Kain-Fritsch convection in HIRLAM. Present status and prospects

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Outline of the talk

- The HIRLAM version of Kain-Fritsch
- Results from the comparison with reference STRACO scheme
- A new version of KF
- Conclusions and plans

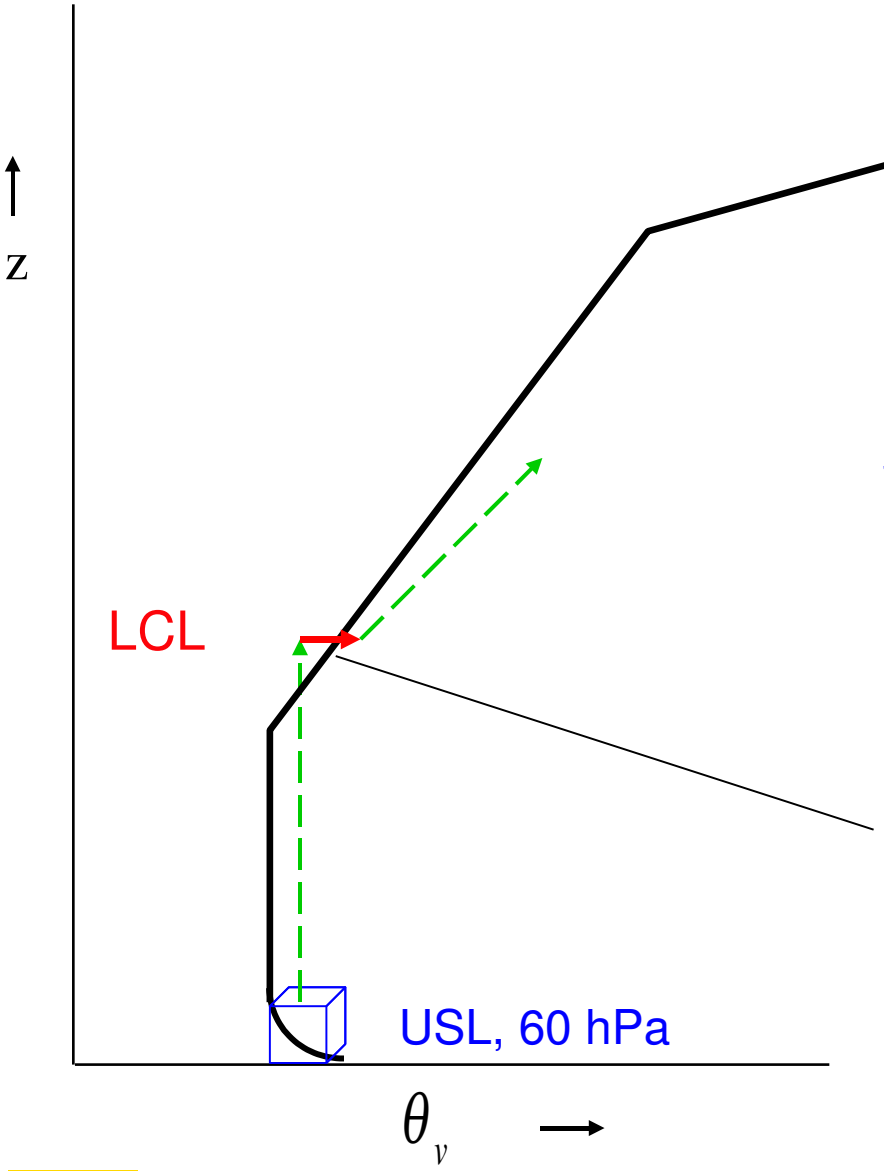
KF-RK moist physics

- Three new components
  - Kain-Fritsch convection
  - Rasch-Kristjansson large scale condensation
  - Diagnostic cloud fraction mainly based on RH
- History of KF in HIRLAM:
  - Implemented by Colin Jones for RCA model (20- 50 km)
    - Several updates mainly concerning shallow convection
  - Operational at SMHI since 2003
  - In the reference as option since September, 2004
    - But not much feedback

KF version in HIRLAM

- Based on recent version of KF (Kain, JAM, 2004: “The Kain-Fritsch Convective Parameterization: An Update”)
- Code comes from original KF, 1990: Messy, poorly documented and difficult to follow. Debugging is difficult.
- Code vectorized by NEC

KF convection: trigger (1)



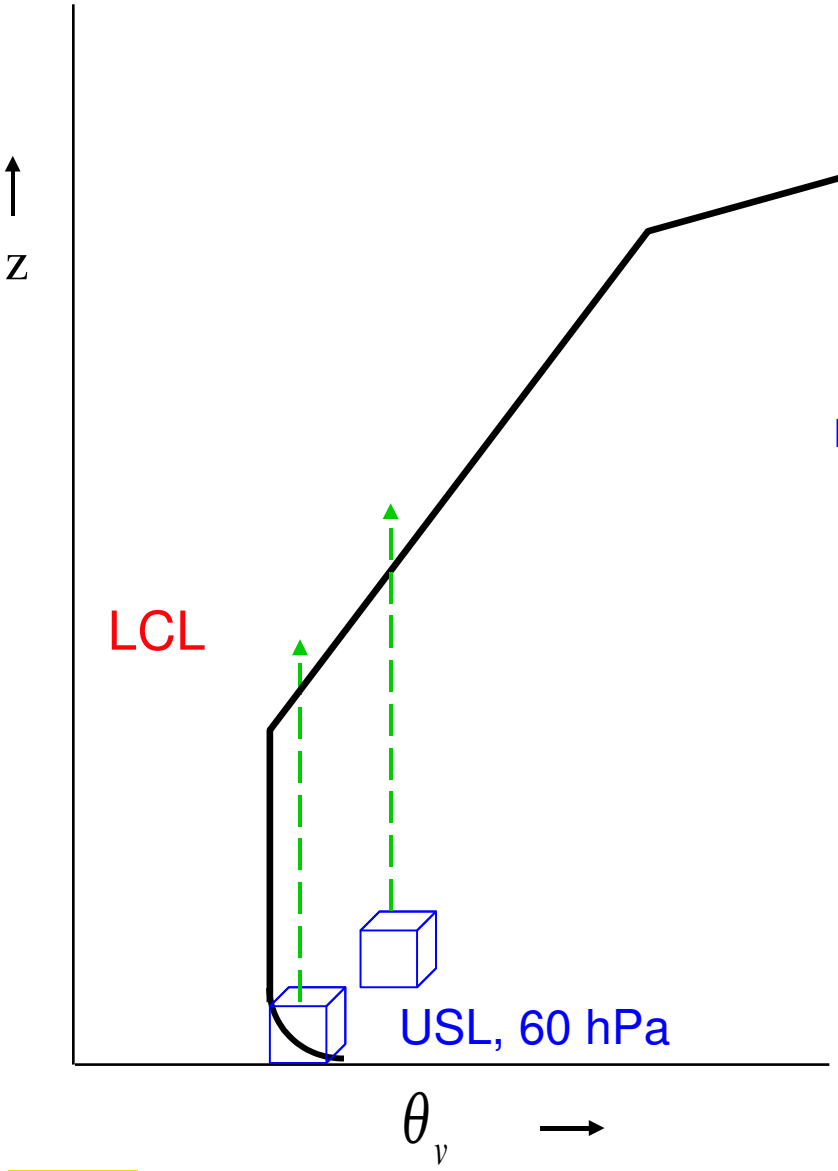
Scan lowest 300 hPa for source level:

- Some dependence on model vertical definition

Trigger: small push, $\delta\theta_v$, depending on

- resolved $w^{1/3}$
- RH at LCL in HIRLAM

KF convection: trigger (2)

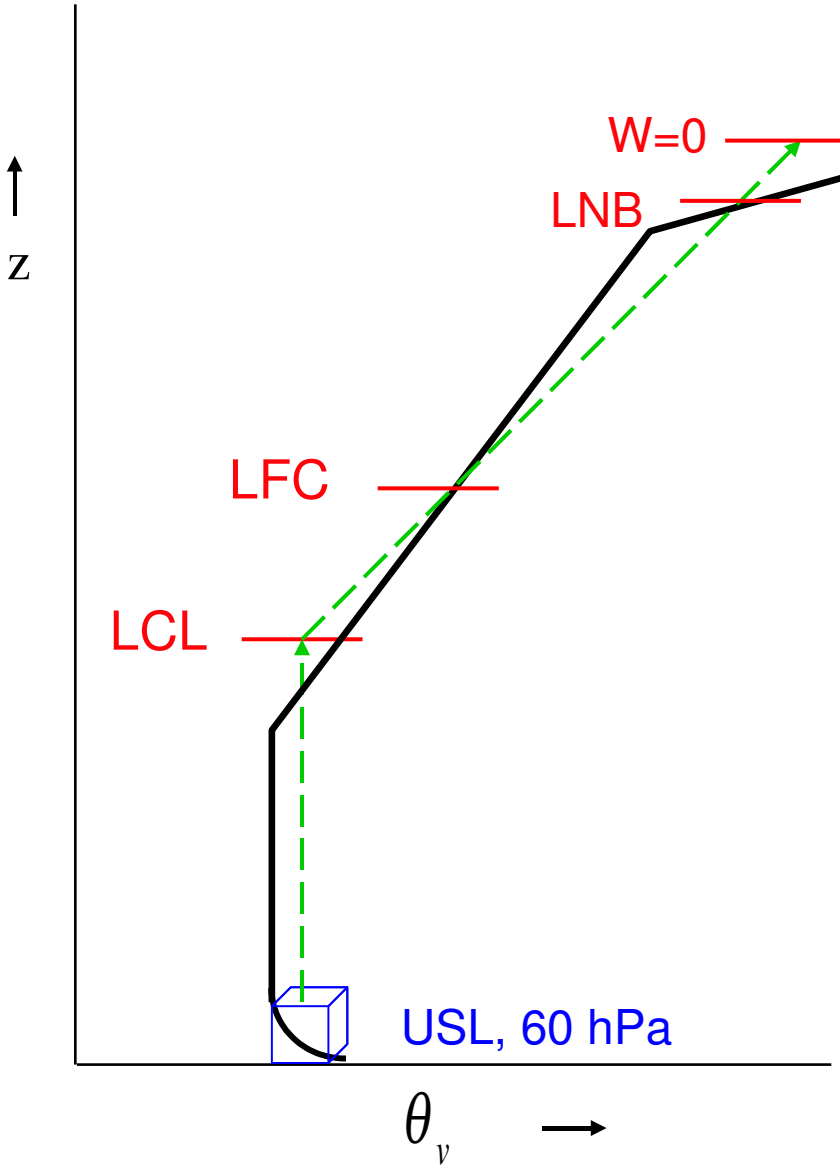


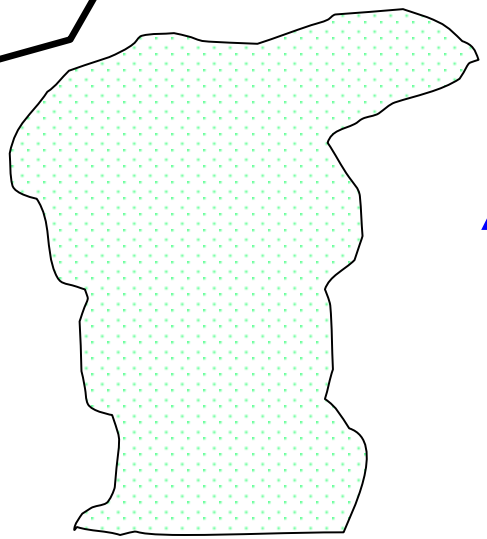
If the particle is buoyant apply cloud model otherwise test next source level

Scan lowest 300 hPa for source level:

- Some dependence on model vertical definition

KF convection: trigger (3)

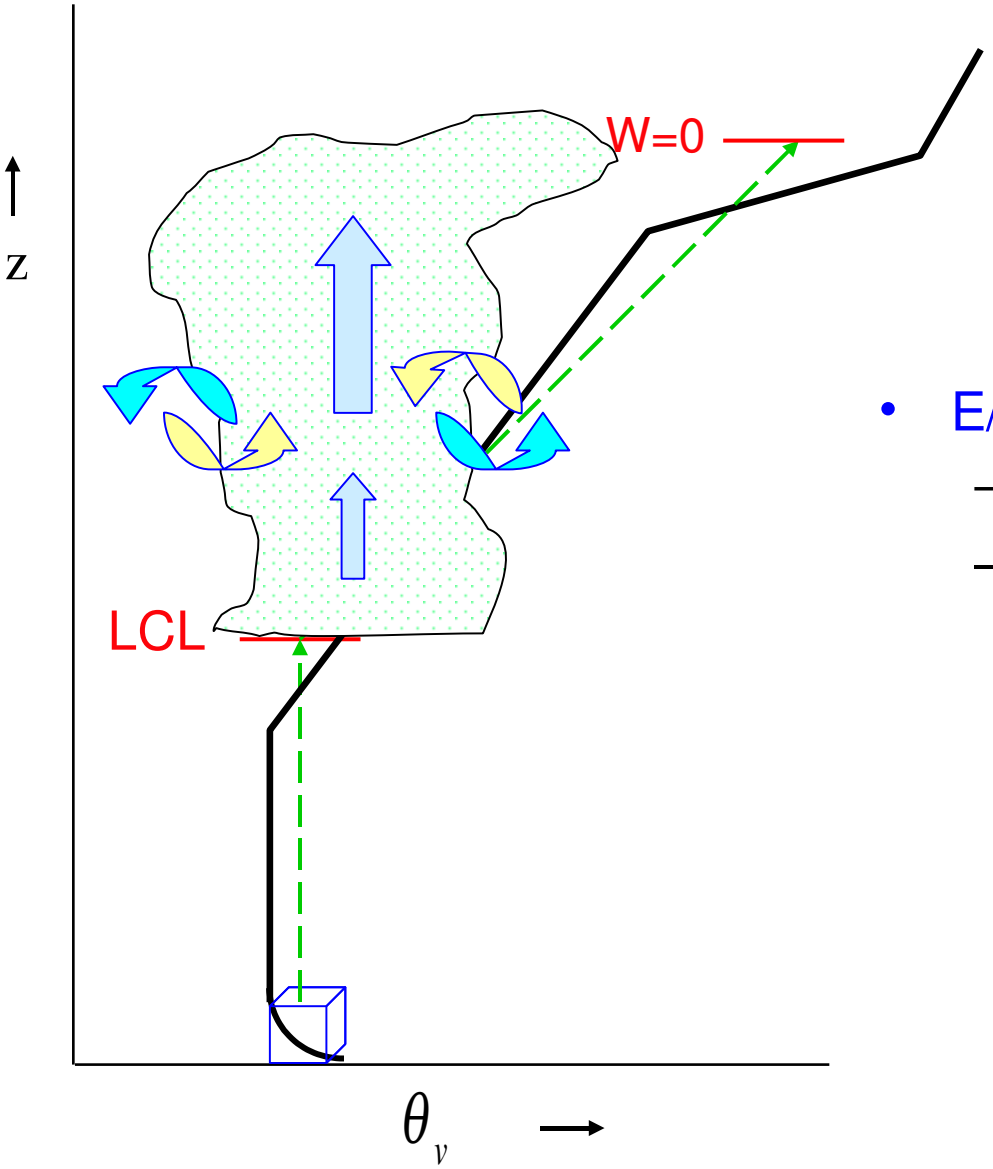




Dmin= min cloud height depending on T_{LCL} (2000-4000 m)

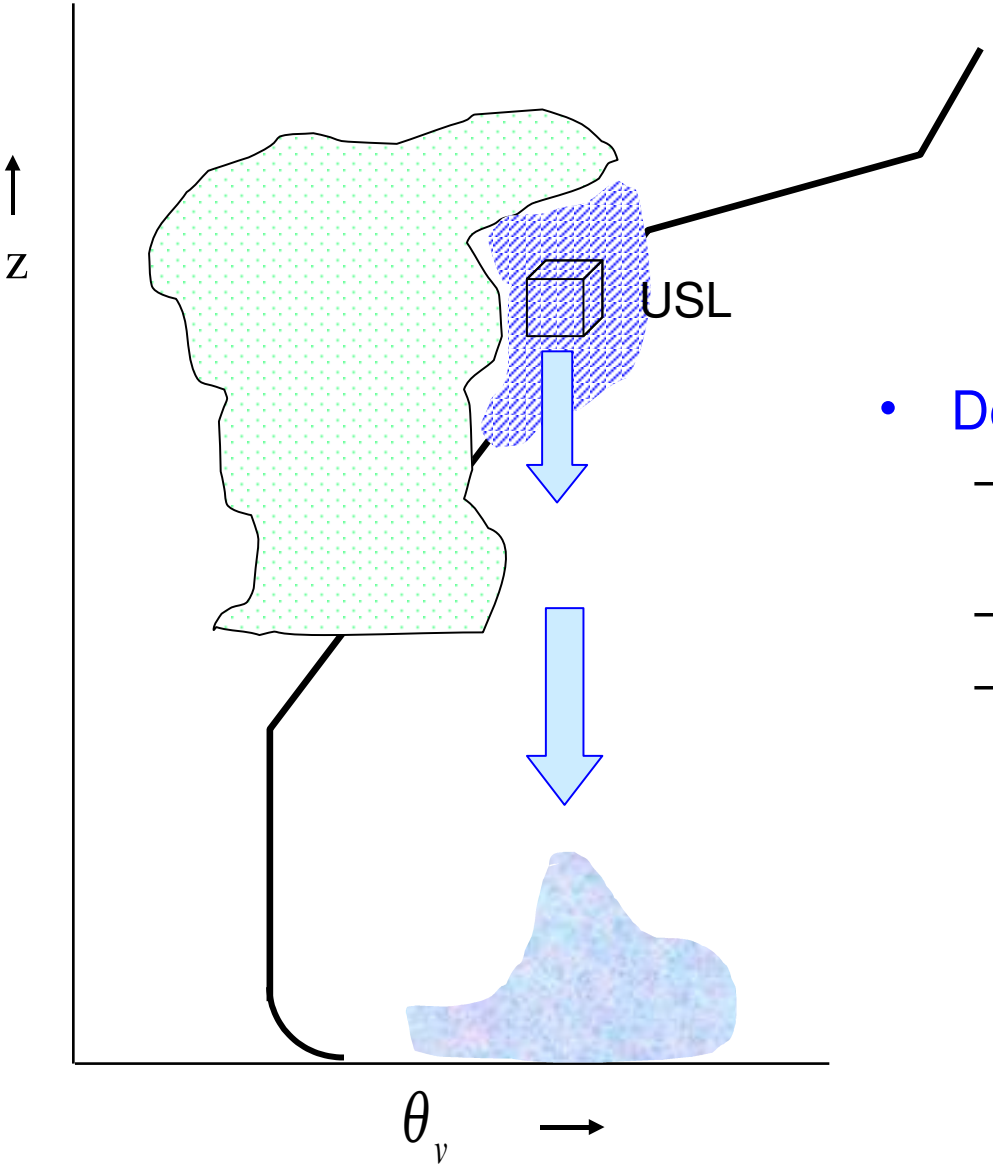
- If Dmin is not reached check next USL level
- If no USL in the lowest 300 hpa is Dmin deep use the deepest possible cloud as candidate for shallow convection

KF convection: cloud model



- E/D plume model
  - Θ_e ,q_v ,q_c are entrained/detrained
  - Variable E/D depending on environmental conditions: buoyancy of the mixture of cloud and enviromental air:
    - E ↑: High parcel buoyancy and moist envir.
    - D ↑: Low parcel buoyancy and dry envir.

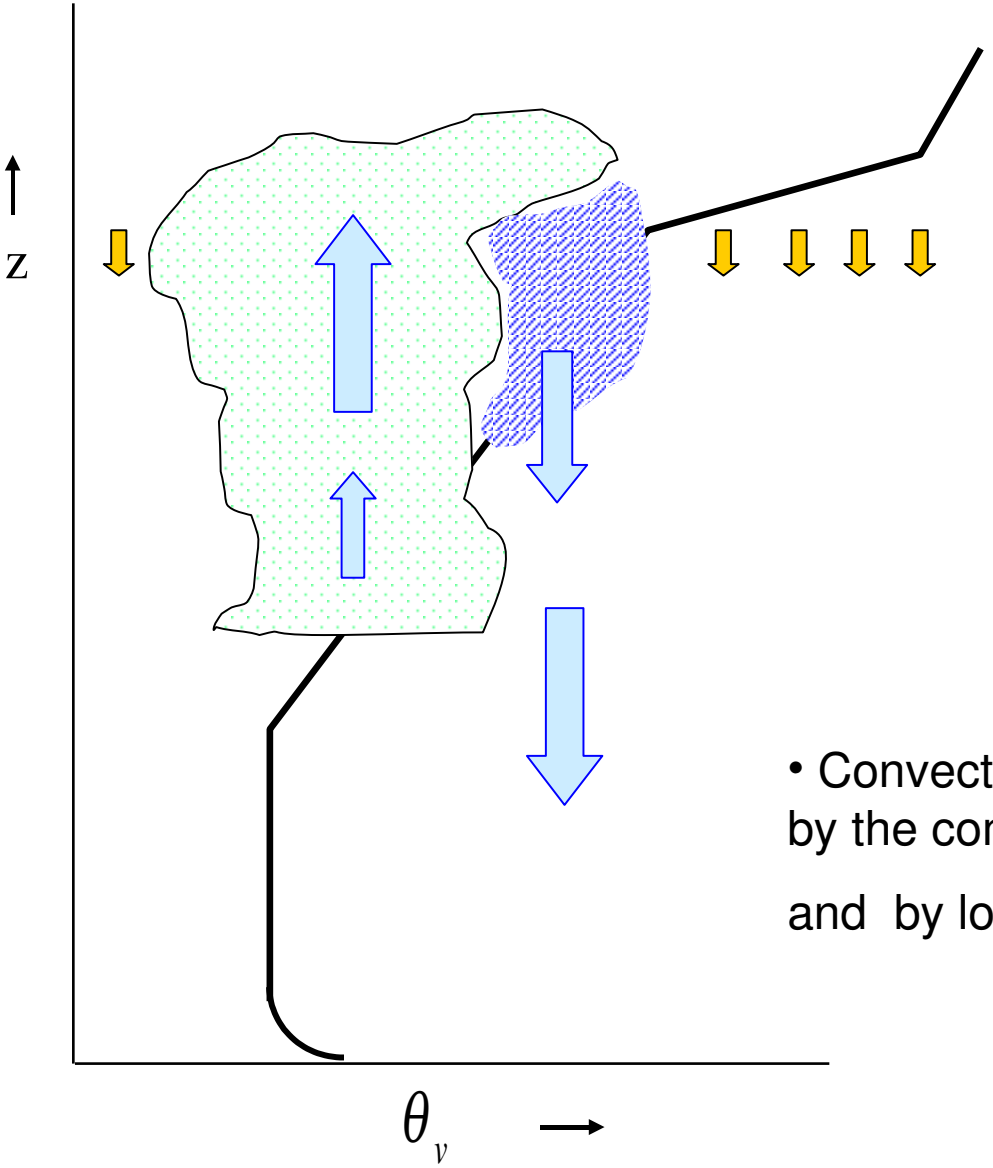
KF convection: downdrafts



- Downdraft
  - Saturated downdraft driven by the evaporation of precipitation
  - Source level: min Θ_{es}
  - Until it becames warmer than environment or it reaches the surface

$$M_{d0} \propto M_{u0}\ \overline{RH}_{cloud}$$

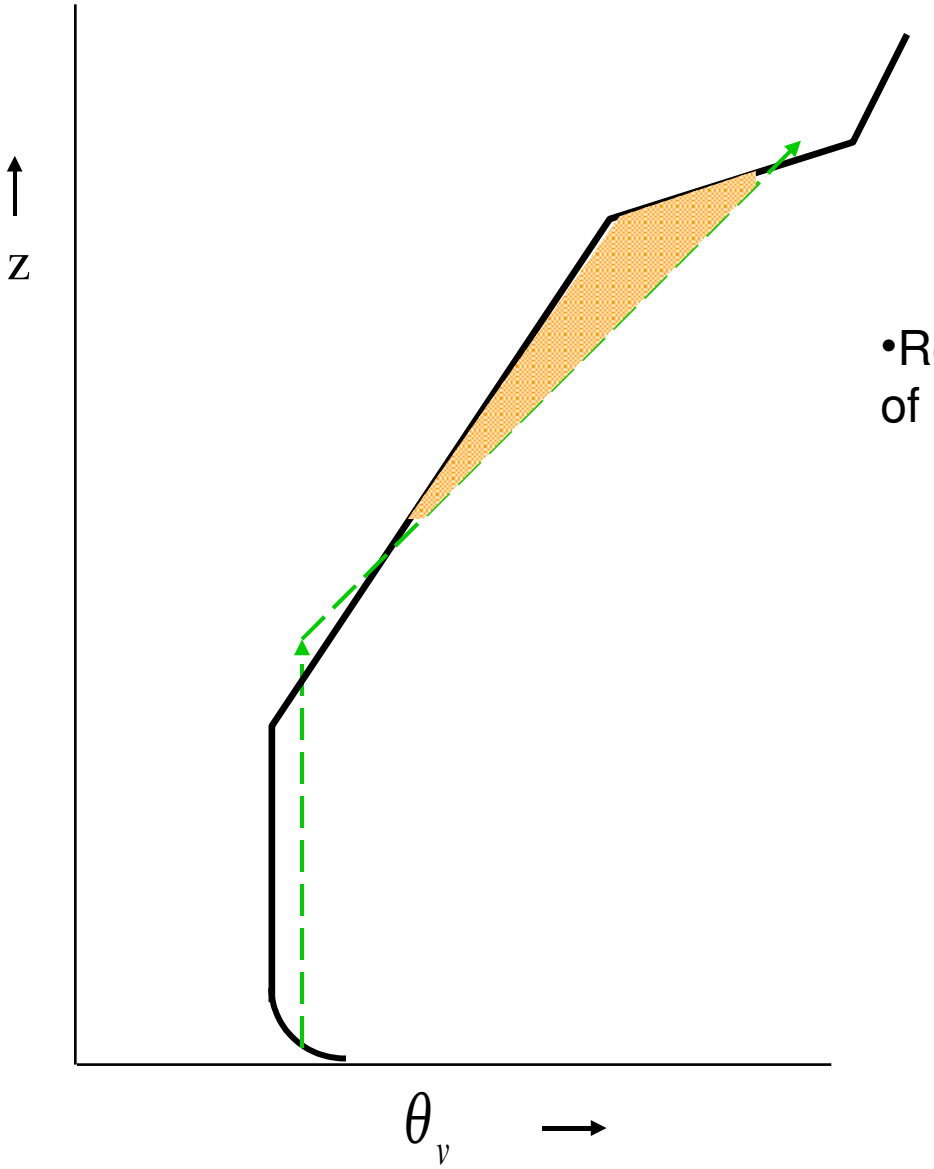
KF convection: compensational subsidence



• Convection stabilizates the atmosphere mainly by the compensational subsidence warming

and by lowering Θe in lower levels.

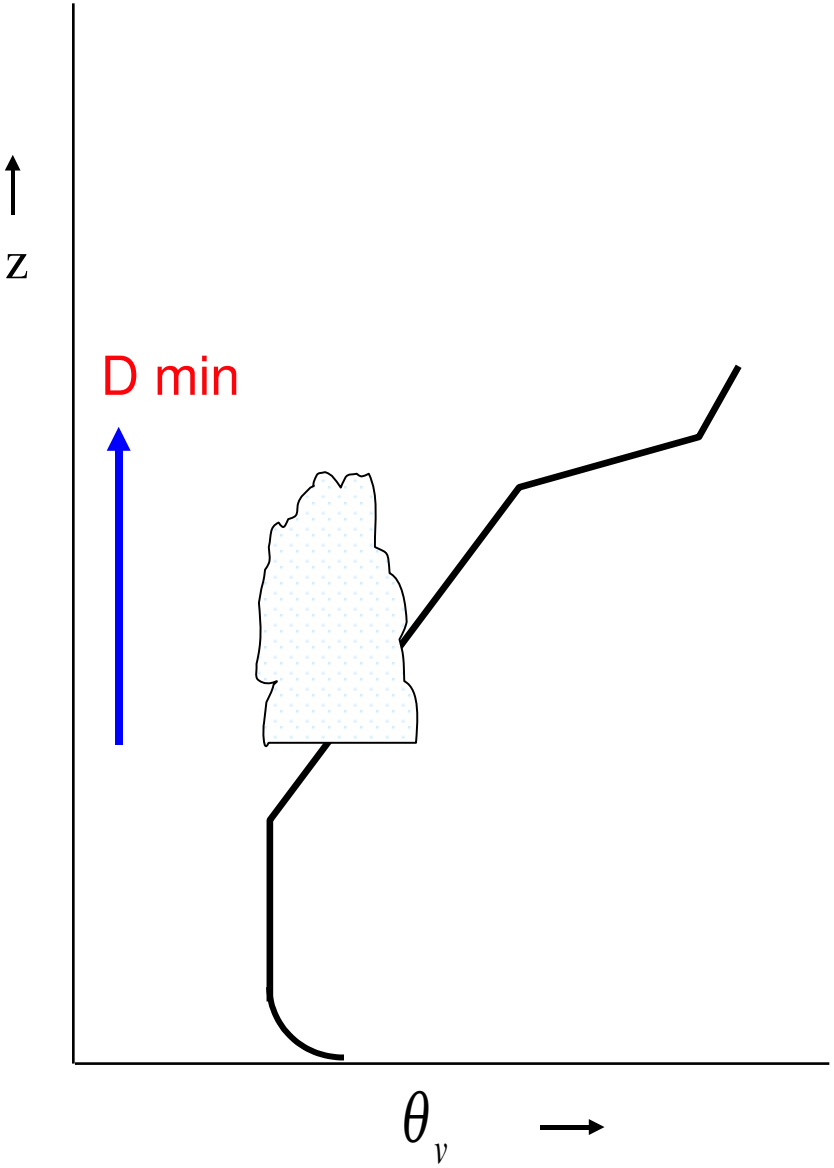
KF deep convection: CAPE closure



•Re-arrange mass-fluxes to remove 90% of CAPE in the convective time period.

$$0.5 < \tau < 1\ hr$$

Shallow convection: TKE closure



- If no cloud reaches minimum cloud depth test for shallow convection.
- No downdraft and precipitation is feedback to resolved scale (no ppt reaching the ground)

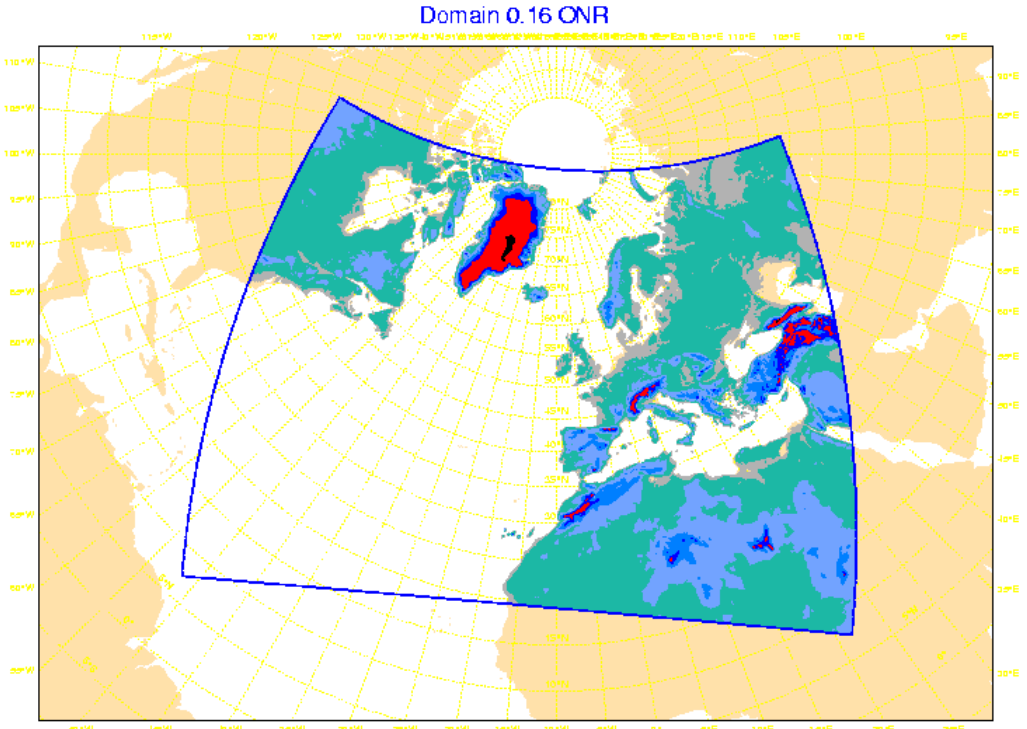
$$M_{u0} \propto TKE_{max\ subcloud}$$

Comparison with reference STRACO scheme

4 short test periods on different seasons. Using HIRLAM 7.1

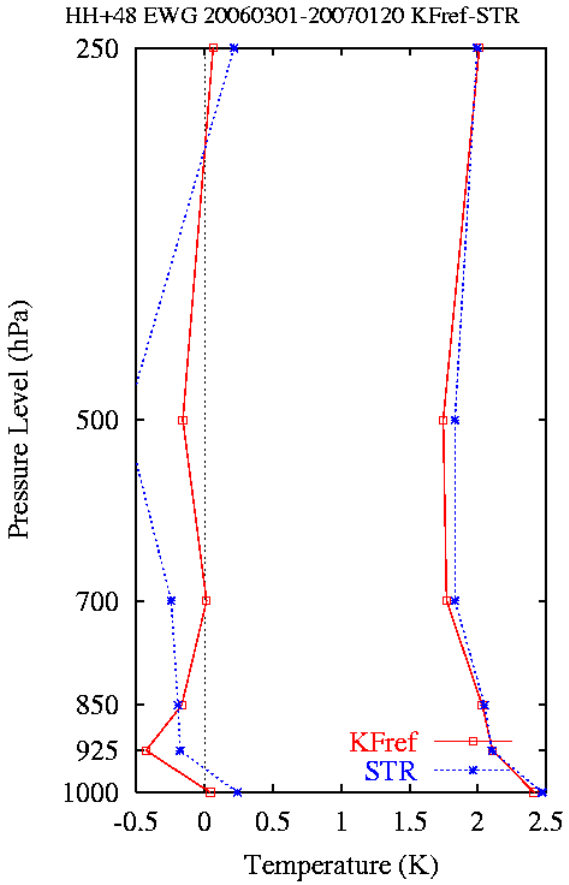
- 0.16 horizontal resolution, 60L
- 3DVAR analysis
- Boundaries from ECMWF T799

- 1-14 March 2006
- 28 Jul- 7 Ago
- 21 Oct- 1 Nov
- 10-20 Jan 2007

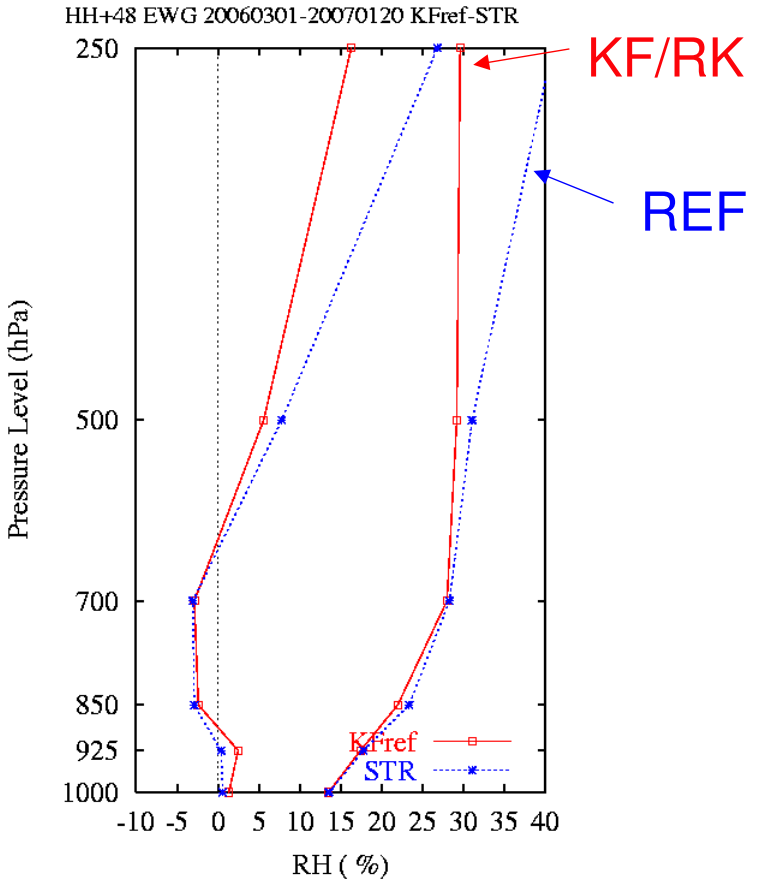


Comparison against EWGLAM soundings: H+48

Temperature



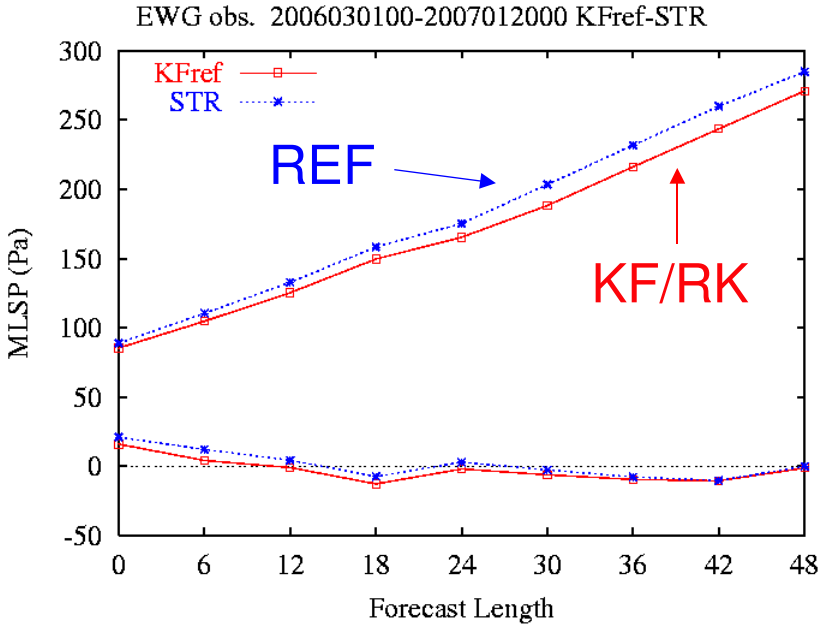
Relative Humidity



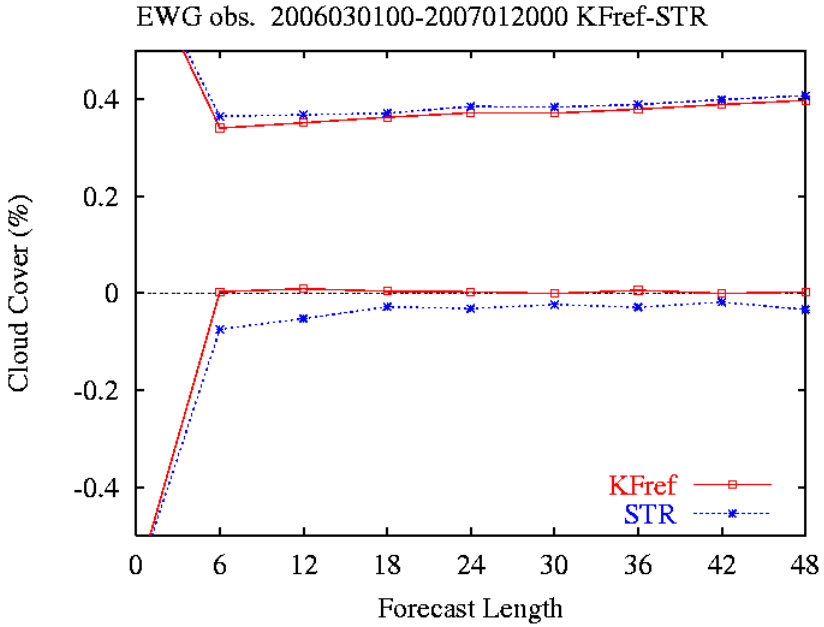
Improvement specially in the humidity field at high levels

Comparison against EWGLAM SYNOP stations

MSLP



Cloud cover



- Improvement in MSLP
- Small impact in cloud cover

Precipitation verification for different categories

REF

Observed (mm/day) →

	<0.2	0.6	2	6	20	60	200
<0.2	68	31	15	8	5	4	4
0.6	13	20	15	8	4	2	1
2	11	24	27	20	11	6	8
6	6	17	26	33	28	15	11
20	2	7	14	27	42	41	21
60		2	2	4	9	28	44
200					1	3	12
Tot:	41478	4458	6844	4553	4750	1735	156

KF

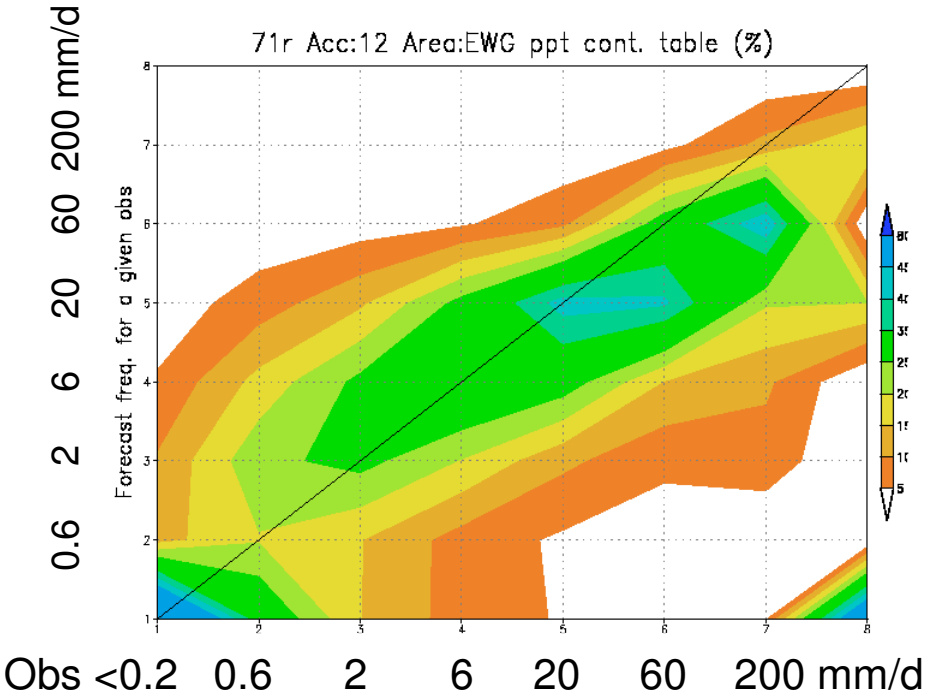
Observed (mm/day) →

	<0.2	0.6	2	6	20	60	200
<0.2	59	20	7	4	2	2	4
0.6	16	15	9	5	2	2	2
2	15	28	25	14	7	4	4
6	8	25	35	35	21	12	7
20	3	11	21	37	52	39	22
60		2	3	5	14	39	44
200						2	15

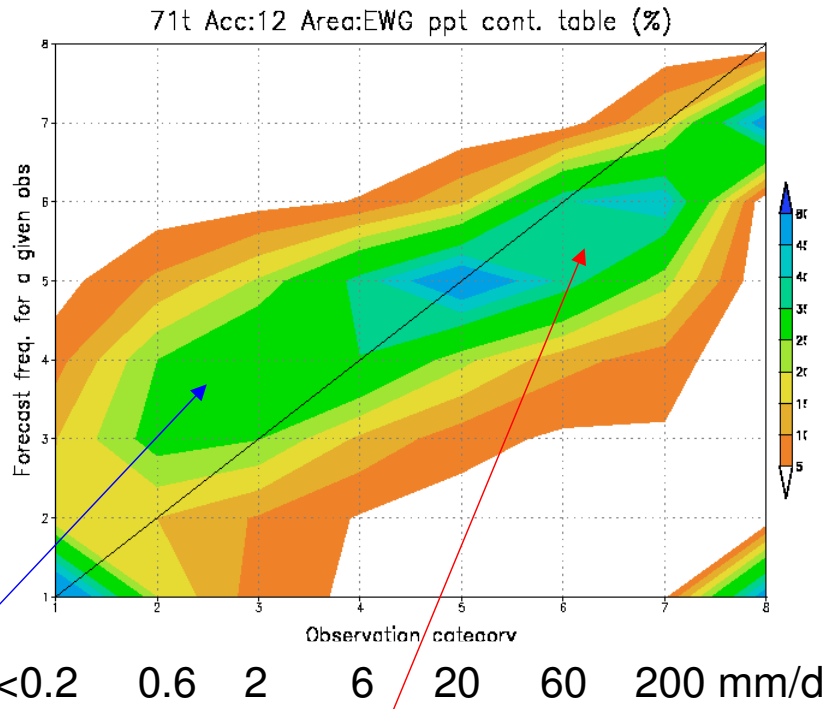
Obs. Accumulated in 12 hr: For a given obs. Category, distribution among the forecast categories (%)

Distribution among the ppt categories: Acc. 12

REF



KF

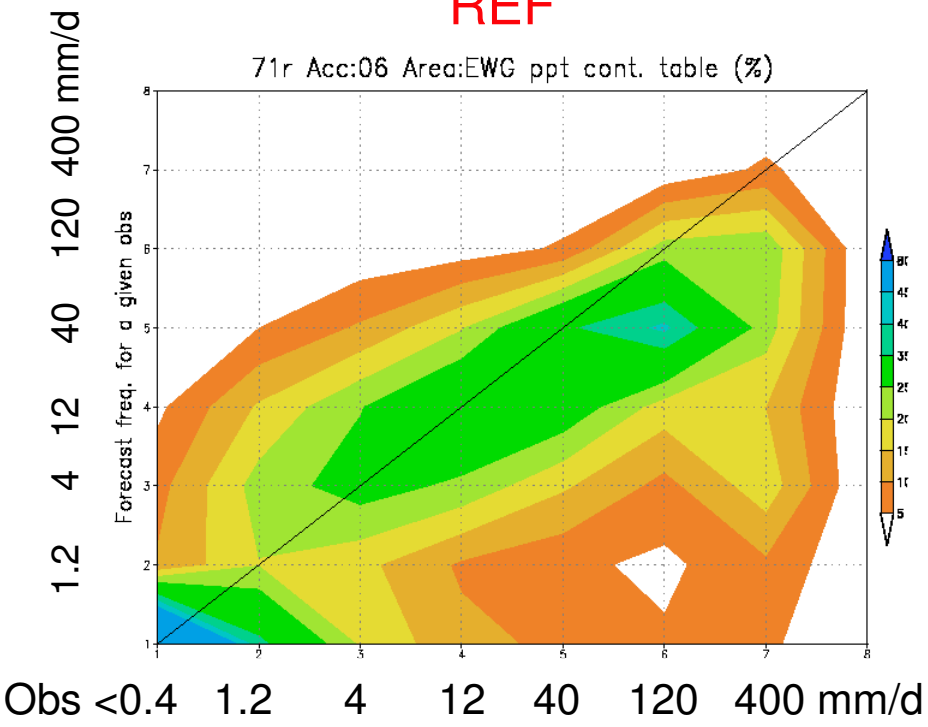


Overpredition for small ppt amounts

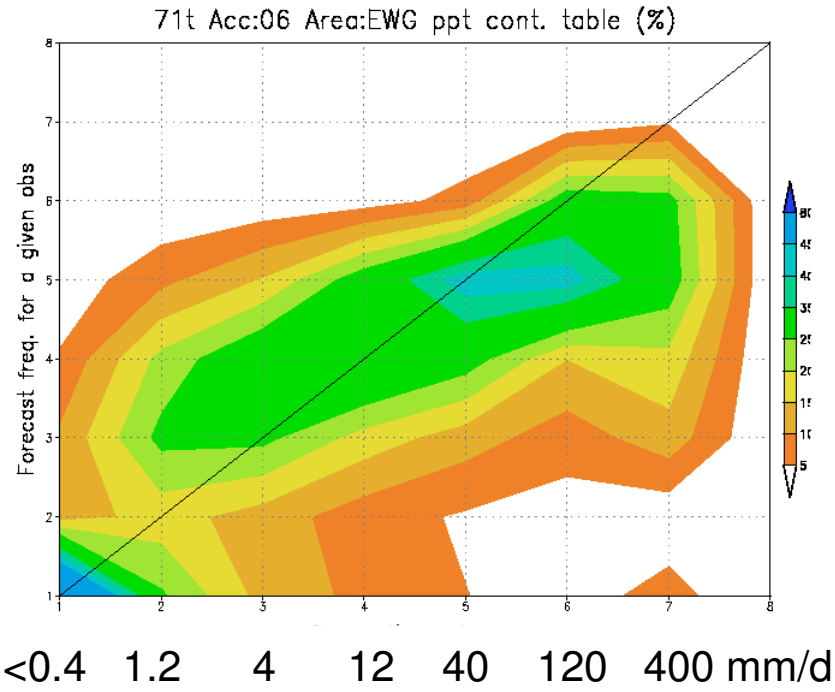
Underpredition for large ppt amounts but improvent compared to REF

Distribution among the ppt categories: Acc.06

REF

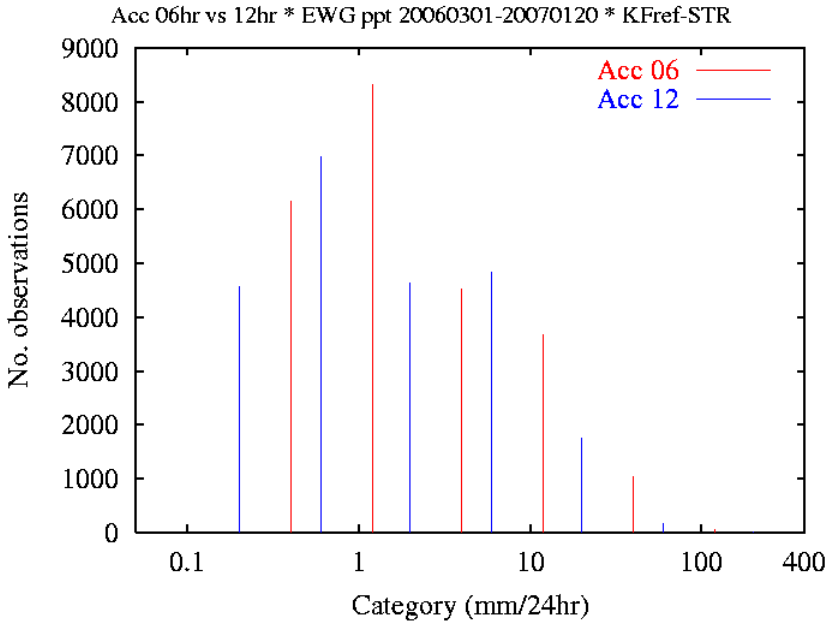


KF

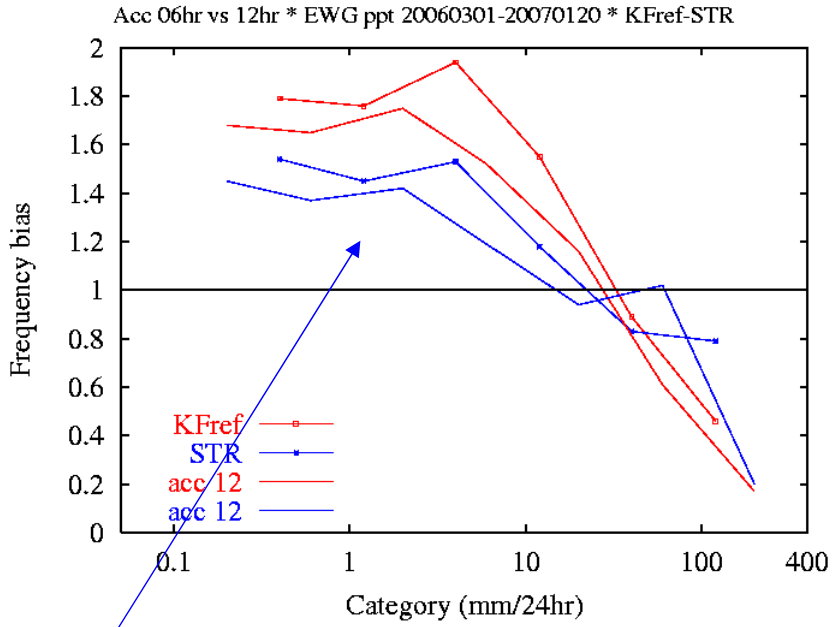


No.of observations and frequency bias: Acc.06 and 12 hr

No. observations



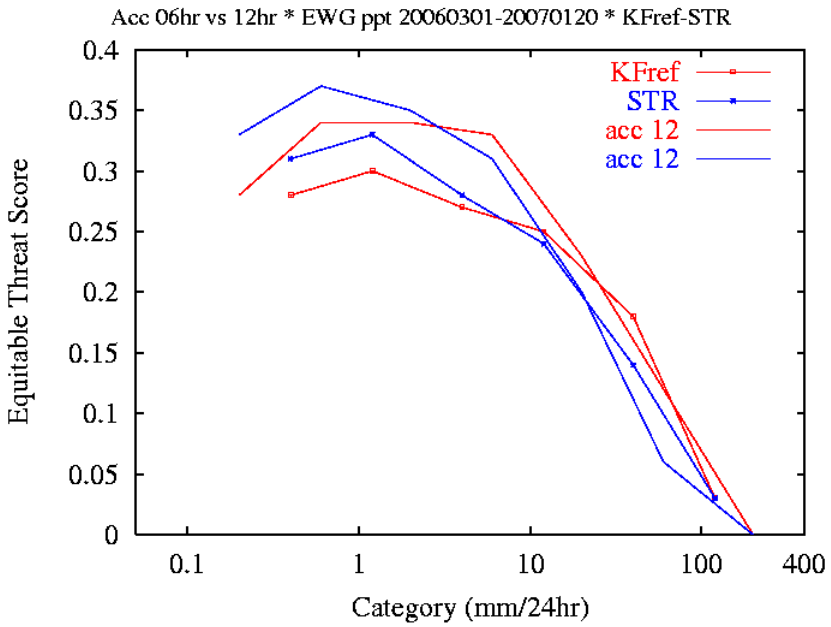
Bias



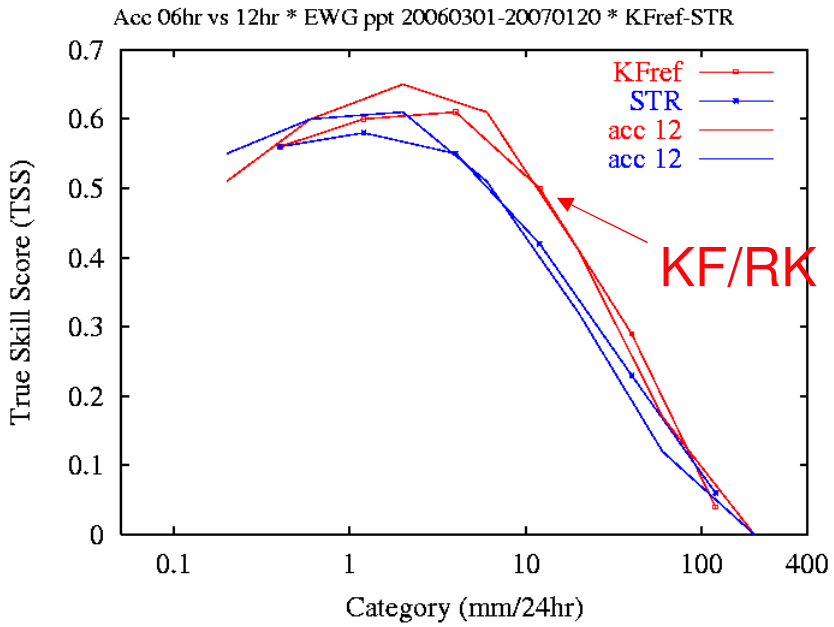
Precipitation more frequent in the forecast. (but no so much if we compare with higher ppt obs networks

Equitable Threat Score and True Skill Scores: Acc 06 and 12 hr

ETS



TSS



- ETS and TSS often used to mesure skill in forecasting precipitation
- TSS mesure the separation between different categories

- KF generally improves the precipitation forecast but
- Deteriorates the small amounts (< 3 mm/day) which indeed are the most frequent

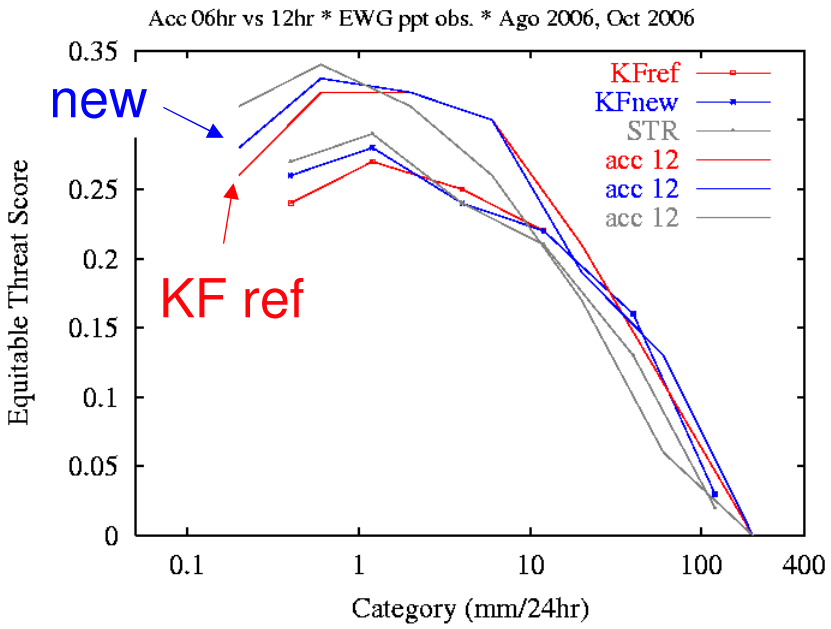
New version of Kain-Fristch

The new version of KF

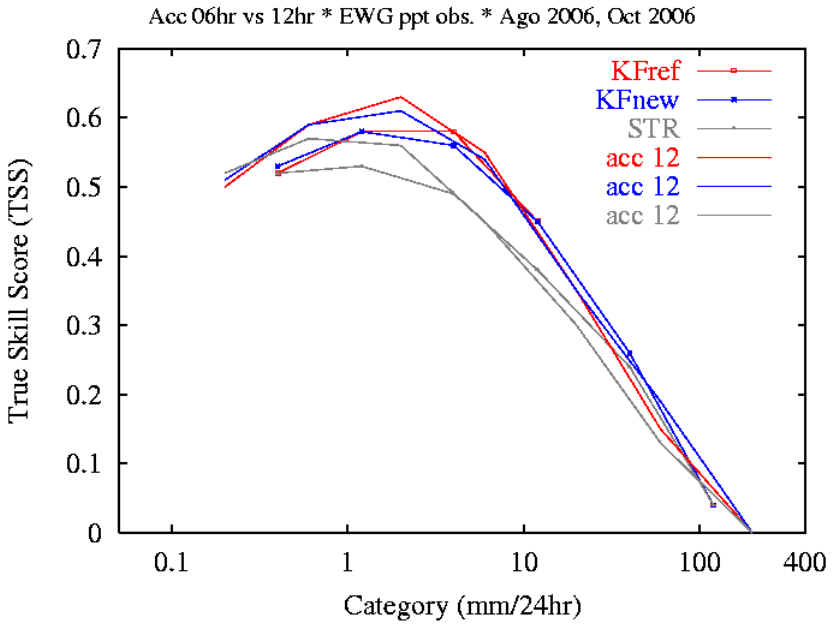
- In order to adapt the code to IFS we are testing a new version of KF convection
  - Code taken from WRF model (KF ETA version)
  - Coded in Fortran 90 but 1D code (non suitable for vector computers) but in principle more robust.
- The science is very similar to HIRLAM reference version but with some differences that may be important
  - Trigger: Initial push depending on RH removed
  - Source layer for downdrafts at a certain height from the updraft source layer instead of using minimum Θ_{es}
  - Radius of shallow cumulus clouds equal to the one for deep cumulus (is lower inKFref): less mixing and probably to deep shallow clouds
  - CAPE computed using dilute parcel ascent

New KF. Equitable Threat Score and True Skill Scores

ETS



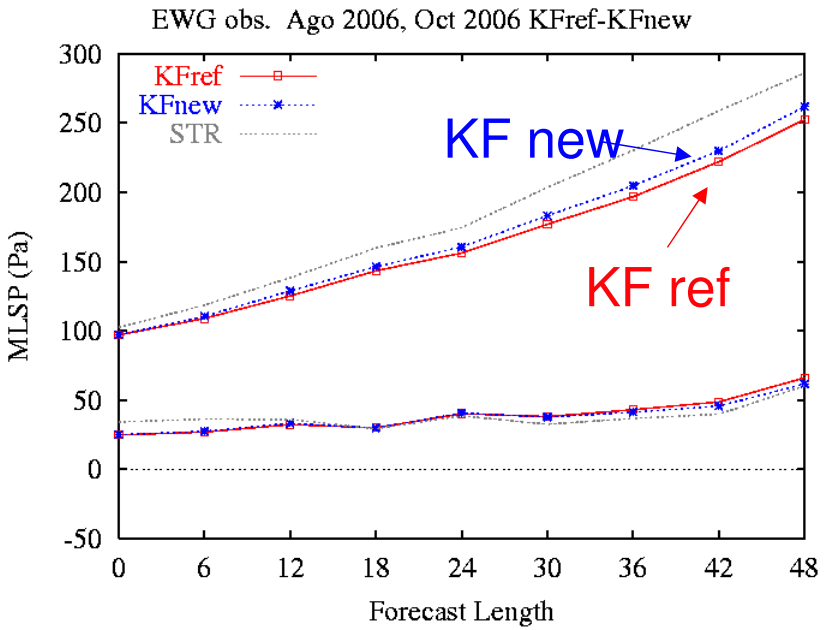
TSS



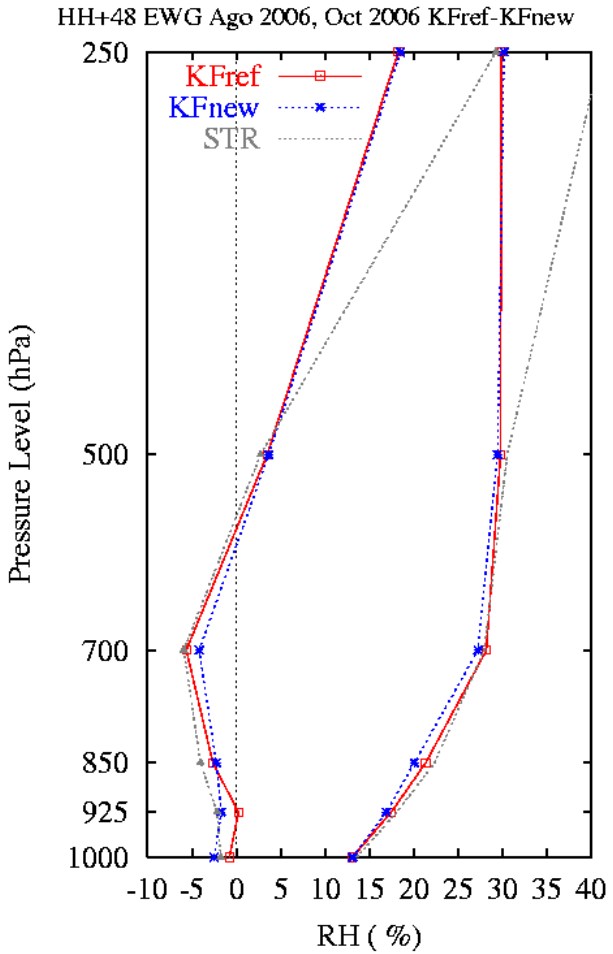
- New KF improve the forecast of small precipitation amounts
- STRACO still better below 1mm/day

New KF. Comparison against EWGLAM stations

MSLP



Relative Humidity



- Drier lower levels?
- Some deteriorarion of MSLP

Conclusions

- From the preliminary comparison with STRACO, it turns out that Kain-Fritsch improves MSLP, Humidity profiles and precipitation except for small amounts.
- Results with the new KF eta version are promising but more testing is necessary.
- Some tuning seems necessary below 10 km resolution.
- For the general comparison with the STRACO scheme we prefer to use the standard HIRLAM KF which is in the reference maybe with some minor update.

That’s all folks