Influence of IASI Data on the forecast of ET events

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Overview

The experiments

Global results

Results for ET

Case study: Hanna
Motivation

Heterogeneous in-situ data coverage in ET events

High density observation network beneficial during ET to describe transition from small to large scales?

Improvement of moisture processes in the model by additional water vapor observations during ET? => downstream development (flooding)
Measurement of radiances by satellites

Monochromatic radiance, measured at the satellite based measurement system, is connected to variables like temperature and moisture by radiation transfer equation

\[ R_v = (I_0)_v \tau_v(z_0) + \int_{z_0}^{\infty} B_v[T(z)] \left( \frac{d\tau_v(z)}{dz} \right) dz \]

- \((I_0)_v\): Irradiance from the surface at height \(z_0\)
- \(\tau_v(z_0)\): Vertical transmission from height \(z_0\) into space
- \(B_v[T(z)]\): Corresponding profile of the Planck function
- \(T(z)\): Vertical temperature profil

weighting function
IASI
(Infrared Atmospheric Sounding Interferometer)

Developed by the french space agency CNES
swath: 2000 km, 30 scan positions, global coverage within 12 hours
height: 837 km
1 orbit: 99 min
~ 14 orbits / day
IASI
(Infrared Atmospheric Sounding Interferometer)

IASI is a hyperspectral measurement instrument
⇒ infrared: 645 – 2760 /cm with a spectral sampling of 0.25 / cm;
IASI provides information on temperature and humidity,
horizontal resolution 12 km at nadir
No cloud affected channels

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IASI weighting functions

IASI operational: 68 channels for temperature

Channels:
Measurement frequencies

Weighting function:
Determines from which layers the radiation is emitted to space
Global model ARPEGE
(Action de Recherche Petite Echelle Grande Echelle)

Resolution: T538, stretching factor: 2.4, 60 layers in hybrid coordinates (surface up to 0.1 hPa)

Data assimilation: 4D-Var with two non-stretched minimisation loops

Close cooperation with ECMWF
Schematic of 4D-Var data assimilation

In Meteo France ARPEGE (similar to ECMWF IFS)
Overview over the experiments

Time period: 1 – 20 September 2008; contains 3 ET cases with probable impact on Europe / Mediterranean: Gustav, Hanna, Ike

Experiments with the data assimilation system

• Control experiment DENS: operational data density $\times 4$

• NOIASI: denial of all IASI data

• IASIWV: 9 additional water vapor channels for IASI
Global impact: High density

500 hPa relative humidity, 24 h forecast

dens oper

Positive global impact of high density

significant for ~ 48 h; in tropics ~ 84 h
Global results

Global impact: Denial of all IASI data

500 hPa temperature, 24 h forecast

|$\Rightarrow$ Impact of denial negative on both extratropic hemispheres

|$\Rightarrow$ positiv in tropics (already corrected, not shown)

|$\Rightarrow$ significant for South: ~ 60 h, North: ~ 24 h, Tropics: ~ 48 h

Positive impact of IASI on northern and southern extratropics and weak signal in tropics also found by Guidard et al. (2010)
IASI temperature and water vapor channels assimilated in the experiments

64 channels for temperature
9 channels for humidity
Global impact: IASI water vapor channels

850 hPa relative humidity, 24 h forecast

- Significant positive impact on Southern hemisphere for ~ 24 h
- Neutral from 24 h on in Northern hemisphere and Tropics
- Significant positive impact for North and Tropics from 0 – 24 h (not shown)
Impact of additional water vapor channels over the Atlantic and Europe

Change of the absolute error
Variable: total energy

\[ E(x) = |f_{\text{fcst}}^{\exp} - a_{\text{EC}}| - |f_{\text{fcst}}^{\text{ctrl}} - a_{\text{EC}}| \]
Influence of additional water vapor data: Atlantic

\[ |F_{\text{exp}} - A_{EC}| - |F_{\text{ctrl}} - A_{EC}| \]\n
over Atl total energy: 000 - 102; mean = 26654.2927 J kg\(^{-1}\)
Results for ET

Influence of additional water vapor data: Atlantic

Short range: 0 – 30 h

Medium range: 36 – 66 h

Longer range: 72 – 102 h
Results for ET

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Slightly improved forecasts when water vapor channels are added around ET times
Influence of additional water vapor data
Europe

Results for ET

$|F_{\text{exp}} - A_{\text{EC}}| - |F_{\text{ctrl}} - A_{\text{EC}}|$ over Eur total energy: 000 - 102; mean = -23553.4509 J kg$^{-1}$

Initialisation time from 20080901 - 20080920 every 24 hours
Influence of additional water vapor data: Europe

Short range: 0 – 30 h

Medium range: 36 – 66 h

Longer range: 72 – 102 h
Results for ET

Influence of additional water vapor data: Europe

Short range: 0 – 30 h

Medium range: 36 – 66 h

Longer range: 72 – 102 h

Initialization date
200 hPa horizontal wind >= 30 m/s (shaded)
surface pressure (blue contours), 200 hPa geopotential (black contours)
Case study Hanna

4 September 2008 00 UTC

background error correction

analysis error correction

dens

iasiwv
Slightly improved correction of background and analysis error
Case study Hanna

4 September 2008 00 UTC

**background error correction**

- Smaller analysis errors in Hanna's outflow

- 200 hPa horiz. wind >= 30 m/s (shaded)
- sfc press (blue), 200 hPa geopotential (black)

**analysis error correction**
Difference propagates into the midlatitudes

Diff: 200 hPa horizontal wind iasiwv - dens

Case study Hanna
Case study Hanna

Smaller errors in the analysis do not yield smaller forecast errors

Total energy RMSE difference

Fcst initialized on 4 Sep 2008 00 UTC

Smaller fcst errors in

- midlatitude trough from 24 h
- tropical cyclones Hanna and Ike
Case study Hanna
Influence on midlatitudes

Smaller forecast errors during ET of Hanna expand in scale

Total energy RMSE difference
Fcst initialized on 4 Sep 2008 00 UTC
Improved representation of jet does not yield strong improvement in surface pressure forecast

102 h forecast: 200 hPa horizontal wind (shaded), mslp (blue contours), 200 hPa geopotential (black contours)

Case study Hanna

Forecast iasiwv

Diff: 200 hPa horizontal wind iasiwv – dens (shaded)
Summary

Global impact:

- High density: Positiv over the whole globe, strongest impact on southern extratropics
- Denial of all IASI data: Negativ on both extratropic hemispheres
- IASI water vapor channels: Positiv on southern extratropics; weakly positive on northern extratropics and tropics for a very short time

Impact of water vapor channels during ET:

- Notable influence (mainly positive) for initialization around ET times
- Better correction of background and analysis error
- Improvement of forecasts can be partly assigned to improved representation of ET events, however improvements are small
Summary

Global impact:

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Merci pour votre attention!
Influence of additional water vapor data
Atlantic

\[
\frac{\text{RMSE}(F_{\text{exp}} - A_{\text{EC}}) - \text{RMSE}(F_{\text{ctrl}} - A_{\text{EC}})}{\text{RMSE}(F_{\text{ctrl}} - A_{\text{EC}})} \times 100 \%
\]

over Atlantic total energy: 000 - 102; mean = 0.015158*100 %
Influence of additional water vapor data: Atlantic

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Longer range: 72 – 102 h
Influence of additional water vapor data
Europe

\[
\frac{\text{RMSE}(F_{\text{exp}} - A_{\text{EC}}) - \text{RMSE}(F_{\text{ctrl}} - A_{\text{EC}})}{\text{RMSE}(F_{\text{ctrl}} - A_{\text{EC}})} \text{ over Eur total energy: } 000 - 102; \text{ mean } = -0.0015687 \times 100 \%
\]
Influence of additional water vapor data: Europe

Short range: 0 – 30 h

Medium range: 36 – 66 h

Longer range: 72 – 102 h