

Preparing the assimilation of IASI-NG in NWP models: a first channel selection

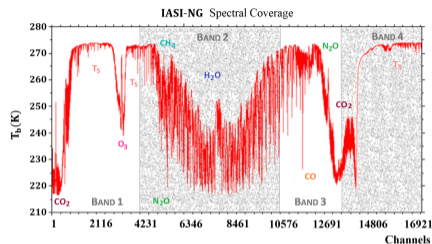
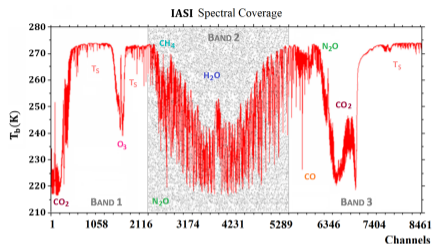
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IASI vs IASI-NG



IASI	Main Features	IASI-NG
4	Pixels in FOV	16
8461	Channels	16921
0.25 cm^{-1} @ L1C	Radiometric resolution	IASI/2
$< 0.25 \text{ K}$ @ 280 K	Spectral sampling	IASI/2
3	Abs. radiometric calibration	IASI/2
	Spectral bands	4

Why a Channel Selection?



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- High amount of data resulting from IASI-NG
- Many challenges in the areas of data transmission, storage and assimilation
- The number of individual pieces of information will be not exploitable in an operational Numerical Weather Predictions (NWP) context

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→ An appropriate IASI-NG channel selection is needed, aiming to select the most informative channels for NWP models

Full IASI orbit computed, for a total of 5 242 448 simulations for each instrument (IASI scan geometry used for IASI-NG) [*Andrey-Andrés et al. (2018)*]

Case Study

- First stage: **nadir - over sea - clear sky** conditions (318 319 profiles)
- Subset of **1099 profiles** judged to be a **representative sample**:
 - May and August
 - polar, mid-latitudes and tropical regions
 - day and night



May
Day



May
Night



August
Day



August
Night

1D-Var retrievals

$$J(\mathbf{x}) = \underbrace{\frac{1}{2} (\mathbf{x} - \mathbf{x}^b)^T \mathbf{B} (\mathbf{x} - \mathbf{x}^b)}_{\text{Background}} + \underbrace{\frac{1}{2} [\mathbf{y} - H(\mathbf{x})]^T \mathbf{R}^{-1} [\mathbf{y} - H(\mathbf{x})]}_{\text{Observations}}$$

\mathbf{x} = model state vector
(Temperature, Humidity, Skin Temp.)

\mathbf{x}^b = background state vector

\mathbf{y} = vector of observations

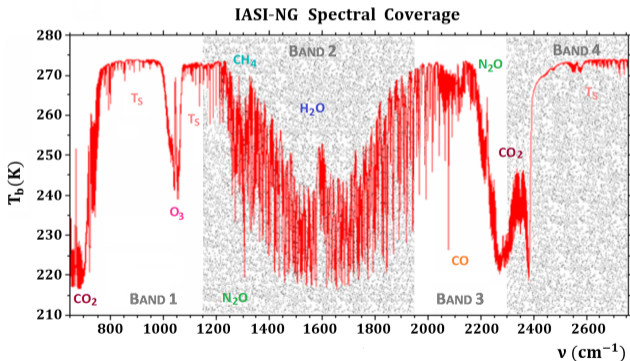
\mathbf{B} = background-error covariance matrix

\mathbf{R} = observation-error covariance matrix

H = observation operator

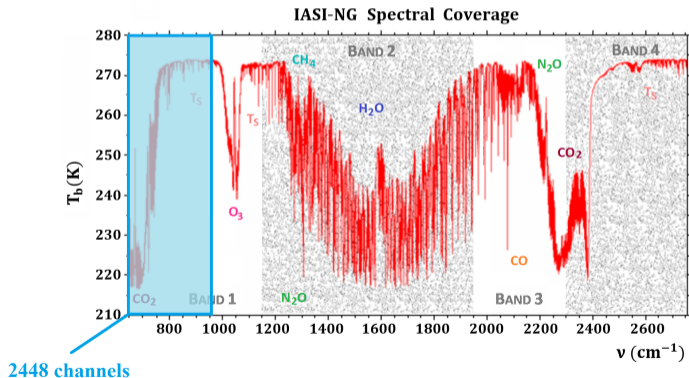
Preparatory study towards the channel selection

To estimate full covariance matrices of the observation errors (\mathbf{R} matrices), a diagnostic procedure introduced by *Desroziers et al. (2005)* was applied to different regions of the IASI-NG spectrum, mainly focusing on **Band 1** and **Band 2**.



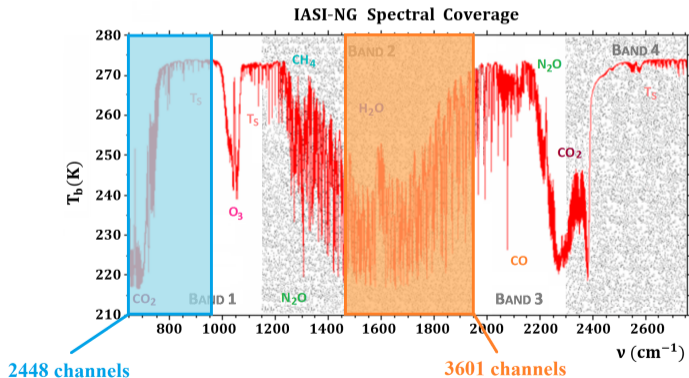
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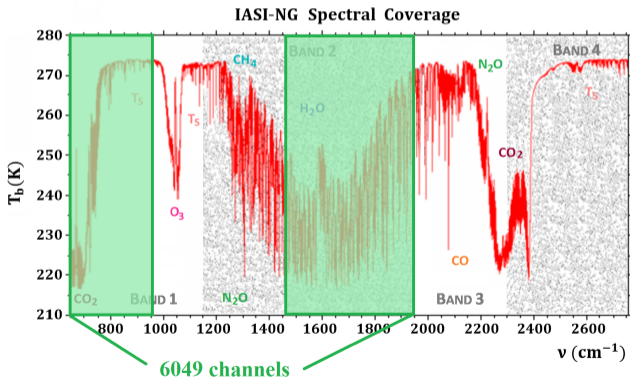
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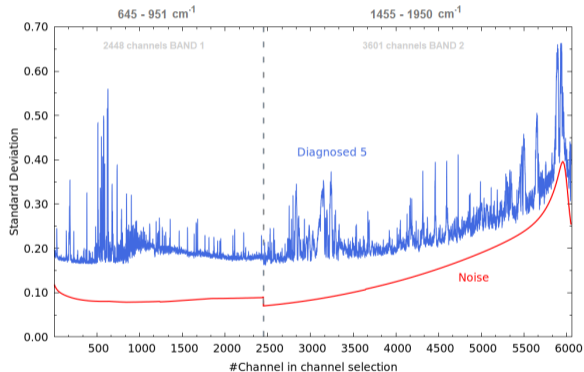
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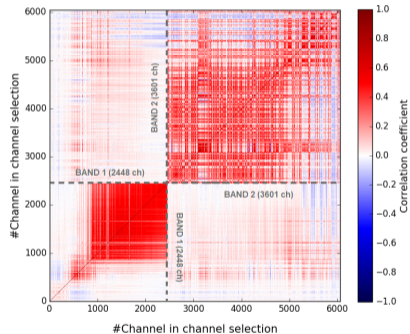


Preparatory study towards the channel selection

Diagnostic error standard deviations from 1D-Var output and instrument noise - 6049 channels



Diagnostic for correlation matrix (5th iteration)
6049 channels from BAND 1 and BAND 2

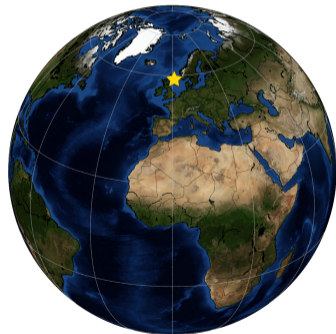


A methodology relying on evaluating the impact of the addition of single channels on a figure of merit has been applied in order to determinate an optimal channel set [*Rodgers (1996)*, *Rabier et al. (2002)*]

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First stage:

- one among the case study profiles has been picked up (August - night - mid-latitude)

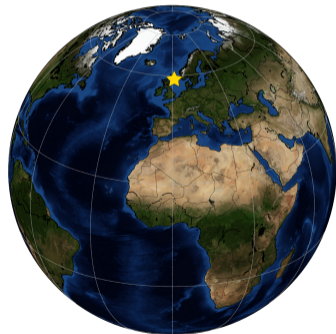


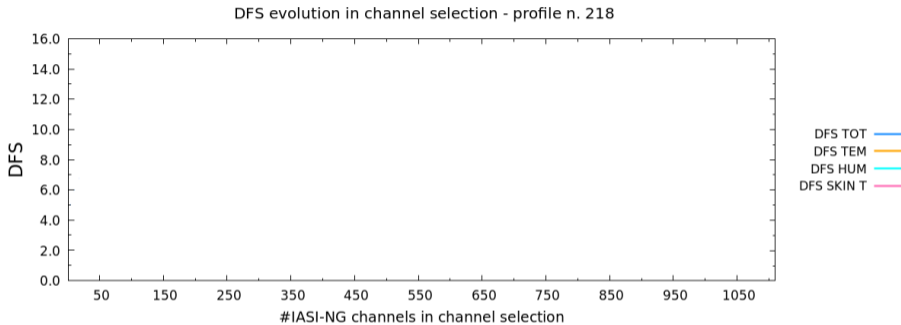
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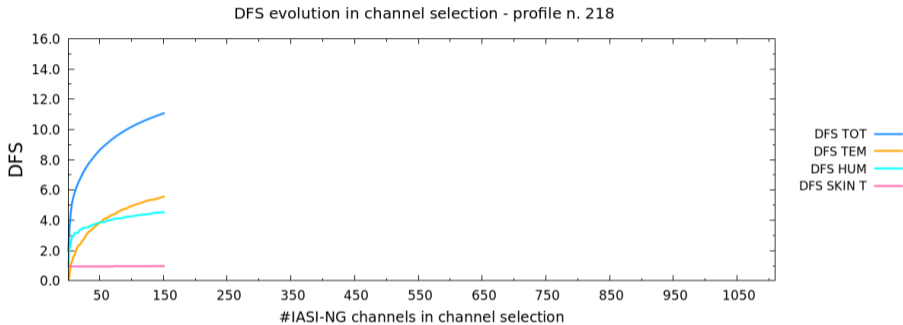
First stage:

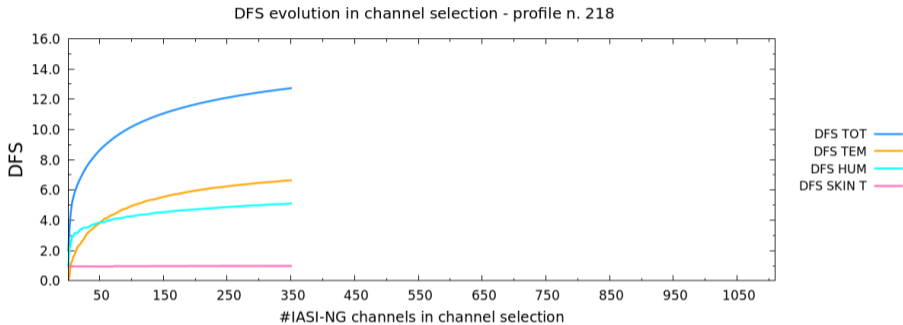
- one among the case study profiles has been picked up (August - night - mid-latitude)
- the figure of merit chosen is the **Total DFS** (Temperature + Humidity + Skin Temperature DFS)

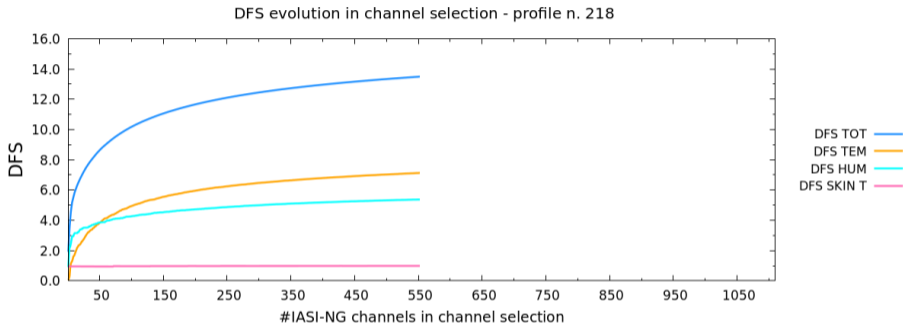
$$\text{DFS} := \text{Tr}(\mathbf{I} - \mathbf{A}\mathbf{B}^{-1}) = [\mathbf{I} + \mathbf{B}\mathbf{H}^T\mathbf{R}^{-1}\mathbf{H}]^{-1}$$

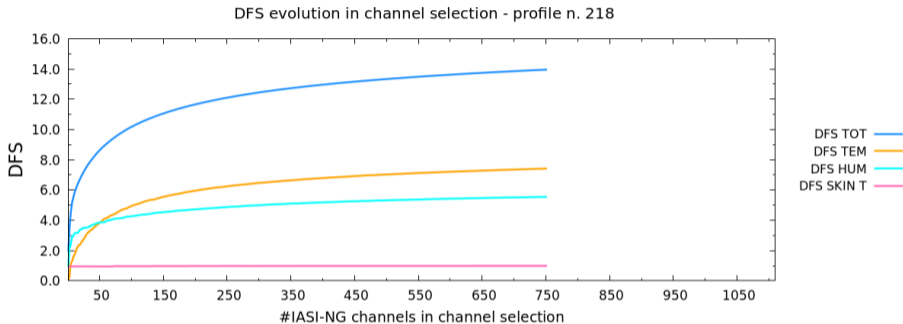


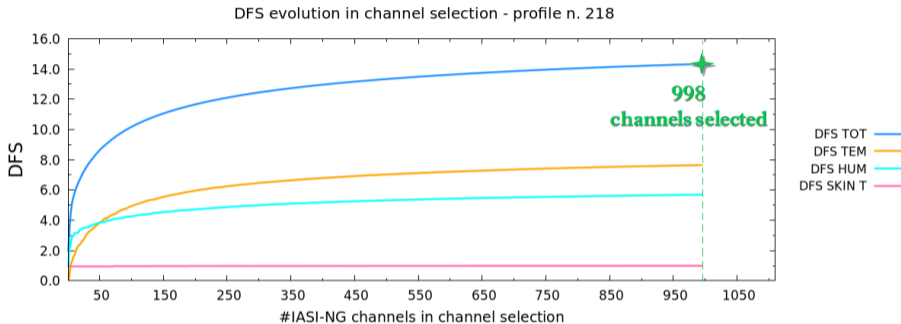




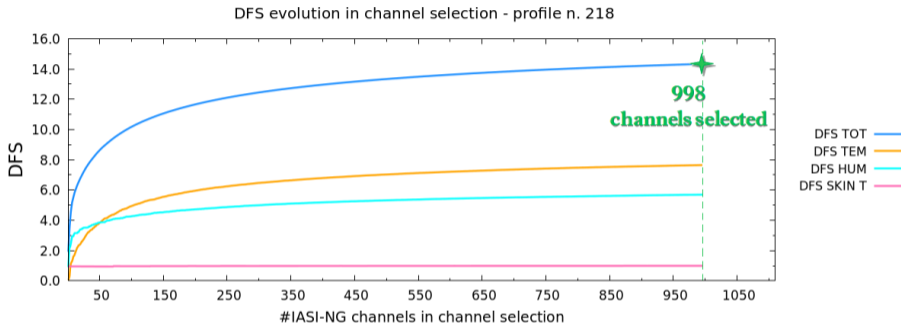








The choice has been narrowed down to the channels showing an **absolute difference of Tot DFS ≥ 0.001** (between one iteration and the previous)



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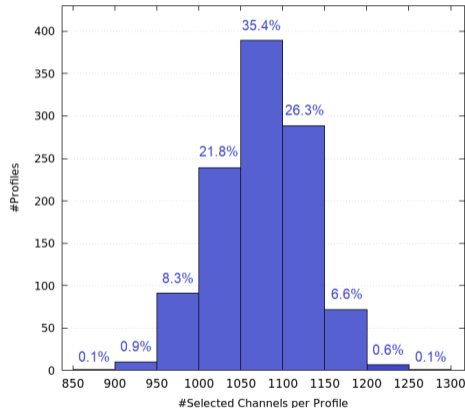
→ This study has been spread to the whole 1099 profile dataset

How many channels do we select?

- In 83.5% of cases (profiles), the amount of selected channels is between 1000 and 1150

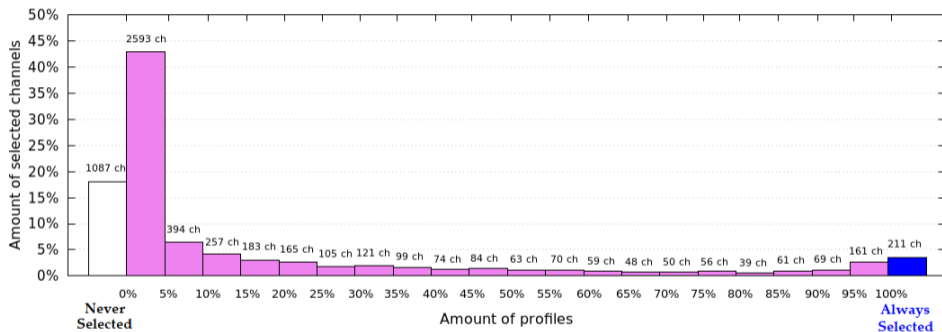
What about DFS?

DFS	Tot	Temp	Hum	Skin Temp
Average	15.2	7.9	6.3	0.99
Max	16.9	8.9	8.0	1.00
Min	13.0	7.2	4.1	0.96

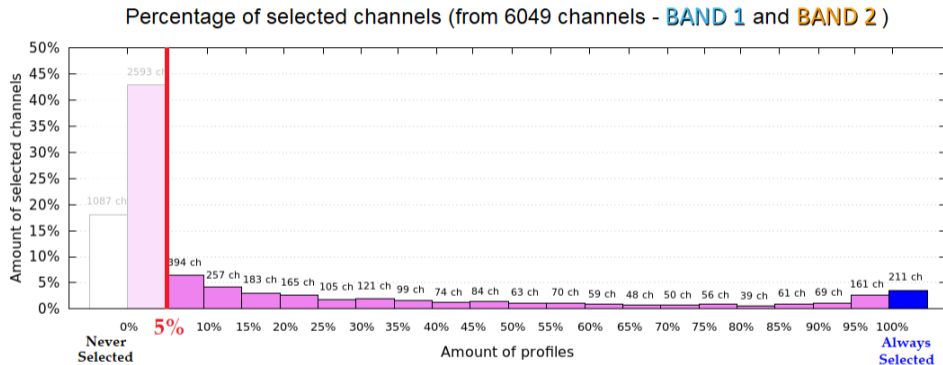


Channel Selection

Percentage of selected channels (from 6049 channels - **BAND 1** and **BAND 2**)

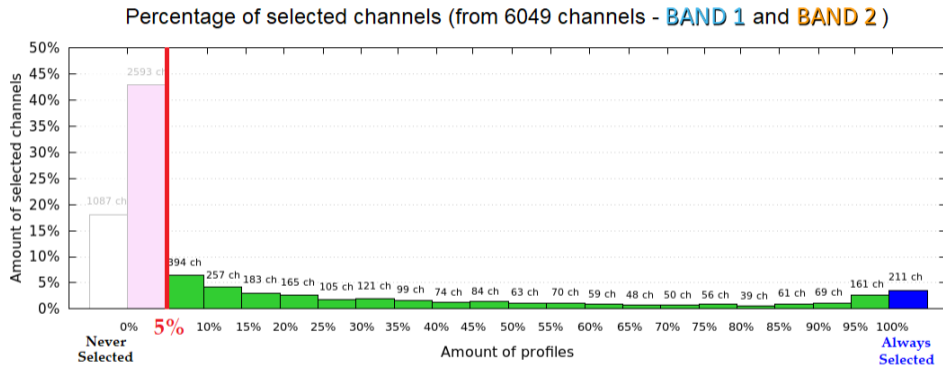


Channel Selection



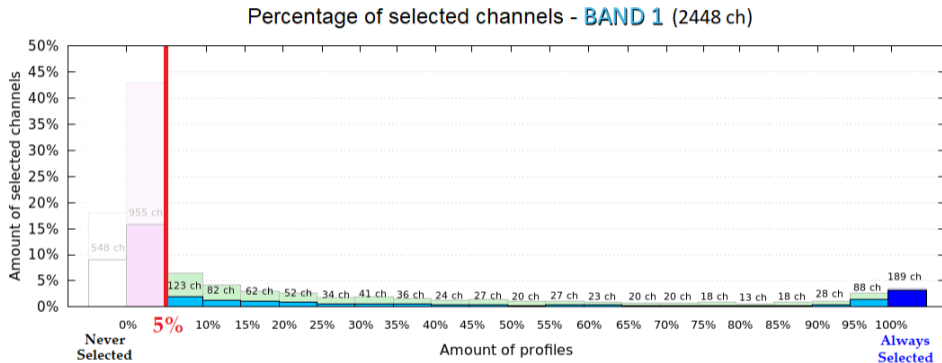
- **3680 channels rejected** (channels selected in less than 5% of cases)

Channel Selection



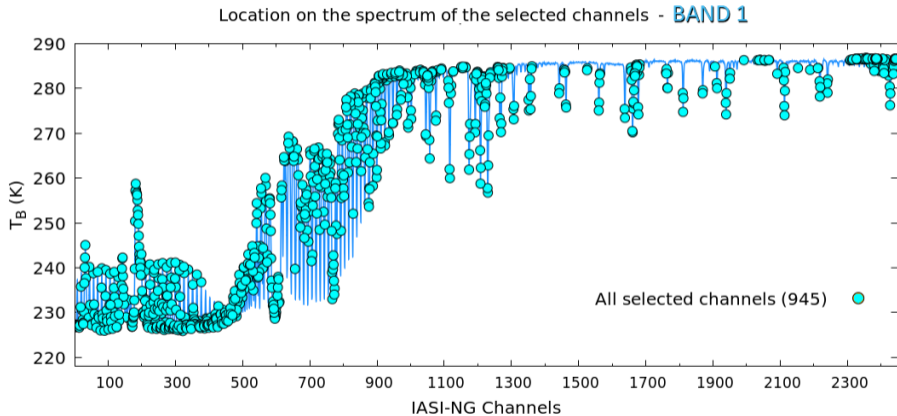
- **3680 channels rejected** (channels selected in less than 5% of cases)
- **2369 channels retained**, among which **211 always selected** (selected in the 100% of cases)

Channel Selection - Band 1

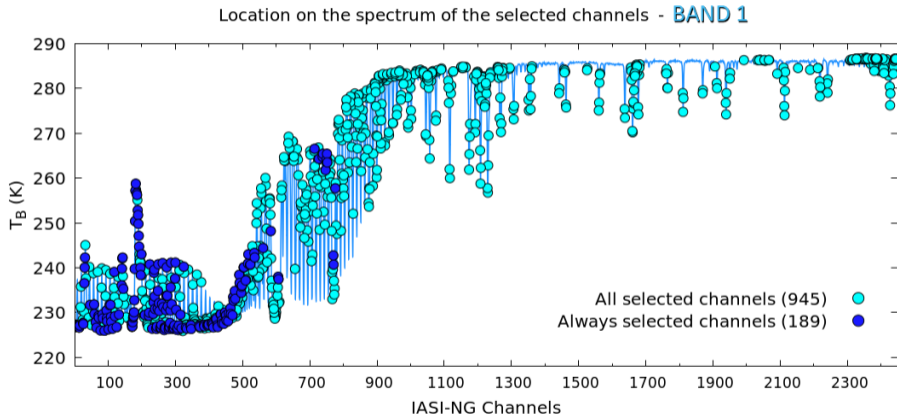


- **1503 channels rejected** (channels selected in less than 5% of cases)
- **945 channels retained**, among which **189 always selected** (selected in the 100% of cases)

Channel Selection - Band 1

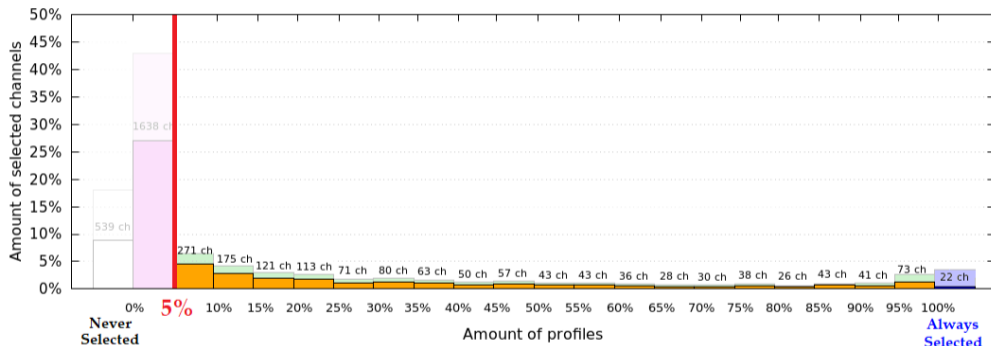


Channel Selection - Band 1



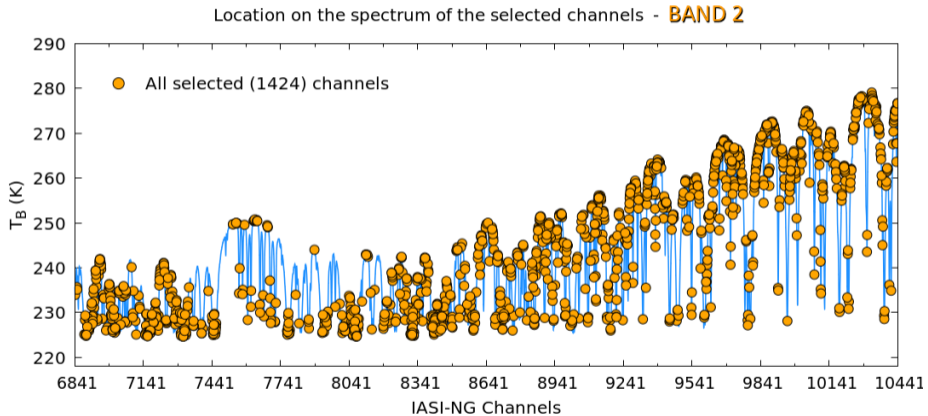
Channel Selection - Band 2

Percentage of selected channels - **BAND 2** (3601 ch)

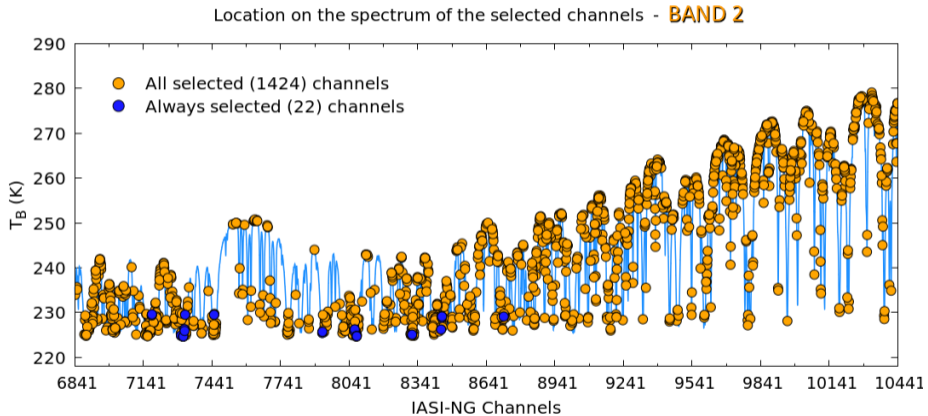


- **2177 channels rejected** (channels selected in less than 5% of cases)
- **1424 channels retained**, among which **22 always selected** (selected in the 100% of cases)

Channel Selection - Band 2

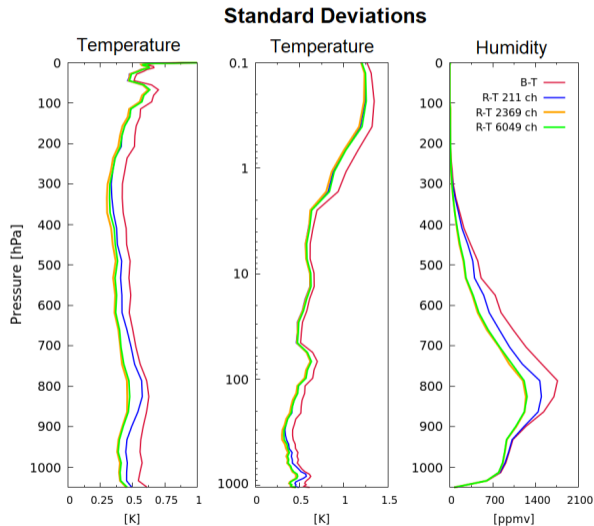


Channel Selection - Band 2



Channel Selection

- 1D-Var run using:
 - **6049** channels from BAND 1 and BAND 2
 - “**all selected**” channels - selected at list in 5% of cases (**2369**)
 - “**always selected**” channels (**211**)
- Background and Analysis Errors averaged on the 1099 profiles case study.
- For the “**all selected**” channels, the **Rate of Improvement** of Retrieval Standard Deviations compared to Background ones, reaches values up to:
 - **30% for Temperature**
 - **50% for Humidity**



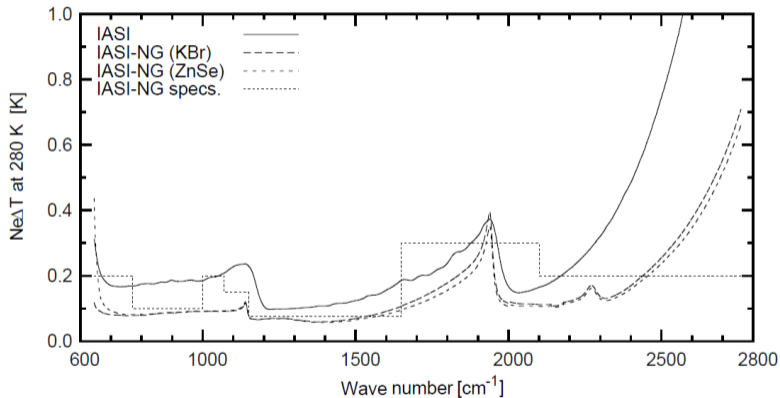
- Another method of selection will be applied, based on selecting the most relevant channels relying on the characteristics of their weighting functions [collaboration with Antonia Gambacorta (NOAA)]
 - *Vittorioso et al.* in preparation
- Bring the selected channels into the global model ARPEGE data assimilation, with all the observations available and over several weeks (OSSE)

Thank you for your attention!

Questions?

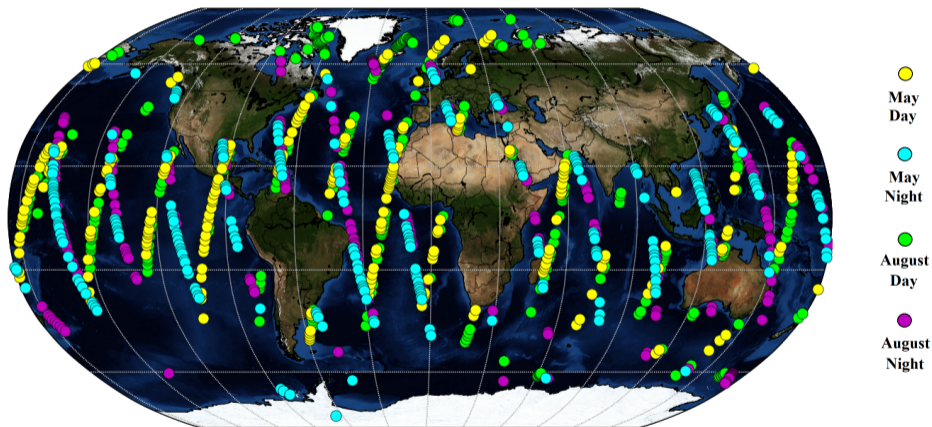


IASI Radiometric Resolution



NETD noise at 280 K for IASI and IASI-NG (source data from E. Pequignot, CNES)

Case Study



$$\textit{Rate of Improvement} = \frac{[(R - T) - (B - T)]}{(B - T)}$$

where R = Retrieval, B = Background, T = Truth