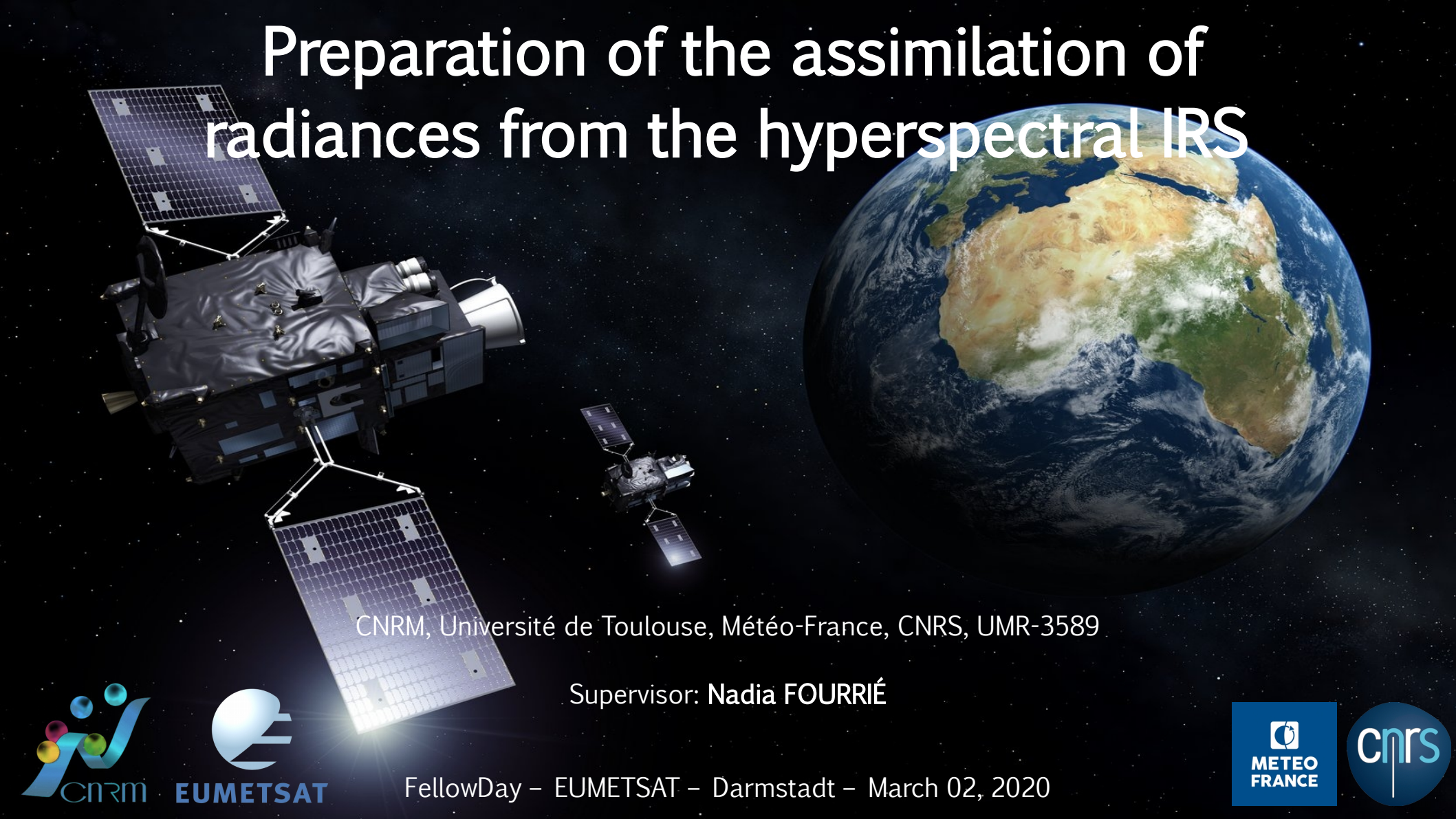
Preparation of the assimilation of radiances from the hyperspectral IRS



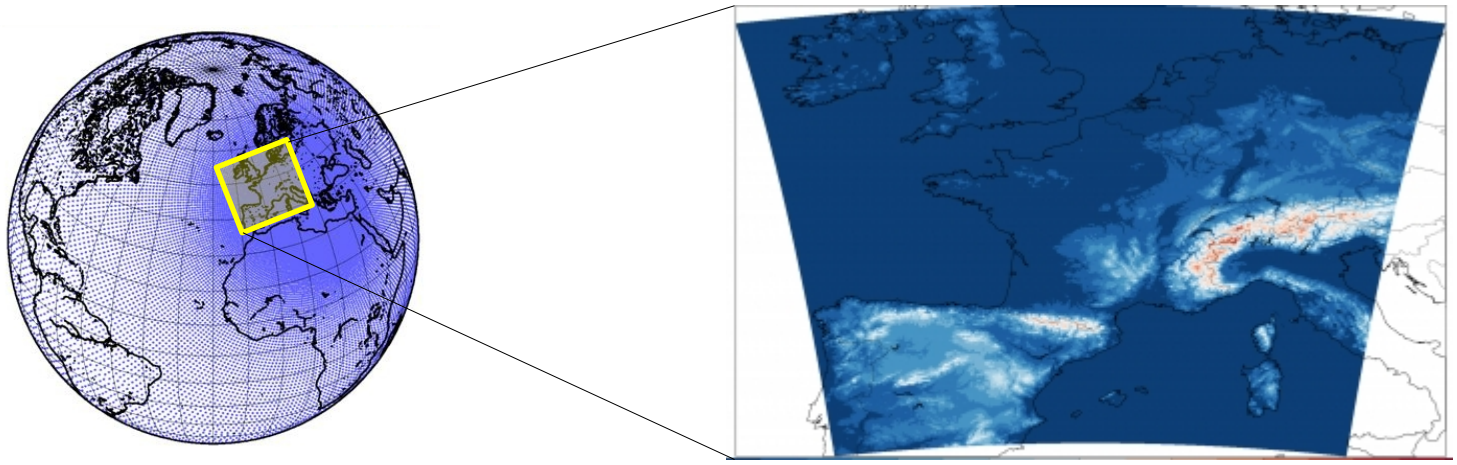
CNRM, Université de Toulouse, Météo-France, CNRS, UMR-3589

Supervisor: **Nadia FOURRIÉ**

FellowDay – EUMETSAT – Darmstadt – March 02, 2020

ARPEGE global model

AROME regional model



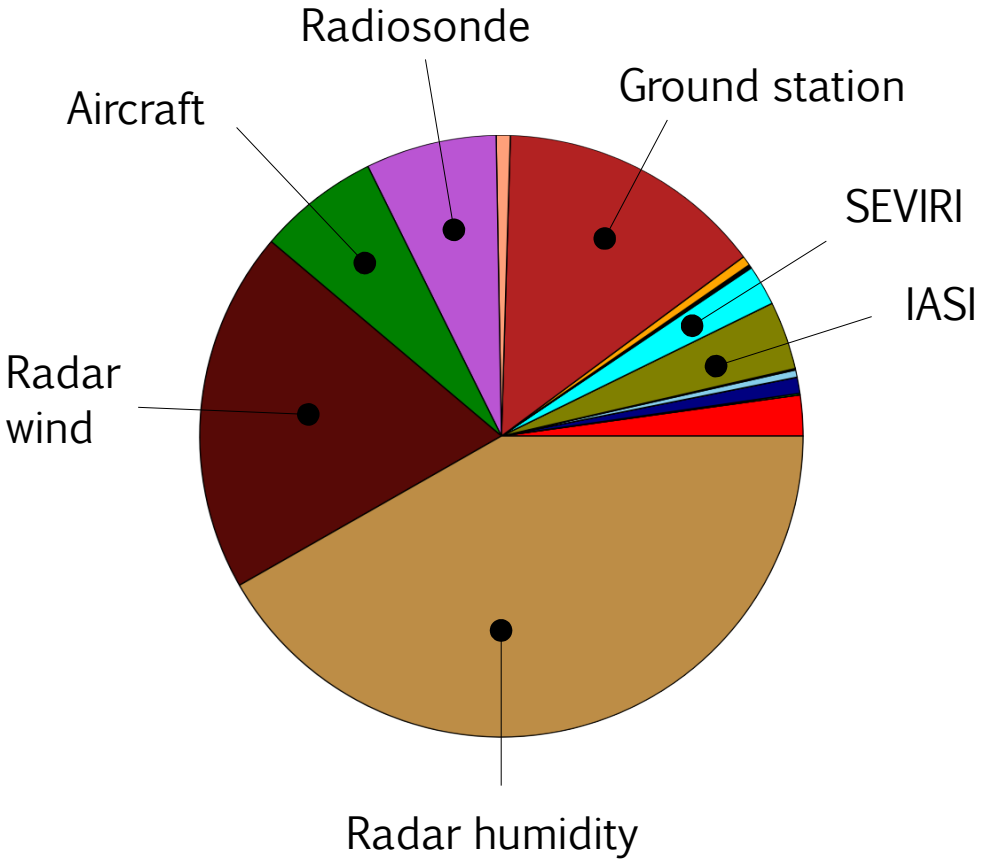
AROME (Applications de la Recherche à l'Opérationnel à Méso-Echelle):

- Fine scale NWP model characterized by a non-hydrostratic dynamical core
- Horizontal resolution of 1.3 km and a vertical resolution of 90 levels from the surface (5 m) to 10 hPa
- High skill short range forecasts of severe events such as intense Mediterranean precipitations, severe storm…

Operational AROME model at Météo-France

- **AROME forecast are initialized using analyses from a 3D-Var data assimilation system with 1h cycling**
  - Radar data represent 60% of the observations assimilated.
  - But radar data do not fully cover the domain (Atlantic ocean, Mediterranean sea)
  - 57.3% of land surface
  - The AROME model needs frequent observation, covering the full domain in 3D
  - **The IRS sounder will be able to provide this amount of data**

Ratio of the number of observations used in the AROME model by observation type [January 2020]



- **IRS instrument:**

Planned launch in 2023 onboard geostationary sounding satellite **MTG-S**

Imaging interferometer with spectral sampling of 0.625 cm^{-1} and spectral resolution of 0.754 cm^{-1}

IRS measures in 2 spectral bands

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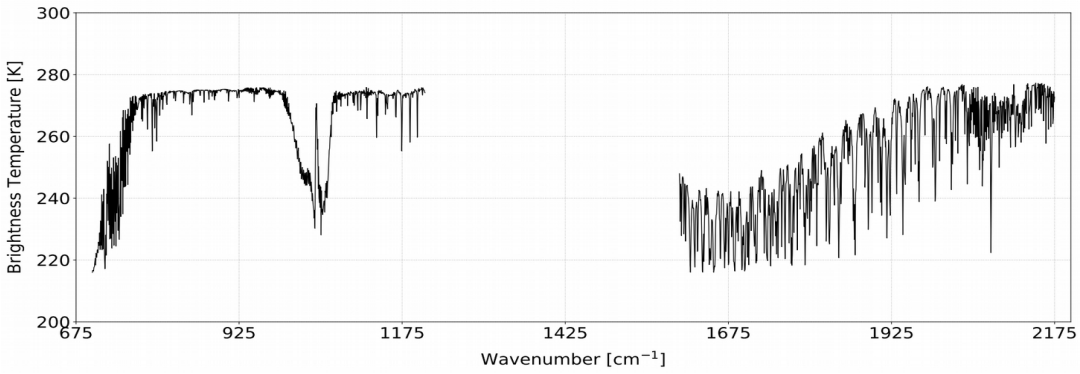

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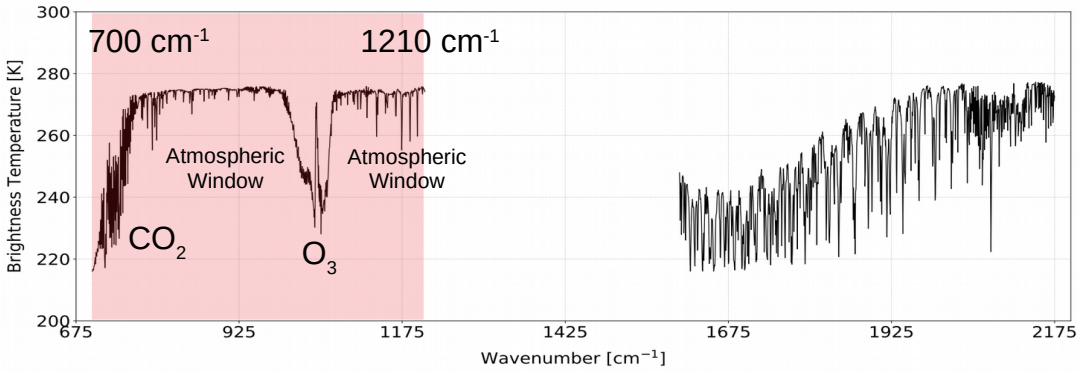

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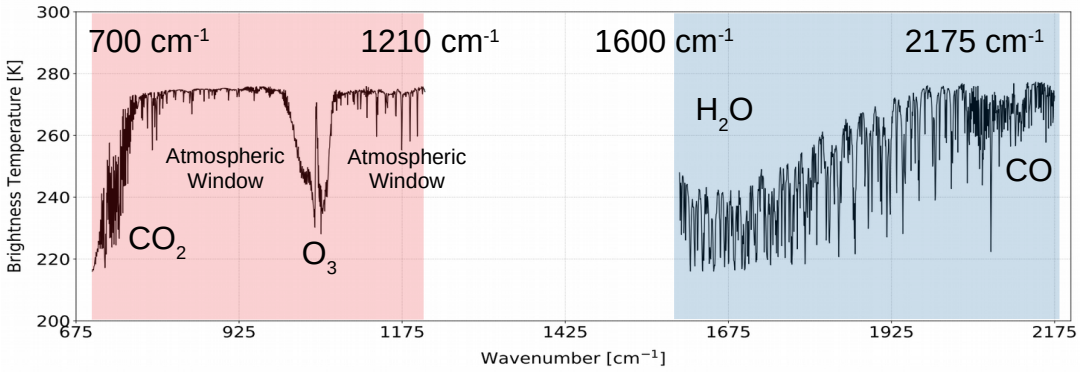
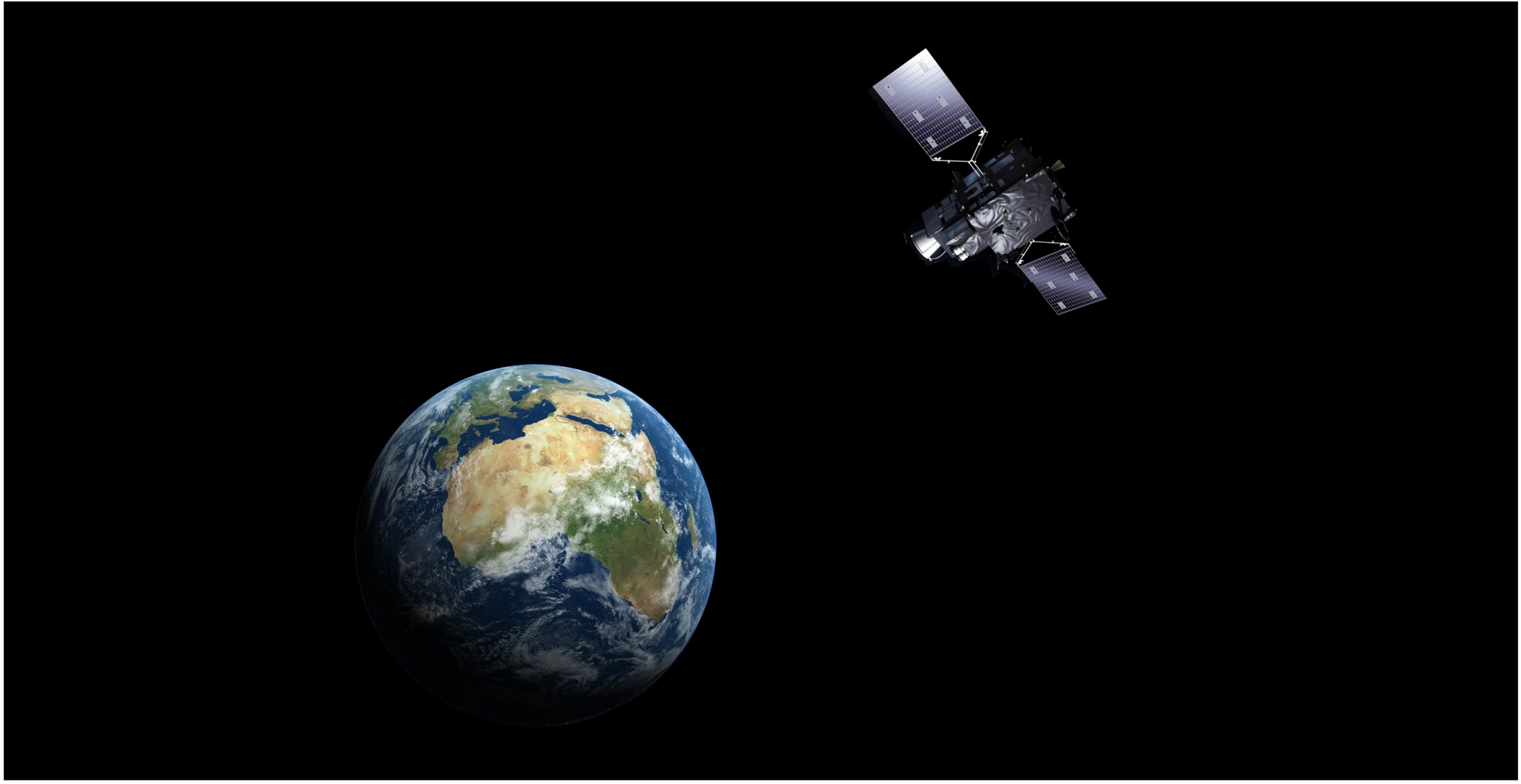
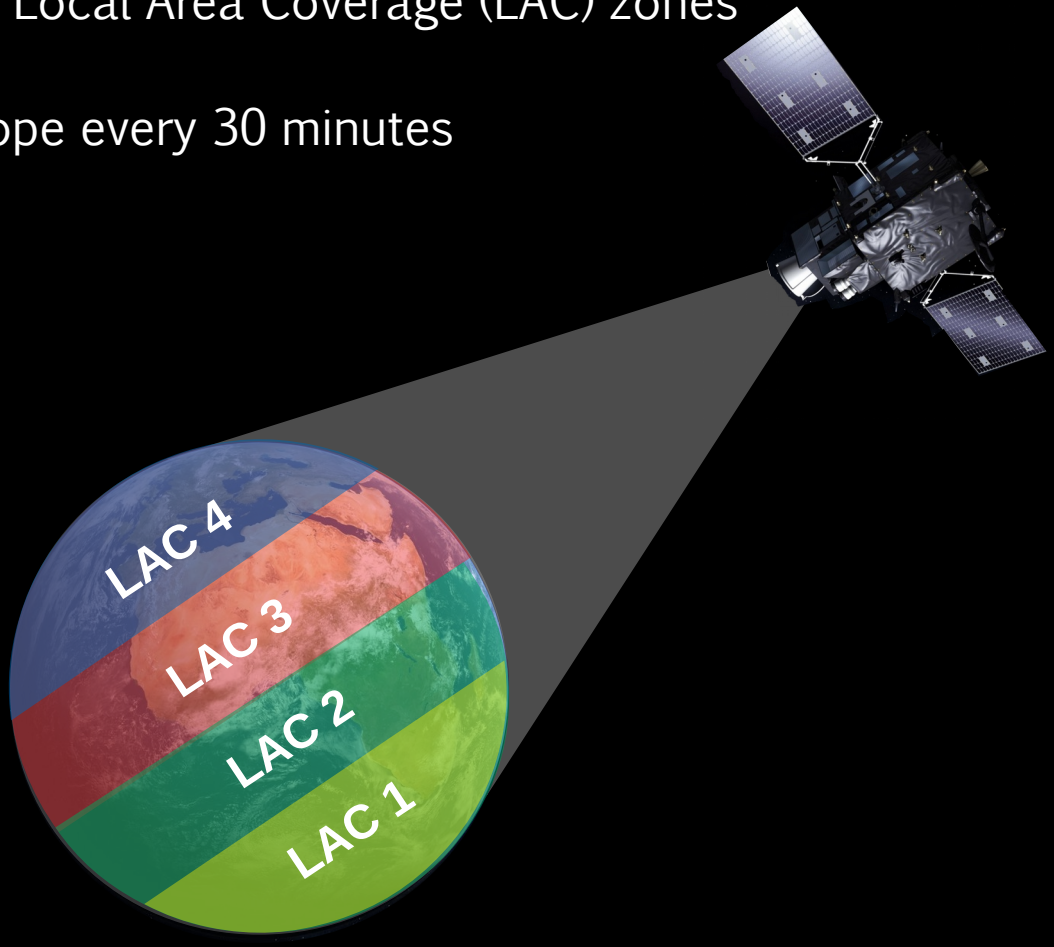




Measurement with 4 Local Area Coverage (LAC) zones

LAC 4 covering Europe every 30 minutes



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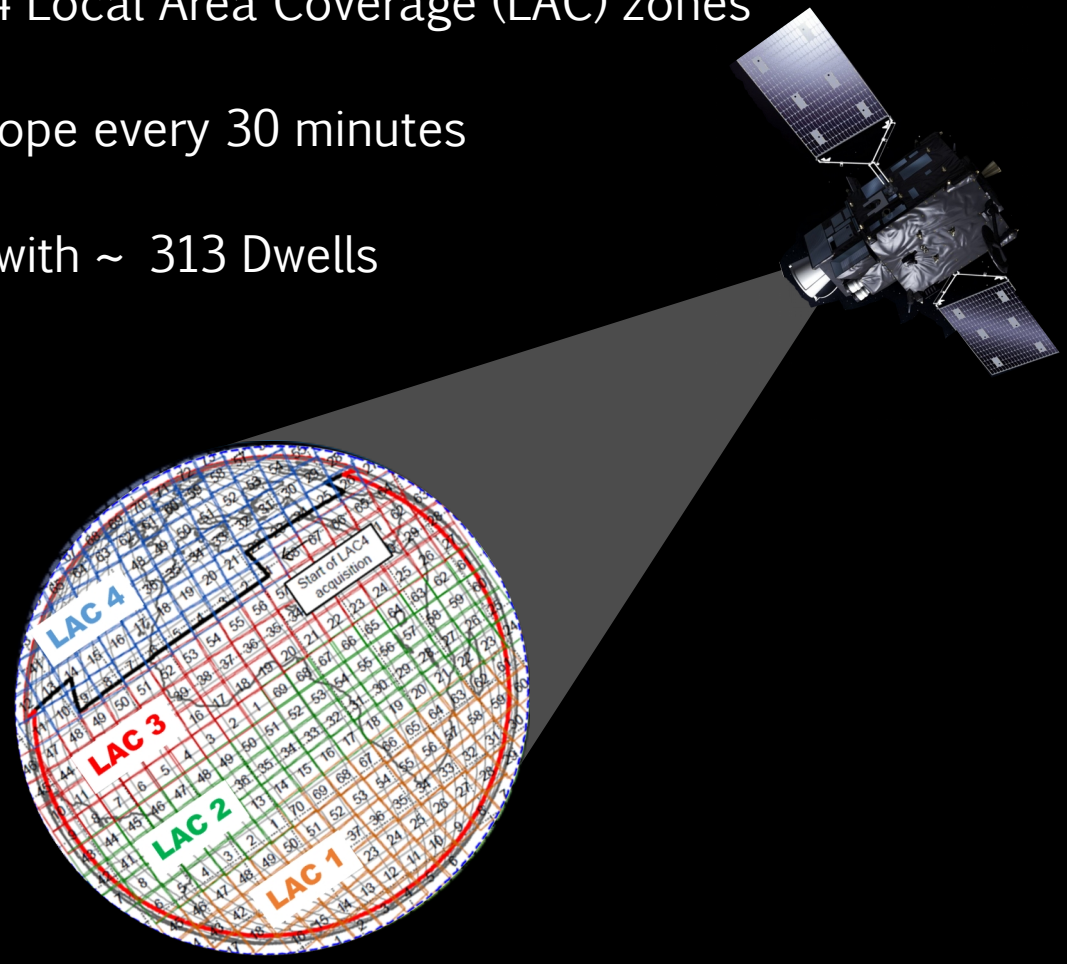
Earth disc covered with ~ 313 Dwells



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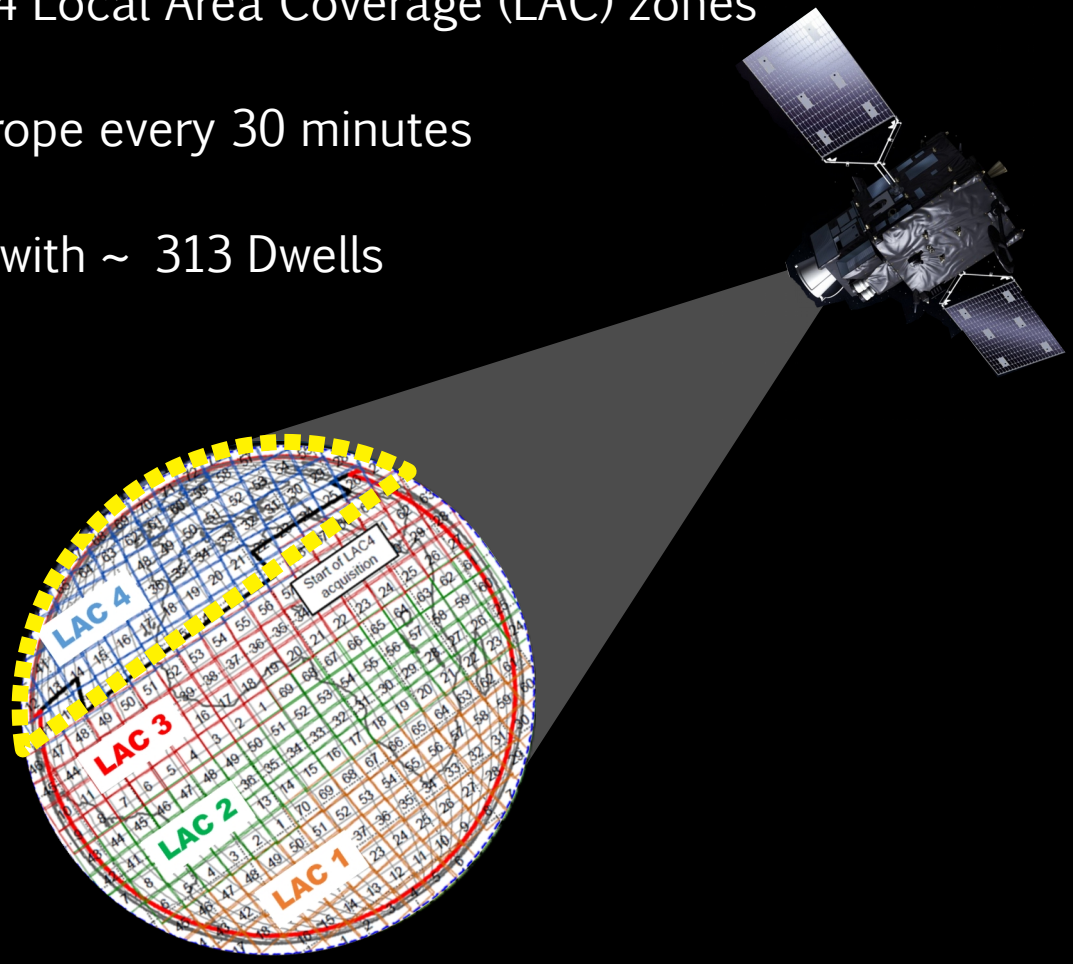
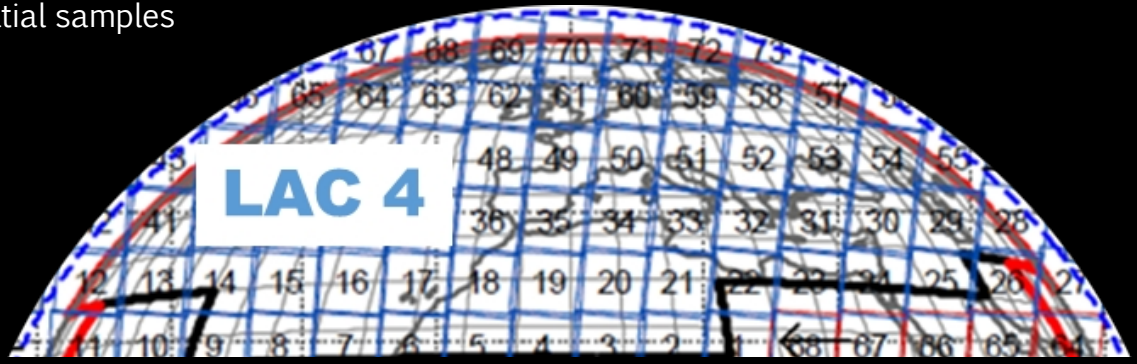


Each Dwell is taken in **10s** and covers about **640 x 640** km² at nadir with **160 x 160** spatial samples



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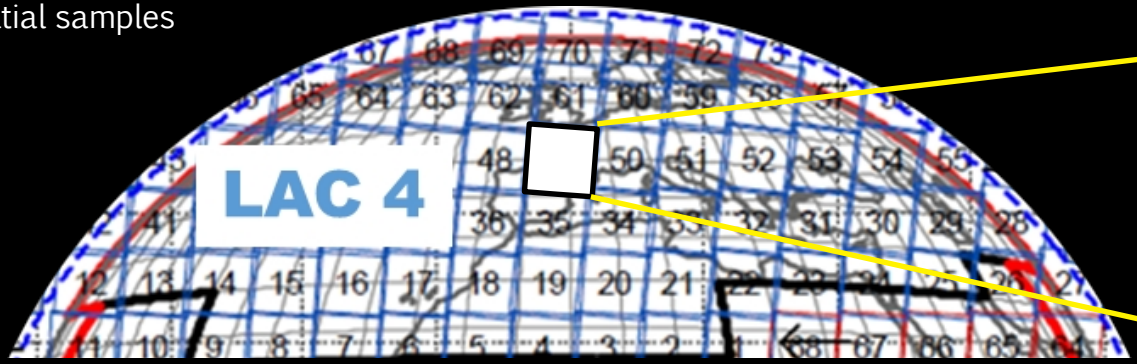

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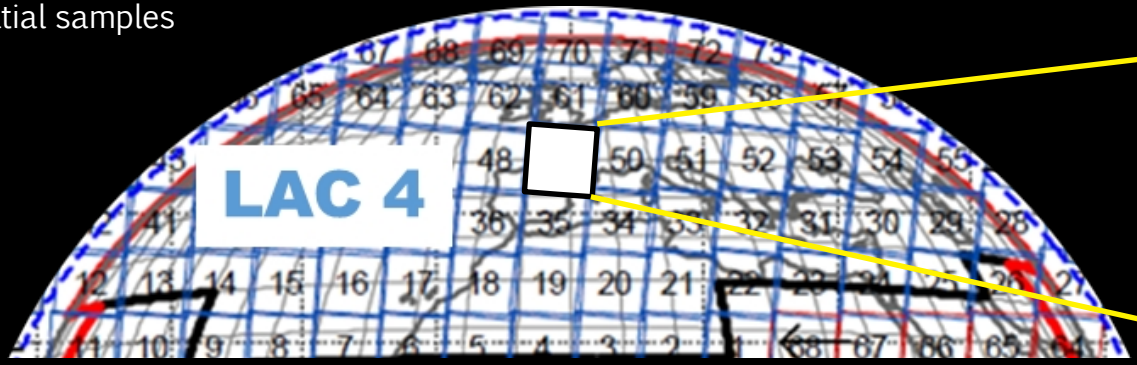

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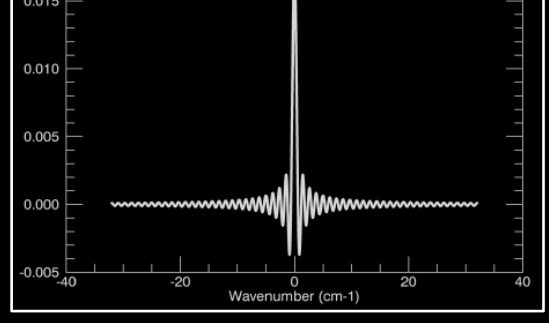

Interferogram (Level 0 product)

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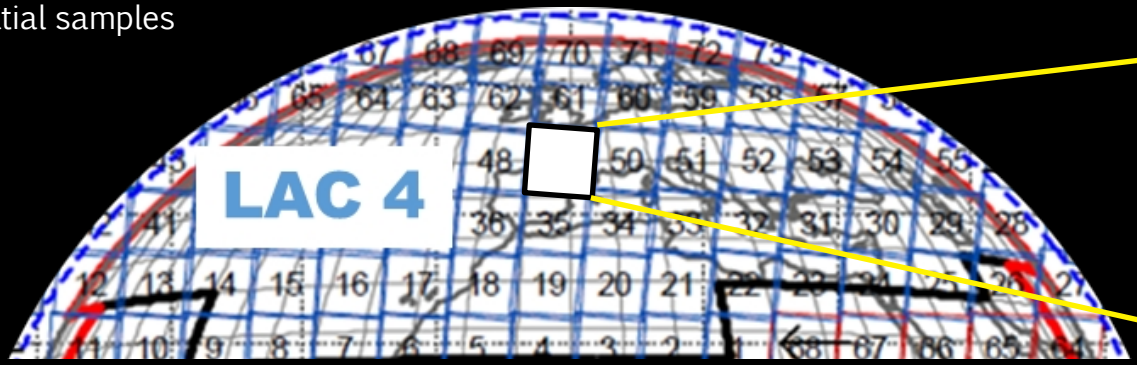

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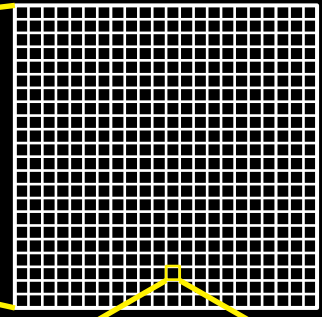
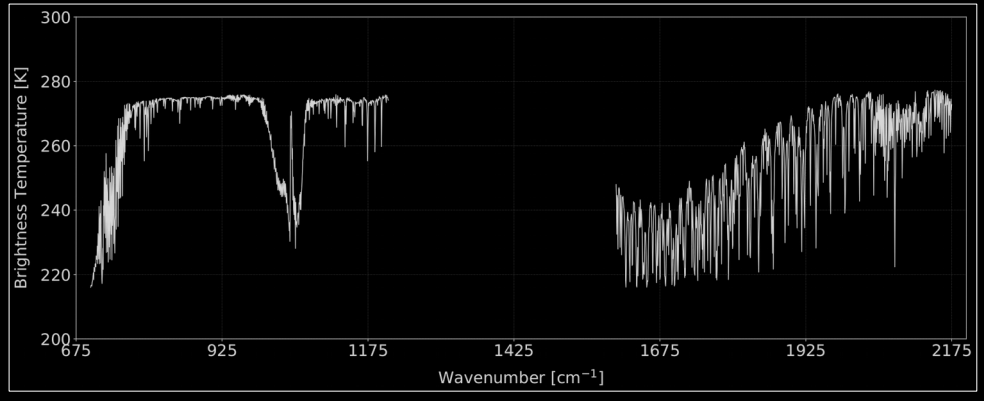
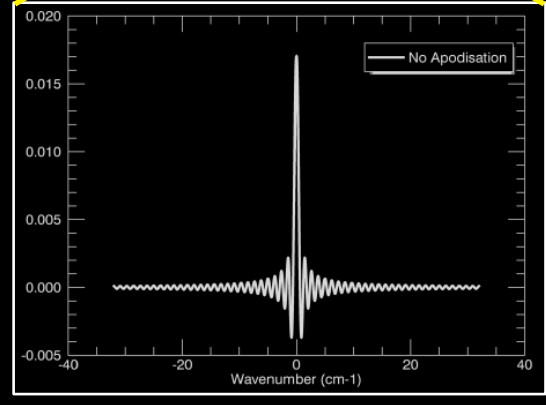


Radiances spectrum (Level 1 product) disseminated in near-real time with Principal component scores (PCs)



Processing



Interferogram (Level 0 product)

- **3D mapping of temperature, water vapour, wind:**
  - High frequency of spatial and temporal temperature and humidity information to improve NWP models
  - Better information to identify pre-convective situations supporting Nowcasting applications to forecast convective initiation
  - Better depiction of the hydrological cycle in models
  - Synergy with Sentinel 4 (UV – Visible – near-infrared) for air quality monitoring and atmospheric chemistry (O_3 and CO)

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- **Preparation of the assimilation of radiances from hyperspectral IRS instrument onboard the MTG in the non-hydrostatic AROME model**

  - Selection of information content from IRS and the adaptation of the AROME model to the use of IRS observations
  - Build an Observing System Simulation Experiment (OSSE)
  - Evaluate the impact of the assimilation of IRS radiances in AROME

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  - Evaluate the impact of the assimilation of IRS radiances in AROME

Objective is to be ready to assimilate real IRS data from day one!

- **Simulated data set for one IRS Dwell over France (March 15, 2016 at 12:08) from EUMETSAT**
  - Simulation generated using RTTOV and ECMWF analyses at 0.125 degrees interpolated to IRS resolution

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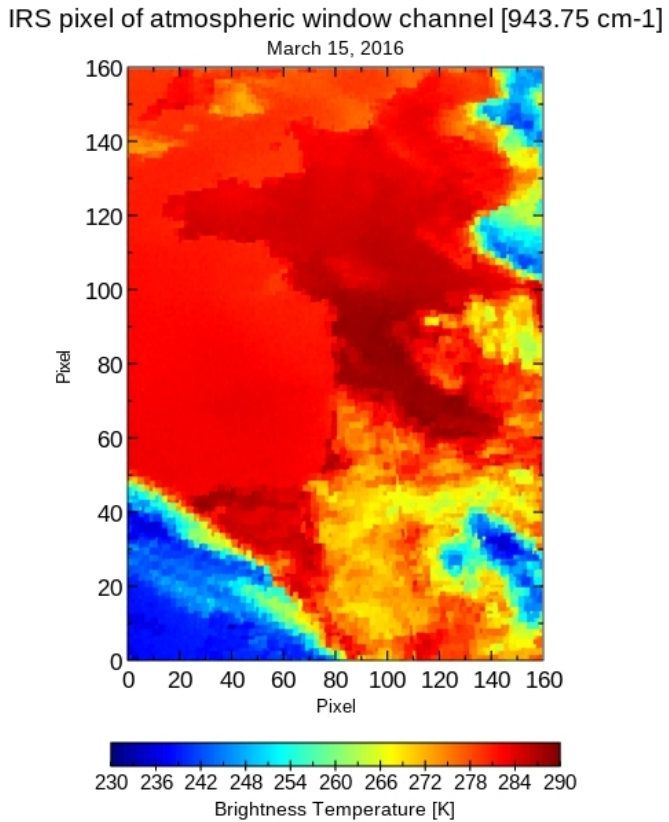

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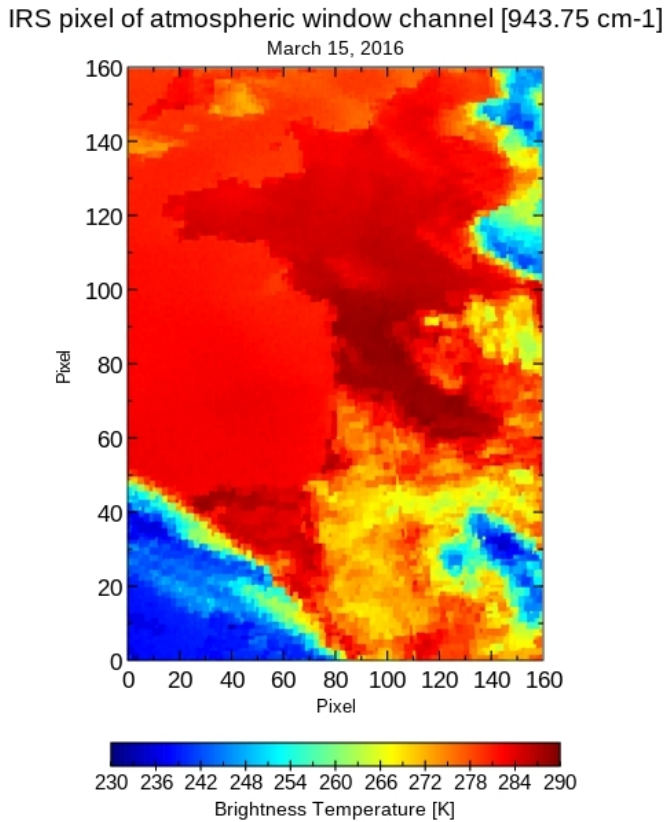

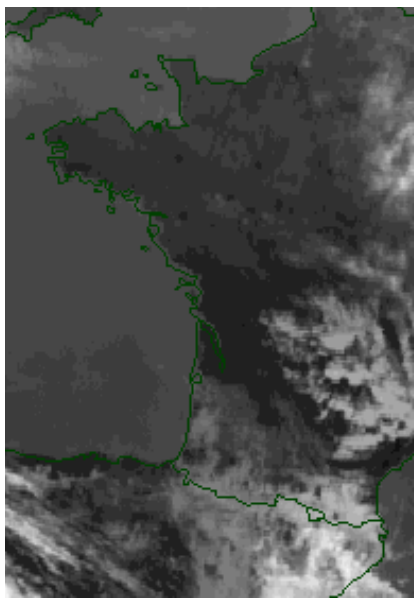

Black and white infrared satellite image (10.8 µm) METEOSAT 10
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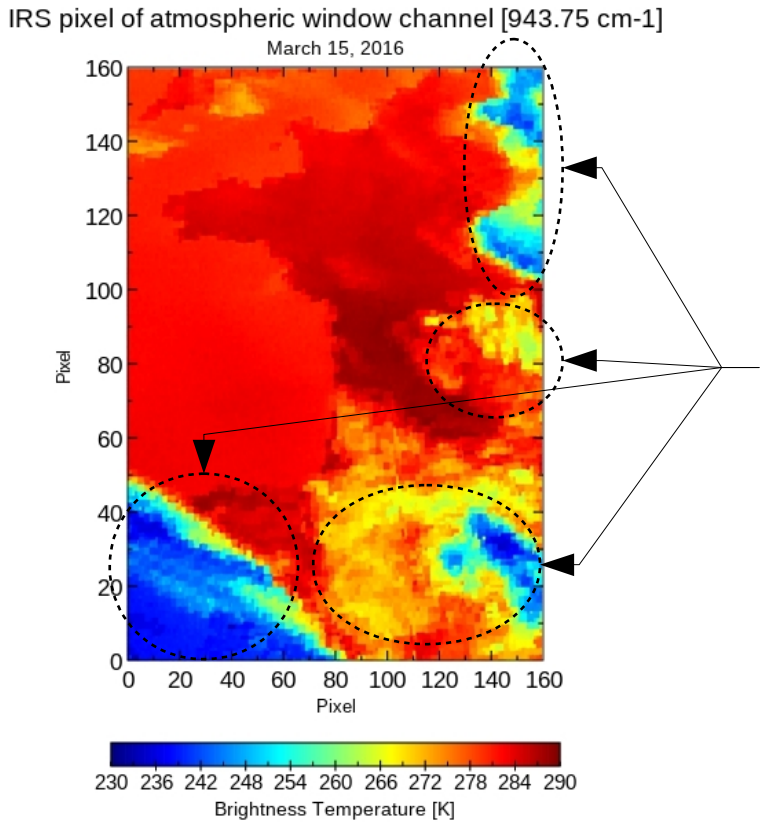
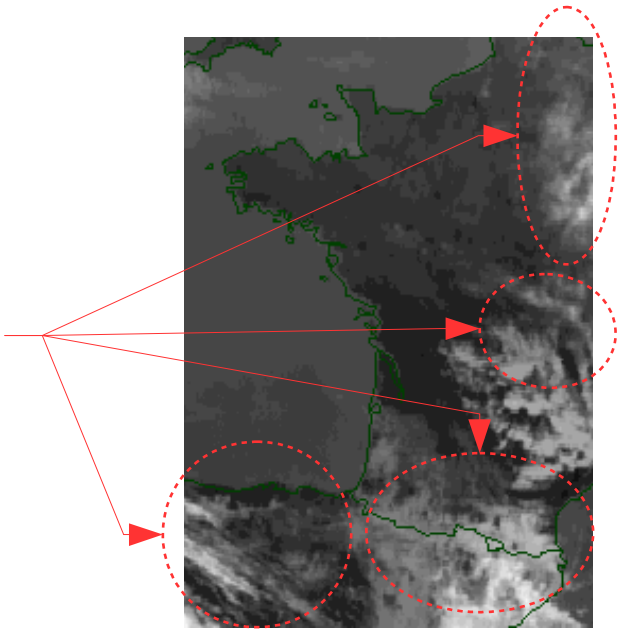


Clouds



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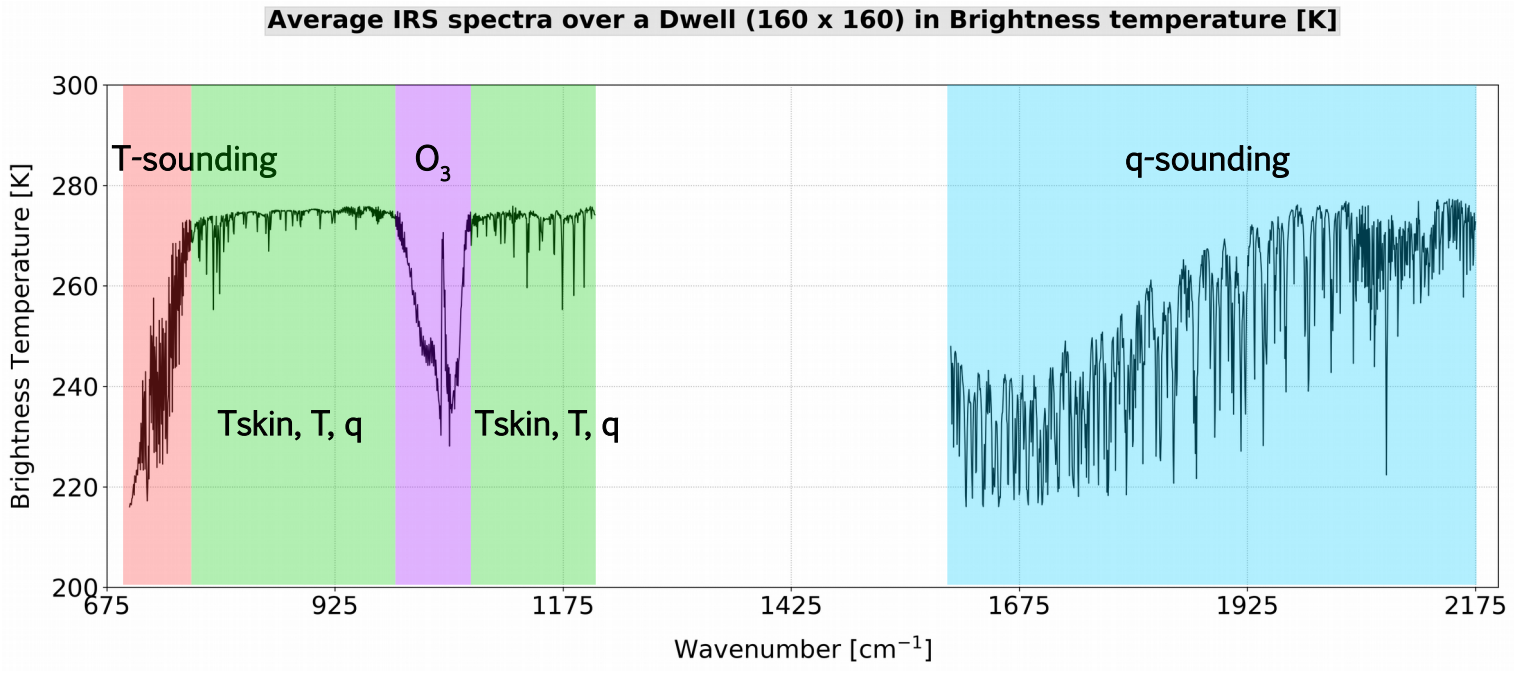
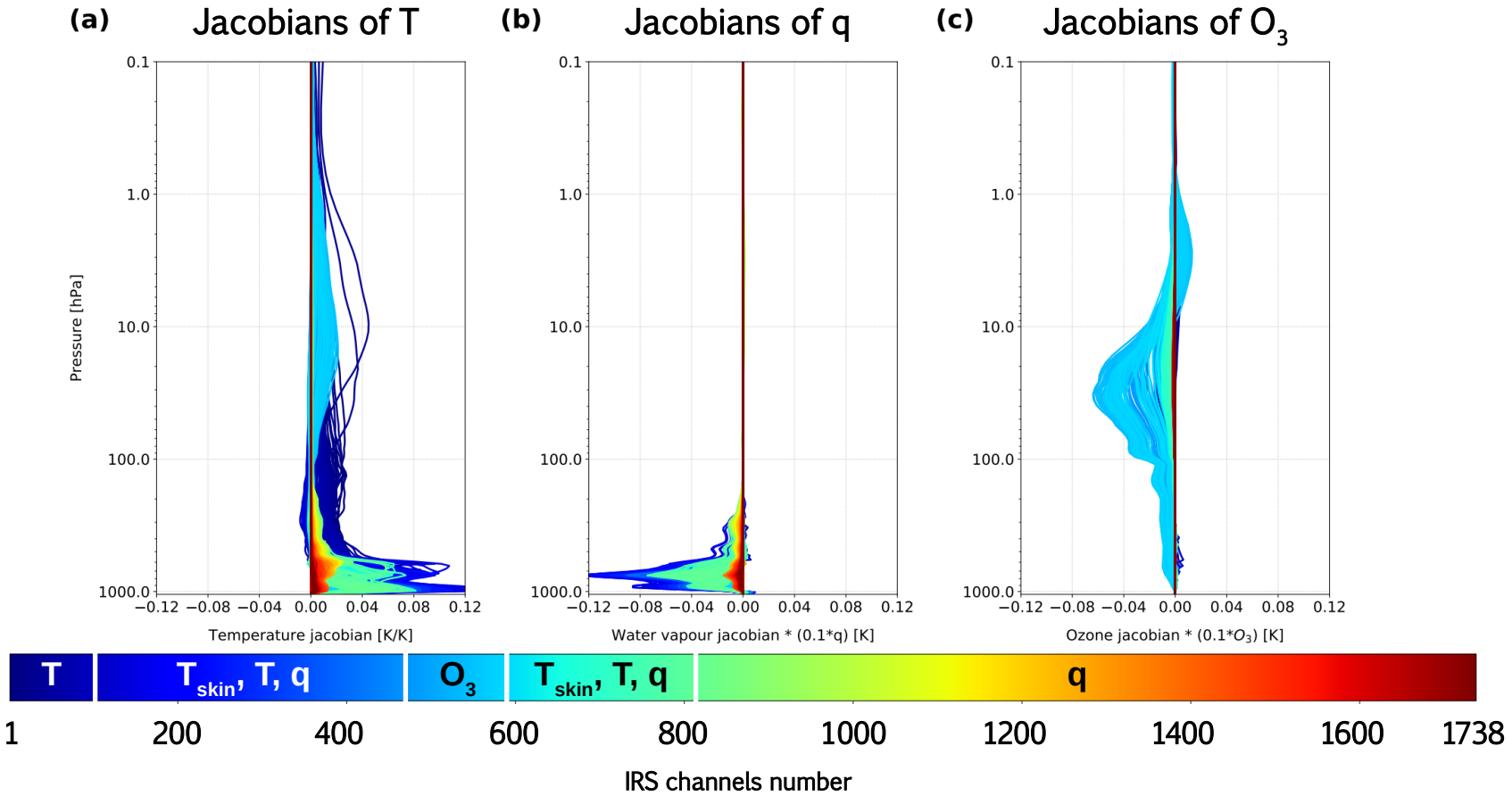
- **Simulated data set for one IRS Dwell over France (March 15, 2016 at 12:08) from EUMETSAT**
  - Simulation generated using RTTOV and ECMWF analyses at 0.125 degrees interpolated to IRS resolution
  - Selection from the 1738 available IRS channels in Bands 1 [700 – 1210 cm^{-1}] and 2 [1600 – 2175 cm^{-1}]



- The selection of IRS channels will be based on a method used to select IASI channels with an R matrix accounting for inter-channel observation-error correlations [*Coopmann et al., 2020* in review]

  - **R** Matrix for IRS channels will be diagnosed using the [*Desroziers et al., 2005*] method
  - We will select the most informative IRS channels in temperature, humidity and skin temperature
  - We will use the Degree of Freedom for Signal (DFS) from information theory [*Rodgers et al., 2000*] as a figure of merit

- Jacobians of IRS radiances generated by RTTOV v12



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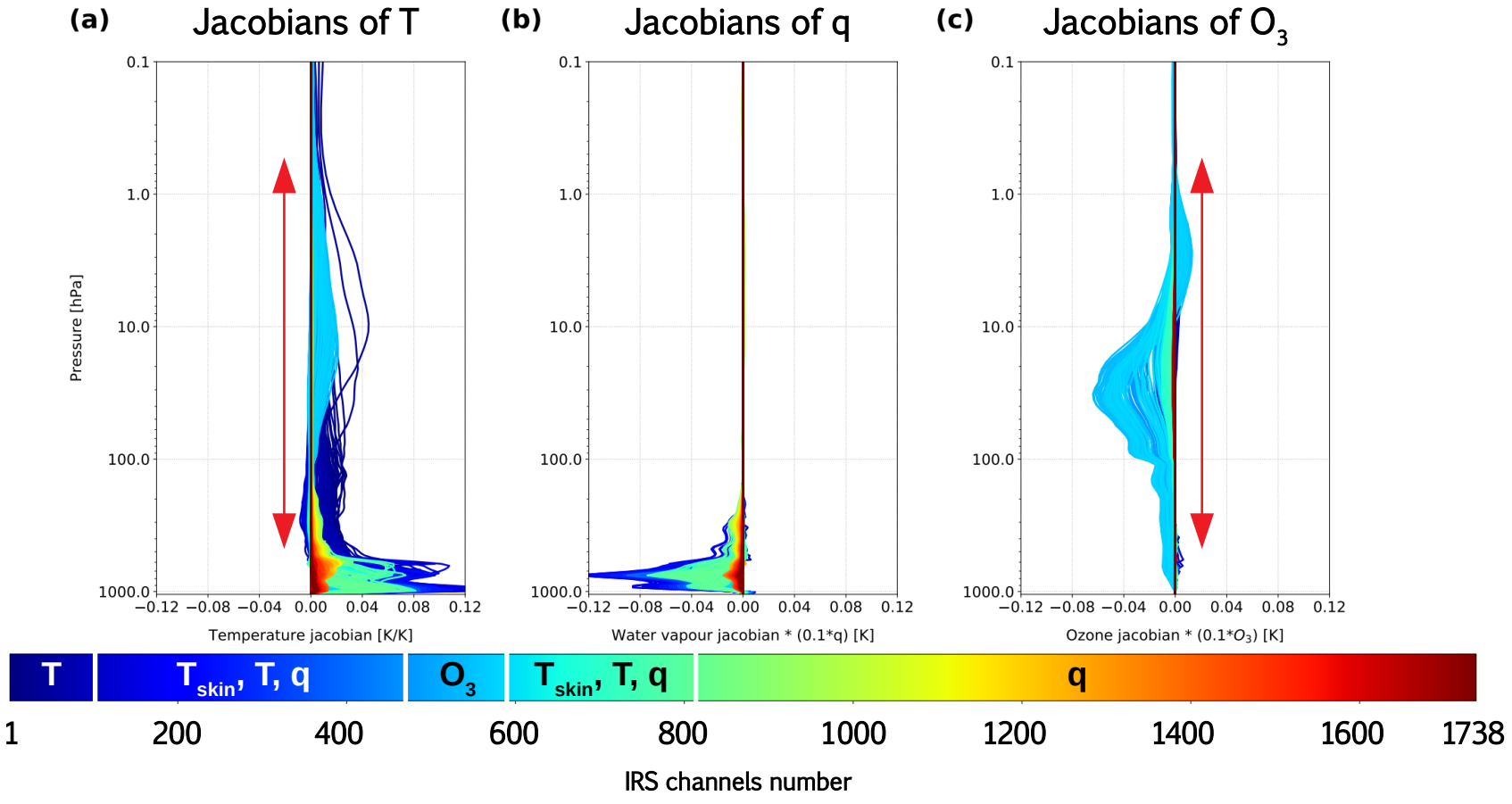

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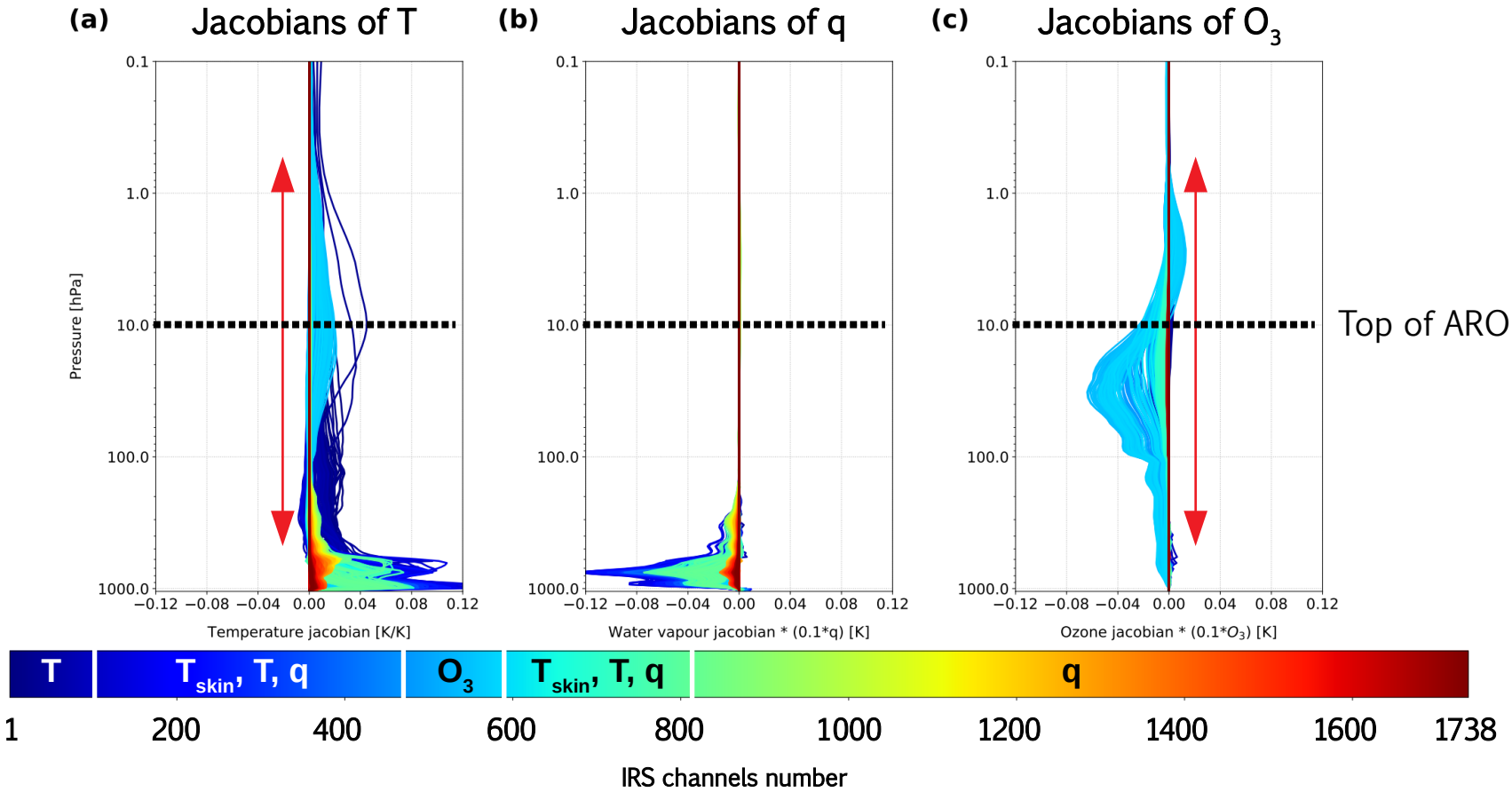

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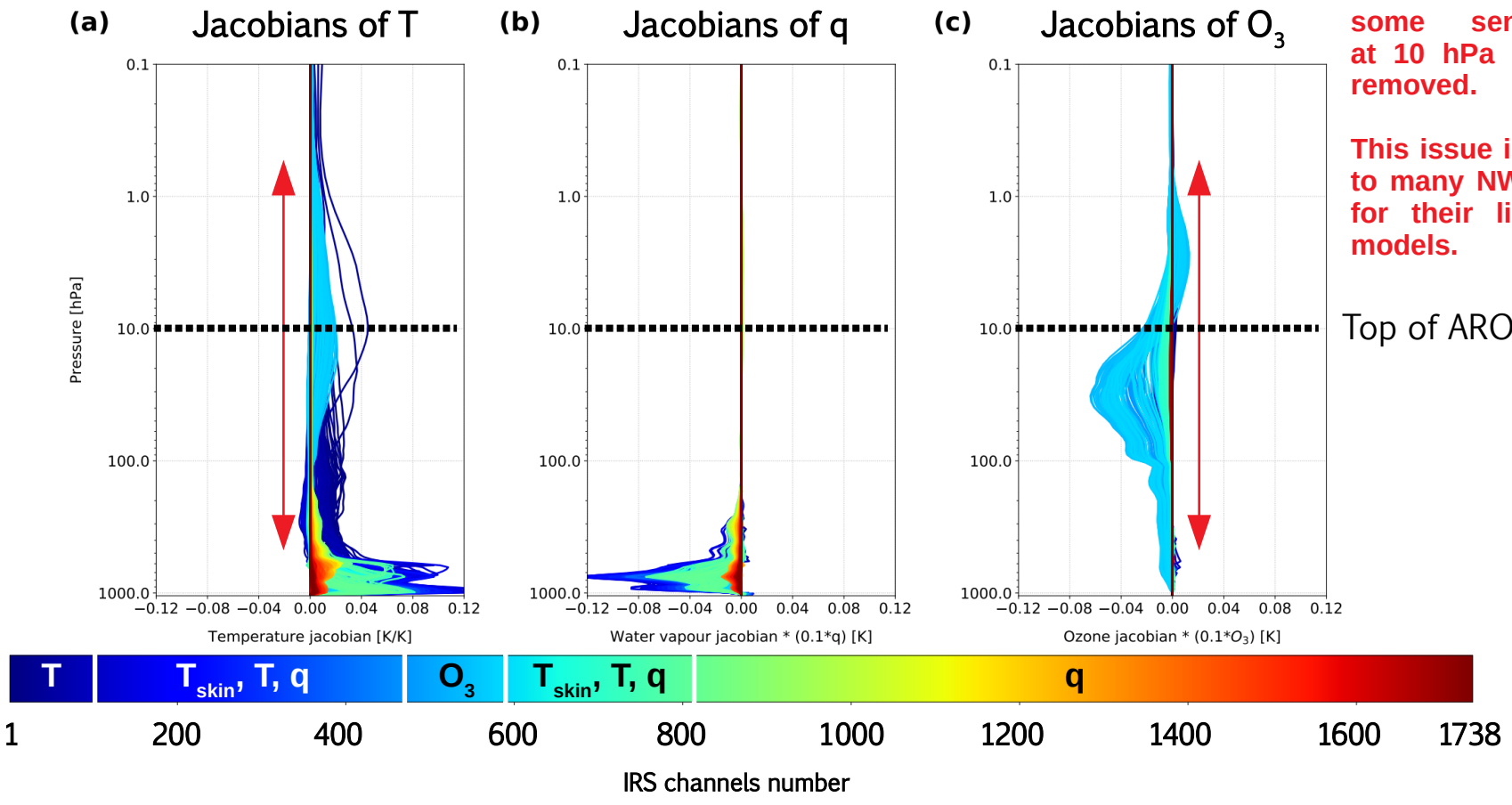
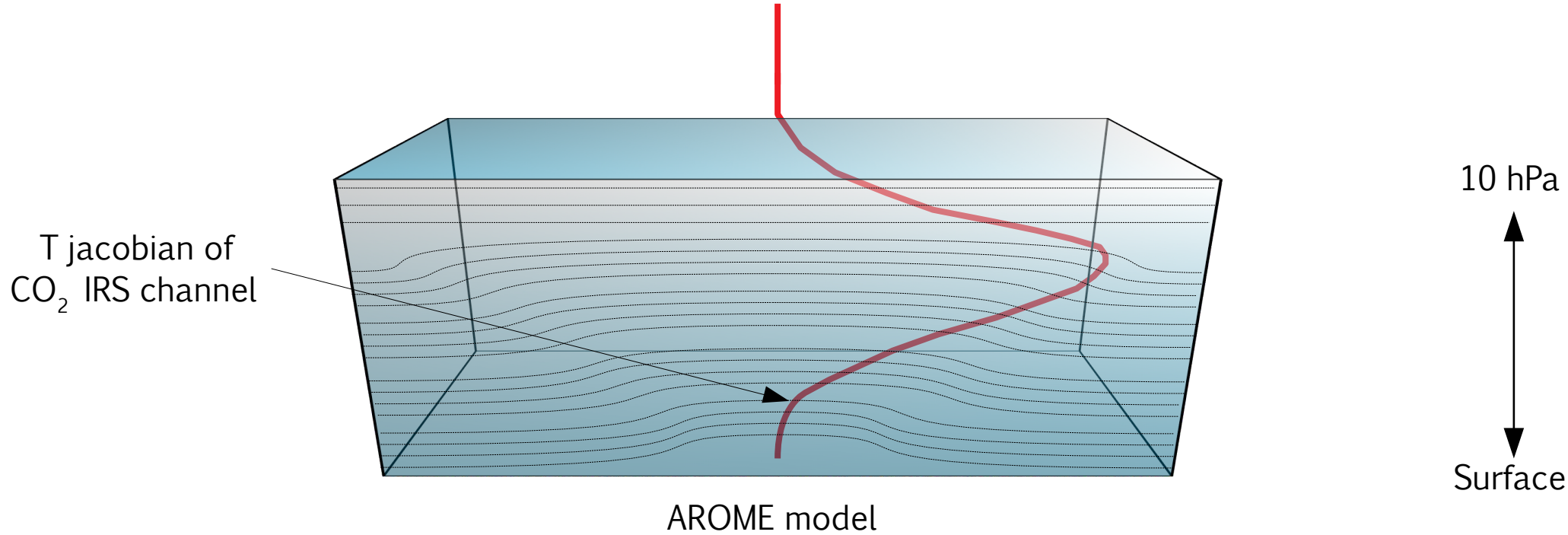


All channels with some sensitivity at 10 hPa should be removed.

This issue is common to many NWP centres for their limited-area models.

Top of AROME model

- **In order to avoid losing these channels in the selection, it is required to be able to simulate IRS observations above 10 hPa**
  - The AROME model is coupled at its limits with the ARPEGE global model, but only for forecasts
  - It would be interesting to use this setup to perform the simulations during the assimilation process



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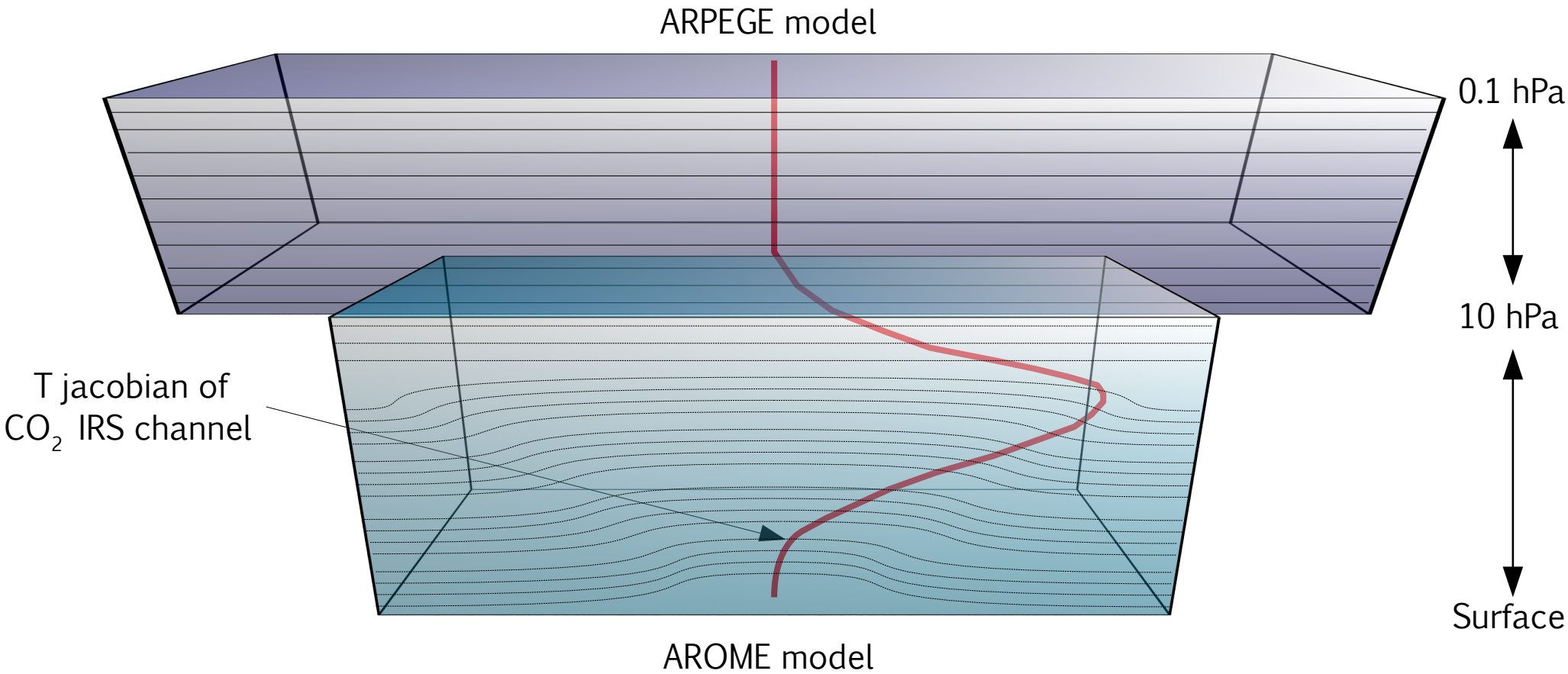
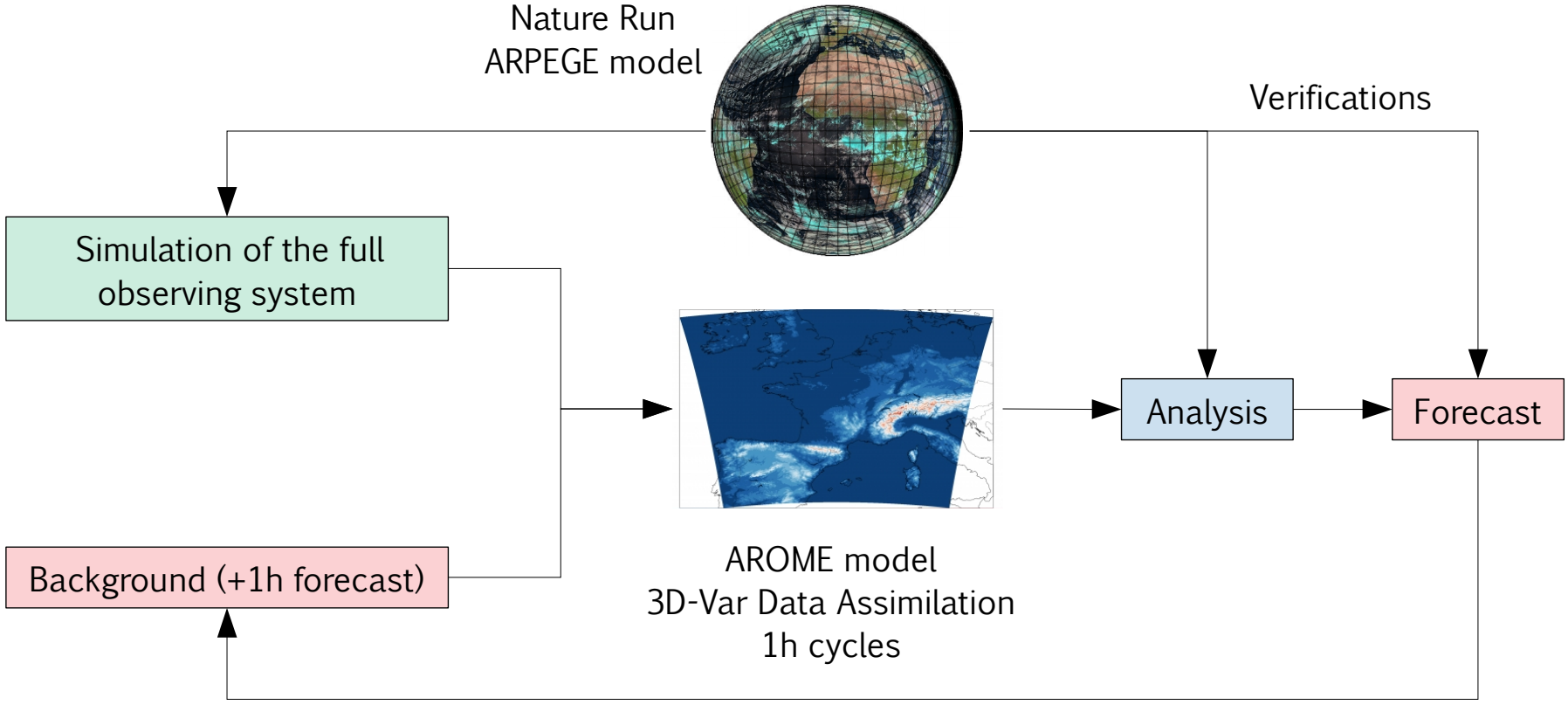


- The basic principle of an OSSE is to assimilate synthetic observations (IRS) derived from an atmospheric model state assumed to represent the truth, and then to determine the impact on analyses and forecasts



Perform an Observing System Simulation Experiment (OSSE)

- **OSSE is useful to:**
  - Simulate full observation system as close as possible to the current operational one
  - Prepare the assimilation system and data flow for IRS observations
- **New challenges of this OSSE compared to previous studies** [*Duruisseau et al., 2017 ; Guedj et al., 2014*]
  - Higher resolution of the Nature Run (5 km) + higher resolution of AROME (1.3 km)
  - Simulation of the full Observing System including Radar data (specific method in Clouds and precipitations) to assess the future impact of the IRS on top of the full set observation
- **What is expected from our study:**
  - Twin experiments (with and without IRS assimilation)
  - Assess the contribution of IRS observations to weather analysis and forecasts

In summary

- **Channel selection will be done on the 1738 IRS channels with the DFS method using a diagnosed R-matrix:**
  - First channel selection Maximum ~ 150
  - Levels above 10 hPa are taken into account for simulation but priority selection is given to channels providing information in the troposphere (area of interest of the AROME model)
  - Currently awaiting definitive IRS coefficient RTTOV (apodization) and instrument geometry data for IRS observation simulations.
- **A new OSSE framework will be built:**
  - Simulation of radars for the first time (60% of the observations used in AROME in operations)
  - Need to know as soon as possible the IRS instrumental specifications (scan geometry) in order to perform the simulations
- **Evaluation of the IRS impact:**
  - Perform OSSE experiments with and without IRS observations (with possibly several channel selection?)
  - Evaluate them in terms of forecast scores


Thank you for your attention