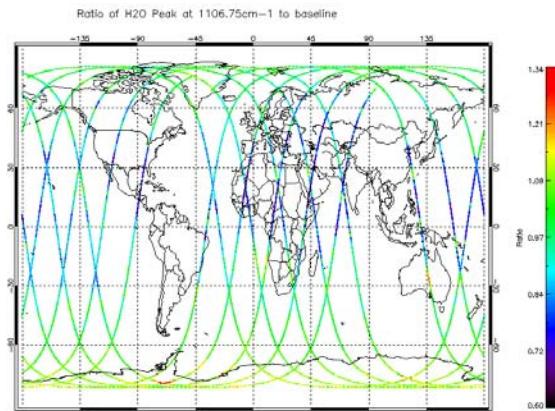
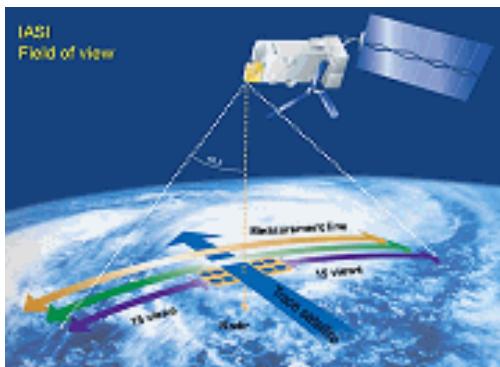
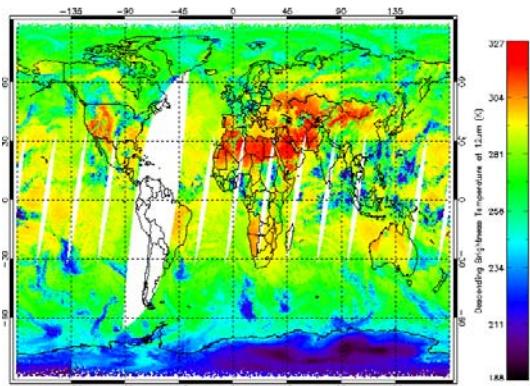




## Signatures of Atmospheric and Surface Climate Variables through Analyses of Infra-red Spectra (SATSCAN-IR)

**J.J. Remedios, R.J. Parker, S. Illingworth, V. Kanawade, G. Corlett and E.J. Noyes**

**EOS-SRC, Physics and Astronomy, University of Leicester, U.K.**





# Structure of the talk

- 1. Objectives of SATSCAN-IR**
- 2. Spectral signatures in IASI data**
- 3. Global radiative signatures**
- 4. Radiative inter-calibration for climate: AATSR vs IASI**
- 5. Reference Atmospheres for MIPAS (IASI)**
- 6. Summary**



## Objectives of SATSCAN-IR

1. To provide internal calibration/validation information on the quality of IASI level 1 spectra
2. To verify radiative transfer modelling of entire nadir spectra
3. To identify interesting spectral features in the data and investigate both their implications for IASI data quality and for scientific exploitation

The approach builds on work developed for the Michelson Interferometer for Passive Atmospheric Sounding (MIPAS) on ENVISAT.

We seek to understand the absolute radiometric calibration for climate purposes and the sensitivity of the IASI instrument to trace gases.



## Assessing spectral signatures and sensitivity of IASI

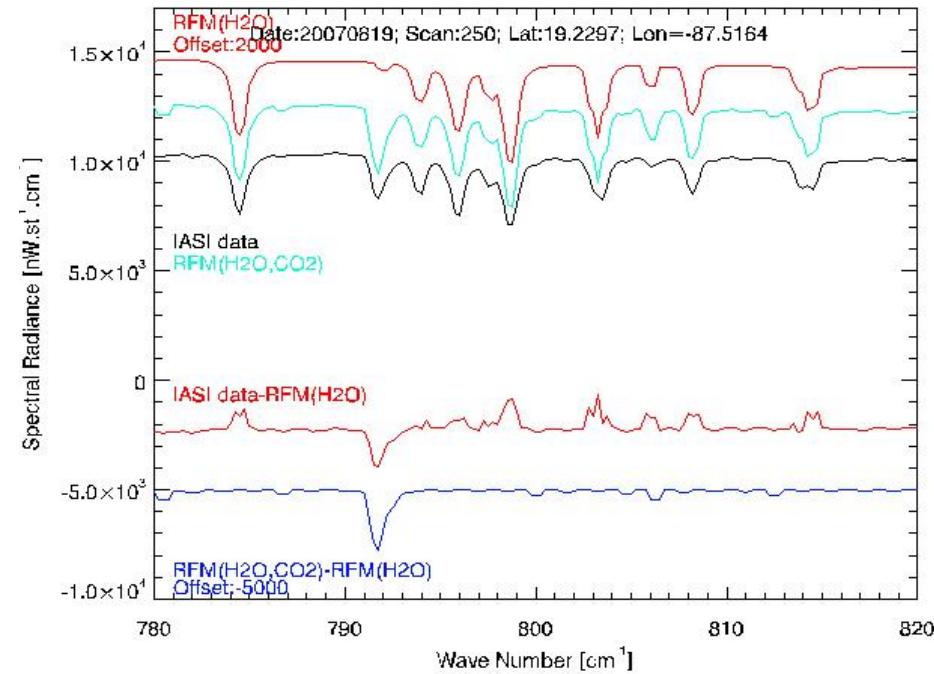
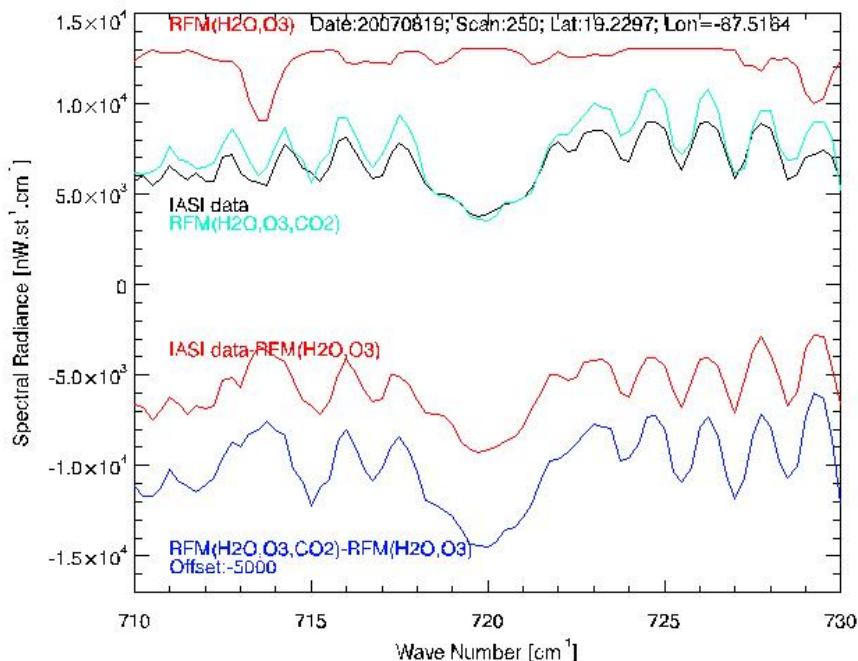
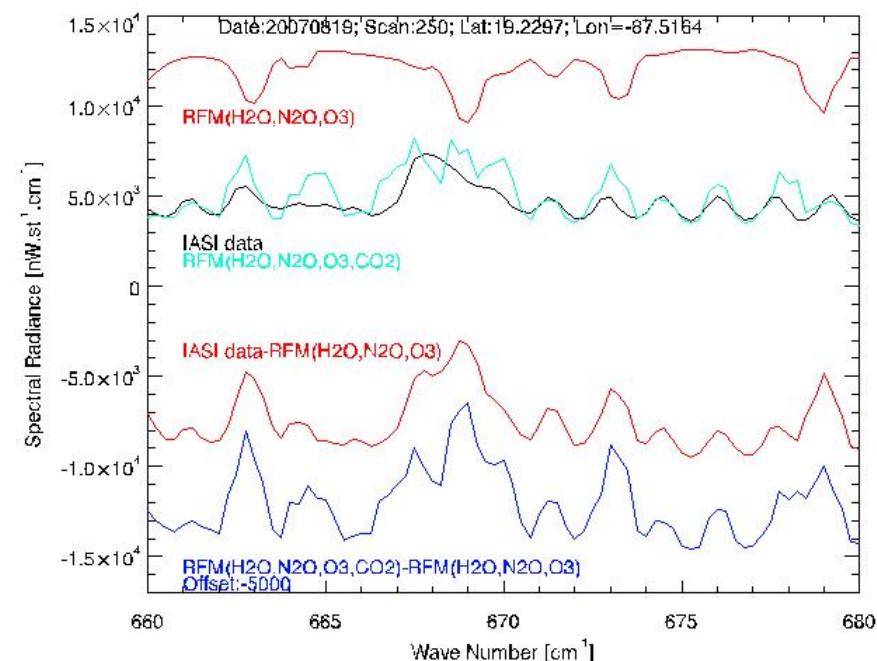
1. First assess major gases
2. Use radiative transfer modelling (one IASI spectrum so far)
  - Oxford Reference Forward Model
  - Reference atmospheres for MIPAS (standard tropical so far; simply 300 K surface with unity emissivity)
  - Full lineshape yet to be implemented (currently smoothing of 3)
  - IASI data level 1c 19/20 August 2007
3. Look at residual behaviour
  - Identification of trace gases
  - Spectroscopic behaviour
4. Looks very good.



# Signature of CO<sub>2</sub> in IASI spectra



University of  
Stern



**IASI instrument and the Oxford Reference Forward Model simulated spectra for CO<sub>2</sub>.**

**IASI vs RFM (full)**

**IASI – RFM (no X)**

**VS**

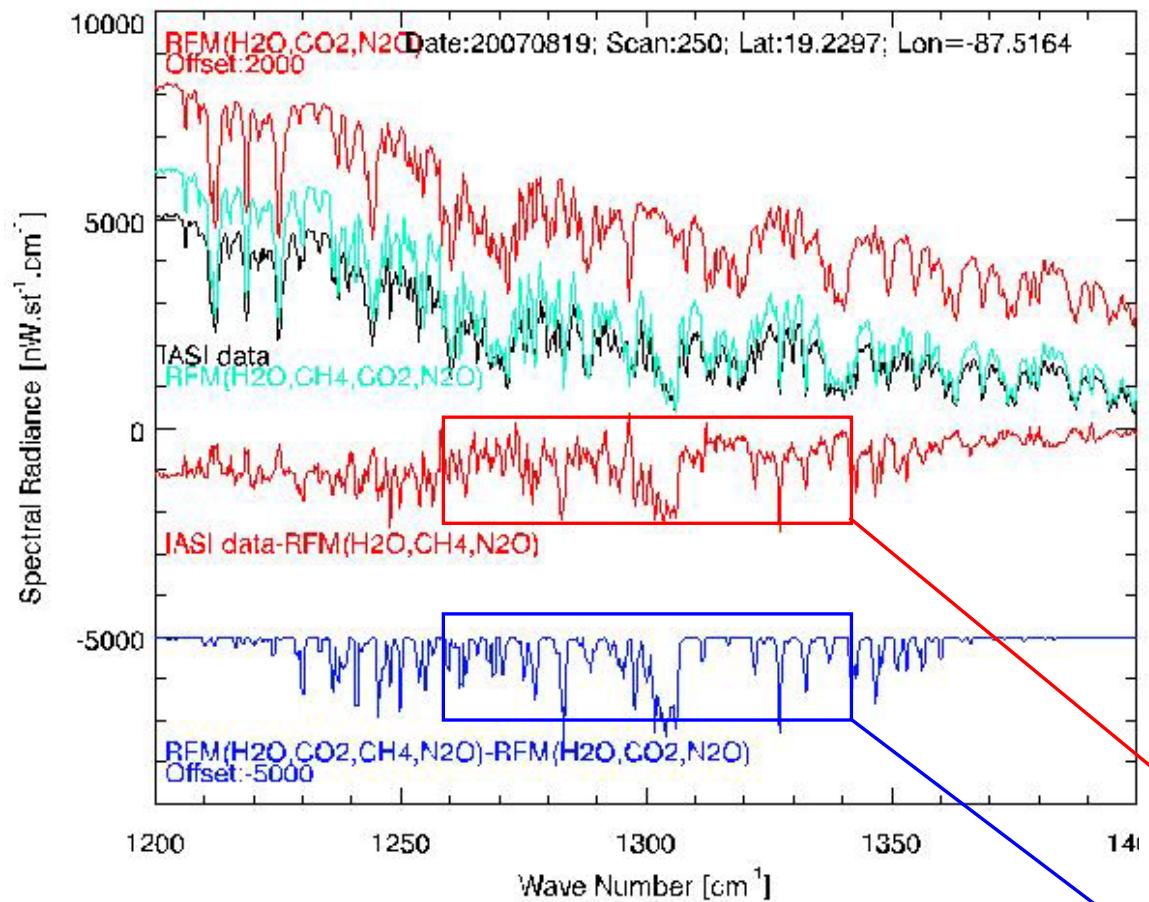
**RFM (full) - RFM (no X)**



# Signature of CH<sub>4</sub> in IASI spectra



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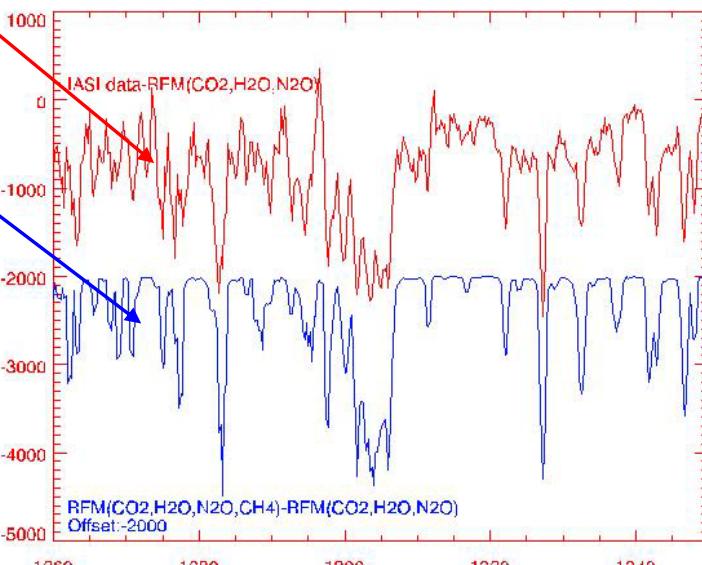


**IASI vs RFM (full)**

**IASI – RFM (no X)**

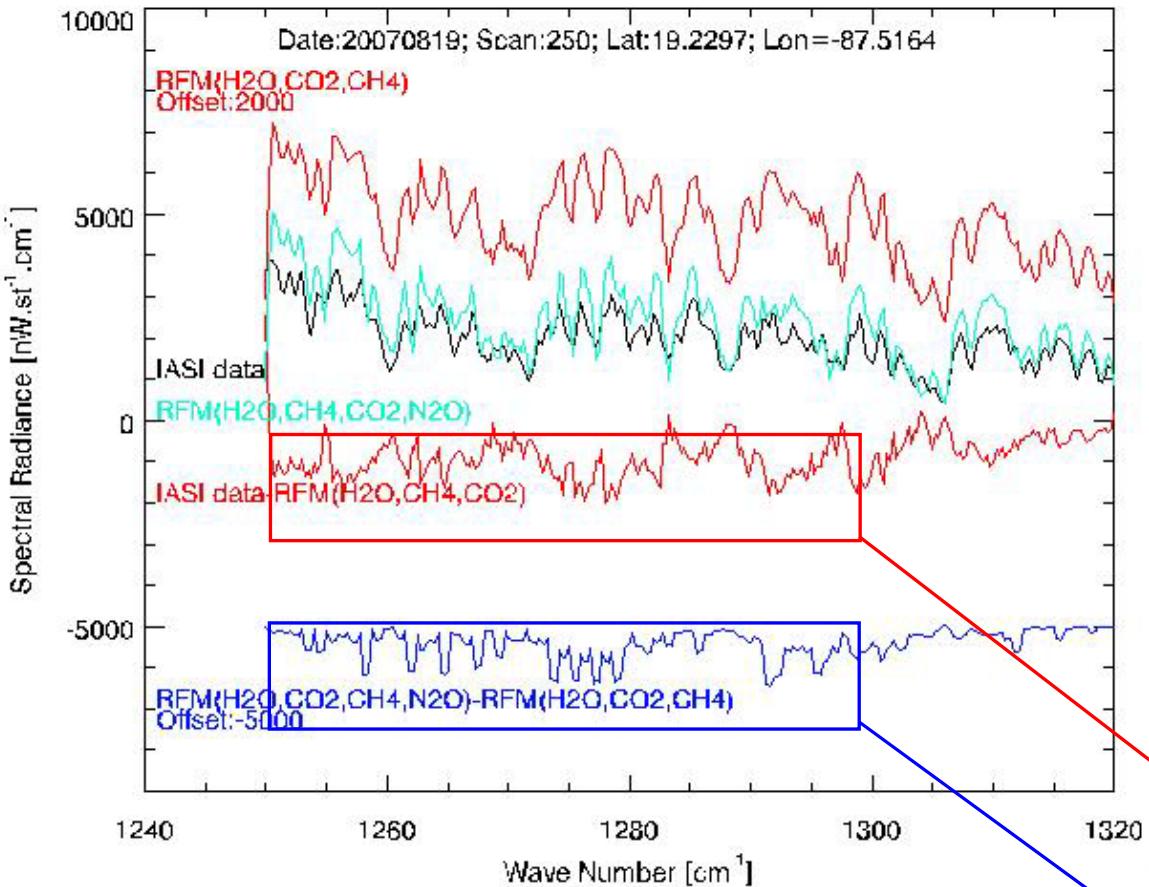
**VS**

**RFM (full) - RFM (no X)**





## Signature of N<sub>2</sub>O in IASI spectra

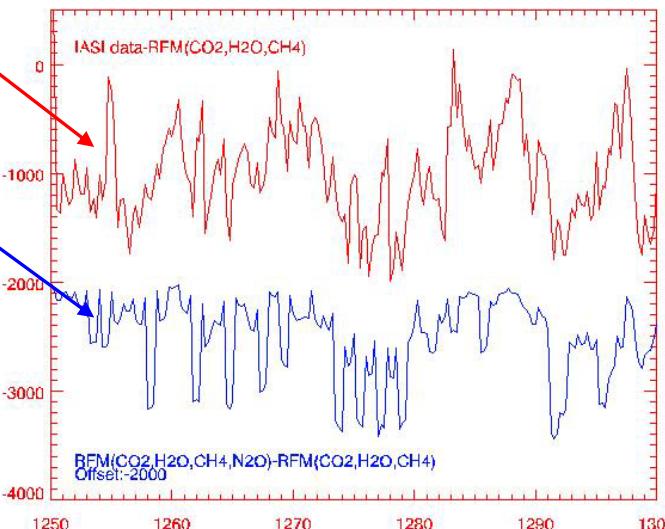


**IASI vs RFM (full)**

**IASI – RFM (no X)**

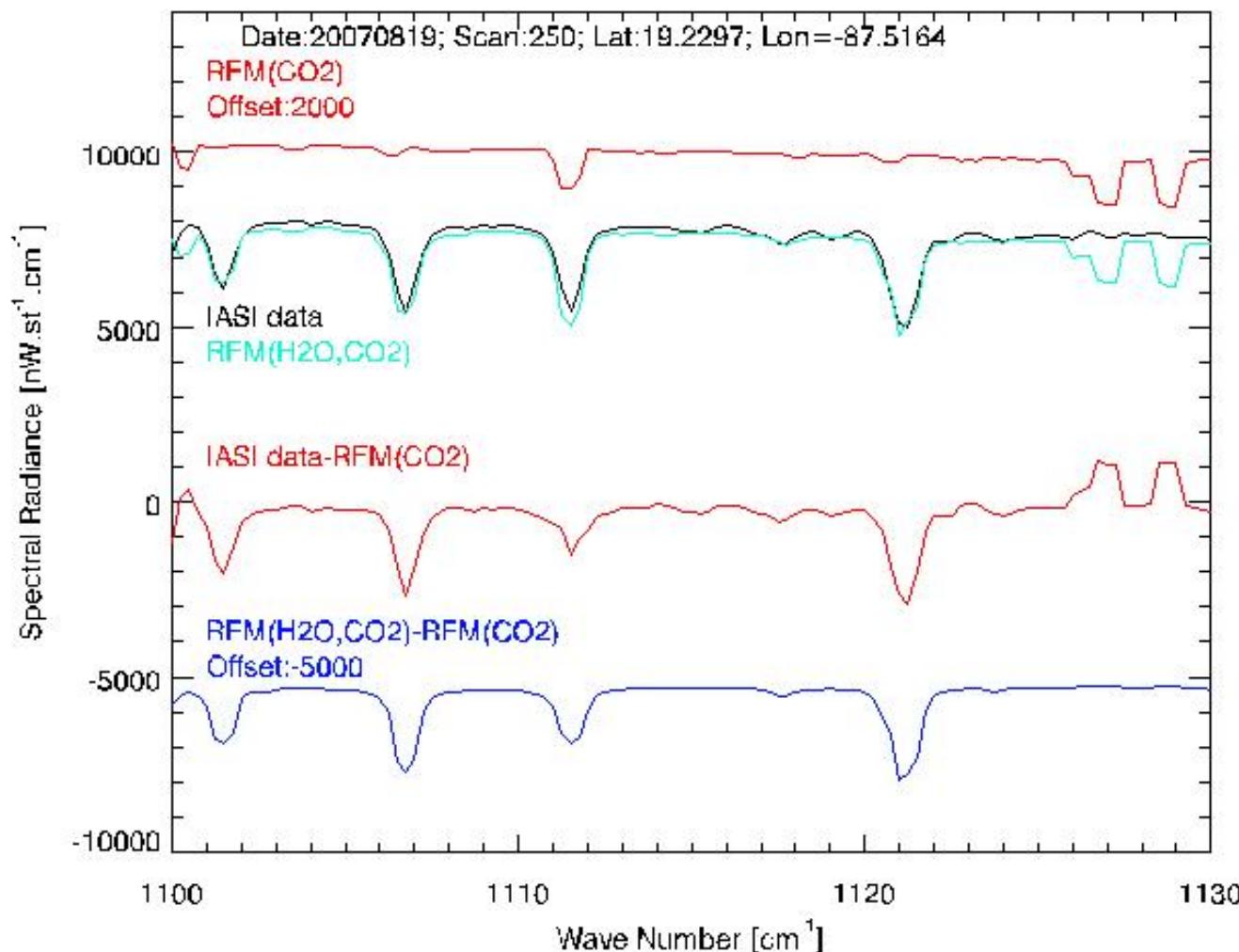
**VS**

**RFM (full) - RFM (no X)**





## Signature of H<sub>2</sub>O in IASI spectra



IASI vs RFM (full)

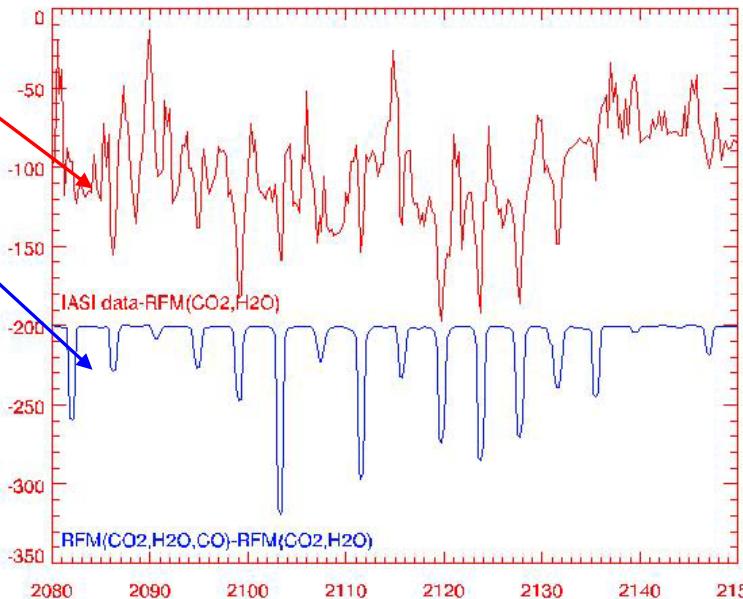
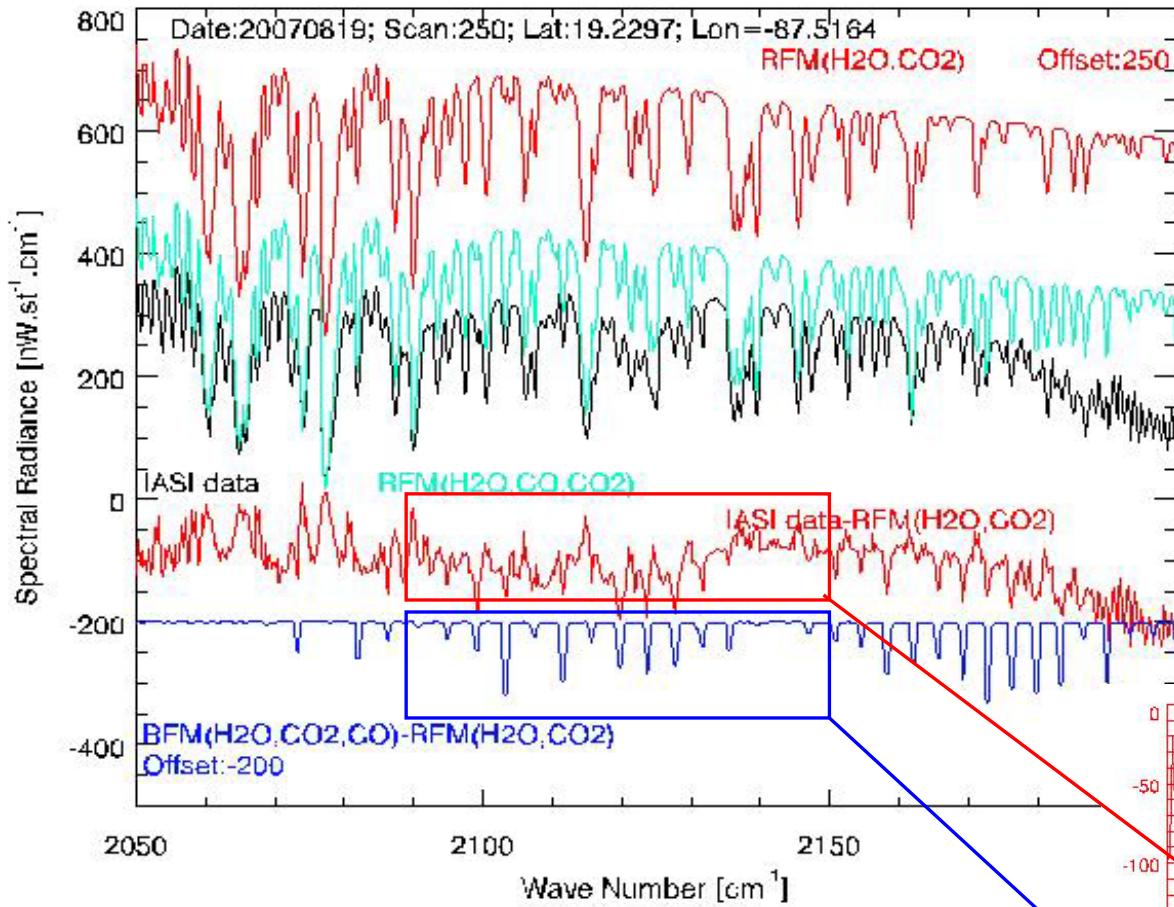
IASI – RFM (no X)

VS

RFM (full) - RFM (no X)



## Signature of CO in IASI spectra



IASI vs RFM (full)

IASI – RFM (no X)

VS

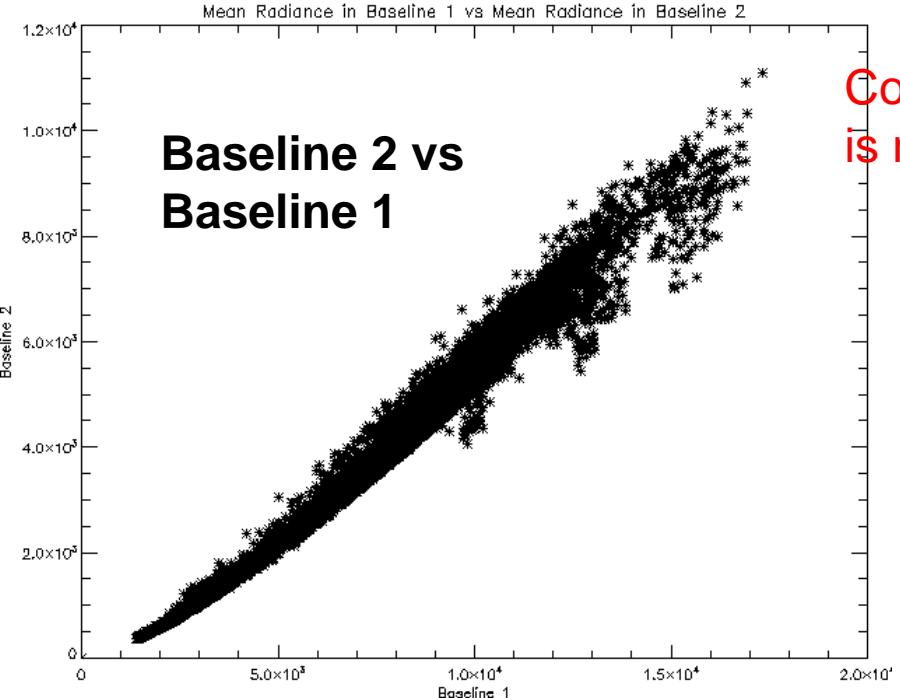
RFM (full) - RFM (no X)



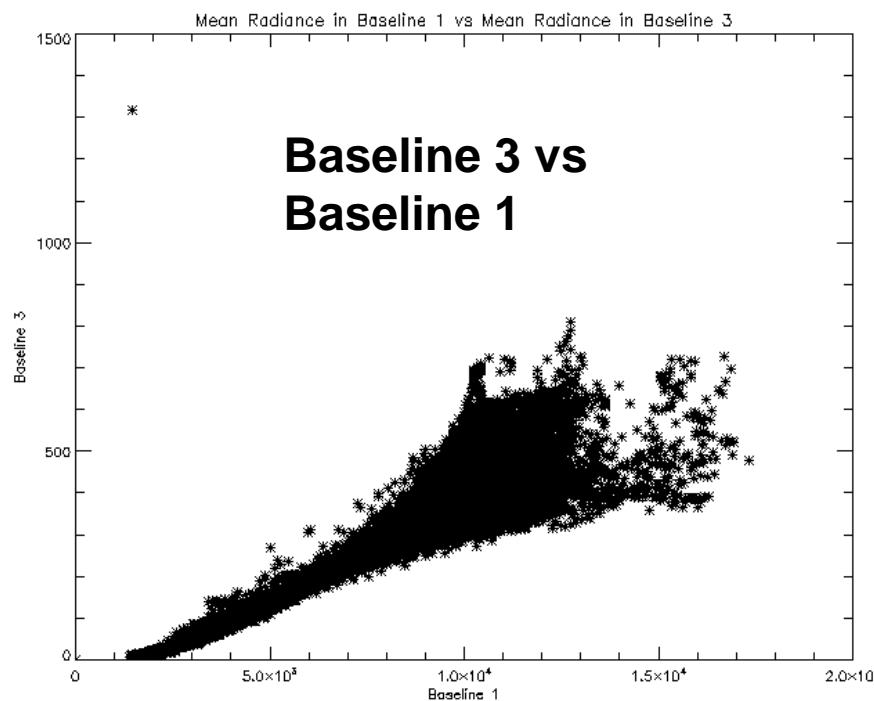
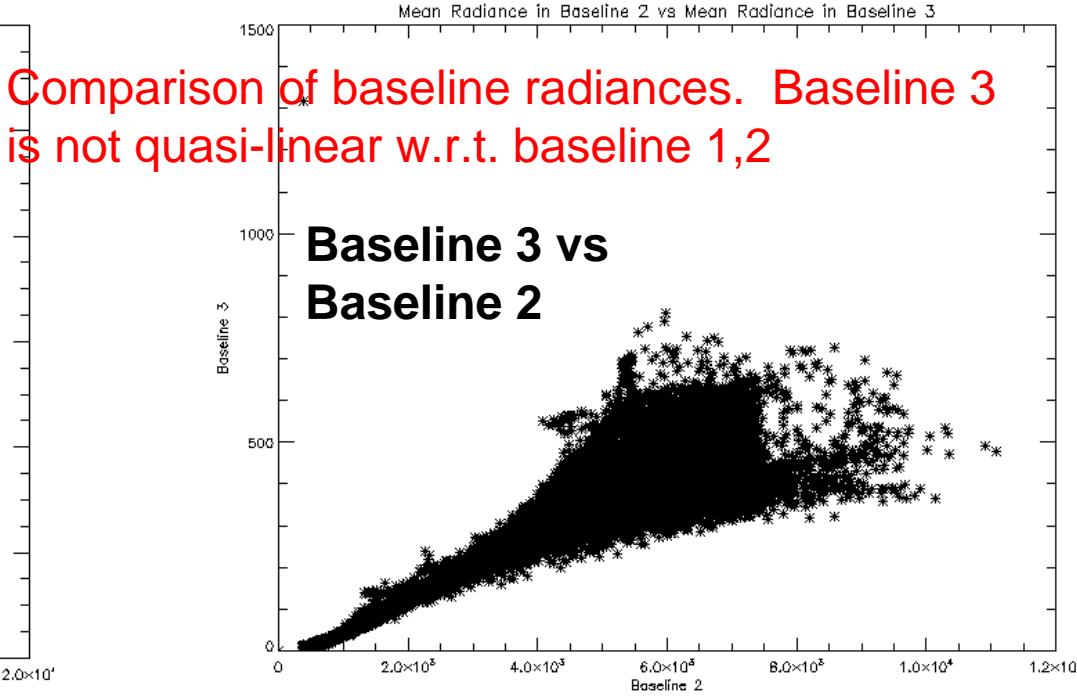
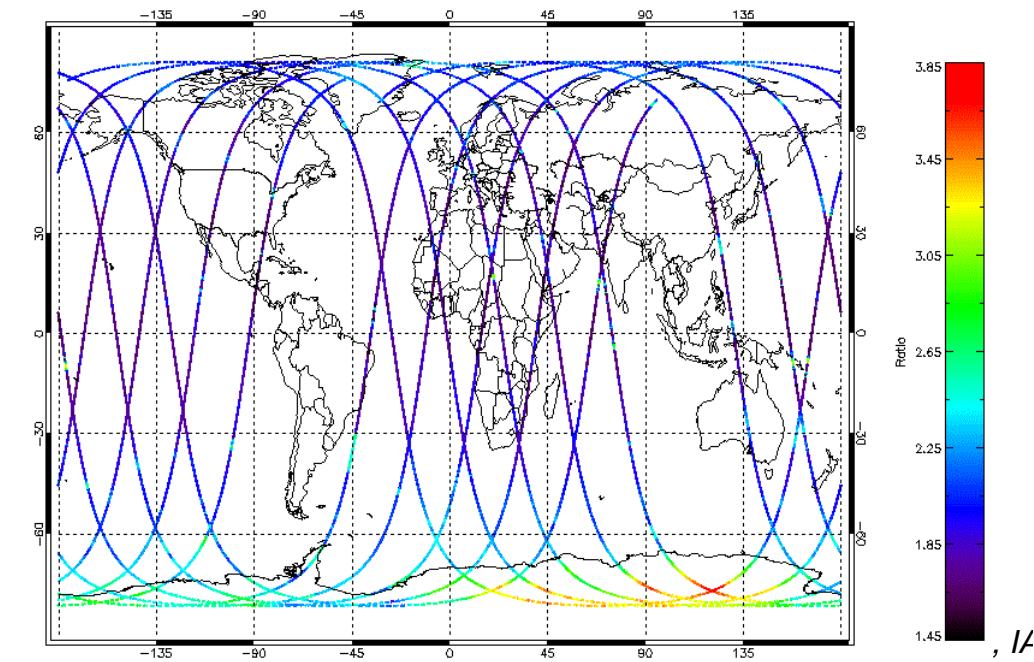
## Global radiative signatures in IASI spectra

- Select trace gas windows
- Develop “simple” indicative signal
- Here: simple ratios to baseline (more complex methods...)
- Process “along-track” pixels of IASI (19<sup>th</sup>/20<sup>th</sup> August 2007)

Gas	Label	Peak cm <sup>-1</sup>	Baseline cm <sup>-1</sup>
H <sub>2</sub> O	h2o_1	1106.75	1124-1131
H <sub>2</sub> O	h2o_2	1121.25	1124-1131
CO <sub>2</sub>	co2_1	791.75	818-823
CH <sub>4</sub>	ch4_1	1288	1124-1131
CO	co_1	2119.5	1124-1131
CO	co_2	2119.5	1857-1858

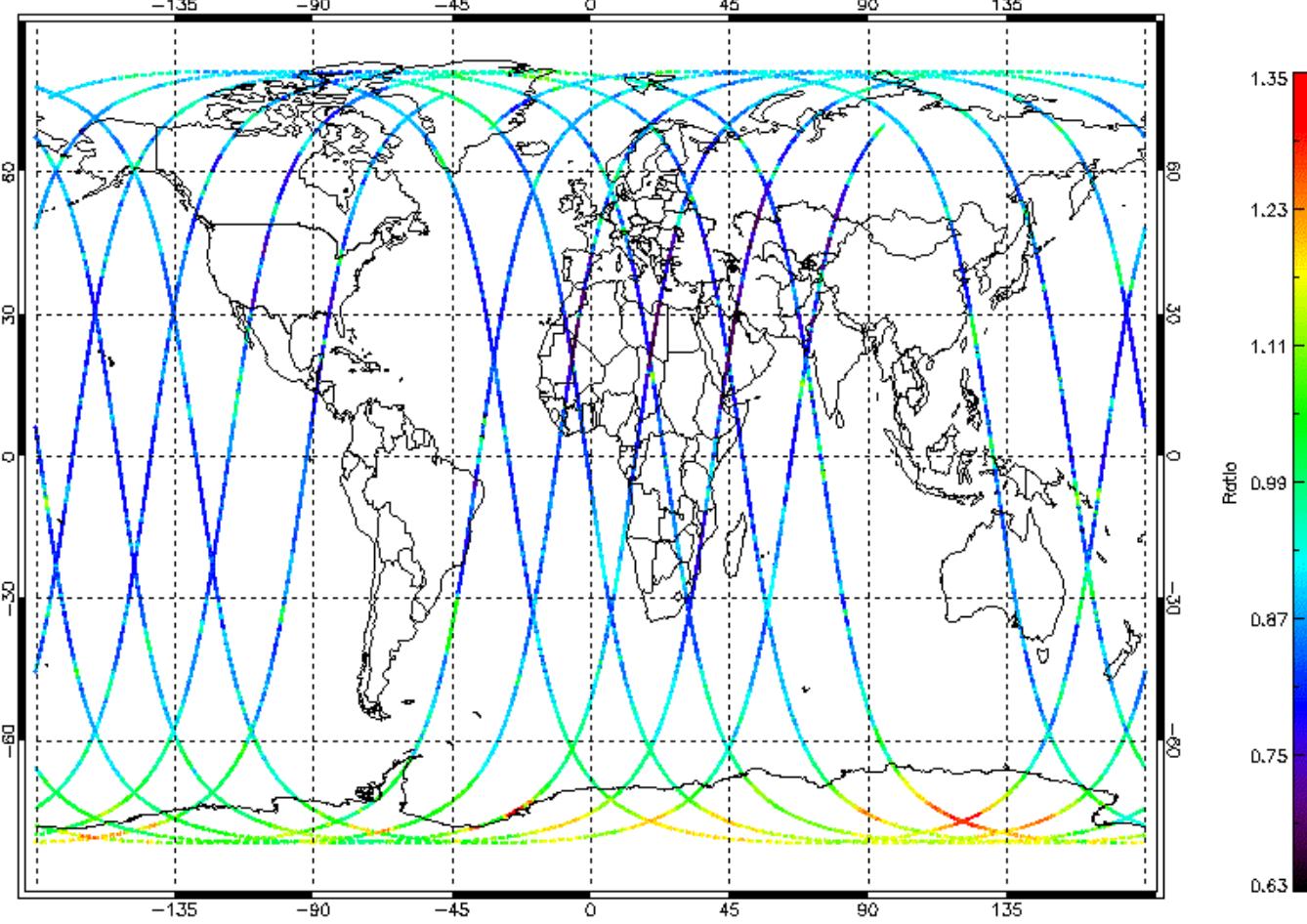


**Baseline 1 / Baseline 2**

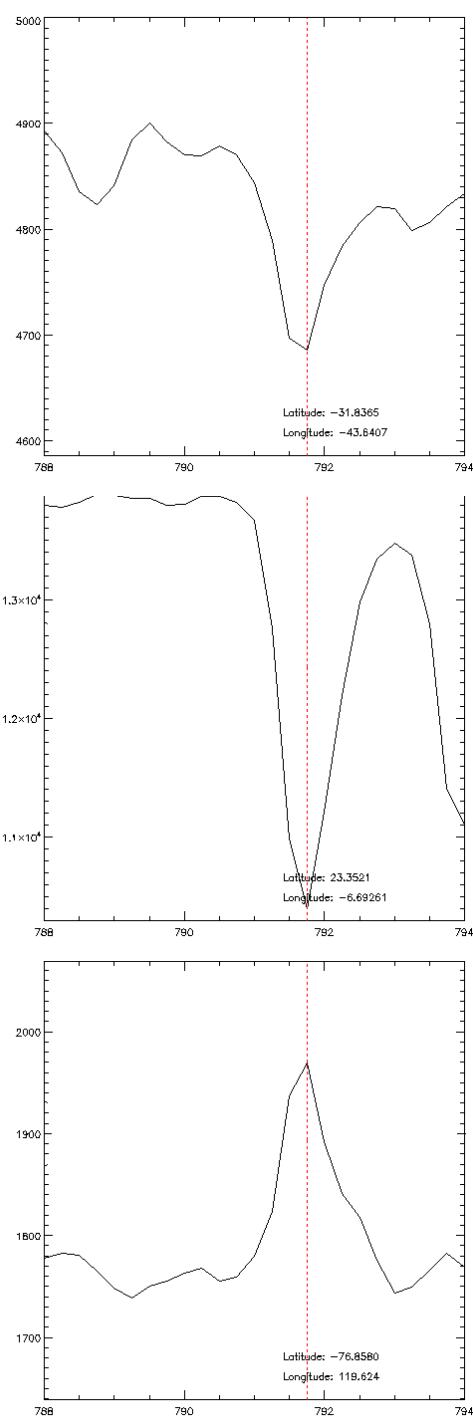


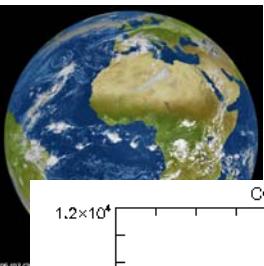
Comparison of baseline radiances. Baseline 3 is not quasi-linear w.r.t. baseline 1,2

Ratio of CO<sub>2</sub> Peak at 791.75cm<sup>-1</sup> to baseline

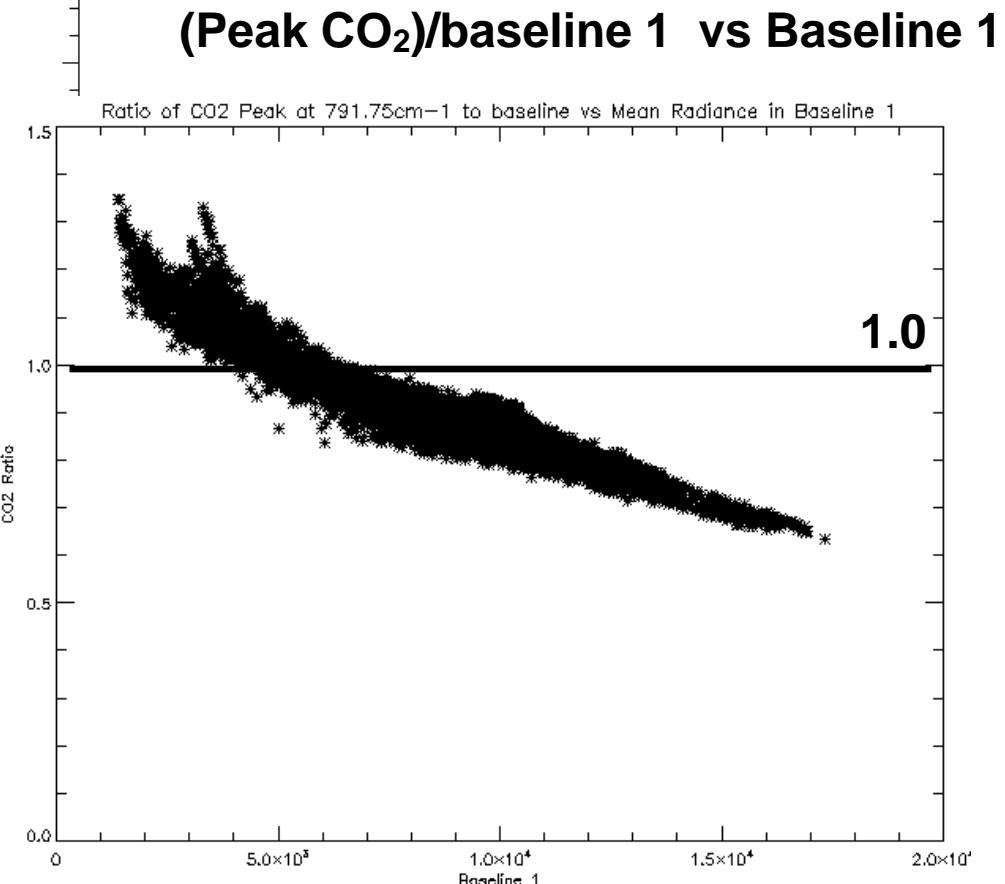
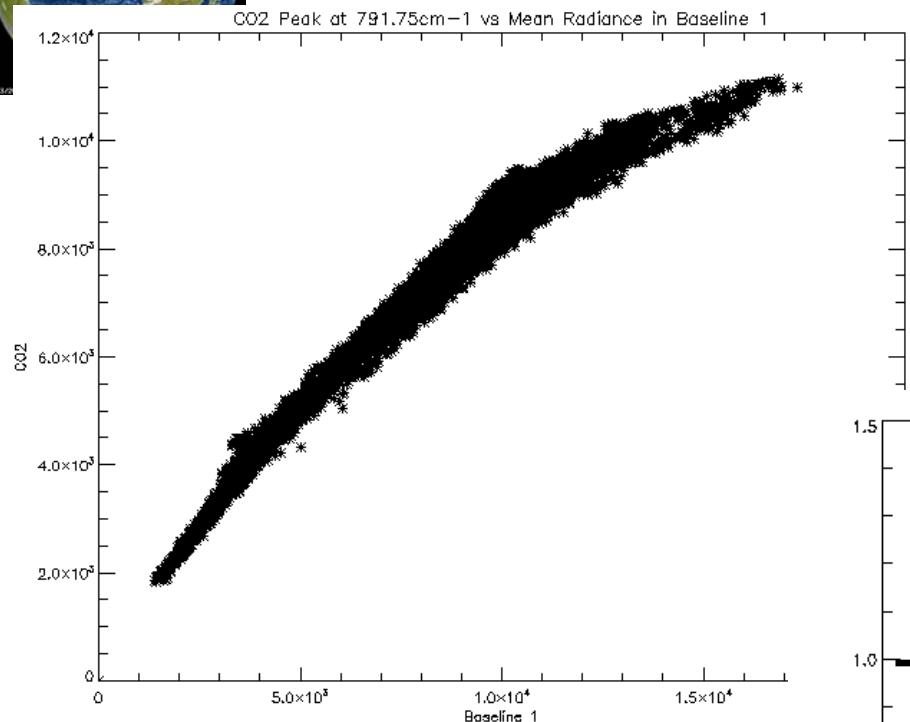


(CO<sub>2</sub> peak at 795.75 cm<sup>-1</sup>)/baseline 1

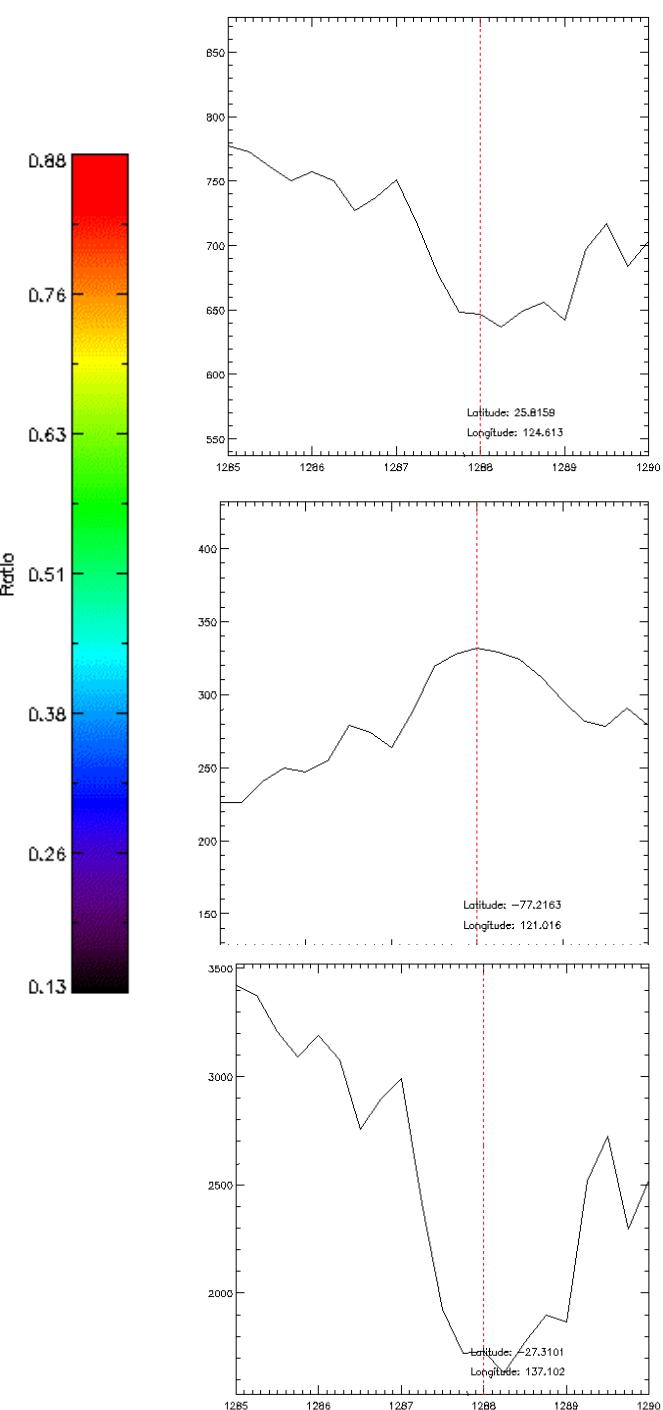
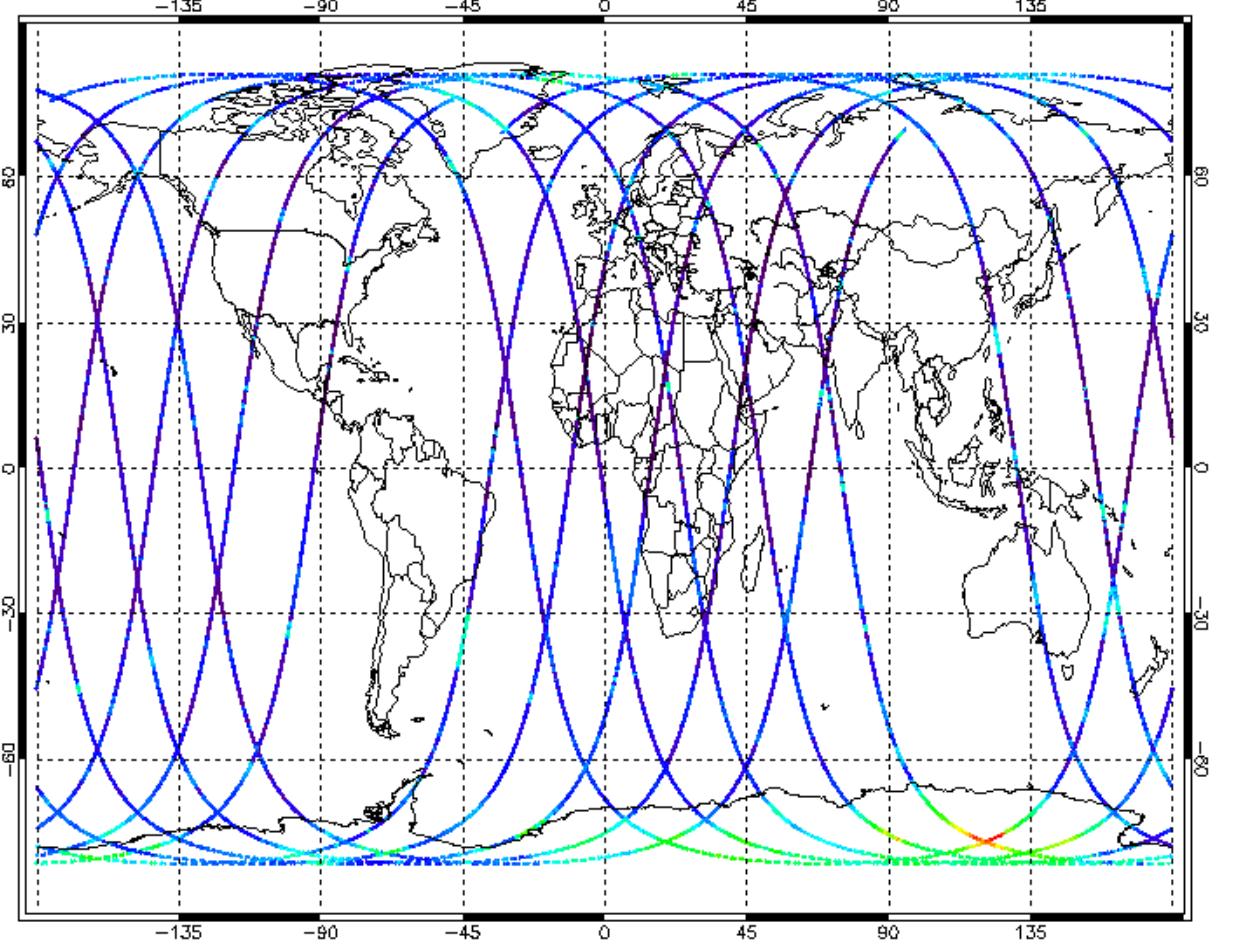




## Peak CO<sub>2</sub> radiance 795.75 cm<sup>-1</sup> versus Baseline 1



Ratio of CH<sub>4</sub> Peak at 1288.0cm<sup>-1</sup> to baseline

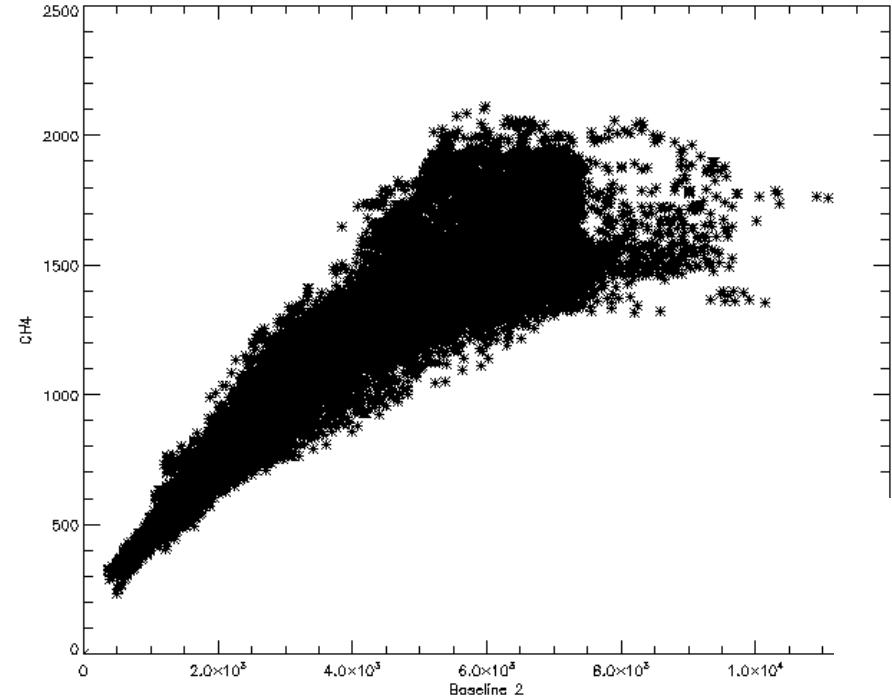


(CH<sub>4</sub> peak at 1288.0 cm<sup>-1</sup>)/baseline 2

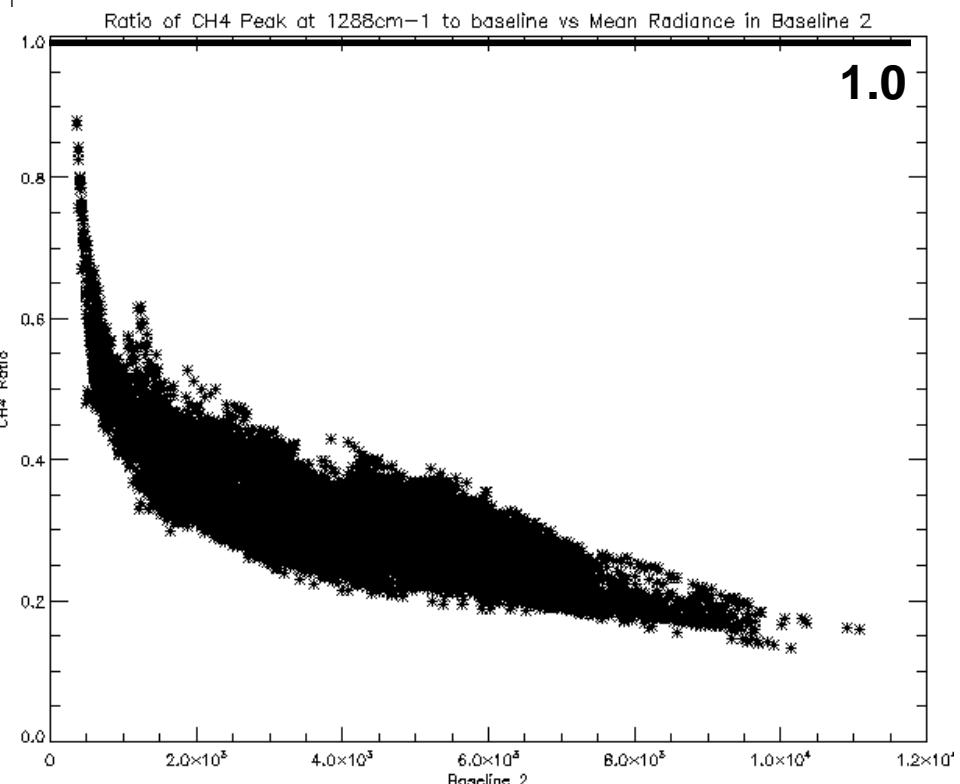


# Peak CH<sub>4</sub> radiance 1288 cm<sup>-1</sup> versus Baseline 2

CH<sub>4</sub> Peak at 1288cm<sup>-1</sup> vs Mean Radiance in Baseline 2

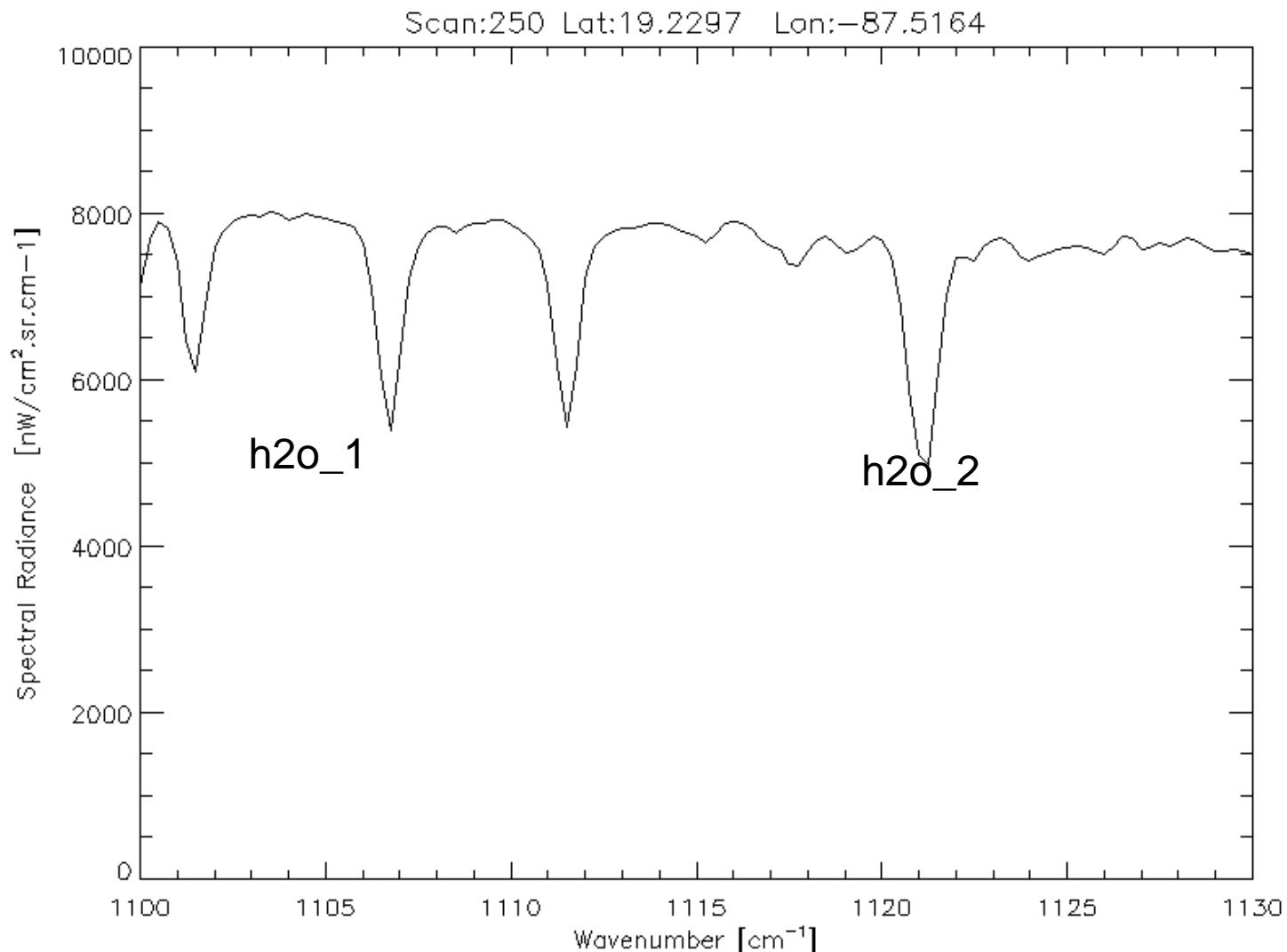


## (Peak CH<sub>4</sub>)/baseline 2 vs Baseline 2



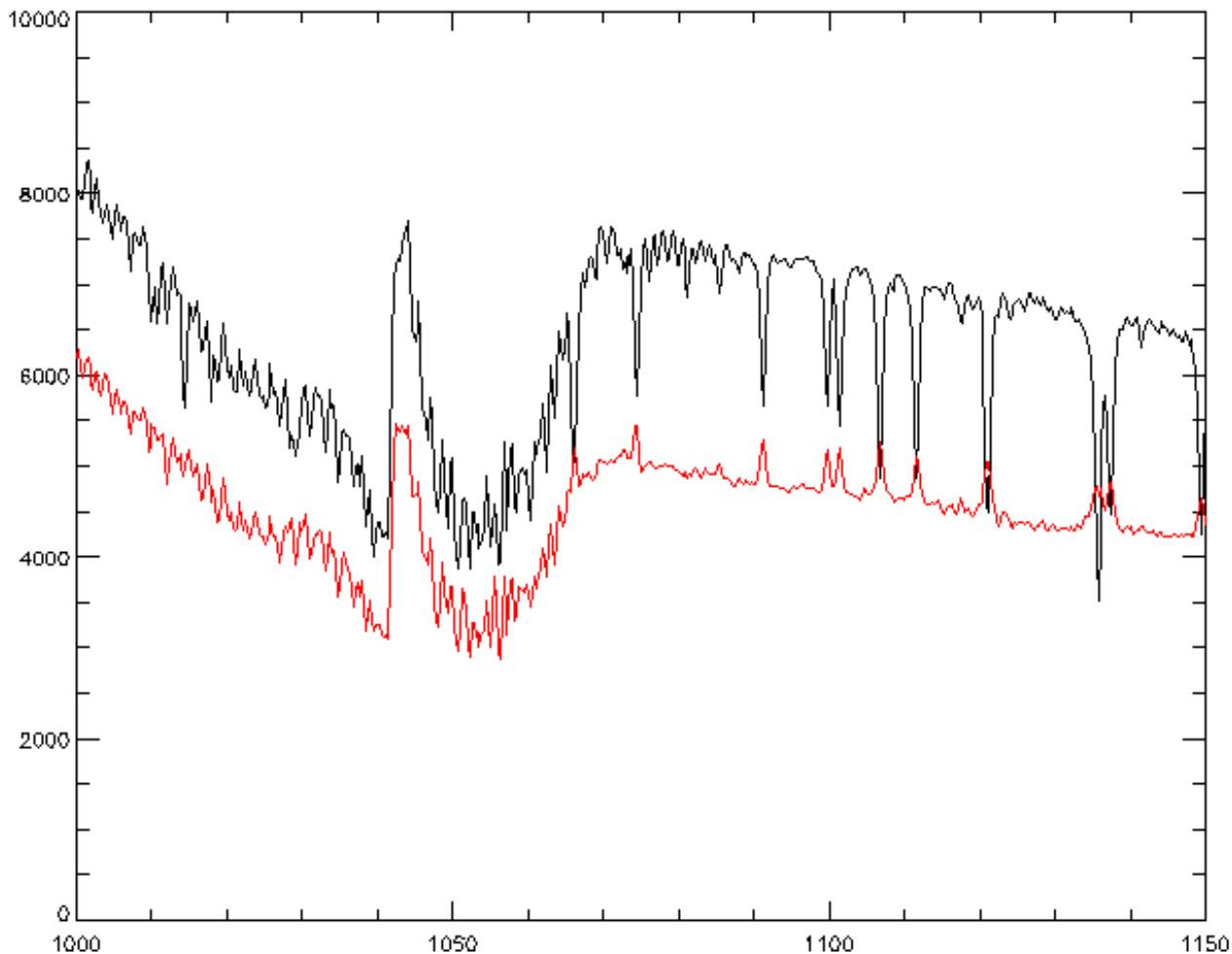


## Two H<sub>2</sub>O peaks used in this analysis

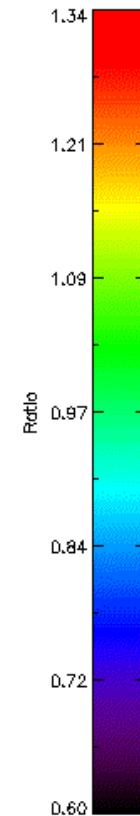
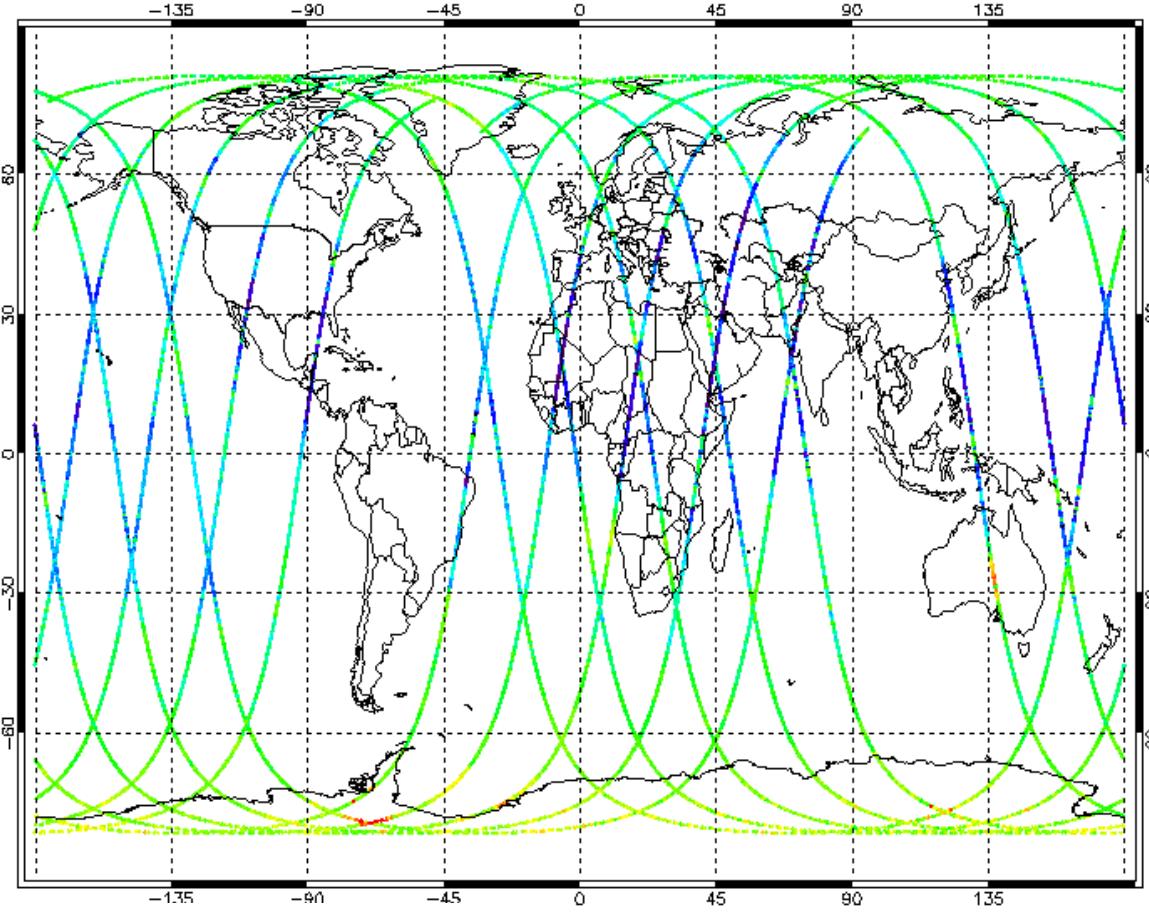




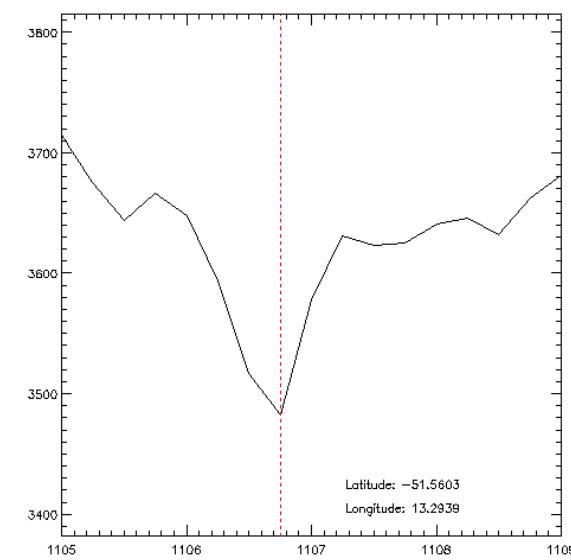
## Water vapour emission and water vapour absorption features (colder cloud, colder surface)



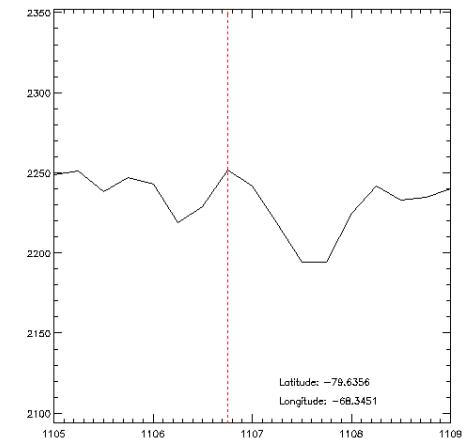
### Ratio of H<sub>2</sub>O Peak at 1106.75cm<sup>-1</sup> to baseline



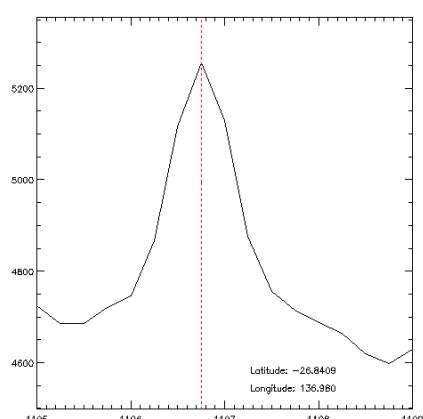
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Longitude: -3.17046



Latitude: -51.5603  
Longitude: 13.2939



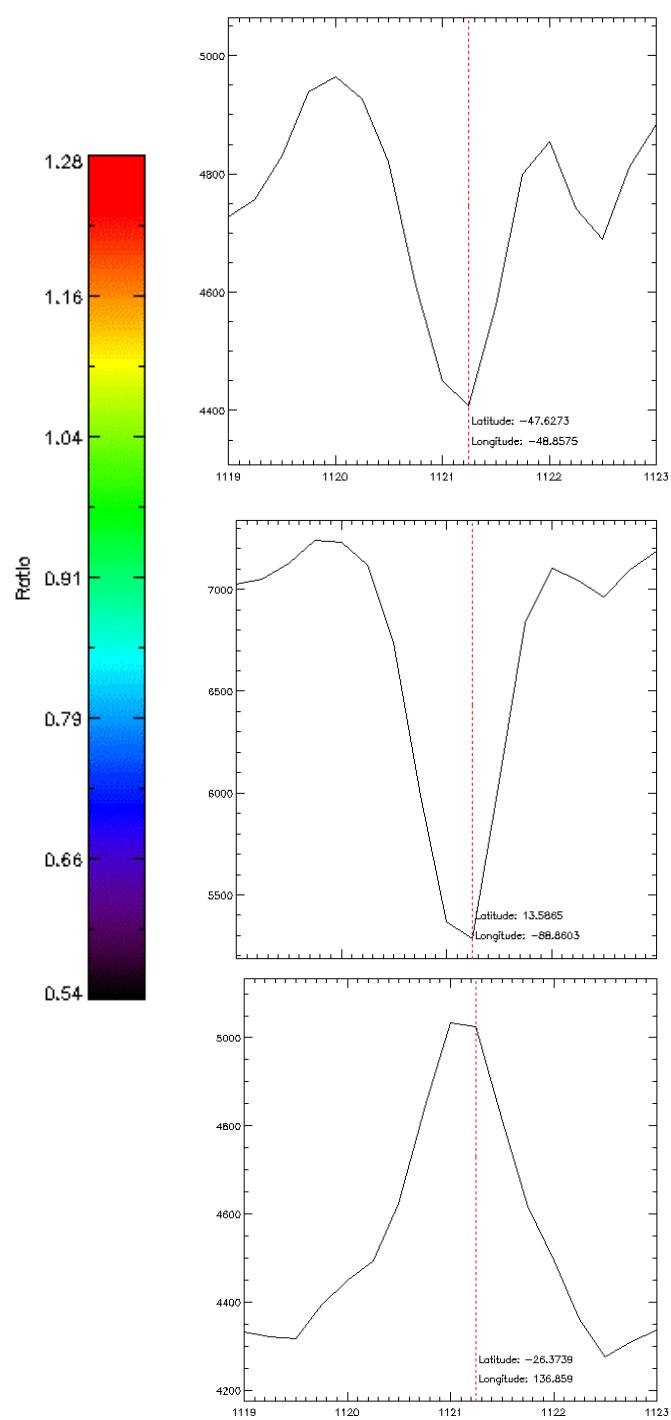
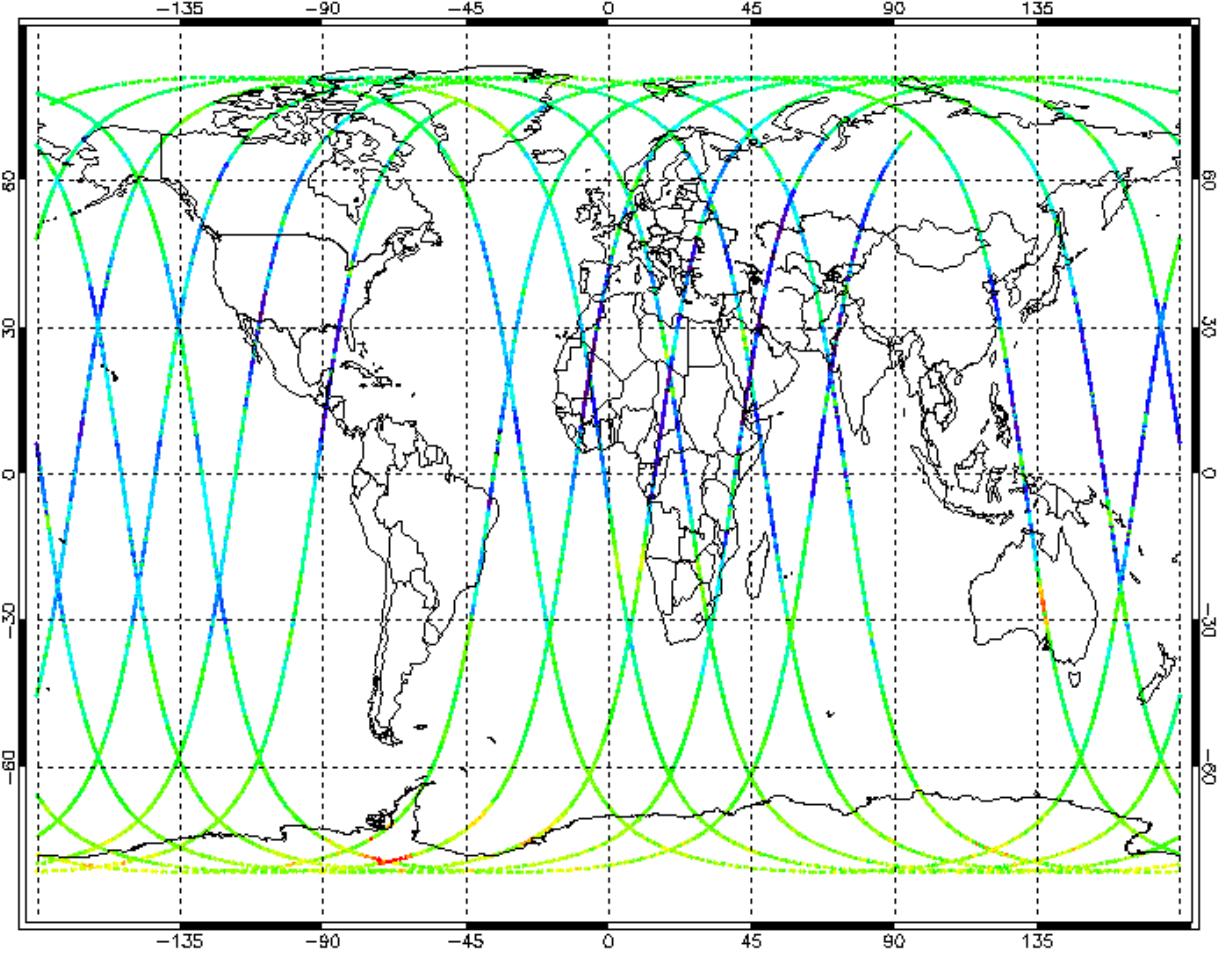
Latitude: -79.6356  
Longitude: -68.3451



Latitude: -26.8408  
Longitude: 136.980

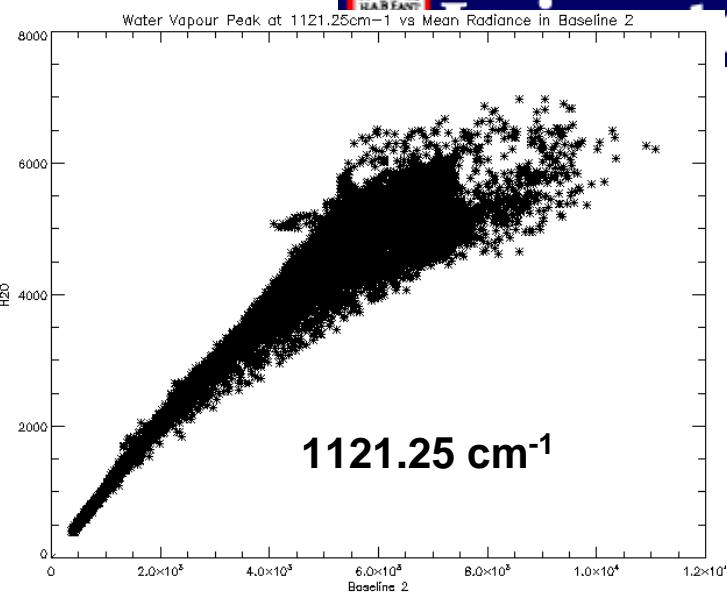
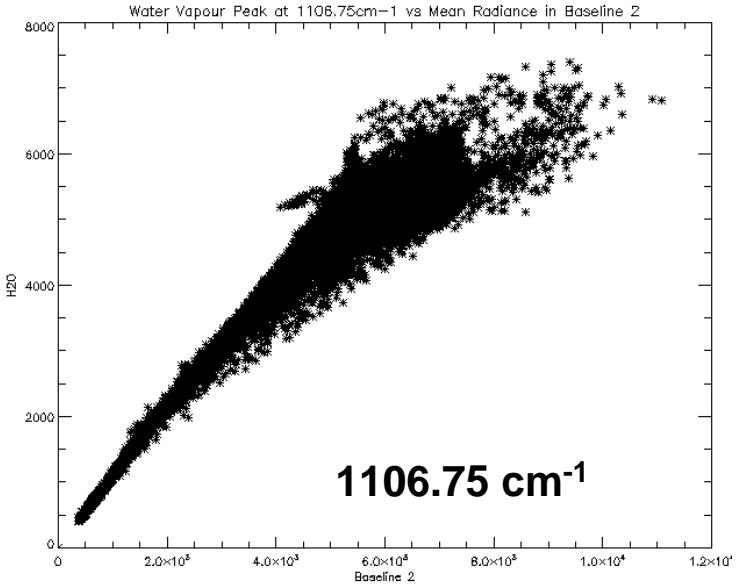
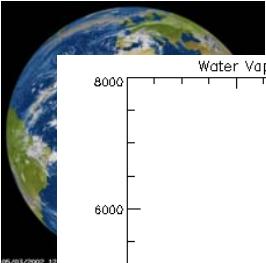
**(H<sub>2</sub>O peak at 1106.75 cm<sup>-1</sup>)/baseline 2**

# Ratio of H<sub>2</sub>O Peak at 1121.25cm<sup>-1</sup> to baseline

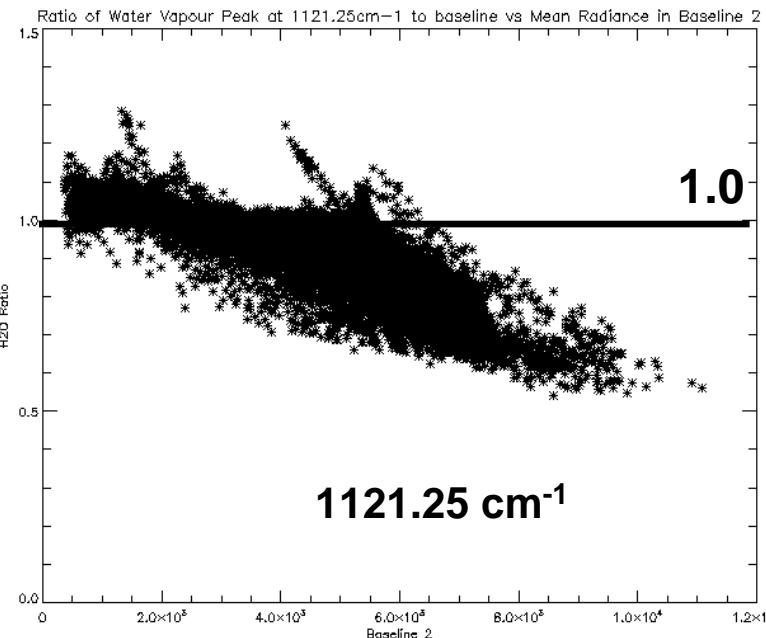
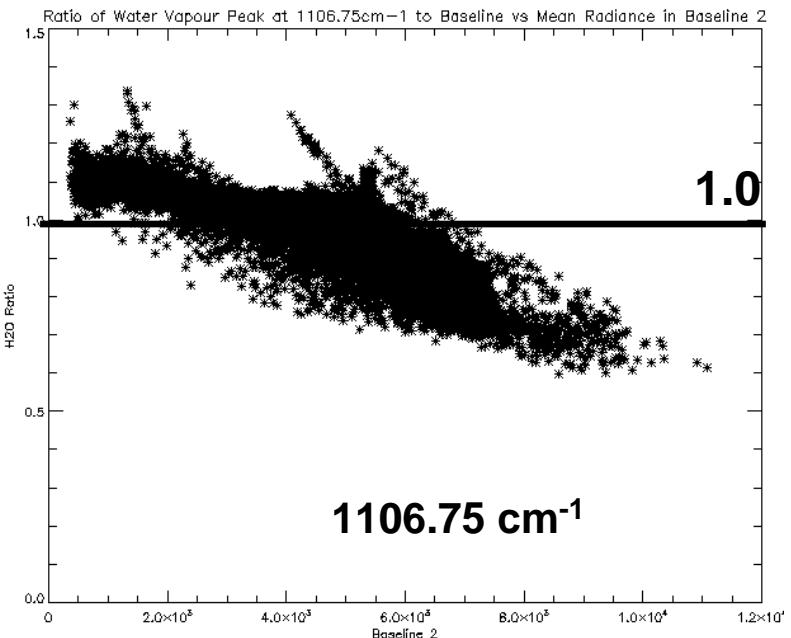


**(H<sub>2</sub>O peak at 1121.25 cm<sup>-1</sup>)/baseline 2**

# Peak H<sub>2</sub>O radiance versus Baseline 2

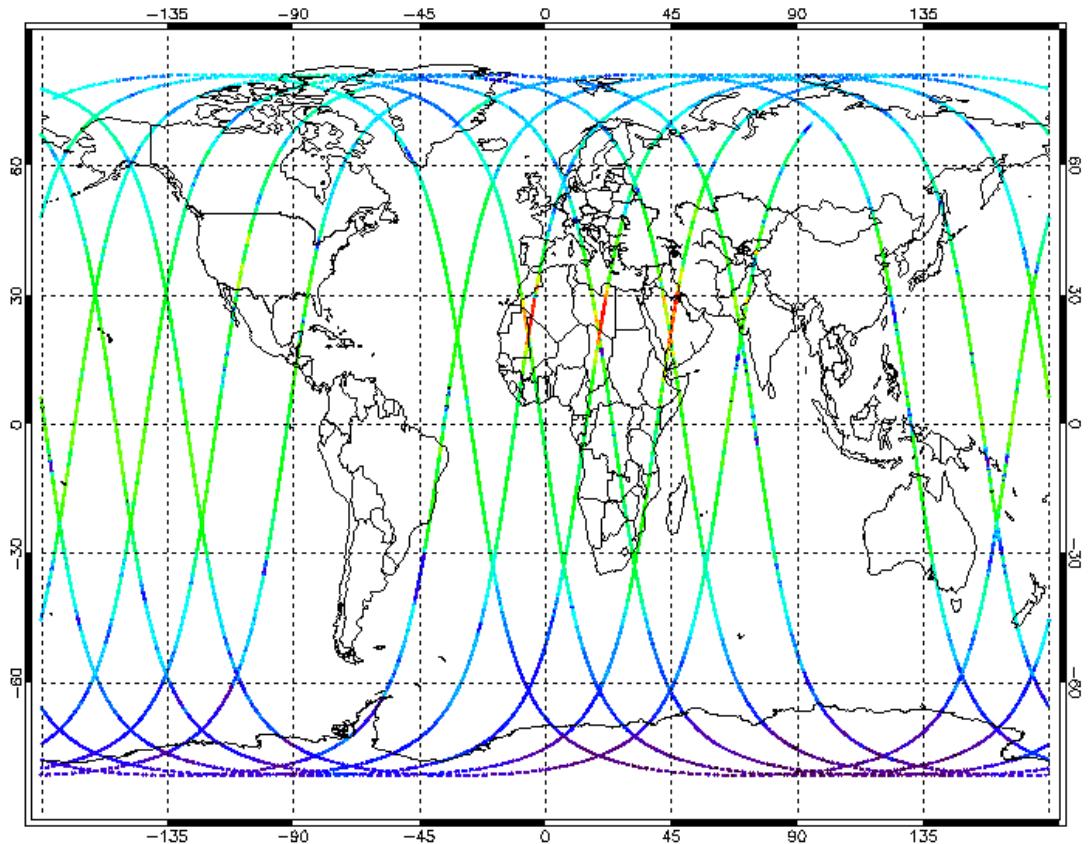


(Peak H<sub>2</sub>O)/baseline 2 vs Baseline 2

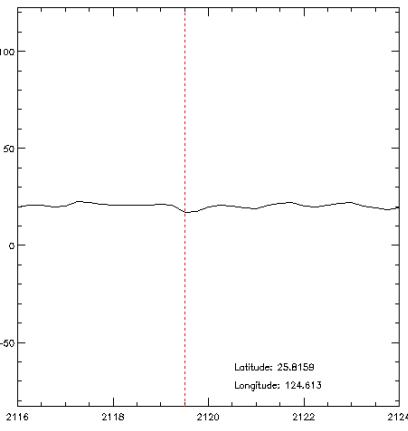
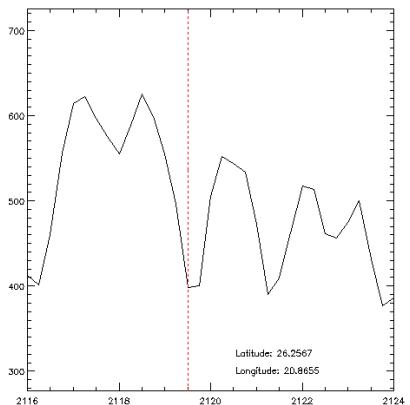
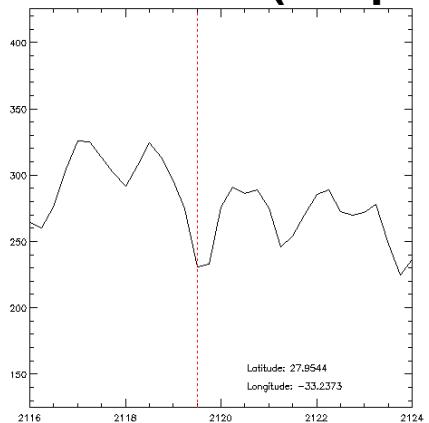




Ratio of CO Peak at 2119.5cm<sup>-1</sup> to baseline

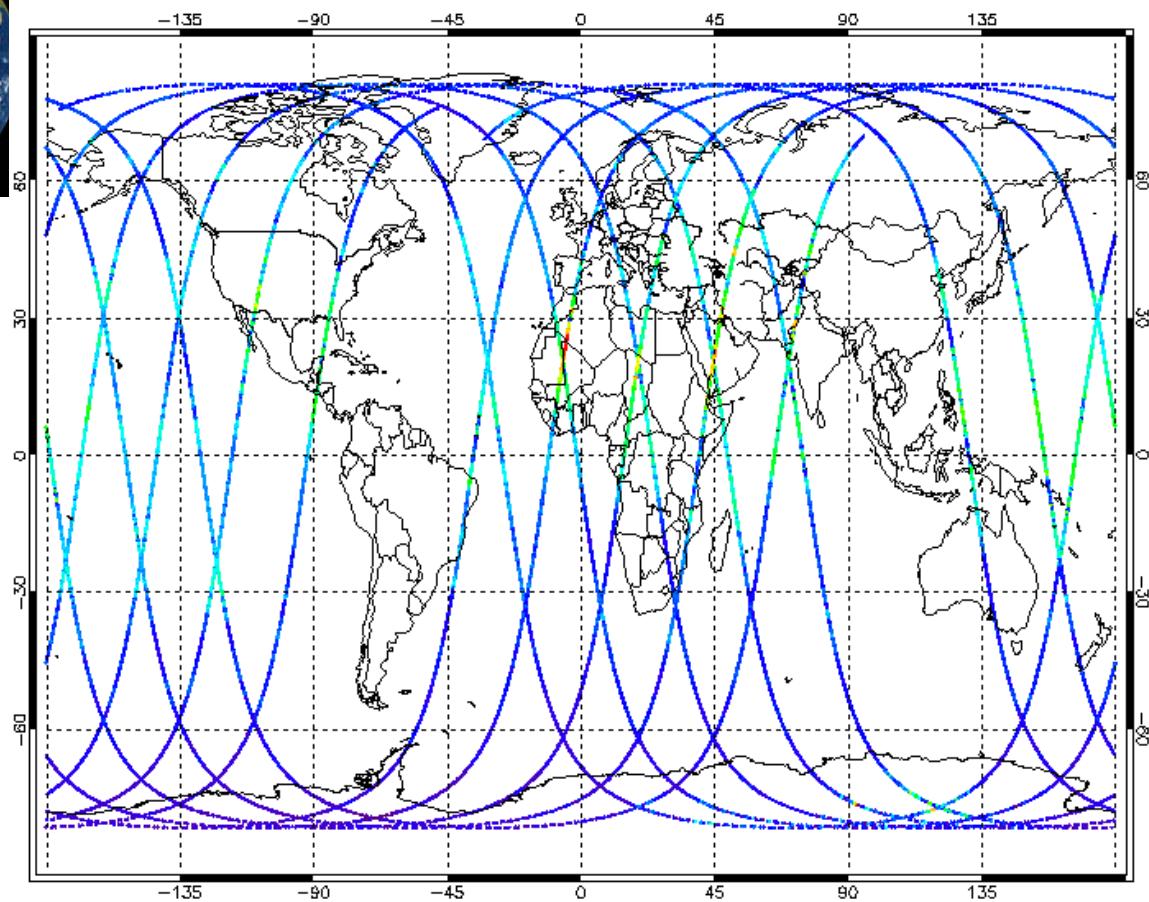


**(CO peak at 2119.5 cm<sup>-1</sup>)/baseline 2**

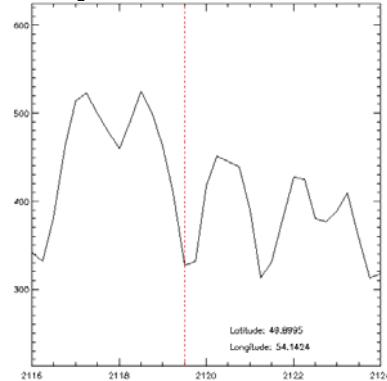
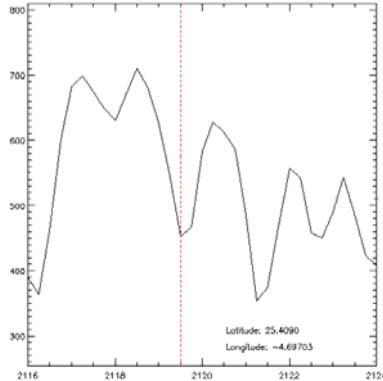




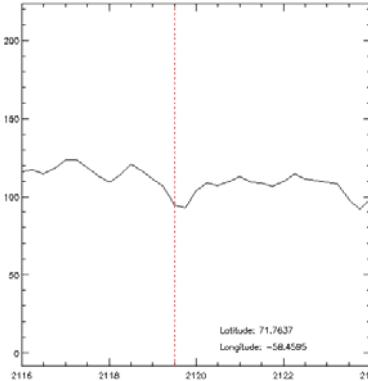
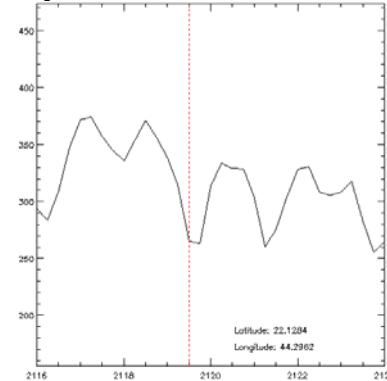
Ratio of CO Peak at 2119.5cm<sup>-1</sup> to baseline



$(\text{CO peak at } 2119.5 \text{ cm}^{-1})/\text{baseline 3}$



'eme

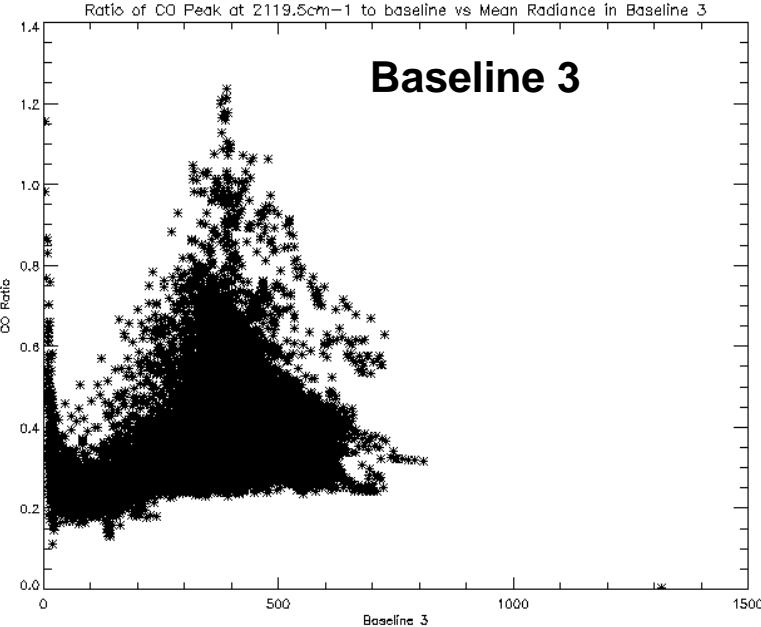
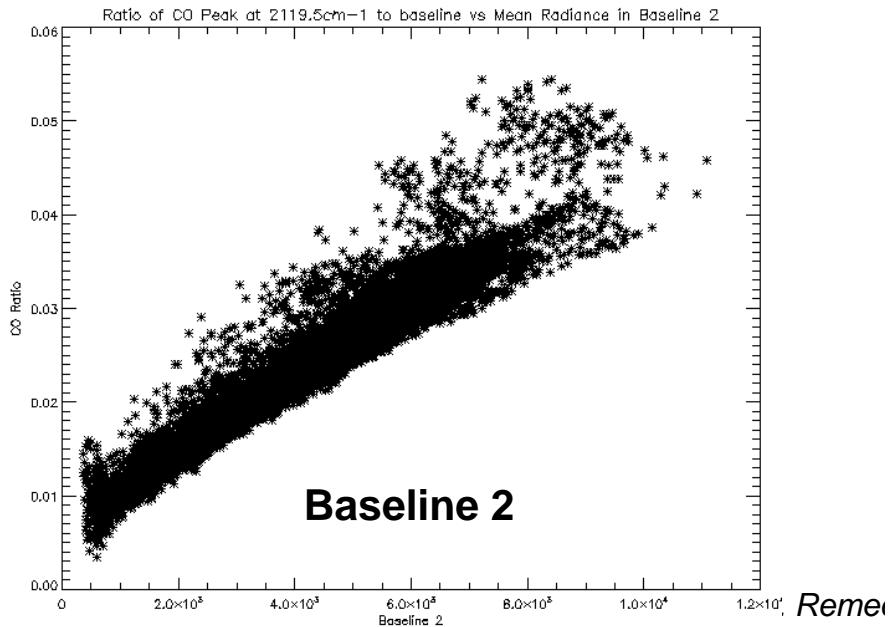
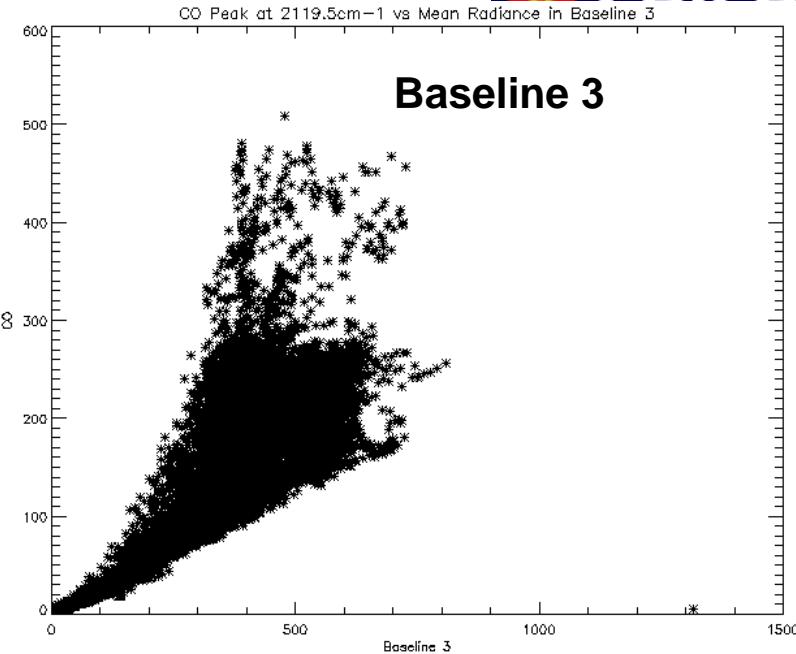
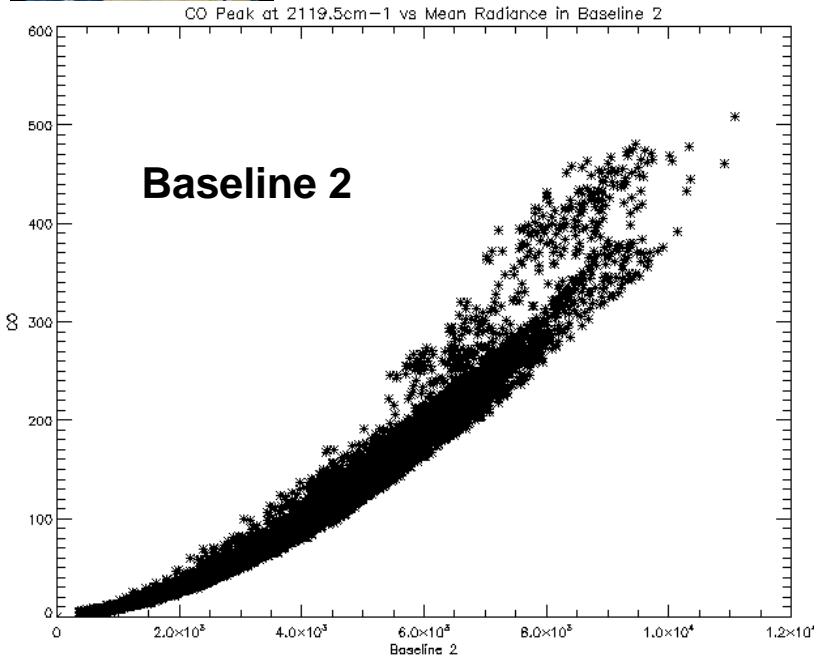




# Peak CO radiance $2119.5 \text{ cm}^{-1}$ versus Baseline



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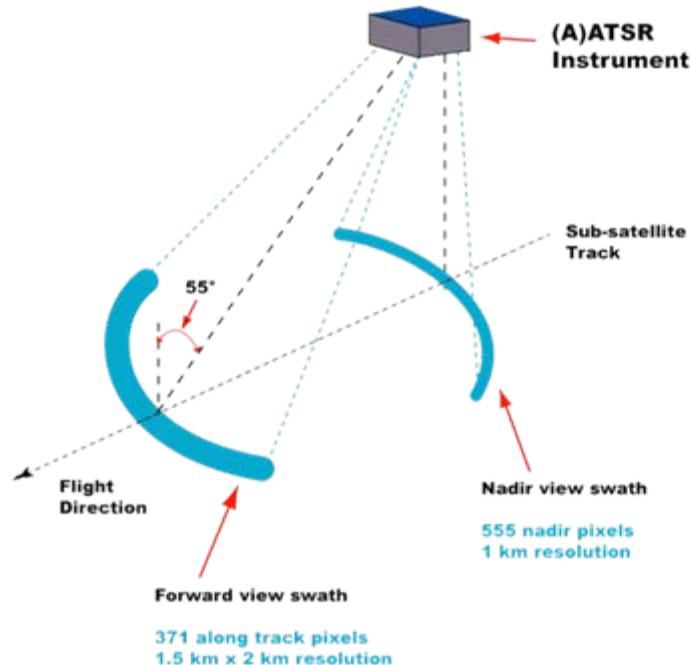
## Radiometric inter-calibration for climate

1. Would like to be able to tie together different satellite sensors so that one can think about integrated long-term records – a climate point-of-view.
2. The Advanced Along Track Scanning Radiometer (on ENVISAT) is believed to be one of the most accurate radiometers in the world.
3. It would be good to compare IASI brightness temperatures to AATSR brightness temperatures.
4. Need to integrate IASI spectra over AATSR spectral filters for each channel – IASI clearly has spectral information also which is potentially very useful – to compute equivalent AATSR BT.
5. Example here is 12  $\mu\text{m}$  (preliminary results)



# The AATSR instrument?

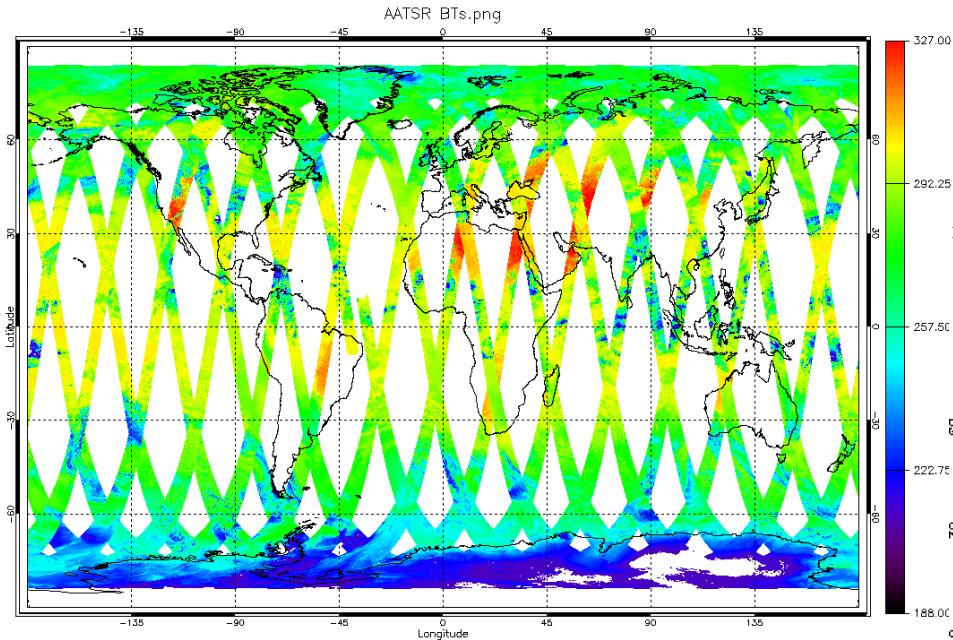
- Dual view thermal and Vis/IR imaging radiometer on ENVISAT
- Thermal emission channels similar to AVHRR, MODIS: 11, 12 and 3.7  $\mu\text{m}$  (nighttime)
- Dual view (nadir and 55° to nadir)
- Intrinsic on board calibration
  - 2 accurate on-board blackbodies for IR calibration (301 K and 262 K)
- 1 km IFOV nominal at nadir
- 500 km swath
- SST < 0.3 K accuracy. Cross-over test of blackbodies agrees to better than 20 mK.



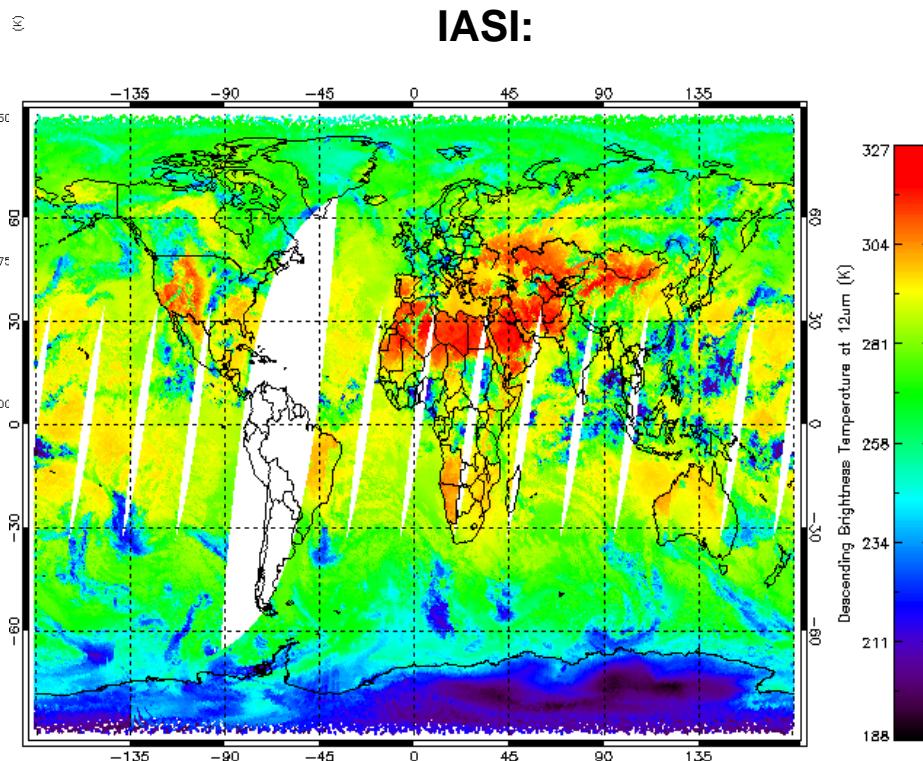
*Image courtesy of Rutherford Appleton Laboratory*



# AATSR-like 12 $\mu\text{m}$ DAYTIME BTs: 19<sup>th</sup>/20<sup>th</sup> August 2007

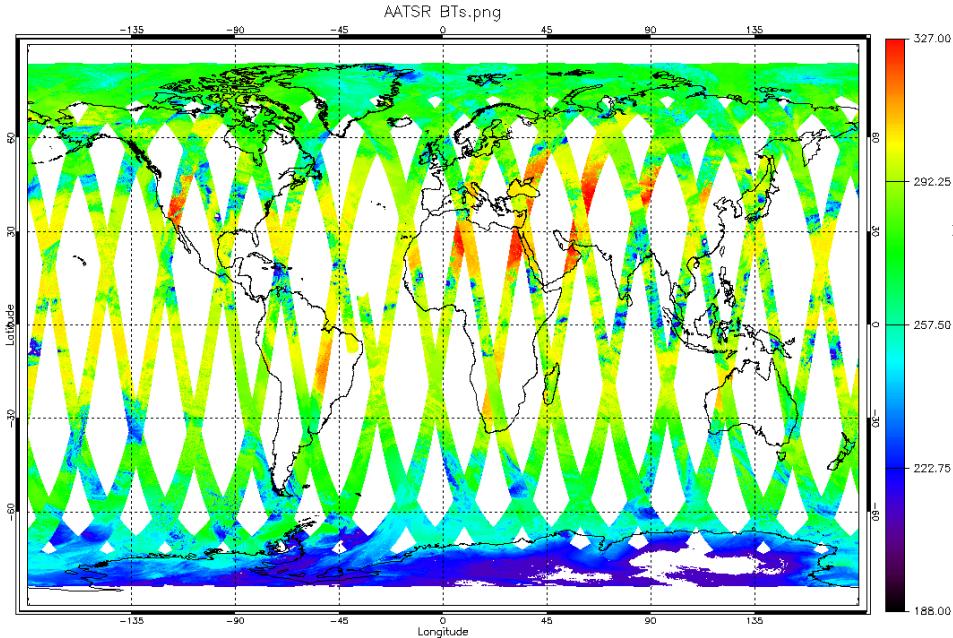


AATSR

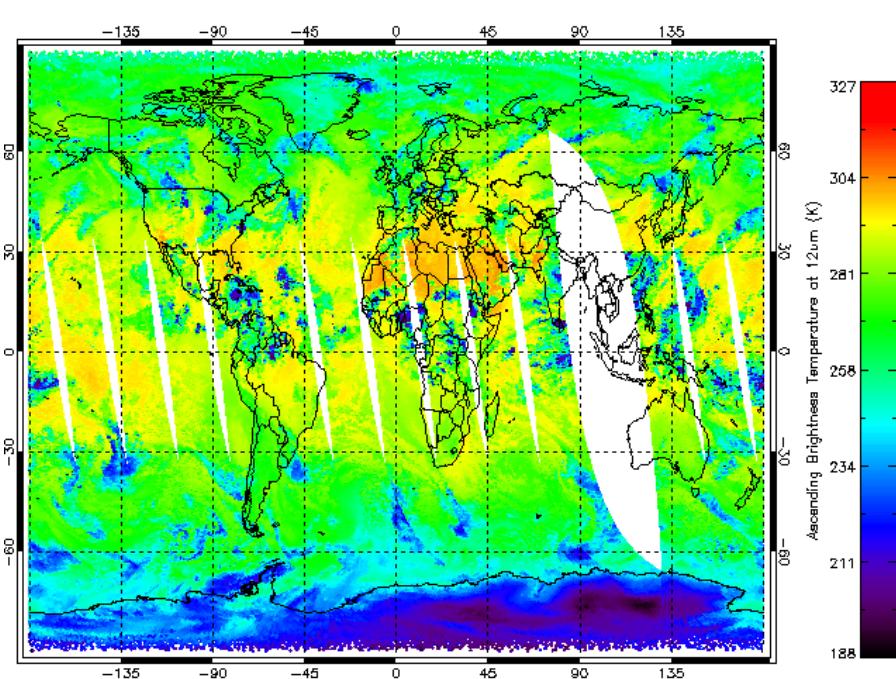




# AATSR-like 12 $\mu$ m NIGHTTIME BTs: 19<sup>th</sup>/20<sup>th</sup> August 2007



AATSR





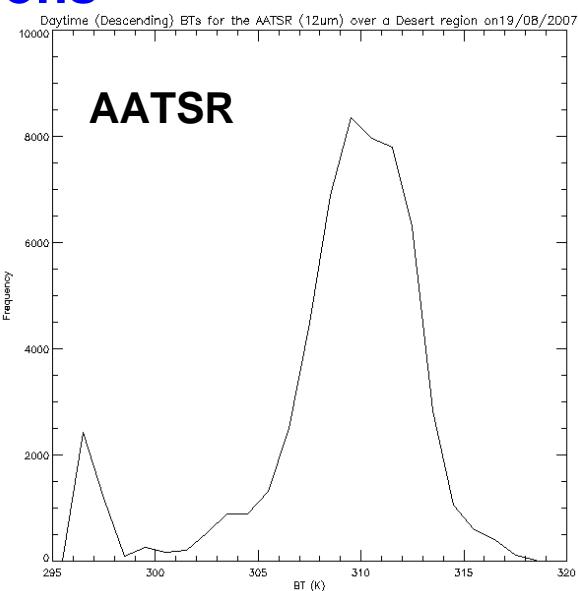
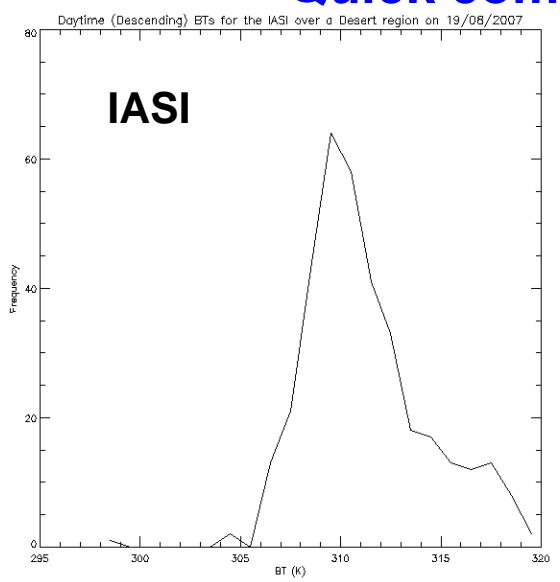
# AATSR vs IASI (AATSR-like) 12 $\mu$ m Quick comparisons



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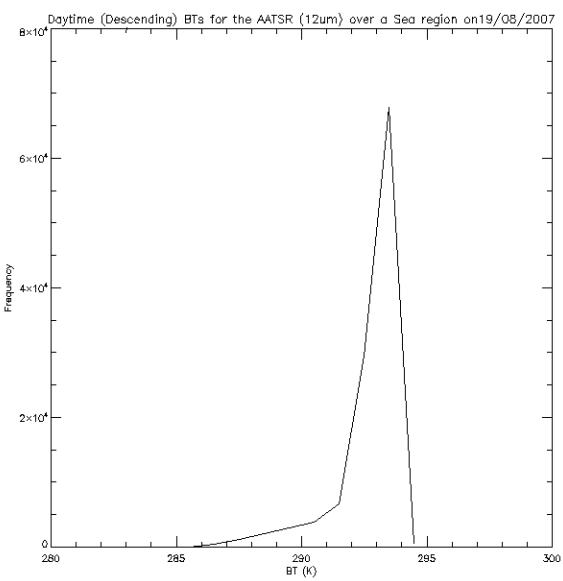
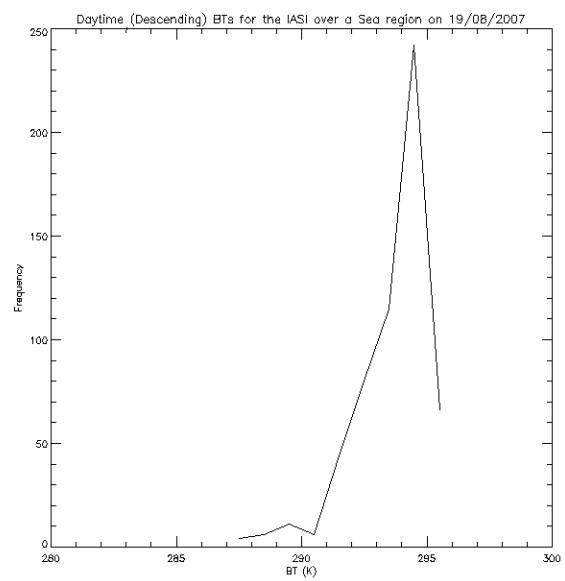
Lat: 29 to 30°

Lon: -10 to 45°



Lat: -2 to 0°

Lon: -160 to -145°





## REFERENCE ATMOSPHERES FOR MIPAS (IASI)

**Standard Atmospheres:** Five atmospheres *tropical, mid-latitude day, mid-latitude night, polar summer, polar winter*) consisting of mean profiles, variabilities (both max/min) and one sigma. *The current version is V3.1 available at*  
[http://www-atm.physics.ox.ac.uk/RFM/rfm\\_downloads.html#atm](http://www-atm.physics.ox.ac.uk/RFM/rfm_downloads.html#atm)

**IG2 Climatology Database:** Consisting of seasonal profiles: *four seasons, six latitude bands*

- Months=January, April, July, October.
- Lat. Bands[centres] =  $\pm(90\text{-}65$ , Mid=[75]),  $\pm(65\text{-}20$ , Mid=[45]),  $\pm(20\text{-}0$ , Mid=[10])

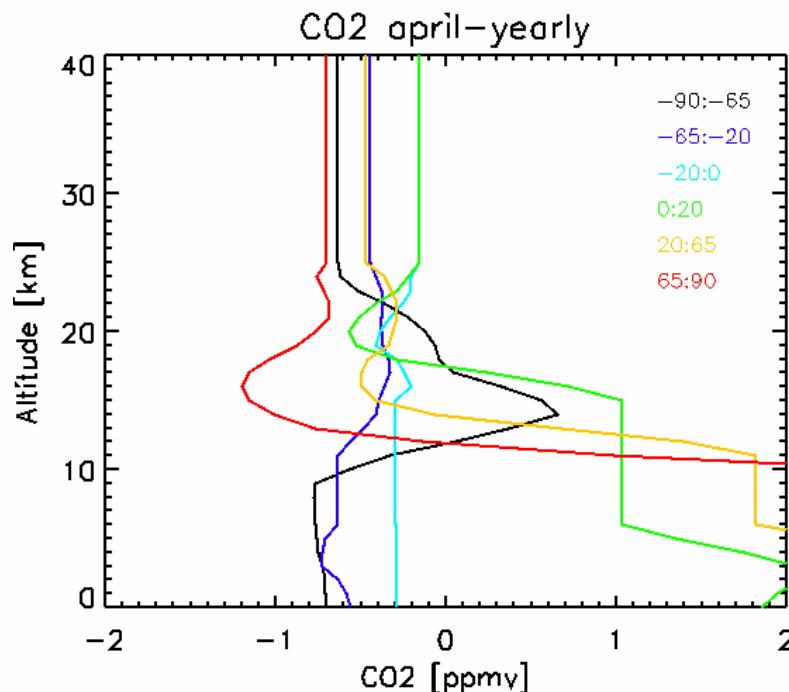
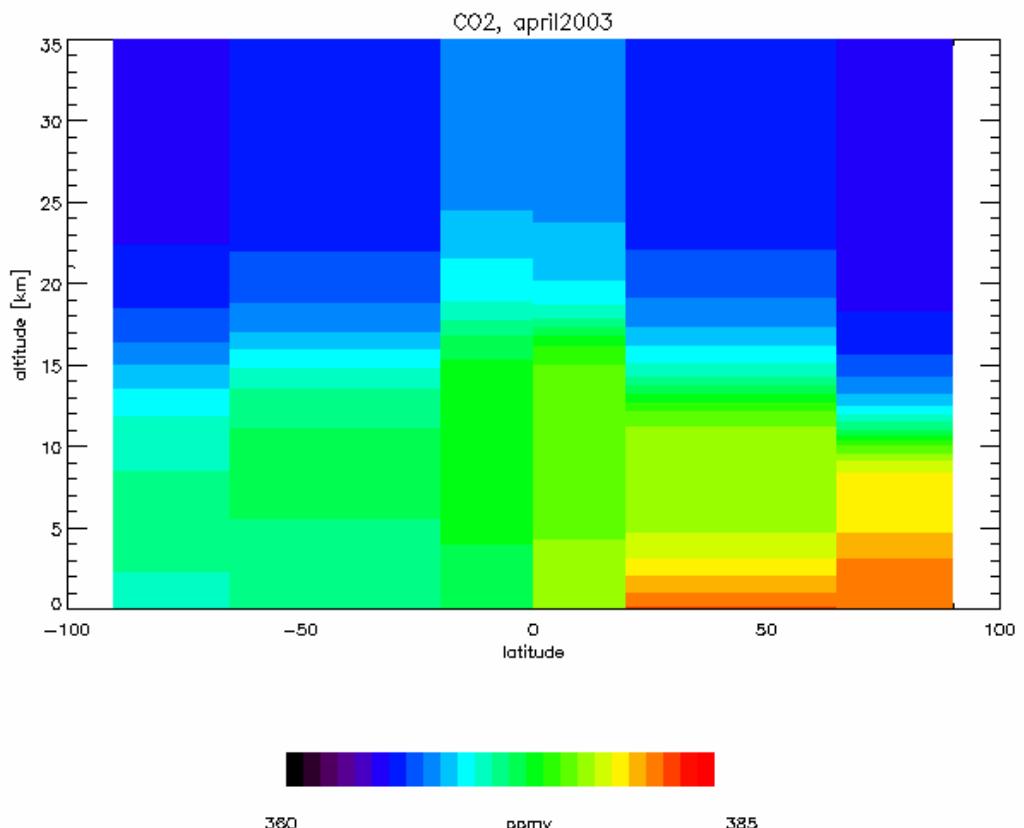
**Both reference atmospheres:** 0-120 km altitude grid (1 km spacing), 37 species: C<sub>2</sub>H<sub>2</sub>, CO<sub>2</sub>, CFC12, HCN, NH<sub>3</sub>, SF<sub>6</sub>, C<sub>2</sub>H<sub>6</sub>, CO, CFC13, HNO<sub>3</sub>, NO<sub>2</sub>, SO<sub>2</sub>, CCl<sub>4</sub>, COF<sub>2</sub>, CFC14, HNO<sub>4</sub>, NO, CH<sub>3</sub>Cl, CFC113, CFC21, HOCl, O<sub>2</sub>, CH<sub>4</sub>, CFC114, HCFC22, N<sub>2</sub>, O<sub>3</sub>, ClO, CFC115, H<sub>2</sub>O<sub>2</sub>, N<sub>2</sub>O<sub>5</sub>, OCS, ClONO<sub>2</sub>, CFC11, H<sub>2</sub>O, N<sub>2</sub>O

An updated IG2 reference climatology (v4.0) has recently been released consisting of:

- All profiles shifted by 1km
- p/T: sourced from CIRA data
- New N<sub>2</sub>O profiles derived from CH<sub>4</sub> tracer correlations
- Annual CO<sub>2</sub> profiles with non-constant mixing ratios with altitude

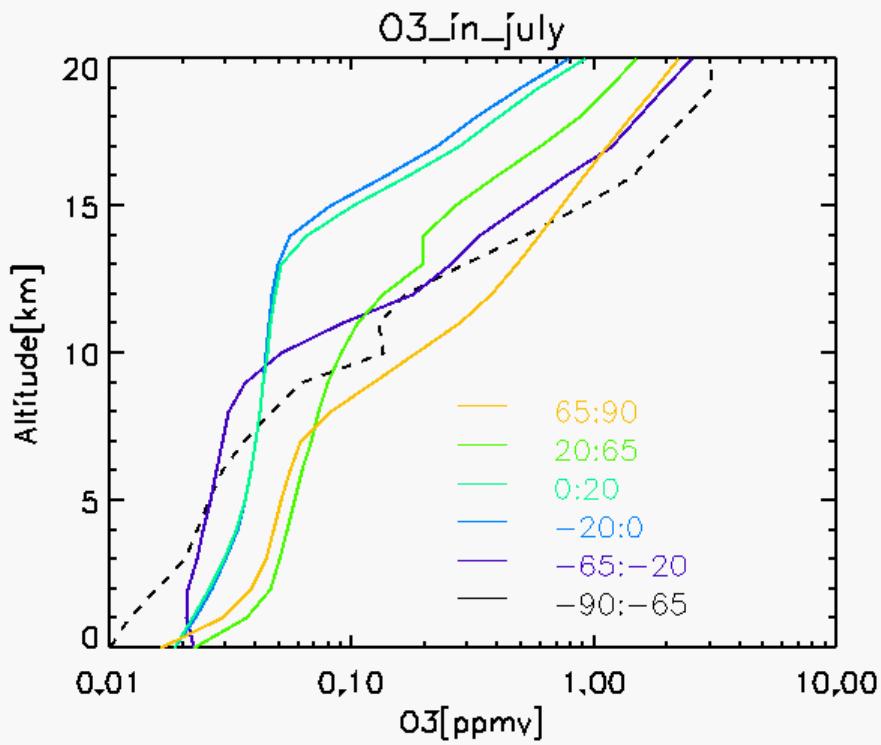
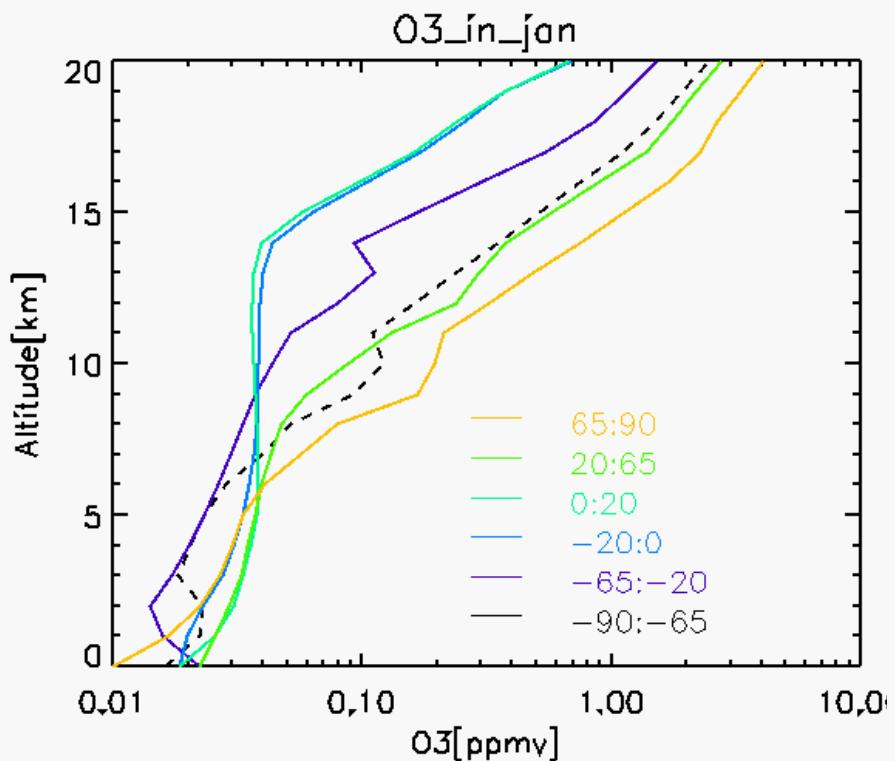


## Updated CO<sub>2</sub> April 03 + 2003 mean





## IG2 O<sub>3</sub> CLIMATOLOGY





## Summary

1. Expected signatures of CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, H<sub>2</sub>O, CO examined – spectra look very good.
2. Simple ratios of spectral quantities may provide some insight into spectroscopy etc.
3. CO spectra in region over Sahara look interesting.
4. Quick comparison with AATSR BTs provides some top-order agreement as expected. Some potential to be exploited (but coincidence criteria, clouds, spectral filter profile, sub-pixel scale structure).

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