3rd IASI Conference
Hyères, 4-8 February 2013

# The IASI-NG mission:
# Scientific objectives and expected results

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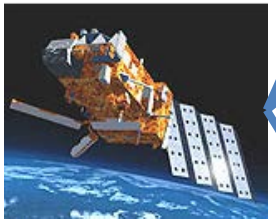
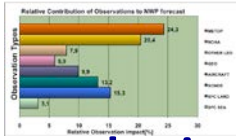
# The IASI-NG mission

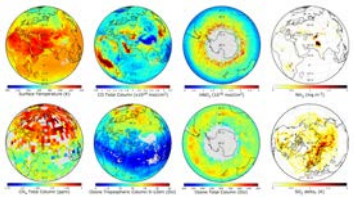


## Numerical Weather Prediction



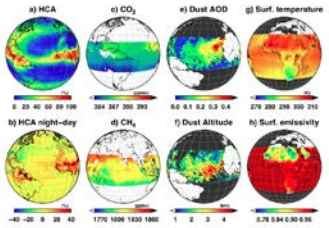
Global NWP, LAM, mesoscale models

## Atmospheric composition



More than 20 species detected, some well quantified ($O_3$, CO, $CH_4$), some only detected ($SO_2$, $HNO_3$, $NH_3$, formic acid, methanol) in special situations (fires, volcanoes)

## Climate

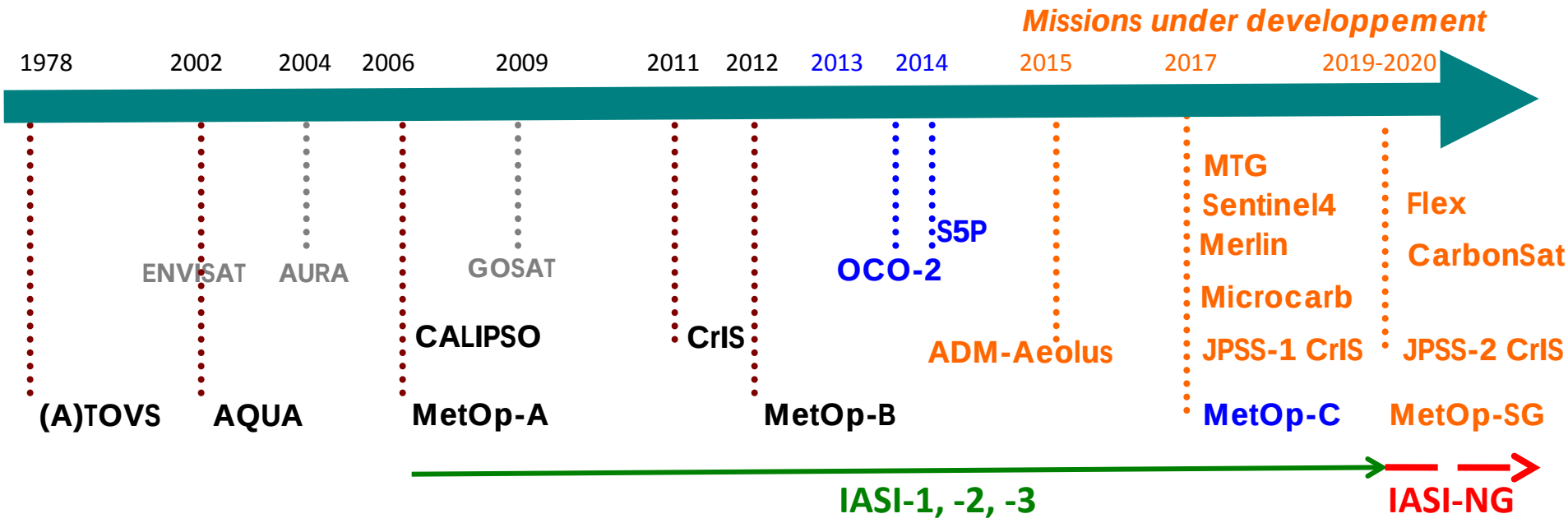



- Essential Climate Variables: T, WV, GHG, Surface characteristics, Clouds, Aerosols.
- Reference for the GSICS.

## Lessons learned with IASI onboard MetOp-A:

- IASI benefits three communities that will be more and more connected (eg: MACC-GMES, Essential Climate Variables)
- Covering continuously the whole TIR domain is very useful.
- To retrieve several variables, other atmospheric data (cloud, T, WV) are mandatory.
- Spectral and radiometric stabilities are very important.
- Retrievals over land/sea by day/night.

# The IASI-NG mission




- **EPS-SG**
  - PFA : MetIMAGE, MWS, IASI-NG, RO, UVNS, 3MI
  - PFB : SCATT, MWI, RO
- **IASI-NG Status**:
  - Phase-A studies at CNES since January 2010, end in April 2012.
  - Two industrial studies have been conducted in parallel (Astrium-France and Thales Alenia Space-France).

# The IASI-NG mission

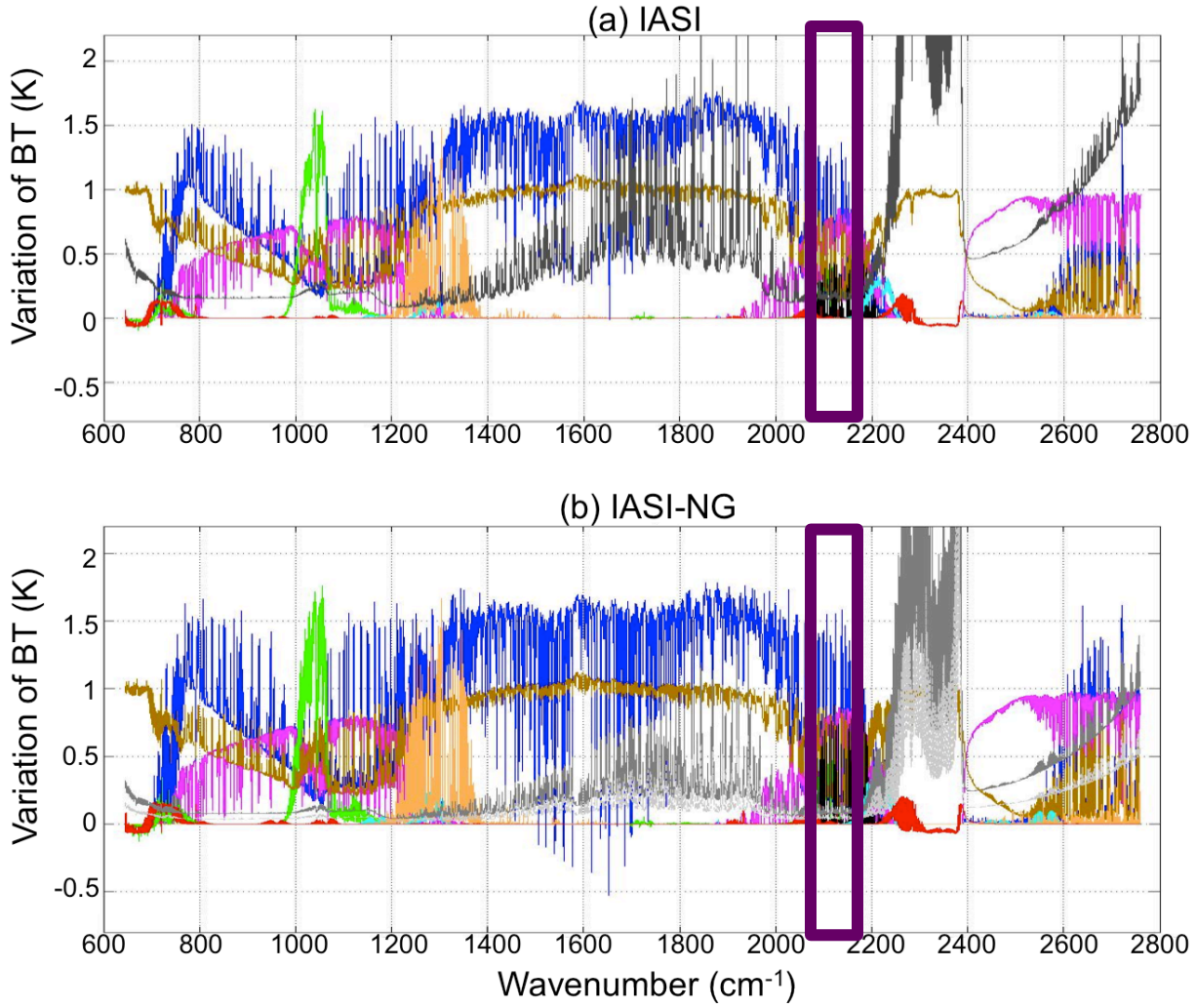
- **Objectives of the mission:**
  - To assure the continuity of IASI for NWP, atmospheric chemistry and climate applications.
  - To improve the characterization of the lower part of the troposphere, the UT/LS region and, more generally, of the full atmospheric column.
  - To improve the precision of the retrievals and to allow the detection of new species.

- **Characteristics**:
  - -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*).
  - -reduction of the radiometric noise by at least a factor of ~2 as compared to IASI.
  - -spatial sampling: 12 km FOV.

➡ How improving both spectral and radiometric characteristics can help reaching the objectives?

# IASI-NG: a few scenarios

| Spectral resolution | IASI noise | IASI noise /2 | IASI noise /4 | IASI-NG noise Threshold | IASI-NG noise Objective |
|---|---|---|---|---|---|
| 0.5 $cm^{-1}$ | IRS1a | IRS1b | IRS1c | - | - |
| 0.25 $cm^{-1}$ | IRS2a | IRS2b | IRS2c | IRS2-T | IRS2-O |

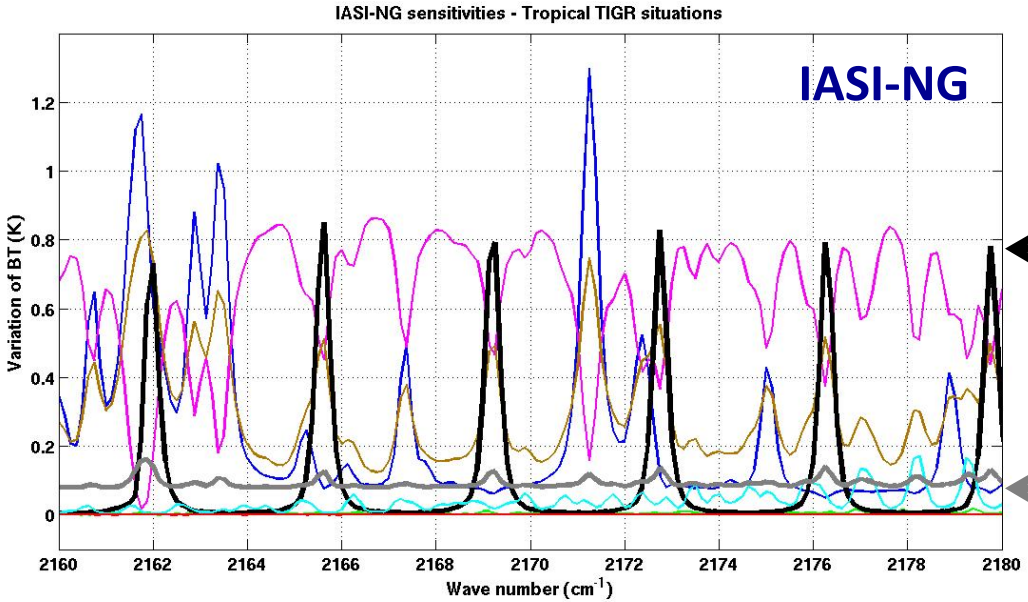



**0.5 $cm^{-1}$**

**0.25 $cm^{-1}$**

# IASI-NG: a few scenarios

**0.25 cm$^{-1}$**

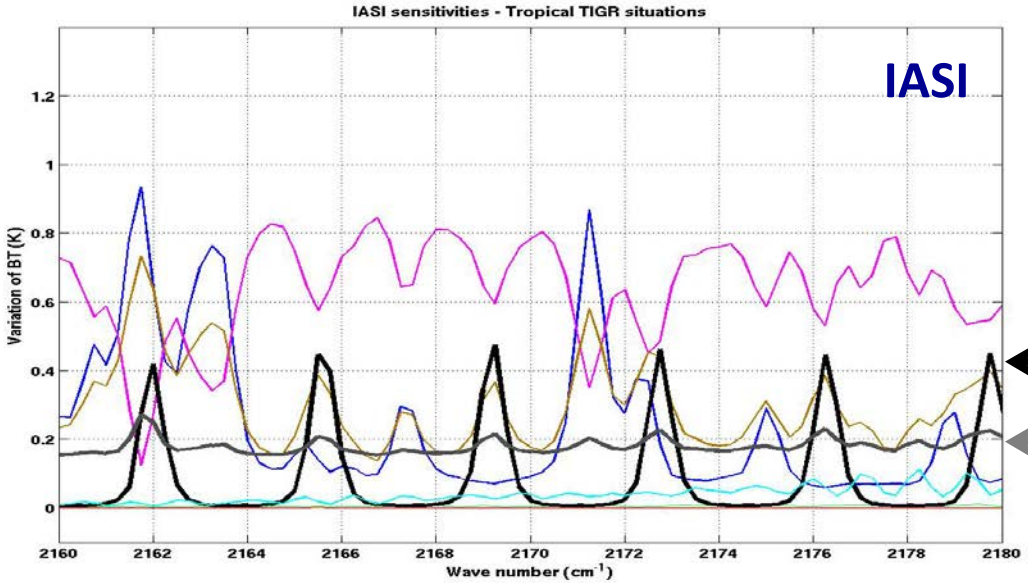



***For a 10ppbv CO perturbation:***

**CO ~0.8 K**

**Noise: ~0.1 K**

**0.5 cm$^{-1}$**




**CO ~0.4 K**

**Noise: ~0.2 K**

T (1K) $H_2O$ (20%) $CO_2$ (1%) $O_3$ (10%) $N_2O$ (2%) CO (10%) $CH_4$ (10%) Tsurf (1 K)

# IASI-NG: a few scenarios

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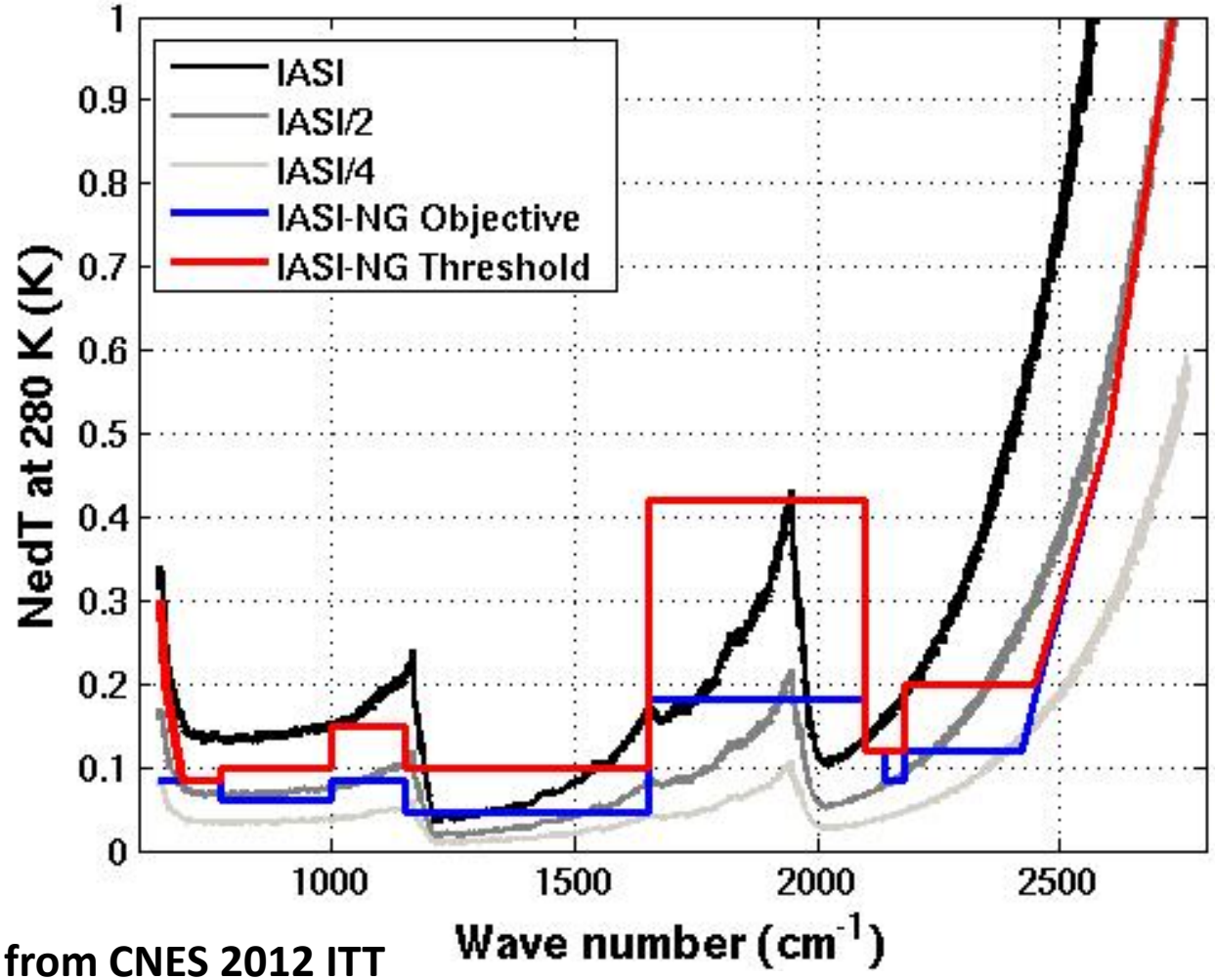
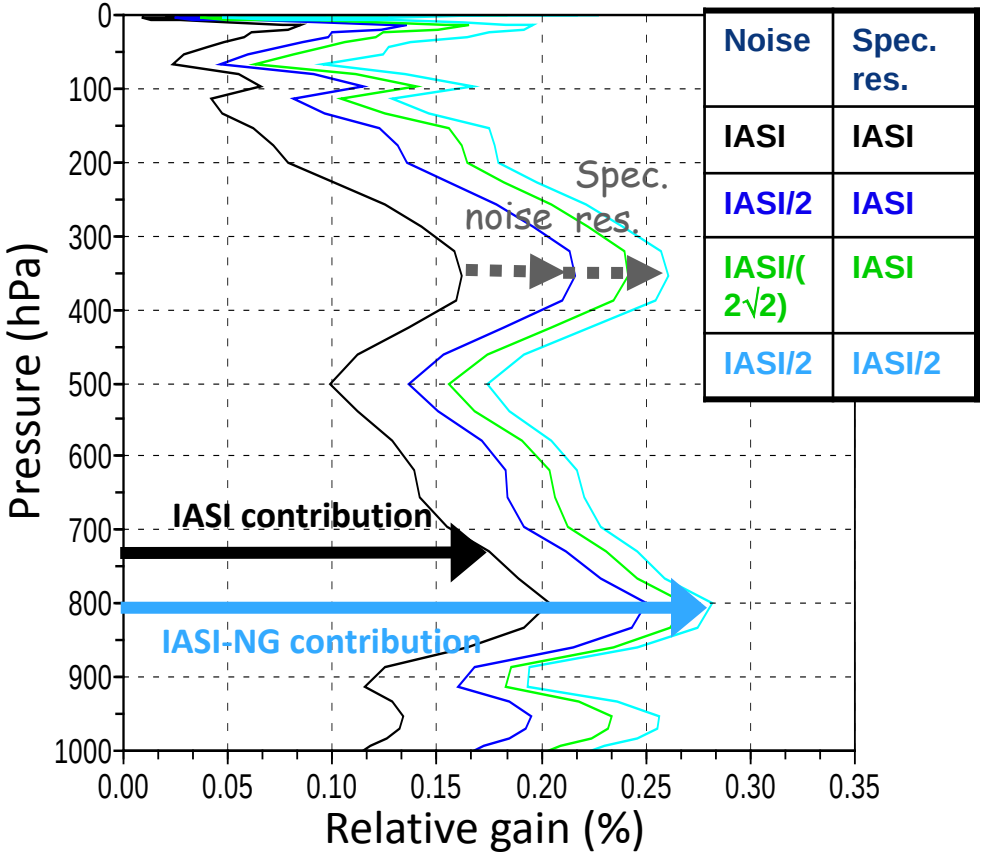



**Specifications from CNES 2012 ITT**

# IASI-NG: impact on thermodynamic variables

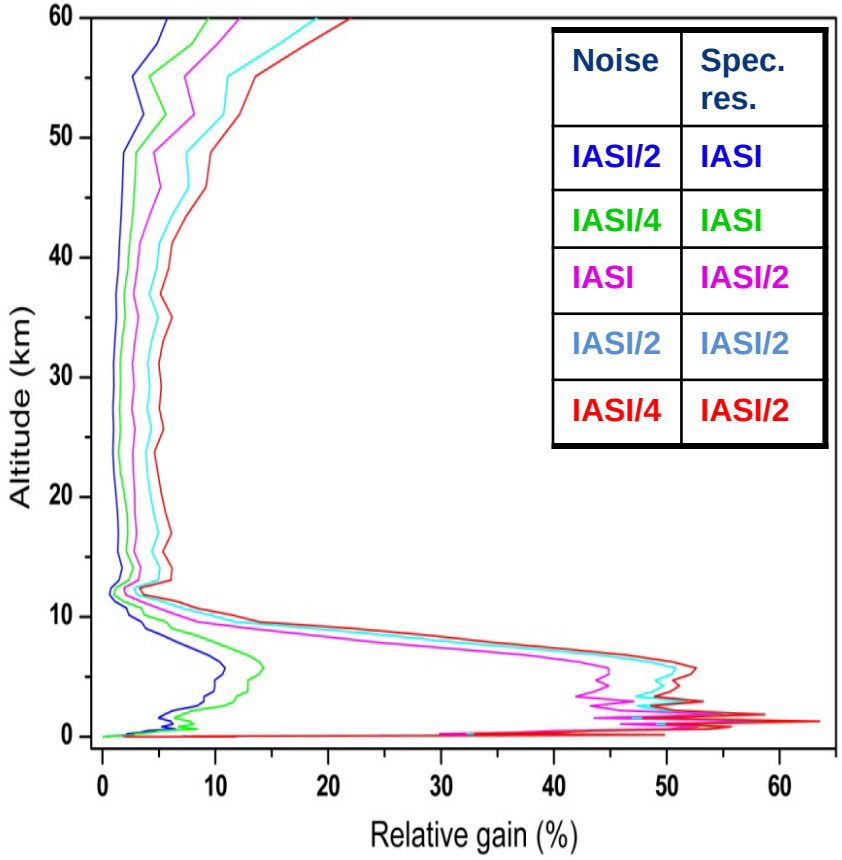
## Temperature

### Relative gain of each scenario (*a posteriori-a priori*)/(*a priori*)




## Water vapor

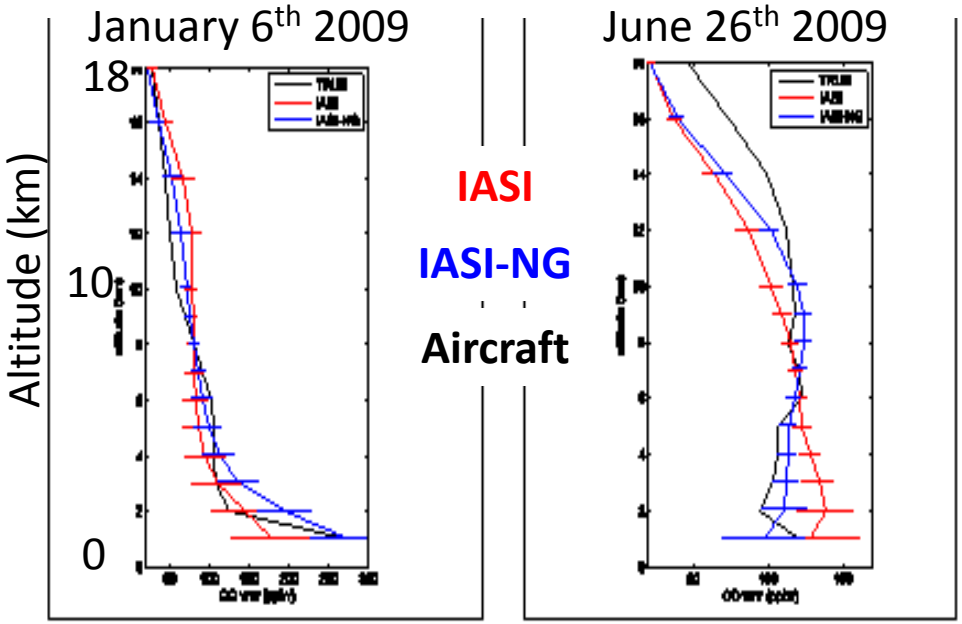
### Relative gain of each scenario compared to IASI




Spectral resolution improves the instrument contribution beyond noise reduction by increasing the number of channels.

# IASI-NG: impact on atmospheric composition

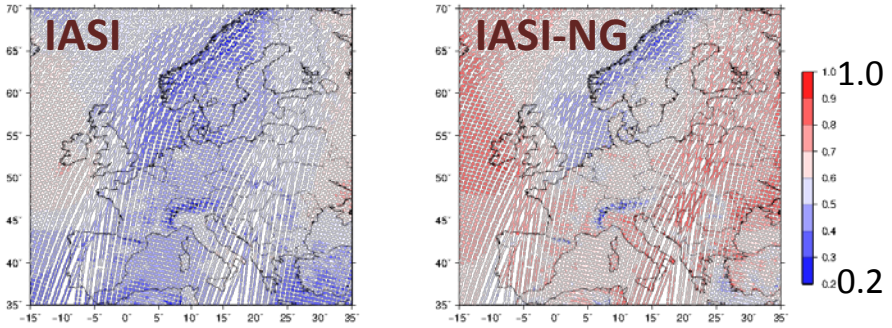
## Carbon monoxide



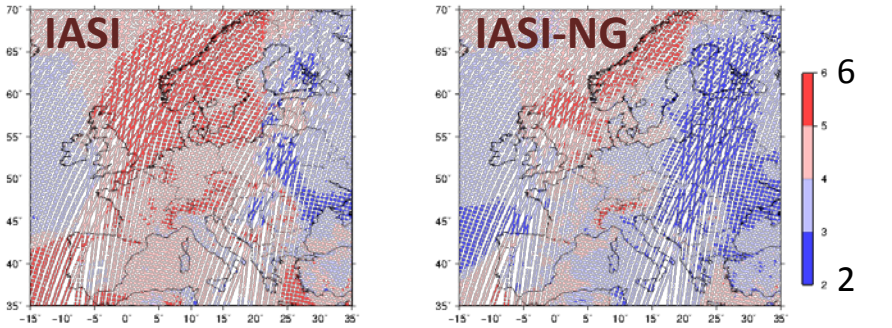

MOZAIC aircraft CO at the Frankfurt airport

## Ozone

DOFS




Altitude of max. sensitivity (km)

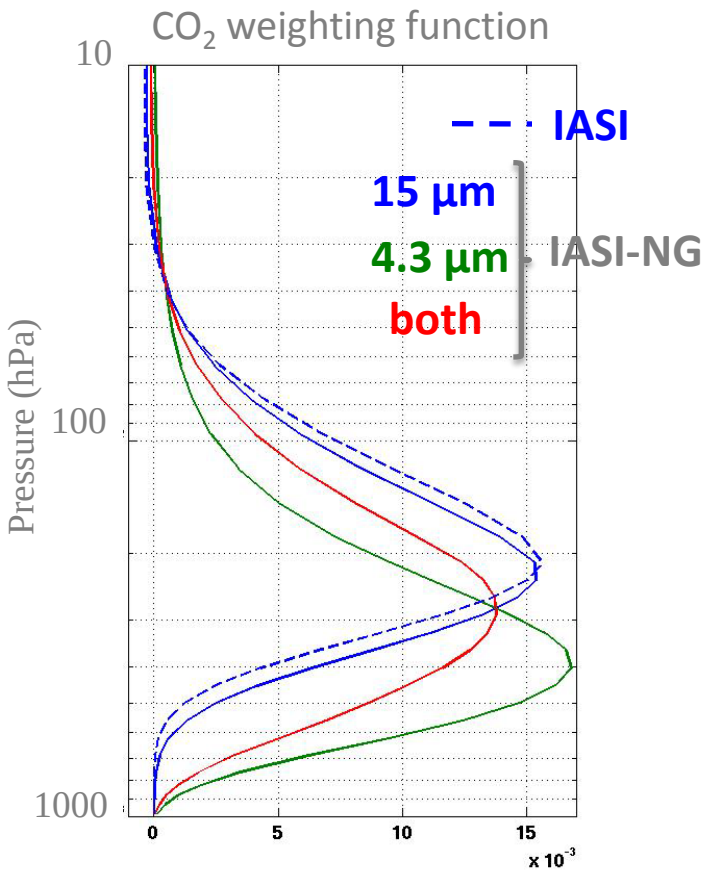



Simulation performed using a regional model that described an increase of (0-6 km) ozone observed in Europe (August 20th, 2009).

# IASI-NG: impact on climate variables

## Carbon dioxide

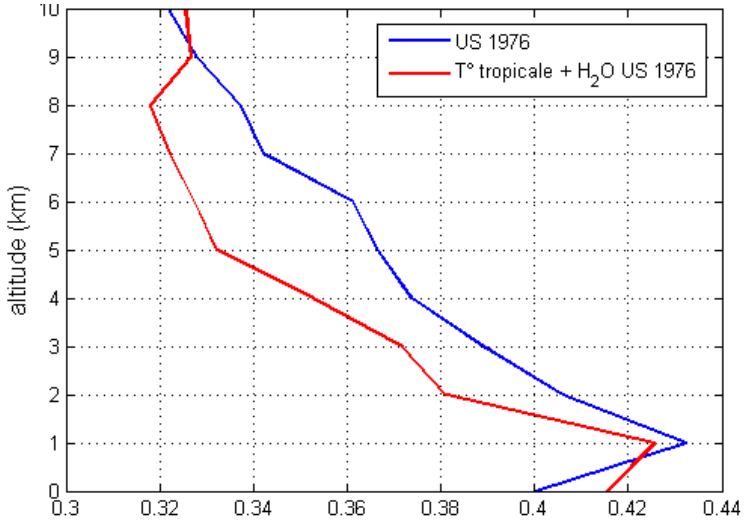
| Spectral bands for IASI-NG | Noise | Improvement of the $CO_2$ precision |
|---|---|---|
| 15 µm | IASI/2 | 30 % |
| 4.3 µm | | 0 % |
| 15 + 4.3 µm | | 45 % |




- IASI-NG will enable the use of 4.3 µm channels, giving access to a lower part of the atmosphere, with a much improved precision.

- Strong and needed complementarity with SWIR obs. (GOSAT, OCO-2, UVNS).
- Still relies on synergy with MWS!
- $N_2O$?

# IASI-NG: impact on detection of atm. species

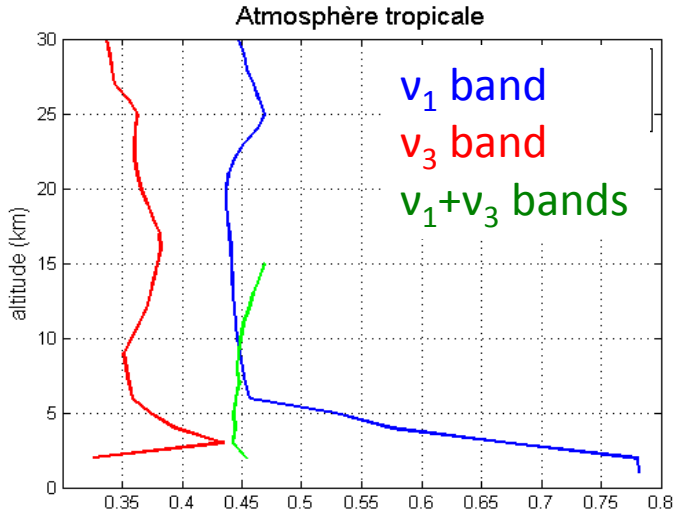



Gain in the detection threshold

•**Ammonia [0-2 km]:** gain of 40 % on the detection limit.

•**$SO_2$**: a 45 % gain on the detection threshold + some information on the vertical structure of the plumes.

•**Volcanic ash:** improvement on the detection limit.




Gain in the detection threshold

→**Improvement of volcanic eruption alert**
**(and more species will be retrieved:** $SO_2$, $H_2S$, $H_2SO_4$, ash)

# IASI-NG: summary

| | IASI | | IASI-NG | | |
|---|---|---|---|---|---|
| ***Chemistry*** | ***DOFs*** | ***Error (%)*** | ***DOFs*** | ***Error (%)*** | ***What the 'NG' brings*** |
| **$O_3$** | 3-4 | PBL : 60%<br>Tropo : 11% | 4-5 | PBL : 40%<br>Tropo : 8% | More information in PBL |
| **CO** | 1-2 | PBL : 16%<br>Tropo : 8% | 2-3 | PBL : 10%<br>Tropo : 6% | More information in PBL |
| **$HNO_3$** | 1 or less | | 2 | | Both tropo and strato |
| **$NH_3$[a]** | detected | - | measured | - | > instrumental noise |
| **Methanol[a]** | detected | - | measured | - | > instrumental noise |
| **$C_2H_4$[a]** | detected | - | measured | - | > instrumental noise |
| **$SO_2$-volcanos** | If > 2DU | - | If > 1 DU | - | + Altitude of the plume |
| ***Climate*** | ***DOFs*** | ***Error (%)*** | ***DOFs*** | ***Error (%)*** | ***What the 'NG' brings*** |
| ***$H_2O$*** | 5-6 | ~13% | 6-7 | ~10% | Error improved by 1.5 |
| ***T*** | 6 | ~0.6K | 12 | ~0.45 K | Error improved by 2.5 |
| ***$CO_2$*** | 1 or less | ~1% | 1-2 | <1% | Low troposphere |
| ***$CH_4$*** | 1or less | ~3% | 1-2 | | Less interferences |
| ***$N_2O$*** | detected | - | measured | - | |
| ***Aerosols*** | dust | | | | More types |
| ***Emissivity*** | | 0,04 @4µm | | 0,02 @4µm | |

# IASI-NG: next steps

So far, most of the studies were based on representative atmospheric situations in « stand-alone » approaches.

Next step: Observing System Simulation Experiments (OSSEs).

**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.

**Team**: CNRM-GAME, LMD, LATMOS, LISA, LA

**First steps**: selection of orbits, gathering information of atmospheric components (clouds, aerosols, trace gases, etc.)

Everyone is welcome to join this effort!!

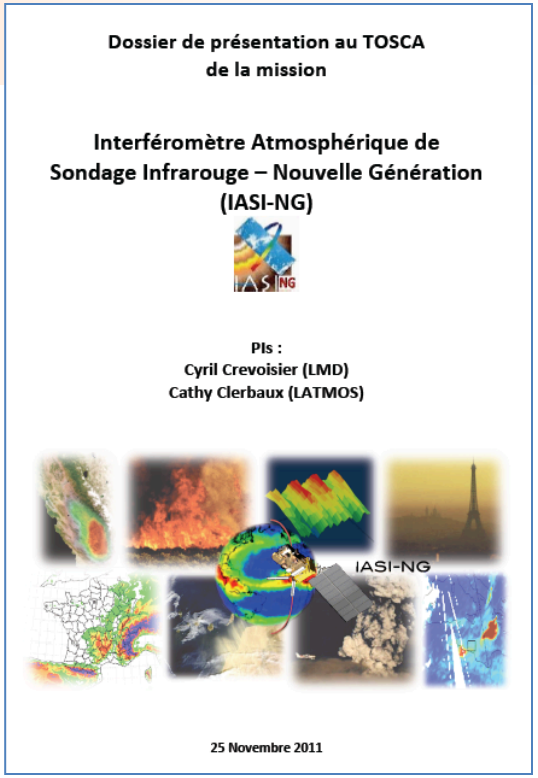
# The IASI-NG science plan

The work done by French team ('MENINGE') has been summarized in a report that was used for the approval of the IASI-NG mission by CNES board.

This report is being adapted to an article (Crevoisier et al., TBS AMT):
Towards IASI-New Generation: impact of improved spectral resolution and radiometric noise on the retrieval of thermodynamics, chemistry and climate variables

According to the CNES/EUMETSAT agreement, ISSWG has officially taken other the responsibility for the scientific preparatory work on IASI-NG (similarly to what was done for IASI).

**First task: writing a IASI-NG Science Plan**

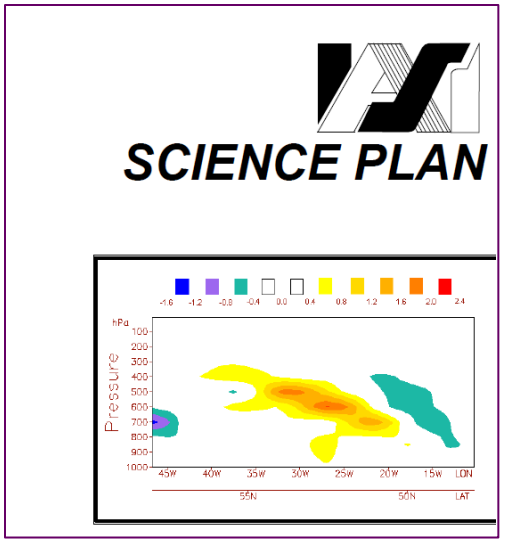

Dossier de présentation au TOSCA
de la mission

Interféromètre Atmosphérique de
Sondage Infrarouge – Nouvelle Génération
(IASI-NG)

PIs :
Cyril Crevoisier (LMD)
Cathy Clerbaux (LATMOS)

IASI-NG

25 Novembre 2011




C. Camy-Peyret and J. Eyre
for the ISSWG 1998

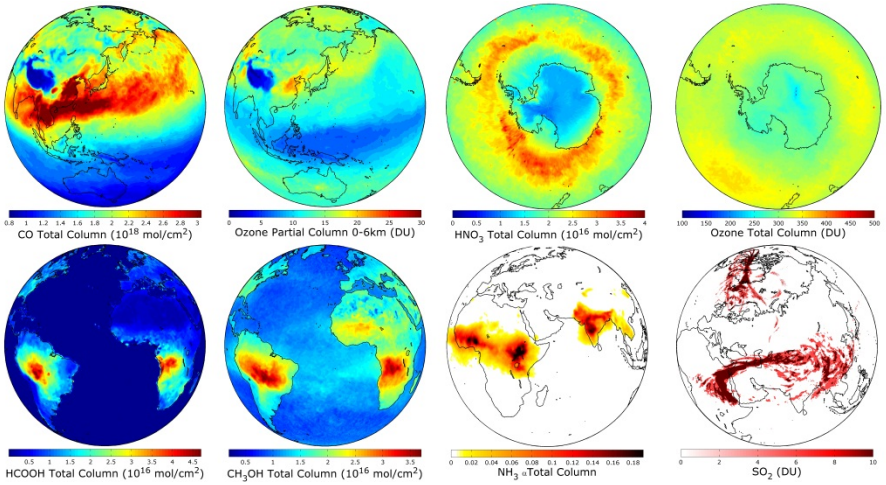
## Numerical Weather Prediction

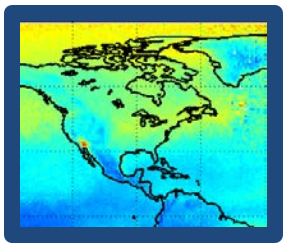
- **What worked best than what we thought** ☺
  - Assimilation techniques have evolved a lot between 1998 and 2006 ! (bias correction, variational techniques, etc.)
  - IASI LW T and WV assimilated in most global NWP models
    - Clear pixel…
    - And also clear channels in cloudy pixels
    - … and cloud-affected radiances !
  - Assimilation of ozone channels at some centres
  - Assimilation in convective scale models, at high spatial density
  - Large positive impact on forecasts, on top of assimilating numerous other instruments (good synergy with other instruments)

## Atmospheric composition

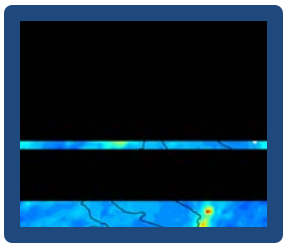
- **What worked best than what we thought**

  - Much more molecules, even reactive species
  - Sensibility close to ground if thermal contrast
  - Operational applications: $SO_2$/ash volcanic plumes, pollution forecasts
  - Societal applications (VACCS, etc.).

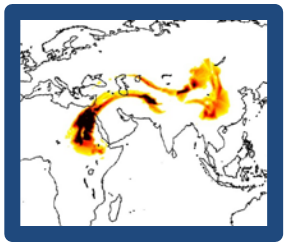


Ozone peaks $NH_3$ sources (>PM)



Long-range pollution



Aviation threat

## Atmospheric composition

- **What worked less than what we thought/work still needed** ☹
  - Coupled retrieval of IASI and GOME-2 to improve vertical information on $O_3$
  - Retrieval of trace gases over cloudy pixels
  - Assimilation of radiances for atmospheric composition studies
  - OSSE difficult to do as we miss high polluted profiles

## Climate

**With IASI:** 5 years of observation: no climate studies per se yet!

… But : climatologies of several ECVs and exceptional spectral and radiometric stability.

→ Potential for long-term monitoring and study of climate.

**With IASI-NG:**

- Opportunity to expend the coverage after the MetOp series.

-For long-term studies, the same level of stability will be needed.

→ Need for proper monitoring and traceability of calibration.

## Climate

**IASI 1998 Priorities for IASI research and development:**

High

- -IR radiation budget.
- -heating rates.
- -cirrus properties.

Low

- -climatologies: WV, $O_3$, $CH_4$, $N_2O$, CO, CFCs and cloud parameters.
- -radiative forcing: UV+IR $O_3$, latitudinal and seasonal.
- -aerosol properties: AOD and surface characteristics.

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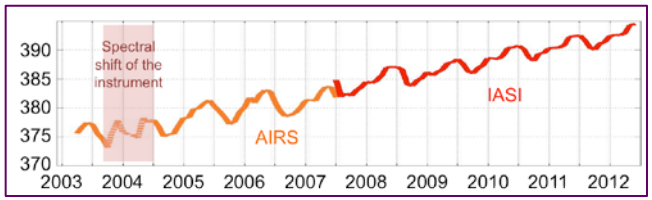
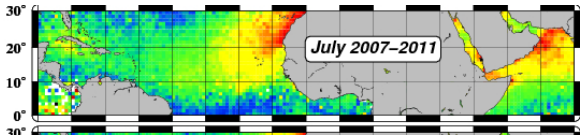
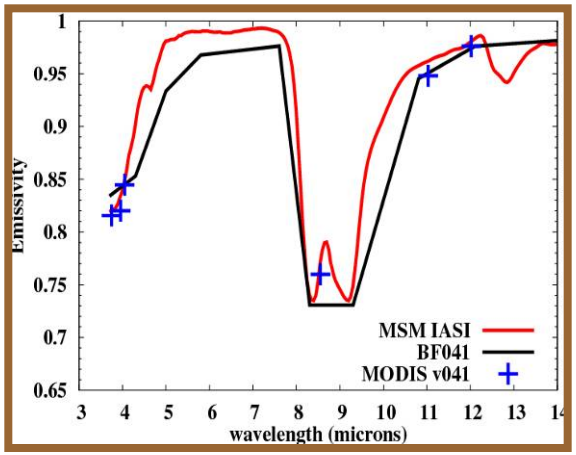



IASI AOD (10µm)




+ altitude + radius



# IASI-NG surroundings

- **GMES:** NWP + atmospheric composition + climate

Monitoring atmospheric composition & climate

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macc Monitoring atmospheric composition & climate

gmes

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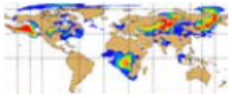
**In Focus: MACC-II forecasts help to interpret Seattle haze**



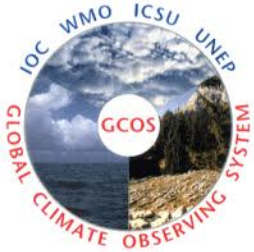
**July 2012** The MACC-II forecasts of the smoke plume from large wildfires in Russia have been instrumental in understanding the origin of the smoke/haze impact on the American north-west. The area around Seattle has suffered from

# IASI-NG surroundings

- **GMES:** NWP + atmospheric composition + climate

- **Focus of many agencies on climate**… with a multiplication of ad hoc committees.

In 2010: GCOS created a list of 50 Essential Climate Variables required to support the work of the UNFCCC and the IPCC (international exchange is required for both current and historical observations).




- ESA Climate Change Initiative.
- WDAC (WCRP Data Advisory Council)
- GSICS (Global Space-based Inter-Calibration System) of CGMS and WMO.

**The promotion and exploitation of IASI-NG will have to be performed in this context.**

# Some concluding thoughts

•Strong relationships between NWP, atmospheric composition and climate through many variables.

•Cal/Val activities and traceability are the key to success.

→Properly archived ATBD are needed.

•Coupling of IASI-NG with companion instruments: both in terms of Level 2 and Level 1 (MW/IR, SWIR/IR, Vis/IR, UV/IR).

•Coupling of variables: clouds+aerosols, gases, cirrus+WV, etc.

•Study of atmospheric and climate processes (various variables + night/day/land/sea!!).

•Design of simulators by coupling atmospheric/climate models and IASI characteristics: clouds, radiative budget, potentially GHG.

•Spectroscopy (including aerosols characteristics).

•RT modeling:

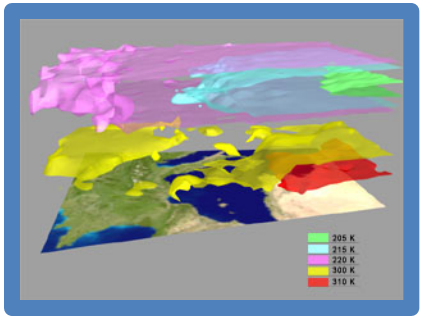
-line-mixing ($CO_2$, $CH_4$)

-non-LTE → both 15 µm and SW.

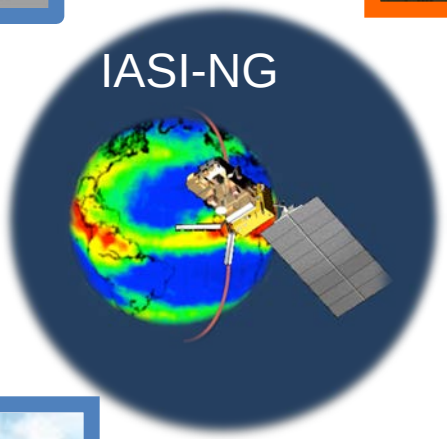
-solar contamination → SW.

# IASI-NG improved contributions to…

**Atmospheric profiling**



**Improvement on pollution forecast**
3 EU controlled pollutants (CO, $O_3$ and $NH_3$)




**Better tracking of long range pollution** (e.g. fire emissions)

**Essential Climate Variables monitoring and understanding**
Clouds, GHG, aerosols

**Improved volcanoe alerts**
Early alerts possible + $SO_2$ and ash tracking

**IASI-NG has the potential for strongly benefiting the NWP, chemistry and climate communities, in addition to assuring the continuity of high quality observations delivery.**