Soil analysis scheme for AROME within SURFEX

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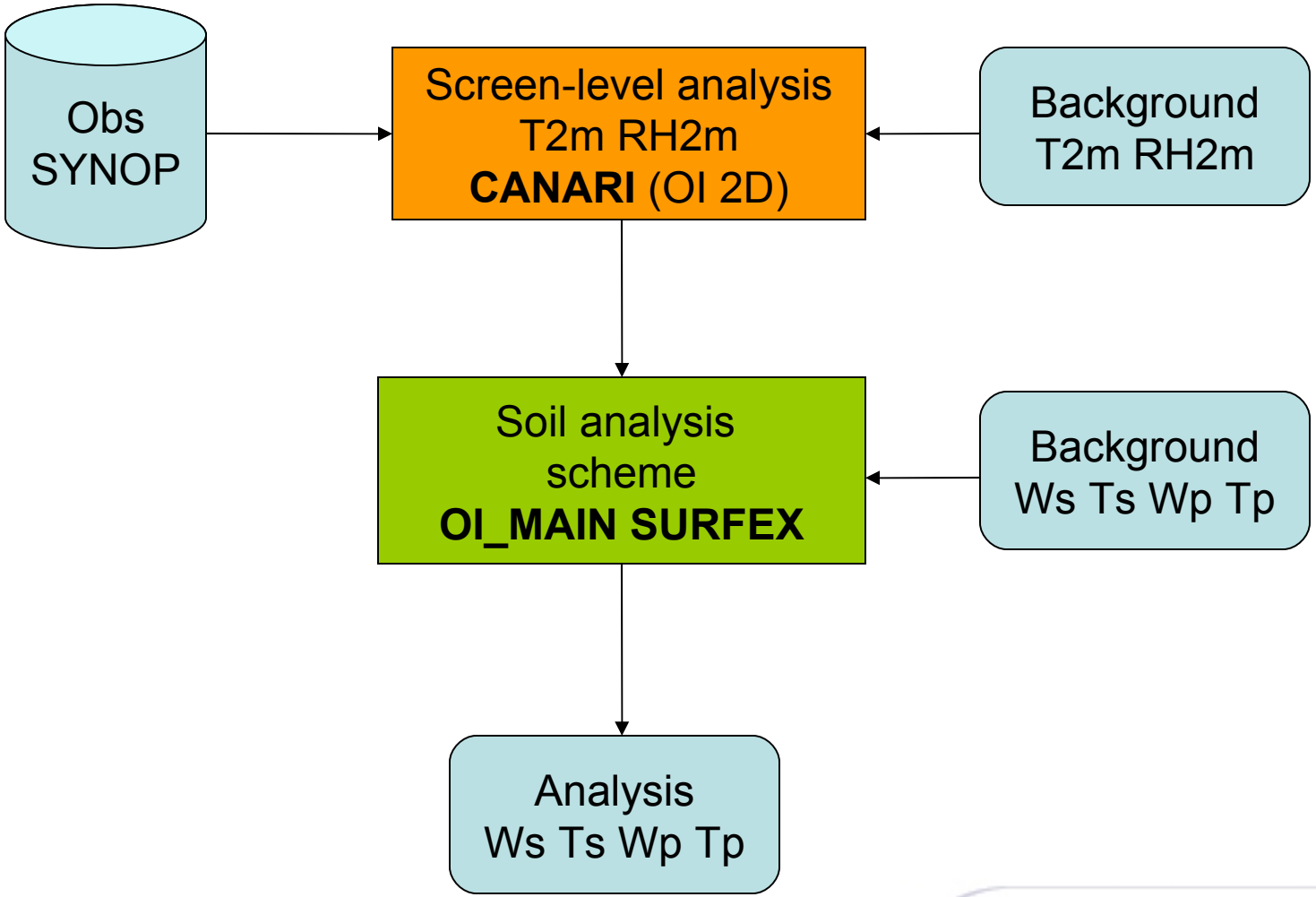
Introduction

- Scientific objective : Initialisation of the prognostic variables of the surface schemes available within SURFEX for the NWP model AROME (Soil temperature and moisture contents of the land surface scheme ISBA + roads and building temperatures of the town model TEB)
- Main features :
  - Variables with long equilibrium time scales = dedicated analysis procedure (e.g. root zone soil moisture)
  - Variables with fast equilibrium times cales = cycling (e.g. prognostic variables of CANOPY)
  - Assignment of temperature from water bodies (lake, oceans) using the CANARI SST analysis
  - Method : same as one used for ALADIN since Feb.2009 at Météo-France (Optimum Interpolation scheme described in Giard and Bazile (2000))

AROME specificities

- Current status : Initial state of surface prognostic variables in AROME interpolated from ALADIN analysis
- Differences between ALADIN and AROME forecasting systems :
  - Higher spatial resolution (2.5 km vs 9.5 km)
  - Deep convection explicitly resolved (no « convective » precipitation)
  - Shorter assimilation cycle (3h vs 6h)
  - Improved description of surface processes :
    - Fractional grid coverage : nature / towns / lakes / oceans
    - ECOCLIMAP land cover / FAO soil type data bases
    - Town Energy Budget (Masson, 2000) = 9 prognostic variables for temperature
    - Three-layer version of ISBA (Boone et al., 2000) = 3 prognostic soil water reservoirs
    - CANOPY surface boundary layer scheme (Masson and Seity, 2009) = 20 prognostic variables (temperature, wind, specific humidity, TKE)

Soil analysis scheme



Soil analysis equations

Analysis increments for the volumetric soil water contents (ws and wp) and the soil temperatures (Ts and Tp) :

$$\Delta w_s = \alpha_1 (T_{2m}{}^a - T_{2m}{}^b) + \alpha_2 (HU_{2m}{}^a - HU_{2m}{}^b)$$

$$\Delta w_p = \beta_1 (T_{2m}{}^a - T_{2m}{}^b) + \beta_2 (HU_{2m}{}^a - HU_{2m}{}^b)$$

$$\Delta T_s = \mu_1 (T_{2m}{}^a - T_{2m}{}^b)$$

$$\Delta T_p = \nu_1 (T_{2m}{}^a - T_{2m}{}^b)$$

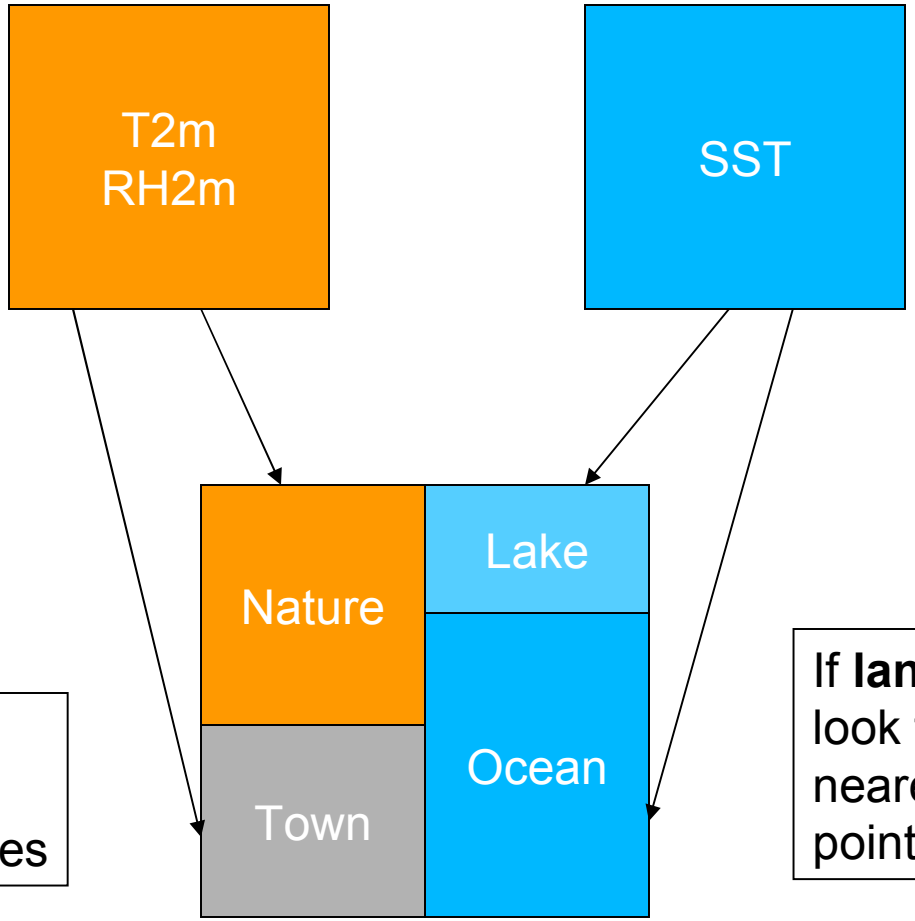
Giard and Bazile (2000)
[Monthly Weather Review]

Surface and soil analyses for AROME

- Adapation of the OI CANARI for screen-level analysis (and SST analysis) to AROME : use background values for T2m and RH2m computed by CANOPY (no vertical interpolation in CANARI) – conservative approach (same statistical model as in ALADIN and ARPEGE)
- Reduction of the OI coefficients for soil moisture corrections by a factor of two in order to account for the reduction of the assimilation window by the same factor
- Initialisation of the same soil water reservoirs as in ALADIN : Ws and Wp. The deeper reservoir W3 does not act directly on evapotranspiration and has a smaller depth than the root zone.
- Initialisation of the deep road temperature (1 m depth) using increments of the deep soil temperature analysis
- Consistency checks for snowmelt and soil freezing
- All other prognostic variables are simply cycled => Analysis = 3h forecast

Correspondence atmosphere-surface

Atmosphere
Land/sea : binary



Surface tiling

If **sea** point :
keep the
background values

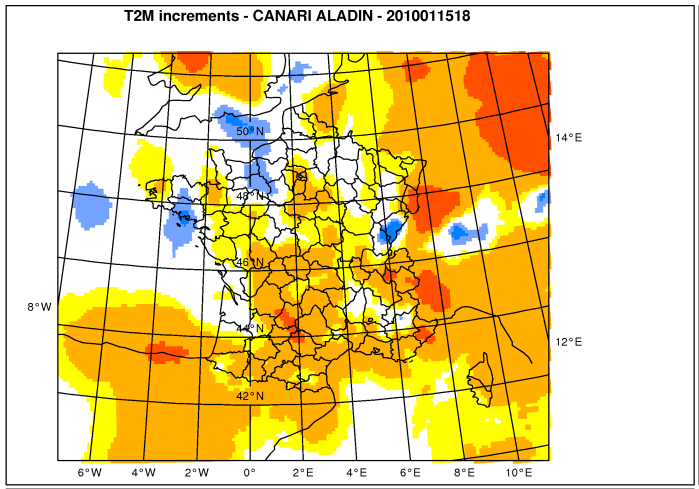
If **land** point :
look for the
nearest sea
point

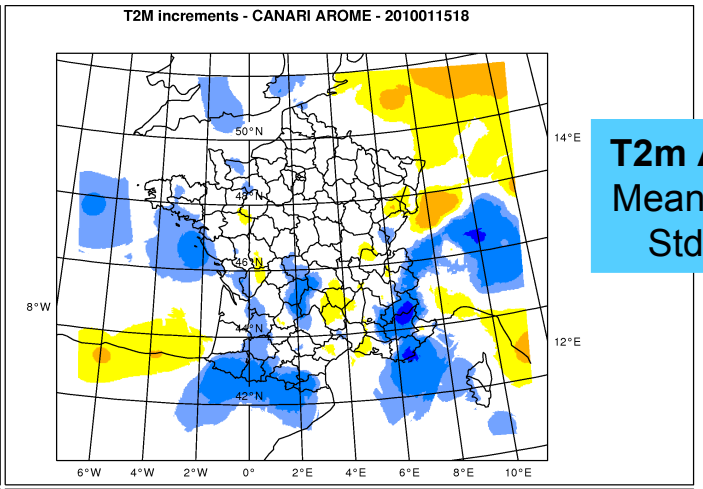
Experiment

- One week 3D-Var assimilation : cy35t2 – compatible with cy36t1 (v2 AROME : 60 vertical levels and coupling with ARPEGE 10 km)
- Period : 15-22 January 2010
- Comparison with parallel suite (operational since 6 April 2010)
- Remark : OK for examining technical issues and soil temperature behaviour – need for a spring/summer longer period to examine soil moisture contents

T2m and RH2m analysis increments

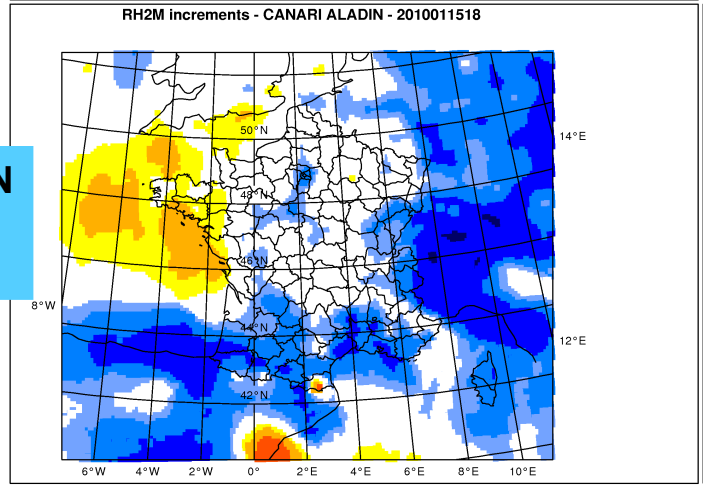
T2m ALADIN
Mean = 0.60
Std=1.01

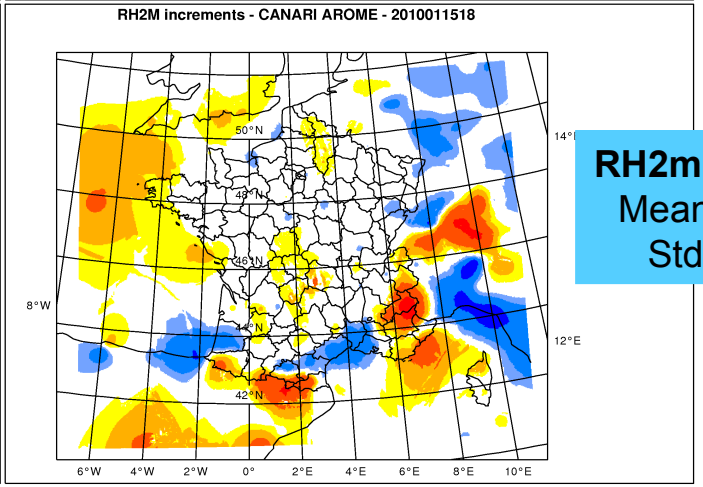




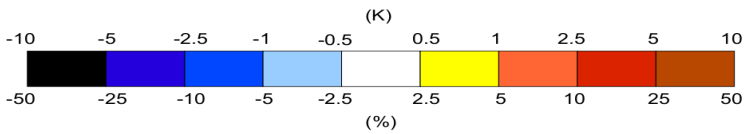
T2m AROME
Mean = -0.14
Std=0.67

RH2m ALADIN
Mean = -2.9
Std=6.03



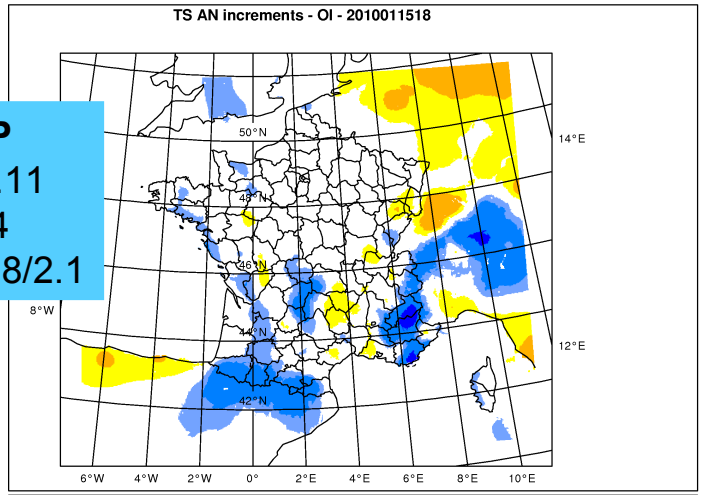


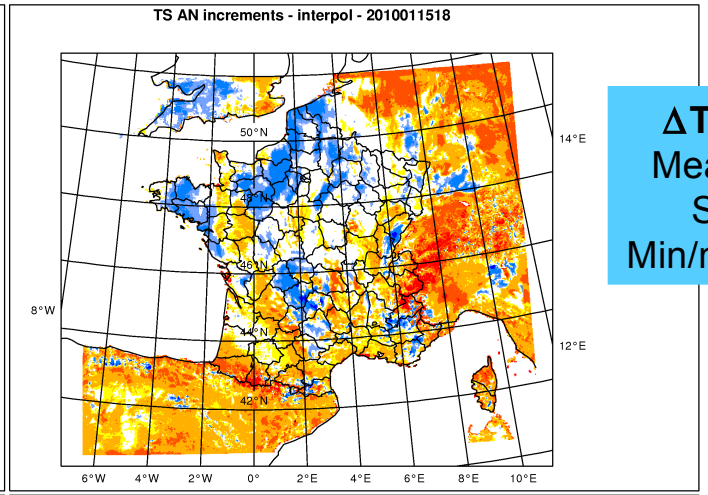
RH2m AROME
Mean = 1.32
Std=4.80



Ts differences with OPER configuration

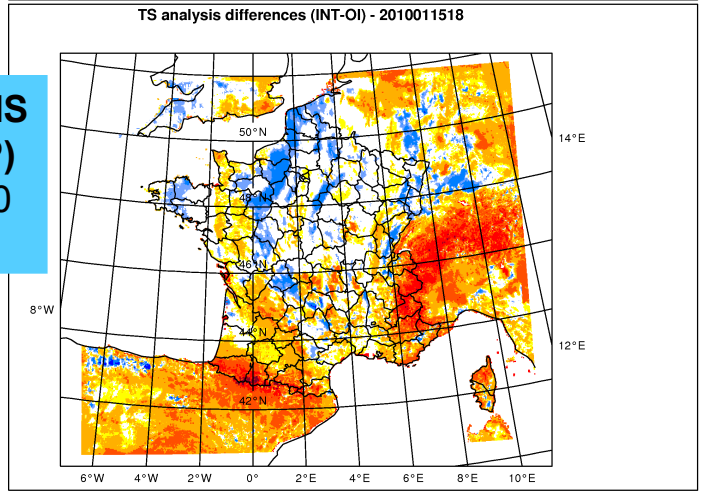
ΔTs EXP
Mean = -0.11
Std=0.74
Min/max : -3.8/2.1

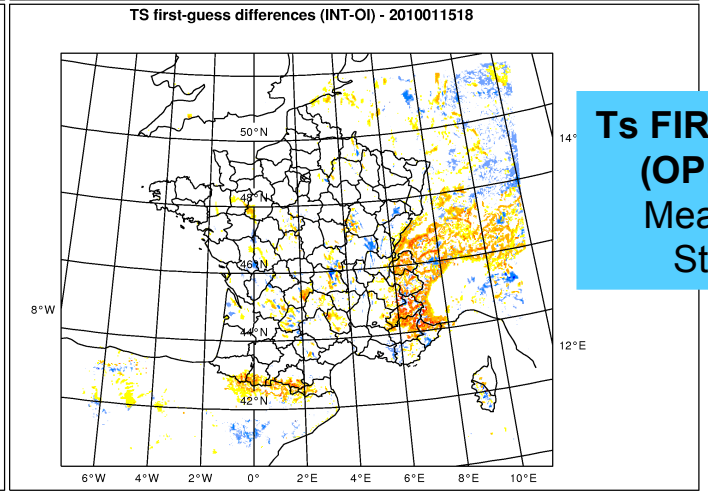




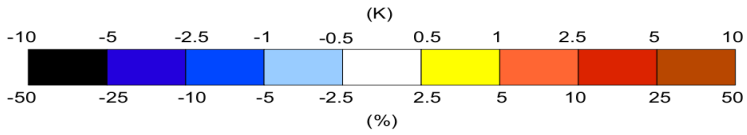
ΔTs OPER
Mean = 0.85
Std=1.5
Min/max : -5/15

Ts ANALYSIS (OPER-EXP)
Mean = 1.00
Std=1.64



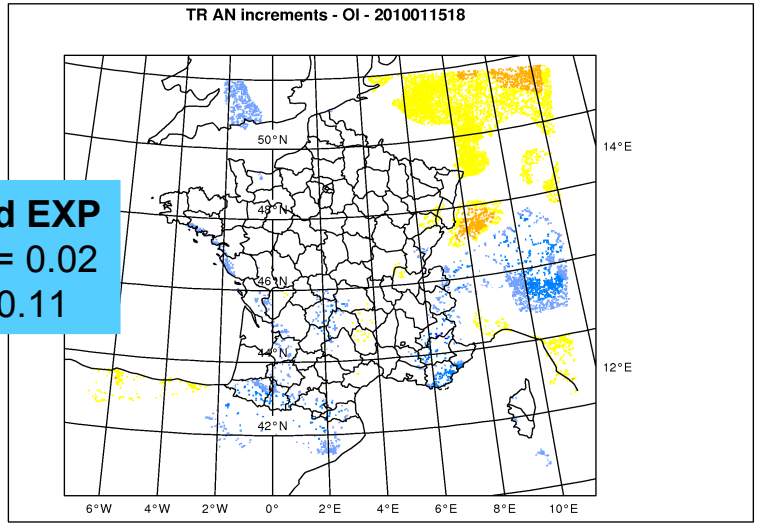


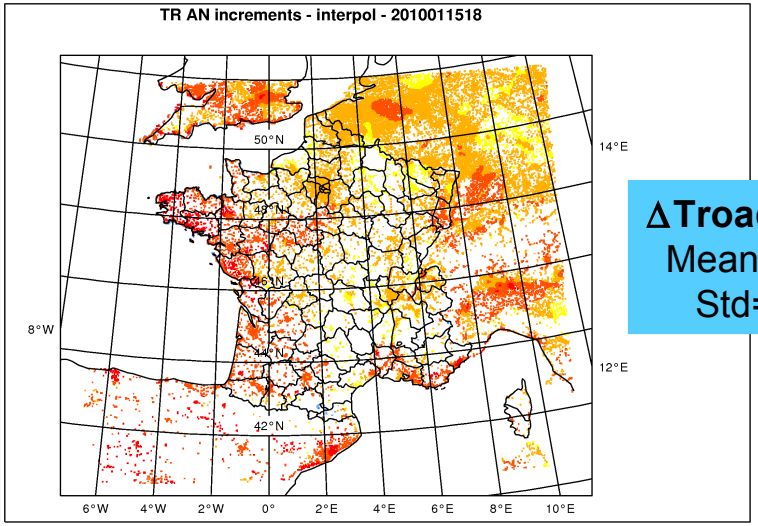
Ts FIRST-GUESS (OPER-EXP)
Mean = 0.04
Std=0.50



T_{road} differences with OPER configuration

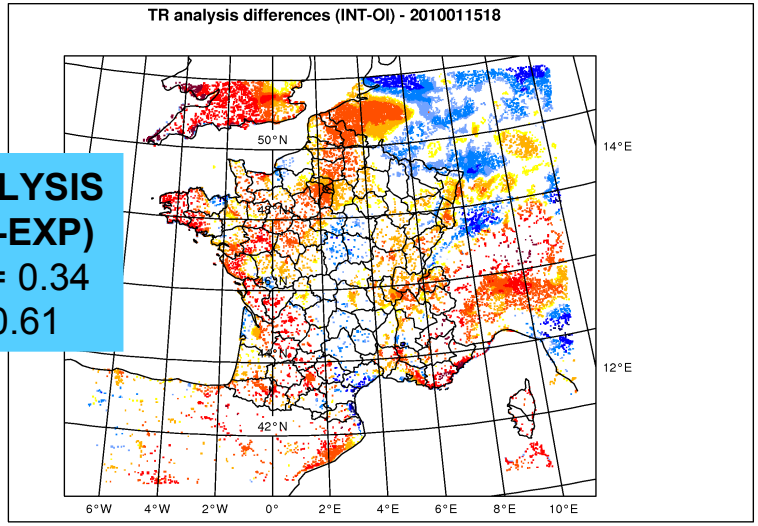
ΔTroad EXP
Mean = 0.02
Std=0.11

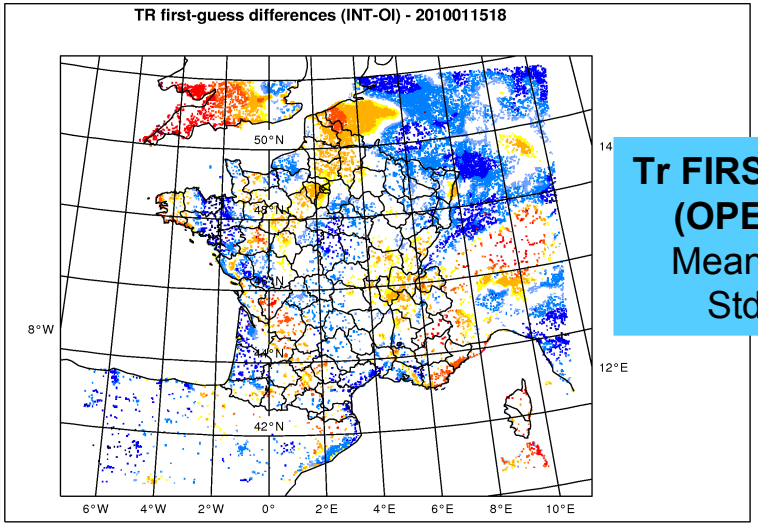




ΔTroad OPER
Mean = 0.43
Std=0.31

Tr ANALYSIS (OPER-EXP)
Mean = 0.34
Std=0.61





Tr FIRST-GUESS (OPER-EXP)
Mean = -0.07
Std=0.49

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CANARI screen-level analysis with AROME

- Current specifications (as in ALADIN and ARPEGE):
  - Statistical model : cor[r] = exp(-r/L)
  - Correlation lengths : L=85 km (T2m) and L=80 km (RH2m)
  - Observation errors : σ_o=1.4 K (T2m) and σ_o=10 % (RH2m)
  - Background errors : σ_b =1.6 K (T2m) and σ_b = 18 % (RH2m)
  - A priori QC : altitude (model-obs) : *none* / station elevation : *none*
- Innovation statistics (one week) :

Std deviation $(\sigma^2_o+\sigma^2_b)^{1/2}$	Computed	Estimated
T2m (K)	1.67	2.12
RH2m (%)	9.6	20

Conclusions

- Soil analysis scheme available within SURFEX (OI_MAIN) and suitable for AROME and ALADIN
- One week 3D-Var assimilation in winter has shown that the cycling works, and has allowed to evaluate the screen-level analysis and the soil temperature analyses
- Smaller CANARI increments with AROME => better background particularly over mountains
- CANARI statistics could be revised : smaller σ_b for RH2m, improved QC over mountains
- The soil moisture analysis needs to be evaluated : 3D-Var assimilation in spring 2010 (just started) – will mostly depend upon the diurnal cycle of T2m and RH2m
- This soil analysis should be included in the next AROME version

Possible improvements

- Reduction of the OI coefficients for the superficial reservoir Ws as it has been done for the deep reservoir Wp (Mahfouf et al., 2009)
- Improve the soil temperature analysis : diurnal cycle of the OI coefficients (larger values during the night and for the deep soil temperature) (Mahfouf et al., 2009)
- Allow the analysis of the surface temperature in the presence of snow on the ground
- Replace the OI scheme by an Extended Kalman Filter

Thanks for your attention

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