

**Development and validation
of a new wave scheme
for trajectory simulations
of TTL dehydration and cirrus clouds**

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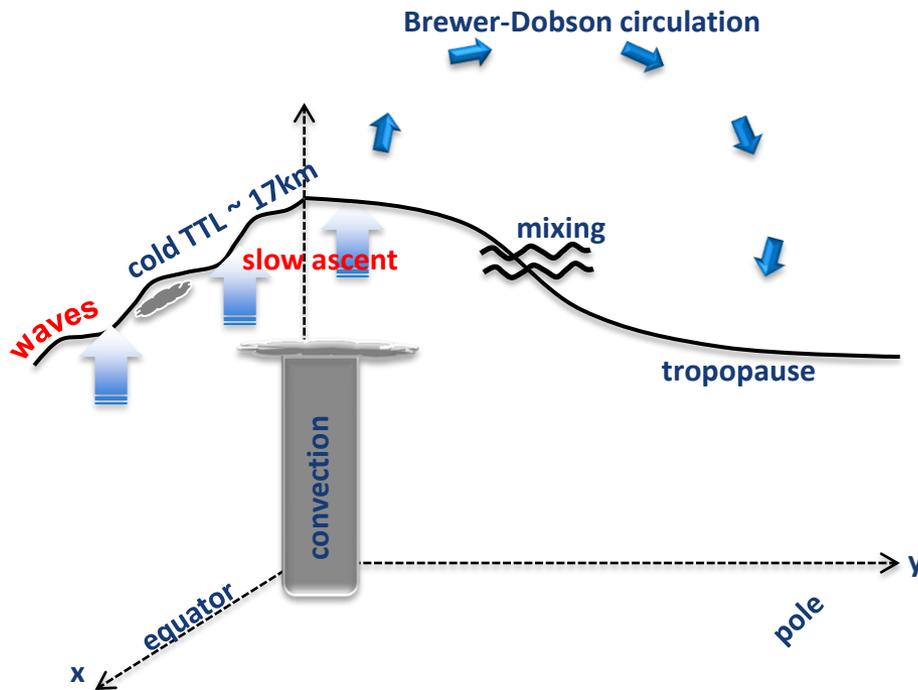
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University of Colorado-Boulder

M. Joan Alexander

NorthWest Research Associates

Kim and Alexander, GRL, Oct, 2013

Trajectory models simulate stratospheric water vapor



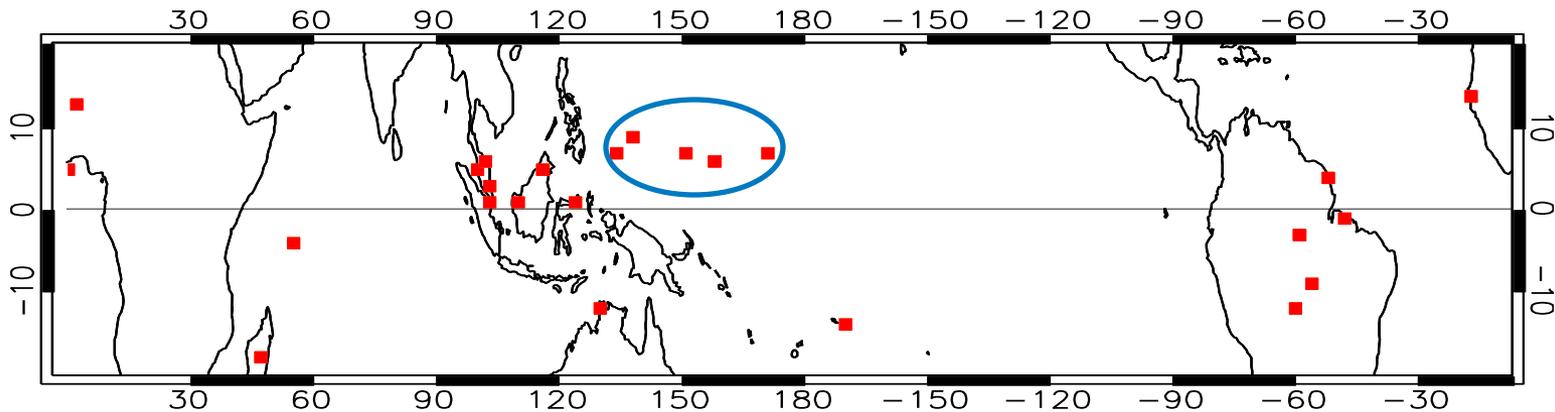
- Trajectory calculations are based on meteorological fields (T, u, v) from (re)analysis data.
- Temperature history of air during ascent is important: coldest temperature and variability
- But, reanalyses have uncertainties in representing TTL waves.

Outline

- Problems in temperature variability in reanalysis data
- New wave parameterization
- Validation and improvements
 - Radiosondes
 - GPS

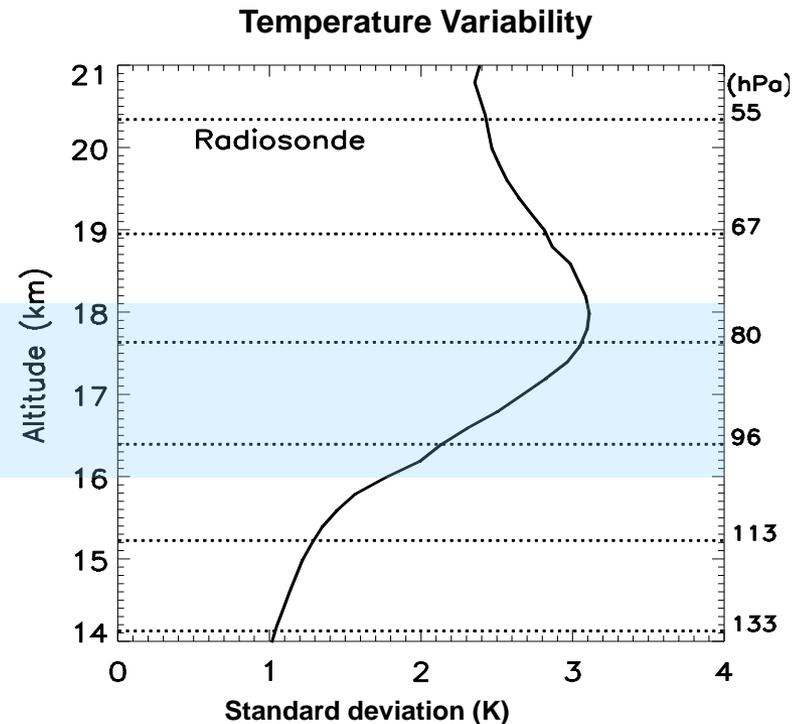
Temperatures from radiosondes and reanalyses

- Evaluation: ERA-interim, MERRA
- 24 sondes, 15S-15N, 1997-2013, DJF+MAM+JJA+SON
 - profiles at 0Z & 12Z
 - High vertical resolution -> binned into 200 m



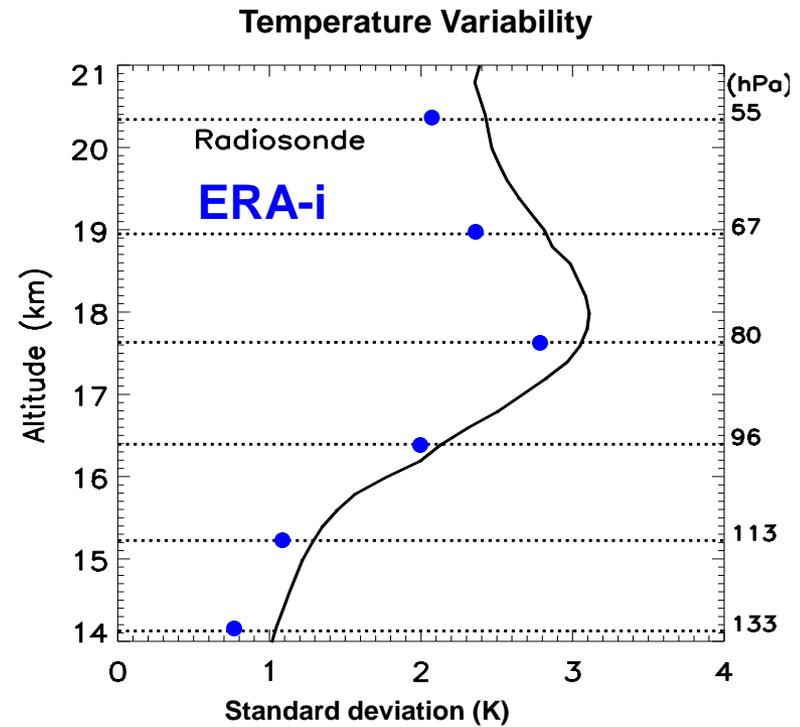
Lots of waves in the TTL

Tropopause in DJF W-Pacific

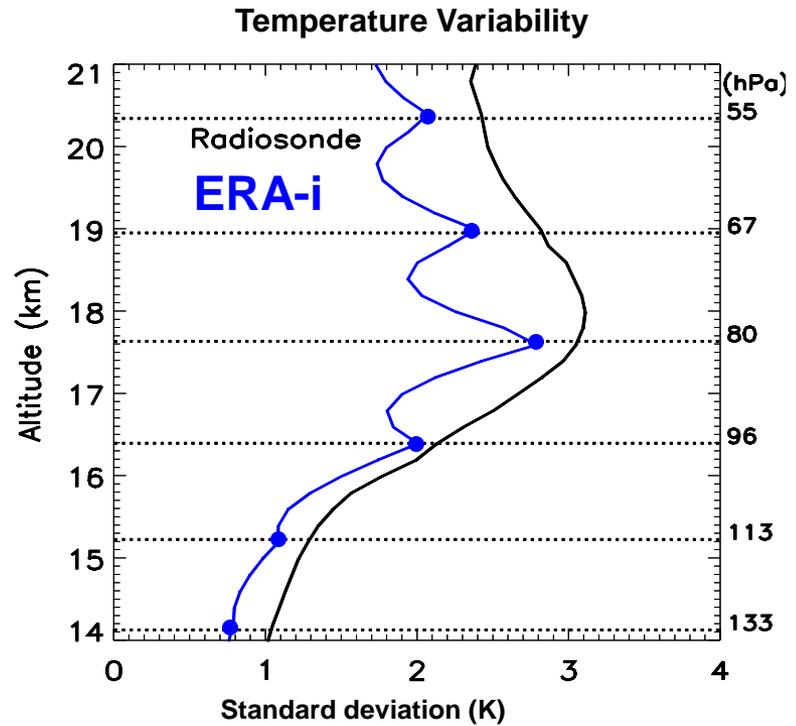


- Cold point tropopause is mostly 16-18 km.
- Temperatures are highly variable near and above TTL.

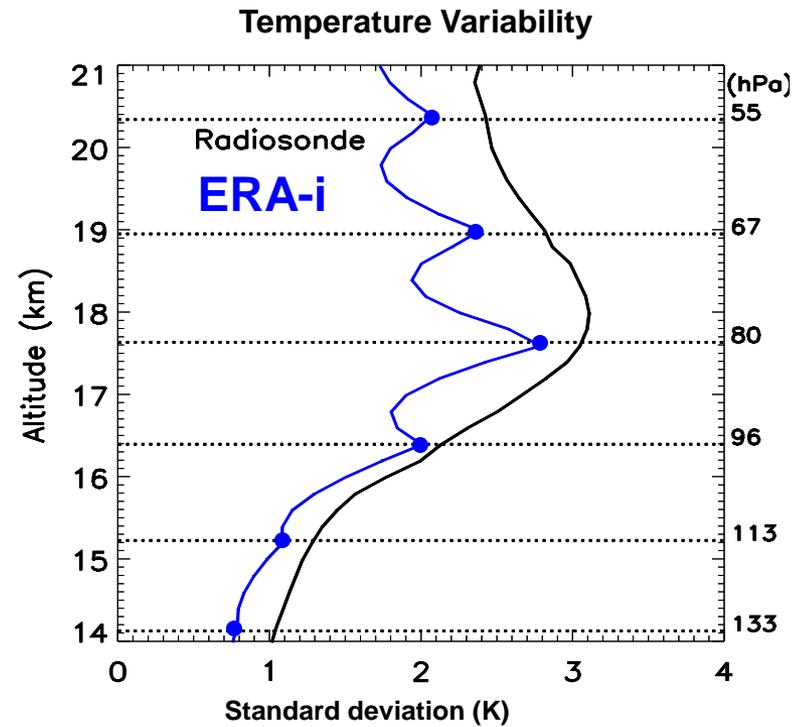
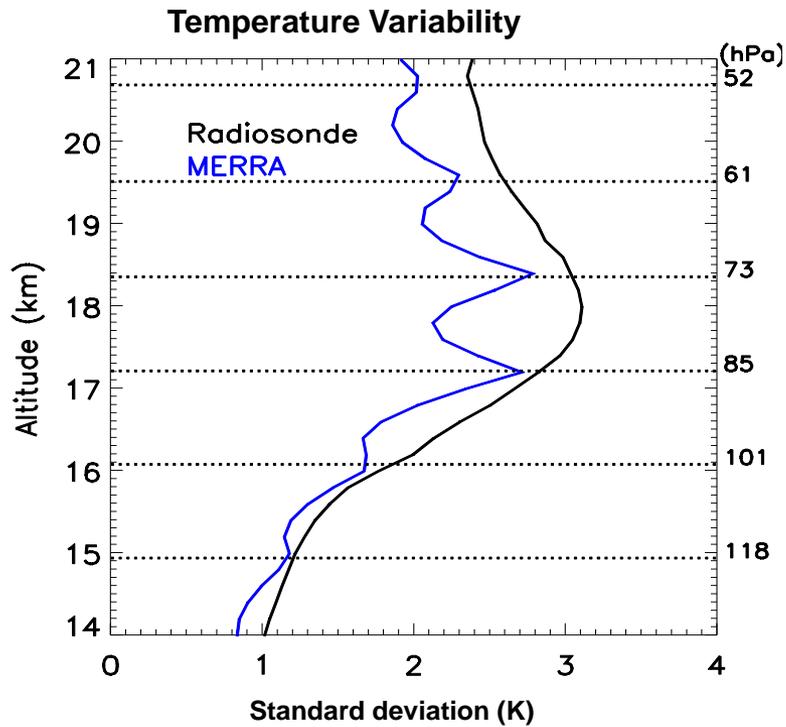
Variability issue 1: Waves are underrepresented



Variability issue 2: Linear interpolation does something..

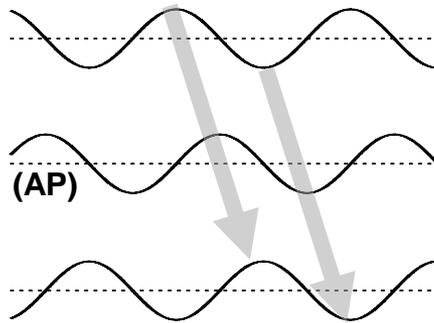


Variability issue 2: Linear interpolation does something..



Interpolation kills variability

Should be like this..



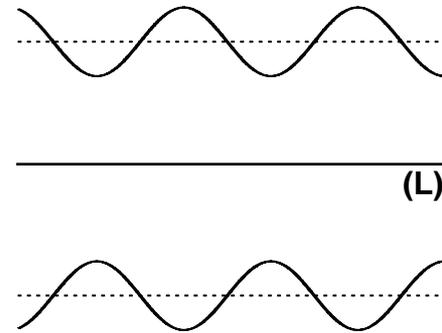
Reanalysis (**z2**)

Interpolated

Reanalysis (**z1**)

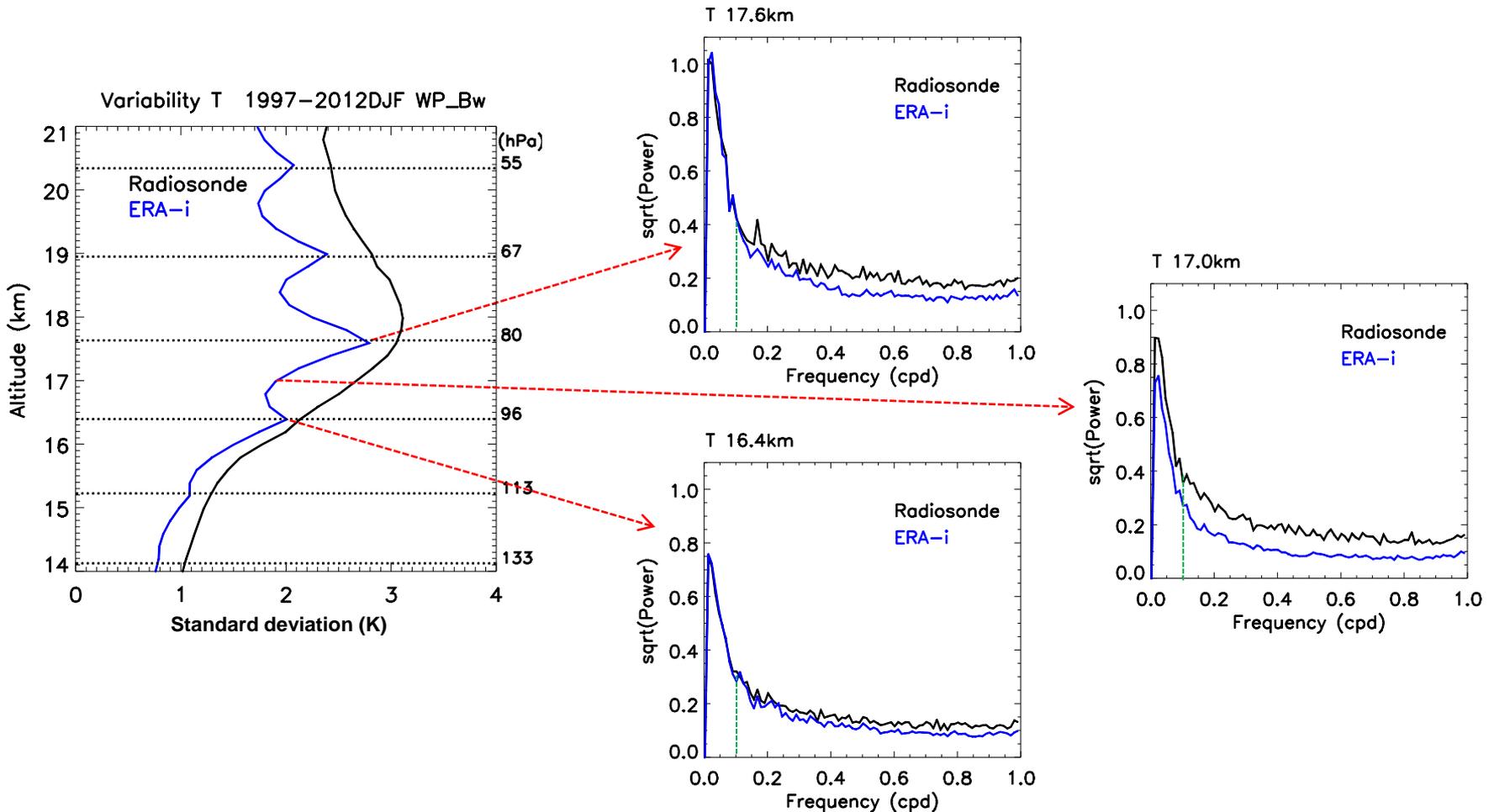
Waves are **alive!**

What's happening with interpolation



Waves are **dead!**

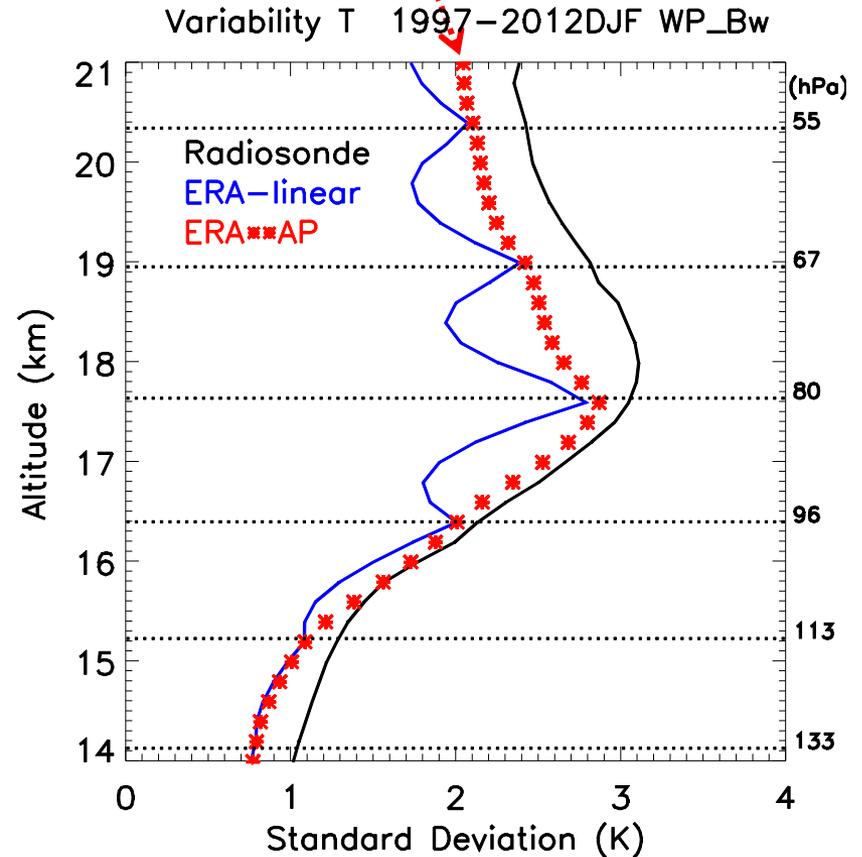
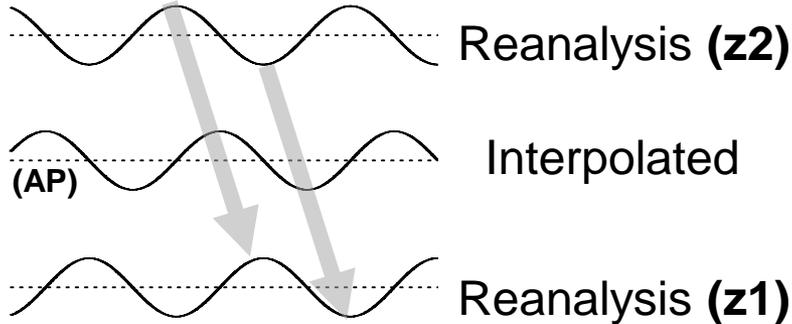
Waves in all frequencies are underrepresented at interpolated levels



- At model levels, waves > 10 days are well resolved and waves < 10 days are lacking.
- At interpolated levels, even longer scale (Kelvin) waves are underrepresented.

Temperature variability in interpolated levels can be improved by **interpolating T in Fourier space**

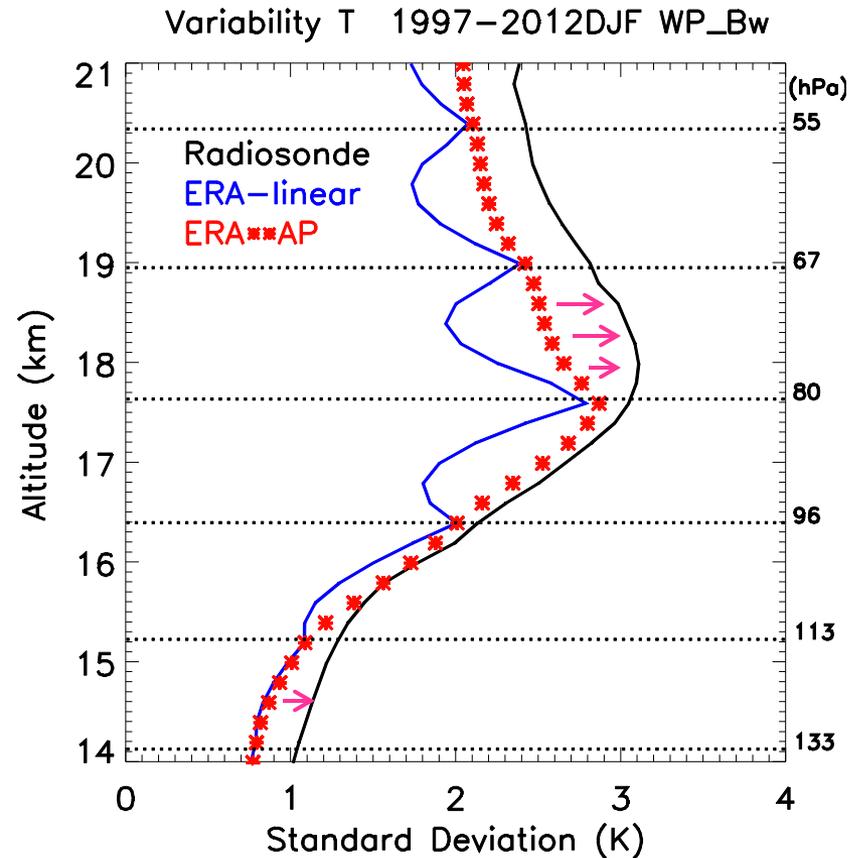
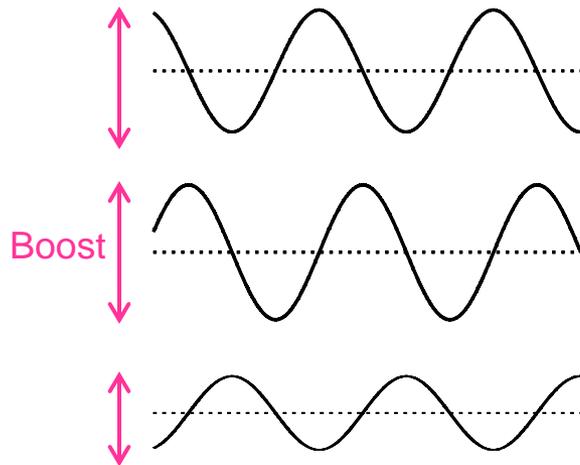
Should be like this..



Use the fact “waves ARE in reanalysis levels”

Enhance power/variability to match observations

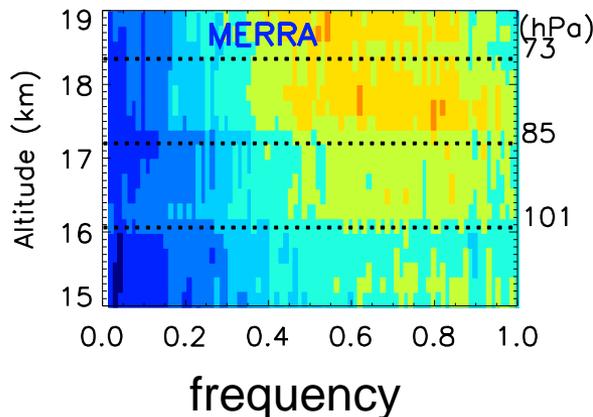
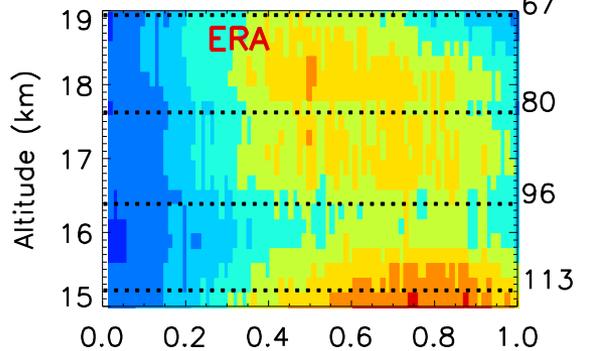
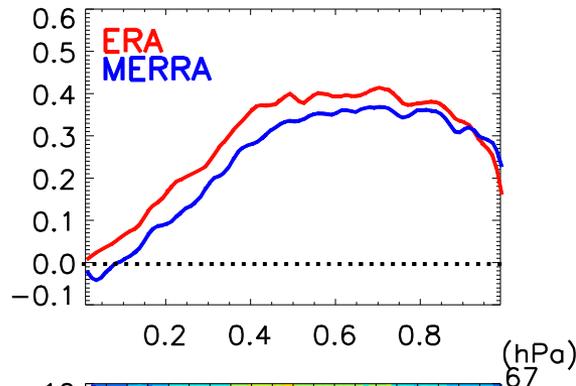
Should be like this..



Use the fact “waves are in reanalysis TO SOME DEGREE”

Wave amplification factors are based on 24 tropical radiosones in DJF+MAM+JJA+SON

Averaged factor at 15-19 km

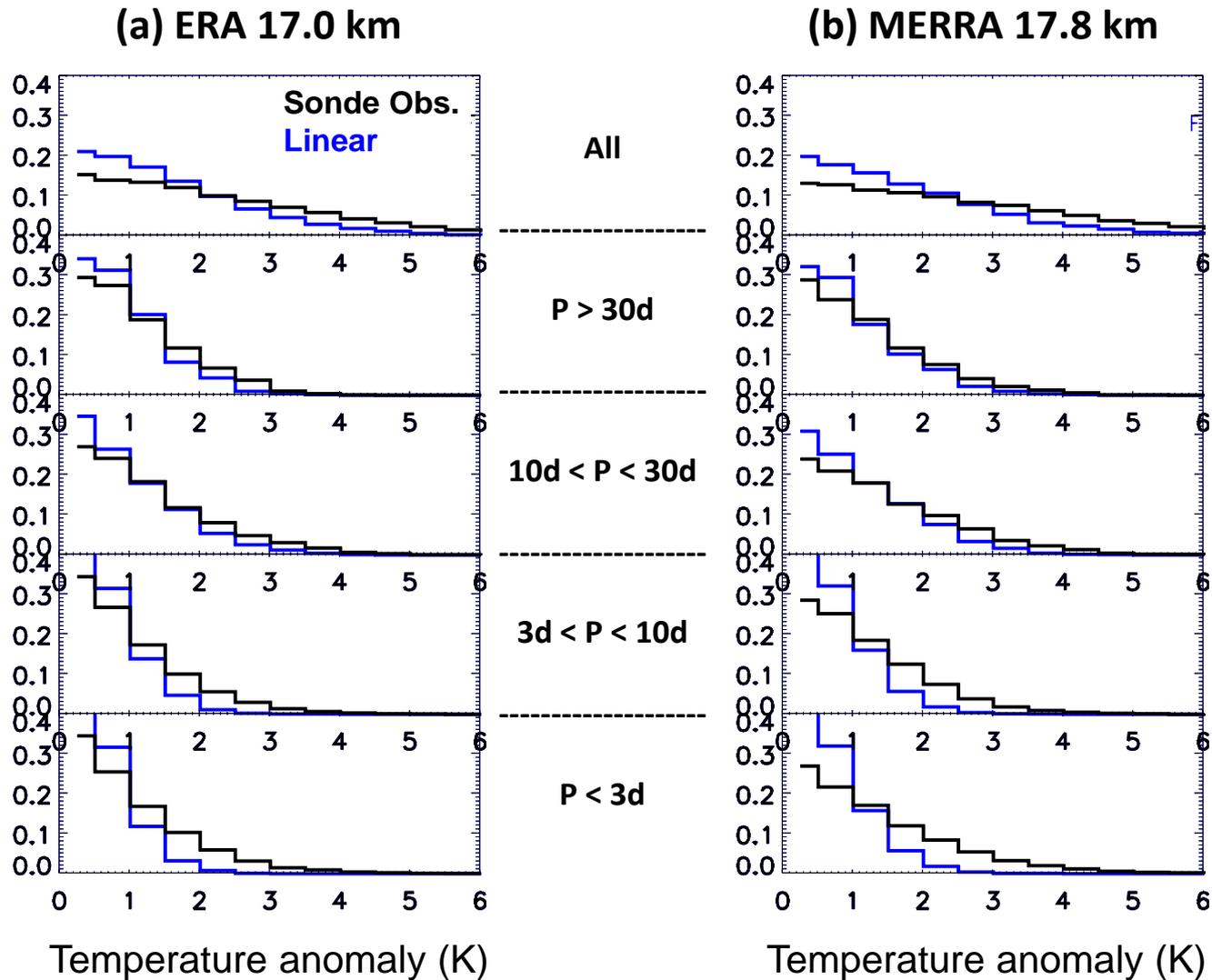


increase wave amplitude in a reanalysis by 40%

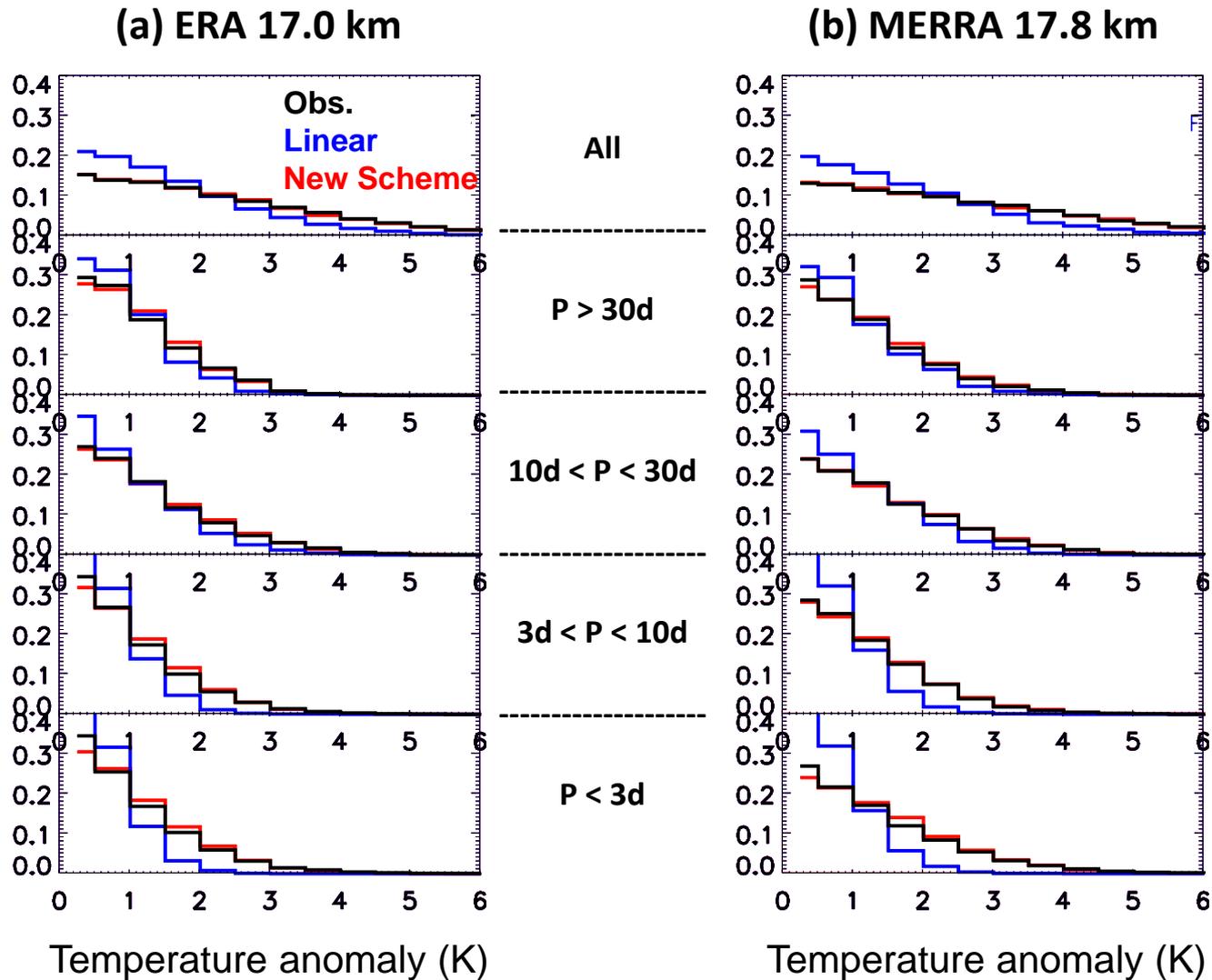
Negative: decrease wave amplitude

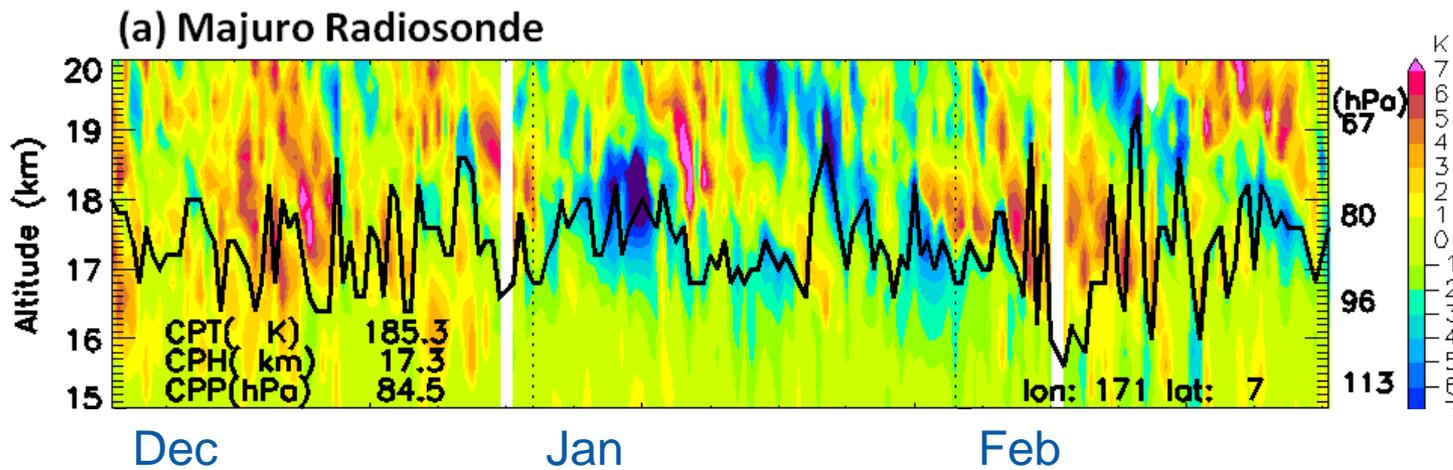
Validation & Improvements

PDF at interpolated levels, 1997-2013 DJF W-Pacific



PDF at interpolated levels, 1997-2013 DJF W-Pacific

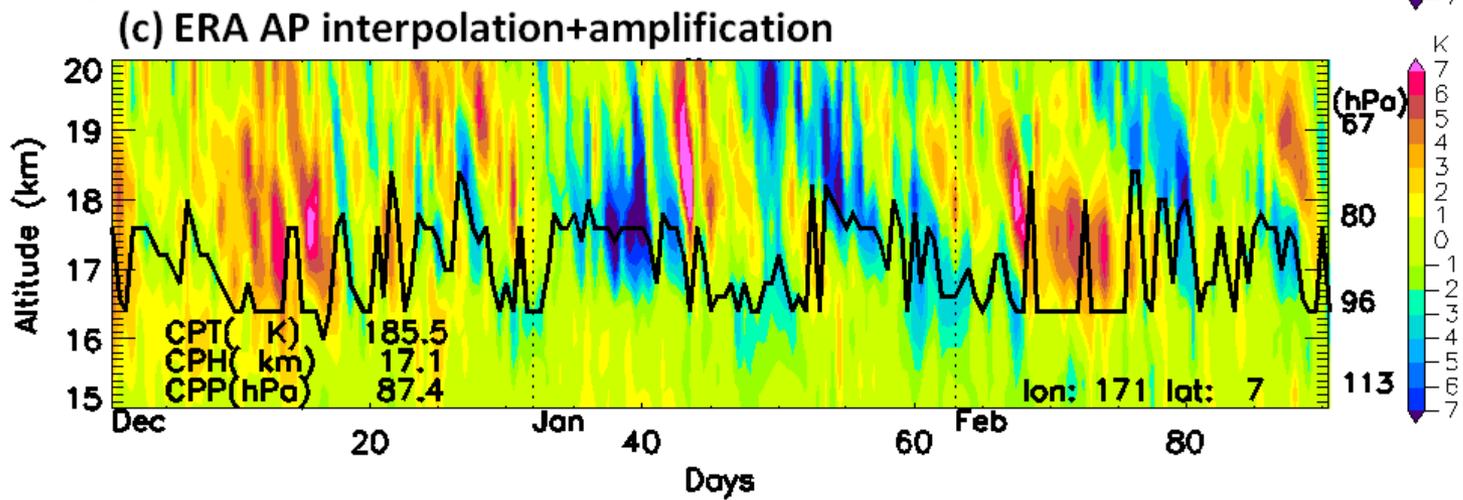
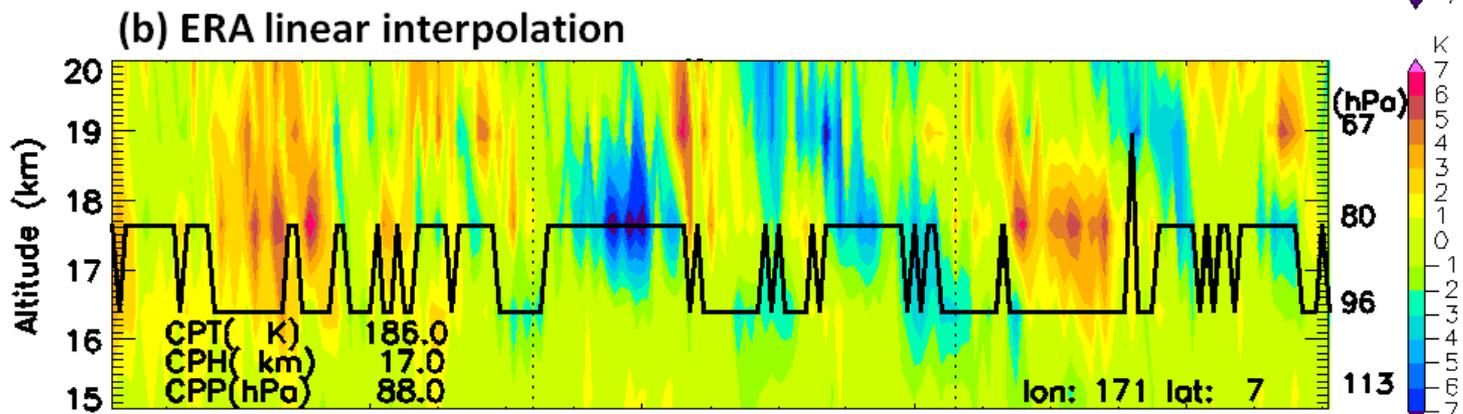
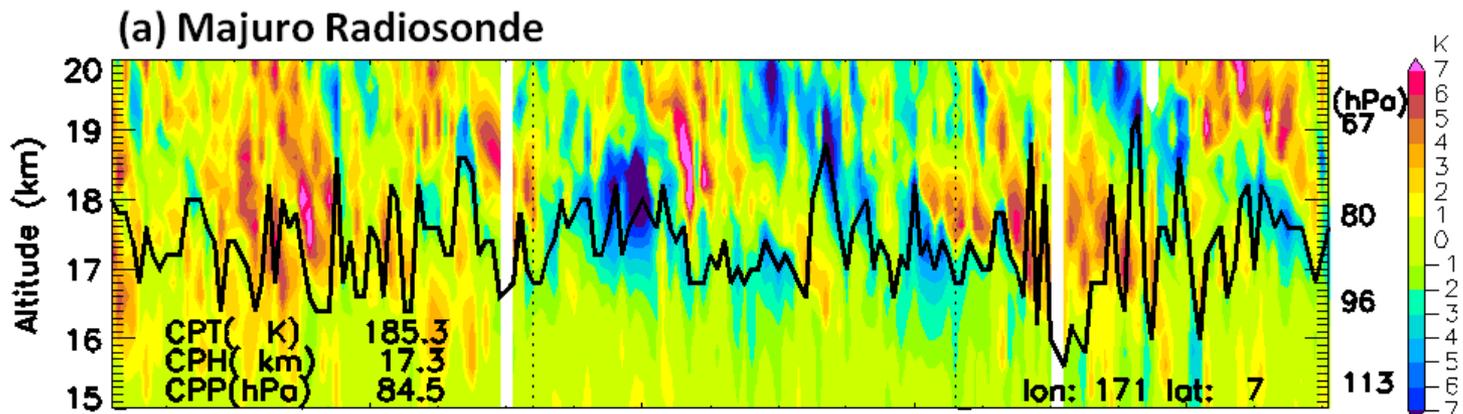




There are:

- Kelvin waves
- Smaller scale waves
- Oscillation of tropopause
- Impact of sudden warming in Jan

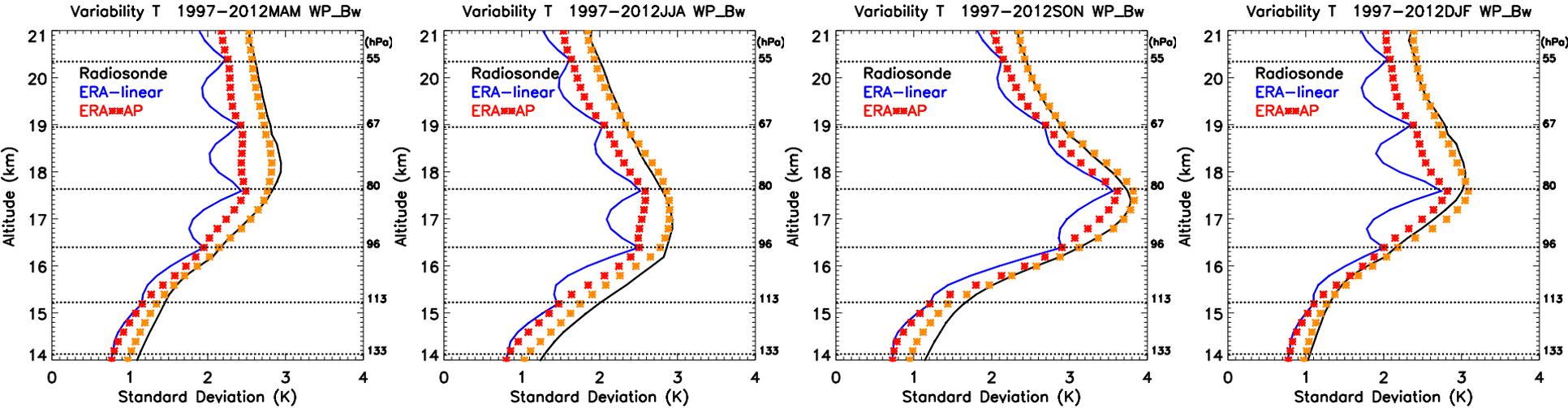
**Time-Height
section
2012-2013
DJF**



•fine scale
features
(1-3K
stronger
amplitude)

•colder
CPT(0.5K ↓)

Is the scheme good for all seasons? (orange is new scheme)

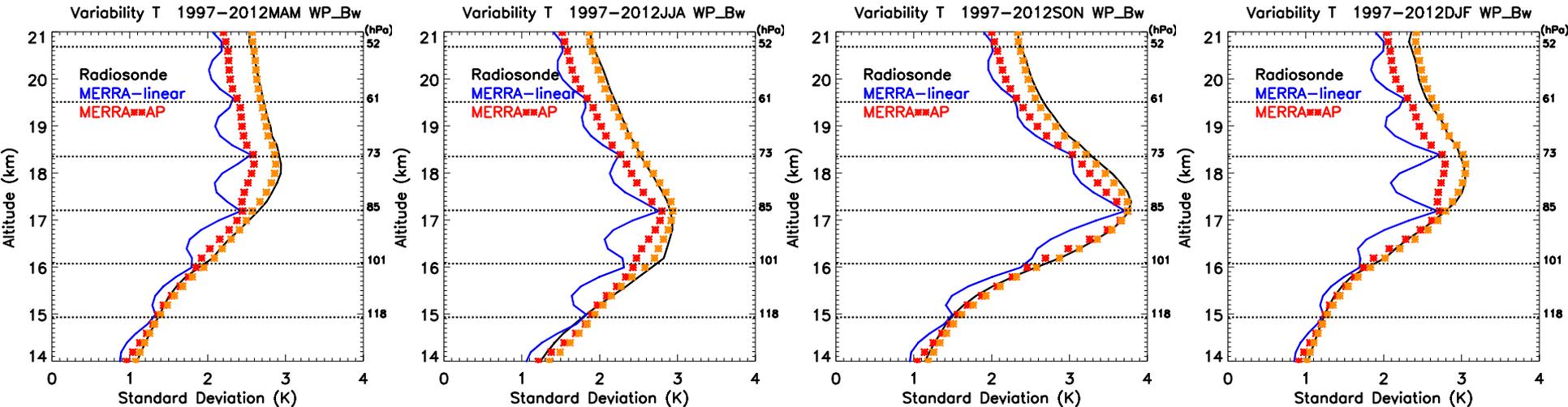


MAM

JJA

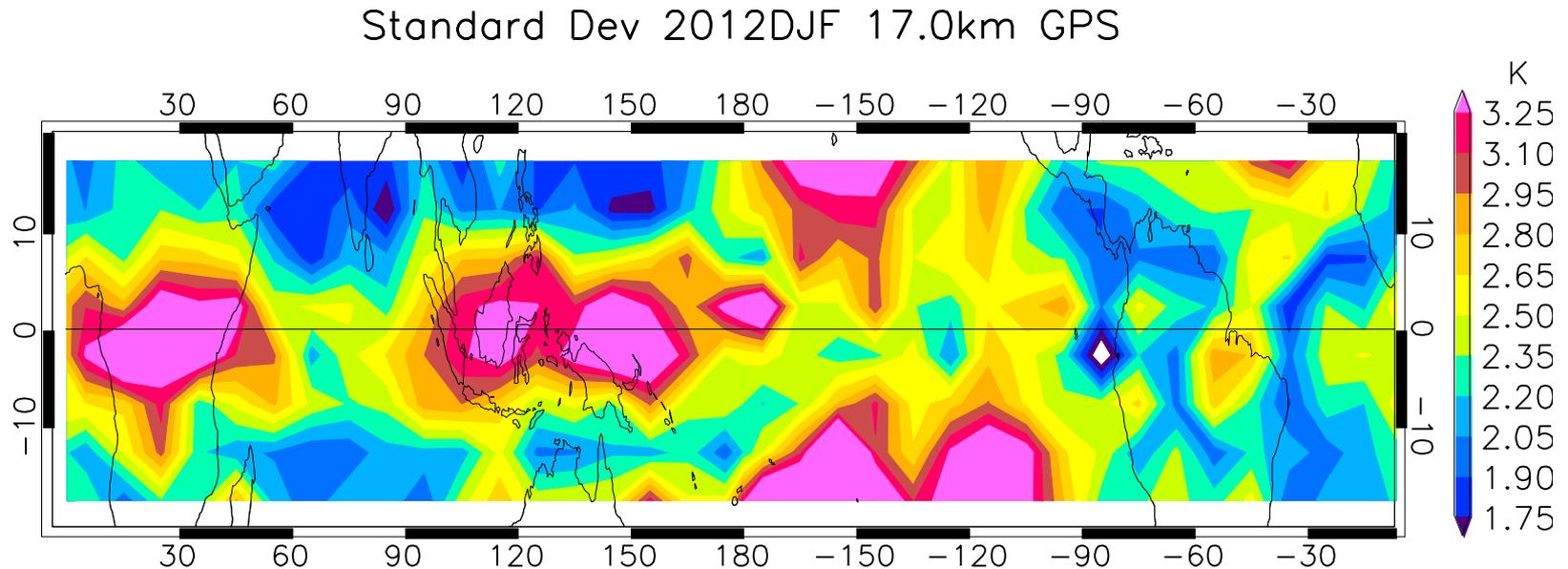
SON

DJF



COSMIC GPS Temperature variability

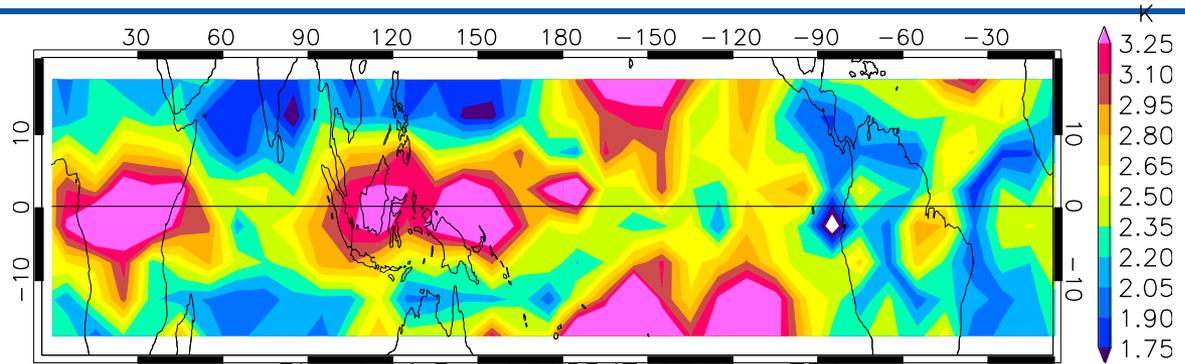
- 10X5 deg grid
- 50-100 profiles in a grid for 3 months



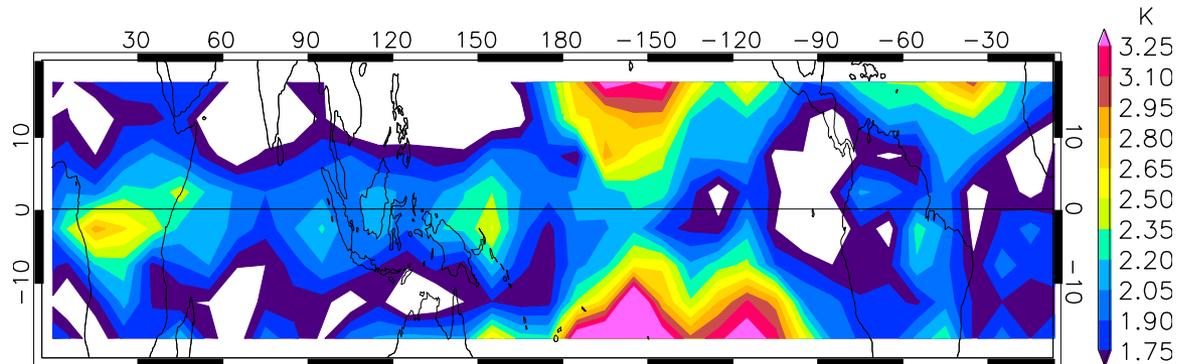
The scheme works well for the whole tropical T variability

Standard Dev 2012DJF 17.0km GPS

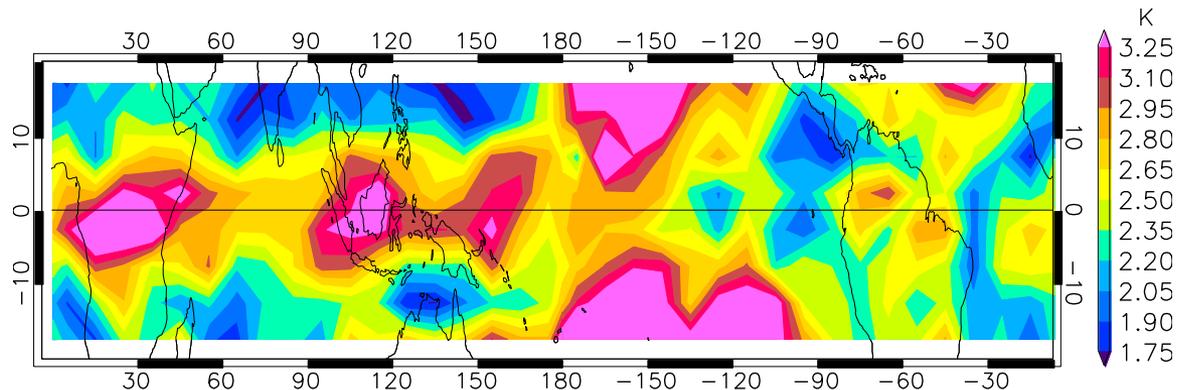
(a) COSMIC GPS obs.



(b) ERA linear interpolated
at 17km

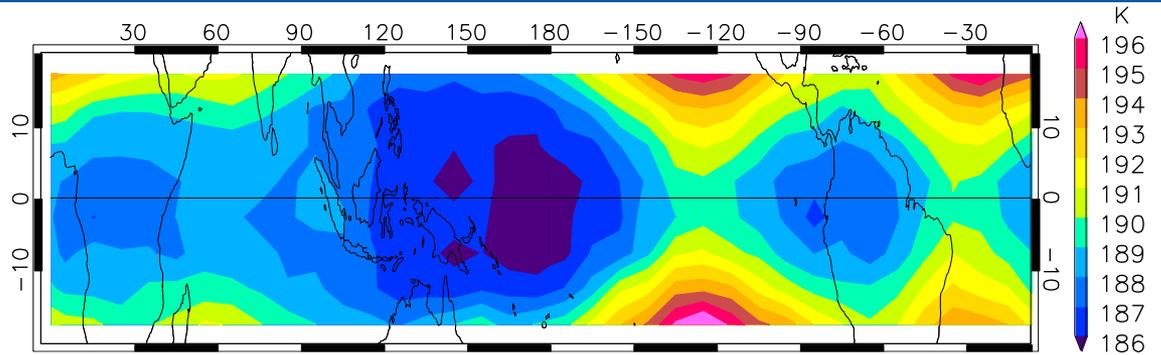


(c) ERA + New scheme



How about cold point tropopause temperature?

Mean CPT 2012DJF GPS

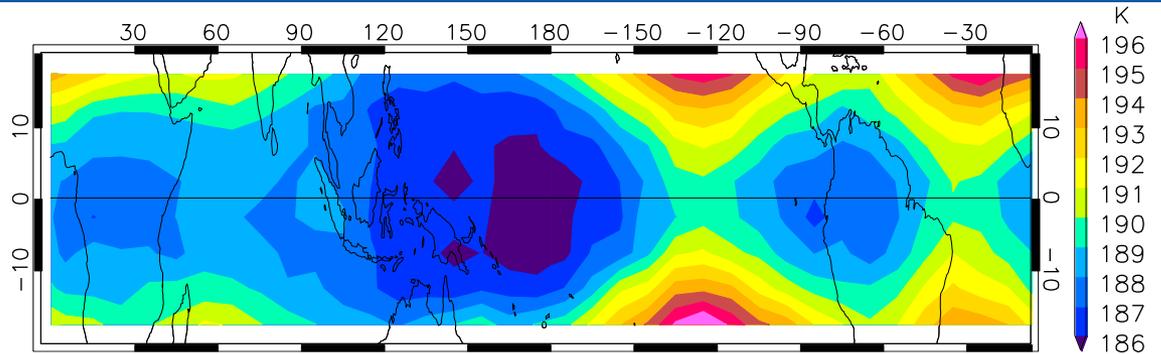


(a) COSMIC GPS obs.

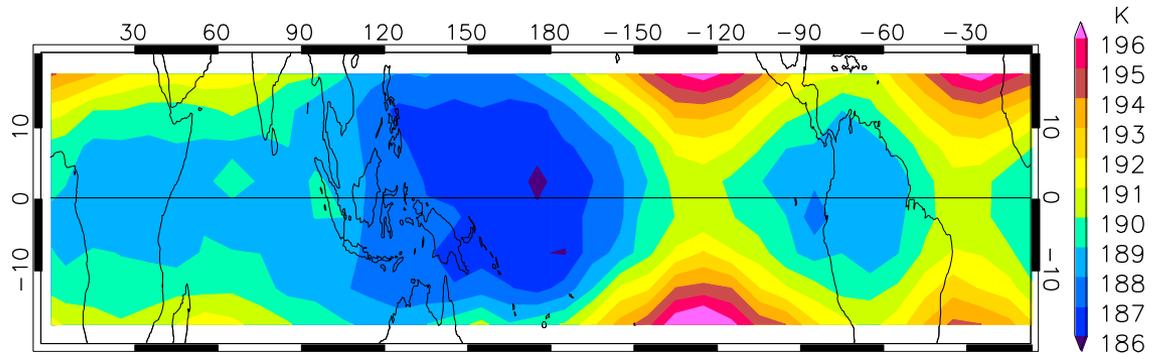
New scheme decreases CPTs

Mean CPT 2012DJF GPS

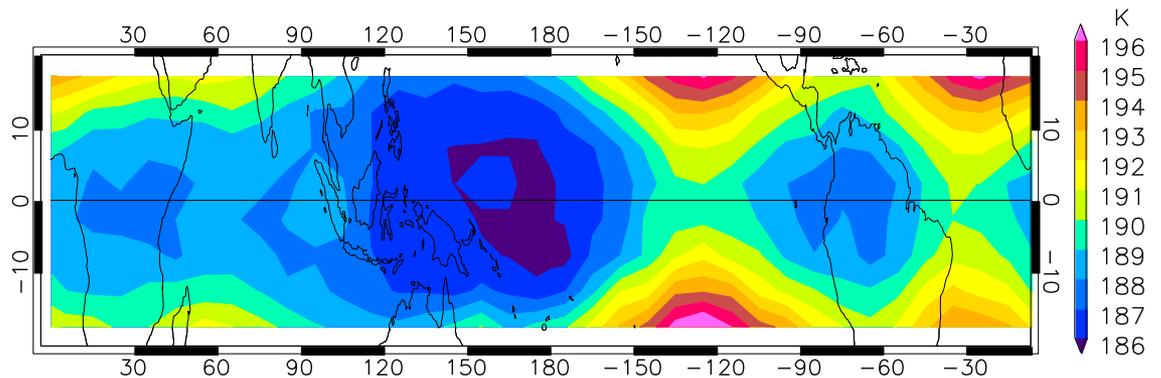
(a) COSMIC GPS obs.



(b) ERA

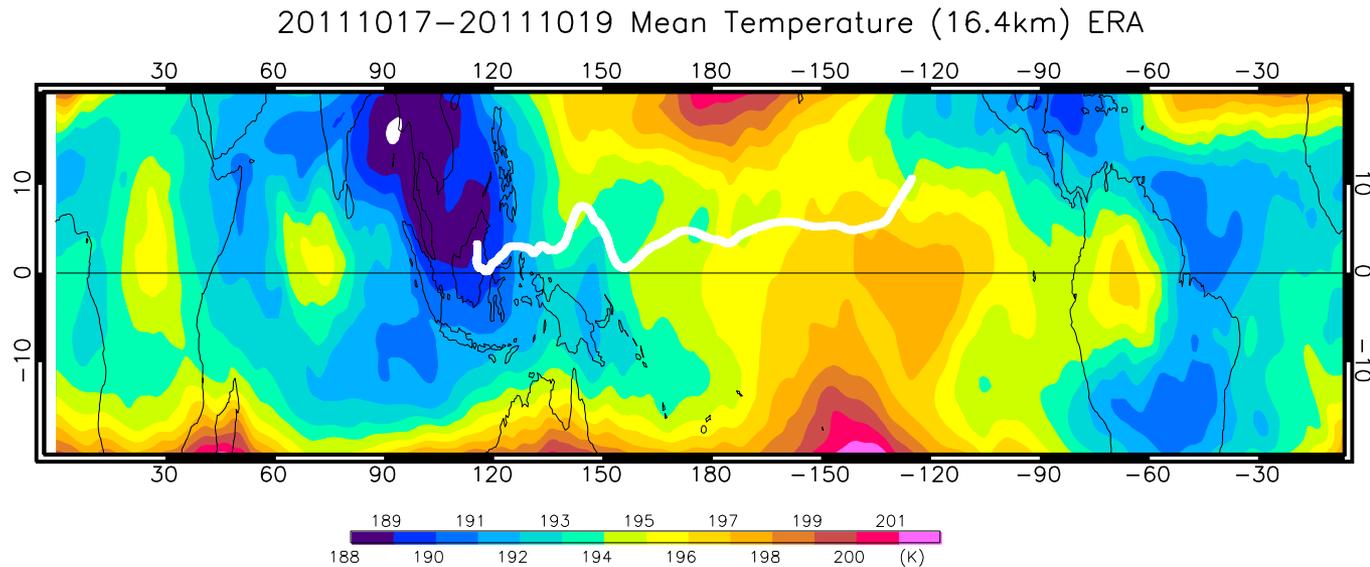


(c) ERA + New scheme



What about temperature along a trajectory?

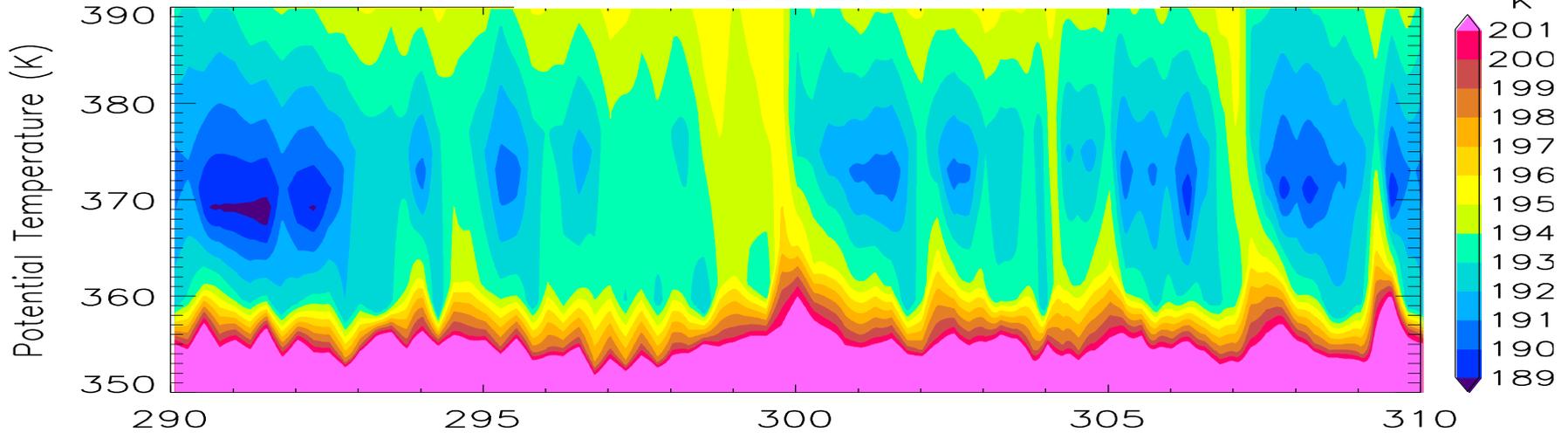
20-day back trajectory for ATTREX 2011



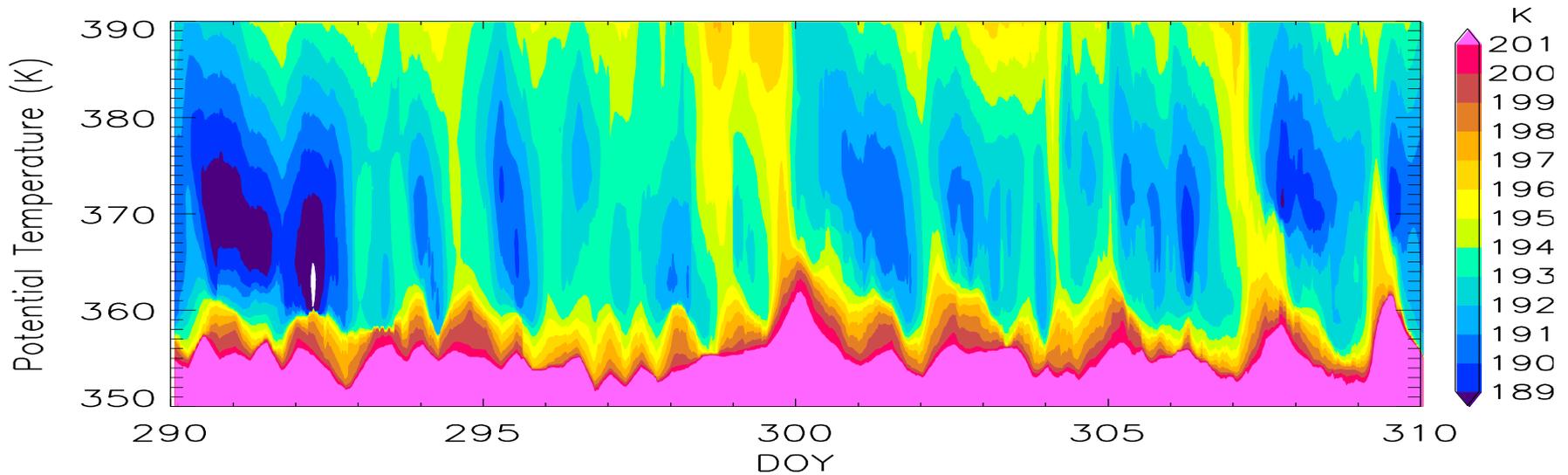
Trajectory path from Eric Jensen, Lenny Pfister, and Rei Ueyama.

Temperature curtains

ERA Linear



New Scheme



Summary

- We found problems in temperature variability in (re)analysis data.
 - Waves < 10 days are weak at model levels.
 - Interpolation at vertical space kills waves.
- How to improve variability?
 - Step 1: Interpolation of amplitude and phase in Fourier space instead of temperatures in real space
 - Step 2: Enhance amplitude of waves
- ➔ This way, we can make realistic wave amplitude and intermittency.
- ➔ The same method could be applied to wind fields.
- ➔ Having realistic variability will reduce uncertainties in trajectory simulations.