The assessment of the simulated cloud parameters and CLOUDRAD effect on global radiation and temperature forecast

M.Shatunova[1], N. Chubarova[2,1], Yu. Khlestova[1,2]

[1]Hydrometcenter of Russia, [2]Lomonosow State University

Moscow, Russia

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OUTLINE

- Motivation
- CLOUDRAD scheme & observations
- Comparison with CLOUDNET data
- Cloud optical parameters
- Effect on global radiation forecast
- Effect on T2m forecast
- Conclusion and outlook

MOTIVATION

- *CLOUDRAD* scheme was implemented in COSMO model and become a good tool to evaluate changes in cloud microphysics and its effect of simulated radiation fluxes and temperature in real conditions.

- Having at our disposal *simultaneous data* on atmospheric moisture characteristics (water content in different states), cloud microphysics, global radiation as well as T2m we can *validate model(s)* in terms of reproducing the clouds vertical structure and their radiation effect.

CLOUDRAD

- *CLOUDRAD* scheme combines **C**loud **N**uclei derived from Tegen (1997) aerosol climatology with cloud activation parameterization by Segal and Khain (2006) based on cloud nuclei and **c**loud **b**ase updraft speed (look-up tables).

$$\mathbf{N_{CCN}} = f(\mathbf{w_{cb}}, \mathbf{N_{CN}}),$$

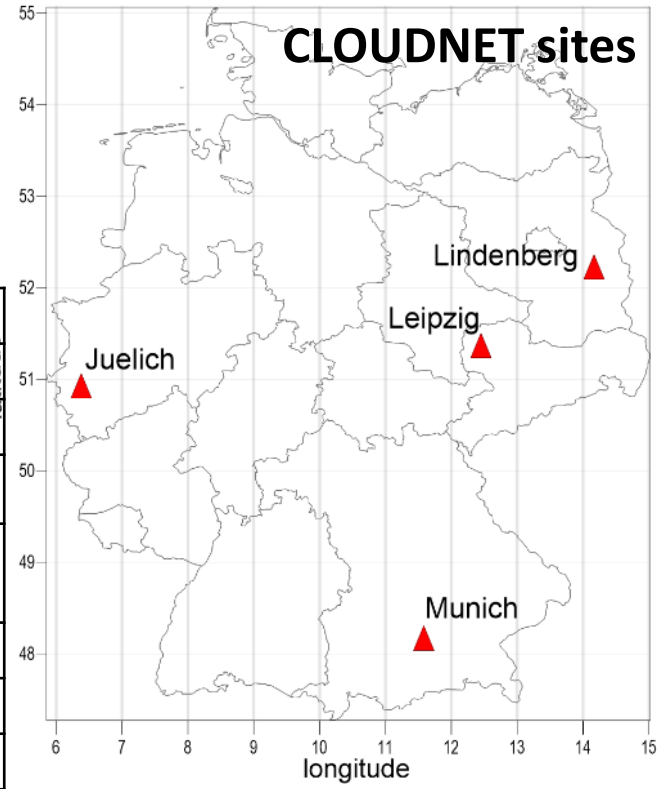
$$w_{cb}^{k} = w_{grid}^{k+1} + \alpha\sqrt{TKE^{k+1}/3} - {}^{c_{pd}}/_{g}\,{}^{\partial T^{k}}/_{\partial t}\Big|_{rad}$$

$\mathbf{R_{eff}^{x}}$ (*for radiation*) is calculated from Q_x and N_{CCN}

N_{CN} can be set constant, e.g. 100 cm^{-3} (maritime stratus), 400 cm^{-3} (maritime / intermediate clouds), 1700 cm^{-3} (continental statiform clouds).

OBSERVATIONS

- CLOUDNET (high-resolution ground-based measurements)
  - Water Vapor – 43 levels, up to 10 km, 50-100 m vert. resolution in the lower
  - Liquid and Ice Water Content – 30 m vert. resolution from 300 to 12 000 m
- BSRN site in Lindenberg



Description of observational datasets at the CLOUDNET sites

Parameter (dimension)	Name	Stations	Instrument	Uncertainty
Water vapor content (kg/m^3)	QV	Juelich	MWR	15%
Water vapor path (kg/m^2)	TQV	Juelich	MWR	15%
Liquid cloud water content (kg/m^3)	QC	all	Cloudnet synergy product	35%
Liquid cloud water path (kg/m^2)	TQC	all	MWR	15%
Cloud ice content (kg/m^3)	QI	all	Cloudnet synergy product	35%
Solar irradiance (W/m^2)	Direct: S	Lindenberg	Eppley NIP	8 W/m^2
	Global: Q	Lindenberg	Kipp &Zonen CM21	10 W/m^2
		Munich	Kipp &Zonen CNR1	3-5%
	Diffuse: D	Lindenberg	D=Q-S	10 W/m^2
Droplets effective radius	Reff	Lindenberg	Integrated Profiling Technique	35%

OBSERVATIONS

- Moscow site (Meteorological Observatory of Lomonosov State University)
  - Solar irradiance: net radiometer Kipp &Zonen CNR4 – 1 min observations, uncertainty is less than 5%
  - Direct solar irradiance: actinometer M3 – 1 hour sum, uncertainty is 5%
  - SYNOP (cloudiness, precipitation, T2m & etc.)

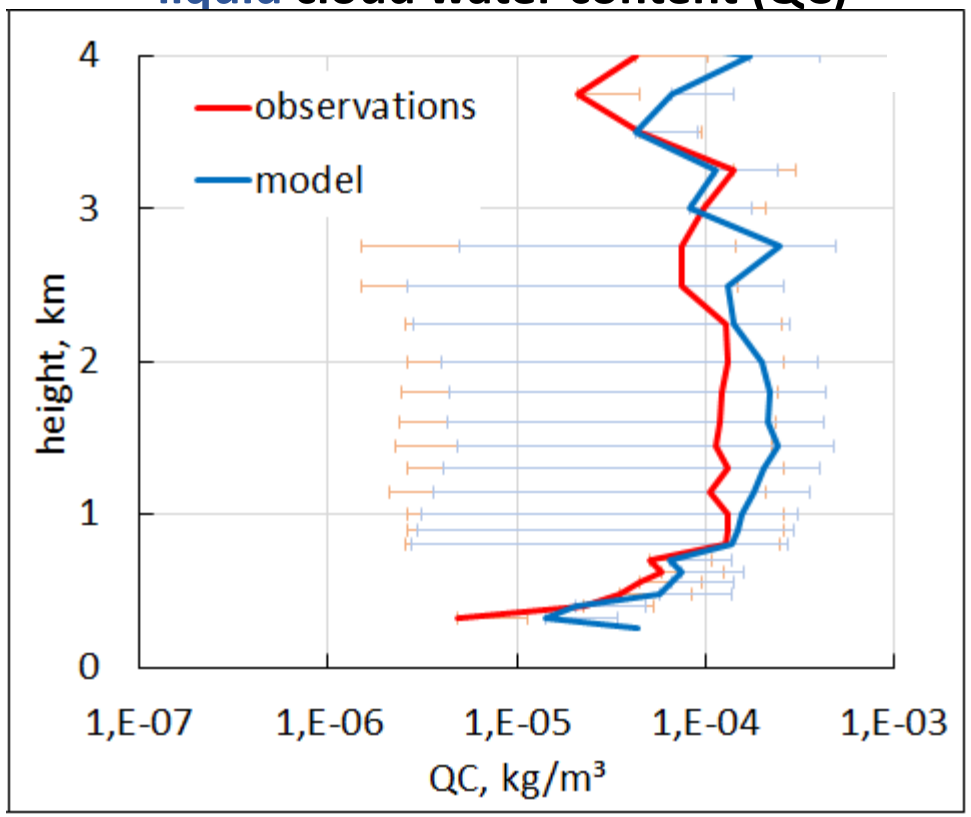
- Observations (radiation) were averaged within 1 h period (±30 min)
- For T2m forecast verification we used observational data at 147 SYNOP stations in Moscow region

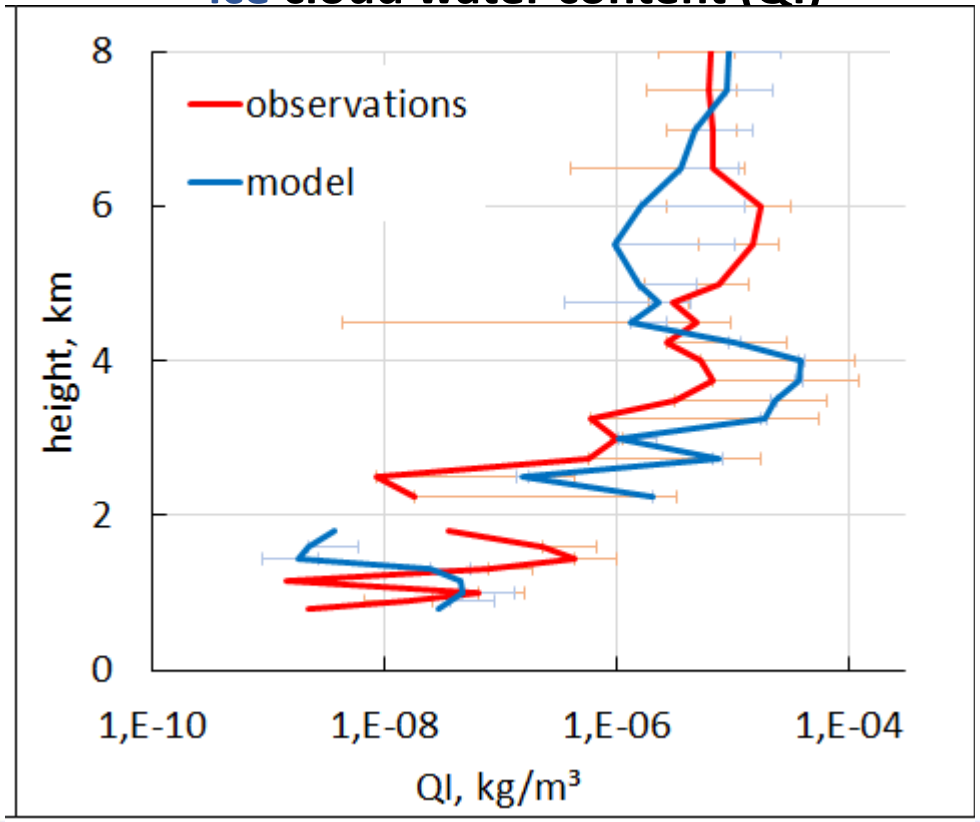
COMPARISON WITH CLOUDNET DATA (FOR GERMAN SITES)

- Period: April – October, 2018
- Experiment setup: COSMO, 2.2 km grid spacing, CLOUDRAD with CCN=400 cm^{-3}

Average vertical profile of the observed and simulated

liquid cloud water content (QC) **and** **ice cloud water content (QI)**

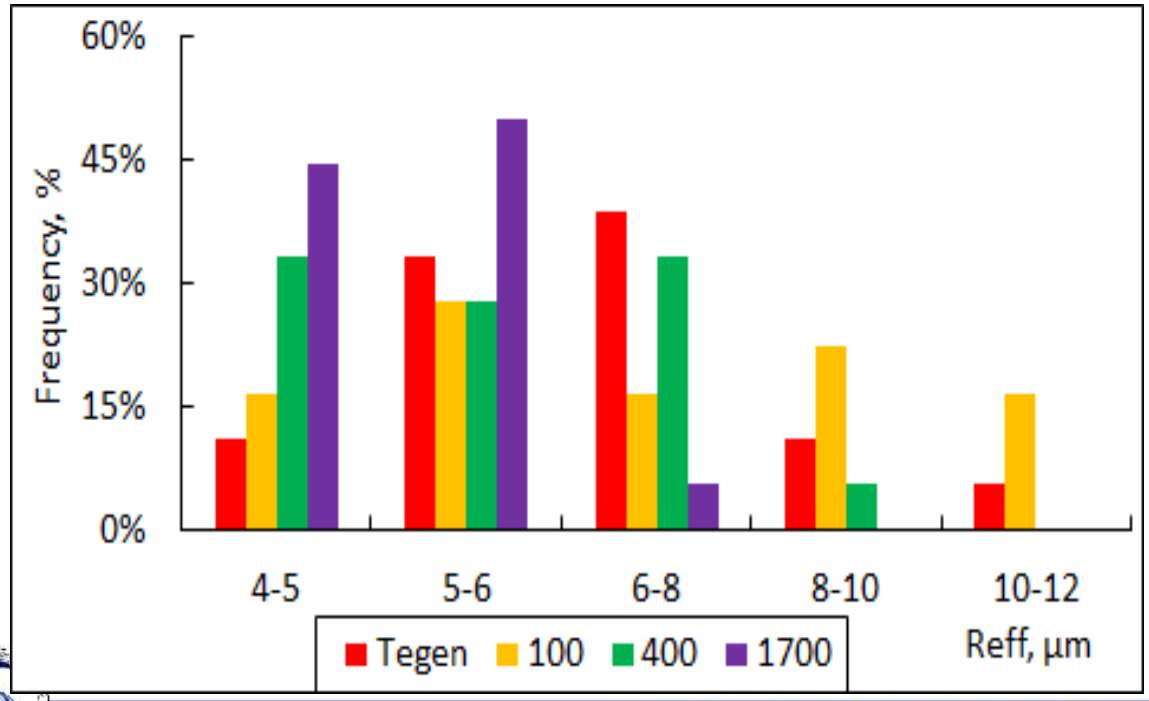




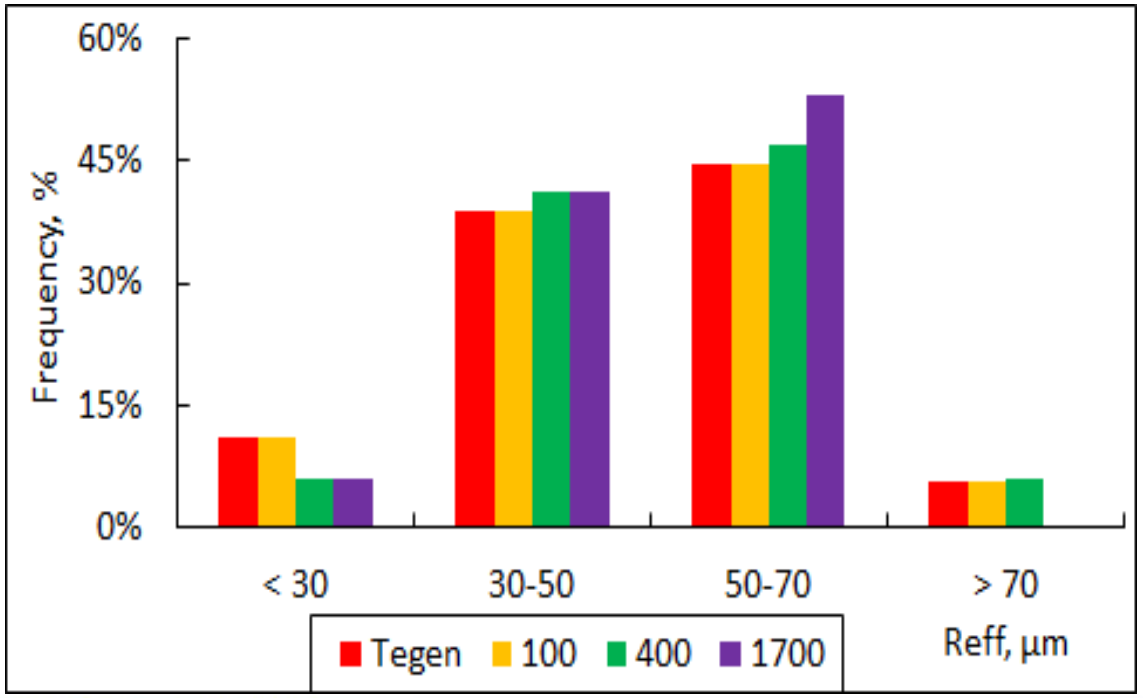
CLOUD OPTICAL PARAMETERS WITH CLOUDRAD (FOR MOSCOW SITE)

- **Period:** April – October, 2018
- **Experiment setup:** COSMO, 2.2 km grid spacing, CLOUDRAD with CCN=100/400/1700 cm^{-3} or from Tegen aerosol climatology

Frequency distribution of droplets effective radius (profile mean) for different CCN



Frequency distribution of ice particle effective radius (profile mean) for different CCN



CLOUD OPTICAL PARAMETERS WITH CLOUDRAD (FOR MOSCOW SITE)

- **Period:** April – October, 2018
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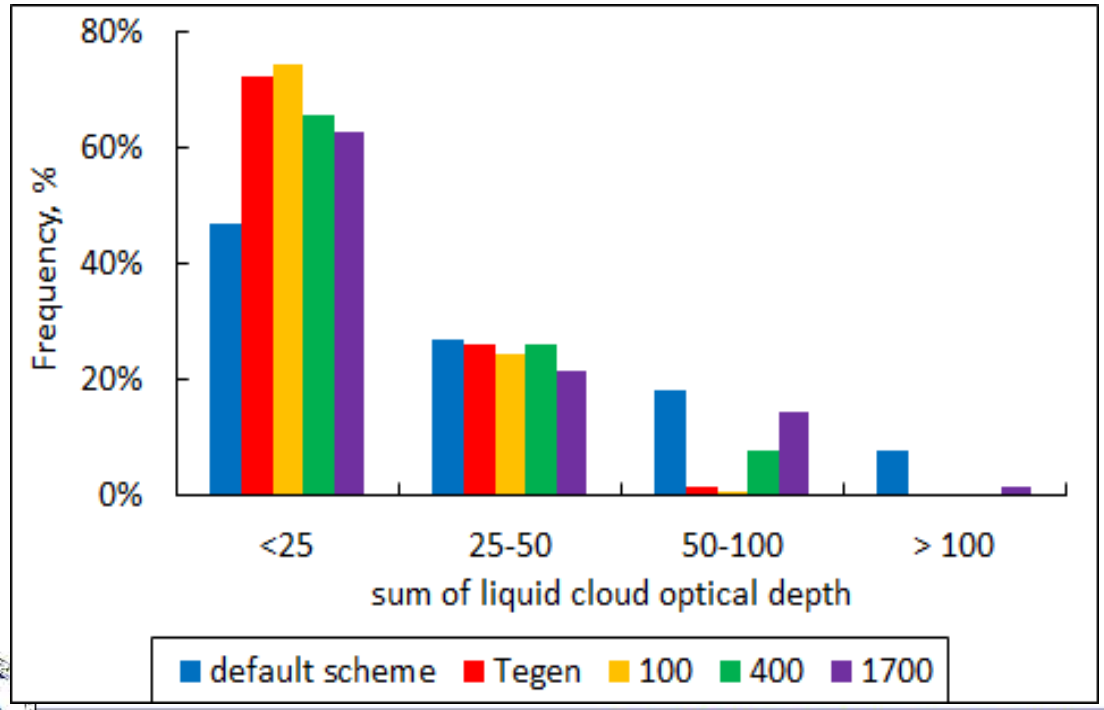
Frequency distribution of of total liquid cloud optical thickness in default scheme and CLOUDRAD



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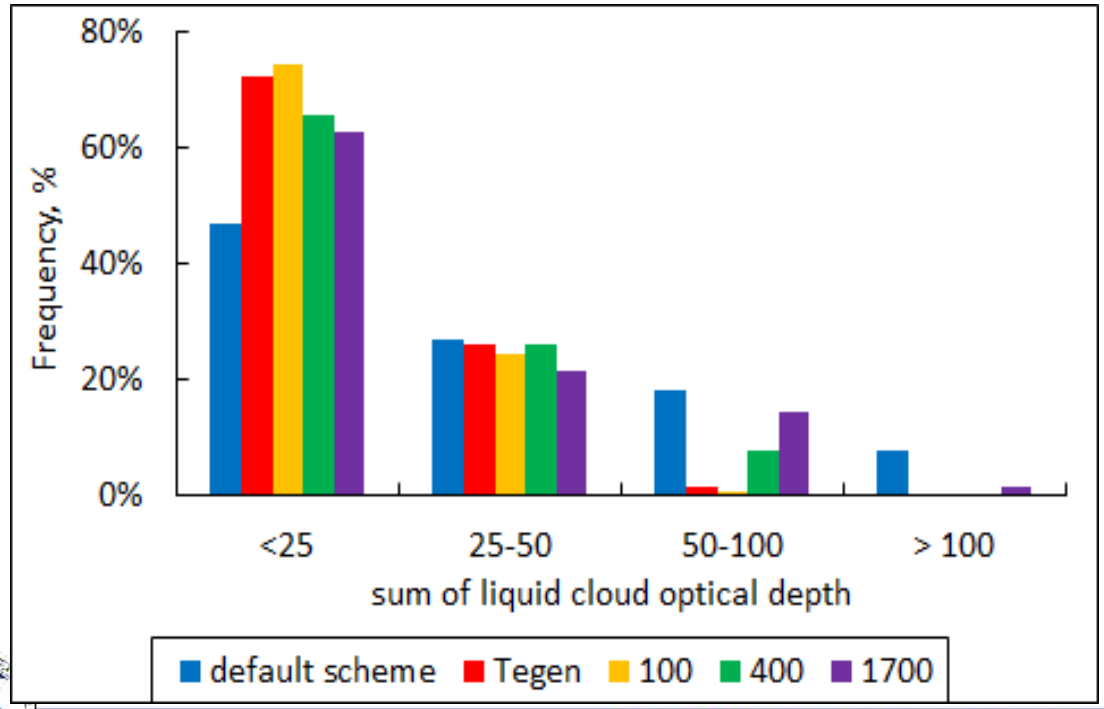
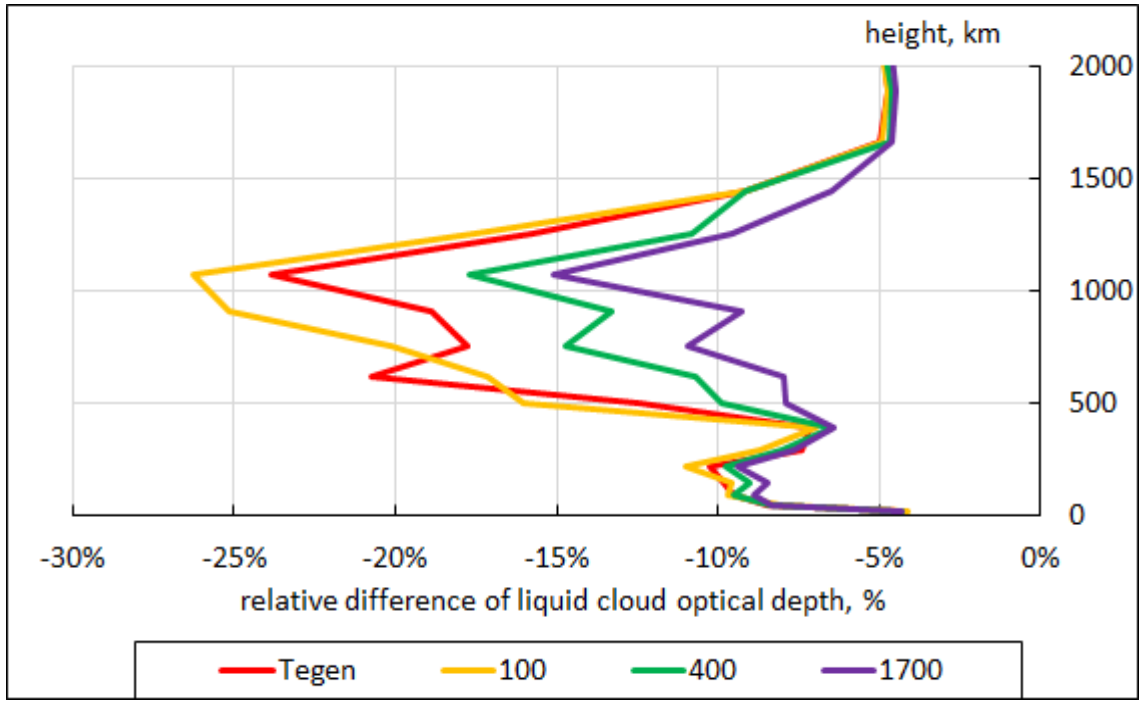


Relative difference of the liquid cloud optical thickness between default scheme and CLOUDRAD



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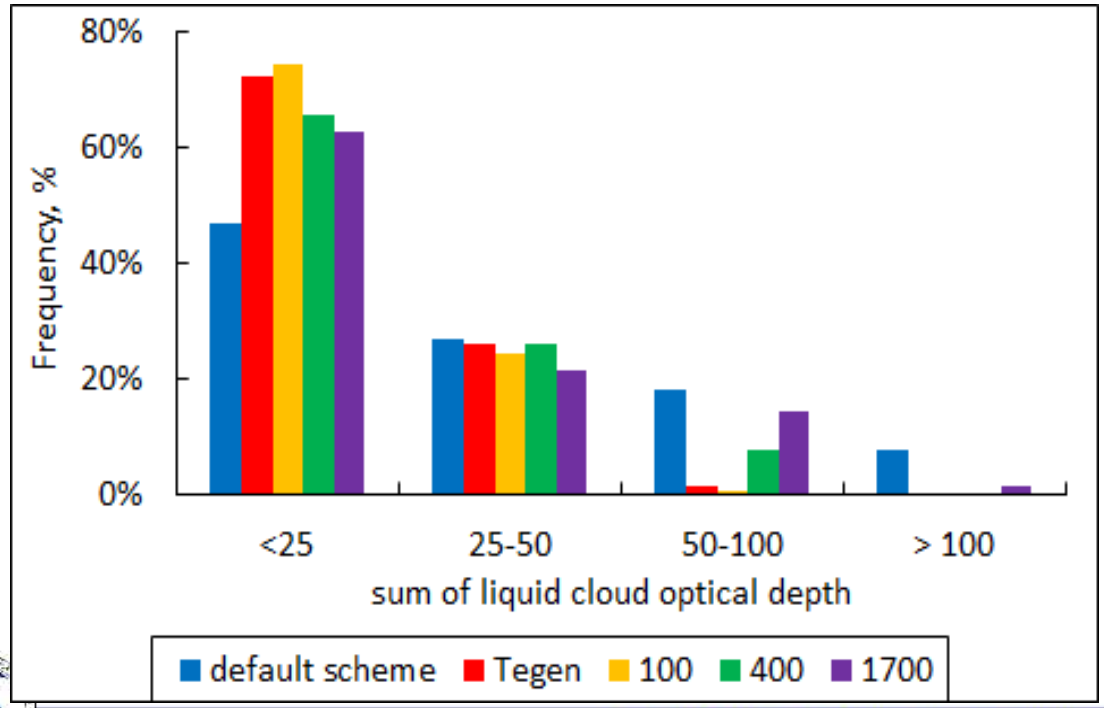
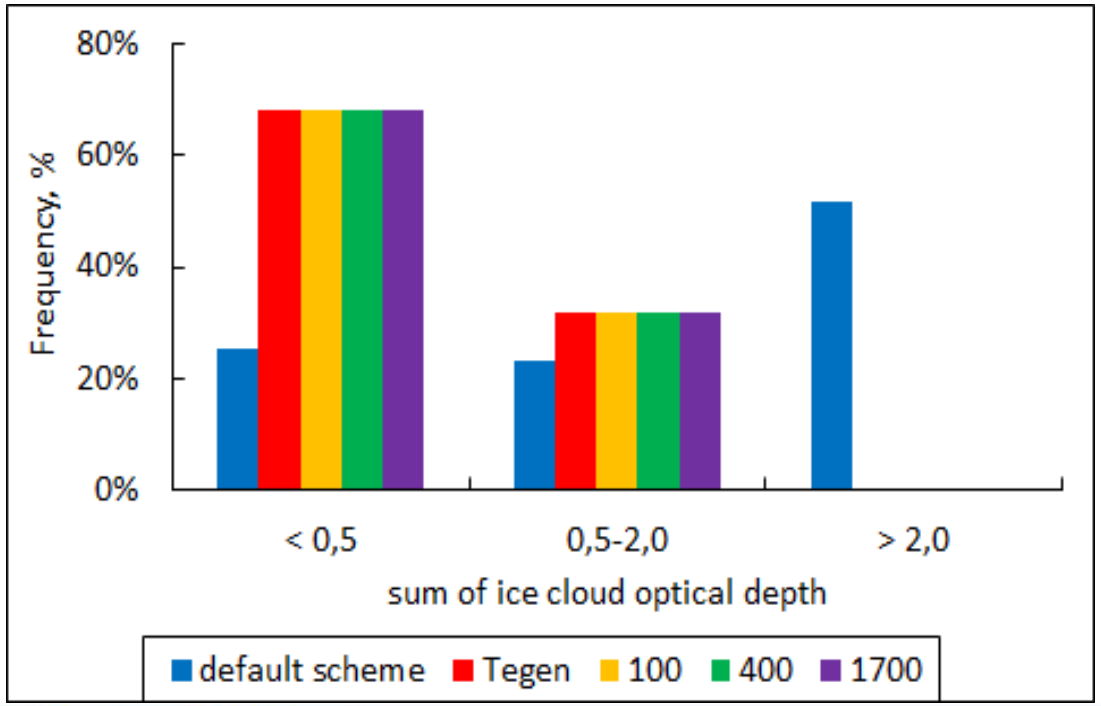
Frequency distribution of of total liquid cloud optical thickness in default scheme and CLOUDRAD



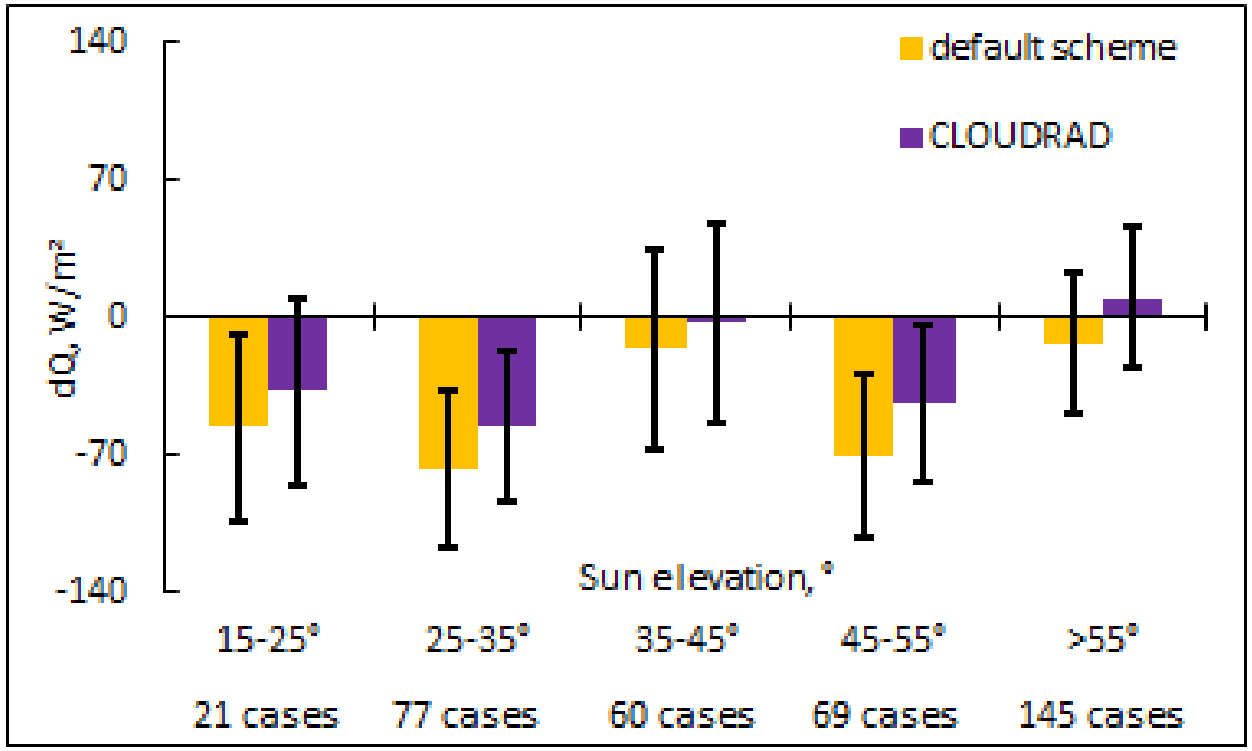
Frequency distribution of of total ice cloud optical thickness in default scheme and CLOUDRAD



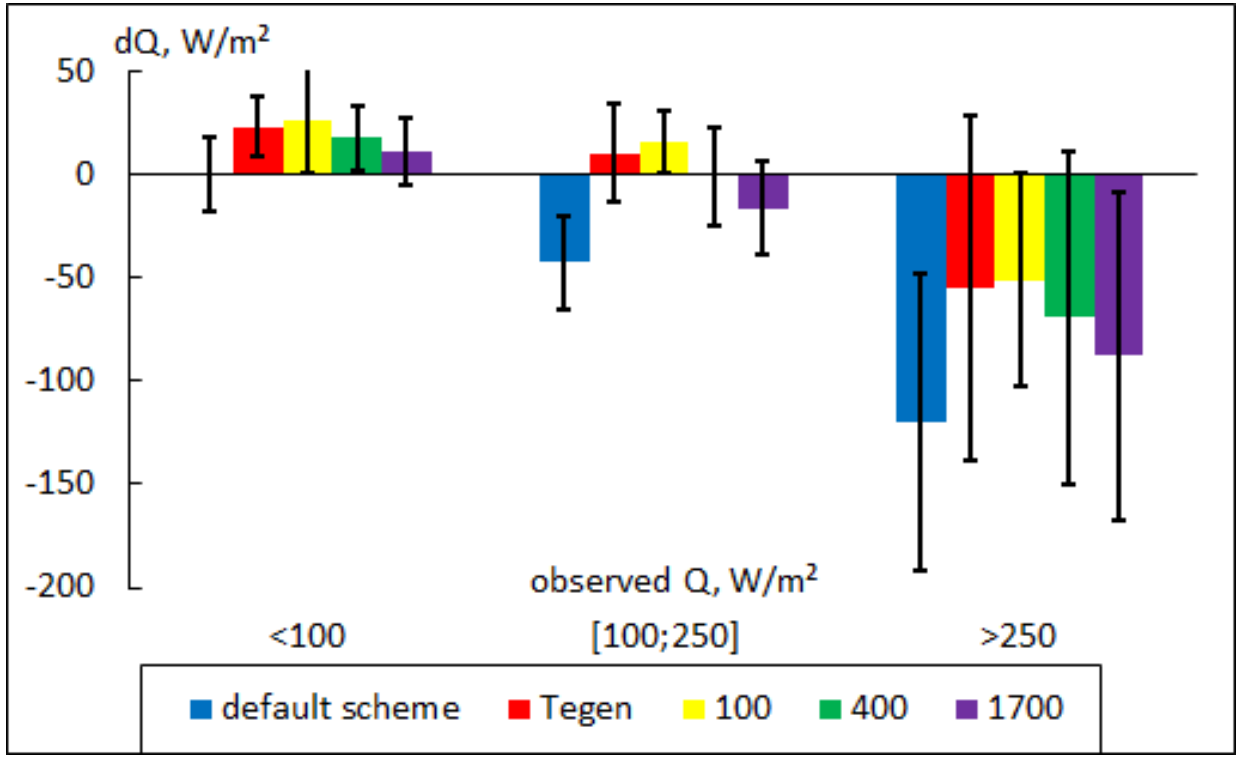
EFFECT ON GLOBAL RADIATION FORECAST

The difference between simulated and measured global irradiance

Lindenberg and Munich sites



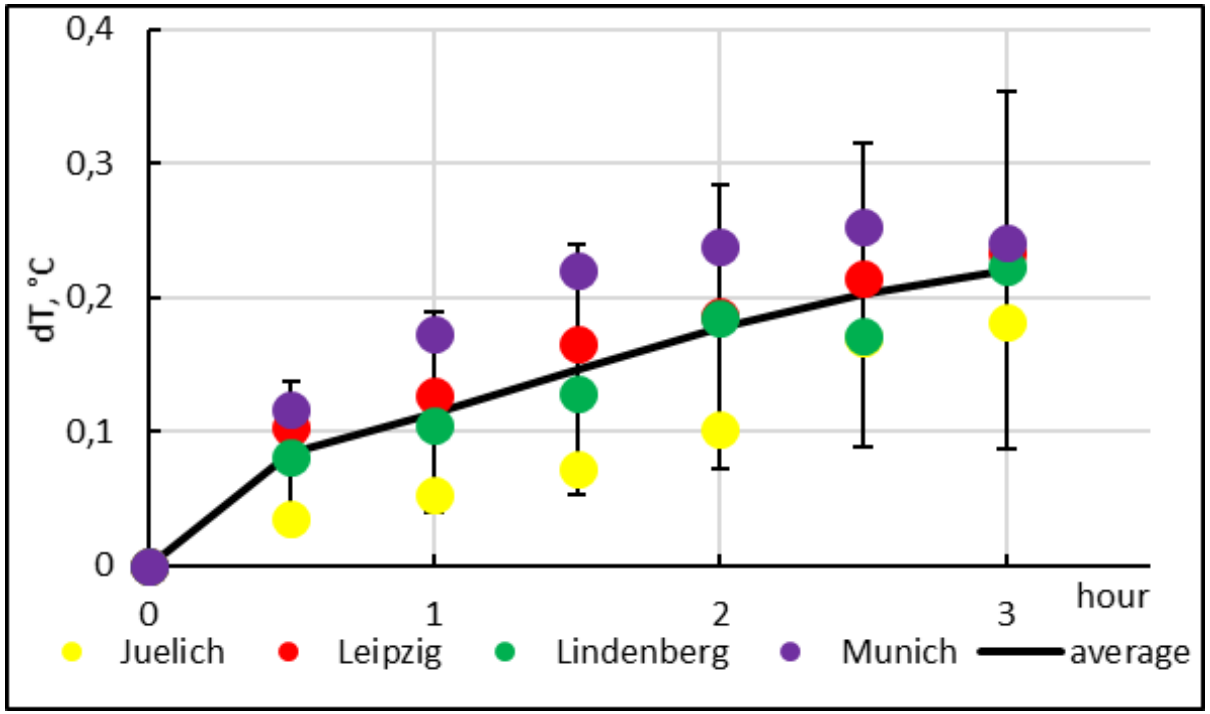
Moscow site



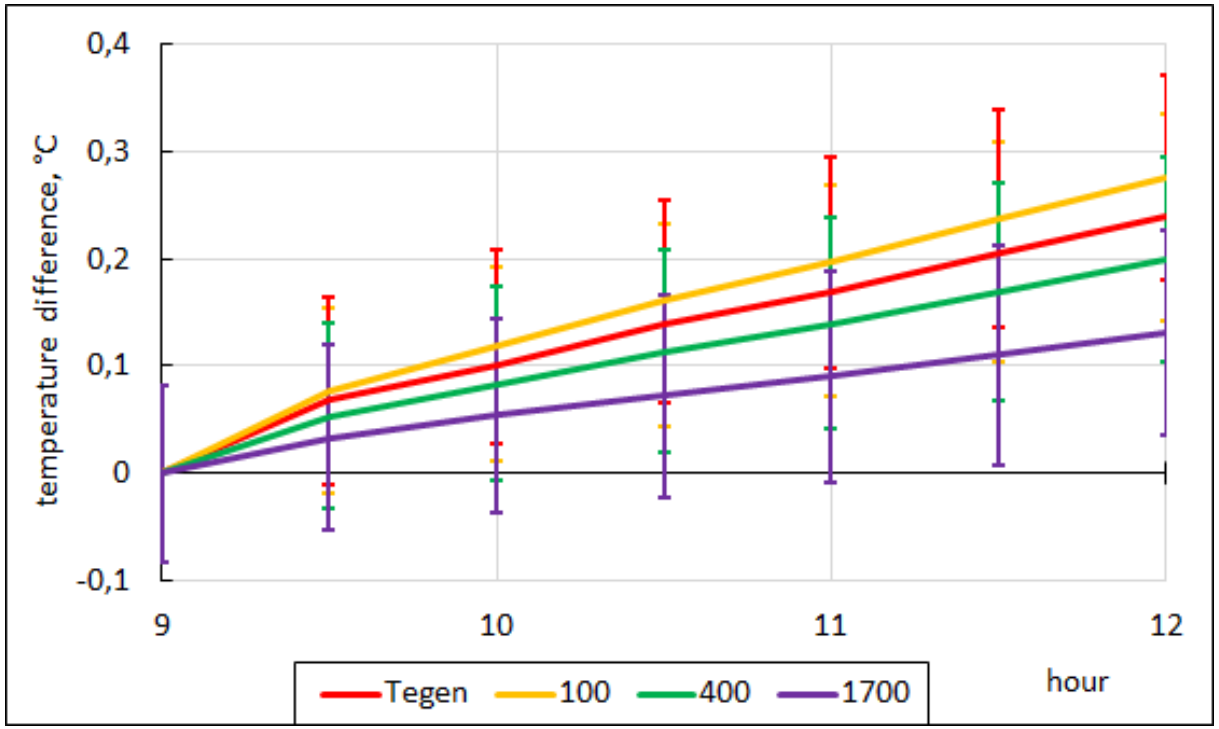
EFFECT ON T2M FORECAST

The evolution of average difference of simulated T2M between CLOUDRAD and default scheme

CLOUDNET sites



Moscow region

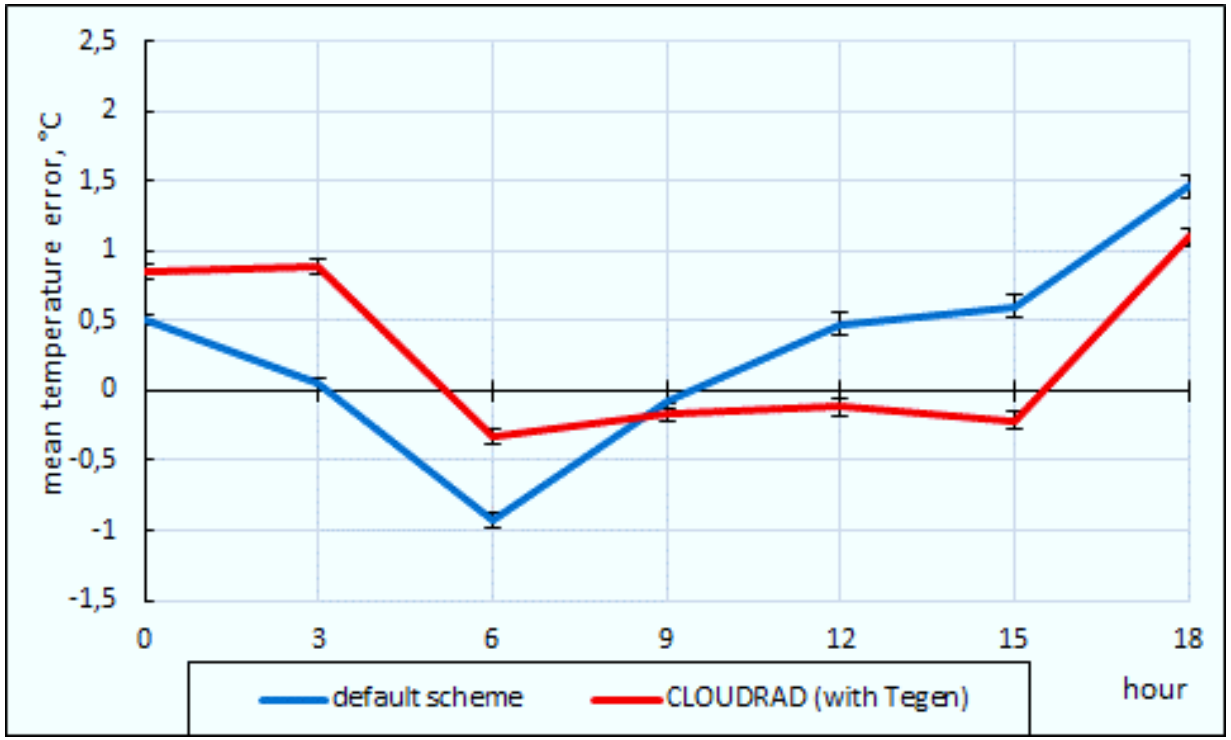


NB: “short” forecasts, all sky

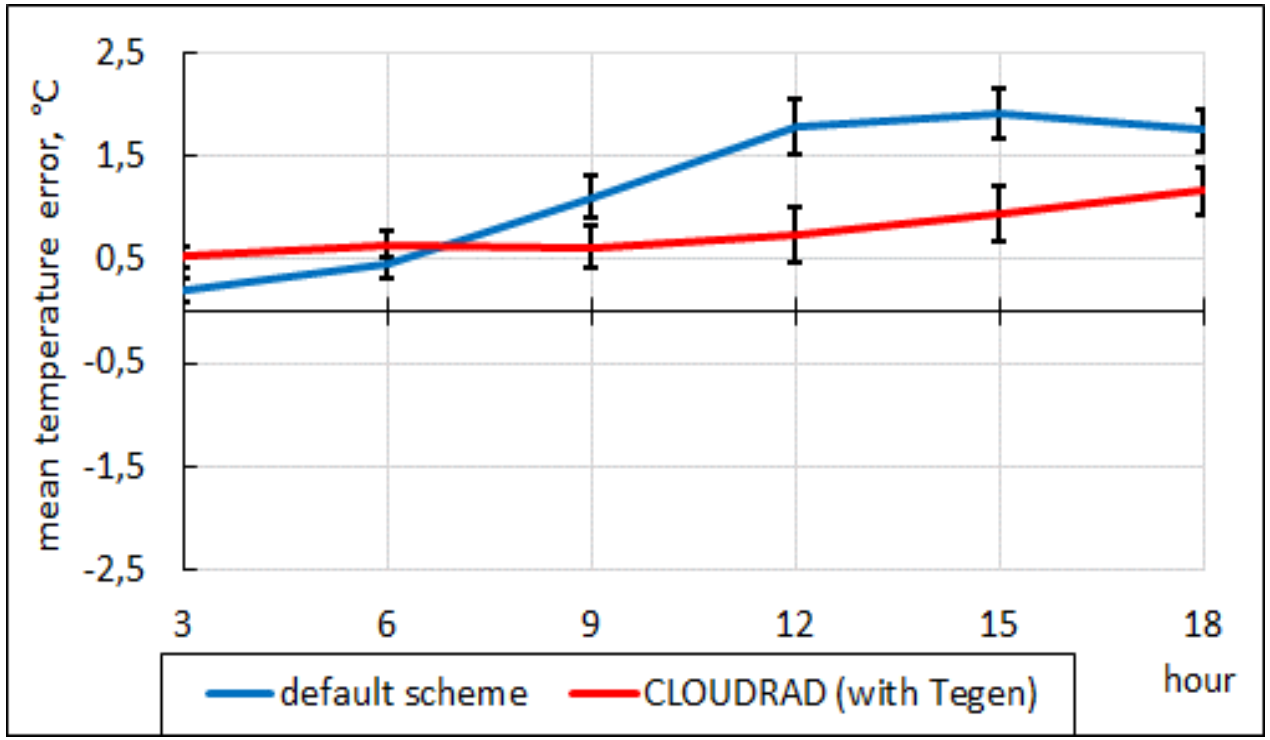
EFFECT ON T2M FORECAST

T2m mean error for CLOUDRAD and default scheme (for Moscow region)

all sky



overcast



NB: 18h forecasts, for the period April-October 2018, verification over 147 SYNOP stations

CONCLUSION

- Obtained results demonstrate an advantage of the new cloud-radiation interaction coupling scheme (CLOUDRAD) compare to default one:
  - ✓Global radiation simulated with CLOUDRAD increased on 15-20% compare to default scheme and is in a better agreement with measurements (Lindenberg, Munich and Moscow sites; period April-October 2018)
  - ✓Results of short-range forecast show that difference in solar irradiance provides a noticeable influence on temperature. T2m difference between two schemes reaches 0.22°C by the end of 3-hour forecast (CLOUDNET German sites and Moscow region; period April-October 2018)
  - ✓Mean error of T2m forecast decreased on 0.5°C in case of CLOUDARD for overcast conditions (Moscow region; period April-October 2018)

- No any noticeable effect on simulated cloud water/ice content was observed

OUTLOOK

- Enlargement of data base for verification: data for two new sites will be included - Ny-Alesund, Svalbard (CLOUDNET) and Graciosa, Azores (ARM)

- ICON-LAM evaluation by AERONET/CLOUDNET/BSRN data for different geographical conditions:
  - to solve some technical issues (initial & lbc data for selected domains)
  - to select cases for evaluation

- Use not only ground-base measurements


Thank you for your attention!