Benefits of a new wave scheme for trajectory modeling of stratospheric water vapor

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# Trajectory models simulate stratospheric water vapor

- Trajectory calculations are based on meteorological fields (T, u, v) from (re)analysis data.

- Temperature history during ascent is critical in dehydration: mean + variability

- But,
  reanalyses have uncertainties in representing TTL waves.

Temperatures from tropical radiosondes

- Evaluation: ERA-interim

- 24 sondes, 15S-15N, 1997-2013
    - profiles at 0Z & 12Z
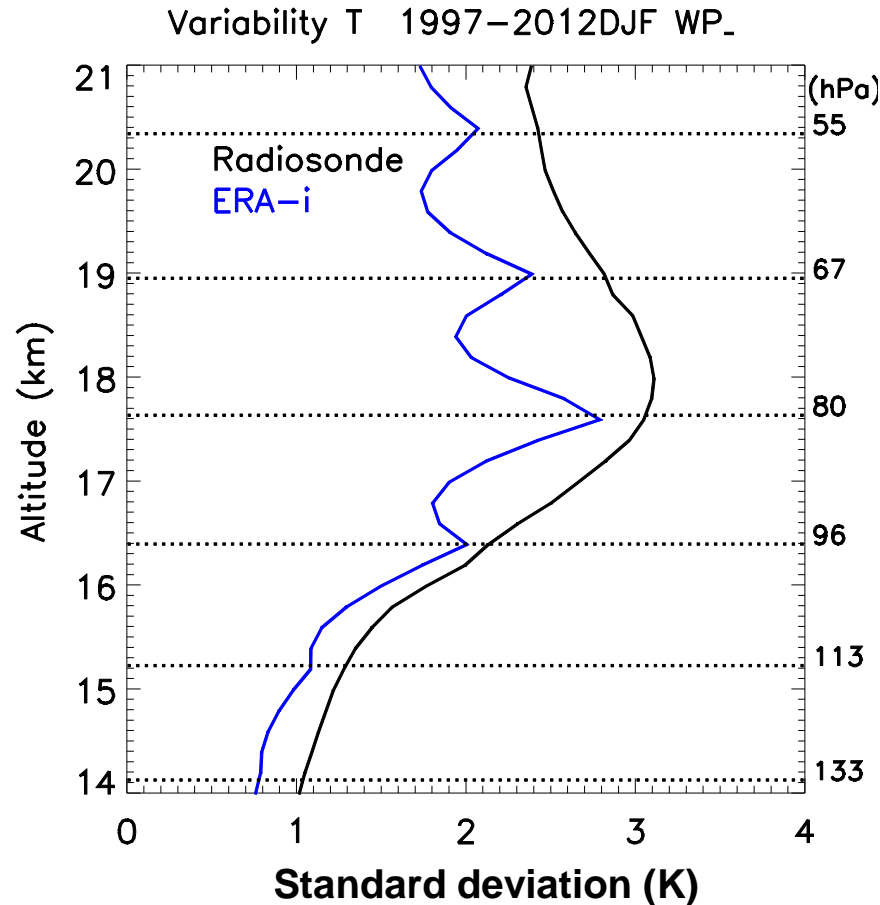   - High vertical resolution -> binned into 200 m
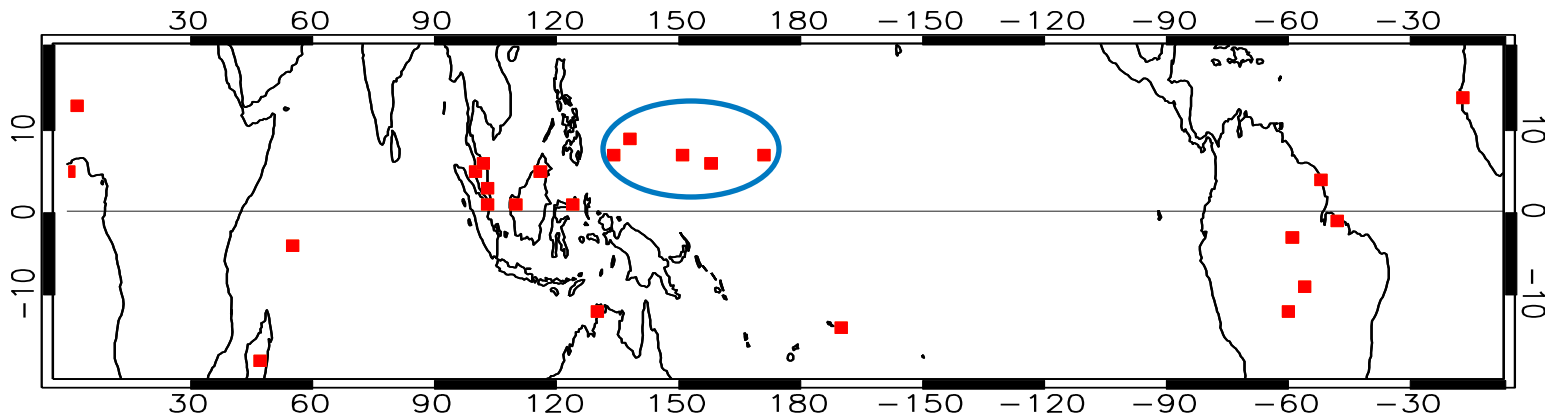
Lots of waves in the TTL

Variability T 1997–2012DJF WP_
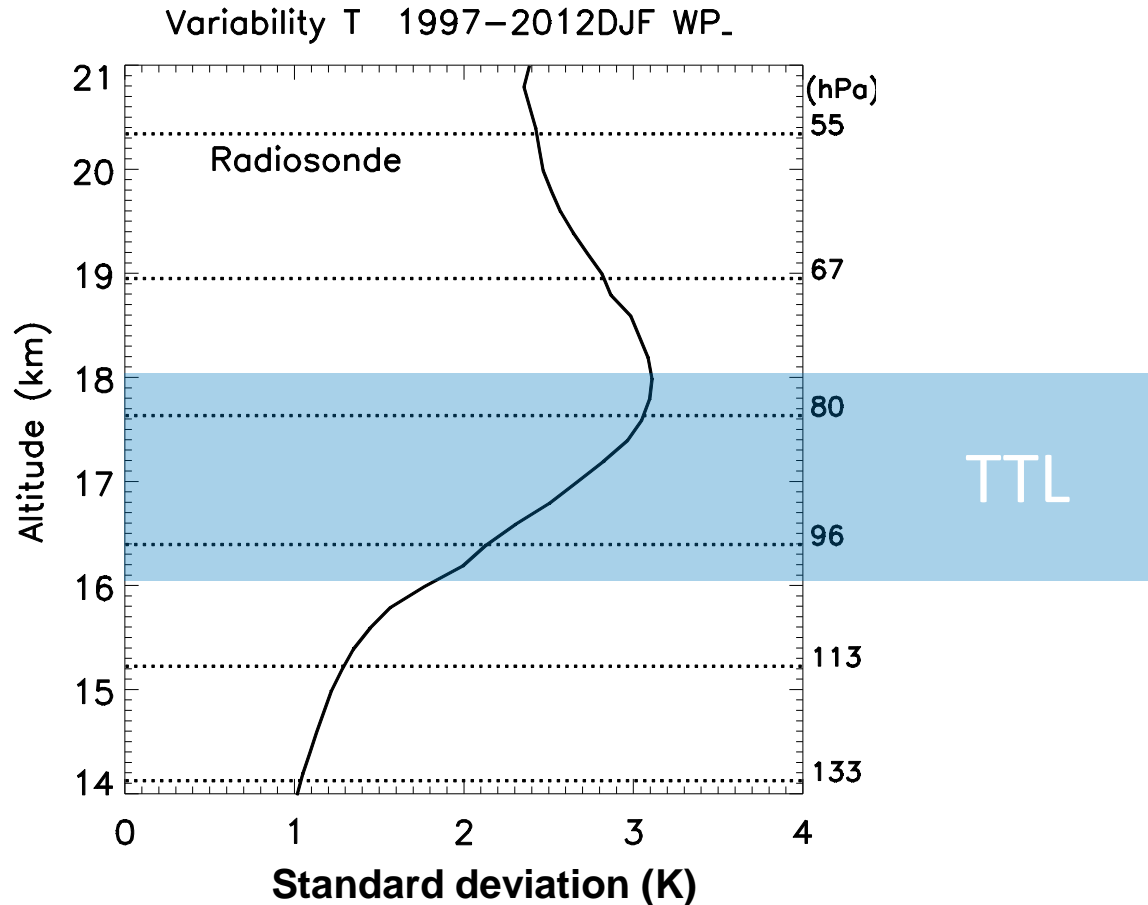
- Temperatures are highly variable near and above TTL.

Radiosonde   vs   ERA linear interpolation

Variability T   1997−2012DJF WP_
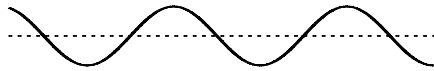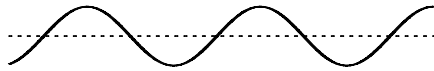
- At model levels, waves are under-represented. (lack of high-freq. variability)
- At interpolated levels, linear interpolation substantially degrades variability.
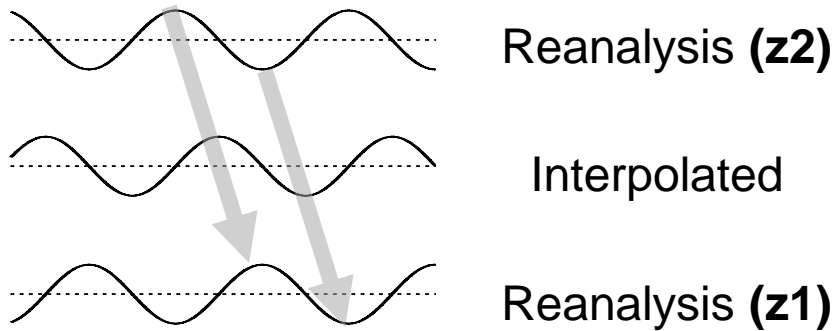
Why?

Suppose..

Reanalysis **(z2)**

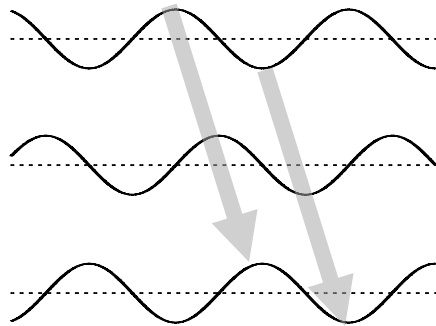Reanalysis **(z1)**

Wave propagates vertically

Should be like this..

Reanalysis **(z2)**

Interpolated

Reanalysis **(z1)**

Waves are **alive!**

Linear interpolation kills variability

Should be like this..

What's happening with interpolation

Reanalysis **(z2)**

Interpolated
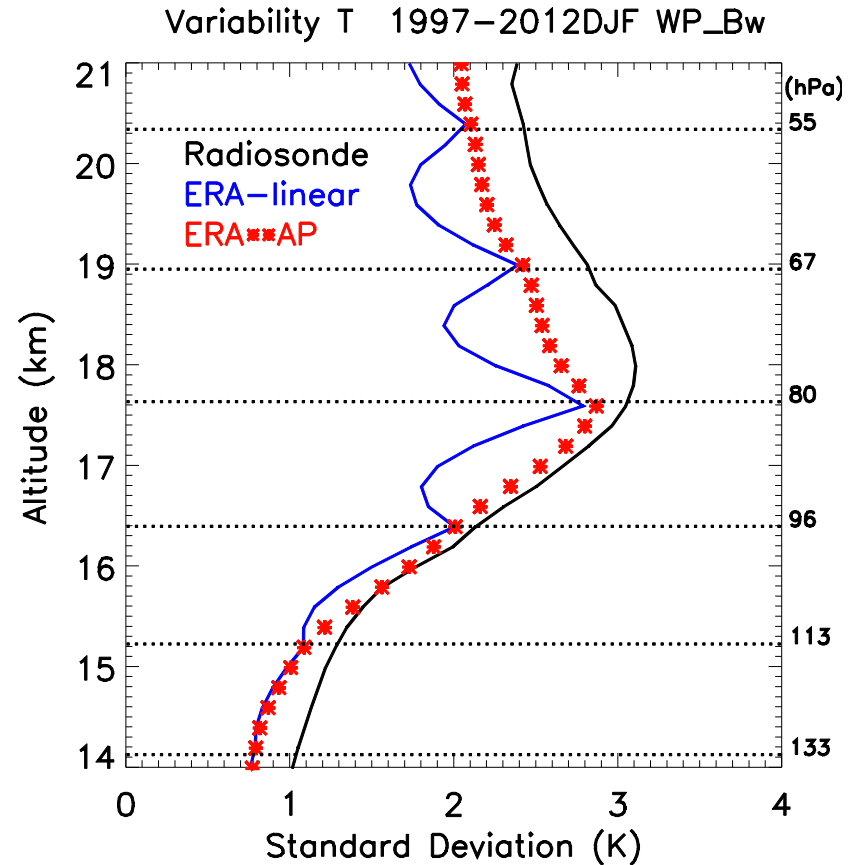
Reanalysis **(z1)**

Waves are **alive!**
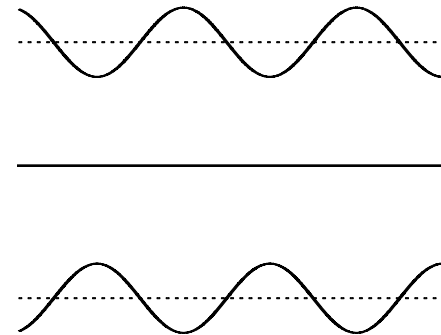
Waves are **dead!**

STEP1:
Interpolate wave amplitudes and phases

Should be like this..

Reanalysis **(z2)**

(AP) Interpolated

Reanalysis **(z1)**

Variability T   1997−2012DJF WP_Bw
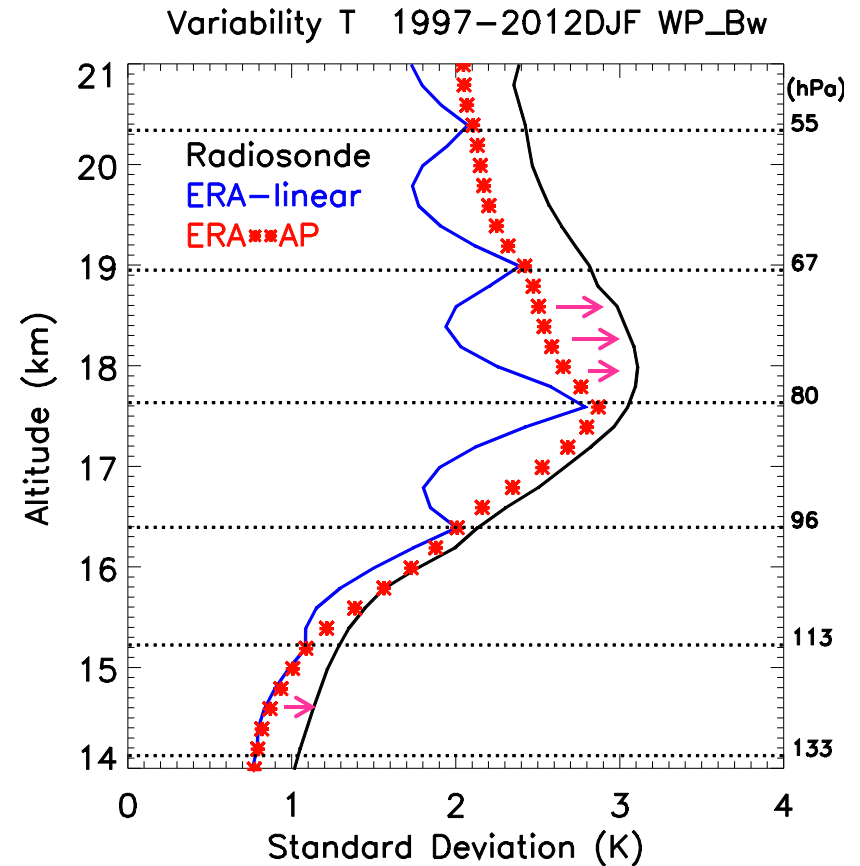
Radiosonde
ERA−linear
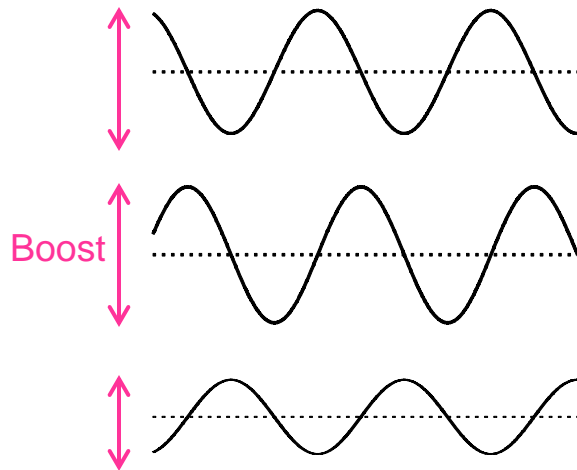ERA**AP

Altitude (km)

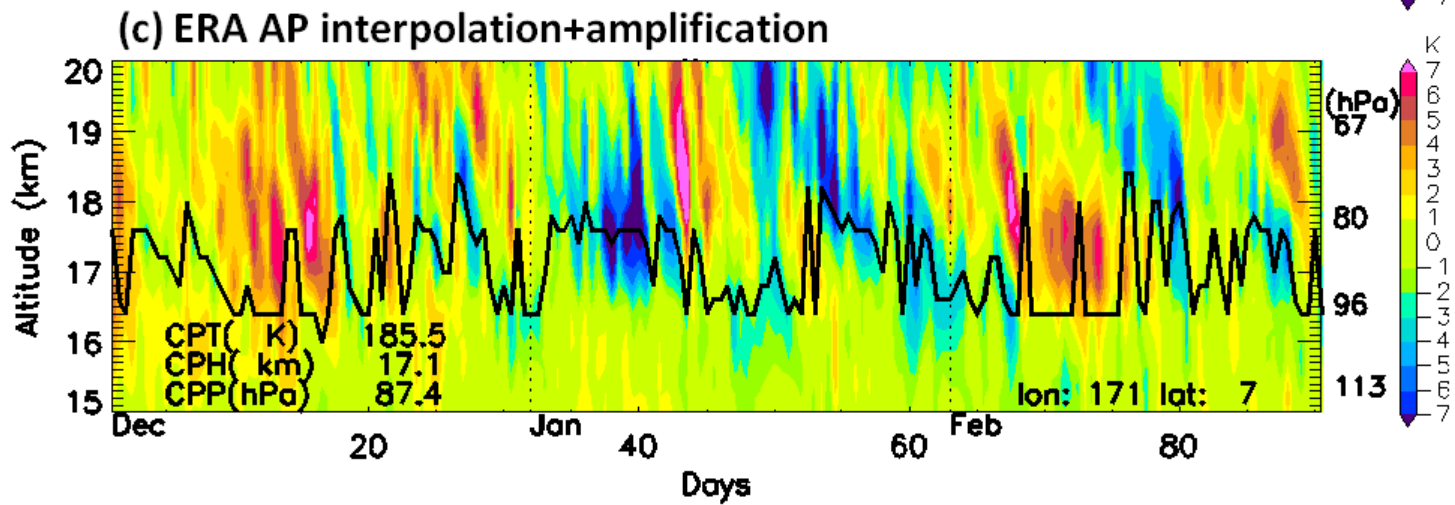Standard Deviation (K)
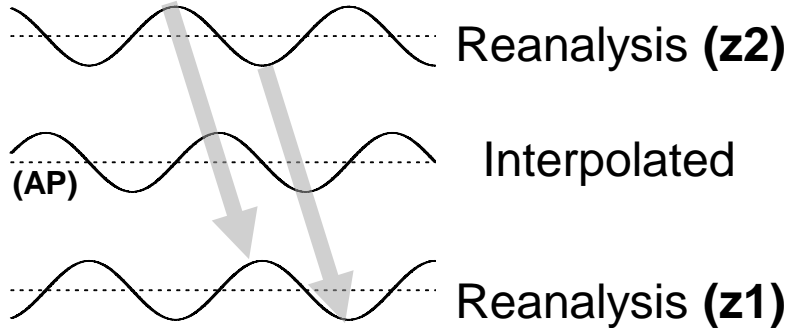
Use the fact "waves ARE in reanalysis levels"

STEP2:
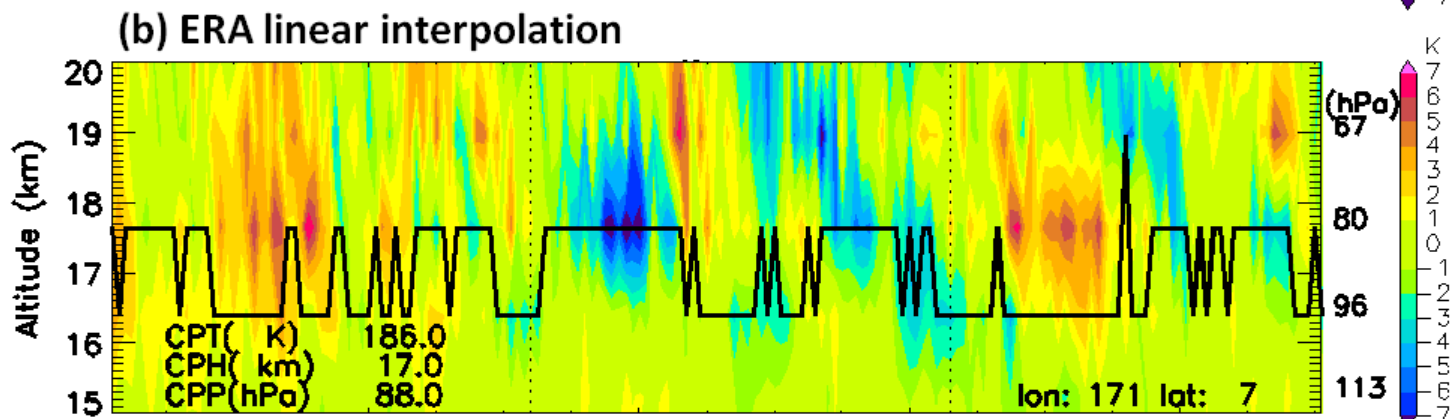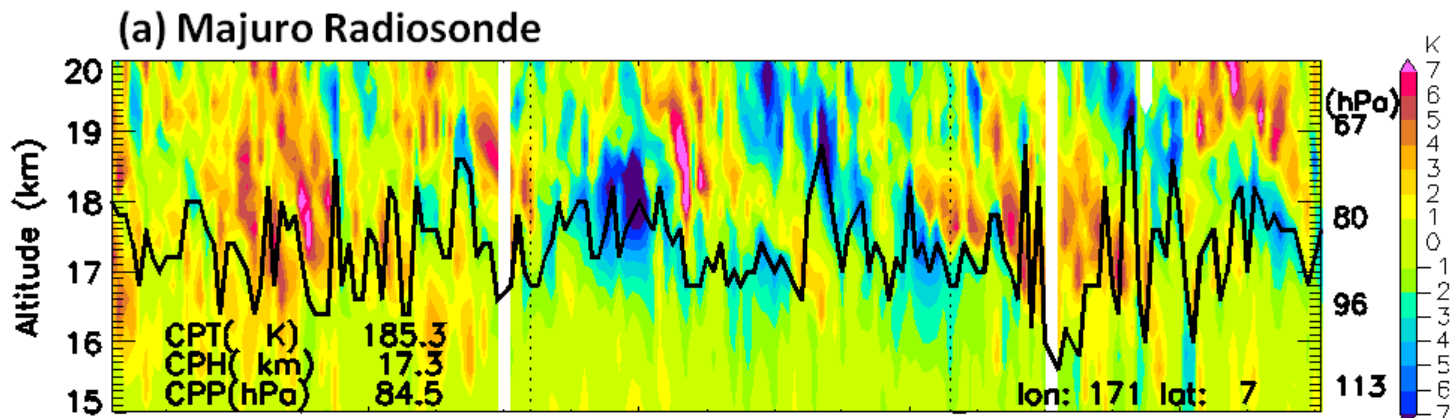# Enhance wave amplitudes to match observations

Should be like this..

Use the fact "waves are in reanalysis TO SOME DEGREE"

(a) Majuro Radiosonde

CPT(K)   185.3
CPH(km)   17.3
CPP(hPa)   84.5

lon: 171 lat: 7

(b) ERA linear interpolation

CPT(K)   186.0
CPH(km)   17.0
CPP(hPa)   88.0

lon: 171 lat: 7

(c) ERA AP interpolation+amplification

CPT(K)   185.5
CPH(km)   17.1
CPP(hPa)   87.4

lon: 171 lat: 7

Dec   20   Jan   40   60   Feb   80
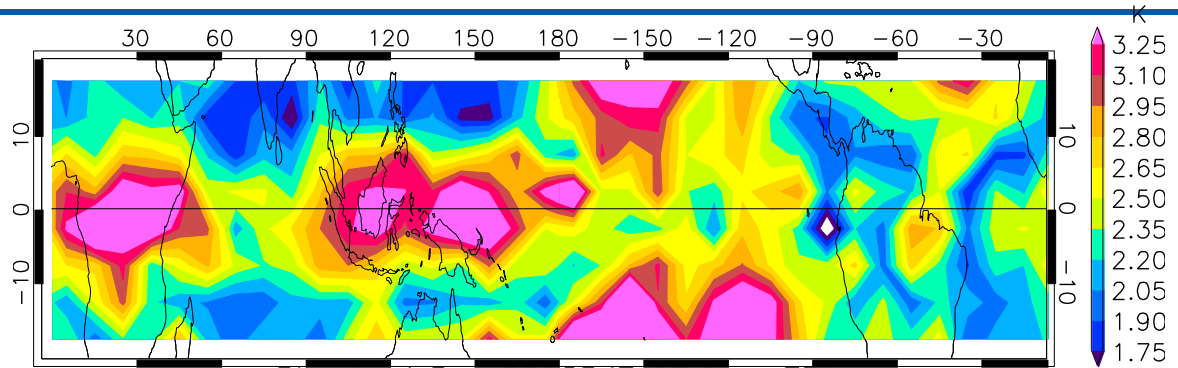
Days

Time-Height section 2012-2013 DJF

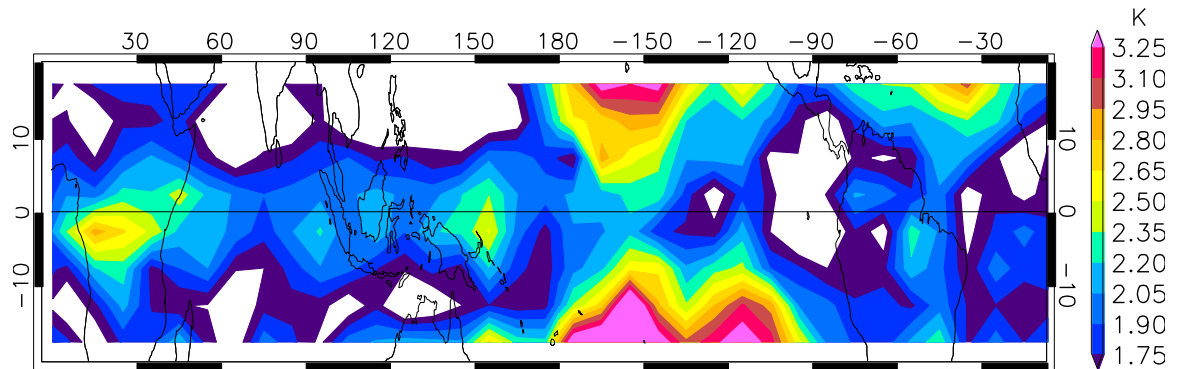**Fine scale features (1-3K stronger amplitude)**

The scheme works well for the whole tropical T variability
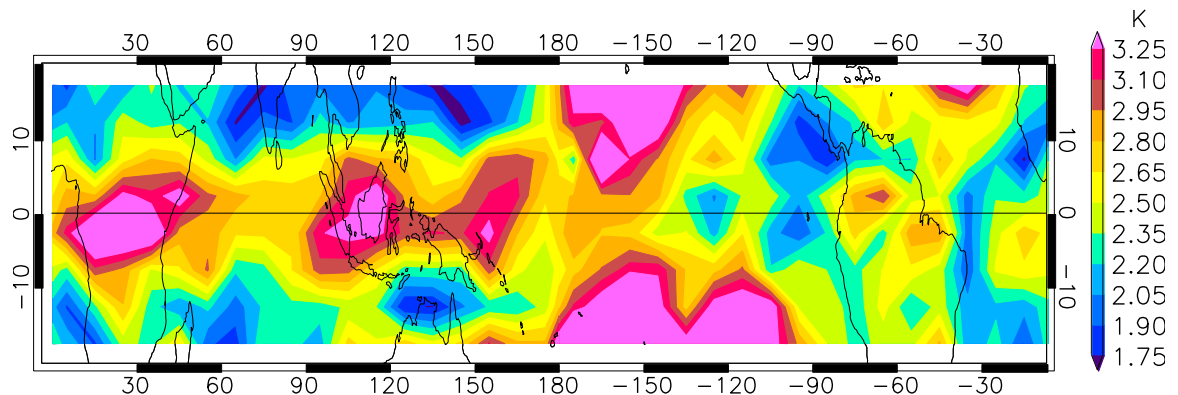
Standard Dev 2012DJF 17.0km GPS

(a) COSMIC GPS obs.

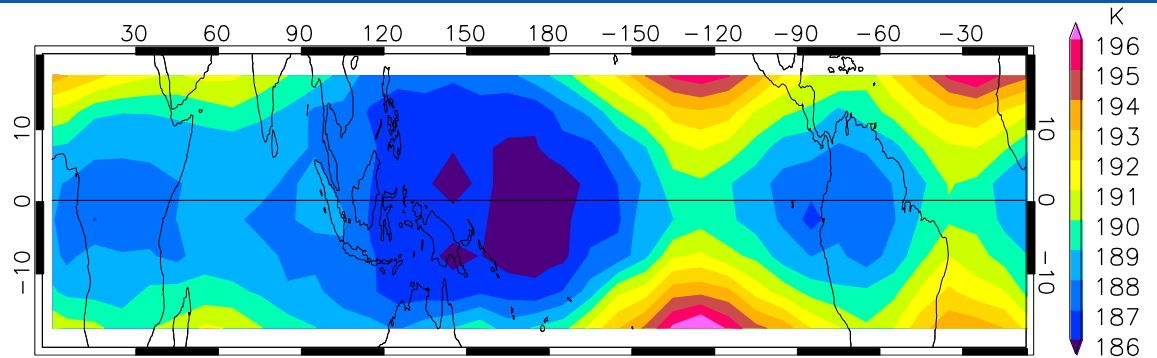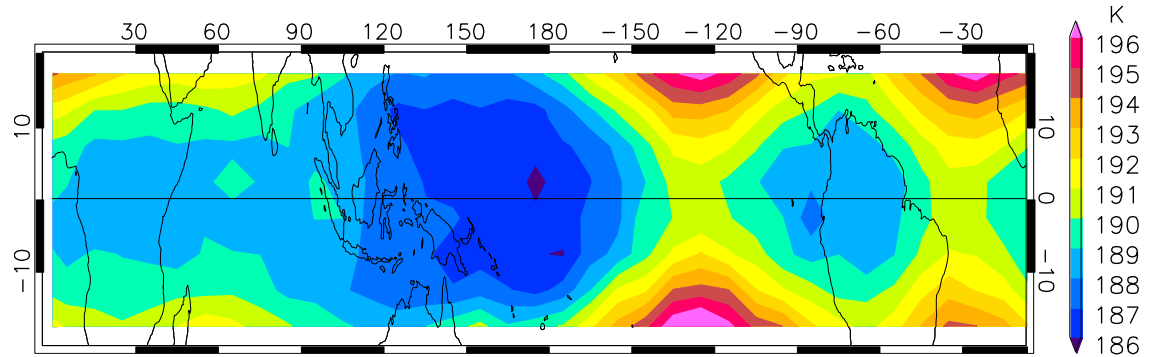**(b) ERA linear interpolated at 17km**

(c) ERA + New scheme

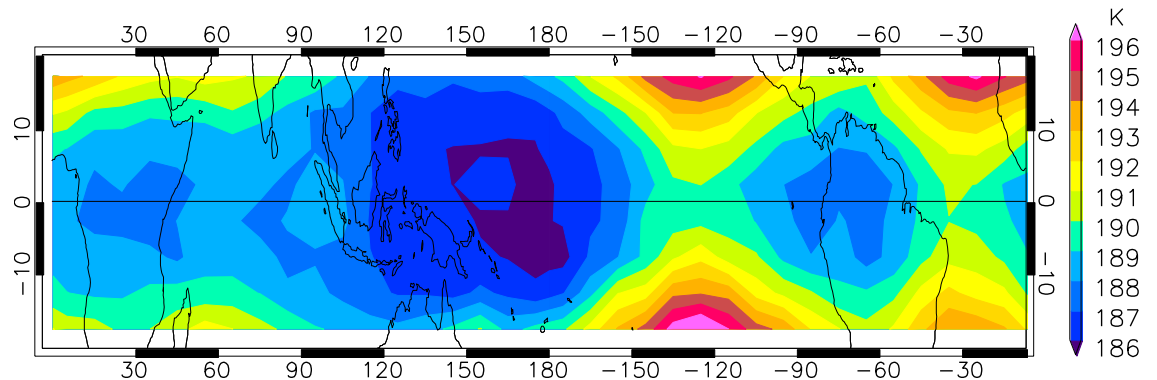# New scheme decreases cold-point T !

Mean CPT 2012DJF GPS

(a) COSMIC GPS obs.

(b) ERA

(c) ERA + New scheme

Waves lower cold-point T → Direct wave impact

Radiosonde T Jan 2013 at Majuro
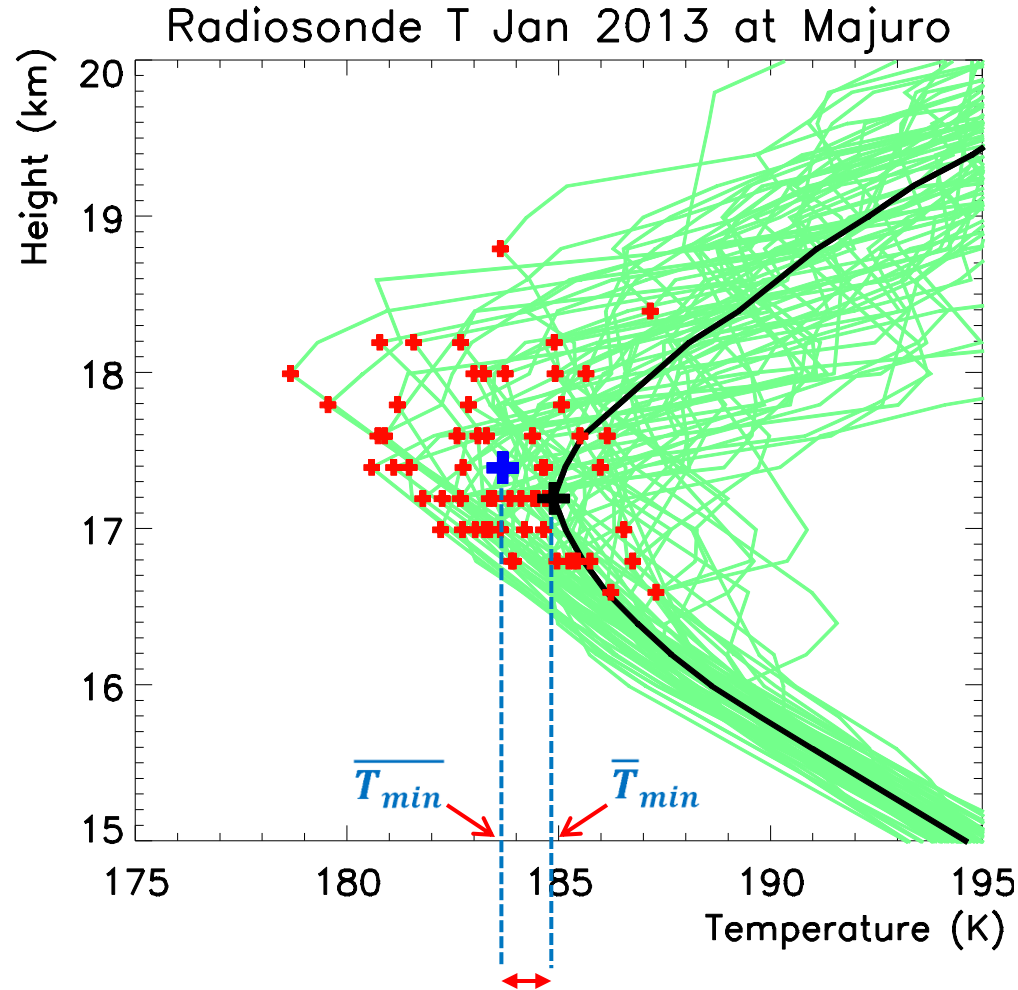
CPT drop by waves (direct impacts): $\Delta T = \overline{\overline{T_{min}}} - \overline{T_{min}}$

Waves lower cold-point T by 1.6K

$$\Delta T = \overline{\overline{T_{min}}} - \overline{T_{min}}$$
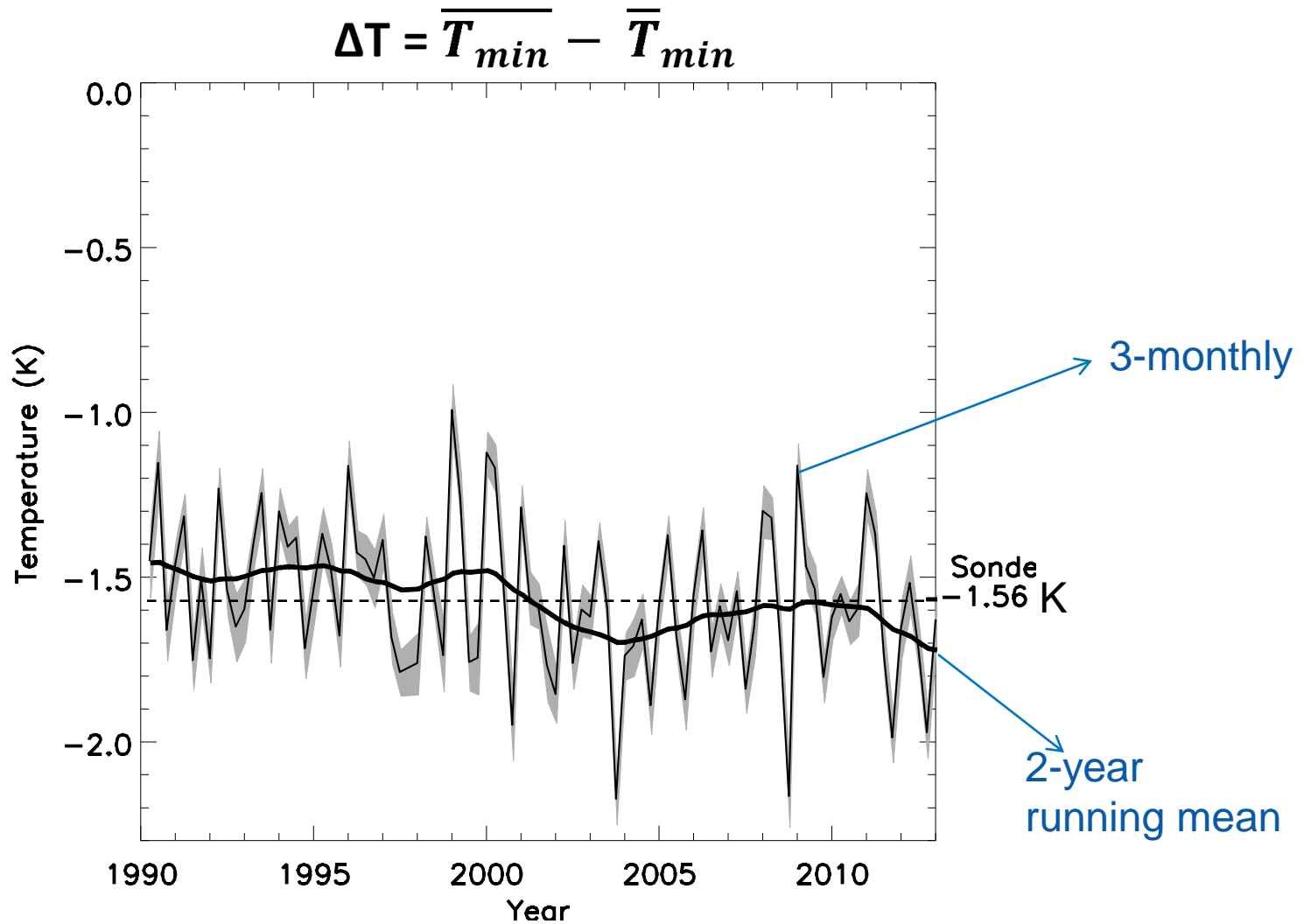
Parameterized waves improve cold-point T representation

$$\Delta T = \overline{\overline{T_{min}}} - \overline{T_{min}}$$
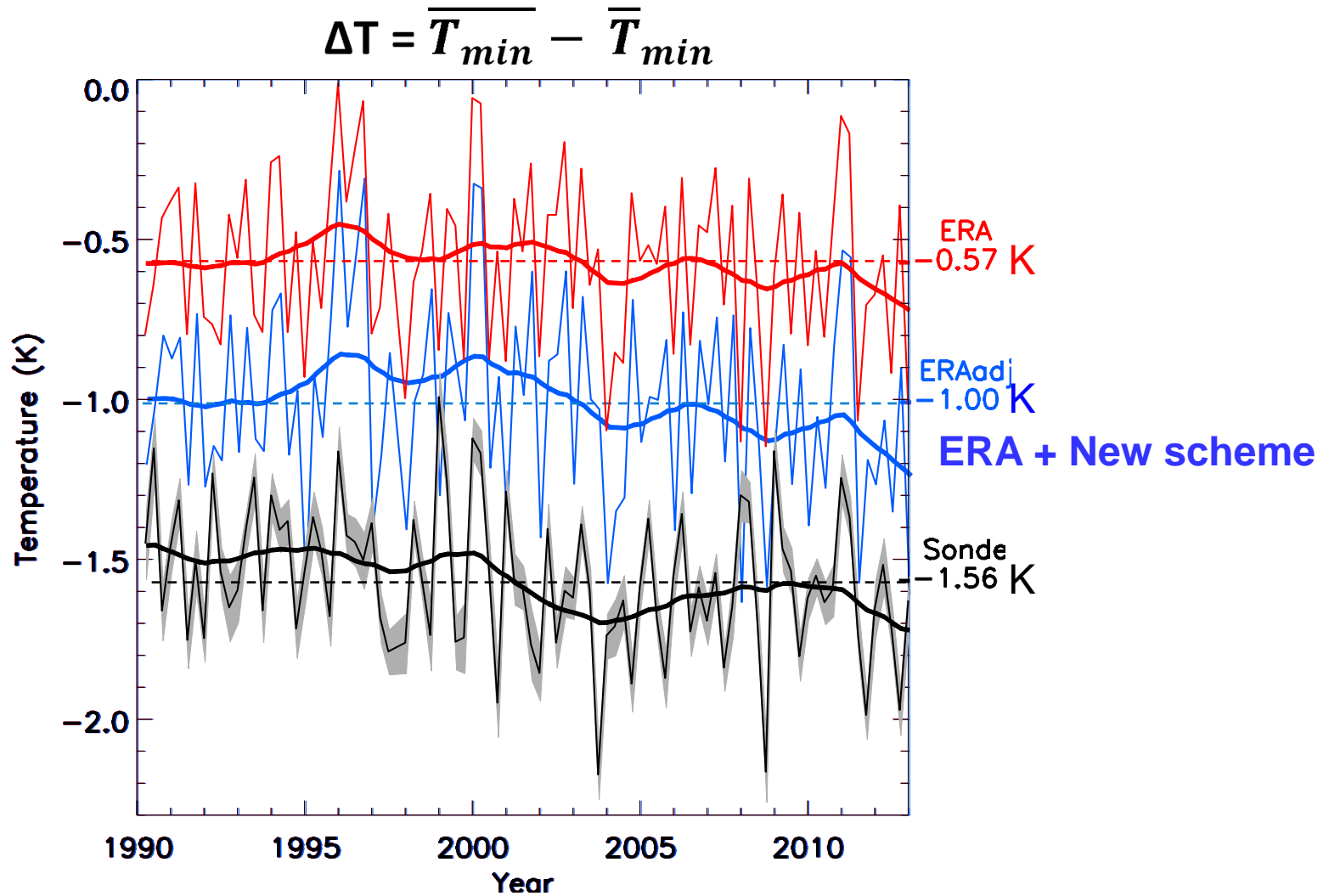
Summary

• We found problems in temperature variability in reanalysis data.

      - Waves are under-represented at model levels.

      - Linear interpolation substantially degrades variability.

• How to improve variability?

      - Step 1: Interpolation of amplitude and phase in Fourier space

      - Step 2: Amplification of wave amplitude

➔ We can make 1) realistic waves

            2) improved representation of tropopause temperature

➔ Having realistic variability will reduce uncertainties in trajectory simulations. (could be also used for winds)