

Improved parametrization of the boundary layer in Harmonie-Arome (focusing on low clouds)

Wim de Rooy

Project CRIME: Cloud Representation, Improvement and Evaluation in Harmonie

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Henk Klein Baltink, Jan Fokke Meirink, Hylke de Vries, Stephan de Roode (TUD)*

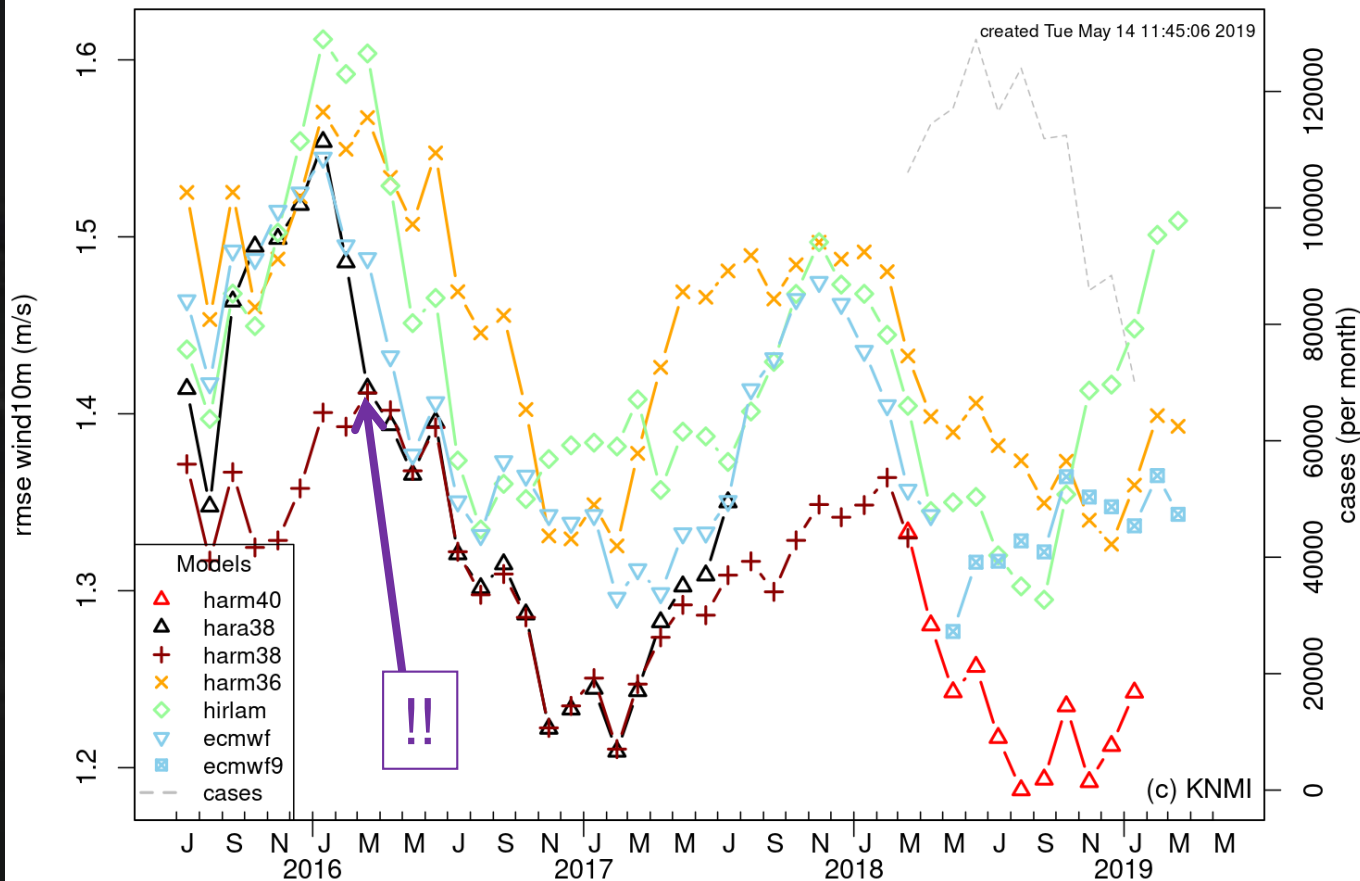


*Other contributions from: Peter Baas (Alertness project), Geert Lenderink,
Sander Tijm, Bram van 't Veen, Bart van Stratum*



First, back in time

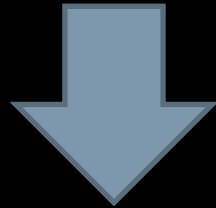
rmse wind10m | selection: NL
 aggregation: 5month [center] leadtime [3...12] dayhour [0...23]



From “one of the models” to the best → HARATU turbulence!

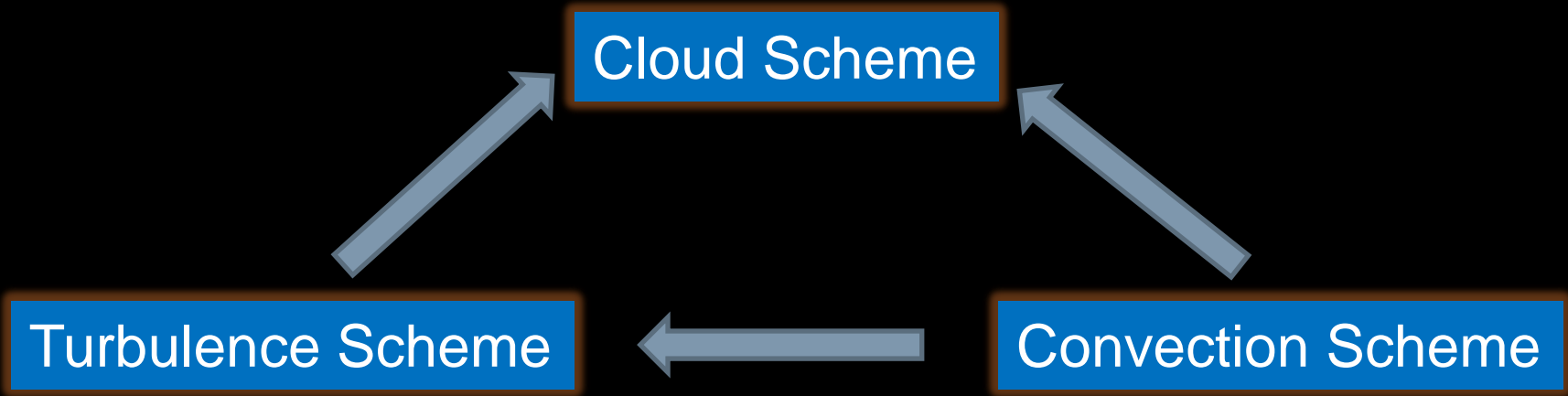
Most important deficiency in HARMONIE-AROME from cy38 onwards:

Underestimation of low clouds
and
overestimation cloud base height (aviation!)



KNMI project CRIME:

Cloud Representation, Improvement and
Evaluation in Harmonie



Integral approach

Develop and optimize tightly coupled parametrizations together!

Substantial modifications to cloud, turbulence and convection scheme

Based on:

Theory

Cloud scheme: Correct derivation thermodynamics
Turbulence scheme: similarity theory

LES ↔ 1D

Turbulence/convection: energy cascade
Convection: improved convective transport
Etc. etc.

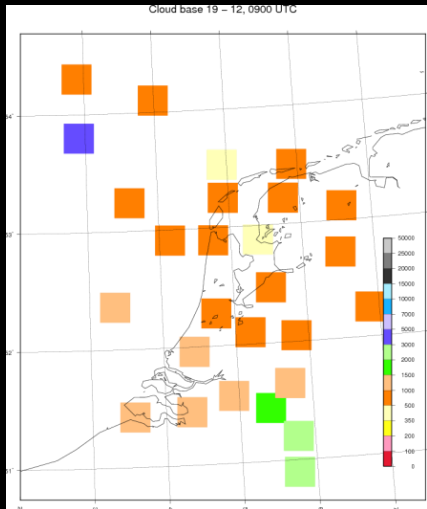
3D

Optimization (uncertain parameters)

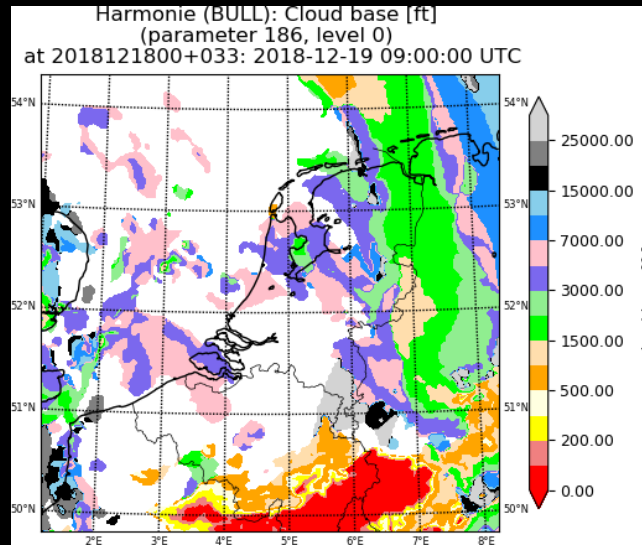
Results of the new configuration

Example underestimation low cloud cover and overestimation cloud base height (aviation!)

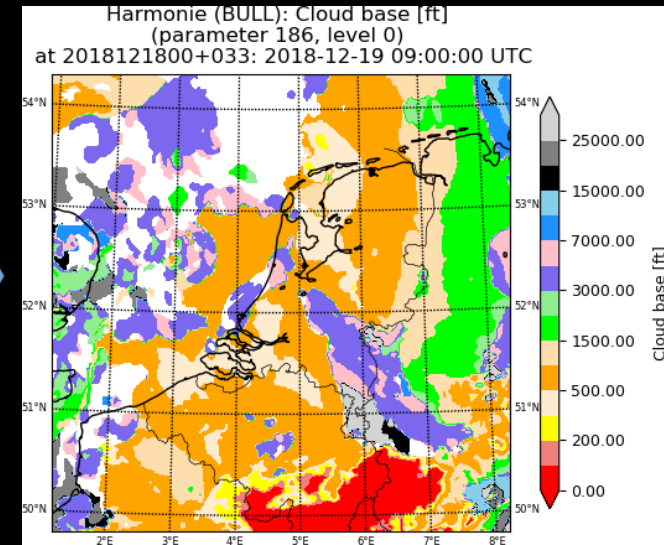
Observed cloud base height



Harmonie cy40



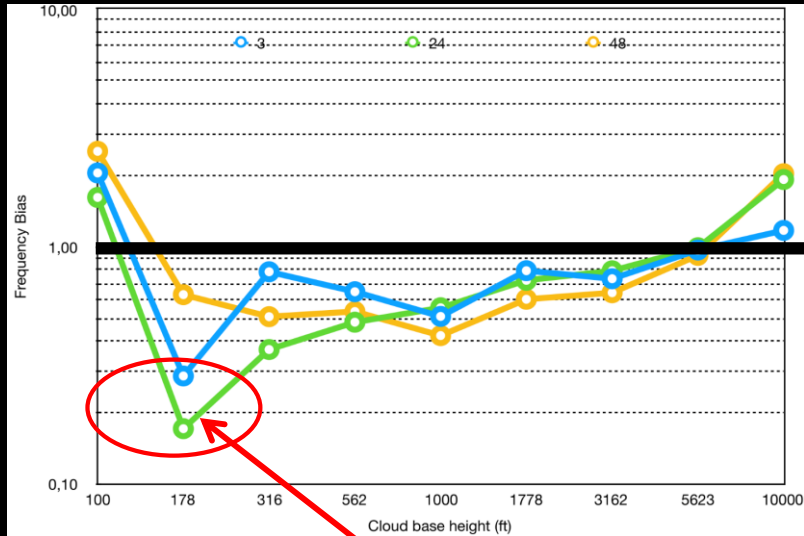
Harmonie cy40 New



Example 19th of December 2018. Cloud base height in feet!

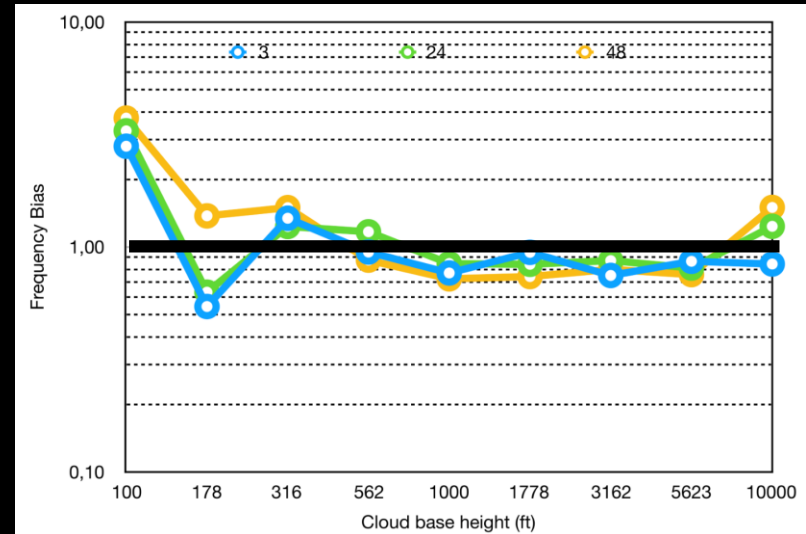
Impact on cloud base height climatology: frequency bias December 2018

Harmonie cy40



Optimal

Harmonie cy40 New



Optimal

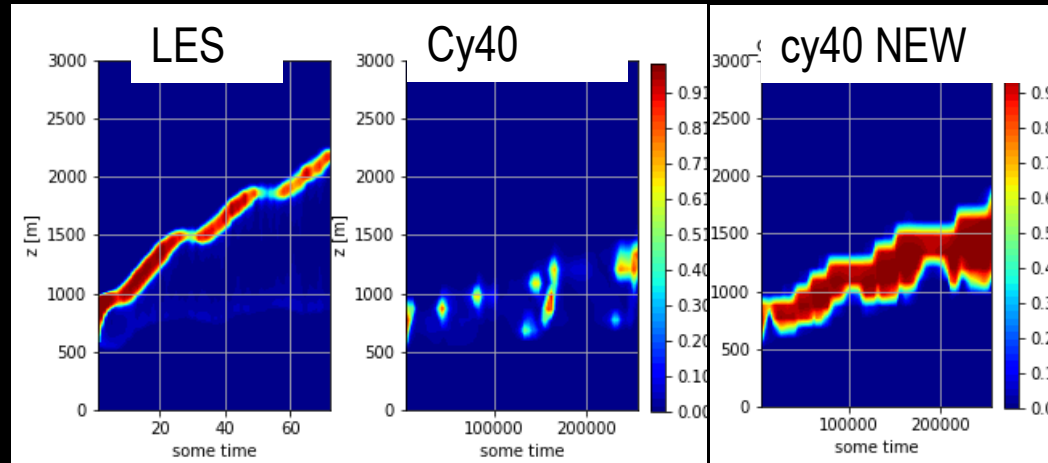
Less than 20% of observed number of cases!



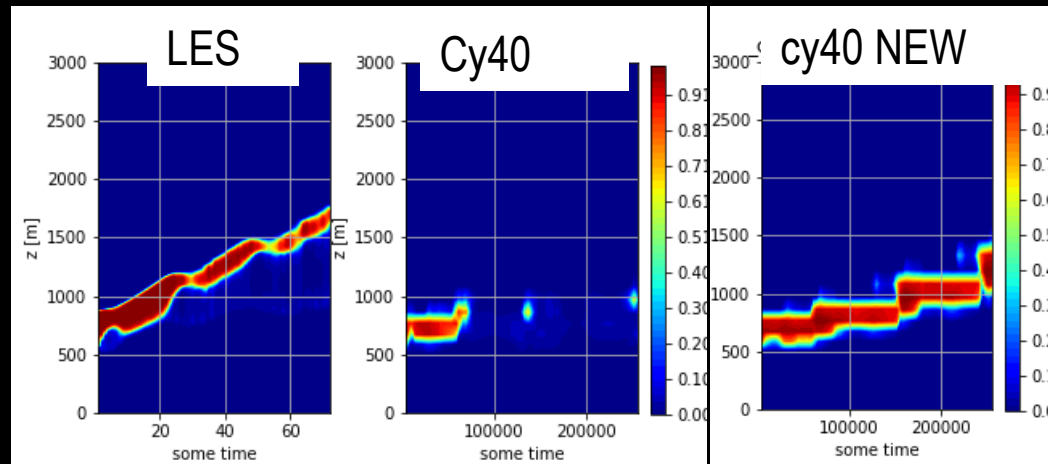
Large improvement (low) cloud base climatology.

CRIME modifications → preservation inversion strength
→ prevent dissolving stratocumulus

ASTEX FAST case
Cloud fraction

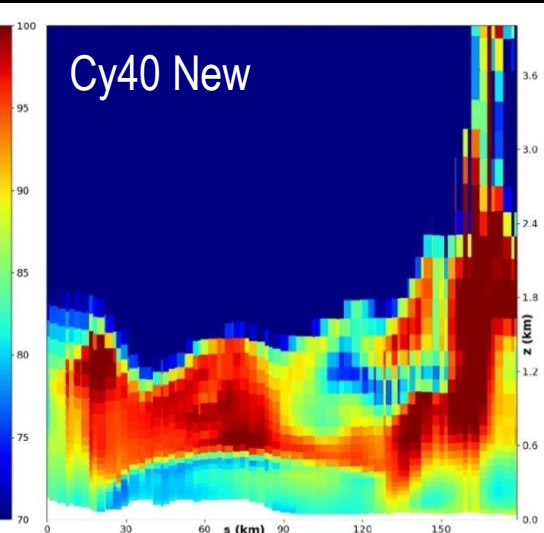
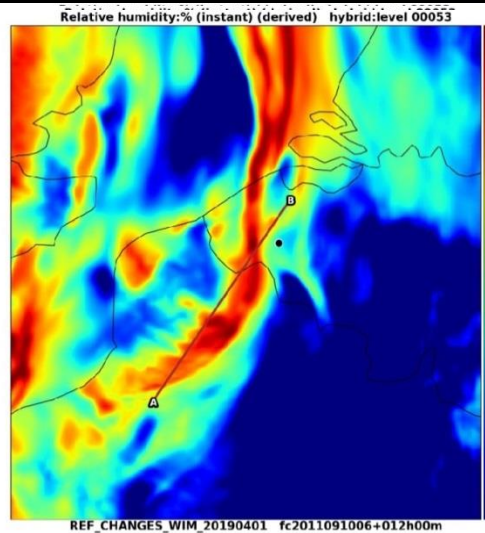
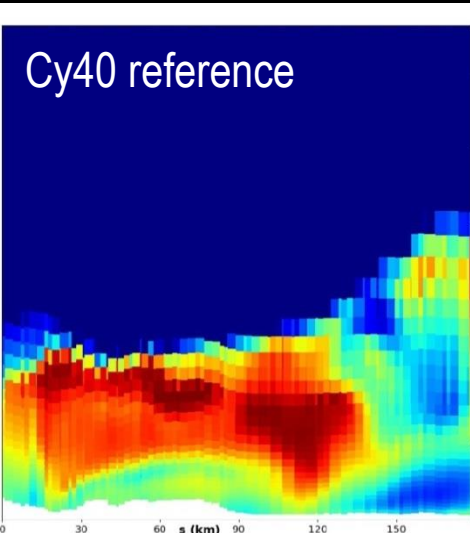
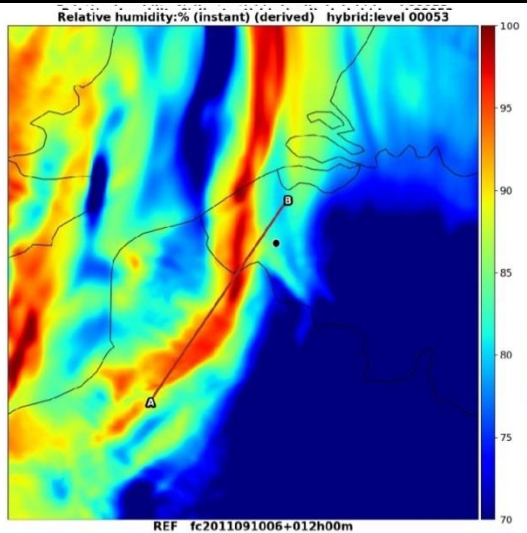


ASTEX slow case
Cloud fraction



CRIME modifications → preservation inversion strength → resolved convective precipitation

Several cases where convective, heavy rain is triggered only with CRIME modifications



Relative humidity

Cross-section

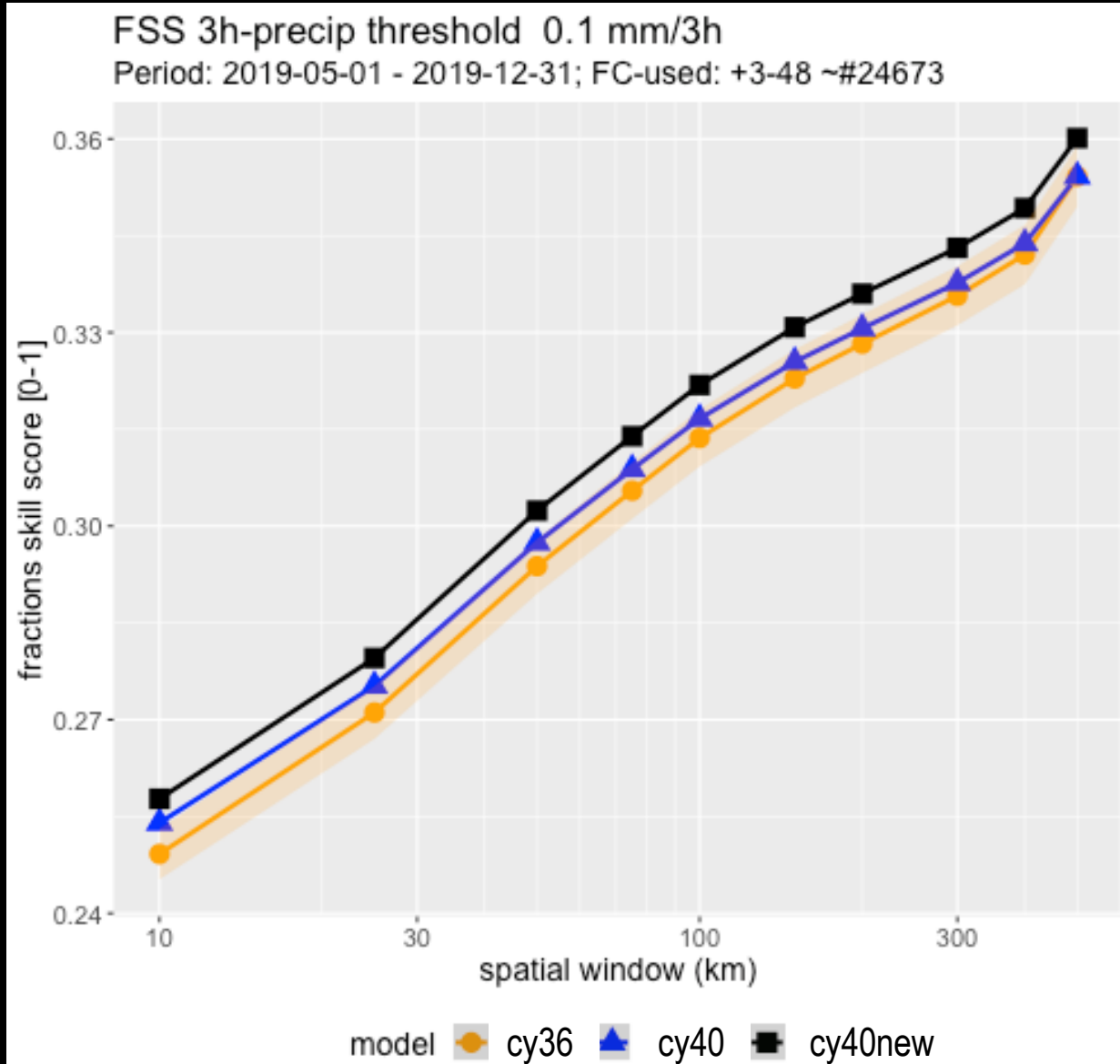
Relative humidity

Cross-section

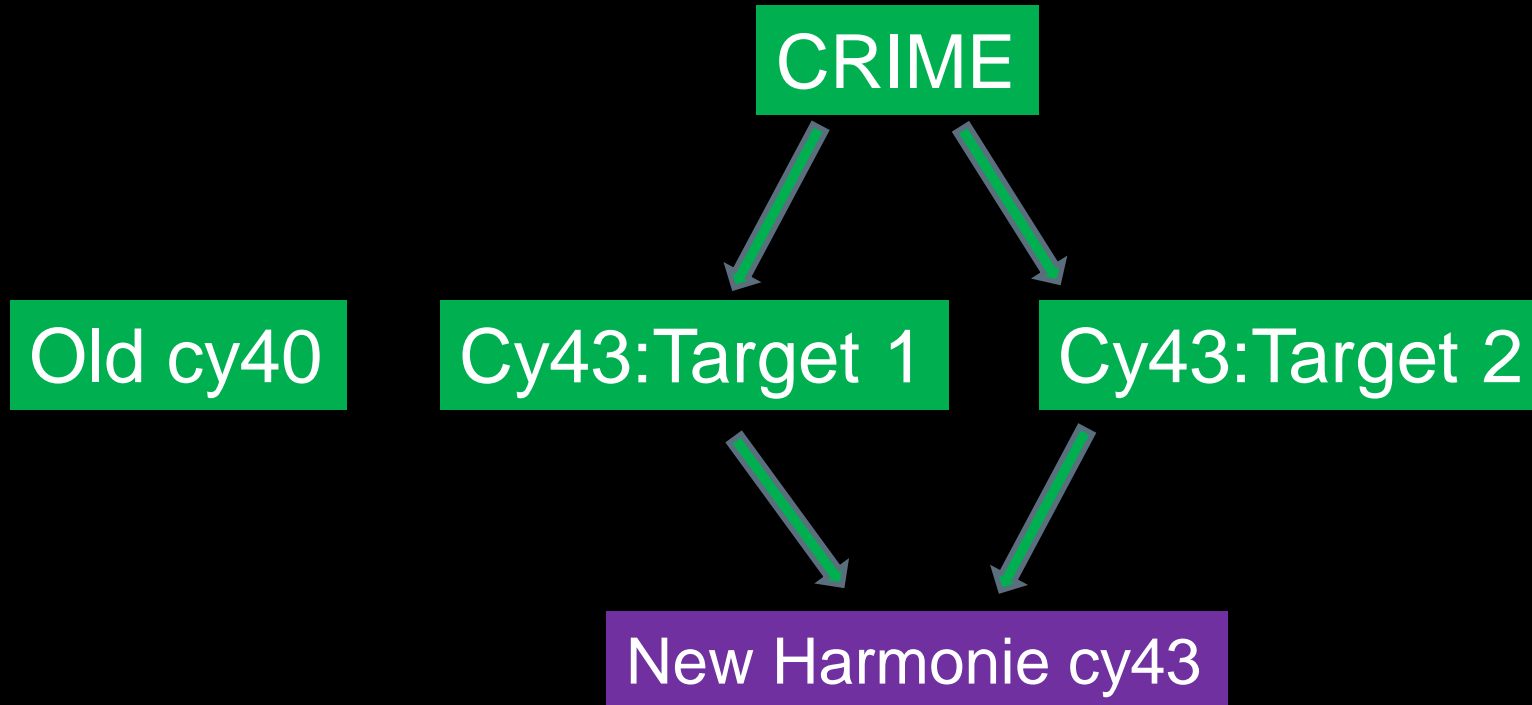
Verification precipitation

Fraction Skill Scores using calibrated radar

- Ten months period
- Rain threshold 0.1 mm/3h
- Forecasts from +3 up to +48h



Now: Definition new Harmonie cy43 for all Hirlam countries



Summary

- Strong feedback between boundary layer schemes demands an integral approach
- Substantial changes to turbulence/convection/cloud scheme based on theory, process studies (LES), optimization.
- Improvement especially on clouds and precipitation. Long validation period thanks to KNMI parallel CRIME-run. Good (e.g. wind) results are kept.
- All modifications included in new (default) Harmonie-Arome cy43. Also the new Harmonie Climate model!
- Building a permanent validation system for cloud parameters based on combination of cloudnet and satellite observations.
- Papers: *Improved parametrization of the boundary layer in Harmonie-Arome* (in preparation QJRMS). Another paper focusing on cloud validation.



**Thanks
Questions?**



Cloud evaluation

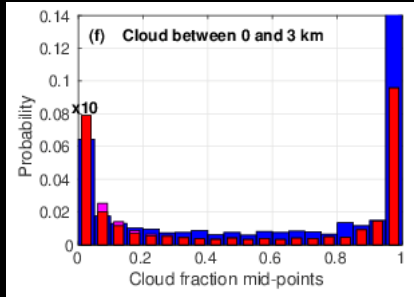
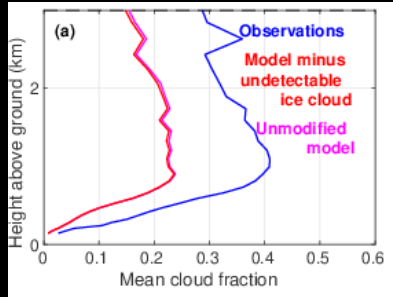
Harmonie

Harmonie cloud simulator

LES

Cloudnet Remote sensing
Cabauw, Juelich,.....

Satellite: FSS, correlation?



Cloudnet consistent with Harmonie resolution

