Dynamic inference of background error correlation between surface skin and air temperature

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Motivation

• Improve low level (P > 850 hPa) temperature analyses from the assimilation of surface sensitive IR radiances. Assimilate these channels routinely over land.

• Make use of ensemble forecasts to obtain flow-dependent information important for data assimilation, namely the $T_{\text{skin}} - T_{\text{air}}$ (hereafter $T_s - T_a$) background error correlation.

• Pave the way for an analysis of $T_s$ over land using both radiances and $T_a$ observations.
IM-4 Temperature Jacobian for a tropical profile (emi=0.97)

Note: Ts Jacobian $\frac{dT_s}{dT} = 0.31$ K/K
Background error correlation (vertical)

- Essential in data assimilation. Allows observations at one level to influence the analysis at neighbouring levels.

- $T_s - T_a$ correlation most often ignored (0) or arbitrary (0.5). For IR surface channels, this implies a non-optimal compromise between corrections to $T_s$ and $T_a$ minimizing the difference between observed $BT$ and background-equivalent $BT$.

- Problem: the $T_s - T_a$ error correlation varies locally depending on how much these variables are related. Ensemble forecasts likely represent the best way to infer that correlation + all others needed.
Ensemble forecasts

- We use 64 members representing 64 6-h forecasts. The forecasts use the same forecast model and differ only from perturbations of observations of all types according to their respective error estimates.

- $T_s$ is fixed over oceans (SST analysis) and predicted over land. Variables most influencing land $T_s$ are temperature and humidity. No $T_s$-$T_a$ error correlation can be inferred over oceans. Satellite radiances influencing $T_s$ are not present in the analyses.

- $T_s$-$T_a$ error correlation fields are obtained from the deviation of each variable with respect to the local mean. Local variances are computed as well.
Link between Ts-Ta error correlation from ensemble forecasts and surface inversions

Ts-Ta error correlation

06 UTC June 02

Ts minus Ta

06 UTC June 02

18 UTC June 03

Ts-Ta error correlation

18 UTC June 03

Ta is lowest predictive level near 70 m.
Experiments

• 4 analyses: 2 times x 2 modes of correlation
  06 UTC and 18 UTC, June 2, 2002 with
  $T_s$-$T_a$ correlation set to: 0.0 and to that from ensembles
  Error correlation between $T_s$ and $T_a$ levels above 70 m
  deduced from the interlevel $T_a$-$T_a$ error correlation

• Use operational data + GOES-East and West IM4 (11μ)
  and IM5 (12μ) radiances in clear regions (sensitive to
  $T_s$ and low level temperature and humidity)

• Horizontal length scale set to $L= 100$ km for $T_s$:
  significant influence of observations up to $2L$.
  $T_a$ length scale is about 200 km in entire column
$T_s$ increments with and without $T_s - T_a$ error correlation

without

06 UTC

with

18 UTC
Effect of $T_s - T_a$ error correlation on $T_a$ increments

$T_a$ inc (with correl)

inc diff (with -without correl)

06 UTC

18 UTC
Impact on 12 UTC Ta (70m) analysis: with minus without Ts-Ta correlation

- Radiosondes not assimilated: kept as independent verification
Comparison of 12 UTC analyses against radiosondes (radiosondes not assimilated)

Grand Junction, CO: improved T

Kelowna, BC: improved T, Td

Black: radiosonde  Blue: without correlation  Red: with correlation
full: Temp  dashed: dew point spread
Other comparisons

Reno, Nevada: improved $T, T_d$

Kuujjuak, Que: deteriorated $T$ due to horiz. correl. impact in transition area

Black: radiosonde  Blue: without correlation  Red: with correlation
full: Temp  dashed: dew point spread
Conclusion

• The $T_s$-$T_a$ error correlation can induce changes of the order of 1 K in the boundary layer from the assimilation of surface sensitive IR channels. The analysis of $T_s$ is also improved in principle.

• Ensemble forecasts provide a powerful tool to infer this correlation and thus make use of local, flow dependent information.

• Impact as expected. Horiz. resolution and correlation effects require more investigation.
Example of $T_a$ profile increment with/without correlation

Correlation = +0.86; lat=29.8 N. lon=250.9 E, 6 UTC June 2, 2002

$\eta = \frac{(P-Po)}{(P-Ps)}$

- blue: without correlation; $T_s$ increment = +3.3 K
- black: with correlation; $T_s$ increment = +2.9 K

$BT4(\text{obs-calc}) = +1.69$ K; $BT5(\text{obs-calc}) = +1.54$ K
Link between $T_s$-$T_a$ error correlation and surface inversions

$T_s$-$T_a$ error correlation
12 UTC June 02

Ts minus Ta
12 UTC June 02

00 UTC June 03

$T_a$ is lowest predictive level near 70 m.