Operational Temperature and Humidity sounding from EUMETSAT hyperspectral missions

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Outline

- EUMETSAT hyperspectral missions (*current and future*)
- T/q profiles + quality indicators, validation results
- EARS-IASI L2 Regional service
- Use in nowcasting:
  - Dialog with forecasters, ongoing studies
  - Preparing for future missions
  - Consolidate requirements
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<table>
<thead>
<tr>
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<tbody>
<tr>
<td><strong>IASI</strong></td>
<td><strong>IASI-NG</strong></td>
<td><strong>MTG-IRS</strong></td>
<td></td>
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<tr>
<td><strong>Low-Earth orbit</strong></td>
<td>sun-synchronous (~820km)</td>
<td>Orbit</td>
<td>Geostationnary</td>
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<tr>
<td>2x2</td>
<td>4x4</td>
<td>Sensor</td>
<td>160x160</td>
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<tr>
<td>12 km</td>
<td>12 km</td>
<td>Spatial (Nadir)</td>
<td>4 km</td>
</tr>
<tr>
<td>0.25 cm(^{-1})</td>
<td>0.125 cm(^{-1})</td>
<td>Spectral sampling</td>
<td>(~0.6) cm(^{-1})</td>
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<tr>
<td>2x / day</td>
<td>2x /day</td>
<td>Temporal</td>
<td>Every 30 min Europe</td>
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<tr>
<td>Metop-A</td>
<td>19 October 2006</td>
<td>2022</td>
<td>2023</td>
</tr>
<tr>
<td>Metop-B</td>
<td>17 September 2012</td>
<td></td>
<td></td>
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<tr>
<td>Metop-C</td>
<td>06 November 2018</td>
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The hyperspectral sounding Swiss knife

Temperature, Humidity profiles

Cloud mask, fraction, top height

Sea surface temperature

Land surface temperature and emissivity

GHG

Ozone

Carbon monoxide

Dust index

SO2

CO2 T

Surface Clouds Dust

O3

Surface Clouds Dust

CH4

H2O

CO

N2O, CO2

Surface Clouds

IRS

IRS spectrum

IASI

IASI-NG
From spectral to vertical resolution

- IASI band 1
- MSG/SEVIRI channels

**Infrared**

- Radiometer
- Hyperspectral

~ 850 channels

(IASI has 8461, IASI-NG 16921!)

**Micro-wave sounders**

AMSU

Sounding in clouds possible

MHS
Temperature and quality indicator validation vs sondes

Jan. – Oct. 2017
< 50km ; < 3h
Match-up QC still needed

Error estimate in low-troposphere
EARS-IASI L2, a new regional service – timely for nowcasting

- Direct broadcast stations
- Timeliness < 30’ from sensing
- Pilot phase since Nov. 2017

Statistical MW+IR retrievals (fast and accurate)
‘All-sky’ forecast-free products

EARS-IASI L2 :: RH :: M01_20170513195732Z_20170513200000Z
Objectives:
Evaluate the feasibility and impact of assimilating the IASI L2 as pseudo-sondes in a regional model

First experiments in a nutshell:
✓ Overall agreement L2 vs AROME
✓ IASI L2 suitable for assimilation in NWP
✓ Data thinning: 160km horiz.; 1-in-3 level
✓ Positive impact on forecast biases vs in situ obs.
✓ Some negative effects at some levels/FCT-steps
✓ Error specs/vertical correlation is critical (diagonal error in these experiments)

Credits: Bruna Silveira, Vincent Guidard, Nadia Fourrié

"Potential benefits of assimilating Metop combined retrieval L2 products in AROME-France", EUM Conference Tallinn 2018
Case study: Cyclone Frederike 18/01/2018 (1 out of 3 cases)

Forecast: The regional model COSMO-DE predicted the development of a sting jet with gusts up to 170 km/h. The challenge for the forecaster was to decide if the sting jet would reach the ground resulting in fatal wind gusts.

Conclusion: COSMO-DE overestimated the gusts, but the stratocumulus clouds in the satellite picture and the IASI-Soundings (showing strong boundary layer) gave hints that the Sting Jet would not reach the surface in the low lands.
Conditional instability detection with IASI?
Severe hail storms – Bordeaux Cognac 26/05/2018
Wind, Lightning Hail storm in Dordogne – 04/07/2018
Wind, Lightning, Hail storm in Dordogne – 04/07/2018

M01 04/07/2018 09:50

ECMWF 04/07/2018 00+09UTC

M02 04/07/2018 10:30

Lifted index

Near surface temperature

IASI L2 > forecasts

Wind Lightning Hail Storm Dordogne 20180704

0 200 400 600 800 1000
Pressure [hPa]

200 220 240 260 280 300
Temperature [K]

0 200 400 600 800 1000
Pressure [hPa]

200 220 240 260 280 300
Temperature [K]

0 200 400 600 800 1000
Pressure [hPa]

200 220 240 260 280 300
Temperature [K]
Blend satellite + surface obs. for instability monitoring

- Hyperspectral infrared have low sensitivity and coarser vertical resolution near-surface
- Impact surface-based instability indices - CAPE dynamic smaller than with sondes...
  - ? Enough to anticipate severe weather
- Blend satellite profiles + surface obs (T/q) - FCT-independent obs. for forecasters
  - ? Significance in relation to severe weather
  - ? Operational feasibility

Formerly studied at University of Wisconsin
Excerpts from an early case study

- Deep convective thunderstorm
- Slovenian border
- 4 June 2018 at 10 UTC

- IASI overpasses 08:29 and 09:11
- ECMWF forecasts 8 and 9 UTC
- Blending IASI L2 (and NWP FCT) with ground-based to evaluate SBCAPE

*Study team: Kalman Csirmaz, Zsofia Kocsis, Maria Putsay (OMSZ)*
Instability monitoring from IASI in view of IRS (OMSZ, Hungary)

8:29 UTC SBCAPE IASI + surface obs increased 454 → 1350 J/kg.
Instability monitoring from IASI in view of IRS (OMSZ, Hungary)

9:11 UTC SBCAPE IASI + surface obs increased 1296 $\rightarrow$ 1703 J/kg.
In this case, IASI lapse rate higher than NWP, yielding larger CAPE.

9:00 UTC SBCAPE ECMWF + surface obs increased 694 → 939 J/kg.
MTG-IRS: unique 4D look into the atmosphere

IASI footprints
12-40km
Not-contiguous
2x per day

IRS pixels
~7km
Contiguous
Every 30'

0 24h
IASI
IRS
CrIS
A full weather story with MTG

Evaluate the thermodynamic state before clouds form.
Gain precision and lead-time in the assessment of potential severe weather.
Summary - Outlook

Retrieval methods
- AI, machine learning...
- Physics modelling
- Instruments synergy, data fusion?
- New products, e.g. cloud μ-physics

Validation / Monitoring
Need reference measurements:
- Traceable uncertainties
- Continuous streams
- Campaign opportunities?
- Challenges (methods/instruments)
  - Representativeness error
  - Validate T/q at 0.7K/5%
  - Cloud microphysics

Scientists ISTP

Users

Regional applications
✓ Timely ‘all-sky’ T/q profiles
➢ Studying pre-convection monitoring
➢ Practical operational aspects
  - assimilation experiments
  - direct use, displaying information
  - blending satellite + surface obs
➢ Consolidate requirements
  ✓ dialog with forecasters
  ? which parameters
  ? forecast-dependency
➢ IRS unique 4D look into atmosphere

Products & Services

Merci pour votre attention!

Try out EARS-IASI L2 !
Get ready for MTG-IRS !