



# Testing the New COSMO Radiation Scheme with CAMS Prognostic Aerosols

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(Supported by Alessio Bozzo ECMWF)

Part of  $T^2(RC)^2$  PP

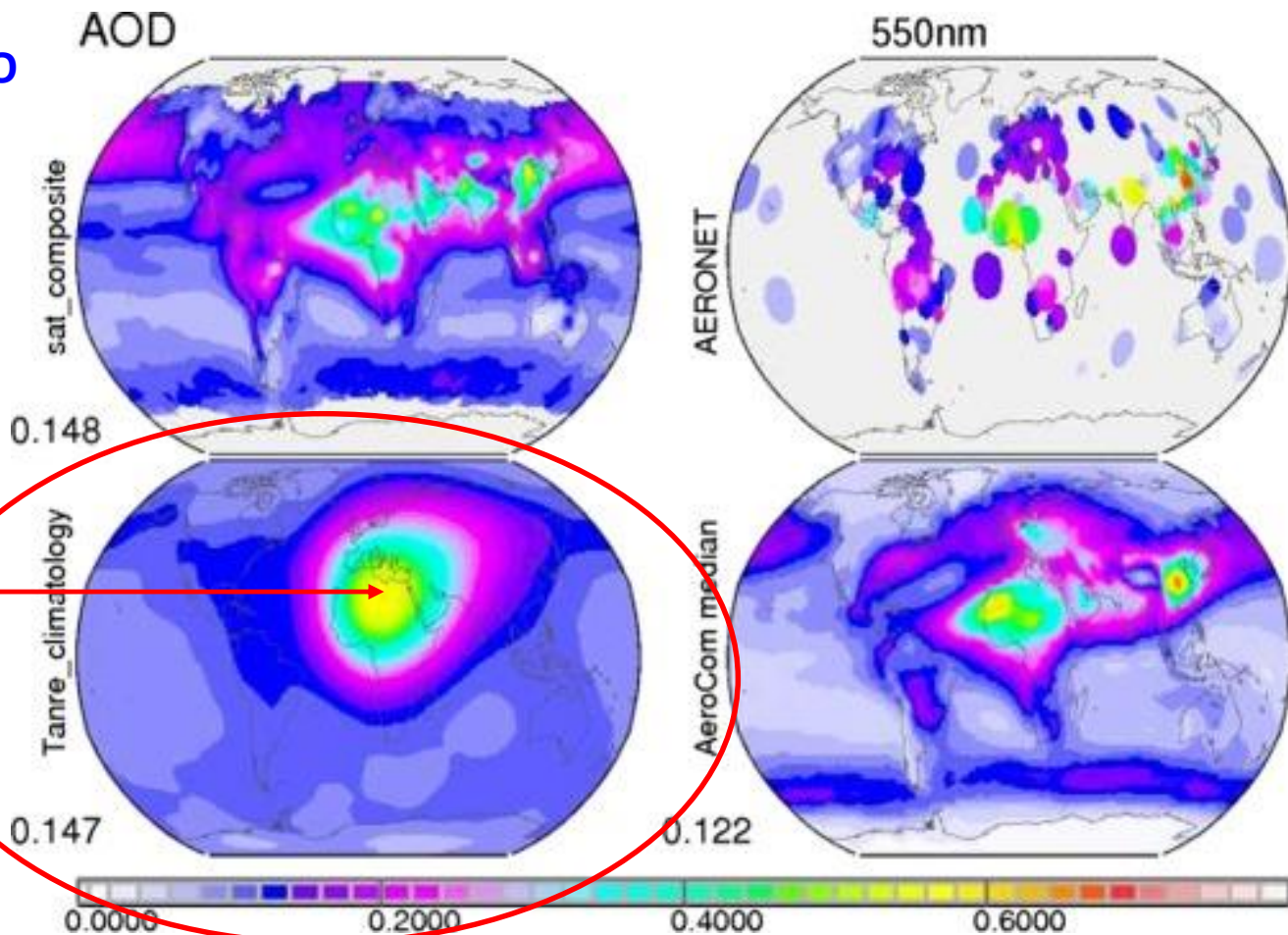
COSMO User Seminar- March 6, 2017

## Outline

- Aerosols models currently available in COSMO radiation scheme
- Explanation on the verification system
- Verifications in **clear** & **cloudy** skies in 29 test cases:
  - Aerosols optical depth - AOD
  - Global radiation - GR
  - Surface temperature – T2m
  - Rain
- Concluding remarks
- Outlook

# Tanre (1984) aerosols annual climatology

itype\_aerosol = 1  
Operational in COSMO



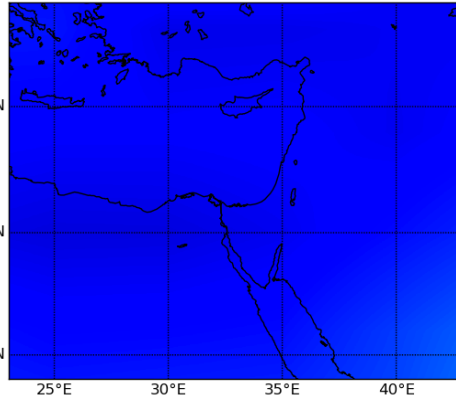
- Fixed in time
- High **overestimation**
- AOD ~ 0.5 in EM

# Tegen (1997) aerosols monthly climatology

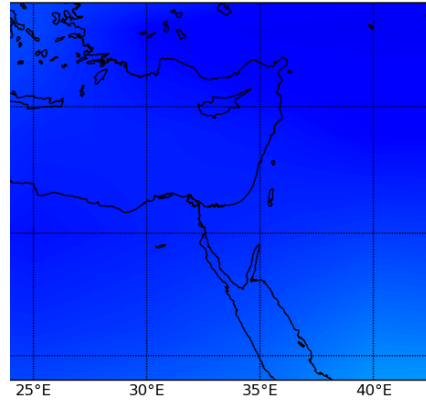
itype\_aerosol = 2

Operational in IFS

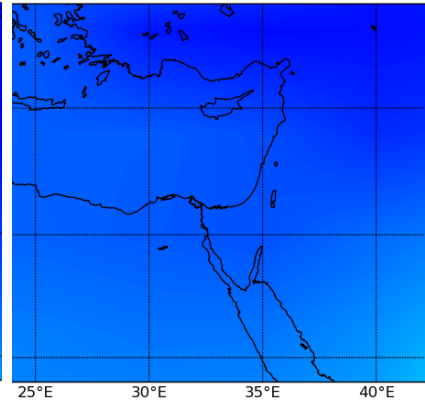
January



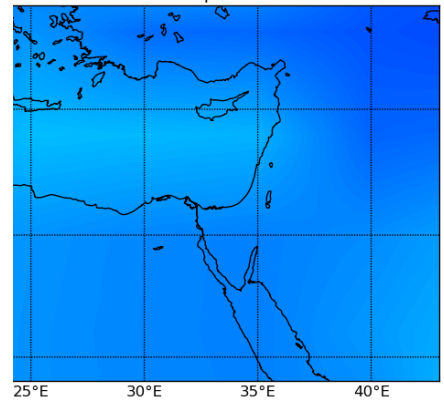
February



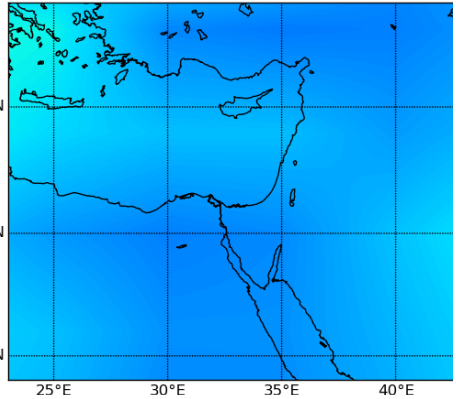
March



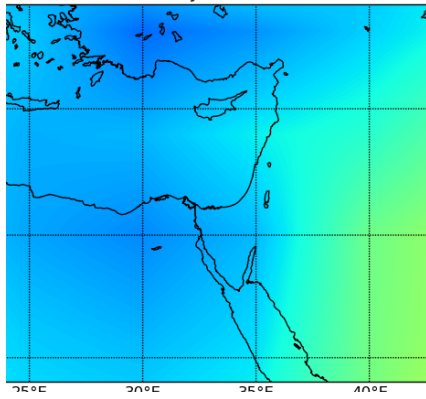
April



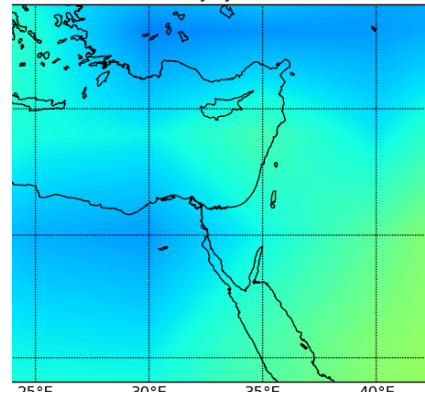
May



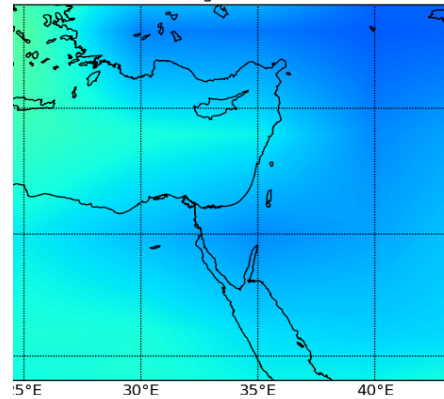
June



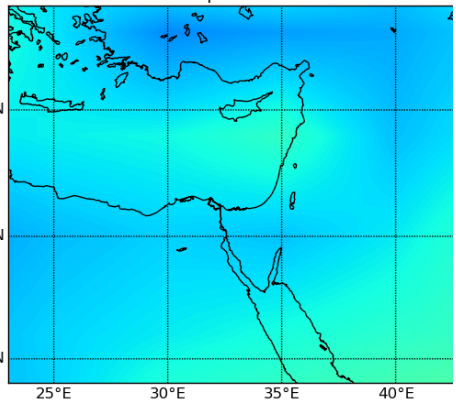
July



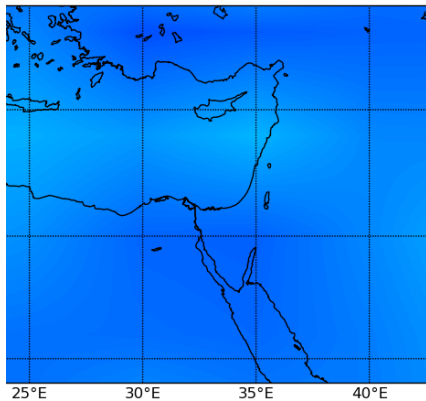
August



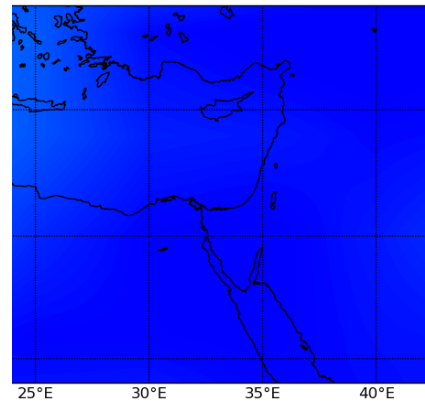
September



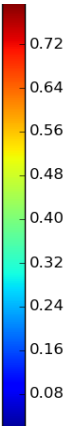
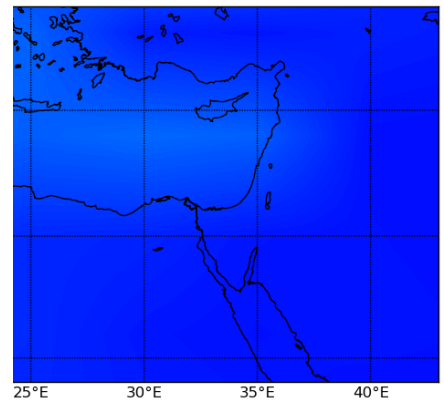
October



November



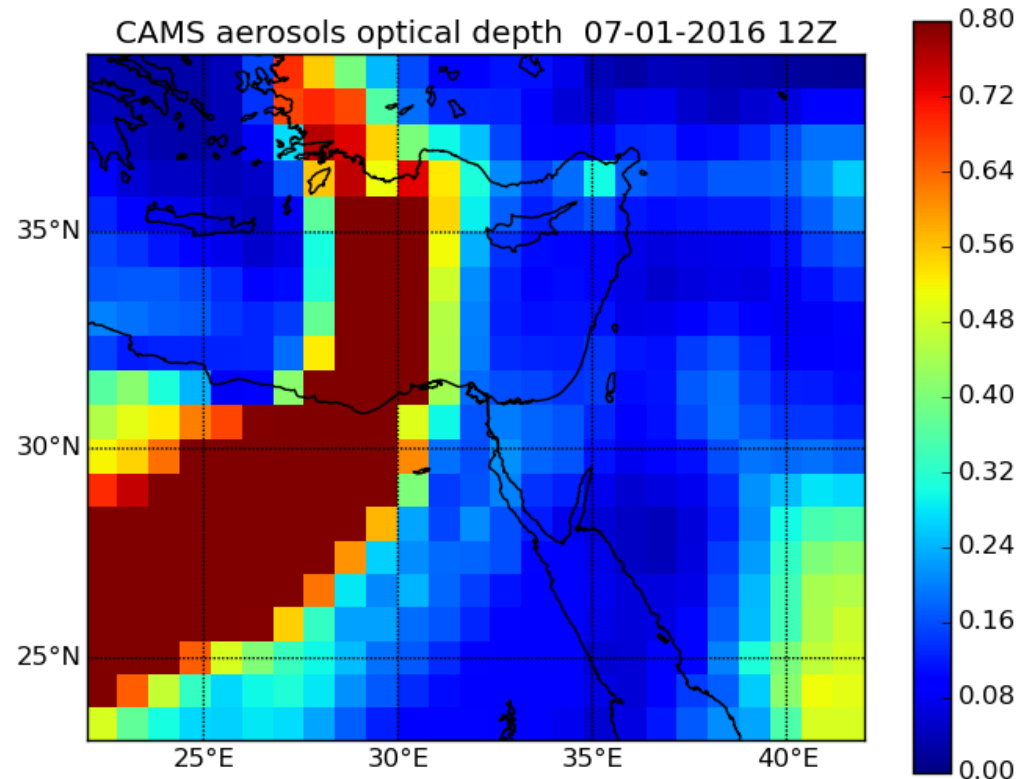
December



# CAMS prognostic aerosols

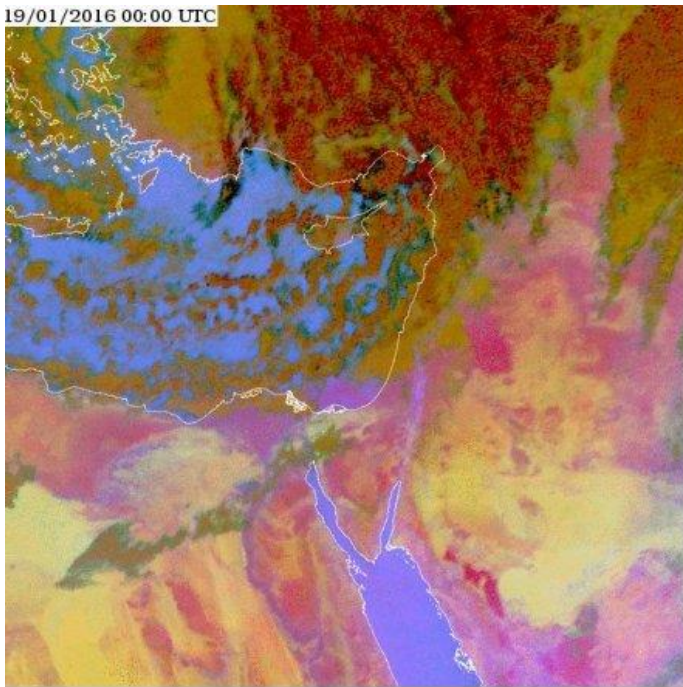
**itype\_aerosol = 4**

- Built on the ECMWF NWP system with additional prognostic aerosol variables
- Input aerosols analysis:
  - NASA/MODIS Terra and Aqua Aerosol Optical Depth at 550 nm
  - NASA/CALIOP CALIPSO Aerosol Backscatter
  - AATSR, PMAP, SEVIRI, VIIRS
- Verification based on AERONET  
 (text adapted from Benedetti CUS2016)

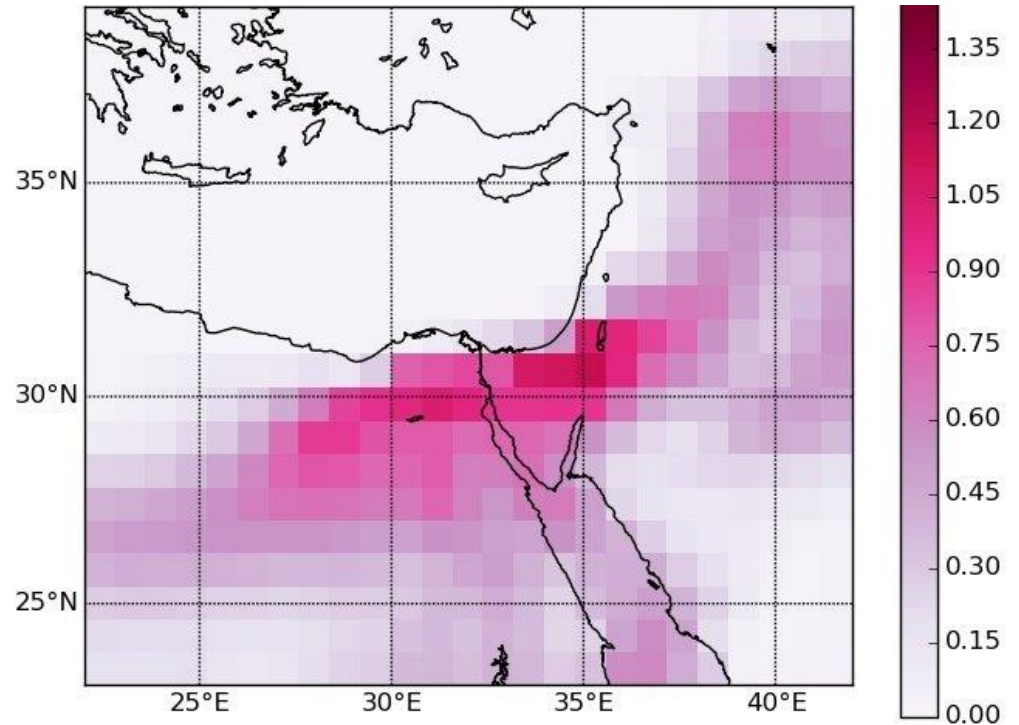


# 16-20/01/2016 Dust Storm Test Case

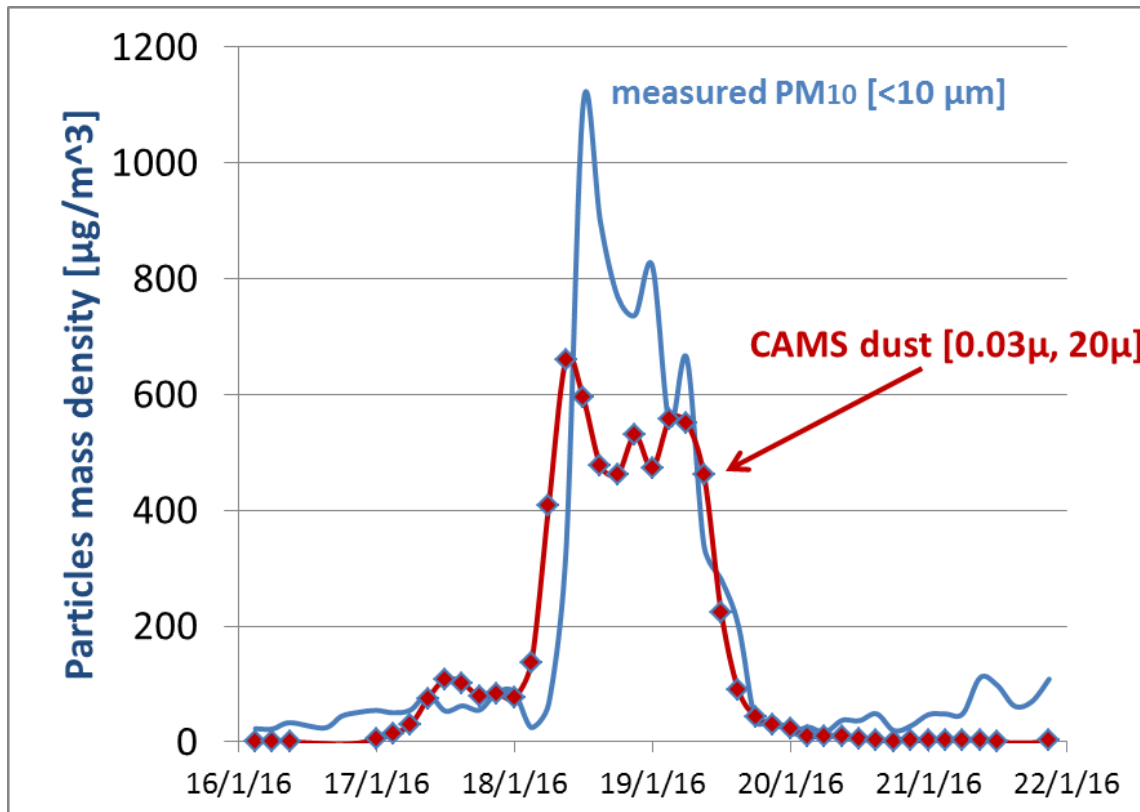
MSG – dust



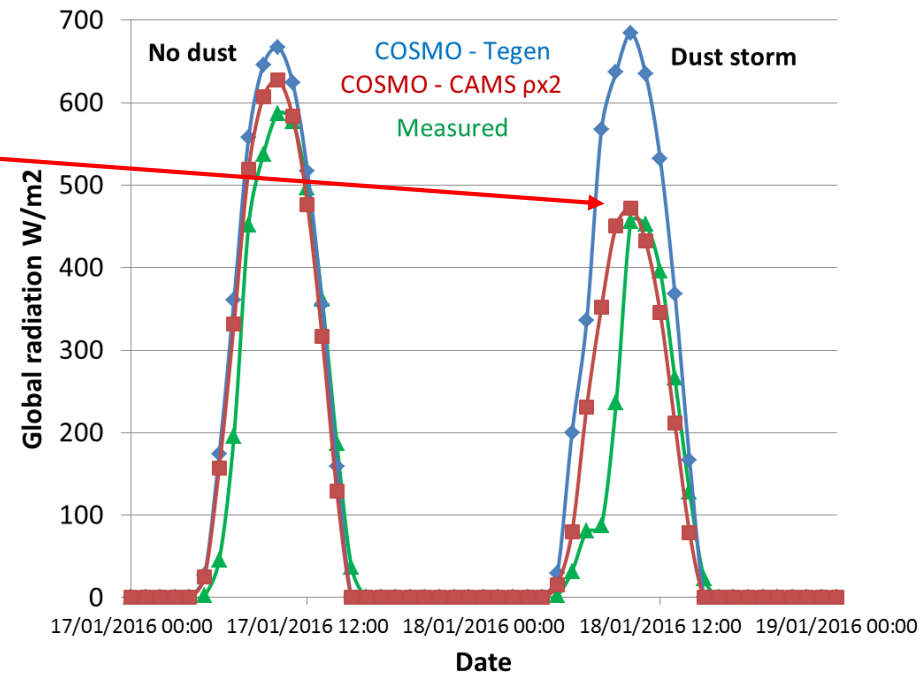
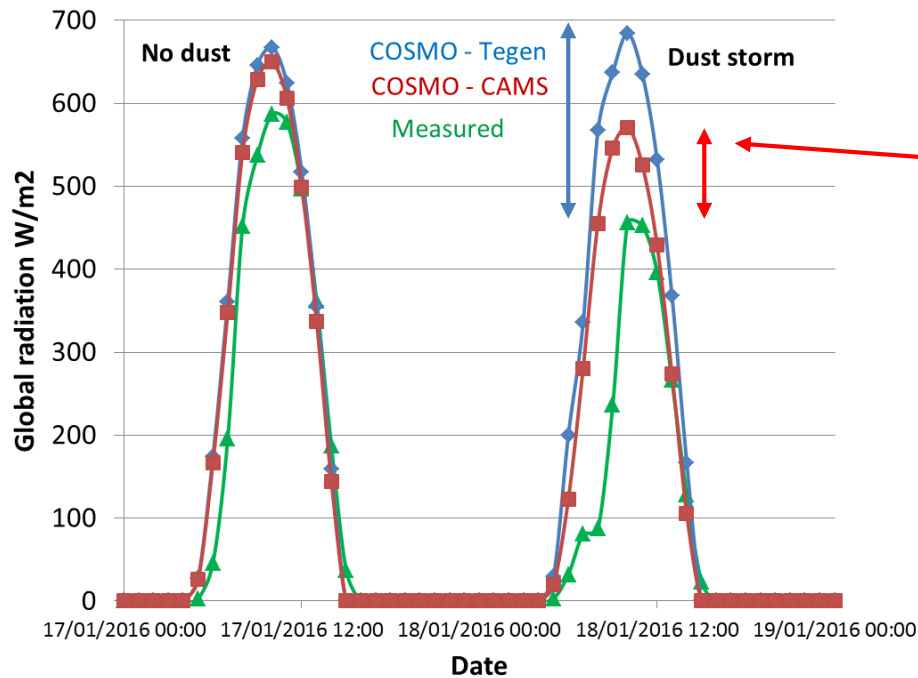
CAMS DOD at 550nm



CAMS aerosols mass density forecast performance vs. measurements in Tel-Aviv



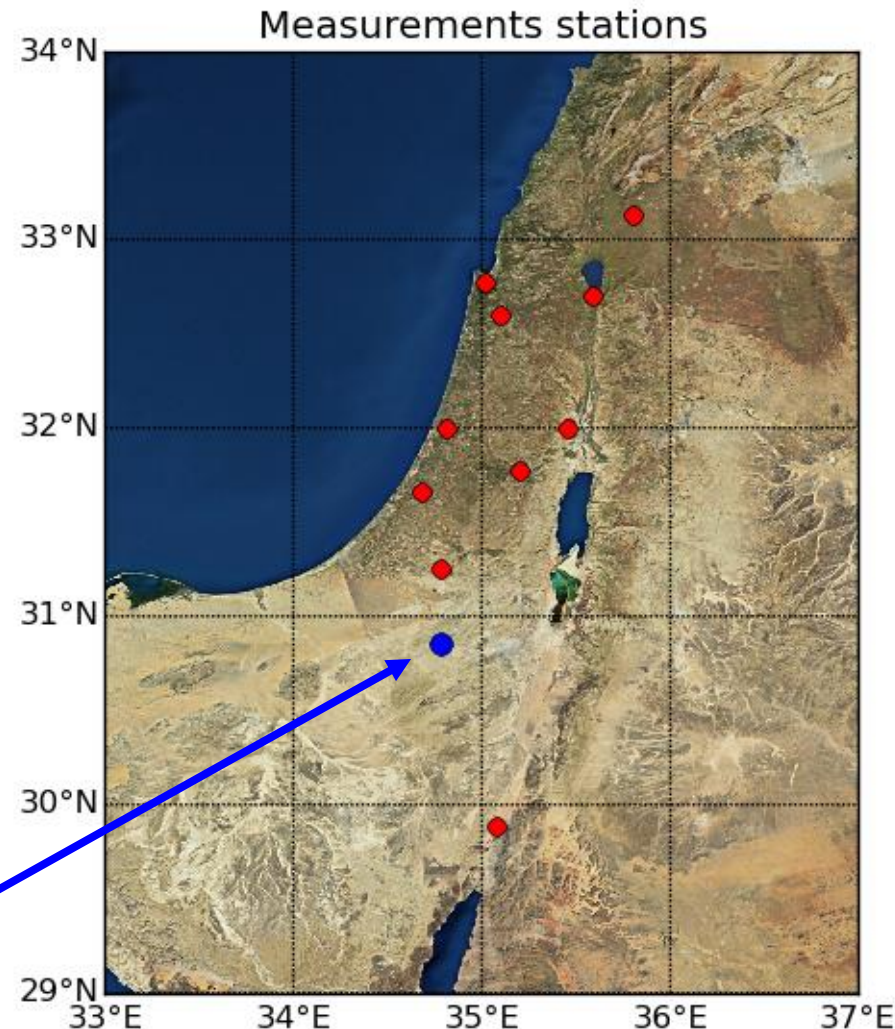
## COSMO radiation schemes verification vs. measurements in Bet-Dagan (near TA)



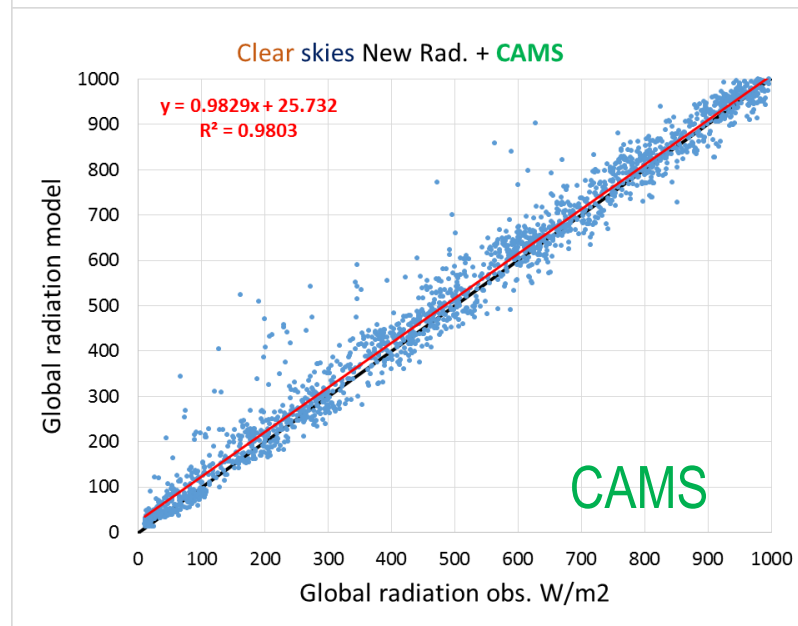
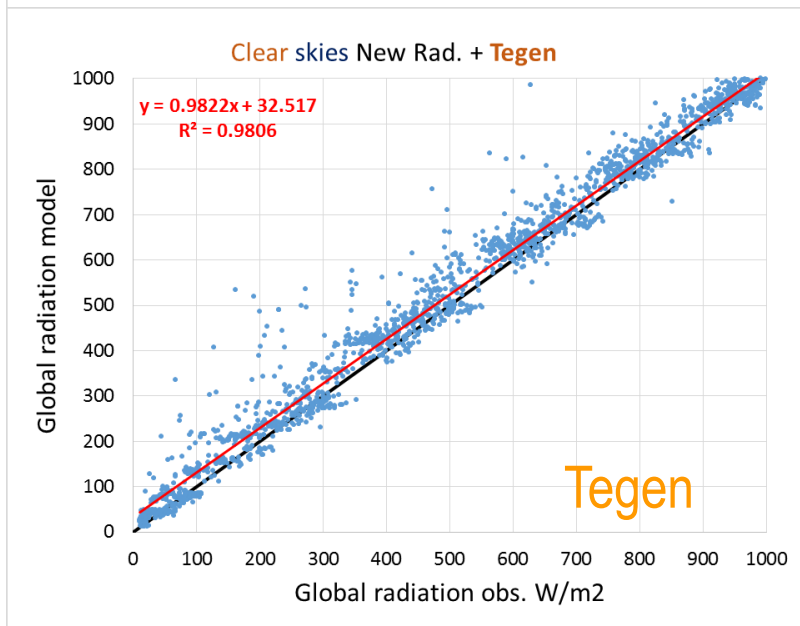
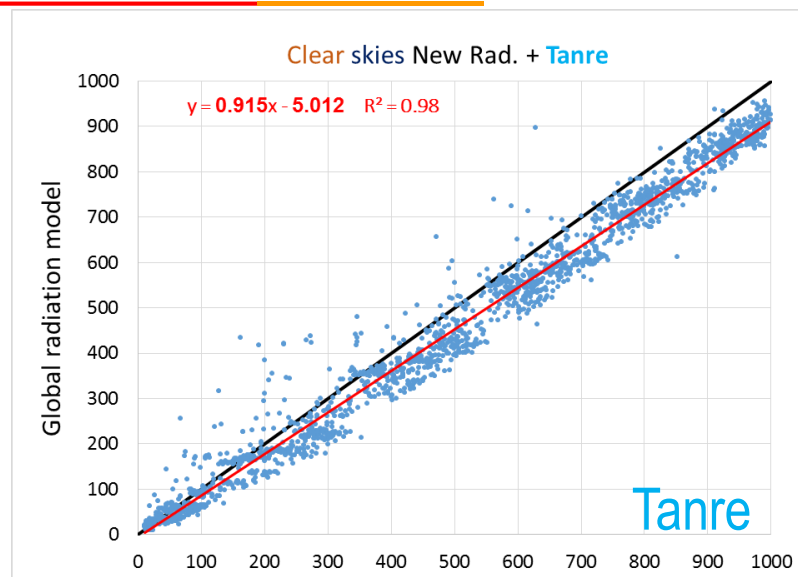
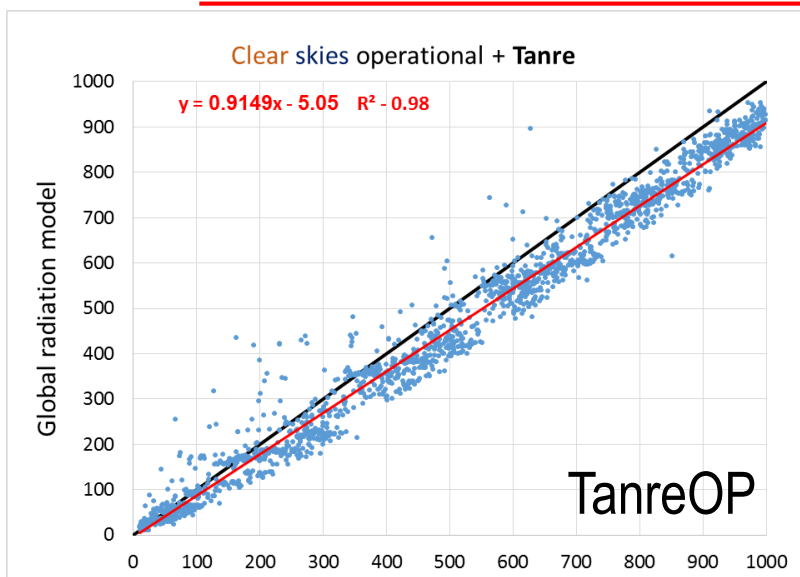


## The Verification system

- **29 test cases** in different weather situations lead time of 30h/42h in 2015-2016
- **10** measurement stations (T2m, GR)
- **1 AEORNET** station in **Sede-Boker** (AOD)
- **Rain** verifications using radar data (10 cases)
- **4 models: COSMO 2.8km 5.0** (driving model IFS):
  - Oper. rad. scheme + **Tanre**
  - New rad. Scheme + **Tanre**
  - New rad. scheme + **Tegen**
  - New rad. Scheme + **CAMS**
- **CAMS** data taken from previous day (-24h but -12h is also available)



# Global radiation – model vs. Observations clear skies

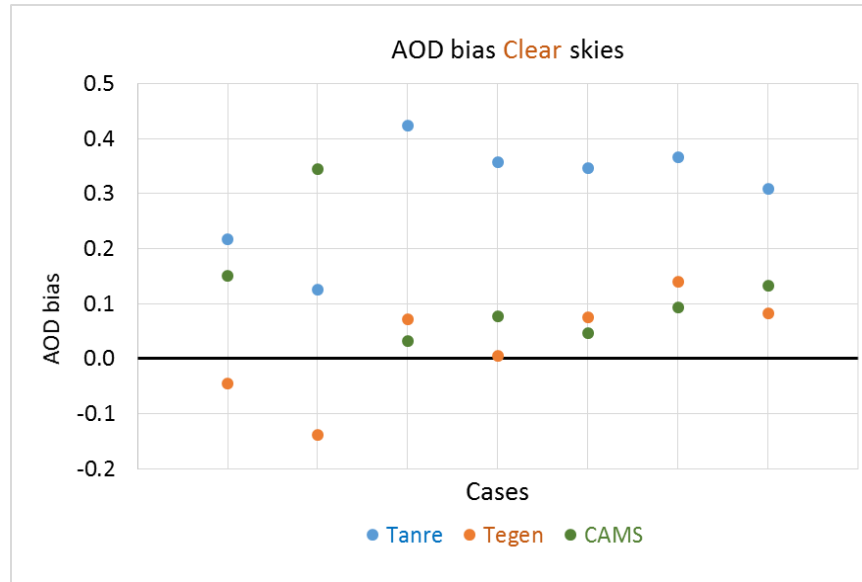


# Global radiation and AOD – model vs. Observations clear skies

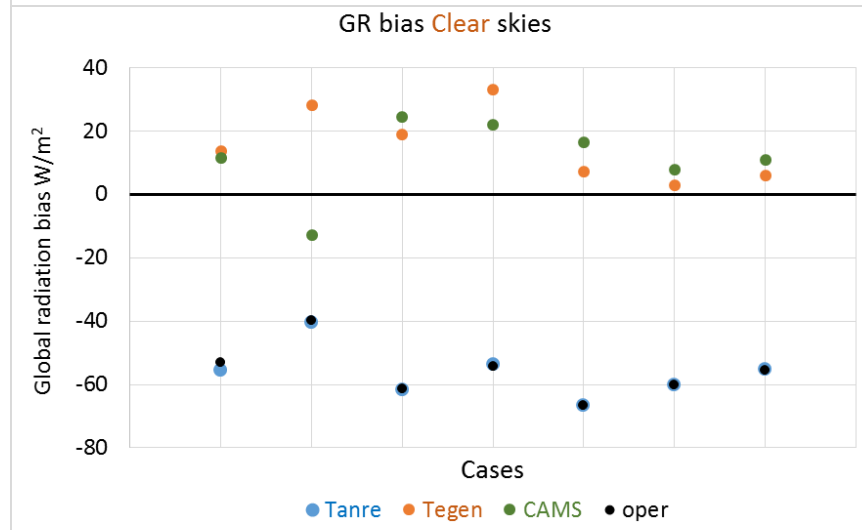


Cases:

- 2015-05-17
- 2015-05-18
- 2016-02-14
- 2016-02-26
- 2016-04-18
- 2016-06-19
- 2016-06-24



**AOD bias:**  
**Tanre 0.31**  
**Tegen 0.03**  
**CAMS 0.12**

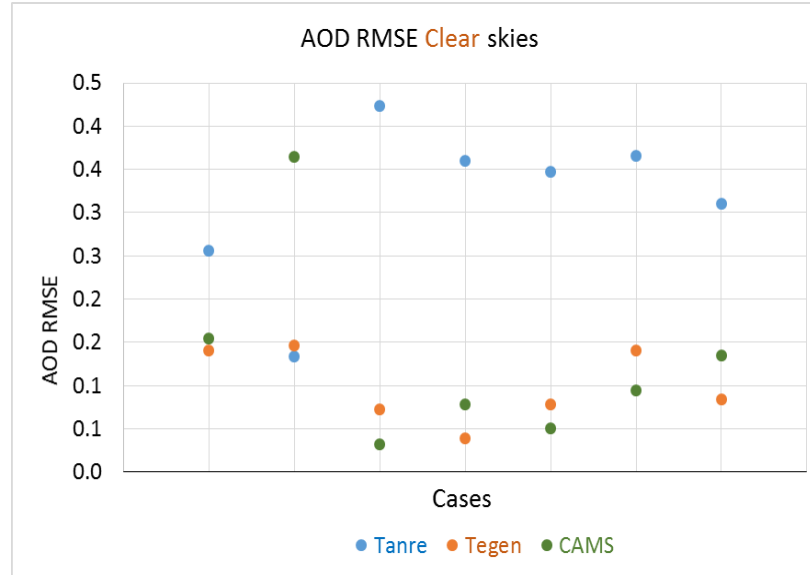


**GR bias:**  
**TanreOP -55.9 W/m<sup>2</sup>**  
**Tanre -56.2 W/m<sup>2</sup>**  
**Tegen 15.6 W/m<sup>2</sup>**  
**CAMS 11.4 W/m<sup>2</sup>**

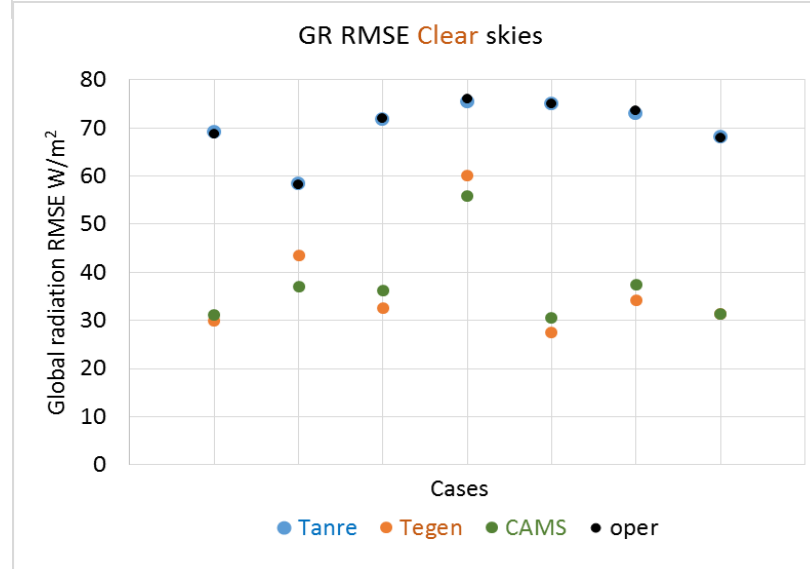
## Global radiation and AOD – model vs. Observations clear skies



- Cases:
- 2015-05-17
  - 2015-05-18
  - 2016-02-14
  - 2016-02-26
  - 2016-04-18
  - 2016-06-19
  - 2016-06-24

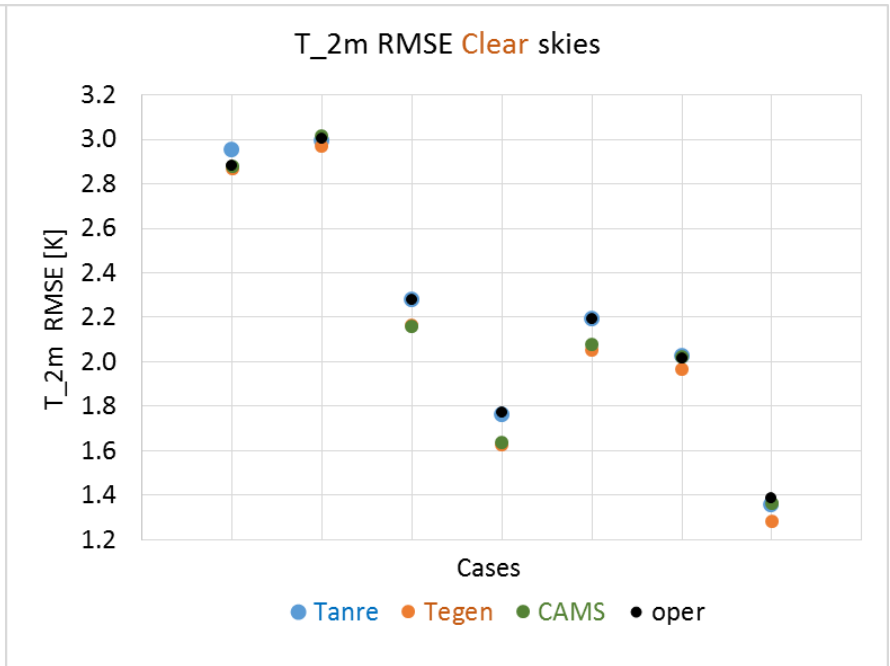
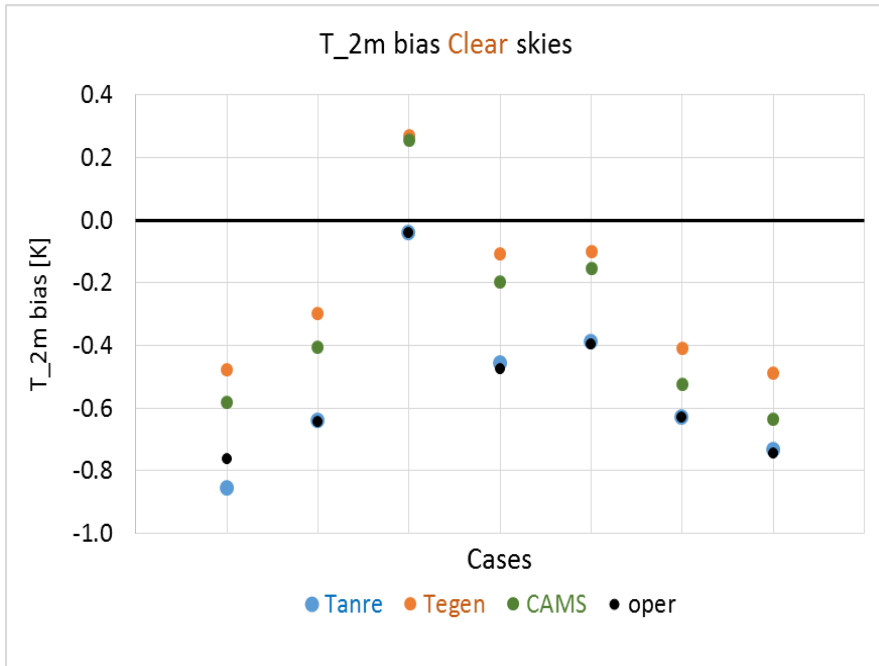


AOD RMSE:  
**Tanre 0.31**  
**Tegen 0.10**  
**CAMS 0.13**



GR RMSE:  
**TanreOP 70.2 W/m<sup>2</sup>**  
**Tanre 70.1 W/m<sup>2</sup>**  
**Tegen 37.0 W/m<sup>2</sup>**  
**CAMS 37.1 W/m<sup>2</sup>**

## 2m-Temperature – model vs. Observations clear skies



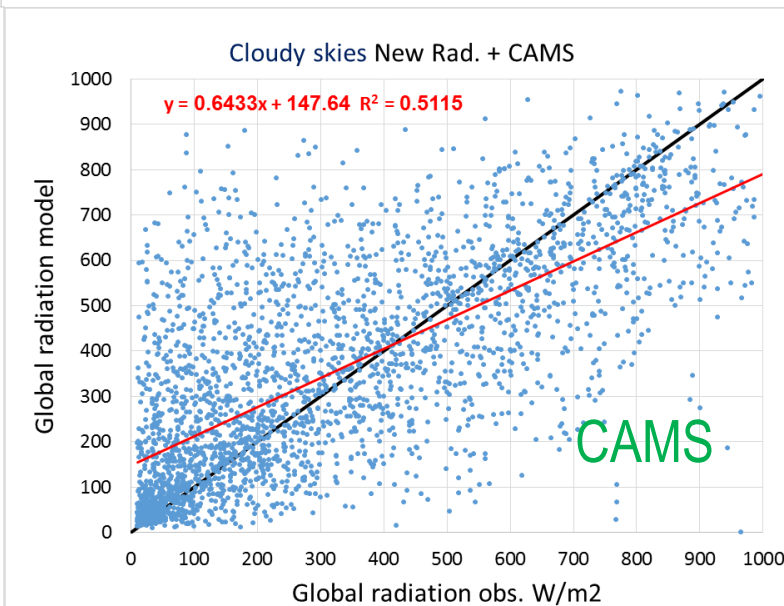
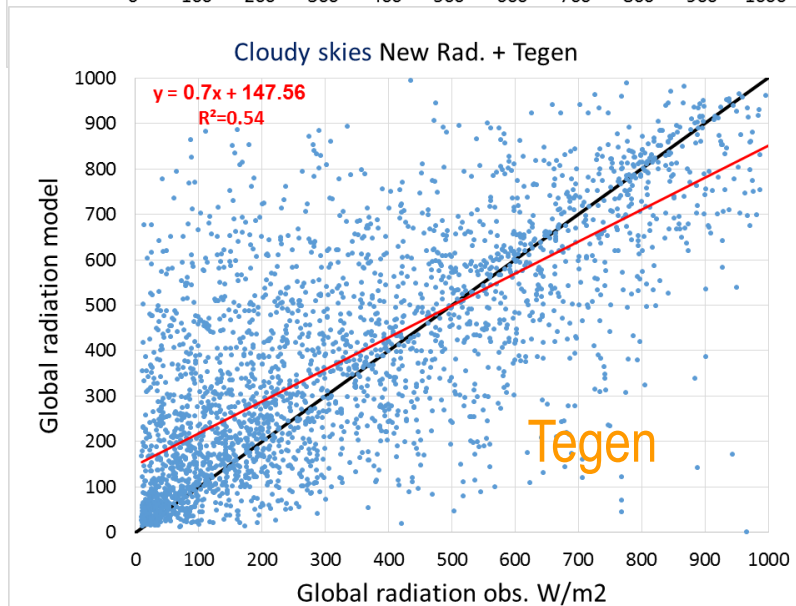
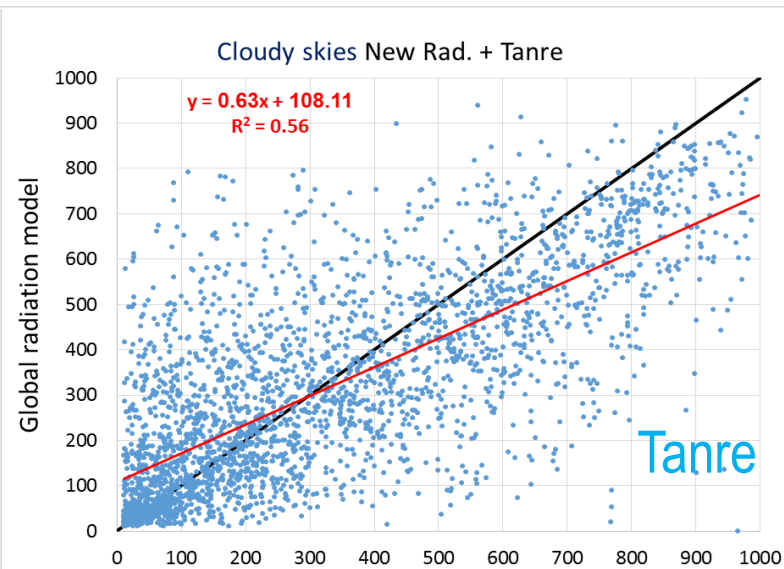
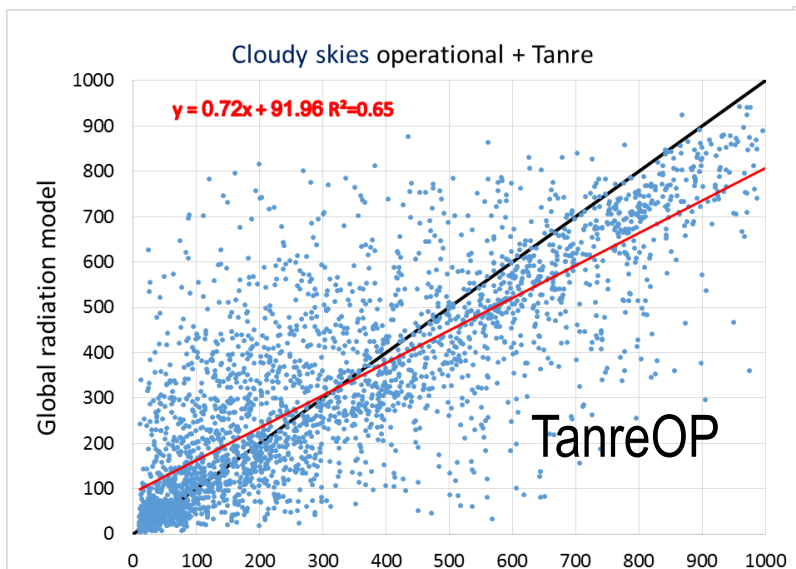
### T2m bias:

TanreOP -0.5 K  
 Tanre -0.5 K  
 Tegen -0.2 K  
 CAMS -0.3 K

### T2m RMSE:

TanreOP 2.2 K  
 Tanre 2.2 K  
 Tegen 2.1 K  
 CAMS 2.2 K

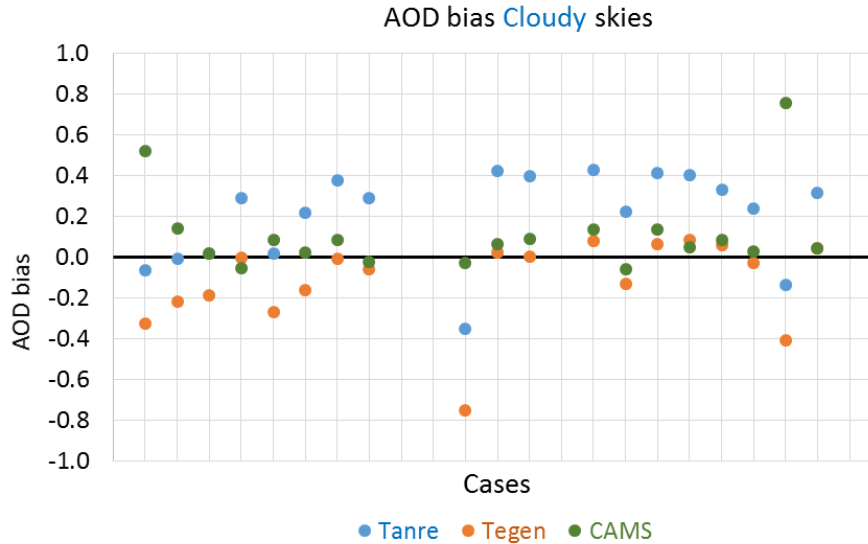
# Global radiation – model vs. Observations cloudy skies



# Global radiation and AOD – model vs. Observations cloudy skies

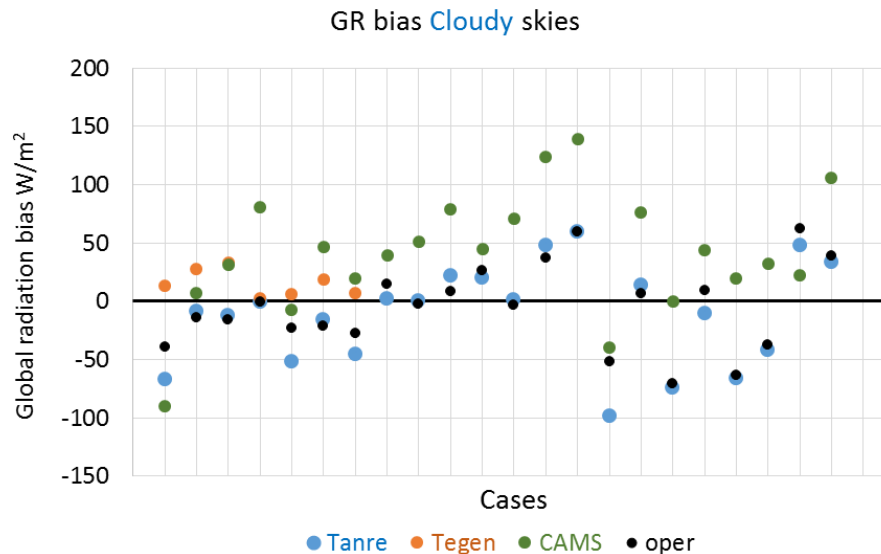
Cases:

- 2015-05-27
- 2015-09-14
- 2015-09-15
- 2015-10-07
- 2015-10-12
- 2015-11-08
- 2015-11-28
- 2015-12-17
- 2015-12-31
- 2016-01-01
- 2016-01-07
- 2016-01-13
- 2016-01-24
- 2016-01-26
- 2016-02-17
- 2016-02-21
- 2016-02-28
- 2016-03-23
- 2016-04-03
- 2016-04-06
- 2016-04-09
- 2016-04-12



AOD bias:

Tanre 0.20  
Tegen -0.12  
CAMS 0.11



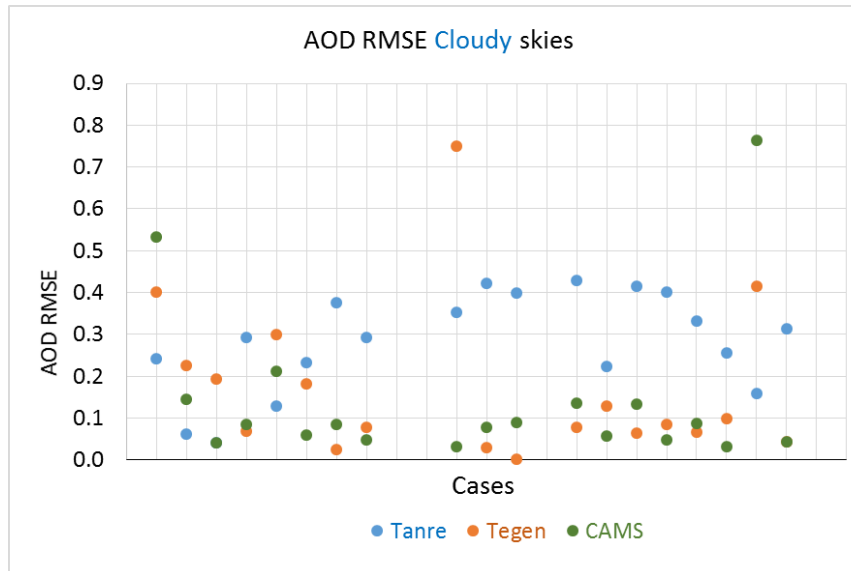
GR bias:

TanreOP -4.8 W/m<sup>2</sup>  
Tanre -11.1 W/m<sup>2</sup>  
Tegen 54.2 W/m<sup>2</sup>  
CAMS 40.7 W/m<sup>2</sup>

## Global radiation and AOD – model vs. Observations cloudy skies

Cases:

- 2015-05-27
- 2015-09-14
- 2015-09-15
- 2015-10-07
- 2015-10-12
- 2015-11-08
- 2015-11-28
- 2015-12-17
- 2015-12-31
- 2016-01-01
- 2016-01-07
- 2016-01-13
- 2016-01-24
- 2016-01-26
- 2016-02-17
- 2016-02-21
- 2016-02-28
- 2016-03-23
- 2016-04-03
- 2016-04-06
- 2016-04-09
- 2016-04-12

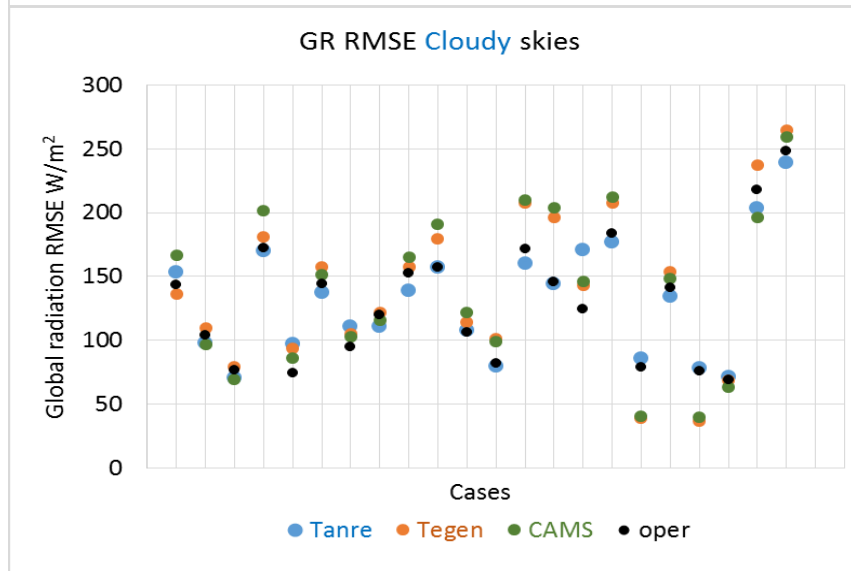


AOD RMSE:

Tanre 0.28

Tegen 0.17

CAMS 0.14



GR RMSE:

TanreOP 131.1 W/m<sup>2</sup>

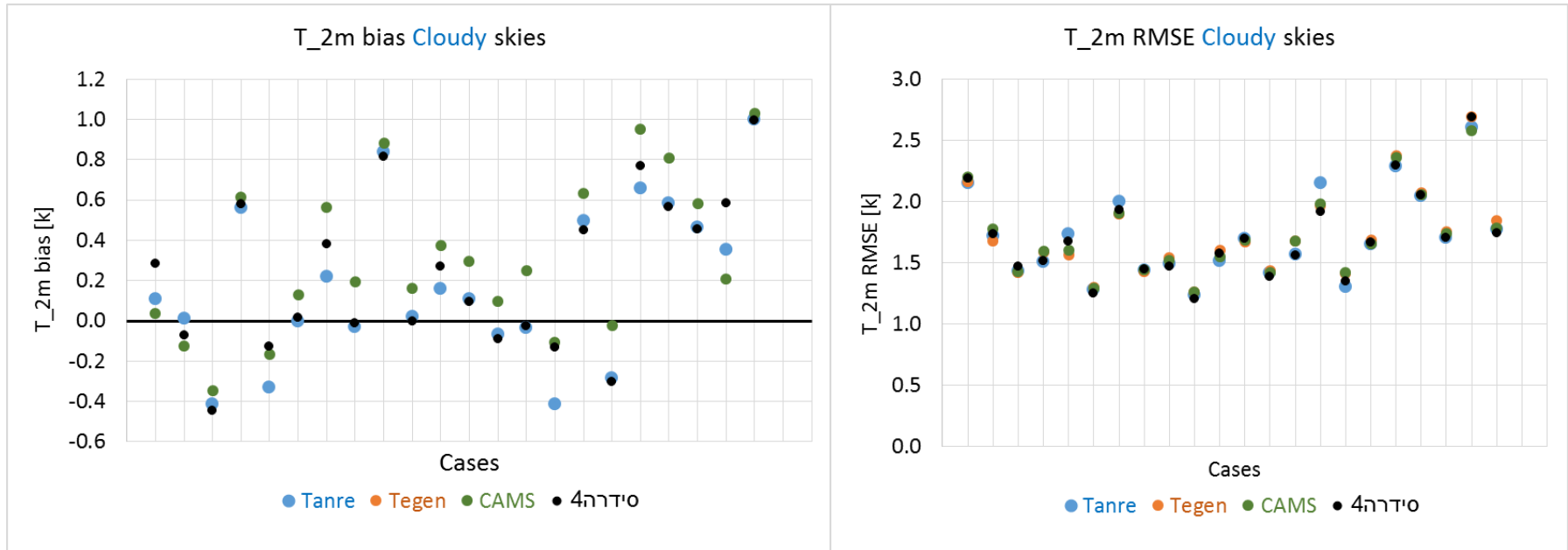
Tanre 131.5 W/m<sup>2</sup>

Tegen 140.5 W/m<sup>2</sup>

CAMS 140.4 W/m<sup>2</sup>



## 2m-Temperature – model vs. Observations cloudy skies



T2m bias:

TanreOP	0.23 K
Tanre	0.18 K
Tegen	0.42 K
CAMS	0.32 K

T2m RMSE:

TanreOP	1.70 K
Tanre	1.71 K
Tegen	1.73 K
CAMS	1.72 K

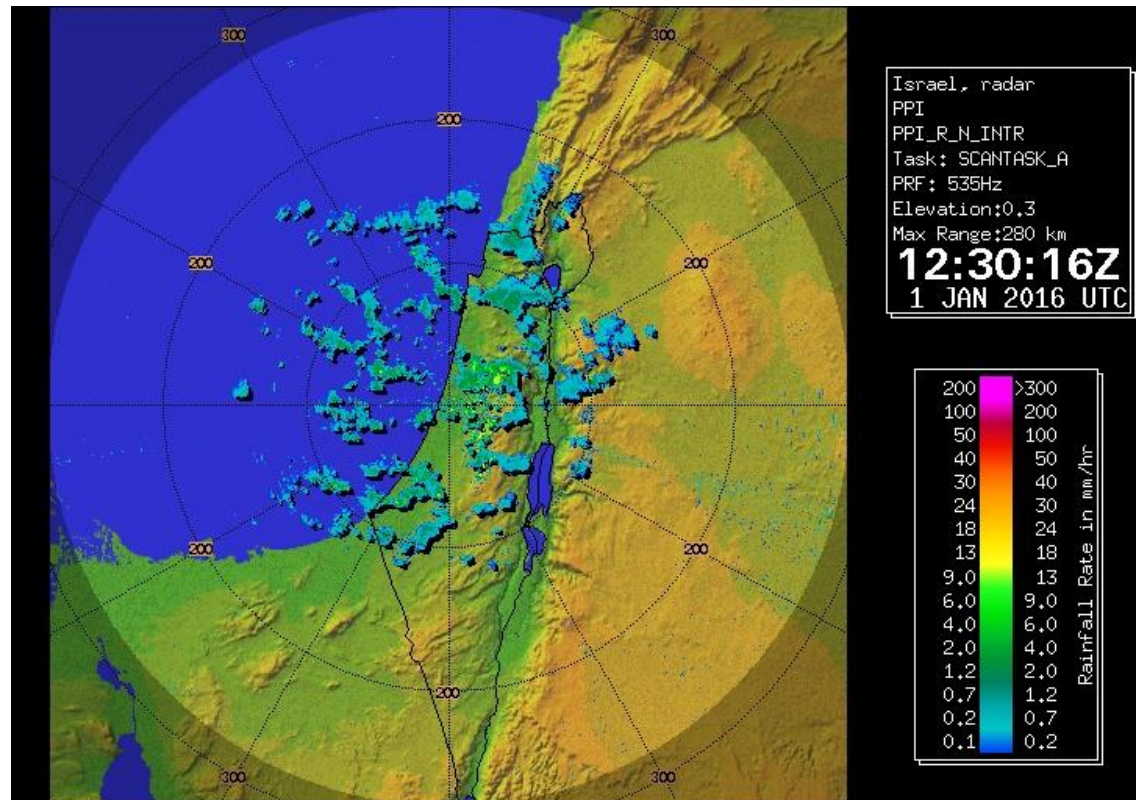
## Rain verification

Verifications using radar corrected with rain gauge measurements  
 (Credit: Elyakom Vadislavski, IMS)

Rainy days

Cases:

- 2015-10-07
- 2015-11-08
- 2015-12-17
- 2015-12-31
- 2016-01-01
- 2016-01-07
- 2016-01-24
- 2016-01-26
- 2016-02-21
- 2016-04-12



## Rain forecast skill verifications

- Cumulative Fractional Skill Score for several rainfall thresholds
- For a 50km radius
- 6h accumulating maps
- Compared with gauge-corrected radar maps

$$\mathbf{FSS} = \sum_{\text{th}} \mathbf{FSS}(\text{th})$$

$$\mathbf{FSS}(\text{th}) = 1 - \frac{\mathbf{BS}(\text{th})}{\mathbf{BS}_{\text{worst}}(\text{th})}$$

$$\mathbf{BS}(\text{th}) = \sqrt{(\mathbf{M}_{i,j} - \mathbf{O}_{i,i})^2}$$

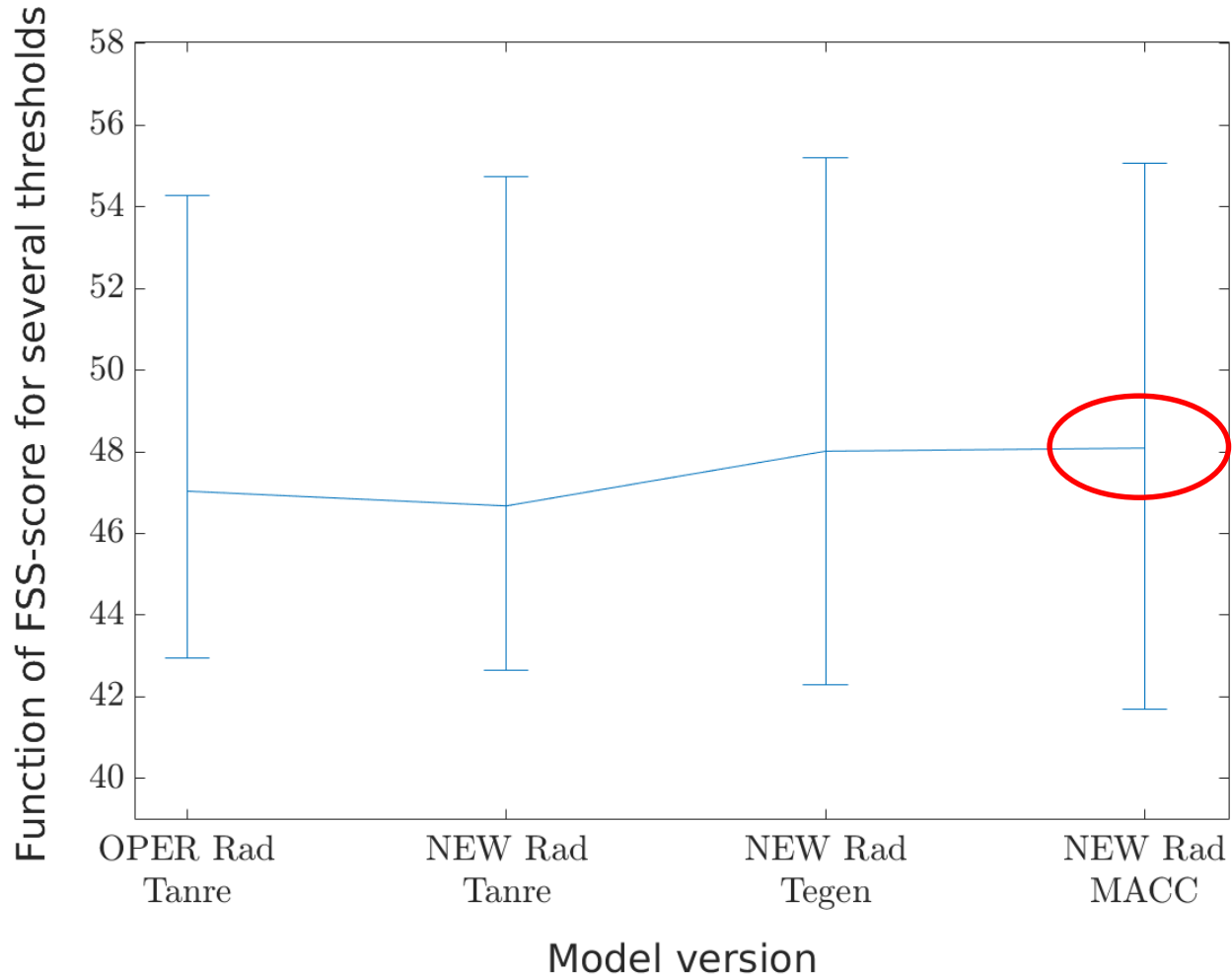
$$\mathbf{BS}_{\text{worst}}(\text{th}) = \sqrt{\mathbf{M}_{i,j}^2 + \mathbf{O}_{i,i}^2}$$

$\mathbf{M}_{i,j}$  = fraction of grid points above threshold in the **model**

$\mathbf{O}_{i,j}$  = fraction of grid points above threshold in **observations**

## Rain forecast skill verifications

Cases:  
 2015-10-07  
 2015-11-08  
 2015-12-17  
 2015-12-31  
 2016-01-01  
 2016-01-07  
 2016-01-24  
 2016-01-26  
 2016-02-21  
 2016-04-12



## Concluding remarks

### Clear sky:

- Tanre climatology has AOD overestimation resulting negative bias of global radiation and surface temperature (-0.5K)
- Slight performance differences between Tegen and CAMS


### Cloudy sky:

- CAMS AOD forecast performs better than other models in terms of bias and RMSE
- The cloud-rad scheme is tuned for the (operational + Tanre) model, thus the GR bias is almost zero in this case – **under estimation of cloud thickness** to compensate for the aerosols over estimation
- GR & T2m RMSE is similar in all models
- Radiation-Aerosols model have small impact on rain forecast

## Bottom line

- The new cloud-rad scheme (RC)<sup>2</sup> perform well and gives better results for the surface temperature compared to the operational scheme.
- It is “safe” to use CAMS as the aerosols input for radiation. In clear skies condition it is good as or better than climatology models.
- After parameter tuning of the cloud-rad scheme, COSMO-CAMS is expected to give the best annual results (lets wait and see....).
- No added computational cost in model run but the pre-processing (int2lm, files download etc.) takes little more time

## Outlook

- New radiation scheme tuning: 10 selected tuning parameters using CALMO methodology. Planned: 1 year run on CSCS/ECMWF computers
- Testing Kinne (2012) climatology **itype\_aerosol = 3** 
- Coupling CAMS aerosols to microphysics
- Implementation of ICON-ART prognostic aerosols in COSMO
- And much more...