

# Recent Validations of infrared and microwave forward models at LMD/IPSL

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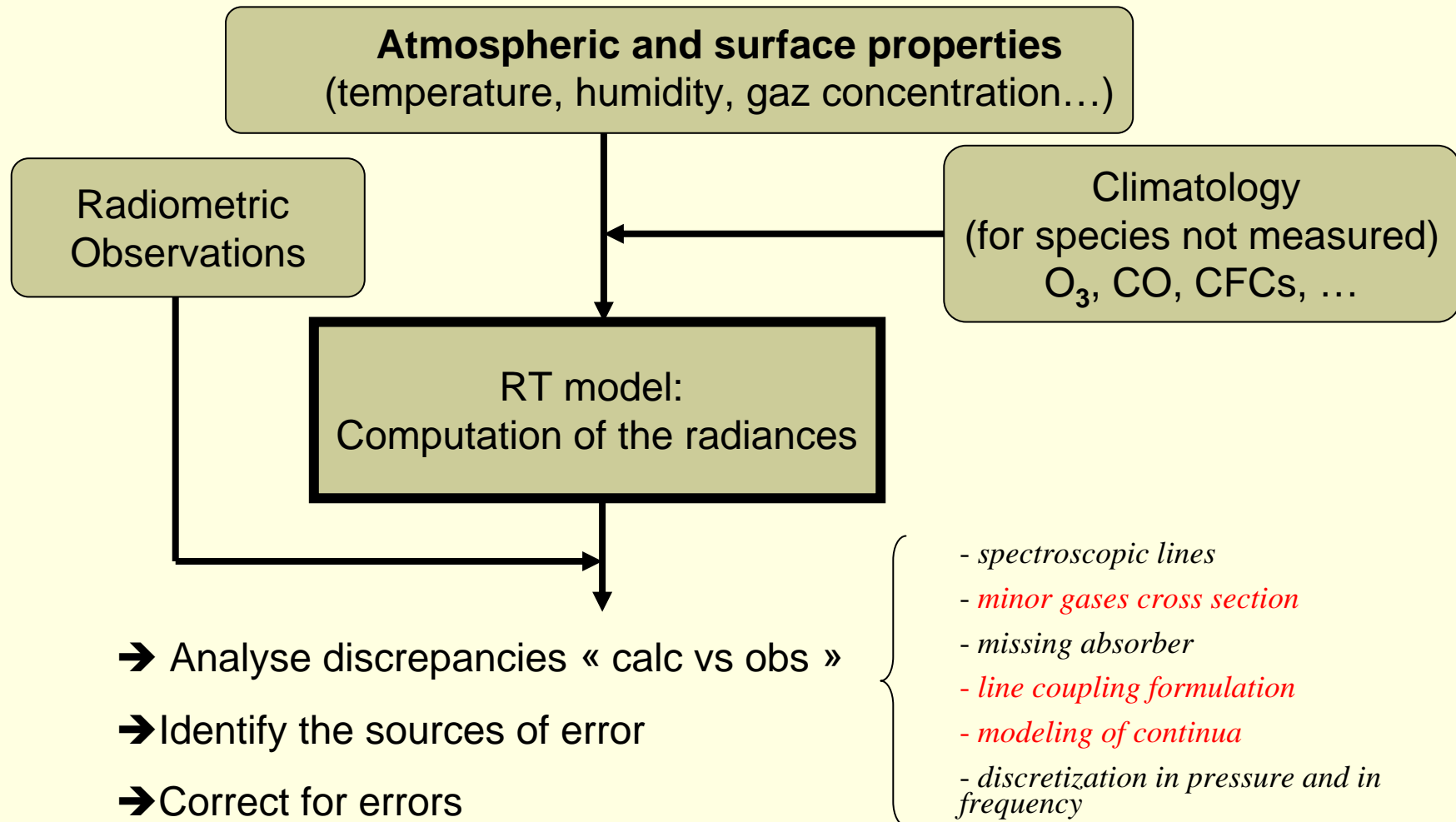
# Objectives of the validation

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With recent and future satellite measurements, (TOVS, ATOVS, AIRS/AMSU/Aqua, IIR/Calipso, IASI/AMSU, Metop, ...) forward modeling requires more and more attention (1-D var, 4-D var, reanalysis, ...)

- forward models (brightness temperatures, transmittances, jacobians) and spectroscopic databases need to increase their precision.
- residuals between observed and calculated models have to be clearly identified and corrected

# Validation scheme



# Forward model computing suite at LMD

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- Used in this study :

→ **Forward models :**

**Stransac** genuine line-by-line and layer by layer model (IR and MWV)

**4A** : 2<sup>nd</sup> generation line-by-line and layer by layer model

→ **Spectroscopic database:**

**GEISA-2003**

- More details on the poster ([Thursday, 13h:14h30](#))

Water vapor, O<sub>2</sub>, N<sub>2</sub>, continua,

CFCs profiles (cfc11, cfc12, Ccl4),

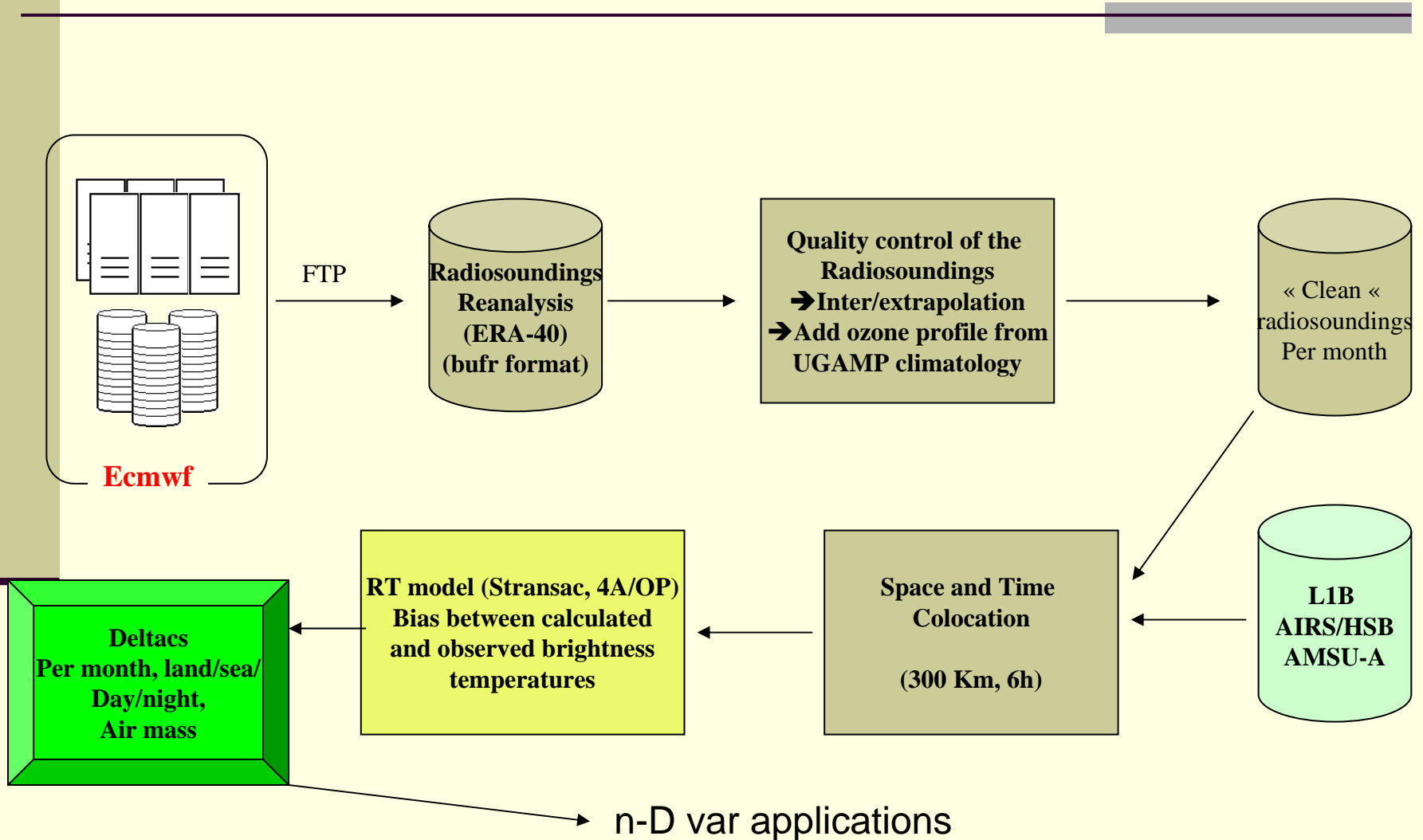
Line-coupling,

Emissivity spectrum

# The validation suite: Example for AIRS/AMSUs/AquaAIRS

(AIRS/AMSU data (11b) automatically desarchived from NASA/GSFC on a daily basis)

April 2003 → « today »



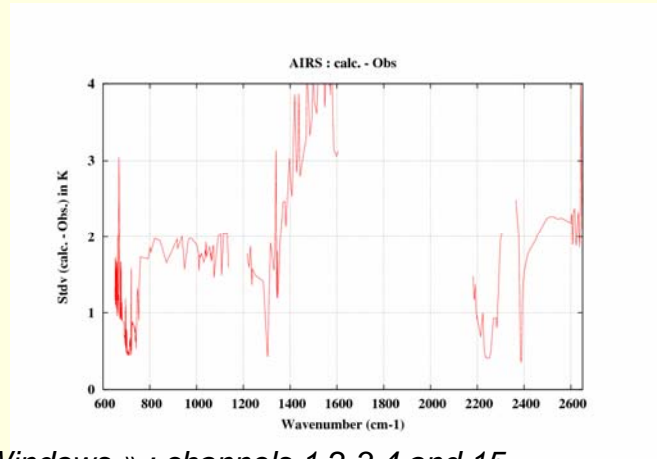
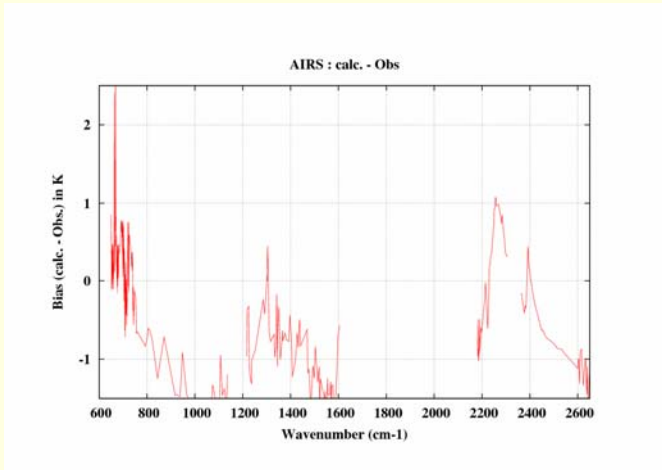
# The validation suite: Example for AIRS/AMSUs/Aqua

*T and H<sub>2</sub>O from radiosoundings*

*No fit of O<sub>3</sub>, N<sub>2</sub>O, CO, CH<sub>4</sub>, Ts and Surface Emissivity*

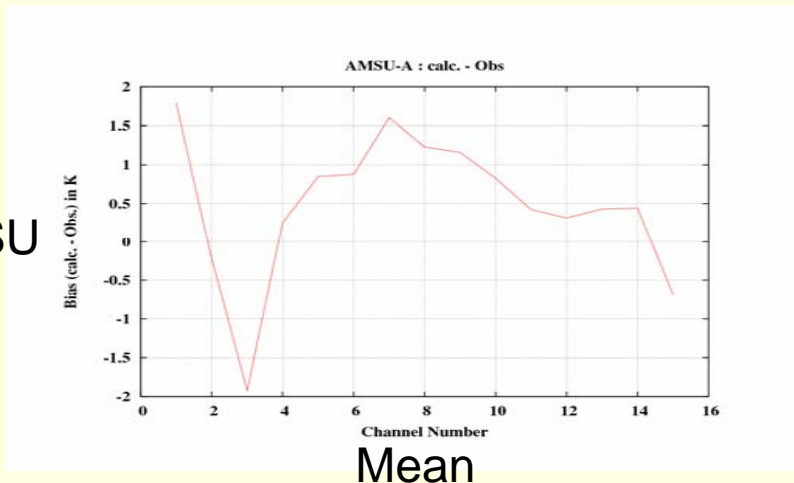
**Sea, Night** (between April 2003 to March 2006, 2000 collocations)

AIRS

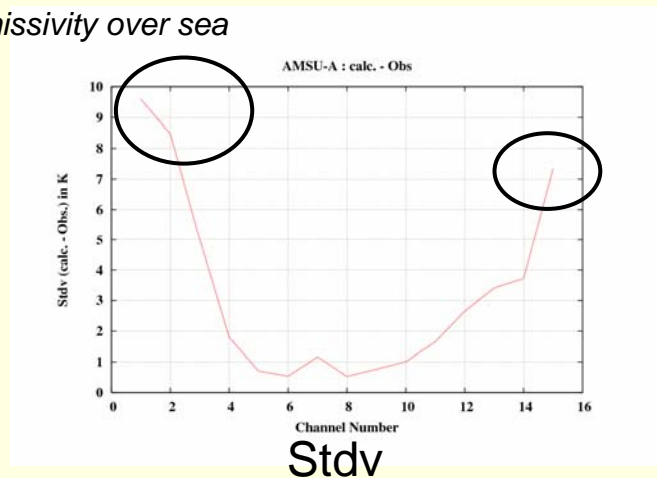


« Windows » : channels 1,2,3,4 and 15

AMSU



Emissivity over sea



# Overview of existing validation datasets

Name	Date/loc.	Obs.	Instruments	Comments
<b>UWITRA90</b> <b>CAMEX I</b>	<ul style="list-style-type: none"> <li>■ Apr. 86,</li> <li>Oct/Nov 88,</li> <li>March 92, US</li> <li>■ Sept 93, US</li> </ul>	Plane or g.b.	HIS + radiosondes	Available on HIS validation dataset website
<b>THORPEX</b>	Fev/Mar 2003 Hawaii	Plane	SHIS, NASTI... + radiosondes	All data are compiled and freely available on a website
<b>IASI-BALLOONS</b>	March 2001 Aug. 2002 Kiruna (Sweden)	Balloons	IASI-balloons spectra + Atm. soundings	Available on ETHER website after registration <u>BUT</u> : no ISRF available
<b>EAQUATE</b>	Sept 2004 UK + Italy	Plane + g.b.	SHIS, NASTI, BOMEM + radiosondes	Some data (which one?) available on FAAM website, after providing details on the research
<b>AVE 2004/2005</b>	Oct/Nov 2004 June 2005 Houston TX	Plane + sat.	SHIS, AURA + AQUA prod. + atm. Properties ?	Restricted to participants and contributor to Aura validation
<b>WINTEX</b>	Mar/Apr. 1999 USA/Canada	Plane + g.b.	AERI, SHIS, NASTI, MAS... +LIDAR, radiosondes	On FAAM website after request (which data?)

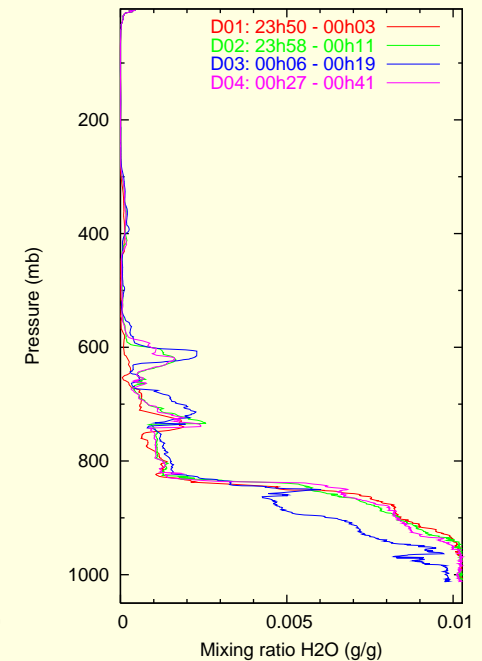
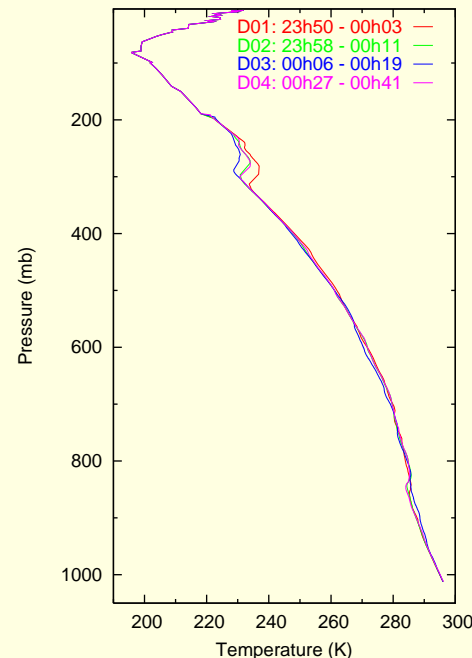
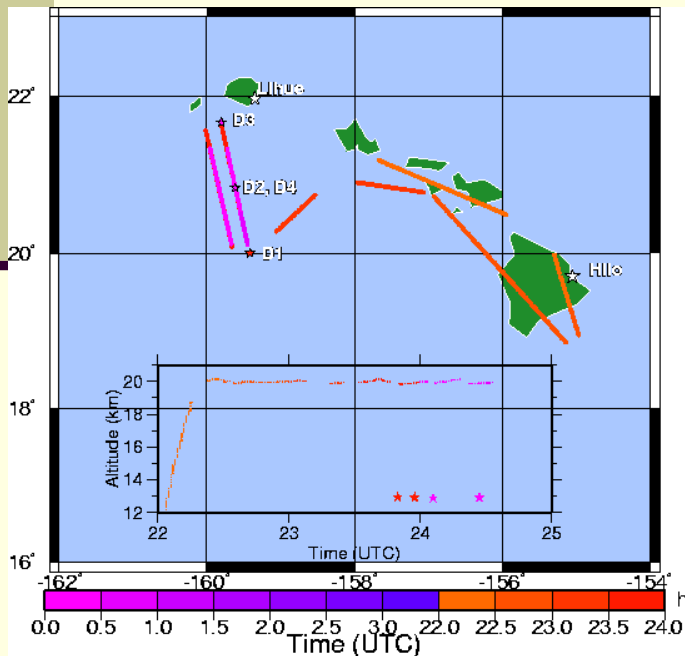
# Overview of existing validation datasets

Name	Date/loc.	Obs.	Instruments	Comments
<b>ADRIEX</b>	Sept 2004 Northern Italy	Plane	SHIS, NASTI + atm. Properties?	On FAAM website after request (which data?)
<b>AFWEX</b> (ARM/FIRE Water vapor Experiment)	Nov/Dec 2000 Oklahoma US	Plane + g.b.	SHIS, NASTI, radiosondes, LIDAR...	<ul style="list-style-type: none"> <li>■ LIDAR, water vapor, GPS, CM sondes, etc... available on ARM website</li> <li>■ SHIS and NASTI not available</li> </ul>
<b>MPACE</b>	Sept/Oct. 2004 Alaska	Plane + ?	SHIS, LIDAR, radiosondes...	<ul style="list-style-type: none"> <li>■ LIDAR data available on ARM website</li> <li>■ No link found to other data</li> </ul>
<b>FIRE.ACE/ SHEBA</b> (Arctic cloud exp.)	Apr/July 98 Alaska US	Plane + g.b +sat	Radiance + several atm. Properties	Data available on Nasa Langley website after (only?) registration
<b>CLAMS</b>	Jul/Aug. 2001 US East coast	Plane + g.b +sat.	SHIS, MODIS, MAS... Radiosondes	Except SHIS, data available on Nasa Langley website after (only?) registration
<b>CAMEX III</b>	Aug./Sep 98 Andros Island	Plane + g.b.	AERI, NASTI, MAS, MIR + radiosondes, LIDAR...	<ul style="list-style-type: none"> <li>■ All data are available on GHRC webpage, after registration (not tested)</li> <li>■ Some data available on CIMSS website</li> </ul>
<b>CAMEX 4</b>	Aug./Sep 98 Andros Island	Plane + g.b +sat.	MAS, MIPS, radiosondes + several atm. Properties	All data seem to be available on GHRC webpage, after registration (not tested)



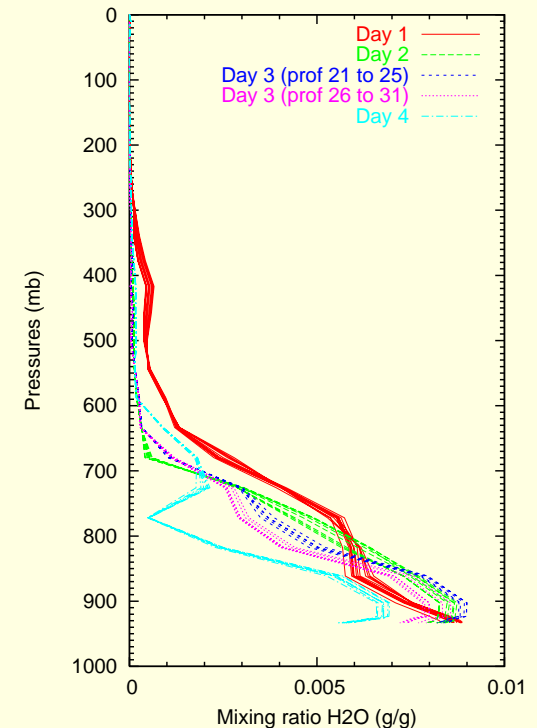
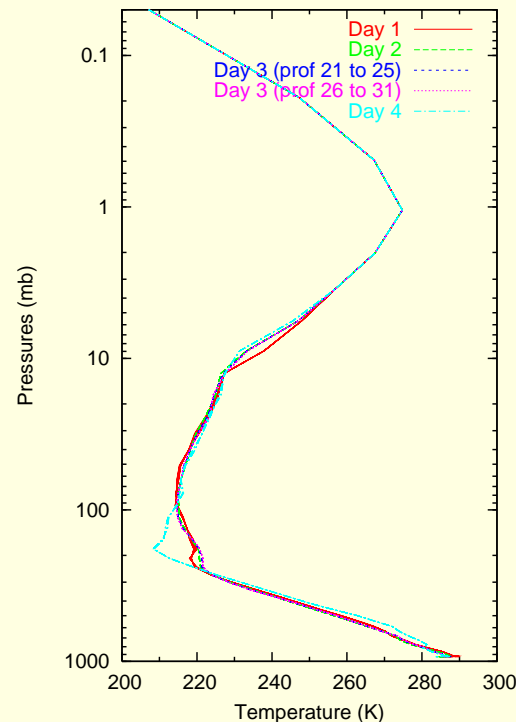
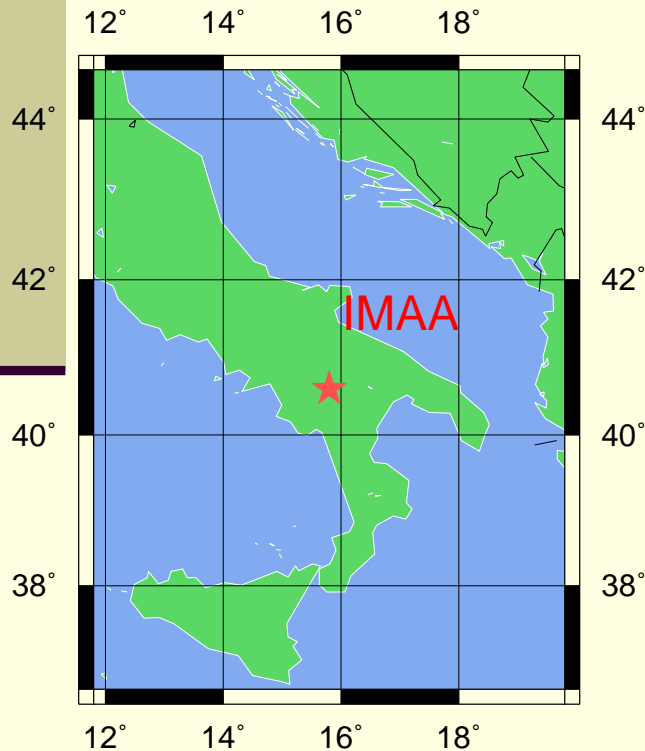
# THORPEX dataset (SHIS)

- SHIS upwelling radiance data collected around Hawaiian Island between 21 February and 15 March 2003 on board ER-2 (altitude of 20km).
- Temperature and water profile measured by dropsondes released at 13km by G-4.
- The 03 March is used here as it is considered as clear-sky measurements.
- Measurements are performed during day-time.
- Data are freely available on: <http://thorpex-data.ssec.wisc.edu/>



# EAQUATE dataset (BOMEM)

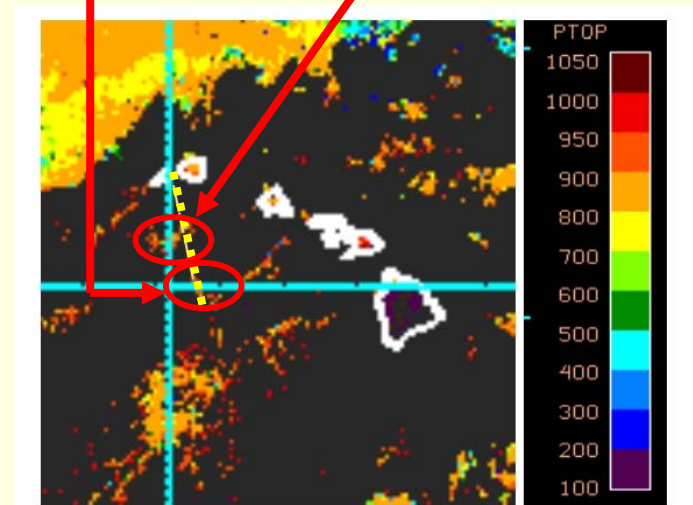
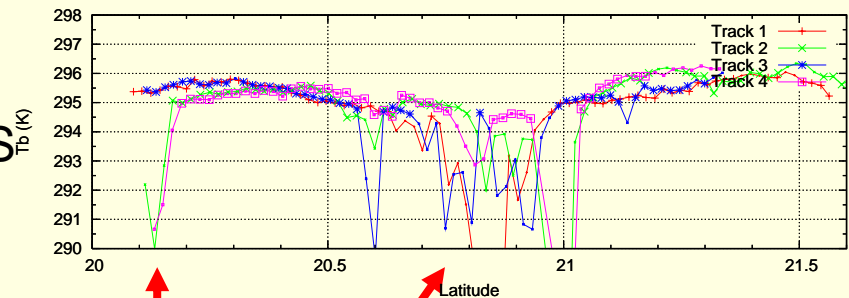
- 38 down looking BOMEM spectra collected on 6-10 Sept 2004, in Italy between 7 pm and 2 am.
- At each spectrum correspond temperature and water profiles.
- Other trace gases have been set according to the climatology (AFGL 2 – mid-latitude summer atmosphere).



# Preprocessing: Example on THORPEX dataset

1. Select among the 286 spectra, those that are not contaminated by cloud.
  - Remains 192 similar spectra, with an  $STD < 0.5K$
2. Atmospheric profiles are extended to SHIS observing altitude by merging the top with the profiles measured at Lihue ground-based station.
3. Concentrations in CO<sub>2</sub>, N<sub>2</sub>O and CH<sub>4</sub> are taken from the daily data of the WDCGG (<http://gaw.kishou.go.jp/wdcgg/station.html?>).
4. CO set to fit the data in the range 2080-2200cm<sup>-1</sup>
5. O<sub>3</sub> taken from the climatology
6. Surface emissivity (assumed to be a constant) and skin temperature are set to fit the data.

Mean Tb between 800-900cm<sup>-1</sup> against latitude



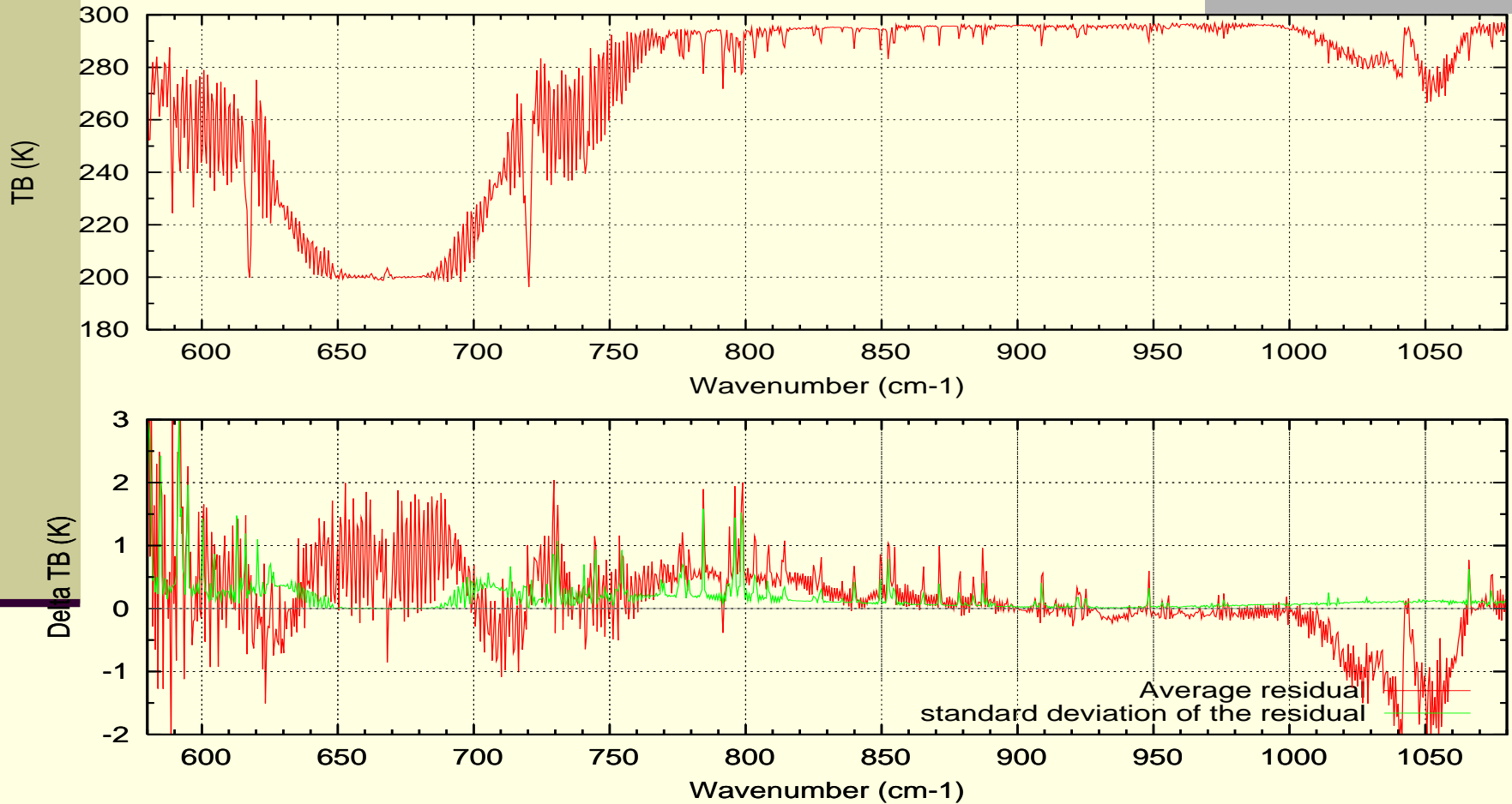
Cloud top pressure

# Upwelling Radiances

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- SHIS: THORPEX (03 March 2003)

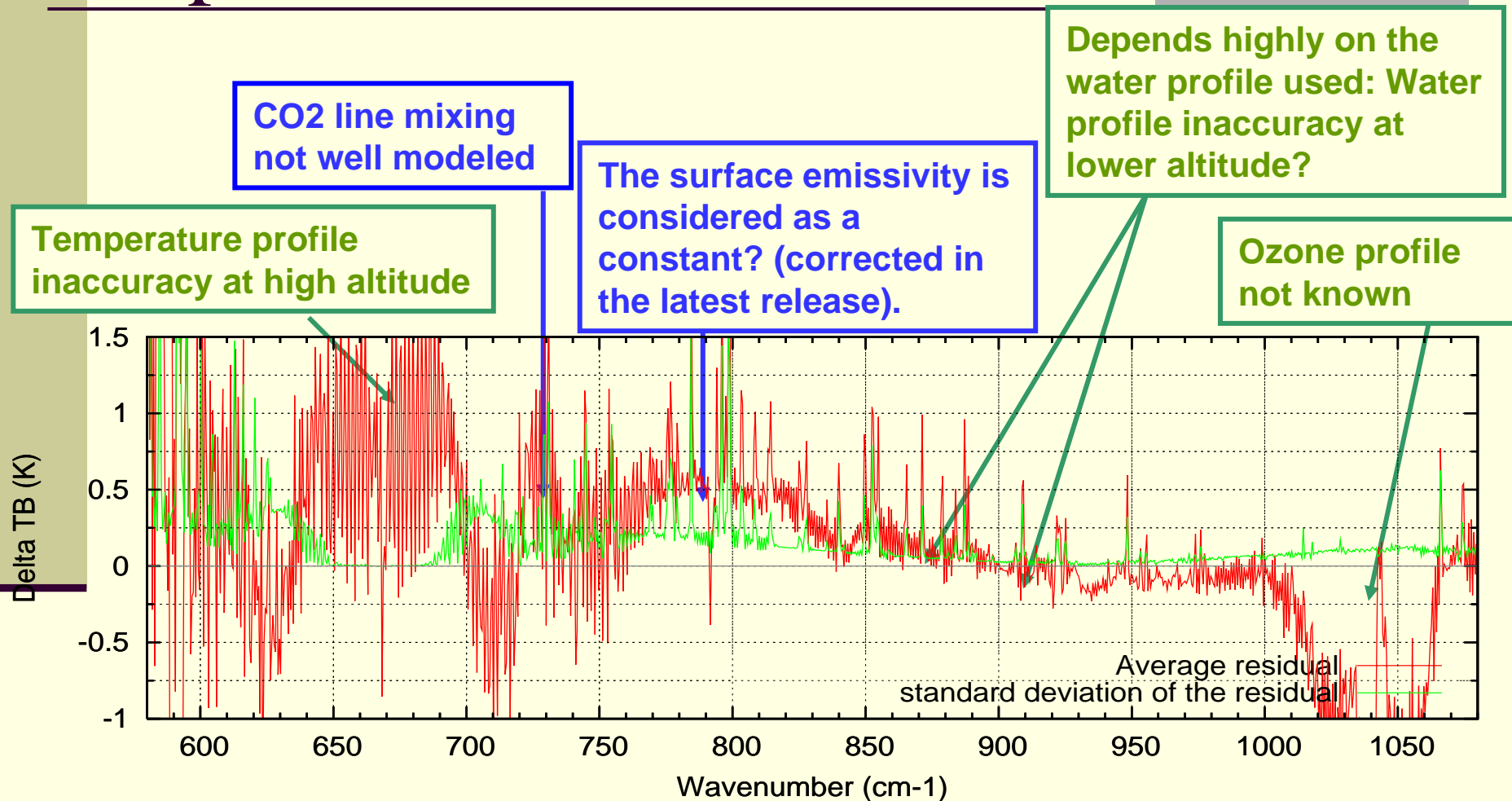
# Upwelling radiance: Comparison calc – obs: 580-1080cm<sup>-1</sup>



- Average of the 192 SHIS spectra (THORPEX data).
- Average residual obtained using 4 measured atmospheric profiles (T + H<sub>2</sub>O) + STD of the 4 residuals.

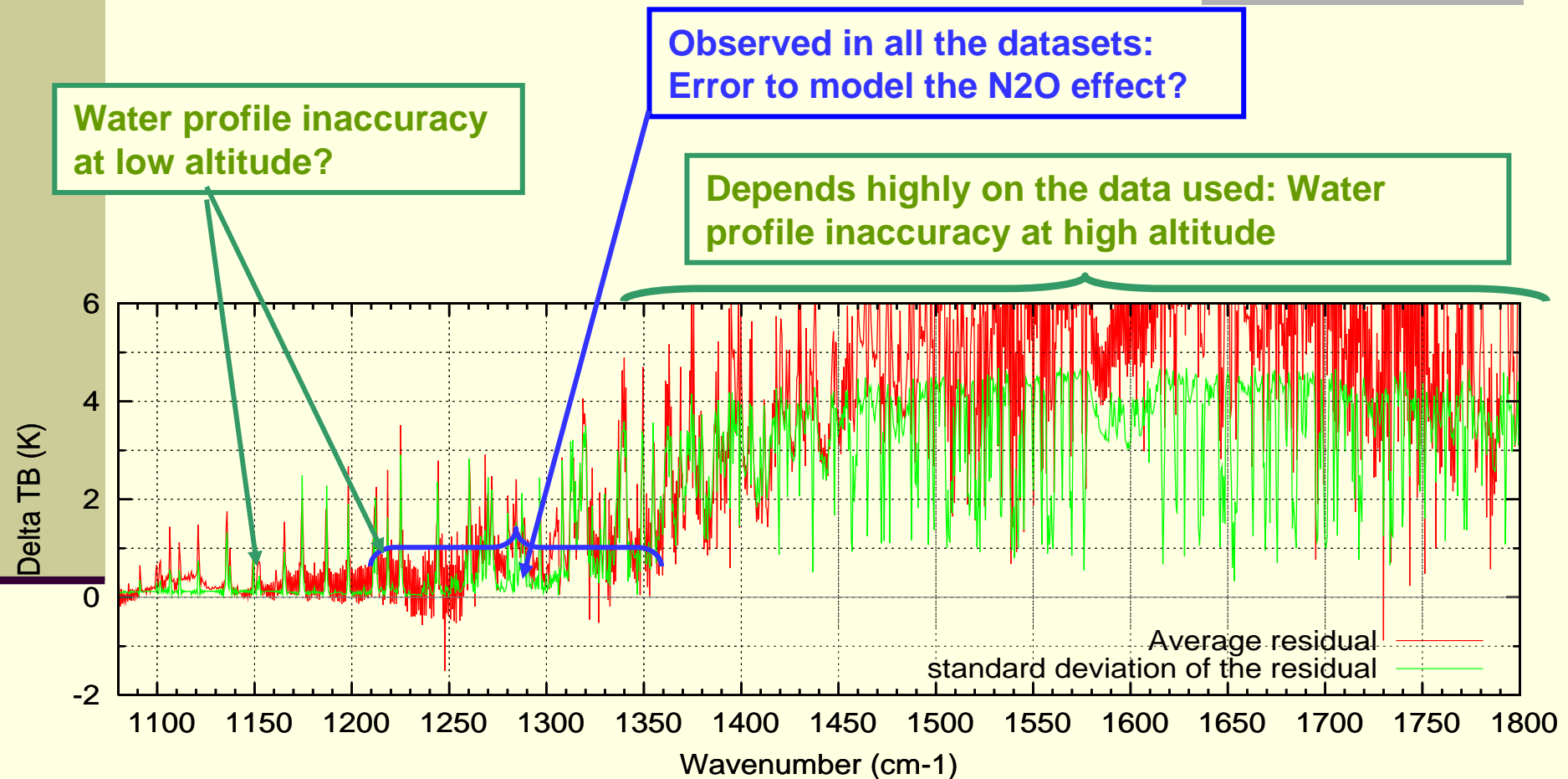
# Upwelling radiance:

## Comparison calc – obs: 580-1080 $\text{cm}^{-1}$



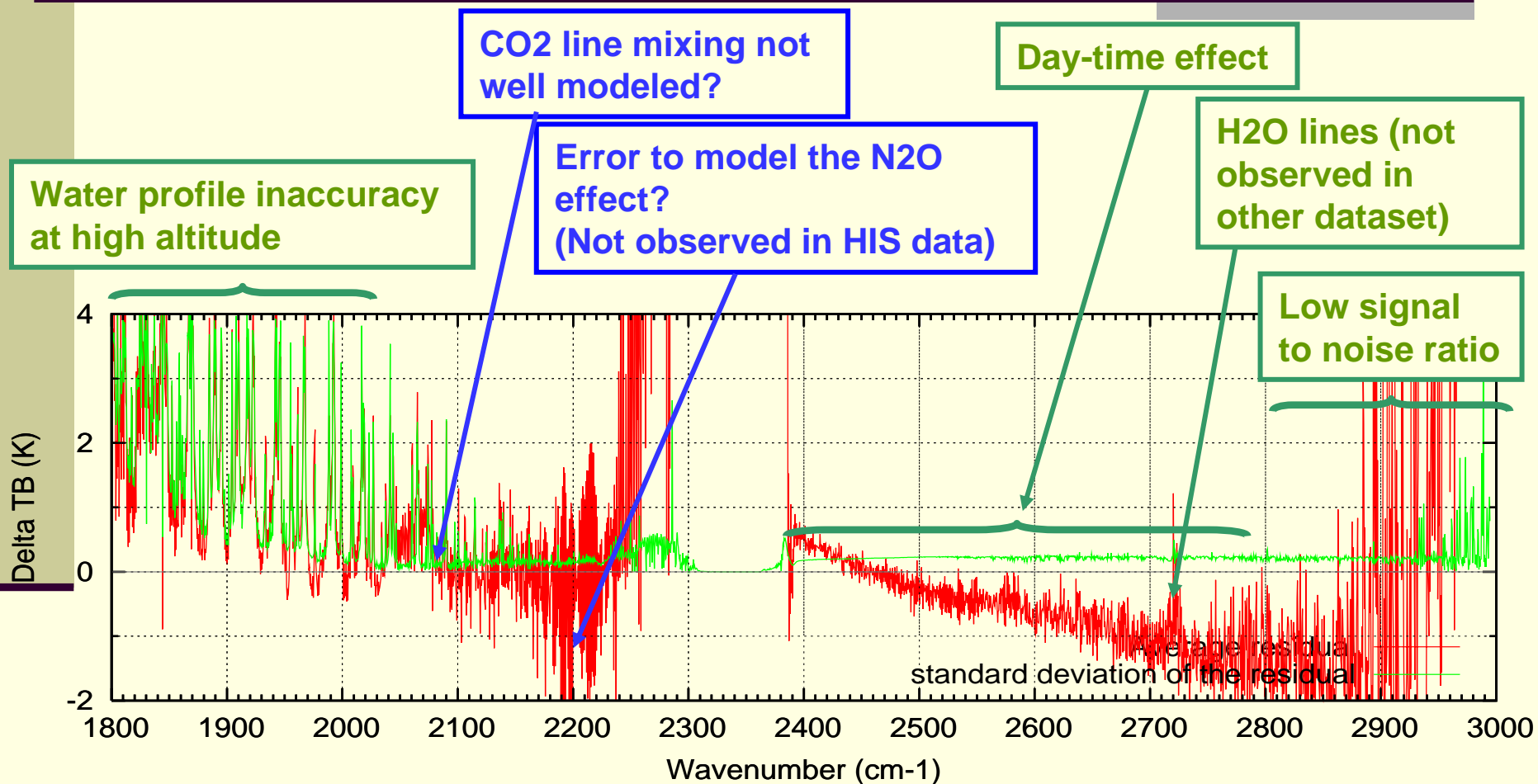
- Average residual (red) + STD of the 4 residuals (green).
- In green: error related to data; in blue: error related to the model

# Upwelling radiance: Comparison calc – obs: 1080-1800cm<sup>-1</sup>



- Average residual (red) + STD of the 4 residuals (green).
- In green: error related to data; in blue: error related to the model

# Upwelling radiance: Comparison calc – obs: 1800-3000cm<sup>-1</sup>



- Average residual (red) + STD of the 4 residuals (green).
- In green: error related to data; in blue: error related to the model



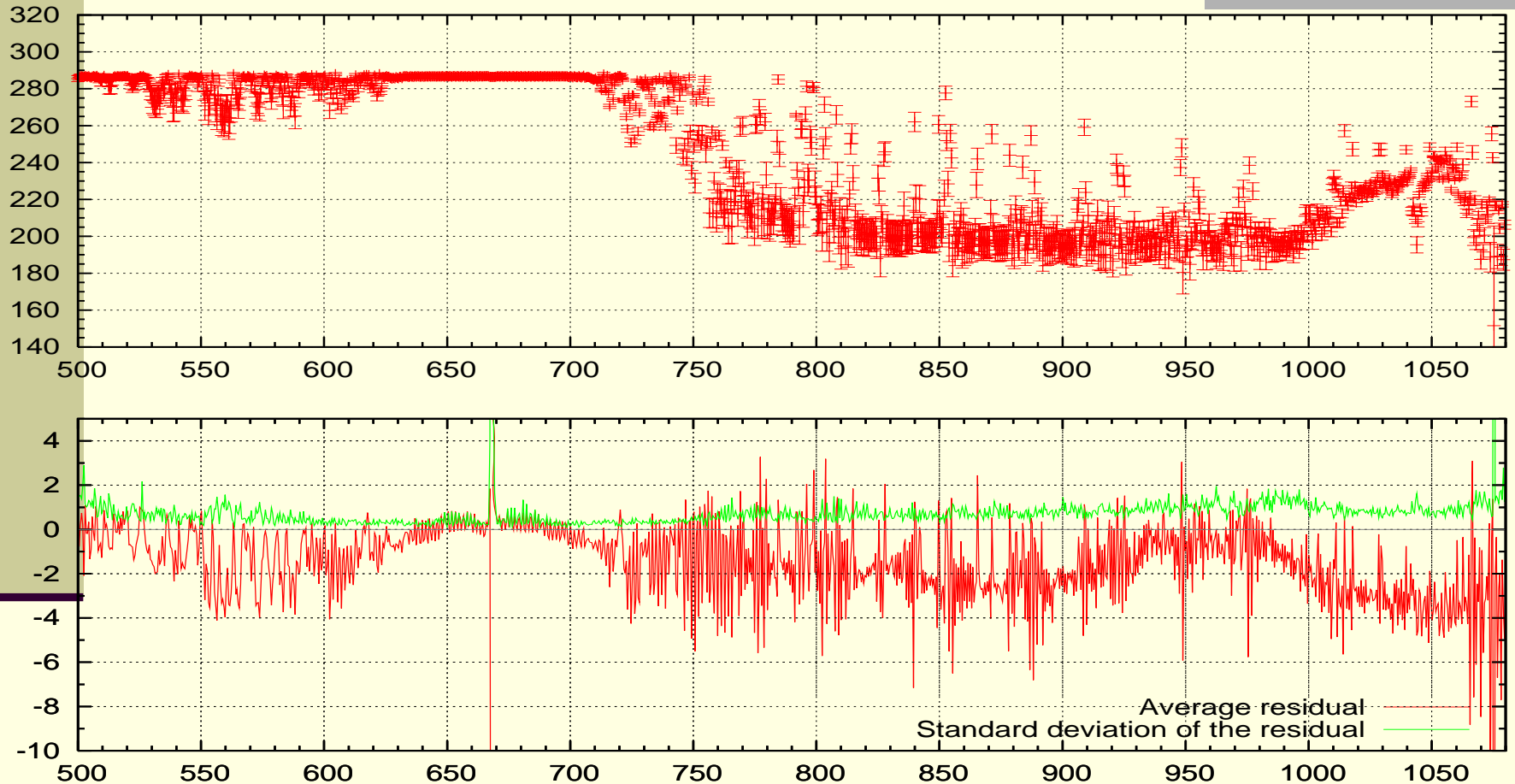
# Downwelling Radiances

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- BOMEM: EAQUATE, Italy (September 2004)

# Downwelling radiance:

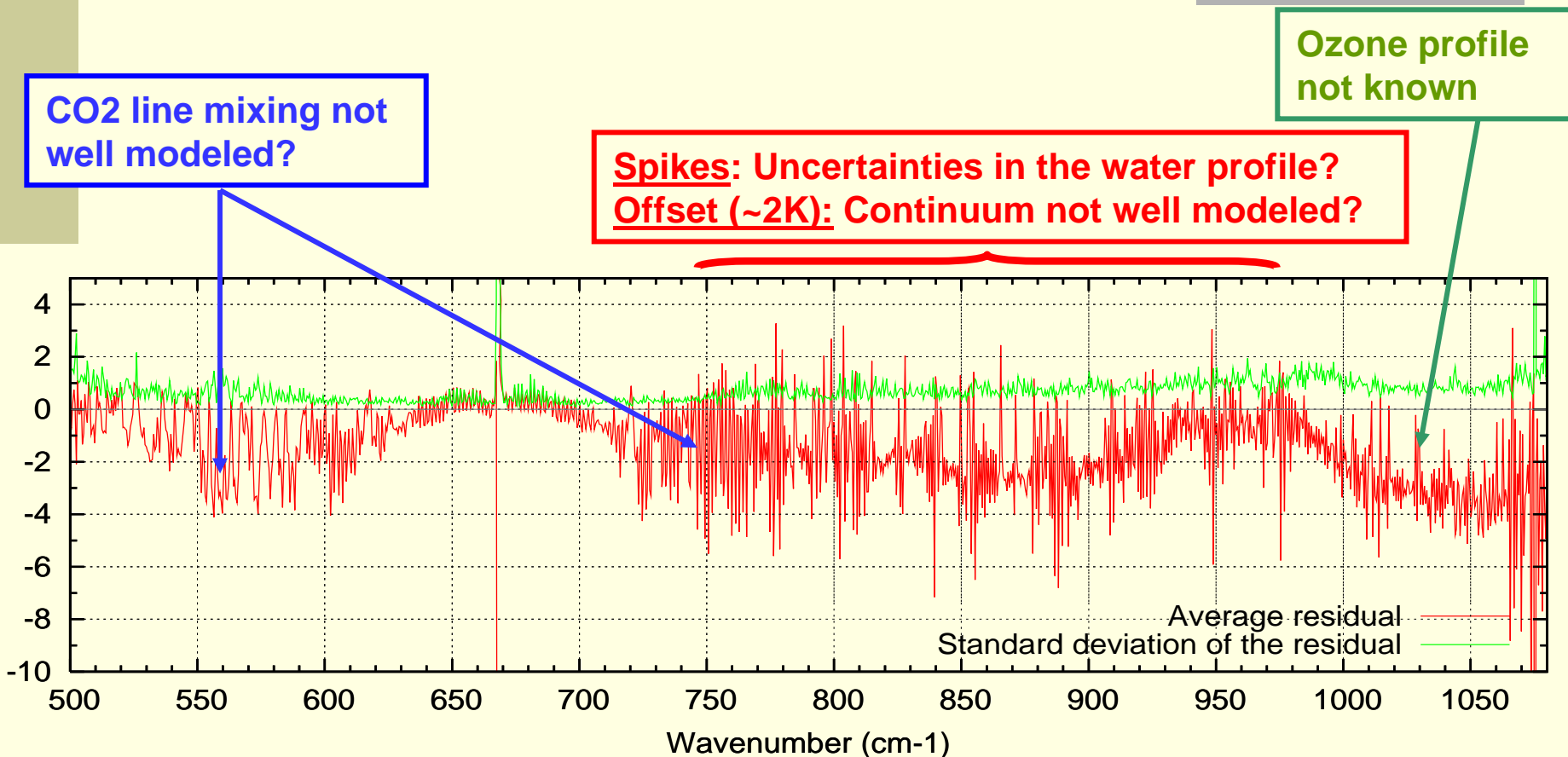
## Comparison calc – obs : 600-1080 $\text{cm}^{-1}$



- Average of the 38 EAQUATE/BOMEM spectra, Italy Sept 2004
- Average residual obtained using the 38 measured atmospheric profiles (T + H<sub>2</sub>O) + STD on the 38 residuals.

# Downwelling radiance:

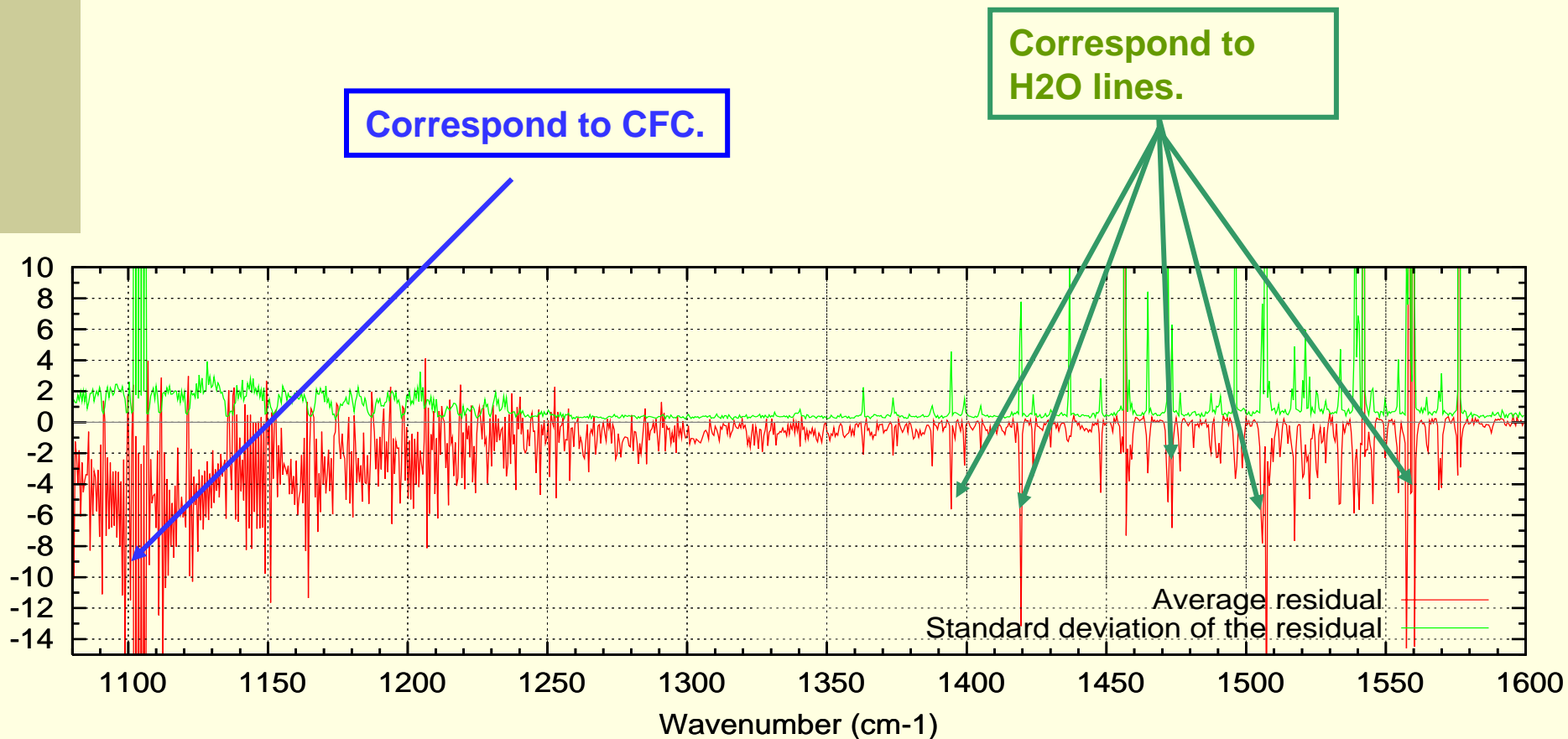
## Comparison calc – obs : 600-1080cm<sup>-1</sup>



- Average residual (red) + STD of the 38 residuals (green).
- In green: error related to data; in blue: error related to the model; in red: source of error not clear.

# Downwelling radiance:

## Comparison calc – obs : 1080-1800cm<sup>-1</sup>



- Average residual (red) + STD of the 38 residuals (green).
- In green: error related to data; in blue: error related to the model.

# Summary

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- Globally low residuals, especially in case of upwelling radiance (atmosphere need to be well known at very high altitude for the downwelling radiance).
- Very difficult to associate good radiometric measurements with a good knowledge of the thermodynamical parameters :
  - atmospheric profile (Temperature and water vapor, O<sub>3</sub>, N<sub>2</sub>O, CO, CH<sub>4</sub>, CFCs)
  - surface properties (emissivity and surface temperature)

# Perspectives

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- New improvements are already added :
  - Introduction of the solar contribution
  - Surface emissivity can vary with wavenumber
  - Introduction of aerosol contribution (under development)
  - Limb view geometry
- Or in progress :
  - CO<sub>2</sub> spectral line shapes have to be improved (especially in the range 700-780cm<sup>-1</sup>).  
Line mixing in CO<sub>2</sub> P/R branches is currently introduced in the model (hartmann, priv. comm. 2006)
  - Improve climatology of CO, CFCs, etc.
- Since early 2000, latest releases of 4A are maintained by Noveltis (4A/OP2006 available under request on <http://www.noveltis.net/4AOP/> )  
→ *See poster session, Thursday, 13h-14h30*

International TOVS Study Conference, 15<sup>th</sup>, ITSC-15, Maratea, Italy, 4-10 October 2006  
Madison, WI, University of Wisconsin-Madison, Space Science and Engineering Center,  
Cooperative Institute for Meteorological Satellite Studies, 2006.