Real case-study of a tropical tropopause layer cirrus and its impact

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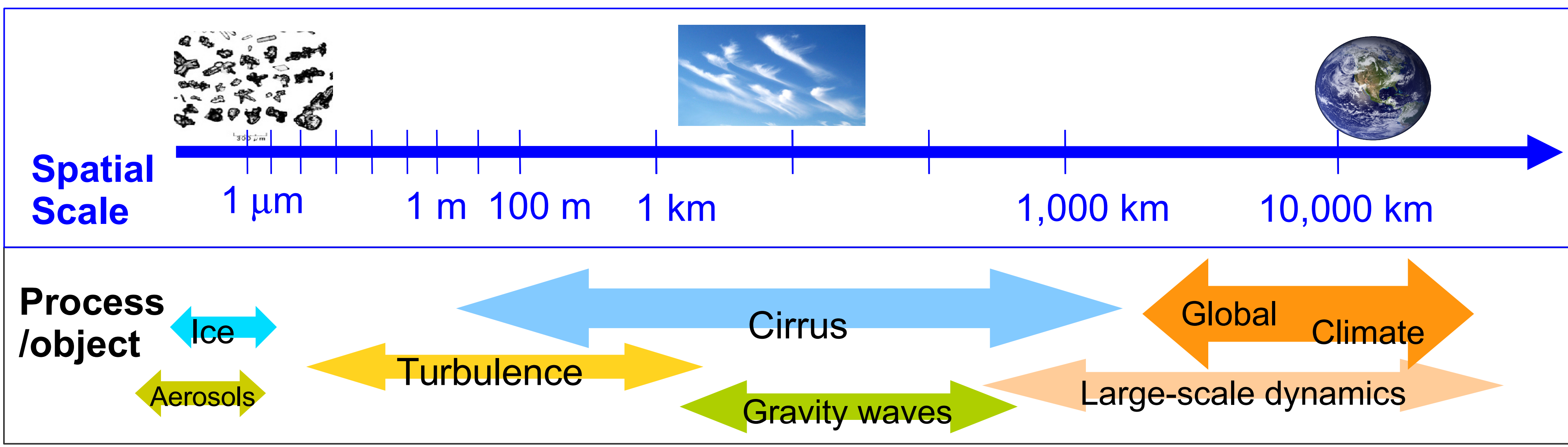
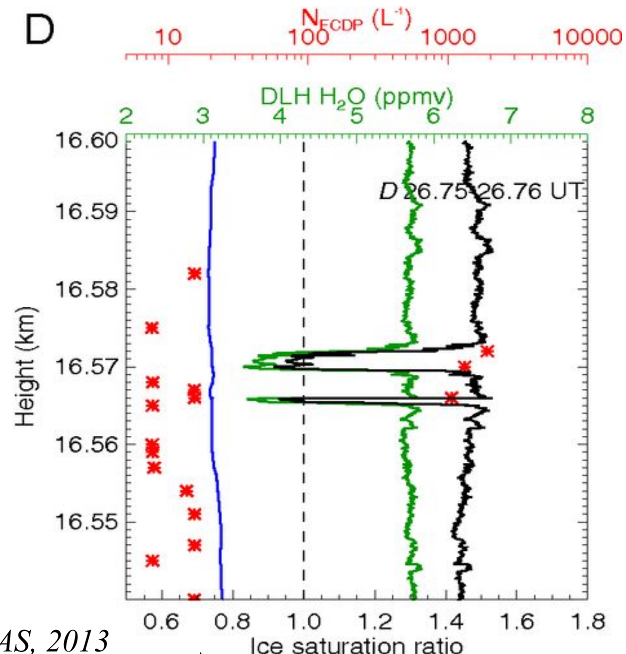
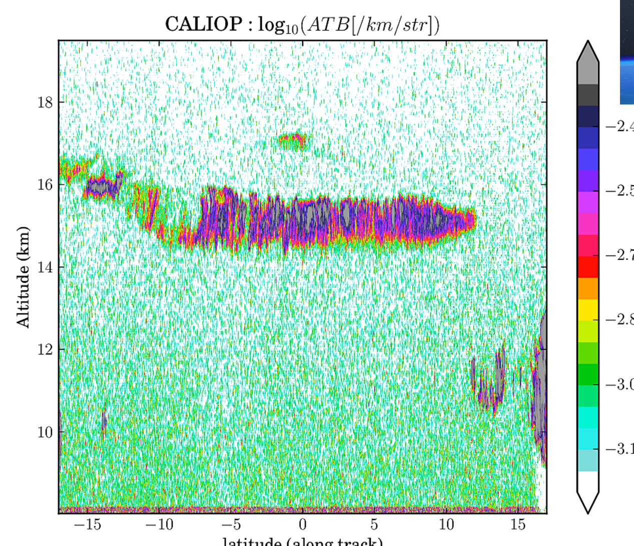


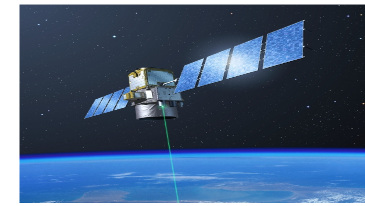
Cirrus : measurements



Small-scales : In situ observations

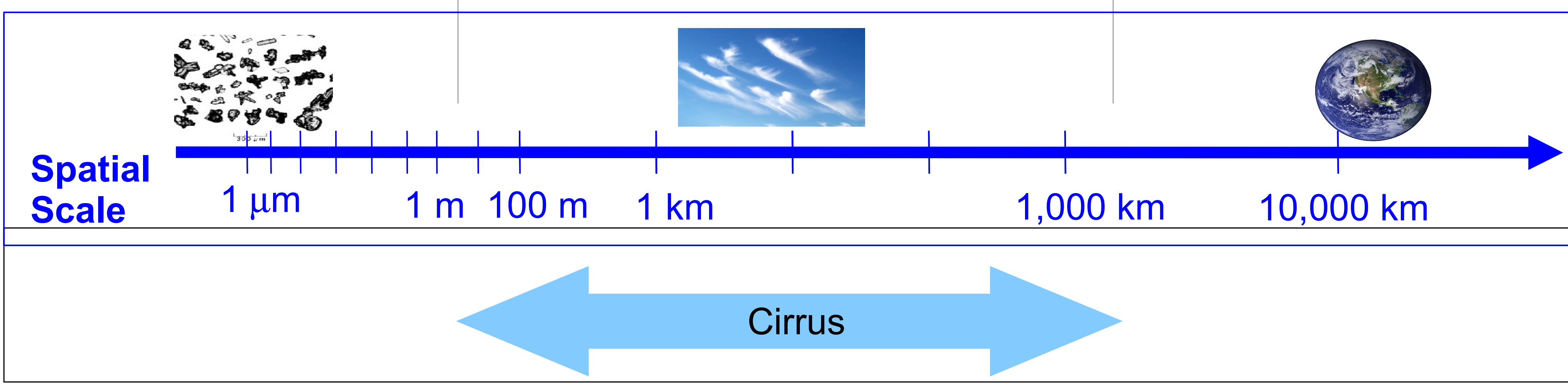
Jensen et al., PNAS, 2013





Large-scale characteristics remotely observed

Taylor et al., ACP, 2011



Mesoscale cirrus modelling

- **To assess the ability/realism of the model and its parameterizations to simulate cirrus**

- To understand cloud formation and interaction with the large-scale

- To quantify the cloud impacts

Modelling set-up

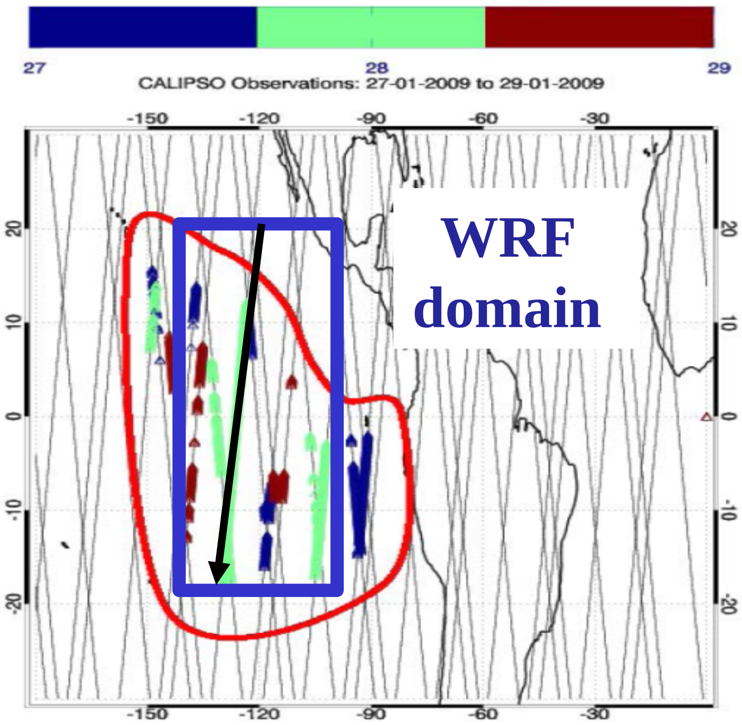
- Mesoscale modeling with the NCAR Weather Research and Forecast model v3, in January 27-29, 2009

- Thompson scheme (2 moments for ice) (and different sensitivities)

- RRTM for radiative transfer

- 10 km horizontal resolution
  (tests with 4 km),
  about 250-300 m vertical resolution

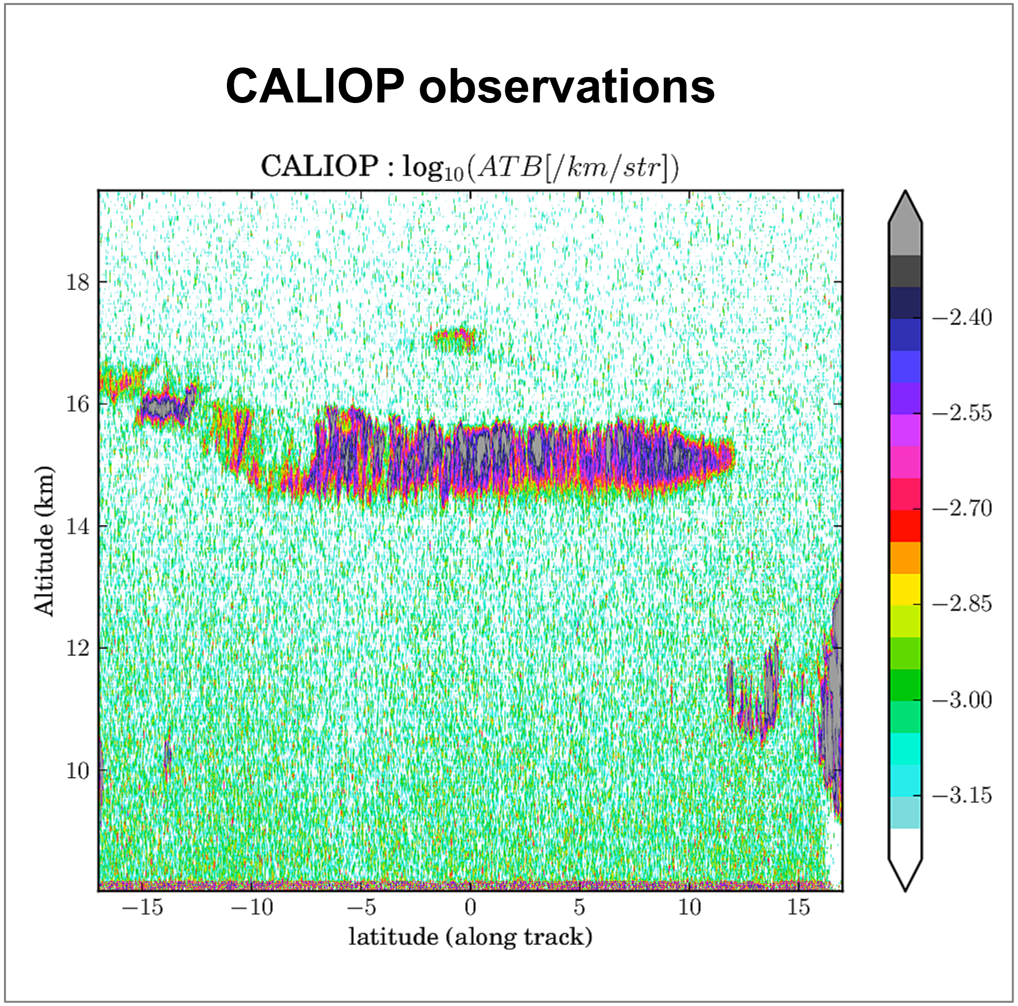
- Domain 40° North-South, 40° West-East

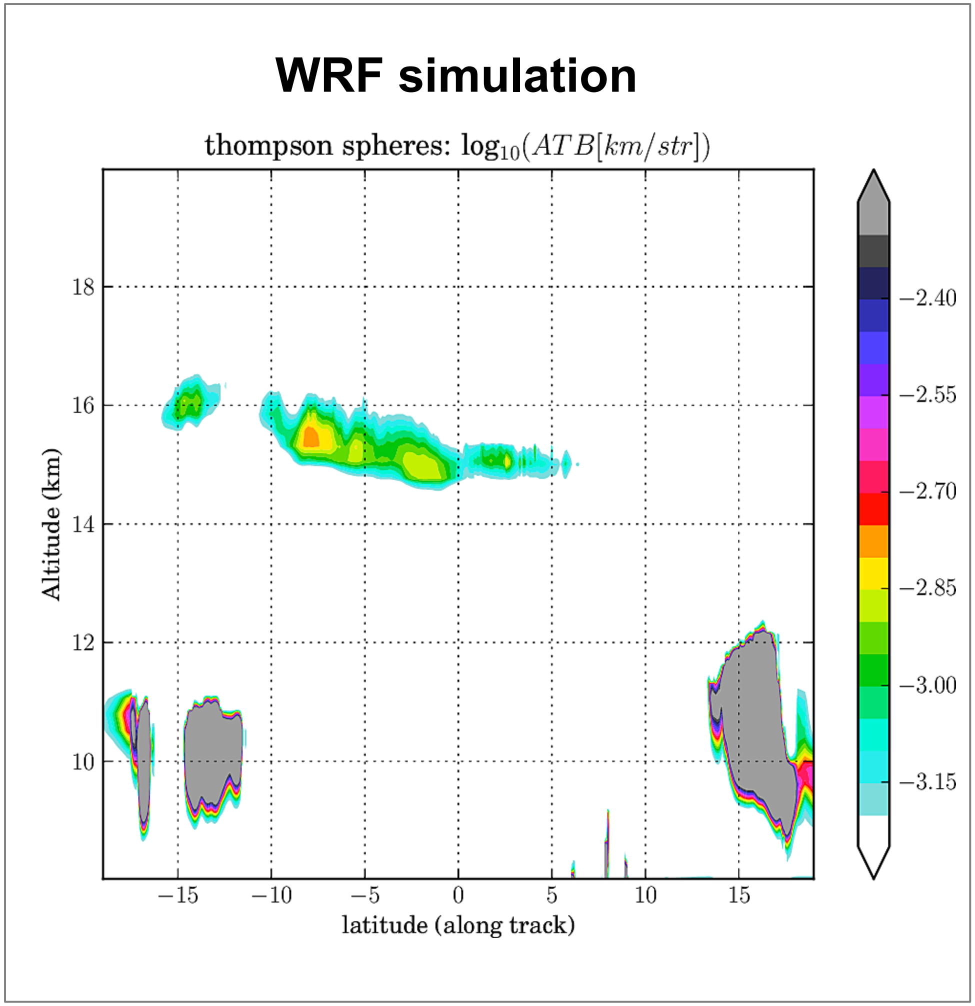


- Initial and boundary conditions taken from ECMWF operational analyses (including water vapor)

Modelling Cirrus clouds

At the « large-scale »





Podglajen et al., ACPD, 2015

Mesoscale cirrus modelling

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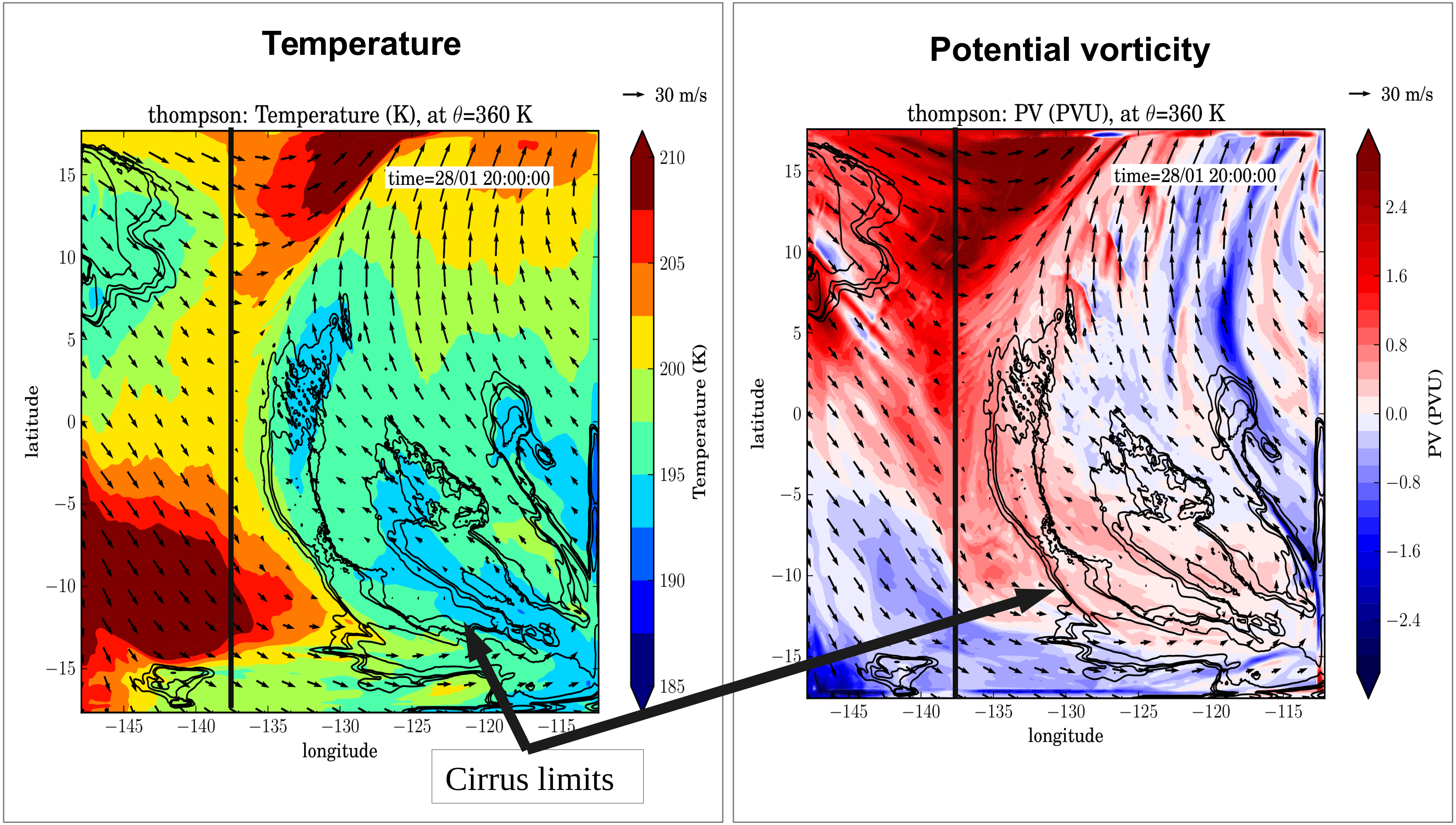
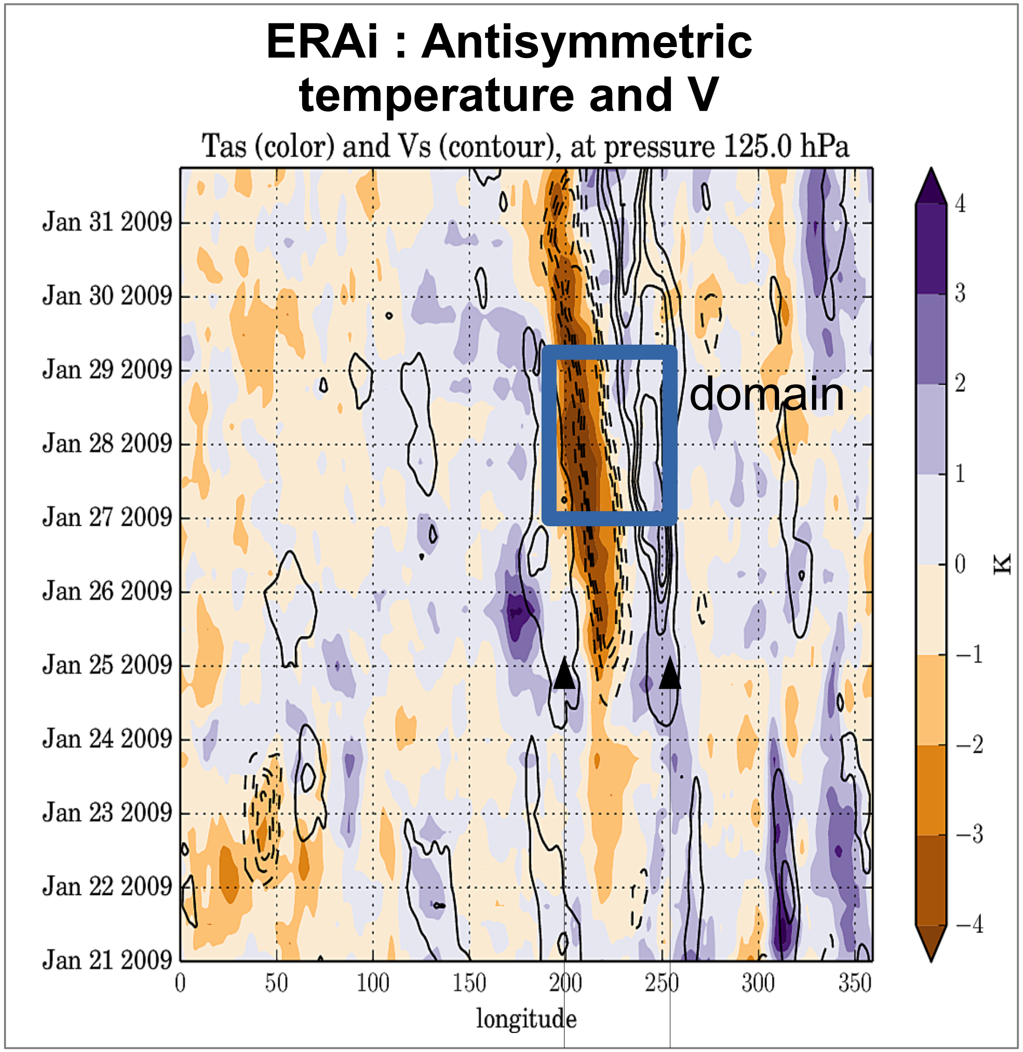
Large-scale dynamics and Cirrus



Large scale ascent and negative temperature anomalies due to equatorial wave excited by a Potential Vorticity intrusion

Large-scale dynamics and cirrus



Temperature signature of a Yanai (Mixed Rossby-gravity) wave during the simulation : explains the overall geometry of the cirrus

Mesoscale cirrus modelling

- To assess the ability/realism of the model and its parameterizations to simulate cirrus

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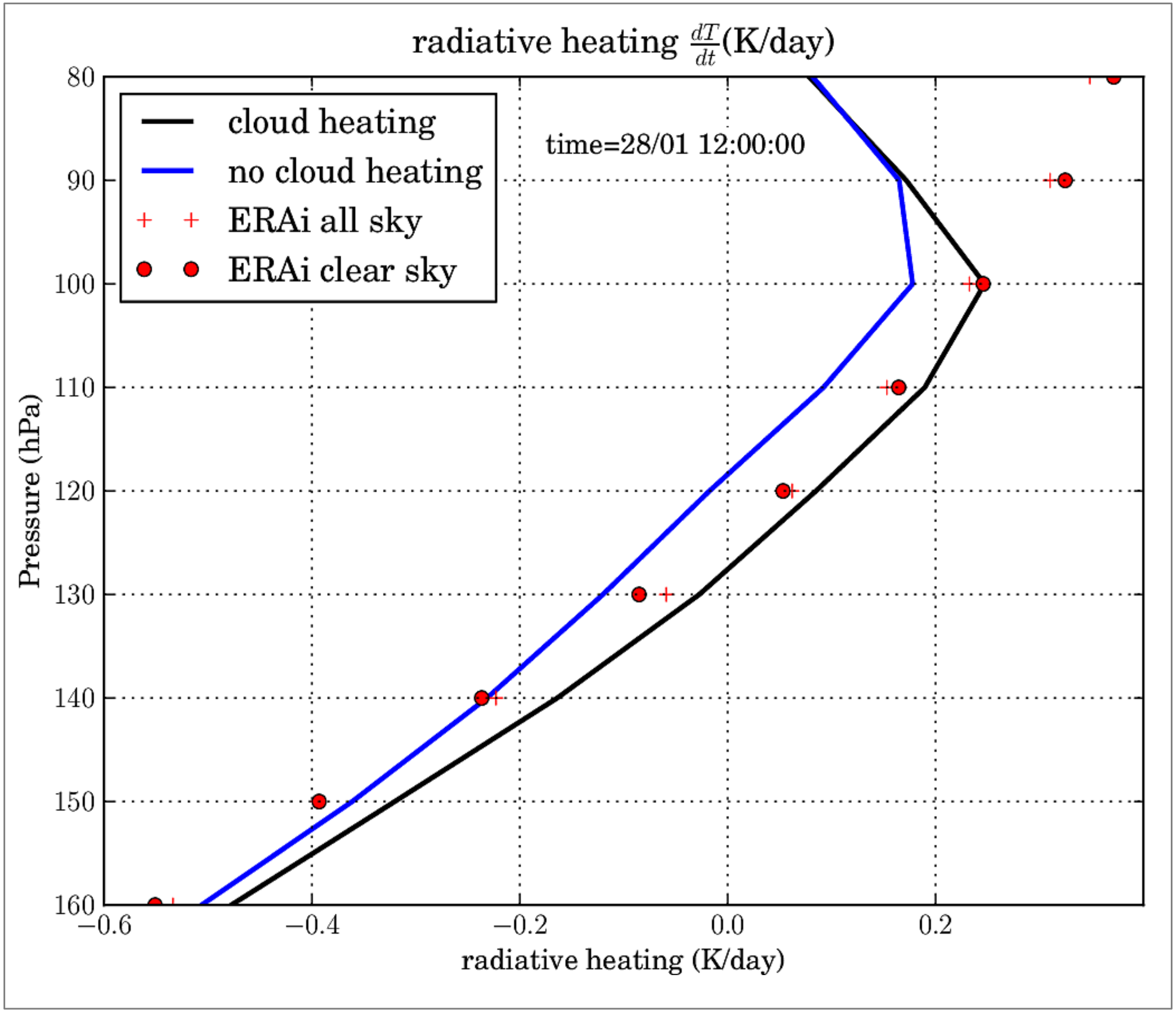
- **To quantify the cloud impacts**

Cirrus impact : radiative heating

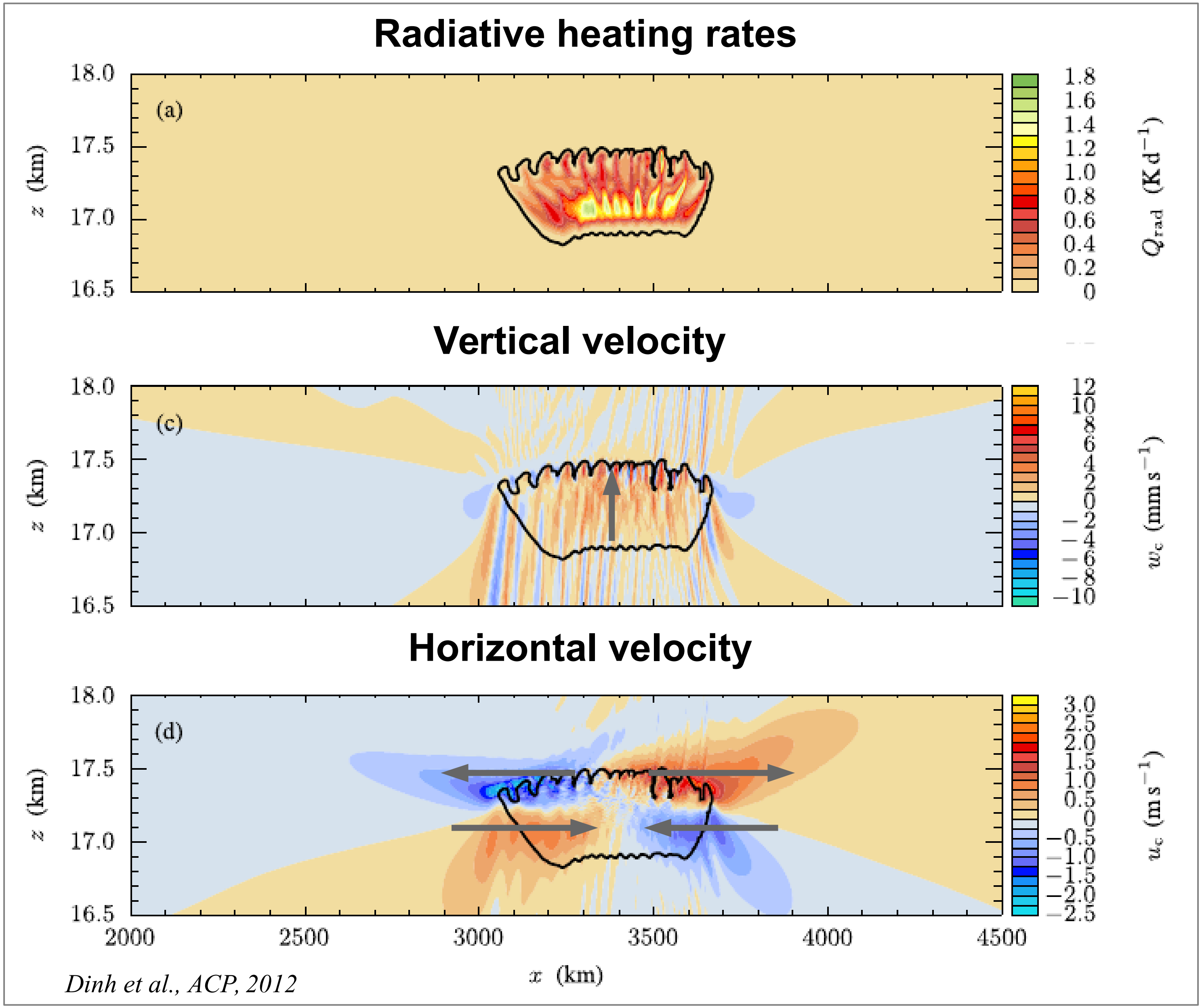


Cirrus radiative impact estimate from simulations with and without cloud radiative heating included (RRTMG scheme):

- Mean heating in the domain of the order of 0.1 K/day by the cirrus

- Cloud radiative effect absent in the ERA interim : bias

Cirrus impact : radiatively-induced circulation

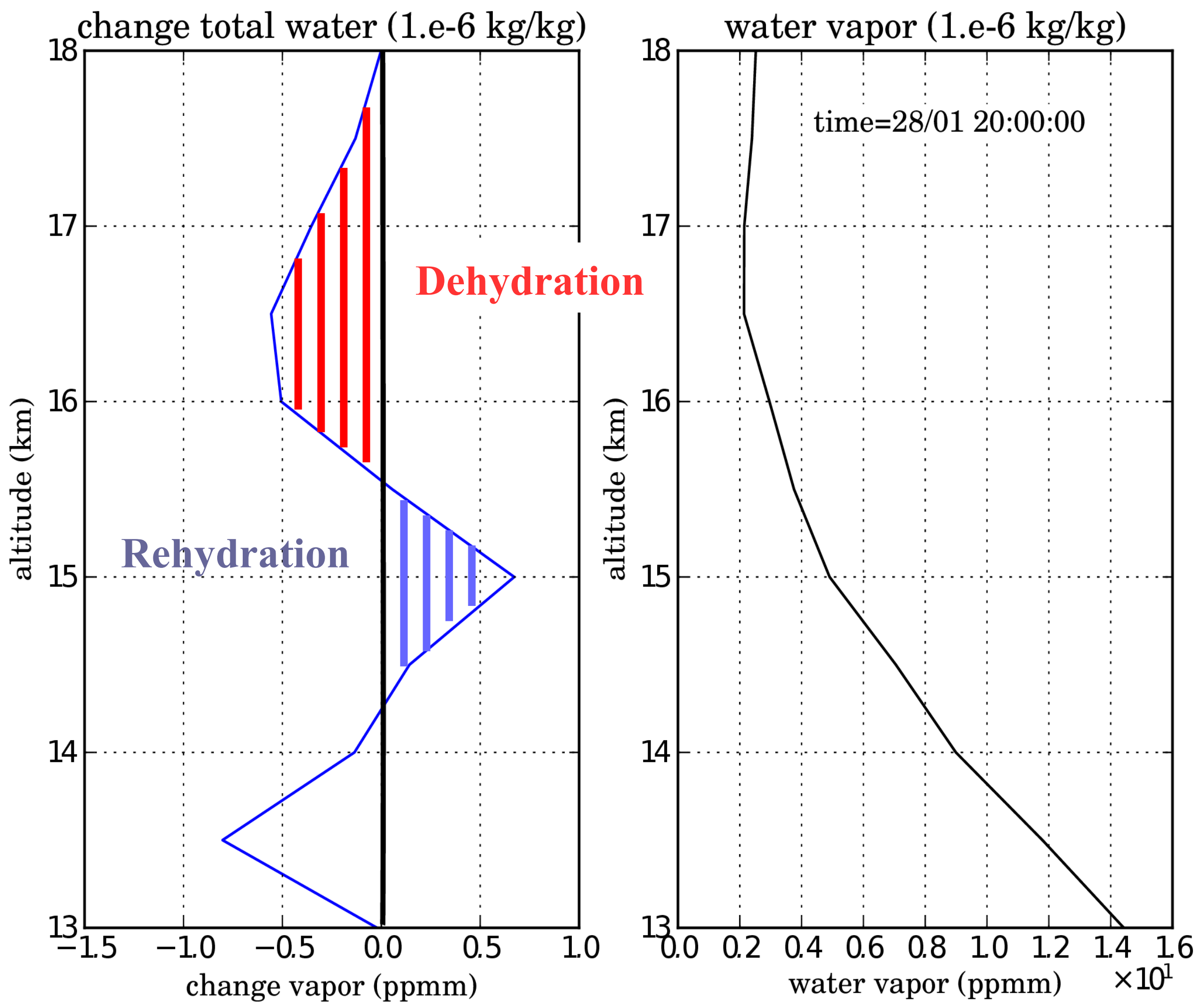


Mesoscale models are a suitable tool to study radiation-dynamics interactions

In some background conditions, radiative heating may induced a recirculation

Longer cloud lifetime with recirculation

Cirrus impact : water redistribution



Podglajen et al., ACPD, 2015

Water vertical transport through sedimentation:

Dehydration at the top of the clouds, rehydration at the bottom, of the order 10 %

Conclusions

- Default WRF able to reproduce the main cirrus characteristics

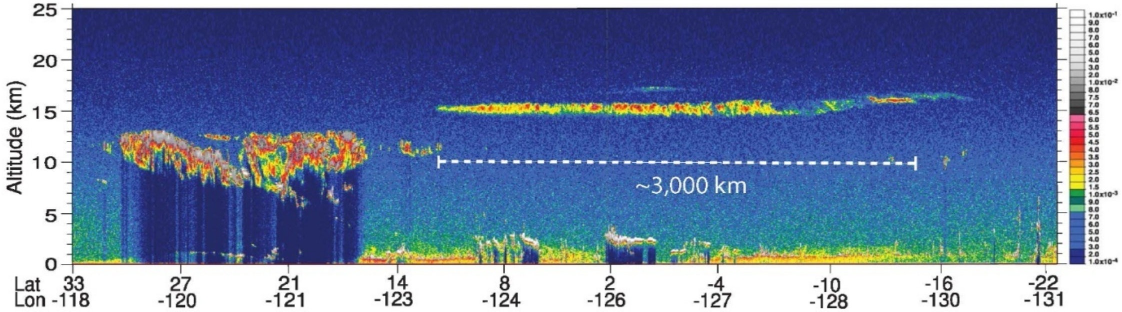
- Cirrus formation due to large-scale dynamics : equatorial wave response excited by interaction with the midlatitudes (PV intrusion)

- Strong sensitivity of the modelled cloud to the initial dynamics (U, T). Initial and boundary conditions in dynamics and in water vapor, and choices for the microphysics parametrization affect different characteristics of the cloud field.

- Cirrus impact : 0.1 K/day in radiative heating, water vertical redistribution with de and re-hydration (- 0.5 ppm / + 0.5 ppm)

Thank you for your attention

Presentation of the case study



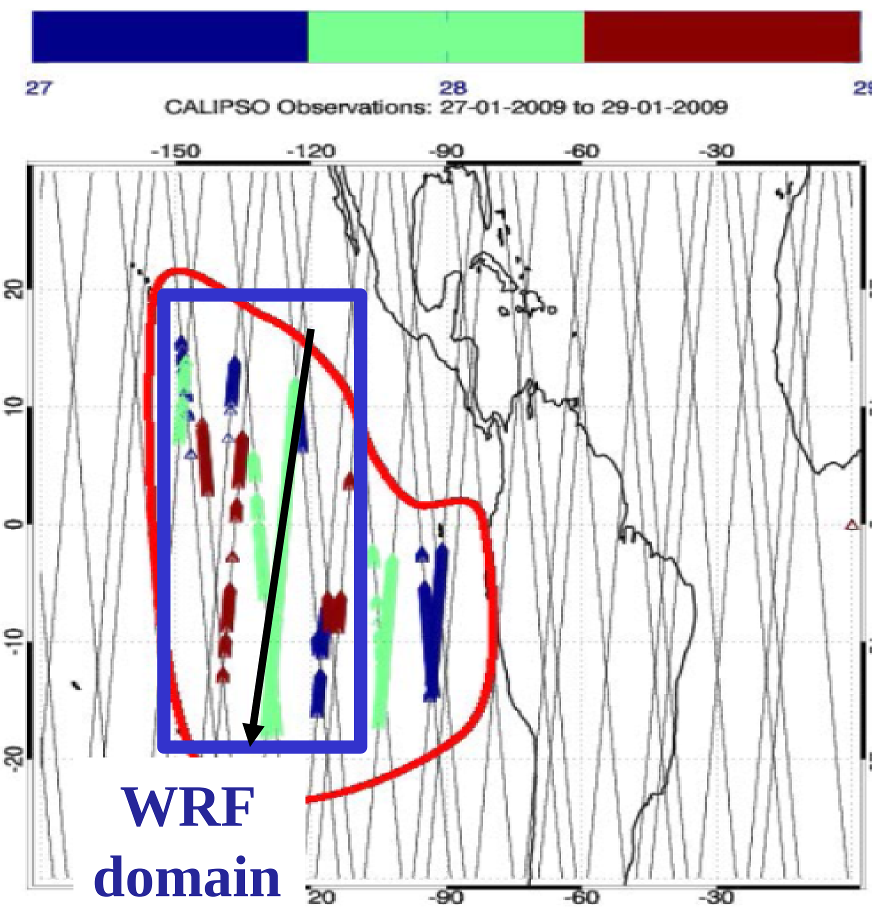
Backscatter along CALIOP track

Large-scale, apparently long-lasting cirrus in the tropical Eastern Pacific in late January 2009

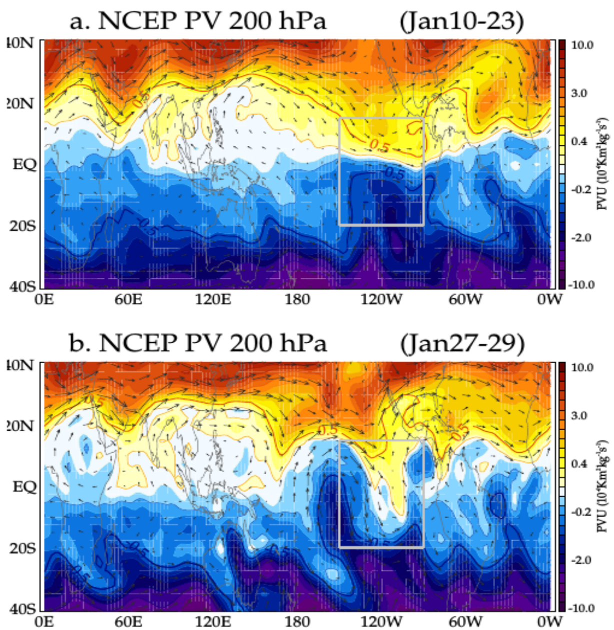
Described from satellite observations by Taylor et al., 2011

Associated with a cold temperature anomaly, and a mid-latitude Potential Vorticity intrusion below the cirrus (200 hPa)

Timing and location of cirrus formation

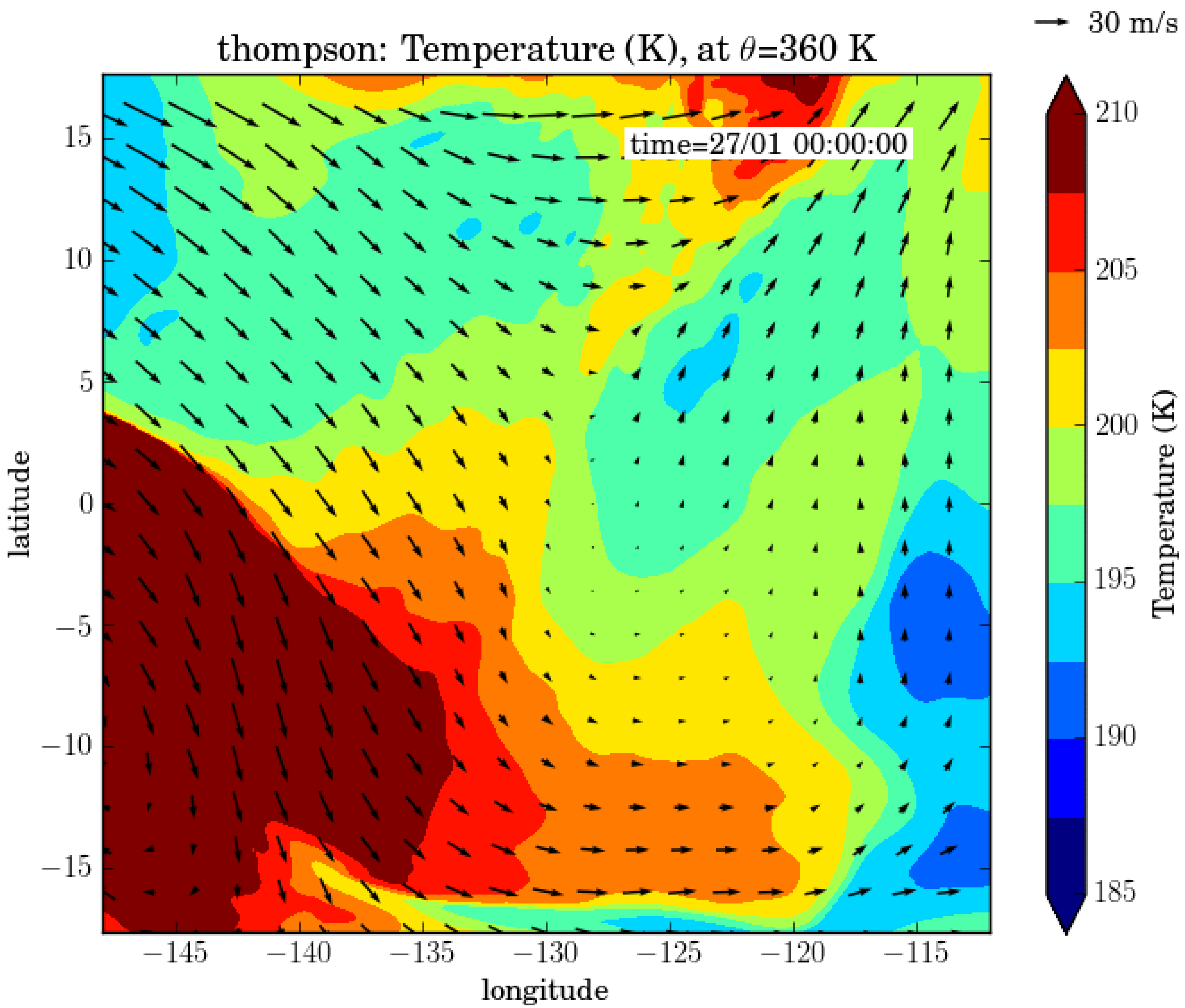


Potential vorticity at 200 hPa, NCEP



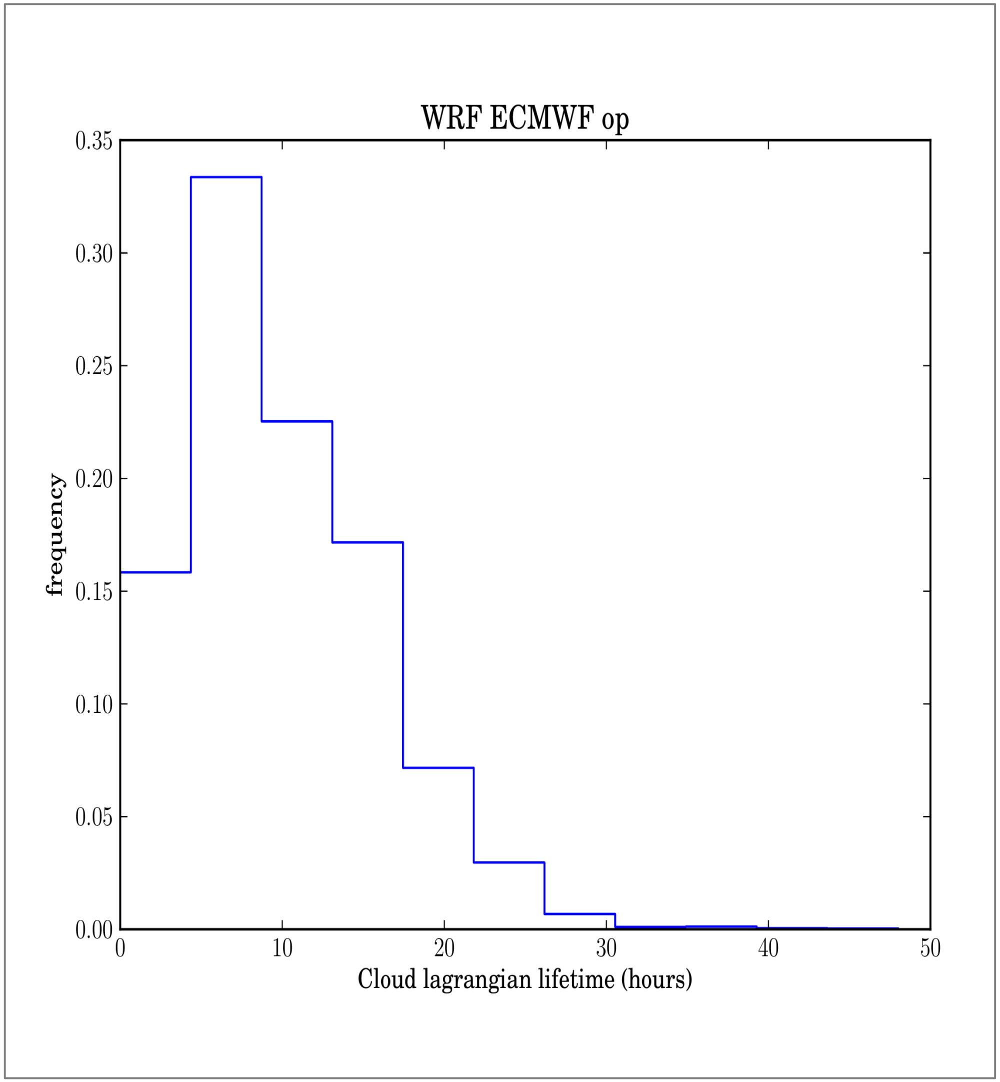
From Taylor et al., 2011

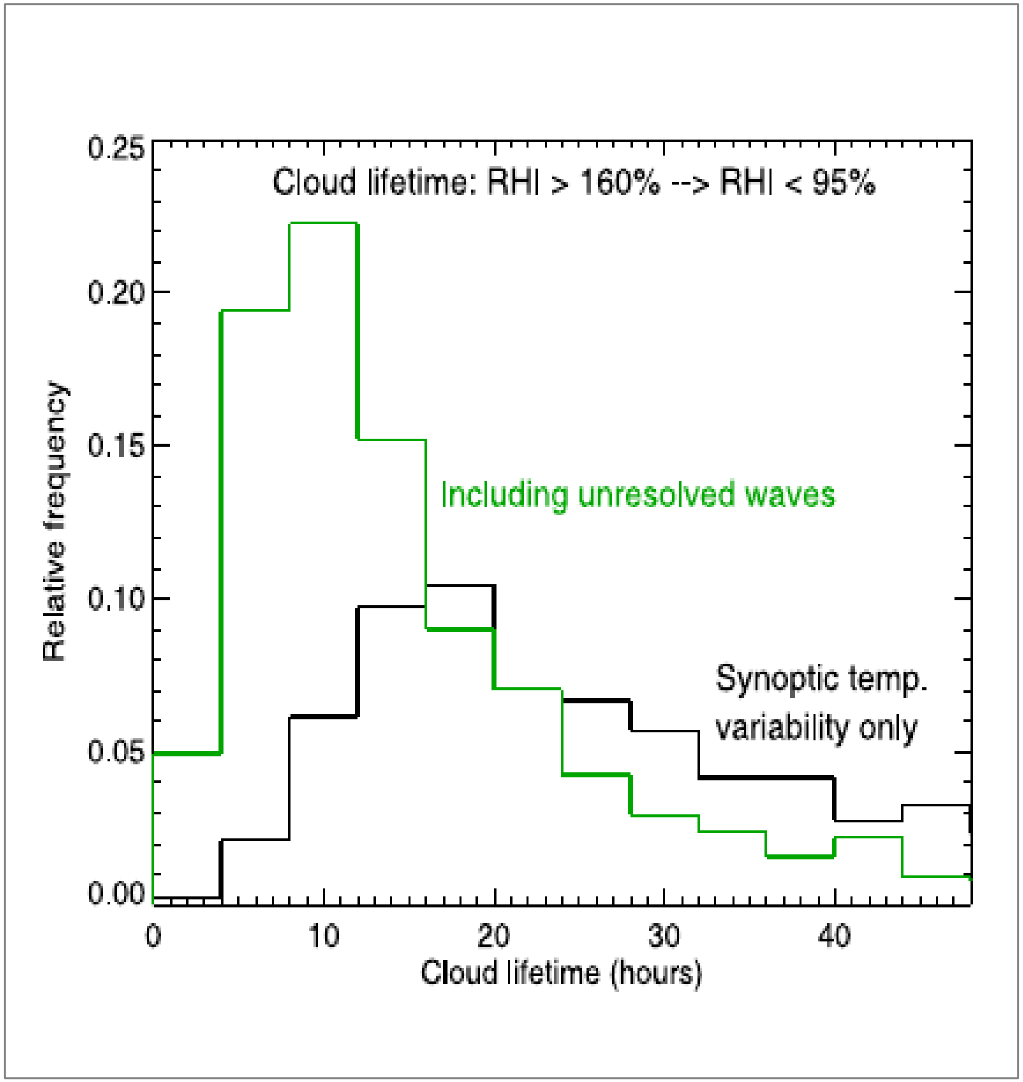
Presentation of the simulation



Black contours = cirrus

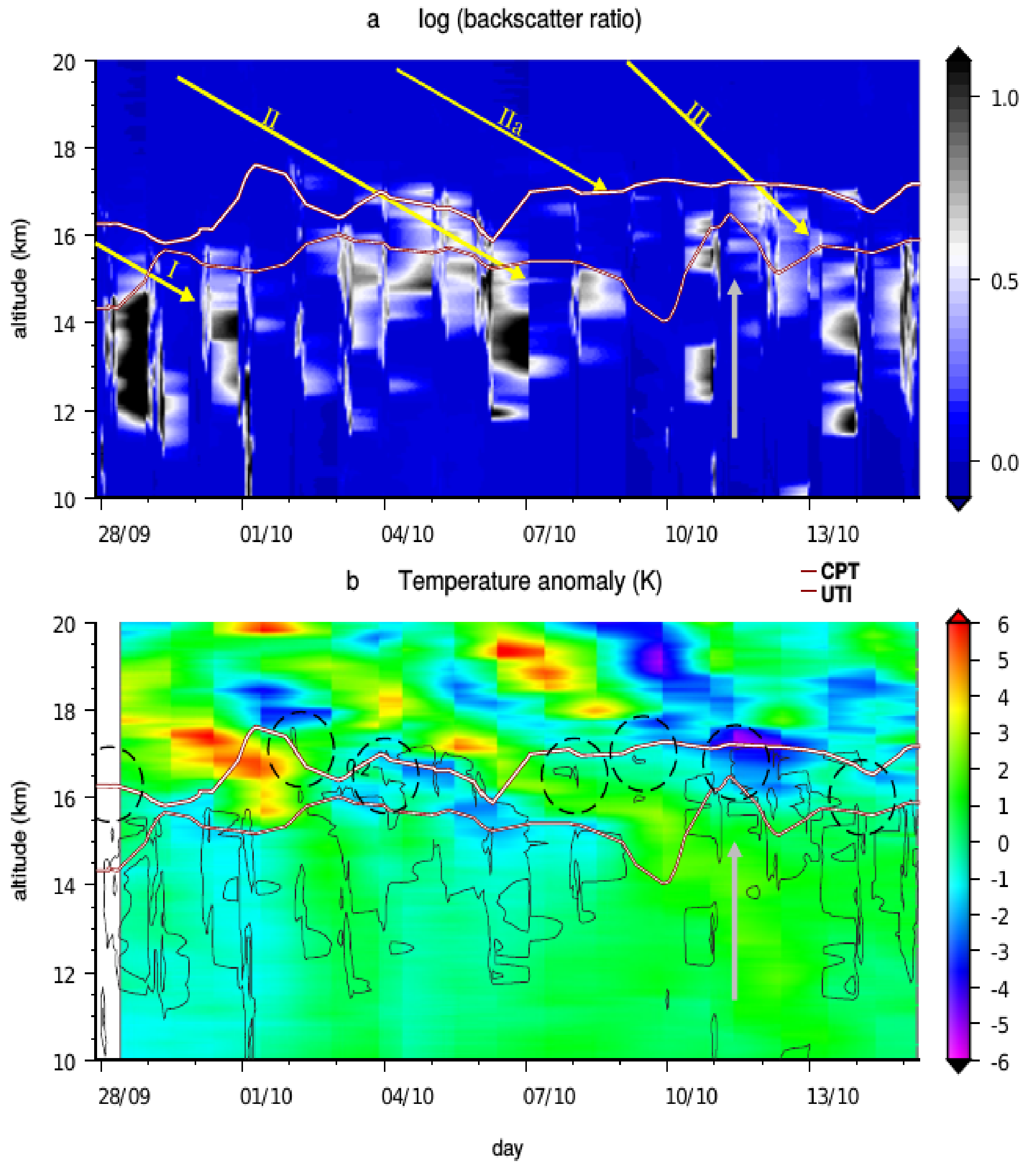
Cirrus : lifetime in models





Large-scale dynamics and cirrus

Tropical cirrus are also sensitive to Kelvin waves



Immler et al., ACP 2008