

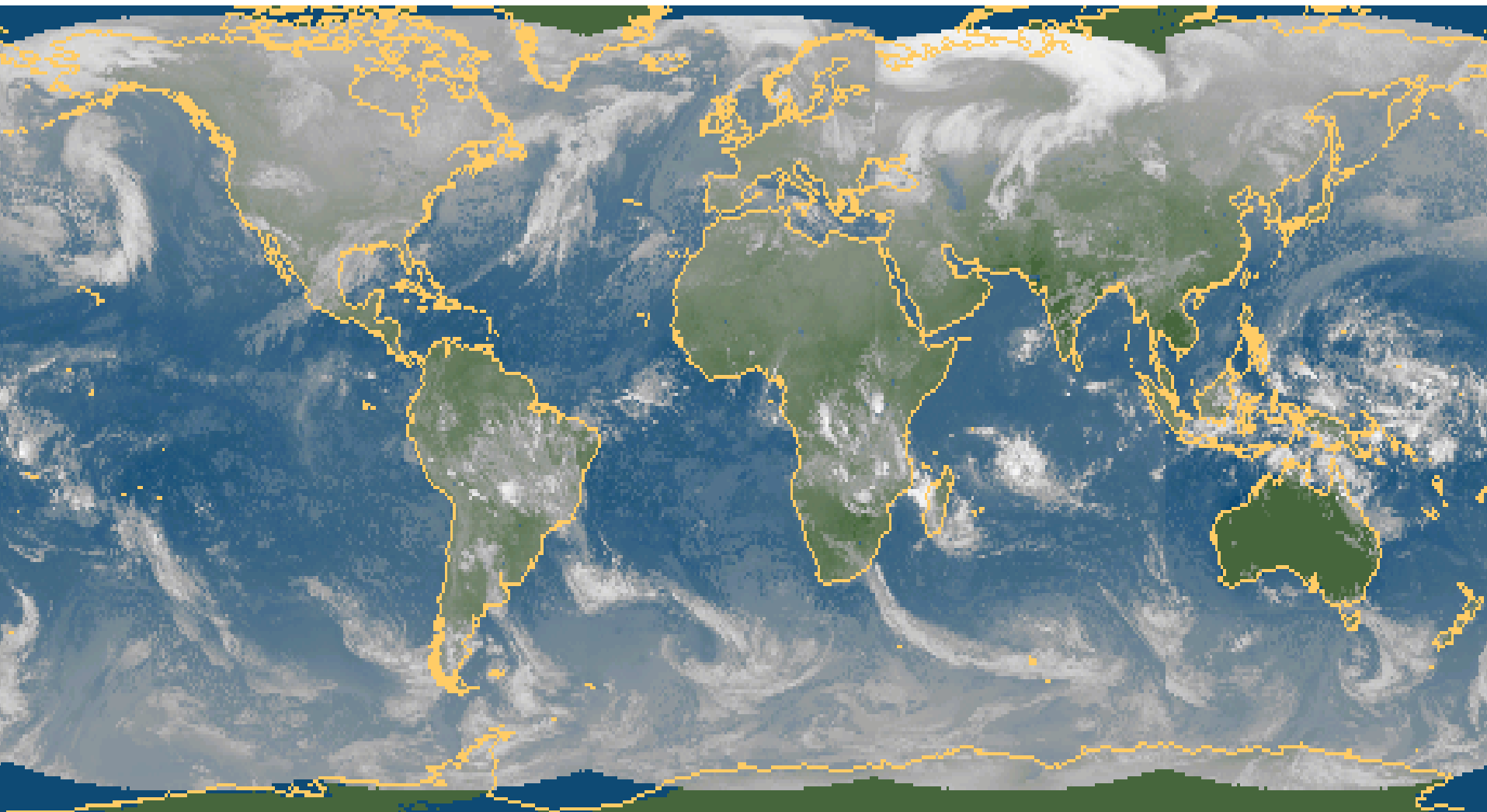


Satellite-based real-time monitoring and verification of model forecasted clouds

3rd International Verification Workshop

31.1. – 2.2.2007, ECMWF

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World Cloud Map 2007-01-30 06:00 UTC - copyright ZAMG



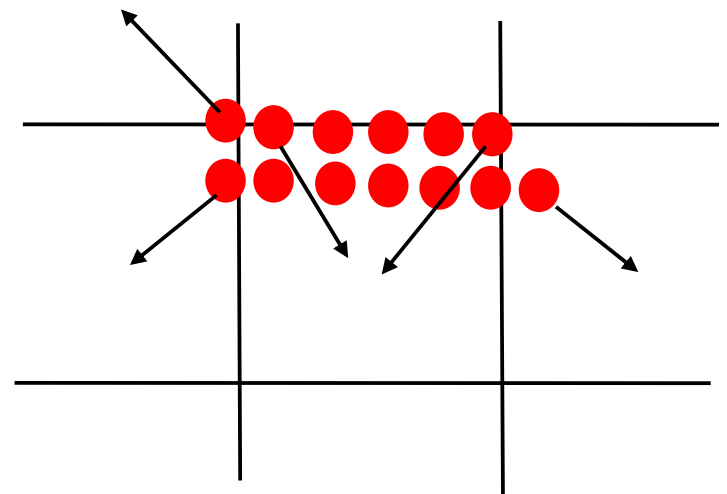
Satellite data:

- Real-time availability
- High temporal resolution
- High spatial resolution
- Spectral resolution

Satellite data:

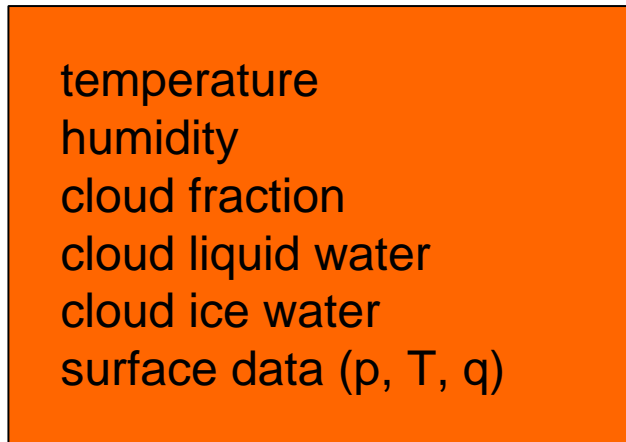
NOAA AVHRR satellite image

- Re-sampling needed: 1km sub satellite point resolution
- Assumptions:
 - a) Forecast model grid value represents mean of all values in box.
 - b) Neighbouring satellite pixels tend to have similar properties.
- Preprocessed AVHRR image pixel center (calibrated and navigated) is assigned to a corresponding HIRLAM grid-box. Simple arithmetic mean.

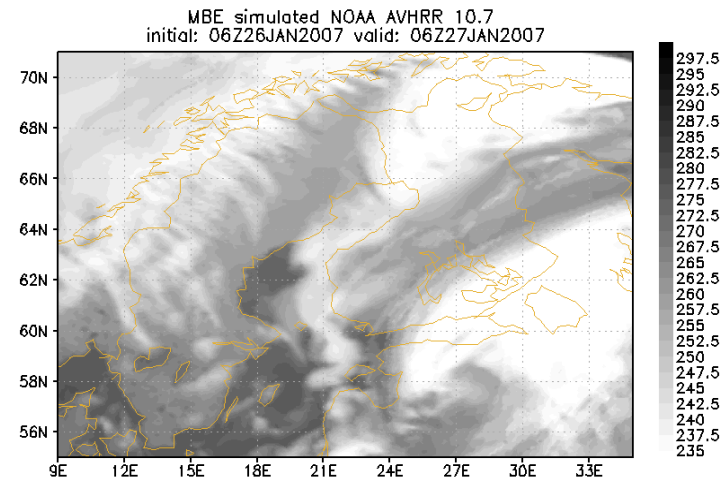




Model cloud forecast:

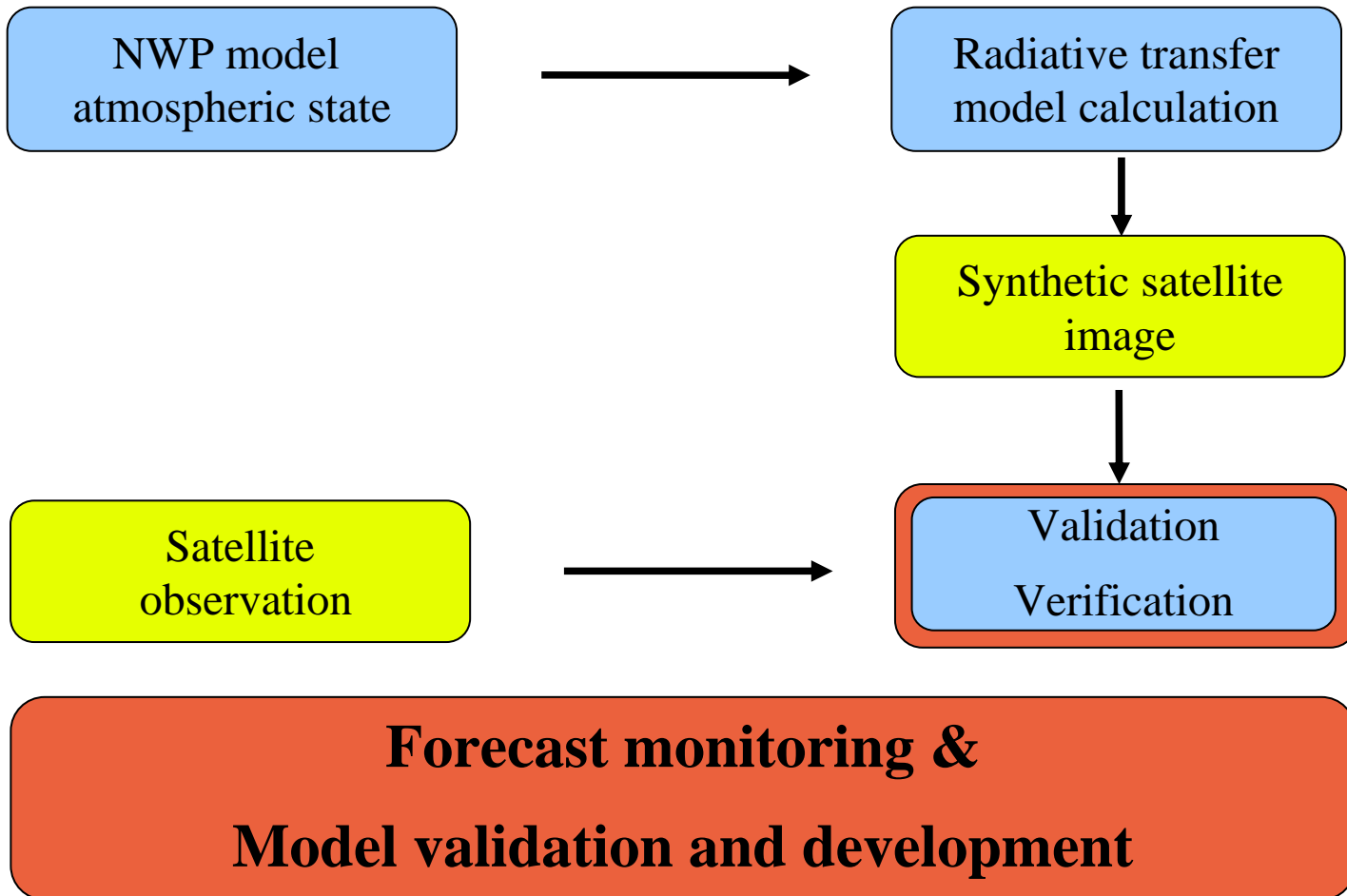


- Simulates clear/cloudy multilevel infrared and microwave radiances
- Consistent random-overlap scheme for clouds in different levels (as Hirlam)
- Multiphase cloud field: water / ice / mixed, crystal size distribution / aggregates





Real-time verification:



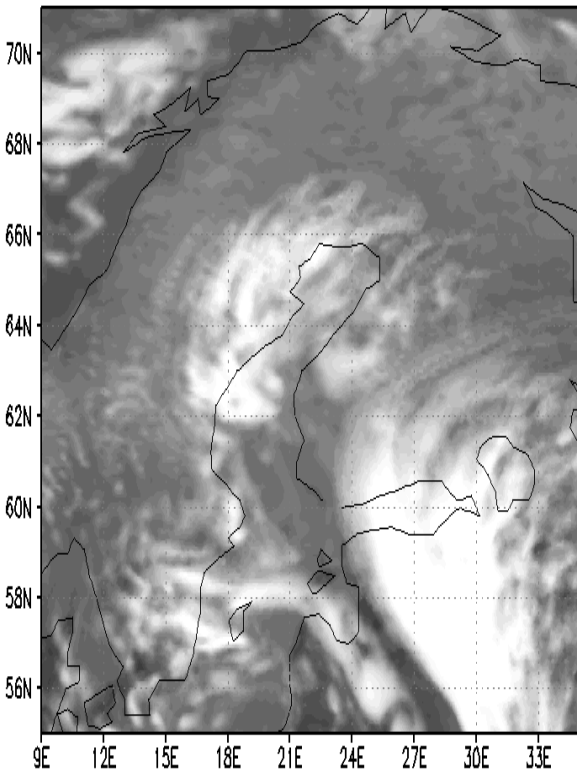


Real-time verification:

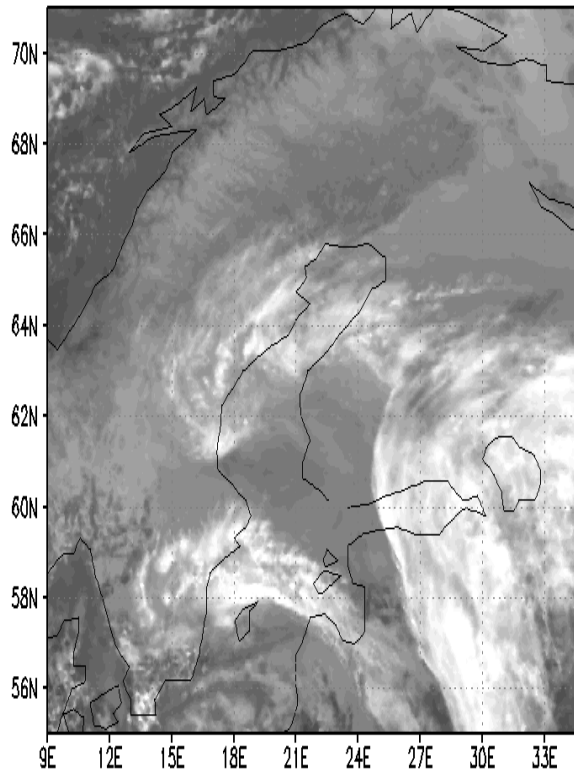
- WEB-based intranet platform at FMI
- Eyeball-verification / side by side comparison of simulation and observation
- Difference plots, histograms, BIAS and RMSE
- Entity-based verification (CRA-method, Ebert & McBride, 2000)



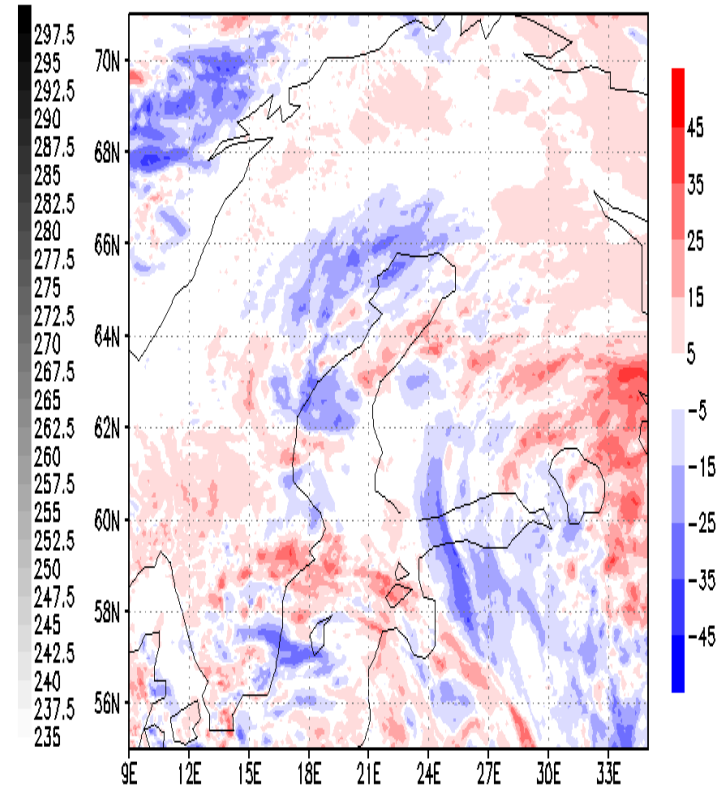
MBE NOAA AVHRR 10.7 05APR2006 13UTC



SAT NOAA AVHRR 10.7 05APR2006 13UTC

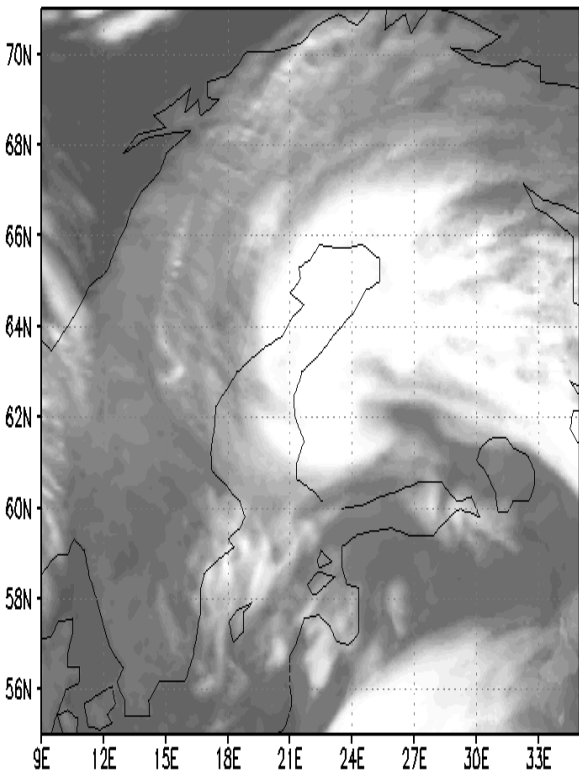


NOAA AVHRR 10.7 FC-OBS 05APR2006 13UTC

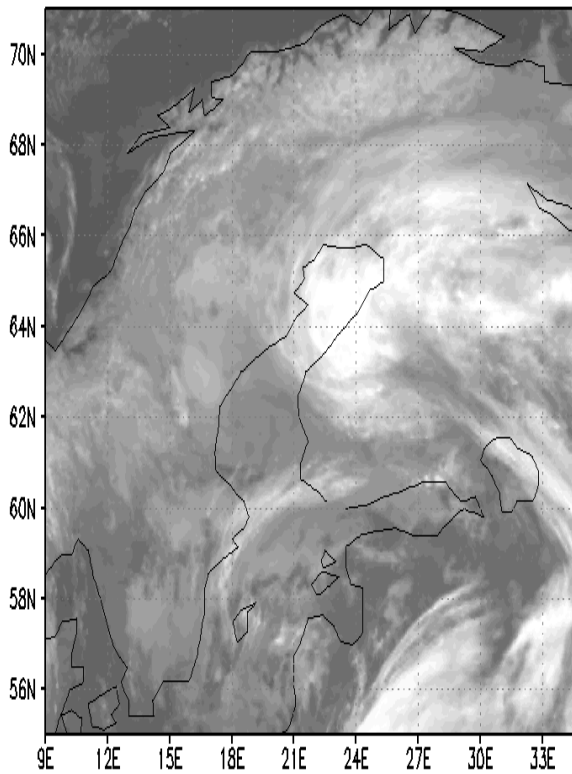




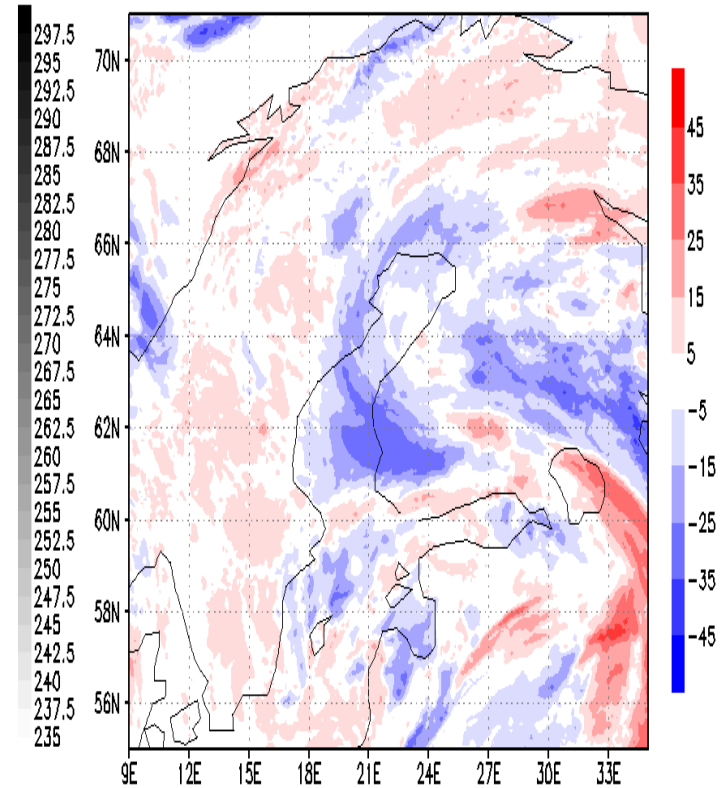
MBE NOAA AVHRR 10.7 06APR2006 01UTC



SAT NOAA AVHRR 10.7 06APR2006 01UTC

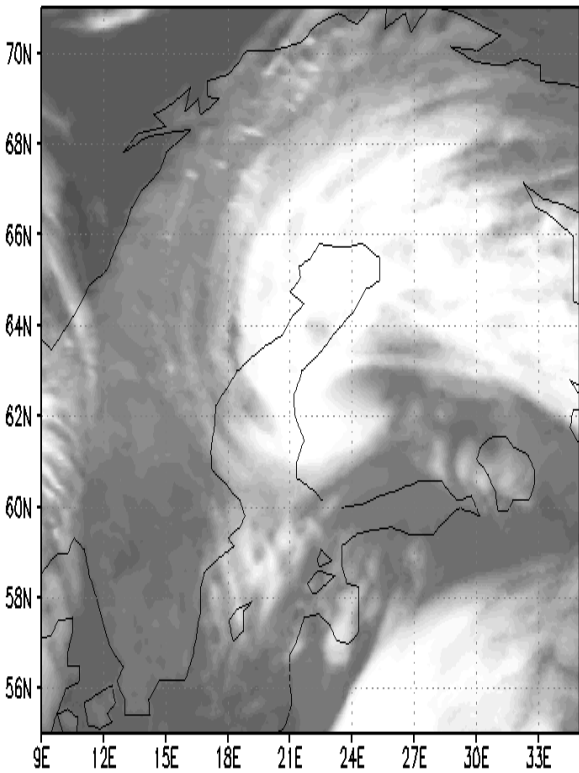


NOAA AVHRR 10.7 FC-OBS 06APR2006 01UTC

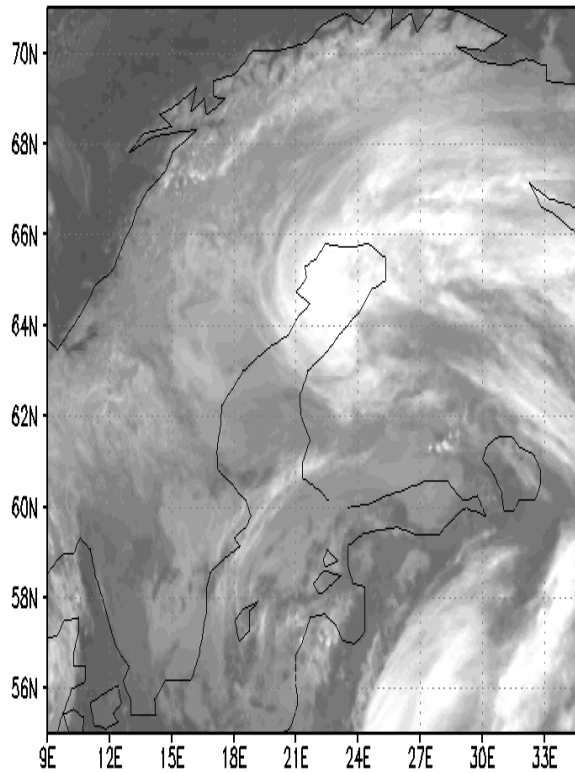




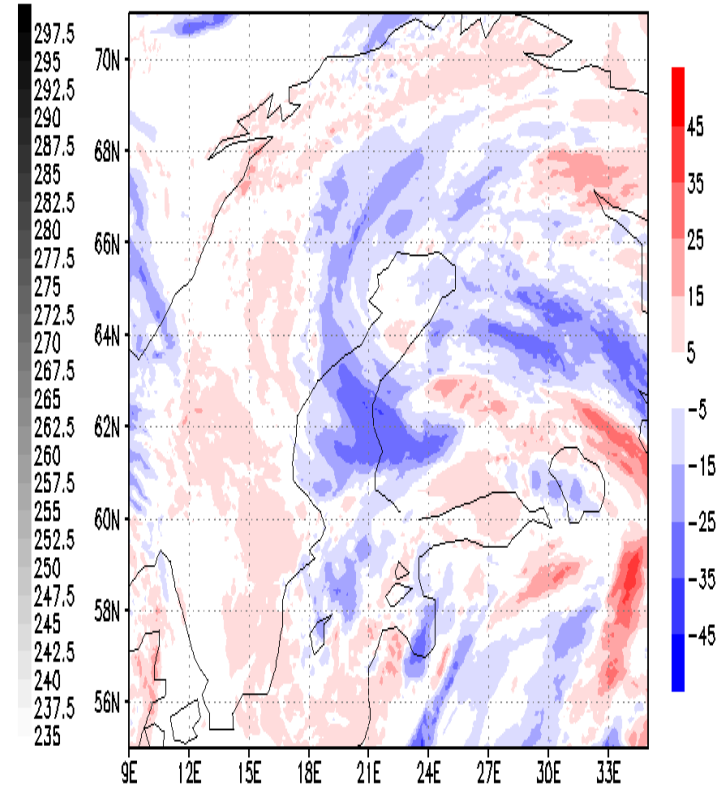
MBE NOAA AVHRR 10.7 06APR2006 03UTC



SAT NOAA AVHRR 10.7 06APR2006 03UTC



NOAA AVHRR 10.7 FC-OBS 06APR2006 03UTC



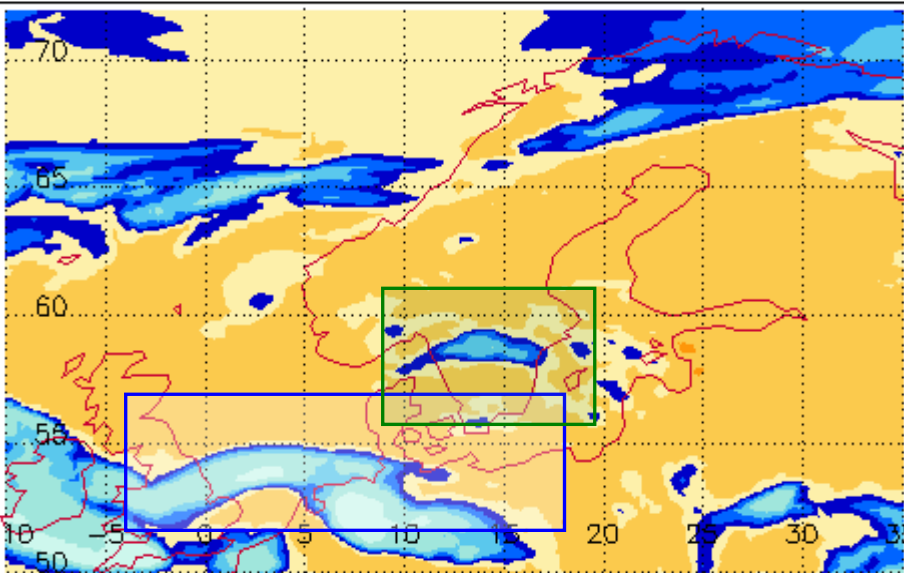


Entity-based verification

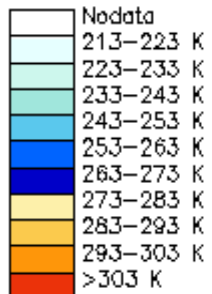
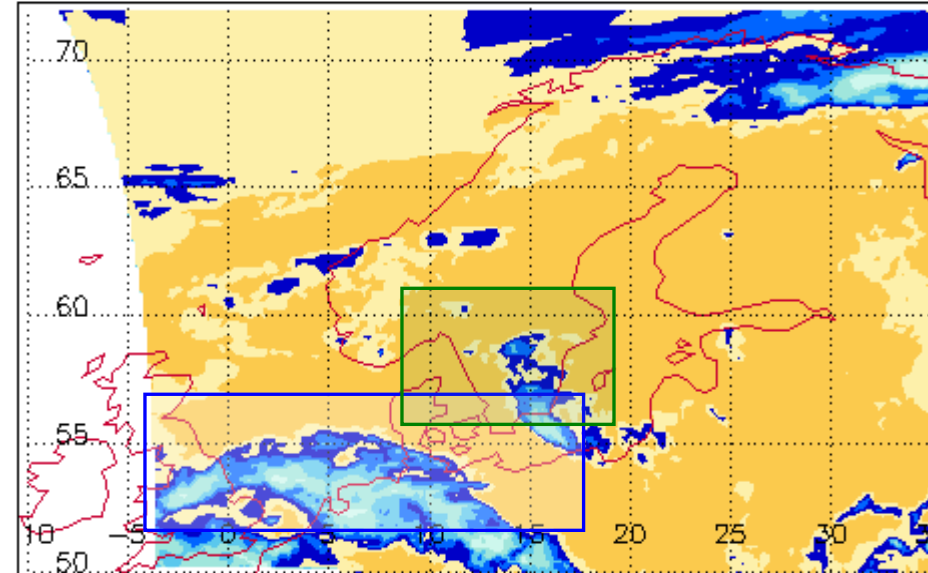
- Entities defined by simple thresholding method
- Entities weighted according to their size
- Forecast moved around in a sub-domain to search for best fit, here minimize MSE (or maximize corr. coeff.) to build vector difference
- Estimates displacement, volume (intensity, amplitude) and pattern (residual) error



HIRLAM 18-07 fcst for 2003071701



Satellite observation for 2003071701



		Observed	
		≤278	>278
Forecast	≤278	5038	2694
	>278	1423	13031

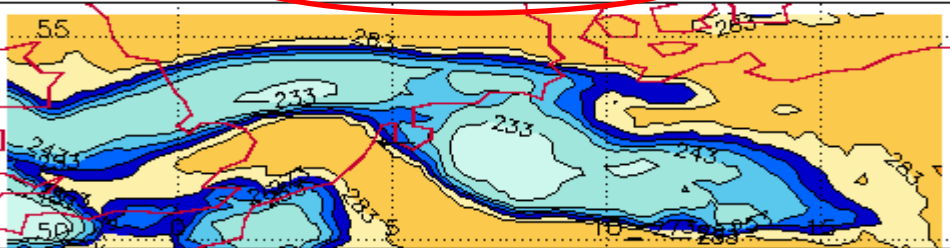
Validation statistics for 2003071701 n=22186 Verif. grid=0.200°

	Observed	Forecast
# gridpoints BT ≤ 278K	6461	7732
Average BT (K)	279.30	278.19
	*****	*****
Minimum BT (K)	221.66	228.15
Min 0.200° BT (K)	221.66	

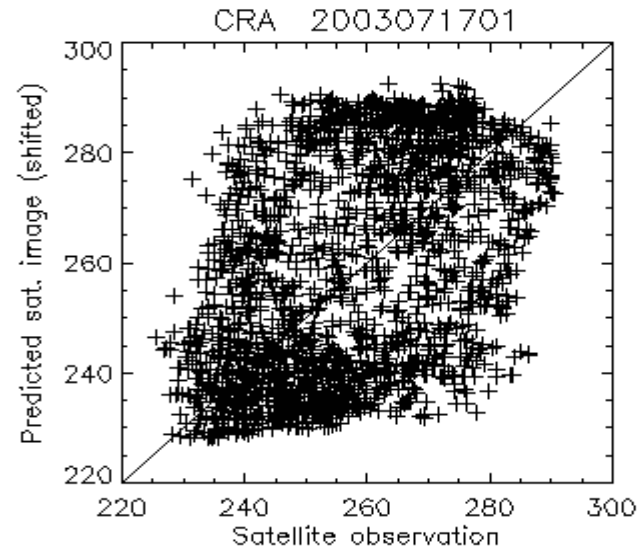
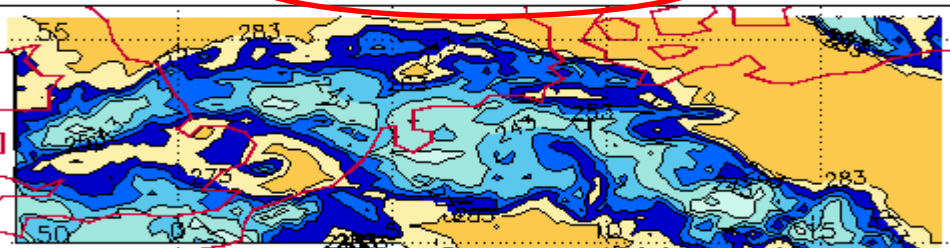
Mean abs error = 6.82 K
RMS error = 10.75 K
Correlation coeff = 0.651
Bias score = 1.197
Probability of detection = 0.780
False alarm ratio = 0.348
Hanssen & Kuipers score = 0.608
Equitable threat score = 0.404



HIRLAM fest 2003071701



Observation 2003071701



HIRLAM 18-07 fest 2003071701 n=2088
(50.00°, -3.80°) to (55.60°, 17.80°)
Verif. grid=0.200° CRA threshold=278.0 K

	Observation	Forecast
# gridpoints ≤ 278 K	1891	1626
Average BT (K)	257.80	259.17
Minimum BT (K)	225.71	228.15
-----	*****	*****

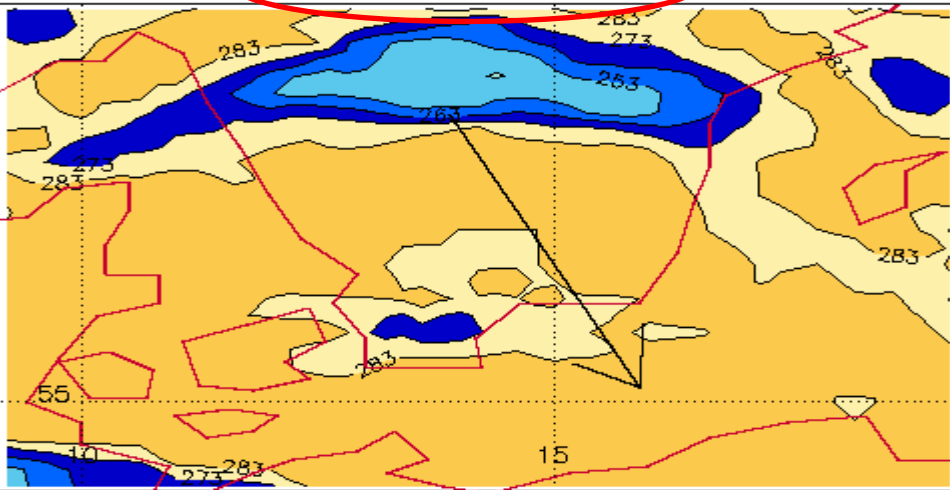
Displacement (E,N) = [0.80°, 0.00°]

	Original	Shifted
RMS error (K)	19.21	18.43
Correlation coefficient	0.402	0.466

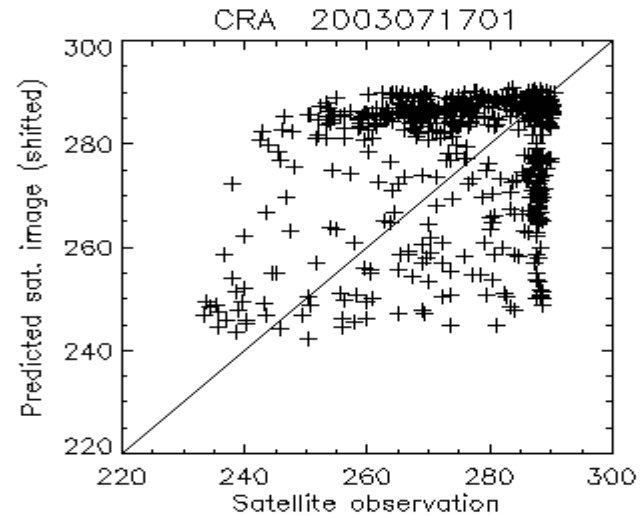
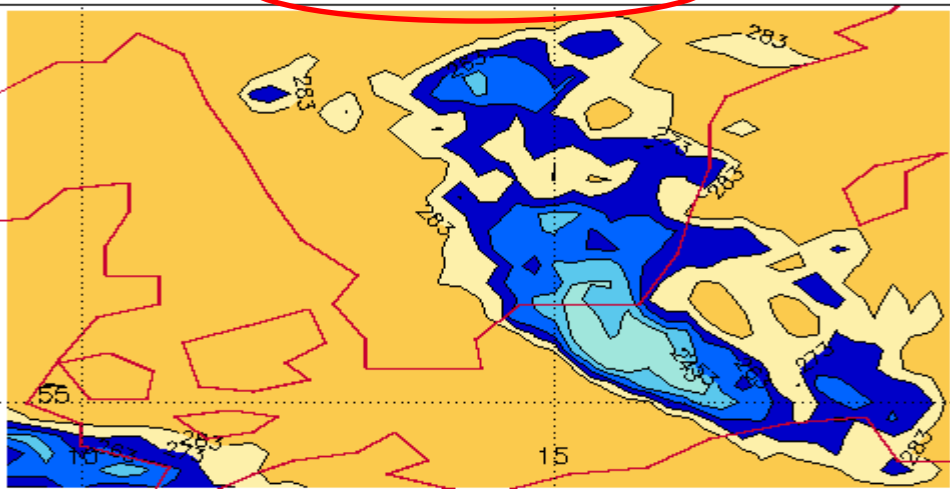
Error Decomposition:	
Displacement error	7.9%
Volume error	0.5%
Pattern error	91.6%



HIRLAM fcst 2003071701



Observation 2003071701



HIRLAM 18-07 fcst 2003071701 n=588
(54.20°,9.40°) to (59.40°,19.00°)

Verif. grid=0.200° CRA threshold=278.0 K

	Observation	Forecast
# gridpoints ≤ 278 K	301	225
Average BT (K)	274.82	277.80
Minimum BT (K)	233.31	242.17
-----	*****	*****

Displacement (E,N) = [-2.00°,3.20°]

	Original	Shifted
RMS error (K)	20.88	16.65
Correlation coefficient	-0.195	0.263

Displacement may be wrong - correlation not signif.

Error Decomposition:	
Displacement error	36.4%
Volume error	2.0%
Pattern error	61.6%



Conclusions

- Use of satellite observations is a powerful tool for real-time verification
- Eyeball, side-by-side comparison and difference plots are easy to use. Problems can be focused quickly.
- Entity-based verification helps forecasters to distinguish between error sources and to focus on important regions in the forecast.
- Still in 'research mode', but will be 'semi-operational' in the foreseeable future.



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Thats all folks!