Highlights from EUMETSAT Workshop on NWC Applications using MTG-IRS

H. Roquet, P. Menzel, S. Tjemkes, R. Stuhlmann
and all IRS-NWC workshop participants

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NWC Applications Using MTG-IRS: Objectives

- Initiate the exchange of information between MTG-IRS science support and the operational NWC user community
  - inform operational NWC forecasters about the potential of MTG-IRS to deliver information on the timely developing atmospheric state
  - get operational NWC forecasters involved to look at the potential of MTG-IRS supporting their NWC applications
  - conclude on a way forward to further strengthen the MTG-IRS science/NWC user interrelation

Workshop took place 25-26 July at EUMETSAT HQ with 24 external participants

Session 1: MTG-IRS Introduction

Session 2: Operational Nowcasting as of Today

Session 3: MTG-IRS NWC Demonstration Projects

Session 4: Operational Nowcasting in 2020 and beyond

Session 5: Recommendations

Session 1: Introduction – MTG-IRS Mission (S.Gigli)

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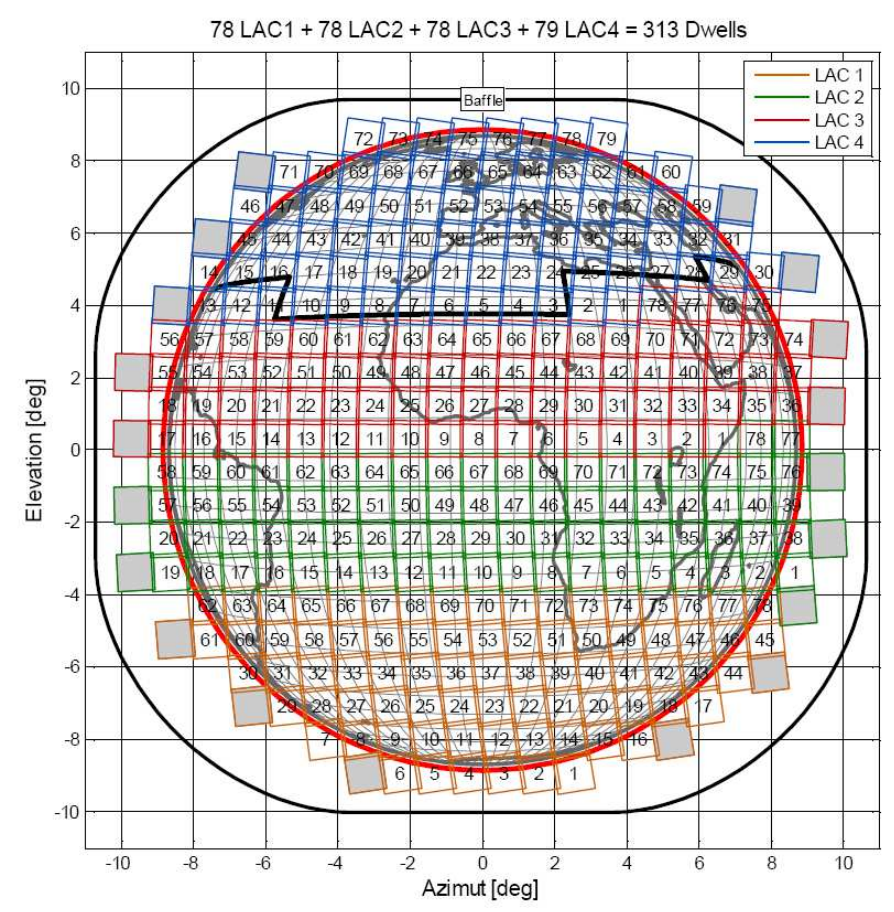
- Earth disc split into 4 LACs
- Each LAC, measured over 15 minutes contains about 80 dwells
- Each dwell measured over 10 seconds contains 160 x 160 samples with 4 km resolution (at nadir), covering an area of 640 x 640 km^2
- Hyperspectral measurements in two bands:
  - LWIR: 680cm^{-1} to 1210 cm^{-1}
  - MWIR: 1600cm^{-1} to 2250 cm^{-1}
  - Spectral Resolution: 0.625 cm^{-1} (~1900 spectral samples)



LAC-4 (covering EUMETSAT Member States) revisited every 30 minutes

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Session 1: Introduction – IRS Information (P. Menzel)

- High resolution IR Level 1 spectra reveal absorption lines providing directly information useful for NWC
  - low level moisture gradients, low level inversions, tropopause inversions,.....

  an ability lost if spectral resolution is degraded to SEVIRI like
- The IRS derived Level 2 products provide information useful for NWC
  - vertical/horizontal moisture and temperature structures, surface properties (temperature/emissivity), dust and volcanic ash, trace gases (O_3, CO, N_2O), cloud properties (altitude, temperature, optical thickness, ice/liquid content),.....
- The IRS 30 minutes repeat cycle (Member States) important for NWC
  - pre-convection stability tendencies, moisture convergence,.....

Session 2: Operational Nowcasting as of Today

- 7 oral presentations by:
  A. Vocino (CNMCA), C. Herold (DWD), N. Mahovic (Meteorological and Hydrological Service, Croatia), P. Francis (Met Office), M. Buzzi (Meteo Swiss), A.C. Fontan (Meteo France) and H. Sellman (SMHI)

- Satellite data is widely used to characterise air masses (RGBs), cloud macro physical properties, to monitor instability,.....
  (Beyond in-house generated application, NWC-SAF applications are heavily used)

- Very advanced methods like NinJo workstation (DWD), MESAN (SMHI), LAPS (FMI), COALITION approach (Meteo Swiss), NEFODINA (CNMCA) are applied

- However, none of the presenters indicated that they have been or will be looking at IASI/CrIS observations for their operational forecasting and warning tasks
  (Limiting factors are the small number of overpasses and challenges with timeliness (1 hour is a very strong threshold) considering small scale (space and time) moisture changes)

Session 3: MTG-IRS NWC Demonstration Projects

- Session 3 presented initial results of 6 Demonstration Projects using MTG IRS like Level 2 proxy data derived by the IRS Level 2 Development and Validation Processor (IRS L2DVP) at EUM on the basis of IASI data:
  - Convection monitoring from space (P. Antonelli, SSEC and A. Manzato OSMER)
  - Nowcasting convection over Sweden (H. Sellman, T. Landelius and A. Dybbroe, SMHI)
  - Potential of hyperspectral sounders to nowcasting heavy convection (S. Bach, C. Herold and Ch. Köpken-Watts, DWD)
  - LAPS 3D atmospheric analysis (E. Gregow, FMI)
  - RGB images from hyperspectral instruments - brainstorming (A. Martinez, AEMET)
  - 3D visualisation of IASI products (F. Debie, S. De Haan, and M. Koutek, KNMI)
- Session 3 was supported by three additional presentations:
  - GII from MSG (M. König, EUMETSAT)
  - Improving very-short-range predictions of the pre-convective environment, from MSG-SEVIRI to MTG-IRS (R. Petersen, CIMSS)
  - Nowcasting applications with Polar-Orbiting Hyperspectral Sounders (N. Smith, E. Weisz and W. Smith, SSEC)

Session 3: Lesson learnt GII from MSG (M. König)

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- Warning regarding common misconceptions:
  - A useful satellite product should be different from a NWP derived product – however, NWP forecast is relatively good and a too much deviating product should worry.
  - A good general correlation to independent observations is a 'good quality indicator' – however, only the correlation in case of meteorological relevant situations are significant

- Overall a very positive outlook into the MTG future for NWC applications, pointing to the great potential combing FCI and IRS information taking advantage of both the higher IRS spectral information and the higher FCI space and time information.

Session 3: from MSG-SEVIRI to MTG-IRS (R. Petersen)

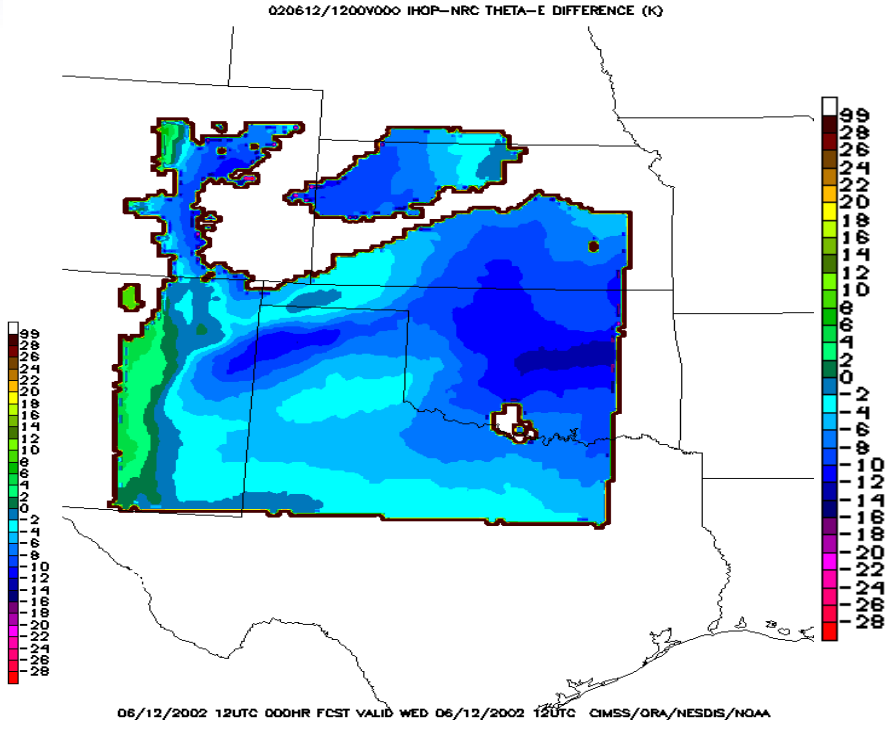
University of Wisconsin-Madison Space Science and Engineering Center
Cooperative Institute for Meteorological Satellite Studies

vertical Theta-E Difference [Theta-E@~500hPa – Theta-E@~780hP]

MTG-IRS provides a thinner and lower layer of Theta-E@~780hPa

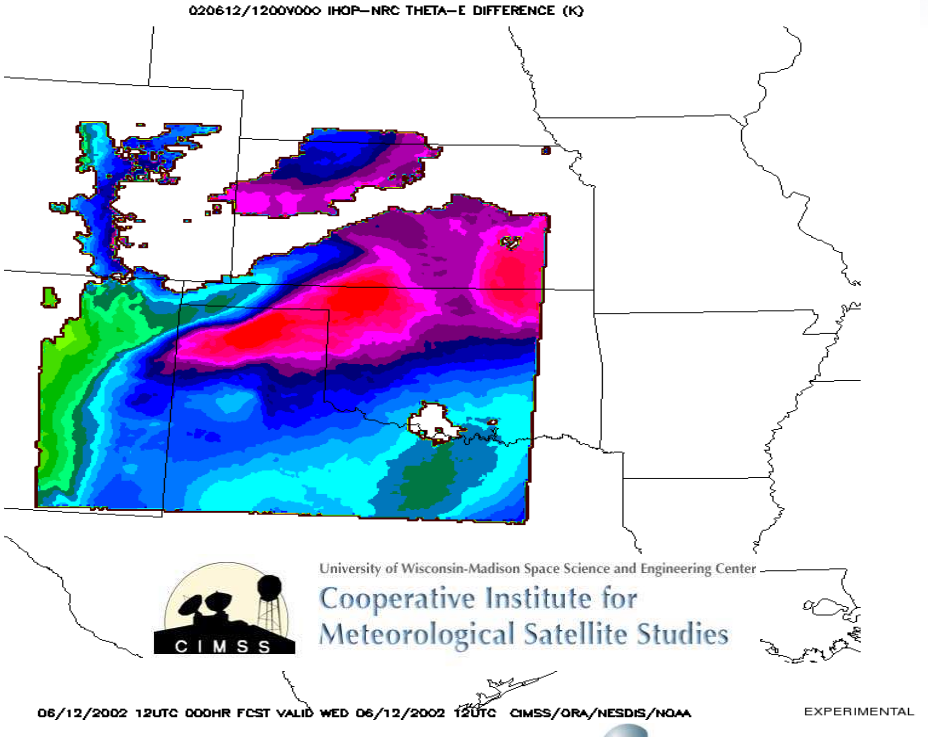
Lagrangian NearCast using Simulated ABI data from 1200 UTC 12 June 2002

MSG-SEVIRI like



Lagrangian NearCast using Simulated HES data from 1200 UTC 12 June 2002

MTG-IRS like



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Session 3: from MSG-SEVIRI to MTG-IRS (R. Petersen)

University of Wisconsin-Madison Space Science and Engineering Center
Cooperative Institute for Meteorological Satellite Studies
CIMSS

How MTG-IRS will improve the short-range predictions:

- **Improved Vertical Moisture Structure**
  - Increase independent layers of information from 2-3 to 6-8
  - Provide information closer to Earth's surface
  - Provides information down to cloud tops
  - *MUST* monitor retrievals constantly for bias and random errors
- **Some Improvement in Temperature Profiles**
  - Improved depiction of Inversions, tendencies and Tropopause
    - Necessary for deriving realistic CAPE
      - Monitor for NWP performance/deficiencies
- **Improvement in Clear-Air AMVs Winds**
  - Needed to judge storm severity
    - Loops of time resolved moisture retrievals could be used to determine Low-Level shear (TBC)
    - Could possibly help determine lower-level lift (TBC)

Session 3: Nowcasting: multi-instrument approach (N. Smith)

For more detail see following presentations by Elisabeth Weisz and William Smith

- A single IASI instrument limits the observations available to only 2 per day
- Combining IASI-A, IASI-B, CrIS and AIRS has the potential to dramatically improve the time sampling of hyperspectral observations (specifically at high latitudes)
- The group of W. Smith, E. Weisz and N. Smith are working on the multi-instrument retrieval approach and results were presented by N. Smith.
- The workshop participants clearly concluded that over the coming years until the MTG-IRS launch in 2020, combining observations from instrument in polar orbits as IASI-A/B, CrIS and AIRS will provide some understanding of the true potential of MTG-IRS for NWC applications.

Session 3: Nowcasting with UWPHYSRET (P. Antonelli)

- UWPHYSRET (physical retrieval code by P. Antonelli) was used over an extended period from 2007 to 2012 retrieving the atmospheric state and related instability indices (A. Manzato) over the local area of Udine, Italy

- Results compared to radiosonde observations were used to introduce, in cooperation with EUMETSAT, new features to improve further retrieval results:
  - New background (deterministic forecast) and covariance (geographically dependent correlations and flow dependent variances from Ensemble forecast) derived from ECMWF.
  - Surface emissivity in state vector and represented as $\varepsilon \rightarrow \ln[\varepsilon/(1-\varepsilon)]$ (e.g. G. Masiello and C. Serio)
  - New quality control based on combination of convergence rate, saturation, and retrieved emissivity and skin temperature

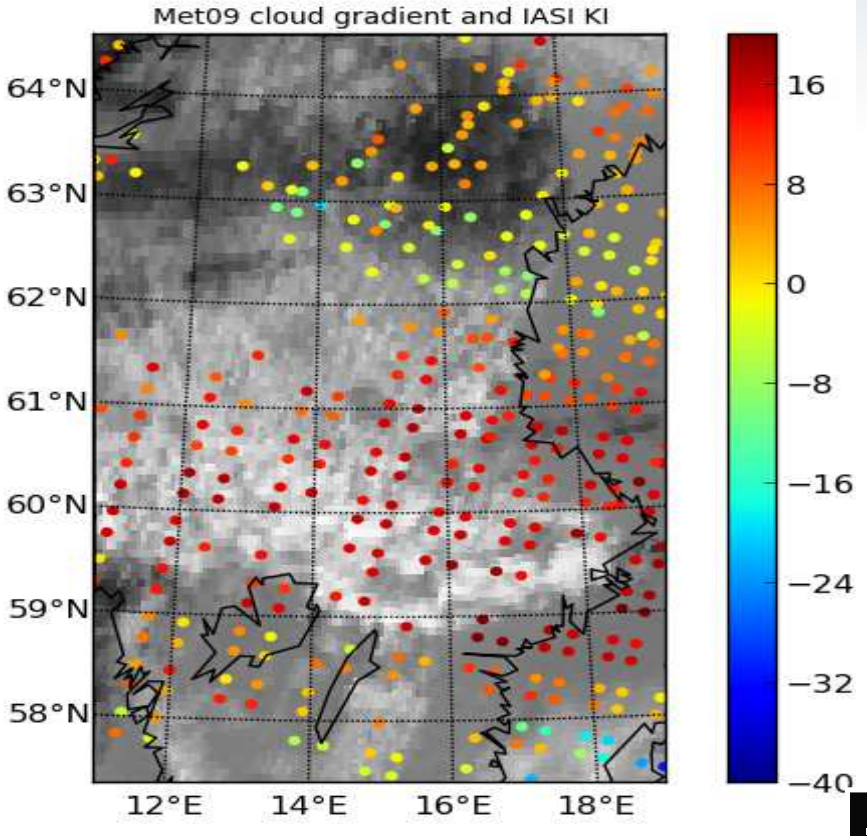
- EUMETSAT implemented UWPHYSRET as the IRS Level 2 Development and Validation Processor (IRS-L2DVP)

- The IRS-L2DVP has been used by EUMETSAT in all following demonstration projects providing the IRS proxy retrieved atmospheric state

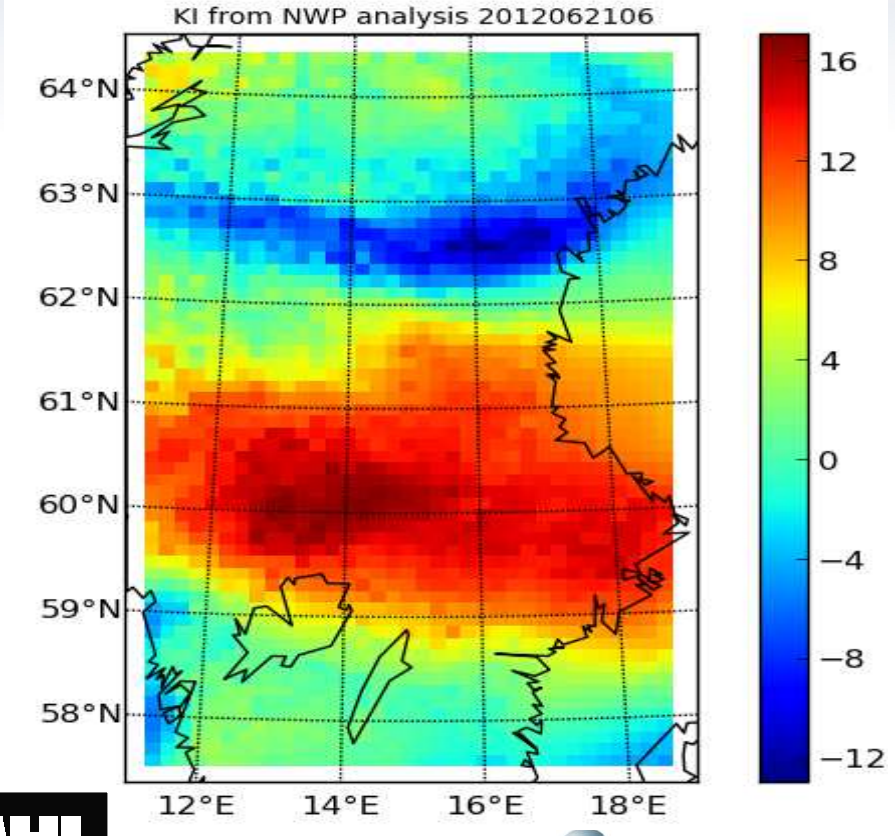
Session 3: SMHI Demonstration Project (H. Sellman)

IRS-L2DVP retrieved atmospheric state as additional input to MESAN - June 21 2012 case study, where convection (mainly shallow) developed over mid-southern Sweden

IRS-L2DVP K Index at 09 UTC



NWP K Index at 06 UTC



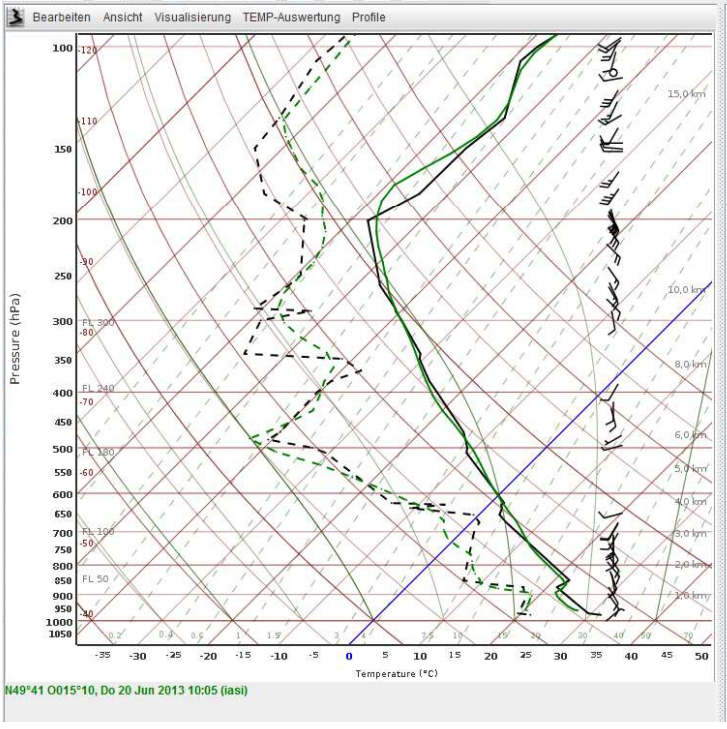
Session 3: Results / Conclusion (H. Sellman, SMHI)

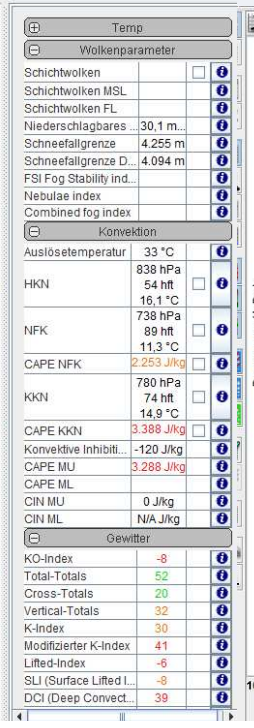
Session 3: DWD Demonstration Project (Ch. Köpken-Watts)

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

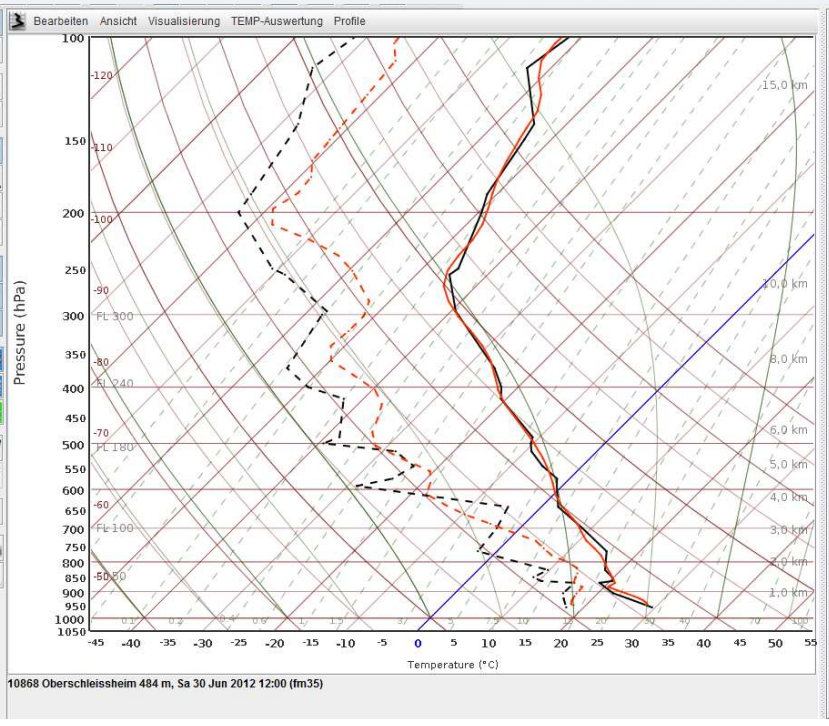
IRS-L2DVP retrieved atmospheric state as additional input to the NinJo workstation for two cases of convective activities over Germany (20 June 2013 and 30 June 2012)

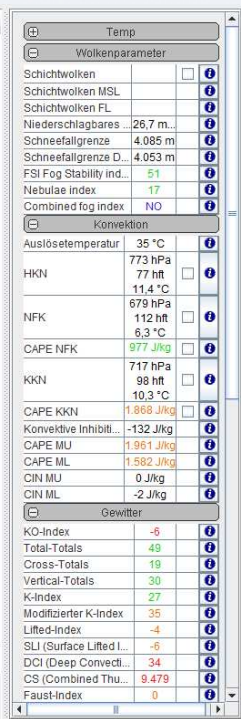
IRS-L2DVP / Radiosounding





IRS-L2DVP / Radiosounding





example 20 June 2013 case

example 30 June 2012 case

Session 3: Conclusion & Outlook (Ch. Köpken-Watts)

Deutscher Wetterdienst
Wetter und Klima aus einer Hand
DWD

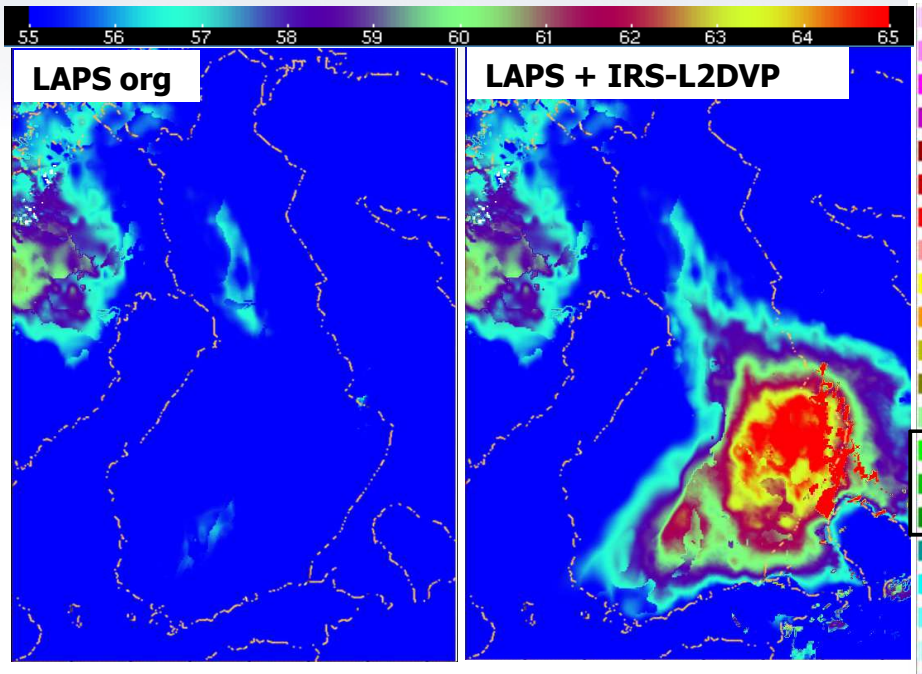
- Promising initial results of IRS-L2DVP using improved setup (ECMWF background,...)
  - First comparison to radiosondes show good agreement for temperature
  - Humidity: possibly a tendency for positive humidity bias?
  - Some questionable features, esp. some spurious low level or surface inversions

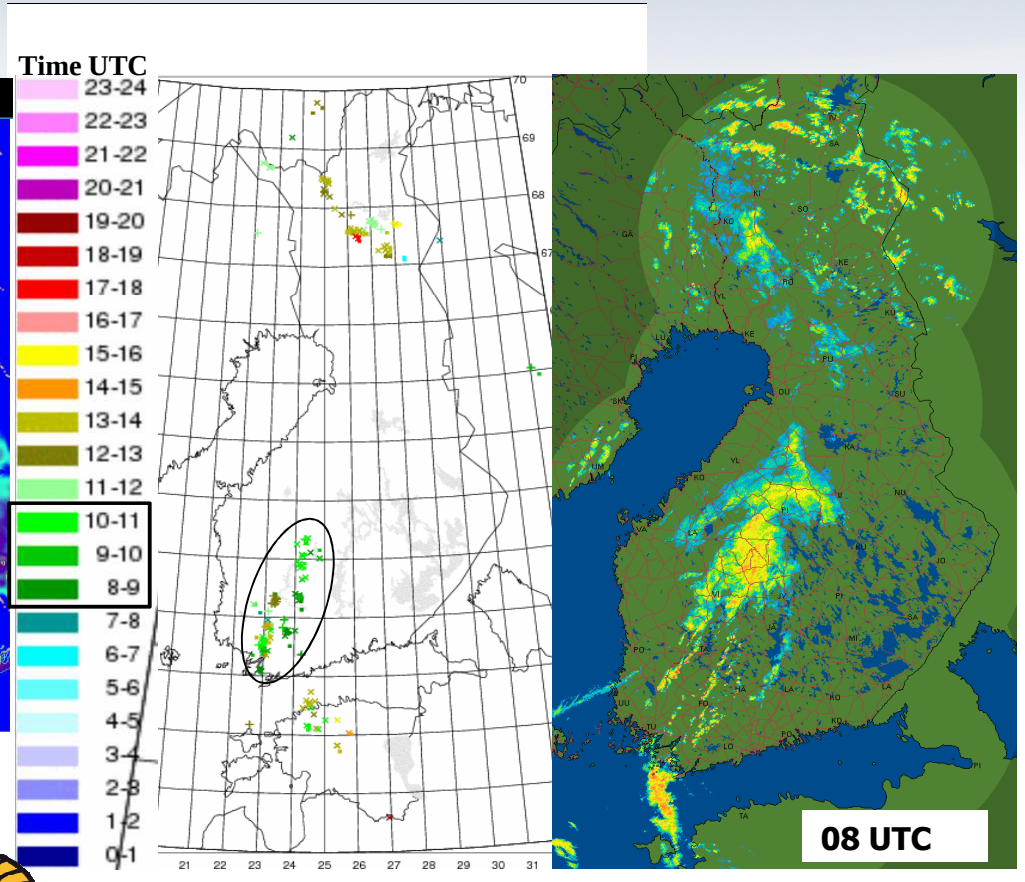
- More detailed evaluation needed (in cooperation with EUMETSAT)
  - Evaluate retrievals together with First Guess profiles
  - Investigation of reasons for faulty retrievals
  - Comparison of retrievals to available model guidance (COSMO-DE, COSMO-DE-EPS)

- Instability information form IRS-L2DVP using IASI (later IRS) shows potential for
  - Observing finer scale structures (on top of NWP information)
  - More precise localized warnings (warning would have improved on 20 June 2013)
  - Earlier indication of risk areas compared to radar

Session 3: FMI Demonstration Project (E. Gregow)

IRS-L2DVP retrieved atmospheric state as additional input to LAPS for two cases of convective activities over Finland (01 June 2012 and 29 July 2012)





TT-index values:

> 50 moderate-severe thunderstorms

> 60 severe thunderstorms

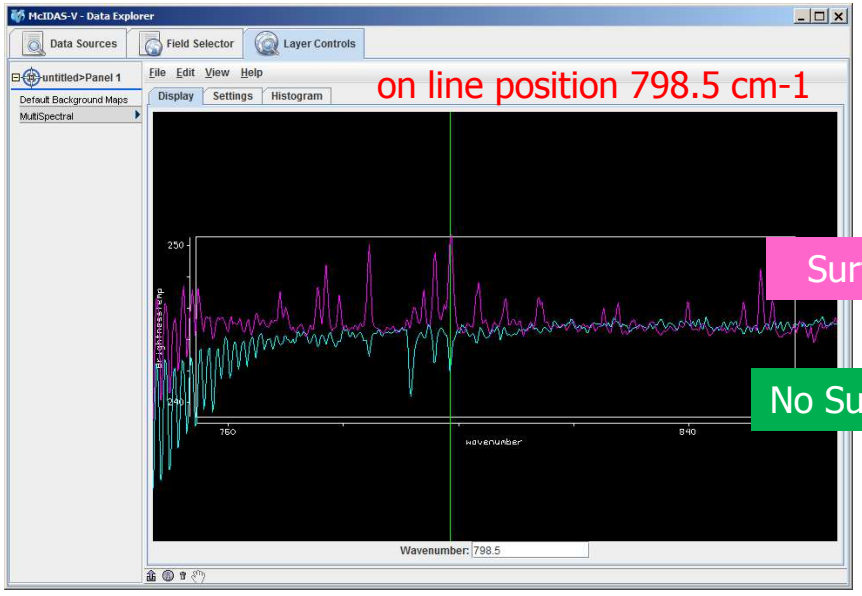
TOTAL TOTALS INDEX, TT = T*850* + Td*850* - 2T*500*

Session 3: Results / Conclusion (E. Gregow)

- Initial results indicated including IRS-L2DVP retrieval in the LAPS system had a neutral to positive impact on the instability indices over Finland
- The position of the analysed instability as indicated by the TotalsTotal index matched better with the actual occurrence of lightning ingesting IRS-L2DVP
- Comparing LAPS runs with and without IRS-L2DVP information to locations were radiosonde information was available indicated consistency, however , near the surface the retrieved temperature profiles frequently had a peculiar shape.
- Overall it is concluded that the IRS-L2DVP profile information has potential to be very useful as there is a lack of 3D information currently going into LAPS
- Open question is if IRS-L2DVP with IRS data will provide the required data quality at high latitudes (impact of long slant pass through atmosphere to be studied)
- Timeliness important – to be at end-user within to 1 hour (threshold – cut-off time) with a goal of 15 minutes

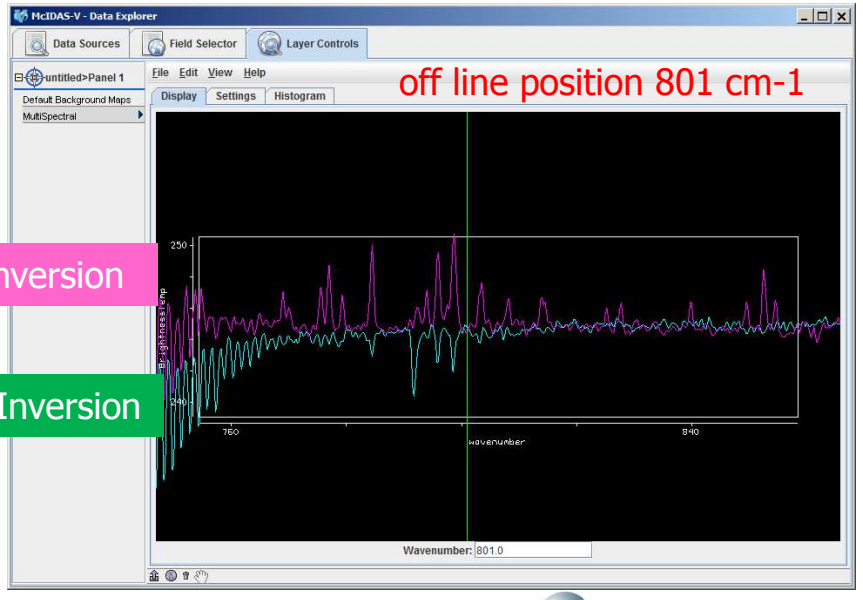
Session 3: Radiance Brainstorming (M. Martinez)

- Surface inversions over east Scandinavia were reported on 16 and 17 January 2013
- The week water vapour line (IASI spectral channel at 798.5 cm^{-1}) within the atmospheric window flips from 'absorpition' to 'emission'
- The difference of radiances in line (798.5 cm^{-1}) and off line (801 cm^{-1}) allows to detect these surface inversions directly from the IASI spectra



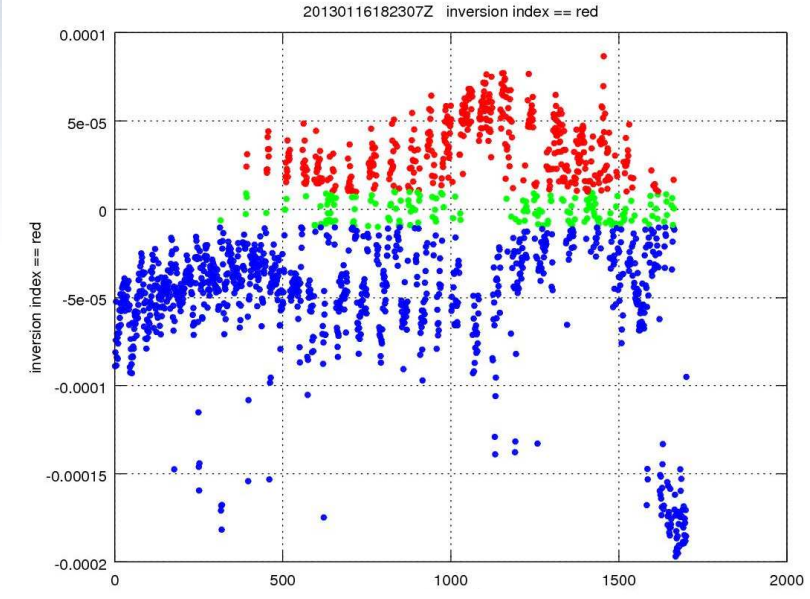
Surface Inversion

No Surface Inversion

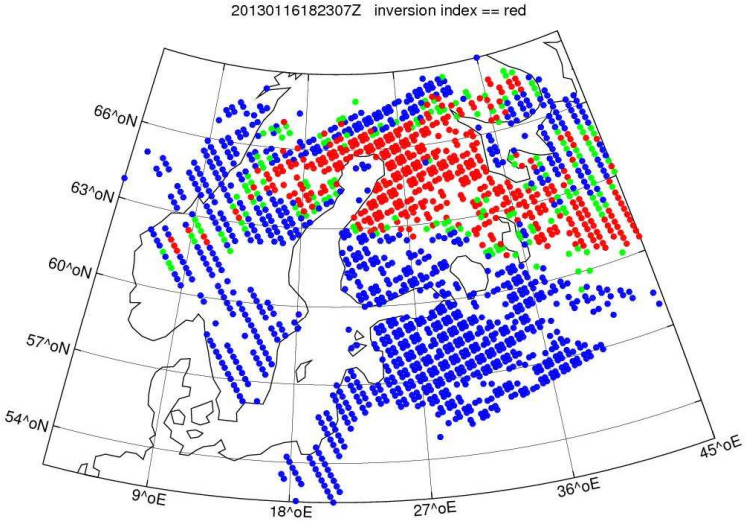


Session 3: Radiance Brainstorming (M. Martinez)

In-line (798.5 cm^{-1}) off-line (801 cm^{-1}) radiance differences 16 January 2013 18:23 UTC



IASI record number



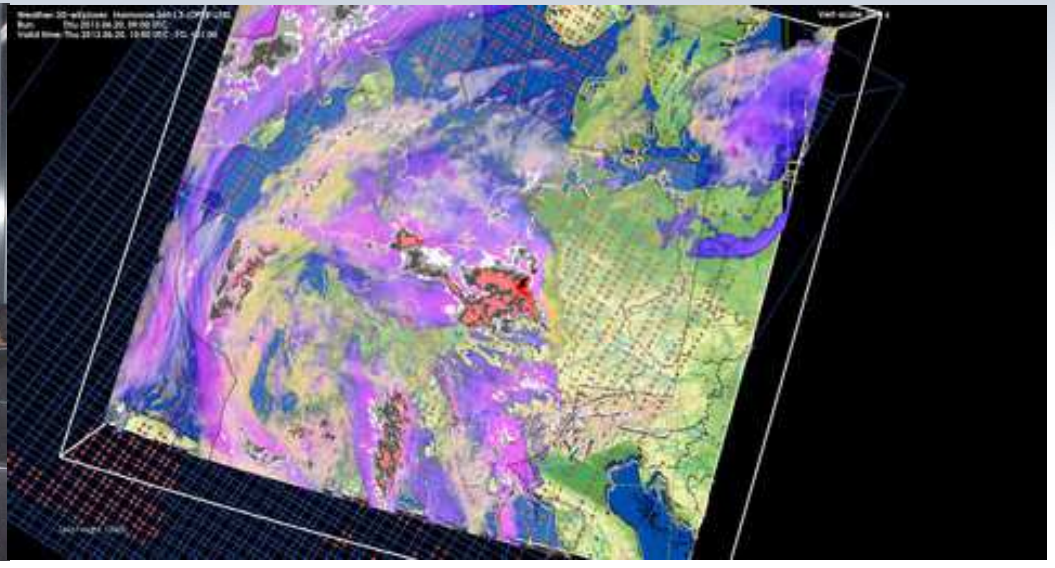
Surface Inversion over Finland

- There is a strong potential to directly use IRS radiance information
- More joint brainstorming between nowcaster and remote sensing scientists to exploit the radiance information in support of nowcasting applications
- There is the risk that important information is not kept after PC compression of IRS radiances, which requires a dedicated assessment

Session 3: 3D visualisation IRS-L2DVP products (F. Debie)

Royal Netherlands Meteorological Institute
Ministry of Infrastructure and the Environment

- https://www.knmi.nl/samenw/w3dx/images/3D-demos/presentation-3D-VIS-IASI-in-W3DX-at-eumetsat/



- IRS-L2DVP products for the 20 June 2013 case, during which a squall line was developing over Europe (same case as assessed by DWD), were ingested into the 3D visualisation tool for a quantitative analysis
- Over ocean moisture (RH and Theta-E) did show a good consistency with the Harmonie
- Over land, especially near surface, some biases specifically for Theta-E were found

Session 4: Nowcasting in 2020 and beyond

- Session 4 was introduced by three presentations:
  - Plans of the NWC-SAF regarding MTG-IRS (M. Martinez, AEMET)
  - Ideas and suggestions for new products fro MTG-IRS (A.C. Fontan, Meteo France)
  - Priority of MTG-IRS essential variables for NWC services (P. Pagano, USAM retiret)

- Session 4 was continued by discussion within three splinter groups on:
  - Identifying improved information from MTG-IRS
  - Anticipating nowcasting in 2020
  - Training and user preparedness

Session 5: Recommendations

- Considerations regarding the operational derivation of L2 products at Day-1
  - Confirm quality of L2 products derived from the geo orbit over high latitudes (Scandinavia)
  - Prepare early for quality monitoring including calibration&validation activities
  - Deliver L2 with a threshold timeliness of 1 hour, trying to achieve the goal of 15 minutes
  - Generate L2 products also over clouds
  - Generate AMVs from clear sky moisture information
  - Include ozone as product in support of Potential Vorticity field analysis
- Promoting user awareness of opportunities provided by MTG-IRS
  - Continue Demonstration Projects using multi-LEO observations as IRS proxy
  - Involve additional operational users, possibly ESSL (Croatian and Slovenian services already confirmed)
  - Investigate on direct use of radiances (RGBs) including possible impact of PC compression
  - Explore synergy with the other MTG missions
- Prepare early operational users of MTG-IRS data and derived products
  - Ensure development of easy accessible data objects and data access (fast and easy use)
  - Identify and link partners for user preparedness (capitalise on WMO ' Guideline for Ensuring User Readiness for New Generation Satellites)
  - Prepare effective training material

Conclusion

- The IRS-NWC brainstorming workshop on 25-26 July 2013 is considered as a successful begin of information exchange between the operational Nowcasting user community and EUMETSAT responsible for MTG-IRS data and products
  - Continuation is needed to ensure an early return on investment put into MTG-IRS
  - A second IRS-NWC brainstorming workshop is anticipated to take place in 1 to 1.5 years

- Interested user planning to use IRS for NWC applications, and interested to participate in an IRS-NWC Demonstration Project should contact EUMETSAT
  - Stephen Tjemkes (stephen.tjemkes@eumetsat.int)
  - Rolf Stuhlmann (rolf.stuhlmann@eumetsat.int)

Thank you for your attention