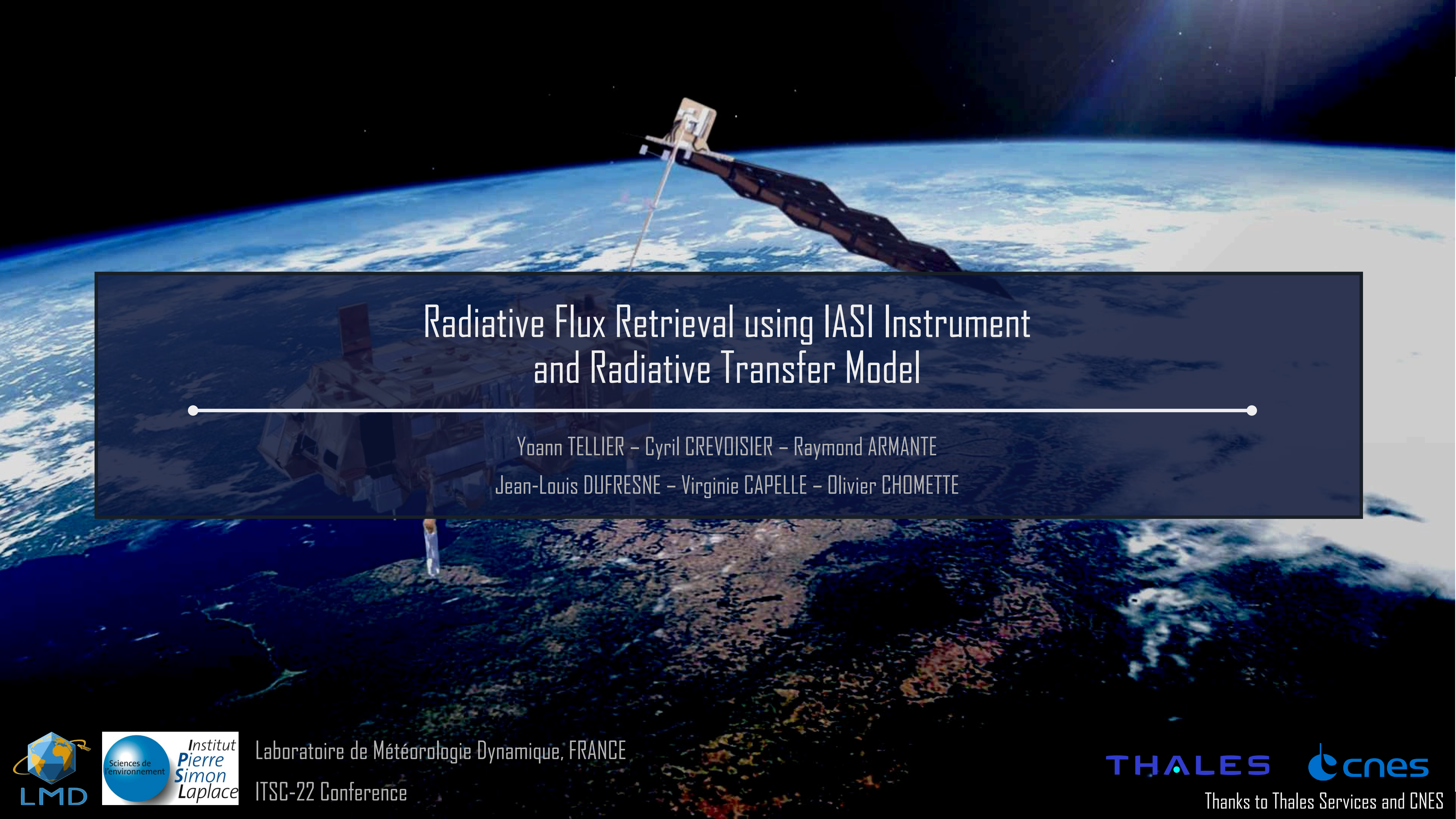

Radiative Flux Retrieval using IASI Instrument and Radiative Transfer Model

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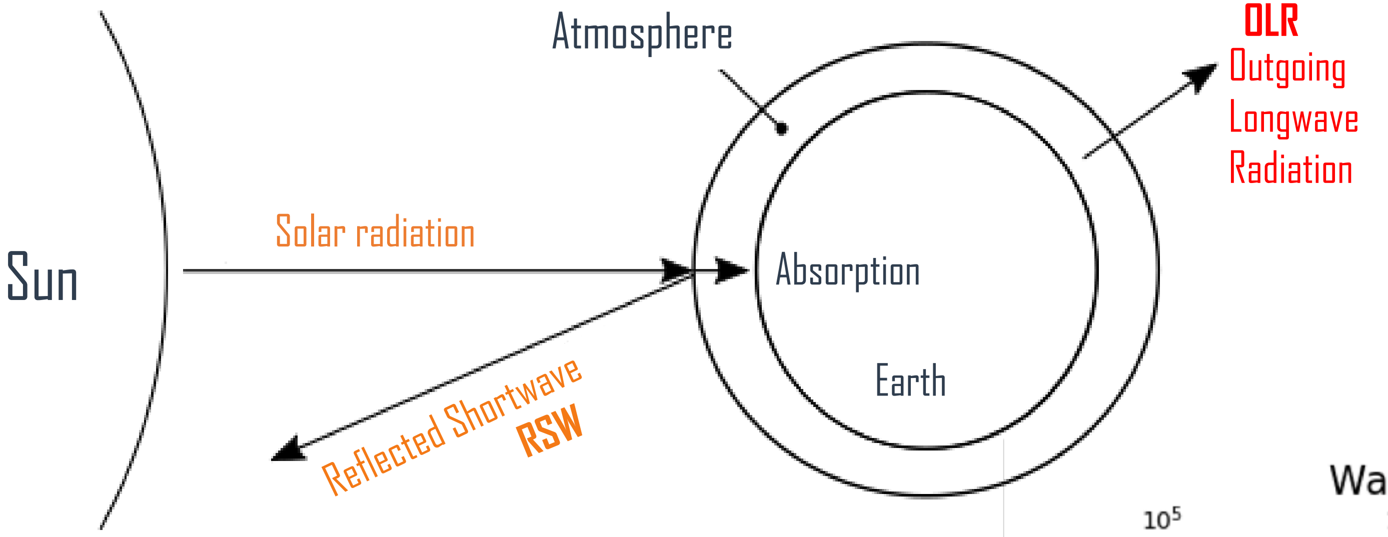
ITSC-22 Conference

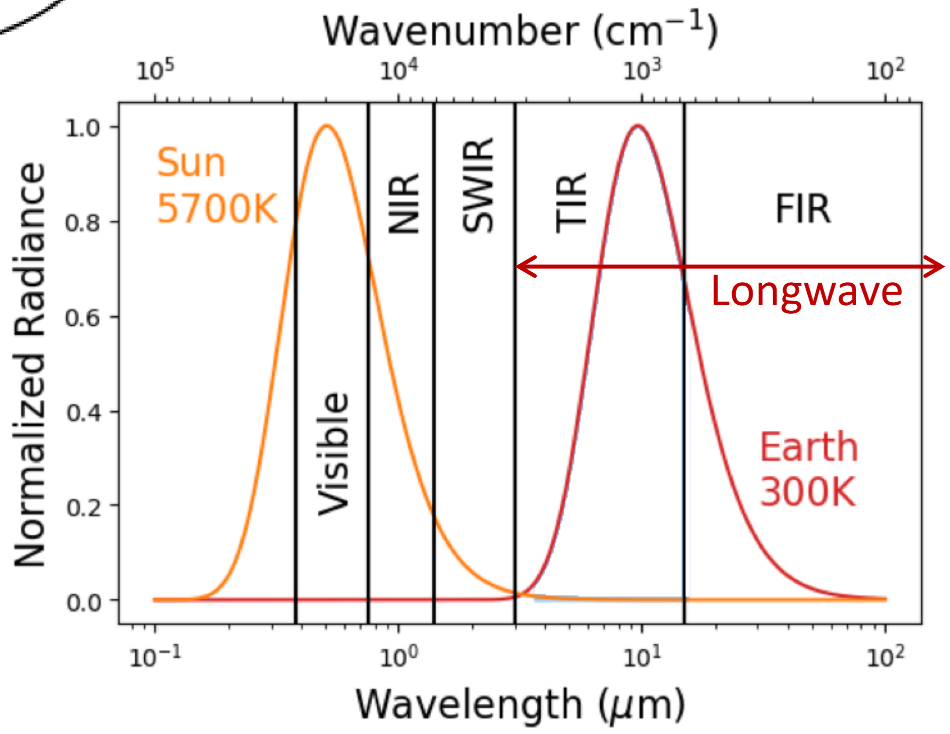
Thanks to Thales Services and CNES

Earth Radiative Budget



- The Earth system is in constant radiative equilibrium
  - Incoming solar radiation
  - Outgoing reflected shortwave (RSW)
  - Outgoing longwave radiation (OLR)
- This equilibrium is the main driver of the climate system

This work focuses on the longwave radiation



Radiative Flux Variables

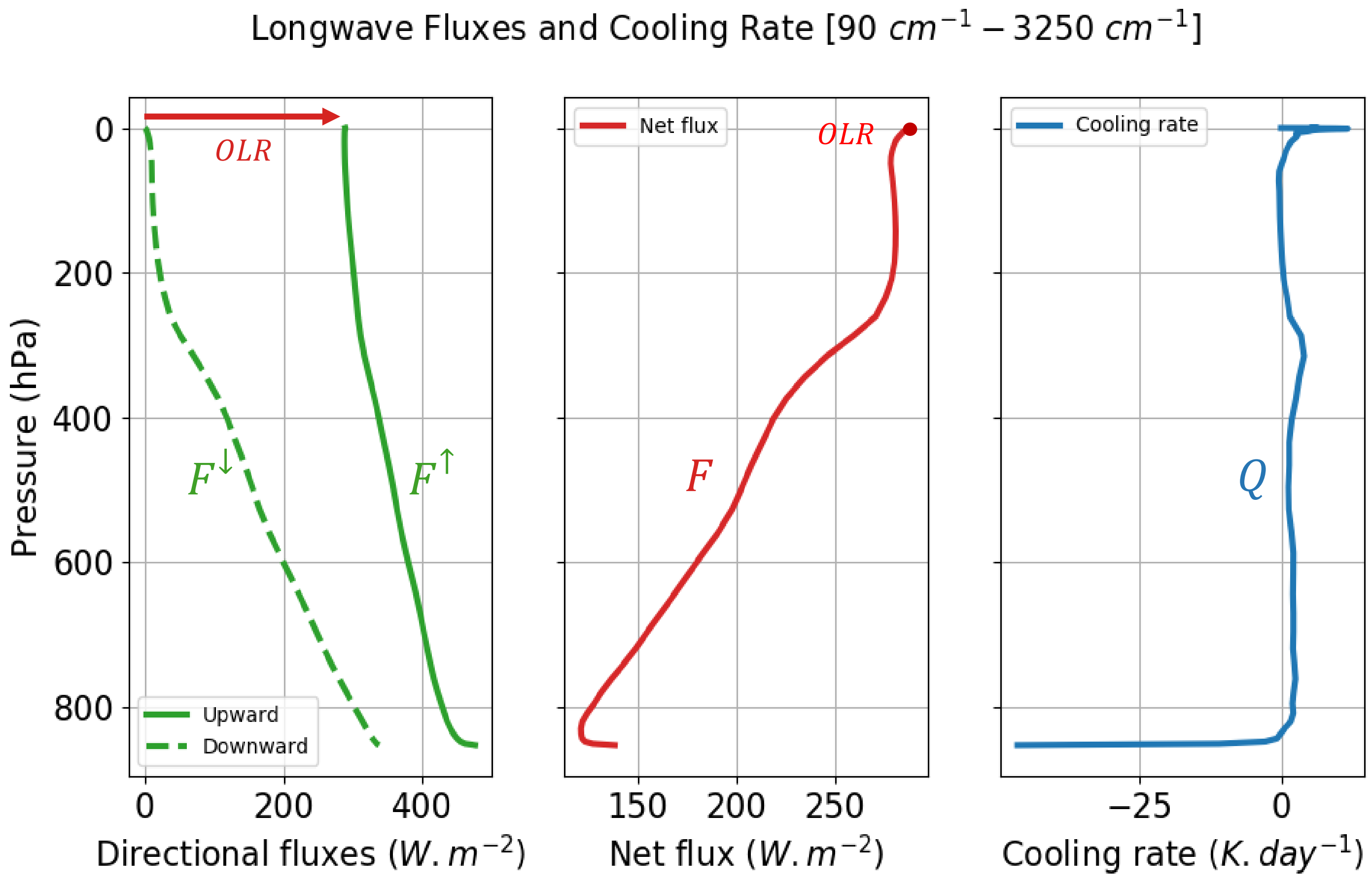
- $I_\nu(P, \mu)$: spectral radiance at level P in the direction $\mu = \cos(\theta)$ at wavenumber ν

- Directional longwave fluxes
  - $F^{\uparrow}(P) = 2\pi \int_{LW} \int_0^1 I_\nu(P, \mu)\, \mu\, d\mu\, d\nu$
  - $F^{\downarrow}(P) = 2\pi \int_{LW} \int_0^1 I_\nu(P, -\mu)\, \mu\, d\mu\, d\nu$

- Longwave net flux
  - $F(P) = F^{\uparrow}(P) - F^{\downarrow}(P)$

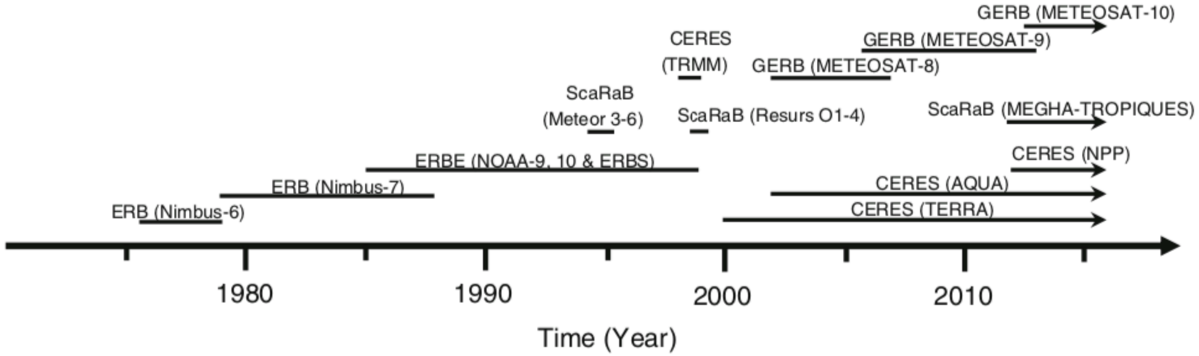
- Outgoing longwave radiation
  - $OLR = F(P_{TOA})$

- Longwave cooling rate
  - $Q(P) = -\frac{g}{c_P}\frac{\partial F(P)}{\partial P}$



Two kinds of spaceborne measurement of the OLR

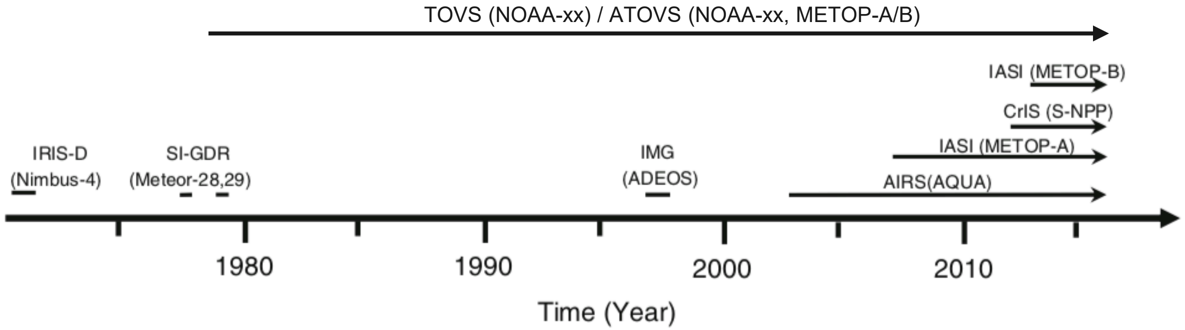
Broadband radiometers



- e.g. ERB, CERES, ScaRaB (1975-…)

IR sounders

Source : Brindley et Bantges (2013)



- Low resolution: e.g. TOVS/ATOVS (1978-…)
- High resolution: e.g. AIRS, IASI, CrIS (2002-…)

Broadband Radiometers	Accessible Variables	IR sounders
✓	TOA Net flux (OLR)	✓
x	Radiative Flux and cooling rate spectra	✓
x	Radiative Flux and cooling rate profiles	✓

- IASI combines a high spectral and radiometric stability and long term coverage (20 years)
- IASI offers a continuous coverage of the TIR spectrum from 645 to 2760 cm^{-1} (3,63 – 15,5 μm)
- IR Radiative flux estimation → One of the main objectives of IASI

How to estimate radiative flux from IASI measurements?

Adaptation of 4A radiative transfer code to compute the clear-sky radiative flux

- Radiative transfer model used : 4A/OP-2016
- For this study:
  - Use of GEISA 2015 spectroscopic database
  - Angular integration performed using the E_3 exponential integral functions
  - Spectral integration performed on bands of $1\ cm^{-1}$

Participation of 4A to the Radiative Forcing Model Intercomparison Project (RFMIP)

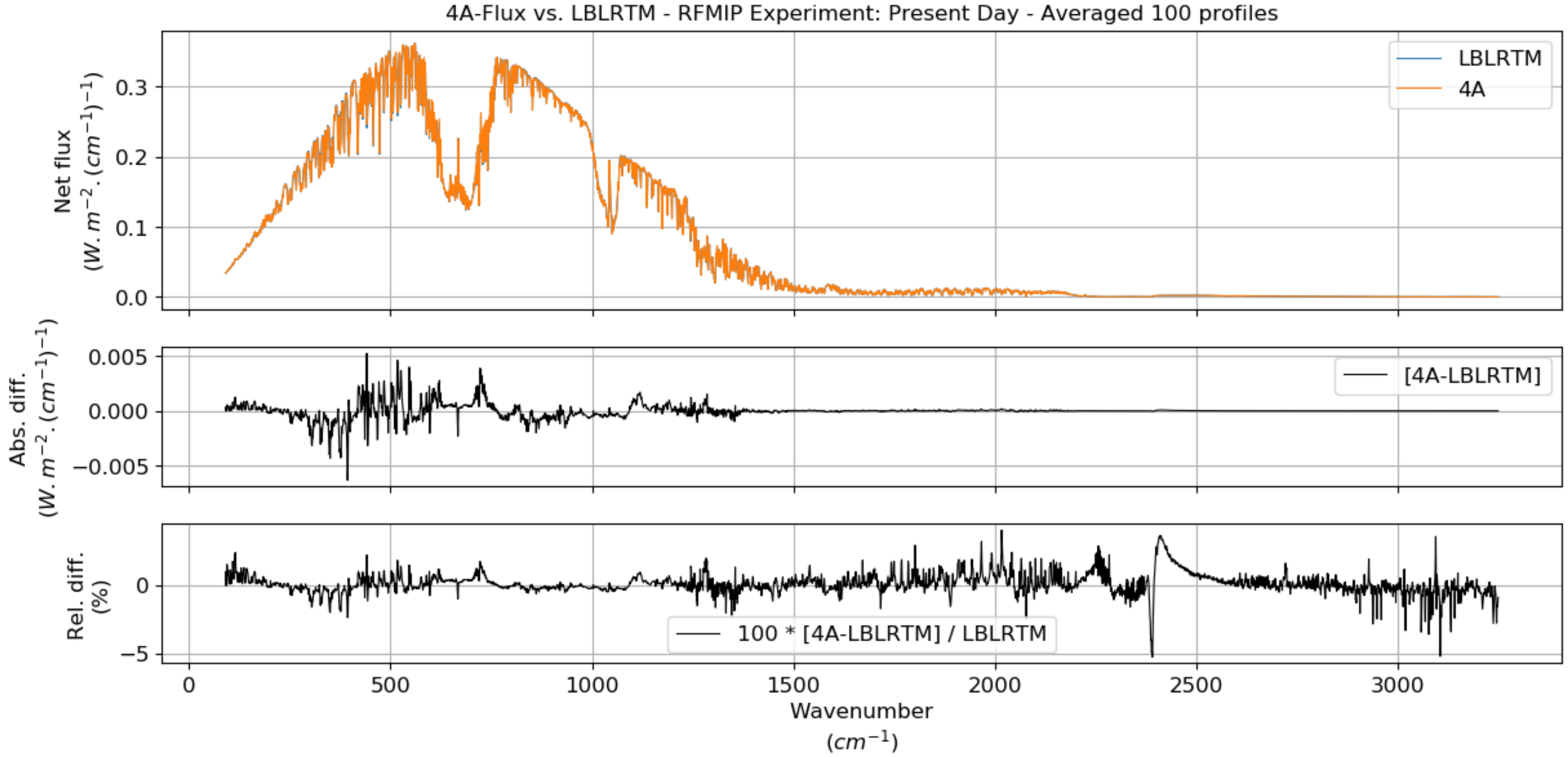
(cf. *Pincus et al. 2016*)

- Objectives no. 2 of RFMIP is assessing the absolute accuracy of clear-sky radiative transfer parameterizations on the global scales relevant for climate modeling
- Sample of 100 atmospheric conditions that can be used to estimate time-averaged global-mean fluxes when the specified weights are used
- Intercomparison between several RTM

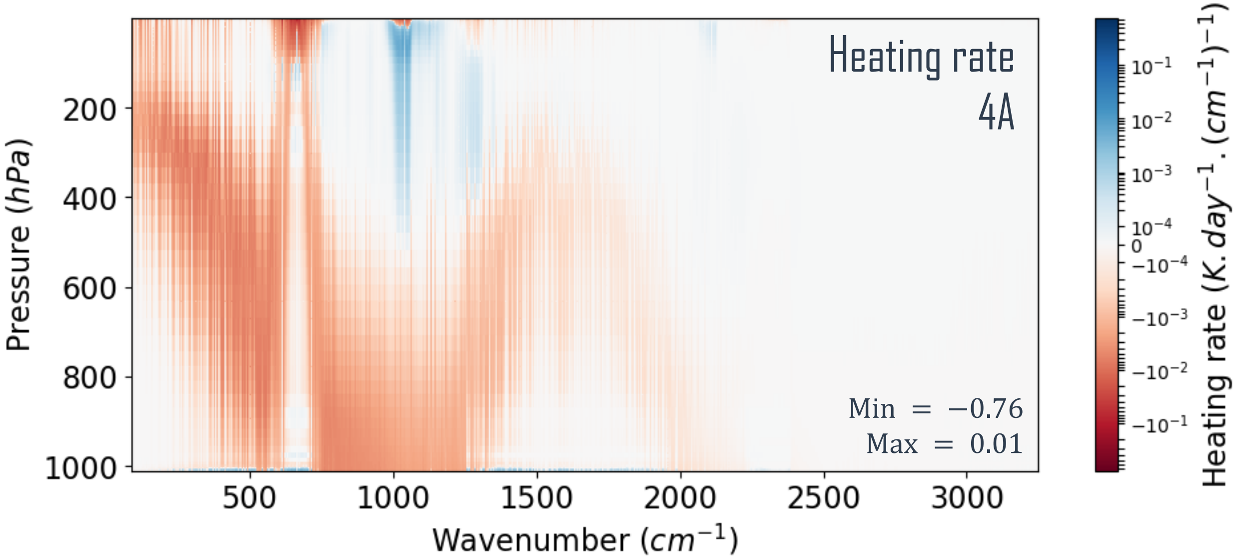
Intercomparison of the OLR between 4A and LBLRTM models

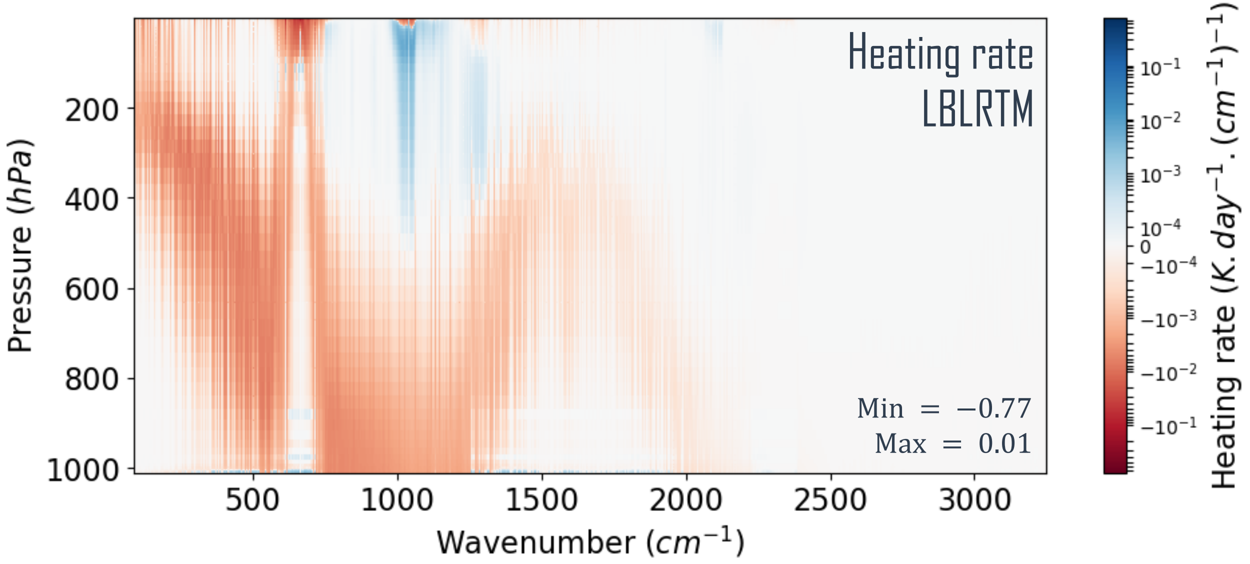
SPECTRALLY INTEGRATED OLR

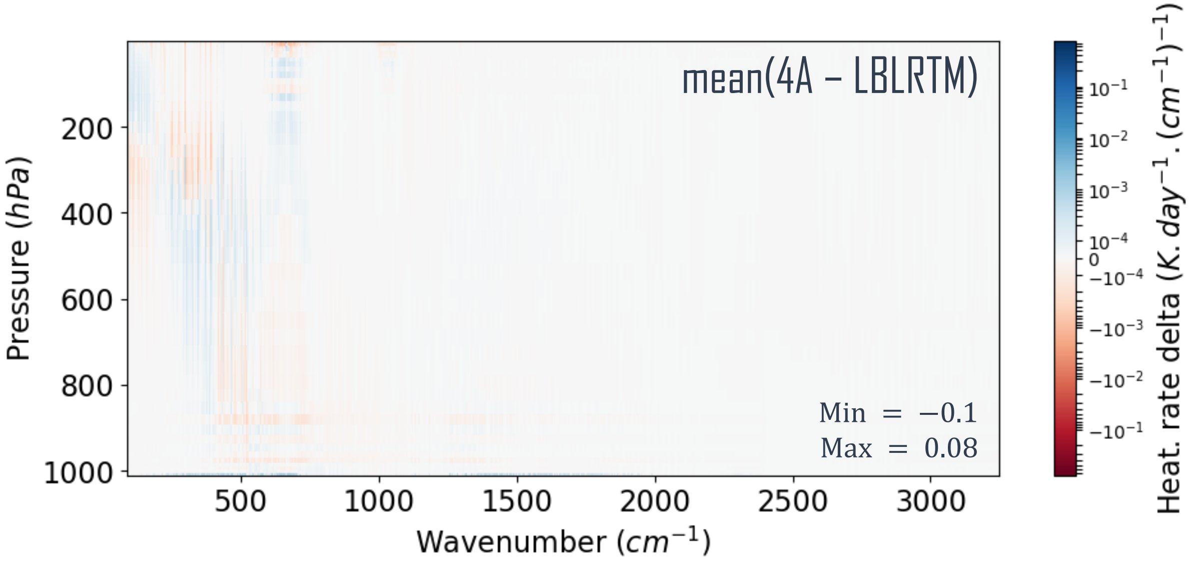
OLR LBLRTM	$262.09 \pm 3.14\ W.m^{-2}$
OLR 4A	$262.06 \pm 3.14\ W.m^{-2}$
Delta OLR (4A-LBLRTM)	$-0.03 \pm 0.01\ W.m^{-2}$
Relative difference	$-\ 0.01\ \%$

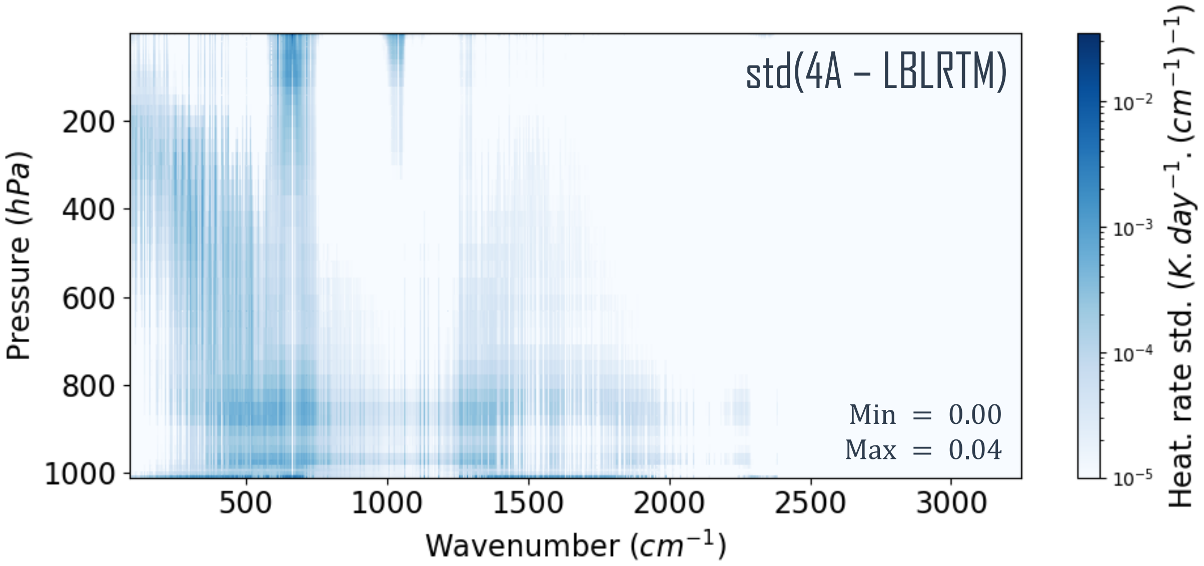


Vertical heating rate comparison on 100 averaged RFMIP atmospheres





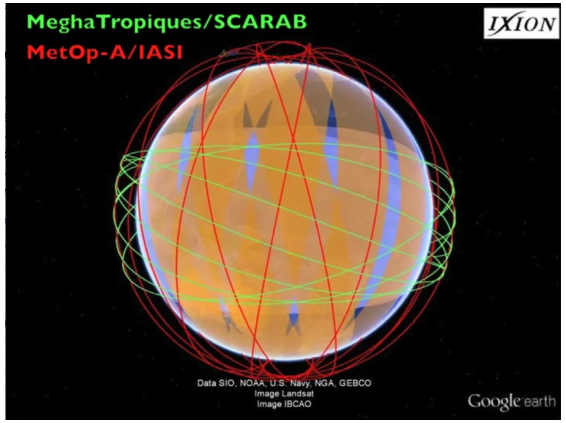




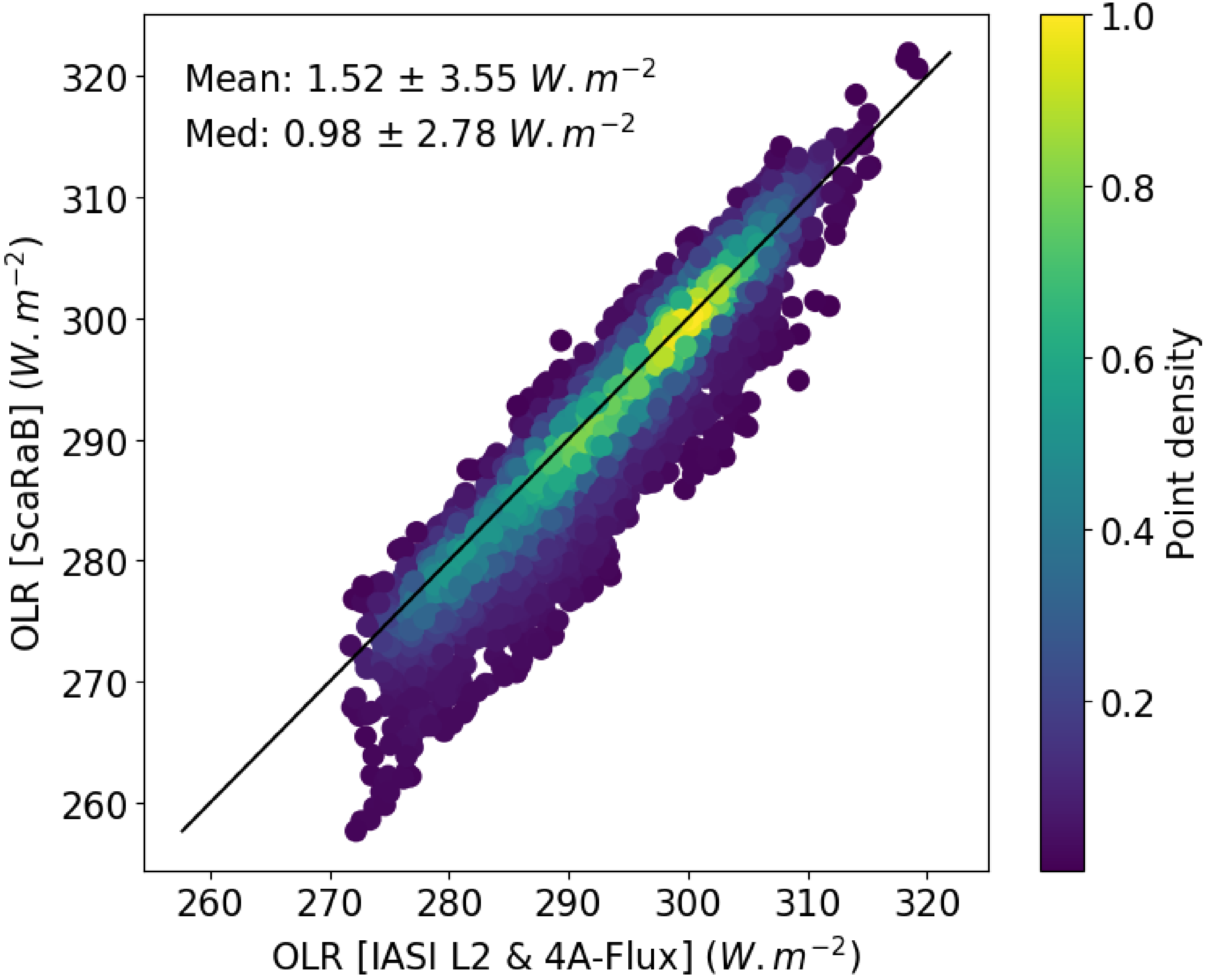
Comparison of 4A retrieval from IASI level 2 with ScaRaB OLR

Preliminary results

- 4263 IASI/ScaRaB collocated points for 2016
  - Maximum distance: 25 km
  - Maximum Timeshift: 4 hours
  - Ocean surface
  - Clear-sky observations
  - Instrument PSF not taken into account

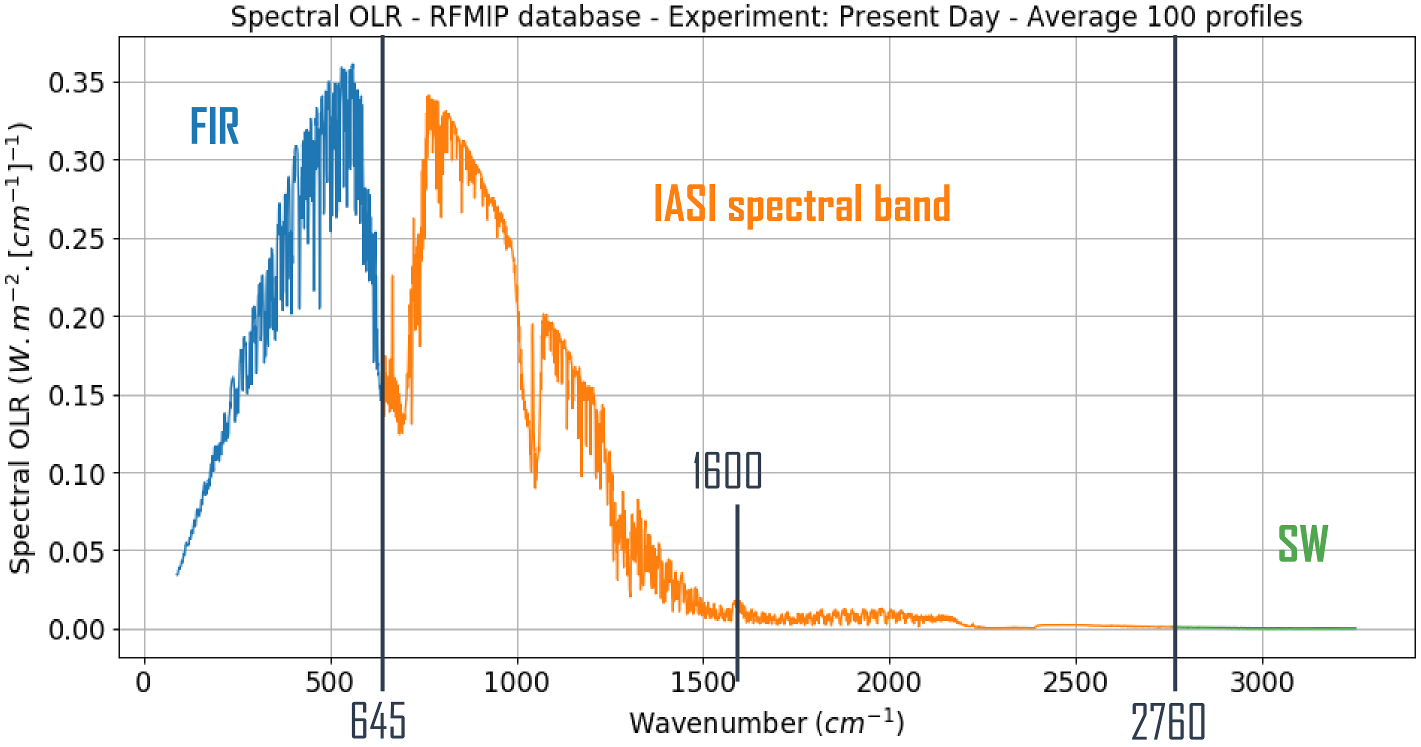


- Good agreement between ScaRaB OLR and flux from IASI
- Bias could be due to the presence of residual clouds



Radiative flux retrieval from IASI level 1c spectra

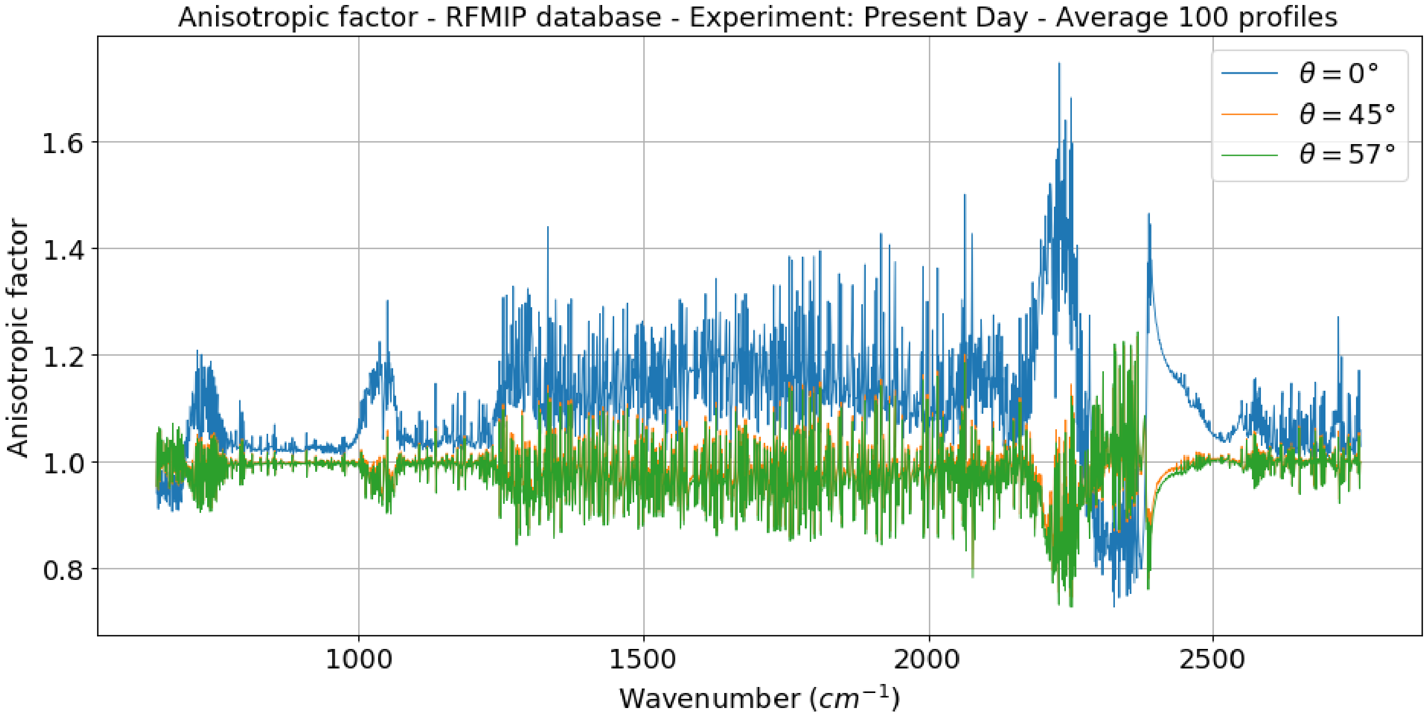
- Challenges using IASI measurement to retrieve radiative flux :
  - Spectral coverage: The longwave spectrum is not entirely covered
    - IASI [645 – 2760] cm^{-1} – Longwave [10 – 3250] cm^{-1}



	Spectral band (cm^{-1})	Flux ($\mathrm{W.m}^{-2}$)	Part (%)
FIR	90 - 645	116.13 ± 0.84	44.31
IASI	645 - 2760	145.79 ± 2.74	55.63
1st segment	645 - 1600	140.72	53.70
2nd segment	1600 - 2760	5.07	1.93
SW	2760 - 3250	0.14 ± 0.01	0.05

Radiative flux retrieval from IASI level 1c spectra

- Challenges using IASI measurement to retrieve radiative flux :
  - Spectral coverage: The longwave spectrum is not entirely covered
    - IASI [645 – 2760] cm^{-1} – Longwave [10 – 3250] cm^{-1}
  - Angular measurement: The measurement is not performed at all angles
    - IASI measures radiances with angles ranging from 0° to 57° – integration over all angles is required



- Angular distribution model defined by the anisotropic factor (Huang et al. 2008):

$$R_\nu(\theta) = \frac{\pi I_\nu(\theta)}{F_\nu}$$

Next steps and summary

Next steps

- To directly and efficiently retrieve radiative fluxes from IASI level 1c spectra : An artificial neural network is being implemented
- The learning database will be produced thanks to 4A applied on the TIGR atmospheric database

IASI spectrum → Multi-layer perceptron → $F^{\uparrow}, F^{\downarrow}$

Summary

- 4A RTM have been adapted to compute radiative flux and vertical cooling rate
- RFMIP: Comparison between 4A and other RTM are being performed
- A first comparison between OLR simulated from IASI L2 and measured by ScaRab instrument shows good agreement
- Thanks to this method the impact of variation of parameters on the flux can be assessed

Thank you for your attention

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