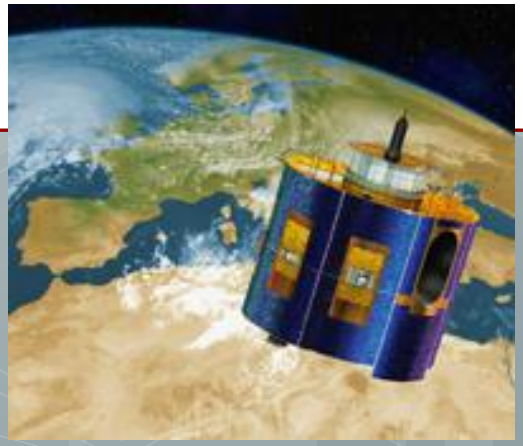
METEO FRANCE
Toujours un temps d'avance

cnrs
dépasser les frontières

CNRM/GAME

Assimilation of low-level SEVIRI IR observations over land



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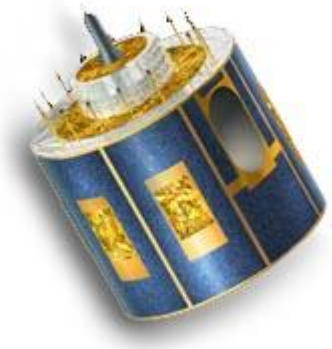
LSA-SAF User Workshop 2010, Toulouse

SEVIRI instrument



- Radiometer onboard METEOSAT-8/-9 (geostationnary)
- Measures « top-of-atmosphere » radiances using 12 channels

⇒ Resolution: - 1 image/15 min
- 3 km at nadir

Valuable information for NWP : **Earth surface**, tropospheric humidity, CO2 …

Channels	Caracteristics	Sensitivity
IR3.9	**Windows**	**Surface**
WV6.2	Water Vapor	~ 300 hPa
WV7.3	Water Vapor	~ 500 hPa
IR8.7	**Windows**	**Surface**
IR10.8	**Windows**	**Surface**
IR12.0	**Windows**	**Surface**
IR13.4	CO2	~ 750 hPa

SEVIRI in the ALADIN/FRANCE system

- Geographic domain : Europe
- Resolution : H=7.5 km , V=70 levels
- Optimal Interpolation for land surface analyse (LST_{ALADIN})
- 3D-Var assimilation system to produce 4 daily atmospheric analyses
- Observation operator : RTTOV-8

Assimilation

Channels	Caracteristics	Sensitivity	SEA	LAND
IR3.9	**Windows**	**Surface**		
WV6.2	Water Vapor	~ 300 hPa	✓	✓
WV7.3	Water Vapor	~ 500 hPa	✓	✓
IR8.7	**Windows**	**Surface**	✓	
IR10.8	**Windows**	**Surface**	✓	
IR12.0	**Windows**	**Surface**	✓	
IR13.4	CO2	~ 750 hPa		

Almost not sensitive to the surface

(Montmerle et al., 2007)

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IR13.4	CO2	~ 750 hPa		✓

Problem : large incertainties about the surface (**EMISSIVITY** & **TEMPERATURE**)

LST computation : Method

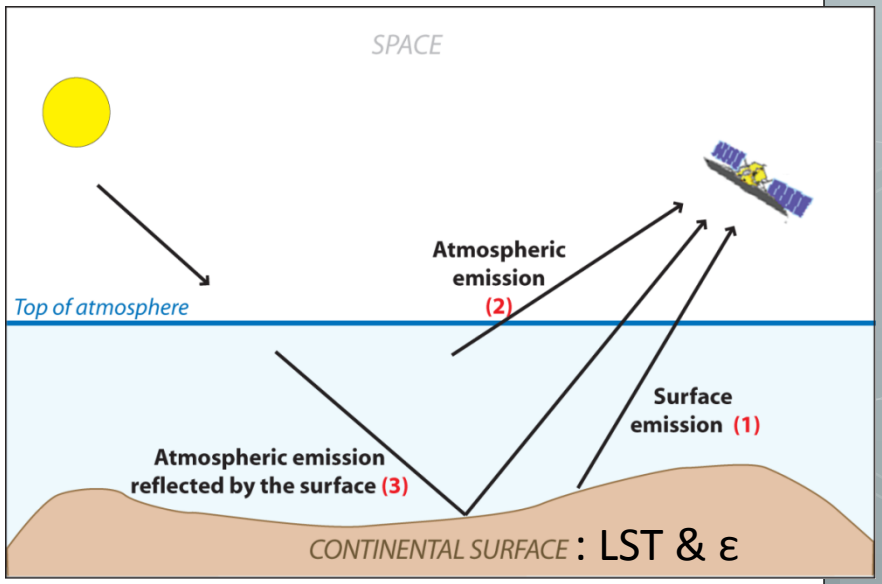
- ⇒ Direct retrieval of LST from SEVIRI observations following *Karbou et al. (2006)*
- ⇒ This method has been successfully implemented to improve the assimilation of MW observations over land.
- ⇒ An adaption for IR observations is performed here using the radiative transfer equation …

$$L = \varepsilon B(LST)\tau + L_{\uparrow} + (1-\varepsilon)L_{\downarrow}\tau$$

(1) (2) (3)

inversion

$$LST = B^{-1}\left[\frac{L - L_{\uparrow} - \tau(1-\varepsilon)L_{\uparrow}}{\varepsilon\tau}\right]$$

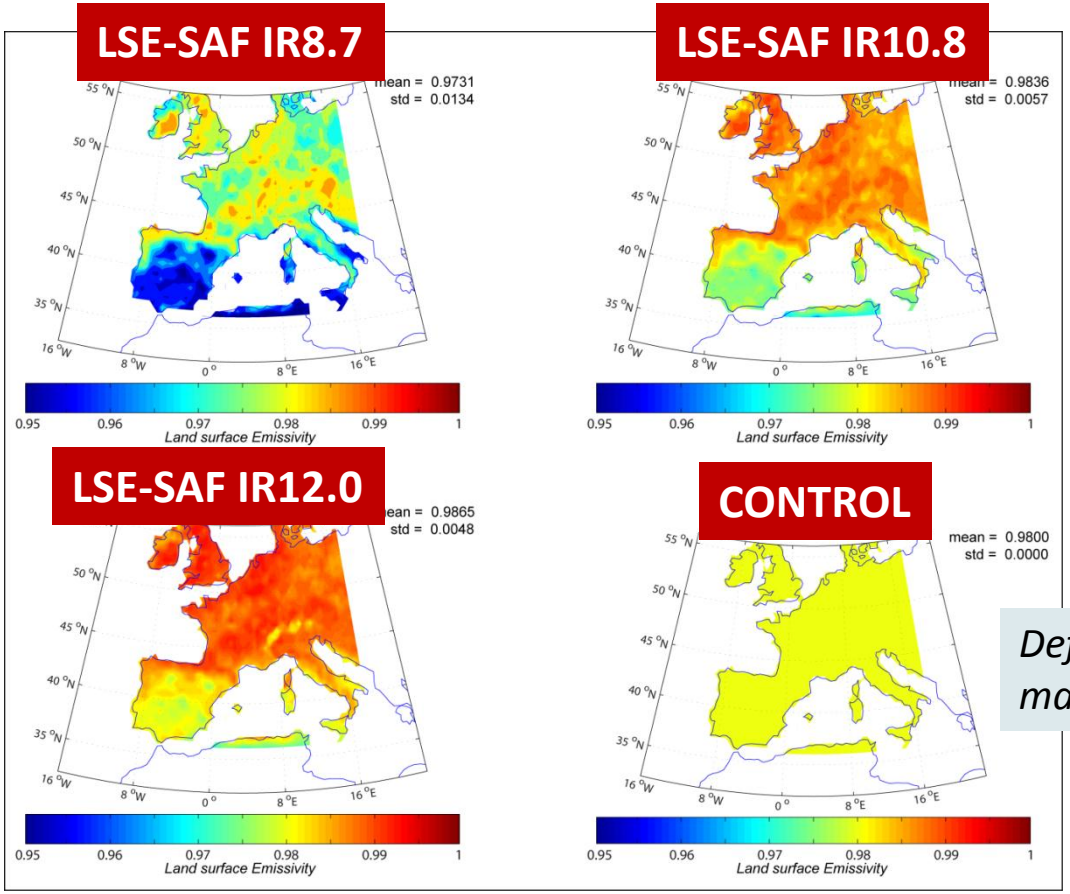


⇒ **As input we need a good estimation of the land surface EMISSIVITY …**

1. LST estimation over Europe

Daily LSE-SAF data have been averaged to produce an atlas for each windows channels

Maps of Land Surface Emissivity (LSE) atlases estimated at 3 SEVIRI channels



Default emissivity map of 0.98

⇒ **LSE-SAF maps exhibit a spatial and spectral variability**

⇒ **The benefit of using LSE-SAF rather than cste emissivity was found positive for RTTOV simulations**

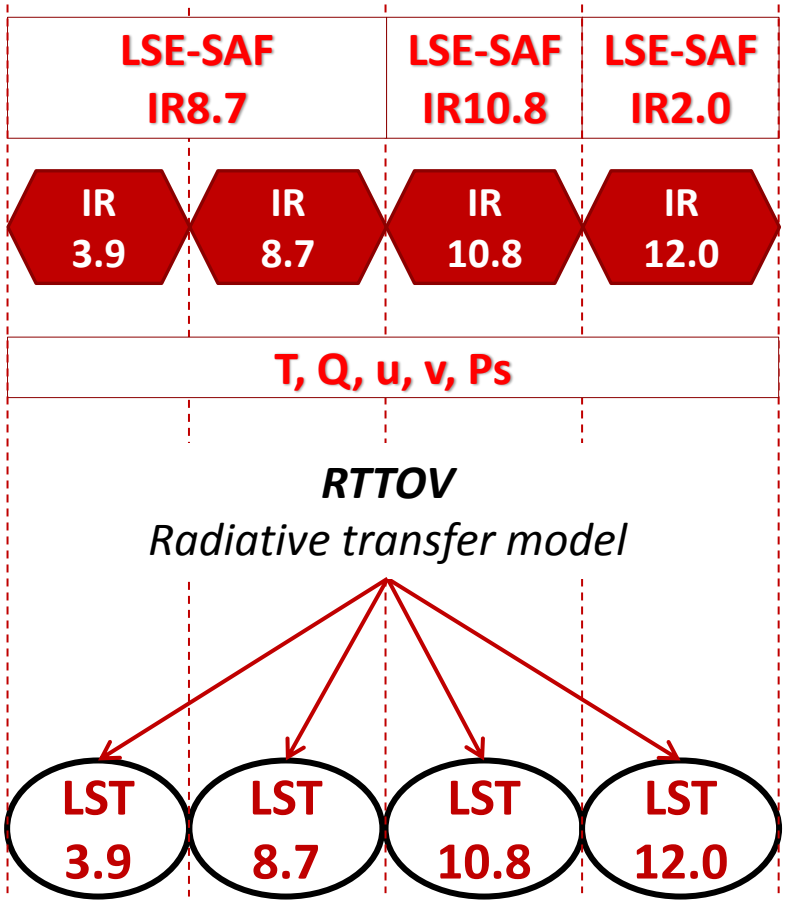
LST computation : Method

several configurations were tested to retrieve LST at SEVIRI channels:

Input 1 : **Emissivity ATLAS**

Input 2 : **Observed Bt**

Input 3 **: Atmospheric profiles**
(short-range forecast)

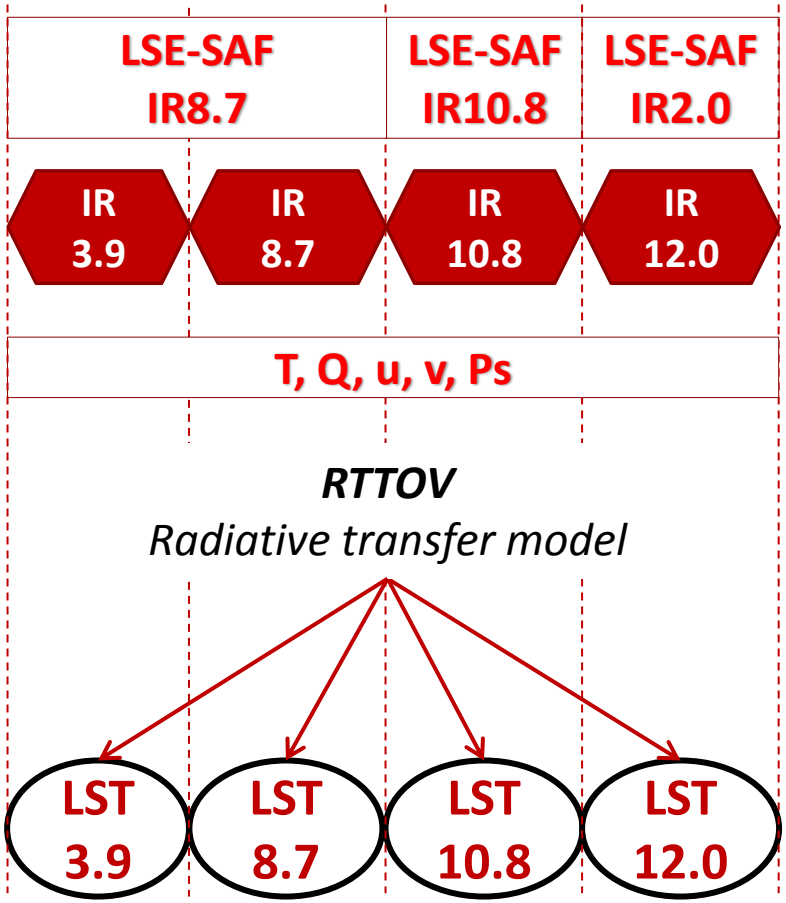


OUTPUT **: LST Retrievals**

⇒ **Ideal situation : $LST_{3.9} = LST_{8.7} = LST_{10.8} = LST_{12.0}$ … Nevertheless …**

LST computation : Method

several configurations were tested to retrieve LST at SEVIRI channels:

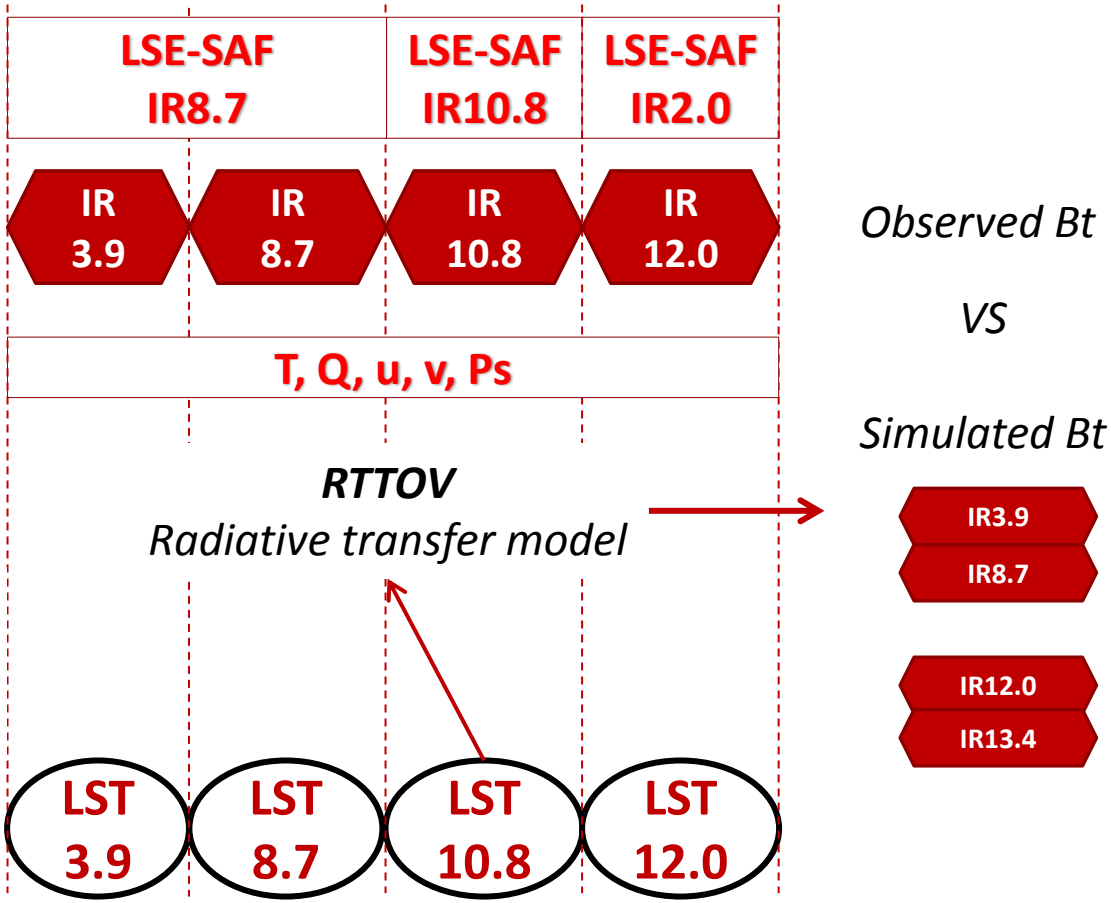


STEP 1 : Evaluation of retrievals vs independent measurements

LST SAF | LST MODIS | LST ALADIN **vs** LST 3.9 | LST 8.7 | LST 10.8 | LST 12.0

LST computation : Method

several configurations were tested to retrieve LST at SEVIRI channels:



STEP 1 : Evaluation of retrievals vs independent measurements

STEP 2 : select the channel which give the most realistic LST (radiances simulations)

STEP 1

Evaluation of retrievals

VS

independent measurements

LST computation : Evaluation

LST_{ALADIN} vs LST_{SAF} vs LST_{MODIS} vs $LST_{RETRIEVALS}$

Day-time and night-time averaged Land Surface Temperature (July 15 to August 15 of 2009)

Errorbars represent the STD

- Night-time retrievals are quite coherent
- Large differences in day-time :

1. $LST_{RET} > LST_{ALADIN}$

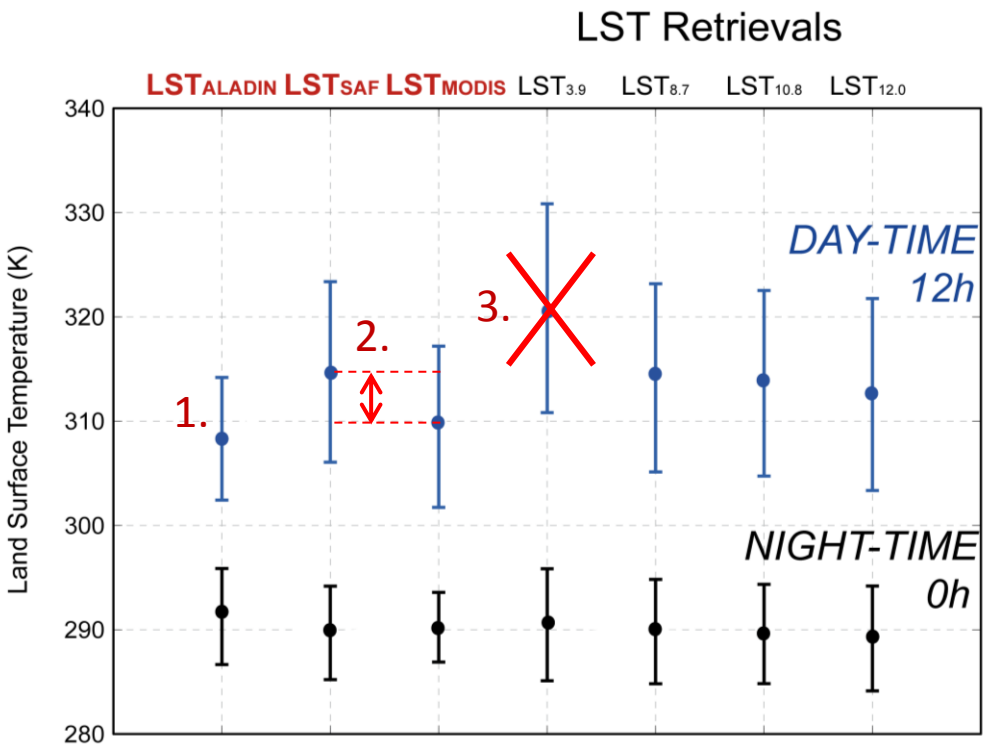
2. $LST_{SAF} < LST_{MODIS}$

⇒ difference in viewing geometry

(Trigo et al., 2008)

3. $LST_{3.9}$ can not be used

(sun contamination & inadequate ε)



LST computation : Evaluation

$LST_{SAF/MODIS}$ VS $LST_{RETRIEVALS}$

Correlations between LST_{SAF} /LST_{MODIS} and $LST_{RETRIEVALS}$ (July 15 to August 15 of 2009)

		LST8.7	LST10.8	LST12.0	N
Day-Time	SAF	**0,95**	**0,95**	0,91	957
	MODIS	0,86	0,85	0,82	
Night-Time	SAF	**0,96**	**0,95**	0,93	7570
	MODIS	0,78	0,78	0,76	

- the temporal and spatial agreement seem to be better between LST_{SAF} and $LST_{8.7}$, $LST_{10.8}$
- Results from $LST_{12.0}$ seem to be less convincing :

⇒ lower sensitivity of this channel to the surface compared with IR8.7 and IR10.8

(Averaged atmospheric transmission : 0.71 for channel IR10.8 and 0.6 for channel IR12.0)

LST computation : Evaluation

Summury of STEP 1

- **$LST_{RETRIEVALS}$ vs LST_{ALADIN}** :
  - LST_{RET} have been found to be colder (warmer) during night-time (day-time) than LST_{ALADIN}
- **$LST_{RETRIEVALS}$ vs LST_{SAF}** : Good spatial and temporal agreement
  - Expected since LSE-SAF is used in both methods (monthly, daily)
  - Only one channel is used for our retrievals

⇒ $LST_{3.9}$ and $LST_{12.0}$ can not be used

⇒ Differences between $LST_{8.7}$ and $LST_{10.8}$ retrievals but which one is the more realistic?

⇒ Only one channel is needed for the assimilation !

⇒ **STEP 2** …

STEP 2

select the BEST channel
which give the most realistic LST
for radiances simulations

Observations vs Simulations: Method

several configurations :

Input 1 : **LST retrievals**

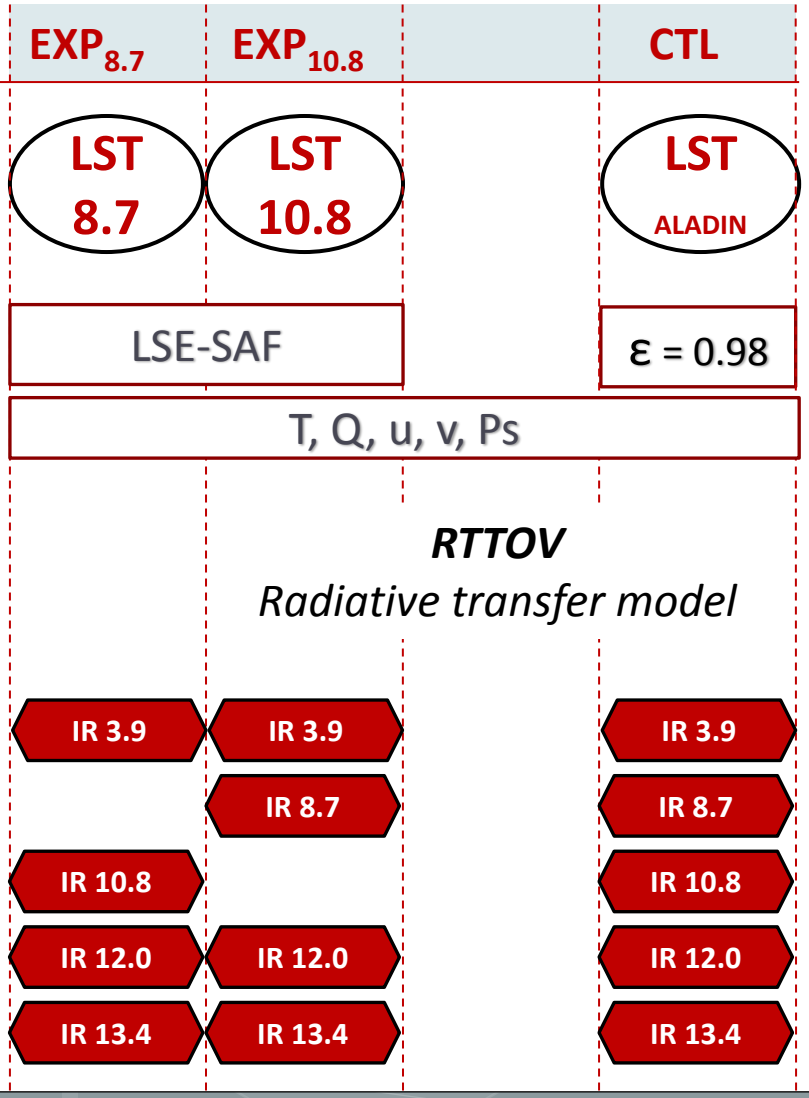
Input 2 : **Emissivity ATLAS**

Input 3 : **Atmospheric profiles**

OUTPUT : **Simulations of SEVIRI Brightness temperature**

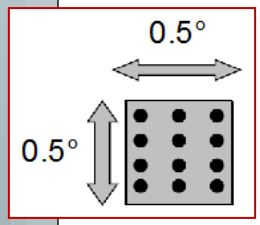
VS

OBSERVATIONS



Observations vs Simulations: correlations

Maps of **correlations** between :



observed Tb

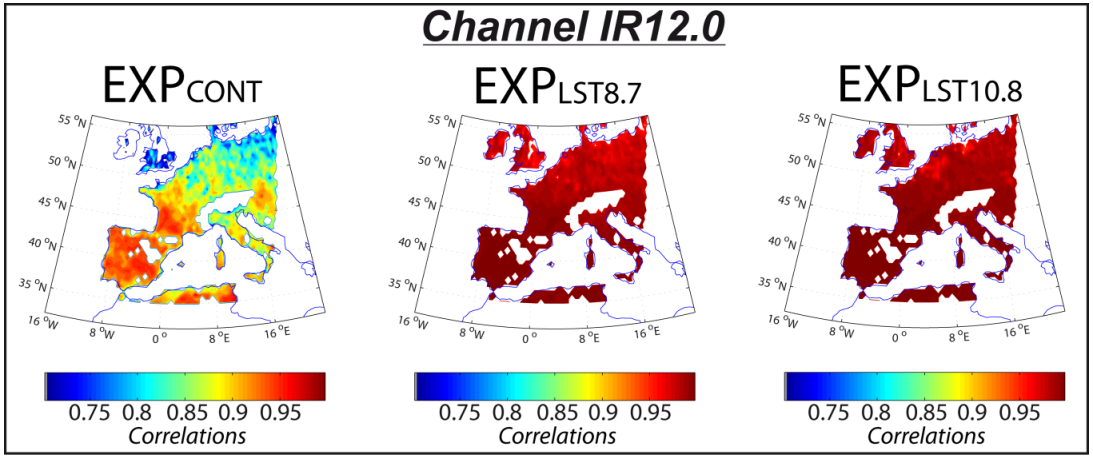
and

simulated Tb

⇒ July 15 to July 31 of 2009

⇒ Both configurations improve radiances simulations

⇒ Best results are obtained when LST is retrieved from channel IR10.8



Observations vs Simulations : bias

SEVIRI data assimilation:

$$|\text{Observations} - \text{Simulations}| < 1.2\text{K}$$

Using our method, we evaluate the amount of SEVIRI observations that could be potentially assimilated

Rate of increase of SEVIRI observations, potentially assimilated, using 2 configurations (ATLAS, ATLAS+LST) when compared with CONT (July 15 to August 31 of 2009)

	IR8.7	IR12.0	IR13.4
EXP_{ATLAS}	+0.99%	+3.14%	+4.98%
$EXP_{RET10.8}$	+62.88%	+57.58%	+5.17%

Conclusion

The aim of this work was to assimilate as many IR SEVIRI observations over land as possible by reducing the incertainties about the surface (**EMISSIVITY** & **TEMPERATURE**)

- LST has been retrieved at several SEVIRI window channel using the radiative transfer equation and LSE from the LSA-SAF

- Evaluation of $LST_{RETRIEVALS}$:
  1. Comparison with other estimates / LST_{MODIS} / LST_{SAF} / LST_{ALADIN} :
     - $LST_{RETRIEVALS}$ have been found to be colder (warmer) during night-time (day-time) than LST_{ALADIN}
     - Good agreement (space, time) has been found between $LST_{RETRIEVALS}$ and LST_{SAF}

     $\Rightarrow$ $LST_{3.9}$ and $LST_{12.0}$ can not be used

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The aim of this work was to assimilate as many IR SEVIRI observations over land as possible by reducing the incertainties about the surface (**EMISSIVITY** & **TEMPERATURE**)

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     - Good agreement (space, time) has been found between $LST_{RETRIEVALS}$ and LST_{SAF}

     ⇒ $LST_{3.9}$ and $LST_{12.0}$ can not be used

  2. Selection of the best SEVIRI channel for LST :
     - RTTOV to simulate SEVIRI radiances
     - Correlation between Obs and Sim has been improved with regard to CONT configuration

     ⇒ Best results when using LST retrieved from channel IR10.8

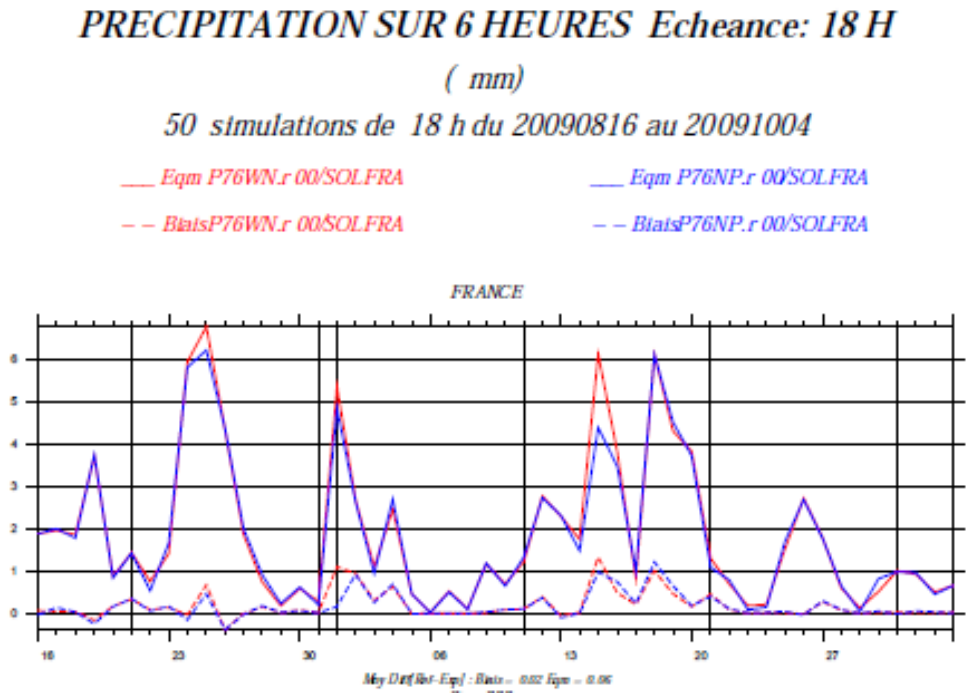
     ⇒ Rate of increase of SEVIRI observations, potentially assimilated > 60%

Conclusion & Future plans

Guedj S., F. Karbou and F. Rabier, Land surface temperature estimation to improve the assimilation of SEVIRI radiances over land, Journal of Geophysical Research, **Submitted**

- Several assimilation experiments have been run using the $EXP_{RET10.8}$ configuration

⇒ To finish, some preliminary scores : 18h-forecasted precipitations VS Observations …



REF vs $EXP_{RET10.8}$

——— RMS

-------- BIAS

Thank You

Guedj S., F. Karbou and F. Rabier, Land surface temperature estimation to improve the assimilation of SEVIRI radiances over land, Journal of Geophysical Research, **Submitted**

LST computation : Evaluation

LST_{SAF} vs LST_{MODIS}

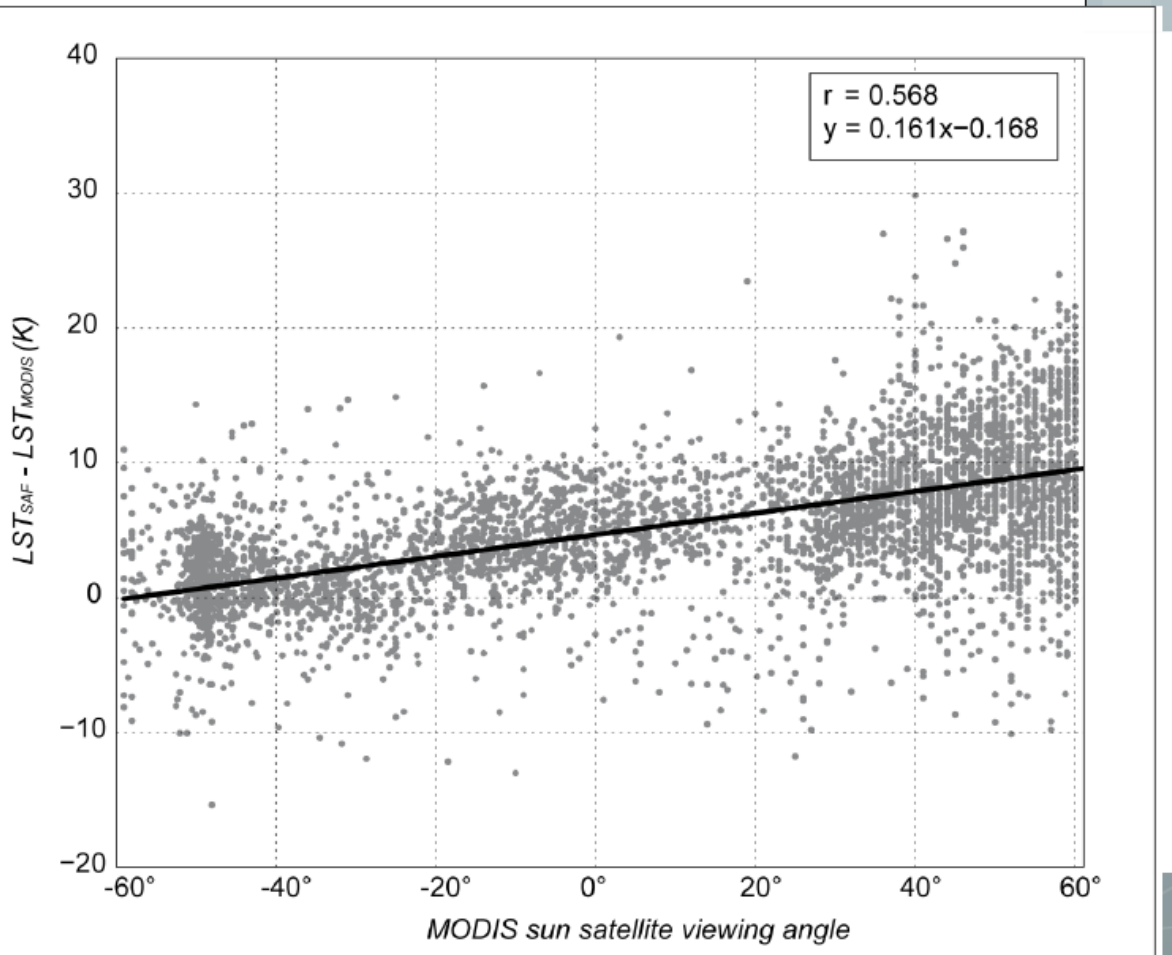
Scatterplot of day-time (12h) LST_{SAF} minus LST_{MODIS} as a function of MODIS sun-satellite viewing angle (July 15 to August 15 of 2009)

- The bias is probably due to the difference in viewing geometry between SEVIRI and MODIS *(Trigo et al., 2008)*

⇒ *Only LST MODIS produced using large **negative** observations angles*

↓

The deviation between LST_{SAF} and LST_{MODIS} is reduced from 5K to 1.4K !!



LST computation : Evaluation

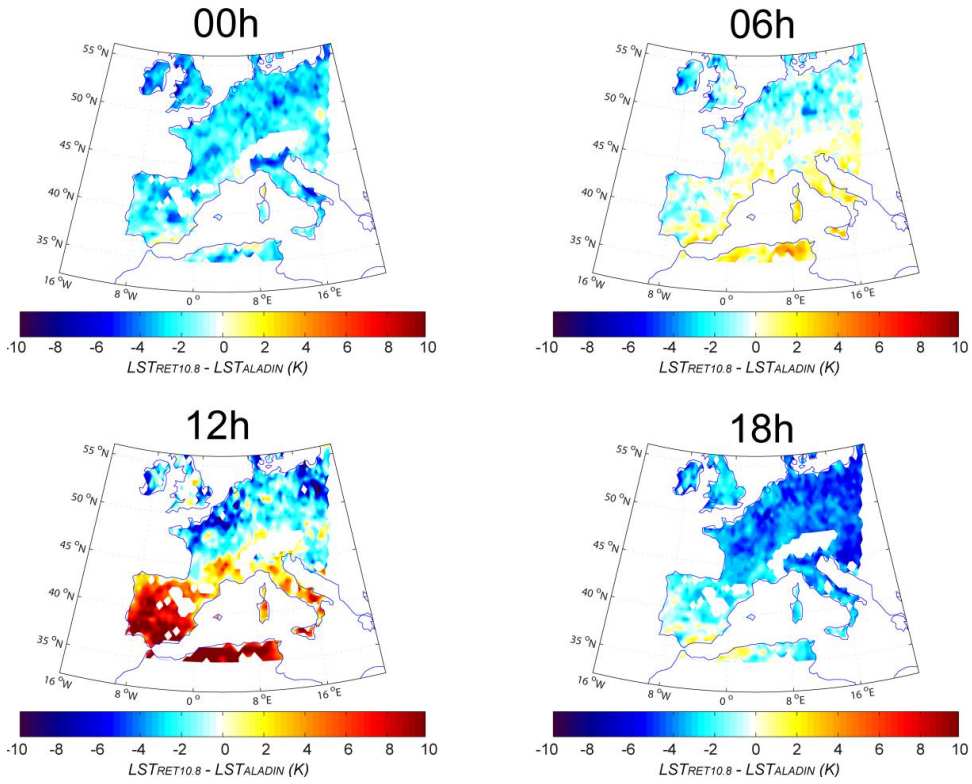
LST_{ALADIN} VS $LST_{RETRIEVALS}$

Mean maps of $LST_{10.8}$ minus LST_{ALADIN} at 0,6,12 and 18h (July 15 to August 15 of 2009)

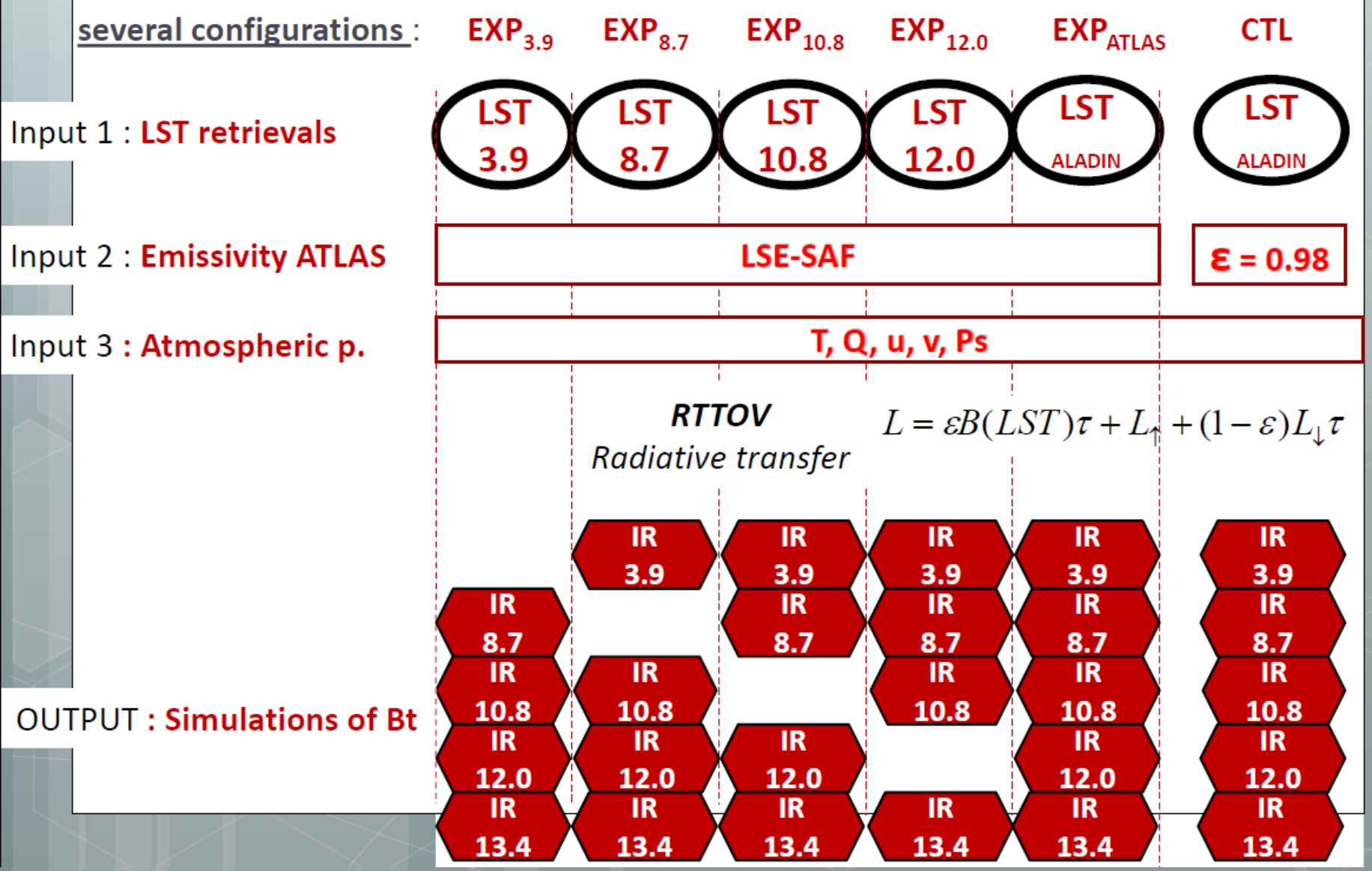
$LST_{10.8} > LST_{ALADIN}$

$LST_{10.8} < LST_{ALADIN}$

- 0h and 18h **$LST_{10.8}$** are colder than **LST_{ALADIN}**
- **$LST_{10.8}$** is warmer than **LST_{ALADIN}** at 12h over the southern part of Europe



Observations vs Simulations: Method



Amount of

potential assimilated SEVIRI observations

⇒ Data are accounted for if :

$$|Tb_{obs} - Tb_{sim}| < 1.2K$$