IRS MAG

June 2025

1. **Action 17.3**: Feedback on possible impacts of the FOV diversity on AC applications and needs of information

2. **Oversampling**: Response to ITT “Enhancing the IRS spatial resolution using successive shifted dwell acquisitions”

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1. **Action 17.3**: Feedback on possible impacts of the FOV diversity on AC applications

Current retrieval approaches used for IASI (at ULB)

FORLI: Fast Optimal Retrieval on Layers for IASI

O_3, CO, HNO_3 vertical profiles

Physical retrieval with iterative fitting

!! Critical parameter !!

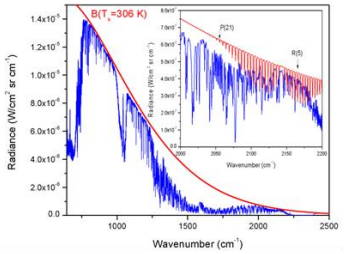
Noise-covariance matrix

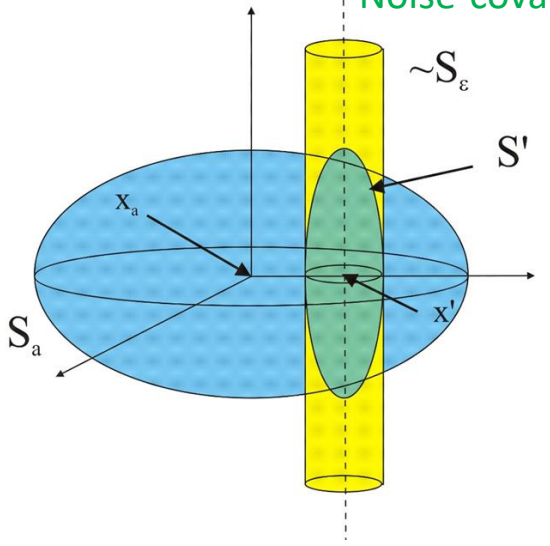
***A priori* state :**

x_a, S_a

Measurement:

y, S_ε





Q: Discontinuation of NRT OEM retrievals for IRS?

ANNI: Artificial Neural Network for IASI

NH_3, SO_2, VOCs, Dust, Altitudes…

Linear approach with neural network

2-step approach

1. Calculation of an Hyperspectral range index **HRI** (large spectral range)

$$\mathrm{HRI} = N K^{\mathrm{T}} \mathbf{S}^{-1} (L - \bar{L})$$

Jacobian; Actual spectrum; Normalization factor; Mean background spectrum; Covariance from ensemble background spectra

!! Critical parameters !!

Mean background spectrum

Covariance matrix

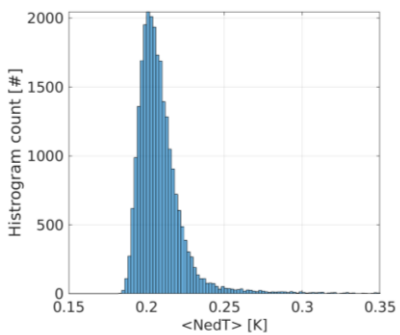
2. Conversion of the HRI to a total column NH_3 using a Neural Network

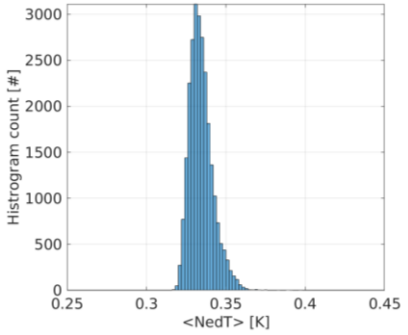
$$\hat{X}^a = \frac{\mathrm{HRI}}{\mathrm{SF}^a} + B$$

Retrieved column; From measurements; Background column; From neural network

1. **Action 17.3**: Feedback on possible impacts of the FOV diversity on AC applications

Noise diversity Related to
- Matricial detector
- Superpixels with possibly bad pixels





Question: Will PC compression not remove the problem?

If not: possible workarounds

Physical retrievals – spectral fitting

- A single (conservative) noise value for all superpixels
- One value per superpixel; scaling value provided by EUMETSAT if possible?

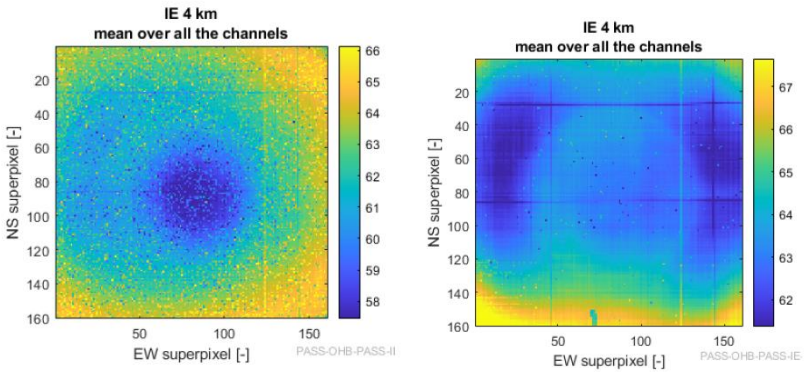
HRI-based approaches

- One ensemble of mean and ensemble (background) spectra per super-pixel

  Drawbak is it would need to be redone if sub-pixels are de-selected

1. **Action 17.3**: Feedback on possible impacts of the FOV diversity on AC applications

PSF diversity



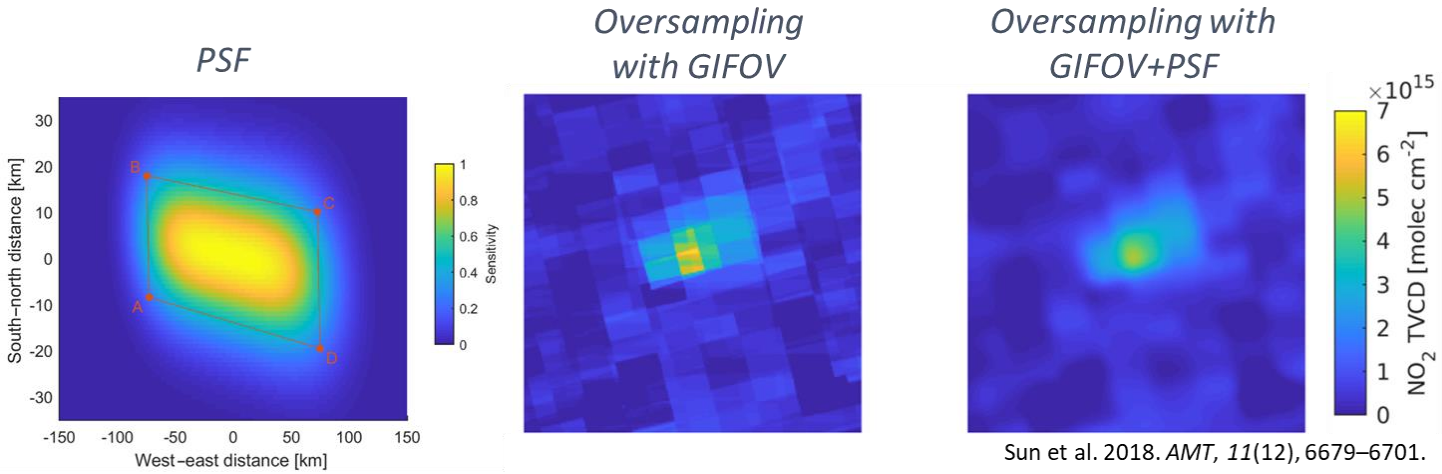
Would the users consider "choosing" the best performing FOV ?

No plan to "deselect" FOVs. For mapping, the more FOVs the better.

Is the exact knowledge of the PSF and co-registration important ? For point source detection ? For super-sampling applications ?

To share a toy model to reconstruct the PSF of any FOV and channels, available on the website?

- Yes knowledge of the PSF is important
- Indeed, a toy model would be helpful
- Co-registration not so much an issue for AQ (as both bands carry different information).



Sun et al. 2018. *AMT*, *11*(12), 6679–6701.

Example for OMI
(5 days of observation)

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2. **Oversampling**: Response to ITT “Enhancing the IRS spatial resolution using successive shifted dwell acquisitions”

Background

Similar to IASI (and other satellite datasets): can we exploit overlapping IRS FOVs to generate oversampled / supersampled distributions and improve on the native spatial resolution?

- Surface monitoring
- Source identification and quantification
- Others?

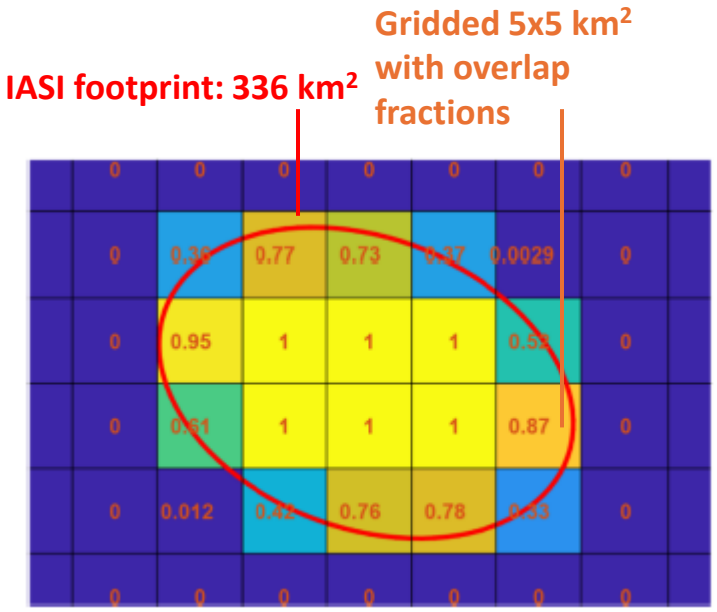
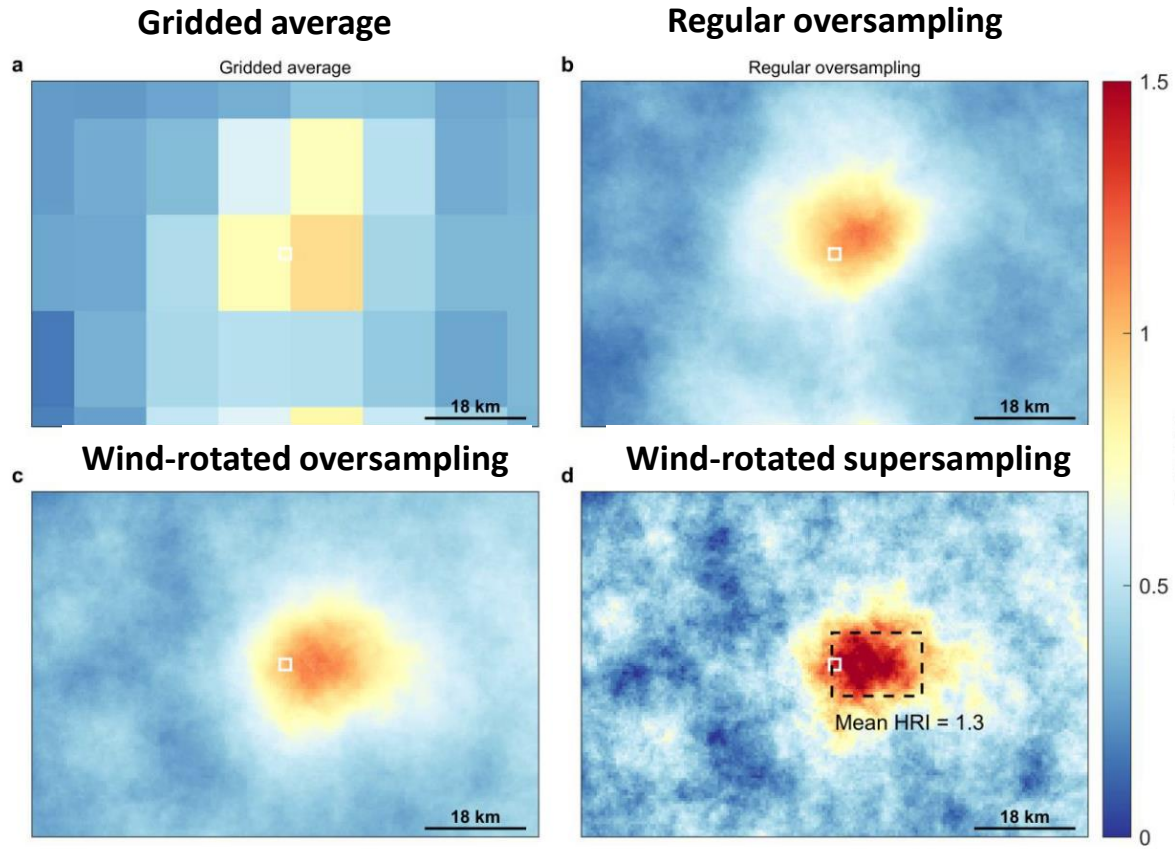


Figure 1. Illustration of IASI footprint (in red) and overlap fractions with target grid cells for an oversampling approach (numbers in red and color-coded from yellow for 1 to blue for 0). The figure is reproduced from (Sun et al., 2018). In this example, the IASI pixel area is 336 km² and the grid resolution is 5 x 5 km.

Example on IASI-NH_3 distributions

Distance to source typically determined within <2km!



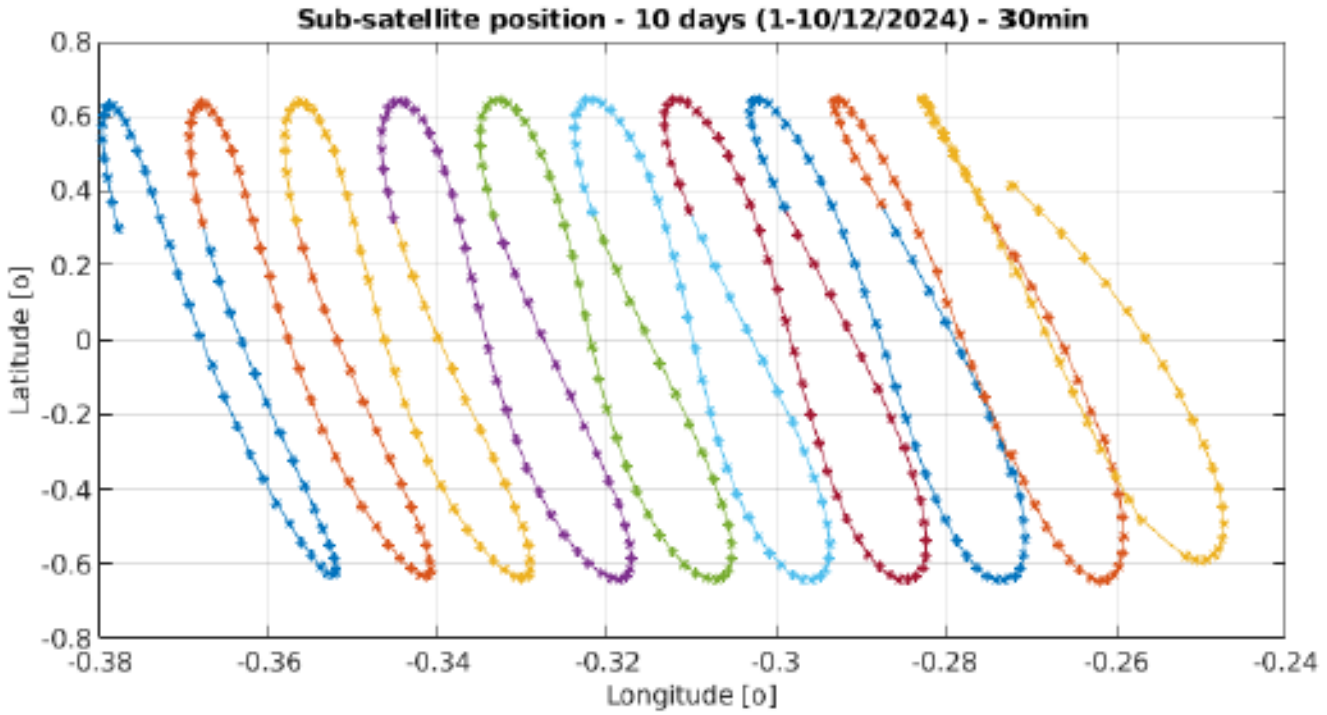
2. **Oversampling:** ITT “Enhancing the IRS spatial resolution using successive shifted dwell acquisitions”

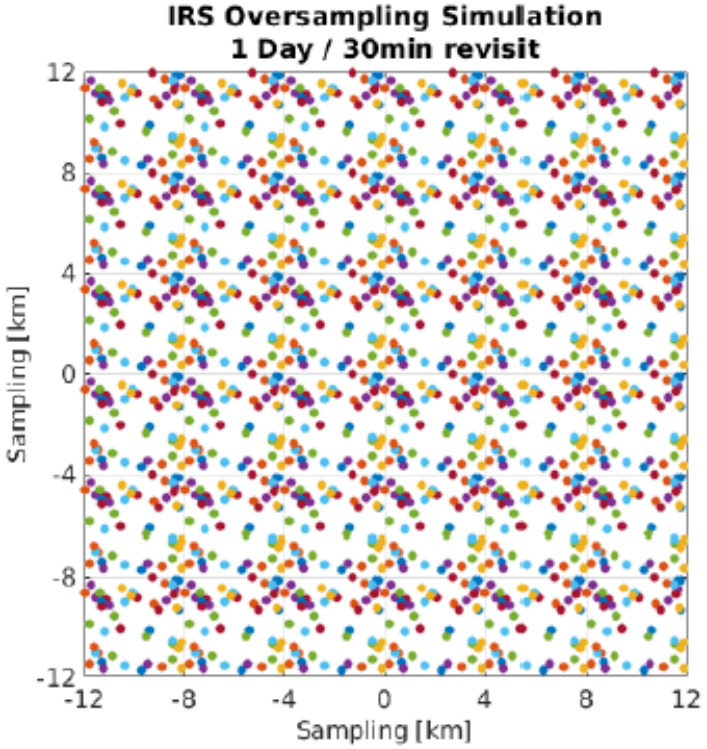
Q: Will **IRS** provide partly overlapping pixels

Email from Bertrand : *The platform will move within its “station keeping box” so that the position of the sub-satellite point will form a “8” shape. The viewing angle will then cycle on a 24h period by ± 0,178° North-South and by ± 0,0178°East-West. We can thus expect a maximum daily viewing oscillations (at NADIR) of the order of:*

- ***NS: 111km = 28 pixels (24h period)***
- ***EW: 11km = 11 pixels (12h period)***

Situation with MTG-I is very favourable





2. **Oversampling:** ITT “Enhancing the IRS spatial resolution using successive shifted dwell acquisitions”

EUMETSAT

Statement of Work for the study called:

“Enhancing the IRS spatial resolution using successive shifted dwell acquisitions”

Doc.No. : **EUM/RSP/SOW/24/1435924**
Issue : **v1**
Date : **11 November 2024**

EUMETSAT
Eumetsat-Allee 1, D-64295 Darmstadt, Germany
Tel: +49 6151 807-7

ENHANCING THE IRS SPATIAL RESOLUTION USING SUCCESSIVE SHIFTED DWELL ACQUISITIONS

A PROPOSAL IN ANSWER TO THE ITT NO. 24/229111 BY ULB-SQUARES

Technical and management proposal
TMP/ULBSQUARES/ITT/24229111

ULB Squares

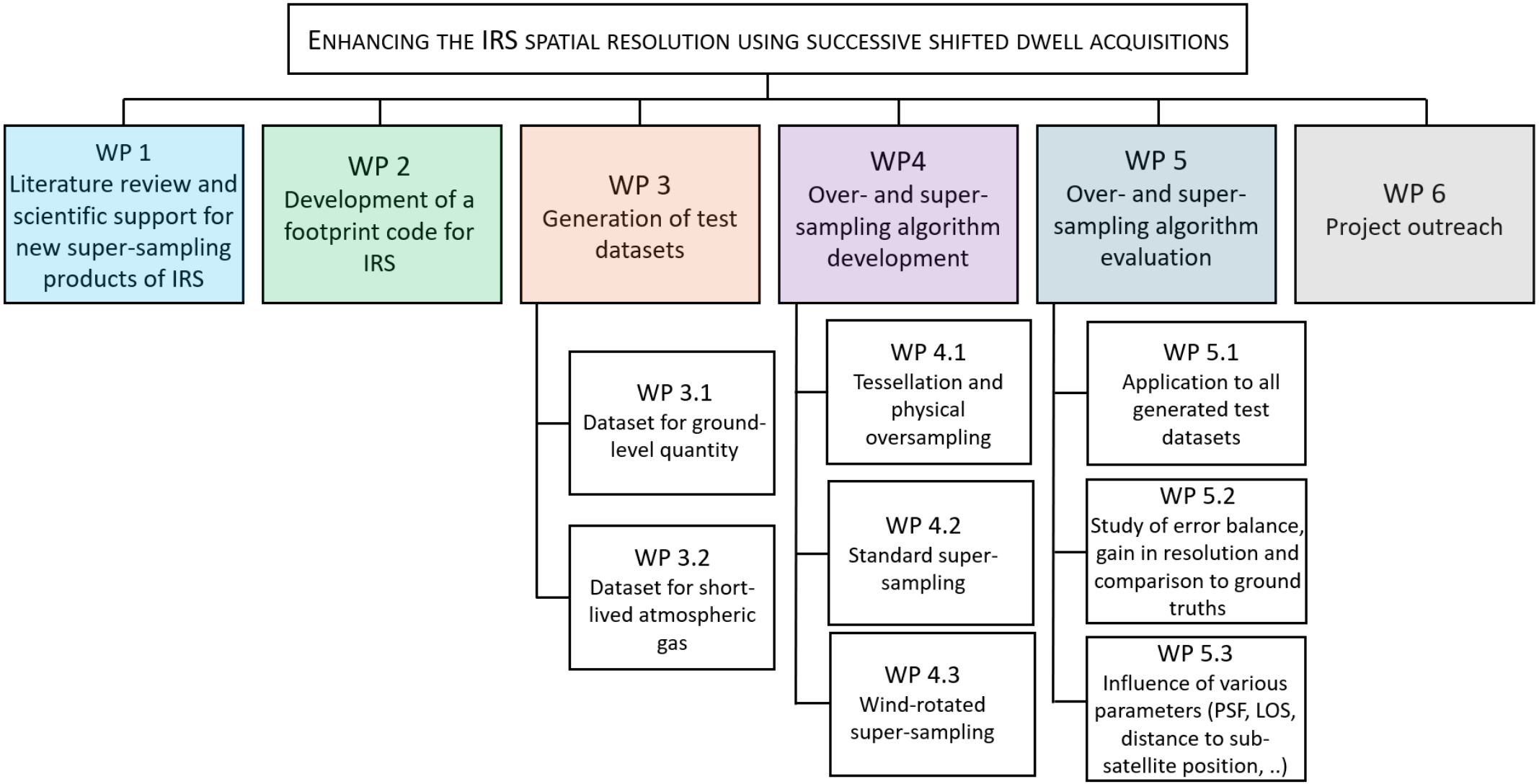

Lieven Clarisse


Antoine Honet

Objective: Developing super-sampling methods for IRS onboard MTG-S, to go beyond its native spatial resolution, by means of time averaging and taking advantage of daily oscillations of MTG-S’s orbital positioning.

- 2-years project
- kick off on June 30.

2. **Oversampling:** ITT “Enhancing the IRS spatial resolution using successive shifted dwell acquisitions”



2. **Oversampling:** ITT "Enhancing the IRS spatial resolution using successive shifted dwell acquisitions"

WP 2
Development of a footprint code for IRS

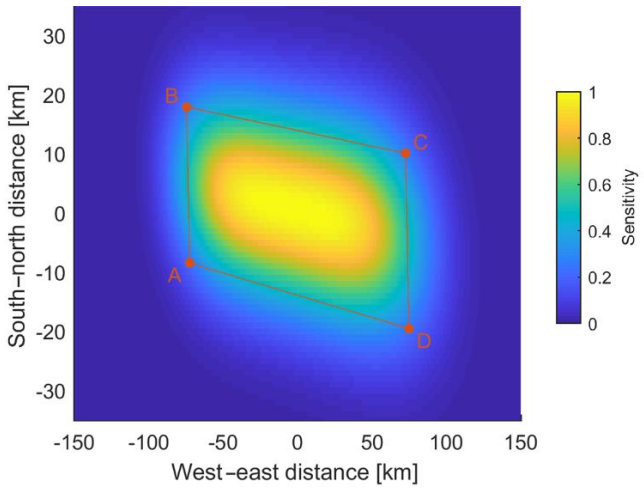
Fast computation of the IRS:
- ground instantaneous field of view (GIFOV)
- spatial response functions (SRF)

Based on **orbital and geometrical** data and IRS **point spread function** (PSF).

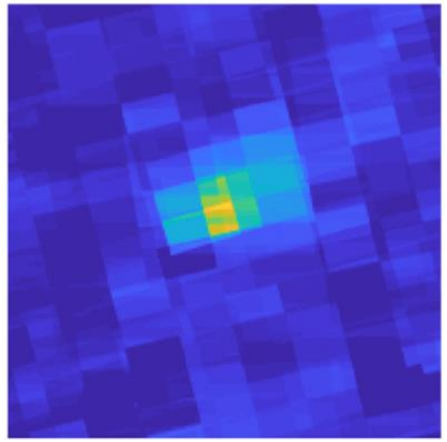
- Test analytical approximations (e.g. ellipse for IASI GIFOV, super-Gaussian for PSF)
- If no analytical approximations:
  - GIFOV → polygons
  - PSF → look-up-table

Example for OMI
(5 days of observation)

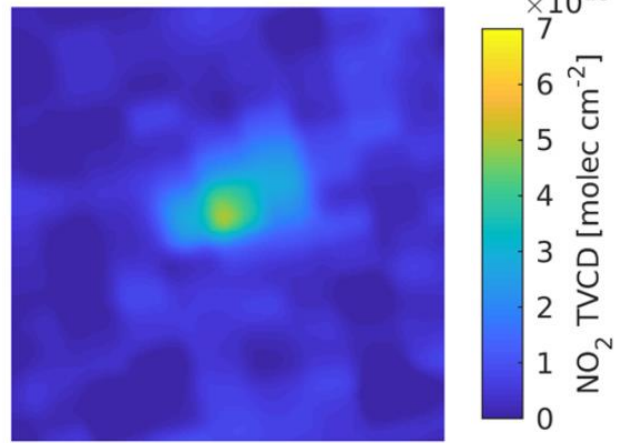
PSF



Oversampling with GIFOV



Oversampling with GIFOV+PSF



Sun et al. 2018. *AMT*, *11*(12), 6679–6701.

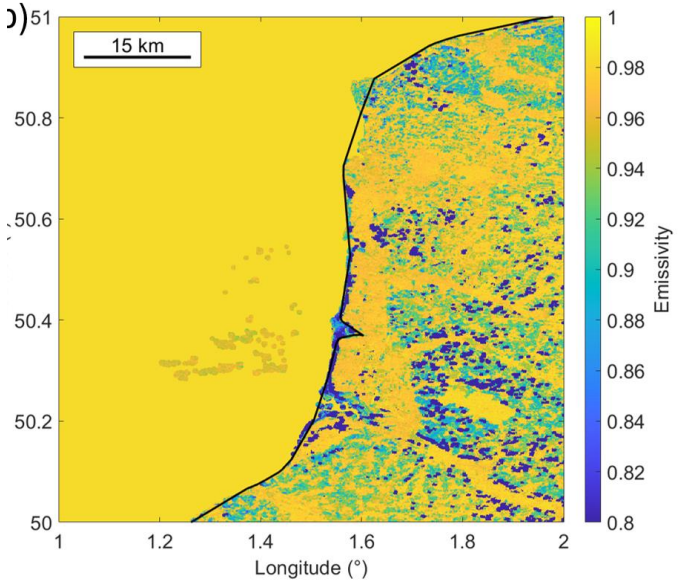
2. **Oversampling:** ITT “Enhancing the IRS spatial resolution using successive shifted dwell acquisitions”

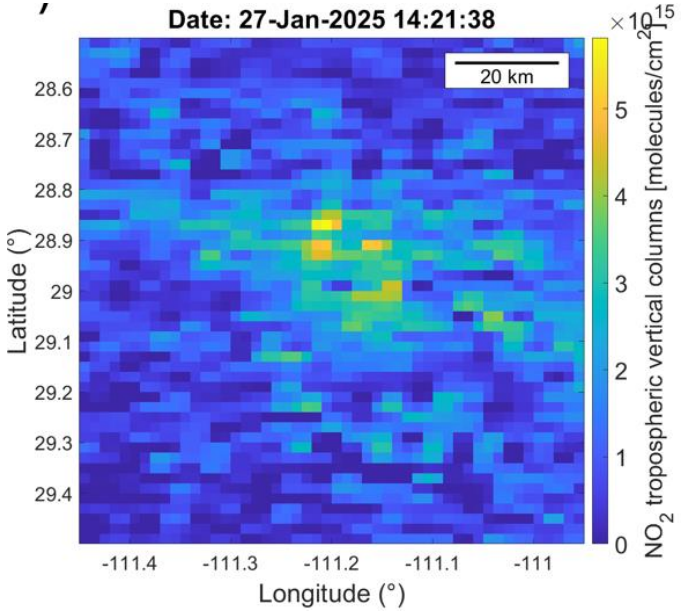
WP 3
Generation of test datasets

Generation of synthetic IRS L2 products, based on:

1. High-resolution data from other sounders
2. PSF
3. MTG-I data orbital data
4. footprint code from WP 2

Emissivity	NO_2 columns
ASTER	TEMPO
100 x 100m^2	2 x 4.75 km^2 (L2 product) 2 x 2 km^2 (L3 product)
Non-wind-rotated over- and super-sampling	Wind-rotated super-sampling

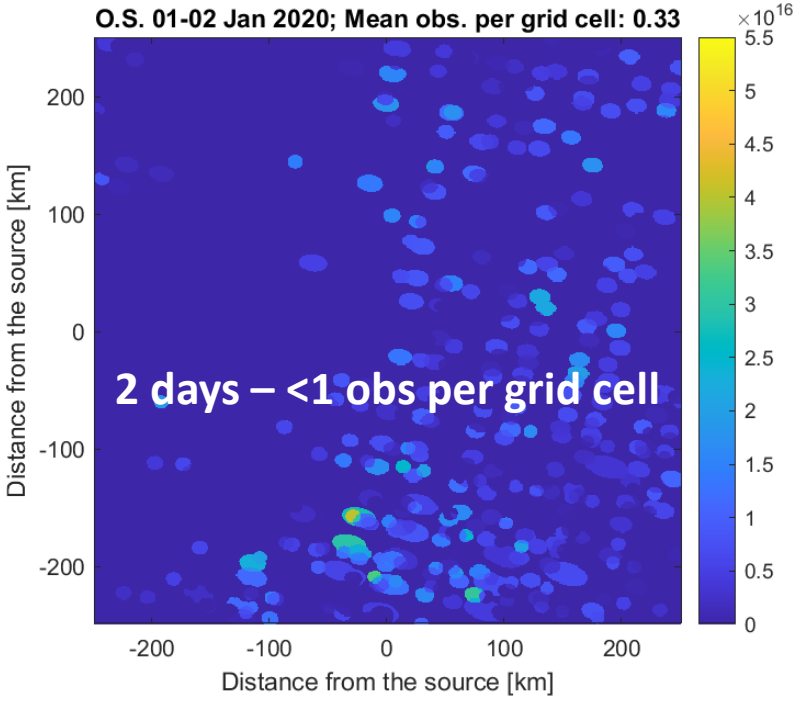


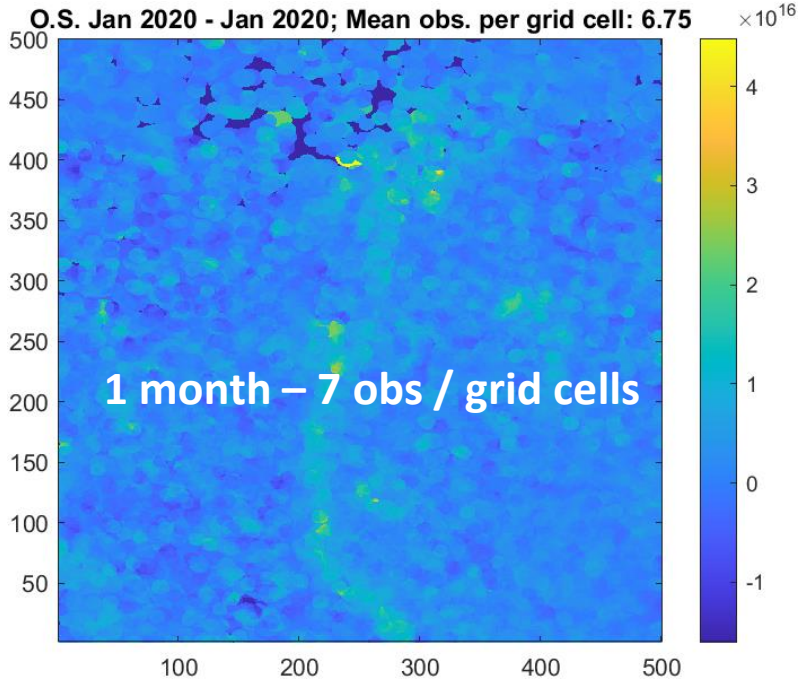


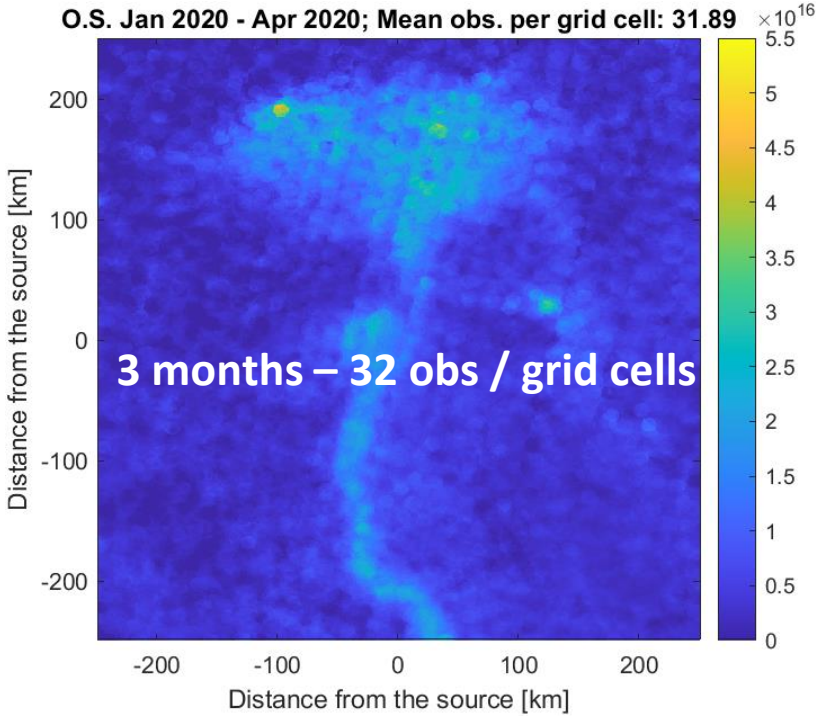
Back of the envelope calculation:

Number of IRS observations typically needed to produce meaningful oversampled distributions for source identification / quantification ?

1. With IASI, **around 30 measurements per grid cells** are typically needed for source identification. Only daytime cloud-free measurements are used; this translates to ~3-4 months of data







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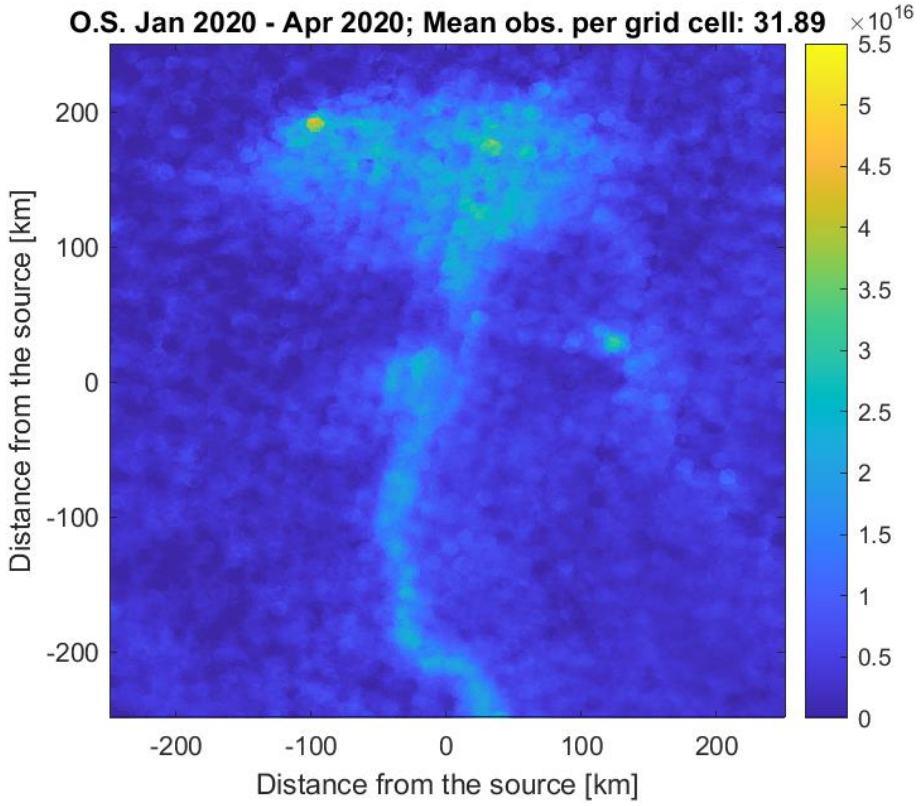

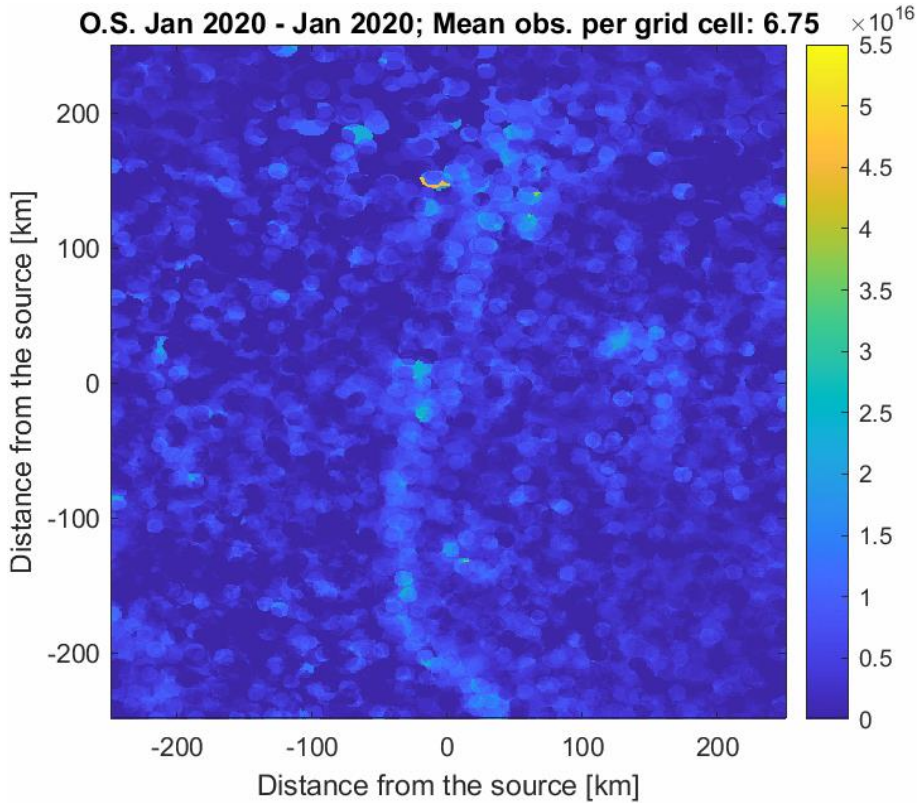

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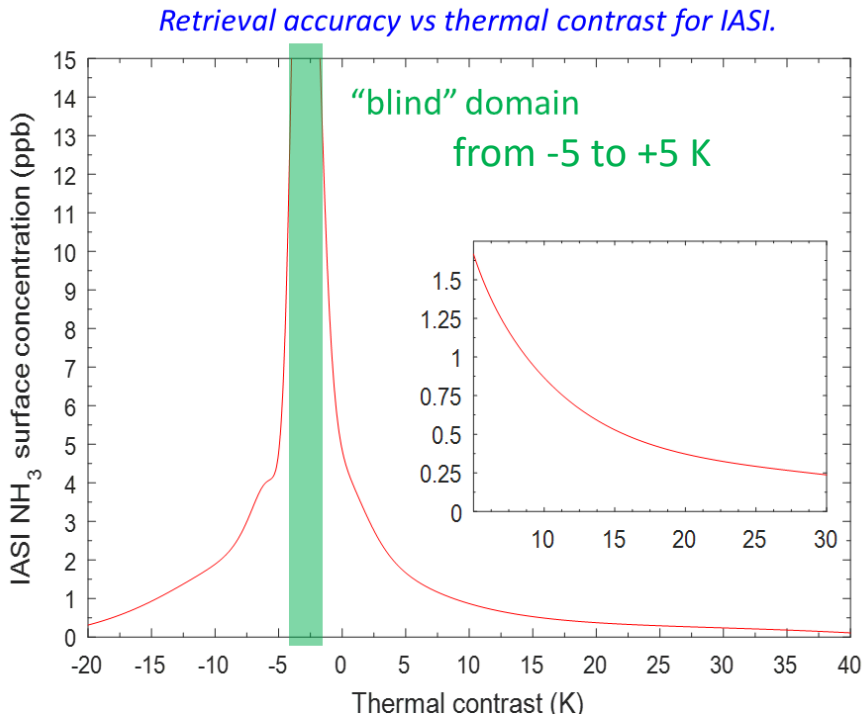
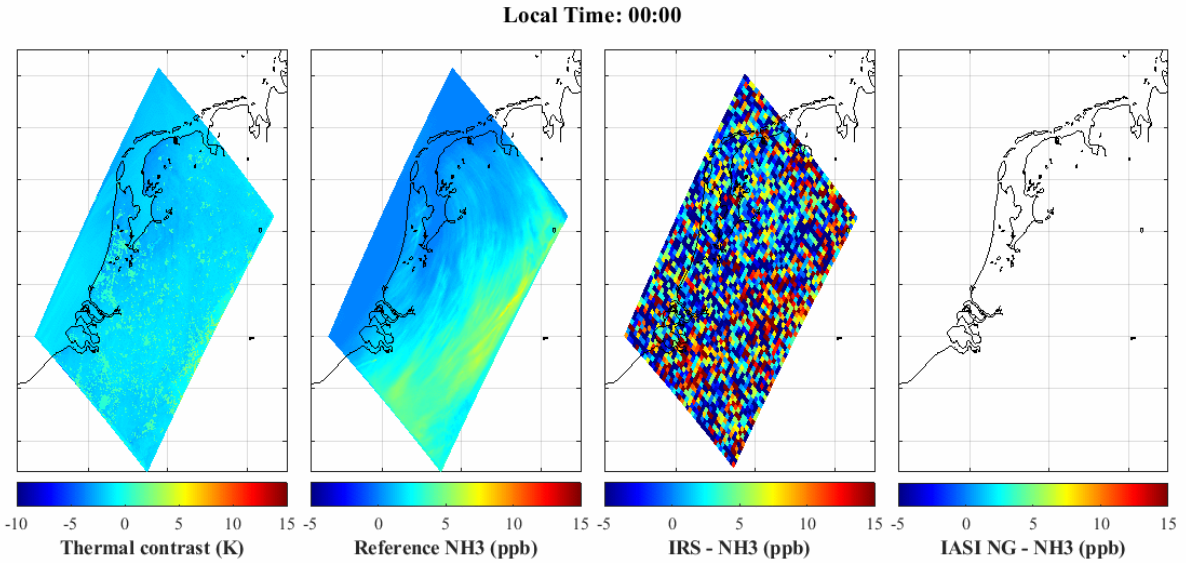
Back of the envelope calculation:

Number of IRS observations typically needed to produce meaningful oversampled distributions for source identification / quantification ?

2. Remember that for source monitoring, we will be heavily dependent on thermal contrast.





For IRS one can expect in "typical" summer conditions to measure surface NH_3 between 7 and 19h

For Europe (LAC 4) that would mean around **25 measurements**

⇨ **Quasi daily oversampled distributions under a cloud free day?????**