# Nowcasting SAF sounding Satellite Humidity And Instability indices (sSHAI) NONLINEAR RETRIEVAL OF ATMOSPHERIC VERTICAL PROFILES FROM MTG-IRS DATA

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# INTRODUCTION (1/5)

## Hyperspectral Infrared Sounders

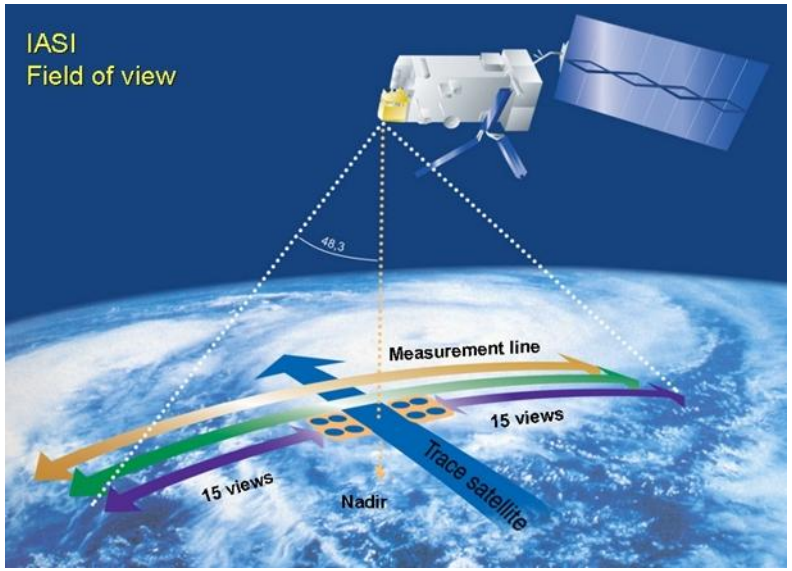
- There are currently **several Hyperspectral Infrared Sounders**:
  - In **Polar orbit**: AISR, IASI ,CriS.
  - **Geostationary**: FY-4, MTG-IRS (in a future).

- The **IRS** on board **MTG** is a new mission for **EUMETSAT**: a hyperspectral sounder in a **geostationary orbit**. First launch year **2023.**
- **IASI**, on board **MetOp**, is a hyperspectral sounder in **polar orbit** and has been delivering operational data since **2007.**

# INTRODUCTION (2/5)

## Hyperspectral Infrared Sounders

**IASI** (Infrared Atmospheric Sounding Interferometer) on board the polar orbiting satellite series **MetOP**.




- **IASI** is a **nadir** looking across scanning infrared spectrometer with **mid/high spectral resolution** (0.5 $cm^{-1}$, 8461 channels) and a **spatial resolution** of **12 km.**
- Provides information on the **vertical structure** of **atmospheric temperature** and **humidity** with an **accuracy** of **1K.**
- And a **vertical resolution** of **1km**.

# INTRODUCTION (3/5)

## Hyperspectral Infrared Sounders

**MTG-IRS**: Meteosat Third Generation (MTG)-InfraRed Sounder (IRS)

- The **IRS** is an imaging interferometer with a spectral sampling of 0.625 cm-1 and spectral resolution of 0.754 cm-1
- Takes measurements in **two bands**:
  - **Mid-Wave Infrared** (MWIR, 1600–2175 cm-1 or 6.25–4.6 µm) with **900 spectral channels**
  - **Long-Wave Infrared** (LWIR, 700–1210 cm-1 or 14.3–8.3 µm) with **800 spectral channels**
- **Spatial resolution of 4 km at nadir**

# INTRODUCTION (4/5)

## Hyperspectral Infrared Sounders

- In this work we have used **IASI as a proxy of MTG-IRS.**
- IASI provides information about the **temperature** and **humidity** of the **troposphere** and **lower stratosphere** .
- IASI also measures the **fractional cloud cover** and **cloud top temperature** and **pressure**.

# INTRODUCTION (5/5)

## sSHAI: sounding Satellite Humidity And Instability from NWC SAF

**NWCSAF** provide satellite **products** for **Nowcasting** and **Very Short Range Forecasting**.

In this context:

- The **iSHAI** (imaging Satellite Humidity and Instability) product generates, among others, the **Total Precipitable Water** (TPW), **Layer Precipitable Water** (LPW, corresponding to the precipitable water in three layers) and **Stability indices**, which are calculated from the retrieved profiles of **temperature and humidity**. Products are generated at **high spatial** and **temporal resolution** to support real time meteorological applications.
- In the future **MTG-S** will host the Infrared Sounder (**IRS**) that will be able to provide a **new product**: the **sSHAI** (sounding Satellite Humidity and Instability), that will provide **instability indices** and **temperature** and **humidity atmospheric profiles.**

# METHODOLOGY

- **Retrievals** are **based on** a fast non-linear regression method, **Kernel Ridge Regression (KRR):**
  - Atmospheric **temperature** and **humidity profiles** are retrieved from IASI data.
  - **Retrievals** are obteined for **clear** and **cloudy scenes (scenes with cloud fraction until 80%).**
- **KRR trained with previous two days using IASI complete orbit:**
  - Model trained with retrievals with cloud fraction until 80%.
  - Model trained with clear scenes.
- **KRR tested on a day suitable for hyperspectral sounders:**
  - July, 15th 2015 at 9:45Z.

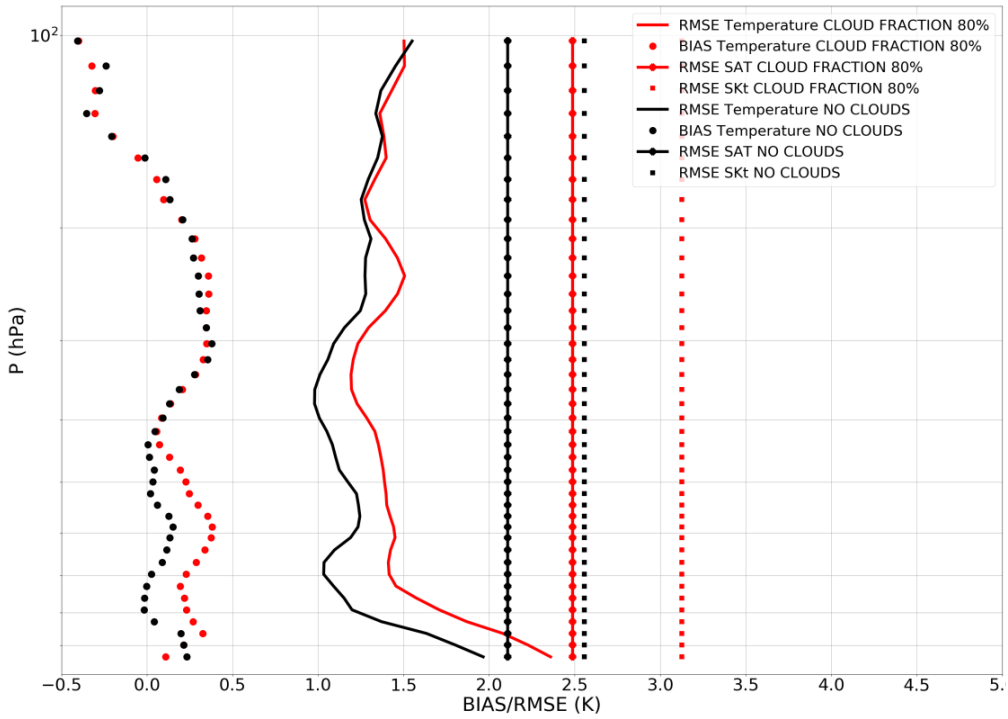
# RESULTS (1/9)

## IASI Nonlinear Retrievals as a proxy for MTG-IRS

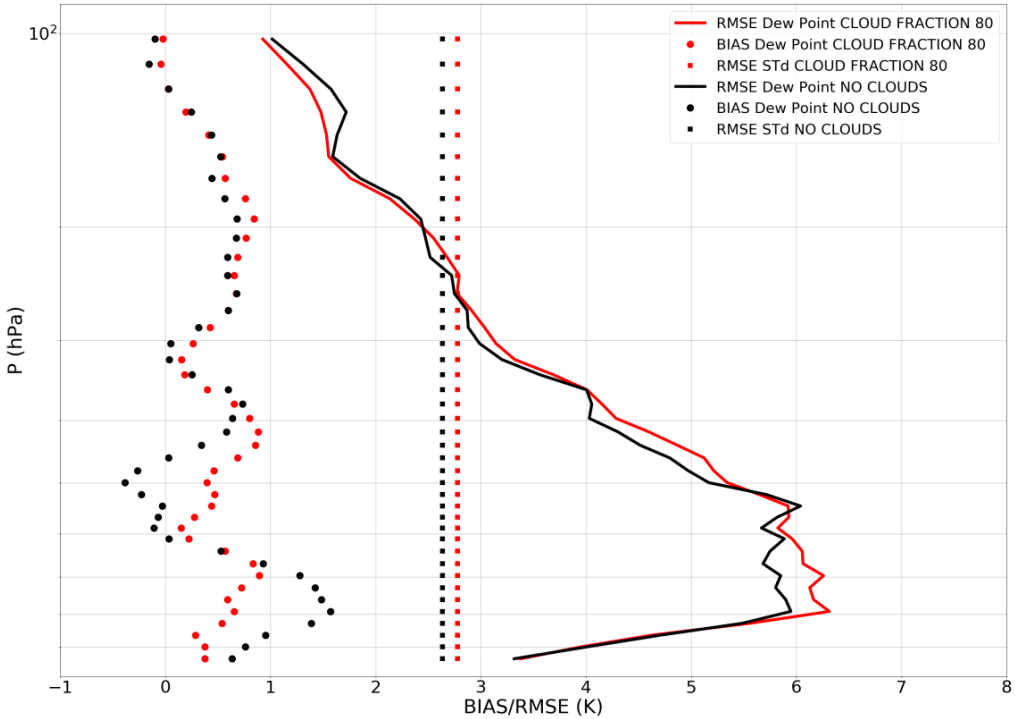
Retrievals based on KRR compared with ECMWF analysis.

IASI complete orbit

Temperature 15 July 2015. 9:45Z




Dew Point 15 July 2015. 9:45Z

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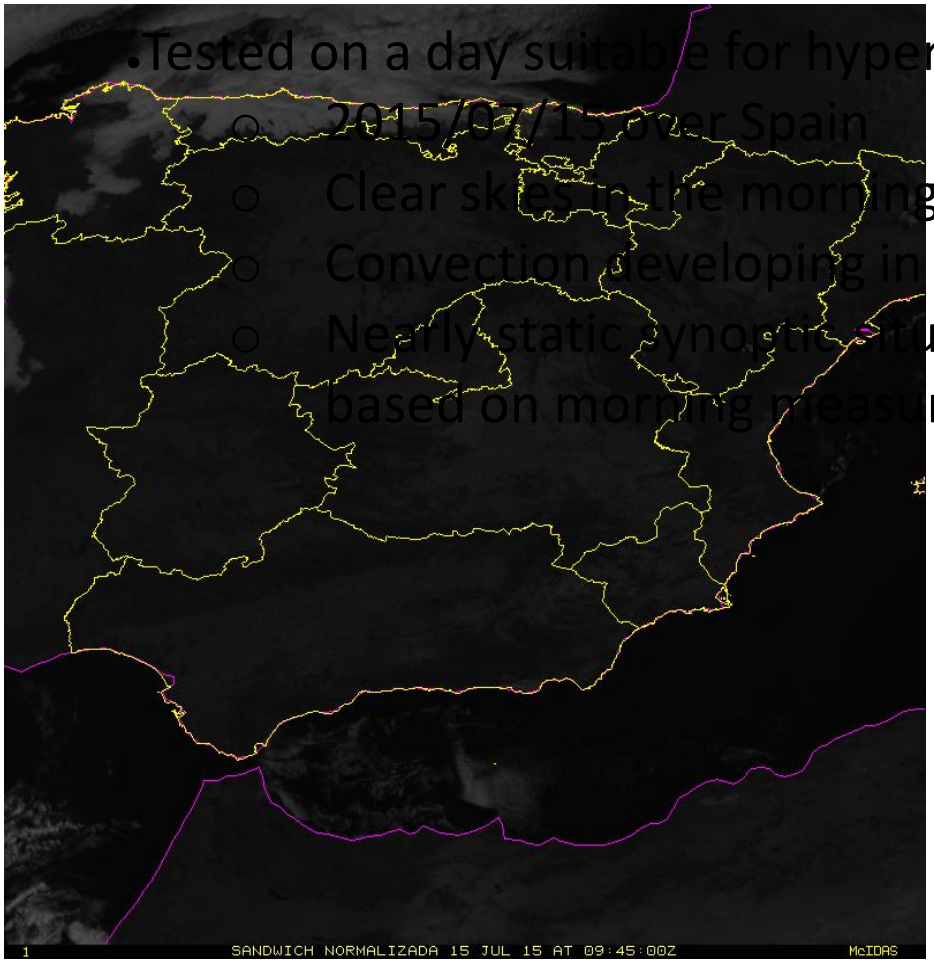
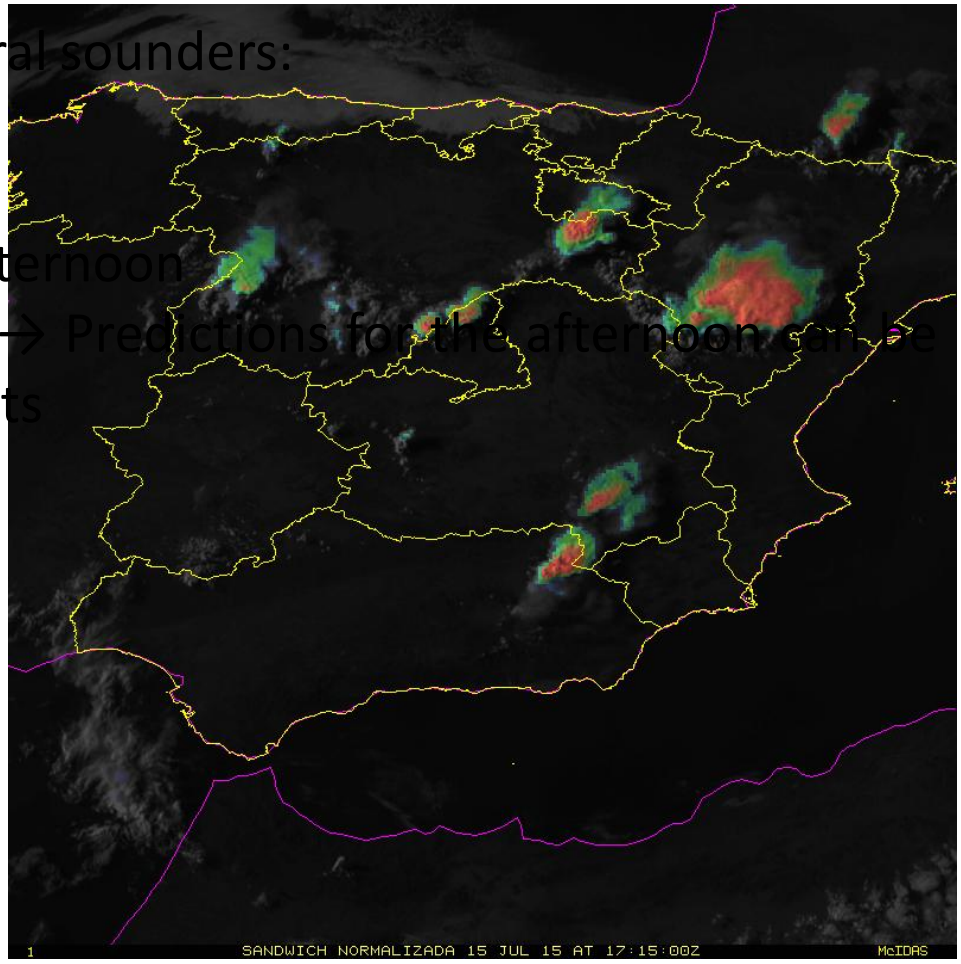
# RESULTS (2/9)

- Tested on a day suitable for hyperspectral sounders:
  - 2015/07/15 over Spain
  - Clear skies in the morning
  - Convection developing in the afternoon
  - Nearly static synoptic situation → Predictions for the afternoon can be based on morning measurements



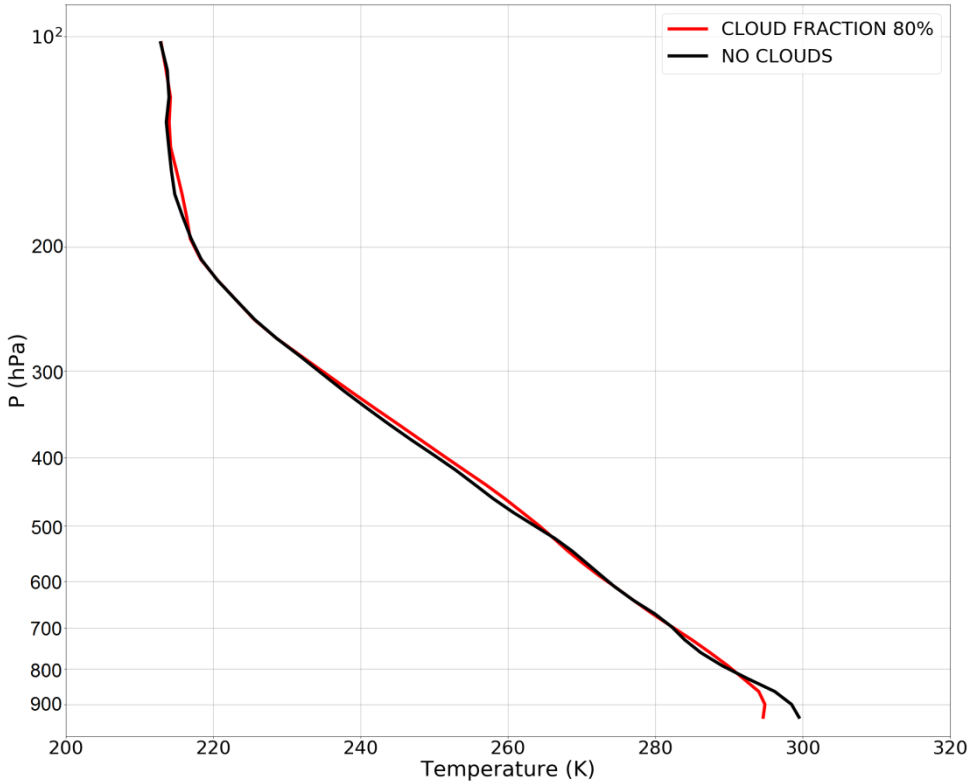

9:45 Z — Example: Meteosat RGB Images — 17:15 Z

July 15th, 2015

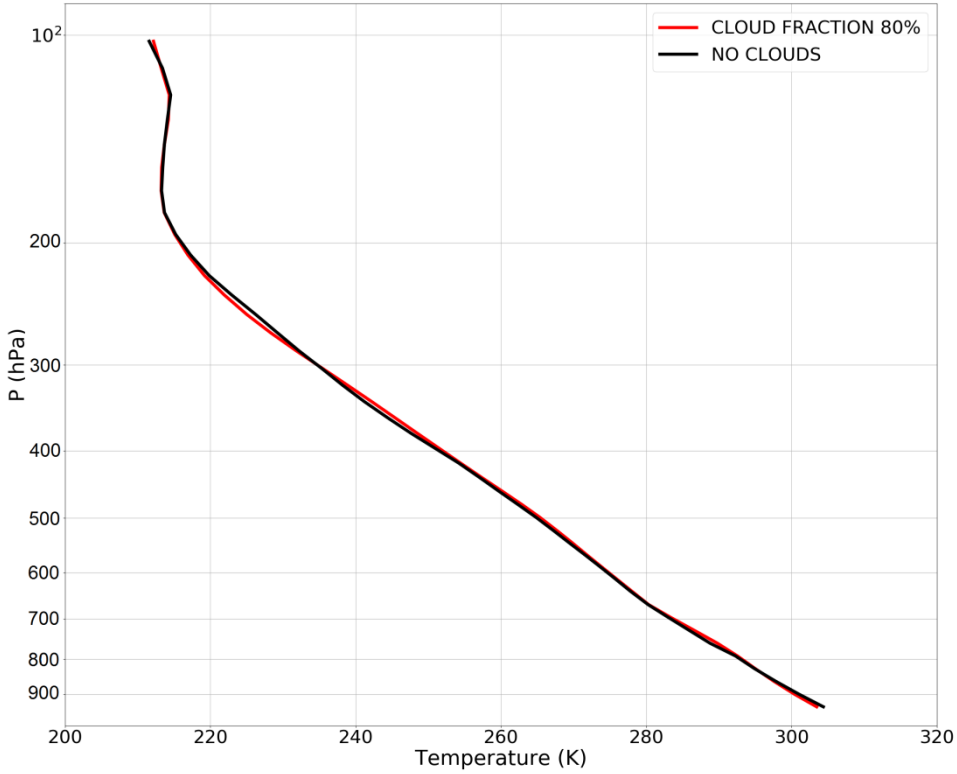
# RESULTS (3/9)

Cloud Top Altitude: Level where Tcloudy ≠ Tclear (W.L. Smith et al., J Appl. Meteorology and Climatology, 2012)

Temperature 15 July 2015. Gijon (43.53,-5.68)




Temperature 15 July 2015. Storm (40.73,-0.9)

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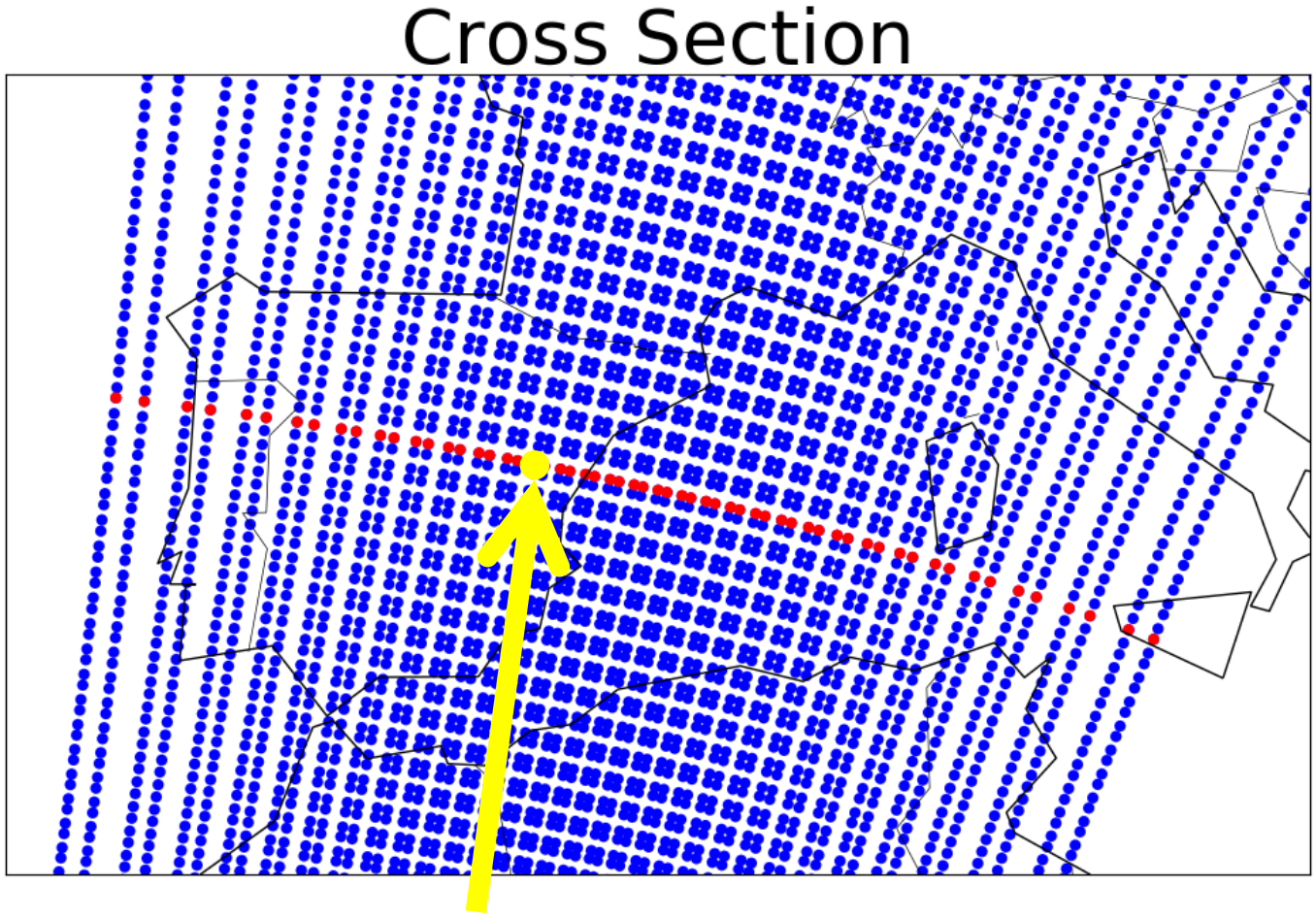
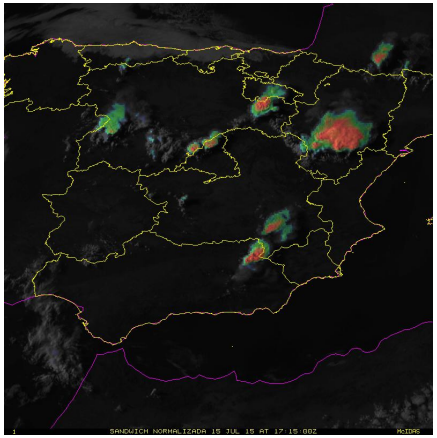
# RESULTS (4/9)

## IASI Retrievals

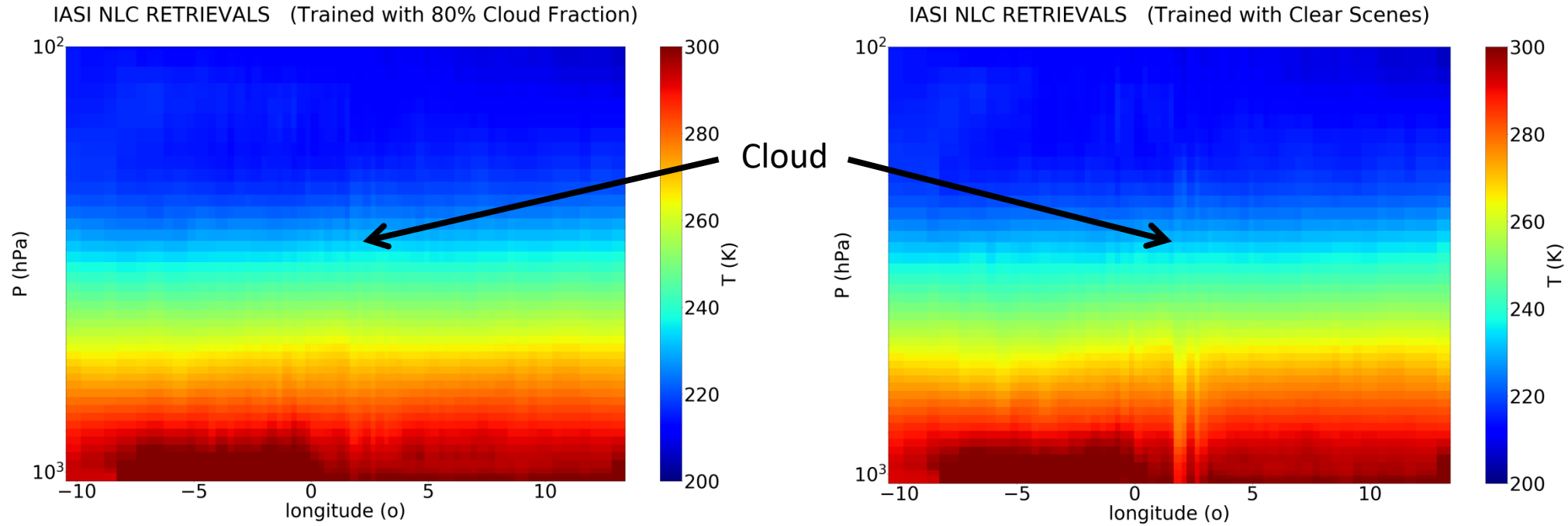


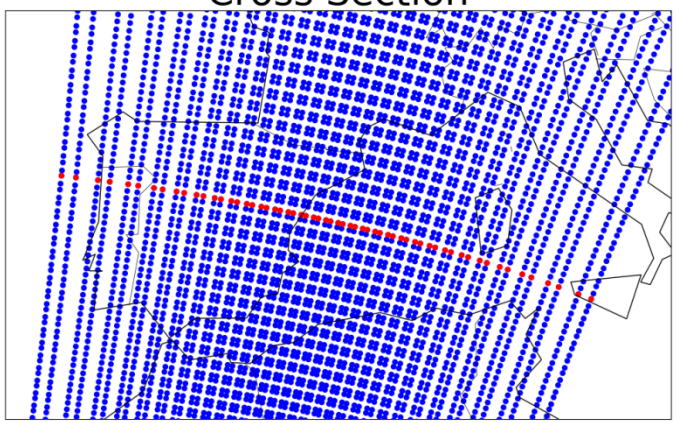
IASI IFOVS at 9:45Z

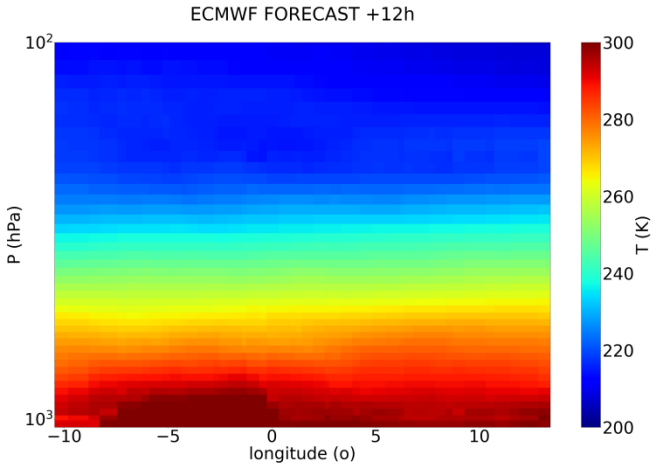
# RESULTS (5/9)

## IASI Retrievals: Temperature



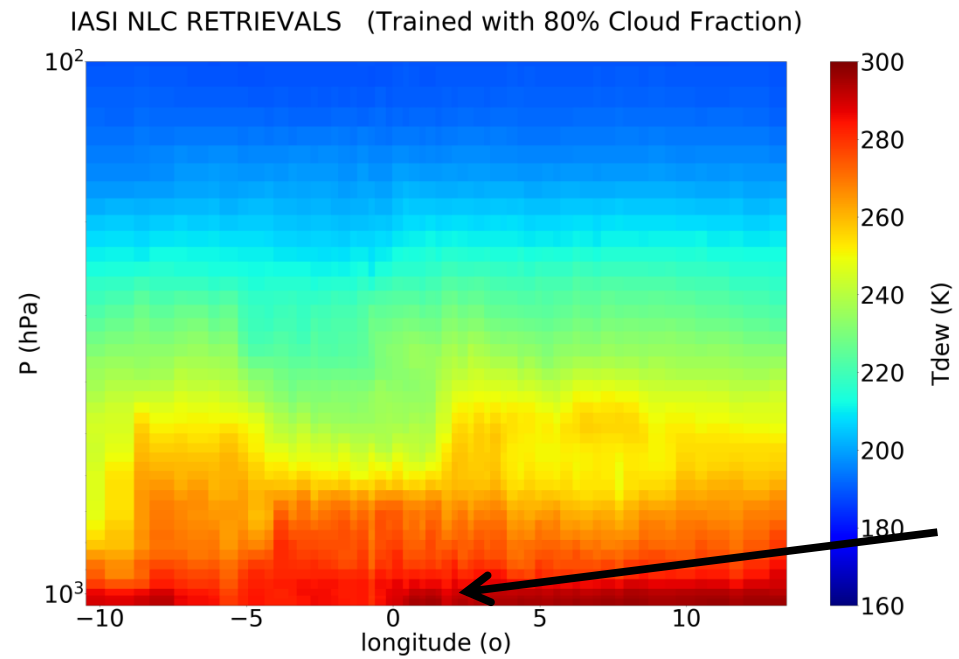

Cross Section



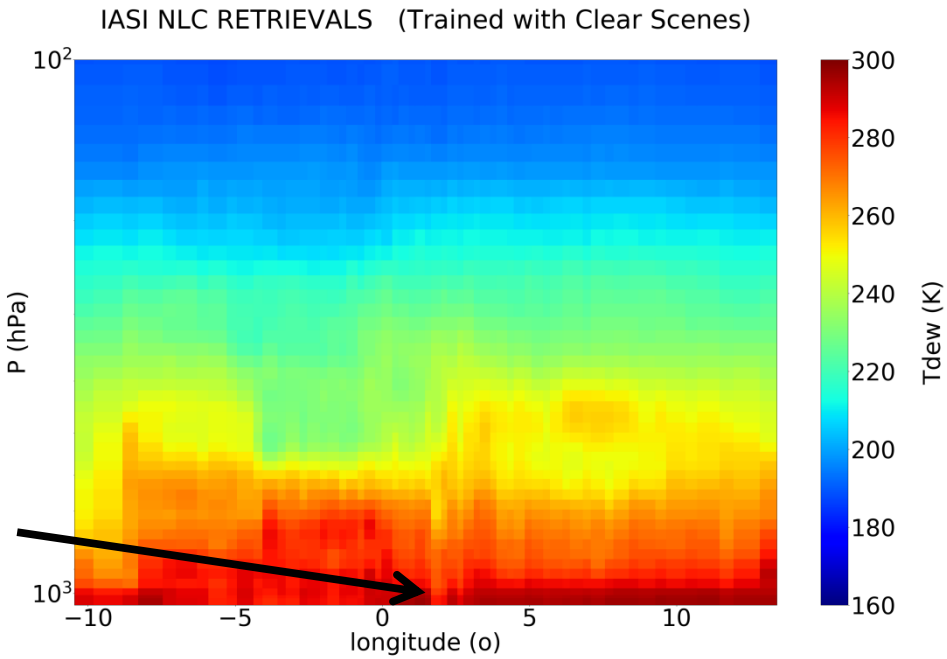


# RESULTS (6/9)

## IASI Retrievals: Dew Point




Cloud

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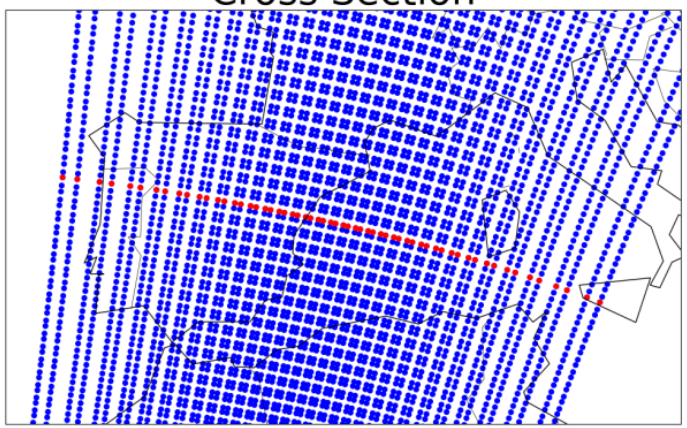
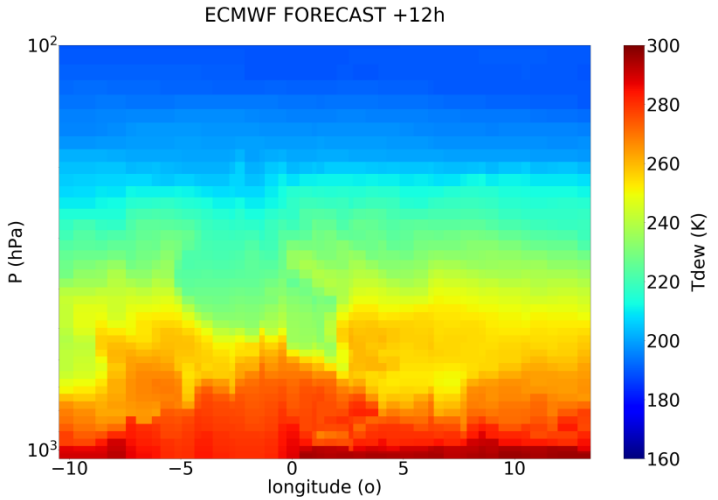
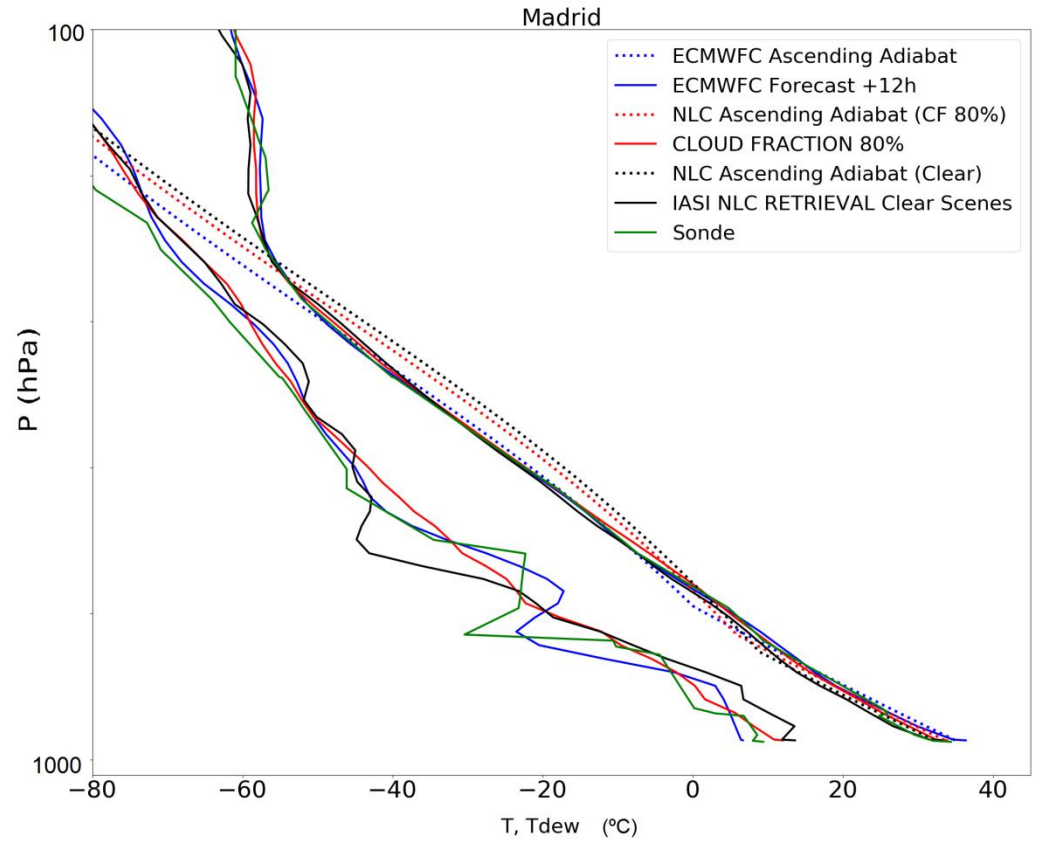
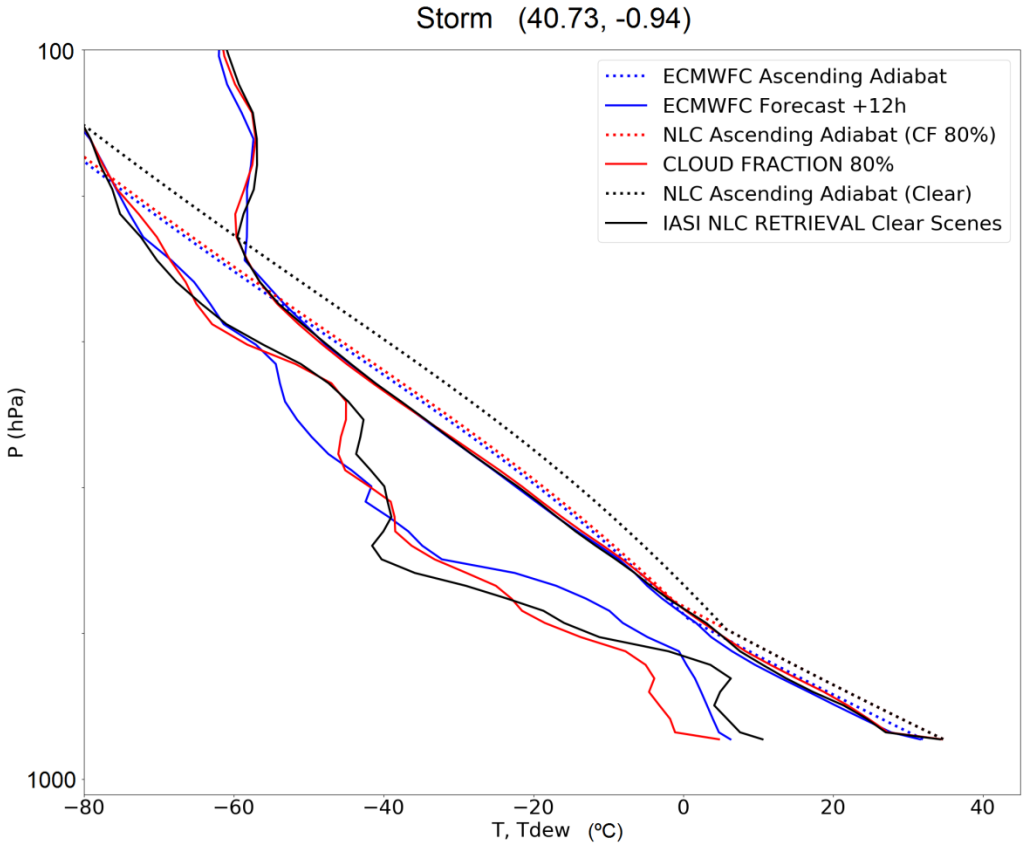




# RESULTS (7/9)

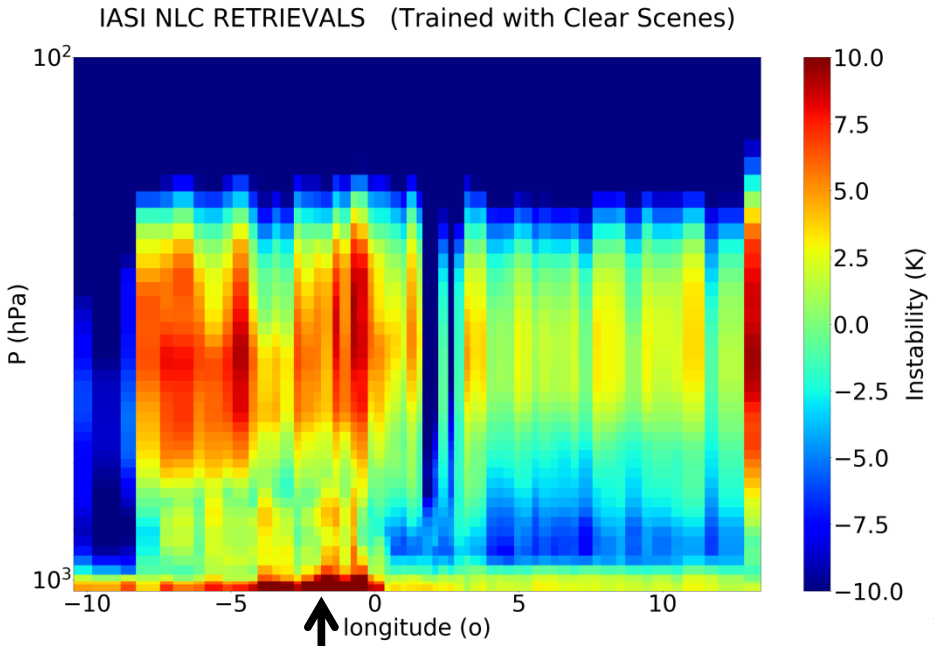
## IASI Retrievals

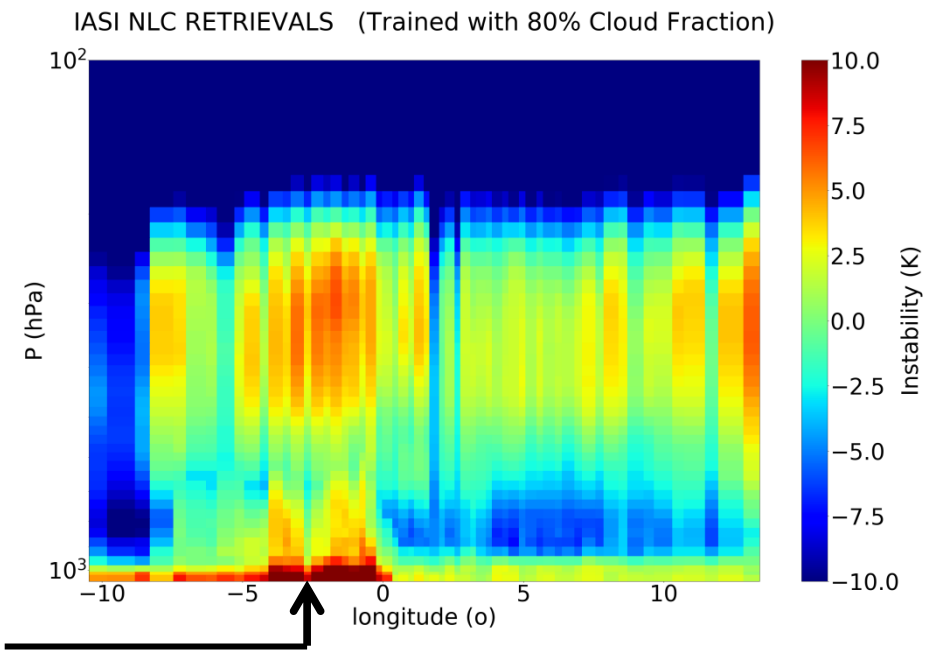


# RESULTS (8/9)

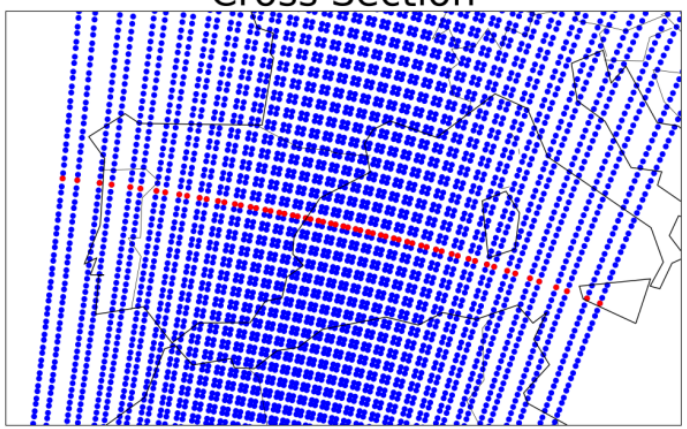
## IASI Retrievals: Instability

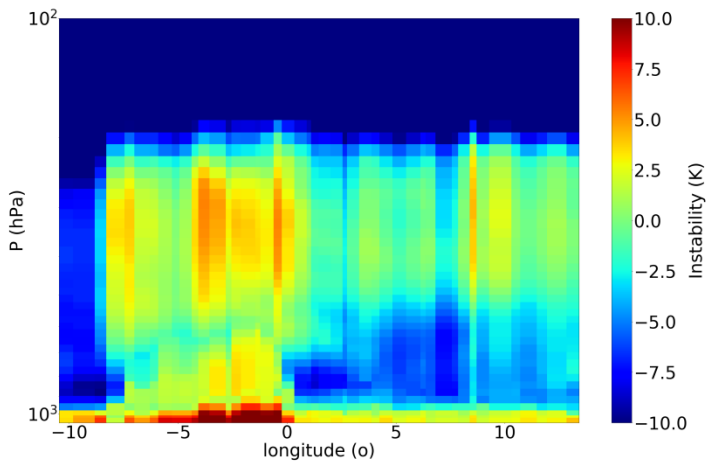



Storm Location

Cross Section

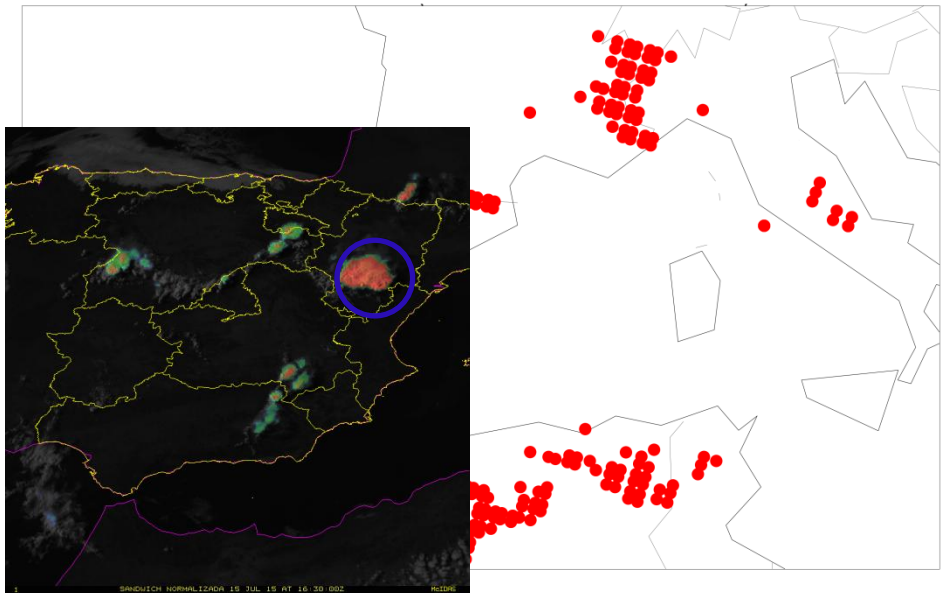




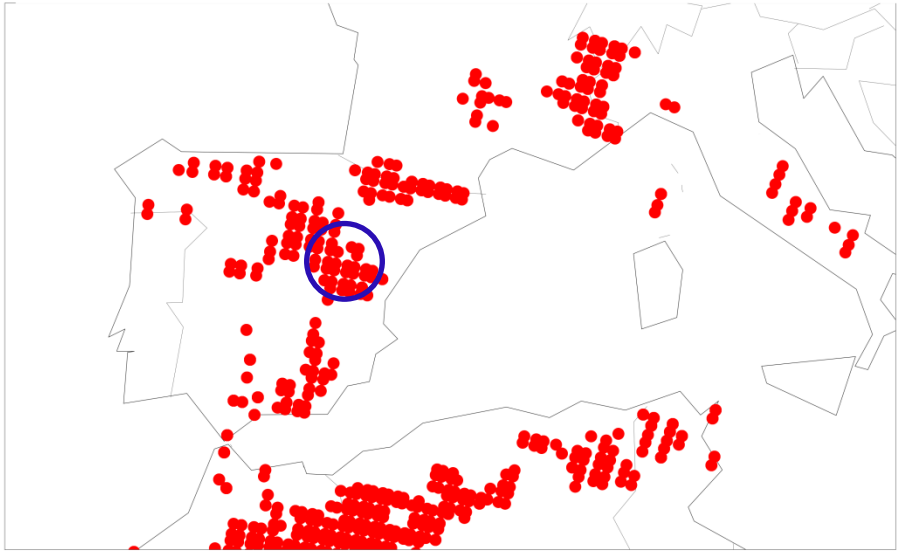
# RESULTS (9/9)

## 9:49 am sSHAI Instability: July 15th, 2015

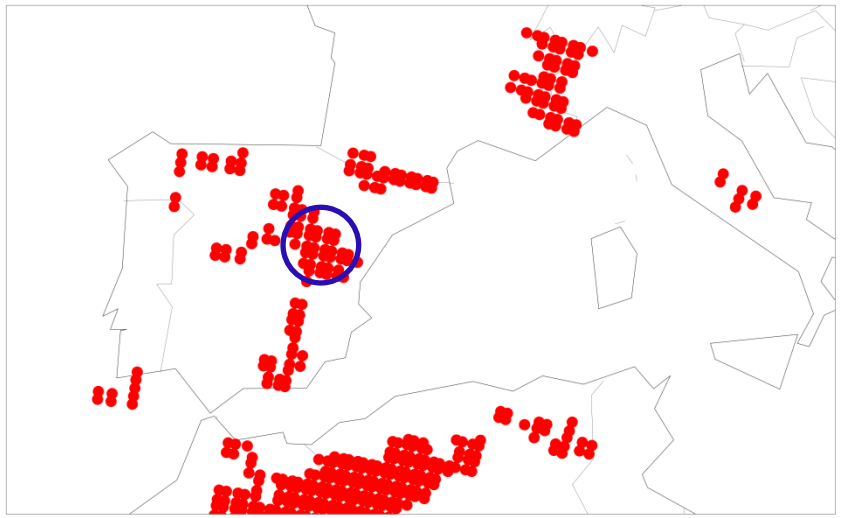
IASI NLC RETRIEVALS (Trained with 80% cloud fraction)



IASI NLC RETRIEVALS (Trained with Clear Scenes)



ECMWF FORECAST +12h



sSHAI: sounder Satellite Humidity And Instability

- Obtained with IASI as proxy for MTG-IRS
- Data obtained at 9:49 am
- Useful for days when synoptic conditions do not change significantly
- Typically on solar triggered convection (summer)

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# CONCLUSIONS

- State of the art **retrievals are necessary** → There is still room for improvement for **MTG-IRS.**
- Non-linear regression method, Kernel Ridge Regression (**KRR**) has a **high potential** to derive cloud, surface and atmospheric porperties from hyperspectral **MetOp-IASI** and **MTG-IRS** spectra.
- The **Non-Linear Retrievals** are **consistent** with **ECMWF** analysis and forecast, even with scenes with **80% cloud fraction.**
- **sSHAI:**
  - **Useful** for days when **synoptic conditions** do not change significantly.
  - Typically on solar triggered **convection** (**summer**).

# FUTURE WORK

- Next, ECMWF Forecast will be used as Input on KRR model to improve non-linear retrievals → There is still room for improvement for **MTG-IRS**

- Dual retrieval from non-linear retrievals (W.L. Smith et al., J Appl. Meteorology and Climatology, 2012)

  Final profile → Clear trained above cloud level

  Cloud-trained below cloud level

# THANK YOU

# FOR YOUR ATTENTION!!

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