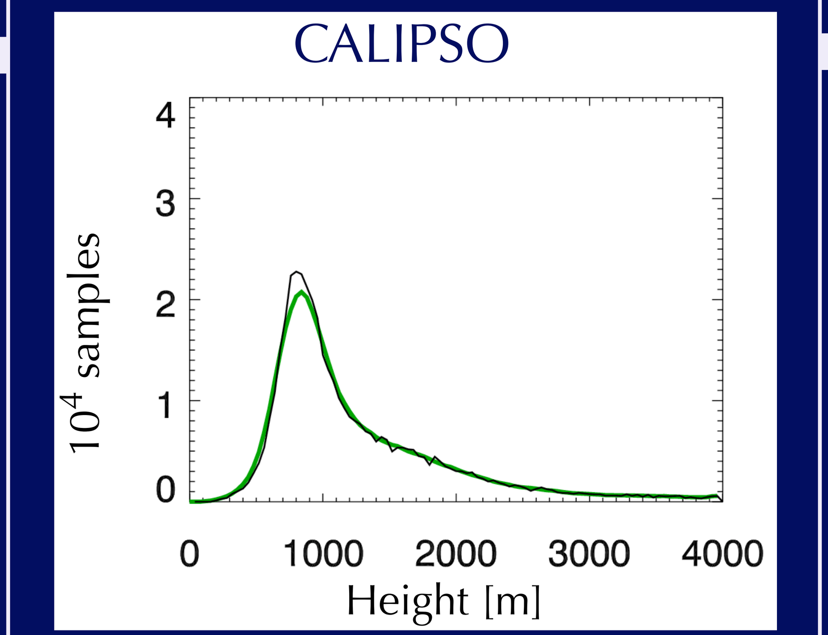
Evaluation of shallow convective cloudiness across ECMWF model cycles

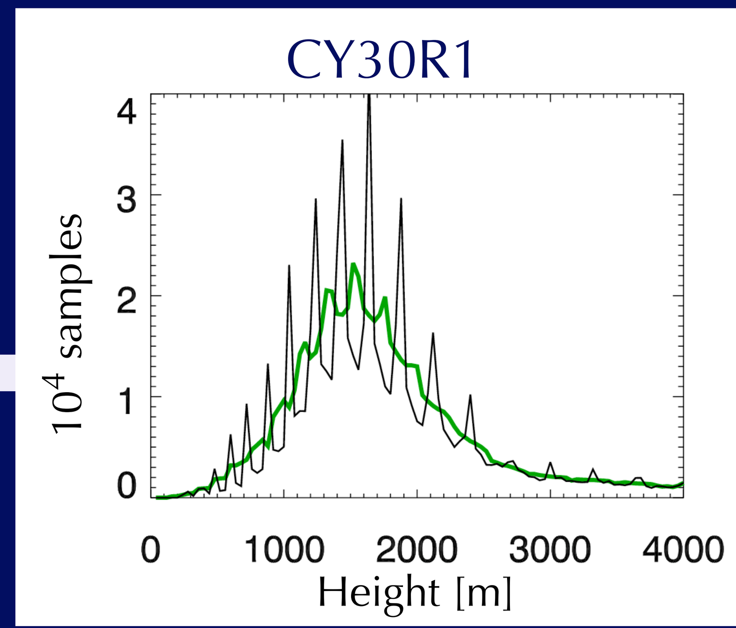
Maike Ahlgrimm, Martin Köhler, Anton Beljaars, ECMWF

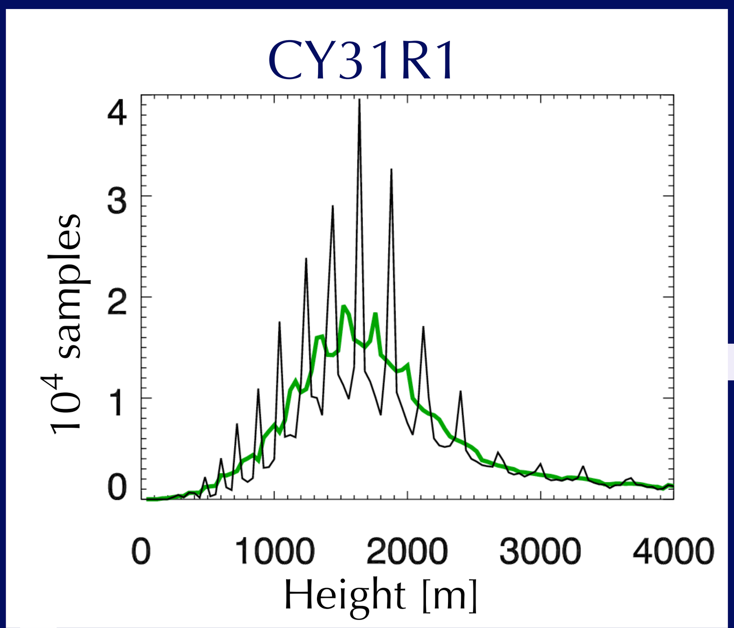
1 The improvement of boundary layer processes (including shallow clouds) in the ECMWF model has been given special emphasis in the past few years. This poster shows how changes in the model affect the cloud top height of trade cumulus clouds (TCu).



2 CALIPSO observations of cloudy layers for the month of July 2008 are used to identify samples with cloud tops below 4 km and 50% or less cloud fraction over the subtropical oceans (30N to 30S). Similar samples are identified in each of the five model cycles.

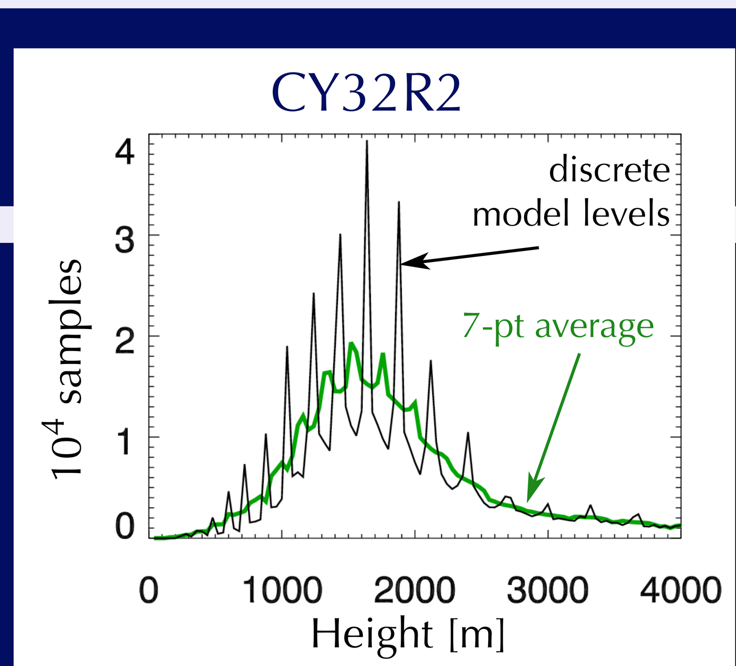
3 The shallow convective parameterization in **CY30R1** prescribes an equal entrainment and detrainment rate in the lower half of the cloud, resulting in a constant mass flux profile. In the upper half of the cloud, entrainment is zero, and the cloud detrains. The detrained cloud volume is a source term for the prognostic cloud cover variable in the large scale cloud scheme. Due to this formulation, **shallow clouds tend to be "top heavy"**. Since the cloud tops in the distribution stem mostly from these "anvils", they are **too high** compared to observations.

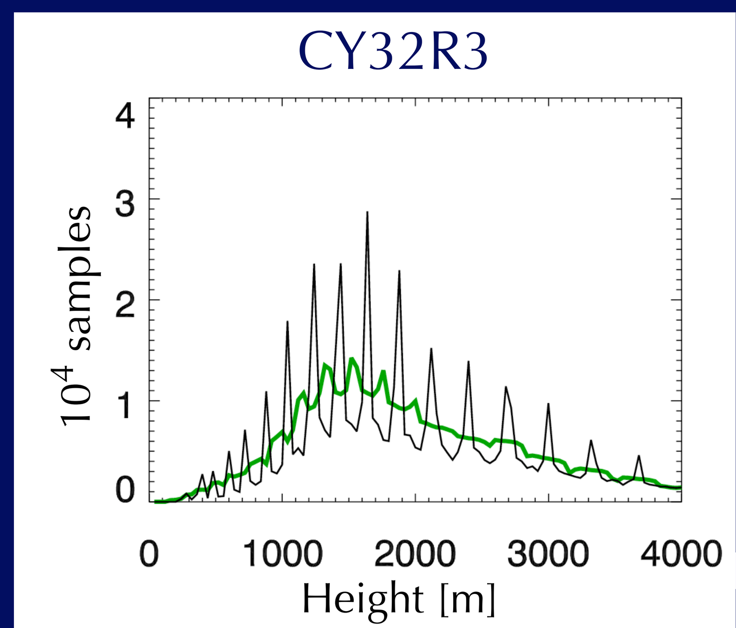




4 In **CY31R1**, the cloud scheme is revised to include supersaturation with respect to ice. In addition, numerical changes in the ice-to-snow conversion are made. Not surprisingly, these alterations have **little impact** on boundary layer clouds.

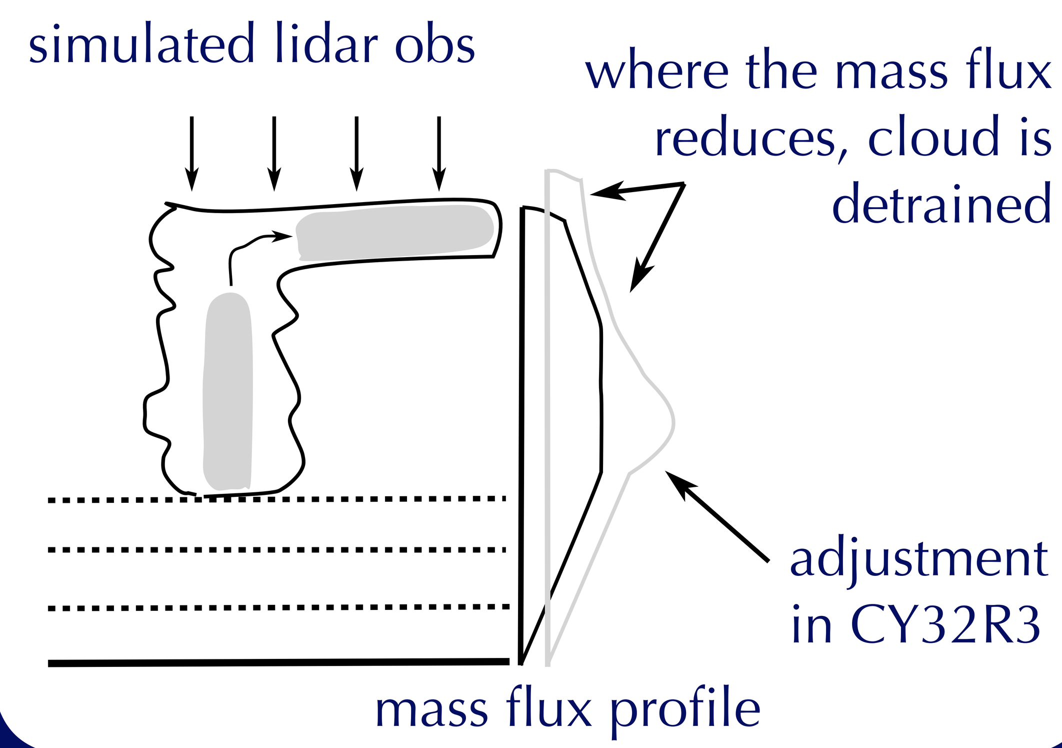
5 In **CY32R2**, the **McICA** for interaction between clouds and radiation is introduced, and the shortwave radiation is calculated using the **RRTM**. Again, there is **little impact on TCu** clouds. Since TCu clouds are predominant in areas of subsidence, there are probably few cases where overlap by upper cloud levels is significant. The microphysical properties important to shortwave radiation also remain unaltered.



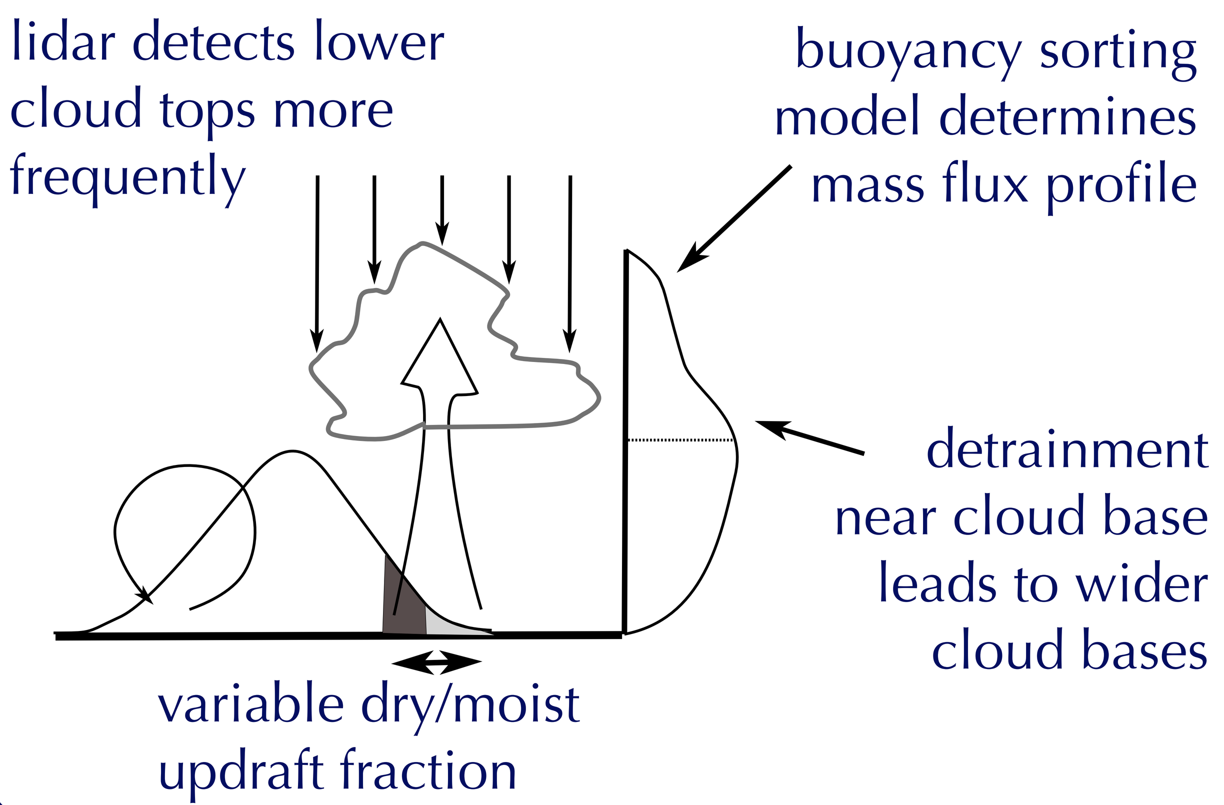


6 In **CY32R3**, the **entrainment/detrainment** formulation is changed in the shallow and deep convective parameterizations. The shallow clouds now net-entrain near the cloud base, but continue to detrain primarily near the cloud top. Another major change is the **reduction of vertical diffusion**, but its impact is felt mostly in areas with strong inversions or shear.
While the peak of the cloud top distribution does not shift much, there are **fewer low cloud tops** and more frequently **clouds reaching to 3 or 4 km**. It is likely that the new entrainment formulation produces less dilute, more agressive parcels that reach higher into the atmosphere before losing buoyancy.

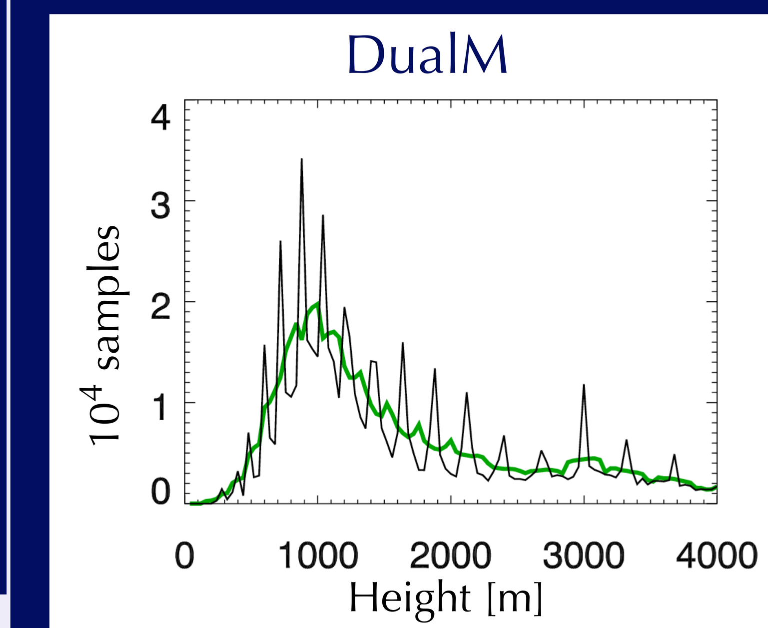
Shallow convective parameterization



DualM parameterization



7 The **DualM** scheme replaces the shallow convective parameterization. **Convective updrafts are modeled explicitly**, and the clear and cloudy fractions of the updraft are variable. Consistent with LES studies, **the in-cloud mass flux is greatest near cloud base**. How quickly the cloud detrains with height is based on a buoyancy sorting model. The positively buoyant part of the updraft directly determines the change in mass flux with height.
As a result, the cloud starts shedding mass at much lower levels, reducing the anvils and leading to wider cloud bases. The cloud top distribution shifts to lower levels and is now in **very good agreement with observations**.



Contact: maike.ahlgrimm@ecmwf.int

A list of references is available on the hand-out. Please take one!