ITSC21
29 Nov.-5 Dec. 2017, Darmstadt

IASI-New Generation: Scientific objectives and foreseen validation

C. Crevoisier, F. Smith, C. Clerbaux, V. Guidard, A. Deschamps, T. August and the ISSWG members

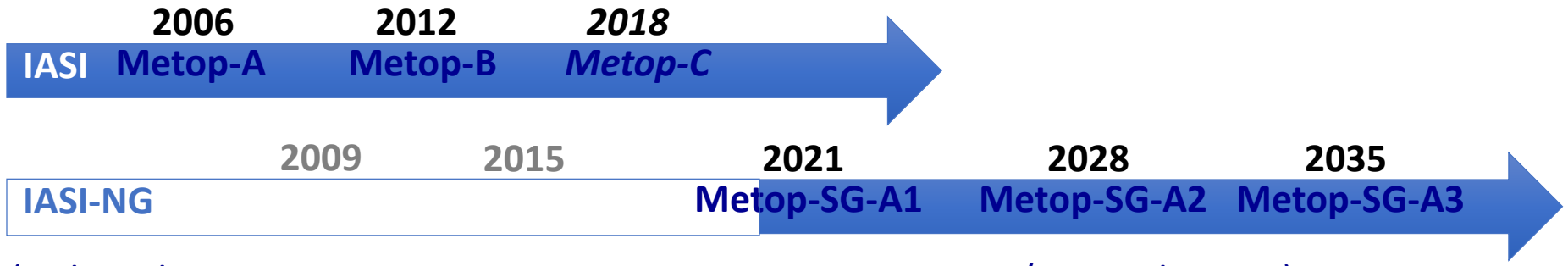
- **ISSWG (IASI/IASI-NG Sounding Science Working Group):**

R. Armante, C. Camy-Peyret, P. Coheur, A. Collard, C. Clerbaux, C. Crevoisier, D. Edwards, R. Eresmaa, V. Guidard, A. Gambacorta, N. Jacquinet, B. Knuteson, M. Matricardi, T. McNally, H. Revercomb, C. Serio, F. Smith, L. Strow, J. Taylor, D. Tobin, A. Uspensky, J. Vidot

- **CNES: F. Bermudo, A. Deschamps, F. Bernard, E. Jacquette**
- **EUMETSAT: T. August, D. Coppens, T. Hulberg, D. Klaes, P. Schluessel**

cyril.crevoisier@lmd.polytechnique.fr

IASI-NG onboard Metop-SG-A in the framework of the EPS-SG program



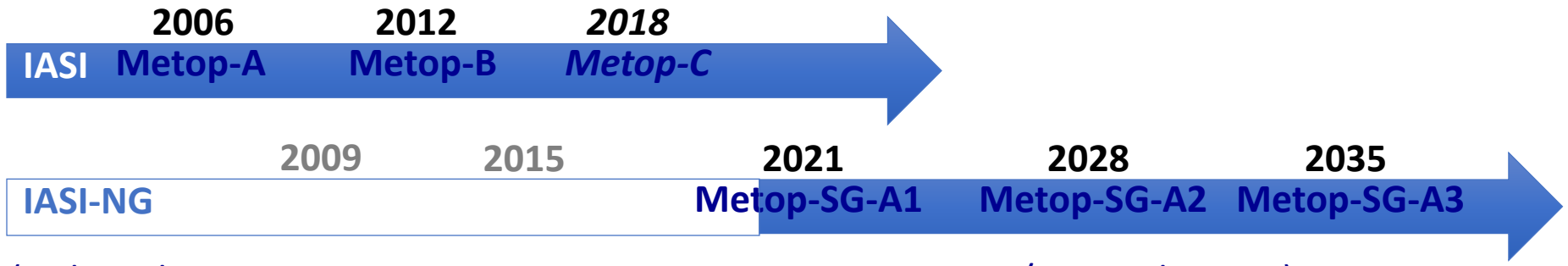
(Onboard Metop-SG-A: MetIMAGE, MWS, IASI-NG, RO, UVNS/Sentinel 5, 3MI)


Metop-SG-A and -B

- **Program status:**
  - Definition phase completed for both instrument and data processing.
  - 2018: validation/consolidation of instrument EM and processing algorithms.
  - 2019: delivery by CNES of 1st Flight Model and L1c processing chains.
  - 2021: launch…

- For more details, please see posters:
  15p.01 (François Bermudo): Program status
  15p.02 (Adrien Deschamps): Level1 Processing
  15p.03 (Flavia Lenti): Level2 Processing

IASI-NG onboard Metop-SG-A in the framework of the EPS-SG program



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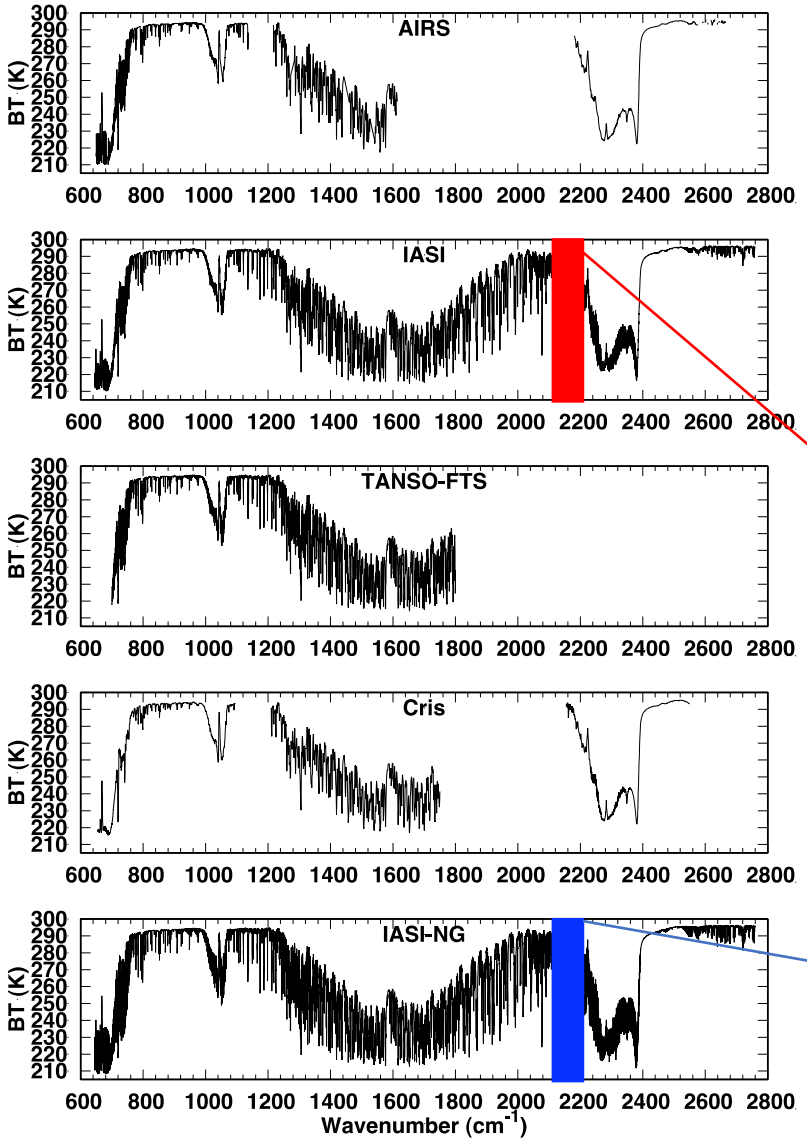
Metop-SG-A and -B

- **Objectives of the IASI-NG mission:**
  - To assure the continuity of IASI for NWP, atmospheric chemistry and climate applications.
  - To improve the vertical coverage of the atmosphere (lower part of the troposphere, the UT/LS region).
  - To improve the precision of the retrievals and to allow the detection of new species.

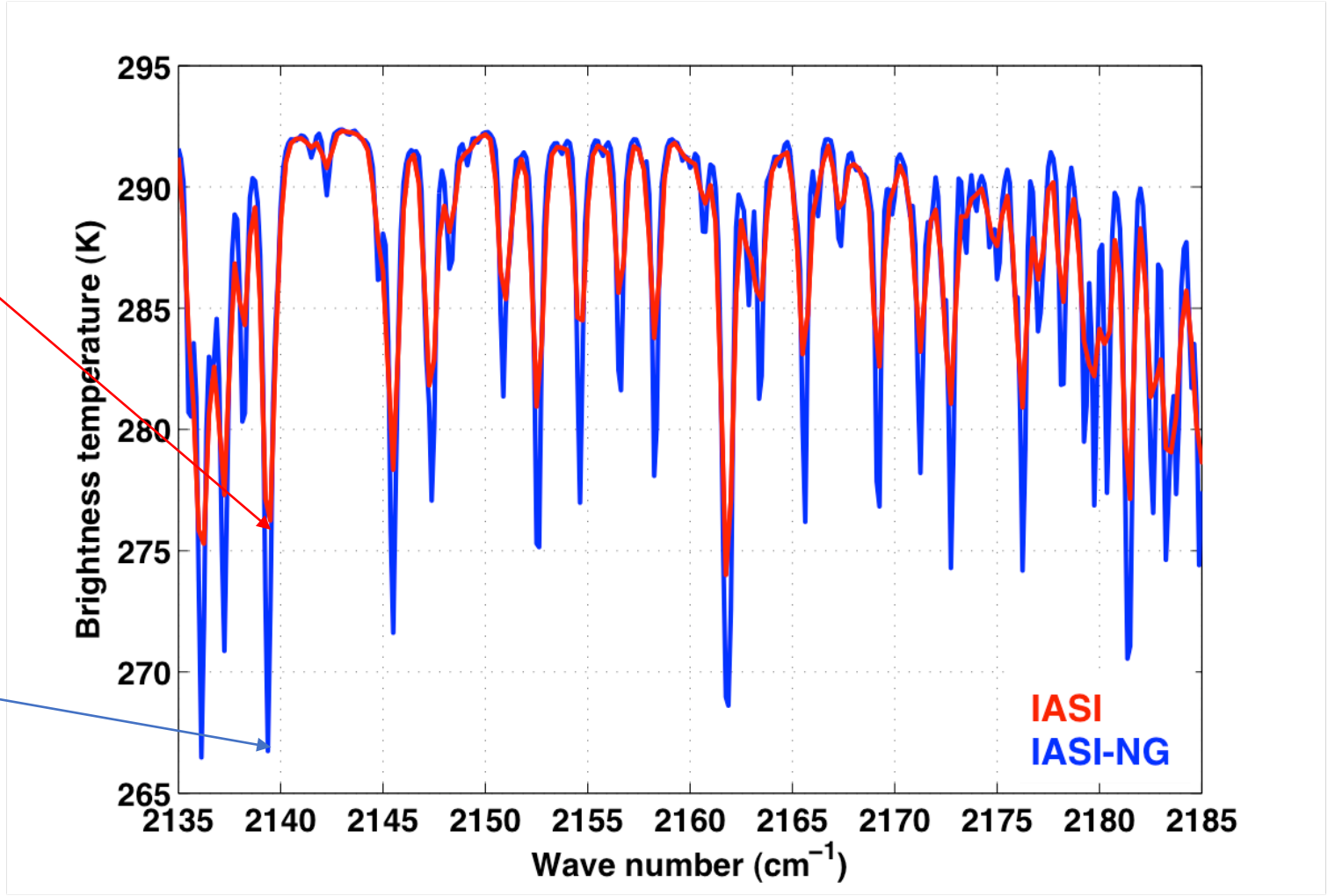
→ **Improvement of spectral and radiometric resolutions**

IASI-NG spectral specifications

BT spectrum for a typical tropical situation



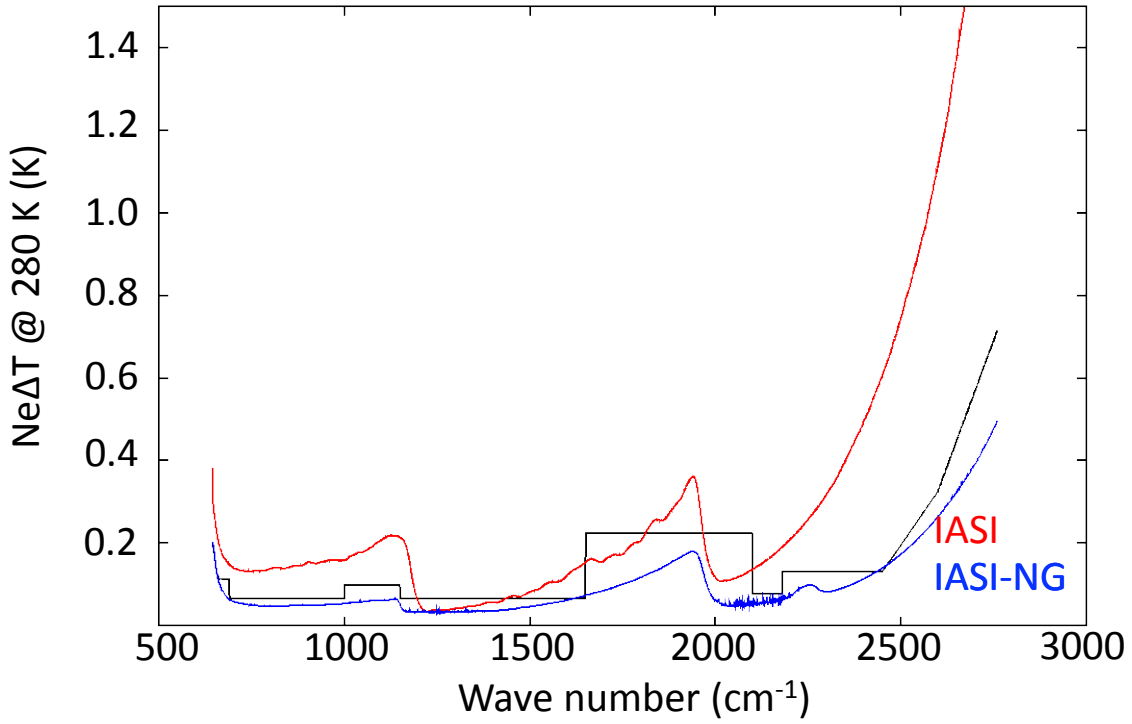
- spectral coverage: 645 - 2760 cm^{-1}
- spectral resolution: 0.25 cm^{-1} after apodisation (*0.50 cm^{-1} for IASI*)
- spectral sampling: 0.125 cm^{-1} (*0.25 cm^{-1} for IASI*).

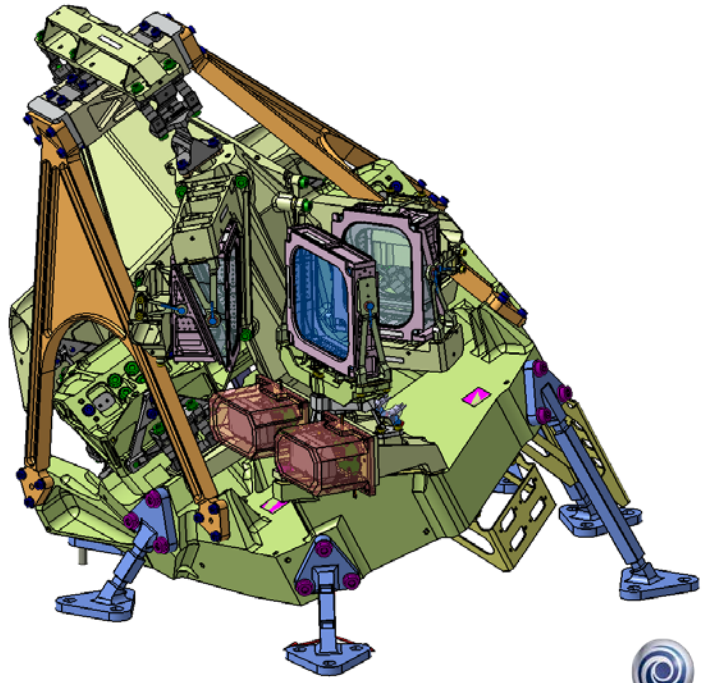


IASI-NG radiometric performances

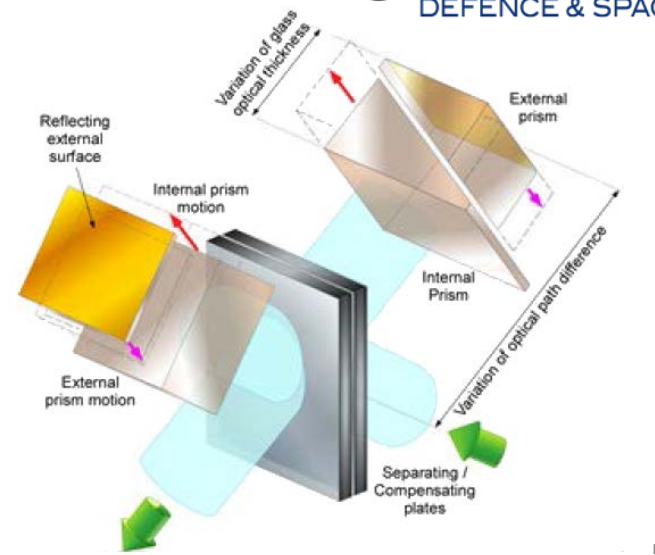
- Innovation: 1st Mertz interferometer in space.
- Patented concept by Airbus DS and CNES: the Dual-Swing mechanism
  → in only one movement: creation of the optical path difference and field compensation of the self-apodization function.
- Material for the optics: KBr (chosen over ZnSe for its better radiometric performances).

Radiometric noise: specifications and expected performances





AIRBUS DEFENCE & SPACE



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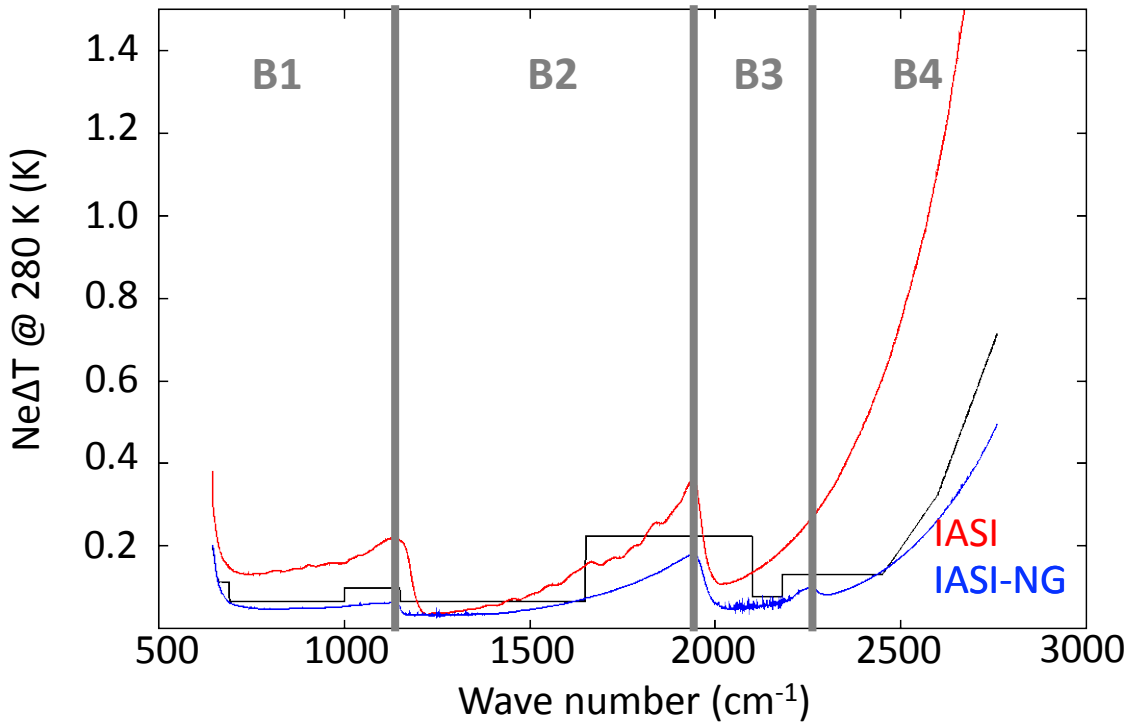

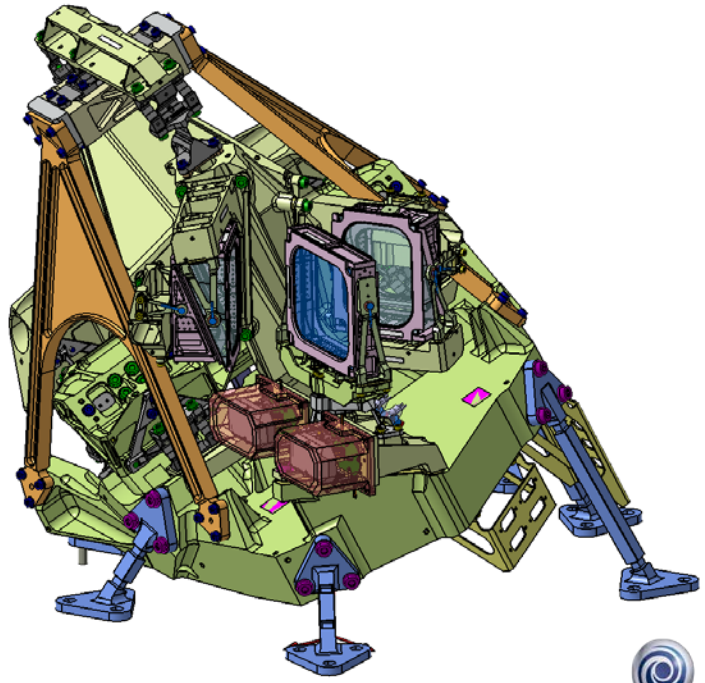

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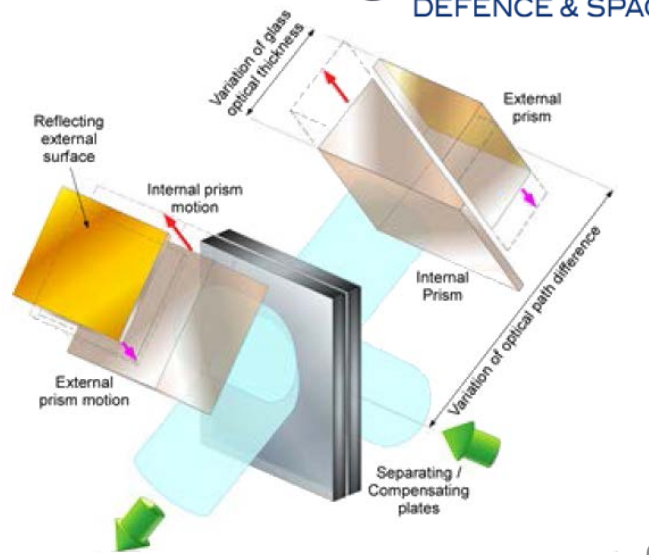
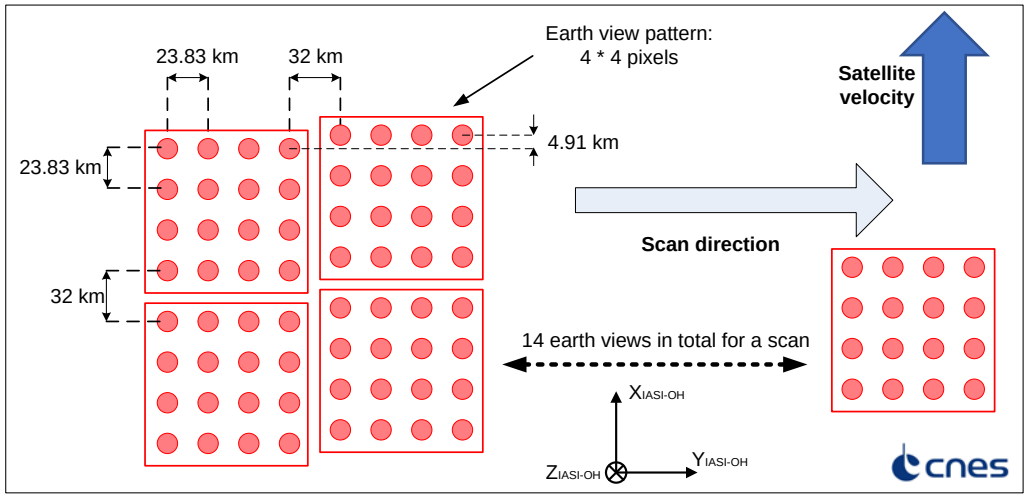
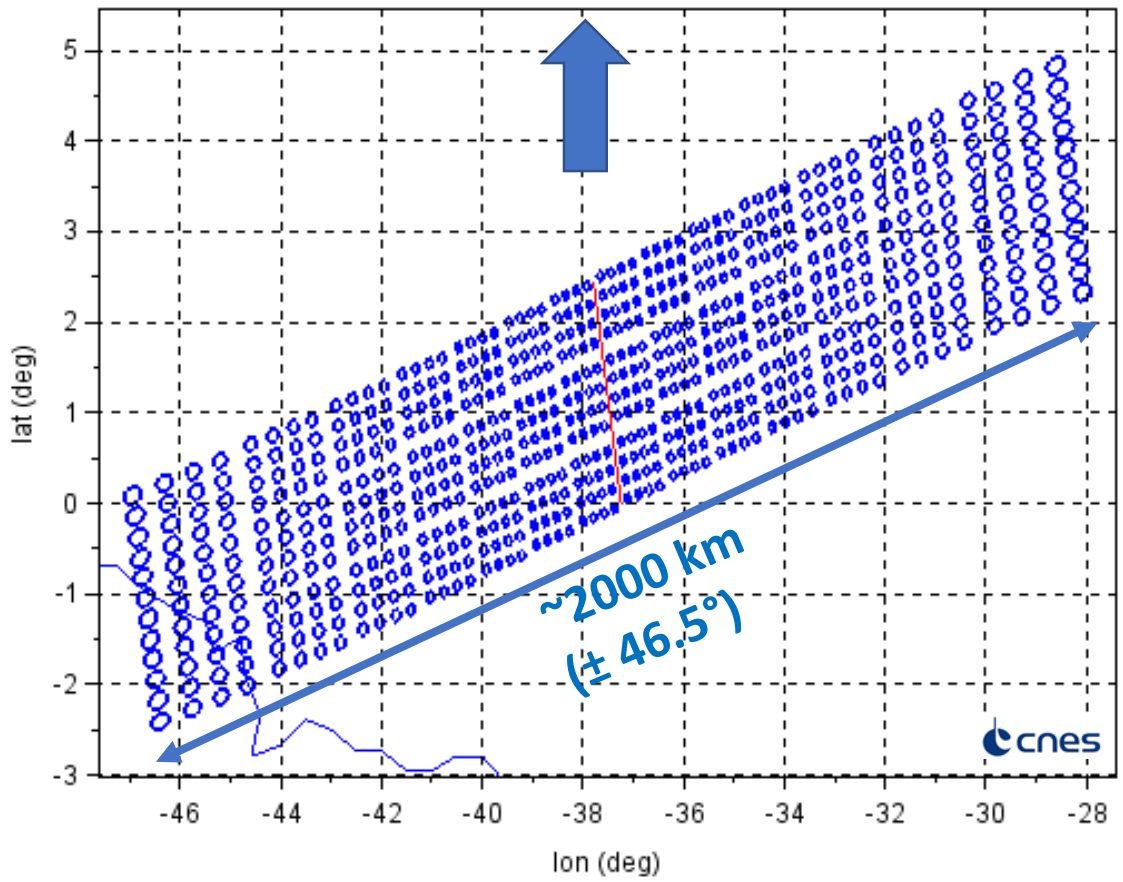


IASI-NG geometry



- 1 FOR (±3° x ± 3°) = 4x4 FOVs
- 1 FOV = 12 km at nadir
- Inter-pixel = 24 km
- Inter-scan = 32 km / 4,91 km
- Inter-line = 32 km

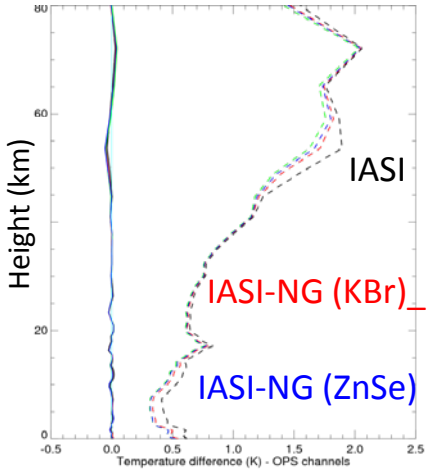
- 19 Views per line :
  - » 14 Earth View
  - » 1 Cold Space
  - » 1 BB 3 transitions



- Swath ~ 2000km, two axis mechanism
- Acquisition duration ~ 730 ms
- Full Scan line (19 views) in 15,6 s

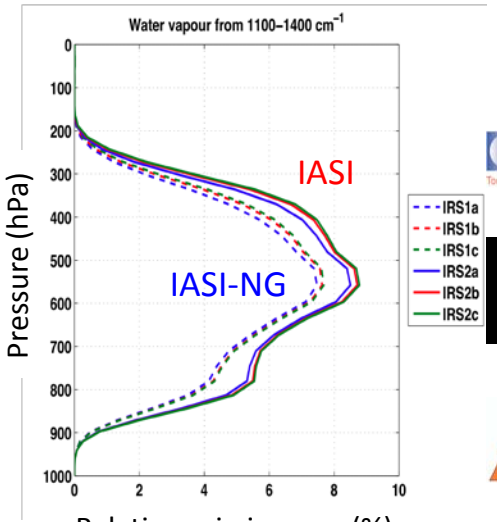
Evaluating impact of IASI-NG through stand-alone/1Dvar retrievals

Temperature



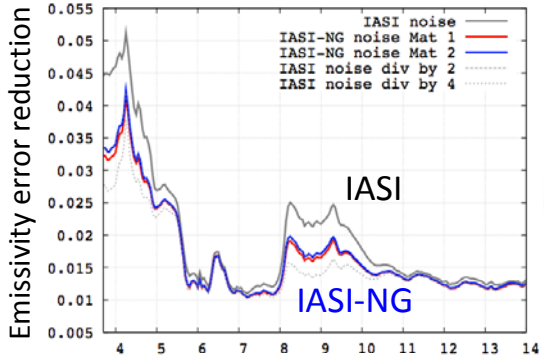
Temp. diff. (K) – OPS channels

Water vapour



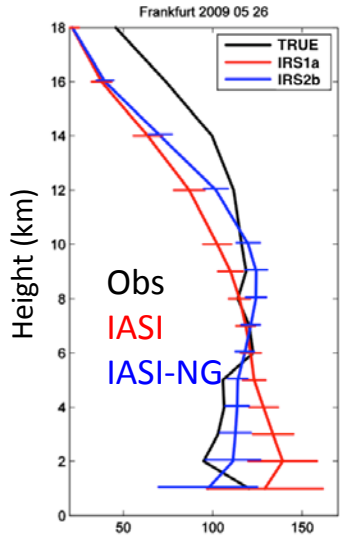
Relative gain in error (%)

Surface emissivity



Wave length (µm)

Carbon monoxide



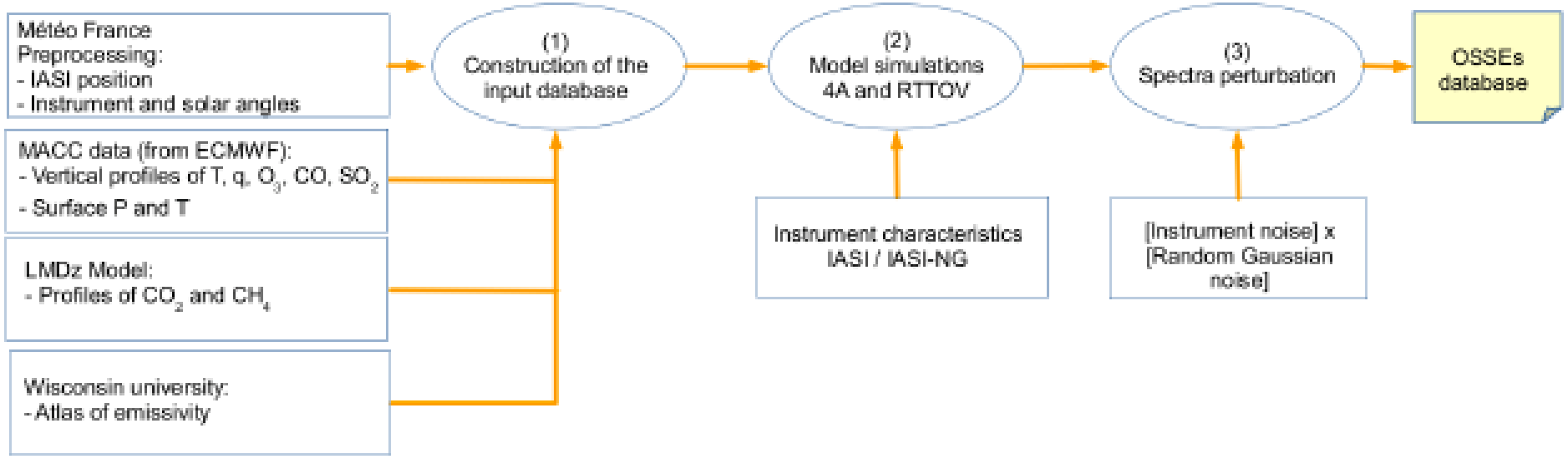
CO (ppb)

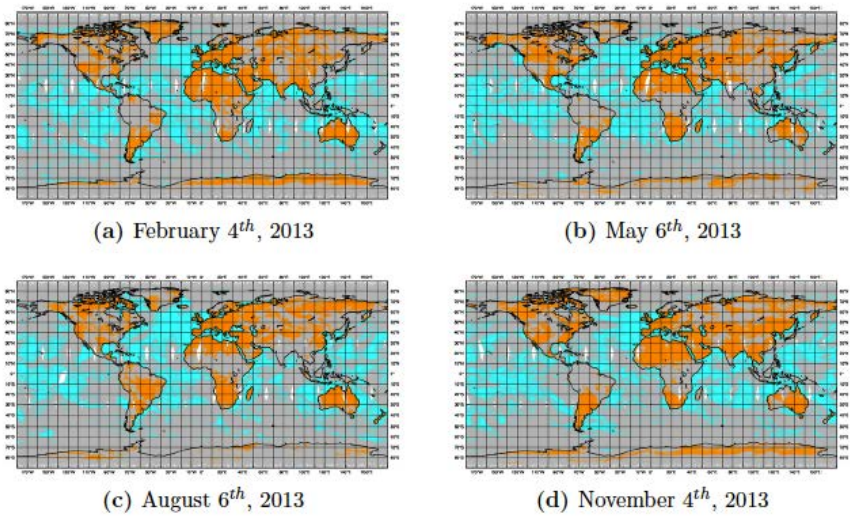
- Depending on the variables, it is either the improved spectral resolution or the improved noise, or the combination of both that matters.
- For most of the atmospheric species, there is no difference between KBr and ZnSe scenarios.

Crevoisier et al., AMT, 2014

Evaluating impact of IASI-NG through OSSEs… for NWP

Objectives: evaluate the impact of IASI-NG (with the latest specification) in NWP assimilation while giving the opportunity to evaluate retrievals of atmospheric species and climate variables in realistic situations.





All observation: 5 241 953
Sea/clear: 418 400
Land/clear: 354 993

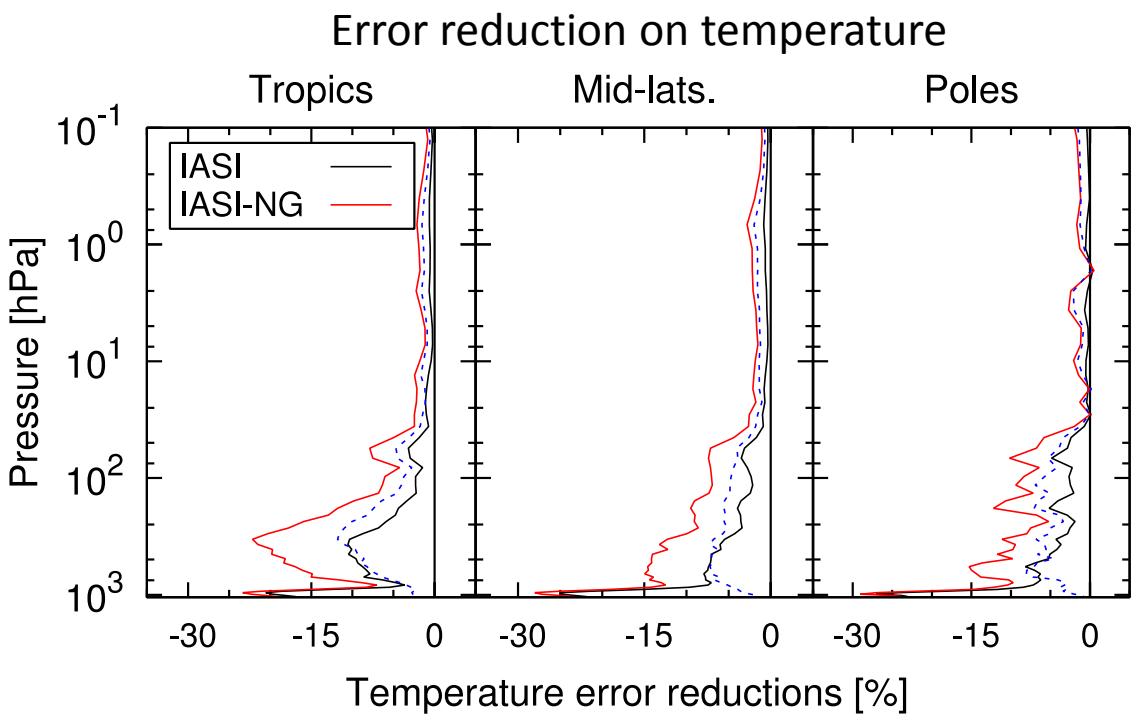
Data set is available to the community:

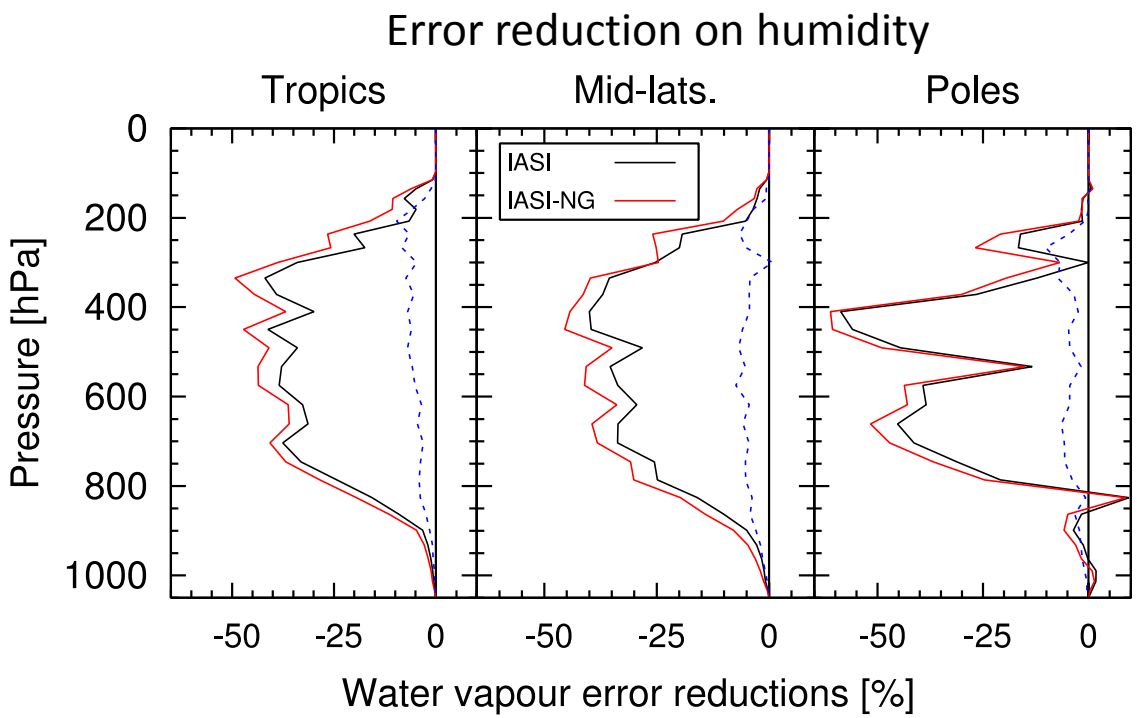
- soon to be on the AERIS community website.
- 196 NetCdf files of 11 Gb each.

Andrey-Andrès et al., AMTD, 2017

Evaluating impact of IASI-NG through OSSEs… for NWP

Error reduction]for temperature and water vapour with the assimilation of 123 channels (in B1 and B2 bands) for **IASI** and **IASI-NG** in 3 regional areas (Tropics, mid-latitudes and polar regions)



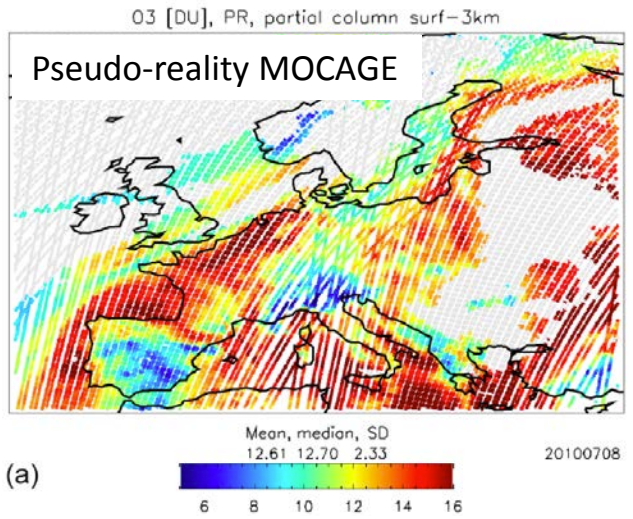


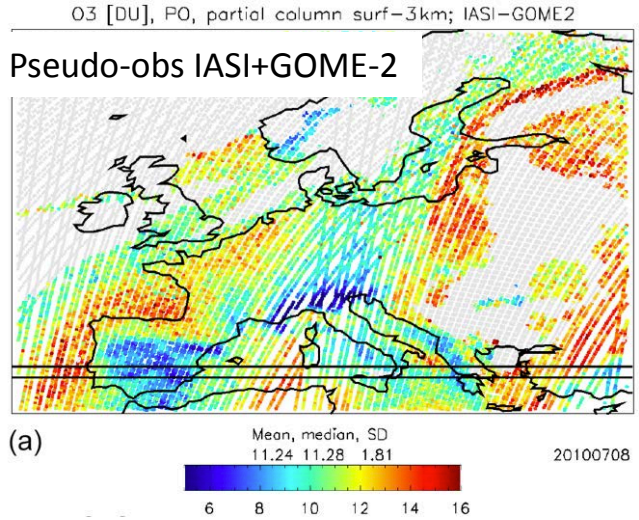
Andrey-Andrès et al., AMTD, 2017

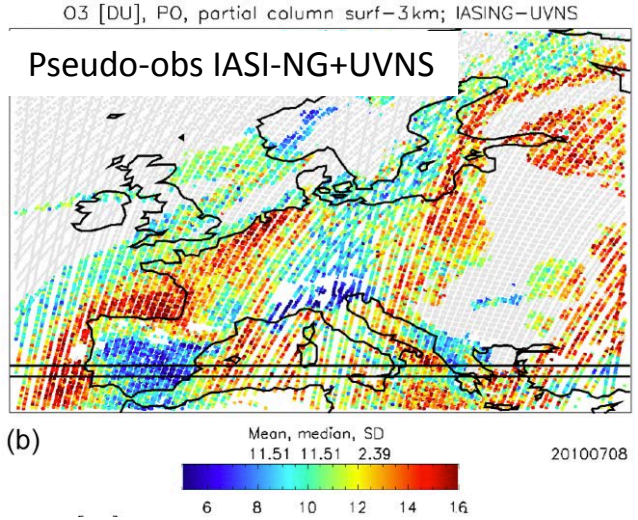
For update of this work, including new channel selection, please see poster 15p.04 by Francesca Vittorioso

Evaluating impact of IASI-NG through OSSEs… for Level 2 products

Observing System Experiments for **Ozone**
4 satellite combinations: IASI, IASI+GOME-2, IASI-NG, IASI-NG+UVNS

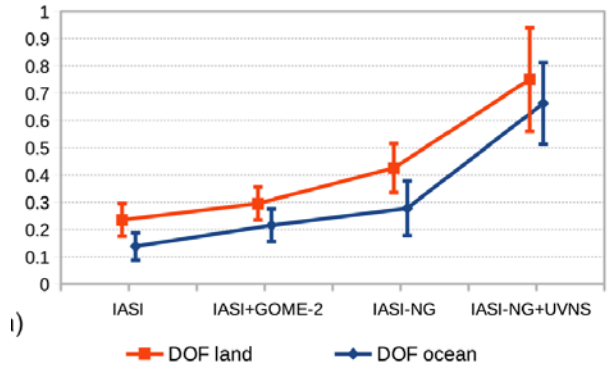




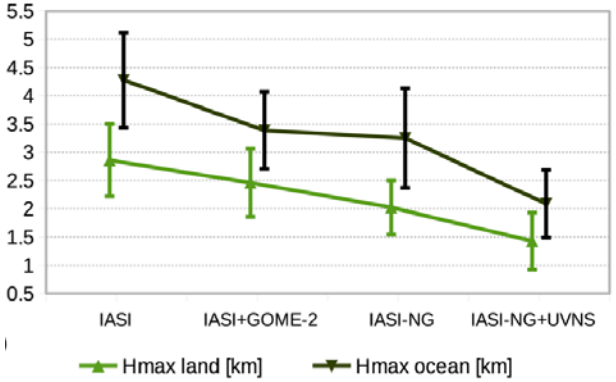


Performance evaluation in terms of DOF, sensitivity height, and errors in the Lowermost troposphere

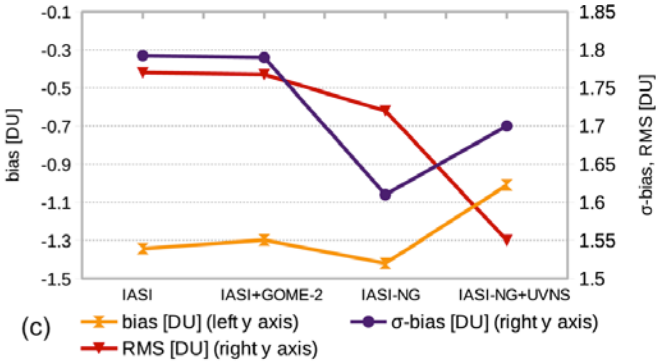
Degrees of freedom



Height of Max. sensitivity



Bias, std and RMS



Sensitivity within the first 2 km, significant improvement of precision and accuracy

Costantino et al., AMT, 2017 Courtesy of G. Dufour

Foreseen Validation activities

- **Strong heritage from IASI and other IR sounders**: several activities can be directly applied to IASI-NG.

- **For level1**:
  - expertise of monitoring and intercomparison activities performed at CNES/EUMETSAT:
    - Technical Expertise Centre (TEC) will support the activities of Cal/Val as well as ground software development and testing.
  - traceability of the documents and datasets (e.g. simulated Data, Bench Test Data, Thermal Vacuum Test Data, Post-launch On-orbit Checkout Data, Validation data used for calibration monitoring, etc).

- **For level2**:
  - The challenge: more than 25 atmospheric species retrieved or detected, in addition to thermodynamics, clouds, aerosols, surface characteristics.
  - Various time-scales to consider:
    - **Pre-launch validation requirements:** ground-based supersites, instrument upgrade/validation, test campaigns.
    - **Short-term validation:** combined ground-aircraft-balloon-surface campaigns.
    - **Long-term validation:** ground networks, satellite inter-comparisons, model comparison/data assimilation (indirect)

→ Creation of compliance matrices to list instrumentation and methodologies (mature, in development or TBD)

Compliance matrices for… thermodynamics and surface variables

	Product	Vertical Resolution	Accuracy	Reference data source
Thermodynamics	Temperature profile	LT, MT: 0.8 km UT, S: 2 km	LT, MT: 0.8 K UT, S: 1.2 K	Sondes (GRUAN) RO dry-T strato NWP analysis
Thermodynamics	Specific humidity profile	LT: 1.2 km MT, UT: 1.5 km S: 3 km	LT: 5 % MT, UT: 7 % S: 20 %	Sondes NWP analysis Ground-based Lidar, MWR
Thermodynamics	Water vapour total column	N/A	5 %	Ground-based GPS High resolution radiometer?
Surface characteristics	Sea surface temperature	N/A	0.3 K	Buoys OSTIA High resolution LEO/GEO radiometers
Surface characteristics	Land surface temperature	N/A	1 K	Ground-based radiometers Space-based high resolution radiometers, e.g. SEVIRI LSA
Surface characteristics	Ice surface temperature	N/A	1 K	In situ measurements... High-resolution radiometers?
Surface characteristics	Land and ice surface emissivity	N/A	1 %	Direct measurments? Aircraft (ARIES?)

Challenge: how to validate the improvement in the retrievals as compared to IASI?

Compliance matrices for… clouds and aerosols

Clouds

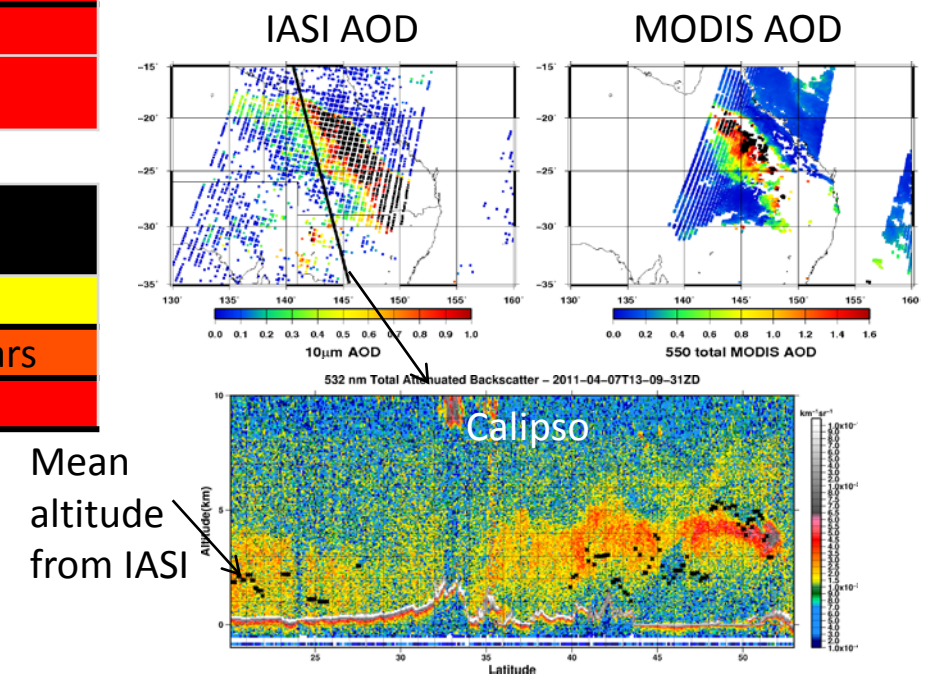
Product	Reference data source
Cloud detection and fractional coverage	GEO/LEO imagery
	Ground-based WSI, other ?
Cloud top phase	Aircraft?
Cloud top height /pressure	Ground-based cloud radar, Lidars
	Space-based active sensors (EarthCare, Mescal...)
Cloud drop effective radius	Aircraft?
Cloud liquid water path	Ground-based radar, MWR?
	Space-borne data: EarthCare?

Aerosols

Product	Reference data source
Dust AOD at 10 µm	GEO/LEO imagery, Aeronet
Dust mean altitude	Ground-based and airborne lidars, space lidars
Effective radius	?

Challenges:

- No active lidar missions with Metop-SG.
- Need for determining cloud/aerosol microphysical properties (aircraft).
- IR vs. visible properties?



Capelle et al., RSE, 2017

Compliance matrices for… trace and greenhouse gases

Product	Vertical Resolution	Accuracy	Reference data source
Carbon monoxide profile	3 km	3 km LT: 30 % MT: 25 % HT, S: 20 %	In situ measurements (airborne, ground) Space-borne missions? Other?
Carbon monoxide PC	3 km	10 %	NDACC ground stations
Ozone profile	3 km	LT,MT, UT: 20 % S: 10 %	O_3 sondes Other space missions? Model?
Ozone total column	N/A	5 %	Ground Brewer, Dobson
Sulphur dioxide total column	N/A	50 %	?
Nitric acid partial column	T, S	20 %	NDACC?
Methane mid-tropo. column	N/A	<1%	AirCores, Aircraft, Space Carbon mission?, Ground-based FTIR (NDACC) Models/Assimilation (CAMS)
Carbon dioxide mid-tropo. column	N/A	<1%	
Nitrous oxide mid-tropo. column	N/A	10 %	

Challenge: Total or partial columns need full description of vertical column to be properly validated.

Conclusion and future work

- **IASI-NG should greatly improved the characterization of the atmosphere as compared to IASI.**
  - IASI-NG Science Plan to be released by ISSWG end of December.
    → Access through IASI-NG website: https://iasi-ng.cnes.fr/fr
  - Continuation of OSSEs and RT developments to prepare the mission.

- **Validation is an essential part to insure the mission success:**
  - Challenge: requirements for IASI-NG are tight; how to validate some products (clouds, aerosol, gases)?
  - **Continuous (and extended) support of ground-based networks is essential**: GRUAN, Aeronet, NDACC, TCCON, etc.
  - Aiming at **automatization** of validation and monitoring tools (e.g. GAIA-Clim).
  - Development of **assimilation as a tool for validation** (NWP, atmospheric composition through CAMS).

- **Validation campaigns pre/post launch**:
  - dedicated campaigns when no coordinated network and routine data flux exist.
  - a IASI-NG demonstrator? TBD in 2018.
  - study of FOV heterogeneities (e.g. use of UAVs).
  - coordination of validation activities between missions would be a real asset:
    - within Metop-SG (IASI-NG, 3MI, Sentinel5/UVNS, etc).
    - between different platforms (e.g. for GHG, organization of the CoMet campaign in 2018 for the validation of IASI-NG, Merlin and MicroCarb all to be launched in 2021-2022).
      → collaborative effort: best use of funding, man-power, instruments availability, scientific objectives.