Quest-Belgium overview

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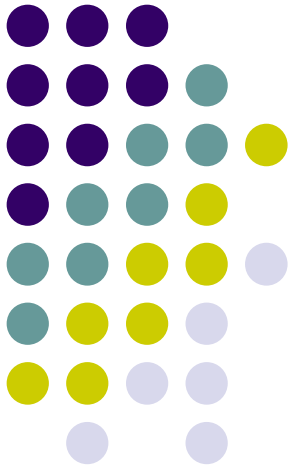
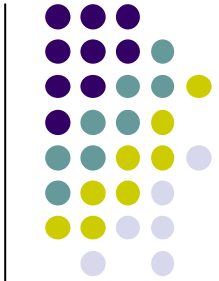


DEPARTMENT OF **EARTH AND ENVIRONMENTAL SCIENCES**
K.U.LEUVEN - BELGIUM

RMI

Goals of Quest-B



→ ***Major goal:*** in-depth analysis of model deficiencies in **COSMO** and **ARPS**

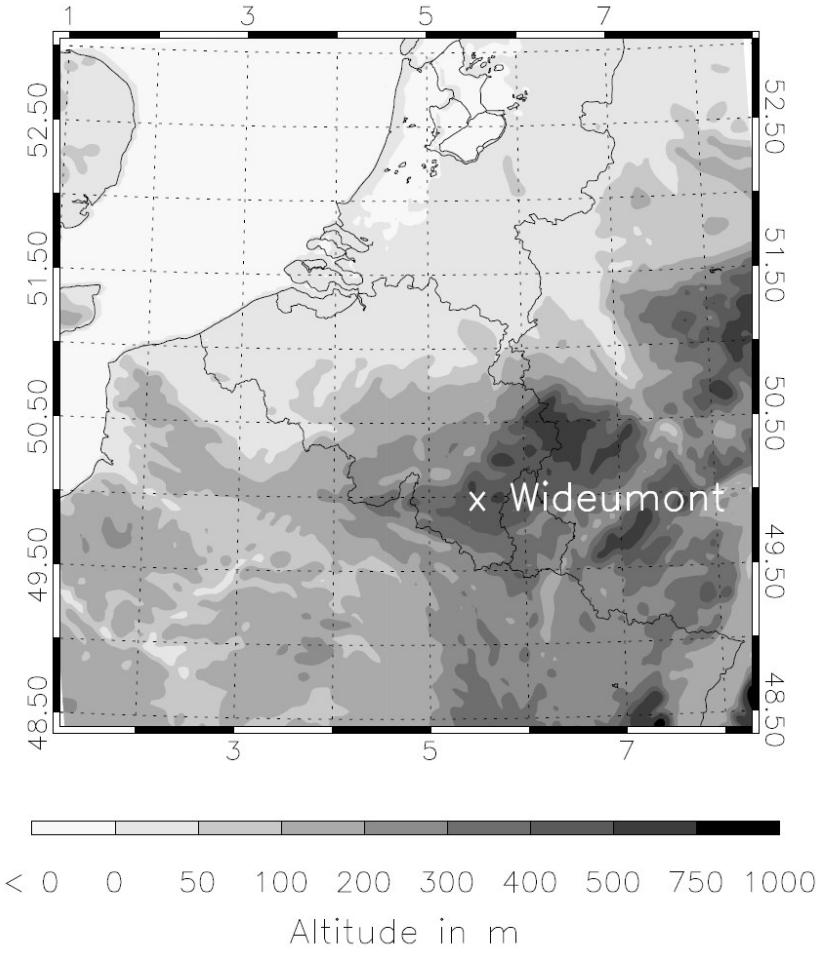
→ using ***remote sensing*** data ***(satellite*** and ***radar)***

→ using ***adapted evaluation techniques***
- → **Model-to-observation** approach **(forward operators)**
- → **Observation-to-model** approach
- → Newest evaluation methods **(object oriented verification)**

→ ***in-depth evaluation of case studies***

→ ***simulation of two contrasting summer seasons***
- → Detect **mechanisms** behind the differences
- → Production of **high resolution time series** for soil erosion and crop yield studies

Materials and Methods: models



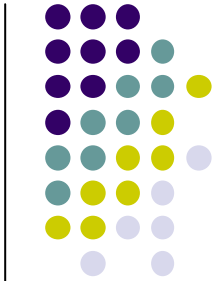
Advanced Regional Prediction System (ARPS)

IN&BC: ECMWF operational analysis (25 km); Double one way nesting (9 km – 3 km)

COnsortium for SMall scale mOdelling (COSMO)

IN&BC: COSMO-EU operational analysis (7km); integrated at 2.8 km resolution

Materials and Methods: models



Advanced Regional Prediction System (ARPS 5.2.8)	**COnsortium for SMall scale mOdelling (COSMO 4.3)**
Dynamical core: Centre-differencing leapfrog	Dynamical core: 3rd order TVD Runge-Kutta
Microphysics: one-moment bulk scheme; prognostic rain, snow, hail, cloud water and cloud ice	Microphysics: one-moment bulk scheme; prognostic rain, snow, graupel, cloud water and cloud ice
12 hour lead time; case studies	12 hour lead time; case studies and long term

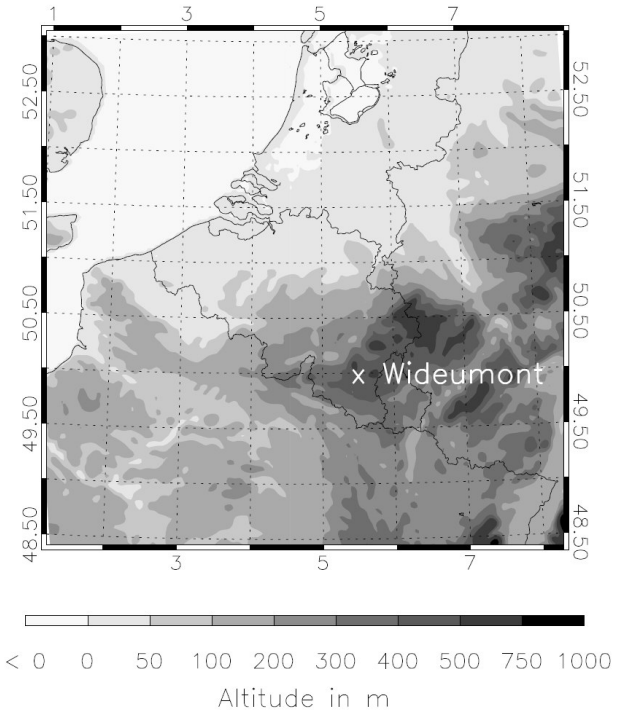
Materials and Methods: observational data

- Radar:

C-band Doppler Radar Wideumont (RMI)

Volume scans performed using 10 elevations (0.5° - 17.5 °) each 15 minutes

Resolution: 500 m in range, 1° in azimuth



- Satellite:

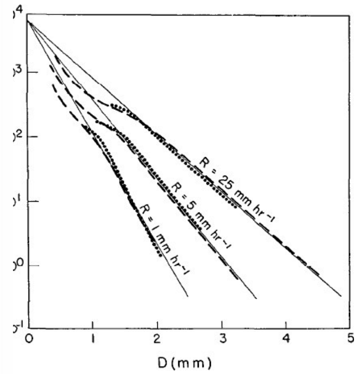
MSG-8 SEVIRI derived cloud optical thickness (CM-SAF)

Hourly information during daytime

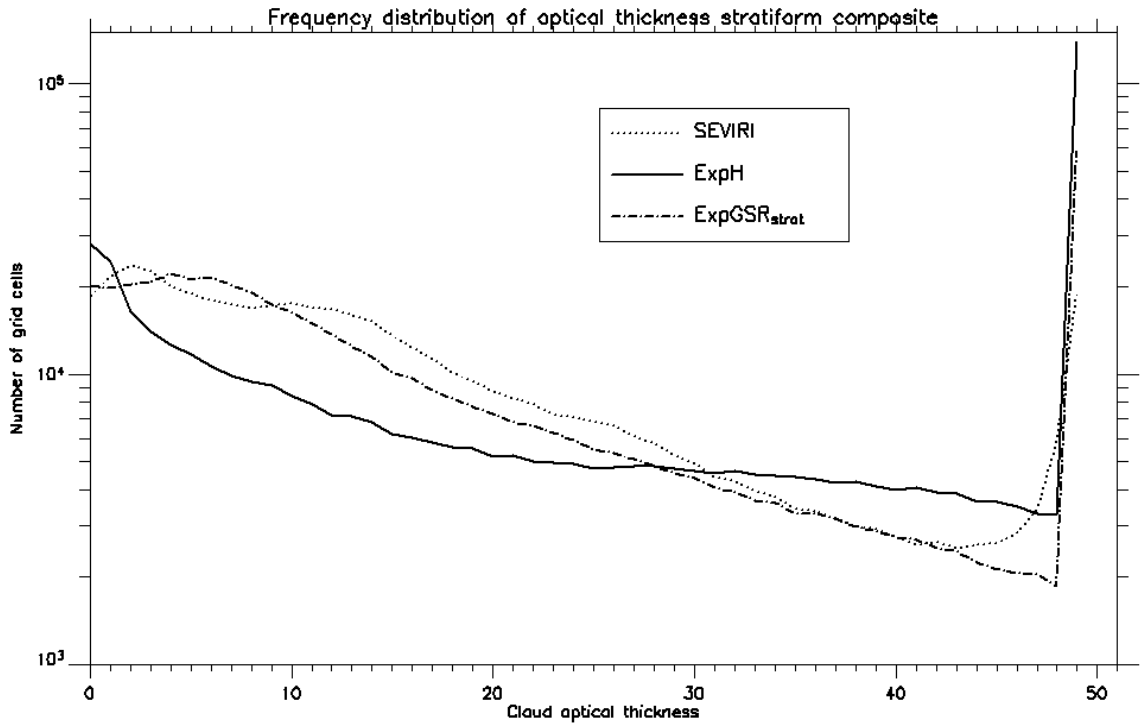
Resolution: 3 km × 6 km in the area of interest

Case studies: ARPS –
microphysics size distribution experiments

	ExpH	ExpHSR	ExpGSR	ExpHSRstrat	ExpGSRstrat
N_{0R}	0.08 *(Marshall and Palmer 1948)*	$0.07106(10^3\rho q_r)^{0.648}$ *(Zhang et al. 2008)*	$0.07106(10^3\rho q_r)^{0.648}$ *(Zhang et al. 2008)*	$0.07106(10^3\rho q_r)^{0.648}$ *(Zhang et al. 2008)*	$0.07106(10^3\rho q_r)^{0.648}$ *(Zhang et al. 2008)*
λ_R	$\left(\frac{\pi\rho_r N_{0r}}{\rho q_r}\right)^{0.25}$	$\left(\frac{\pi\rho_r N_{0r}}{\rho q_r}\right)^{0.25}$	$\left(\frac{\pi\rho_r N_{0r}}{\rho q_r}\right)^{0.25}$	$\left(\frac{\pi\rho_r N_{0r}}{\rho q_r}\right)^{0.25}$	$\left(\frac{\pi\rho_r N_{0r}}{\rho q_r}\right)^{0.25}$
V_R	$\frac{2115\Gamma(4+0.8)}{6\lambda_r^{0.8}}\left(\frac{\rho_0}{\rho}\right)^{1/2}$ *(Liu and Orville 1969)*	$\frac{2115\Gamma(4+0.8)}{6\lambda_r^{0.8}}\left(\frac{\rho_0}{\rho}\right)^{1/2}$ *(Liu and Orville 1969)*	$\frac{2115\Gamma(4+0.8)}{6\lambda_r^{0.8}}\left(\frac{\rho_0}{\rho}\right)^{1/2}$ *(Liu and Orville 1969)*	$\frac{2115\Gamma(4+0.8)}{6\lambda_r^{0.8}}\left(\frac{\rho_0}{\rho}\right)^{1/2}$ *(Liu and Orville 1969)*	$\frac{2115\Gamma(4+0.8)}{6\lambda_r^{0.8}}\left(\frac{\rho_0}{\rho}\right)^{1/2}$ *(Liu and Orville 1969)*
N_{0S}	0.03 *(Gunn and Marshall 1958)*	$0.02\exp[0.12(T_0-T)]$ *(Houze et al. 1979)*	$0.02\exp[0.12(T_0-T)]$ *(Houze et al. 1979)*	$0.02\exp[0.12(T_0-T)]$ *(Houze et al. 1979)*	$0.02\exp[0.12(T_0-T)]$ *(Houze et al. 1979)*
λ_S	$\left(\frac{\pi\rho_s N_s}{\rho q_s}\right)^{0.25}$ *(Lin et al. 1983)*	$\left(\frac{0.0074N_{0s}\Gamma(2.1+1)}{\rho q_s}\right)^{1/(2.1+1)}$ *(Locatelli and Hobbs. 1974)*	$\left(\frac{0.0074N_{0s}\Gamma(2.1+1)}{\rho q_s}\right)^{1/(2.1+1)}$ *(Locatelli and Hobbs. 1974)*	$\left(\frac{0.0069N_{0s}\Gamma(2+1)}{\rho q_s}\right)^{1/(2+1)}$ *(Cox 1988)*	$\left(\frac{0.0069N_{0s}\Gamma(2+1)}{\rho q_s}\right)^{1/(2+1)}$ *(Cox 1988)*
V_S	$\frac{152.93\Gamma(4+0.25)}{6\lambda_s^{0.25}}\left(\frac{\rho_0}{\rho}\right)^{1/2}$ *(Locatelli and Hobbs. 1974)*	$\frac{209.60\Gamma(0.28+2.1+1)}{\lambda_s^{0.28}\Gamma(2.1+1)}$ *(Locatelli and Hobbs. 1974)*	$\frac{209.60\Gamma(0.28+2.1+1)}{\lambda_s^{0.28}\Gamma(2.1+1)}$ *(Locatelli and Hobbs. 1974)*	$\frac{148.07\Gamma(0.527+2+1)}{\lambda_s^{0.527}\Gamma(2+1)}$ *(Cox 1988)*	$\frac{148.07\Gamma(0.527+2+1)}{\lambda_s^{0.527}\Gamma(2+1)}$ *(Cox 1988)*
N_{0H}	0.0004 *(Federer and Waldvogel 1975)*	0.0004 *(Federer and Waldvogel 1975)*	4.000 *(Gilmore et al. 2004)*	0.0004 *(Federer and Waldvogel 1975)*	4.000 *(Gilmore et al. 2004)*
λ_H	$\left(\frac{\pi\rho_h N_h}{\rho q_h}\right)^{0.25}$ *(Lin et al. 1983)*	$\left(\frac{\pi\rho_h N_h}{\rho q_h}\right)^{0.25}$ *(Lin et al. 1983)*	$\left(\frac{0.0702N_{0h}\Gamma(2.7+1)}{\rho q_h}\right)^{1/(2.7+1)}$ *(Locatelli and Hobbs. 1974)*	$\left(\frac{\pi\rho_h N_h}{\rho q_h}\right)^{0.25}$ *(Lin et al. 1983)*	$\left(\frac{0.0702N_{0h}\Gamma(2.7+1)}{\rho q_h}\right)^{1/(2.7+1)}$ *(Locatelli and Hobbs. 1974)*
V_H	$\frac{\Gamma(4.5)}{6\lambda_h^{0.5}}\left(\frac{4g\rho_h}{3C_D\rho}\right)^{1/2}$ *(Wisner et al. 1972)*	$\frac{\Gamma(4.5)}{6\lambda_h^{0.5}}\left(\frac{4g\rho_h}{3C_D\rho}\right)^{1/2}$ *(Wisner et al. 1972)*	$\frac{234.42\Gamma(0.37+2.7+1)}{\lambda_h^{0.37}\Gamma(2.7+1)}$ *(Locatelli and Hobbs. 1974)*	$\frac{\Gamma(4.5)}{6\lambda_h^{0.5}}\left(\frac{4g\rho_h}{3C_D\rho}\right)^{1/2}$ *(Wisner et al. 1972)*	$\frac{234.42\Gamma(0.37+2.7+1)}{\lambda_h^{0.37}\Gamma(2.7+1)}$ *(Locatelli and Hobbs. 1974)*

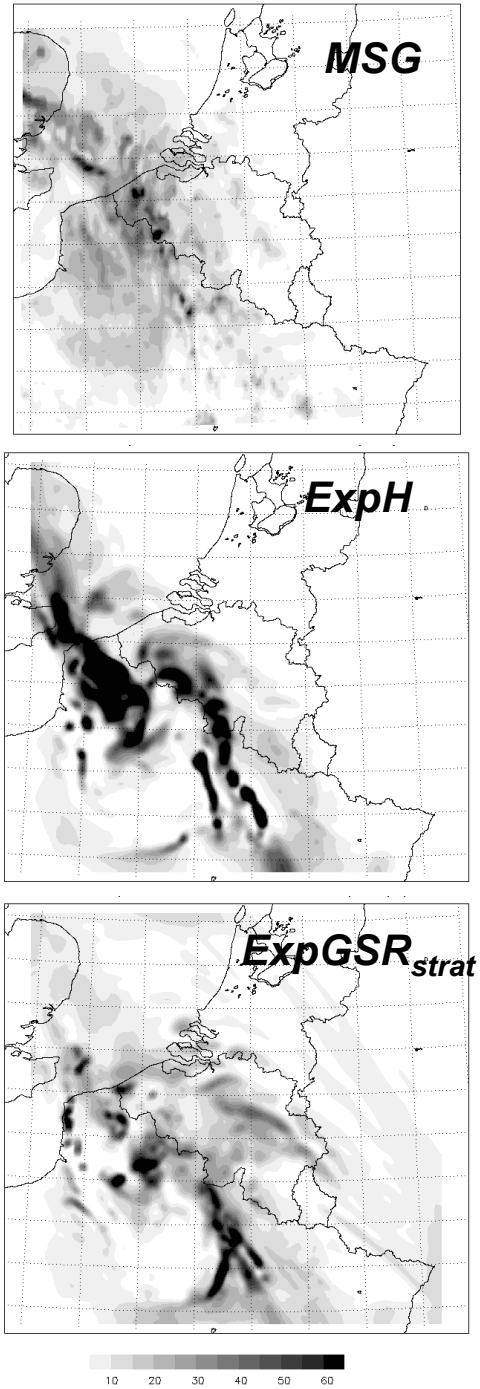


Case studies: ARPS – MSG
stratiform composite

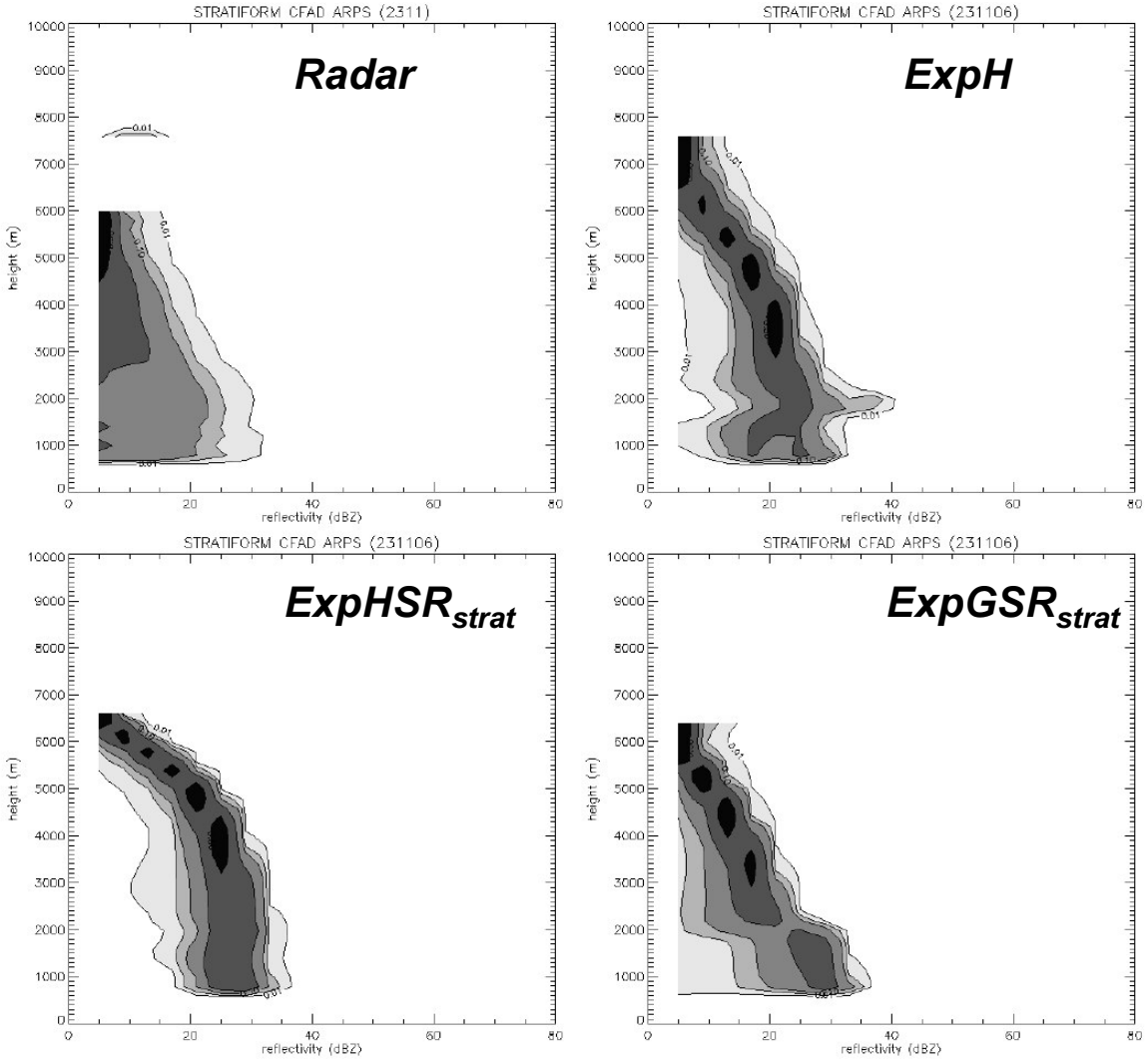


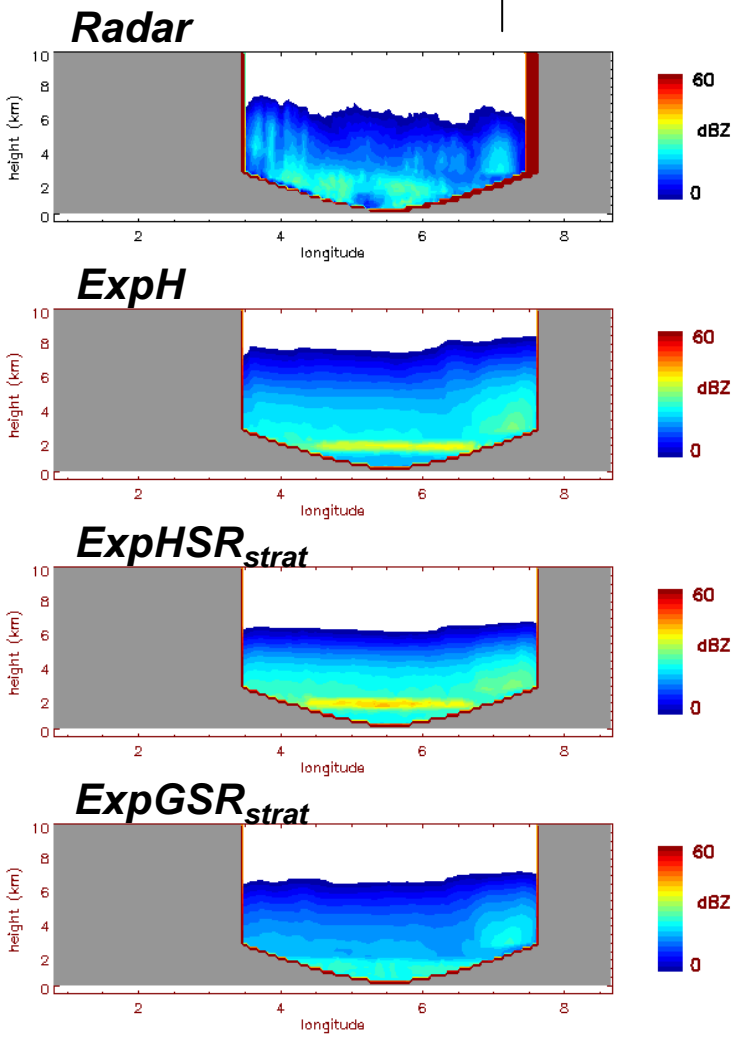
$$\bar{\tau} = -\mu \ln\left(1/N \sum_i \exp(-\tau_i/\mu_i)\right)$$

Observed:	*ExpH*	*ExpGSR$_{strat}$*
3.6	*3.1*	*3.7*



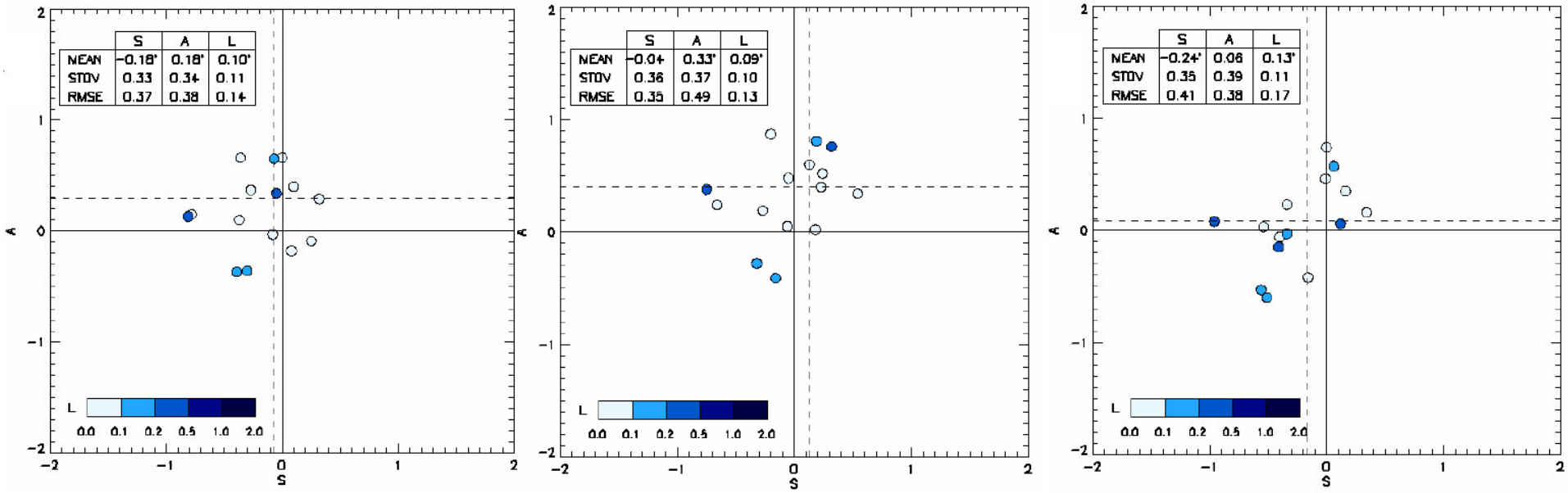
Case studies: ARPS – Radar
stratiform composite (23 November 2006)



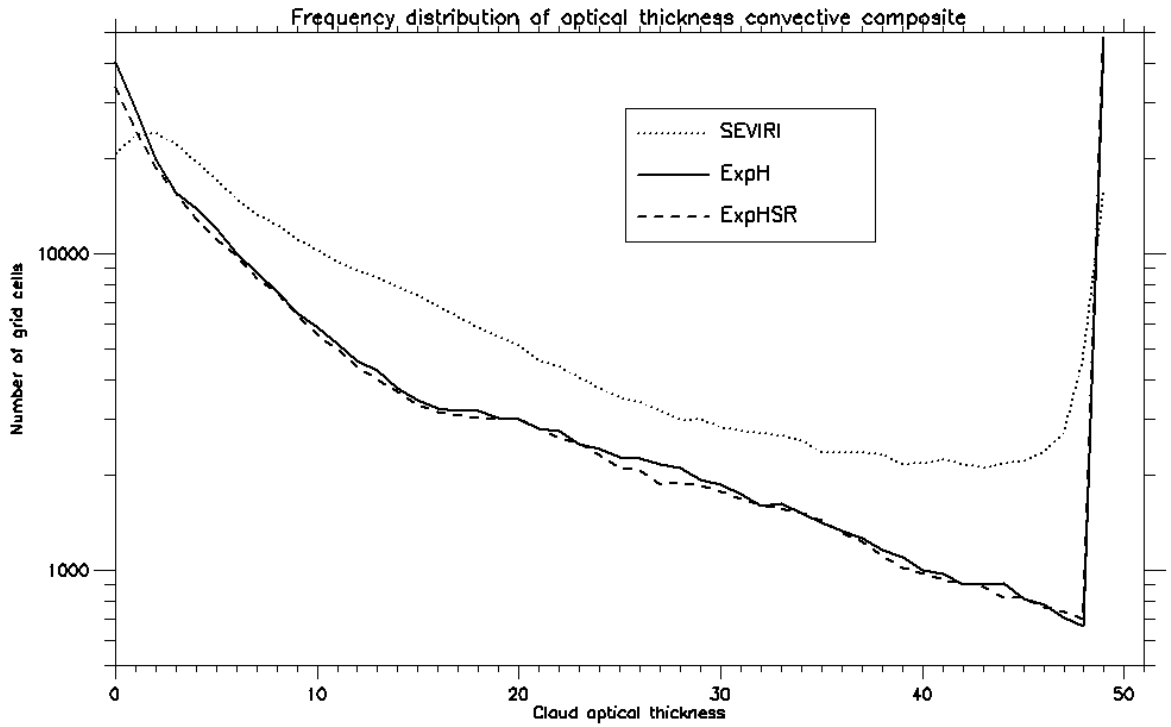


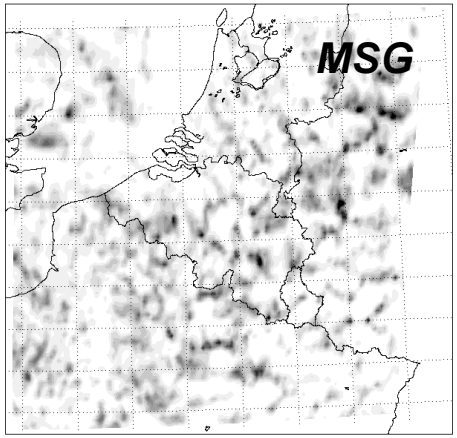
Case studies: ARPS – Surface rain stratiform composite

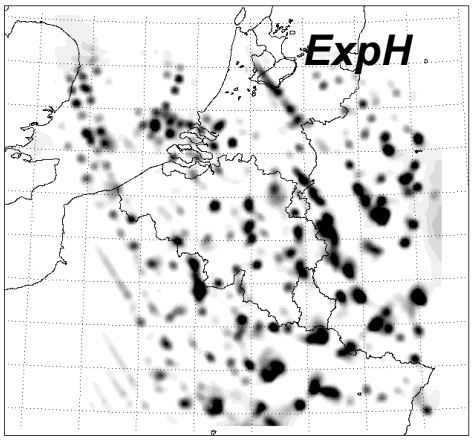
ExpH ***ExpGSR$_{strat}$*** ***ExpGSR$_{strat}$ (conserved water)***

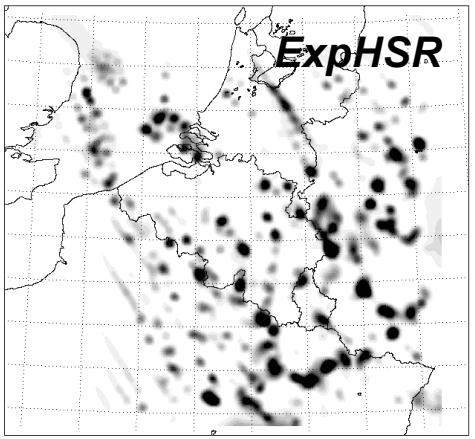


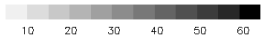
Case studies: ARPS – MSG
convective composite







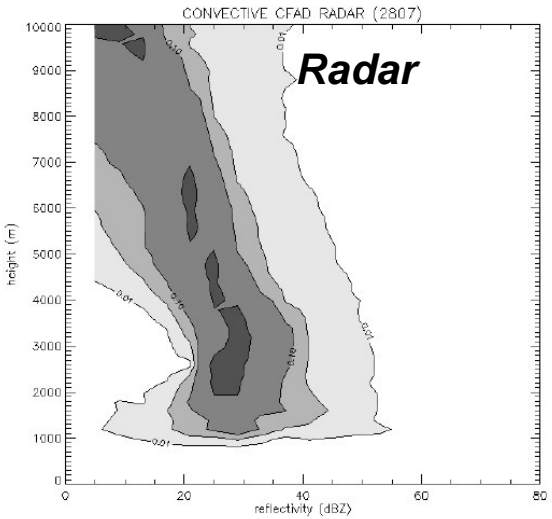


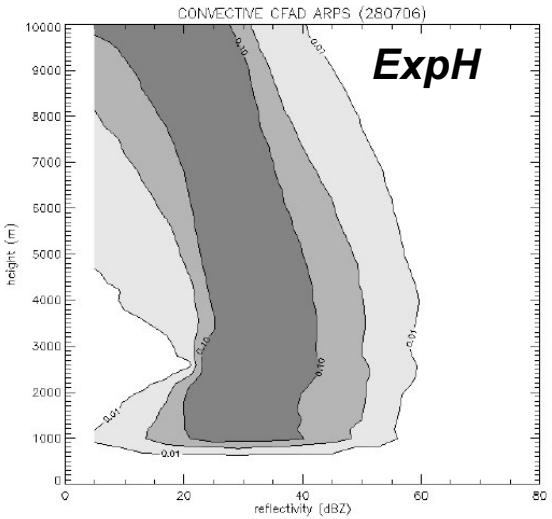


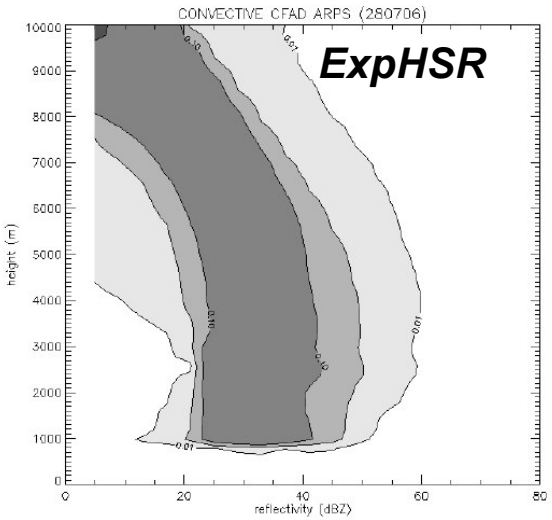
$$\bar{\tau} = -\mu \ln\left(1/N \sum_i \exp(-\tau_i/\mu_i) \right)$$

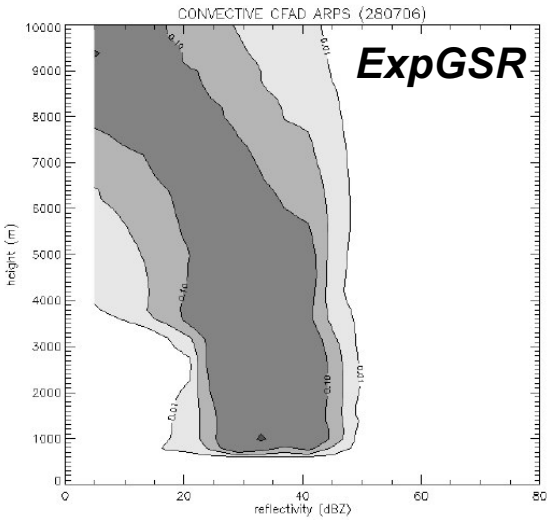
Observed:	*ExpH*	*ExpHSR*
3.2	*2.8*	*2.8*

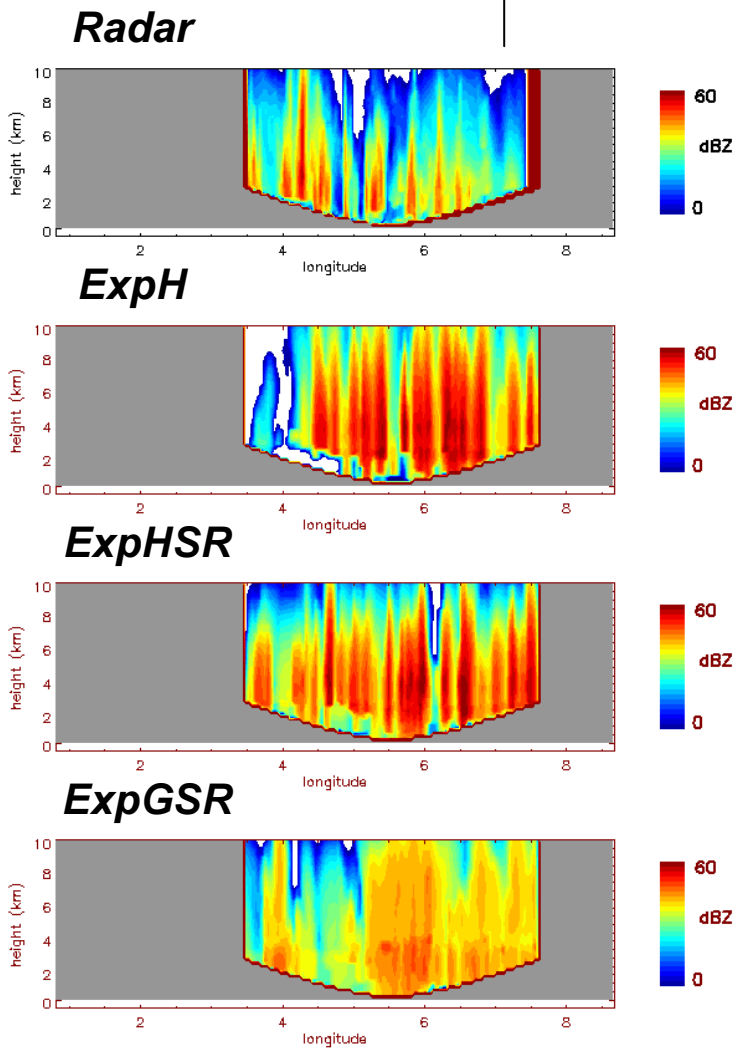
Case studies: ARPS – Radar
convective composite (28 July 2006)





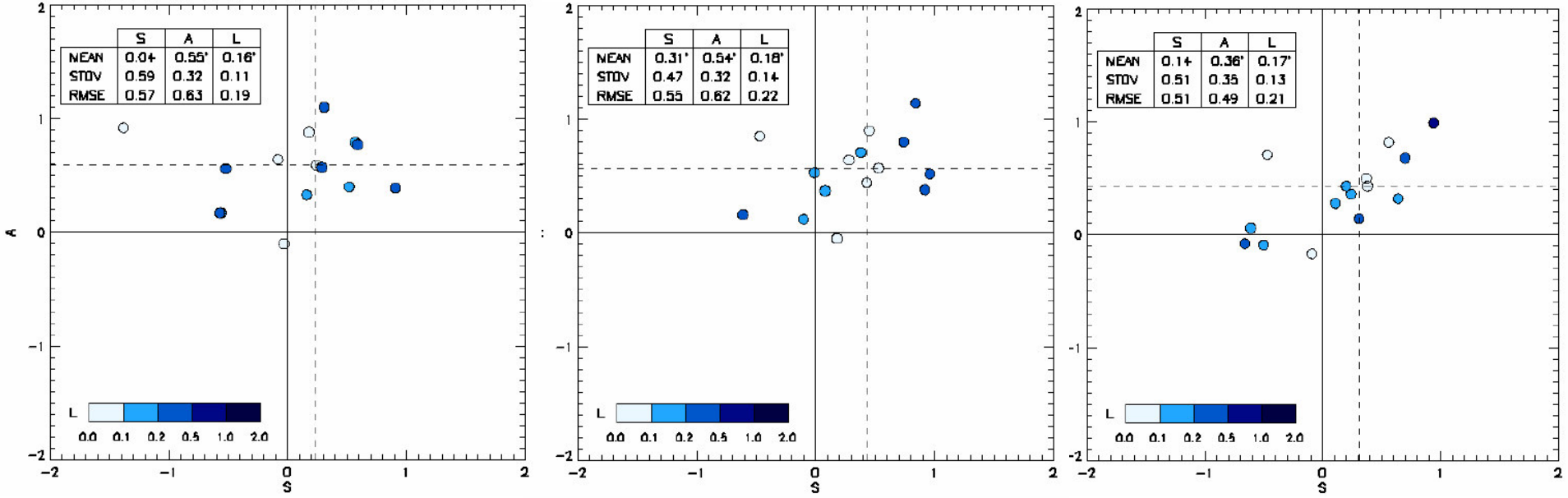






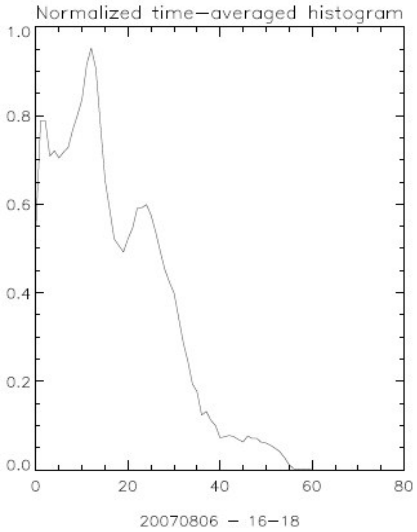
Case studies: ARPS – Surface rain
convective composite

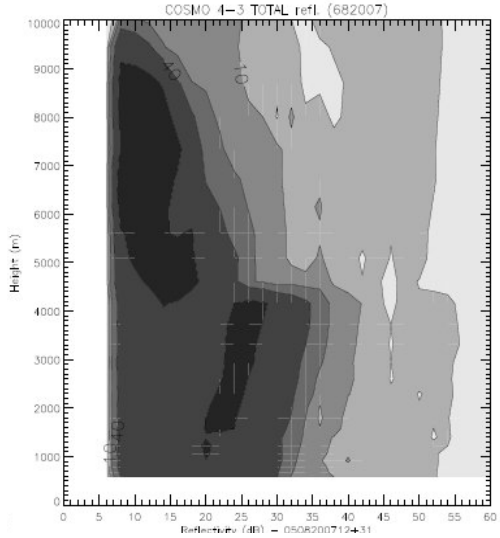
ExpH ***ExpHSR*** ***ExpHSR (conserved water)***



Case studies: COSMO – Radar
convective composite (06 August 2007)

COSMO



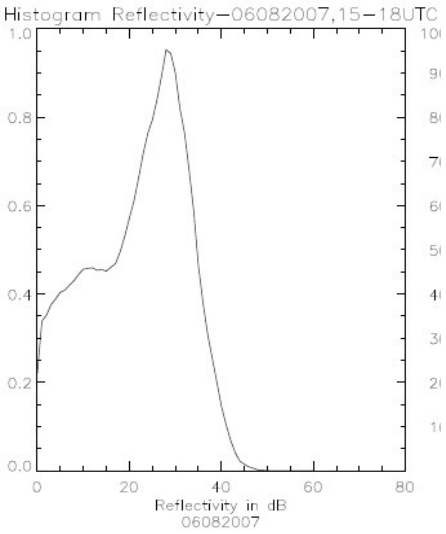


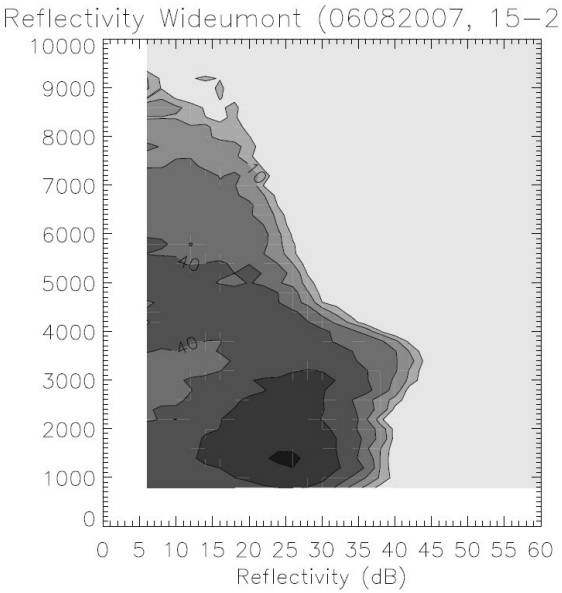
Zmax = 13 dBZ

nmax = 80

dZ = 27 dBZ

Radar



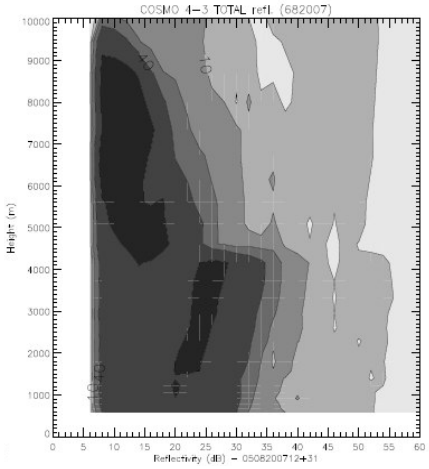


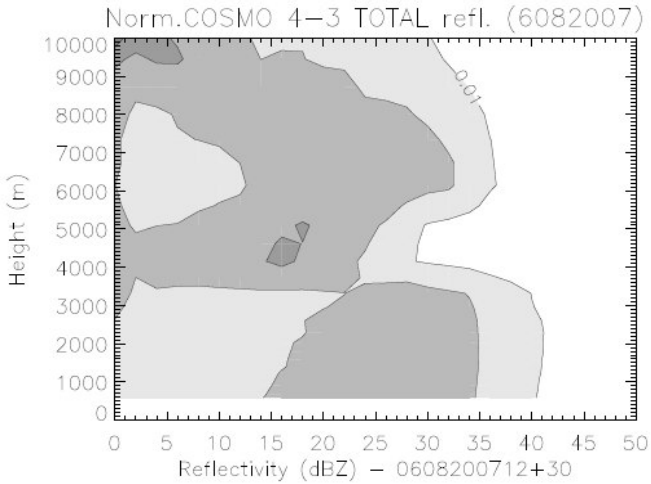
Zmax = 29 dBZ

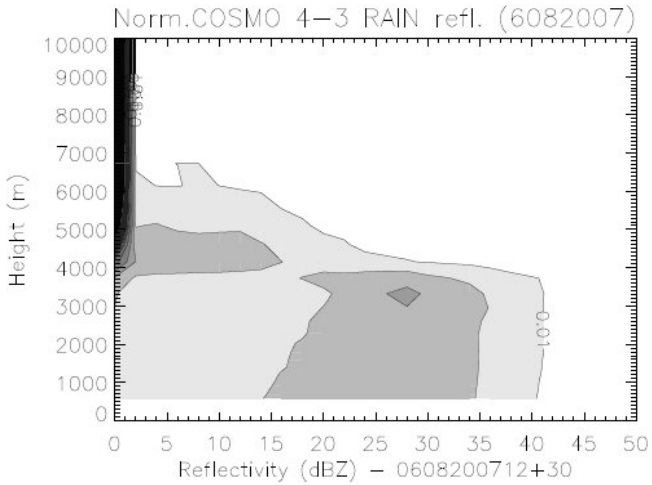
nmax = 124

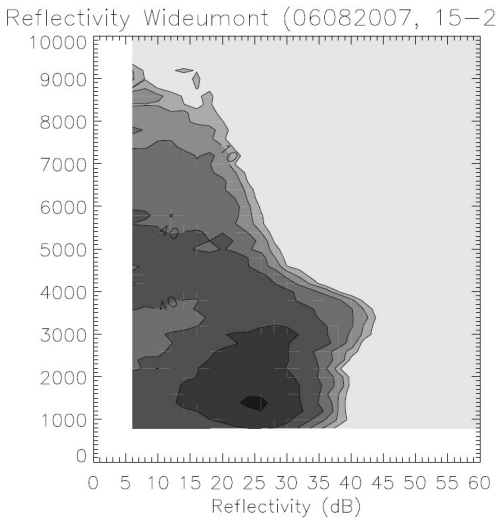
dZ = 16 dBZ

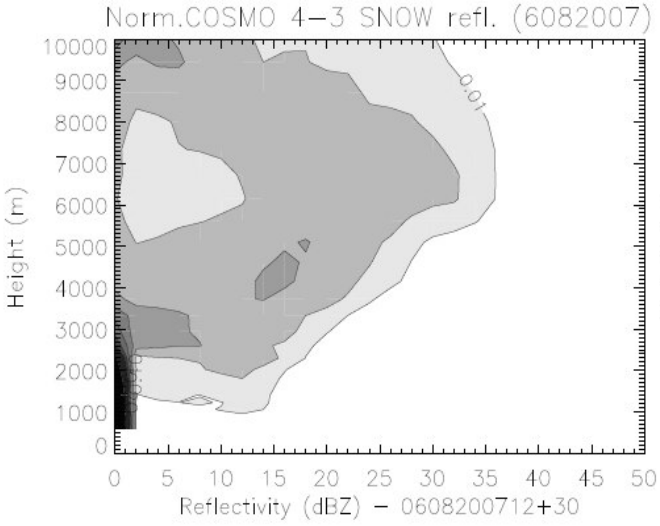
Case studies: COSMO – Radar
convective composite (06 August 2007)

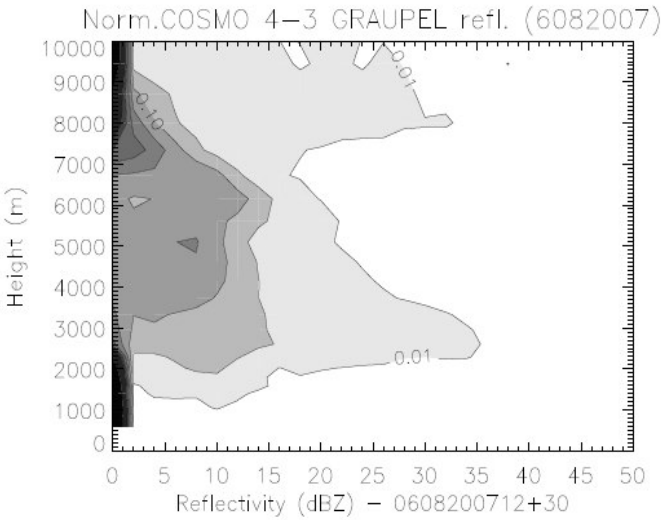




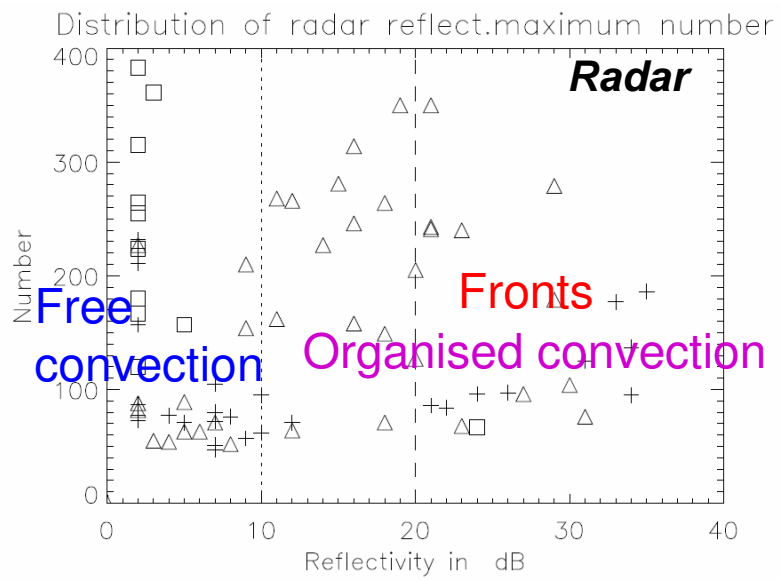


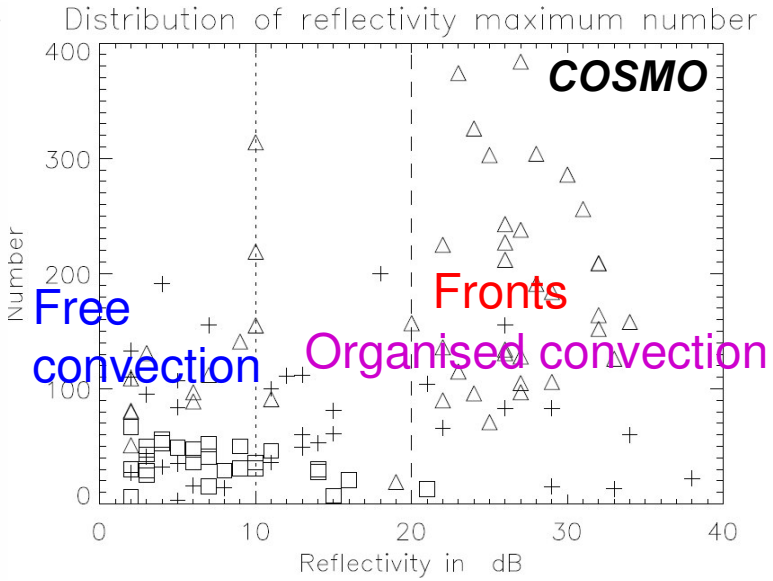


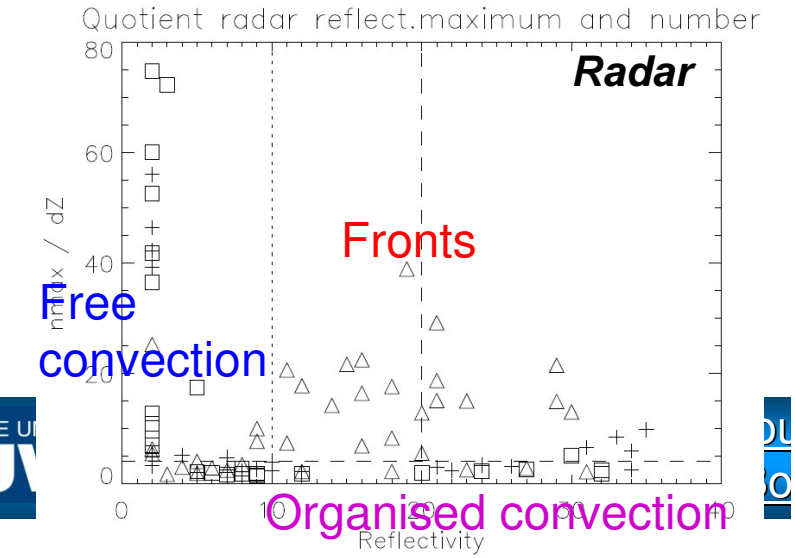


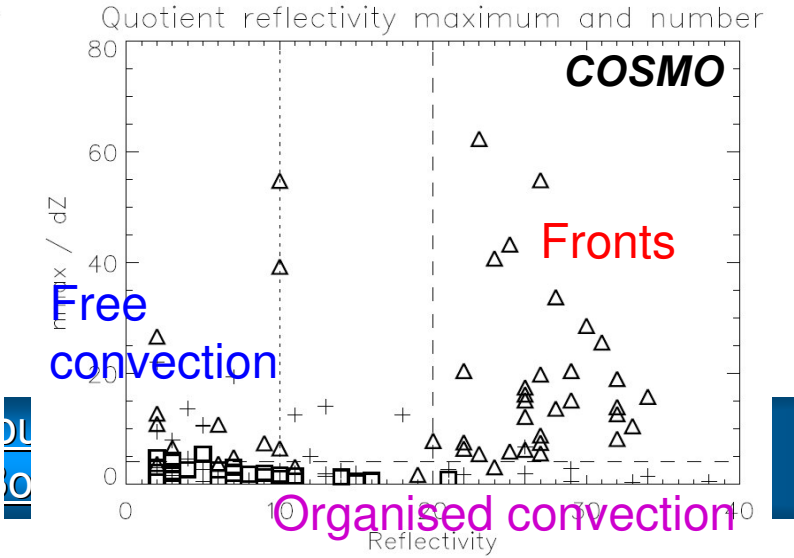


Case studies: COSMO – Radar



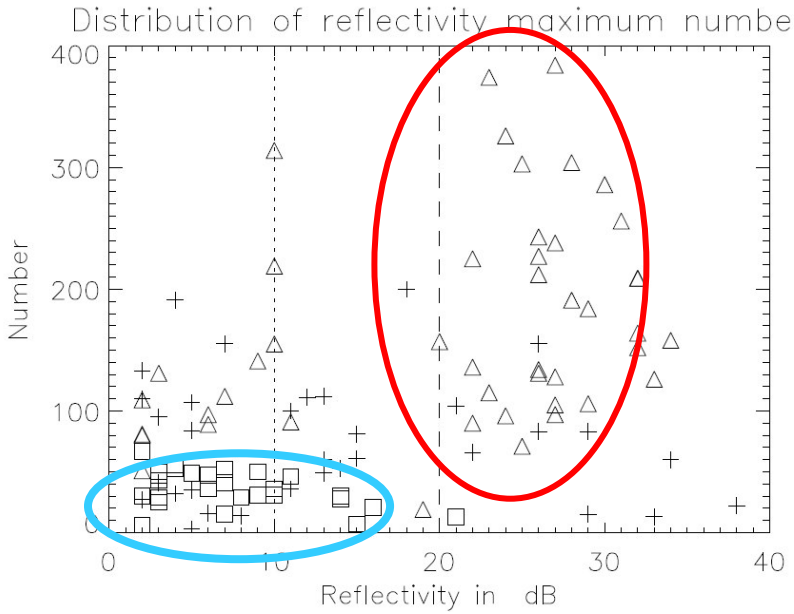




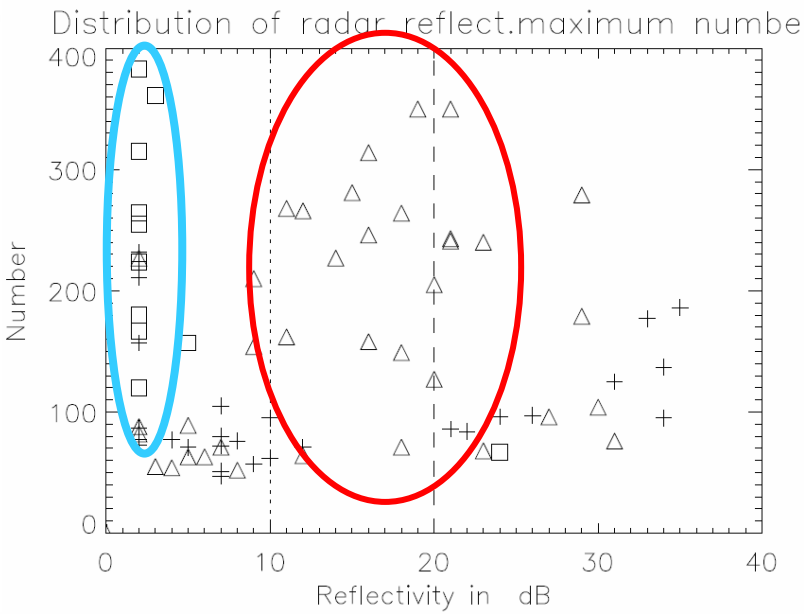


Case studies: COSMO – Radar

COSMO

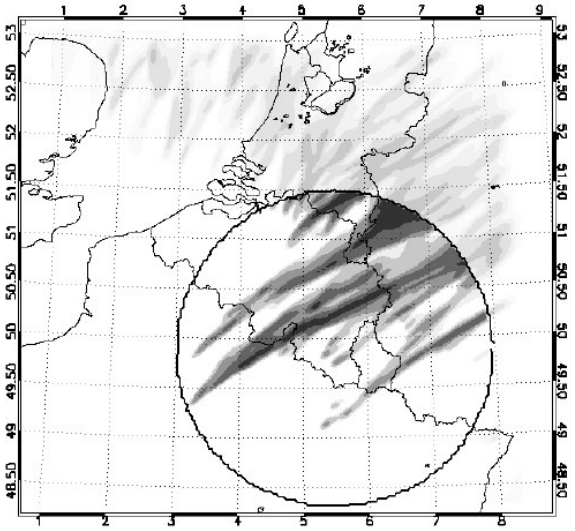


Radar

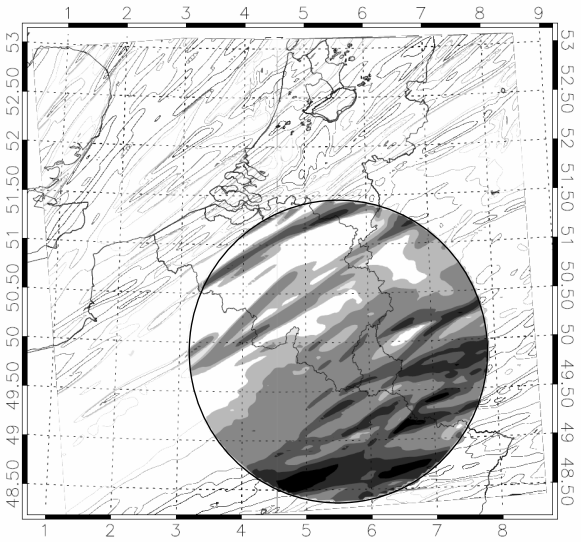


Case studies: ARPS – COSMO – Radar
convective composite (01 October 2006)

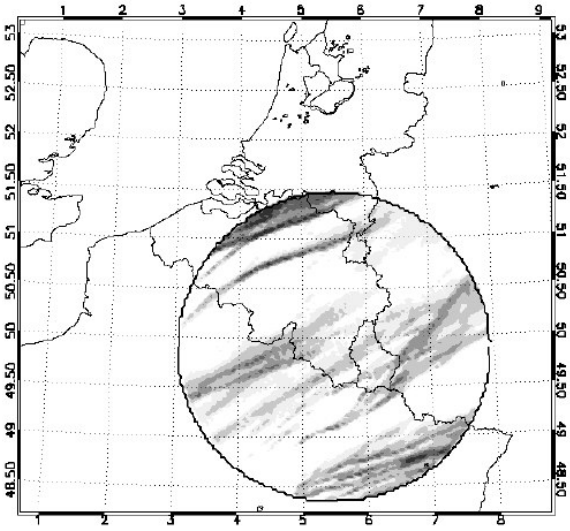
ARPS

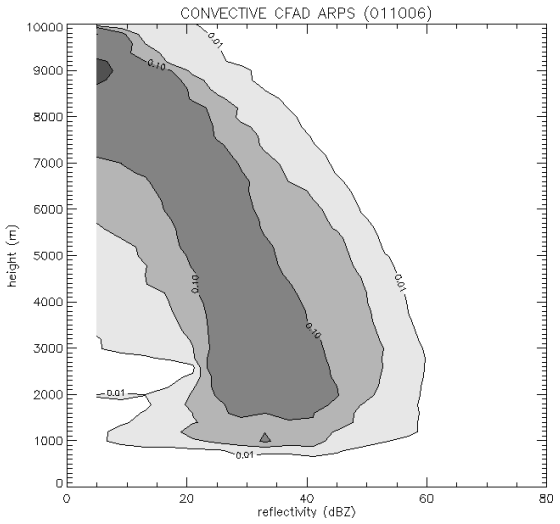


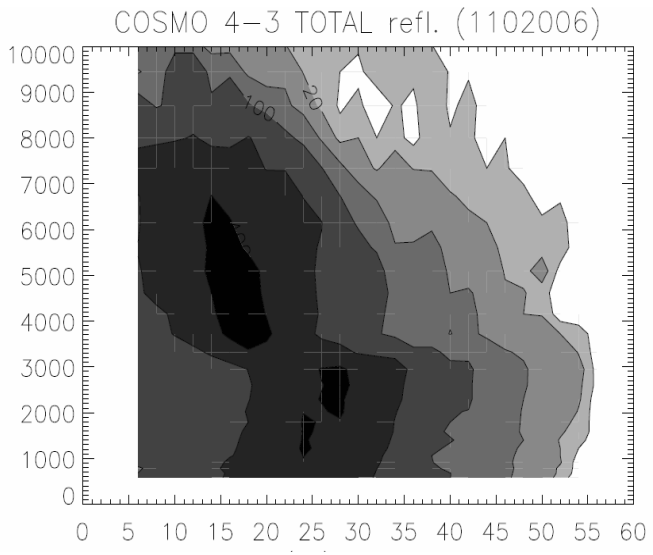
COSMO

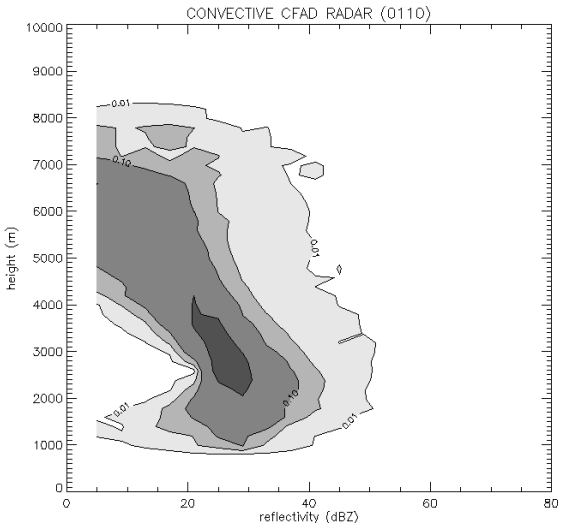


Radar

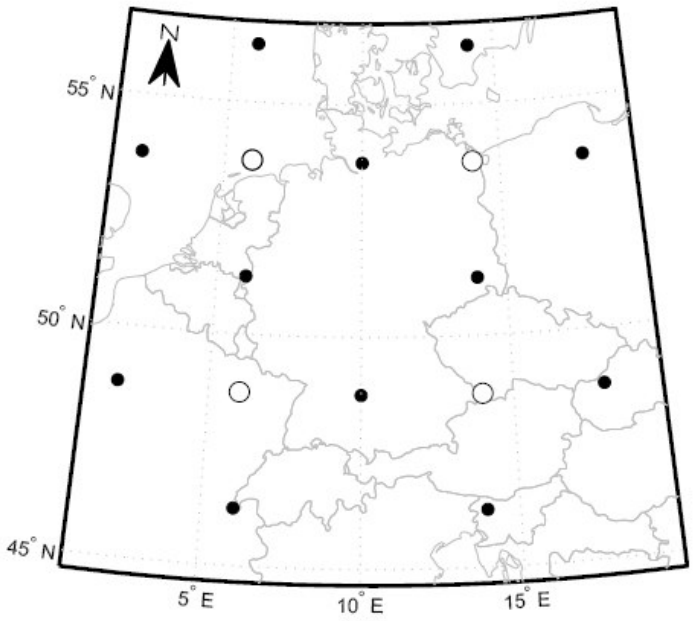


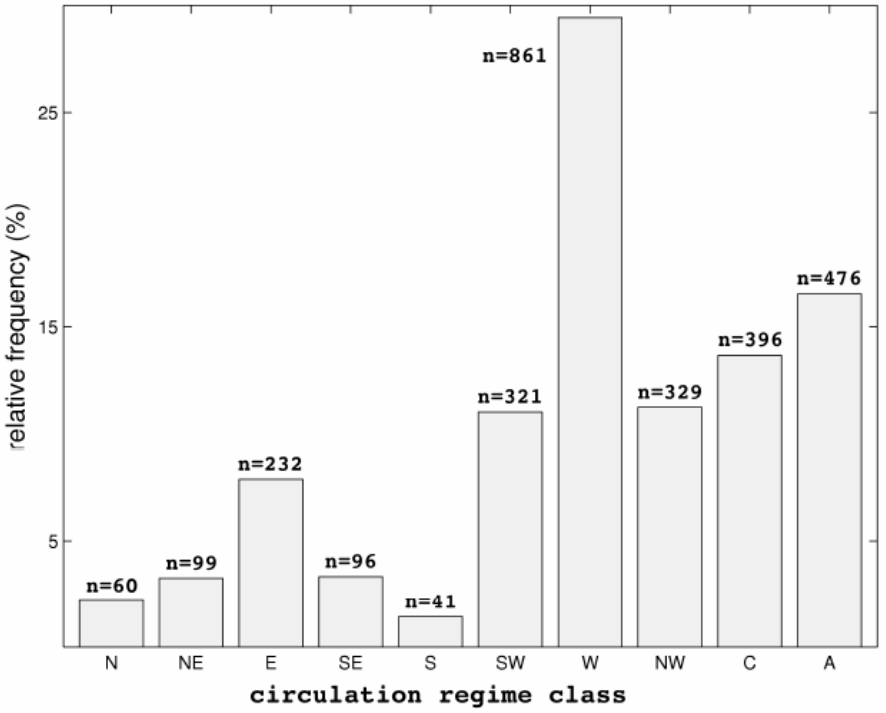






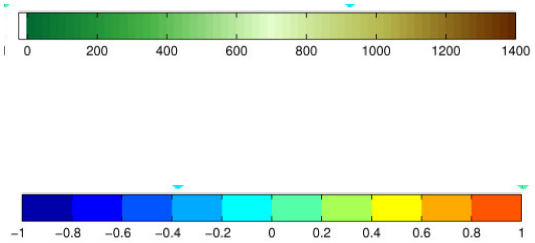
Long-term analysis: COSMO
regime dependent evaluation

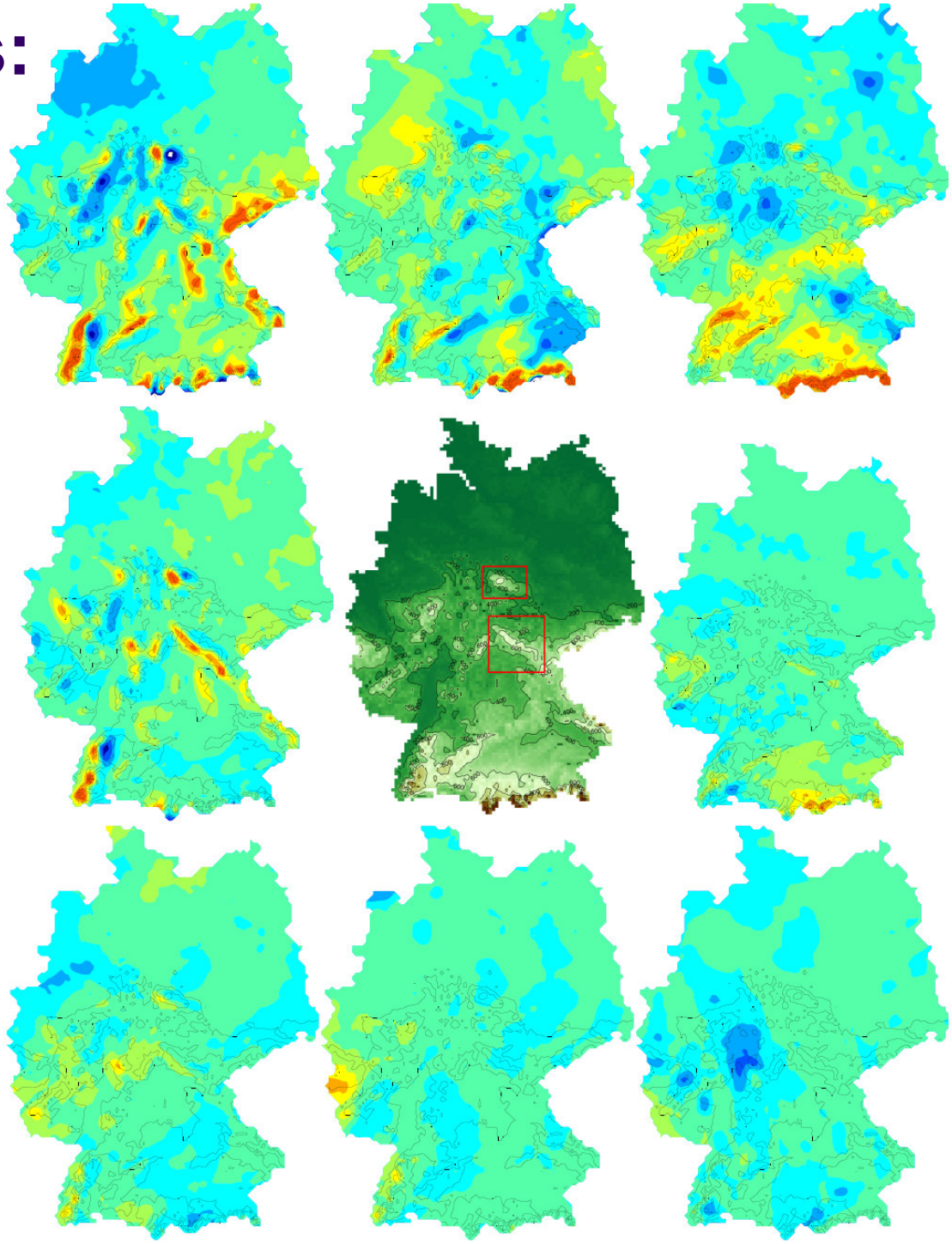




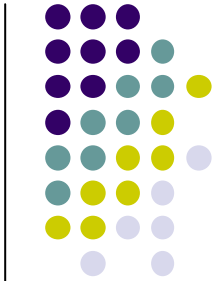
Long-term analysis: COSMO

regime dependent evaluation





Conclusions so far



→ ***Major goal:*** in-depth analysis of model deficiencies in **COSMO** and **ARPS**

→ ***in-depth evaluation of case studies***

ARPS

- *Underestimation of average COT, mainly due to too many very thin clouds, but excessive snow*
- *COT distribution can be improved significantly by replacing hail formulation by graupel*
- *Both hail and graupel should be included in an operational setup for realistic moisture fields*
- *Surface precip unsensitive to microphysics experiments but improvement when conserving water*

COSMO (4.3)

- *Overestimation of frontal stratiform precipitation*
- *Excessive snow in the upper troposphere*
- *Too intense convective cells*

→ ***evaluation of long-term studies***

- *Windward-lee effect in surface precipitation bias (associated with convection parameterization)*
- *Height dependence of precipitation bias (Difficulty with observations during snow conditions?)*

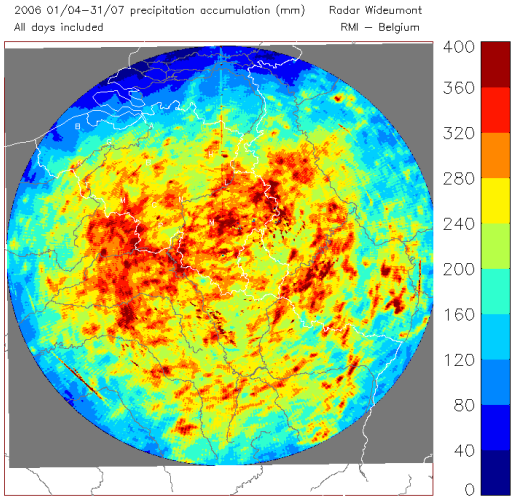
Outlook

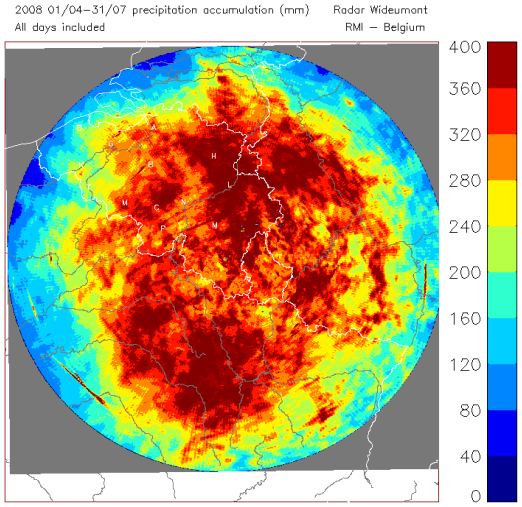
Compilation of precipitation characteristics for
two contrasting spring/summer seasons (04-07/2006 + 2008)

→ Input analyses data in 1h-distances, 36 hours runs

→ Output in 1h distances resp. 15 min distances for precipitation

→ Precipitation patterns / characteristics in Belgium





Interdisciplinary research:
→ Result as input for other subjects of geography, hydrology and agriculture e.g. soil erosion models → focus on spring time