Evaluation of IFS surface radiation from the ground and satellite

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Overview

• Monitoring of radiation biases (BSRN)
• Attribution of 2m temperature biases (SYNOP, BSRN, CM SAF)
• Evaluation of cloud/radiation predictability (CM SAF)
• Scale-dependence of cloud/radiation forecast skill (CM SAF)
• Summary
Baseline Surface Radiation Network
BSRN station Lindenberg (Germany)

Surface downward solar flux, LIN [LAT: 52.2; LON: 14.1], +072 h

Shortwave

SW bias ~0 Wm$^{-2}$

LW bias -5 Wm$^{-2}$

e.g. Cabauw (Netherlands)
Lindenberg (Germany)
Palaiseau (France)
Toravere (Estonia)
Tateno (Japan)
Florianopolis (Brazil)

5-15 Wm$^{-2}$ underestimation of LW flux except Minami-Torishima (Pacific)

0-15 Wm$^{-2}$ overestimation of SW flux

Surface downward longwave flux, LIN [LAT: 52.2; LON: 14.1], +072 h

Longwave

SDEV = 29.8
BIAS = 4.4

SDEV = 13.8
BIAS = -5.7
2m temperature, bias, DJF 2017-18
Total cloud cover, bias, DJF 2017-18

TCC, RUN=12, STEP=060, ME (%), expv=1

00UTC

TCC, RUN=12, STEP=072, ME (%), expv=1

12UTC
T2m Bias DJF 2016-17 00UTC, dependence on cloud error
T2m Bias DJF 2016-17 00UTC, dependence on cloud error

RMSE = 1.99 K
ME = -0.84 K

Weighted contribution to total error
Bias in downward solar radiation at the surface, NDJ 2017-18

SSRD, RUN=00, STEP=036, ME (W/m²), expv=1

SYNOP

CM SAF
Solar flux downward, bias NDJ 2017-18 12UTC, dependence on cloud error
Solar flux downward, bias NDJ 2017-18 12UTC, dependence on cloud error

Weighted contribution to total error

RMSE = 73 Wm$^{-2}$

ME = 25 Wm$^{-2}$
Longwave flux error: dependence on cloud error (BSRN Lindenberg)

-10 Wm\(^{-2}\) lw flux bias when TCC is correct

→ bias in cloud type / cloud base height?
Solar radiation predictability
Cloud and solar radiation forecast skill

Buizza and Leutbecher (2015)

ECMWF Newsletter No 143 (2015)
Forecast skill horizon of downward solar radiation

Skill horizon (ACC<0.3)  

Observed variability (sub-monthly)
Seasonal changes in large-scale error characteristics

- Cloud effect too weak: $r=0.82$
- Cloud effect too strong: $r=0.57$
Normalized downward solar radiation (7 Oct 2016)
Large area of closed-cell convection
Cloud fraction: forecast 00 UTC +12 h

2016/10/07
12 UTC
Aqua / MODIS - 7 Oct 2016
Aqua / MODIS - 7 Oct 2016
K. Lonitz
- Sc typically have low LWP → weak signal in microwave imagers
- Cloud albedo sensitive to LWP at small values → strong signal in solar radiation
- Effective radius also important for cloud albedo

M. Ahlgrimm (this Workshop)
- IFS underestimates Sc cloud fraction and LWP
- Relationship between solar radiation and grid-scale LWP affected by choice of FSD
Solar radiation - activity
Standard deviation of obs and fcst (2012-2016) - activity
Difference and ratio of standard deviations (activities)
Conditional bias:

- Cloud radiative effect too weak when less cloudy
- Cloud radiative effect too strong when cloudier
Evolution of activity with lead time

Day 2 – Day 1

Day 10 – Day 1
Scale-dependence of forecast skill
Downward solar radiation, anomaly correlation

ACC at 16 km

ACC at 80 km
Downward solar radiation, anomaly correlation

ACC at 16 km

ACC at 300 km
Downward solar radiation, anomaly correlation

ACC at 16 km

ACC(300 km) – ACC(16 km)
Summary

• BSRN: consistent biases in sw (+) and lw (-) in IFS across regions
• SYNOP downward solar: good agreement with satellite data
• Wintertime T2m biases at least partly due to lack of cloud cover/optical depth
• Subtropical South Atlantic has shortest forecast skill horizon for cloudiness
• Skill already low at day 1 → assimilation issue?
• Substantial drop in skill from 300 km to 16 km, more than in the Southern Ocean
Forecast skill horizon for downward solar radiation

Skill horizon (ACC<0.3)  Annual precipitation
Forecast skill horizon for downward solar radiation

Skill horizon

Topography