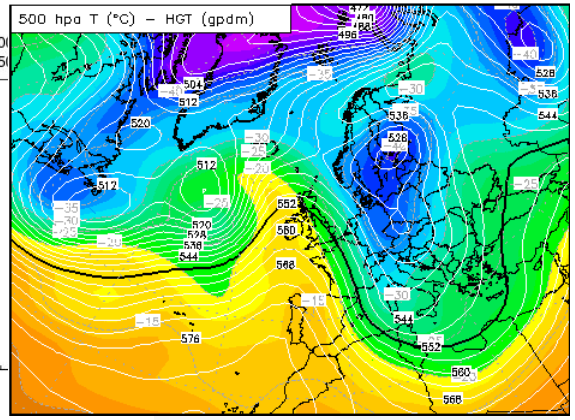
6-Northerly cyclonic

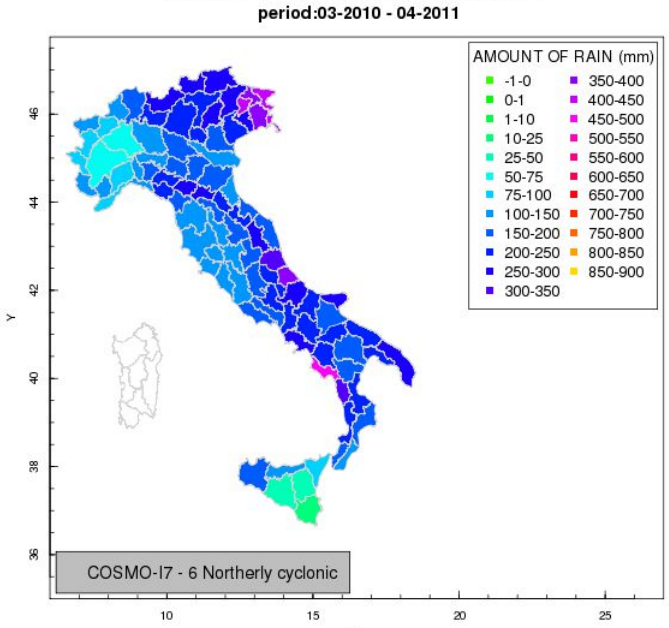




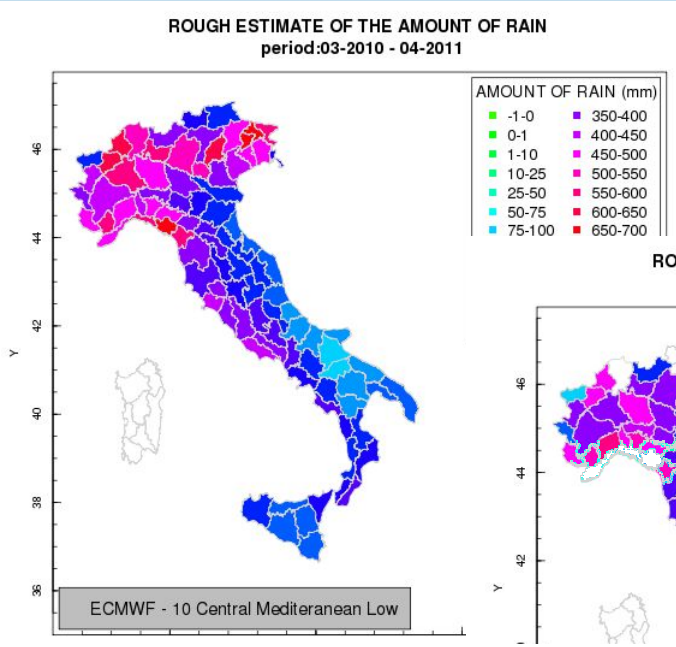


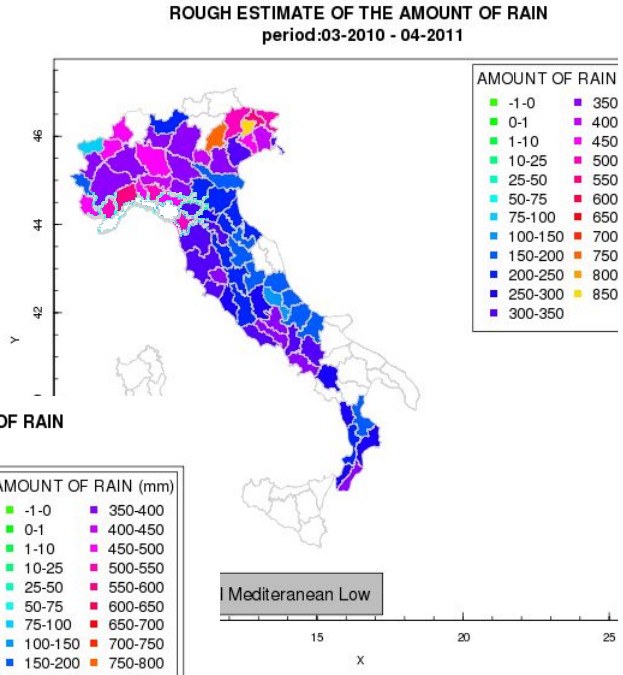


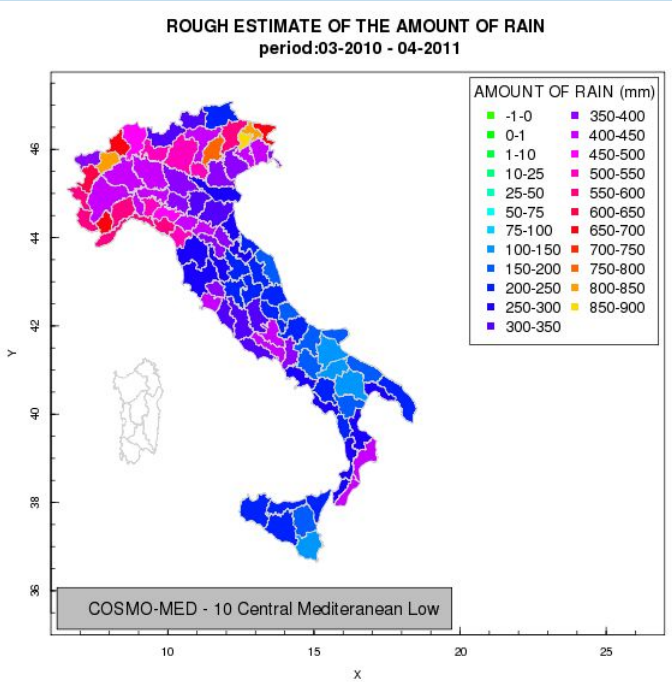


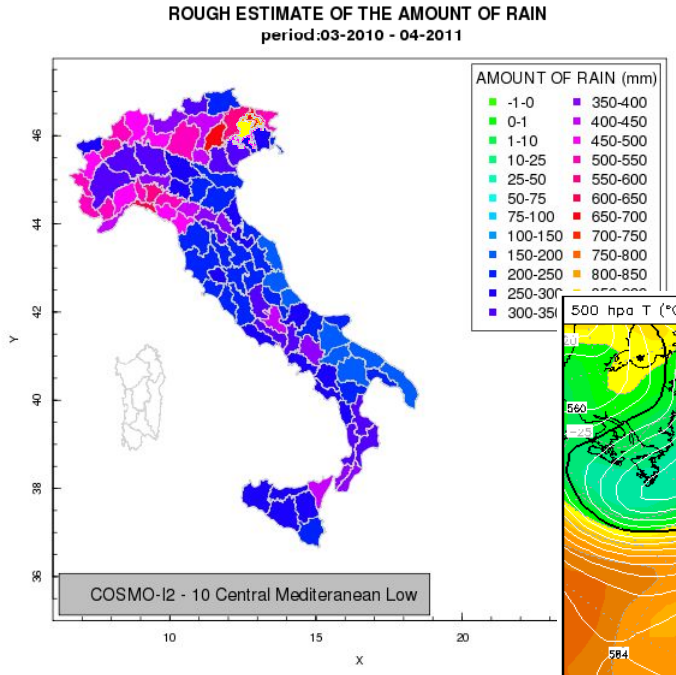


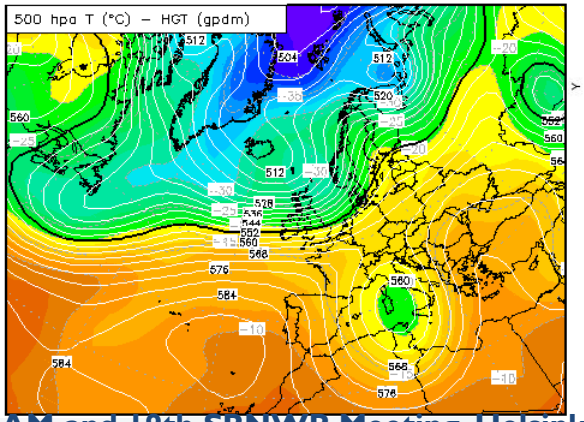
10-Central Mediterranean Low

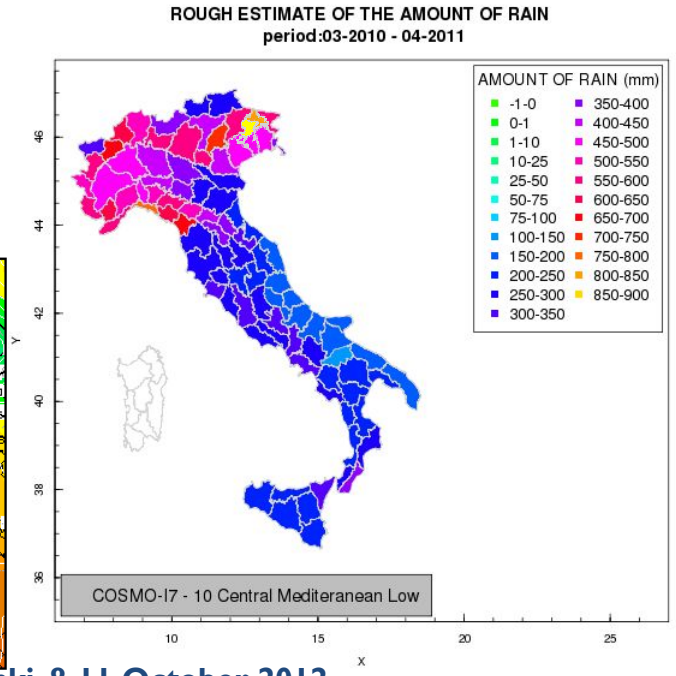




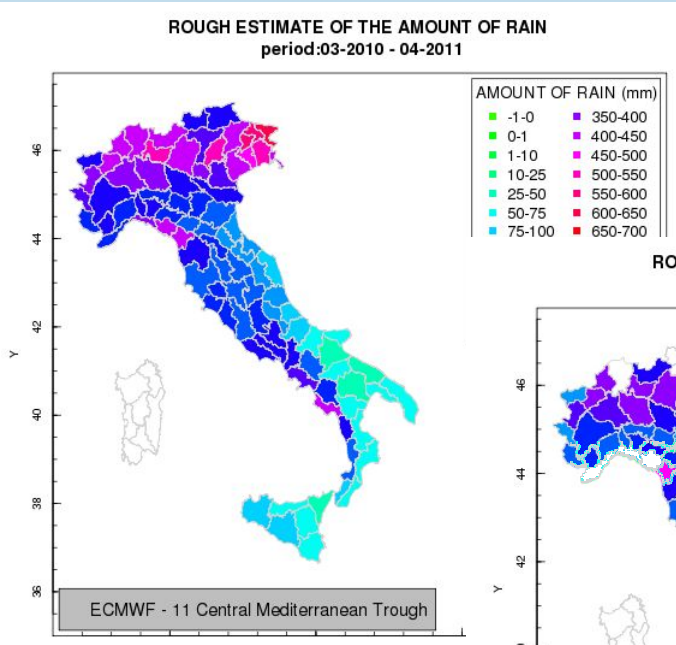


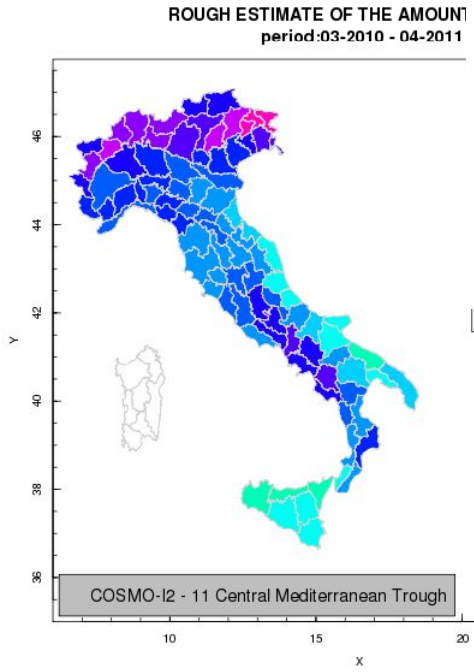


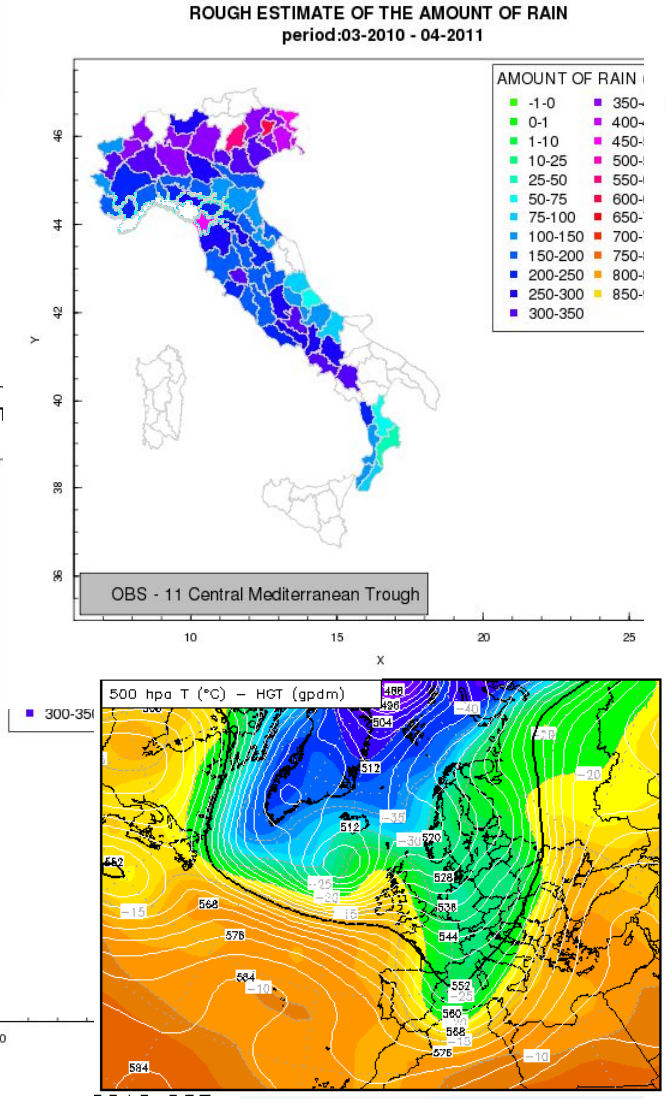


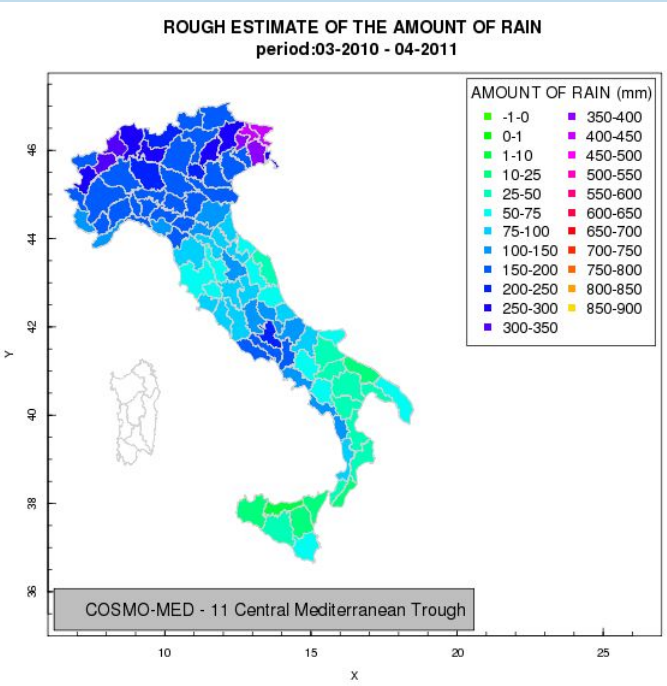


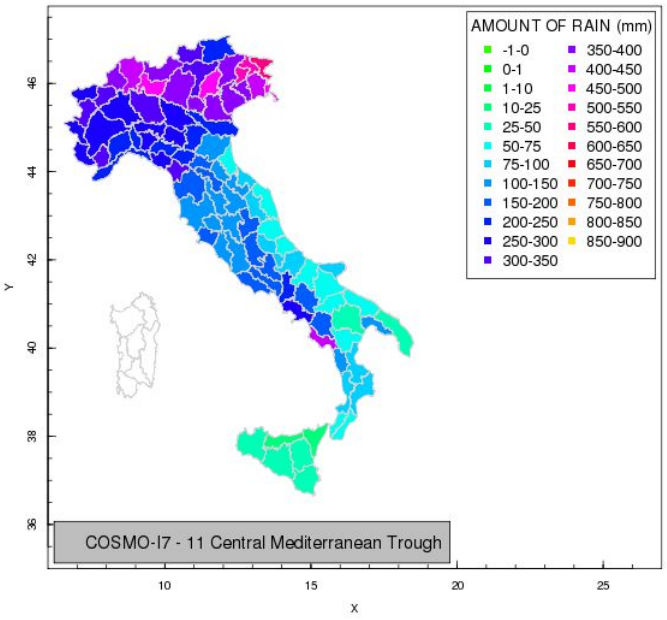
11-Central Mediterranean Trough











	2 ZWC	4 MC	6 NC	7 NA	8 CMH	9 CMR	10 CML	11 CMT	ALL
WEST ALPS	↓↔↔↔	↑↑↑↑	↑↑↔↑	↑↑↔↓	↑↔↔↑	↑↑↑↑	↑↑↑↔	↑↑↓↔	↑↑↔⟲
EAST ALPS	↔↔↑↔	↔↑↑↔	↔↑↔↑	↔↑↓↔	↓↔↑↑	↔↑↑↑	↔↔↔↔	↑↔↓↔	↔⟲⟲⟲
NORTH WEST	↓↓↔↓	↑↑↔↔	↑↔↓↑	↑↑↔↔	↔↔↔↔	↔↑↔↔	↑↑↑↔	↔↔↓↓	⟲⟲⟲⟲
PO VALLEY	↓↓↔↓	↑↑↔↓	↔↓↓↓	↑↑↔↑	↔↑↑↑	↔↑↑↔	↔↔↔↓	↑↔↔↔	⟲⟲↔⟲
NORTH APPEN	↓↔↔↔	↔↑↔↔	↔↔↔↔	↑↔↑↔	↔↑↑↑	↔↑↑↑	↔↑↑↑	↔↔↓↓	⟲⟲⟲⟲
SOUTH APPEN	↓↓↑↓	↓↓↓↓	↓↔↓↔	↔↓↔↓	↓↓↓↓	↓↔↓↔	↓↔↑↑	↔↔↔↔	↓⟲⟲⟲
TIRRENIAN COST	↓↓↑↓	↔↓↔↓	↔↓↓↓	↔↔↓↔	↔↔↔↔	↑↔↔↑	↑↔↑↓	↔↓↓↓	⟲⟲⟲⟲
ADRIATIC COAST	↓↔↔↓	↔↔↔↔	↔↑↔↔	↑↔↔↔	↔↔↔↔	↔↔↔↔	↔↓↔↔	↔↓↓↓	⟲↔↔↔
SOUTH	↔↔↔↔	↔↓↓↓	↑↓↓↔	↑↓↓↔	↔↔↔↔	↔↑↔↔	↓↔↑↑	↔↓↓↑	↔⟲⟲⟲
Globally	↓⟲↔↔	⟲⟲⟲⟲	⟲⟲⟲⟲	↑⟲⟲↔	↔↔↔⟲	⟲↑⟲⟲	⟲⟲↑⟲	↔⟲↓⟲	

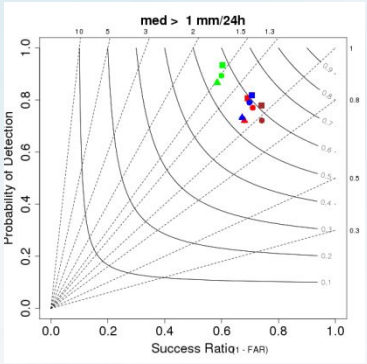
ECMWF COSMO-I7 COSMO-MED COSMO-I2

↑overestimation ↓ understimation
↔ almost correct ⟲ variable behaviour

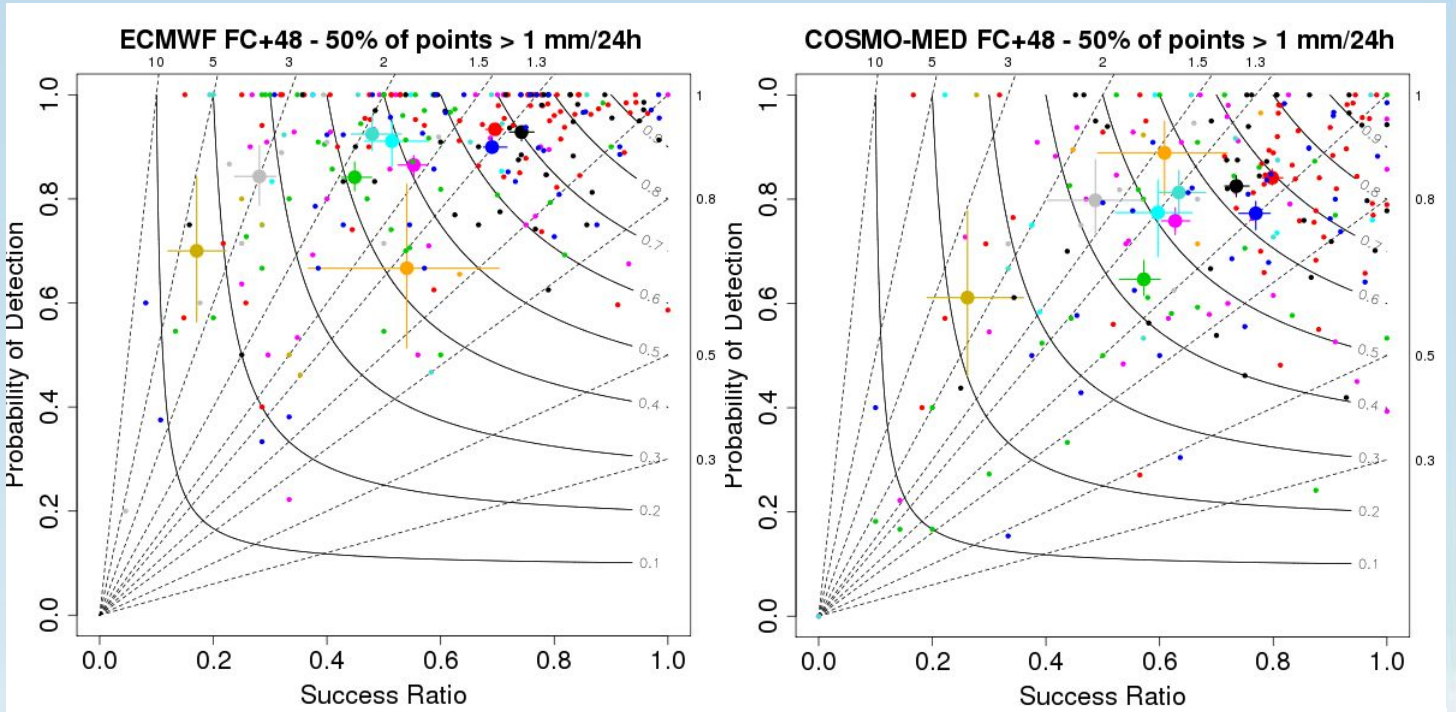
Small dots =
daily scores

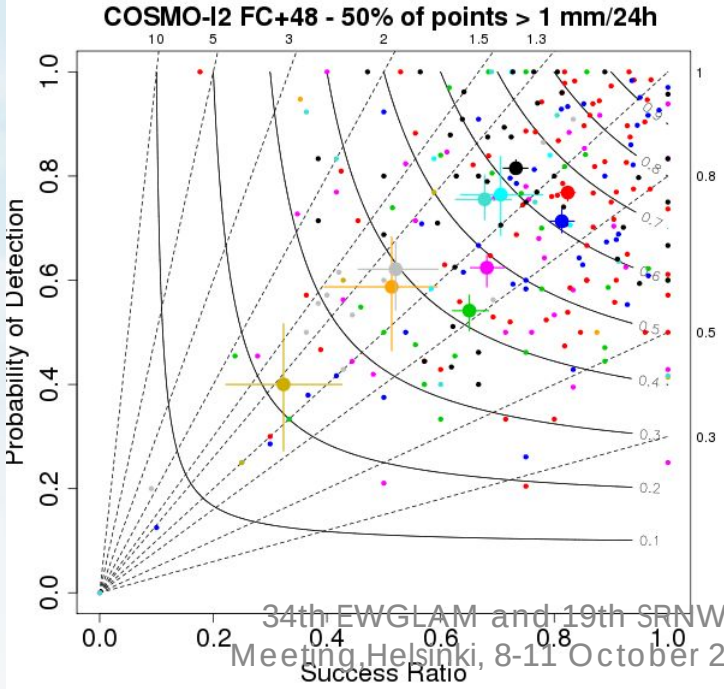
Big dots =
scores over the days in each category

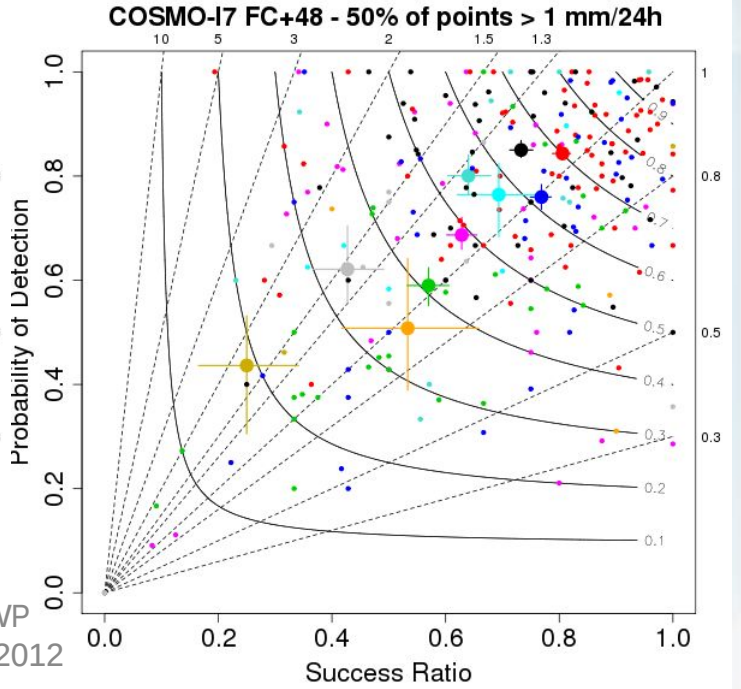
- 1 Zonal Westerly anticyclonic
- 2 Zonal Westerly cyclonic
- 3 Easterly
- 4 Meridional cyclonic
- 5 Meridional anticyclonic
- 6 Northerly cyclonic
- 7 Northerly anticyclonic
- 8 Central Mediterranean High
- 9 Central Mediterranean Ridge
- 10 Central Mediteranean Low
- 11 Central Mediterranean Trough



All cases







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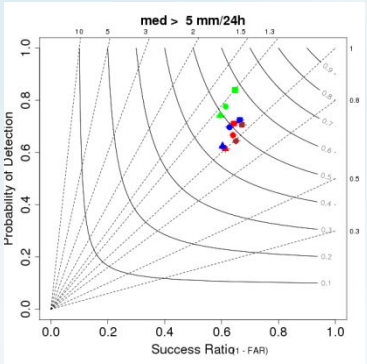
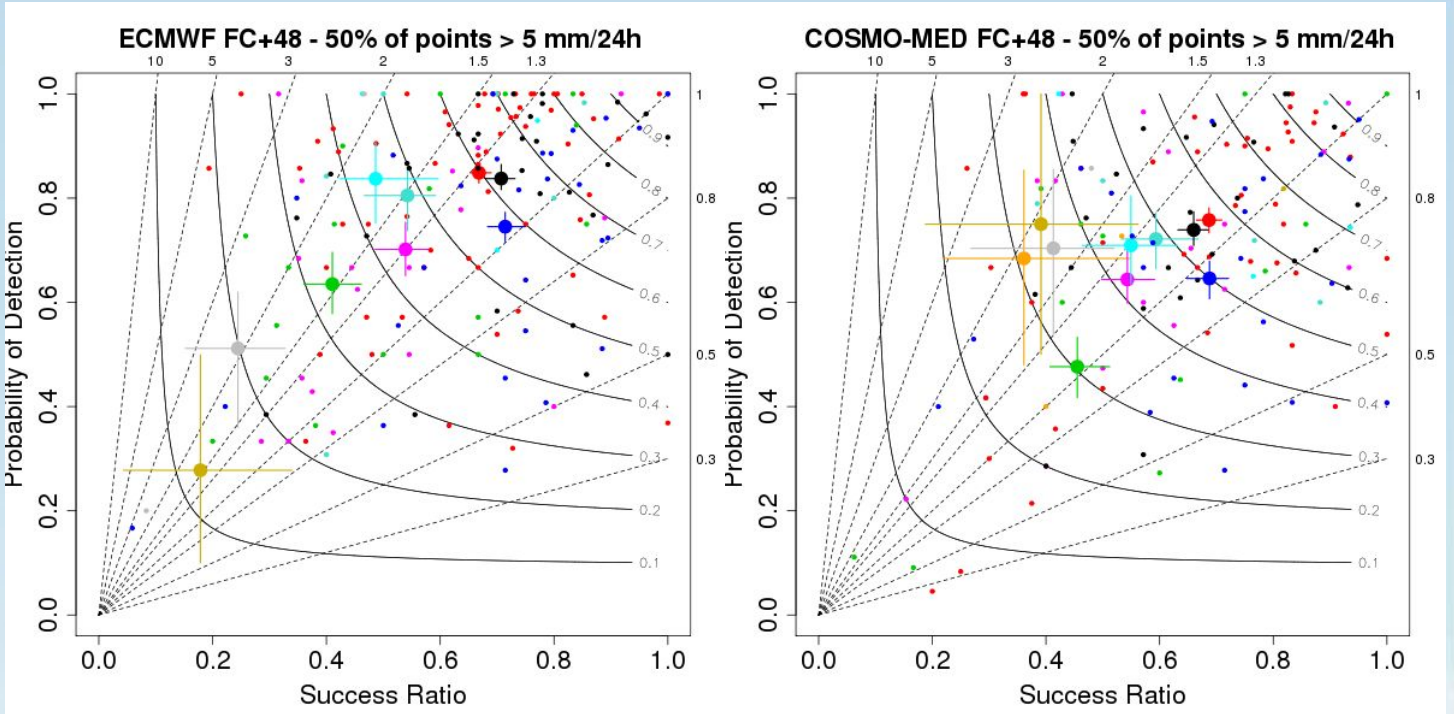
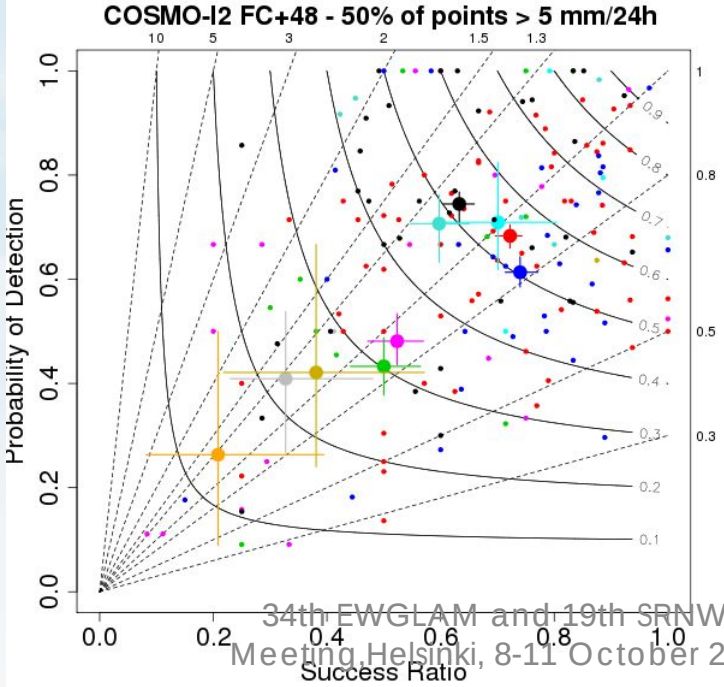
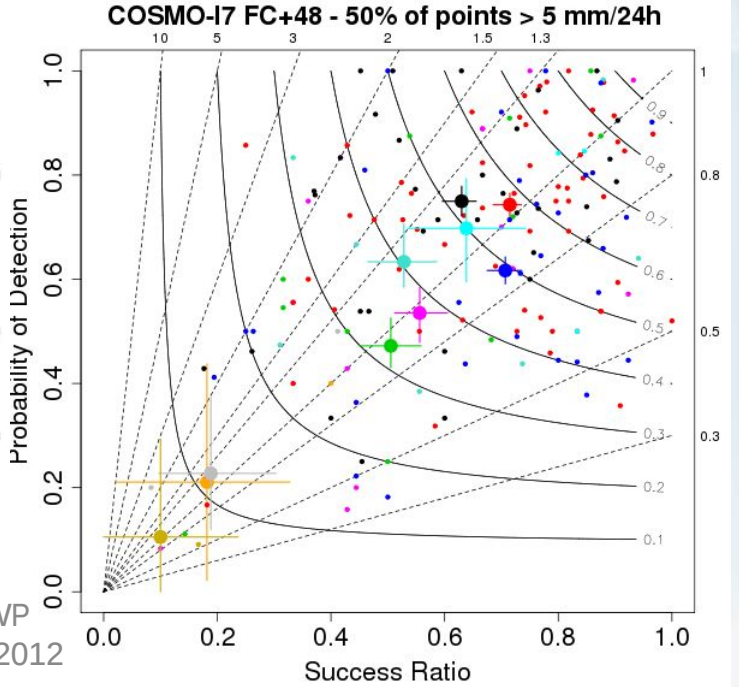


All cases







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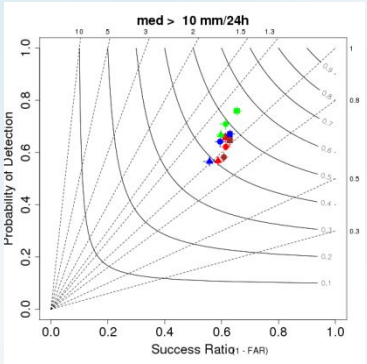
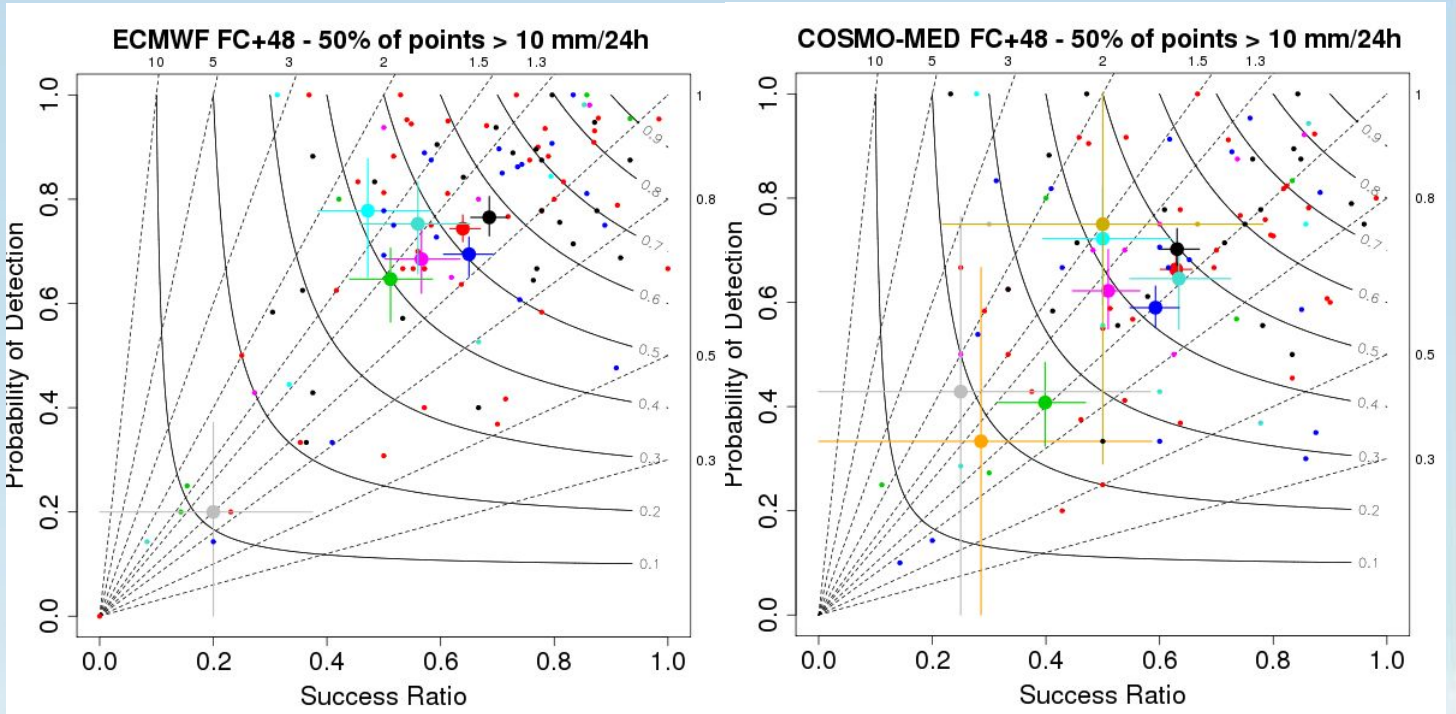
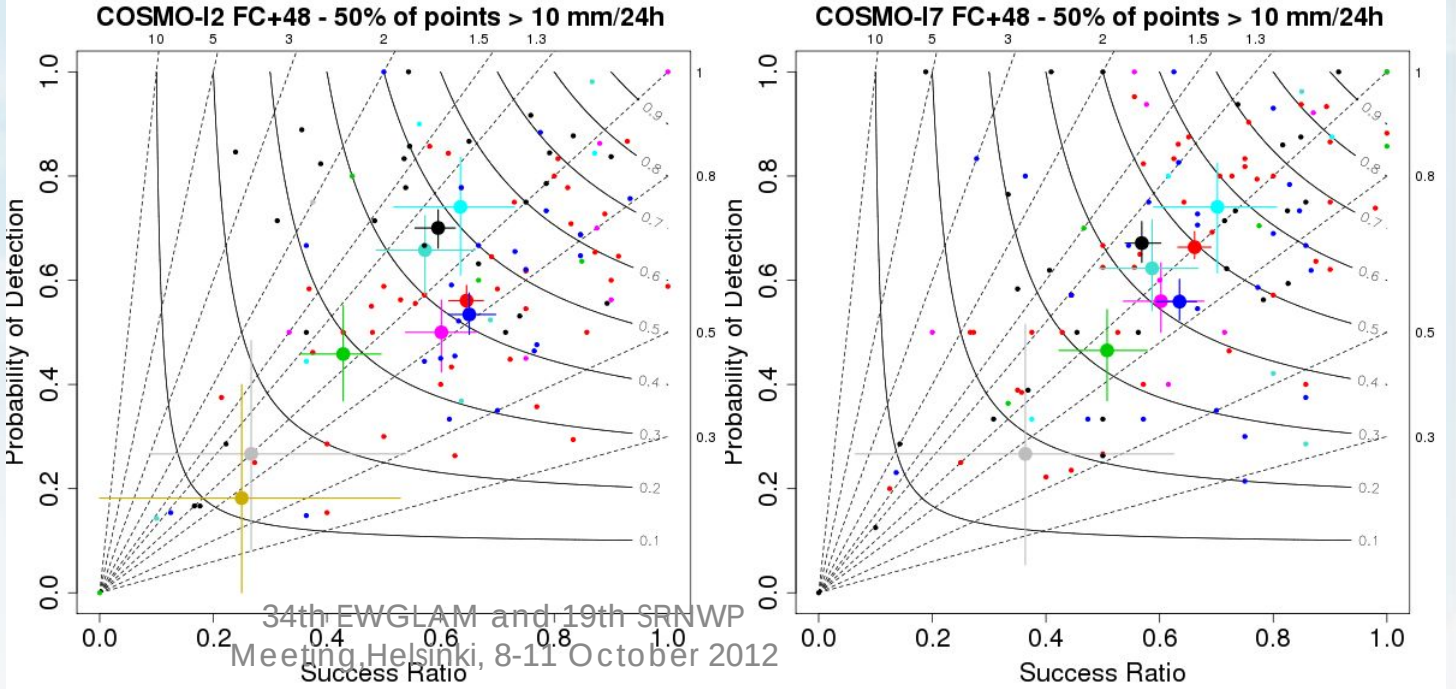


All cases





Thoughts on CV & WDV methods

- ✓ Conditional verification provides us with tools for analysing rather complex COSMO model errors
- ✓ Use of intensive measurement sites (e.g. sensible and latent fluxes for clear sky temperature error, soil moisture for temperature and dewpoint error) and radiosoundings
- ✓ Identify suitable stratifications for precipitation (e.g. appropriate time integrations for CAPE or convective time scale, so far no success with weather classes)
- ✓ WDV requires a very large sample to be able to provide us with indications for favorable weather regimes – seasonal analysis is also desirable

CV can be a tool for modelers to identify model deficiencies
whether WDV is a tool to extract useful guidelines
for forecasters

General Conclusions

- **Both methods face the problem of verification from a different point of view: the statistical score is not central anymore, but the behavior of the model dependant on imposed condition is examined**
- **The approach can be applied to several kind of scores and verification methods (Object Oriented, neighborhood…)**
- **Direct interpretation of the outcomes by the users (e.g. modelers and forecasters) connected with physics and weather situation**

Thank you - **Ευχαριστώ**