

# Assimilation of IASI observations to enhance the coupling between Numerical Weather Prediction and Chemistry Transport Models

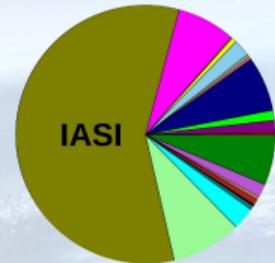
- Olivier Coopmann <sup>1</sup> – PhD Student (2<sup>nd</sup> year) – [olivier.coopmann@umr-cnrm.fr](mailto:olivier.coopmann@umr-cnrm.fr)
- <sup>1</sup> CNRM, Université de Toulouse, Météo-France, CNRS, France
- Supervisors : Vincent Guidard <sup>1</sup> & Nadia Fourrié <sup>1</sup>

IASI : Infra-red Atmospheric Sounding Interferometer

- Onboard the **Metop A&B (Metop C soon !)**
- **8461** channel – spectral range [**645 to 2760 cm<sup>-1</sup>**]
- Provides  $T_B$  at the top of atmosphere and indirect information on:
  - Temperature and humidity profiles
  - Cloud cover and surface properties
  - Aerosols
  - Atmospheric compounds :  $O_3$ ,  $CO_2$ ,  $CH_4$ ,  $CO$ ,  $N_2O$ ...

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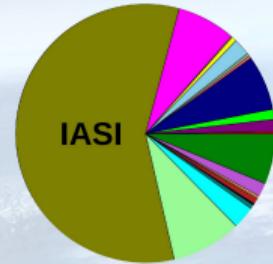
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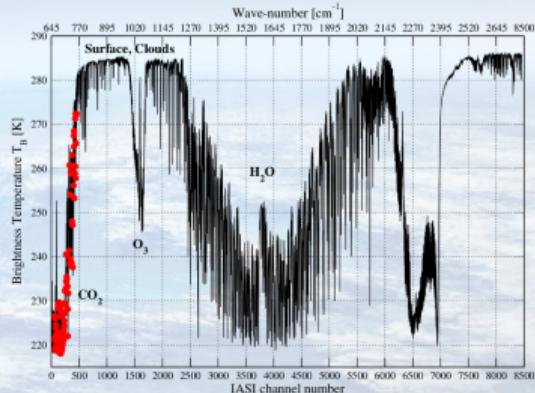
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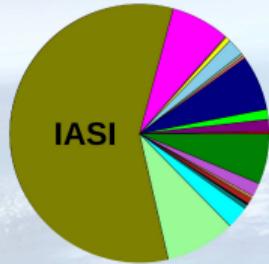


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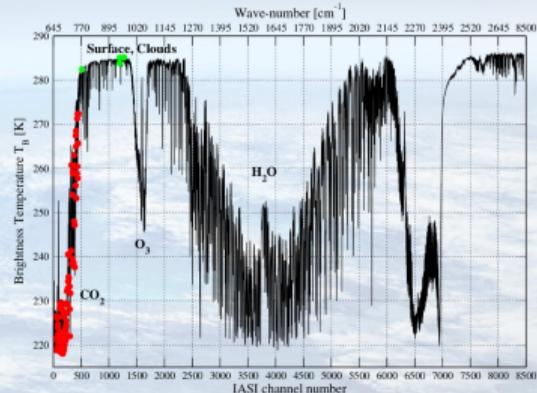


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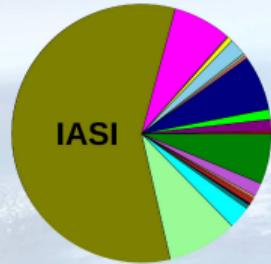


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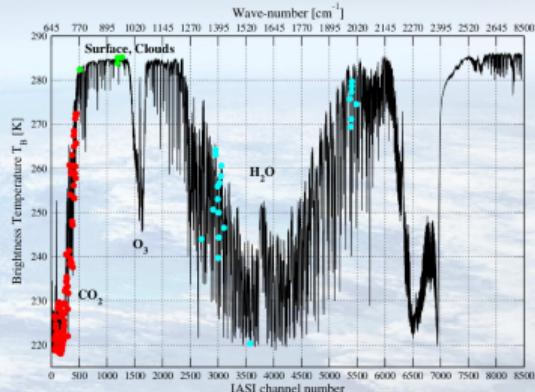


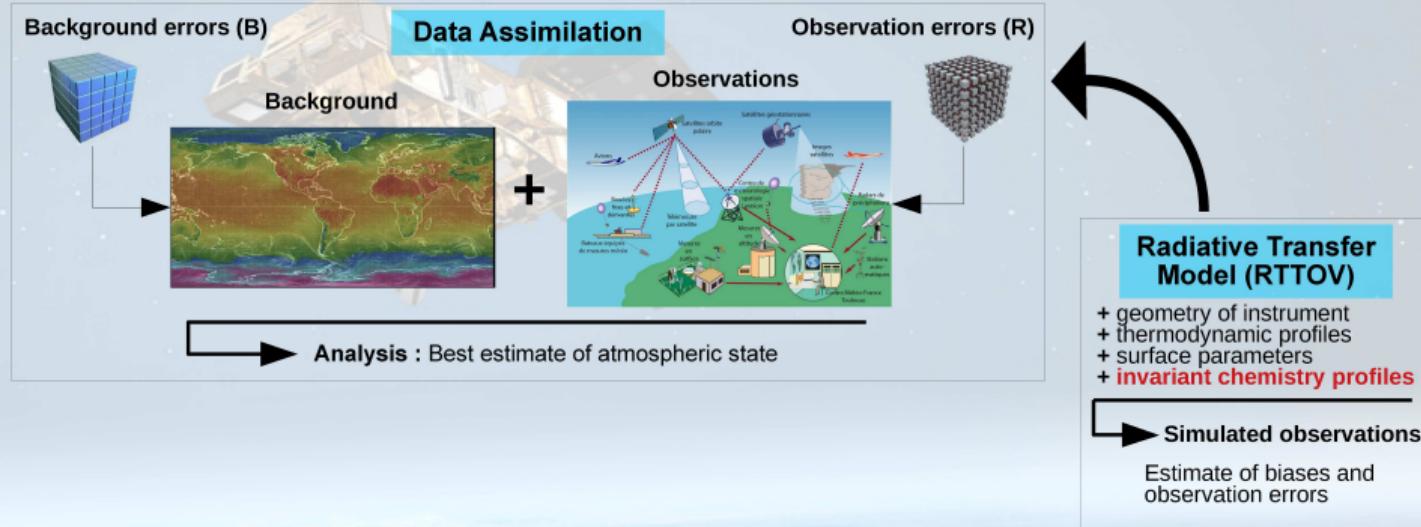
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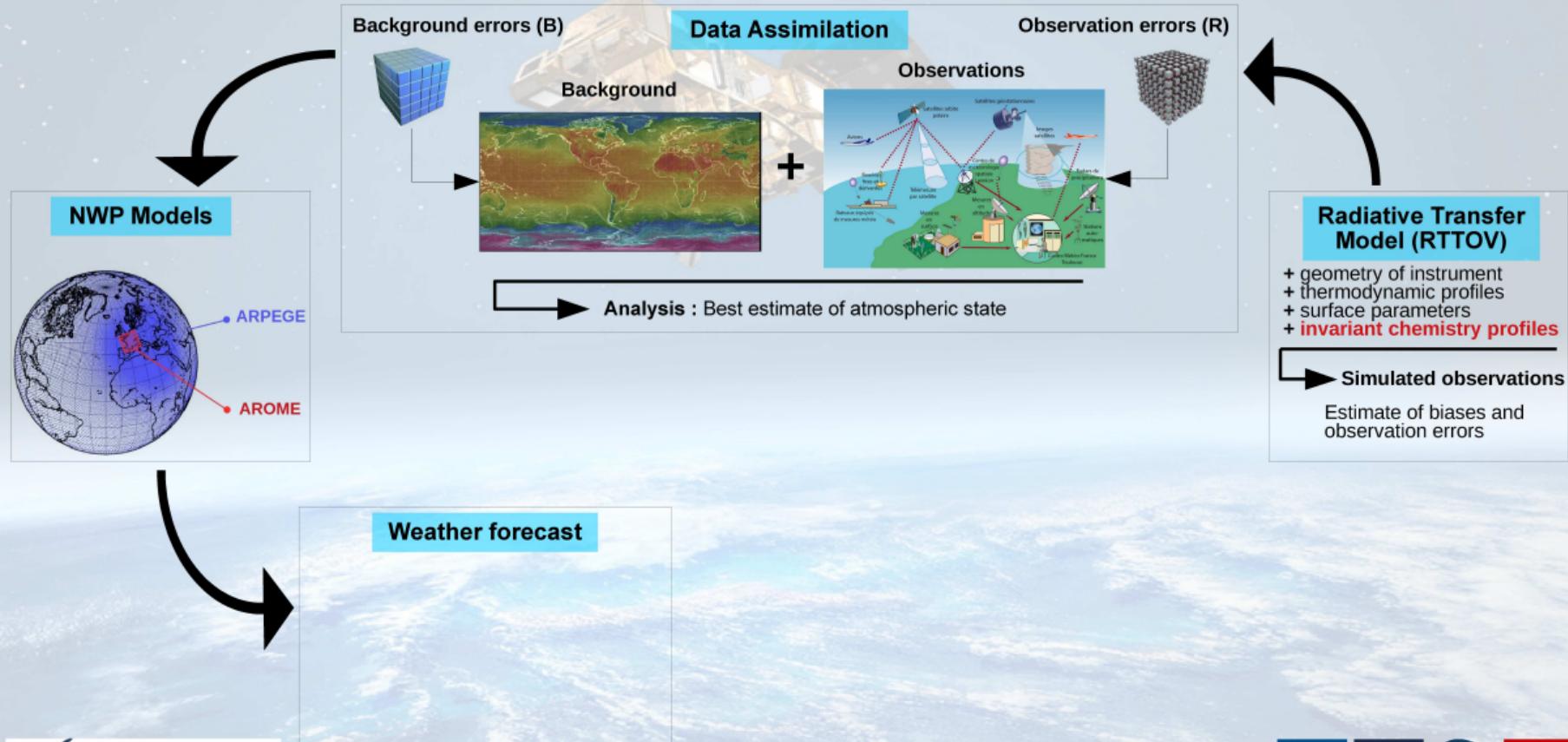
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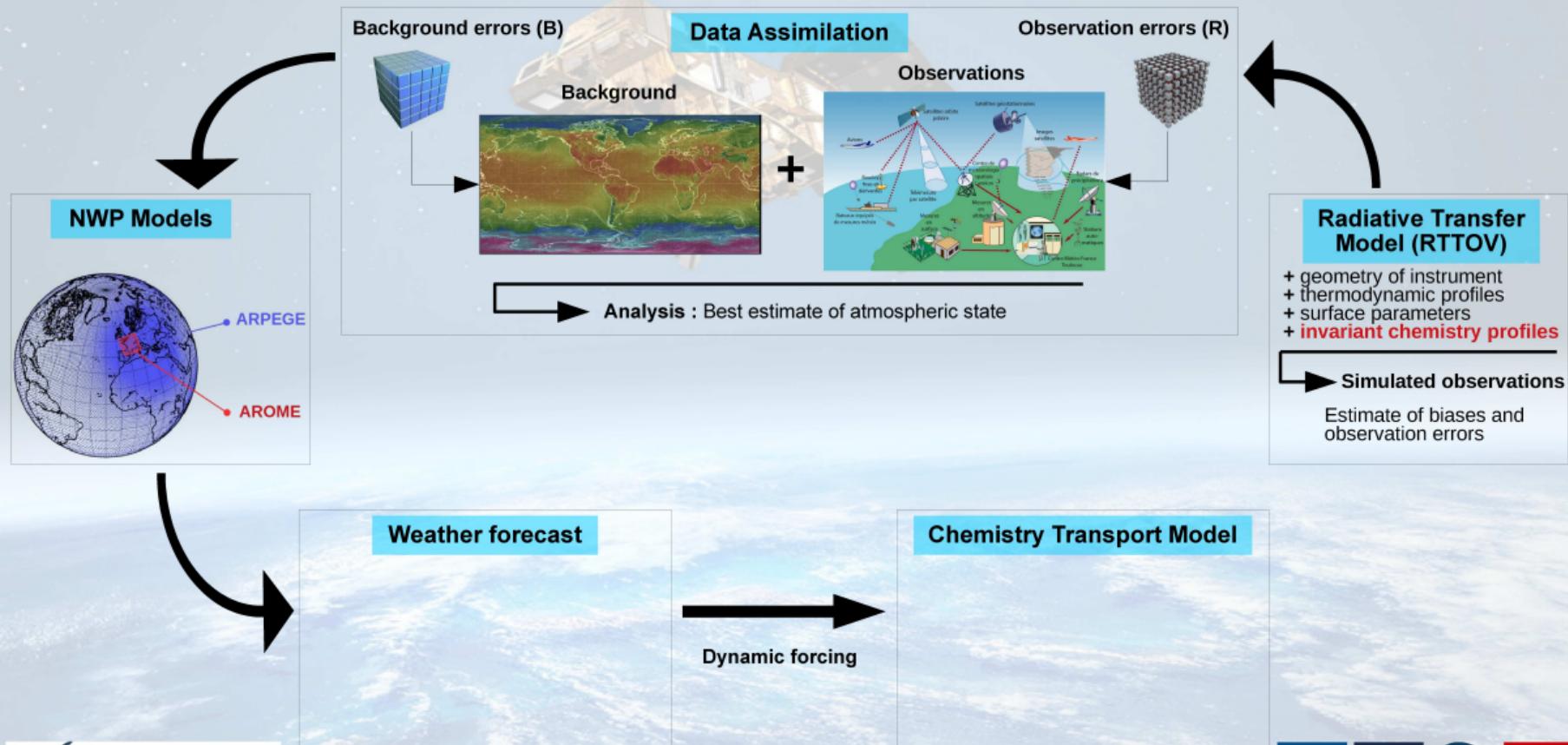


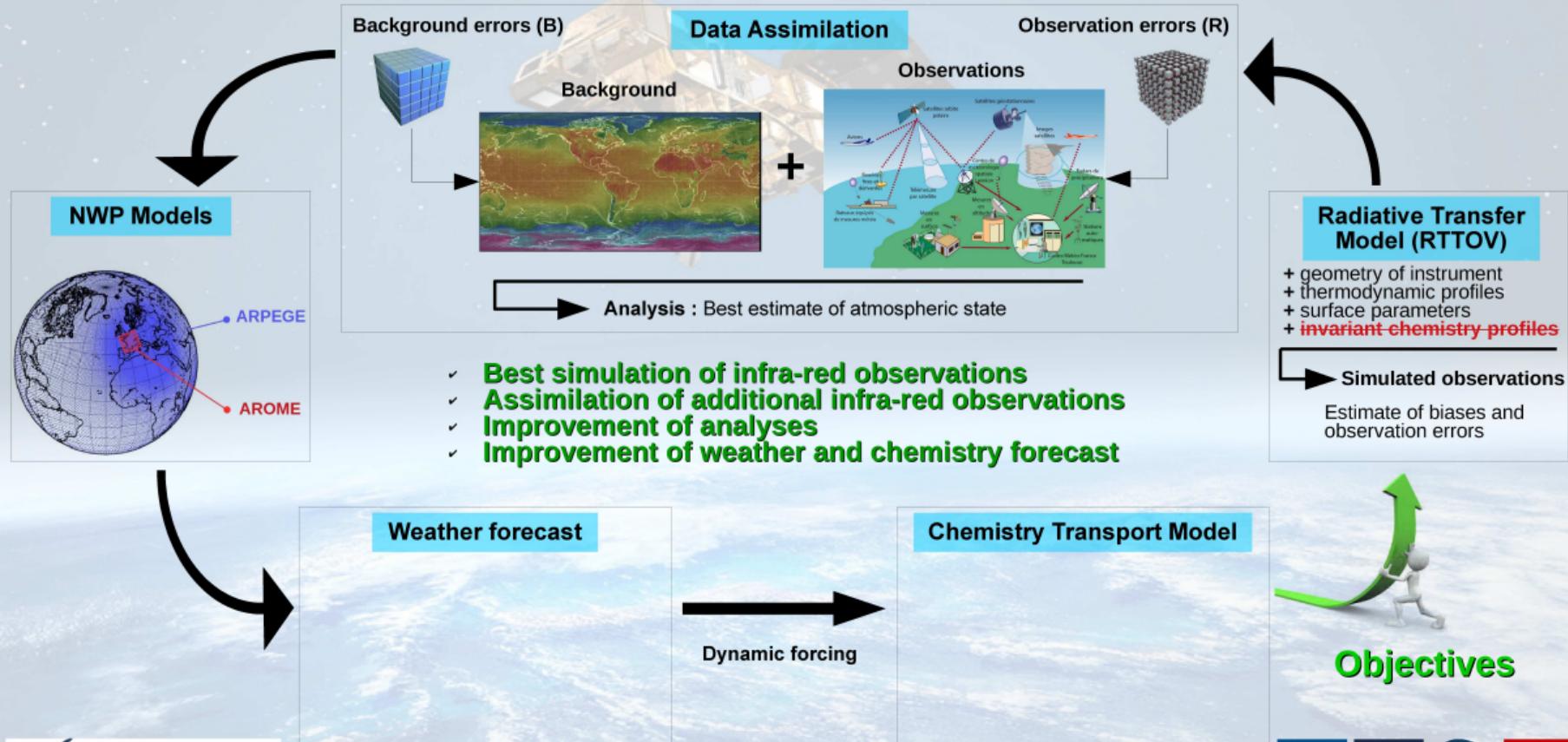
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    - ✓ **4** window channels
    - ✓ **20** WV sensitives channels →  $q$  profiles











- Coopmann et al., 2018, « Assimilation of IASI ozone-sensitive channels in preparation for an enhanced coupling between Numerical Weather Prediction and Chemistry Transport Models » for the Journal of Geophysical Research Atmospheres

→ Which sensitivity of simulation to O<sub>3</sub> informations

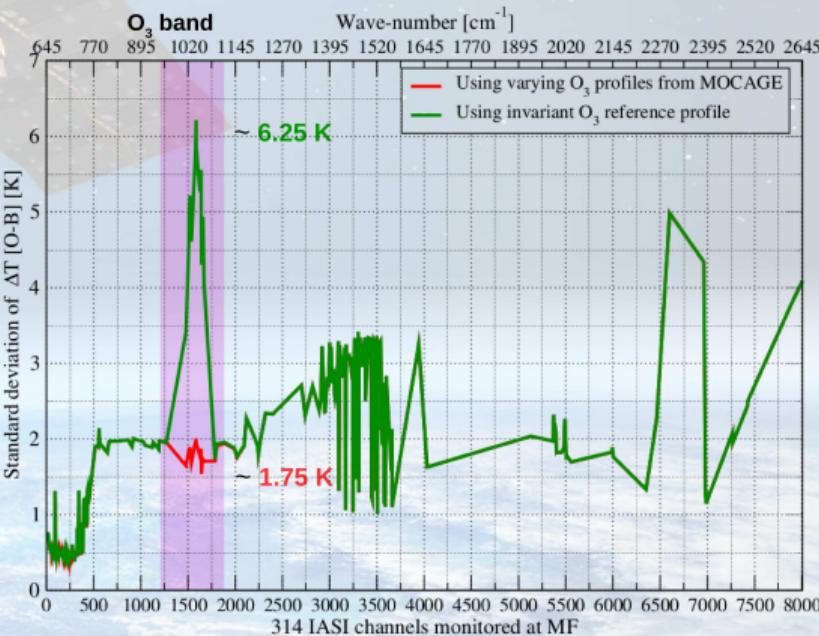
- Using realistic O<sub>3</sub> information → better simulation of O<sub>3</sub> IASI radiances

→ Which impact of IASI O<sub>3</sub> sensitive channels to analyses

- Beneficial contribution on the 15 O<sub>3</sub> IASI channels to analyses

→ More O<sub>3</sub> sensitive channels are available over full IASI spectrum

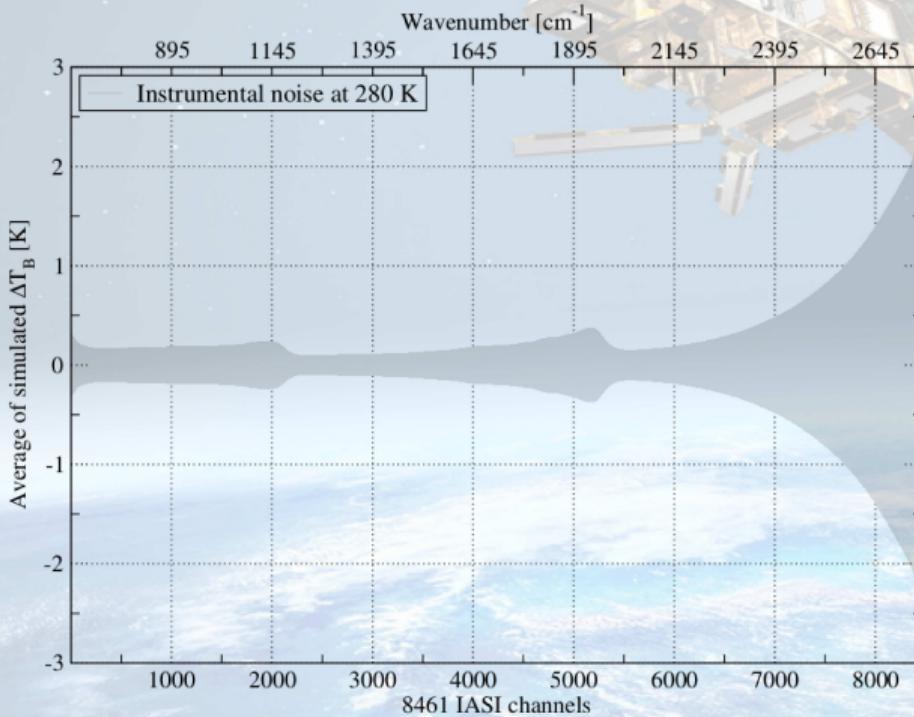
- New O<sub>3</sub> channel selection



Standard deviation of  $\Delta T_B$  (O-B) with respect to 314 monitored IASI channels including 15 O<sub>3</sub> sensitive channels

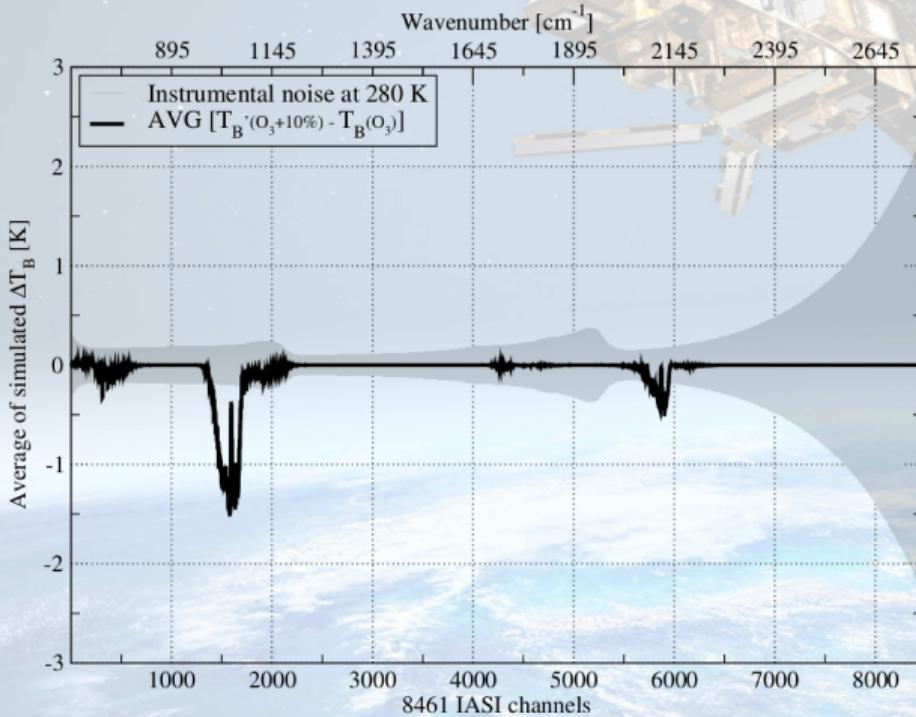
- Identification of IASI O<sub>3</sub> sensitive channels over full spectrum
- Observation error covariance matrix R
- Background error covariance matrix B
- O<sub>3</sub> IASI channel selection → DFS method
- Conclusions
- Perspectives

## Identification of O<sub>3</sub> sensitive channels over full IASI spectrum



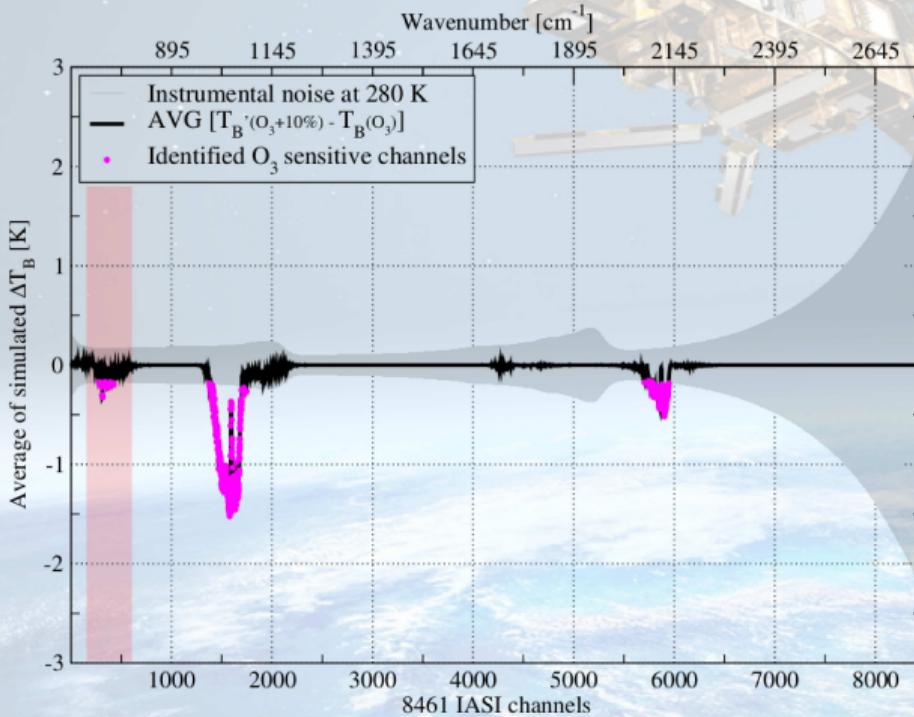
→ IASI instrumental noise at 280 K over **8461** channels

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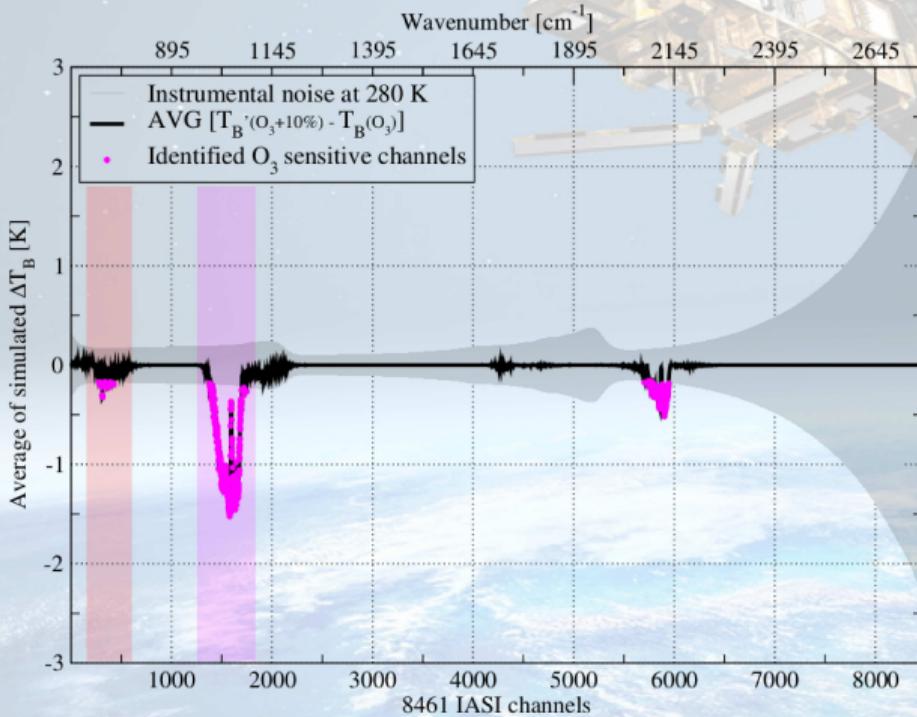
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- RTTOV Experiment : Average of simulated  $\Delta T_B$  with **[O<sub>3</sub> profiles + 10 % - O<sub>3</sub> profiles]**

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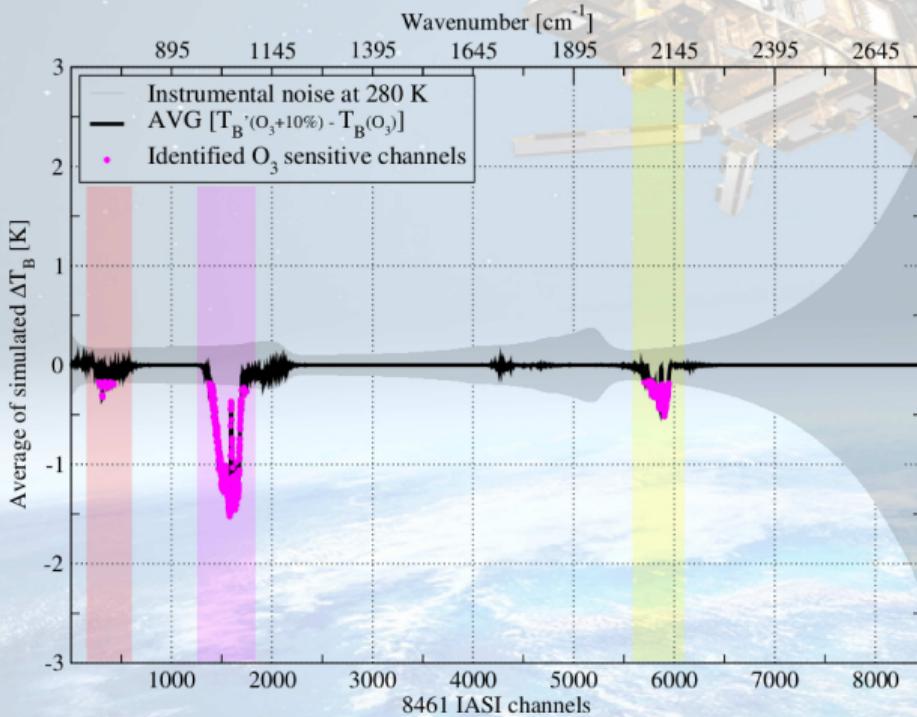
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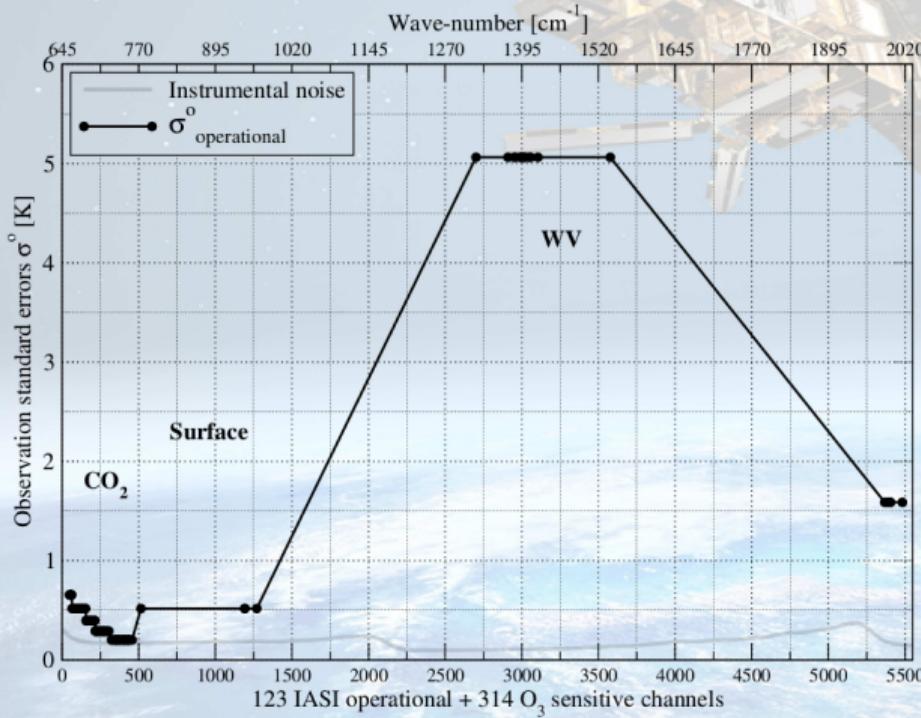


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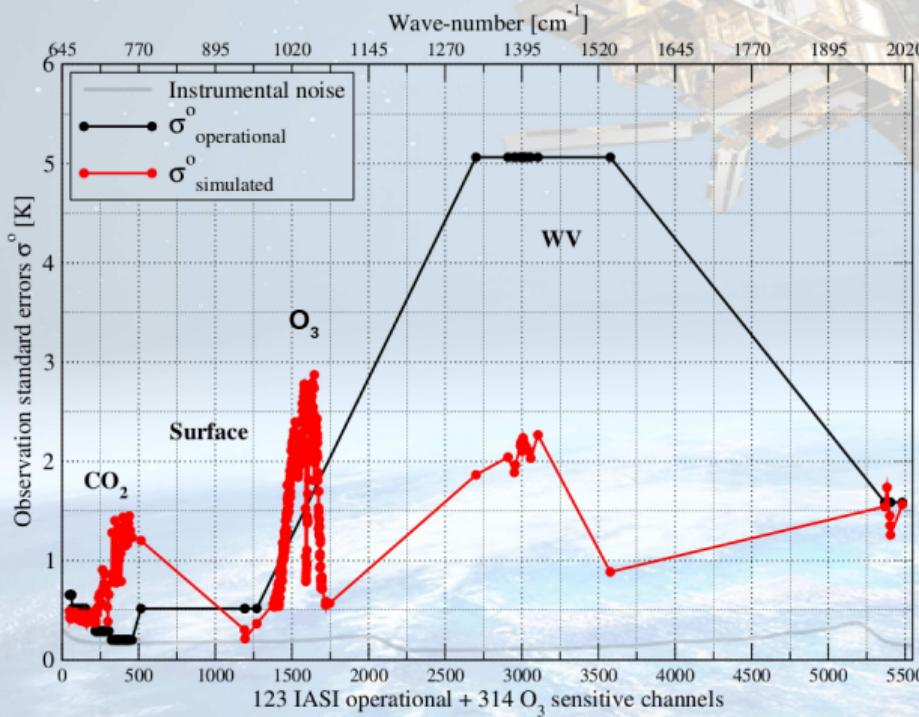
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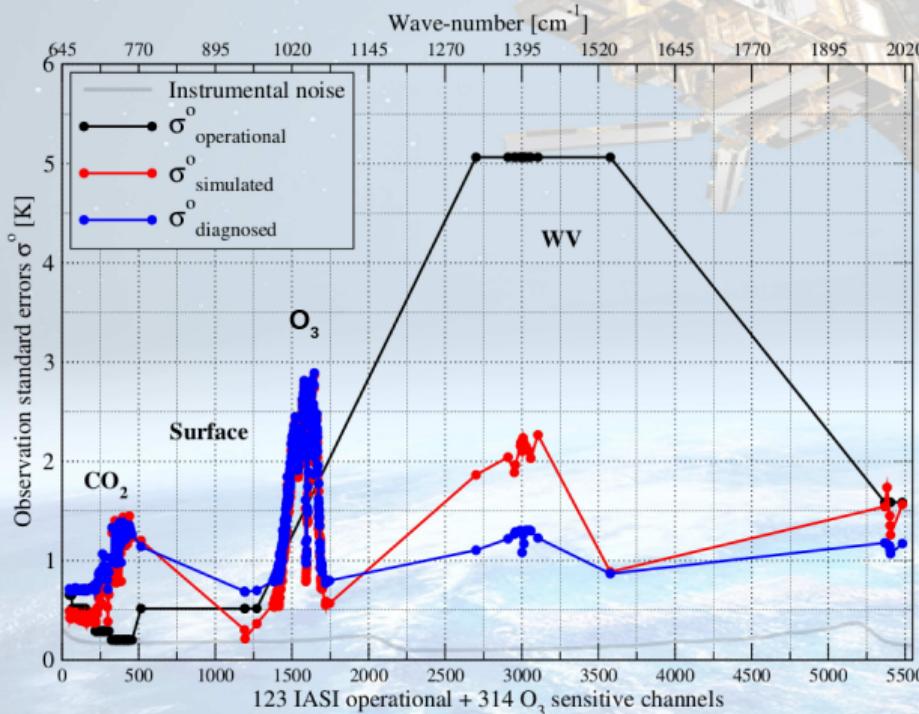
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  - **171** channels between [2071 – 2131  $\text{cm}^{-1}$ ] not selected → short wave with important instrumental noise



- IASI instrumental noise over 123 operational + 314 O<sub>3</sub> sensitive channels
- Observation standard errors [K] with respect to 123 operational channels**

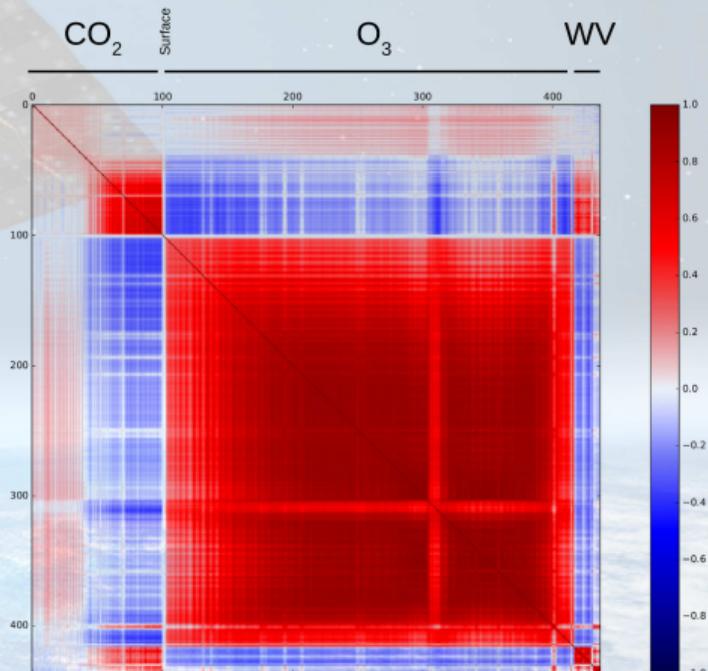
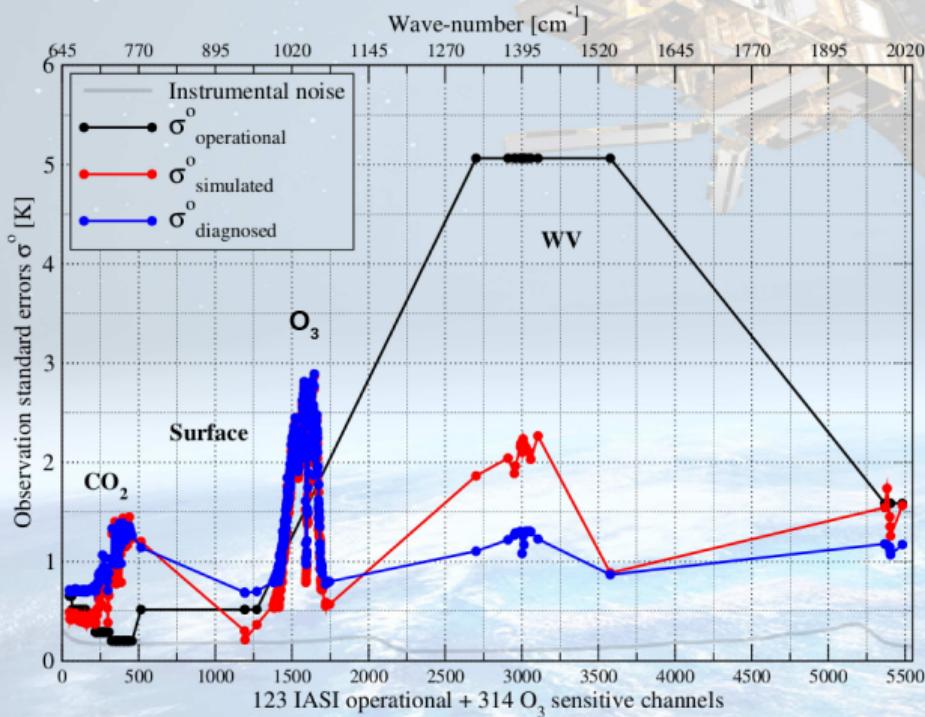


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  - T, q,  $T_{surf}$ ,  $q_{surf}$  from **ARPEGE**
  - $T_{skin}$  retrieved using **1194** IASI channels
  - Emissivity atlas from **CAMEL**
  - O<sub>3</sub> from **MOCAGE**

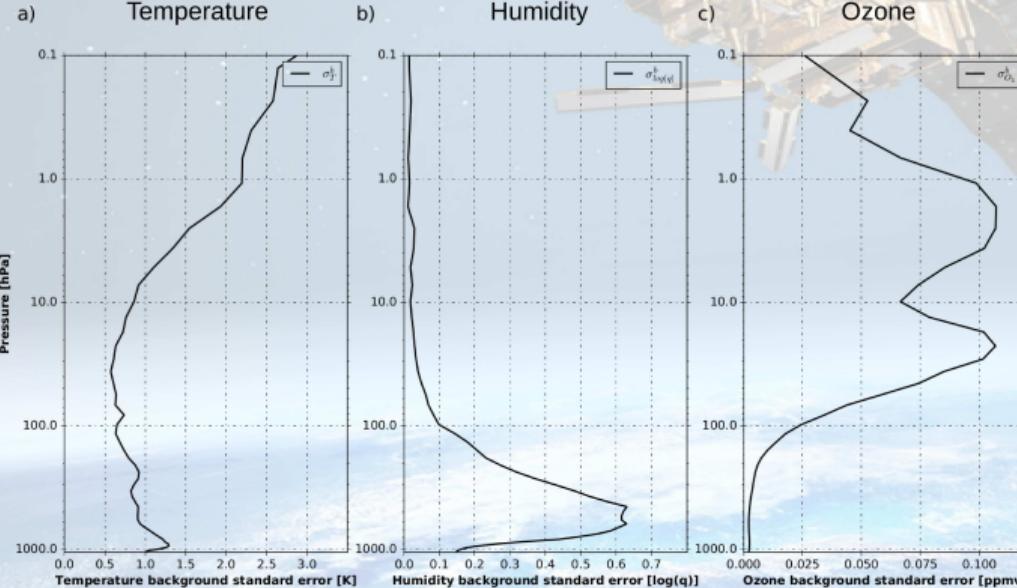


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- Observation standard errors [K]** diagnosed by the [*Desroziers et al, 2005*] method using iterative 1D-Var up to convergence and using the same framework as previously

# Observation error covariance matrix → R



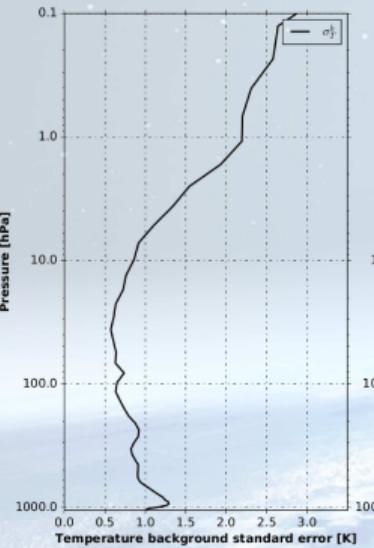
Diagnosed observation error correlations matrix



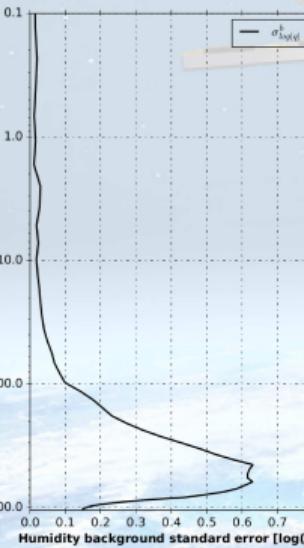
- **Background standard error for:**
  - a) Temperature [K]
  - b) Humidity [ $\log(q)$ ]
  - c) Ozone [ppmv]
  
- Multi-variate **B** matrix calculated using **NMC** method [*Derber and Parrish, 1992*] coming from differences between forecast ranges (**36H – 12H**) valid at the same time over a 1 year period of forecast
  
- These forecast ranges have been implemented especially for this study using a research version of **MOCAGE**

# Background error covariance matrix → B

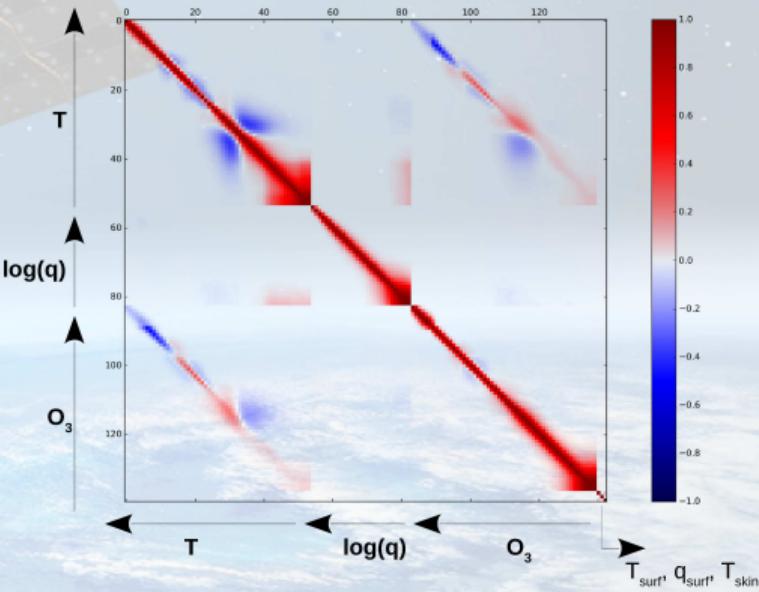
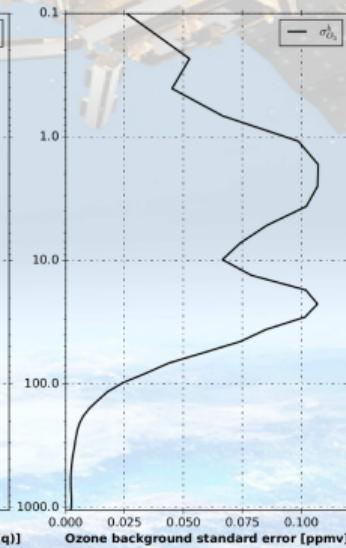
a) Temperature



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Background error correlations matrix

**Framework:**

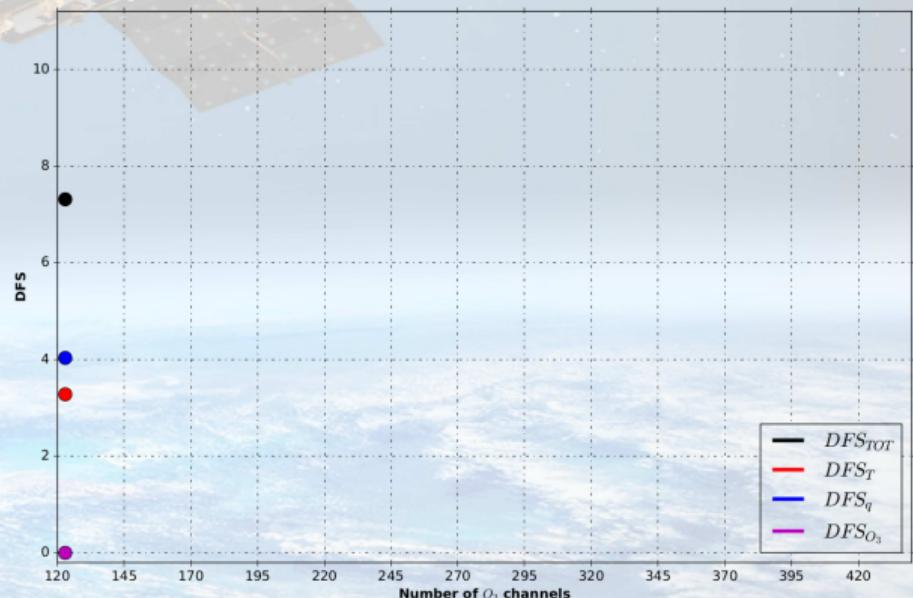
- $\text{DFS} = \text{Tr} [\mathbf{I} - \mathbf{AB}^{-1}]$
- $\mathbf{AB}^{-1} = [\mathbf{I} + \mathbf{BH}^T \mathbf{R}^{-1} \mathbf{H}]^{-1}$
- $\mathbf{B}$  : multi-variate matrix with T, q and O<sub>3</sub> errors
- $\mathbf{R}$  : diagnosed matrix including **123 + 314** channels
- $\mathbf{H}$  : jacobians of T, q and O<sub>3</sub> for **123** and **314** channels calculated with **RTTOV** using 347 profiles
- IASI O<sub>3</sub> selection for 347 profiles using **DFS<sub>TOT</sub>**

$$\text{DFS}_{\text{TOT}} = \text{DFS}_T + \text{DFS}_q + \text{DFS}_{O_3}$$

**Threshold:**

- **Thr 1:** Stop selection if  $|\text{DFS}^n - \text{DFS}^{n-1}| \leq 0,01$
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Example of **DFS** evolution from O<sub>3</sub> channel selection for 1 profile



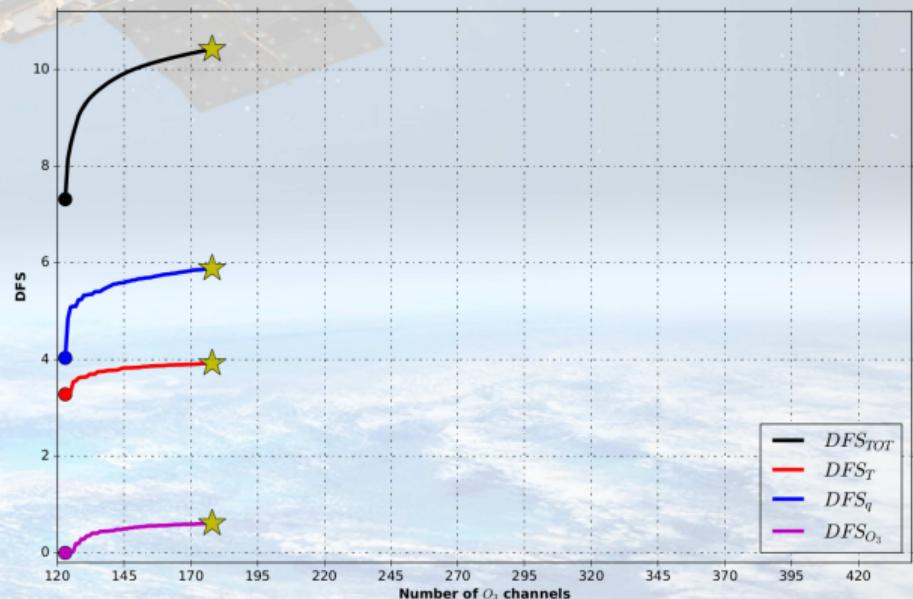
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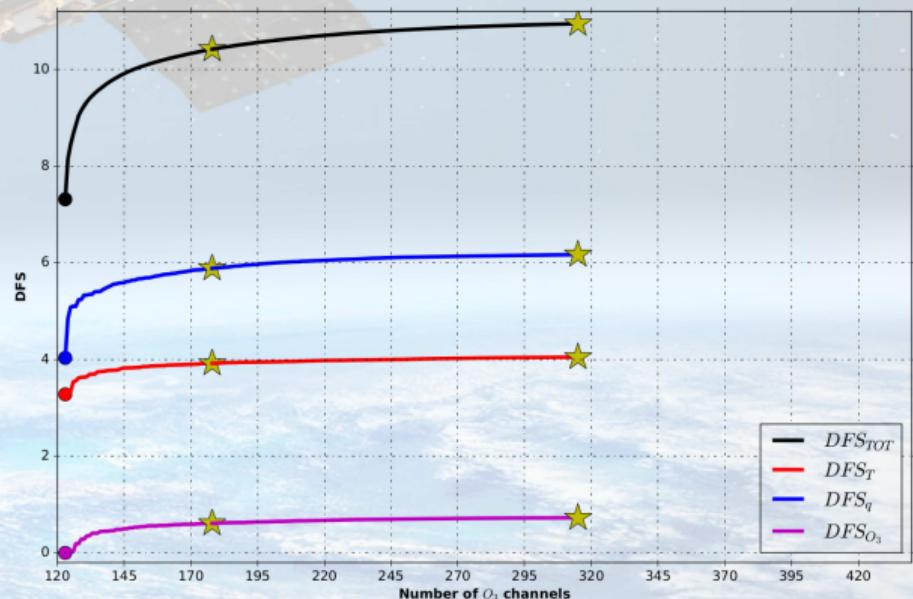
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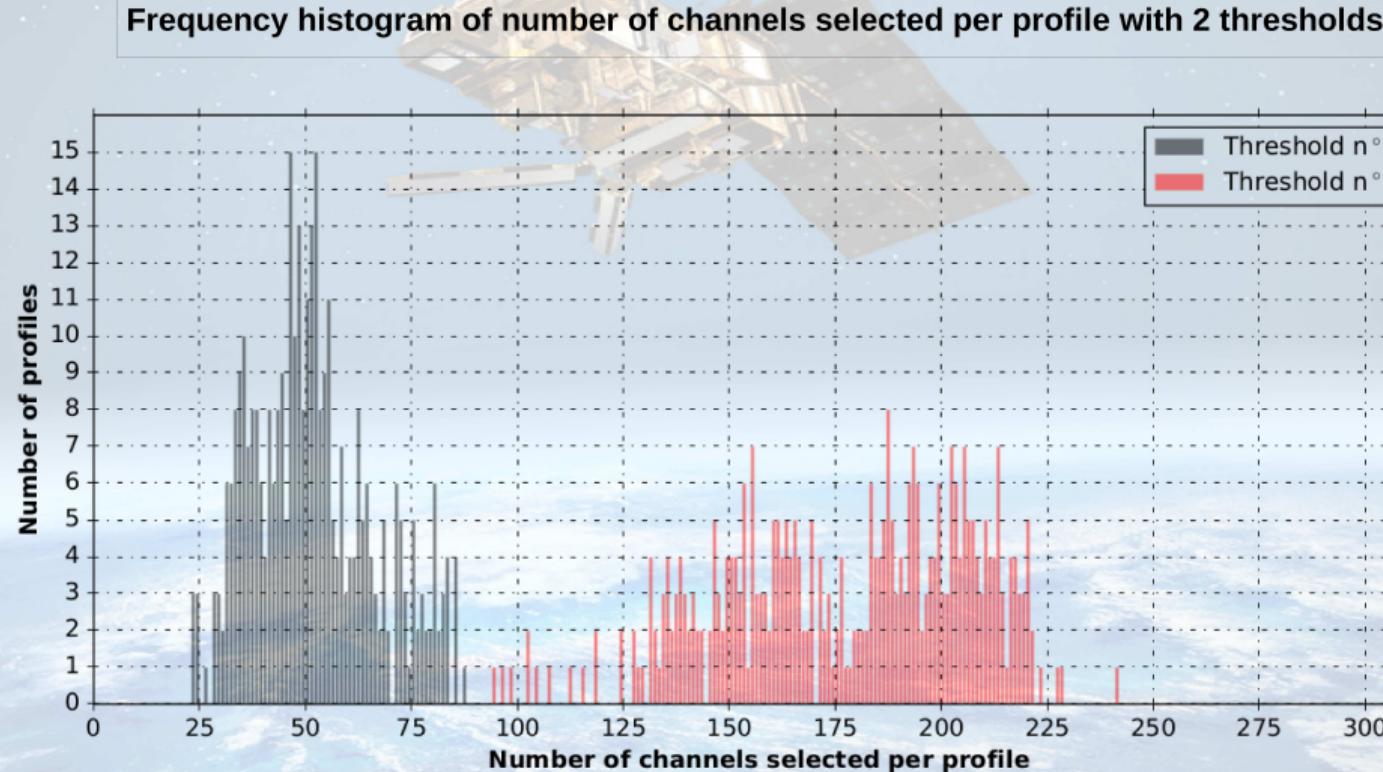
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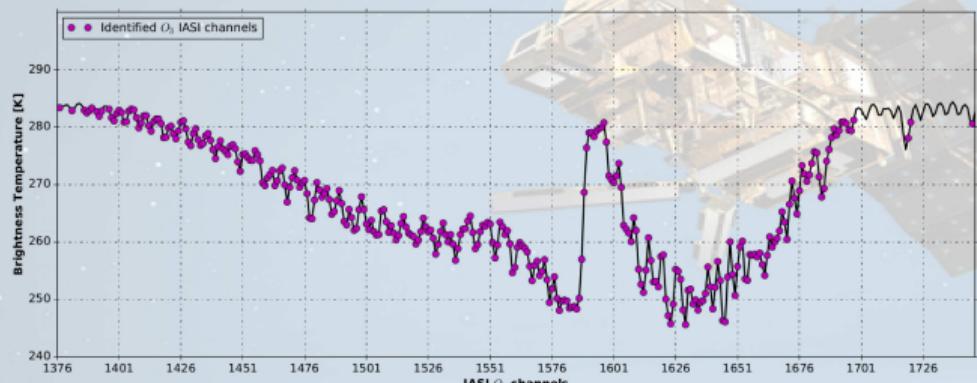
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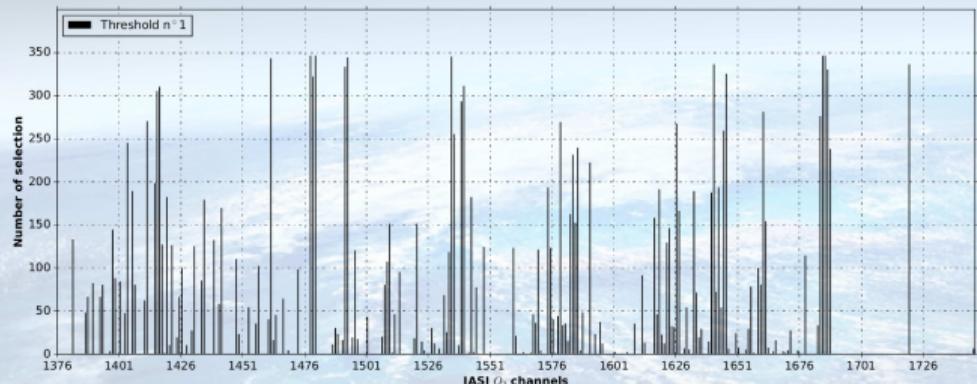
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→ Position of O<sub>3</sub> sensitive channels over the spectrum

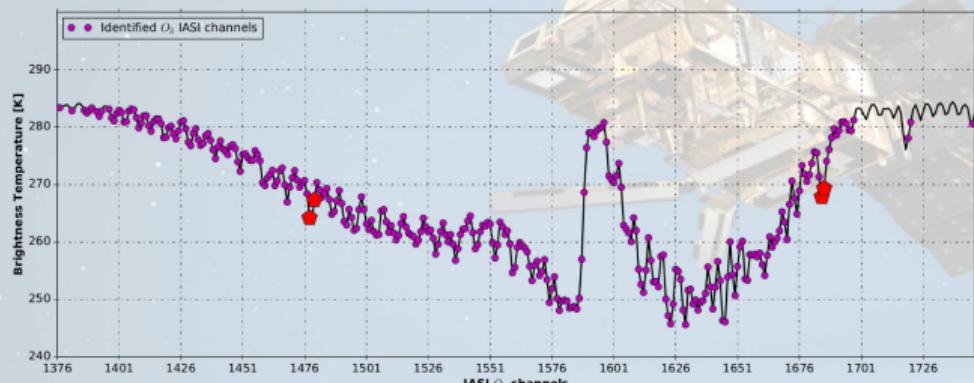
b)



→ Number of profiles for which each channel is selected

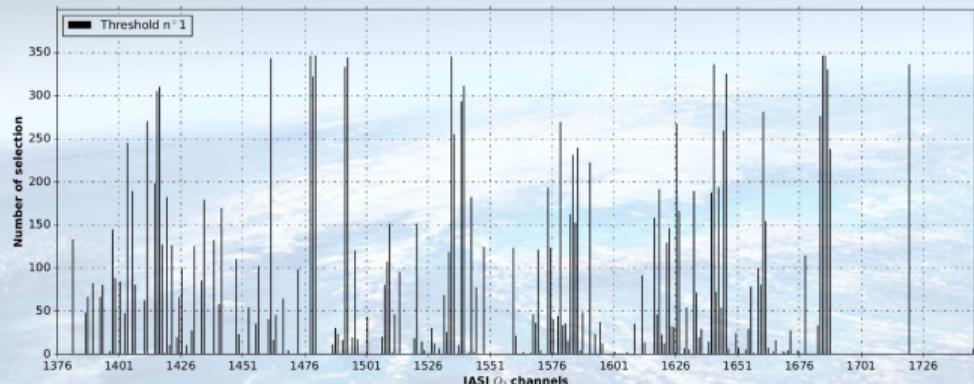
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- 4 channels always selected

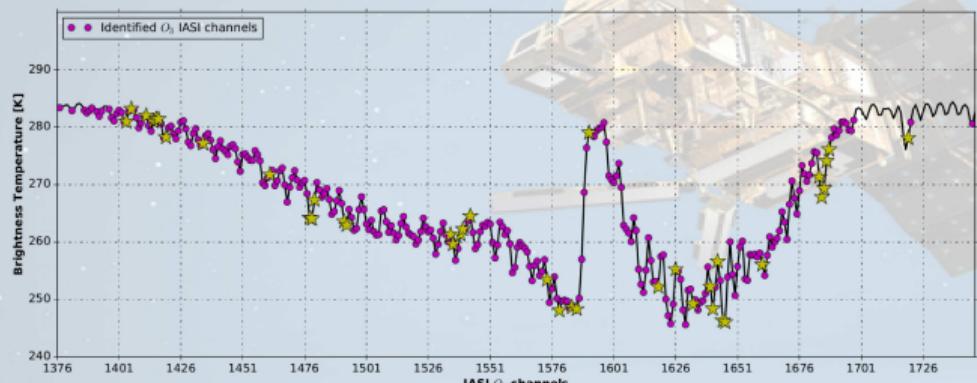
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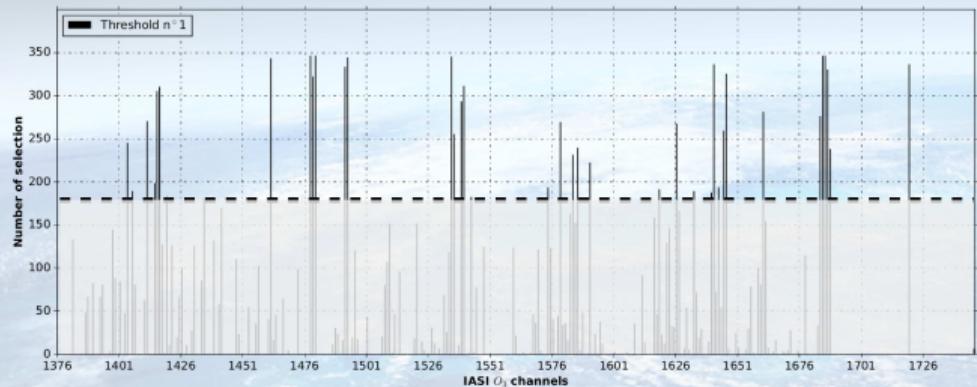
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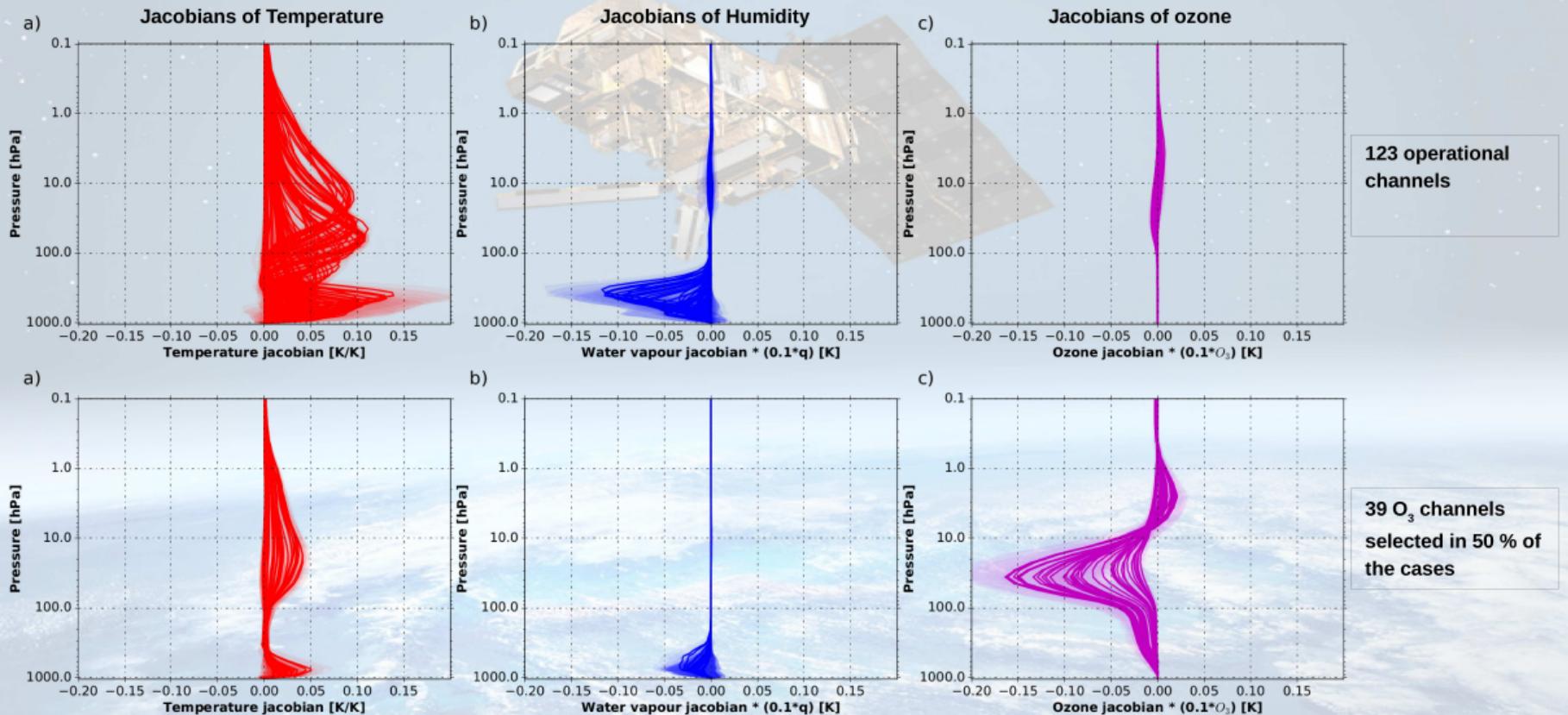
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b)



- Number of profiles for which each channel is selected
- Channels selected for more than 50 % of total profiles → 39 channels selected

# $O_3$ IASI channel selection → DFS method



## → Channel selection of O<sub>3</sub> IASI channels

- Statistics on DFS :

	Average #channels selected	Average DFS <sub>TOT</sub>	Max DFS <sub>TOT</sub>	Min DFS <sub>TOT</sub>
123 channels		9.8	12.8	6.4
123 + thr1 selection	~ 51	13.4	17.6	9.2

- Additional informations provided for operational selection :

- ✓ **thr1** selection → DFS<sub>TOT</sub>: **+ 36.8 %**
    - DFS<sub>T</sub>: **+ 18.8 %**
    - DFS<sub>q</sub>: **+ 36.4 %**

## → The final channel selection is currently being completed and tested in 1D-Var

→ Coming soon - O<sub>3</sub> case - Coupling between ARPEGE and MOCAGE models in 4D-Var

- Add the new O<sub>3</sub> IASI channels selection in ARPEGE
- Add O<sub>3</sub> in the 4D-Var control variable
- Use a new **B** matrix including ozone errors
- Use ozone field from **MOCAGE** in ARPEGE

→ In the future – Other species? - Other infra-red instruments!

- CH<sub>4</sub>, CO ...
- CrIS, AIRS, SEVIRI ... & MTG-IRS, IASI-NG!

# Thank you for your attention

