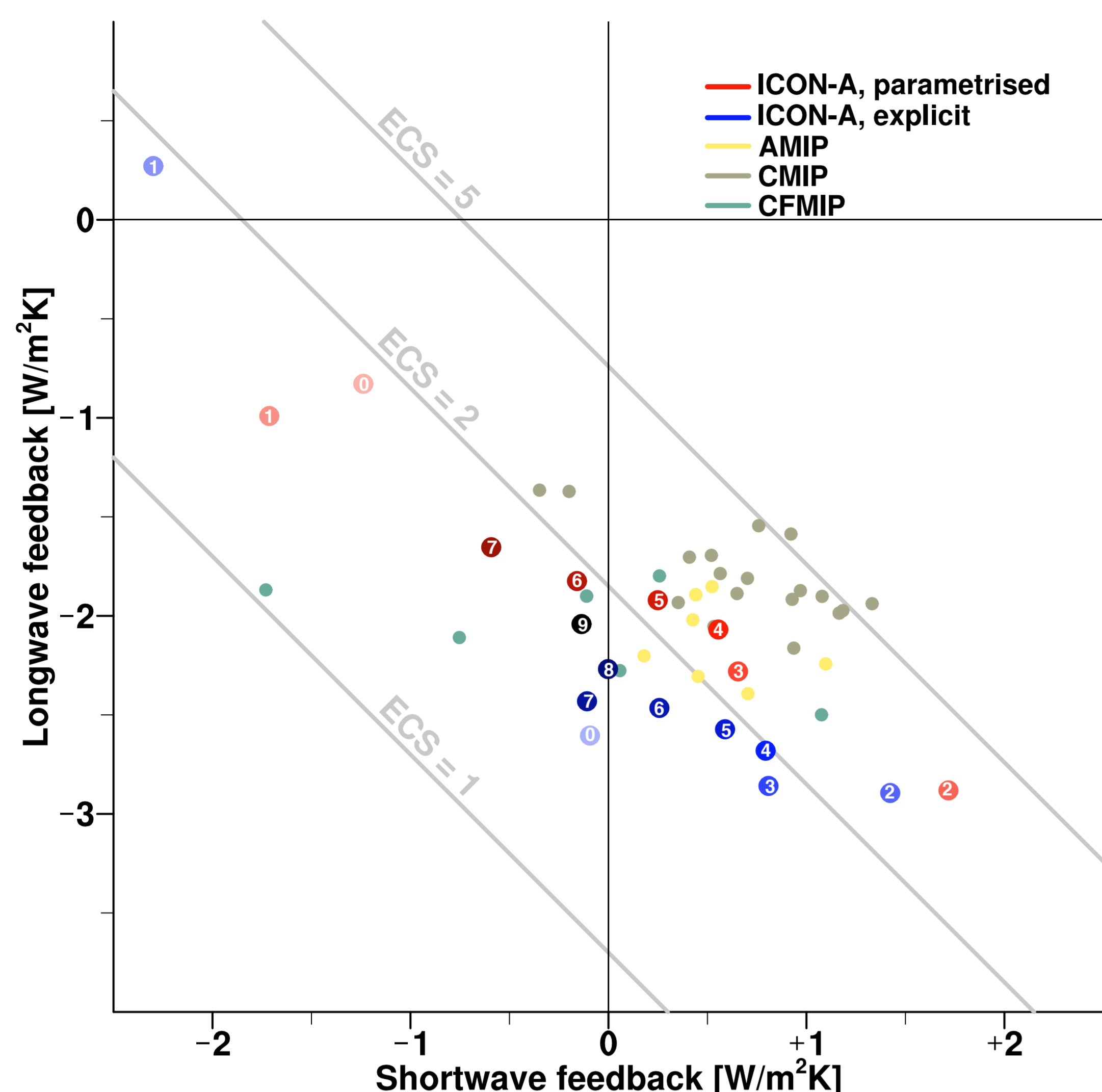


# Feedbacks in the General Circulation Model ICON-A for Explicit and Parametrised Convection across Resolution

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## Global Mean Feedbacks of ICON-A



- Feedbacks are changes of earth system properties due to global warming, e.g. cloud cover, which act positively or negatively onto global warming, i.e. they enhance or damp global warming.
- Equilibrium climate sensitivity (ECS) is the rise of the global mean surface temperature for an applied forcing after the earth system has reached equilibrium. In Figure 1 an forcing of  $3.7 \text{ W/m}^2$  is assumed for the grey ECS lines.
- ICON-A without a convection parametrisation, named *explicit* convection, consistently has a lower ECS due to more negative longwave feedbacks.

Figure 1: Global mean longwave and shortwave feedbacks for aqua-planet experiments of ICON-A at different resolutions as shown in the red table below. Also shown are the feedbacks from General Circulation Models of different Model Intercomparison Projects (MIP), such as the Atmospheric, the Coupled and the Cloud Feedback MIP.

## Summary and Outlook

- The explicit convection setup of ICON-A has more negative longwave feedbacks and more positive shortwave feedbacks at nearly all horizontal resolutions, except the lowest ones.
- A weaker moistening for explicit convection in the drier half area inside  $\pm 20^\circ$  explains up to 27% of the global mean longwave feedback differences between the parametrised and explicit convection setup of ICON-A. Clouds do not play a role in this area.
- The longwave feedback differences in the moister half area inside  $\pm 20^\circ$  are also due to different changes of cloud radiative effects. Where exactly those different changes of cloud radiative effects arise, is not clear yet.
- The more positive global mean shortwave feedbacks for the explicit convection setup originate also from high latitudes where three important shortwave feedbacks act more negatively for parametrised convection.

## Experiment Setup

ICON-A, the ICON version with the ECHAM physics package, is used.

4 different experiments are conducted on an aqua-planet setup:

- Fixed 'realistic' surface temperature & uniformly added 4 K to mimic global warming.
  - Each for Parameterised & Explicit convection (switched off parametrisation scheme).
- Simulation period is 5 years until the 20 km resolution. For 10 and 5 km it is 3 months.

All experiments are conducted on resolutions from 2525 to 5 km, see Table below.

The given lengths are the side lengths of a square with the area of one ICON-triangle.

Acronym	b0	b1	b2	b3	b4	b5	b6	b7	b8	b9
Resolution [km]	2525	1263	631	316	158	79	39	20	10	5

## The Longwave Feedbacks

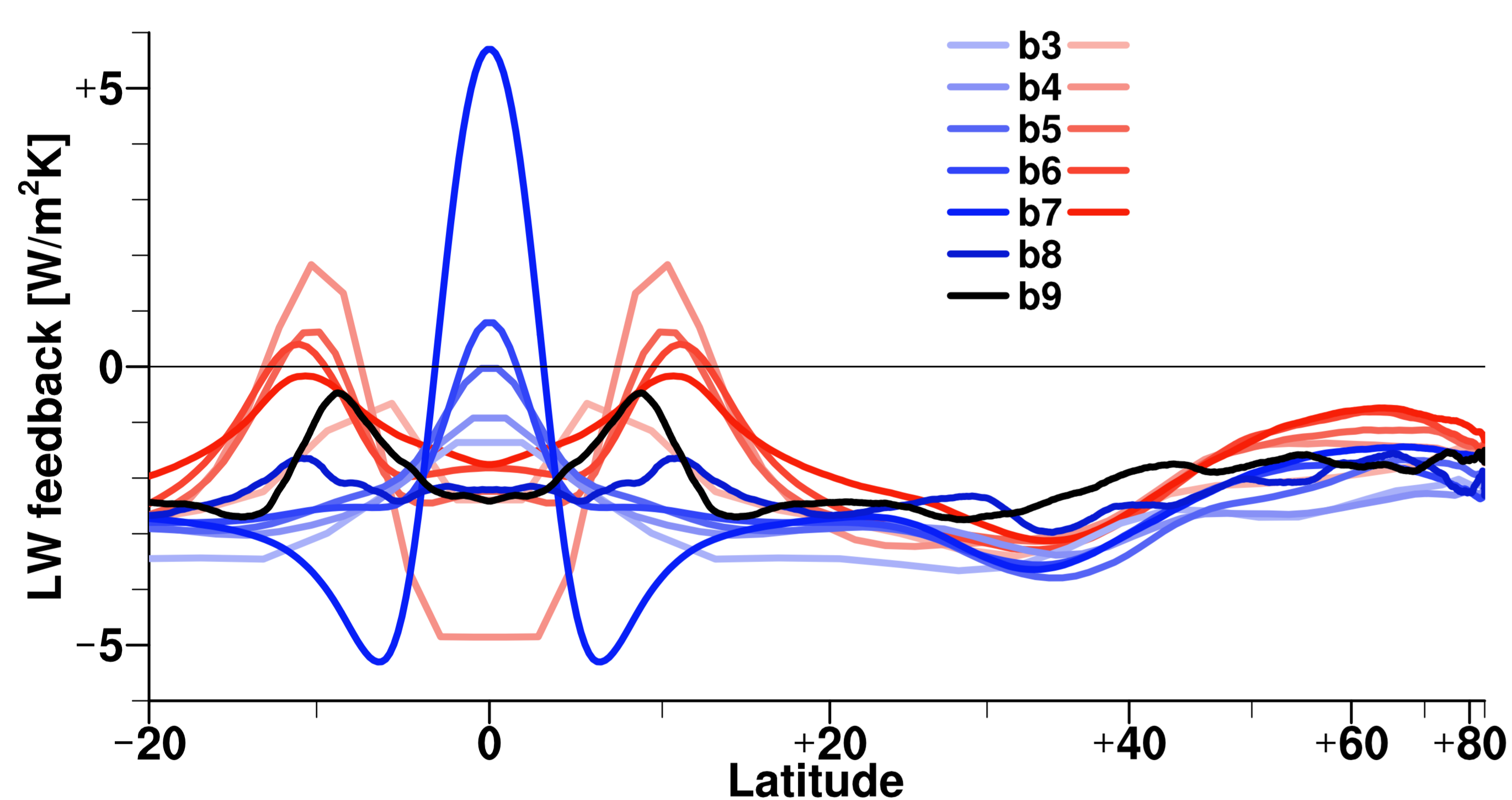


Figure 2: Zonal mean longwave feedbacks for aqua-planet experiments of ICON-A at resolutions as shown in the red table above.

- Longwave (LW) feedback differences between ICON-A's setups occur mainly in the tropics (Figure 2).
- For the half area inside  $\pm 20^\circ$  with less column water vapour, these different feedbacks arise from a stronger moistening, i.e. increase of column water vapour, for the parametrised setup, which is a more positive feedback for parametrised convection.
- Changing cloud radiative effects, which are the difference between 'clear-sky' and 'all-sky' feedbacks in Figure 3, are not responsible for the different longwave feedback between the setups, but are very well responsible for changes across resolution.

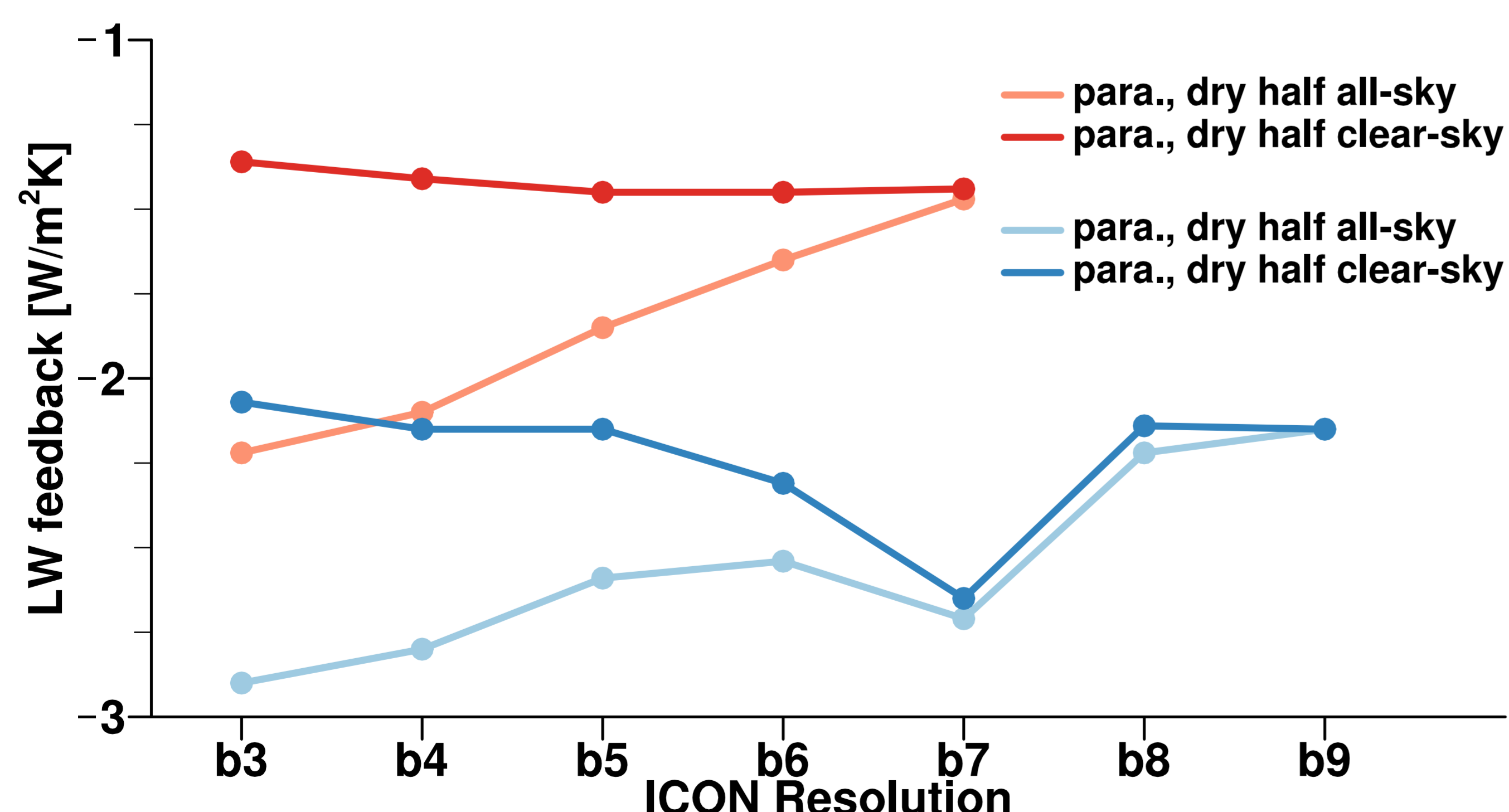


Figure 3: Clear-sky and all-sky feedbacks in the drier half area inside  $\pm 20^\circ$  for the parametrised and explicit convection setup.

## The Shortwave Feedbacks

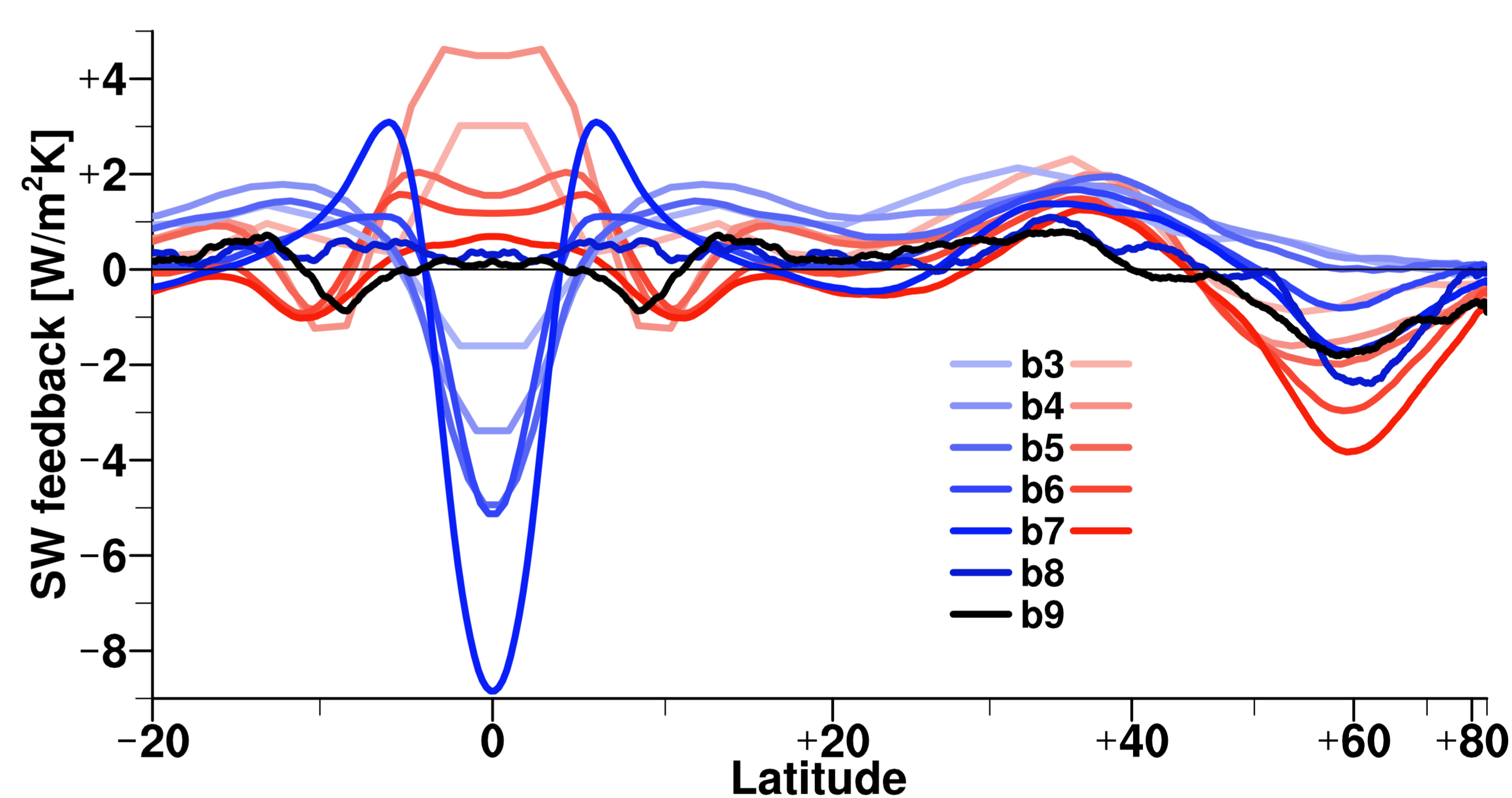


Figure 4: Zonal mean shortwave feedbacks for aqua-planet experiments of ICON-A at resolutions as shown in the red table above.

- Shortwave feedback differences between ICON-A's setups occur in the tropics and at high latitudes (Figure 4).
- At high latitudes the three feedbacks of total cloud water increase, cloud cover increase and change of phase from cloud ice to cloud liquid particles act all more negatively for parametrised convection and also towards higher resolutions.
- The most important feedback seems to be the cloud water feedback (Figure 5), yet at lower resolutions of explicit convection the cloud cover feedback is dominating.

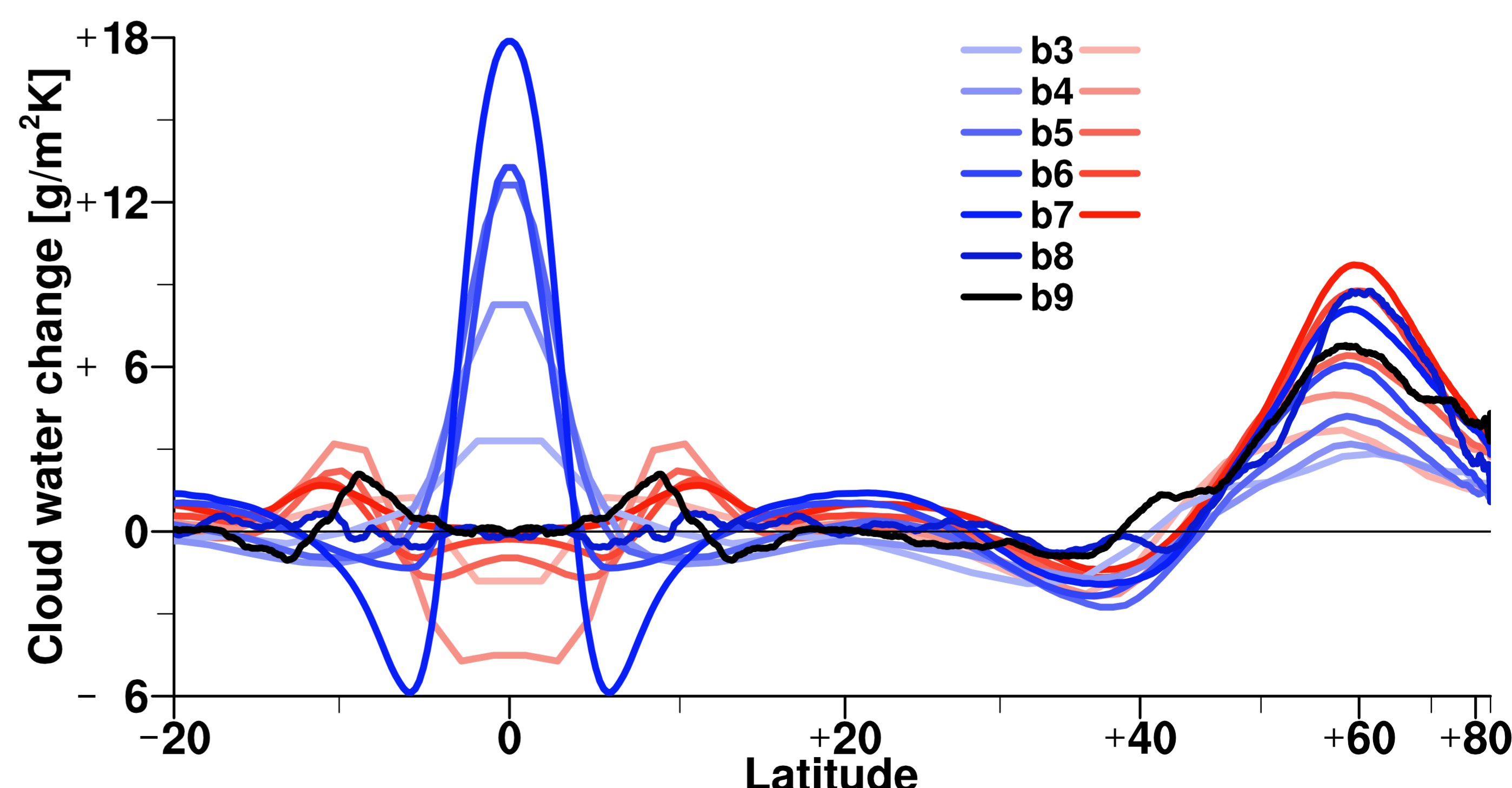


Figure 5: Zonal mean change of total cloud water (cloud liquid + ice particles) at resolutions as shown in the red table above.

