Assimilation of visible channels in a convective-scale data assimilation framework

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Deutscher Wetterdienst
We are running **ICON EDA** in our Routine since Jan 2016

- 40 Members each with 40km global resolution and 20km NEST over Europe
- 1 deterministic 13km/6.5km
- **EPS forecasts** 40 Members 7 Days + 1 Deterministic
- **Output for convective-scale EDA/EPS**

**Global Hybrid Ensemble - Variational, 3h cycle**
Hybrid Methods: EnVAR Scores

WMO verification against observations
- lead-time: 24h
- valid-time: 12UTC
- level: 850hPa

Temperature forecast quality NH 850hPa 24h

RMSE: The Lower the better

4D-VAR Class

Date

Roland Potthast
Hybrid Methods: EnVAR Scores

WMO verification against SYNOP
lead-time: 48h
valid-time: 12UTC

2017+2018

NH

TR

SH

Operational forecast Synop 48h

RMSE: The Lower the better

lead-time

48
KENDA for COSMO & ICON

4D-LETKF for Convection Permitting Model

COSMO-DE & ICON LAM Resolution 2.2km Central Europe
Why talk about data assimilation of solar channels in the context of boundary layer meteorology?

In contrast to WV channels: *visibility of low clouds*

Low clouds are connected to boundary layer processes

- Convective initiation: temporal extension of the warning horizon
- More accurate representation of low stratus

Feedback on boundary layer variables

- Cloud-boundary layer coupling
- Improvement of screen-level variables through better radiation
Example: Observations & model equivalents

Observations

Model equivalents
Observations

- Cloud-sensitive imager channels in the visible spectral range (0.6 µm)
- Reflectance: percentage of in-falling solar radiation reflected by earth's surface & clouds
- SEVIRI instrument on MSG (0°/0°)
- Temporal resolution 15 minutes
- 5km x 3km satellite pixels (over German COSMO domain)
Model equivalents

**Observation operator**

- **Fast** 1D-RT radiative transfer method MFASIS (Scheck, 2016)
- Makes **operational assimilation** of visible channels conceivable
- Implemented to **RTTOV** (A. Fernandez & O. Stiller; NWP-SAF)

Model variables

- Temperature
- Pressure
- Specific humidity
- Cloud water
- Cloud ice
- Snow
- Cloud cover
- Scattering angle

Look Up Table

- Integrated optical depth
- Effective particle radius
- Albedo
- Sun zenith angle
- Satellite zenith angle
- Scattering angle

Simulated satellite image
Why assimilate visible channels?

- Information on cloud cover
- Added value to WV channels: visibility of low clouds
- No mixed temperature-humidity signal: only cloud-sensitive

- < 5% upper-air observations in convective-scale DA are moisture-sensitive
- Up to 50,000 additional obs/day

- Primary goal is improvement of cloud cover
- Through correlations, dynamics and physics improvement of moisture fields, precipitation, radiation, screen-level variables
Why are solar channels interesting in the context of boundary layer meteorology?

- In contrast to WV channels: visibility of low clouds
- Convective initiation: temporal extension of the warning horizon
- Low stratus
- Cloud-boundary layer coupling
- Improvement of screen-level variables through better radiation
Can we correct for the miss and false alarm in the deterministic run?

Proportion of clouds in ensemble

Before assimilating SEVIRI

Observation

Deterministic run
All-Sky data assimilation

Case study: Analysis 06 UTC

Proportion of clouds in ensemble

With SEVIRI

Proportion of clouds in ensemble

Miss is generated in both det. Run & ensemble using SEVIRI-VIS; false alarm is eliminated
All-Sky data assimilation

Case study: First Guess 07 UTC

With SEVIRI

Proportion of clouds in ensemble

ENN FG

BETTER

7:00 UTC

Observation

Deterministic run

Die Korrektur bleibt in der Vorhersage bestehen
(I) Assimilation experiments
Assimilation experiments: Configuration

- Convective period (May / June 2016)
- COSMO-DE (Δx=2.8 km)
- KENDA routine set-up including LHN
- Superobbing 5 x 7 Pixel
- Assimilation 1/hour at analysis time
- Observation error
- Localisation (hloc=35km, vloc=10)

- Conventional obs + Mode-S (reference)
- Conventional obs + Mode-S + SEVIRI-VIS (experiment)
Cloud cover

Reflectance RMSE (FG, SEVIRI)

- **Mit SEVIRI-VIS**
- **Ohne SEVIRI-VIS**

Cloud cover BIAS (FC, SYNOP)

Reflectance verified against SEVIRI-Vis and cloud cover verified against SYNOP
Moisture fields

Relative humidity verified against radiosondes

12-hour forecasts
06,12,18,00
31.05.2016 to 13.06.2016

With SEVIRI-VIS
Referenz

RH RMSE (FG, TEMP)

Better with SEVIRI-VIS

RH RMSE (FC, TEMP)

RH BIAS (FG, TEMP)
Convective precipitation

Precipitation rate FSS (FC, Radar)

0.1mm/h (Skala 11 GP)

5mm/h (Skala 11 GP)

Lead Time

Verified against derived radar rain rates
Screen-level variables verified against SEVIRI-VIS

12-hour forecasts
06,12,18,00
31.05.2016 to 13.06.2016
Error growth during forecast

Reflectance (RMSE, BIAS; SEVIRI)

Precipitation rate (FSS; Radar)

Verified against derived SEVIRI reflectance and radar rain rates
Inverse Modeling
An introduction to the theory and methods of inverse problems and data assimilation

Gen Nakamura
Roland Potthast