Cloud and aerosol effects on radiative fluxes and meteorological characteristics at ground according to measurements and modelling

Natalia Chubarova[1,2], Marina Shatunova[1], Alexei Poliukhov[1,2], Julia Khlestova[1,2], Gdali Rivin[1,2], Ulrich Görsdorf[3], Ralf Becker[3], Harel Muskatel[4], Ulrich Blahak[5], Daniel Rieger[5], Alexander Makshtas[6]

1 - Hydrometeorological Centre of Russia, 11-13, B. Predtechensky per., Moscow, 123242, Russia
2 –Faculty of Geography, Moscow State University, 119991, Moscow, Russia
3 - Deutscher Wetterdienst, Meteorologisches Observatorium Lindenberg, Am Observatorium 12, D-15848 Tauche, Germany
4 - Israel Meteorological Service, P.O box 25, Bet-Dagan, 5025001, Israel
5 - German Weather Service, Research and Development, Numerical Models Division, Deutscher Wetterdienst Frankfurter Str. 135, 63067 Offenbach, Germany
6. – Arctic and Antarctic Research Institute, Bering str, 38, 199397, St. Petersburg, Russia

ICCARUS2019, Offenbach, March 18 – 20, 2019

OUTLINE:

CLEAR SKY CONDITIONS: AEROSOL RADIATIVE EFFECTS

1. Testing different kinds of aerosol climatologies in various optical conditions.
2. Radiative effects of aerosol over COSMO ENA domain
3. Implementation of the ICON-ART dust aerosol. Aerosol and radiative effects.
4. Case studies of urban aerosol from COSMO-ART model over Moscow. Discussion

Verification of Macv2 aerosol climatology in COSMO model over ENA domain in all conditions.

CLOUDY CONDITIONS: CLOUD-AEROSOL-RADIATIVE EFFECTS

1. Operational scheme: analysis of cloud characteristics from surface observations (CLOUDNET standard retrieval algorithm) over Lindenberg and their radiative effects.
2. New model experiments with the experimental cloud-aerosol scheme over Moscow. Radiative effects.
3. New model experiments with the experimental cloud-aerosol scheme on cloudiness and precipitation over Pyeongchang area (South Korea) .

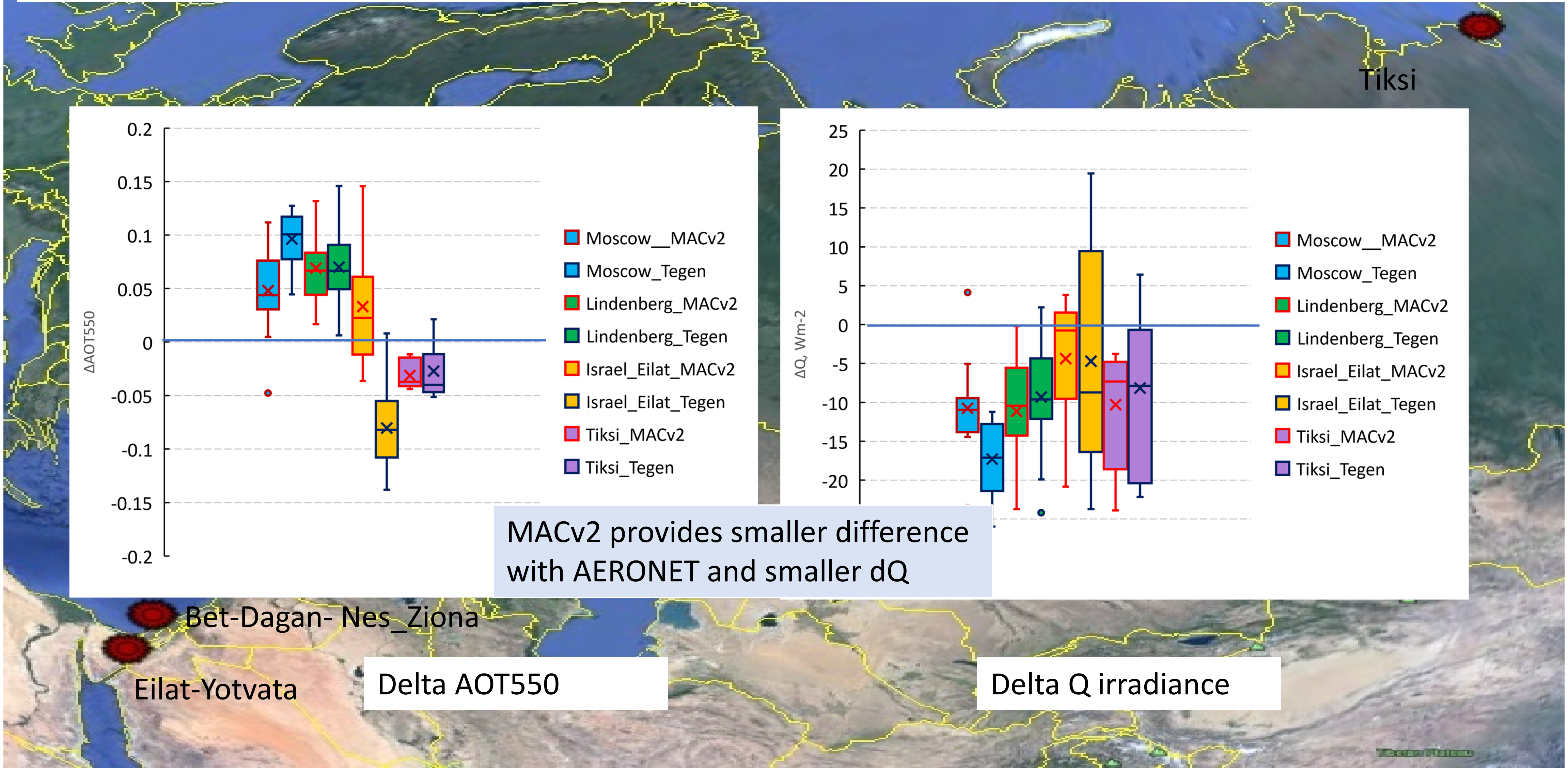
Clear sky conditions

What are the approaches of aerosol accounting in the COSMO model?

AEROSOL DATASETS	COMPUTER TIME	ACCURACY
AEROSOL CLIMATOLOGIES: TANRE TEGEN **MACv2 (or Kinne or AEROCOM)**	EFFICIENT	LARGER UNCERTAINTY FOR PARTICULAR CONDITIONS EVEN FOR THE BEST CLIMATOLOGIES
DIRECT AEROSOL SIMULATIONS (COSMO-ART /ICON_ART)	TIME CONSUMING	GOOD BUT DEPENDS ON OUR KNOWLEDGE ON PRECURSORS
AEROSOL FORECAST DATA FROM OTHER SOURCES: (CAMS, FOR EXAMPLE)	EFFICIENT	GOOD BUT ALSO MAY DEPENDS ON OUR KNOWLEDGE ON PRECURSORS

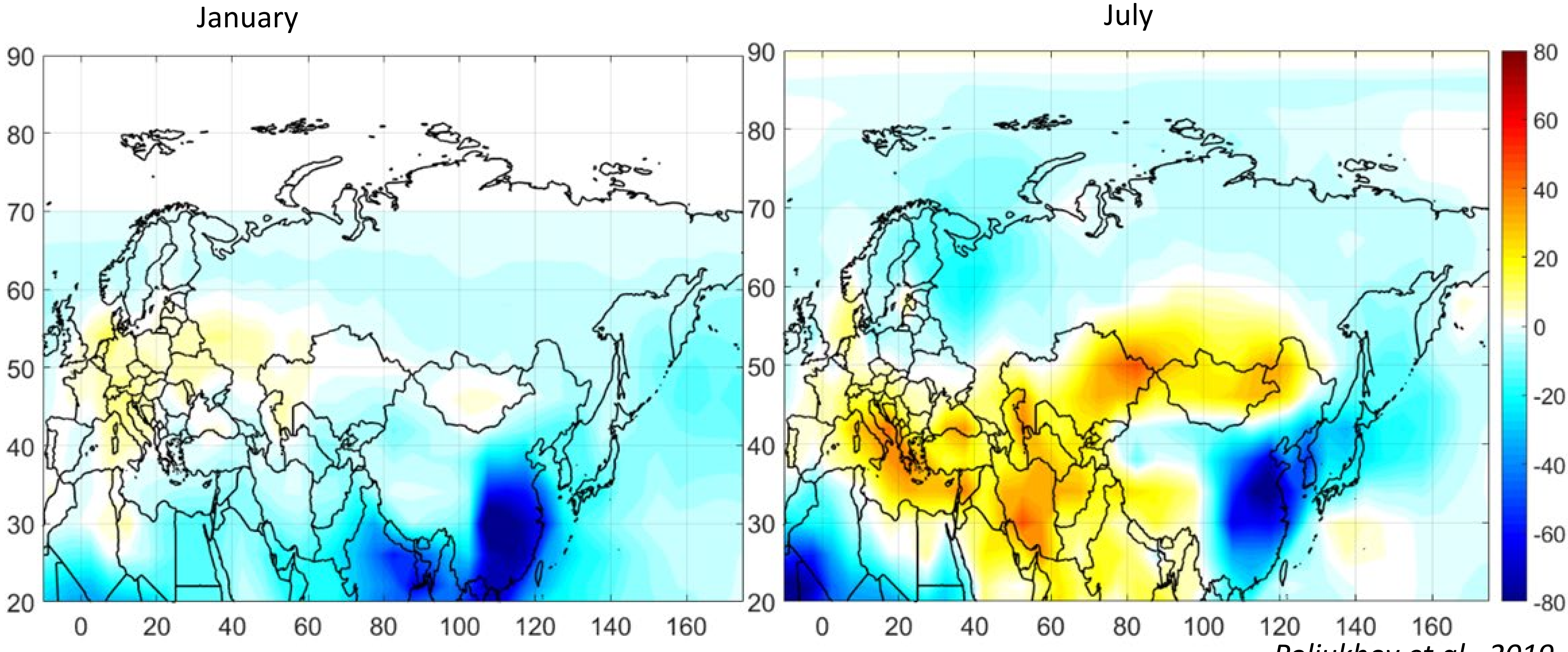
TESTING AEROSOL AND RADIATION:

Differences between AOT from aerosol climatologies (Macv2, Tegen) and AERONET, and their effects on global shortwave irradiance Q according to RT simulations at different sites



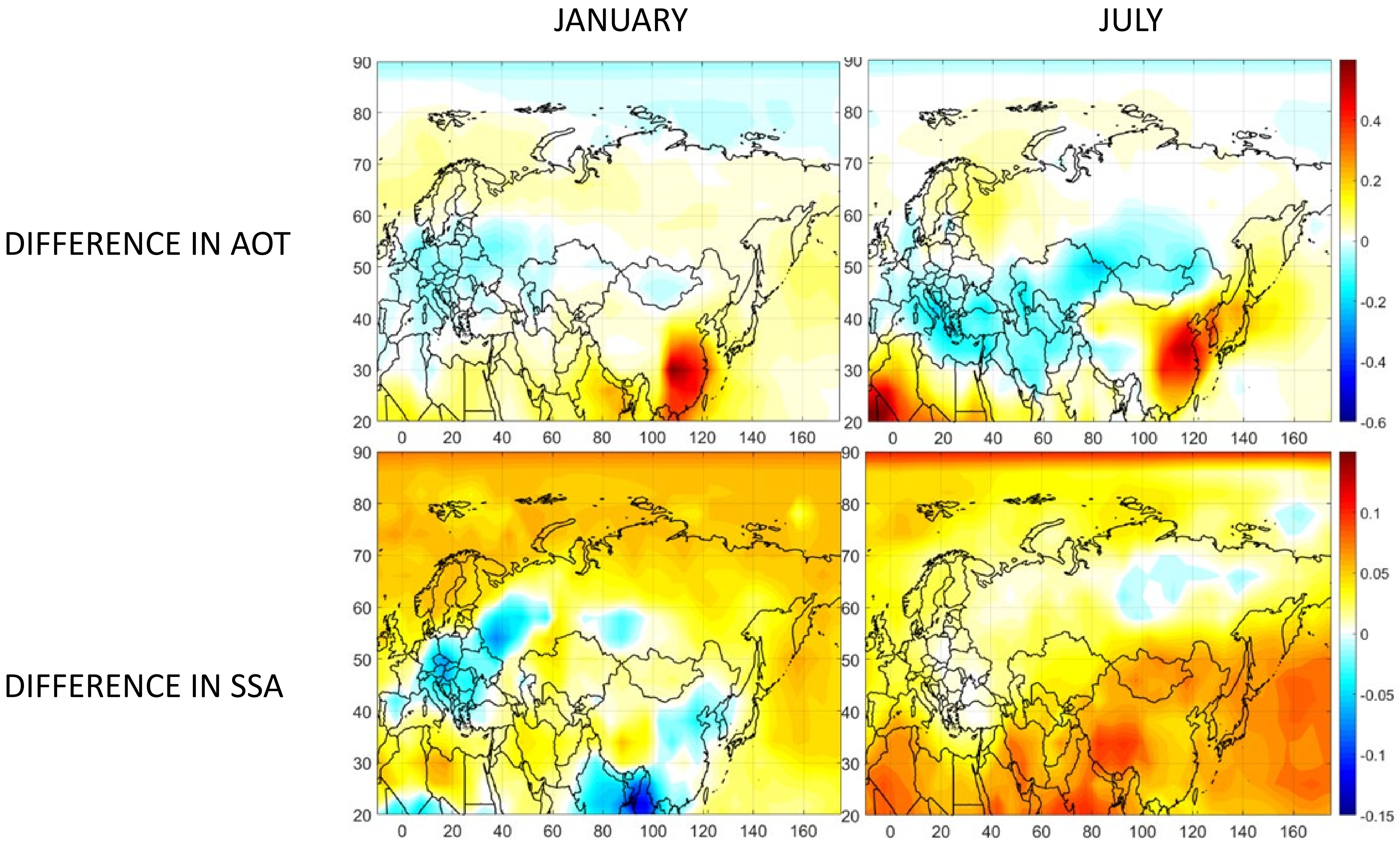
Noon difference in solar irradiance (Wm^{-2}) due to different aerosol climatologies. RT model simulations.

$\Delta Q = Q_{MAcv2} - Q_{Tegen}$



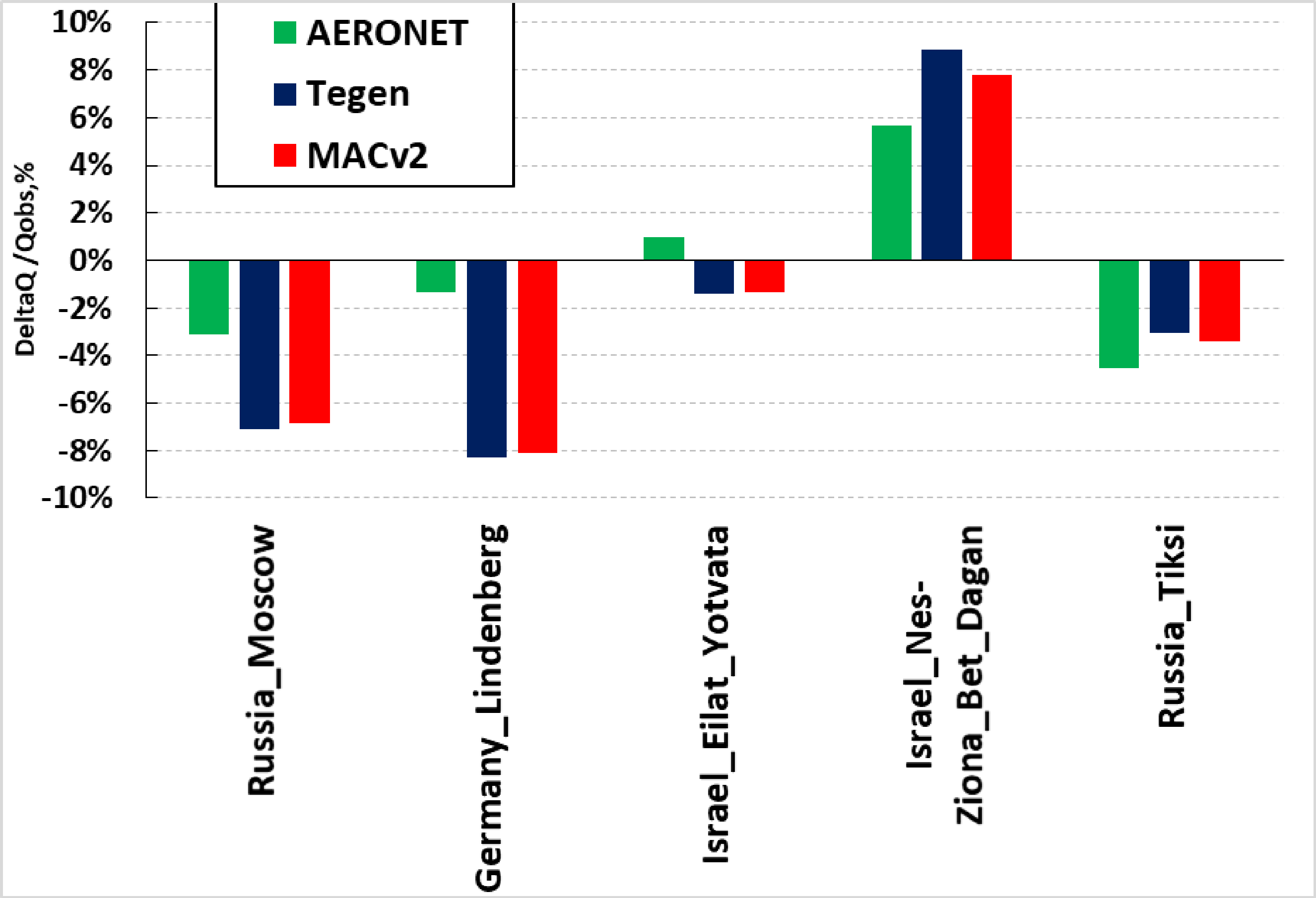
Poliukhov et al., 2019

Difference in AOT and SSA between MACv2 and Tegen aerosol climatologies

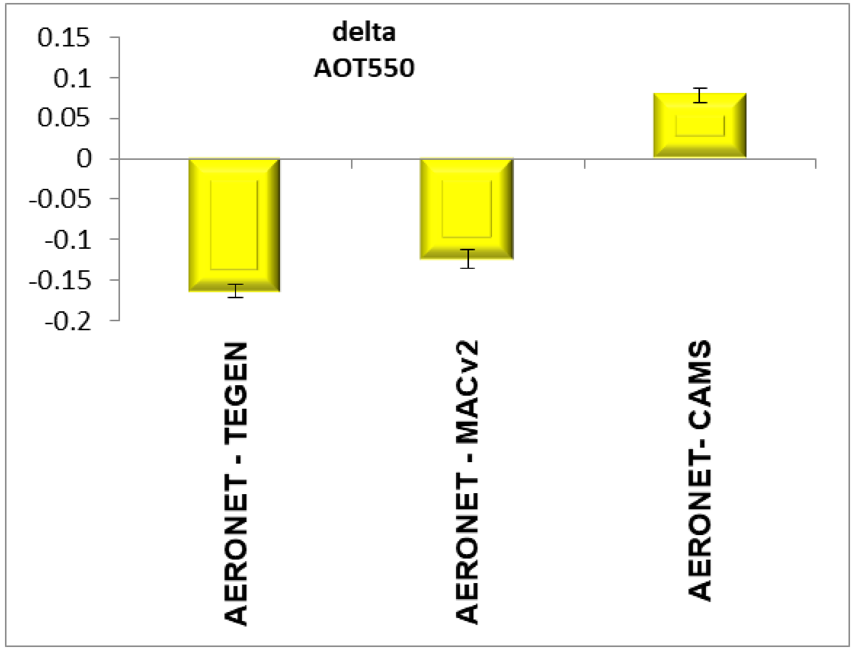


Poliukhov et al., 2019

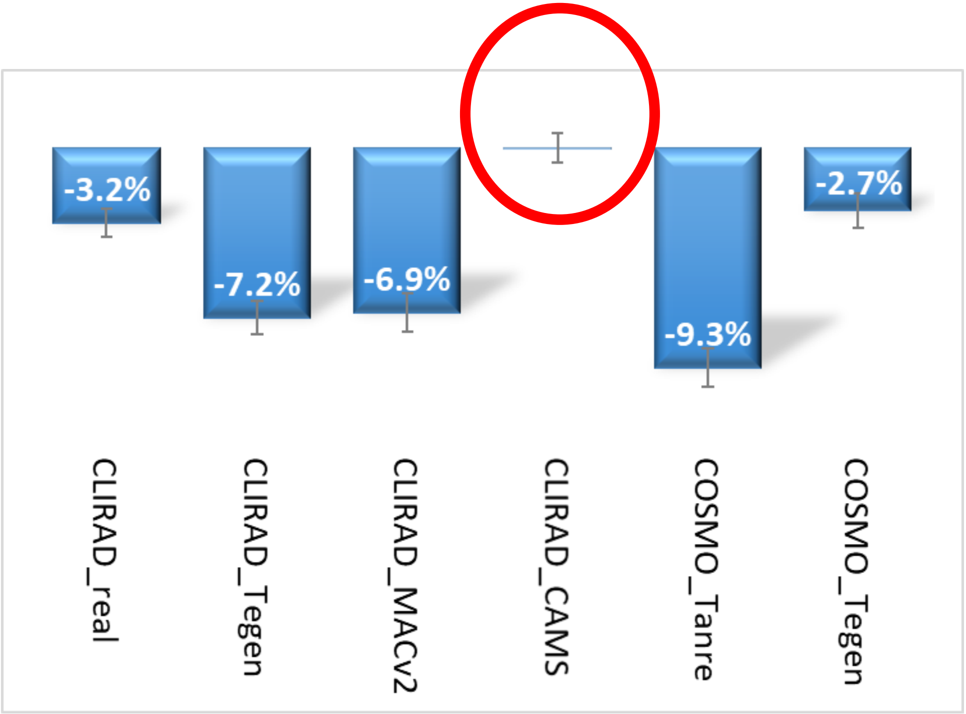
Relative difference between RT modelling (CLIRAD(FC05)-SW) with different aerosol climatologies and shortwave irradiance measurements.



Difference between AERONET AOT observations and Tegen (Macv2, CAMS*) AOT climatologies. Moscow

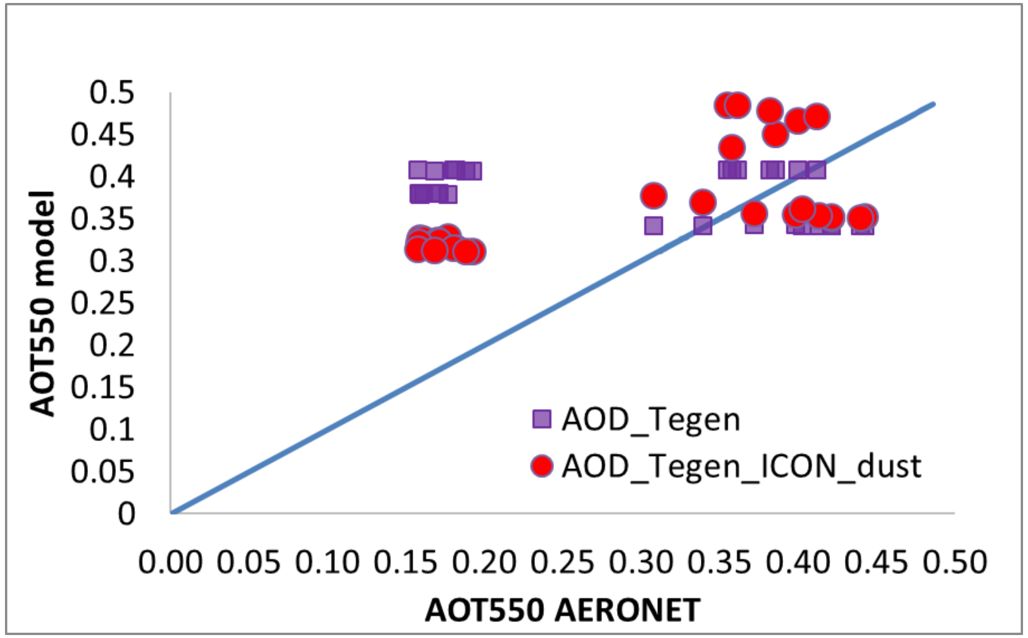


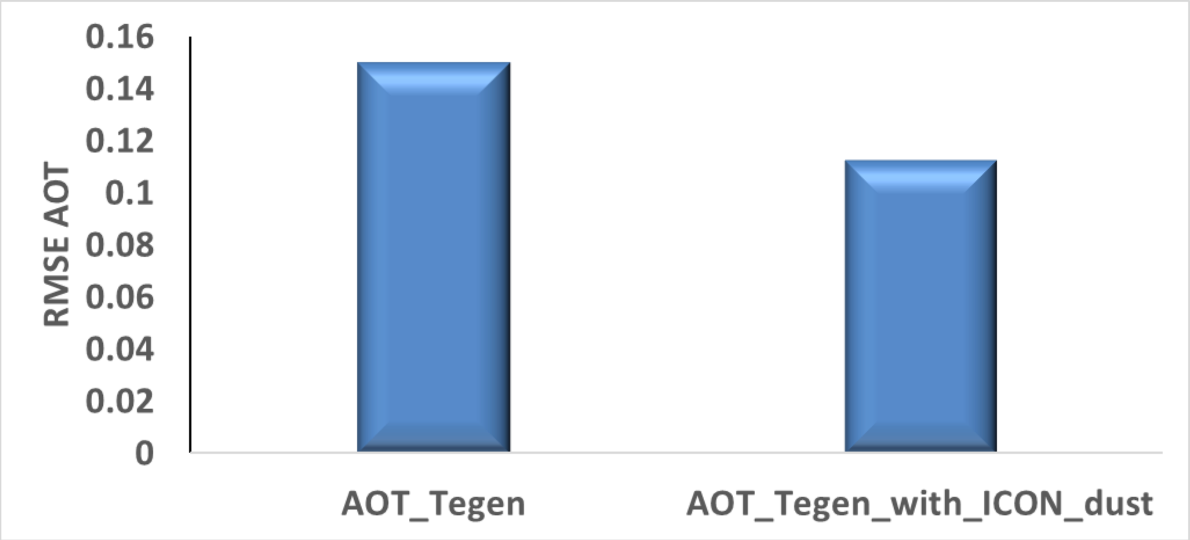
Relative difference between RT modelling (CLIRAD(FC05)-SW) with different aerosol climatologies and aerosol CAMS dataset with shortwave irradiance measurements. Moscow

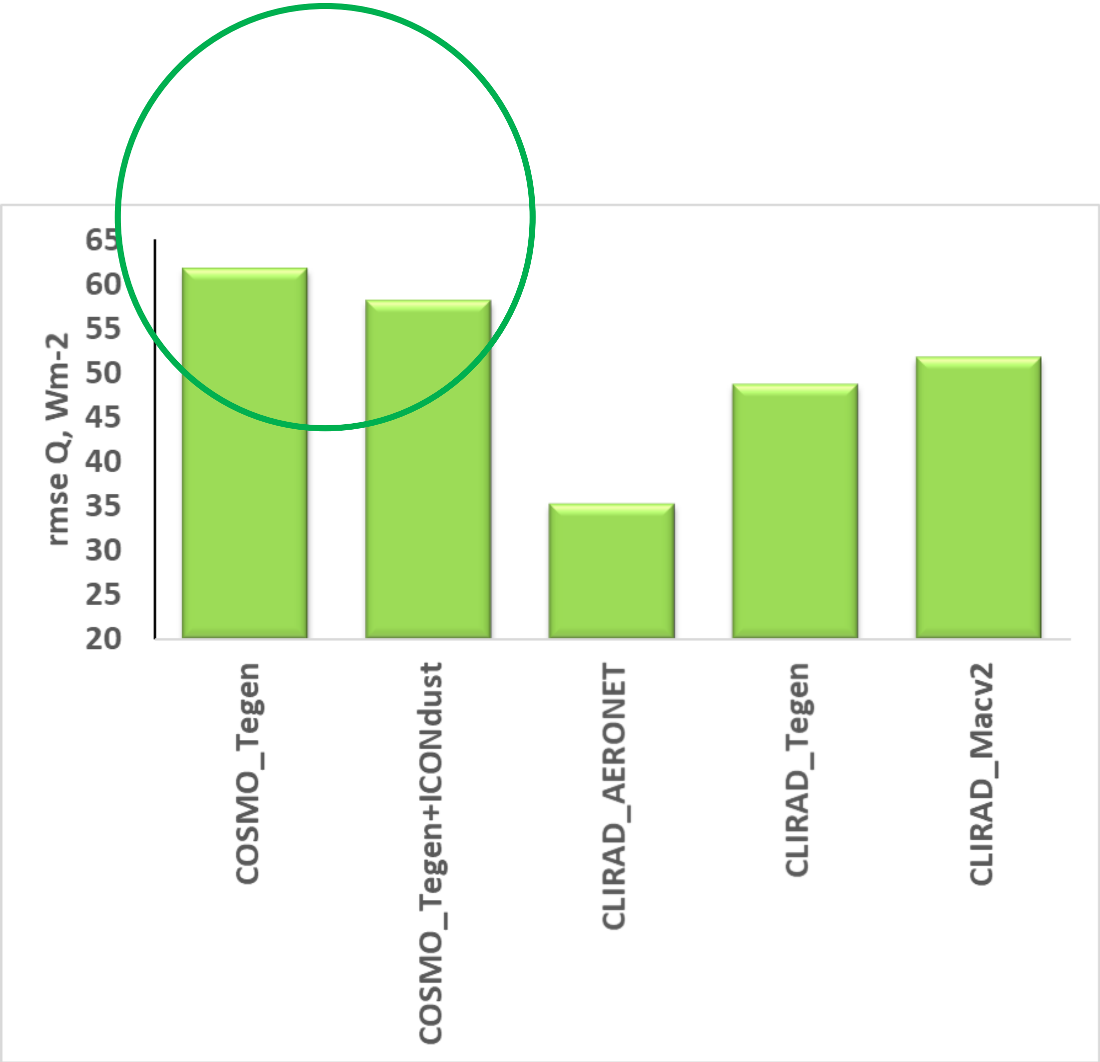


***-CAMS** - Copernicus Atmosphere Monitoring Service aerosol

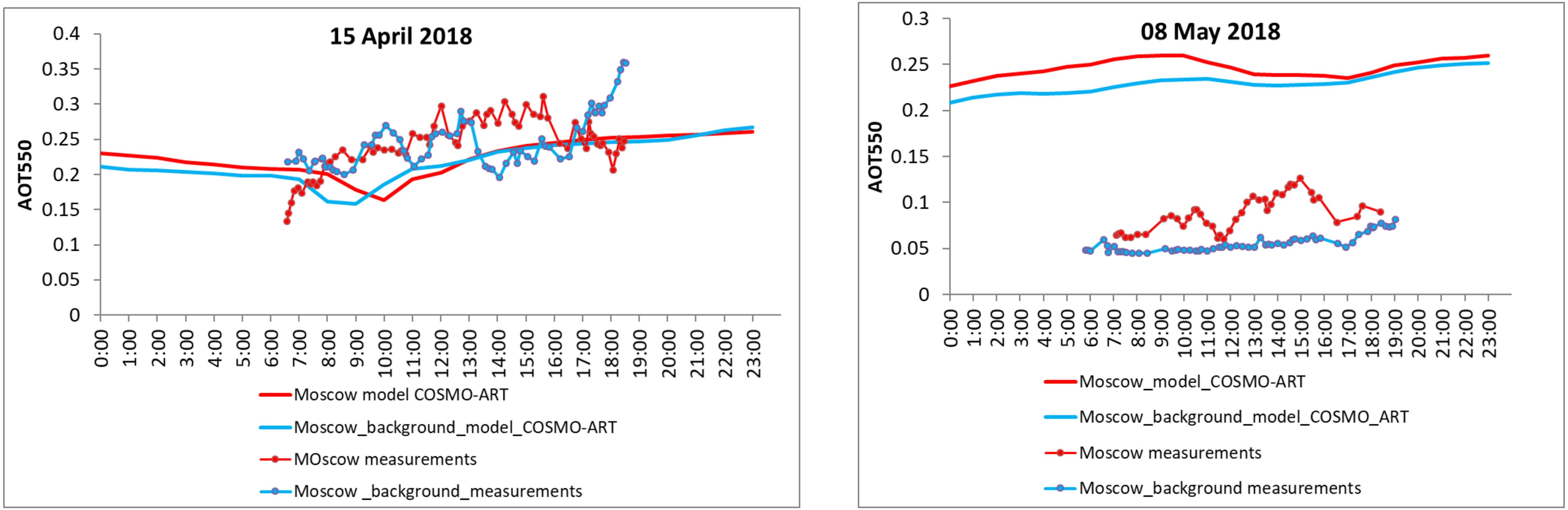
ICON DUST EXPERIMENTS OVER NES-ZIONA (Israel)





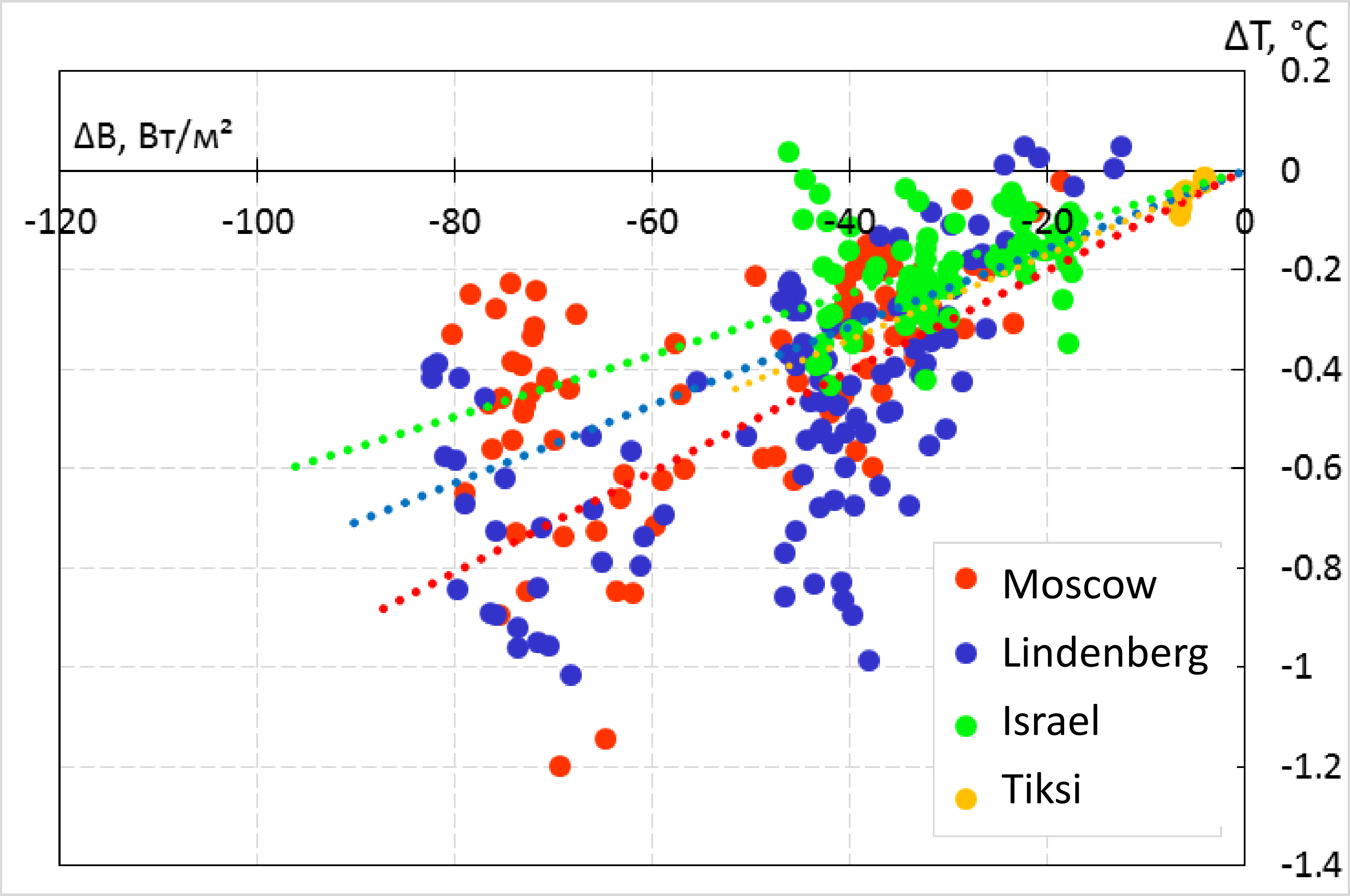


COSMO-ART simulations (*lines*) for urban (red color) and background conditions (blue color) and comparisons with AOT observations (*dots*) from the two AERONET sites (MSU Moscow and Zvenigorod (background)). 2018. TNO 2010



Credits: Alexander Kirsanov for COSMO-ART simulations

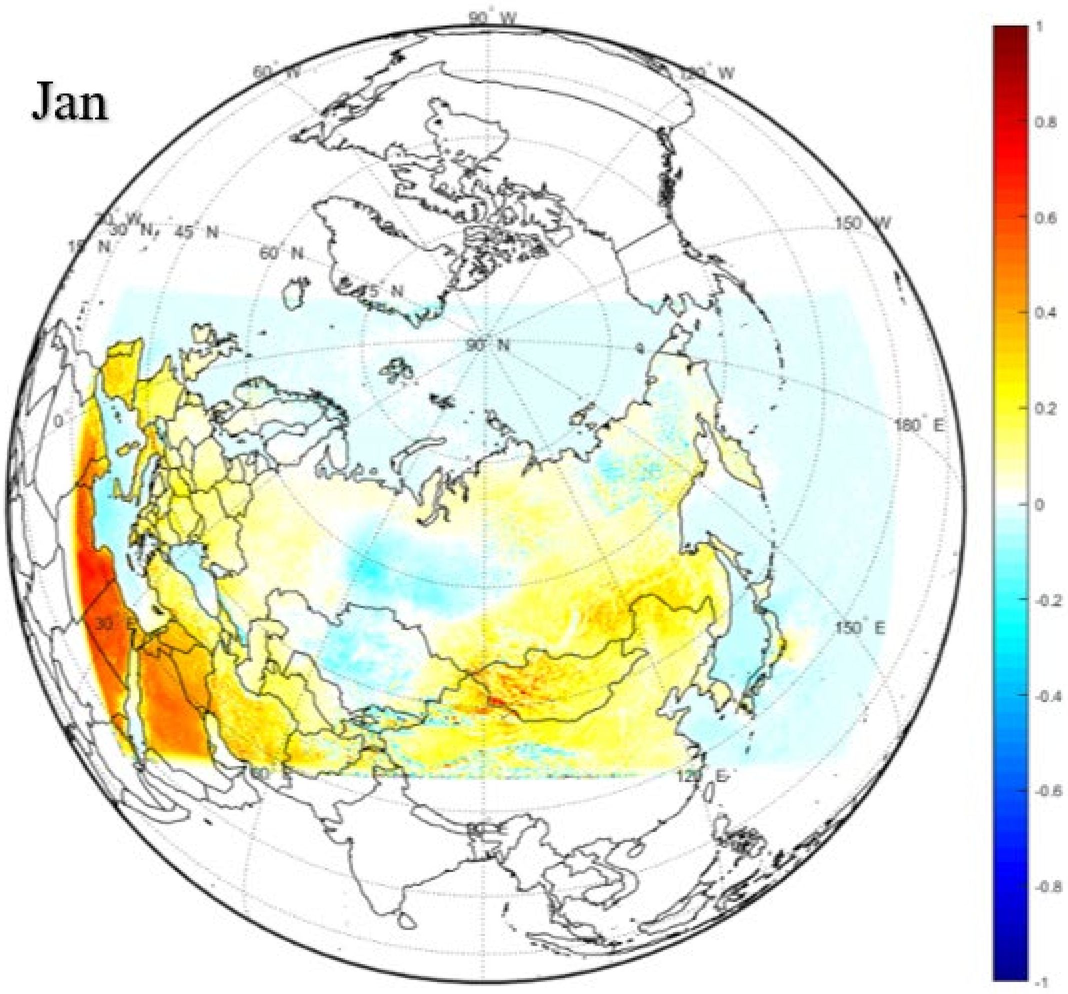
Temperature sensitivity to the aerosol radiative effects at ground for different aerosol types

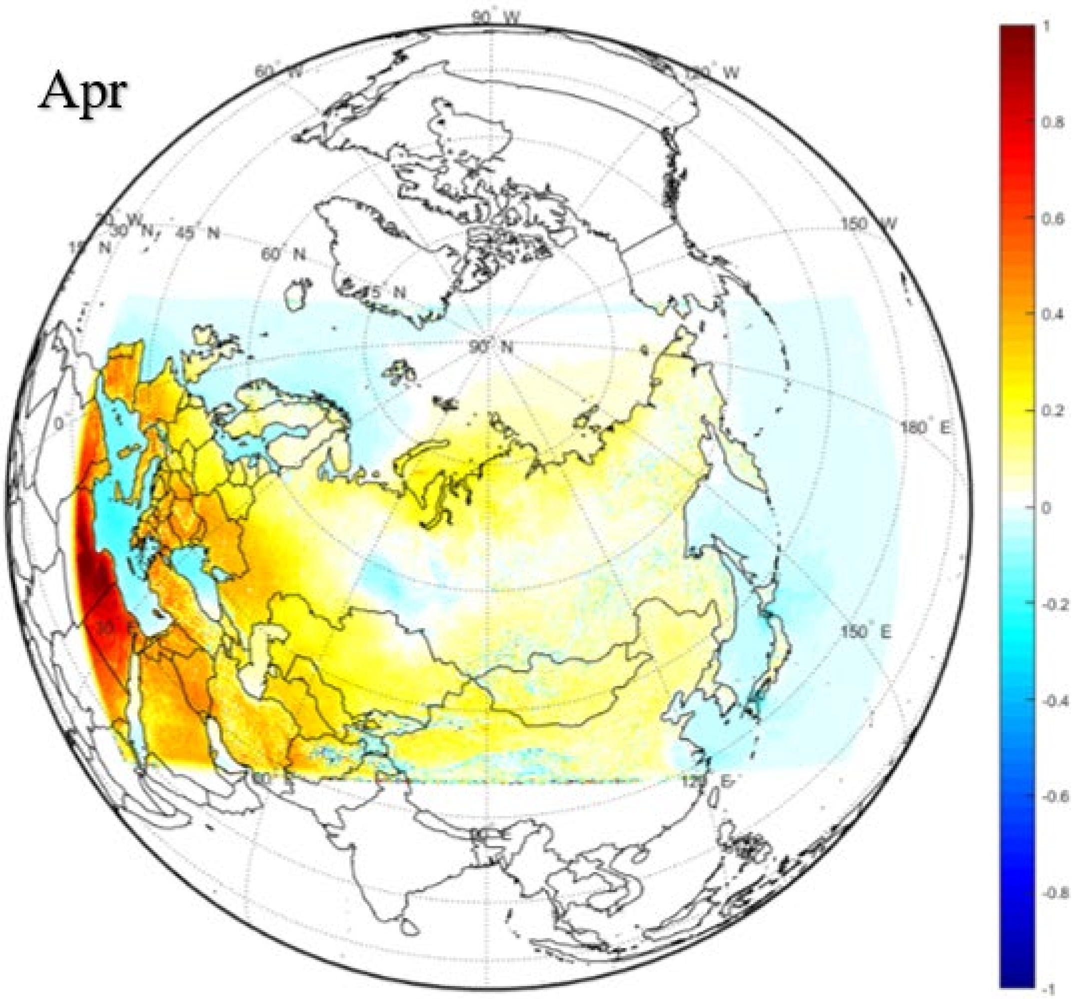


Poliukhov et al., 2019

Verification of Macv2 aerosol climatology

All sky conditions, temperature at 2 m (T2M): delta T2M=T2M(MACv2)-T2M(Tanre)

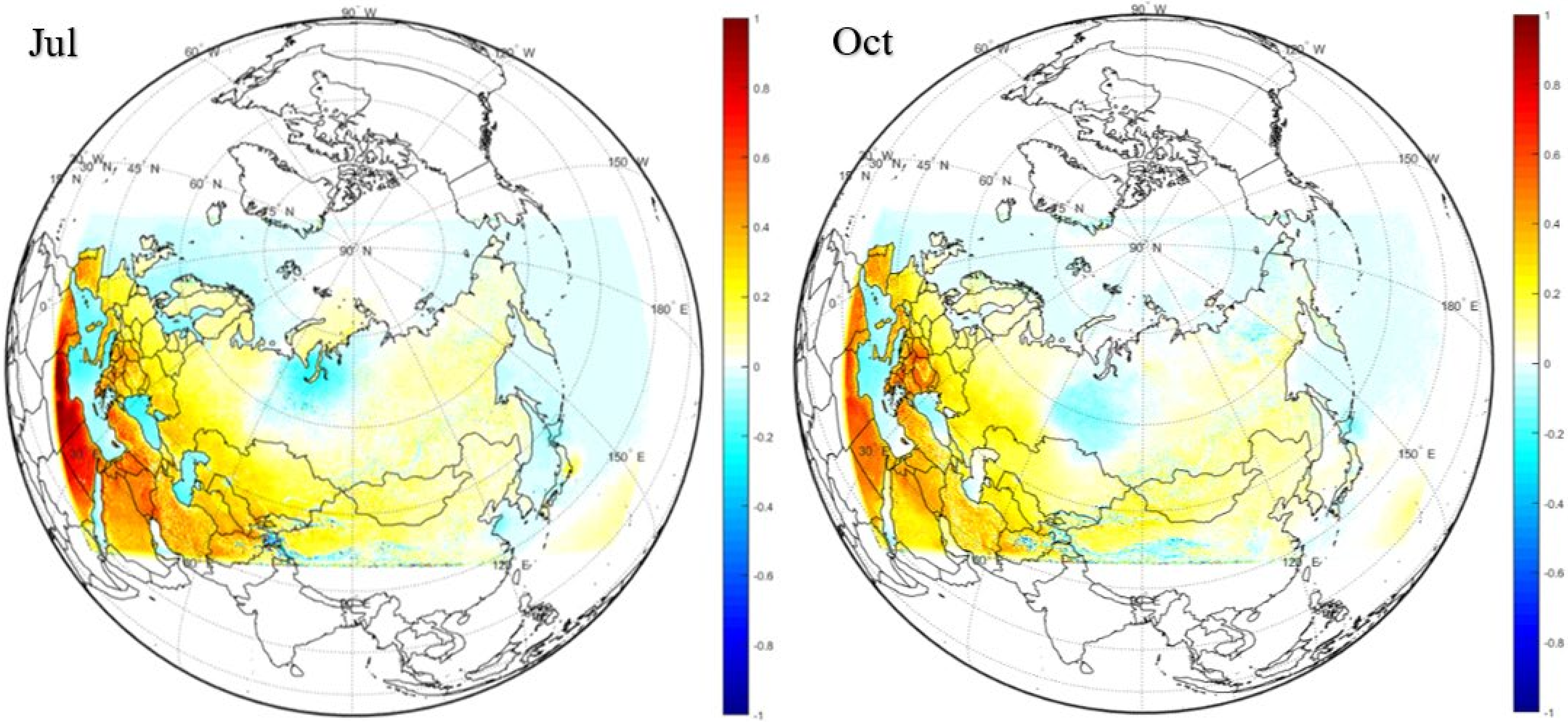




ENA region with 13 km step, COSMO version 5.05, for 2017

Verification of Macv2 aerosol climatology

All sky conditions, temperature at 2 m (T2M): delta T2M=T2M(MACv2)-T2M(Tanre)



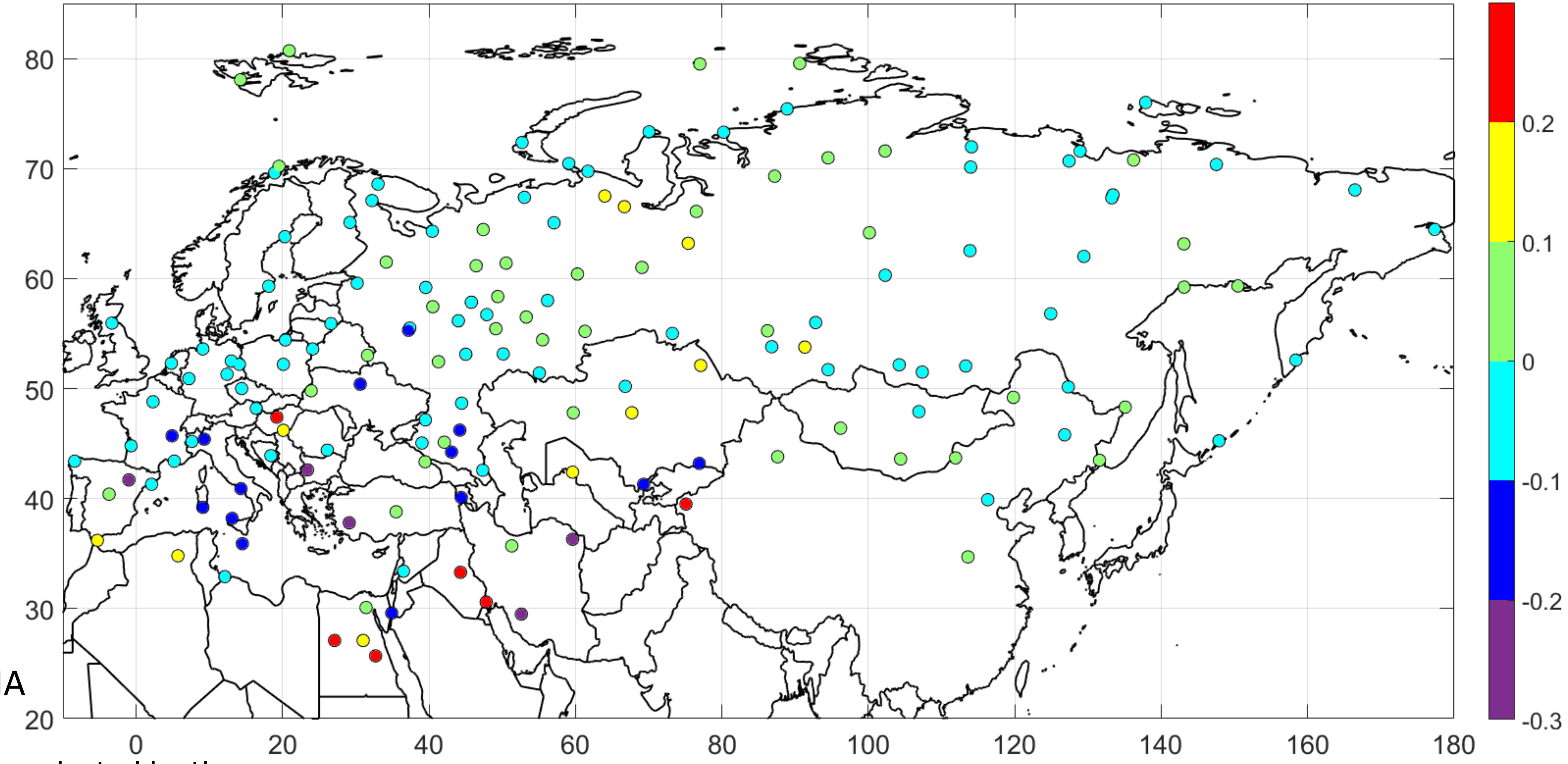
ENA region with 13 km step, COSMO version 5.05 for 2017

Verification for temperature T2M:

Blue points mean better results for Macv2 aerosol climatology compared with Tanre

$$\text{Delta}RMSE = \sqrt{\Sigma\,(T_{Macv2} - T_{obs})^2} - \sqrt{\Sigma\,(T_{Tanre} - T_{obs})^2}$$

Comparisons with Tanre aerosol climatology



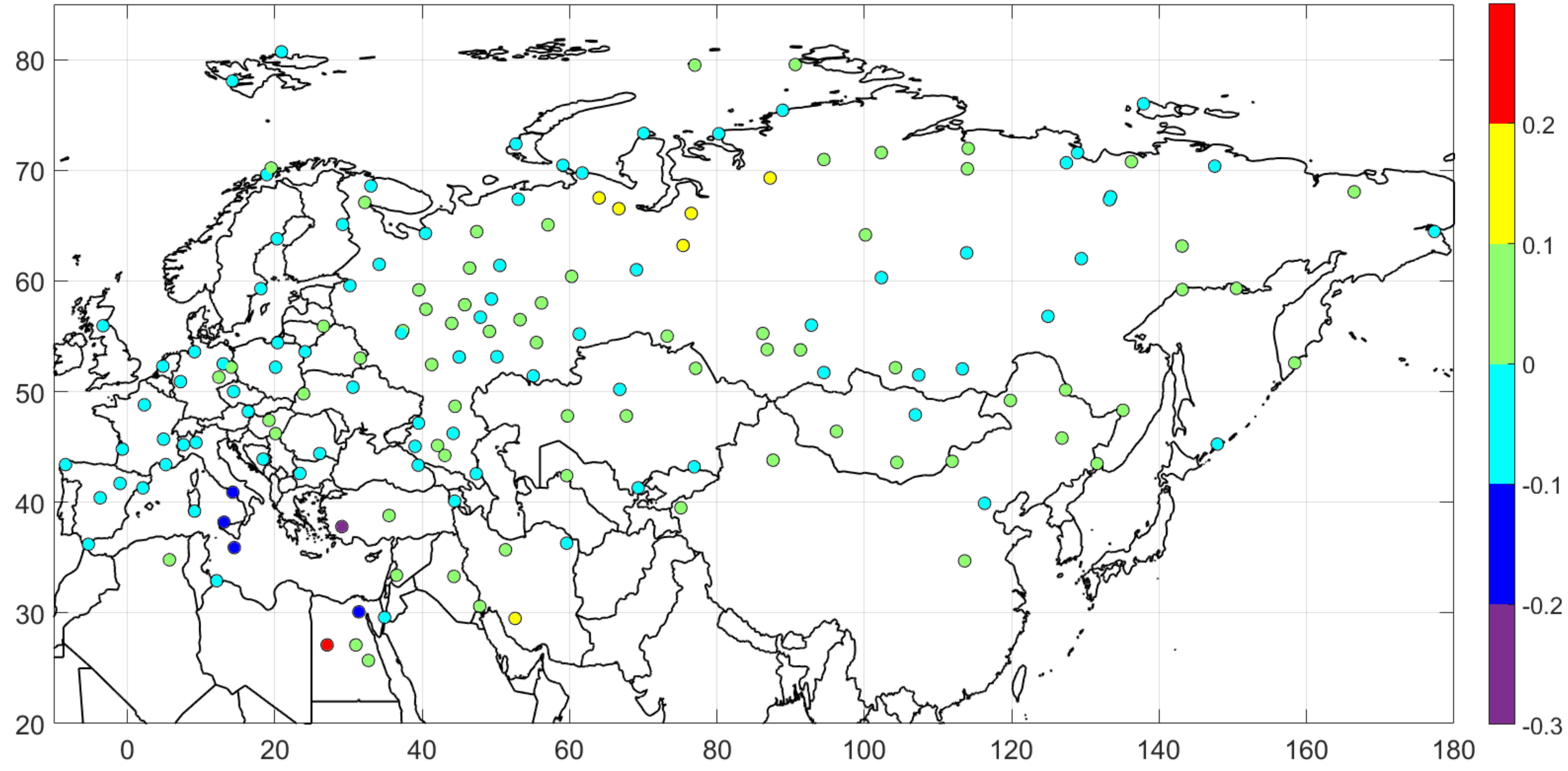
For 163 stations over ENA

Nodes from the model were selected by the neighborhood method

Verification for temperature T2M: **Blue points mean better results for Macv2 aerosol climatology compared with Tegen**

$$\mathrm{Delta}RMSE = \sqrt{\Sigma\,(T_{Macv2} - T_{obs})^2} - \sqrt{\Sigma\,(T_{Tegen} - T_{obs})^2}$$

Comparisons with Tegen aerosol climatology



July

For 163 stations over ENA

CONCLUSIONS FOR THE PART DESCRIBING AEROSOL DIRECT EFFECT:

- Macv2 aerosol climatology provides better agreement with AOT and radiative observations.
- The application of ICON-DUST aerosol provides smaller RMSE. But better agreement is observed not always.
- The best agreement with radiative observations was obtained with prognostic CAMS aerosol dataset.
- COSMO-ART has a good ability in modelling urban columnar AOT with TNO2010 emissions.
- Temperature (T2M) verification with Macv2 climatology provides better agreement with observations over Europe, large territory of Russia.

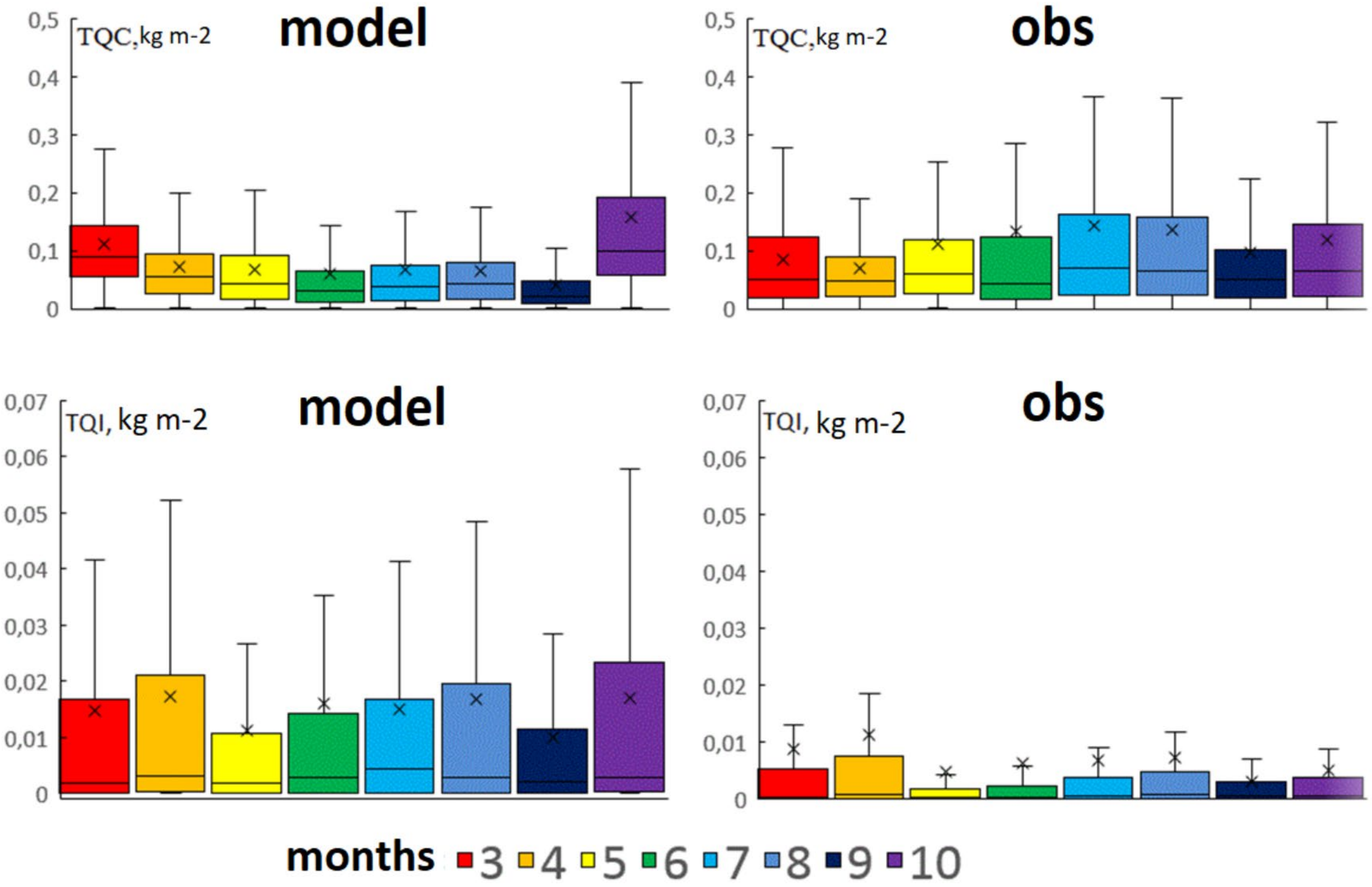
CLOUDY CONDITIONS:

Lindenberg, 2016

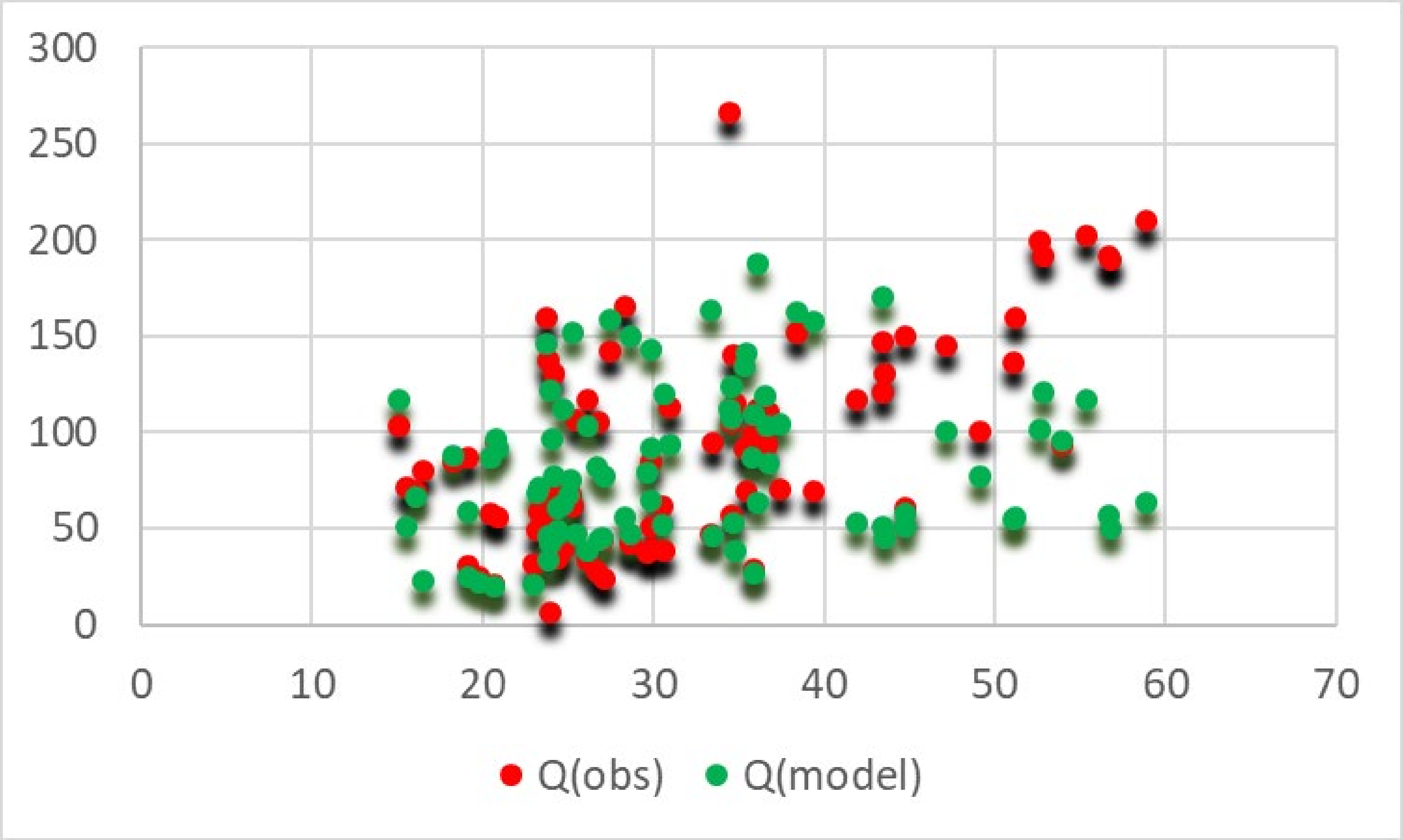
OBSERVATIONS – CLOUDNET ALGORITHM

TOTAL WATER CONTENT

TOTAL ICE CONTENT



The comparisons of model and observed shortwave irradiance (Wm^{-2}) in overcast conditions as a function of solar elevation. Lindenberg.



1-hour averages.

Evaluation of the non direct cloud-aerosol effect

Moscow experiment – April 2018

Measurements:

MSU Meteorological Observatory, Kipp&Zonen CNR4

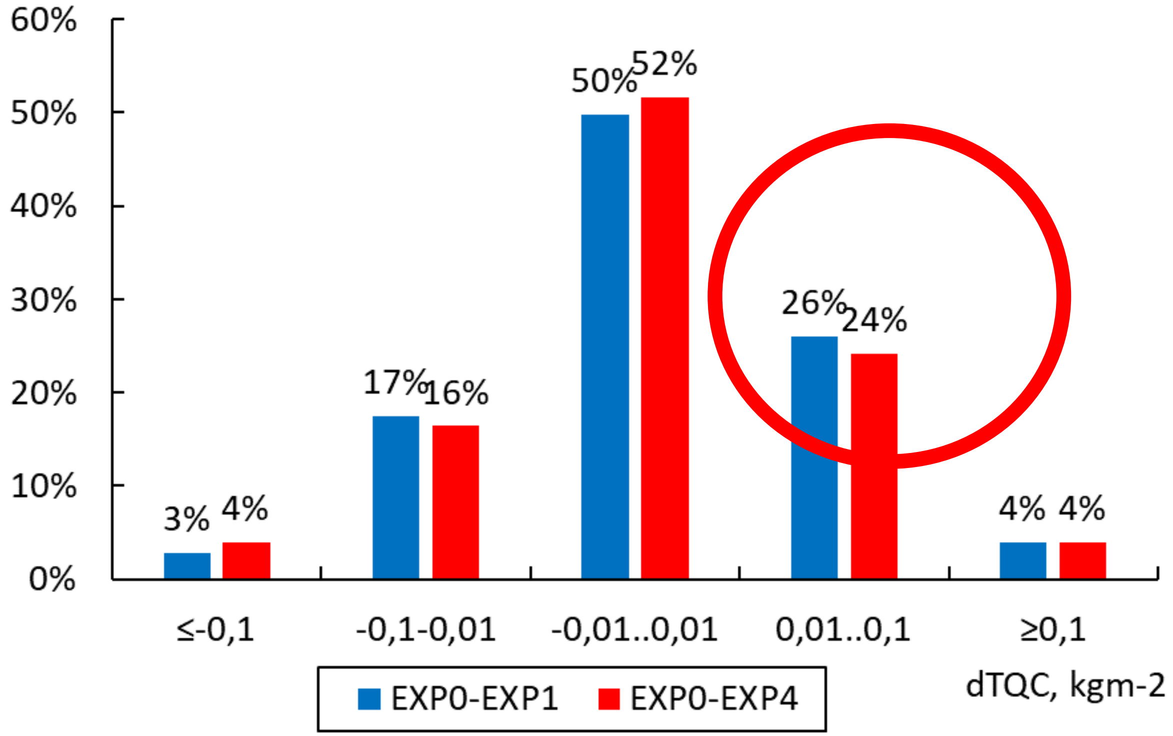
Model experiments:

E0 – standard scheme

E1 – new cloud-radiation scheme with Tegen

E4 – new cloud-radiation scheme with $N_0=5*10^8\ m^{-3}$.

Frequency distribution of total water content (TQC) differences:
TQC(Exp0-standard) – TQC(Exp1)
TQC(Exp0-standard) – TQC(Exp4)

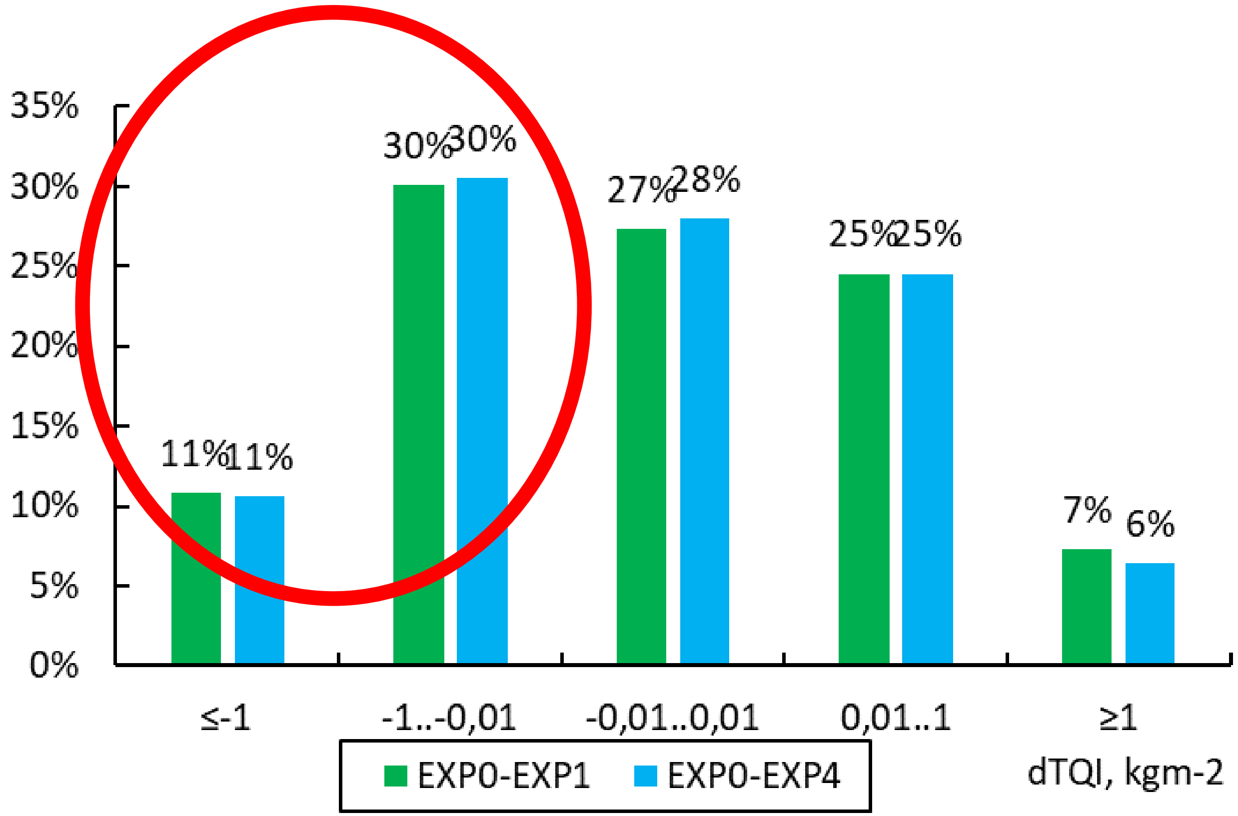


Mean difference:
-0.0054 kgm-2 for EXP1;
-0.0029 kgm-2 for EXP4.

Model experiments:
E0 – standard
E1 – new cloud-radiation scheme with Tegen
E4 – new cloud-radiation scheme with N_0=5*10^8 m-3

Smaller TQC with new scheme.

Frequency distribution of total ice content (TQI) differences:
TQI=TQI(Exp0-standard) – TQI(Exp1)
TQI=TQI(Exp0-standard) – TQI(Exp4)



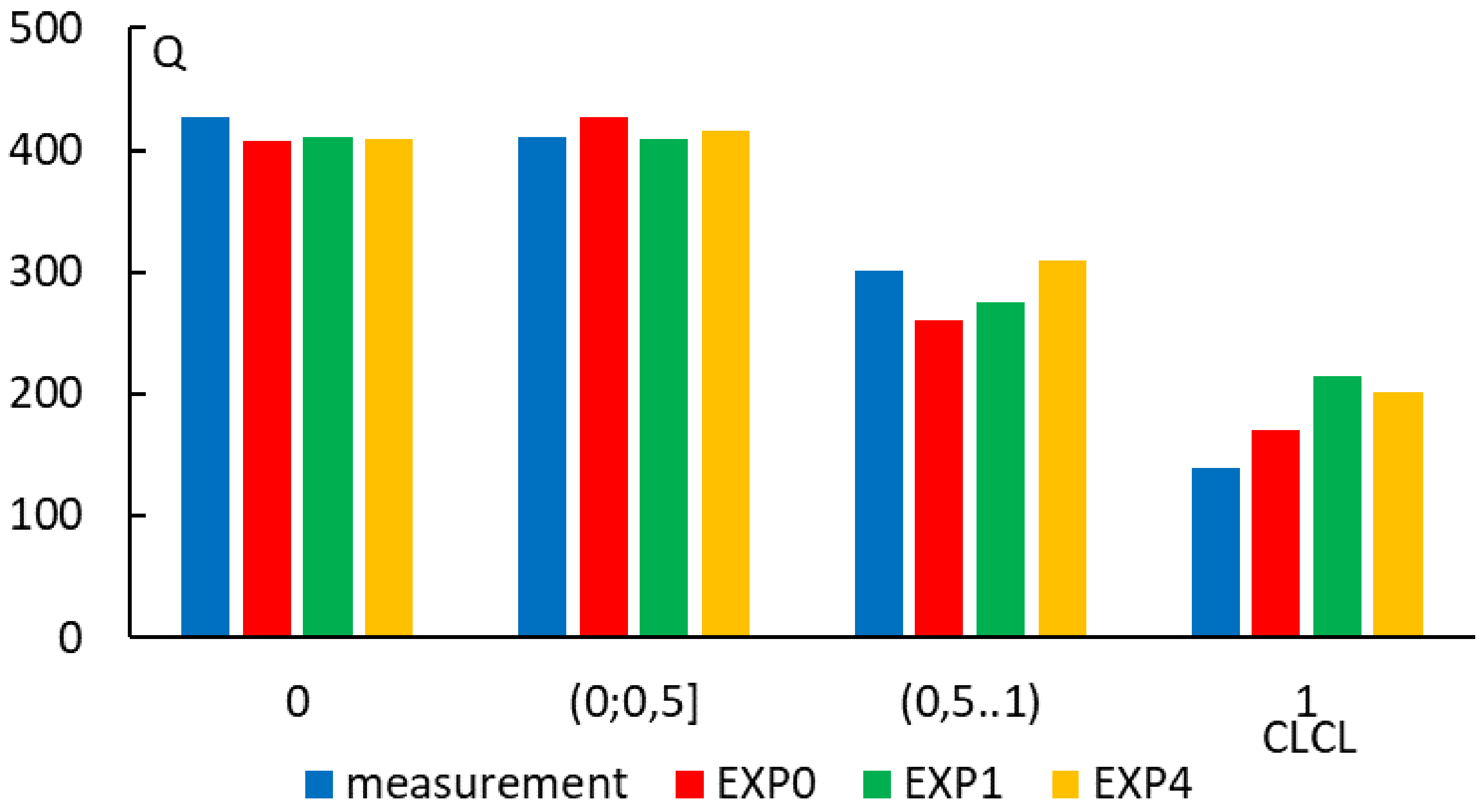
Model experiments:

E0 – standard

E1 – new cloud-radiation scheme with Tegen

E4 – new cloud-radiation scheme with $N_0=5*10^8$ m-3

Shortwave irradiance for different low layer cloud amount bins according to observations and different model experiments. Moscow.



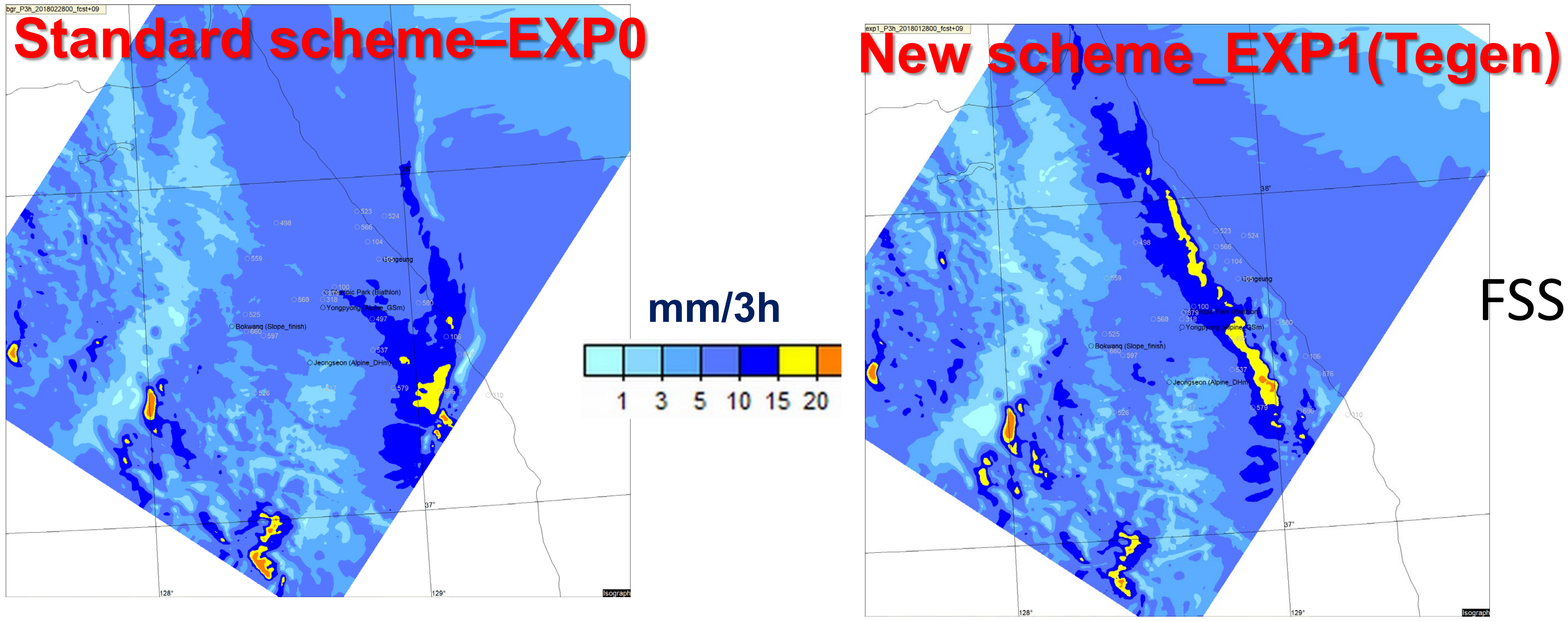
Impact on precipitation forecast: the experiments over Pyeongchang area (KOREA)

COSMO-ICE005, 28.02.20180, 00UTC

- ❑ **Precipitation localization and amount**

  3h accumulated precipitation, fcst+09

FSS=0.73



FSS=0.83

Experiments were made within the framework of T2(RC)2 and ICE-POP2018 projects.

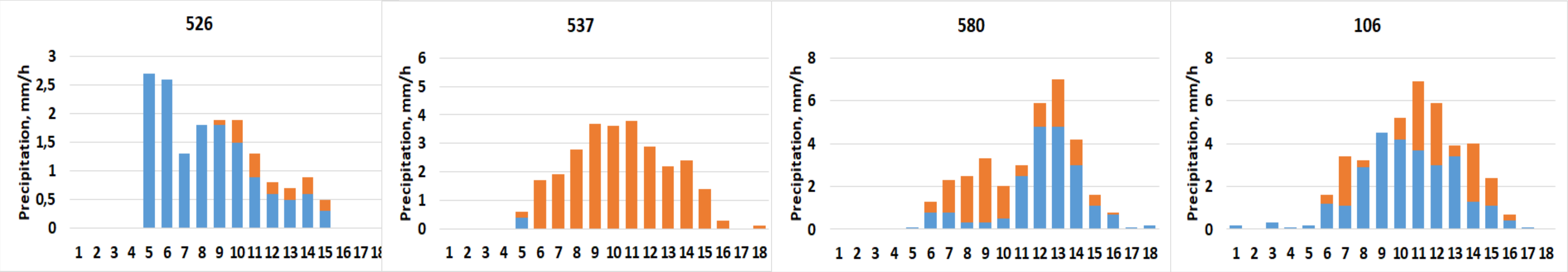
Impact on precipitation forecast

Pyeongchang area, COSMO-ICE005, 28.02.20180, 00UTC

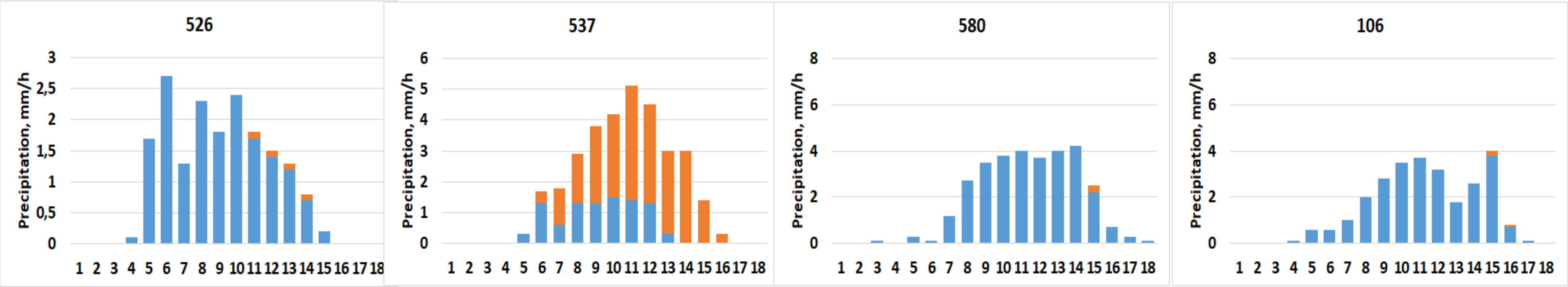
❑ Precipitation rate (mm/h) and phase

Mountain cluster → *Coastline*

Exp0-STANDARD



Exp1_Tegen



rain snow

More details on these experiments can be found at the POSTER20 (Shatunova et al., P20: COSMO for ICE-POP2018: status, verification results and future plans)

CONCLUSIONS for CLOUD PART:

Evaluation of cloud parameters in standard COSMO algorithm has some biases compared with observations especially TCI (total ice content).

New scheme provides mainly the increase in global shortwave irradiance due to smaller TQC.

Korean experiment has revealed an increase in proportion of liquid precipitation.

NEED MORE EXPERIMENTS AND TESTS !


THANK YOU FOR YOUR ATTENTION!