# HARATU(update)

## HArmonie with RAcmo TUrbulence

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**HARATU:**

- Arguments
- Theory
- Case and statistics

**HARATU update:**

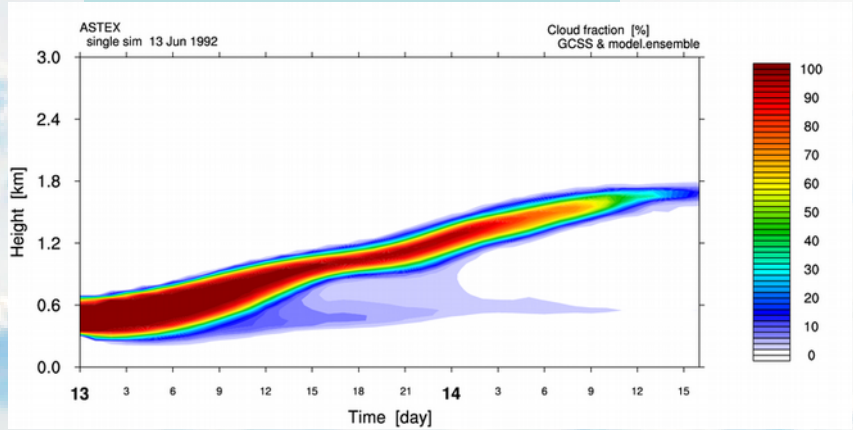
- Arguments
- Theory
- Case and statistics

**Discussion**

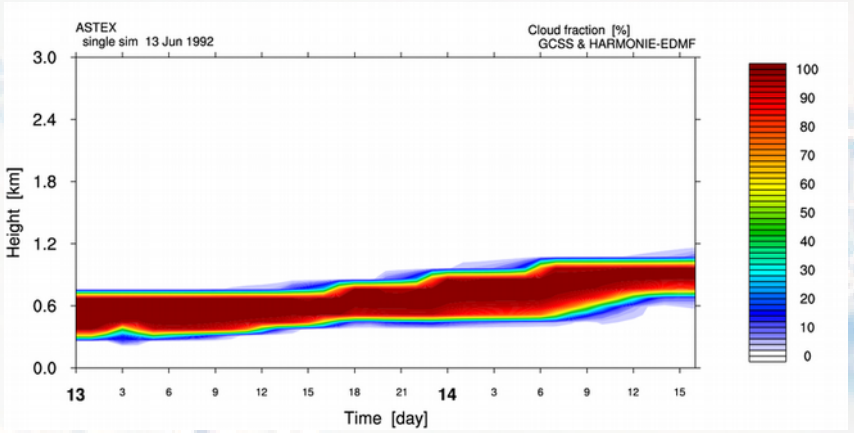
# Arguments: Why changing the turbulence scheme?

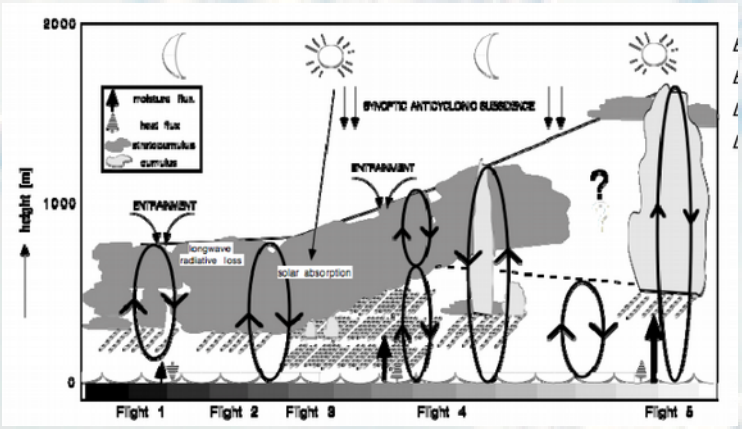
ASTEX intercomparison case. Rising and breaking stratocumulus above sea

Cloud cover “observed“




Harmonie model (CBR, edmf)



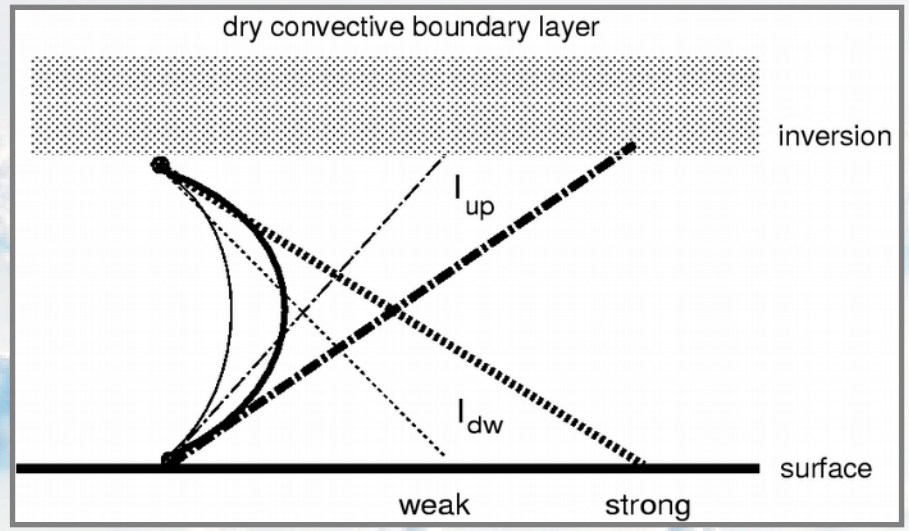

**Turbulence scheme produces not enough top entrainment!**

**Link to operational experience!:**

- **Too low cloud base**
- **Too much stratus (fog)**
- **Too low boundary layer height**

# Haratu theory

Integral length scale formulation for weakly stable to unstable conditions
Lenderink & Holtslag QJRMS 2004




$$l_{up} = \int_0^z f(Ri)dz$$

$$l_{dw} = \int_z^h f(Ri)dz$$

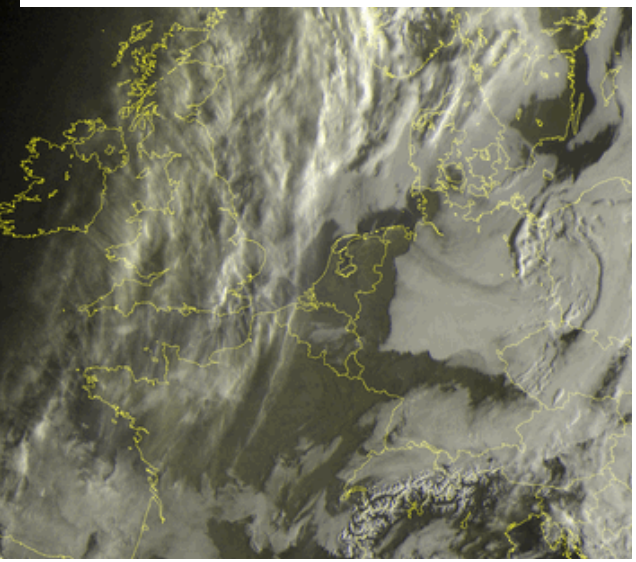
$$\frac{1}{l} = \frac{1}{l_{up}} + \frac{1}{l_{dw}}$$

Main differences with CBR:

- integral length scales formulation
- all stability corrections included in length scales
- TKE at half levels (top entrainment can be better controlled)
- numerically robust (smooth)
- contribution from mass flux to small scale turbulence

⇨ More top-entrainment

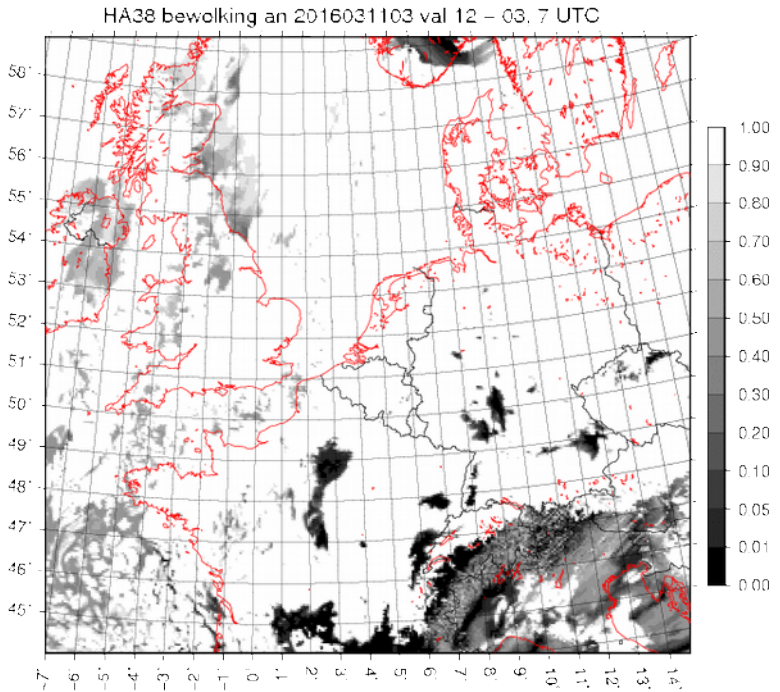
# Case illustrating large impact HARATU on Cloud cover

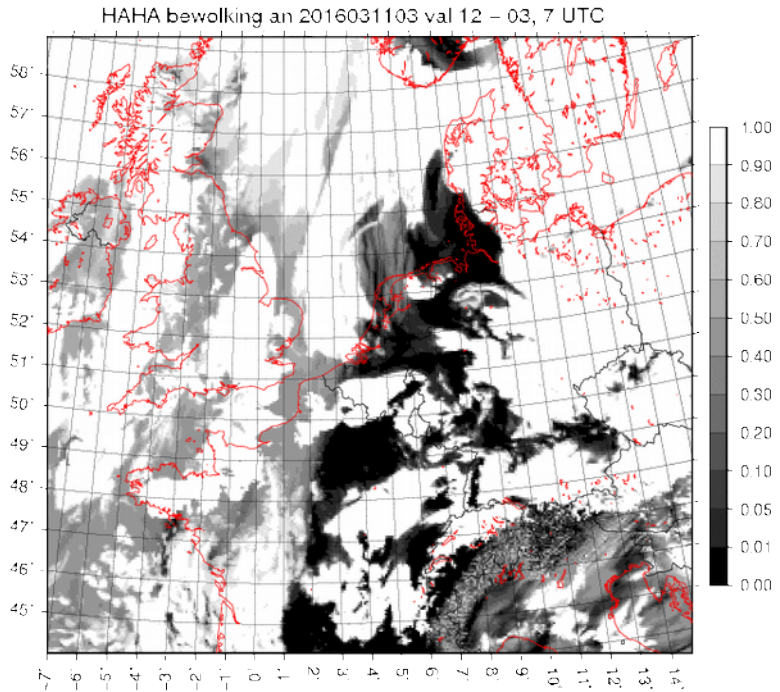


Satellite

**Impact turbulence**

Harmonie CBR → HARATU

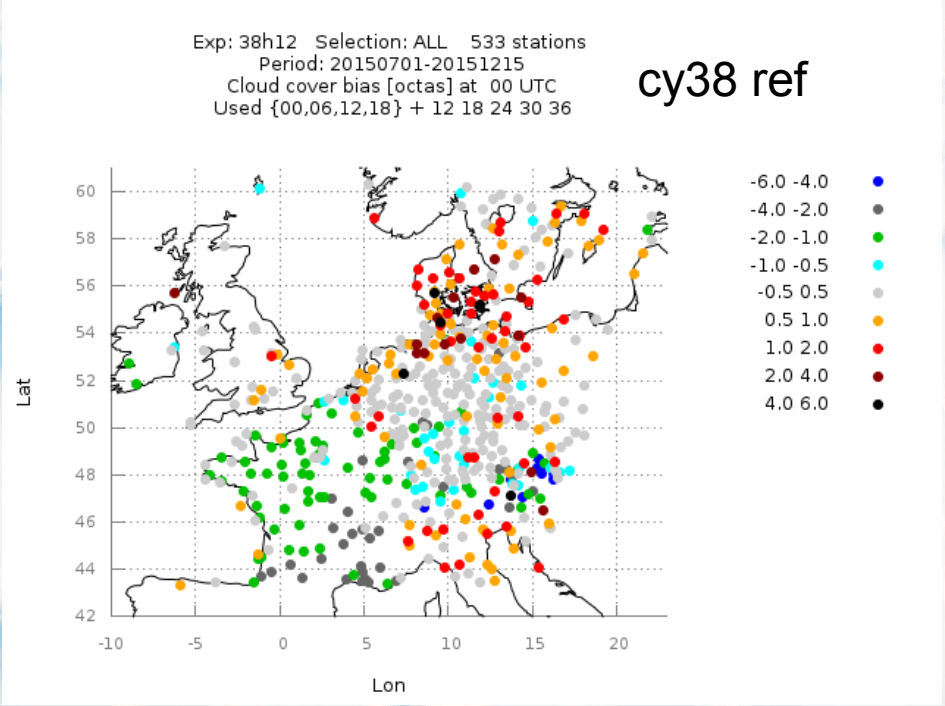


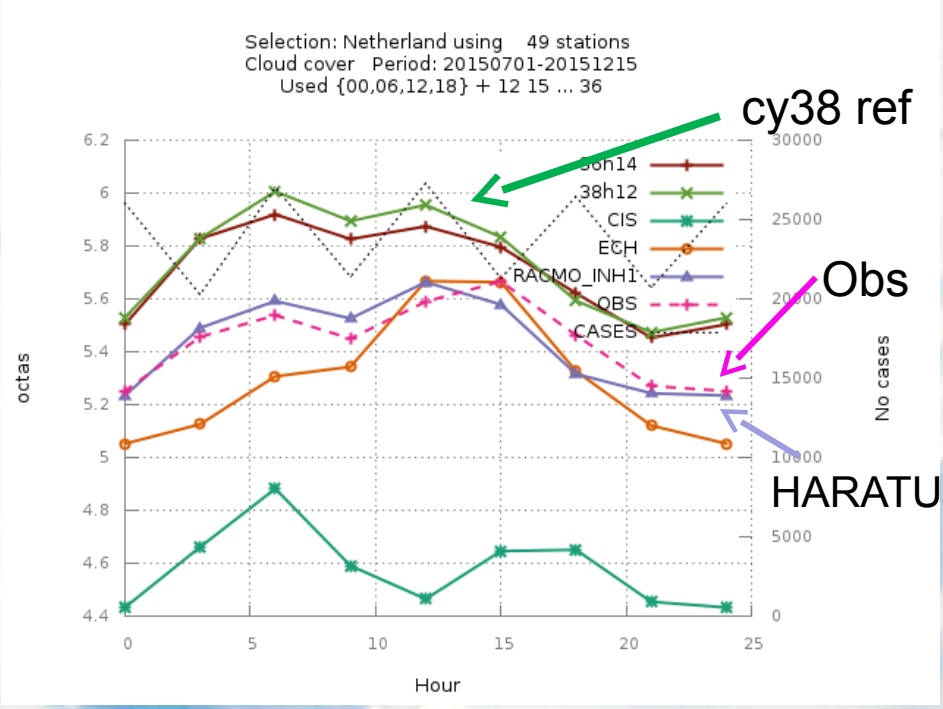
# Statistics Haratu
(July-December 2015)

## **Cloud cover**: Less clouds. Clear improvement for most countries

### Domain dependence cc bias




### Diurnal cycle of cc in Netherlands




Observations in France?

For NL cc very good

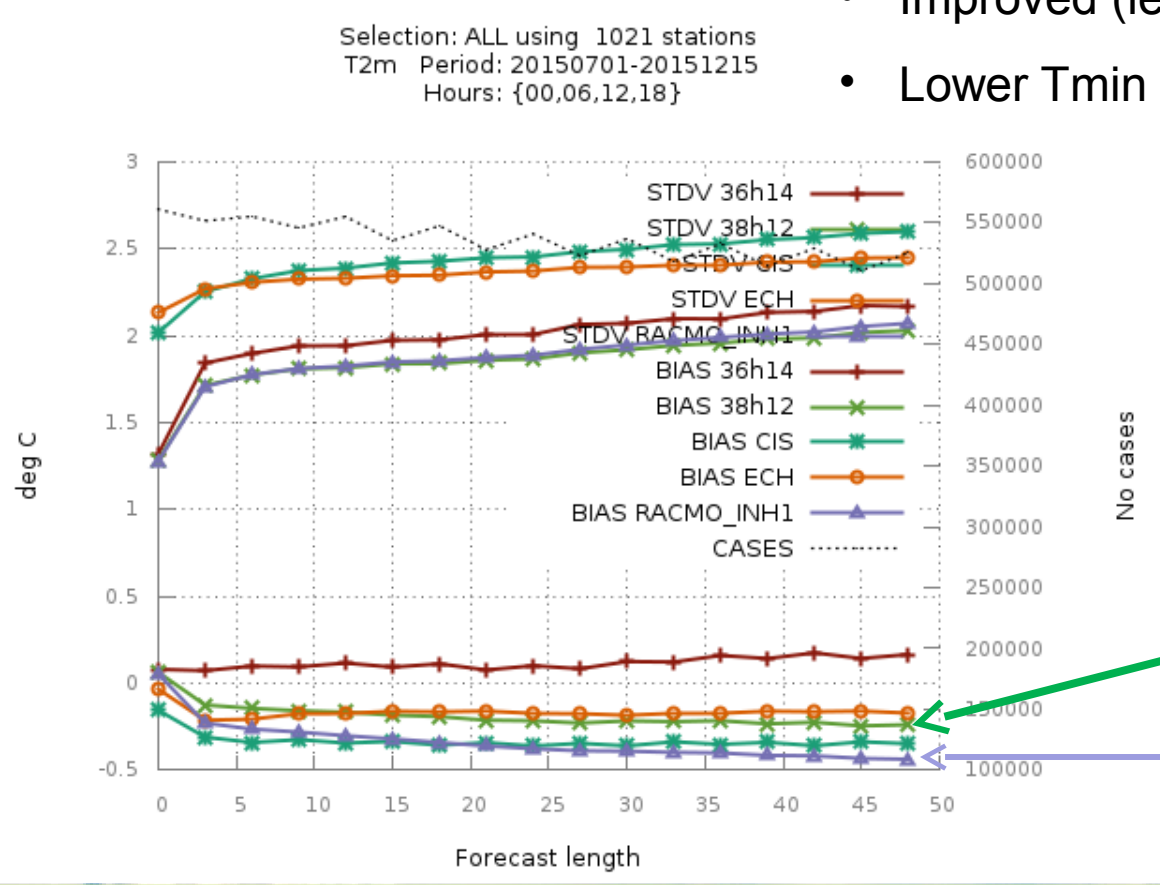
Important: Verification against Cloudnet and MSG (underway)

# Statistics Haratu
(July-December 2015)

**Humidity** (q2m): Generally a small impact

**Temperature** (T2m):

- Increase in negative bias due to lower Tmin.
- Negative T2m bias increases from virtually 0 in summer to clearly negative in winter
- Improved (less) cc but worse Tmin -> micro.?
- Lower Tmin can lead to formation fog



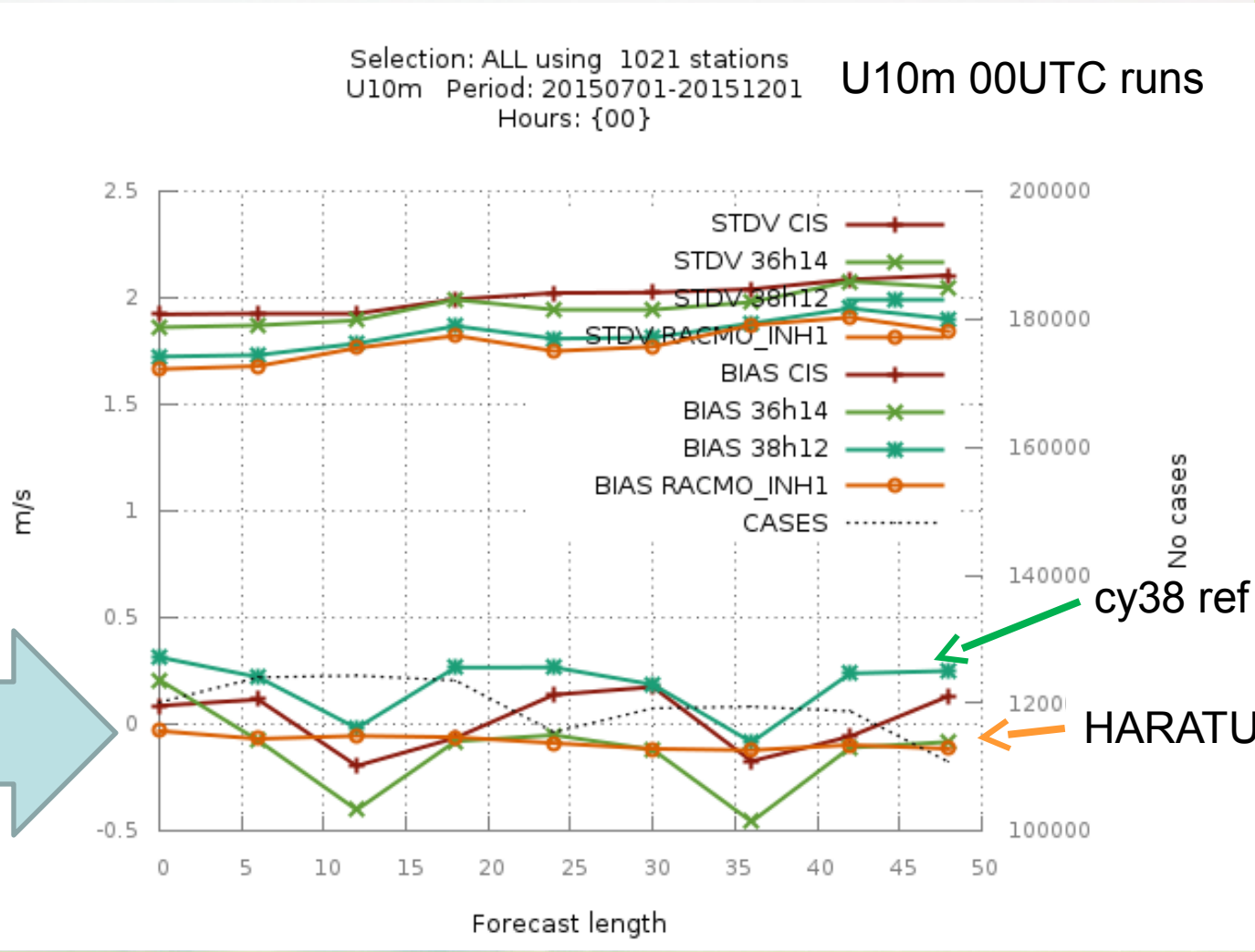

cy38 ref

HARATU

# Statistics Haratu
(July-December 2015)

## **Wind speed**: clear improvement

- positive wind speed bias becomes (overall)≈0 (domain dependent
- improved scores against scatterometer (sea)
- much better representation of diurnal cycle

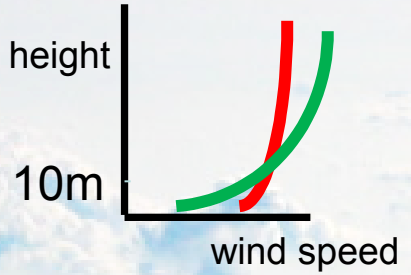



But.....

# Arguments Haratu update

Zooming in on the (known) problem: Slightly stable, high wind speed conditions

Evaluation against Cabauw 213m high tower observations




High wind speed stable conditions

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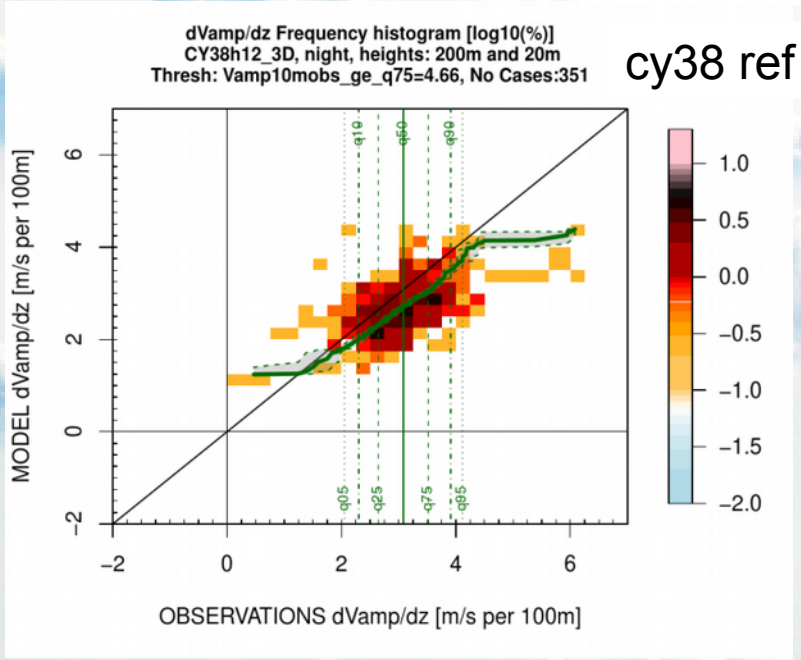
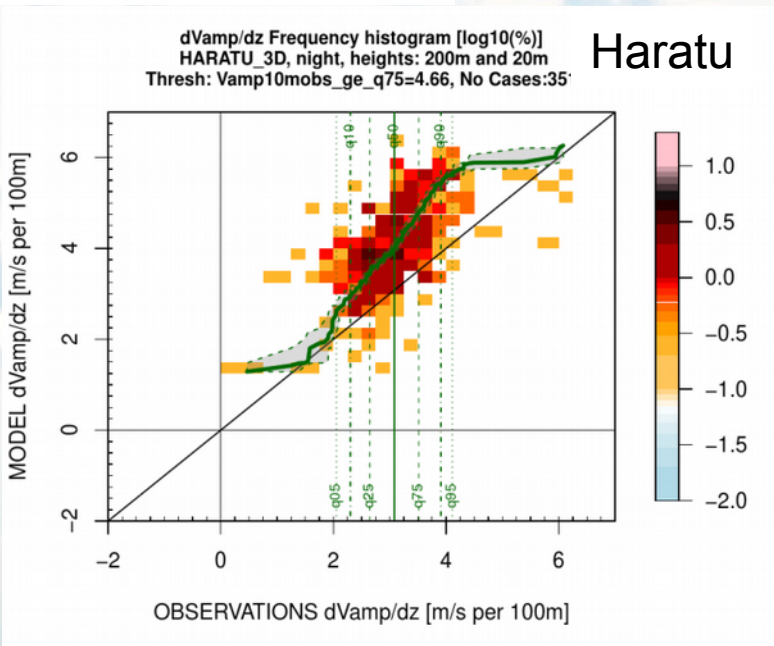



Haratu




too less mixing => too low u10m &
too high u higher up

# Haratu update theory

Increase mixing in high wind speed weakly stable conditions

Adaptations (smooth, continuous impact):

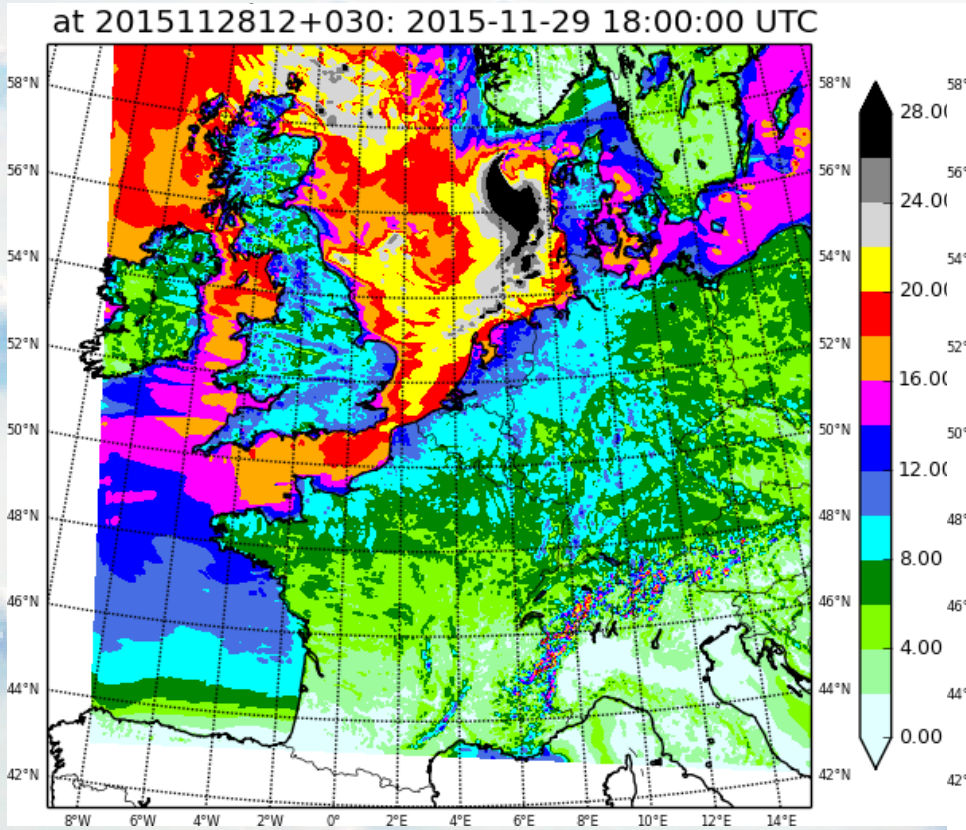
- Increase mixing in neutral conditions (small overall increase in 10m wind speed)
- change in Prandtl number and dependency on Ri in accordance with original paper
- changes depending on wind stress affecting high wind speeds situations over land

Overall result:

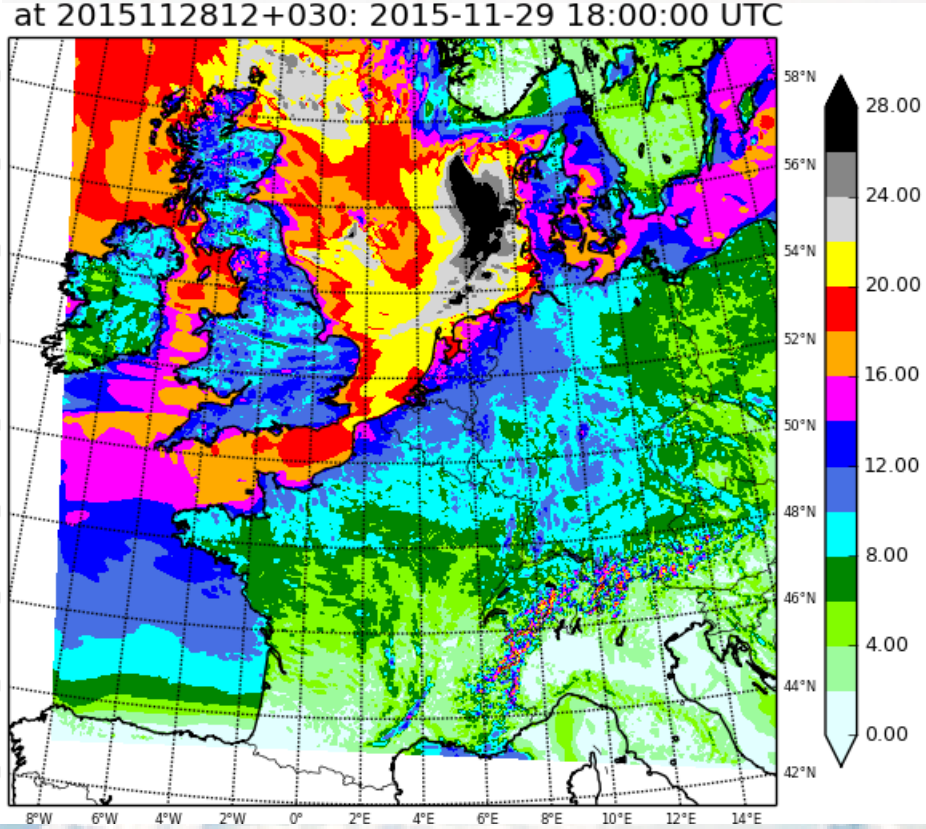
- slightly more mixing near the surface
- considerably more mixing at intermediate heights

# Impact Haratu update on a storm case

HARATU




HARATU Update



# Statistics Haratu update

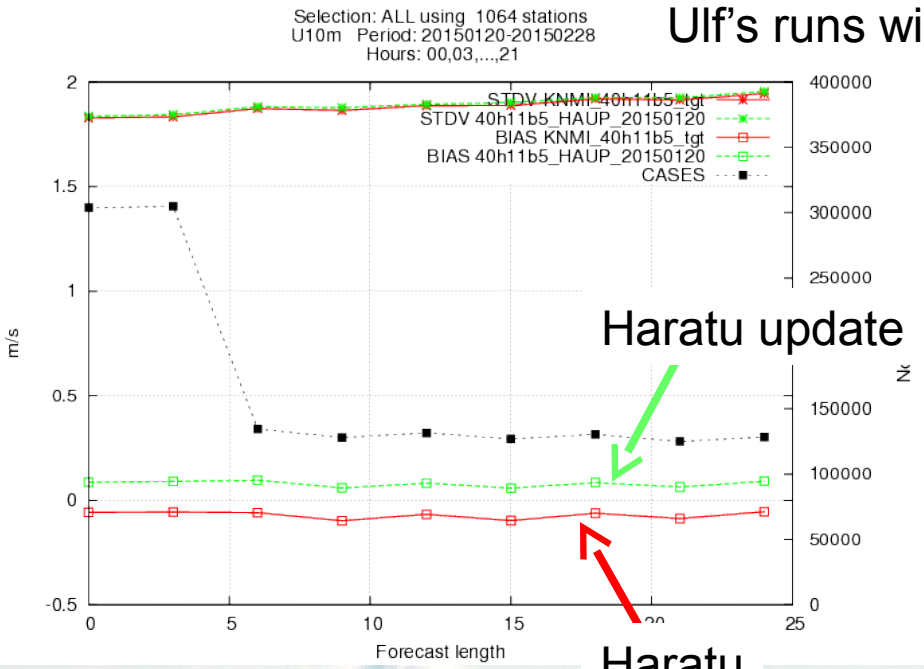
winter month 2015 (Ulf, Metcoop)

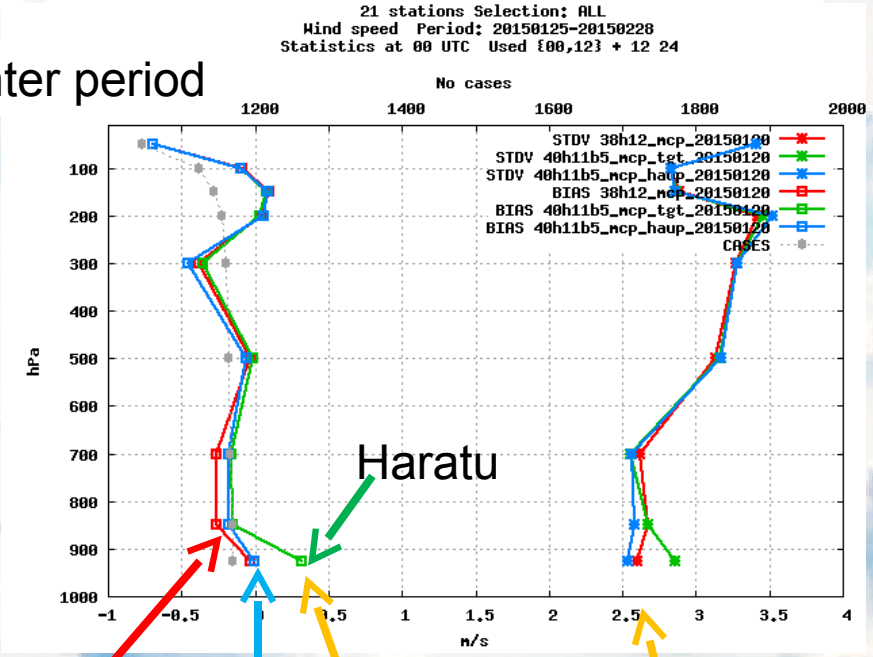
## Generally: small impact in summer but clear impact in winter

Wind speed: Overall small increase in u10m
Improvement or not depends on the domain

Verification against radiosonds reveals clear and consistent improvement.

Ulf's runs winter period




elimination over-estimation 925 hPa

better SD, smoother fields (increased mix)

# Statistics Haratu update

Jan-Feb 2016

## Wind gradients against Cabauw

Results for Jan.-Feb. 2016, Night time

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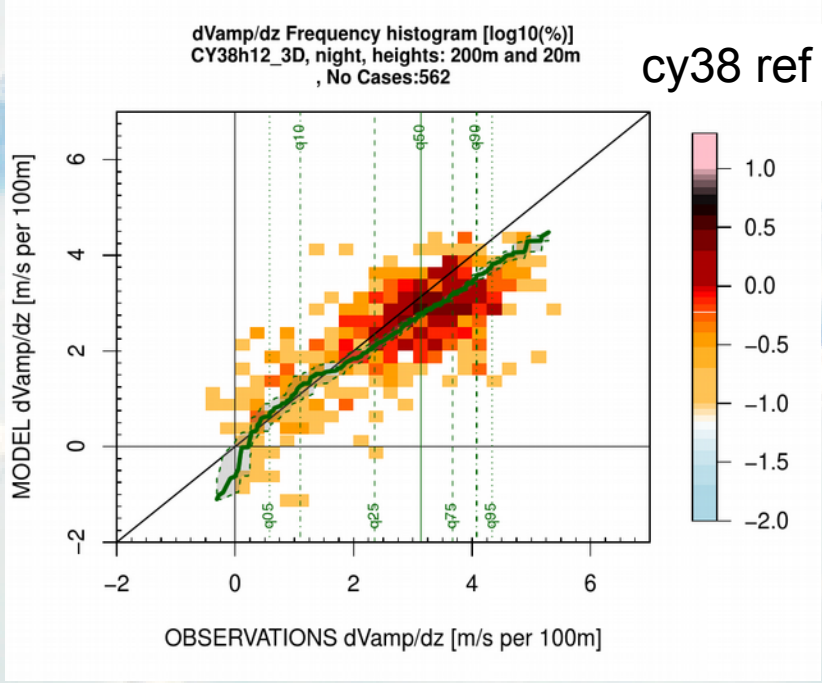
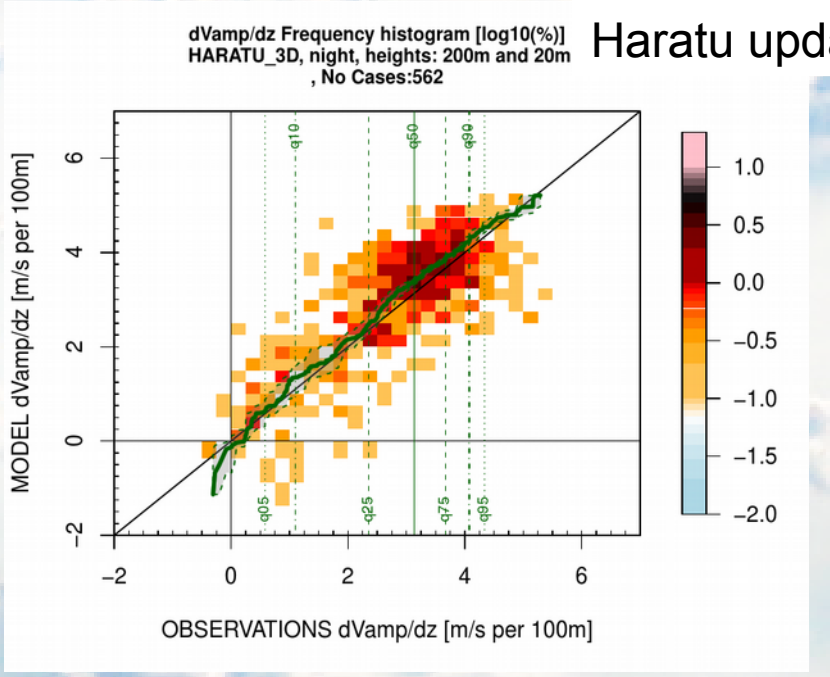



Haratu update



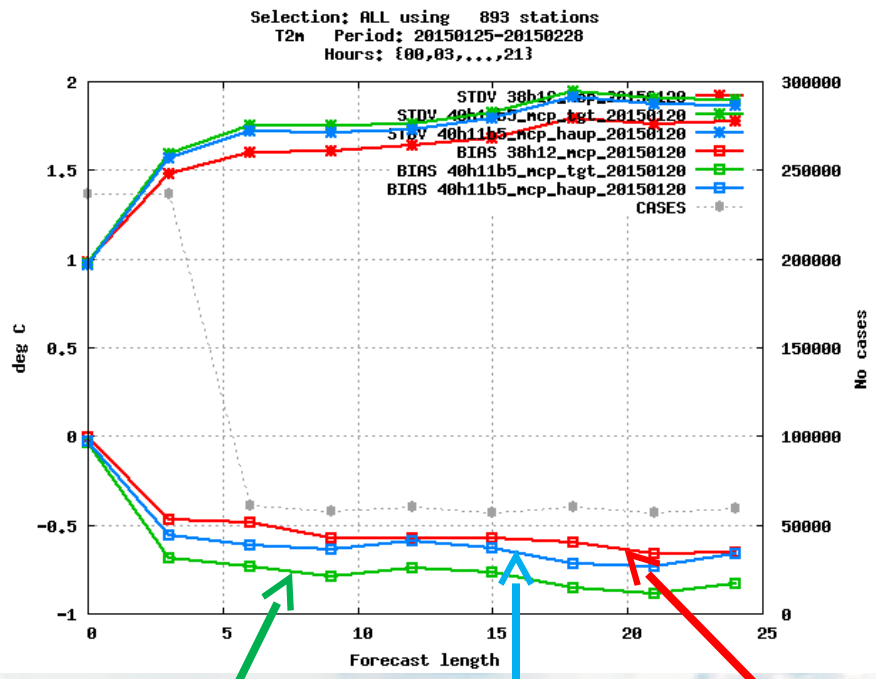
# Statistics Haratu update

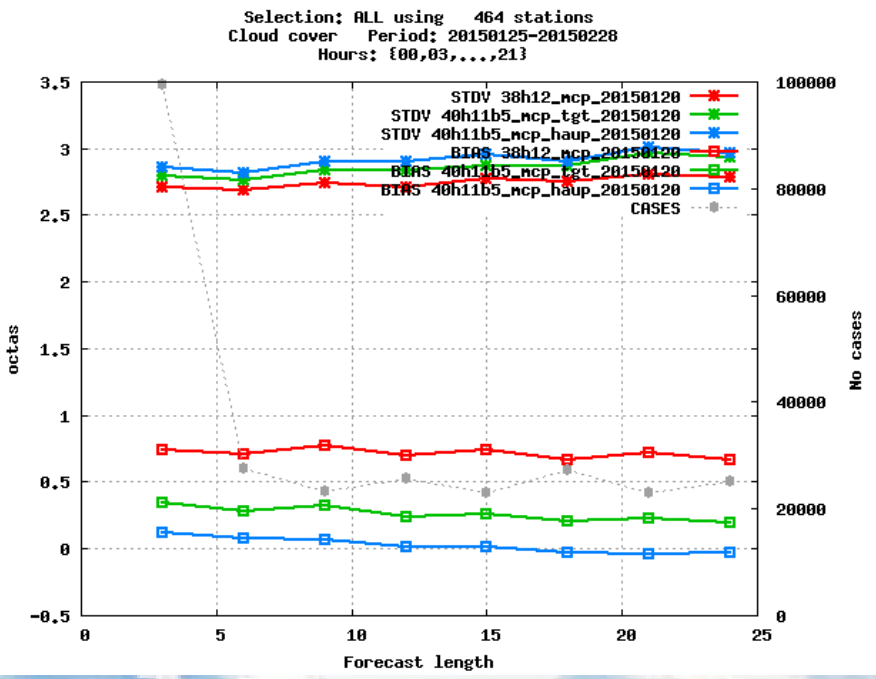
winter month 2015 (Ulf, Metcoop)

T2m

Ulf runs (metcoop) winterperiod

Cloud cover




Haratu

Haratu update

cy38 Ref

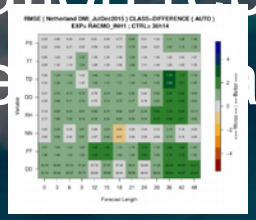
Increase in negative T2m bias almost disappears. Will have impact on fog.

Somewhat less clouds in winter
Improvement or not depends on domain

# Conclusions

- HARATU: cc (++), wind(++), T2m (-), High wind speed

- HARATU update: T2m bias alleviated, high U and U against radiosonds improved
- Soon verification report: monitor, MSG: SW and cc, scatterometer, Cabauw, Cloudnet, trajectories, buoys, scorecard

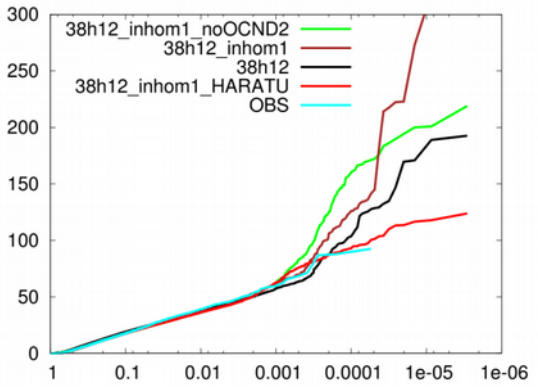


- too spotty behavior seems solved. Now after OCND2 & HARATU even too coherent and large structures?

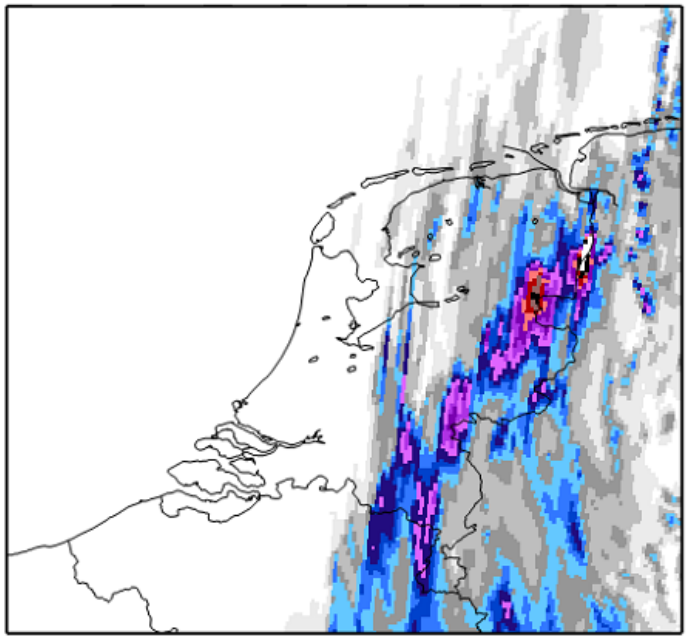

Thanks
Questions?
www.cloudappreciationsociety.org

# August 2006 Extremely wet month.

Hindcast runs (only +12 till +36h)

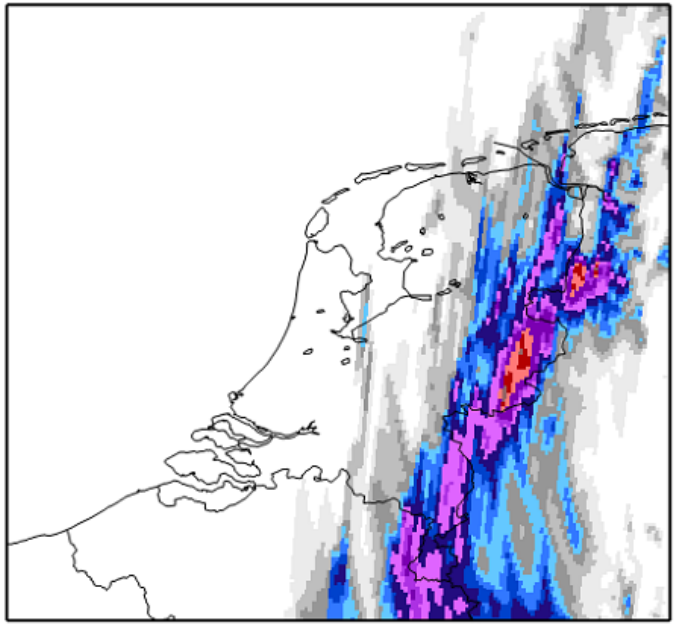


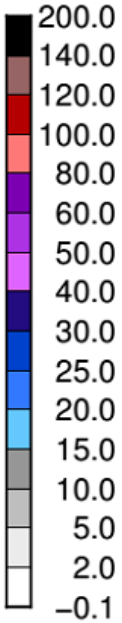

Harm 38h12_inhom1 20060804



Peak precipitation 200-300 mm in versions with standard turbulence

Harm 38h12_inhom1_HARATU 20060804






Peak precipitation 120 mm in version with RACMO turbulence