Indirect aerosol effects on deep convection over the Maritime Continent

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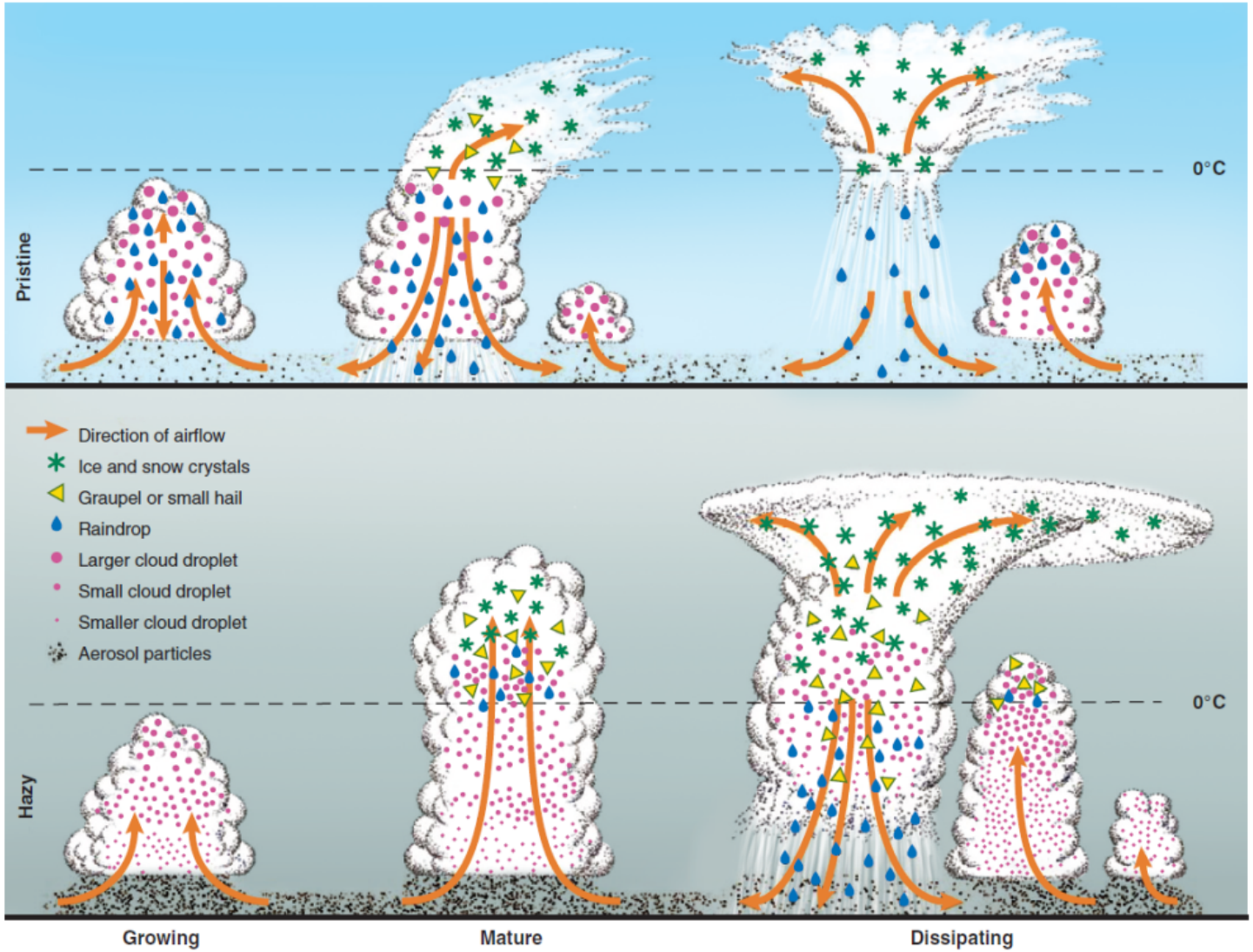
Aerosol indirect effects on deep convection: convective invigoration hypothesis



Rosenfeld et al. *Science*, 2008
"Flood or Drought: How Do Aerosols Affect Precipitation?"

Aerosol-cloud-precipitation effects over Germany as simulated by a convective-scale numerical weather prediction model

A. Seifert[1], C. Köhler[1,2], and K. D. Beheng[3]

ACP 2012

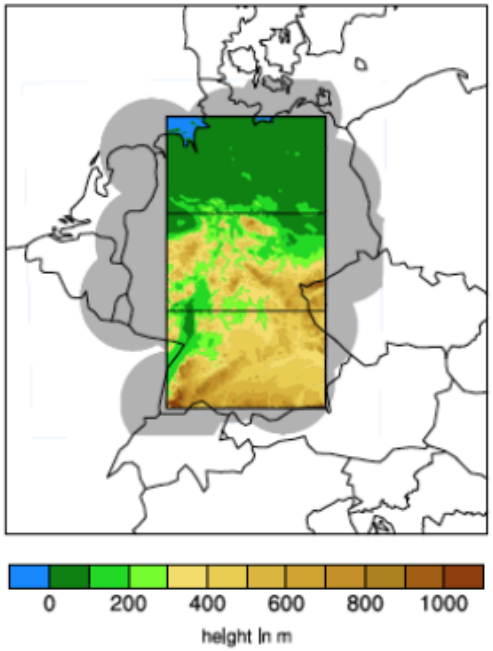
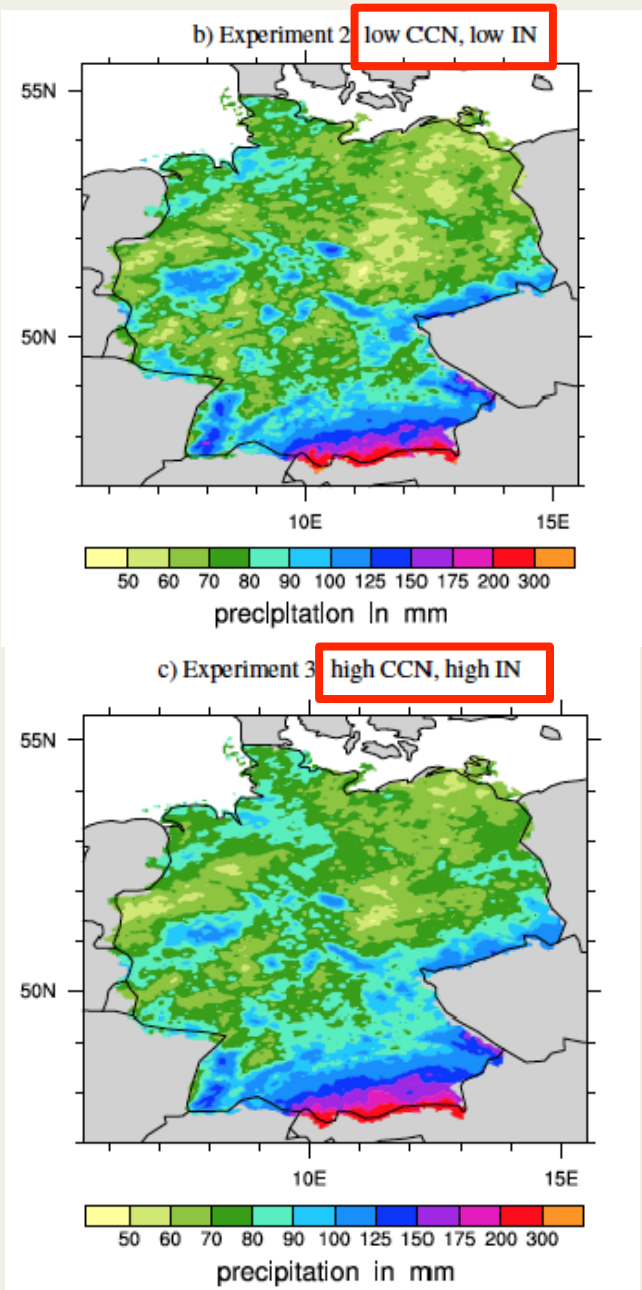
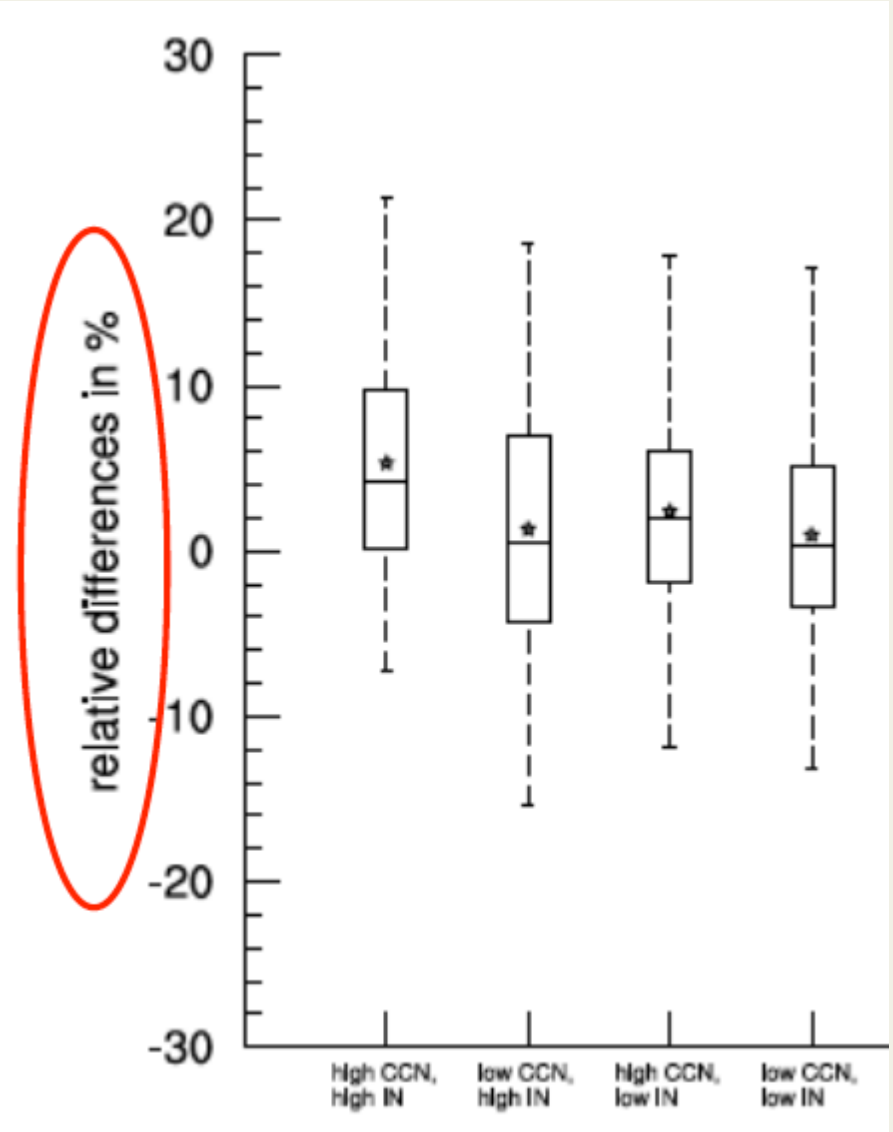


Fig. 1. COSMO-DE model domain, with insertions of coverage of the German radar composite (grey), and the three evaluation sub-domains with the model orography.

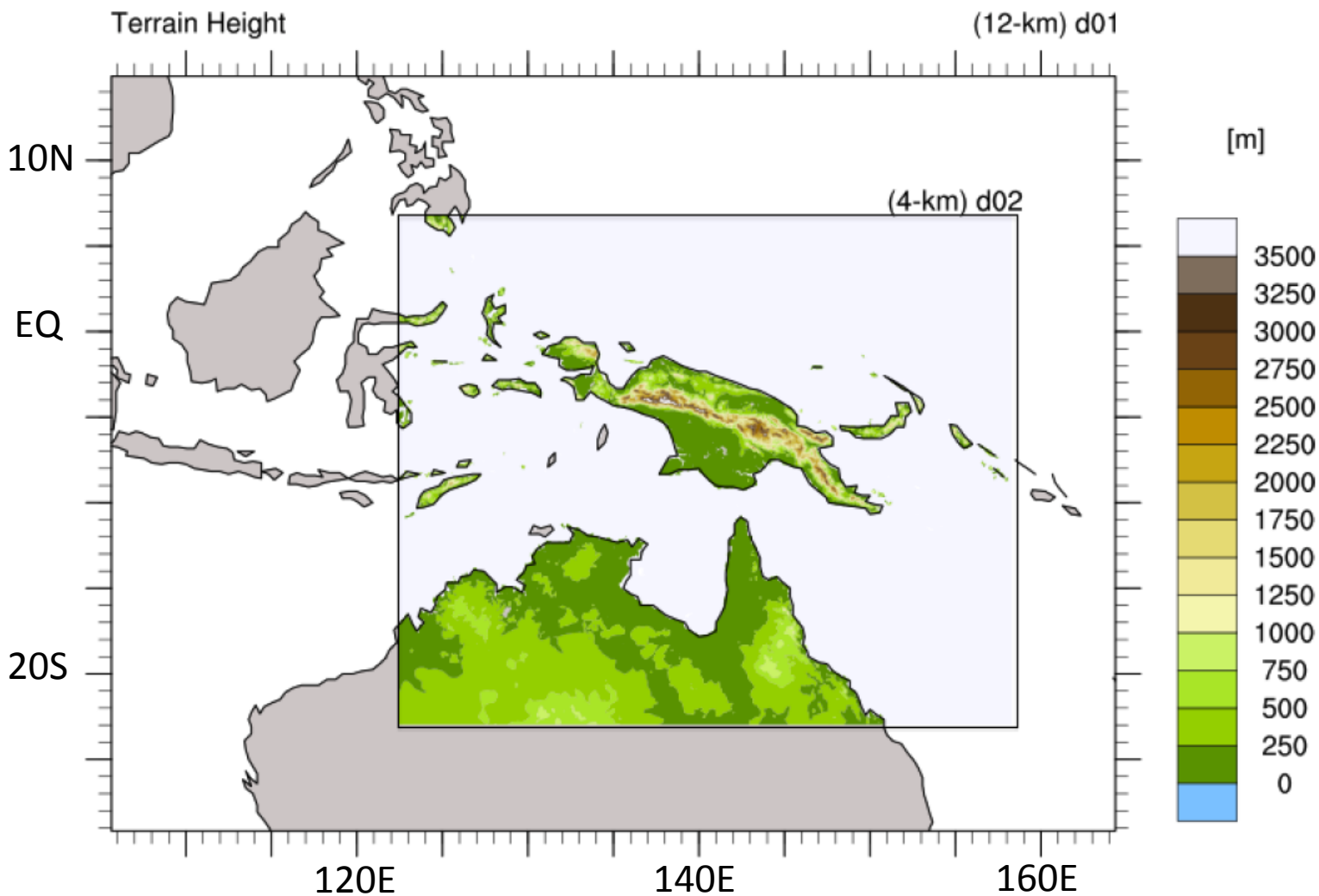
2008, 2009, 2010 summers (JJA) convection-permitting (~3 km gridlength) 48-hour hindcasts using COSMO-DE





Seifert et al. *ACP* 2012

Hassim et al. (to be submitted)



WRF model 2-domain configuration: Δx=12 km outer domain with Kain-Fritsch convection scheme, and Δx=4 km convection-permitting inner domain.

Thompson's 6-class microphysics (Thompson et al. 2008):

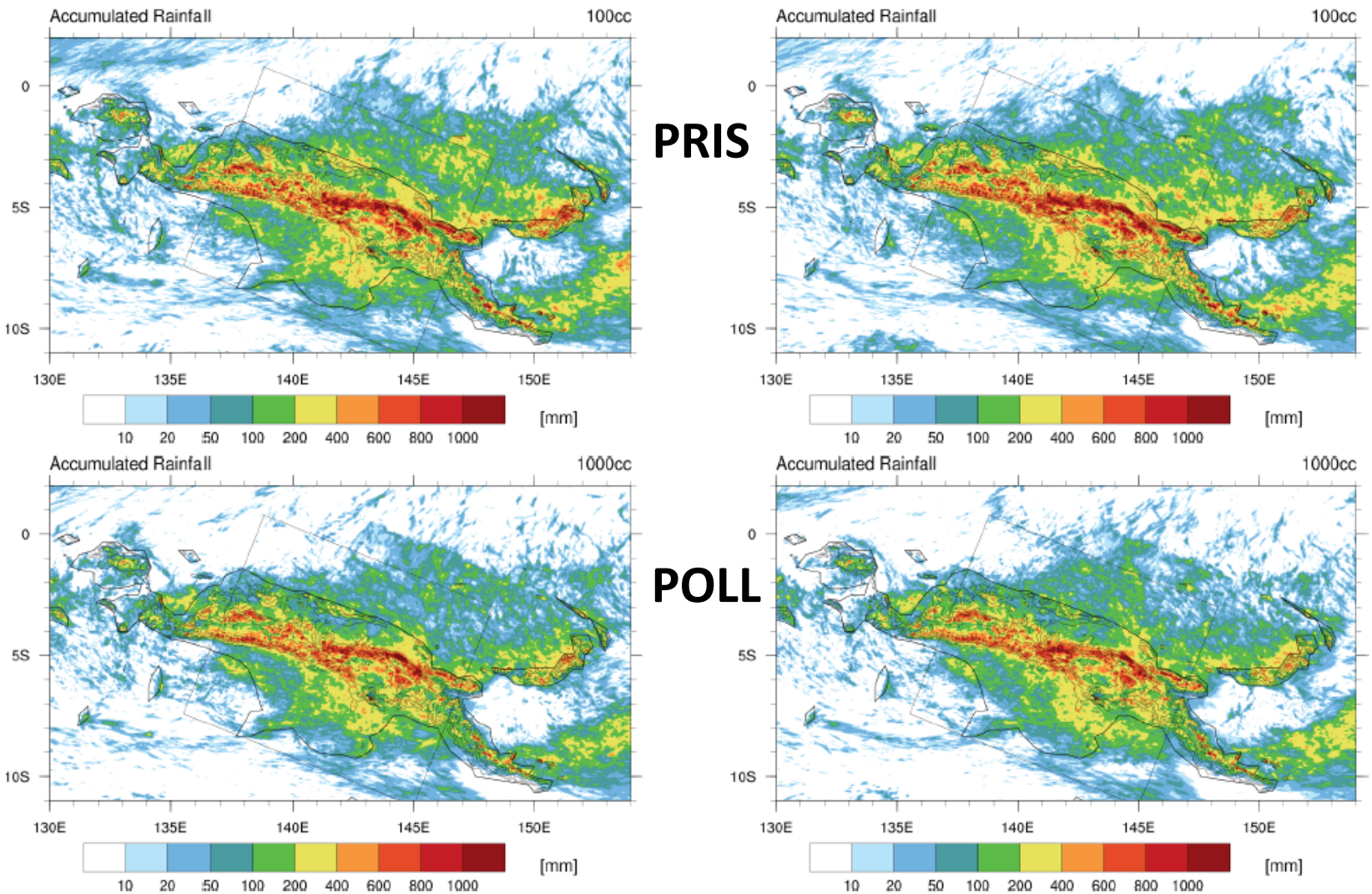
- cloud water: mixing ratio q_c with *prescribed* droplet concentration N_c
- rain water: mixing ratio q_r, number concentration N_r
- cloud ice: mixing ratio q_i, number concentration N_i
- snow: mixing ratio q_s
- graupel: mixing ratio q_g

contrasting pristine (PRIS; N_c = 100 cm^{-3})
and polluted (POLL) N_c = 1000 cm^{-3}) conditions

Simulation period: February 1-15, 2010
Initial and lateral boundary conditions, and SSTs: ERA-Interim reanalysis

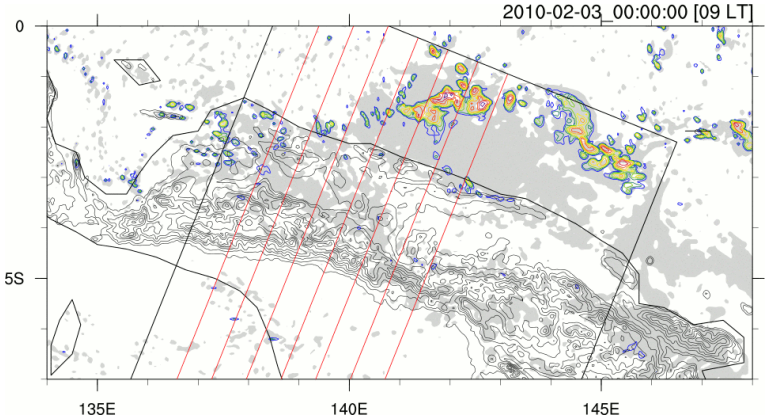
WRF version 3.3 and 3.5.1 (mini-ensemble?)

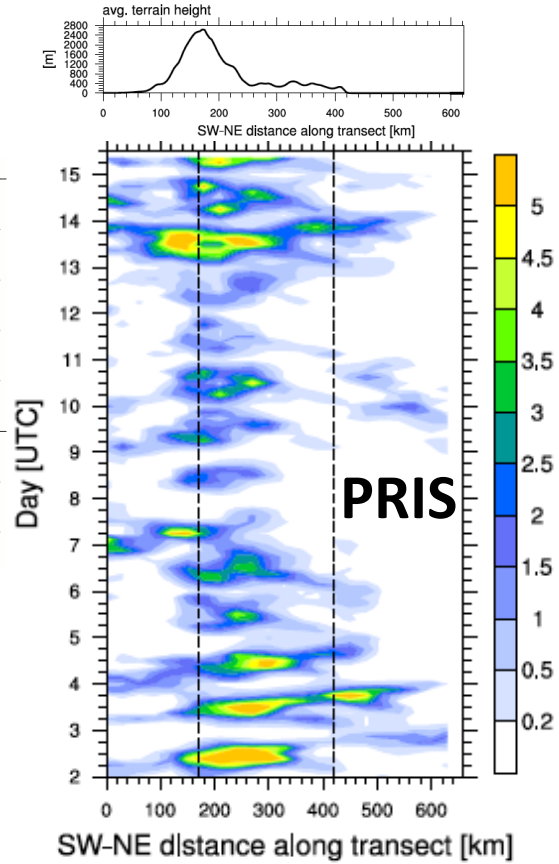
Results: distribution of the accumulated rainfall

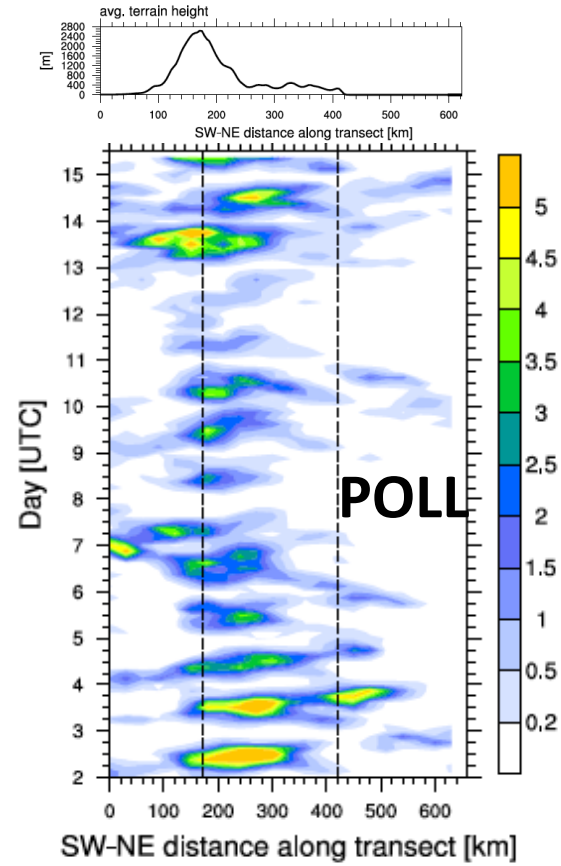


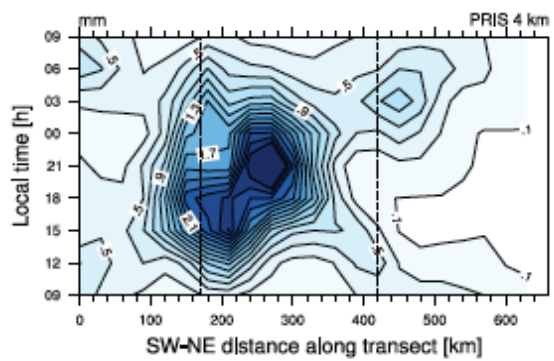
v3.3

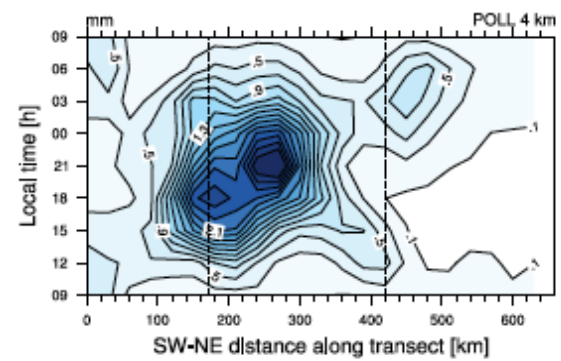
v3.5.1


2010-02-03_00:00:00 [09 LT]
0
5S
135E
140E
145E

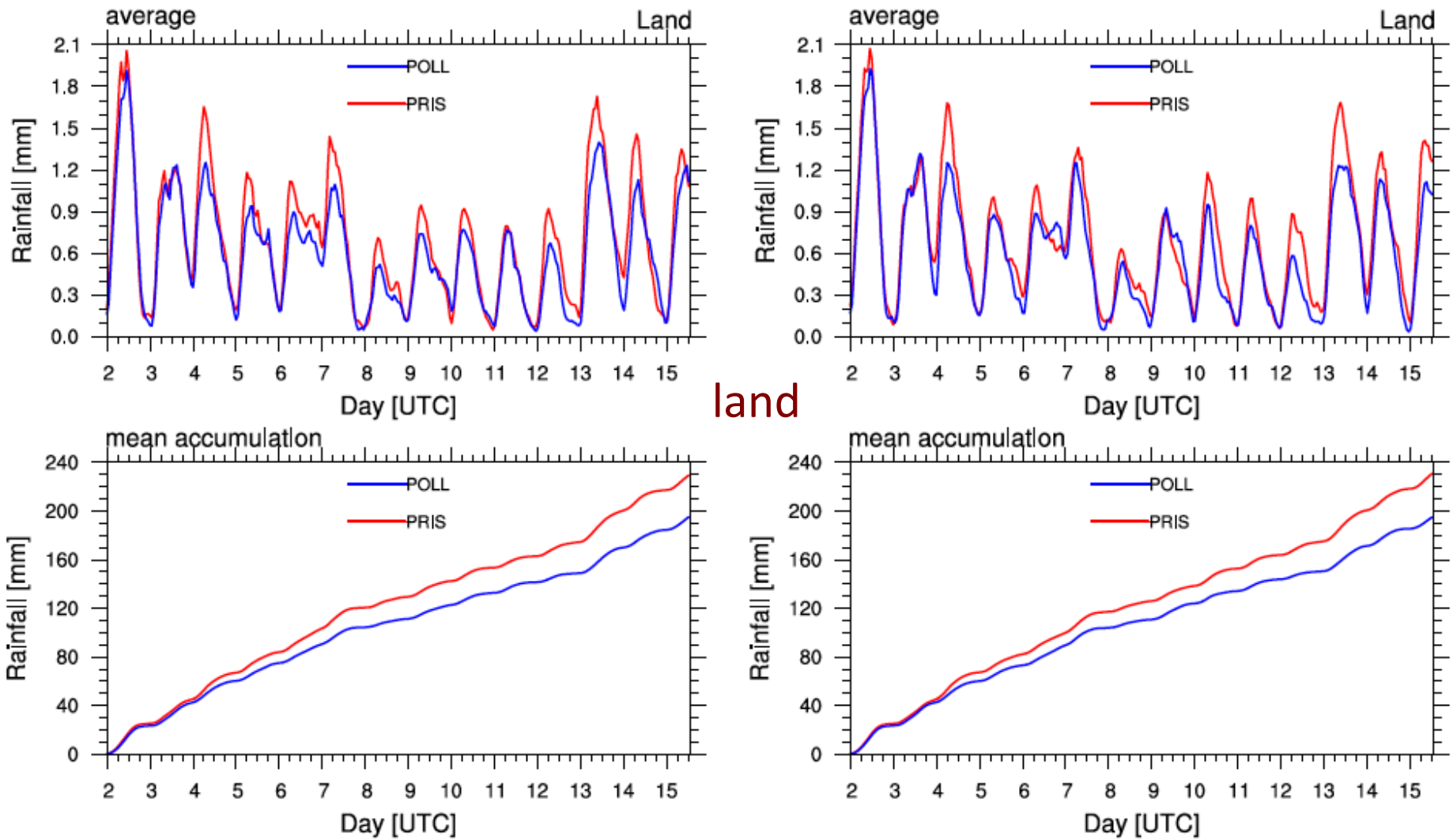

avg. terrain height
[m]
SW-NE distance along transect [km]
Day [UTC]
PRIS
SW-NE distance along transect [km]


avg. terrain height
[m]
SW-NE distance along transect [km]
Day [UTC]
POLL
SW-NE distance along transect [km]


mm
PRIS 4 km
Local time [h]
SW-NE distance along transect [km]


mm
POLL 4 km
Local time [h]
SW-NE distance along transect [km]

Results: total accumulated rainfall – land

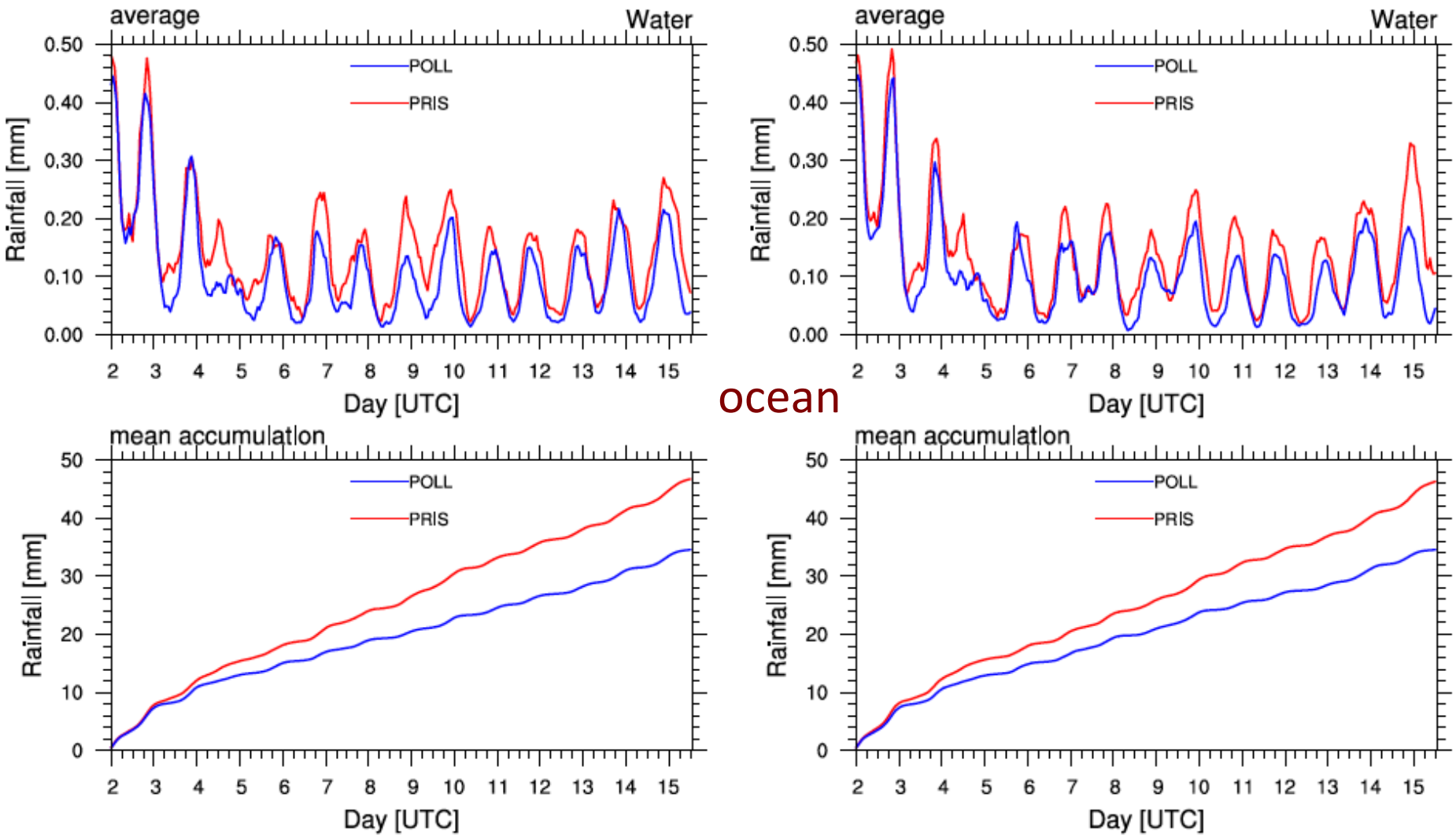


land

(a) v3.3

(b) v3.5.1

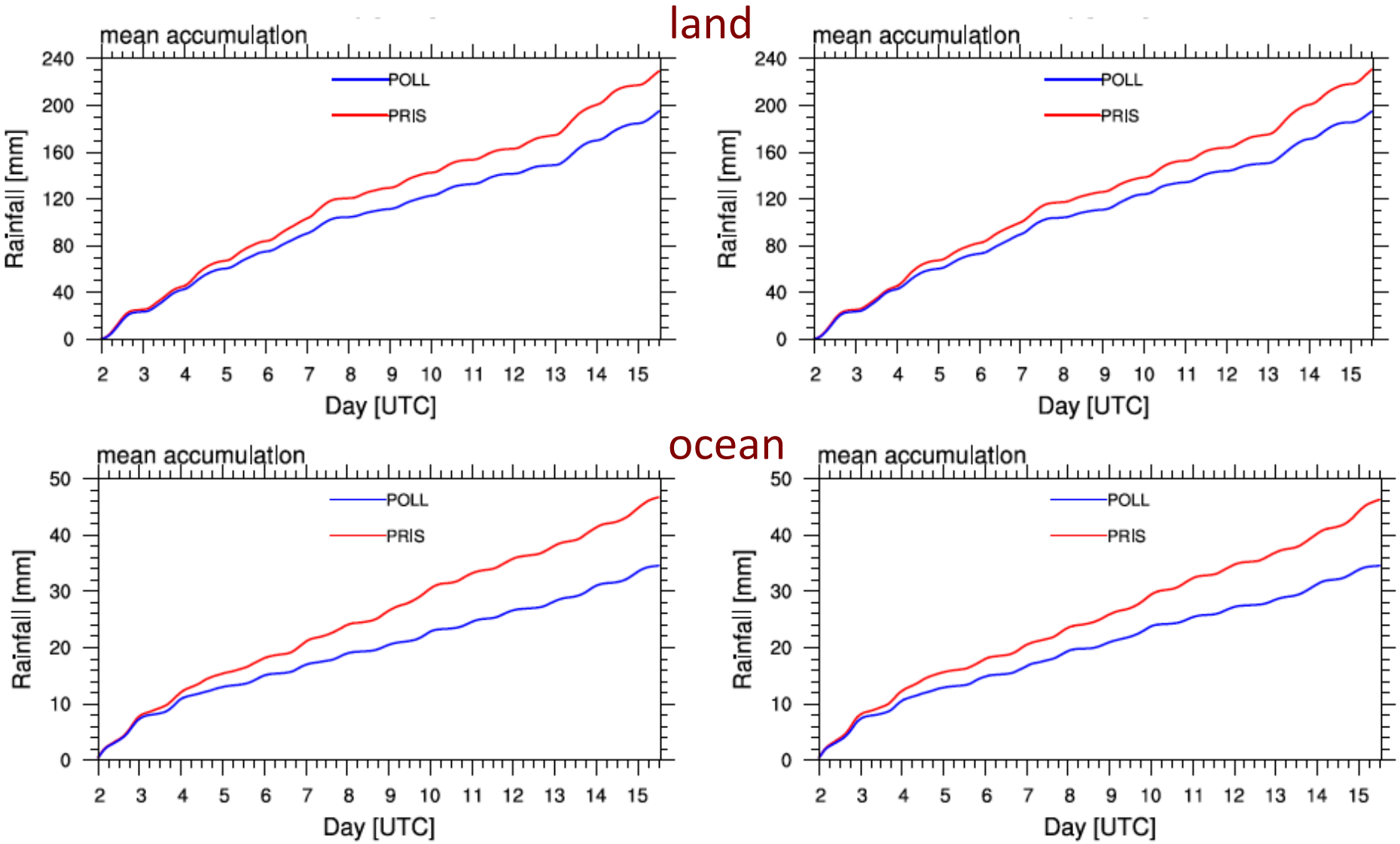
Results: total accumulated rainfall – ocean



(a) v3.3

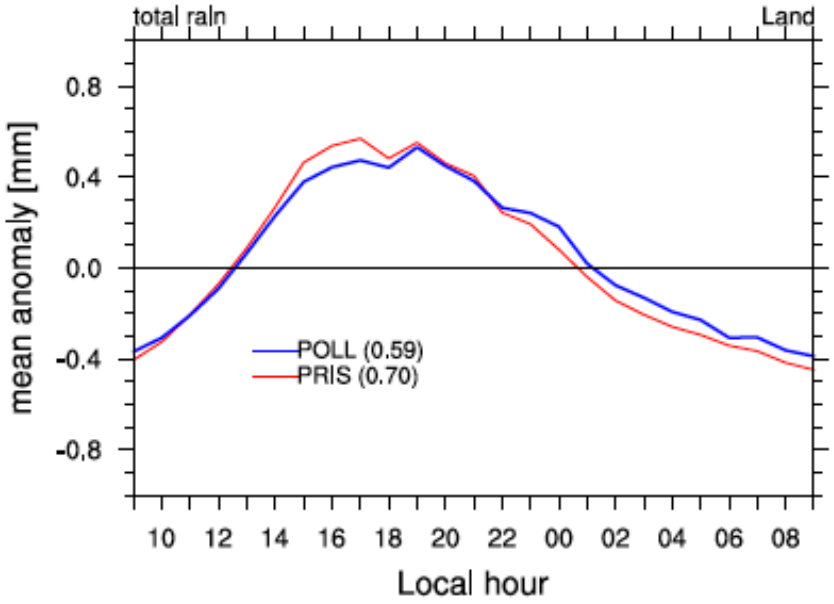
(b) v3.5.1

Results: total accumulated rainfall – land versus ocean

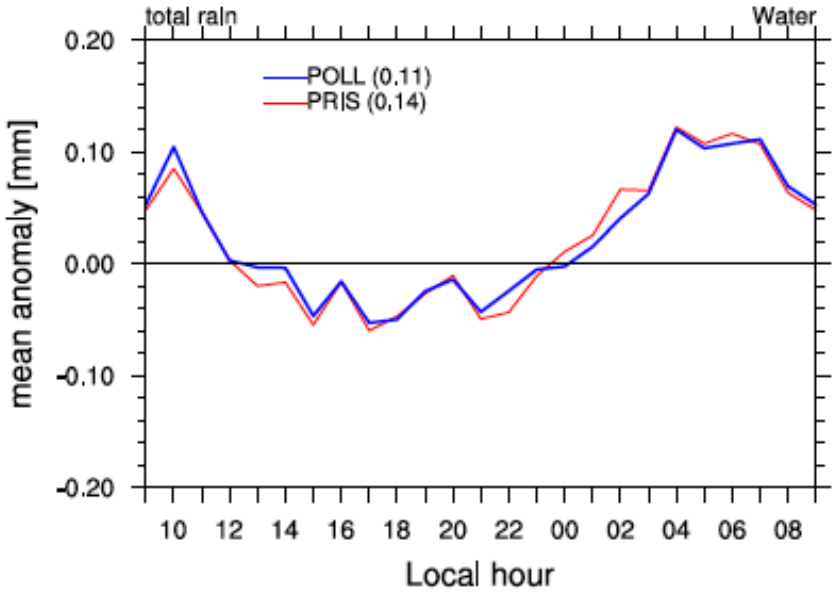


(a) v3.3 (b) v3.5.1

Results: diurnal cycle over land and ocean

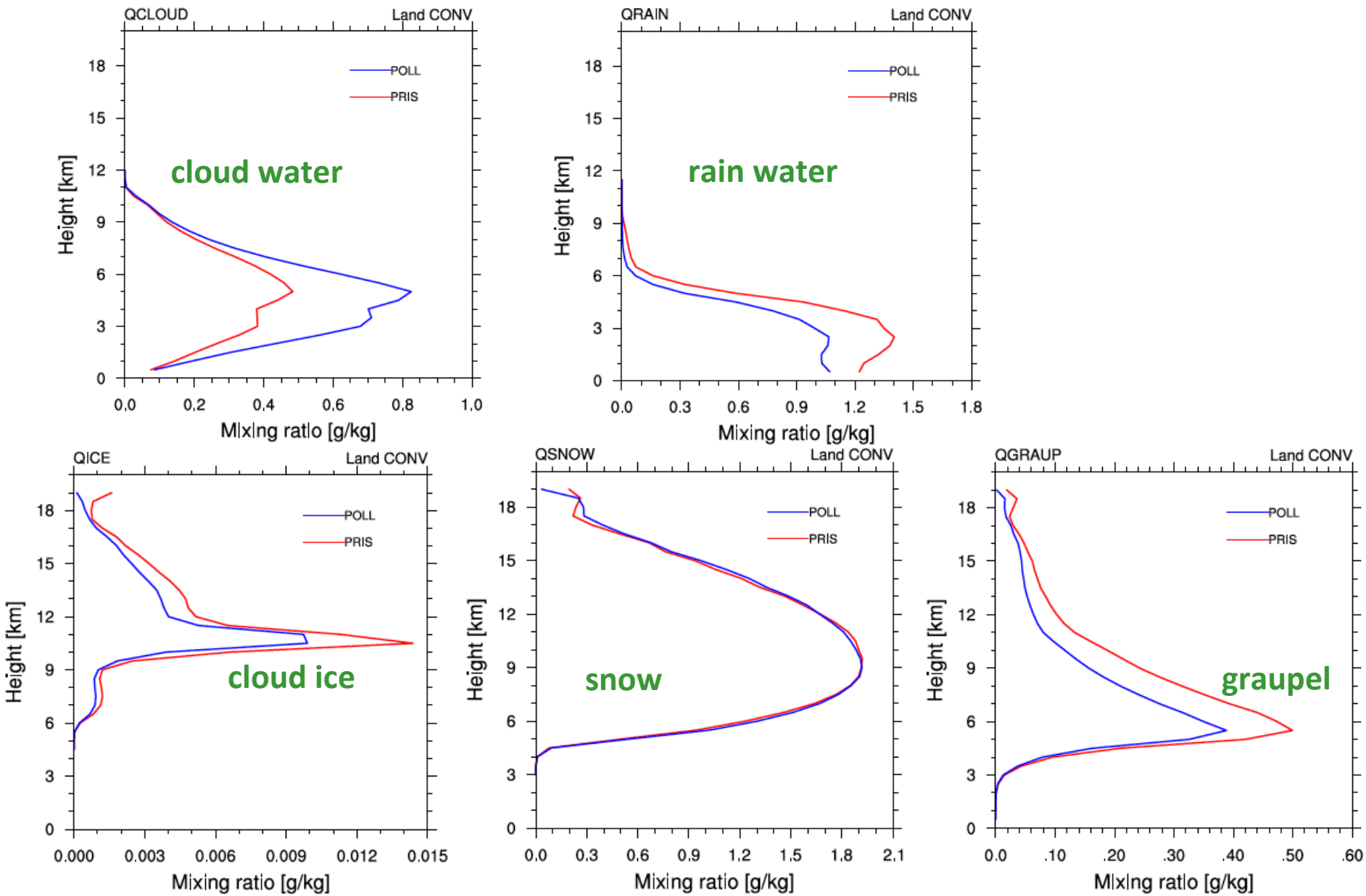


land

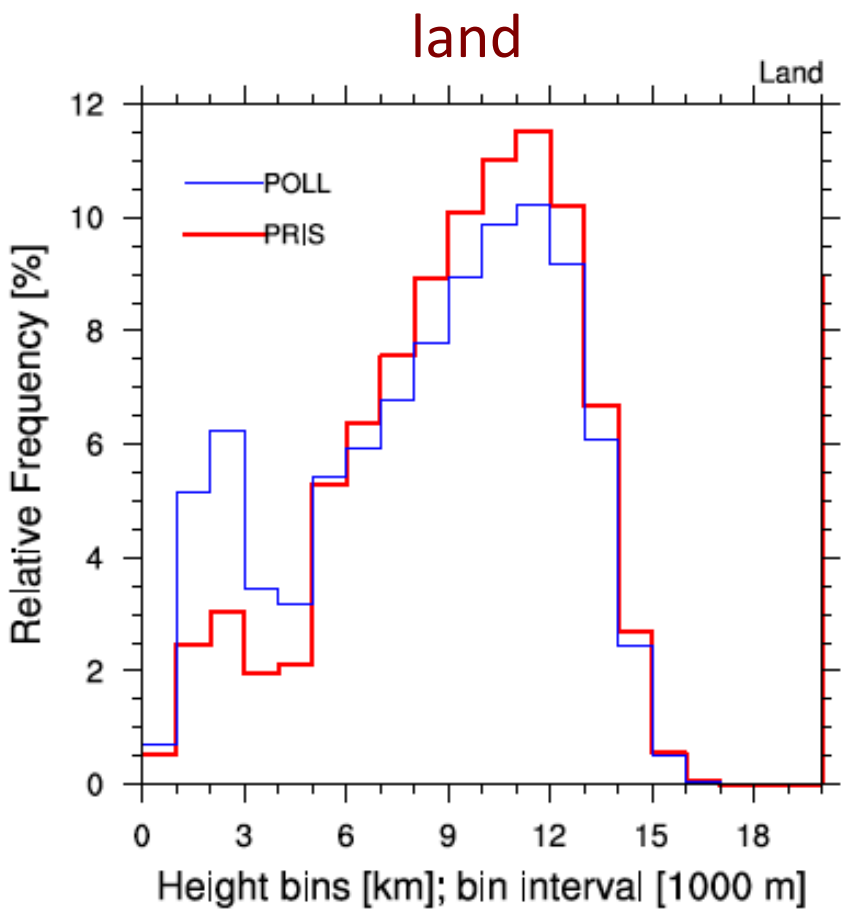


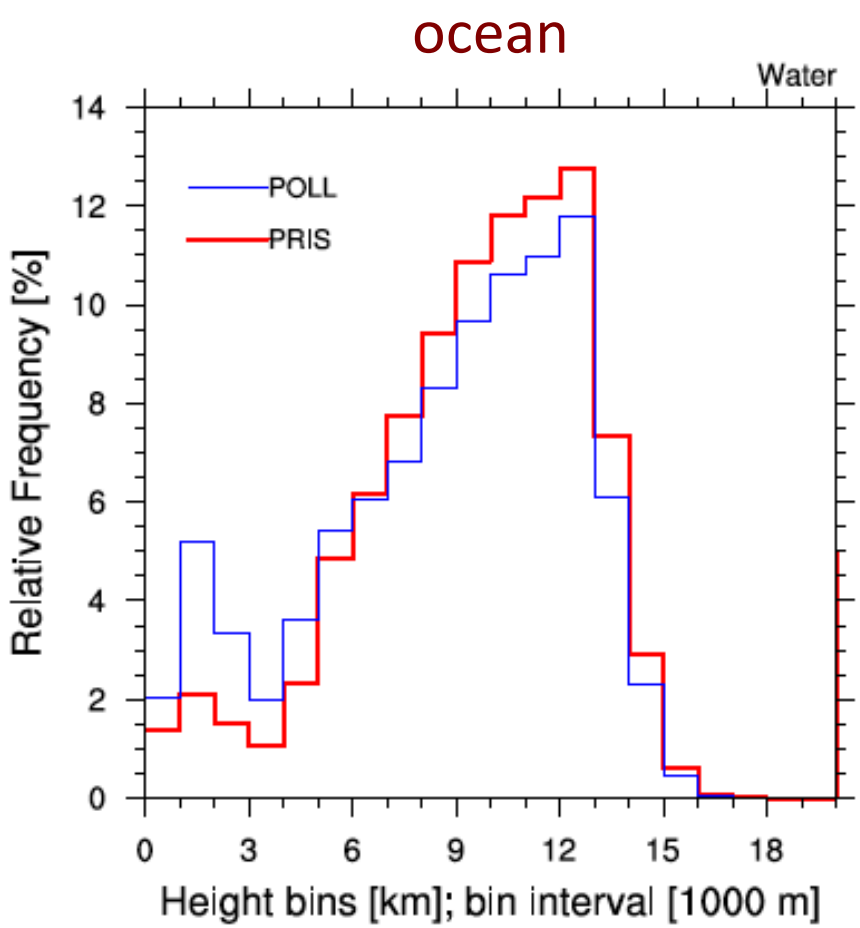
ocean

Results: conditionally-sampled water species



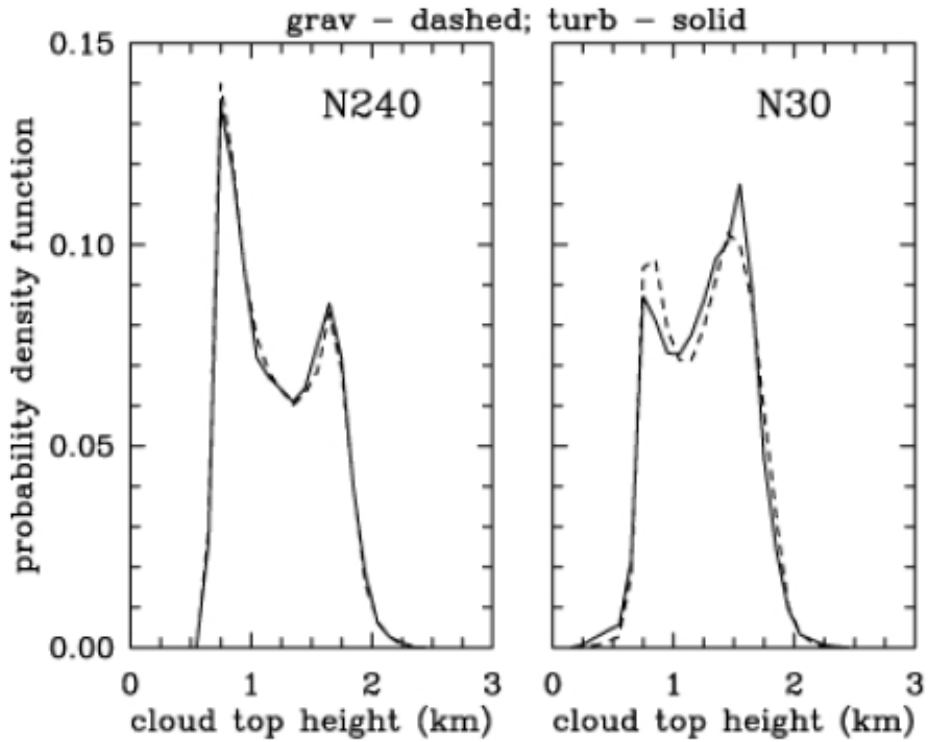
Results: histogram of the “cloud top” height





The mechanism: off-loading cloud condensate instead of increasing latent heating above 0 degC level?

Contrasting bin-microphysics simulations of a shallow-convection cloud field with significant rain (N30) and with trace of rain (N240) applying the classical gravitation kernel (grav; *dashed lines*) and the kernel with effects of small-scale cloud turbulence included (turb; *solid lines*).



Turbulent collision-coalescence in maritime shallow convection

A. A. Wyszogrodzki[1], W. W. Grabowski[1], L.-P. Wang[2], and O. Ayala[2,3]

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Atmospheric Chemistry and Physics
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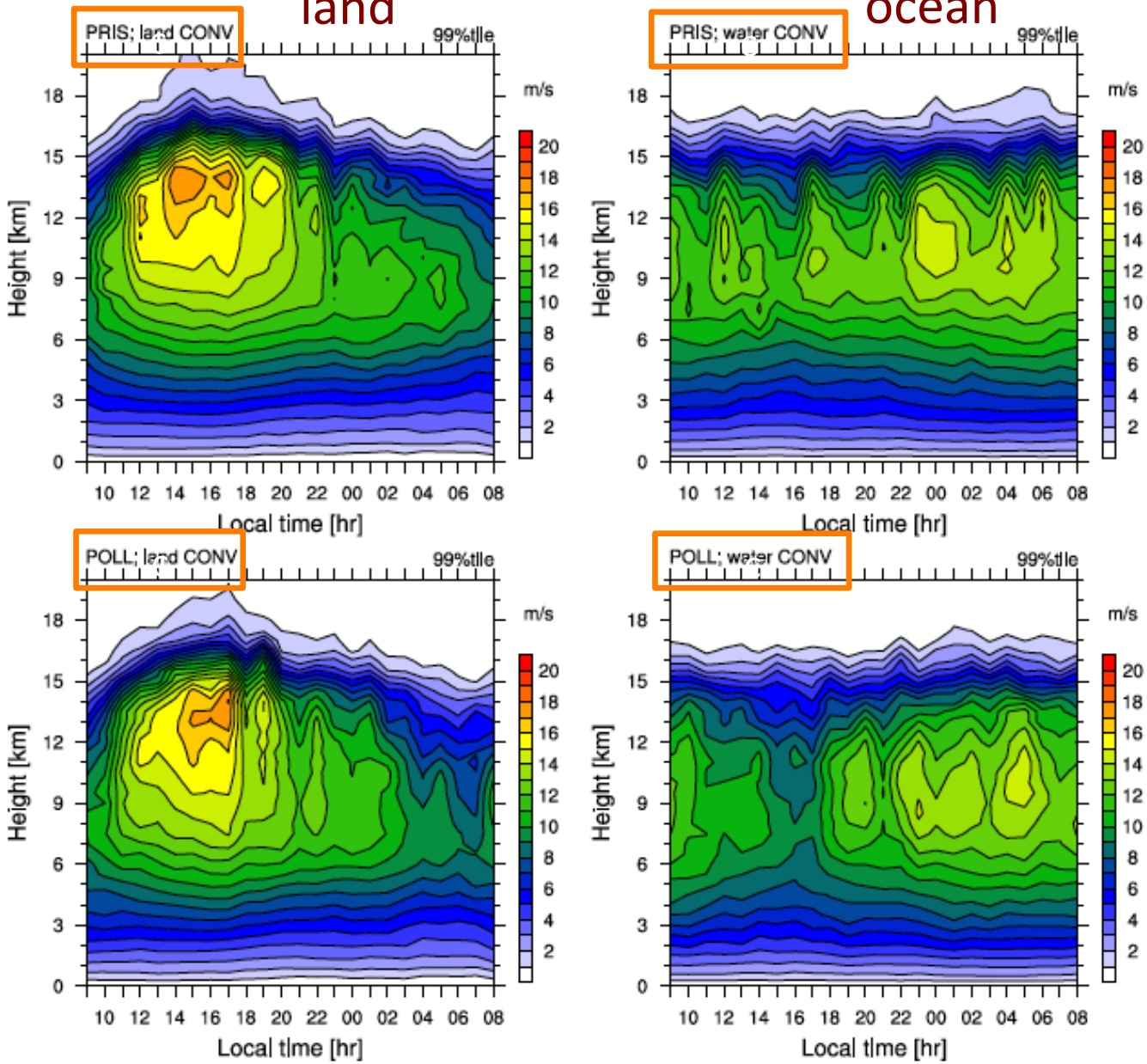
Results: diurnal cycle, 99% of mean convective updraft

land

ocean

PRIS

POLL



Conclusions:

Idealized 2-week-long convection-permitting simulations of cloud and precipitation processes over Maritime Continent during suppressed large-scale conditions have been performed, contrasting clean and polluted aerosol environments. No direct effects of aerosols were considered.

Tropical rainfall in a polluted environment is significantly reduced (15 to 20%) over both the land and the ocean. This in contrast to the convection invigoration hypothesis in a polluted environment.

Model results suggest that buoyancy effects due to condensate off-loading, similar to mechanism simulated in shallow maritime convection, might be responsible for this outcome.

Additional simulations, in particular applying higher horizontal resolution, are needed to further substantiate these results.