# Evaluation of the tropical upper tropospheric cloudiness simulated by the storm resolving models (SRMs) from DYAMOND project

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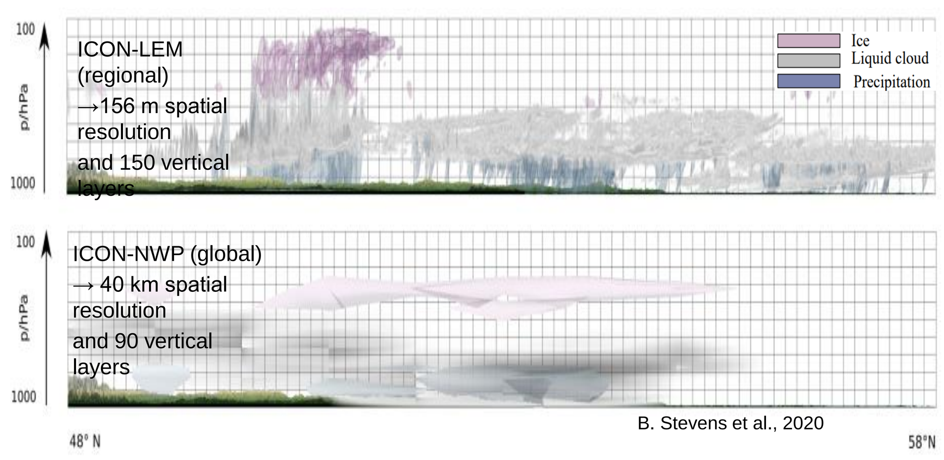
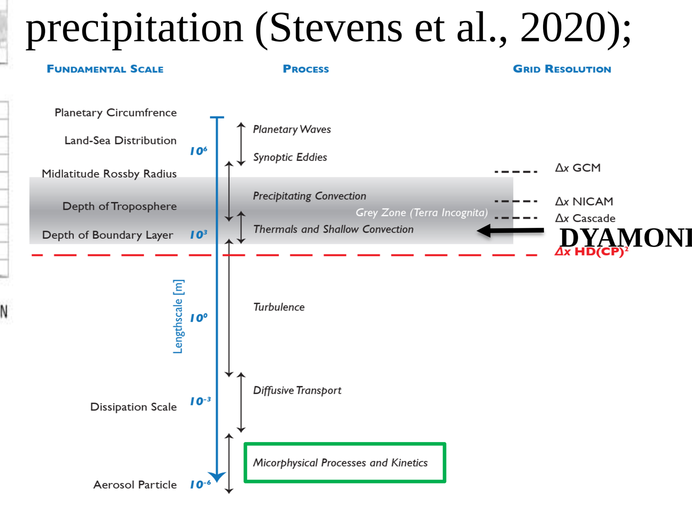
## With deep convection mainly resolved, how well is the tropical UT cloudiness simulated?




SRMs → better representation of vertical velocities, clouds and precipitation (Stevens et al., 2020);

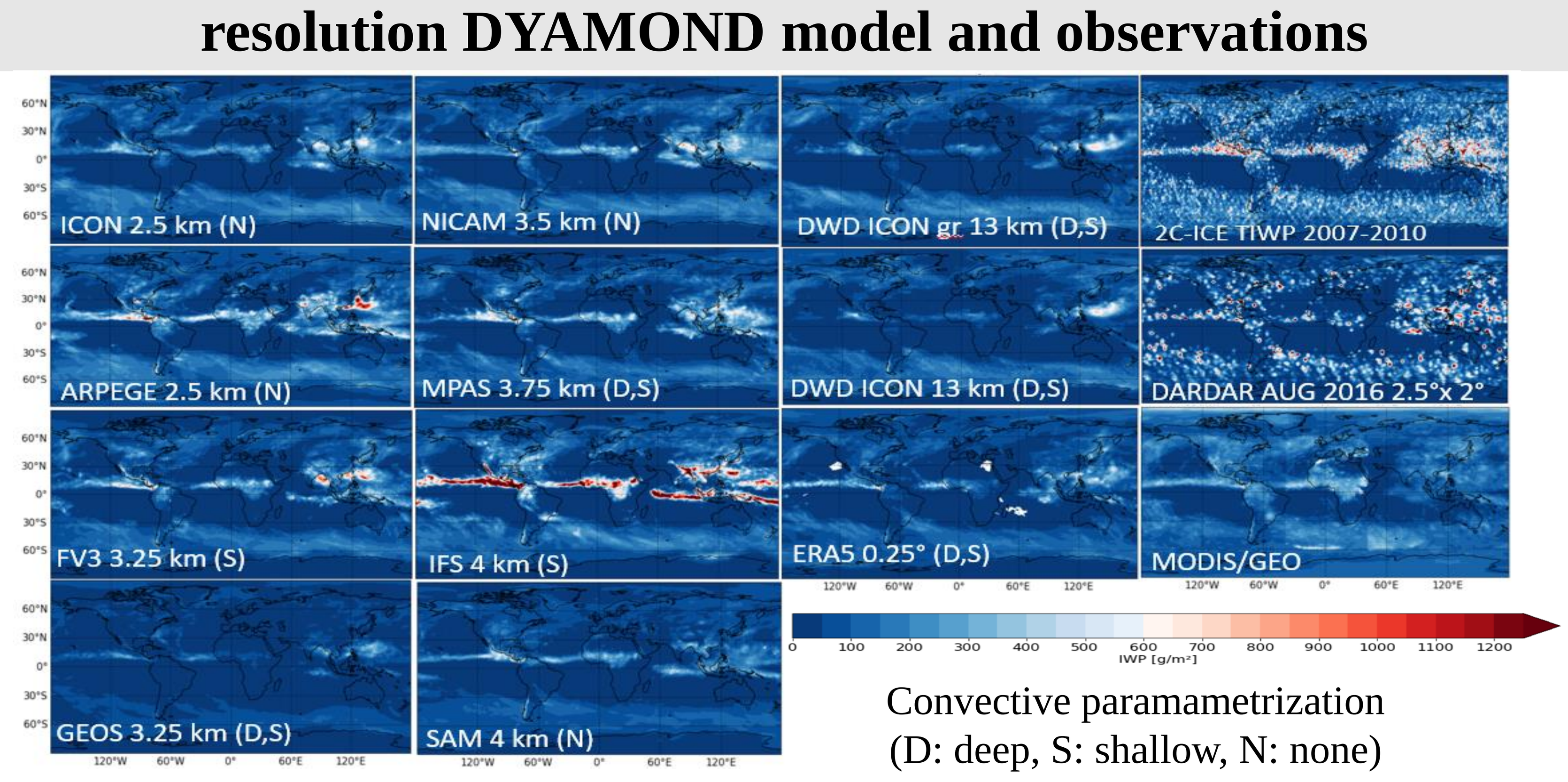



B. Stevens et al., 2011 HD(CP)2

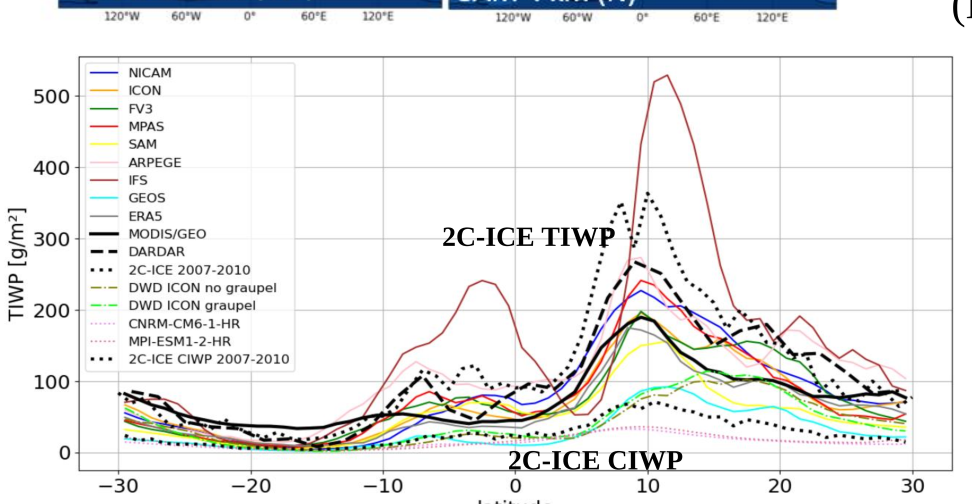
Water budget in the tropical UT is controlled by convection

→ Area of interest: Tropics

## Total (ice + snow + graupel) ice water path (TIWP) in high-resolution DYAMOND model and observations




Convective paramametrization (D: deep, S: shallow, N: none)




Tropical TIWP generally underestimated.

High resolution models reproduce observations significantly better than lower resolution models (NWP + GCMs).

NWP: ITCZ maxima displaced

## Is lack of TIWP in models due to dynamics or cloud scheme?

$$\overline{CWP} = \int_{-\infty}^{\infty} PDF_w \, CWP_w \, dw$$

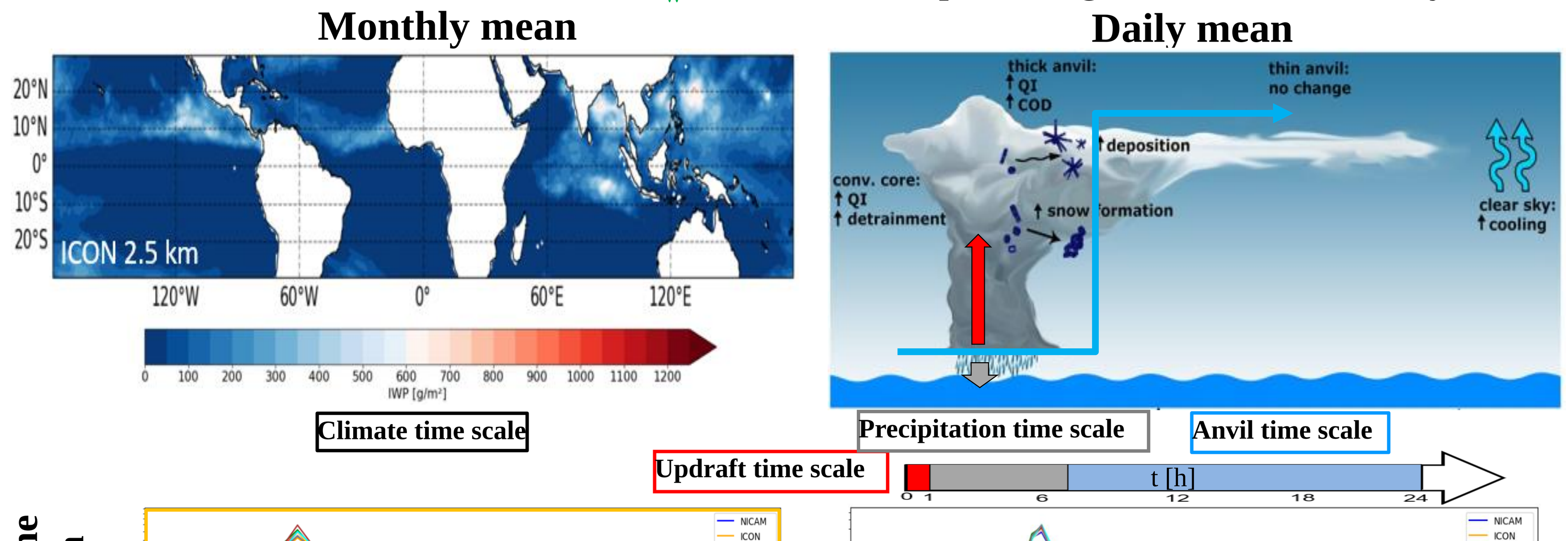
S. Bony et al., 2004

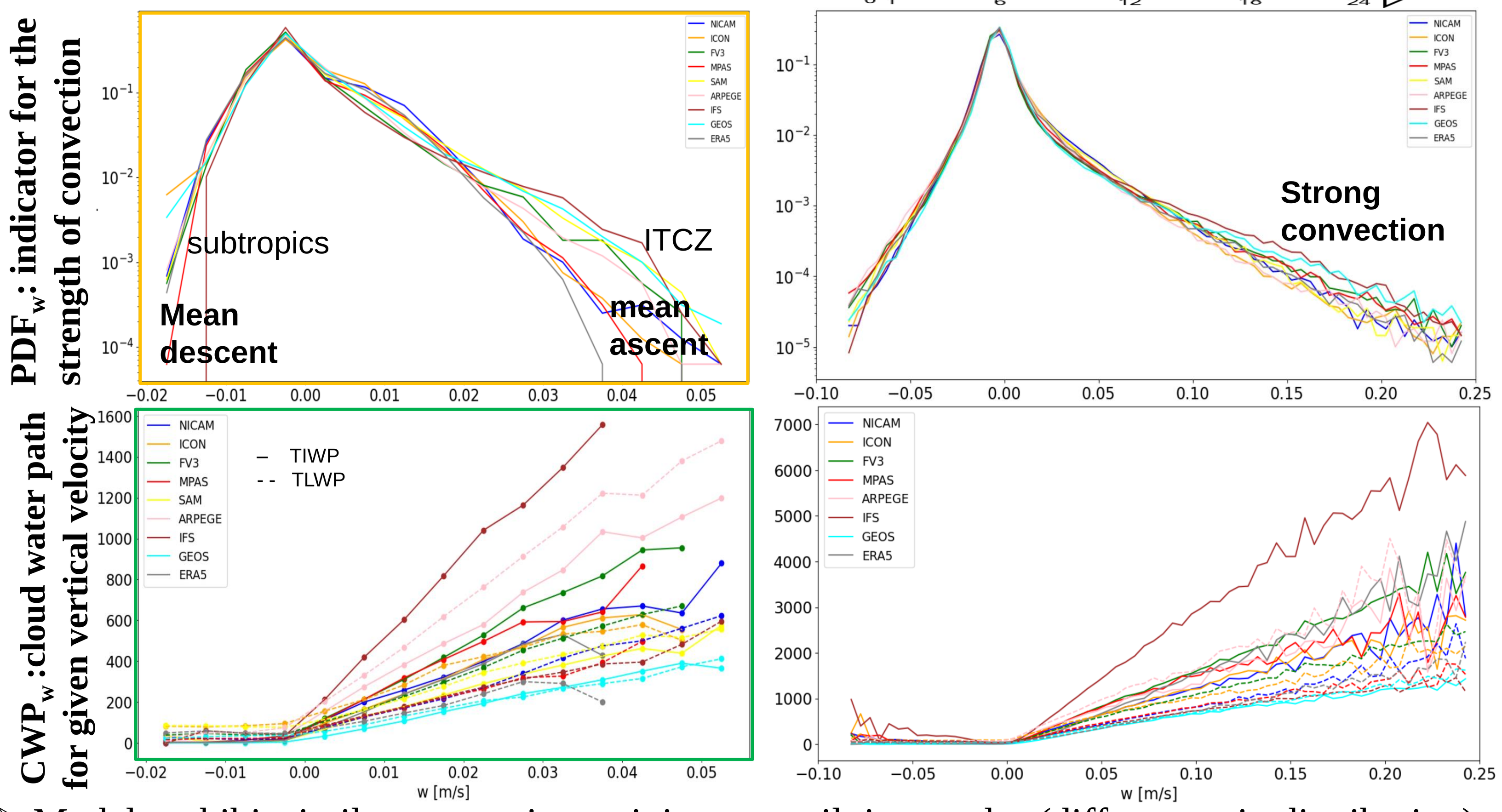
CWP – Cloud water path

$PDF_w$ – PDF of vertical velocity w (at 500 hPa);

$CWP_w$ – Cloud water path for given vertical velocity

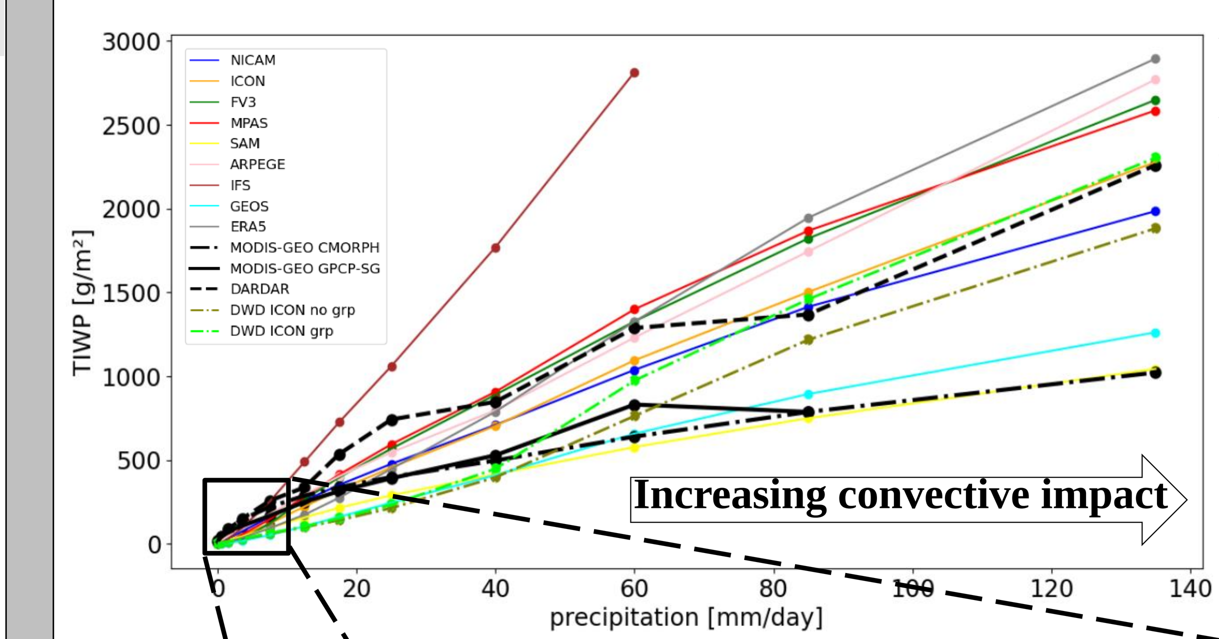
**Monthly mean** **Daily mean**



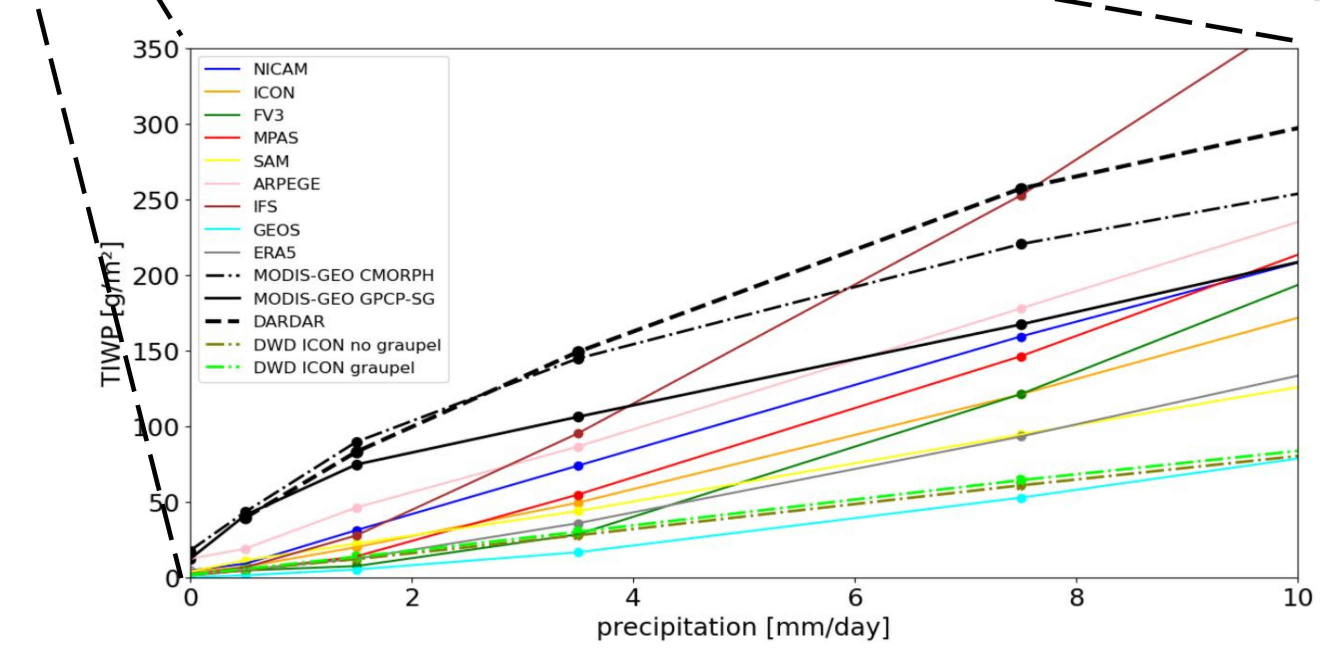

- Models exhibit similar convective activity on anvil time scales (differences in distribution)
- Reaction of cloud properties (TIWP & TLWP) to strength of convection shows large model variability (differences due to cloud microphysics)

## Evaluation of partitioning of TIWP & precipitation




Using precipitation as an indicator for convective strength:

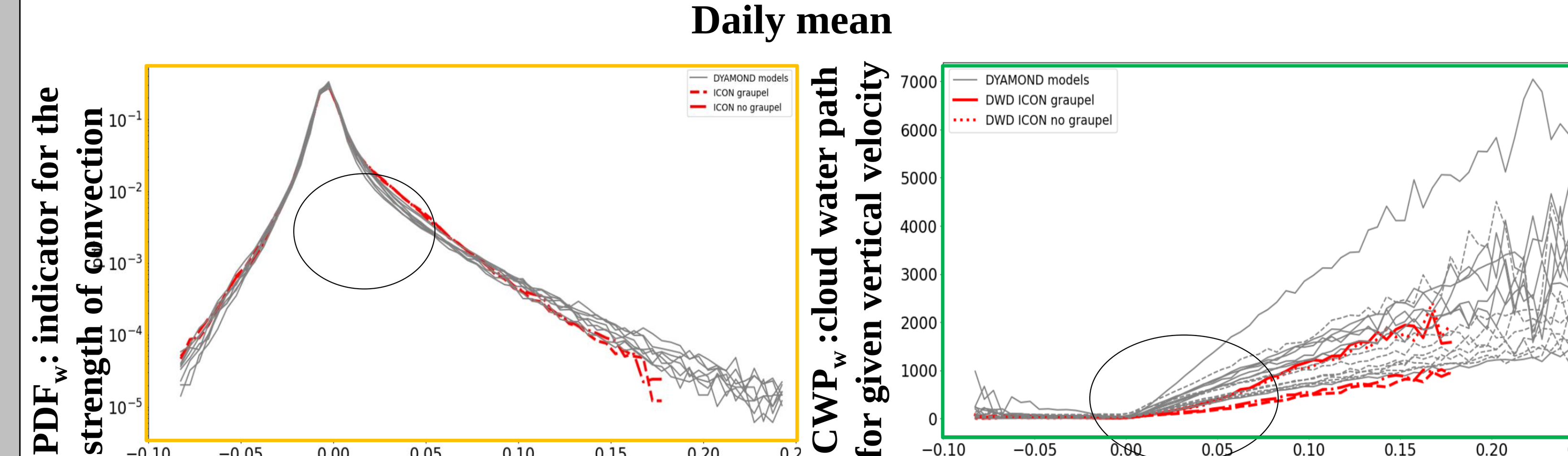
- Passive remote sensing shows saturation in areas of high IWP.
- TIWP is generally underestimated especially at lower convective strength compared to active remote sensing




- DYAMOND models improved compared to ICON-NWP
- TIWP underestimated in very low precipitation areas even relative to passive remote sensing!
- Large deficiency of TIWP in SRMs comes from weaker and/or aged convective systems while strong and young convective systems are simulated well also in NWP

## How different are NWP models compared to high-resolution models?

**Daily mean**




- Higher probability for weaker convection compared to high-resolution DYAMOND models
- Compared to high-resolution: smaller TIWP at lower convective strength / aged systems

## Conclusions and outlook

**Conclusions:**

Deep convection is mainly resolved in DYAMOND models (resolution < 5km):

Cloud scale dynamics is much improved in the high-resolution simulations (B. Stevens et al., 2020)

When analysing IWP dependent on convective strength:

- Improved TIWP when compared to ICON-NWP in particular at lower convective strength
- SRMs still exhibit large spread in simulated cloud properties.
- **Largest deficiency of TIWP in models comes from weaker and/or aged convective systems**
- The spread likely results from uncertainty in cloud microphysics - too fast conversion into precipitating hydrometeors?
- Connection between the strength of the convection and the ice water path is very stable (not shown here)

**Outlook:**

- Double moment microphyisics may lead to improvements in simulated convective life cycles.
- New data sets, such as those coming from Earthcare or initiatives learning from lidar, radar and in-situ measurements, may help advance the field in the near future

**Literature:**

Stevens, B., et al. (2020) The added value of large-eddy and storm-resolving models for simulating clouds and precipitation. *Journal of the Meteorological Society of Japan, Series II*. https://doi.org/10.2151/jmsj.2020-021

Bony, S., Dufresne, JL., Le Treut, H. *et al.* On dynamic and thermodynamic components of cloud changes. *Climate Dynamics* **22**, 71–86 (2004). https://doi.org/10.1007/s00382-003-0369-6

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