Assimilation of tropospheric-sensitive infrared radiances over land

Reima Eresmaa, Cristina Lupu, Tony McNally
What we said in ITSC-20?

We didn’t expect to get far by using the same methods over land as those used over sea.

Summary

Applying a departure-based cloud detection over land introduces correlation between observation and background errors – these cannot be handled properly by any data assimilation scheme.

Recent and near-future developments to the cloud detection aim at reducing the dependency on background information.

- Using colocated imager information
- Exploiting inter-channel differences in observed spectra

The future use of infrared radiances over land will rely on fundamentally different cloud detection and observation error covariance as compared with the use of radiances over sea.
Current use of hyperspectral radiances (Cy43r3)

- **AIRS**: Active channel index vs. count (k-obs) for Sea and Land.
- **CrIS**: Active channel index vs. count (k-obs) for Sea and Land.
- **IASI**: Active channel index vs. count (k-obs) for Sea and Land.

- **~716 cm⁻¹**
- **~775 cm⁻¹**
Near-future use of hyperspectral radiances (Cy45r1)
Land-sensitive channels are rejected on a case-by-case basis

In terms of the cloud detection, the transitioning from Cy43r3 to Cy45r1 changes nothing

→ Continued use of departure-based scheme also over land

Instead of rejecting / activating fixed channel subsets in a blacklist, exactly the same channels are set active over land as over sea

Surface-sensitive channels are identified and rejected on a case-by-case basis
How much is too much of land surface sensitivity?

We set a threshold based on channel height assignments (CHA)

→ A channel is considered surface-sensitive if its CHA exceeds 90% of the maximum CHA in the spectrum

→ Independent background fit diagnostics indicate little sensitivity to threshold value in the range 80—95%

A global 3-month sample of observation minus background departure data
Short-range performance evaluation

Conventional U / V

“No IR” control

IR impact without data over land

IR impact with data over land

Global 8-month observation minus background departure statistics

Conventional T

TEMP Q

AMSU-A

MHS
Medium-range performance evaluation

IR impact without data over land
IR impact with data over land

No IR control

N.Hem. 500 hPa geopotential

S.Hem. 500 hPa geopotential

Wind 850 hPa Tropics

Global 8-month forecast RMSE as verified against own analysis
Towards using surface-sensitive channels over land?

Try activating land-sensitive IASI channels in the daytime when the following requirements are met:

1) All non-surface-sensitive channels are clear

2) Maximum inter-cluster BT difference in the 10.8 $\mu$m AVHRR channel is less than 1.0 K

3) Mean visible AVHRR channel reflectance falls below a solar-angle dependent threshold
~8% increase in global data count in the long-wave window

Additionally using surface-sensitive channels

Using non-surface-sensitive channels over land

Skin temperature error distribution?

773.5 cm⁻¹
Impact of land-sensitive channels is still mixed at best

Global 8-month observation minus background departure statistics

BG fit improved
BG fit degraded
Conclusions

Situation-dependent identification of channels that are sensitive to surface emission

→ Allows to use majority of IR channels in the same way over land as they are used over sea
→ Results in a notable enhancement in IR radiance impact on NWP

Use of surface-sensitive channels over land remains a challenge

→ Relying on both IR and visible channels of a collocated imager, the cloud detection is probably good enough
→ It is necessary to improve the modelling of skin temperature and its error statistics