Naval Stealth from Design to Real Life

The RNLN ADCF

TNO | Knowledge for business

H.J.M. Heemskerk

Contents

- Introduction to naval radar signature design rules
- Design
  - stealth on the drawing board
  - subscale modelling
- Effect of add-on systems
- Stealth properties in real life
  - full scale measurements
  - add-on systems
- Environmental effects

Introduction
to naval radar signature design rules

- geometrical shaping
  - avoid 90° angles
  - hide details behind bulwarks
  - tilt flat plates
- radar absorbing material
- minimise antenna scattering term
- band-pass radome
- frequency selective surface

but take into account all other actions to improve the ships operability and survivability

leading to integrated topside designs

Interest to the collaboration with respect to the radar signature of the ADCF

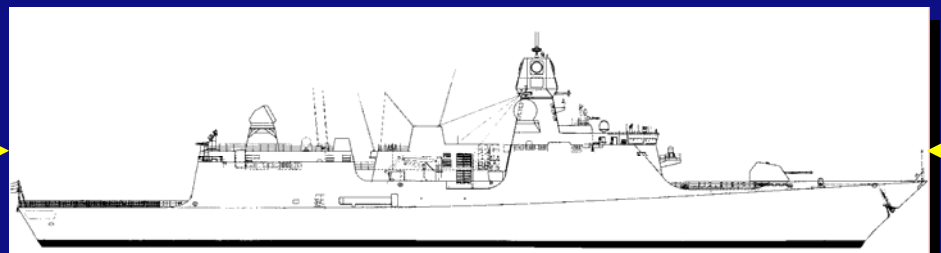
RNLN

- obtain an ADCF with optimised properties with respect to the radar signature that meet the design targets
- evaluation of the design philosophy

TNO

- scientifically support the RNLN by advising, computations and measurements in all phases from design till operational life
- improve computational and measurement techniques with respect to radar signature incl. environmental effects

Above water signature design process for the ADCF



DESIGN CATIA / RNLN

RCS simulation
RAPPORT / TNO

CAD description

IR signature simulation
SHIPIR / TNO

- geometry
- RAM / RAS

subscale model
RCS measurement/TNO

- IR signature
- pre-wetting
- insulation
- IRLEP

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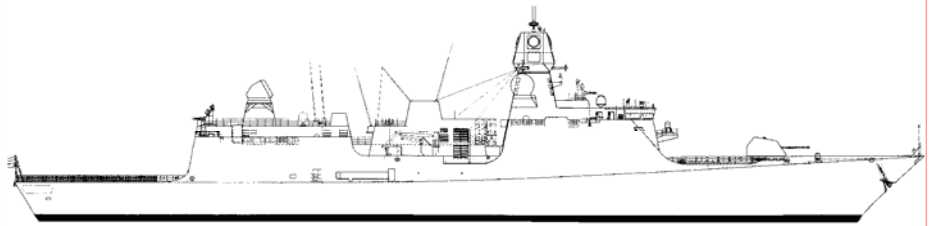
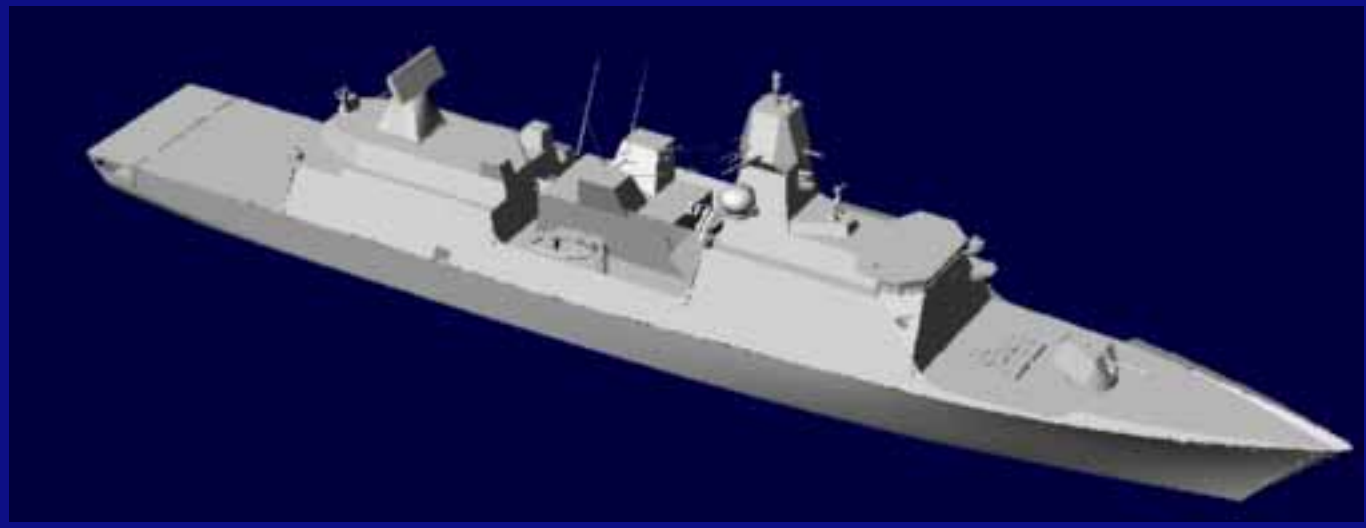
Stealth on the drawing board

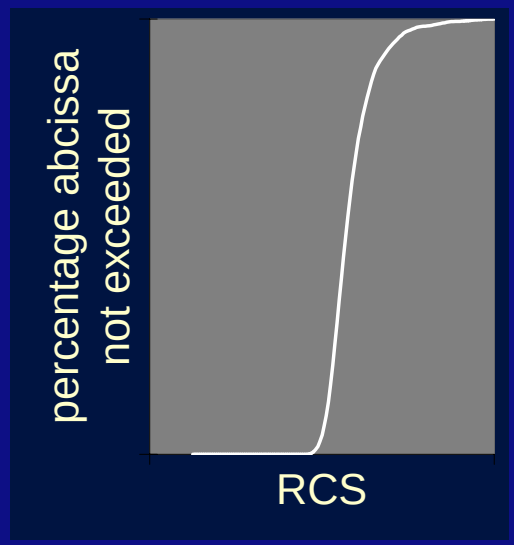


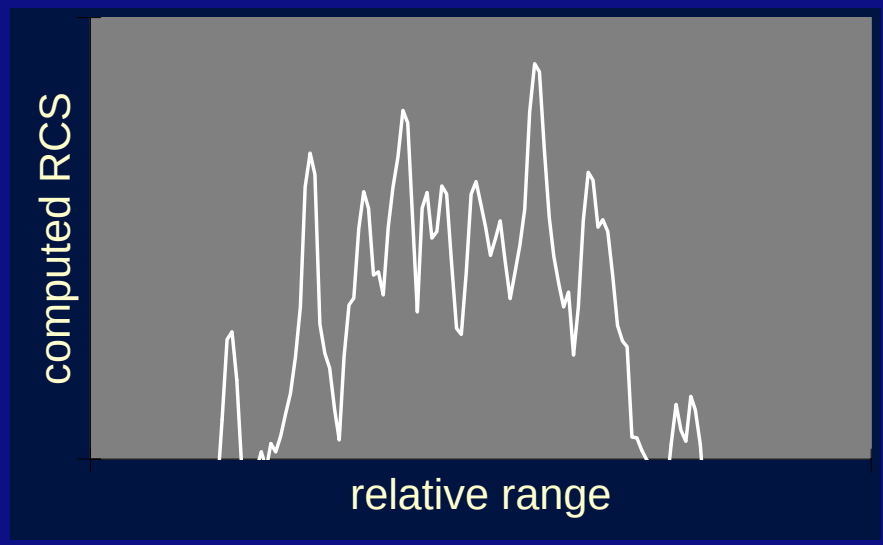
Objectives

- optimum design of the ADCF with respect to its radar reflecting properties,
- validation of the RCS computer simulations on the geometry of the ADCF
- insight into
  - the radar reflecting properties of the ADCF,
  - the location of remaining scattering centres, and
  - the possibilities to reduce these scattering centres

Stealth on the drawing board







Lessons learned RCS computations

- Several iterations with respect to ship design were needed
- Final design will very likely meet the design targets
- Computations have been made in free space, assuming perfectly conducting materials and taking into account the add-on systems as good as possible,

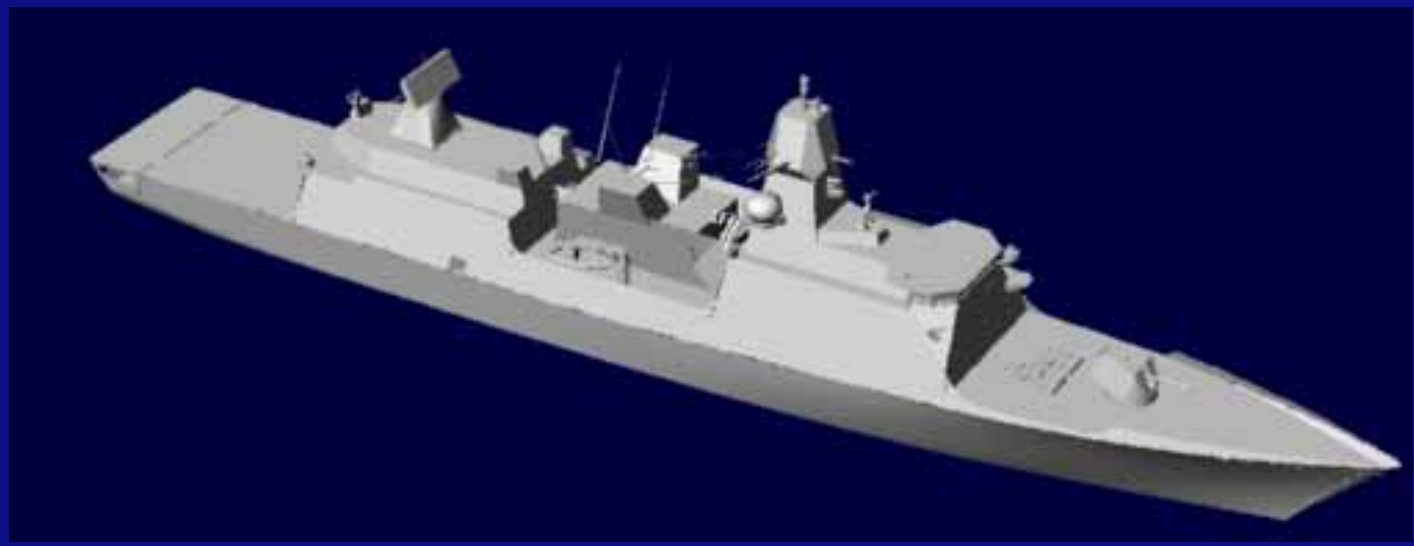
but

– how does the actual ship building process affect the radar signature ?

– what is the actual effect of add-ons like weapon systems, antennas ?

– and what about the environmental effects ?

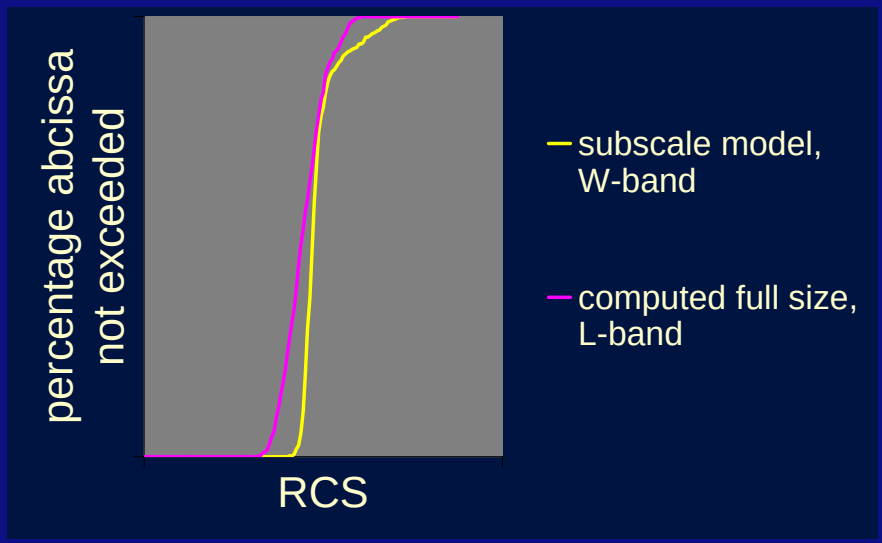
Subscale modelling



Subscale modelling

quantity	full-scale system	model system
length	l	$l' = l/S$
time	t	$t' = t/S$
frequency	f	$f' = f.S$
wavelength	λ	$\lambda' = \lambda/S$
conductivity	σ_c	$\sigma_c' = S.\sigma_c$
resistance	R	$R' = R^*$
permittivity	ε	$\varepsilon = \varepsilon^*$
permeability	μ	$\mu = \mu^*$
antenna gain	G	$G'=G$
RCS	rcs	$rcs' = rcs/S^2$

Subscale model



Objectives

- validation of RCS prediction code
- first impression of ADCF design and scattering centres

Subscale modelling - lessons learned

- A 1:75 scale model has been made using the same geometry as has been used for the RCS computations, giving good insight into the radar reflecting properties to be expected of the actual ship.
- Measurements show the positive effect of the bulwark that screens a part of the superstructure resulting in an RCS reduction in relevant aspect angle areas.
- Inclining the walls of the superstructure reduces the RCS except for those frequencies where the edge deviations are small with respect to the wavelength.
- Good agreement between measurements and computations

measurement configuration

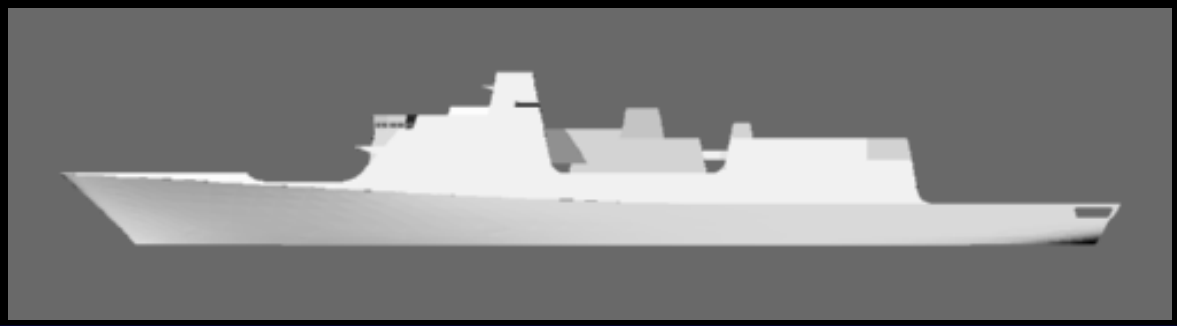
Effect of add-on systems

computation configuration

Inert ship
measurements and computation

measurement configuration

computation configuration



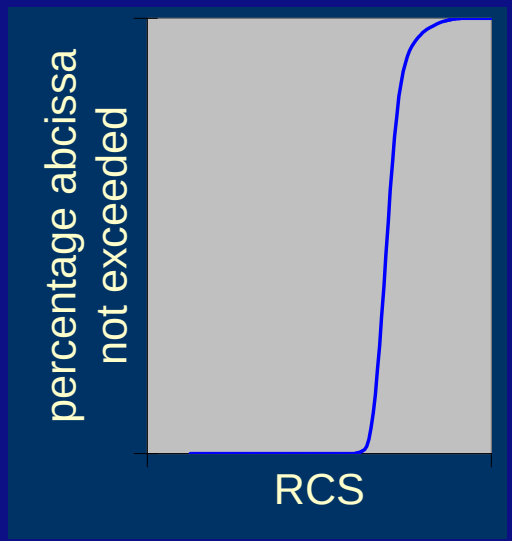
Stealth properties in real life
full scale measurements

Objectives full size ADCF measurements

- to determine to which extend the ADCF meets its requirements
- to verify the design specifications
- to determine remaining hot spots
- to evaluate the design philosophy of the RNLN
- to establish tactical guidelines by the RNLN

  for the deployment of softkill measures.

Stealth properties in real life



measurements

- 8 CW and 8 CCW runs
- I- and J-band
- HH and VV
- range resolution 1m

Effect of IR signature reduction techniques on the radar signature - example

- Pre-wetting : use of the onboard wash-down system
  to reduce the IR signature
- Measurement of the radar signature of the ADCF with pre-wetting on
- Positive effects on the radar signature have been observed

Operational test of radar absorbing paint

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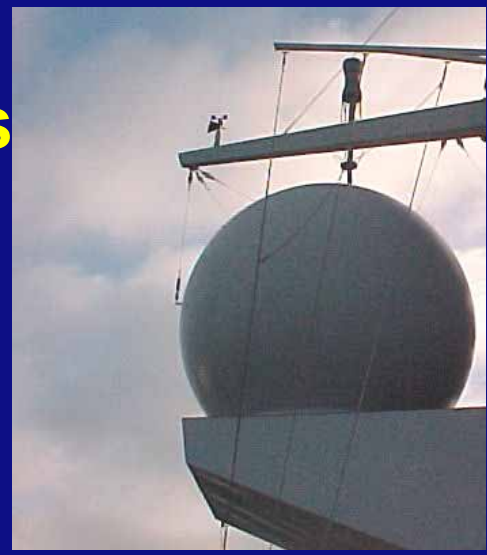
RCS contribution add-on systems

26 February 2006

- All measures applied on starboard
- Port side is reference

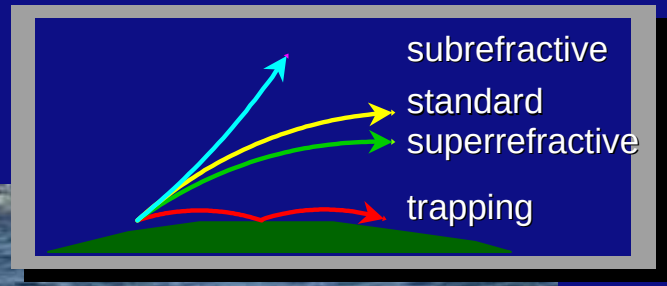


re-orienting satcom antenna

cover of ventilation grids

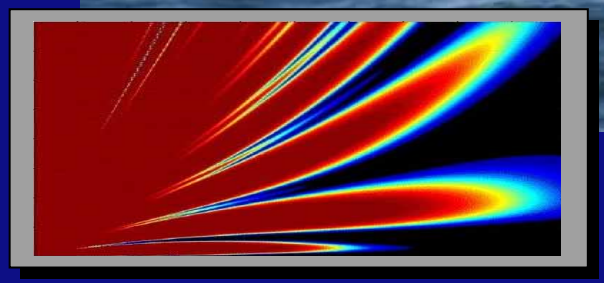
reduction of crane

reduction of torpedo recess



Environmental effects

general discussion



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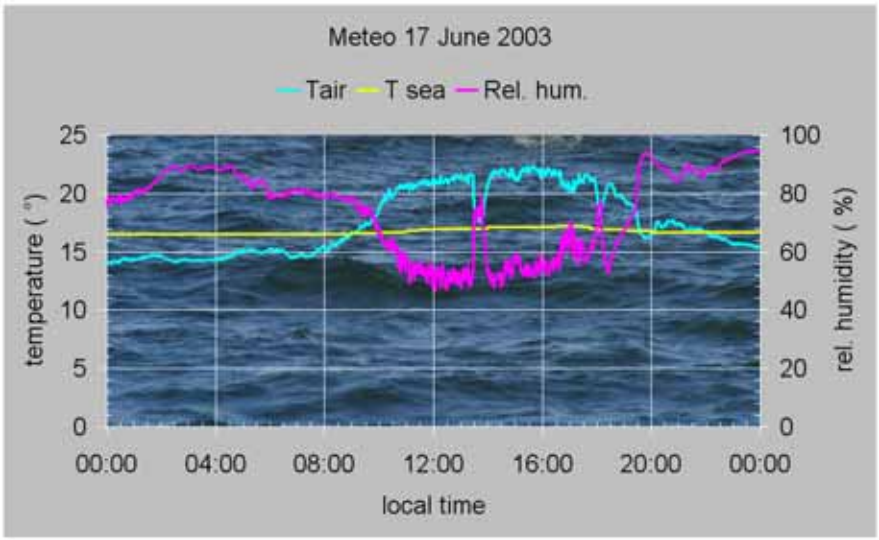
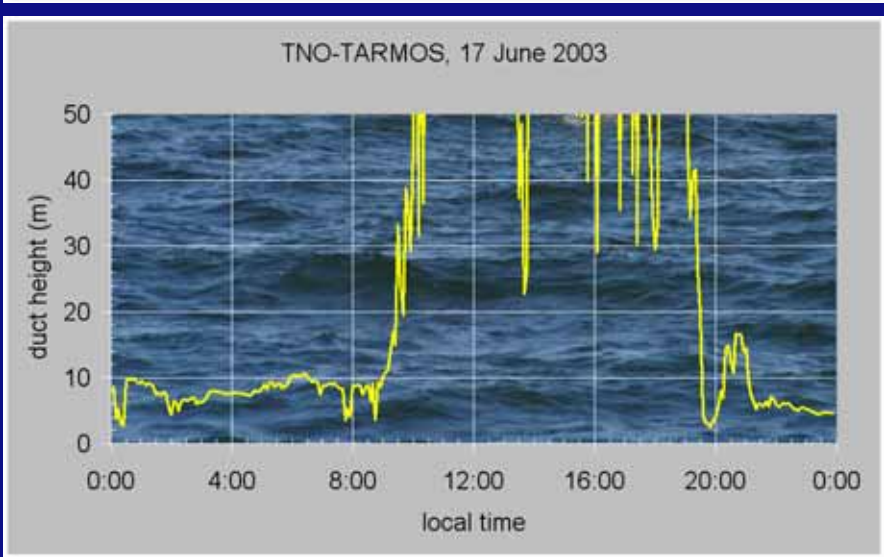
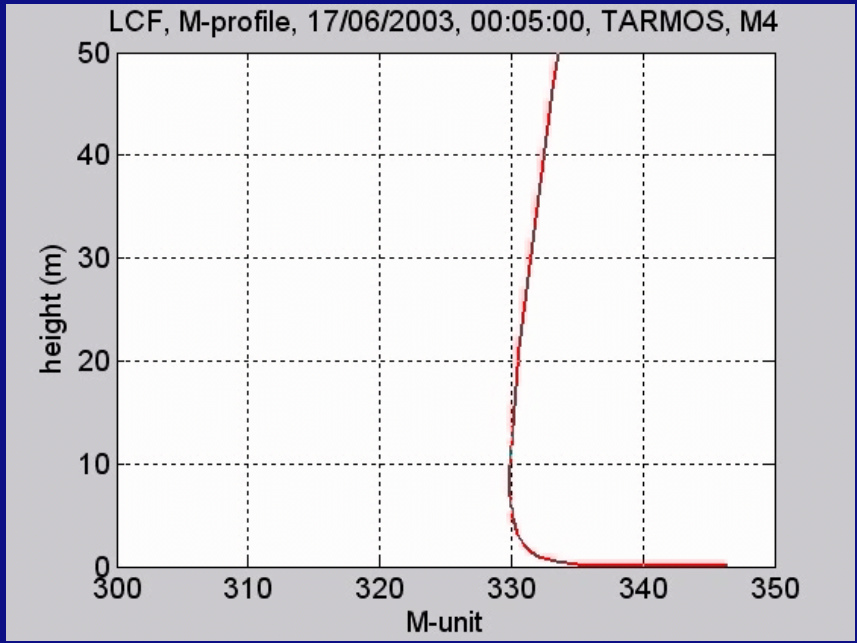
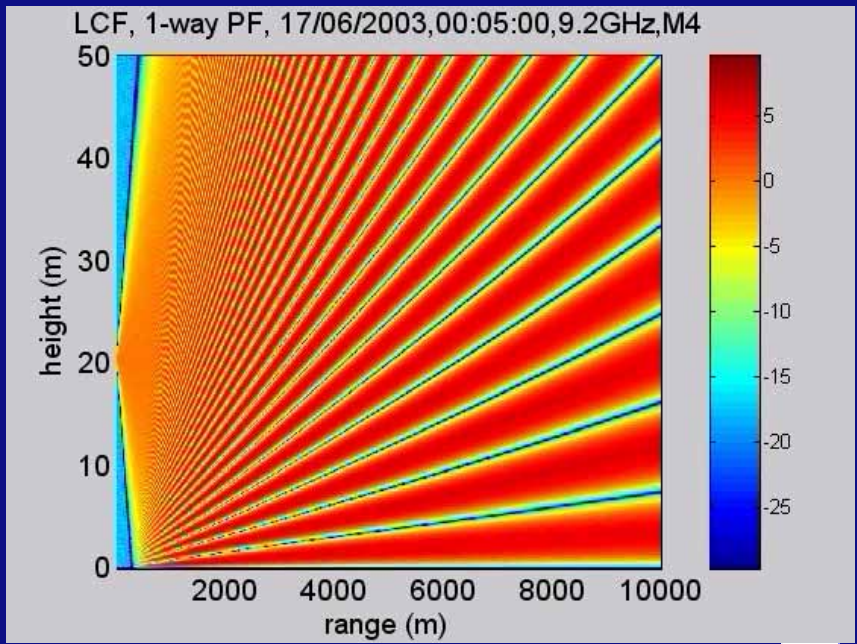
Environmental effects
example







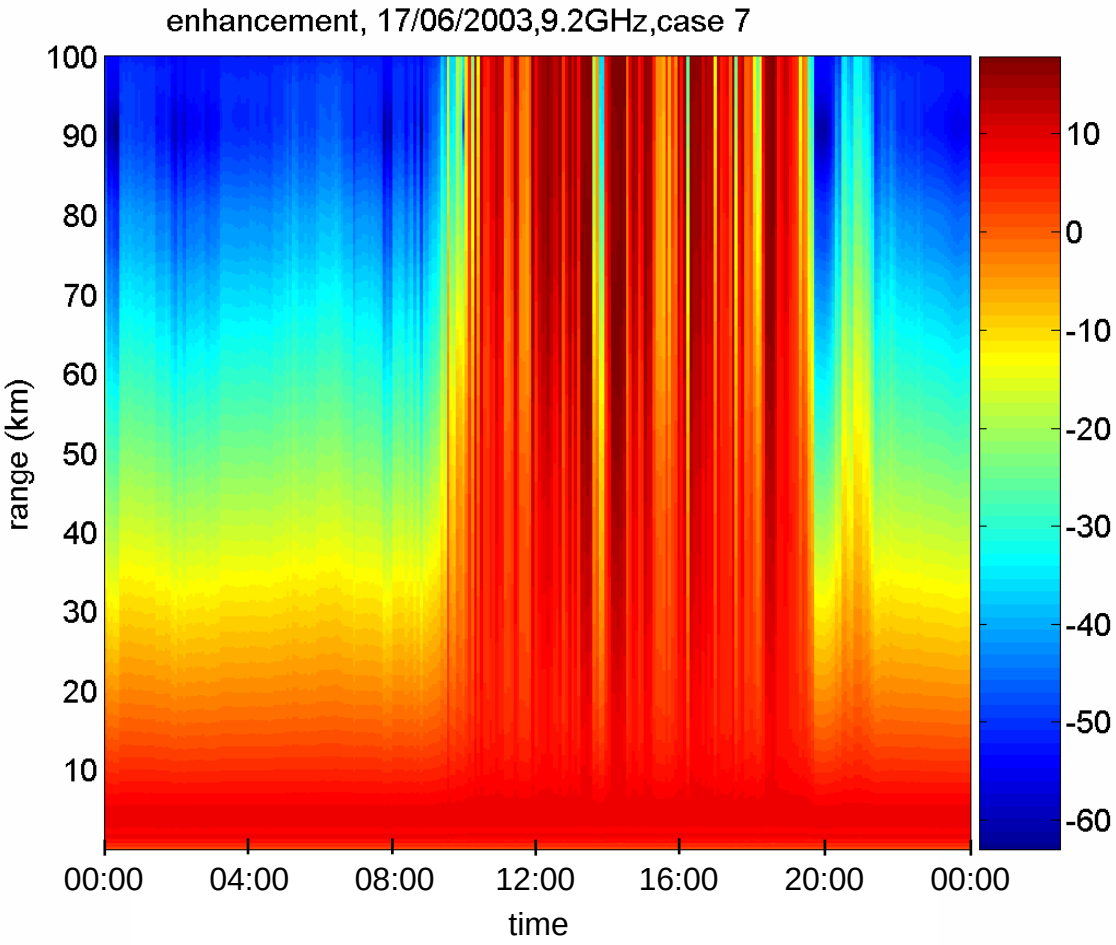


Environmental effects

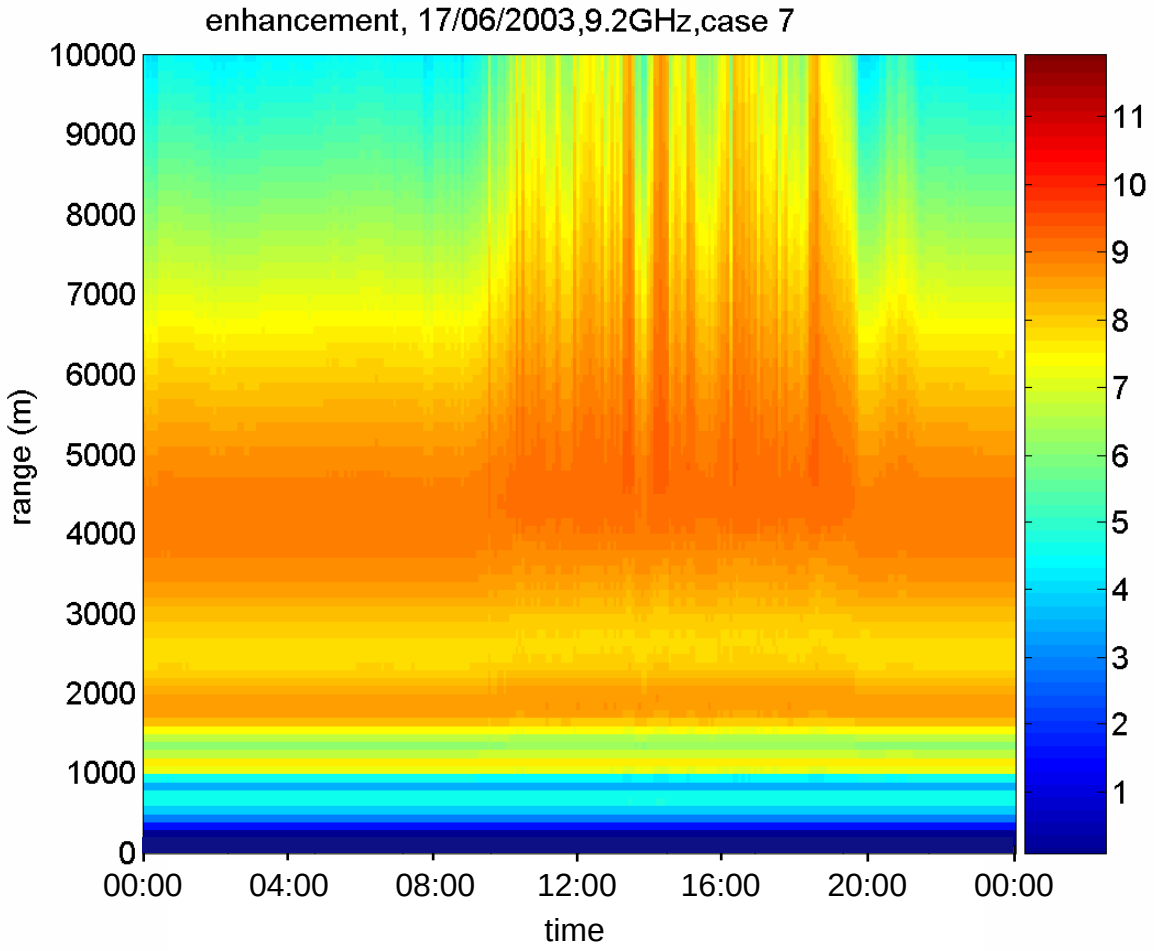
case	#1	#2	#3	range
1	11 m	6 m	19 m	2.5 km
2	11 m	6 m	19 m	5.0 km
3	11 m	6 m	19 m	10.0 km
4	9.5-12.5 m	5-7 m	18-20 m	2.5 km
5	9.5-12.5 m	5-7 m	18-20 m	5.0 km
6	9.5 12.5 m	5-7 m	18-20 m	10.0 km
7	9.5 12.5 m	5-7 m	18-20 m	0-100 km
8	4-29 m	4-29 m	4-29 m	0-100 km

all scatterers equal amplitude

Environmental effects



Environmental effects



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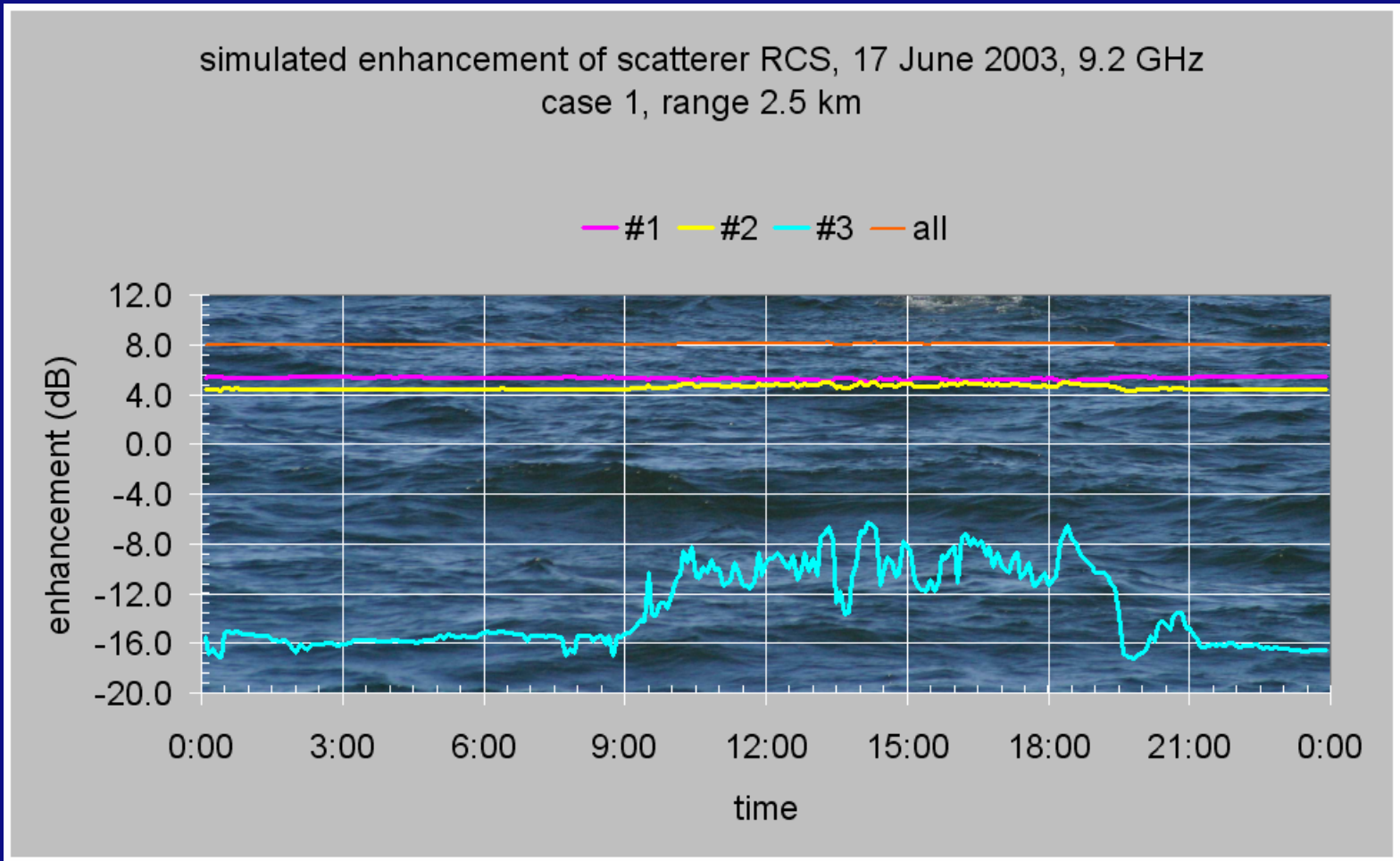

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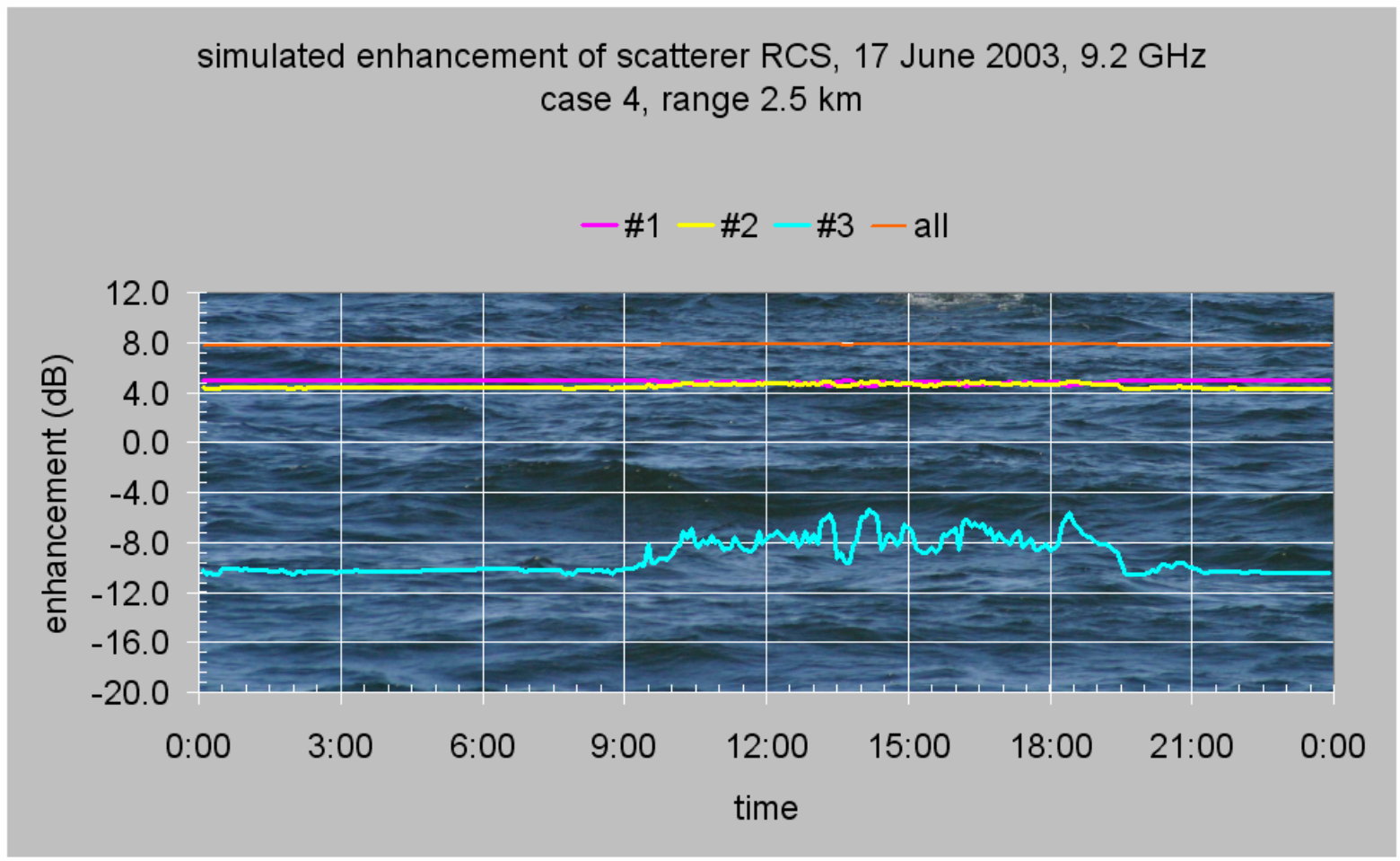
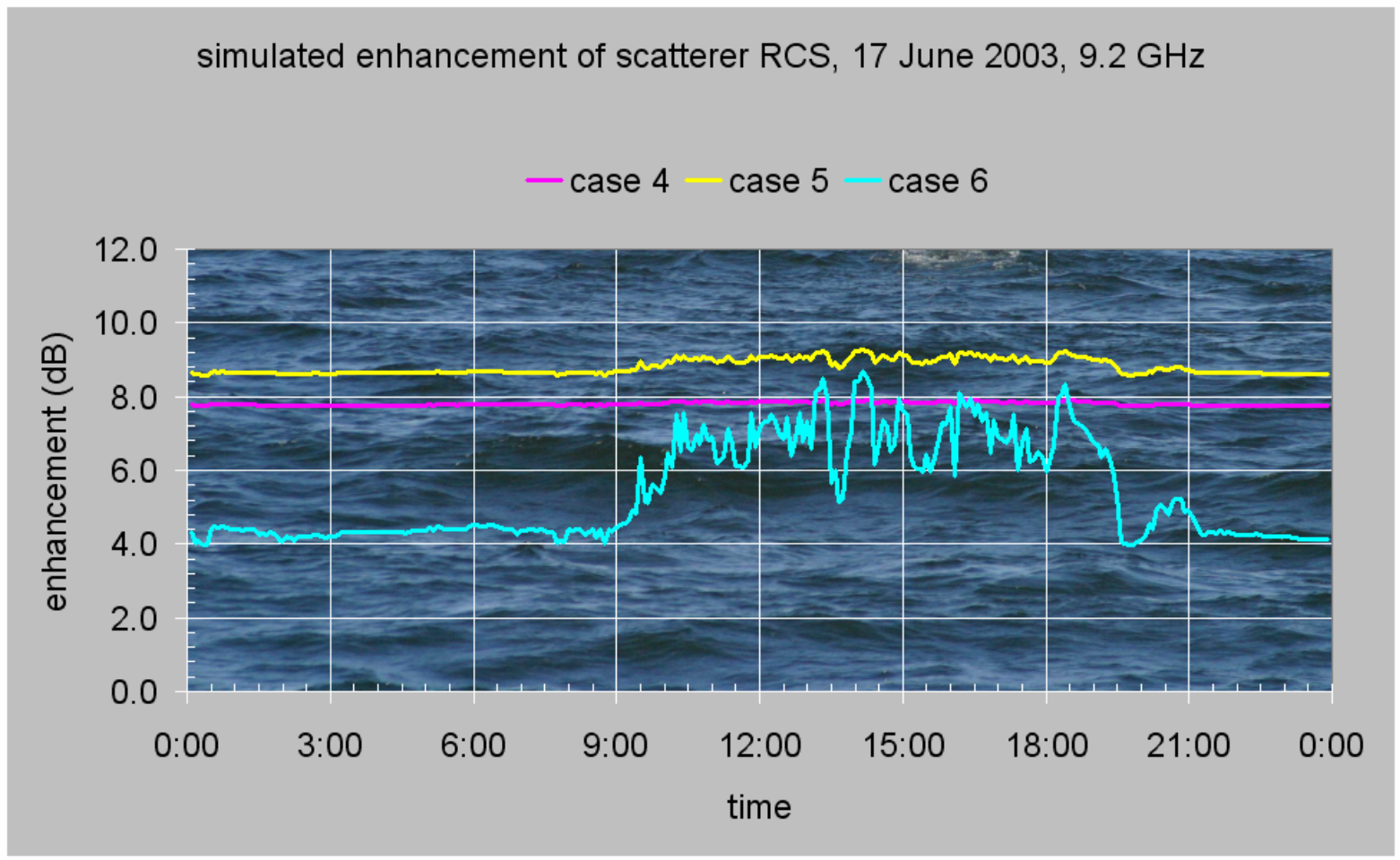
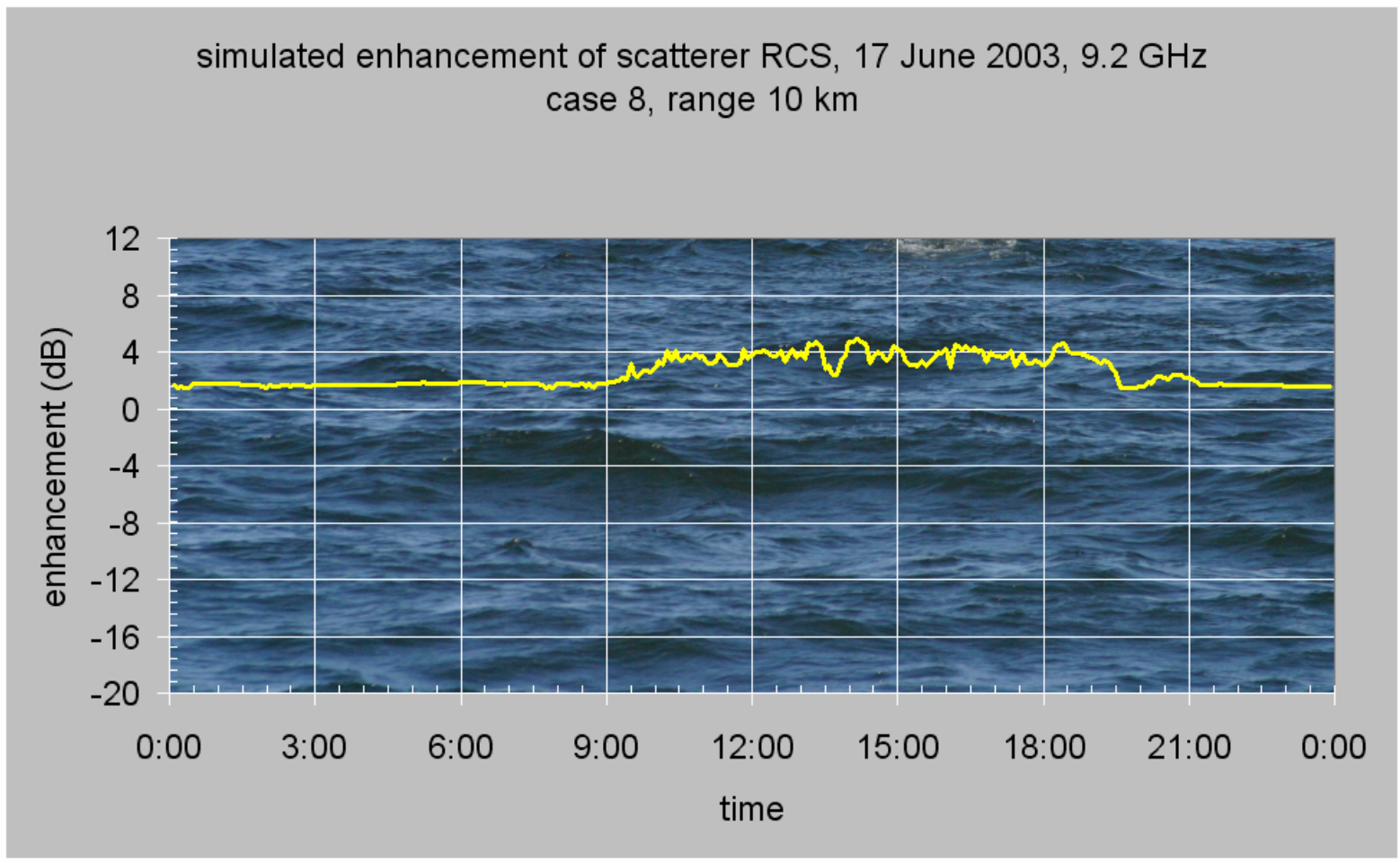


Environmental effects



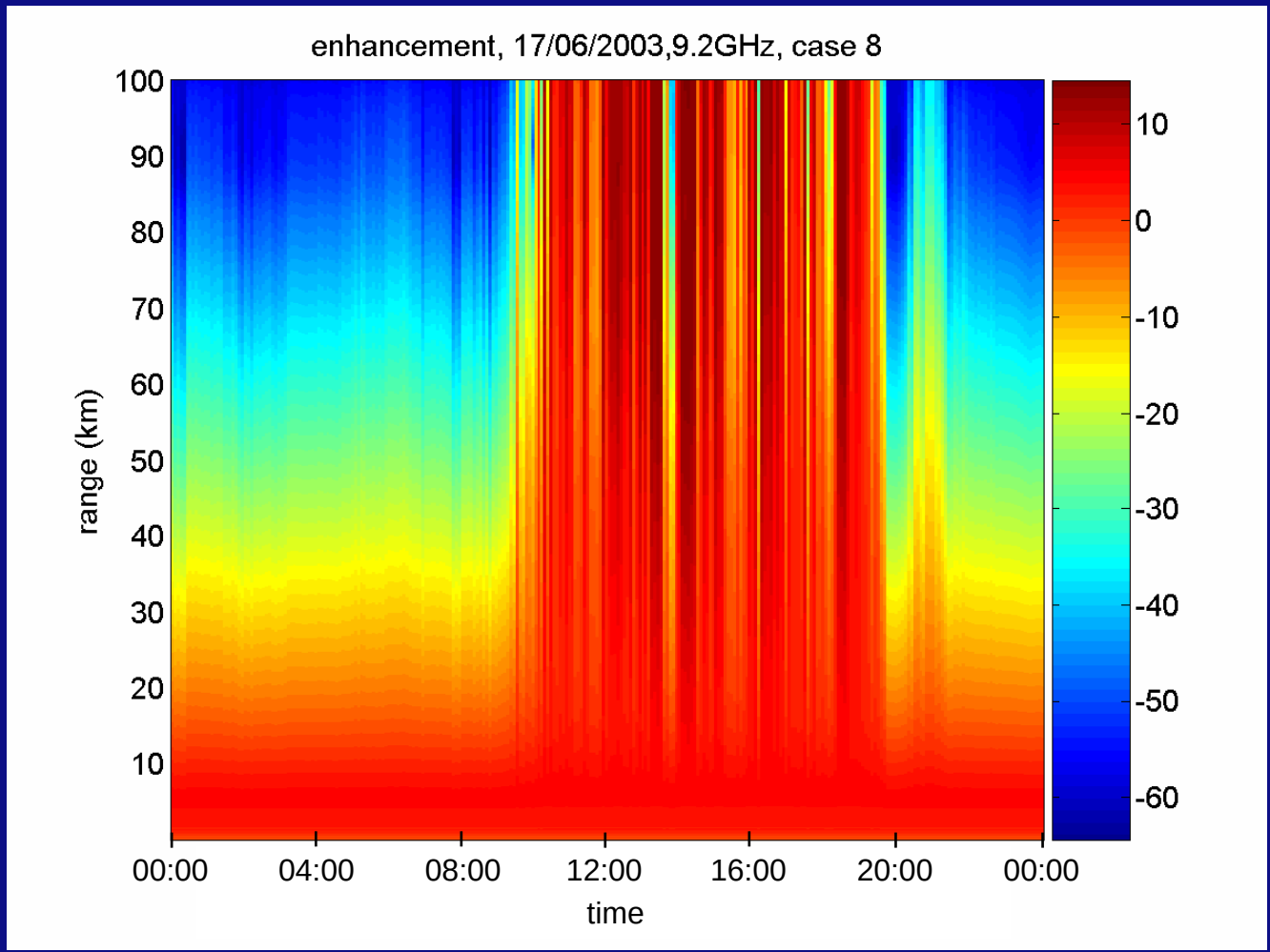
Environmental effects

scatterers uniformly distributed between 4-29 m
all equal amplitude



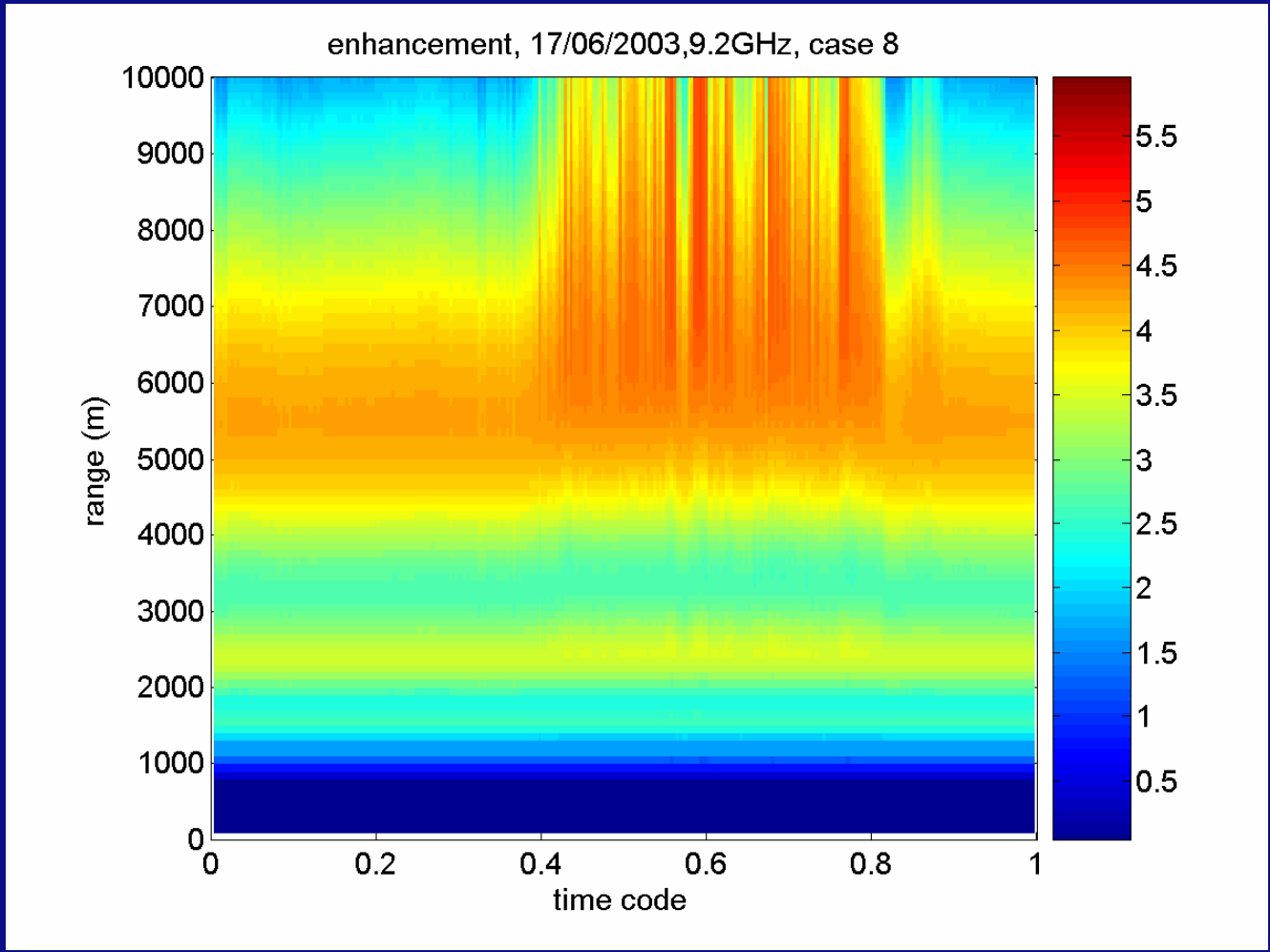
Environmental effects

scatterers uniformly distributed between 4-29 m, equal amplitudes



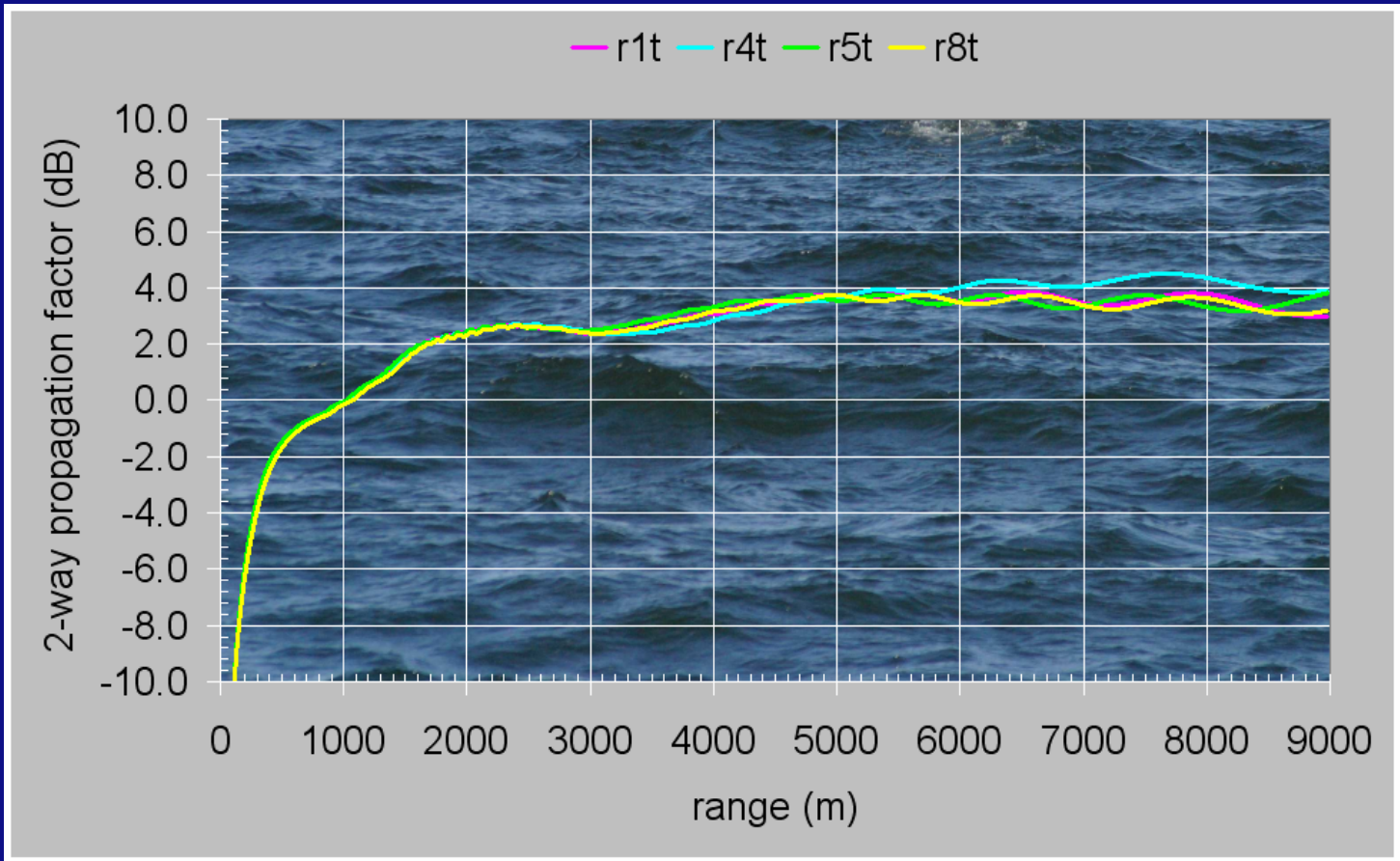
Environmental effects

scatterers uniformly distributed between 4-29 m, equal amplitudes



Environmental effects
case 8

computed 2-way propagation factor, scatterers uniformly between 4-29m



Conclusions

- Environmental do affect the radar signature of ships
- The effect is largely dependent on the amount of dominant scatterers, their height position, radar frequency, sea state, and atmospheric conditions
- For stealthy ships, having no dominant scatterers the effect can be approximated by computing an average propagation factor assuming that the scatterers are uniformly distributed in height.

Conclusions

- Very good collaboration between the RNLN and TNO in all phases of the ADCF from drawing board to real life
- The overall linearly averaged RCS of the ADCF meets the design targets
- The ship design philosophy is successful with respect to the radar signature