Potential of ground-based remote sensing networks

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Smart Earth Observation System Design Workshop, 9-11.12.2025 Cologne

Monitoring Regional Atmospheric Stability with Hyperspectral Satellite Observations Enhanced with a Potential Network of Ground-Based Microwave Radiometers

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Online Publication: 15 Sep 2025

Print Publication: 01 Oct 2025

Collections: Hans-Ertel Centre: Interdisciplinary Research in Weather Forecasting and Climate Monitoring

DOI:
https://doi.org/10.1175/JAMC-D-24-0212.1

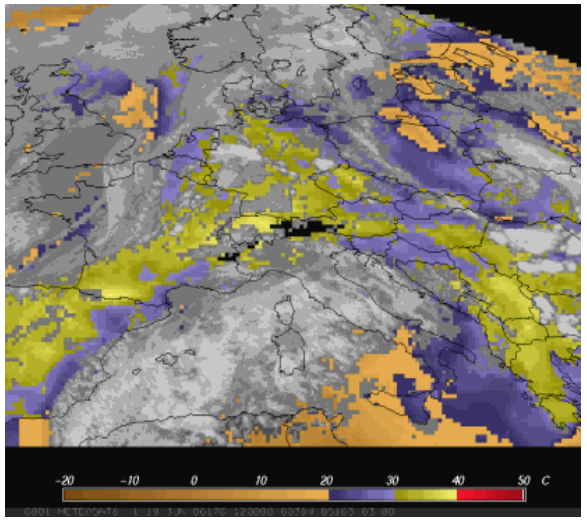
Stability index products from satellite observations

Temperature and Humidity Profiles (ABL)

→ Atmospheric stability

→ Stability indices (CAPE, LI)

MSG- SEVIRI-Global Instability Index Product



Koenig and de Coning 2009

Indices: KI, KO, LI, TPW
Physical retrieval

Only under clear sky conditions

MTG-IRS

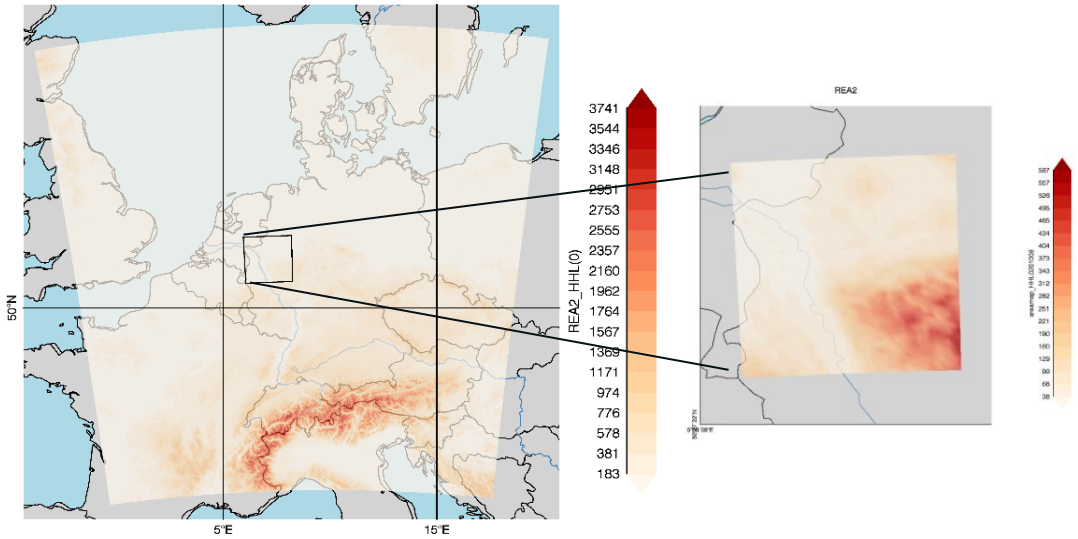
Launched on 1 July 2025

- first hyperspectral sounding instrument in geostationary orbit over Europe.
- high-frequency data on temperature, humidity and trace gases

→ improved accuracy but still limited by clouds

In what extent a ground-based MWR network can contribute to the assessment of atmospheric stability and complement satellite observations?

Reanalysis COSMO-REA2



(Bollmeyer et. al. 2015)

150*150km domain

2010-11, May-September

4km horizontal and

1h temporal resolution

IRS (Meteosat Third Generation Sounding Mission)

- 1738 channels in IR
- 30 min over Europe
- 4km (nadir) horizontal res.

Microwave Radiometer HATPRO

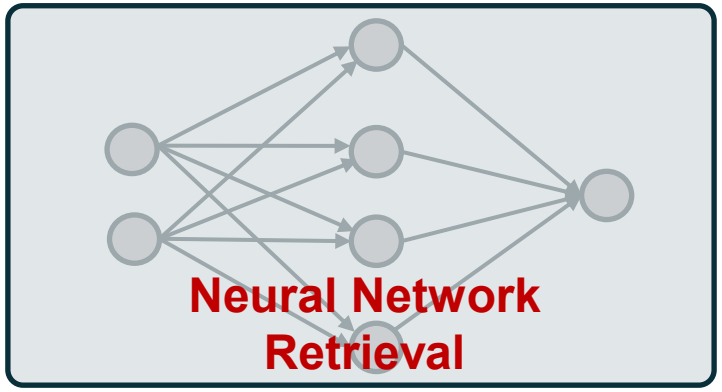
- high accuracy IWV, LWP
- profiles of T (ABL) and humidity (low res.)
- 14 Channels, 4 elevation angles

Neural Network Retrieval

Reanalysis COSMO-REA2

T-, q-, P-profiles, LWC, IWC

Simulated Observations



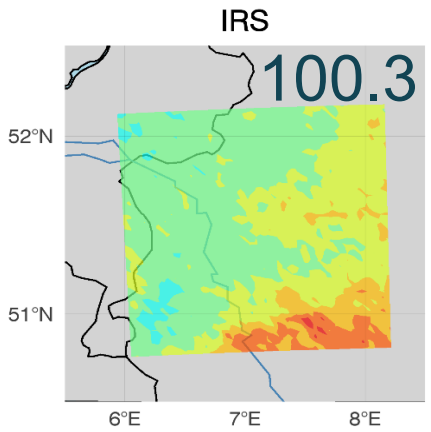
CAPE, LI

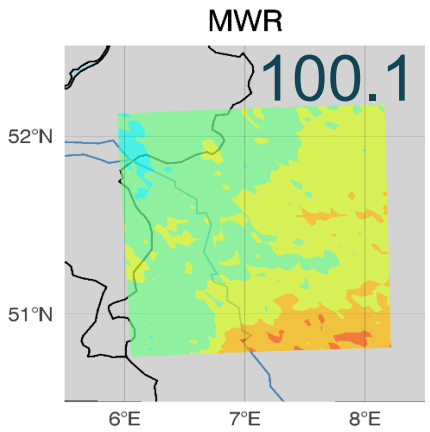
Test set observations

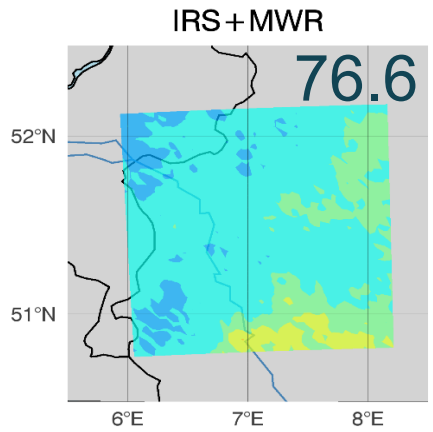
Test set CAPE, LI

RMSE of CAPE, J/kg

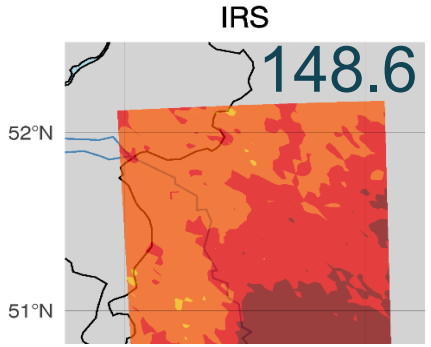
Clear sky

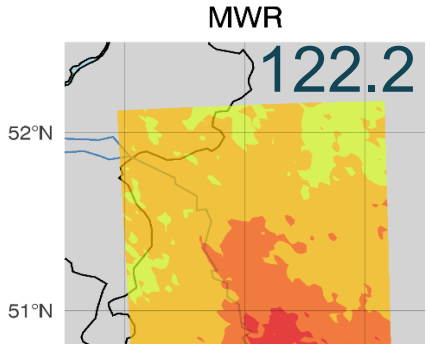


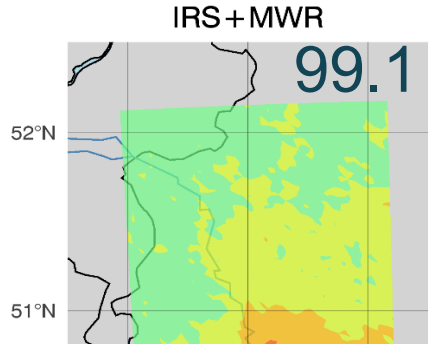




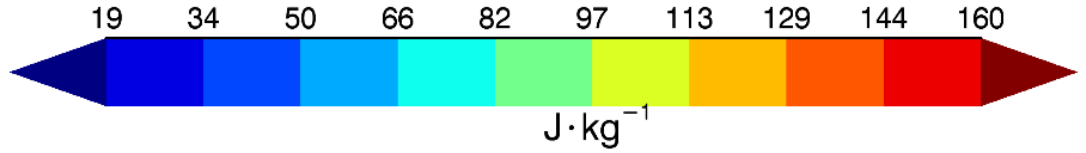
Cloudy



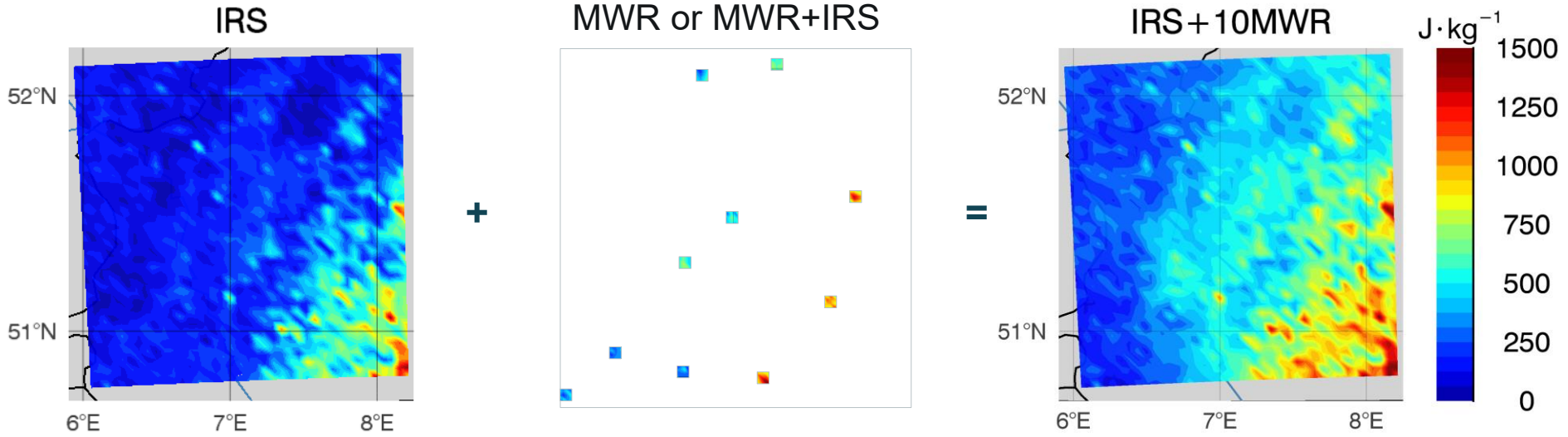




How to combine CAPE/LI fields from IRS observations with single MWR measurement?



Spatial Statistical interpolation



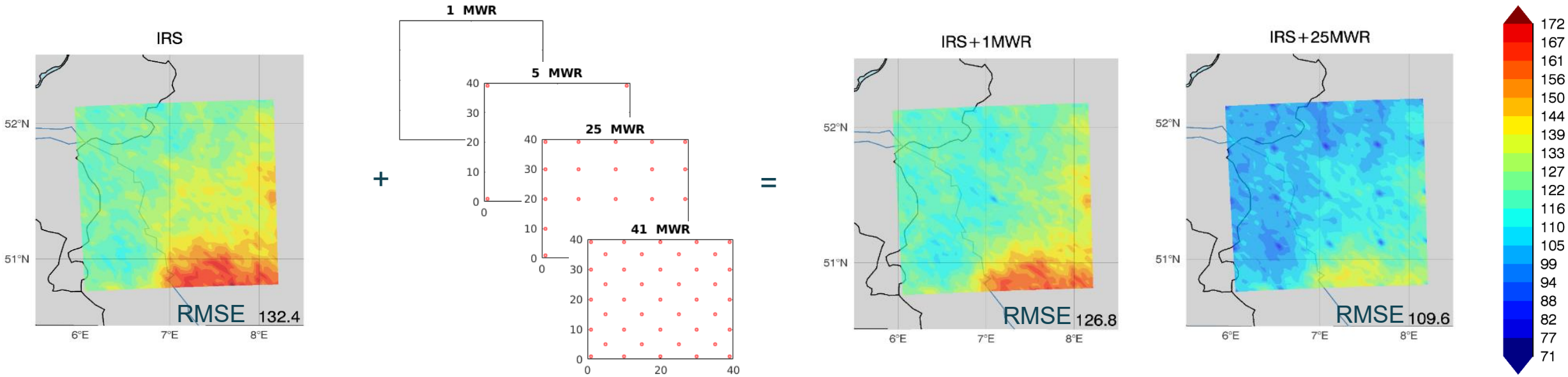
X_b: CAPE/LI from IRS + Y: CAPE/LI from MWR or MWR+IRS = X_a

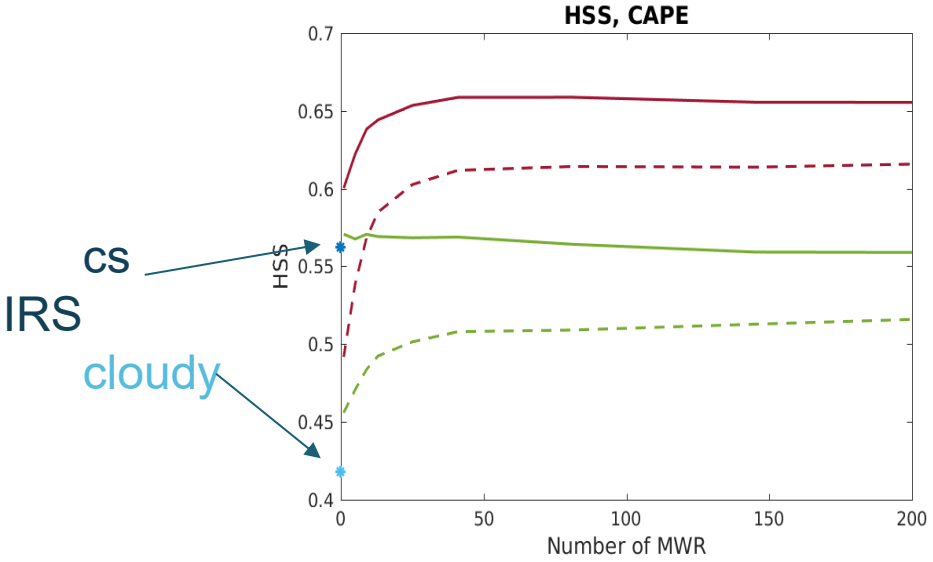
$$X_a = X_b + W(Y - H(X_b))$$

$$W = BH^T(HBH^T + R)^{-1}$$

W: weight matrix
B: error covariance of IRS retrieval
R: error covariance of MWR or MWR+IRS retrieval

Statistical interpolation between CAPE fields retrieved from IRS and MWR observations





+ synerg. IRS+MWR

+ MWR

		IRS		IRS+25MWR
CAPE	**HSS**	**0.46**	→	**0.62**
LI	**HSS**	**0.55**	→	**0.75**

Conclusions

- **CAPE/LI Retrievals**

  MWR-only retrieval outperforms IRS under cloudy conditions.

  → for stronger impact apply synergistic **IRS+MWR** retrievals.

- **CAPE fields**:

  additional observations from gb MWR–network improve the IRS retrieval under both clear sky and cloudy conditions (if synergistic retrieval is applied, max 25 sensors). Still low accuracy!

  → add insitu surface T, q, DIAL.

  → combine with prior information (forecast)

- **LI fields**: Li retrieval based on IRS observations is more accurate than CAPE (max 15 sensors). BUT affected by clouds!

  → gb MWR observations effectively replace the cloud affected IRS retrieval.

Thank you for your attention!