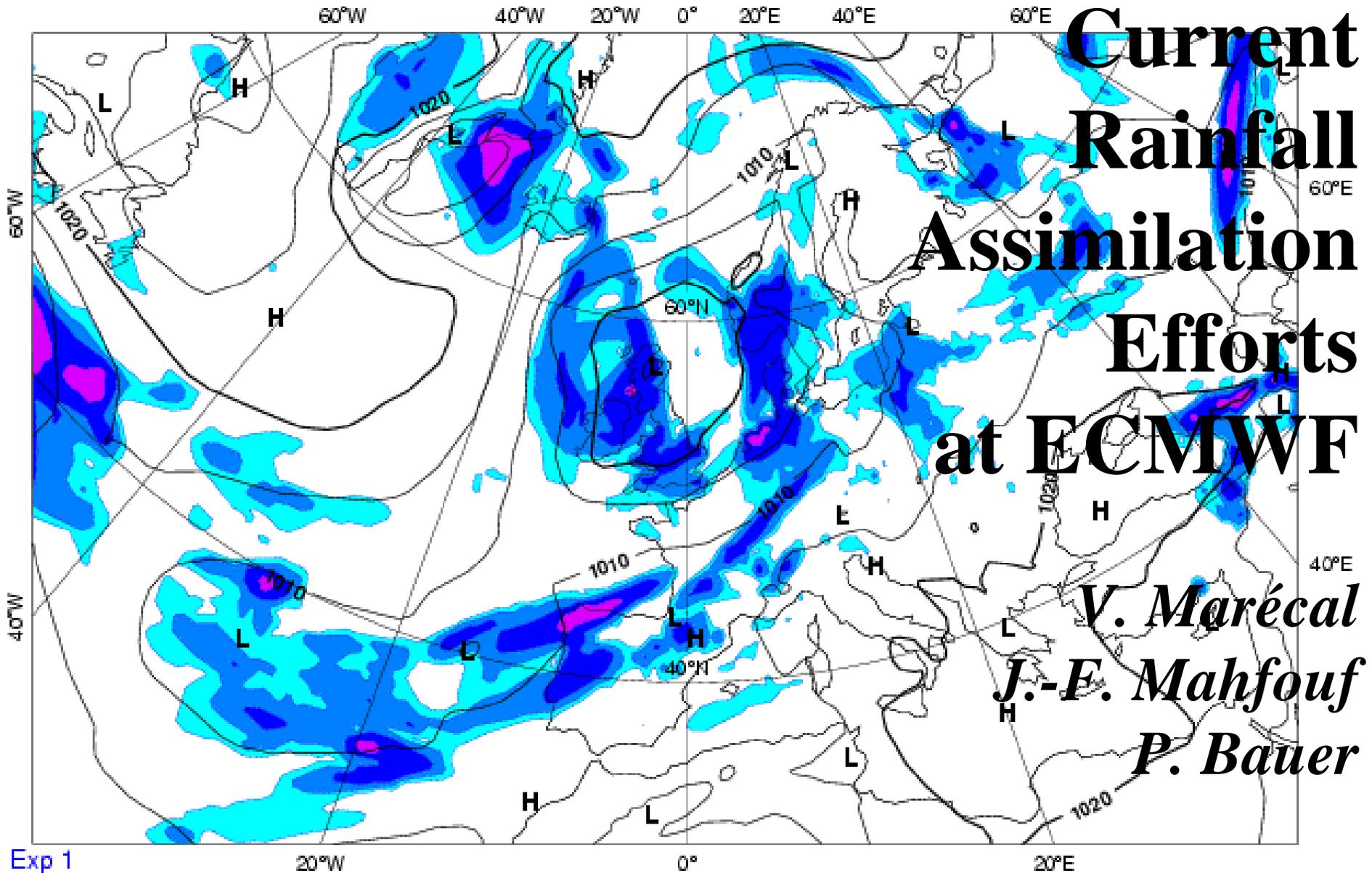


Sunday 13 May 2001 12UTC ECMWF Forecast t+ 72 VT: Wednesday 16 May 2001 12UTC
SURFACE: MSL Pressure / Accumulated Precipitation 00-24z



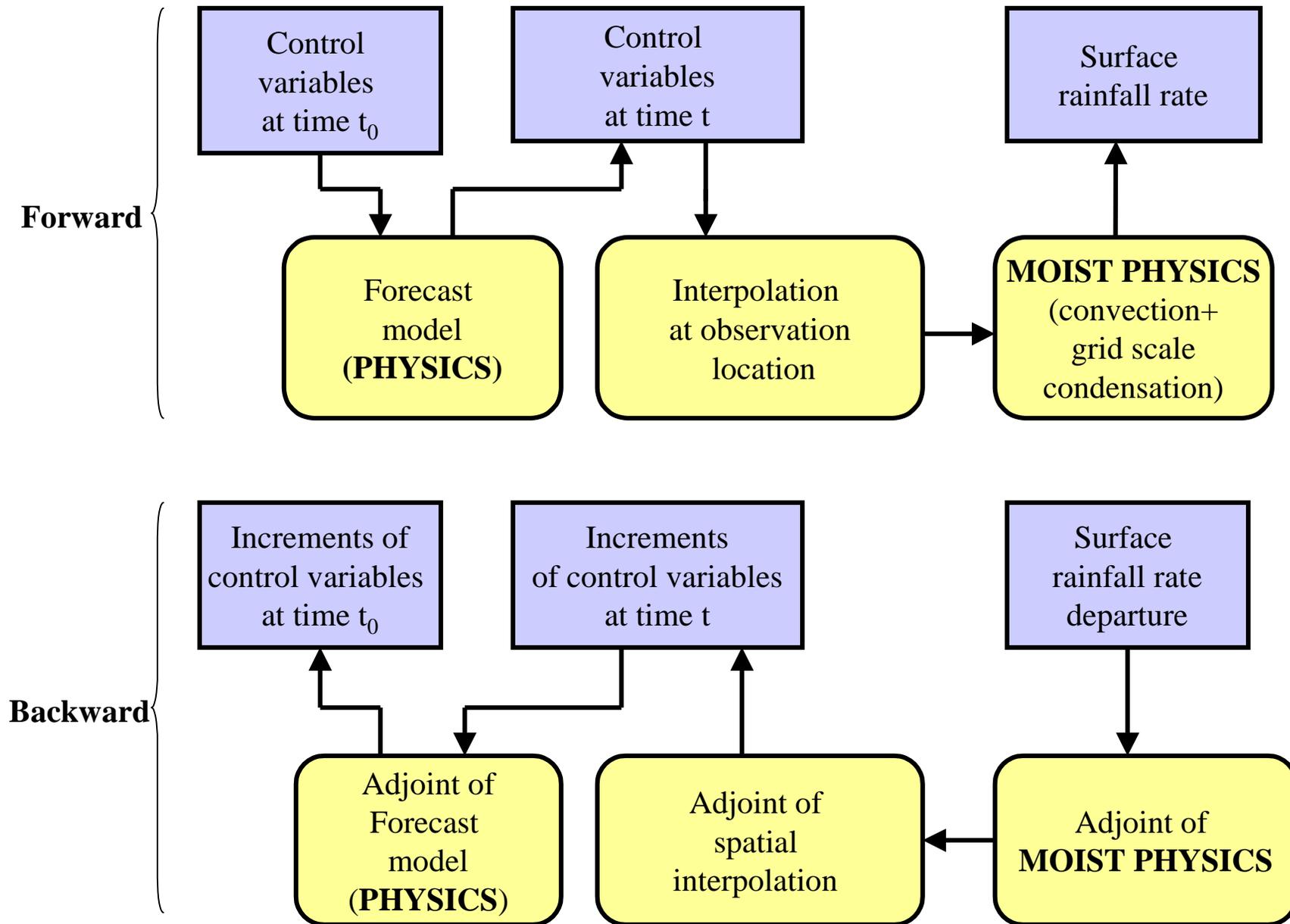
Status of satellite data assimilation

- T_L 511/L60 resolution for deterministic forecast ('outer loop'),
 T_L 159/L60 for 4D variational assimilation over 12h window ('inner loop').
- Strategy towards radiance via parameter assimilation:

<i>Satellite</i>	<i>Operational</i>	<i>Planned</i>
Meteosat-5/7, GOES-8/10 GMS-5	Wind vectors	Wind vectors cont'd. IR radiances (2001)
MSG		SEVIRI radiances (2002/3)
NOAA-15+	HIRS/AMSU radiances	Cont'd.
DMSP-13+ (DMSP-16)	SSM/I WV path, Sfc. windspeed	SSM/I(S) radiances (2001) Rainrates (2003)
ERS-2	SCAT Sfc. wind vector	Cont'd. SBUV ozone profiles (2001)
EOS-AM/PM		AMSU/AIRS radiances (2001)
METOP		MHS/IASI radiances ASCAT wind vector (2005)
ADEOS-2, Quikscat, Envisat		SeaWinds wind vector (2001) MIPAS/SCIAMACHY ozone prof.



4DVAR rainfall assimilation



4DVAR rainfall assimilation (cont'd.)

- Minimization of an objective function :

$$J(x) = \frac{1}{2}(x - x_b)^T \mathbf{B}^{-1}(x - x_b) + \frac{1}{2}(H(x) - y)^T \mathbf{R}^{-1}(H(x) - y)$$

- For an observation (y), the observation operator (H) includes :
 - Time propagation of the initial state to the observation time
 - Horizontal interpolation of the control vector at the observation location
 - Physical parameterization of moist processes

- Need for linearized physical parameterizations to estimate the gradient of the objective function:

$$\nabla J = \mathbf{B}^{-1}(x - x_b) + \mathbf{H}^T \mathbf{R}^{-1}(H(x) - y)$$

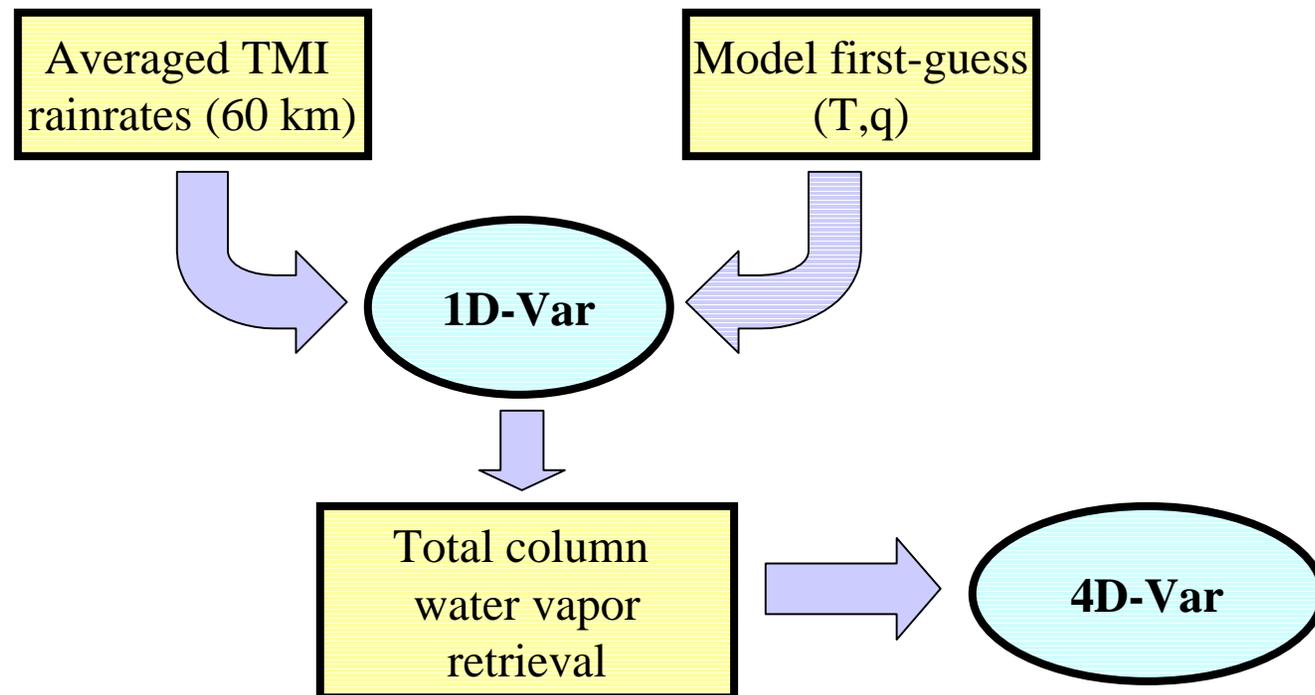
- The operator \mathbf{H}^T can be obtained :
 - explicitly (Jacobian matrix) [1D-Var]
 - using the adjoint technique [4D-Var]



Status of rainrate assimilation*

- Observed rainfall rate with an associated observation error
- Rainfall rate produced by the non-linear physical parameterizations (deep cumulus convection, large scale condensation) from an atmospheric profile $x=(T, q, p_s)$
- The optimum profile x minimizes the following cost-function :

$$J(x) = \frac{1}{2}(x - x_b)B^{-1}(x - x_b) + \frac{1}{2}\left[\frac{R(x) - R_o}{\sigma_o}\right]^2$$



* Initiated during EC-project EuroTRMM (1999-2001) from TRMM products and to be continued during ESA-project EuroTRMM-2 for SSM/I(S) products.

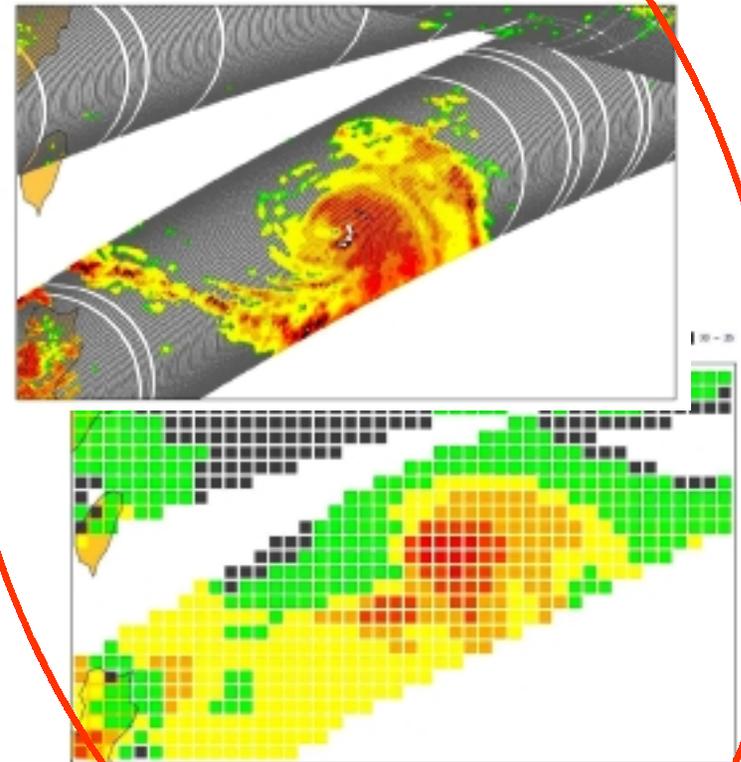
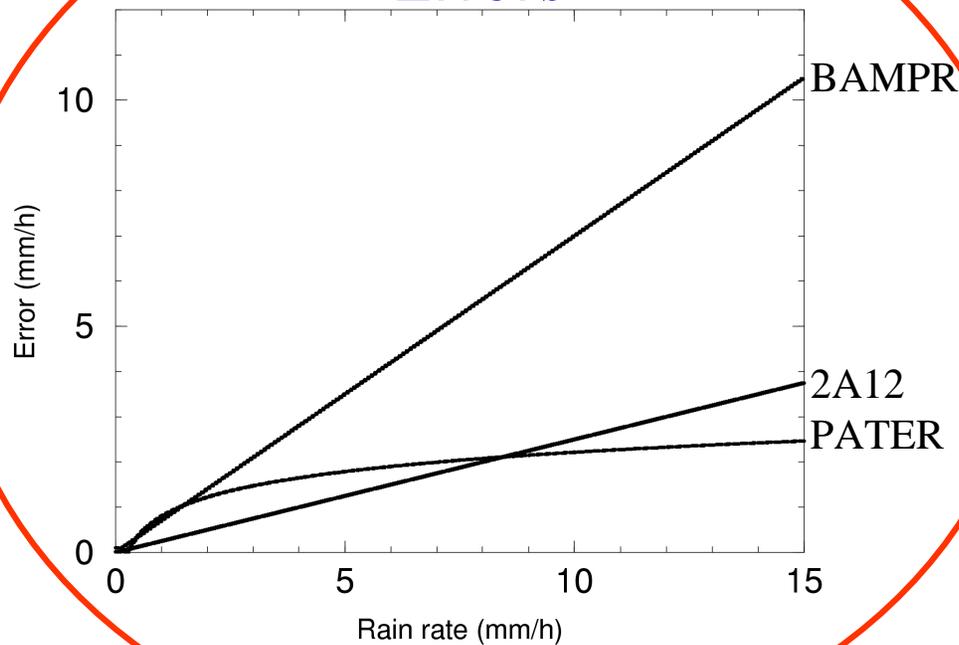


Experimental assimilation

3 rainfall products from TMI (and PR) for two periods in 1998/99 and 1999/2000:

- 2A12 TRMM TMI standard product (Kummerow et al. 1996) 5x7 km²
- PATER* TMI-PR product (Bauer et al. 2001) 27x44 km²
- BAMPR** TMI-PR product (Mugnai et al. 2000) 10x16 km²

Errors



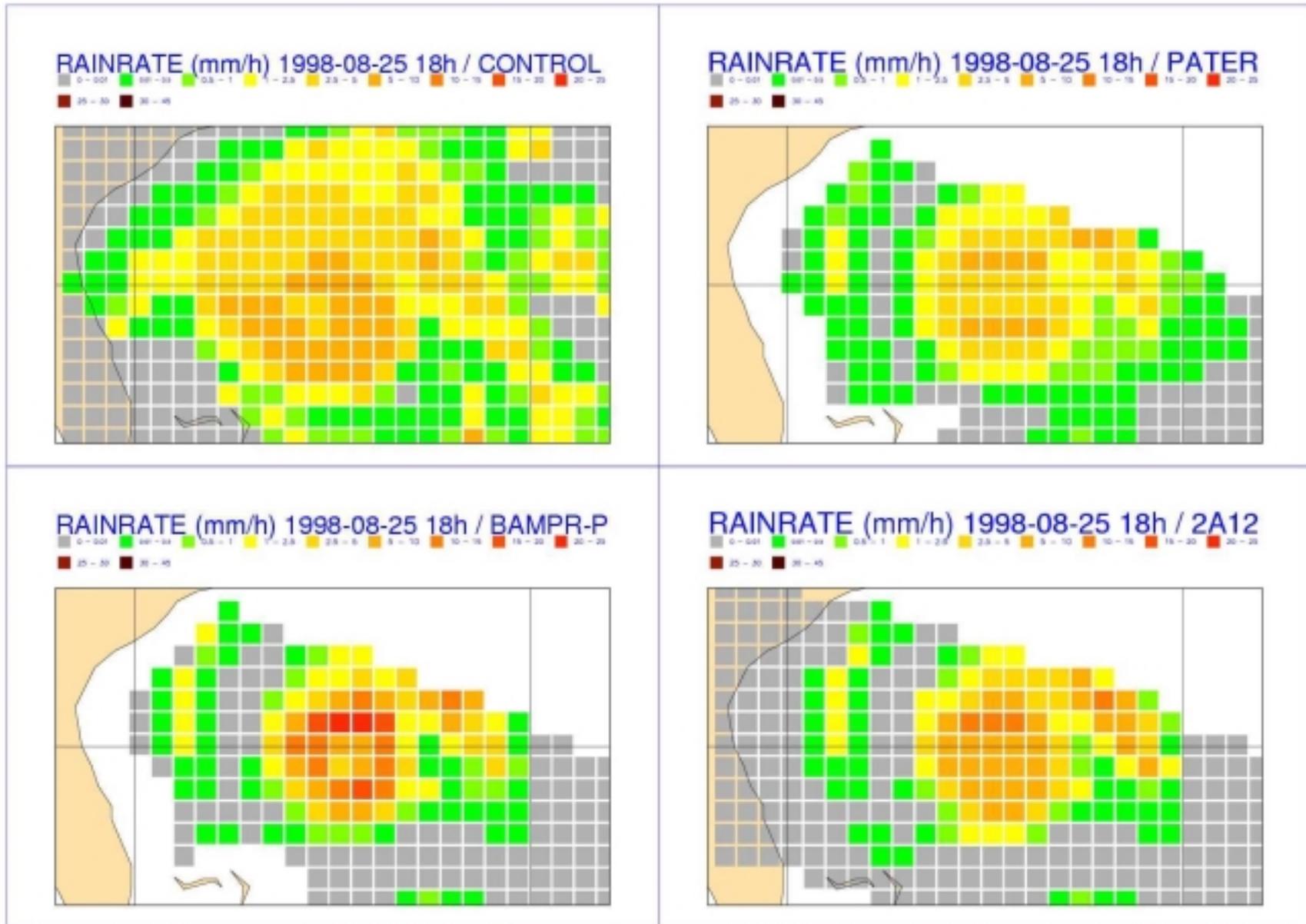
Product Resolution

* PR Adjusted TMI Estimation of Rainfall

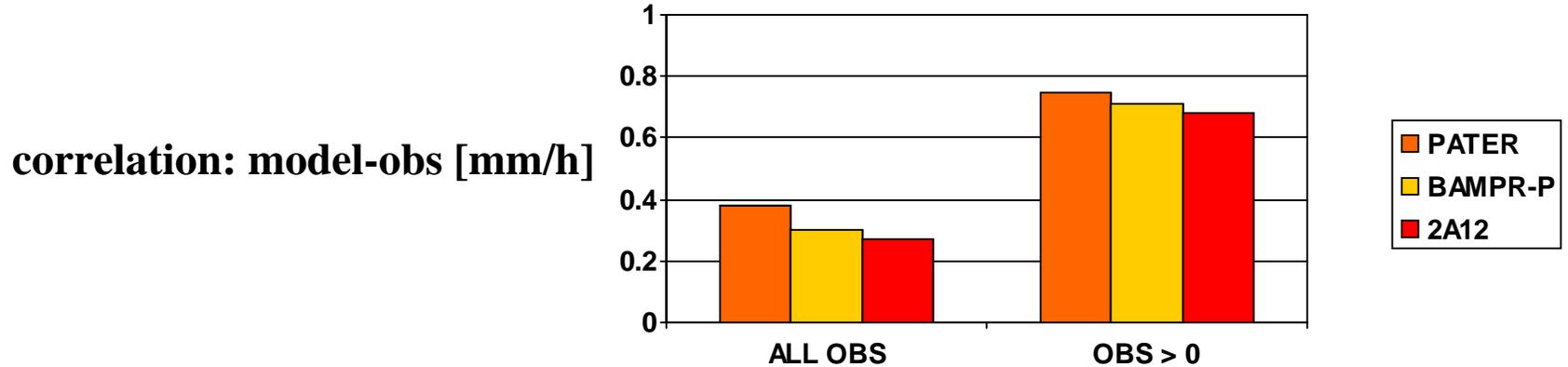
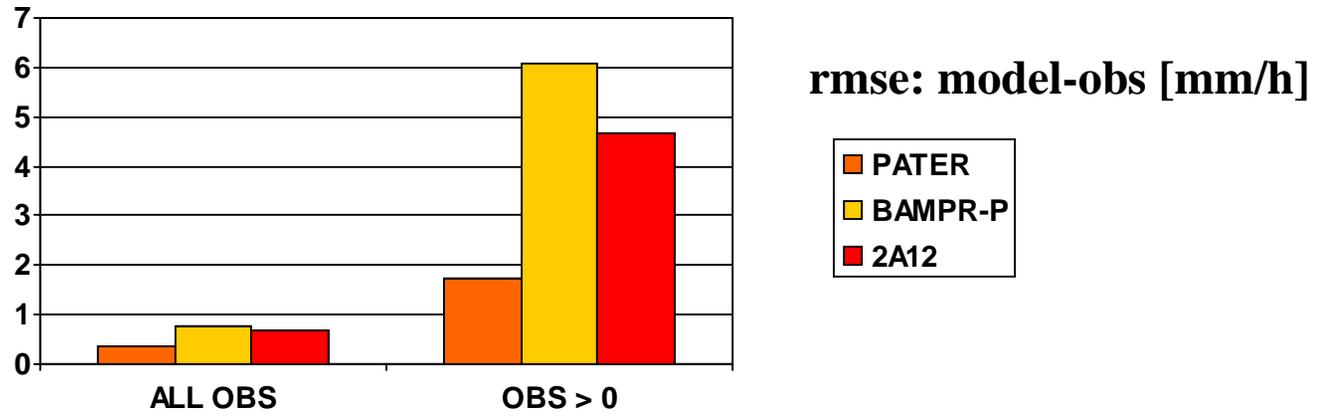
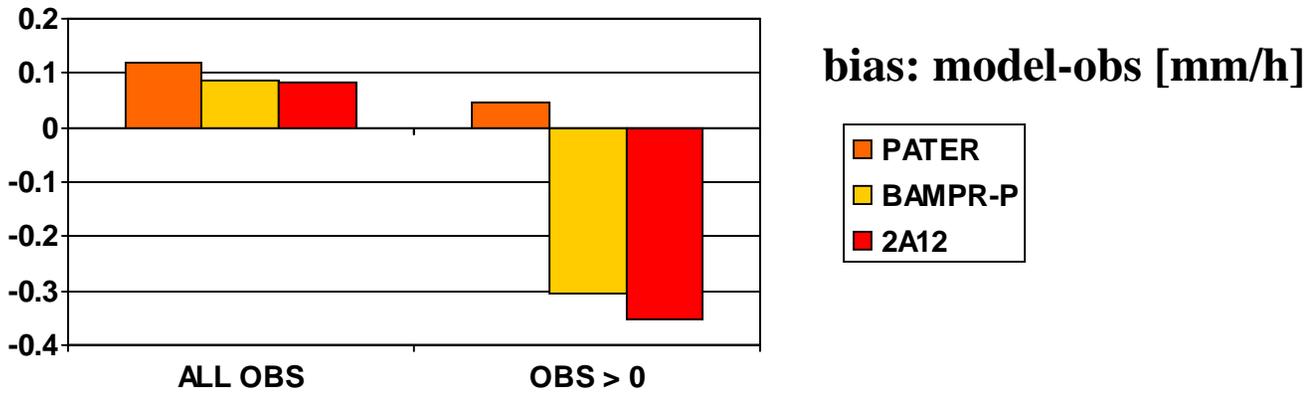
** Bayesian Algorithm for Microwave Based Precipitation Retrieval



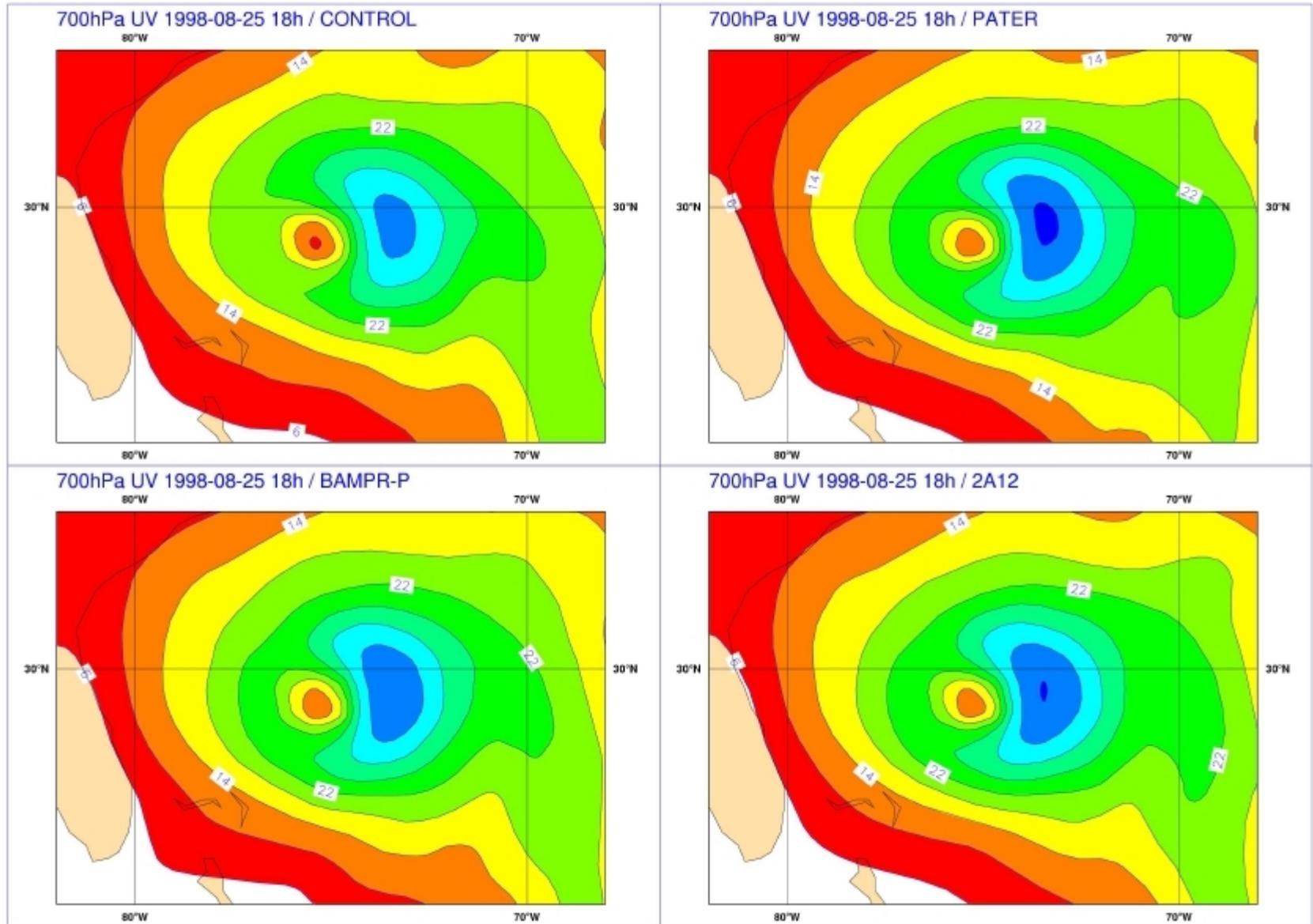
Example of different products: Bonnie



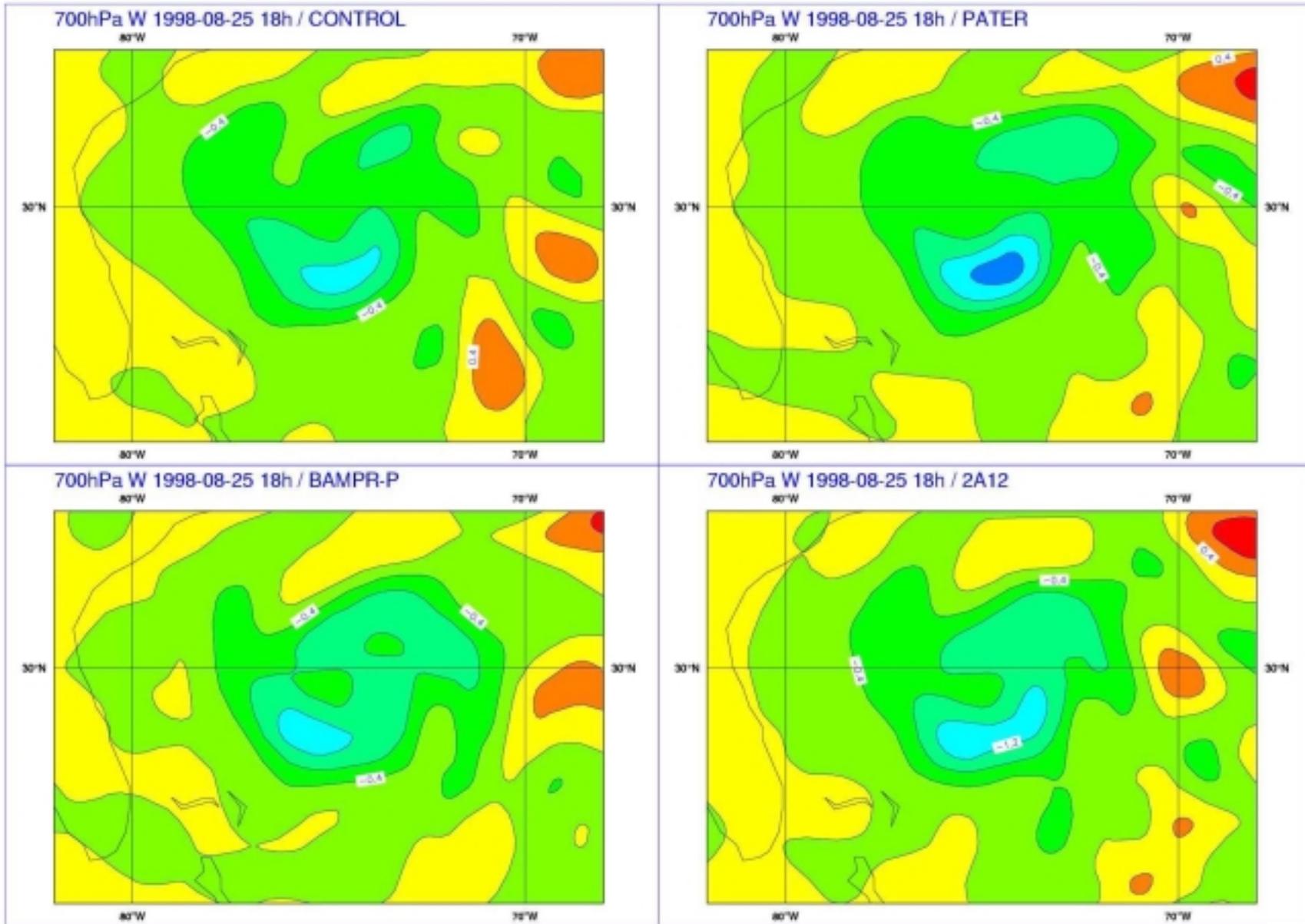
Statistics for different products: Bonnie-period



Impact on u-v: Bonnie



Impact on w: Bonnie



Impact on track forecast: Bonnie

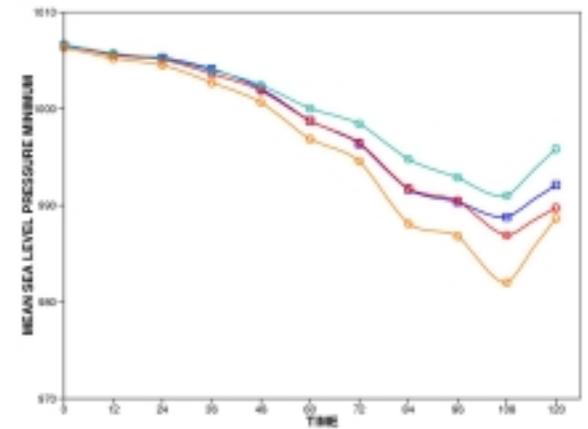
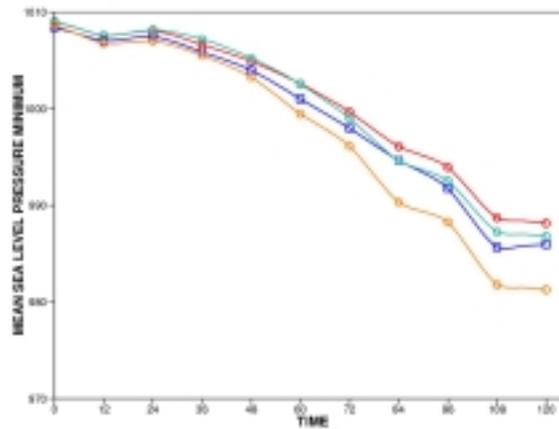
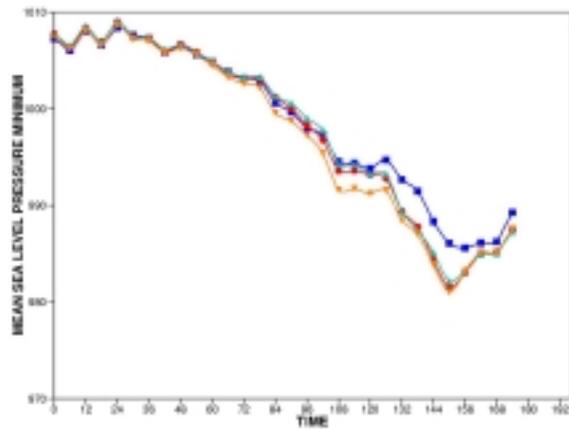
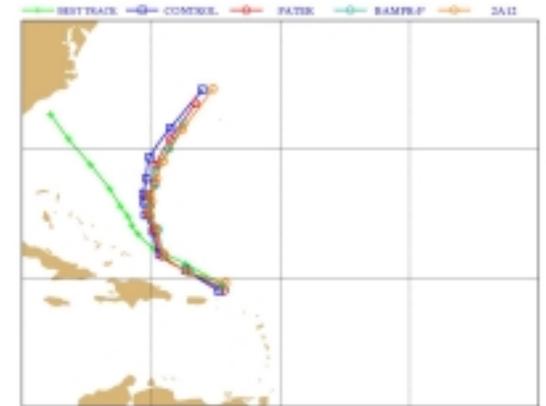
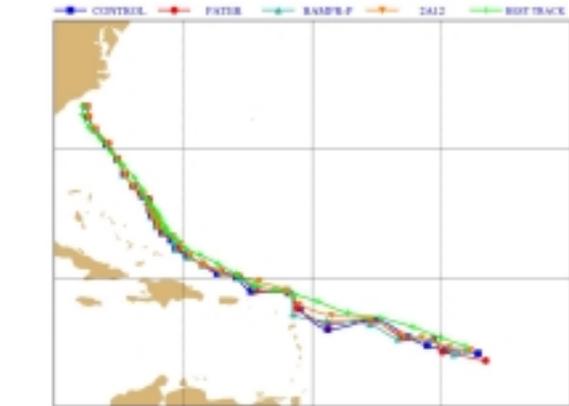
control

PATER

BAMPR-P

2A-12

best track

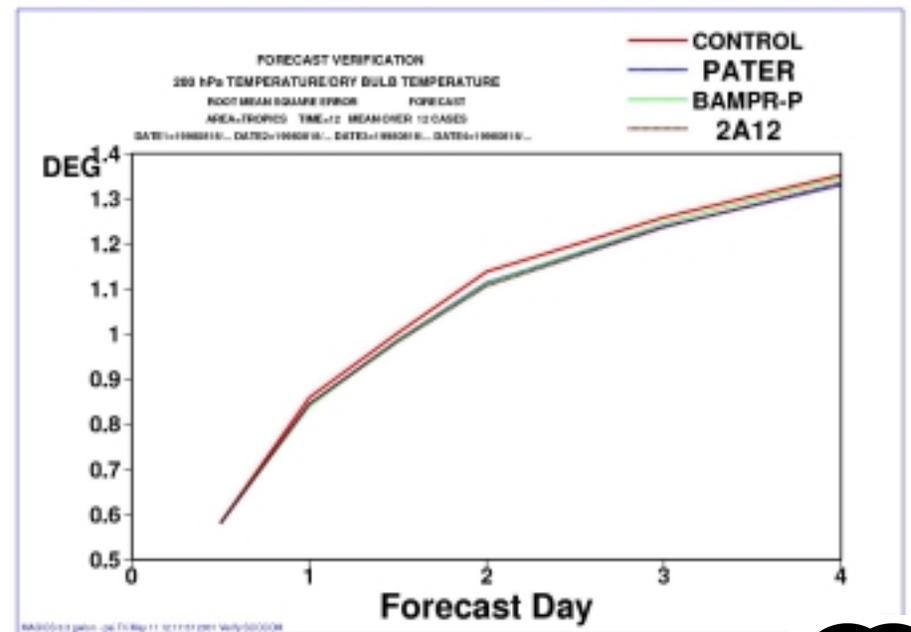
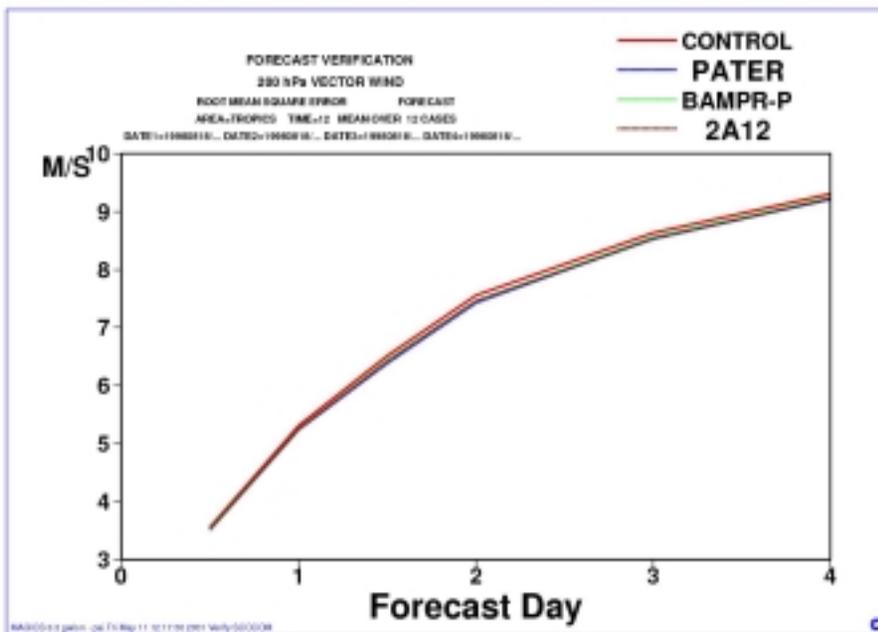
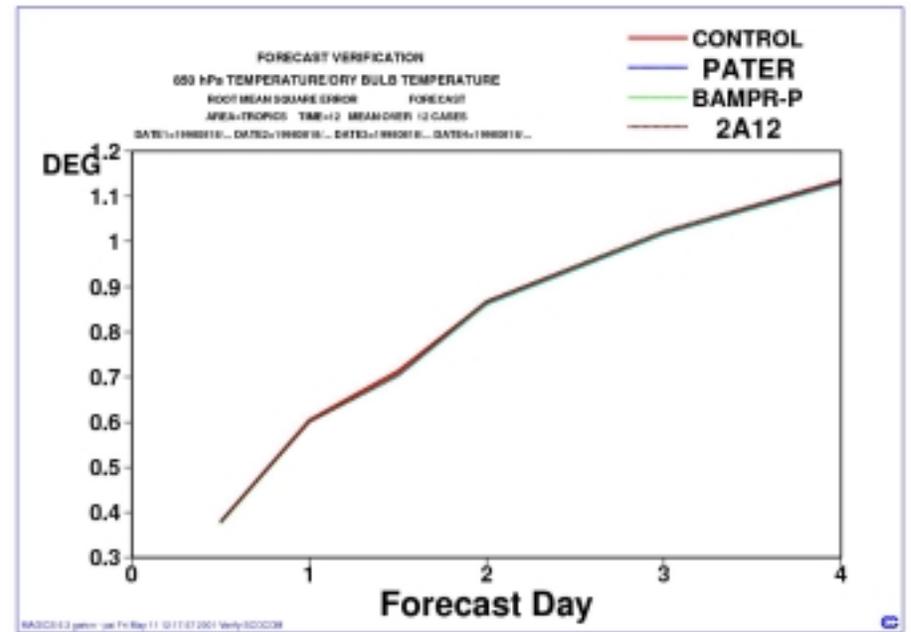
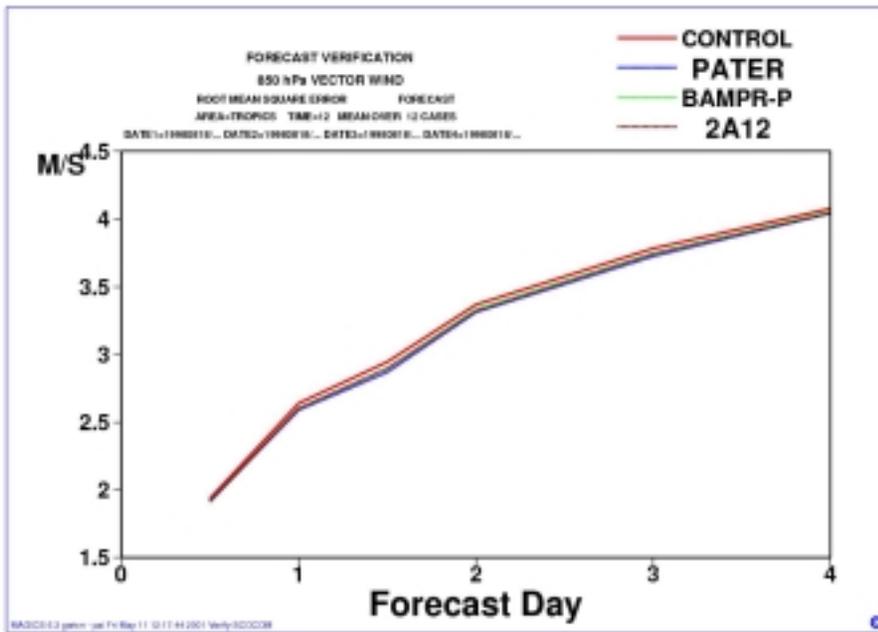


analysis: 08/19/98 + n-6h

forecast: 08/20/98 12:00

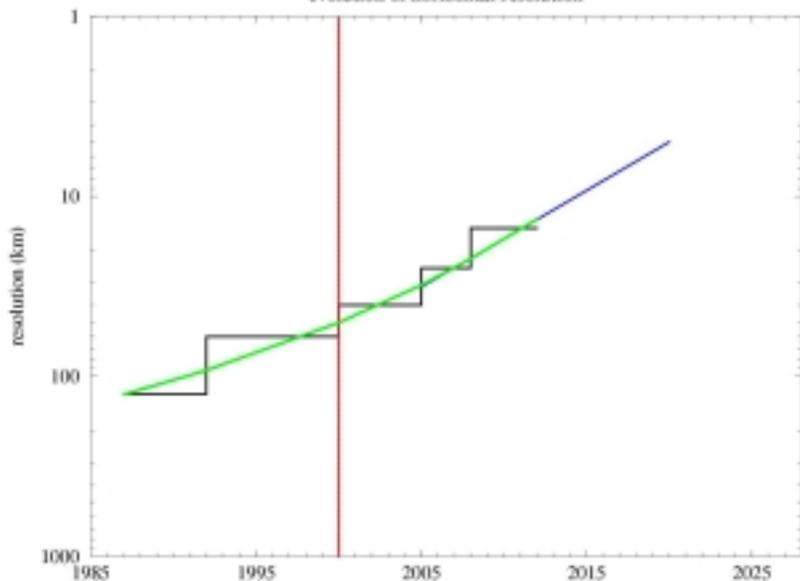
forecast: 08/21/98 12:00





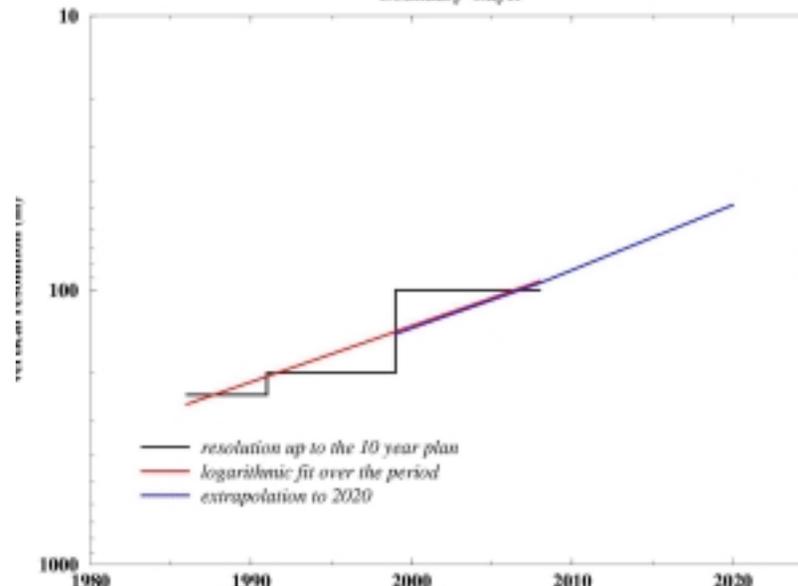
ECMWF model

evolution of horizontal resolution



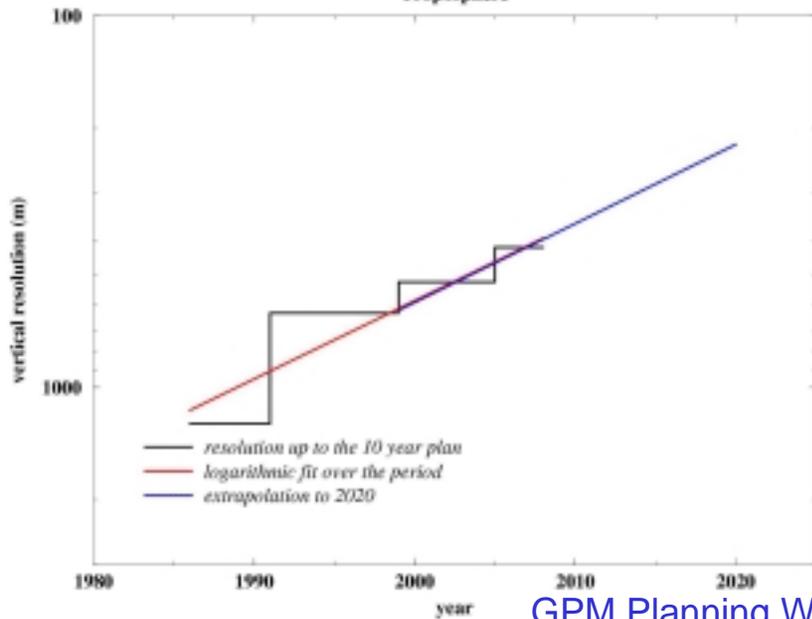
ECMWF vertical resolution evolution

Boundary Layer



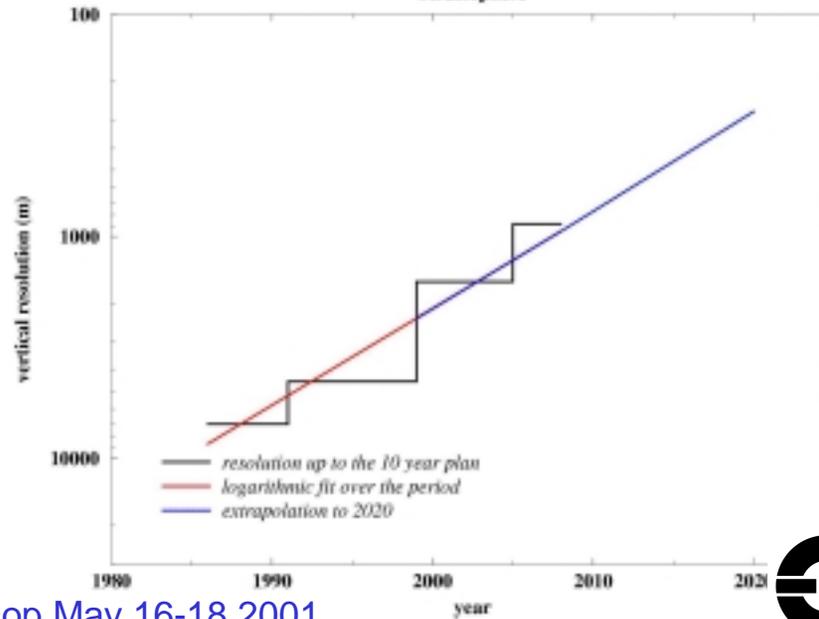
ECMWF vertical resolution evolution

Troposphere



ECMWF vertical resolution evolution

Stratosphere



Requirements for GPM from rainfall assimilation experience

Spatial Resolution:

- Definition of real-time product spatial resolution (given that ECMWF-model will have 15 km forecast / 30 km assimilation res.)

Sampling:

- ‘rather less often but more accurate’

Errors:

- Quantification of retrieval error/bias functions = $f(RR)$
- Error of rain detection (rain-PDF)
- Inter-satellite stability of retrievals/errors
- Assessment of errors due to spatial/temporal sampling mismatch

Plans at ECMWF:

- Evaluation of rainrate vs. (simplified) radiance assimilation
- Improved estimation of humidity profile forecast errors
- Improved spatial resolution

