Biases in AIRS data

and a correction strategy

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Overview

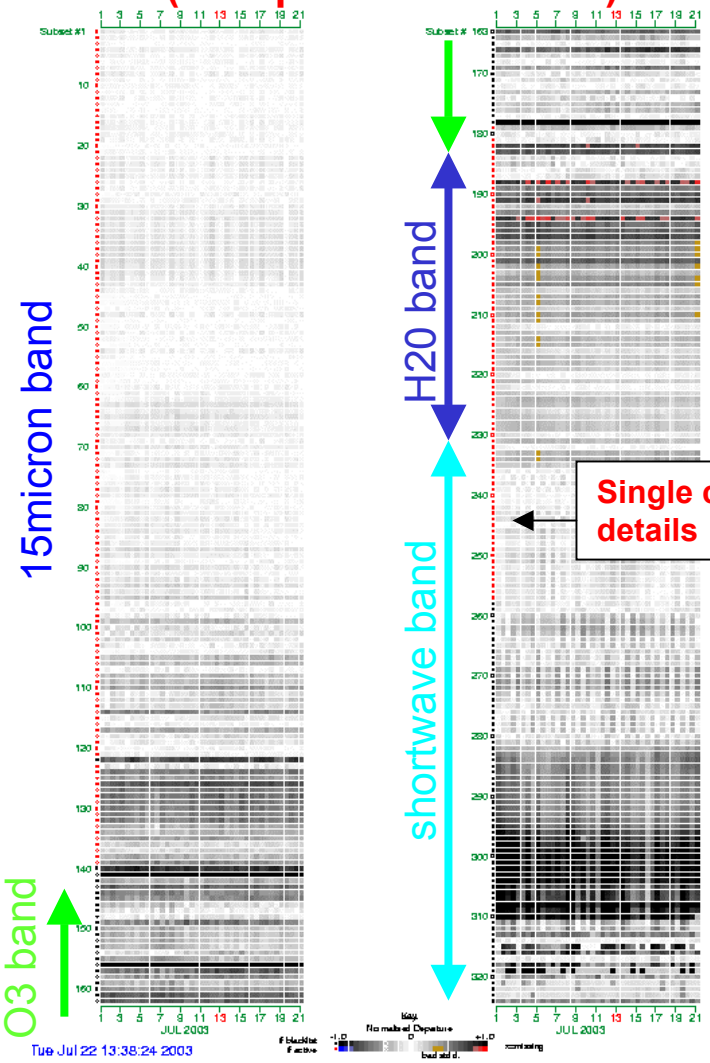
- Bias monitoring
- Temporal / geographical stability
- Airmass Index - a useful tool
- Attribution
- Correction: [δ,γ]
  - demonstration with AMSU-A / AIRS
  - Estimation procedure
  - Assimilation results
  - Limitations
- Summary and conclusions

Monitoring

- Unless otherwise stated:
- All results are for Observation minus First guess
- First guess = RaditativeTransferModel(forecast background)
- RTM:
  - RTTOV-6m
  - Spectral Response Functions from 18-Aug 2001
  - Fixed CO_2
- Global (except where indicated as Tropical (30°S-30°N)
- Cloud-free
- Unselected (No masking to sonde locations)
- 324 Near Real Time channel set

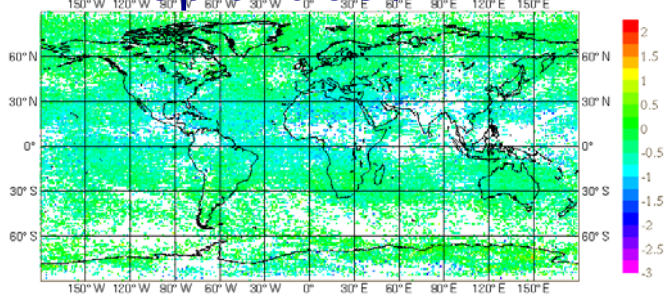
AIRS bias monitoring

All channels time series (for operational alerts)

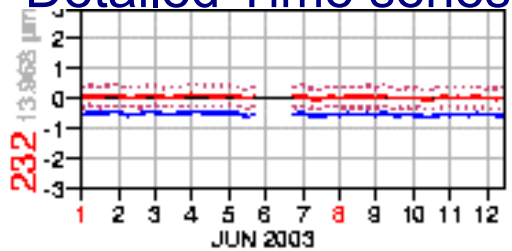


Single channel details

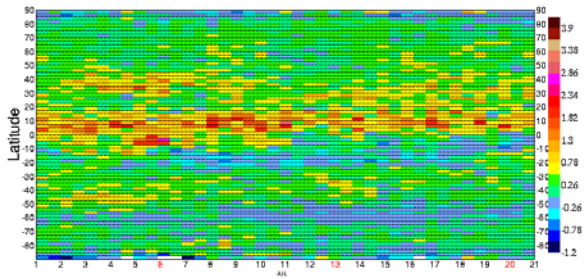
Map of bias /



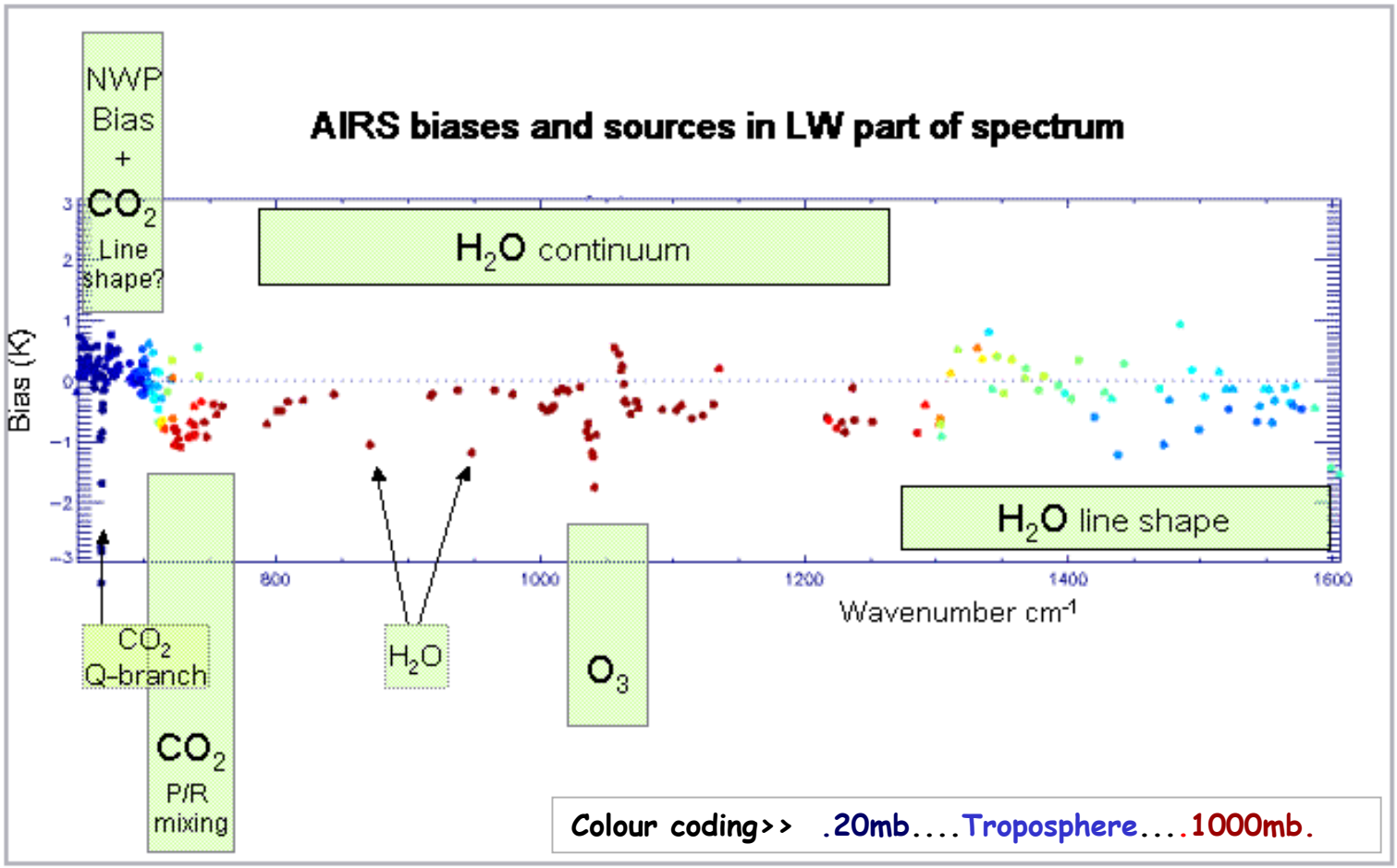
Detailed Time series



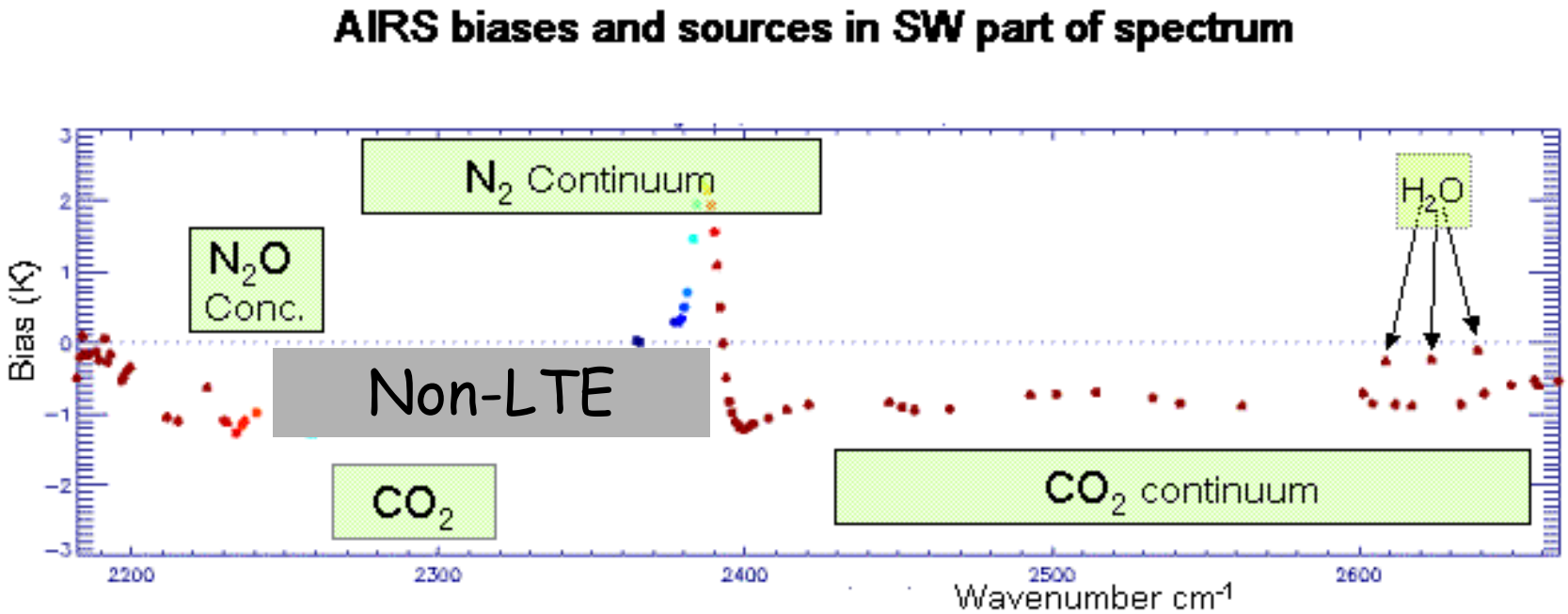
Hovmoller time



Bias Overview 650-1600 cm^{-1}

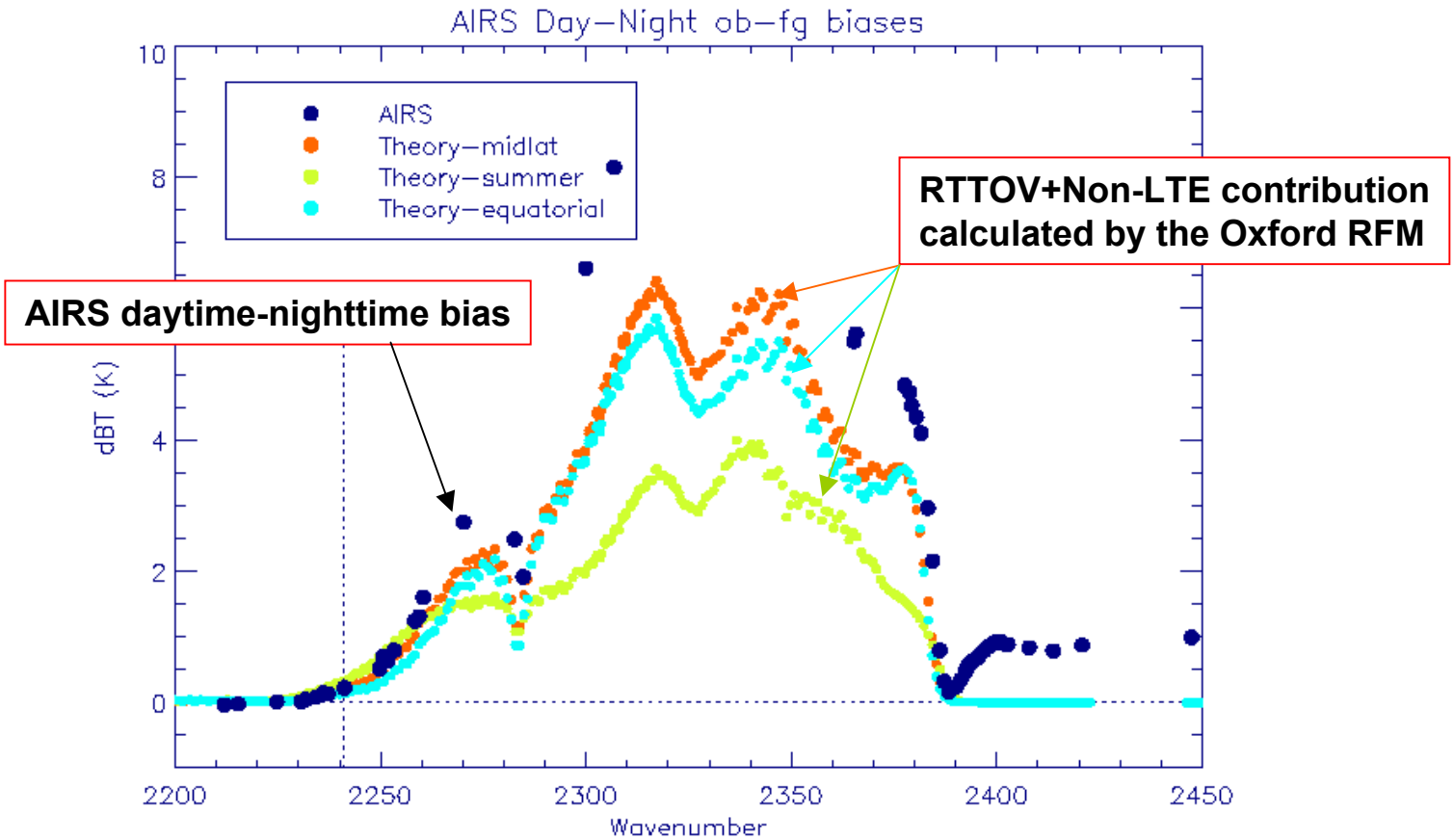


Bias Overview 2180-2670 cm^{-1}



Colour coding>> .20mb....Troposphere....1000mb.

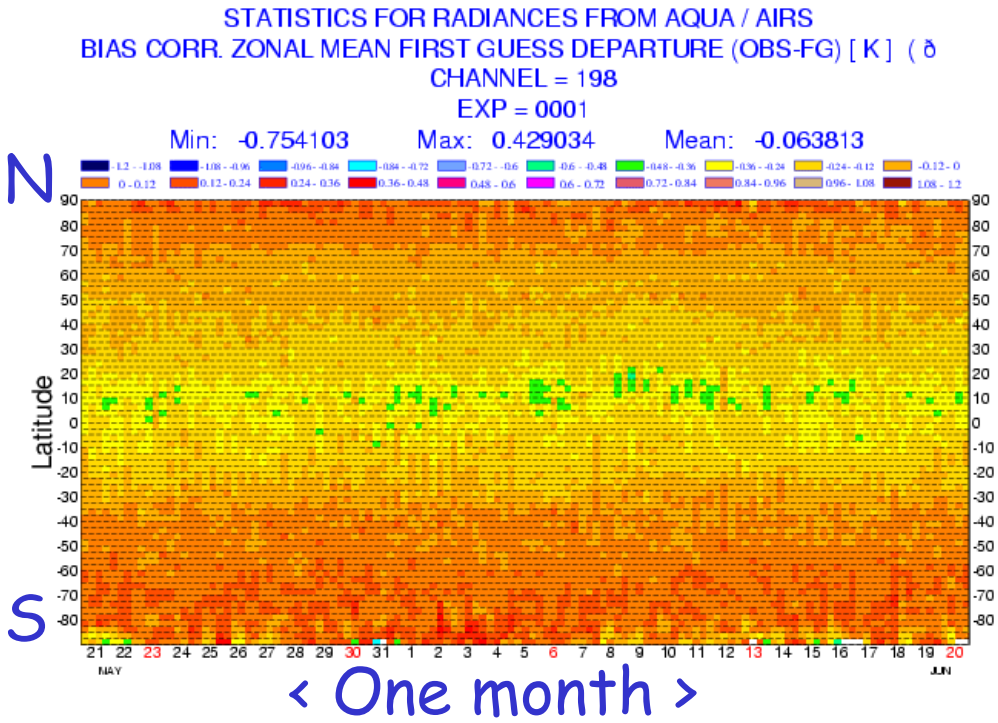
Non-LTE 2240-2390 cm^{-1}



Thanks: Niels Bormann, Anu Dudhia

Stability

- Except for known NWP model temporal biases (e.g. stratopause errors) biases are temporarily stable

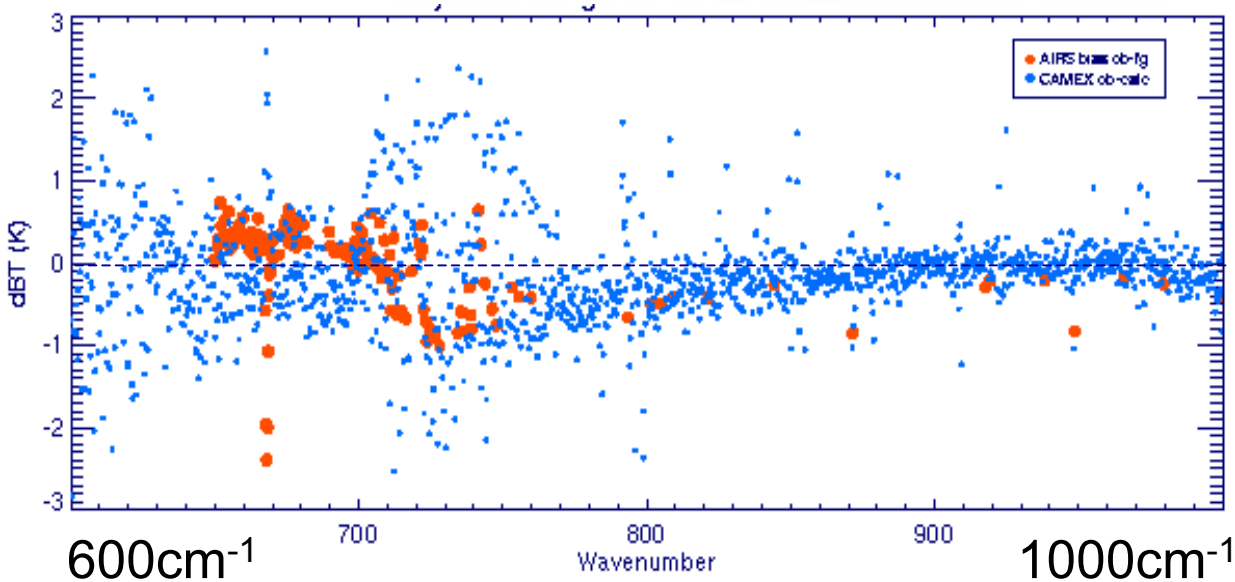


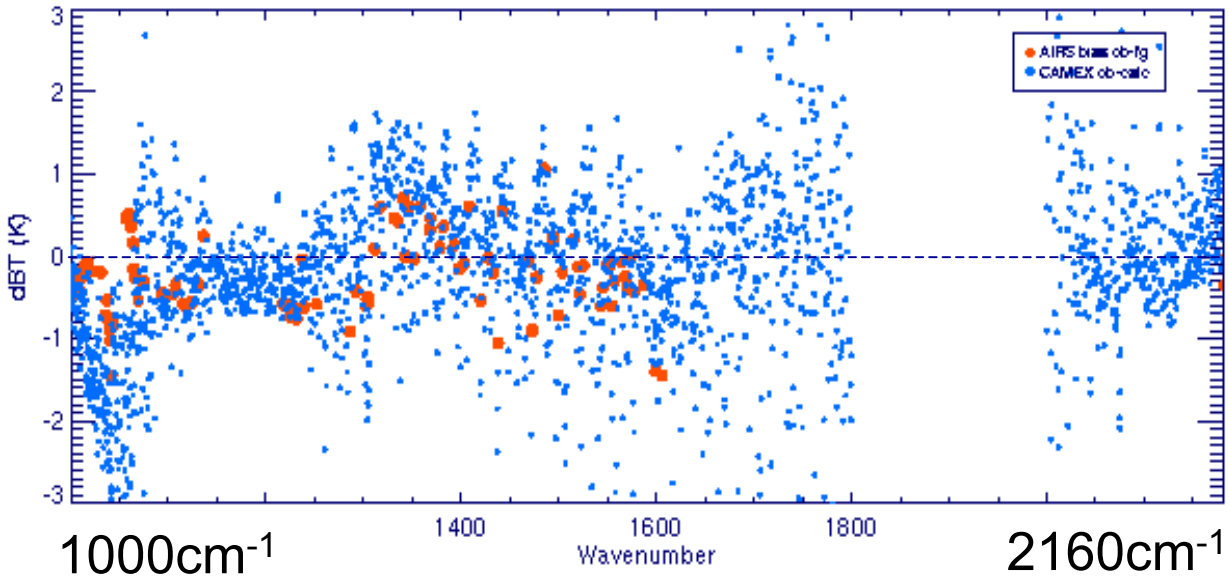
14.16 μm

‹ One month ›

- Masking to sonde locations has no noticeable effect on global bias
  - NWP error small or 'constant'

CAMEX

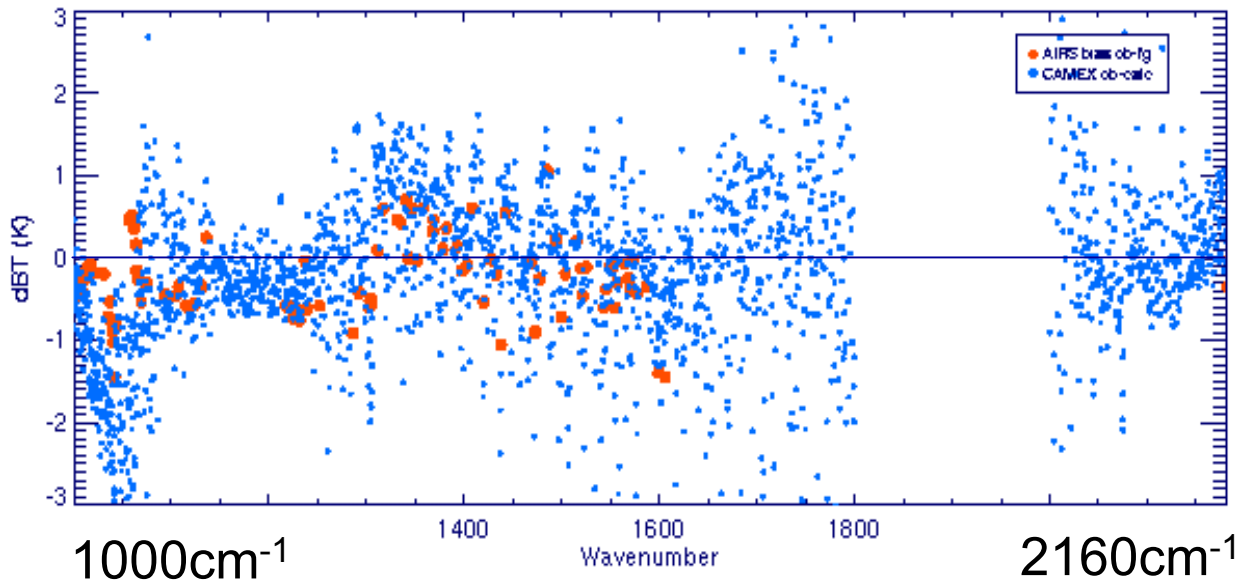


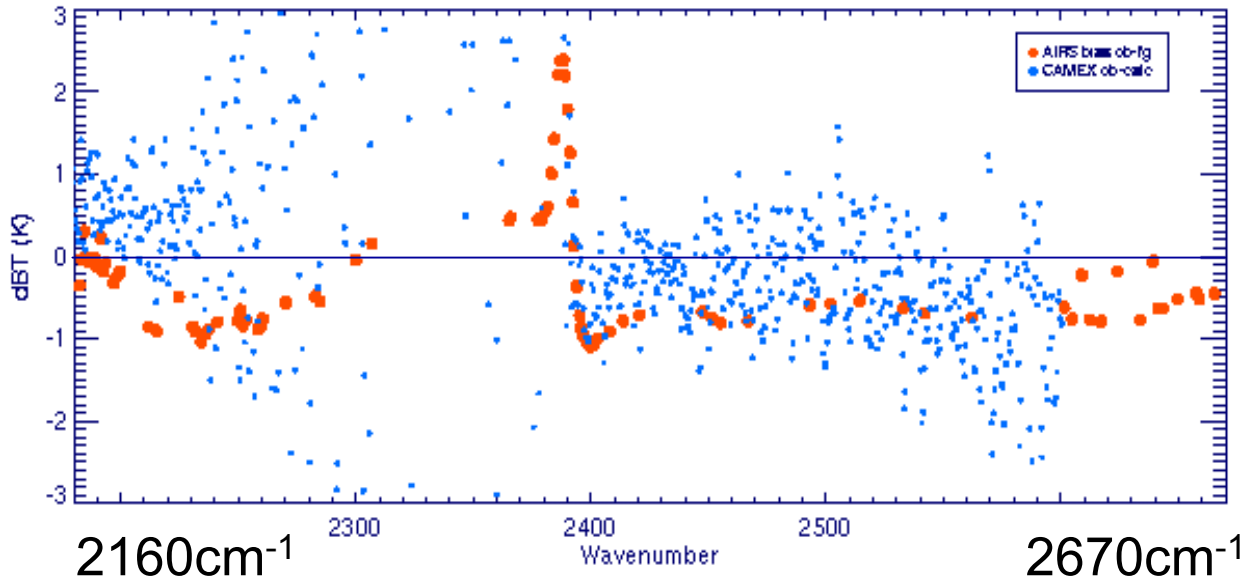


AIRS minus Genlin2(NWP)

HIS (20 Km) minus Genlin2(*in situ*)

CAMEX



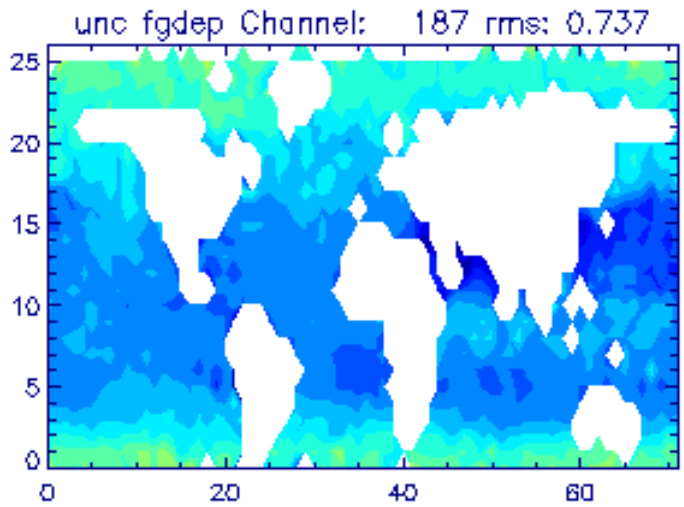


AIRS minus Genlin2(NWP)

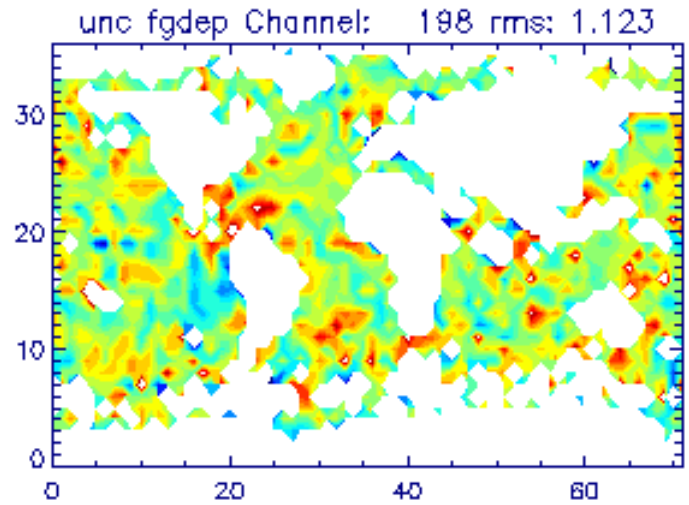
HIS minus Genlin2(*in situ*)

Geographical stability

- Airmass dependency
  - Ch. 1403 (λ = 7.67/1303.8)
  - N2O
  - Significant airmass dep.

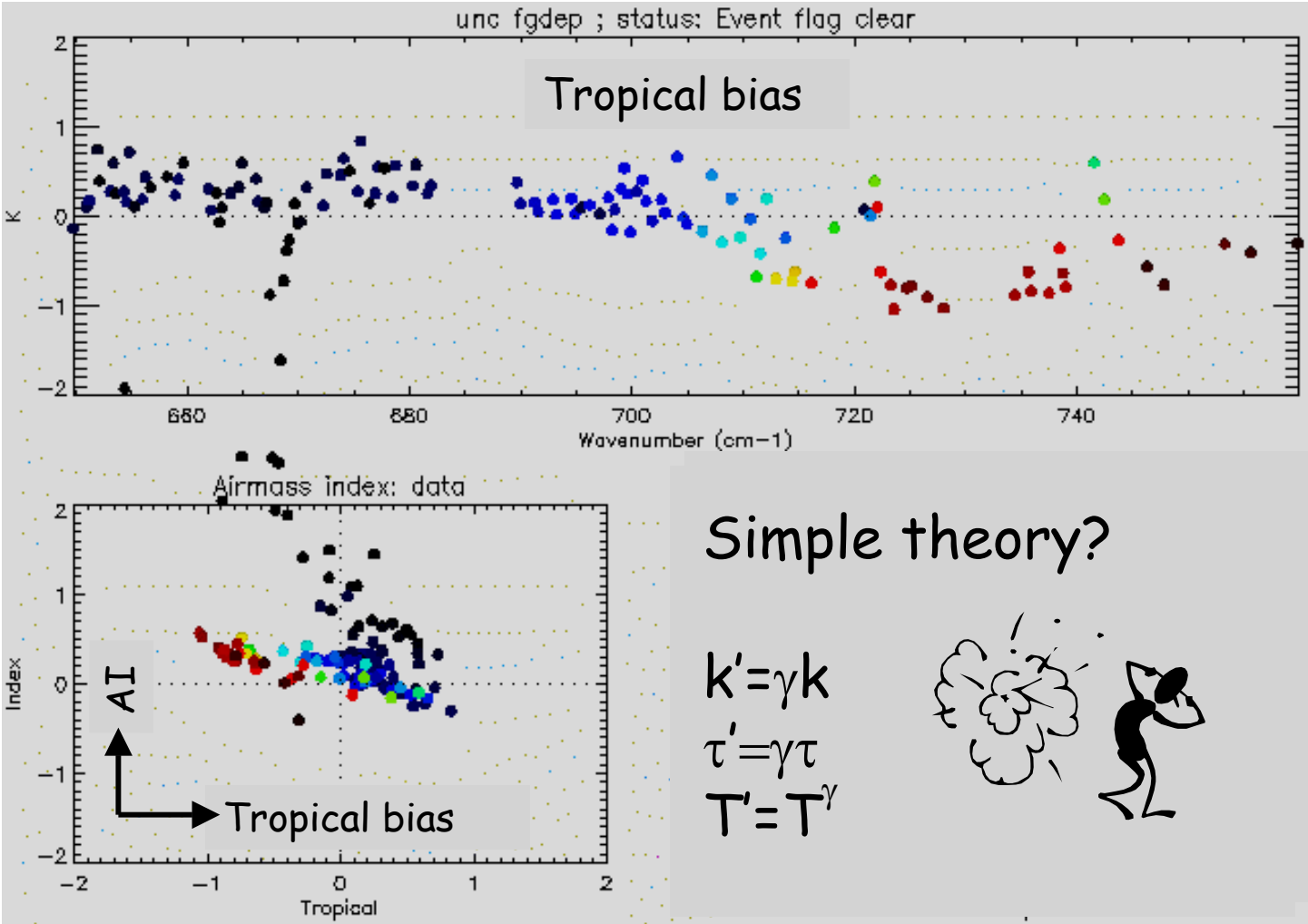


  - Ch. 1519 (λ = 7.31/1367.3)
  - H2O
  - No significant or hidden airmass dep.



Airmass (dependency) Index (AI)

- Transmission error > lapse rate > BT error
  - Tropical lapse rates generally > high latitude lapse rates
- AI = b(30°- 90°) minus b(30°-30°)

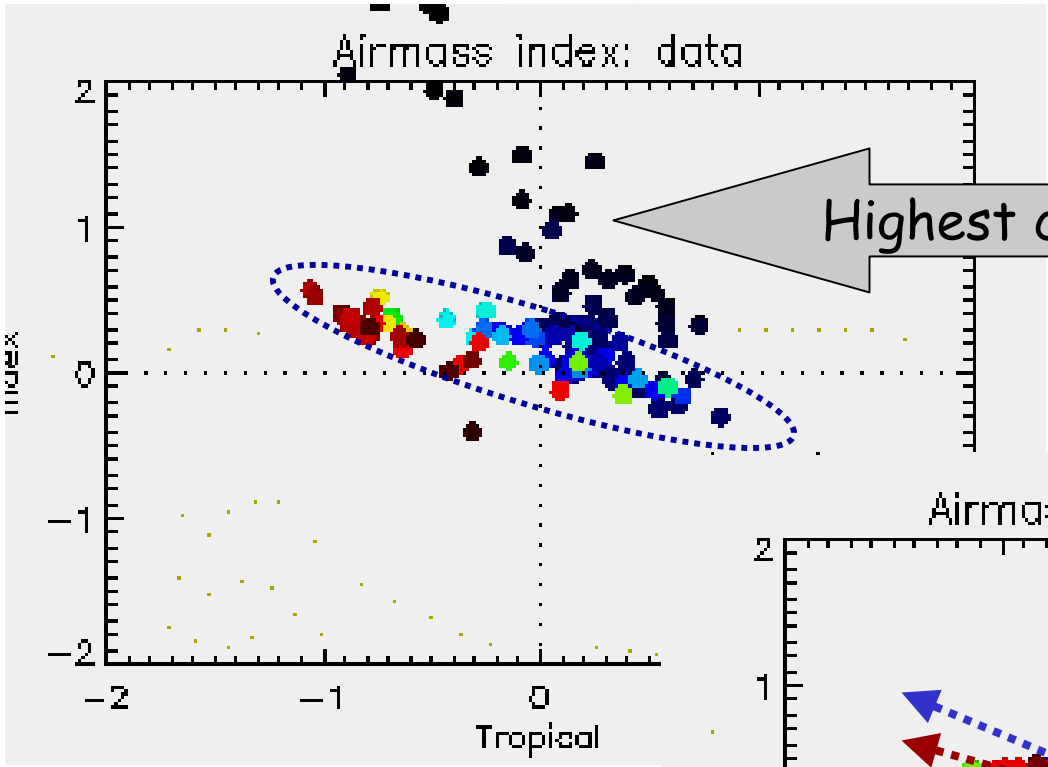


20mb

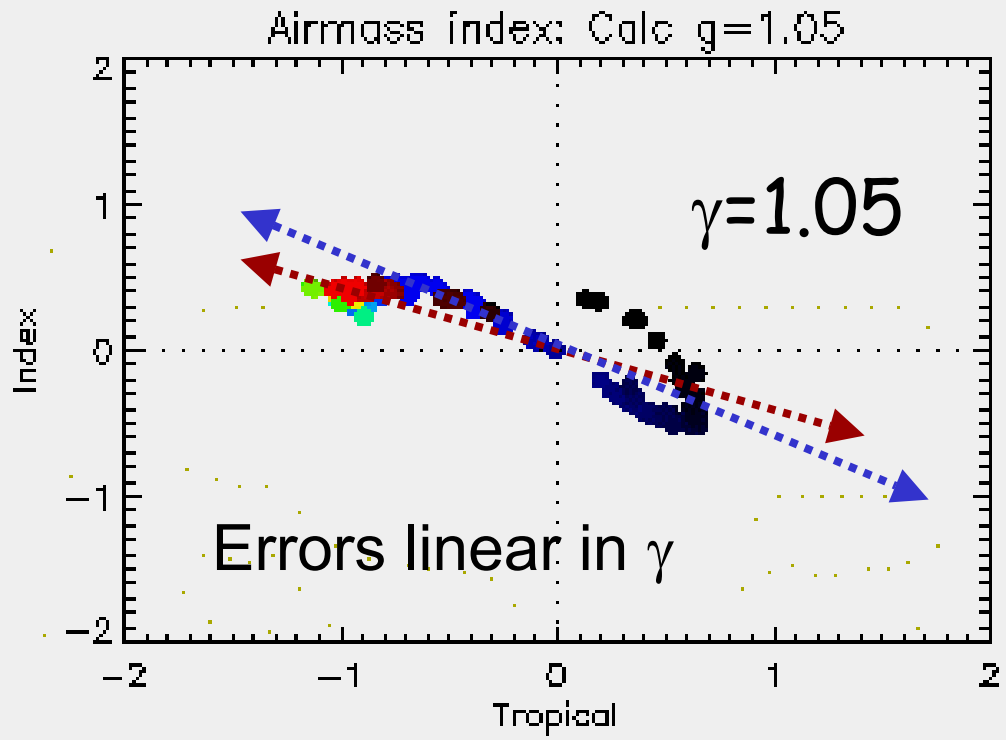
Tropo-sphere

1000mb

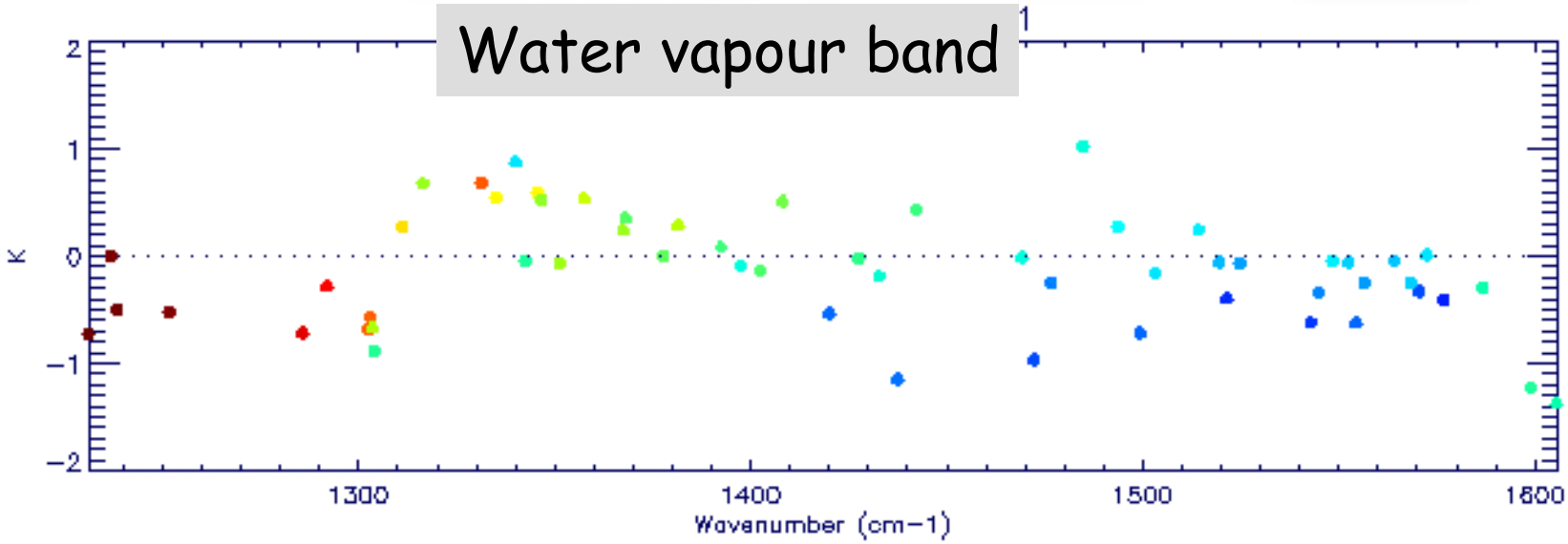
Airmass Index (AI)

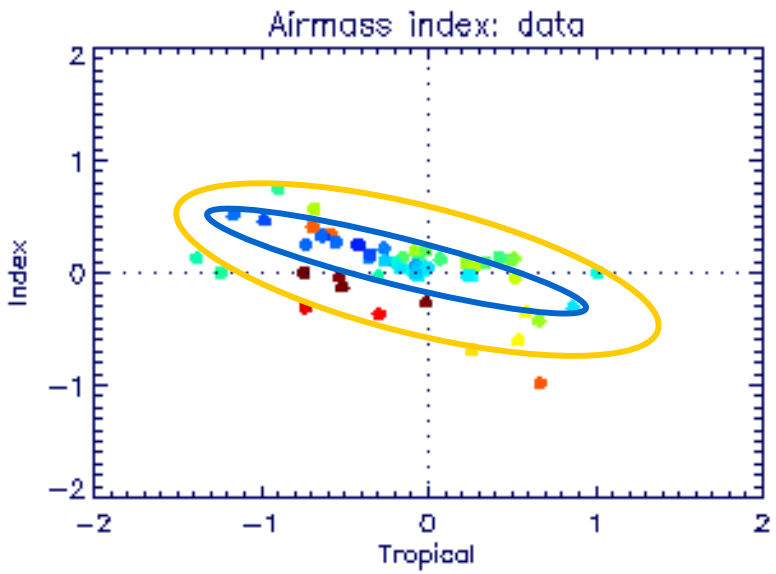


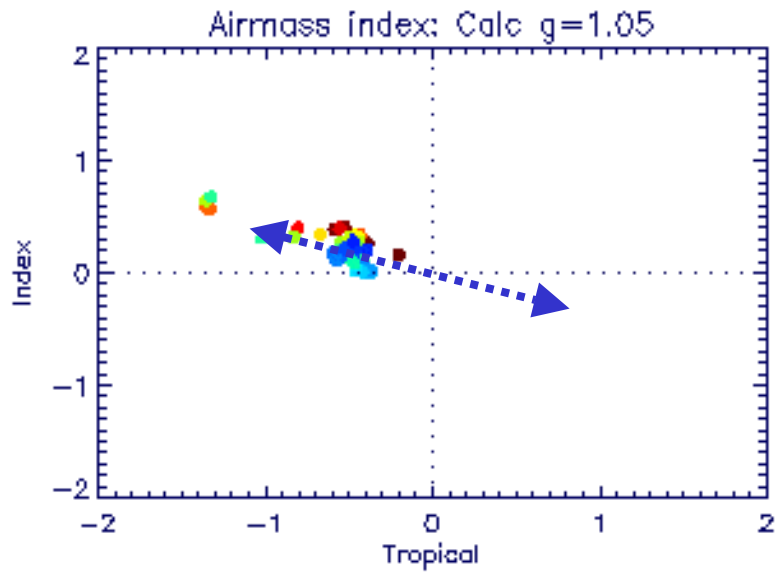
Highest channels: NWP error



Airmass Index (AI)

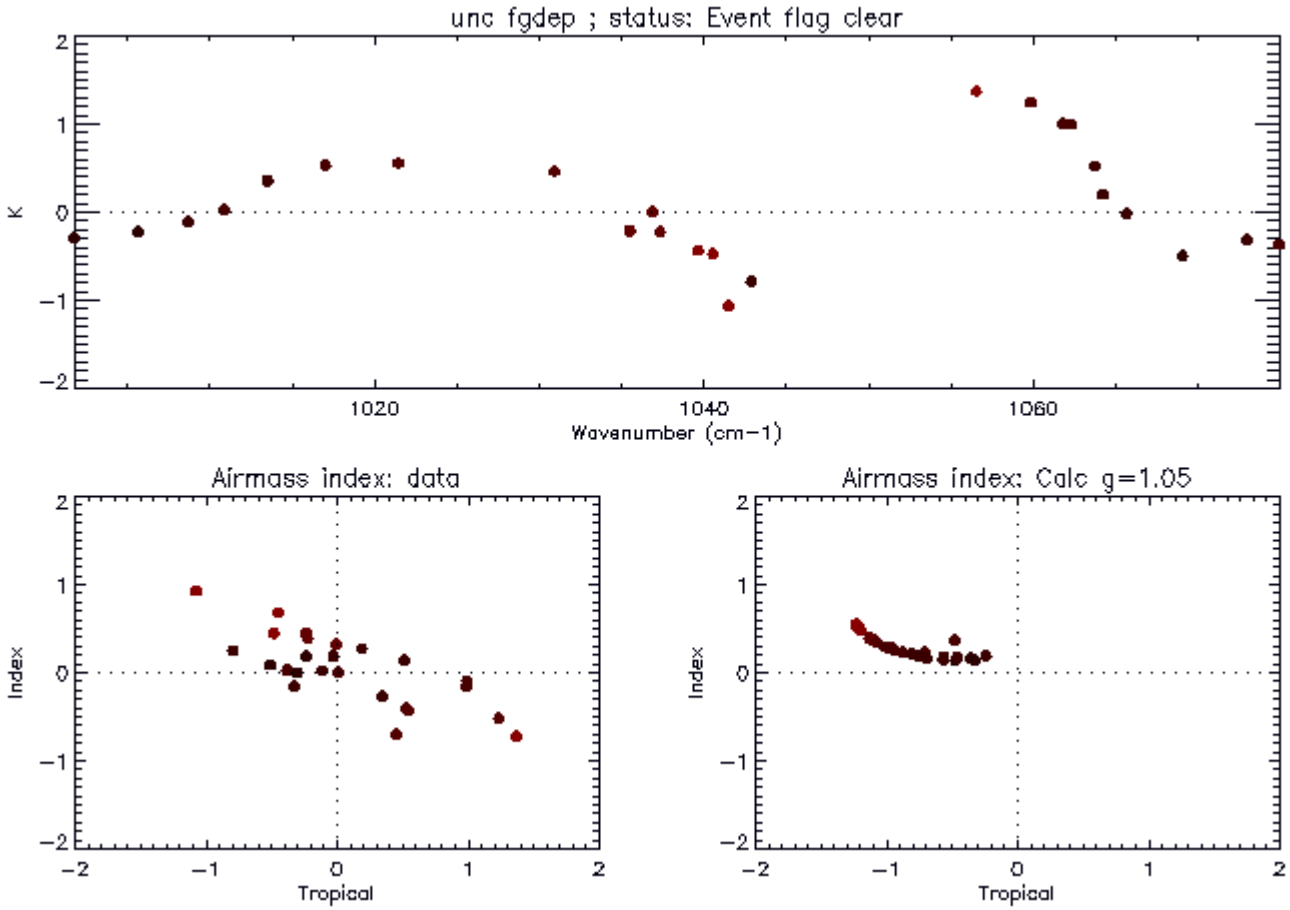






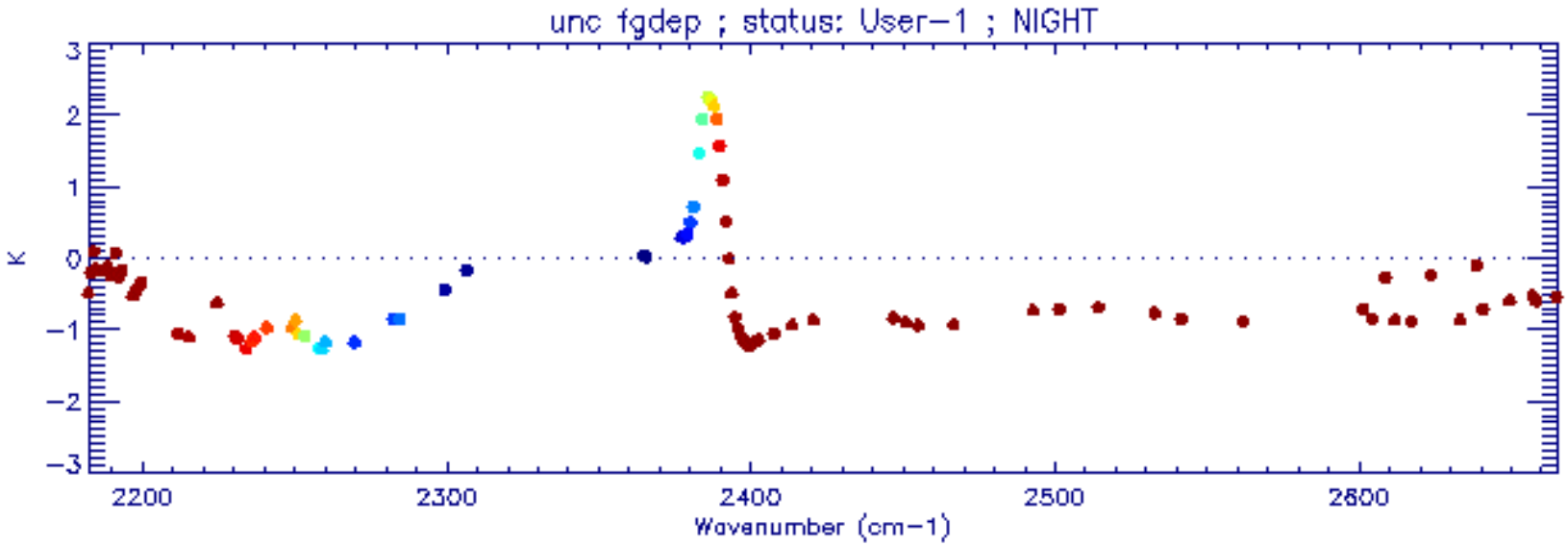
Airmass Index (AI)

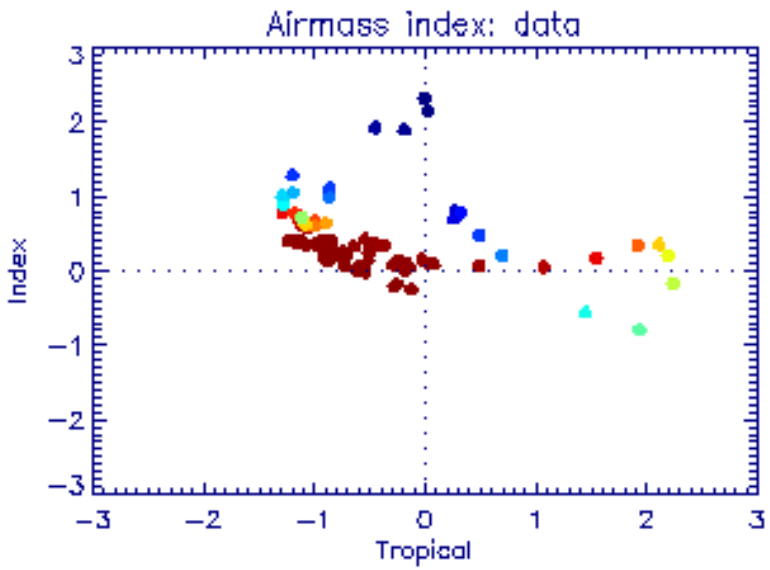
Ozone band

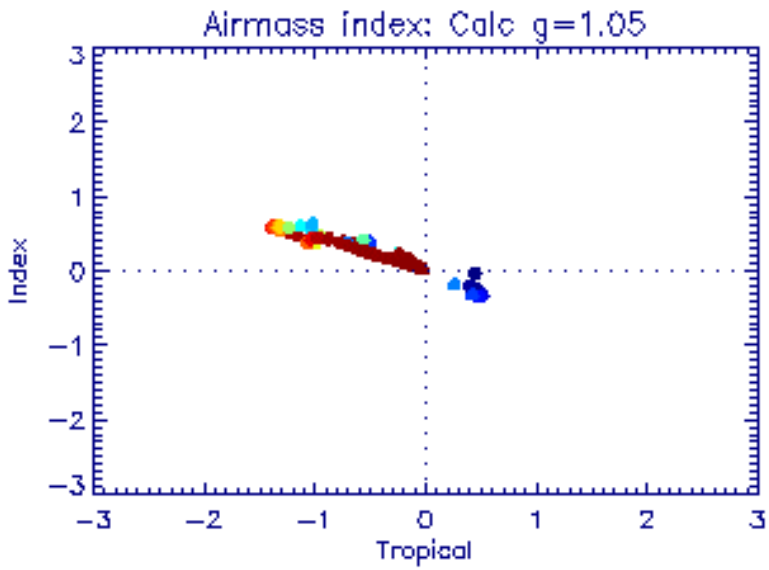


Airmass Index (AI)

Shortwave

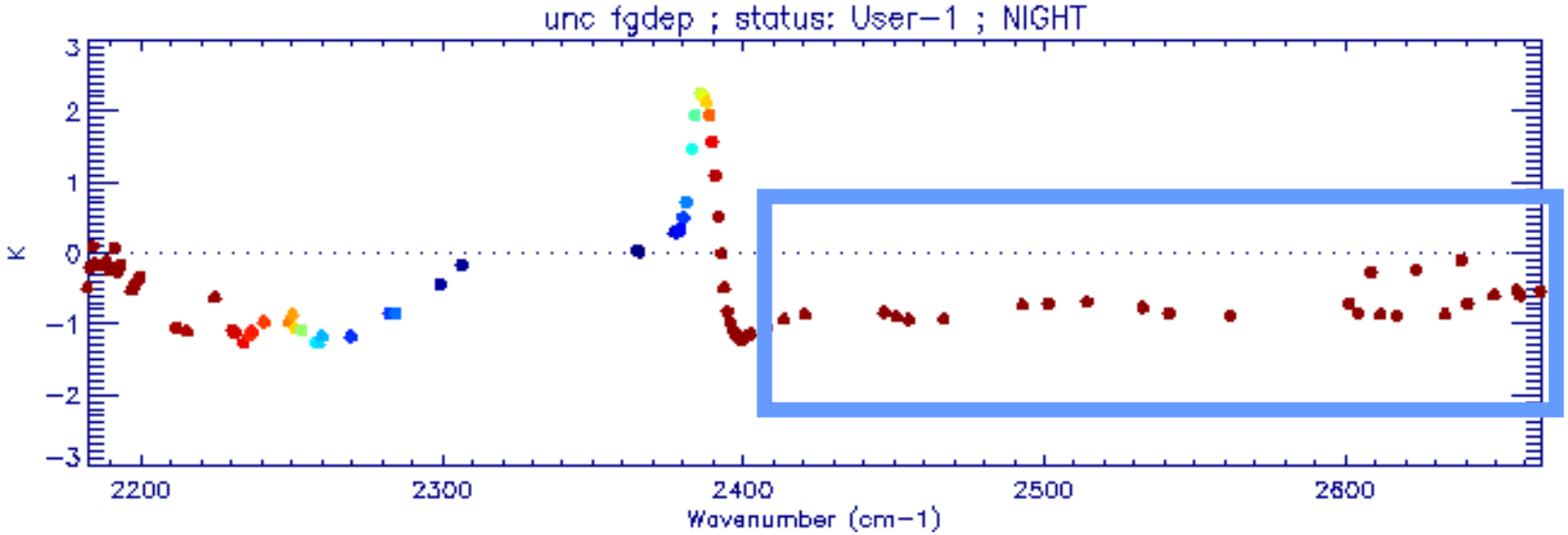


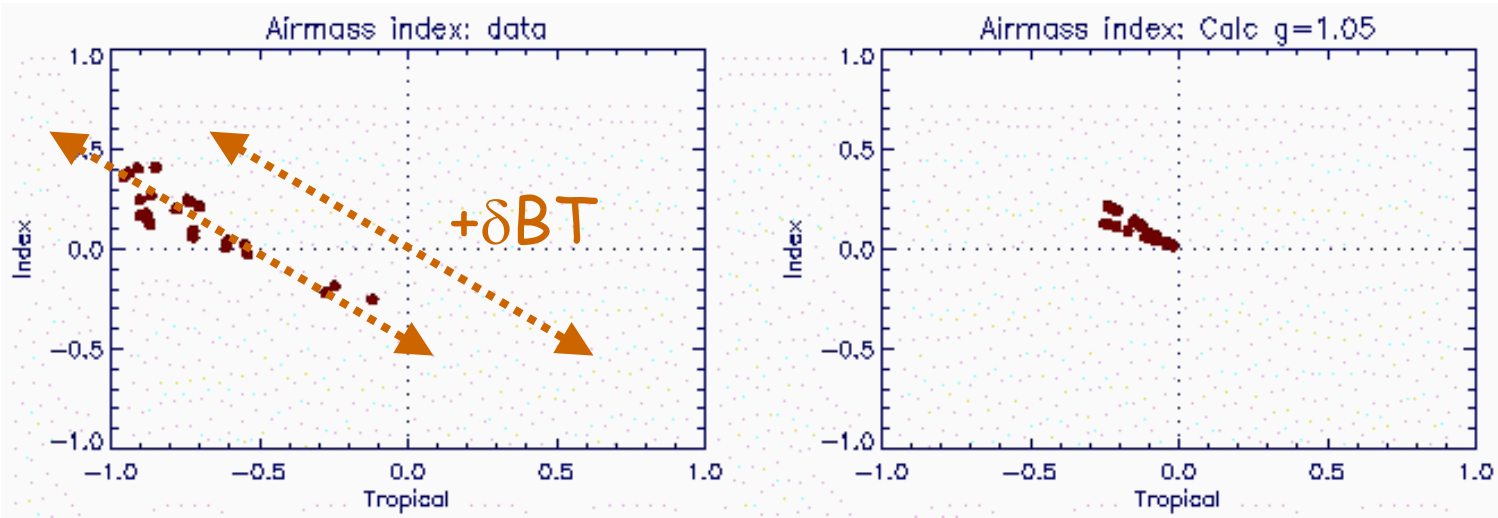




Airmass Index (AI)

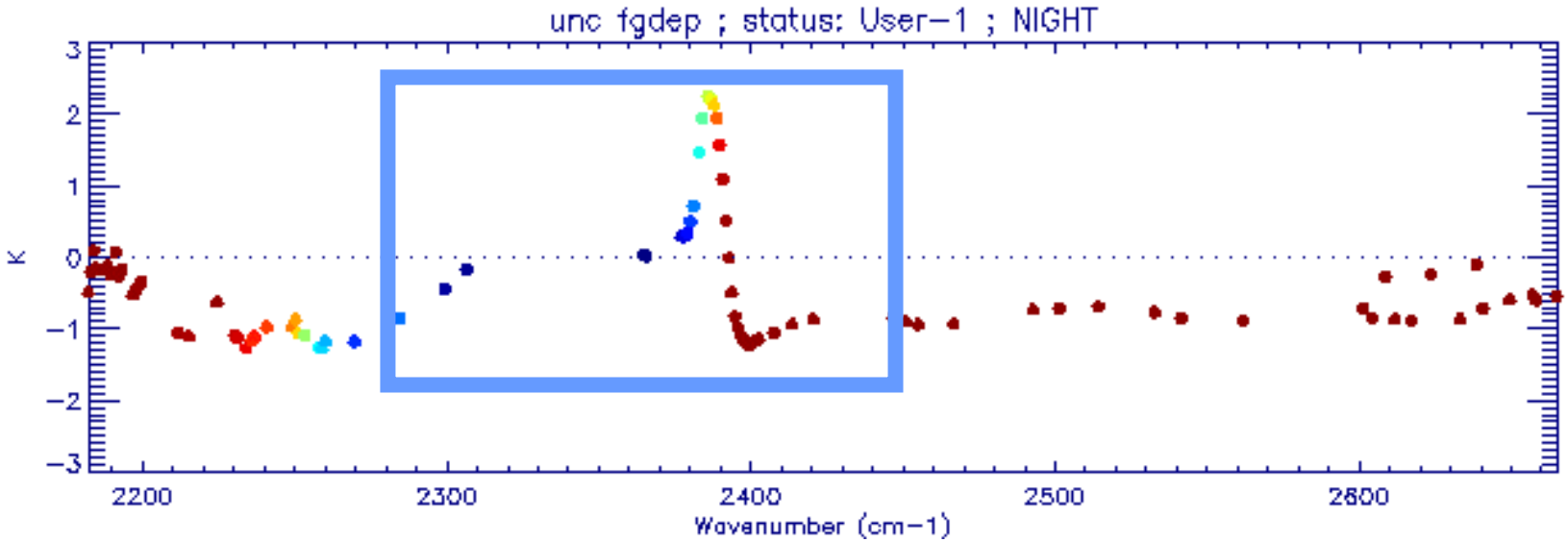
Shortwave: Window, 2420-2670 cm^{-1}

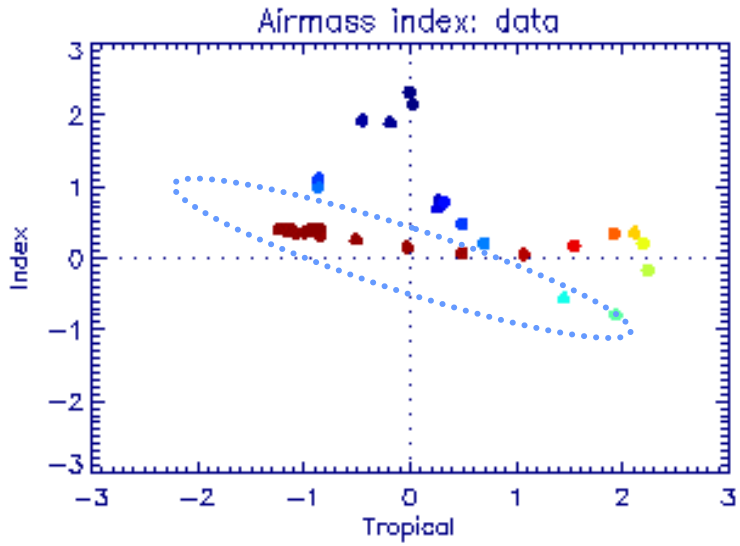


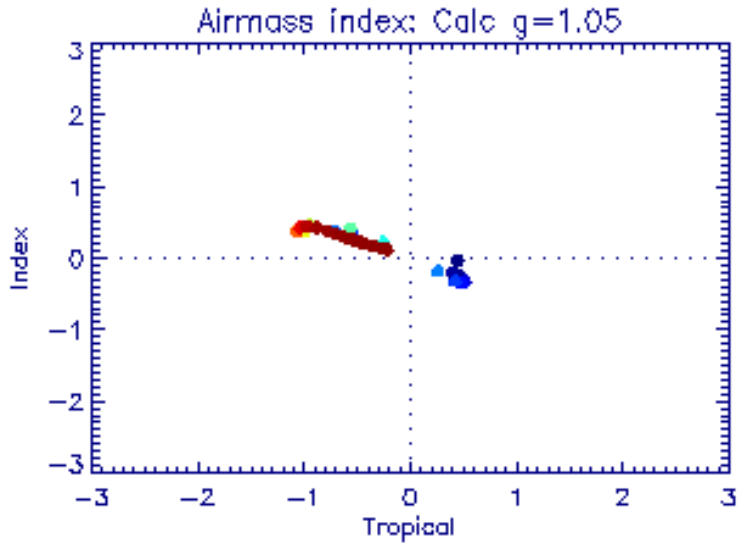


Airmass Index (AI)

Shortwave: significant N_2 absorption

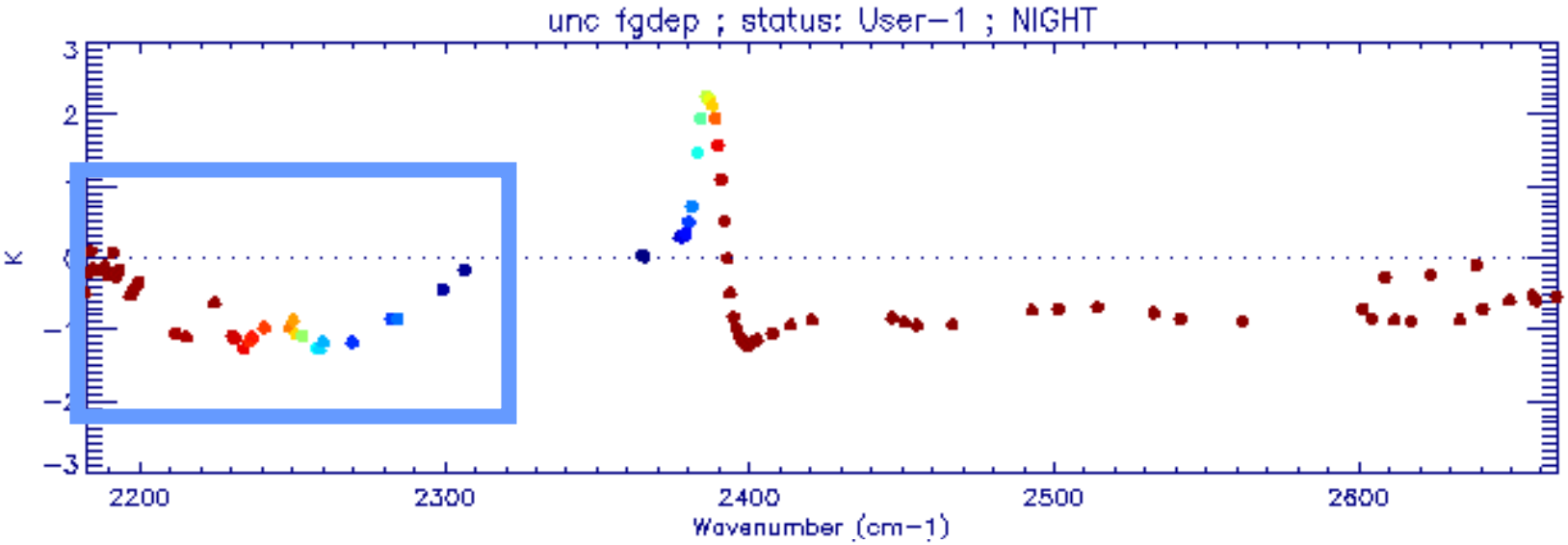


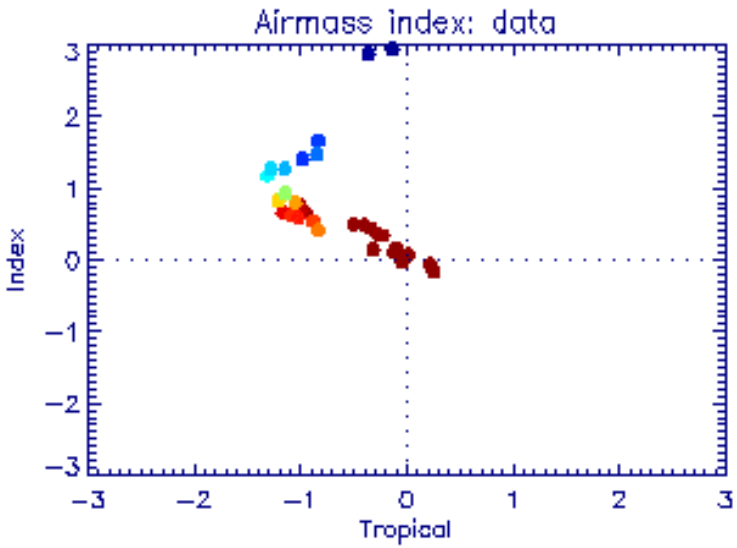


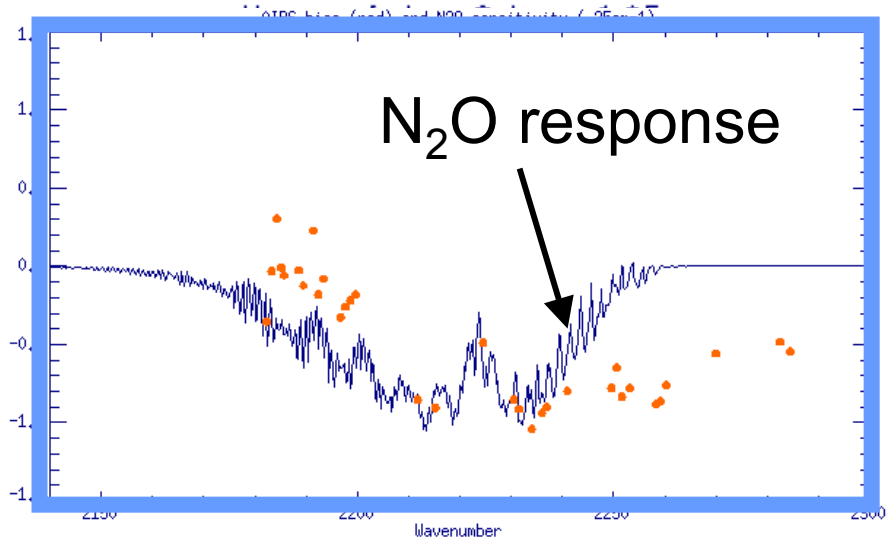


Airmass Index (AI)

Shortwave; CO_2, N_2O

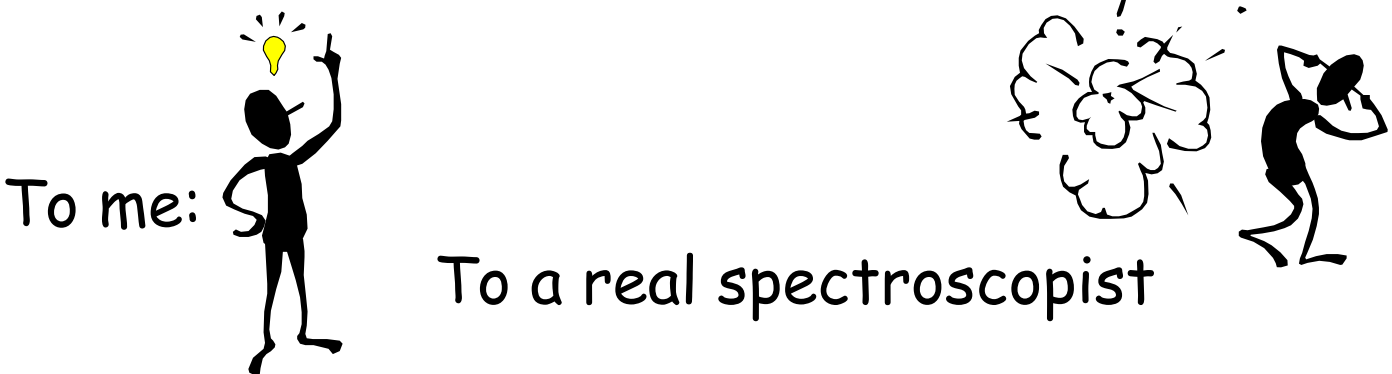






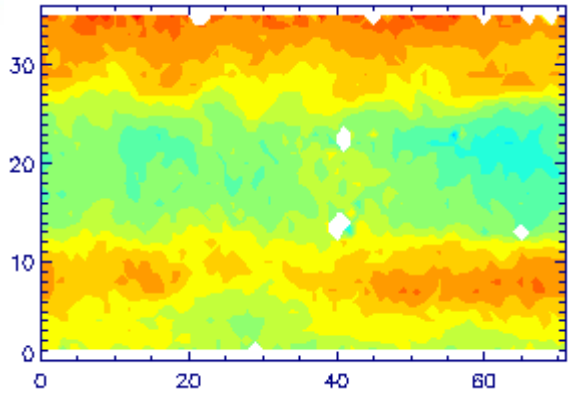
Correction strategy

- Possibilities:
  - Airmass regression
    - Powerful, established technique (AMSU/HIRS/SSM-I…)
    - Uncorrected element? > Add predictor
    - Undiscriminating correction
  - $[\delta,\gamma]$
    - Tried before (HIRS)
    - Limited power (although can be combined with regression)
    - Physically based - discriminating correction



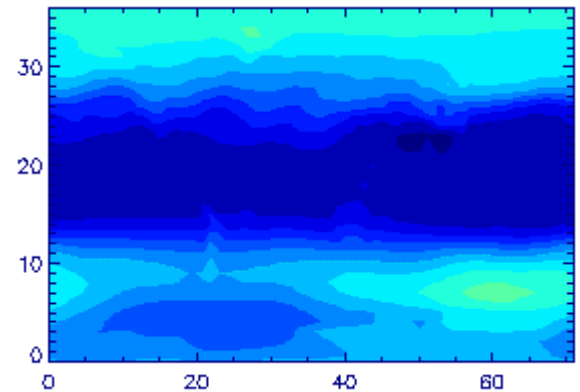
δ,γ - Estimation

1. Monthly mean ob-fg @ 5° ⇒



+ Monthly mean NWP(T,Q,O)

2. Effect of γ=1.05 using NWP ⇒

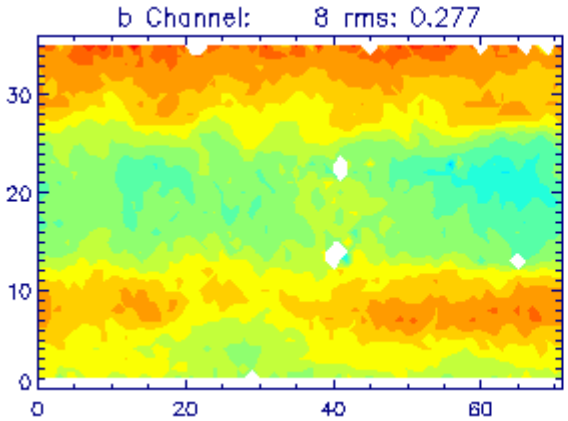


3. Best fit x=[δ,γ] :

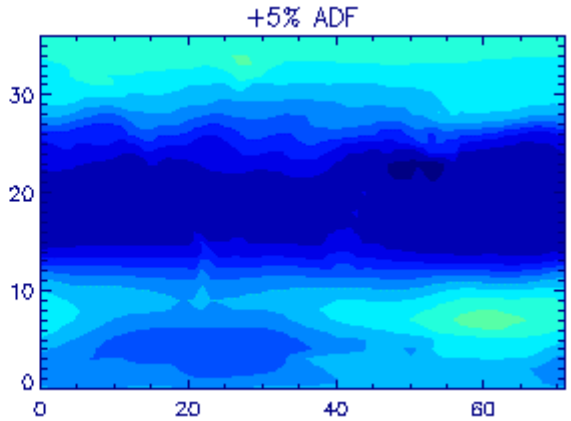
$$J = \frac{1}{2}\sum_{m}\frac{\left(d_m - \left[\delta + \varepsilon(\gamma)_{i,j}\right]\right)^2}{\sigma_o^2} + \frac{1}{2\sigma_b^2}(x - x_b)^2$$

δ,γ - Estimation

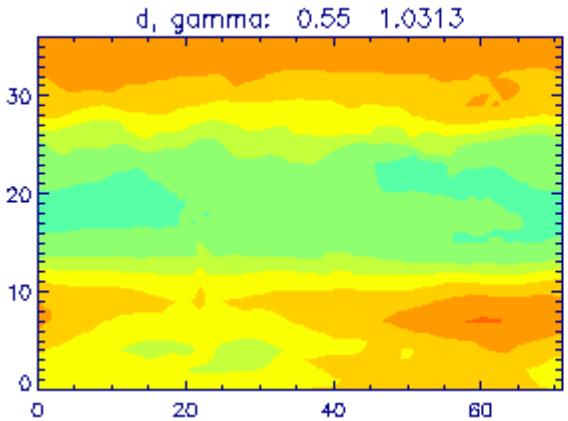
Monthly mean ob-fg @ 5°



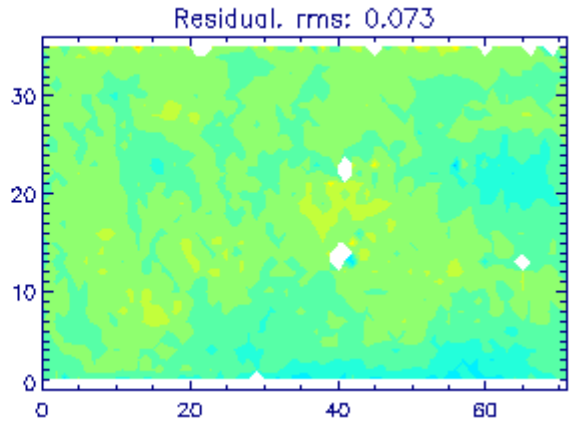
γ=1.05 using NWP



Best fit [δ=0.55,γ=1.0313]

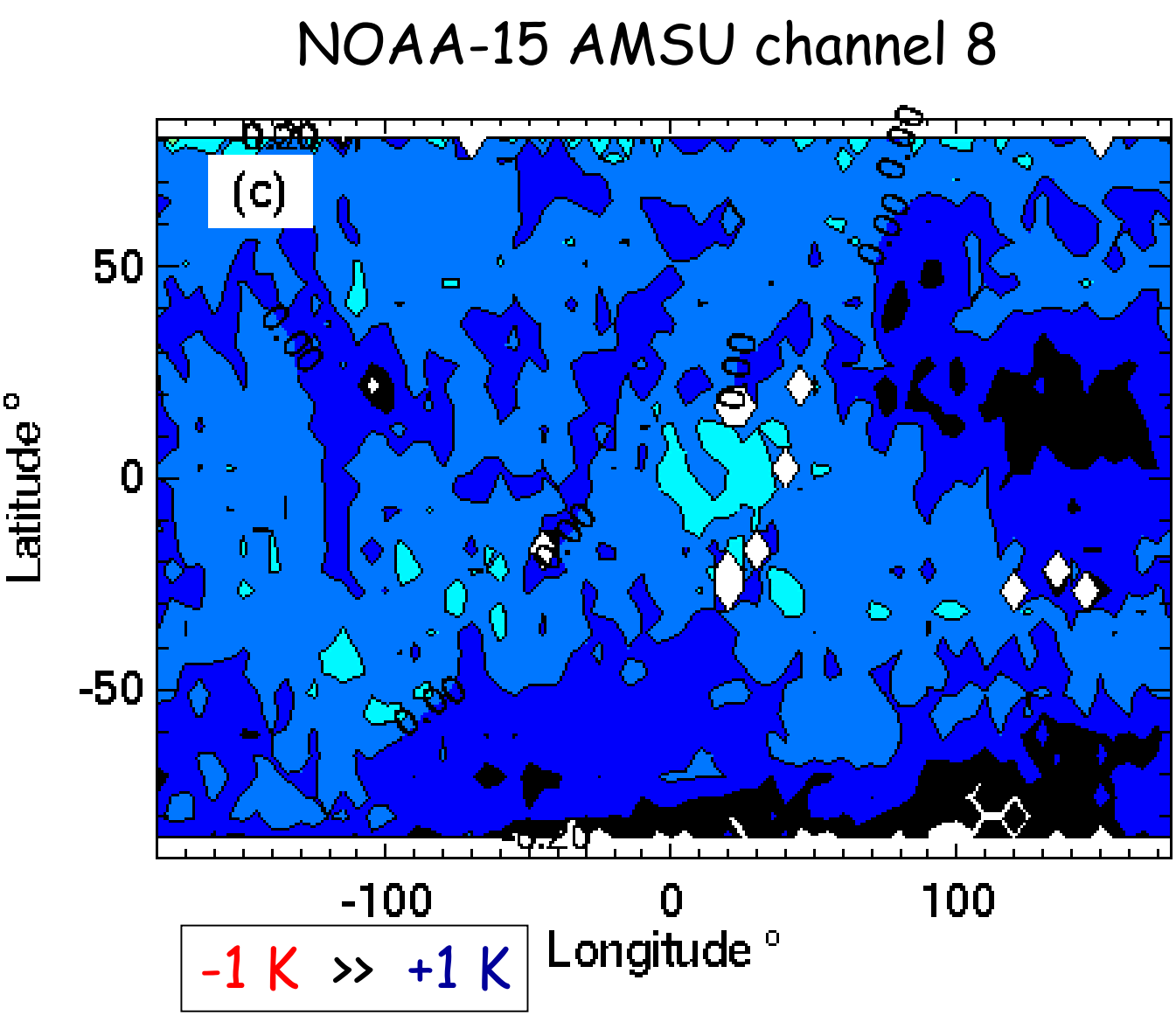


Residual



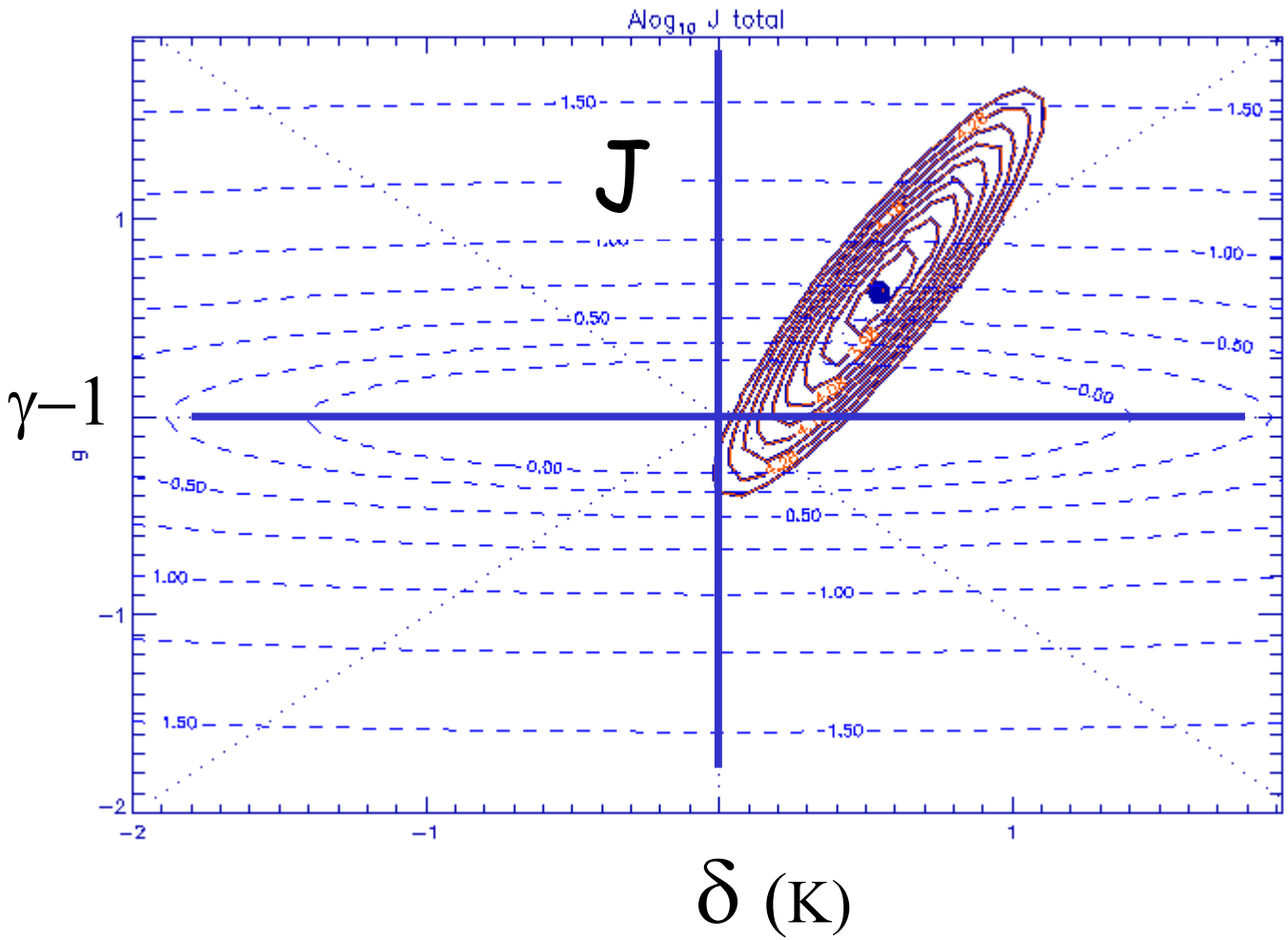
-1 K >> +1 K

δ,γ - Estimation



δ,γ - Estimation

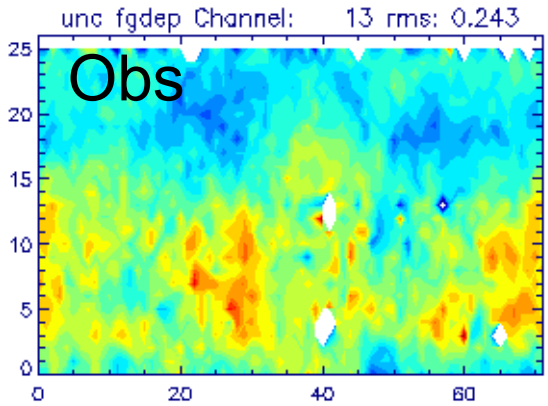
NOAA-15 AMSU channel 8

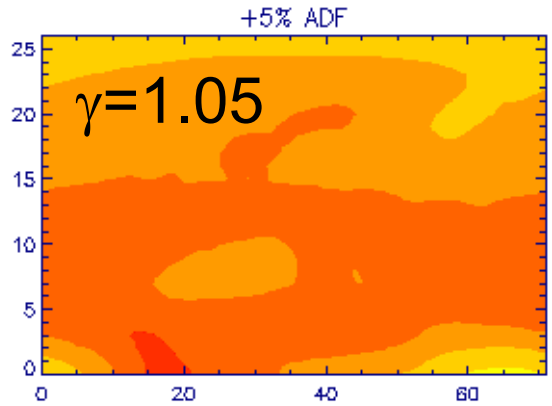


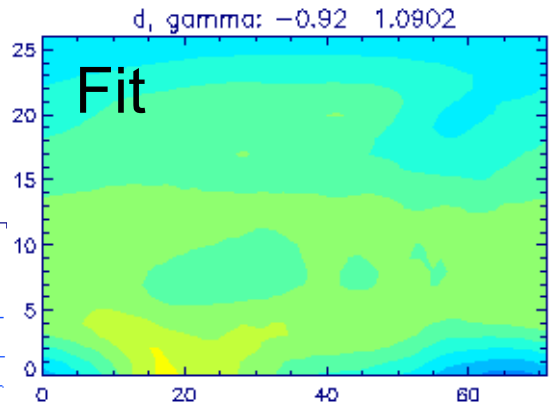
δ,γ both well determined without prior

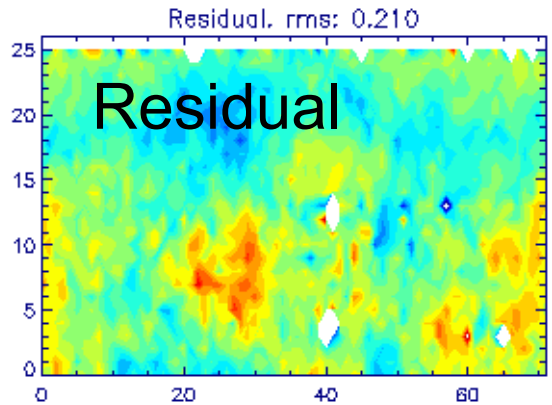
δ,γ; NOAA-16 AMSU-A channel 13

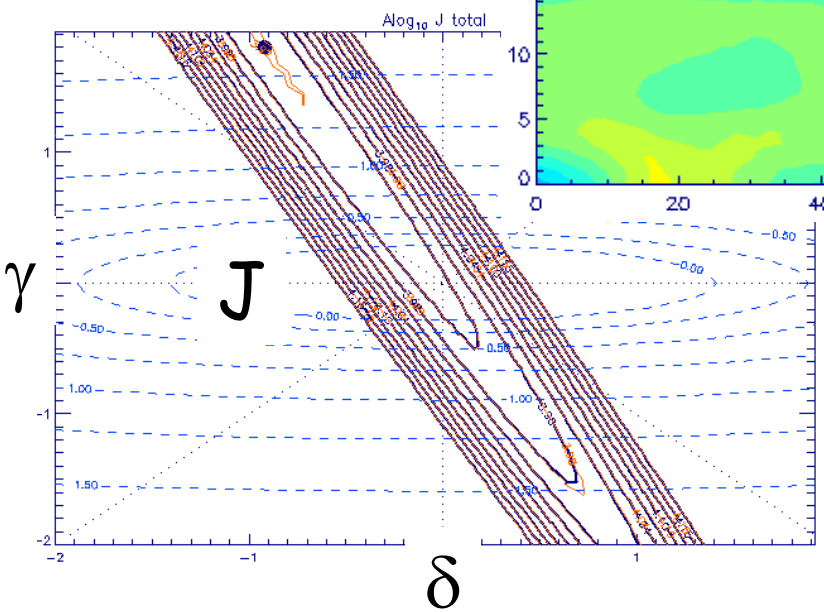
-1 K >> +1 K







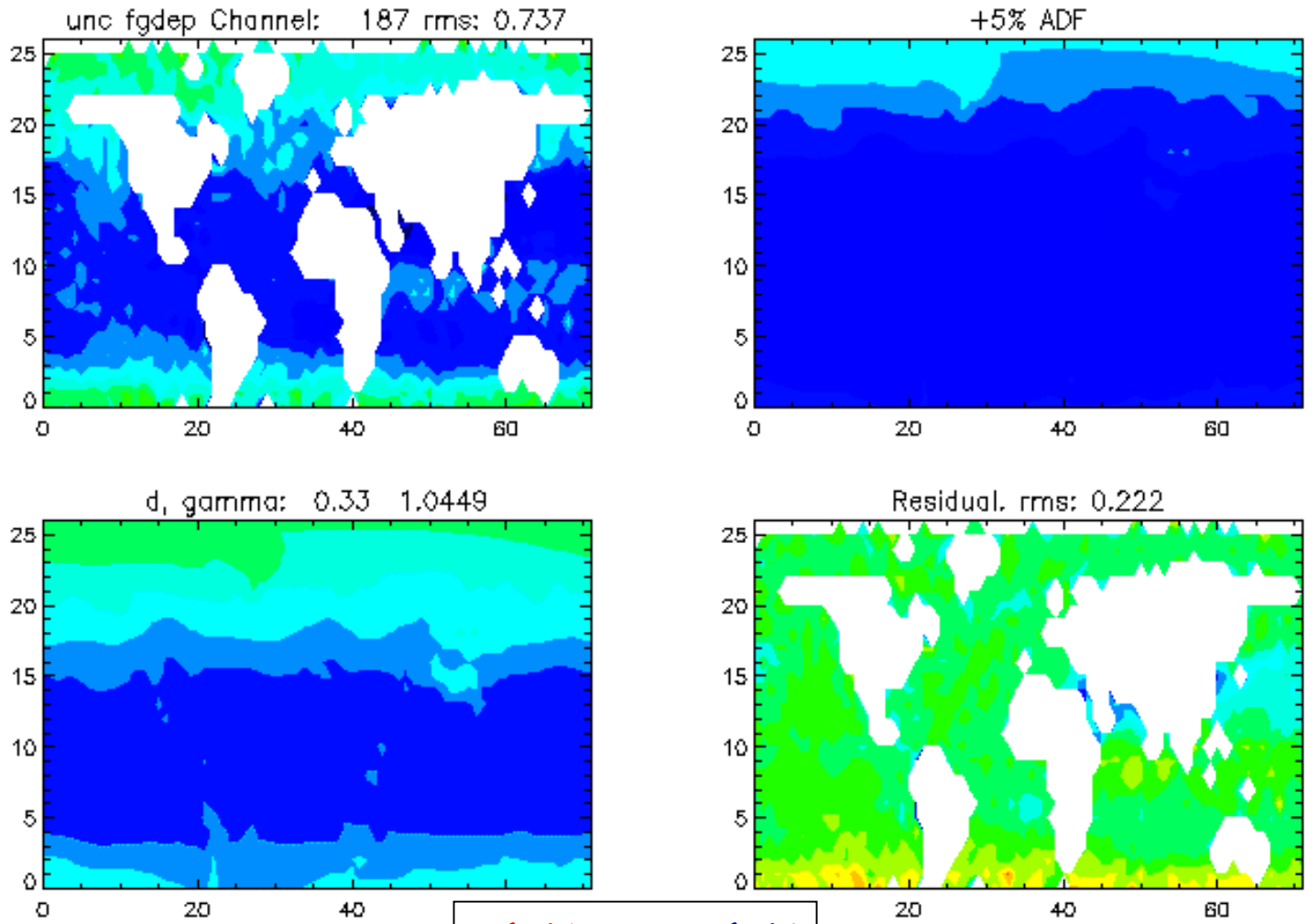




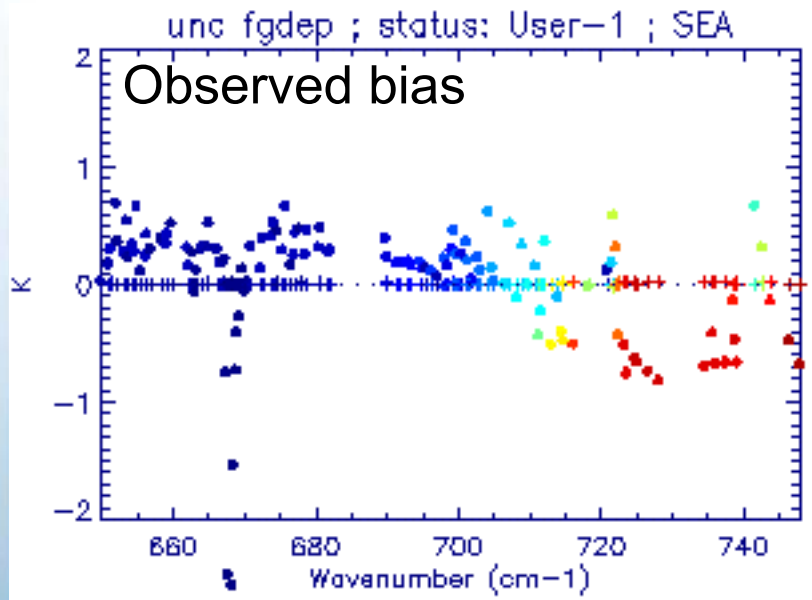
Stratospheric channel
NWP model errors
Poor fit
δ,γ large correlated errors

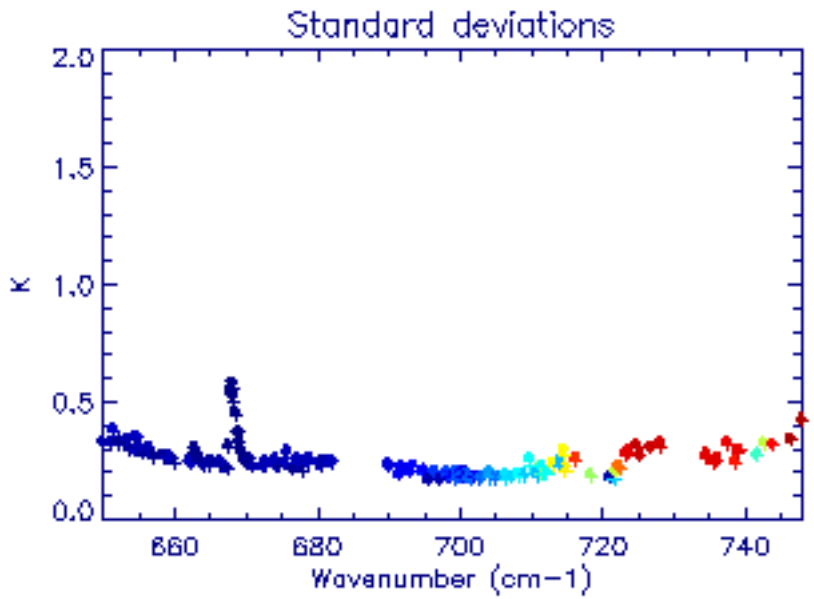
δ,γ; AQUA AIRS channel 1403

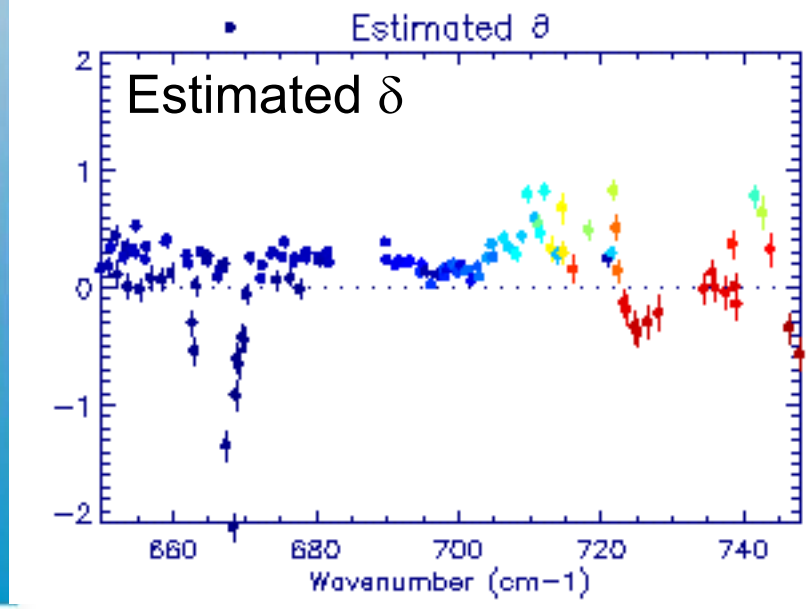
λ = 7.67/1303.8

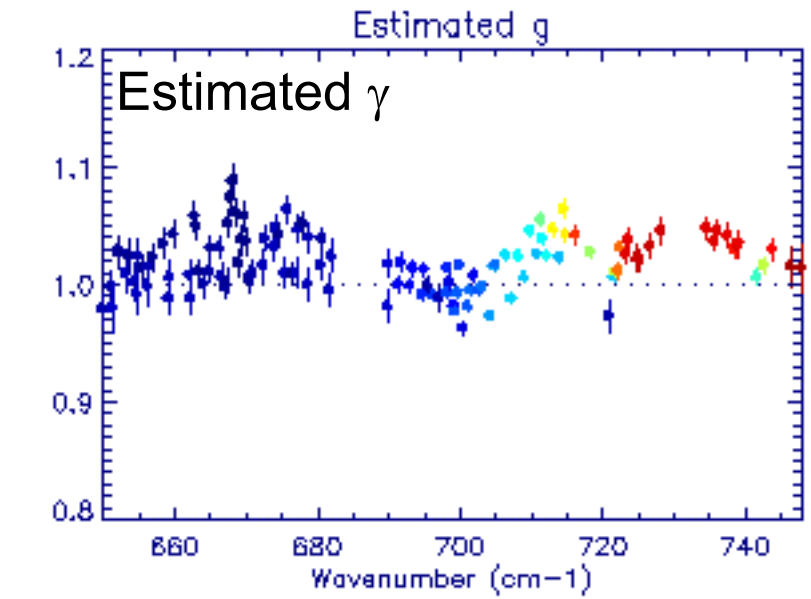


[δ,γ] estimates 650-750 cm^{-1}

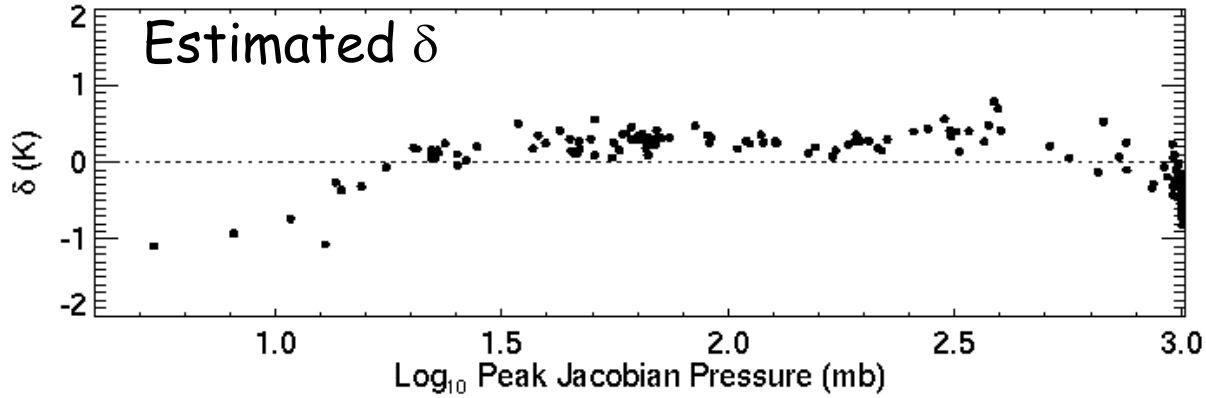


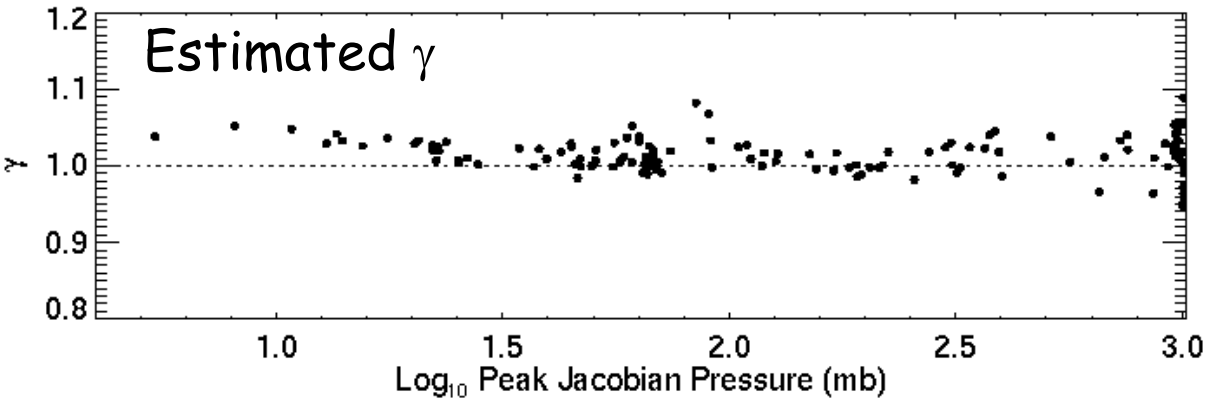






[δ,γ] estimates 650-750 cm^{-1} : Pressure ordered



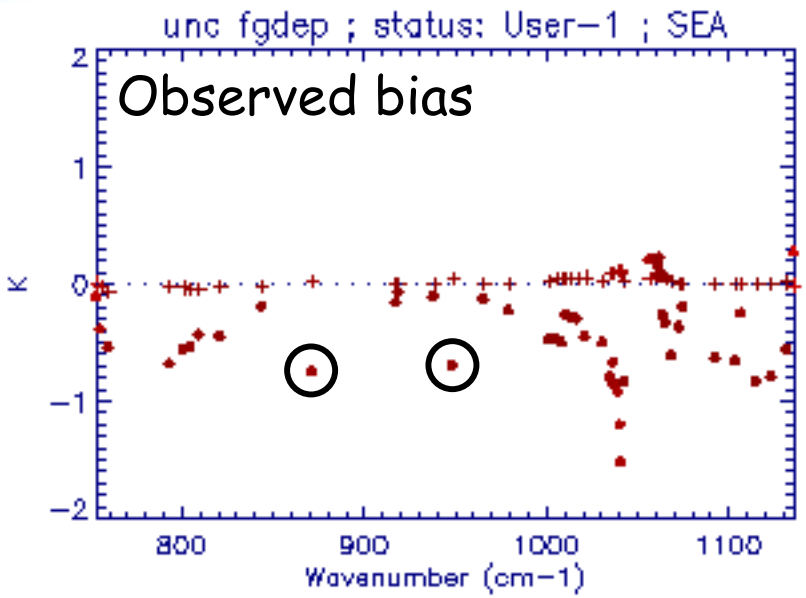


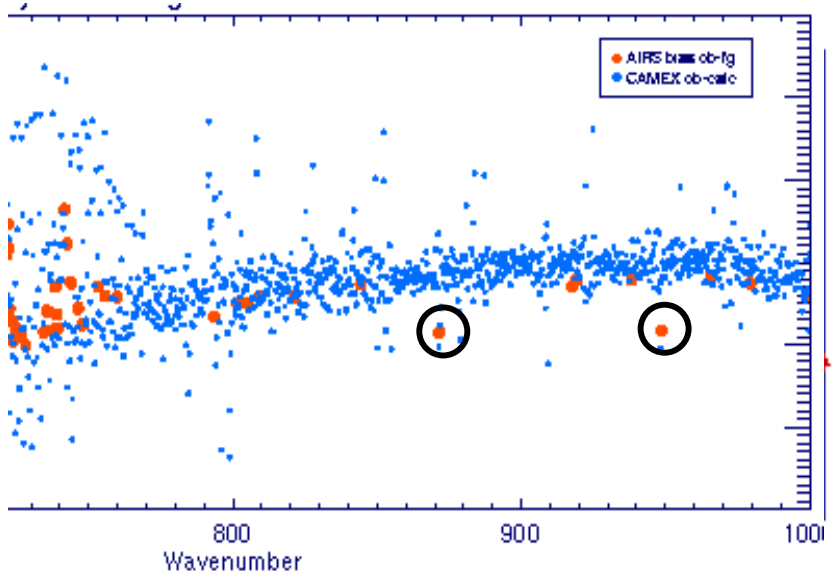
δ values show some consistency through the atmosphere:

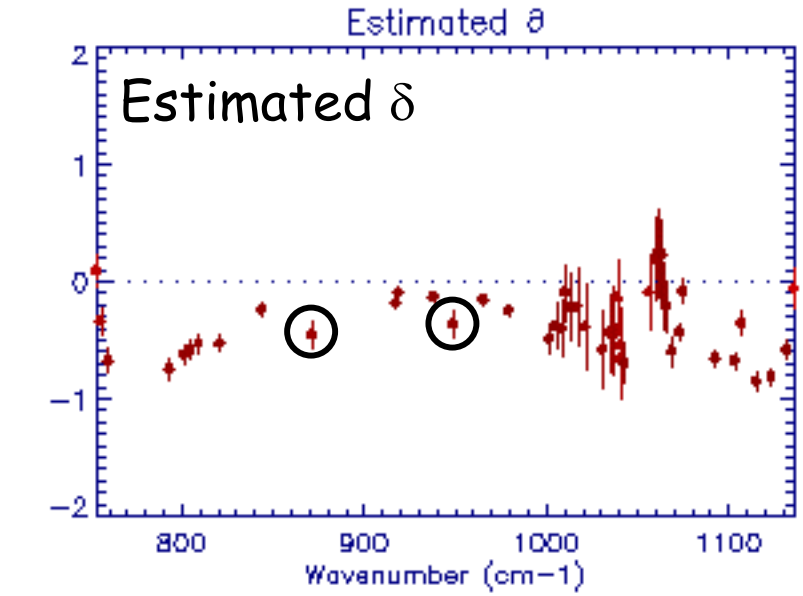
+0.2-0.3 NWP model stratospheric T bias?

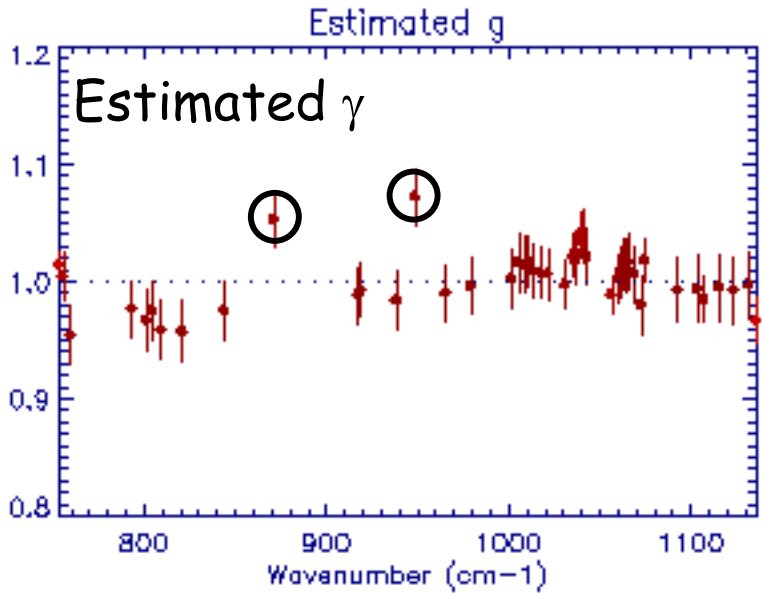
Could be used as a 'smoothness' constraint on δ?

[δ,γ] estimates 750-1150 cm^{-1}

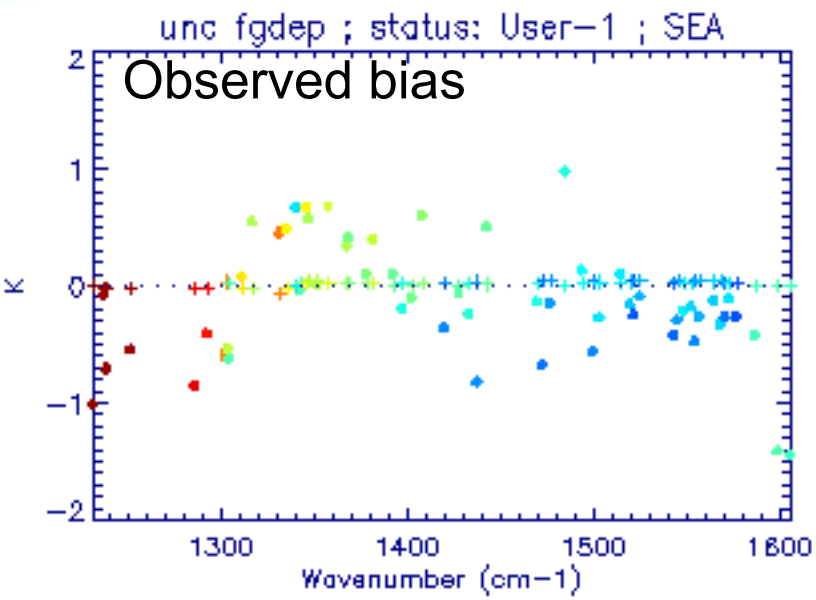


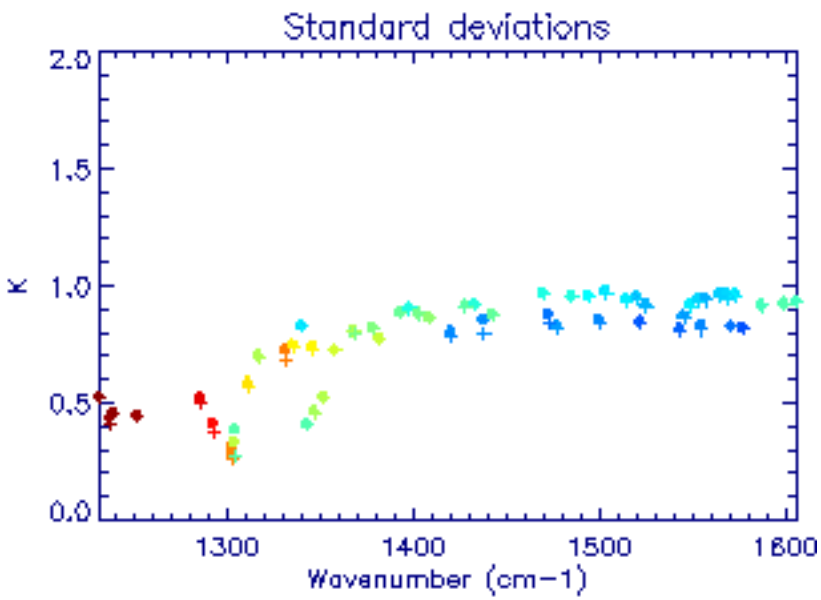


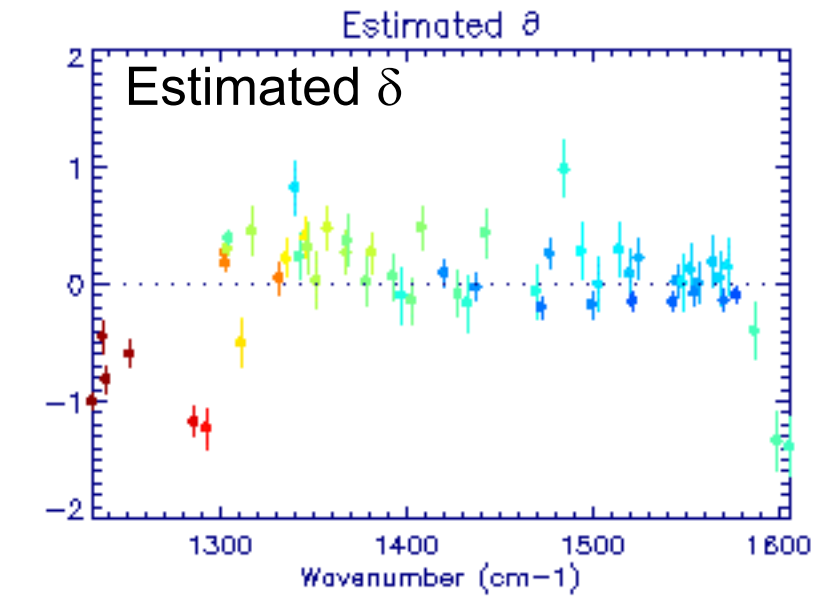


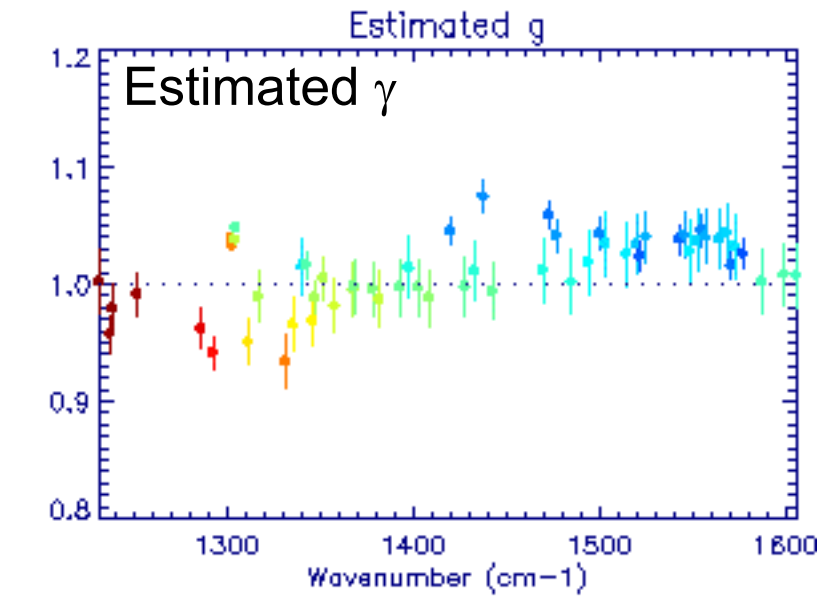


[δ,γ] estimates 1150-1600 cm^{-1}

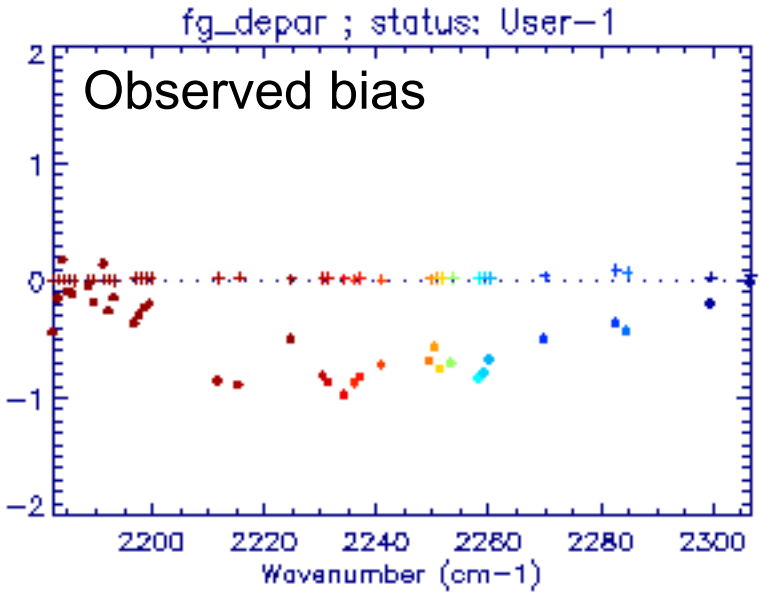


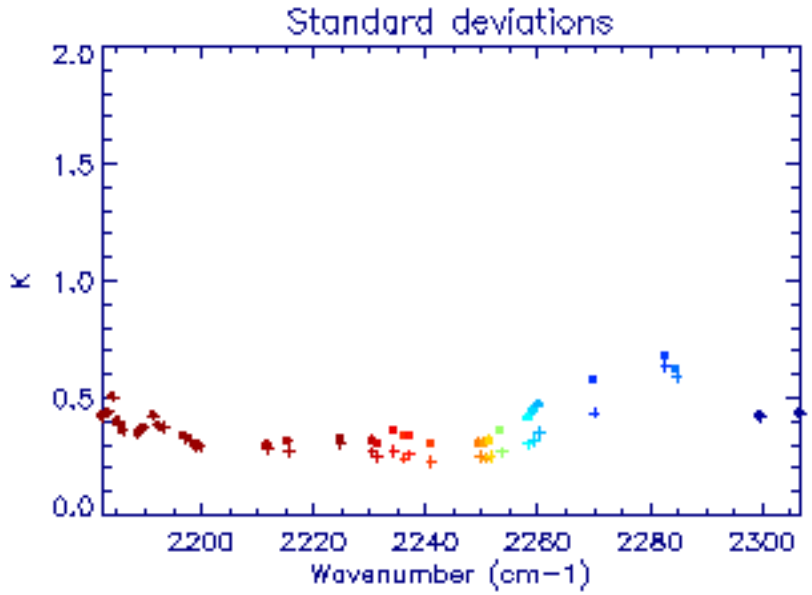


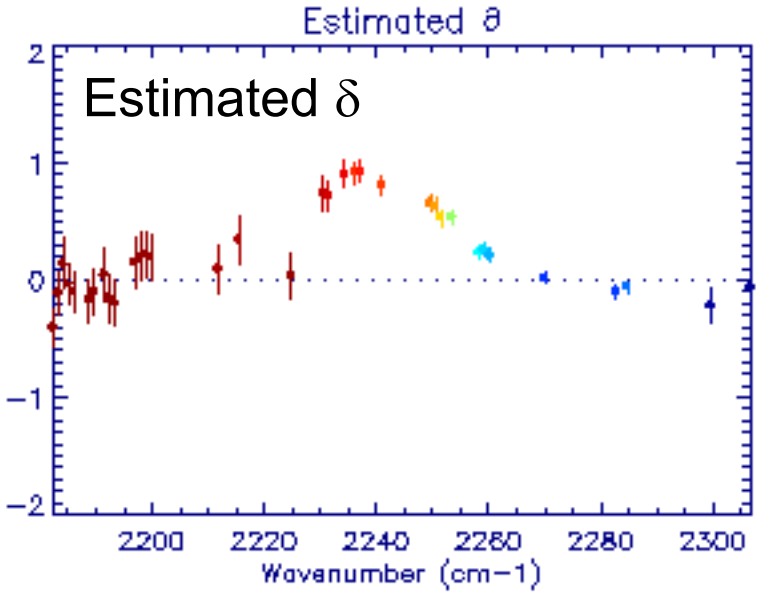


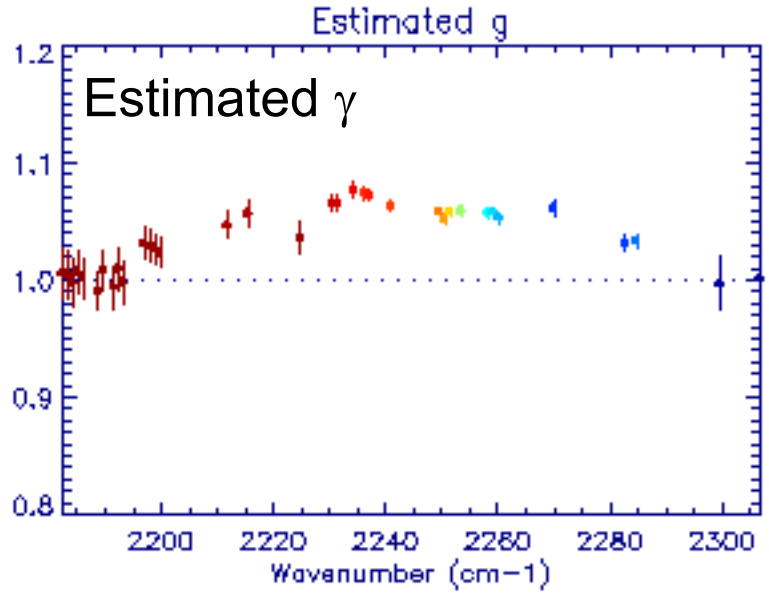


[δ,γ] estimates 2170-2310 cm^{-1}

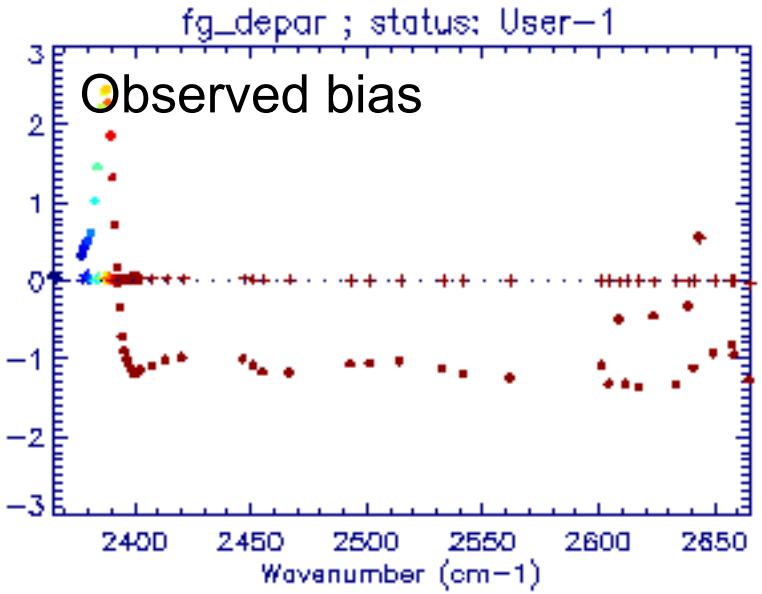


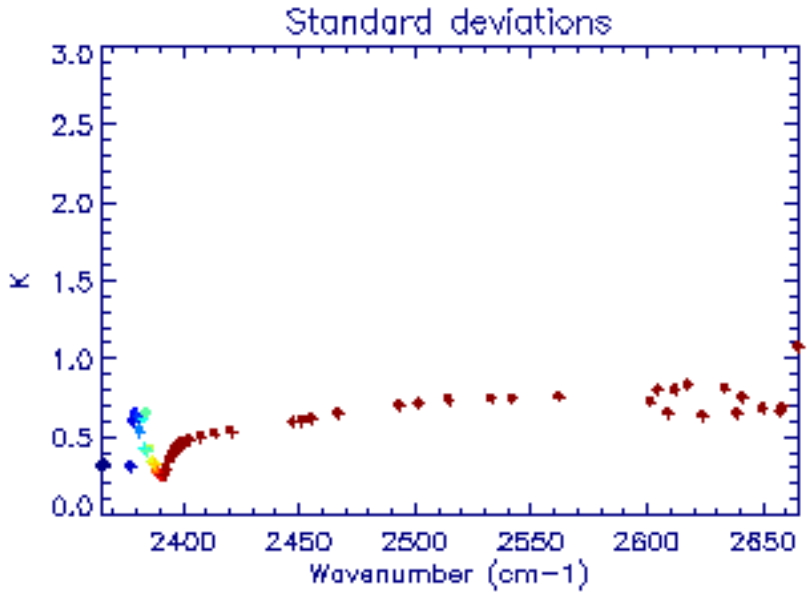


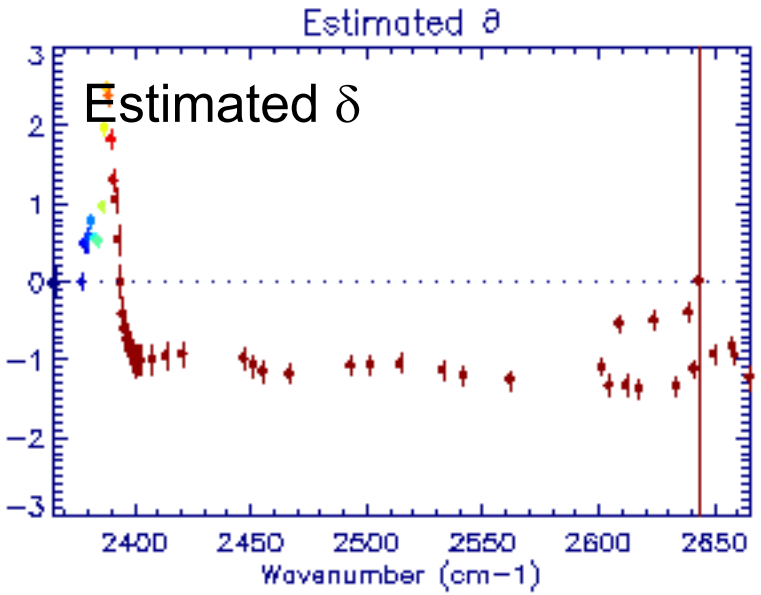


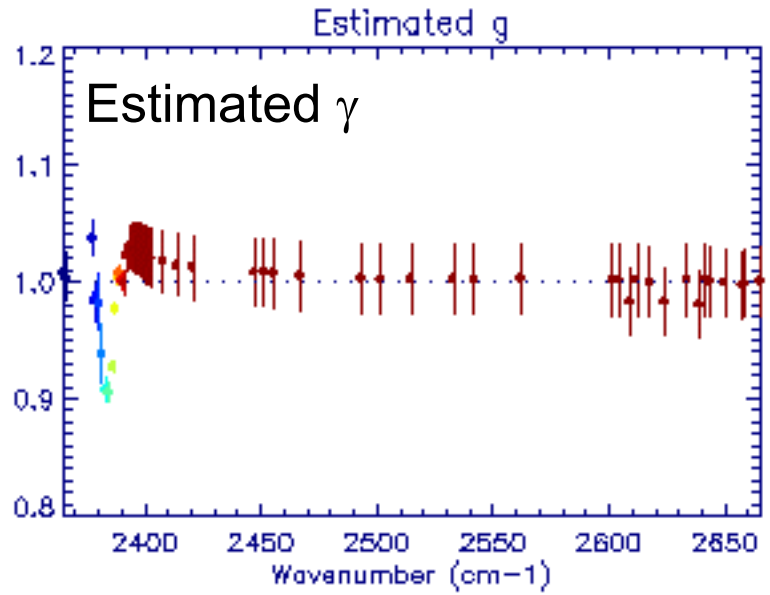


[δ,γ] estimates 2170-2310 cm^{-1}



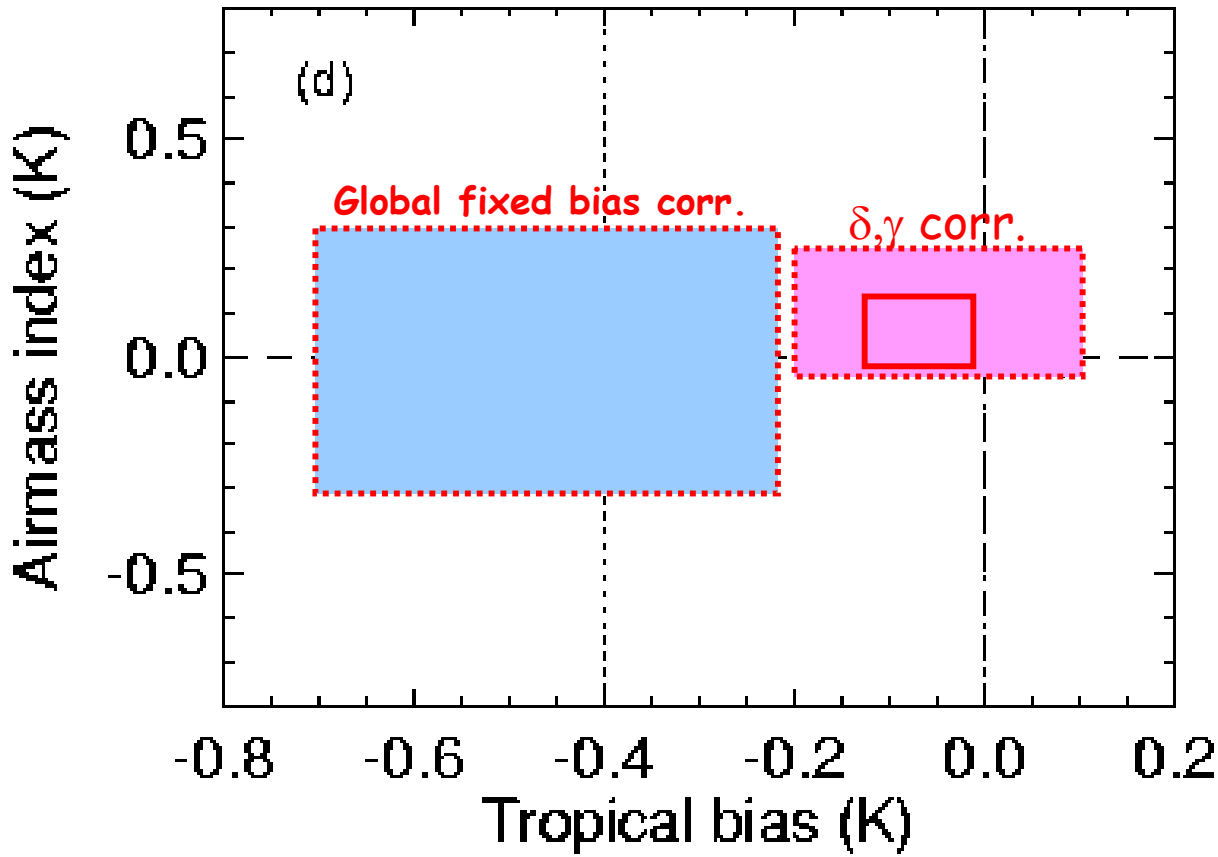




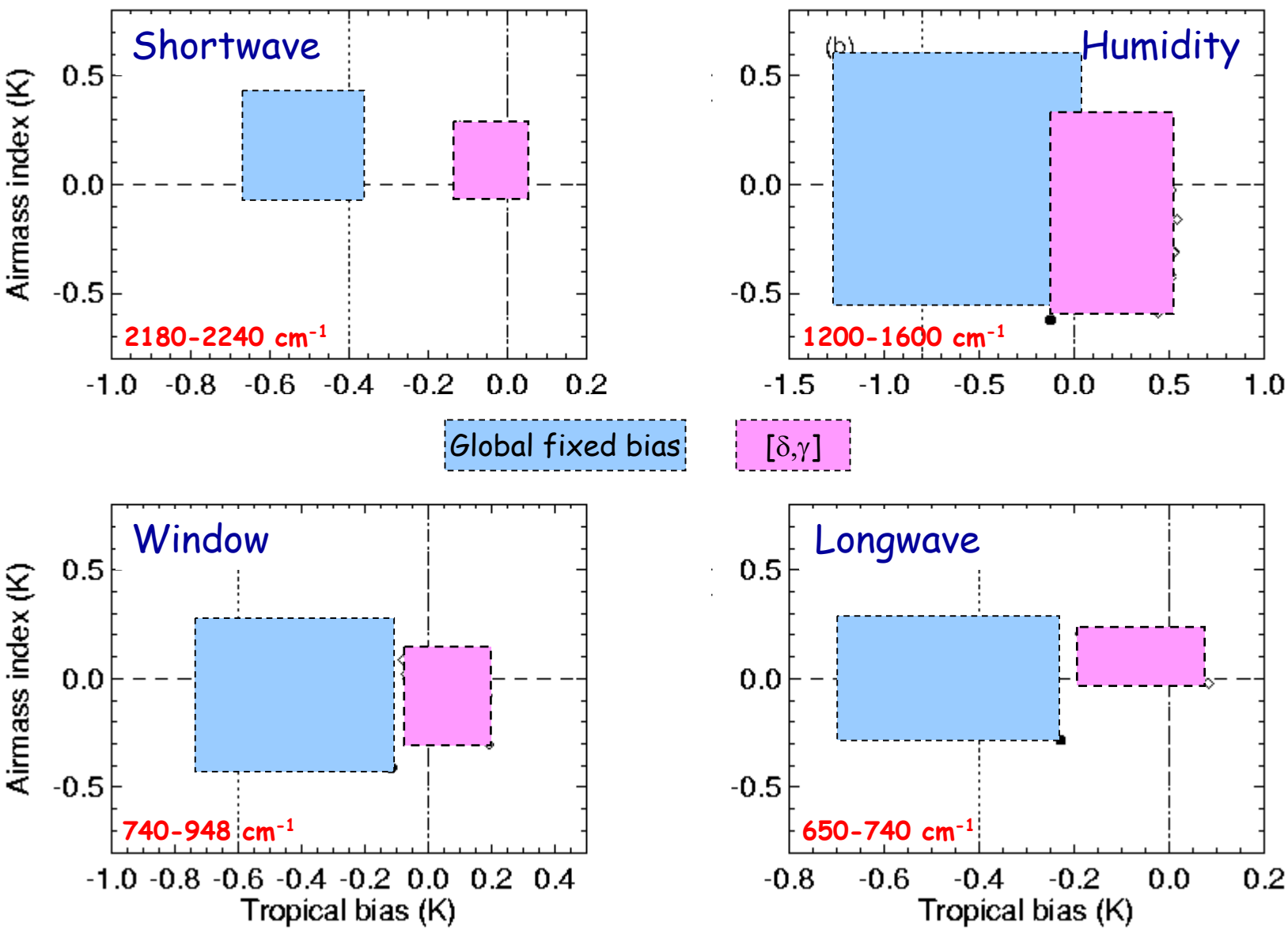


Assimilation results, δ,γ; 15 um band: AI

Cycle 26R4
δ,γ from 2003/06
Experiments: **2003/06/01-22 + 2004/01/01-22**
Control: Global fixed bias [δ=b, γ=1] (operational) from 2002/11



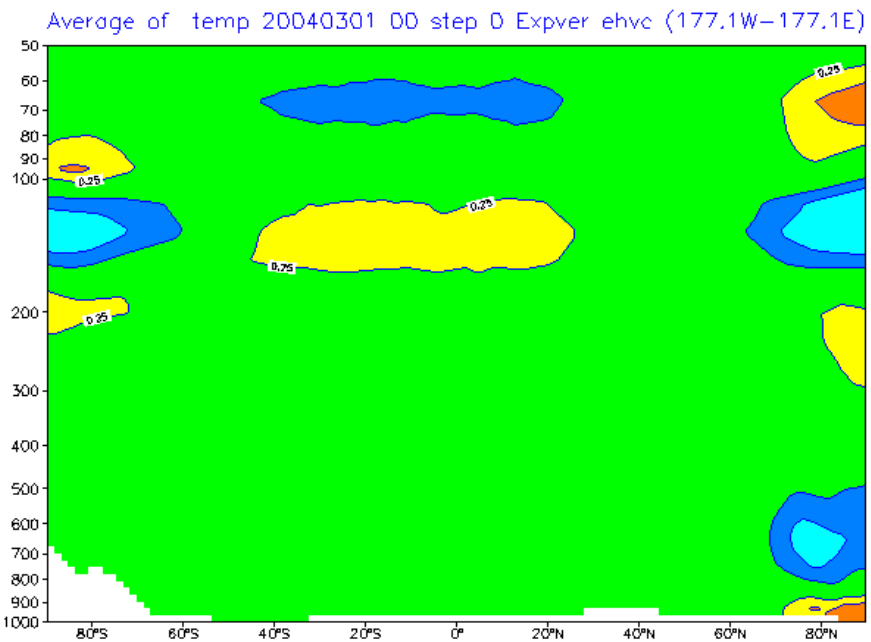
Assimilation results, δ,γ; AI



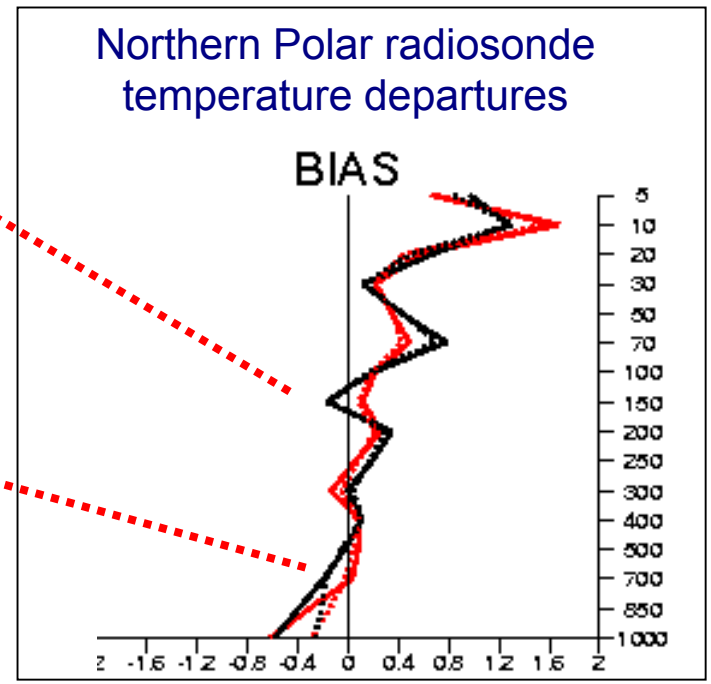
Assimilation results, δ,γ

- The *[δ,γ]* adjusted RT model reduces analysis increments and improves the mean fit of the assimilation to radiosonde data

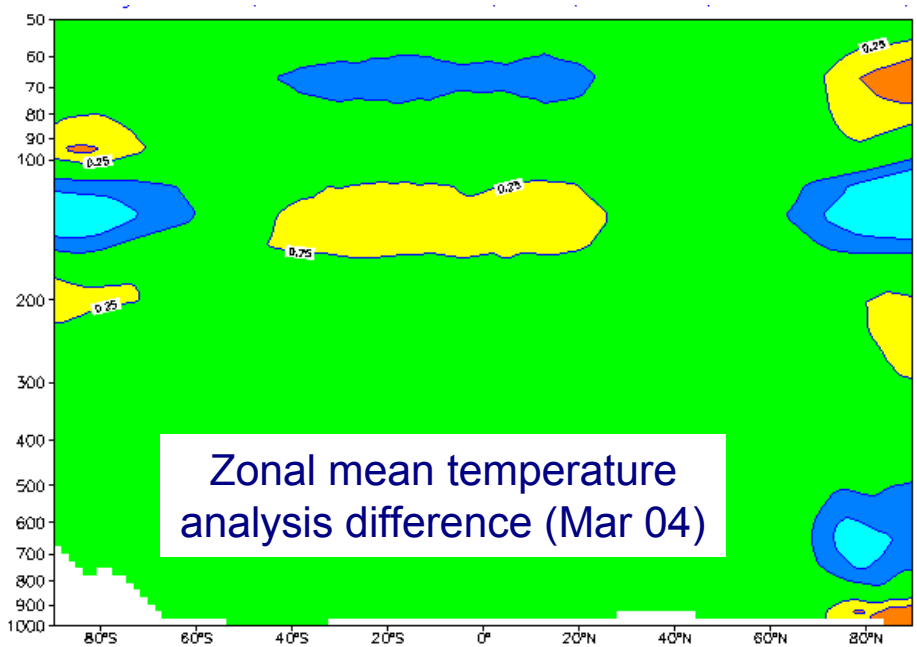
Zonal mean temperature analysis changes



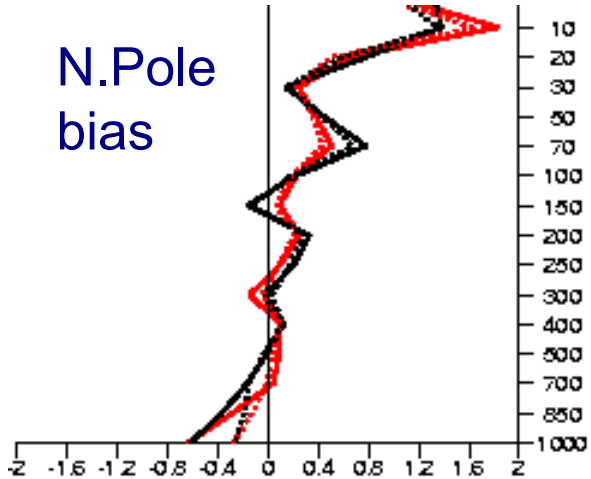
Northern Polar radiosonde temperature departures



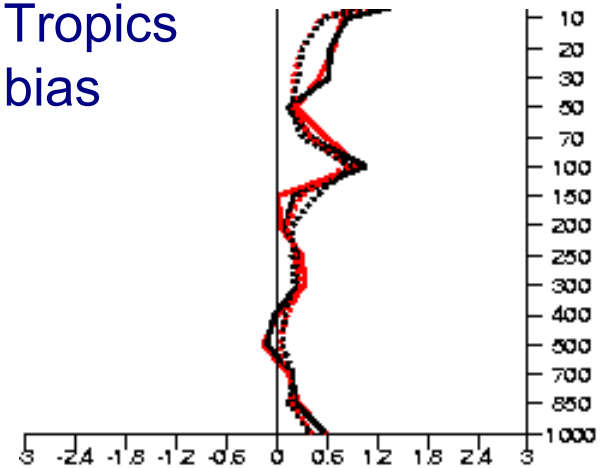
Assimilation results, δ,γ



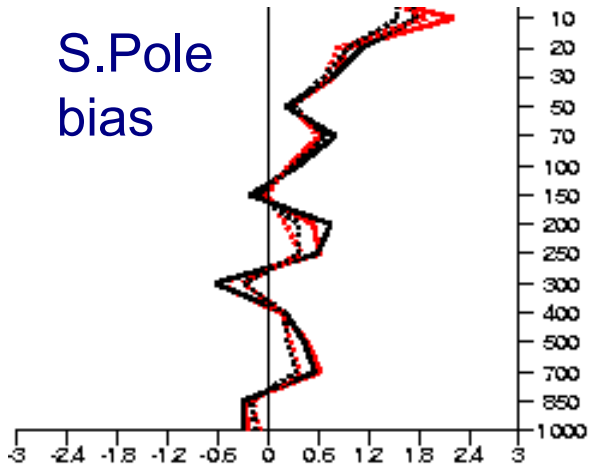
N.Pole bias



Tropics bias



S.Pole bias



Assimilation experiment: scores

- Modest improvement in f/c scores with [δ,γ] correction
- No areas degraded
- Best improvement in SH
- Lost the plots!
- Significance testing on improvements:

Geopotential AC	**N. Hemisphere**		**S.Hemisphere**		**Europe**	
Forecast period	500mb	200mb	500mb	200mb	500mb	200mb
Day-1	5%	5%	0.5%	0.1%	0.1%	2%
Day-3			2%	1%	5%	
Day-5	10%		2%	2%		
Day-7	2%			10%		

[δ,γ] Limitations

- AIRS
- Seasonal stability of estimates poor (<50% variation),
- O-B statistics good
- Scores better than fixed δ correction
- (airmass regression not fully tested)
- More rigorous estimation procedure:
  - Cycle by Cycle updates over one month ('towards Dee'..)
  - Stable estimates
  - Poorer scores

- AMSU-A
- Seasonal stability of estimates good (<10% variation)
- O-B statistics good
- Scores poorer than airmass regression correction
- Somewhat imperfect implementation (interaction with scan-bias)?

Summary

- Biases moderate < 1K; variation small < 0.5 K
  - Little temporal variation
  - Significant geographical / airmass variation
- Most channels biases first order behaviour accords to a simple transmission error.
  - Exceptions:
    - N_2 absorption area 2300 cm^{-1}
    - Channels affected by NWP high level errors
    - Window channels
  - Provides a reasonable correction mechanism if added constant used.
- A step in the right direction?
  - More emphasis on physical modelling of 'bias' errors:
    - **[δ,γ] + (RT modeller expertise) = [better physical model]?**
  - NWP environment provides excellent RTM verification opportunities
  - Complementary to local intensive effort (e.g. ARM)
  - Useful *feedback* to RT even if regression methods remain as operational bias correction