Far infrared sensitivity to water vapour variability near the Tropopause: The importance of airborne measurements

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Talk:

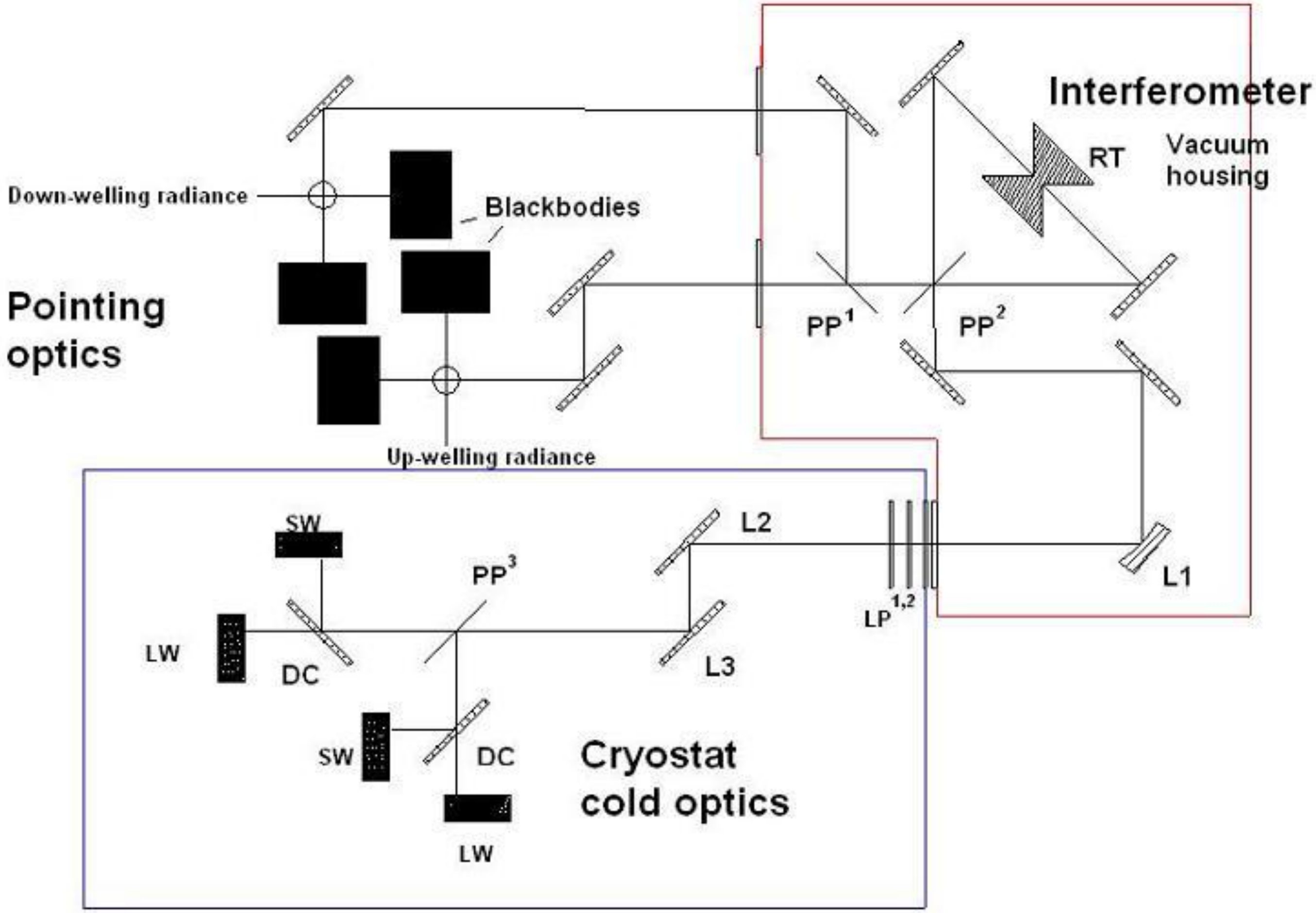
Start with a brief description of the instrument

Describe the results of a recent campaign
(This is the work of Paul Green)

Compare, through a series of observations, the up- and down-welling radiance sensitivity to an altitude change

Tropospheric Airborne Fourier Transform Spectrometer (TAFTS)

4-port polarising interferometer employing thin film beamsplitter and helium cooled detector.



Instrument Specifications

Interferometer	Martin-Puplet
Spectral range	80 – 300 cm-1 330 – 600 cm-1
Resolution	0.1 cm-1 (unapodised)
Single scan Acquisition time	2 s
Dimensions	1.0 x 0.5 x 0.5 meters
Mass	90 kg 30 kg
Two input ports	Differential measurement

First: Some results of an airborne campaign

Paul Green has recently had a paper accepted by the Royal Society

"Recent advances in measurement of the water vapour continuum
In the far-IR spectral region"

Philosophical Transactions of the Royal Society A

Volume and page info forth coming

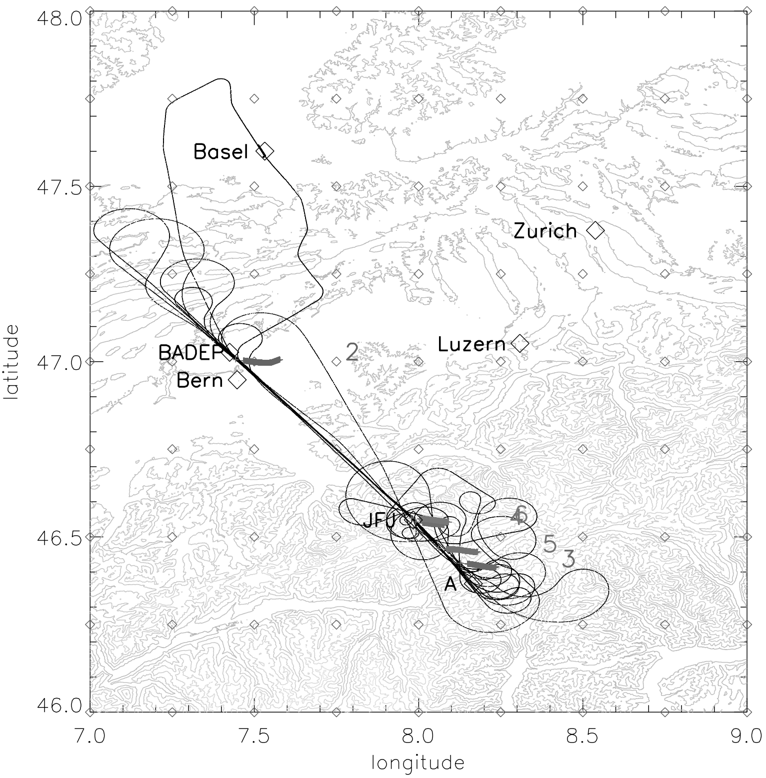
Based on work undertaken as part of the CAVIAR campaign (Continuum Absorption by Visible and Infrared Radiation and its Atmospheric Relevance)

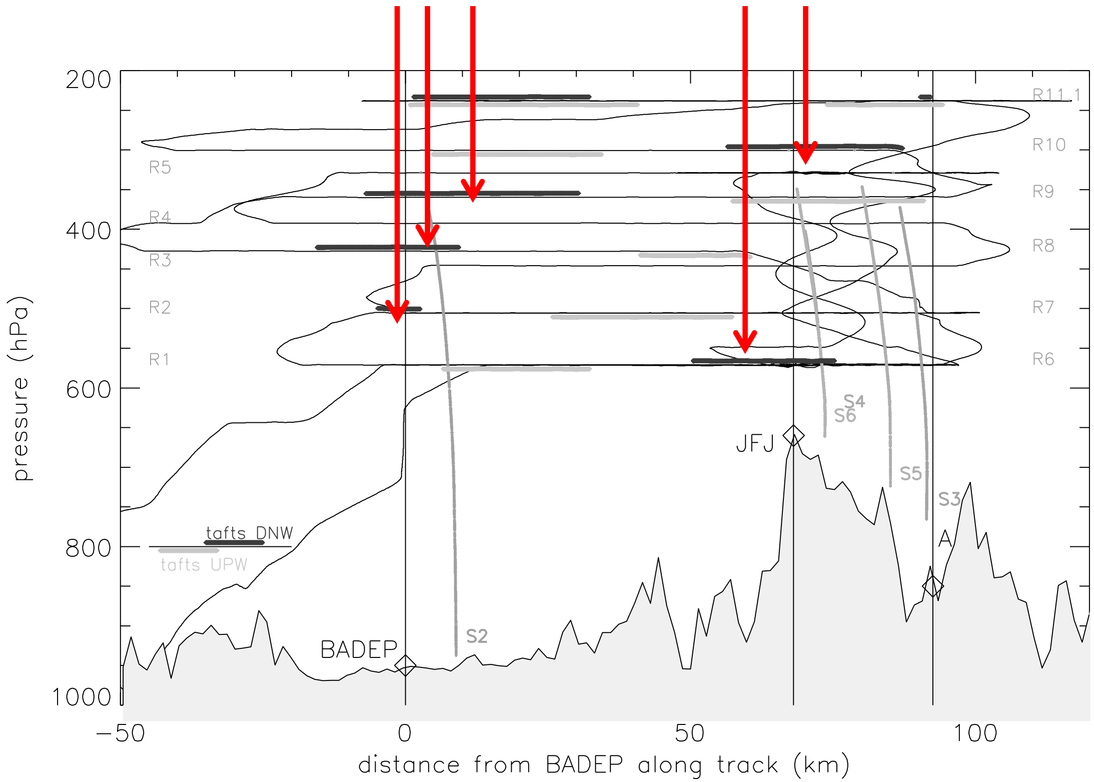
CAVIAR campaign, FIR continuum measurements

FAAM Flight B467 (19^{th} July 2009)

Continuum calculations derived from 5 level runs

Swiss Alps





Considerable care was taken in constraining the atmospheric state and both measurement uncertainties and measurements variability were incorporated into determination of the state uncertainties

Base line profile ECMWF 3-hourly forecast fields on $0.25^{o} \times 0.25^{o}$ grid ◊

Superposed on this baseline are

Vaisala RD93-type dropsonde data from Airborne Vertical Profiler System (AVAPS)

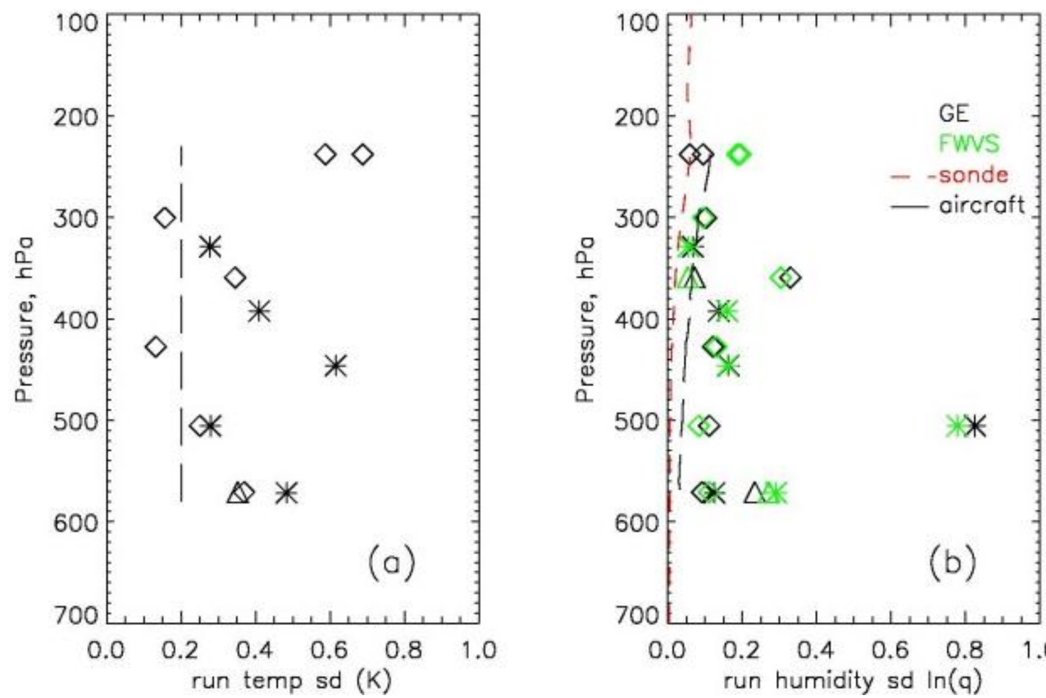
Vaisala RS92-type radiosonde

Aircraft based

GE1011B frost point hygrometer

Flourescence WV sensor (FWVS)

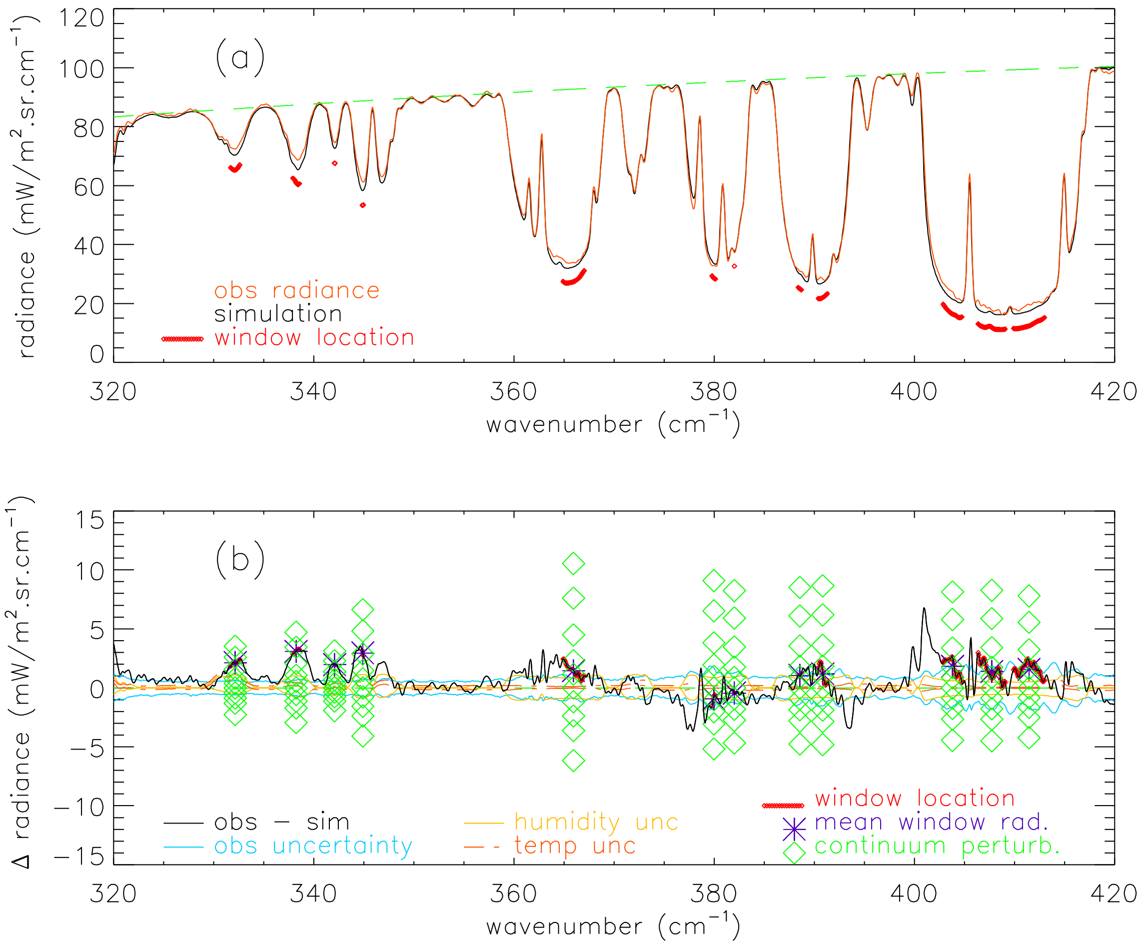
Rosemount type 102 temperature probes



Along run temperature and humidity variability

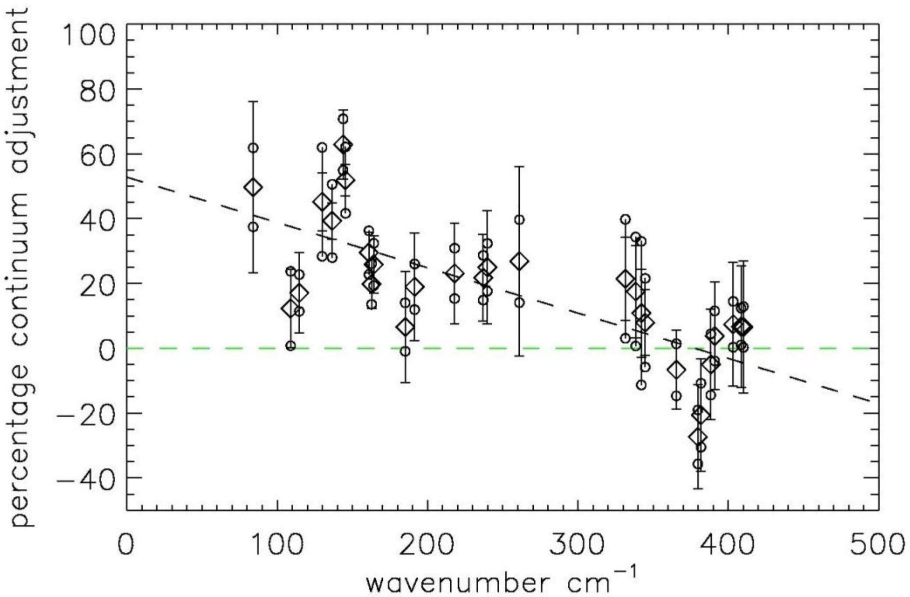
An example calculation

Radiance simulated using LBLRTM v12.0 (MT-CKD 2.5 continuum)
150 pressure levels

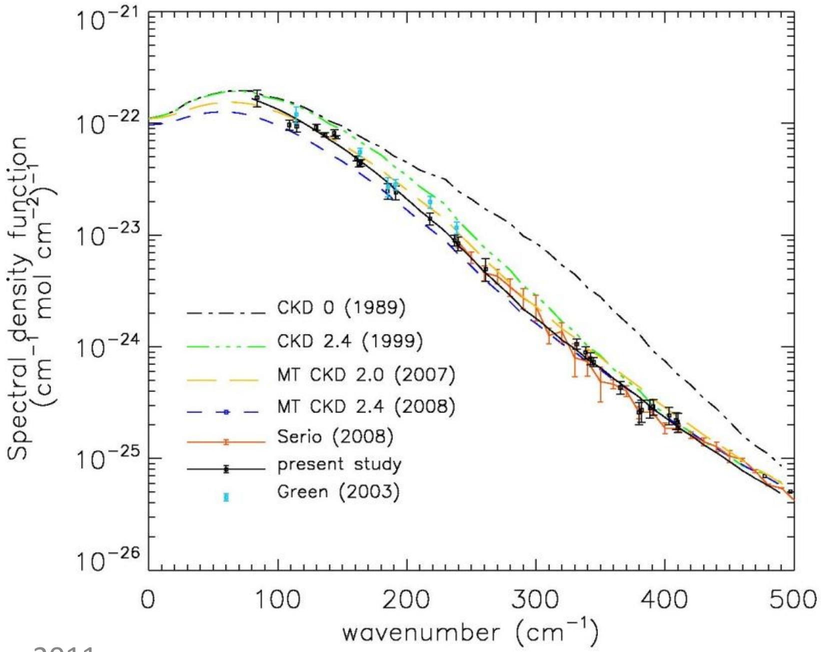


Model spectra computed
For a range of perturbed
Continuum strengths from
50%-200%

The perturbations required to match the discrepancy between radiative simulation and measurement are shown below



Foreign-broadened continuum
Adjustment to MT-CKD 2.5



Concluding this part of the talk

These measurements represent the first Continuum coefficients published in the 85 cm^{-1} – 240 cm^{-1} wavenumber range

In this part of the talk I’m heading back to data taken in 2002 during the EMERALD II campaign
In Darwin, Australia. Flying on the Egrett aircraft

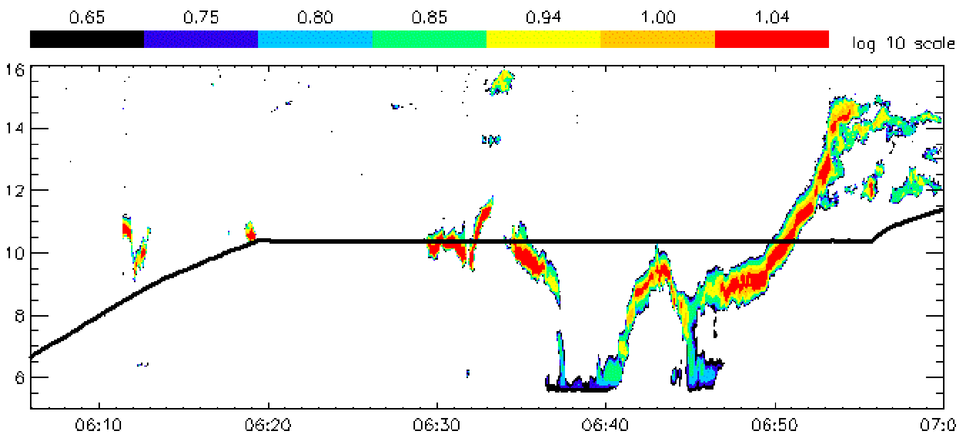
FIR (80 cm^{-1} – 250 cm^{-1}) measurements taken during this campaign
Show significant sensitivity to the water column above the aircraft.

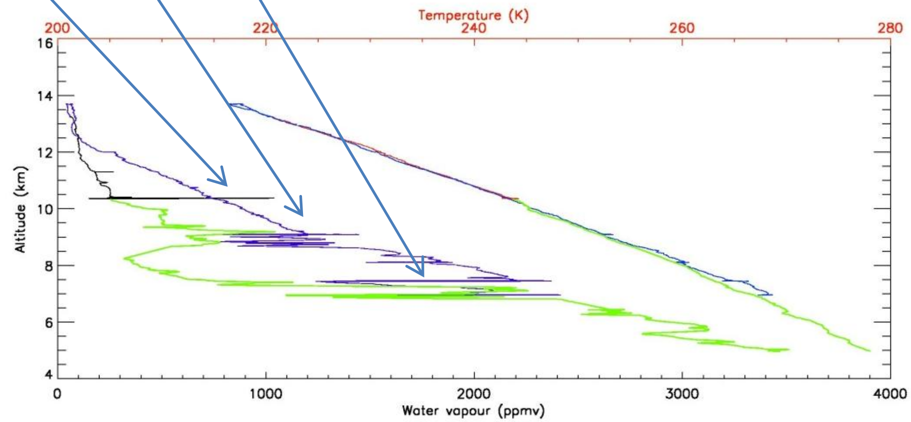
However, knowledge of the water vapour in this region proves impossible to tie down.

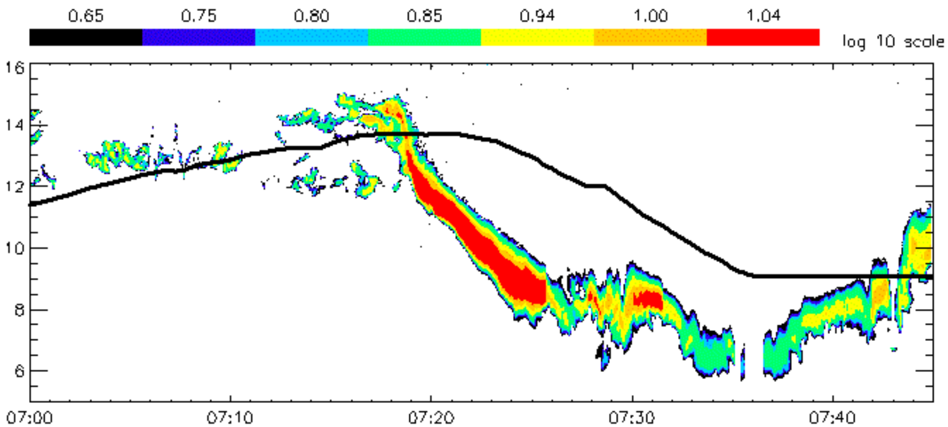
Regardless of the unknown atmospheric state the acquired Radiances raise some interesting questions on the comparative Sensitivity between down and up looking views

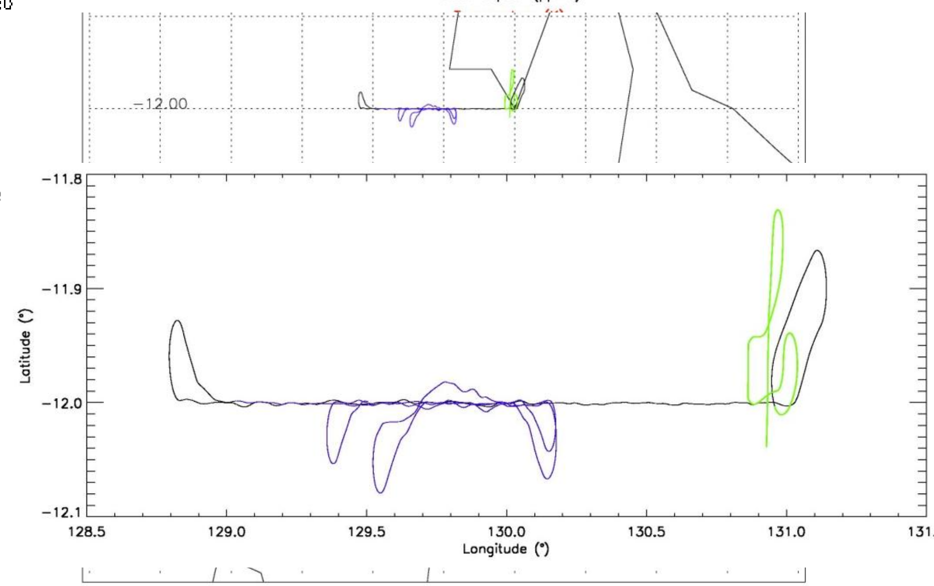
One aspect of our interests lies in validation of space borne observations in the FIR. An understanding of the relative sensitivities between a down looking view from space and an aircraft based instrument looking both up and down is therefore an important area for study

Where the aircraft FL is constant we see significant WV variations









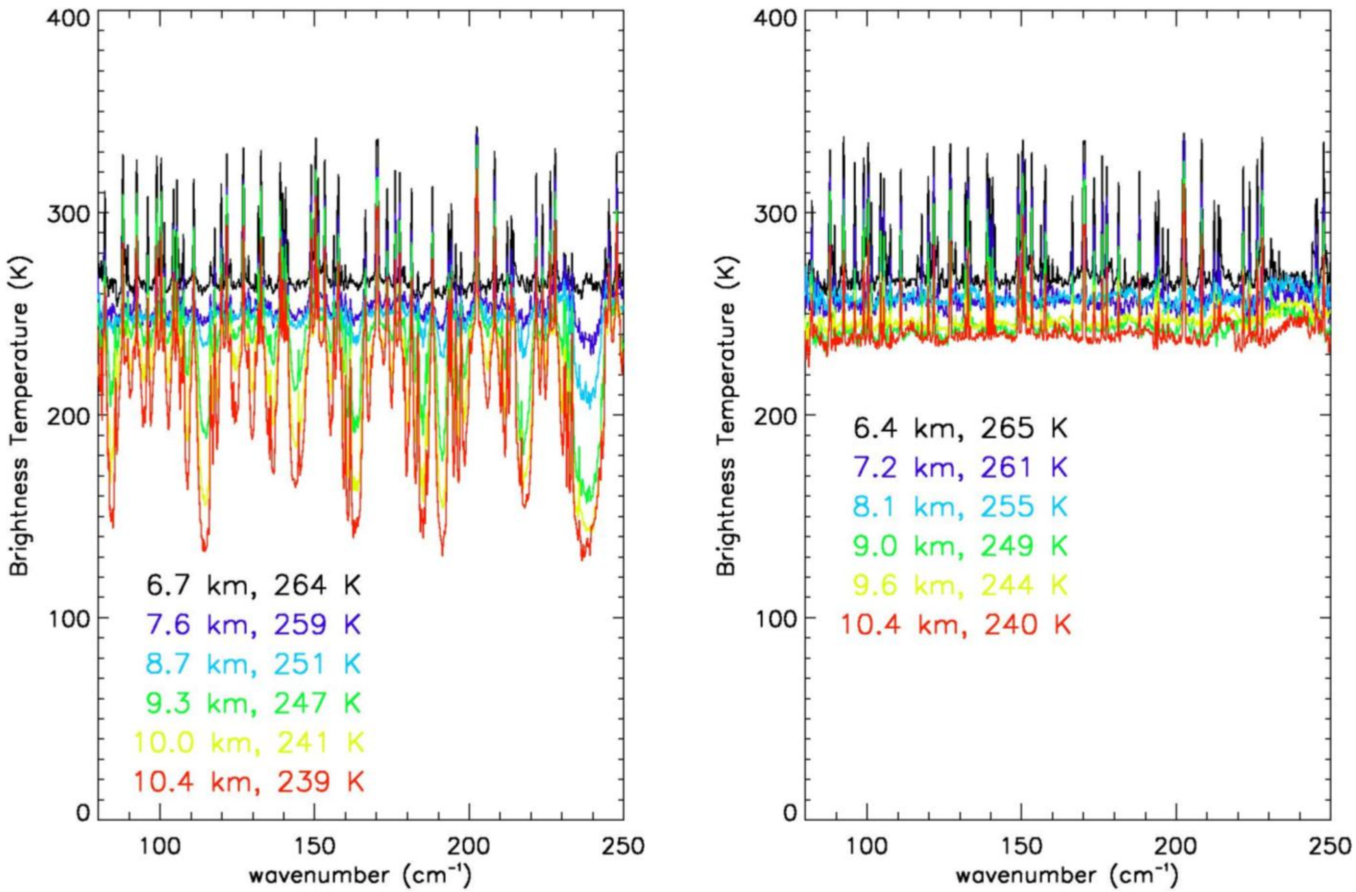
Darwin EMERALD II campaign: 2nd December 2002 flight, initial ascent

Pressure (hPa)

Down	up
450	463
400	415
345	373
317	330
285	301
272	272

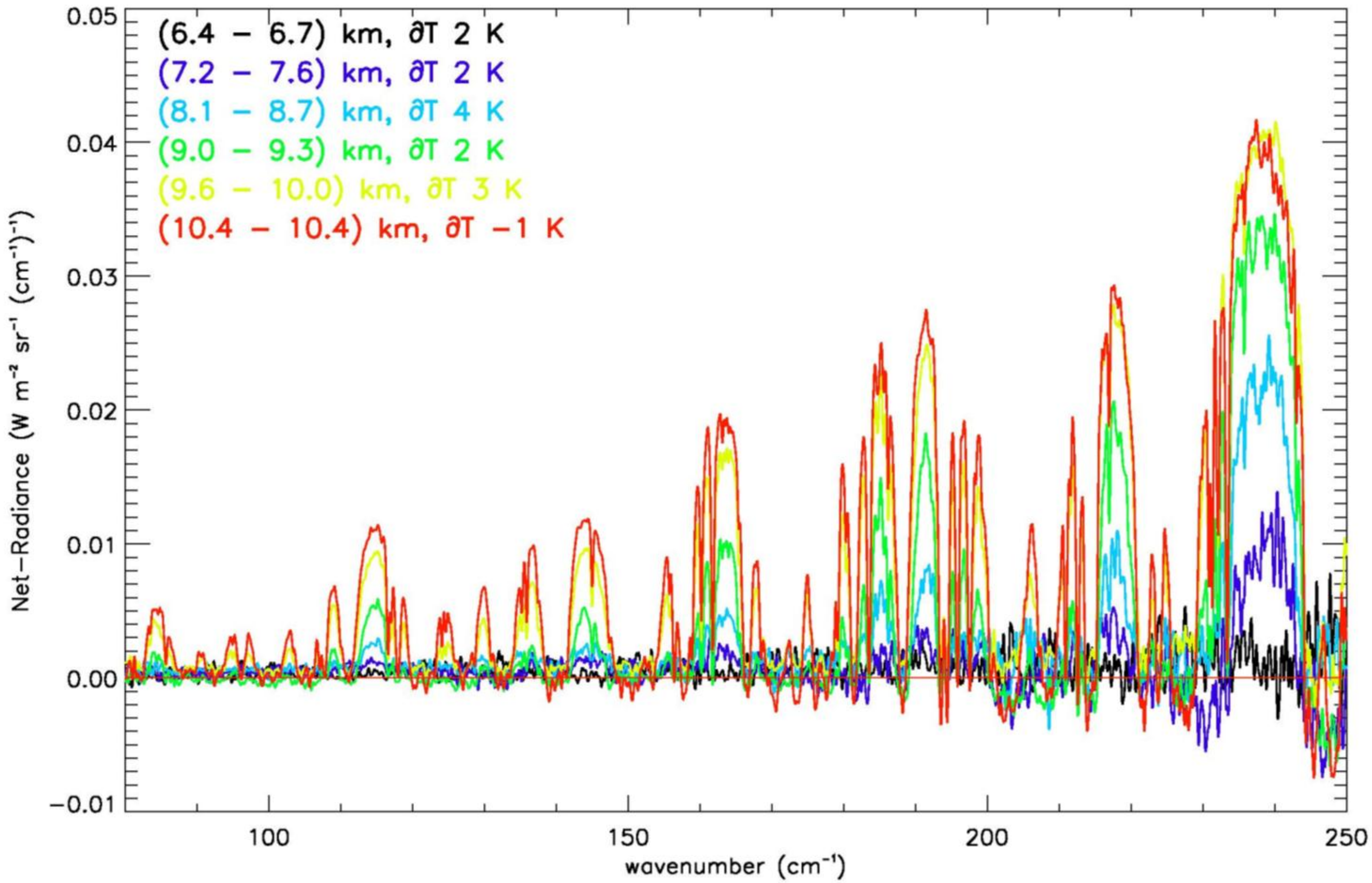
Strong water vapour
Features saturating at
BB surface temperature -

Down and up-welling radiance's (30 s data sets)



The saturated water vapour lines can be removed, to first order, by subtraction of adjacent altitude ranges (BB temperatures are varying slowly)

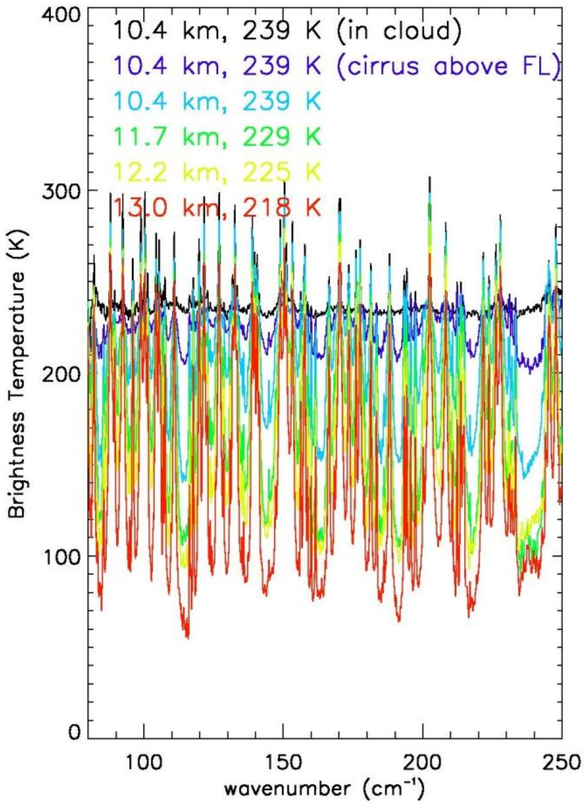
Up-welling – down-welling radiances

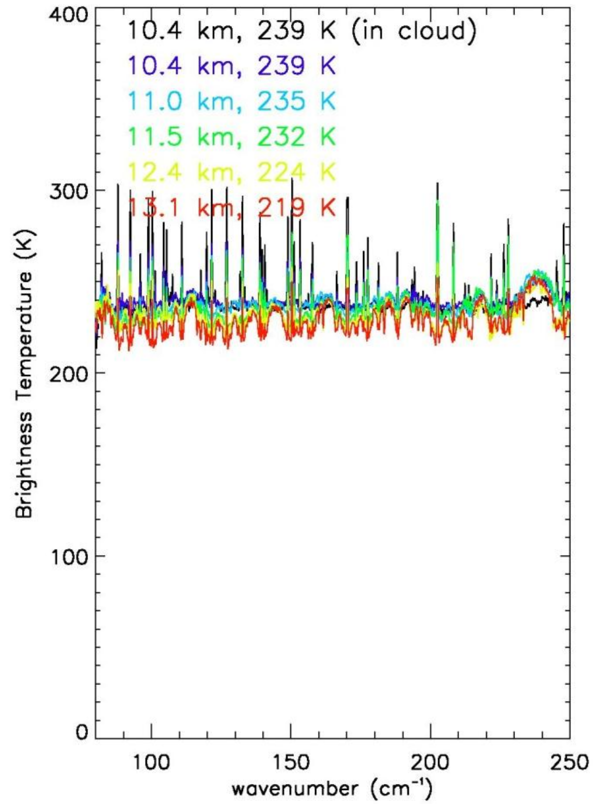


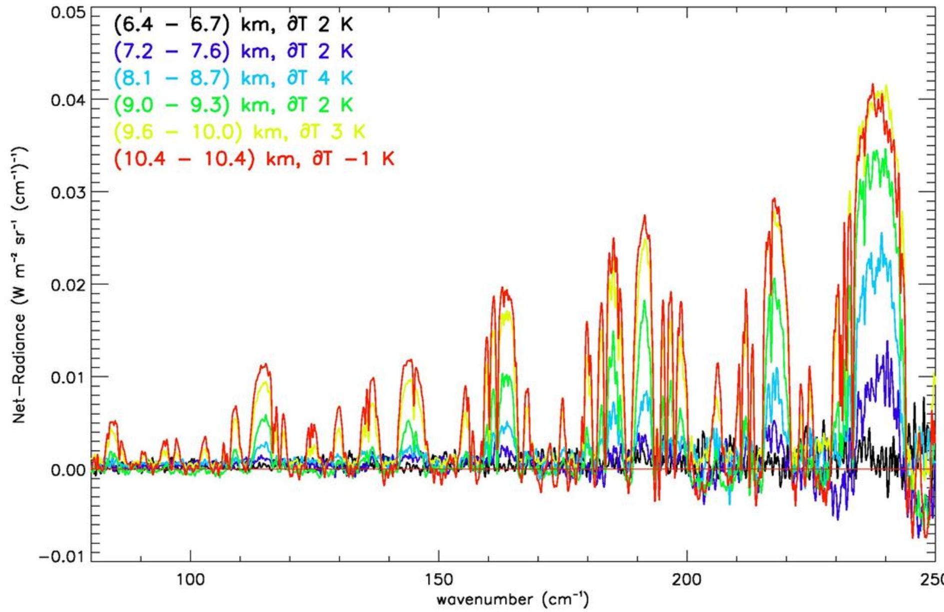
Darwin EMERALD II campaign: 2nd December 2002 flight, ascent continuation
After RL10.4 km of 30 mins

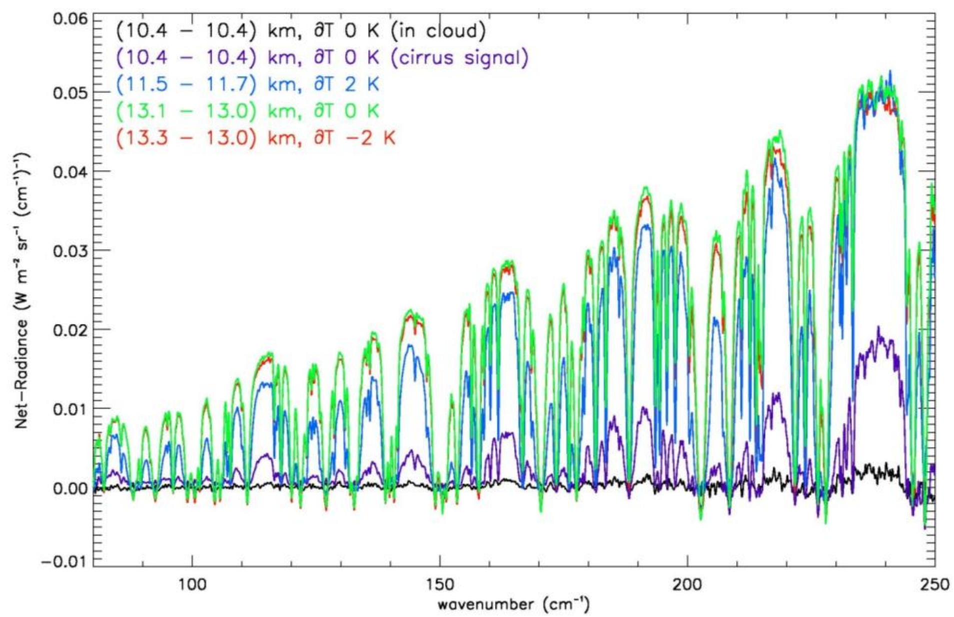
Pressure (hPa)

Down	up
273	273
273	275
273	250
224	234
208	201
184	182









Pressure (hPa)

up	down
273	273
273	273
201	208
182	184
175	184

These measurements show very different sensitivities to an observed altitude range when viewed from above and below

Initial studies (Daniel Jabry, post grad student) show that this view sensitivity can be as much as an order of magnitude

For validation campaigns care is required to fully understand these view sensitivities and will help inform on optimal flight scenarios

Conclusions

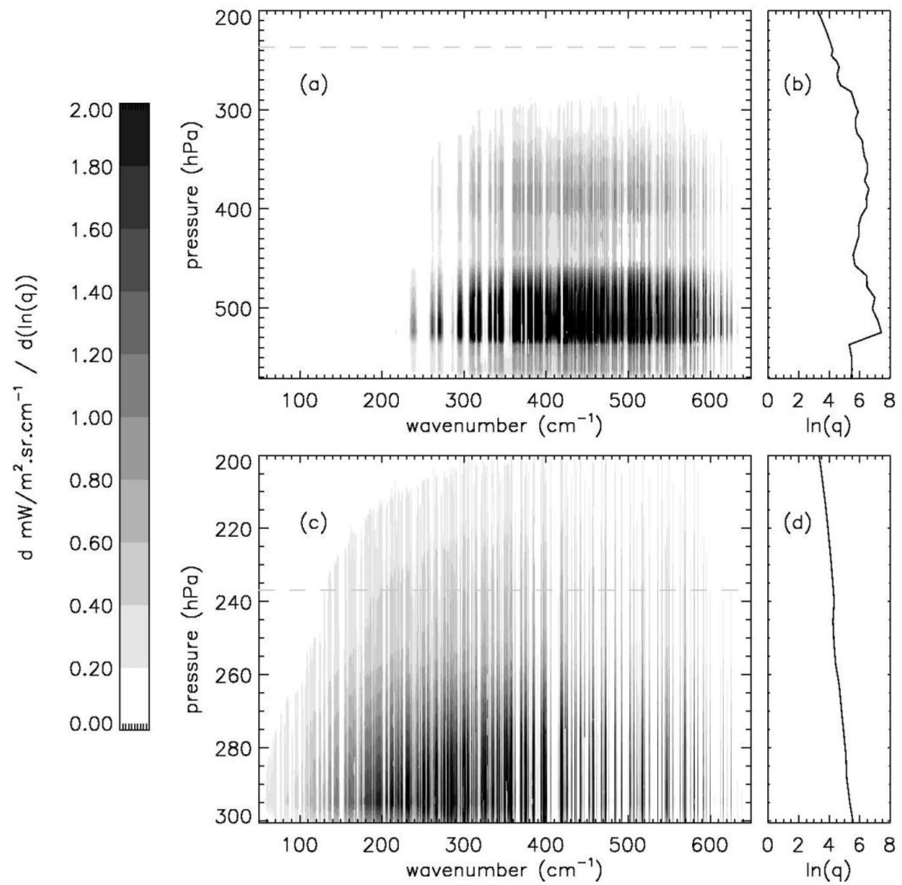
Airborne measurements are not going to give full Earth coverage
Nor will they be able to build a temporal picture of sufficient length for climate studies

However, in-situ airborne observations are required to improve understanding of the transmission properties of the atmosphere
In support of space borne observation

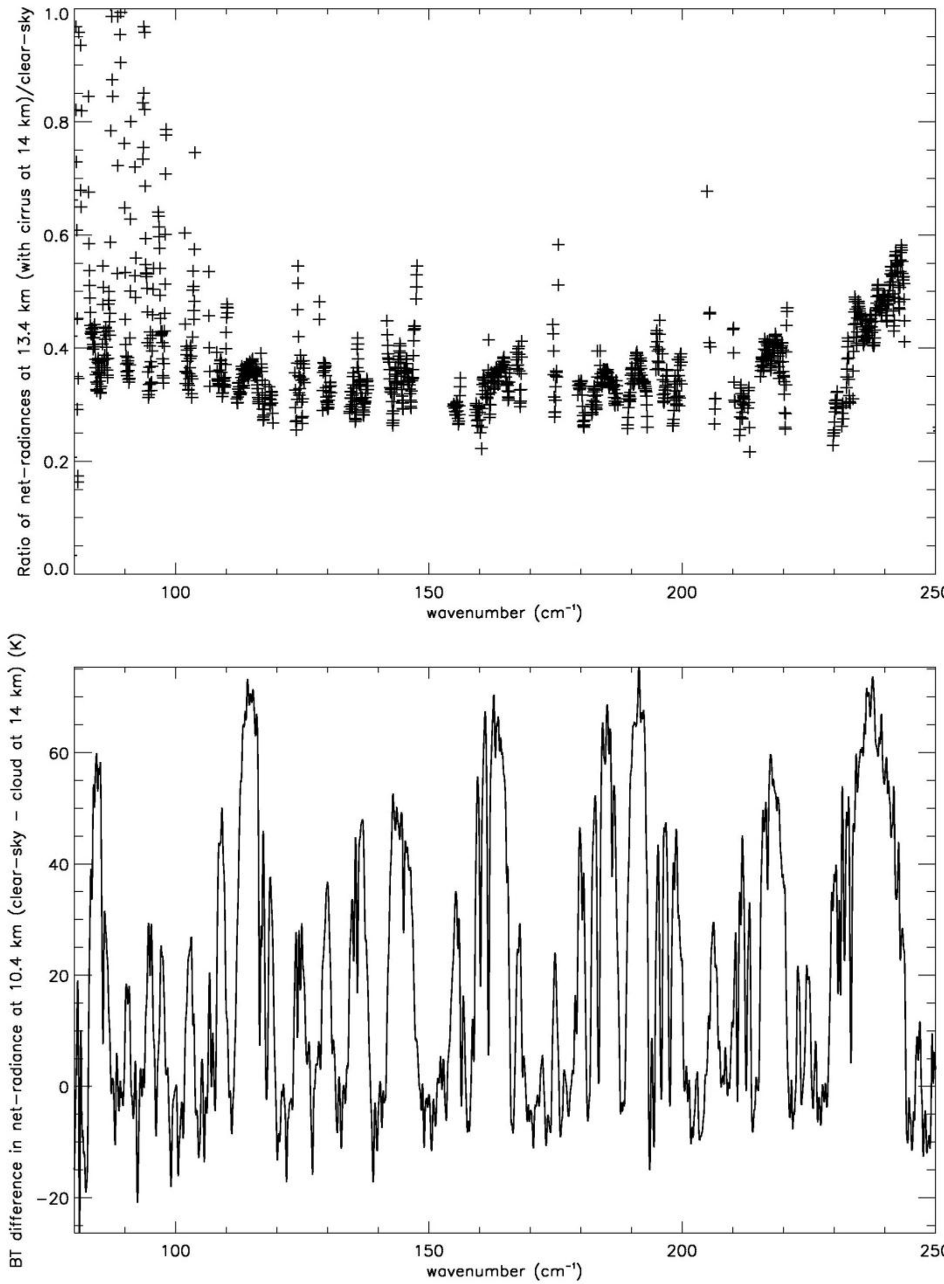
As well as supporting the validation process during the initial observational phase of space borne instruments

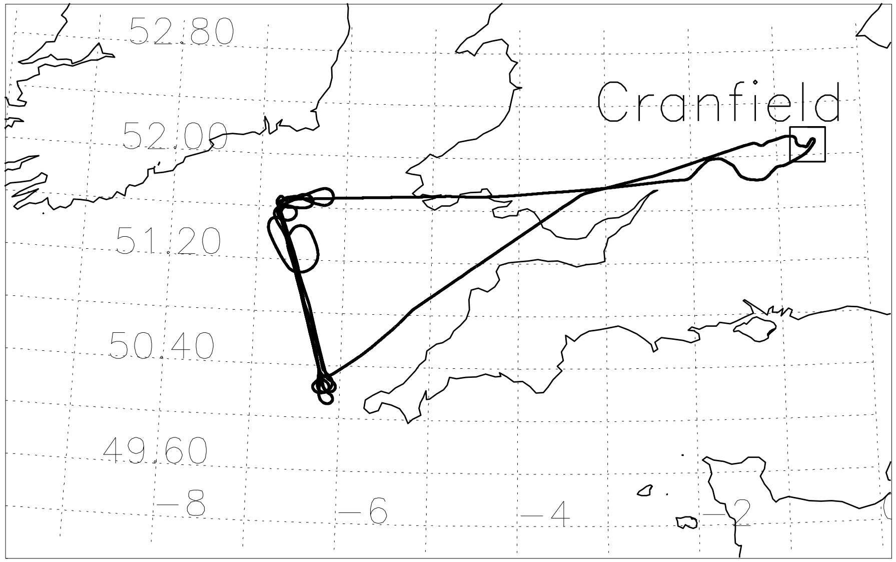
In contrast the Jacobians computed for the CAVIAR campaign
Show a well constrained atmosphere.

Lowest pressure level is aircraft position (looking up) dashed line represents
The upper altitude position of the aircraft during flight

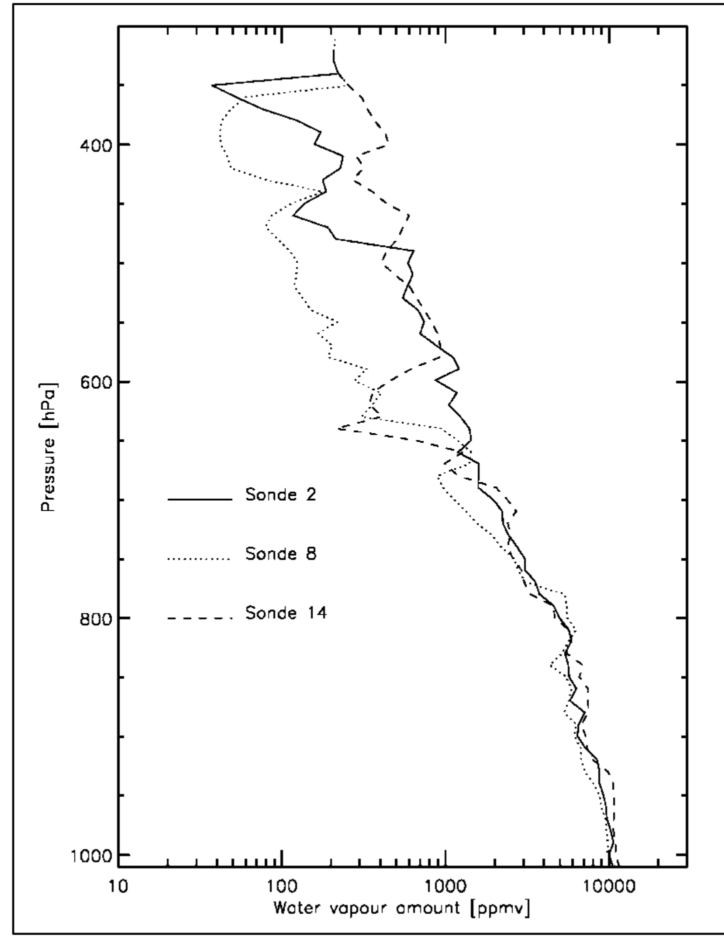


Impact at 10.4 km net-radiance
Due to cirrus cloud at 14 km



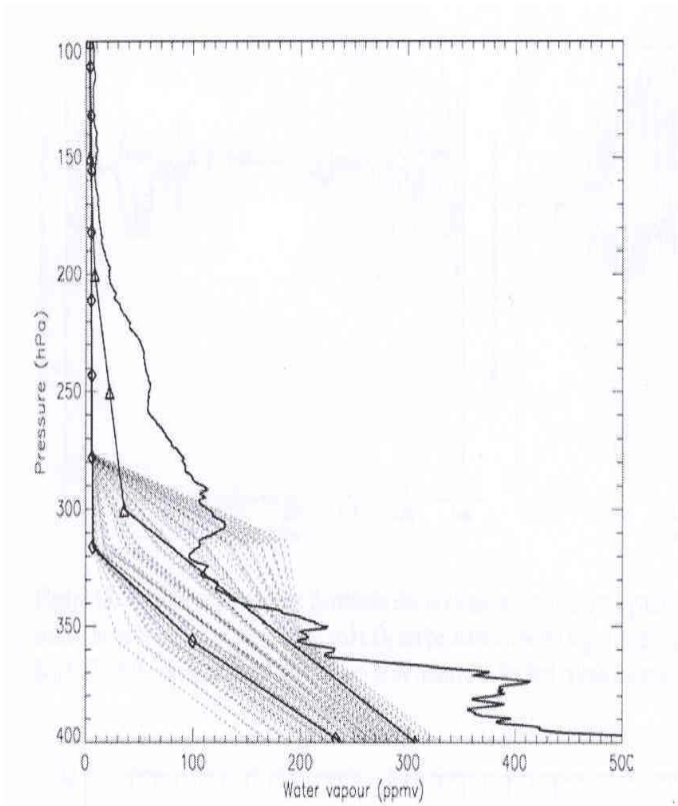


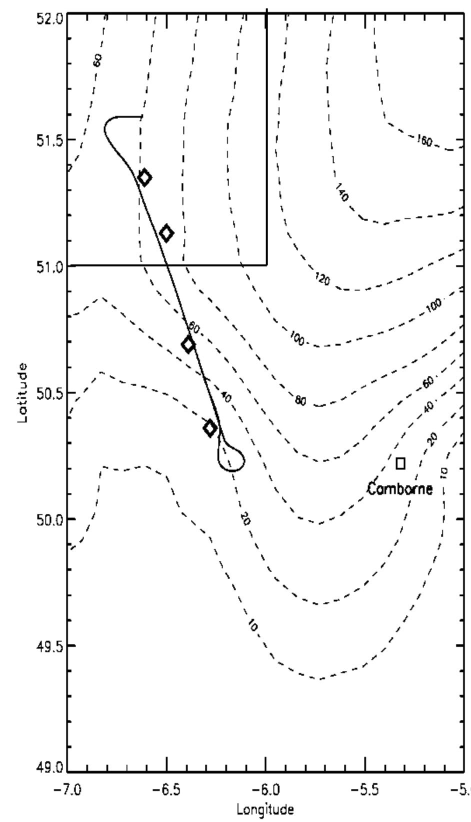
13 Vaisala RD93 Dropsondes



EAQUATE CAMPAIGN

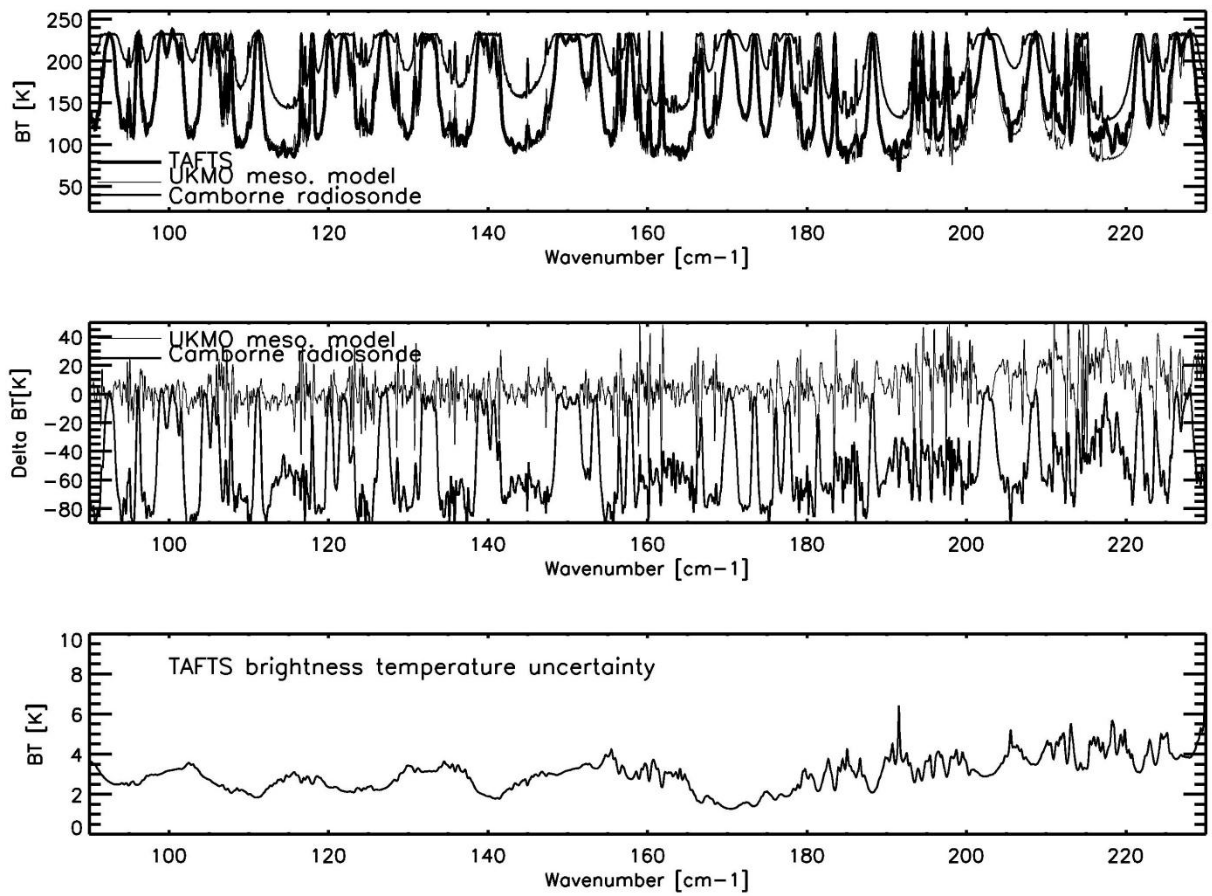
Upper troposphere water vapour
Radiosonde (solid line) Camborne
ECMWF (connected triangles) $1^o \times 1^o$
UKMO Mesoscale model (connected diamonds) $.11^o \times .11^o$
spread of mesoscale model within $1^o \times 1^o$ box





Atmospheric down-welling radiance simulations radiosonde and UKMO meso-scale

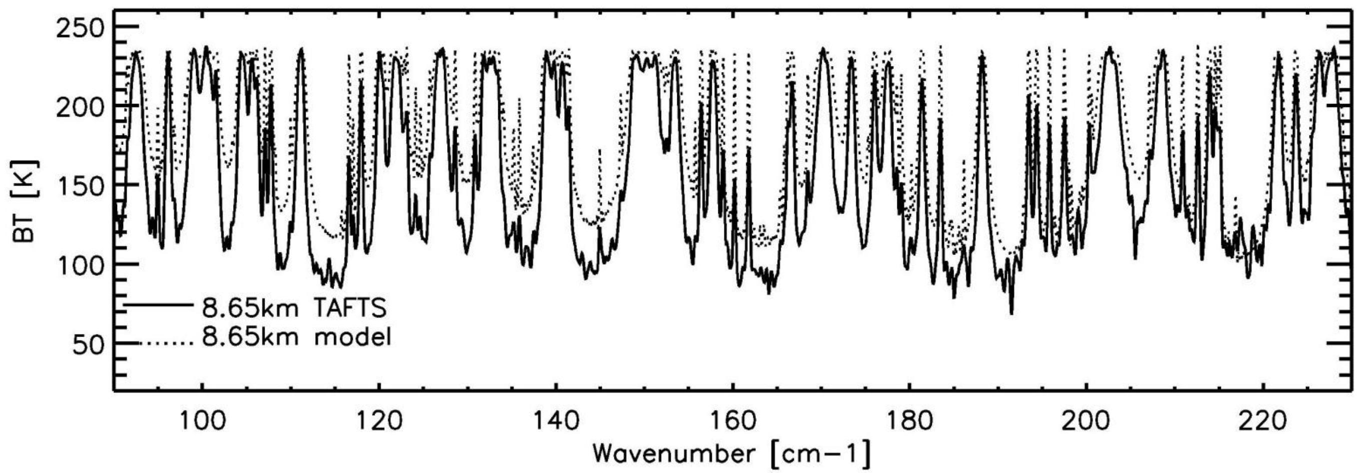
Comparisons with in-flight observations at

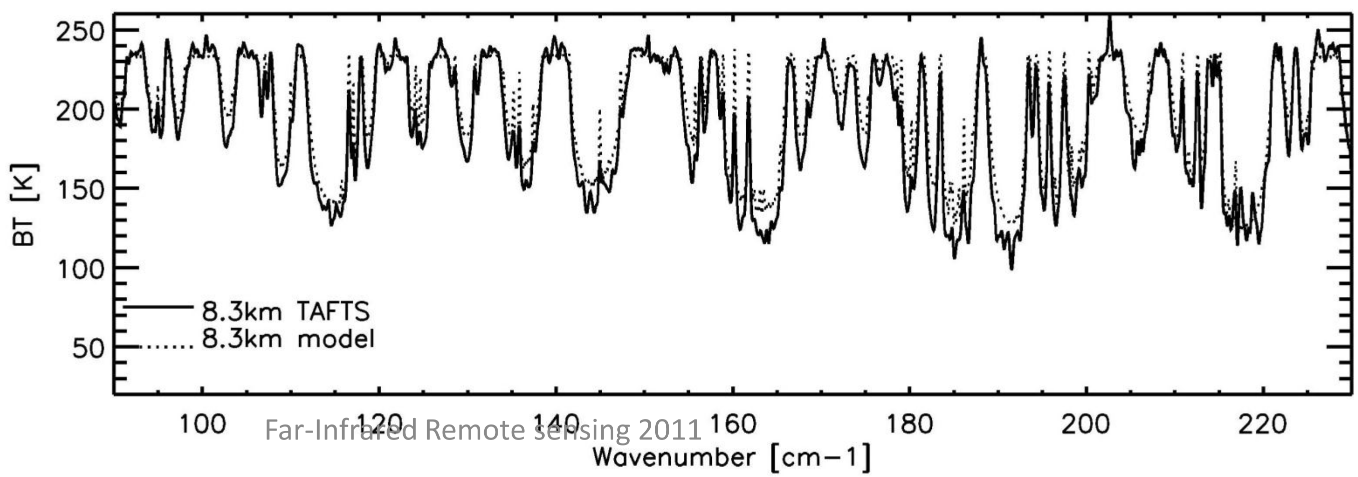


Model data incorporates mesoscale data above 300 hPa and aircraft data
Between 329 and 300 hPa.

Discrepancies at 8.65 km
Suggests the profile has a
wet bias

Variability in humidity not captured or poor measurements





The FIR variation observed across the FL track is limited by that of the measurement uncertainty, however, the model deviation (derived from the meso-scale atmosphere variation) should be just discernible.