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

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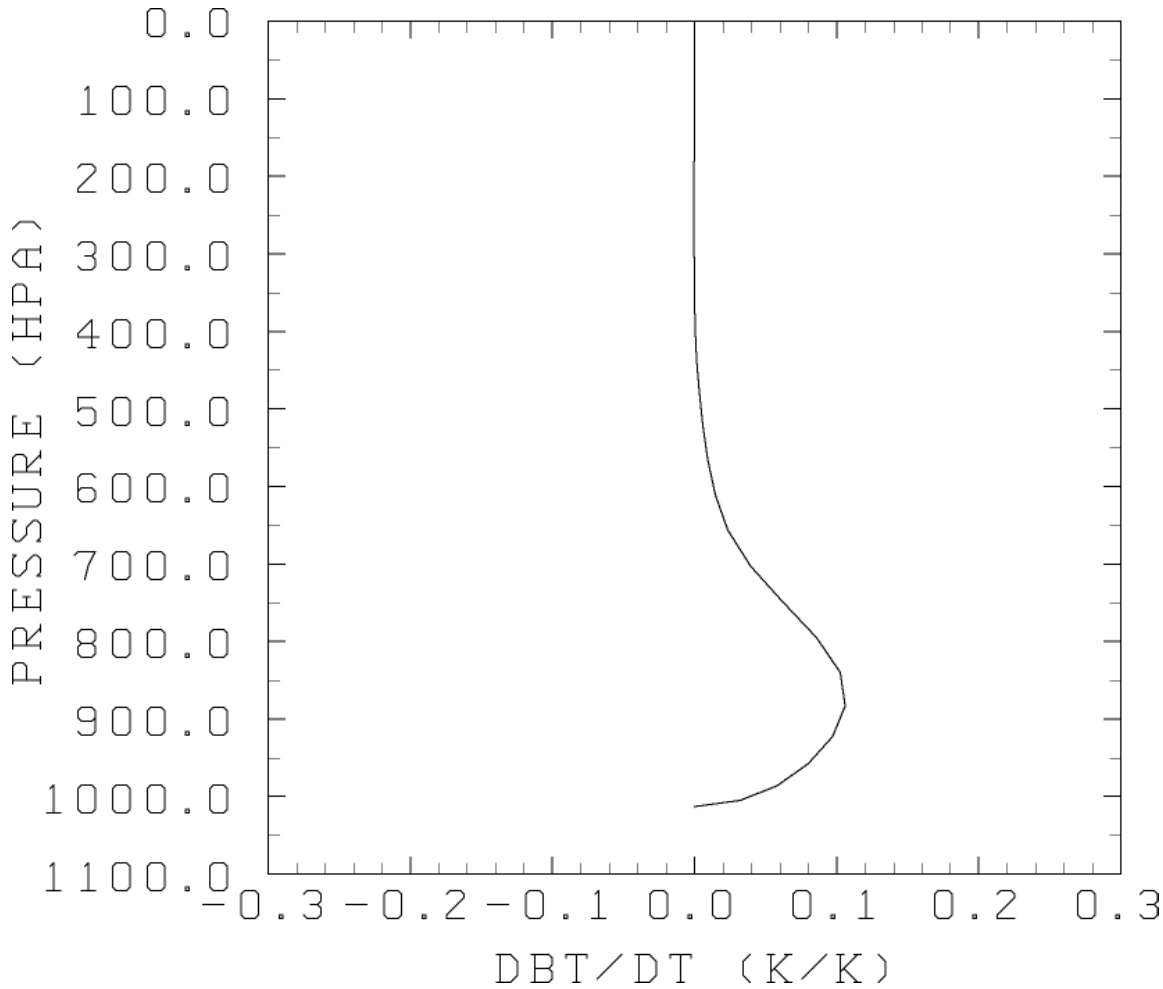
Motivation

- 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_{skin}-T_{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 dBT/dT_s = 0.31 K/K

Background error correlation (vertical)

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

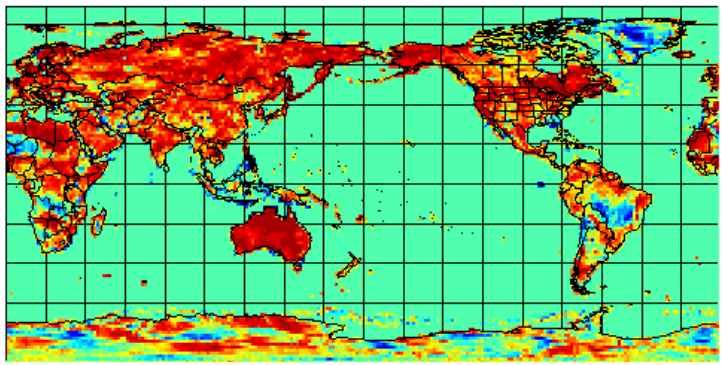
- T_s is fixed over oceans (SST analysis) and predicted over land. Variables most influencing land T_s are temperature and humidity. No T_s-T_a error correlation can be inferred over oceans. Satellite radiances influencing Ts are not present in the analyses.

- 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.

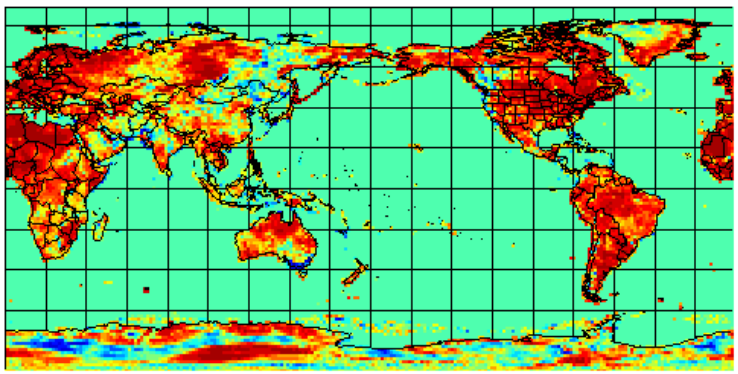
Link between Ts-Ta error correlation from ensemble forecasts and surface inversions

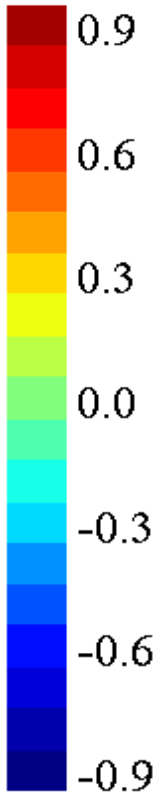
T_s-T_a error correlation

06 UTC June 02



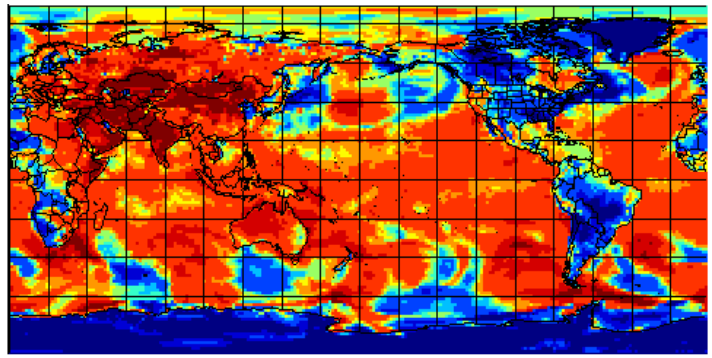
18 UTC June 03



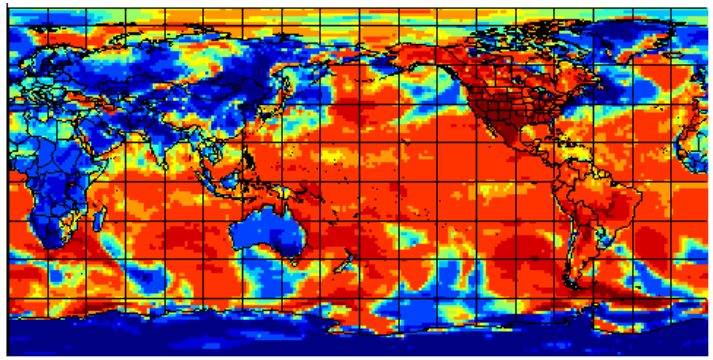


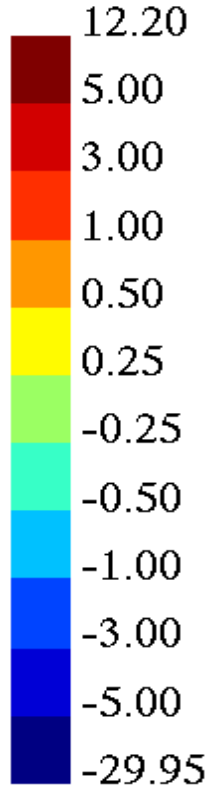
T_s minus T_a

06 UTC June 02



18 UTC June 03





T_a 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)

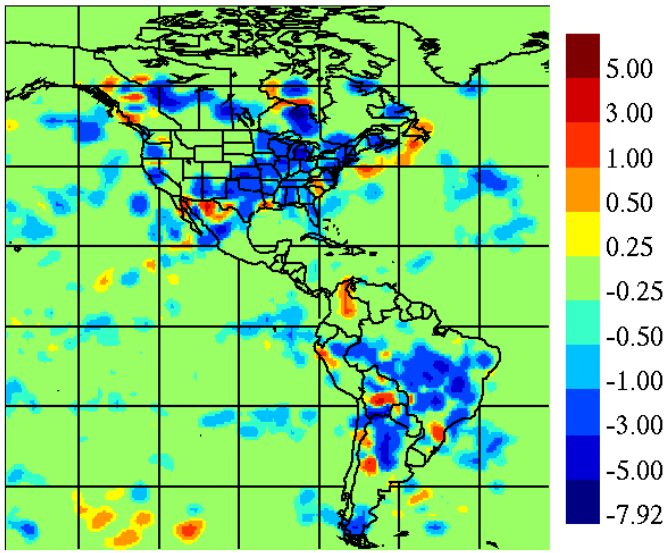
- Horizontal length scale set to L= 100 km for T_s:
  significant influence of observations up to 2L.
  T_a lenght scale is about 200 km in entire column

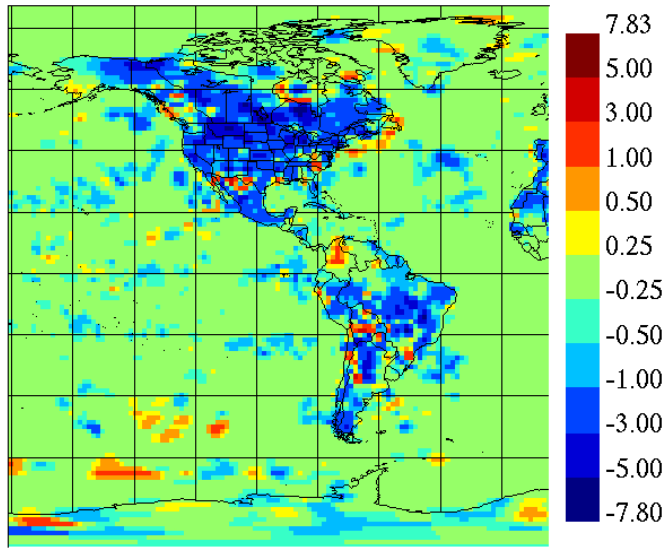
T_s increments with and without T_s-T_a error correlation

without

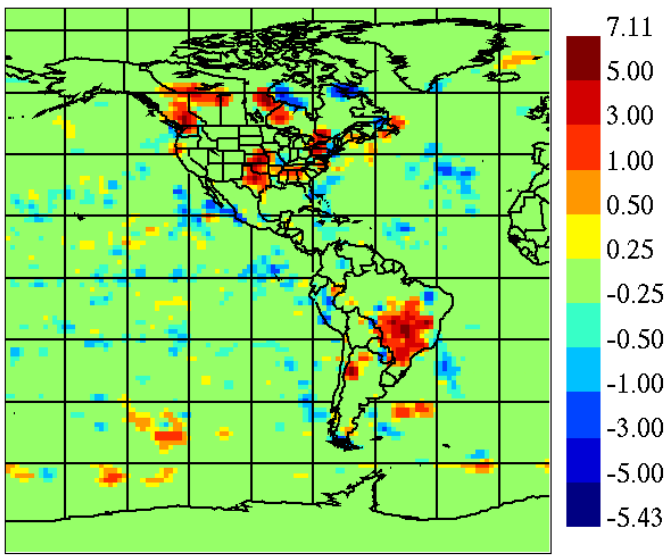
with

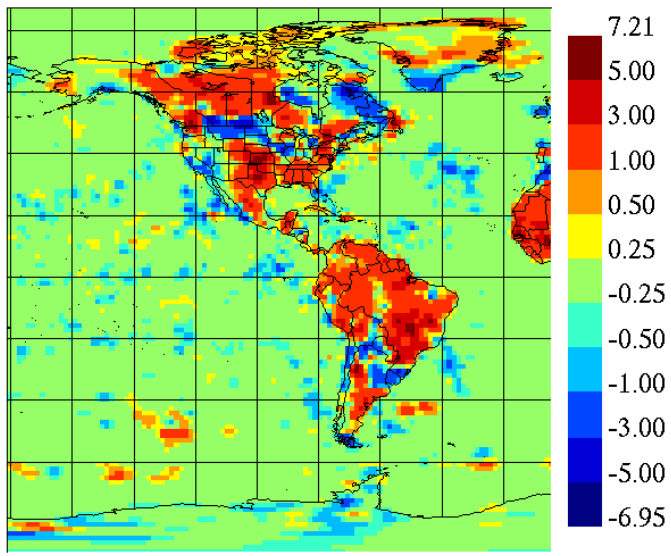
06 UTC





18 UTC



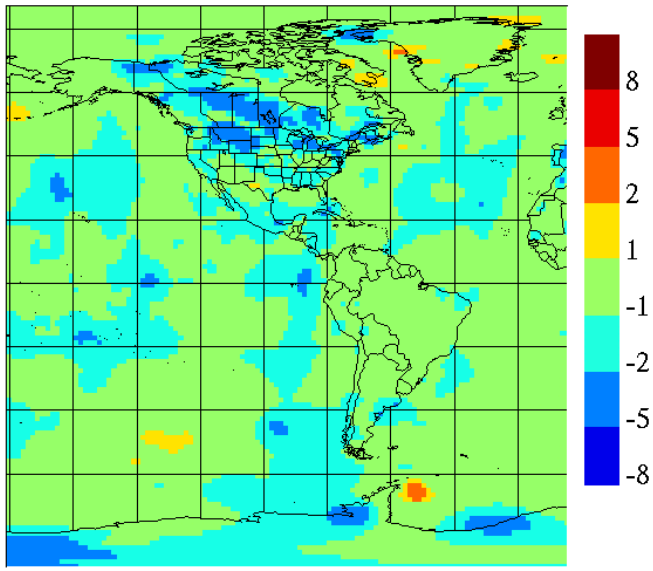


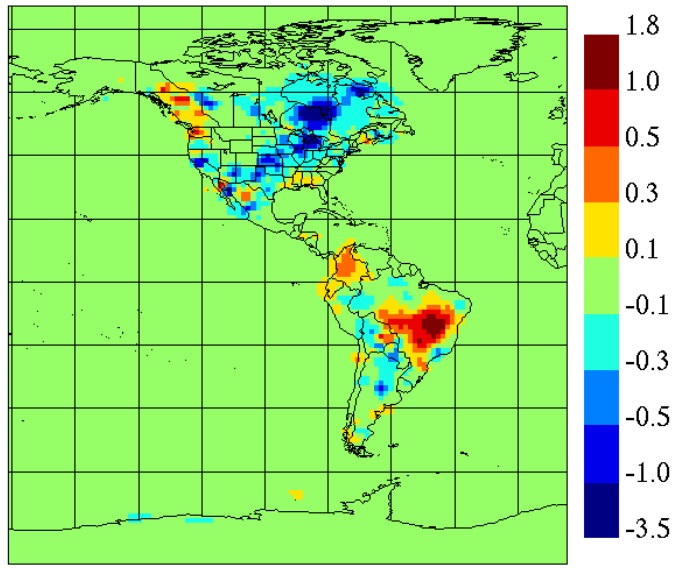
Effect of T_s-T_a error correlation on T_a increments

T_a inc (with correl)

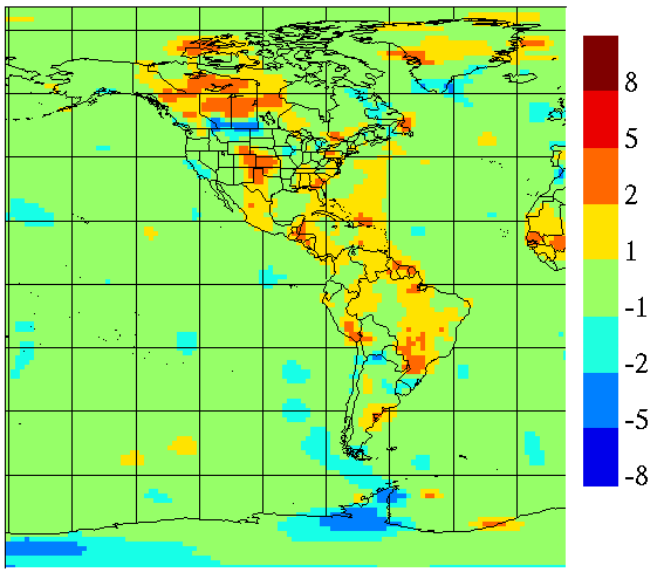
inc diff (with -without correl)

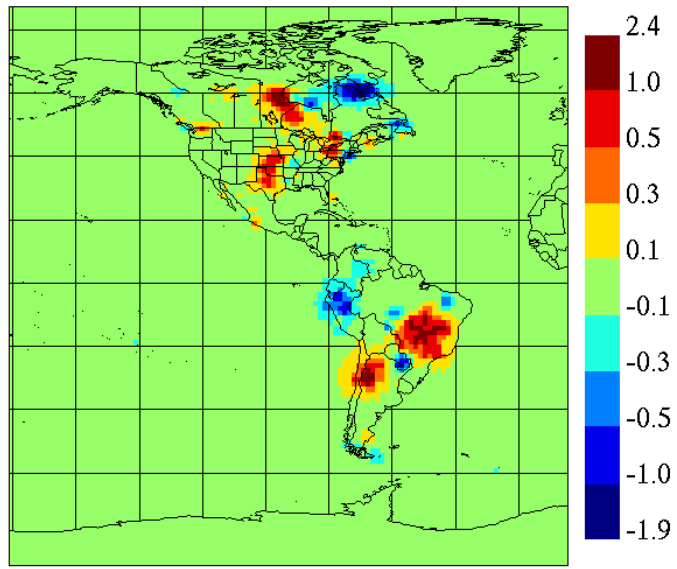
06 UTC



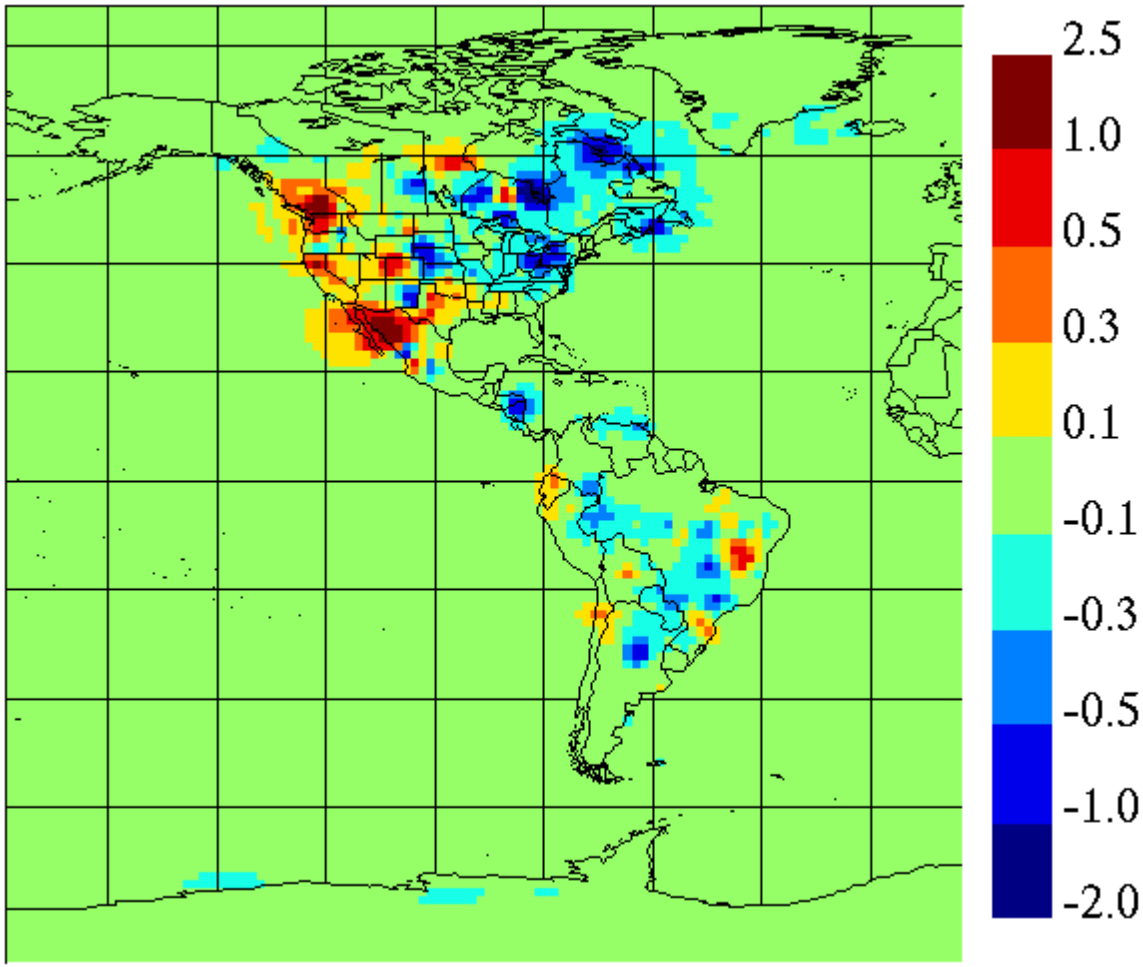


18 UTC





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

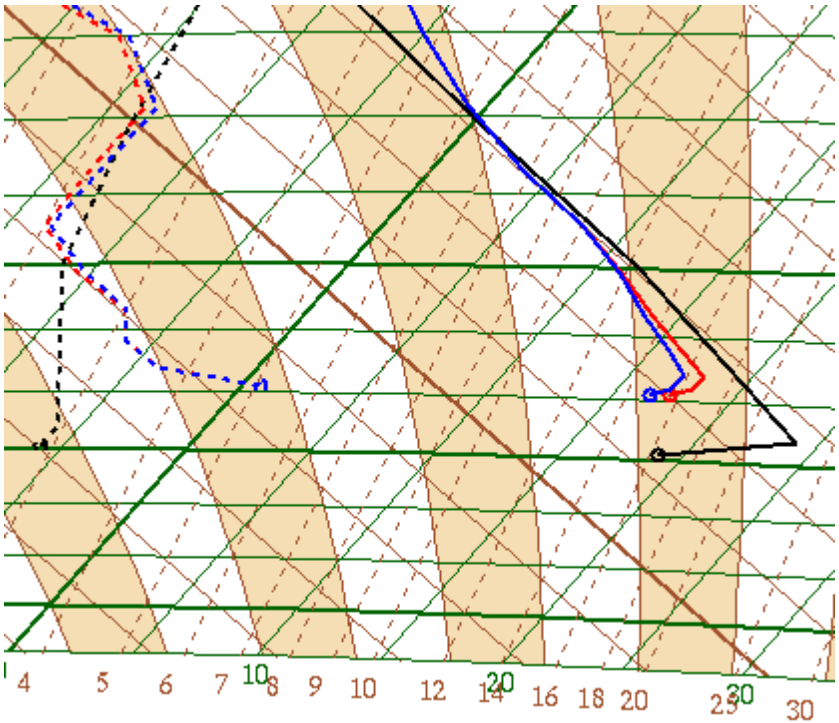


- **Radiosondes not assimilated: kept as independent verification**

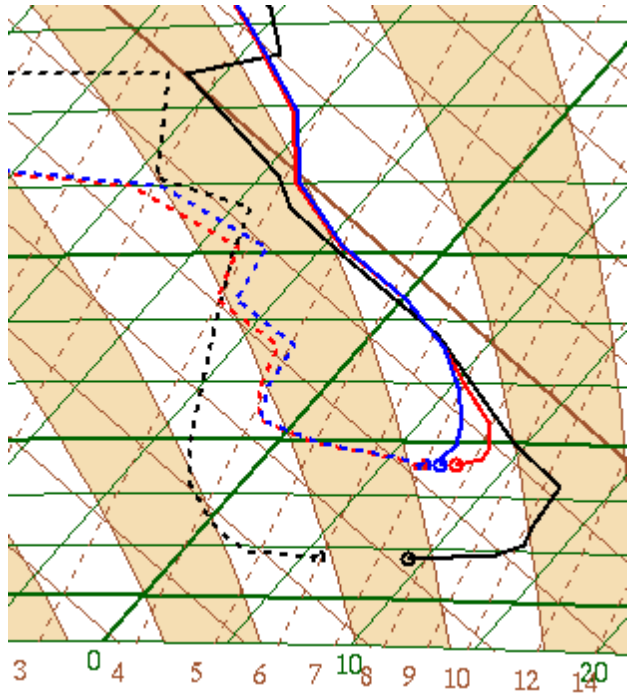
Comparison of 12 UTC analyses against radiosondes

(radiosondes not assimilated)

Grand Junction, CO: improved T



Kelowna, BC: improved T,Td



700 mb

850 mb

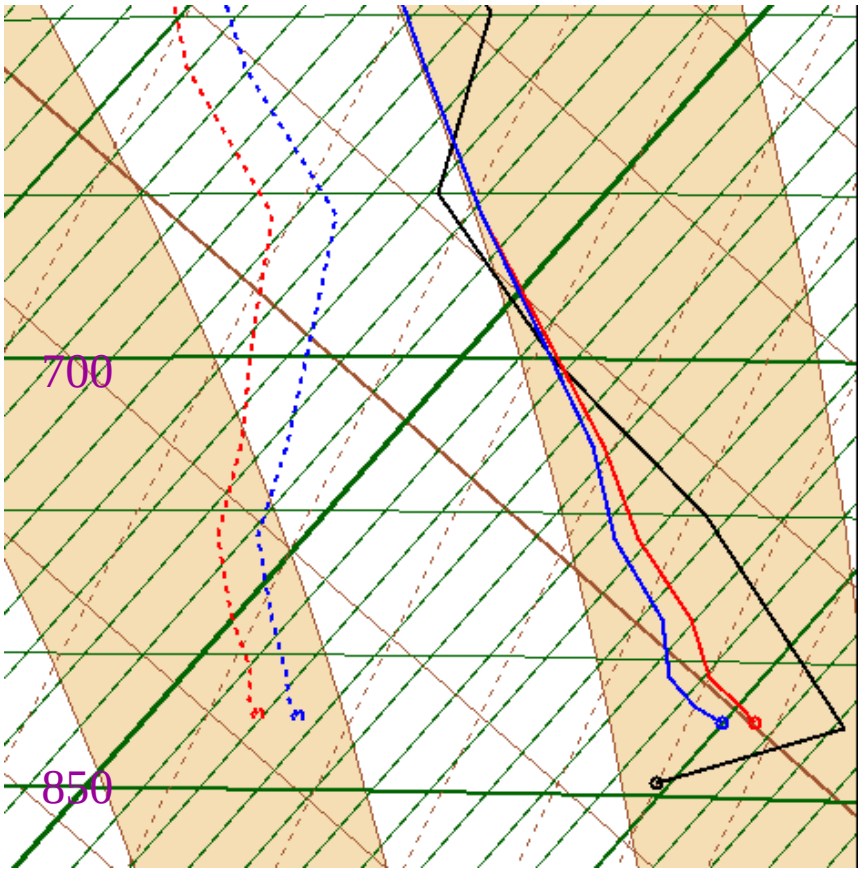
1000 mb

Black: radiosonde Blue: without correlation Red: with correlation

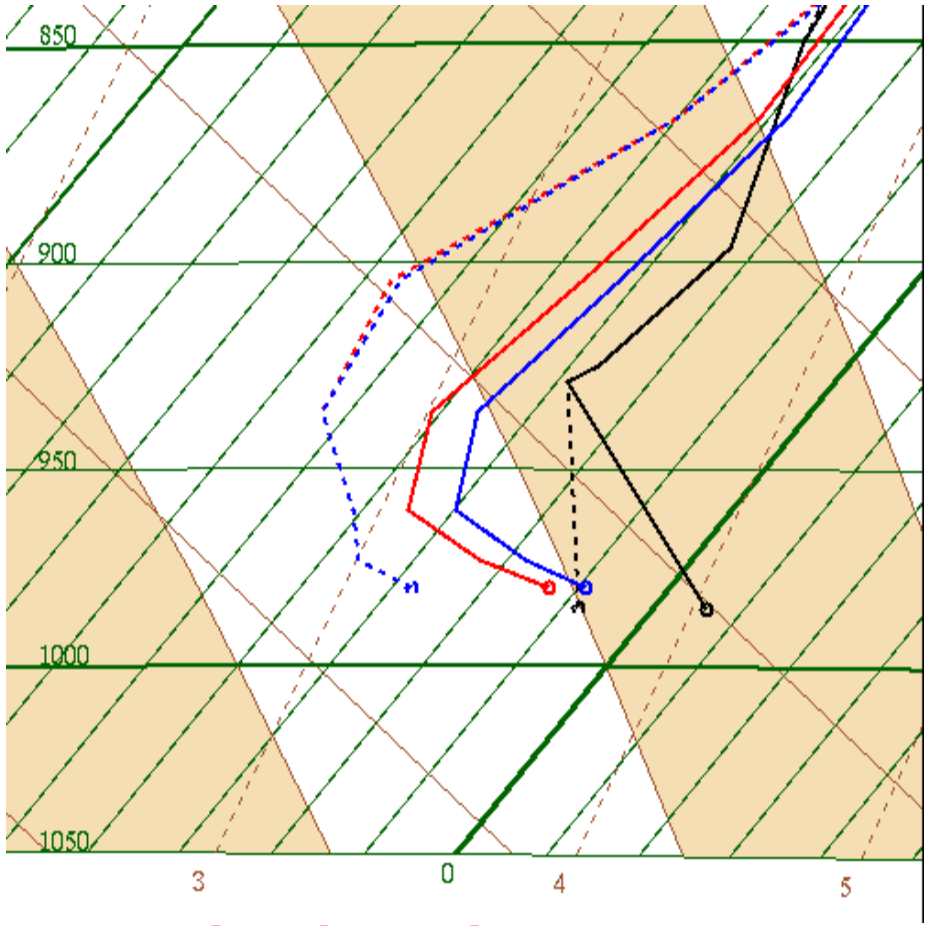
full: Temp dashed: dew point spread

Other comparisons

Reno, Nevada : improved T,Td



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

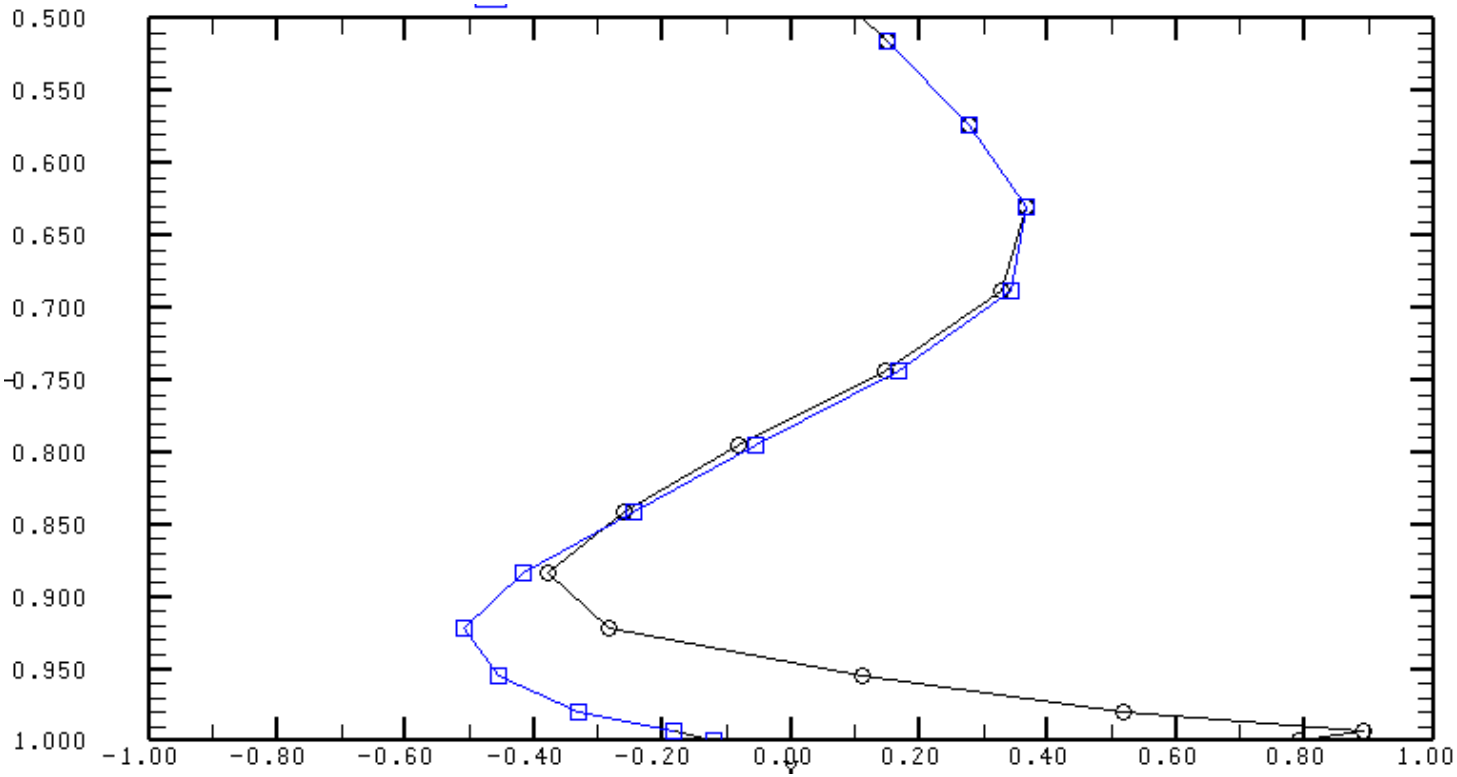
- The T_s-T_a error correlation can induce changes of the order of 1 K in the boundary layer from the assimilation of surface sensitive IR channels. The analysis of T_s is also improved in principle.

- 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



blue: without correlation; T_s increment = +3.3 K

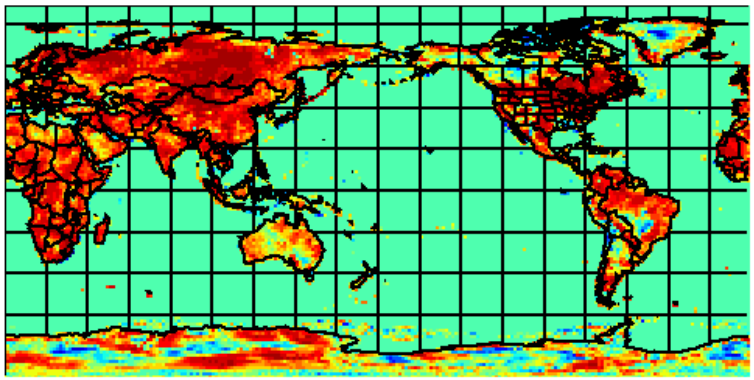
black: with correlation; T_s increment = +2.9 K

BT4(obs-calc) = +1.69 K; BT5(obs-calc) = + 1.54 K

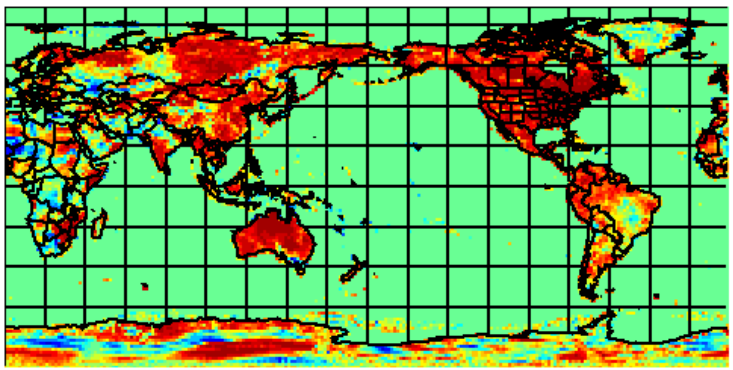
Link between Ts-Ta error correlation and surface inversions

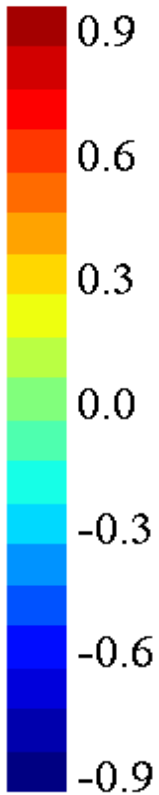
T_s-T_a error correlation

12 UTC June 02



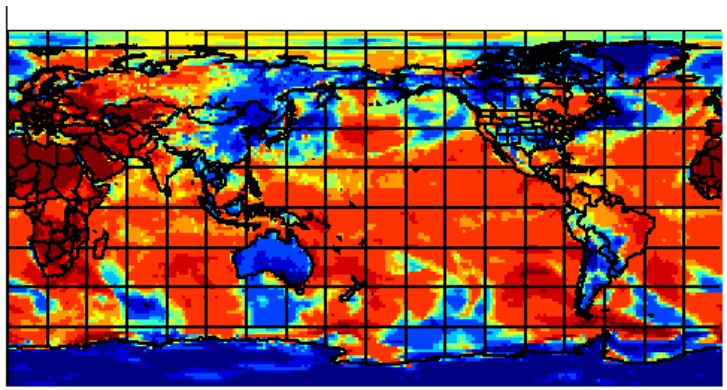
00 UTC June 03





T_s minus T_a

12 UTC June 02



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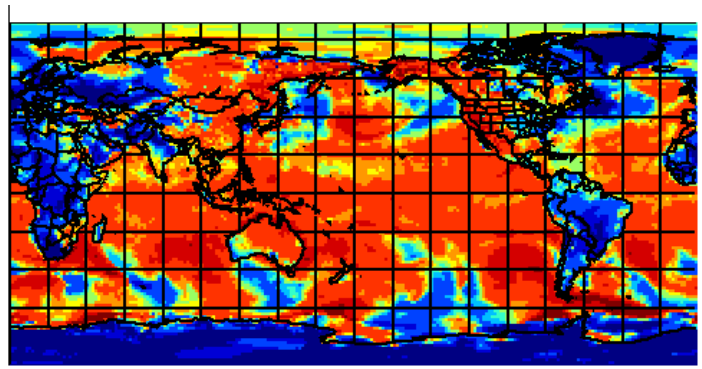

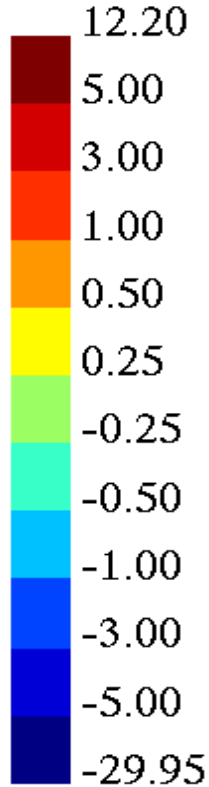

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