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paths emerge in that we walk them

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Atmospheric Remote Sensing and Climate System Research Group
ARSCiS y s

Sensitivity and impact of the ionospheric kappa-correction on RO climatologies

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Hertha-Firnberg Project: NEWCLIM



Problem:

- Residual Ionospheric Errors (RIE) in RO data due to 1st order ionospheric correction

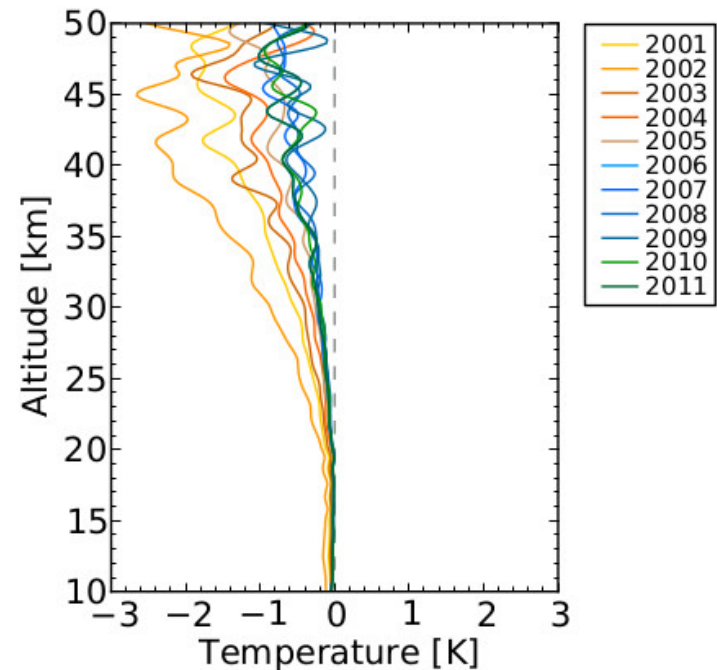
[e.g., Vorobev and Krasilnikova (1994)]

- RIE varies with solar cycle

[e.g., Danzer et al. AMT (2013)]

Goal:

- Increase RO data quality in stratospheric altitudes



Danzer et al. AMT (2015)

- Healy and Culverwell AMT (2015) calculate residual error for Chapman layer ionosphere

$$\Delta\alpha \equiv \alpha_c(a) - \alpha_N(a) = \kappa(a)(\alpha_1(a) - \alpha_2(a))^2$$

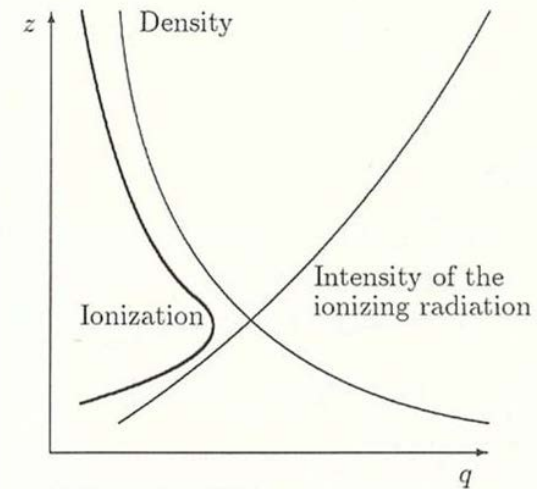
$\alpha_c(a) - \alpha_N(a)$... residual error $\propto TEC^2$

$(\alpha_1(a) - \alpha_2(a))^2$... rapidly varying factor $\propto TEC^2$

$\kappa(a)$... slowly varying factor, independent of TEC

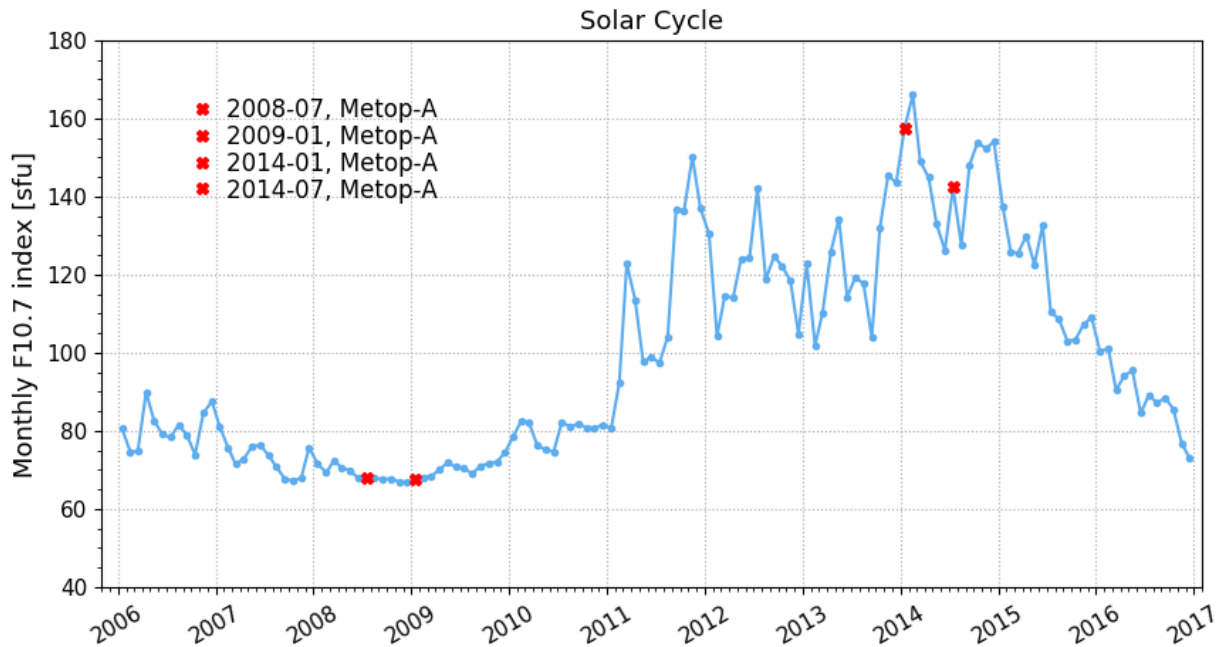
- Simulation study (NeUoG) Danzer et al. AMT (2015)
- κ improved! $\kappa = a + b f_{10.7} + c\chi + dh$ Angling et al. AMT (2018)

Formation of a Chapman layer



Kallenrode, 1998

- Monthly Metop-A RO climatologies from 2008 - 2015
- 3 modes:
 - zero- κ : $\kappa=0 \text{ rad}^{-1}$; standard 1st order ionospheric correction
 - scal- κ : $\kappa=14 \text{ rad}^{-1}$; reasonable approximation
 - func- κ : functional modeling
- Reference data: Mipas, ERA-Int, ERA5



Combination

- κ -correction with **average profile inversion (API)**

Ao et al. GRL (2012), Gleisner and Healy AMT (2013)

1. Individual Profile Processing \implies **Background information!**

$$\Delta\varphi \longrightarrow \alpha \longrightarrow N \longrightarrow \rho \longrightarrow p \longrightarrow T \longrightarrow q$$

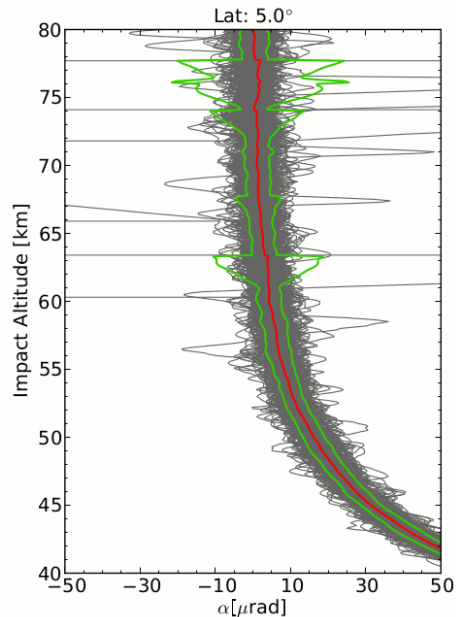
2. Climatology

Idea – NEWCLIM:

1. **Climatology** at bending angle level
2. **Processing of averaged profiles**

- Data can be used up to 80 km
- Avoids complicated statistical optimization

CHAMP: Jan 2007, no QC



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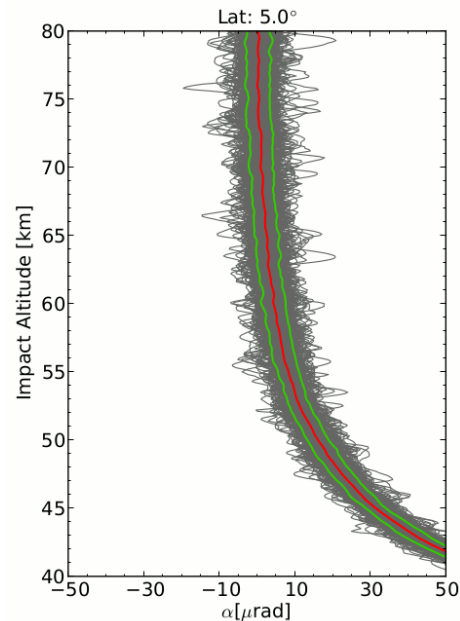
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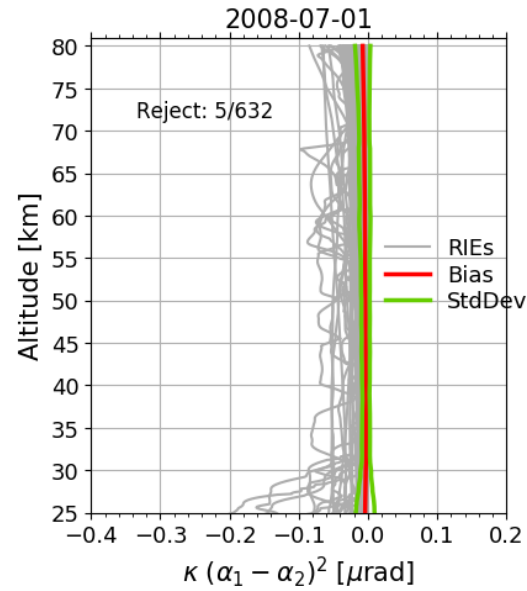
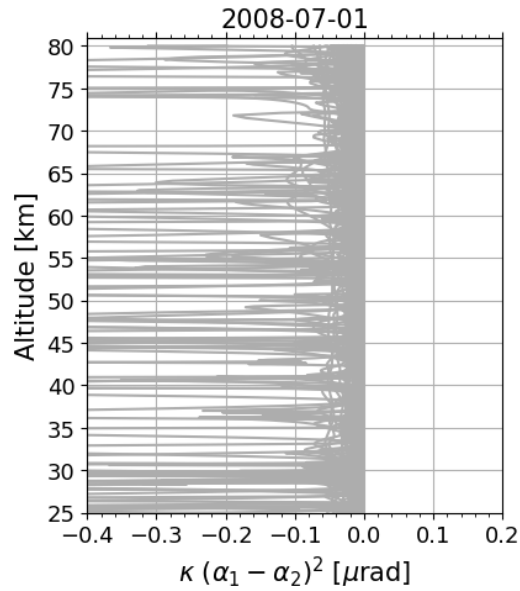
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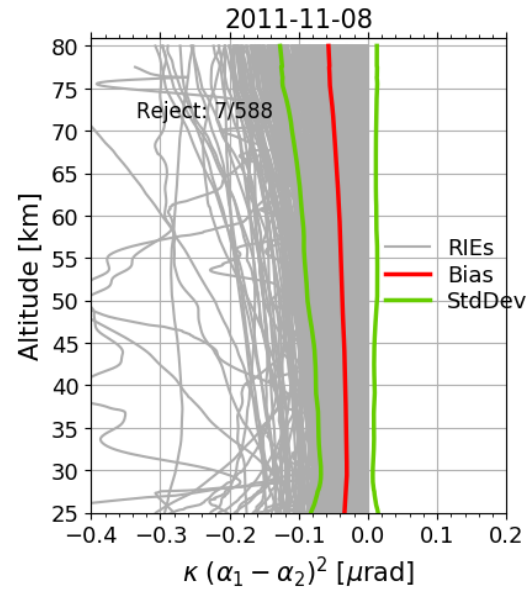
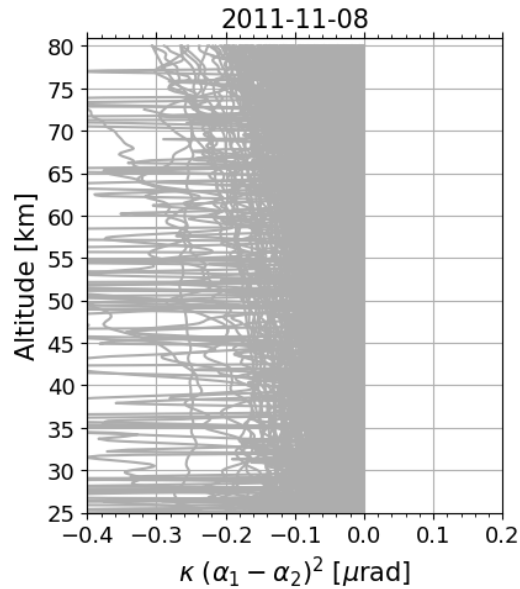
CHAMP: Jan 2007, add QC



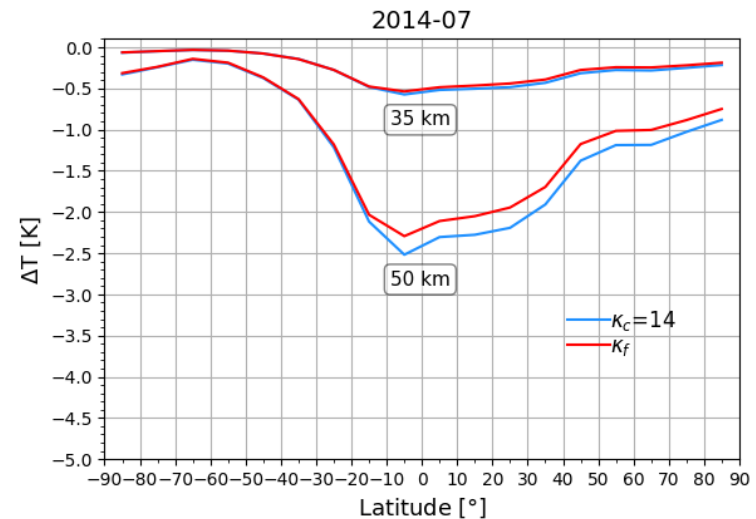
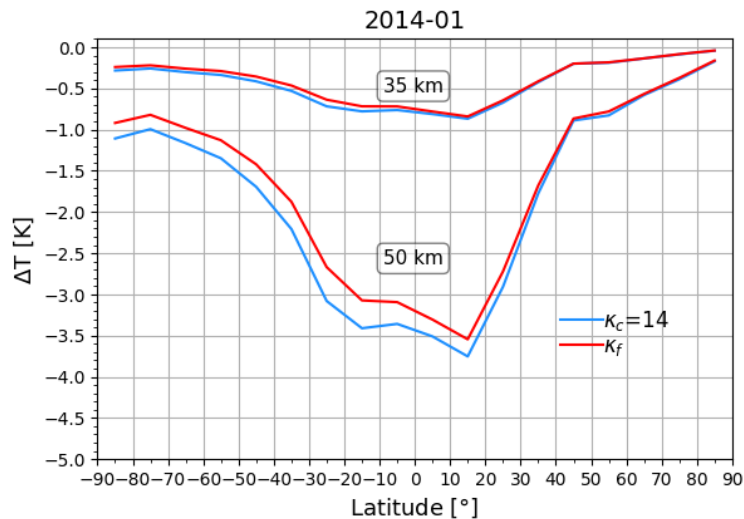
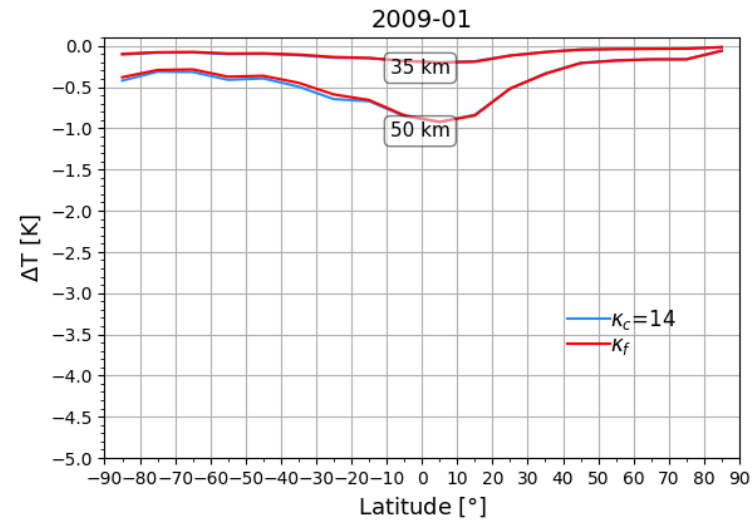
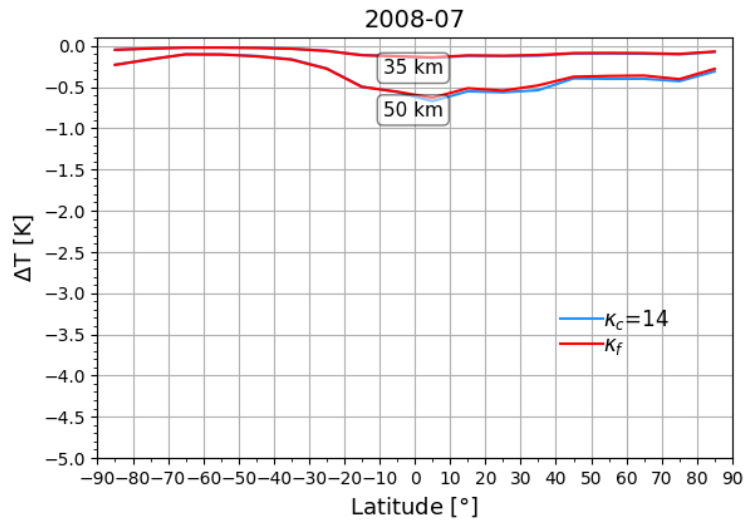
Smoothing & Filtering



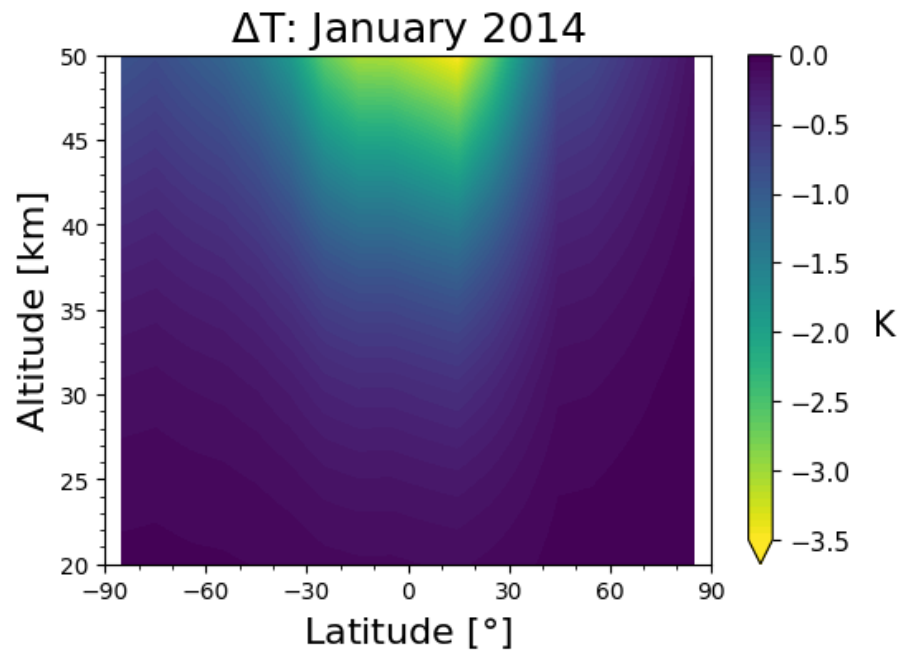
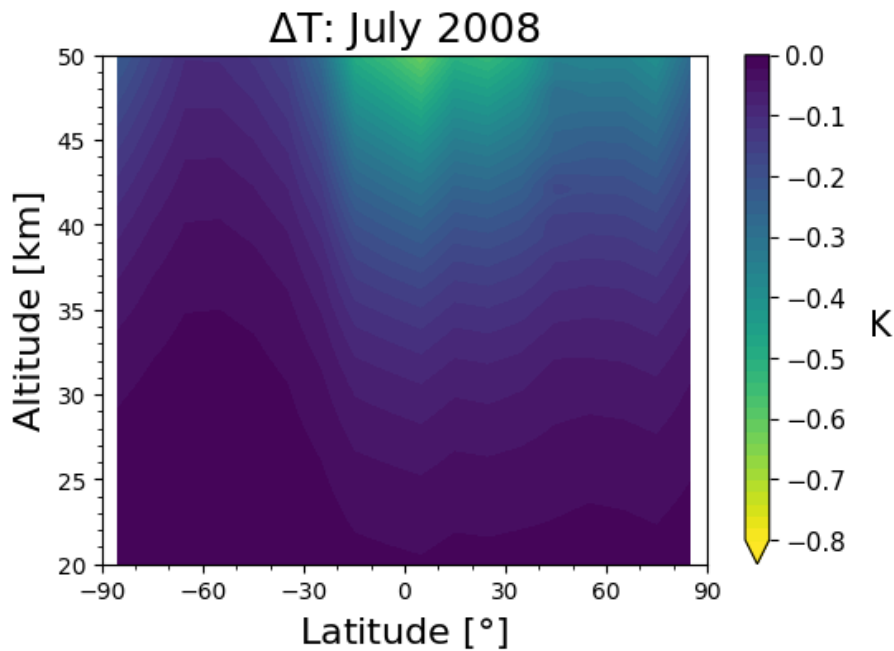
- Outlier rejection
- Moving average



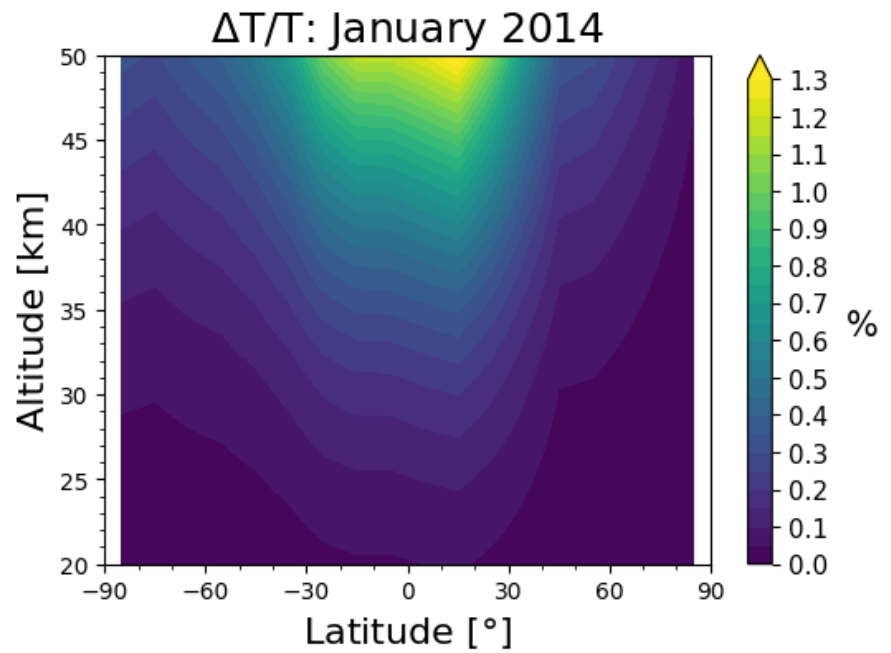
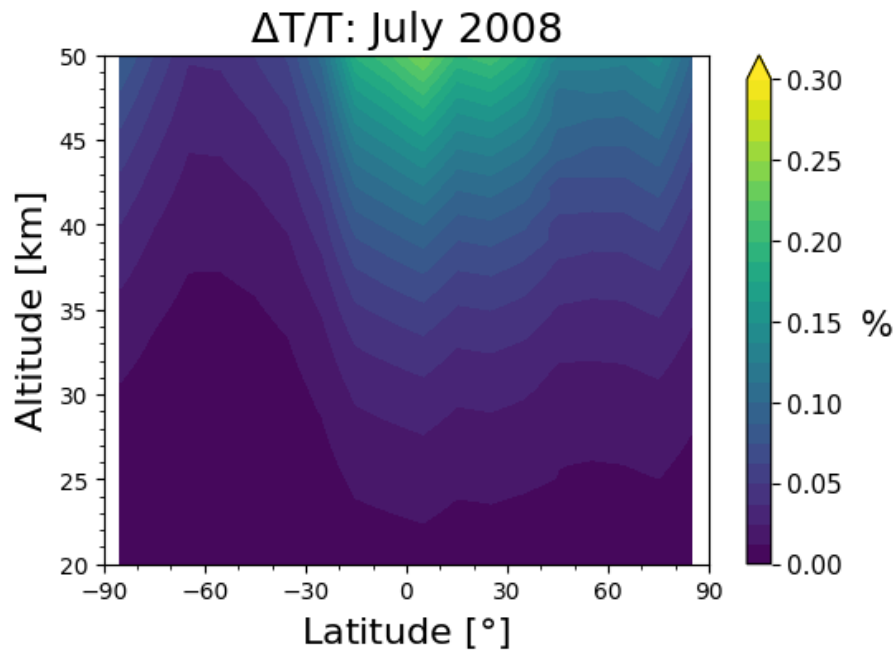
- k-correction on temperature level: $T - T_k$



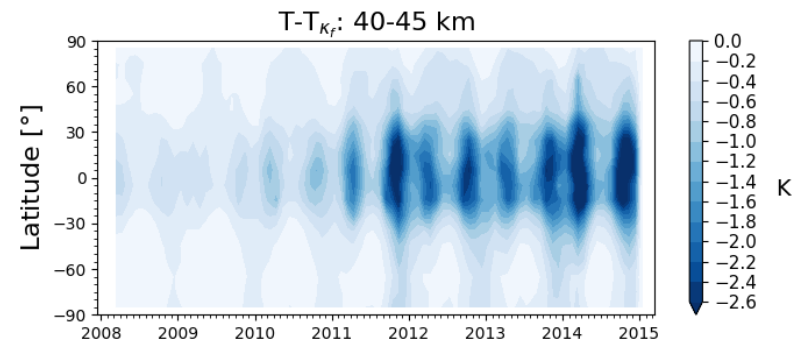
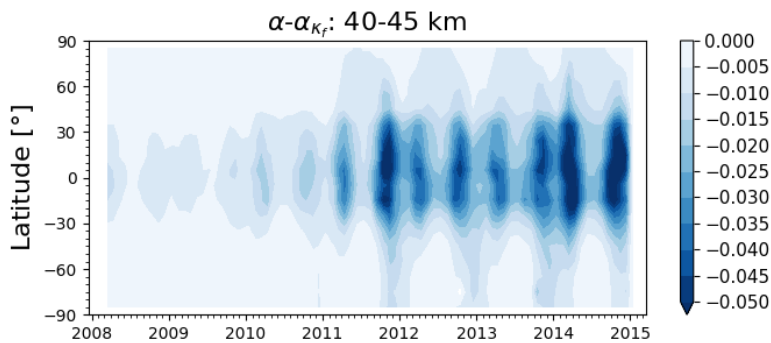
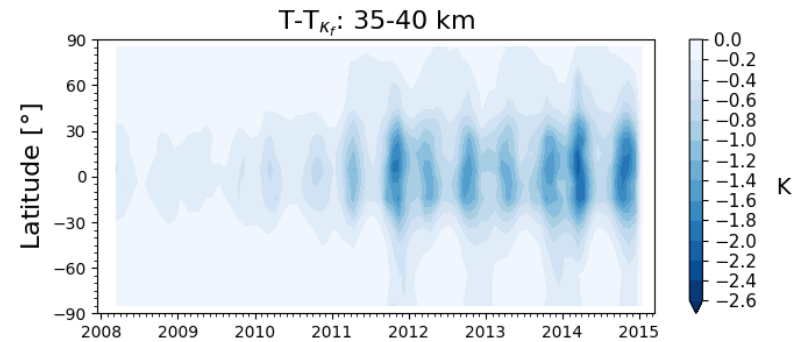
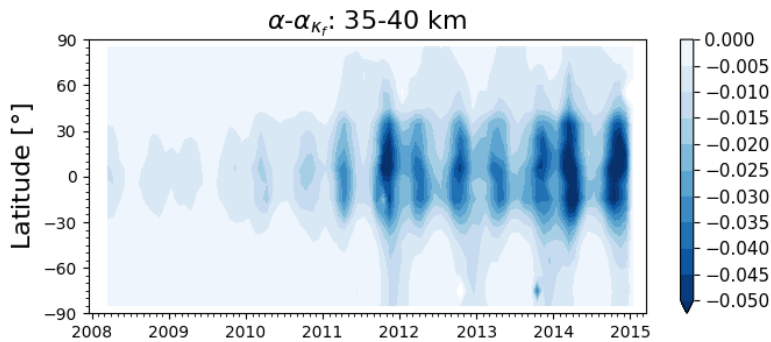
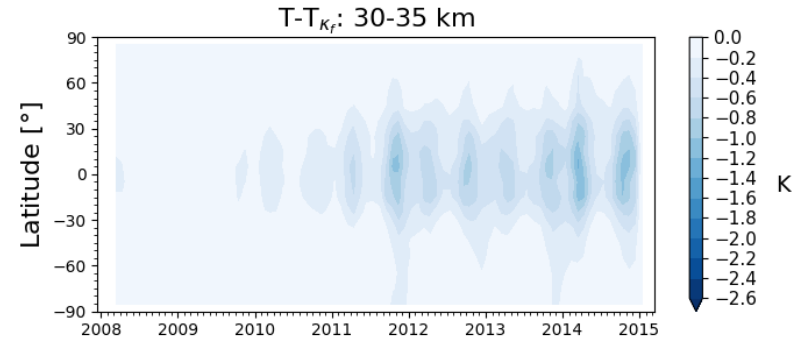
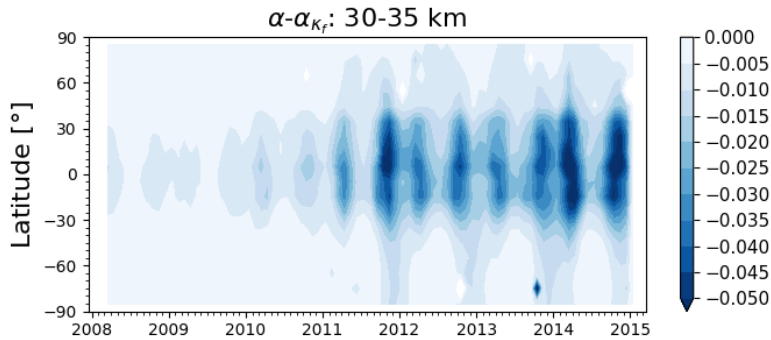
Impact on T-level



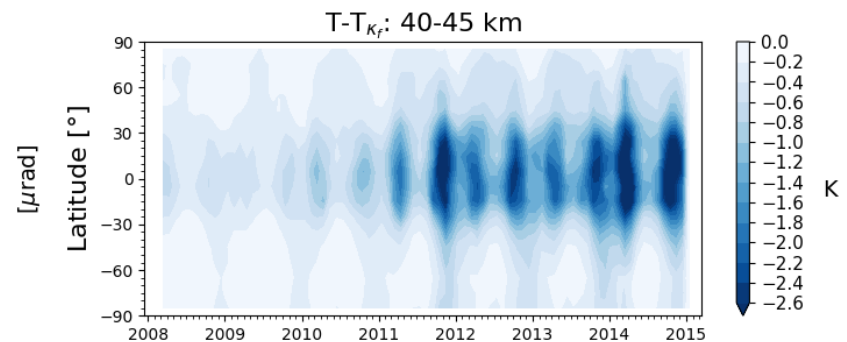
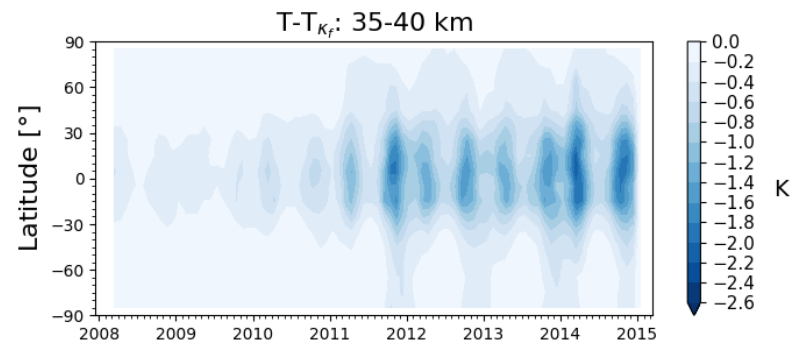
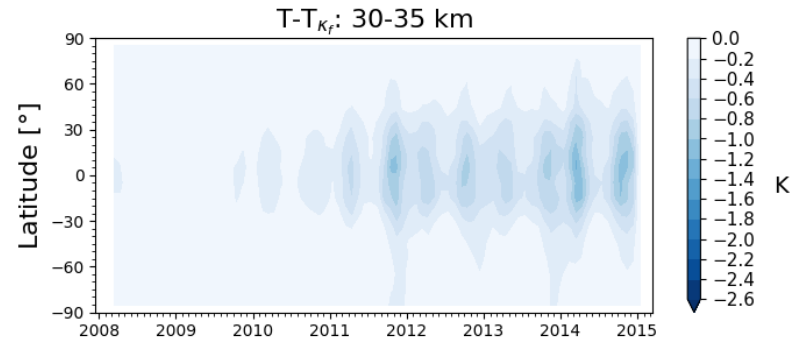
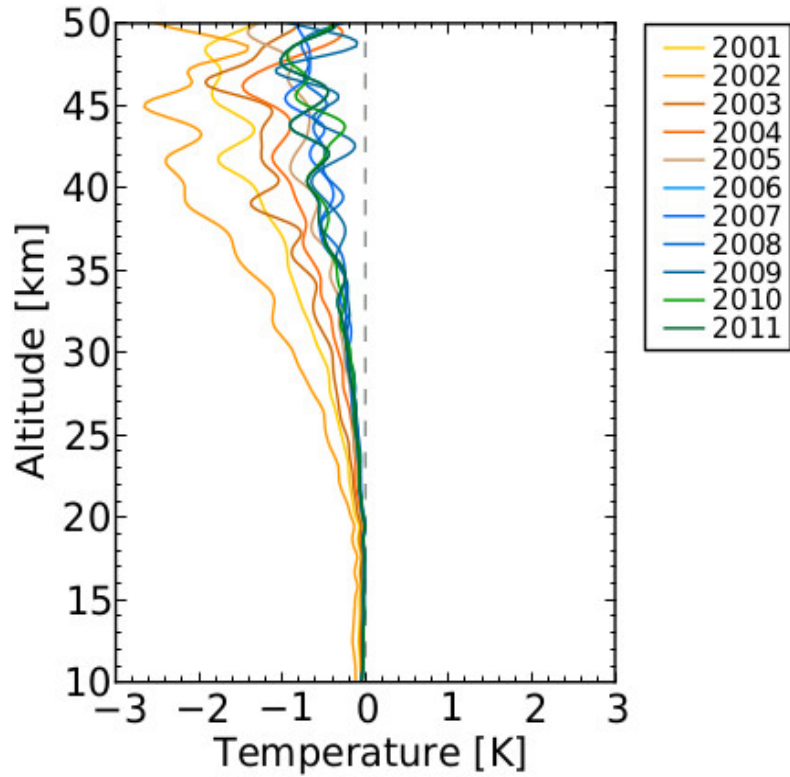
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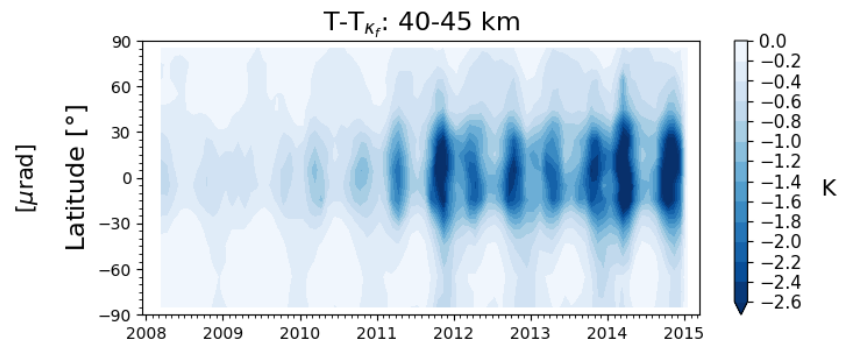
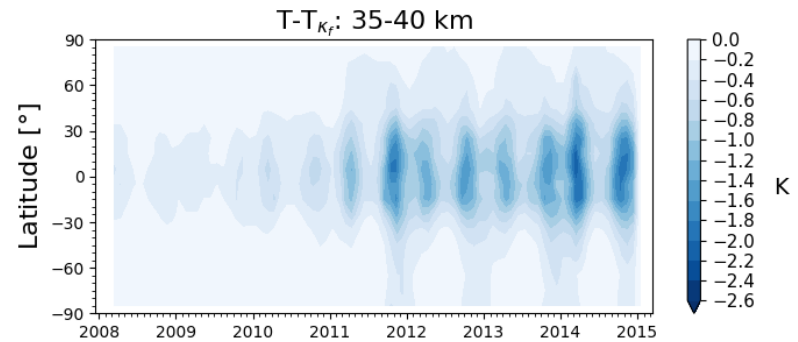
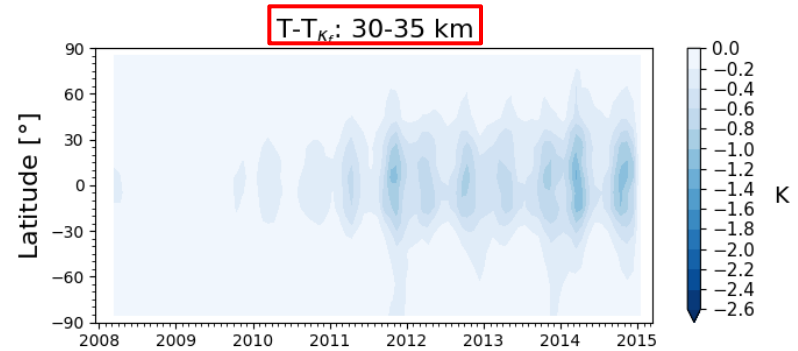
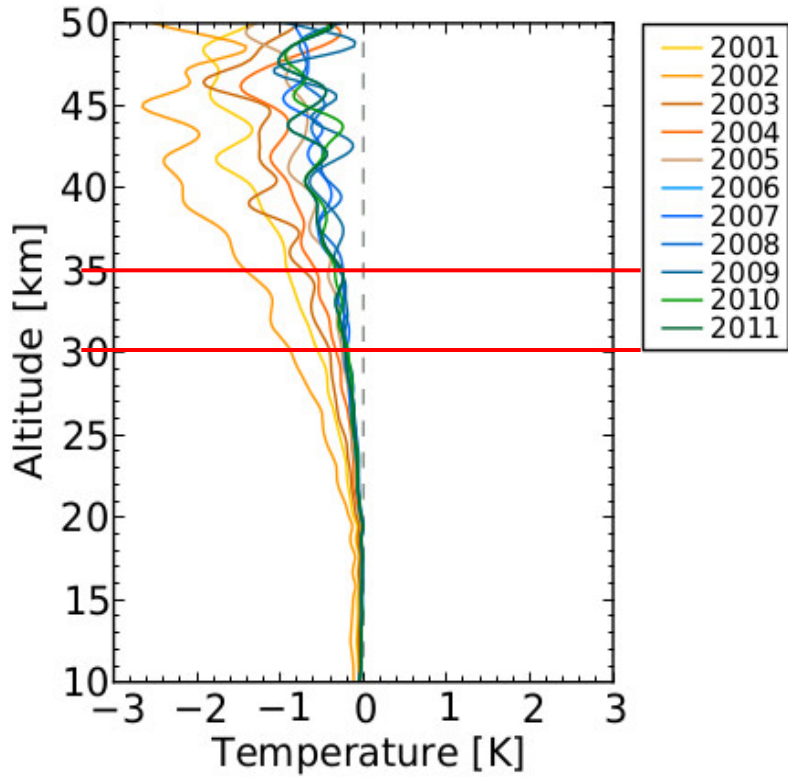
Sensitivity



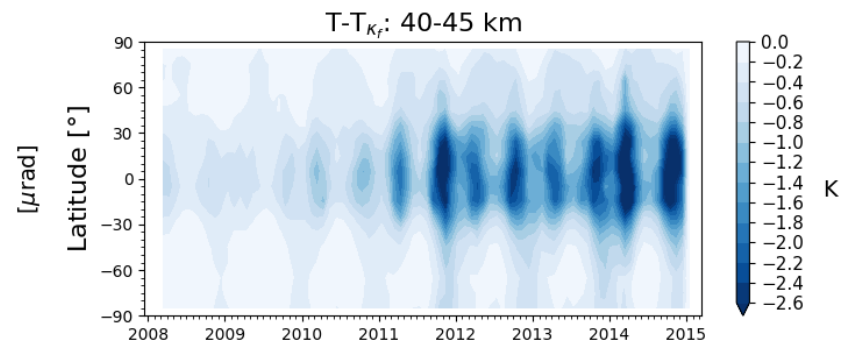
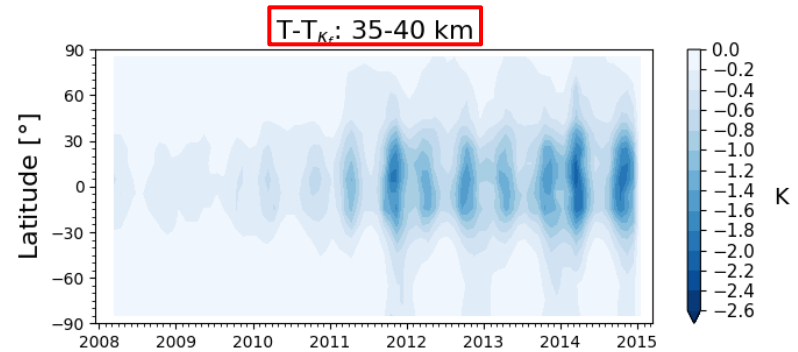
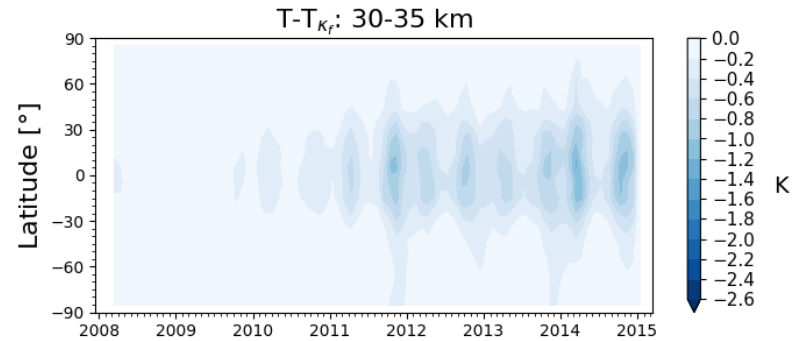
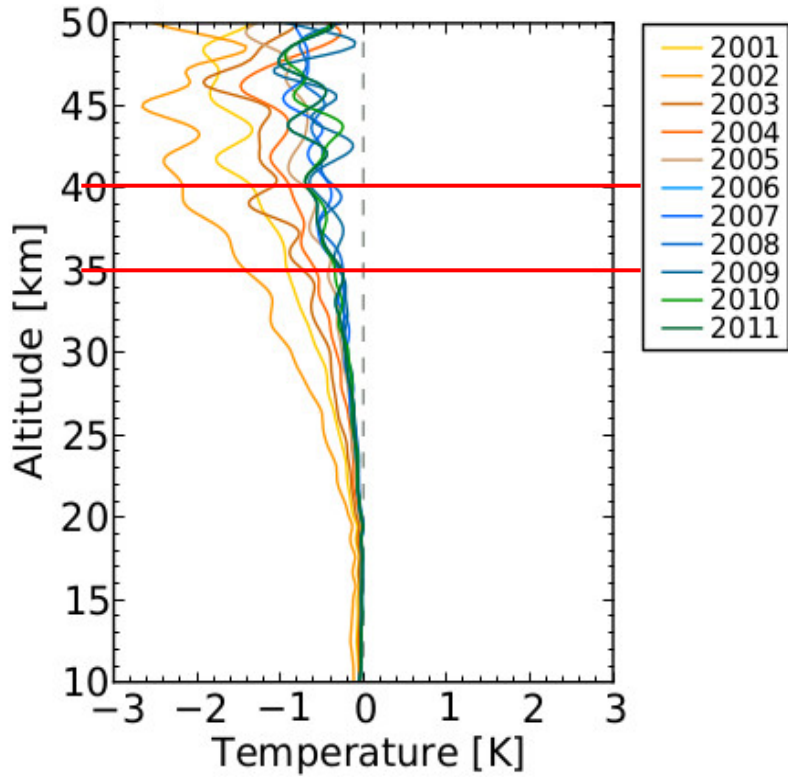
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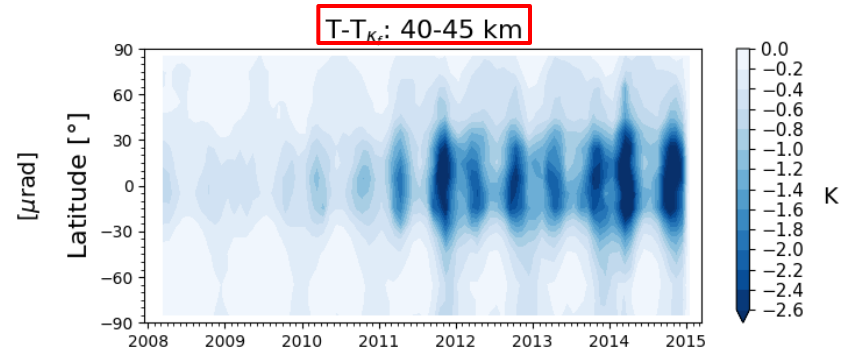
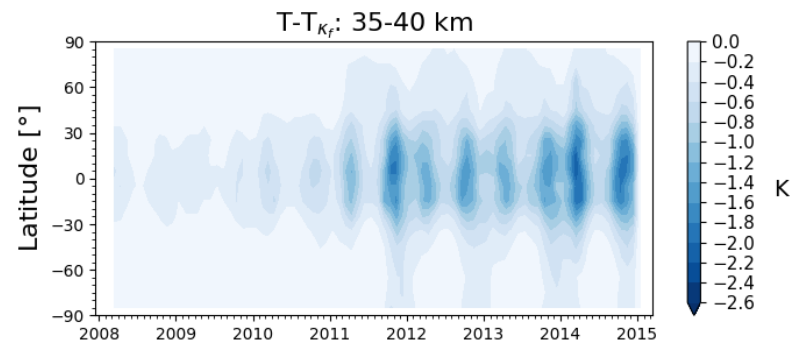
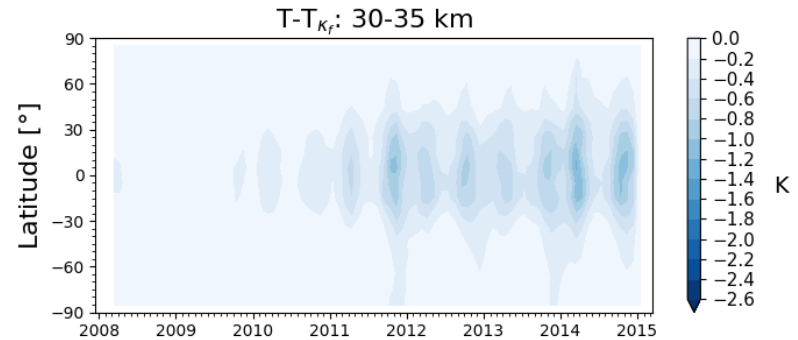
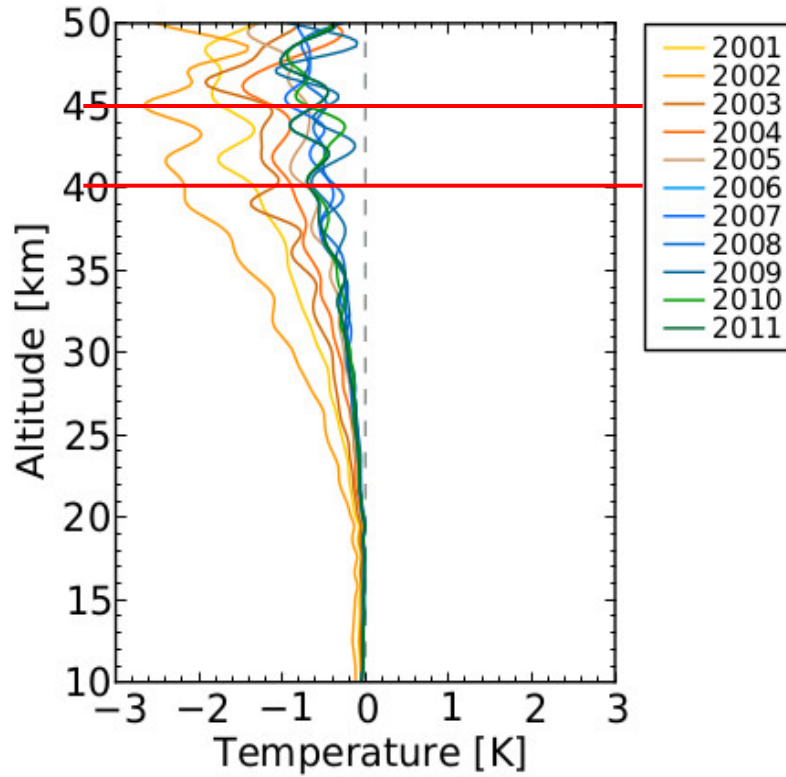
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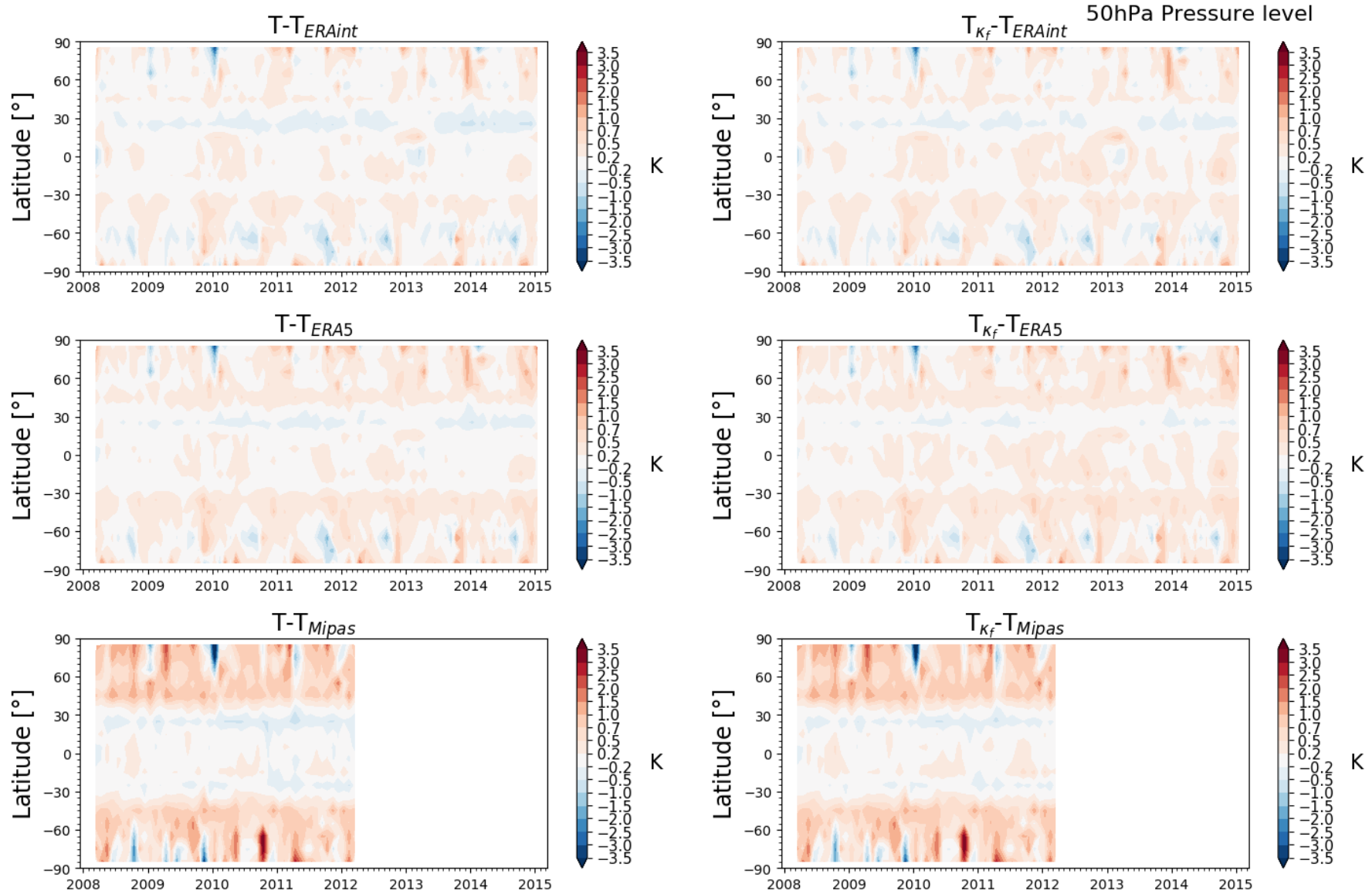
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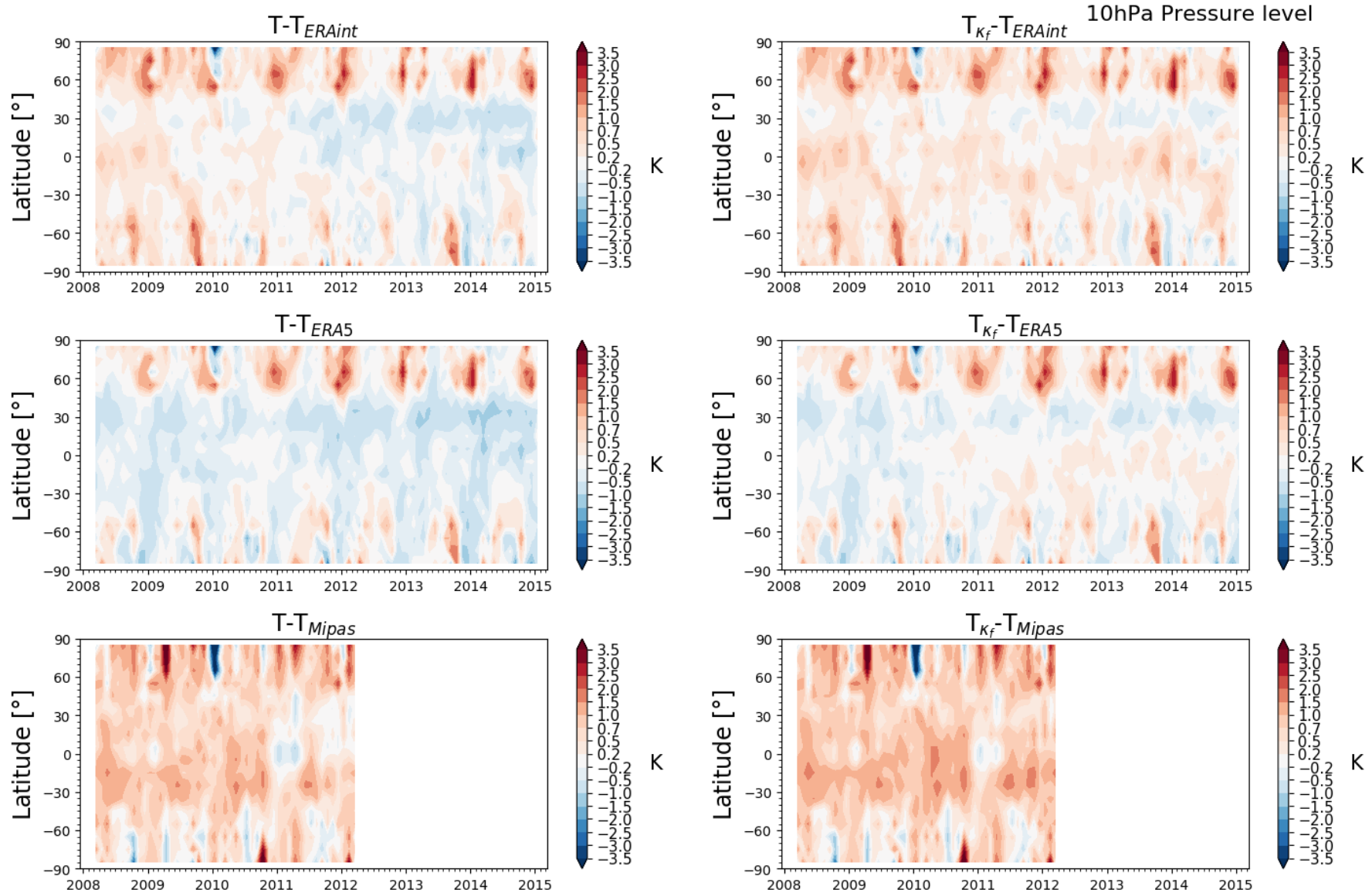
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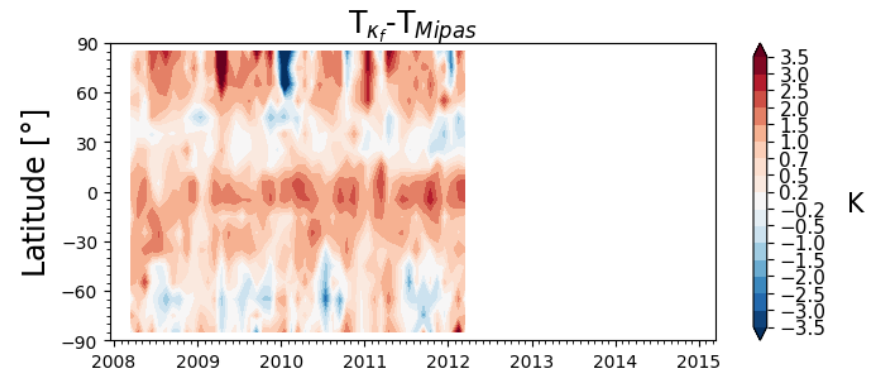
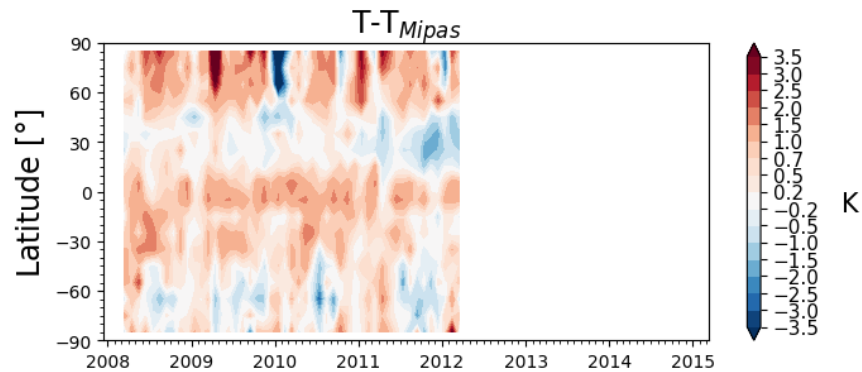
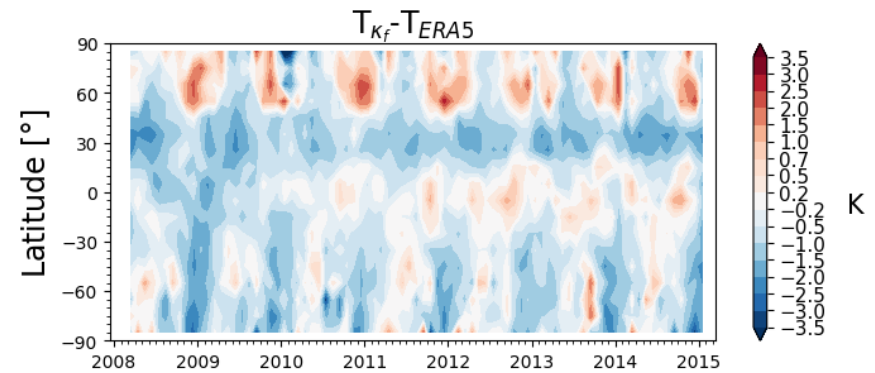
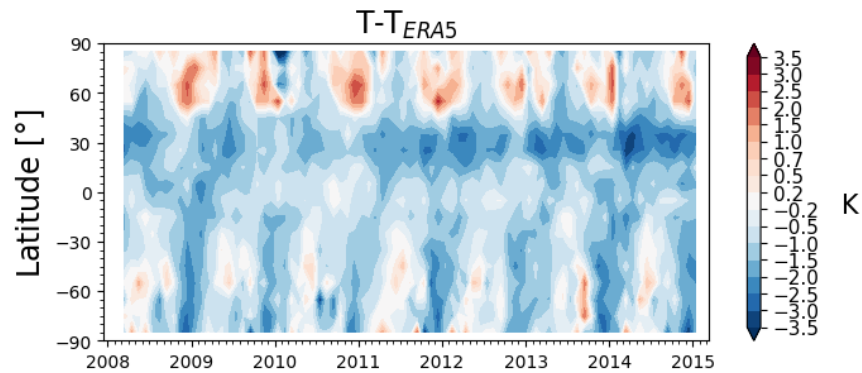
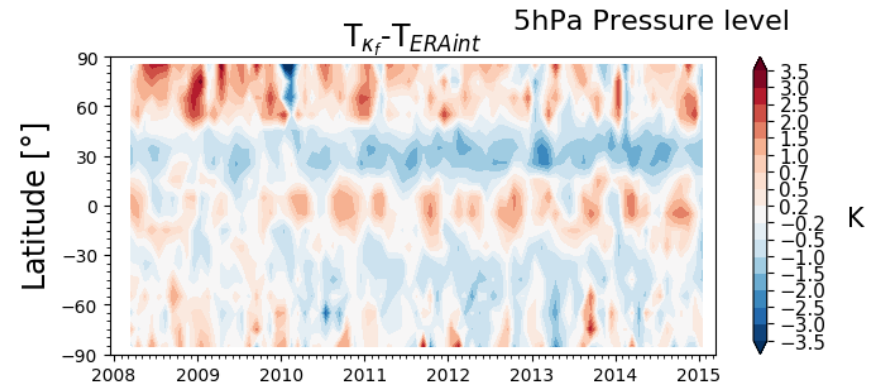
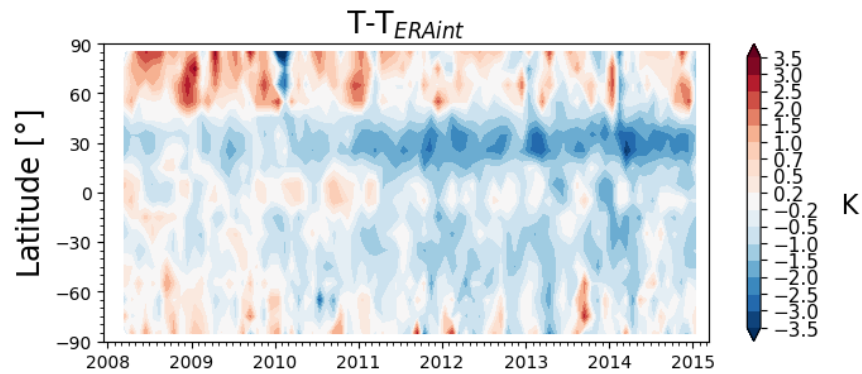
Comparison to Reference Data



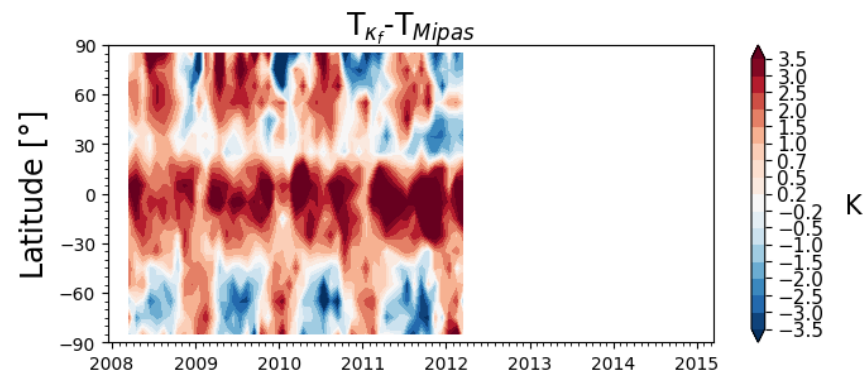
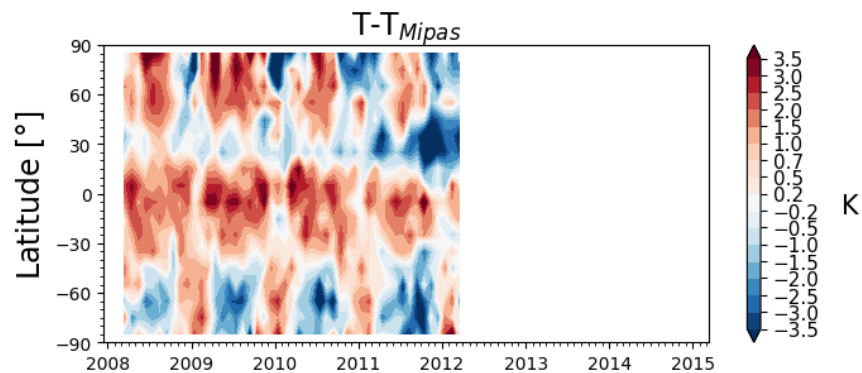
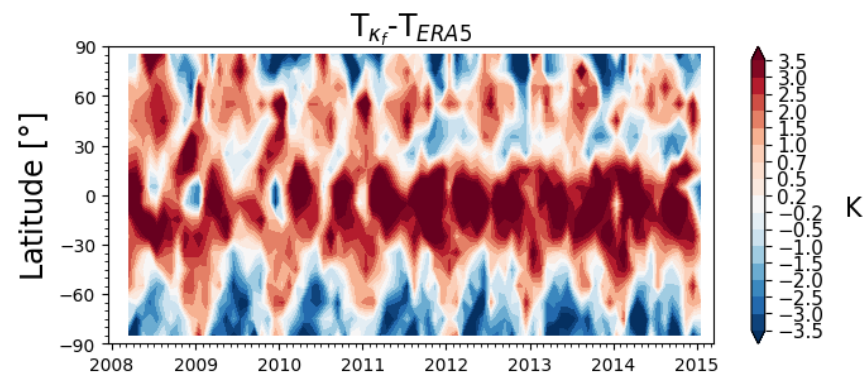
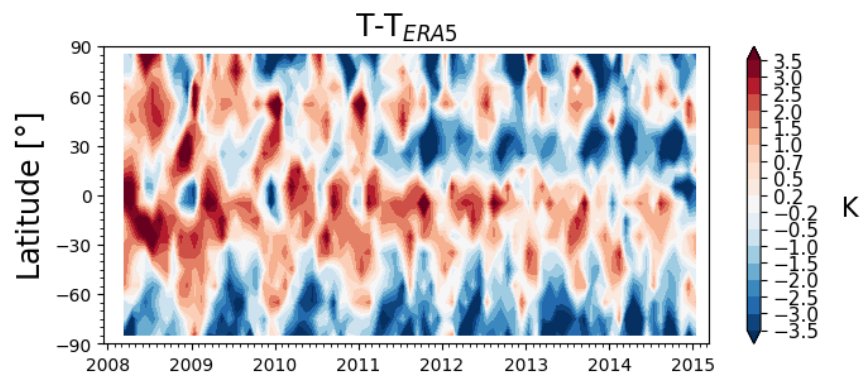
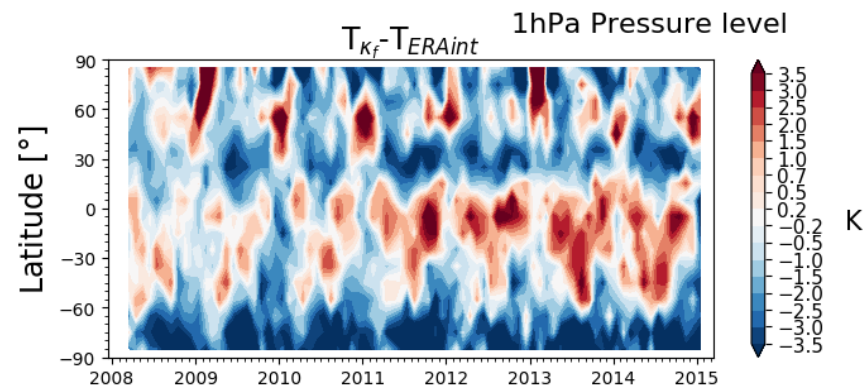
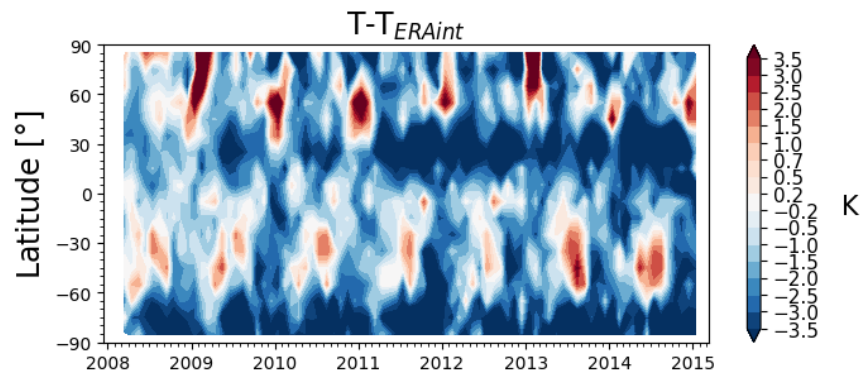
Comparison to Reference Data



Comparison to Reference Data



Comparison to Reference Data



- kappa-correction – solar cycle dependent correction
- Sensitivity analysis:
 - Altitude range 30 km – 35 km: 0.2 K up to about 1.0 K
 - Altitude range 40 km – 45 km: up to about 2.0 K
 - Largest correction over tropics
- Comparisons to ERA-Int, ERA5, and Mipas
 - Warming of RO temperature climatologies
 - Negative biases decrease – positive biases increase
 - $T_{RO} - T_{ERA} < 0$: agreement tends to improve
 - $T_{RO} - T_{Mipas} > 0$: agreement tends to decrease
- Mixed results
 - Biases in reference data
 - Small ionospheric correction value

Thank you very much for your attention!

