Tropical analysis and forecast uncertainties & Kelvin waves: what can be learnt from the Aeolus wind profiles?

Nedjeljka Žagar

Universität Hamburg

DER FORSCHUNG | DER LEHRE | DER BILDUNG

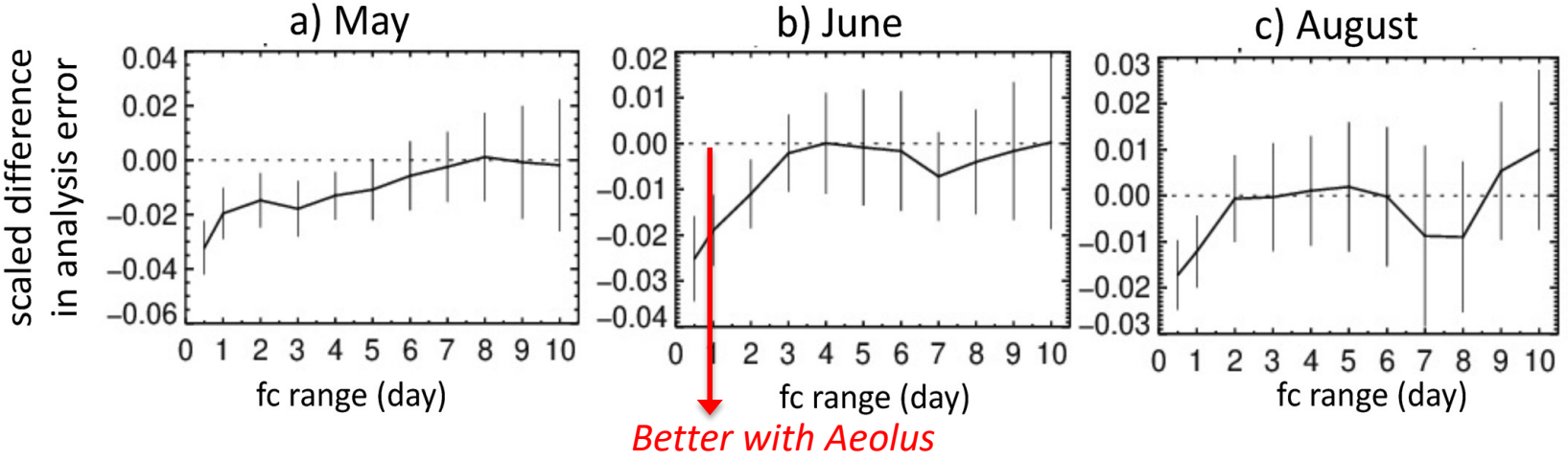
With Michael Rennie and Lars Isaksen, ECMWF

GRL paper *https://doi.org/10.1029/2021GL094716*

Aeolus wind profiles brings largest changes in the tropical tropopause layer. Why? What processes are better represented by Aeolus?

ECMWF OSE FM-B, April - September 2020

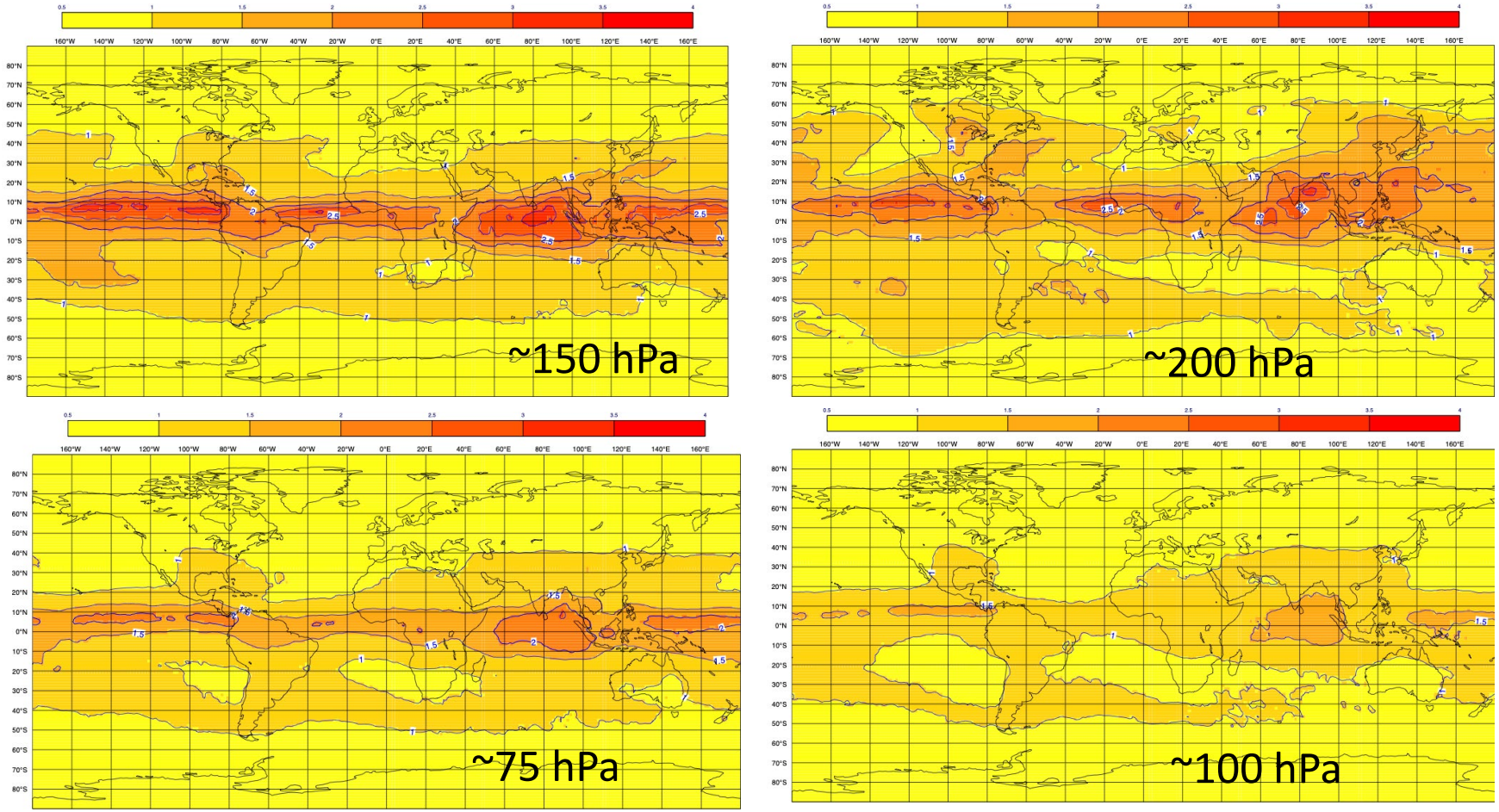
Varying impact on forecasts argued to be coupled to QBO



Normalized difference of the root-mean-square errors (rmse) of forecasts minus respective analyses for zonal winds in the tropics at 100 hPa.
The difference is taken between the rmse of Aeolus and NoAeolus experiments and the normalization is by the rmse of the Aeolus experiment.

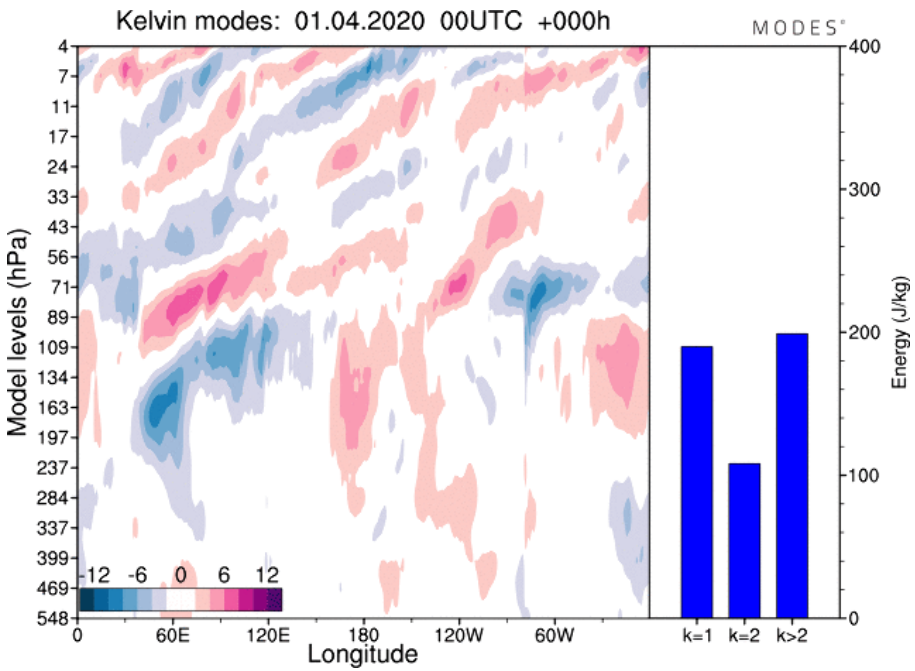
Largest analysis uncertainties remain in the tropics

Short-range forecast (background) uncertainty: ECMWF EDA zonal wind, 1 May 2020:

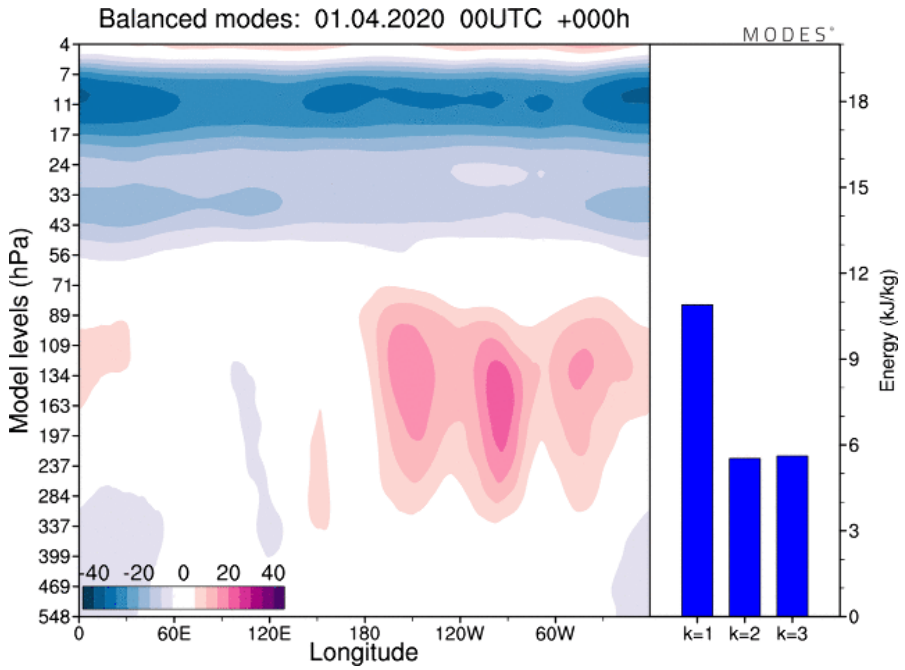


Uncertainties largest over Indian ocean and western Pacific

Tropical variability during May-Sep 2020
(operational ECMWF analyses)



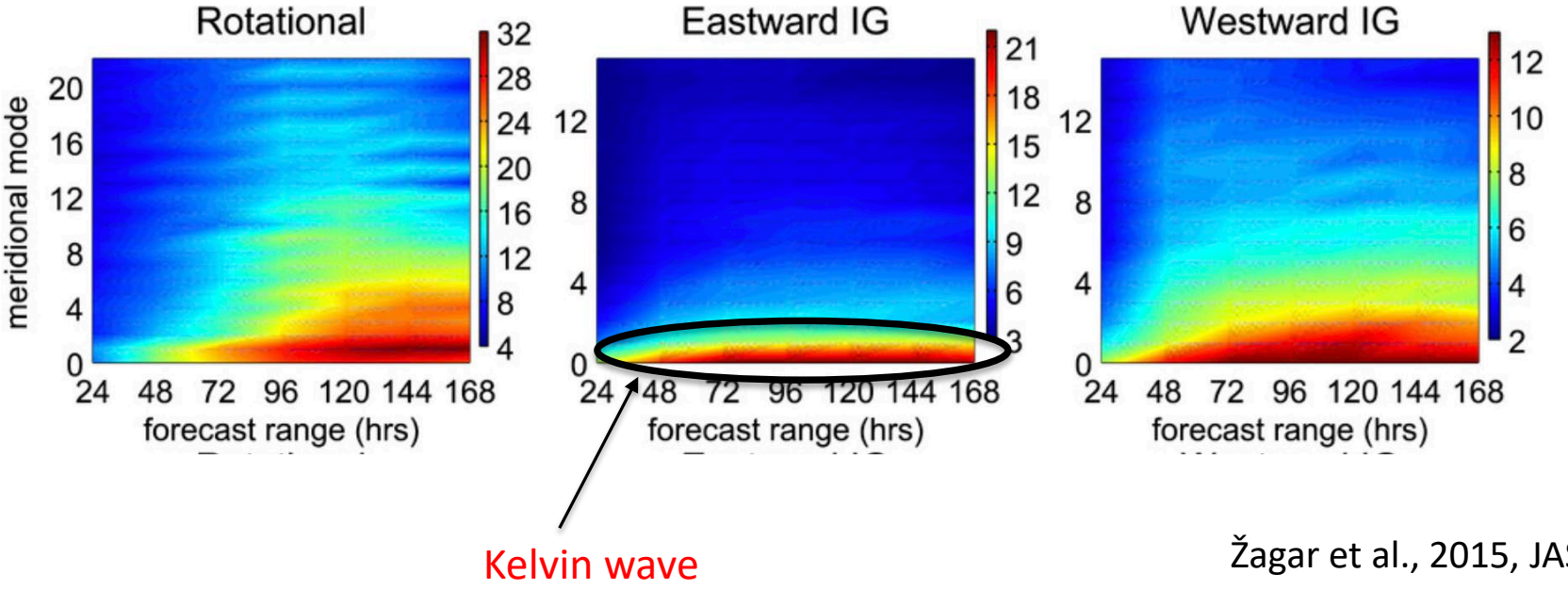
Kelvin wave zonal wind
along the equator



Balanced zonal winds
along the equator

April-September 2020: period of ECMWF FM-B OSE

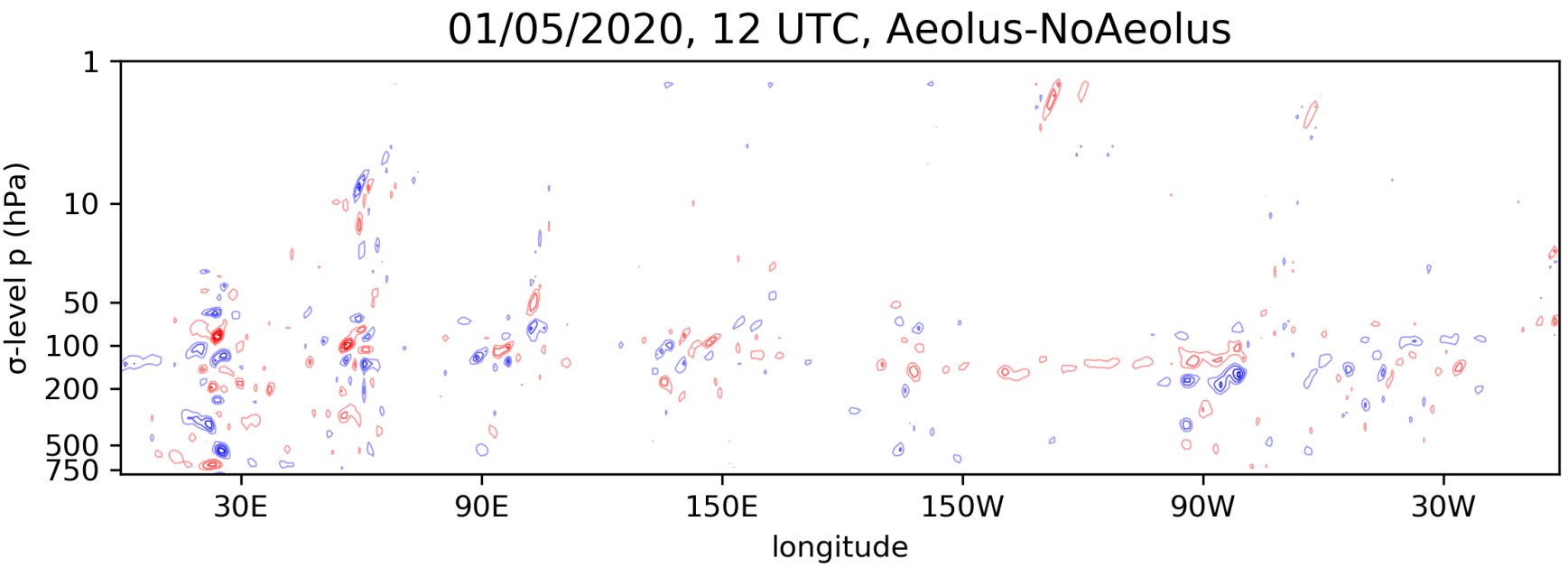
Growth of forecast uncertainties in different dynamical regimes and wave types



Žagar et al., 2015, JAS

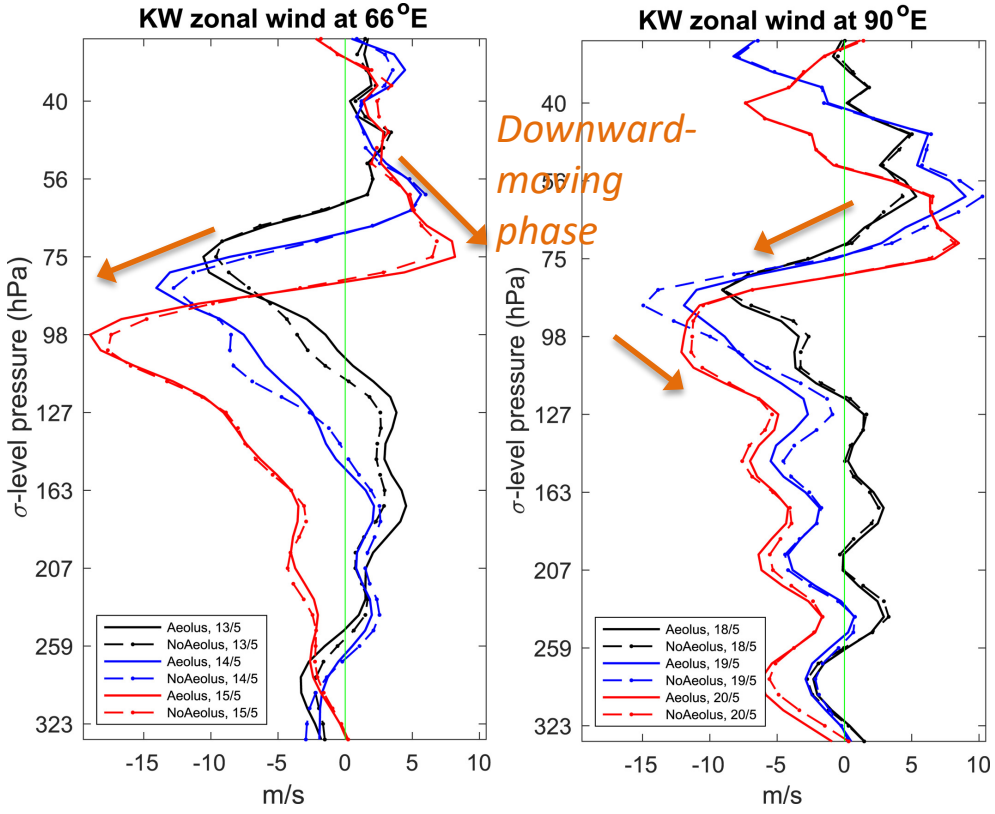
Given Aeolus impact on forecast, we ask to what extent (if) does Aeolus change properties of Kelvin waves in the tropopause layer?

Aeolus – NoAeolus: Kelvin wave



The difference between the Kelvin wave zonal winds in Aeolus and NoAeolus analyses.
Isolines are every +/- 0.5 m/s, starting at +/- 1 m/s.
Red-positive, blue-negative difference

Aeolus – NoAeolus analyses: Kelvin wave



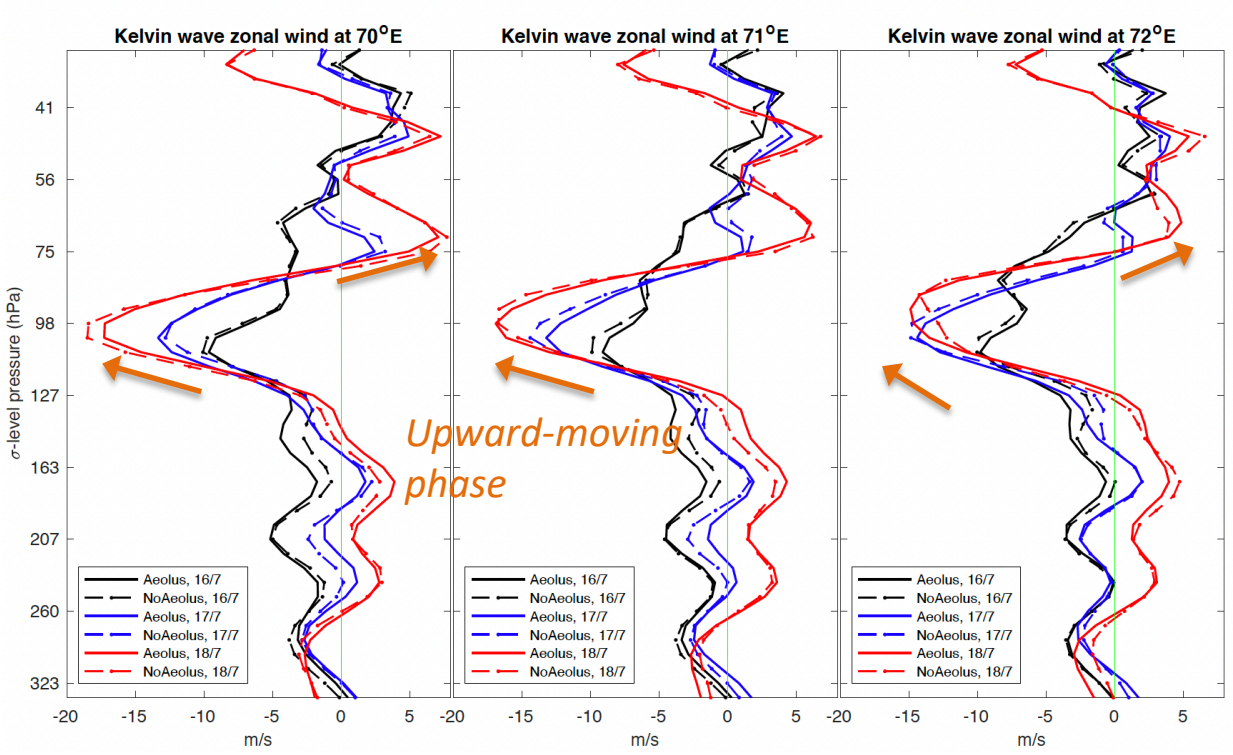
Upward-propagating Kelvin wave energy in May 2020

Aeolus

NoAeolus

Kelvin wave zonal wind 12 UTC analyses at three subsequent days in May 2020 in Aeolus (full lines) and NoAeolus (dashed lines)

Aeolus – NoAeolus analyses: Kelvin wave



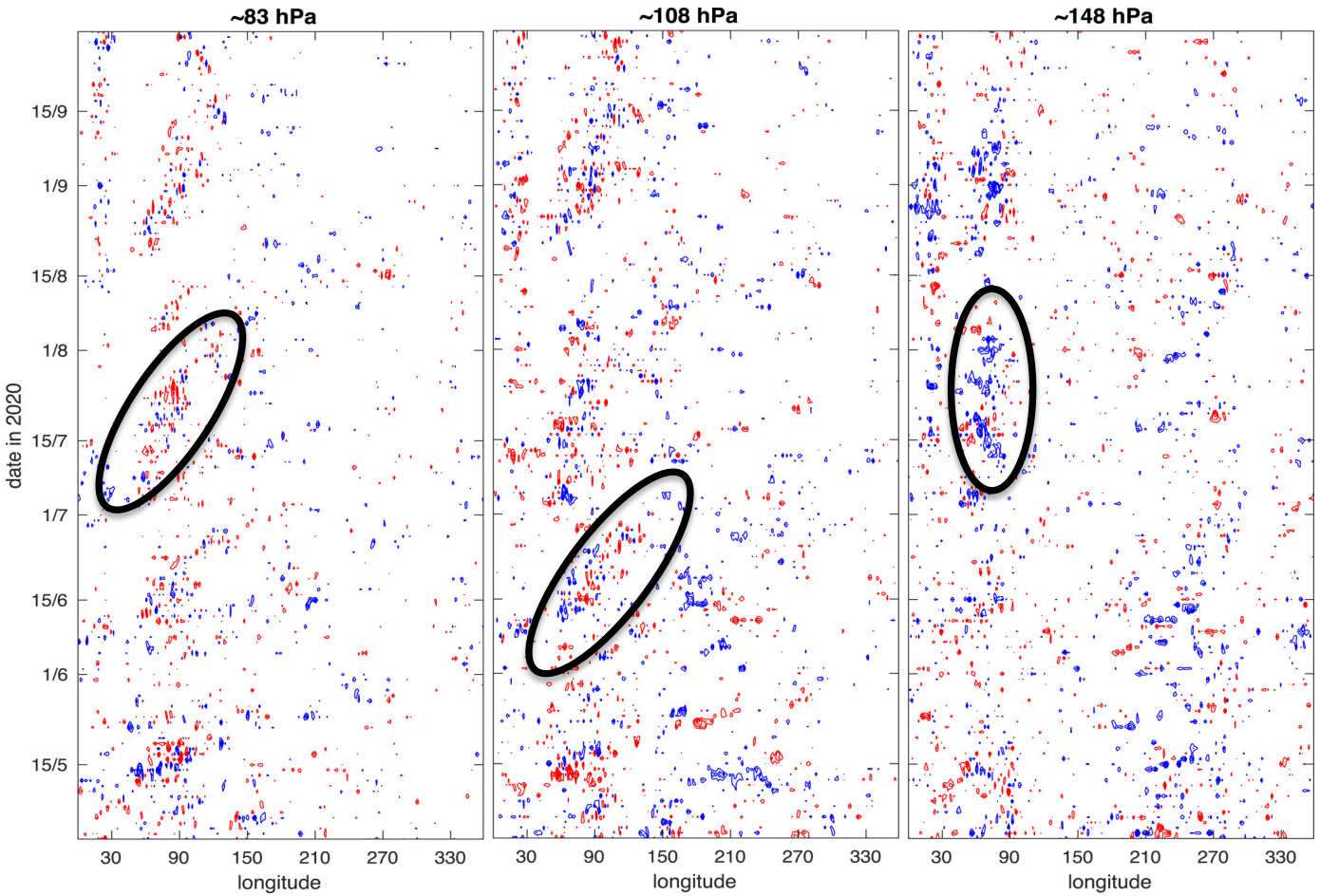
Downward-propagating Kelvin wave energy in Aug 2020

Aeolus

NoAeolus

Kelvin wave zonal wind 12 UTC analyses at three locations and three subsequent days in August 2020 in Aeolus (full lines) and NoAeolus (dashed lines)

Aeolus – NoAeolus analyses: Kelvin wave



Dynamics of Aeolus increments ⇔ Kelvin wave dynamics

Summary

Forecasts improvements in the tropical UTLS by Aeolus wind profiles are at least to some extent due to Aeolus changes of the representation of vertically propagating equatorial waves.

For the Kelvin waves we showed that Aeolus is adding increments in the regions of the strongest shear across the tropopause.

Impact of assimilating Aeolus winds in the ECMWF system from May to September 2020 is coupled to the easterly QBO phase, with a stronger impact earlier in the phase, when the upward propagation of the Kelvin waves was more present.

The Kelvin wave is a showcase of process diagnostic that can be done for Aeolus OSEs and Aeolus follow-on OSSEs.