Wet tropospheric correction in coastal regions

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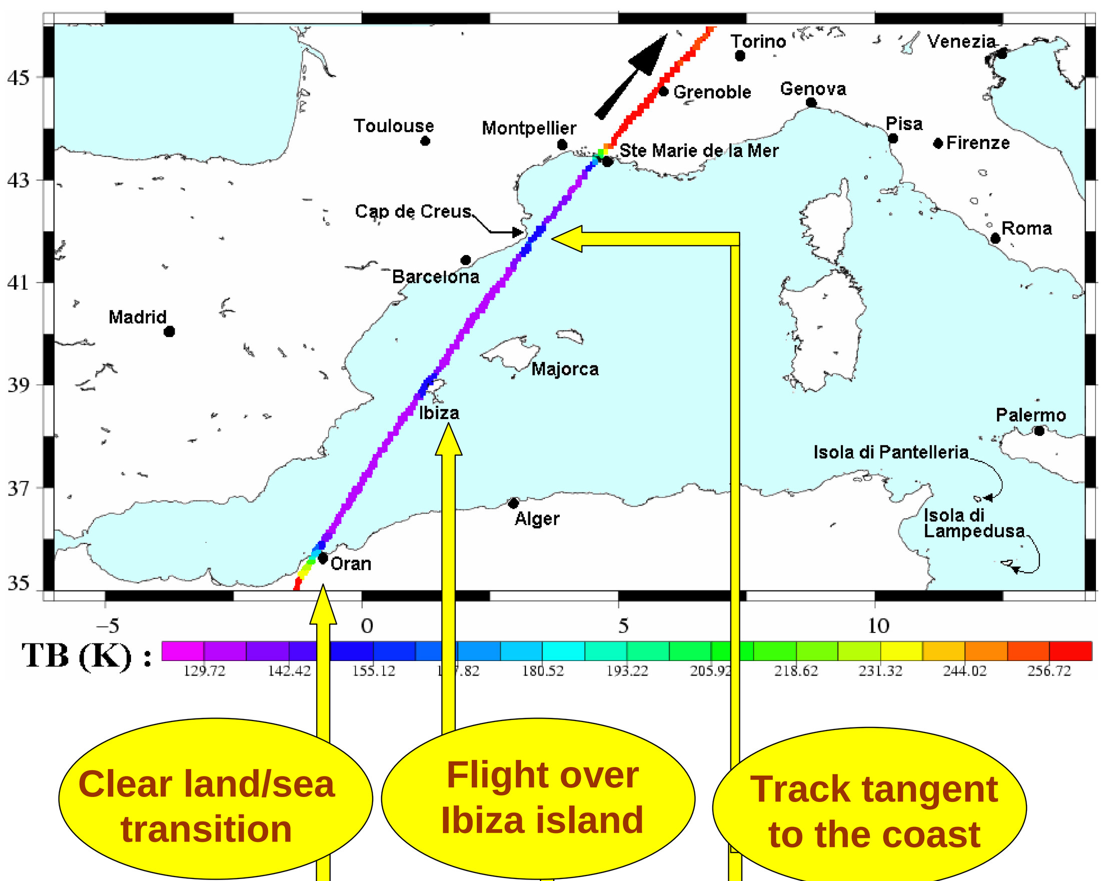
In order to correct the altimeter range from tropospheric humidity, a Microwave Radiometer has been embarked on TOPEX/Poseidon. On open ocean, the combination altimeter/radiometer is satisfactory. But in coastal zones, the signal coming from the surrounding land surfaces contaminates the measurement and makes the humidity retrieval method unsuitable. Nevertheless, the exploitation of altimetry in coastal and inland water areas becomes necessary for oceanography, and studies are in progress to exploit altimetry for hydrological budgets over large continental basins.

1. Development of a radiometer simulator

The purpose of this new tool is to simulate the brightness temperatures measured by the Topex/Poseidon Microwave Radiometer (TMR). We used:

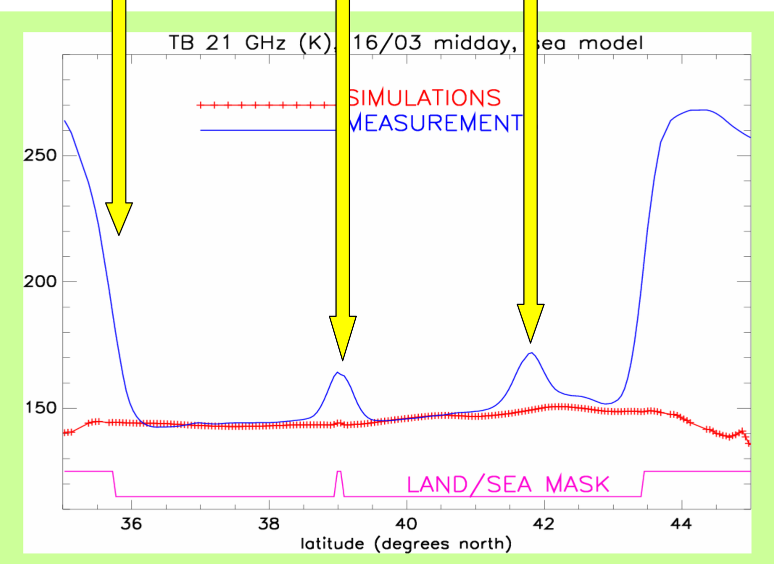
- the output fields of **Aladin** (Meteo-France model) of March and April 1998, validated by the FETCH experiment (in-situ measurements on board a research vessel and on moored buoys in the northwestern Mediterranean Sea): **surface parameters and atmospheric profiles.**
- the collocated **TMR measurements** at 18, 21 and 37 GHz on the following track, that presents interesting cases of contamination.



❖ First step:

We have at our disposal a radiative transfer model that simulates on both sea and land the three brightness temperatures (TBs) from Aladin's outputs, **with a sea surface emissivity model**. Simulations are thus wrong on continental surfaces.

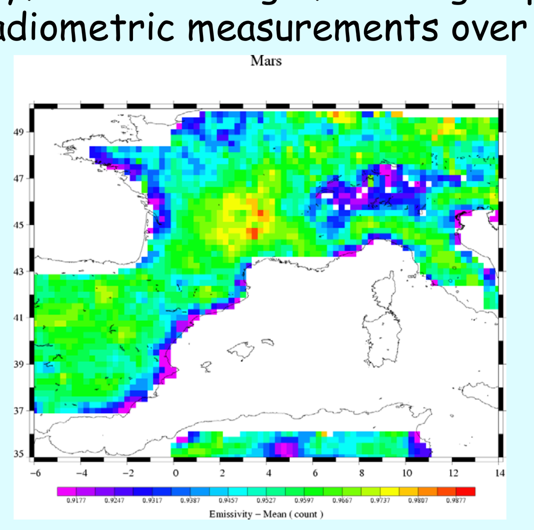
The TB at 21 GHz along the above track is exposed here:



❖ Improvements:

Land Emissivity Maps

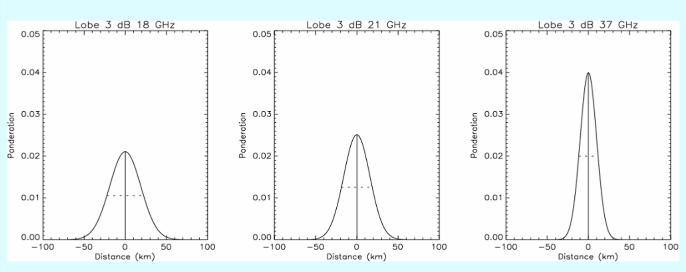
Recent studies conducted by F. Karbou (2004) have shown the feasibility of an estimation of **land emissivity** depending on the soil type, frequency, incidence angle, allowing exploitation of radiometric measurements over land.



We use these emissivities for pixels which center is on land.

Antenna simulation

The **antenna lobe** is correctly simulated by a Gaussian function which standard deviation is function of the lobe-width *D* at 3 dB.
D depends on frequency:



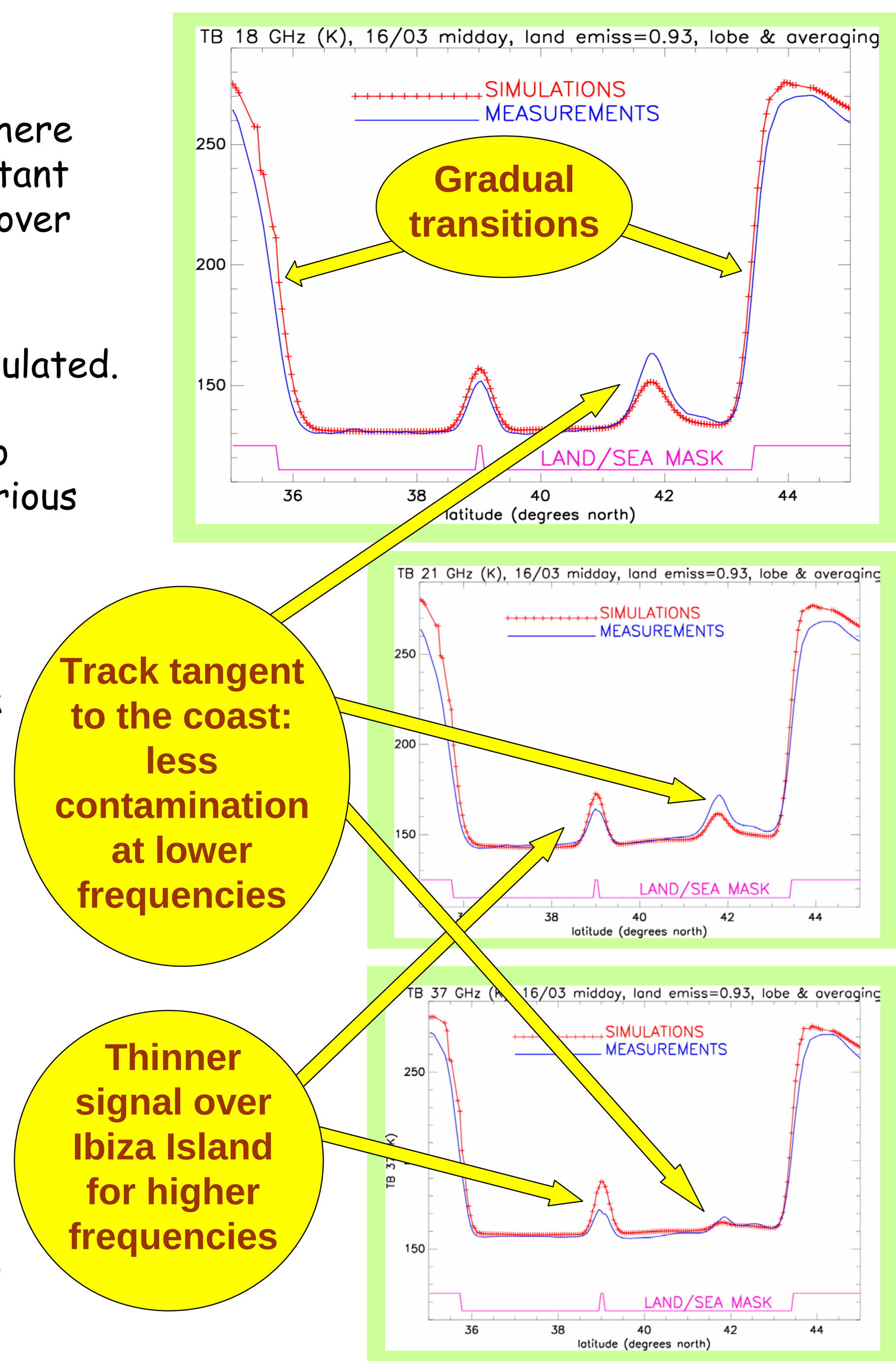
For each studied pixel, we take into account all the surrounding simulations which values are weighted by the Gaussian.

❖ Final step:

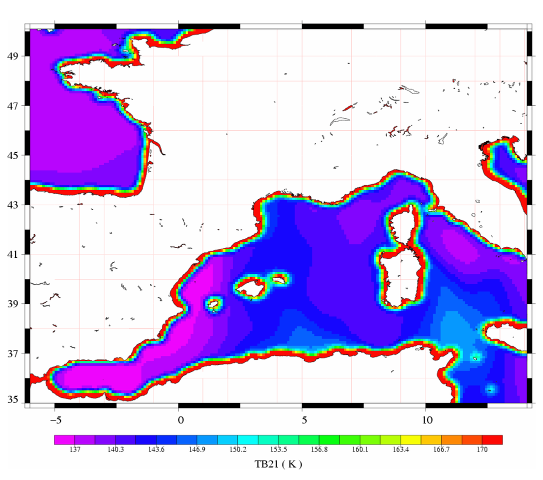
We apply the along-track averaging, and here the emissivity on land is forced to a constant value (e = 0.93). This means the dynamic over land is only caused by atmosphere.

All types of signals are now correctly simulated.

The simulator has been validated for two different atmospheric conditions and various geographic configurations.



Moreover it gives 2D data: we can now simulate radiometric measurements on a grid with a 0.1° resolution.



Simulated TB at 21 GHz: we can notice the contamination when approaching coasts, from about 50 km.

❖ Creation of an appropriate retrieval algorithm: Path Delay = f (TB_{18}, TB_{21}, TB_{37})

With the simulated TBs from all Aladin fields, by linear regression we found the relation:

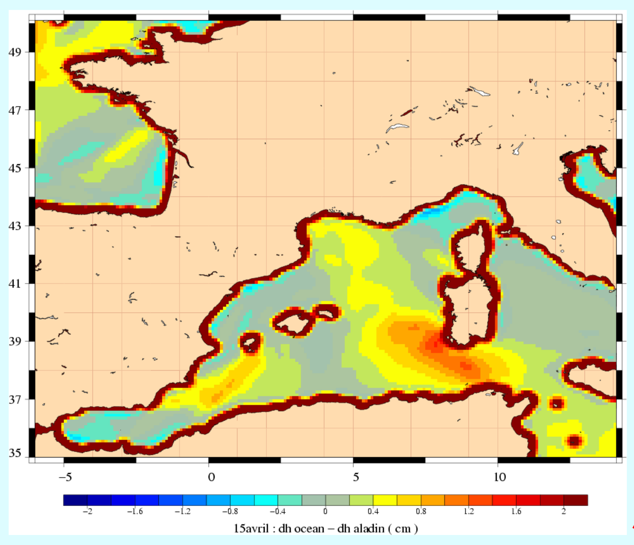
PD= 187.051 +34.615 *ln* (280−TB18) −71.0399 *ln* (280−TB21) −0.81085 *ln* (280−TB37)

2. Evaluation of some current methods

❖ Calculation of the Wet Path Delay from simulated TBs, and corrections

Without any correction

The Path Delay is highly contaminated near coasts:

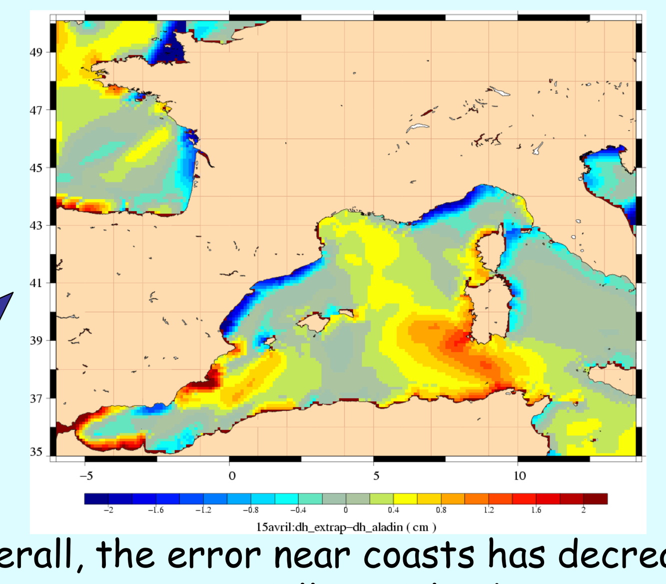


15 April: humid atmosphere

Error maps in comparison with Aladin Path Delay

Extrapolation of the closest uncontaminated PD

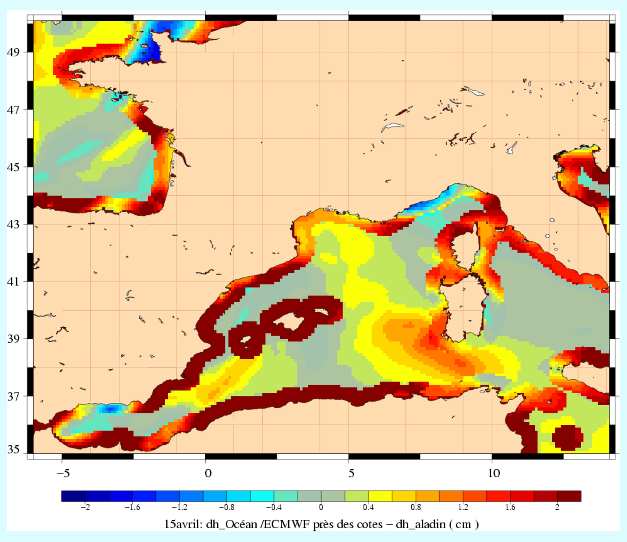
We considerate as contaminated the points of the grid at less than 50 km to the nearest coast.



Overall, the error near coasts has decreased, especially on islands.

Use of the ECMWF Path Delay near coasts

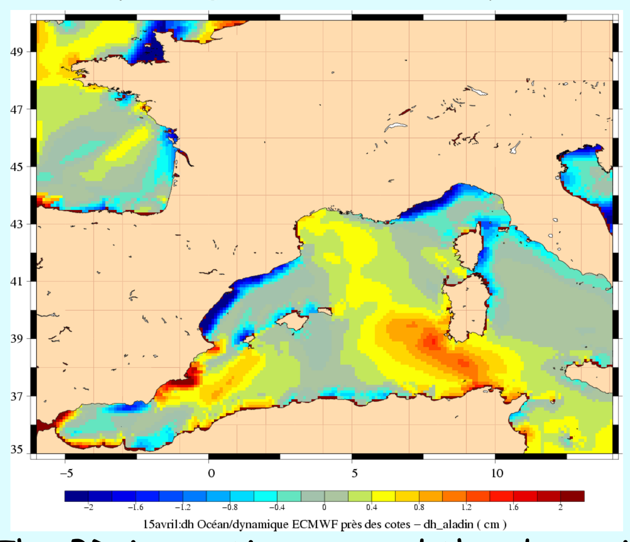
In the coastal strip, calculated PD switches to ECMWF PD (less accurate).



This method is not satisfactory: it creates a non natural step.

Extrapolation with ECMWF dynamic

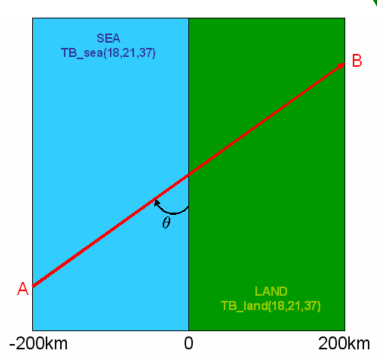
We extend the closest uncontaminated PD imposing the ECMWF dynamic.



The PD is continuous and the dynamic seems more realistic.

3. On a theoretical & analytical correction of TBs

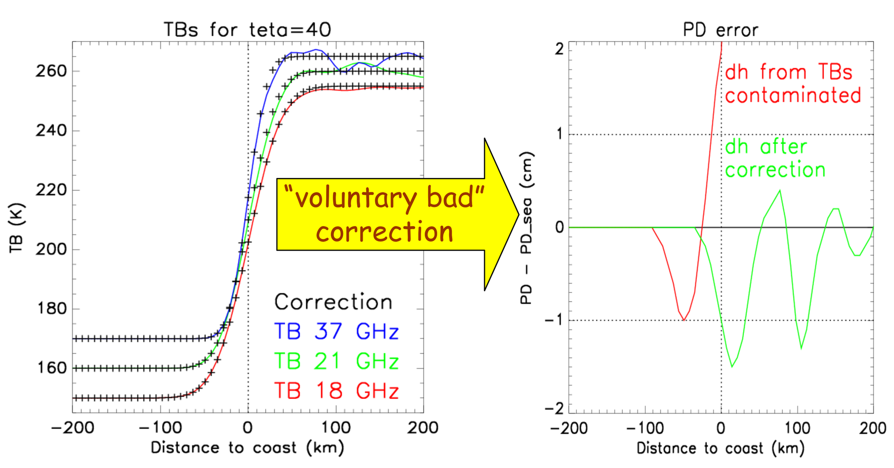
We improved the method proposed by C. Ruf by taking account of the angle **teta** between the track and the coastline, and of the variations of TBs on land, so as to test the sensitivity of this method.
The new correction function, where *d* is the distance to the coast and α is a parameter depending only on **teta** and on frequency, is:



$$corr(d) = \frac{(TBland - TBsea)}{2}\,(1 + erf(\frac{d}{\alpha}))$$

To simulate TBs: TBsea + *corr*, introducing a random error on TBland.

To correct, we take *corr* away from the simulated TBs. We show here an example:



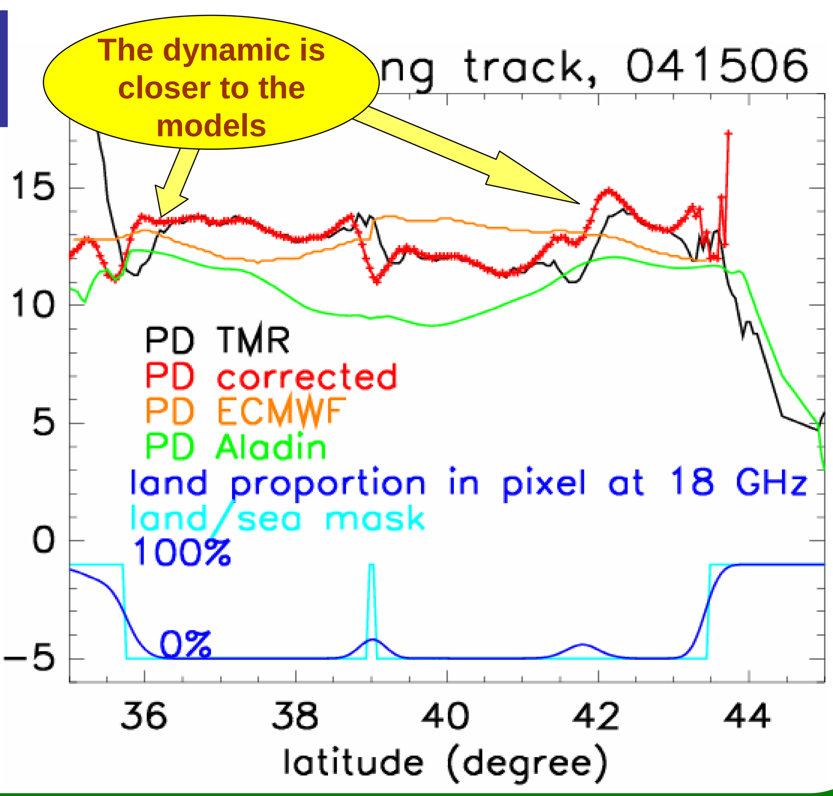
For a standard deviation σ = 2.7 K, the mean error on PD after correction, on sea, is 1 cm (which is the accuracy in open ocean). But we estimated σ = 5.1 K in the northwestern Mediterranean coast.

The error due to TBland estimation has to be add to those due to teta and TBsea estimations. The total error is far too much, considering that the coastline will never be rectilinear. Furthermore, this method does not allow to treat complex (normal!) cases, like islands (incomplete transitions) or tangent tracks (teta does not exist).

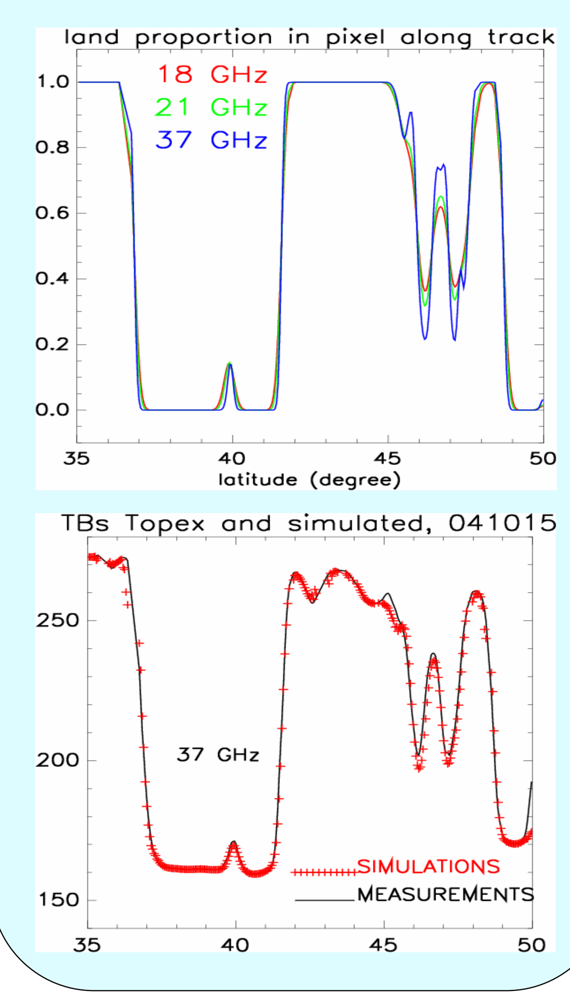
4. Using the proportion of land in the pixel

This new approach, inspired by R. Bennartz, is based on the linear dependency between TBs and proportion ***p*** of land in the pixel along track. ***p*** is calculated by means of a 0.01° resolution land/sea mask, taking into account the TMR field of view characteristics.

$$corr(p,\nu) = [TBland(\nu) - TBsea(\nu)] \times p(\nu)$$



We manage to simulate TBs in all the most complex configurations, as shown below:



This robust method allows the processing of any configuration, it seems adapted to an operational processing. But the hypothesis of a linear dependency, not completely valid (especially at 37 GHz), leads to ignore atmospheric phenomena.

Studies are in progress to evaluate the feasibility of a retrieval with a variational method.